

Advanced bent crystal collimation system at the Tevatron (T-980)

FNAL, SLAC, CERN, PNPI, IHEP, INFN

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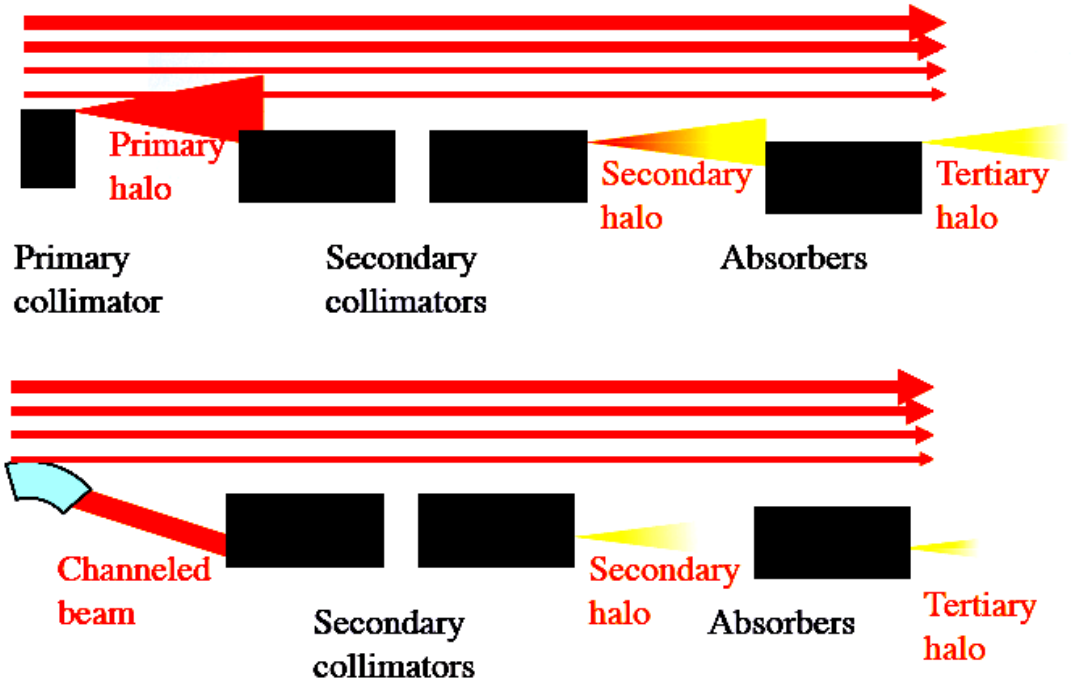
Outlook

- Basics
- Experimental layout
- Crystals
- Experiment: angular and collimator scans
- Data Analysis
- T-980 results
- PIXEL telescope
- Conclusions and Plans

Standard vs. Crystal Collimation (CC)



Developed CC system at the Tevatron, FNAL

Prospective collimation system for the LHC!!!

Why?

Drive the beam halo deeper into a secondary collimator (coherently)

Reduced secondary and tertiary halo

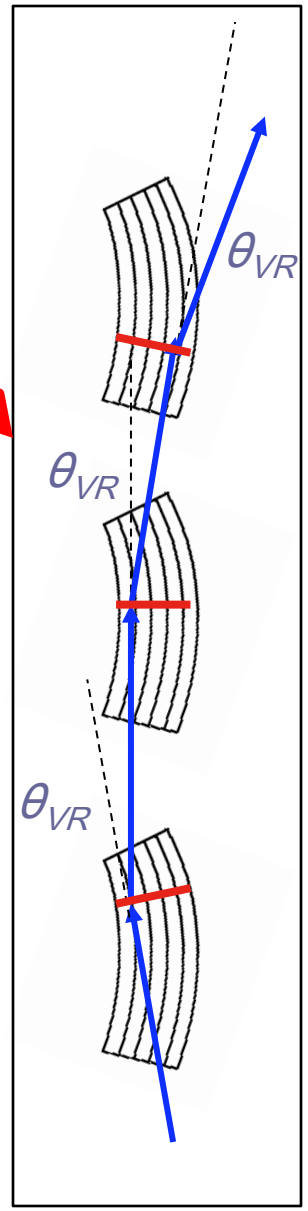
- Reduced beam losses at Critical Locations
- Reduced radiation loads at the downstream superconducting magnets

How crystals work?

