UA9 STATUS REPORT FOR 2011

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for the UA9 Collaboration

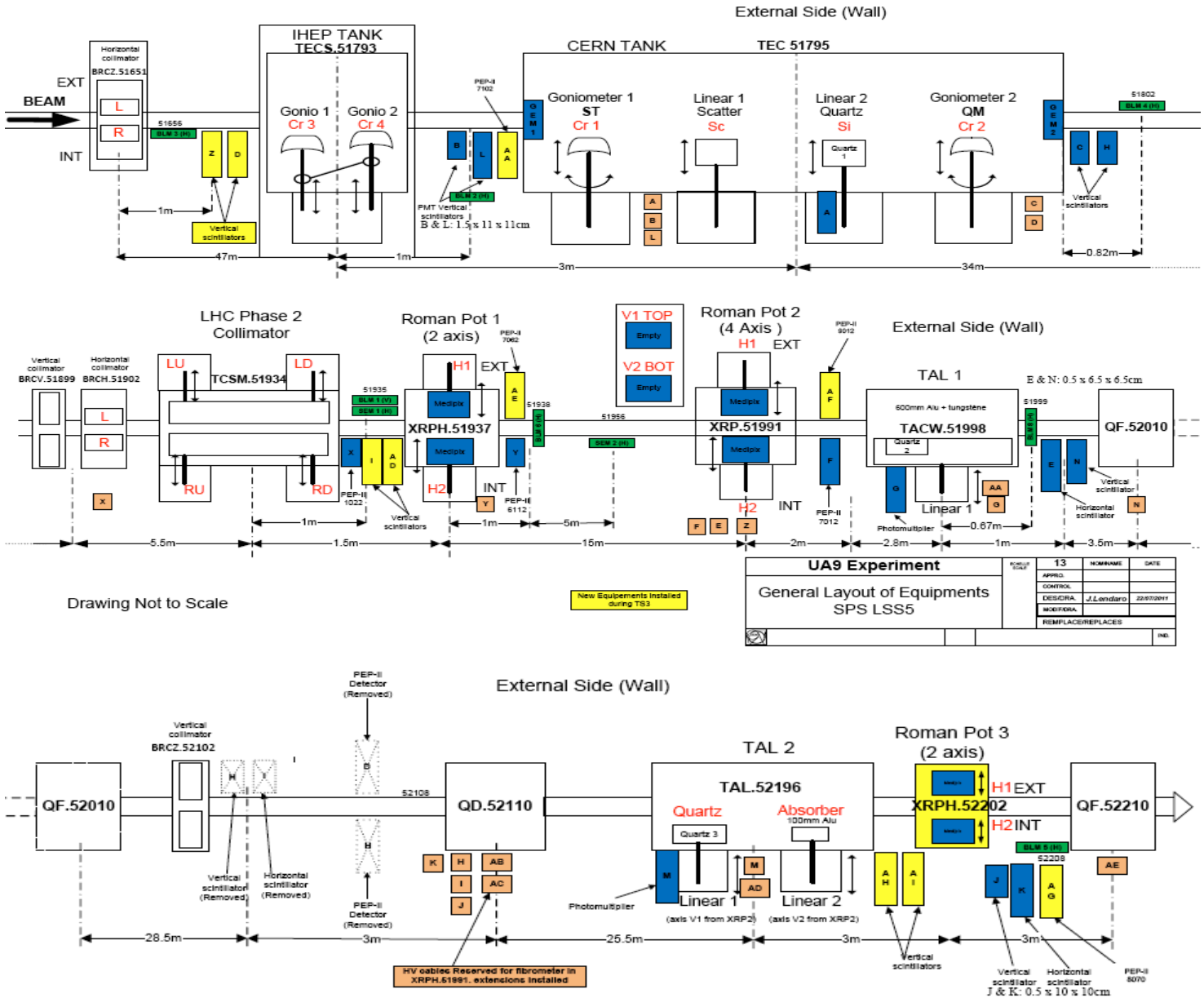
CERN – IHEP - Imperial College – INFN – JINR – LAL - PNPI – SLAC

SPSC, October 25, 2011

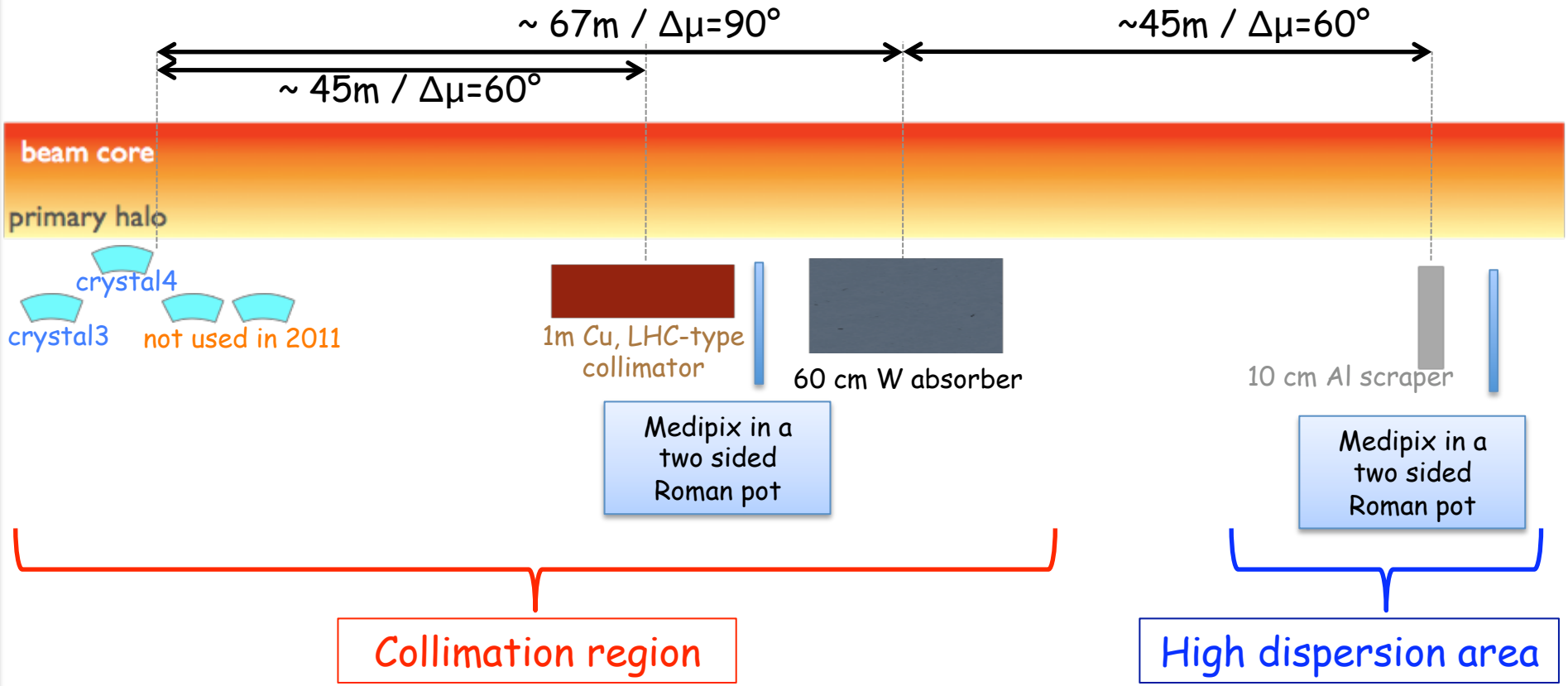
UA9 hardware in 2011

Collimation region

High dispersion area



UA9 basic layout



Observables in the collimation area:

- Intensity, profile and angle of the deflected beam
- Local rate of inelastic interactions
- Channeling efficiency (with multi-turn effect)

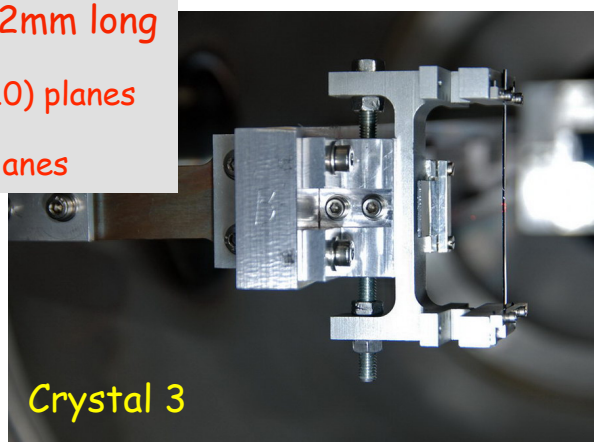
Observables in the high-D area:

