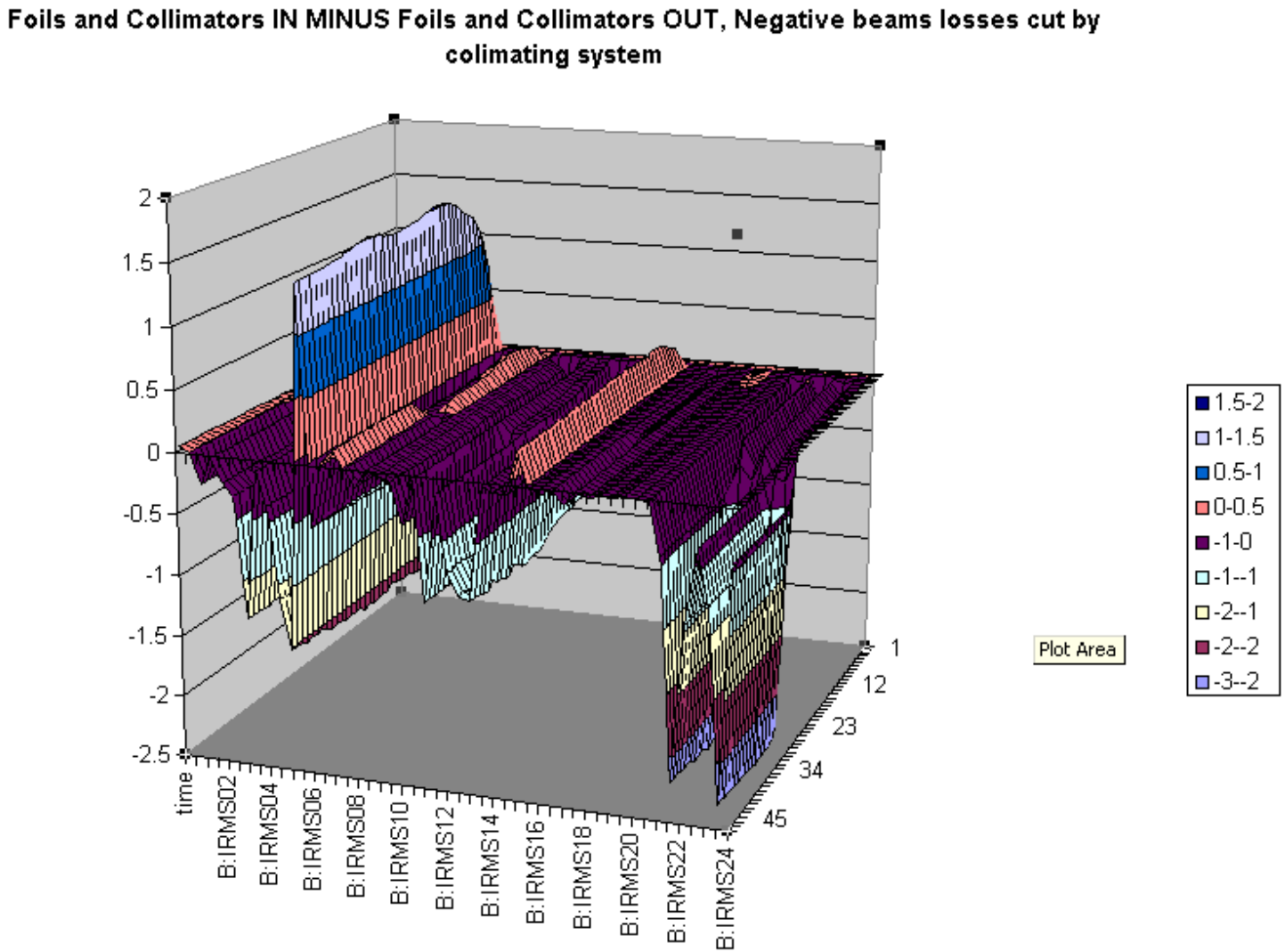
Collimation Working Group Summary

Angelika Drees, Nikolai Mokhov

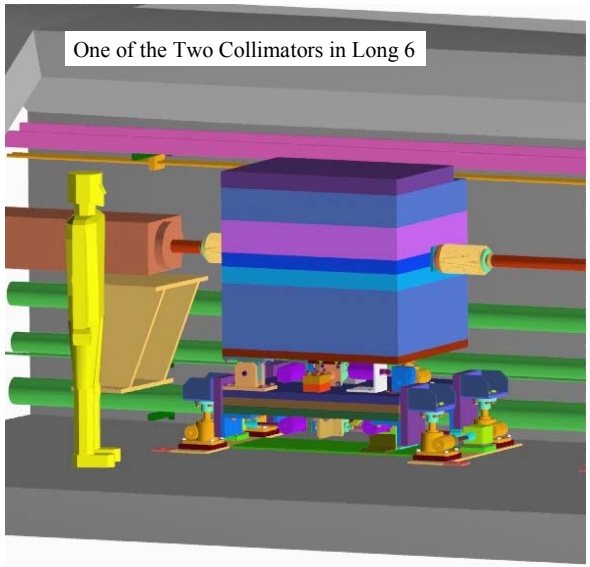
Plenary talks by: N.. Mokhov, T. Raubenheimer, J.Wei

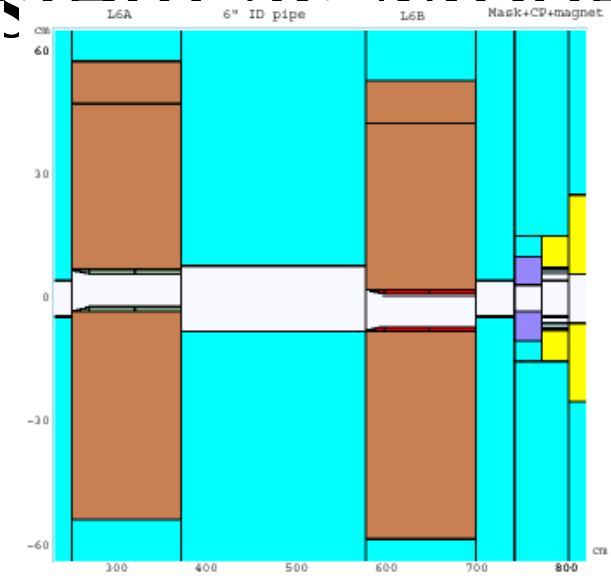
Presentations: C. Warsop (ISIS), E. Prebys (FNAL Booster), N. Nakao (J-PARC), N.Simos (SNS Design), H. Ludewig (SNS Radiation), G. Murdoch (SNS Handling), D. Still (Tevatron), R. Schmidt (LHC Challenges), J.B. Jeanneret (LHC status), I. Rakhno (LHC accidents), R. Fliller (RHIC crystal), M. Kostin (code development), A. Seryi (Nonlin. Optics), A. Drees (RHIC), W. Kozanecki (LC detector req.), A. Seryi (LC performance), F. Zimmermann (CLIC), T. Markiewicz (GEANT3), T.Markiewicz (NLC muons), T. Markiewicz (renewable technology), H. Schlarb (TTF), P. Tennenbaum (Wakefields), D. Kaltchev (DiMAD LHC)

