



*Fermilab*

*Accelerator Physics Center*

*US LARP*

# STATUS OF T980 CRYSTAL COLLIMATION EXPERIMENT AT THE TEVATRON

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Fermilab

LARP Collaboration Meeting 11

Fermilab, Batavia, IL

October 27-28, 2008

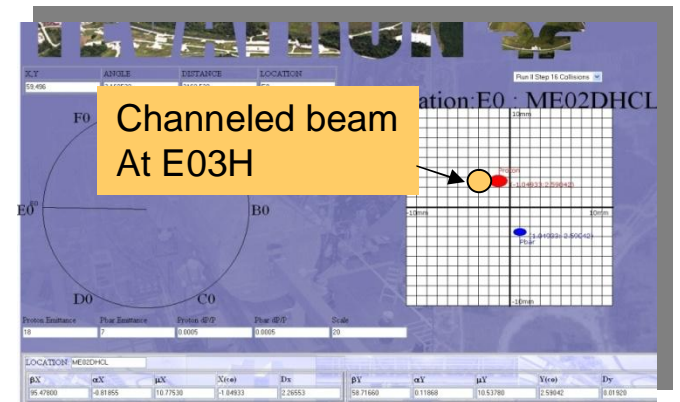
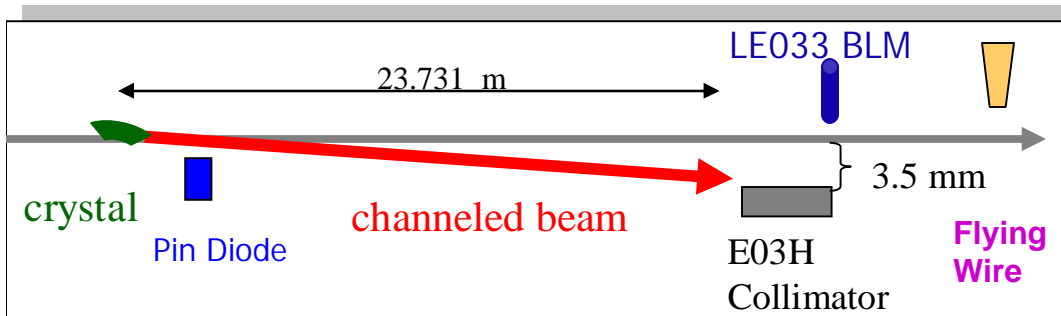
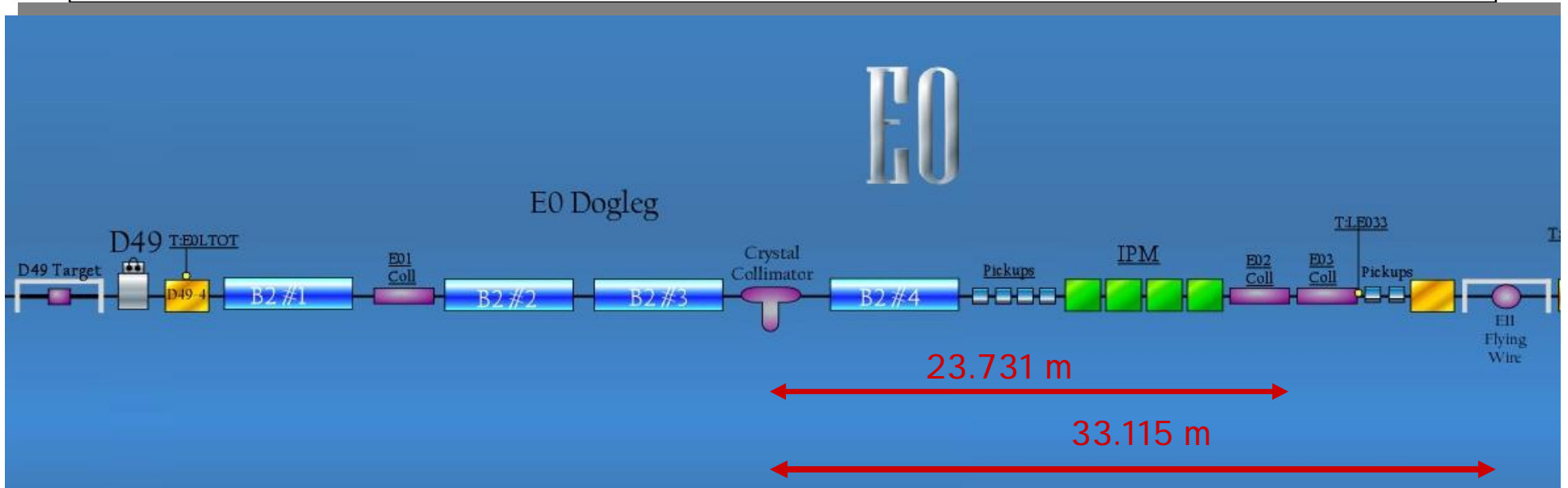
## OUTLINE

