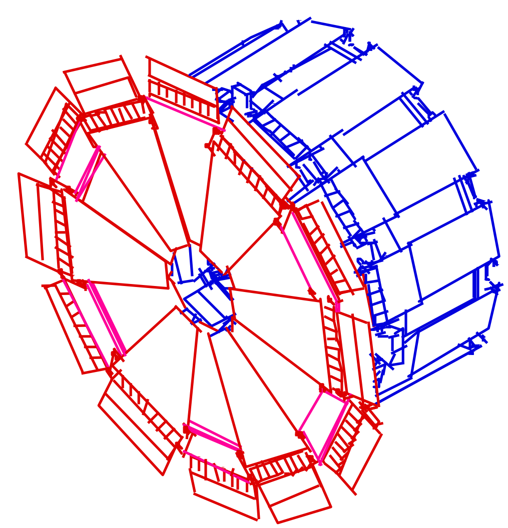
The D0 Silicon Tracker

Ronald Lipton, Fermilab
7th Vertex Conference, Rio

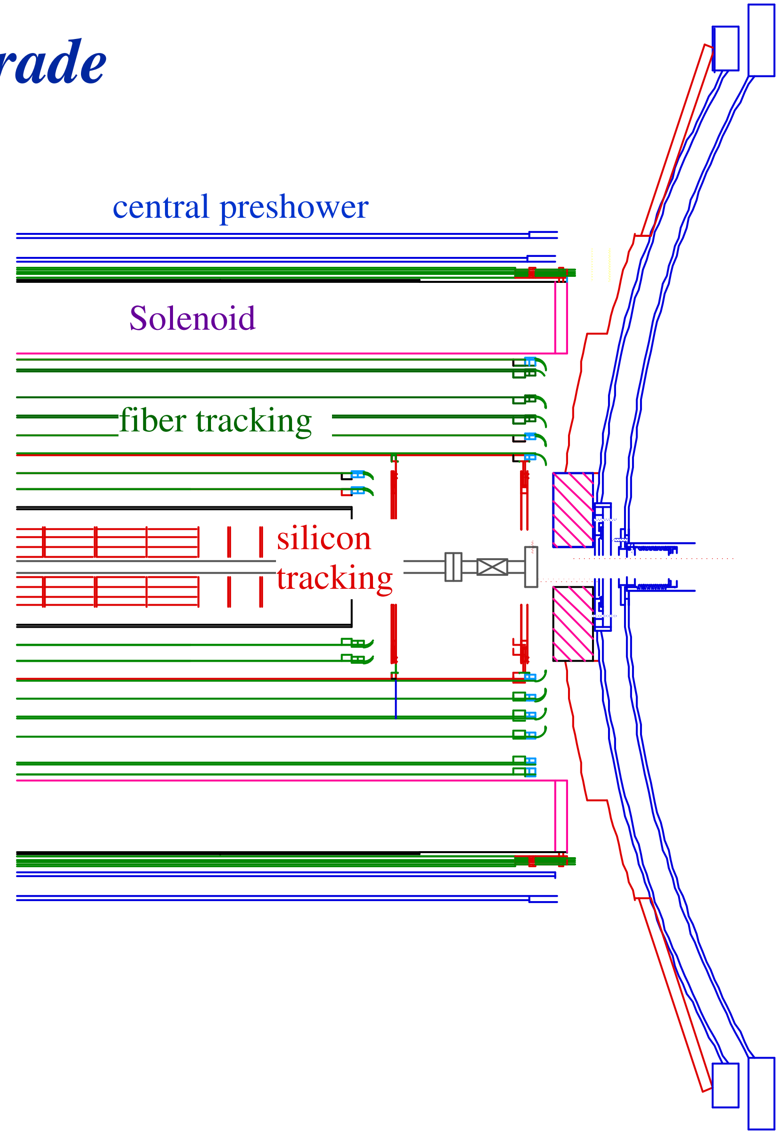


Outline:

- The D0 Silicon Tracker
- SVX II Chip
- Detectors
- Mechanical Assembly
- Status

D0 Upgrade

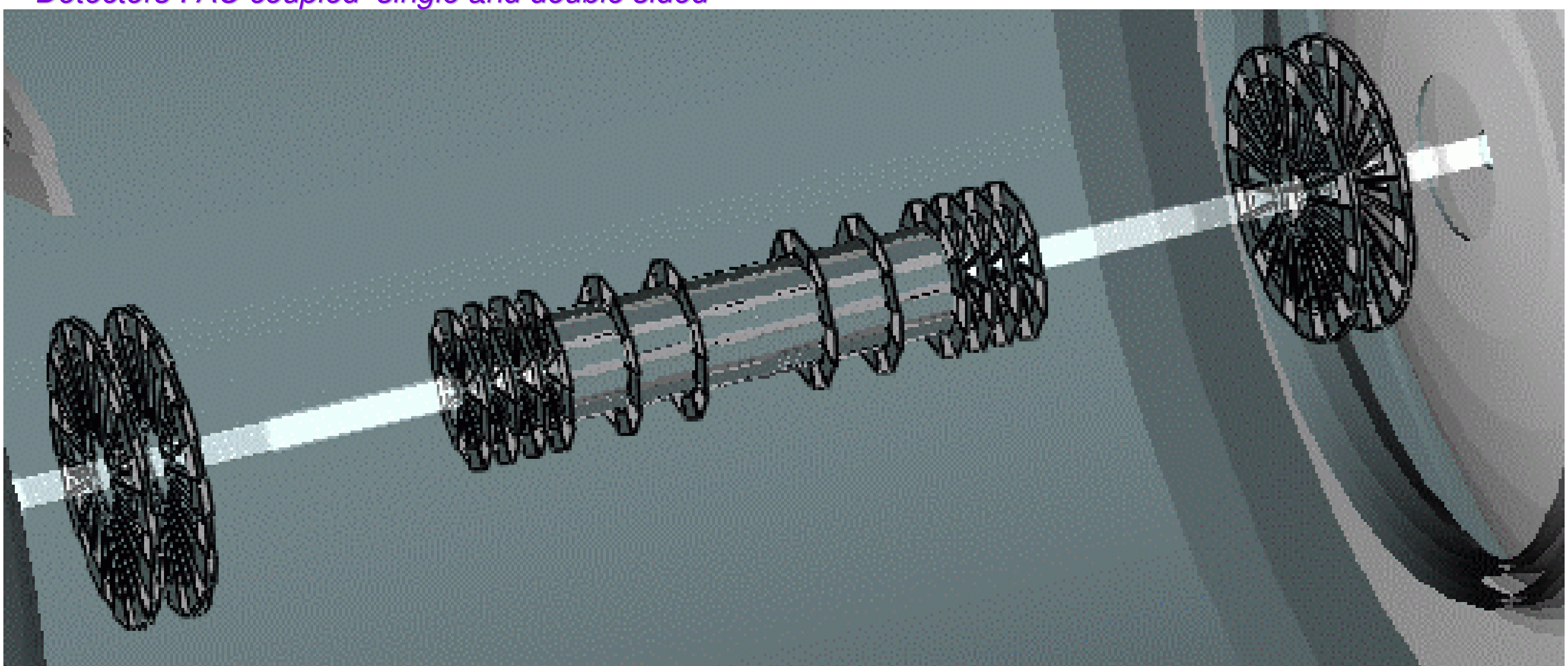
- Upgrade to accomodate 100x increase over D0 design Luminosity
- 2 Tesla Solenoid Magnet
- Silicon / fiber tracking system
  - 50 cm radial space
- Upgraded muon system
- VLPC based forward/central preshowers
- New calorimeter electronics
- Upgrades to trigger and DAQ
- Ready for 1999 main injector run