- Off-momentum halo population escaping from collimation (with multi-turn effect)
- Off-momentum beam tails

Crystals

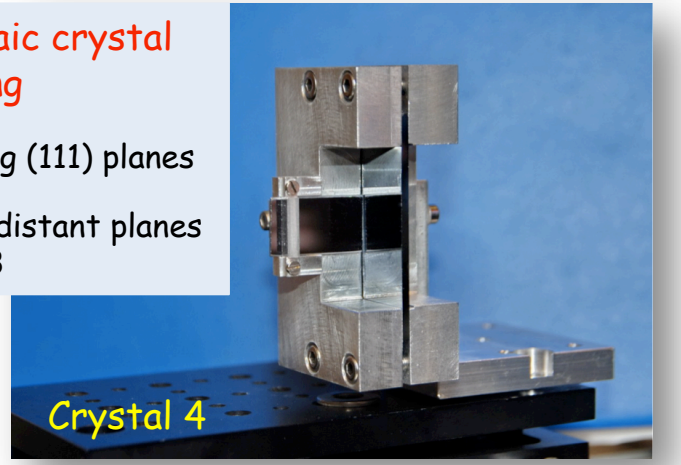
Strip crystal 2mm long

- Bent along (110) planes
- Equidistant planes



Quasimosaic crystal 1.9 mm long

- Bent along (111) planes
- Non-equidistant planes d1/d2 = 3



Residual imperfections:

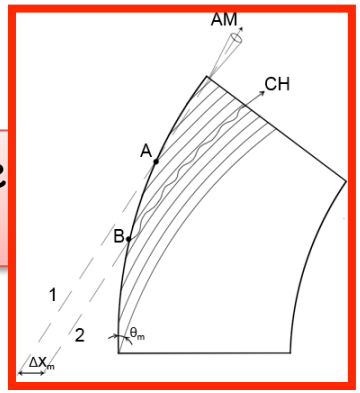
- ✓ Residual torsion ≈ 1 μrad/mm → different paths for different vertical hit points
- ✓ Amorphous layer size ≤ 1 μm
- ✓ Miscut ≈ 100 μrad

→ different paths at small impact parameter

Torsion is no longer an issue

- torsion over the beam size < critical angle
- full mitigation of the detrimental effects

Schematic view of the residual miscut angle

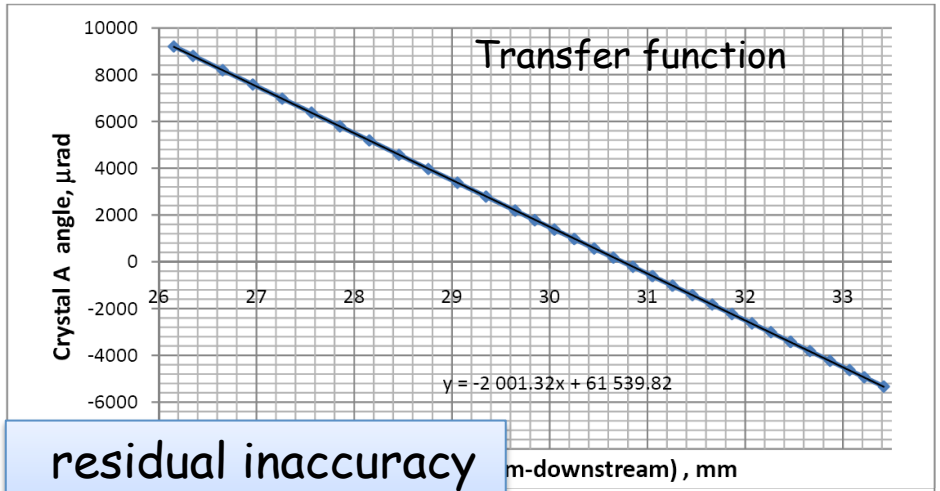


Goniometer

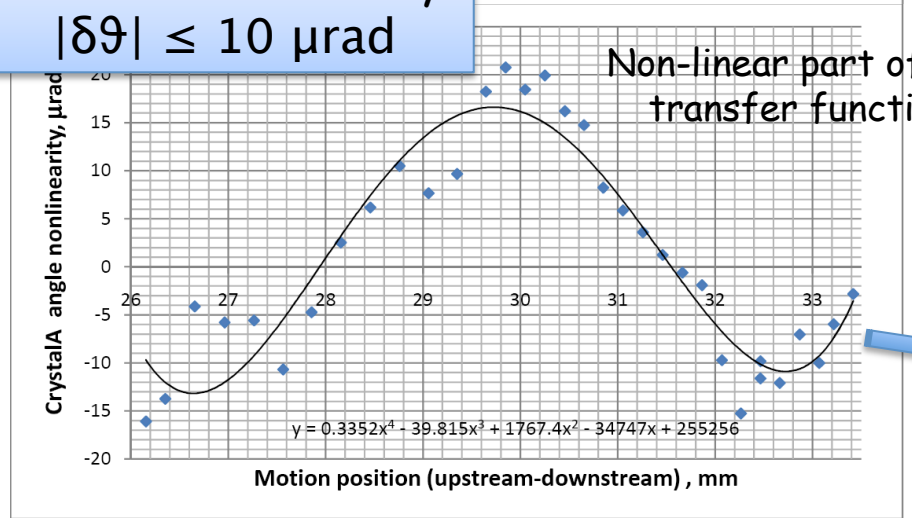
The critical angle governs the acceptance for crystal channeling

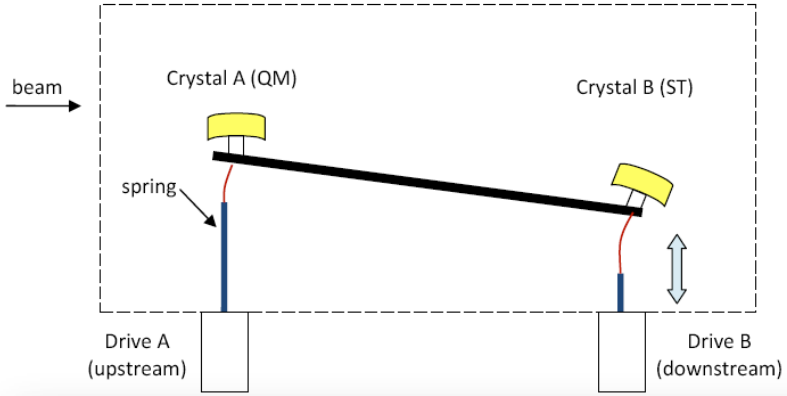
- 120 GeV ➔ θ_c = 20 μrad
- 270 GeV ➔ θ_c = 13.3 μrad

