CDF and the IP position – why we worry

Rainer Wallny, UCLA

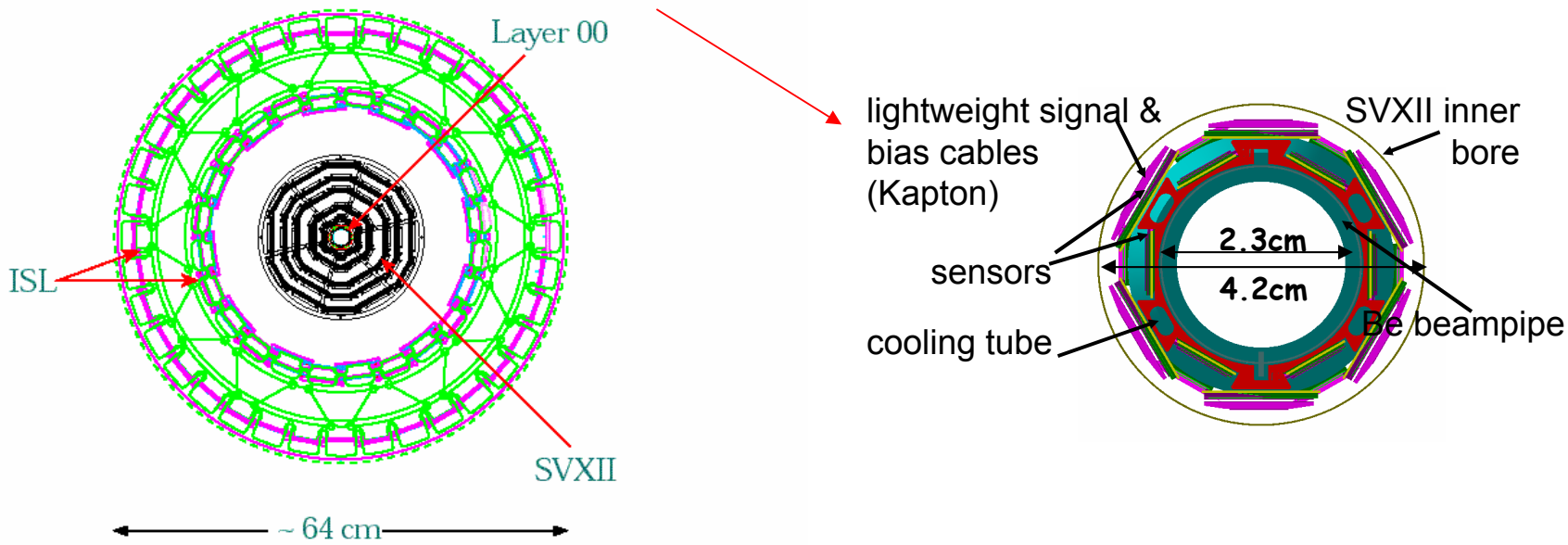
CDF Silicon Project Co-Leader

on behalf of the

CDF Operations Group

- Recent history of measured beam offsets and tilts.
- Impact on the silicon detector lifetime.
- Impact on the physics performance of CDF.
- Some options, a suggestion and a conclusion.

