Status of the CMS Pixel project

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RD07 Florence
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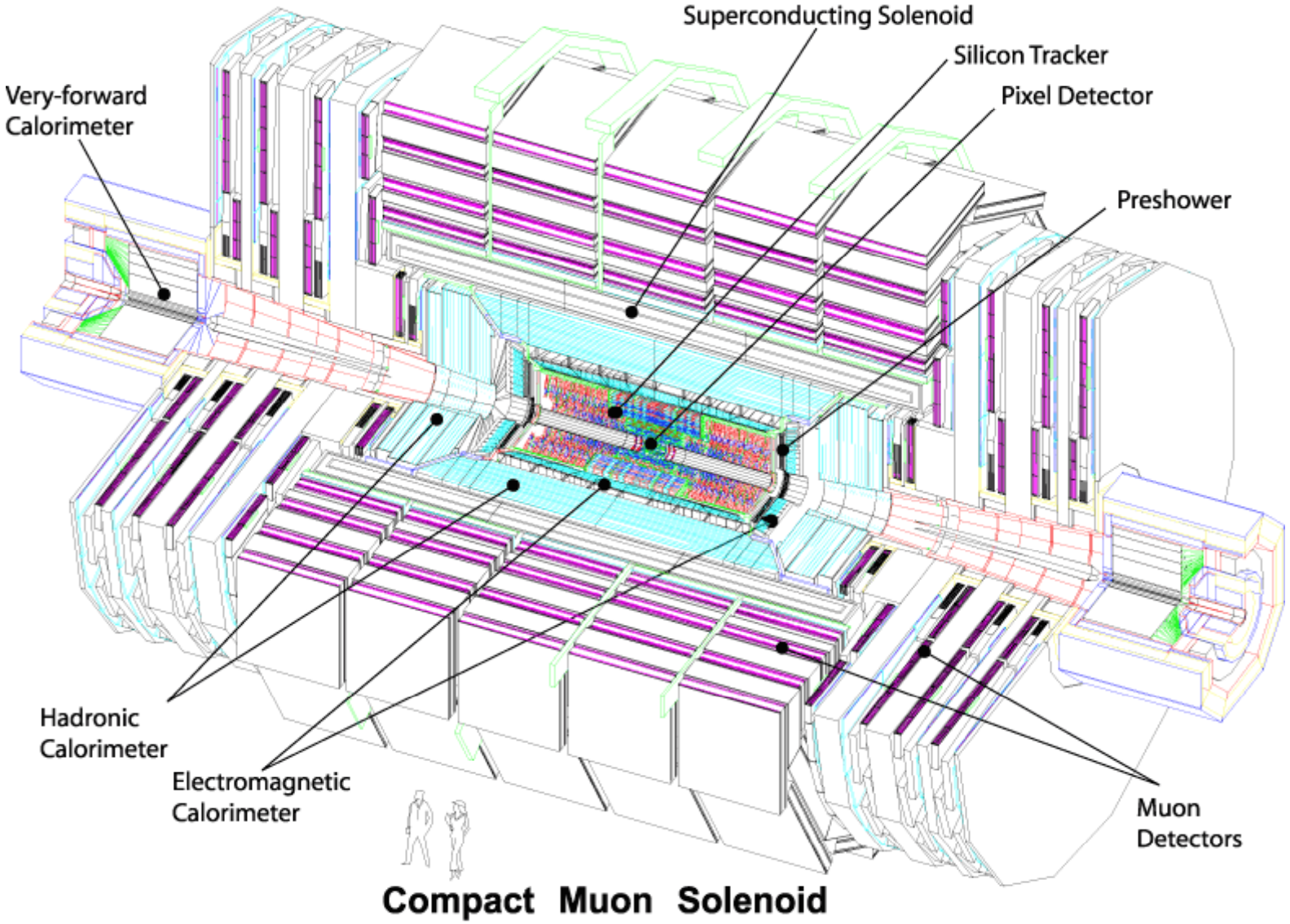
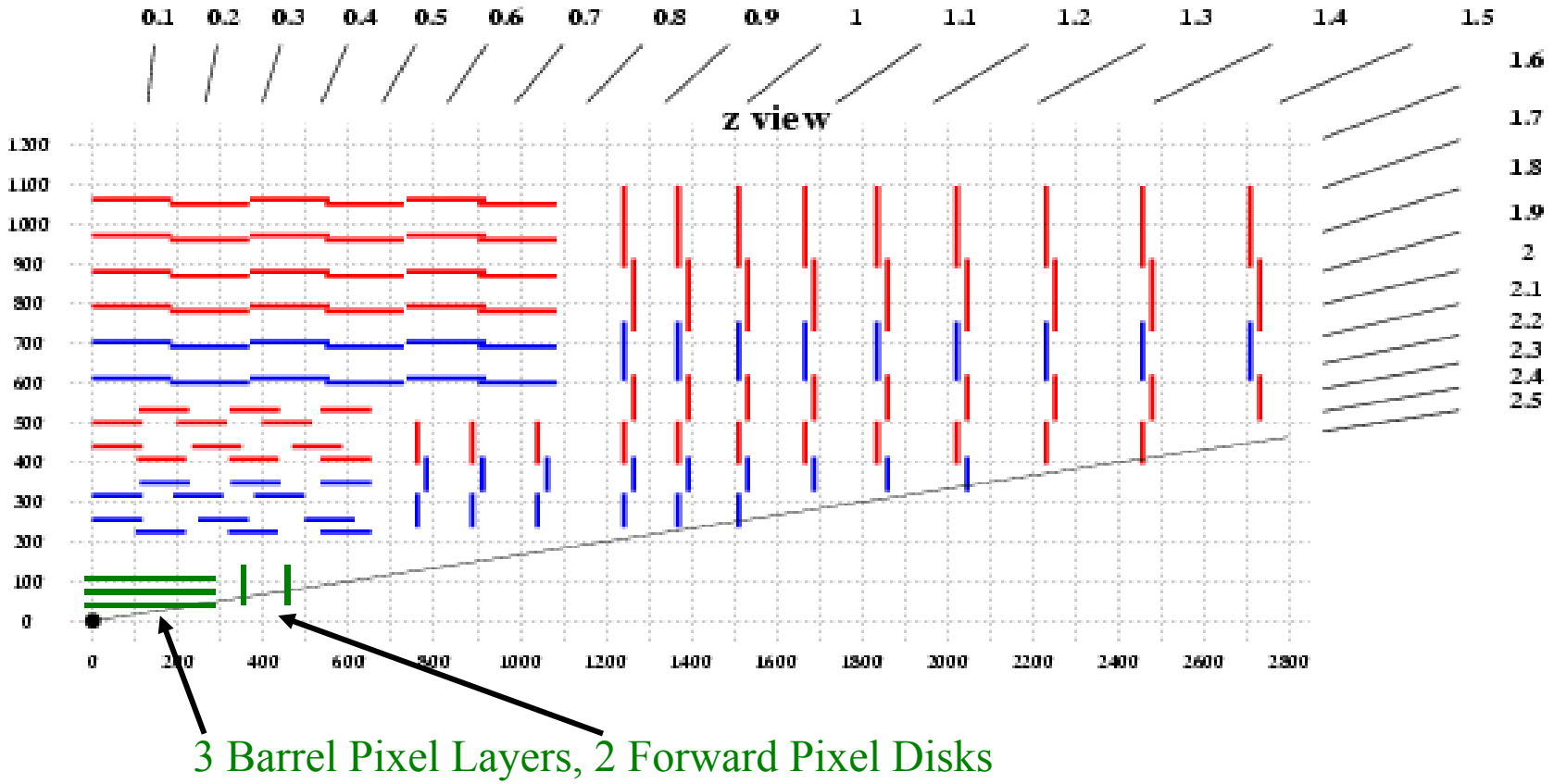
CMS Detector