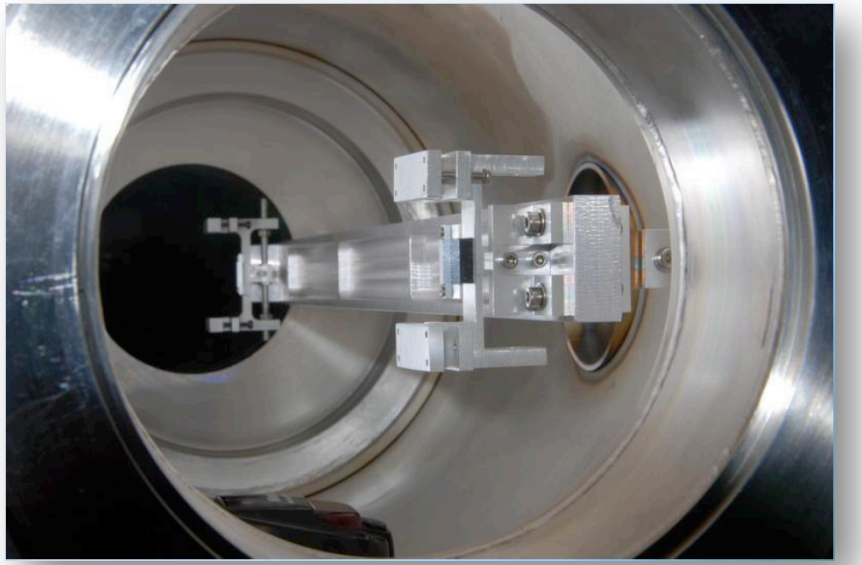
$$\theta_c = \sqrt{\frac{2U_0}{E}}$$



residual inaccuracy
$|\delta\vartheta| \leq 10$ μrad

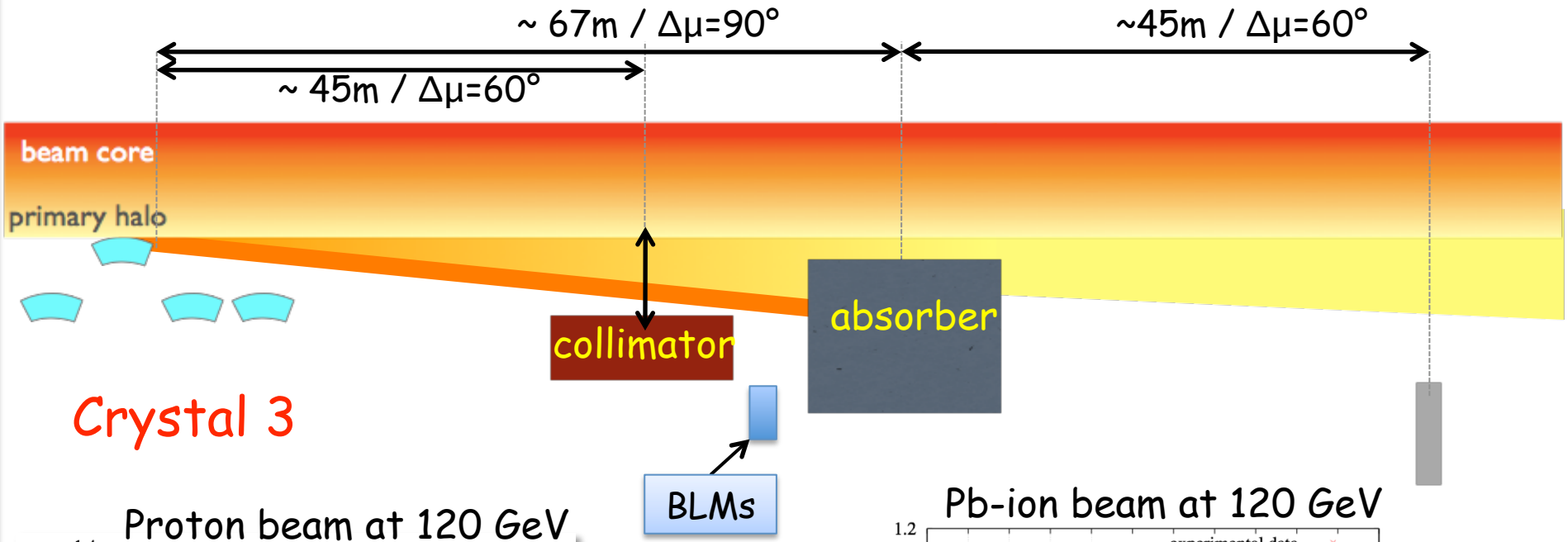




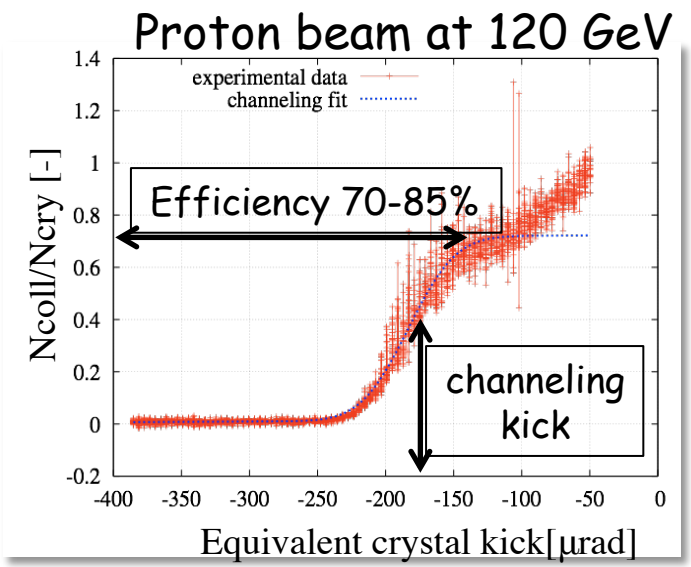


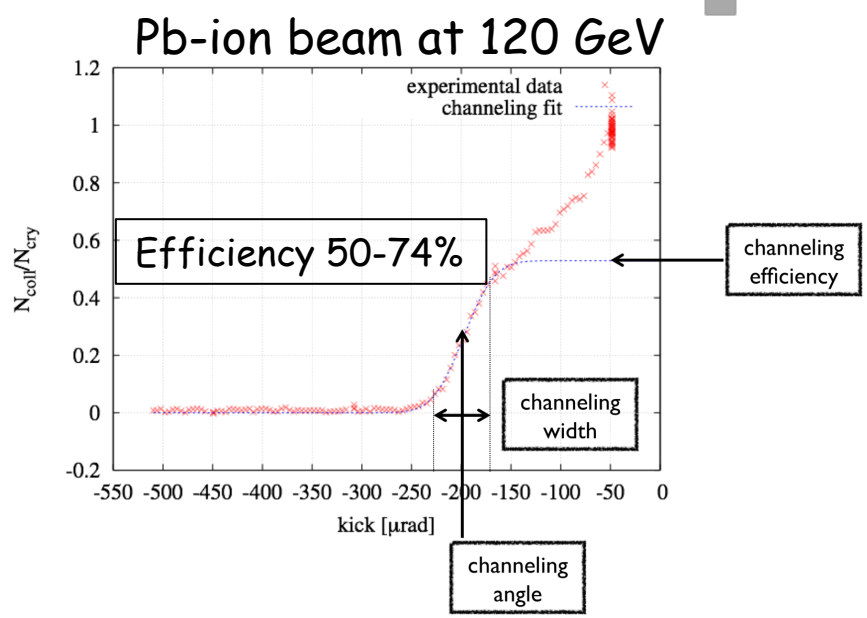
in a full angular scan
the drive position changes by 300 μm
around the initial value in the plotted range

