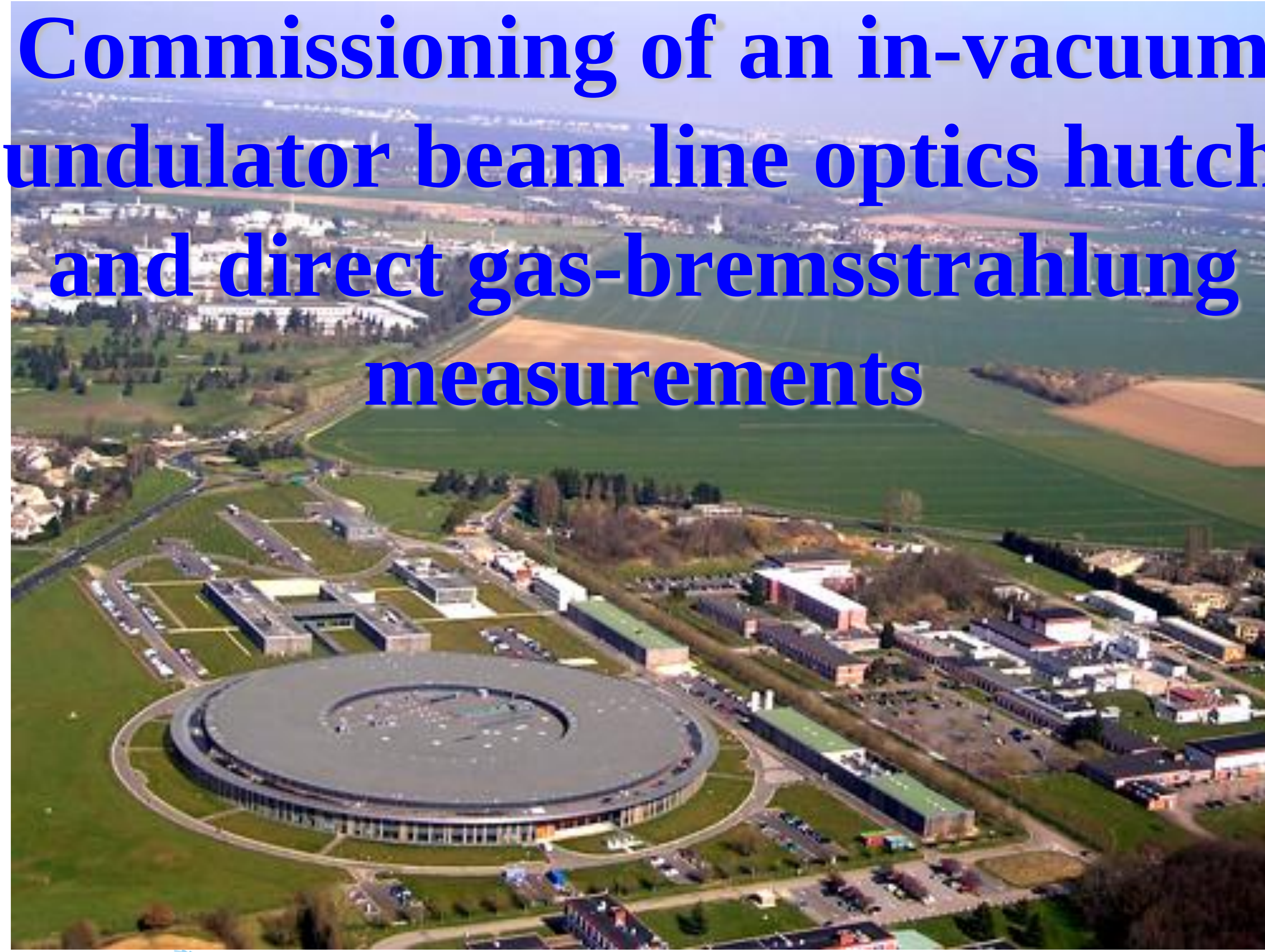
Commissioning of an in-vacuum undulator beam line optics hutch and direct gas-bremsstrahlung measurements



RadSynch'09 – elettra   May 21-23 2009   Jean-Baptiste PRUVOST

CONTENTS

- Radiation safety commissioning of the first optics hutch of SIXS beam line at SOLEIL
  - – Brief present SOLEIL status
  - – Short description of the beamline
  - – Measurements set up
  - – Results & comparison with MC calculations (P. Berkvens)
  - – Cumulative Troubles
  - – Conclusion
    - Direct gas-bremsstrahlung measurements
      - – Radiation measurements results

SOLEIL present status

- SOLEIL accelerators consists on:
  - 100MeV LINAC, 3-8nC @ 3Hz (normal op.), 10Hz (tests)
  - 156m circ. BOOSTER accelerating electrons up to 2.75GeV, 3Hz
  - 354m SR for 500mA, top-up mode operations, ¾, 4/4, single or 8 bunches mode and hybrid filling patterns
  - Now able to run up to 450mA and top-up mode, ~6h life time for machine operations
  - 300mA and top-up mode since November 2008

- 20 BL already constructed, 2 more by the end of 2009
  - 11 phase I BL, 5BM(2IR) and 6ID
  - 9 phase II BL, 3BM and 6ID
  - 6 remaining phase II ID BL to be built, 2(1canted invacID) in 2009, 3(1 invacW) in 2010, 1(canted invacID) in 2011

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16 operating with users in top-up mode @ 300mA

4 under commissioning

Brief SIXS beam line description

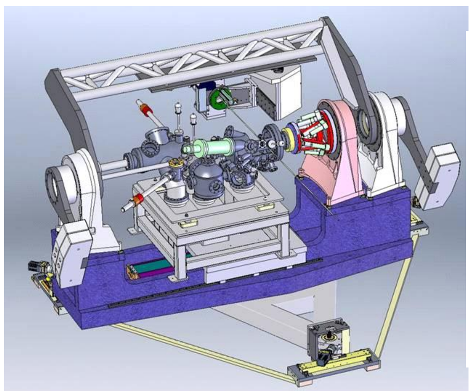
Surface and Interface X-ray Scattering (SixS)

A. Coati, B. Voisin, M. Sauvage, Y. Garreau

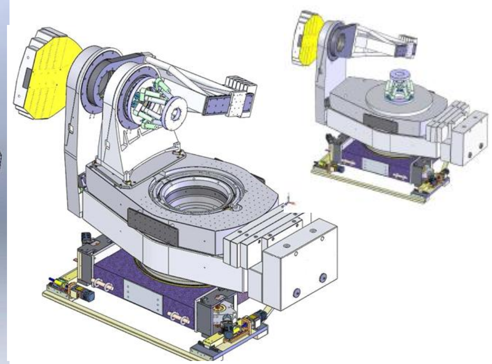
GIXD, GISAXS, XRR, magnetic X-ray scattering, coherent scattering

Open to users in 2010

UHV facility



Multi Environment facility



Scientific Case

UHV Diffractometer

- Solid surfaces and interfaces structures
- Nanostructures
- Self-organised surfaces
- Original in-situ growth
- Surface magnetic X-ray diffraction
- Surface in catalytic environment
- Solid-liquid electrochemical interfaces
- Buried soft interface
- Liquid-liquid interfaces

ME Diffractometer

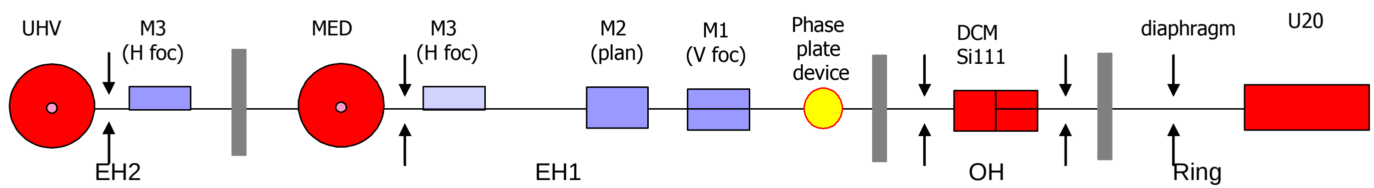
Beam characteristics

UHV: Dimensions : ~ 50x120 μm² (FWHM)
Divergence: ~ 600x60 μrad²

ME: Dimensions : ~ 60x60 μm² (FWHM)
Divergence: ~ 600x120 μrad²

Flux

4 10^{13} ph/s with $\Delta E/E \sim 10^{-4}$ (6 keV)
3 10^{12} ph/s with $\Delta E/E \sim 2\ 10^{-4}$ (15 keV)



Brief SIXS beam line description

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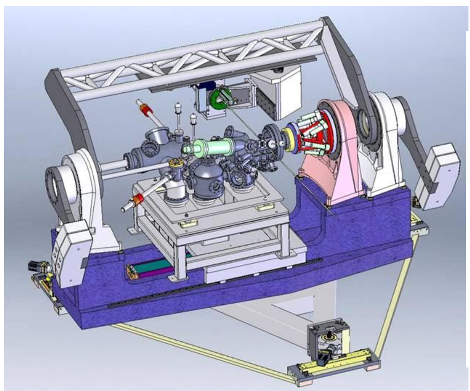

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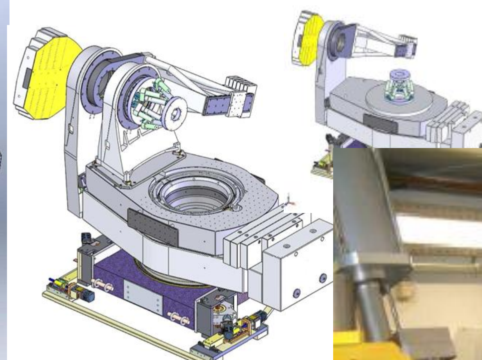