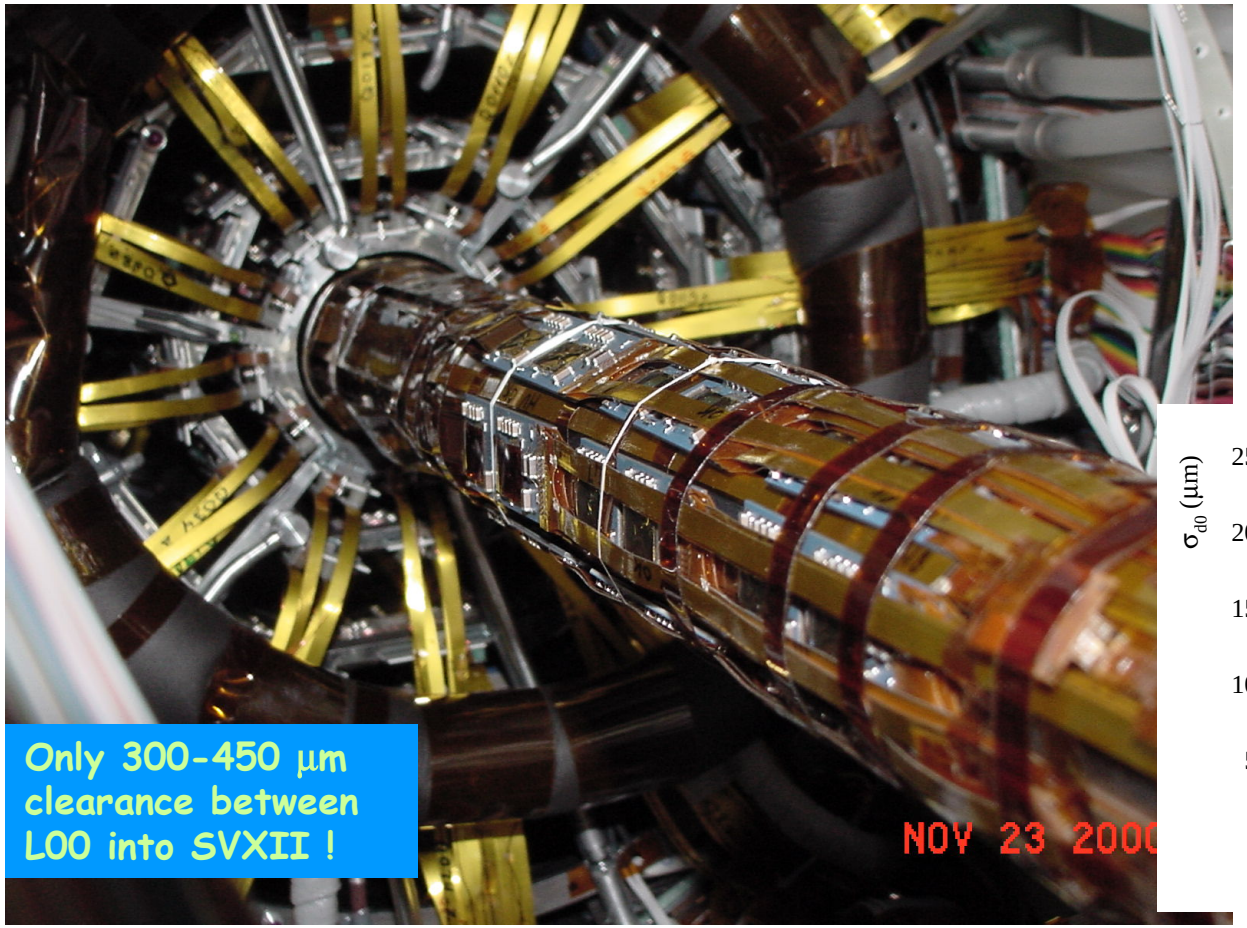
CDF Run II Silicon

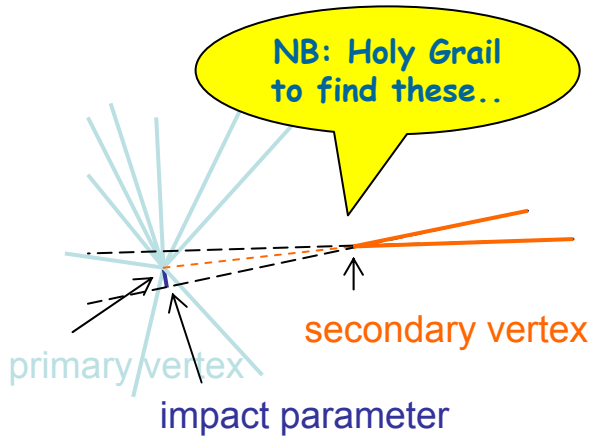


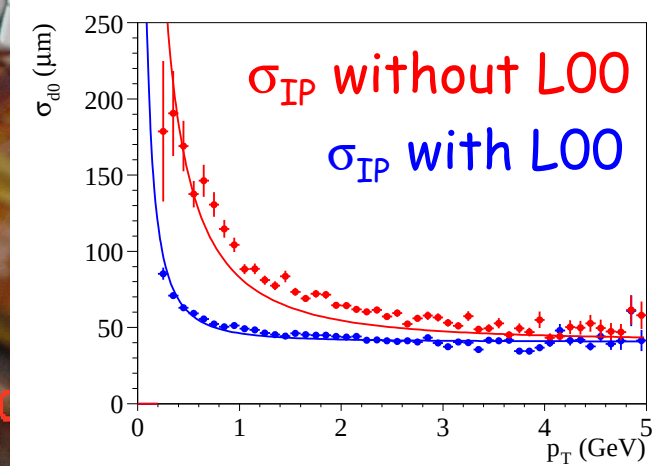
- L00 (1 layer) : 6 wedges × 2 Barrels ×4 Ladders - single sided, LHC style design
- SVXII (5 layers) : 12 ϕ wedges × 6 Bulkheads × 5 Ladders - double sided
- ISL (2 layers): 6 ϕ "wedges" × 6 Bulkheads × 5 Ladders - double sided
  - Total: 722432 channels
    => Biggest existing Silicon Detector in a Collider Environment
  - L00 pretty darn close to the beam – r=1.35/1.7 cm
    => closest a Silicon Tracker ever got to a beam!
  - CANNOT BE ACCESSED!

L00: Stuck between a Rock and a Hard Place …

… but a very useful tool for physics analysis:





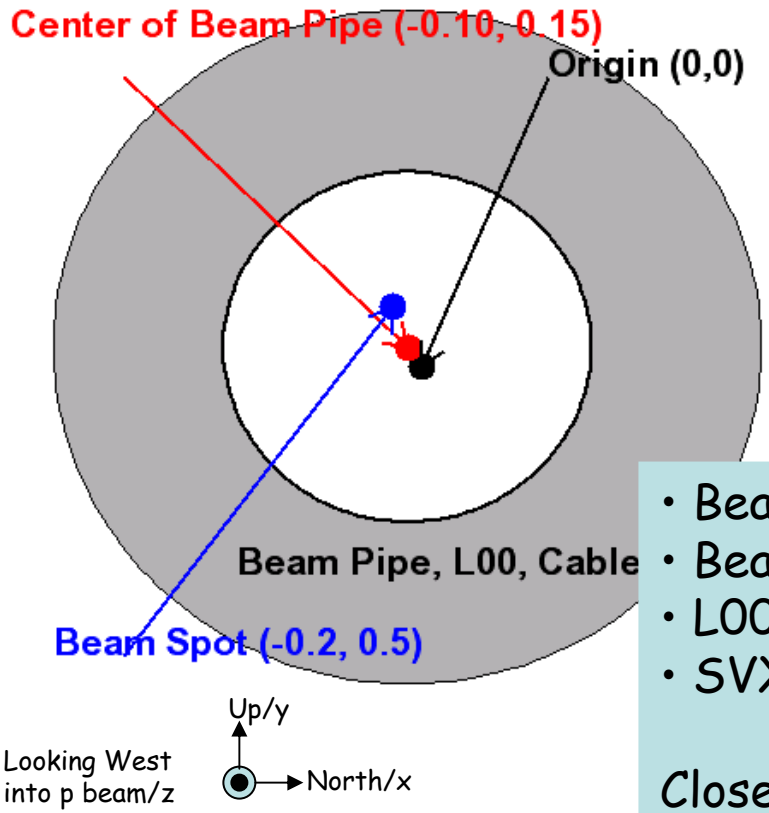


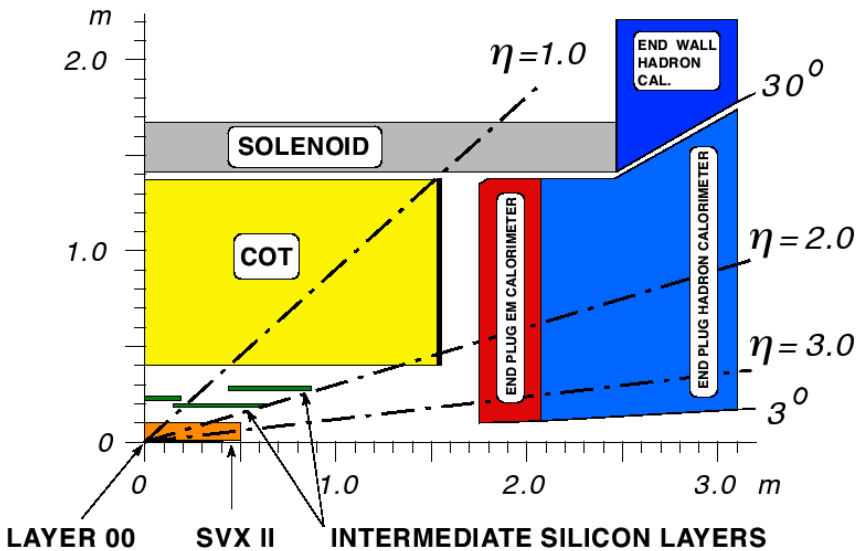
NB2: CDF can find displaced vertices **online** using the Silicon Vertex Trigger (SVT)
(not using L00 info though …. Sigh …)

Where is the beam in CDF ?

The CDF coordinate system is defined by the COT (Central Outer Tracker)

