WBS 5 - Forward Pixels

Bruno Gobbi

DOE/NSF Mini-Review

of the

U.S. CMS Construction Project

FNAL. May 20, 2004

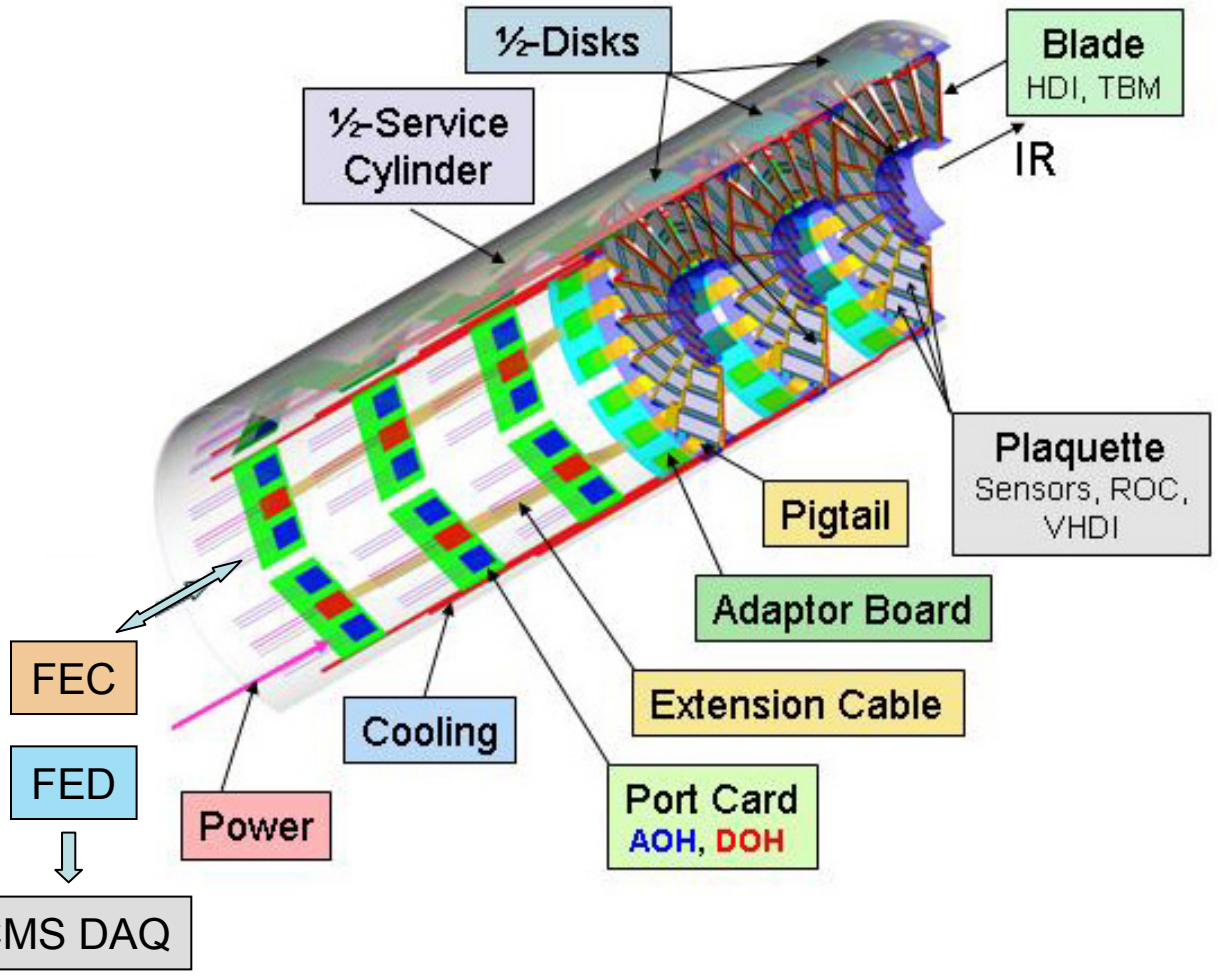
System Overview and Deliverables

FPix (baseline):

US delivers 4 ‘disks’

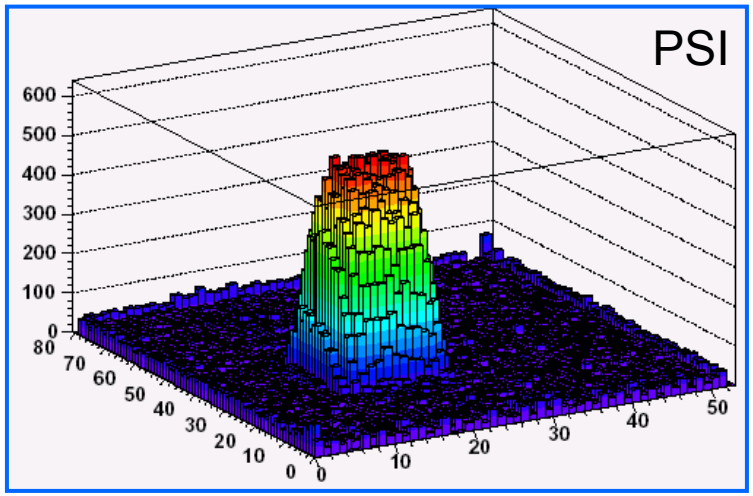
TBM (Token Bit Manager)

- Mechanical support with insertion/extraction system, and cooling
- Pixel Sensors
- All the required electronics designed by us, except the ROC, FED, FEC and OL designed by collaborators



ROC: PSI-46 (¼-µm). Testing at PSI

- August 13 ’03 Wafers of first ¼-µm submission delivered
  - Extensive testing of chip at PSI including test beam
  - Yield 83%
  - 14 minor modifications identified and implemented



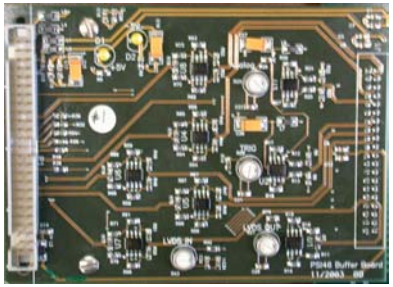
- Next Submission (MWP) PSI-46V2 (version 2) June ’04
  - We expect this to be a pre-production allowing the assembly of modules very similar to the ones for the final assembly.

