Beam Indu ounds and Radia CDF

.J. Tesare
Fermilab
1/28/04

Initial Operational Problems

Low voltage power supply failures

- 12 power supplies lost in single day (St. Catherine's Day)
- catastrophic component failure

Physics backgrounds

- Missing ET distributions
- High calorimeter occupancy

Radiation

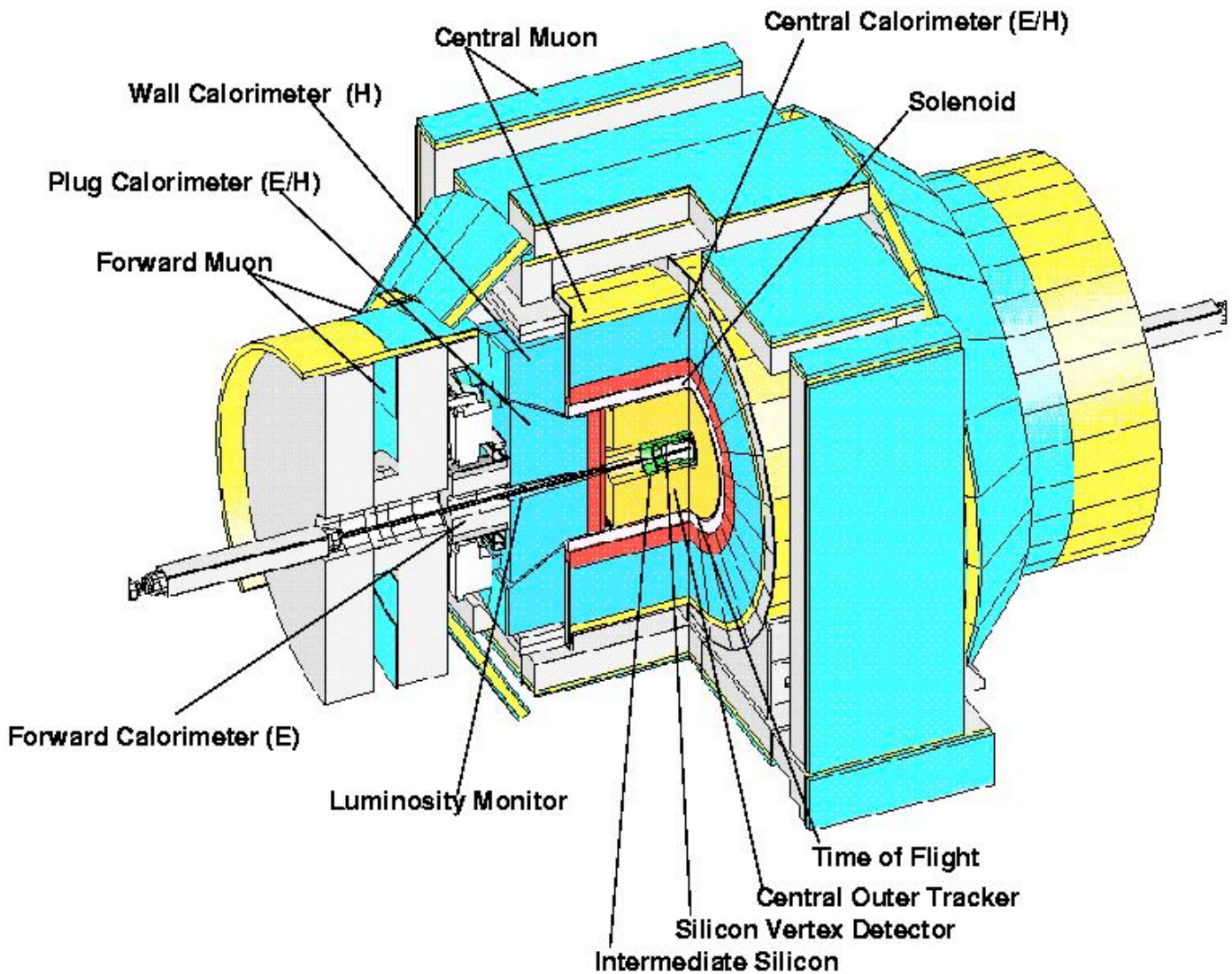
- Detector damage/lifetime

Silicon detector "incidents"/concerns

- Beam related failures

> Work still in progress

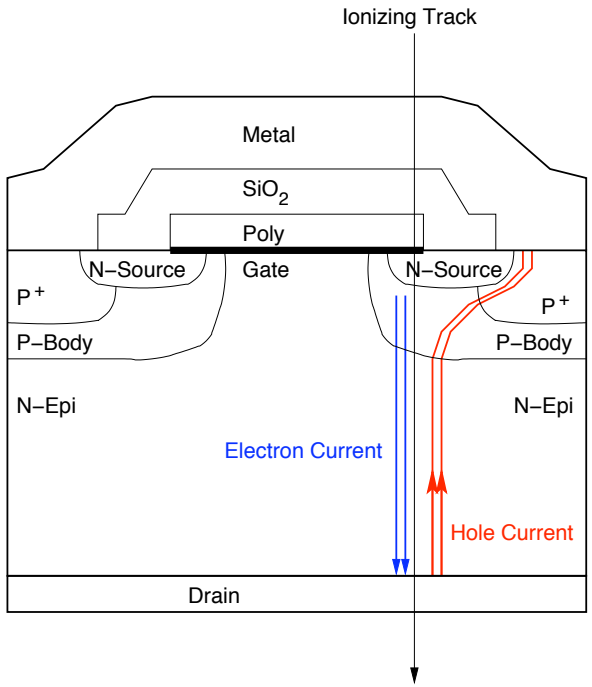
CDF-II Detector (G-rated)

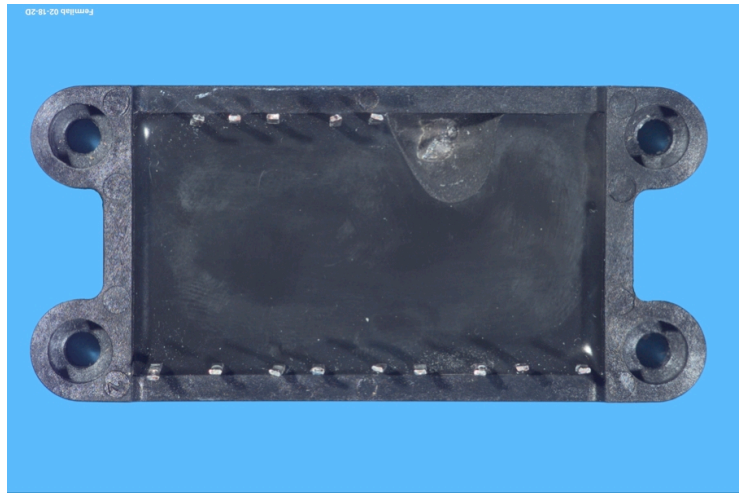


L.V. Power Supply Failures

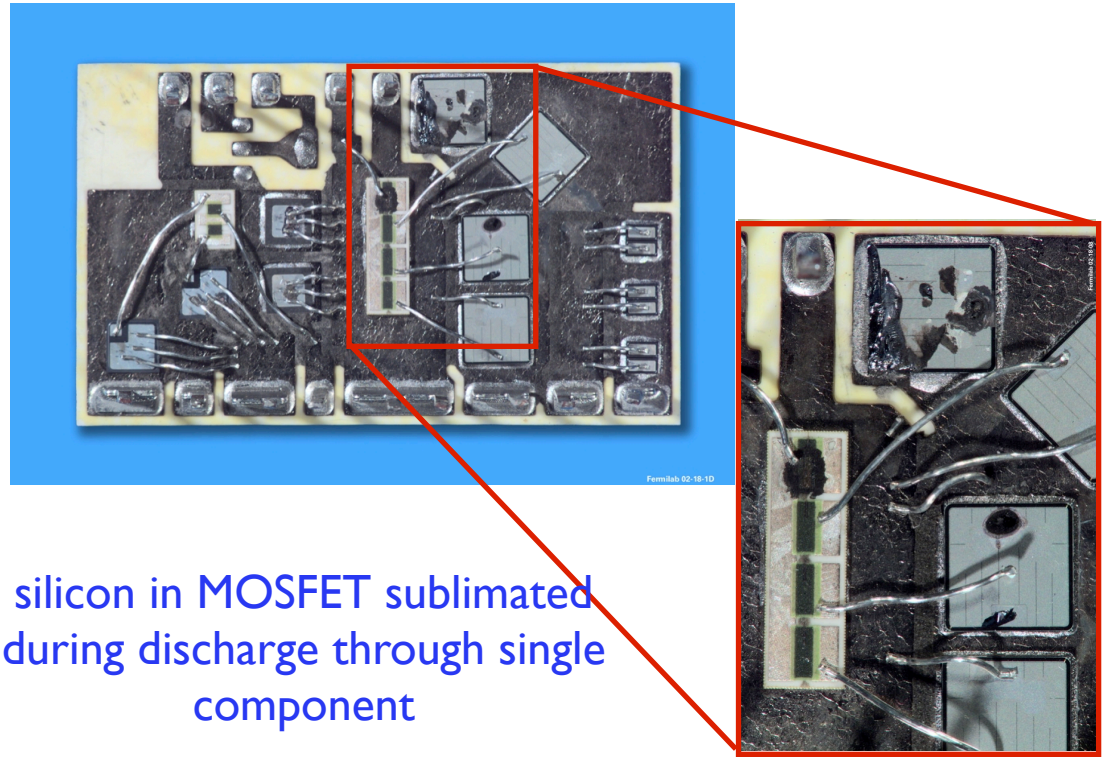
- Power Factor Corrector Circuit
- Most failures were associated with high beam losses or misaligned beam pipe

