

Review of Critical Radiation Areas for LHC Electronics and Mitigation Actions Radiation Monitoring and First Results Session 6 - 27<sup>th</sup> January 2010

Chamonix 2010"

January 27th

**Radiation 2 Electronics** 

!! Many Thanks To Everybody !!! R2E Study Group www.cern.ch/r2e



#### Monitoring – "Benchmarking" – Early Operation :

Experience from Commissioning

Overview

- **Calibration** of RadMons and Benchmarks
- The LHC Radiation Environment

### (Quick!) Review of Radiation Levels:

- Some examples of new FLUKA Calculations
- Summary as a function of 'LHC-Operation'
- Criticality List

#### **Mitigation Options:**

- How much can we do with Shielding ('Simple' and 'Complex')
- Where is **Relocation** required
  - Early Relocation
  - Complete Relocation
- What Other Options do we have (Civil Engineering, SCL)

What do we have to do more?

What is critical when?

What can we do about it?







# Monitoring & Benchmark



### Some Parts in Short

#### **RadMon Improvements**

- Refined Calibration (benchmark experiments, dedicated tests,...)
- **Relocation** of detectors to allow for better early measurements
- The LHC Radiation Environment
- Change of Voltage Settings
- New RadMon Developments (e.g., Battery Driven Version)

#### **Inventory & Additional Monitoring**

- Through Point-Iterations monitor locations were checked & documented -> visualisation tool suggested (to be developed)
- more than 200 TLD detectors placed around critical areas
- will allow for an early analysis at even low-intensities
- we will start collecting them in late-summer

### Combined Monitoring Tool (see link):

- Beta-Release of Combined Monitoring Tool
- Allows for quick analysis of various detector types
- Extensively used during early operation
- Not only useful for R2E purposes







## Radiation Physics/Effects/Monitoring





## Reality Is Complicated (e.g., UJ76)







### Having a look in literature

DEVICE SEU CROSS SECTIONS, FROM THERMAL AND HIGH ENERGY NEUTRONS, CURRENT MEASUREMENTS

	Туре	Vendor	DC/	Hi E SEU X-	Therm SEU	Ratio-SEU,
Part			Feat Size	Sec, cm <sup>2</sup> /bit§	X-Sec, cm <sup>2</sup> /bit	Therm/ Hi E
S-1	SRAM	VS-1	0446/0.15µ	2.1×10 <sup>-14</sup>	3.3×10 <sup>-16</sup>	1.6×10 <sup>-2</sup>
S-2	SRAM	VS-1	0446/0.15µ	7.9×10 <sup>-15</sup>	1.7×10 <sup>-19</sup>	2.2×10 <sup>-5</sup>
D-1	DRAM	VD-1	0446/0.15µ	6.4×10 <sup>-17</sup> *	1.3×10 <sup>-15</sup>	20
D-2	DRAM	VD-1	0422/0.13µ	2.95×10 <sup>-16</sup> *	1.18×10 <sup>-16</sup>	0.4
P-1	μprocess	VP-1	0240/0.18µ	1.5×10 <sup>-14</sup>	2.2×10 <sup>-17</sup>	1.5×10 <sup>-3</sup>
P-2	µcont.	VP-2	0439/0.13µ	1.02×10 <sup>-3</sup> †	1.68×10 <sup>-5</sup> †	1.7×10 <sup>-2</sup>
P-3	µcont.	VP-2	0532/0.15µ	6.99×10 <sup>-4</sup> †	6.03×10 <sup>-6</sup> †	8.6×10 <sup>-3</sup>
P-4	μcont.	VP-2	0341/0.18µ	1.54×10 <sup>-4</sup> †	1.34×10 <sup>-5</sup> †	8.7×10 <sup>-2</sup>
P-5	μprocess	VP-3	0311/0.18µ	1.3×10 <sup>-15</sup>	No upsets	0

† In units of Upset/dev-hr;

IEEE Trans. on Nucl. Sci., Vol 5, p. 3587-3595

\* No actual upset detected; cross section based on 1 assumed upset § E> 10 MeV

#### Sensitivity ranges over four order of magnitudes

- Some: similar or larger xSection
  - Others: a factor of 10-100 or further below

□ How does is compare to our particle energy spectra?

## What's about the Critical Areas





Chamonix 2010: January 27<sup>th</sup>

## The Risk of Low-Energy Neutrons



### The Risk of low-energy neutrons can't be excluded

- @ after shielding and with similar cross-sections dominant
- e significant contribution even with a cross-section of a factor of 10-100 less
- Important criteria for shielding and relocation approaches
- Only preliminarily studied so far (main concern to reduce the high-energy hadron fluence – still helps for low energy neutrons)
- Oifferent shielding strategies (Boron, ...)

@ Risk:

- Important for old components possibly containing borated glass
- e also not to be excluded for new COTS, etc...





# Do we have Early Measurements?

## WIC Failure during TI8 Injection Test



- WIC failure observed in June (stopped CNGS and LHC Injection)
- Immediate analysis of available measurement data
- □ FLUKA simulations: respective radiation levels (10<sup>8</sup>-10<sup>9</sup>cm<sup>-2</sup>)
- Detailed review of WIC layout and available test measurements
- Analysis confirmed that the failure was very unlikely
- During the additional TI2/8 test about 4x10<sup>13</sup> protons were 'dumped' on the upstream collimator -> no WIC failure observed





## **W** UJ87: setup of TCDIH.87904





## CERN

### TCDQ Losses 07-09.11.2009





#### Chamonix 2010: January 27th

#### Session 6 - Radiation To Electronics: R2E Summary

## TCDQ Losses 07-09.11.2009

High energy (>20MeV) hadron fluence for (2.6+0.74)E13 protons/year



- ~ $3x10^{10}$  cm<sup>-2</sup> high-E hadrons for 7TeV and 2.6x10<sup>13</sup>
- rough scaling: ~2x10<sup>9</sup> cm<sup>-2</sup> at 450GeV
- this results in  $\sim 4x10^5$  per  $5x10^9$  shot
- **Thanks Brennan!** We had about 50 (full) shots on the TCDQ -> ~2x10<sup>7</sup> expected
- 5.6x10<sup>7</sup> measured at the tunnel location (~30counts!)
- In the UA, the monitor is set to 3V (factor of 10 more sensitive) -> nothing measured -> confirms the expected attenuation factor of ~1000

## Early Monitoring - Important Analysis



#### a long table -> don't try reading © E. Lebbos

- Continuous analysis of monitor readings helps verifying simulation predictions as well as identifying additional weak-points (in case)
- A draft table of possible loss-cases (intended losses for R2E purposes) was developed and is in iteration with operation (R. Assmann, B. Goddard)
- Coming months will be particularly important and time and effort is required for a dedicated R2E analysis