Tracker



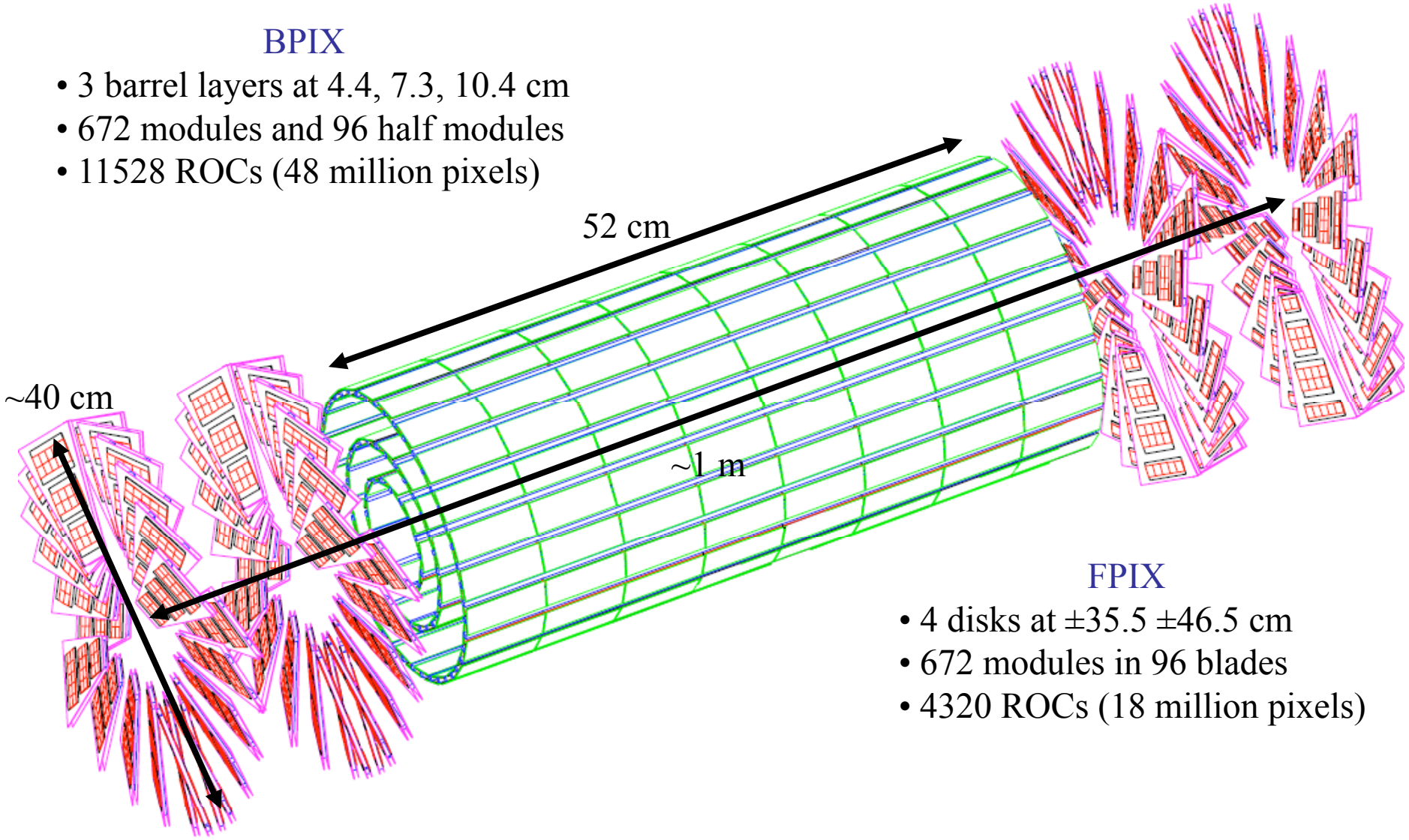
The design guarantee 3 pixel hits, up to a $|\eta| = 2.5$, that are used for three main purposes:

- seeds used for pattern recognition in all tracker
- improve the vertex resolution near the IP
- fast tracking and vertexing in the High Level Trigger using only the pixel info

Pixel Detector

BPIX

- 3 barrel layers at 4.4, 7.3, 10.4 cm
- 672 modules and 96 half modules
- 11528 ROCs (48 million pixels)



