



# **RAMSES**

## **Induced Activity Monitors**

**5<sup>th</sup> LHC Radiation Day**  
**CERN - 29 November 2005**

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**on behalf of the RAMSES team**  
**(SC/RP, SC/IE and TS/CSE)**

**EDMS 684840**



# RAMSES Project



## Mandate/Scope

- The RAMSES will provide LHC, and finally CERN, with an integrated **RA**diation **M**onitoring **S**ystem for the **E**nvironment and **S**afety covering acquisition, transmission, logging and display for the LHC machine, LHC experiments and experimental areas.
- The Safety Commission will exploit this system to assess radiation risks and to control the release of radioactivity.

## RAMSES for Personnel Safety

**RAMSES NOT for ~~equipment protection~~**



# RAMSES Project



## Main functions

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

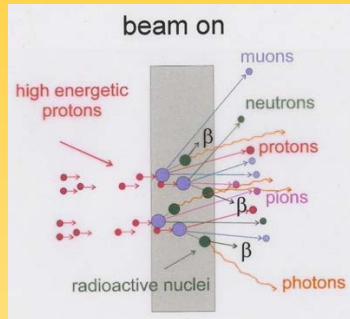


# Radiological risk @ LHC



The operation of accelerators involves interaction of high energy particles with matter

## Accelerator in operation :



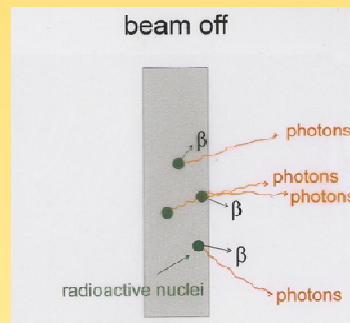
Beam losses : nuclear interaction of high energy protons with matter

- production of mixed radiation fields (Hadrons, neutrons, muons, photons, etc.).
- production of pulsed radiation fields (unavoidable or planned beam losses)

### Stray radiations

Irradiation risk for personnel (accessible areas) and risk for the environment (through access pits, releases of water and gases).

## Accelerator stopped :



Material activation due to beam losses.

### Radiation dose rate due to activation

Irradiation risk for personnel (maintenance works) and risk for the environment (dispersal of radioactive material).

Calibration of detectors (experiments).

### Radioactive Sources

Irradiation risk for personnel and for the environment (dispersal of radioactive sources).



# RAMSES Project



## Monitors for radiation protection

### ◆ LHC accelerator and experimental areas :

- Area REM-Counter monitor [ARC];
- Area Gamma dose rate Monitor [AGM];
- Area Mixed field radiation Monitor [AMF];
- Tunnel Gamma dose rate Monitor [TGM];
- Tunnel Mixed field radiation Monitor [TMF];
- X Rays Monitor [XRM];
- Induced Activity Monitor [IAM];

### ◆ Other monitors & equipment :

- Hand & Foot monitor [HFM];
- Site Gate monitor [SGM];
- Tools & material controller [PCM];
- Alarm radiation display [PAD];



# Induced Activity Monitors



## Use of IAM (Induced Activity Monitors)

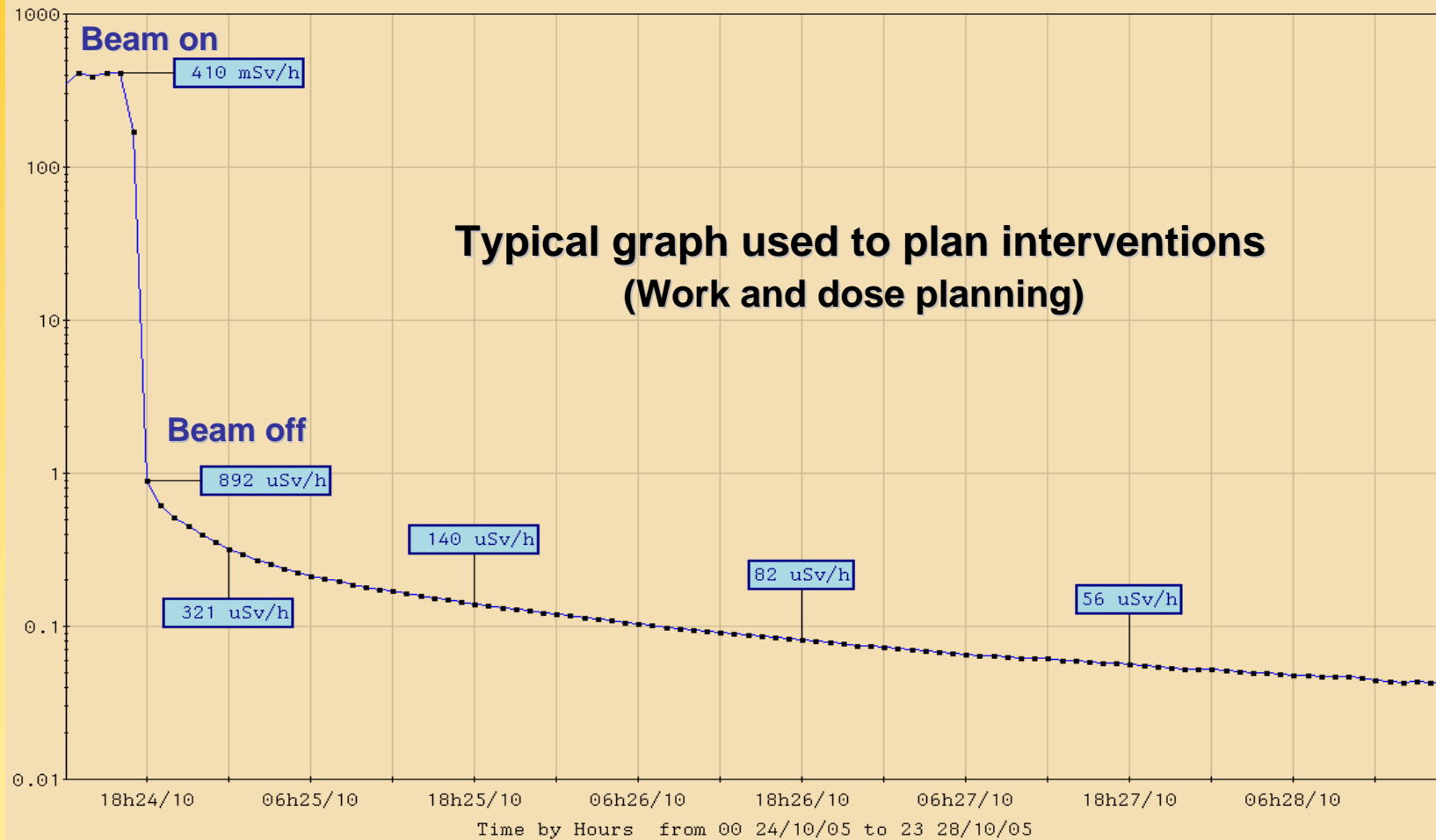
- IAM installed in the LHC machine tunnel to monitor components subject to activation due to beam losses (collimators, absorbers, kickers, etc.);
- IAM installed in LHC experimental caverns (around and inside experiments);
- During LHC beam off / shutdown periods
- Remote on-line indication of the remanent dose rate from radioactive components;
- Used by RP to follow of the radioactivity level decrease (cooling) to establish work and dose planning prior to an intervention in an area with radioactive components;