Channeling efficiency by coll. scans

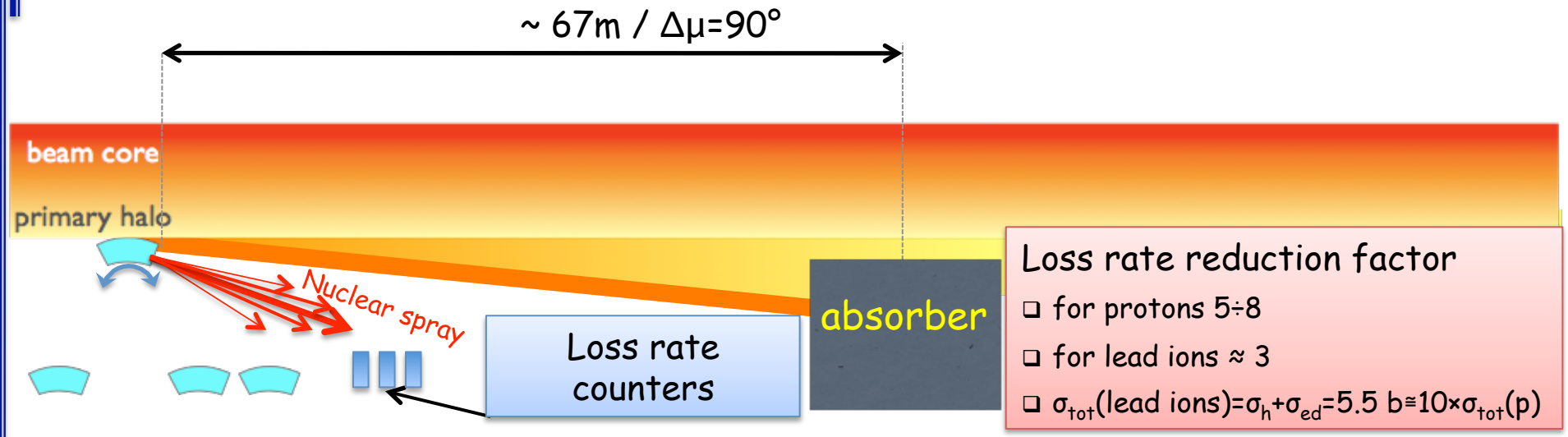


Crystal 3



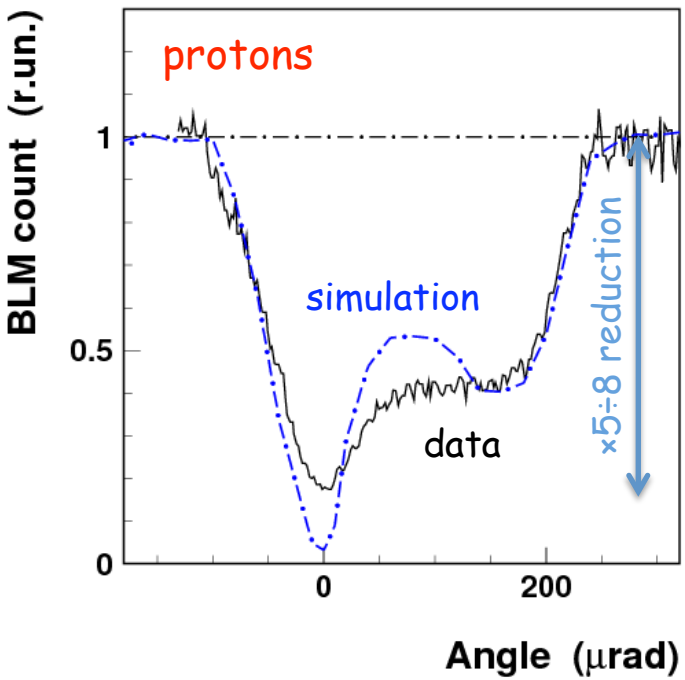


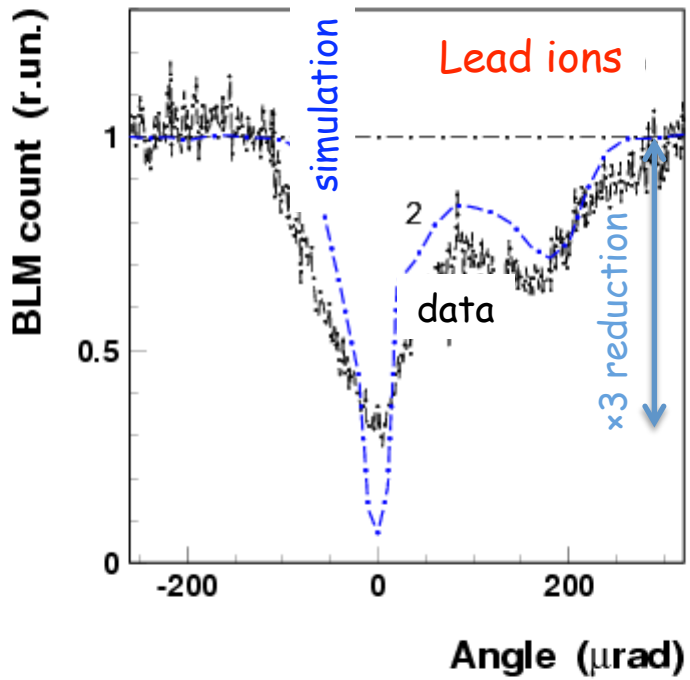
Loss rate reduction at the crystal



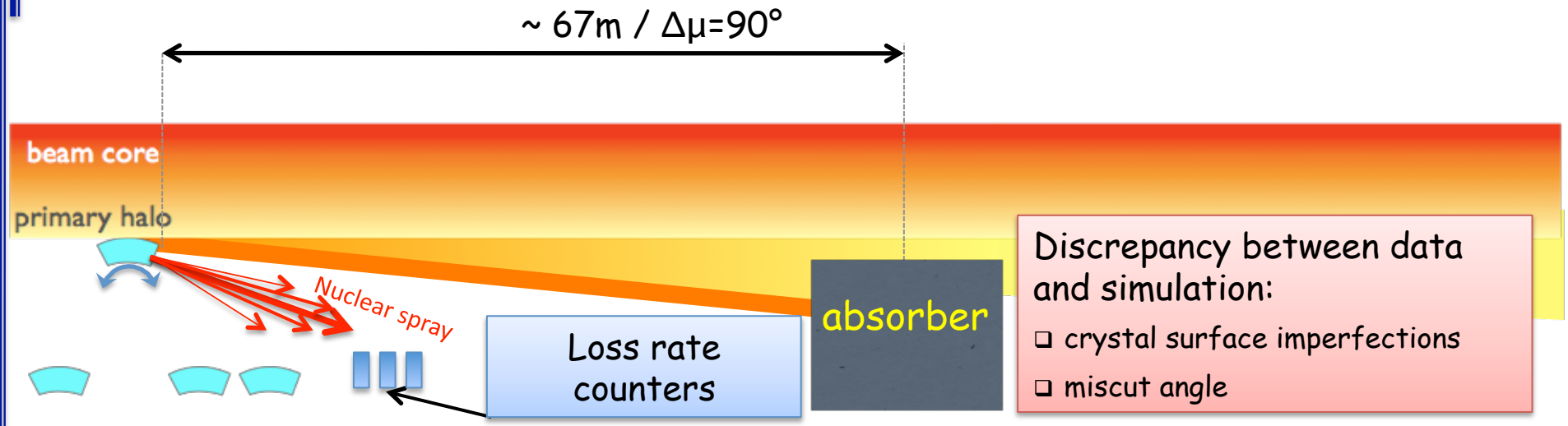
Loss rate reduction factor

- for protons 5÷8
- for lead ions ≈ 3
- σ_{tot}(lead ions)=σ_h+σ_{ed}=5.5 b≅10×σ_{tot}(p)



