



Fermilab

Accelerator Physics Center

US LARP

T980 Crystal Collimation Status & Plans

Nikolai Mokhov

LARP CM15 Collaboration Meeting

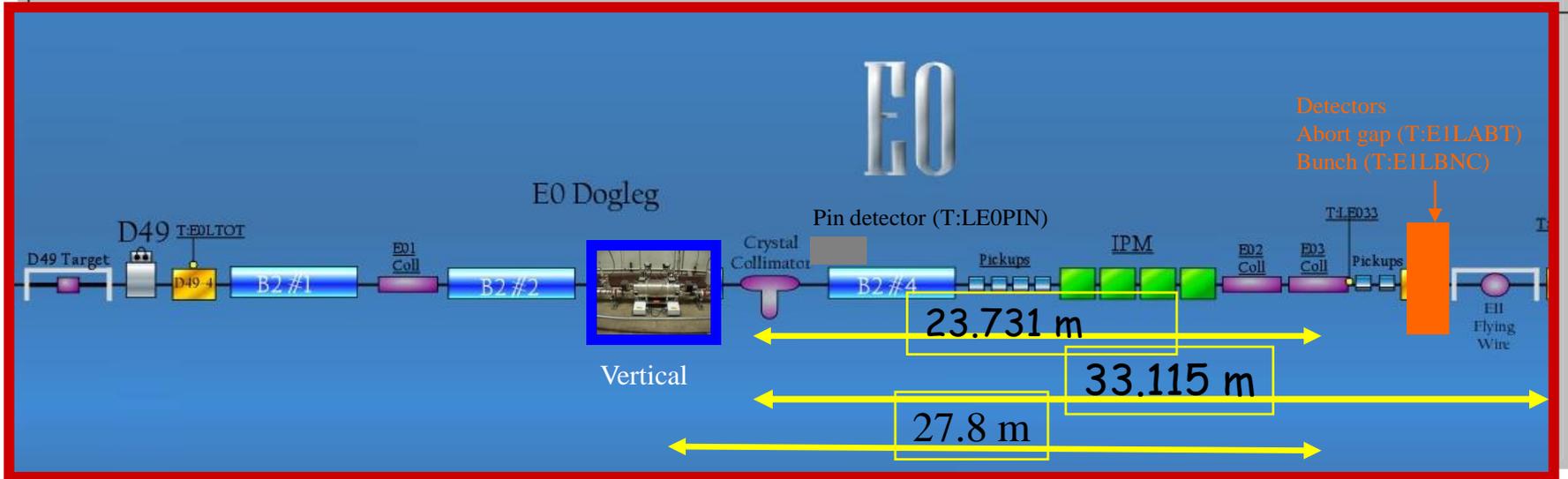
SLAC

November 1-3, 2010

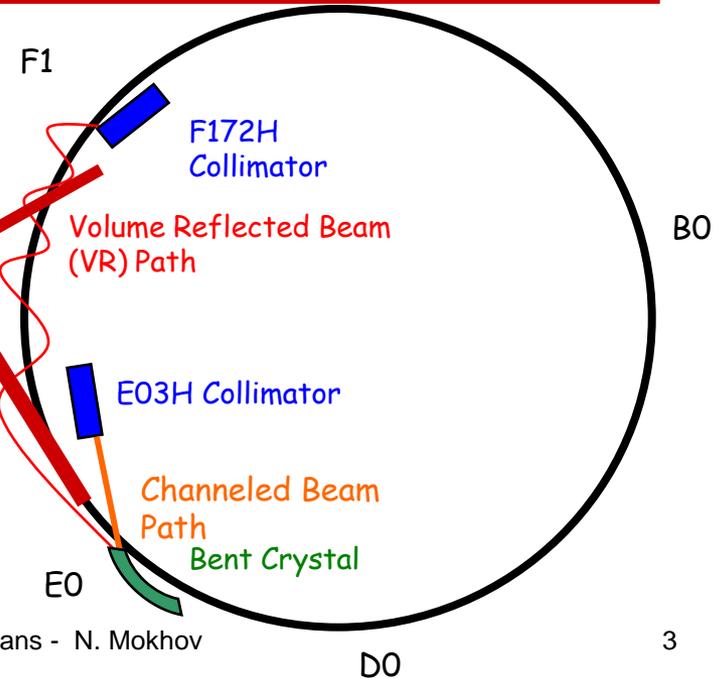
OUTLINE

- Status and New Results
- New Crystals and Beam Diagnostics
- Beam Study Plans

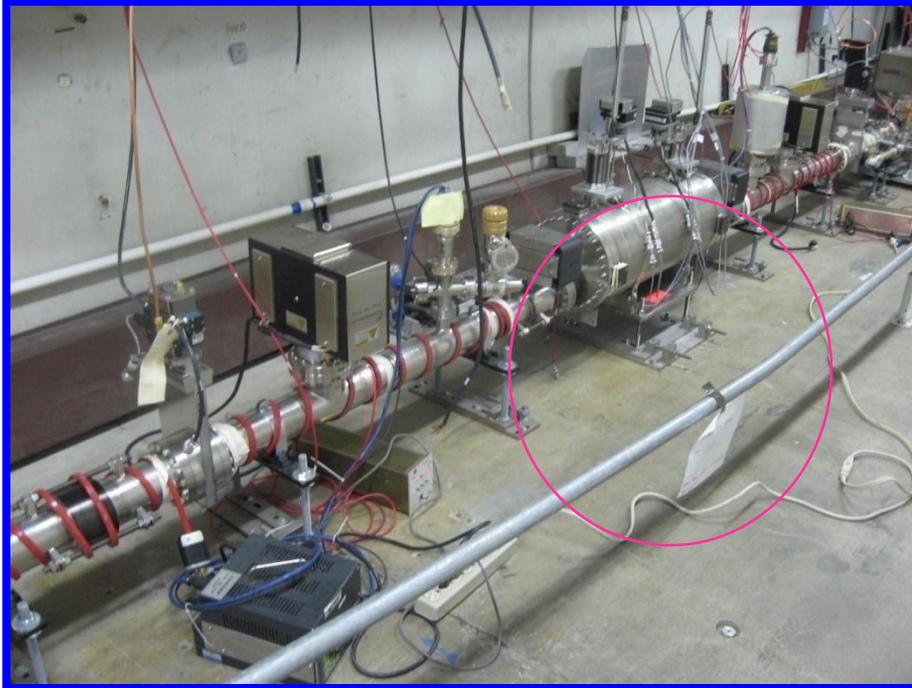
T980 Setup in Tevatron E0 for 2009-2011



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



Goniometer Installations



Newly built and installed (Summer 2009) vertical goniometer at E0. It is ~ 4m upstream of the Horizontal one.

