How Radiation Will Change (Y)our Life

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on behalf of DGS

Chamonix , 26th February 2010

Thanks to M. Nonis,
R. Trant, S. Weisz

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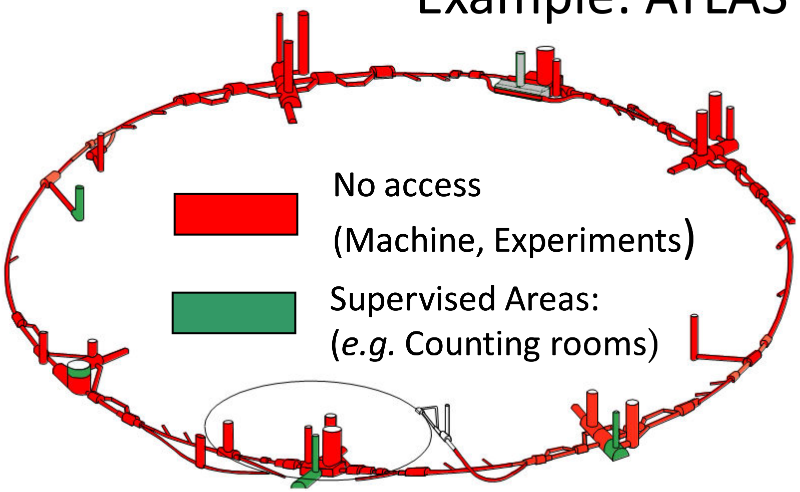
Radiation Risk During LHC Operation

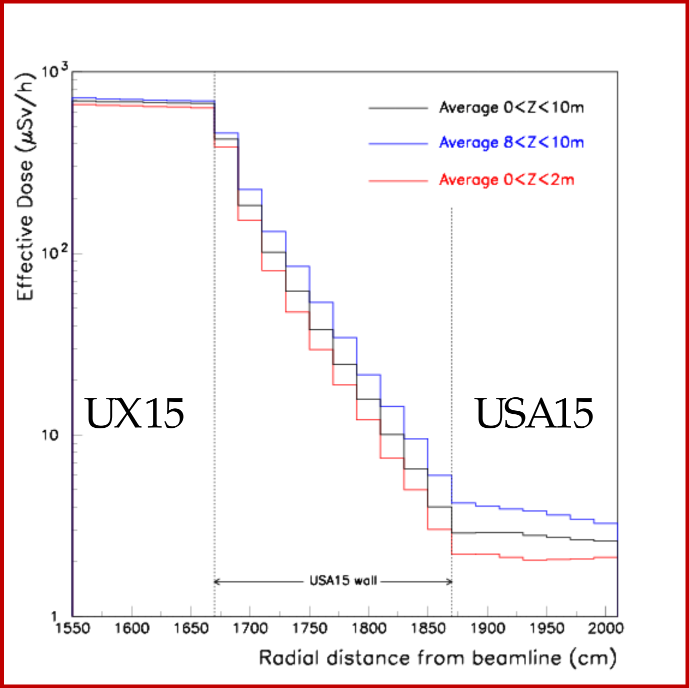
Example: ATLAS



Radiation levels in experimental caverns scale with luminosity

Luminosity	Individual dose	Collective dose
2% nominal	< 100 uSv/y	~ 2.5 man-mSv/y
nominal	3.2 mSv/y	120 man-mSv/y