> Power MOSFET SEB (radiation induced)





epoxy covering fractured



silicon in MOSFET sublimated during discharge through single component

Single Event Burnout (SEB)

SEB Features

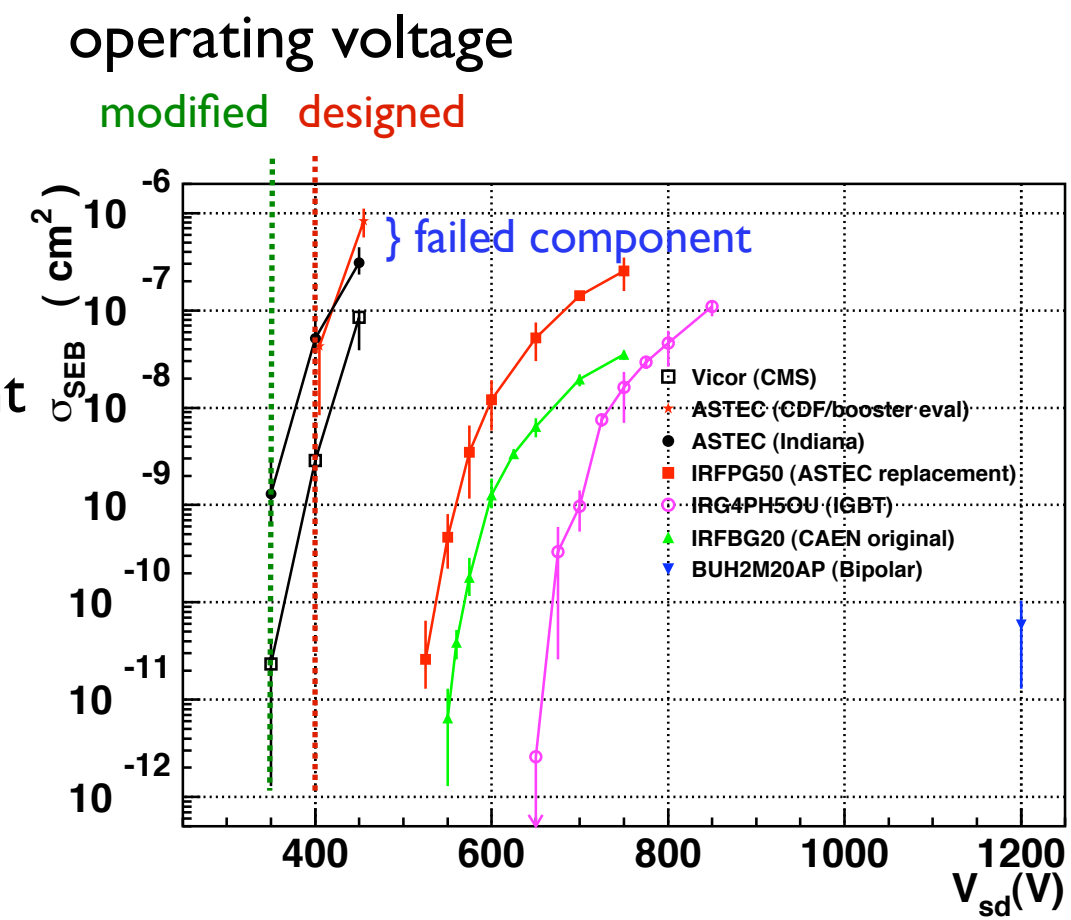
- beam related
- damage at low doses
- depends on bias voltage

SEB cross section measurement

Solution (lower Vbias)

- Factor of 50 reduction in radiation sensitivity
- No failures in > 1 year operation

What about radiation?



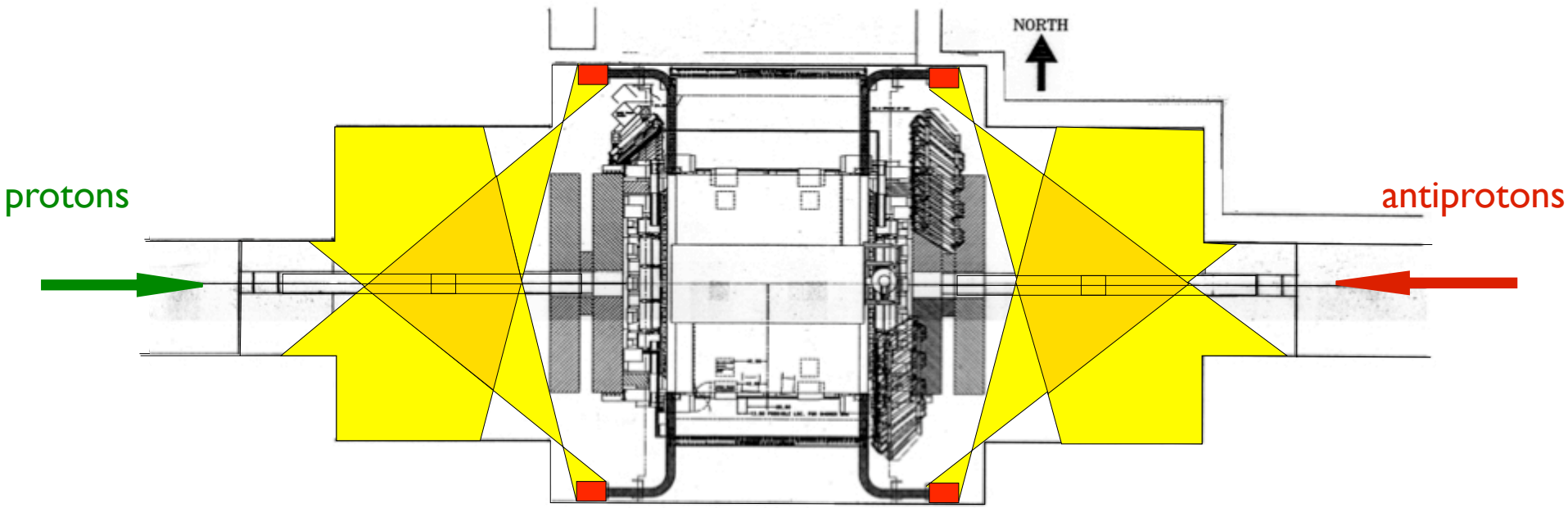
Test beam data, 20 MeV protons

Radiation Source?

- Power supply failure analysis shows largest problem on the west (proton) side of the collision hall.

Measure radiation in the collision hall using thermal luminescent dosimeters (TLDs).

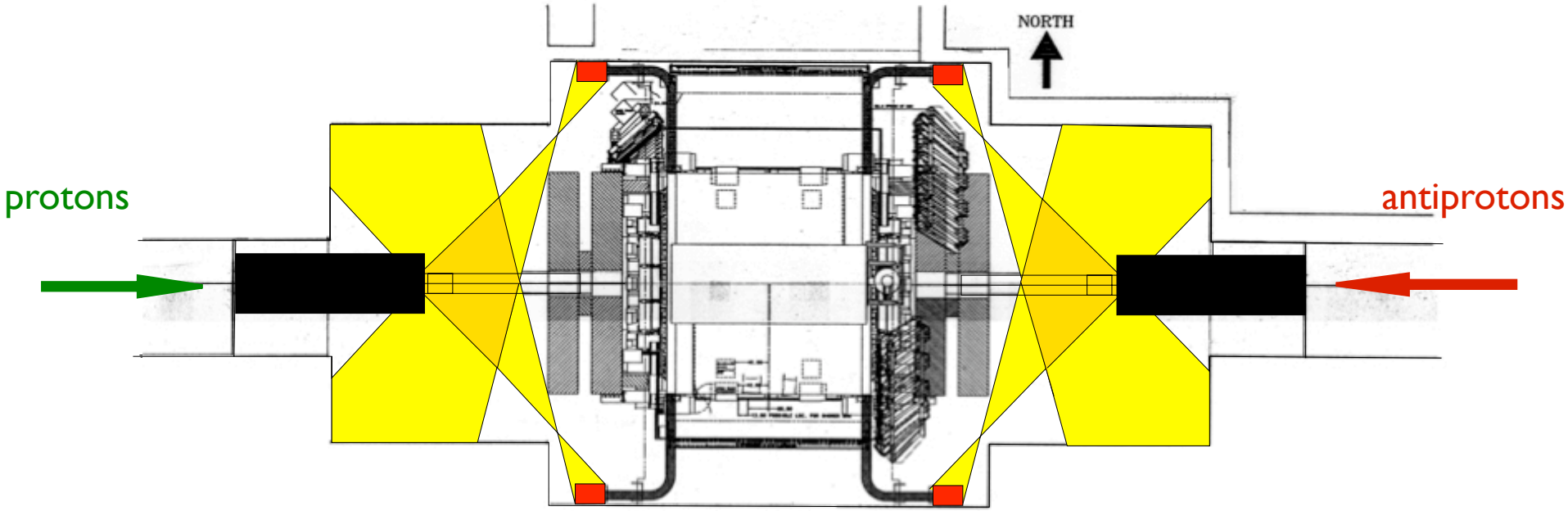
CDF Detector (R-rated)



Radiation Shielding?

- Counter measurements show low beta quadrupoles form a line source of charged particles.
- Power supply failure analysis shows largest problem on the west (proton) side of the collision hall.