### **!!! HELP NEEDED !!!**

Image         Image <th< th=""><th></th><th></th><th></th><th><u> </u></th><th></th><th></th><th></th><th></th><th><u>.</u></th><th><math>\overline{\mathbf{N}}</math></th><th></th><th>)</th></th<>				<u> </u>					<u>.</u>	$\overline{\mathbf{N}}$		)
Figure 1         2555.00         11.0075         300.44.11.0015         900.46         900.46         900.477         0.022/n.h.           B13.2         2555.00         1.0015         300.40         1.0015         0.001         0.003         0.003         0.003         0.003/n.h.         0.003/n.h.           B17.1         145.00         1.00075         SMA.UXIS.1E075         900.46         92         1         1.007-0         0.032/n.h.           B17.1         145.00         1.00075         SMA.UXIS.1E075         900.46         92         5         0.017-0         0.032/n.h.           B17.1         145.00         1.00155         SMA.UXIS.1E075         900.46         92         5         0.017-0         0.057/n.h.           B17.1         240.00         1.00165         SMA.UXIS.1E075         900.46         97         0.84767         0.037/n.005           U22         3045.00         YE         2.00055         SMA.UXIS.2210.005         900.40         97         2.6         2.206-07         0.037/n.013           U22         3045.00         YE         2.10005         SMA.UXIS.21005         900.40         97         2.6         2.206-07         0.037/n.013           U22         3045.00         <	Location	Area	Deum [m]	Critical Area	RadMon Ident. Nb	Localization (SIMA)	RadFET 1/2	SEU sens	Counts	Fluence hadrons [cm <sup>-2</sup> ]	Dose [Gy]	Neutro eq. 1 M
Figure         26516.00         11/11/18         300-40         90         55         1.108-68         0.03/k.h.           1000         0.00         1.80075         30.40.41.10.1015         0.000         0.021/h.h.         0.021/h.h.           1017         145.00         1.80075         50.40175         400 vie         90         25         5.008-07         0.032/h.h.           1017         145.00         1.80075         50.40175         400 vie         90         1.814.00         6.0090/h.h.		RI132	26516.00		1LM07S	SIMA.4L1.1LM07S	400/ 100	5V	48	9.60E+07	0.022/n.k.	Neutring           Neutring           1           5           -
LUGS         0.00         180275         SMALUGS.BEO27         mmode         yu         1         1.087-66         0.021,063           B1271         14.500         15M0075         SMALUGS.BEO275         mmode         yu         5         5.004-07         0.032,06.3           B1271         14.500         15M0075         SMALARI.BMOTS         wu         59         1.187-66         0.032,06.1           B1271         224.00         15M005         SMALARI.BMOTS         wu         59         1.187-66         0.032,06.1           B1271         224.00         15M005         SMALARI.BMOTS         wu         59         1.867-66         0.027,06.0           B1271         224.00         15M005         SMALU22.21M065         990-40         59         7         1.406+07         0.079,00.0           U22         3045.00         YE5         21M065         SMALU22.21M065         990-40         59         2.50         5.024+08         0.079,00.01           U23         13.88.81         YE5         21M065         SMALU22.21M065         990-40         59         2         4.004+06         0.007,00.01           U23         13.88.81         YE5         21M065         SMALU22.21M055         990-40		RI132	26516.00		1LM185	SIMA.4L1.1LM18S	dep/ dep	5∨	55	1.10E+08	0.028/n.k.	
BIT         11:50         11:MOS         SMA.4R.1:MOS         900         90         2.5         5.007-07         0.002/c.h.           BIT         14:500         1.18MOS         SMA.4R.1:MOS         900         90         18:400         0.0000/c.h.           BIT         12:00         1.18MOS         SMA.4R.1:MOS         900         90         1.87.400         0.0056/c.h.           BIT         24:00         1.18MOS         SMA.4R.1:MOS         900         90         1.87.400         0.0556/c.h.           BIT         24:00         1.18MOS         SMA.4R.1:MOS         900         8.47.405         0.0379/c.001           UU22         303.4.21         YE         2.18MOS         SMA.41.22.21MOS         900         8.47         0.5024-08         0.070.047           UU22         304.50         YE         2.1MOS         SMA.U22.21MOS         900         9.4         2.6         2.2024-07         0.009/c0.01           UU2         304.50         YE         2.1MOS         SMA.41.21MOS         900         9.4         2         4.0024-06         0.007/c0.037           UU2         304.50         YE         2.1MOS         SMA.41.21MOS         900         9.4         2         1.066.40	POINT 2 POINT 1	UX15	0.00		1RE07S	SIMA.UX15.1RE07S	1000/ 400	3V	1	1.69E+06	0.021/0.053	
Q         BI71         14.60         1 MINDS         SMA.481.34M15         900 000 000 0000         900 0000         900 0000         1188-06         0.000000000           BI71         224.00         1 MIMDS         SMA.481.13M105         900 000 90 90         7         3.040-00         0.055/n.k.           BI71         224.00         1 MIMDS         SMA.481.11M145         900 000 90         7         3.040-00         0.055/n.k.           BI71         JLL         247.60         1 MIMDS         SMA.481.11M145         900 000 90         0         6.478-05         0.0370.000           U22         3004.20         YES         ZIM005         SIMA.UI22.21M065         300 00         90         251         5.028-08         0.077(0.047           U23         13.80         YES         ZIM005         SIMA.UI22.21M055         300 00         90         2         4.000+06         0.007(0.031           U23         13.88.3         YES         ZIM005         SIMA.UI22.21M055         300 00         90         2         4.000+06         0.007(0.031           U23         13.88.83         YES         ZIM005         SIMA.UI22.21M055         900         2         4.000+06         0.007/0.031           U23         13.8		RI171	145.00		1RM075	SIMA.4R1.1RM07S	400/ 100	5V	25	5.00E+07	0.032/n.k.	
EDD         127.1         22.00         1 MIMAS         SMA.REI.18MIAS         400 00         90         17         3.405-07         0.055/h.k.           U122         247.60         1 MIMAS         SMA.REI.18MIAS         500 00         8.476-05         0.015/h.k.           U122         3045.00         YE         21,0605         SIMA.LILLAS         500 00         8.7         1.405-07         0.378/h.00           U122         3045.00         YE         21,0605         SIMA.U122.21,0405         500 00         8.7         7         1.405-07         0.378/h.0123           U122         3045.00         YE         21,0605         SIMA.U122.21,0405         500 00         8.7         2.5         5.024-08         0.07/h.047           U123         13.60         YE         21,0005         SIMA.U122.21,0005         500 00         9.7         2.6         2.205-07         0.009/h.031           U123         13.60         YE         21,0005         SIMA.U122.21,0005         500         9.7         2         4.005-66         0.007/h.053           U123         13.80         YE         21,0005         SIMA.U122.21,0005         500         9.7         2         1.664-60         0.007/h.053           U127 </td <td>8</td> <td>RI171</td> <td>145.00</td> <td></td> <td>1RM195</td> <td>SIMA.4R1.1RM195</td> <td>1000/400</td> <td>5∨</td> <td>59</td> <td>1.18E+08</td> <td>0.0090/0.015</td> <td></td>	8	RI171	145.00		1RM195	SIMA.4R1.1RM195	1000/400	5∨	59	1.18E+08	0.0090/0.015	
BitZ/BitZ         247.69         11MI45         SMA-R3.1.1MI45         999-00         97         0         8.47E-05         0.0130.00           ul22         302.421         Yt5         ZIM05         SIMA.UI22.2IM065         999         0         8.47E-05         0.0139.0.00           ul22         3024.21         Yt5         ZIM05         SIMA.UI22.2IM065         999         0         8.47E-05         0.0179/0.123           ul23         3045.00         Yt5         ZIM05         SIMA.UI22.2IM055         999         97         2.6         2.206-07         0.07/0.047           RA3         3188.33         Yt5         ZIM05         SIMA.UI23.2IM055         997         2.6         2.206-07         0.07/0.051           U/33         139.90         Yt5         ZIM05         SIMA.UI23.2IM055         997         2         1.667-66         0.07/0.051           U/34         139.90         Yt5         ZIM055         SIMA.UI23.2IM055         997         2         1.667-66         0.007/0.051           28/9/A27         3391.0         2         ZIM055         SIMA.UI23.2IM055         996         2         1.667-66         0.007/0.051           28/9/270         2         ZIM055         SIMA.LI23.2IM055<		RI171	224.00		1RM105	SIMA.6R1.1RM10S	400/ 100	5∨	17	3.40E+07	0.055/n.k.	
UD2         302.4.21         VIS         ZLM065         SIMA.U22.2LM068         300-40         P/         7         LA0E-07         0.378/0.123           UD2         3045.00         VIS         ZLM055         SIMA.U22.2LM068         300-40         P/         251         5.021-68         0.070.007           UD2         3045.00         VIS         ZLM055         SIMA.U22.2LM055         300-40         P/         251         5.021-68         0.070.007           UD2         3045.00         VIS         ZLM055         SIMA.U22.2LM055         300-40         P/         26         2.205-07         0.099/0.031           UL2         138.80         VIS         ZLM055         SIMA.U22.2LM055         800-40         P/         2         4.005-66         0.007/0.035           UL7         139.90         Z2M055         SIMA.U22.2LM055         SIMA.U22.2LM055         800-40         P/         2         1.667-66         0.007/0.035           28         397.00         ZM055         SIMA.U22.2LM055         SIMA.U22.2LM055         90-02         2         1.667-66         0.007/0.035           28         492.00         ZM055         SIMA.U22.2LM055         SIMA.U22.2LM055         90-02         1         8.476-65		RI12/RR17	247.69		1LM14S	SIMA.8L1.1LM14S	1000/400	5∨	0	8.47E+05	0.019/0.00	
UD2         S08.500         YES         ZLMOSS         SIMA-UD2-ZLMOSS         SUB - B         S2         LS.024-08         0.07/0.047           U03         13.60         YES         ZLMOSS         SIMA-UD2-ZLMOSS         SUB - B         26         2.264-08         0.07/0.047           U03         13.60         YES         ZLMOSS         SIMA-UD2-ZLMOSS         SUB - B         26         2.264-02         0.009/0.031           U03         13.80.83         YES         ZLMOSS         SIMA-UD2-ZLMOSS         SUB - B         2         4.065-66         0.094/n.k.           U037         13.98.09         YES         ZLMOSS         SIMA-UD2-ZLMOSS         SUB - B         2         1.087-66         0.017/0.35           U377-73         33930         ZMMDSS         SIMA-UD2-ZLMOSS         SUB - B         2         1.087-66         0.017/0.31           U377-73         33930         ZMMDSS         SIMA-UD2-ZLMOSS         SUB - B         2         1.087-66         0.017/0.31           U378-77         238700         ZMMDSS         SIMA-UD2-ZLMOSS         SUB - B         2         1.087-66         0.017/0.31           U28         4040.00         ZMMDSS         SIMA-UD2-ZLMOSS         SUB - B         2	POINT 2	UJ22	3024.21	YES	2LM06S	SIMA.UJ22.2LM06S	1000/ 400	5∨	7	1.40E+07	0.178/0.123	