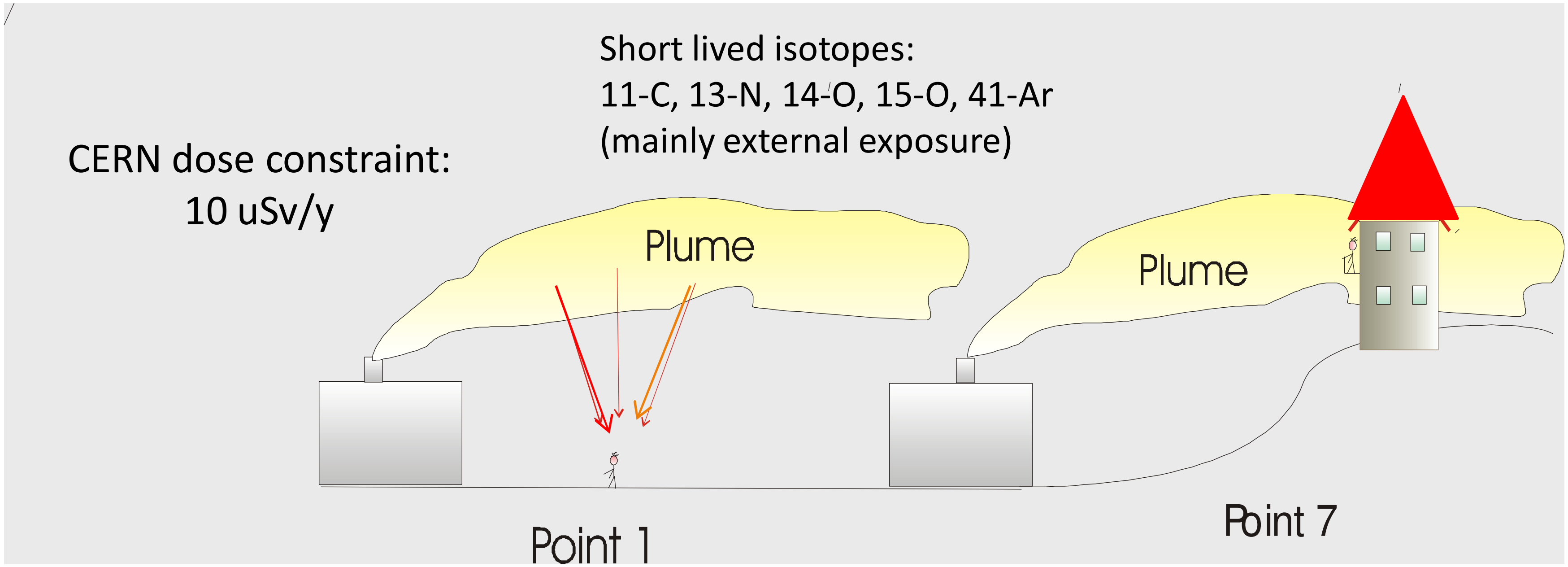
Prompt, Ionizing Radiation



Luminosity	Dose equivalent rate in USA15
2% nominal	2 x background
nominal	2-4 uSv/h

Radiation Risk During LHC Operation

Releases of radioactivity by air into the environment scale with beam energy, beam losses for machine and luminosity for experiments



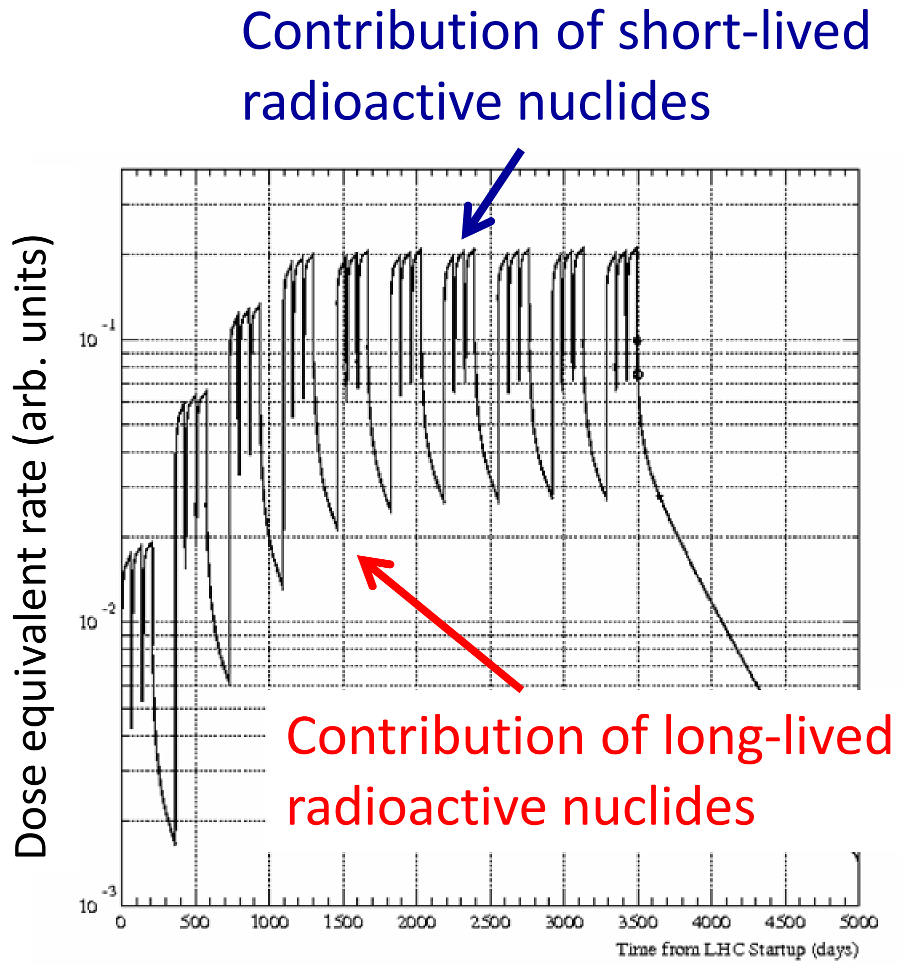
Intensity	Dose to person of reference group Point 1	Dose to person of reference group Point 7
2010	~ 100 nSv/y	~1 uSv/y
Nominal	5 uSv/y	4 uSv/y (assuming modifications installed)

Radiation Risk During Maintenance

Beam line and detector components, tunnel structure, etc. are radioactive

Risk of
- external exposure (all work)
- internal exposure (destructive work)

Radioactivity of material is function of
- chemical composition
- impurities
- radiation fields
- beam energy
- beam losses (machine)
- luminosity (experiments)

