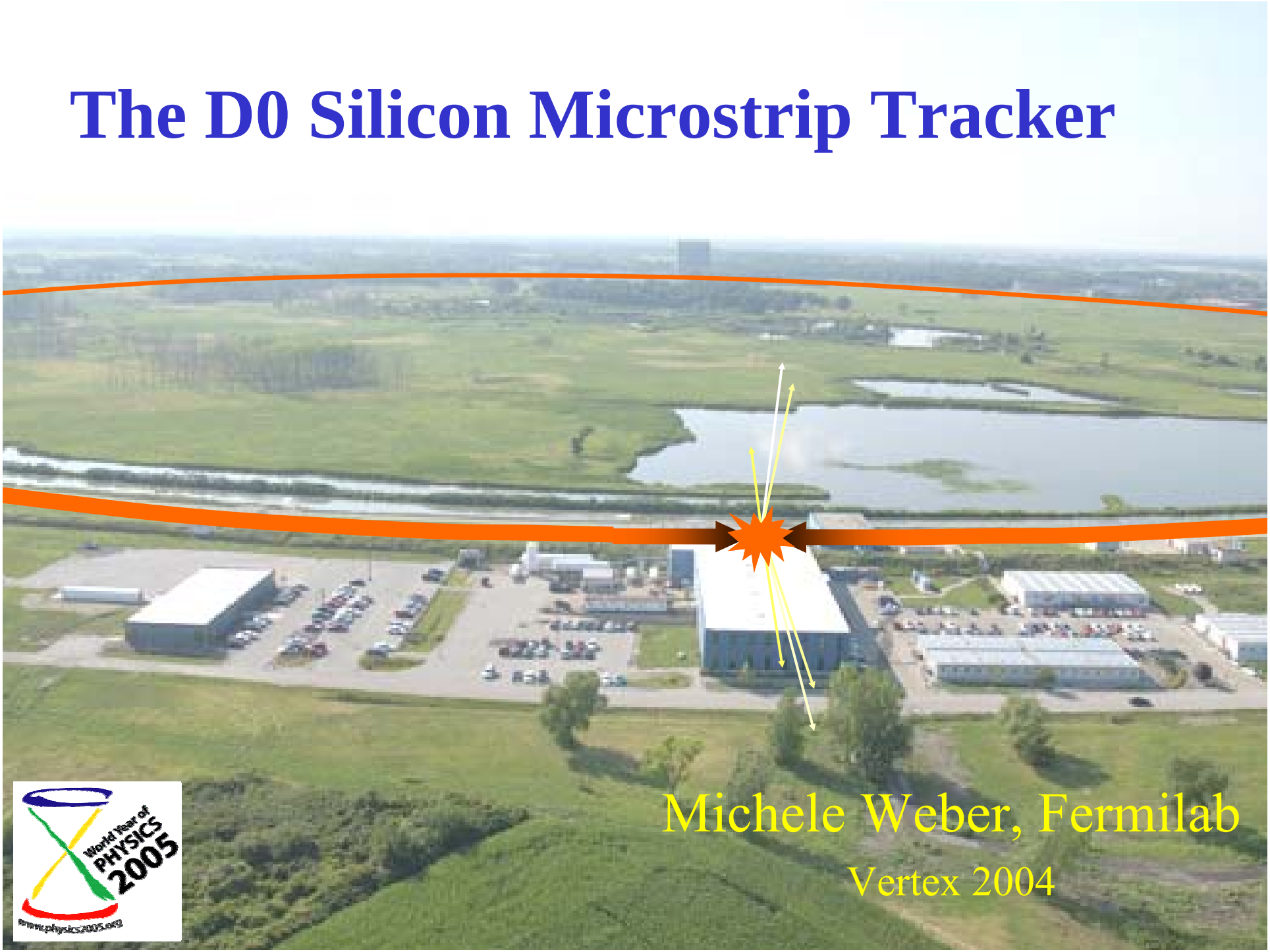
The D0 Silicon Microstrip Tracker



Michele Weber, Fermilab

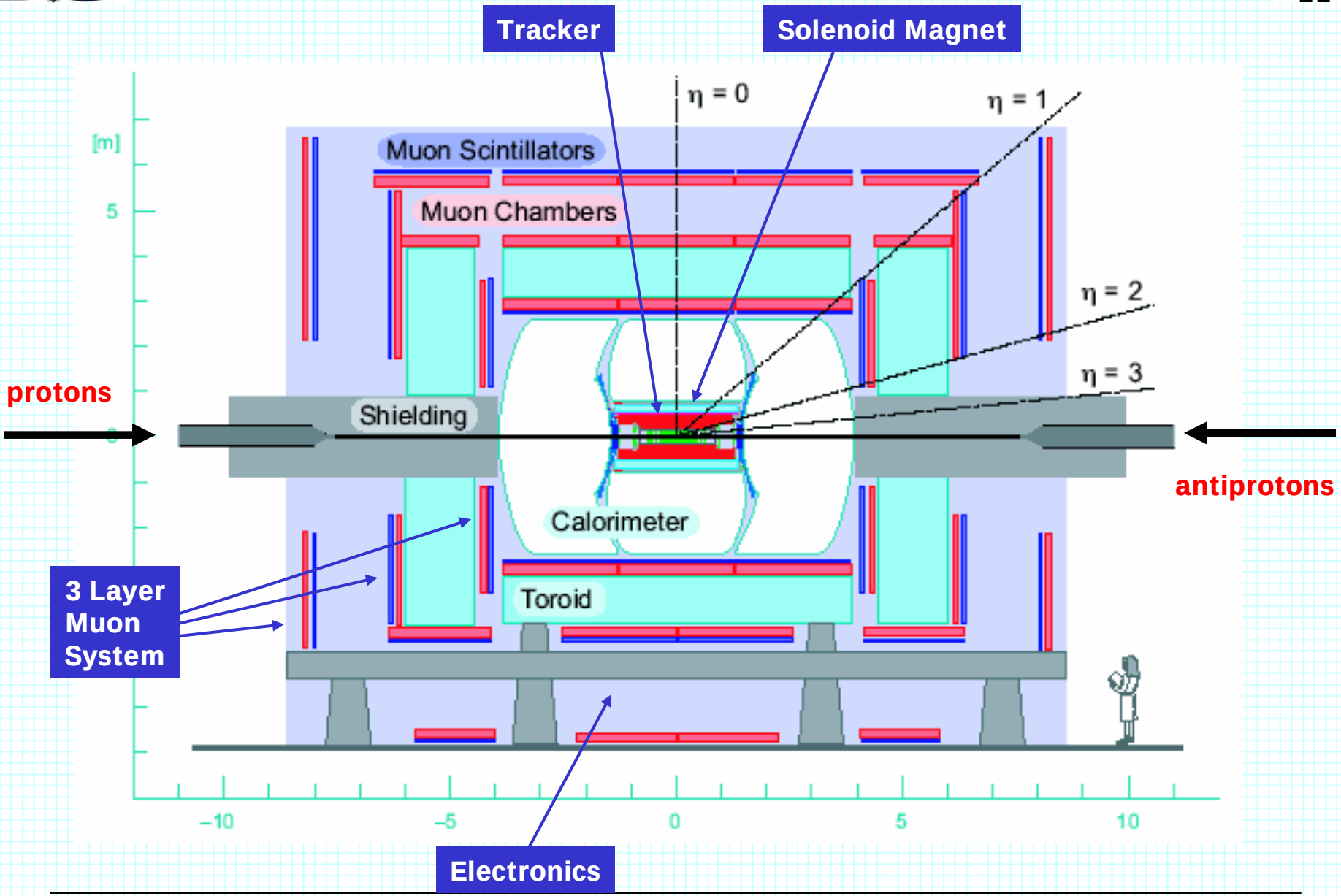
Vertex 2004

Overview

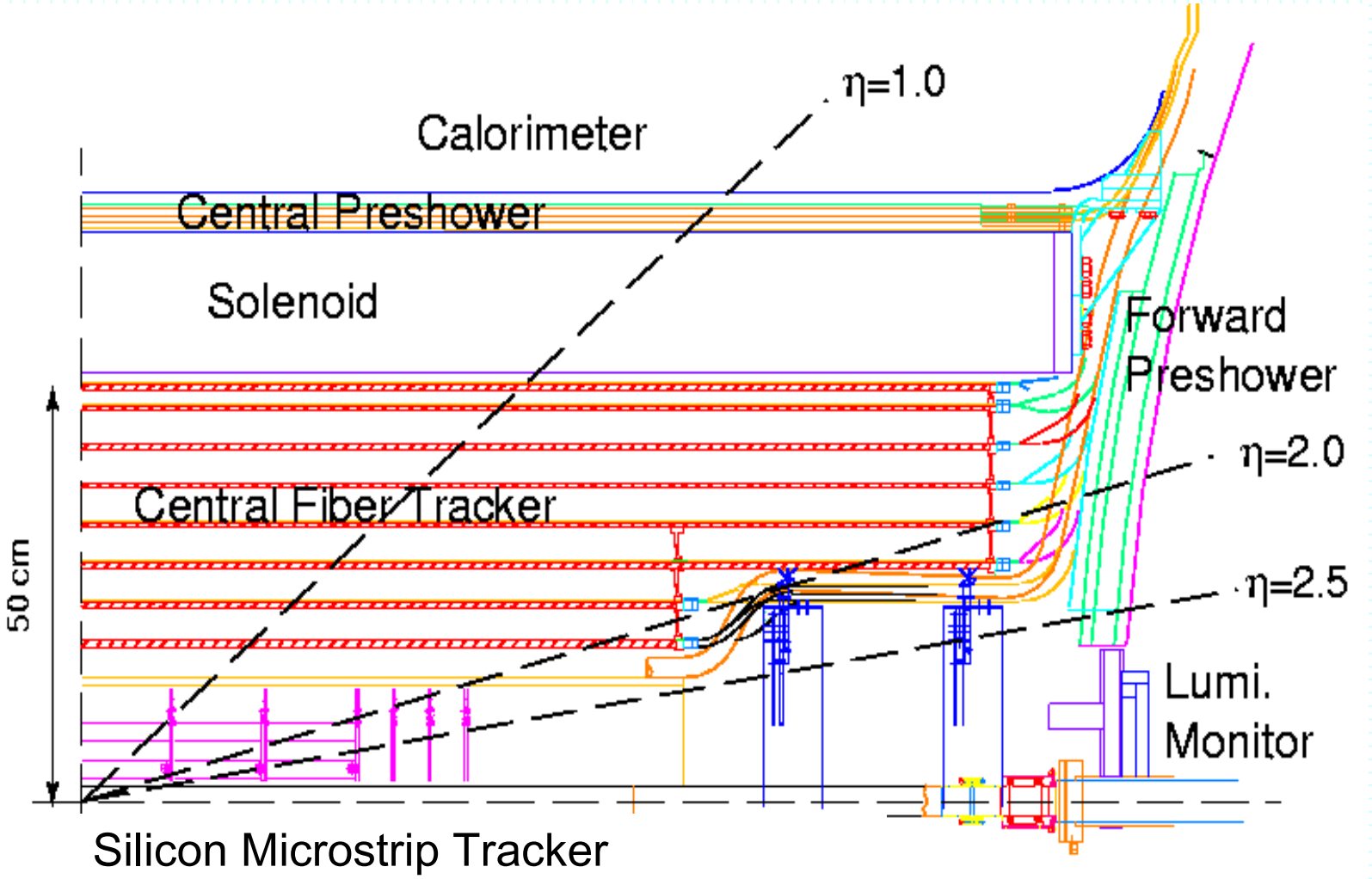
- Design of the D0 Silicon Microstrip Tracker
- Detector status
- Performance tracking / vertexing
- Radiation
- Layer 0

DØ

19 Countries
77 Institutions
~ 650 Collaboators
~100 postdocs
~140 grad. students

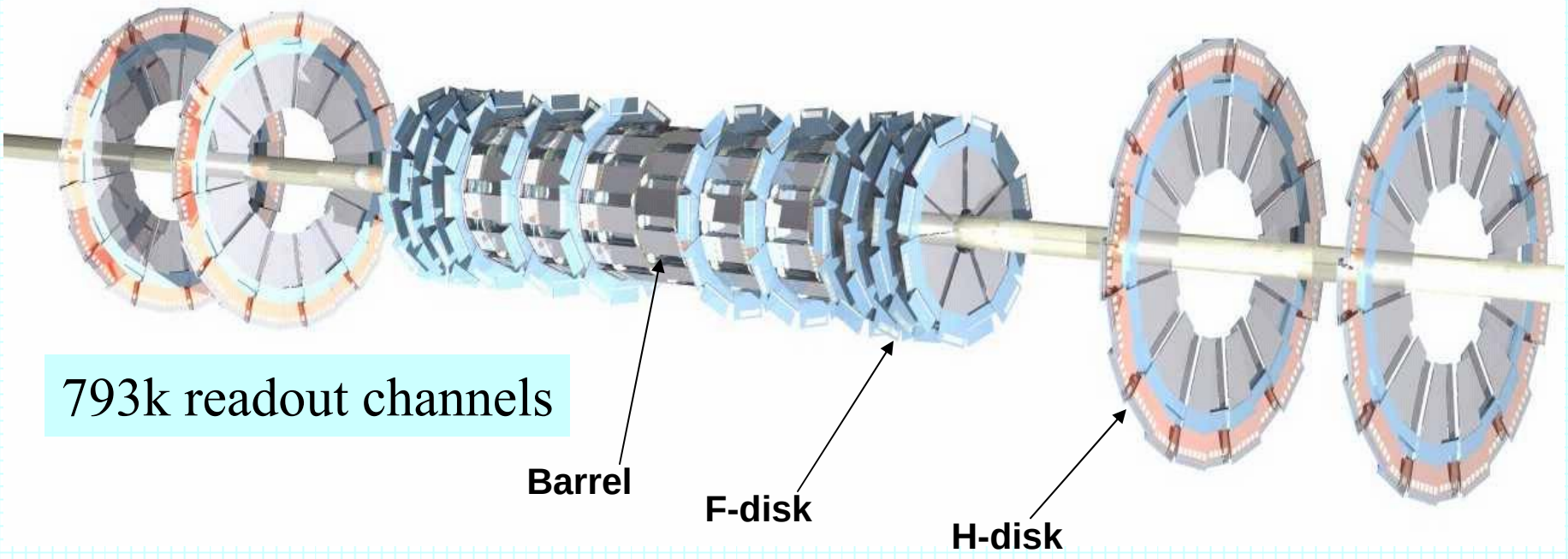

Tracker
Solenoid Magnet
η = 0
η = 1
η = 2
η = 3
[m]
5
Muon Scintillators
Muon Chambers
protons
Shielding
antiprotons
Calorimeter
3 Layer Muon System
Toroid
Electronics
−10
−5
0
5
10

