ARCON/RAMSES: Current Status and Operational Risk

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Legal Background

CERN has the legal obligation to protect the public and the persons working on site from any unjustified exposure to ionizing radiation.

-> monitoring of

- ambient dose equivalent rates (in- and outside of CERN perimeter)
- releases of radioactivity by air, gases and effluents

allows preventive assessment of radiological risks and the optimization of individual and collective doses

-> fixed installed radiation monitoring systems:

- ARCON (Area Controller, since 1988 – LEP era, CERN in-house development)
- RAMSES (Radiation Monitoring System for Environment and Safety, since 2007 – LHC era, industry standard based technology)

(in total ~ 800 monitors, data acquisition and storage, alarms and interlocks)

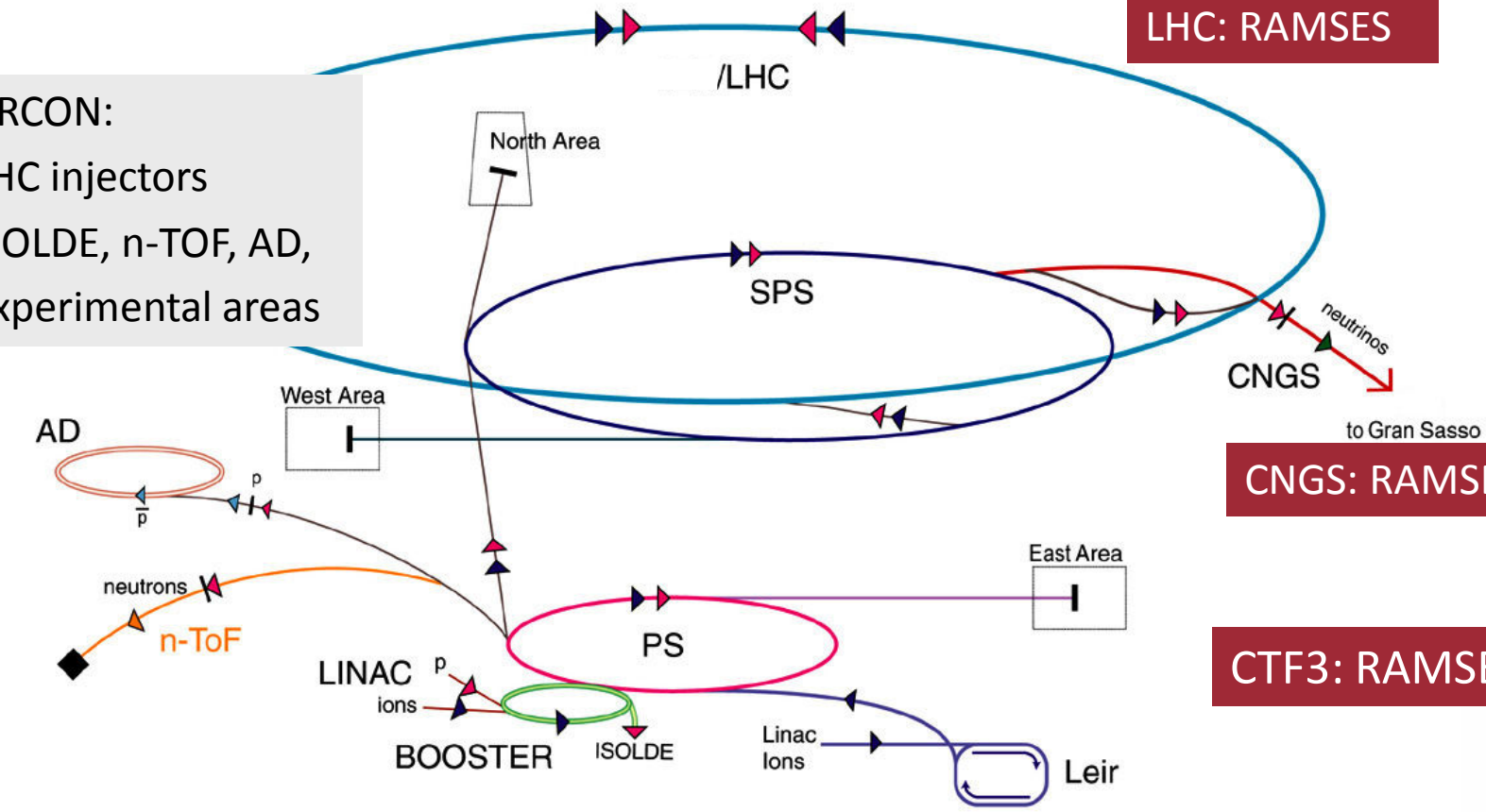
ARCON/RAMSES at CERN

ARCON:
LHC injectors
ISOLDE, n-TOF, AD,
Experimental areas

LHC: RAMSES

CNGS: RAMSES

CTF3: RAMSES



Monitors for Protection of Environment

ARCON and RAMSES use the same/similar type of monitors

Stray radiation Monitoring

EPIC

ERC

Water Monitoring station

RWM - RWS

Ventilation Monitoring

VGM - VAS

Wind onitoring

USA

Operational Radiation Protection Monitors

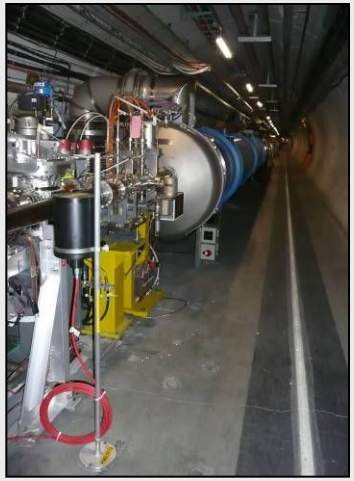
ARCON and RAMSES use the same/similar type of monitors

REM counter

Gas filled, high pressure ionization chamber

Beam-on: to protect workers in areas adjacent to accelerator tunnels and experiments against prompt radiation (mainly neutrons, E < some GeV)

Alarm function



Air filled ionisation chamber

Beam-off: to protect workers during maintenance and repair against radiation fields caused by decay of radionuclides (mainly gammas, E < 2.7 MeV)

No alarm function

Operational Radiation Protection Monitors

Special monitors

Hand&Foot monitor

Site Gate Monitor

SGM already prepared for connection to access system

Monitoring station

RAMSES: reading of radiation levels directly available

≠ ARCON

Radiation Alarm Unit (RAMSES)

Alarm Levels for Designated Areas