UI23         113.60         YE         21.0045         SIMA-UI2.21.0056         100 cm         77         2.6         2.206-07         0.00/0.031           84.33         3188.83         YE         2.0067         SIMA-UI2.21.0057         400 '10         97         2         1.007-00         0.00/0.031           40.33         3188.83         YE         2.0007         SIMA-UI2.21.0075         97         2         1.007-00         0.000/n.h.           40.33         118.93         YE         2.00015         SIMA-UI2.21.0015         987         2         1.007-00         0.000/n.h.           40.37         1393.10         2.00015         SIMA-UI2.21.0015         987         1         8.472-66         0.0007/n.h.           500         977         2         1.007-h.6         0.0007/n.h.         1         8.472-66         0.0007/n.h.           528         4070.00         2.984015         SIMA-102.200105         97         2         1.007-66         0.007/n.b.           528         4070.00         2.984015         SIMA-102.200105         97         1         8.477-65         0.002/n.025           528         4233.00         2.984015         SIMA-102.200105         97         1         8.477-65 </td <td>UJ22</td> <td>3045.00</td> <td>YES</td> <td>2LM05S</td> <td>SIMA.UJ22.2LM05S</td> <td>1000/ 400</td> <td>5∨</td> <td>251</td> <td>5.02E+08</td> <td>0.07/0.047</td> <td></td>		UJ22	3045.00	YES	2LM05S	SIMA.UJ22.2LM05S	1000/ 400	5∨	251	5.02E+08	0.07/0.047	
BOD         BA33         S188.33         VfS         ZMN71         SMA.41.2 ZMN75         MeV 100         P/L         2         AUG-06         D.004/n.k           UA3         139.89         VfS         ZMN75         SMA.41.2 ZMN75         MeV 100         P/L         2         L007-06         D.004/n.k           UA3         139.89         VfS         ZMN15         SMALUA22 ZMN75         MeV 10         P/L         2         L007-06         D.007/n.05           SMN47         139.10         2         ZMN15         SMAL02 ZMN155         MeV 10         SM         100         L007/n.15         MeV 10         SMA152         MeV 10         SM         100         L007/n.15         MeV 10         SMA142 ZMN155         MeV 10         SMA142 ZMN155         MeV 10         SMA142 ZMN155         MeV 10         SMA142 ZMN155         MeV 10         Z         L007/n.15         MeV 10         Z <td>UJ23</td> <td>13.60</td> <td>YES</td> <td>2LM04S</td> <td>SIMA.UJ23.2LM04S</td> <td>1000/ 400</td> <td>3∨</td> <td>26</td> <td>2.20E+07</td> <td>0.009/0.031</td> <td></td>		UJ23	13.60	YES	2LM04S	SIMA.UJ23.2LM04S	1000/ 400	3∨	26	2.20E+07	0.009/0.031	
UA3         139.90         Vf         24001         940.403         940.413.403.403.503.403.403.403.503.505         940		RA23	3188.83	YES	2LM07S	SIMA.4L2.2LM07S	400/ 100	5∨	2	4.00E+06	0.004/n.k.	
Up:         13::00         2 20005         SMALUA27.20005         900.000         1         8.477-65         0.0001           12:80::07:00         2 80005         SMALUA27.20005         900.000         90         10         3667-60         0.0107/n.k           12:80::07:00         2 80005         SMALUA27.20005         900.000         2         2         1.087-66         0.0107/n.k           12:80::07:00         2 80005         SMALUA27.20005         900.000         2         2         1.087-66         0.0007/n.k           12:80::07:07:00         2 80005         SMALU32.20005         900.00         3         2         1.087-66         0.0007/0.01           12:80::07:07:07:07:07:07:07:07:07:07:07:07:0		UA23	139.90	YES	2LM015	SIMALUA23.2LM015	1000/ 400	3V	2	1.69E+06	0.007/0.035	
Page         Page <th< td=""><td>UA27</td><td>139.90</td><td></td><td>2RM01S</td><td>SIMA.UA27.2RM01S</td><td>1000/400</td><td>3V</td><td>1</td><td>8.47E+05</td><td>0/0.031</td><td></td></th<>		UA27	139.90		2RM01S	SIMA.UA27.2RM01S	1000/400	3V	1	8.47E+05	0/0.031	
Fig.         Sign: 0         Z 20005         Sign: 200         Z 200         Sign: 200         Z 200 <thz 200<="" th=""> <thz 200<="" th="">         Z 200</thz></thz>		R28/RA27	3391.10		2RM19S	SIMA.4R2.2RM19S	400/ 100	5V	180	3.60E+08	0.107/n.k.	
100         128         3927.00         204000         3044.482.2404.00         992 est         yr         4         3.384.66         0.0010.01           28         4034.00         20441.53         5044.672.2404.13         506.66         3026.00.02         1.684.66         0.008(n.0.02)           28         4040.00         20441.53         5044.172.2404.133         506.66         3026.01.031         6.076.67         0.002.01           293         4157.00         20441.53         5044.172.2404.133         506.66         3026.01.031         6.076.67         0.002.01           203         4157.00         20441.53         504.07.175         500.06         30         1         8.474.66         0.012.000           813         5912.00         20480.55         504.07.173.3400.55         500.66         0.017.000         1         8.474.66         0.012.000           813         502.00         3400.55         504.04.23.3401.55         400.966         50         2         6.046.70         0.07.4.           814         6512.00         3400.15         504.06         50         2         6.046.70         0.07.4.           814         6512.00         3400.15         504.06         9         2         6.046.7		R28	3877.00		2RM09S	SIMA.13R2.2RM095	1000/400	3∨	2	1.69E+06	0.004/0.016	
100         28         4034.00         2 mm 2 (2000)         2 mm		R28	3927.00		2RM105	SIMA.14R2.2RM105	1000/ 400	3∨	4	3.39E+06	0.01/0.012	
V0000         200003 </td <td></td> <td>R28</td> <td>4034.00</td> <td></td> <td>2RM12S</td> <td>SIMA.16R2.2RM12S</td> <td>1000/ 400</td> <td>3V</td> <td>2</td> <td>1.69E+06</td> <td>0.008/0.026</td> <td></td>		R28	4034.00		2RM12S	SIMA.16R2.2RM12S	1000/ 400	3V	2	1.69E+06	0.008/0.026	
1000         128         4137.00         200035         500-00         yr         1         8.477-05         00/00.00           128         428.00         200045         20042         300405         20042         300405         20047           1828         423.00         200475         500A2         300415         500-00         1         8.477-05         0/0.002           1833         6062.00         200475         500-02         300405         500-02         3         1         8.477-05         0/0.000           1833         6062.00         300005         500-02         30         1         8.477-05         0.001/0.000           1833         6062.00         300055         500-02         30         1         8.477-05         0.001/0.000           1833         6062.00         300055         500-02         30         6         5.062-00         0.021/0.053           184         6426.00         300055         500-02         30         6         5.062-07         0.021/0.53           184         6426.00         300055         500-07         600-07         0.027/0.5         5.002-07         0.021/0.5           184         6422.00         300055		R28	4090.00		2RM13S	SIMA.17R2.2RM13S	1000/ 400	3∨	2	1.69E+06	0.008/0.031	
128         4248.00         2011         <		R28	4197.00		2RM155	SIMA.19R2.2RM15S	1000/ 400	3V	1	8.47E+05	0/0.028	
Bigs         4274.00         28M/15         Sinda RE28.2M/15         source         yr         1         8.474-05         0.012.000           Bigs         5912.00         31M005         SindA/TG.33M005         source         yr         1         8.474-05         0.012.000           Bigs         6067.00         31M005         SindA/TG.33M005         source         yr         1         8.474-05         0.012.000           Bigs         6027.00         31M005         SindA/TG.33M005         source         yr         1         8.474-05         0.002.000           Bigs         6124.00         31M005         SindA/TG.33M005         source         yr         1         8.474-05         0.002.70.053           Bigs         6134.00         31M015         SindA/TG.33M005         source         yr         8         1.064-07         0.07.1x.           Bigs         6132.1         3184.25         SindA/TG.33M005         source         yr         2         6.024-07         0.07.1x.           Bigs         118.24         Yf5         SindA/TG.35M005         source         yr         2         5.024-07         0.07.1x.           Bigs         118.02.4         Yf5 <sinda td="" tg.35m005<="">         source         yr<td></td><td>R28</td><td>4248.00</td><td></td><td>2RM16S</td><td>SIMA.20R2.2RM16S</td><td>1000/ 400</td><td>3V</td><td>2</td><td>1.69E+06</td><td>0.021/0.025</td><td></td></sinda>		R28	4248.00		2RM16S	SIMA.20R2.2RM16S	1000/ 400	3V	2	1.69E+06	0.021/0.025	
Bit         Style         S		RE28	4273.00		2RM17S	SIMA.RE28.2RM17S	1000/ 400	3V	1	8.47E+05	0.012/0.00	
B33         6007.00         380005         SMA, 14.3.380005         source         yr         1         8.478-05         0.0002/0000           B34         6424.00         380005         SMA, 14.3.380075         source         yr         1         8.478-05         0.0002/0000           B34         6454.00         380005         SMA, 13.3380075         source         yr         8         1.068-07         0.002/0.053           B34         6454.00         3800155         SMA, 23.380155         edores         yr         2         0.642-07         0.07.4.           B34         6452.00         380155         SMA, 23.380155         edores         yr         2         0.642-07         0.07.4.           B37         532.02         1382.44         SMA05         SMA04         SM009         9         2         0.642-07         0.07.4.           B37         1382.47         YT         S         SM005         SMA04         SM009         9         1         0.642-07         0.07.4.           B37         1382.47         YT         S         SM005         SM044         SM009         9         1         5         0.057.6.           B37         1387.27         YT <t< td=""><td></td><td>R33</td><td>5912.00</td><td></td><td>3RM03S</td><td>SIMA.17L3.3RM03S</td><td>1000/400</td><td>3∨</td><td>2</td><td>1.69E+06</td><td>0.011/0.00</td><td></td></t<>		R33	5912.00		3RM03S	SIMA.17L3.3RM03S	1000/400	3∨	2	1.69E+06	0.011/0.00	
Bit         6133         6124.00         34M075         SMA.133.34M075         rot         rs         6         5.088±06         0.0027.053           Bit         6458.00         34M015         SMA.43.34M155         400±ee         9V         81         1.667±07         0.07/r.k.           Bit         6512.00         34M015         SMA.43.34M155         400±ee         9V         32         6.408±07         0.07/r.k.           Bit         6512.00         34M015         SMA.43.34M155         400±ee         9V         32         6.408±07         0.07/r.k.           Bit         1532         13182.84         V15         SMA05         SMAA12.55M075         400±ee         9V         32         6.408±07         0.07/r.k.           Bit         1512         13187.24         V15         SMM05         SMAA4.55M075         400±te         9V         32         6.408±07         0.07/r.k.           Bit         13507.27         V15         SMM05         SMAA4.55M075         400±te         9V         12         20±60±0         0.04/r.k.           Bit         13507.27         V15         SMM05         SMAA455MM055         400±te         9V         3         0.60±00         0.04/r.k. <t< td=""><td>~</td><td>R33</td><td>6067.00</td><td></td><td>3RM06S</td><td>SIMA.14L3.3RM06S</td><td>1000/ 400</td><td>3V</td><td>1</td><td>8.47E+05</td><td>0.002/0.0080</td><td></td></t<>	~	R33	6067.00		3RM06S	SIMA.14L3.3RM06S	1000/ 400	3V	1	8.47E+05	0.002/0.0080	