Testing PSI-46 Chips (¼-μm). Fnal

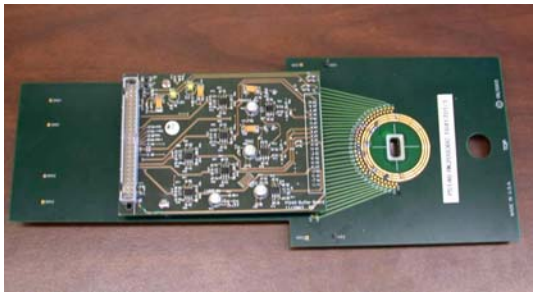
B. Baldin, C. Gingu. W. Wester

- Received 2 full and ½ diced wafers

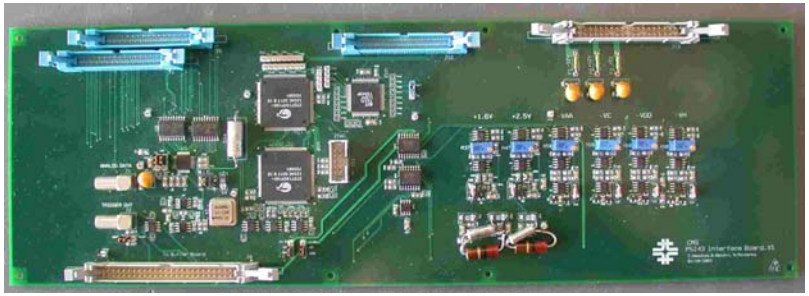
Use semiautomatic probe station



Designed PSI46 Buffer Board



Custom designed PSI46 probe card



Application Specific ASIC Interface Board

- Developed new interface and software

Testing PSI-46 Chips. Fnal

- Downloaded recommended settings from PSI
- Testing straight forward (Feb. 04)

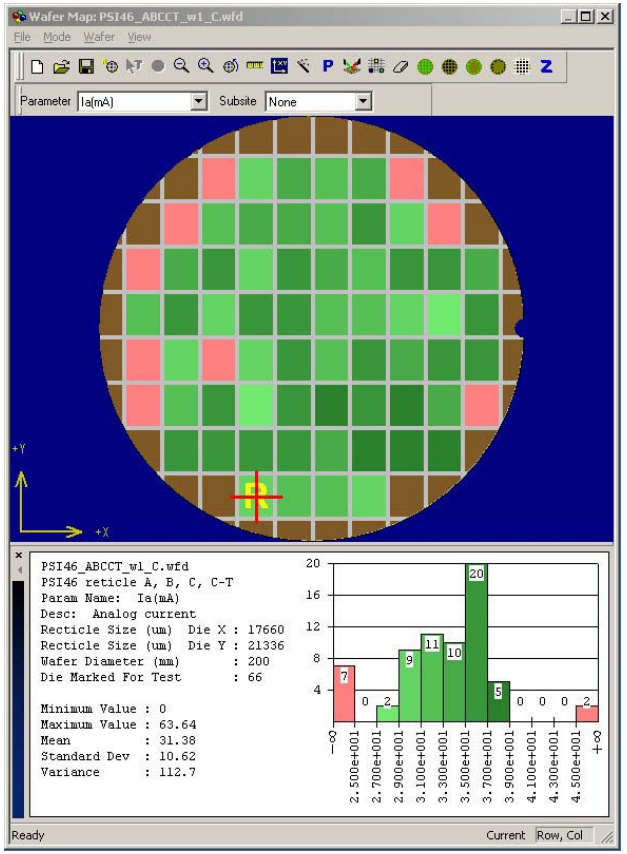
  gigantic improvement when compared to PSI-43
- Took only a few days

Yield: 83%, 121 mW/chip

(these chips have all pixels operating.
diced chips show same yield)

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

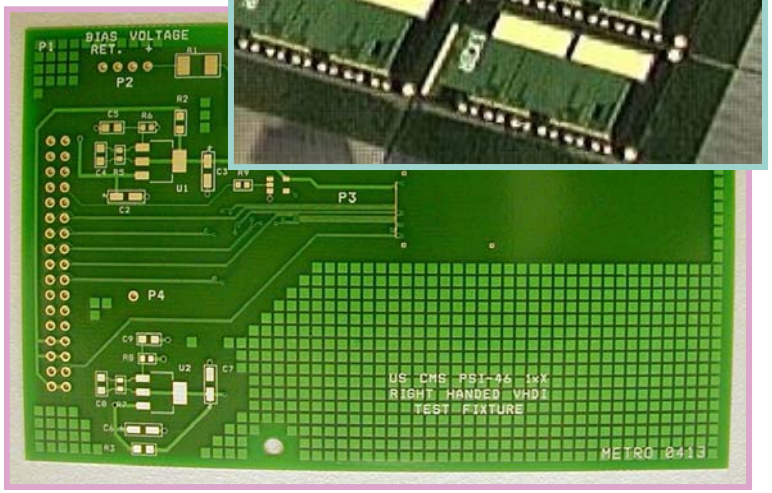
- Detailed report of test results available



Testing with PSI-46 in US

- VHDI 1 x 2 for PSI-46 on hand

- Tested PSI-46 ROC on hand
- HDI Board is on hand



- Negotiating bump bonding with IZM
  (other vendors under consideration)
- Electronics and software for the test setup is being developed by Rutgers (good progress)
- Testing
  - To be carried out with setups developed for the PSI-43 (at Fnal, Purdue, Rutgers)
    and in the
  - Test Beam at Fnal

Expect Tested Prototype-Plaquettes with PSI-46 by end '04

Token Bit Manager. TBM ¼ - µm, Rutgers

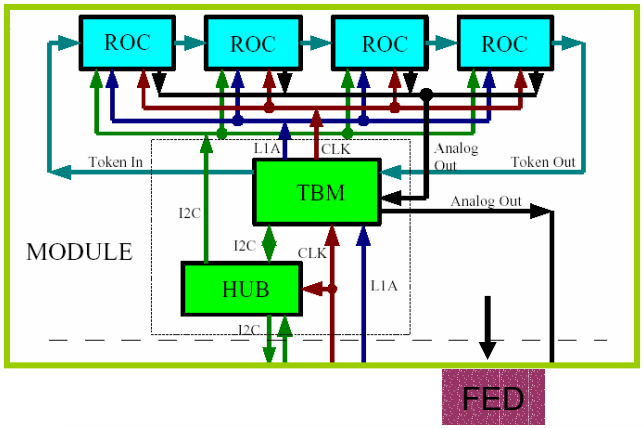
1st MPW Subm. TBM in DMill: May. 2002
Fully functional

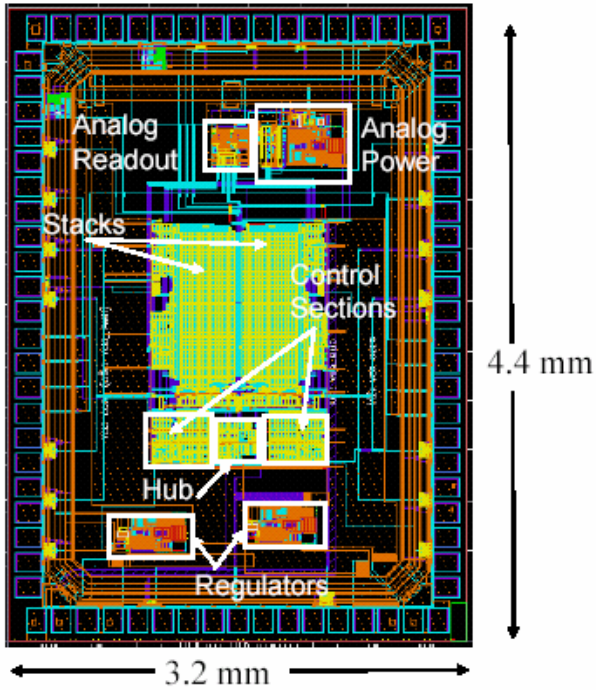
2nd MPW Subm. HUB ¼-µm: June 2003
Chip returned : Sep. 2003
Tested: Fully Functional at 40MHz