Preliminary Results from

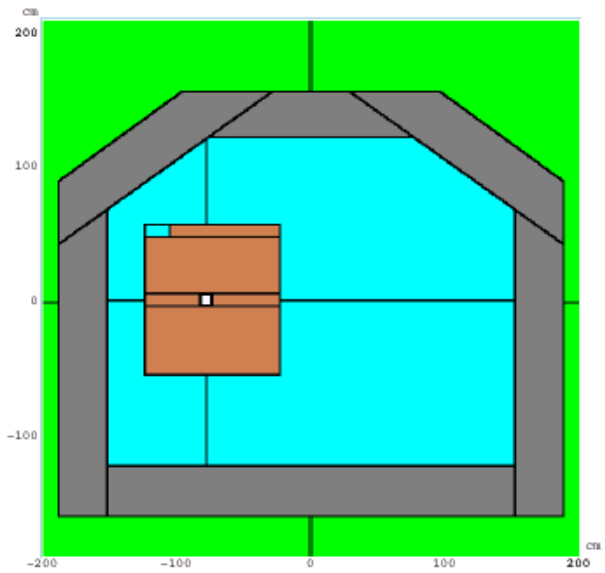


System as Modeled



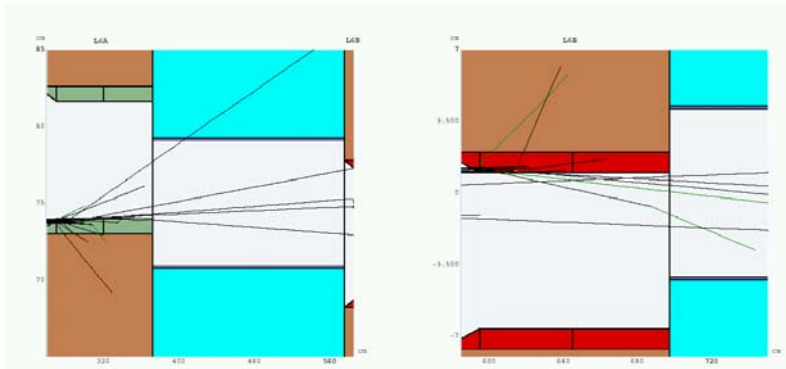


Period 6 Side View

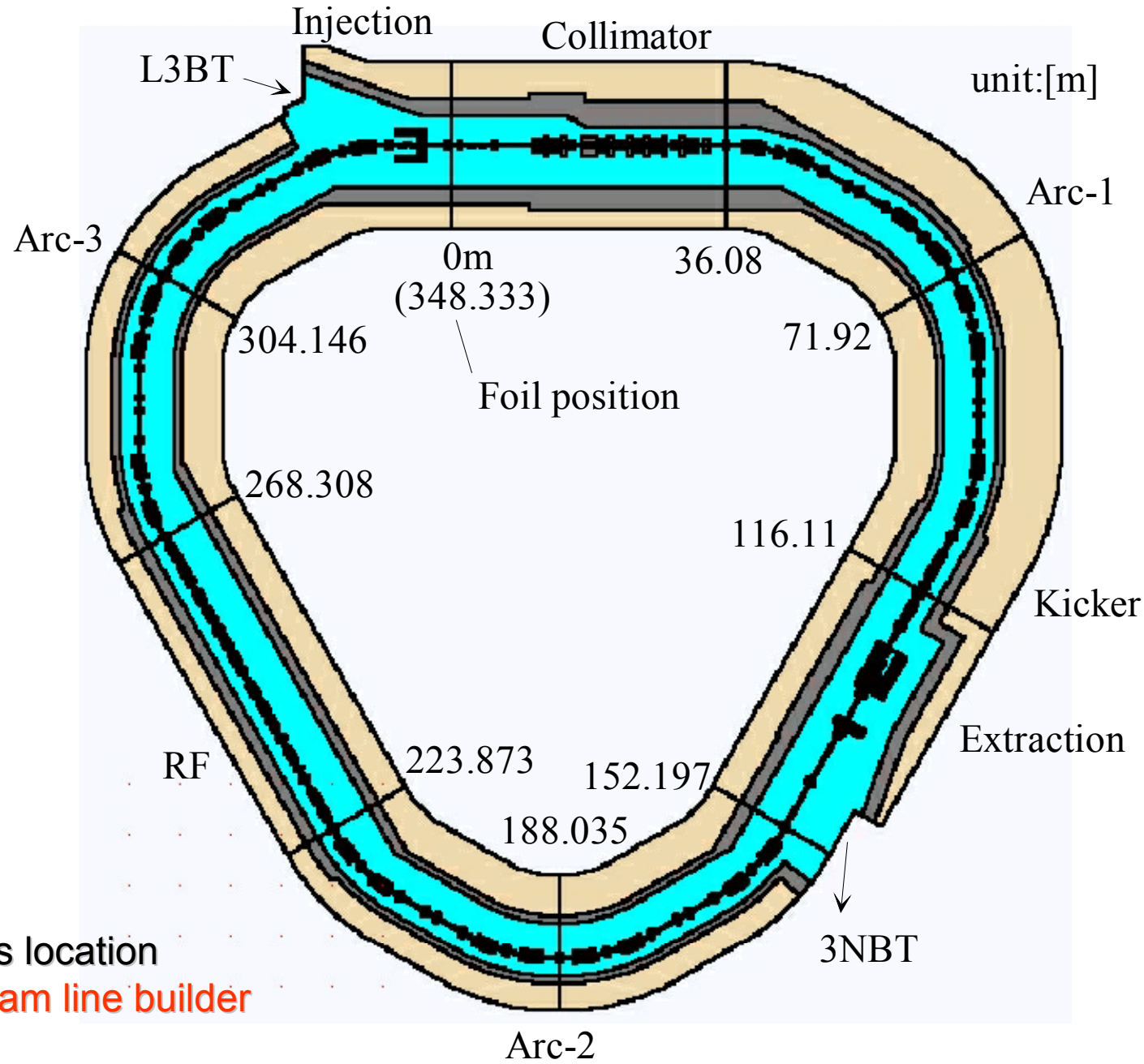


End View

- 3”x3” aperture
- Stainless steel collimator integrated into steel shielding.
- Total length: 48”
- Width: 43.5”
- Height: 43.5”