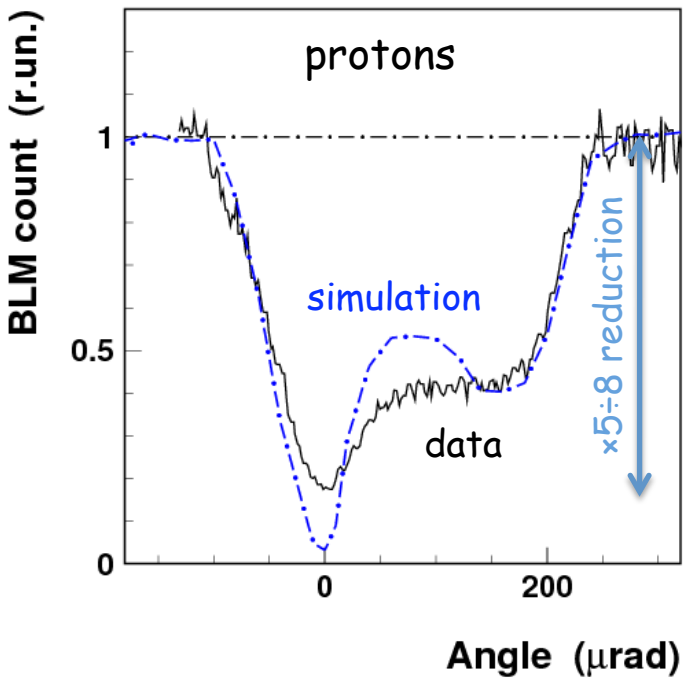


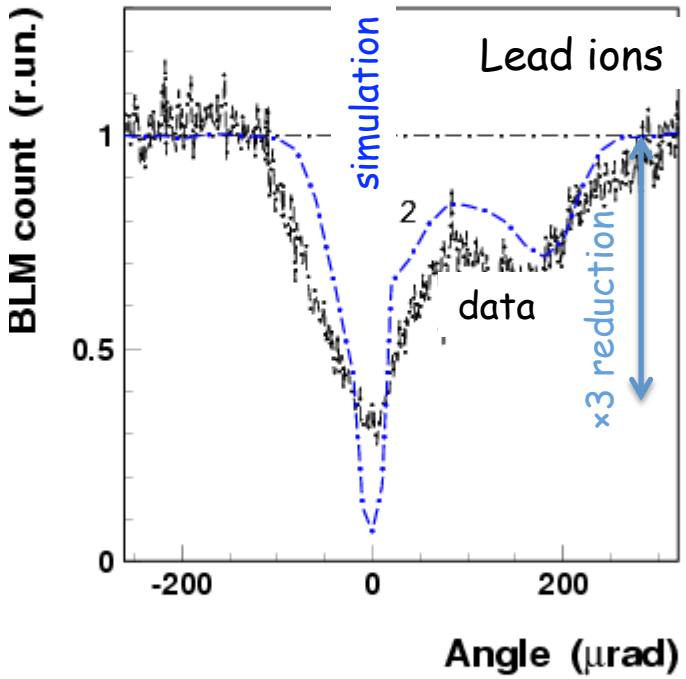
Loss rate reduction at the crystal

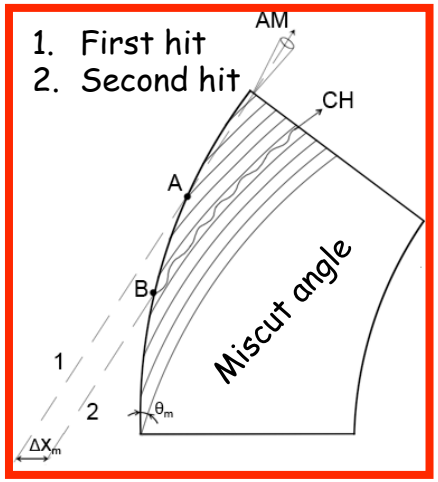


Discrepancy between data and simulation:

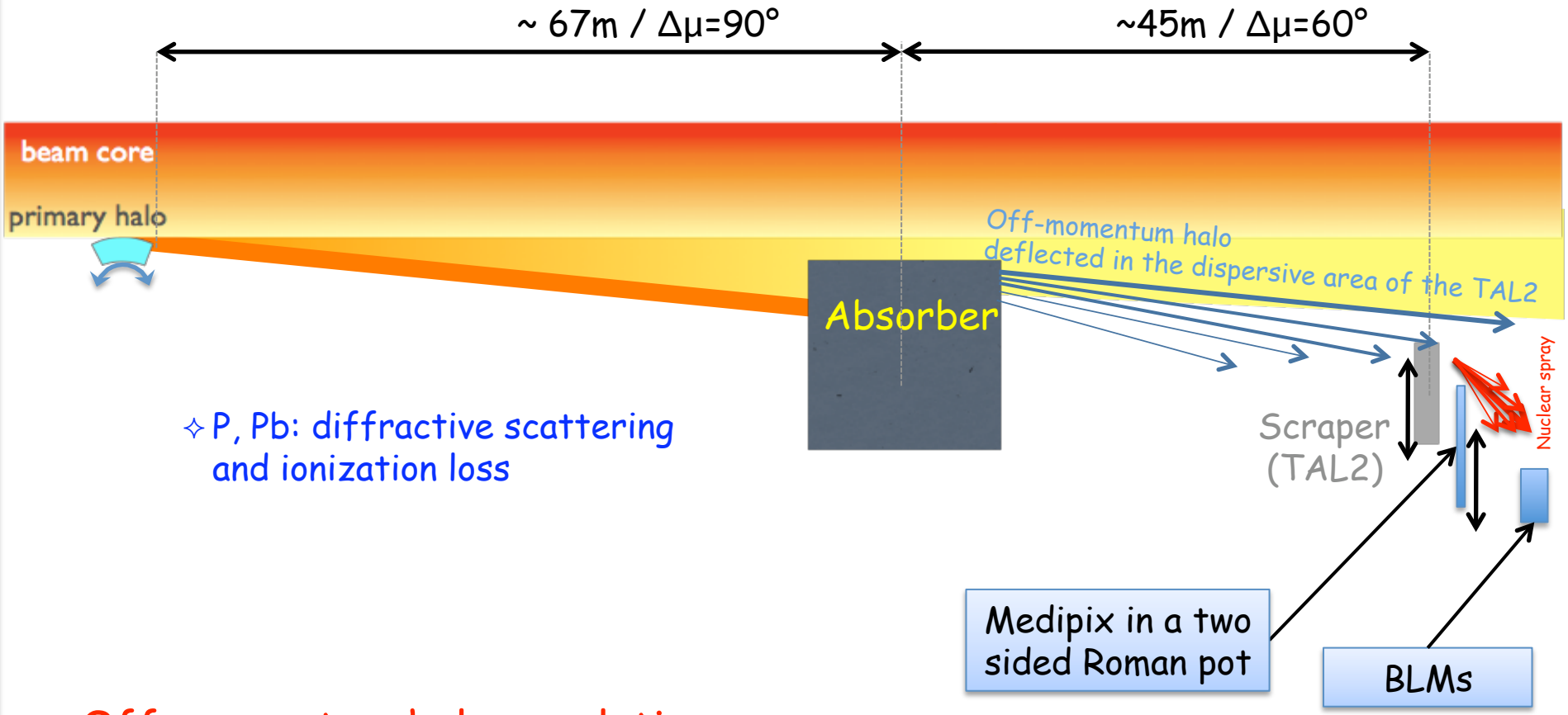
- crystal surface imperfections
- miscut angle







off-momentum halo population



✧ P, Pb: diffractive scattering and ionization loss

Off-momentum halo population

1. Linear scan made by the TAL2 (or Medipix) with the crystal in fixed orientation
2. angular scan of the crystal with the TAL2 (or the Roman pot) in fixed position in the shadow of the absorber

