

Status of UA9

Walter Scandale

For the UA9 collaboration

(CERN, INFN, IHEP, Imperial College, PNPI, JINR, SLAC, LBNL)

SPSC No. 98

28 September 2010

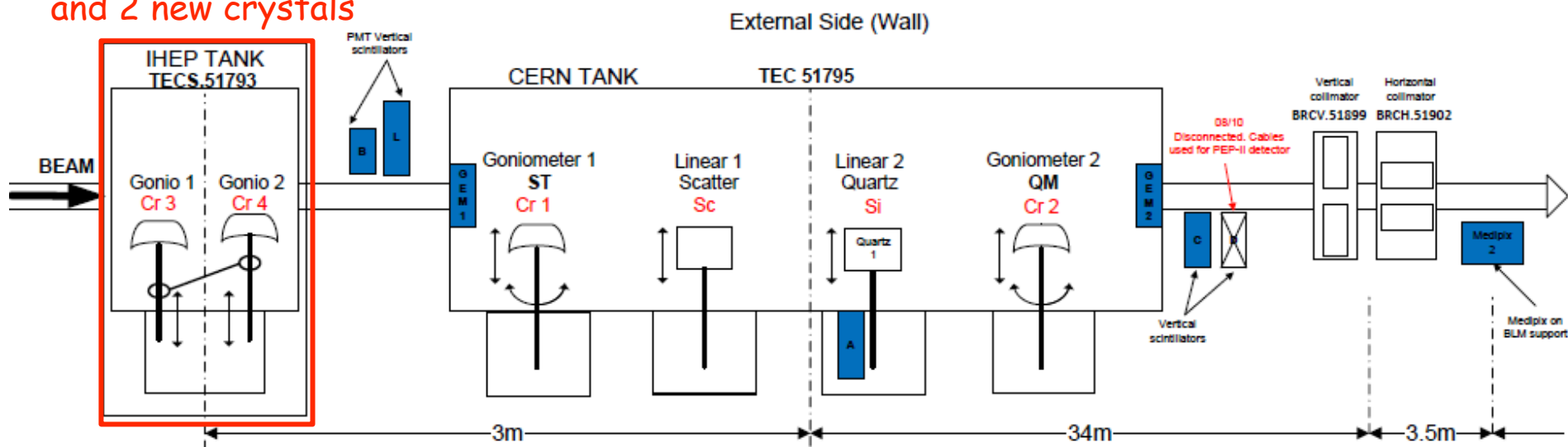
November 2009:

plans and requests of UA9 to the SPSC No. 94

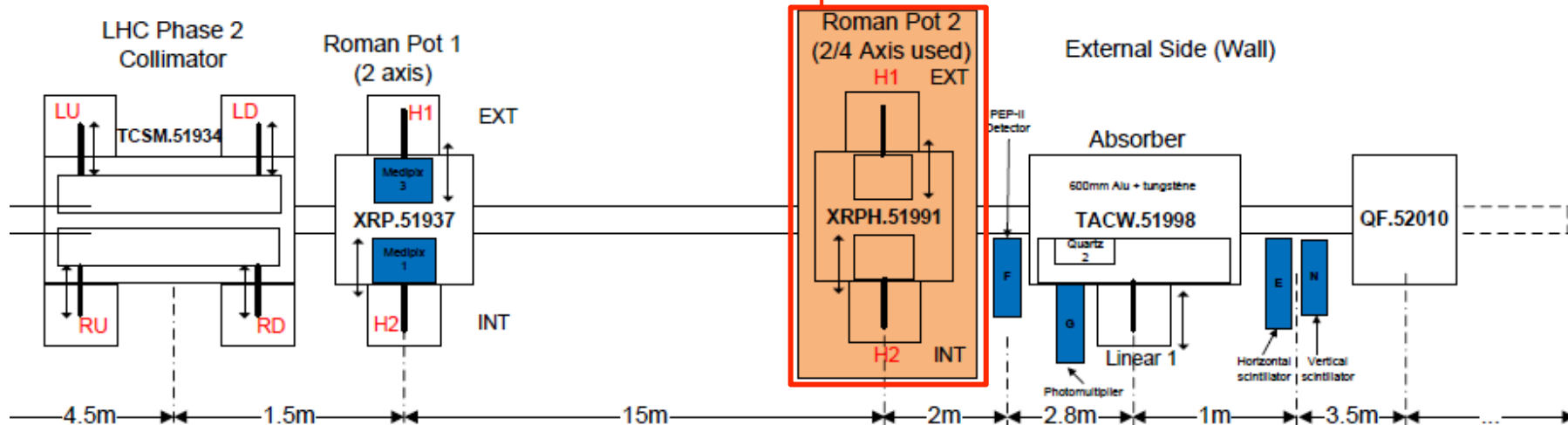
- ◆ Dedicated runs in the SPS and in the North Area also during 2010
 - ◆ SPS: 5 full days of dedicated operation in storage mode at 120 GeV/c
 - ◆ North Area: 5 full weeks of dedicated operation in H8 with a micro-beam
- ◆ Additional hardware installation in the SPS
 - ◆ The IHEP goniometer with two new crystals
 - ◆ Roman pot 2 with medipix
 - ◆ New station in the high dispersive area of the SPS after the crystal-collimation set (upstream of QF5-22) containing
 - ◆ Aluminum stopper
 - ◆ Cherenkov in vacuum
 - ◆ The aim is to detect the collimation leakage and the diffractive events

UA9 device in 2010 (1/2)

