The H1 Silicon Tracker

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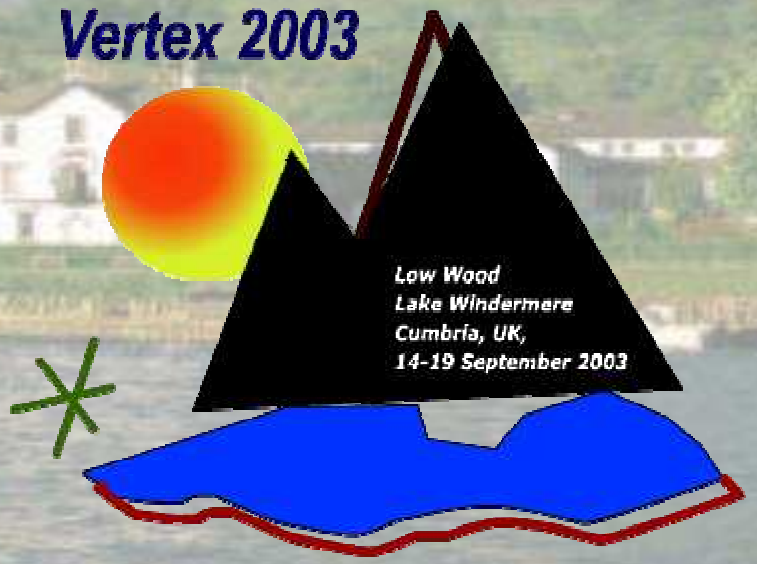
Institute for Particle Physics

VERTEX 2003

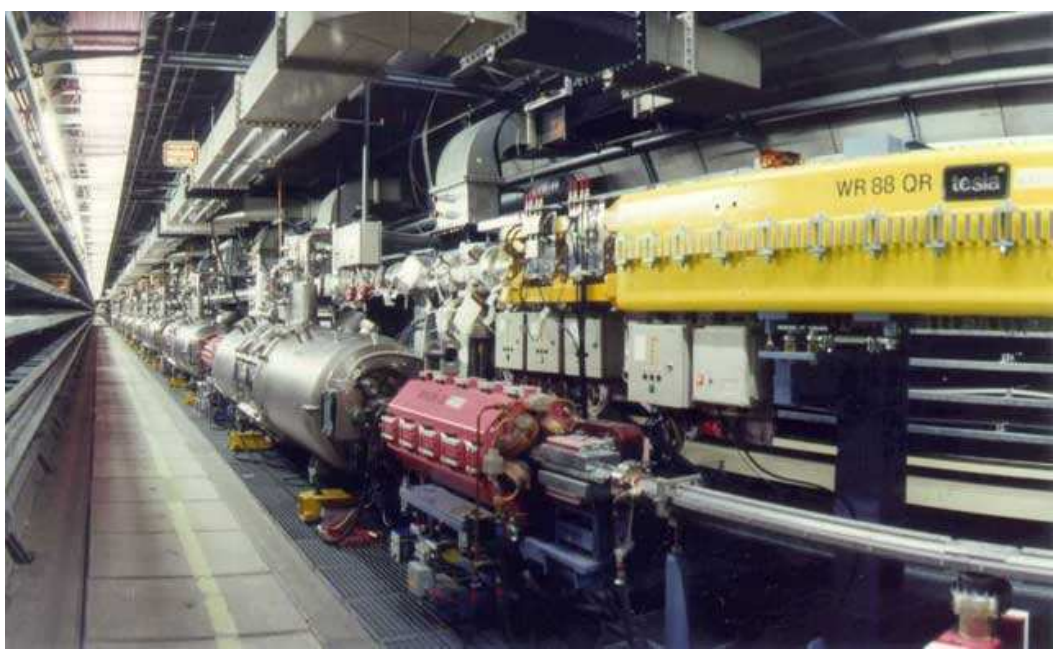
15.9.2003

- HERA and H1
- The H1 silicon tracker
- Recent results
- Changes in 2003
- Lessons from the Pit

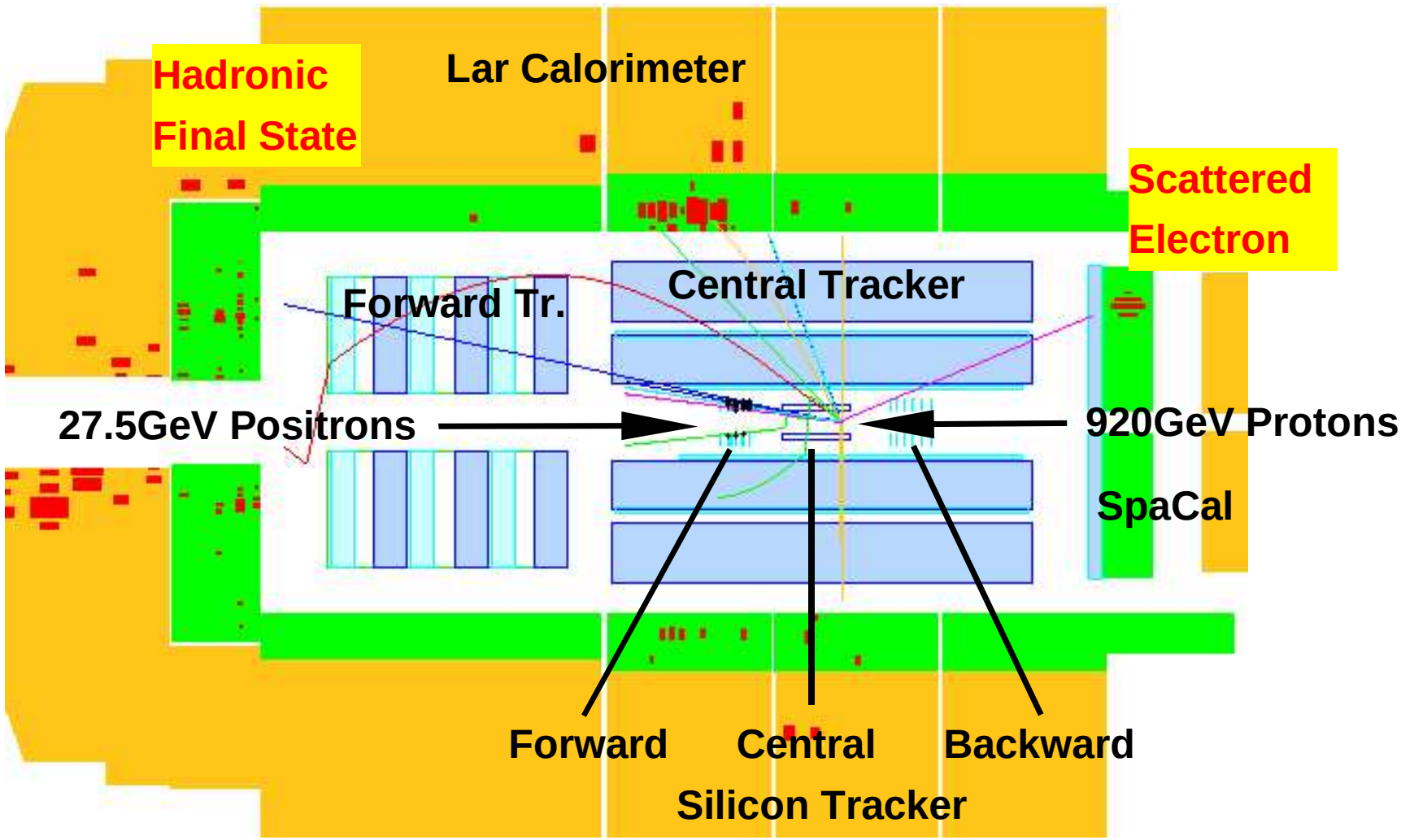


The HERA ep Collider

- Located at DESY in Hamburg
- 27.5 GeV electrons/positrons on 920 GeV protons
- HERA−I: 1992−2000, 120pb^{-1}
- 2000: Luminosity upgrade
- HERA−II: 2001−2007, 1000pb^{-1} expected