Inner tracker

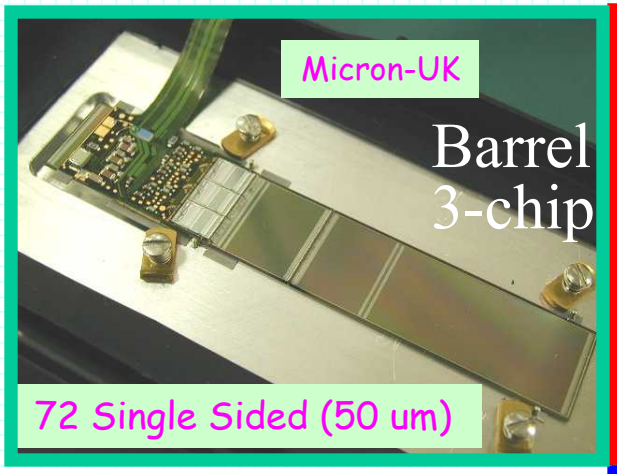


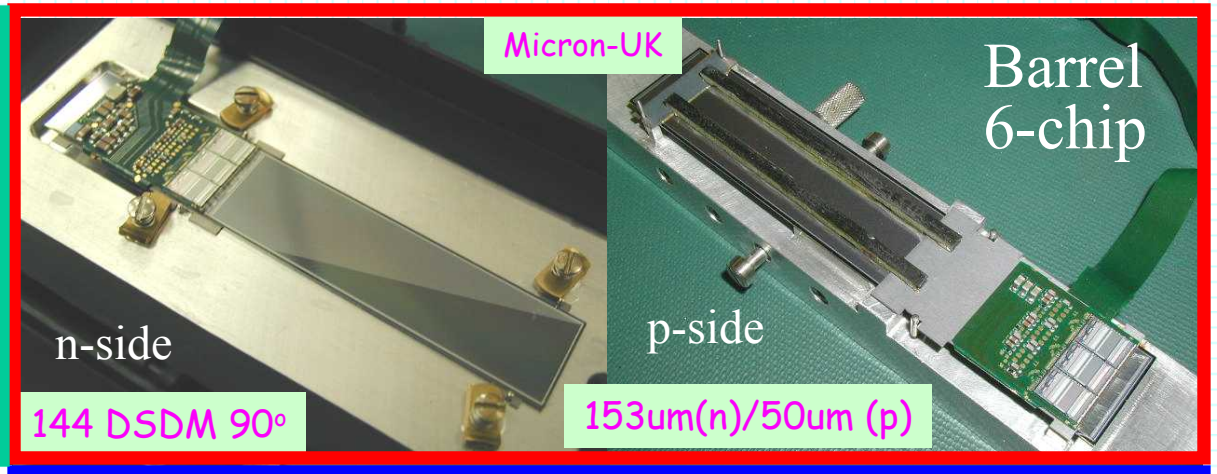
Silicon Tracker Design

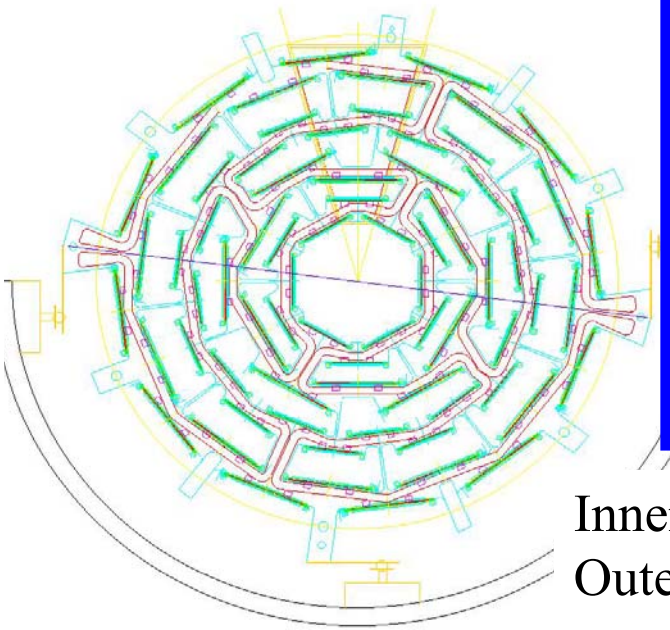
- six 12cm long barrels (four detector layers) with interspersed disks (F-disks) for forward tracking
- External large area disks (H-disks) for forward tracking ($2 < |\eta| < 3$),
- 3D track reconstruction capabilities
- Good acceptance for high p_T tracks

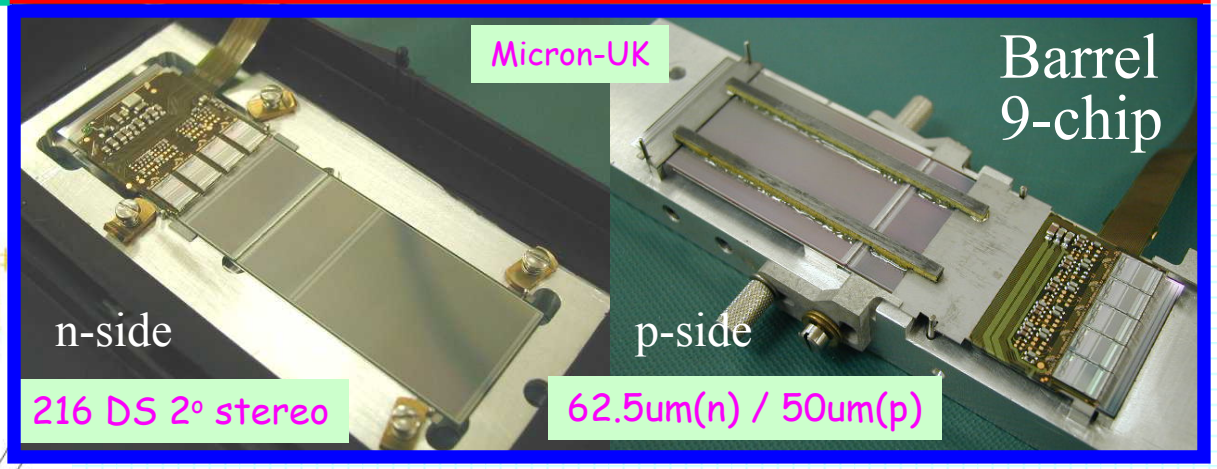


6 Barrels

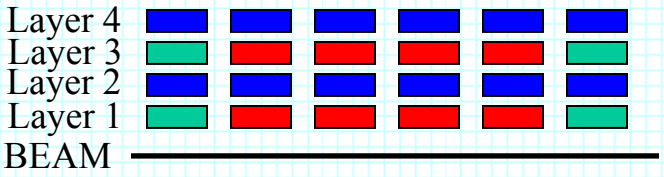






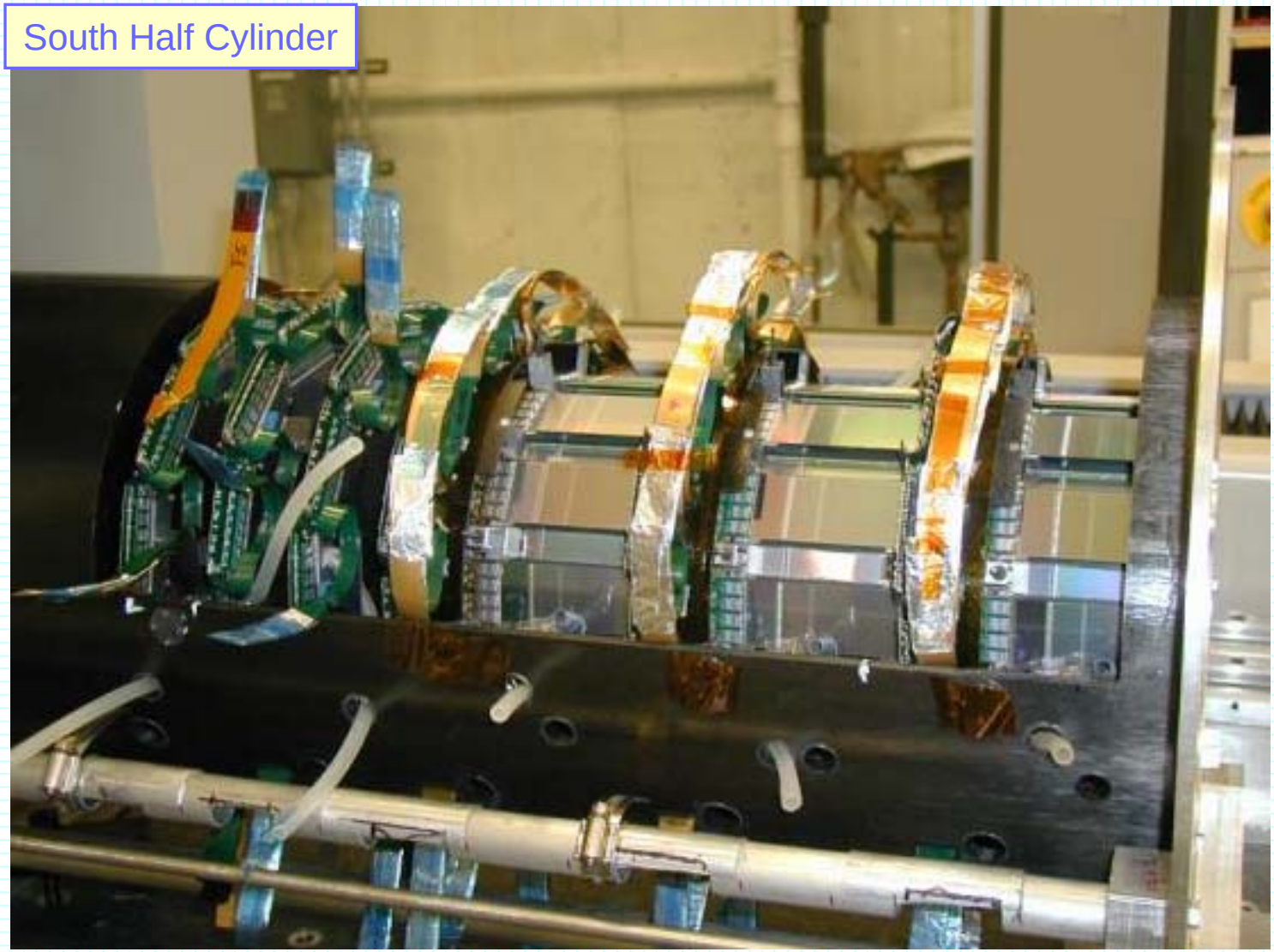


Inner radius: 2.7cm
Outer radius: 9.4 cm

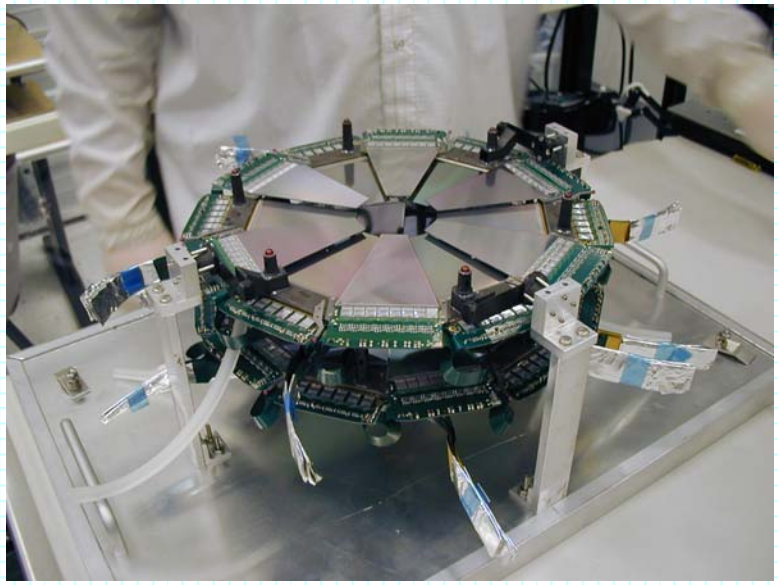


Assembly: 1/2-cylinder

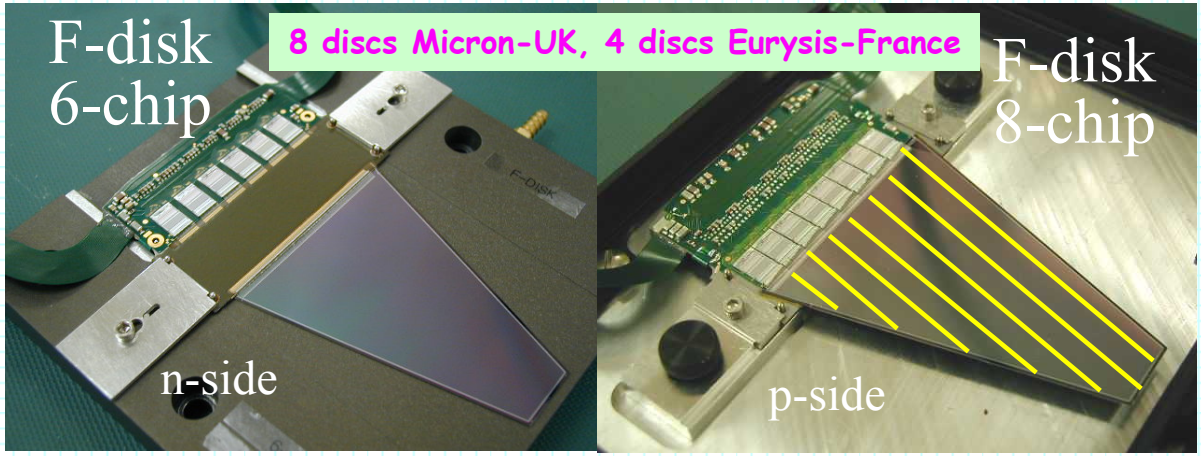
South Half Cylinder



12 F-Discs

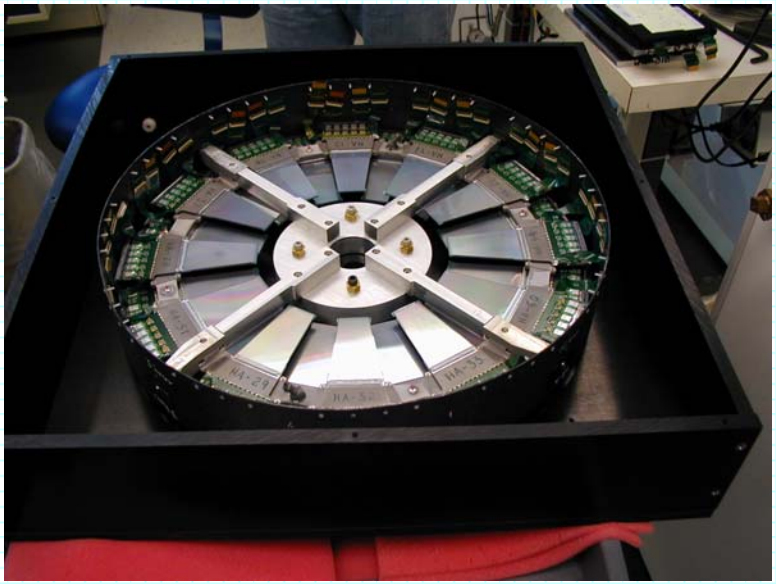


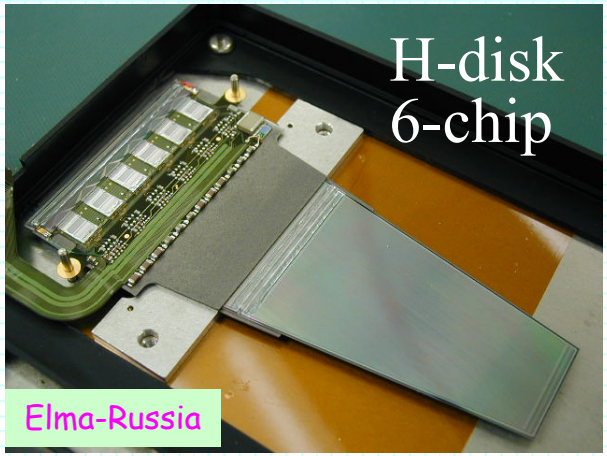
- 144 wedges
- 2.6 cm < r < 10 cm
- 50 μm (p-side)
  62.5 μm (n-side) pitch
- Double sided wedges
  with $\pm 15^0$ (30^0 effective stereo)
- Variable strip length



