

The CMS Silicon Microstrip Tracker



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Outlook

- Introduction
- The CMS Silicon Tracker Layout
- Tracker Performance
- Silicon Sensors technology
- The detector modules and electronics
- Conclusions

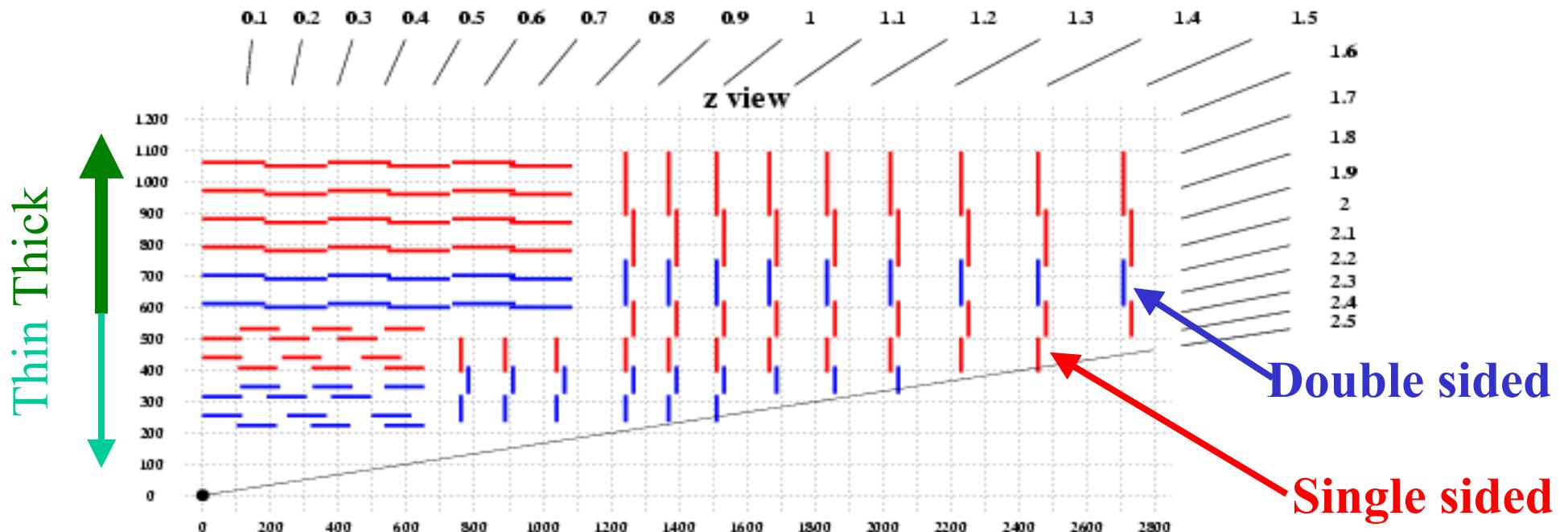


Tracker Design Goals

- Reconstruct isolated high p_t tracks with an efficiency $> 95\%$ and high p_t tracks in jets with an efficiency $> 90\%$.
- Reach a momentum resolution for isolated charged leptons in the central region of $\Delta p_t / p_t = 0.1 p_t$ (p_t in TeV/c).