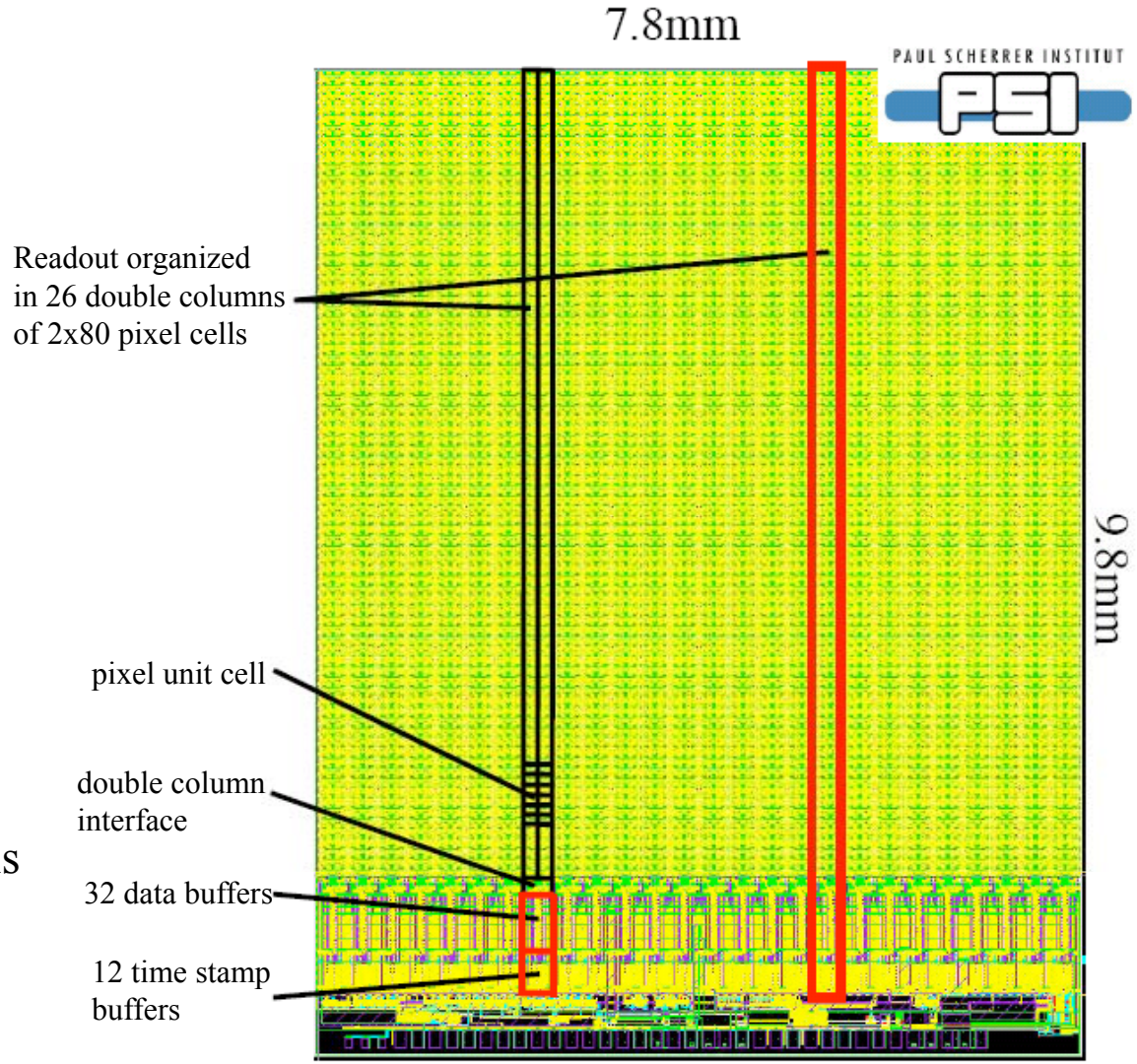
FPIX

- 4 disks at ±35.5 ±46.5 cm
- 672 modules in 96 blades
- 4320 ROCs (18 million pixels)

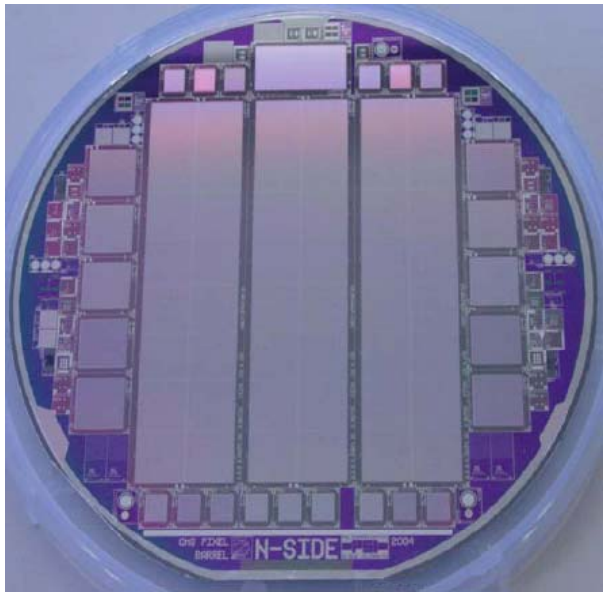
The inner modules will absorb 3×10^{14} $n_{eq}/cm^2/yr$ at a luminosity of 10^{34} $cm^{-2}s^{-1}$!

Pixel Read-out Chip

- 0.25µm IBM CMOS rad hard technology
- 100x150 µm pixel cell size which provide a spatial resolution of ~10µm in rφ and ~20µm in z
- 52x80 cells organized in double columns
- 32 data and 12 time stamp buffers
- Data are encoded on 6 analog levels



n on n Sensors

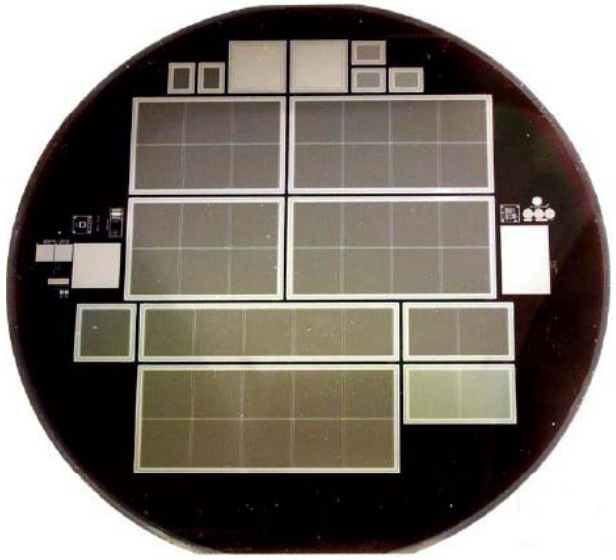


BPIX

- Sensors use p-spray isolation and they are all in hand from CIS
- They are bump bonded to the ROCs in house at PSI using indium

FPIX

- Sensors use partially open p-stop isolation and they are all in hand from Sintef
- They are bump bonded to the ROCs at two different vendors, RTI and IZM using PbSn