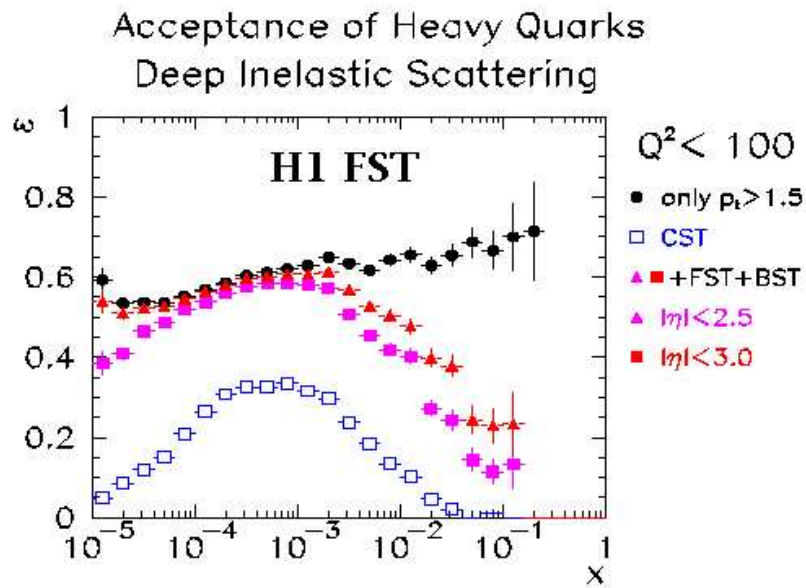


The H1 Detector

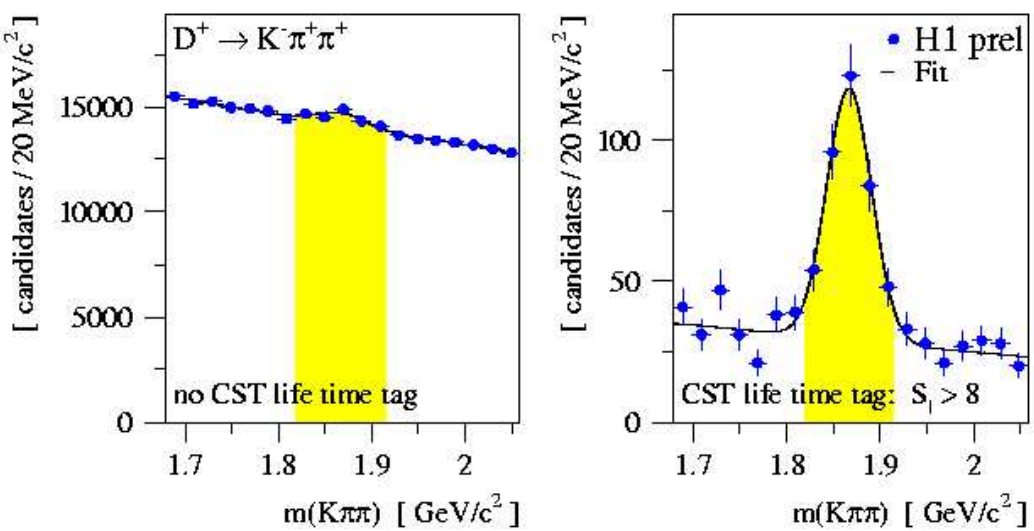


Physics Requirements (I)

- FST:
  - Extend tracking (with vertexing capability) into forward direction: high track density!
    => good pattern recognition

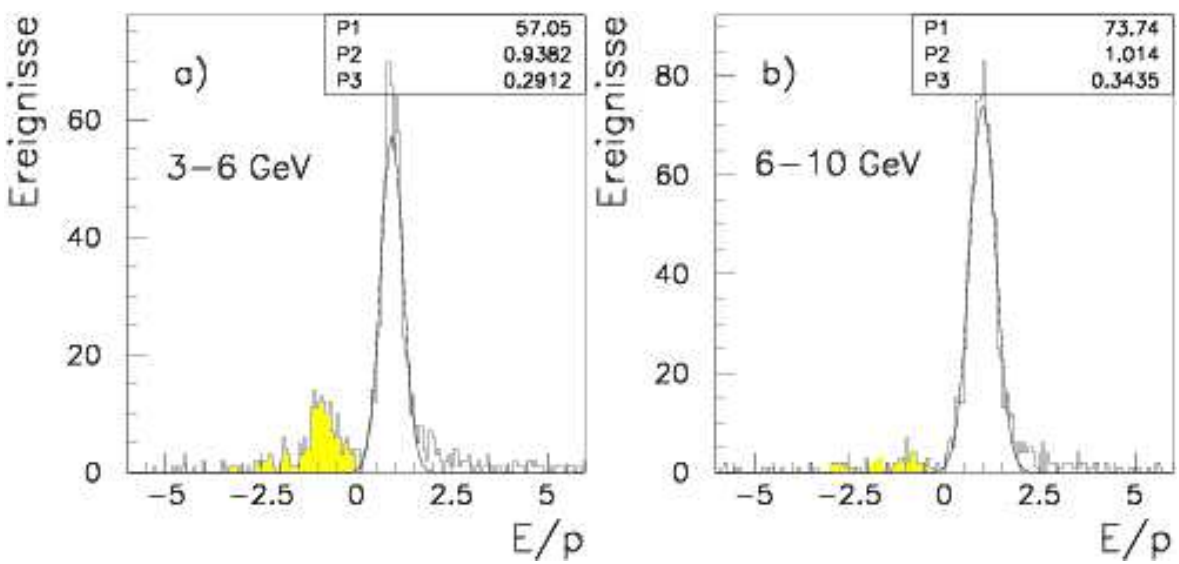


- CST:
  - Provide vertexing capability in central region (charm, beauty)
  - Resolution dominated by multiple scattering: thin detector!



