T980 at the Tevatron: Plans for 2010-2012

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Tevatron Accelerator Study Workshop
Fermilab
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OUTLINE

- T980 Mission
- T980 Status
- Questions to be Answered
- Post Collider Physics Studies

T980 MISSION

- Develop a collimation system for hadron colliders based on channeling crystal techniques, which has a promise to reduce machine impedance, beam losses in superconducting magnets, improve background conditions in the collider detectors and be compatible with heavy-ion operation.

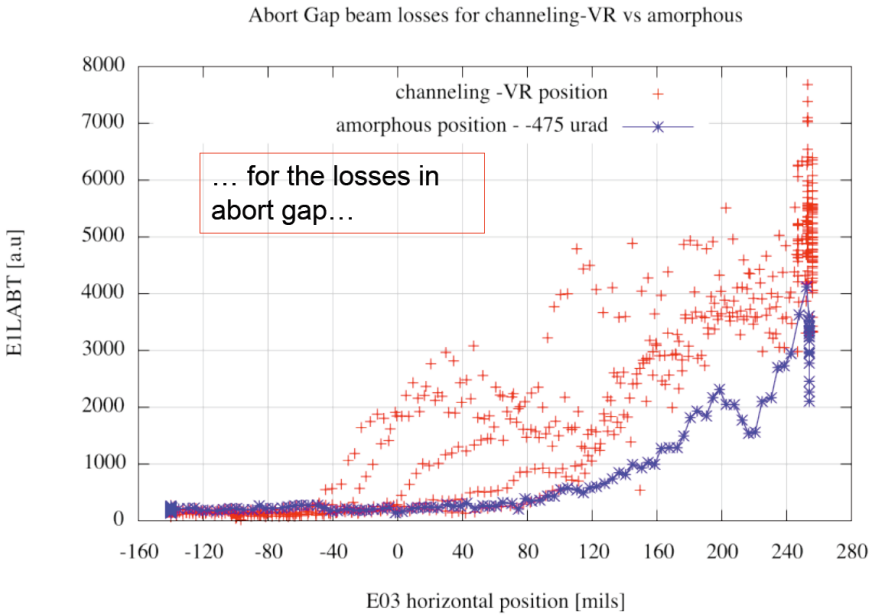
- Start routine use of crystal collimation in the entire Tevatron collider store.

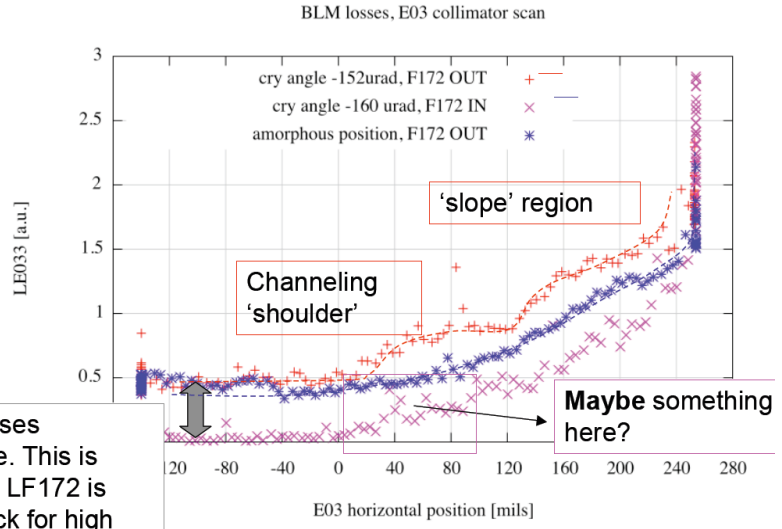
- Study the system's performance and underlying beam dynamics exploiting the unique possibility provided by the Tevatron collider to evaluate an engineering implementation of this technique in the LHC.

Beam Tests in First Half of 2009 in 1 Slide

Original O-shaped xtal (large miscut).
Hor goniometer improved in early 2009.

Channeling improves localization!



