MONITORING SYSTEMS FOR RADIATION PROTECTION

Session “High intensity beam, radiation and safety issues”

IEFC Workshop 2010

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on behalf of DGS/RP & DGS/IE

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Radiation monitoring

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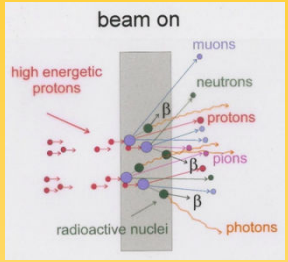
Introduction

Operation of accelerators involves beam losses,



CERN has the **legal obligation** to protect the public and the people working on site from any unjustified exposure to ionising radiation !

DGS/RP has the mandate **to monitor the radiological impact** of CERN's accelerators and installations by active monitoring.

Consequence for beam operation as defined in **SR16**:

Stop of operation when monitoring system fails.

Monitoring systems for RP

Content of the presentation

- Monitoring systems overview
- ARCON
- RAMSES
- Reliability & maintainability
- ARCON – RAMSES Bridge project
- RAMSES II Light project
- Conclusions

Monitoring systems for RP

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Overview

Complexity of monitoring evolves with CERN activities

- High intensity beams → risks of higher losses
- Size of machines and number of areas
- Radiation to electronics
- High magnetic fields
- Aging of infrastructures
- Limited intervention time
- Limited resources → more dependency to external partners

And not only

- Legal requirements → Decrease of max dose to public & workers
- Compliance to international standards for RP instrumentation

Monitoring systems for RP

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Overview - Main functions

- **Monitoring radiation variables (local and remote display)**
  - **Permanent real-time monitoring of ambient dose equivalent rates** (underground accessible areas, on the surface, in- and outside CERN perimeter)
  - **Permanent real-time measurement of radioactivity in released gases and fluids** (radioactive nuclides)
  - **Permanent measurement of induced activity during accelerators stop/shutdown**
- **Alarm functions (local and remote)**
  - **Generate radiation alarms based on ambient dose equivalent rates**
  - **Generate interlock signals**
  - **Generate technical alarms**
- **Long term permanent and reliable data logging**
  - **Measured values**
  - **Events** (radiation alarms, interlocks, system fault alarms, technical alarms)
  - **System configuration** (historic of changes)

Monitoring systems for RP

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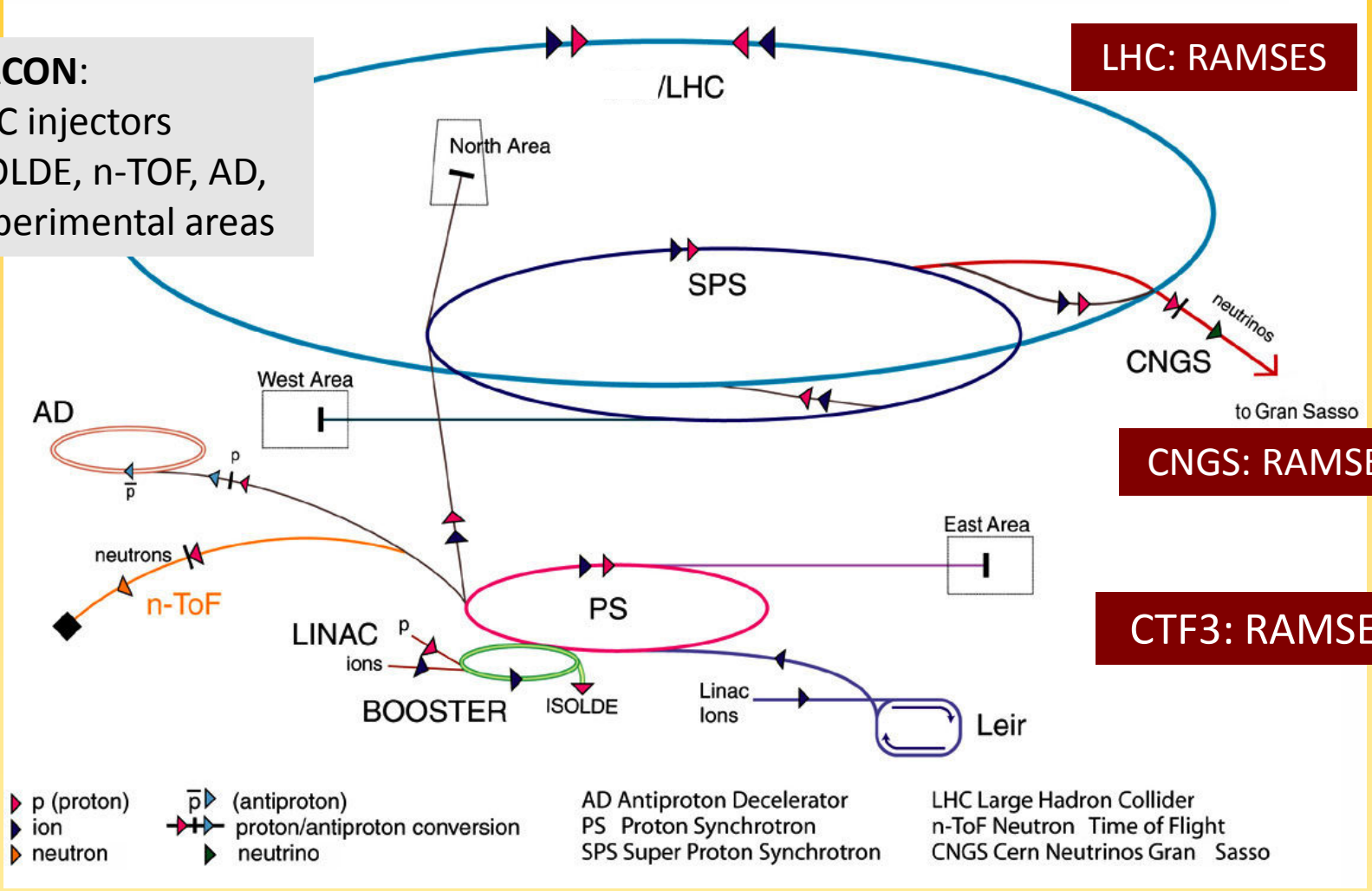
2 systems ARCON / RAMSES ~800 monitors