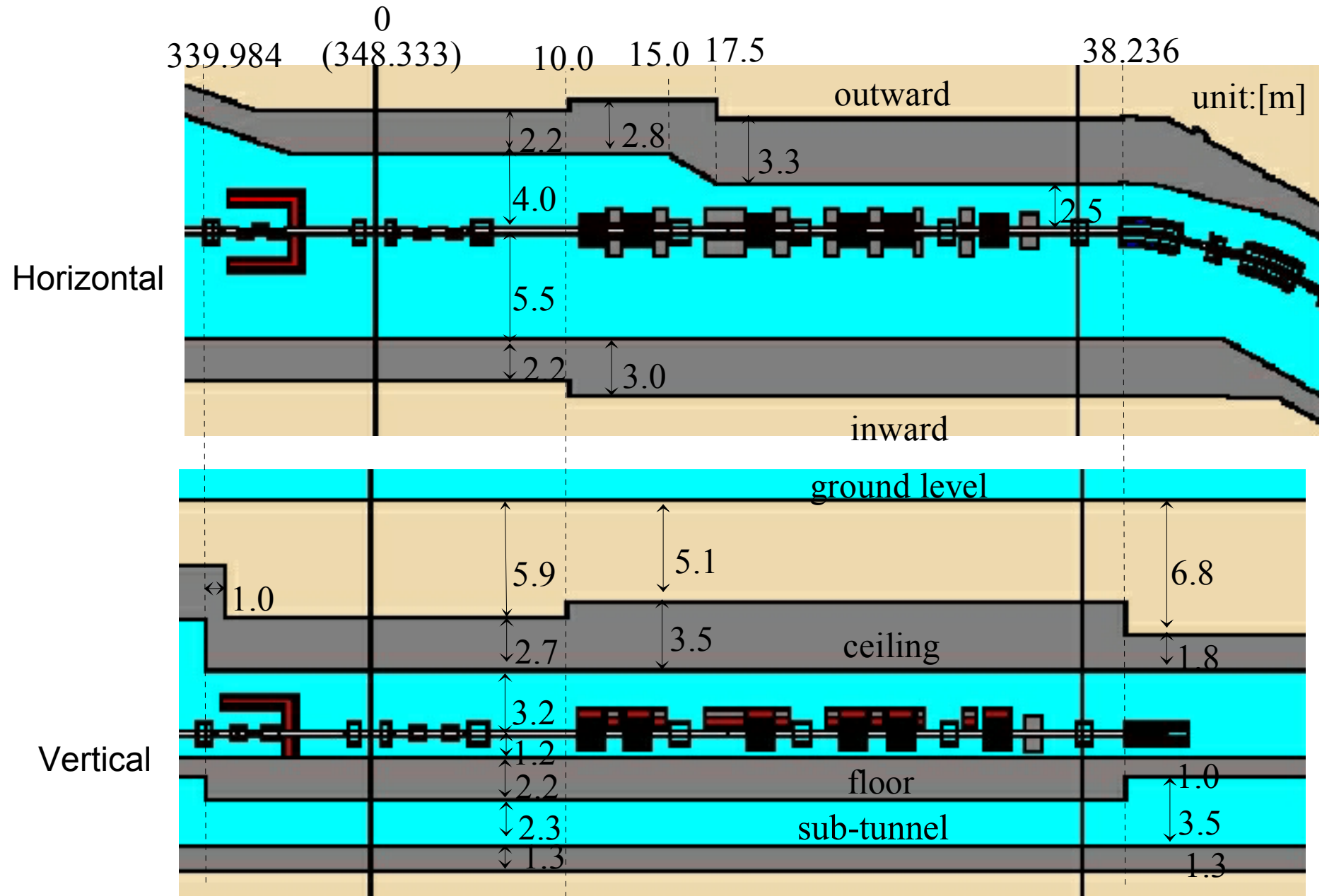
MARS calculation geometry



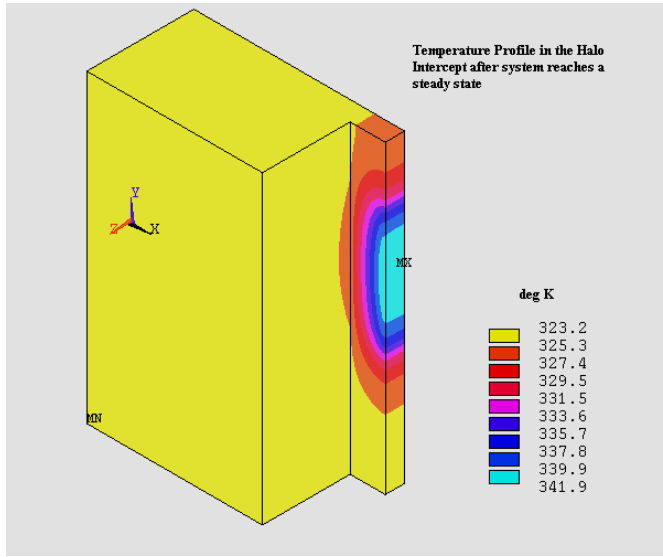
Beam line modules location

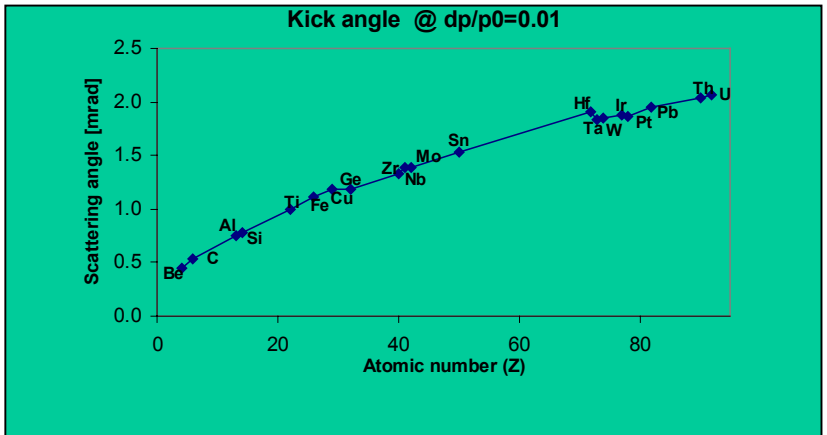
→ MAD-MARS beam line builder

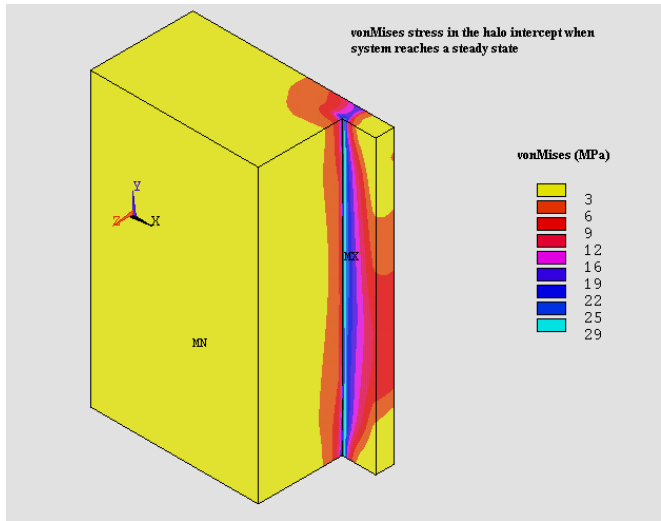
Tunnel Cross Section at Injection and Collimator Region



Collimation – RING – Movable Scrapers

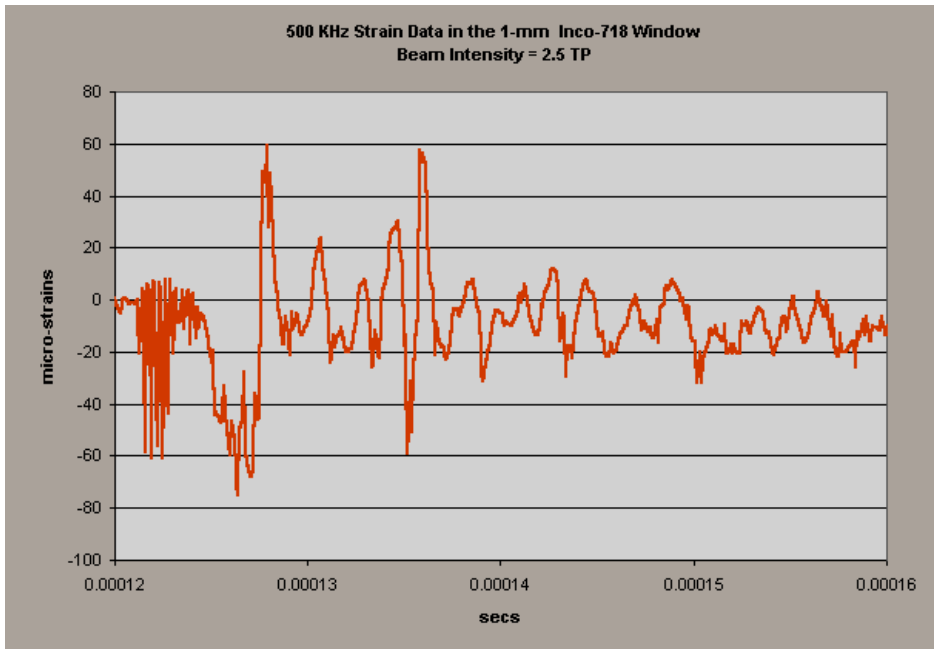


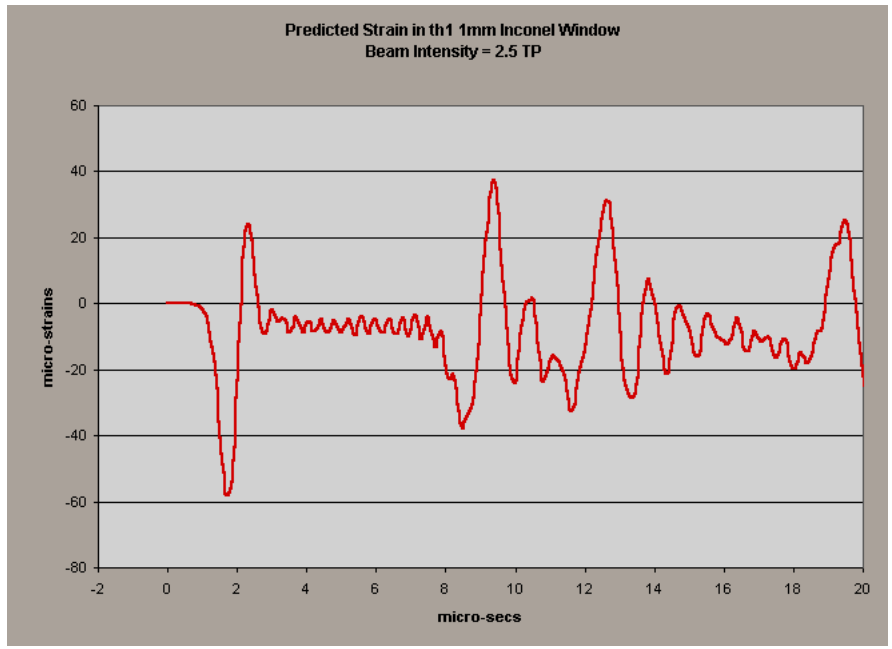




HALO-2003

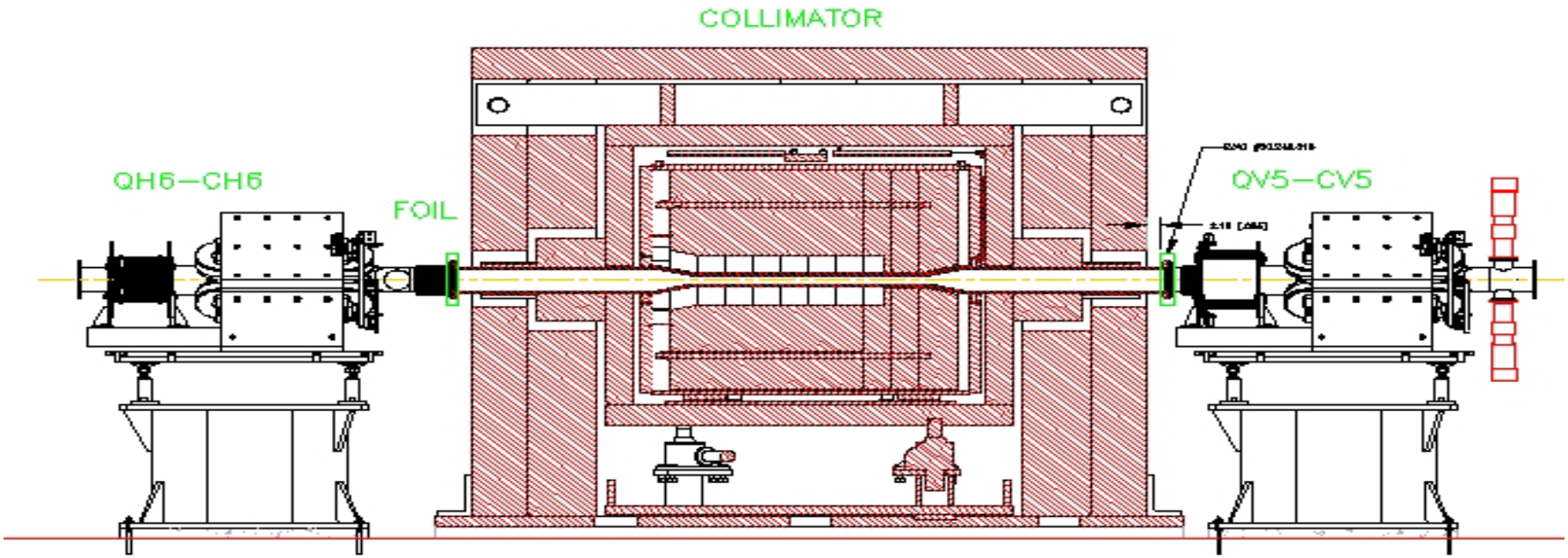
Measured and predicted strains in the 1mm thick Inconel