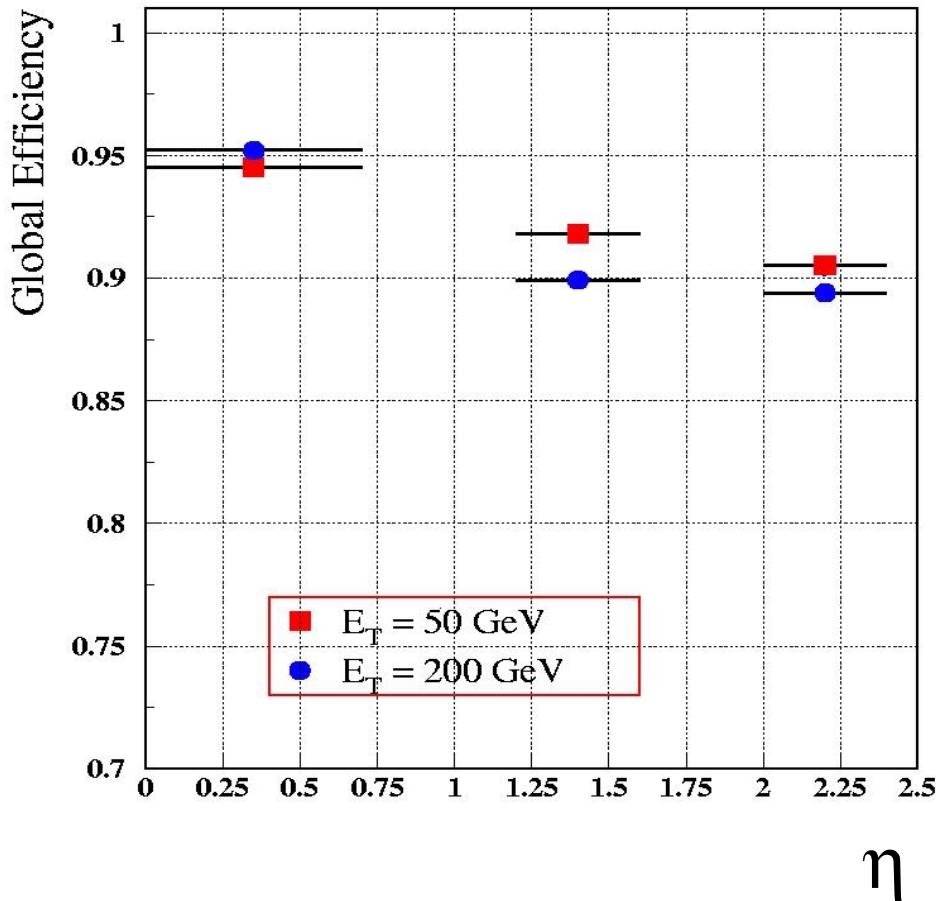
Silicon Strip Tracking system Layout



Silicon sensors of two different thickness:
320 μm in the inner region ($r < 600 \text{ mm}$) and
500 μm in the outer region.



Expected Tracker Performances (1)