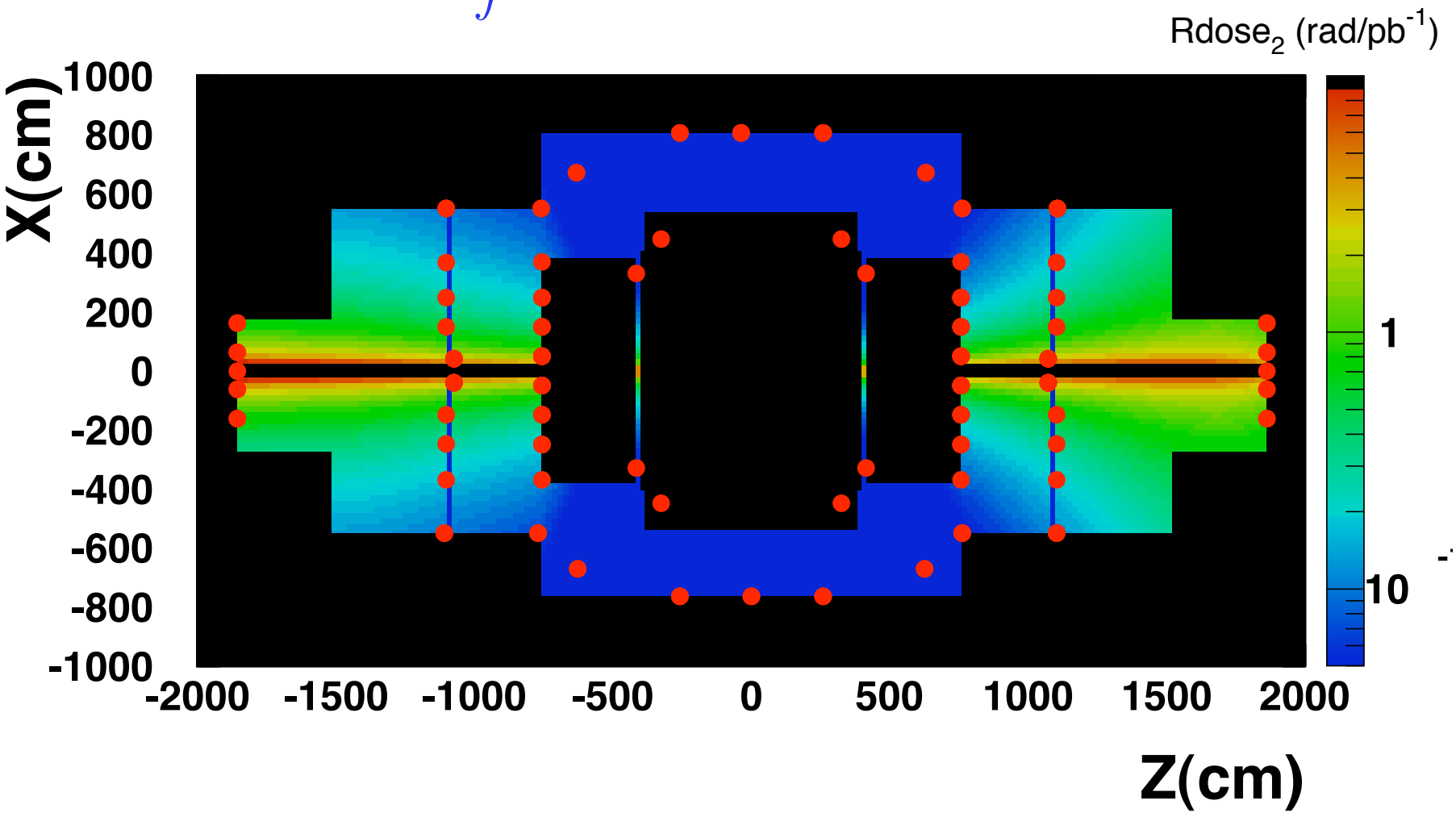
CDF Detector w/ additional shielding



Collision Hall Radiation Field

Radiation Field in the CDF collision hall

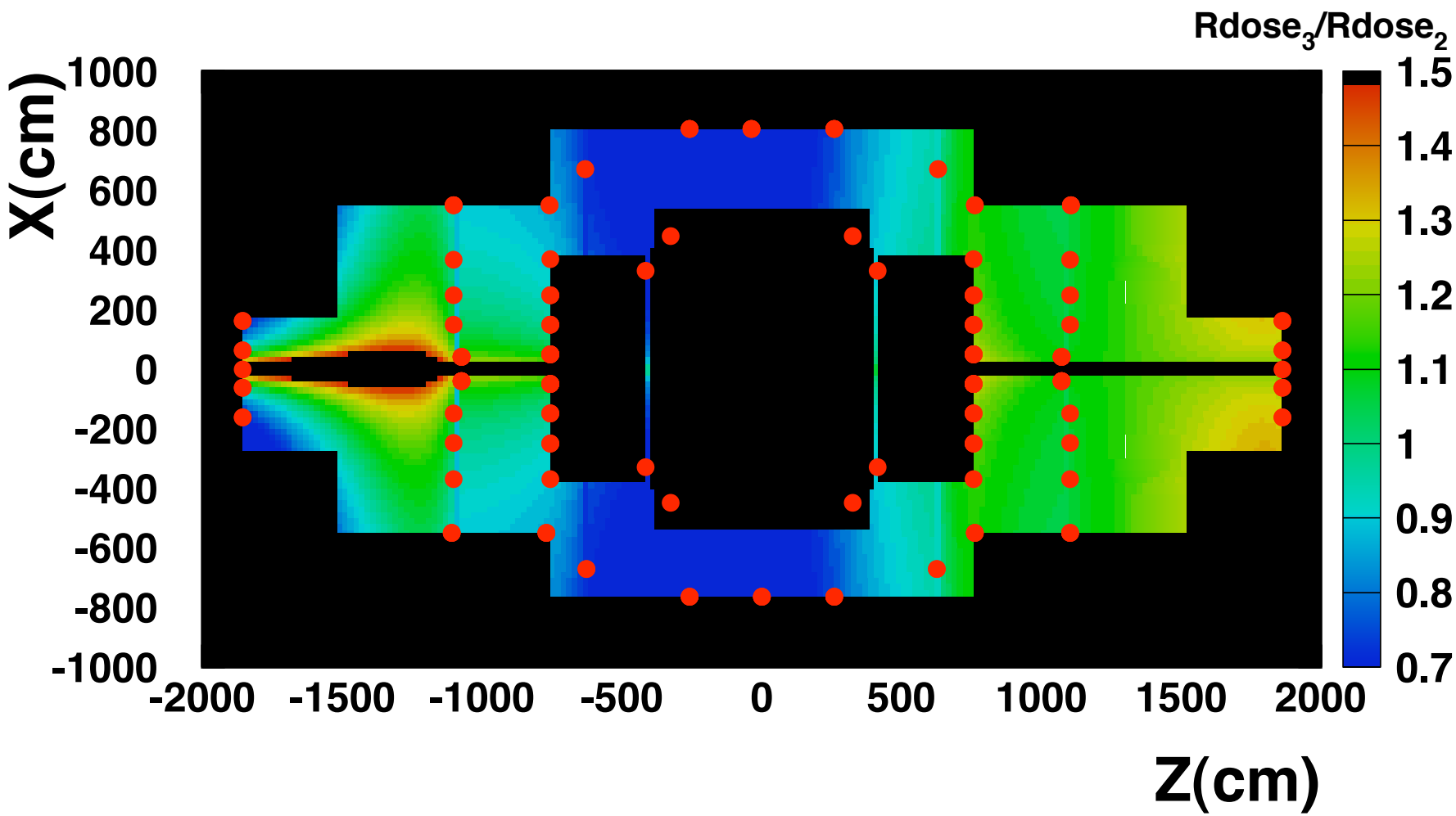
$$R_i = Dose / \int \mathcal{L} dt$$



Collision Hall Radiation Field

Radiation Field in the CDF collision hall

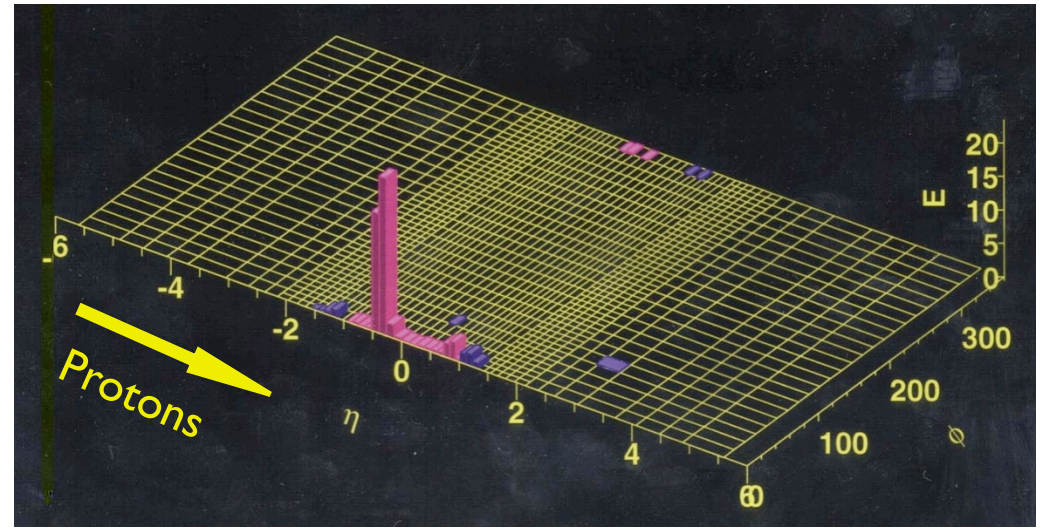
$$Ratio = R_{shielding}/R_{no\ shielding}$$



