Operation at High Intensity of the CERN Machines

Session 2 of ATC/ABOC Days 2008

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Presentations of Session 2

- Radiation Protection Constraints for the Operation of CERN’s Beam Facilities
  H. Vincke, SC-RP
- The ARCON-RAMSES Bridge
  D. Perrin, SC/RP
- Radiation Issues of the PS and SPS accelerator
  G. Simone, AB/ABP
- Are Radiation Constraints limiting the ISOLDE Operation in 2008
  R. Catherall, AB/ATB
- Towards a Modified n-TOF Facility to Increase Radiation Safety
  M. Brugger, AB/ATB
- Ensuring Safe and Reliable Operation of CNGS as of 2008
  E. Gschwendtner, AB/ATB

Radiation Protection Constraints for the Operation of CERN's Beam Facilities

- Revised Safety code F (Radiation protection) was issued in November 2006 to bring CERN in line with European radiation protection legislations and regulations

- CERN's revised Radiation Protection rules and regulations were endorsed by the Swiss and French authorities

- CERN Reference levels – an ambitious goal?
  - The individual, effective dose of occupat… should stay below **6 mSv per year**
  - The effective dose due to internal expos… than **1 uSv per hour of stay**
  - The annual effective dose to members o… should stay below **10 uSv per year**

2007:

Goal achieved !

Revised Classification of CERN's Radiation Areas

< 2007 | <2.5 $\mu Sv\ h^{-1}$ | <7.5 $\mu Sv\ h^{-1}$

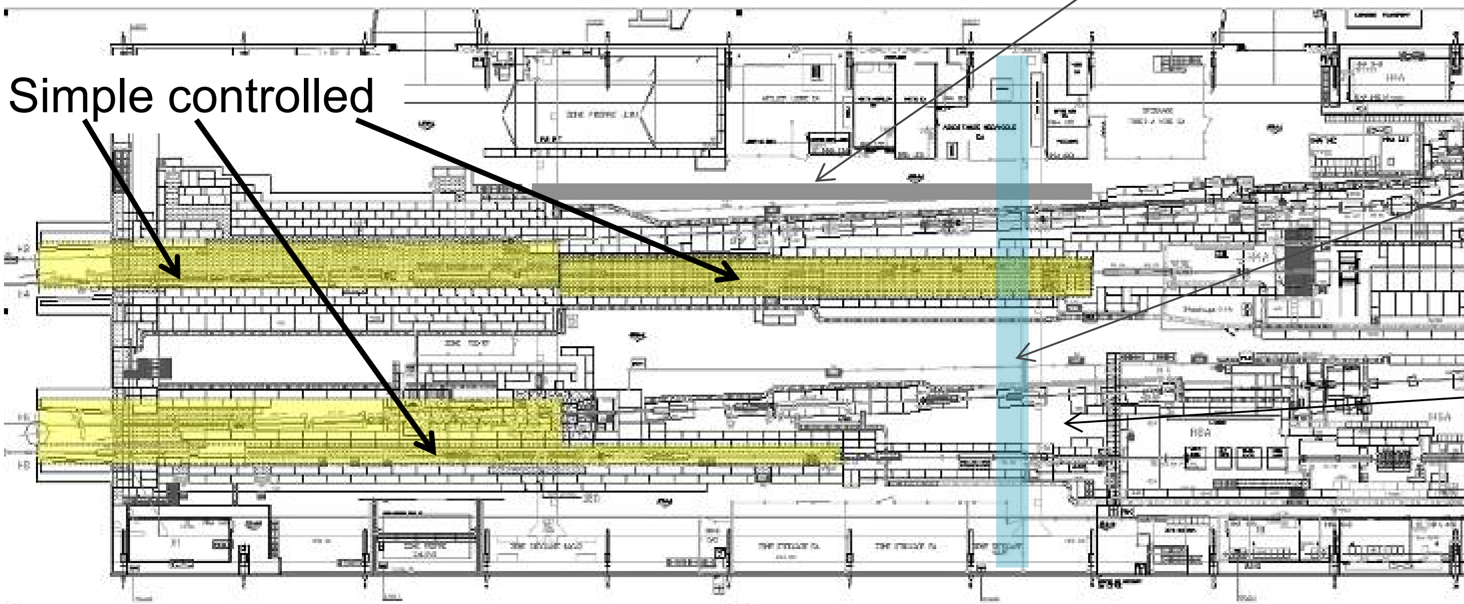
Area Classifica-tion	Dose limit	Ambient dose equivalent rate *At workplaces*	Ambient dose equivalent rate *In low occu-pancy areas*
Non-designated			
New Area			
Simple Controlled Radiation area	20 mSv/y	< 10 μSv/h	< 50 μSv/h

Radiological reassessment
of
all CERN areas required

< 2007 | <25 $\mu Sv\ h^{-1}$ | <100 $\mu Sv\ h^{-1}$

Safety Instruction S3-GSI1, EDMS 810149

Example: EHN1 – revised area classification



< 2006:
~160 uSv/h on top of H6 beam line

2007:
~ 20 uSv/h due to additional 6.4 m thick iron shielding in TCC2

Courtesy: Lau Gatignon

ALARA at CERN

most of the ALARA elements were already used all over CERN in the past

since December 2006:

- systematic, formalized approach
- requires "close collaboration" between RP and the maintenance teams

ALARA procedures – 3 levels:

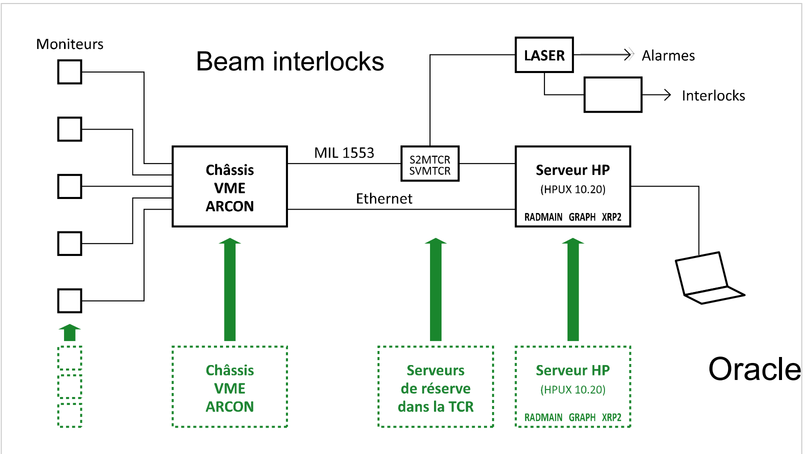
- If the rad. risk is **low**
  a light procedure is sufficient
- If it is **medium**
  an optimization effort is required
- If it is **high**
  an optimization effort is required, the procedure will be submitted to the ALARA committee

