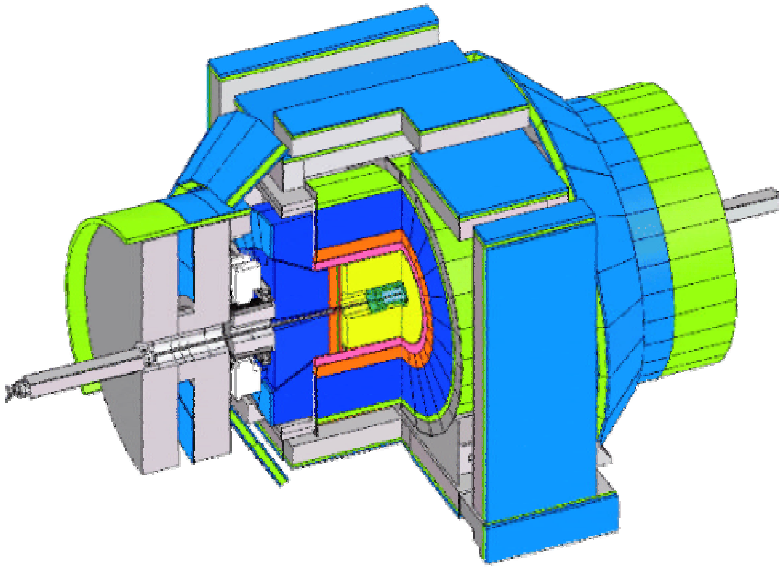


# Status of CDF Tracking

**Steve Nahn**

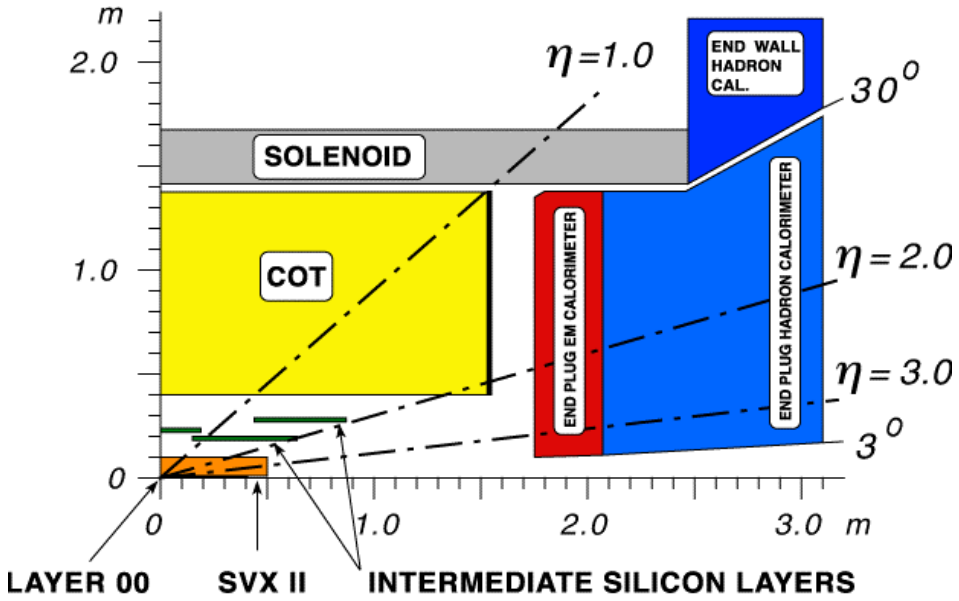
**Yale University/CDF**

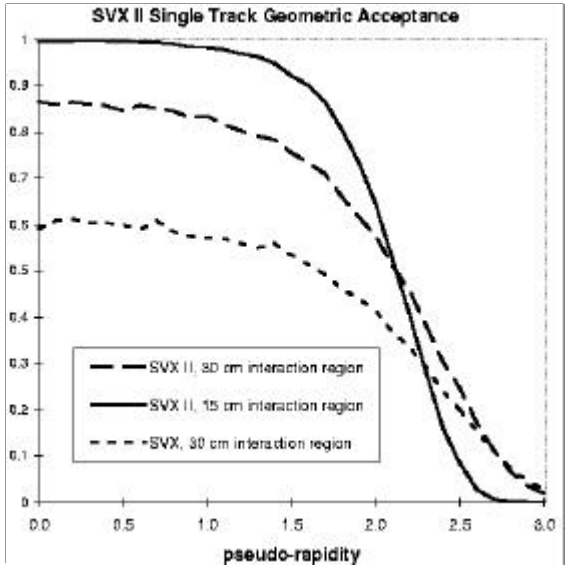
# CDF Run II Tracking

- **Subject Matter**
  - Session: “R&D on Future”
  - Abstract: “Current CDF Silicon”
  - Title: “CDF Tracking”

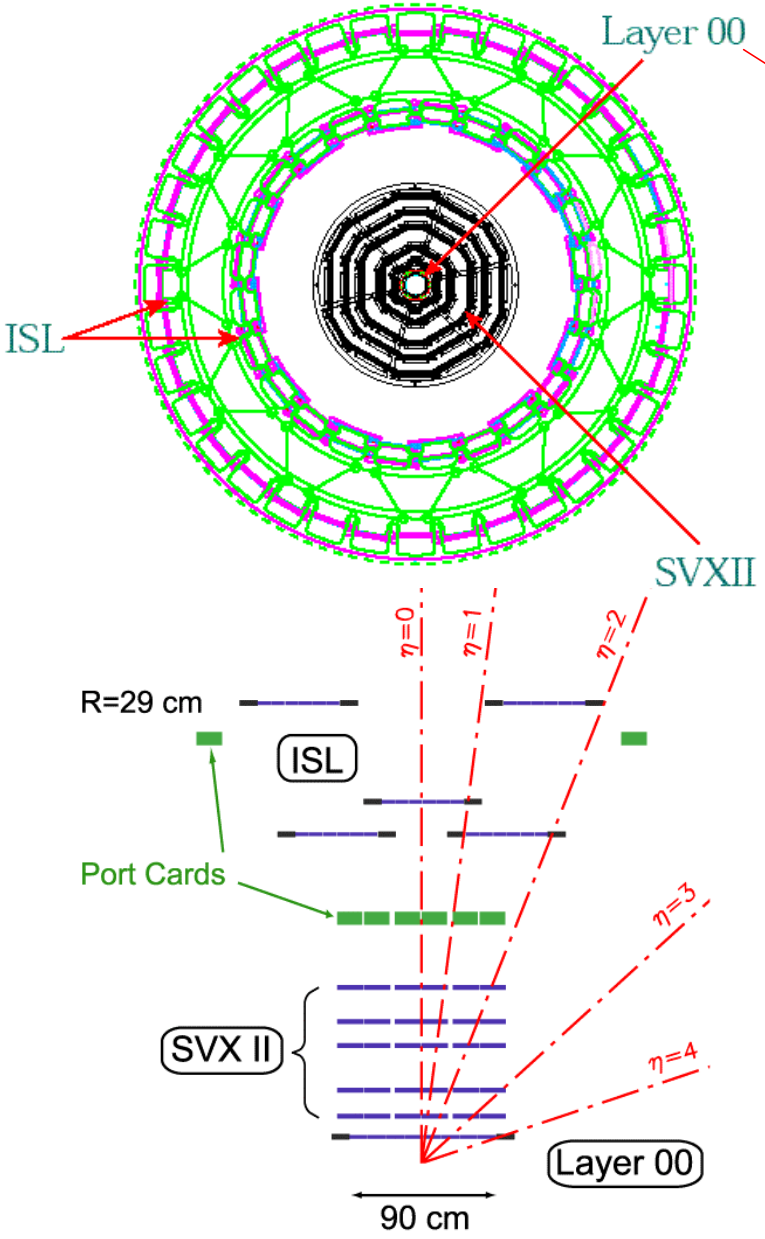
**∴Hardware of CDF Tracking with emphasis on Silicon and lessons learned**

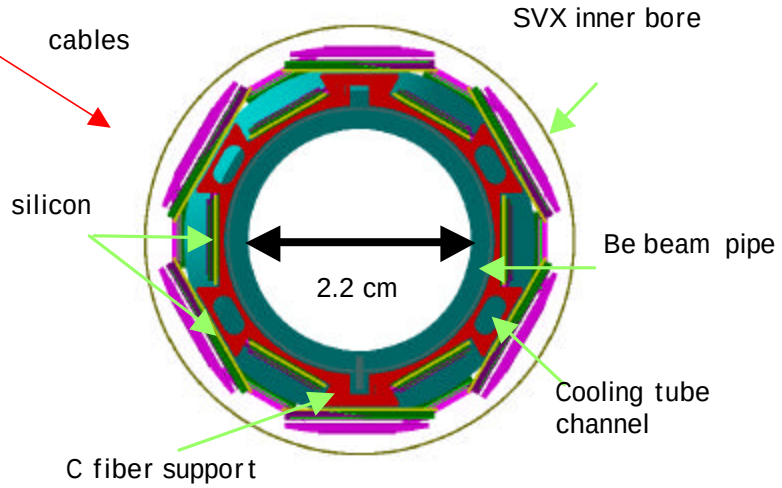
- **CDF Run II Motivations**
  - Find b quarks for top, Higgs, CKM, Exotica, …
  - Maintain pT resolution for EW…
  - Increase coverage
- **Talk Roadmap**
  - Tour of CDFII Silicon and Commissioning
  - Si Performance
  - Glance at Wire Chamber
  - Trigger Innovations
  - Physics