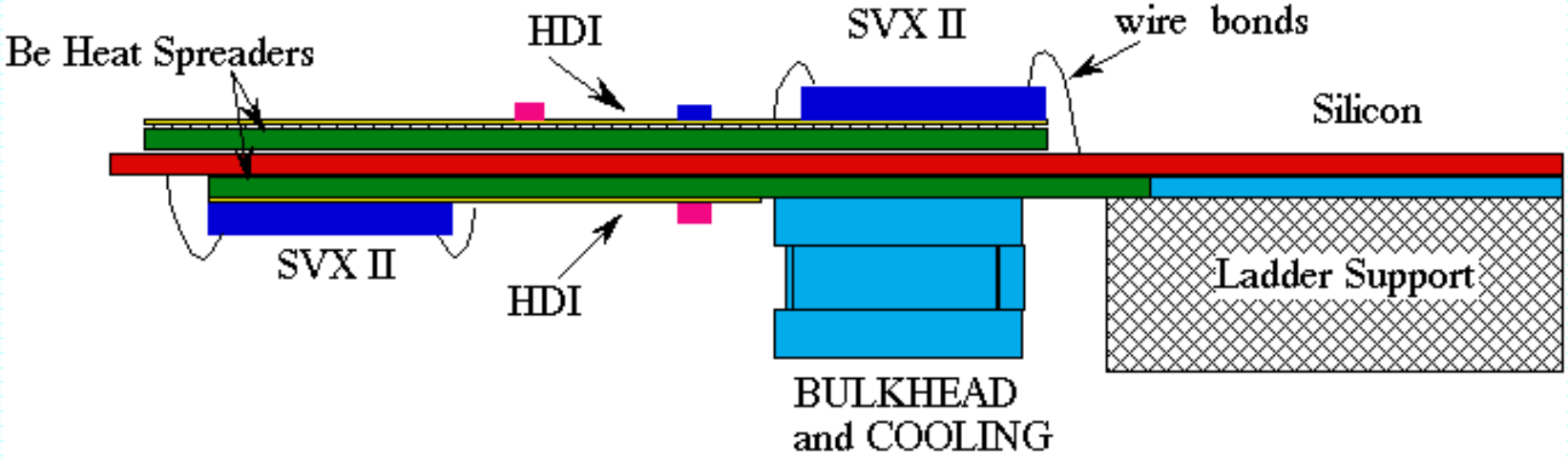
4 H-Discs

- 9.6 cm < r < 23.6 cm
- 192 Wedges
- Single sided, glued back-to-back with $\pm 7.5^0$ (15^0 effective stereo)
- 40 μm (p-side) strip pitch
  80 μm readout pitch
- Variable strip length

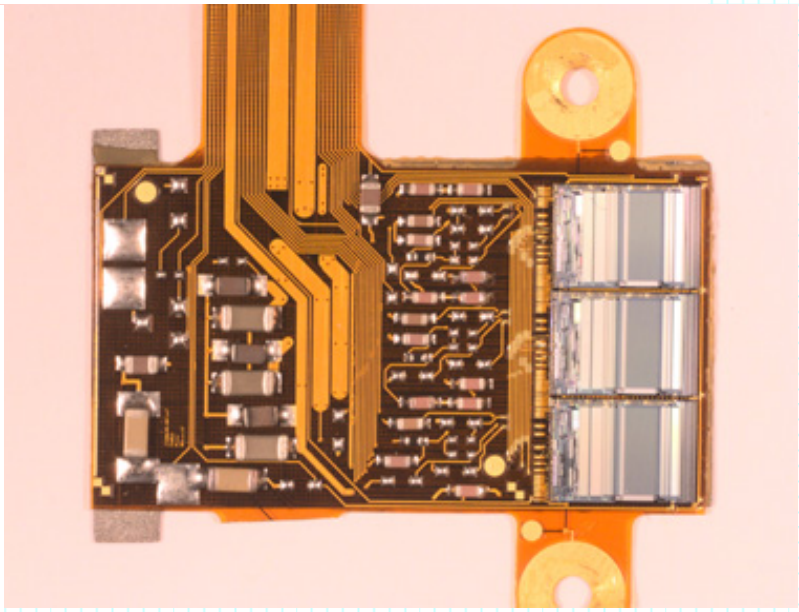


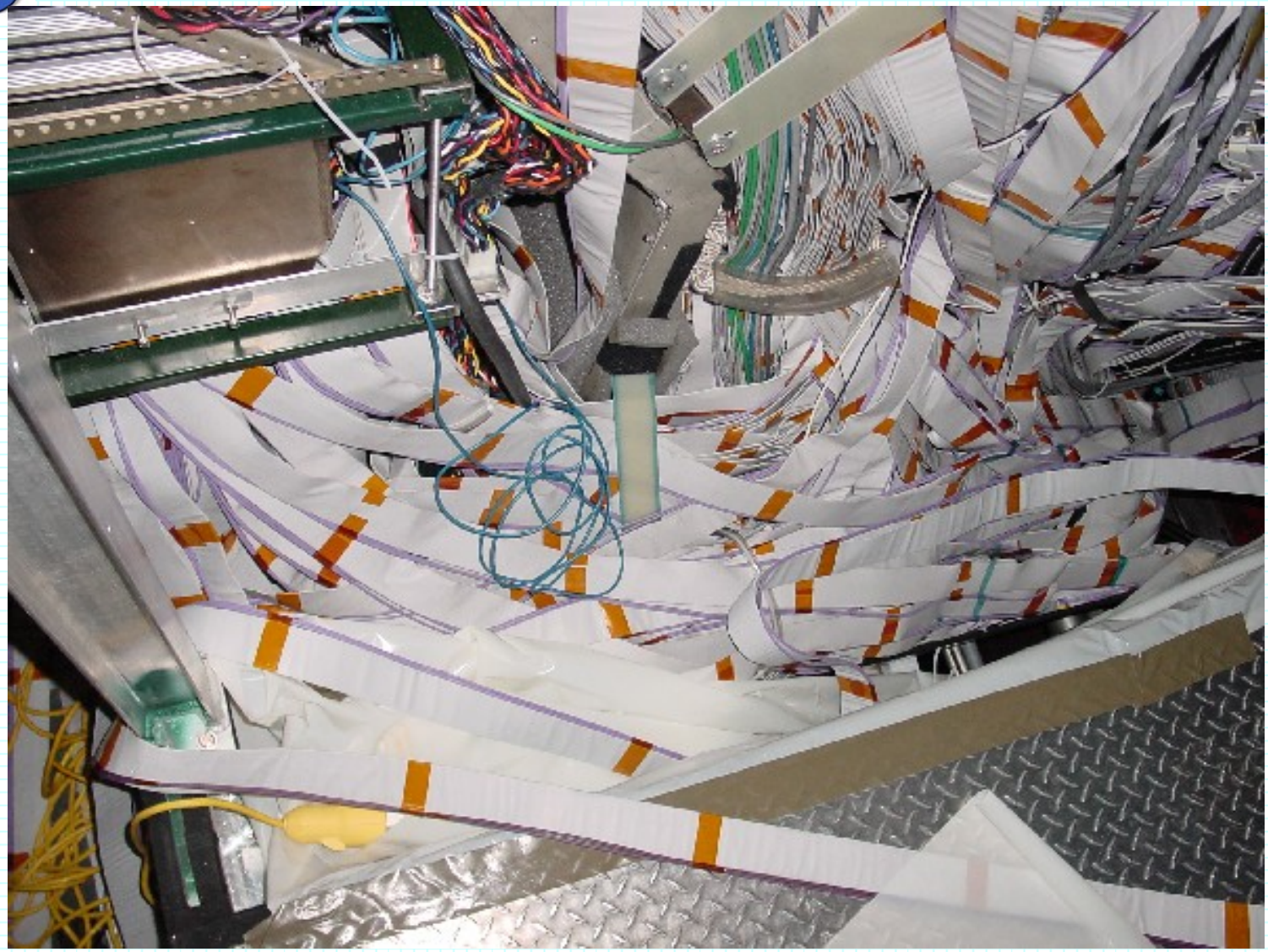


High Density Interconnect (HDI)

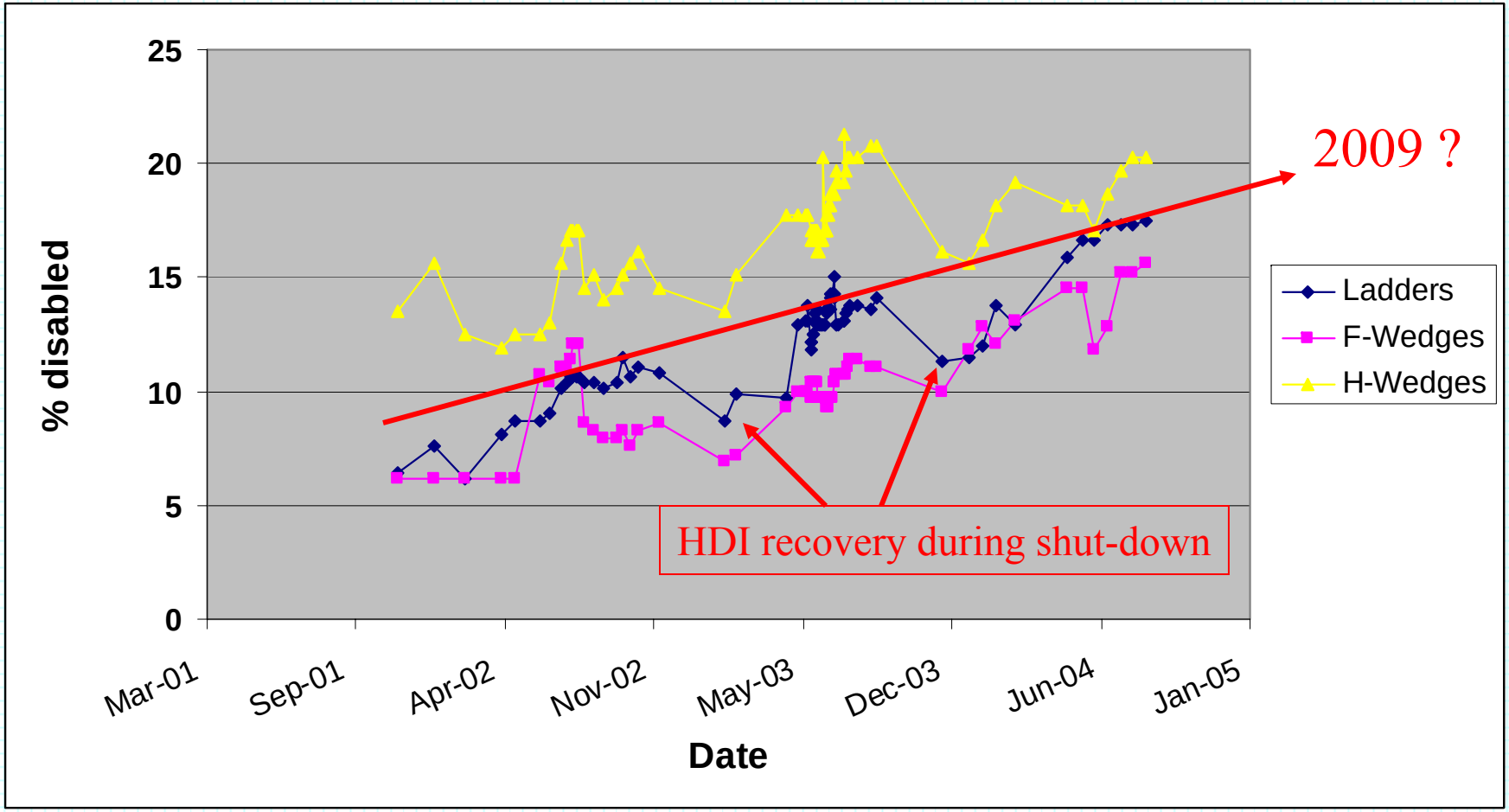


- Kapton based flex circuit with SVX IIe
- Laminated to beryllium substrate, and glued on silicon sensor
- Connected to low mass cable which carries signal out to the interaction region