Physics Requirements (II)

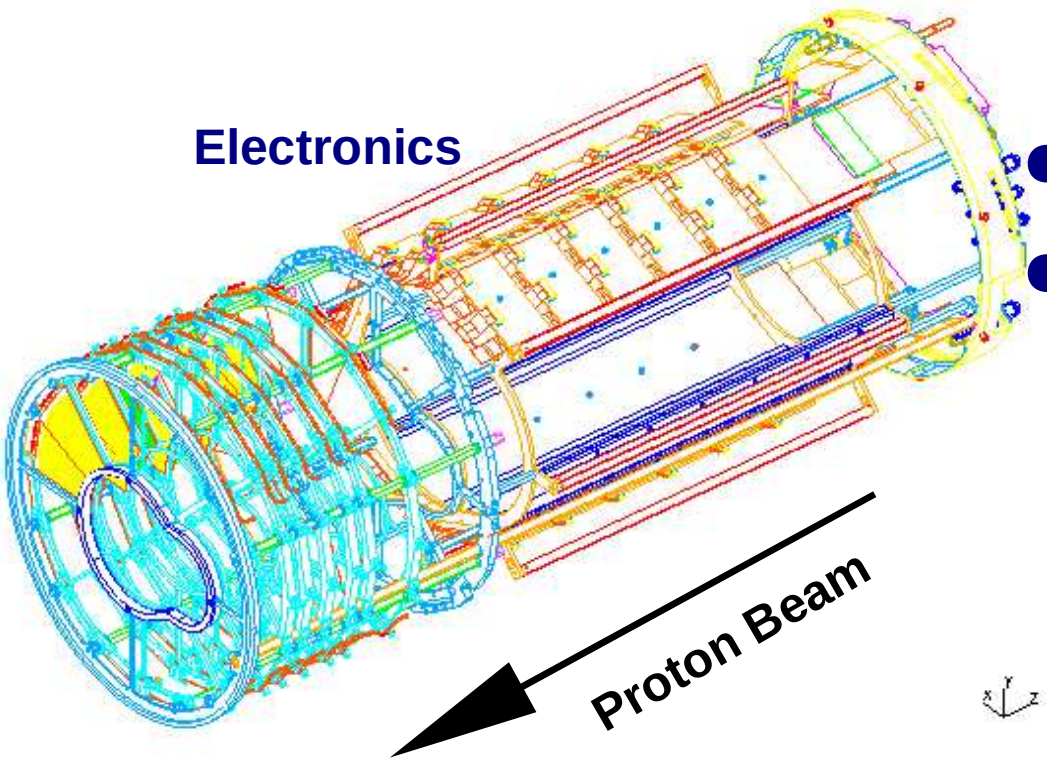
- BST:
  - Measure and trigger scattered electron at low angles: suppress fake electrons from $\pi^0 \rightarrow \gamma\gamma$
  - Generally low track density in backward direction



Separation of pions and elctrons by measuring energy E in the calorimeter and momentum p in BST.
D. Eckstein, DESY−THESIS−2002−8.

FST: Forward Silicon Tracker

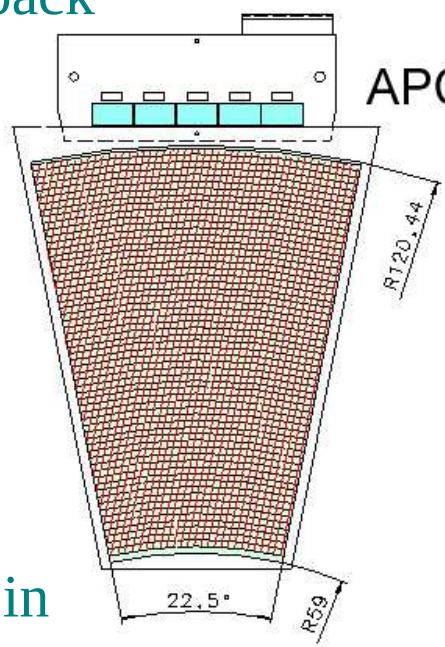
Collaboration of
DESY−Zeuthen, DESY, Prag, RAL



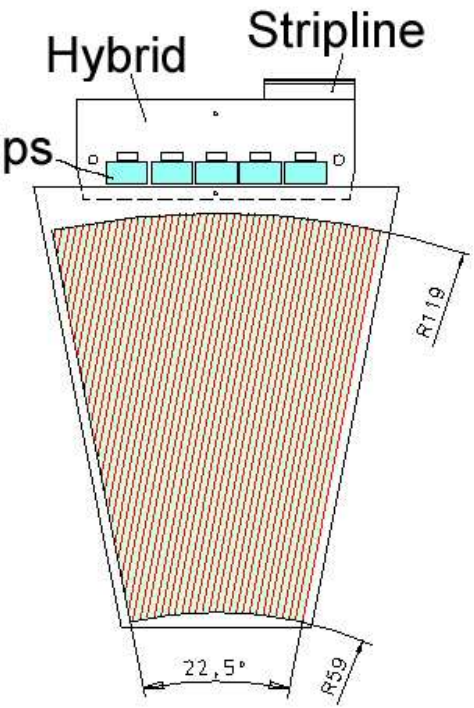
- 7 sensor wheels,
  2 types: u/v and r
- 3384cm^2 silicon
  - from CIS (Erfurt)
- 92160 channels
- Readout with APC
  (Analog Pipeline Chip)
  - developed at PSI
  - SACMOS: 1.2µm CMOS
  - Manufactured by Faselec

FST Sensor types

- 5 wheels with u/v coordinate:
  - single sided silicon, back−to−back
  - good signal/noise
- 2 wheels with r strips
  - single sided silicon
  - readout with 2nd metal layer
  - reasonable S/N
  - needed for pattern recognition in high multiplicity events (ambiguity resolution)