- 132 and 396 ns bunch spacing
- Luminosity 4-30?? fb^{-1}

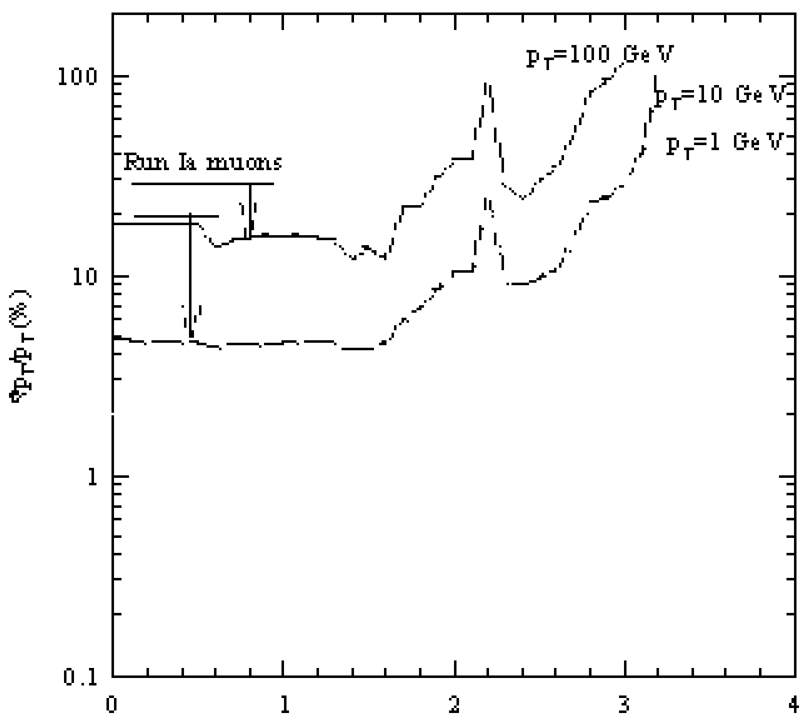
Design

- Large (25cm σ) interaction region drives design
- Good acceptance for high Pt (top ...) - long barrel length
- Silicon based tracking /vertexing for $2 < \eta < 3$ - good forward coverage
- Six 12 cm disk/barrel modules
- Four layers $(r\phi,90^o),(r\phi,2^o),(r\phi,90^o),(r\phi,2^o)$
- Interspersed disks ($\pm$ 15 ^{o}) - forward tracking
- External large area disks ($\pm 7.5^o$) for momentum resolution
- ~ 800,000 channels
- SVX II readout chip
- Detectors : AC coupled single and double sided



Design II

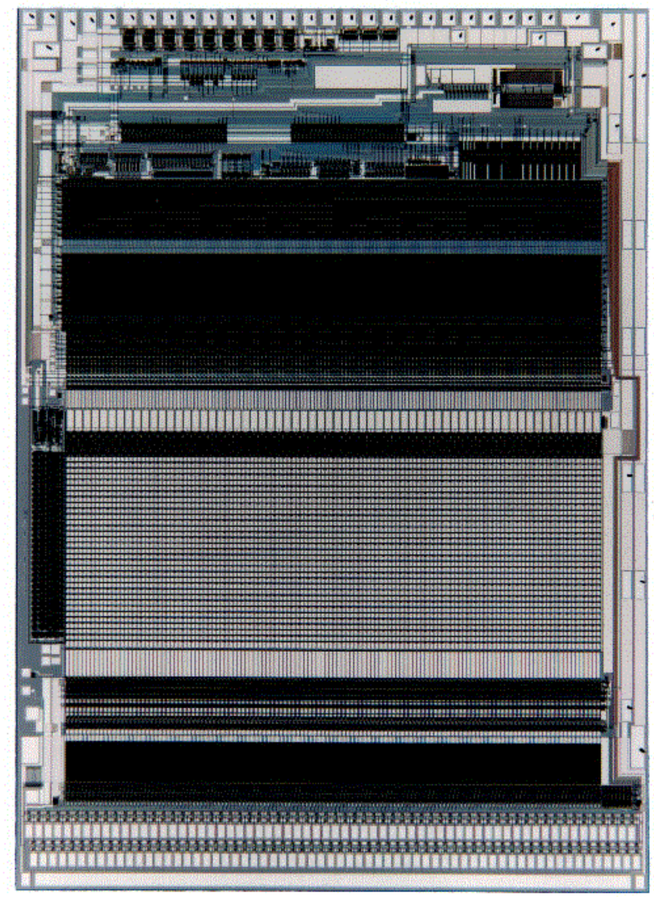
- Disk/Barrel design provides tracking to η=3
- Large area H disks
- Minimize inter-module gaps
  - inboard electronics
  - inboard cable routing
    - 8 sublayers
    - large overlap
  - thin disk modules
- Large overlap among 8 sublayers
  - 5.5 hits/track at η=0
- 2-3 µm variation in IP resolution and hit # with phi



SVX II Chip

The SVX II is a 1.2µm CMOS amplifier / analog delay / ADC chip. Fabricated in the UTMC rad hard process.

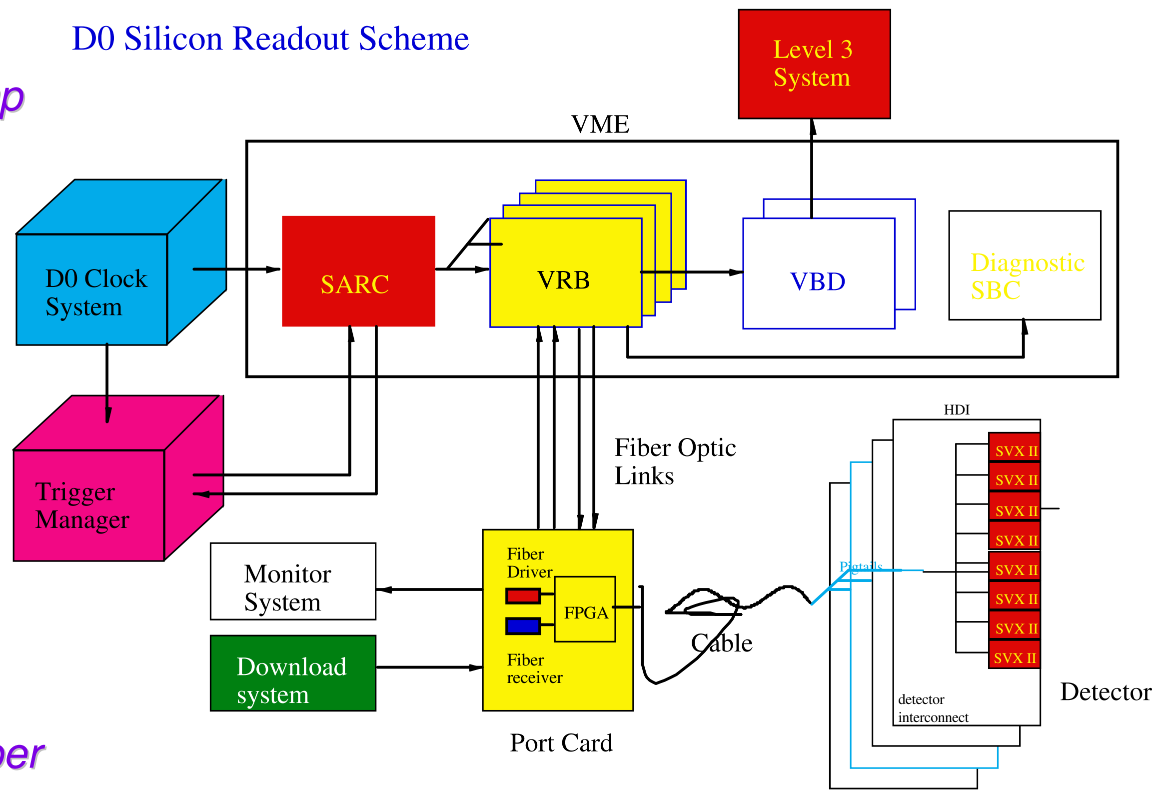
- *LBL / Fermilab group (Milgrome / Yarema)*
- *Features:*
  - *32 cell pipeline*
  - *Programmable test pattern, ADC ramp, pedestal, bandwidth, calibration , polarity*
  - *53 MHz readout+digitization*
  - *~ 6.4 x 9.7 mm*
  - *5 mW / channel*
- *Chips are FINISHED and TESTED*
  - *77 % pass on-line digital tests*
  - *64 % pass off line analog analysis*
  - *Additional 10% loss with “narrow” dicing*



SVX II / Readout system

- Operation at 53 (106) Mhz is tricky
  - Match impedances carefully - no short stubs
  - plenty of close bypassing (ramp ref)
  - properly timed data strobes
  - clock noise
- Problems
  - misplaced bonds
  - damaged bonds
  - vaporized DVDD bonds by operation in the wrong mode
    - install fuses
    - Chips not damaged
  - Flat pedestal achieved by proper bypassing of AVDD
- Black hole “fix” installed