% Disabled HDIs



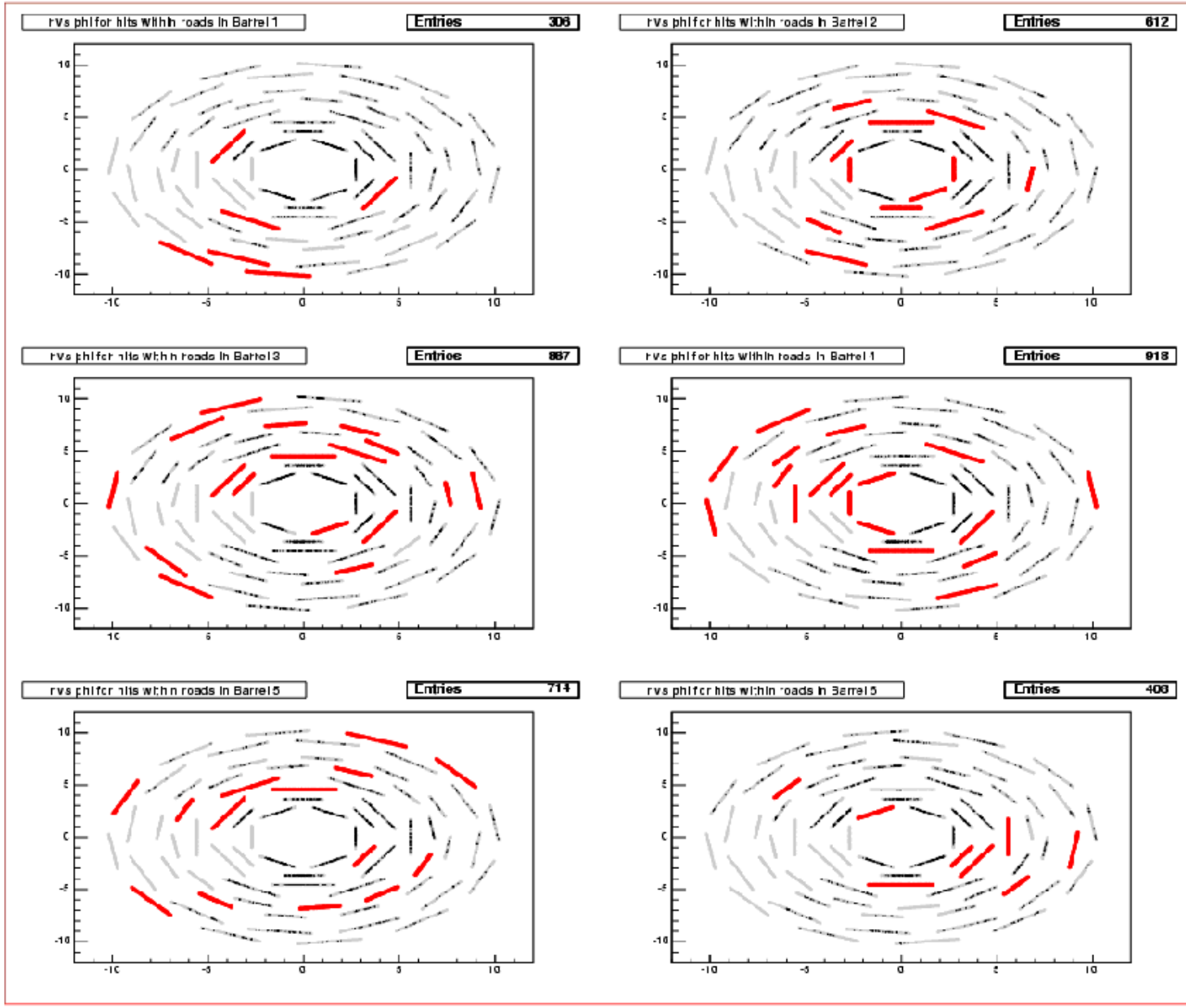
Status

Total 912 HDIs

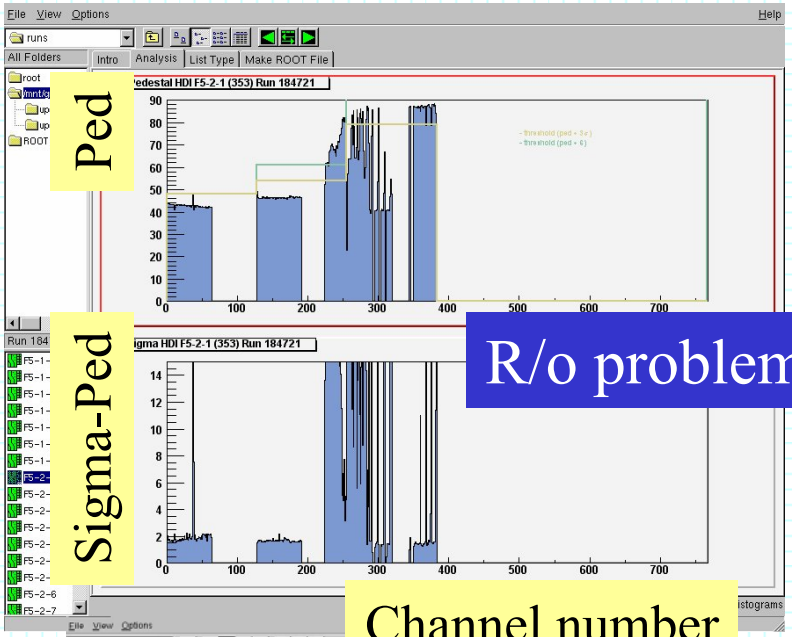
- 16% HDIs are NOT read out
- 8% problem in non accessible part
  - readout problems (preventing read out completely)
  - 'no download' = problem configuring SVXII
  - Low voltage trips
  - HV problem
  - Clock lines

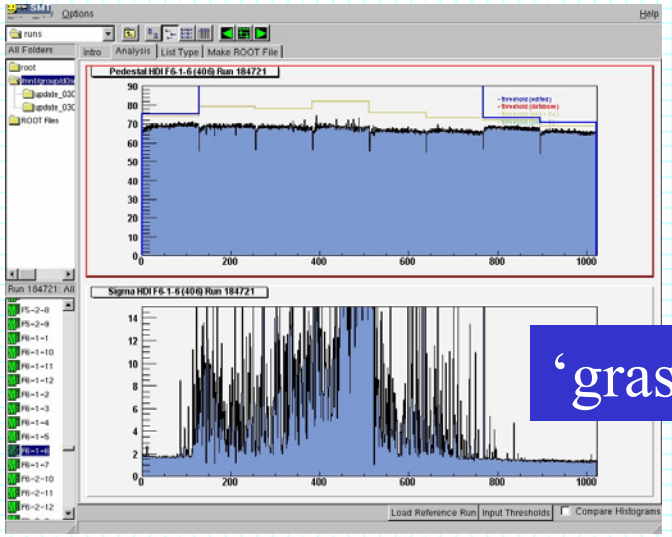
In ½ of these we found shorts/open lines at the low-mass cables

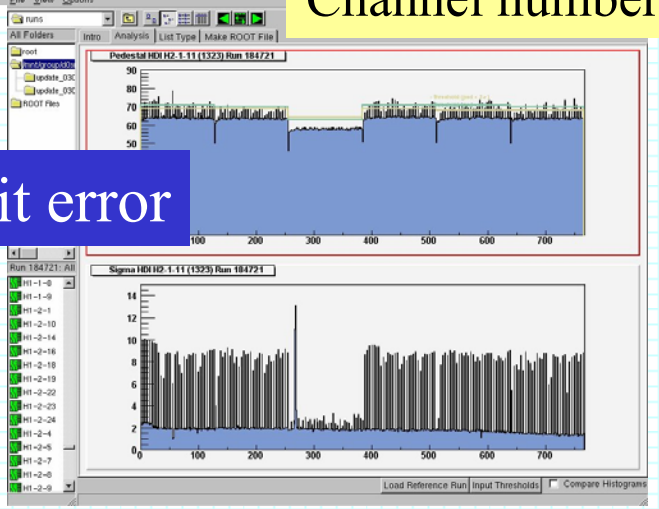
- ~10% unstable

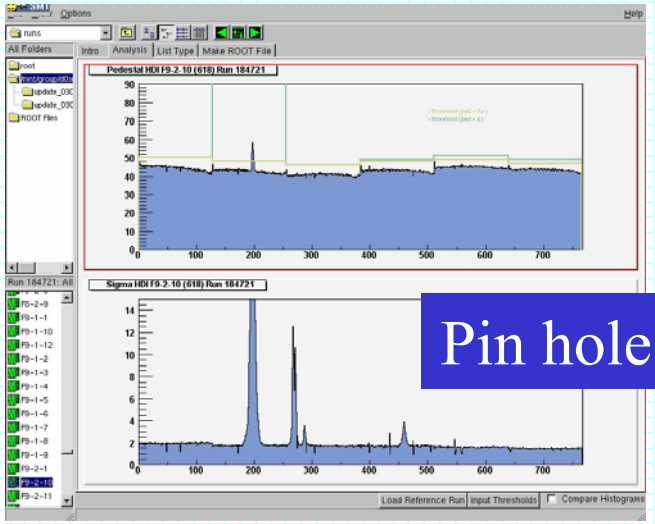

rVs phi for hits within roads in Barrel 1
Entries 306
rVs phi for hits within roads in Barrel 2
Entries 612
rVs phi for hits within roads in Barrel 3
Entries 887
rVs phi for hits within roads in Barrel 4
Entries 918
rVs phi for hits within roads in Barrel 5
Entries 714
rVs phi for hits within roads in Barrel 6
Entries 408

Problematic HDIs…

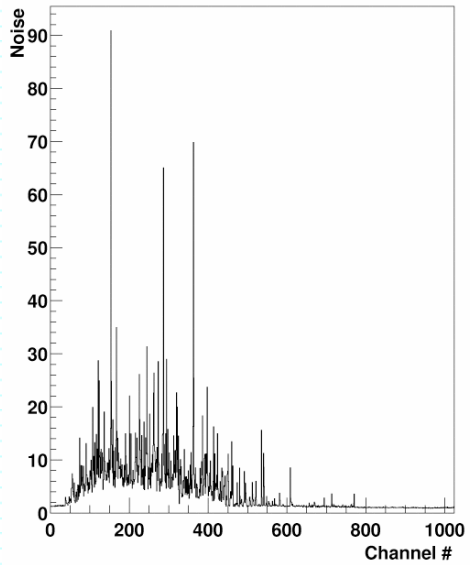




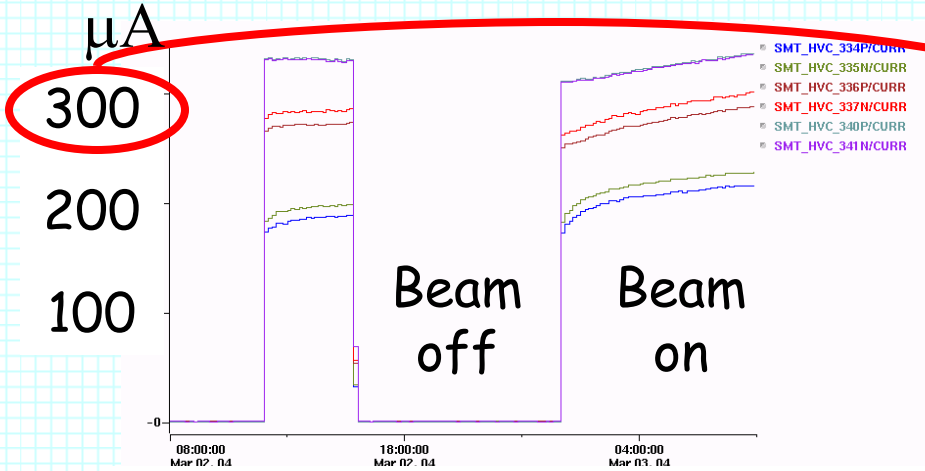




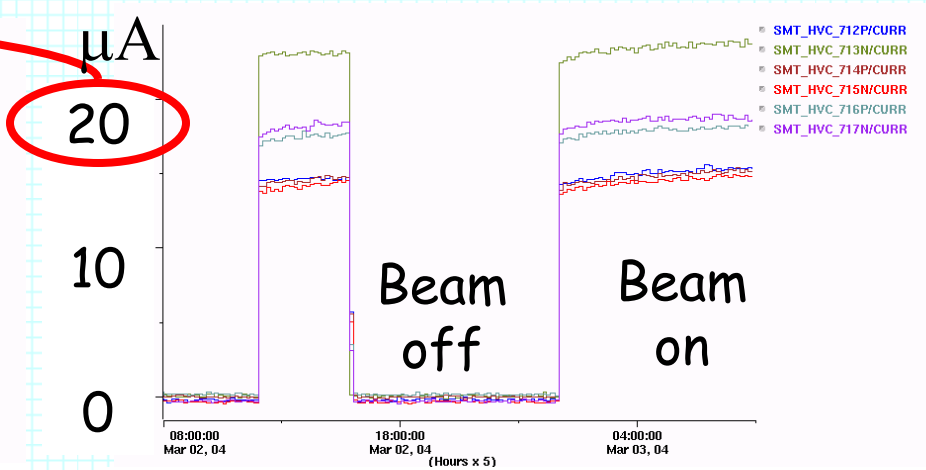
F-disk Noise



- 15% of the Micron r/o channels
- Looks like micro-discharge
- This appeared only after a several months operation
- Does not depend on bias scheme or temperature
- Charge-up effect, too