3rd MPW Subm. TBM ¼-µm: Nov 2003
Returned Feb. 2004
Tested: Fully Functional at 40MHz
Power consumpt. 100 mW

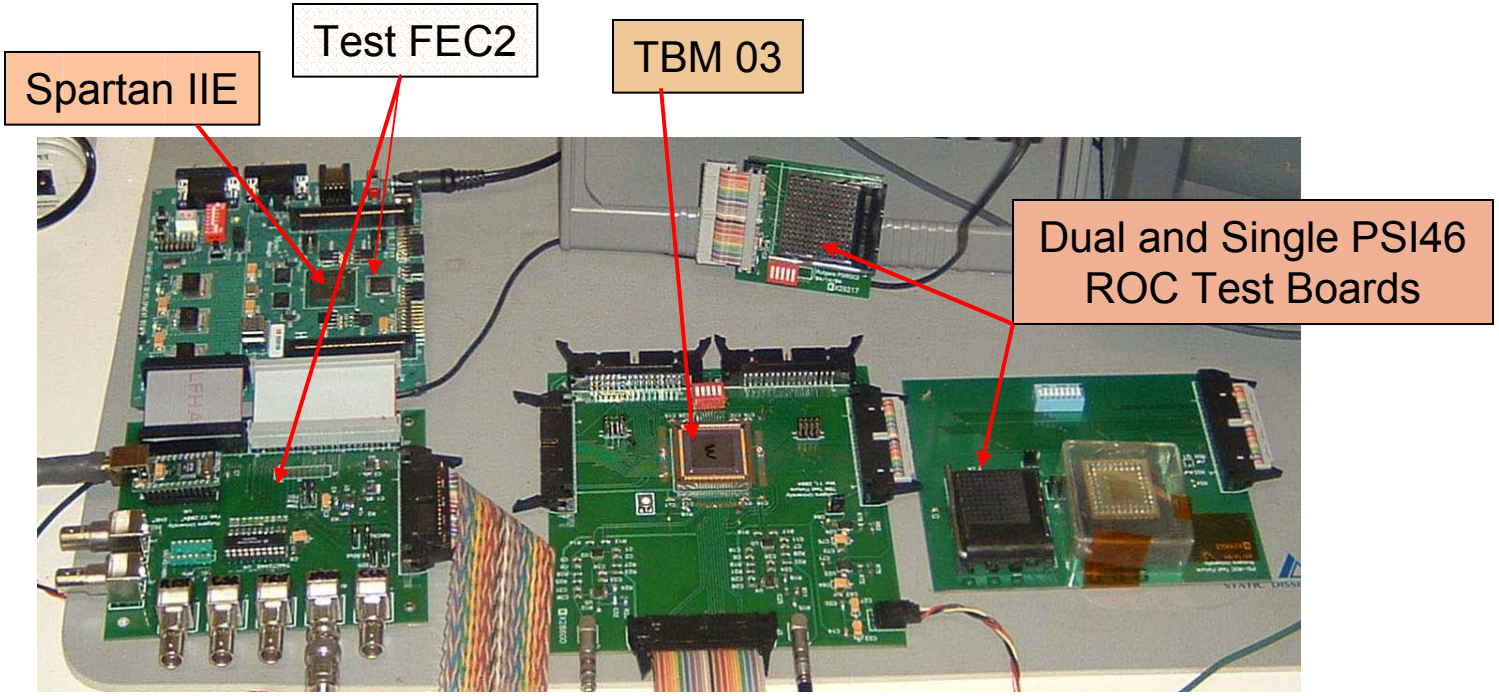
4th MPW Subm. TBM ¼-µm: June 2004
Pre-prod. Includes 6 modifications
Testing of chips to be done at Fnal