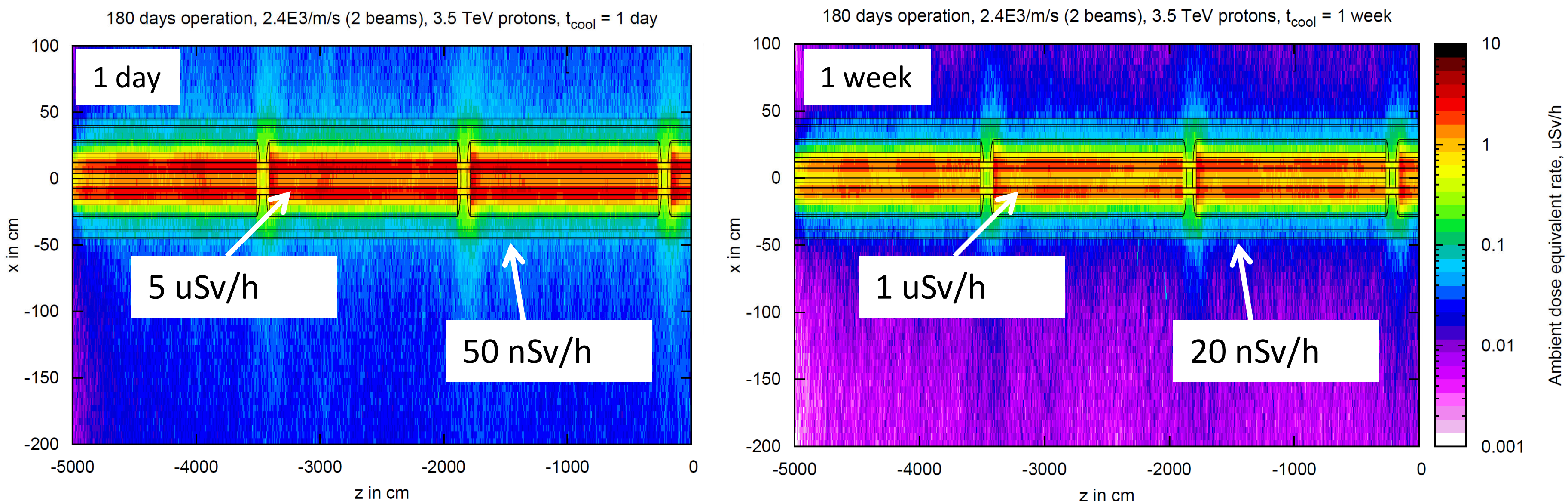


M. Huhtinen, RPC/2003/XXXVIII/138

Arc: Beam Gas Interaction 2010

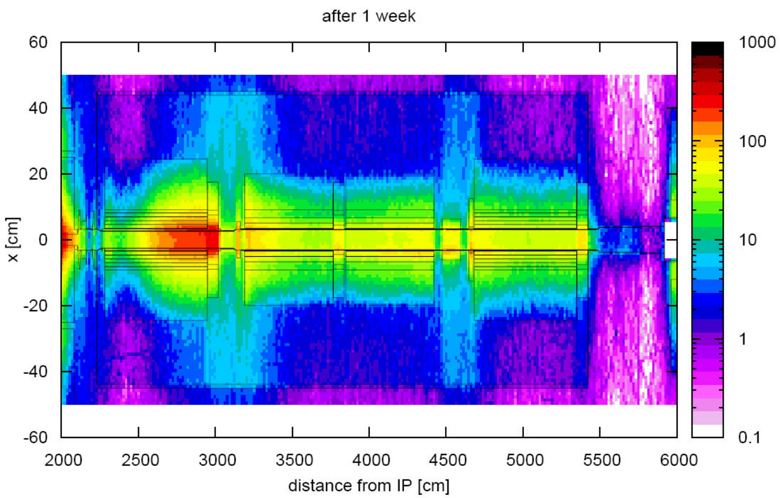
Assumption: 2400 protons/m/s (both beams, 10% nominal intensity), 3.5 TeV
(corresponds to an H_2-equivalent beam gas density of 4.5×10^{14} /m^3)