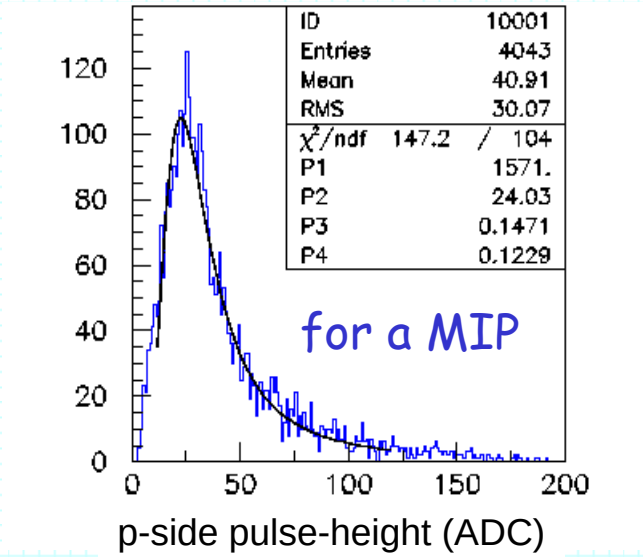


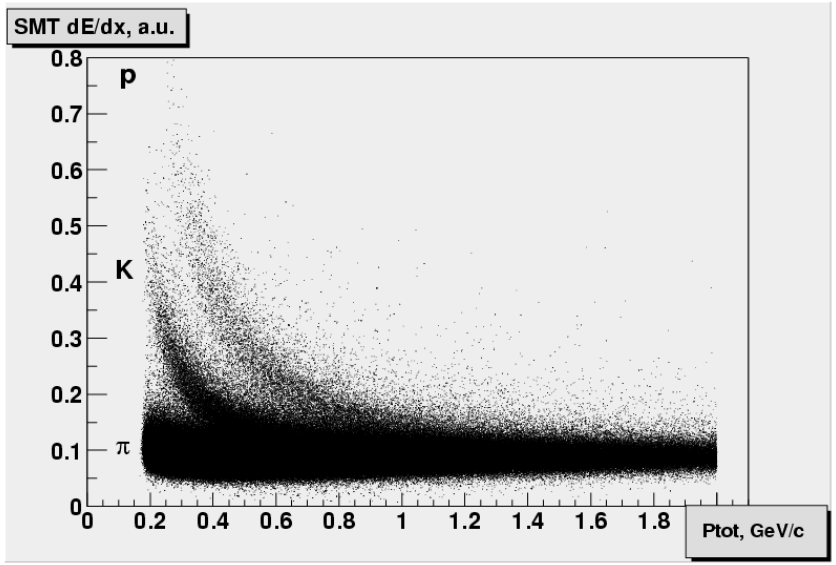
Micron sensors

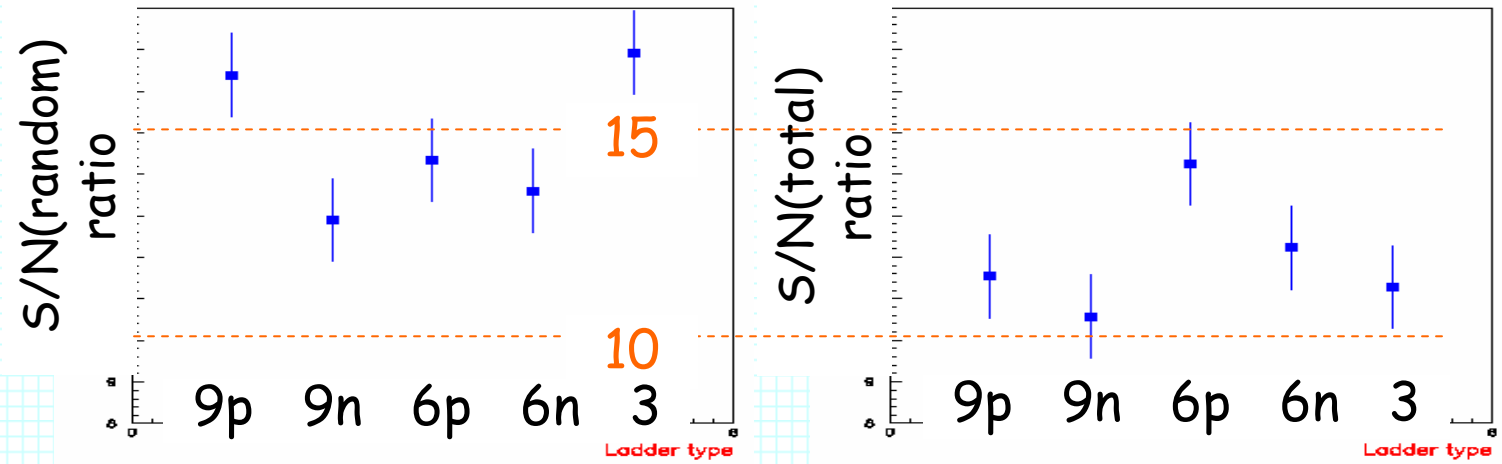


Eurysis sensors

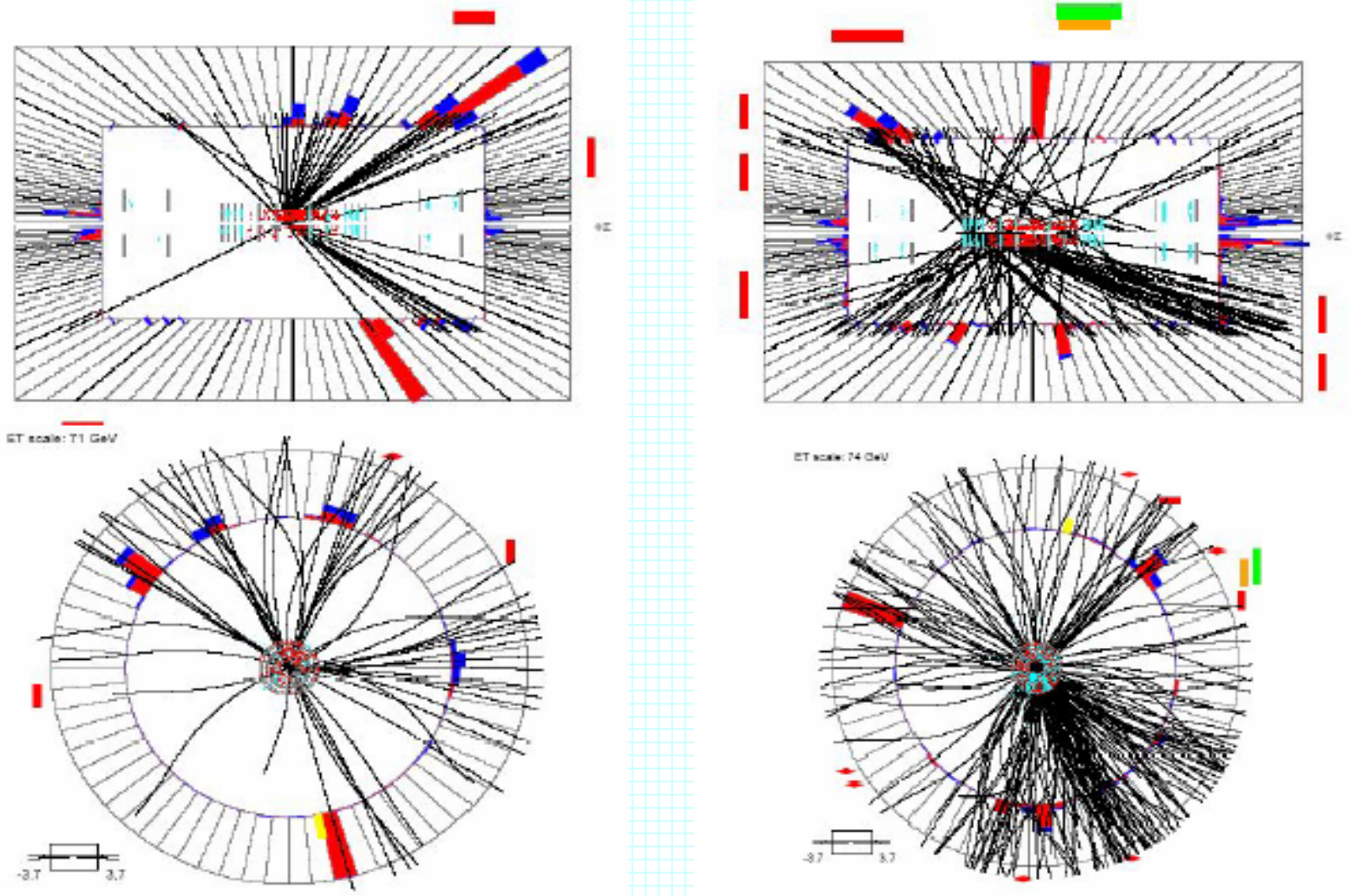
Performance



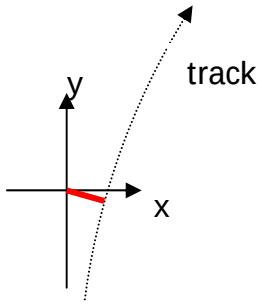




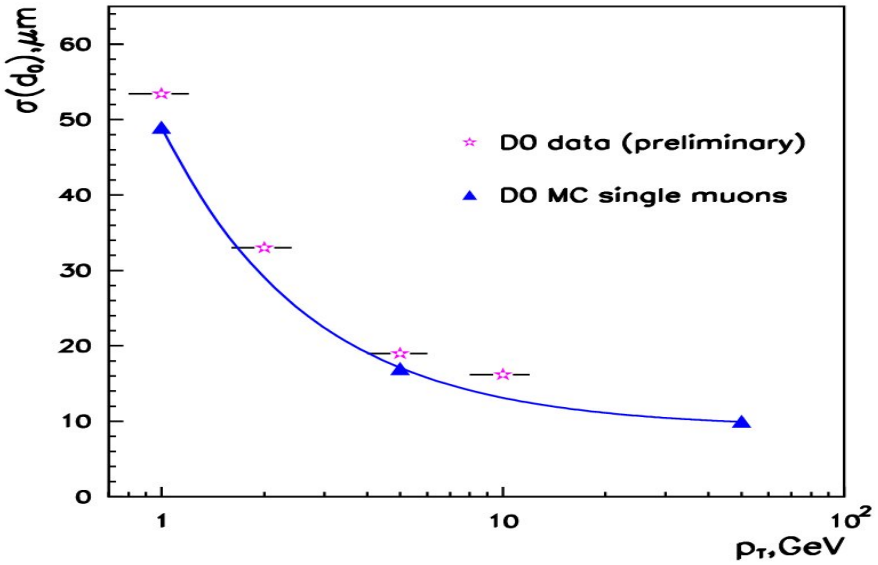
Tracking



Tracking



Impact Parameter Resolution



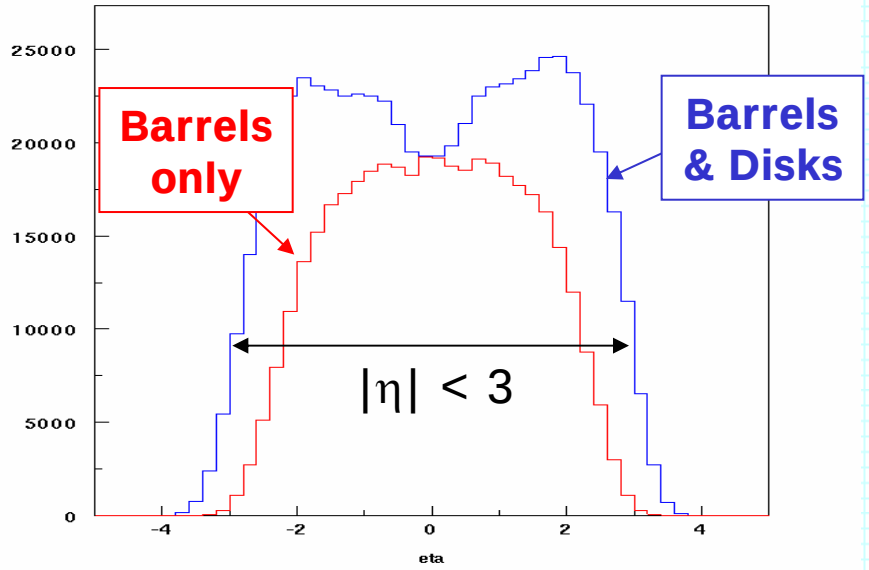
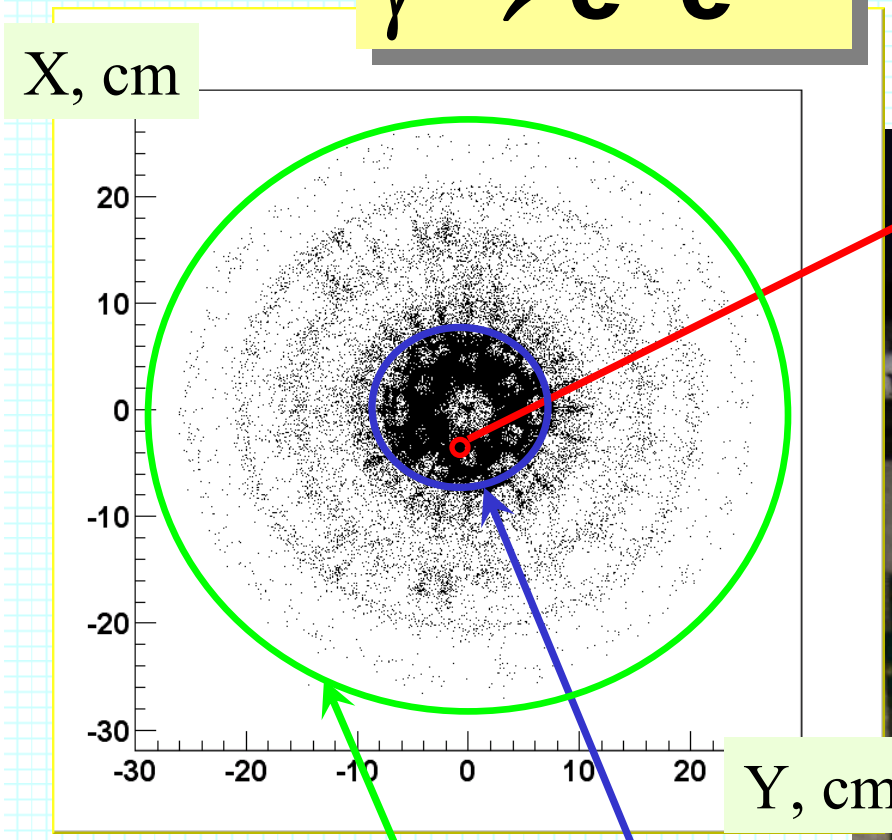
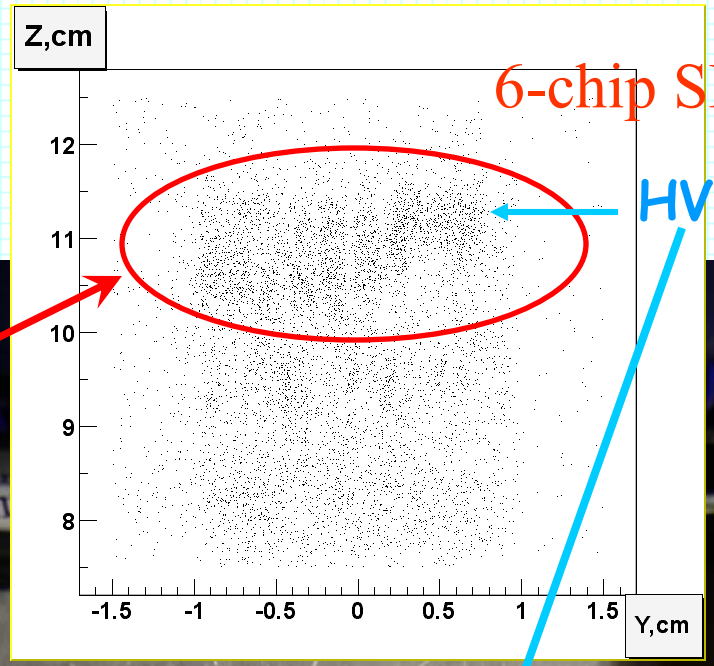


