CMS Pixel Forward Detector

LHCC – Referee Meeting

CERN 8 Sept. 2004

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for the
US-CMS Pixel Group*

• Fnal, U. of California Davis, Johns Hopkins U., Kansas State U., Louisiana Tech U., U. of Mississippi, Northwestern U., Purdue U., and Rutgers University

Deliverables and Overview of the CMS Pixel Disks

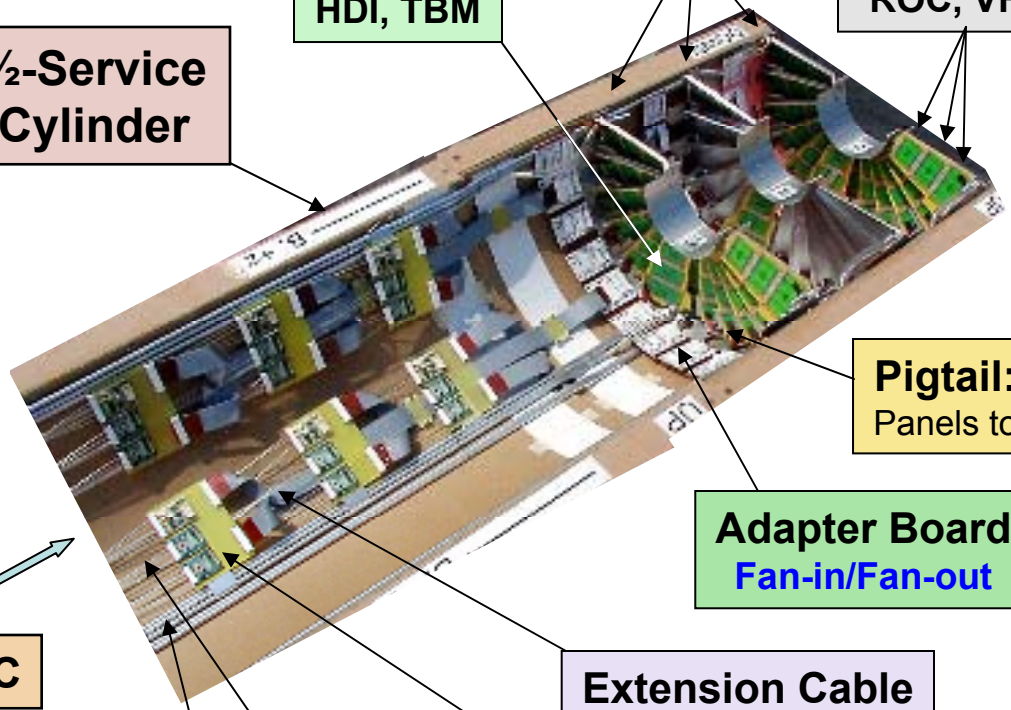
FPix (baseline):

US delivers:

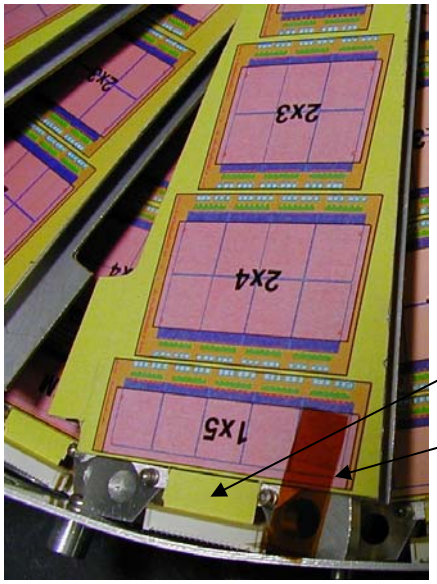
4 'disks'

TBM (for CMS Pixels)

- Mechanical support and cooling
- Pixel Sensors
- Assembled pixel detectors
- The required electronics (adapter board, port card) except the: ROC, FEC, FED and OL