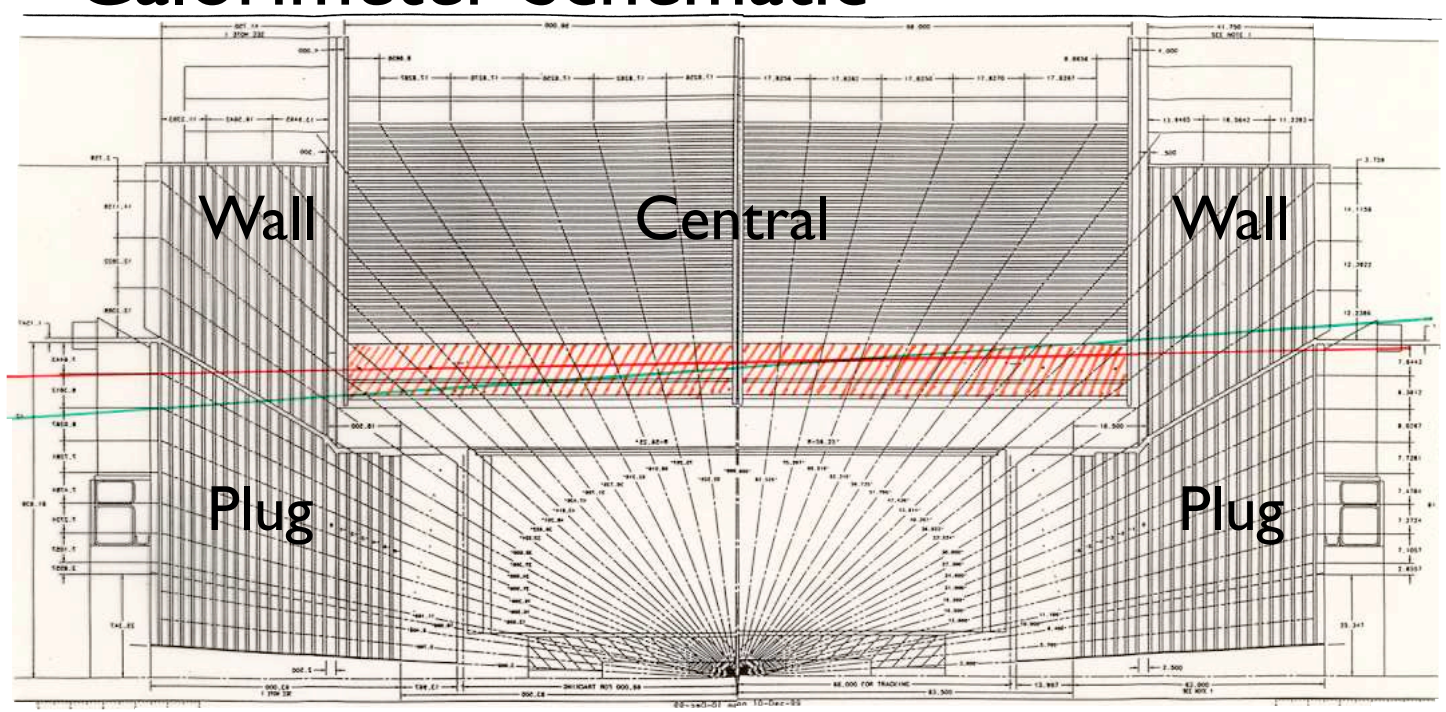
"Jet" Background Events

Events show "track" in calorimeter

- High energy muon
- Beam "halo" hitting Roman pot detectors



Calorimeter Schematic

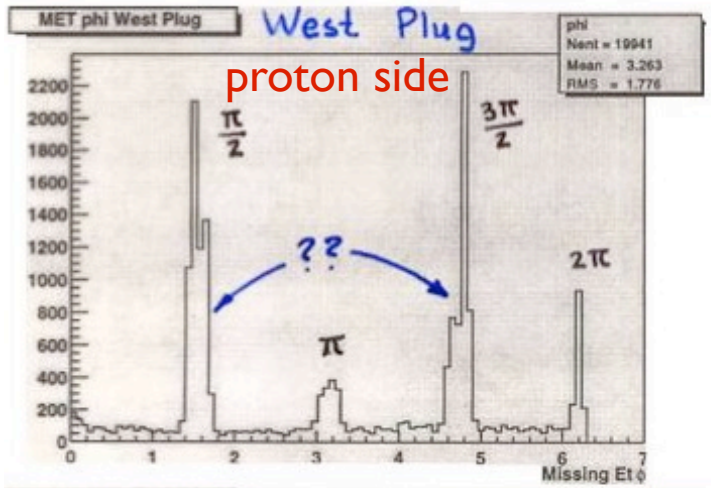


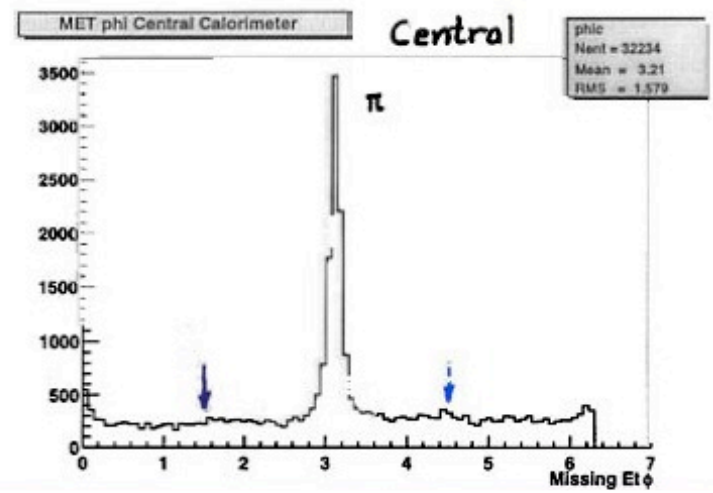
Particle "tracks"

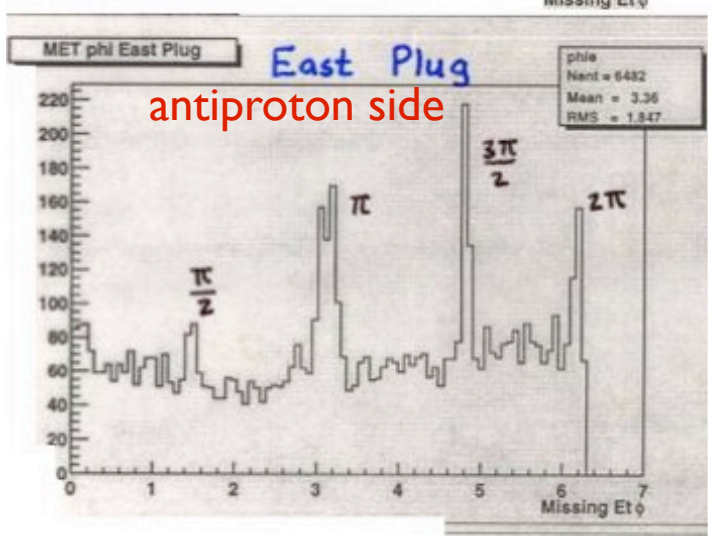
protons → ← antiprotons

W Backgrounds

- W trigger requires Energy imbalance in calorimeters.