D0 Silicon Readout Scheme



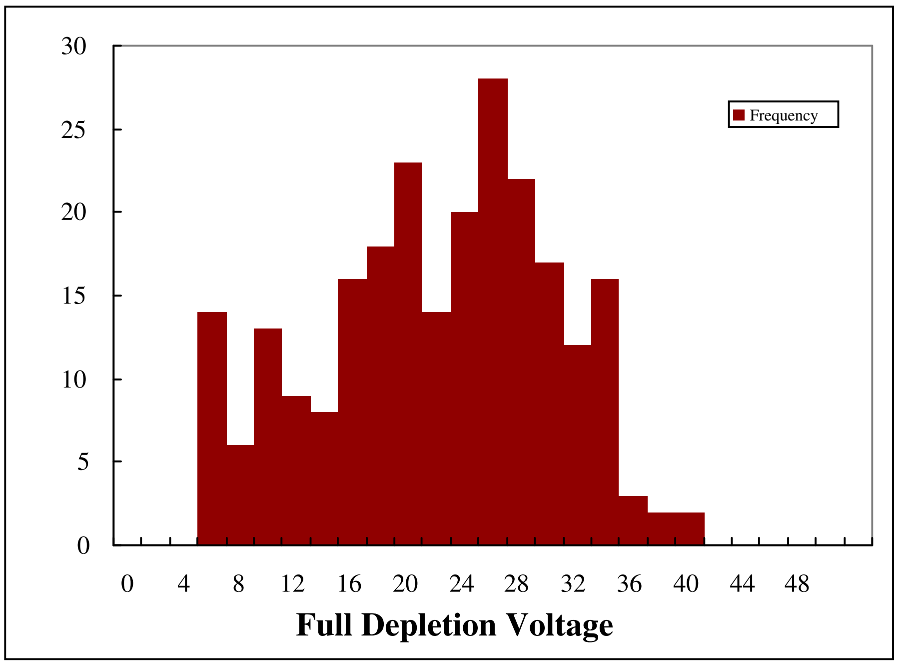
Disk Detectors

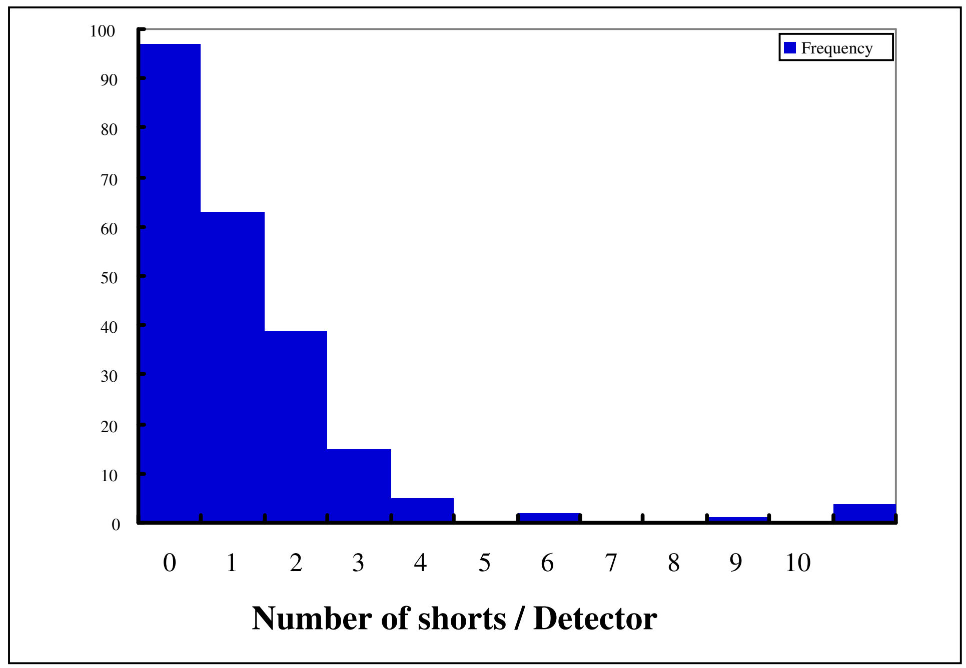
- F - Disk detectors (144)
  - Properties:
    - Double sided wedges
    - 50µm(p) and 62.5 µm(n) pitch
    - variable strip length - no inter-detector bonds
  - Status:
    - Under production at Micron

- H Disk detectors (384)
  - Properties:
    - readout pitch= 80 µm, strip pitch= 40 µm
    - single sided, AC coupled wedges (back-to-back assembly)
- Status:
  - Vendor (Elma) qualified last Fall
  - Production detectors received in Moscow

Barrel Detectors

- Single sided barrel detectors (144)
  - Properties:
    - Single sided AC coupled
    - 50 µm pitch
  - Status:
  - All detectors received
  - ~ all tested, 75% yield @99.5% good strips



