The US-CMS Pixel Project

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The US CMS FPix Project

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Rutgers: J. Conway, S. Schnetzer, R. Stone, S. Worm, E. Bartz, E. Doroshenko, L. Perera, S. Sherman, Y. Streltsov

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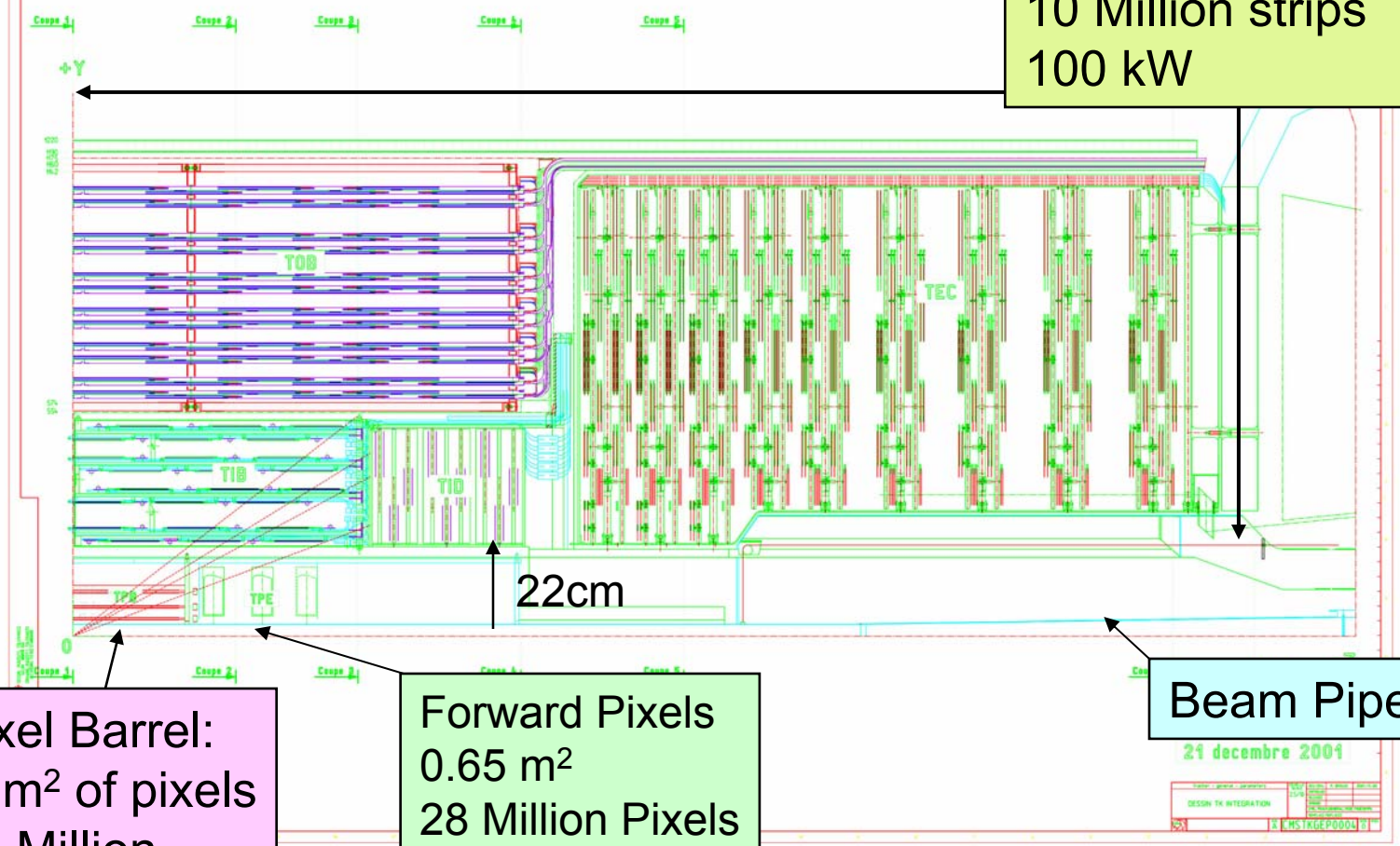
CMS Tracker

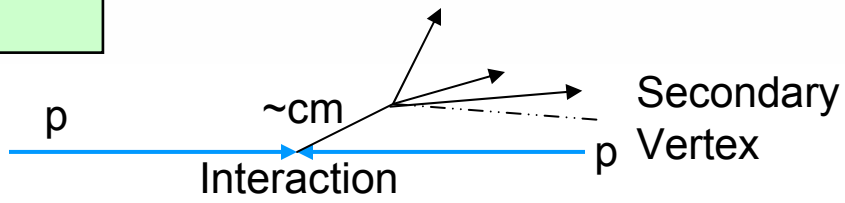
Silicon Strips:
200 m^2 of sensors
10 Million strips
100 kW