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



LHC: RAMSES

CNGS: RAMSES

CTF3: RAMSES

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Monitors for protection of the 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 Monitoring

USA

Monitoring systems for RP

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Operational radiation protection monitors

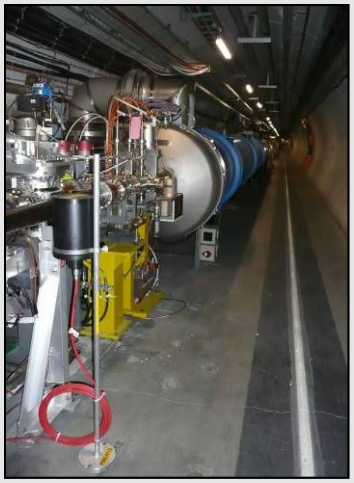
ARCON and RAMSES use the same/similar type of monitors

REM counter

Gas filled, high pressure ionisation 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

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Operational radiation protection monitors

Special monitors

HFM

Hand & Foot monitor

Site Gate Monitor*

*ready for connection to access system

Monitoring systems for RP

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Operational radiation protection monitors

RP monitors
(ARCON)

VME chassis
(ARCON)

Monitoring station
(RAMSES)

Radiation Alarm Unit
(RAMSES)

ARCON

(Area Controller)

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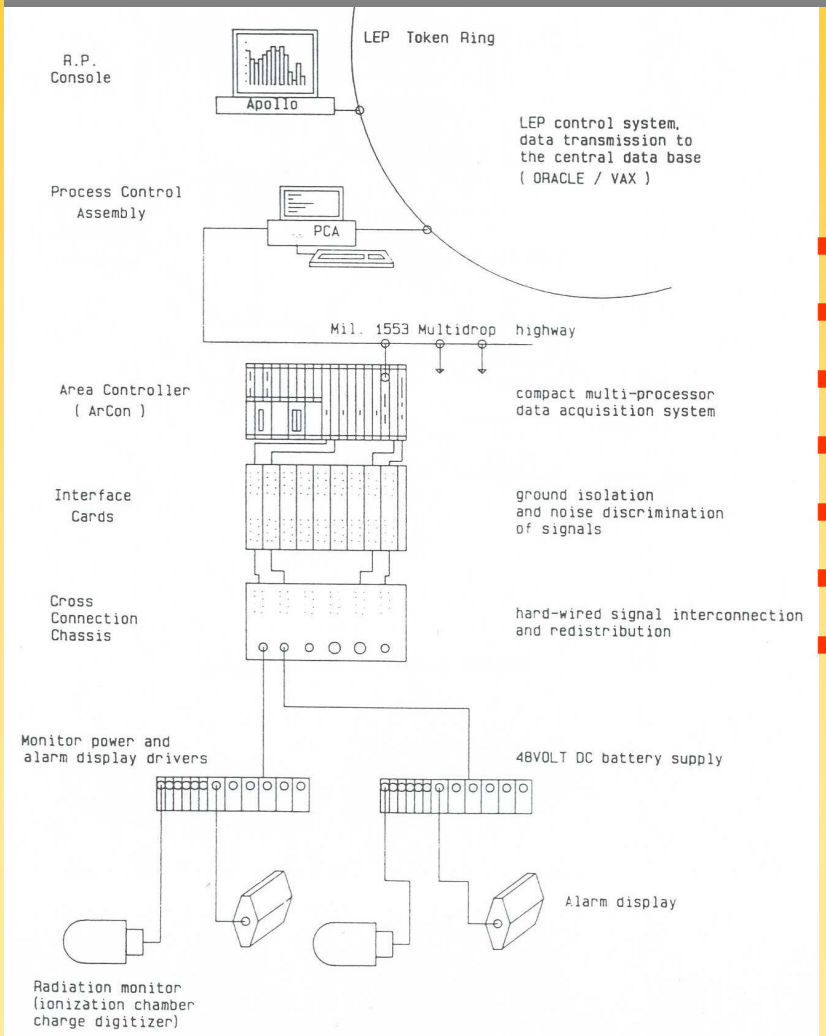
Overview - Main features



