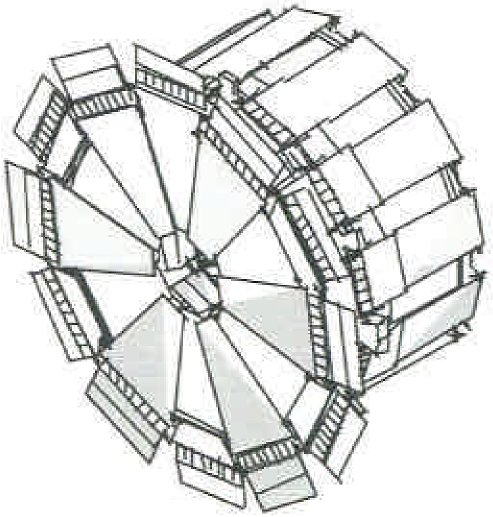
The DØ Silicon Vertex Detector

- Presented by Petros A. Rapidis, Fermilab on behalf of the DØ SMT group and the whole collboration

- Emphasis on present status, testing, problems, ...



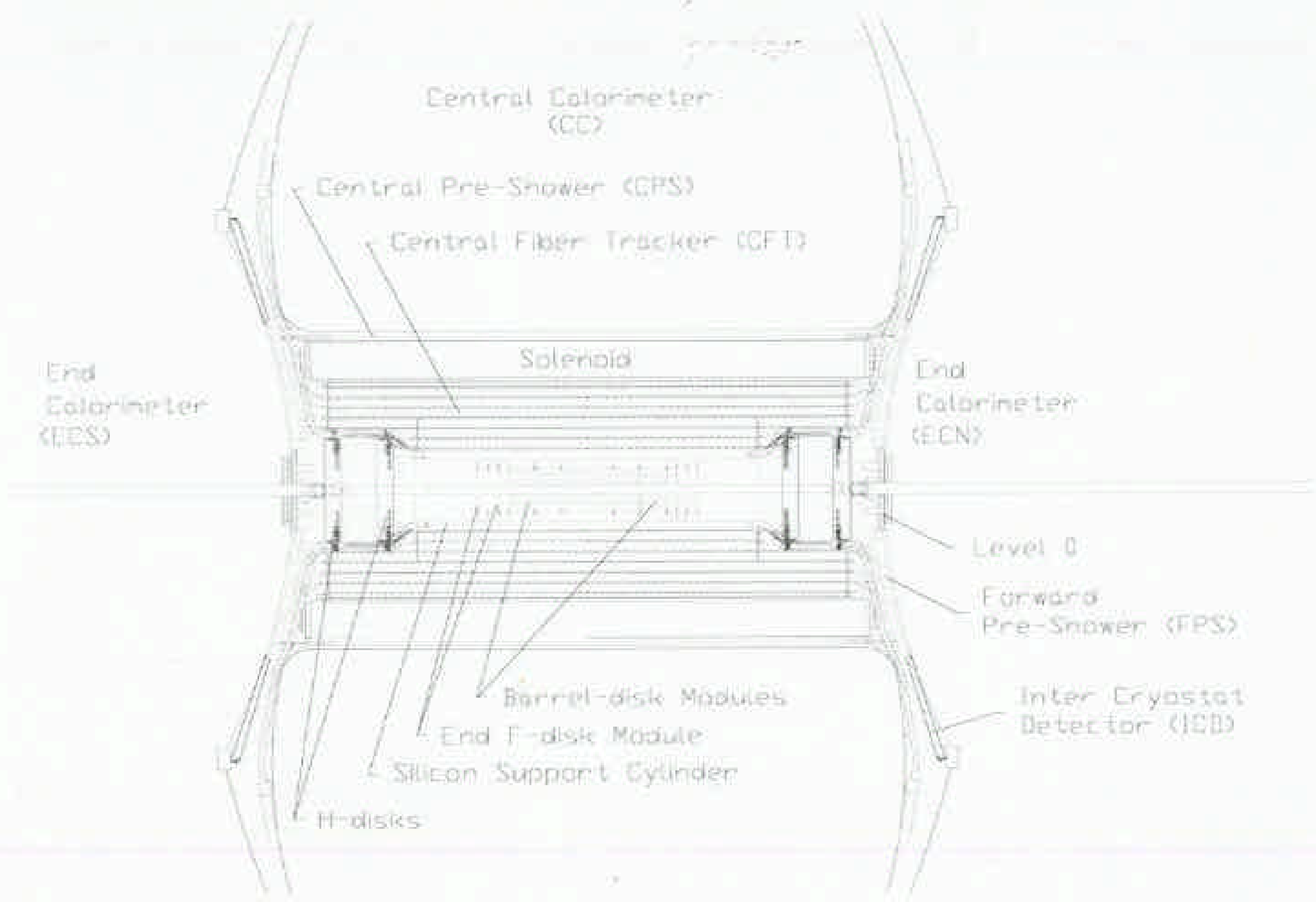
XXX ICHEP Osaka, July 2000

Physics Requirements for the DØ Silicon Detector

- Top physics, EW physics, Higgs searches, and physics beyond the Standard Model
  - Good performance for tracks with high p_T in $|\eta|<3$; good performance for jets
- B physics
  - good performance for tracks with low p_T in $|\eta|<3$.

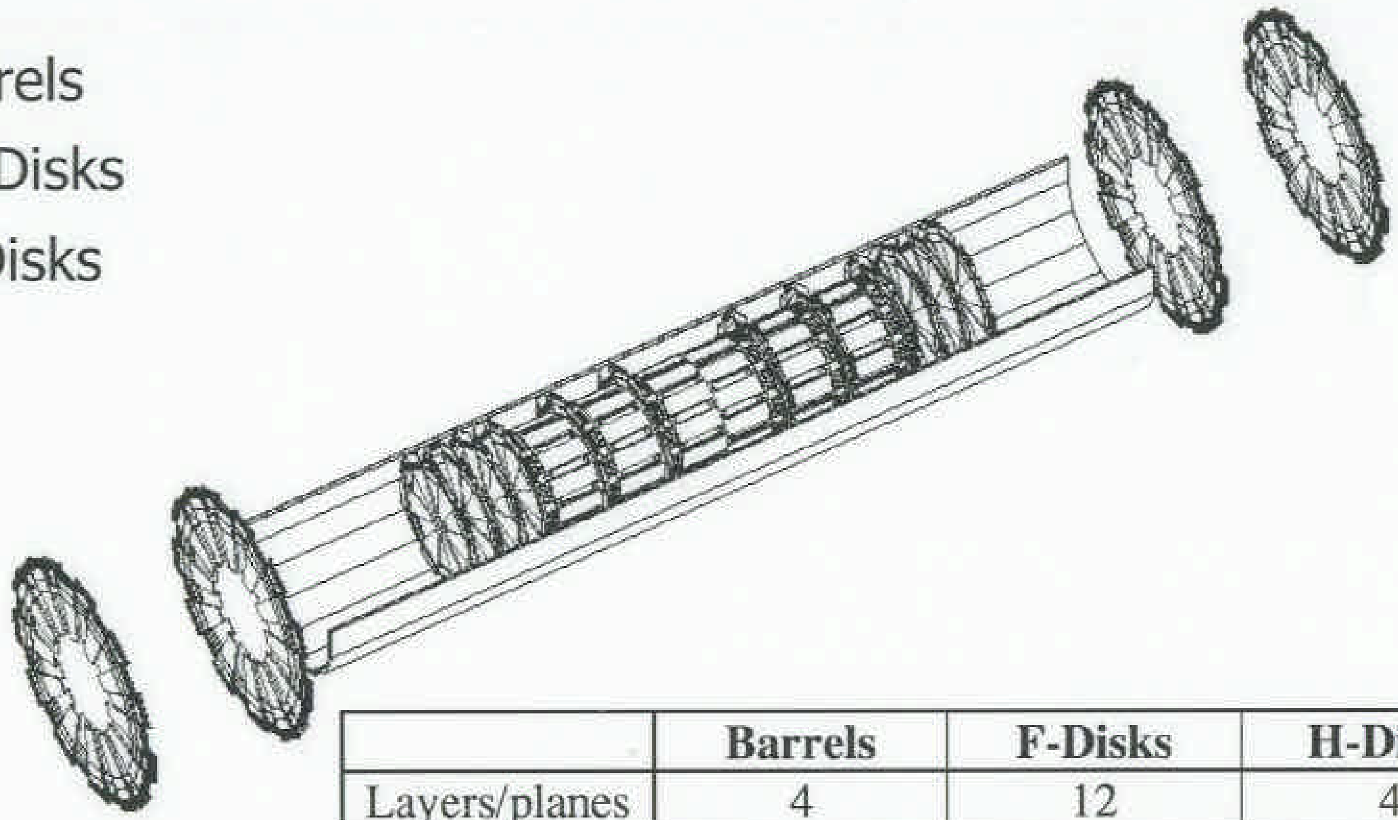
- As small as possible a number of dead and noisy channels;
- Small impact of alignment to the detector resolutions;
- Allow for proper operation of the STT
- Small inefficiency and fake hit rate
- Resistant to radiation.