Image of Tracker from γ-conversions

$\gamma \rightarrow e^+ e^-$





6-chip SMT HDI

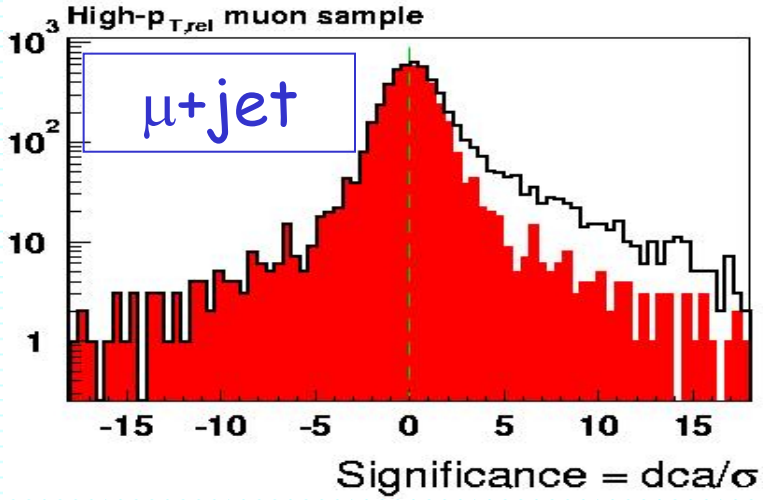
HV cap

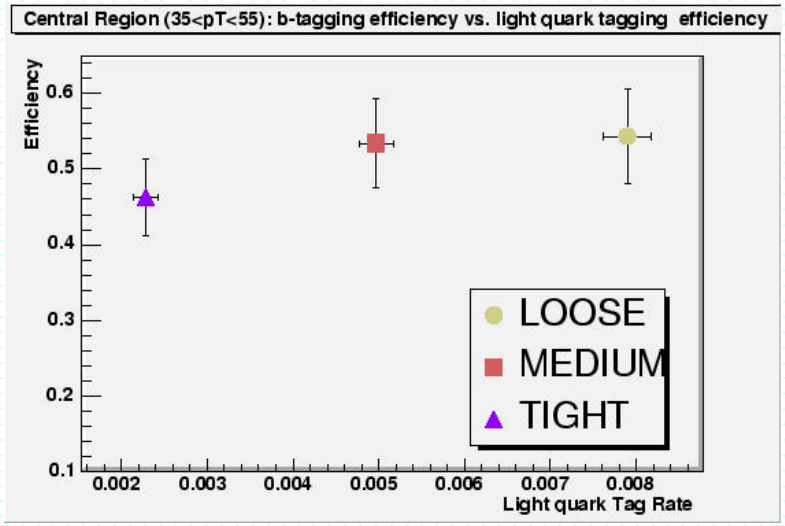
CFT

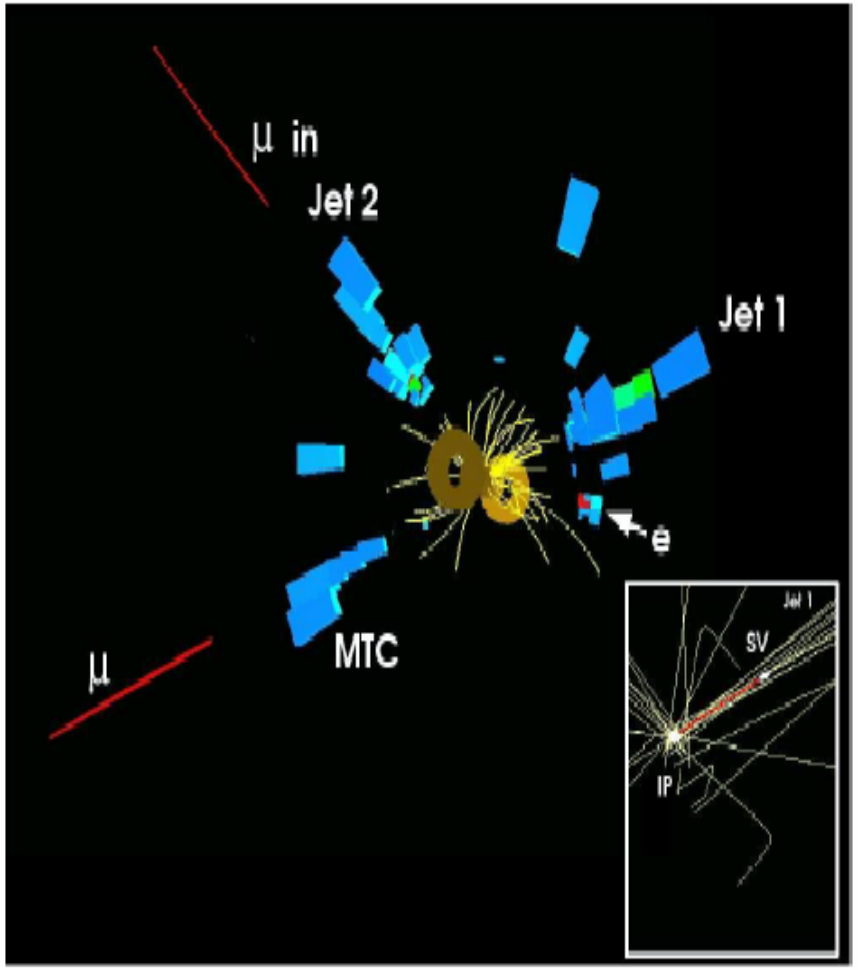
SMT

M.W

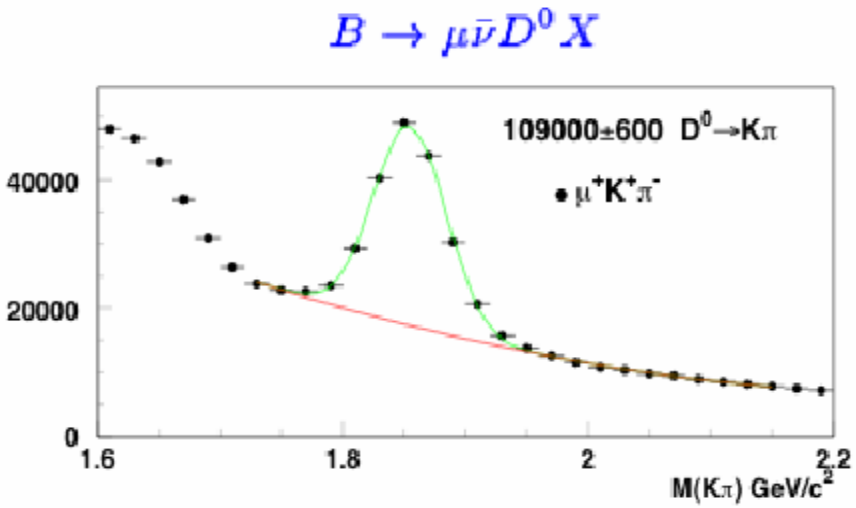
Vertexing

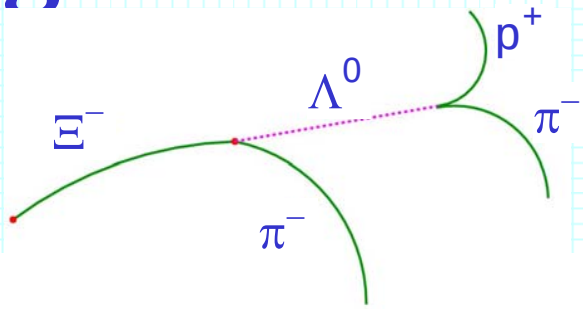

High-$p_{T,rel}$ muon sample
μ+jet
10^3
10^2
10
1
-15 -10 -5 0 5 10 15
Significance = dca/σ

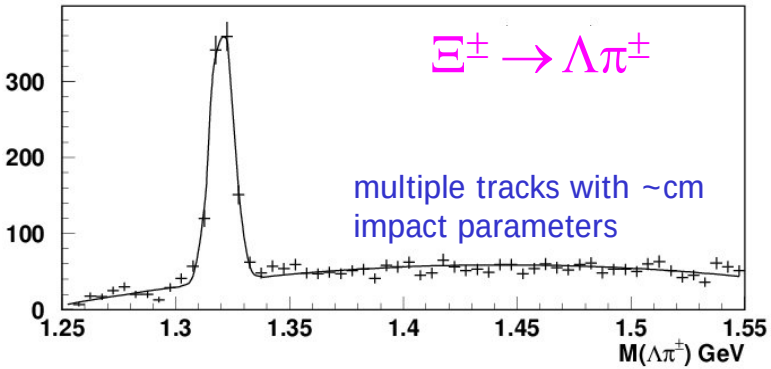

Central Region (35<pT<55): b-tagging efficiency vs. light quark tagging efficiency
Efficiency
0.6
0.5
0.4
0.3
0.2
0.1
0.002 0.003 0.004 0.005 0.006 0.007 0.008
Light quark Tag Rate
LOOSE
MEDIUM
TIGHT

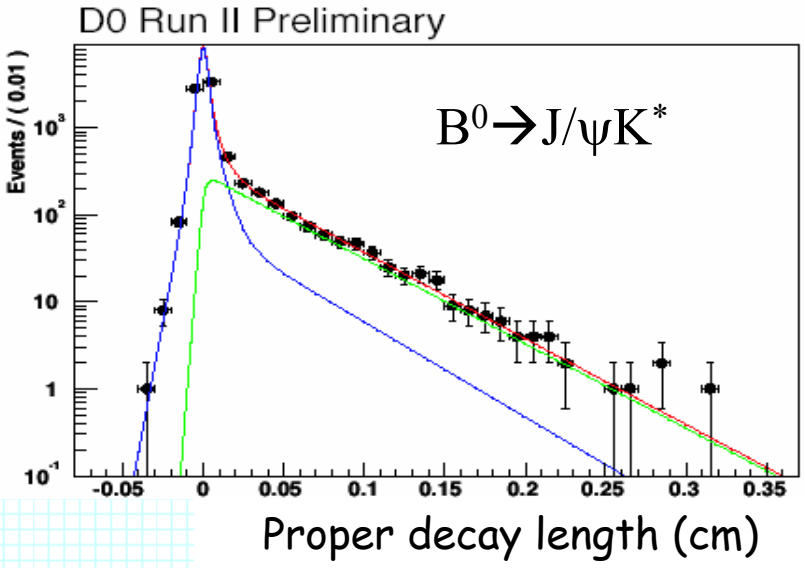

μ in
Jet 2
Jet 1
e
MTC
μ
Jet 1
SV
IP

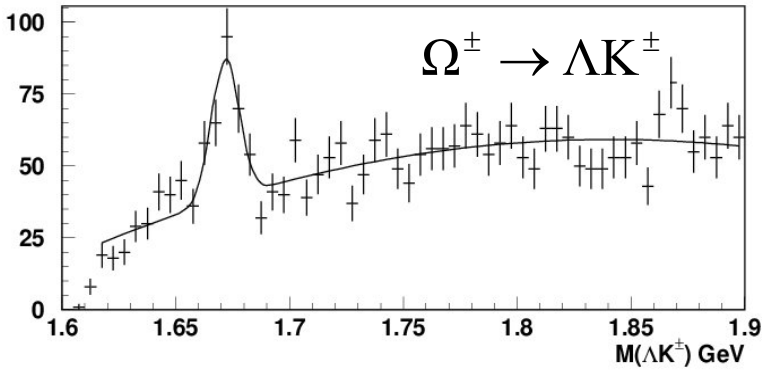
Vertexing

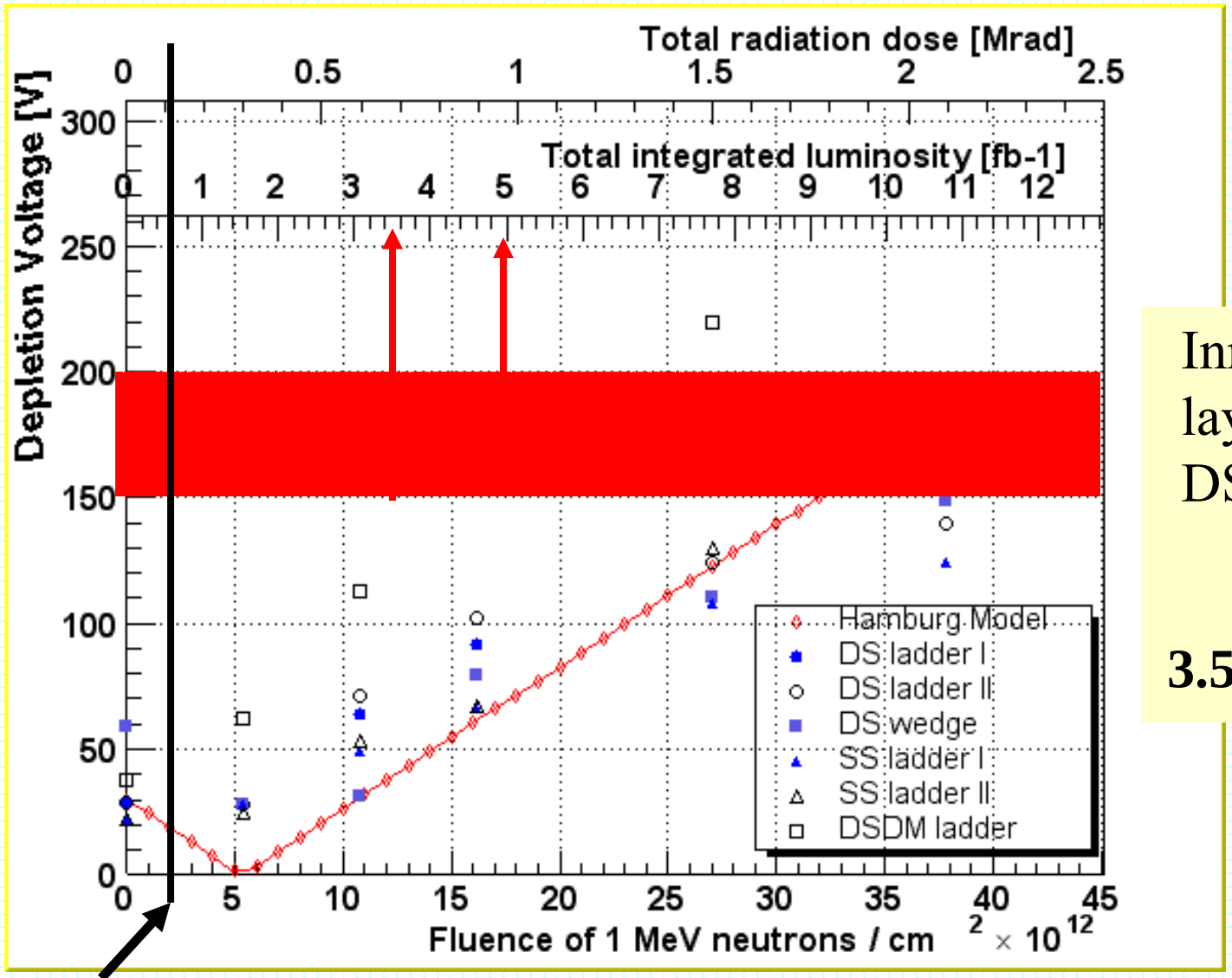

$B \to \mu\bar{\nu}D^0X$
109000±600 $D^0 \to K\pi$
$\mu^+K^+\pi^-$
40000
20000
0
1.6
1.8
2
2.2
M(Kπ) GeV/c²


p^+
Λ^0
Ξ^-
π^-
π^-


$\Xi^\pm \to \Lambda\pi^\pm$
multiple tracks with ~cm impact parameters
300
200
100
0
1.25
1.3
1.35
1.4
1.45
1.5
1.55
M(Λπ±) GeV