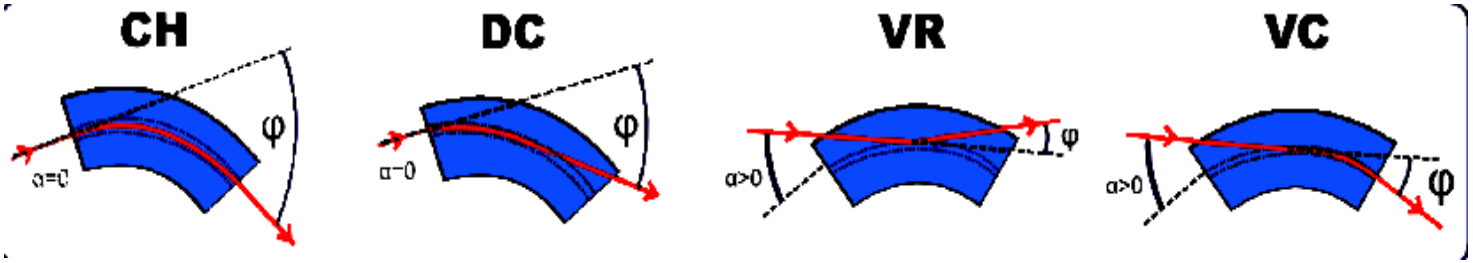
Six processes in bent crystals:

- ✓ channeling
- ✓ volume reflection
- ✓ multiple volume reflection
- ✓ volume capture
- ✓ multiple (random) scattering
- ✓ de-channeling