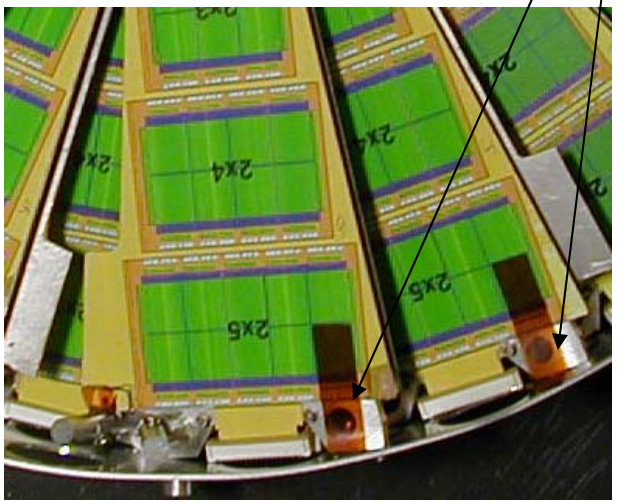


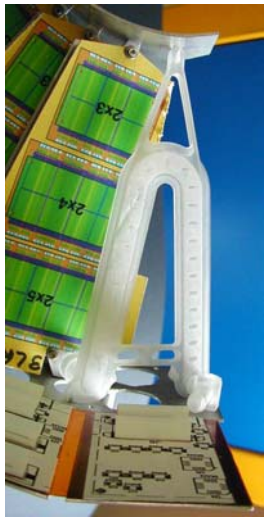
½-Disk Mechanics



Modifications:

- Increased gap between Blades of 1mm for a safer insertion/removal of the Panels. The total disk width has increased by 1cm.
- Shorter Pigtail for HDI.
- Dedicated Pigtail for Bias V for each panel.
- Prototype Disk will be ordered by end ’04.





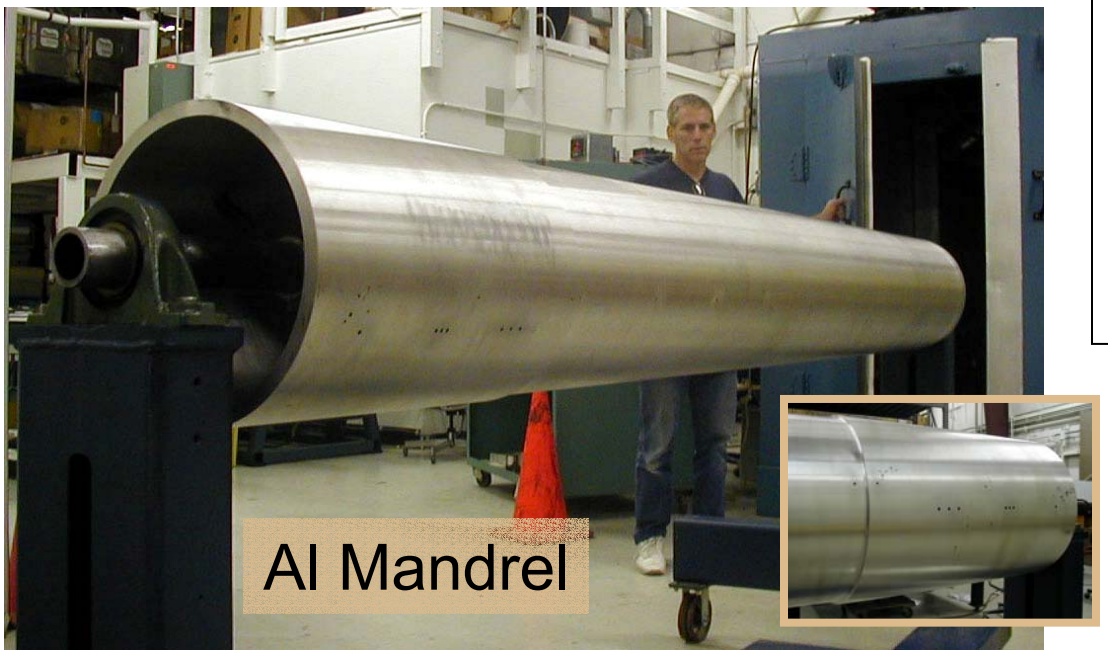
Service Cylinder

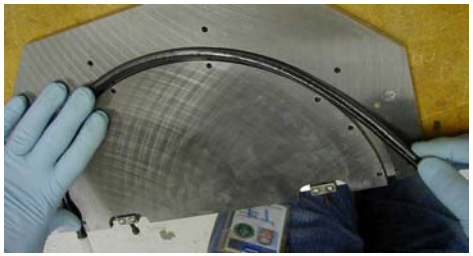
Structure is made out of CF-skins and C-ribs/straight-ribs

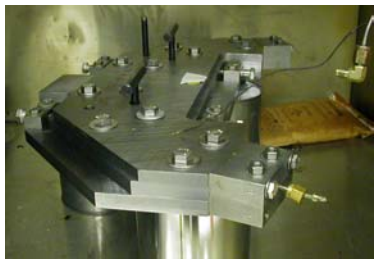
<u>Mandrel:</u> Delivered. Being surveyed.