Pixel Barrel:
1. m^2 of pixels
40 Million
20 kW

Forward Pixels
0.65 m^2
28 Million Pixels
8 kWatts

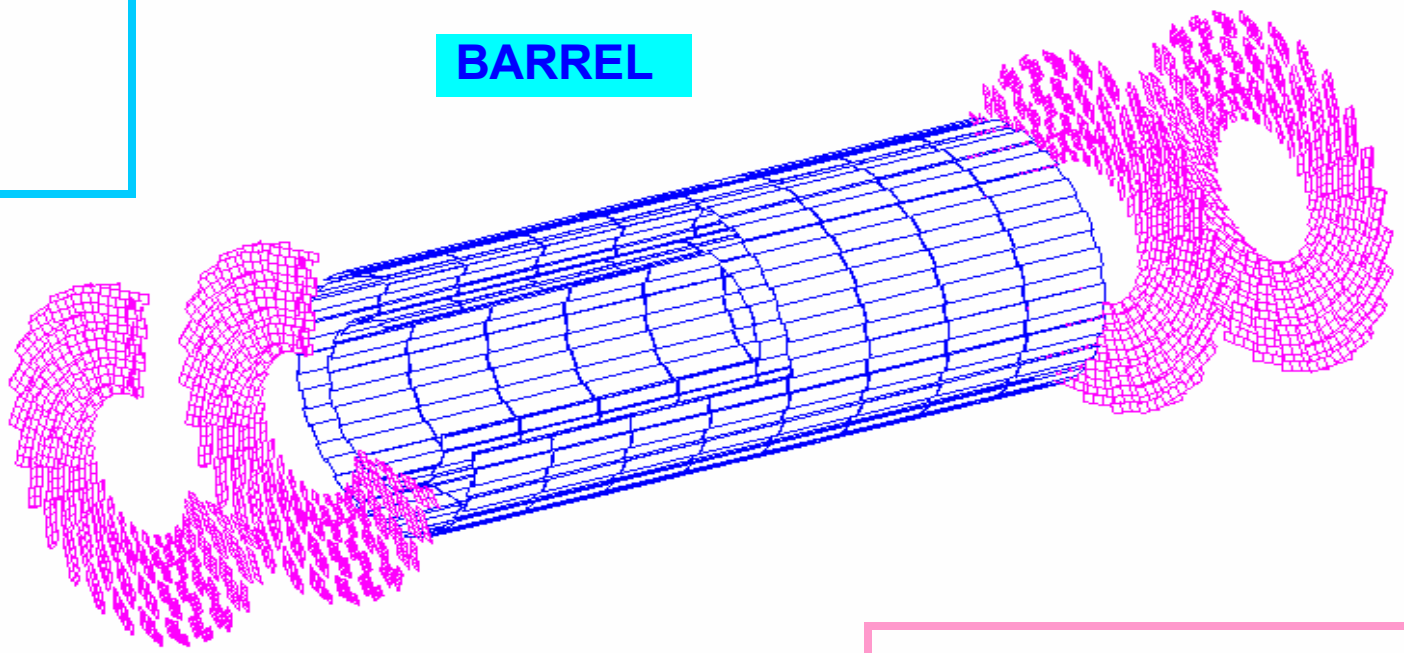
Beam Pipe



CMS Pixel COLLABORATION

PSI (Horisberger)
ETH
U. Zurich
U. Basel
IHEP Wien
RWTH Aachen
New Zealand

BARREL



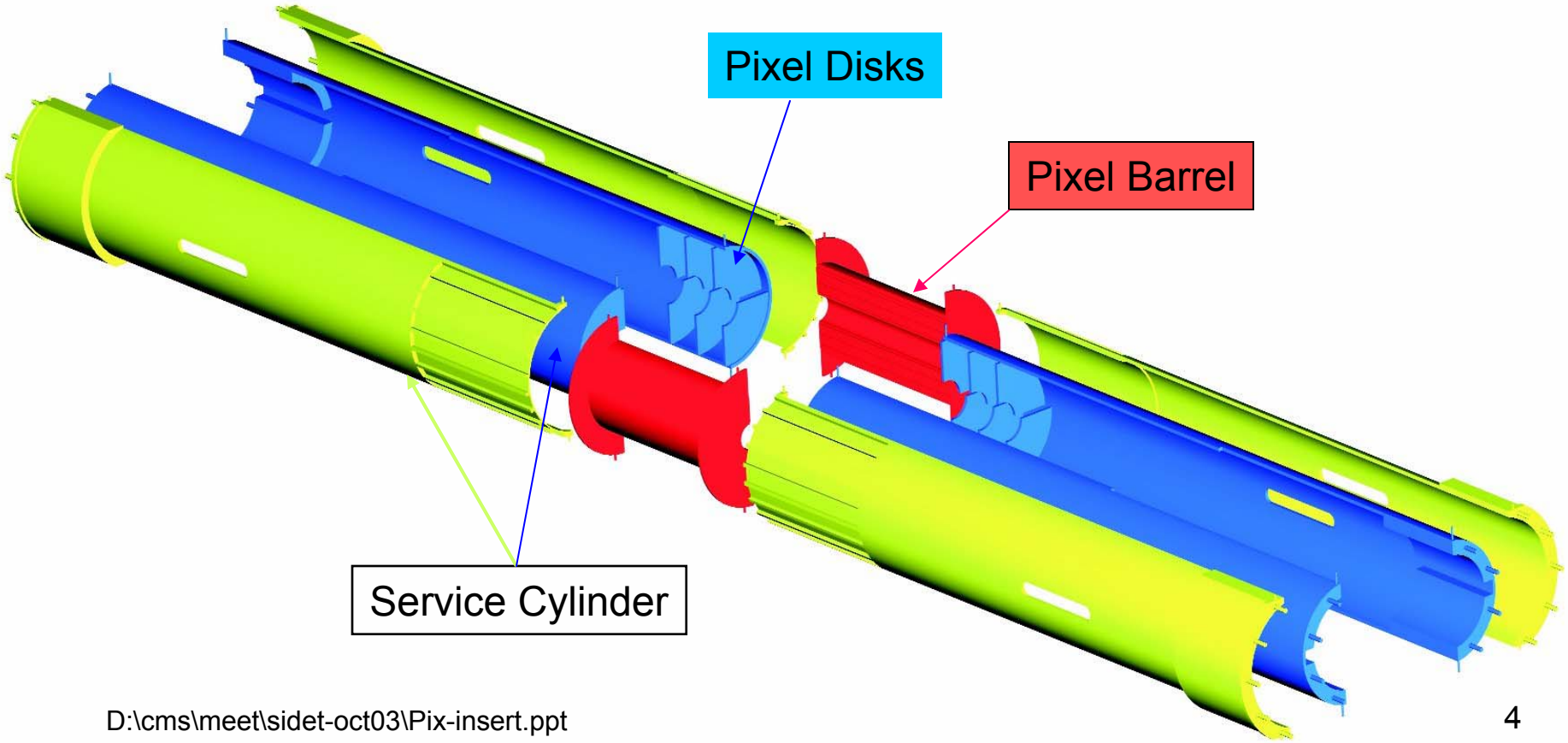
FORWARD DISKS

US CMS

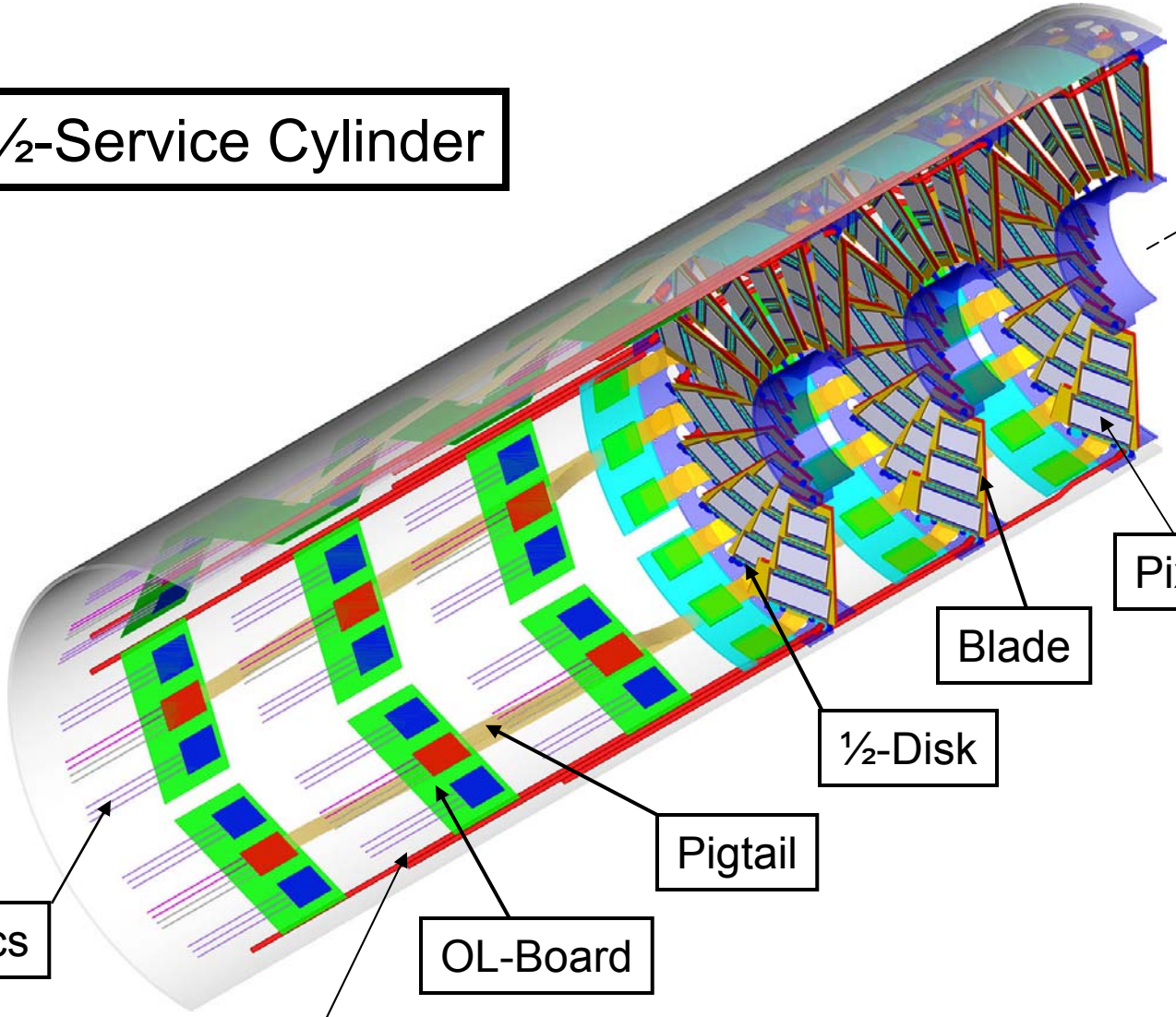
UC Davis	**Northwestern**
Fermilab	**Purdue**
Johns Hopkins	**Rutgers**
Mississippi	