It houses (since June 2010) new QM and INFN multi-strip crystal (replacement to IHEP MS and old O-shaped crystals).



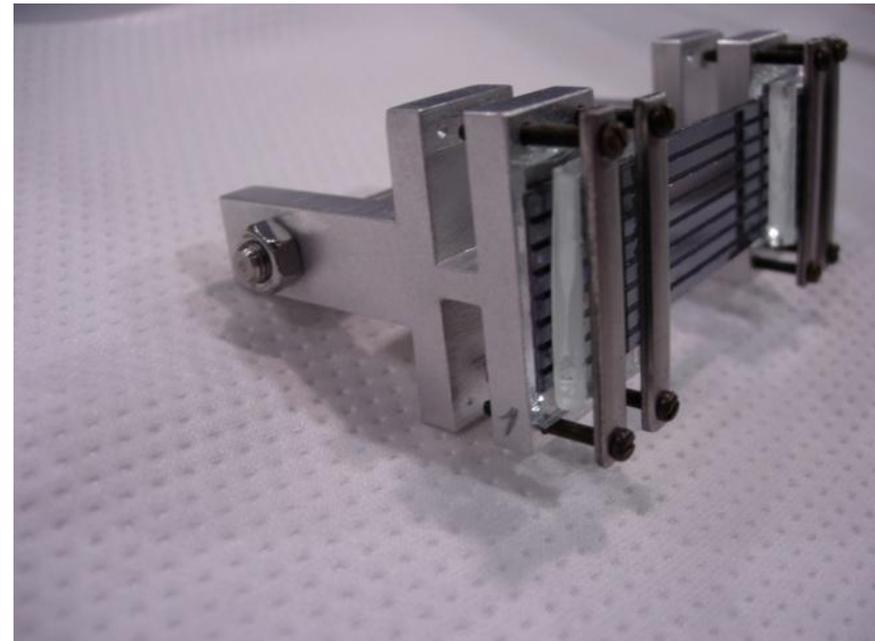
Modified horizontal goniometer. Replaced old large miscut positive angle O-shaped crystal with new small negative miscut angle O-shaped during Summer 2009.

Two IHEP Crystals Studied in 2010



IHEP O-shaped
Bend: 360 μrad , Miscut: 120 μrad
In horizontal goniometer

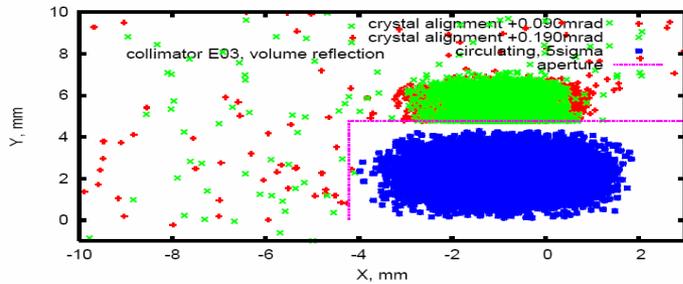
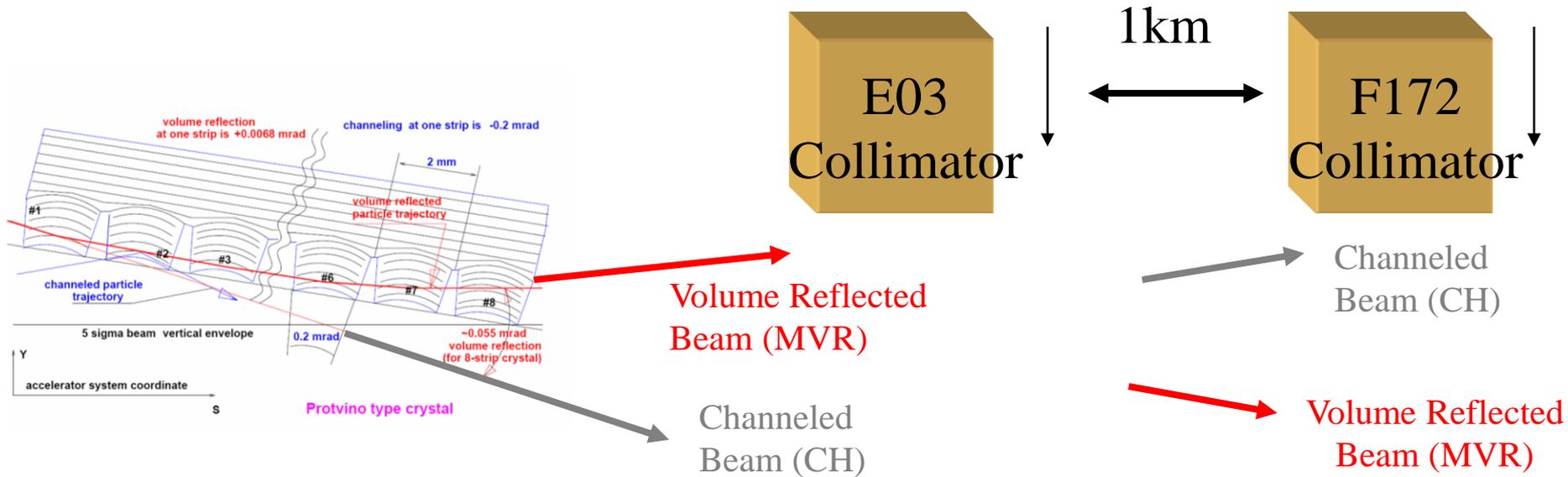
IHEP 8-strip, 63 μrad (VR).
In vertical goniometer
(just replaced with Ferrara Multi-strip)



Beam Studies & Data Analysis in 2010

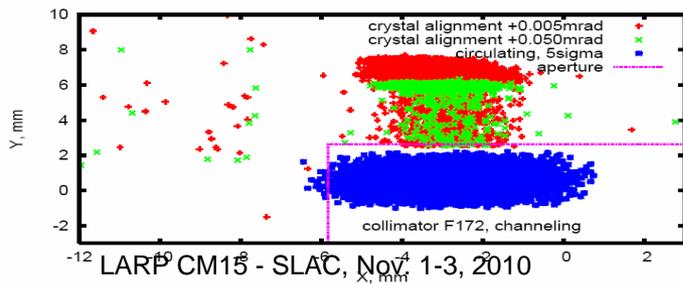
1. Focused on IHEP multi-strip MS-08-09 crystal in vertical goniometer:
 - Good match to TeV environment. Easy to work with!
 - Measured losses of a multiple-VR beam at E03 collimator and a single-strip channeled beam at F17(2) collimator in a good agreement with simulations.
2. First ever attempt of 2-plane crystal collimation
3. ORIGIN-8 based system created; all 2005-2010 data analyzed
4. Refined simulation continued