Scientific Case

UHV Diffractometer

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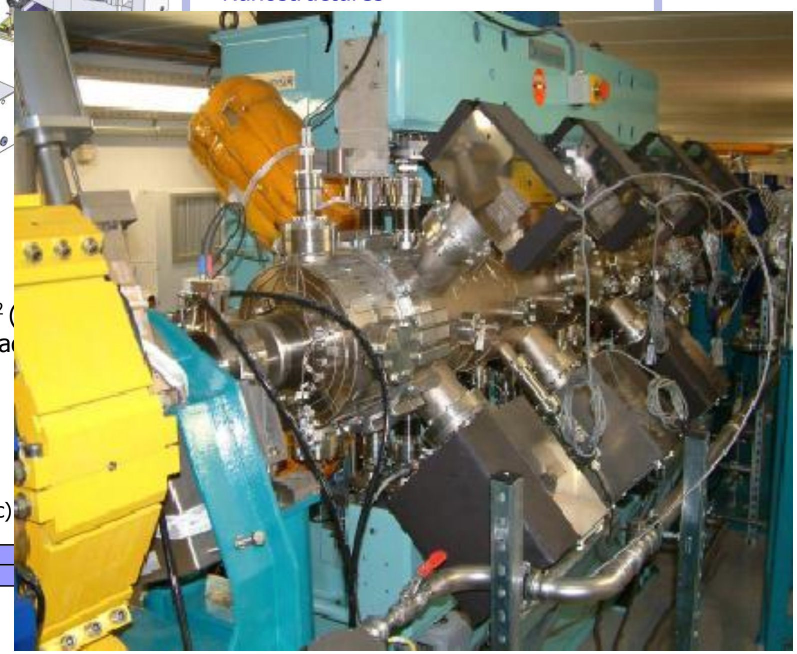

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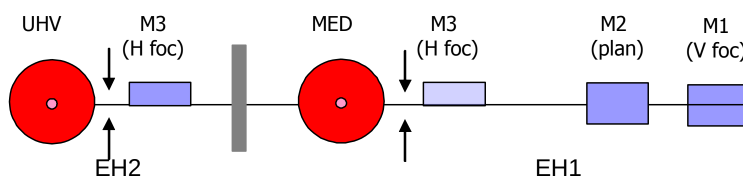
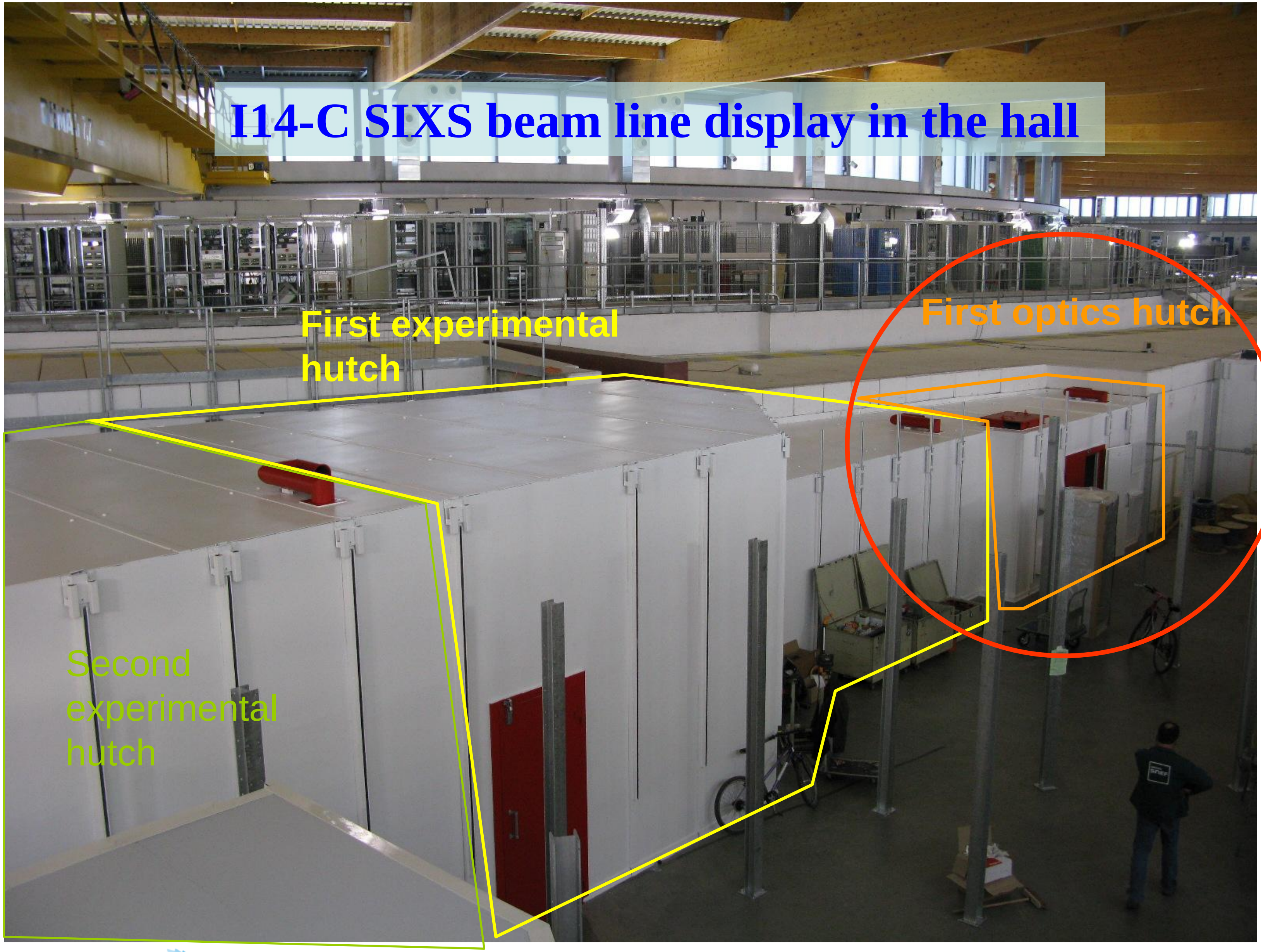
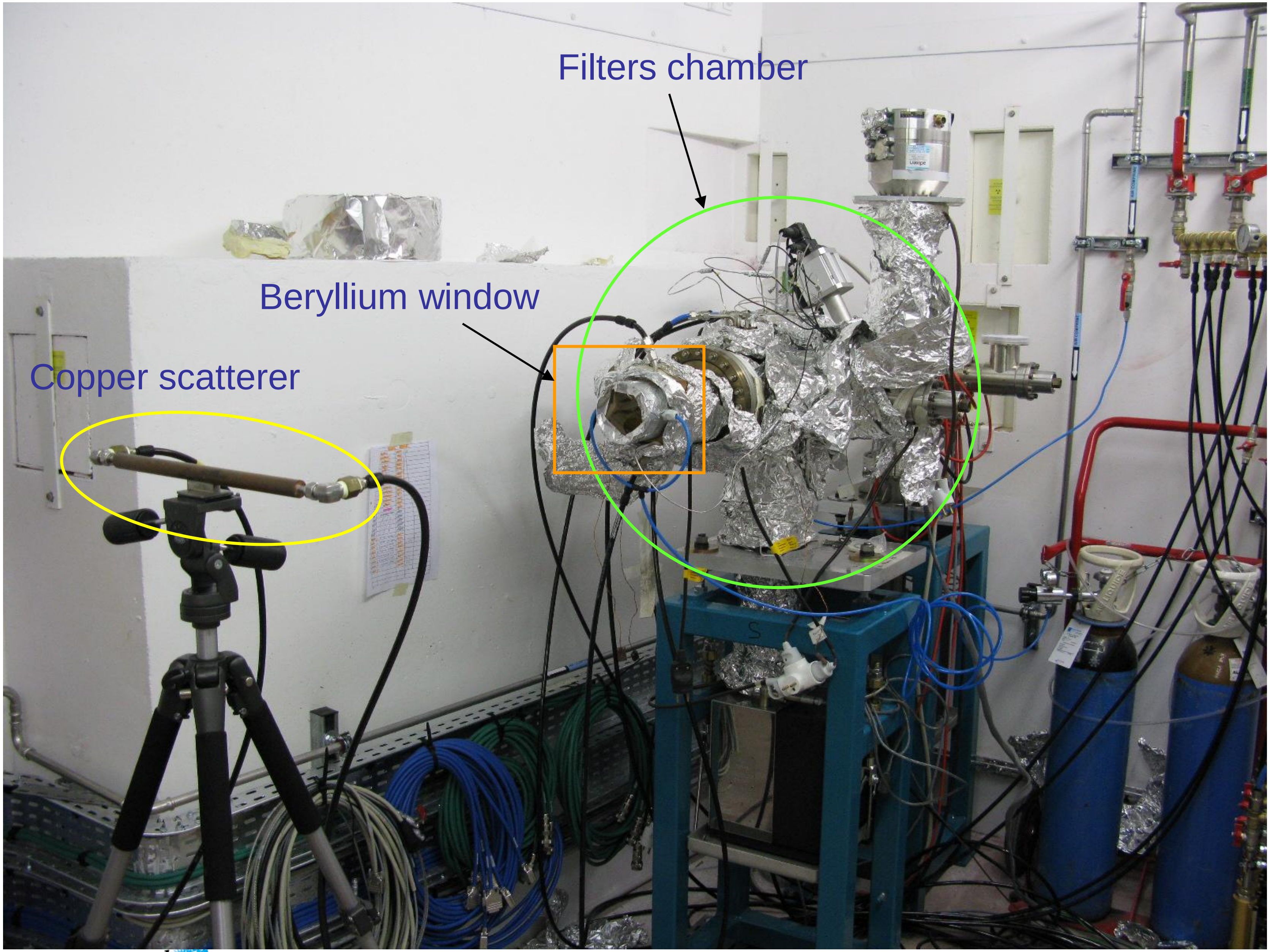