Pixel Insertion & Integration

- Beam pipe bakeout → insertion/removal of pixel detector
- Rail system for barrel & forward pixel & supply tubes



½-Service Cylinder



Components US CMS FPix

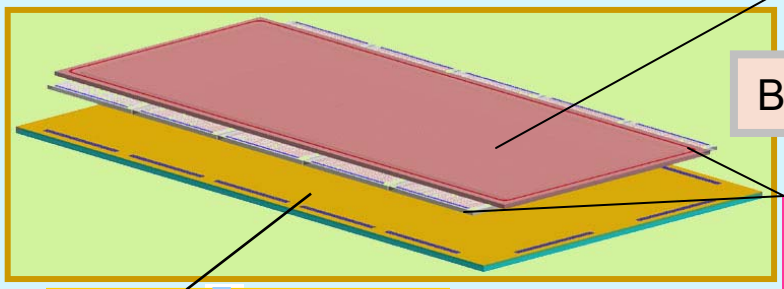
Plaquette (700, 5 types)

Sensors

Bump bonded

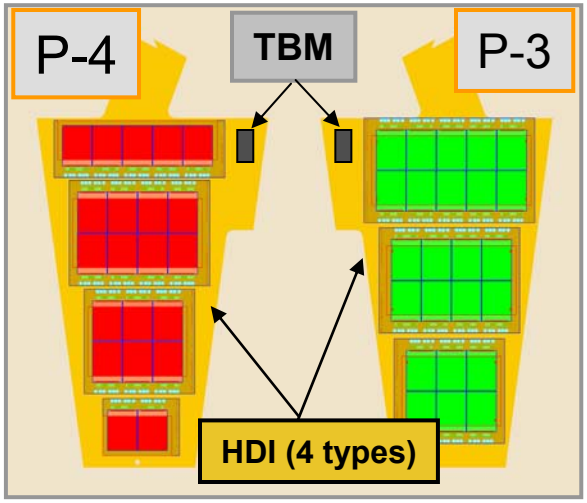
ROC (4,500)

Detector Unit (700)

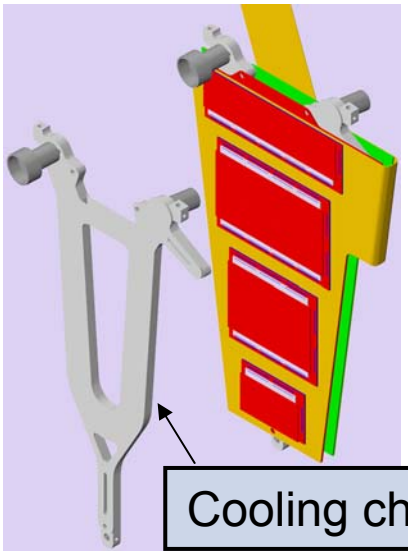


VHDI (700, 7)

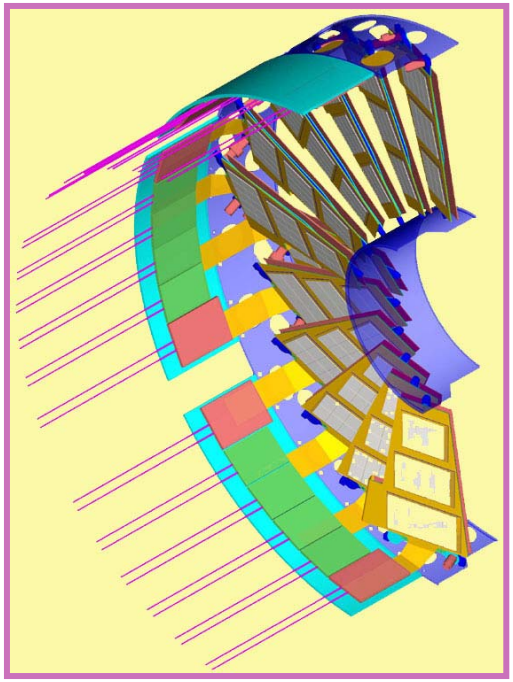
Panels, (200)



Blade, (100)