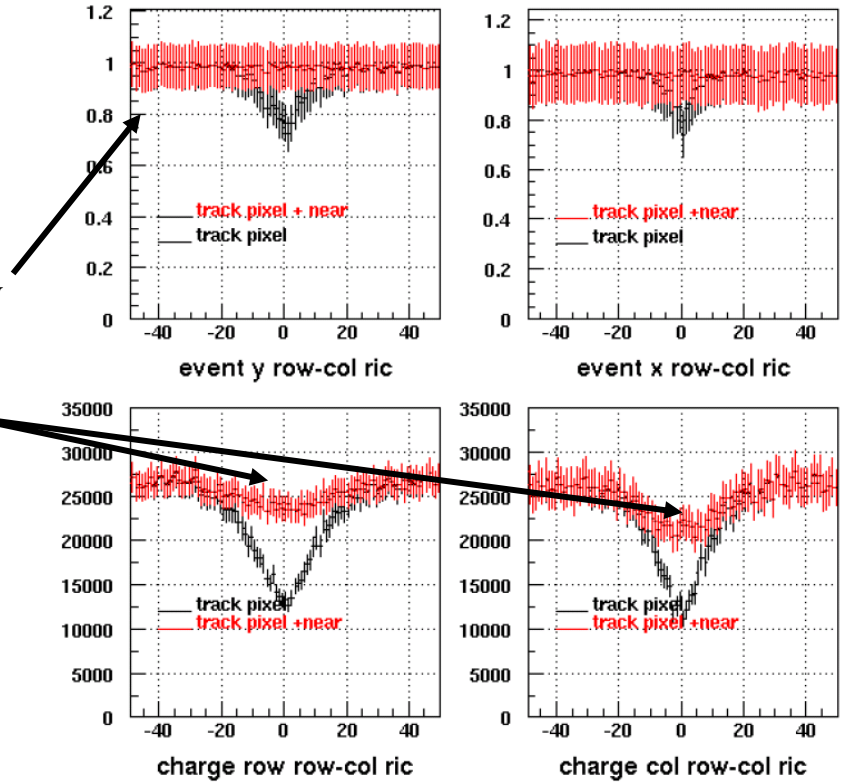
Charge Collection in Irradiated Devices

Extensive studies have been done in the past years to guarantee high efficiencies for highly irradiated detector.

The track detection efficiency was measured for both technologies. After a fluence of 8×10^{14} neq/cm^2, above the goal of the CMS TDR, the detection efficiency is > 99% both for BPIX and FPIX.

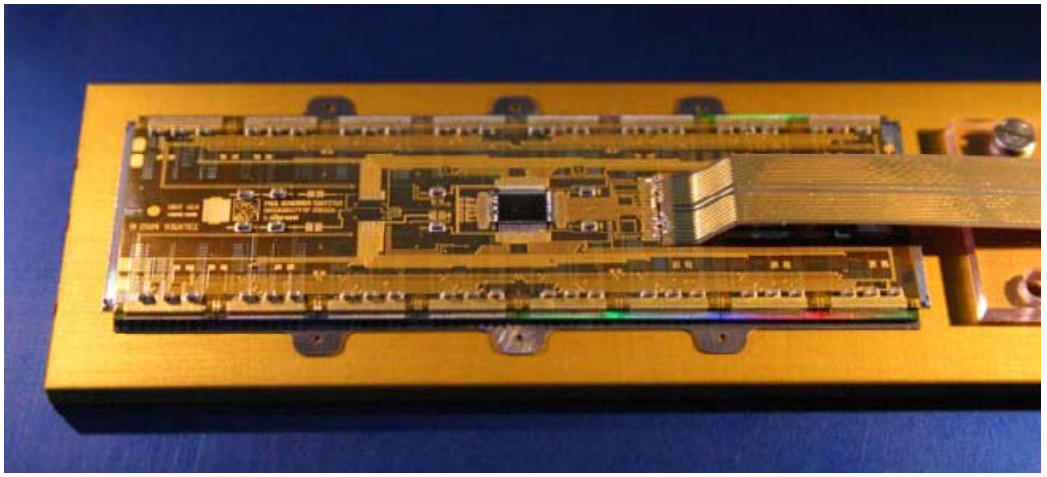
FPIX testbeam 2006

- No evident loss in detection efficiency
- Some enhanced charge loss when compared with non irradiated devices
- Some asymmetry between row and column sharing



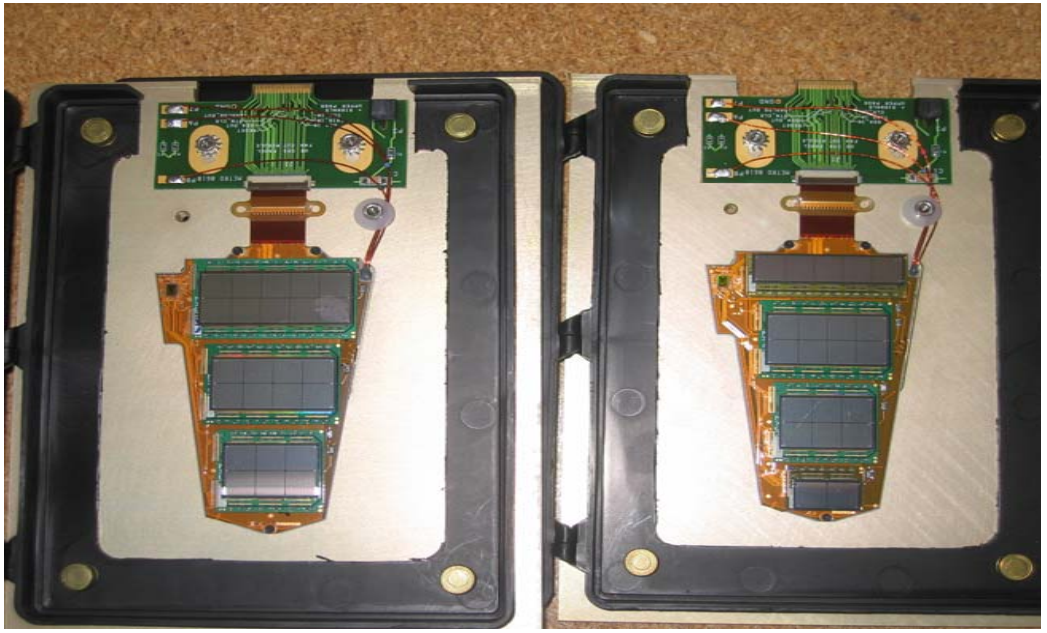
Module and Panel

Two different types of BPIX modules:
- full module (16 ROCs)
- half module (8 ROCs)



Five different types of FPIX modules with 2,5,6,8,10 ROCs.