E         B14         6458.00         38MUSS         SMA (R.3.38MUSS         400 mp         9°         8         1.608-07         0.027/r.k.           B14         6555.00         38MUSS         SMA (R.3.38MUSS         400 mp         9°         8         1.608-07         0.027/r.k.           B14         6555.00         38MUSS         SMA (R.3.38MUSS         400 mp         9°         8         1.608-07         0.027/r.k.           B15         31812.44         W15         SMA (R.3.38MUSS         400 mp         9°         2         6.484-07         0.07.r.k.           B15         31812.44         W15         SMA (R.3.38MUSS         400 mp         9°         2         6.484-07         0.07.r.k.           B15         13812.44         W15         SMA (R.3.58MUSS         400 mp         9°         1.084-06         0.007/r.k.           B17         13507.27         W15         SMA SS SMA SS         400 mp         9°         1.099         0.007/r.h.         1.096-0         0.007/r.h.           B12         13507.27         W15         SMA SS SMA SS         400 mp         9°         2         1.696-60         0.007/r.h.           B12         13507.27         W15         SMA SS SMA SSS	LZ Z	R33	6124.00		3RM07S	SIMA.13L3.3RM07S	1000/ 400	3∨	6	5.08E+06	0.012/0.053	
Bit4         6515.00         3MML65         SMA/S 1.38ML5         eto/emp         yp         32         6.408-67         Q/n.k.           Bit4         6512.00         3MML75         SMA/S 1.38ML75         eto/emp         yp         32         6.408-67         Q/n.k.           Bit4         6512.00         3MML75         SMA/S 1.38ML75         eto/emp         yp         32         6.408-67         Q/n.k.           Bit5         1318.24         VE         SLM075         SMA/S 1.53ML75         eto/emp         yp         32         6.408-67         Q/n.k.           Bit51         1347.727         VE         SLM055         SMA/A 485.54M005         eto/emp         yp         3         6.608-60         Q/n.k.           Bit51         13477.27         VE         SLM055         SMA/A 485.54M005         eto/emp         yp         3         6.608-60         0.03/n.k.           Bit51         13477.27         VE         SLM055         SMA/A 485.54M005         eto/emp         yp         3         6.608-60         0.03/n.k.           Bit52         1557.70         6.4M1455         SMA/A 146.64.0035         eto/emp         yp         2         1.687-66         0.037/n.k.           UA3         106	ō	R34	6458.00		3RM15S	SIMA.6L3.3RM15S	400/ dep	5V	8	1.60E+07	0.02/n.k.	
B34         663.20         3MM375         SMA 43.38M375         e00 emp         9°         26         5.208-07         00237n/n.k           900         B52         13182.44         YES         SMM05         SMM 53.50075         e00 emp         9°         2.6         6.874-07         00237n/n.k           852         13182.44         YES         SMM05         SMM 53.500.75         e00 emp         9°         1         2.008-66         0/n.k.           1317.24         YES         SMM05         SMM 53.500.75         e00 emp         9°         3         6.087407         00237n/n.k.           1317.27         YES         SMM05         SMM 53.500.76         e00 emp         9°         3         6.087407         00337n/n.k.           1021         1395.77         YES         SMM05         MA106.410.50         e00 emp         9°         3         6.087466         0.005/n011           1043         156.640         EMM255         SMM.106.81.04053         e00 res         9°         3         5.08-66         0.057/n015           1043         156.640         EMM255         SMM.106.81.04053         e00 res         9°         3         5.08-66         0.037/n.h.           1044         1691.90 <td></td> <td>R34</td> <td>6515.00</td> <td></td> <td>3RM16S</td> <td>SIMA.5L3.3RM16S</td> <td>400/ dep</td> <td>5∨</td> <td>32</td> <td>6.40E+07</td> <td>0/n.k.</td> <td></td>		R34	6515.00		3RM16S	SIMA.5L3.3RM16S	400/ dep	5∨	32	6.40E+07	0/n.k.	
952         1318.24         1YE         51.0075         600 res         99         32         6.608-67         0077.h.k.           853.2         1918.244         1YE         51.00055         900 res         99         1         2.005-66         0/n.k.           857.1         13.477.27         1YE         55.00055         900 res         99         3         6.608-67         0.077.h.k.           857.1         13.977.27         1YE         55.00055         900 res         99         3         6.008-66         0.04/n.k.           857.1         13.977.27         1YE         55.00055         900 res         91         3         6.008-66         0.04/n.k.           8622         1955.70         6.041405         50.001 res         91         3         6.008-66         0.05/n.016           8622         156.60         6.04135         50.004 res         91         6.3         1.268-66         0.035/n.016           104.3         166.06         6.04135         50.044.054.04005         900 res         91         6.3         1.268-66         0.035/n.016           104.3         16605.00         1YE         6.00025         900 res         91         3         6.002-66         0.032/n		R34	6632.00		3RM17S	SIMA.4L3.3RM17S	400/ dep	5V	26	5.20E+07	0.023/n.k.	
Bit         Statu         YE         SLM055         SMM 23, SSLM045         SMM 25, SSLM045, SSLM	5	R532	13182.84	YES	5LM07S	SIMA.4L5.5LM07S	400/ 100	5∨	32	6.40E+07	0.077/n.k.	
0         1671         11477271         YEs         54M055         94M485584005         990         1595         3.19E-09         0.5157h.k.           1871         1350772         YES         54M055         34M4855840055         900         9         1595         3.19E-09         0.5157h.k.           1871         1350772         YES         54M055         34M485584005         900         9         4.002         0.004/n.k.           1862         19557.0         64M165         54MA455         54M455         900         9         2         1.68E-60         0.035/0.016           1862         1616.05         64M135         54M4455         900         9         6.3         1.26E-60         0.035/0.016           1043         16606.0         175         64M035         54M4456.40035         900         9         6.3         1.26E-60         0.035/n.k.           1044         16610.00         175<	NT	R542	-	YES	5LM04S	SIMA.2L5.5LM04S	1000/ Dep	5V	1	2.00E+06	0/n.k.	
□         IS371         13507.72         YTS         STM000S         SMA_SRS_SMM00S         sequence         yr         3         6.008+06         0.004/r.k           R622         15955.70         64M64         SMA_ATS         SMA         yr         2         1.084+06         0.006/r.0061           B622         1616.66         64M64         SMA_ATS         SMA         yr         2         1.084+06         0.006/r.0015           B621         1616.66         64M64         SMA	ő	R571	13477.27	YES	5RM05S	SIMA.4R5.5RM05S	400/ 100	5V	1595	3.19E+09	0.515/n.k.	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	_	R571	13507.72	YES	5RM06S	SIMA.5R5.5RM06S	400/ 100	5V	3	6.00E+06	0.04/n.k.	
BE22         1611.605         64.M135         SMA.136.66.M135         900.000         yr         2         1.684-06         0.037/0.015           U643         1064.00         64.M25         SMA.406.63.MU25         400.109         by         63         1.264-06         0.037/0.k.           U64         16960.00         YE5         64.M025         SMA.406.64.M025         400.109         by         63         1.264-06         0.037/0.k.           U64         16915.00         YE5         64.M025         SMA.406.64.M025         400'109         by         3         6.004-06         0.037/0.k.           U64         16915.00         YE5         64.M025         400'109         by         3         1.624-08         0.14/0.k           U66         16704.00         YE5         64.M025         400'109         by         81         1.624-08         0.039/0.k.           U67         193.09         YE5         64.M055         SMA.406.64.M055         400'109         yr         8.474-05         0.011/0.01           U67         10.000         64.M025         54.00'109         90'109         Yr         5.467-07         0.039/0.k.		R622	15955.70		6LM16S	SIMA.16L6.6LM16S	1000/ 400	3∨	2	1.69E+06	0.006/0.061	
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		R622	16116.05		6LM13S	SIMA.13L6.6LM13S	1000/400	3V	2	1.69E+06	0.025/0.016	
UIS4         16606.00         YES         64.0015         SMA.46.54.0015         400 r00         59         3         6.008-06         0.032.71.nk.           UIG4         1.6619.00         YES         64.006.25         400 r00         59         22         5.444-66         0.14/n.k.           UIG6         1.6719.00         YES         64.006.25         400 r00         59         21         5.447-68         0.031/n.k.           UIG6         1.6704.00         YES         64.006.55         400 r00         59         51         1         6.476-68         0.031/n.k.           UIG6         1.9704.00         YES         64.006.55         400 r00         59'         51         8.476-60         0.031/n.k.           UIG6         1.9704.00         YES         64.006.55         400 r00         59'         51         8.476-60         0.031/n.k.           UIG6         1.9704.01         YES         64.006.57.680/CS5         400 r00         59'         27         5.467-67         0.037/n.k.           UIG6         1.020.01         64.005.27.680/CS5         400 r00         59'         27         5.467-67         0.037/n.k.		UA63	106.40		6LM25S	SIMA.UA63.6LM25S	400/ 100	5∨	63	1.26E+08	0.087/n.k.	
UI64         16610.00         YTS         64M02S         SMA4.66.04/025         e00*08         p>         272         5.44f-68         0.34/n.k.           UI66         16704.00         YTS         64M02S         SMA4.66.04/025         e00*08         p>         11         16.7f-68         0.34/n.k.           UI67         193.00         YTS         64M02S         SMA4.66.04/025         e00*08         p>         11         16.7f-68         0.03/n.k.           UI67         193.00         YTS         64M05S         SMA4.067.64M05S         e00*08         p>         27         5.44f-68         0.03/n.k.           UI67         193.00         YTS         64M05S         SMA4.067.64M05S         e00*08         p>         27         5.44f-68         0.03/n.k.           UI67         104.00         64M02S         SMA4.067.64M05S         e00*08         p>         27         5.44f-67         0.03/n.k.		UJ64	16606.00	YES	6LM01S	SIMA.4L6.6LM01S	400/ 100	5V	3	6.00E+06	0.032/n.k.	
UI66 16704.00 YE5 66M025 [SIMA.UA65.68M025 400'100 SV 81 1.52£408 0.039/n.k UA67 193.90 YE5 66M065 [SIMA.UA67.66M0665 1000.400 SV 1 8.47£+05 0.011/0.021 UA67 104.00 66M055 [SIMA.UA67.66M055 400'10 SV 27 5.40E+07 0.059/n.k		UJ64	16619.00	YES	6LM02S	SIMA.4L6.6LM02S	400/ 100	5V	272	5.44E+08	0.14/n.k.	
UA67 193.90 YES 6RM06S SIMA.UA67.6RM06S 1000/400 3V 1 8.47E+05 0.011/0.021 UA67 104.00 6RM25S SIMA.UA67.6RM25S 400/100 5V 27 5.40E+07 0.059/n.k.	9	UJ66	16704.00	YES	6RM02S	SIMA.4R6.6RM02S	400/ 100	5V	81	1.62E+08	0.039/n.k.	
C UA67 104.00 6RM255 SIMA.UA67.6RM255 400/100 5V 27 5.40E+07 0.059/n.k.	NT	UA67	193.90	YES	6RM06S	SIMA.UA67.6RM06S	1000/ 400	3V	1	8.47E+05	0.011/0.021	
	Q	UA67	104.00		6RM25S	SIMA_UA67.6RM25S	400/ 100	5V	27	5.40E+07	0.059/n.k.	