5th Subm.: Prod. TBM ¼-µm (MPW?)
By end '04



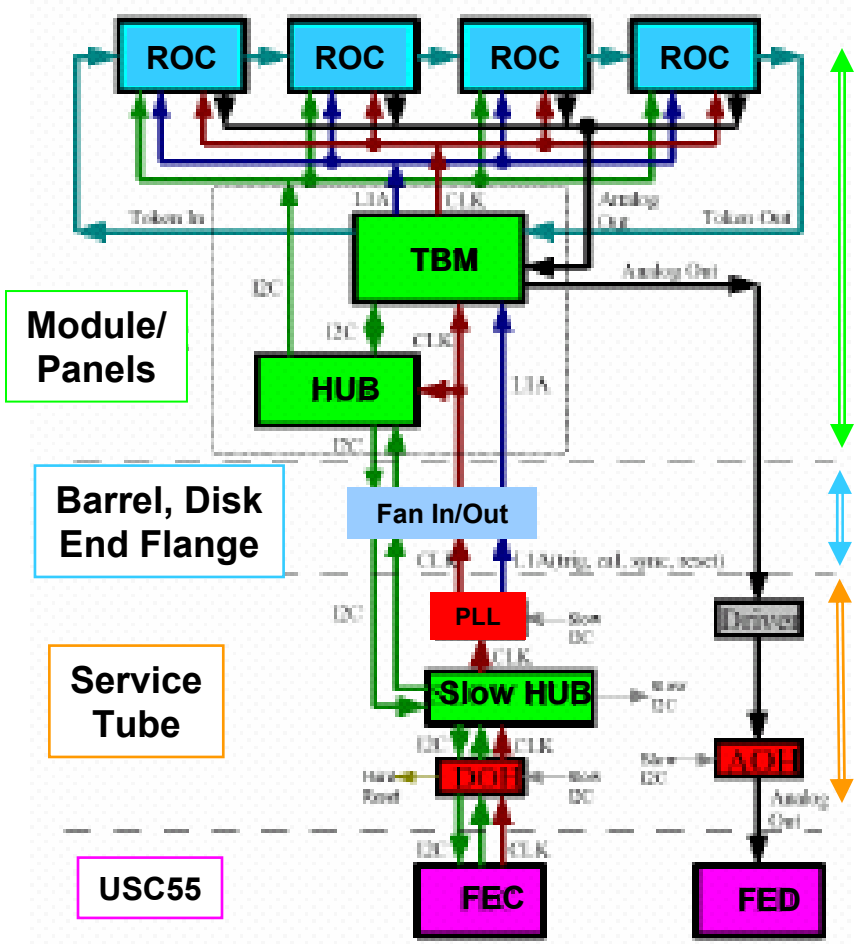


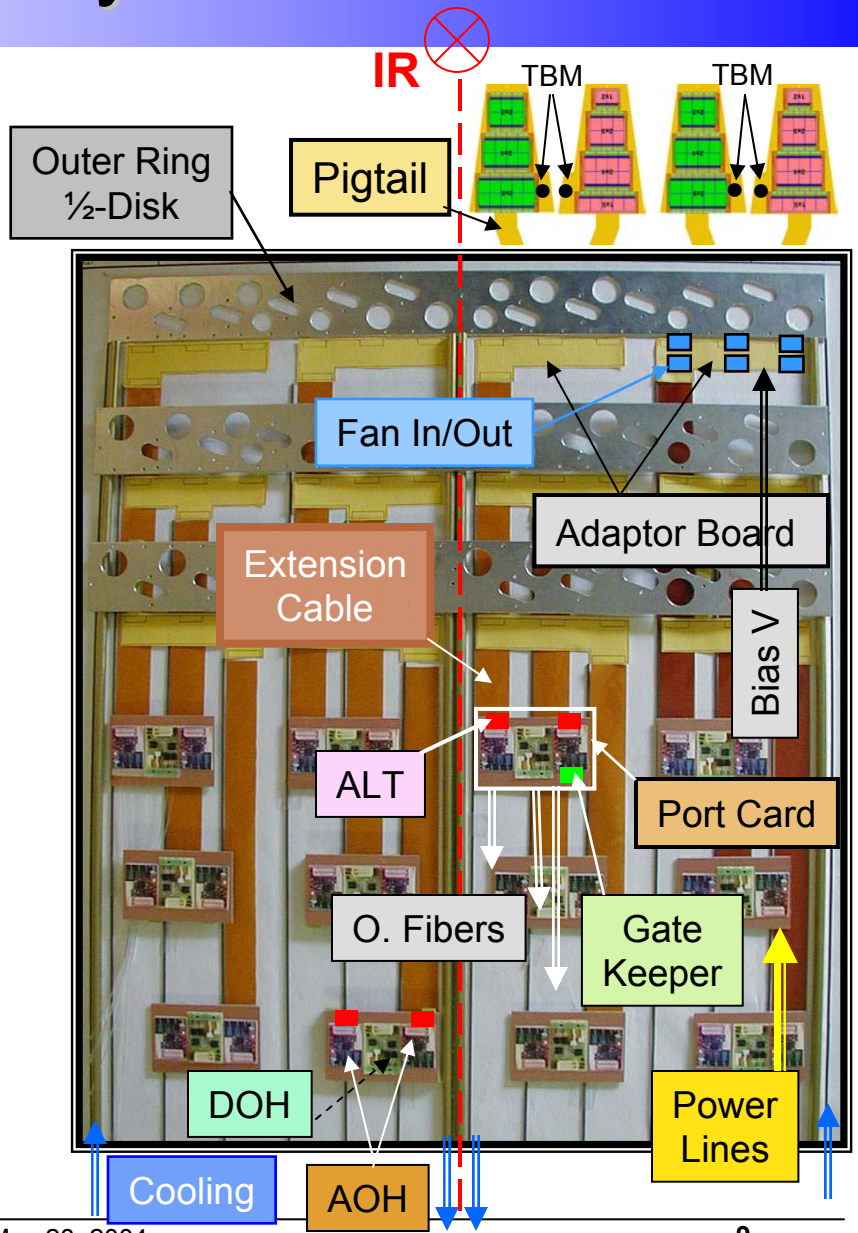
Test setup TBM ¼ - μm, Rutgers



- SEU test of TBM must be carried out
- Test of TBM with 4 groups of ROCs is next
- This set up will be used for
  - R&D with PSI-46
  - Testing of Plaquettes during production