=> Origin = Center of COT



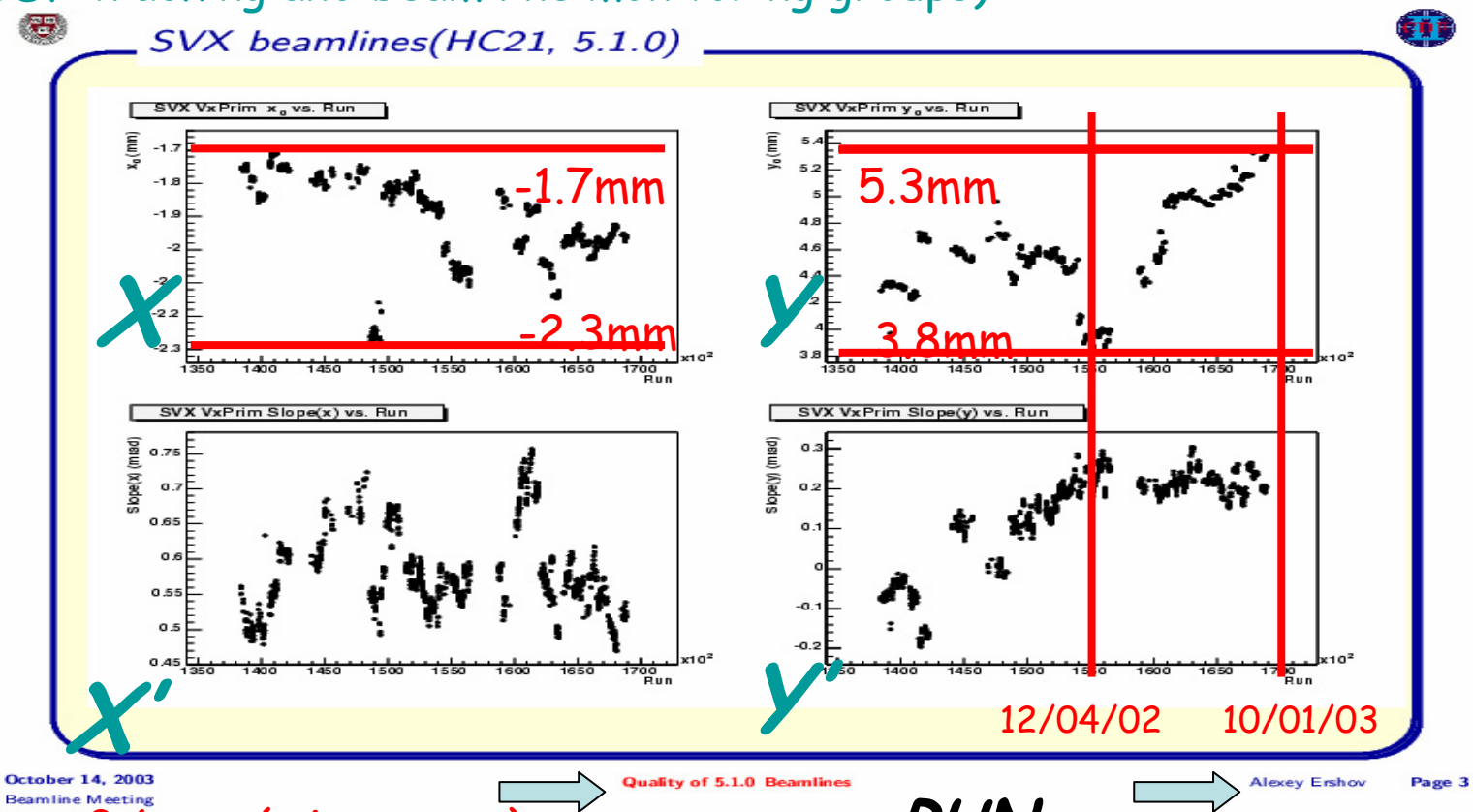


- Beamline: currently ~(-2,+5)mm in COT coords
- Beampipe: currently centered ~(-1, +1.5)mm in COT
- L00: currently centered ~(-1.2, +1.3)mm in COT
- SVX: currently centered ~(-1.1, +1.4)mm in COT

Closest distance between beamline and L00 is ~10mm

Time Dependence of Beam Position

From offline tracking, alignment and primary vertex reconstruction
(CDF tracking and beam line monitoring groups)



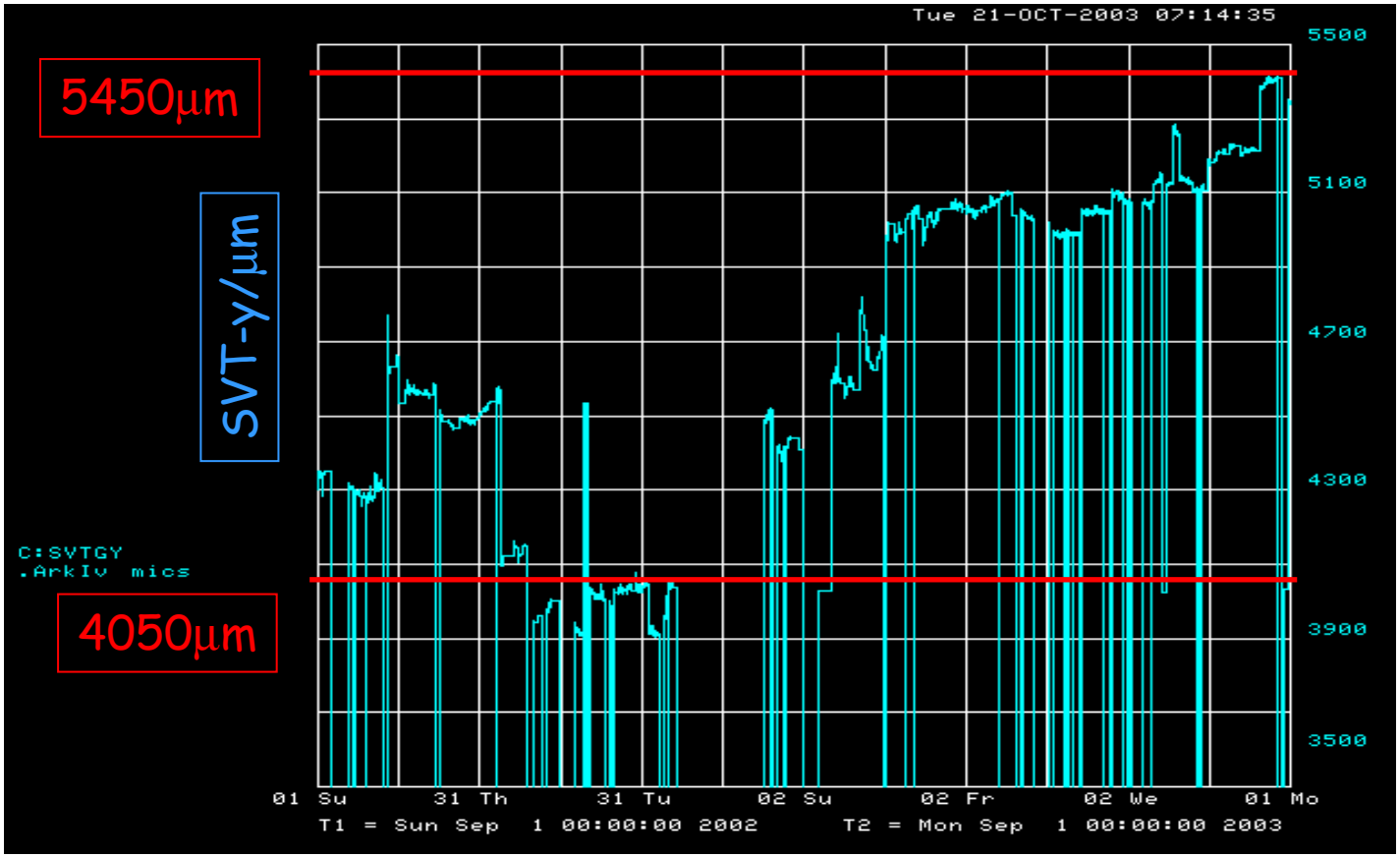
RUN

- Δx=-0.6 mm (min to max)
- Δy=+1.5 mm since Dec 2002 -> CDF 'sinking' ? (since then ???)
  Tevatron floating (seasonal changes ?)