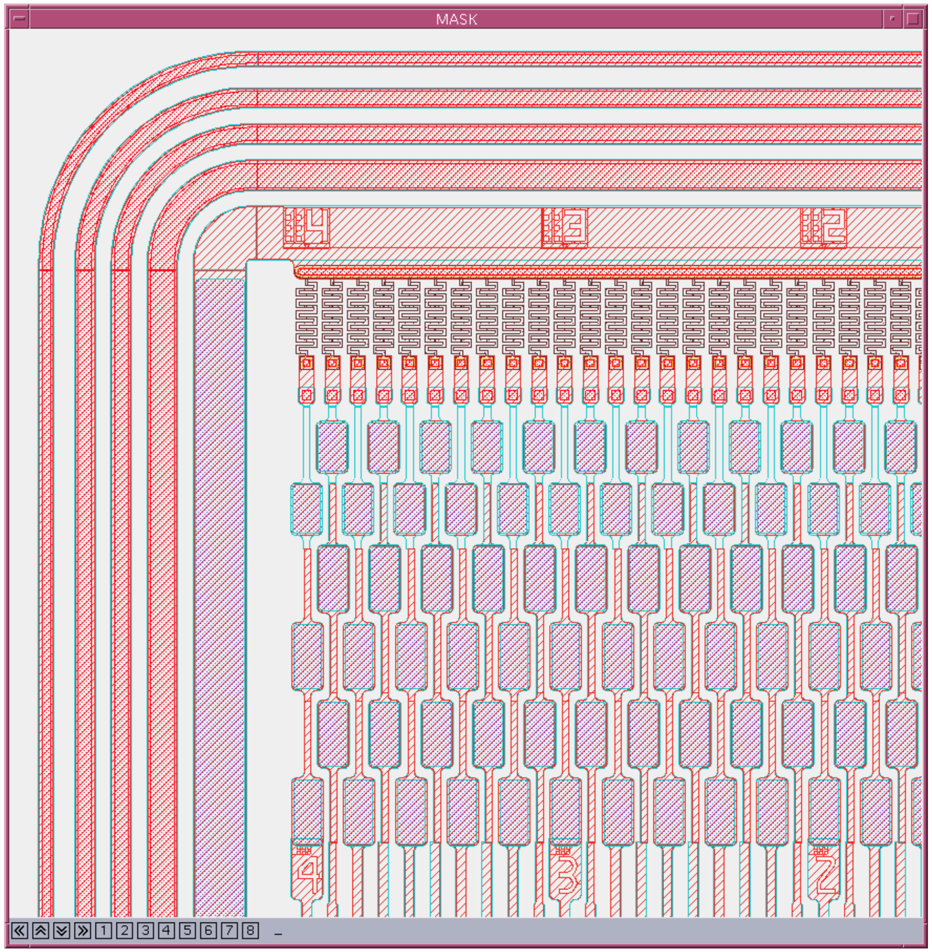


Barrel Detectors II

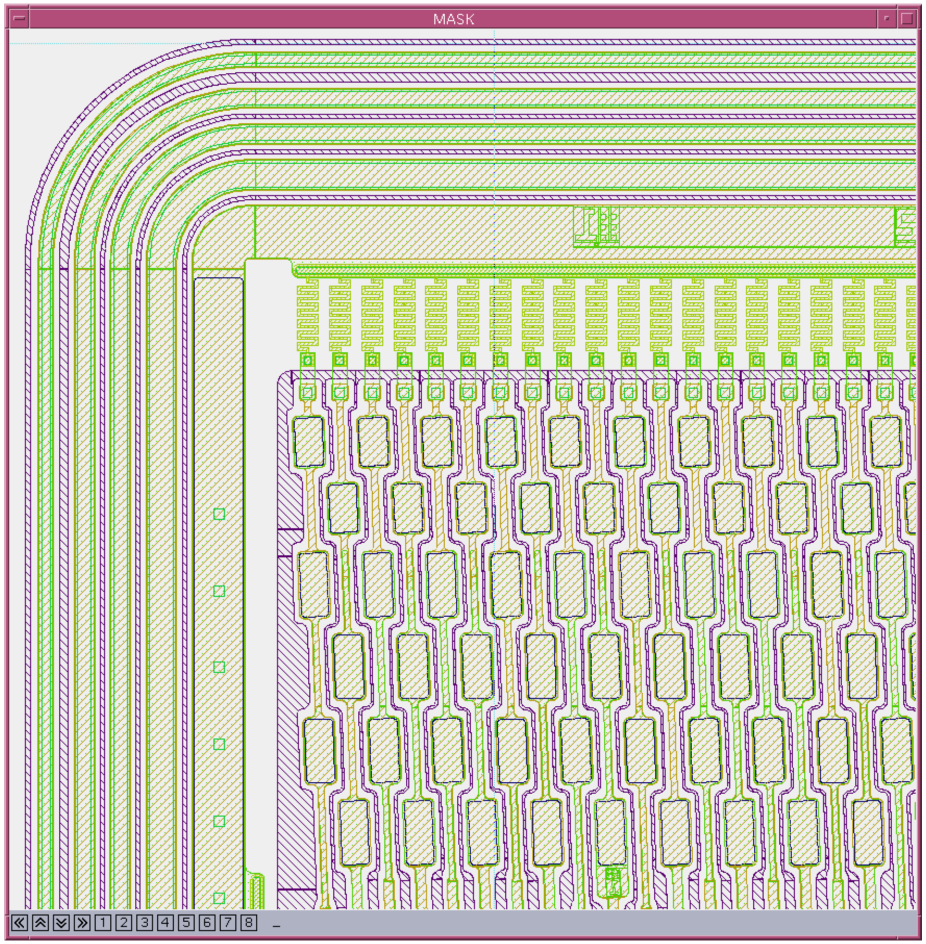
- 2 degree stereo barrel detectors (336)
  - Properties:
    - Double sided
    - 50µm(p) and 62.5 µm(n) pitch
  - Status:
    - Masks complete 9/96
    - Failed processing at passivation step
      - Atlas guard ring design
      - test structures also fail
    - deep implant wafers now being processed
    - Real cause for failures unknown ...
- 90 degree stereo barrel detectors (288)
  - Properties:
    - Double sided double metal, 6" technology
    - 50µm(p) and 156µm(n) pitch
  - Status:
    - Mask design underway

DS Barrel Mask

p side



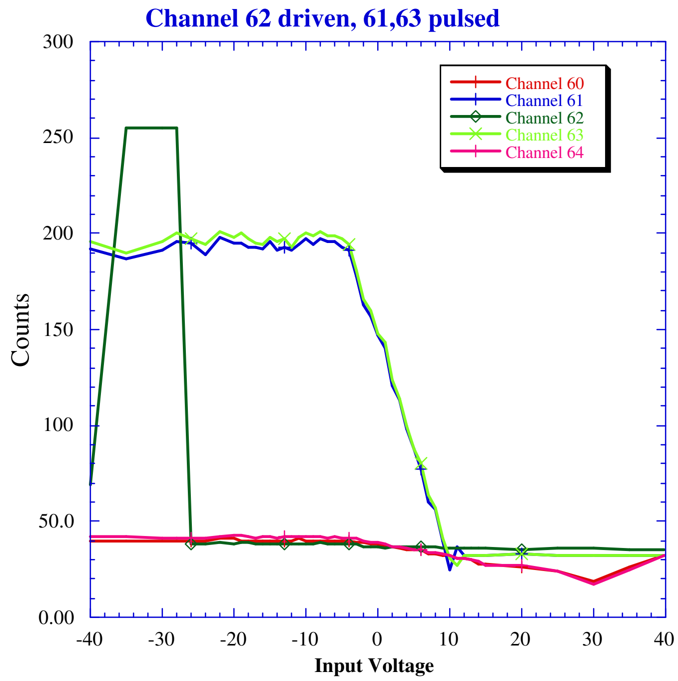
n side

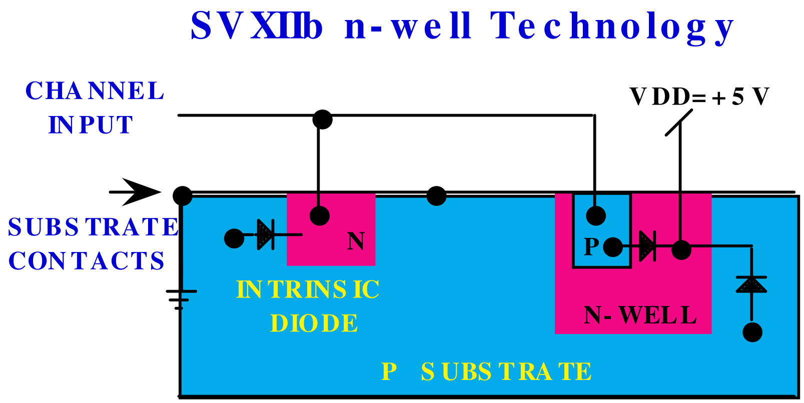


Black Holes

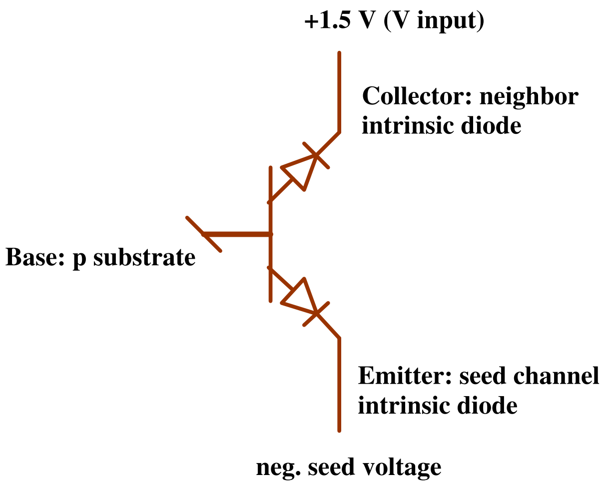
Areas of strips affected by large leakage currents or shorted capacitors

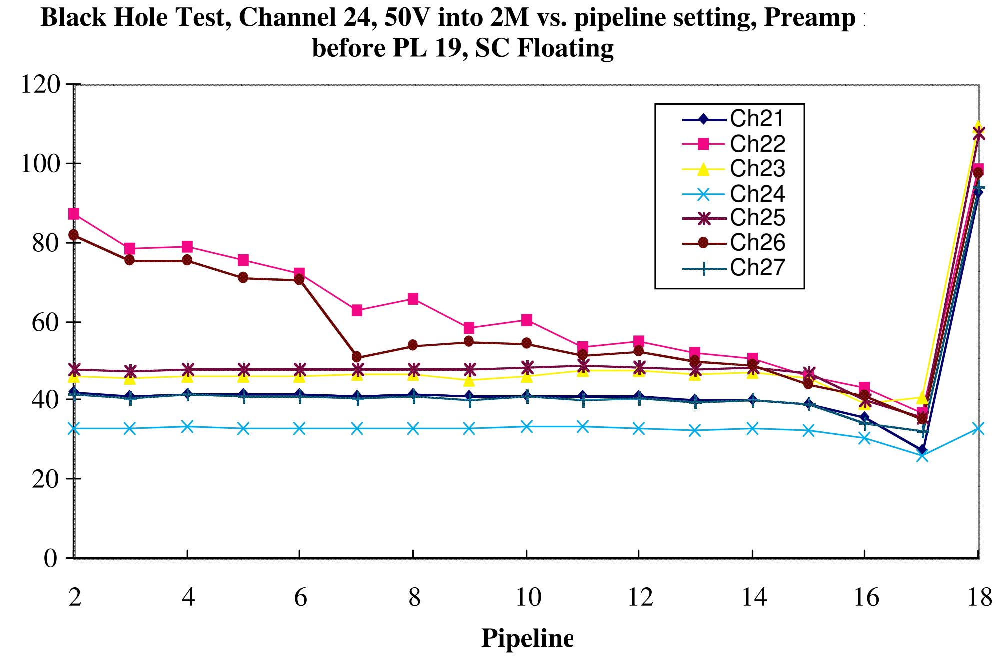
- *Simulate shorted coupling capacitor using chip bonded to detector*
  - *Source is chip - not detector*
- *Effect depends on current polarity and chip technology*
  - *Problem with + V in n-well*
  - *Problem with - V in p-well*
- *Effected area proportional to current*
- *Source of the problem: Saturated amp forces input to rail, turning on protection diodes. In p-well process current is dumped to substrate and diffuses to the neighbor channel. This forms the base junction of a parasitic transistor - forcing the neighbor into saturation.*