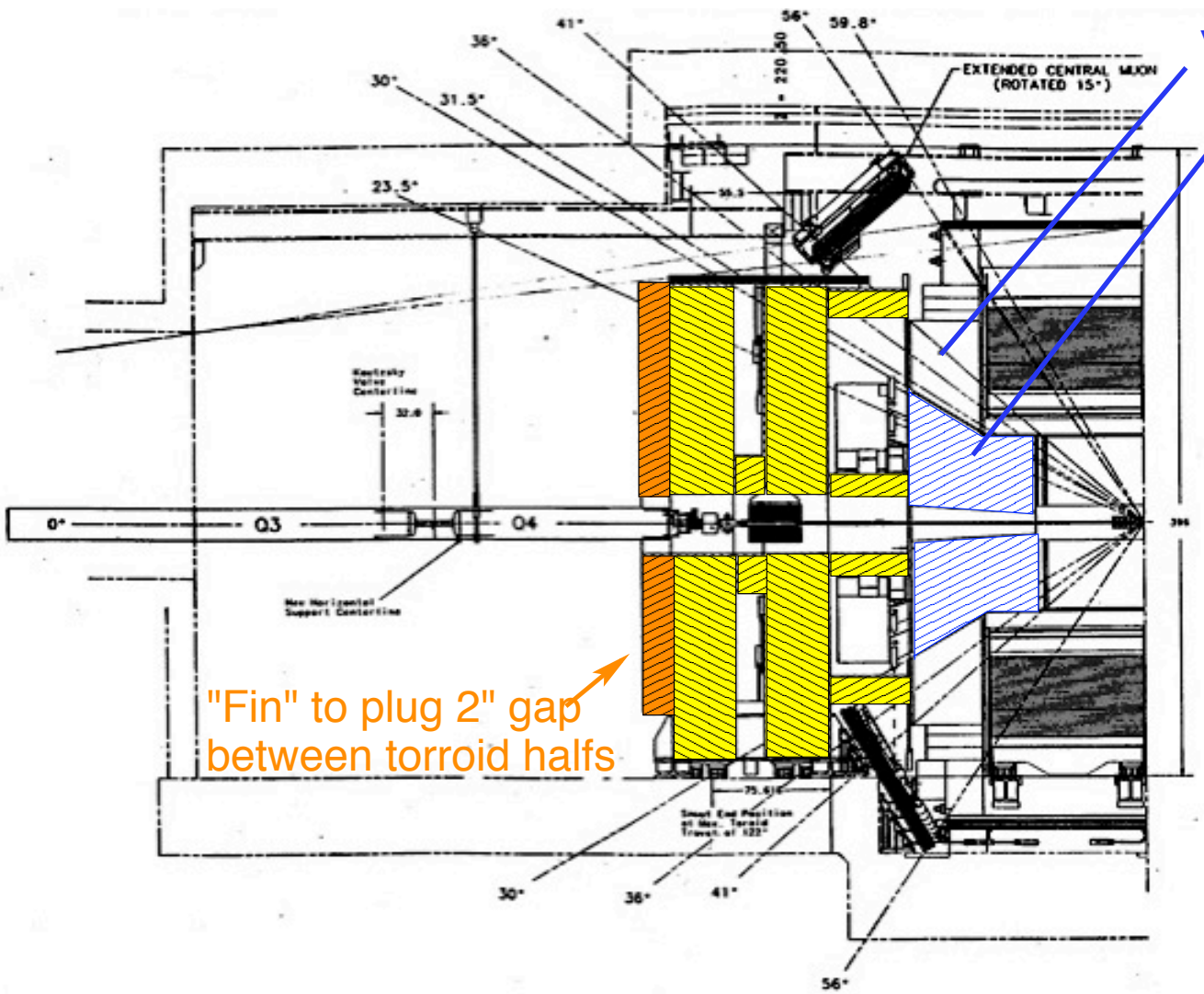
Trigger: Missing Et > 25 GeV

$\phi = \pi$: muon bremsstrahlung

$\phi = \frac{n\pi}{2}$:peak/background ~ beam current

Plug Backgrounds

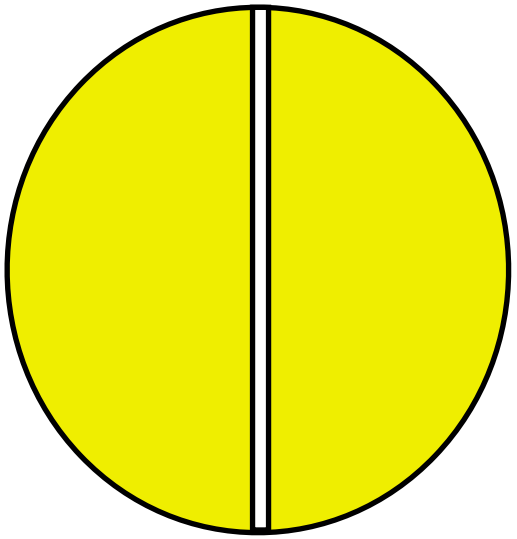
Gaps in shielding aligned with backgrounds



Wall Calorimeter

Plug Calorimeter

torroid steel

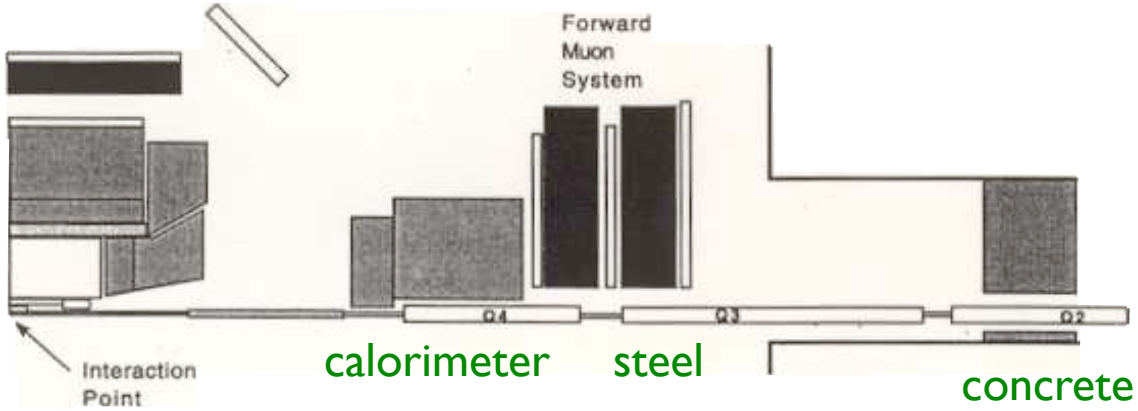


2" gap

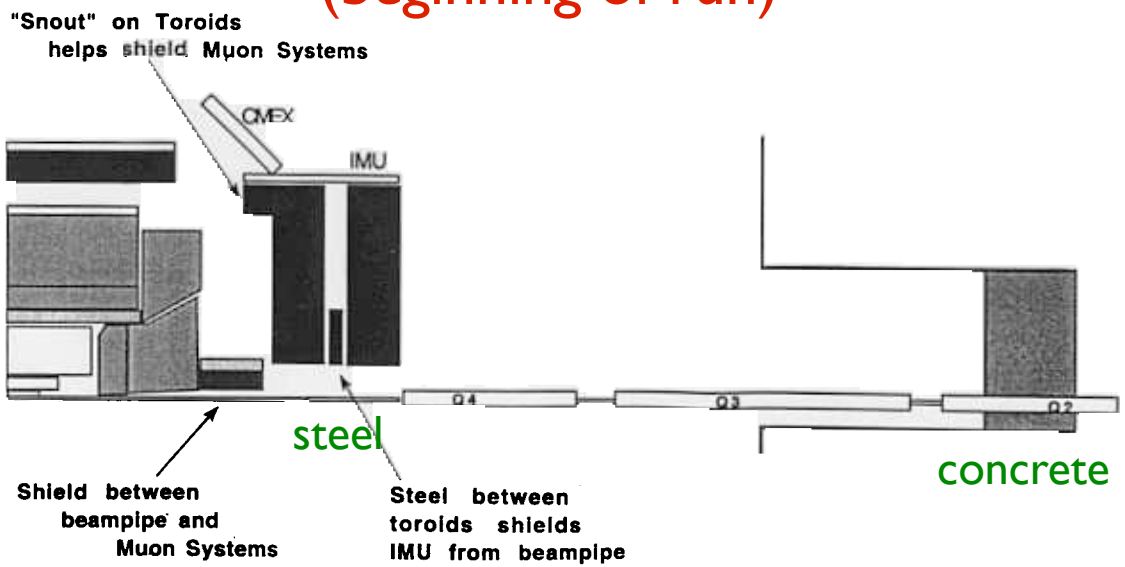
Run I Shielding

- Detector configuration different in Run II
  - Run I detector "self shielded"
  - Additional shielding abandoned (forward muon system de-scoped).
  - Shielding installed surrounding beam line.
- Evaluation of shielding continues

Run I Shielding



Run II Shielding
(beginning of run)



Measuring Losses/Halo

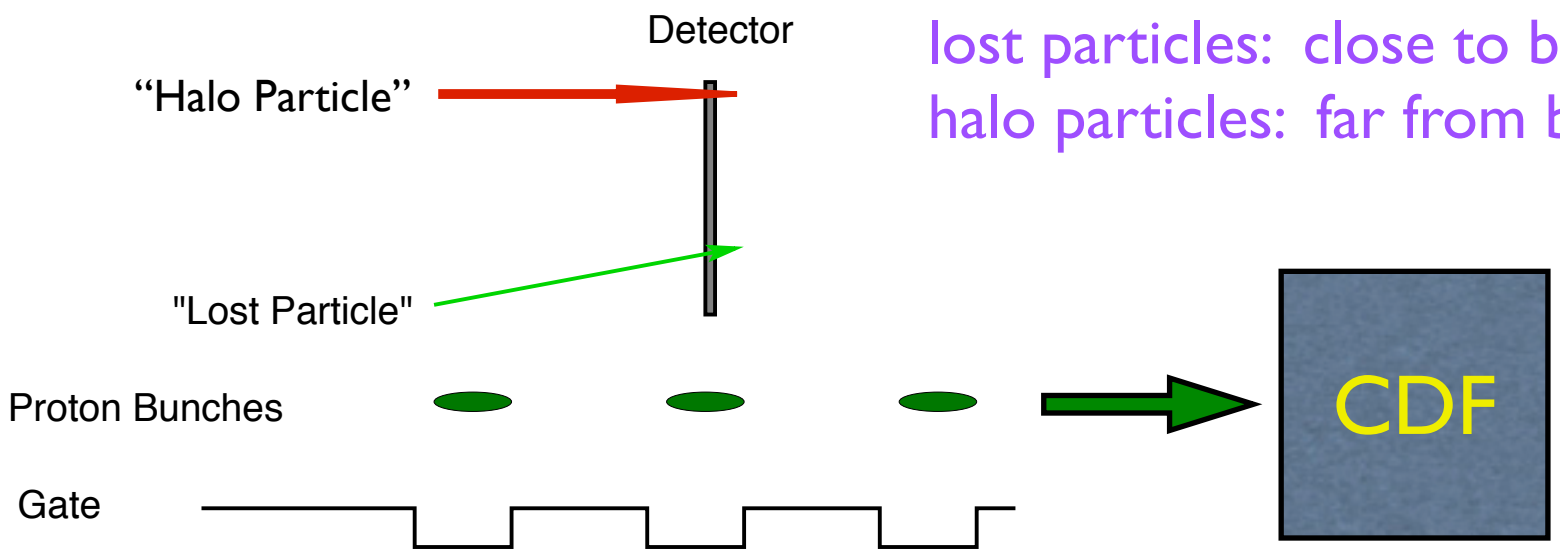
Beam Losses all calculated in the same fashion

- Detector signal in coincidence with beam passing the detector plane.
- ACNET variables differ by detector/gating method.
- Gate on bunches and abort gaps.