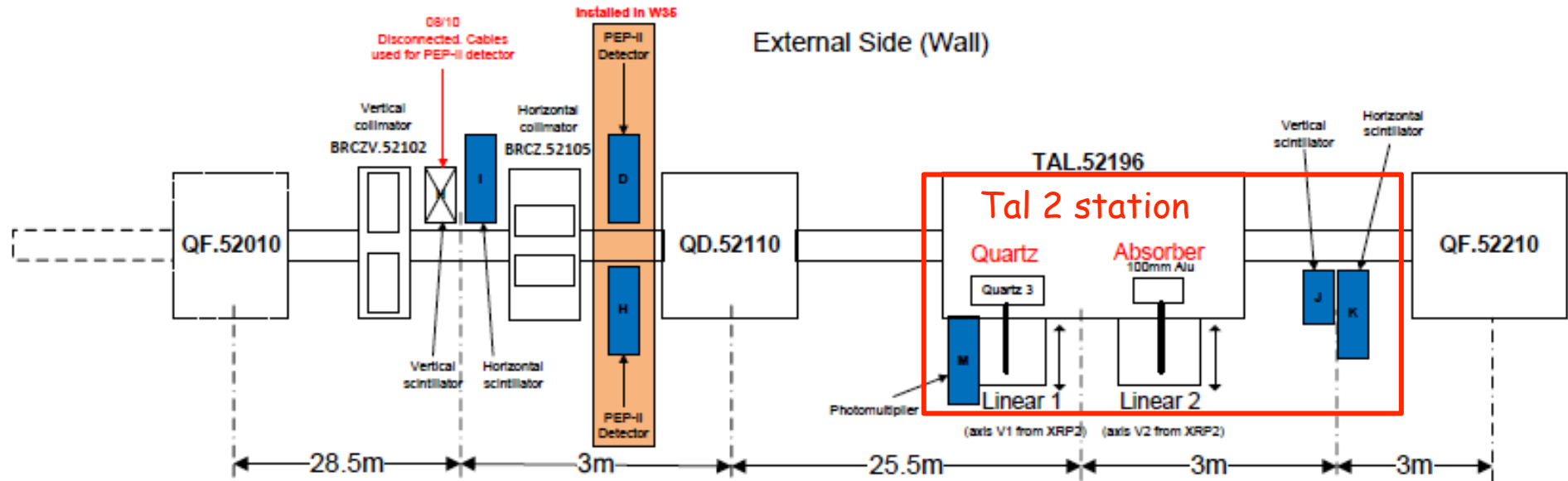
New goniometer and 2 new crystals



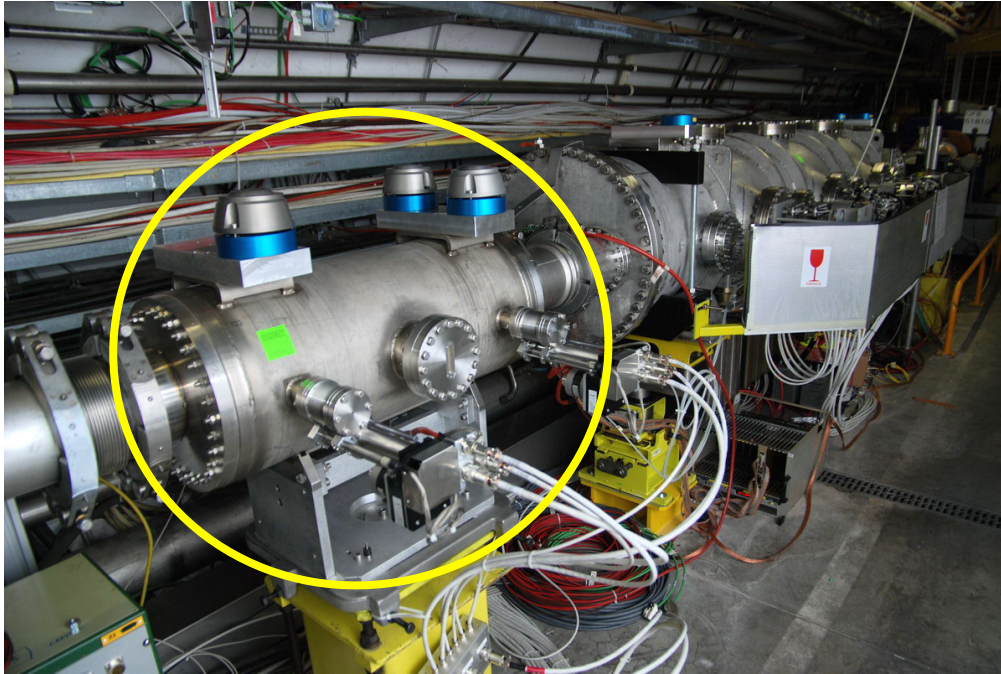
Roman pot without detectors



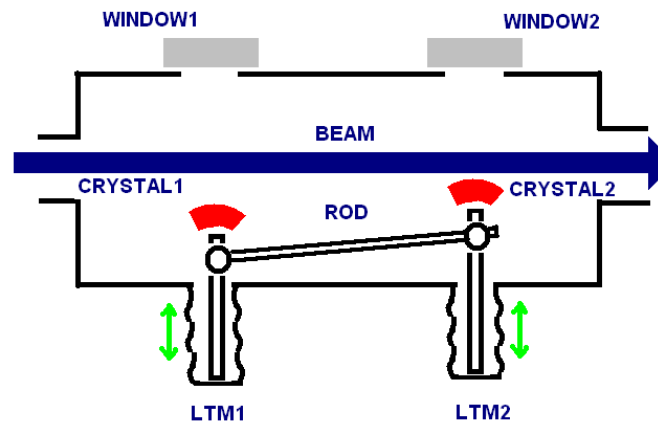
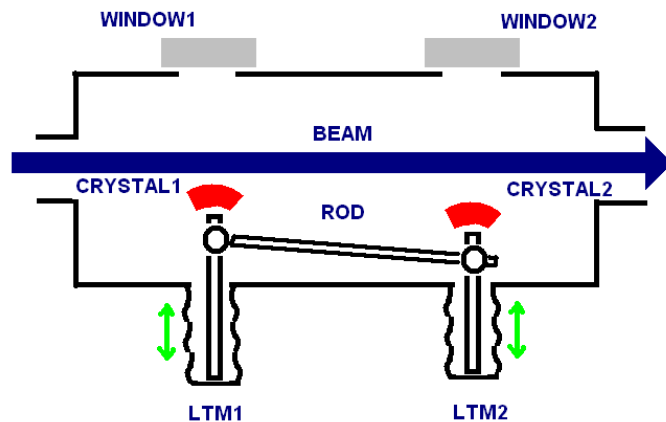
UA9 device in 2010 (2/2)