- T980 Crystal Collimator Developments:
  - Crystal analysis and replacement
  - Goniometer modifications
  - Beam diagnostics enhancement
  - Simulations
- Meeting with Directorate, CDF & D0 Experiments in May, Installation Review in August, and 2008-2009 Plans
- September-October Beam Tests
- T980 LARP Budget & Deliverables for FY09

## T980 DEVELOPMENTS

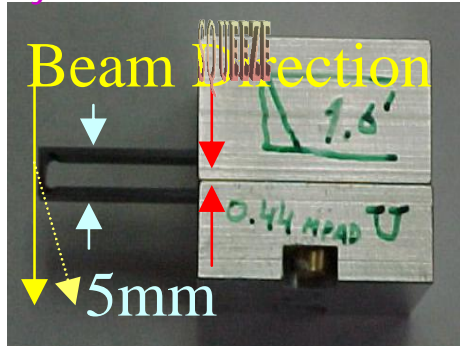
- T980 hardware, software and beam diagnostics have been drastically improved and enhanced since earlier studies in 2005-2007.
- Progress on simulation front.
- Preliminary discussion at LARP CM10.
- Installation in the Tevatron tunnel on August 28, 2008.
- First End-of-Store studies on September 14 and October 3, 2008.
- Fixes and improvements in the tunnel on Oct. 23.
- Request for next EOS for October 30-31.

# E0 Crystal Collimation Layout



# CRYSTAL ANALYSIS AND REPLACEMENT

"Successful" 0.44mrad O-shaped crystal of 2005-2006 studies



"Unsuccessful" 0.15mrad strip crystal of 2007 studies



Suspicious strip crystal and unstable goniometer were removed from the tunnel in December 2007 after several unsuccessful attempts during the year. After cooldown, the crystal was shipped to Italy last week for its analysis.

The O-shaped crystal of successful studies of 2005 was shipped to Europe in January 2008 for its characterization.

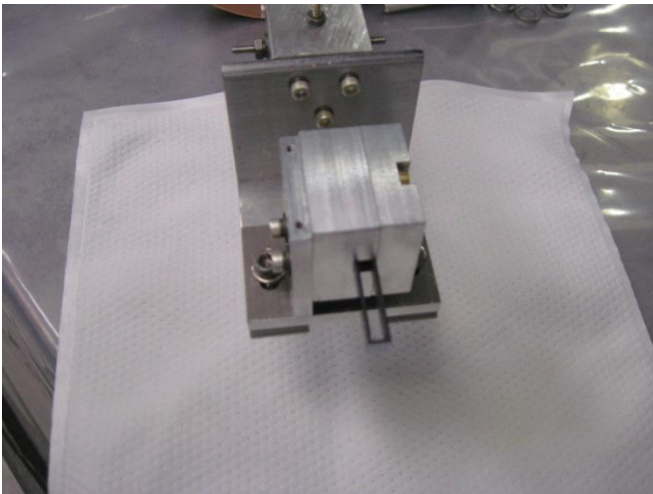
Analysis with 2-MeV He<sup>+</sup> ions performed by V. Guidi at Ferrara, INFN, has shown that quality of the surfaces is very good, and it needs no treatment.

X-ray measurements of bending angle and miscut angle with 5% accuracy performed by Yu. Ivanov, PNPI; the angles are  $0.41 \pm 0.02$  mrad and  $1.6 \pm 0.1$  mrad, correspondingly.

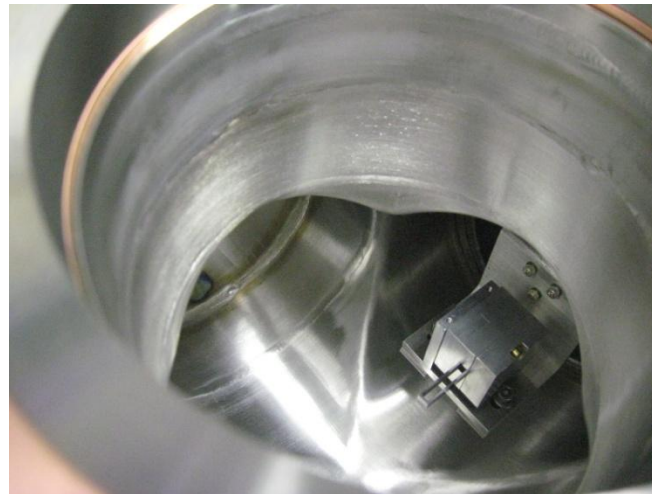
The crystal received back in April and is now installed in the Tevatron tunnel.