Radiation monitoring system of the PS complex and the SPS

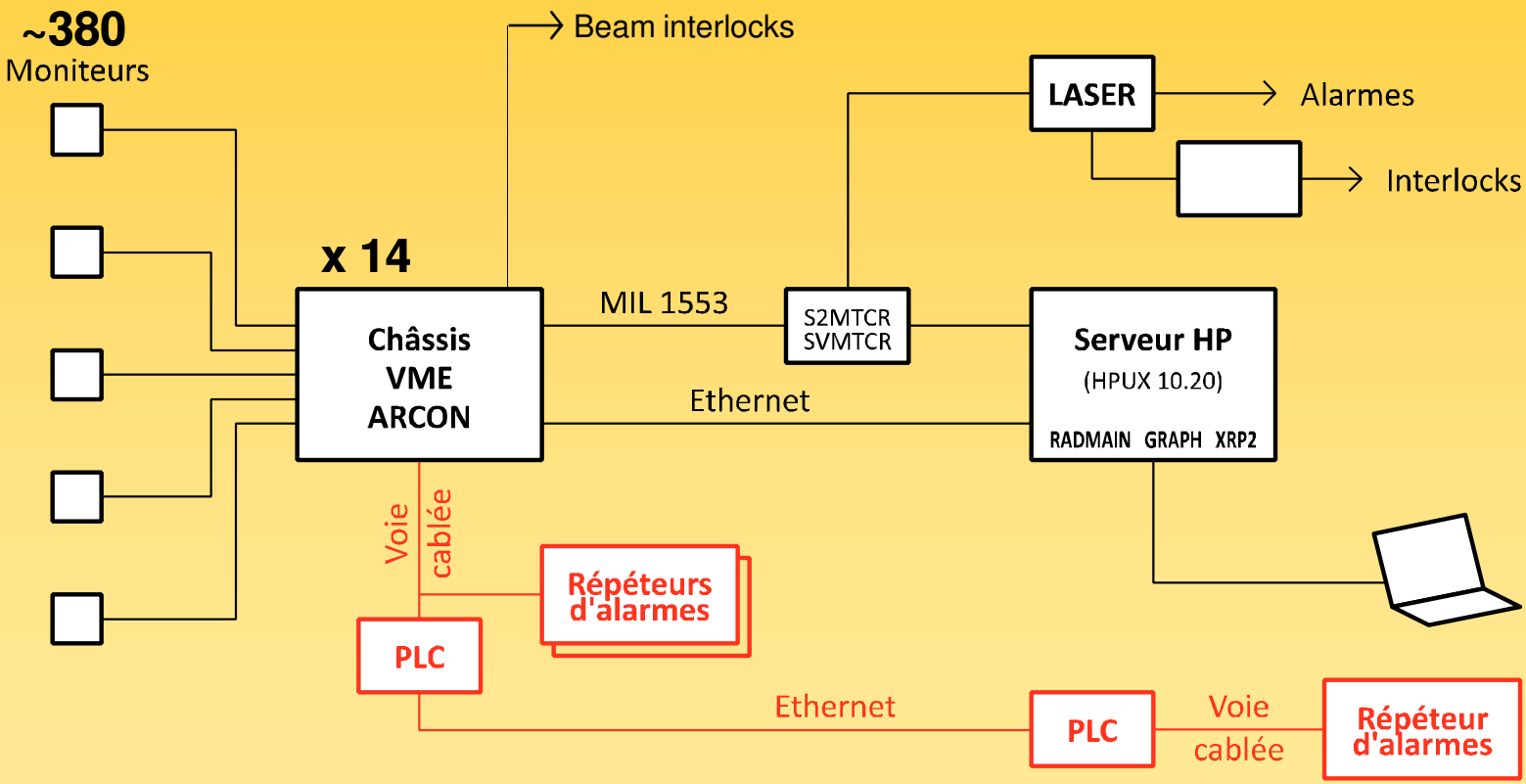
- CERN development in the early 80's for LEP
- VME Bus (CPU 68040)
- OS9 (Operating system)
- MIL1553 (field bus) / Ethernet TCP/IP
- Up to 64 counting inputs (current pulses)
- Up to 64 status outputs
- **Still about 380 channels on ARCON**

Main ARCON dates:

- 1989: Commissioning at LEP
- 1990 to 1994: Deployment on rest of CERN
- 1995: Diskless version – Ethernet link
- 2010: Beyond end-of-life time, still **use for LHC injectors** and related facilities