The DØ Upgrade Tracker



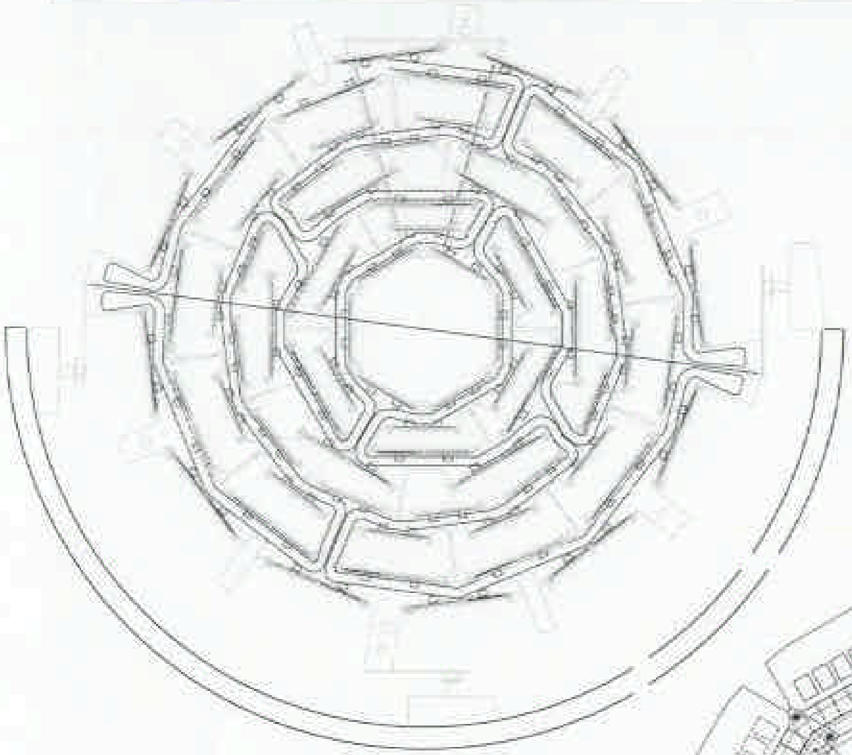
Silicon Microstrip Tracker

- 6 Barrels
- 12 F-Disks
- 4 H-Disks



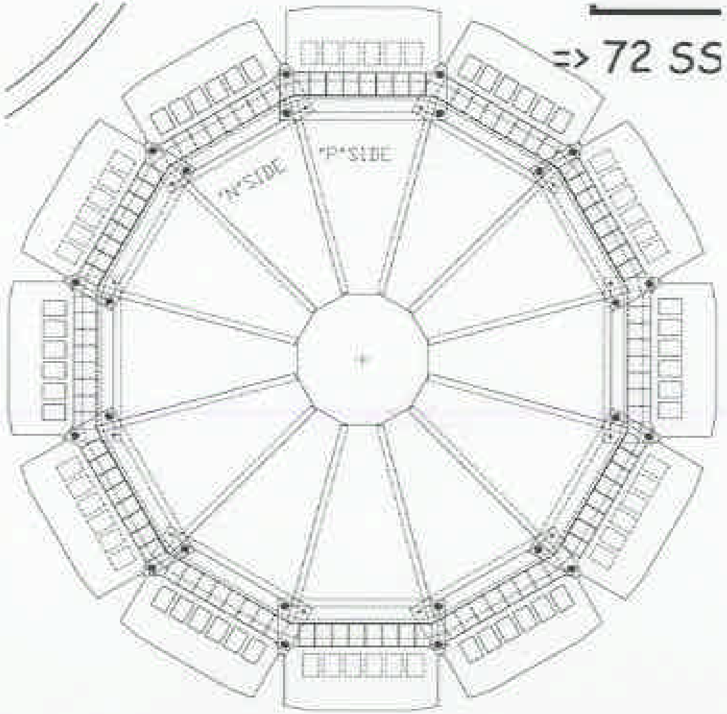
	Barrels	F-Disks	H-Disks
Layers/planes	4	12	4
Readout Length	12 cm	7.5 cm	14.6 cm
Inner Radius	2.7 cm	2.6 cm	9.5 cm
Outer Radius	9.4 cm	10.5 cm	26 cm

Cross sectional view



	B1&B6 (large z)	B2-B5 (small z)
Lr 1	12 SS	12 DS_90°
Lr 2	12 DS_2°	12 DS_2°
Lr 3	24 SS	24 DS_90°
Lr 4	24 DS_2°	24 DS_2°

=> 72 SS - 144 DS_90° - 216 DS_2°



A formidable task

- A vertex detector whose size is intermediate (I.e. a geometrical mean) between past silicon detectors and the future ones (LHC).