Area classification			Permanent workplaces		Low-occupancy	
			Warning	Action	Warning	Action
Non-designated Area			Guideline EMDS 788938			
Radiation Area	Supervised Radiation Area		3 µSv/h	6 µSv/h	15 µSv/h	30 µSv/h
	Controlled Radiation Area	Simple Controlled	10 µSv/h	20 µSv/h	50 µSv/h	100 µSv/h
		Limited Stay Area	-	-	**not applicable**	
		High Radiation Area	-	-	**not applicable**	
		Prohibited Area	-	-	**not applicable**	

EDMS 900889

Radiation measurement: typical sampling time: 100 -300 s

→ extrapolation to 3600 s

→ above limit: alarm

Beam-On:

accessible areas are shielded towards beam areas

-> classification as Supervised Radiation Area or Simple Controlled Radiation Area is sufficient

Monitors in designated areas (accessible during beam on): uniform alarm and interlock levels

Alarm Philosophy

- Two different philosophies:

  Either **beam interlock** on alarms or **operator action** following an audible/visual signal. Interlocks are preferred above operator action by RP. Choice is mainly made due to required and available reliability level and weighted according impact on machine operation.

- Transmission of radiation protection alarms

  PS complex: Radiation Alarm Repeater Panels –> visual and audible alarm to operators, no ARCON interlock on LINAC, Booster of PS beam, RAMSES interlocks in operation at CTF3, action OP and RP

  SPS complex: LASER system -> ARCON interlock on SPS beam, action OP and RP

  LHC: LASER system + visual and audible alarm (to be implemented), no RAMSES interlock on LHC beam (with exception of RF commissioning), Action OP and RP

Alarm Philosophy

- Transmission of alarms from site gate monitors: alarms to be transferred to TCR via RAMSES and ARCON; action OP and RP
- Transmission of environmental alarms (pH and temperature) to TCR; action IE, OP and CV
- No transmission of radiological environmental “alarms=action level”*) to other systems than ARCON or RAMSES; action IE and RP
- No technical alarms of RAMSES or ARCON are transmitted to TCR**) for the time being (for historical reasons)