#### one example (first part)

Location	Area	Dcum [m]	Critical Area	RadMon Ident. Nb	Localization (SIMA)	RadFET 1/2	SEU sens	Counts	Fluence hadrons [cm <sup>-2</sup> ]
POINT 1	RI132	26516.00		1LM07S	SIMA.4L1.1LM07S	400/ 100	5V	48	9.60E+07
	RI132	26516.00	516.00		SIMA.4L1.1LM18S dep/ dep		5V	55	1.10E+08
	UX15	0.00		1RE07S	SIMA.UX15.1RE07S	1000/ 400	3V	1	1.69E+06
	RI171	145.00		1RM07S	SIMA.4R1.1RM07S	400/ 100	5V	25	5.00E+07
	RI171	145.00		1RM19S	SIMA.4R1.1RM19S	1000/ 400	5V	59	1.18E+08
	RI171	224.00		1RM10S	SIMA.6R1.1RM10S	400/ 100	5V	17	3.40E+07
	RI12/RR17	247.69		1LM14S	SIMA.8L1.1LM14S	1000/ 400	5V	0	8.47E+05





# Review Of Radiation Levels and Updates







Chamonix 2010: January 27th

Session 6 – Radiation To Electronics: R2E Summary





#### Beam-Gas calculation assumptions:

- residual gas density: 10<sup>15</sup> mol/m<sup>3</sup> (H<sub>2</sub>-equivalent)
- beam 1 only, results scaled by a factor of two

















### Tunnel: DS/ARC







## Tunnel: DS/ARC



Magnet Do	se/Gy/y	Error / %
MQ 7:	26.3	6.3%
MQ 8:	37.0	8.7%
MBA 8:	13.9	2.0%
MBB 8:	8.6	2.7%
MQ 9:	32.9	6.3%
MBA 9:	7.1	2.5%
MBB 9:	6.7	2.3%
MQ 10:	34.2	5.5%
MBA 10:	6.9	2.1%
MBB 10:	6.2	2.4%
MQ 11:	14.4	4.8%
MBA 11:	6.8	3.4%
MBB 11:	6.3	3.5%
MQ 12:	2.8	12.0%
MBA 12:	6.1	2.8%
MBB 12:	1.4	6.7%
MBC 12:	0.4	10.1%
MQ 13:	3.5	10.3%
MBA 13:	0.4	7.9%
MBB 13:	0.3	12.2%
MBC 13:	0.2	10.2%

### Summary Table:

- Doses highest in change from LSS to bent region
- Peaks where matching is done (Q8, Q11)
- MBB12 worst case for Power-Converters
- >=MBB13: <=1Gy/y</p>
- -> what comes from the LSS?



### Tunnel: DS/ARC



#### Beam-Gas Only as before

#### Thanks to R. Assmann et al.

Magnet	Dose/Gy/y	Error / %	S
MQ 7:	26.3	6.3%	
MQ 8:	37.0	8.7%	<ul> <li>Colli</li> </ul>
MBA 8:	13.9	2.0%	• ho
MBB 8:	8.6	2.7%	• lim
MQ 9:	32.9	6.3%	
MBA 9:	7.1	2.5%	
MBB 9:	6.7	2.3%	• 11
MQ 10:	34.2	5.5%	←
MBA 10:	6.9	2.1%	
MBB 10:	6.2	2.4%	
MQ 11:	14.4	4.8%	
MBA 11:	6.8	3.4%	
MBB 11:	6.3	3.5%	_
MQ 12:	2.8	12.0%	only
MBA 12:	6.1	2.8%	an
MBB 12:	1.4	6.7%	est
MBC 12:	0.4	10.1%	
MQ 13:	3.5	10.3%	
MBA 13:	0.4	7.9%	
MBB 13:	0.3	12.2%	
MBC 13:	0.2	10.2%	
	Magnet MQ 7: MQ 8: MBA 8: MBA 9: MBA 9: MBA 9: MBA 10: MBA 10: MBA 10: MBA 11: MBA 11: MBA 11: MBA 12: MBA 12: MBA 12: MBA 12: MBA 13: MBA 13:	MagnetDose/Gy/yMQ 7:26.3MQ 8:37.0MBA 8:13.9MBA 8:13.9MBB 8:8.6MQ 9:32.9MBA 9:7.1MBB 9:6.7MQ 10:34.2MBA 10:6.9MBB 10:6.2MQ 11:14.4MBA 11:6.8MBA 12:2.8MBA 12:2.8MBA 12:0.4MBA 13:0.4MBC 13:0.4MBA 13:0.3MBC 13:0.2	MagnetDose/Gy/yError / %MQ 7:26.36.3%MQ 8:37.08.7%MBA 8:13.92.0%MBB 8:8.62.7%MQ 9:32.96.3%MBA 9:7.12.5%MBB 9:6.72.3%MQ 10:34.25.5%MBA 10:6.92.1%MBB 10:6.22.4%MQ 11:14.44.8%MBA 11:6.83.4%MBA 11:6.83.4%MBB 11:6.33.5%MQ 12:2.812.0%MBA 12:6.12.8%MBA 12:0.410.1%MBC 12:0.47.9%MBA 13:0.312.2%MBB 13:0.210.2%

Chamonix 2010: January 27th

Scaled with	Collimation Loss IR7 [Gy/y]	All Magnets at Quench [Gy/y]
Callingation	bad statistics	926.2
Collimation	417.2	497.7
<ul> <li>horizontal Loss</li> </ul>	bad statistics	277.2
<ul> <li>limited statistics</li> </ul>	5.3	69.4
Quench	501.9	418.2
	348.2	181.0
	258.3	84.7
$\longleftrightarrow$	349.6	447.6
•	20.2	264.9
	7.5	78.4
	2913.6	1100.3
	321.5	173.9
	110.1	74.1
oniy a quick	scoring problem	632.2
and rough	43.2	252.1
estimation	1.7	45.8
!!!	bad statistics	64.7
	30.2	527.7
	bad statistics	60.0
	bad statistics	43.0
	bad statistics	54.1
24	Session 6 – Ra	diation To Electronics: R2E Summary

## R1: UJs, RRs and ULs



LHC Point 1, right side;

© A. Mereghetti et al.

FLUKA implementation of the ATLAS cavern, the LHC tunnel up to the RR17 with UJ16, UJ17 and UL16 service tunnels;



## Beam-Beam collisions

### High energy hadron fluence [units of 10<sup>6</sup> cm<sup>-2</sup> per 100 fb<sup>-1</sup>] © A. Mereghetti et al.



- Hot spots: Triplet, TCL5.R1.B1;
- RR: Consistent with earlier estimates Baishev et al.
- UL: long distance to UJ required (+shielding)

## IR1: UJs, RRs and ULs









# What is a 'safe' limit in terms of high-energy hadron fluence?



## Scaling With LHC - Operation

- Good idea for 2009/10
- Possible view for 2011
- General problem when putting 'years' (longer operational period, etc...)
- Below table as currently used (not final) and easy update possible
  © M. Lamont

Loss Mode	2009/10	2nd Oper.	3rd Oper.	4th Oper.	Nominal	Ultimate	SLHC
Average Intensity (%of Nominal)	5	15	30	40	100	148	296
Peak Intensity (%of Nominal)	15	15	30	40	100	148	296
Peak Intensity (p/beam)	4.8E+13	4.8E+13	9.7E+13	1.3E+14	3.2E+14	4.8E+14	9.5E+14
Peak Intensity (p/beam/s)	5.4E+17	5.4E+17	1.1E+18	1.5E+18	3.6E+18	5.4E+18	1.1E+19
Peak Luminosity	1.0E+32	3.0E+32	1.0E+33	3.0E+33	1.0E+34	2.3E+34	1.0E+35
Average Luminosity	5.0E+31	1.0E+32	5.0E+32	1.0E+33	1.0E+34	2.3E+34	5.0E+34
BeamGas-Density (ARC)	2.00E+14	1.00E+14	3.00E+14	1.00E+15	1.00E+15	1.00E+15	1.00E+16
Integrated Luminosity (LHCb) [interactions/y]	3.2E+12	3.6E+13	8.0E+13	1.1E+14	1.6E+14	3.7E+14	8.0E+14
Integrated Luminosity (CMS, ATLAS) [fb-1]	0.5	1.2	10	30	100	230	500
Direct losses (IR7, single beam)	5.75E+14	1.73E+15	3.45E+15	4.60E+15	1.15E+16	1.85E+16	3.40E+16
Direct losses (IR3, single beam)	1.58E+14	4.73E+14	9.45E+14	1.26E+15	3.15E+15	5.07E+15	9.31E+15
Direct losses (DUMP)	5.75E+14	1.73E+15	3.45E+15	4.60E+15	1.15E+16	1.85E+16	3.40E+16
Direct losses (TCDQ)	1.70E+12	5.10E+12	1.02E+13	1.36E+13	3.40E+13	5.47E+13	1.01E+14
Direct losses (TED)	2.00E+15	3.00E+15	3.00E+15	4.00E+15	1.00E+16	1.61E+16	2.96E+16
Beam gas interactions (/m/y/beam)	2.76E+09	4.14E+09	2.48E+10	1.10E+11	2.76E+11	4.08E+11	8.16E+11
Beam gas P4 (/m/y/beam)	2.40E+08	3.60E+08	2.16E+09	9.60E+09	2.40E+10	3.55E+10	7.10E+10