SIX BARREL DESIGN										
	F	H	L1-SS	L1-DS	L2	L3-SS	L3-DS	L4	TOTAL	
# detector sides	2	1	1	2	2	1	2	2		
# detectors (total	144	384	48	48	144	96	96	288	**1248**	**<- pieces of sili**
# IC's	2016	1152	72	288	648	144	576	1296	**6192**	<-SVX2E Chips
# Kchannels	258	147	9.2	37	82.9	18.4	73.7	165.9	**792.576**	**<-Channels**
module count	144	192	24	48	72	48	96	144	**768**	**<- Ladders**
silicon area	3977	12586	611	1221	2661	1221	2442	5322	30041.8	**<-wafer area**
wrire bonds/modul	4	4	4	4	6	4	4	6		**Total wire bonds**
bias wire bonds	576	768	96	192	432	192	384	864	3504	**1574400**
HDI count	288	192	24	48	72	48	96	144	**912**	
Total HV Pods	288	192	24	96	144	48	192	288	**1272**	
Total HV modules	72	48	6	24	36	12	48	72	318	318

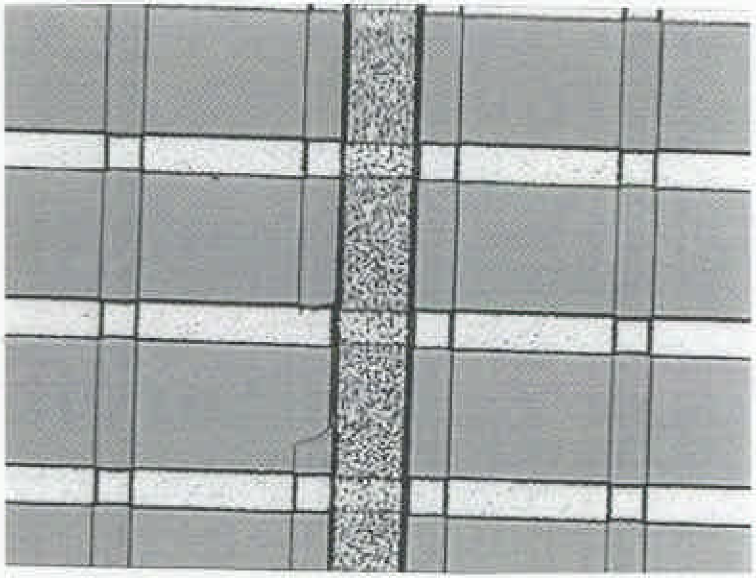
Overview of testing

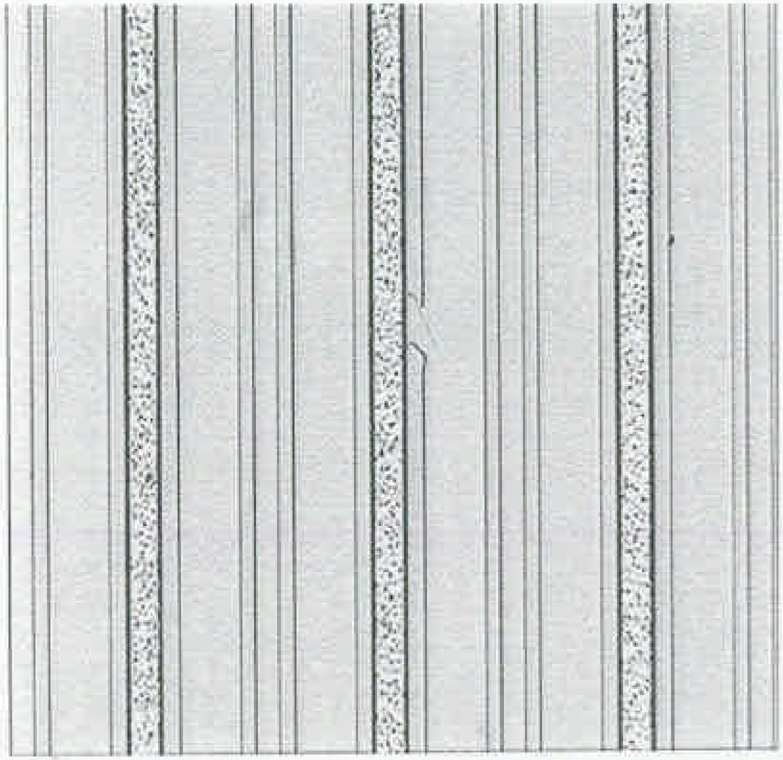
- Sensors are probe tested for bad strips (broken capacitors), proper V-I characteristics, and adequate V_{depl}
- Sensors are assembled into detector modules (ladders or wedges) by gluing the electronics package on top of them (the HDI)
  - HDI's have been tested and burned in before hand
- Detectors are tested, burned-in, repaired, and finally tested with an IR laser on a traveling x-y gantry
- Detectors get tested again once they are mounted on a barrel
- They will be tested again as part of a larger assembly (e.g. the barrel and/or a disk).

  - Note the word that repeats all the time ...

Sensor Defects

- 144 90^0-stereo barrel detectors (6-chip)-problems
  - p-stop isolation defect on mask has led to low yield at the manufacturer (30%)