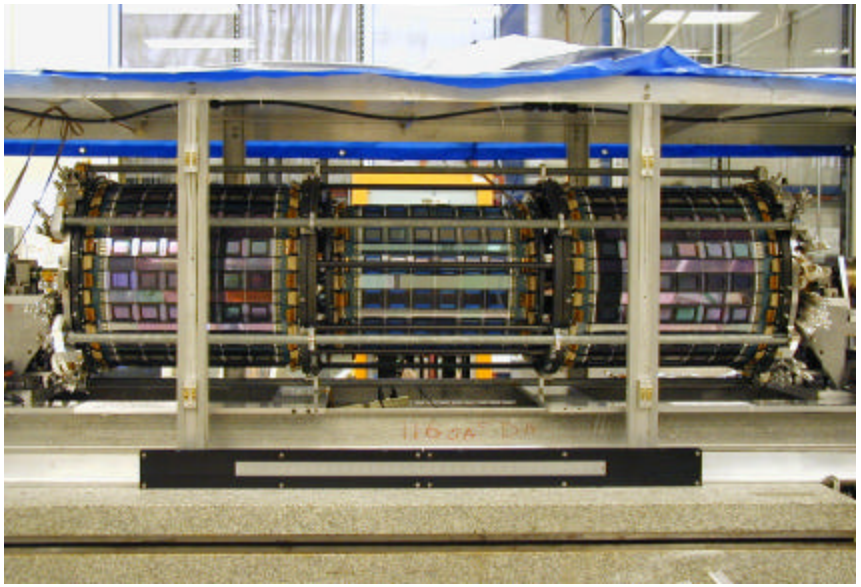
# CDF II Silicon

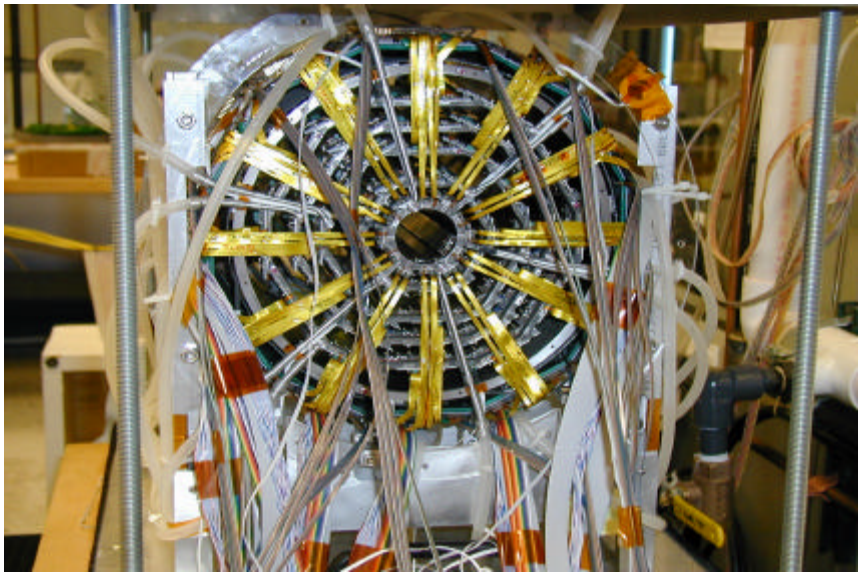


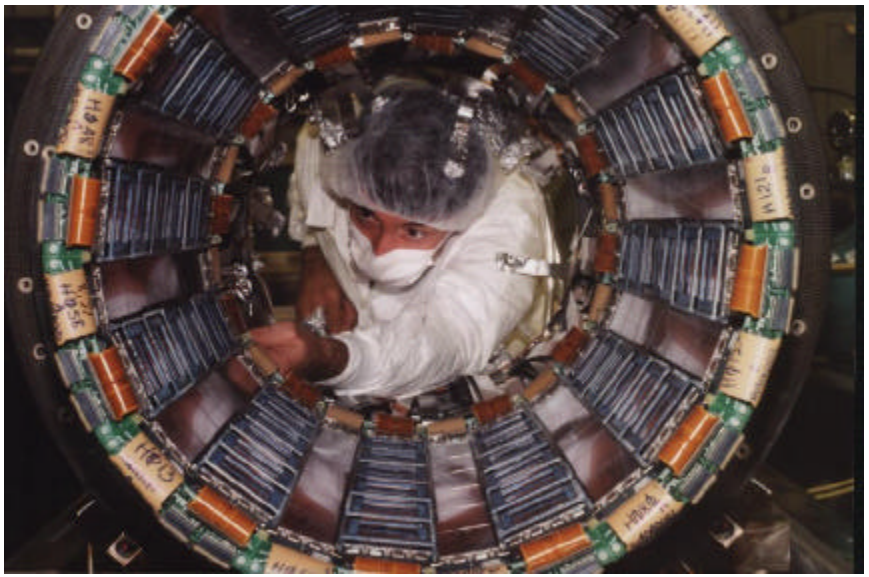



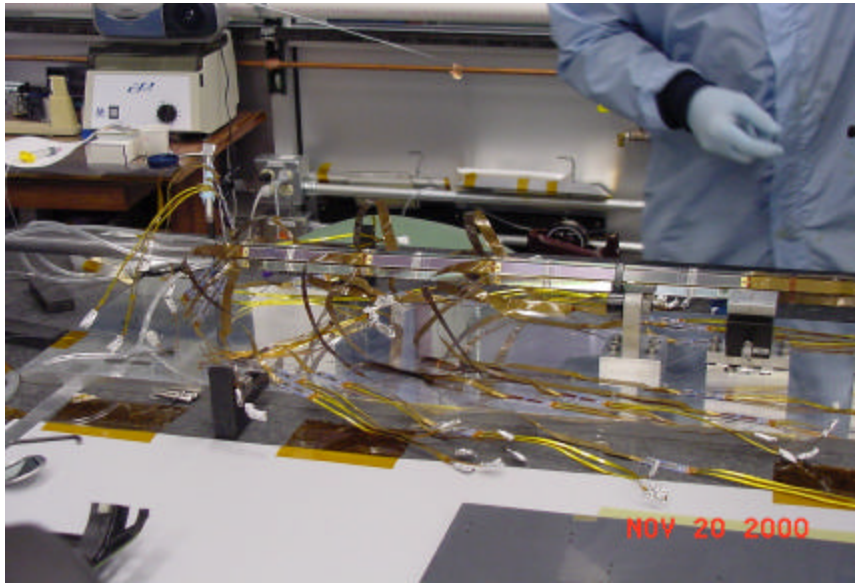

- **8 Layers, 704 ladders, 722432 Channels**
  - SVXII: 5 Double Sided Layers
    - **3 90º, 2 1.2º, 2.5 < r < 10.6 cm, l = 90 cm**
    - **360 ladders, 405505 Channels**
    - **3D tracking, Displaced Track L2 trigger**
  - ISL: 2 Double Sided Layers
    - **1.2º r = 20, 28 cm, l = 1.9 m!**
    - **296 ladders, 303104 Channels**
    - **Hits out to ½h½=2**
  - Layer 00 (L00): 1 Single Sided layer
    - **48 ladders, 13824 Channels**
    - **Improves IP resolution**

# Construction Pictures



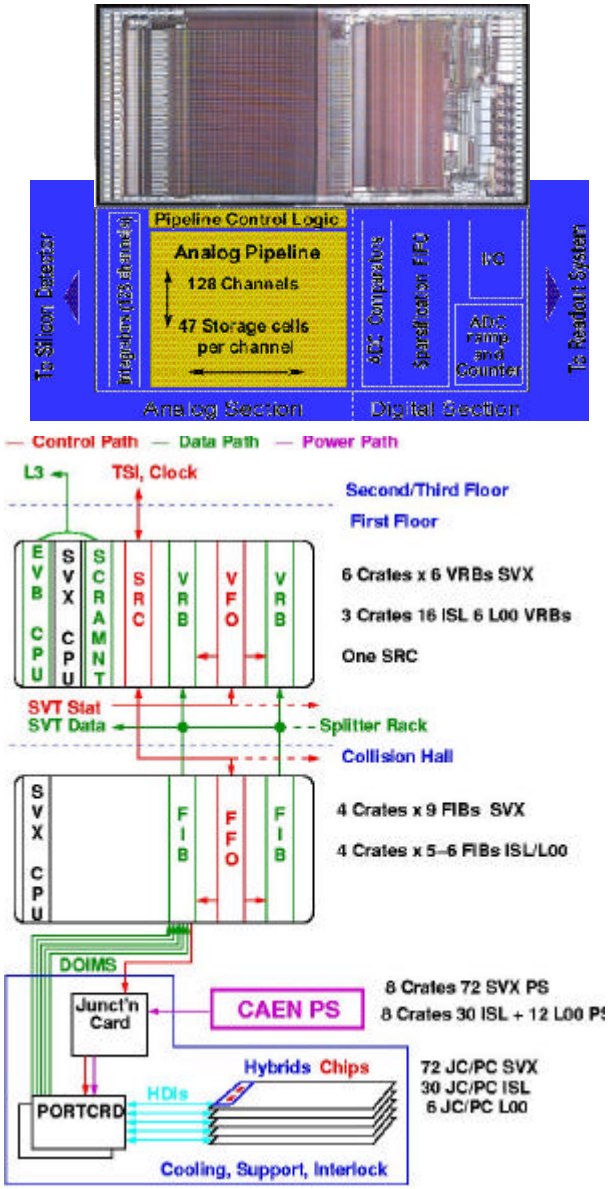




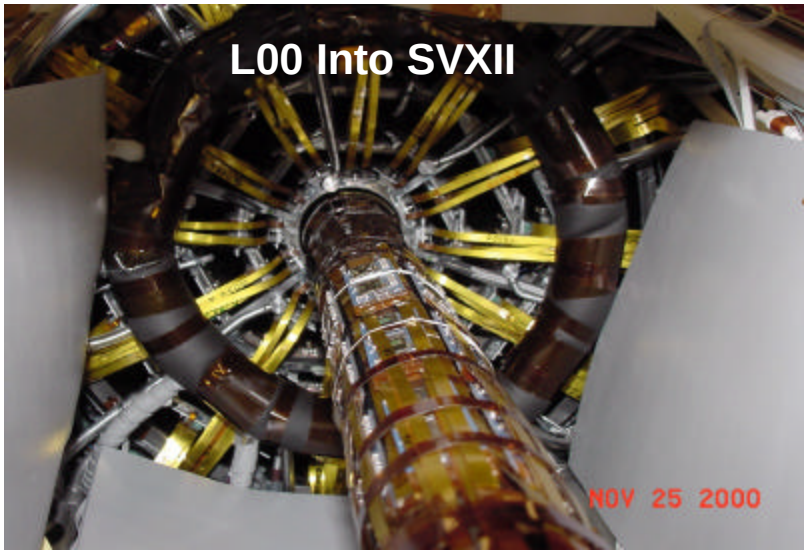


# Si DAQ (common)

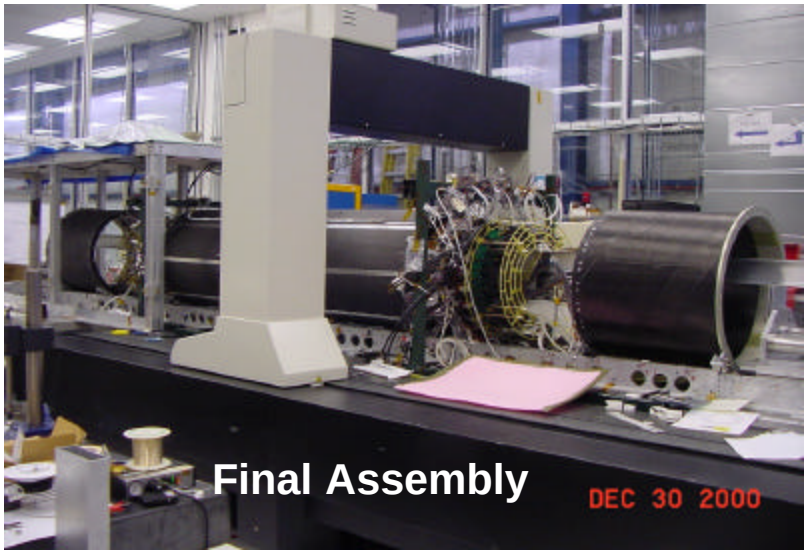
- **SVX3D Chip**
  - 128 Ch x 46 Capacitor Ring
  - "Deadtimeless"-Acquires during Readout
  - Features: Common Noise suppression, Sparsification…
- **Portcards**
  - Control: 1⇒5 Fanout
  - Data: Electrical ⇒ Optical
- **Custom VME DAQ and PS**
- **Cooling, Interlocks, Radiation Protection, etc**