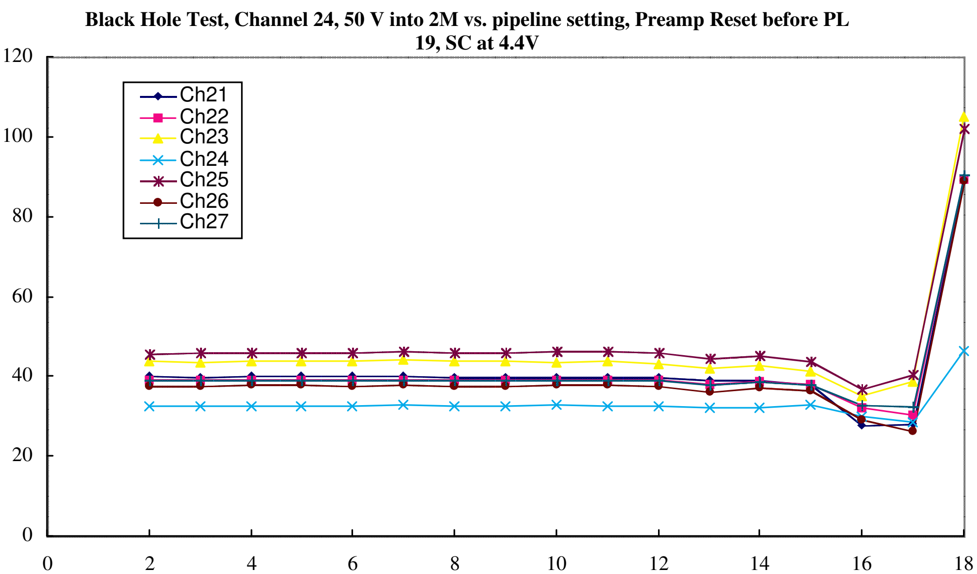




Black Holes III



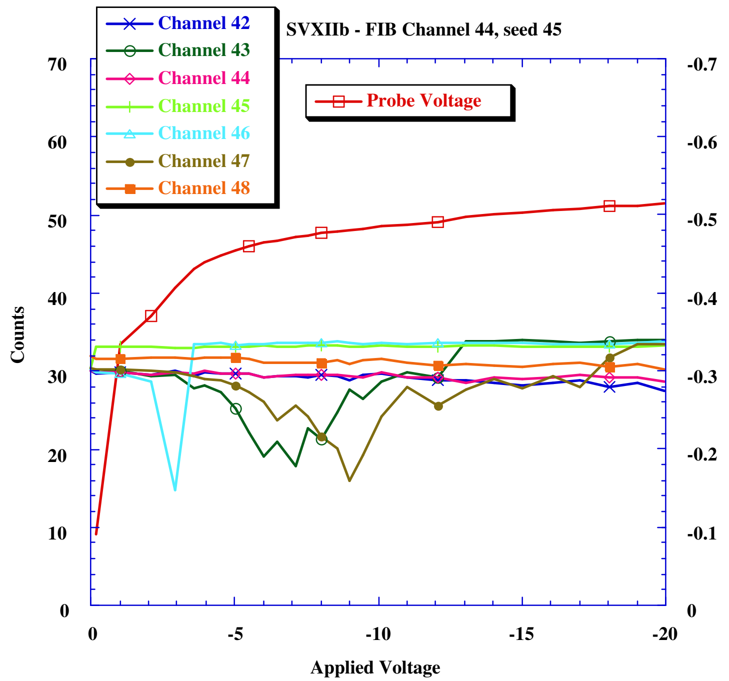




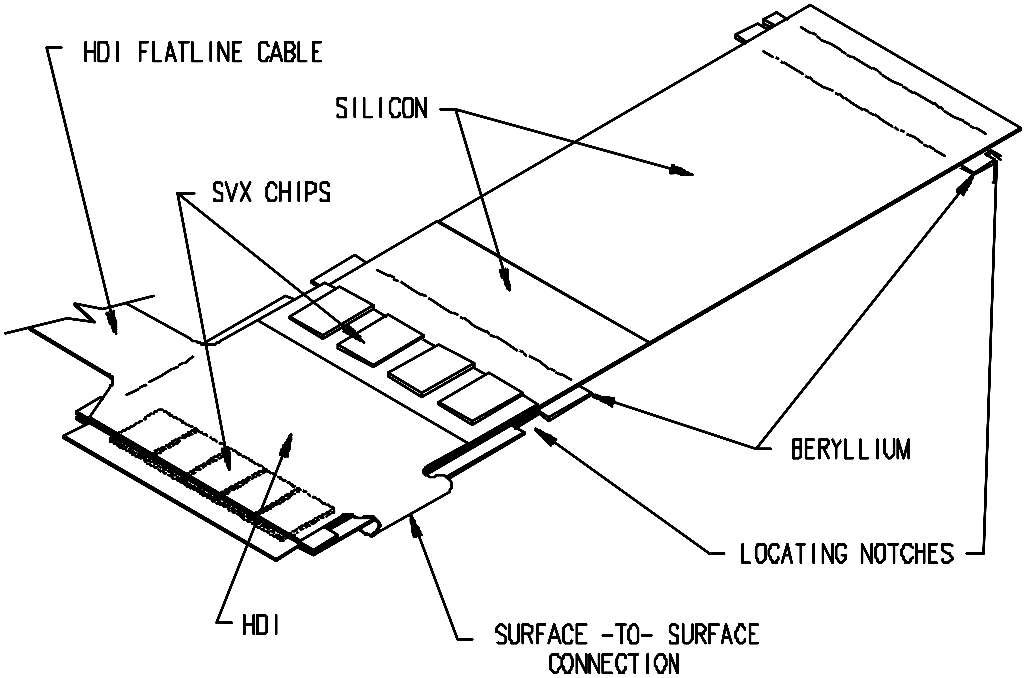
- *Rad hard submission - add a well diode to 4.4 V to shunt current away from substrate - black holes dissappear*

Black Holes II

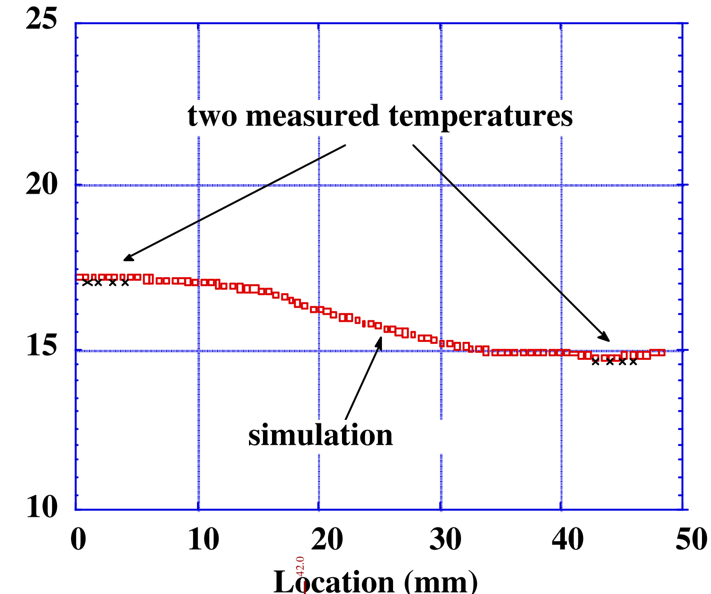
- *Focussed ion beam - cut out and bypass diode*