ALARA committee

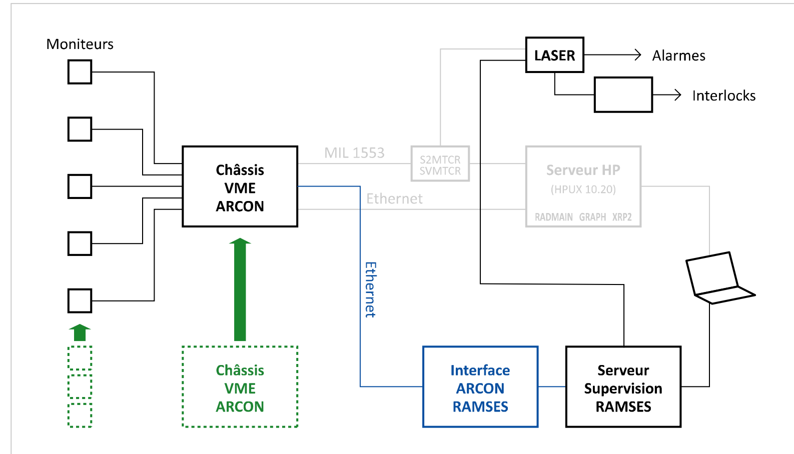
- First ALARA committee meeting was held 19/11/2007
  (only part of class III works were discussed, the rest will be done in February 2008)
- Conclusions and recommendations
  - Many jobs are already optimized thanks to
    - experience
    - good co-ordination of the activities by machine superintendants
    - investment (e.g. SPS magnet repair: workshop in ECA5)
  - Improvements are still possible
    - Remote radiation measurement device
    - Remote visual inspection device
    - Use of fluorescence tubes with double the life time
    - Switching off the light during beam operation
    - ……