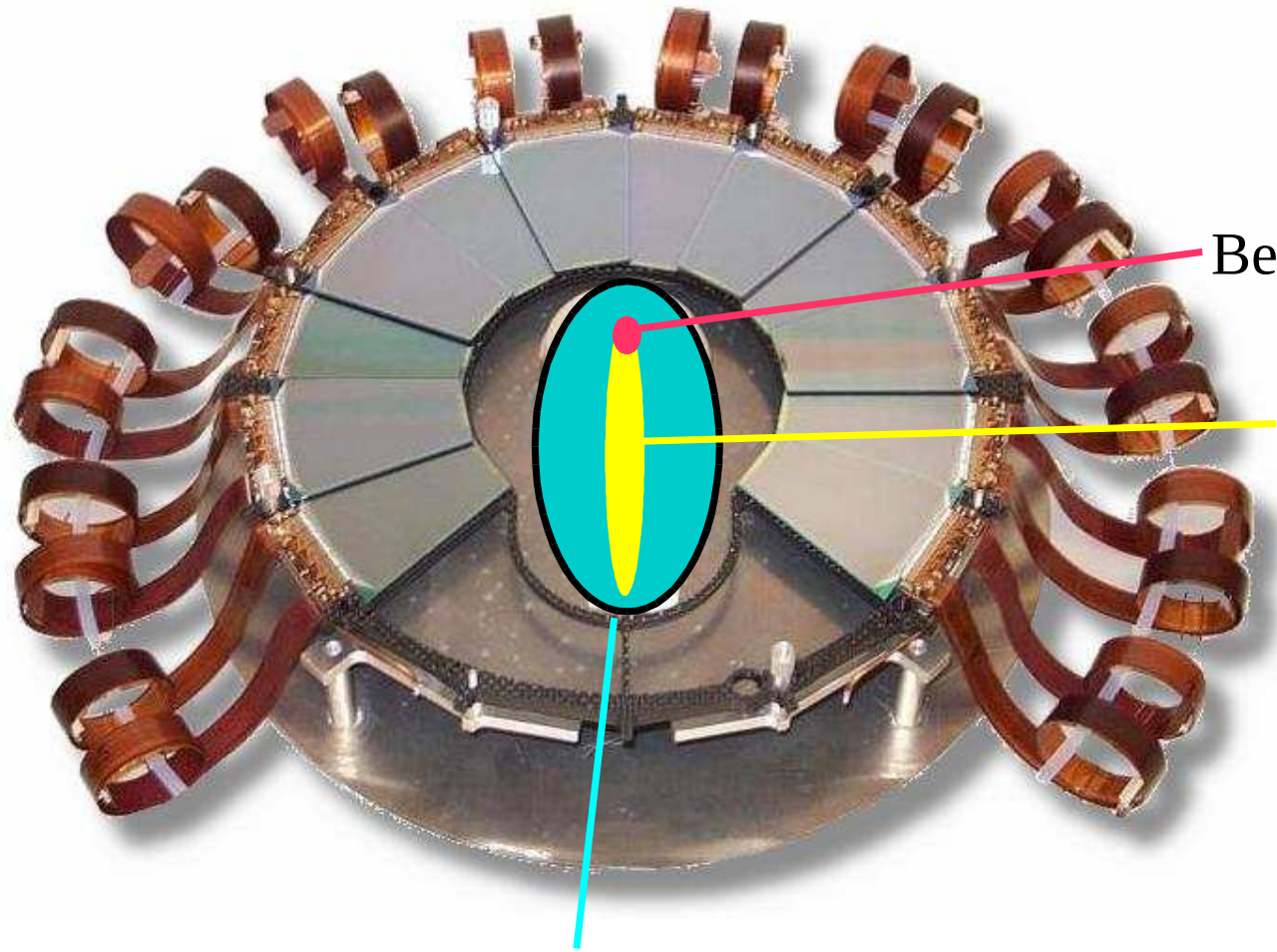


r sensors



u/v sensors

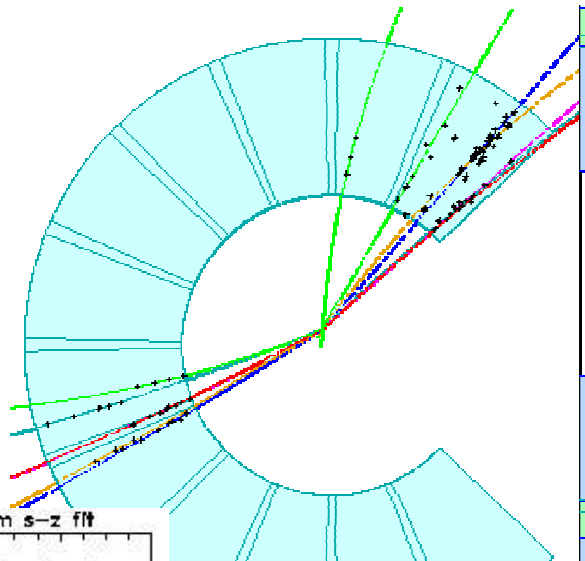
BST/FST Sensor Wheel

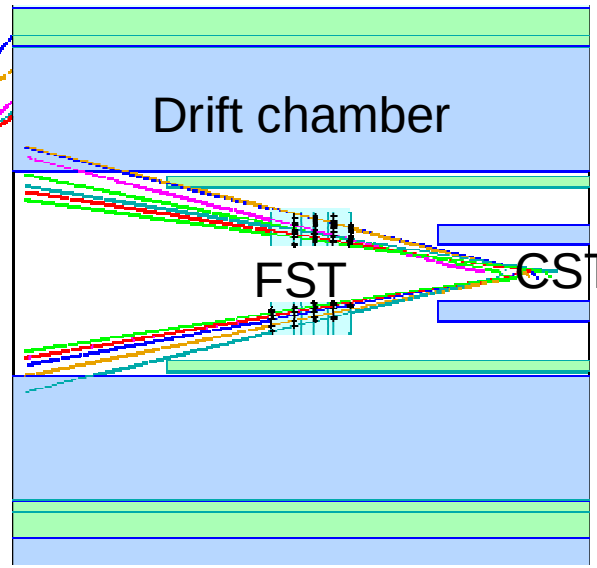


FST Performance

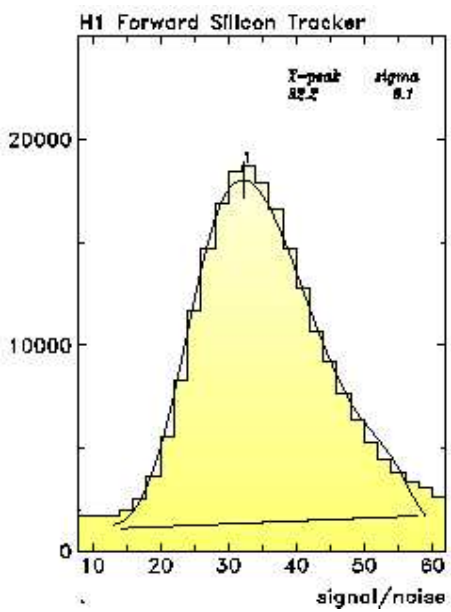
- Signal/Noise:
  - 30 for u/v detectors
  - 15 for r detectors
- Resolution 12µm (from triplet sagitta)