Vertical Multi-Strip Orientation



Volume Reflected beam (MVR) at E03 Collimator

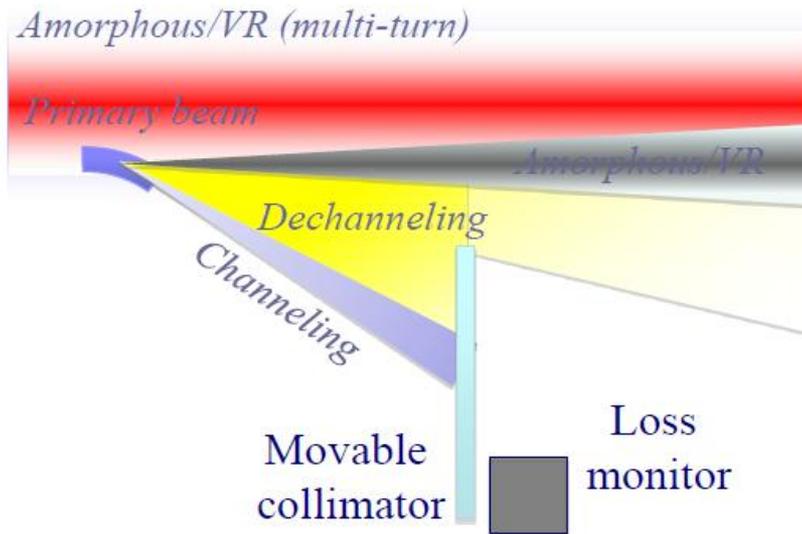
Core



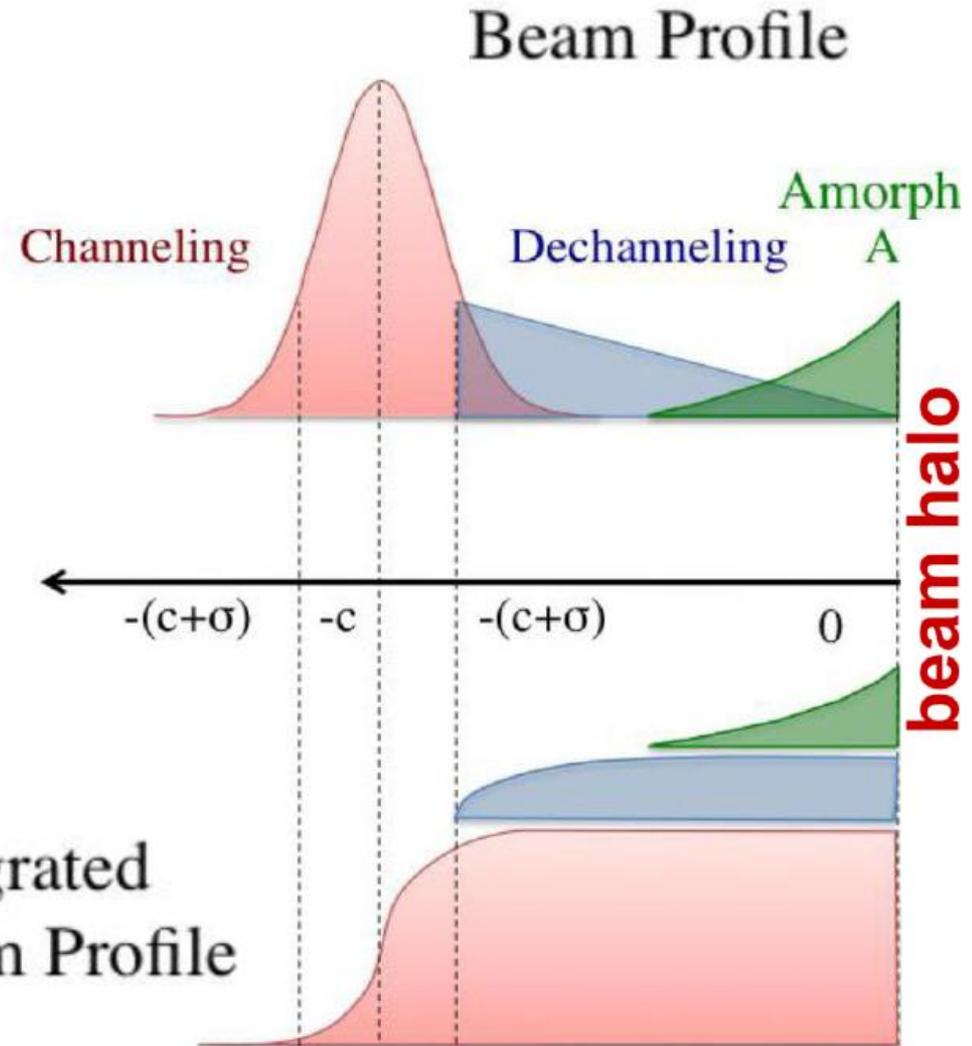
Channeled Beam (CH) at F172 Collimator

Core

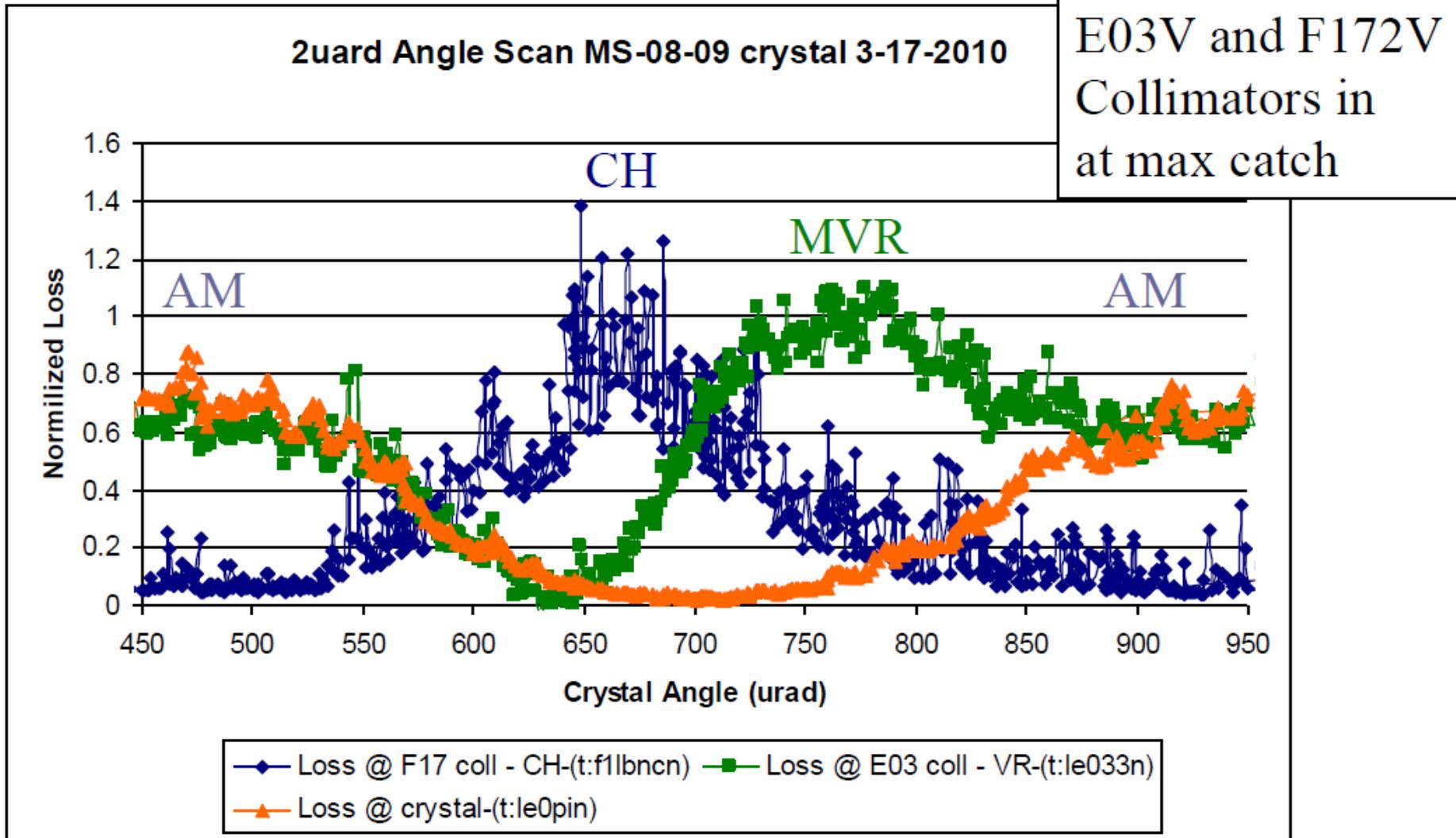