# Induced Activity Monitors



## Example of dose rate decrease monitoring



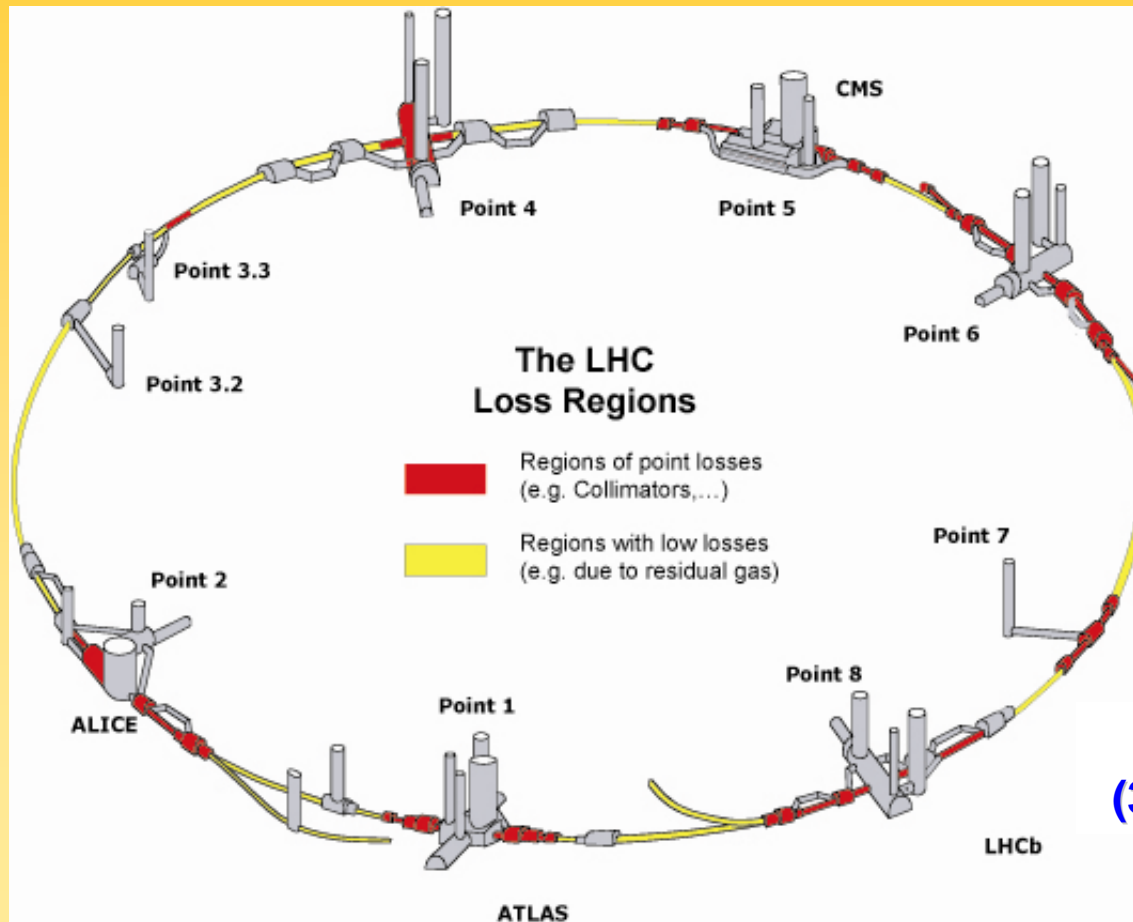




# Induced Activity Monitors



## Locations around LHC



IAM are installed in **high loss regions** (red) around the LHC. Especially in the two beam cleaning insertions (Points 3 and 7) and the dump caverns (point 6).