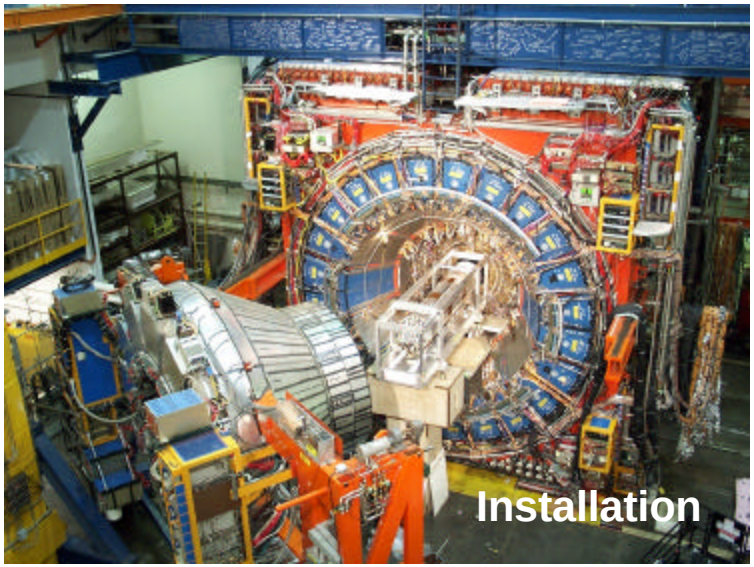


# Silicon Integration and Installation







# Silicon Commissioning Issues

- **Vendors**
  - ➢ Delay, failure of PS

**Relentlessly Pursue**

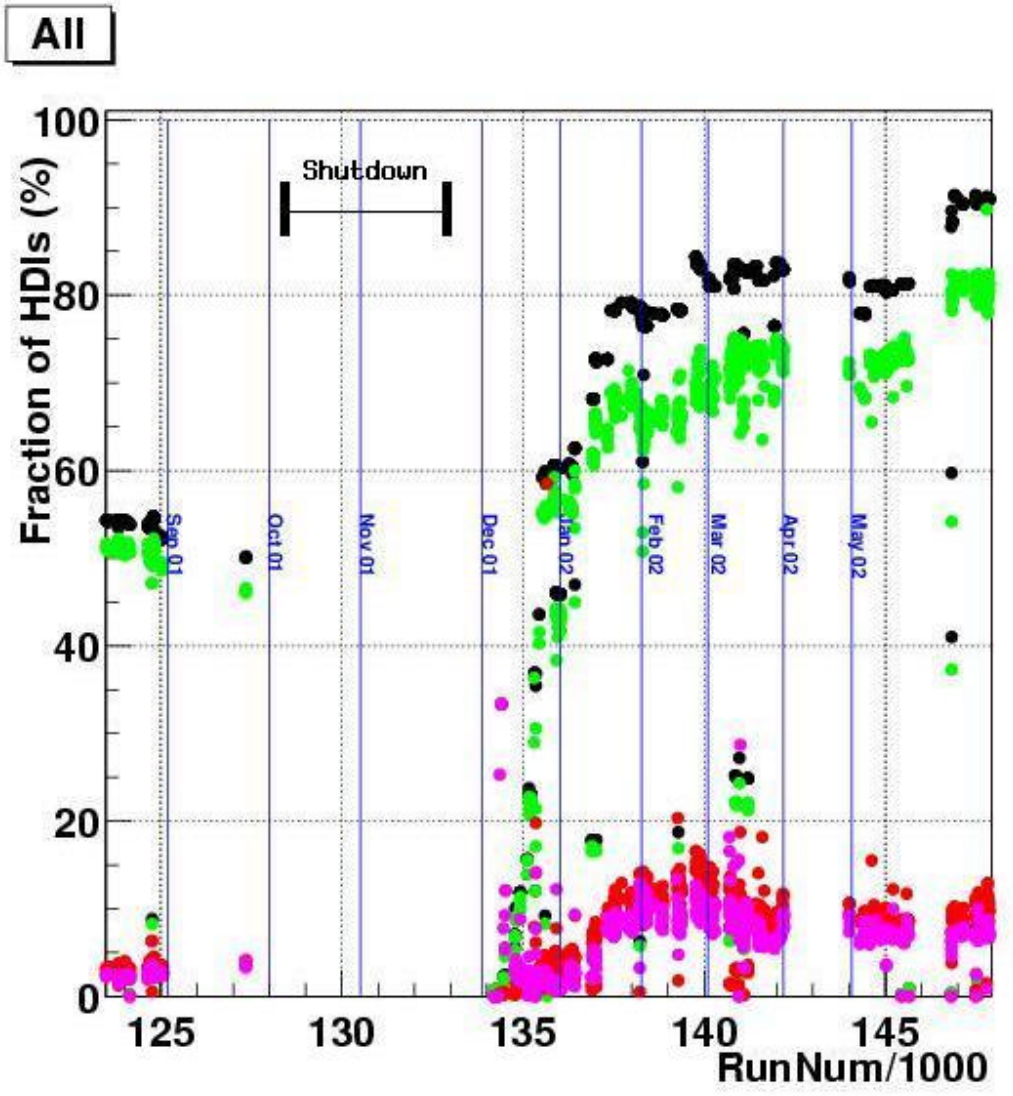
- **Realistic Testing**
  - ➢ ISL blocked cooling
  - ➢ L00 noise issues
  - ➢ Optical problems

**Get to operating conditions ASAP**

- **Beam**
  - ➢ Chip Damage
  - ➢ VME PS failure

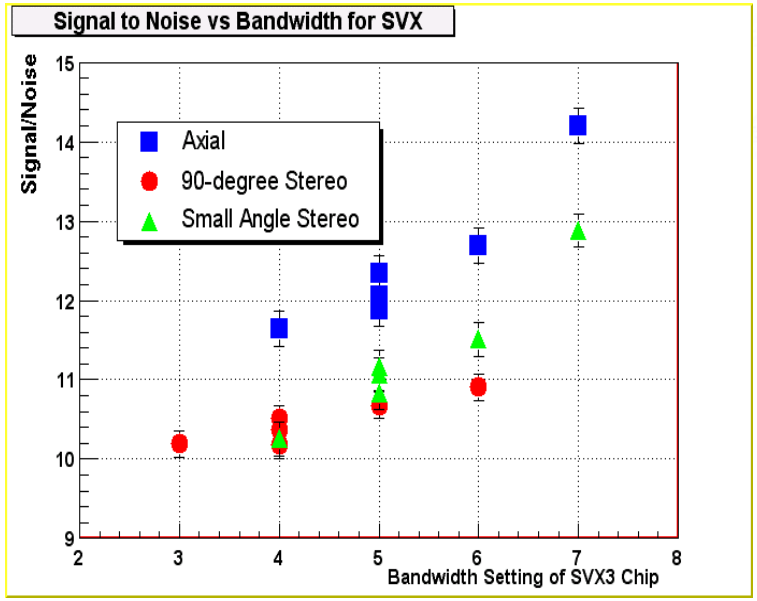
**Characterize failure modes before Installation**

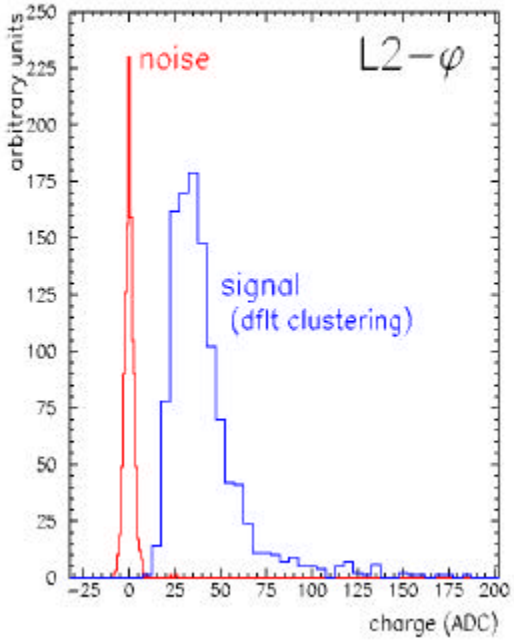
- **Currently 90%/80% and stable**



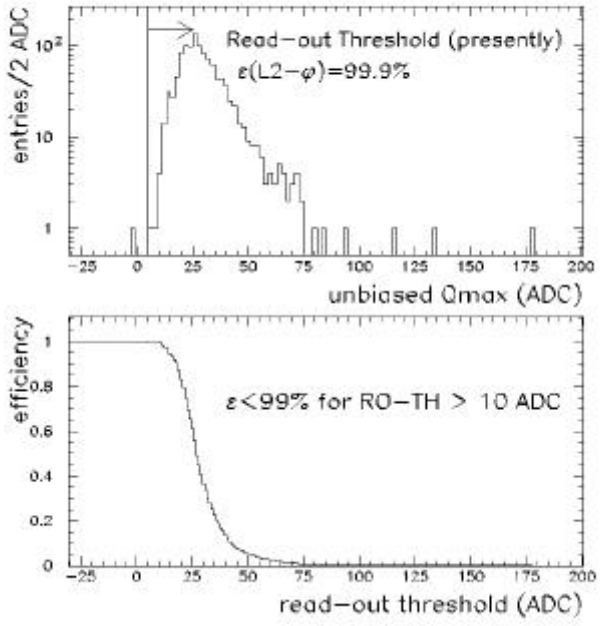
# Performance of Silicon (1)