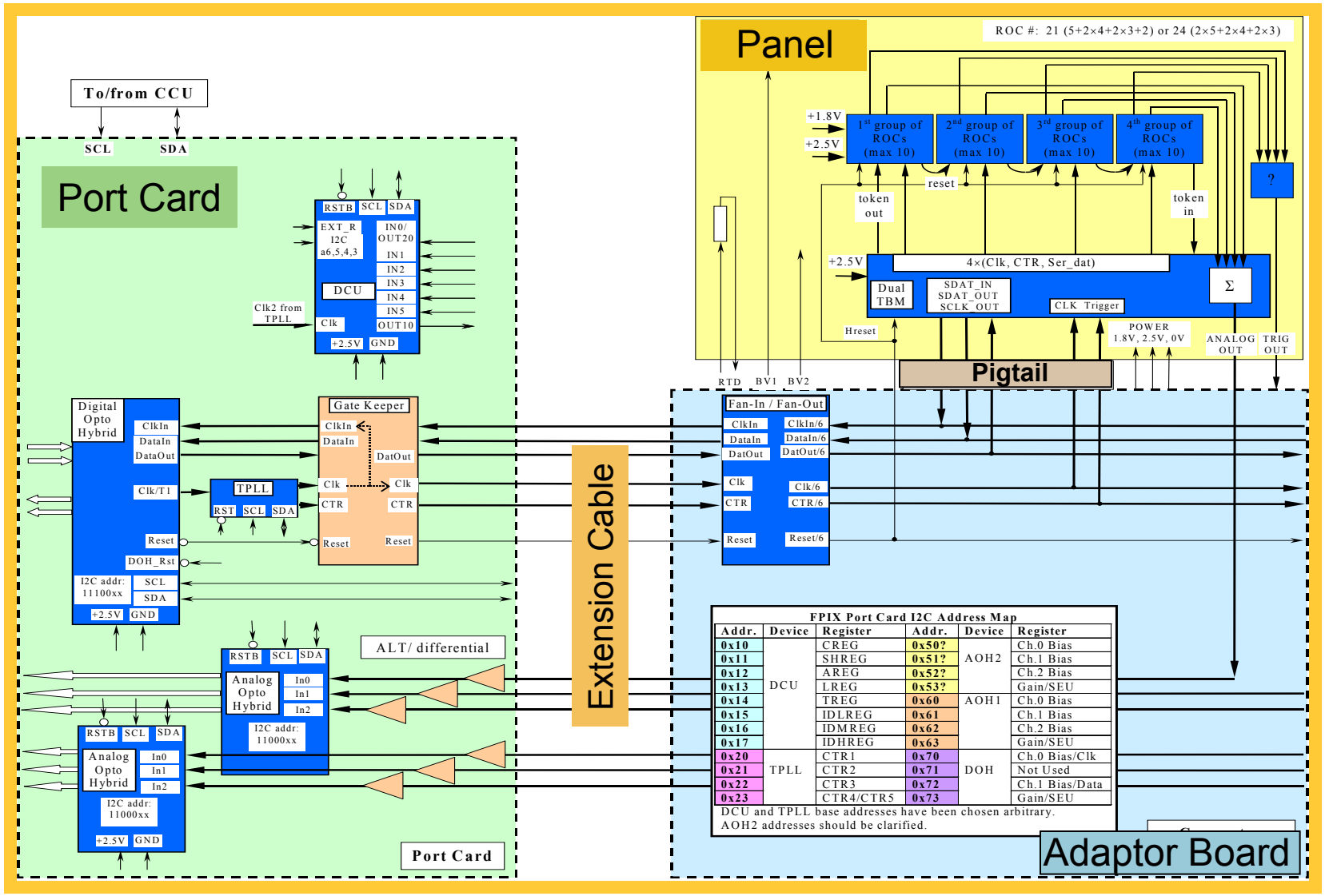
CMS Pixel. System Read-Out





Three New Chips Needed:
Fan In/Out, ALT, Gate Keeper

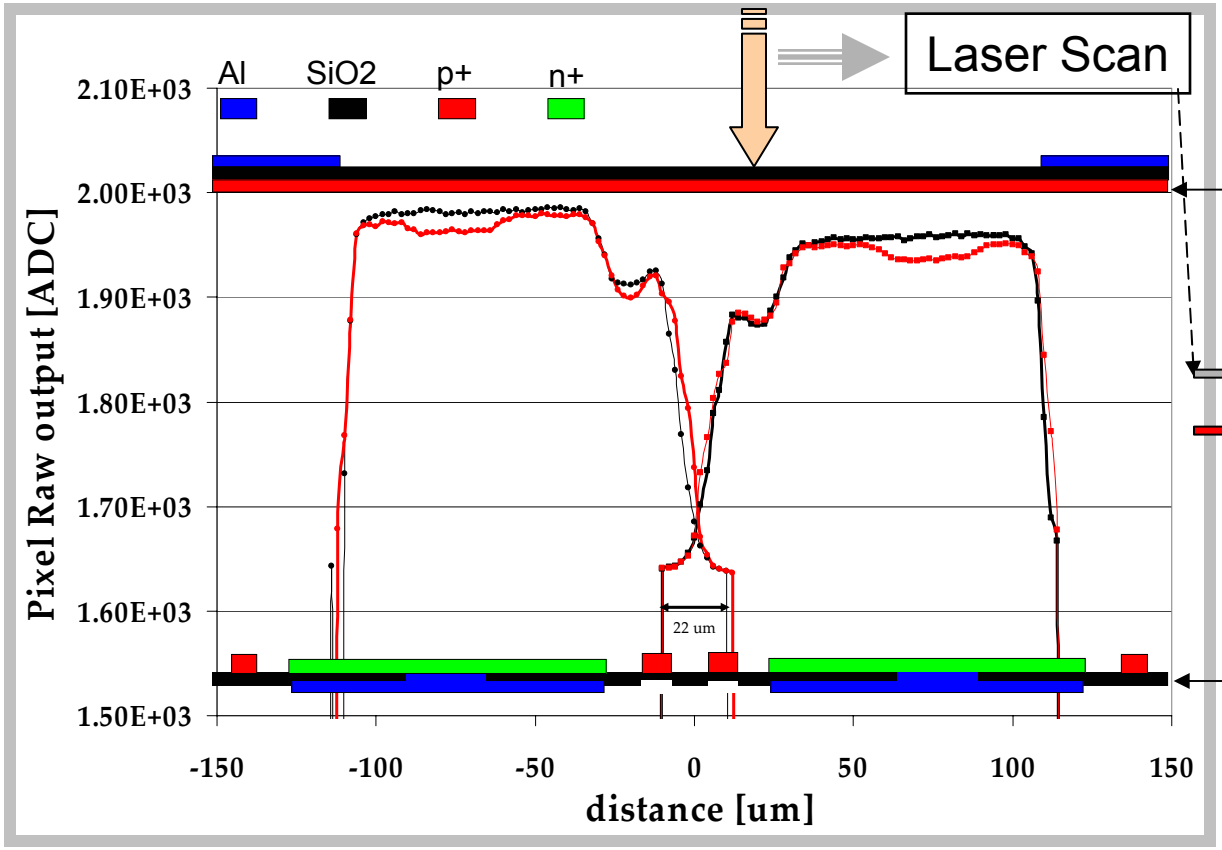
FPix Block Diagram

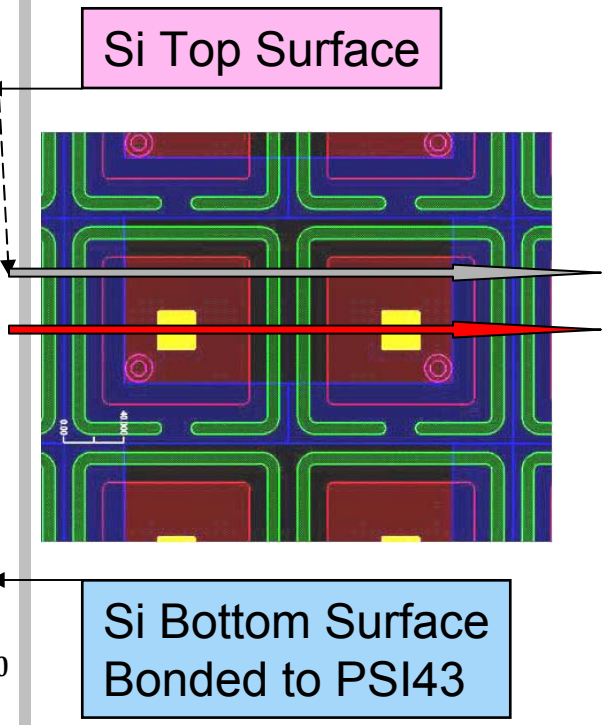


Sensors (Purdue)

- Prototype Submission of 15 wafers (4”) wafers is in progress with SINTEF
  - Choose a higher resistivity silicon
  - Incorporate individual ID for each sensor
  - New test fixtures included
  - Delivery by end summer ’04
- Radiation hardness studied in a beam at CERN
  - Observed an inefficiency (<5%) in sensors made using p-stop (FPix) when compared to p-spray (Barrel).$10^{14}cm^{-2}$
  - These studies are continuing, using
    - Laser pulser
    - Test beams at Fnal and CERN
- Place order for Production in Fall ‘04