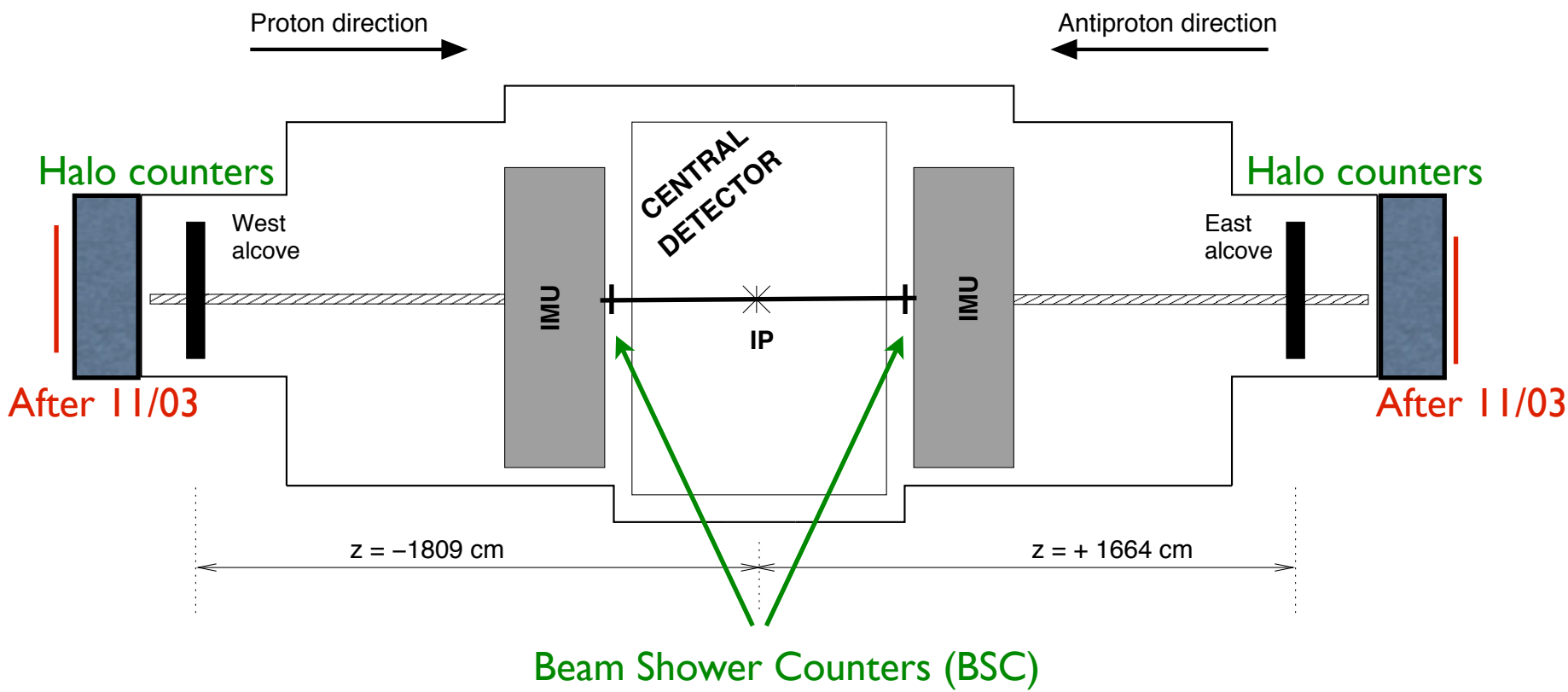
Definitions:

lost particles: close to beam

halo particles: far from beam



Beam Monitors

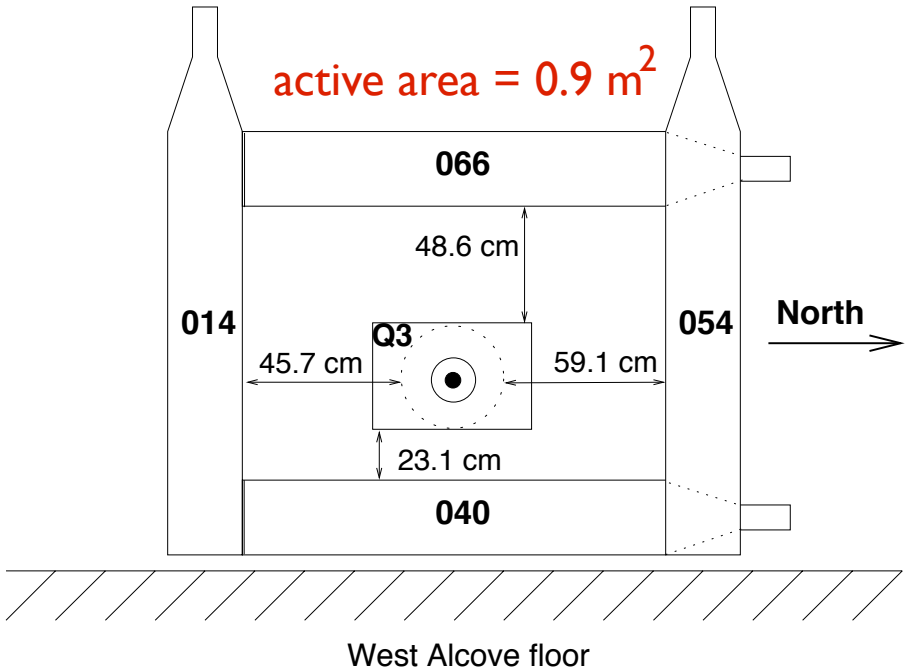


BSC counters: monitor beam losses and abort gap

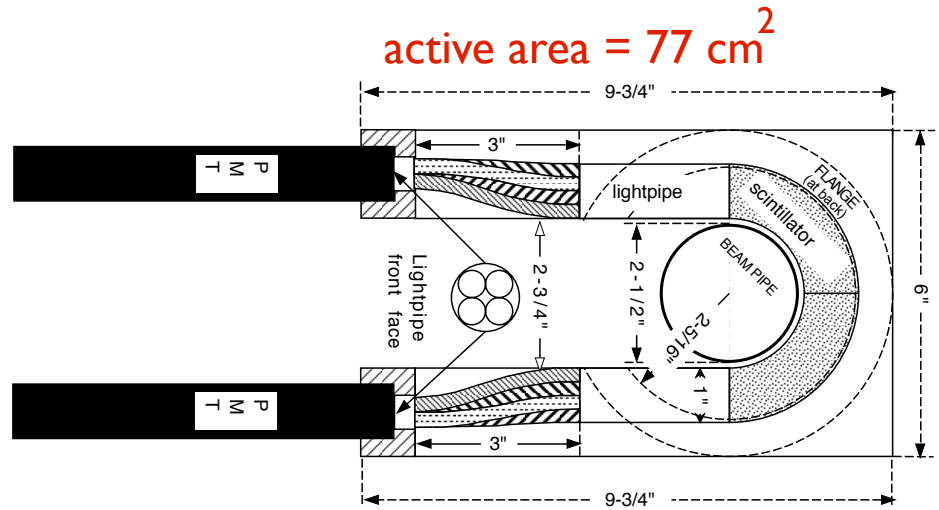
Halo counters: monitor beam halo and abort gap

Detectors

Halo Counters



Beam Shower Counters

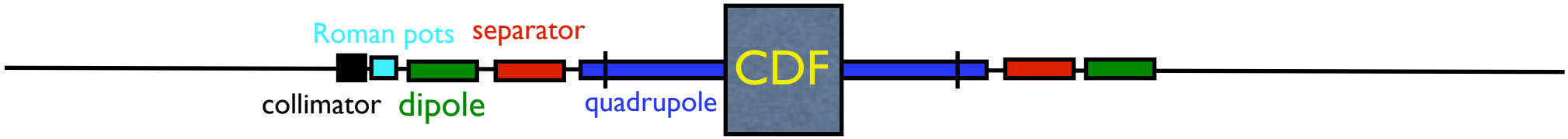


ACNET variables:

B0PHSM: beam halo
B0PBSM: abort gap losses
B0PAGC: 2/4 coincidence abort gap losses

B0PLOS: proton losses (digital)
LOSTP: proton losses (analog)
B0MSC3: abort gap losses (E*W coincidence)

Beam Halo Counters



Typical Store

Beam Parameters:

Protons:	5000 - 9000	10^9 particles
Antiprotons:	100-1500	10^9 particles
Luminosity:	10 - 50	$10^{30}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$