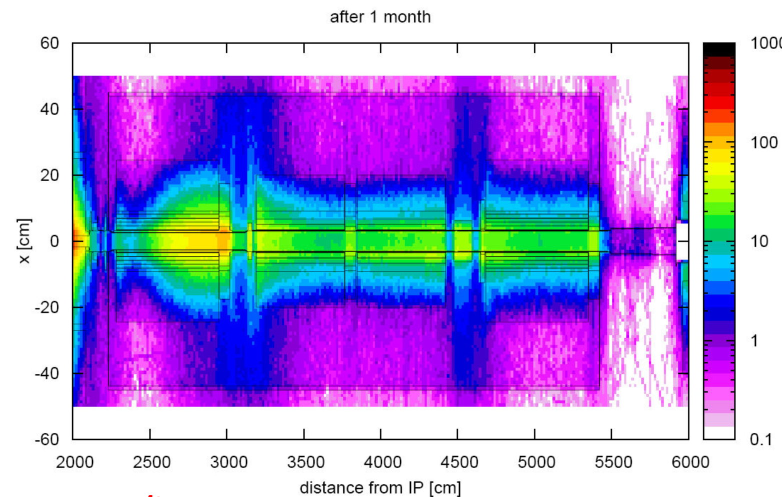
cooldown of



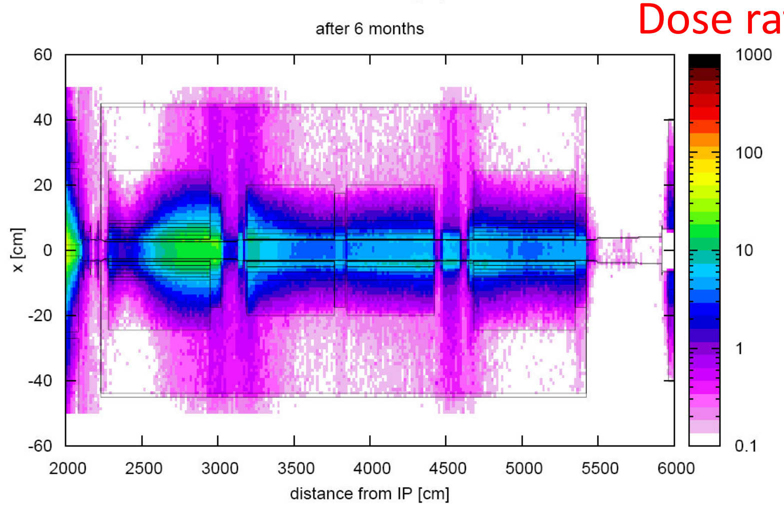
Inner Triplet and pp-Collisions

Assumption: 1 month operation at 10^{32} /cm^2/s





Dose rates in uSv/h



on the cryostat surface

~ 10 uSv/h after 1 week

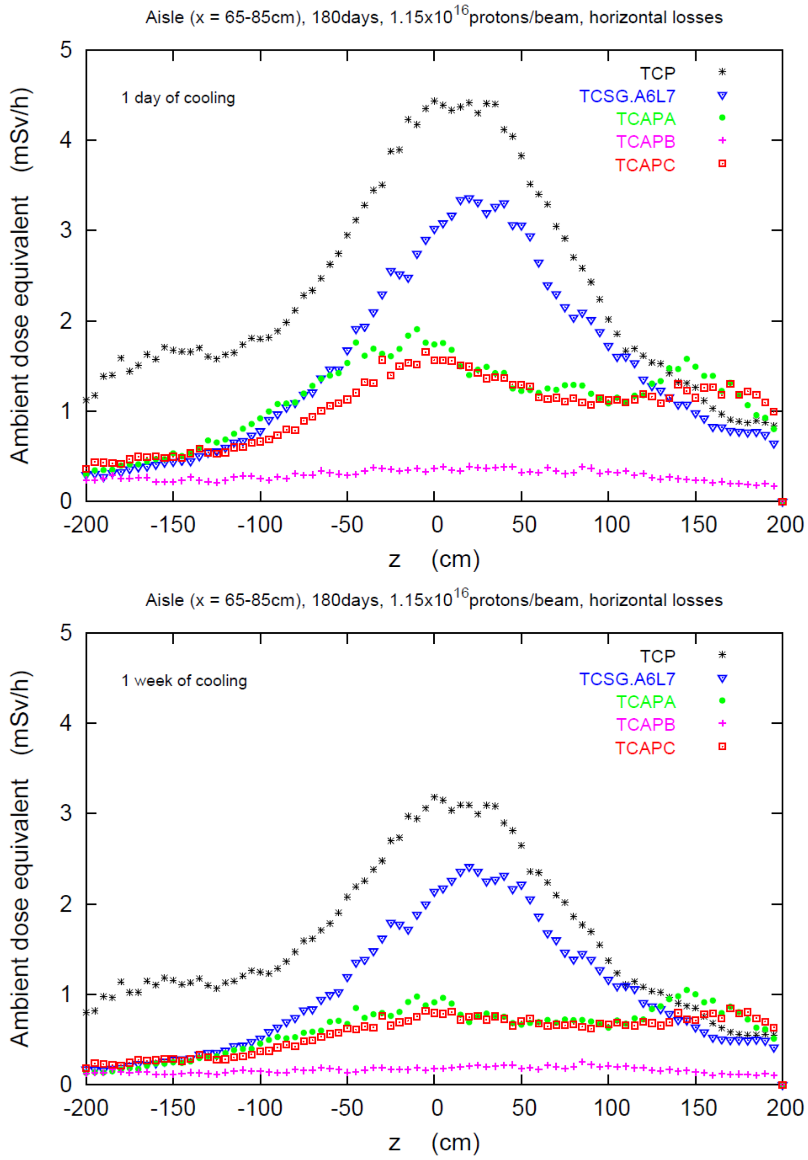
few uSv/h after 1 month

~ 1 uSv/h after 6 months

Courtesy of F.Cerutti, EN-STI

Collimator Region

- Residual dose rates from losses at nominal beam intensity reach few mSv/h after few days of cooling
- 2010 a factor 20 less: ~100 uSv/h

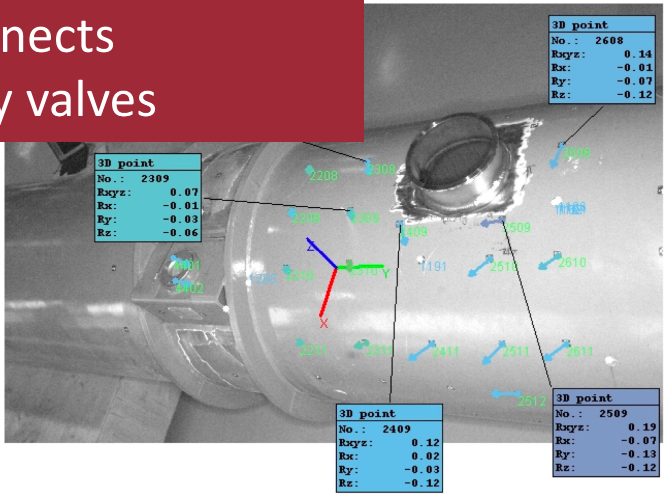


RP Requirements for Maintenance and Repair

- Only radiation workers are allowed to access the LHC and/or to work on radioactive equipment

- Any destructive work (machining, cutting, drilling, etc.) on machine components and tunnel infrastructure requires risk assessment by DGS-RP (in collaboration with maintenance team), work procedures and tooling need to be discussed with and approved by DGS-RP prior to the start of the work.

Strong impact on maintenance jobs:
  opening of interconnects
  installation of safety valves



Grinder and similar "dirty" devices are not permitted (see Chamonix 2009)!!

RP Requirements for Maintenance and Repair

Maintenance and repair work in areas like collimator regions, inner triplets, TAN, TAS, beam dump areas, etc.) will be the first to become subject to CERN's formal approach to job and dose planning (ALARA).