Arcon-Ramses Bridge

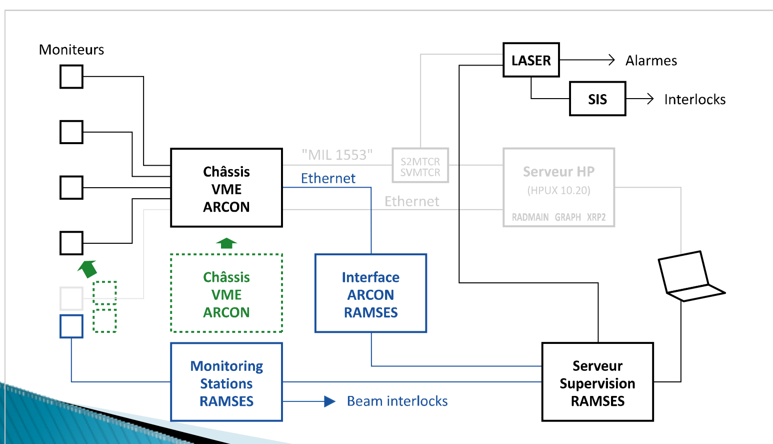
Spare parts



ARCON-RAMSES interface



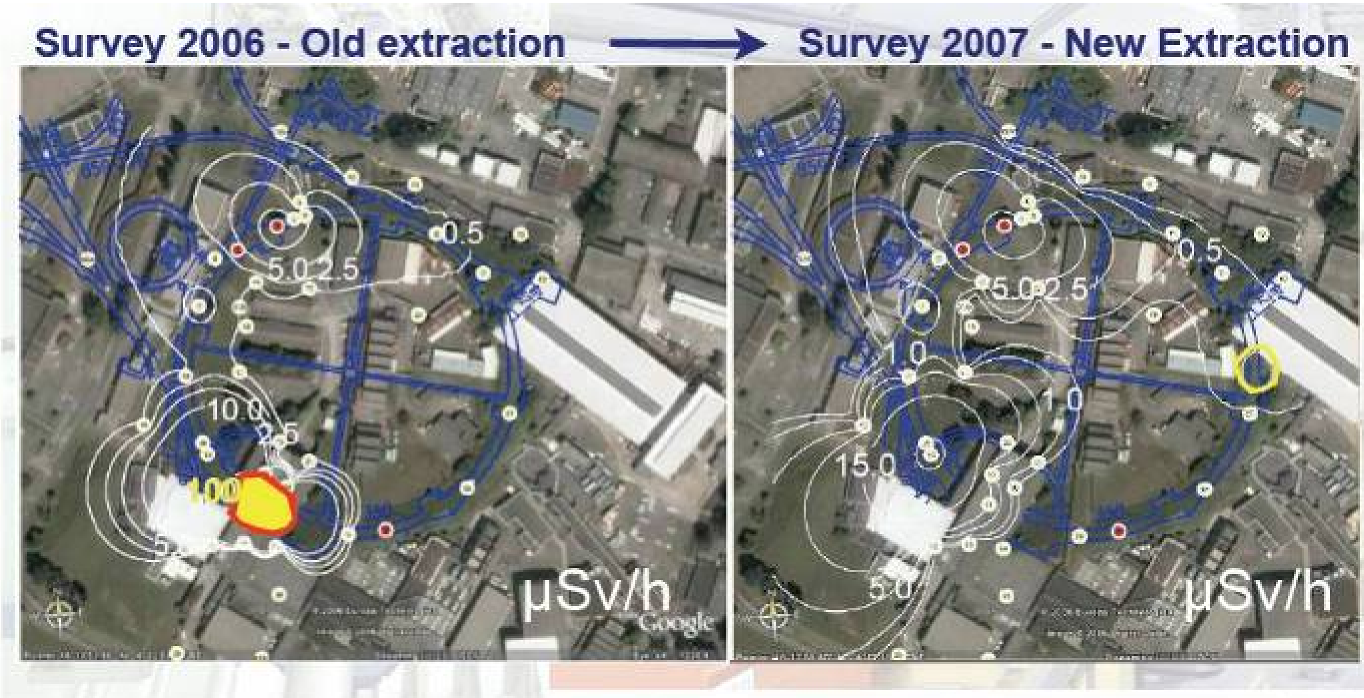
Limited RAMSES deployment

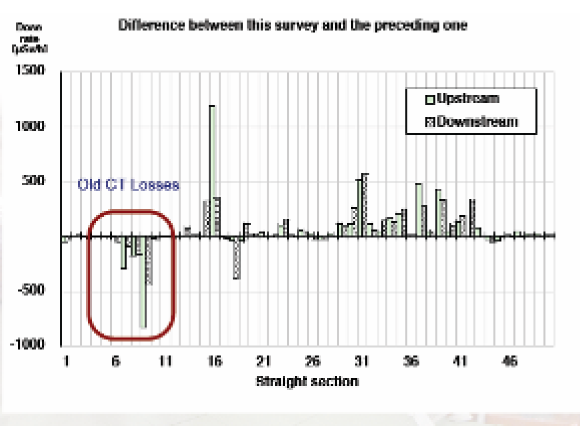


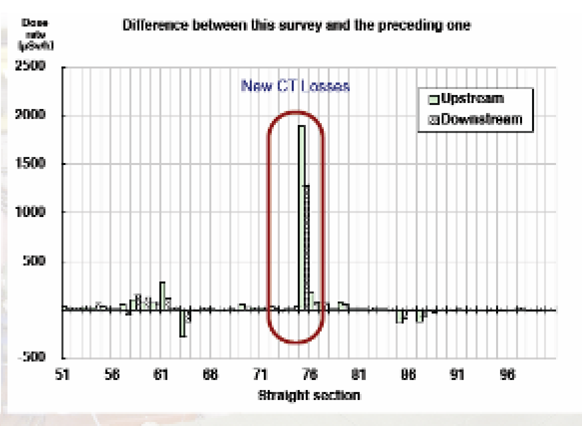
Compensatory measures already identified – to be translated into operational procedures

PS and SPS Radiation Issues

PS bridge





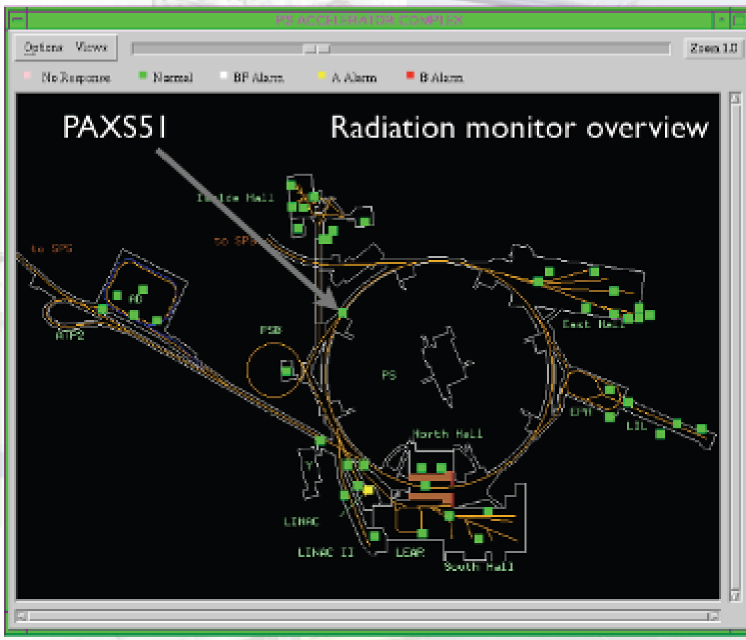


PS bridge problem cured by displacing beam losses from section 5 to 73

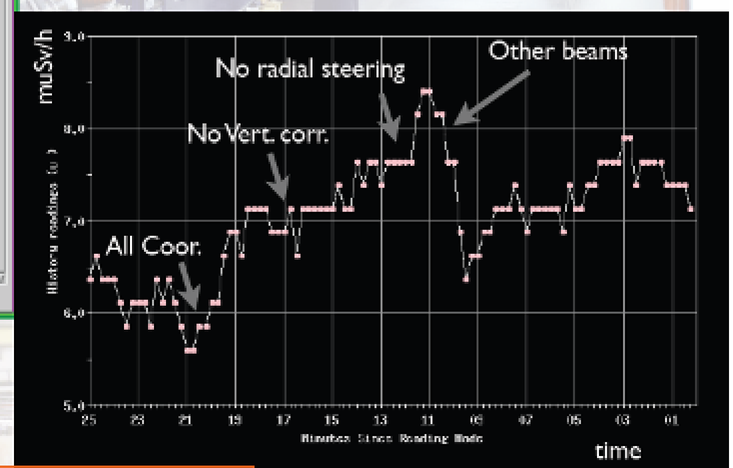
Final solution: MTE

PS and SPS Radiation Issues

Radiation monitor on Route Goward: PAXS51



Influence of different corrections tested wrt beam losses but also wrt the dose measured outside the tunnel on the Route Goward by the PAXS51



Radiation is caused by losses during injection – difficult to minimize more

(starting from the dose level of that particular day and related to the particular supercycle):

1. removal of vertical correction: *from about 6 muSv/h to about 7 muSv/h* *≈ 15 %*
2. removal of radial steering: *from 7 muSv/h to about 7.6 muSv/h* *≈ 10%*

MTE will reduce the losses by about 50 %
– might be not yet sufficient

- Most of the recommendations from BLRWG have been or are being pursued. Detailed and systematic radiation measurements have allowed to identify some additional weak points and solutions are being implemented

- PS radiation issues:

  - CT losses under PS Bridge: new extraction optics displaced the losses in a better shielded region of the machine. Issues of south and north hall, MCR (new CMS control room) and radiation at the CERN fence solved.

  - Goward Road (injection losses) beam studies started with some actions taken for this SD. Some sources of losses has been identified and losses have been minimised. However, it could turn out that even with the best injection and minimum losses the shielding is not sufficient. Not yet clear whether it will be possible to reduce radiation below level required for non-designated area (< 2.5 μSv/h)

  - Transition losses minimised. Still some work to do for 2008.

  - With MTE losses related to CT extraction (SS31/PS Bridge/a part of Goward Road) will disappear.

- SPS radiation issues:

  - Automatic procedure to correct CNGS-SFTPRO SPS injection trajectory implemented and losses reduced by about a factor of 2.

  - The zone above the TDC2 (TT20) area and buiding 898 will be fenced and converted into radiation area.