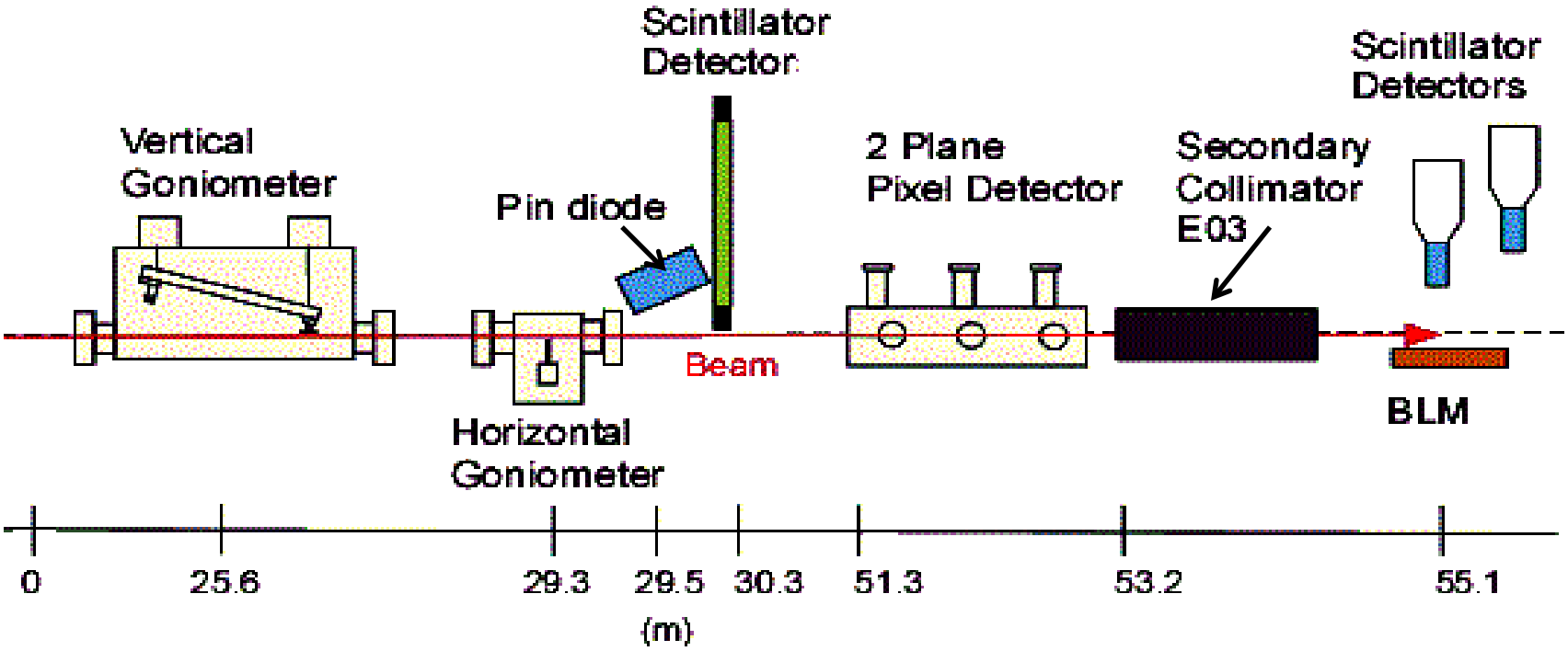
Multiple Volume Reflection



Channeling **De-channeling** **Volume reflection** **Volume capture**

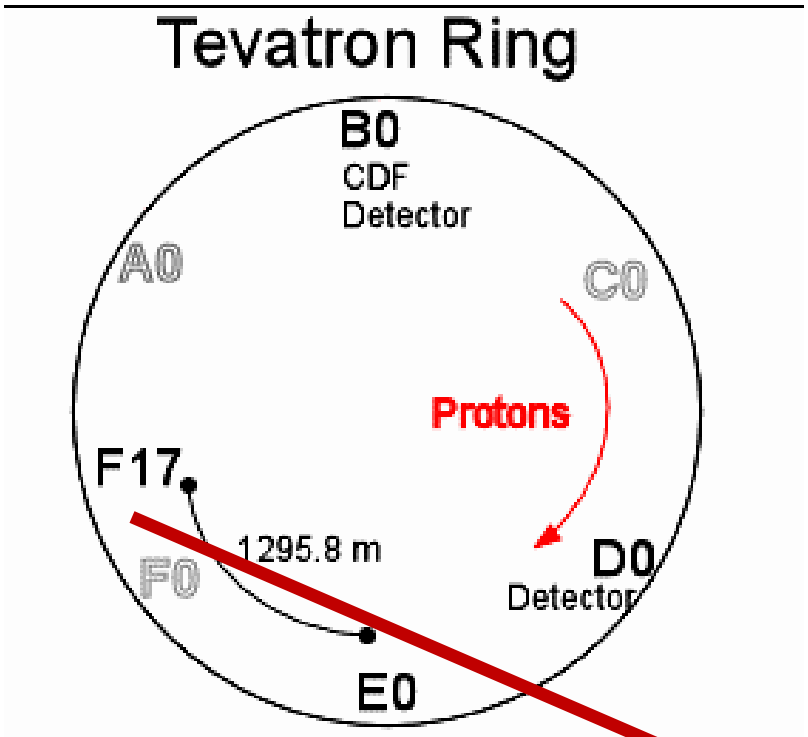


T-980 layout (E0 location)

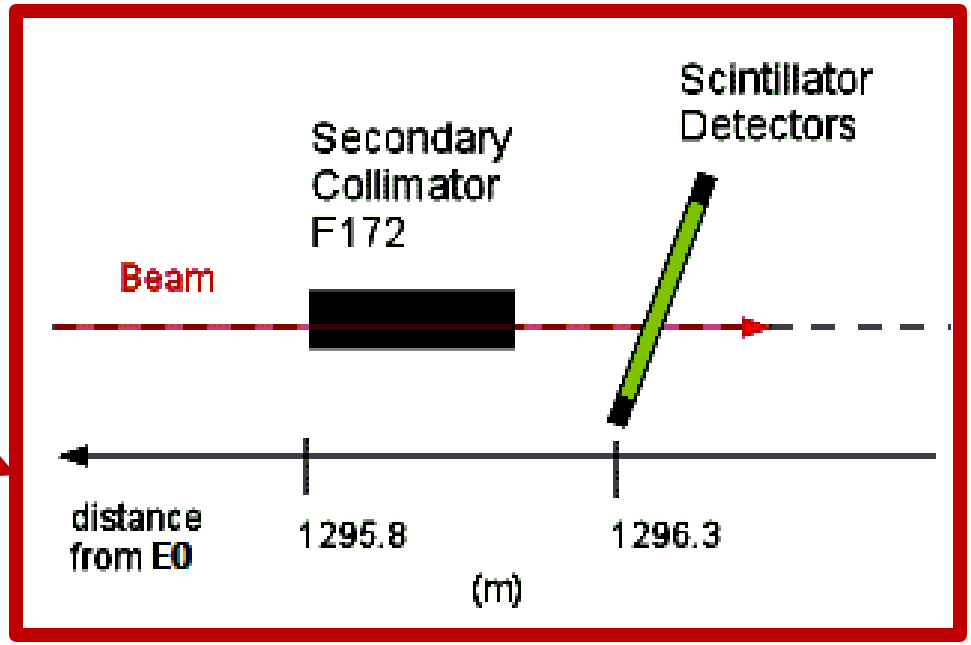


- Goniometer moves and rotates a crystal to a precise ($\sim 2\mu rad$) angle
- Crystal inserted at 5σ
- Collimators inserted at $6-7\sigma$ intercept **Channeled** particles
- Loss monitoring system: PIN diode, BLM, Scintillating paddles

T-980 layout (F17 location)