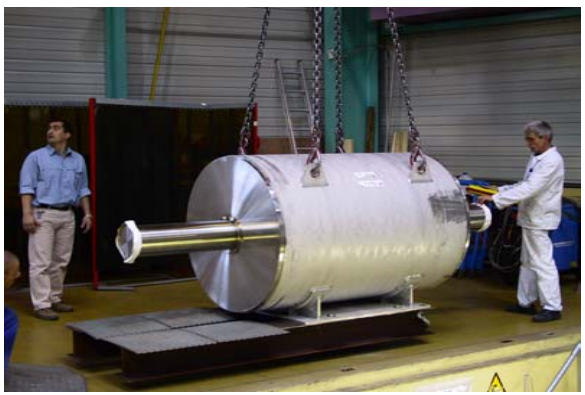




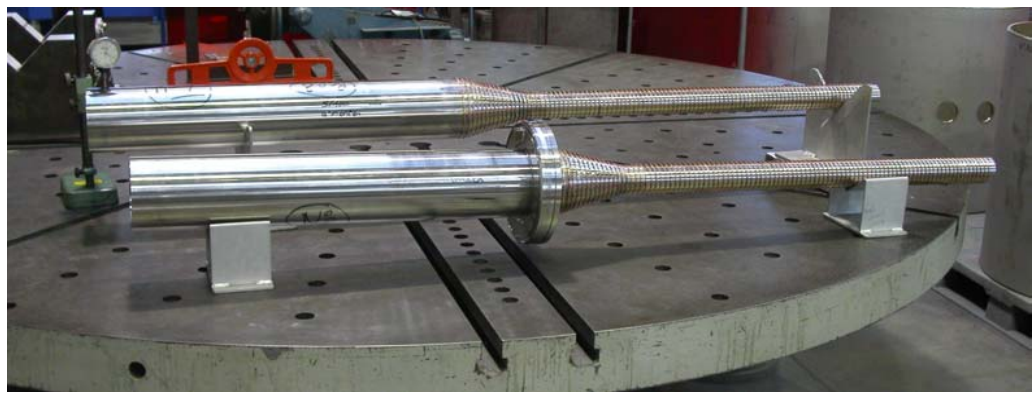
HALO-2003

HEBT Collimators Layout





Collimator Body



Beam Tube

Collimator Removal Procedure & Design Status

- **Remove QV09 & Beam Pipes**
- **Flush Water System**

  CLOSED LOOP DOUBLE CONTAINED WATER SKID WITH BACK-FLUSH IN DESIGN
- **Disconnect Water Flow/Return**

  REMOTE WATER FITTING DESIGNED
- **Disconnect Helium Pipe**
- **Disconnect Vacuum Clamps**

  REMOTE VACUUM CLAMPS DESIGNED & BUILT, INTEGRATE TO EXISTING COLLIMATOR DESIGN
- **Retract**
- **Attach Crane to Outer Shielding**

  INTEGRATED LIFTING FIXTURE/DUAL LIFTING EYES DESIGNED & INTEGRATED TO DESIGN
- **Remove Front and Top of Outer Shielding (single lift)**
- **Attach Crane to Collimator**

  INTEGRATED LIFTING FIXTURE/DUAL LIFTING EYES DESIGNED & INTEGRATED TO DESIGN
- **Remove Collimator from Outer Shield**
- **Deposit into Shielded Cask**

  NOT DESIGNED

High Power Machines

* Regardless of machine beam power (64 kW for FNAL Booster thru few MW machines) power on collimator is about the same: 2kW.
$\Rightarrow$Same radiation, cooling, thermal, engineering, handling, mechanical ….

* Dry runs are very useful (coll. Removal procedure, etc.)

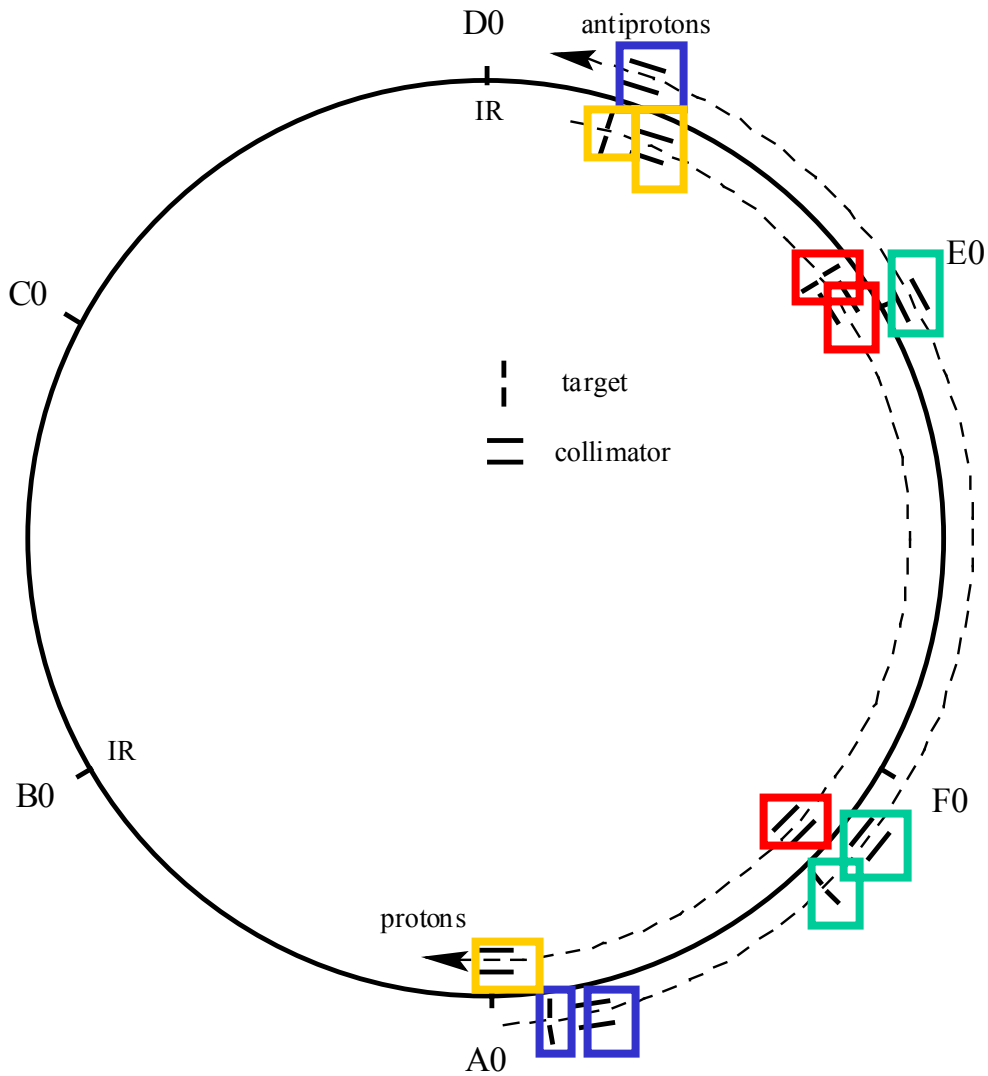
* Codes are reliable but benchmarking of residual dose would be useful.

Tevatron Collimator Layout

12 collimators total
4 Targets
8 Secondary collimators

Arranged in 4 sets
2 proton sets
2 pbar sets

Proton Set 1
D49 Tar, E03 & F172 2nd
Proton Set 2
D171Tar, D173 & A0
Pbar Set 1
F49 Tar, F48 & D172
Pbar Set 2
F173 Tar, F171 & E02