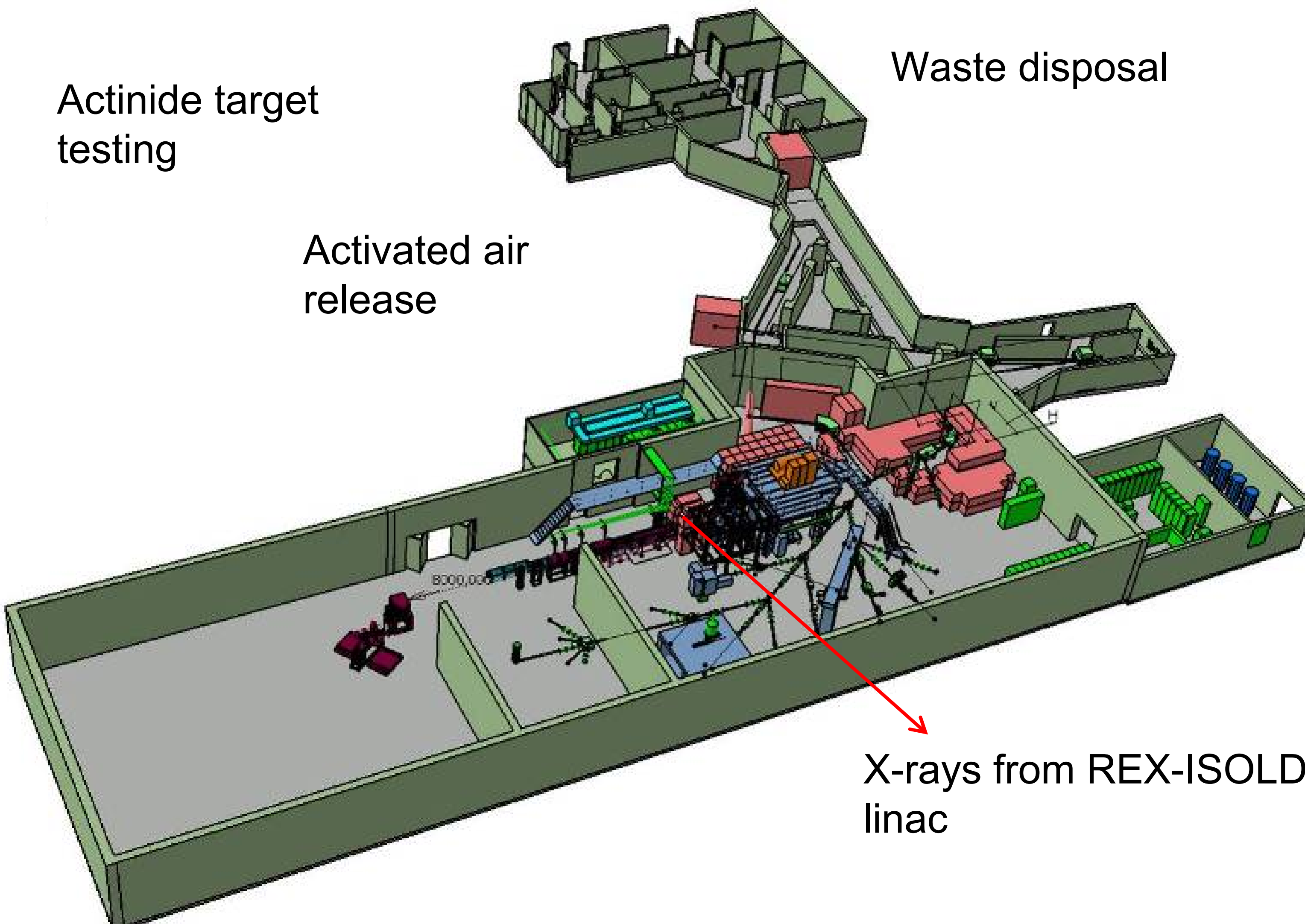
  - Increase of the PGC1 shielding will be done during current shutdown.