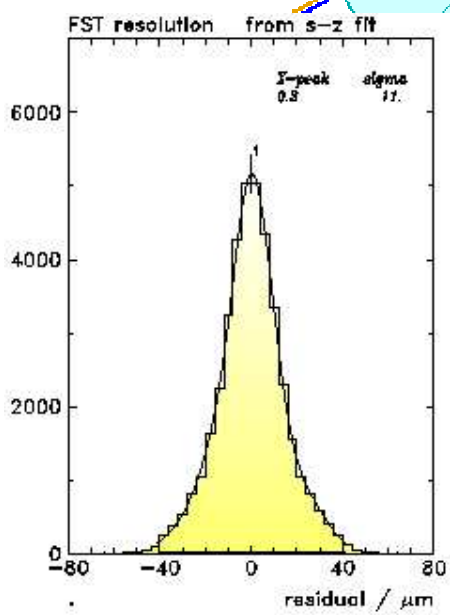
6 tracks in 1 ϕ sector



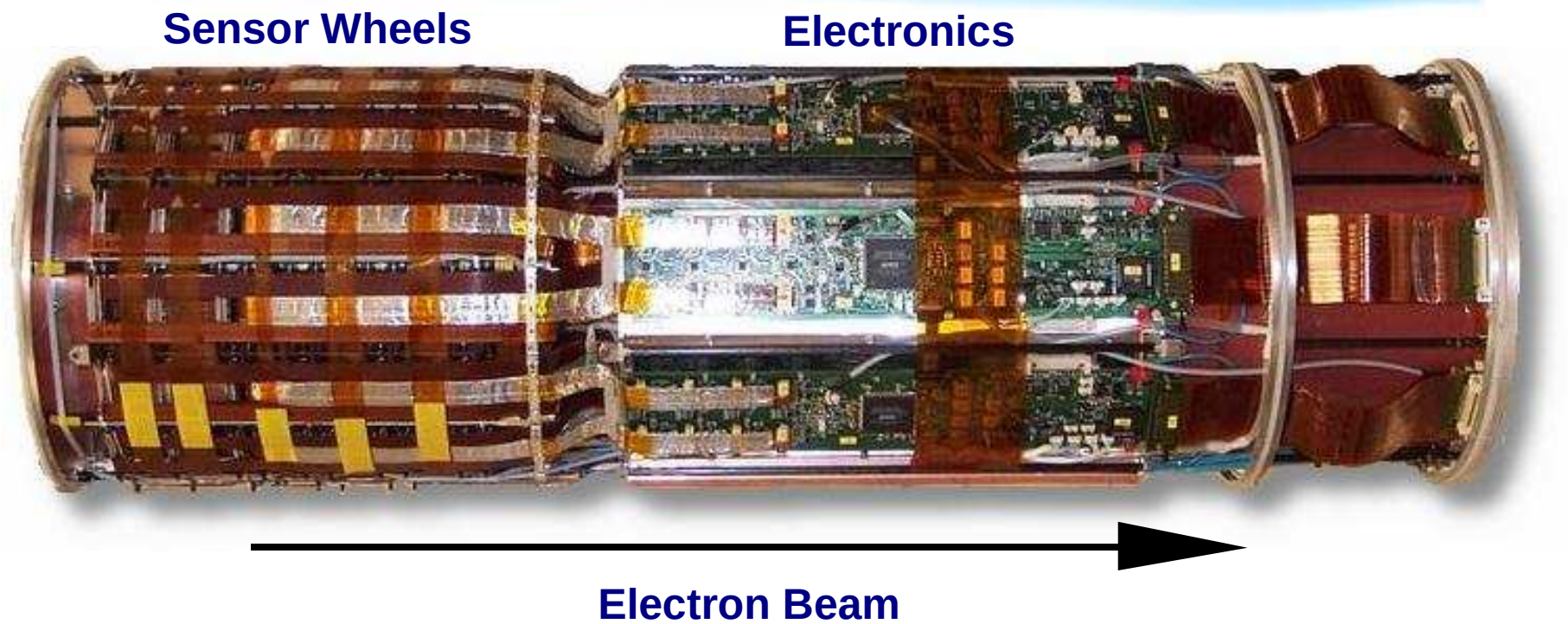


A multitrack event reconstructed in the FST





BST: Backward Silicon Tracker

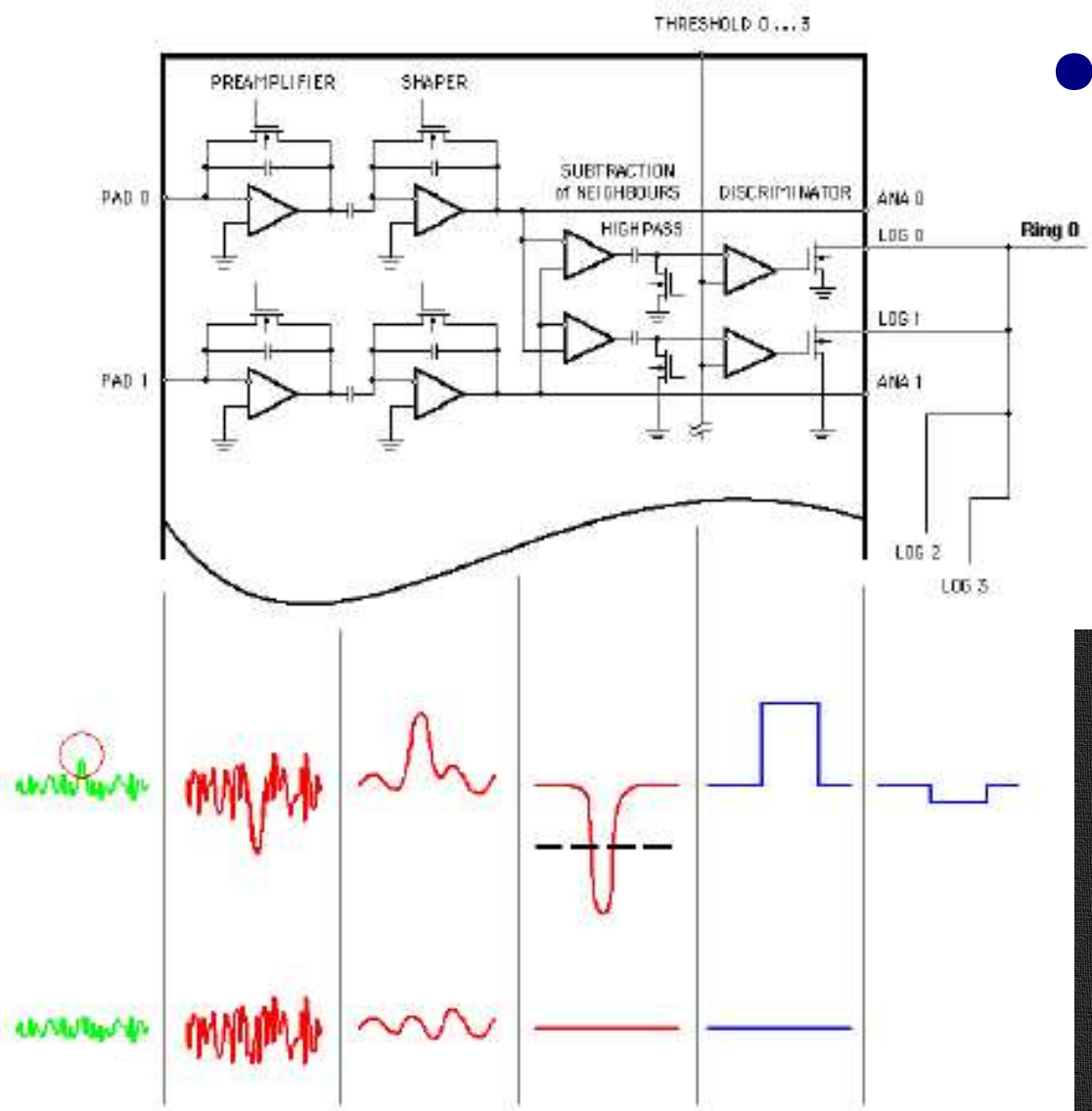


- 6 wheels with u/v coordinates, same as in FST: tracking
  - no r wheels needed, typically low multiplicity in backward direction
- 4 wheels with pad detectors: triggering
  - Hit detection + track finding done on frontend, at 10.4MHz

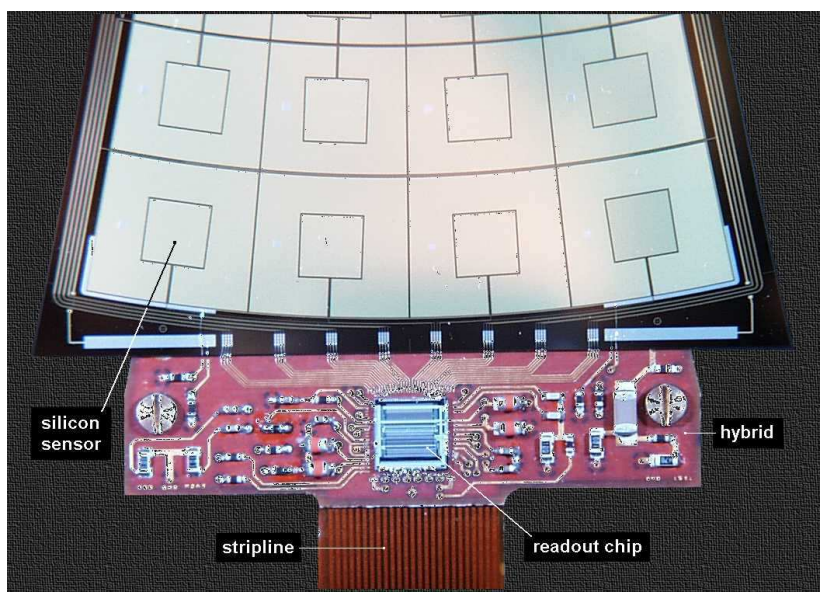
BST 1, 2, 3

- BST−1: Installed 1995:
  - 4 wheels of r detectors × 16 sensors = 64 sensors, 40960 channels
- BST−2: Upgrade 1998:
  - 4 + 4 wheels of r detectors × 16 sensors = 128 sensors, 81920 channels
  - 8 prototype ϕ sensors (u coordinate): 5120 channels
- Upgrade 2001:
  - 8 wheels of r detectors × 12 sensors = 96 sensors, 61440 channels
  - BST−Pad: 4 wheels of pad detectors × 12 sensors: 48 sensors, 1536 pads
- BST−3: Upgrade 2003:
  - 6 wheels of u/v detectors × 12 sensors = 132 sensors, 84480 channels
  - BST−Pad: 4 wheels of pad detectors × 12 sensors: 48 sensors, 1536 pads