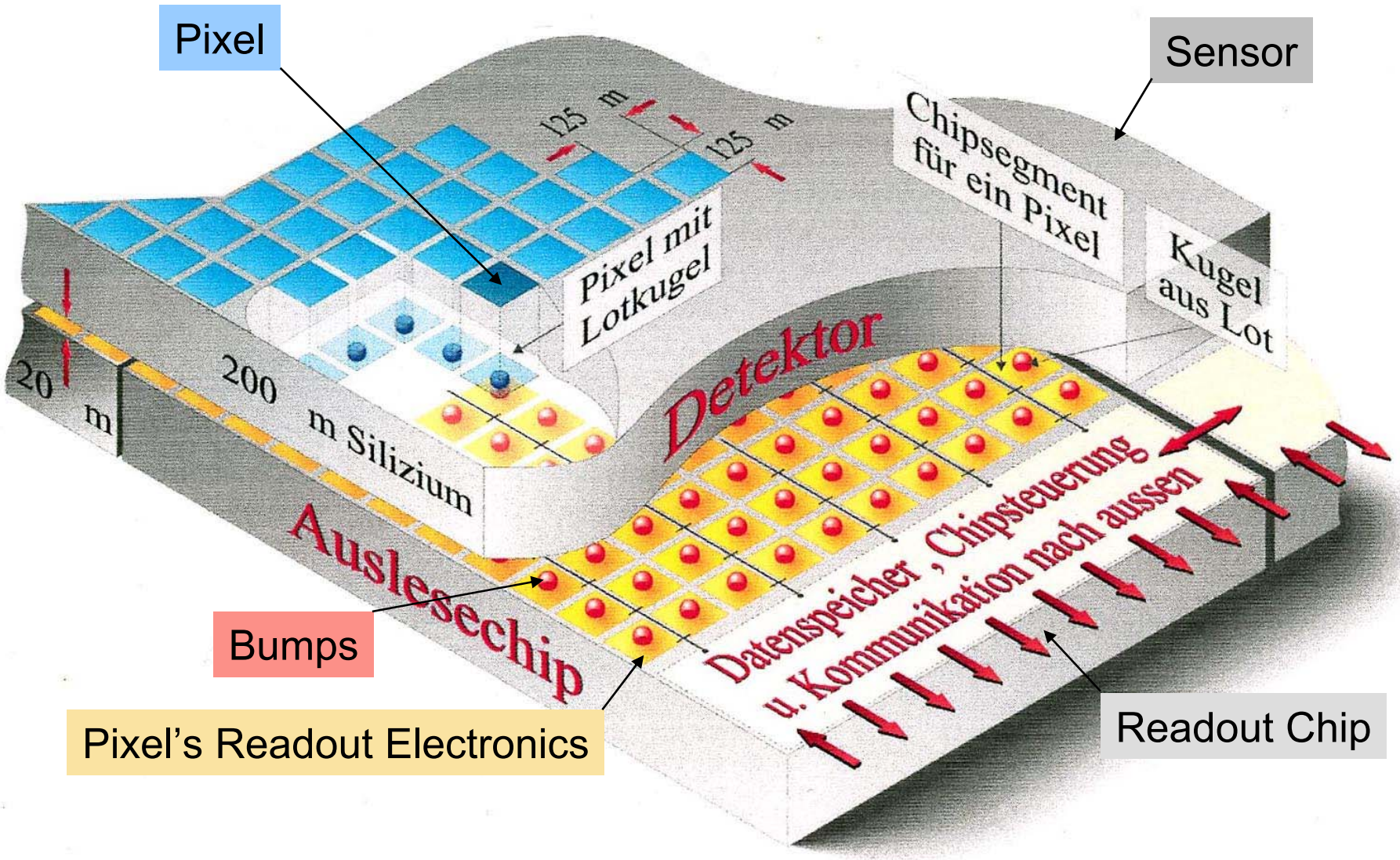


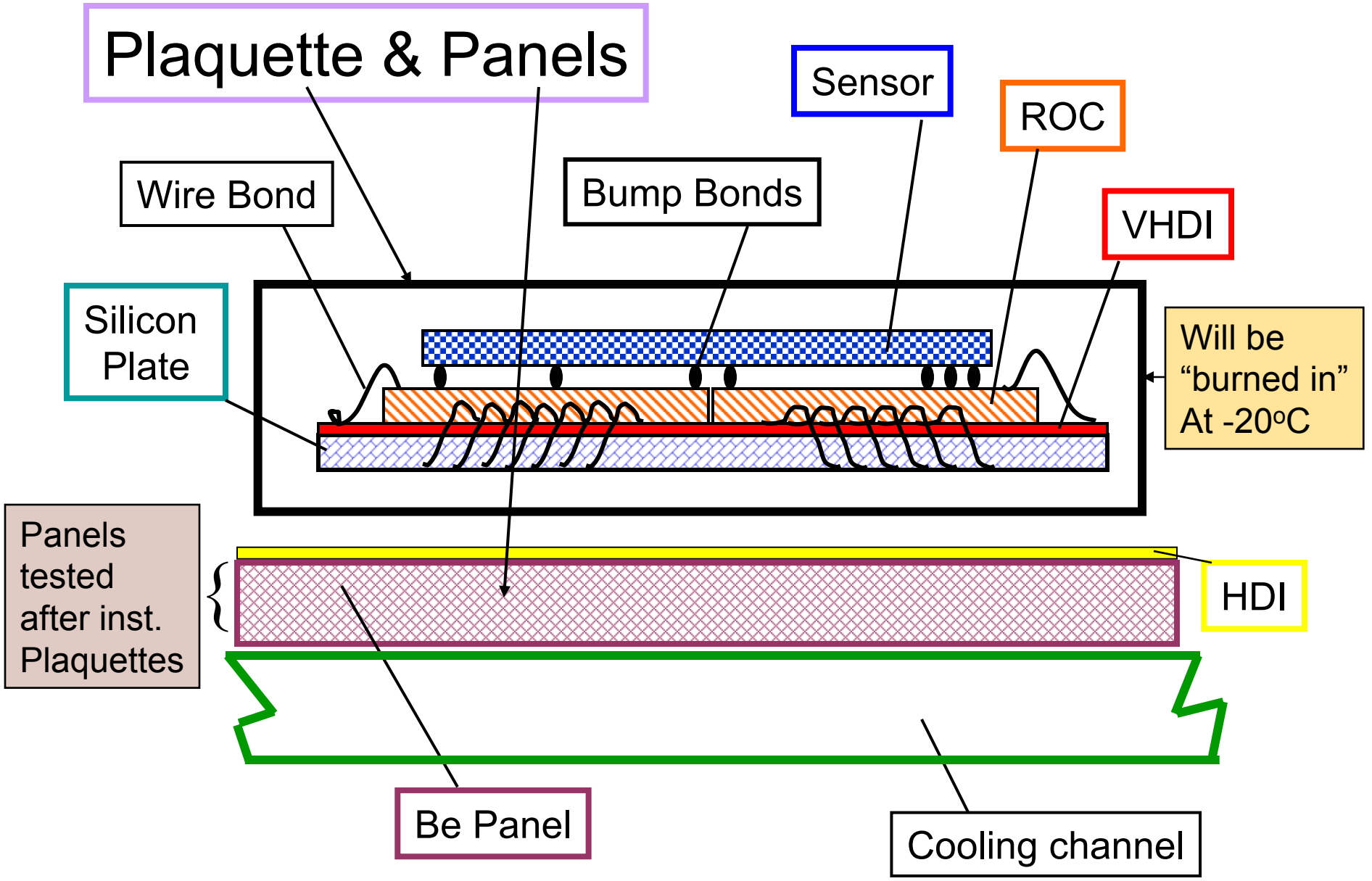
Cooling channels, (100, 4)



½ -Disk (8, 2 types)