- Precision O(5μm) for offsets

Time Dependence of Beam Position (cont'd)

From SVT:



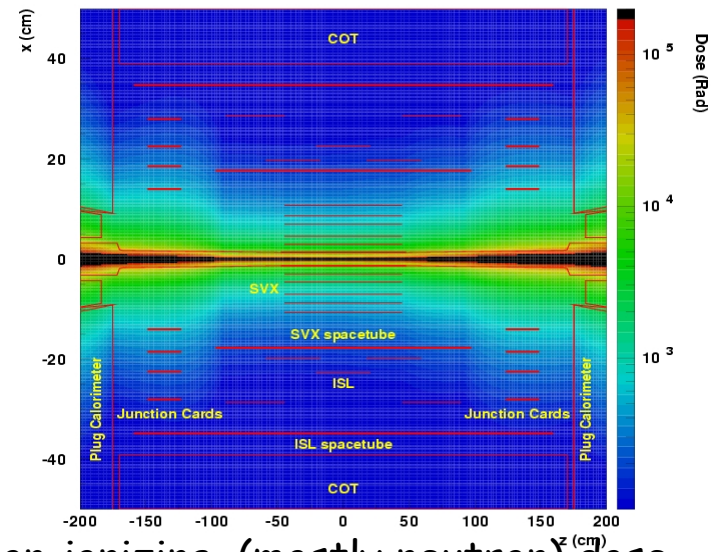
- Δy_{SVT}=+1.4 mm (Sept 1st, 2002 – Sept 1st, 2003)
- SVT can cope with lateral displacement of a few mm but **does not like slopes**

Radiation Field in CDF

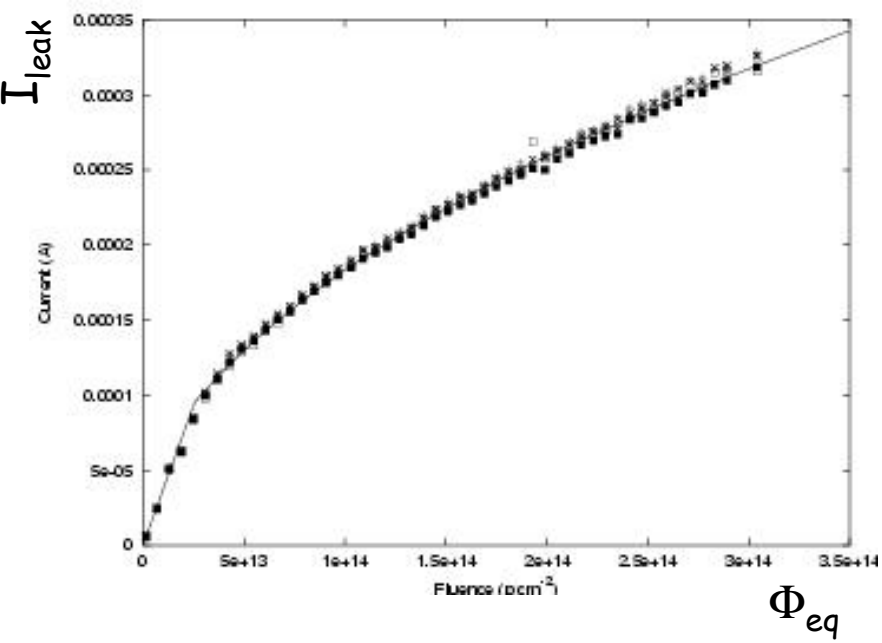
Hadron Colliders are high intensity particle radiation sources:

- Ionizing (charged particle) dose affects mainly the readout electronics -
  => Interesting scale is MRad
  => Relatively easy to measure (using TLDs)

Cross Section of Radiation Field in CDF



CDF Radiation Monitoring Group



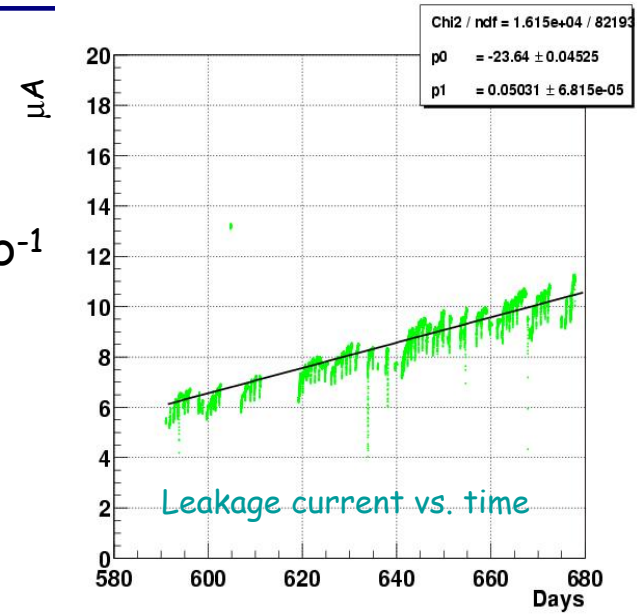
- Non-ionizing (mostly neutron) dose affects the silicon bulk material by displacing lattice atoms
  => measured in $[\Phi_{eq}]$=(1 MeV n)/cm^2
  => Not so easy to measure …

BUT:

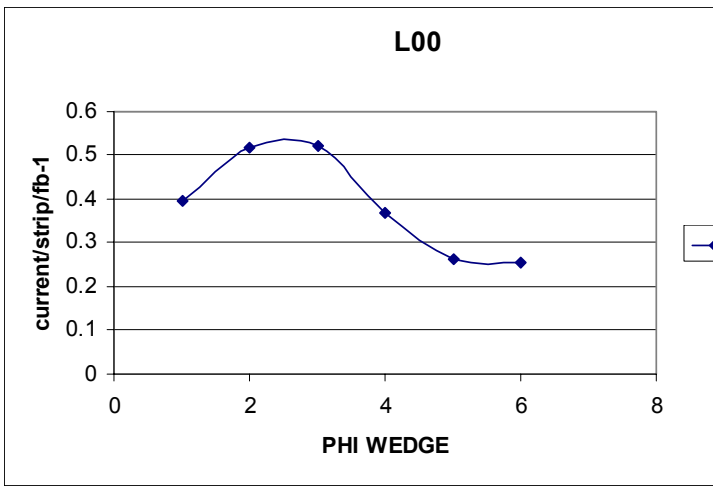
- Silicon strip detectors are essentially reversed biased pn-Junctions which change properties under irradiation
  => Radiation damage can be measured with increase of dark current

Leakage Current Measurements

- 326 pb^{-1} total luminosity delivered to CDF
- We measured Leakage Current vs Luminosity
  - measured for a stable run period of 100.7 pb^{-1}
  - Large systematic uncertainties from sensor temperature and sensor to sensor variation



	ΔI/ ladder [μA]	RMS [μA]	Fluence 1 MeV n 1E12 /cm²/fb⁻¹
Layer00 narrow	4.89	1.57	30
Layer 00 wide	6.47	1.93	20
Layer 0	10	1.99	9.3
Layer 1	8.1	2.00	5.1
Layer 2	5.2	2.94	2.4
Layer 3	5.88	1.60	1.8
Layer 4	4.37	2.41	1.2