<u>Ribs:</u> Jigs for Assembly Completed. Production Of C-ribs has started.

Expect first Prototype By end of 2004.



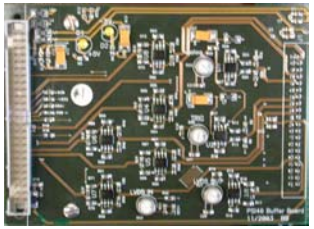




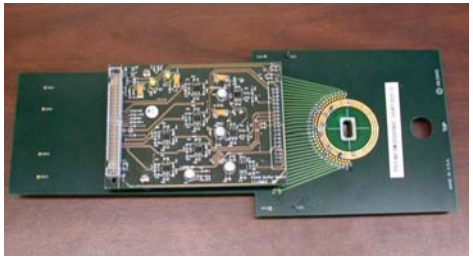
Testing PSI-46 Chips. FNAL

- Received 2 full and a ½ diced wafers
- Designed:

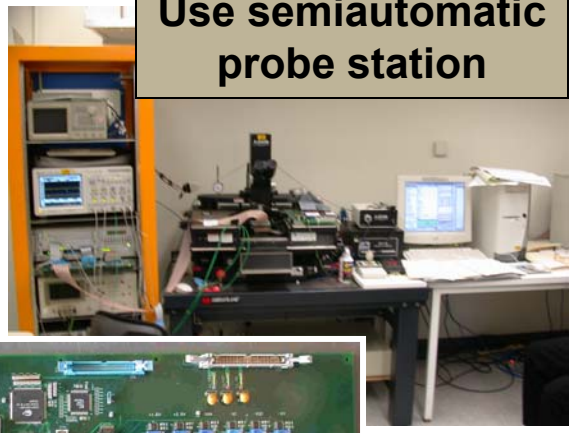
Buffer Board



PSI46 probe card

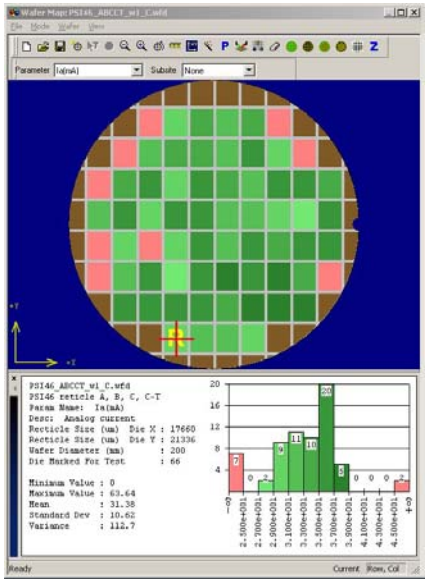


Use semiautomatic probe station



ASIC Interface

- Developed new interface and software



- Used recommended settings from PSI
- Testing straightforward (Feb. '04)
  gigantic improvement when compared to PSI-43
- Took only a few days

  Yield: 83%, 121 mW/chip

  (all pixels operating, same for diced ROC)

  PSI-43: Yield was 40%, 300 mW/chip

Token Bit Manager. TBM ¼-μm. (For Barrel and Disks)

Rutgers

3rd MPW Submis. TBM: Nov. 2003 / Returned Feb. 2004

Tested: Fully Functional at 40MHz. Power consumption 100 mW.

Will be irradiated Sept. 10th 2004, with 205 MeV, p.

Flux: 10^7 to 10^{10} $cm^{-2}s^{-1}$ (100 times LHC level at Barrel L1) increasing the Flux in steps of 5.

Irradiate a TBM and a TBM connected to one PSI-46 (ROC not in beam).

Record data with dedicated DAQ.

Look for "Freeze-up", Data Corruption, and Recovery Time.

4th MPW Submis. TBM **Pre-prod.** Submit. June 2004 / Returned Aug 2004

First testing at Rutgers, then at the Fnal chip testing facility.