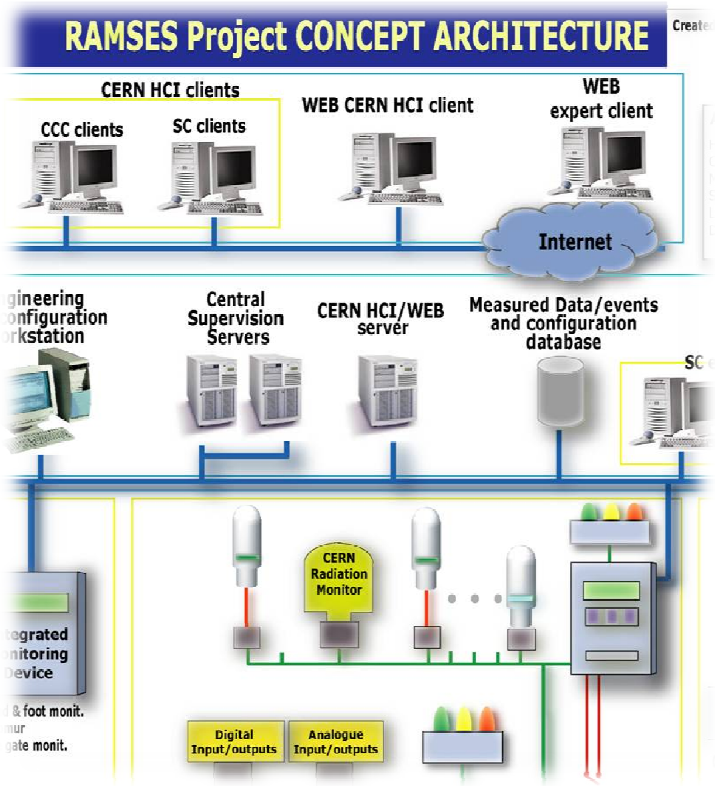
*) DGS-IE + BFSP: environmental radiation monitoring does not require alarm function

**) with exception of pH and temperature

RAMSES

Radiation Monitoring System for the Environment and Safety

- Designed to **cover all CERN** installations
- 2002: RAMSES limited to LHC due to budget restrictions
- Presently monitoring system for **LHC**, **CNGS** and **CTF3**
- Developed, installed and maintained by an **industrial contractor**
- **State-of-the-art** integrated decentralised monitoring system, designed to fulfil SIL 2 level for the basic monitoring, alarming and interlock functions.
- Standard system for **new projects (LINAC4);** or extension of existing installations **(HiRadMat)**



RAMSES Reliability and Availability

- ✓ Compliant to applicable international standards for radiation protection instrumentation (ISO)
- ✓ IEC 61508 closely used as reference
  - *Functional safety lifecycle*
  - *Project Management Plan*
  - *Hazard Analysis*
  - *Safety Integrity Levels assigned to safety functions*
- ✓ Decentralised radiation monitoring system
- ✓ Each detector-alarm unit operates autonomously, back-up with batteries, unit continues to operate even if rest of the RAMSES system fails
- ✓ Safety integrity level (SIL) 2 for radiation alarms and interlocks

RAMSES Maintenance

Preventive maintenance:

- ✓ Systematic, regular control of operational reliability for each single equipment item (every 2 weeks to once a year)
- ✓ Performed by contractor and DGS-RP, DGS-IE

2009:

- ✓ Hardware and software updates have been implemented in 2009.
- ✓ Annual maintenance completed

Corrective maintenance (TCR not yet involved):