## GONIOMETER MODIFICATIONS (1)

- Deleted angular swing motion inchworm motor and limit switches
- Deleted internal angular motion LVDT
- Deleted ball-screw type horizontal insertion drive slide
- Deleted electric brake on horizontal motion
- Removed strip crystal, installed original O-shaped RHC crystal again
- Repaired vibration problem with crystal mounting bracket
- Repaired dragging arm problem with angular swing motion



LARP CM11 – Fermilab, Oct. 27-28, 2008

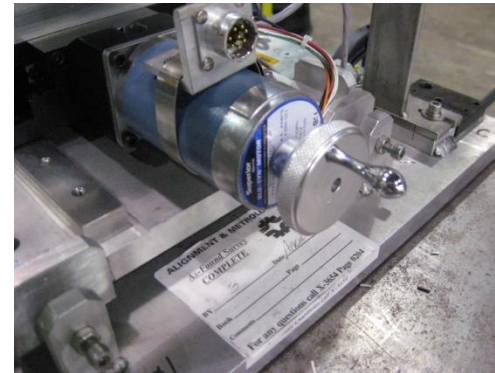
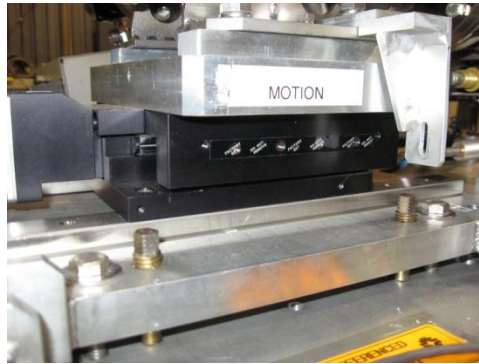


T980 Status - N.V. Mokhov

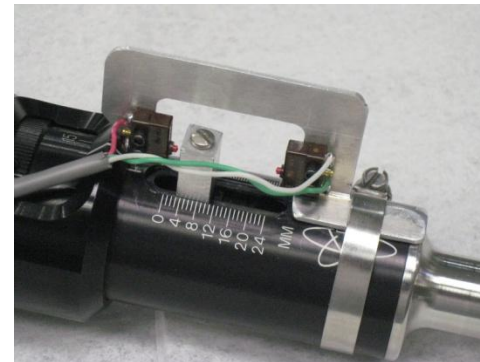
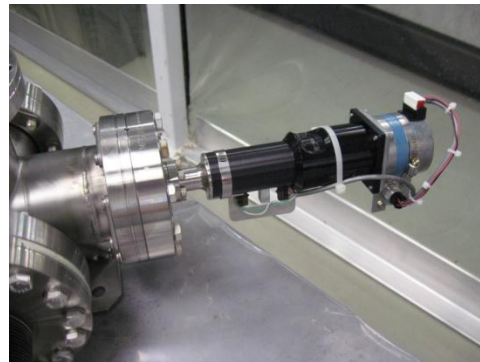
R. Reilly, A. Legan

## GONIOMETER MODIFICATIONS (2)

- New horizontal insertion drive slide is self-locking lead-screw type, not affected by vacuum load.
- New horizontal insertion drive stepper motor with hand crank, in case of motor or controls failure the crystal can be cranked out of the beamline by hand; linear motion .00005" per step.



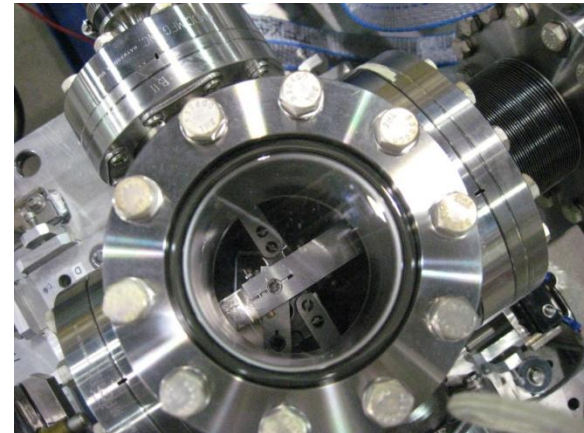
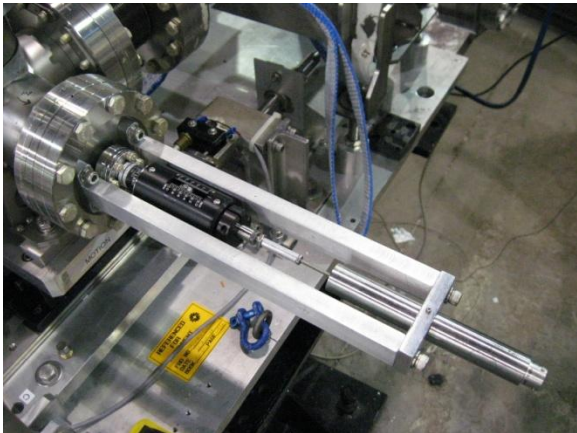
- New angular swing motion linear actuator vacuum feedthru with external stepper motor and limit switches, thumbwheel for hand operation; angular positioning of the crystal in steps of 1.36 urad.



R. Reilly

## GONIOMETER MODIFICATIONS AND INSTALLATION

- New linear feedthru with external LVDT and visual position indicator for angular swing motion; angular measurement 2.1 urad.
- Glass viewport to observe angular swing motion.