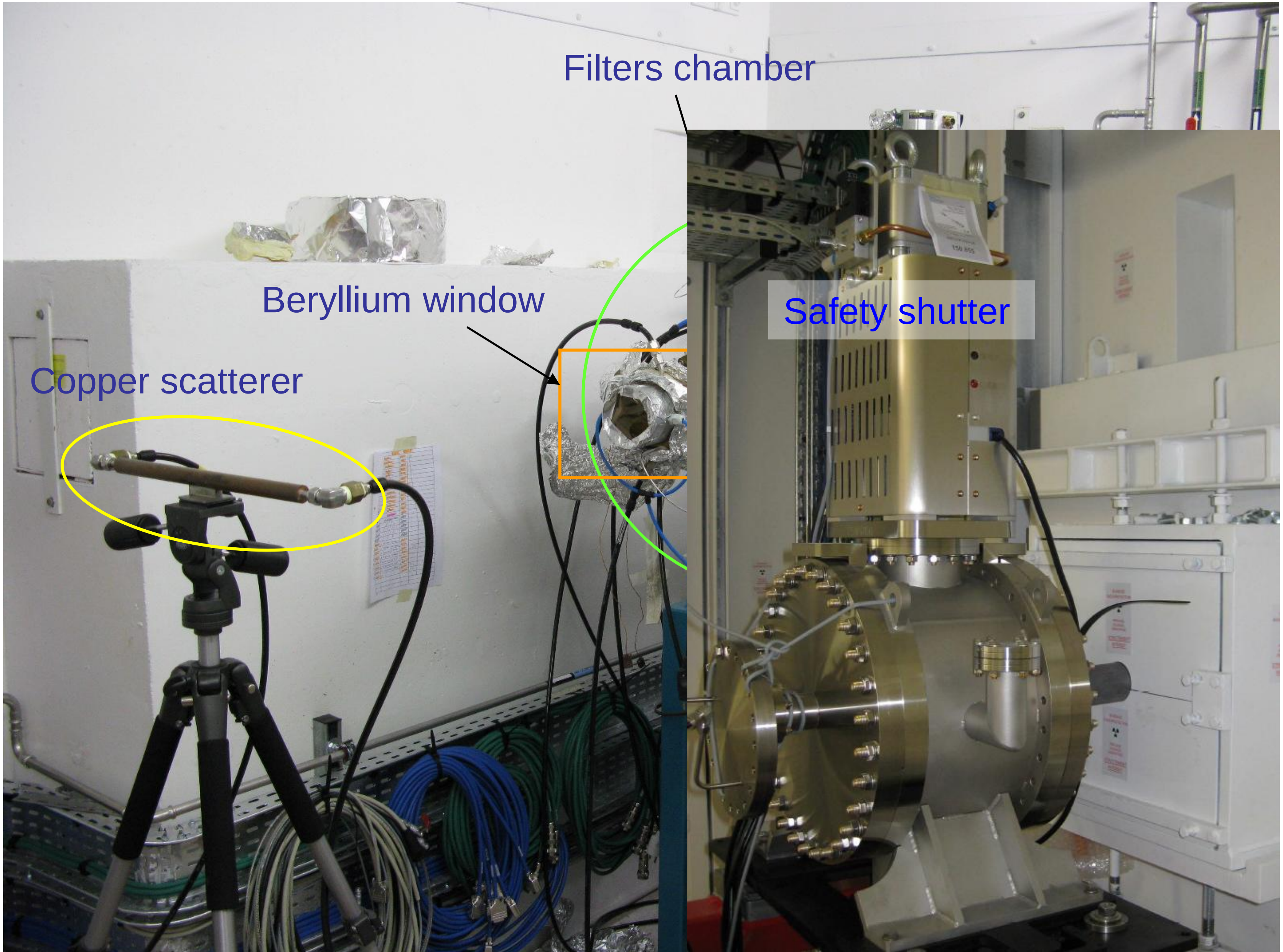
I14-C SIXS beam line display in the hall



SIXS first optics hutch

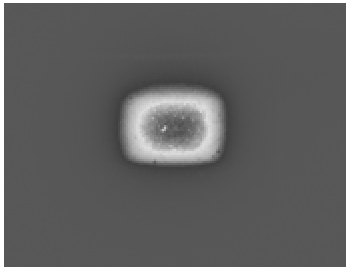
- Shielding designed for gas-bremsstrahlung scattering radiations and hard Xrays synchrotron radiations (500mA, 2. 10^{-9}mbar)
  - Side Wall : 15mm of lead
  - Back Wall : 80mm of lead
  - Roof : 10mm of lead
- Empty of any optics elements at the moment of the radiation safety test
  - FE vacuum valve
  - Filters chamber to protect Be window from beam power
  - Safety shutter at the end of the hutch

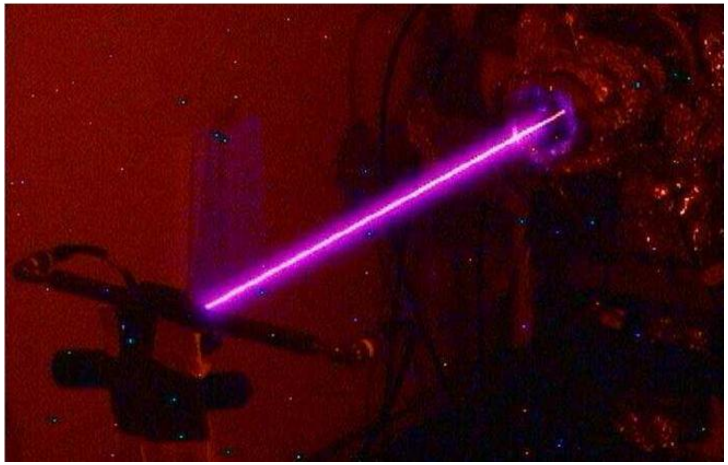

Filters chamber
Beryllium window
Copper scatterer


Filters chamber
Beryllium window
Safety shutter
Copper scatterer

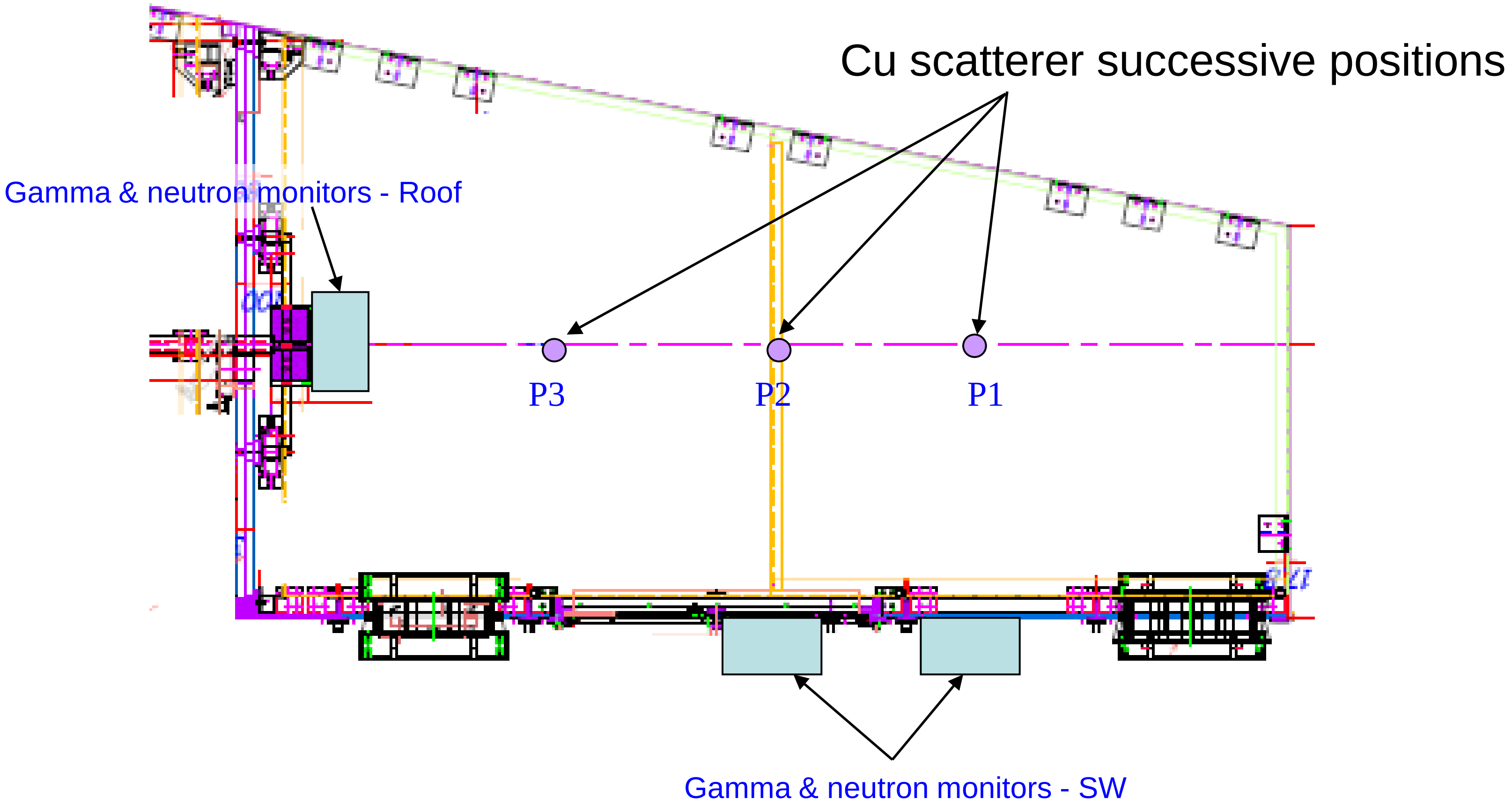
Radiation tests course

1. Checking alignment SR source and FE elements at low current
2. Leakage search around the hutch at low current (<50mA)
3. Scattering g-BS and SR radiation at max current (400mA, 5.5mm U20 gap)
4. Complete radiation survey of the OH with portable radiameters and TLD