CRITÈRE DE DOSE INDIVIDUELLE

Équivalent de dose prévisionnel individuel (H_i) pour l'intervention, ou pour l'ensemble des interventions de même nature lorsque celles-ci sont répétées plusieurs fois sur une année :

niveau I	niveau II	niveau III
< 100 µSv	100 µSv – 1 mSv	> 1 mSv

CRITÈRE DE DOSE COLLECTIVE

Équivalent de dose prévisionnel collective (H_C) pour l'intervention, ou pour l'ensemble des interventions de même nature lorsque celles-ci sont répétées plusieurs fois sur une année :

niveau I	niveau II	niveau III
< 500 µSv	500 µSv – 10 mSv	> 10 mSv

Dossier intervention au milieu radioactif (DIMR)

CERN aims to optimize

- work coordination
- work procedures
- handling tools
- design
- material

to reduce dose to personnel

RP Requirements for Maintenance and Repair

- All material that had been in the LHC tunnel or in the operational zone of the experiments during beam operation and will leave the LHC needs to be controlled by DGS-RP
- All radioactive material needs to be maintained in appropriate workshops – but only some few workshops are available.


Bat 109

Compensatory measures:

•maintenance and repair jobs to be limited to the minimum,
•sophisticated radiological risk assessment,
•temporary rad. work places to be set up,
•tight control by RP

=> very costly in man-power, time and budget for all parties involved

RP Requirements for Maintenance and Repair

Traceability of LHC material required:

- Risk of mixing radioactive and non-radioactive components (due to lack of appropriate infrastructure)
  - in workshops
  - in storage areas
- Increase of efficiency for any radiological risk assessment in context of
  - maintenance
  - shipping
  - disposal
- Status:
  - most experiments use a modern traceability system (e.g. ATLAS)
  - machine: functional specification released (L. Bruno, EDMS 1012291)

RP Requirements for Maintenance and Repair

Traceability requirement for LHC accelerator (similar to LHC experiments):

- Equipment owner removes and labels material (barcode!)
- RP controls and enters the result in the data-base
- All material receives an entry in the database (non-radioactive, radioactive)
- All material is marked according to its radiological risk (non-radioactive, radioactive)
- Non-radioactive material needs no further tracing – the label(s) are sufficient
- All movements of radioactive material need to be traced via the database

Today (ZO, ZDC, Non-activated)

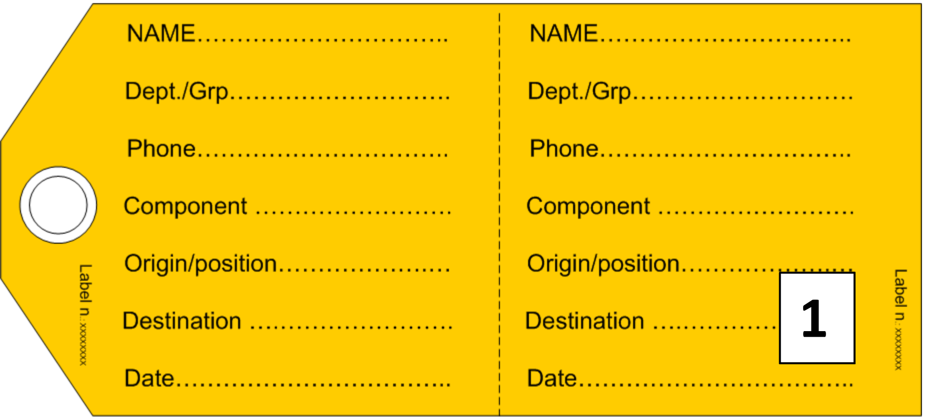
Equipment Id : **3 23 4567 8901 2345 6789**
Owner : **CMS, Tracker**
Origin : **UXC55** *Check Time :* **2009 NOV 12 (12:45)**
Operational Zone: **YES** *Radioactive Waste Zone :* **NO**
Background Value : **60** *count/s* *Above Background :* **NO**

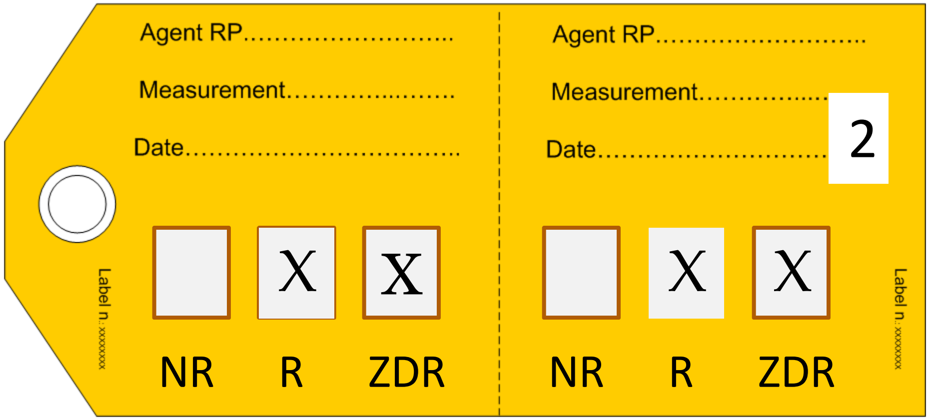
Possible Inside Detector (ZO, ZDR, Non-activatec

Equipment Id : **3 23 4567 8901 2345 6789**
Owner : **CMS, Tracker**
Origin : **UXC55** *Check Time :* **2009 NOV 12 (12:45)**
Operational Zone : **YES** *Radioactive Waste Zone :* **YES**
Background Value : **60** *count/s* *Above Background :* **NO**

Equipment Id : **3 23 4567 8901 2345 6789**
Owner : **CMS, Tracker**
Origin : **UXC55** *Check Time :* **2009 NOV 12 (12:45)**
Operational Zone: **YES** *Radioactive Waste Zone :* **YES**
Background Value : **60** *count/s* *Above Background :* **140** *count/s*