ARCON

Present architecture

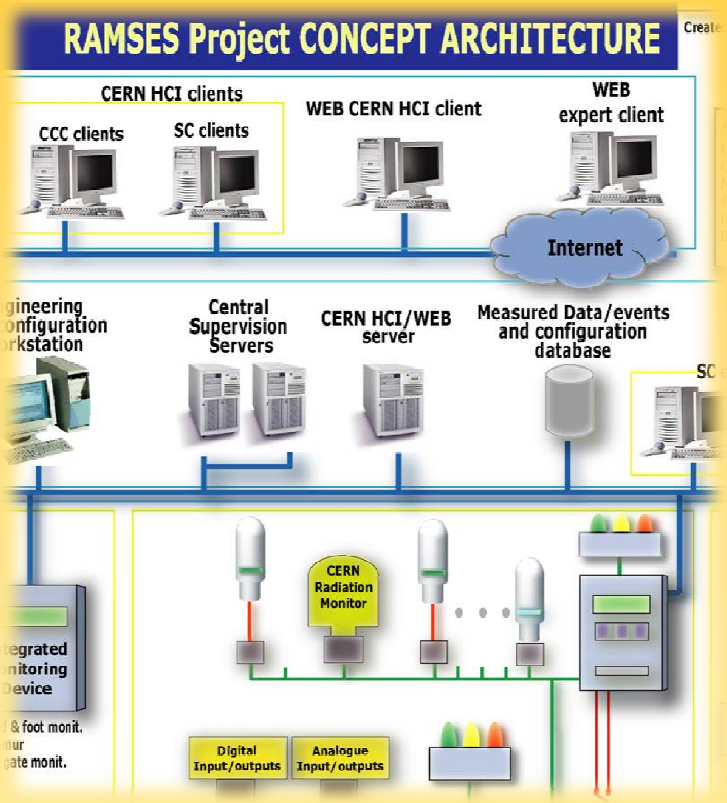


RAMSES

(Radiation Monitoring System for the Environment and Safety)

Overview - Main features

- Designed in 2004 to **cover all CERN** installations
- RAMSES limited to LHC due to budget restrictions
- Presently monitoring system for **LHC**, **CNGS** and **CTF3**, about **400 channels**
- Developed, installed and maintained by an **industrial contractor**
- **State-of-the-art** failsafe decentralised monitoring system, designed to fulfil SIL 2 for the basic monitoring, alarming and interlock functions.
- Standard system for **new projects (LINAC4)** or extension of existing installations **(HiRadMat)**



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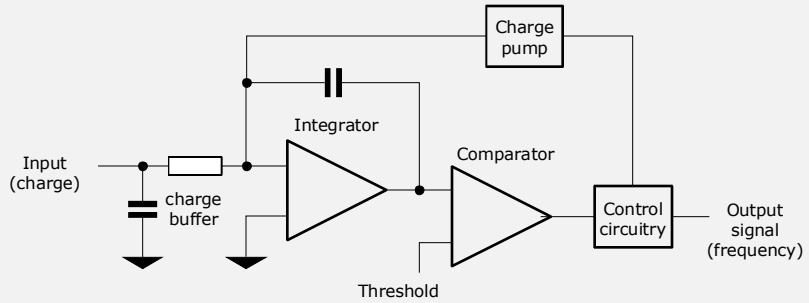
RAMSES

Enhanced read-out electronics

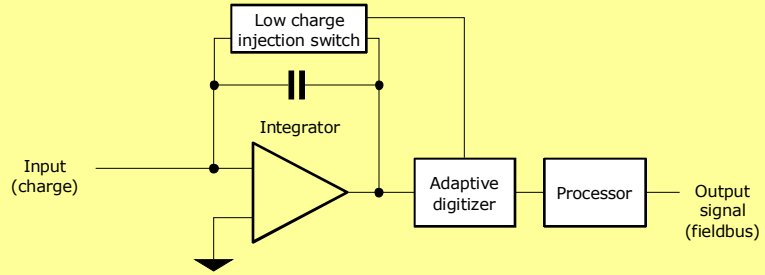
For PULSED RADIATION FIELDS

Measure current ranging from 10 fA (background level) up to 10 µA

NO CHARGE LOSSES ➔ NO switching permitted



CERN former electronics
as well as components of the shelves
cover 5 to 6 decades



Developed electronics covers
9 decades
Tested up to 300 nC / pulse
(50 % of the charge in 2 ms)