**156 IAM installed at LHC  
(33 in experimental caverns)**

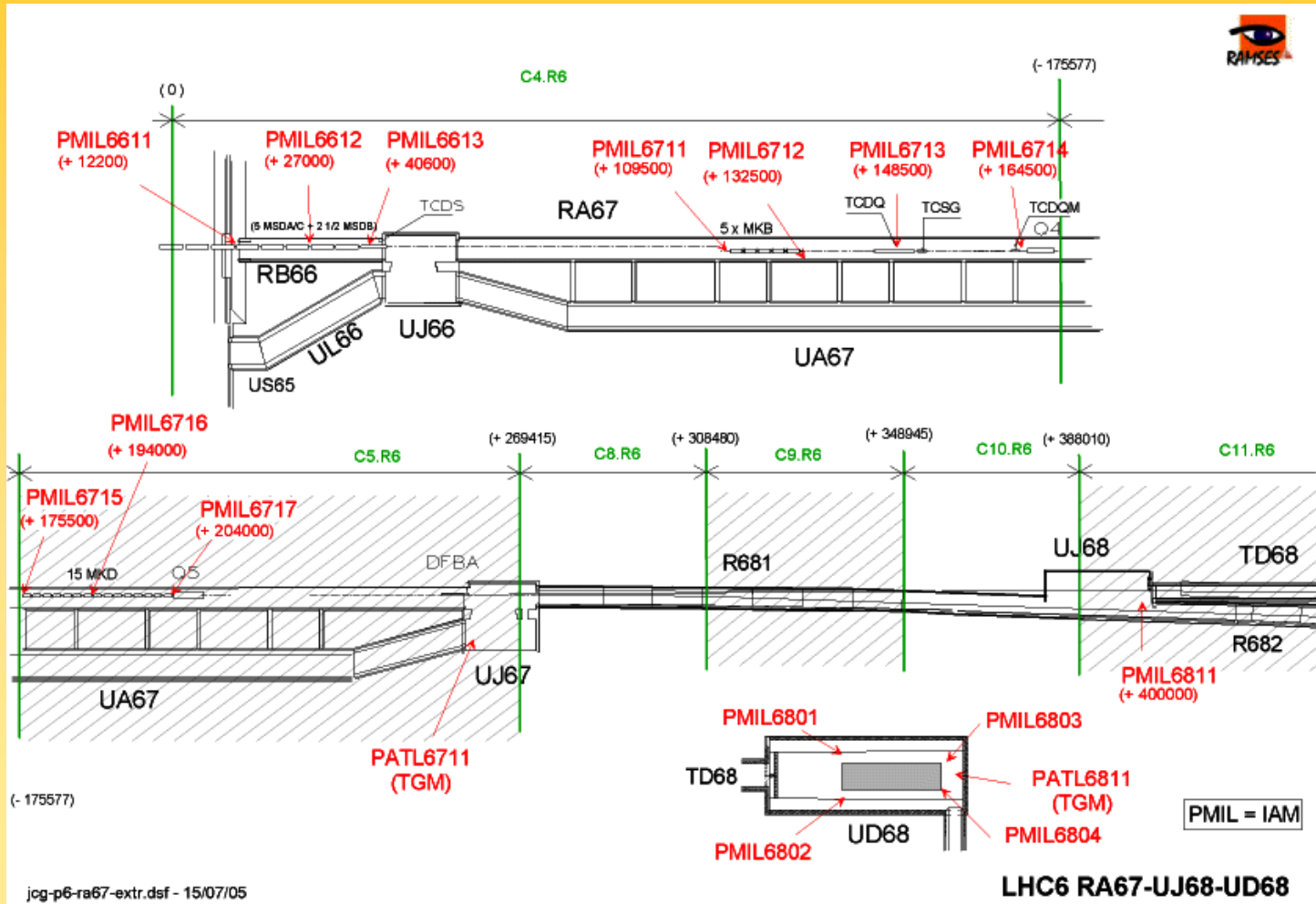




# Induced Activity Monitors



## Example of IAM locations at LHC point 6

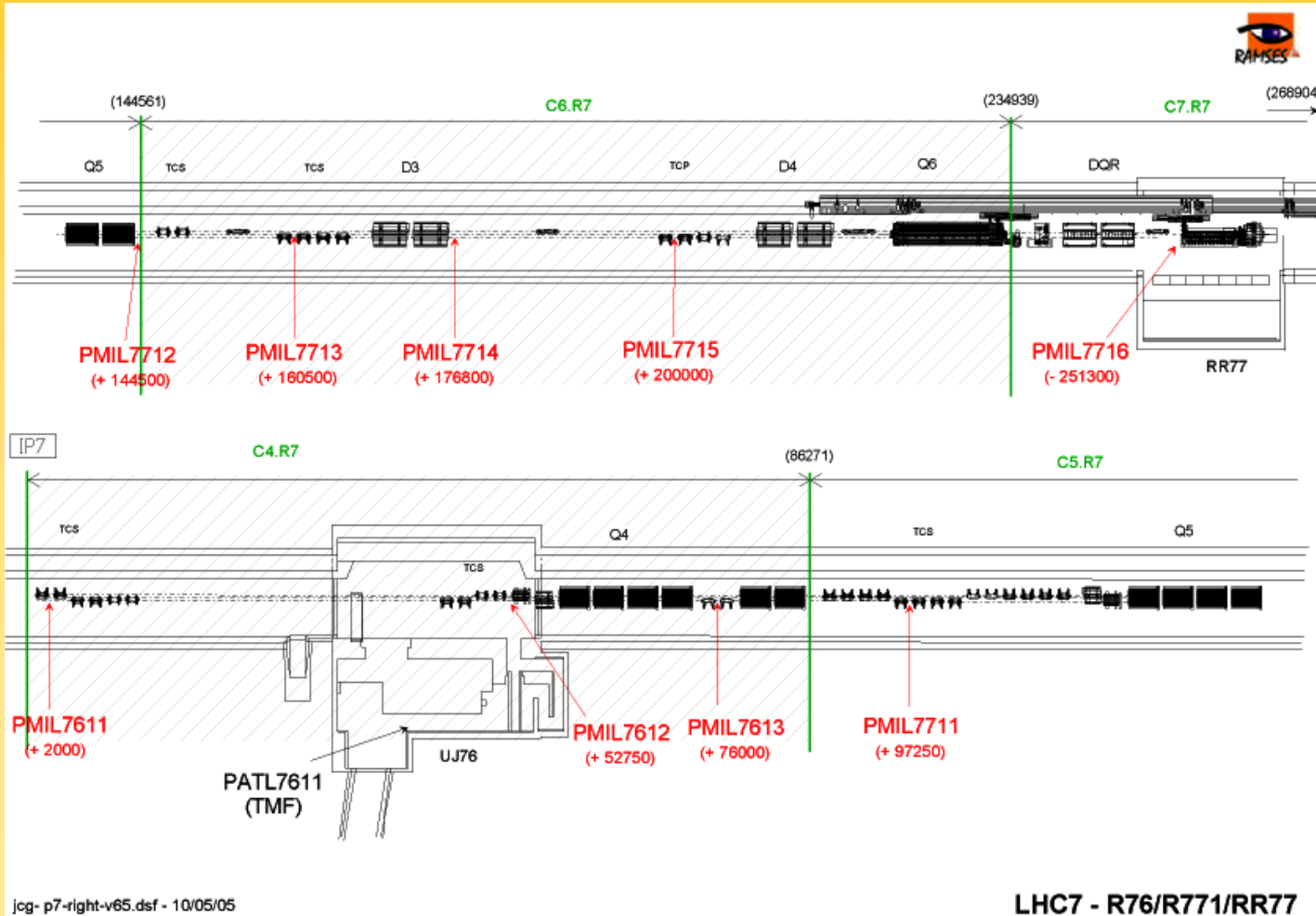




# Induced Activity Monitors



## Example of IAM locations at LHC point 7

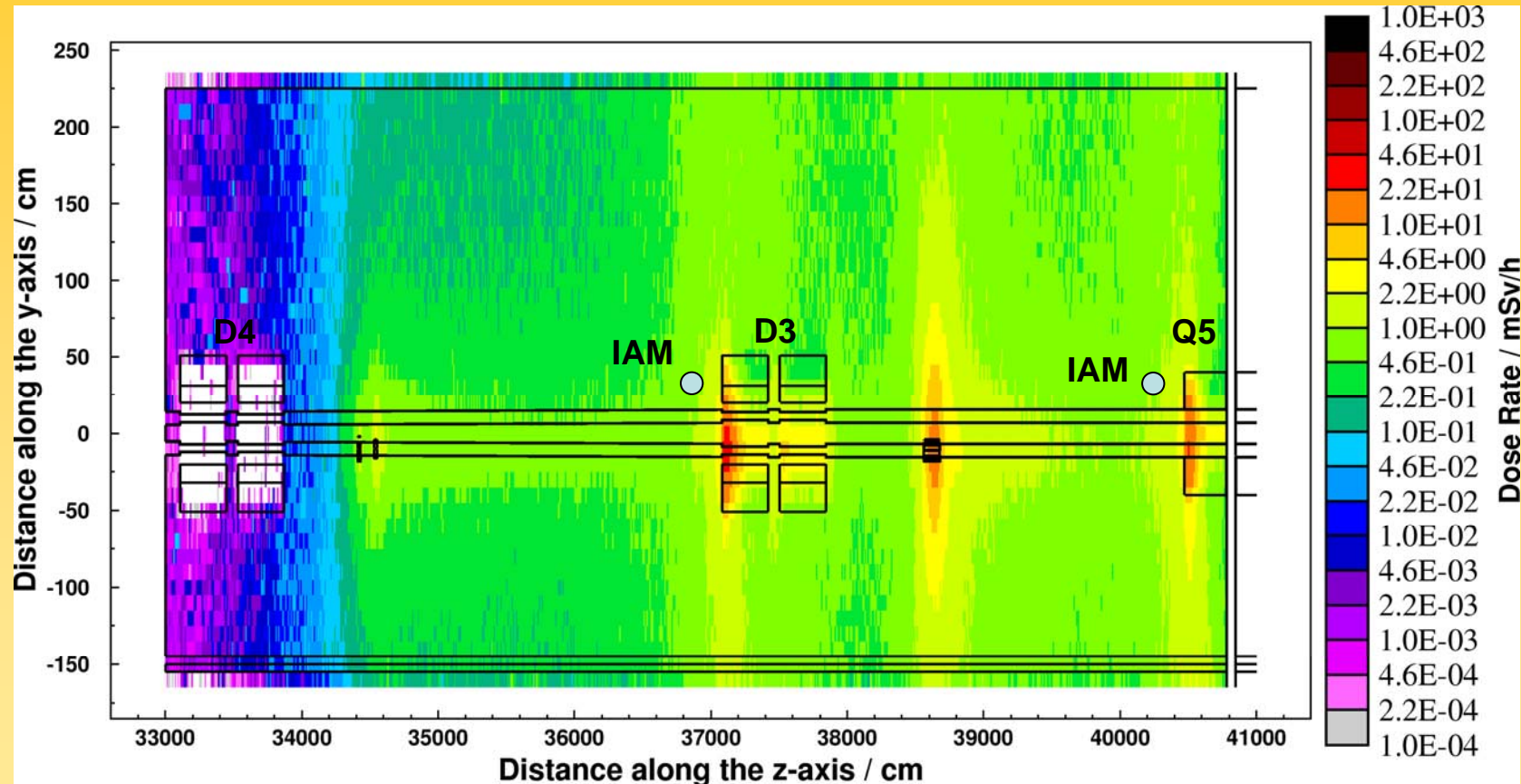




# Induced Activity Monitors



## Radiation levels



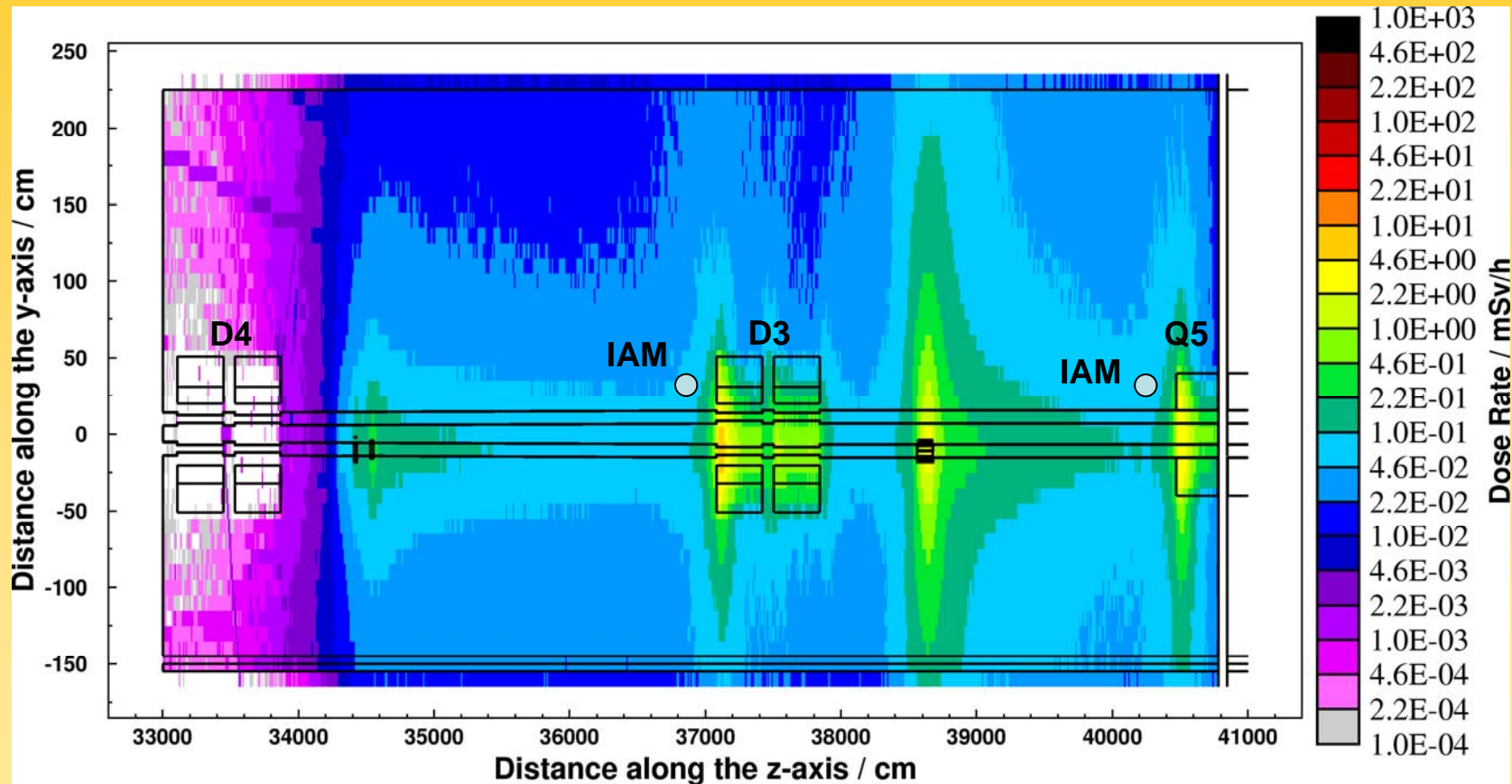
Remanent dose rate distribution after 180 days of continuous operation and **one day of cooling period** shown for a horizontal section through the geometry at the height of the beam axes [1].



# Induced Activity Monitors



## Radiation levels



Remanent dose rate distribution after 180 days of continuous operation and 4 months of cooling period shown for a horizontal section through the geometry at the height of the beam axes [1].