D0 Run II Preliminary
$B^0 \to J/\psi K^*$
Events / (0.01)
10^3
10^2
10
1
10^{-1}
-0.05
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
Proper decay length (cm)


$\Omega^\pm \to \Lambda K^\pm$
100
75
50
25
0
1.6
1.65
1.7
1.75
1.8
1.85
1.9
M(ΛK±) GeV

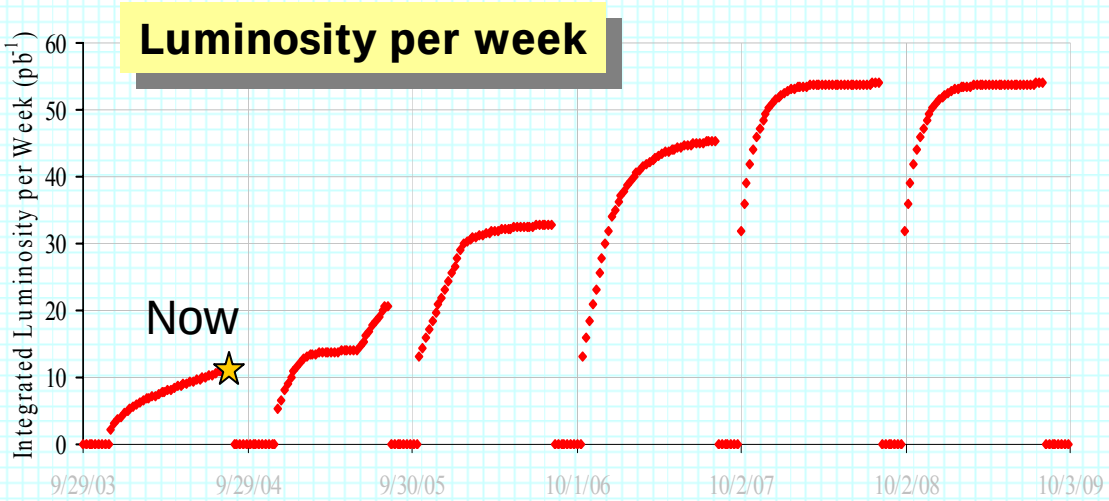


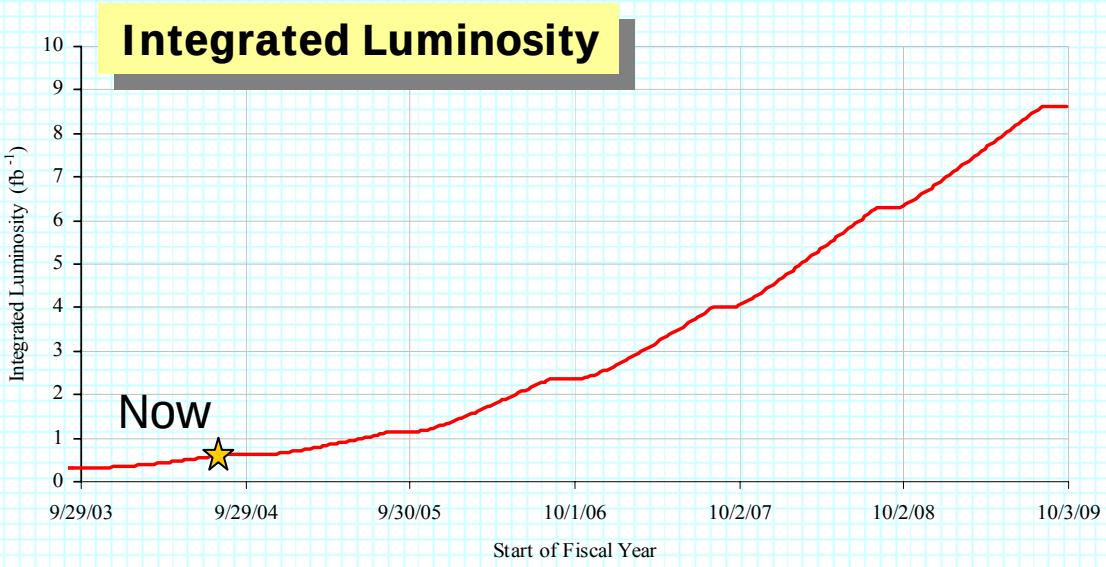
September 04

Innermost layers are DSDM

3.5fb^{-1} to 5fb^{-1}

Tevatron Prospects

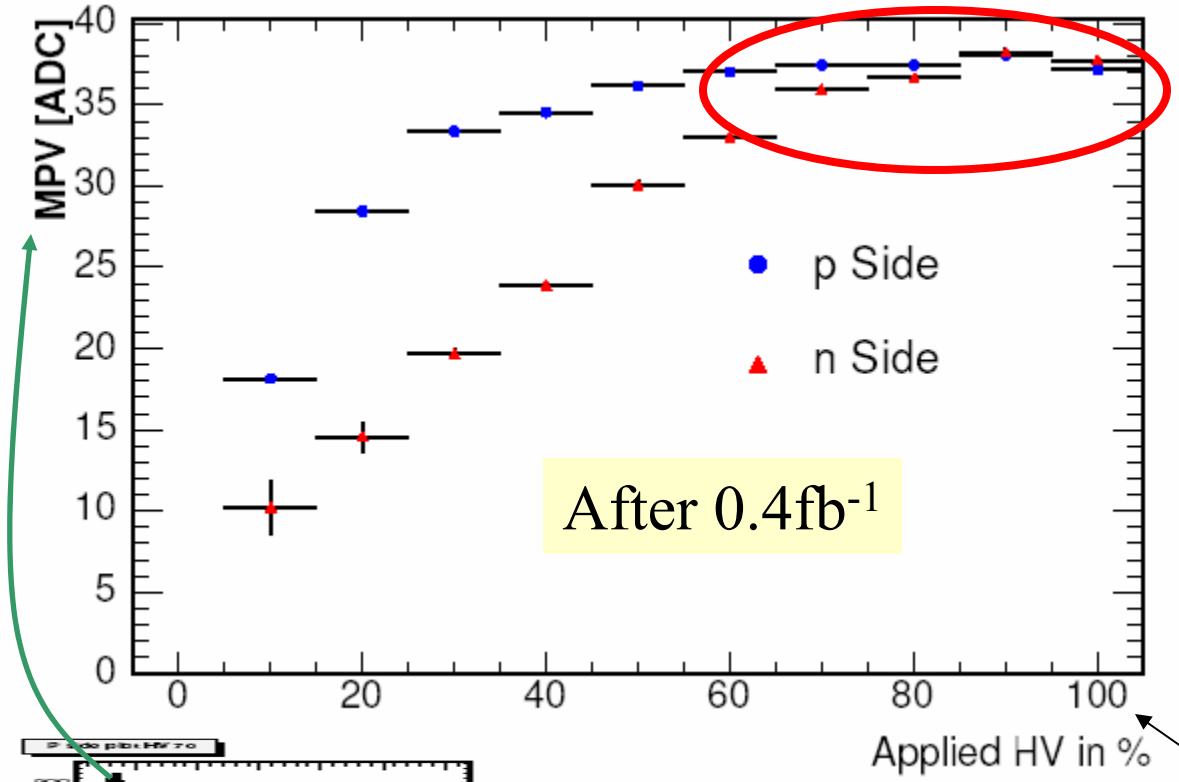


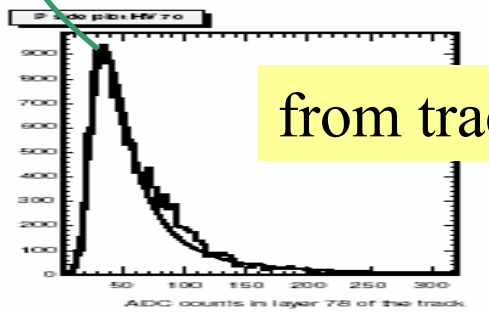


Major improvement will come from increasing the antiproton current: Recycler Ring, with electron cooling

Accumulated Luminosity		
Fiscal Year	Design (fb^{-1})	Base (fb^{-1})
FY03	0.3	0.3
FY04	0.6	0.6
FY05	1.1	0.9
FY06	2.4	1.4
FY07	4.0	2.0
FY08	6.3	3.1
FY09	8.6	4.0

Depletion Voltage Measurement





from track hits

No conclusion on reduced V_d

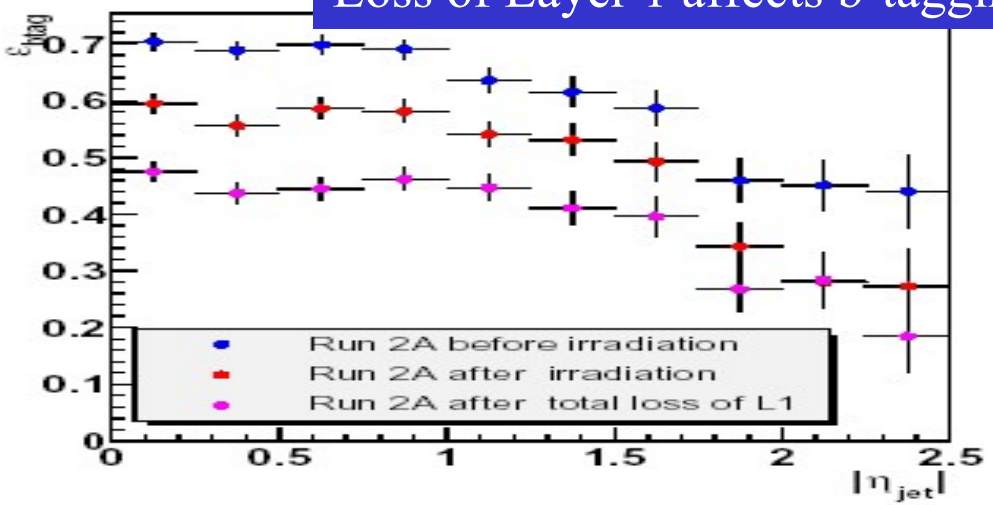
No type-inversion yet, as expected

100% is the current operation voltage (10%-20% above V_d)

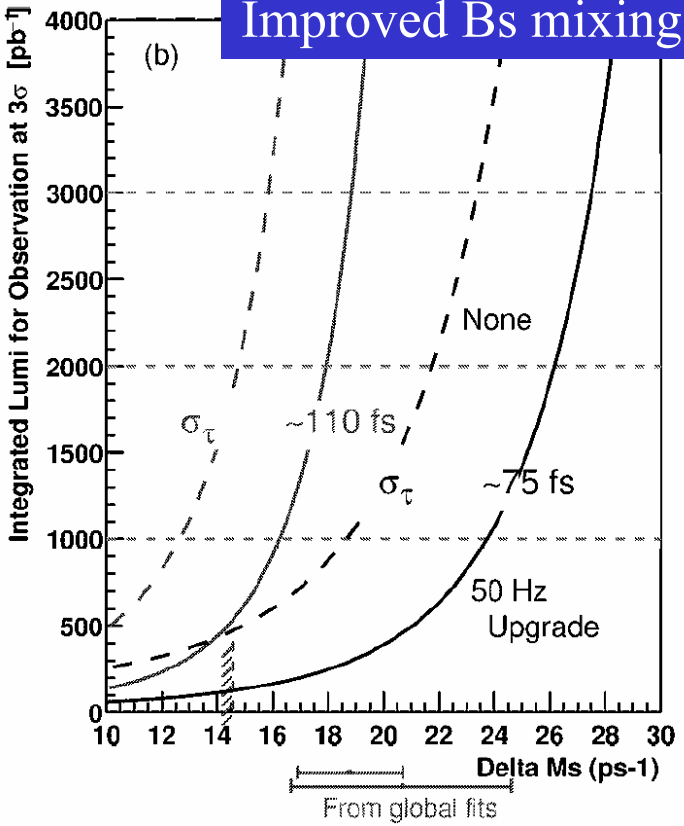
A new Layer 0

(Full replacement of the current silicon detector was cancelled last year)

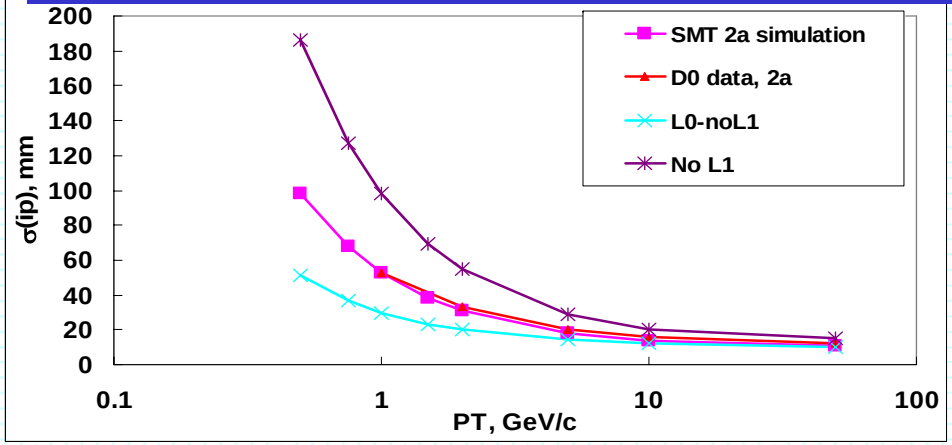
Loss of Layer 1 affects b-tagging



Improved Bs mixing

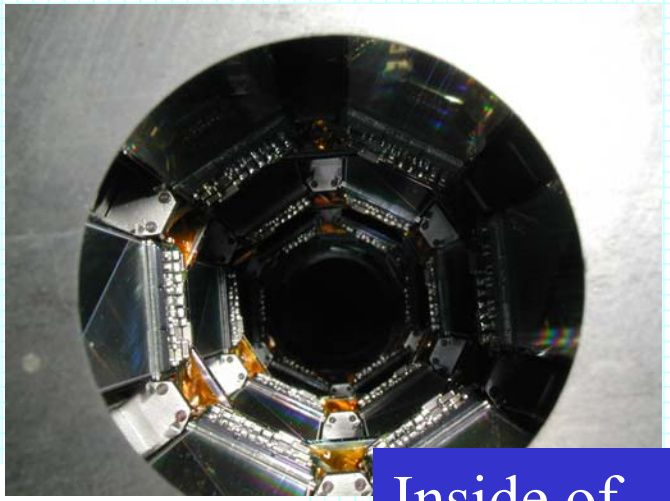


Better impact parameter resolution with L0

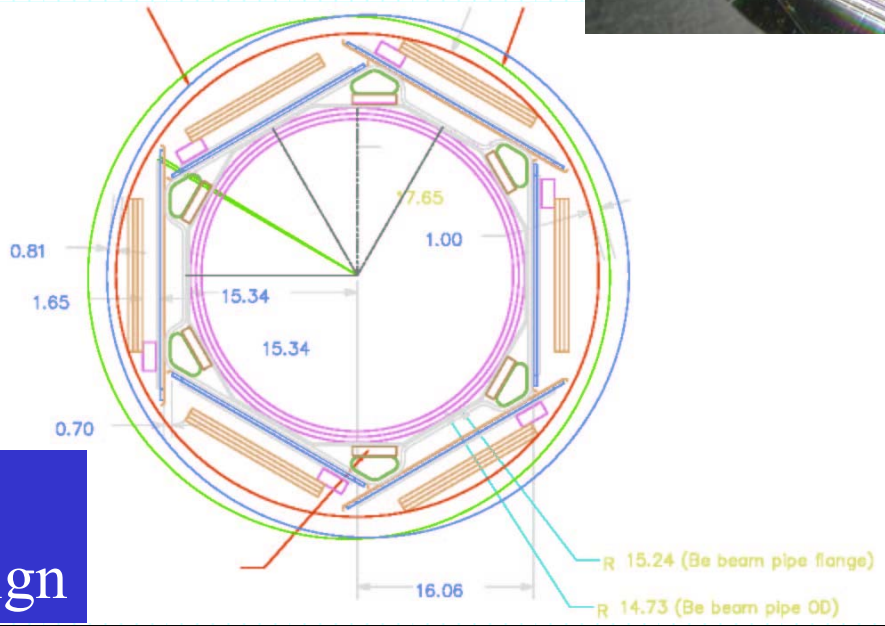


Layer 0 design

- Fits inside present silicon layers at r~1.6cm (only 6.8mm gap !)
- Layer 0 has 6-fold symmetry
- 4 sensors /z half (2x7cm, 2x12cm)
- 71μm readout pitch (inner) and 81μm (outer)
- 98.4% ϕ acceptance
- 48 hybrids
- SVX4 chip