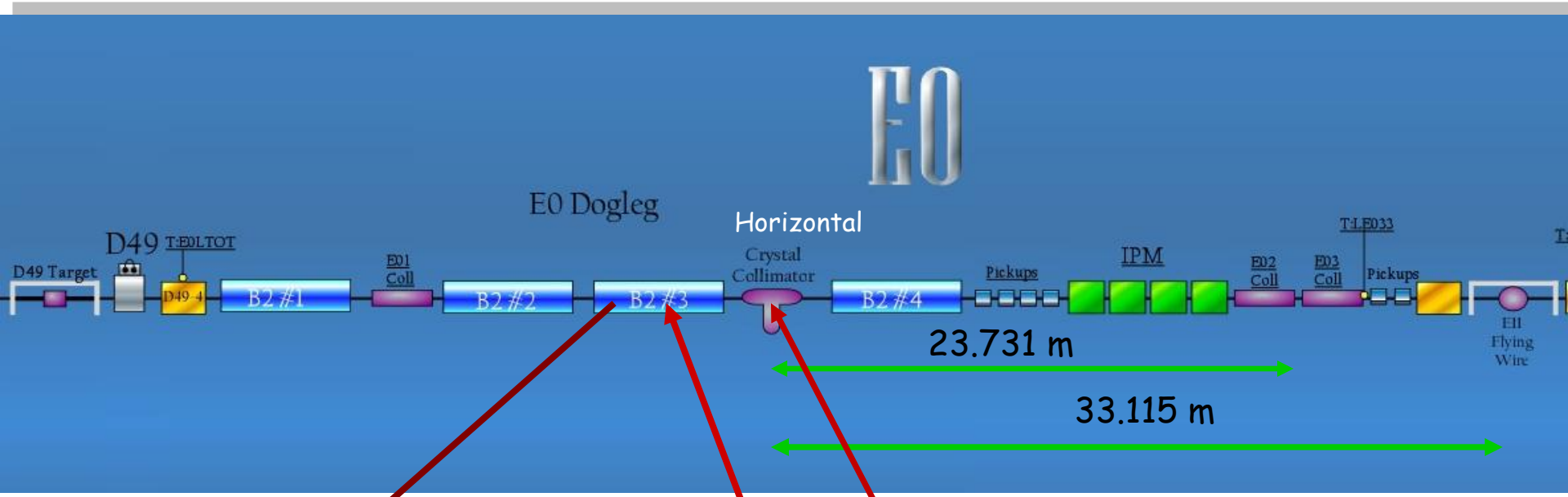


Total losses decrease. This is because LF172 is bottleneck for high off-momentum beam!

Other collimator positions need to be tuned for the crystal collimation!

March 17-18, 2009: First use of crystal for the entire Collider store. Successful test of crystal automatic insertion with no impact on the store. Evidence of better cleaning.

T980 Setup in Tevatron E0 for 2009-2011



Replaced old O-shaped xtal with new 0.36mrad O-shaped with negative 0.12mrad miscut

Removed B2-3 dipole

Installed new Vertical 2-xtal goniometer 4 m upstream of the Horizontal gonoimeter

Now able to use 1 or 2 xtals in beam, alternating them without breaking vacuum !

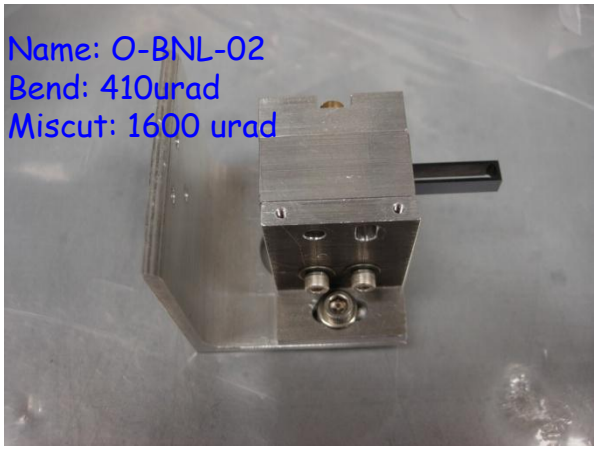
Installed new detectors at F17 to measure VR beam