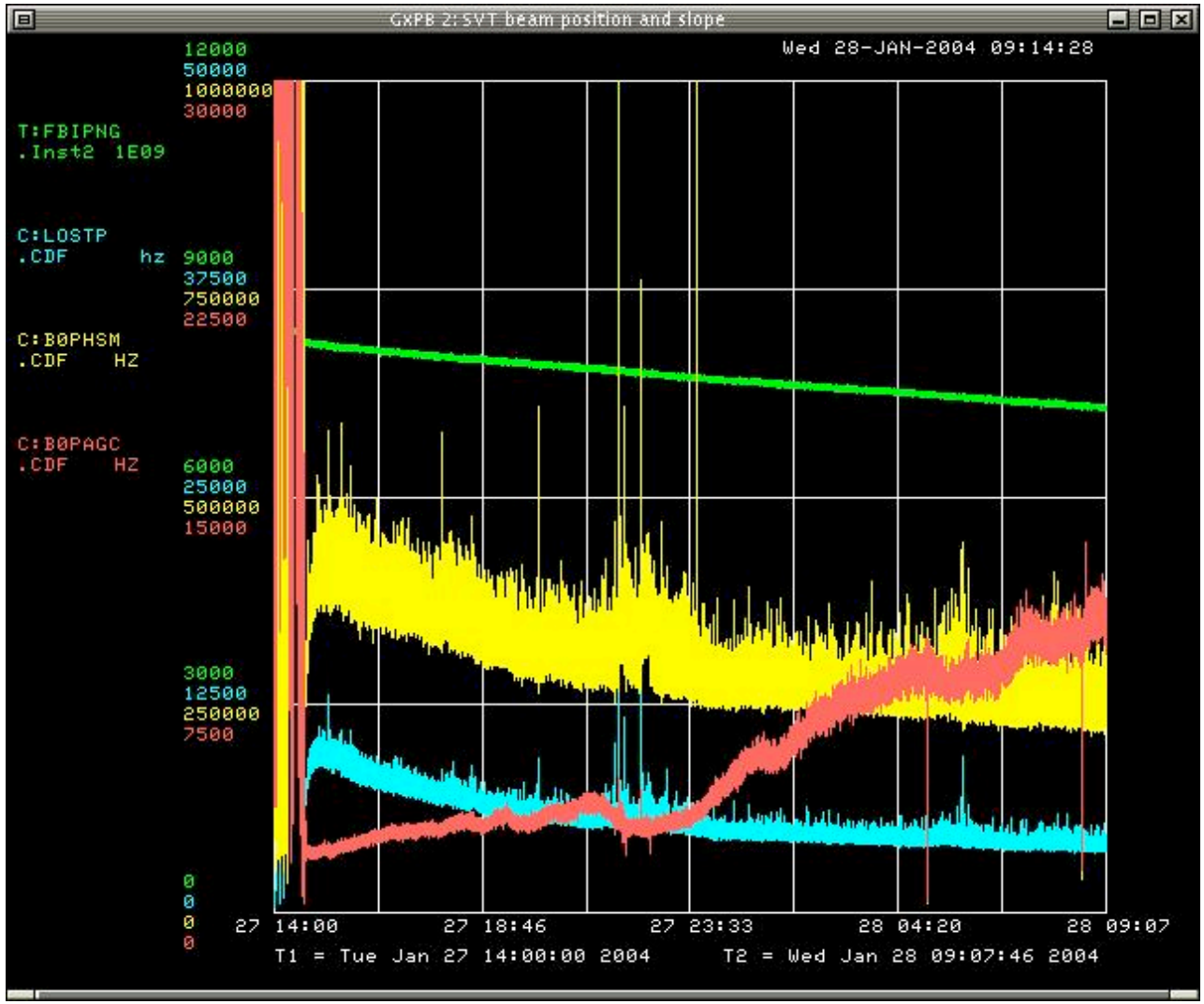
Losses and Halo:

Quantity	Rate (kHz)	Limit (kHz)	comment
P Losses	2 - 15	25	chambers trip on over current
Pbar Losses	0.1 - 2.0	25	chambers trip on over current
P Halo	200 - 1000	-	
Pbar Halo	2 - 50	-	
Abort Gap Losses	2 - 12	15	avoid dirty abort (silicon damage)
L1 Trigger	0.1-0.5		two track trigger (~1 mbarn)

Note: All number are taken after scraping and HEP is declared.

Monitor Experience

"Typical good store"



proton beam current

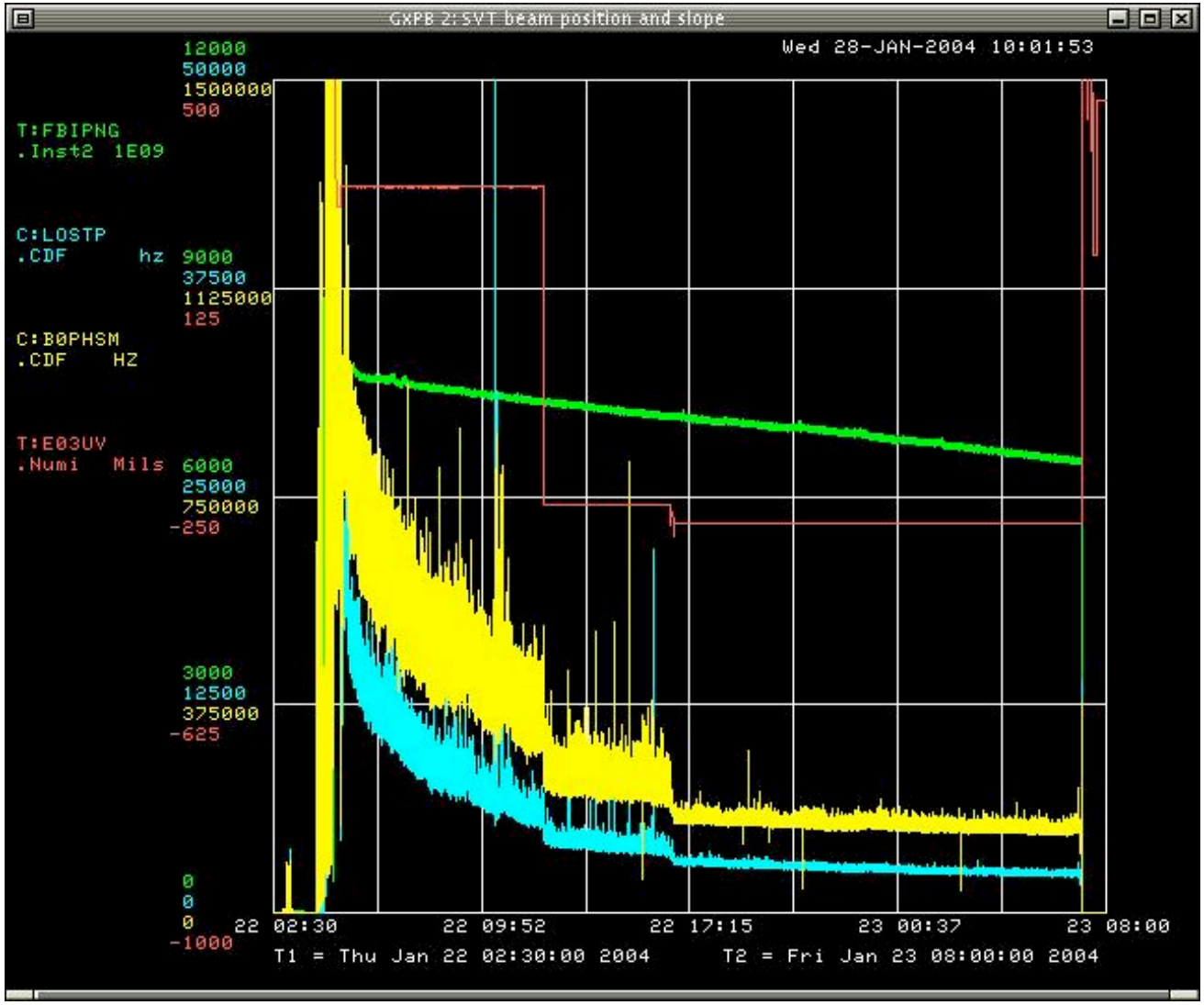
proton abort gap

proton halo

proton losses

Beam Collimation

Background reduction at work



E0 collimator

proton beam current

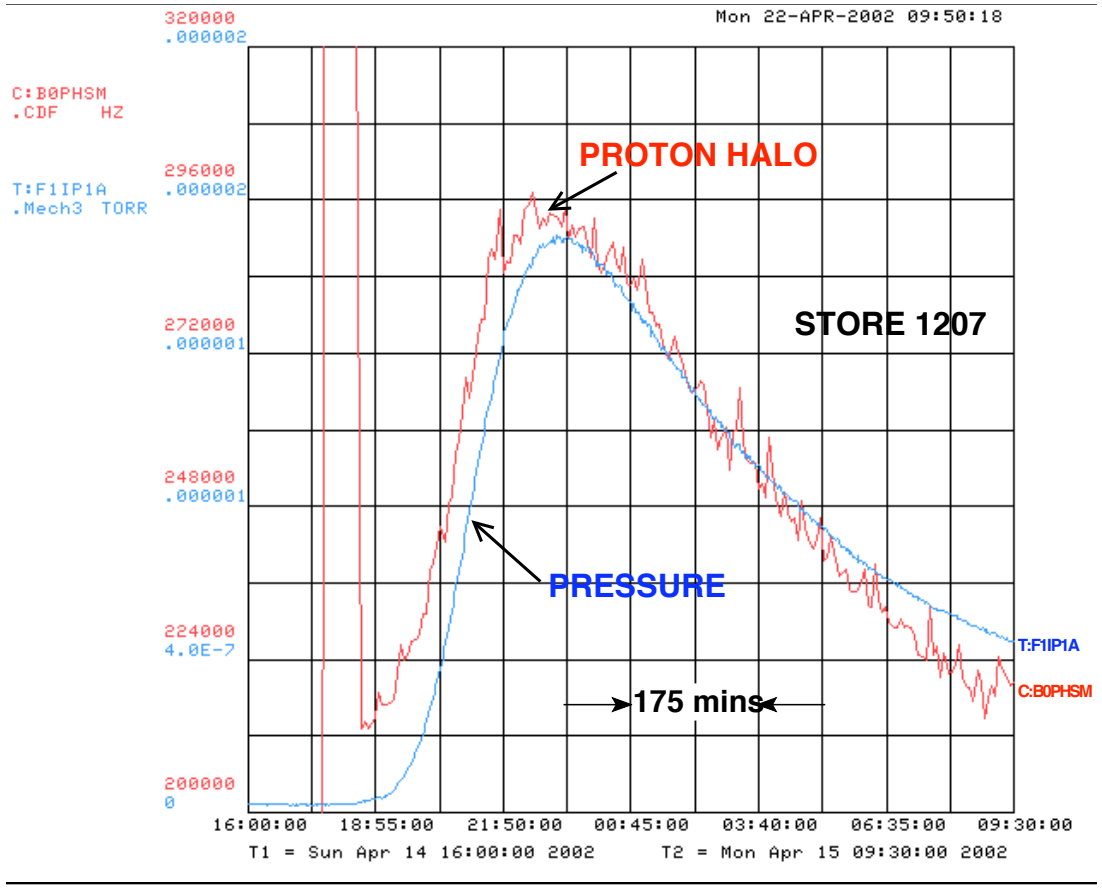
proton halo

proton losses

Halo Reduction

- Vacuum problems identified in 2m long straight section of Tevatron (F sector)
- Improved vacuum (TeV wide)
- Commissioning of collimators to reduce halo