ISOLDE Radiation Issues

Actinide target testing

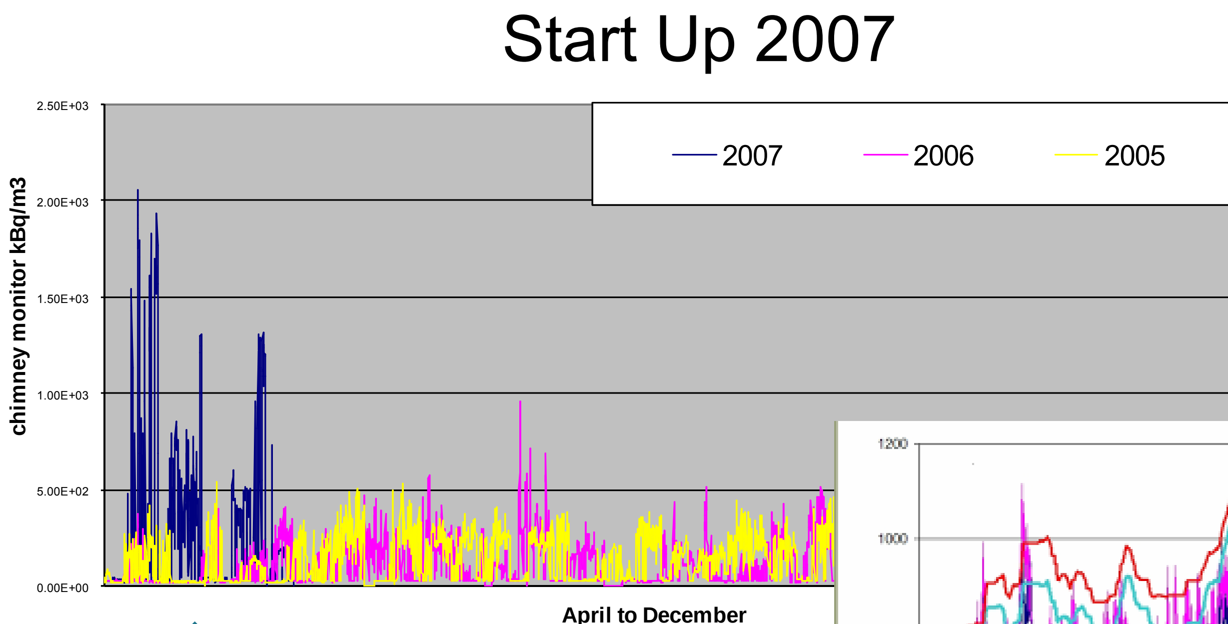
Waste disposal

Activated air release



X-rays from REX-ISOLDE linac

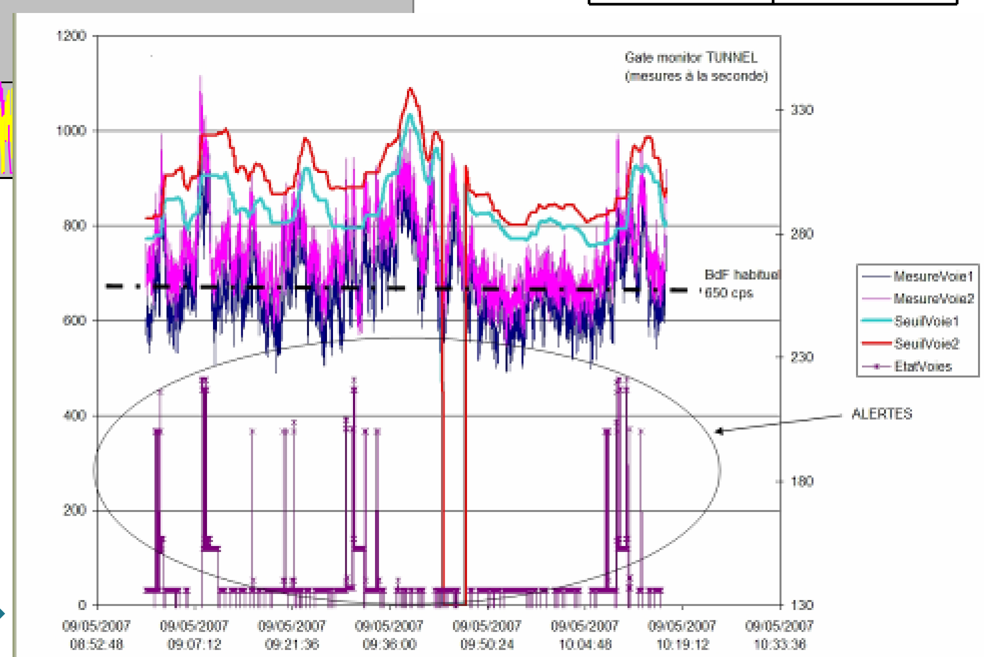
Activated Air Emissions– History



Isotope	Half life
O-14	71 sec
O-15	2 min
N-13	10 min
C-11	20 min
Ar-41	1.83 h

Radiation monitor PMVG170C showing higher levels compared to 2 previous years

Tunnel gate monitor alarms set o



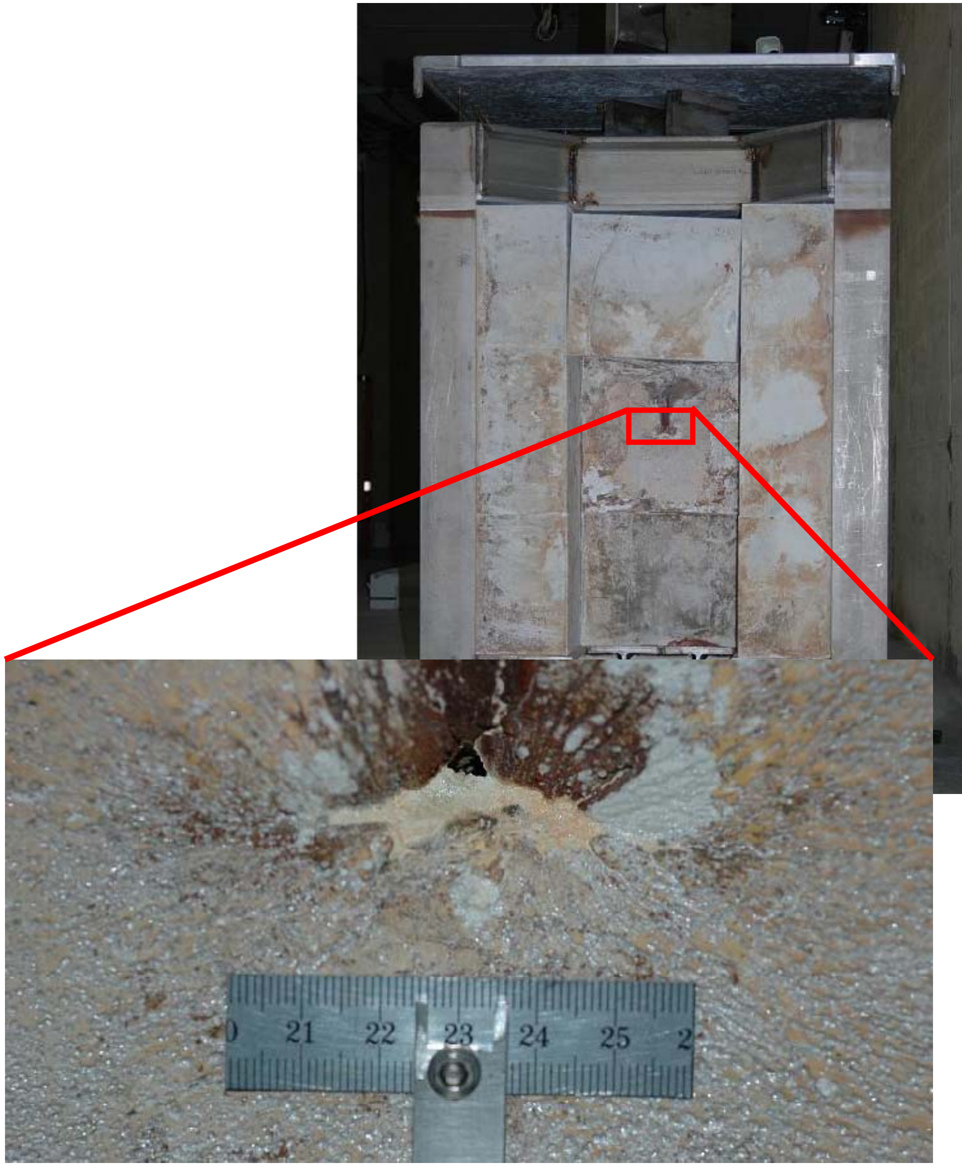
ISOLDE

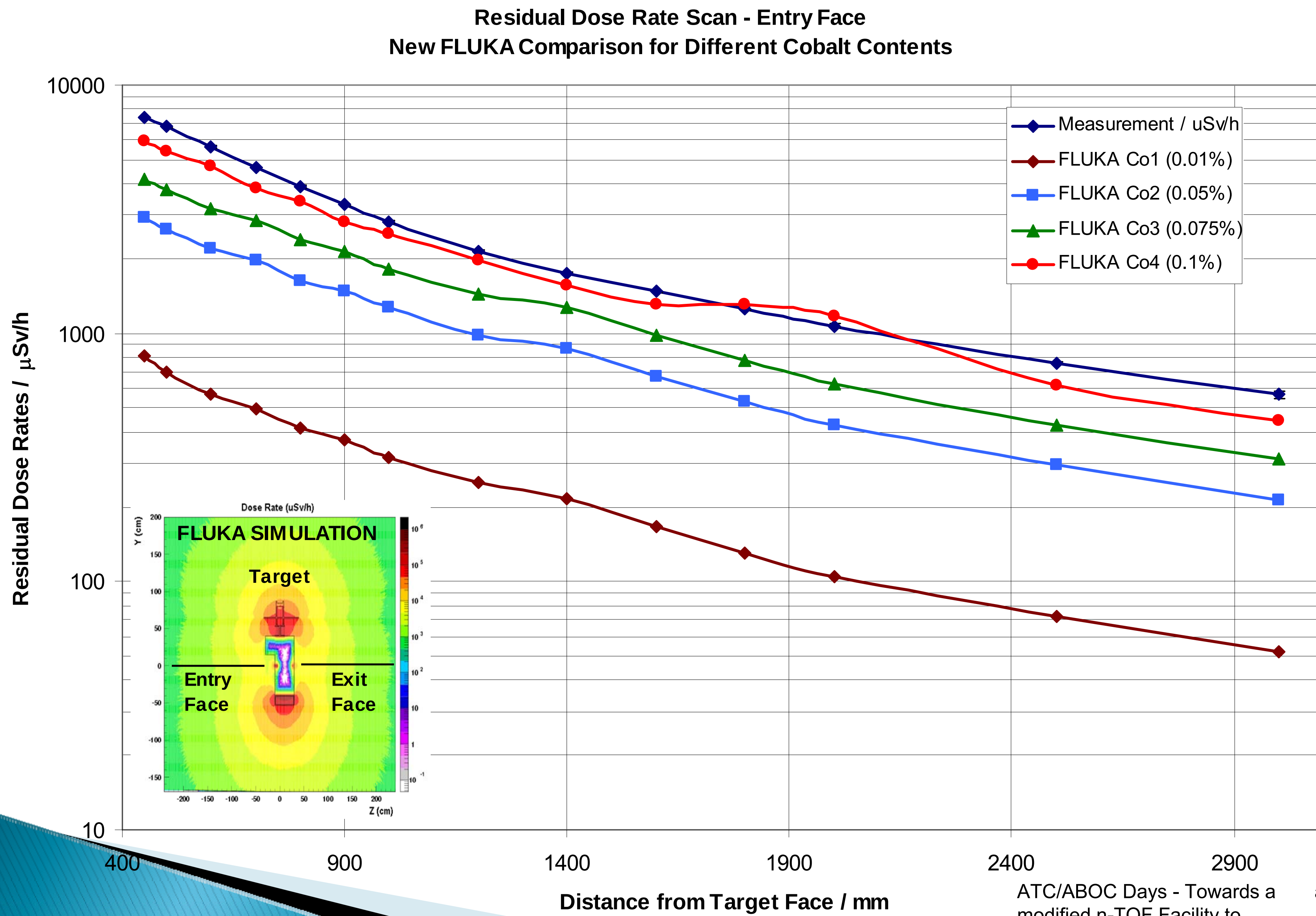
- Ventilation
  - Studies performed by TS-CV, simulations going on – the situation will be improved before the start up of 2008
- REX-ISOLDE
  - Lead collimator type shielding under study
- Radioactive Waste Management
  - Situation is progressing in terms of slightly radioactive non-actinide targets.
    - Agreement with PSI/Nagra, 3rd campaign under way.
  - Dismantling of actinide targets to be studied – pre-requisite for final disposal as waste
- Off-line separator in Class A lab required to outgas actinide targets