30

Chamonix 2010: January 27th



## Summary Of Areas







### Summary Of Areas – See Direct Link



	LHC	Area(s)		High-Energy Hadron Fluence [cm-2/y]								1
LHC	Point	Alea(S)	2009/10	2nd Oper.	3rd Oper.	4th Oper.	Nominal	Ultimate	SLHC	Ratio	Priority	n
Point	Deint 7	UJ76	1.0E+08	3.0E+08	6.0E+08	8.0E+08	2.0E+09	3.2E+09	5.9E+09	2.0	1	ty
	Point /	RR73 RR77	1.0E+07	3.0E+07	6.0E+07	8.0E+07	2.0E+08	3.2E+08	5.9E+08	50.0	1	
Point 1		TZ76 (start)	1.0E+06	3.0E+06	6.0E+06	8.0E+06	2.0E+07	3.2E+07	5.9E+07	10 (guess)	4	
		UY85b	2.05+07	2.05+06	5 0E+09	6 7E+09	1.05+00	0.2E±00	5.0E+00	0.2	1	
		US85	5.0E+06	5.6E+07	1.3E+08	1.7E+08	2.5E+08	5.8E+08	1.3E+09	2 (guess)	2	
Point 3	Point 8	UW85	1.0E+06	1.1E+07	2.5E+07	3.3E+07	5.0E+07	1.2E+08	2.5E+08	10 (guess)	3	
		UA83/87	5.0E+05	5.6E+06	1.3E+07	1.7E+07	2.5E+07	5.8E+07	1.3E+08	5 (guess)	4	
Point 4	TI2	UJ23	1.4E+07	2.1E+07	2.1E+07	2.8E+07	6.9E+07	1.1E+08	2.1E+08	5 (guess)	3	
	112	UA23	6.9E+06	1.0E+07	1.0E+07	1.4E+07	3.5E+07	5.6E+07	1.0E+08	10 (guess)	3	
Point 5	Т18	UJ87	1.4E+07	2.1E+07	2.1E+07	2.8E+07	6.9E+07	1.1E+08	2.1E+08	5 (guess)	3	
		UA87	6.9E+06	1.0E+07	1.0E+07	1.4E+07	3.5E+07	5.6E+07	1.0E+08	10 (guess)	3	
Point 6		ARC: MBs	6.4E+07	9.5E+07	5.7E+08	2.5E+09	6.4E+09	9.4E+09	1.9E+10	4.0	3	
		ARC: MQs	6.4E+08	9.5E+08	5.7E+09	2.5E+10	6.4E+10	9.4E+10	1.9E+11	2.0	3	
	ALL	DS: MBs	5.0E+09	1.5E+10	3.0E+10	4.0E+10	1.0E+11	1.6E+11	3.0E+11	4.0	3	
		DS: MQs	5.0E+10	1.5E+11	3.0E+11	4.0E+11	1.0E+12	1.6E+12	3.0E+12	2.0	3	
		REs	1.7E+05	2.5E+05	1.5E+06	6.7E+06	1.7E+07	2.5E+07	4.9E+07	20 (guess)	4	

Chamonix 2010: January 27th

Session 6 – Radiation To Electronics: R2E Summary

















# "Easy Options"





### **Access-Gates in UJ14/16/23/87**

- **Can be switched off during operation**
- Procedure with OP in preparation
- contact: L. Ponce, R. Nunes

### **Equipment which can remain (partly) in place**

- **QPS** (further development possible)
- **BPM** (mostly ok)
- **BLM** (VME crate only temporarily)
- **Some cryogenics control** (partly the same as in tunnel)
- Details in Equipment-Summary (G. Spiezia, see link) and talks from D. Kramer and T. Wijnands




# "Rad-Tol Design"





#### **Remote-Valve-Controllers in US85**

- Solution known from other areas
- Order started Installation in 2010/11

### **Power-Converters (120/600A)**

- Details in talk from Y. Thurel
- **New FIP Development** 
  - Details in talk from J. Serrano
- **Common Developments**

Possible working group with PH-ESE for common development of FPGA or micro-processors?

e.g., generic field-bus, or acquisition module for temperature, pressure, low precision voltage measurement etc...





# Shielding



## UJ87/88 – UJ23/22 – Shielding





- Shielding installed before LHC-re-start
- Analysis confirms the expected improvement
- ~Factor of 10 less radiation (high-energy hadron fluence)
- Relaxed situation for this years operation
- Long-Term solution will require further measurements
- Possible issue with low-energy neutrons



## UJ14/16 Shielding Options



#### Updated FLUKA Calculations for Various (Theoretical) Shielding Layouts

To Compare: Unshielded Case (as installed now) ... at least theoretically





## UJ14/16 Shielding Options



#### Correct ...







#### **Reason for Shielding Limitation:**











Improving the Weak-Points













#### Assuming 1 year of operation at nominal luminosity (100 fb<sup>-1</sup>)





#### Assuming 1 year of operation at nominal luminosity (100 fb<sup>-1</sup>)







- **Smart-Shielding'** in UJ14/16 can lead to significant improvement -> not a final solution, but also important in order to possibly use parts of the UL
  - staged implementation possible
  - @ detailed integration study to be launched as soon as possible
  - Iurther optimization required (currently about 60m<sup>3</sup> iron and 40m<sup>3</sup> concrete)

### **Q** UJ56-shielding is only effective at the lower-floor

- e useful either for protection of safe-room equipment
- or in case reshuffling with power converters has to be considered
- cost estimate available: ~500kCHF
- e no other option in place...

## Other Areas – Where Shielding is an Option



- UJ76: Safe-Room shielding could be slightly improved
  - e safe-room equipment remains at risk
- UJ/UA/23/87: already improved, further steps possible
  - combined simulation/integration study required
- @ RR/13/17/53/57
  - e shielding similar to RR73/77 possible
  - @ more complex shielding could be envisaged (see existing conceptual ECR)
- @ UA63/67
  - ducts already shielded
  - additional rods could be added if required
- @ UJ32 (RE32)
  - In case monitoring shows that beam-gas is a long-term issue





# Relocation

# Early Relocations

#### Fire/ODH Control Racks

Relocation already performed in UX/S85

UJ76, UJ56 pending

#### Possible impact on safety

To be scheduled for next shutdown

#### Fire Detectors

Possible impact on safety chain (not a safety issue)

#### Most areas affected

- For long distances tests ongoing
- To be scheduled for next shutdown

#### Other Equipment

Scenarios studied (partly prepared for)

- BIC, PIC, WIC
- Timing/Remote-Reset

## Complete Relocation: e.g., US/UW85



# Good News / Bad News Solution exists / Expensive and Time Consuming

#### Most of the Equipment has to be relocated

Cryogenics, WIC, Timing, Remote-Reset, UPS, Access Control, Network, AUG control, Electrical Distribution (Control), GSM, Fire/ODH (already done)

#### **Detailed Study (A.L. Perrot + Equipment Owners)**

Cost and Time estimate available (1MCHF, Long-Shutdown)

Cabling needs to be prepared early

(4-6 month lead time)

2-3 month of work to prepare for possible relocation (report in final draft version)

Planning/Coordination/Follow-Up required soon







## UJ14/16 – Upgrade Study









## Other Areas – Where Relocation is an Option



## OJ76: preparations in place

- @ change possible if required to house RR equipment
- e decision required soon

## @ UJ14/16: possibility in US15 and UL

- @ first studies for upgrade not trivial
- to be studied further

## UJ56: option in UP/USC-bypass

- @ first studies for upgrade not trivial
- PM56 is most probably not an option

### RRs

- RR73/77: possible to relocate equipment into TZ (see above), but requires significant TZ-layout changes
- others: not possible





# **Civil Engineering**

# Locally Enlarging Areas



#### Considered as hardly feasible with equipment in place...





## RR Shafts & Caverns (P1 and P5)







#### Constraints:

- Large Costs (~10MCHF each)
- Important lead time required (~4 years)

### Known Solution:

- Solves issue at RR13/17/53/57
- Allows for work during operation
- Relocation could be optimized during one shut-down
- No issue with cable lengths

### In Addition – See Talk(s) from S. Weisz:

- Accidental Helium-Release
- Opens further doors for LHC Upgrade-Scenarios
  - could this also solve UJ56 ??? (UA extension)







# **Other Options**

# Superconducting Links



- **R&D Work** is being carried out at CERN for the development of HTS links on two fronts (A. Ballarino):
- Development of semi-flexible MgB<sub>2</sub> link for the powering of the Triplets for the upgrade phase-1 (up to 100 m length, ~ 120 kA in multiple circuits, EDMS N. 1046267);
- 2) FP 7 European collaboration for the development of gas- cooled HTS links operating at higher temperatures and suitable also for vertical transfer of current.
- Immediate' option for power converters at Point-7 ? (similar to SCL at Point-3, DSLC-length of ~450m)





# How To Compare

## How To Compare the various 'Options'



- Qurrent planning summarized in 'working table', constantly updated (see <u>link</u>)
- **@** Taking into account:
  - Area Priority
  - Possible Mitigation Option

### Comparing:

- Radiation Levels (before and after)
- Cost + Uncertainty
- Required Lead- and Installation-Time
- Long-term Sustainability

### Q Next: grouping of options by operational period

A veeery long table....