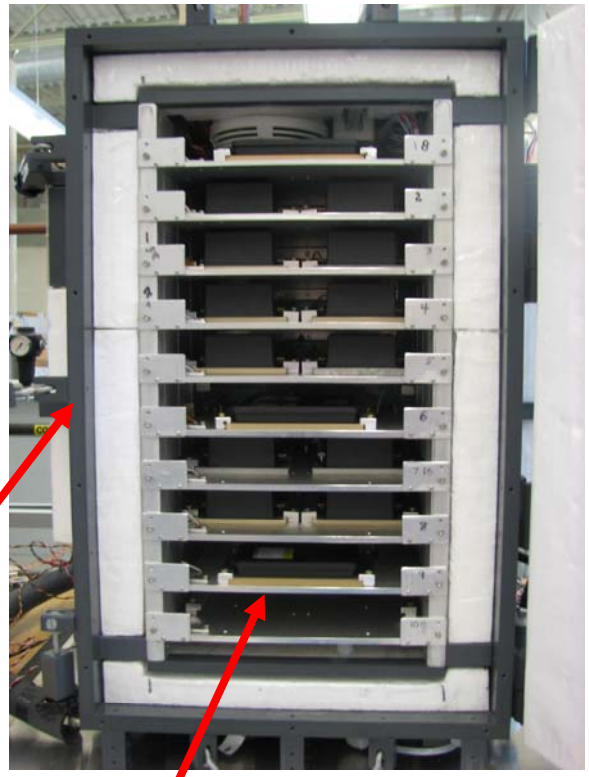
Modules mounted on two different types of panel:
- 4 modules panel
- 3 modules panel



Module Testing

To obtain the expected performances of the pixel detector it is necessary to test the modules in every phase of the assembly.
To this extent the noise of the pixel must be evaluated, together with several other parameters that influence the performance of the detector, such as the value of the break-down voltage or the percentage of broken bump-bond contacts

- Modules are assembled and quickly tested at Purdue University at a production rate of 6 modules/day
- They are shipped to FNAL and when they arrive, are visually inspected.
- The modules then undergo a two-day thermal cycling process consisting of ten cycles between +20 and -15 °C



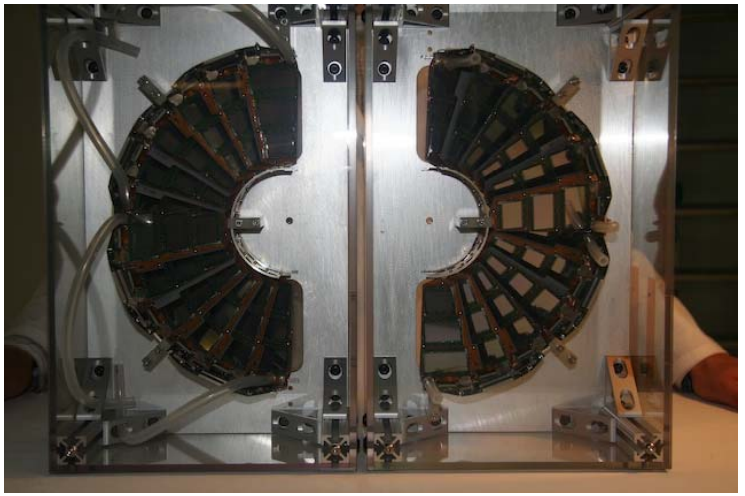
Module Testing

- Since the detector will operate at cold temperatures, to minimize the effects of radiation damage, plaquettes and panels undergo detailed characterization at -15ºC.

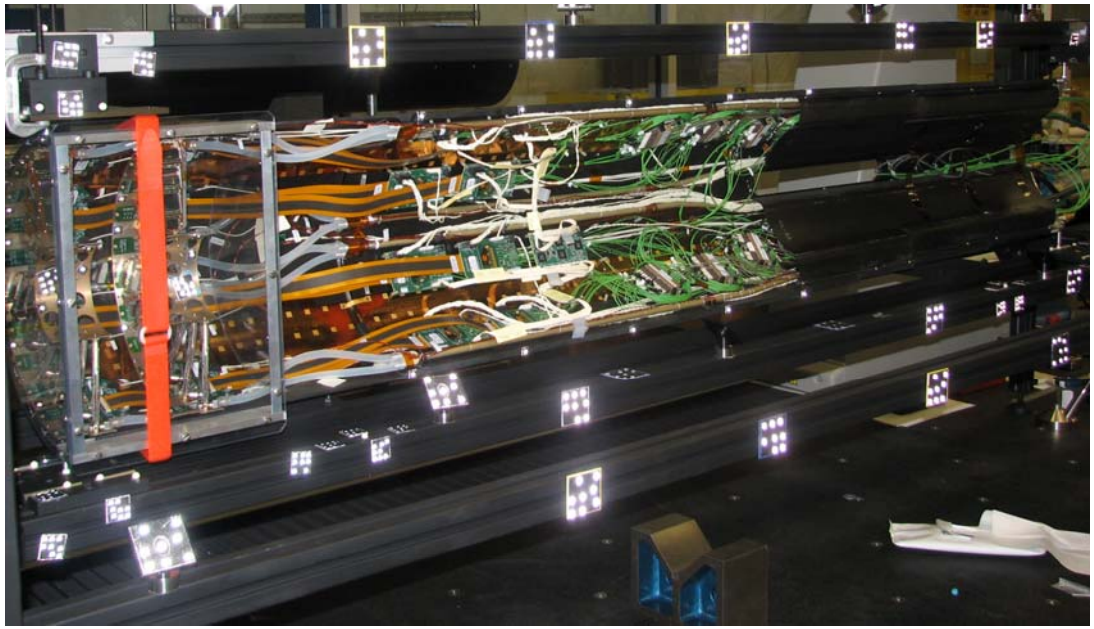
- To cope with the production rate four test stations have been fully equipped and they are enough to keep up with the required rate.