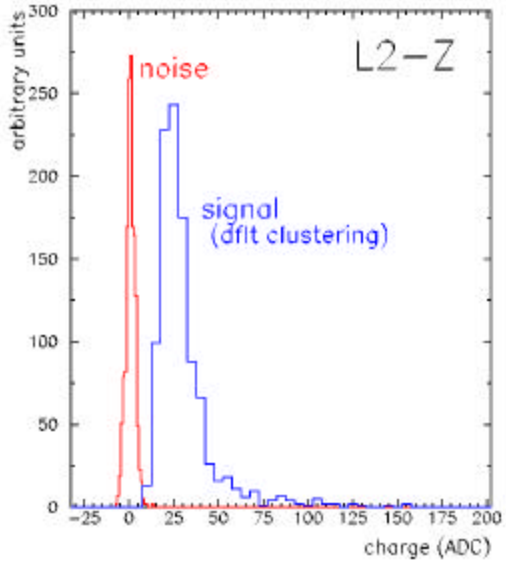
- **Signal to Noise > 10**



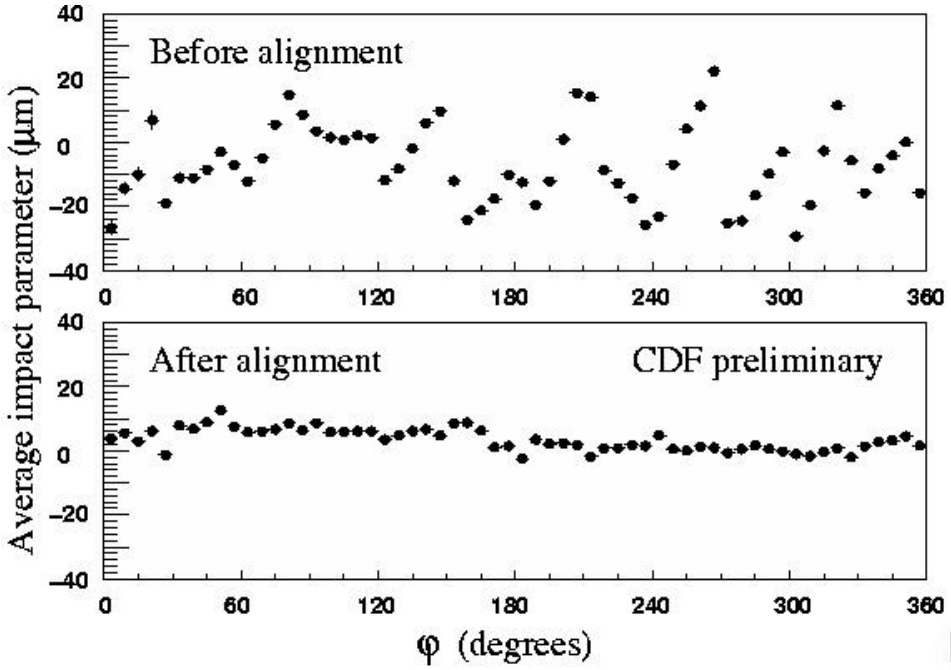



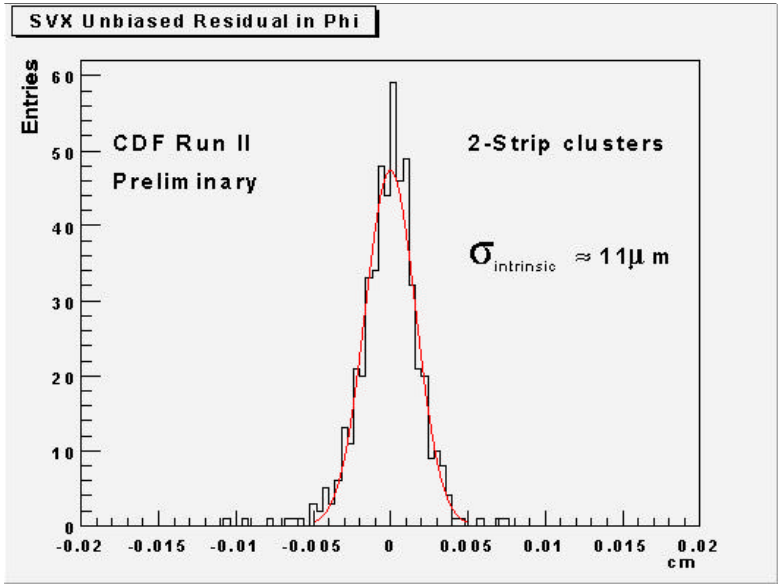

- **Efficiencies**
  - ➢ Single Hit
    ε > 99%

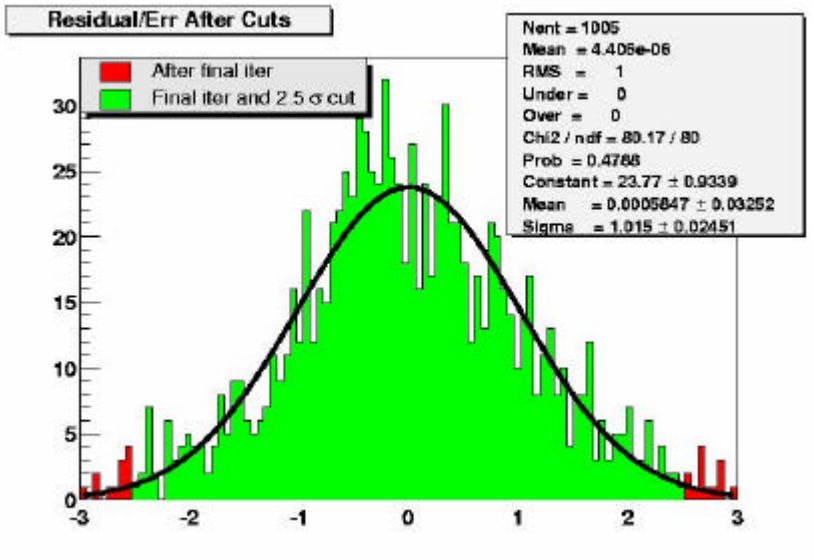


# Silicon Performance(2)



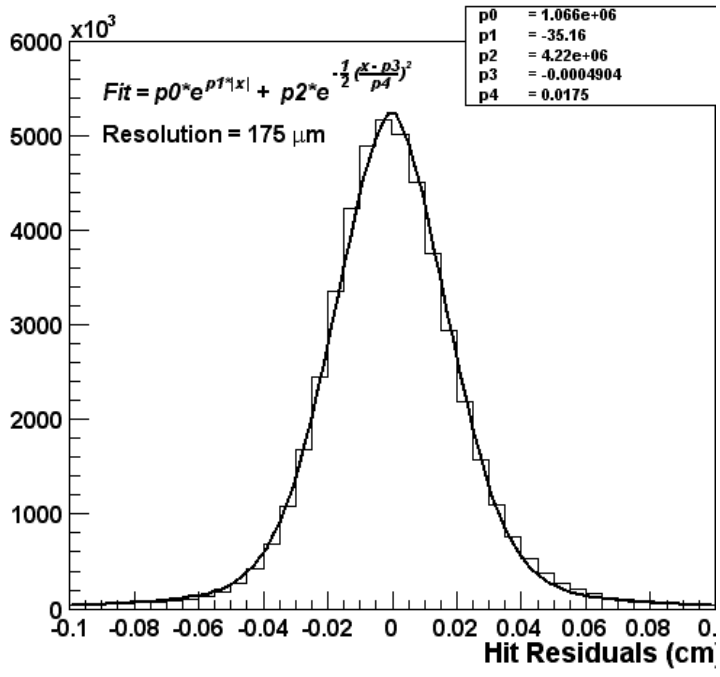



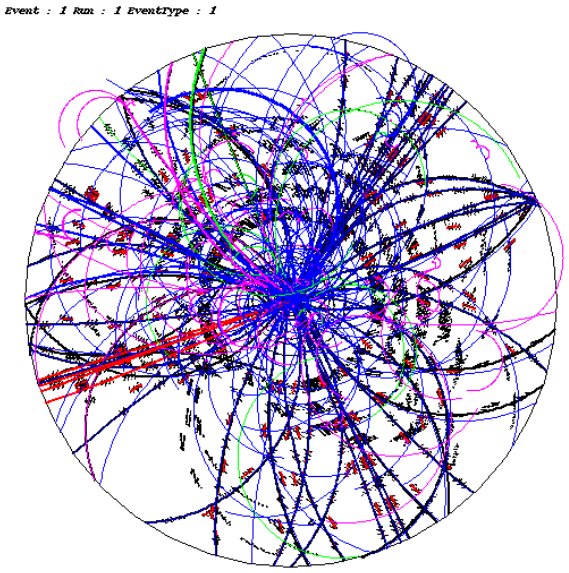




- **SVXII Alignment**
  - ➢ d0 vs. φ before and after
- **SVXII 2 Strip Resolution**
  - ➢ Deconvolute pointing resolution ⇒ residual ~ 11 μm
  - ➢ Track by track pull has σ = 1

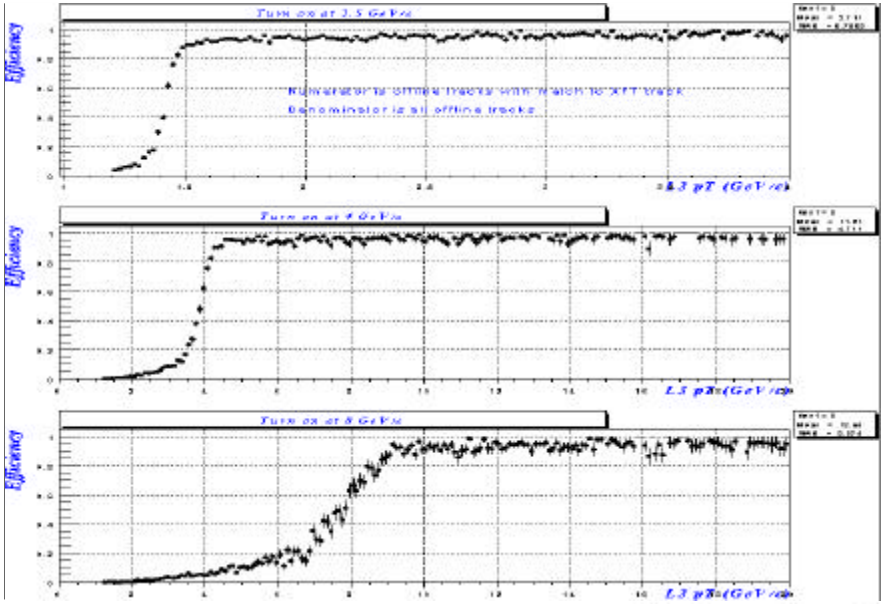
# CDF Central Outer Tracker

- **More Hits on tracks**
  - 5x Run I sense wires
  - 2x Run I Stereo layers
- **Uniform Drift Field**
- **Maintain Run I momentum resolution**

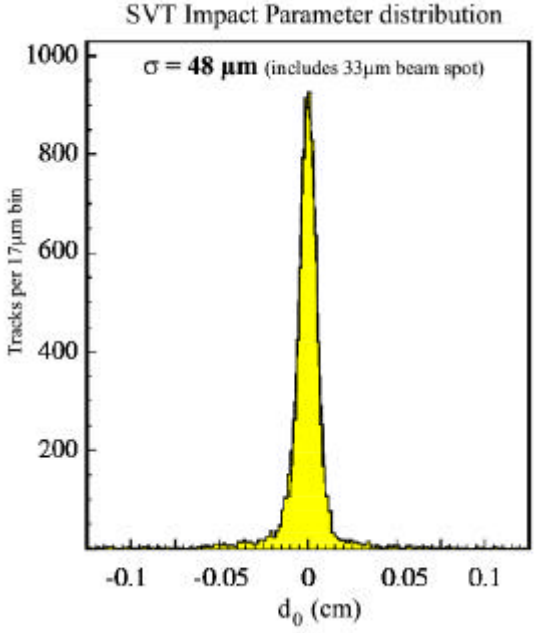


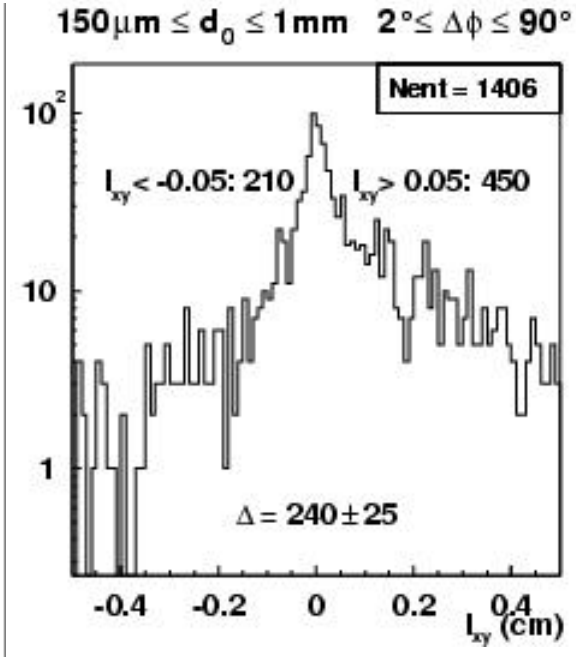



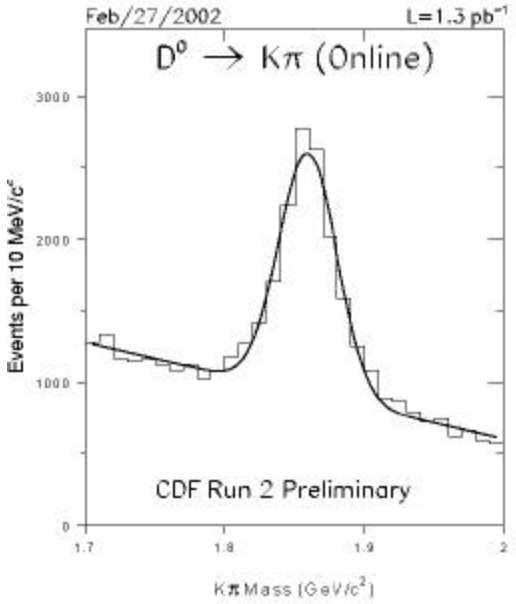
# Trigger Innovations



- **COT Tracking at L1**
  - Feeds CAL, Muon, and Two-Track triggers
- **Secondary Vertex Trigger**
  - Combines Silicon Hits with L1 tracks, looks for large d0 in 2D