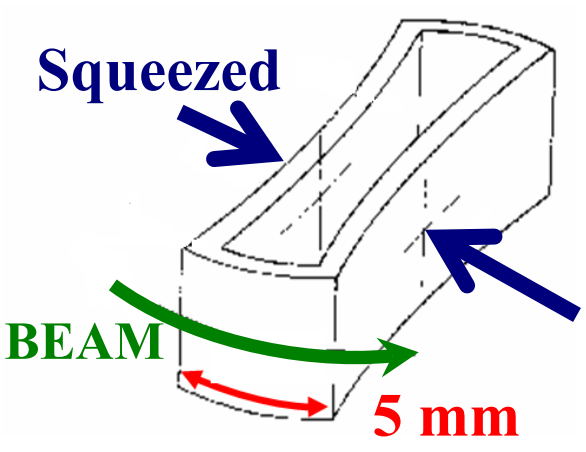
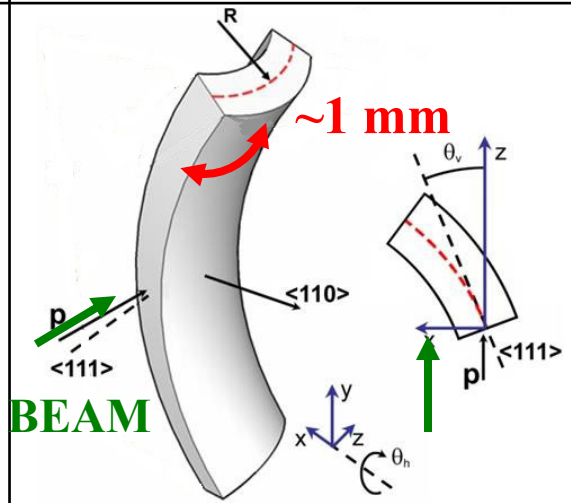
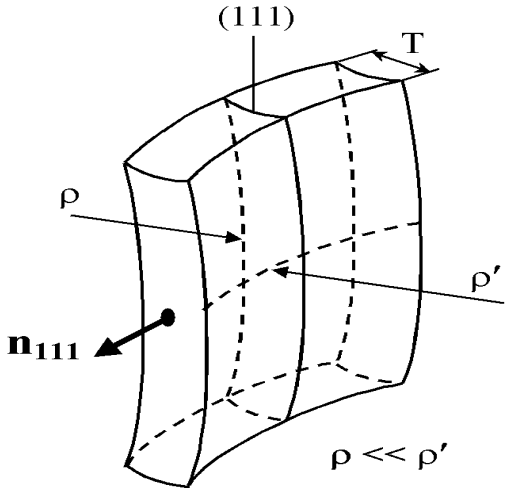
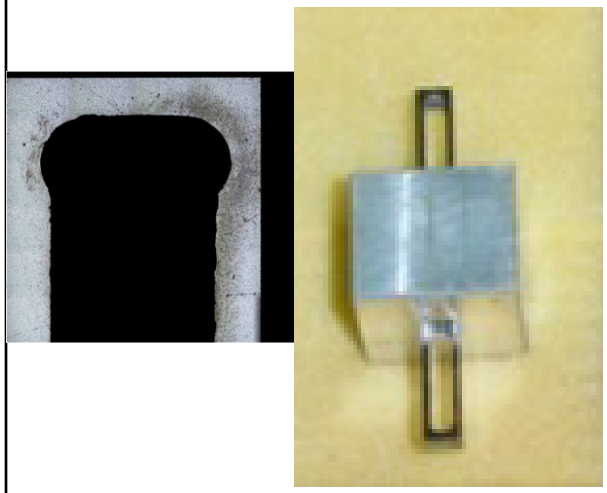
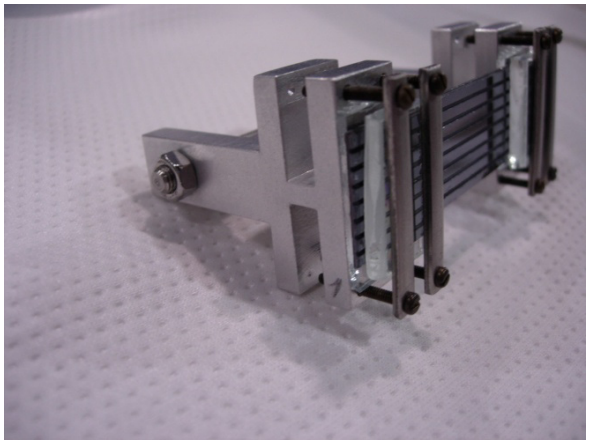
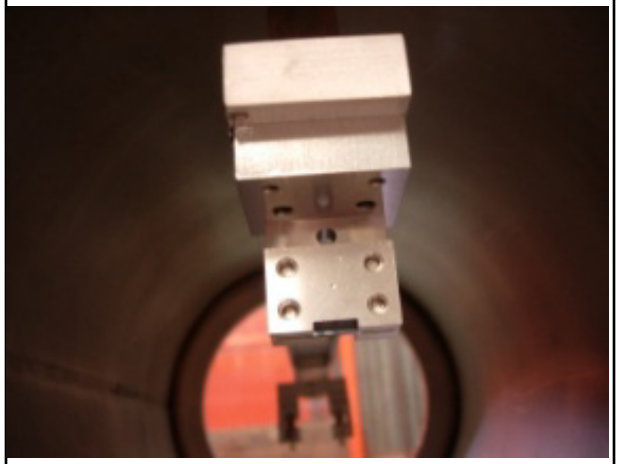