Collimator Scans of Extracted Beams



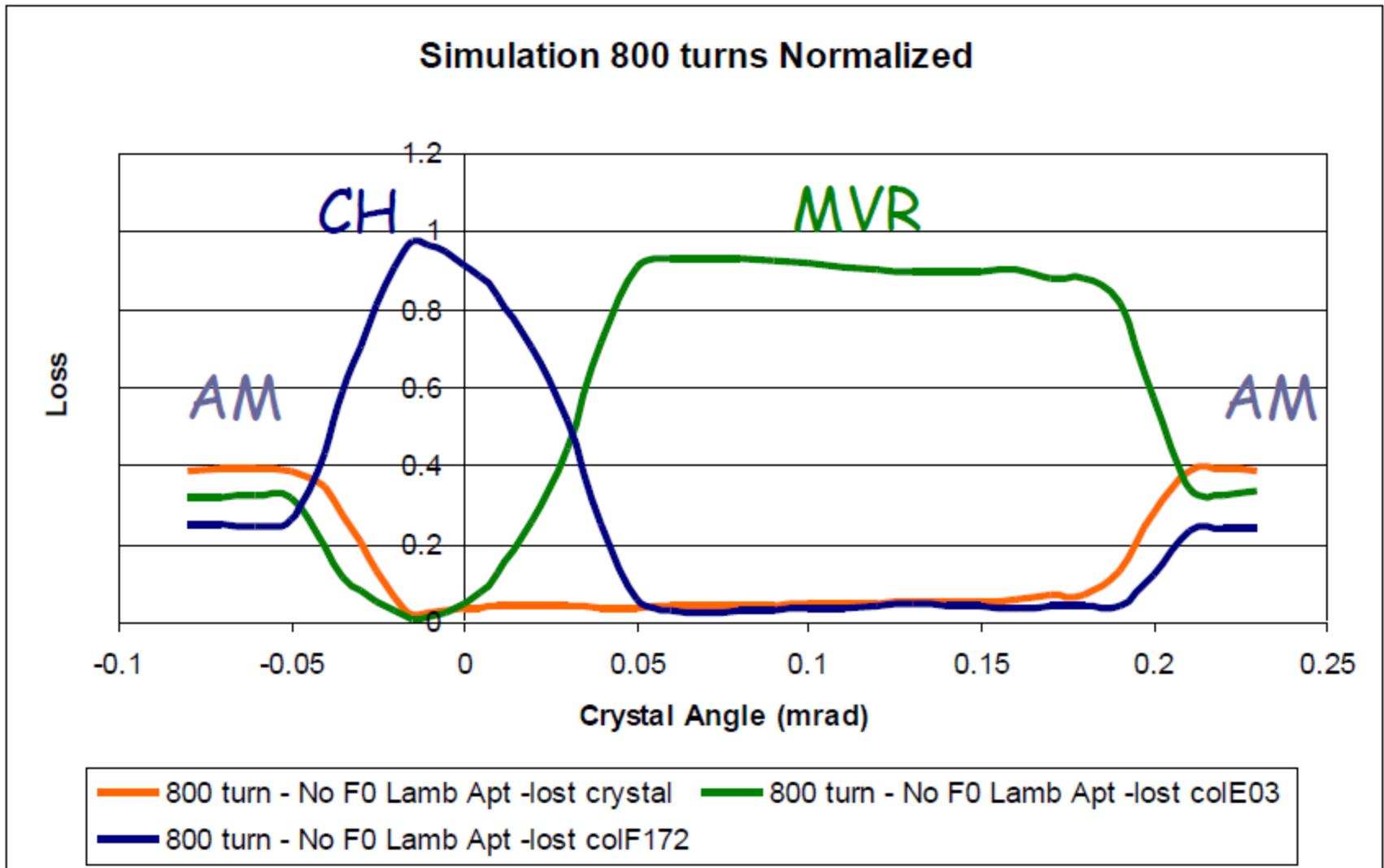
- Move collimator into the beam halo
- Vary crystal angle to observe CH/VR beam
- Observe the losses vs collimator X position (indicates intensity)