RAMSES

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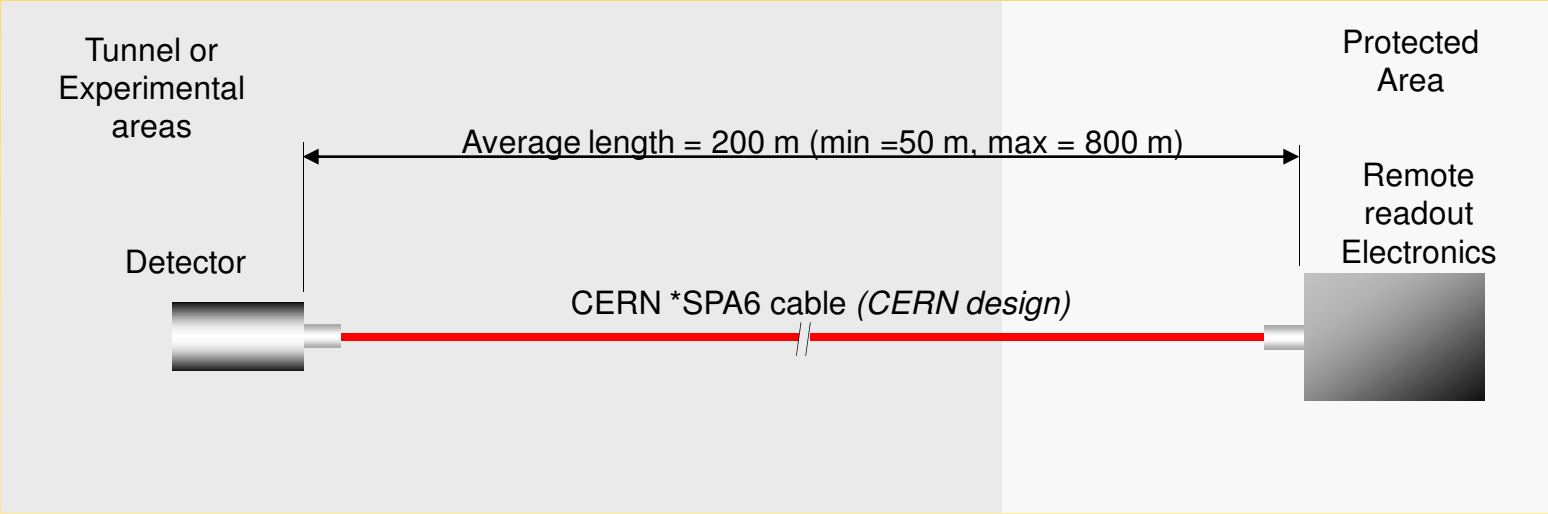
Very low current over long distances

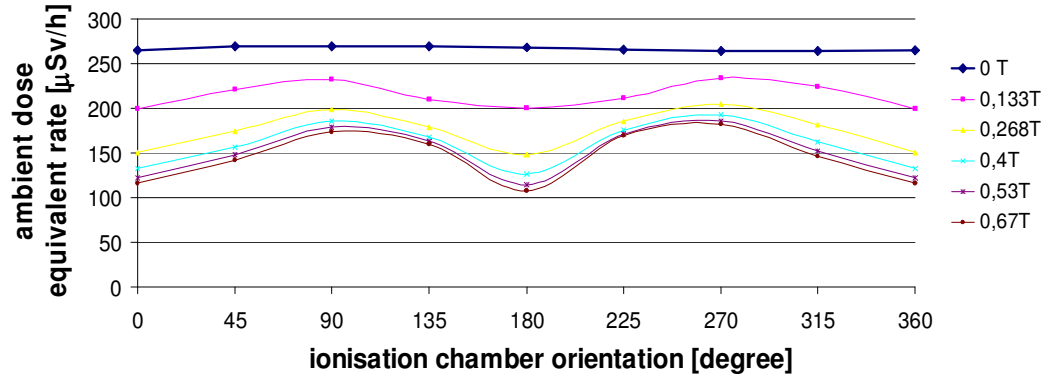
HIGH RADIATION FIELDS during BEAM ON ➔ REMOTE ELECTRONICS

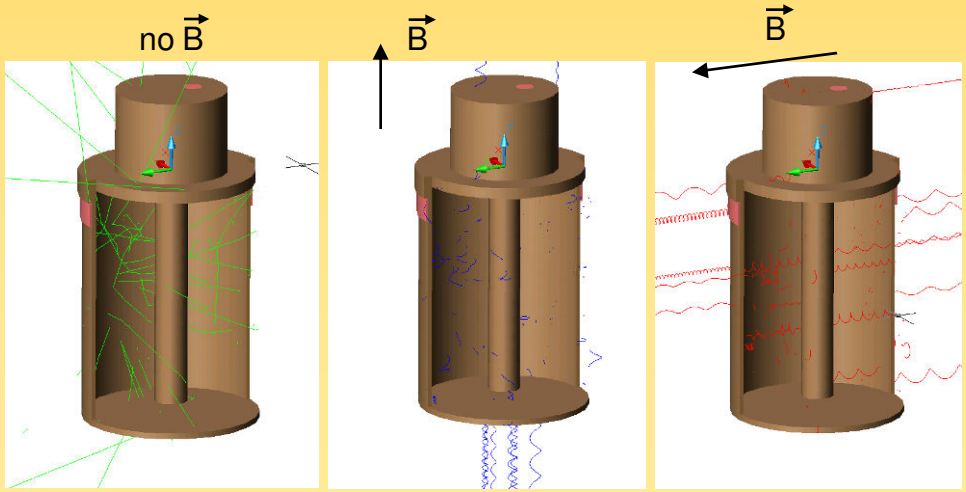
Measure current ranging from 100 fA up to 10 nA at a distance up to 800 m