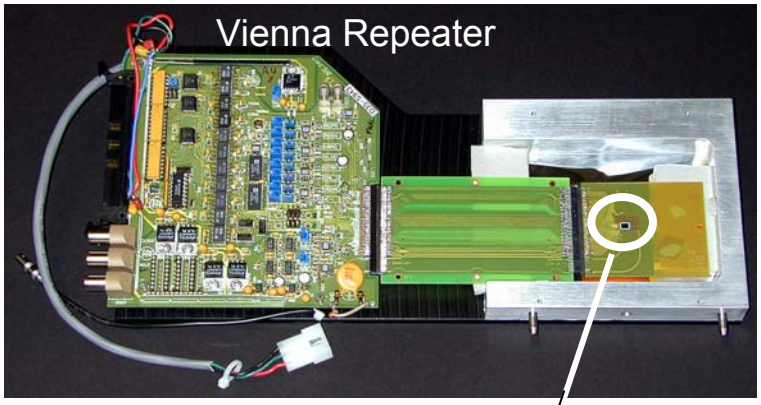
Der Pixel Vertex-detektor von CMS




Plaquette & Panels
Sensor
ROC
Wire Bond
Bump Bonds
VHDI
Silicon Plate
Will be "burned in" At -20°C
Panels tested after inst. Plaquettes
HDI
Be Panel
Cooling channel

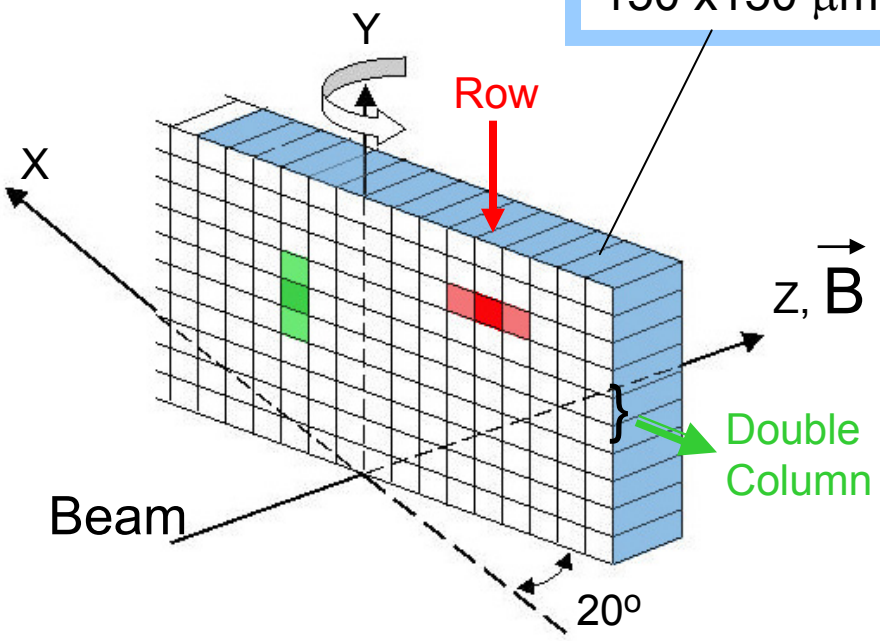
Status of the US-CMS Project

FPix. Test Beam Results



Charge Sharing

Pixels
150 x150 μm^2



Position resolution of sensors

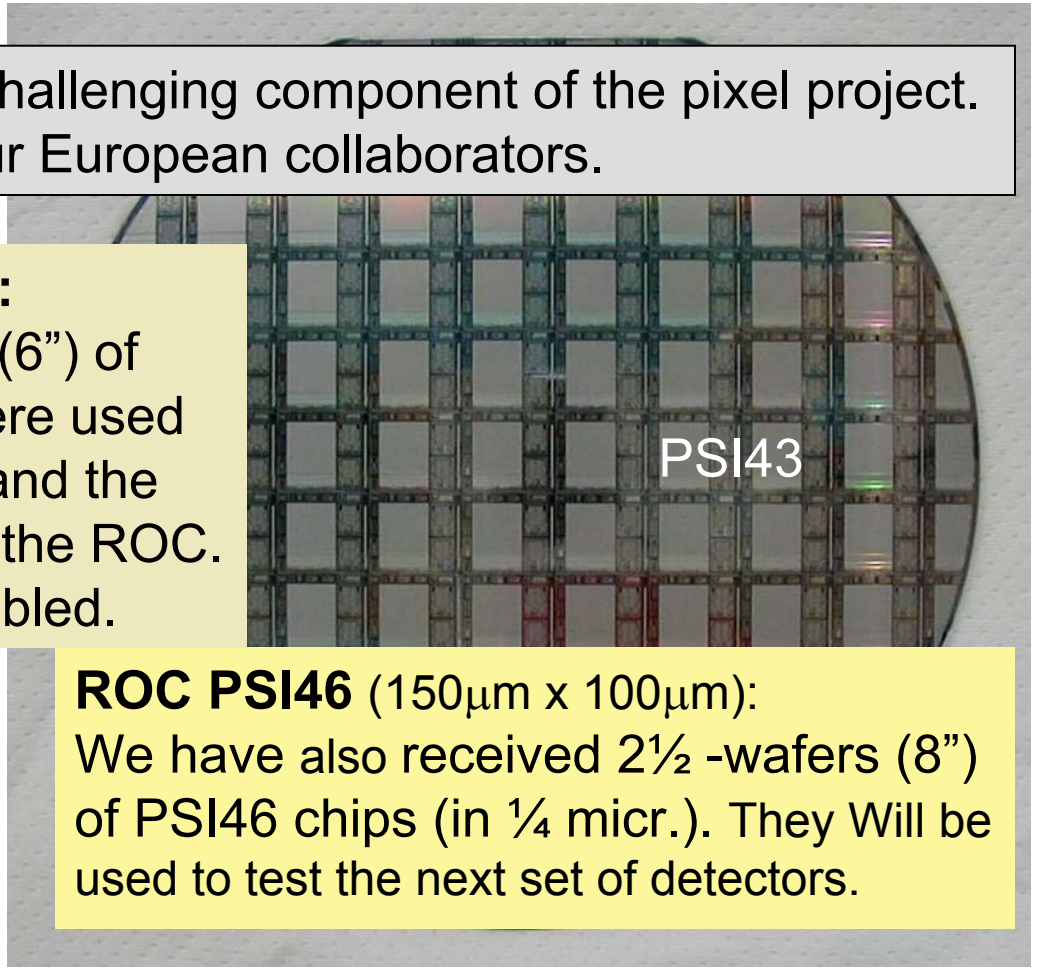
Rotated 20deg:
$\sigma = 14\mu m$

NOT Rotated:
$\sigma = 43\mu m$

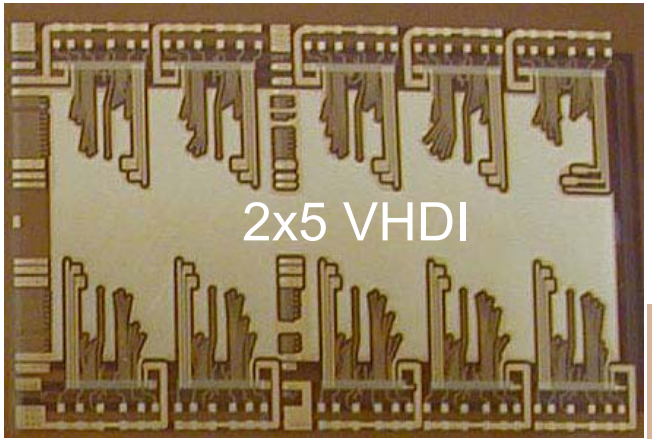
ROCs and VHDIs

The ROC are the most challenging component of the pixel project. They are designed by our European collaborators.