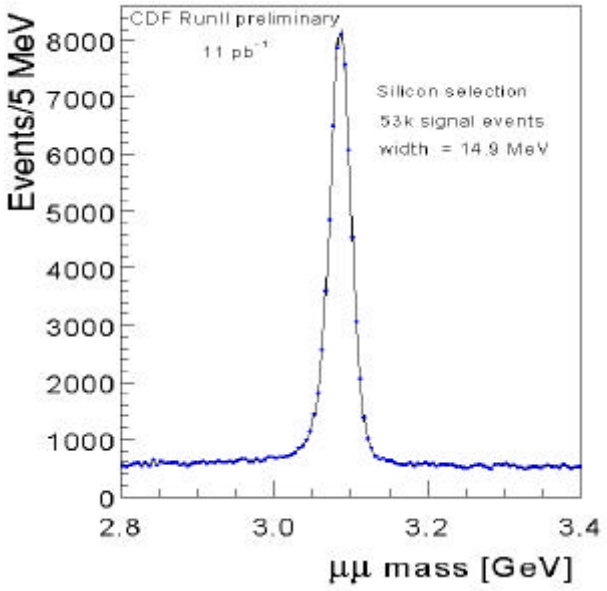


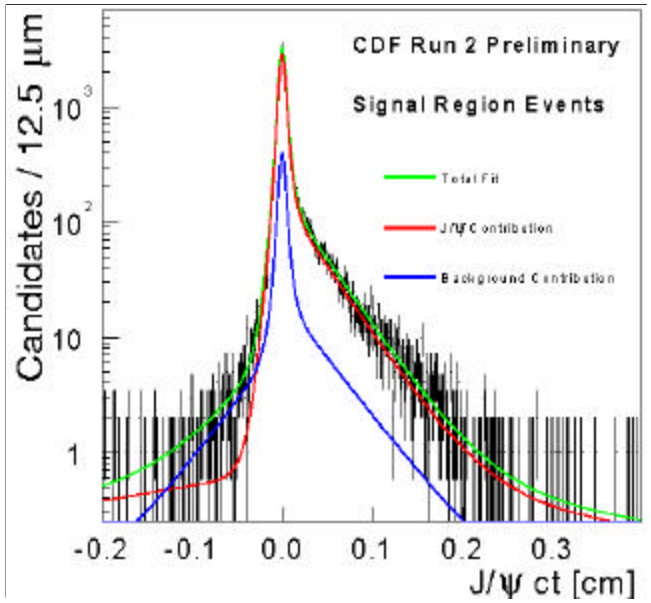



# Calibration from Physics

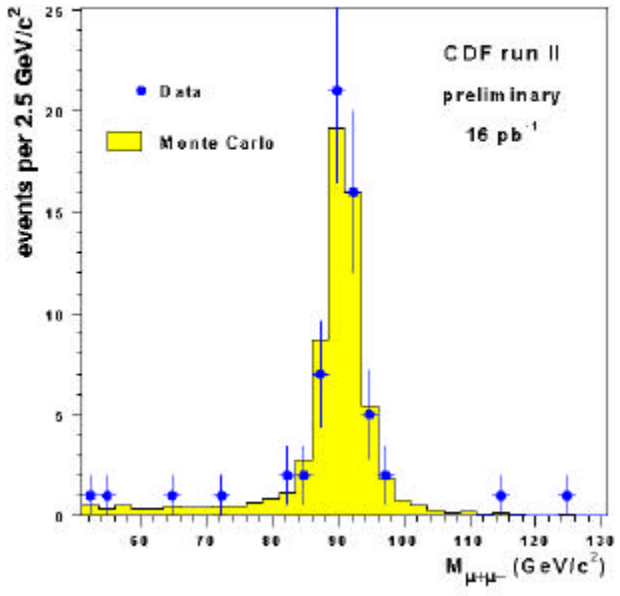
- **J/ψ**

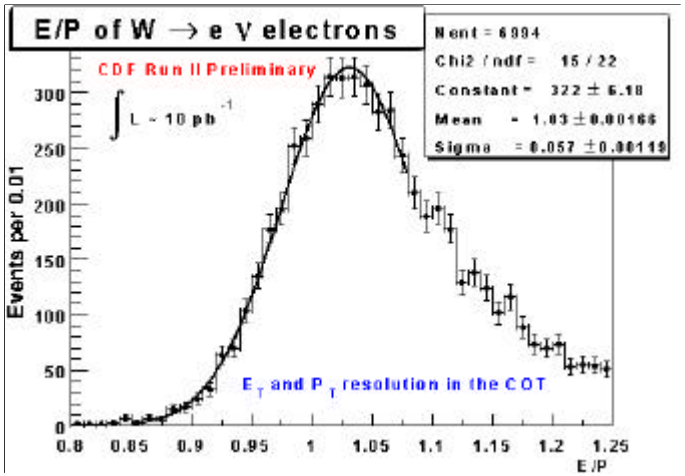



**cτ = 458 ± 10 ± 11 μm**



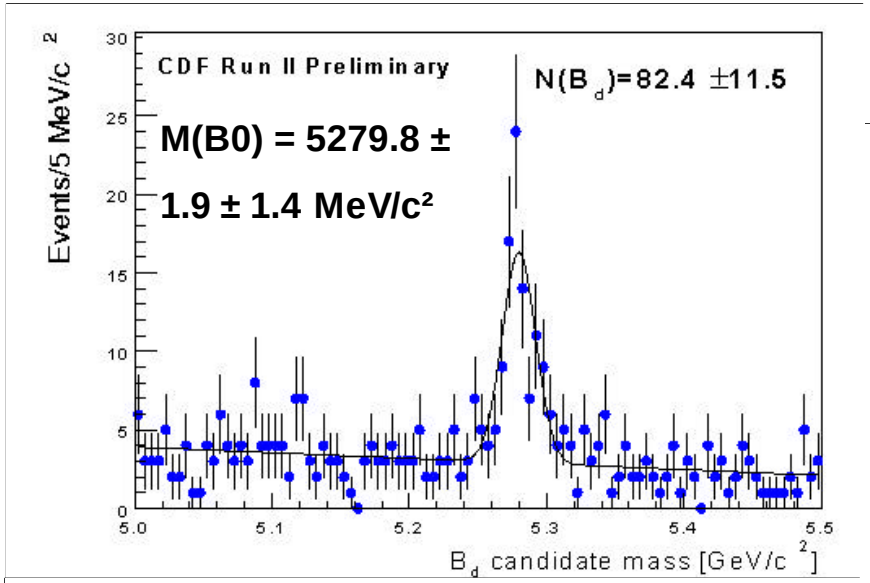

- **Zs, Ws**

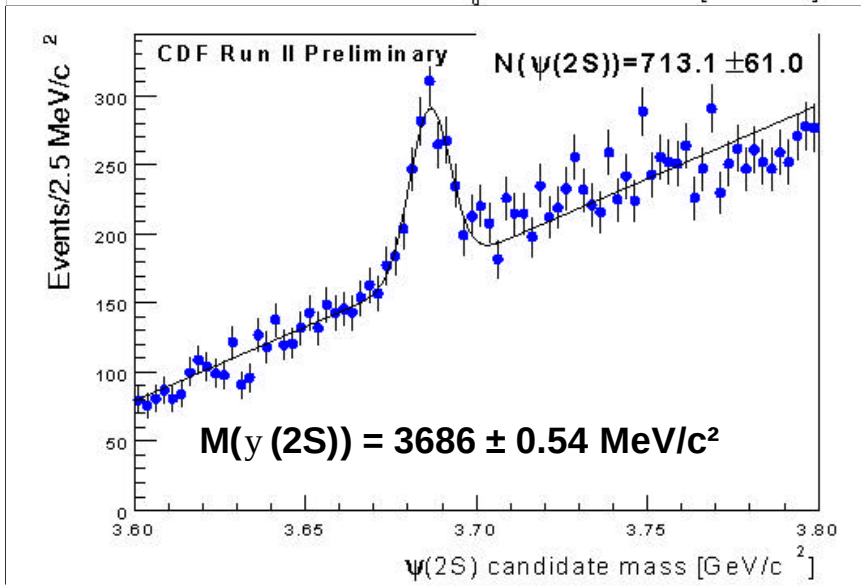


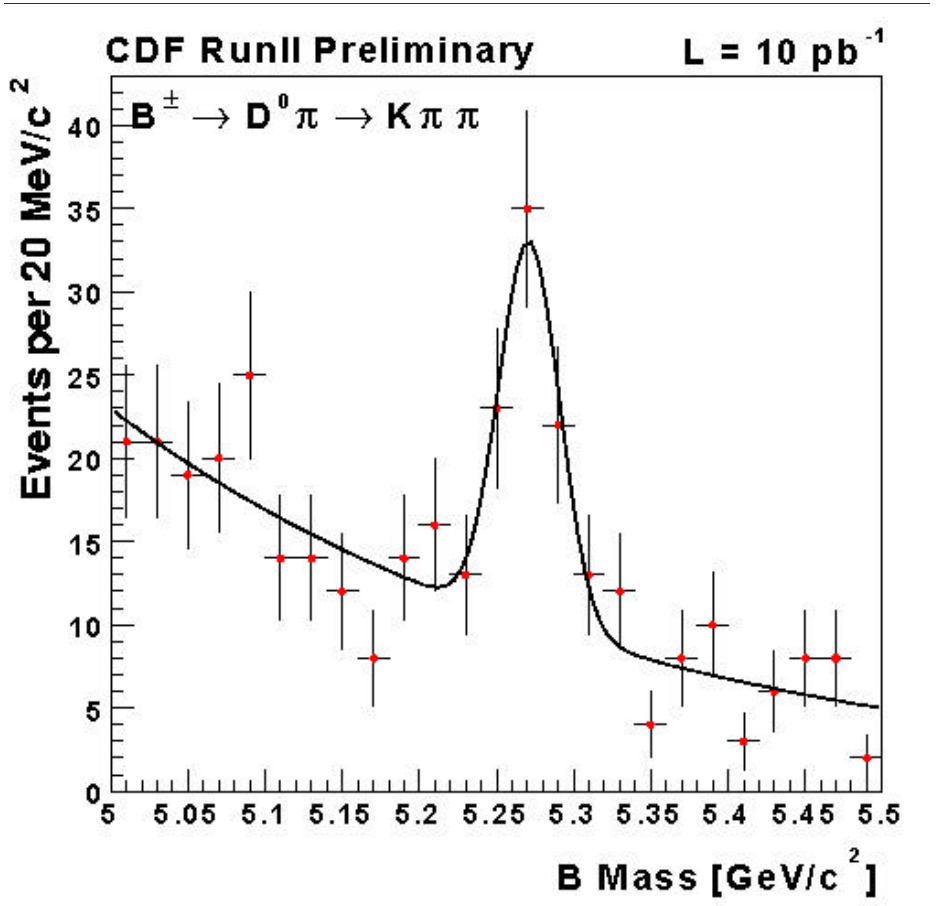




**COT:** $s_{p_t}/p_t^2 < 0.13\%$

# B Physics from CDFII



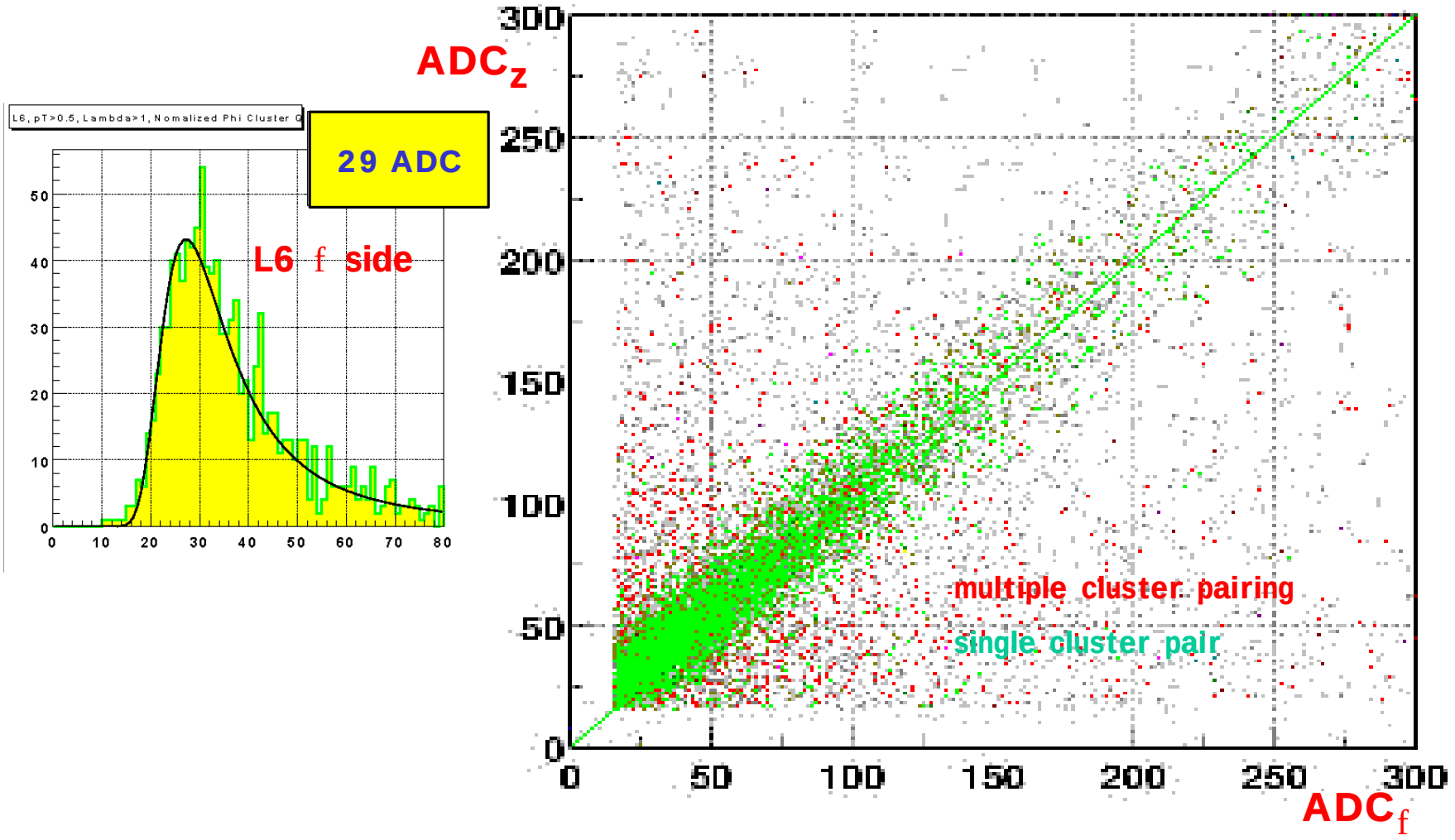



# Summary

- **CDF Run II tracking performing well**
  - Si detector is producing clusters and tracks
  - Trigger innovations enhancing physics content of data
  - CDF tracking-based results being presented at ICHEP2002
- **Light at the End of the Tunnel…**