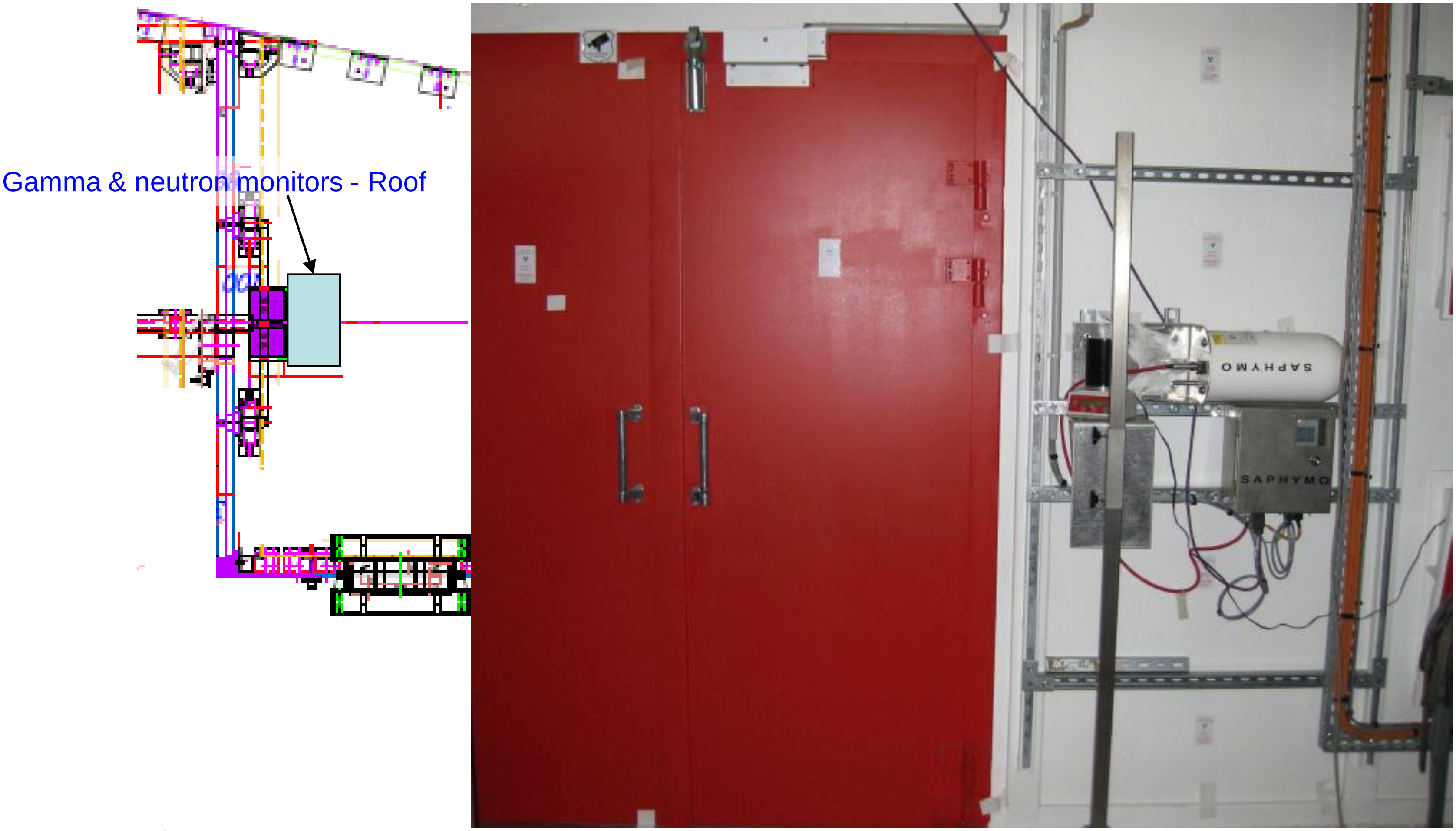




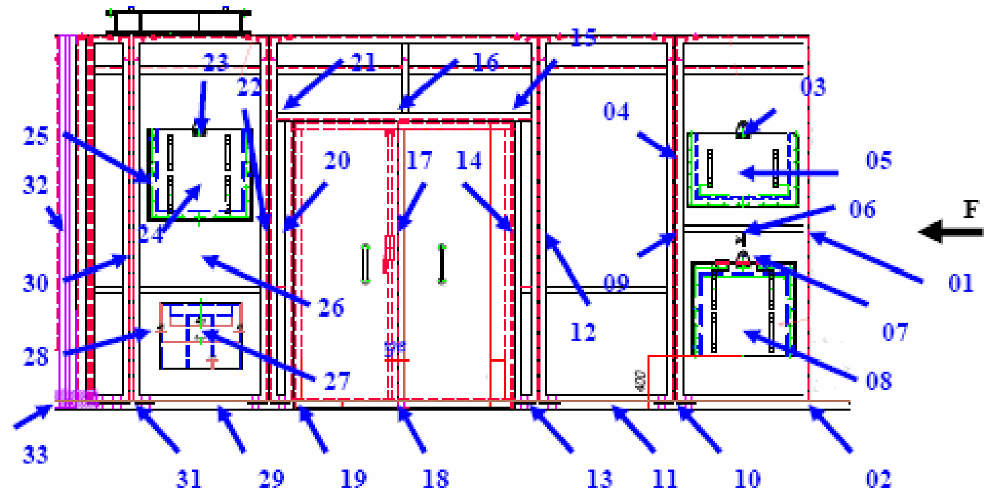
Radiation measurements (1)

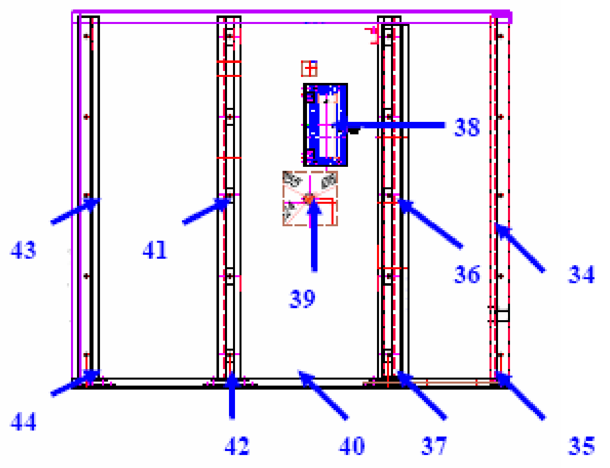


Radiation measurements (1)



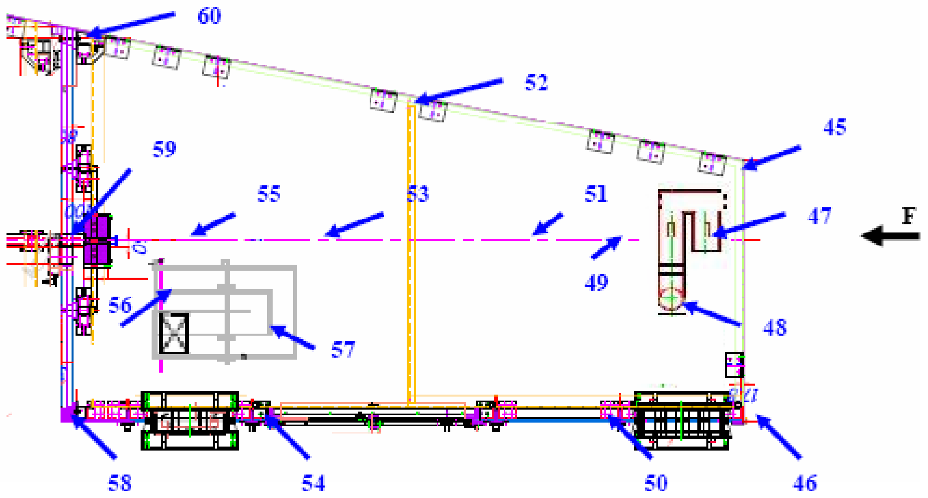
Radiation measurements (2)