ROC PSI43 (150μmx 150μm)**:**
We have tested 2½ -wafers (6”) of PSI43 chips. Two wafers were used to evaluate bump bonding, and the rest to learn how to operate the ROC. Detectors have been assembled.

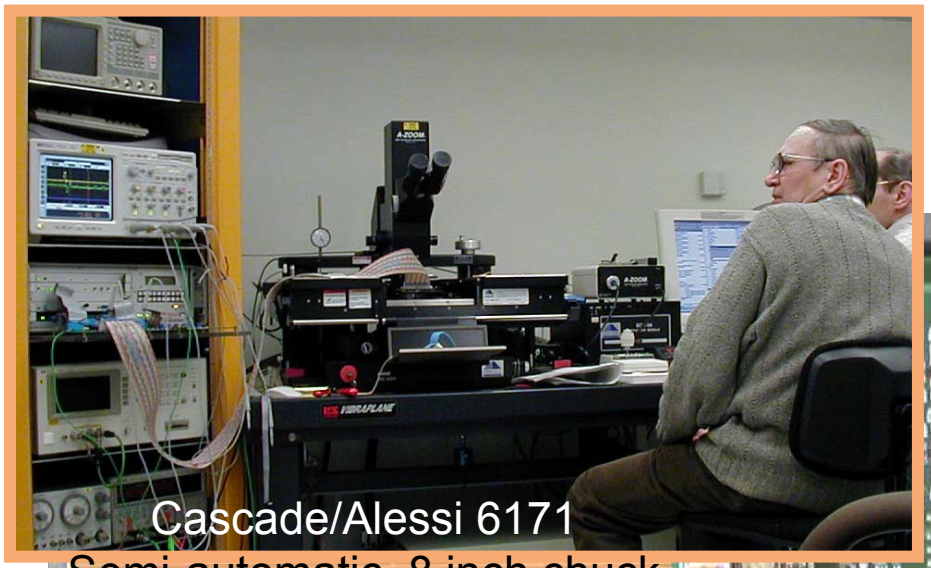


ROC PSI46 (150μm x 100μm):
We have also received 2½ -wafers (8”) of PSI46 chips (in ¼ micr.). They Will be used to test the next set of detectors.

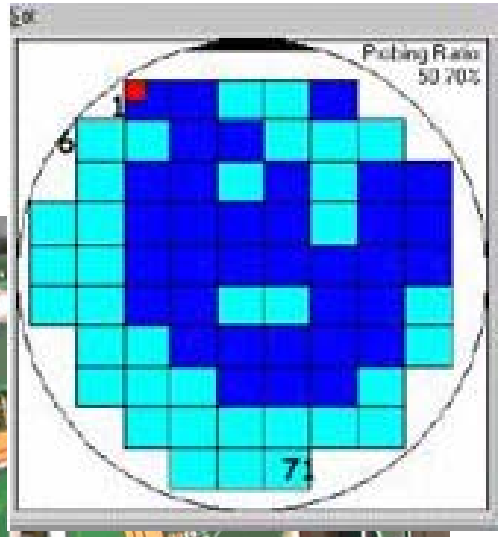


VHDIs have been developed for the 1x1 and 1x5 ROCs and also 2x5 ROCs.