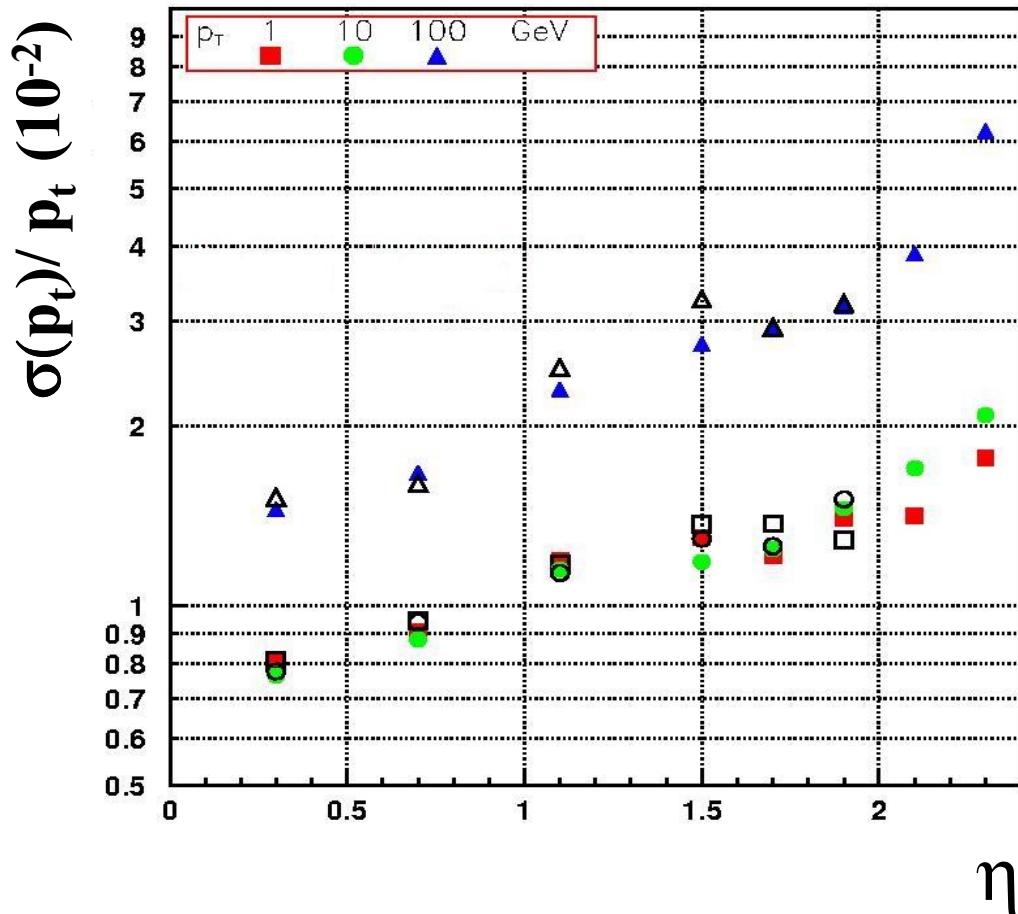


Track reconstruction efficiency inside a (50-200 GeV E_T) b jet.

Track visibility in a high density environment.



Expected Tracker Performances (2)



Momentum resolution
for isolated Muons
with tracker only.



Silicon Sensor Technology (1)



- Requirement: To operate the detector up to 10 years of LHC with a $S/N > 10$
- Major issue: Radiation hardness

Radiation damage bulk effects:

- Increasing of leakage current (e.g. noise)
- Increasing of depletion voltage after inversion (e.g. breakdown)
- Decreasing of charge collection efficiency (e.g. signal)