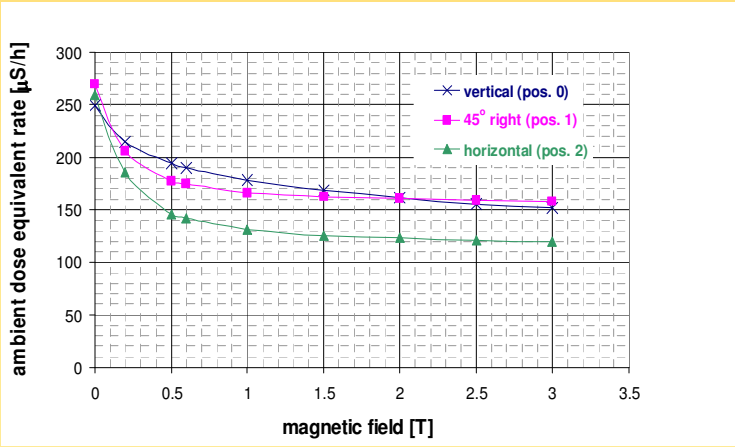


RAMSES

Measurement in magnetic field







Reliability / Maintainability

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ARCON issues

Ageing system and technologically obsolete → increase of breakdowns

- **Lack of spare parts** (include monitors for radiation and environmental protection)
- **Failure of measurement electronics** (due to aging of electronics)
- **VME chassis not to CERN** standard (difficult to maintain, no longer produced)
- **Microware OS9 no more supported**
- **Supervision system: no more maintenance from HP for HP10.20 operating system and hardware for HPSLZ18 server** (not possible to migrate to a newer OS)
- **MIL1553** (not fully compliant to standard, difficult to maintain, few experts)
- **Applications difficult to maintain, no possible evolution** (rely only on 1 expert + *an old development tool, actions undertaken in 2009 to secure it*)
- **Not compliant with current standards for radiation protection instrumentation** (auto diagnostic, safety integrity level)
- **Loss of expertise** (personnel retirements, documentation not up to date)
- **Very manpower intensive system**

The availability and reliability of a radiation monitoring system for the PS and SPS complexes is of prime importance for the operation of LHC

Reliability / Maintainability

ARCON operational risks

- Monitor failures → beam stop and spare monitor to be installed (worst case: from experimental areas): 2 to 4 hours
- Problem of supervision server, of MIL1553, no data and no alarm transmission → beam stop and repair of the related equipment: 1 day
- Failure of an entire ARCON system will result in the loss of radiation monitoring for a whole area → beam stop and replacement of ARCON: 1 to 3 days

Spare ARCON
in DGS/RP-IL laboratory

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Reliability / Maintainability

RAMSES basics

- ✓ Compliant to applicable international standards for radiation protection instrumentation (ISO & IEC)
- ✓ IEC 61508 closely used as reference
  - *Functional safety lifecycle*
  - *Project Management Plan*
  - *Hazard Analysis*
  - *Safety Integrity Levels assigned to safety functions*
- ✓ A safety integrity level (SIL) 2 for radiation alarms and interlocks,
- ✓ 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)

Reliability / Maintainability

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 or DGS-IE

2009:

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

Corrective maintenance (CCC 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

Reliability / Maintainability

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RAMSES

First statistics

- ✓ 3 false alarms in 2009 (1 hardware failure at LHC-3, 2 at CTF3 – cured by replacement of equipment)
- ✓ No false interlock signal in 2009
- ✓ 99 %* data availability in database
- ✓ No call of the hot line during non-working hours

* Present checking limit

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Reliability / Maintainability

Safety Commission

How to prevent **potential stoppage** of CERN accelerators including LHC in the coming years due to ARCON unavailability ?