Required hardware (interface board, probe card) and software are being prepared now.

5th Submis. (Eng.) TBM **Production** Submission Oct/Nov. '04

Anticipated return of wafers is Feb. '05.

Testing of wafers to be done at FNAL.

Expect tested TBM chips by end of June '05

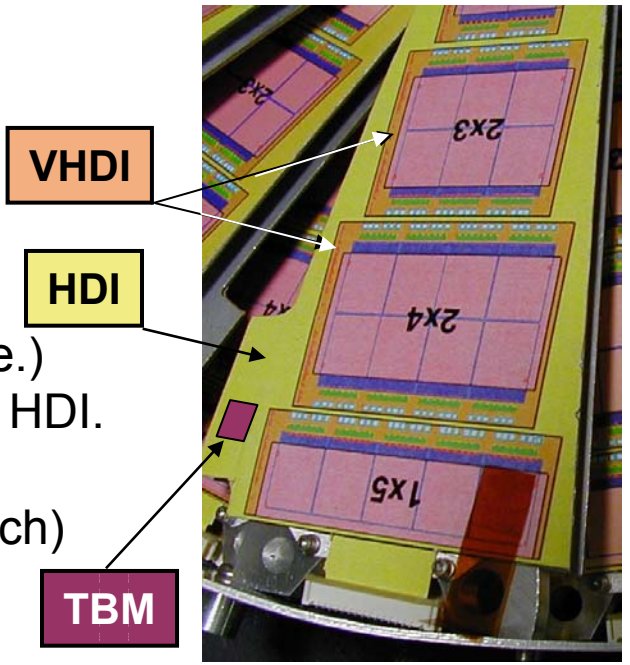
VHDI, HDI FNAL

VHDI-46

VHDI-46 (1 x 2) has been produced and tested with ROC. The design of the VHDI-46 for all 7 types {$(1 \times 2)_{L,R}$, $(1 \times 5)_{L,R}$, (2 x 3), (2 x 4), (2 x 5)} is completed.
Prototypes have been ordered, we expect the parts back in October.
We will install PSI-46 on these VHDI, mount them on HDI-46 boards and read out calibration pulses. These tests will certify that the VHDI-46 are ready for production. Testing will continue in the fall with sensors, first in the Lab and in January in the test beam.
Goal is to place the order in February '05.

HDI-46

Design has started. Three layers are required.
We expect prototype samples by November.
(Some concern about radiation hardness of glue.)
First tests will be with a (2 x 5) Plaquette on the HDI.
This is the longest readout chain in the system!
We expect to carry out this test in Dec. '04 (bench) and in Jan. '05 (beam)
Place production order in March '05.



Adapter Board, Port Card FNAL

Adapter Board

It is a flex circuit (with support panels attached to the Disk) interfacing 3 Blades to the Port Card. It has:

- Fan-in Fan-out chip, RC filters for the bias V
- connectors for:
  - the pigtails of the Panels and for the V_{bias} to the Plaquette.
  - the cable to the Port Card. Extension cable.

The space for this board has been assigned. The design will proceed within a few weeks after the assignment of the lines of the HDI is completed.
Prototype boards are expected in January ’05.

Port Card

This board will be designed after the Adapter Board has been laid out. Components located on this board are: AOH (2), DOH, ALT, Gate Keeper, TPLL, and DCU.
We expect prototypes in March ’05.

Sensors Purdue-JHU

Pre-production with SINTEF (15 wafers) is in progress.

- FM type pixel design. Modifications of the present devices are: lower resistivity and narrower p-stop ring.
- Each wafer has the sensors needed to assemble one Blade.
- Delivery on September 15, ’04.
- Wafer will be tested at Purdue (visual inspection and I-V curve).
- Units will be used in the testing of Pre-production electronic components on bench and in the test beam.

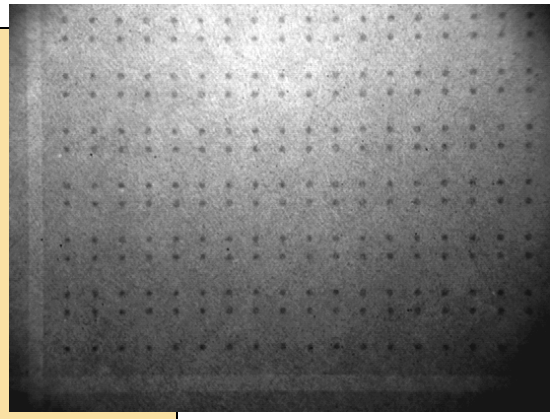
Production will be done by SINTEF.