Radiation damage surface effects:

- Increasing of interstrip capacitance (e.g. noise)



Silicon Sensor Technology (2)

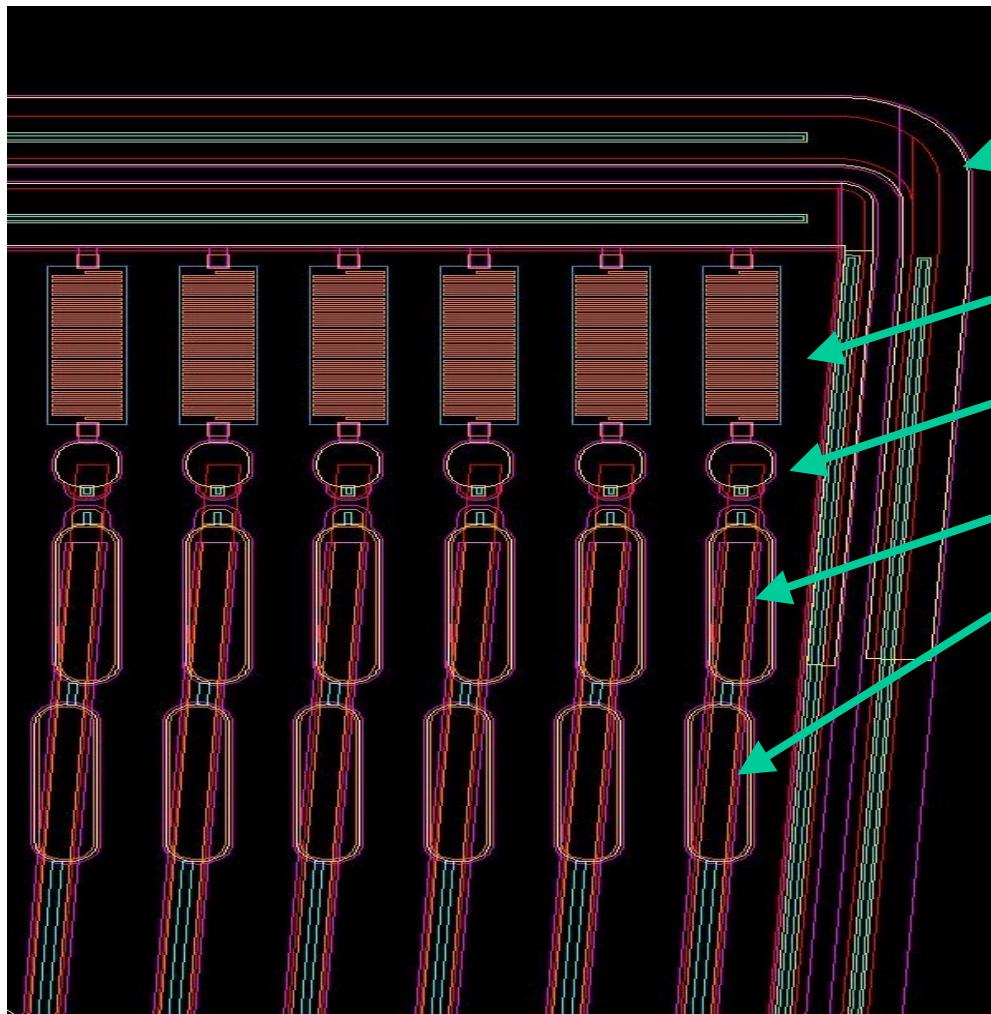
- After an extensive R&D program our choice is:
 - Single sided p-type implant strips on n-type substrate
 - Integrated AC coupling of read-out strips
 - Polysilicon resistor biasing of the p+ implant strips
 - Low resistivity substrate ($1.5\text{-}3 \text{ K}\Omega\text{cm}$) in the inner Tracker
 - Silicon lattice orientation $\langle 100 \rangle$
 - Metal overhanging over the p+ strips.