Operated under vacuum  
Vacuum chamber baked  
Vacuum certified  
Installed in 12 hr access

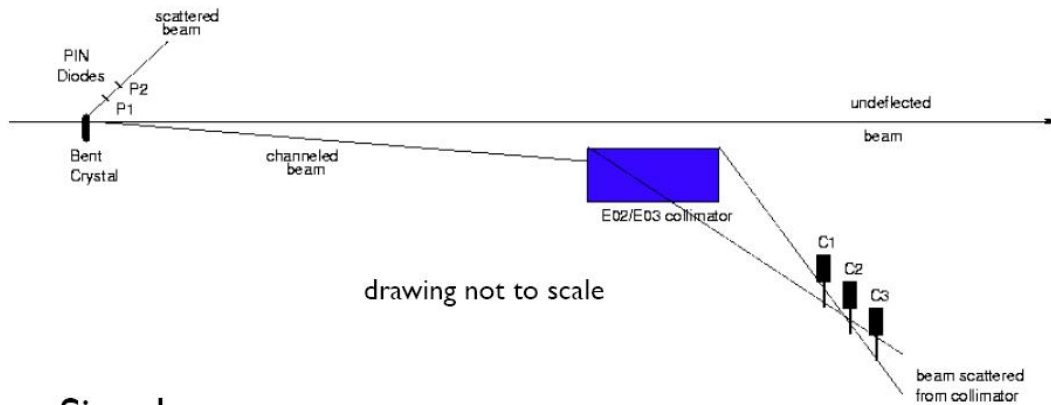




## BEAM DIAGNOSTICS ENHANCEMENTS

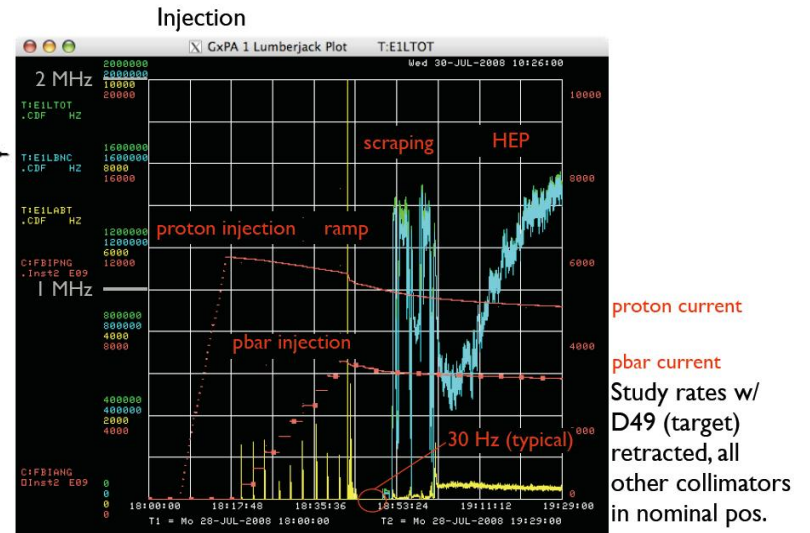
- 1-cm<sup>2</sup> PIN diodes immediately downstream xtal arranged in telescope
- LE033 beam loss monitor (~24 m downstream)
- EOCH (EI) scintillation counter telescope (running since June 2008)
- E11 flying wires (~33 m downstream)
- CDF beam loss monitors (~3 km downstream)
- Possible D0 near-beam halo finger scaler monitoring system

# EOCH (EI) COUNTERS



Signal:

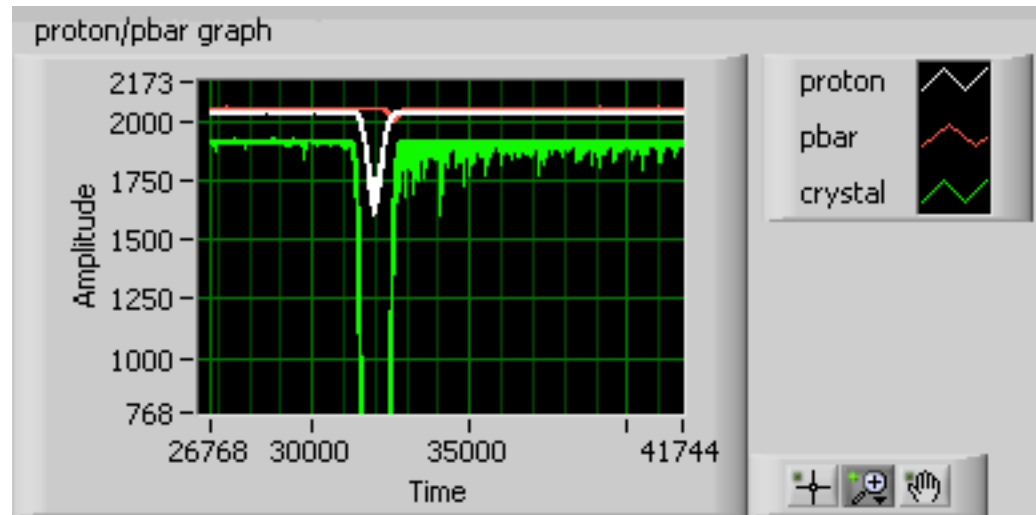
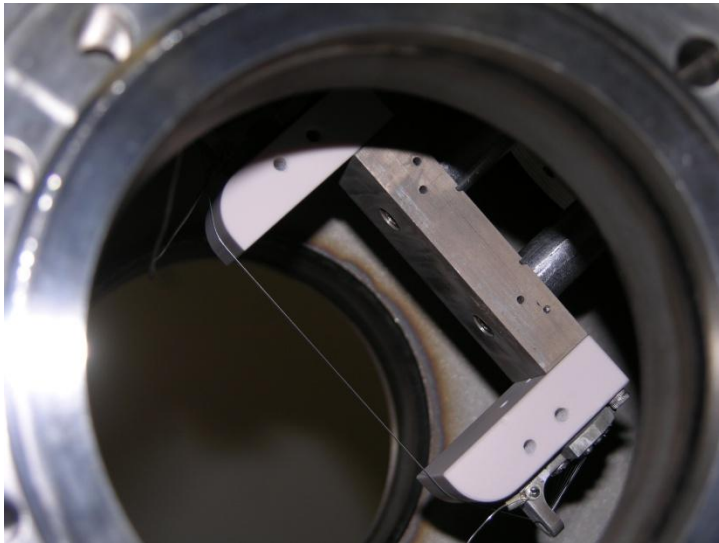
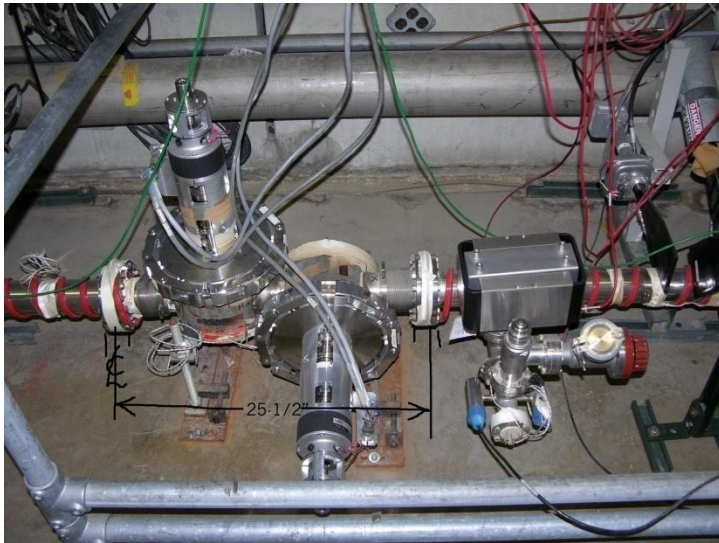
- increased rates in counters
- decreased rates in PIN diodes



Behavior with beam as expected, but issue: beam size and xtal & E03 collimator positions at end of store

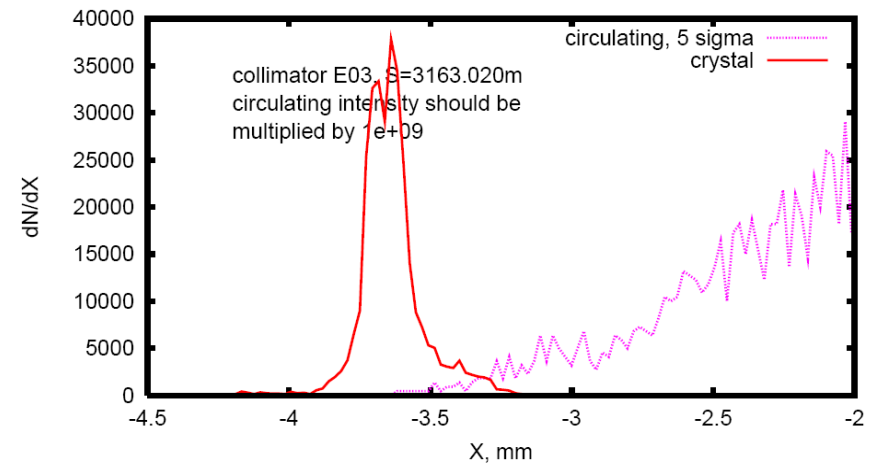
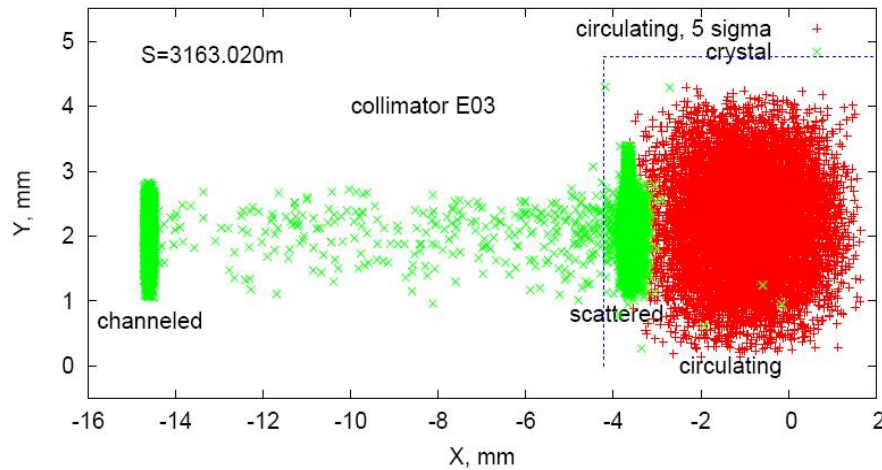
S. Shiraishi, R. Tesarek