- Order of 120 blank wafers is being processed.
- Processing of the wafers is under negotiation.
- Expect to place the order Nov ’04.
- Partial delivery (60 wafers) after 22 weeks.

Bump Bonding UCD

VTT has bump bonded blank components of the (2x5) with the pattern of the PSI-46. This required processing 8” wafers and thinning the wafer.
The bonding yield is 0.99989±0.000064.

X-ray scanning at Fnal shows a very high yield.

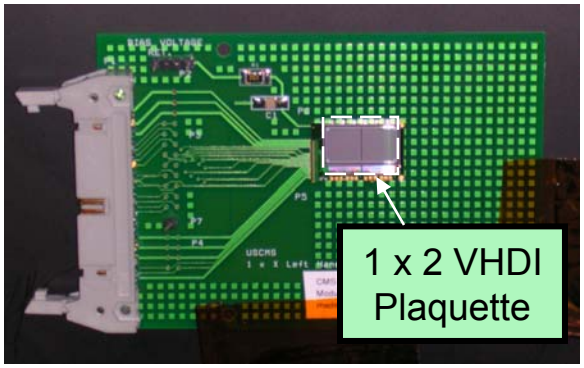


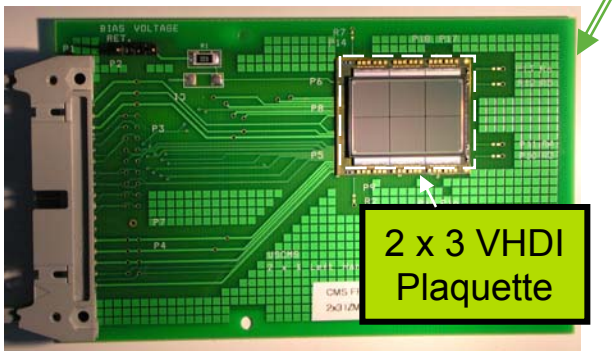
We have a pending order with IZM for bump bonding of two 4” wafers of SINTEF and one 8” wafer of PSI-46. We are hoping for bump bonded parts in November ’04.

We are also negotiating submissions with VTT, and AJAT.

Bump Bonding has a long delivery time!
Additional wafers are needed to test potential vendors.

Test Results of Plaquettes, PSI-43





Test setups at: Rutgers, Purdue, Fnal

HDI Board

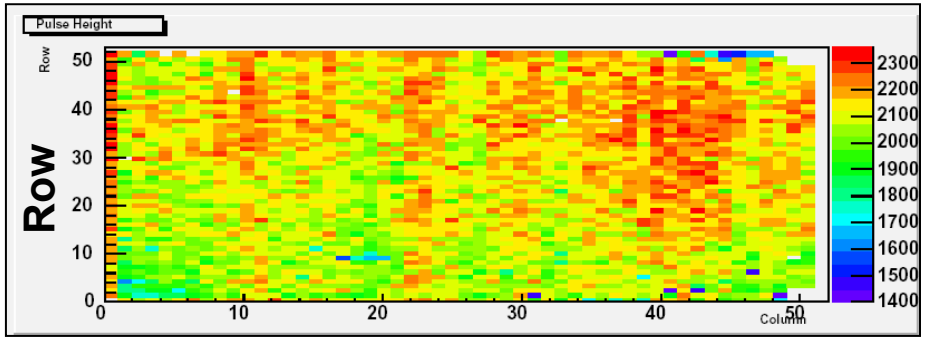
Gives expected Landau Distribution with β-source