New Crystals

Broken during installation

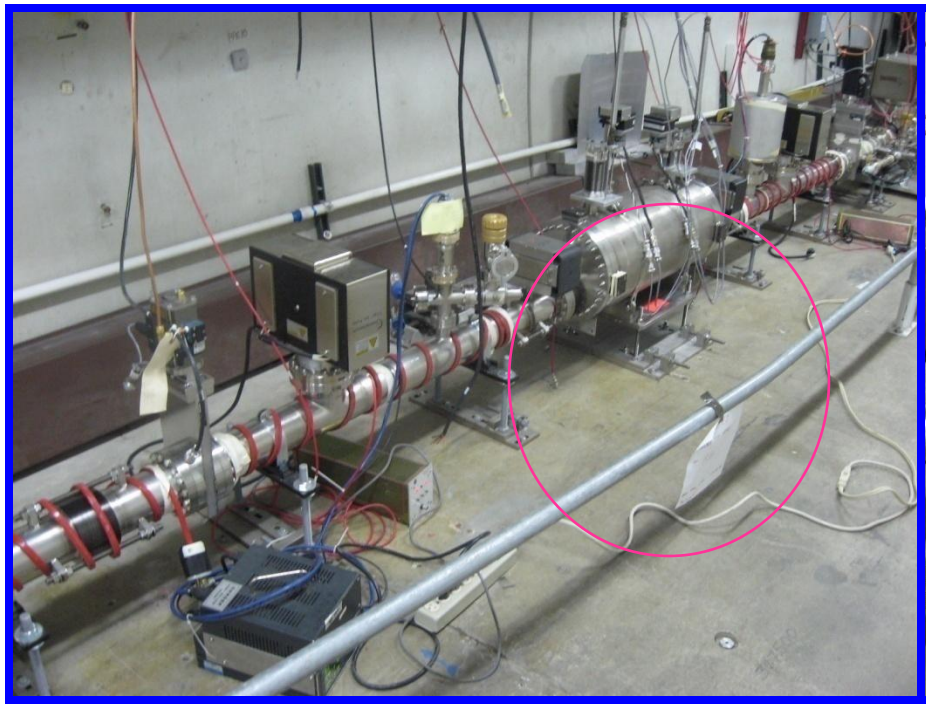
Installed Ver Dnstrm goniometer

Installed Hor goniometer



Installed Ver Upstrm goniometer

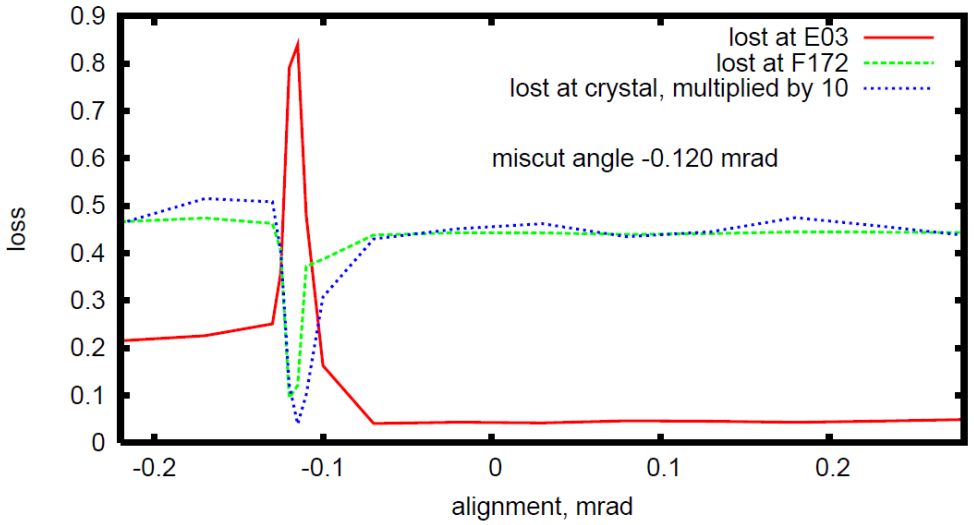
Goniometer Installations



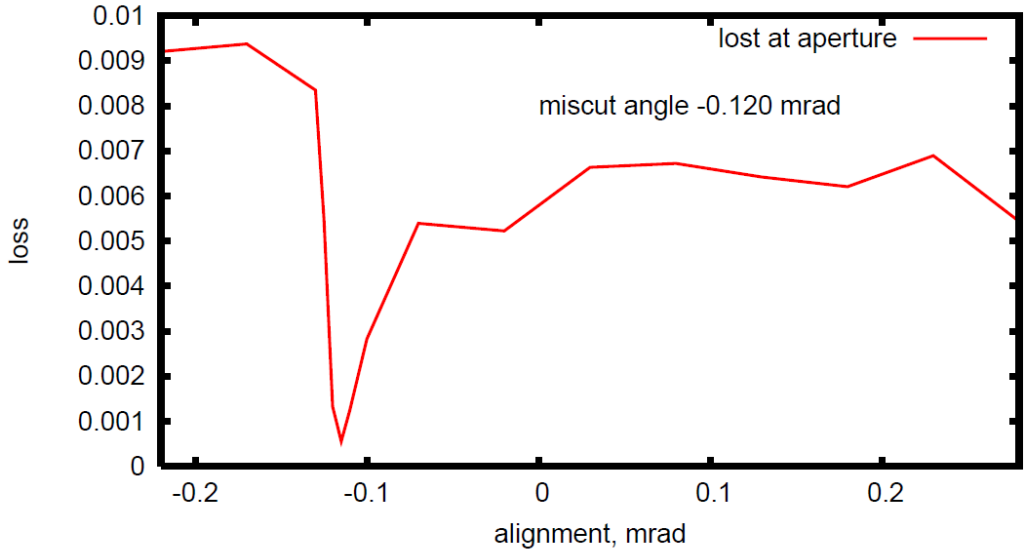
Newly built and installed (Summer 2009) vertical goniometer at E0.
It is ~ 4m upstream of the Hor. one.
Ver. goniometer houses old O-shaped crystal (reversed for negative miscut) and multi-strip crystal.

Modified horizontal goniometer.
Replaced old large miscut positive angle O-shaped crystal with new small miscut negative angle O-shaped during Summer 2009.

STRUCT/CRYAPR Beam Loss: New O-shaped (H)