…a Temporary Solution for LHC Accelerator





- Equipment owner fills in side 1 before leaving the component in the buffer zone,
- RP technician fills in side 2 and ticks the appropriate box
- Radioactive material : RP attaches a trefoil «radioactive « to the material
- One part of the label is kept by RP, the other remains attached to the component
- The labels are progressively numbered, allowing to trace back the components

Water Activation

Cooling water and infiltration water will get activated – but will most likely not exceed the limit above which it needs to be handled as radioactive water

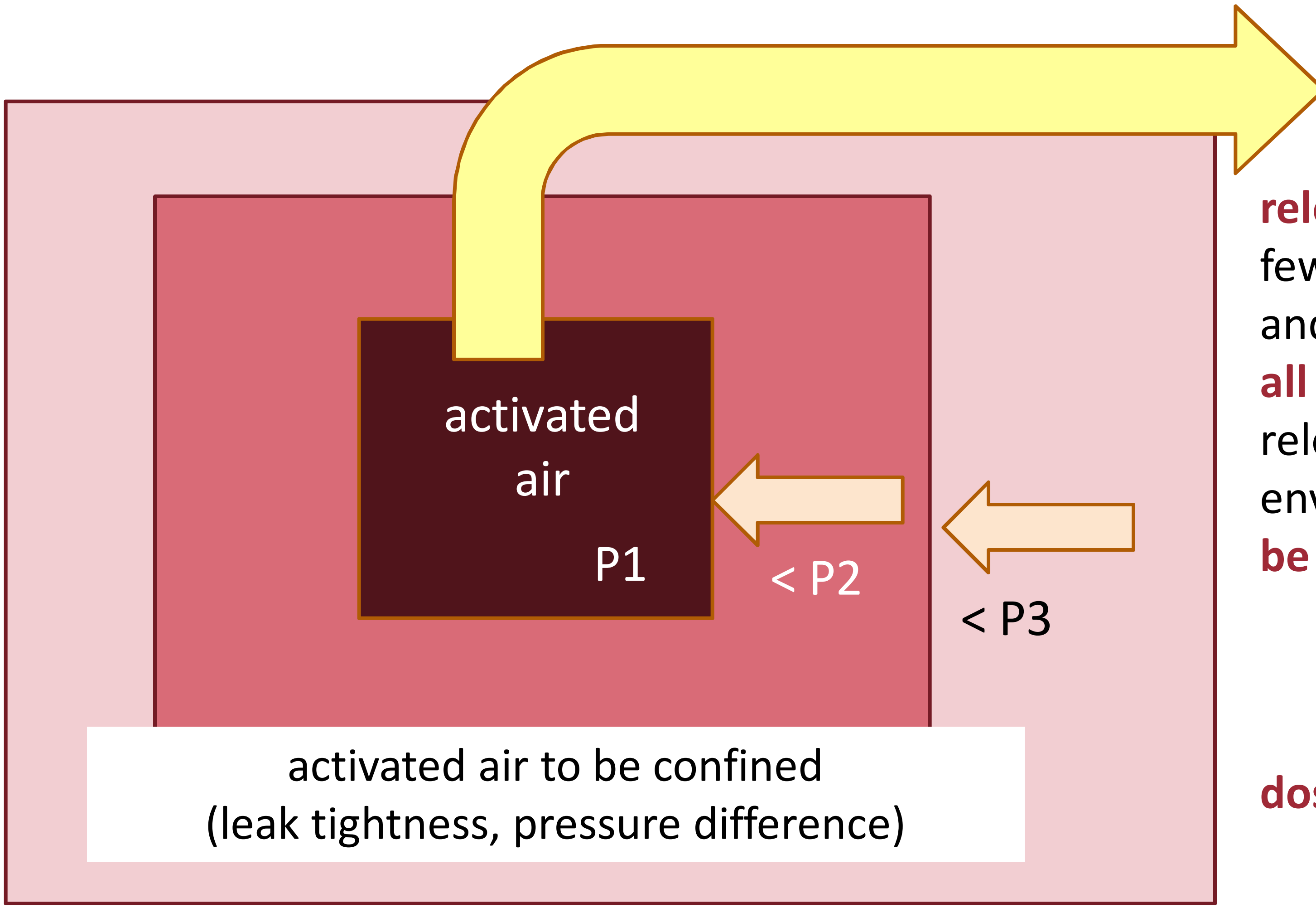
Expected dose to the public:

Ion exchanger will become radioactive!

	D_{max} in mSv	
LHC Point 1	0,005	Rejets d'eau du circuit d'eau brute du LHC dans la rivière Nant d'Avril.
LHC Point 3	0,001	Rejets d'eau d'infiltration du secteur 4→3 du LHC. Prise en compte du faible débit du court d'eau recevant cette eau.
LHC Point 7	0,001	Rejets d'eau déminéralisée et d'eau glacée des circuits de refroidissement de la zone de rabotage des faisceaux du point 7 acheminés et extraits au point 8 et rejetés dans la rivière « Le Nant ».