Bump bonded by

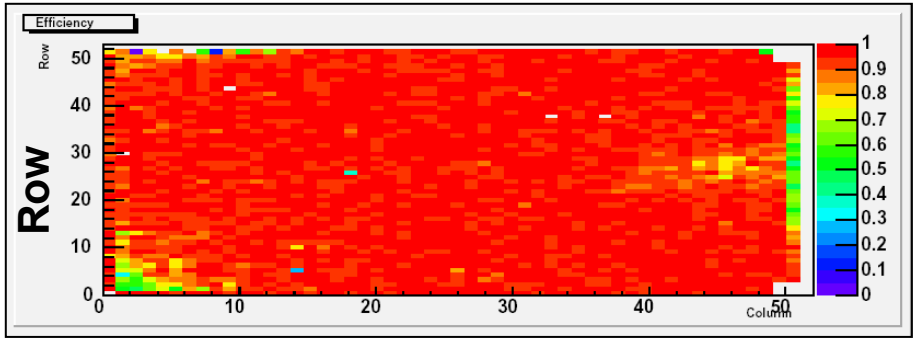
IZM	MCN	UCD	Tot	Tsted	Good	Bad
16	12	2	30	19	14	5

Measure Pulse Height and Efficiency with LED Pulser

Pulse Height

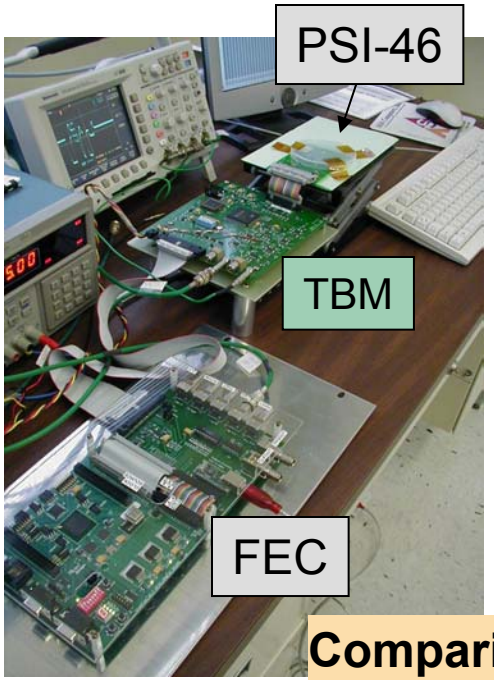


Efficiency



Results PSI-46

Thermo cycling Plaquettes with PSI-43

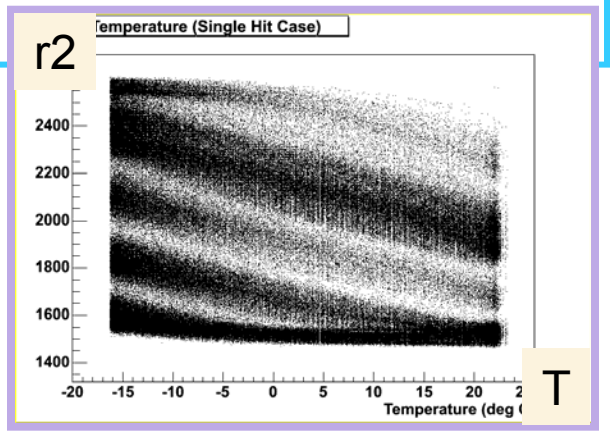


Lower T from +25°C to -30°C. Stay at -30° for 8h, repeat 6 times. No failures. Device returns to initial conditions.

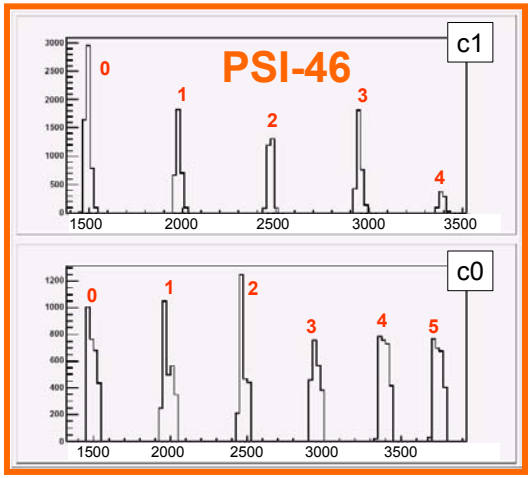
Thermo cycle +25°C to -16°C, 24 times.