Laser Scan Across 2 Pixels



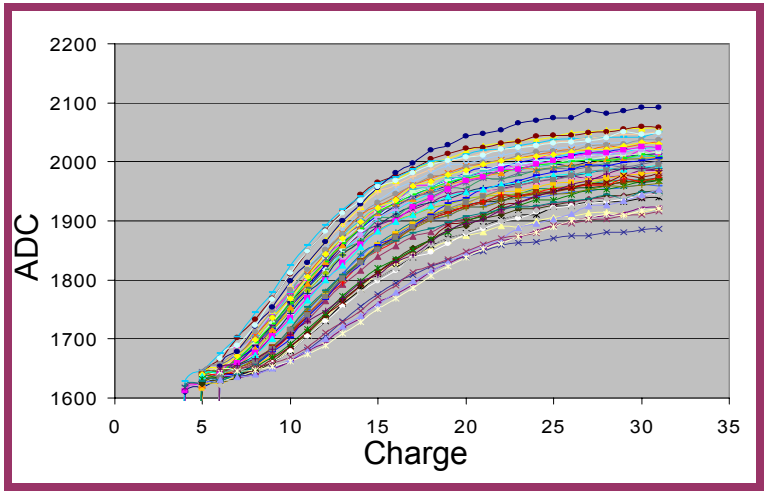


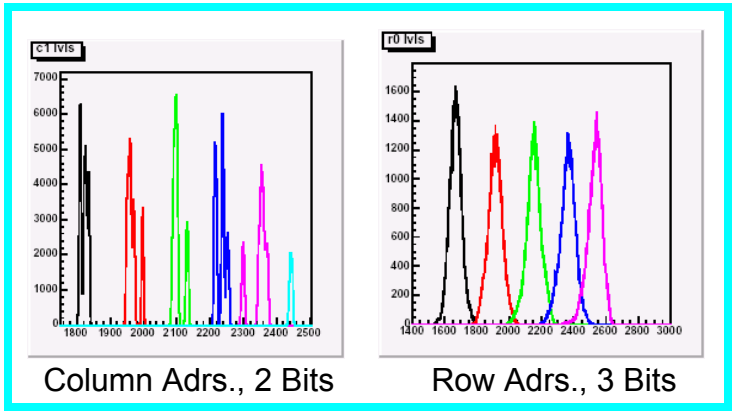
Signal before and after irradiation with Co^{60} at 1Mrad:
no difference in signal

Irradiate with 10^{13}p (Indiana):
… wire bonds damaged! … test to be repeated

Testing with PSI-43, ROC Tuning

- Each PSI-43 chip has 21 DACs, of which 11 requiring tuning
- They are different for different chips and also for different pixels.
- Considerable effort was invested in developing the software needed to optimize the performance of the ROC and in automating the collection of relevant parameters.
- Observe physics signals only after proper tuning of the DACs (~1h/ROC)
- These tools will be used for the PSI-46