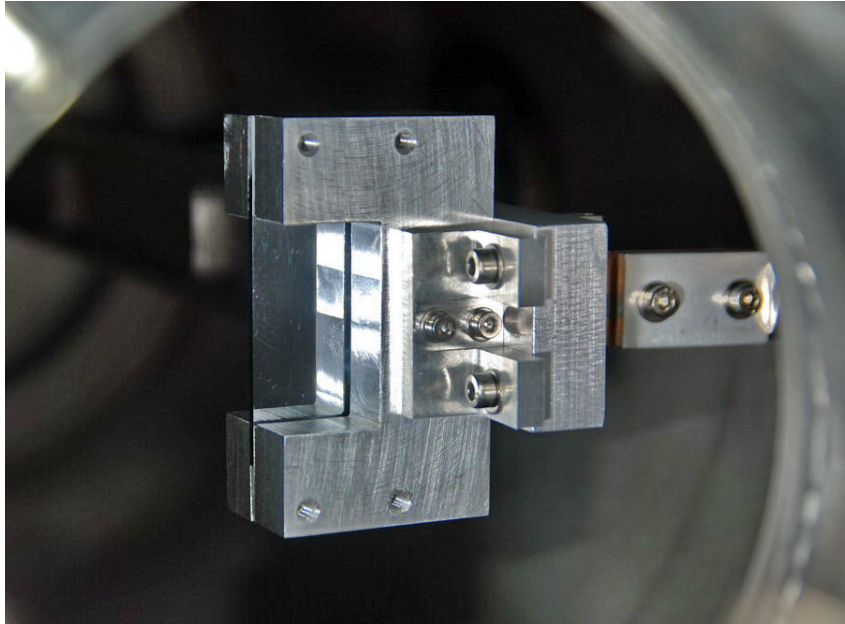
The IHEP goniometer



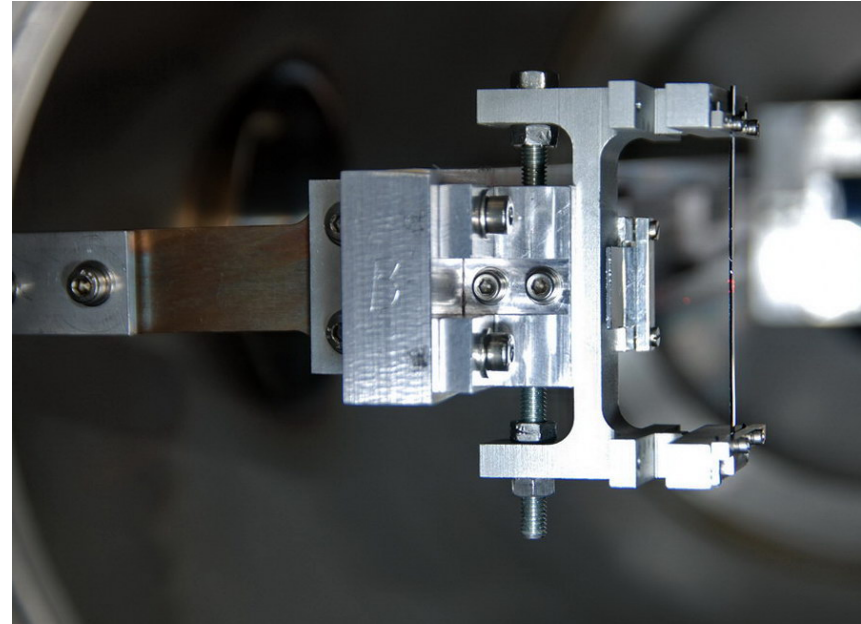
- ◆ Installed upstream of the RD22 tank
- ◆ It supports two new crystals
- ◆ Angular resolution $\pm 10 \mu\text{rad}$



The two new crystals

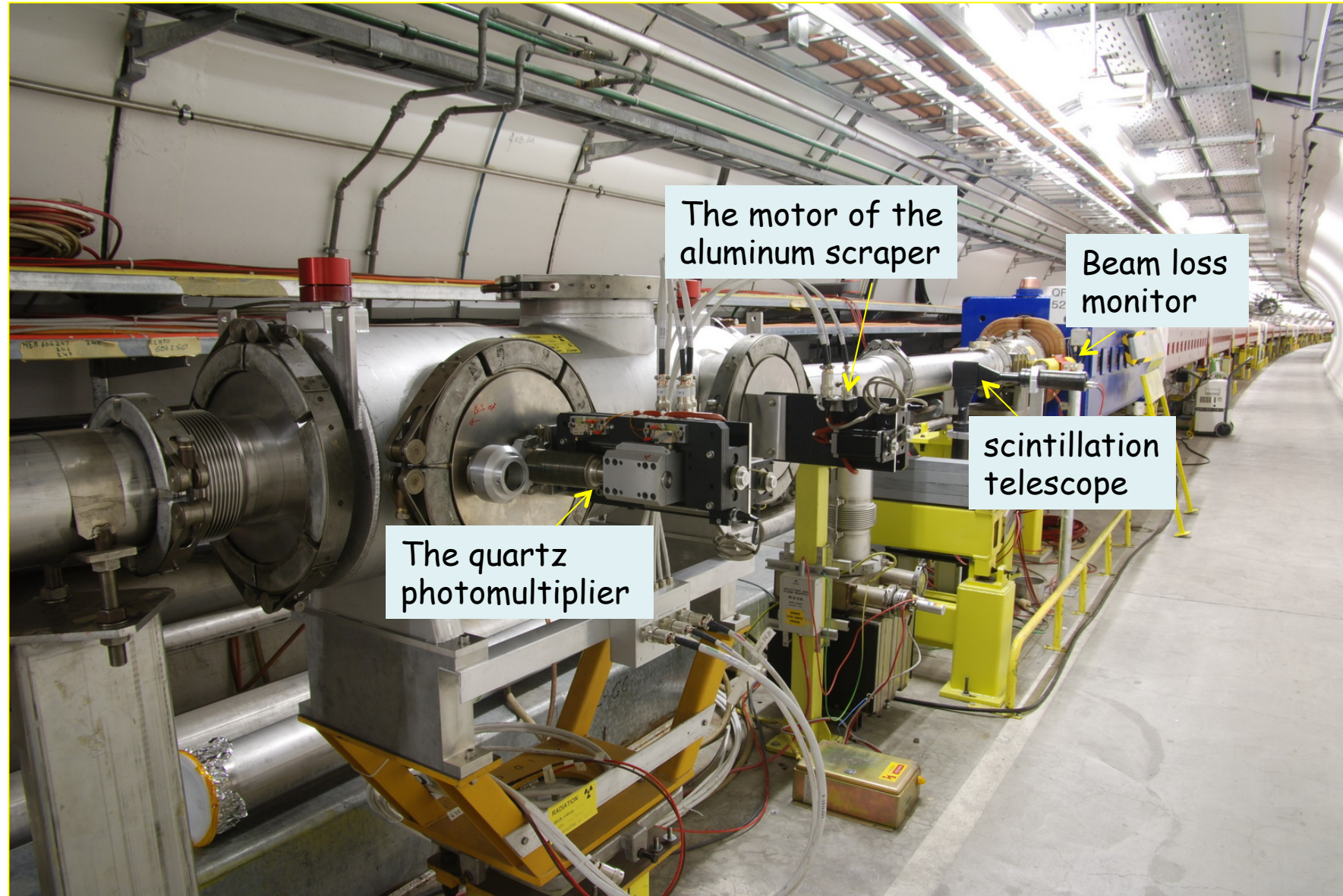


- ◆ Quasimosaic crystal supported by a large frame to avoid loss of large amplitude particles