•**Volume Reflected** particles are intercepted by **F172** secondary collimator

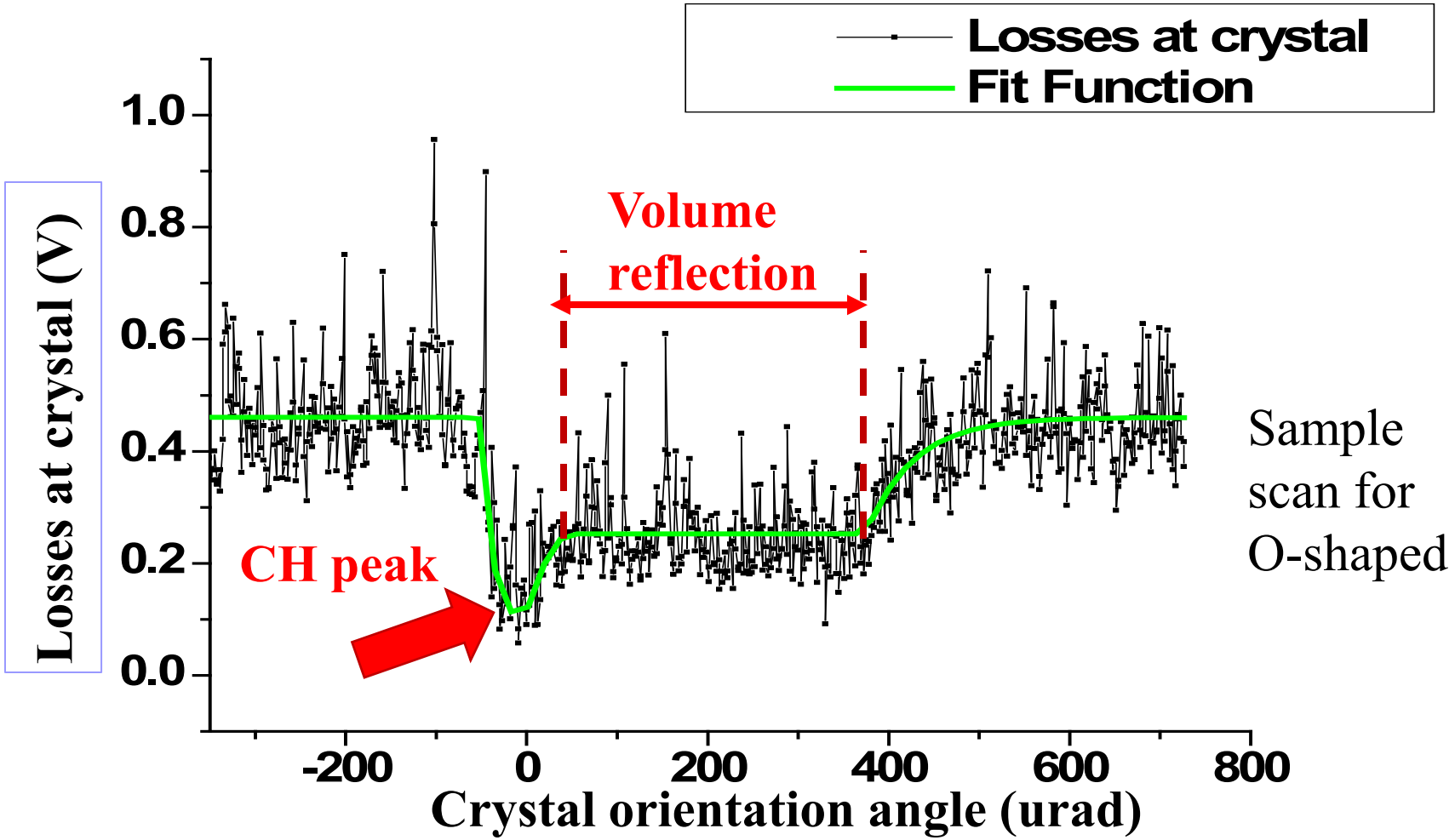


Loss monitoring system: Scintillating paddles

T-980 crystals

O-shaped (PNPI)	Multi strip (IHEP, INFN)	Quasi-mosaic (PNPI)
		
		