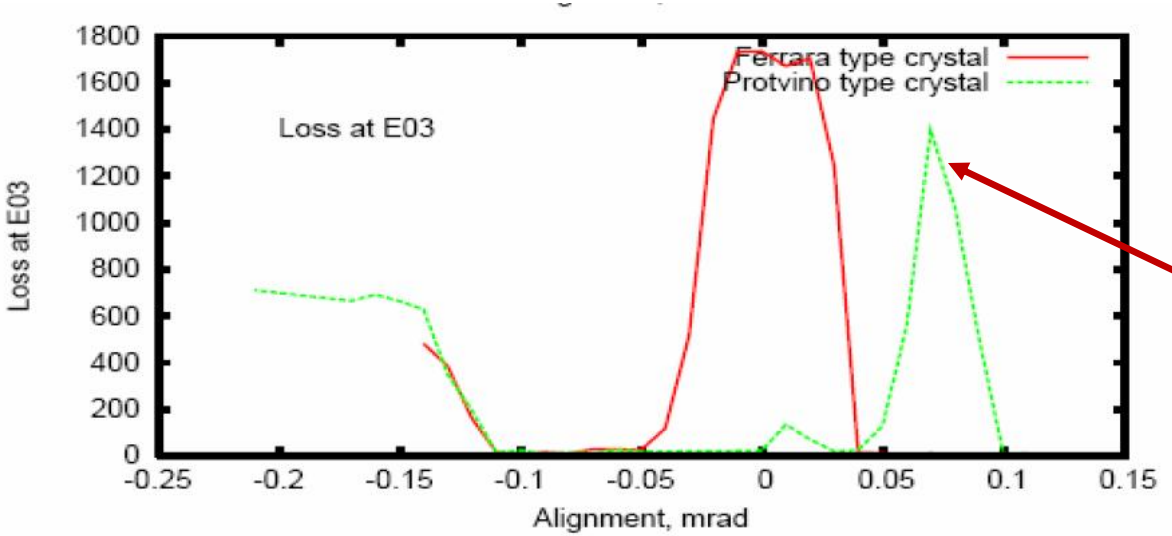
E03 and F172 collimators and xtal



Rest of the Tevatron

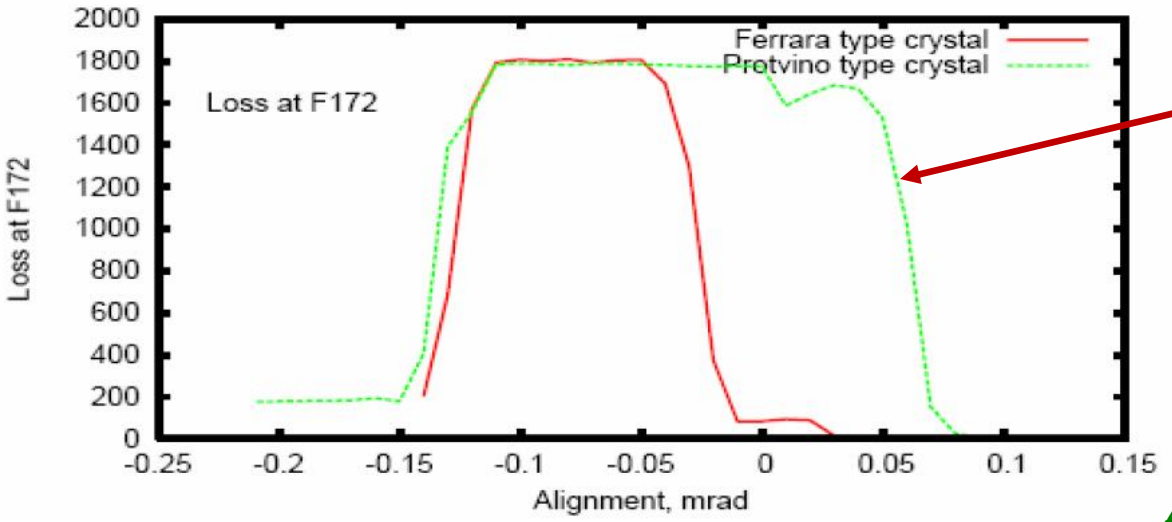
A. Drozhdin

STRUCT/CRYAPR Beam Loss: New Multi-strip (V)