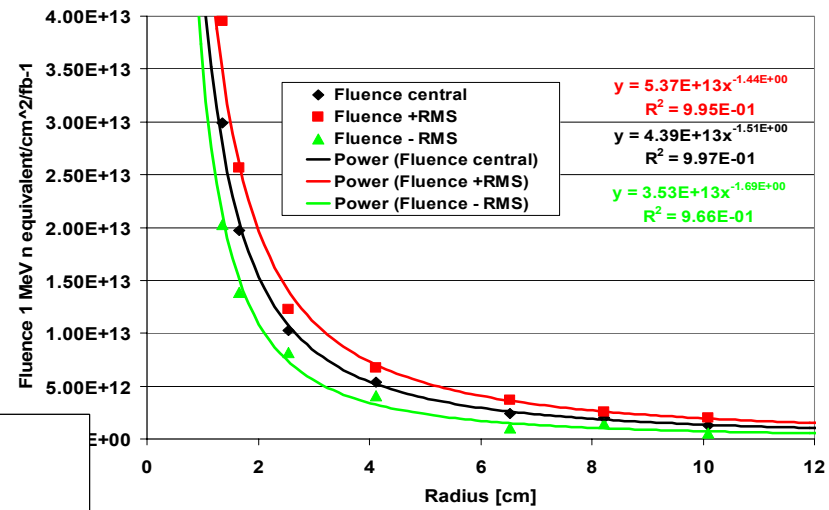


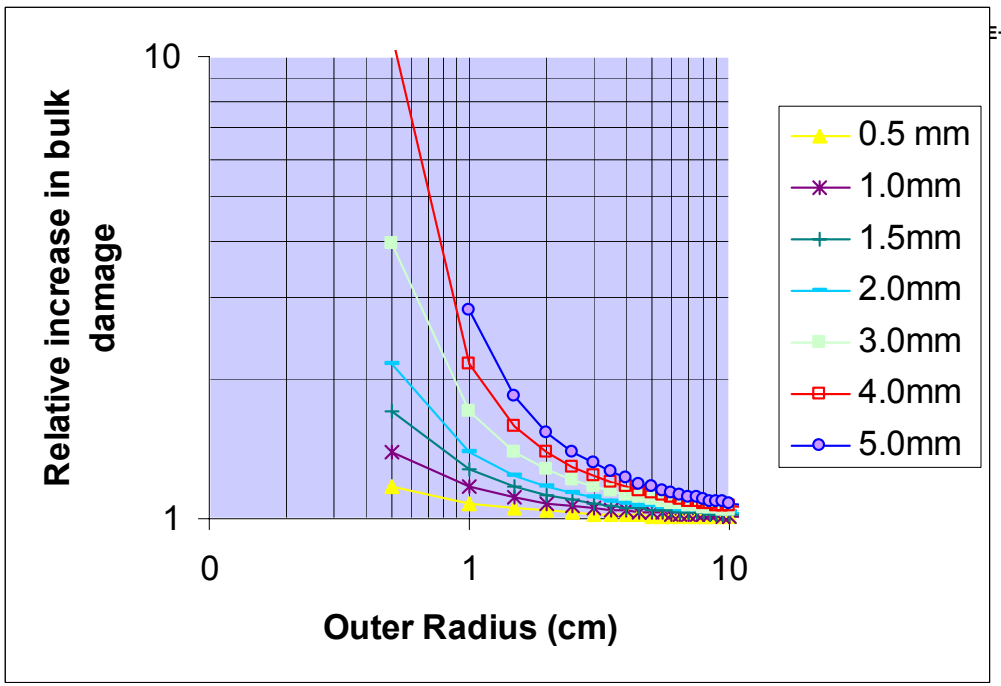
- Effect of Radiation Damage already visible
- Beam offsets lead to non-uniform irradiation

Effect of Beam Offsets on L00

- Radiation Field exhibits strong radial dependence ~ $1/r^{1.5-1.7}$

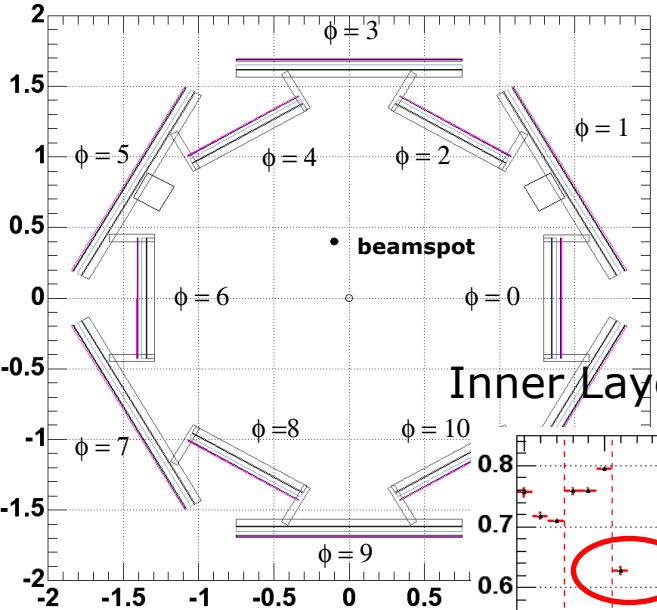
Beam offsets modify this power law: Simple scaling exhibits 40%-50% more irradiation on top wrt. bottom





- Current 'used' lifetime ~5%, but top part aged ~8%
- Not (yet) a big deal, but different irradiation cannot be equalized any more => operational issues
- Aging scales linearly with luminosity. The earlier we fix it the better.

L00 Efficiency

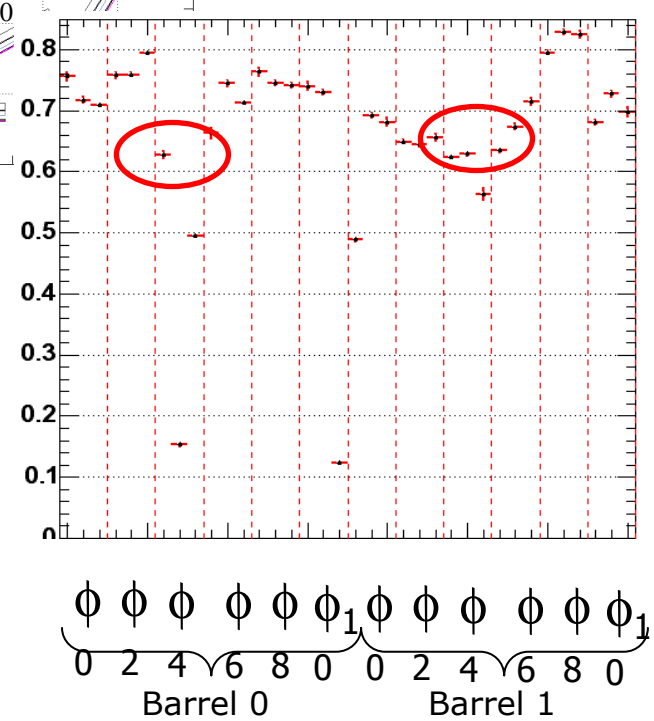


Hit occupancies are higher in the L00 top half:

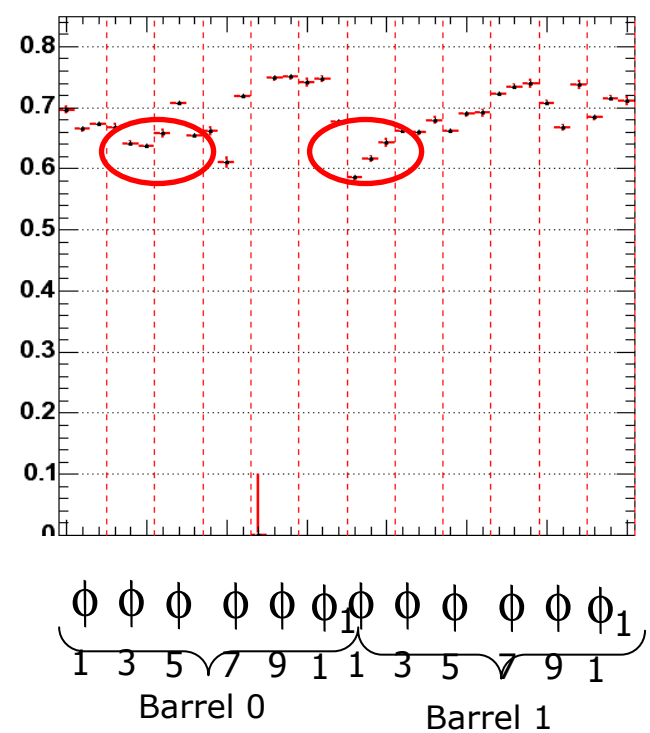
⇒ Tracking algorithm has a higher chance of picking up a spurious hit or