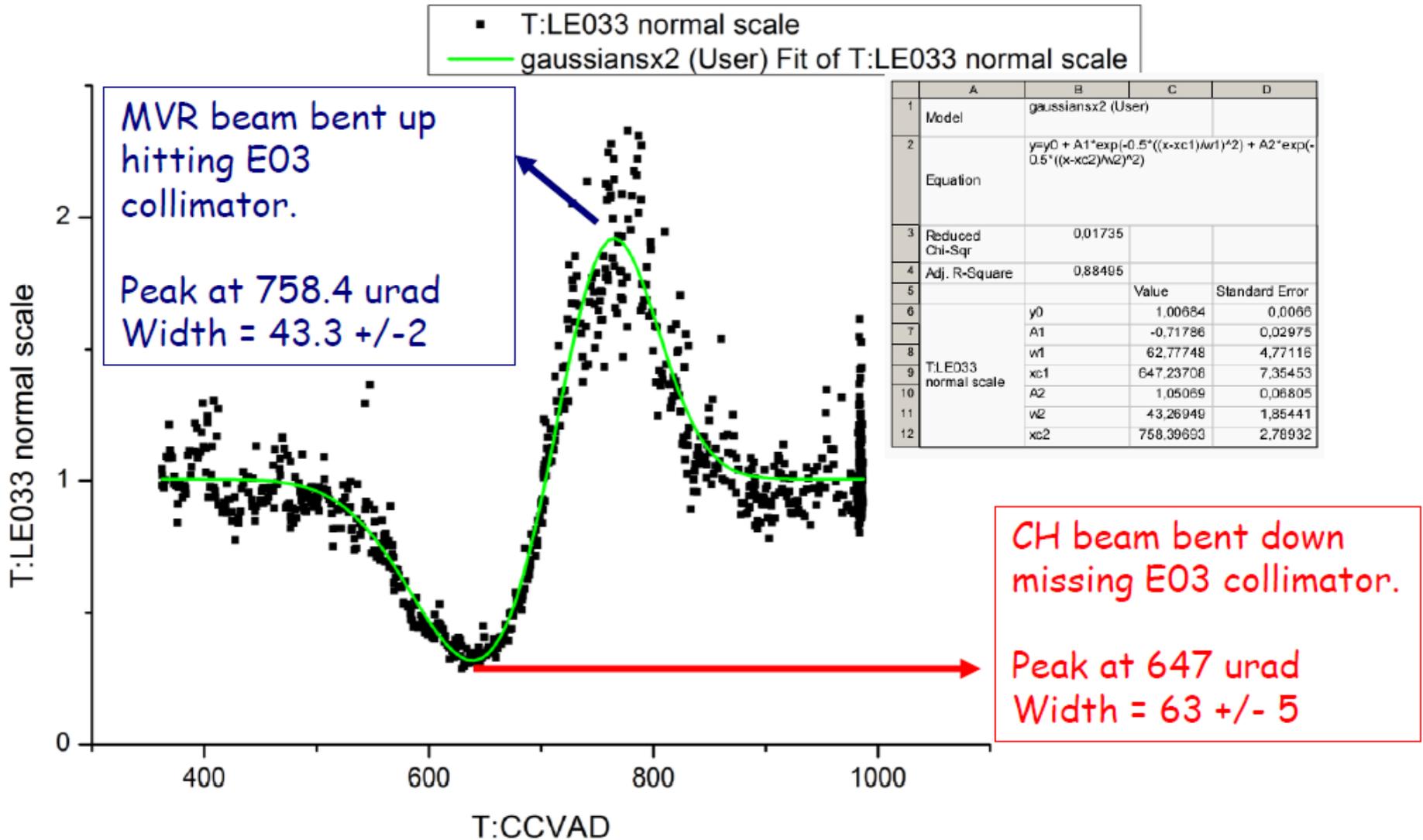
Vertical MS Angular Scan: Data



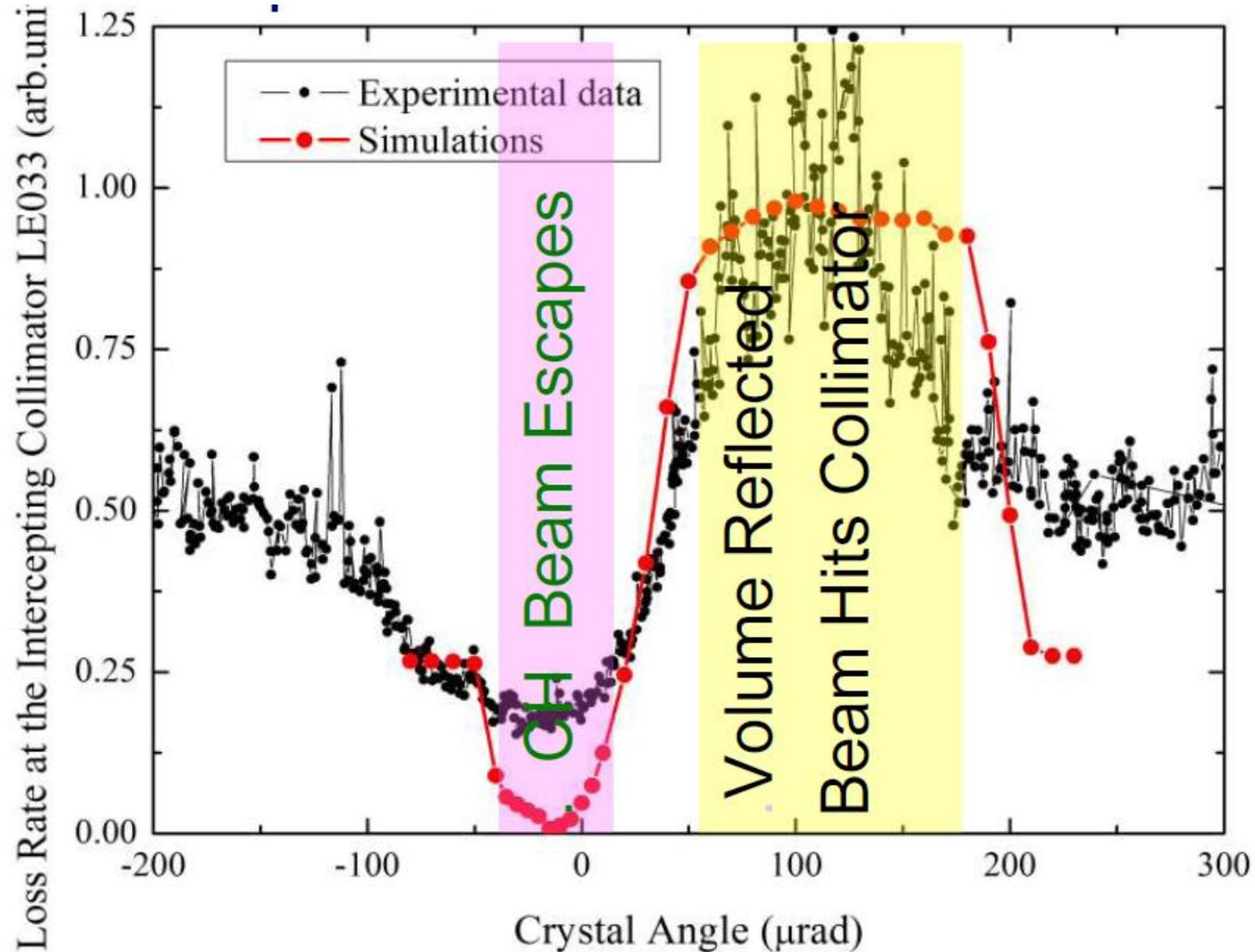
Vertical MS Angular Scan: MC Simulation



Angle Scan Depicting CH & MVR Beams on LE033

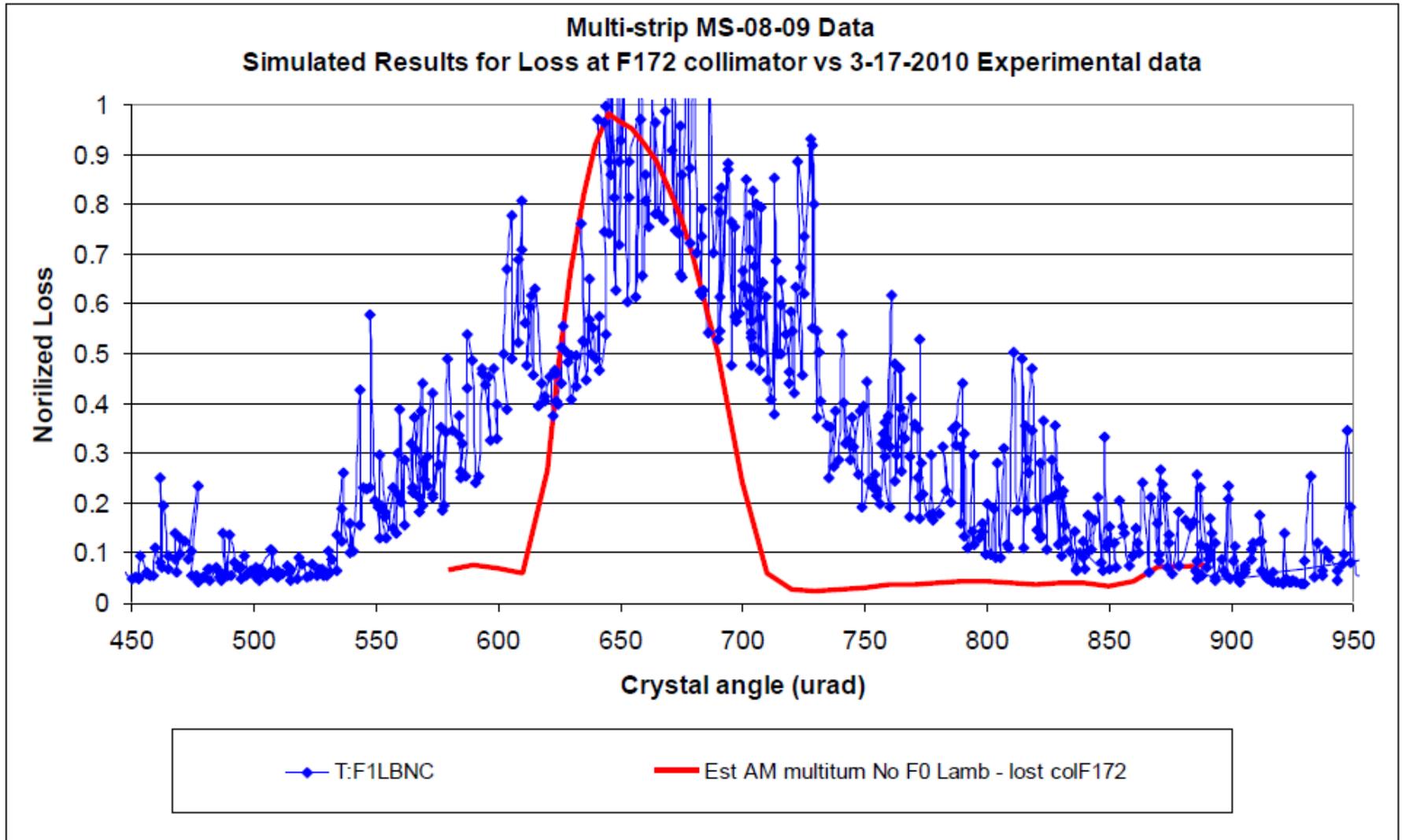


Losses on E03 Collimator: Monte-Carlo vs Data



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Losses on F172 Collimator: Monte-Carlo vs Data



MVR Parameters for MS-08-09 Crystal

Specified VR angle = 64 urad (8 strips X 8urad/strip) Note: This is not a strictly defined angle

	MVR angle (by collimator scan) (μ rad)	MVR width (μ rad)	MVR displaced at E03V collimator (mm)	MVR efficiency (%)	Bend angle (by angle scan) (μ rad)	MVR peak (μ rad)
Measured	74.6 (+/- 7.5 stat) (+/- 1.6 instr)	36 (+/- 10 stat) (+/- 2.5 instr)	1.7 (+/- .6 (stat)) (+/- 1.6 instr)	83.5% (+/- 4 instr)	255 (+/- 28.3 stat) (+/- 6 inst)	767 (+/- 12.72 stat) (+/- 3 inst)
Simulated	64	43.3 (+/- 1.9)	1.61	-	-	758 (+/- 2.9)
SPS H8 Run Result	60* <small>* scaled by 1/sqrt(E)</small>	28.6* <small>* scaled by sqrt(E)</small>	-	-	300 (+/- 50)	-
Measured /Expected	SPS 1.24 Simulated 1.17	SPS 1.25 Simulated 0.83	Simulated 1.05	-	SPS 0.85	Simulated 1.01

Channeling Parameters for O-05-09 Crystal

This crystal will be used in the horizontal plane for 2 plane Crystal collimation.