BST Pad Hit Detection

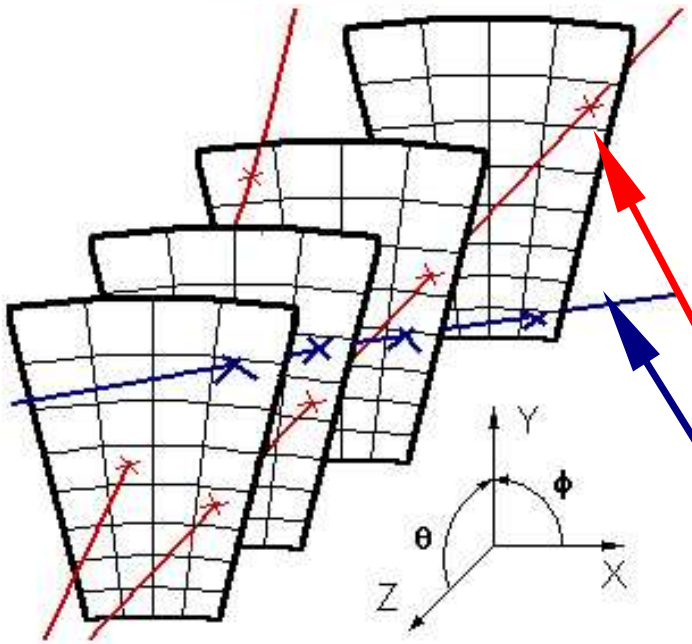


- ASIC PRO/A:
  - 1.2µm CMOS process
  - from IDE AS (Oslo)
  - 32 channels per chip
  - noise: 600e + 15e/pF
  - shaping time 30ns

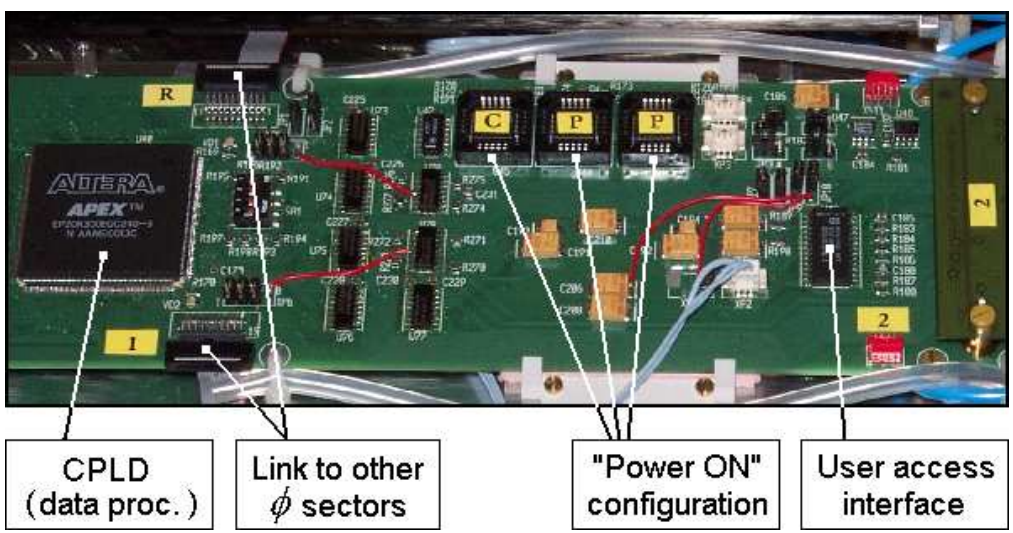


Pad sensors: 8×4=32 pads

BST Pad Trigger Concept

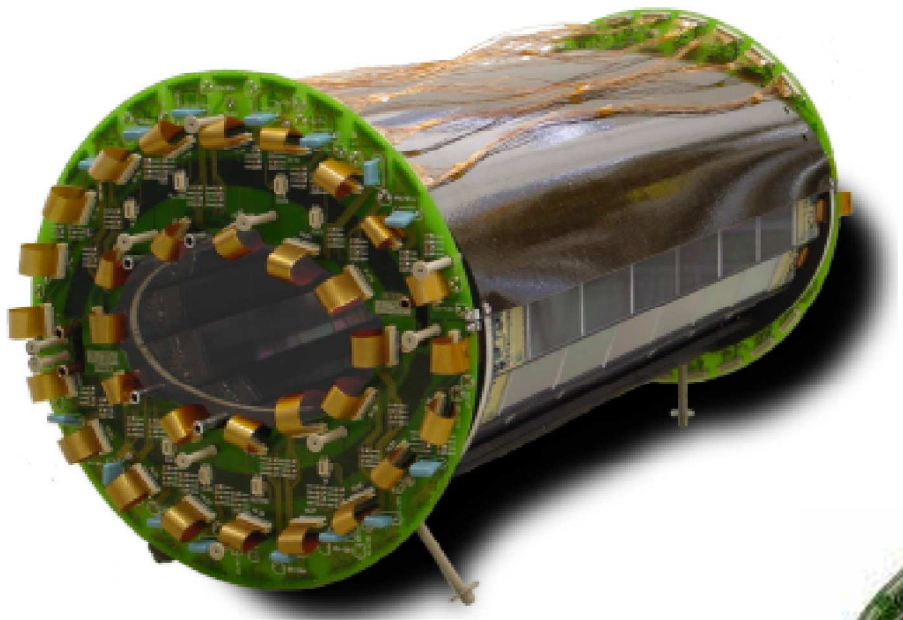


- One motherboard for 2 sectors (8 sensors), mounted directly behind sensor volume
- Complex Programmable Logig Devices (CPLDs) from ALTERA for trigger
  - Recognises tracks from IP
  - Rejects tracks from outside interaction region
  - Flexible, for shifted vertex runs