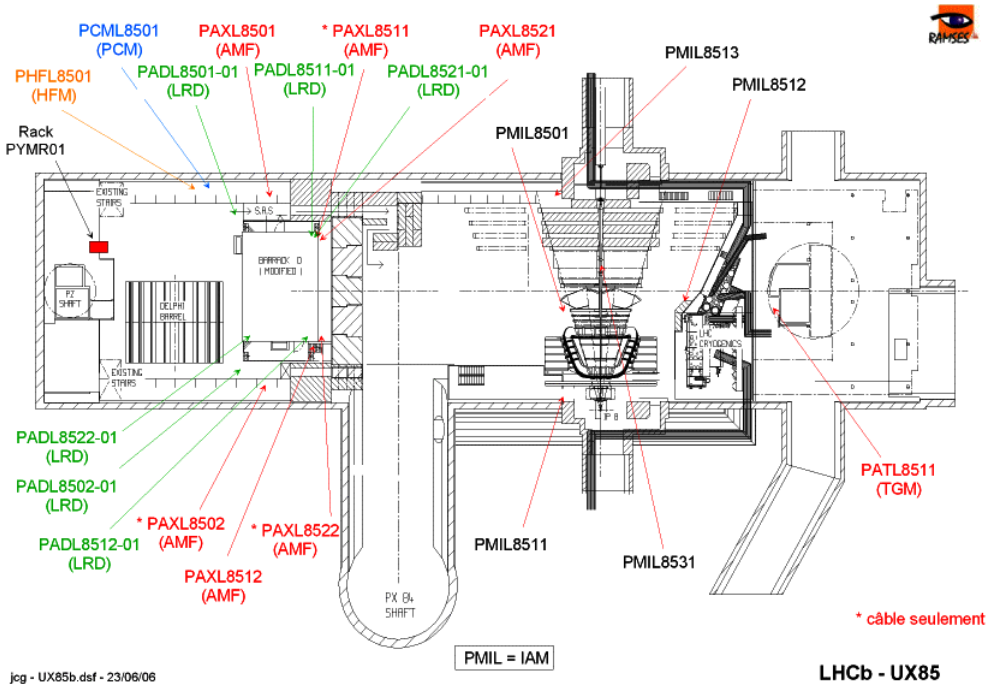
- ✓ During working hours: performed by 1st intervention line (DGS/RP-IL)
- ✓ During non-working hours: RP on-call service and DGS/RP-IL on a best effort basis
- ✓ Contractor Hot Line (24H/24H, 7d/7d)
- ✓ Contractor 8 – 48 hours to solve problem on site

RAMSES - Operational Risk

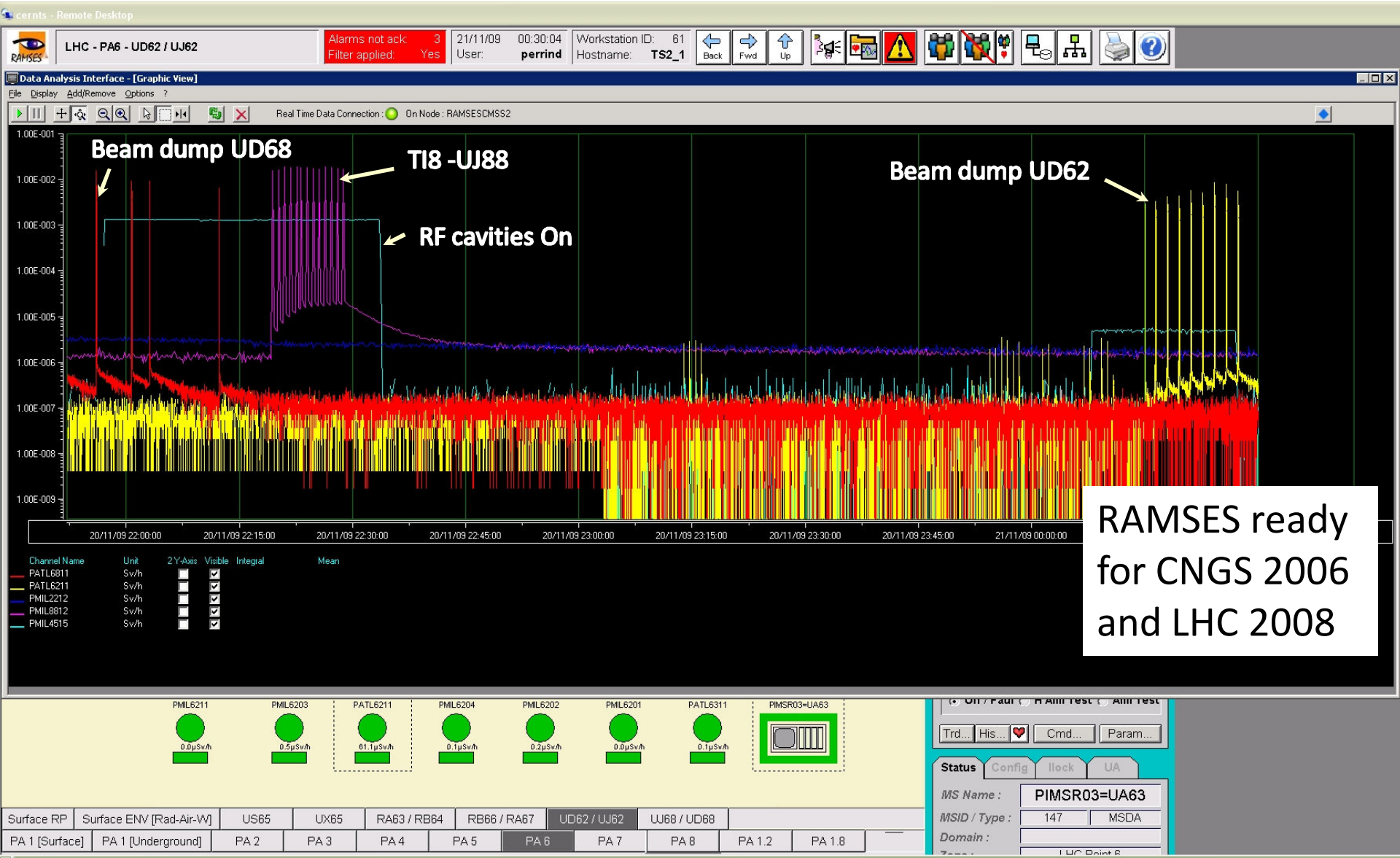
RAMSES statistics:

- ✓ 3 false alarms in 2009 (1 hardware failure at LHC-3, 2 at CTF3 – cured by replacement of faulty equipment)
- ✓ No false interlock signal in 2009 in LHC
- ✓ 99 %* data availability in database (* Present checking limit)

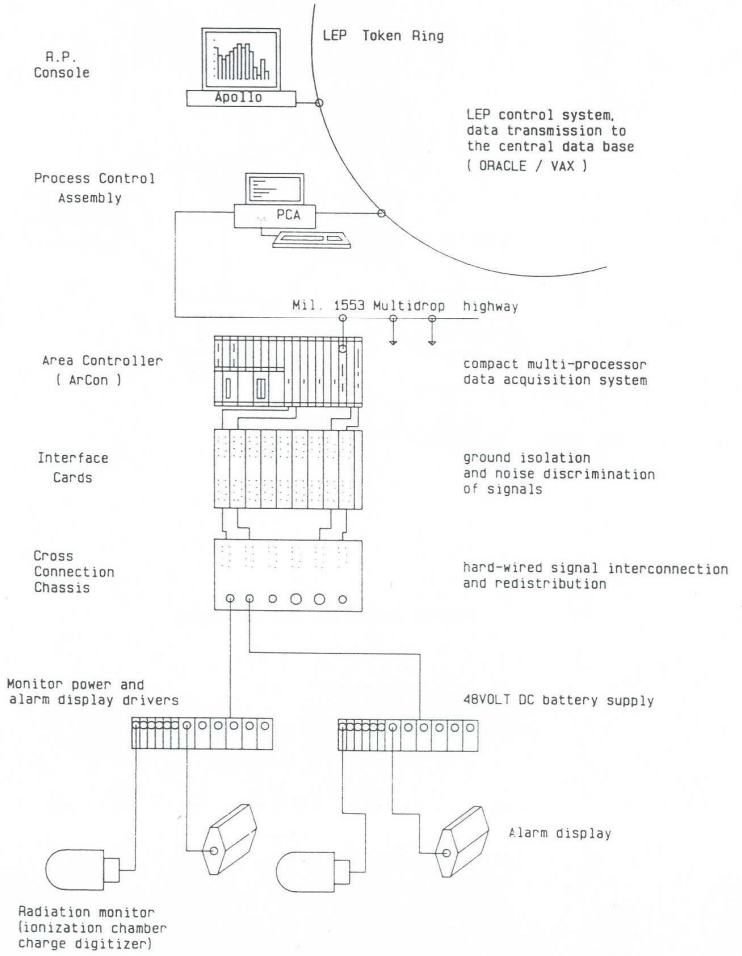
Areas are sufficiently well covered with monitor stations, provisions are made to increase redundancy even more



RAMSES data : i.e. LHC restart in 2009



ARCON



- CERN development in the 80's for LEP
- VME Bus (CPU 68040)
- OS9 (Operating system)
- MIL1553 (field bus) / Ethernet TCP/IP
- Up to 64 counting inputs (current pulses)
- **Still about 380 channels on ARCON**