N-TOF

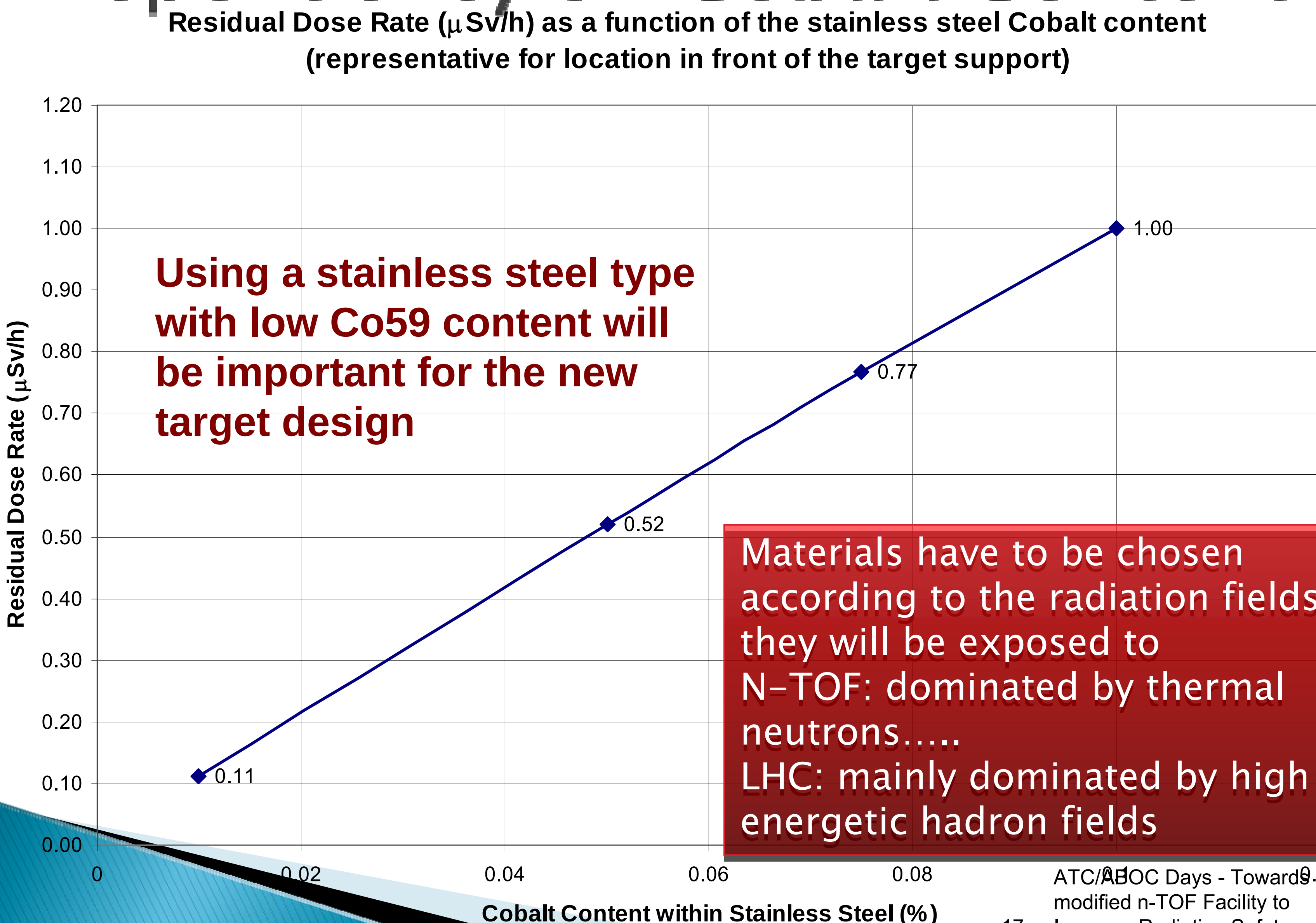
Target Inspection

- Pitting corrosion caused a hole at the proton impact location
- Important surface oxidation due to rupture of protection layer when the drying (heating) was performed (flush)
- Target shape didn't allow for a correct water flow at the entrance face
- Modular assembly lead to a mechanical instability and deformation




Residual Dose Rate Scan - Entry Face
New FLUKA Comparison for Different Cobalt Contents
Residual Dose Rates / μSv/h
Distance from Target Face / mm
10000
1000
100
10
400
900
1400
1900
2400
2900
Measurement / uSv/h
FLUKA Co1 (0.01%)
FLUKA Co2 (0.05%)
FLUKA Co3 (0.075%)
FLUKA Co4 (0.1%)
Dose Rate (uSv/h)
FLUKA SIMULATION
Target
Entry Face
Exit Face
Y (cm)
Z (cm)

Dependency on Cobalt Content

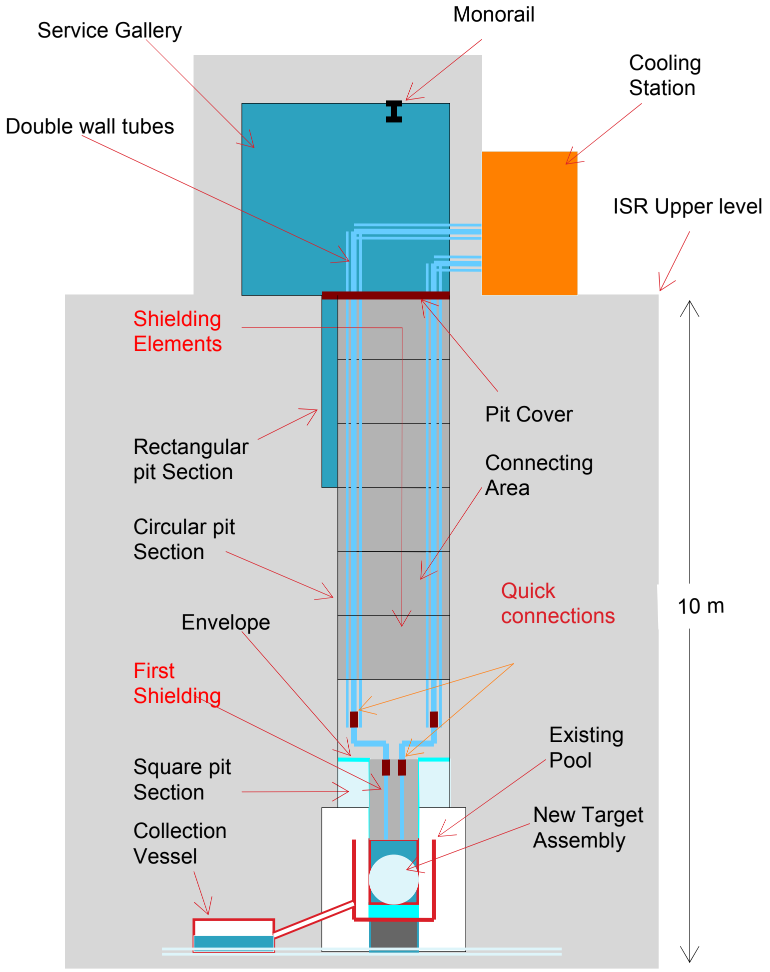


Using a stainless steel type with low Co59 content will be important for the new target design

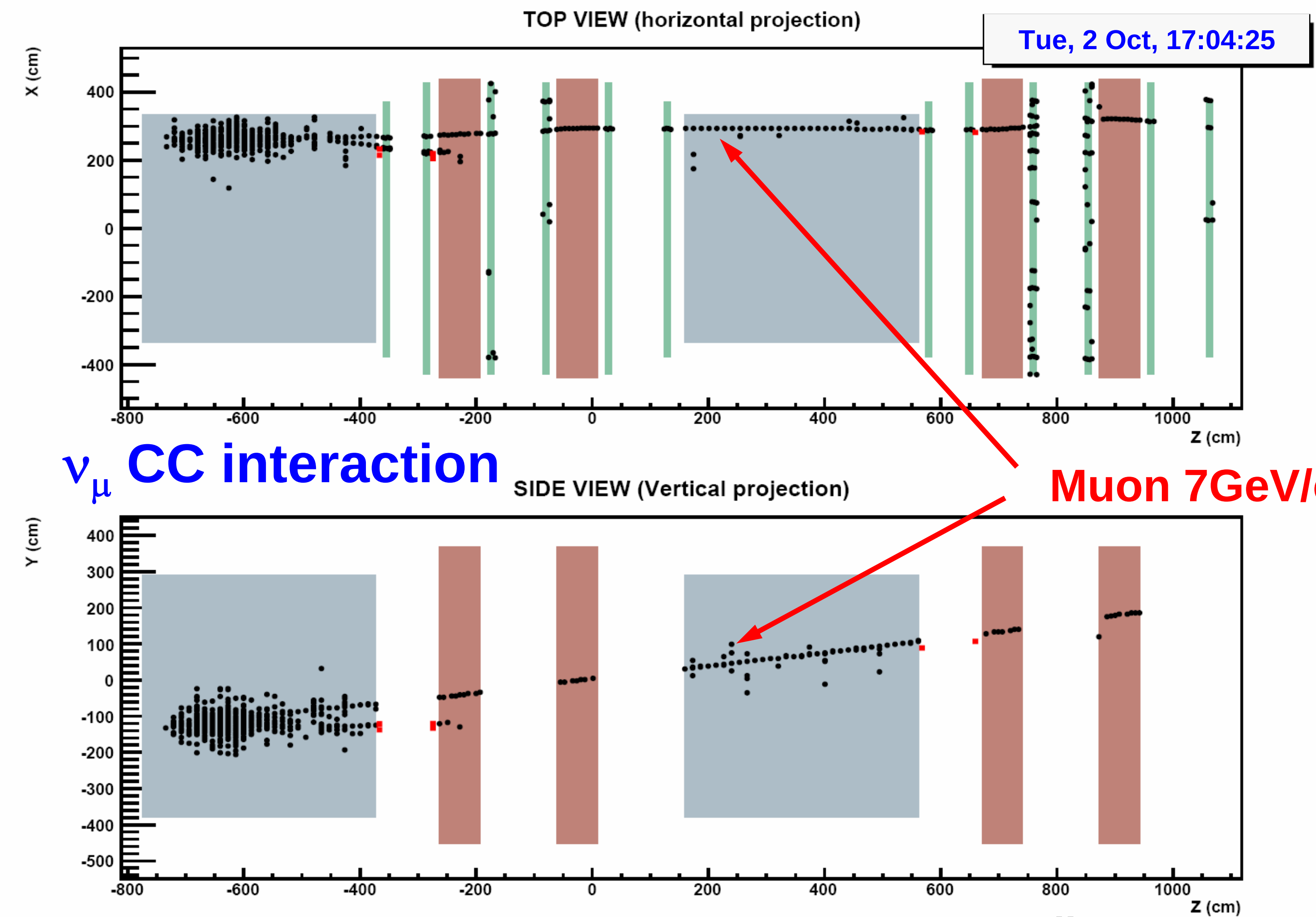
Materials have to be chosen according to the radiation fields they will be exposed to
N-TOF: dominated by thermal neutrons…..
LHC: mainly dominated by high energetic hadron fields