⇒ Leeds to degraded resolution or efficiency loss (overlapping hits, large clusters)

Inner Layer (ϕ even)



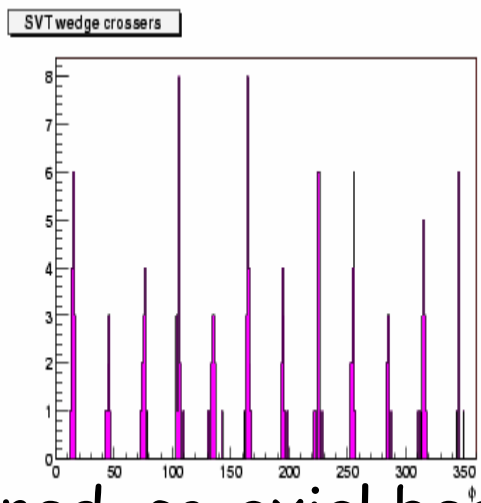
Outer Layer (ϕ odd)

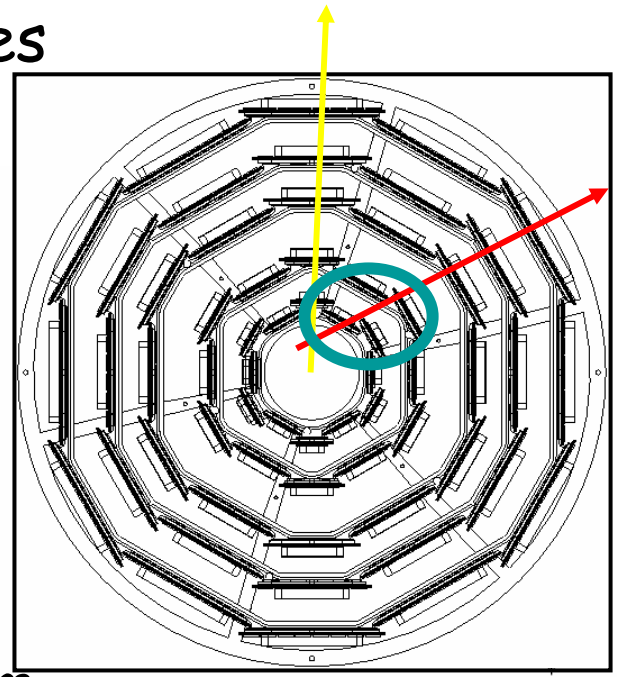


CDF Tracking Group

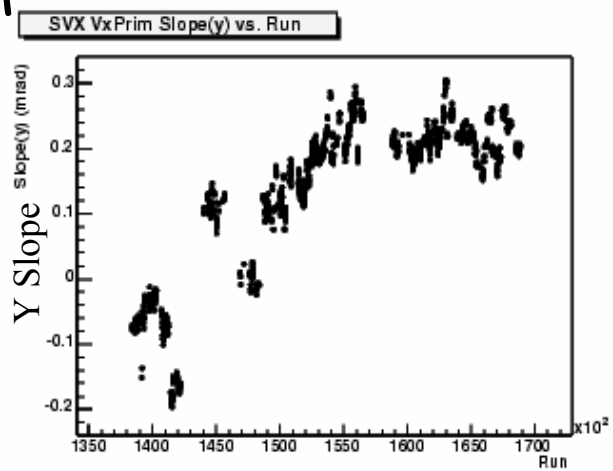
Effect on Beam Offset and Tilts on SVT

- SVT cannot trigger in different wedges
  - $Bs \rightarrow D_s \pi$: O(25%) lost due to wedge crossing
  - reduction of the useful luminosity delivered for this physics channel
  - As this is trigger-inefficiency, it cannot be recovered.



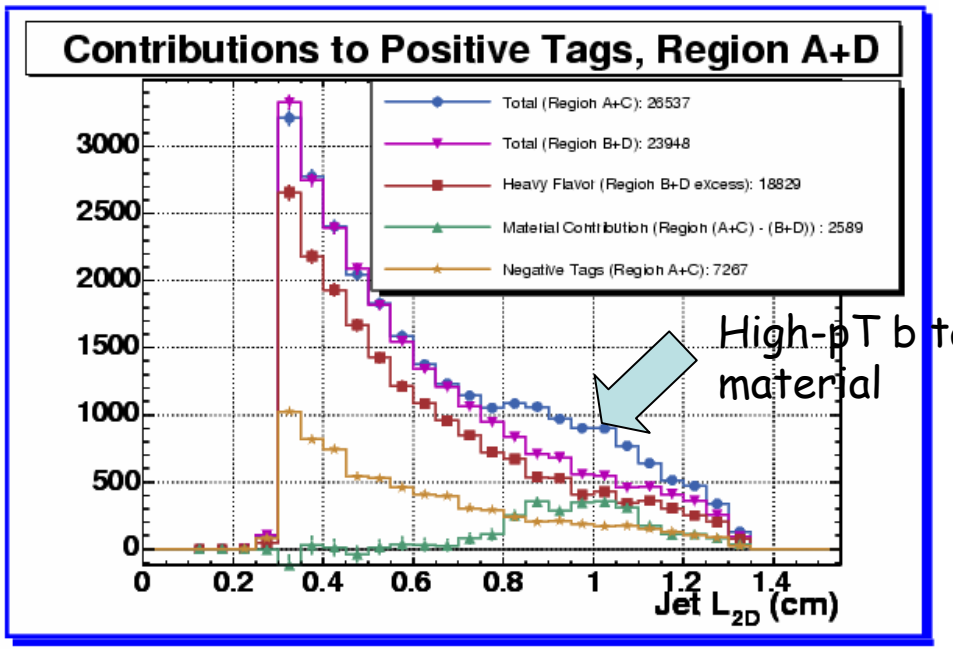


- SVT needs a well aligned, co-axial beam
  - Designed to tolerate +/- 100 μradians
  - Can cope with more but needs tedious re-programming
  - Currently at the edge.

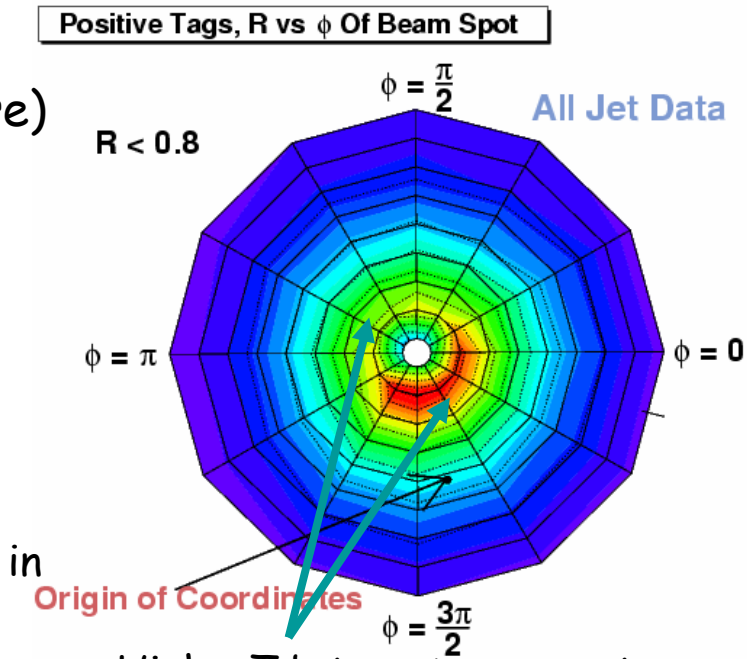


Effect on B-Tagging – The Holy Grail

- B tag ϕ-asymmetry: 40% toward/away detector center (probably soluble in software)



High-pT b tags in material



High-pT b tags ϕ asymmetry

- B tags in material: 10% of positive tags, would lose O(15%) on top if required to cut away (non-distinguishable from conversions etc.)