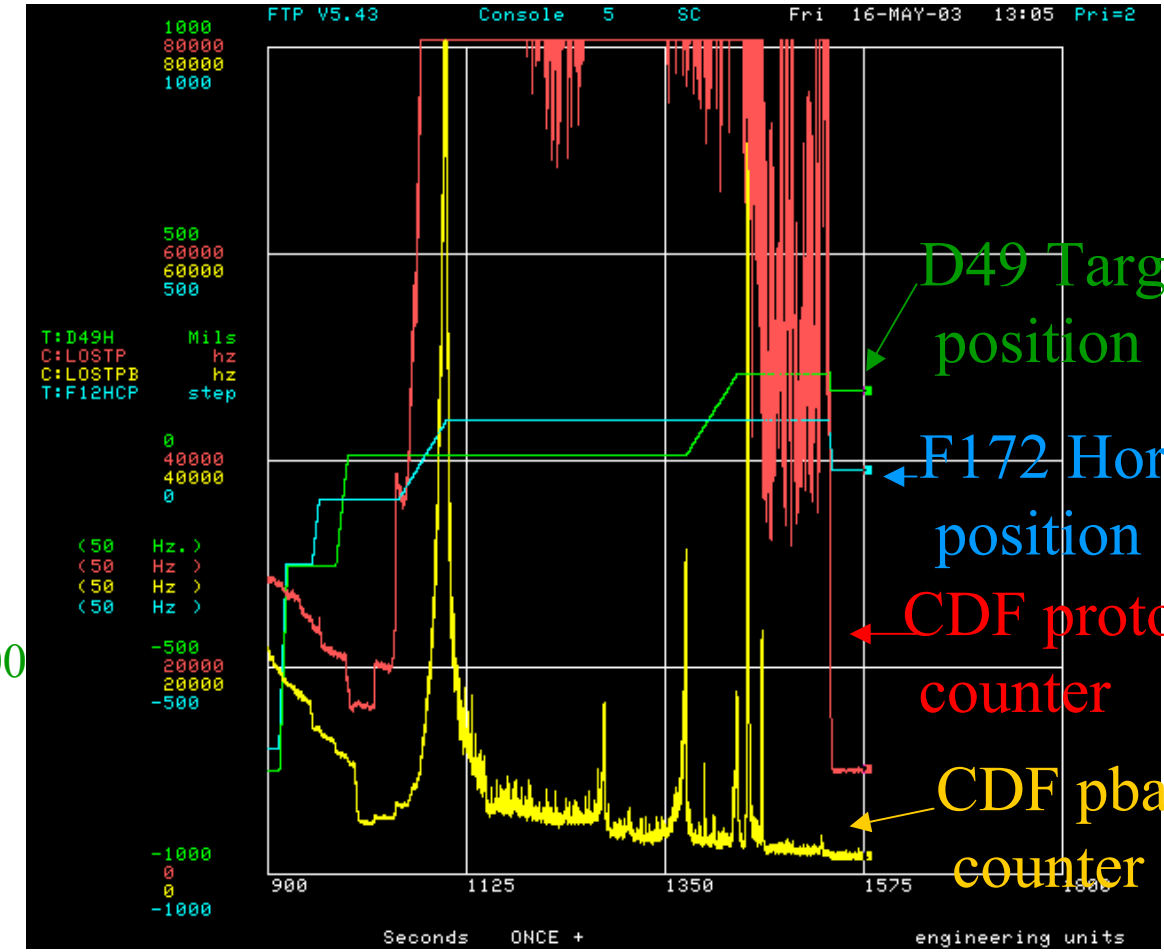
Merit of Halo Removal Efficiency

CDF proton halo loss
reduced by factor of 9

CDF pbar halo loss
reduced by a factor of 28

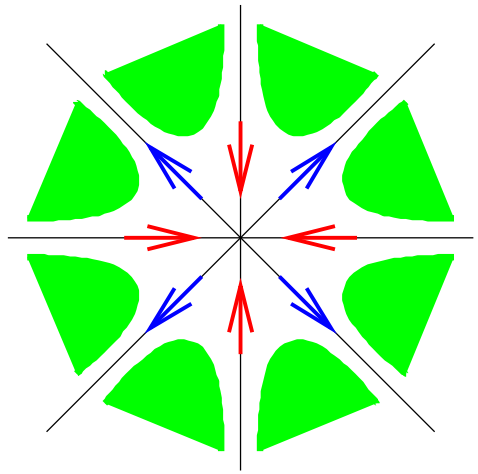
D0 proton halo loss
reduced by a factor of 1

D0 pbar halo loss
reduced by a factor of 100



Nonlinear handling of beam tails in NLC BDS

- **Can we ameliorate the incoming beam tails to relax the required collimation depth?**



Single octupole focus in planes and defocus on diagonals.

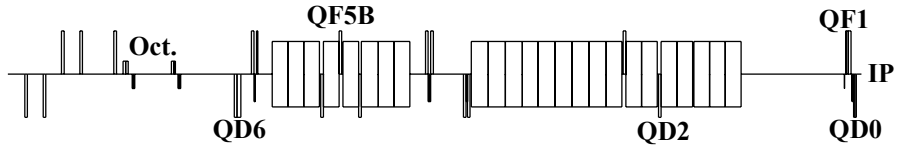
An octupole doublet can focus in all directions !

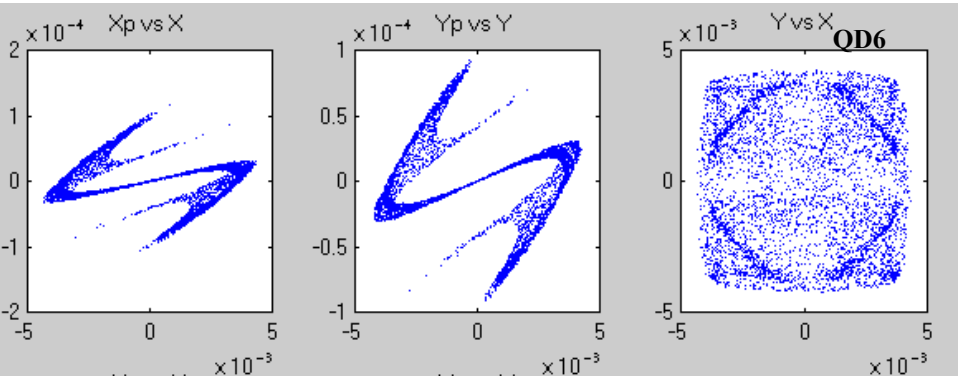
- One wants to **focus beam tails** but not to change the core of the beam
  - use **nonlinear** elements

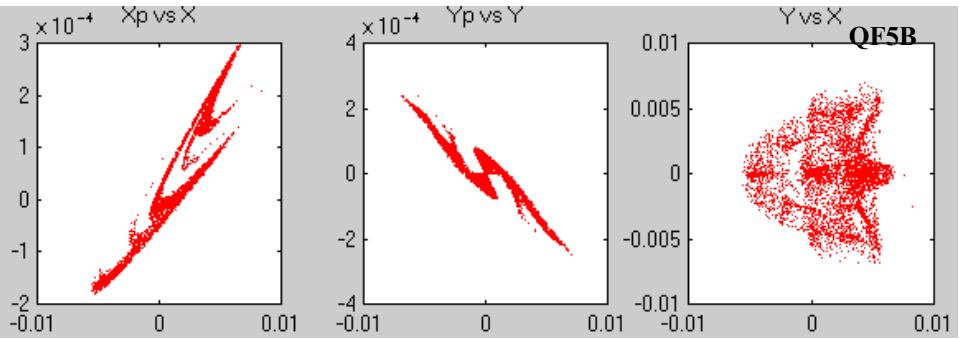
- **Several** nonlinear elements needs to be **combined** to provide **focusing in all directions**
  - (analogy with **strong focusing by**