Module Testing

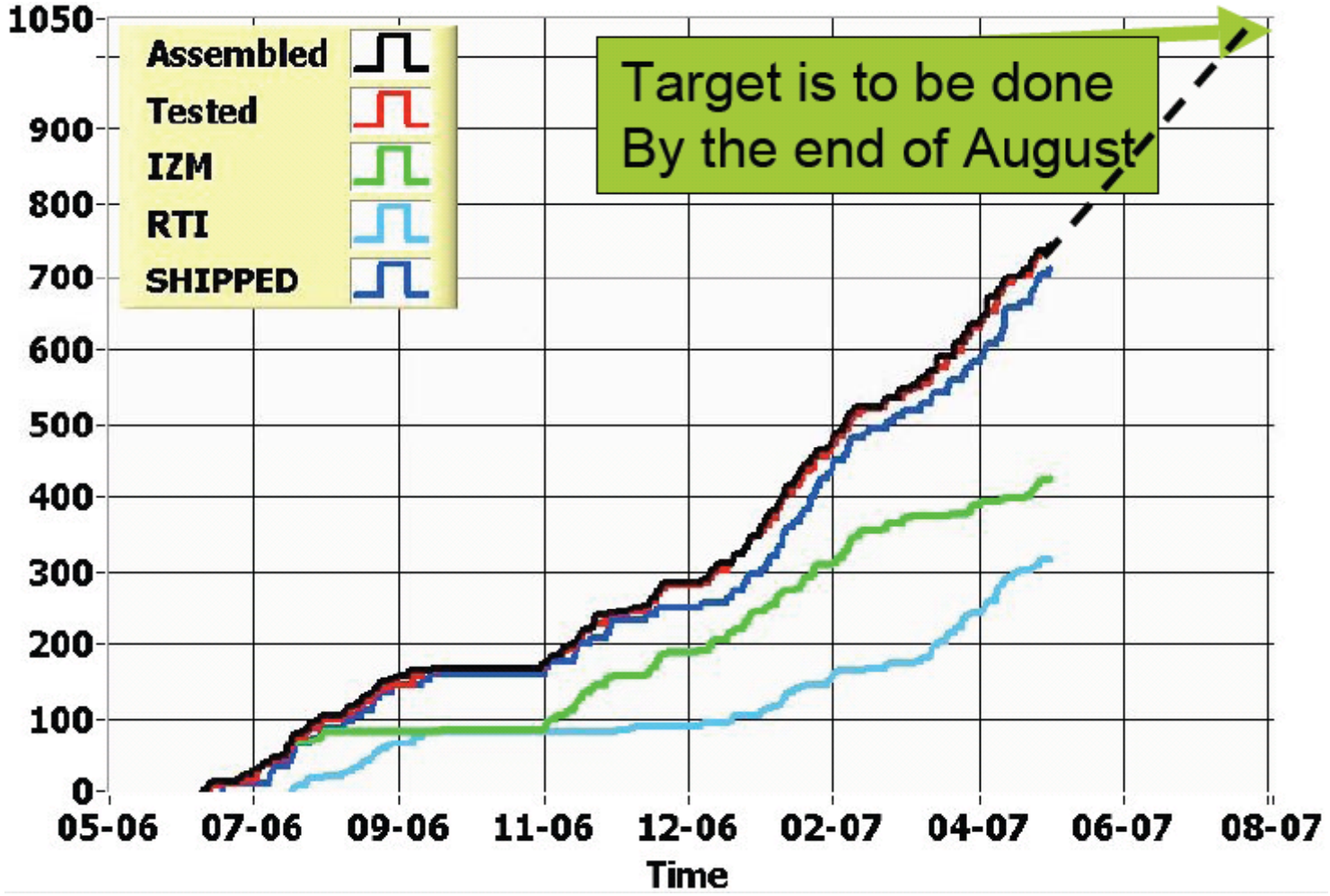
Panels are mounted on the half disks



The two half disks are then mounted in the half service cylinder to be tested with the final DAQ electronics, before being shipped to CERN



FPIX Production Outlook



Our plaquette production target is to be done by the end of August.
The extrapolation seems to be still valid!

BPIX Production

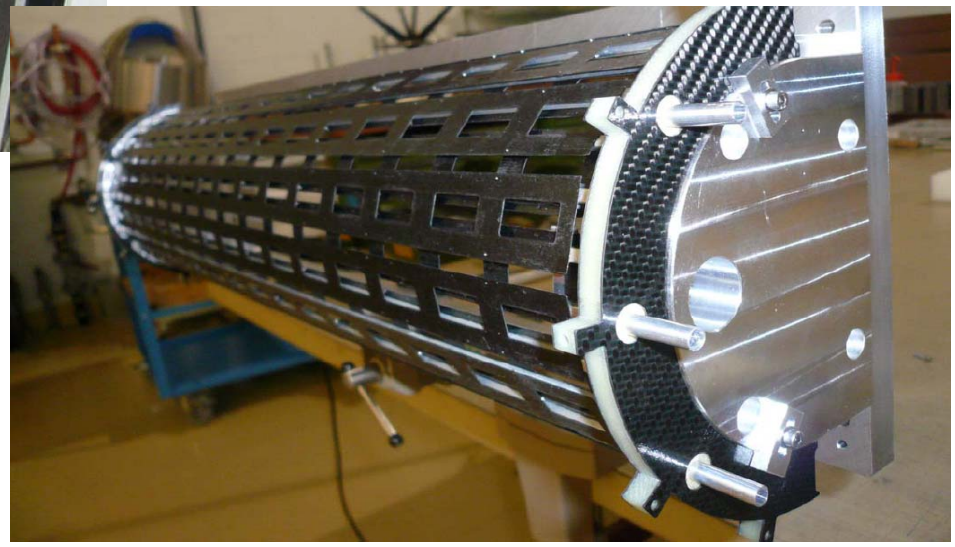
Production rate:
4 full modules/day
+
2 half modules/day
or
6 full modules/day

Status: 12 Jun 2007

Needed for the 3 layers : 672 full modules + 96 half modules
Prod. status (good modules): 573 full modules + 73 half modules (~80% completed)