Regular RP sampling campaigns to keep control on the risk to workers and public - under normal and accident conditions

Management of Activated Air

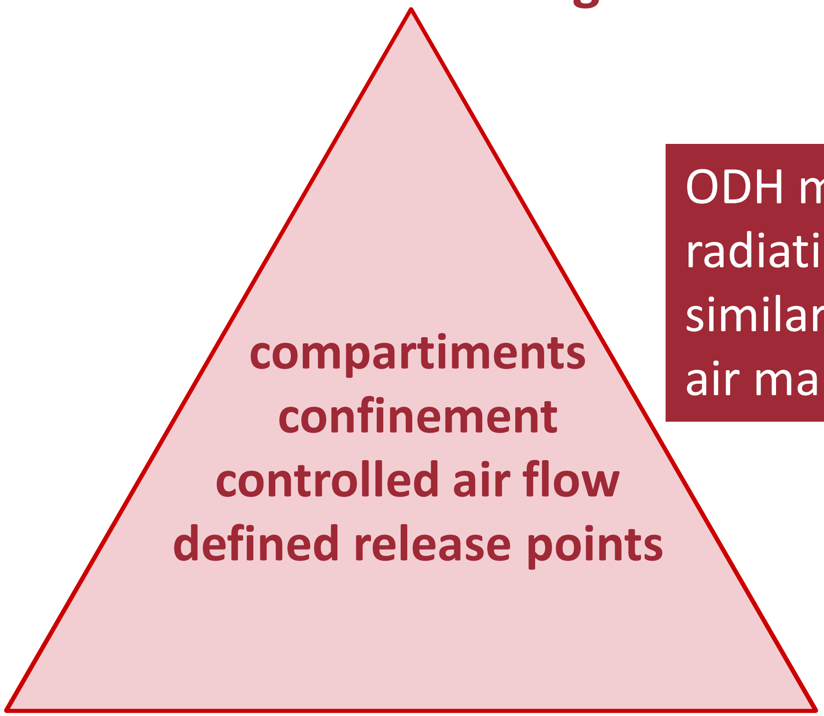


release points:
few, well defined
and controlled;
all activated air
released into the
environment **to**
be monitored

↓

dose to the public

Air Management for LHC Tunnel



ODH mitigation, fire and radiation protection have very similar needs with respect to air management

Air Management for LHC Tunnel

Consequences of incident Pt 3-4 in 2008:

no adequate Helium release path for machine tunnel available

=> depressurisation and fast release of Helium: removal of ventilation doors in UAs

⇒loss of compartiments, confinement, controlled air flow

Compensatory measures for 2010:

RP: limitation of beam intensity (beam power)

=> no problem for 2010 run (see M. Lamont),

access waiting times (30 minutes) for UAs and ULs

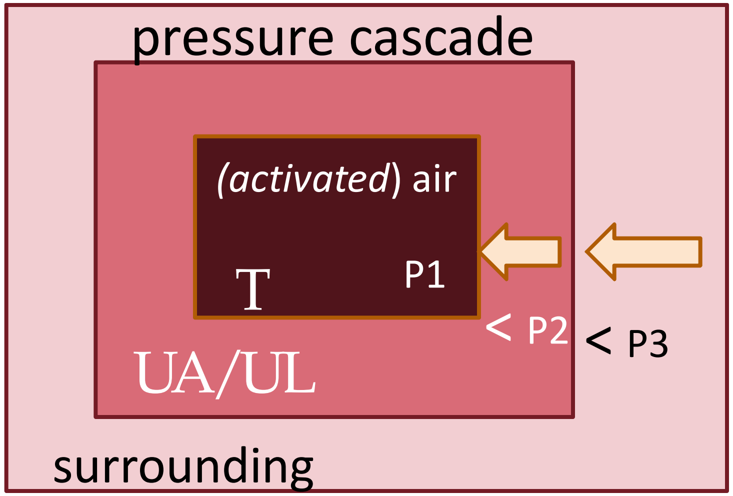
ODH: power testing in one sector -> adjacent sectors are closed

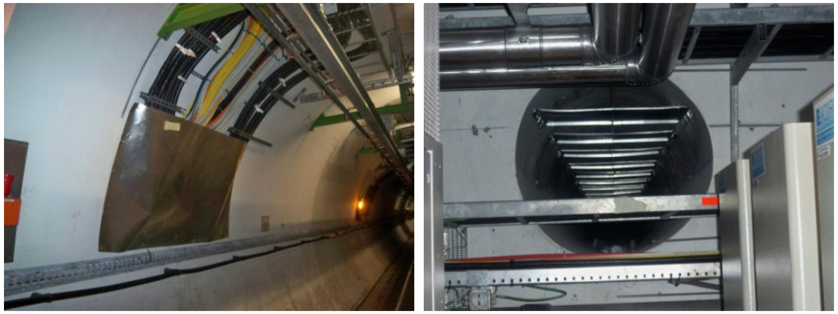
FP: no compensatory measure possible

DGS Request for LHC Tunnel Air Management

Confinement of *(activated)* air**:**

- overpressure in machine areas (UA, UL, US) when compared to accelerator tunnel
- separation between UAs/ULs and the tunnel (reinstallation of ventilation doors in 2010/11 shut-down; closure of cable ducts, etc.)
- additional p-measurement stations between UAs and/or ULs and tunnel





2006: First attempts (UA87/RA87)
2010/11: Consolidation
- air tightness (strict flow control UA=>RA)
- pressure and fire resistant seals