Ideal solution, financially and technically speaking:

→ Replace the ARCON by RAMSES = RAMSES II project

Drawback: 4 - 5 years for implementation

Interim solution had to be found:

→ ARCON RAMSES Bridge project

→ RAMSES II Light project

ARCON-RAMSES Bridge project

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Deliverable & status

- **ARCON-RAMSES Interface to replace MIL 1553 and HP 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 the OPC server software.
- **Improve availability of ARCON spare parts**
  - ✓ **Stock of spare parts** was replenished from old LEP ARCONs
  - ✓ Spare parts are **tested** and **available**
- **Improve reliability of ARCON network link**
  - ✓ ARCON network star points are secured by UPS
- **Improve battery and power supply surveillance**
  - ✓ Installed on all ARCONs

ARCON-RAMSES Bridge project

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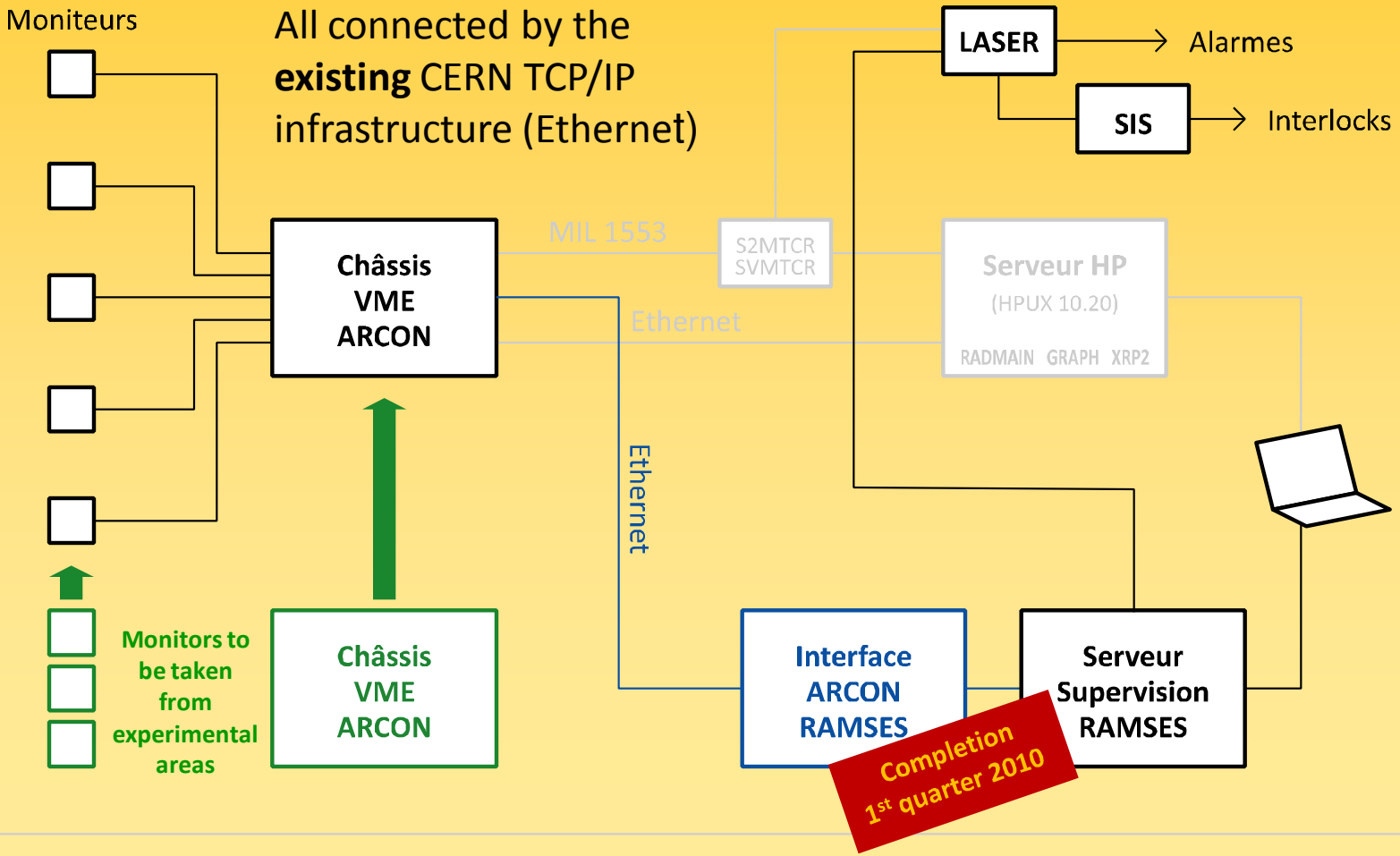
Overview



RAMSES II Light project

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Deliverable and status

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

- ✓ Project includes ARCON monitors replacement, consolidation, new projects (LINAC4, HiRadMat) and spare parts
- ✓ Project passed Finance Committee in March 2009 (extension of the existing RAMSES contract)
- ✓ Contract amendment and related order were signed in December 2009
- ✓ Two phases project – **strongly depends on accessibility of areas during accelerators operation for cabling, civil engineering and network installation**:
  - Commissioning and acceptance tests of instrumentation in accessible areas → October 2010
  - Full commissioning and acceptance tests by the end of 2010-2011 shutdown period, end of 2011 at the latest !