  - Exiting Commissioning phase, entering Maintenance
  - Getting to the small and subtle problems is progress
  - Lessons learned about vendor dependencies, realistic testing, and probing failure modes while not entombed
- **Still fair amount of work yet to do**
  - Most of the remaining problems are the hard ones…
  - New things appear from time to time

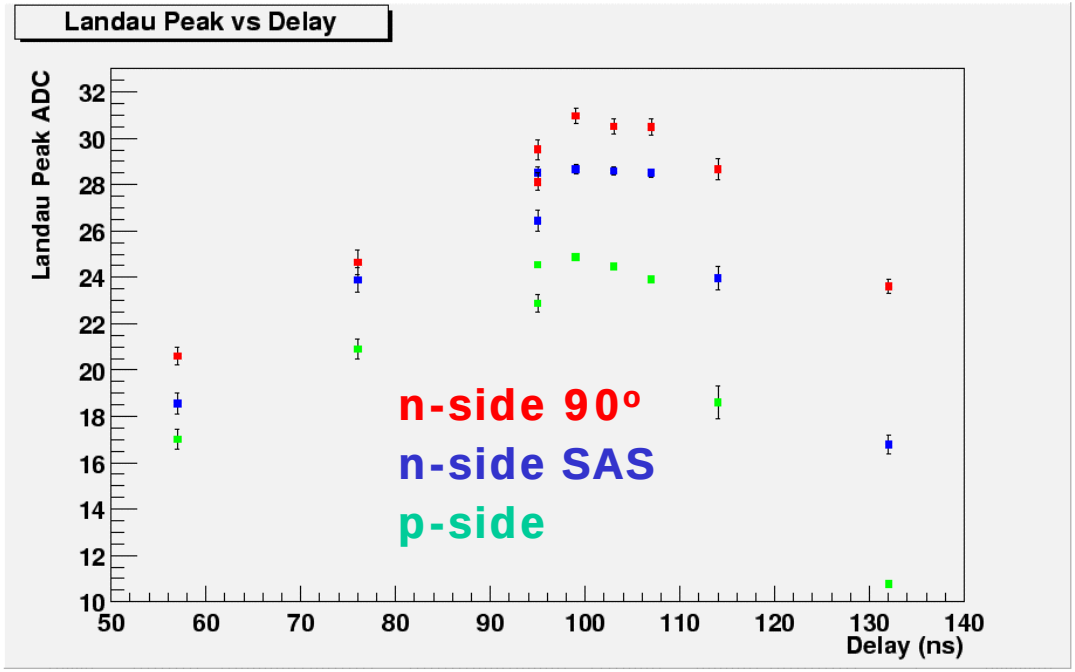
**Support Slides Follow this one**

# Charge correlation (ISL)

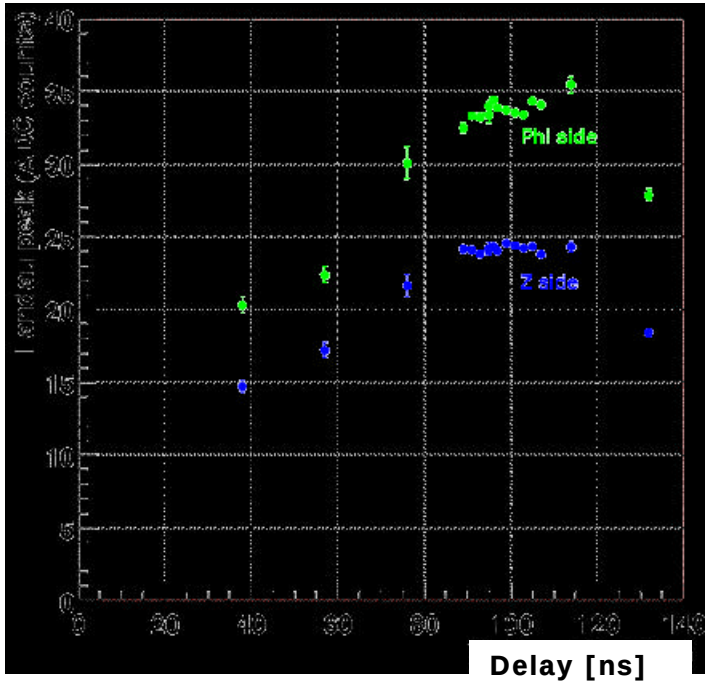


# Timing scan results

## SVXII



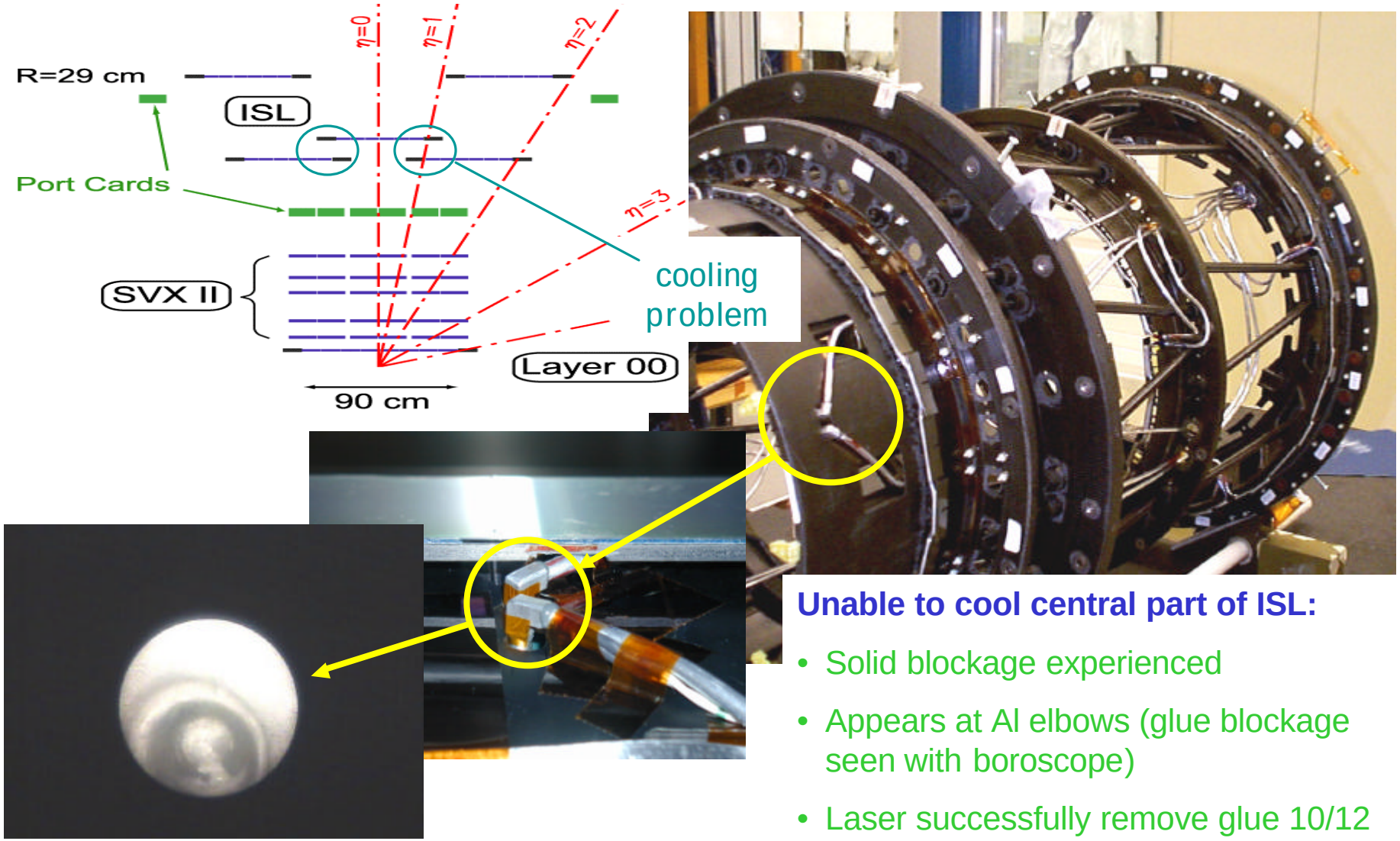

## ISL




All detector types peak at roughly the same timing!

(n- & p-side responses different here due to timing problem in FIB sequence, later fixed.)