# How To Compare

- Further Analysis necessary
- Details required to fully compare various options
   **QUR SUPPORT IS NEEDED**
- **General Work** to be defined for all groups (draft list exists)
   **General Work** extended seminar will be organised to the organised to
  - specify detailed needs

# Workshop to be scheduled @ ~ Mid-April

Based on its result a (phased) proposal is to be prepared for the management

safety warning: don't try to read

	LHC Pekt	Area	Auton	Option	Cost (MCHF)	Uncertainty [14]	Radiation (Max) Level Before Jam 2 v/11	Radiation (Max) Level After Jorn 2 v.13	Required When	Required Load Time Invested	Required Installation Time Dependent	Reference	Converts	Ewish Austria
	40	Taxad	NewFOP Development and exchange PC development/schange of		1	100	1.005-1	name	20127 (348 Ran Paried) 20127	12			Javier any estimate for the FIP? priceous in-defail as far, Yosa	ave.
	-	Sure Per Point	diag part" Option 1:		NOF	Option 2	1.00.11	MOHE	Option 2		NOF		Johns de processagent for the SEA part. Tradit de processagent de tabler as there is an other scholar and the	
	-	SUVs (heleficor)	anprove sherdeg sale room	0	0.2	10	1000-0	1,02+6	22rd Raw Parind (			ECKRepat	the safe-news equipment free detectors to be revised from the 10.75 and installed in the TZ (in	Schein
	'	0.09	Fre-cescorecaron			20	THE V	1.161	(2rd Ran Paried)			Curchapar	case of failers of one datactor the full chain could get Nocked)	574
	'	60%	(five(0DH Caves))	0			Line-or	e let	(2rd flars Paried) (2011)			ECRIRaport	toold remain undedented. > andy relocation into TZ recommended	SVe
							1.00.00		(2nd Ran Paried)				the ECR for detectors to be relocated and installed in the TZ (in case of failure	
		NRITS	Pre-celector rescalor	0	1	14	186-0	< 16.1	(2nd Ears Paried)				of one behavior the full chain could periodolece) -> the long balance (> 2054) regimes a special installation convertly under study of convert extended on a cell automatic	574
		8823	Power Converter statistical reducing? + soliciation	1		100	1005-0	< 167	20127 (3rd fran Parind)	12			involves PC development (costs of development party included?)	10
													(30x24970) (50+12 Conv) + 300x7687400xxx272 + 52 preparation (10 uf state: 300247)	
	· .	8871	Power Converter RedTol Design? + exercities		Ι,	100	1005-0		20127				If convert shallding is not sufficient as for other points a ratheard design cauld be serviced. In measures anteness, then 1 years (production costs extinated survive to above	140
			relocation										(20x24F30 (60+12 Core) + 200x56F300xx222 + Fadriant design contex (100x of tetral development cont: EMCHF > 0.59ECHF)	
	7	8875	kng 90L	3	15	100	1.02-0	< 18T	2012? (3rd flam Paried)	м		2	long SCL Nov TZ is RR $\sim$ costs (pare-pass. IROPF instalation, 10th of total development costs: 28CHF $\simeq$ 8.258CHF)	Anala
	7	6877	Fire-Detector relocation	0	6.1	58	1.025-0	< 187	20117	6		2	the detectors to be relocated and installed in the TZ (in case of falces of one detector the full chain could perticulate) -> the large datasets	114
										-			2-20% regimes a special initialities cancelly under study of cancel shallong a net sufficient facilities of the decement	-
	1	6877	Power Converter dossical redesign? = relucation	1	-	900	1.025-0	< 167	(3rd Ran Paried)	12			process in, our approach loods of development party included?5 30x2x8798 (dit=12 Corv) = 308rr987400mm2*2 = 32 preparation	PEL Yang Amelie SCL
													r carvet shading a ret sufficient	-
	7	8877	Press Cerverter RodTot Dwign? • senaining relocation	2	-	100	1.025-0	1414	2012? (2xt Face Paried)	21	5	2	with the other panels a subhard design could be enviraged in resources ariseses, time 3 years (production costs withroaded surfar to allever 30x34F100 (68+12 cow) + 308th/687400mx272 + Raditard design	744
										-			caria (108 si*642/development cart: 4MCHP ~ 0.09CHP)	
	1	898.77	krep 901.	3	1.5	100	1.000-00	- 167	(3rd Ran Parted)	м		2	(c) post term to the local part part part (c) term provident, (c) of obtained on expression costs: 2800 PF → 2,2800 PF) second of the ratio for the part costs of the local part part (c) pa	Anala
	1	Sure Per Fuint	Deteror Collimation in IR3 Option 1	- 14	NOF	Ciption 2	1.00-0	MCHF	Option 3	4.6	MONT	Marwo	123 below option 3 is unlikely	ta ge
		UNIS UNIS	education Circ-Mocation	0	0.31	100	6.000-co	< 167 (4) 10 Kill # 167	201			endy ICL Initial 3. Candel	pere guess based on prel. Externate	Parata
		Nabilicem	add, Sheiding (in addition to shat is already in place)		0.36	8	6106-0	< 16.7	20127	2		partinization	to be writed if and when required	Anna Gaura Prances
		AWWS .	edocation	1	0.26	908	1.000-00	< NET	2019/127	6			pere guess	Panani Panani Anne saure
		LAWES .	sharding	2	0.5	100	1.05-0	- 167	2016127				per pers	Parana Anne-bas'e
		1081 UART	shariling	-4	- 11	900	6.000-07	< 167	20127				to be writed if required	ranat
		10.84 10.84	shielding	-4		200	LogV	< 167	20121				to be writed if required	
		33.54 Sure Par Point	Outline, 1:	- 12		Option 2		WCHF	Option 2	1.2	MOHE		and the later is the second	<b>—</b>
		0054	easy shielding	0	0.25	68	6.006-0	1,002-4	0/20147	,		Hudy KL	recense sources (but holping), anyway required to allow for UI, to be used later free detectors to be removed horn the UDH (in case of failure of one	Panasis
		10.04	Tre-Delactor-relocation	0		50	5.005-07	< 16T	20117	2			detector the full chain scalif get blacked) -> the new location has to be defeed	Panasis
		80.94	esergius shahferg	1	0.26	100	5.000-00	1,00-4	8/2011/127			-	power convertiers have to remain in place and are not red-foll forward convertiers have to remain in place and are not red-foll if alreading a not sufficient a cathord design could be an inserted in	Panasis
	· ·	0094	sadital Power Converter	2	- 16	100	6105-0	1410	20127	10			water and a second state of the second state o	744
	-									-			1385 of Nail Averagement cost: ERCHT -> E3MCHT) conte pure guess (SMCHT installation, 18th of Istal Averagement	
	'	10794	80.	3	0.75	908	5.000-00	< 9ET	20137	м		1	case 2002-07 $\sim$ 0.25002407) $\sim$ NET CLEAR where minimum-and in residued (vertical version from surface assumed to be improvided)	Anala
		0.095	excyshielding	0	0.25	100	5100-0	1,02-0	9 20117	,		andy KL	ion's temporary (but heijing) lead time dominated by integration and optimization	America America (C.)
		0.046	Fre-Detector relocation	0	0.1	50	5.005-01	- 18T	20117	2			For detectors to be removed from the 10-16 (in case of failure of one detector the full chain stall get blacked) in the rese location has to be detector.	Sive Panala
		0.05	complex shielding	1	0.25	100	5.000-00	1.00-0	0 201 1/127				dill not final solution, but required in case solution has to be found that loover converters have to remain in obice and are not rad-kol	Farcela Teles
			sal ta Parer							-			f shelding is not sufficient a sufficient design could be enviraged measures calcourt, firm 2-years (production costs antimated samlar	
	· ·	0.96	Converter development	2	1.6	500	5.000-0	1000	20137	24			Is down: 30x249*16 (13+3 Con-(+2973)2+1 spans)+ RadNas(-design-costs 31.986 of Iosal development cost: #ROPF -> E5M24P)	140
	,	0.75	90,		0.75	100	6.005-01	< 957	20137	ы			cents: pure puese (SMCHF installation, 18th of Islai development cent 2802HF $\simeq 0.25MCHF) \simeq NCF$ CLEAR where station would be	Anata
		005416	adocation				60050	1.97	2013/2013 (crift) 161				plateted particle variable from surface assumed to our impossions) philat education of equipment (other flow Poul to US15, POs to	-
	1	6813	single shielding	0	4.5	64	1.026-0	1.806+6	Bhardeg' a gor short			1987 experience	week, USIS peeble simple block shedding could improve situation as in P? -> question if	Panaia
	•	698.13	Fire-Defactor relocation	0	0.1	68	1.000-07	< 1027	201 9 127			1	The detectors to be relocated (in case of failure of one detector the full chain mald (at blocked) in the long detained (-200m) regimms a	Sive Panelo
													complex sheeting as discussed in available ECR -> can this be replecemented as such and what is the read gave? (NOT CLEAR #	
Ľ		6415	control strenged	'			100-0	1,00,4	*20177			(CCCNapa1	PAIT TOGETHER WITH SMPLIC SHELDING, THEN THE FLUENCE COULD GO DOWN TO SOME LET	Paran
	1	8810	6405	2	11.5	8	1.025-0	< 1627	20137	10	5	1	Instantion MCOP 12 (dec) = 1 (prop) = 5 (prove) (org 512), how IP area (MCP CLEAR where to reside the station/10 FR	2/cain
		CIRR	krg SC.	3	1.5	100	1.025-01	< 102.7	20127	м			<sup>2</sup> cosh juan paras. WColf instalation, VBI of total development paras. 20(2)(7): 8.228(2)(7) control. biol. shadlow could improve shadron as in 172 - 1 mandres if	Anala
		100.17	Englis English				10040	108.1	augur shart			tor aquesesa	possible free detactors to be relocated (in case of failure of one detactor the full basis of the detactor of the detactor of the detactor of the failed of the detactor of th	Tanan Iva
					-						-		special installation convertis ander shafe complex sheeting as discussed in providine ECH -> can time ter	Panala
		8817	xorgies shielding	1	- 63	68	1.06-0	1,05+0	020137			ECR.Report	Philling all be selfand in the long term, problems expected > P PUT TOGETHER WITH SMPUE INELLOWG, THEN THE PLUENCE	Parado
	1	68.17	6403		11.5	52	1.025-0	< 162.7	20137	10		2	COLD GO DOWN TO SOME TO softwate MORE TO Jacob + 1 (perc) + 3 (nouve)	A/van
	,	88.17	keg SOL		1.6	900	1.005-01	< 957	20127	м	5		long SCL from IP area (NCP CLEAR when to restal the station) to FR in only pane game. TROPF installation, 1999 of total development seeks. 2009 (2):4 2(802)(4).	Anda
	•	0751470	heat releasion	- 4	0.35	100	1.000-07	+ 108	20127	,			Incluars if required (possibly sufficiently tot.) If you than atomy gradient, thus important representant possible data to possible atom.	A1040
		Sure Per Point	Option 1:	2.68	(MOF	Option 2	28.71	(MOF	Option 2	7.95	MOHE		option 1 includes risk, option 3 is artikely and/u for lower four to possibly	_
	5	11.94	shariting	0	6.5	900	5.000-0	over foe: <25 aper foe: 223	20117			endy KL	heig exten equipment in pace. The instrument (in a shading requirement) of least GAX f others are	fancti
	7	11.56	Fie-Detector wiscator	0	6.1	62	6.005-0	< 167	20117	2			position to be received after two developments. The distributes to be received if have the 10.001 and installed in the UP (detailed location to be defined)	NV8 Parcet
	1	1056	Early Relection (FireODH Canini)	0	0.1	64	6.000-0	< 167	20117	2			precide-correct radii considered as possible safety asse in case of fire (coold remain andedecked) -> early relocation recommended (ocation to be defined)	Stvia Panosis
													PCs must server of least GAX F others pre-	
	,	0.95	niceater Phase-I:	0	- 65	100	5.005-02	5.02-0	2011/127 5 (with add.				positive to be moved prior new cases of development or stay is place in case of RadToI design- see needpoint PC design) - as the above pheating will improve the situation-only at the lower floors a two-stage	haven
									comong.				restaution sould be envirologed, altowing first to engly the lower part and relacate (study-pending), then more the PCs to the lower fluor (share shalding year addet)	
							10000		2012107				in case shielding is not sufficient, relocation of possibly remaining	
	1	1054	Indocation Phase (1	0	8.6	100	(encare 1.302-08	< 167	(with add. Sharideg)	· ·		1	possible to be moved john new classical development) or skap in place (in case of EadToi design: see next point PC design)	Parcel
			Press Canadar										A site degra not sufficient socilises PC de integrised	
		0.96	dassal redesge3 + relication	'		900	6.000-00	< 167	20127	12			(costs of development party included?) (0x0HF*16 (13+3 Coru) + 201*3 (2+3 pare) + 458A skill has to encal (sheeled)	he
			Power Carverler										f chiefdog is net sufficient. In fer ofter paints a cadrant design cauld be revisaged -> resources.	
	· '	n:095	non-of Design? + nonaining ndocation	2	1.6	100	5.00E+0		10127	24			Distances, first 3 years (production costs instruded similar is above 30(DHP*16(13)-3 Conv(+2073(2+1 spars))* Radifiant design-costs (318) of Iolal development.cost. 48(CHP -> 1,5M(CHP))	740
	5	11.54	90.	3	1.6	100	6.000-0	< 967	20137	ы			NCL from UJ to 777 AURCL-> conto (para guesse TMCHF installation, 10th chicks development cash: 240-0F -> 12540-0F1	Anda
		8853	singlik shialding	0	0.5	50	1.005-07	1.00-4	0 20117	,		197 experience	simple block shelding could improve situation as in $\mathrm{PT} \to \mathfrak{gaustion}$ if presettin	Panelo
	1	8853	Pre-Delector relocation	0	0.1	50	1.005-07	< 18T	2011/127	6			pre-entrement to be iniciated (in case of failure of one detector the full chain muld-periblicited) -> the long distance (-250m) requires a special establishion currently under shafty	Sive Panala
	5	KIRS3	complex ubiniding	1	0.3	50	1.000-0	1,02>4	0 20137	6		CORReport	complex sheeting as document in available ECR -> can this be represented as such and orbit is the real gam? (ROT CLEAR # chesting will be sufficient in the law.)	Panada
	5	8853	dada	2	11.6	50	1005-07	< 167	20137	18			odmate MOP 12 Med + 1 (proj.) + 5 (movi	Shain
	5	8850	keg SC.	3	1.5	100	1.000-00	< 1017	20127	м		2	ong SCL from P zesa (USC?) to RR -> costs (pare guese: VBCHF restallation, UBb of total development costs; (280-H -> 0.2580CHF)	Anala
	5	8857	single shaldeg	0	0.3	52	1005-0	1.02>0	8 20117	,		027 espetence	complections shelding could improve situation as in $PT \rightarrow$ question if potentials	Paners
		8857	For-Detector relocation	0	- 61	68	1.002-0	< 167	2014121				chain read-pail blocked) > the long detares (-200m) requires a special netallation currently ander shalp	Panan
	5	8857	surgios shiridag	1	6.3	64	1.025-0	1,000-4	8 20137			CCR:Report	complex shielding as discussed in available ECR > can this be replexented as such and what is the real gam? (NOT CLEAR #	Paran
	5	68.57	éscia	2	11.5	50	1.000-00	< 187	20137	10			where a second s	3ylvan
	5	888.57	keg SC.	3	1.5	932	1.055-0	< HET	20121	м			ong 90, fors P ana 3/901/to RP - cests jours guess: 1804F restatation, 1985 of total development costs: 280-4F -> 0/29804F1	Anala
	5	UP \$56	keal-obsation		0.36	100	1.005-07	< 166	20127	,			not sure if required (possibly sufficiently tol.) If yes then strong guideant, thus important representate possible due to	Artono
		Sure Par Point	Option 1:	2.75	NOF	Option 2:	24.60	(MCHF	Option 2	6.55	MOHT		option 1 includes risk, option 3 is anikely. [103] cantibution to be verified -> will define date of installation	<b>—</b>
	5	10020	(selfy re-anargoment)	1	4.5	900	up xi 383	s 987	1011127			-	reaer were distributed by programs and optimization PCDI sent-button to be verified -> wit define date of essained	hancels
		NUBT DAST	addtoxal shelding (saffy re-anangement)	1	6.5	900	ap to 528	< 96.7	2014/127			1	installation and time dominated by integration and epitedepitor	Amon
		Sure Par Point	Option 1: add. Thinking		MOF 02	Option 2		MORE	Option 2		MOHT	part installation	aad inte given through	tavair
								·					en model	
		Total	Options	1 2	18.5	19	maining risk (RR solution for PC+	s, UJs) In UJS6	-					
			(not all combinations)	3	21.7	SCL 6	olution technical	y unknown	1					
				Fix	3.8	shield	ing, early relocati	onak, US85	1					