To be phased out and replaced by RAMSES system:

- ARCON-RAMSES interface (to replace HPSLZ18 server)
- RAMSES2light (RAMSES for injectors)
- RAMSES2 (RAMSES for rest of CERN facilities, i.e. ISOLDE, n-TOF, AD and experimental halls)

ARCON versus RAMSES

	ARCON	RAMSES
Developed	80th for LEP	2000th for LHC
Standard	CERN standard	Industrial standard
SIL	< SIL	SIL2 for alarms and interlocks
Size	~ 380 monitors	~ 400 monitors
Detectors	same type of detectors – different electronics	
System	Grouped (several monitors on one ARCON station)	Autonomously operating monitors, grouped into smaller entities
Worst risk in case of failure - RP	Several channels fail in case of ARCON failure -> whole area without radiation monitoring	Single channel fails -> radiation monitoring ensured by remaining channels
Supervision / Software part	HP server, proprietary software no longer supported	PCview SCADA solution, OPC client/server technology

Interim Solution for ARCON

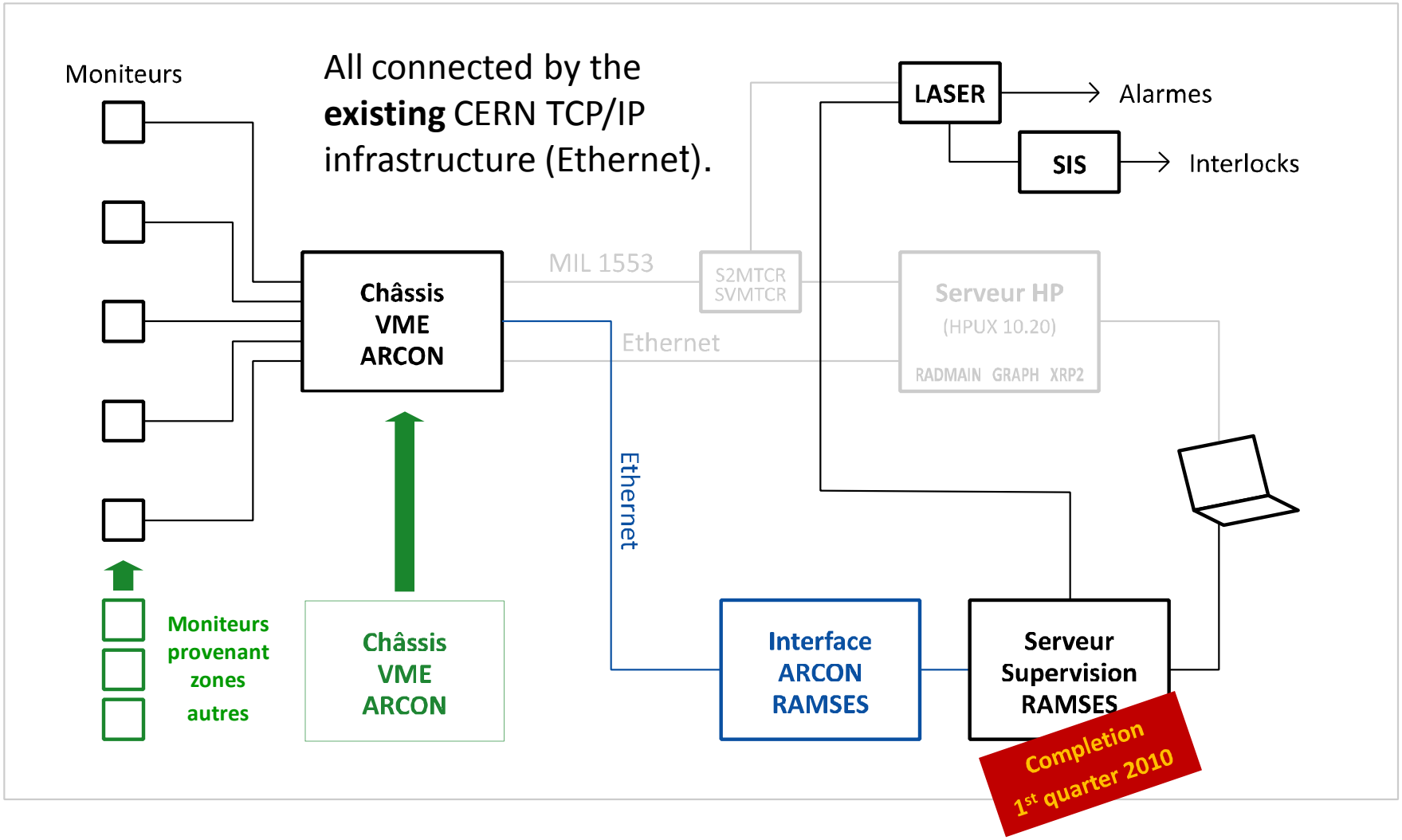
	ARCON	Interim Solution
SIL	< SIL	< SIL
Size	~ 380 monitors	Maintains all existing ARCON channels
Detectors	Detectors (spares missing)	Spare detectors available to some extent or may be taken from experimental areas – in case of need
System	Grouped (several monitors on one ARCON station)	ARCON remains operating surveillance system
Worst risk in case of failure - RP	Several channels fail in case of ARCON failure -> whole area without radiation monitoring	Electronic spare parts (from LEP) are tested and operational in case of need
Supervision / Software part	HP server, in-house developed software	ARCON-RAMSES bridge (eliminates HP server and proprietary software)