Testing ROCs (WH14E) and Pixel devices at SiDet

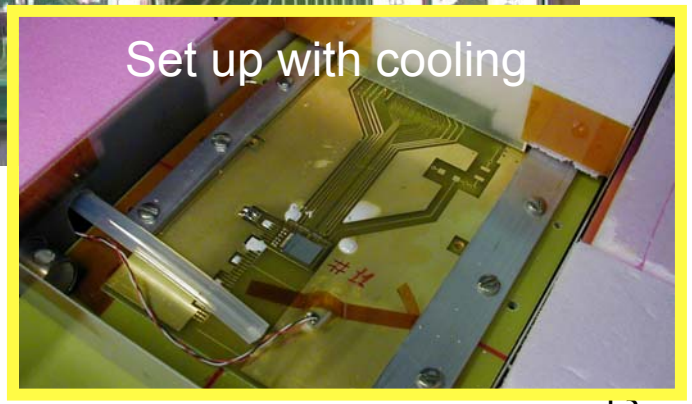


Cascade/Alessi 6171
Semi-automatic, 8 inch chuck



PSI43 Buffer Board

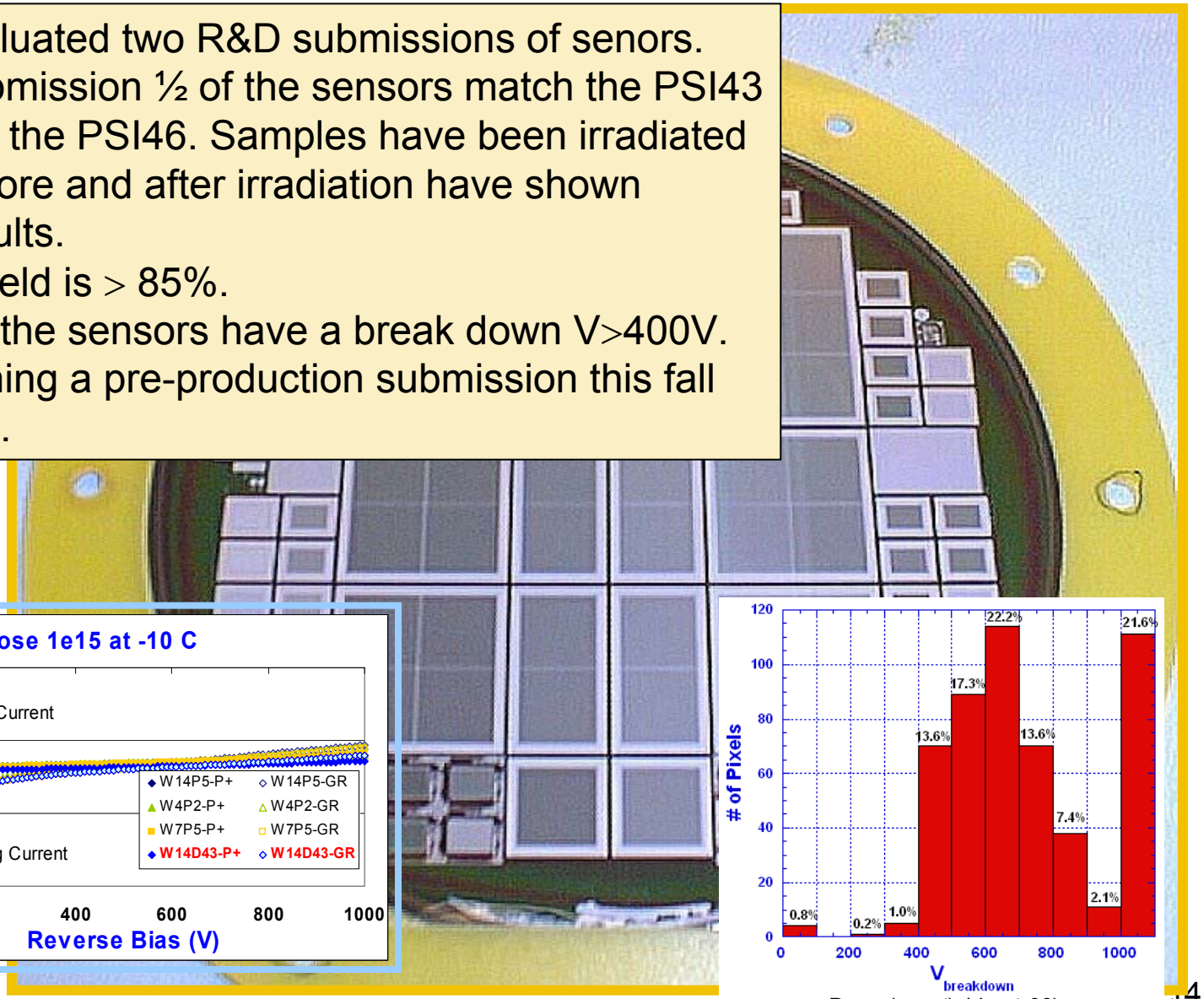
Bench set up for devices on VHDI



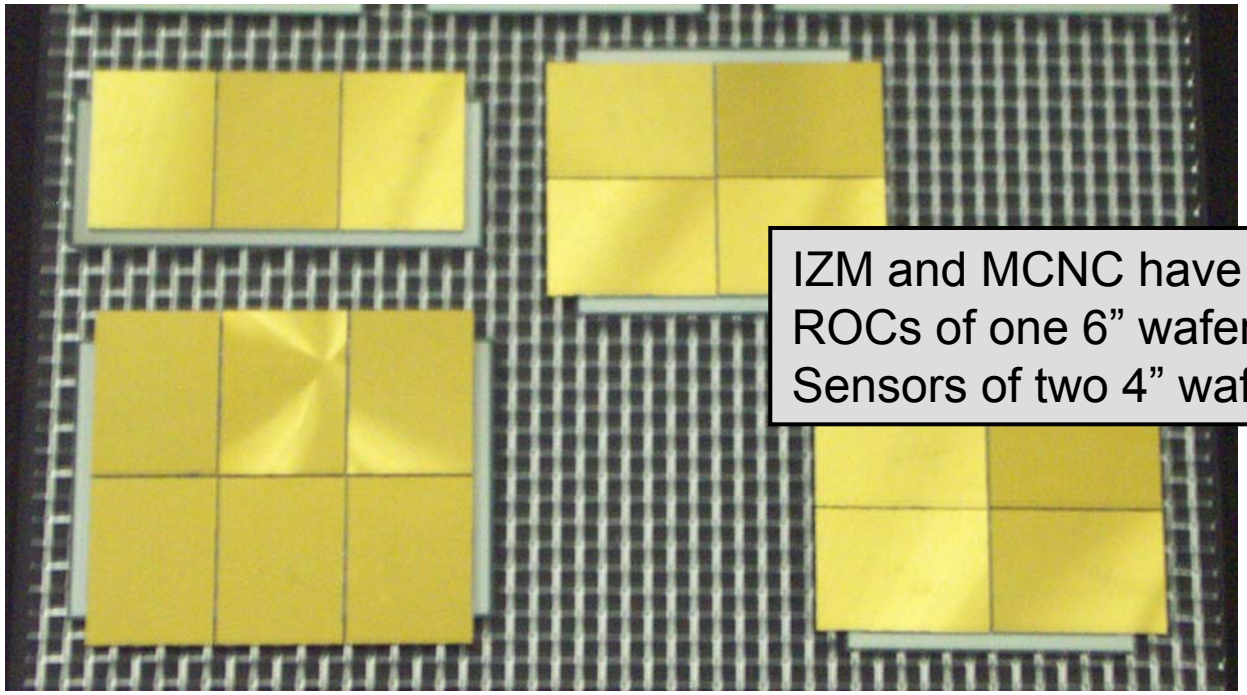
Set up with cooling

US-CMS Pixel The Sensors

We have evaluated two R&D submissions of senors.
In the 2nd submission ½ of the sensors match the PSI43 and ½ match the PSI46. Samples have been irradiated and tests before and after irradiation have shown excellent results.
Production yield is > 85%.
Over 97% of the sensors have a break down V>400V.
We are planning a pre-production submission this fall for the PSI46.



Bump Bonding with 3 vendors



IZM and MCNC have Bump Bonding the ROCs of one 6” wafer of PSI43 to the Sensors of two 4” wafers from SINTEF.

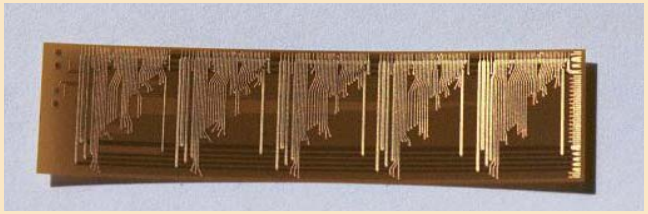
We have on hand 28 modules bump bonded to 83 ROCs

VTT is processing a blank 8” wafer (thinned to 200μm) of ROCs and sensors with the same bumps pattern as the PSI46.

Soon to submit wafers of the ROC PSI46 (8” wafers, ¼-μm) for bump bond.

Plaquettes Testing

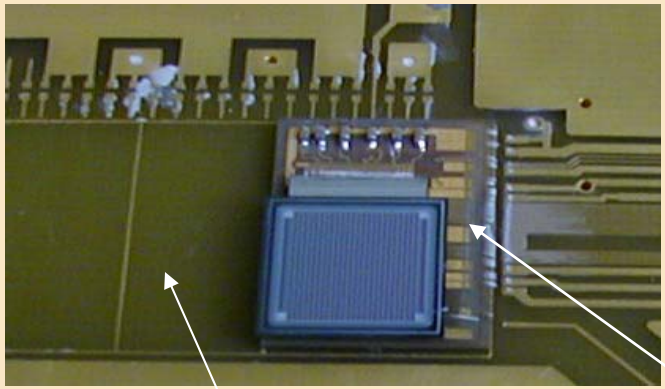
1x5 VHDI



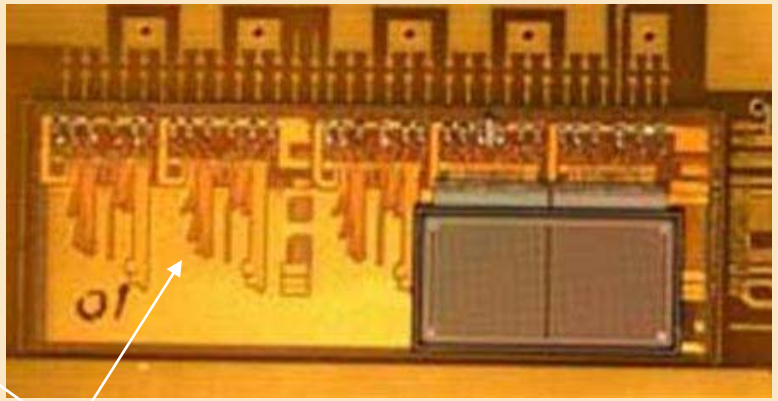
1x5 ROCs

Measured noise: ~200e$^-$

1x1 Sensor



1x2 Sensor



HDI
(PC Board)