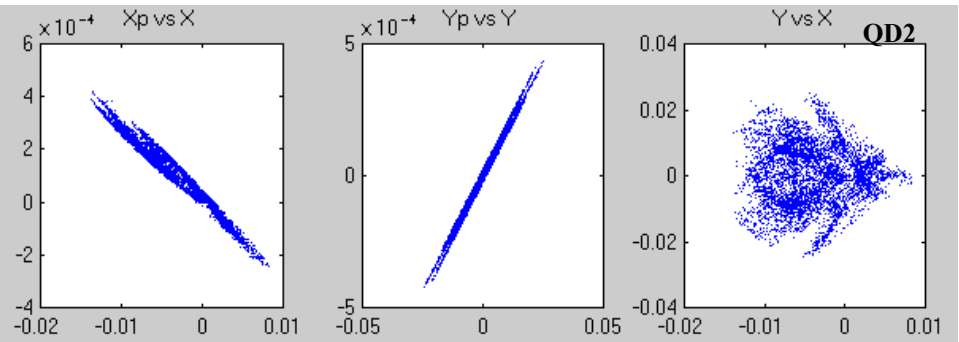
Tail folding *or Origami*

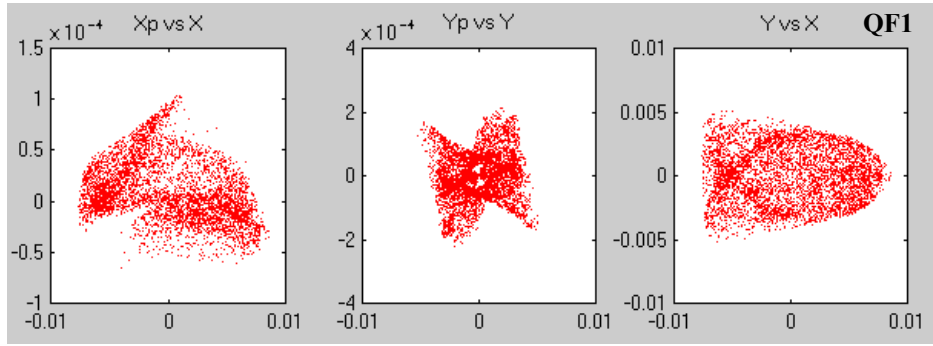
Zoo

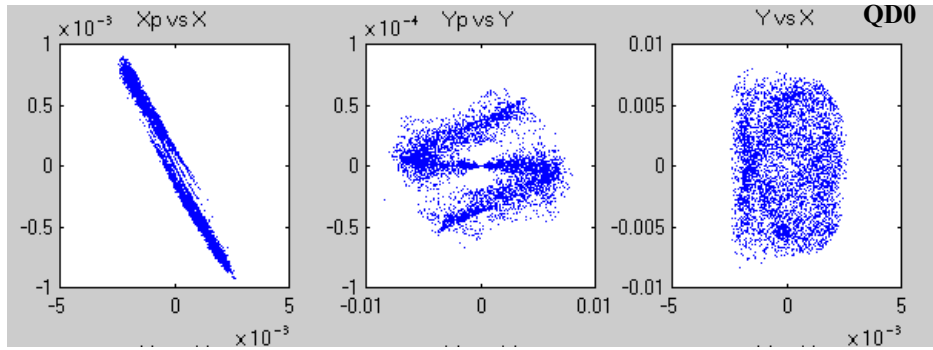


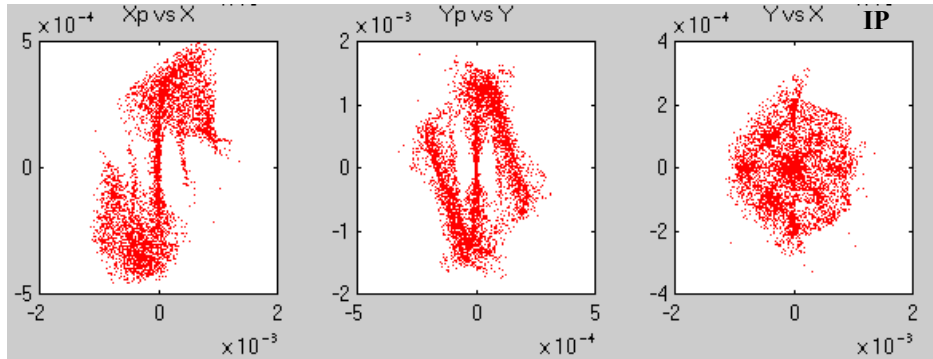








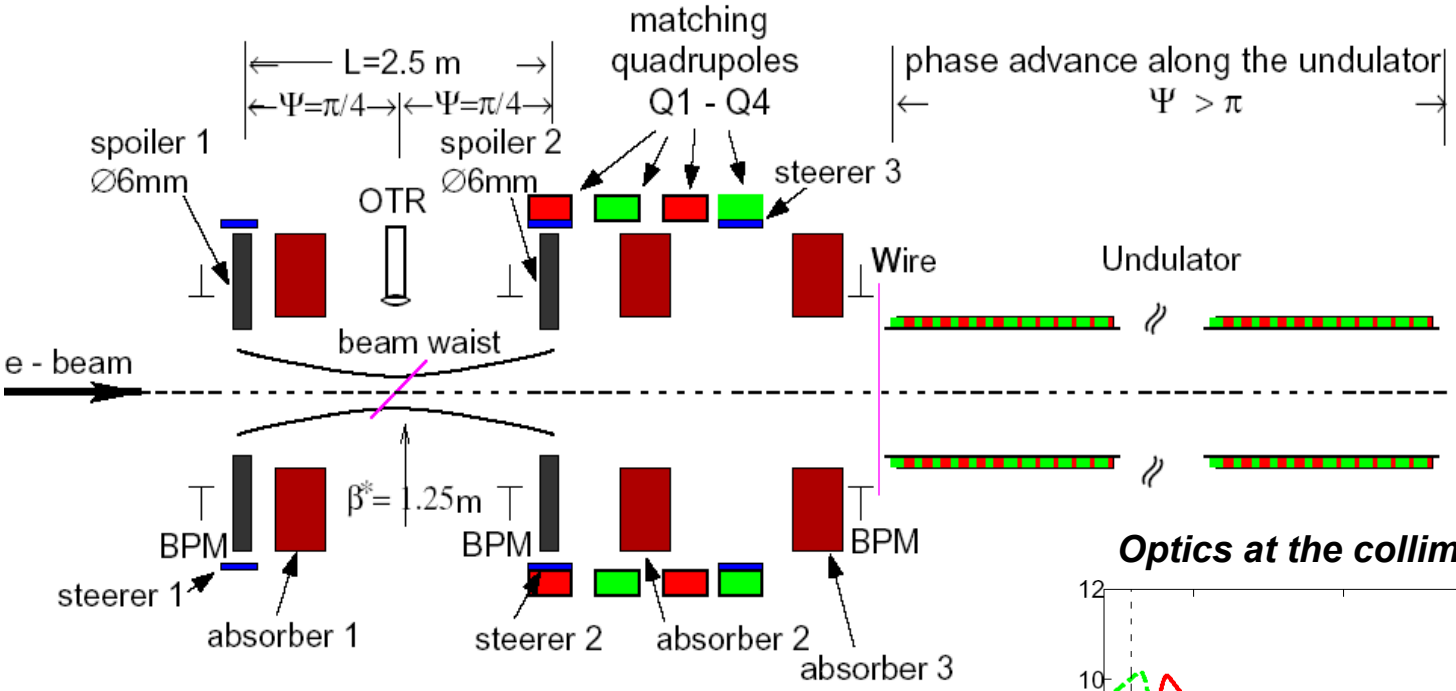




Hadron Colliders

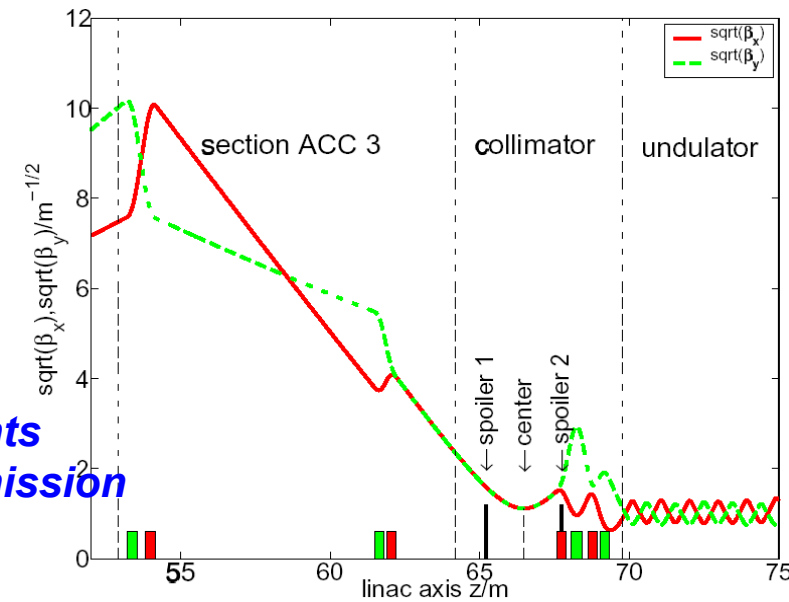
- Successful operation of Tevatron collimation system: 12 L-shape, fully automated, control, BLMs, 0.4% of intensity, mask for CDF & D0
- RHIC: 2 stage collimation needed! Present 1 stage only. Crystal channeling demonstrated for the 1st time with heavy ions - but collimation efficiency too low for operations.
- LHC: impedance constraints are important, material choices crucial and still discussed. SLAC –CERN R&D on Be proposed.
- Code status: Unification? No. Geometry compatibility. 3 reqs for official codes: documentation, benchmarking, user community.
- Octupole halo folding developed for LC discussed.

Scheme of the collimation section



- *2 spoilers to restrict the phase space acceptance*
- *2 absorber to remove secondary particles*
- *4 quadrupoles for optics match to undulator*
- *2 bpms to center beam in the spoilers*
- *1 OTR-screen to match beam into collimator*
- *4 steerers to correct for quadrupole misalignments*
- *toroids and photomultiplier to monitor the transmission*
- *water cool and temperature controlled*

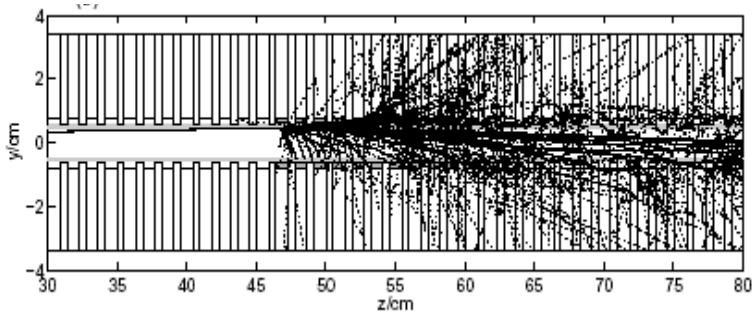
Optics at the collimator section:

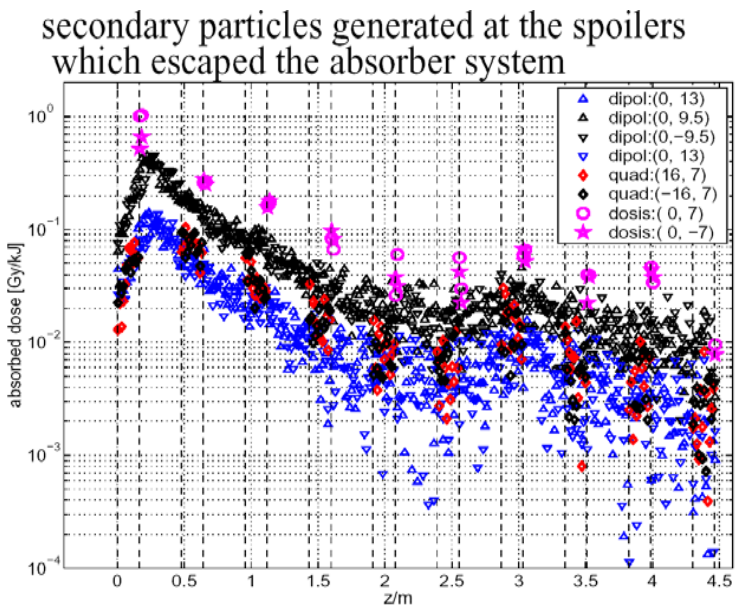


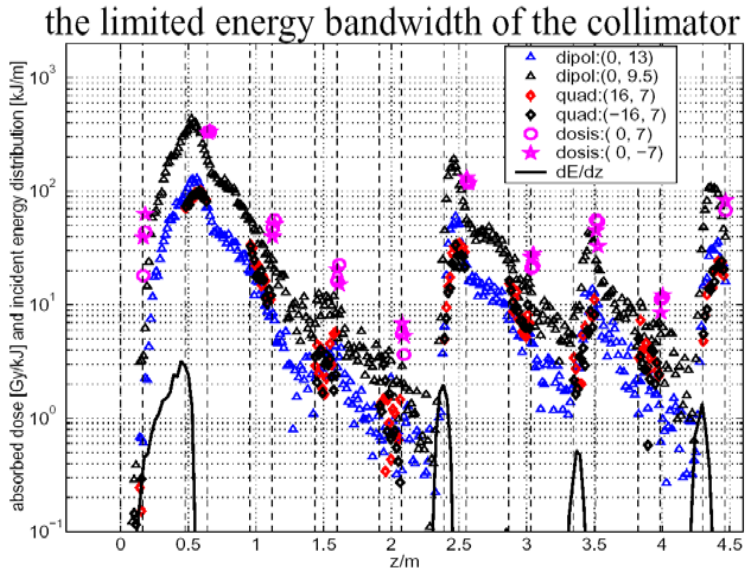
Collimator Performance

- energy deposition in undulator -

EM-shower in undulator

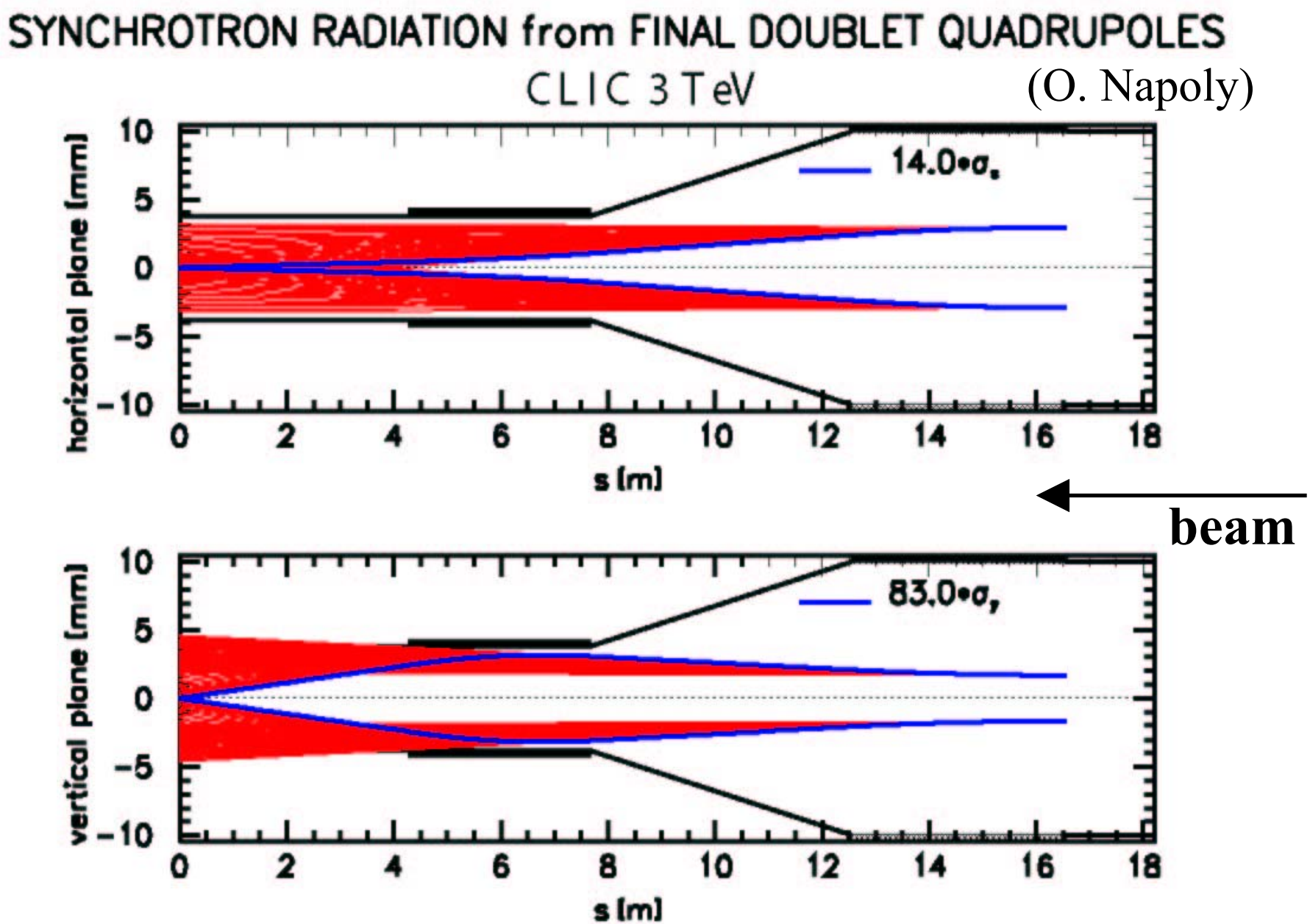






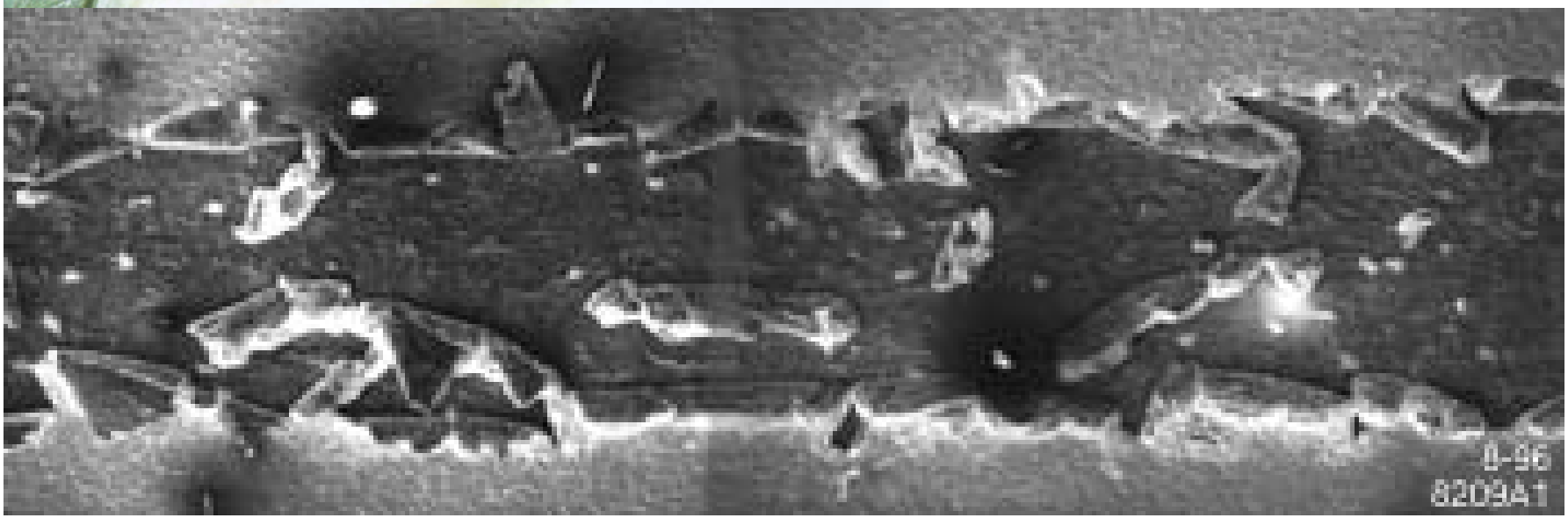
- ***Gain of about 3 orders in magnitude (primary versus secondary losses)***
- ***Rapid drop of dose in lateral direction***
- ***Pattern strongly dependent on beam loss mechanism***
- ***Simulated dosimeter overestimate deposited dose***
- ***Can be used to identify operation errors of collimator section***

SR fans at 3 TeV with beam envelopes at 14 σ_x and 83 σ_y

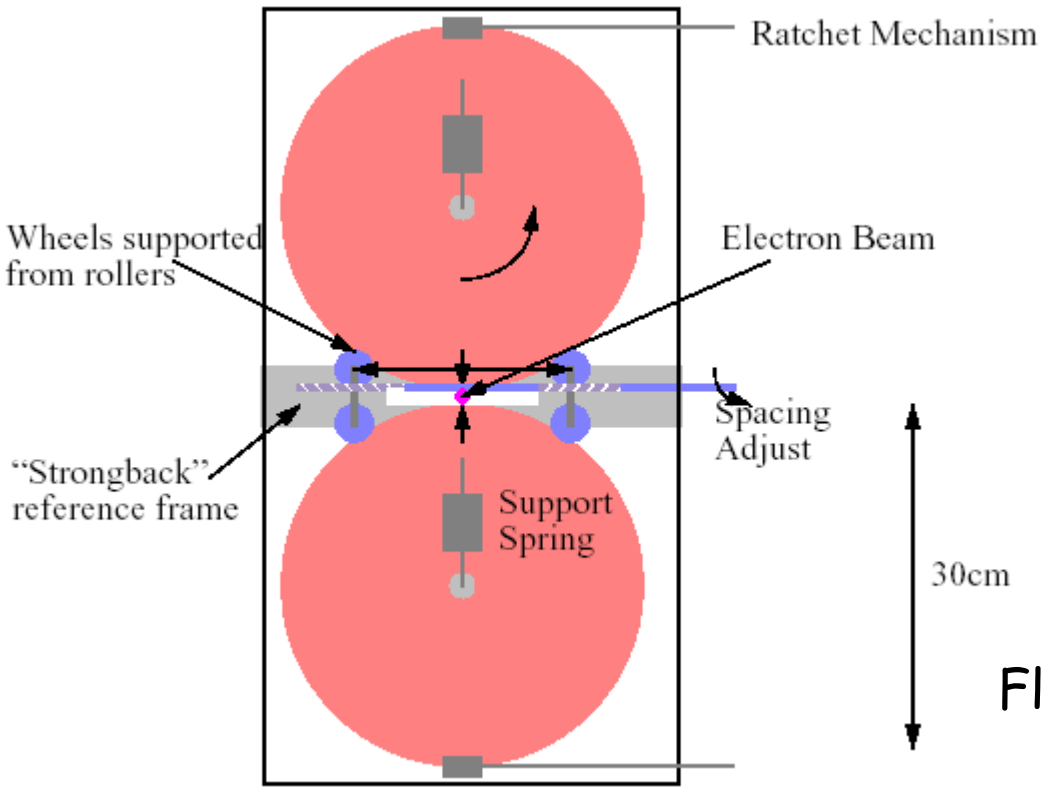


collimator survival?

surface of 20-μm gold-plated Ti-alloy collimator at the end of SLC linac after damage; CLIC beam is ~10^4 times more intense!