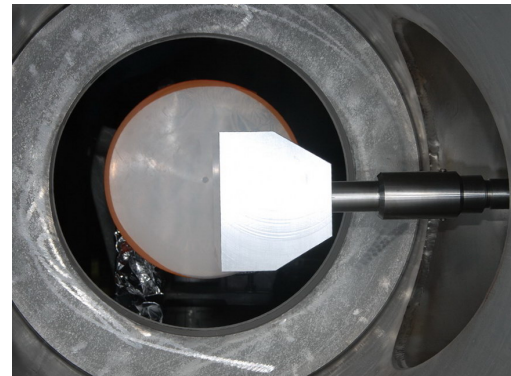
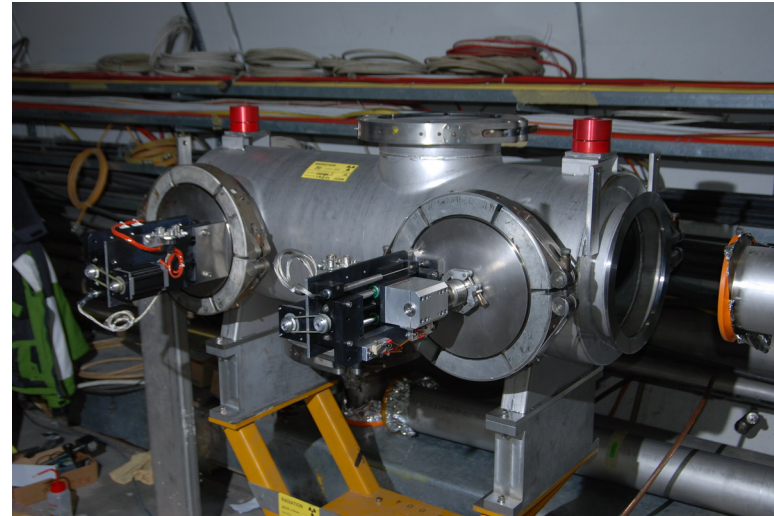
- ◆ Strip crystal supported by a large bending frame to avoid loss of large amplitude particles

The TAL 2 in the missing magnet half-cell

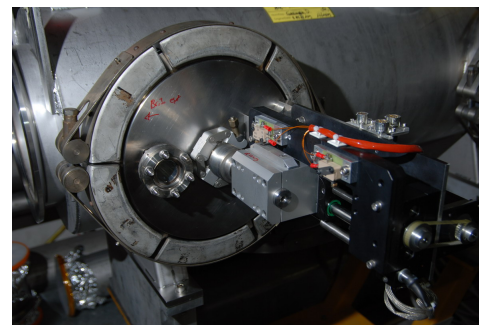


The TAL2 in the dispersive area

- ◆ The **TAL 2** is installed in the **dispersive area** of the missing magnet, just down stream of the absorber-TAL
- ◆ It should intercept
 - ◆ halo not absorbed by the crystal collimation system
 - ◆ Off-momentum particles produced in the crystal
- ◆ The measurement is based on the scanning of the beam peripheral
- ◆ The observable is
 - ◆ Either the spray rate produced in a aluminum scraper
 - ◆ Or the spray rate measured by the Cherenkov quartz



Aluminum
scraper

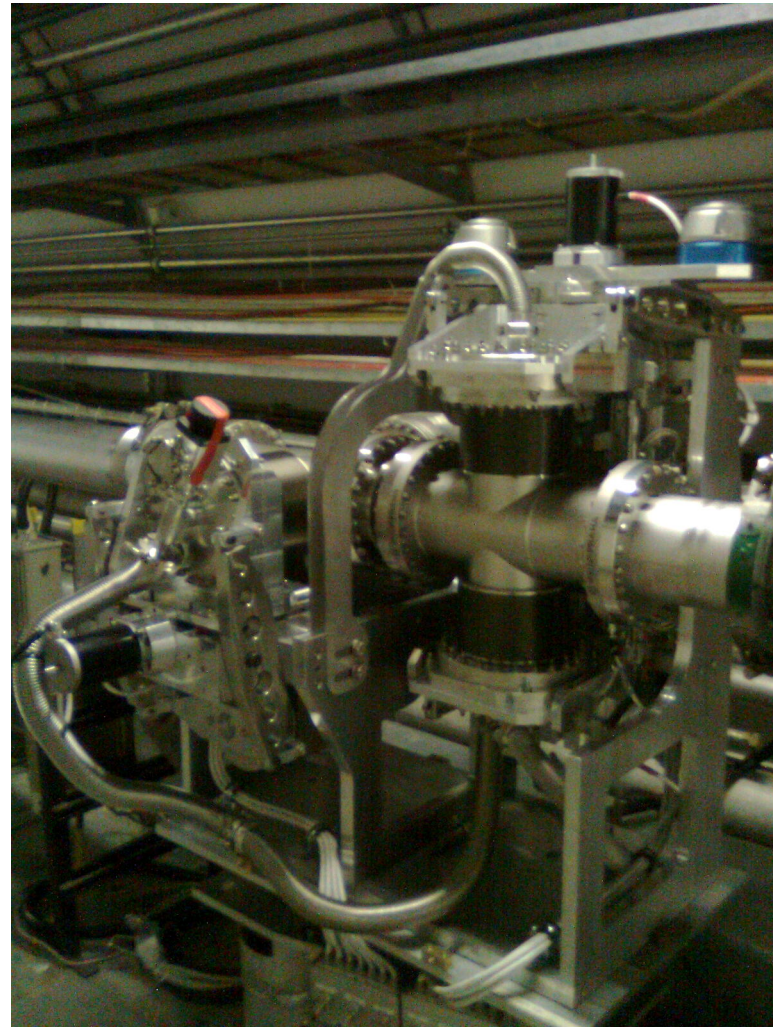


Quartz
Cherenkov

The Roman pot 2

◆ RP2 setup

- ❑ Very close to TAL, better position to see channeled beam!
- ❑ No detectors yet
- ❑ Place to install 4 Medipix (2 Horiz and 2 Vert.)
- ❑ Relevant to measure channeled beam direction in conjunction with the RP1 (from centroids)