BPIX Production

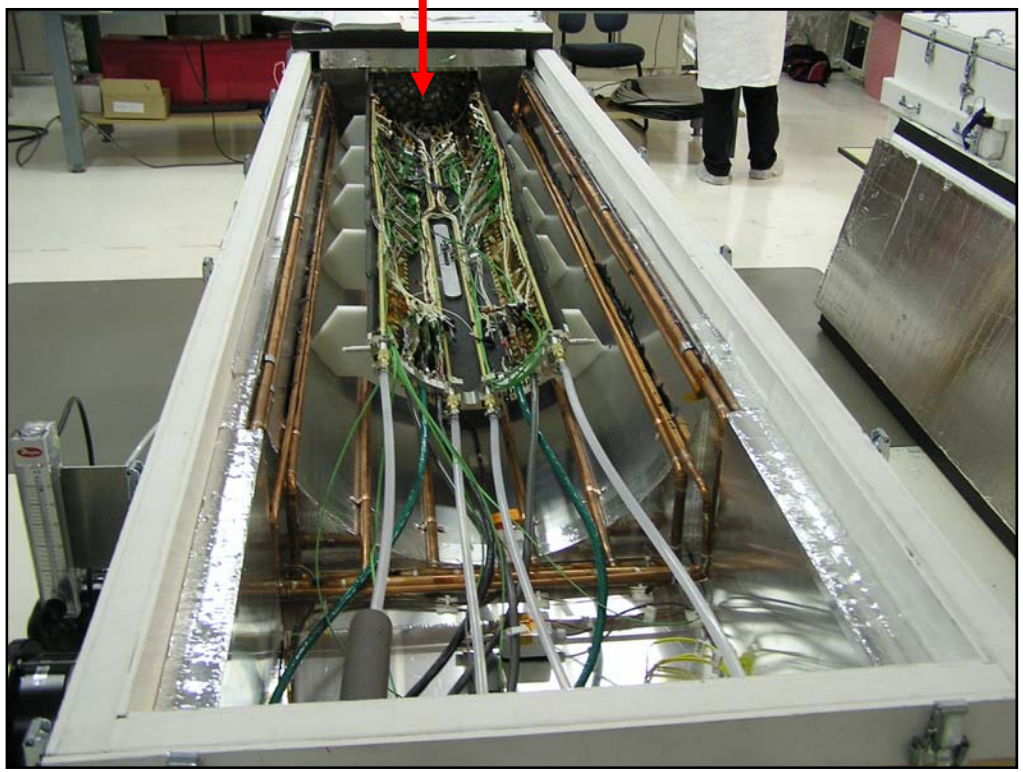
Modules are stored in dry boxes ready to be mounted on the carbon fiber support structure



Part Delivery at CERN

- 50% (4 half disks) of the FPIX detector has been delivered at CERN. The last two half disks will be delivered in November.
- The barrel will be assembled at PSI and then shipped to CERN in one piece at the end of January.

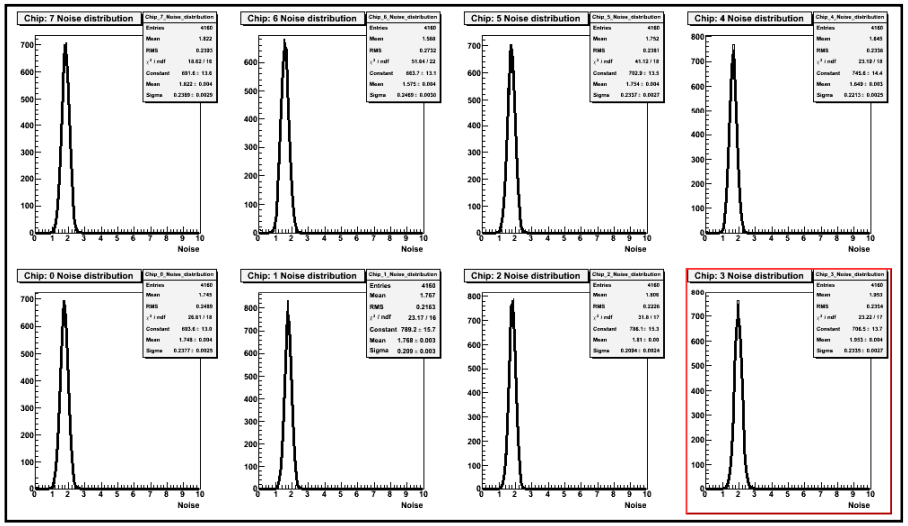
Cold box where the half disks can be tested at low temperature



Dry box for half disks storage at CERN

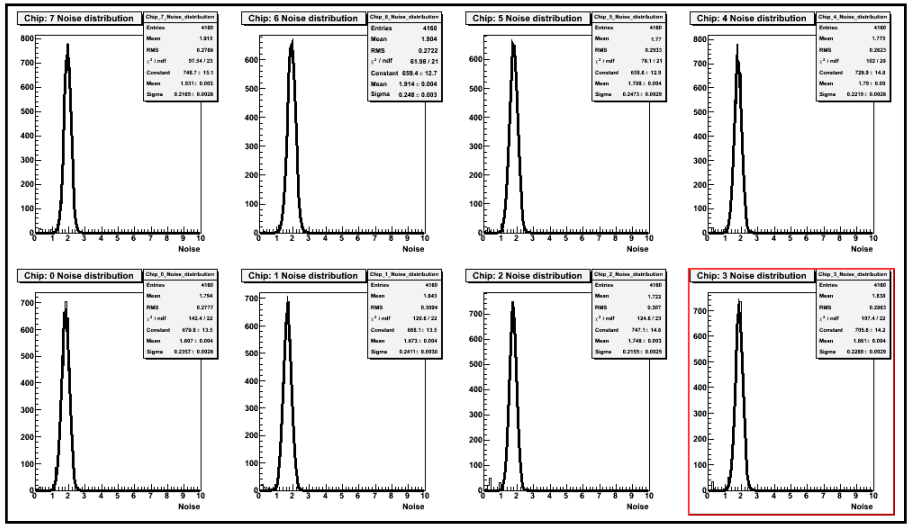
Noise Measurements on Delivered Parts

Once the half disks are inserted in the cold box and connected to the electronic they undergo a series of tests to make sure that are still working properly.