	CH angle (by collimator scan) (μ rad)	CH width (μ rad)	CH displaced at E03H (mm)	CH Efficiency (%)	Bend angle (by angle scan) (μ rad)	CH peak (μ rad)
Measured	158.8 (+/- 22.8 stat) (+/- 1.2 instr)	16.2 (+/- 5.3stat) (+/- 1.5 instr)	3.8 (+/- .5 stat) (+/- 3 (instr)	79.57 (+/- 9.38)	280.4 (+/- 53.5 (stat) (+/- 100 inst)	-960.8 (+/- 9.1 stat) (+/- 1.5 inst)
Simulated	360	10.5 (+/- 1.1 stat) (+/- 1.0 inst)	8.5	-	192.8 (+/- 20)	-962.8 (+/- 1.6 stat) (+/- 1.0 inst)
Measured /Expected	.44	1.5	.45	-	1.45	.99

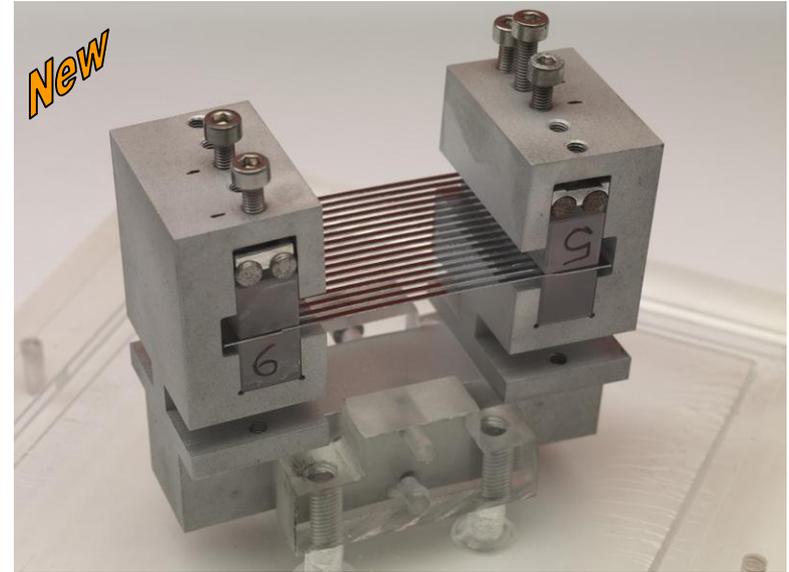
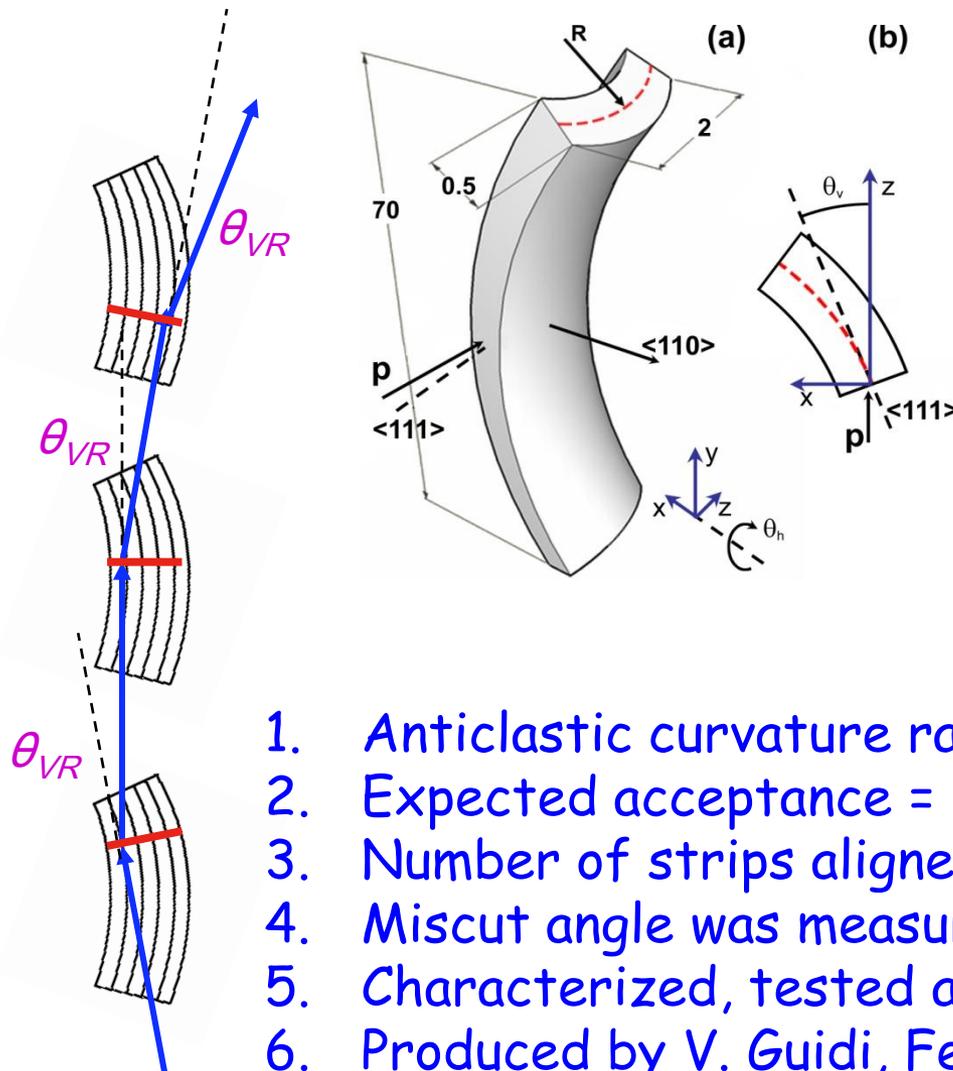
The CH angle being smaller is a consistent result with the other O-shaped crystal O-BNL-02 (300 μ rad/410 μ rad = .72 Meas/Exp). Thought that this was miscut related but O-05-09 miscut = 120 μ rad not 1600 μ rad like O-BNL-02.

Think this is related to the O-shaped crystal beam-side profile.