# Flying Wires at E11

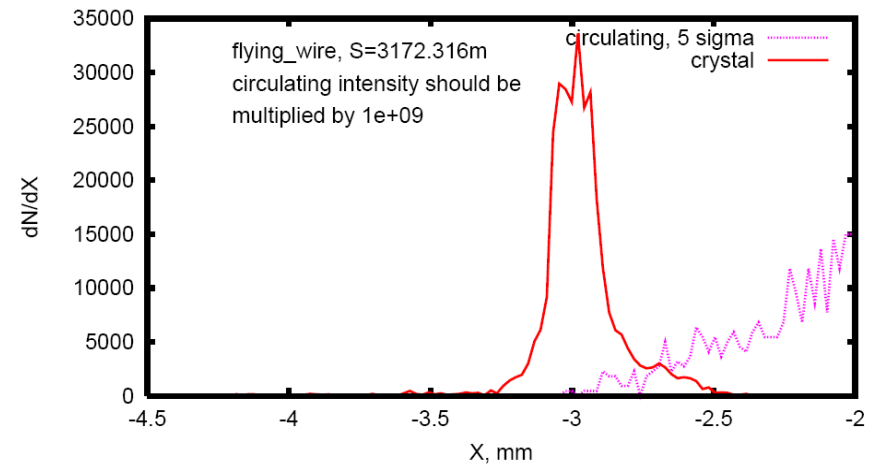
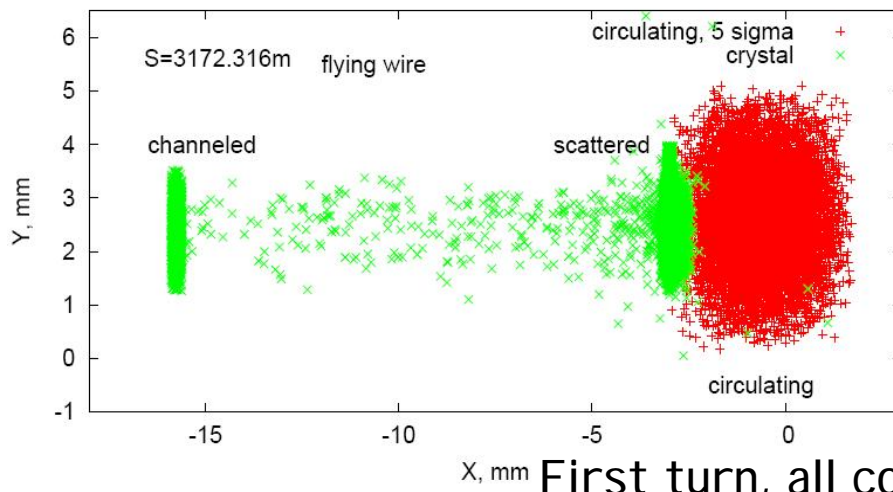