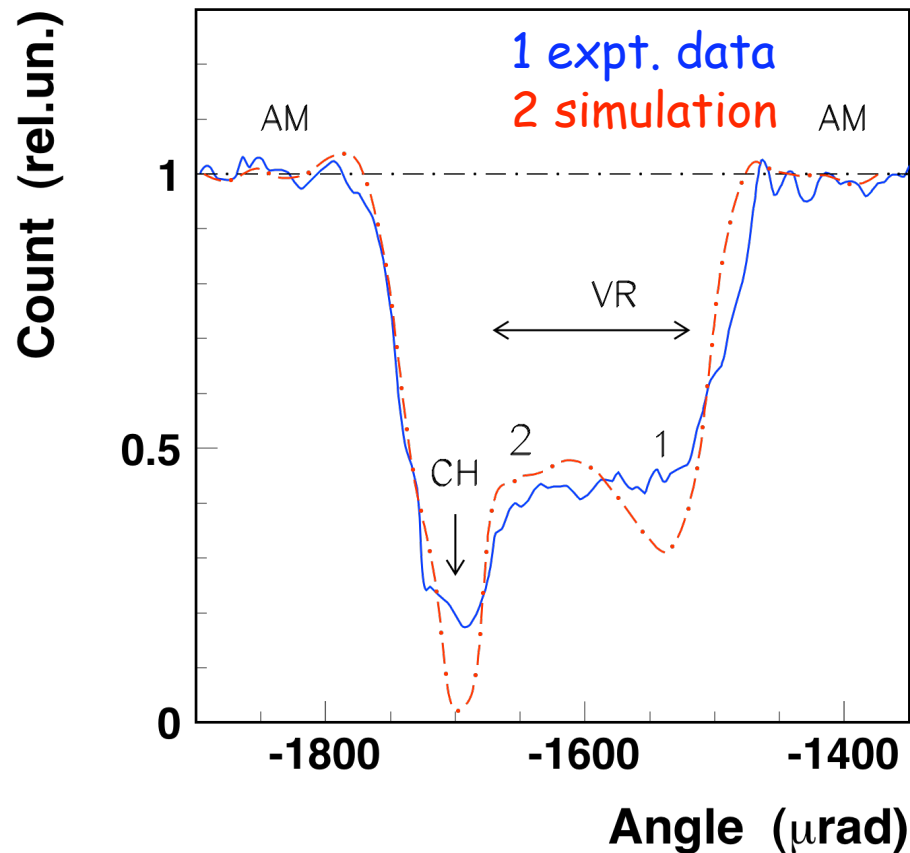
UA9 summary results of the 2010 MDs

- ◆ Runs already undertaken in the SPS and in the North Area
 - ◆ SPS: 3 days of dedicated operation in storage mode at 120 GeV/c (efficiency 70%)
 - ◆ North Area: 2 weeks of dedicated operation in H8 with a micro-beam
- ◆ Crystal collimation works very well based on *channeling process*
 - ◆ Optimal crystal alignment easily detected and achieved
- ◆ *Collimation leakage* in amorphous orientation larger than in channeling
 - ◆ *Collimation leakage* rate reduced by more than a factor of 5 at the TAL2 in the dispersive location (sextant 5, position 22)
- ◆ *Nuclear loss rate* (including diffractive) strongly depressed
 - ◆ In channeling versus amorphous mode : $\times 16$ in multi-turn (SPS)

Analysis of the 2009 results

W. Scandale et al. / Physics Letters B 692 (2010) 78-82

Crystal no. 1 (strip)



- ◆ Loss reduction in channeling mode ($\times 5$)

- ◆ smaller than in MonteCarlo simulation ($\times 36$)

- ◆ Deflection angle and loss rate depression varying from scan to scan: alignment errors induced by