Summer 2010 Shutdown: New Hardware

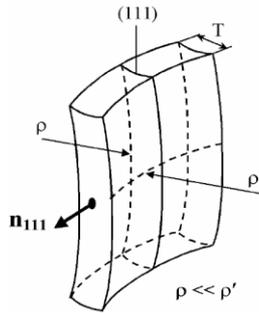
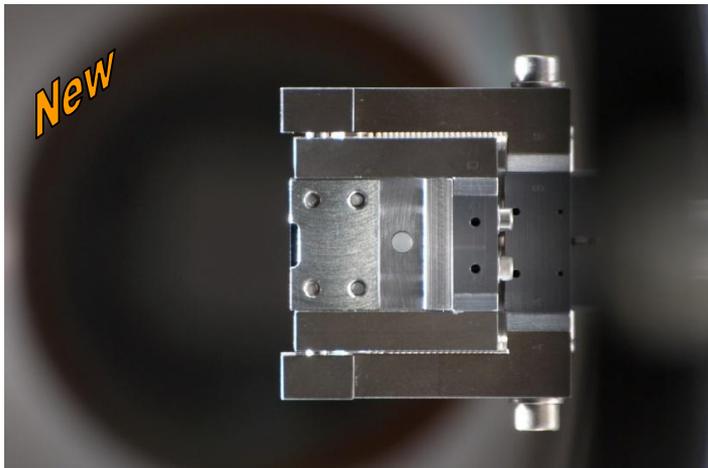
1. Replaced IHEP 8-strip with Ferrara **14-strip crystal** in vertical goniometer.
2. Installed a new **quasi-mosaic crystal** into vertical goniometer.
3. Manufacture and test two 6-plane telescopes with **pixel detectors** along with corresponding mechanics, electronics, control and software to **measure channeled and MVR beam profiles** on E03 and F17 collimators.

New Ferrara Multi-Strip Crystal



1. Anticlastic curvature radius = 4.2 m
2. Expected acceptance = 80 μrad
3. Number of strips aligned/used = 13
4. Miscut angle was measured as 600 μrad
5. Characterized, tested and installed in vertical goniometer
6. Produced by V. Guidi, Ferrara, INFN

New PNPI Quasi-Mosaic Crystal

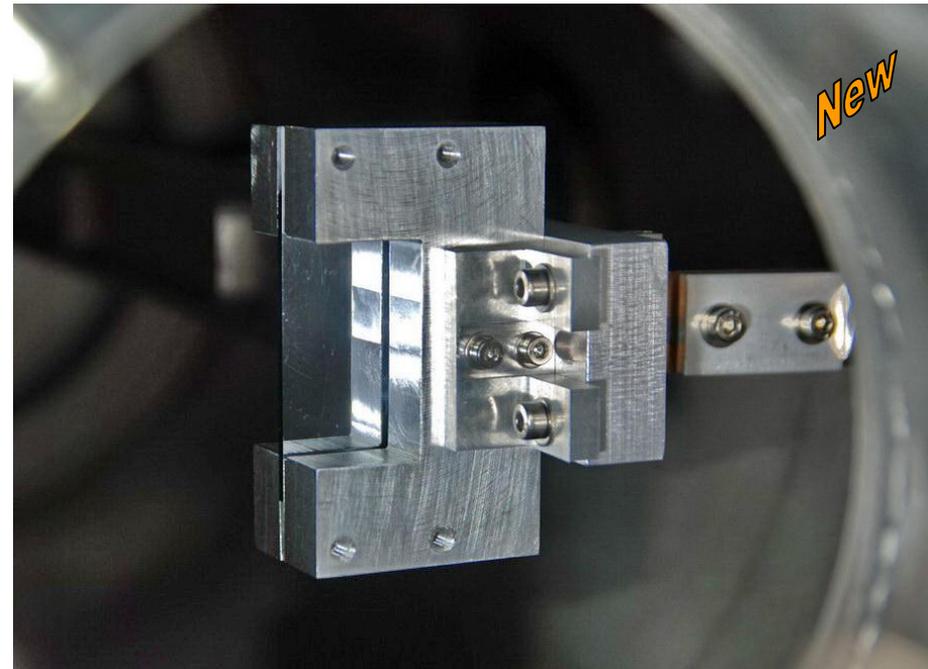


QM crystals used for UA9 measurements at SPS in 2009

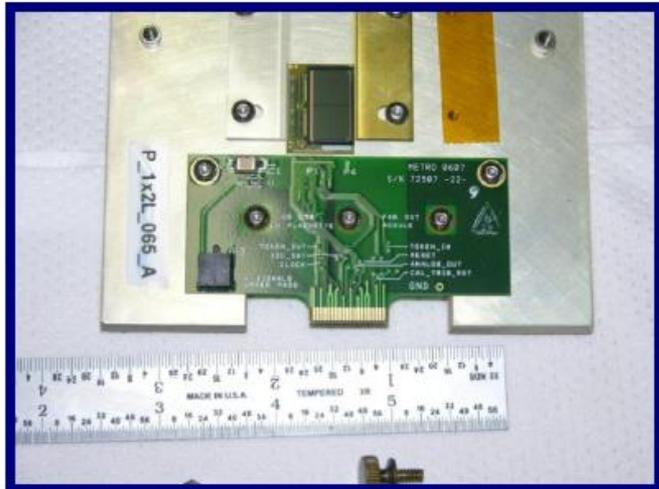
Opening in bending device $2 \times 10 \text{ mm}^2$

2-mm thick, 120- μrad bending, miscut angle 50 μrad

Characterized, tested and installed in the vertical goniometer.
Produced by Y. Ivanov, PNPI



Pixel Telescope Detectors



- Multi-chip modules are of CMS forward pixel production.
- 1x2 cm² with a sensitive area 0.8x1.6 cm².
- Pixel size 100x150 μm², resolution 7-8 μm.



- Building 2 detectors
 - 1 installed in front of E03 collimator
 - 1 installed in front of F172 collimator
- Consists of 3 telescoping pixels per plane.
- Problems vacuum certifying pixel boards due to baking temperatures.
- Should install ~ December 2010

T980 Plans for 2010-2011: End-of-Store Studies

1. Characterize both crystal parameters with beam.
2. Establish routine measurements of channeled/reflected beam profiles with pixel telescopes (**1/4 FTE CD**).
3. Measure crystal collimation efficiencies for O-shaped, quasi-mosaic and multi-strip crystals in channeling and volume reflection modes.
4. Establish simultaneous horizontal and vertical collimation for various combinations of crystals.
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.

Total: 5 to 7 EOS studies (~3 hrs each), Oct. 2010 - Sept. 2011

FY11: \$100k LARP and matching amount OP-FNAL

T980 Plans for 2010-2011: Full Collider Stores

- Study crystal collimation system efficiency - in the most optimal configuration found in EOS - during **several full 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.

Proposal for Post-Run II Studies

1. Detailed investigation of the principal crystal collimation issues focusing specifically on LHC-related questions in dedicated collider stores in controllable conditions with crystals and beam diagnostics tuned in 2010-2011 End-of-Store studies. Four 8-hour collider stores spread over two months.

Endorsed by the Fermilab AAC in July 2010 as one of the most compelling in terms of advancing the world's knowledge of the accelerator physics phenomena in high-energy proton colliders.

2. Antiproton-beam crystal collimation (no AAC support).

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.
- A post-Run II period would provide a unique possibility for even deeper, controllable, dedicated studies of several key issues of the program.