

Sensor Development for the CMS Pixel Project

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- ▶ CMS overview
- ▶ Semiconductor detectors
- ▶ CMS pixel
- ▶ Prototype results

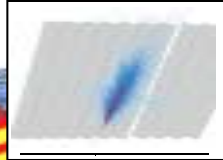
The Compact Muon Solenoid (CMS)

SUPERCONDUCTING COIL

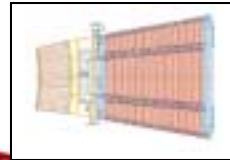
Total weight : 12,500 t
 Overall diameter : 15 m
 Overall length : 21.6 m
 Magnetic field : 4 Tesla

CALORIMETERS

ECAL Scintillating $PbWO_4$ Crystals

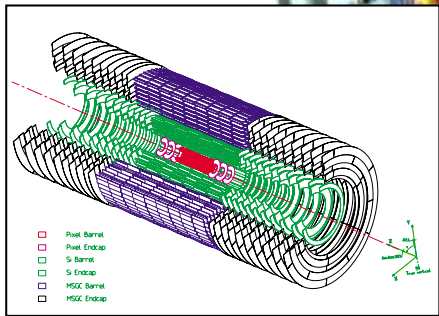


HCAL Plastic scintillator copper sandwich



IRON YOKE

TRACKERS



Silicon Microstrips
 Pixels

MUON BARREL

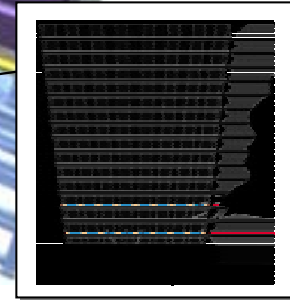


Drift Tube Chambers (DT)



Resistive Plate Chambers (RPC)

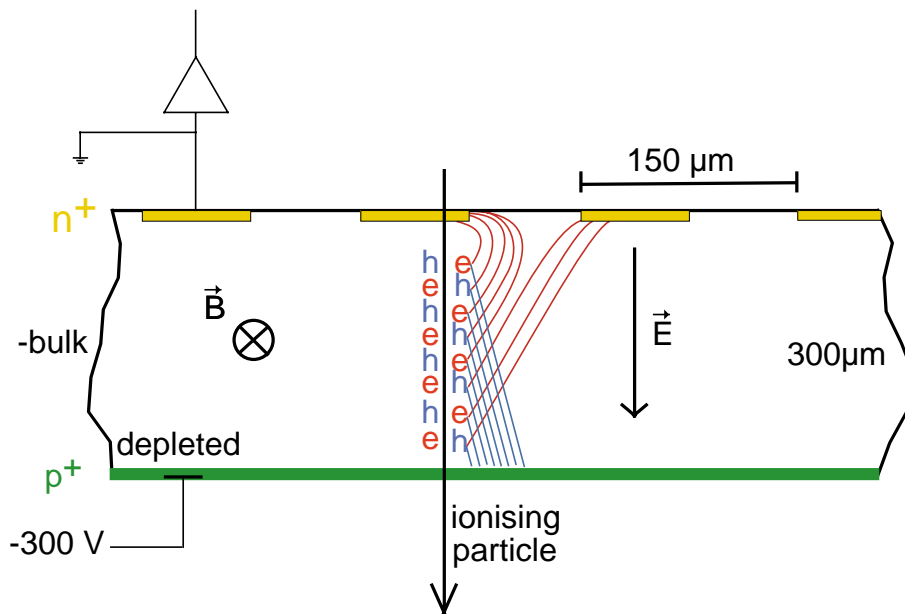
MUON ENDCAPS



Cathode Strip Chambers (CSC)
 Resistive Plate Chambers (RPC)