RAMSES II Light project

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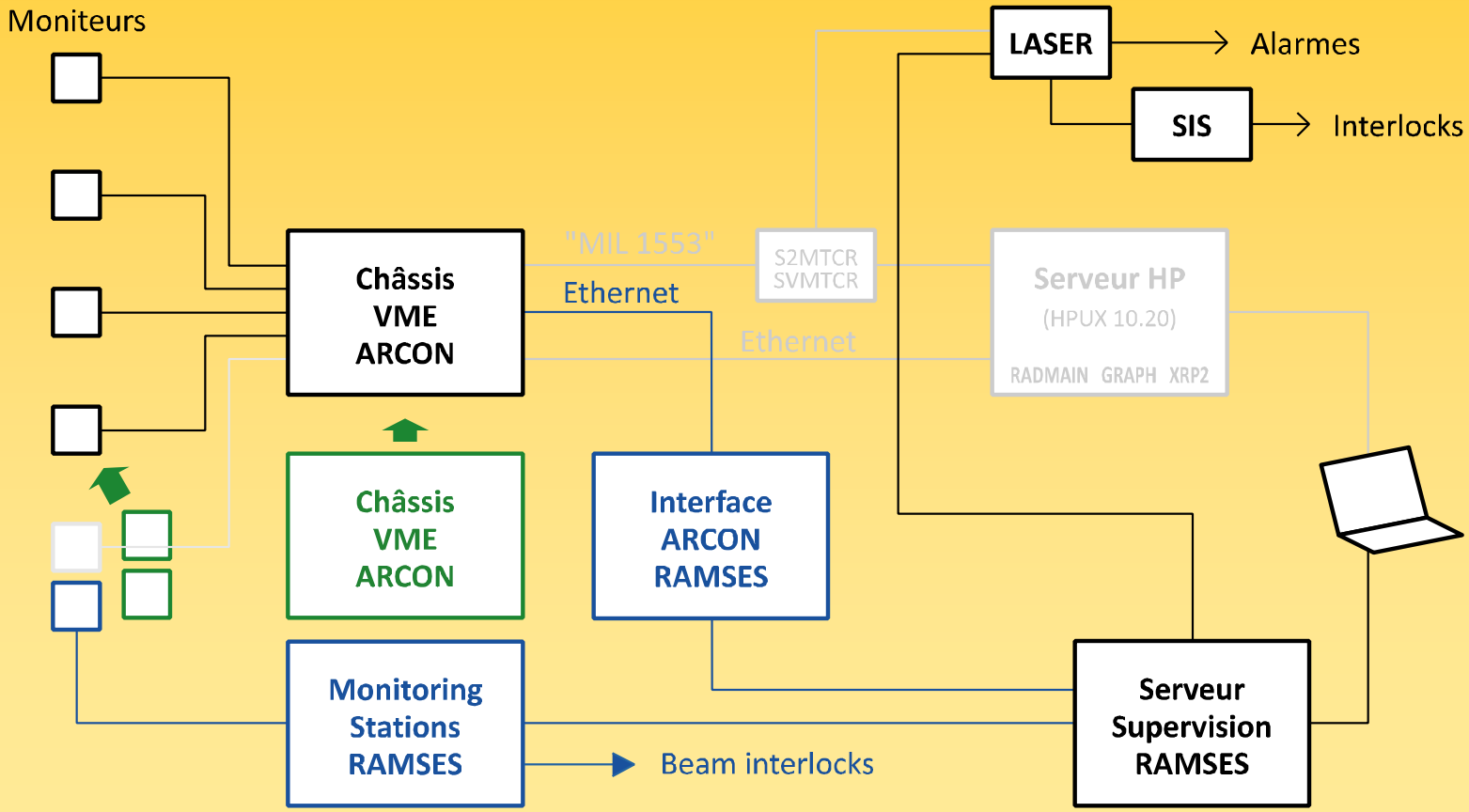
Overview



Next actions

RAMSES II = Replace ARCON by RAMSES

Due to financial restrictions, RAMSES II project divided into **two parts**:

1. **RAMSES II Light**, in the order of 3 MCHF (2010 – 2011), approved
2. **RAMSES II**, would amount to about 8 MCHF (2012 – 2016), not yet approved
3. **RAMSES consolidation**, from 2012 onwards…

Conclusions

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Accelerators startup 2010

PS Complex and SPS

- Due to the pending final reception ARCON-RAMSES interface, the accelerator start-up in 2010 still relies on the HP server based supervision system until April:
  - ✓ **Parallel operation** of both systems for a certain period
  - ✓ **Fade out of the HP server** based supervision during the run 2010
- RAMSES II Light to be ready in 2011 (terms of the contract)

LHC, CNGS and CTF3

✓ RAMSES is operational for start-up with beam

Start-up of accelerators in 2010 with operational radiation monitoring system confirmed

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Safety Commission

THANKS for your attention

Special thanks to the RAMSES team, DGS/RP-IL members, Doris Forkel-Wirth (DGS/RP), Markus Widorski (DGS/RP), Helmut Vincke (DGS/RP), Gustavo Segura (DGS/IE)

RAMSES II Light project

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i.e. Instrumentation PS complex