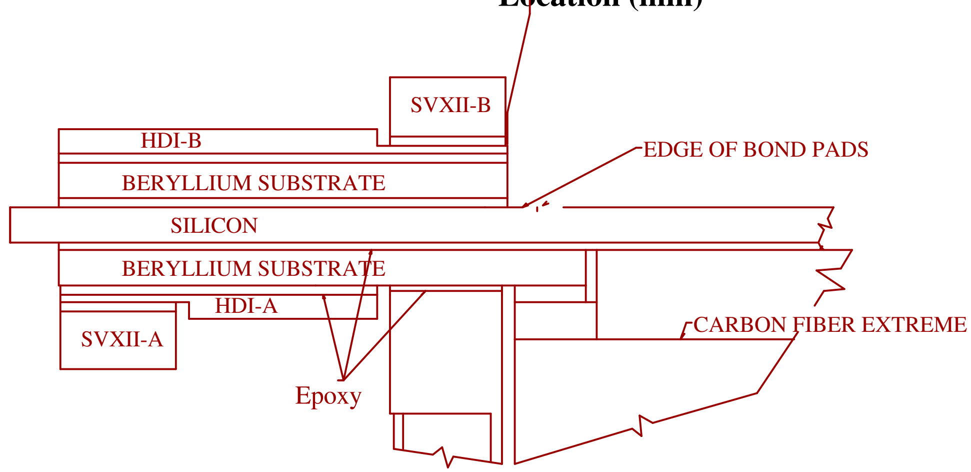


Ladder thermal design and mechanical assembly

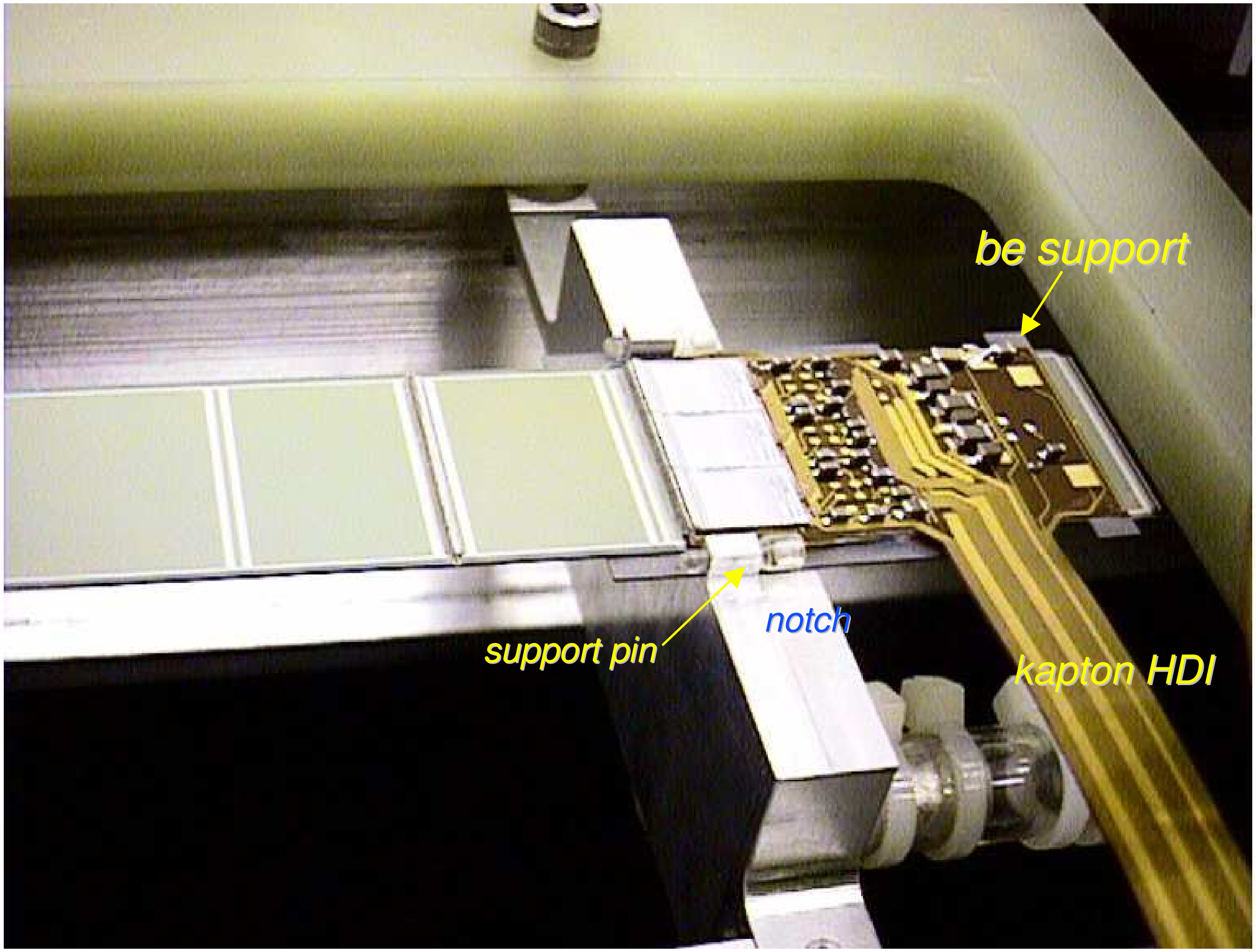


5 degree water



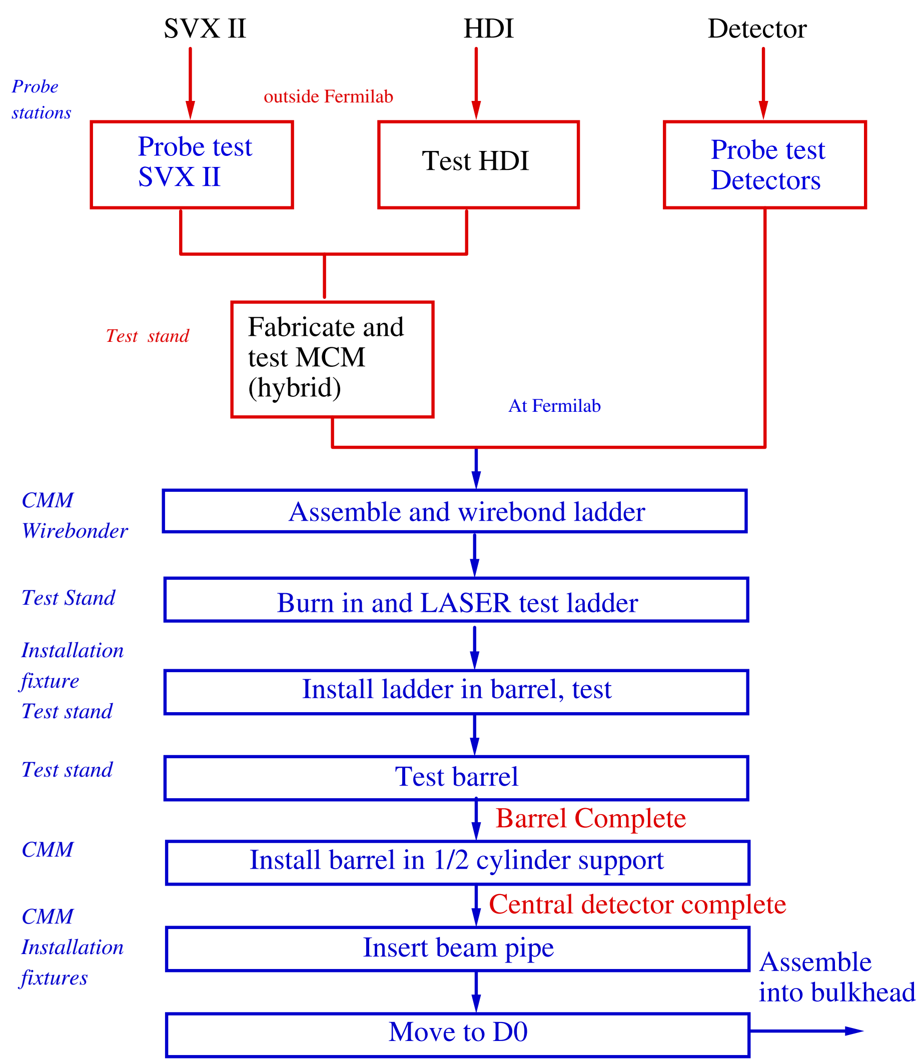


D0 Ladder

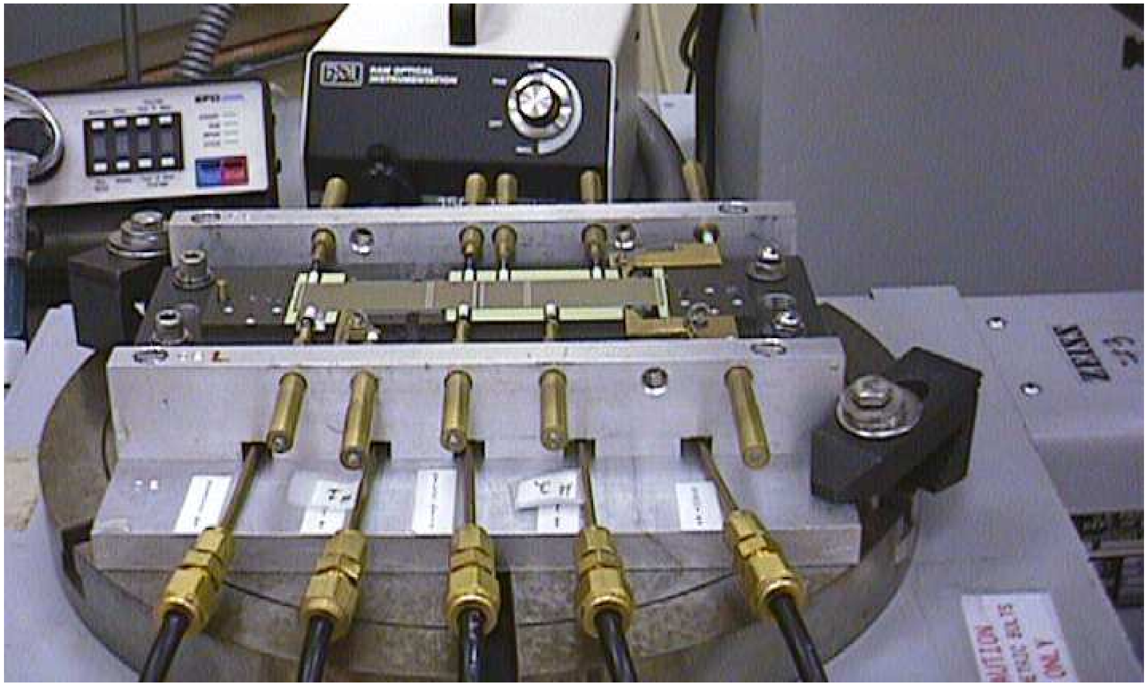


Be heat spreaders
2 layer kapton HDI
pins

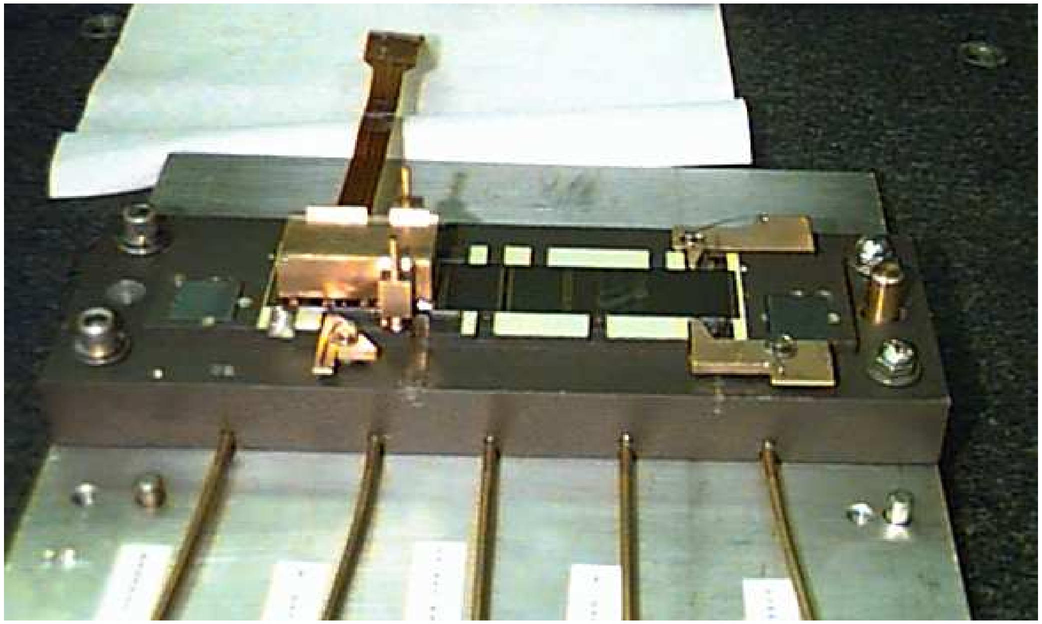
Tracker Fabrication



Ladder Fabrication



Production fixture on Zeiss CMM



Completed ladder with pigtail

Mechanical Design Features

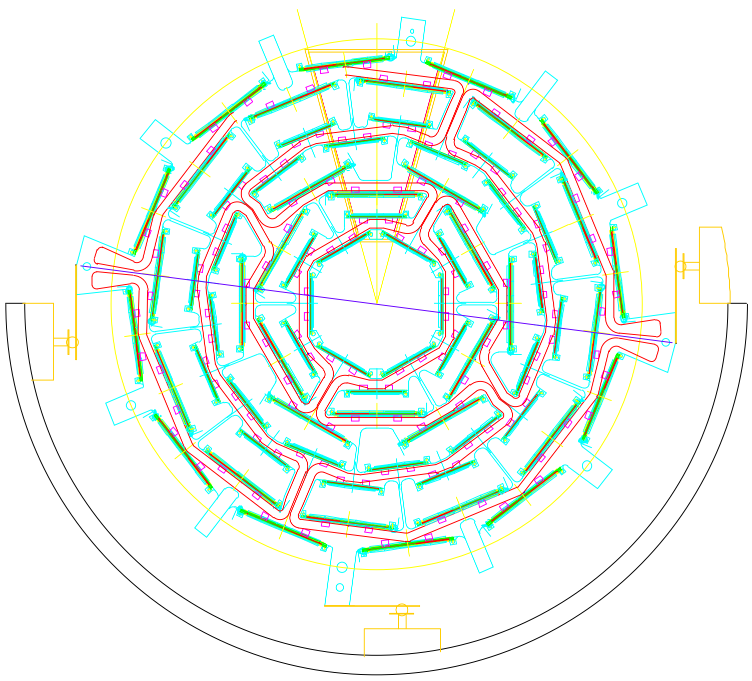
- *Barrels*
  - *Active (cooled) and passive bulkheads*
  - *Small (2mm) disk-barrel gap*
  - *Alignment using machined posts/notches on bulkheads/ladders*
  - *Ladder assembly to 2-3 µm on Zeiss CMM*
  - *passive bulkhead supported by ladders from active*
  - *“Removable” ladders pinned into position*
  - *Assembled ladders measured by optical automatic CMM*
  - *All cables within active area*
  - *Water cooled (to -10 deg C)*
  - *Design requires:*
    - *Precise machining of bulkheads and heat spreaders*
    - *Precise matching of active and passive bulkheads*
    - *flexible HDI “tails”*