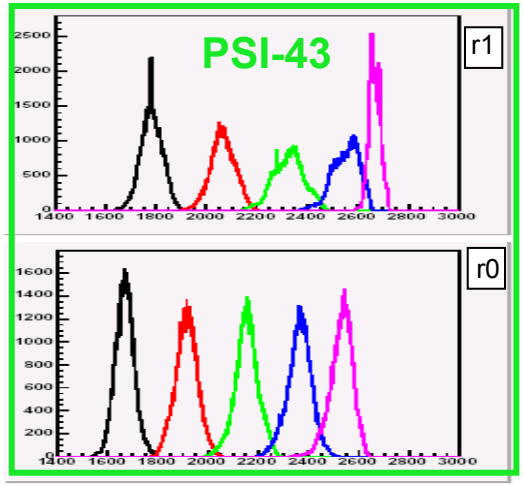
At most 10% variation of value of the levels.

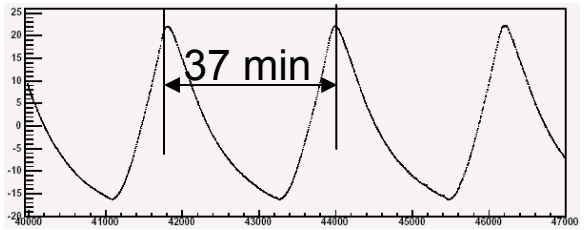
Preparing for PSI-46!



Comparison Levels -43 and -46







Beam Test to Measure Yield of Sensors. Fnal. PSI-43

Beam 120 GeV/c, p. Beam spill 0.6s every 20s. RF 20 ns.

Set up:

Si Telescope (Rutgers)

- 4 planes of Si strips (*x,y, x,y*) up- and down-stream
- Pixel (Plaquette) operated at -13ºC
- read out with PSI-43.

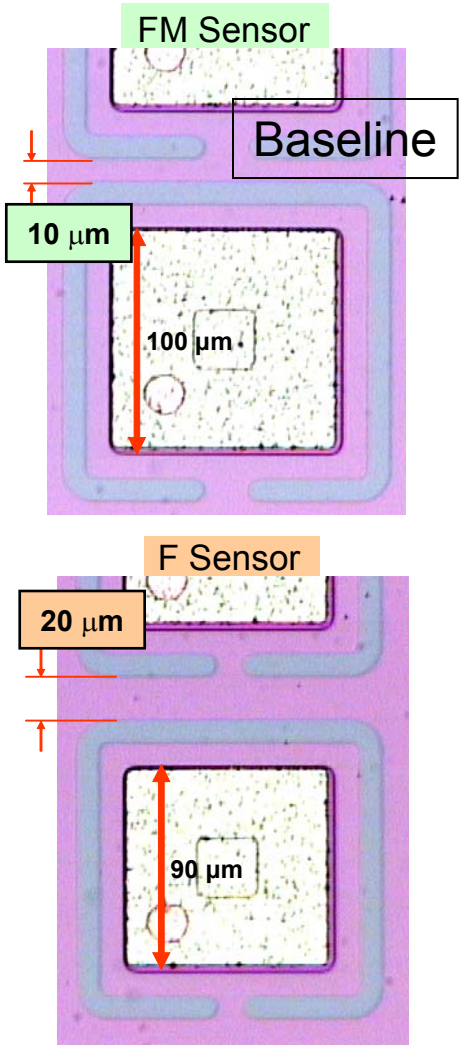
Plaquettes tested:

- IZM 34b [1x2] (FM), chip 0, 1. ⊥ and 20º to beam
- MCNC 9 [2x2] (F), chip 0 . ⊥ and 20º to beam
- IZM 29b [2x3] (F), chip 0 . ⊥ to beam

Goal is to measure for FM and F design:

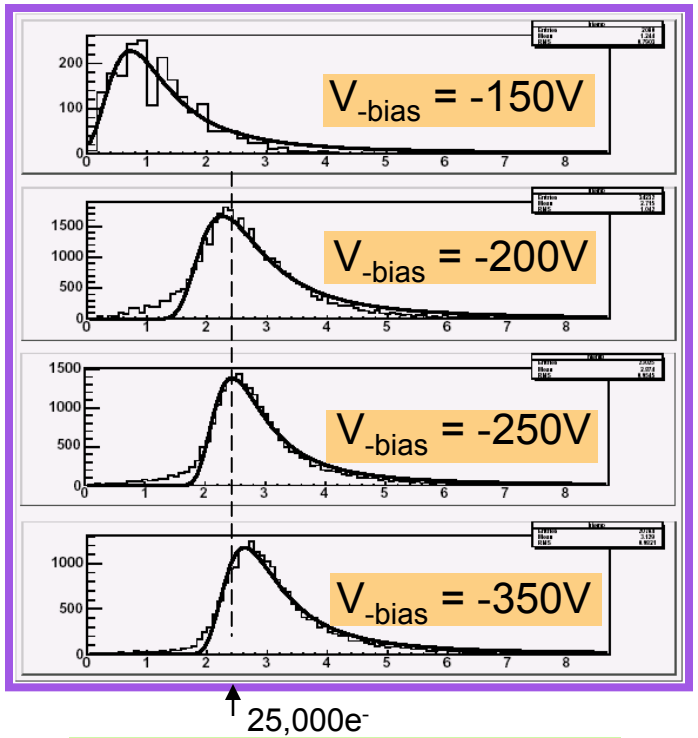
- pulse height and position resolution for different V-bias, DAQ settings, and geometry

Testing from May to August. Collected ~50 M tracks. Analysis is in progress.



Test Beam. Fnal.

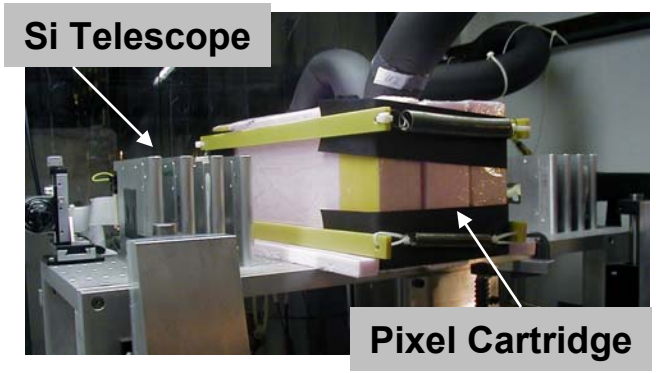
Pulse Height Pixels vs. Bias V.
No Si Tk. Fit with Landau



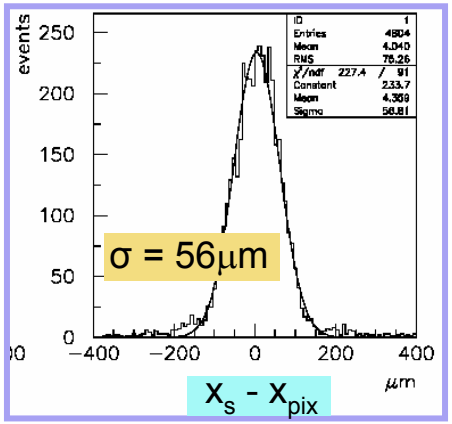
One device to be irradiated to 2×10^{13} (Sept 10, '04)

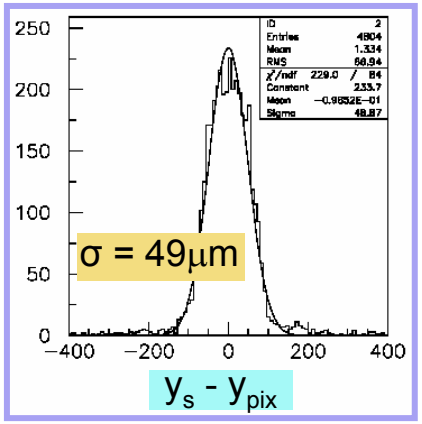
Beam will resume in January '05.

Preliminary Results



σ Position for No Charge Sharing
Expect 150μm/√12 = **σ = 43μm**





Recent changes & Conclusions

Changes since last year:

The FEC unit is now build by CERN.
Disk volume starts at z = 32.3cm (was 30cm).
Increased space between Blades by 1mm → Disk 1cm higher.

Conclusions:

The components of the readout chain (pixel to ADC) are now defined and their location has been assigned; their design is proceeding with adequate manpower (EE). Until all these components have been produced and perform as required, the final assembly cannot proceed.

We anticipate this crucial test to be possible by mid ’05.

The instrumentation assembled to test components and to readout devices during the R&D phase, have generated test equipment, expertise, and software that can be taken as a basis for what will be needed for the assembly and commissioning of the pixel Disks. The additional manpower needed to prepare for the assembly phase is now becoming available.

Unquestionably, there is still much more work and ’05 will be a critical year.