E03 and F172 collimators

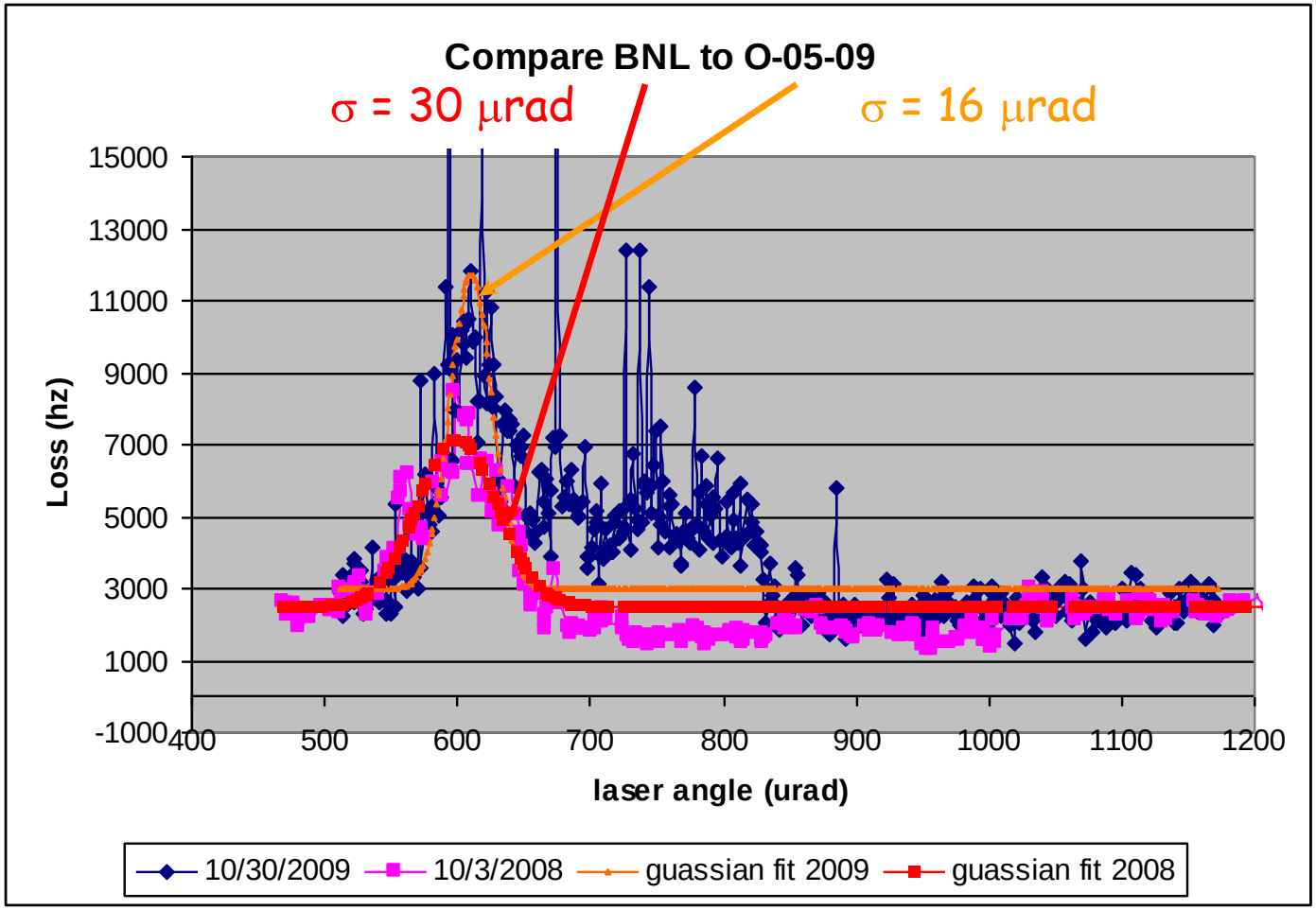
Channeling



Volume Reflection

A. Drozhdin

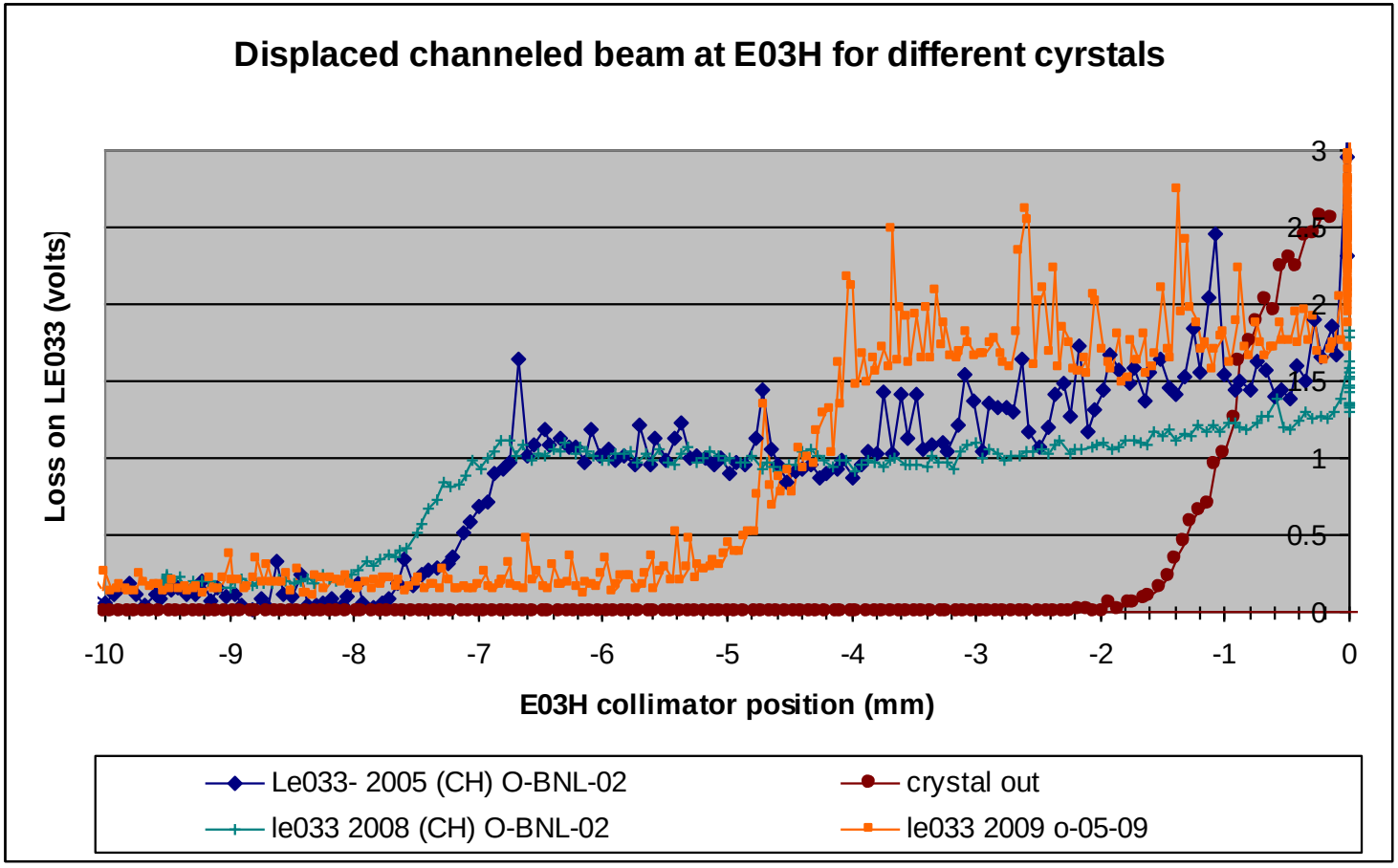
Old *vs* New Crystal Performance (Fall 2009)