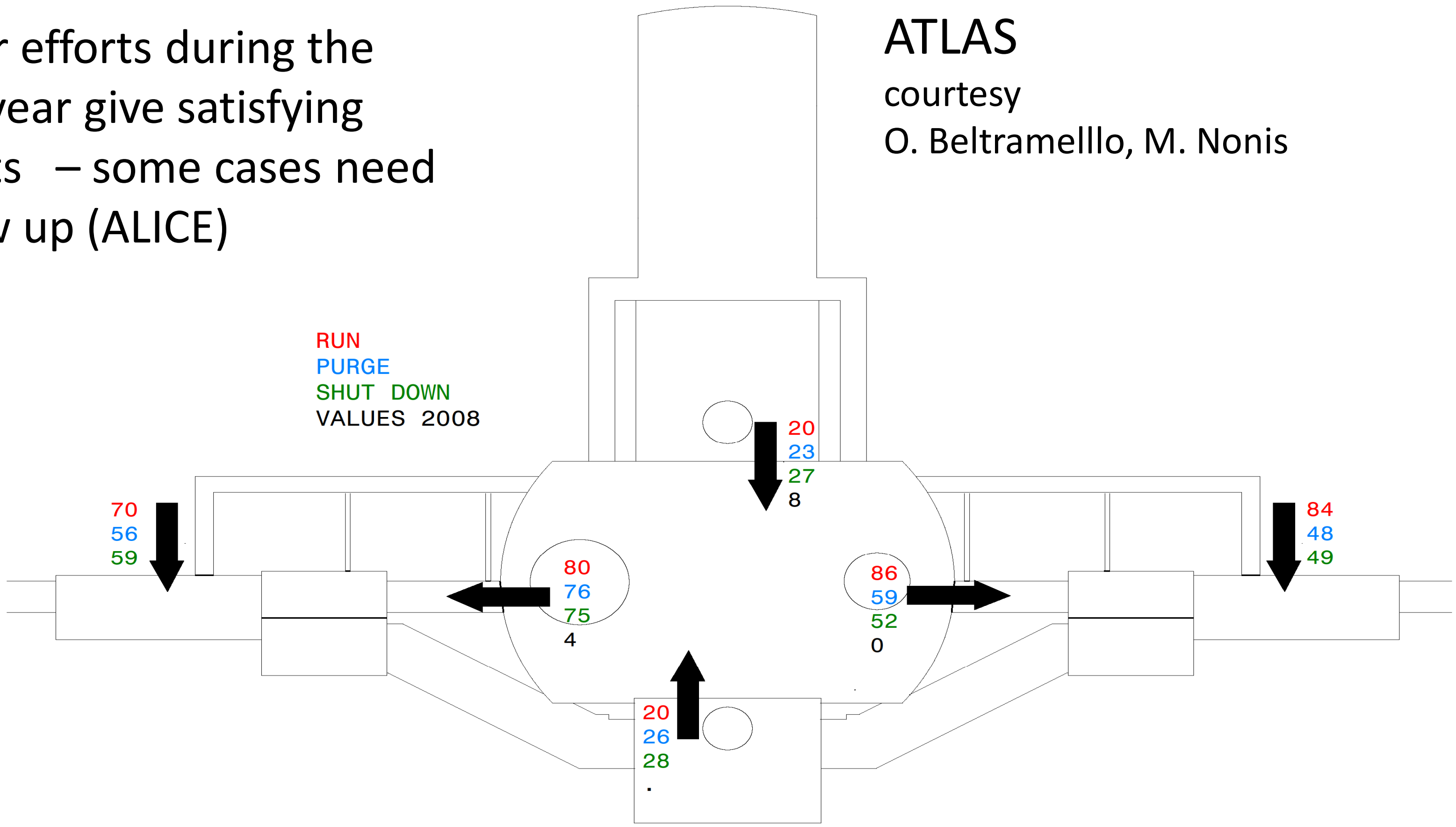
Air Management in Experiments

Major efforts during the past year give satisfying results – some cases need follow up (ALICE)

ATLAS

courtesy

O. Beltramelllo, M. Nonis



DGS Request for LHC Air Management

Tunnel

- **overpressure in machine service areas** when compared to tunnel
- **overpressure in service areas** (accessible during beam on) when compared to experimental caverns and tunnel
- continuous **monitoring of pressure difference, direction, air flow**
- **monitoring of activated air** in experimental areas – spot-wise, possibly permanent
- **all released radioactivity to be monitored** – additional monitoring stations required in Point 4 and Point 6 (to be installed for 2011 run) (*only « negligible » amount of radioactivity is permitted to be released without monitoring*)
- **RP does not request HEPA** (high efficiency particulate absorbing) filters for LHC – for the time being

Conclusions (1)

Beam-On:

- Experiments (2010):
  ambient dose equivalent rates (ATLAS) very low due to low luminosity (1-2% of nominal)

- Public (2010):
  dose to the public well below CERN's constraint of 10 uSv/year – based on calculations and extrapolations – to be confirmed by measurements *(beam intensity: ~10%, beam energy 3.5 TeV; factor 20 less produced radioactivity when compared to nominal – provided beam losses scale with intensity and energy)*

Conclusions (2)

Beam-Off:

- Accelerator components will be radioactive – vacuum-, interconnect- and collimator teams the first to be concerned
- Job and dose planning (DIMR) required – prepare work procedures now! Work procedures to be approved by RP (e.g. no grinder!!)
- All material leaving the accelerator tunnel and the « Zone operationelle » of the experiments need to be controlled by RP
- Traceability required
- Appropriate workshops required for maintainence and repair of radioactive equipment -> Bat 867 and some more (e.g. TE-EPC, cold magnets) to be adapted for this purpose
- Preventive, regular water sampling campaigns to be implemented

Conclusions (3)

LHC air management:

- shall meet the requirement of ODH mitigation, fire and radiation protection
- required actions (sealing, implementation of pressure cascade, installation of ventilation doors, fire doors, *(see slides 19 and 21))* to achieve
  - compartiments
  - confinement
  - controlled air flow
- actions to be taken during shut-down 2010/2011