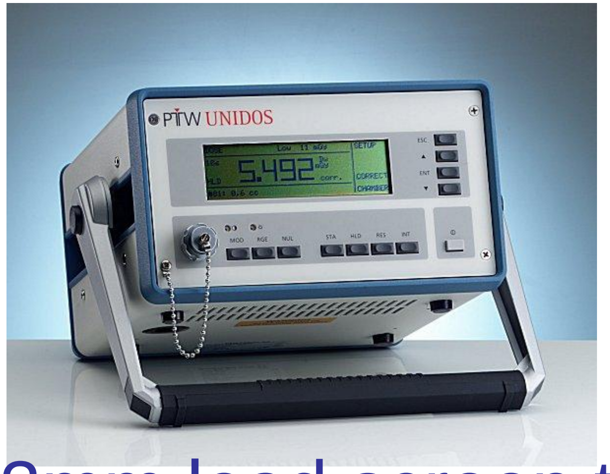
120 TLD

Hp(10) & Hp(0.07)



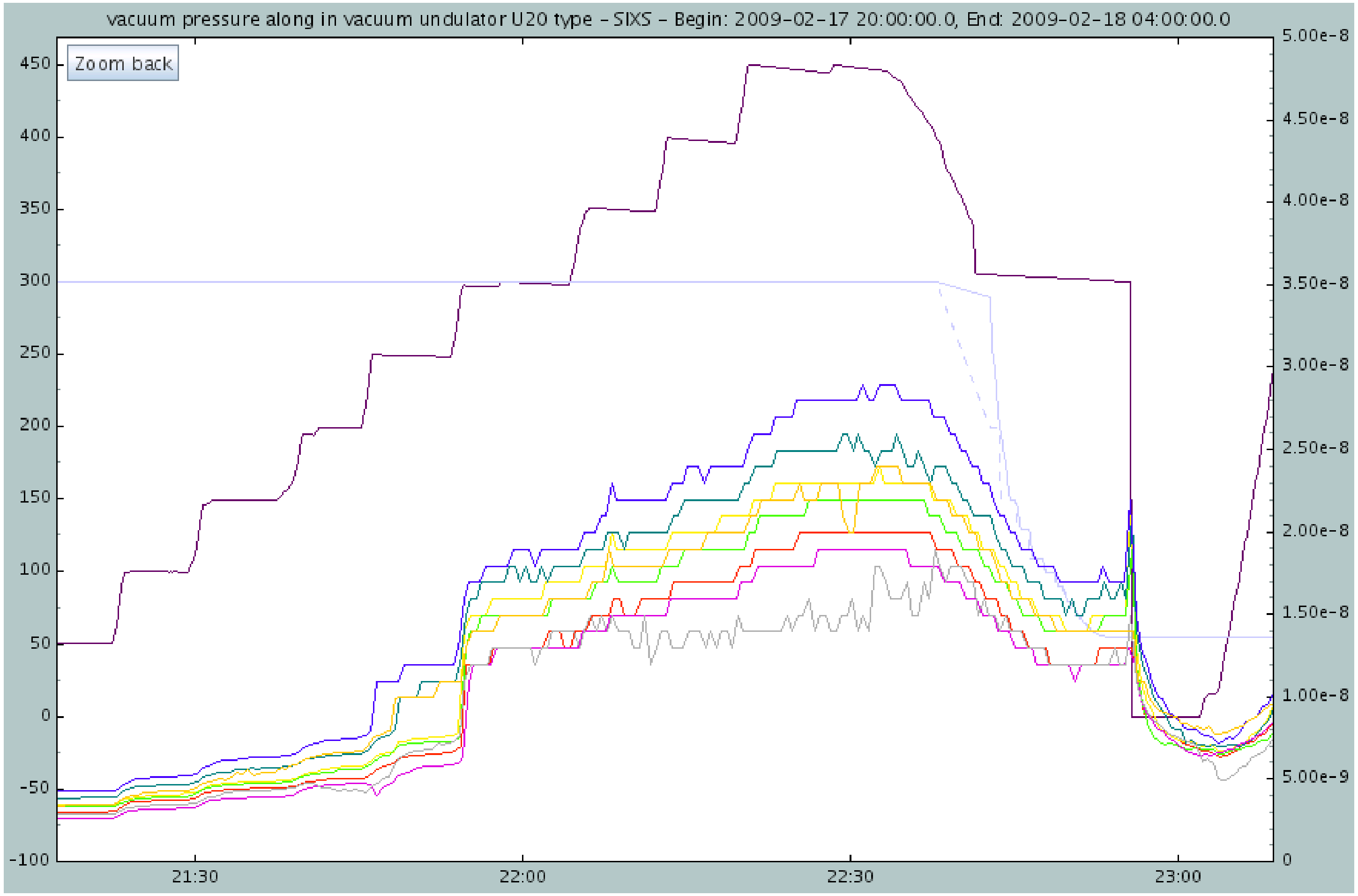
Direct gas-bremsstrahlung measurements

- Farmer type ion-chamber
- PTW Unidos electrometer

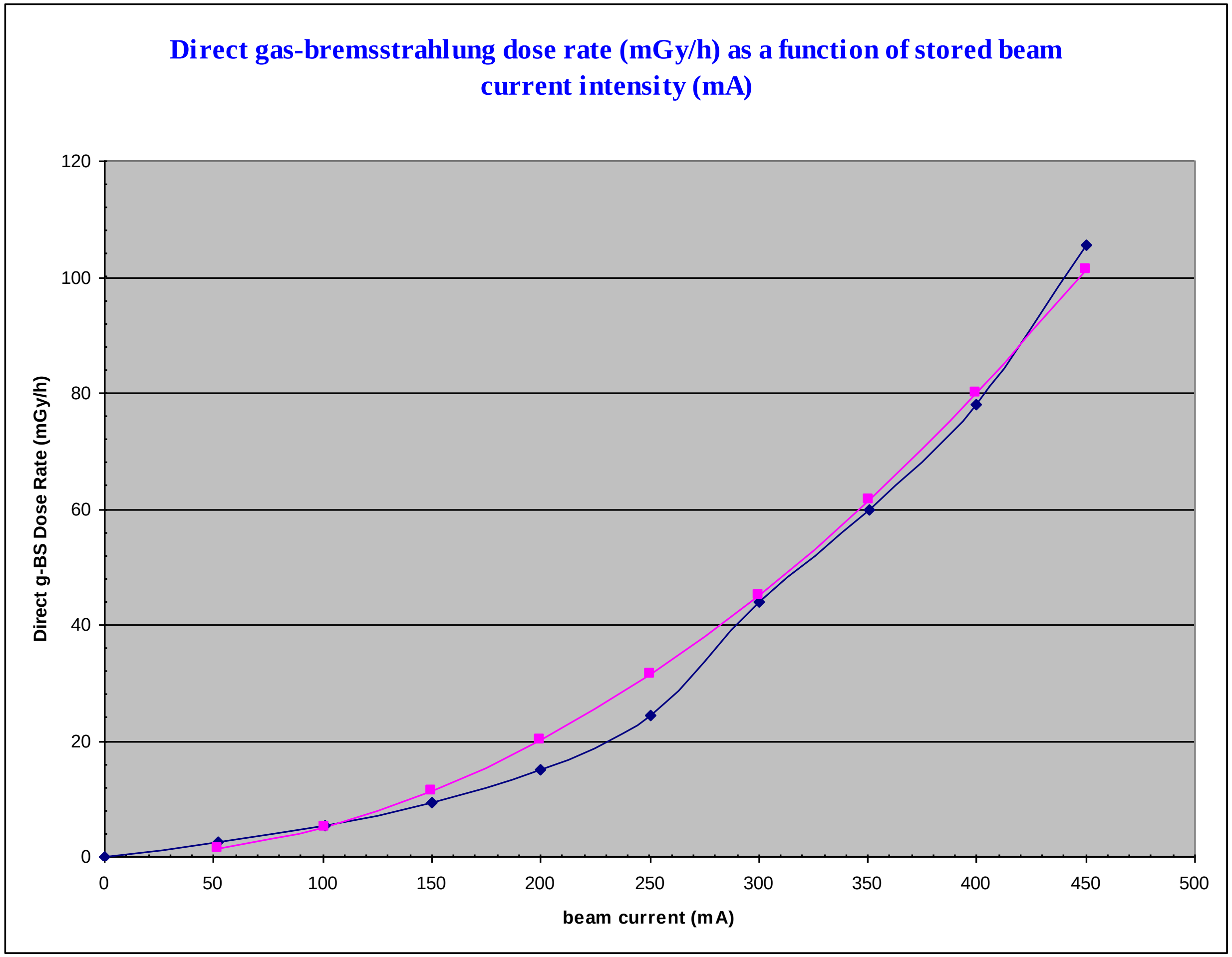


- Behind 13mm lead screen to protect from BM SR light
- U20 undulator jaws fully opened to avoid any SR beam

Direct gas-bremsstrahlung measurements



Direct gas-bremsstrahlung measurements



- Taking into account natural background
- And vacuum residual gas static pressure
- Good agreement with quadratic fit depending to stored current level