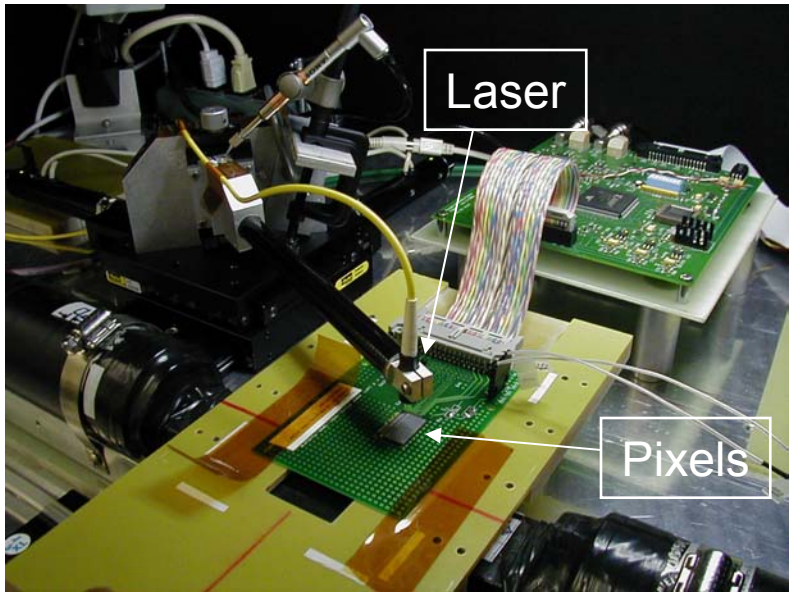


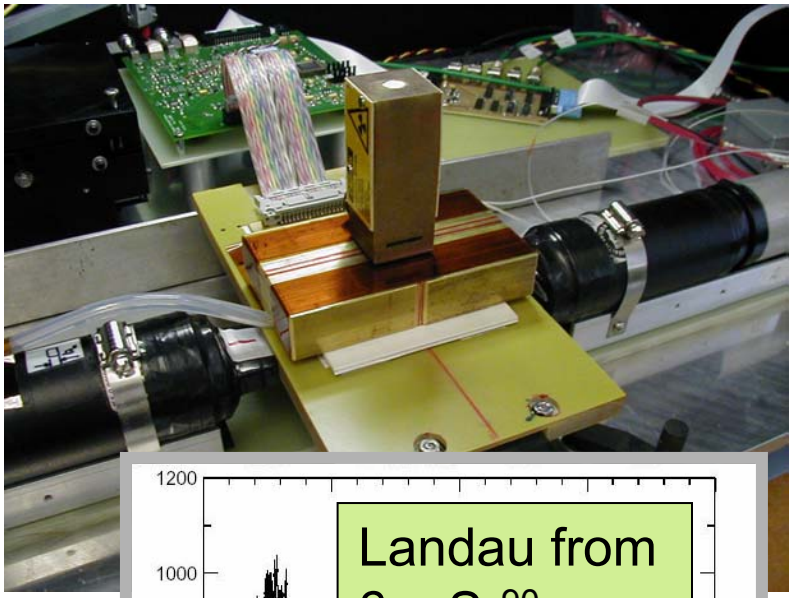
Column Adrs., 2 Bits

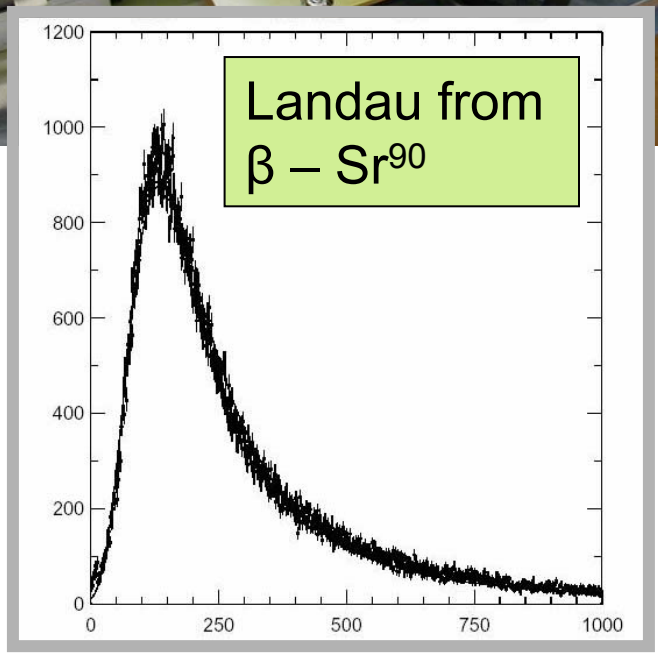
Row Adrs., 3 Bits

T: 70ADC-ch/1°C

Test Set-ups for Plaquettes





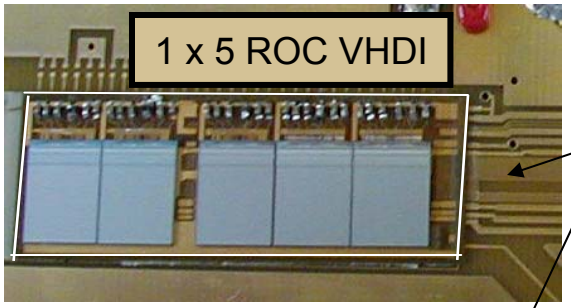


Readout Station
Rutgers

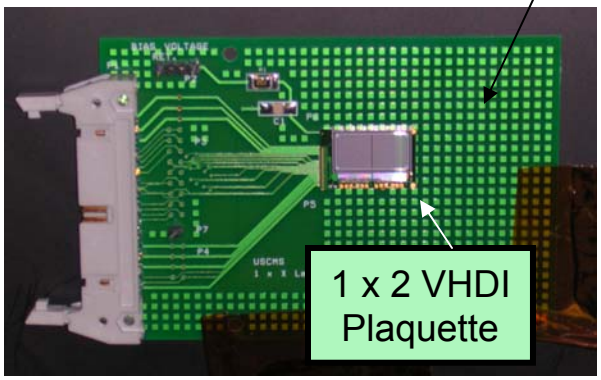
Test setups:
Fnal, Purdue, Rutgers

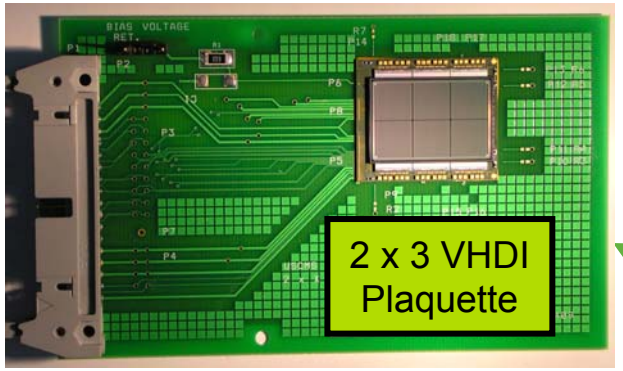
- Cooling (-30C)
- β-Source
- Laser Pulser

Test Results of Plaquettes - PSI43



HDI Board





HDI Board

Test setups at
Rutgers
Purdue
Fnal

ROC-Sensors:

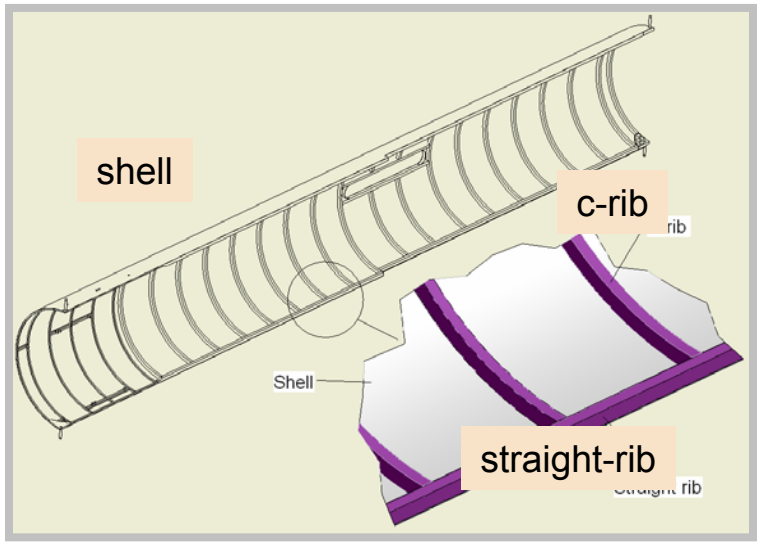
Bump bonded by

	IZM	MCN	UCD	Tot	Tsted	Good	Bad
1 x 1	4	3	2	9	9*	4	5
1 x 2	4	3	-	7	5	5^{-2}	0
1 x 3	2	2	-	4	3	3^{-1}	0
2 x 2	4	2	-	6	2	2	0
2 x 3	2	2	-	4	0	0	0
	16	12	2	30	19	14	5

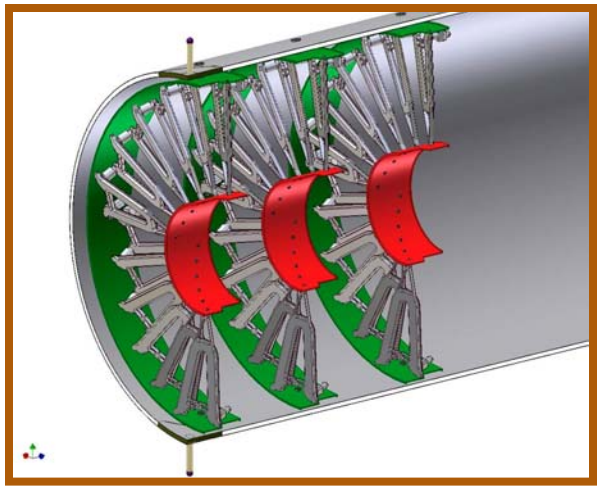
Gives expected
Landau Distribution

Mechanics

- Service Cylinder
  - Section assembled, tested, extensive FEA
  - Aluminum Mandrel ordered
  - Jigs for assembly ribs in mach. shop



  - Prototype ready by Fall ’04



- ½-Disk
  - Design & tests are completed
  - Order prototype by end ‘04

To Complete the Assembly

The Pixel Project must assemble 4 Disks of 2 different geometries.

This requires:

- The Assembly of 800 Plaquettes of 7 different types.
  5 steps are required to assemble one Plaquette.
- The Plaquettes will then be installed on 200 Panels of 4 different configurations. It will require 8 steps to produce one Panel.
- The Panels will then be mounted on 8 ½-Disk units, with two configurations, before they are installed on the 4 ½-Service Cylinders.

To organize an efficient assembly line, groups of Taskforces have been convened weekly over the last 2 months.
These groups are assessing each step of the production process. They optimize the assembly, evaluate the resources required, and risks involved.