For the first time, VR beam seen at F172 collimator, 1/6 ring downstream

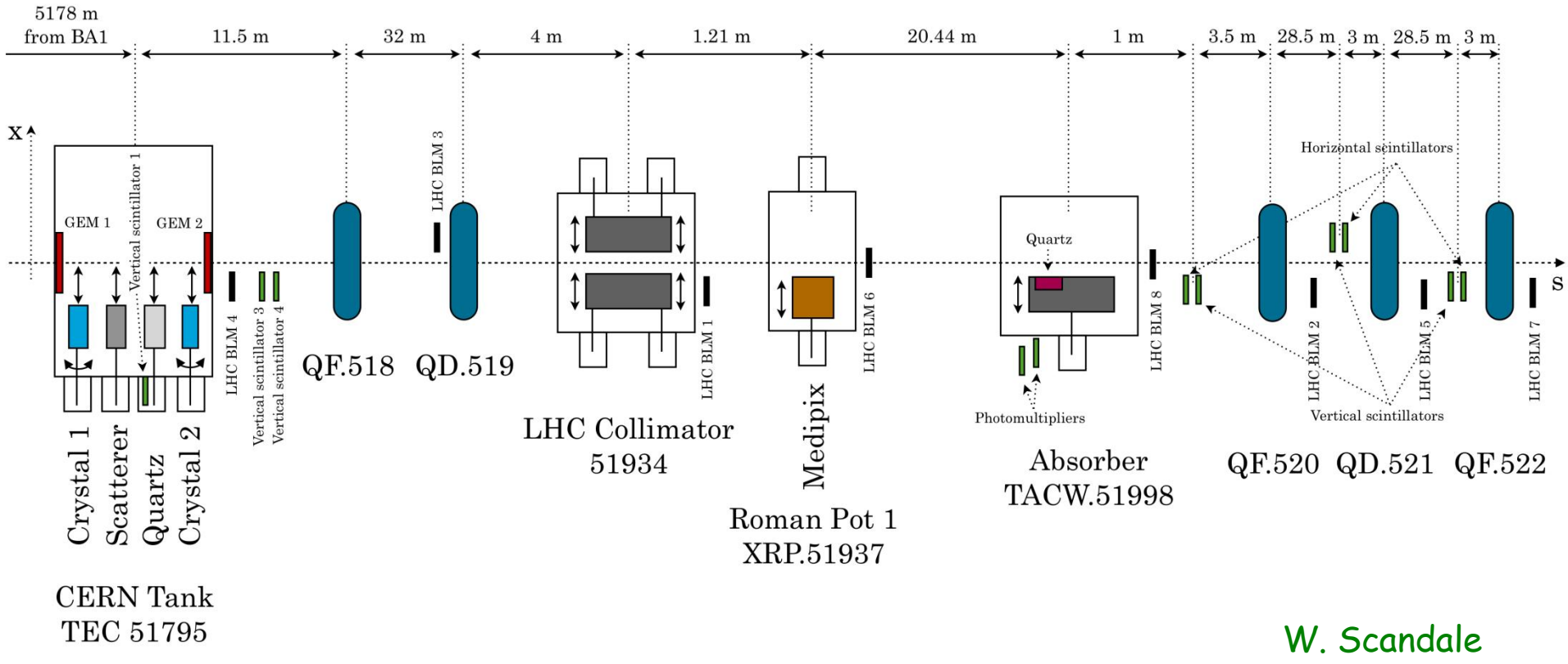
D. Still

E03H Collimator Scans: 2005, 2008 & 2009



D. Still

UA9 at SPS



W. Scandale

Many good results from 2009 runs: easy operation, high collimation efficiency, strong reduction of nuclear rate once the crystal is in channeling. Some issues: efficiency lower than predicted, channeling peak width is larger than predicted, goniometer reproducibility. Request to run in the SPS and NA for one more year, and start preparation for test in LHC.

Questions to be Answered: Generic

- What are the effects of miscut angles on crystal collimation process?
- How many degrees of freedom in aligning the crystal are critical for crystal collimation with respect to skewed planes and axial channeling?
- Is two-plane crystal collimation consistent with simulations and reasonable for reducing halo efficiently?
- Do multi-strip crystals work in the collider and are they efficient at removing halo?
- Can axial bending be used?
- Is there a role for negative particle volume reflection?
- What is perspective on possible needs for negative particle collimation and bending dechanneling (muon and e^+e^- colliders, specialized extraction, …)
- How well dechanneling lengths have been measured in proton collimation studies for various crystals?
- What is implication of increased loss at local small radii of curvature?

Questions to be Answered: LHC-Specific

- Is there a negative effect on collider performance with crystal in?
- What is the ring loss reduction utilizing crystal collimation and is this consistent with simulation?
- What type and parameters of crystals are best for LHC crystal collimation?
- Does this employ channeling or VR or systems that involve both?
- What are the operational limits in using crystal collimation in the LHC?
- Are crystal angles and systems reproducible for injection, ramp, flattop and squeeze to the level of quench protection and halo removal?
- What type of instrumentation would the LHC need to confirm channeling or VR during collimation?
- What type and or style of goniometer will be needed for the LHC?

T980 Objectives for 2010-2011 (1)

A. End-of-Store Studies

1. Compare channeling efficiencies for O-shaped crystals for large and small miscut angles, and for negative and positive miscut angles.
2. Compare crystal collimation efficiencies for O-shaped crystals in channeling and volume reflection modes with a default amorphous primary collimator.
3. Investigate crystal collimation efficiency with a multi-strip crystal utilizing volume reflection and compare it to that with a crystal in a channeling mode and with a default amorphous primary collimator.
4. Investigate simultaneous horizontal and vertical collimation for the most optimal crystal type and configuration.
5. Study crystal collimation system performance – with respect to beam losses in the ring and at IP - for the bunched beam and beam in the abort gap.
6. All of the above in comparison with simulation predictions.

T980 Objectives for 2010-2011 (2)

B. Development of Adequate Beam Diagnostics

Rad-hard Medipix in vacuum etc.