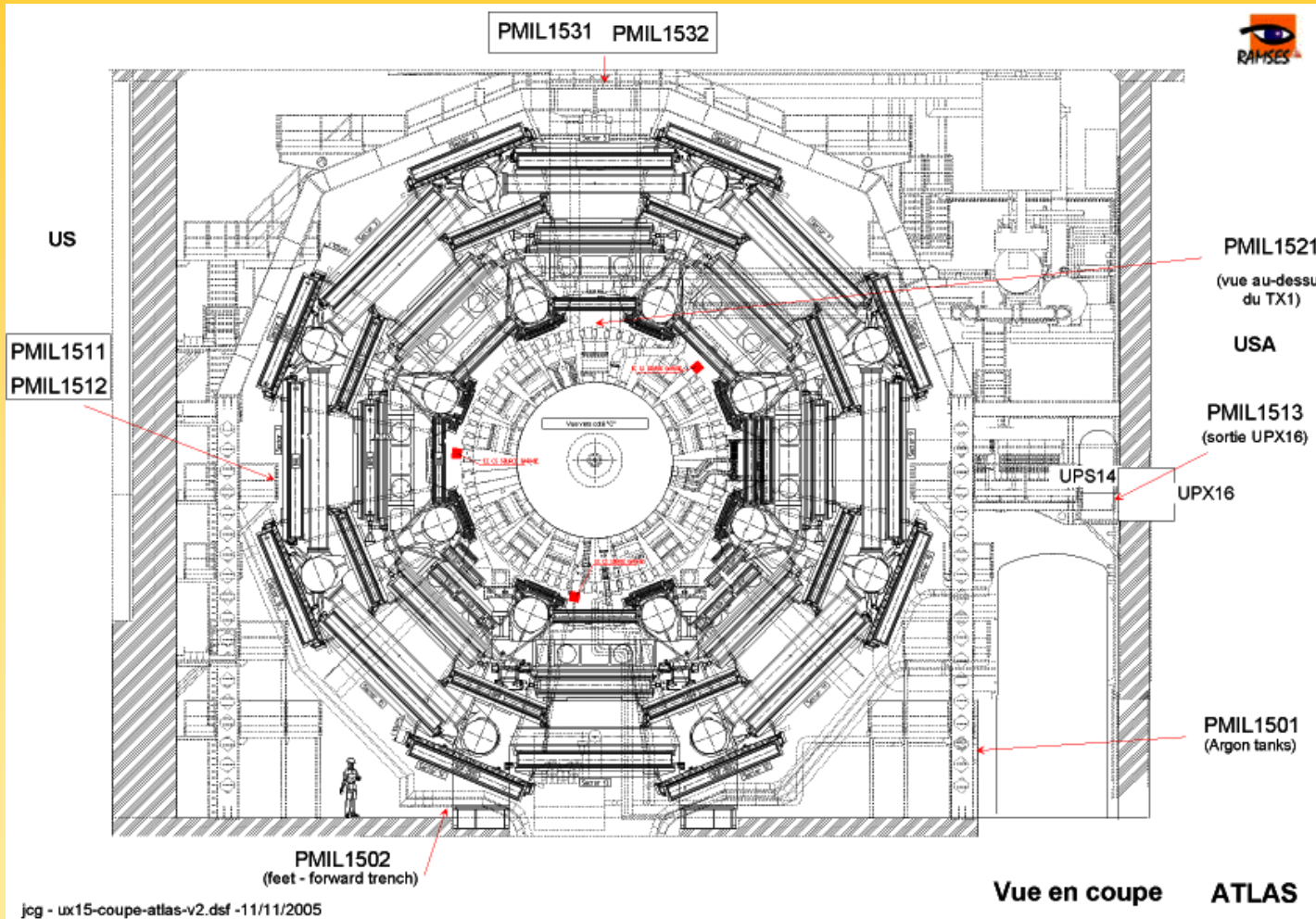




# Induced Activity Monitors



## IAM in the ATLAS cavern

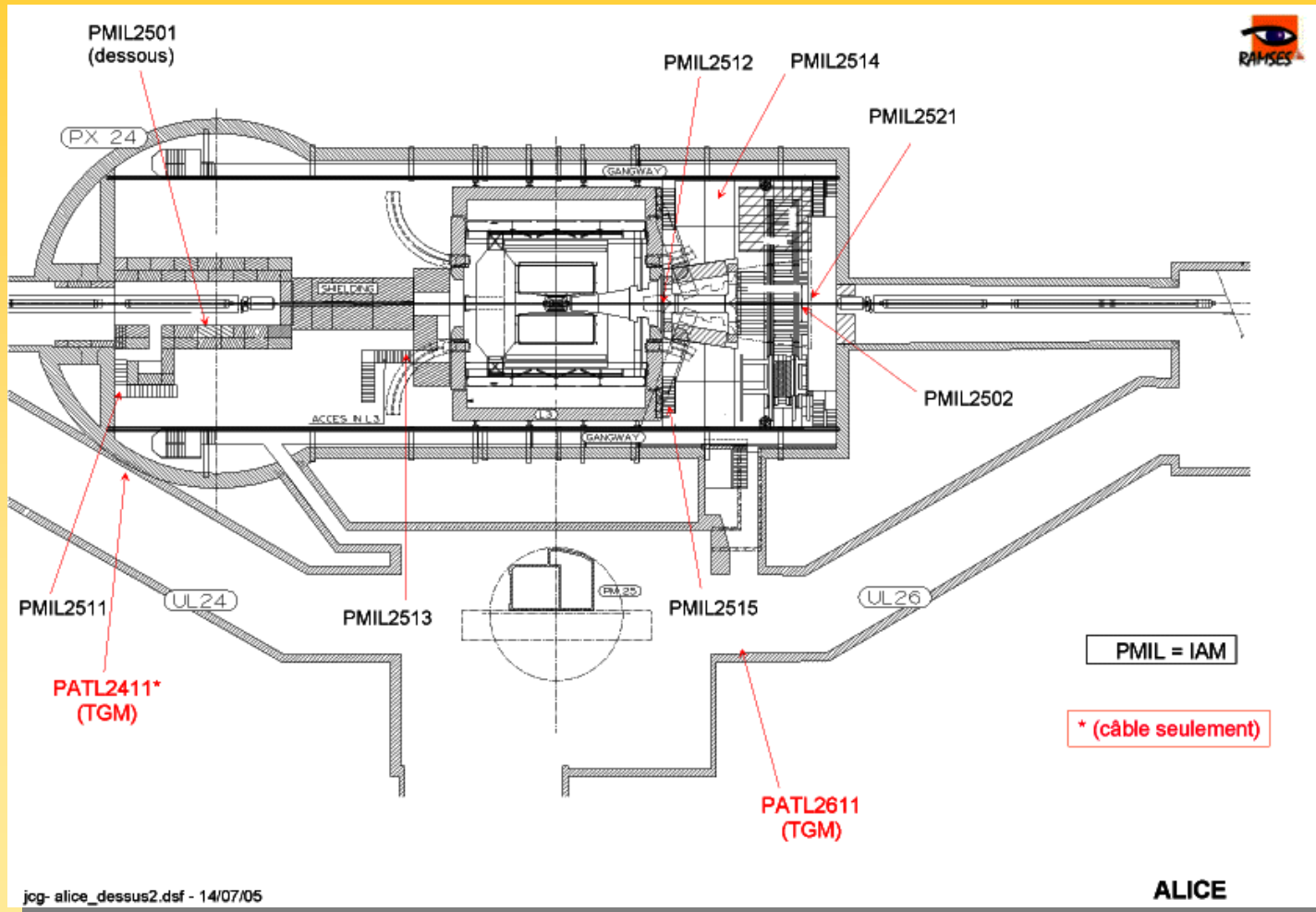




# Induced Activity Monitors



## IAM in the ALICE cavern

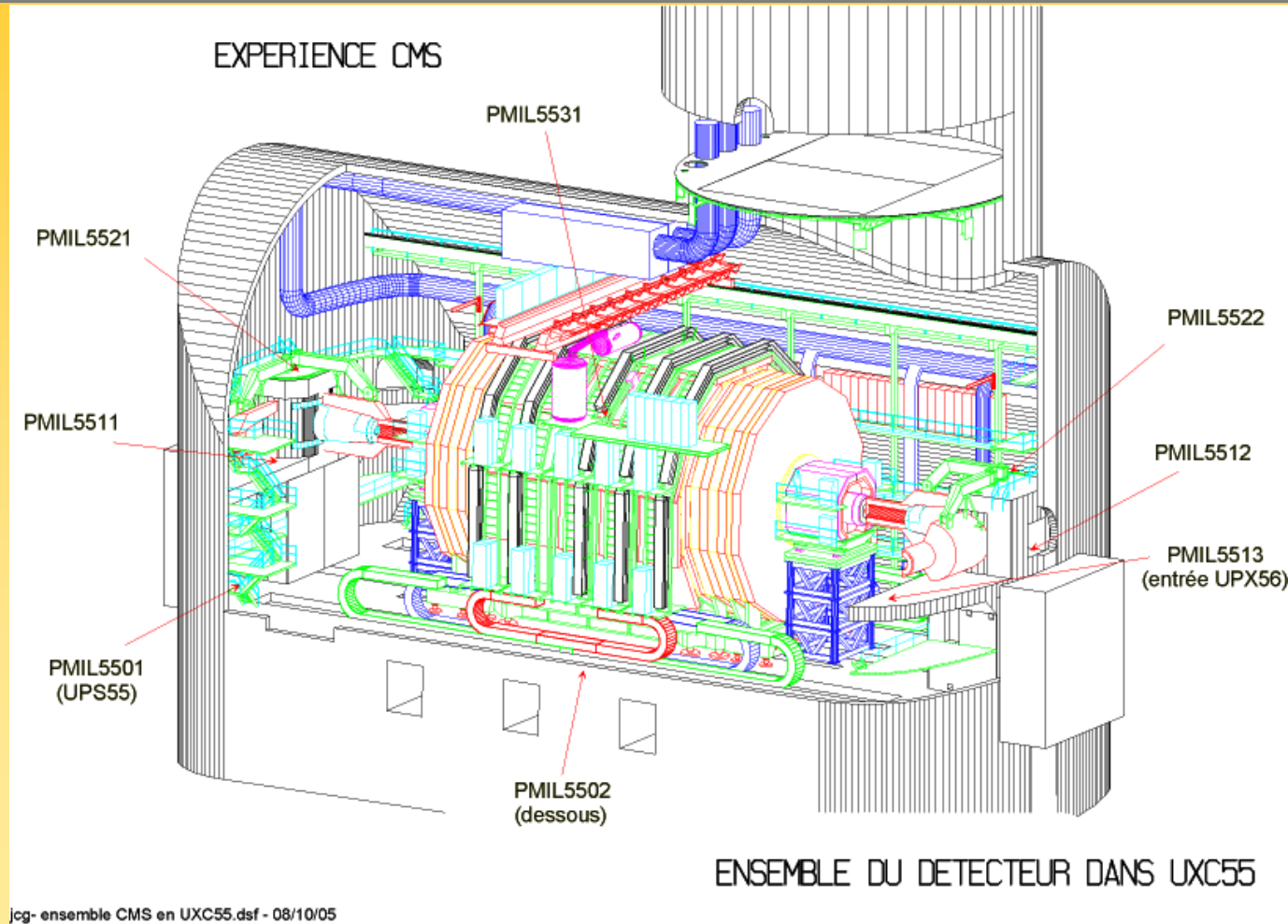




# Induced Activity Monitors



## IAM in the CMS cavern



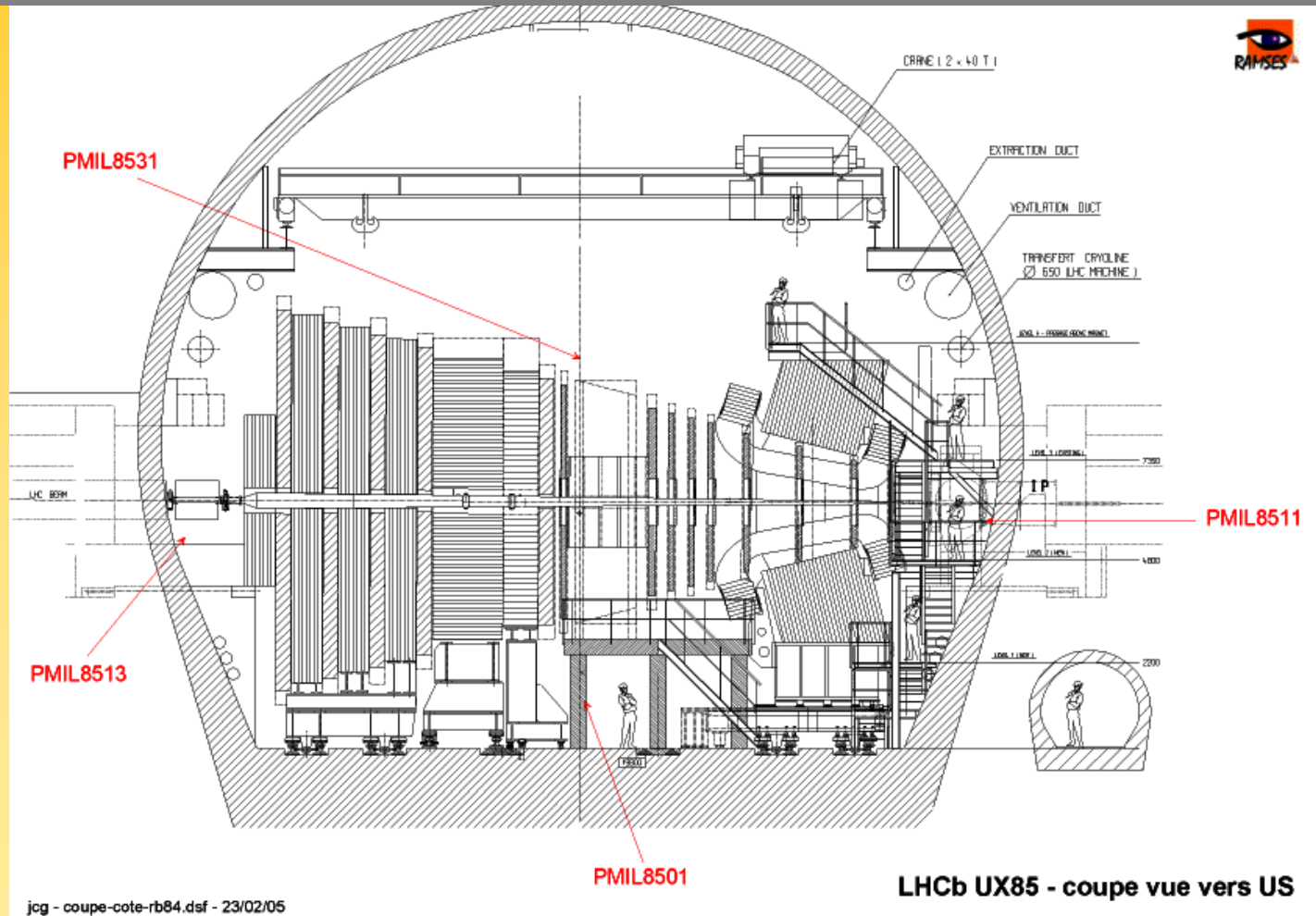




# Induced Activity Monitors



## IAM in the LHCb cavern



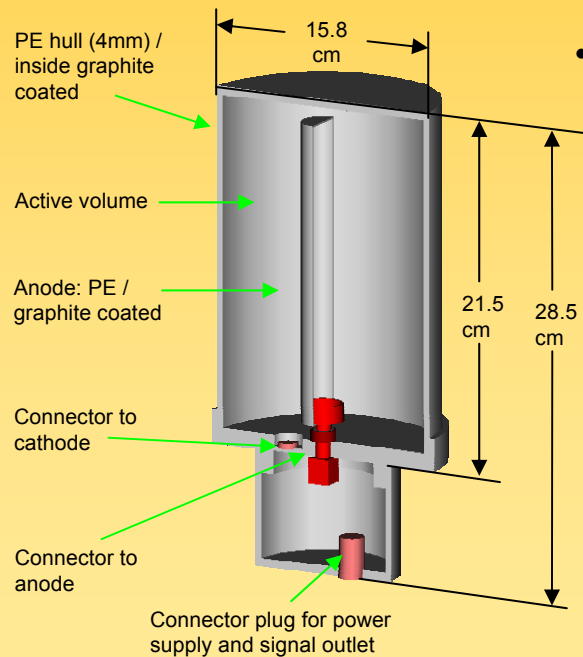


# Induced Activity Monitors



## Main characteristics

- Measure the ambient dose equivalent and ambient dose equivalent rate in photon fields (beam off);
- Plastic ionisation chamber (3 litres, 1 atm. Air-filled);  
Manufactured by PTW Freiburg;
- Performances :
  - Measuring range : 5  $\mu\text{Sv/h}$  to 500 mSv/h
  - Energy range : 50 keV to 7 MeV
  - Measuring time : from 1 to 3600 s  
Typical value 60 s
  - HV = -1 kV