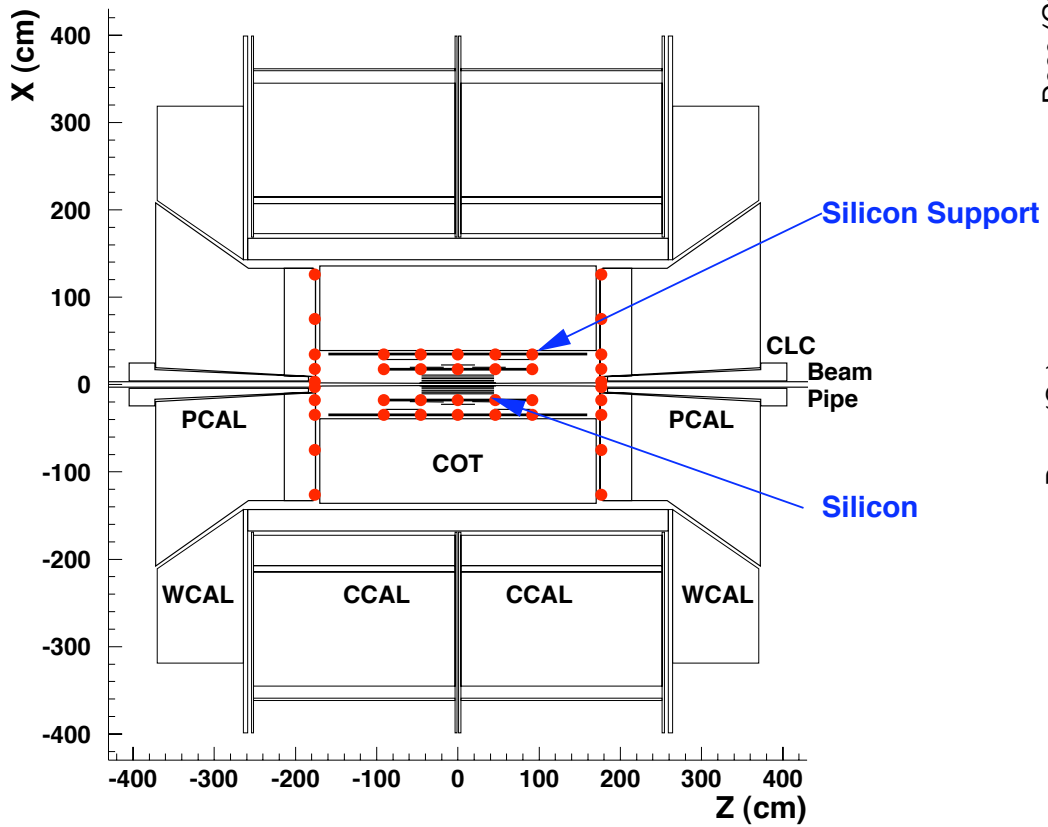
> Physics backgrounds reduced by ~40%

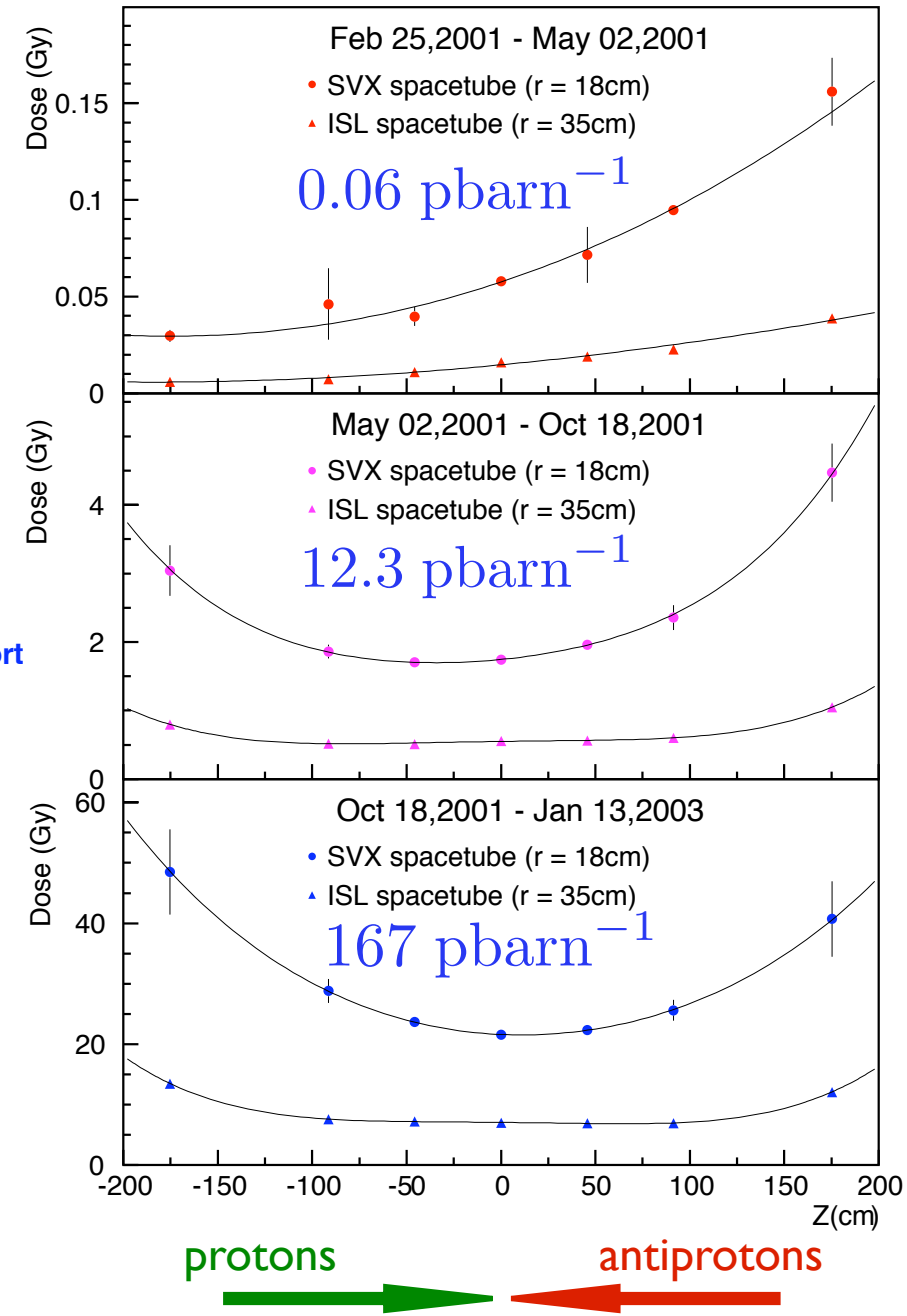


R. Moore, V. Shiltsev, N.Mokhov, A. Drozhdin

Radiation Measurements

- TLDs installed in tracking volume
- 3 exposure periods
  - 0.06 pbarn^{-1} (p-loss dominated)
  - 12.3 pbarn^{-1}
  - 167 pbarn^{-1}





Summary

- Halo/Losses contribute to operational problems
  - High chamber currents
  - Damage to rad-soft equipment
  -
- Accelerator problems contribute to backgrounds
  - Good vacuum important
  - Good collimation system essential
  -
- Monitor beam conditions
  - Dedicated monitors of accelerator operation

References (Incomplete List)

- General:
  - http://ncdf67.fnal.gov/~tesarek
  - http://www-cdfonline.fnal.gov/acnet/ACNET_beamquality.html
- CDF Instrumentation:
  - M.K. Karagoz-Unel, R.J. Tesarek, *Nucl. Instr. and Meth.*, **A506** (2003) 7-19.
  - A.Bhatti, *et al., CDF internal note*, **CDF 5247**.
  - D. Acosta, *et al., Nucl. Instr. and Meth.*, **A494** (2002) 57-62.
- Beam Halo and Collimation:
  - A. Drozhdin, *et al., Proceedings: Particle Accelerator Conference(PAC03)*, Portland, OR, 12-16 May 2003.
  - L.Y. Nicolas, N.V. Mokhov, *Fermilab Technical Memo:* **FERMILAB-TM-2214** June (2003).
- Radiation:
  - D. Amidei, *et al., Nucl. Instr. and Meth.*, **A320** (1994) 73.
  - S. d'Auria, *et al., Nucl. Instr. and Meth.*, **A513** (2003) 89-93.
  - K. Kordas, *et al., Proceedings: IEEE-NSS/MIC Conference*, Portland, OR, November 19-25 (2003).
  - R.J. Tesarek, *et al., Proceedings: IEEE-NSS/MIC Conference*, Portland, OR, November 19-25 (2003).