# STRUCT/CATCH Simulations: Profiles at 9 Critical Locations in Tevatron with O-Shaped Crystal

## E03 collimator



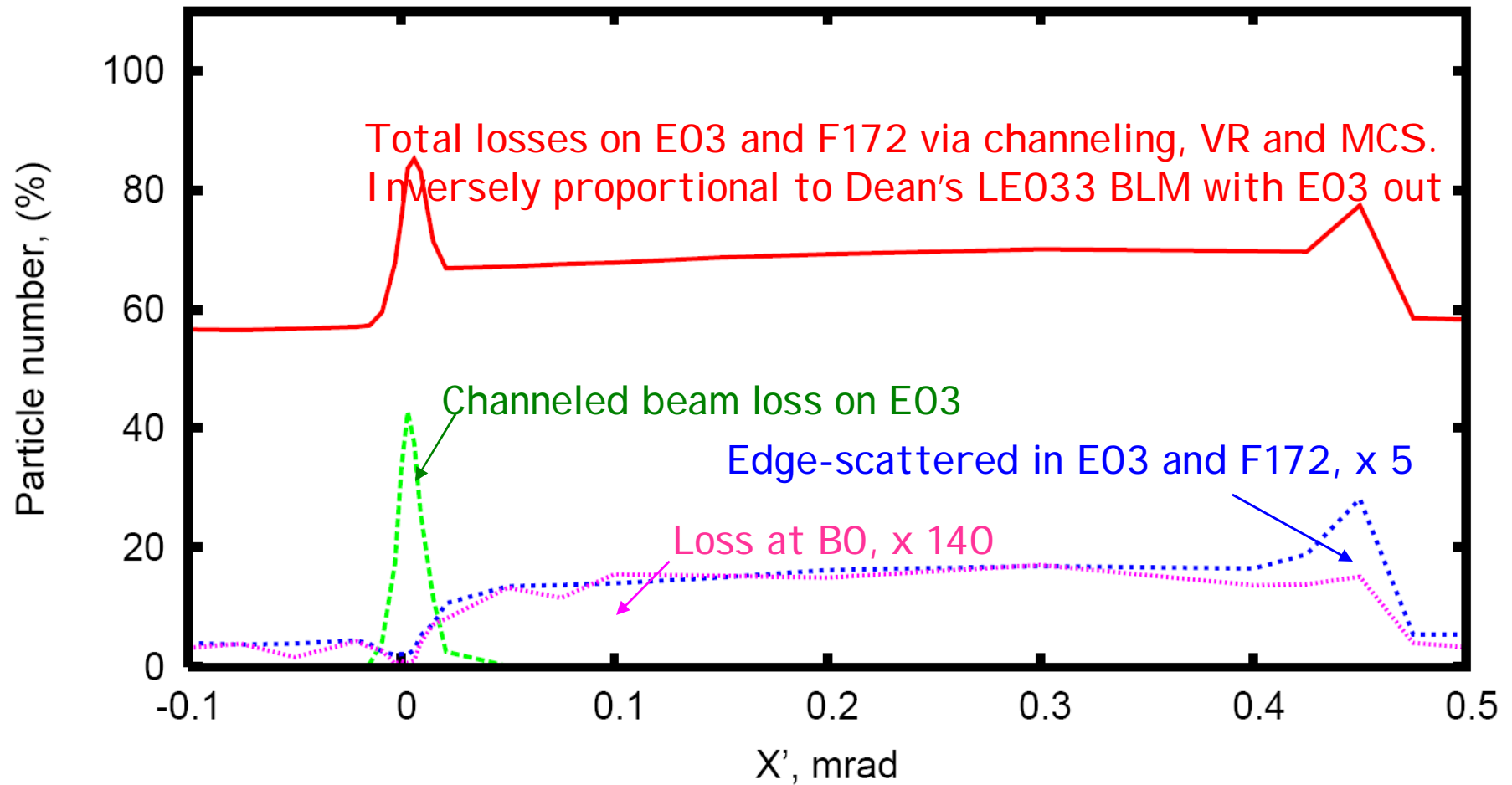
## E11 flying wire



First turn, all collimators are retracted

A. Drozhdin

## Multi-Turn Simulations with 0.44-mrad O-shaped Crystal



All collimators are in working positions

A. Drozhdin

Switched to I. Yazynin's code

## MEETING WITH DIRECTORATE AND CDF&D0, 05/21/08

1. Thorough discussion of T980 goals and plans, and of impact on CDF & D0 programs/performance.
2. Support of Phase I goals/plans (until Spring 2009):
  - ☺ Measure channeled, volume-reflected and scattered beams as well as beam losses downstream of the crystal setup in comparison with simulations.
  - ☺ Demonstrate reproducible beam loss reduction in the B0 and D0 in comparison with simulations, aiming at a routine use of crystal-based collimation in the Tevatron stores.
3. Plans for Phase II (>Spring 2009) are subject to another review and 2009-2010 Collider Run plans.

## Impact on CDF/D0

- Benefit to CDF/D0: at least a factor of 2 reduction in beam loss (2005 data). Can be a more substantial reduction with new crystals and other hardware of Phase II (> June 2009).
- Possibly another crystal at F49 to reduce pbar losses in CDF/D0.
- Maximum possible luminosity loss in Phase I: 20 hrs, or  $4.3 \text{ pb}^{-1}$  out of  $1300 \text{ pb}^{-1}/\text{yr}$ , or 0.33% (compared to 0.68% difference in CDF and D0 luminosities).
- Nothing happens if the crystal doesn't channel (Dec. 2007 results).
- Minimal risk to the silicon: only the target at E0 is retracted, nothing else moves.
- Effect or risk to CDF/D0 with crystal collimator for full store (BOS)
  - (i) crystal works: losses reduced via efficient scraping;
  - (ii) crystal doesn't work: re-insert tungsten target, lose small amount of luminosity at beginning of store (10 minutes), beam losses the same.

## T980 INSTALLATION REVIEW, August 7, 2008

Accelerator Division, CDF and D0 Committee, chaired by Roger Dixon, to assess the overall risk of T980 installation with respect to the impact on the Fermilab Collider program. From the Review Summary:

The Committee was most concerned about any damage to the Tevatron or the detectors that could result during the installation and the initial positioning of the crystal. The proponents of T980 managed to convince us that such possibilities are remote since we have done very similar experiments with the previous crystals, and the installation has been improved since that time. In addition, the diamond detectors and BLMs provide faster aborts for better protection.

In conclusion, the Committee recommends that installation and commissioning of the crystal and its associated hardware for T980 be allowed.