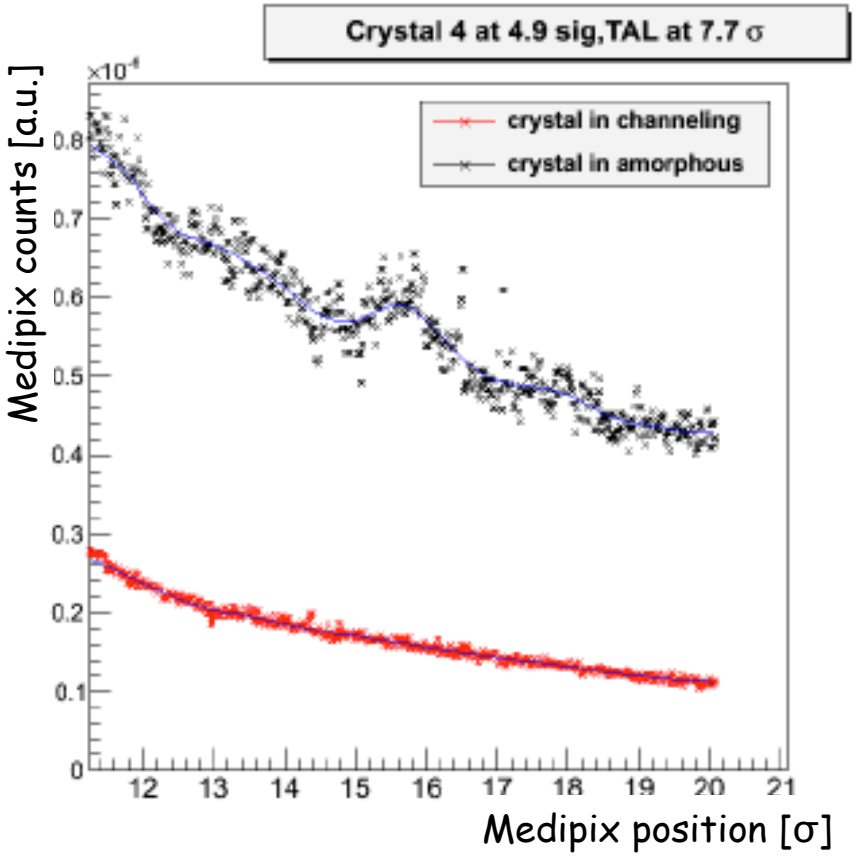
off-momentum halo: linear scans

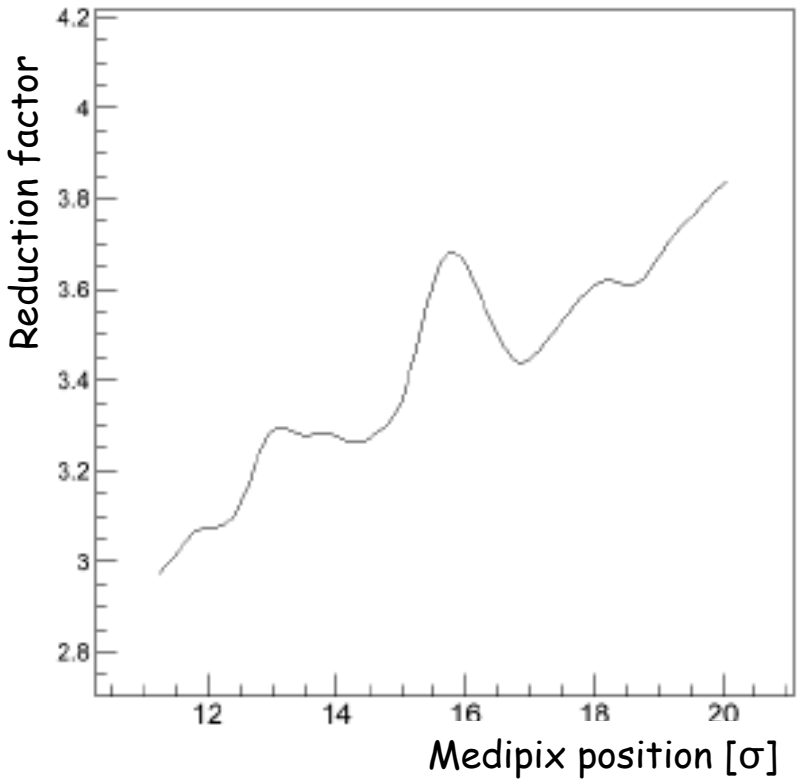
proton beams

Crystal 4

- Crystal at 4.9 σ
- TAL at 7.7 σ

scans with the Roman pot of the internal side (momentum loss side)

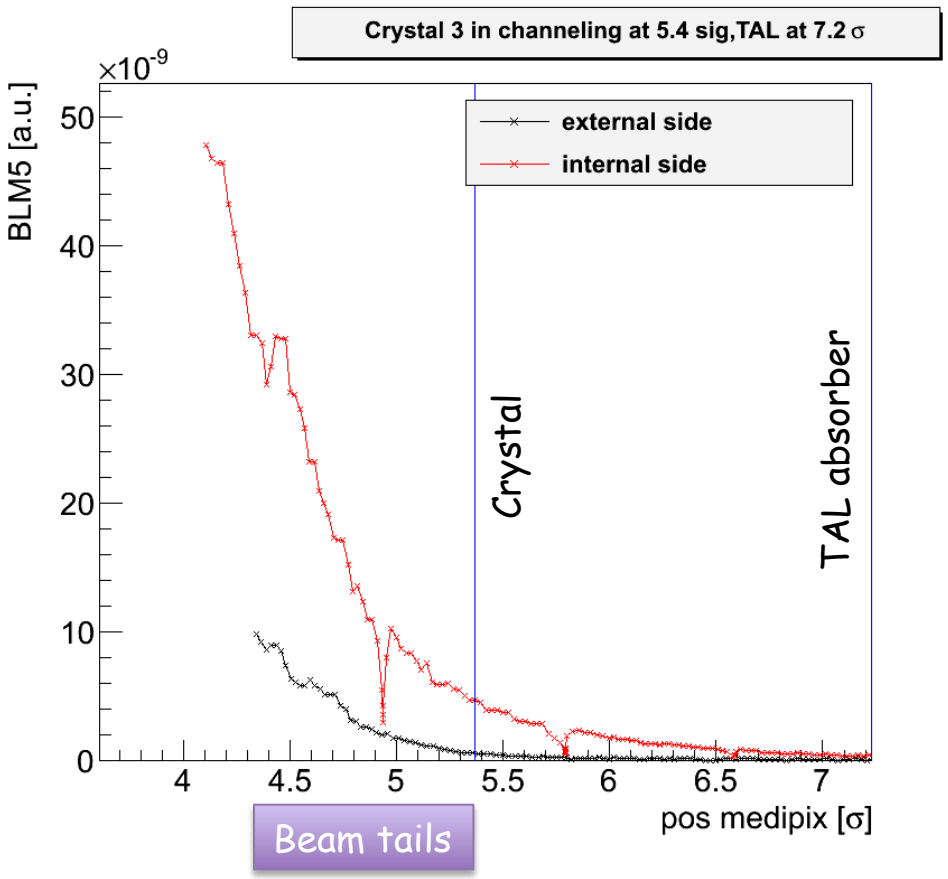




off-momentum halo: beam tails

preliminary

Loss rate as a function of the medipix position at the high-dispersion location



proton beams

Crystal 3

- Crystal at 5.4 σ
- TAL at 7.2 σ

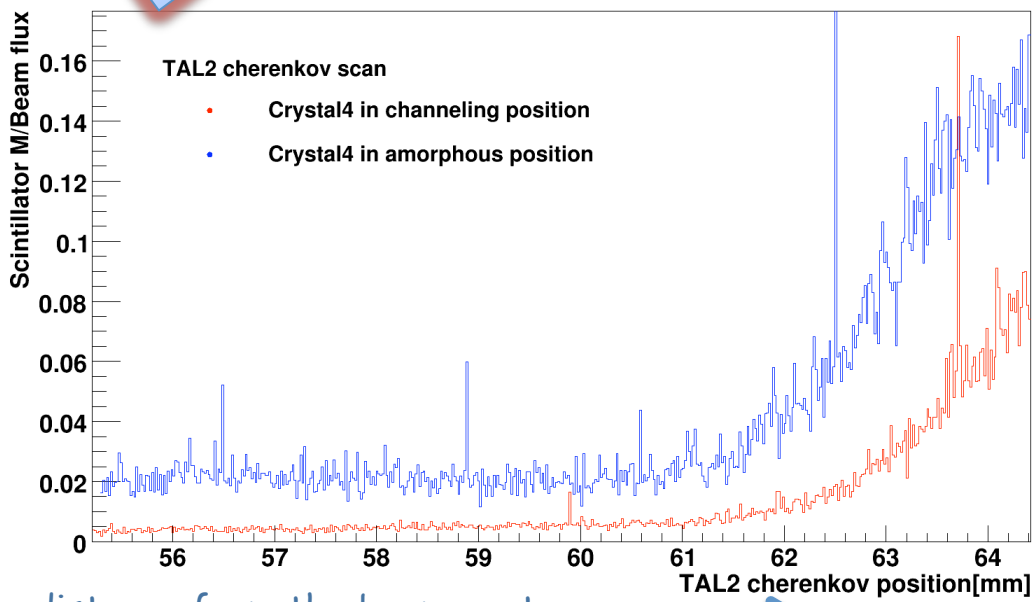
- More populated tails on the internal side than on the external side
- Particles that have lost momentum are continuously produced by the interactions with the crystal and the absorber edges