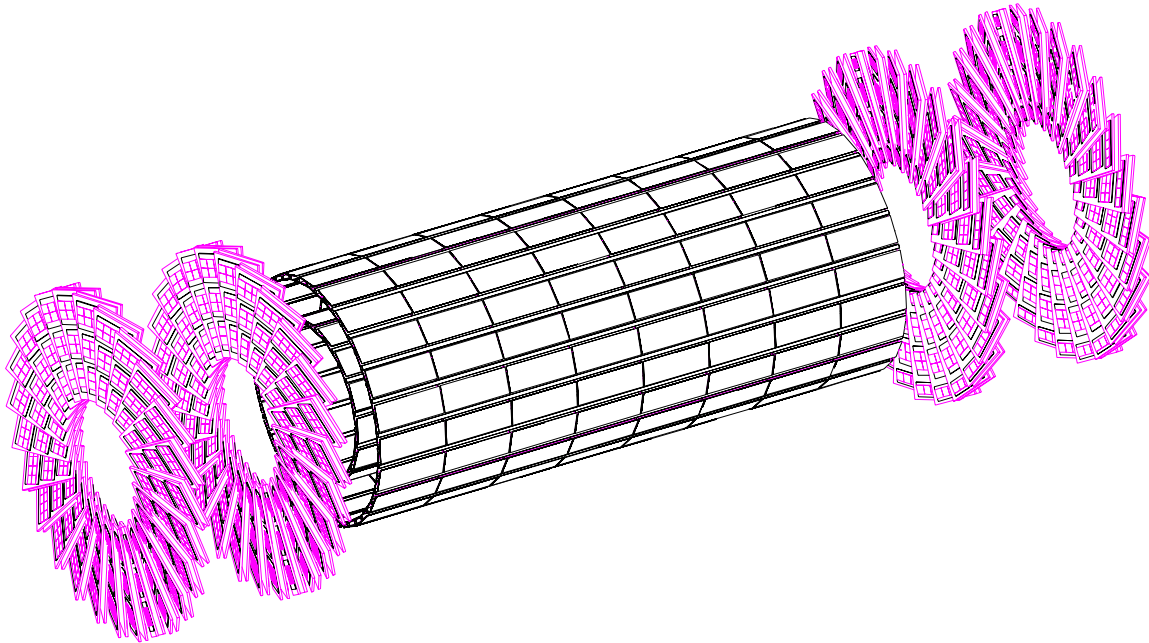


Semiconductor Detectors



- ▶ Reverse biased, segmented p-n junction
- ▶ Separation of ionized charge in E -field
- ▶ Moderate bias voltage (50-300 V)
- ▶ Signal collection time ~ 10 ns
- ▶ Signal charge: 1 e-h pair $\leftrightarrow 3.6$ eV (Silicon)
- ▶ Per MIP ~ 4 fC charge (300 μm)
 \Rightarrow needs strong amplification

CMS Pixel Detector

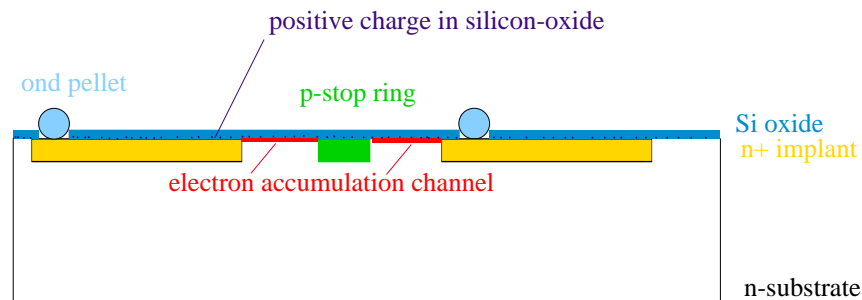


Parameters of CMS Pixel Barrel:

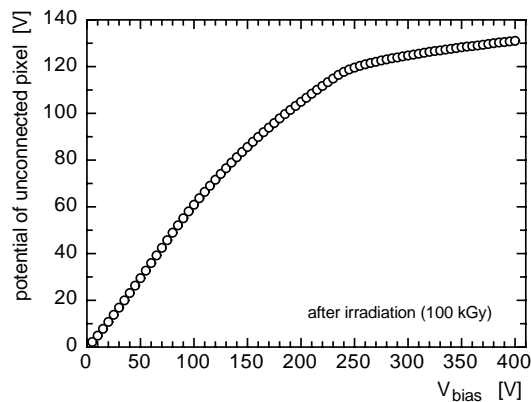
	Configuration	Radius [mm]	Chips	Pixels	Area [m ²]
Layer 1	low lumi	41 - 45	2304	6.35×10^6	0.15
Layer 2	low & high L	70 - 74	3840	10.6×10^6	0.25
Layer 3	high lumi	107 - 112	5888	16.2×10^6	0.38