Rotating Wheel Design Features



1 d.o.f. internal mechanism referenced to rigid backplane provides aperture

Control through transversely adjustable stops

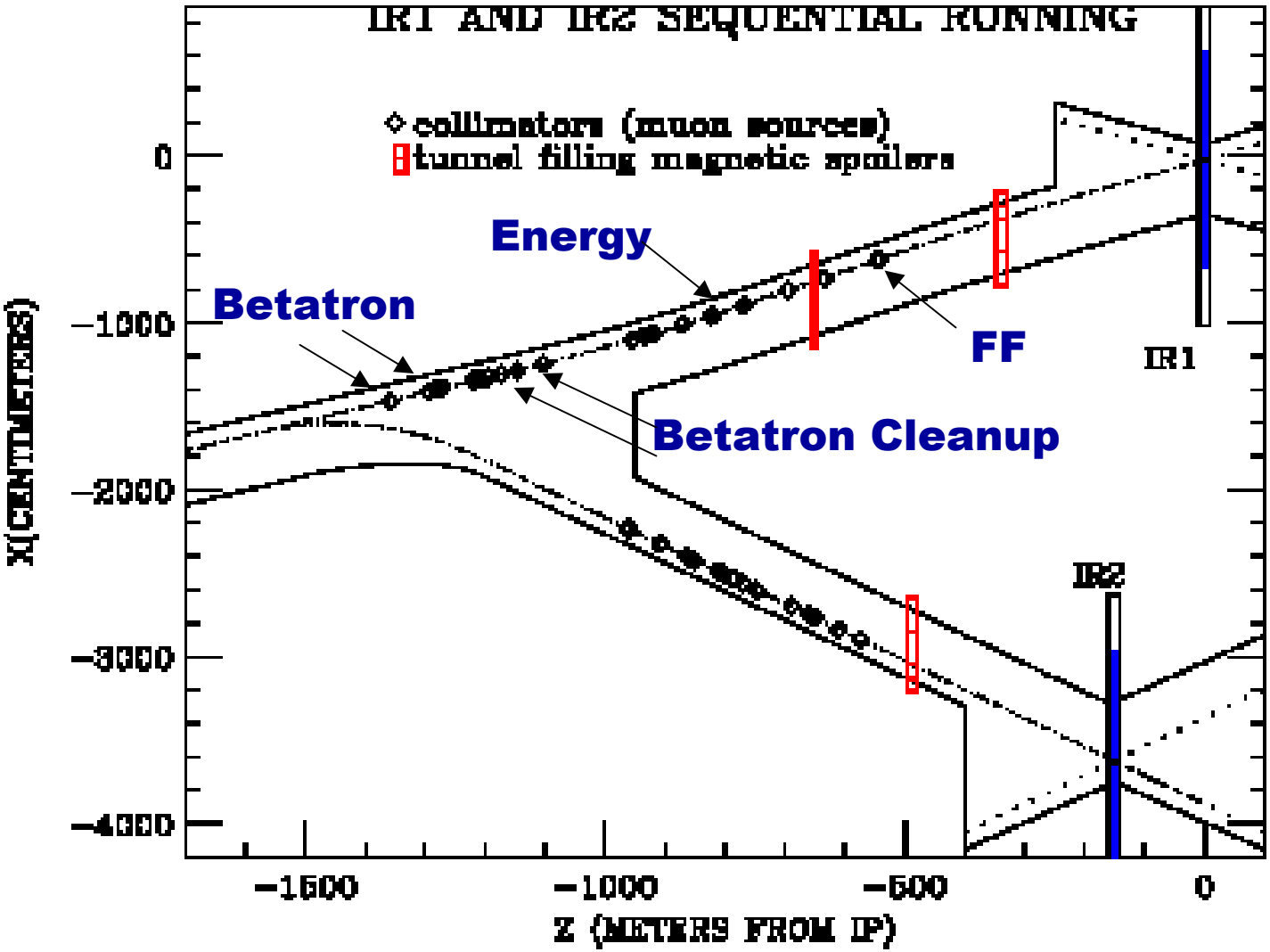
Flexure pivots eliminate backlash

Vacuum bearings

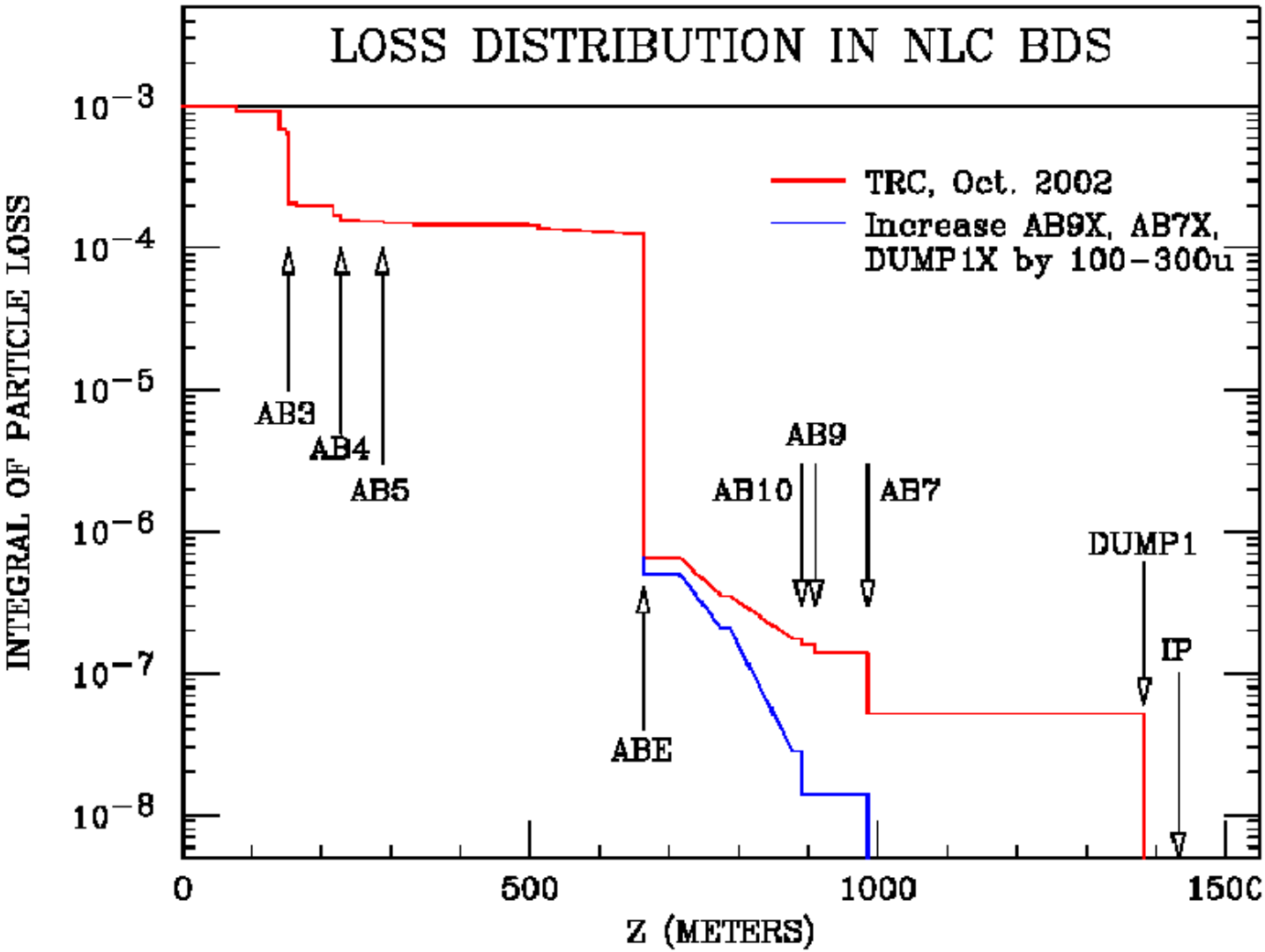
Engineer to minimize thermal effects

Housing aligned to beam via external movers & BPMs

Layout of Spoilers, Absorbers & Protection Collimators



Efficiency of NLC Collimation System
(Talk by Andrei Servi)



E=250 GeV

N=1.4E12

0.1% Halo distributed as 1/X and 1/Y for $6<A_x<16\sigma_x$ and $24<A_y<73\sigma_y$ with **$\Delta p/p=0.01$** gaussian distributed

Linear Colliders

- Challenges: small beam sizes, high rep. rate, beam power
- Detector specs
- Sources of background: synchrotron radiation & muons
- Careful layout of BDS necessary.
- Consumable and renewable collimators.
- Octupole halo folding