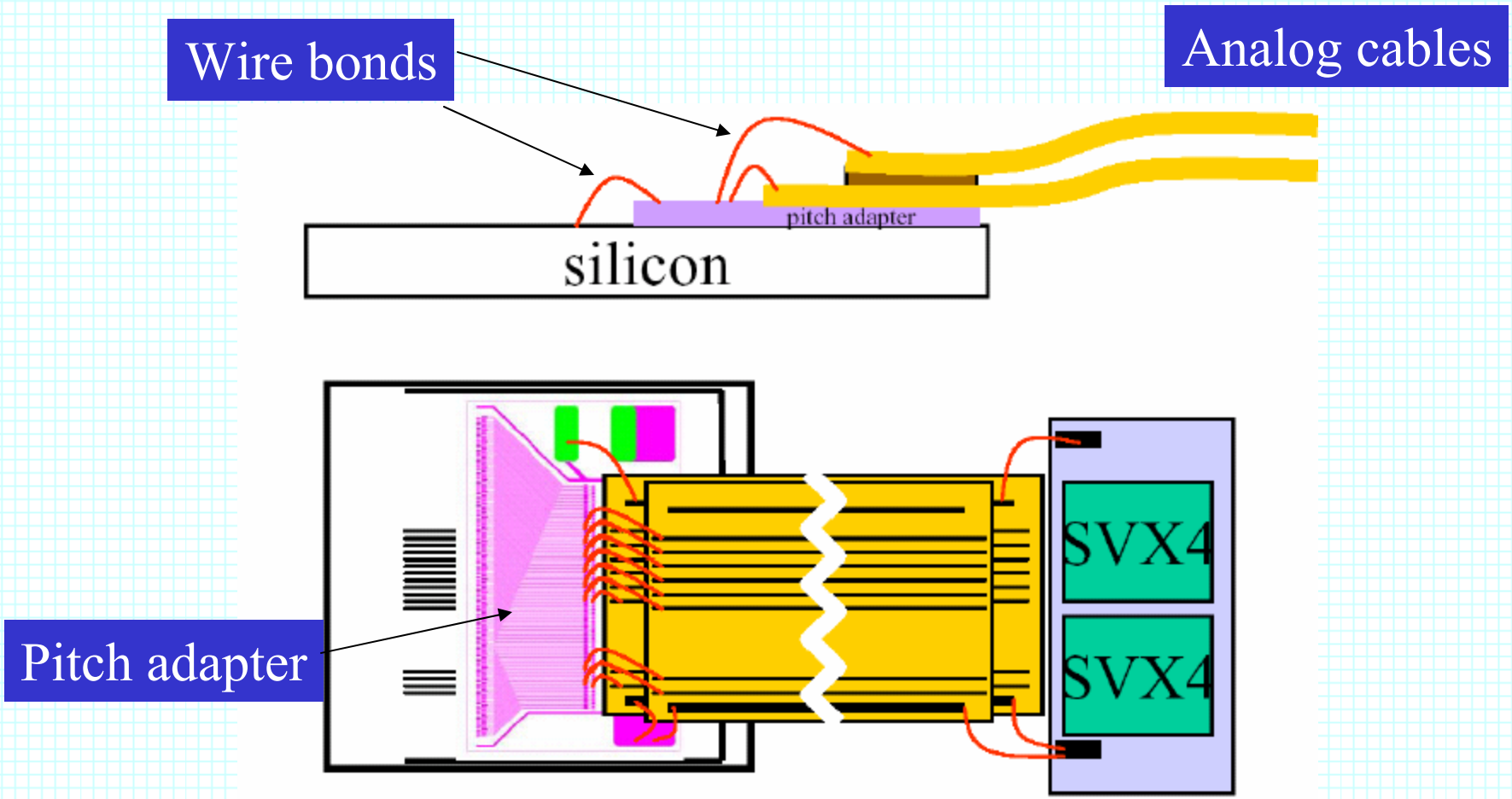


Inside of the current detector



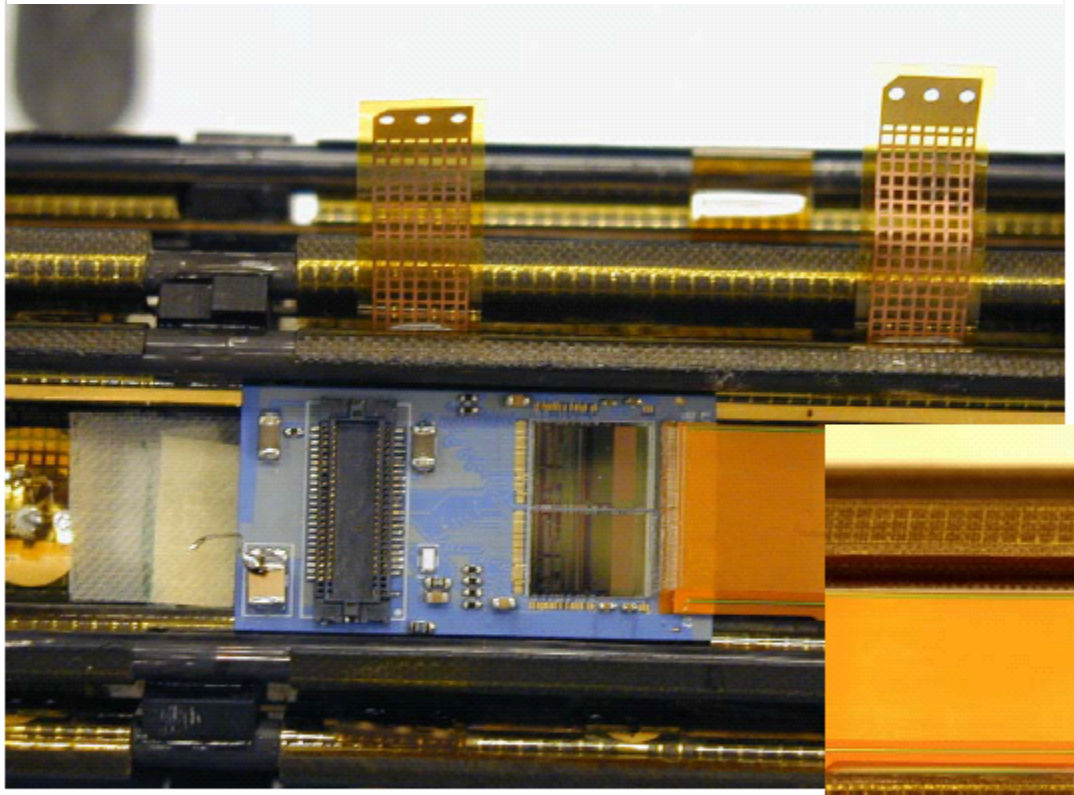
L0 design

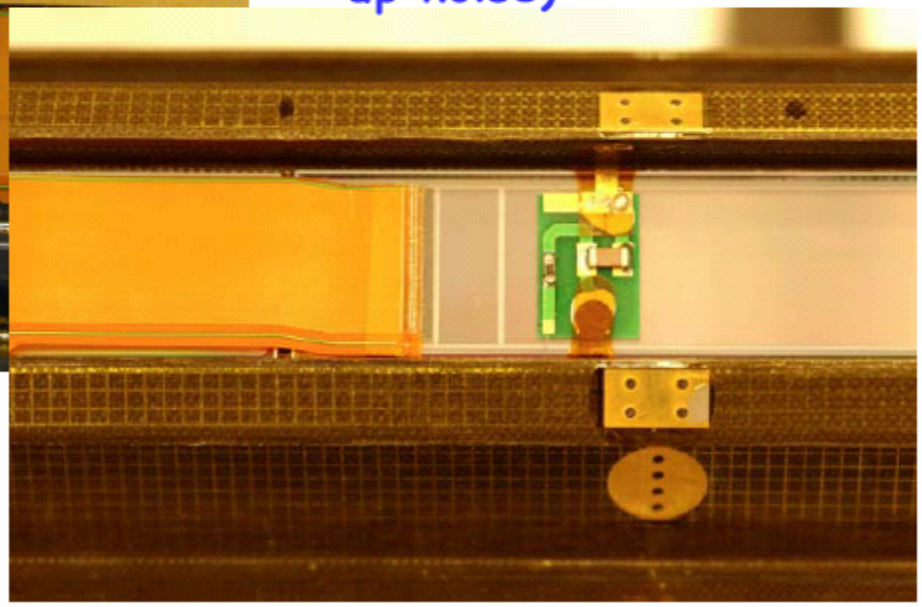
Readout channel



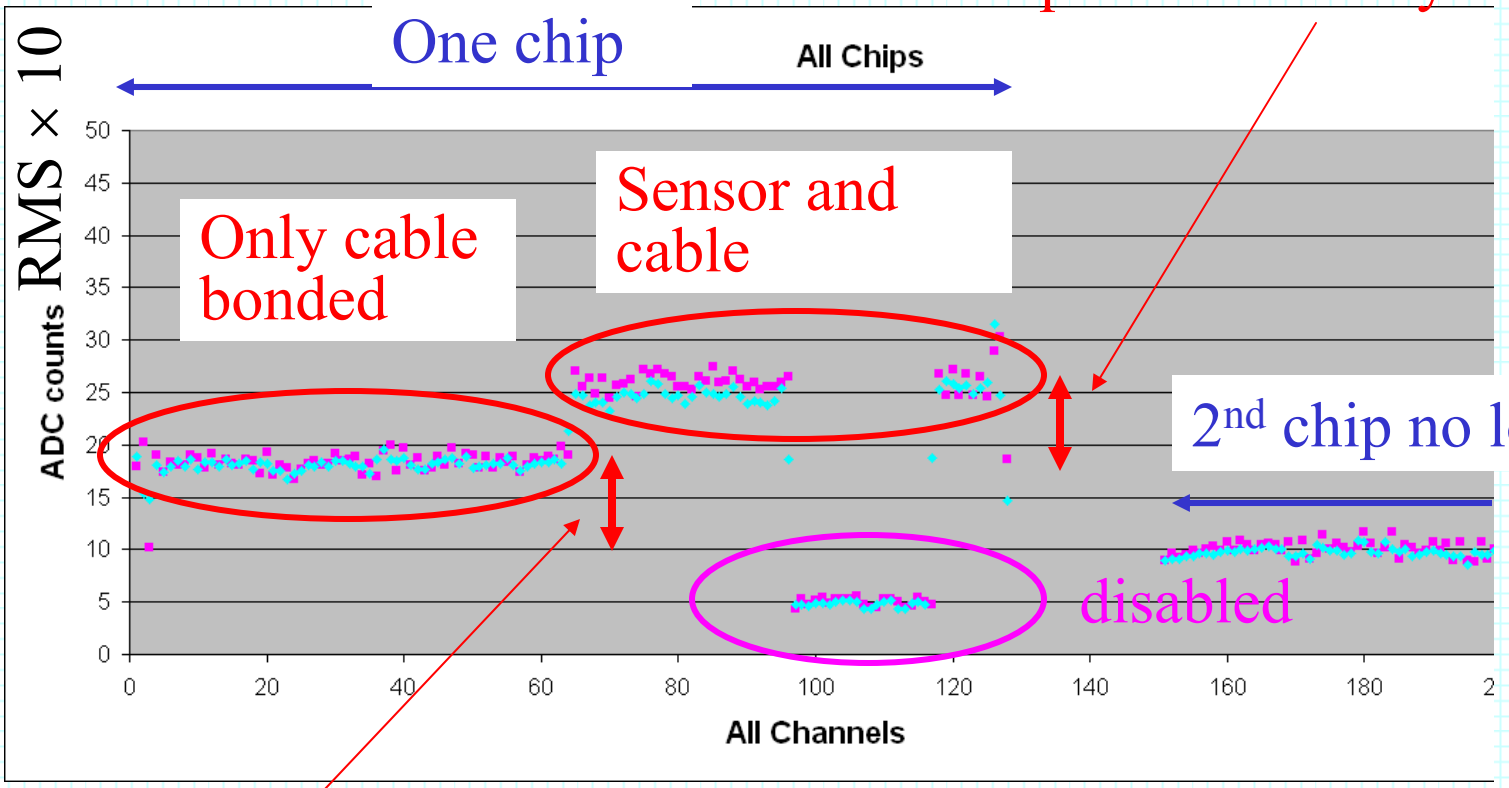
Layer 0 Grounding

- Implements new grounding approach : laminated ground mesh covering all CF surface
- Excellent noise performance without Faraday cage (no pick-up noise)





Noise of L0



capacitive load by cable (0.8ADC~600e)

- SVX4 ENC: const+41*C*/pF ➔ C = 15pF for ~45cm as expected
- 1 M IP ≅ 22000e ➔ S/N ~ 12

Conclusions

- D0 SMT operational since more than 2½ years
- Good tracking ($|\eta|<3$; $\sigma=16\mu m$) and vertexing (b-tagging; B lifetime)
- 85% active channels
- Expect the inner layer to succumb radiation after 3.5fb^{-1} to 5 fb^{-1} (design is 8fb^{-1} by 2009)
- New Layer 0 being built (installed 2005)