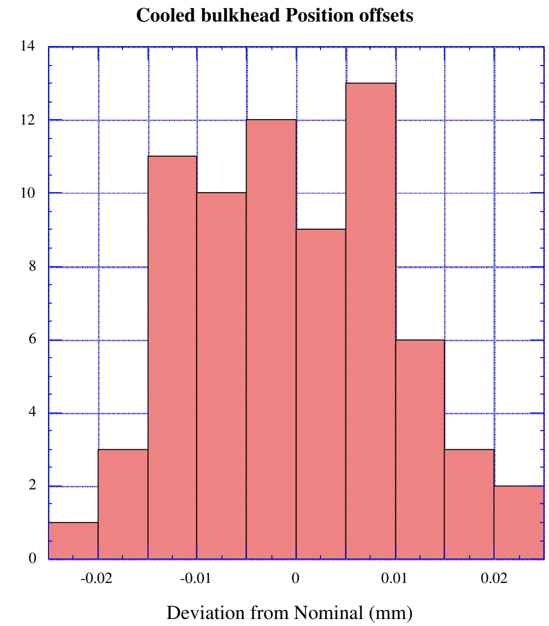
Mechanical Design Features

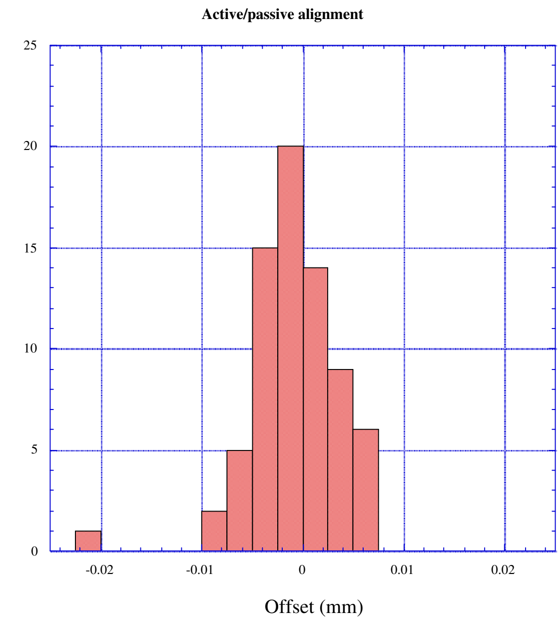
- *Disks*
  - *F disks*
    - *outboard electronics*
    - *kapton jumper (62.5 μm pitch)*
    - *Single cooling ring*
    - *optical (hand) alignment*
  - *H disks*
    - *Single sided detectors*
    - *Si-Be-Si sandwich construction ±15 deg*
    - *Inboard electronics*
- *Supports*
  - *Carbon fiber half-cylinder*
  - *Beam pipe threaded through assembled detector*

D0 Bulkheads

Alignment set by machining tolerances.
First "production" bulkhead:

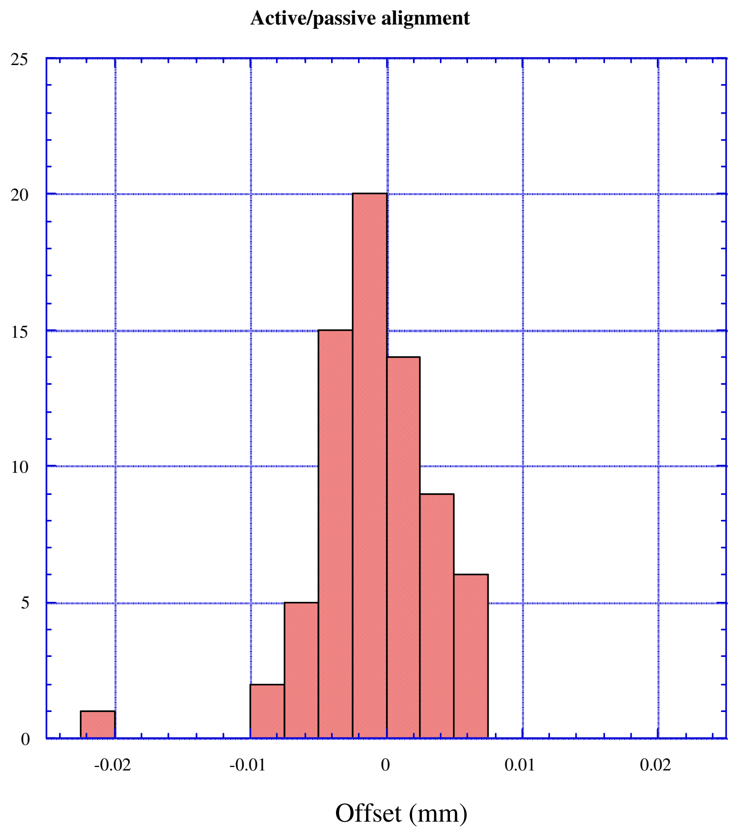


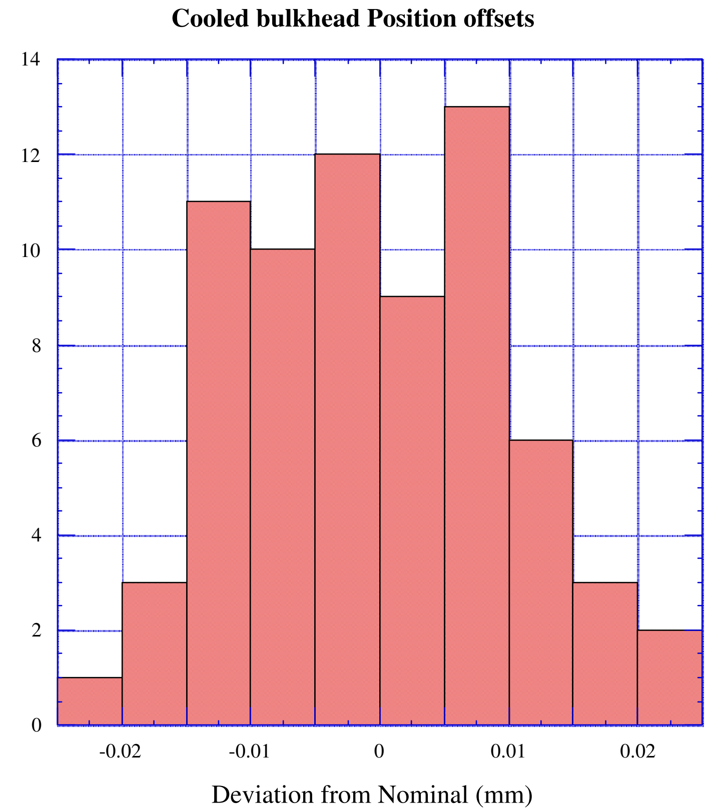




R. Lipton, Vertex 97

Bulkhead measurements





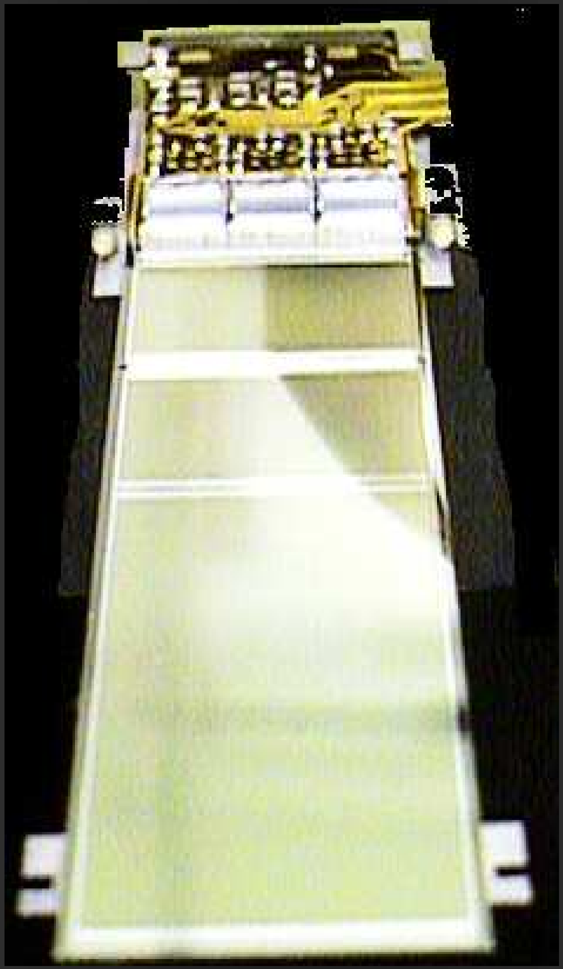
Status

- Detectors
  - SS ladder production has begun
  - DS ladder detectors - Micron having problems producing good devices
    - due last Jan ...
    - "Atlas" style multiguard fails final passivation
    - Trying deep implant
  - F disk detector production started
  - H disk detector production started in Russia

- Production Testing
  - SVX II e testing complete
  - Full final readout system used in test beam
  - LASER test stand + burn-in station under development
  - Optical CMM at FNAL

- Test beams
  - Run complete - see Maria's talk
    - test response of detectors in magnetic field and vs angle

The D0 tracker is under construction



More news in 1998 when ...

The Empire Strikes back!