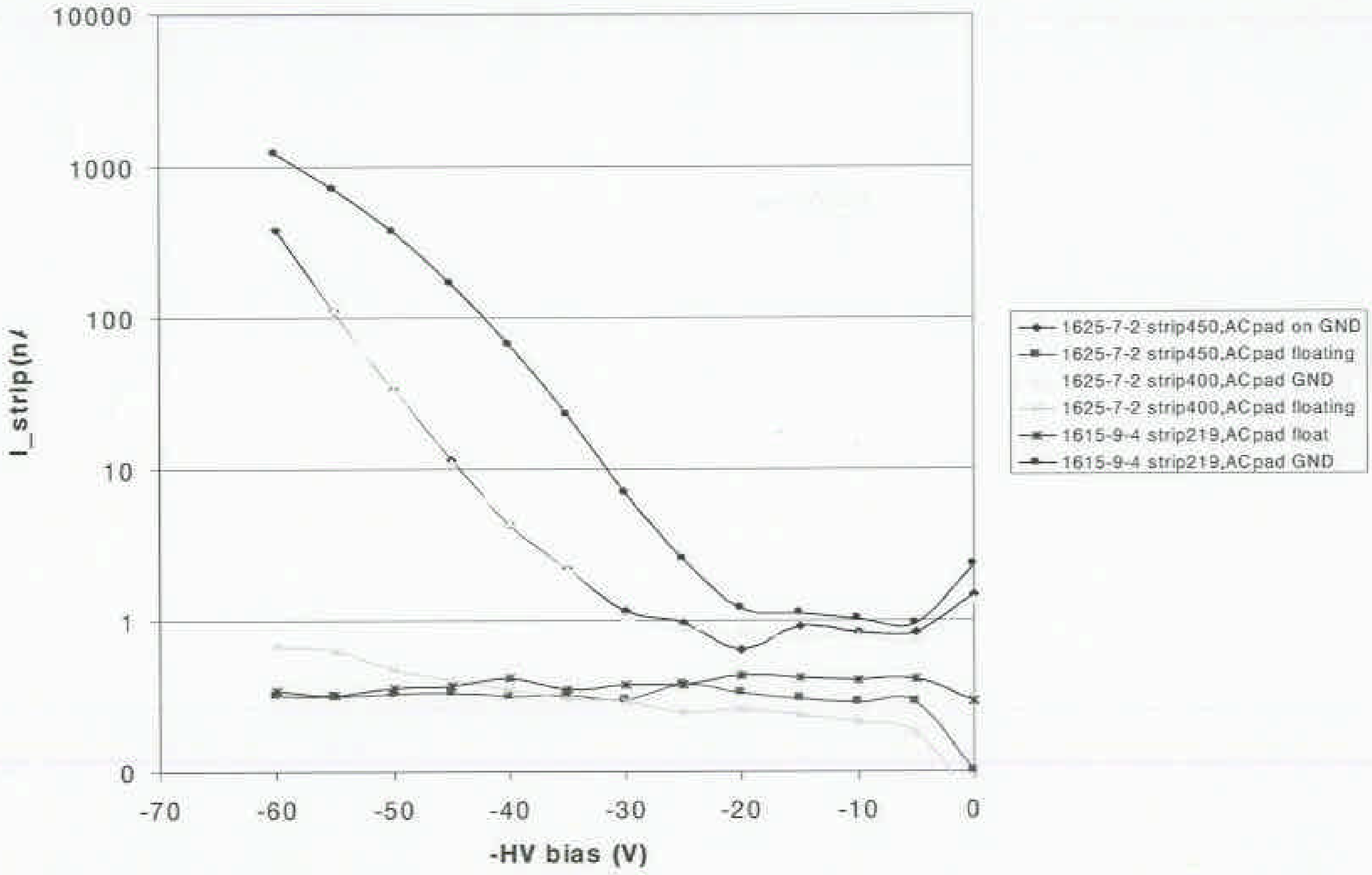




Microdischarges

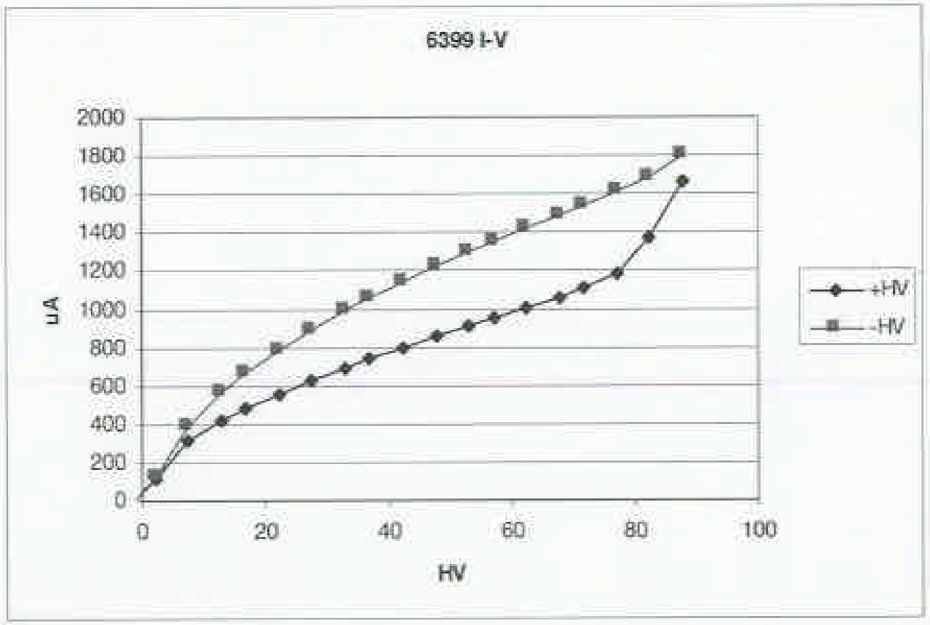
- With positive bias (n side at ground, p side on negative potential) used to avoid large anomalous currents through shorted n-side coupling capacitors we observed a burst-like noise. Observation is consistent with microdischarges at the edge of strips (as seen by KEK group KEK 93-129).
- Steep increase in strip current if the coupling capacitor is grounded.
- Effect correlates with misalignment of Al-strips and implant
- Effect caused by field distortions and charge accumulation near the p-implant when p-side capacitor is grounded. Effect does not appear on the n+ strips
- We should expect that after irradiation and type inversion from n to p silicon the effect should disappear from the p side and move on to the n- side

Microdischarges (cont)

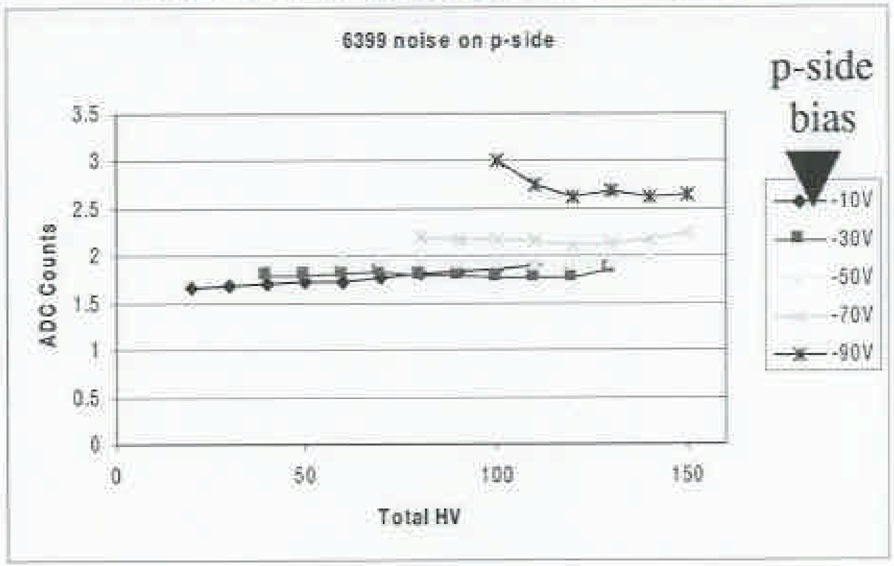


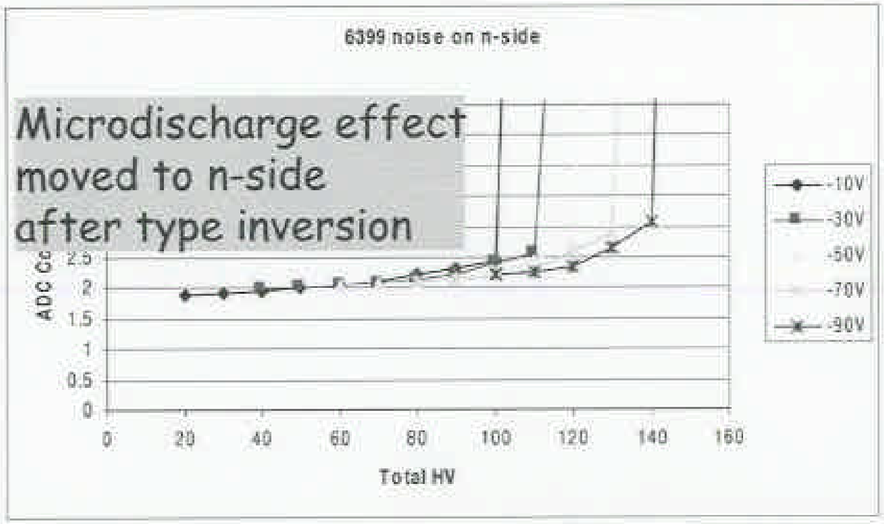
Irradiated 90 degree detector

- 90 degree double-sided detector was irradiated with neutrons
  - Fluence: 1.0×10^{14} neutrons/cm^2
  - 5 years of running for innermost layer
  - Type inverted
  - Kept at room temperature for 4 months for accelerated antiannealing