C. Full Collider Stores

Study crystal collimation system efficiency - in most optimal configuration found in (A) - during full Tevatron collider stores with respect to beam loss localization in the collimator region, reduction of beam losses around the ring, and specifically in the collider detector regions.

D. Experiment preparation for the post collider physics studies

1. Experiment design.

2. New crystals, hardware and control as well as beam diagnostics.

3. Antiproton experiment design. Requirements such as short crystals, instrumentation in the antiproton direction, time to make any new instrumentation or devices, tunnel time required for installation, etc.

T980 Objectives for Post Collider Physics Run (2011-2012)

1. Detailed investigation of the principal items described above in proton only and collider stores: dedicated studies in controllable conditions.
2. Deeper studies of LHC-related possibilities with crystal collimation revealed in 2009-2011 beam tests.
3. Antiproton beam studies in antiproton only and collider stores (see Dick's talk).

Collaboration and Installation for 2010-2012

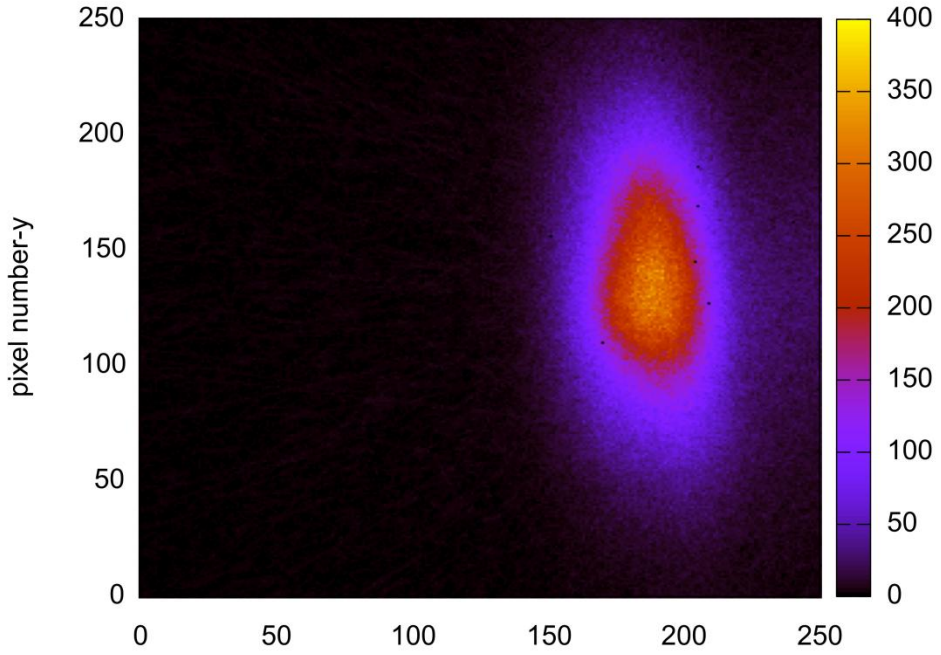
FNAL, SLAC, BNL, CERN, INFN, IHEP, PNPI and Japan.

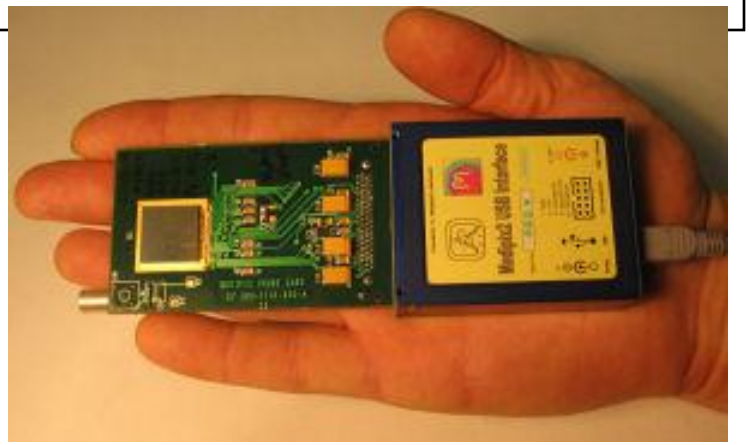
CERN/INFN:

- Characterization of Tevatron crystals with SPS beams
- Multi-strip crystals (Ferrara)
- Beam diagnostics (rad-hard MEDIPIX in vacuum)
- Participation to beam test planning and measurements
- CRYSCOL troops

Hardware installation in the tunnel: shutdowns in Summer 2010 and after the end of collider physics (October 2011), a few weeks each.

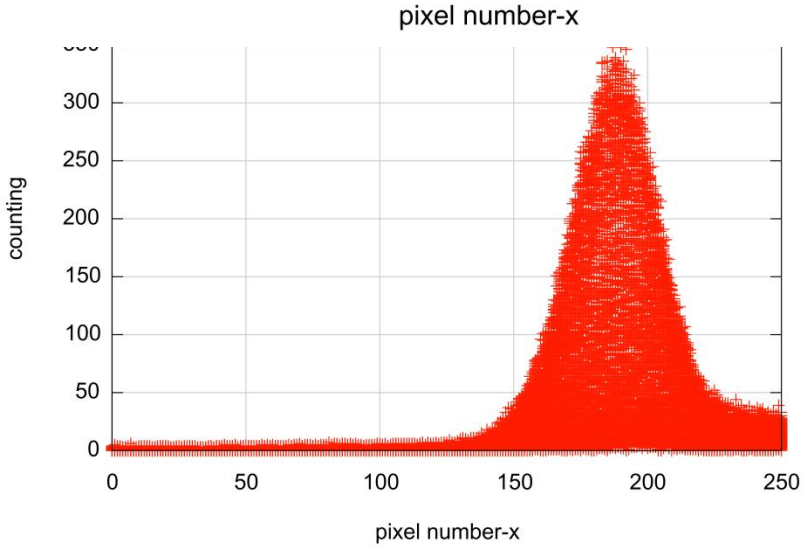
Deflected beam profile with medipix





Medipix sensor of the type inserted in the UA9 roman pot,
provided by L. Tlustos (PH/ESE)