Interim Solution for ARCON

- **ARCON-RAMSES Interface (to replace MIL 1553, HPSLZ18 Server)**
  - ✓ Interface completed,
  - ✓ Supervision part completed,
  - **Final reception** of the RAMSES based supervision system for all ARCON was scheduled for end 2009 ➔ **1st quarter 2010** due to a technical problem identified with OPC server software.

- **Back-up for LHC injector chain ARCON:**
  - ✓ **Electronic spare parts** are **tested** and **available**
  - ✓ **Spare detectors** still critical → To be **taken from experimental areas** (according to a predefined list), **new spare detectors** will be bought within the **RAMSES II light project**
- Improved reliability of **ARCON network link** → ARCON network star points are **secured by UPS**
- Improved battery and power supply surveillance → Installed on all ARCON

ARCON-RAMSES Interface



Operational Risk - ARCON

- Problem of supervision server (outdated system (HP server) to communicate with continuously up-dated modern software systems (Operation) for data and alarm transmission – to be cured by ARCON RAMSES bridge
- Failure of an entire ARCON system will result in the loss of radiation monitoring for a whole area -> beam stop and replacement of ARCON
- Monitor failures -> spare monitors to be installed (worst case: from experimental areas)

Worst case scenarios:

1) faulty ARCON equipment – similar to a broken magnet, septa or power supply -> beam stop

Replacement of an entire ARCON:

1- 3 days

2) ARCON software (for equipment control):

Difficult to maintain, common weak point to all ARCONs

Final solution:

RAMSES2light

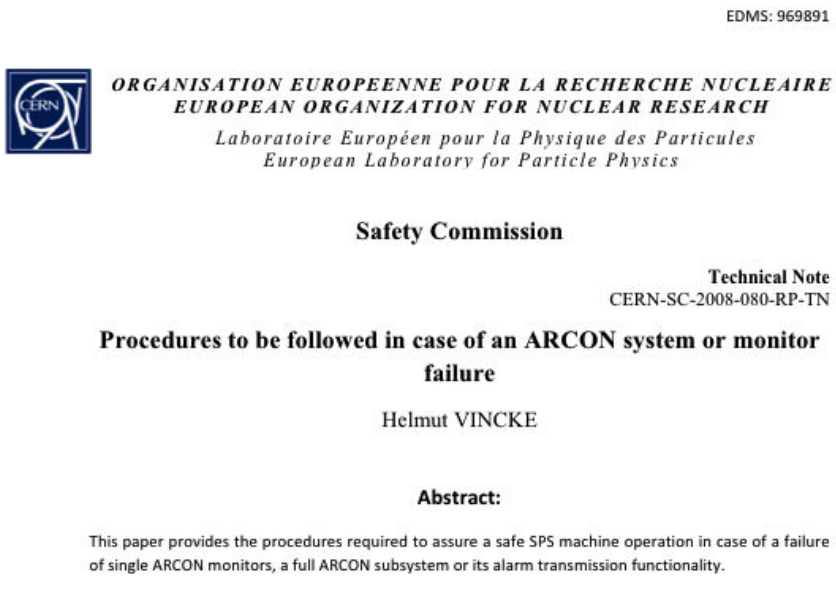
RAMSES2

Operational Risk - ARCON

- Basic guideline defined in SR16 (Safety Rule 16, BE/OP)
  - Specific action and information for PS Complex available to operators on: http://cern.ch/rp-ps
  - Specific action and information for SPS Complex defined in technical note EDMS 969891.