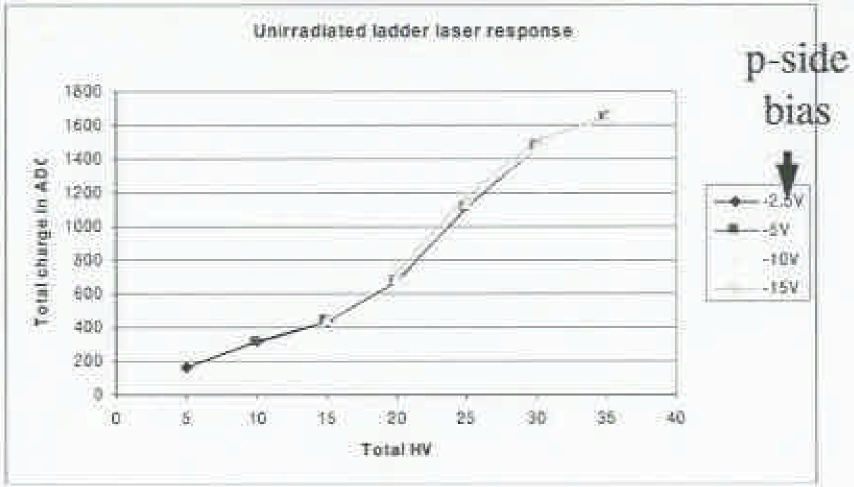
- Noise level increase 30~40%

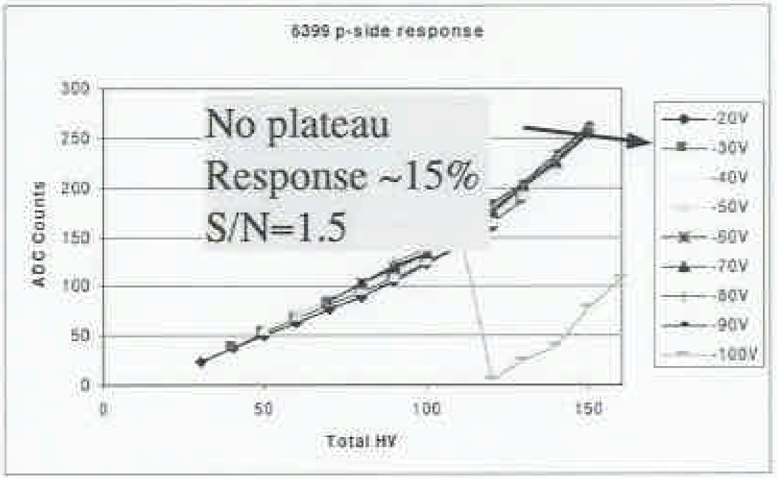


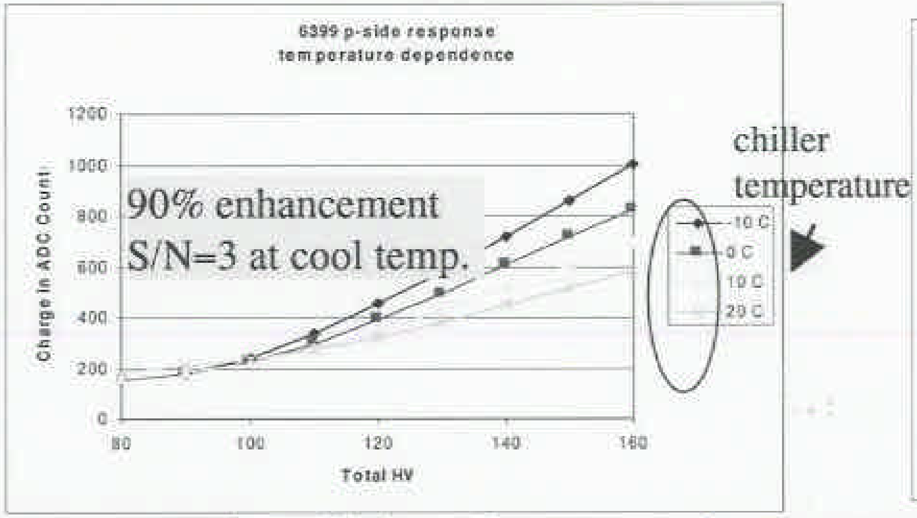


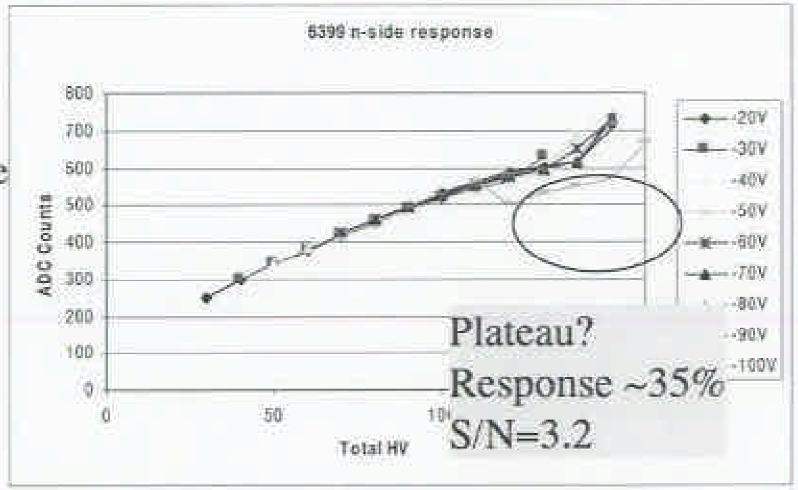
Response of Irradiated Detector

- Response to IR laser illumination







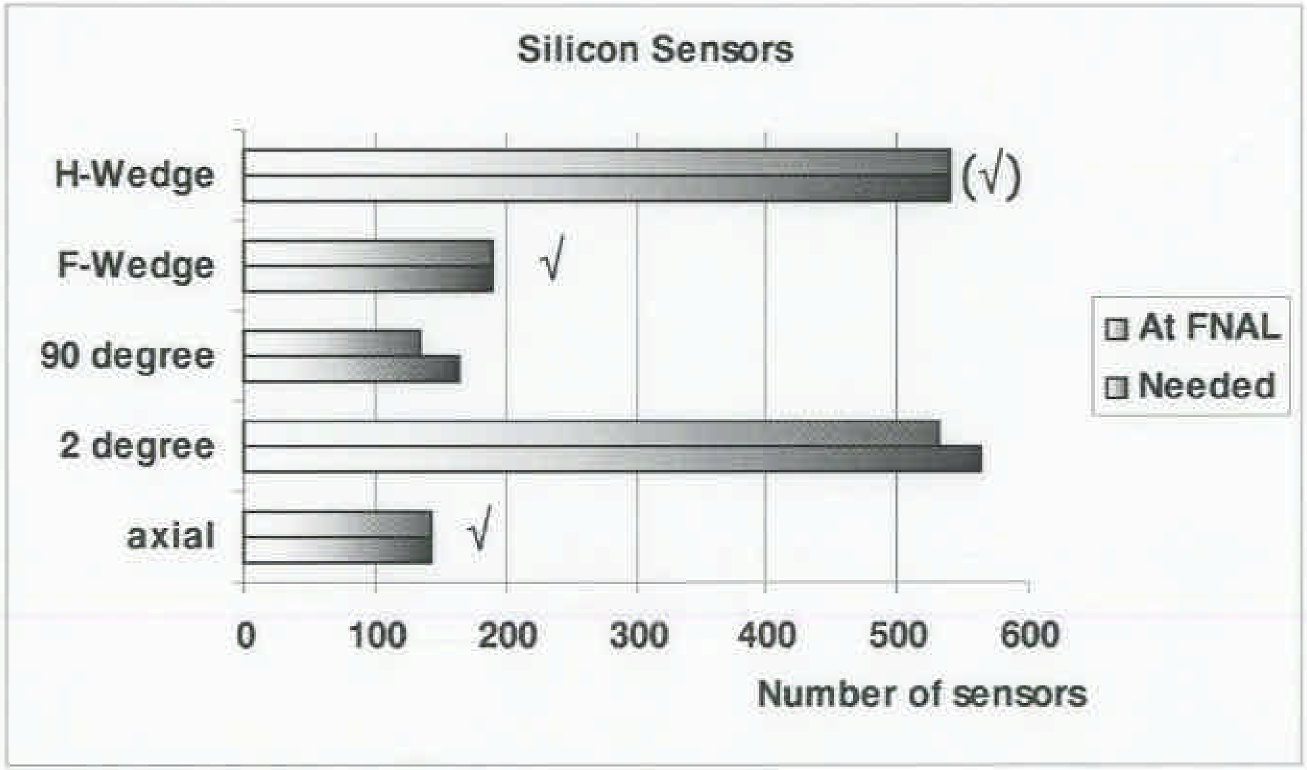


Charge collection efficiency increases at lower temperature
Detector is still usable after fluence of 10^{14} !

Petros Rapidis (FNAL)

Sensor Delivery

A major problem that is (almost) behind us