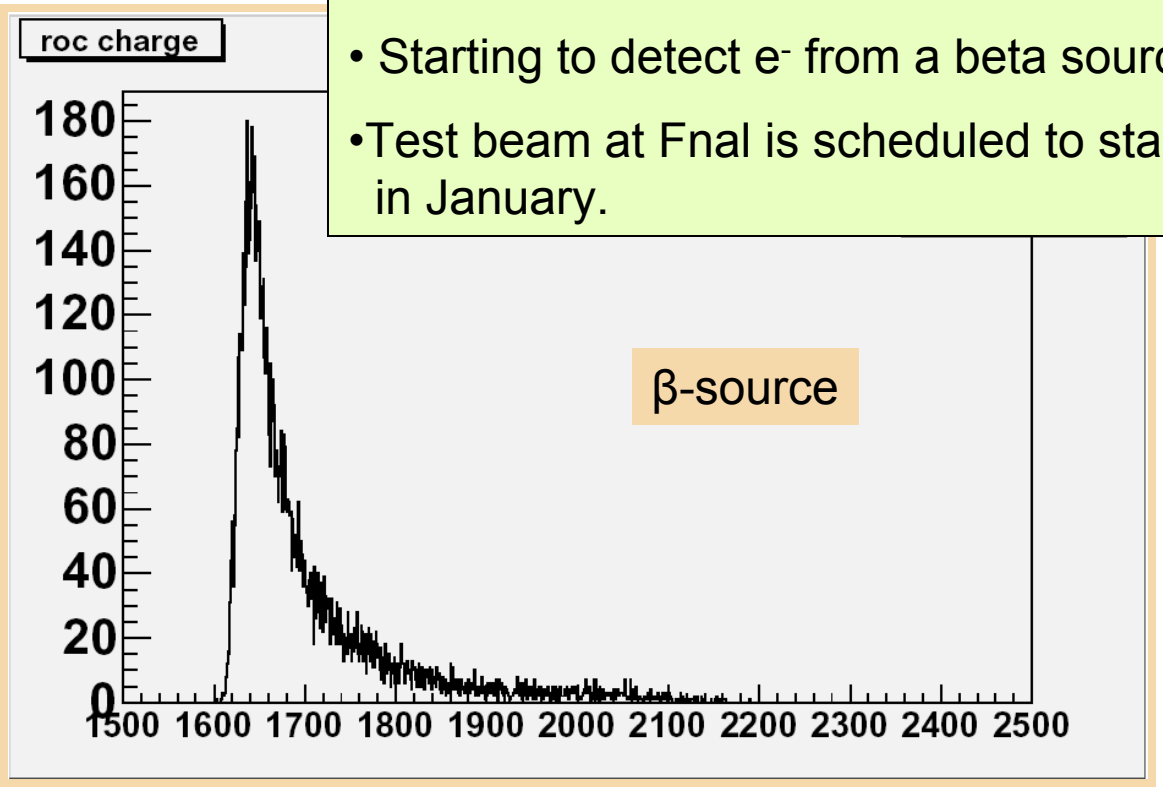
VHDI18

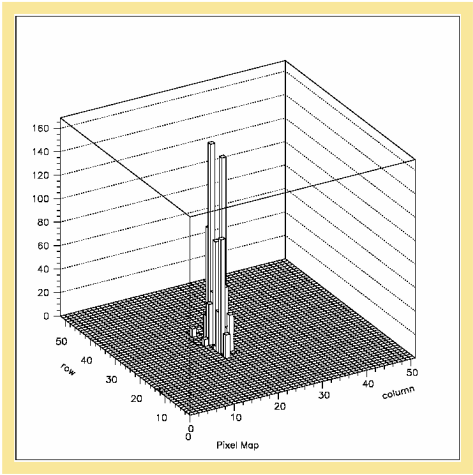
Test setups a Rutgers
Purdue, Fnal, EU

Testing Plaquettes

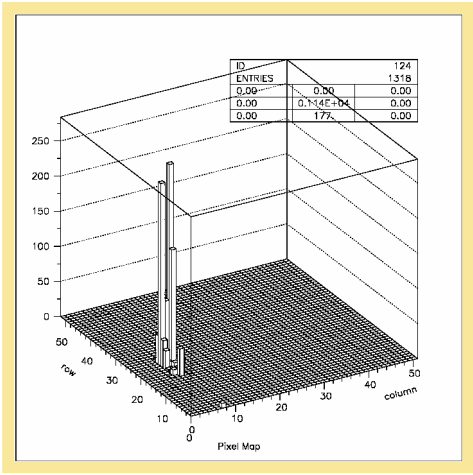
STATUS:

- We are starting to test pixel devices.
- First signals have been seen with a laser pulser.
- Starting to detect e^- from a beta source.
- Test beam at Fnal is scheduled to start in January.





Move laser



What will it take to complete the Project ???

Job to be completed by ‘07

This project requires a
large number of different components.

For 4 Disks, we will need to assemble (without spares):

- 700 Plaquettes; 5 types
  - 700 VHDIs; 5 types
  - 700 bump bonded units; 5 types
    - 4320 ROCs; 1 type
    - 700 sensors; 5 types
- 200 Panels; 1 type
  - 100 HDIs; 4 types
- 8 ½-Disks (mechanical support); 4 types
- 4 ½-Service Cylinders; 2 types

All **components** must be tested.

Assembled modules must be tested at each step of the assembly line.

This will require:

- Numerous **assembly jigs** must be designed and assembled.
- The development of a large number of different **test setups**.

The feasibility of assembling the detector must be ensured with the help of **mock-ups**.

This will require:

- Engineers, designers, machinists, techs, etc.

It will also require:

- Wire bonding of many different components.
- Extensive surveys of
  - Assembly jigs.
  - Mechanical structures (½-Disks & ½-Service Cylinder).
  - Assembled ½-Disks; survey position sensors relative to the mechanical support.

The construction of this Pixel detector is part of the US-CMS Project.

It is an approved project funded by DOE & NSF.
(It has strict accounting and schedules, but it also has adequate contingencies assigned.)

The CMS pixel detector is indispensable for carrying out the physics goals of LHC. (They can be met only if the trajectory of particles is measured close (few cm) to the beam interaction point.)

The pixel detectors will need to be replaced every few years, because of the damage done to the sensors by radiation. We are building the first prototype and during the lifetime of CMS replacement pixel detectors will be needed.

This project will not succeed unless additional manpower joins the effort.

Above all, additional physicists must participate and assume responsibilities . Because the center of this project is Fermilab, a larger number of Fermilab physicists must be part of this project.

A considerable number of people at SiDet will be asked to take part in this effort.

The CMS pixels are a new type of detector, indispensable for the physics goals at the LHC. It is the first of a new generation of detectors that will allow a deeper understanding of how the universe is made.

Do not miss the opportunity to be part of this effort!