To be added to OP shut-down lectures – see FOM 19/1/2010

1	2	3	4	5	6	7	8	9
Name	Surveyed installation	Action in case of monitor failure	Alarm Zone	A Alarm	B Alarm	Alarm transm.	Mon. fault	Class
ARCON SUD (PCZP21)								
PAXS11	PS ejection, Linac 2 ejection	Stop PS FT16 ejection	SUD	50	100	B	Yes	ZCS
PAXS12	Linac 3, RF cavities	Stop Linac 3 operation	-	10	20	-	Yes	ZCS perm
PAXS14	PS ejection, Linac 3 source	Stop PS operation	SUD	10	20	B	Yes	ZCS perm
PAXS21	Linac 2, measurement line	Stop Linac 2 operation	SUD	10	20	B	Yes	ZCS perm
PAXS23	Linac 2, close to proton source, D.21	Stop Linac 2 operation	SUD	10	20	B	Yes	ZCS perm
PAXS31	PS, South Hall, LEIR (B.150)	Stop PS operation	SUD	15	30	B	Yes	ZS
PAXS32	PS, South Hall (B.150)	Stop PS operation	SUD	15	30	B	Yes	ZS
PAXS33	PS, South Hall (B.150)	Stop PS operation	SUD	15	30	B	Yes	ZS
PAXS34	PS, South Hall (B.150)	Stop PS operation	SUD	1.3	7	B	Yes	ZNR



EDMS: 969891

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Laboratoire Européen pour la Physique des Particules
European Laboratory for Particle Physics

Safety Commission

Technical Note
CERN-SC-2008-080-RP-TN

Procedures to be followed in case of an ARCON system or monitor failure

Helmut VINCKE

Abstract:

This paper provides the procedures required to assure a safe SPS machine operation in case of a failure of single ARCON monitors, a full ARCON subsystem or its alarm transmission functionality.

Operational Risk - ARCON

PS complex

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PAXS34	PS, South Hall (B.150)	Stop PS operation	SUD	1.3	7	B	Yes	ZNR

number of monitors to be increased
-> consolidation

Operational Risk - ARCON

SPS complex

Example (EDMS 969891) – *RP part only, DSO actions to be included*

PAXTA40: (**monitor in SPS interlock system)**

Function: stray radiation monitor to protect personnel in the ECA4 cavern at floor level during SPS operation.

Procedure to be followed in case of failure or unavailability of monitor:

- SPS operation to be stopped
- Inform RP on the monitor problem (phone: 75252 or 74848).
- ECA4 floor to be cleared and closed.
- If not possible to block access to floor level of ECA4 only, the whole ECA4 area to be cleared and closed at the surface.
- Operation may continue – after clearance by DSO, RSO and RP (beam permit sheet?)

SPS complex:
underground installation
–> less impact of ARCON failures when compared to PS complex

RAMSES 2 Light Project

Replacement and consolidation of ARCON by RAMSES for the entire LHC injector chain

- ✓ Project passed Finance Committee in March 2009 (extension of existing RAMSES contract)
- ✓ Project includes ARCON replacement, consolidation, new projects (LINAC4, HiRadMat) and spares
- ✓ Contract amendment and related order signed in December 2009 (after having solved EMC problems)
- ✓ Two phase project – depends on accessibility of areas during accelerators operation:
  - ✓ Commissioning and acceptance tests of instrumentation in accessible areas → October 2010
  - ✓ Full commissioning and acceptance tests by the end of 2010-2011 shutdown period

Conclusion

- RAMSES (LHC) has proven to be reliable (SIL2 level)
- Provisions had been made to increase RAMSES redundancy even more
- Actions had been taken to secure injectors for LHC run 2010
- ARCON (injectors) to be replaced by RAMSES2light latest until end of shut-down 2010/11
- RAMSES2light replaces and consolidates existing monitoring system at the LHC injectors
- Technical alarms from RAMSES and ARCON to be transferred to TCR
- Radiation alarms from site gate monitors to be transferred to TCR