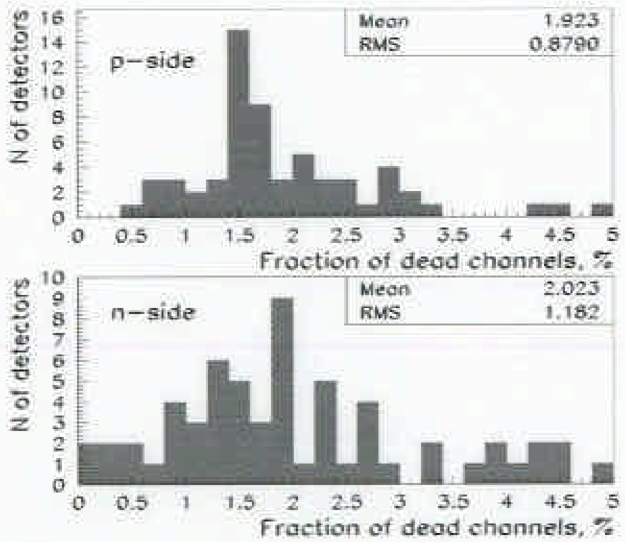


Overall Quality of the first half cylinder

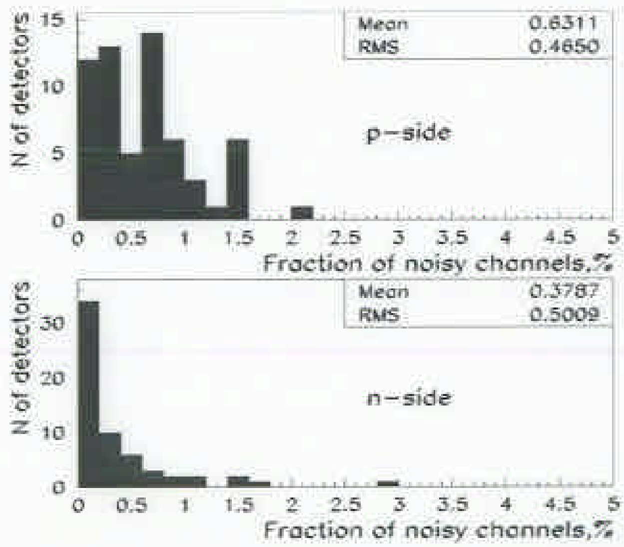
- Classification:
  - dead: laser response < 40 ADC counts
  - noisy: pedestal width > 6 ADC counts
  - A grade: < 2.6% dead/noisy channels
  - B grade: < 5.2% dead/noisy channels

9-Chip Ladders

Dead Channel Count



Noisy Channel Count



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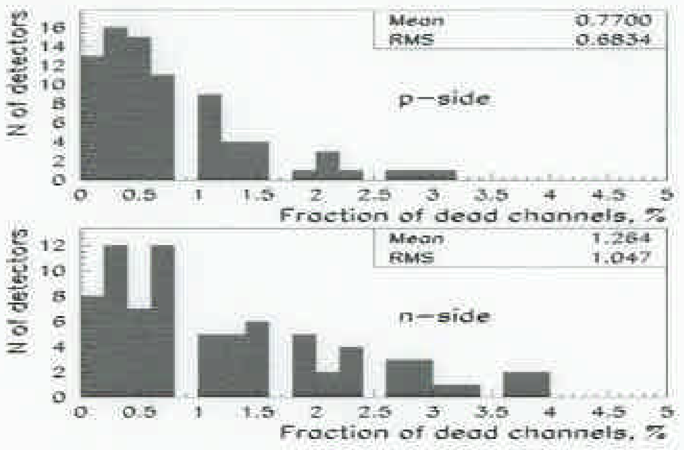
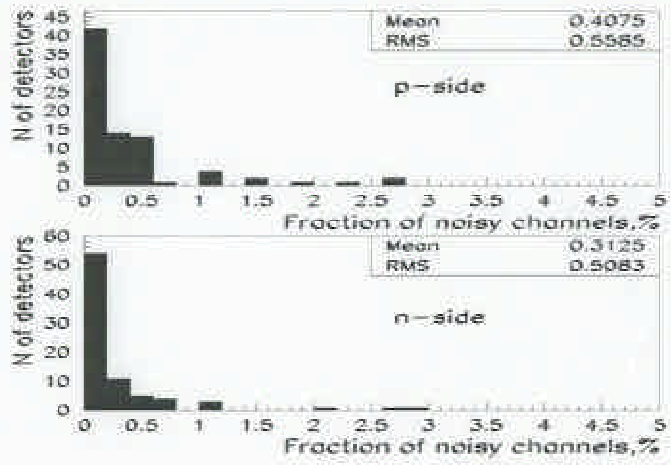
Overall quality of the first half cylinder (cont)