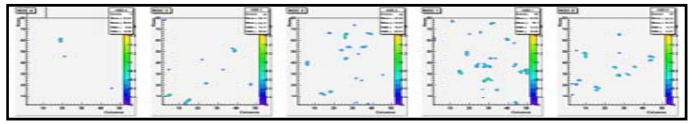
Noise measured at FNAL at +15°C
➢~1.8 ADC

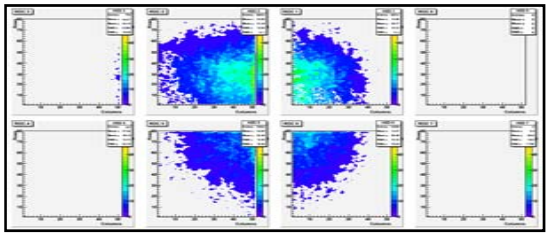
Noise measured at CERN at -10°C
➢~1.7 ADC



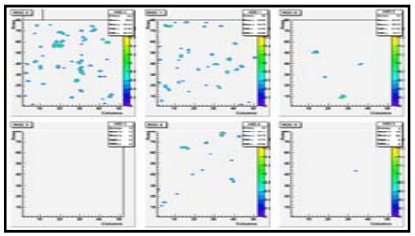
Source Test of Pilot Run Detector

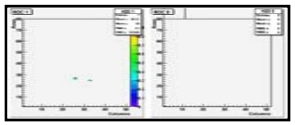
We also have the capability of using a radioactive source to test the functionality of all data acquisition in running mode.
This has been an important exercise to debug all the components making sure that everything is working properly.

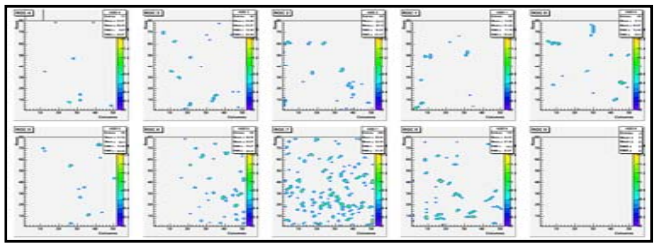




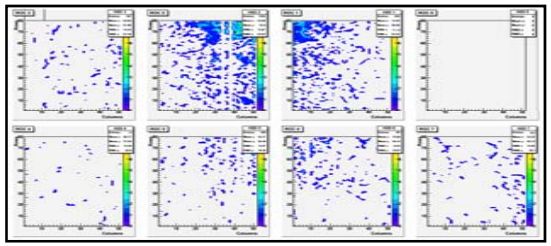
4R panel

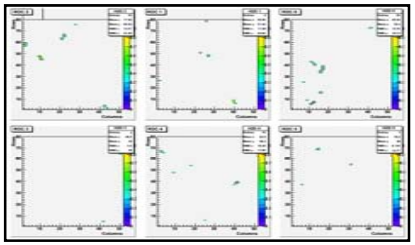






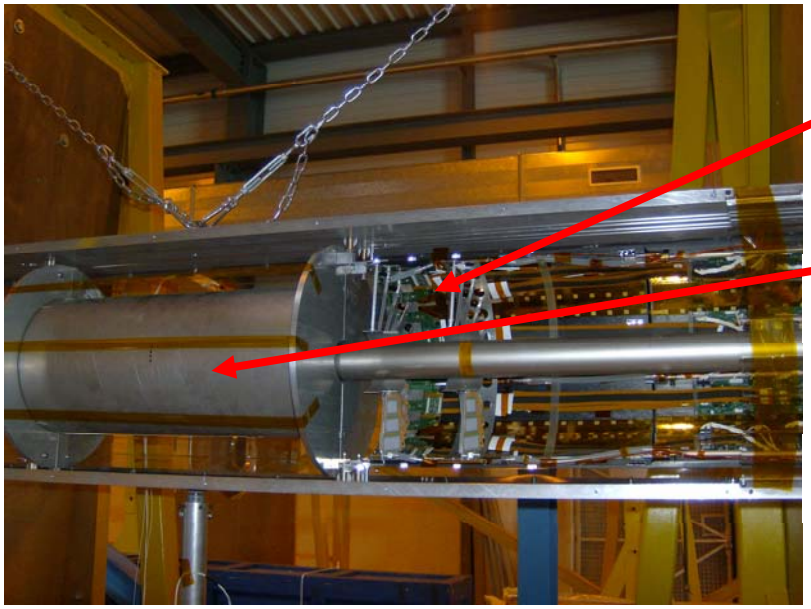
3R panel

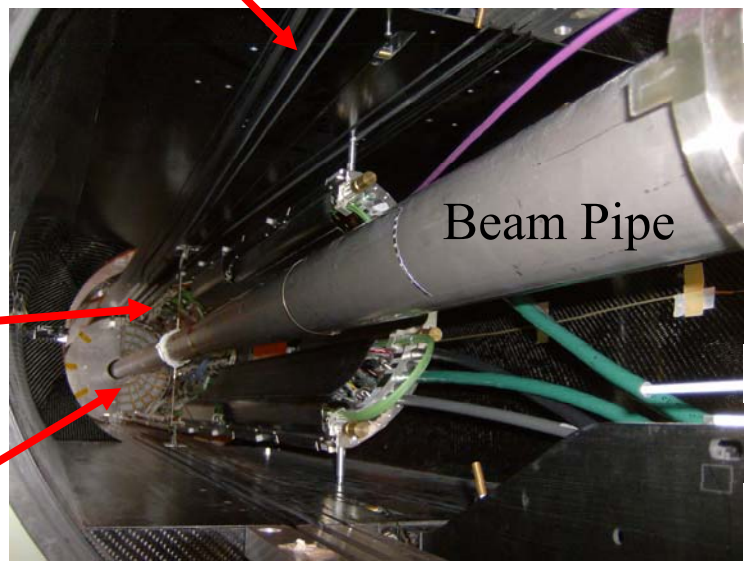




Installation Test

- Mockup half disks in a real half-cylinder
- Mockup of Barrel and Barrel half-cylinder
- Mockup of center rail (real one is in the tracker)
- Real beam pipe supports and beam pipe (except the beryllium center section)





✓Clearance of FPIX from beam pipe/support and BPIX was verified
✓Motion of FPIX along tracks was verified
✓Survey group verified feasibility to survey fiducial marks using photogrammetry

Conclusions

- Sensors and ROCs perform as expected after high doses of radiation
- The pixel production is running smoothly. To achieve the best quality, extensive tests are performed at every stage of assembly
- The CMS pixel project is on schedule and there are no major problems
- In the next two months we will have two other important tests:
  - integration of the pilot run detector with the silicon strip tracker
  - test in a 4T magnetic field at Fermilab of a fully FPIX instrumented sector
- If we will not have major surprises from these two tests the BPIX and FPIX will be ready early next year.

We are planning to install the full detector for the 2008 7TeV x 7TeV physics run!