New Target Design

- **Cooling station** equipped with a closed retention vessel
- **Double contained** piping between the cooling station and the target vessel
- **Water leak collection** in the old pool using the existing envelope
- The water collected in the pool is **extracted by an externally** accessible closed collection vessel



First CNGS Neutrino Interaction inside an OPERA Brick



ν_μ CC interaction

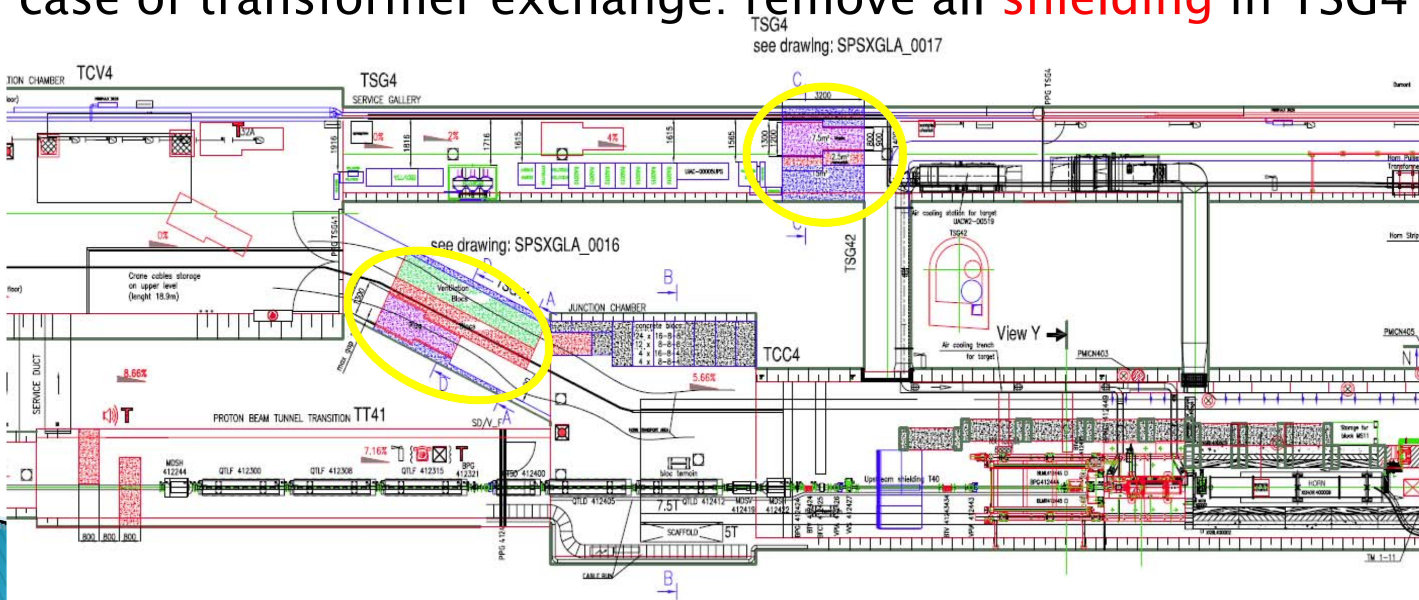
Muon 7GeV/c

Event display

CNGS Operational Aspects

Strict access procedures:

- Minimum 1day waiting time for access
  - change to access mode in ventilation → reliable system!
  - RP: air and dust probes, dose map, etc…
- Any access to TCC4 and downstream part of TSG4: shielding plugs must be opened (~2hrs).
- In case of horn/reflector/target exchange: remove entire shielding in TSG41 (1-2 weeks).
- In case of transformer exchange: remove all shielding in TSG4 (1-3 days)



Summary 1/2

- RP Constraints
  - RP constraints due to revised Safety Code F are respected by applying compensatory measures:
    - Reduction of beam losses
    - Shielding
    - Fencing
    - Access procedures
  - Formalized ALARA approach introduced
    and first "retour d'experience"

  - PS + SPS
  - Radiation problems around PS and understood
    and solutions already implemented and/or foreseen
    or still under study

- ARCON
  - ARCON will be gradually transformed into RAMSES.

Summary 2/2

- ISOLDE:
  - Ventilation problem under study and improvements will be implemented for operation in 2008
  - Lead-type shielding for REX under study
  - Disposal of used targets in progress, dismantling of actinide targets remains open issue
  - Off-line separator for actinide targets required
- N-TOF:
  - Failure of n-TOF target and contamination of cooling water understood
  - FLUKA calculations of ambient dose rates and measurements agree very well
  - Choice of material as function of radiation fields
  - New target design in good progress
- CNGS:
  - Successful commissioning and first OPERA results
  - Major modifications required to protect electronics against radiation damage.