6-Chip Ladders

Dead Channel Count

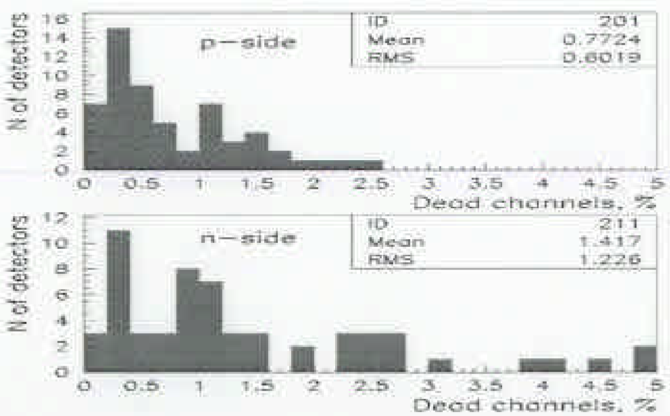


Noisy Channel Count

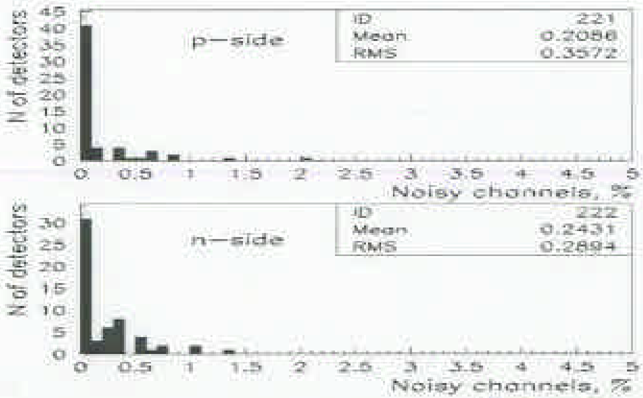


F Wedges

Dead Channel Count

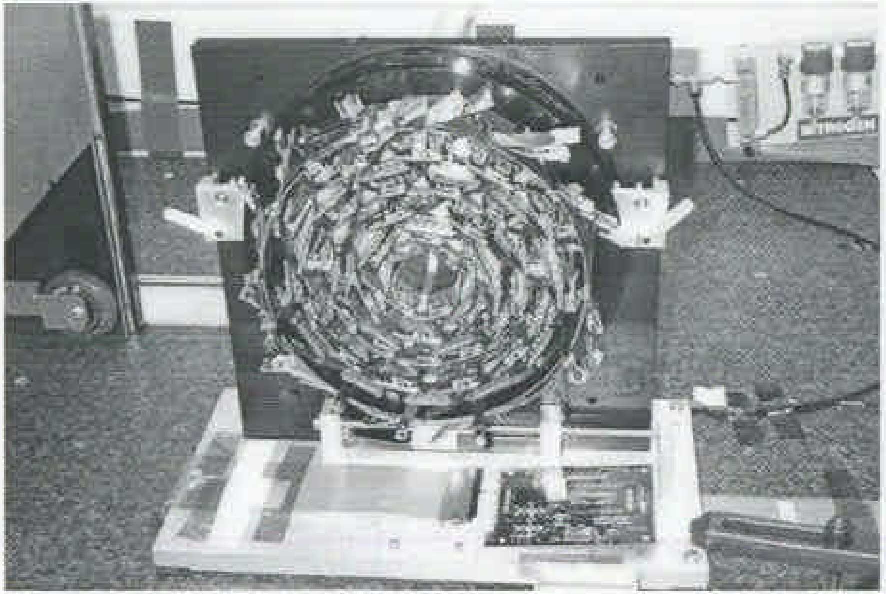


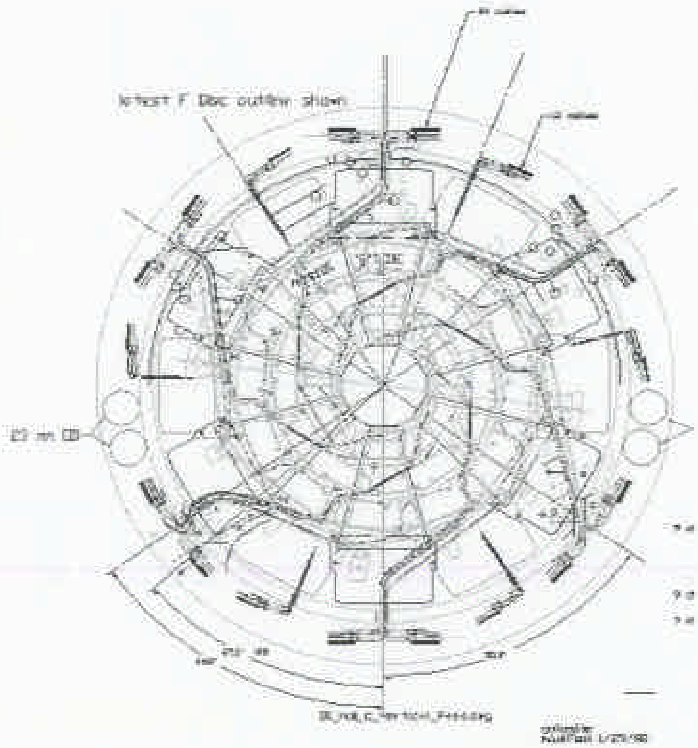
Noisy Channel Count



Barrel assembly

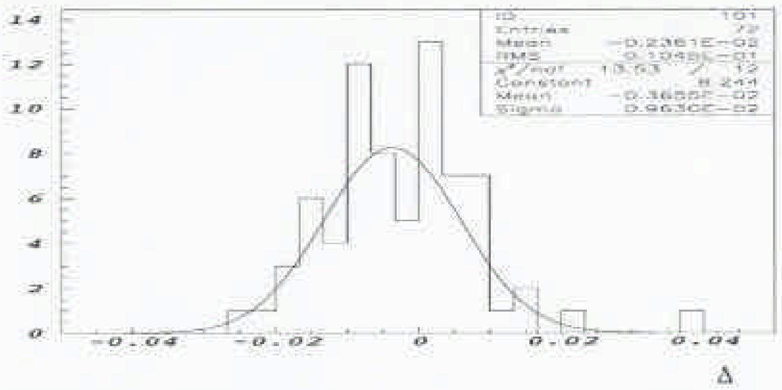
Assembly takes place under a CMM machine to monitor and assure accurate placement of sensors (rule of thumb: accuracy should be better than 20 μm)