Special in CMS Pixel

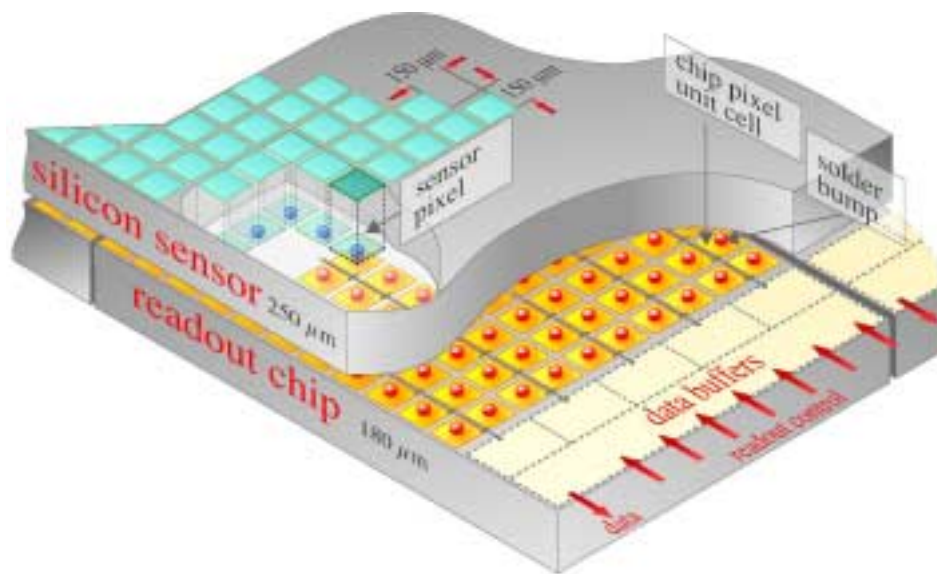
- ▶ ~ 70 million pixels
⇒ special read out chip, special bonding technique
- ▶ Harsh radiation environment
⇒ change of doping due to crystal damages
⇒ high bias voltage ($\geq 300V$)
⇒ change of surface parameters
- ▶ Pixel isolation:



- ▶ Potential of unbonded pixel



Bump Bonding Technique



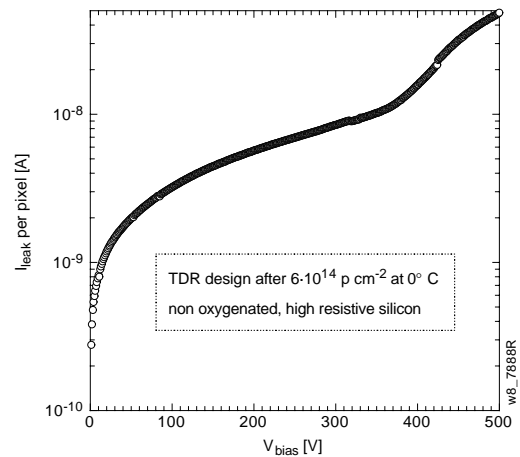
Prototype Results

- ▶ 2 test submissions in 1999 with CSEM and SINTEF, including high and low resistive silicon + oxygenated material
- ▶ n^+ pixels ($150 \times 150 \mu\text{m}^2$) on n-bulk ($300 \mu\text{m}$)



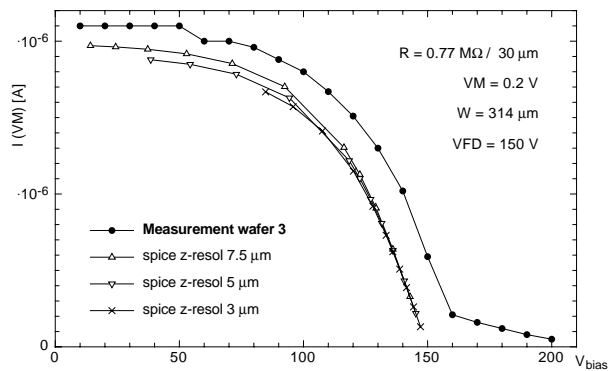
Pixel isolation with open p-stop rings

- ▶ Irradiations at CERN (p) and PSI (π) up to 10^5 Gy
- ▶ Leakage current within specifications:

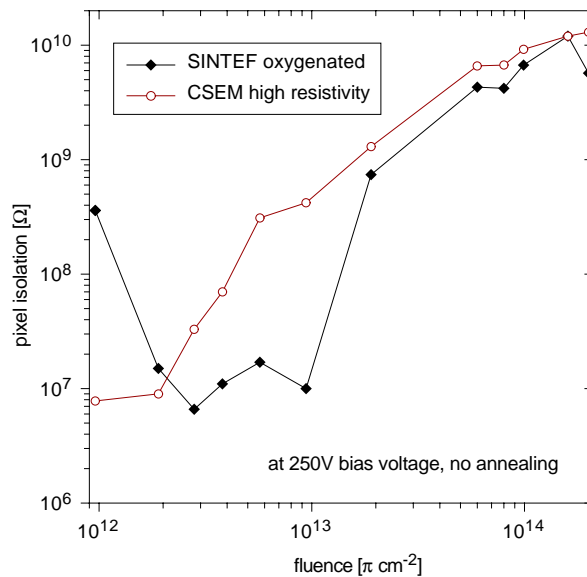


stable up to 500V

► Pixel isolation:



- 3D resistive network simulation for undepleted bulk conduction



- Pixel isolation increases with dose
- Effects of lost pixel bumps still under investigation