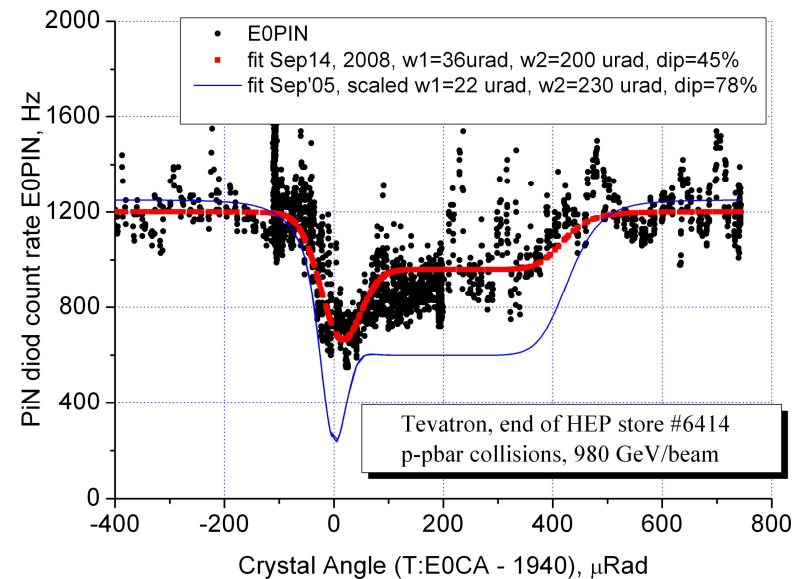
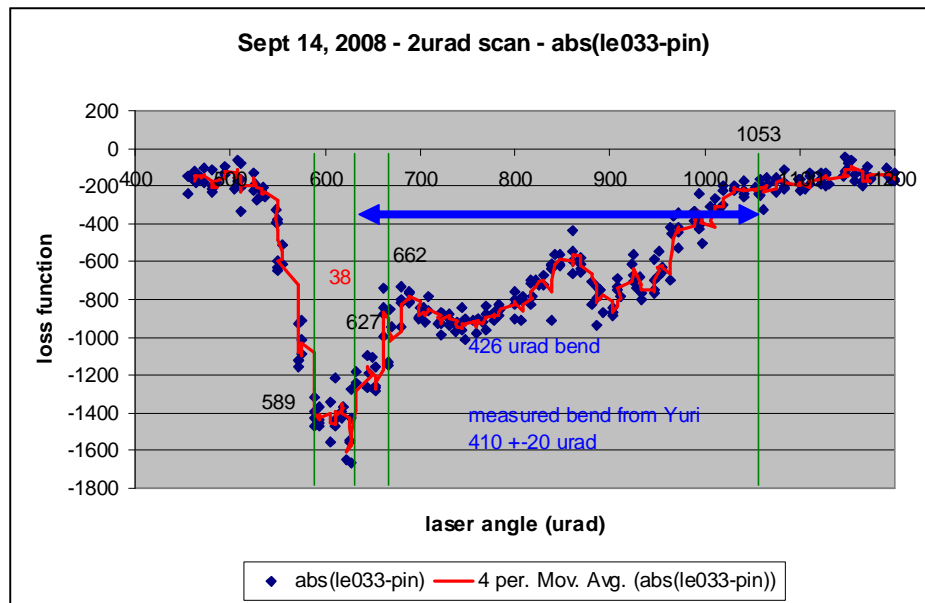
*Installation in the Tevatron tunnel was done on August 28, 2008.*



# FIRST T980 BEAM TESTS (1)

Sept. 14, 2008: First End-of-Store (EOS) study (3 hours) with the new setup:

- aligning crystal
- first angle scan produced channeling results!



Analysis by V. Shiltsev

See Dean Still's talk at Crystal Collimation Workshop

## FIRST T980 BEAM TESTS (2)

Oct. 3, 2008: Second EOS study (5 hours) with the new setup:

- angle scan results are reproducible!
- problems revealed with laser and angular motion drift (fixed on Oct. 23).
- possible problem with relative positioning of the xtal and EO3 collimator at the EOS.

Dedicated EOS requested for October 30-31, 2008.

## T980 LARP BUDGET & DELIVERABLES

- FY08: "Crystal Collimation", \$100k (FNAL), \$50k (BNL) - on budget
- FY09: "T980", \$206k (FNAL), \$10k (BNL), \$10k (SLAC)  
[BNL&SLAC's FY09 budget is predominantly in UA9]

### FY09 deliverables:

- Reproducible results on multi-turn dynamics and beam loss reduction with a crystal as a primary element of the Tevatron collimation system.
- Possible routine use of the crystal-based collimation through the entire Tevatron collider stores.
- Results of benchmarking against T980 and UA9 data.
- Studies launched on optimal crystal/goniometer/instrumentation exploring and exploiting possible novel crystal technologies and volume reflection phenomenon, compatible with LHC Phase II collimation requirements.
- Reports on all of the above.
- Plans and hardware (UA9?) for beam studies from mid-2009 to the end of the Tevatron collider runs, subject to Run II plans.