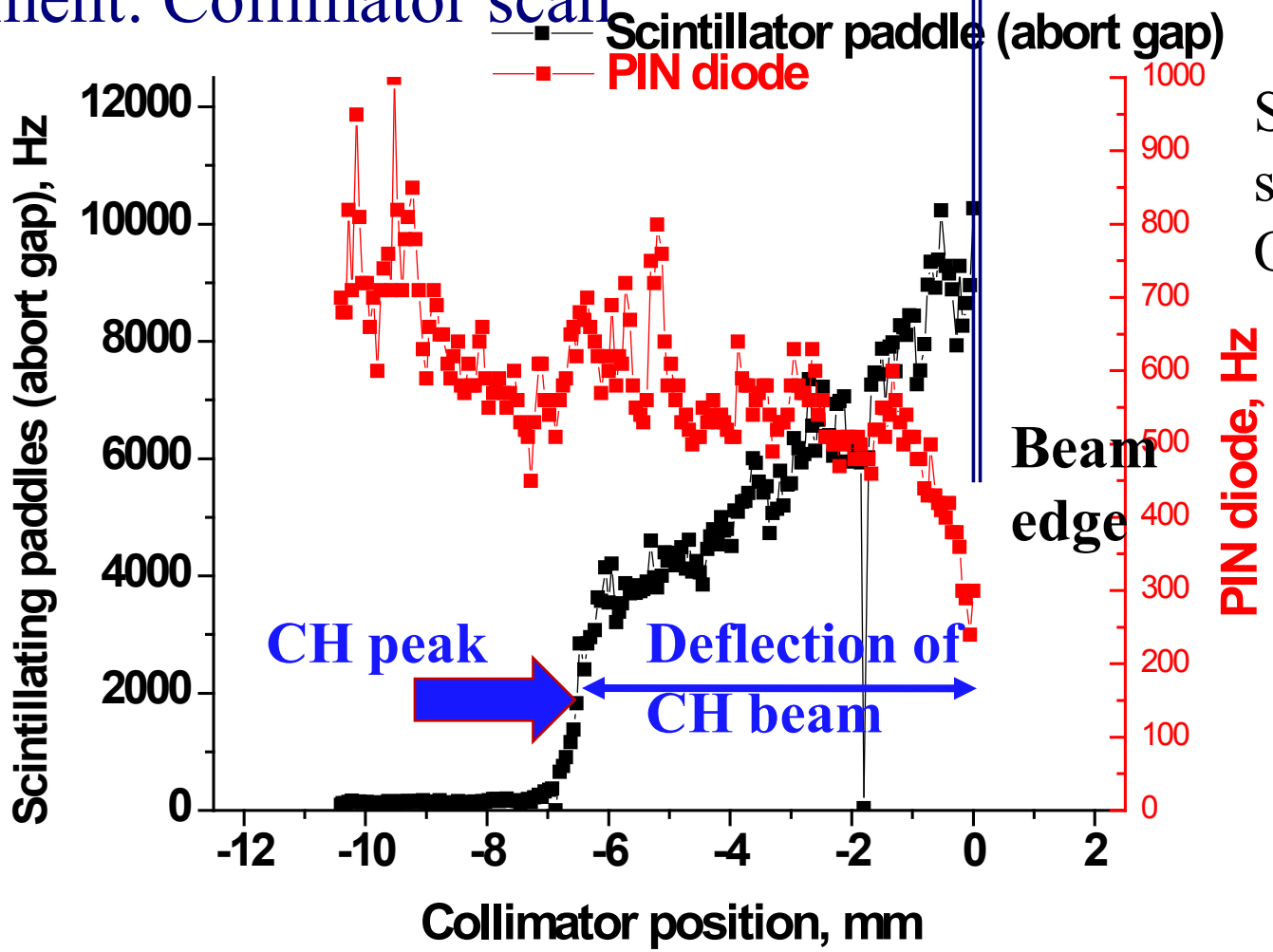
Experiment: Angular scan



Sample scan for O-shaped

Observe the losses vs. crystal orientation (slowly changed)