# ISL Cooling Problem

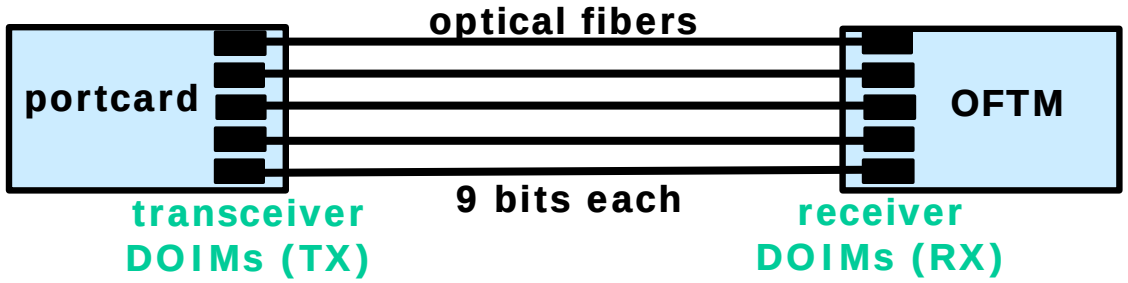



**Unable to cool central part of ISL:**

- Solid blockage experienced
- Appears at Al elbows (glue blockage seen with boroscope)
- Laser successfully remove glue 10/12 lines so far, finish in Oct 2002.

# Optical Problems

- **Largest single source of problems**
- **Time consuming to fix (requires Access)**
  - ➢ Light Level too low: Increase voltage
    - **Caviat: voltage shared by 5 ladders x 9 bits**
  - ➢ Light Level too high: Introduce attenuation
    - **Caviat: Attenuation shared by 9 bits**
  - ➢ Light level OK: Bad connectivity of TX
- **Solutions at the RX side are being implemented**



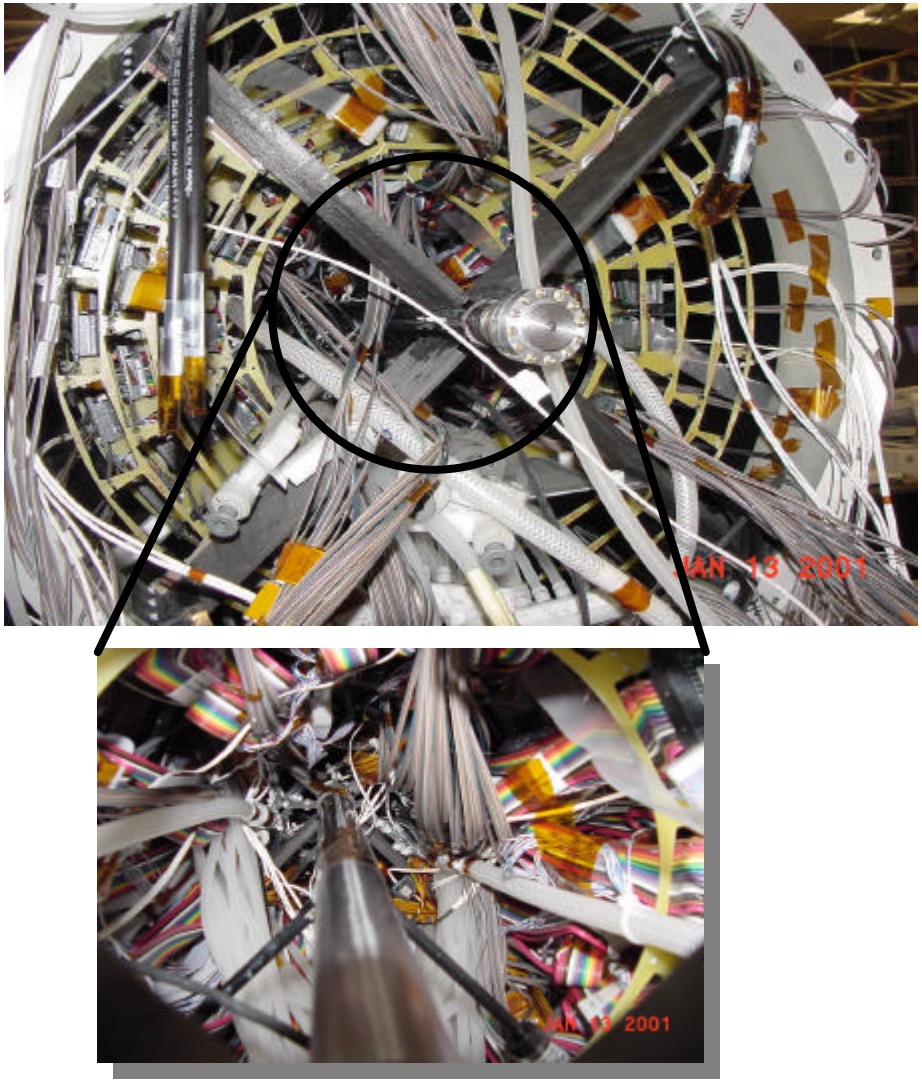

| Chan | OBDV | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|
| SB0W6-4 | 880 | 820 | 800 | 900 | 600 | 900 | 400 | 1000 | 900 |

| Chan | OBDV | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|
| SB0W3-0 | 296 | 156 | 44 | 204 | 64 | 144 | 264 | 216 | 240 |

# Beam Incidents

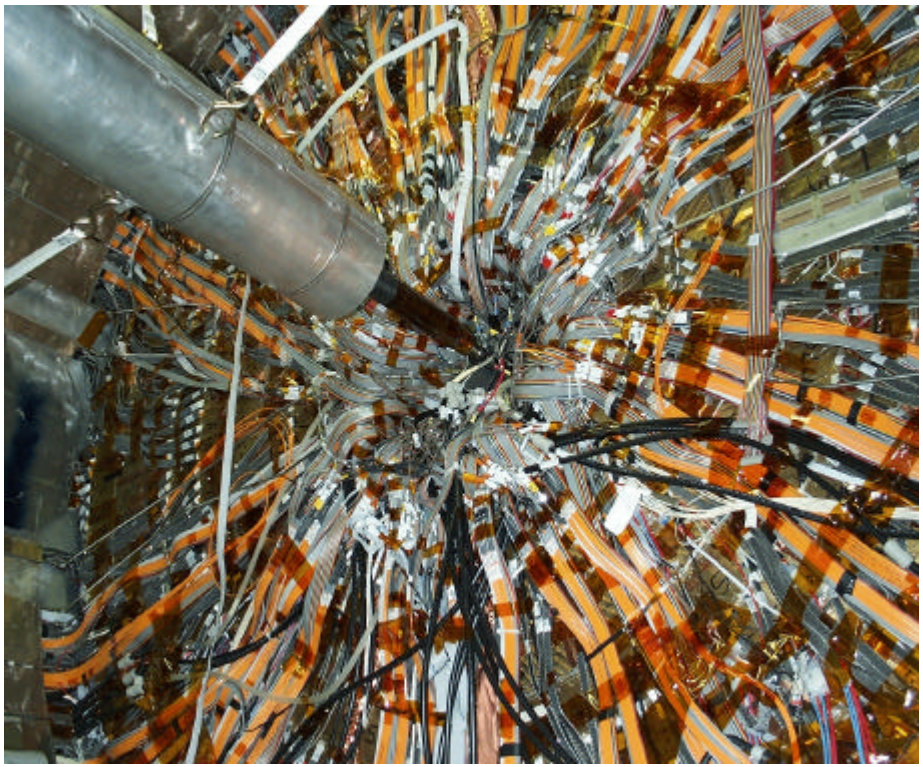
- **During Oct 01 Shutdown, found new failure mode consistent with Analog power not getting to a chip on a ladder**
  - ➢ Suspected thermal cycles mechanically breaking connection, or perhaps anomalous high current states blowing bonds
- **March 30, 2002 Beam incident damages 6 single chips on 6 different ladders in a similar fashion**
  - ➢ Saw high currents on other voltage lines etc
  - ➢ Suspect high **DOSE RATE** causes failure
- **Test beam tests failed to reproduce the symptoms**
  - ➢ Fell back to “Only the strong survive”
  - ➢ Required new interlocks on Beam and tighter constraints on beam conditions for safe operation

# Connecting the full detector



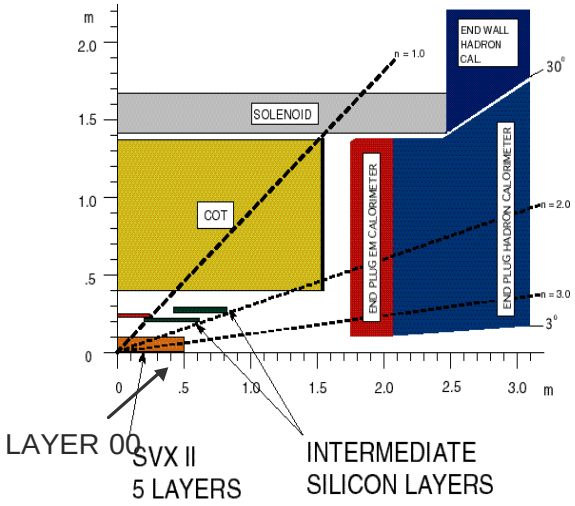

*Intensive pre-testing of cables, power supplies, optical components, cooling and interlocks took place before connection of the real detector… nonetheless:*

**Connecting the full detector took 7 weeks, 24 hrs/day, 4 people at a time!**

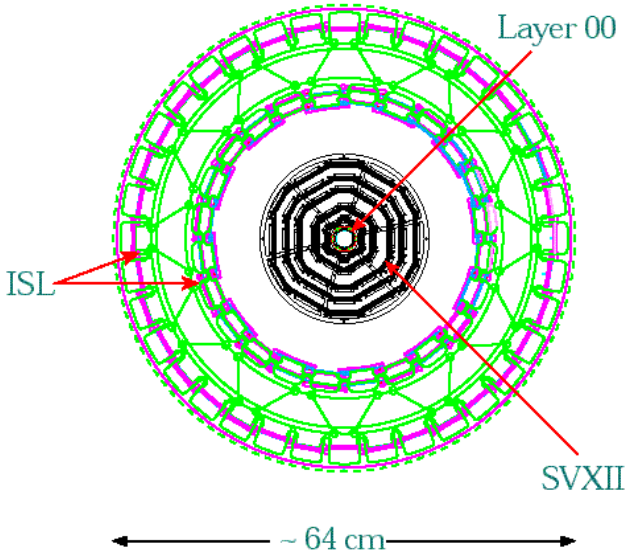


# CDF Run IIa Silicon

| Layer | Inner/Outer Radii [cm] | Axial Pitch [μm] | Stereo Angle | Stereo Pitch [μm] |
|---|---|---|---|---|
| 00 | **1.35/1.62** | **25** | **-** | **-** |
| 0 | **2.5/3.0** | **60** | **90** | **141** |
| 1 | **4.1/4.6** | **62** | **90** | **125.5** |
| 2 | **6.5/7.0** | **60** | **1.2** | **60** |
| 3 | **8.2/8.7** | **60** | **90** | **141** |
| 4 | **10.1/10.6** | **65** | **1.2** | **65** |
| 5 Forward | **19.7/20.2** | **112** | **1.2** | **112** |
| 5 Central | **22.6/23.1** | **112** | **1.2** | **112** |
| 6 Forward | **28.6/29.0** | **112** | **1.2** | **112** |