- ◆ vertical torsion of the crystal

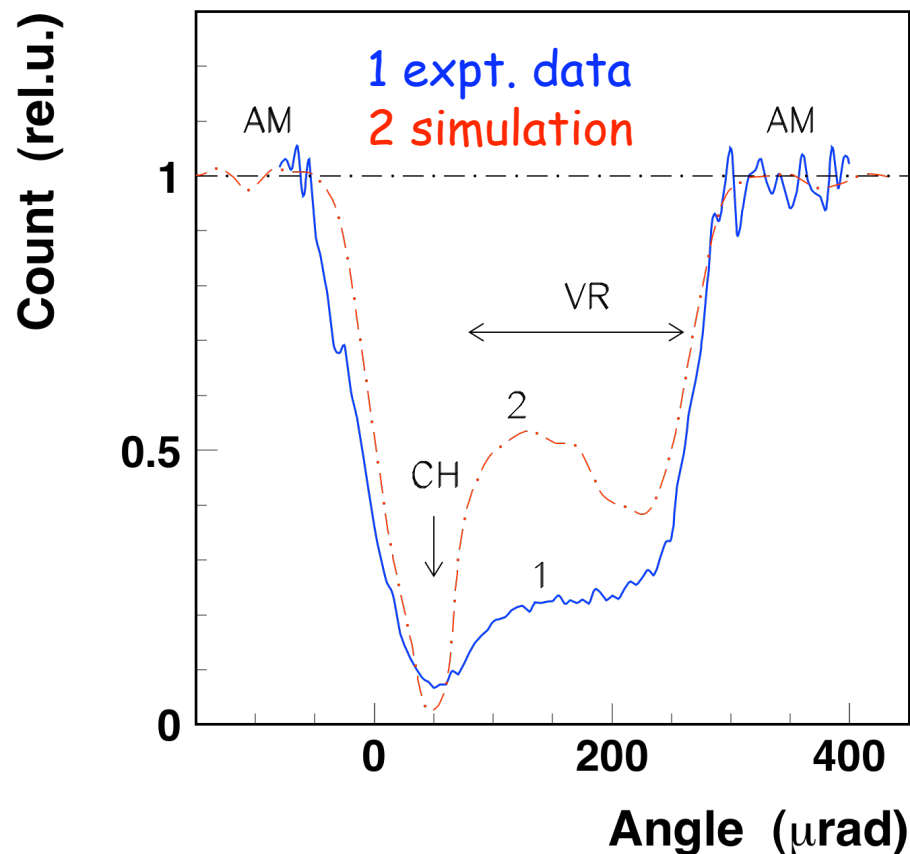
- ◆ inaccuracy of the Goniometer

Deflection efficiency for crystal 1 and 2 : $(75\pm 4)\%$ and $(85\pm 5)\%$

Results in 2010: angular scan of crystal 3

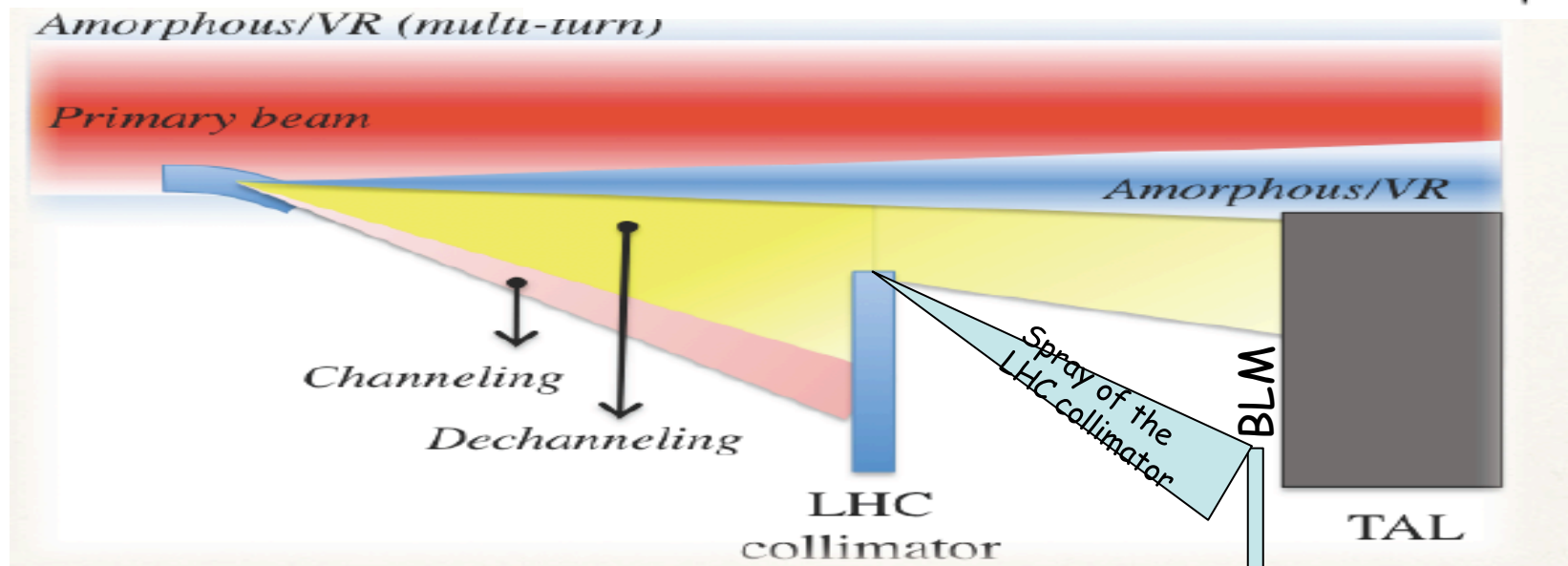
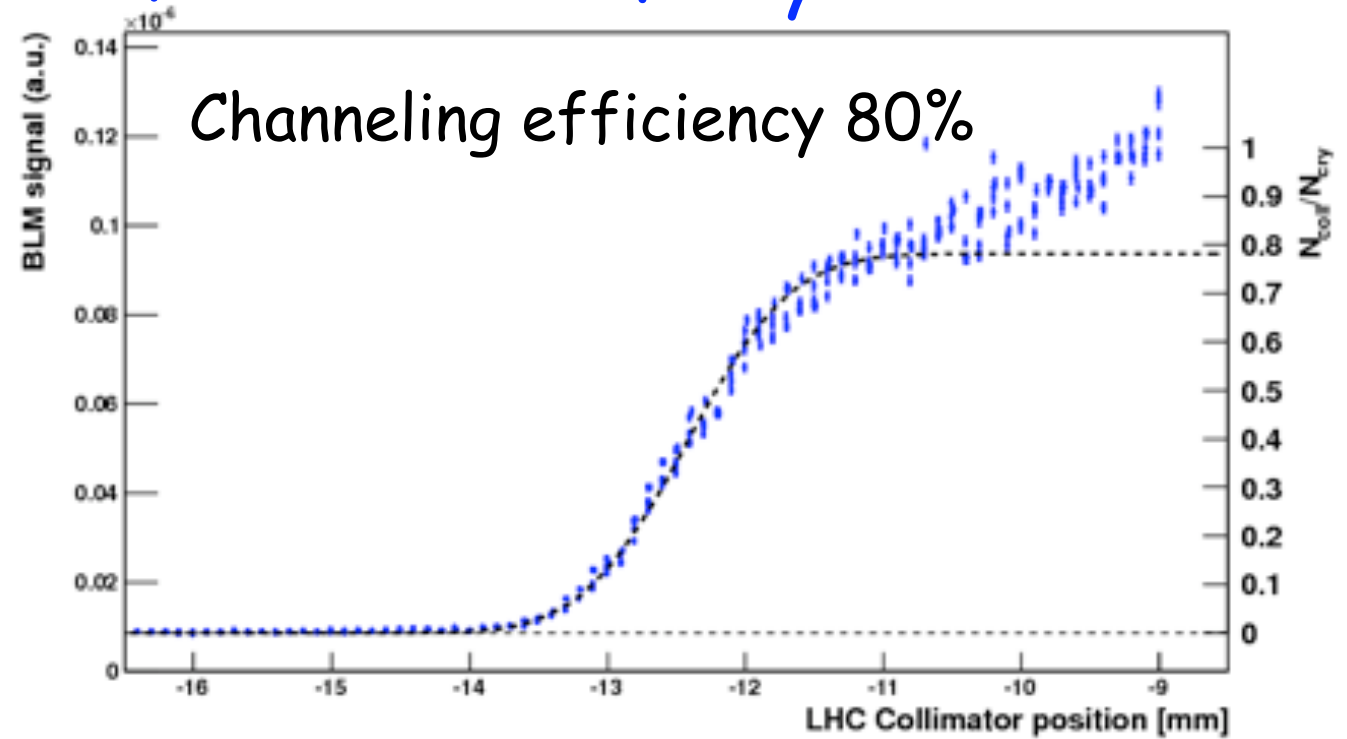
Crystal no. 3 (quasimosaic)

- ◆ with a small residual torsion
- ◆ operated by the IHEP high quality goniometer

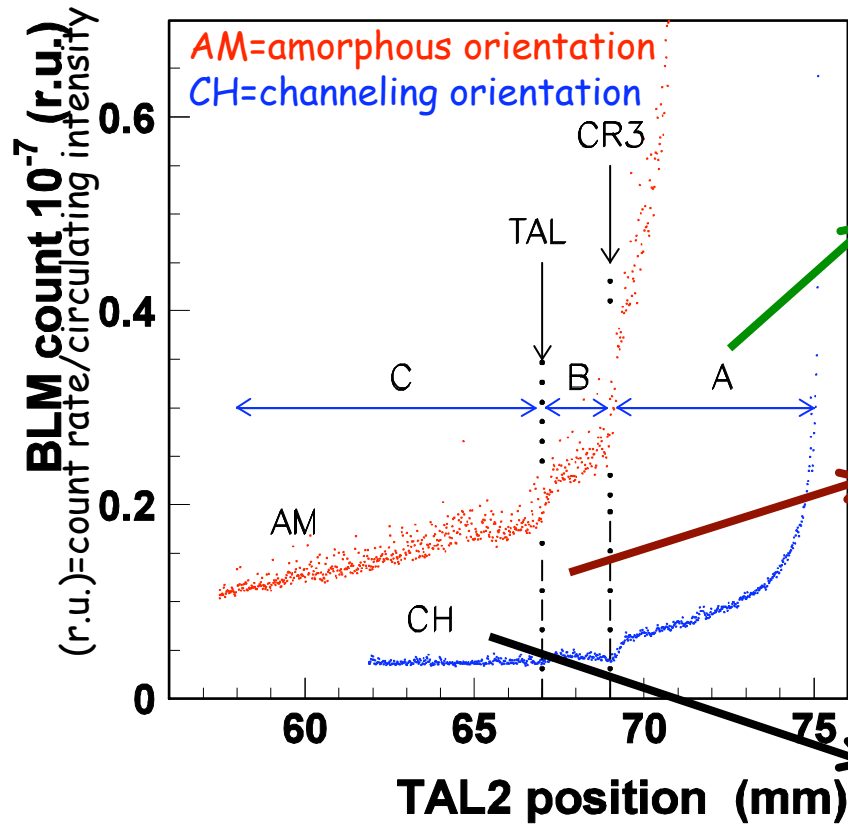


- ◆ Loss reduction in channeling mode ($\times 16$)
 - ◆ smaller than in MonteCarlo simulation ($\times 33$)
 - ◆ larger than in crystal 1 ($\times 5$)
- ◆ Small variations of the deflection angle in different scans [better control of the alignment errors]
- ◆ Why such an improvement ?
 - ◆ Lower vertical torsion of the crystal
 - ◆ Smaller inaccuracy of the Goniometer
- ◆ Loss depression in VR mode with respect to MonteCarlo simulation still under investigation