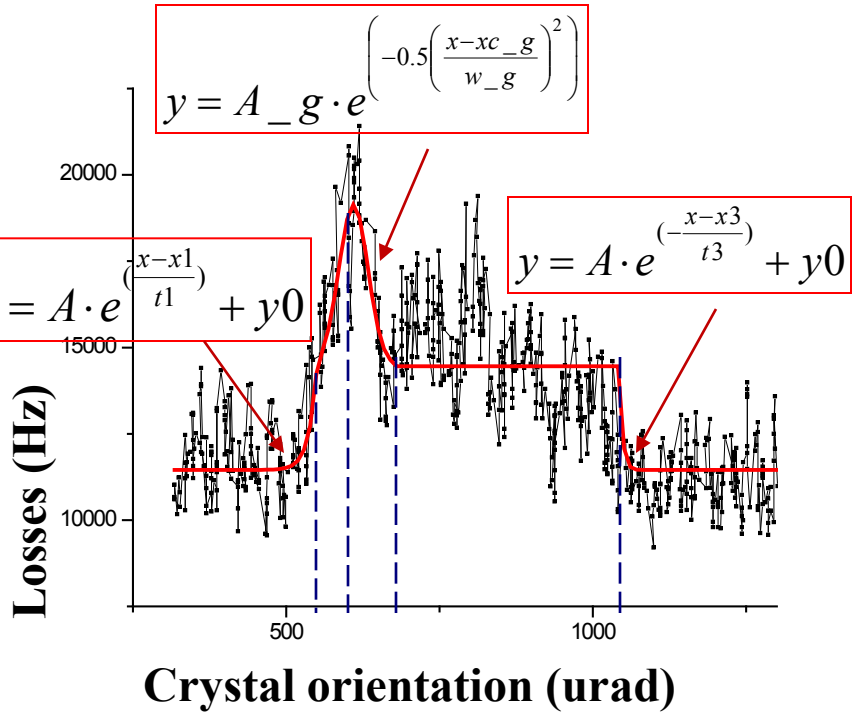
Experiment: Collimator scan



Sample scan for O-shaped

- Crystal fixed in CH or VR position
- Observe the losses vs. coll position (from totally retracted to the beam edge)

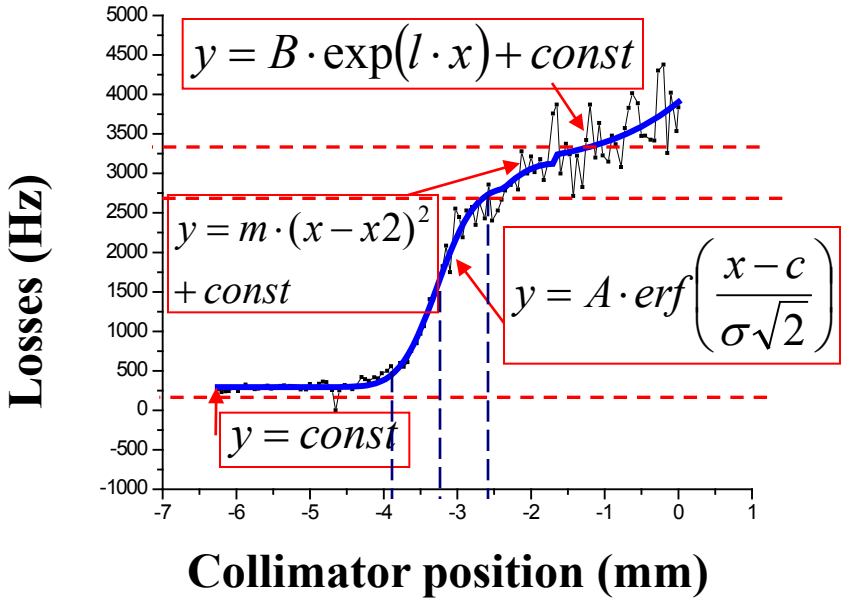
Data Analysis (ORIGIN based)



CH peak position
CH acceptance
VR acceptance

CH peak exact position
CH acceptance
CH efficiency!!!