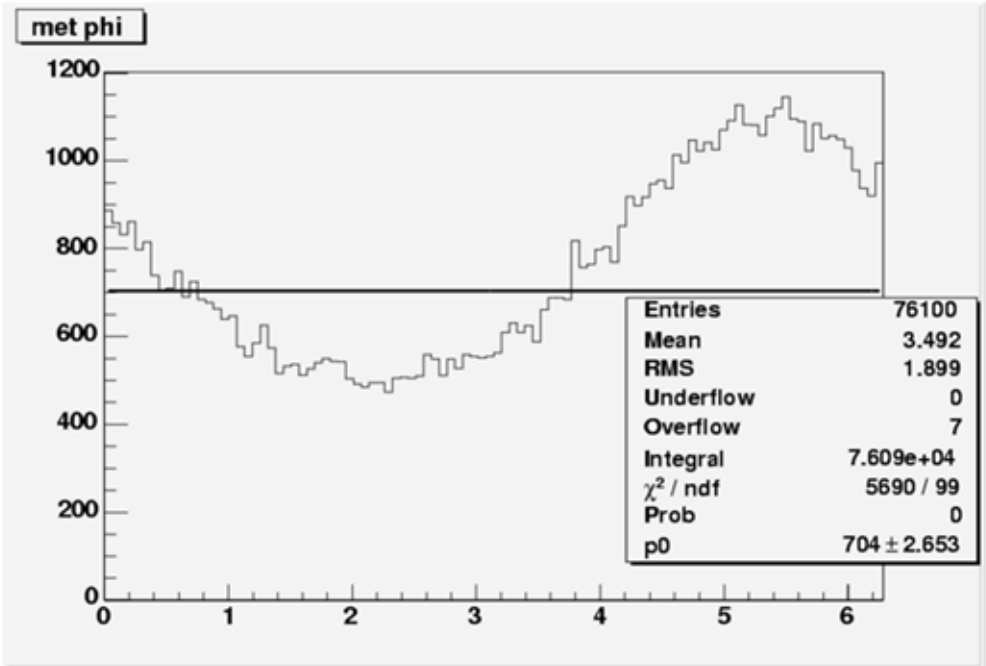
NB: 'double B-tag efficiency' was metric chosen by PAC in the Run IIb Si Upgrade Discussion

CDF high P_T Btag Group

Effect on 'Missing E_T' reconstruction

- Used to identify neutrinos – particles which don't leave any traces in the detector but carry away transverse energy and momentum
- Crucial for physics like finding our beloved *top* quark but also for SUSY searches and W mass precision measurements

- Should be ϕ symmetric – beam offset can only partially be compensated since online zero suppression cuts into low energy tails
- Effect is huge – Factor x 2.



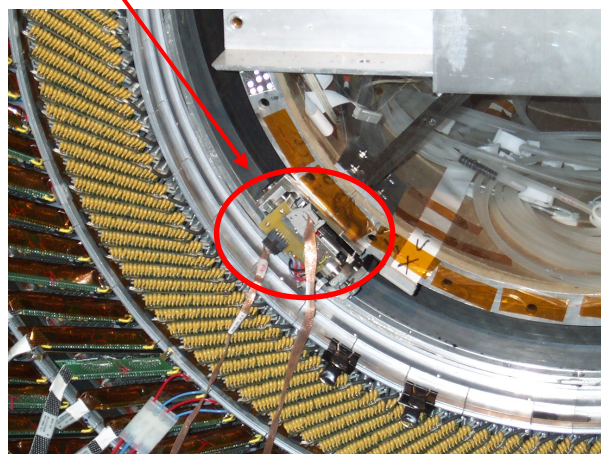
"What is to be done ?" V.I. Lenin, (1902)

Well, somebody's gotta move ....

Option	Pros	Cons
BD moves quads	nothing delicate in CDF moves,realignmen	Changes lattice, requires warming up
Raise CDF	Not as delicate as below, can get 5 mm	Jack access:shutdown, move chambers
Raise COT		CAL realignment, SUVA, TOF clearance
Raise SVX		Inchworms maxed out, beampipe, L00
Magnet Currents	No moving parts	Not enough motion, lose alignability

We can move CDF up to 5 mm. Need to

- disconnect services (gas, cryo...)
- warm up solenoid
- remove muon chambers at bottom,
- install jacks
- pick CDF up
- shim it and lower it.



No schedule has been drafted, but cannot possibly do it in less than a few weeks.
Alternative: low beta quad movement.

NB: If beam moves more than 1 mm away from pre-shutdown position, we might have to perform this move before next shutdown.

CDF Sinking aka What's going on?

- In the commissioning run w/Barrel 4, the Si detector was 1.65 mm high
- During roll-in of CDF-II, we added 2.5 mm to compensate for this and a possible sag
- The detector sunk 0.7mm over 3 months during the commissioning run and 0.5 mm during Run I (not O(5mm))
- We did a survey after roll-in of CDF-II. We did not do it since.
- We have requested a survey to do this and will require an 8 hour access at some point

That should settle the issue who's moving.

Suggested Plan:
Once beam is stable and MCR happy:
- perform an aperture scan and make sure it is centered in the low betas
- use correctors to lower beam as is prudent w/o risking instabilities

Conclusions

- The beam is offset in CDF by more than 5mm. This is more than it has ever been.
  - L00 ages prematurely.
  - This is (not yet) an emergency. BUT:
  - Important physics performance is compromised
  - Can be directly translated into an equivalent loss of luminosity of 10-25% for several physics channels which are at the core of our program
  - It may become an emergency when the beam moves more than 1mm additionally.
- The offset can not be compensated for by the CDF silicon tracker alignment system ('inchworms') which is already maxed out
  - Without moving the whole CDF detector, only 1 mm or so can be achieved on our side, and it's a very delicate job.
  - Time for whole CDF movement is estimated to be at least a few weeks.
- We have requested an alignment survey and suggest exploring beam movements via correctors and then see where we stand.