*Beamlines** MC calculations

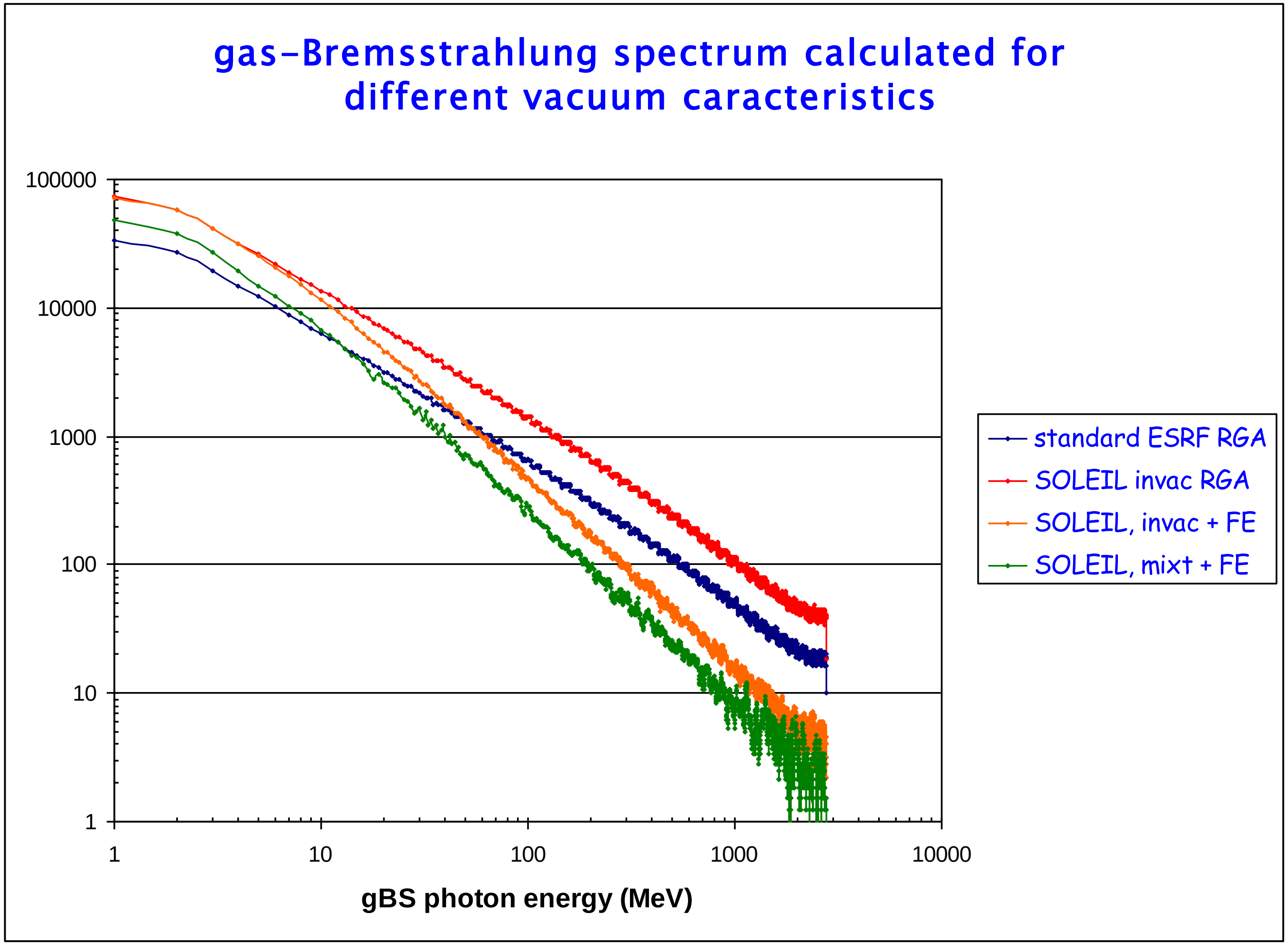
- Shielding design done assuming a « standard » residual gas composition (2. 10^{-9}mbar at 500mA) with large FE aperture 2x2 mm^2
  - H2 80%
  - CO 10%
  - CO2 5%
  - CH4 3%
  - H20 2%
- Actual residual gas RGA SOLEIL in vacuum ID (U20 SIXS)
  - H2 42%
  - CO 30,4%
  - CO2 5,6%
  - CH4 3%
  - H20 9%
  - CF4 10%

→ **Leads to higher gas-bremsstrahlung production rate because of the higher Z of residual gas**

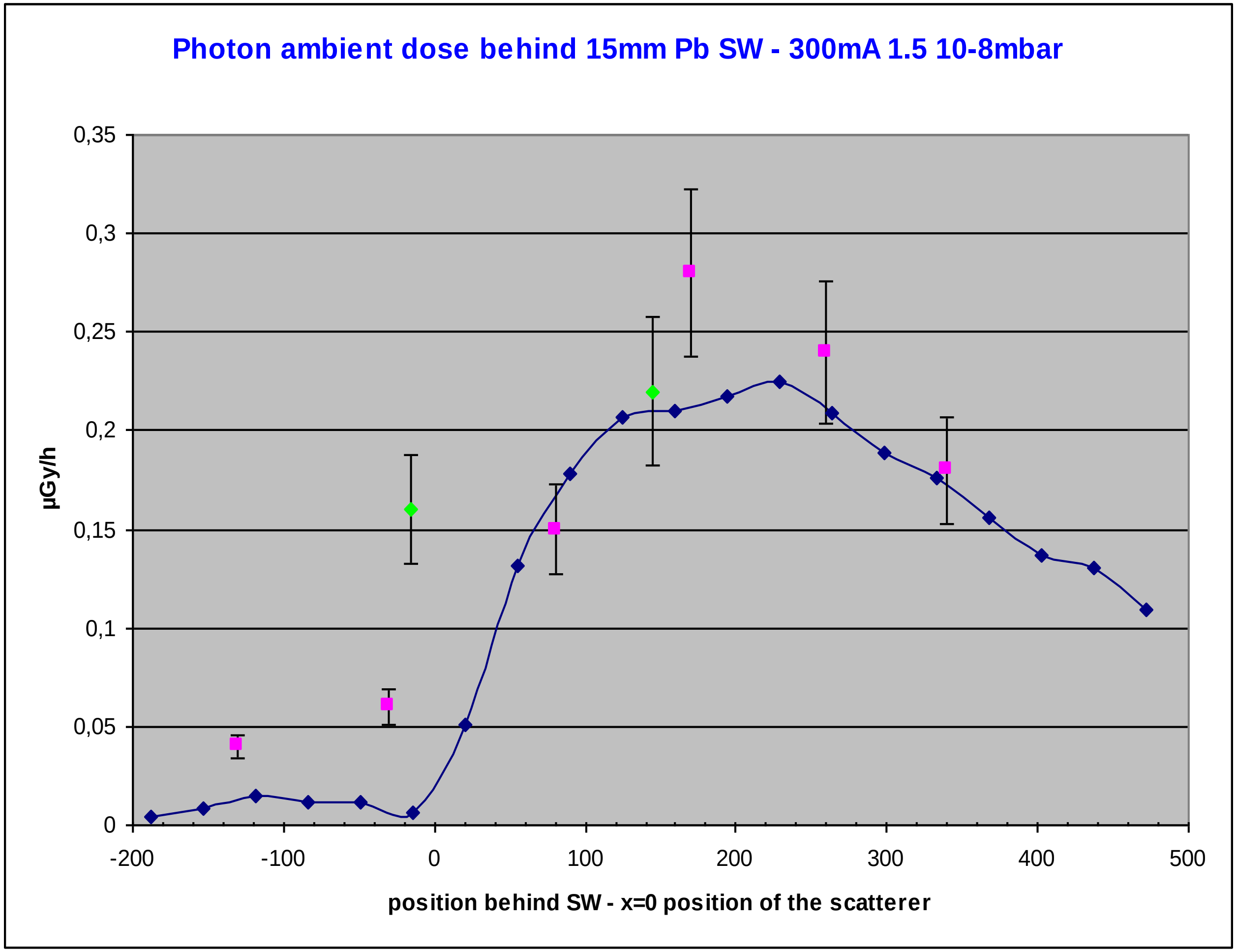
- Reduced actual FE aperture (0,6 x 1,8 mm^2 @ 11.7m)