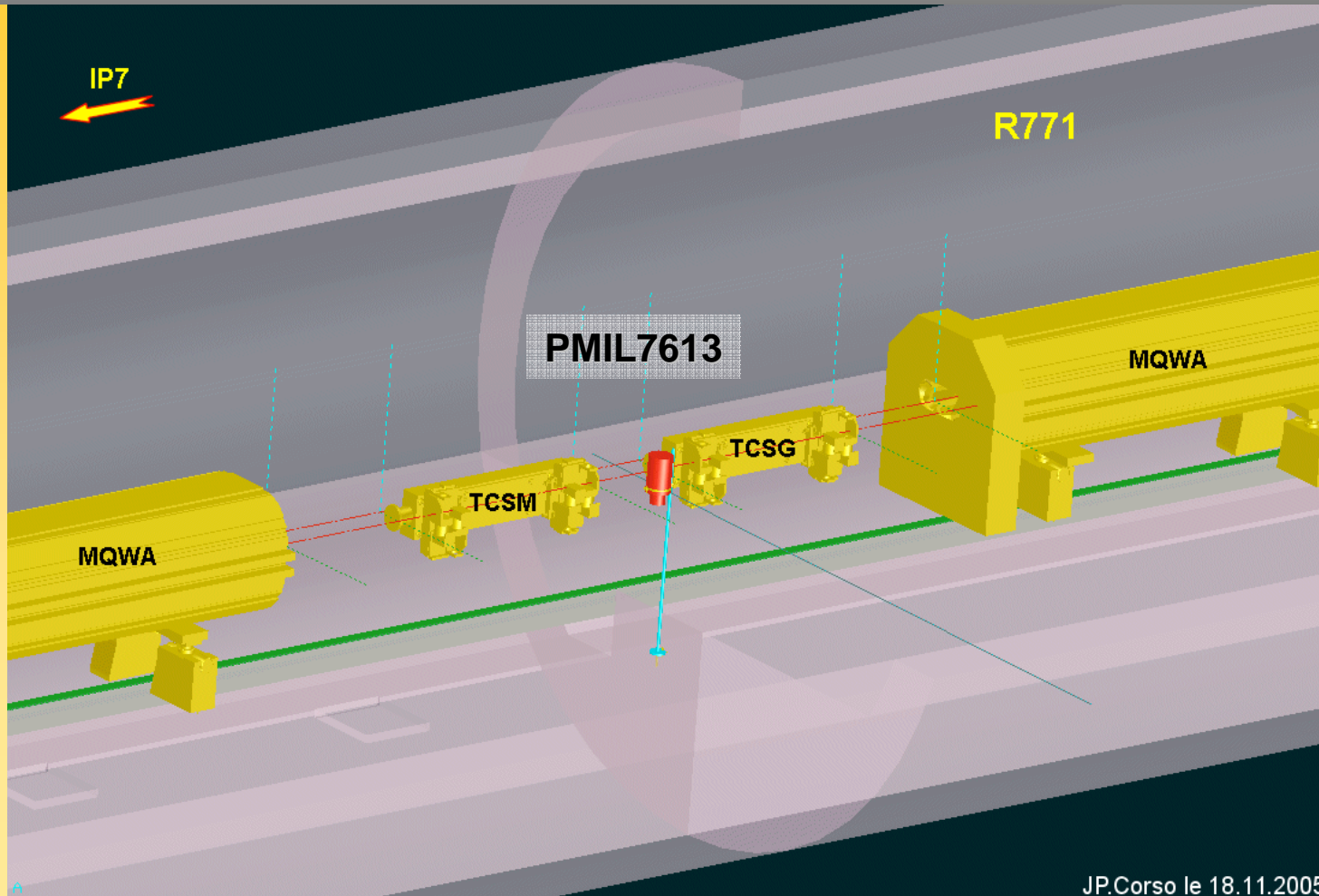
[2] Reference H. Vincke et al.



# Induced Activity Monitors



## Typical IAM Integration at LHC



JP.Corso le 18.11.2005



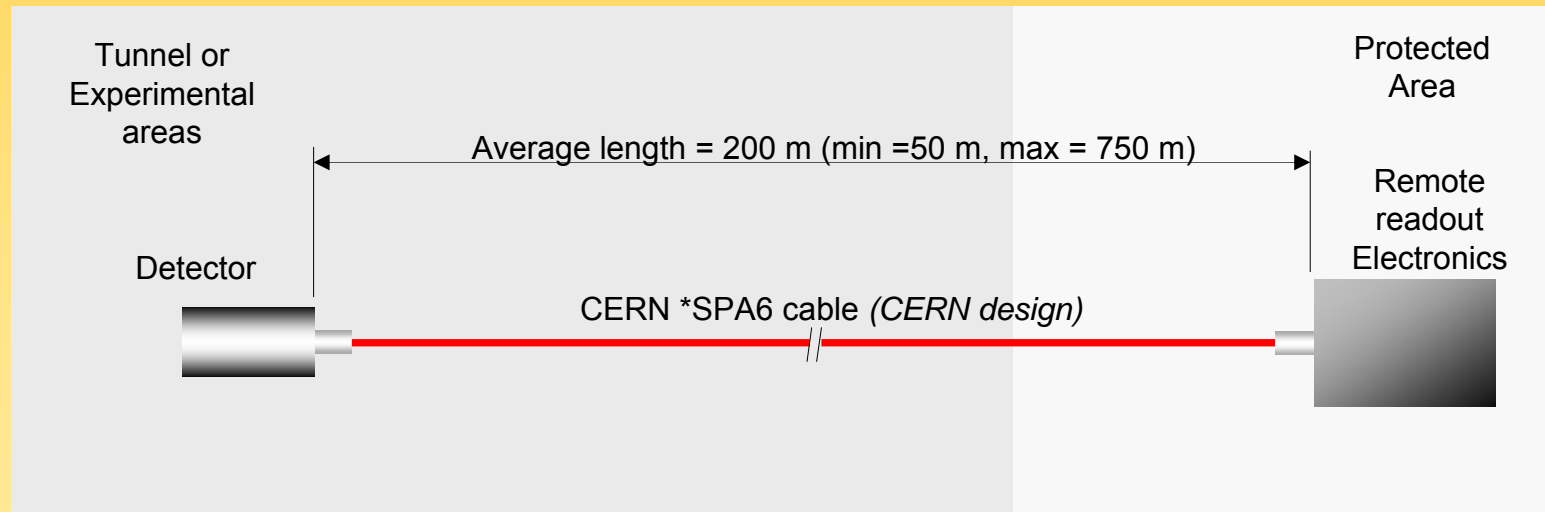
# Induced Activity Monitors



**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 750 m



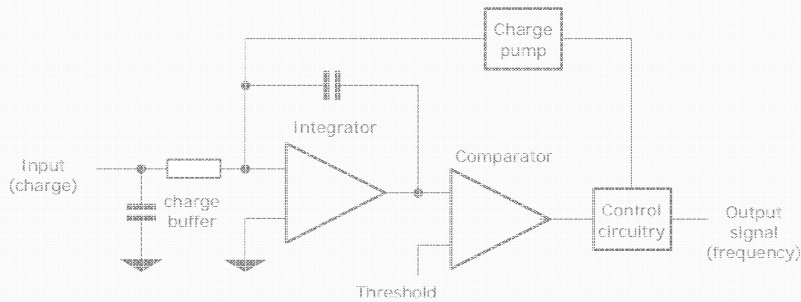
*\*SPA6 cable registered by CERN Technology Transfer Group*