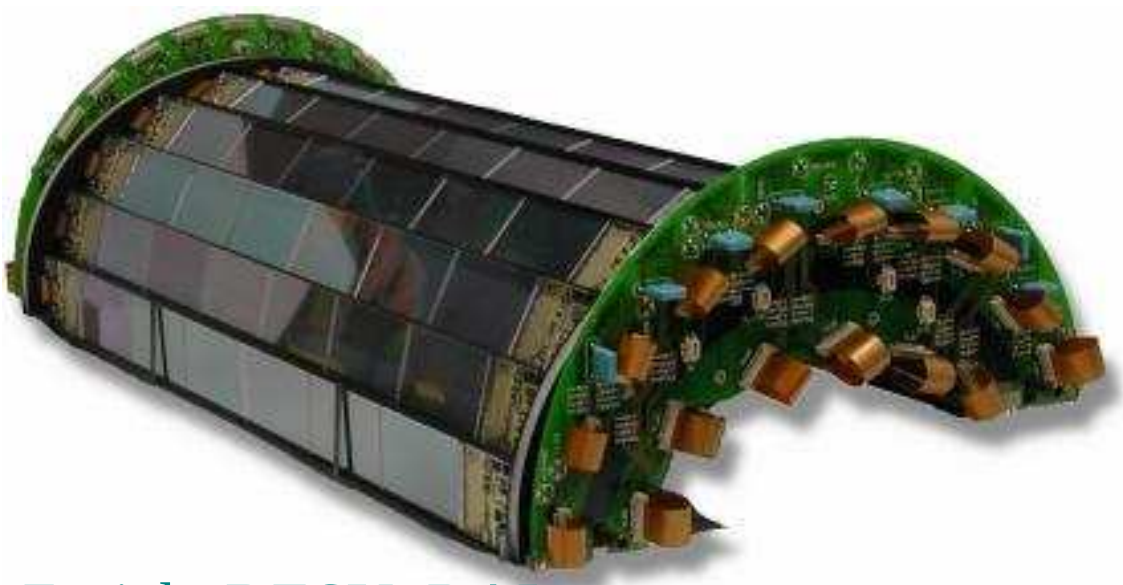


- Uses Content Adressable Memory (CAM) to compare hit patterns with predefined hit patterns from tracks

The CST



- 2 barrel layers, 12+20 ladders
- 192 sensors 3.4x5.9cm^2
- 3850cm^2 silicon
- 3 sensors read out together
- 81920 channels
- Very thin: 1.4% X_0 in radial direction

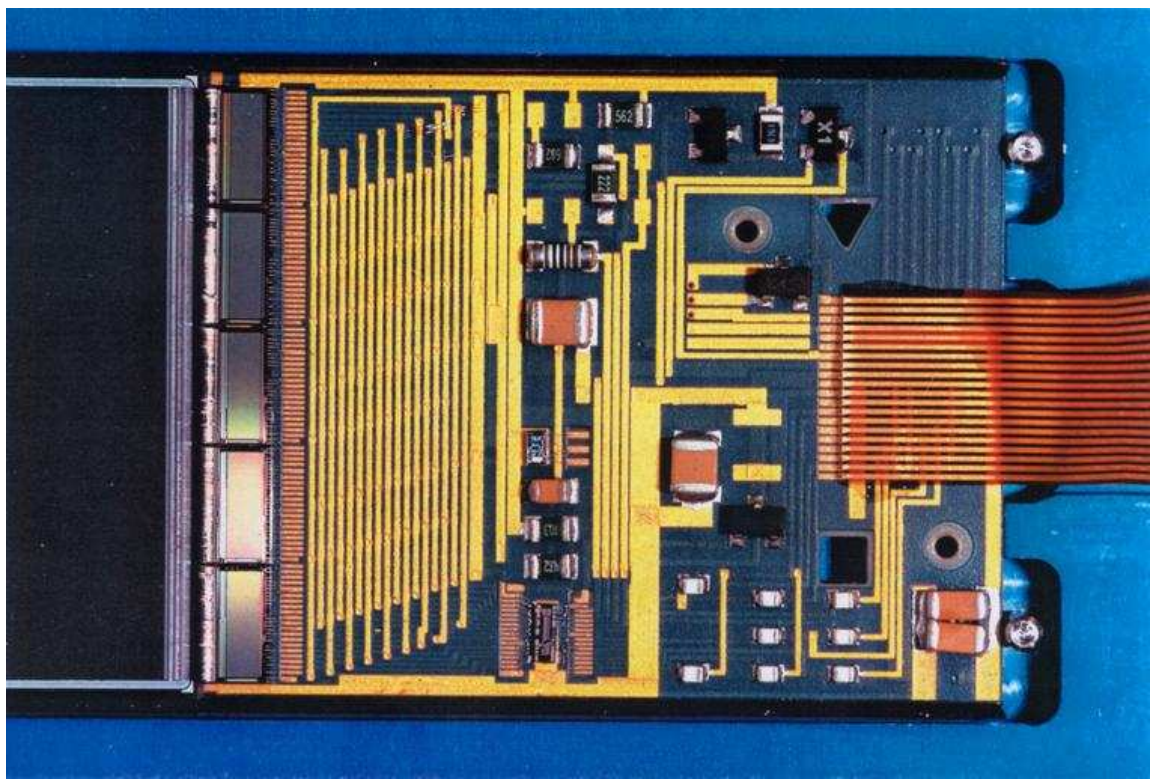


- Analog readout with rad−hard DMILL APC
  - ➢manufactured by ATMEL
- Optical signal transmission

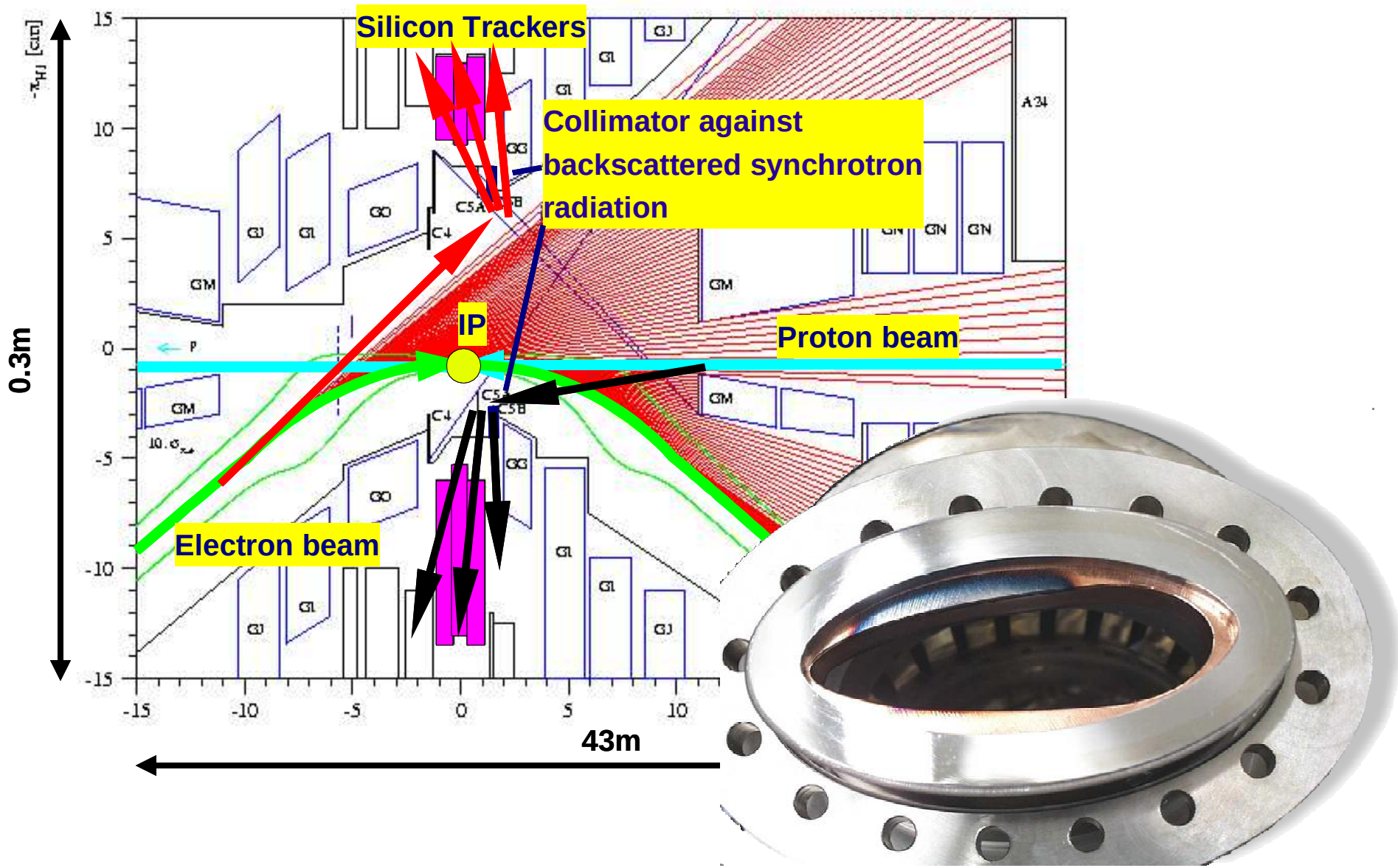
Built by ETH Zurich, PSI, Uni. Zurich, DESY, RAL