* MC code developped by P. Berkvens, see Radsynch07 proceedings

Bremsstrahlung source term



Measurements results at 300mA

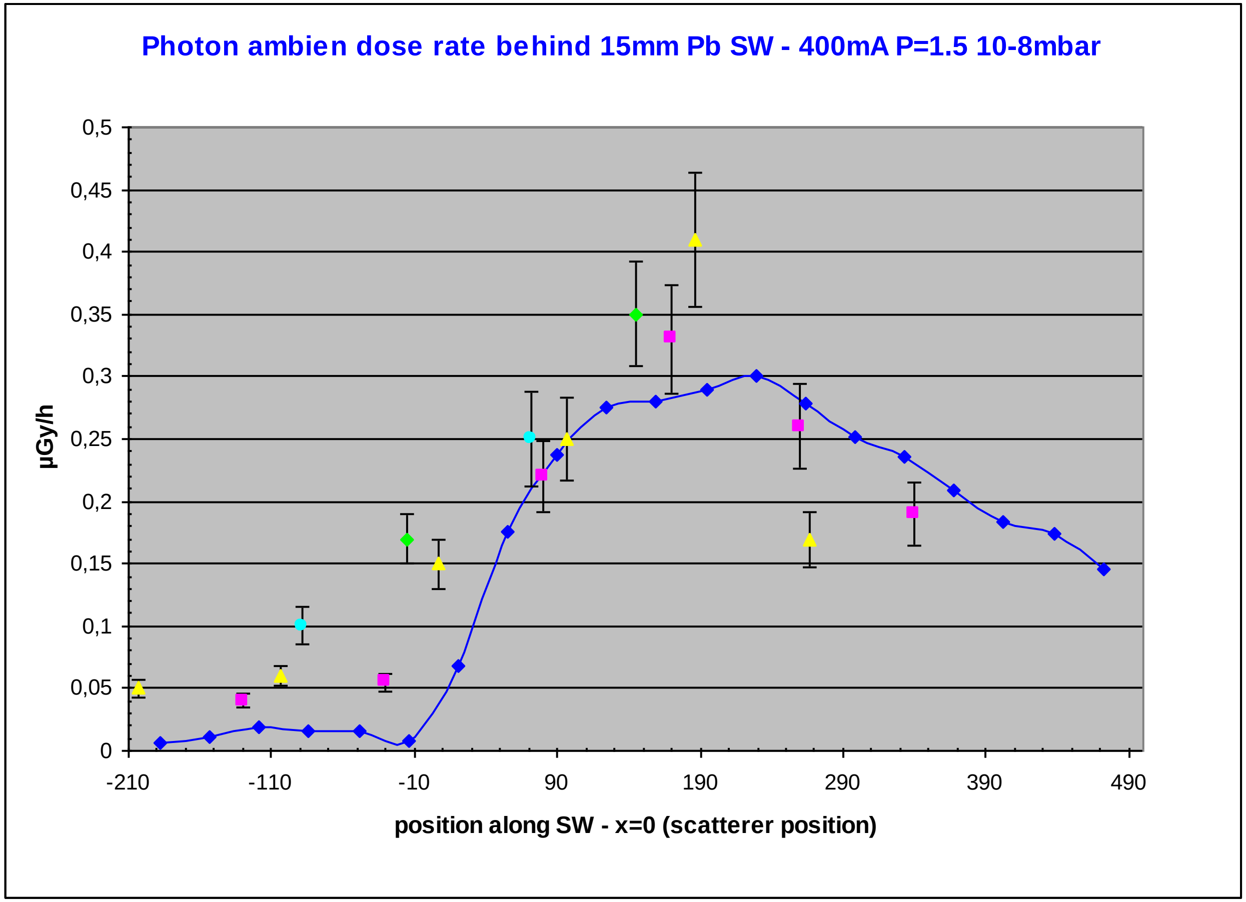


February 17^{th}

Pv(U20)=1.5 10^{-8} mbar

- Portable ion chamber
- Fixed ion chambers (SW+door)
- MC calculations

Measurements results at 400mA



March 31st

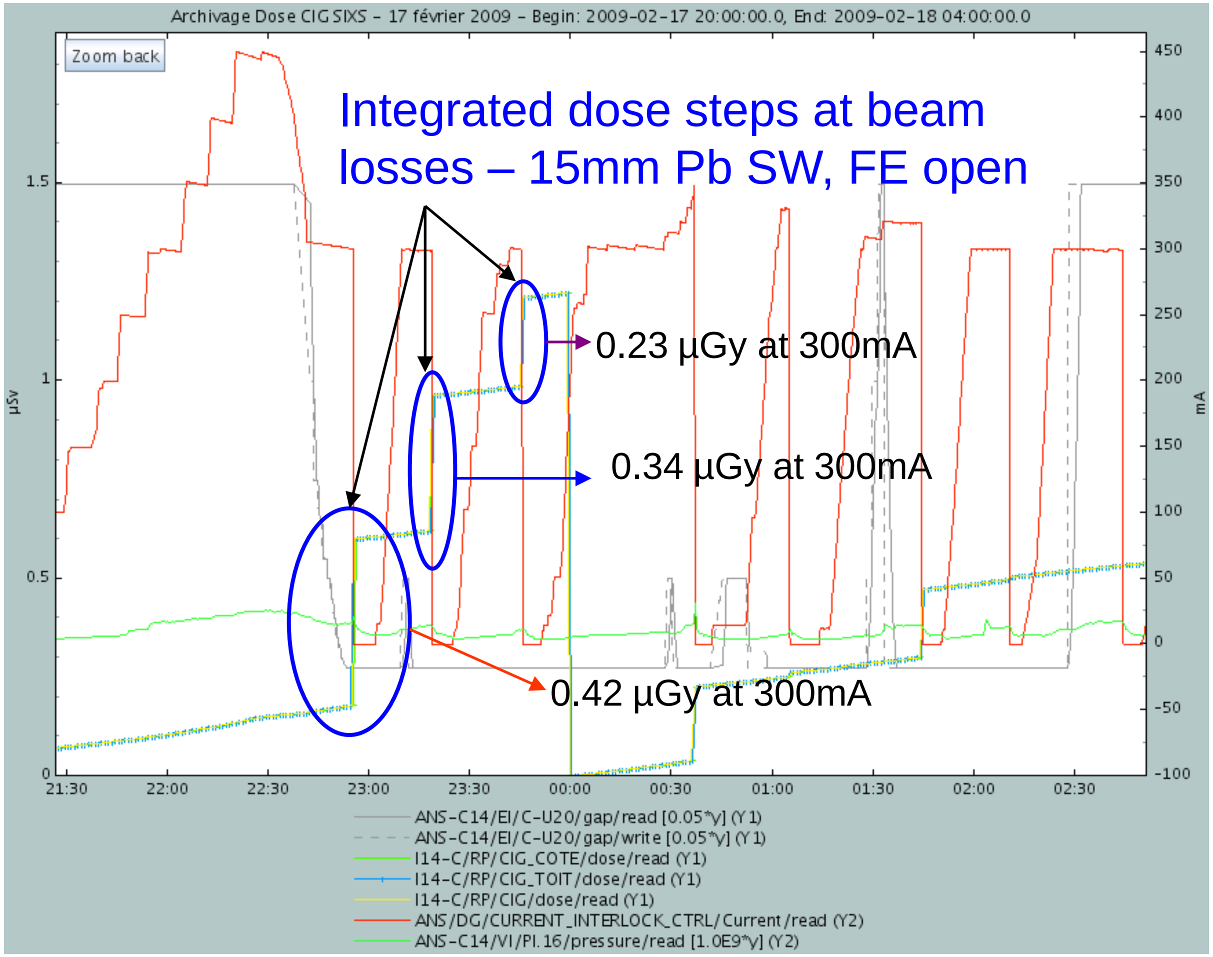
Pv=1.5 10-8mbar

- MC calculations
- Portable IC for P1
- Portable IC for P2
- SW+door IC for P1
- SW+door IC for P2

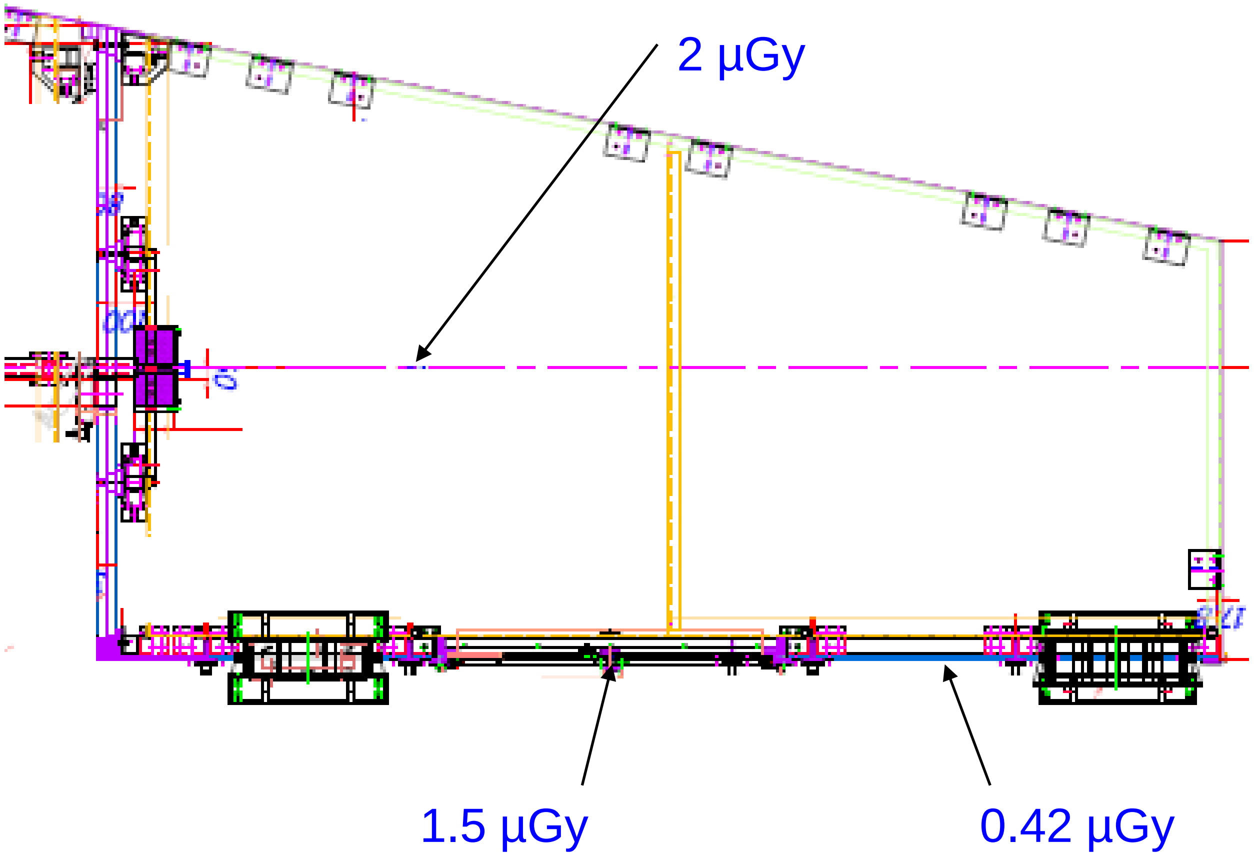
Cumulative troubles !

- High Z residual composition
- Full beam losses because of instabilities
- Concentration of the losses in the C14 straight section
- Presence of an obstacle in the straight ?