- 256×256 square pixels
- 1 pixel size = 55 μm
- 1 frame integration time 1 s



W. Scandale

- Pick/valley density ratio = 10
- We observed a ratio of 30 (recording lost for a computer crash)

IHEP/PNPI Proposals for 2010-2012

1. Multi-crystals for volume reflection: tests of newly designed crystals at the Tevatron. Crystals at Fermilab this Spring. To optimize their parameters, info is needed on performance of the MS crystal installed in the vertical goniometer.

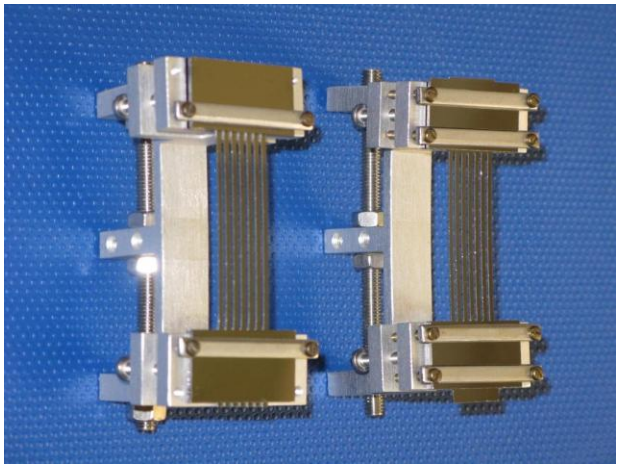
2. Quasi-mosaic and strip crystals for channeling. It seems that the most optimal xtals for the Tevatron should be similar to those at SPS (2-mm long with a bending angle of 0.15 mrad). Crystals at Fermilab this Spring.

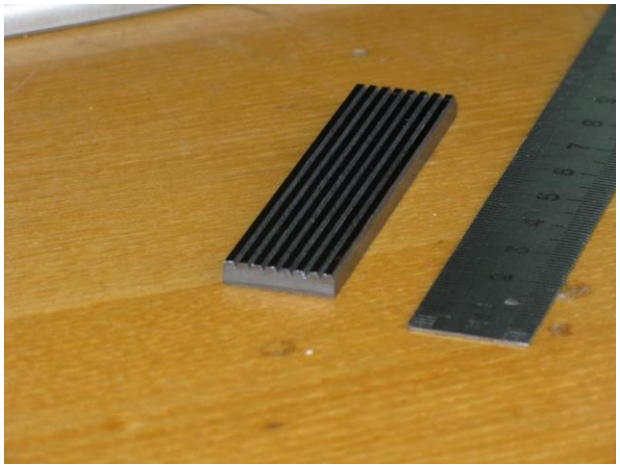
3. Beam diagnostics. If MEDIPIX delayed, one can install a luminescent screen on E03 and CCD.

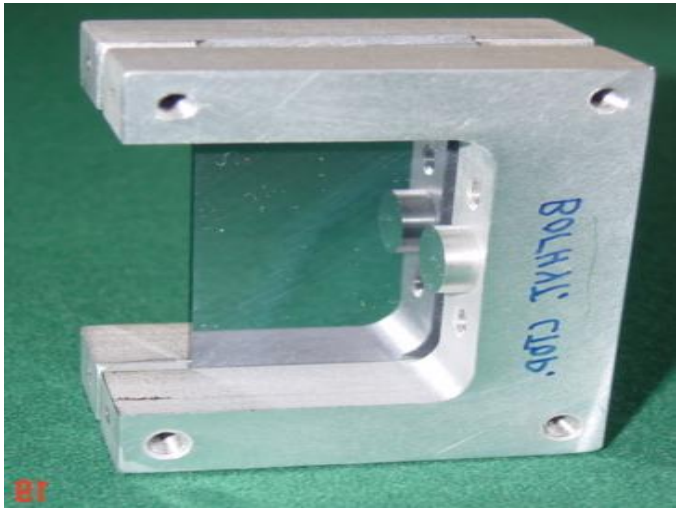
4. Computer simulations.

IHEP/PNPI Proposals for 2010-2012 (2)

Multi-crystals for VR (IHEP)







Quasi-mosaic xtal for channeling (PNPI)

Y. Chesnokov

SUMMARY

- With new crystals, goniometers and instrumentation installed, and first encouraging results obtained, there is a confidence that we will be able to fulfill the T-980 all-encompassing program of 2010-2011: End-of-Store and Full-Store studies. Need one new crystal (quasi-mosaic or strip) for the vertical goniometer and further enhanced beam diagnostics.
- A period after the end of collider physics at the Tevatron starting in about October 2011, would provide a unique possibility for even deeper, controllable, dedicated studies of several key issues of the program with addition of antiproton channeling. A proposal to be prepared within a month or two and finalized by the Crystal Collimation Workshop at Fermilab this April.