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on behalf of UA9 collaboration



#### UA9 Instrumentation and Detectors in the CERN-SPS and beam tests

- Activity on circulating beam [SPS]
  - Installation new hardware
  - First 2010 data-taking
- Activity on extracted beam [H8, BTF]
  - Detector R&D
  - Crystal test-bed layout preparation
- Future activity



- Less impedance
- Reduced tertiary halo

Demonstrate this is a robust new collimation technique.



### Our "to do list "



- Develop and test
  - Crystal alignment and *collimation operation* on beam
  - Measure *collimation efficiency* 
    - Measure extracted beam (intensity, direction,...)
  - Measure effects of *inelastic interaction* and quasi-elastic interaction (diffractive events)
  - Measure *leakage* on the rest of the ring
- Test new crystals
  - Special crystals, LHC type crystals,...
- Measure inelastic interaction "cross section" in channeling/VR





### SPS activity



#### Collimation region at SPS





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#### **Chrystals and Detectors**















2 Triple GEM detector at large angle Active area 10x10 cm<sup>2</sup> 128 pads 6x12 mm<sup>2</sup>

3 Medipix in roman pot Active area 1.4x1.4 cm<sup>2</sup> 65536 pads 55x55 μm<sup>2</sup>

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#### Alignment procedure



Crystal and all UA9 movable devices are acquired in their positions and angles. The parameters are recorded in the same environment and controlled online. Then they are synchronized with the SPS data for the offline analysis.

LHC Phase 2 Collimator



Measurement of beam position to limit the aperture of the SPS to the desired value (6  $\sigma$ ), and cut with the beam halo beyond this aperture.



Crystal and all UA9 movable devices are aligned during each fill. Standard and fast procedure (10 min) to find

channeling configuration and collimation!



#### **GEM Monitors**



The GEM are acquired every second getting an online image of inelastic scattering at large angle





Current vs time.

When an angular scan is performed on chrystal (1 or 2), a drop appear on the total rate measured by the downstream GEM during the channeling time period.

Also the total current drawn by the GEM chamber is a good measurement of the flux of particles from inelastic interactions.



#### Inelastic interactions





#### Crystal 3

- Measure rate close to the crystal (BLM- GEM1)
- Observed reduction in channeling: factor ~20
- Reproduced in several scans during different fills!



## Medipix in SPS 2010



- During Two Machine Developments (Jul and Aug)
  - Test of all hardware
    - » New IHEP goniometer working well
    - » Calibration of movable devices in situ!
  - 3 new crystals installed
    - » 2 quasi-mosaic and 1 strip INFN FE







## H8 beam tests



#### **Scintillators**





- Use Medipix to image proton during one spill
- Fast procedure to find channeling (30 min)



Channeled beam



## TPG for ion beam



It's essentially a small TPC with a 4 cm drift and readout with triple GEM In this way also high current beam can be monitored in position



The material budget crossed by a particle is only two kapton foils  $(<0.2\%X_0)$  used for the field cage necessary for the drift field uniformity





#### A TPC-GEM

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Active area 5x5×3 cm<sup>3</sup> 16×8 pads, 3×6 mm<sup>2</sup> *Our only device to study ion channeling (when they come...)* 





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#### CMS LHC Si strip readout system Provided by Imperial College group

5 planes altogether (10 silicon strip sensors) each plane provides 2 co-ordinates: XY or UV

UV plane = XY plane rotated through 45<sup>o</sup> (resolves ambiguities for multiple hits / trigger)





# Inelastic interaction in channeling



NPB 144 (1978) 1-21,S.K.Andersen et al.



Fig. 8. The experimental "differential cross section" (explained in the text) for  $p + Ge \rightarrow$  charged particle + anything as function of scattering angle  $\theta_{1ab}$ . The figure shows two different curves, the solid one corresponding to random incident directions and the dotted one to angles of incidence,  $\theta_i$ , in the interval  $0 < \theta_i < 0.56 \psi_1$ . Error bars are only indicated on the dotted curve because these are much larger than those associated with the solid curve.





- Measure "large" deflection angles events
- Measure track multiplicity in downstream detectors

Better measuments Better crystals

 Correlate to hadronic interaction activity in channeling/ amorphous/volume reflection



#### Planar GEM



A new planar GEM was placed downstream the proton beam for large angle measurements : beam spot and beam profile can be easly shown online in an active area of 5x5 cm<sup>2</sup>

In future detector of  $10x10 \text{ cm}^2$ and  $20x20 \text{ cm}^2$  can be put on beam test





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Summary



Sevral detetectors and instrumentation have been placed on SPS at CERN to measure the chrystal channeling effect on a high energy proton beam with the aim of a new beam collimation strategy for LHC.

- ✤ GEM detectors for large angle measurements around the beam pipe
- Medipix for channeled beam images inside the roman pot
- Scintillators and Cherencov detectors as beam loss monitors
- GEM TPC tracker for future ion channeling studies
- CMS silicon tracker for efficiency measurements at H8

2010 data taking analysis is in progress ..... stay tuned