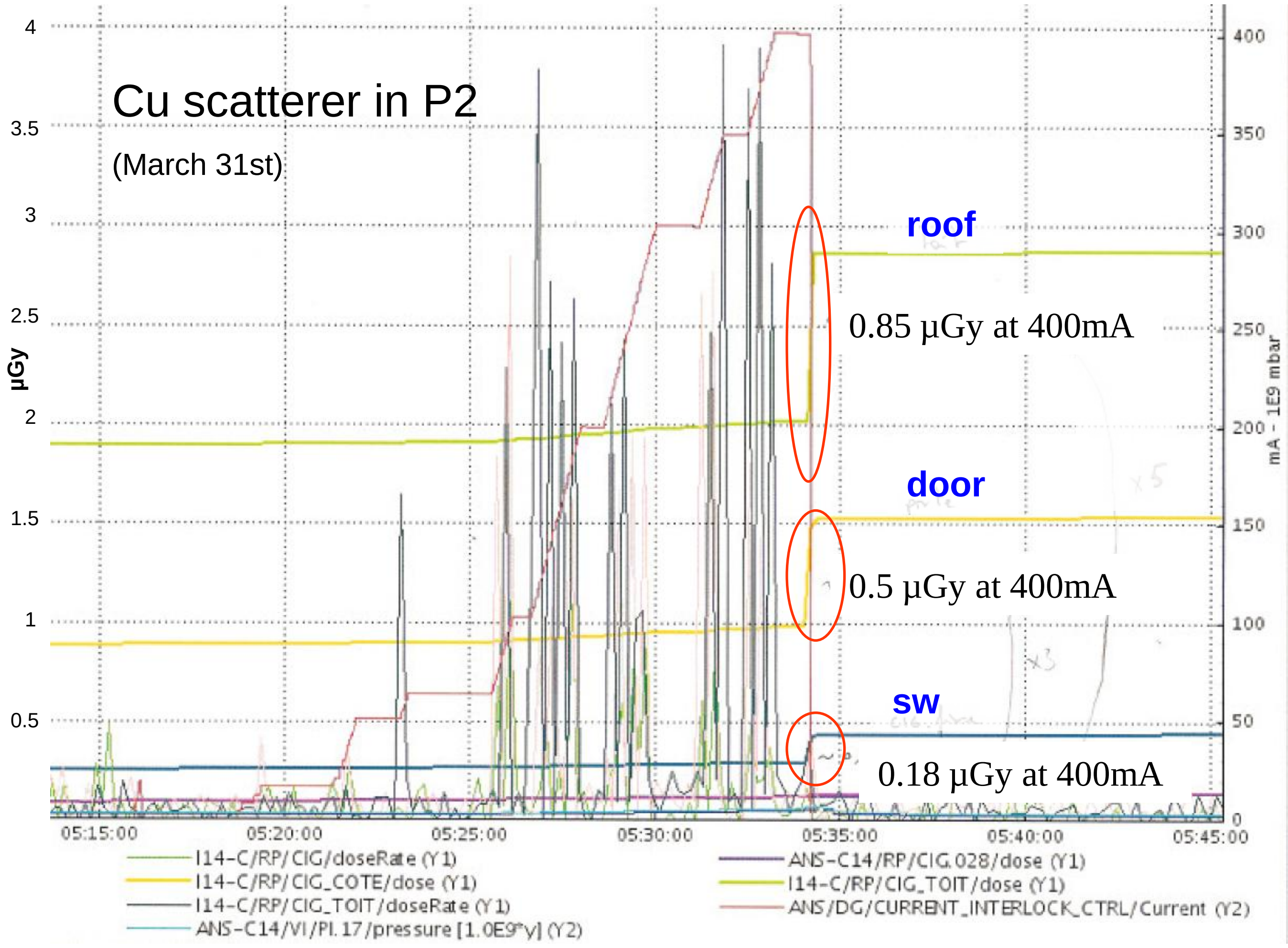
Dose observed during beam losses (1)



Maximum dose observed at 300mA beam losses



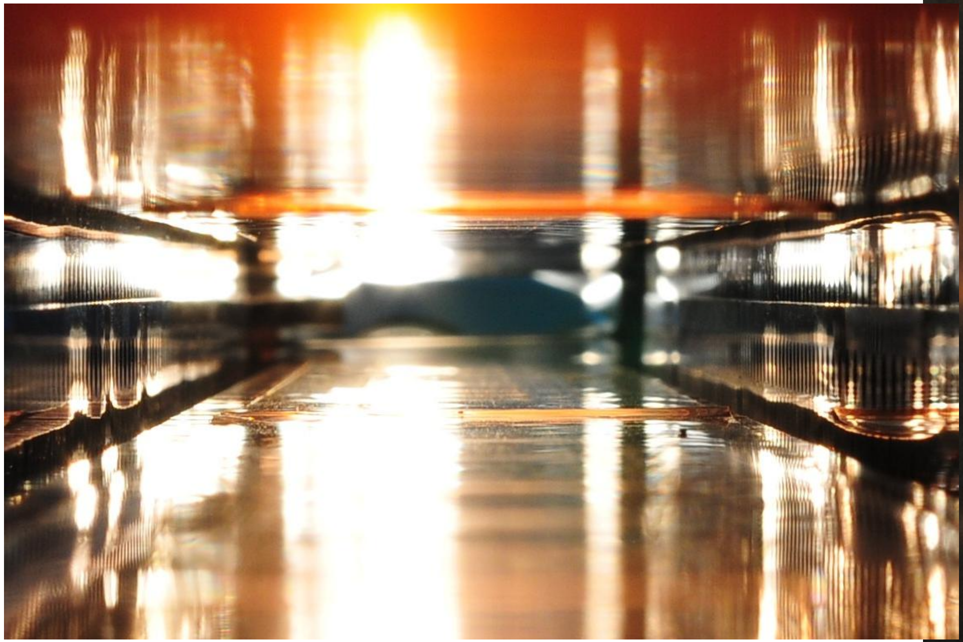
Dose observed during beam losses (2)

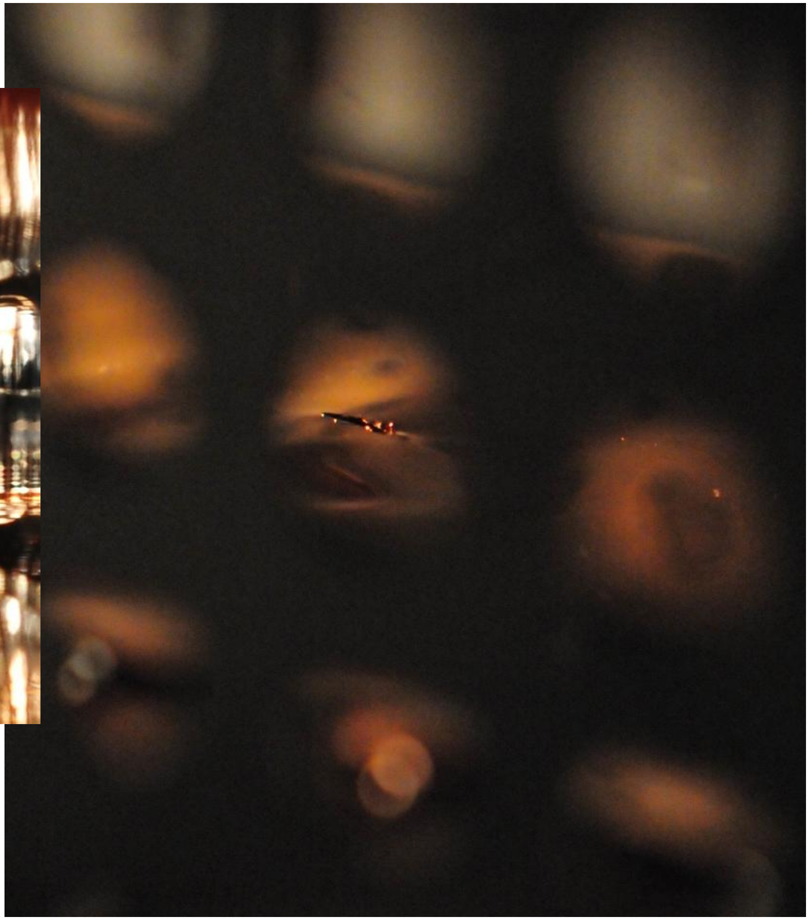


Dose observed during beam losses (3)

- Fortunatly dose observed with radiation monitors are more or less confirmed by the TLD results (Hp(10)) in terms of magnitude order
  - 6 300mA beam losses during the whole test duration
  - SW total dose : 3 µSv, ~ 0.5 µSv/beam loss
  - Door total dose : 8.6 µSv, ~ 1.4 µSv/beam loss
  - Roof total dose : 20 µSv, ~ 3 µSv/beam loss

SIXS U20 liner damages





Conclusion

- SIXS beam line Optics hutch shielding have been validated @ 400mA in decay mode of operation
- U20 in vacuum out of the ring now, but beam losses still occure in cell 14 in case of RF beam trip

  → there is probably a physical obstacle just a little upstream of the ID position
- Next shutdown, a new U20 in vacuum vessel will be installed on the ring to replace the former one
- Investigations will be done in order to find the obstacle
- An other radiation safety test is foreseen during the next run in order to validate the shielding during top-up mode operation at 400mA.

Aknowledgements

- Paul Berkvens, ESRF safety group
- Corinne Mage, SOLEIL radiation safety group
- Fabien Justine, SOLEIL radiation safety group

THANK YOU FOR YOUR ATTENTION