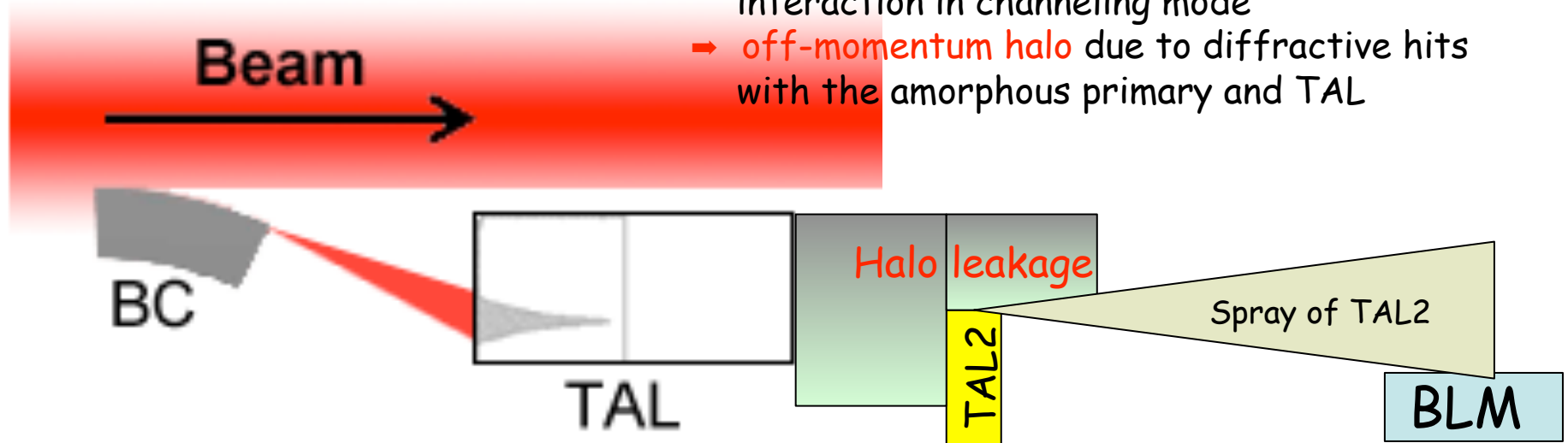
LHC collimator scan of crystal 3



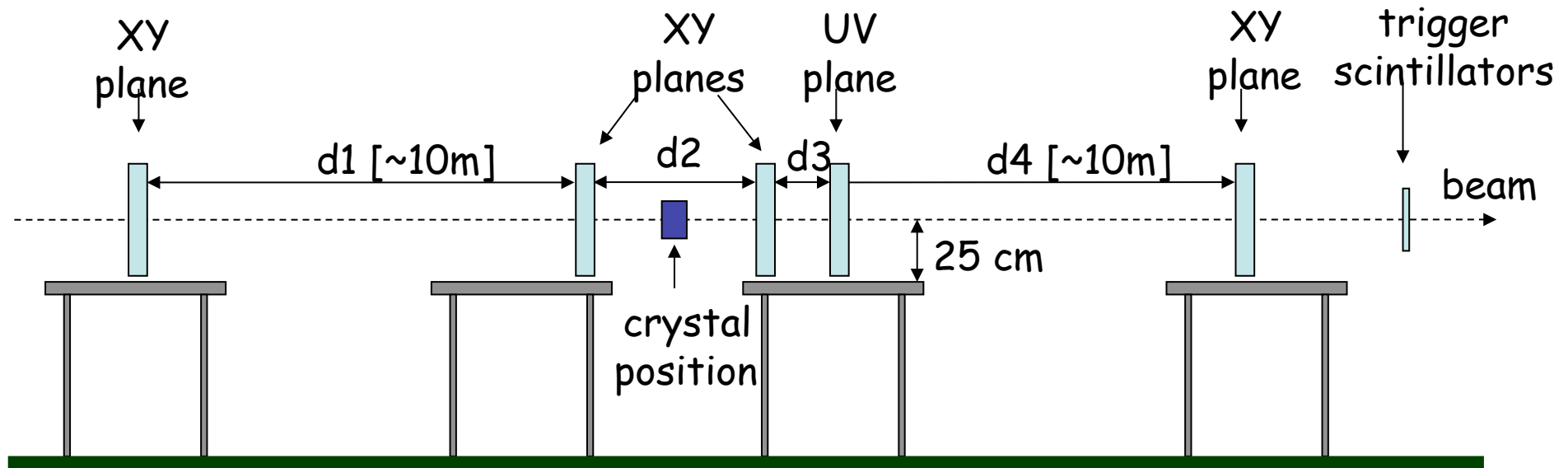
Collimation leakage in a high dispersive area



- ◆ A) tail of the circulating beam
 - fast depletion in channeling mode
 - linear descent of the population in amorphous orientation (or with the tungsten scatterer)
- ◆ B) multiple Coulomb scattering area
 - fast depletion by high probability of prompt channeling at the first crystal hit
 - slow depletion due to multi-turn hits of the amorphous primary (very slow extraction)
- ◆ C) shadow of the absorber
 - low population due to low probability of nuclear interaction in channeling mode
 - off-momentum halo due to diffractive hits with the amorphous primary and TAL