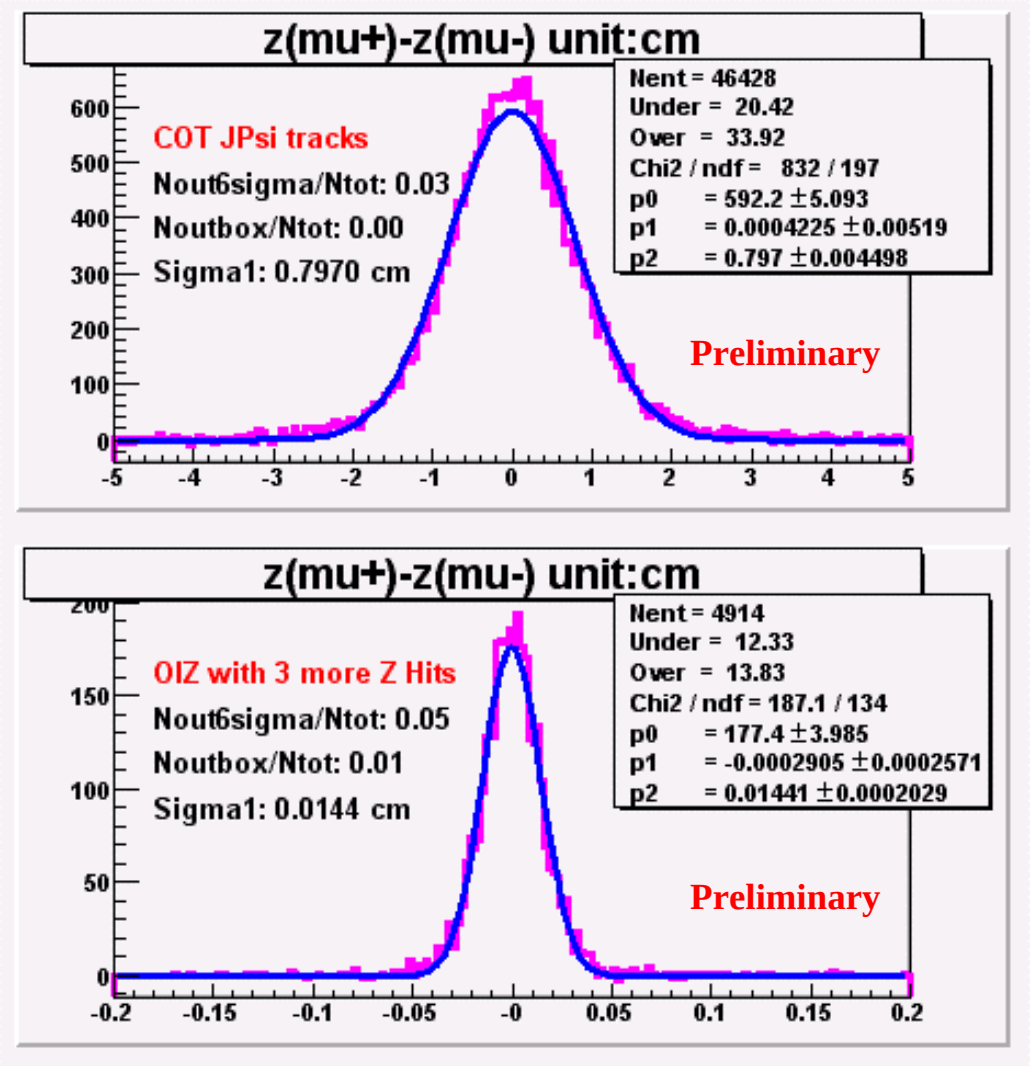



| **CDF** | Layer 00 | SVX II | ISL | Totals |
|---|---|---|---|---|
| Layers | 1 | 5 | 2 | 8 |
| Length | 0.9 m | 0.9 m | 1.9 m | |
| Channels | 13824 | 405504 | 303104 | 722432 |
| Modules | 48 SS | 360 DS | 296 DS | 704 |
| Readout Length | 14.8 cm | 14.5 cm | 21.5 cm | |
| Inner Radius | 1.35 cm | 2.5 cm | 20 cm | 1.35 cm |
| Outer Radius | 1.65 cm | 10.6 cm | 28 cm | 28 cm |
| Power | ~100 W | 1.4 kW | 1.0 kW | 2.5 kW |



# Z Resolution

## △z distributions for J/ψ → μμ tracks

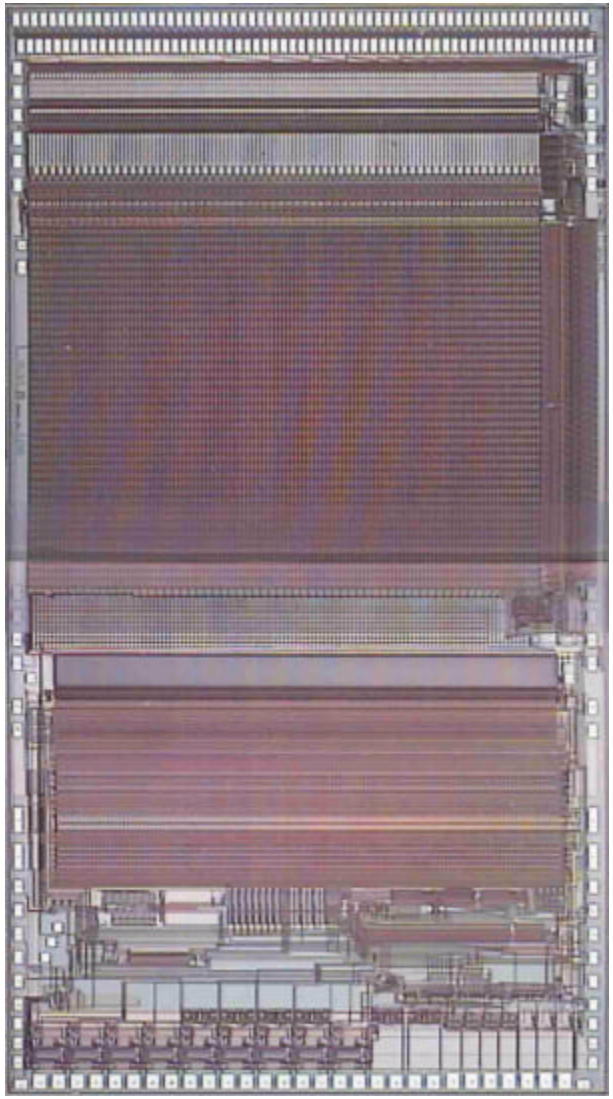



COT only

High quality SVX tracks

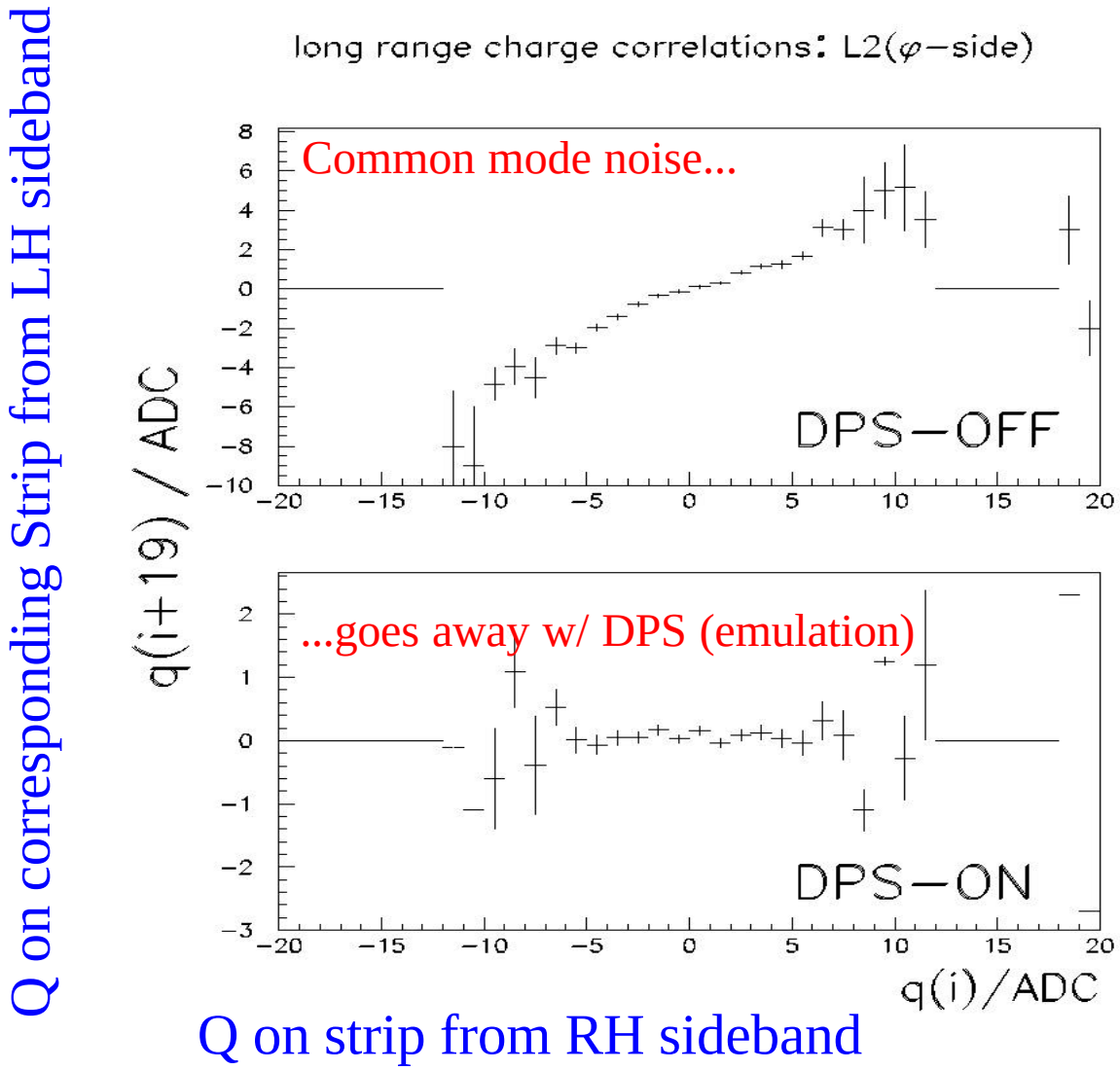
Data taken from Aug to Oct 2001
J/ψ mass window: 3.08 ± 0.05 GeV
Sidebands: (2.88, 3.00) and (3.16, 3.28) GeV

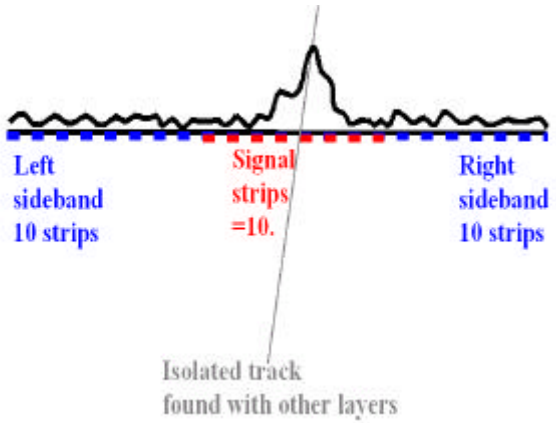
# SVX3D ASIC



- 128 input channels
- Designed to operate with 132 or 396 ns beam crossing rate
- ENC = 700 + 53 electrons/pF
- 46 cell analog pipeline
- Buffers up to 4 events
- 8-bit Wilkinson ADC, digital readout
- Deadtimeless operation
- On-chip sparsification and common mode noise suppression
- Fabricated in the Honeywell 0.8μm radiation hard process

# Dynamic Common Mode Suppresion works as designed




There is common mode noise on the strips, and DPS suppresses it efficiently.

# Measurement of Radiation Dose

- May – Oct 2001 running
- Collision dominated, but losses still present
- Measurements found radial and z dependence of dose
- Radial dependence fit to $1/R^{\alpha}$ scaling
- Result: $\alpha(z) = 1.5\text{-}2.0$
- Run IIa lifetime estimates assumed $\alpha = 1.7 \pm 30\%$ (OK)