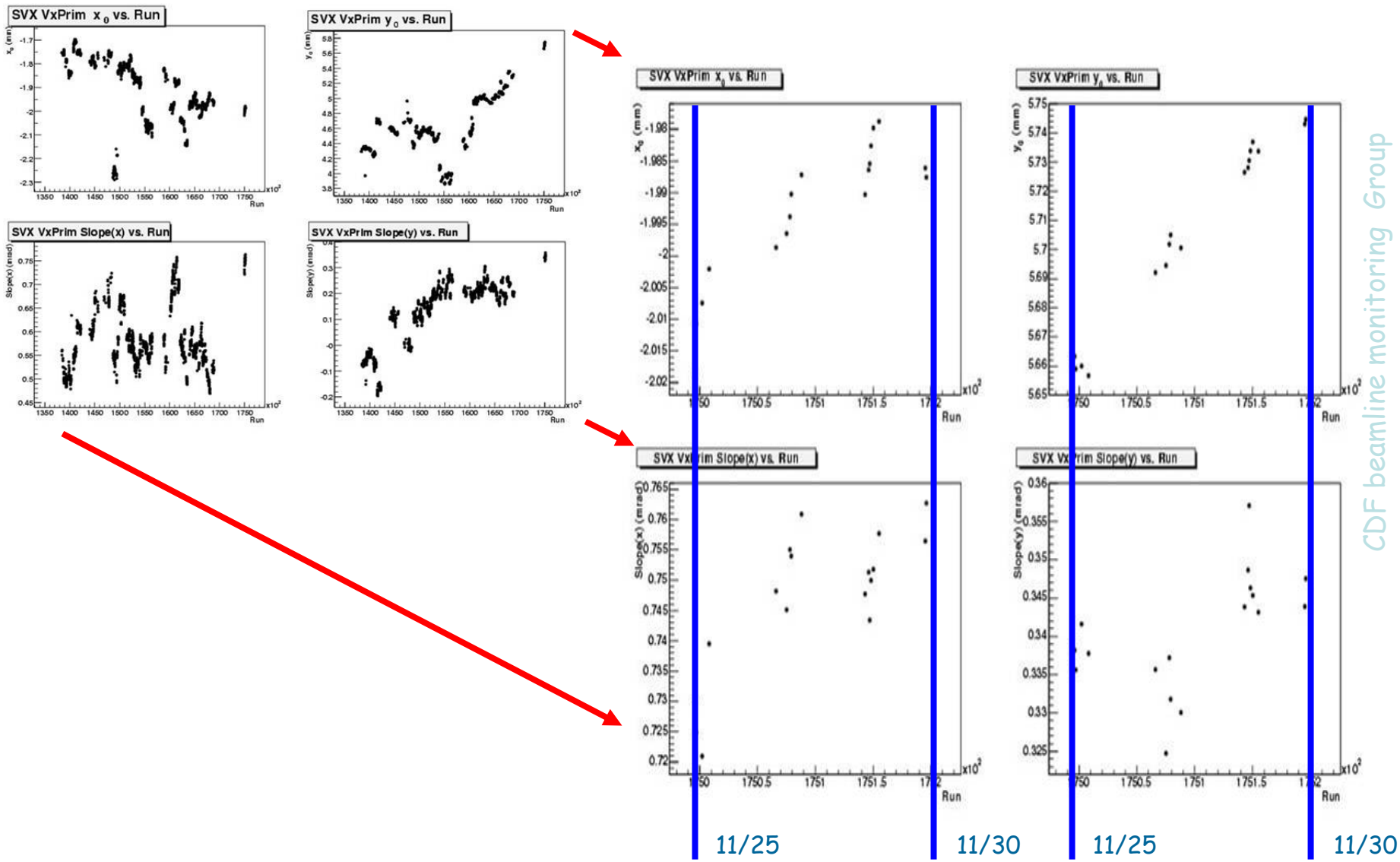
Backup: On ACNET Variables

- B0[P/A]LOS,C:LOSTP,LOSTPB all now working.
- Halo ACNET variables (C:B0[P/A]HSM, C:B0[P/A]BSM) need to be timed in.
  - Need 1 hr coalesced p beam, 1 hr reversed injection protons or 1.5-2 hrs of collision

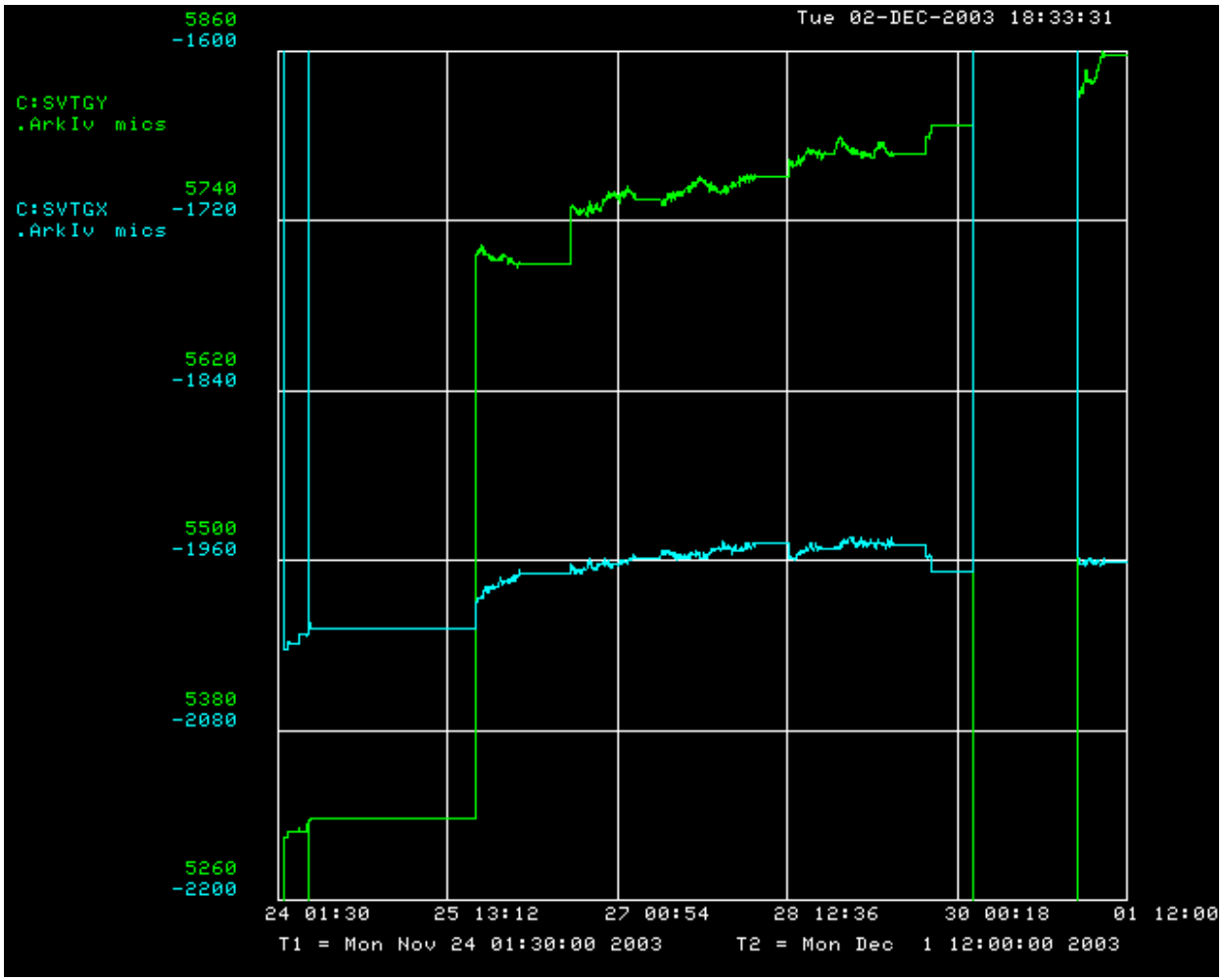
Note: Rates may change significantly since halo counters have moved.

R.J. Tesarek, CDF Radiation Monitoring Group.

Postscriptum: Post-Shutdown Beamlines



Postscriptum: Post-Shutdown SVT Beam Position



Recent SVT Measurements:

y: +5860 μm
x:-1960 μm