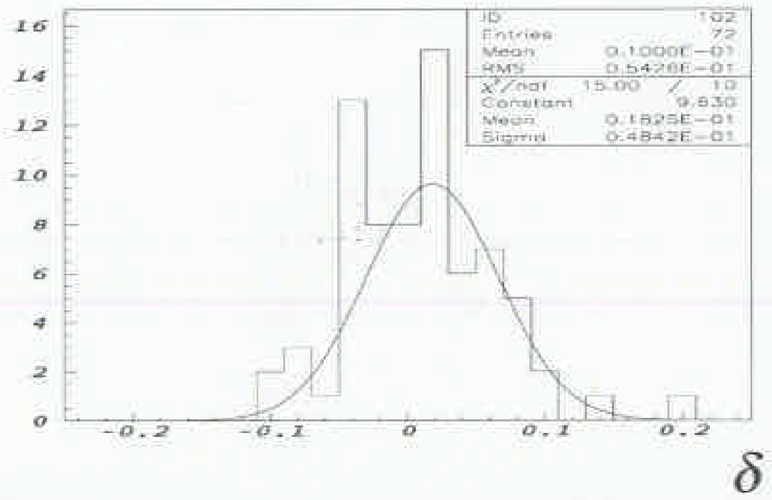
Barrel Alignment

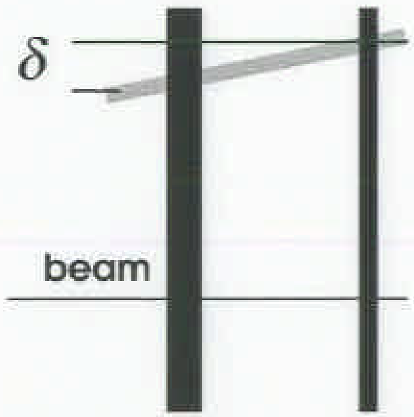
- Rotation in the ladder plane



Δ of 10 microns induces error of 2.9 microns

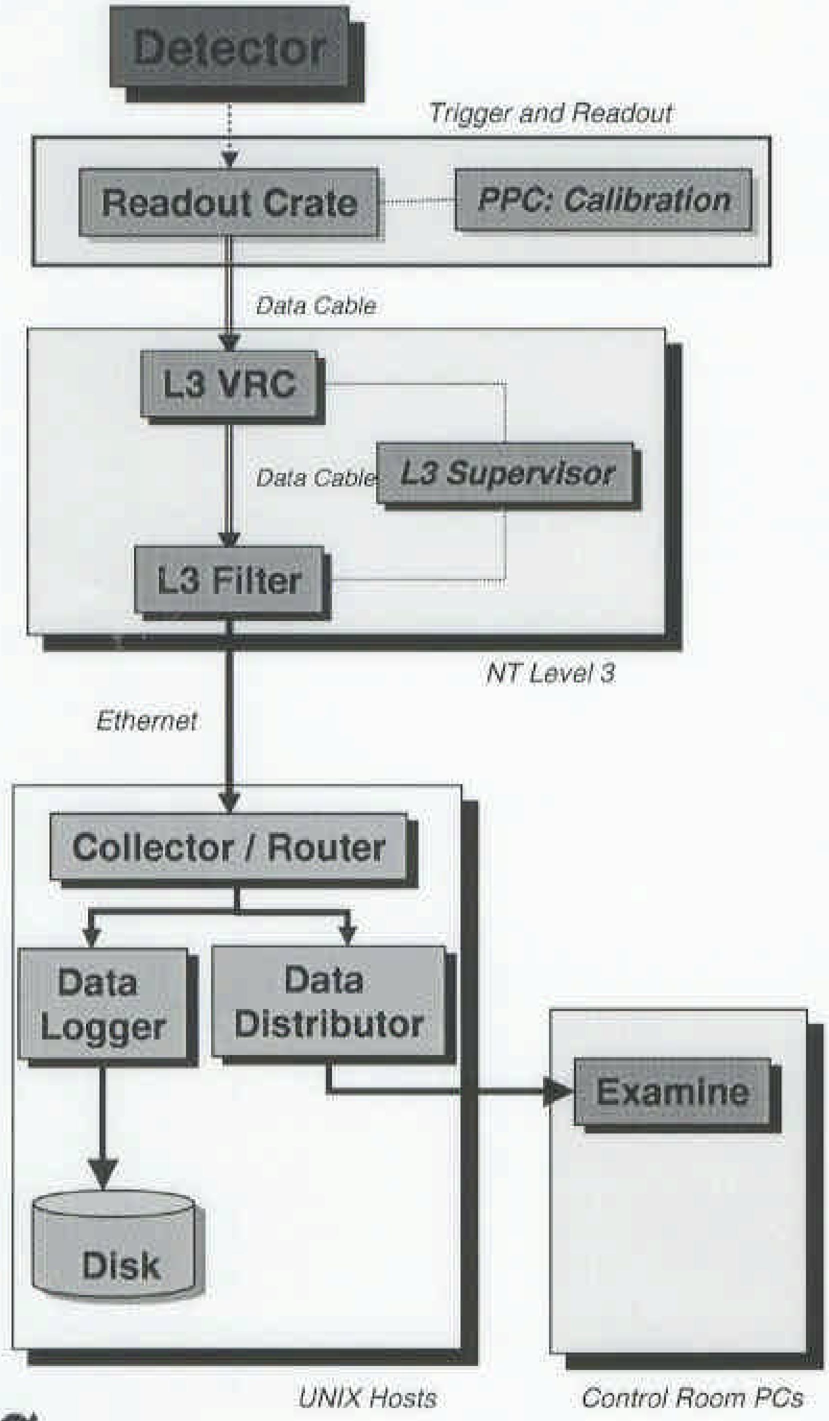
- Slope of the ladder with respect to beam





δ of 50 microns induces error of 3.3 microns in inner layers

Test of Full Readout System (July 14)

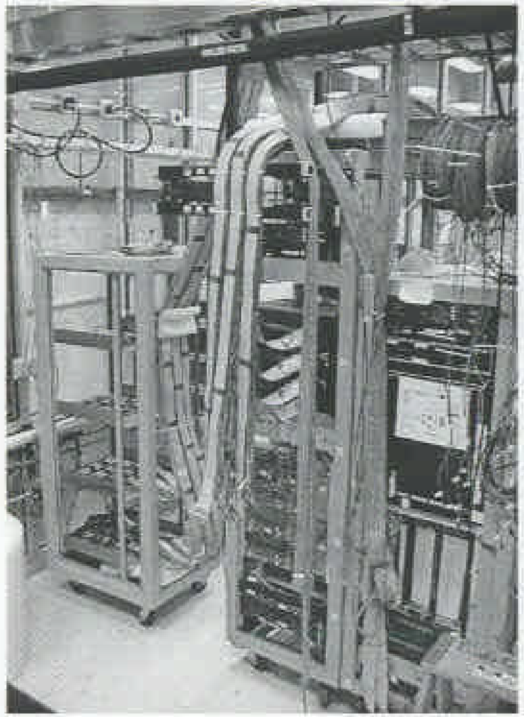


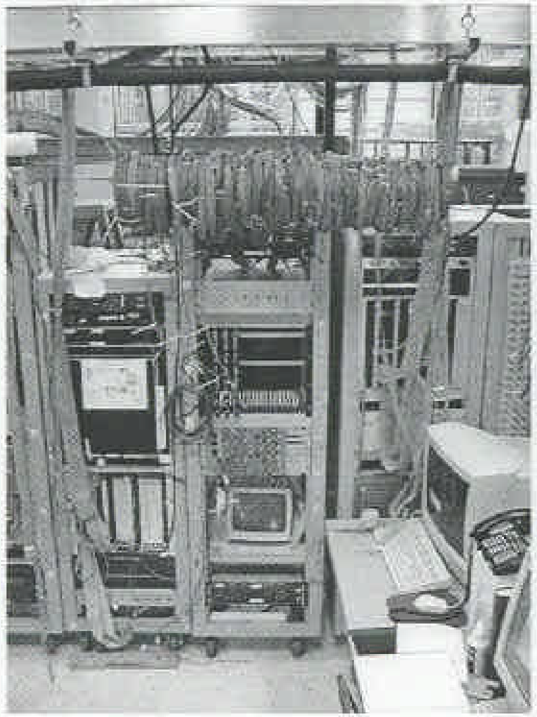
- Plan was to readout full F disk (F14) and exercise whole DAQ chain
- Instead, readout 3 hdi's
  - missing cooling, interlocks and some infrastructure

COOR controlled:

- Run Calibration in Front End
- Download parameters in Database
- Retrieve parameters from Database and download chips using proper protocol
- Start run
- Unpack and Analyze data in Level 3 node
- Ship data through collector / router to host
- Log data
- Store in SAM
- Analyze data online (Examine)

10 % System test





- To be used to test readout system, electronics integration, noise studies,
- Also to test larger detector assemblies (barrel/disk modules)
- And, to also do a cosmic ray study of a detector assembly

Petros Rapidis (FNAL)

Schedule, Lessons learned

- Presently 3 barrels and 6 F disks are ready
- First half cylinder being readied – expected in August
- Detector completed by the end of this year – we expect to be taking data by March 2nd, 2000
- This has been a much larger logistics enterprise than originally anticipated – design, procurement, construction, testing, and repairs all have taken much much more effort than originally anticipated
- One should strive for a simple uniform design – too much variety is too much disruption
- Double sided silicon may not be worth it – the present thinking for the upgrade (to the upgrade!) envisions single sided silicon sensors glued back to back.