Reports from these groups can be found at: http://ppd.fnal.gov/experiments/forward_pixel/Review_2004/index.html

Taskforces to prepare for Assembly

1 Storage of Plaquettes during assembly
(800 Plaquettes (assembly at Purdue), and 200 Panels (at Fnal). Use same storage for the 8 different types of Plaquettes and 4 different Panels during the entire assembly. This including shipping, testing, and storage between assembly tasks.
(**Kirk Arndt**, Mikhail Kubantsev, Bill Kahl, Umesh Joshi, Bruno Gobbi)

2 Testing VHDI and HDI
(VHDI completed, HDI probably similar to VHDI but need a large surface area flying head probe station. Will modify a probe station at SiDet.)
Mike Matulik, Mikhail Kubantsev, Eckhard von Toerne, Kim Dongwood, Eric Spencer

3 Electrical tests needed during assembly
(detailed outline formulated of the types of tests, the equipment and software needed, and who is responsible for what)
(**Boris Baldin**, Ed Bartz, Mike Matulik, Sergey Los, Gino Bolla, Umesh Joshi, Kim Dongwook, Bruno Gobbi)

4 Burn-in station
(operate Plaquettes for days while cycling the temperature (+200C to -300C). Will identify weak components.)
Gino Bolla, Bruno Gobbi, Bill Kahl

5 Encapsulation of wire bonds
(wire bonds could break because of a current pulse in B of CMS, or during shipment. Tests in progress.)
Muzaffer Atac, Gino Bolla, Eckhard von Toerne, Mikhail Kubantsev,

Task Forces to prepare for Assembly. cont

6 Shipment to CERN
Bill Kahl, Kirk Arnd, Bruno Gobbi
(what units can be shipped safely to CERN, and what is the most reliable transportation)

7 Possibility to surveying the FPix at CERN
(yes: (x,y,z) = (1600, 600, 600) mm^3, to 3-5 μm)

8 Electronic Logbook
(easy access to updated information of the assembly status)
Umesh Joshi, J.C., Mikhail Kubantsev, Kim Dongwood, Eric Spencer

9 DAQ software
Umesh Joshi, Kim Dongwood John Doroshenko, J. C., Bob Stone, Eric Spencer,

10 Data Base
(together with PSI, US-CMS, and CERN)
Umesh Joshi, J. C., Kim Dongwood

11 List of Parameters needed for Physics
Morris Swartz, Daniela Bortoletto, ...

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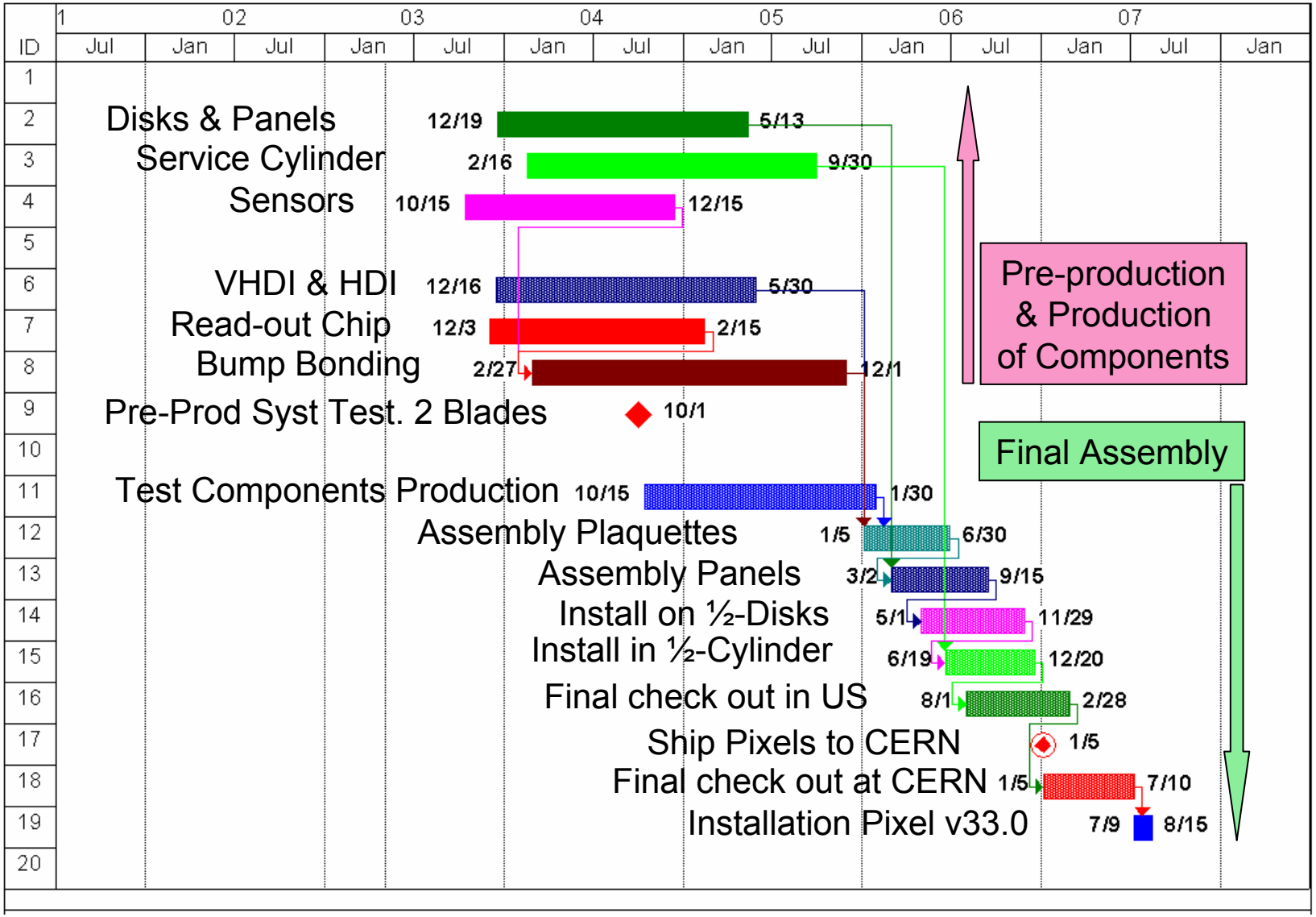
FPix Critical Path 2004



Issues

- For this project to succeed, the number of physicists, with experience in working at complex HEP projects must be urgently increased.
- These physicists are mostly needed at the assembly centers.
- Ideally, they should be committed to the Pixel project full time or for a definite period adequate for completing a given task.

- Bump bonding of pixels by industry takes considerably longer than anticipated. One example is the experience of the Atlas experiment.
- We must increase our effort to identify additional vendors capable for carrying out each one at least part of our production.

Summary

- The PSI-46 performs substantially better than the DMill version. The availability of these chips beginning in ’05 is now realistic.
- The read out chain of the CMS Pixel is now defined. The US effort now has adequate expertise, with 4 EE, to cover its tasks in electronics.
- We have tested Plaquettes (PSI-43) in the Lab (Sr-90, Laser, LEDs) and soon we will take data in the MT6 beam. Expertise, test equipment, and related software are now available in our group, but additional physicists are necessary for the production phase.
- The final assembly is being formulated in detail, and the tools will be developed and tested during the next 6-8 months.
- Components approaching production stage include: Sensors, VHDI, ½-Disk mechanics, and test setups for the Plaquettes.