### Conclusions



- **Radiation levels** currently based on simulations, early measurements will have to improve this
- **Local shielding** supposed to improve the situation, even if not a solution in the long term for most areas gaining time
- **Relocation** options foresee all sensitive equipment
  - e safety issues: Fire/ODH rack in P5/7, fire detectors general
  - when final locations are identified, early relocations possible
  - In al relocation campaigns shall be done ideally for complete areas only

#### Q Alternative mitigation options:

If or areas where other solutions will be hard to find – their integration shall foresee also future requirements

#### First decisions required soon ...



### Conclusions



- **Review of radiation levels** important for the coming years
- **@** Early operation will be an important input work needed now!
- Oetailed analysis of mitigation options
- Important inter-departmental effort to get as far as possible
- Stringent time constraints, it will not be enough to do things 'sequentially' (*i.e.*, first observe and then react)
  - Parallel work required (we already started in this direction)
- Required resources will significantly increase
- Continued support required from various key contributors (Planning and Integration, Equipment Owners, Point-Owners, FLUKA Team, RadMon Team, RP, RadWG,...)
- Follow-Up Workshop Required to prepare final proposal
  - When the second seco



## Your Support Is Essential...





## Many Thanks to Everybody

EN/MEF, EN/HE, EN/EL, BE/OP, DG/PRJ, EN/STI, DGS/RP, EN/CV, GS/SEM, BE/ABP, TE/ABT, TE/MSC, EN/GMS, TE/EPC, FP/PI, BE/ASR, GS/ASE, PH/ESE,...

## Documentation & Reports



- besides R2E meetings, minutes and presentations @ LMC, former Chamonix,...
- R2E Website: <u>www.cern.ch/r2e</u>
- Document Database & Questionnaires (linked through above): www.cern.ch/info-r2e-documents
- □ Area Overview of Radiation Levels (see <u>link</u>)
- **Equipment Inventory (working document, see** <u>link</u>**)**
- Mitigation Options (working document, see <u>link</u>)
- Memorandum for possible temporary move betatron cleaning to IR3
- UJ76 Relocation (see ECR)
- **R2E Status Report @ Chamonix (see paper)**
- **RR73/77** Shielding Improvement (see ECR)
- □ Mid/Long-Term Action Plan (see <u>report</u>)
- □ R2E <u>Memorandum</u> for Short-Term Resources
- Power-Converter Summary (see internal report)
- Point-8 Iteration Summary (see <u>final draft</u>)
- **Point-1/5 Iteration Summary (in preparation)**
- Online Mitigation Project Tracking (see <u>link</u>)
- **R2E** Radiation School (see <u>program</u> and <u>summary</u>)





# Backup



## And Testing at CNGS?





Chamonix 2010: January 27<sup>th</sup>

## An Example: US85 Safe-Room Shielding





Chamonix 2010: January 27th

R2E Status Report

2009

Session 6 – Radiation To Electron?2s: R2E Summary
## IR7: Phase-II Collimation as Absorbers









- Studied in the early R2E days
- Allows relocating the losses from IR7 to IR3

(up to a certain beam intensity)

- Impact studied
  - tracking studies (R. Assmann et al.)
  - FLUKA studies radiation load in IR3 (UJ33, superconducting link, warm magnets,...)
- Results/Proposal summarized in memorandum (R. Assmann, see <u>link</u>)
- Proposal studied as temporary solution
- To be possibly reworked looking towards current collimation status and planned/possible upgrades

## New equipment in US15



© Y. Muttoni