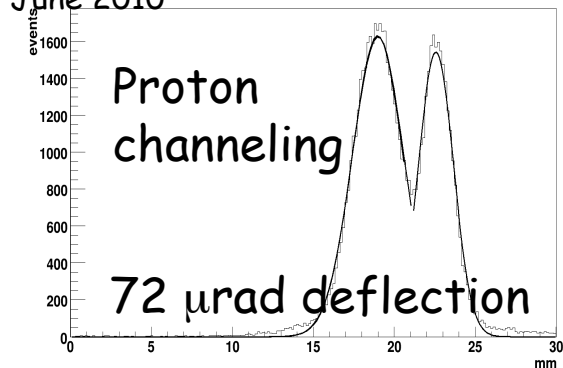
Sep 2010 H8 telescopes



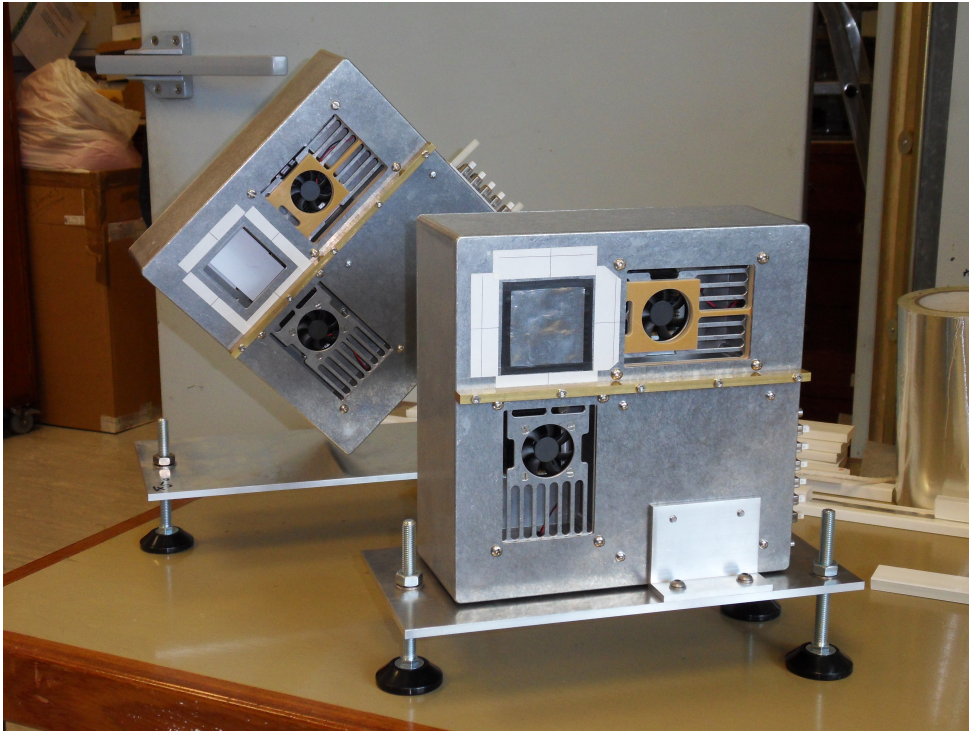
- ◆ 5 planes altogether (10 silicon strip sensors) each plane provides 2 co-ordinates: XY or UV
- ◆ UV plane = XY plane rotated through 45° (resolves ambiguities for multiple hits / trigger)
- ◆ 65 m downstream: TPC- GEM and Medipix (fast scan) + Planar GEM

Image with the TPC-GEM

June 2010



Si strip detector



- › CMS LHC Si strip readout system
- › Provided by Imperial College group
- › DAQ, calibration, raw data and recorded
- › Tested in H8 in June one telescope working suitable for UA9 physics investigation

What next ?

- ◆ Complete the runs in 2010 (pending request of one additional shift of 8 h to partly compensate the two UA9 shifts used to fill LHC)
- ◆ Main goals
 - ◆ Improve the estimate of the collimation efficiency
 - ◆ Improve loss map detection in the dispersive area
 - ◆ Test the remaining crystals
 - ◆ Add one or two Medipix in the Roman pot 2
 - ◆ Test with IONS Pb₈₂
- ◆ Extension of the UA9 apparatus in the 2011 winter shutdown
 - ◆ Replace gonios 1 and 2 with more accurate short goniometers (suited for LHC)
 - ◆ Complete the beam loss detectors (a coincidence telescope everywhere)
 - ◆ Fill the RP2 with 4 medipix and 2 fiber hodoscopes
 - ◆ Add SPS collimators and loss detectors in 2 more areas to introduce betatronic aperture restrictions.

Beam request for 2011

- ◆ In the SPS - 6 full days (1 more than in 2010)
- ◆ Main goals
 - ◆ Complete the assessment of crystal collimation for p beams
 - ◆ Extend the findings with IONS Pb₈₂
- ◆ In H8 - 5 weeks
 - ◆ Test of new crystals in view of using them in LHC
 - ◆ Test goniometers to be used in LHC
 - ◆ Extend to IONS our finding on single-pass loss produced during the crystal traversal

Publications in 2010

- ◆ *Observation of channeling and volume reflection in bent crystals for high-energy negative particles* Physics Letters B 681 (2009) 233-236
- ◆ *First observation of multiple volume reflection by different planes in one bent silicon crystal for high-energy protons* Physics Letters B 682 (2009) 274-277
- ◆ *Multiple volume reflections of high-energy protons in a sequence of bent silicon crystals assisted by volume capture* Physics Letters B 688 (2010) 284-288
- ◆ *Probability of inelastic nuclear interactions of high-energy protons in a bent crystal* Nuclear Instruments and Methods in Physics Research B 268 (2010) 2655-2659
- ◆ *IPAC10 (INT. CONF. ACC. PART. 2010)*
 - ◆ CRYSTAL COLLIMATION EFFICIENCY MEASURED WITH THE SPS UA9 EXPERIMENT
 - ◆ UA9 BEAM LOSS MONITOR OPERATION AND DATA ANALYSIS
 - ◆ MEASUREMENT OF NUCLEAR REACTION RATES IN CRYSTALS USING THE CERN-SPS NORTH AREA TEST BEAMS
 - ◆ UA9 INSTRUMENTATION AND DETECTORS IN THE CERN-SPS
 - ◆ MANIPULATION OF NEGATIVELY CHARGED BEAMS VIA COHERENT EFFECTS IN BENT CRYSTALS

acknowledgments

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

2011 road-map for a test in LHC

- ◆ Crystals in preparation at PNPI and INFN-Ferrara to be tested in H8
- ◆ Goniometer in preparation with and industrial partnership with CINEL, to be tested in H8
- ◆ Special instrumentation [loss detectors and mini-Roman pots] in preparation at CERN with the help of INFN and Imperial College to be tested at the SPS
- ◆ Layout and simulations under investigation at CERN

Parameters	Obtained in 2009	Obtained in 2010	Required for LHC
Channeling efficiency, %	75	80	90-95
Nuclear loss reduction	5	16 - 20	20 - 30
Goniometer angular accuracy, μrad	30 - 40	10	1 - 2
Crystal bend angle, μrad	140 - 150	150 - 170	50 - 100
Crystal torsion, μrad	20 - 30	5 - 10	0.5 - 1
Amorphous layer on crystal	About zero	About zero	About zero
Collimation leakage reduction	-	5	Should be analysed