off-momentum halo: linear scan

preliminary

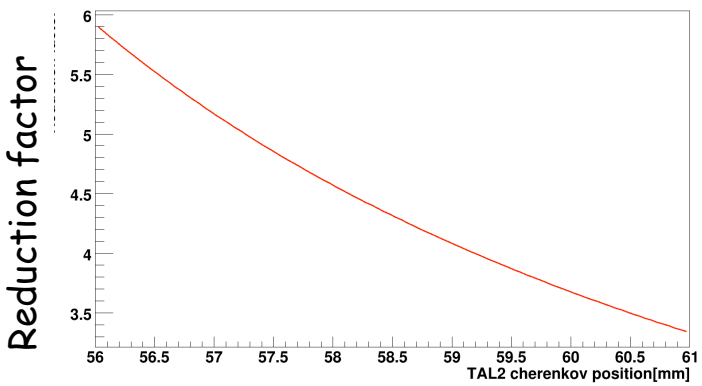
Crystal 4

Pb-ion beams



1 σ ≈ 1.2 mm

decreasing distance from the beam centre



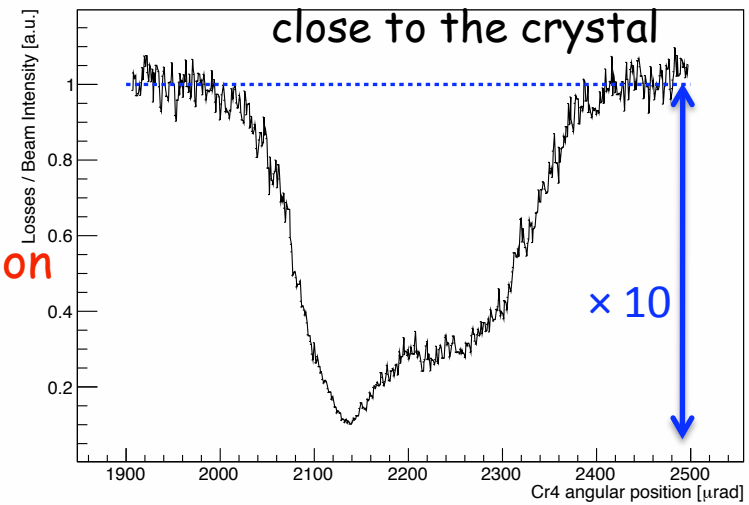
off-momentum halo: angular scans

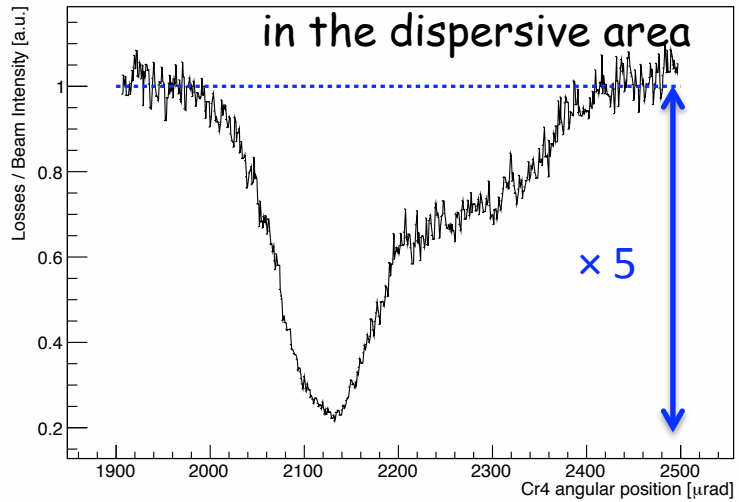
Crystal 4

proton beams

Loss rate as a function of the crystal orientation

- Crystal at 5.6 σ
- TAL at 7.6 σ
- TAL2 at 9.3σ





reduction factor in the dispersive area

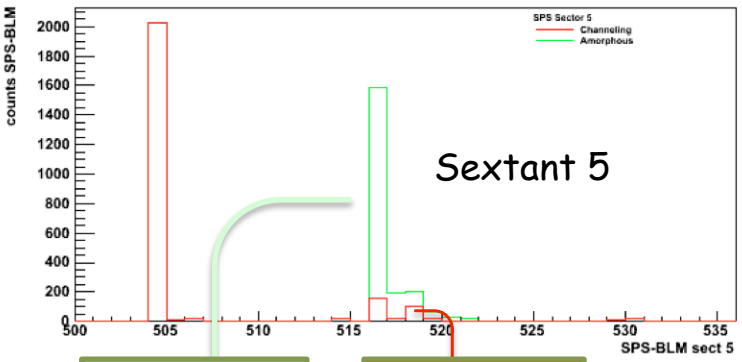
- Decreases due to off-momentum particles produced in the absorber
- Increases when the TAL2 is more and more retracted