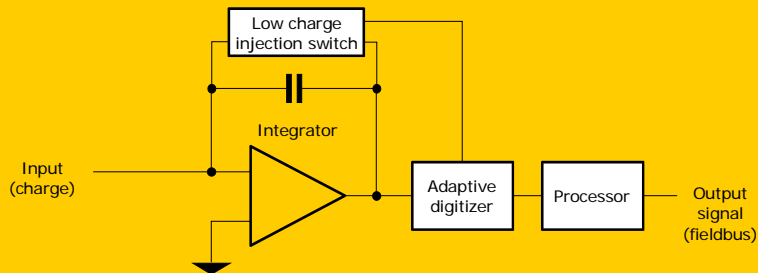
# Induced Activity Monitors



## Read-out electronics



Present CERN electronics covers 5 decades



Newly developed electronics covers 9 decades

Measure current ranging from 10 fA (background level) up to 10  $\mu$ A

NO CHARGE LOSSES → NO switching

**IAM will benefit of the new read-out electronics → 5  $\mu$ Sv/h to  $\gg$ 10 Sv/h (to be validated)**

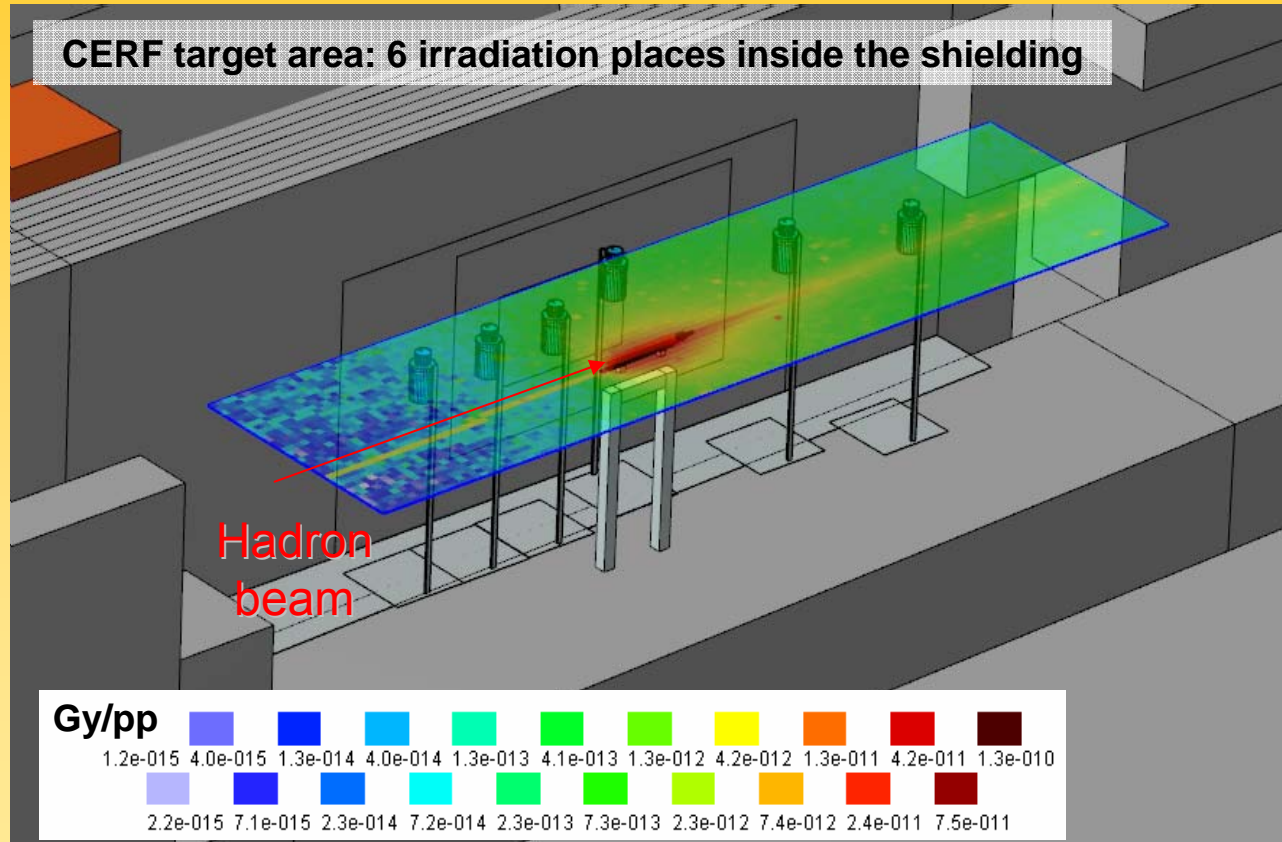




# Induced Activity Monitors



## Response to mixed radiation fields (HEP)



### Target

Material: Copper  
 Length 50 cm  
 Diameter 7 cm

### Parameters of the beam

Typical CERF momentum:  
 120 GeV/c

Intensity:  
 $9 \cdot 10^7$  hadrons per SPS cycle (16.8 s)

Beam composition:  
 60.7%  $\pi^+$ ,  
 34.8 % protons  
 4.5 %  $K^+$

Radiation field different at each position

Good agreement between simulations (FLUKA MC code) and experiment at CERF\*

[2] Reference H. Vincke et al.

\* CERN European Reference Field

IAM Measures Gy in air within 20% accuracy



# RAMSES Project CONCEPT ARCHITECTURE

Created by: The RAMSES team



CERN  
Integration Modules

LASER and DIP server



CERN HCI clients



WEB CERN HCI client



WEB expert client



Internet

### Acronyms

HCI: Human Computer Interface  
 CCC: Common Control Center  
 MCR: Meyrin Control Room  
 SC: Safety Commission  
 LASER: LHC Alarm Server  
 DIP: Data Interchange Protocol

RAMSES  
Software Infrastructure

Wireless configuration client



Engineering and configuration workstation



Central Supervision Servers



CERN HCI/WEB server



Measured Data/events and configuration database



SC expert HCI



RAMSES  
Monitoring Stations



Integrated meteorological Station

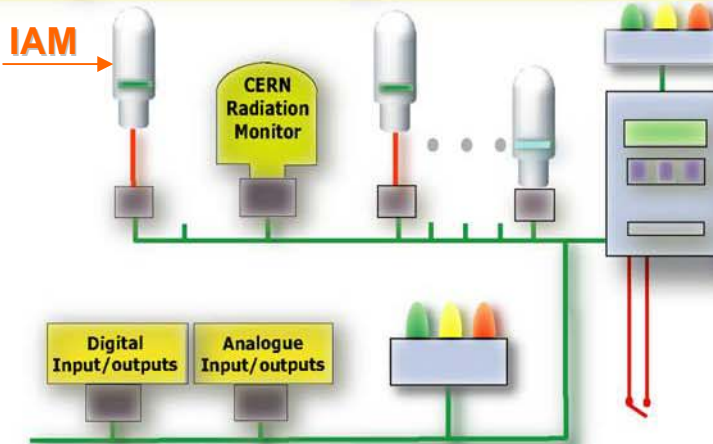


Integrated Monitoring Device

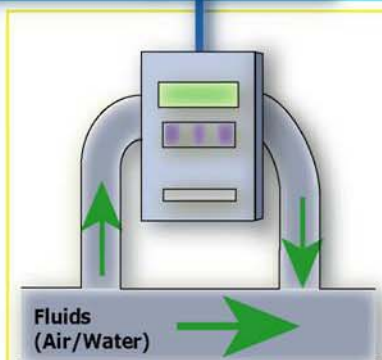
- Hand & foot monit.
- Picomur
- Site gate monit.
- ....

Integrated monitoring station

IAM



Radiation monitoring, alarms and interlock station



(It includes measurements of non-radiation parameters like water temperature, pH, etc.)

Radioactivity in fluids monitoring station





# Induced Activity Monitors



## Data provided by IAM / RAMSES

- **DAI (Data Analysis Interface) → RAMSES consoles;**  
(last 2 weeks high time definition data then data reduction but not for time windows of one hour before and after radiation alarms)

Typical IAM measuring time → 60 s

- **DIP server (Data Interchange Protocol) → Library to access data;**
- **LASER server (LHC Alarm Service) → Dedicated alarm consoles;**



# THANKS for your attention

The RAMSES team

RAMSES web site → <http://ramses-dev.web.cern.ch>

References:

- [1] M. Brugger, D. Forkel-Wirth, H.G. Menzel, S. Roesler, *Estimation of individual and collective doses for interventions at the LHC beam cleaning insertions*, CERN Technical Note CERN-SC-2005-012-RP-TN (2005)
- [2] Helmut Vincke, Norbert Aguilar, Doris Forkel-Wirth, Michel Pangallo, Daniel Perrin, Michel Renou and Chris Theis, *Measurements and simulations of the PMI Chamber Response to the Radiation Field inside the CERF Target Area*, CERN Technical Note SC-RP-2004-RP-TN