Shutdown Work on CST

- March−June 2003: 17 weeks shutdown
- CST: Repairs, upgrade to radhard readout:
  - Last 12 of 64 half ladders were equipped with radiation hard (DMILL) readout chips; now all CST readout ASICs are DMILL chips

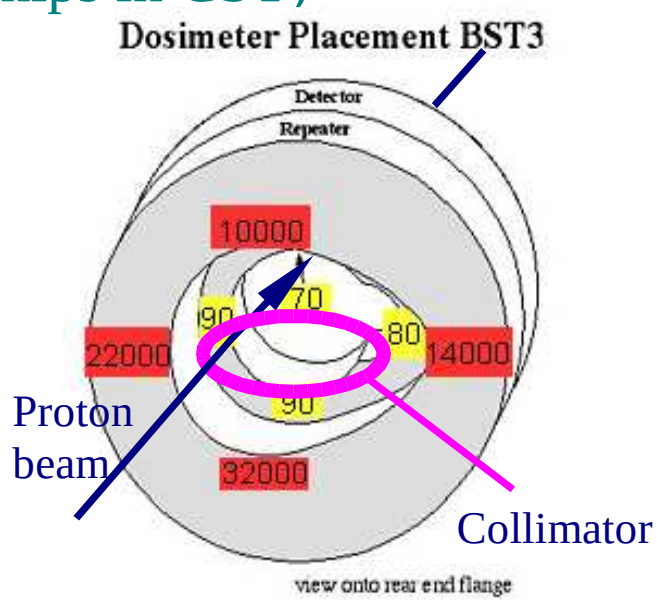


Backgrounds



Radiation Damage to BST

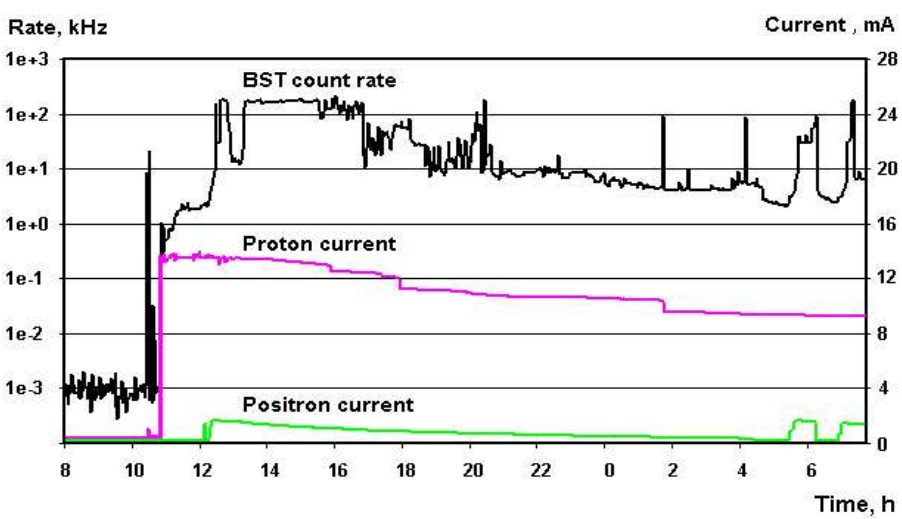
- Dosimeters in BST showed up to 30kGy of dose
- High dose only in small region at −z end (around collimator), FST, CST, forward region of BST received <100Gy
- Damages:
  - APC chips of BST: do not hold charge long enough (1ms) for readout (same problem lead to installation of radhard chips in CST)
  - BST slow control circuitry damaged
  - line receivers, drivers damaged
  - ALTERA CPLD chips survived!
  - Voltage regulators for CST damaged (located at same *z* position as BST electronics)

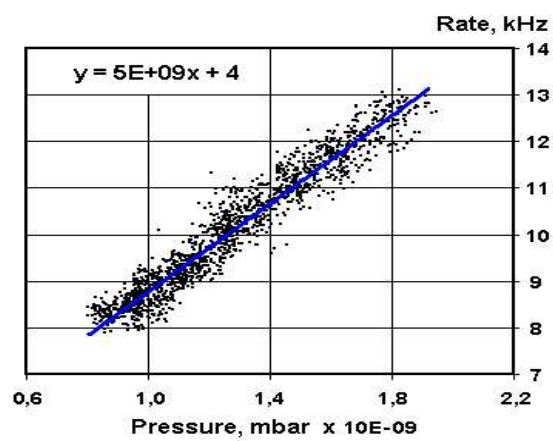


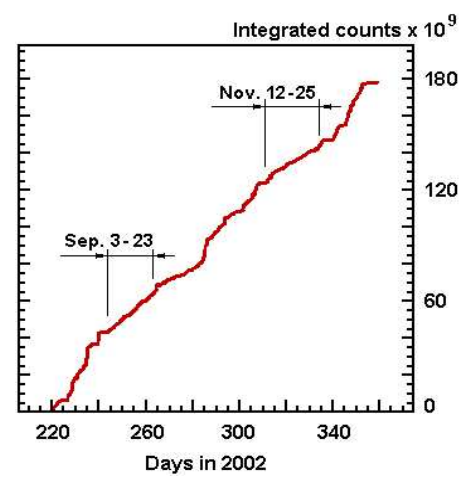
BST radiation doses in Gy

Beam optimization using BST Pad Rates

- Use single pad rate to monitor beam conditions
- Very useful for beam tunig
- Problem:
  - Large background spikes (from beam missteering) deprogram CPLDs
- This was an unforeseen application, shows advantage of CPLDs: can be easily adapted to new demands







Summary

- HERA−II had a slow start, but is now on track
- Radiation damage occured mainly from an incident where synchrotron radiation directly hit a collimator
- Normal operation of HERA leads to doses ~100Gy/y
- BST and CST have been repaired
- CST now fully equipped with DMILL chips
- Looking forward to next data taking