off-momentum halo: angular scans

proton beams

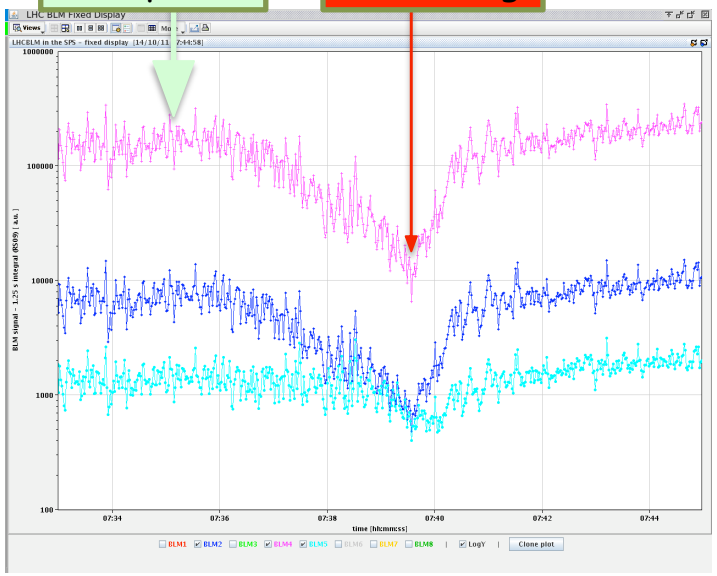
preliminary

Loss rate along the SPS



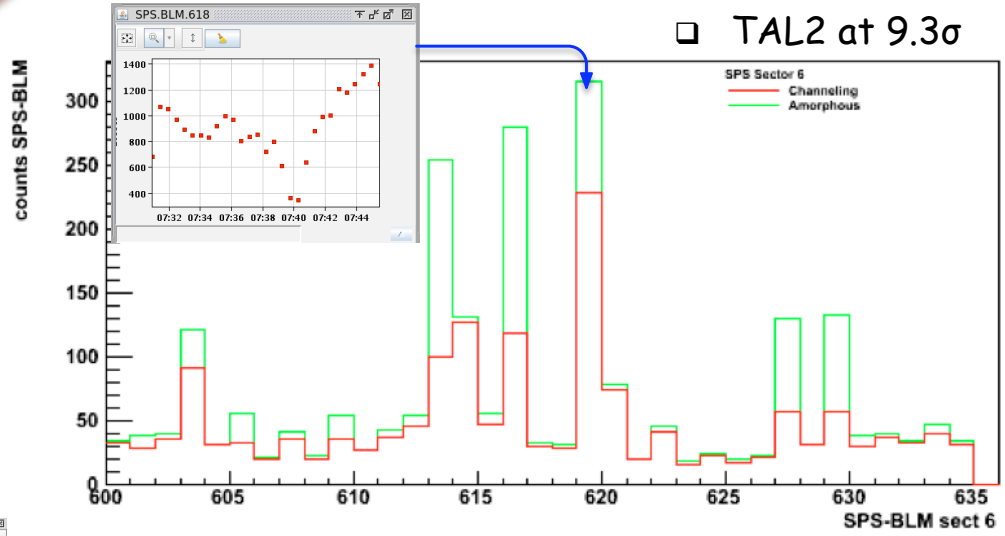
amorphous

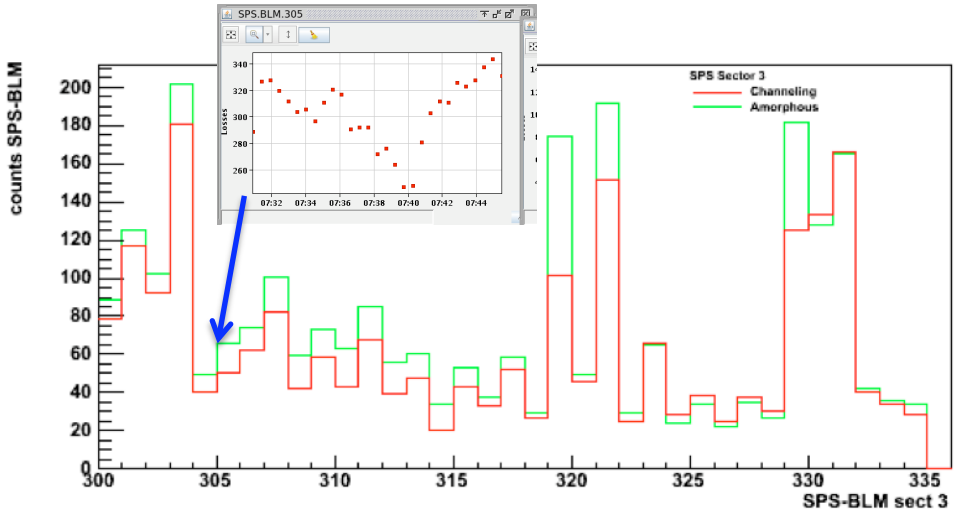
channeling



Crystal 4

- Crystal at 5.6 σ
- TAL at 7.6 σ
- TAL2 at 9.3σ





Perspective for 2012

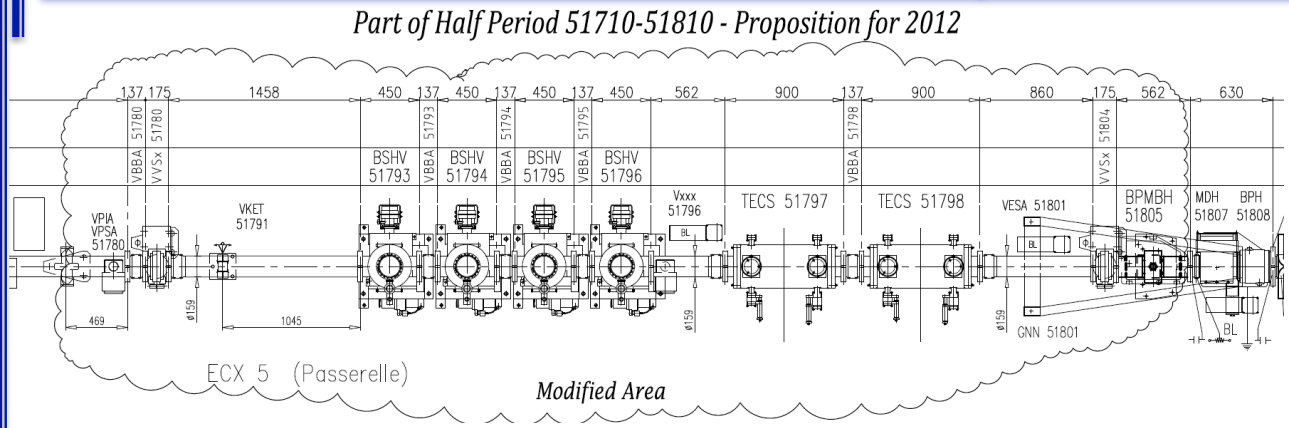
- The extension of UA9 to LHC is seen favorably by LHCC and by the accelerator directorate (to be announced soon)
  - ✓ time allocation in LHC to be shared in between the machine and the experiments (however very limited)
  - ✓ dedicated run time to avoid conflicts with the high-luminosity operation.
- UA9 in the North Area and in the SPS
  - ✓ The main goal will be to validate scenarios, detectors and hardware for LHC
  - ✓ Upgrade of the SPS experimental setup required

UA9 request to the SPSC

- 5 days in the SPS (4 with protons and 1 with Pb-ions)
- 5 weeks in H8 (3 with protons and 2 with Pb-ions)

- crystal collimation scheme for the high-intensity SPS operation.
  - ✓ Preliminary investigations based on UA9 experimental setup
  - ✓ Later an ad-hoc setup is required.
  - ✓ The collimation is requested at high-energy in pulsed mode
    - ➠ Very demanding constraints on crystal acceptance and on goniometer stability

New hardware and priorities for 2012

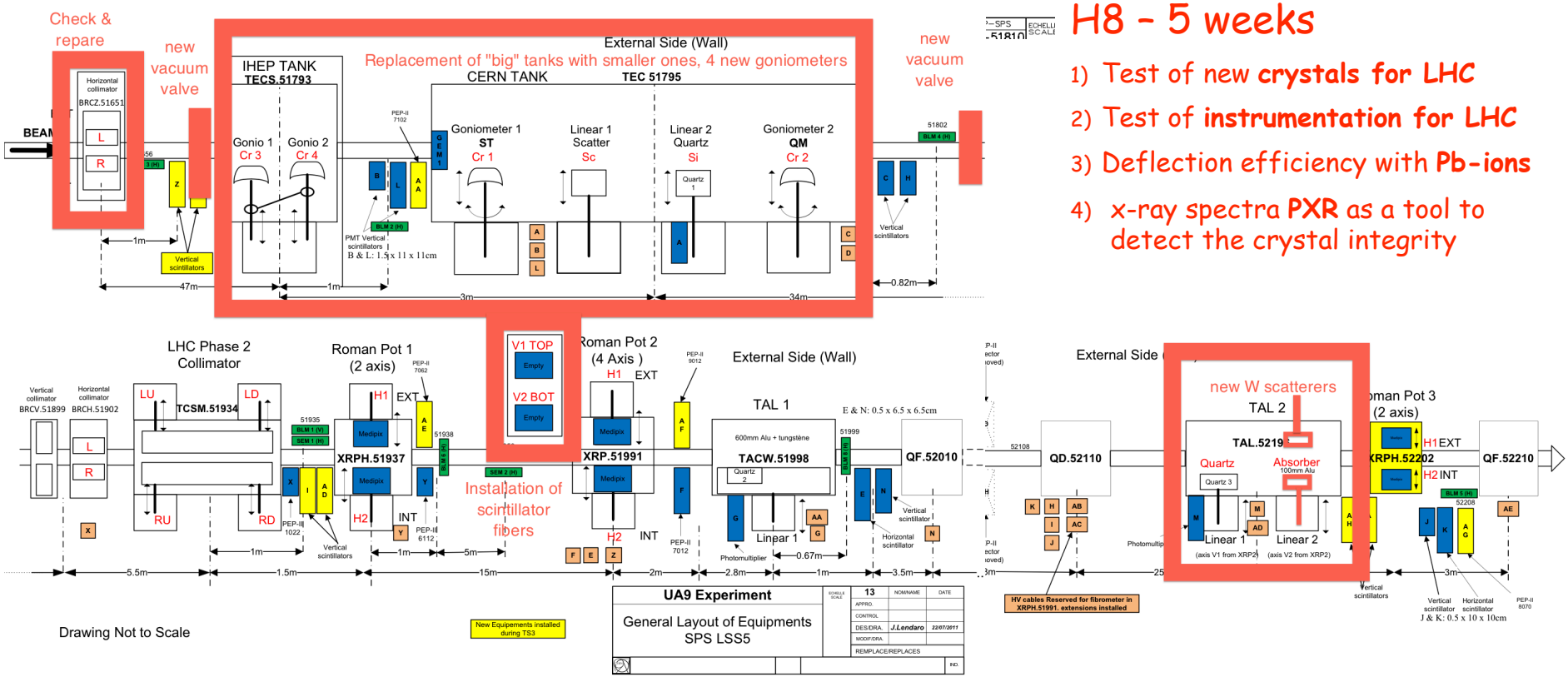


SPS – 5 full days

1) High intensity, high flux operation for **loss maps** along the SPS
2) Operation with **Pb-ions**
3) Hardware test for LHC (**crystals and goniometer**)
4) Collimation efficiency of **multi-strip crystals**

H8 – 5 weeks

1) Test of new **crystals for LHC**
2) Test of **instrumentation for LHC**
3) Deflection efficiency with **Pb-ions**
4) x-ray spectra **PXR** as a tool to detect the crystal integrity



Publications

1. W. Scandale et al., **Physics Letters B** 692 (2010) 78–82, "First Results on the SPS Collimation with Bent Crystals"

2. W. Scandale et al., **Physics Letters B** 693 (2010) 545–550, "Deflection of high-energy negative particles in a bent crystal through axial channeling and multiple volume reflection stimulated by doughnut scattering".

3. W.Scandale et al. Probability of Inelastic Nuclear Interactions of High-Energy Protons in a Bent Crystal. **Nucl. Instr. Meth. B**, 268 (2010) 2655.

4. W.Scandale et al. Multiple volume reflections of high-energy protons in a sequence of bent silicon crystals assisted by volume capture. **Phys. Letters B**, 688 (2010) 284.

5. W.Scandale et al., Observation of Multiple Volume Reflection by Different Planes in One Silicon Crystal for High-Energy Negative Particles. **EPL** 93 (2011) 56002.

6. W. Scandale et al, **JINST**, 1748-0221_6_10_T10002, Geneva (2011), "The UA9 experimental layout".

7. W, Scandale et al., **Physics Letters B** 701 (2011) 180–185, "Observation of parametric X-rays produced by 400 GeV/c protons in bent crystals".

8. W. Scandale et al., **Physics Letters B** 703 (2011) 547–551, "Comparative results on collimation of the SPS beam of protons and Pb ions with bent crystals".

9. W. Scandale et al., "Status of UA9, the Crystal Collimation Experiment in the SPS", Invited talk at the **IPAC11**, San Sebastian, Spain, September 2011.

acknowledgments

- The EN/STI group was of an extraordinary support to UA9
- BE/OP-BI-RF groups carefully prepared the SPS for our needs
- Special thanks to our funding agencies, reference Committees and Referees