Same for VR

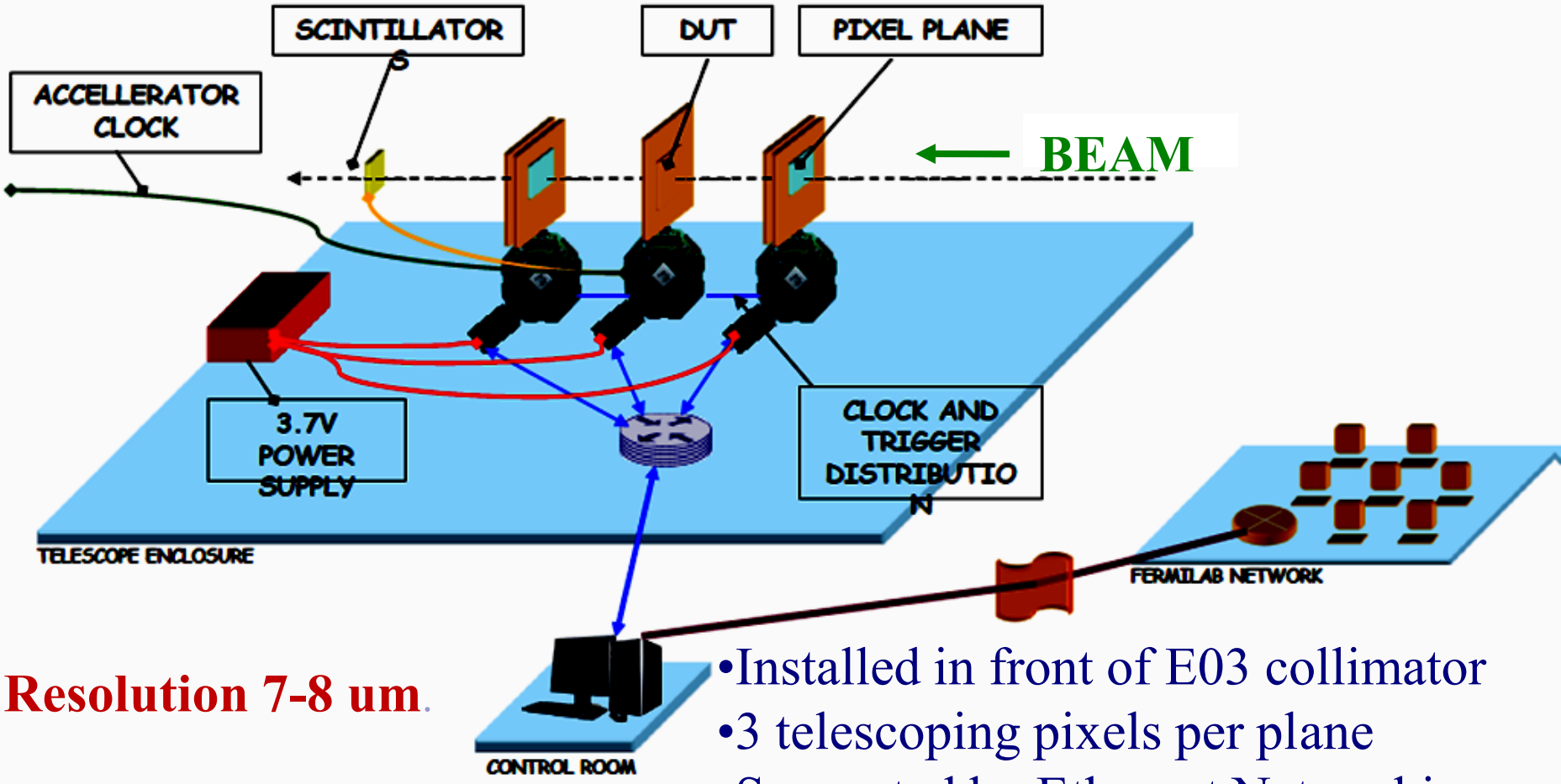


T-980 results

Crystal's name	CH plane, deflection type	From	Bend angle/VR angle, urad	Size along the beam, mm	Miscut angle, urad	Displacement of particles at E03 (CH/VR), mm, simulated	Displacement of particles at F172 (CH/VR), mm, simulated	Maximum Efficiency, %
O-BNL-02	(110), hor	PNPI	410/9	5	1600	-10/0.43	25.55/-1.13	CH 75
O-05-09	(110), hor	PNPI	360/16	5	120	-8.13/0.39	22.44/-1.06	CH 60
MS-08-09	(111), vert	IHEP	200 and 8/strip	0.9	small	5.04/-1.56	-6.58/2.07	VR 70
MS-16-11	(110), vert	INFN	250 and 13.5/strip	1/strip	600	6.3/-5.36	-8.23/7.11	
QM-01-10	(111), vert	PNPI	120/15-	2	50	2.9/-0.37	-3.95/0.49	

PIXEL telescope

TRACKING Channeled and
Volume Reflected particles!!!



Resolution 7-8 um.

- Installed in front of E03 collimator
- 3 telescoping pixels per plane
- Supported by Ethernet Networking

Conclusions

- ✓ Crystal collimation studies were conducted for more than 5 years (2005-present).
- ✓ A reduction of ring losses was reproducibly observed along with local loss effects on the collimator due to crystal channeling.
- ✓ T980 has had a great experience in testing various bent crystal technologies. There are currently 2 new Multistrip crystal installed which will be further studied for 2011. NOW we have crystals to conduct **2-PLANE** collimation!
- ✓ Estimated max Channeling efficiency of the O-shaped crystals is 65-75%, Volume Reflection efficiency for 8 strip Multistrip crystal is 70%.
- ✓ T-980 favors Multi strip crystals: Larger angular acceptance, EASY to work with, Multiple Volume Reflection gives larger deflection.

Future plans

- ✓ Future profiles of Channeled and Volume Reflected beams by using recently installed PIXEL telescopes.

- ✓ Aggressive plans till October 2011 for thorough study of two-plane crystal collimation efficiency in End-Of-Stores and full collider stores.

- ✓ A post-Run II period (approximately October 2011) would provide a possibility for deeper, dedicated studies of several key issues of the program.