The design and the choice of materials are compatible with high volume industrial production on 6" wafer lines.

CMS Silicon Sensors are **simple** and **robust**



Silicon Sensors

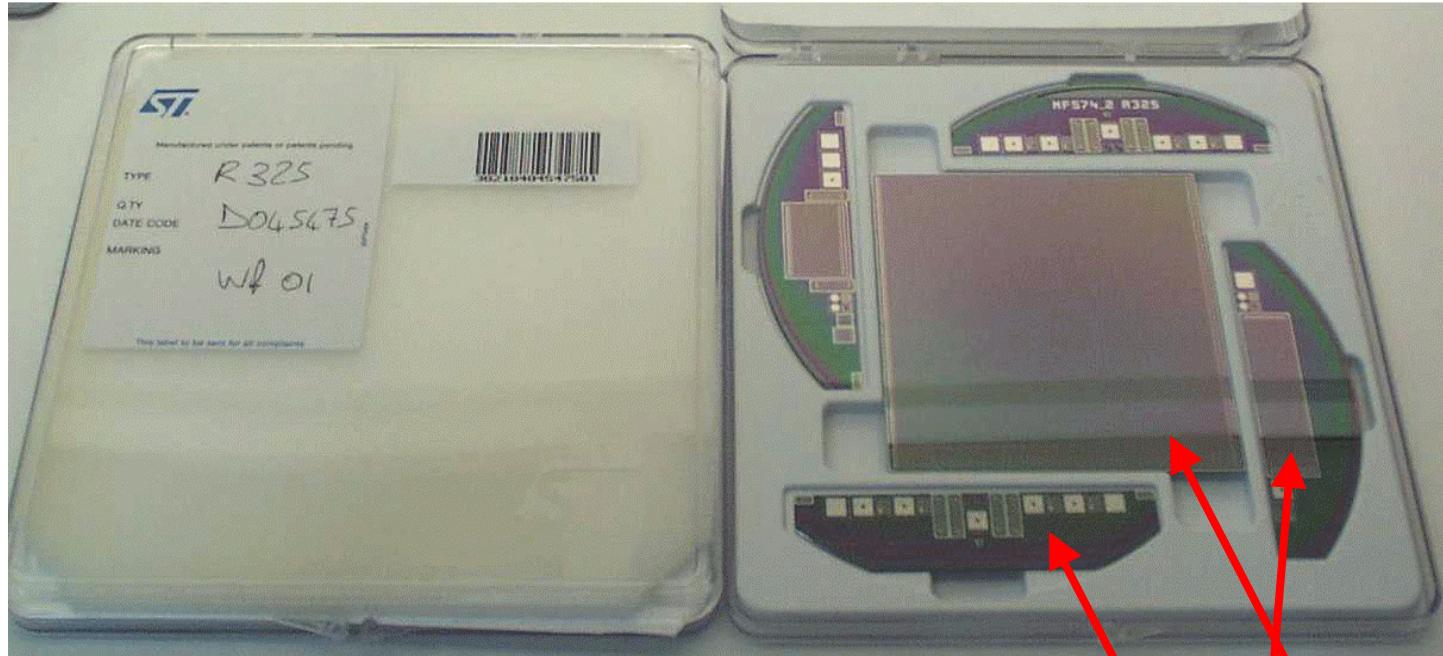


Guard rings
Poly resistors
DC pads
AC (bonding)
pads

Wedge type Sensor
(a corner....)



Sensors Prototypes

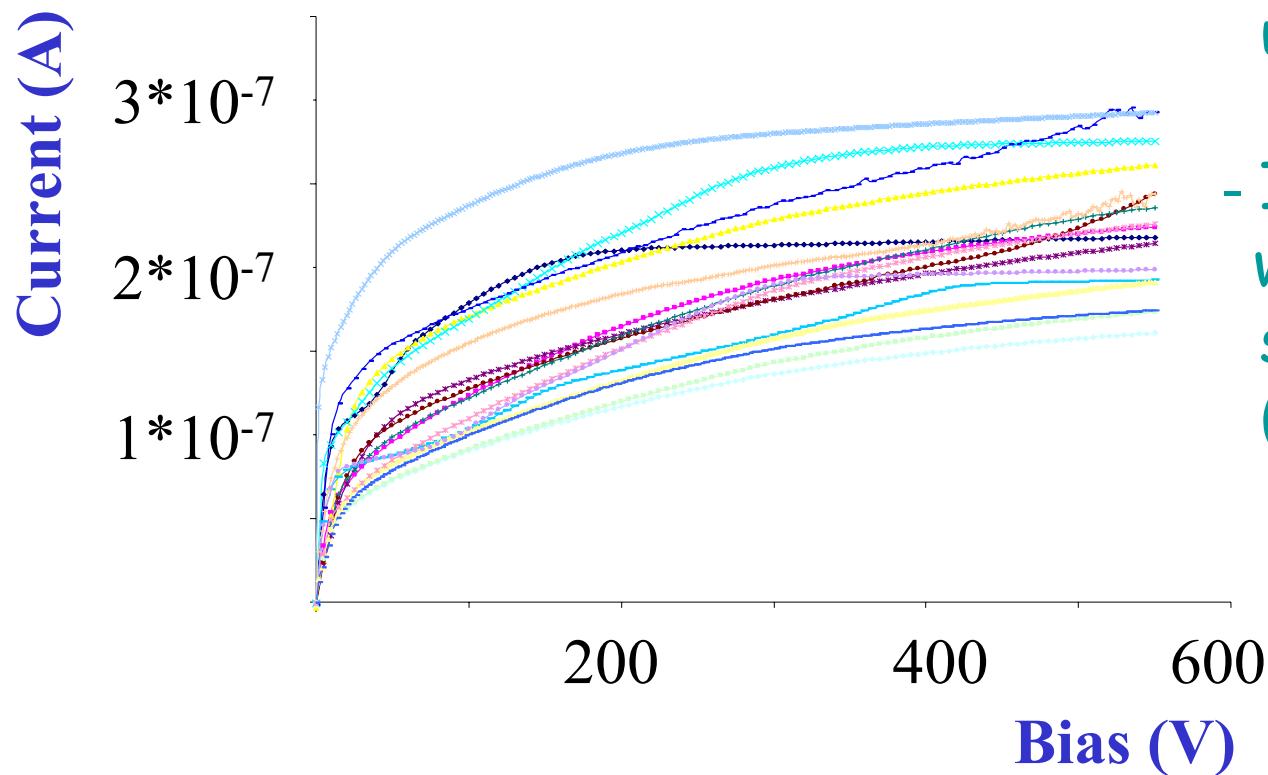


To be used for Detector Modules
Pre-production
-Hamamatsu
-STMicroelectronics

Sensor
Test Structures



Total leakage current - IV curve Hamamatsu pre-production

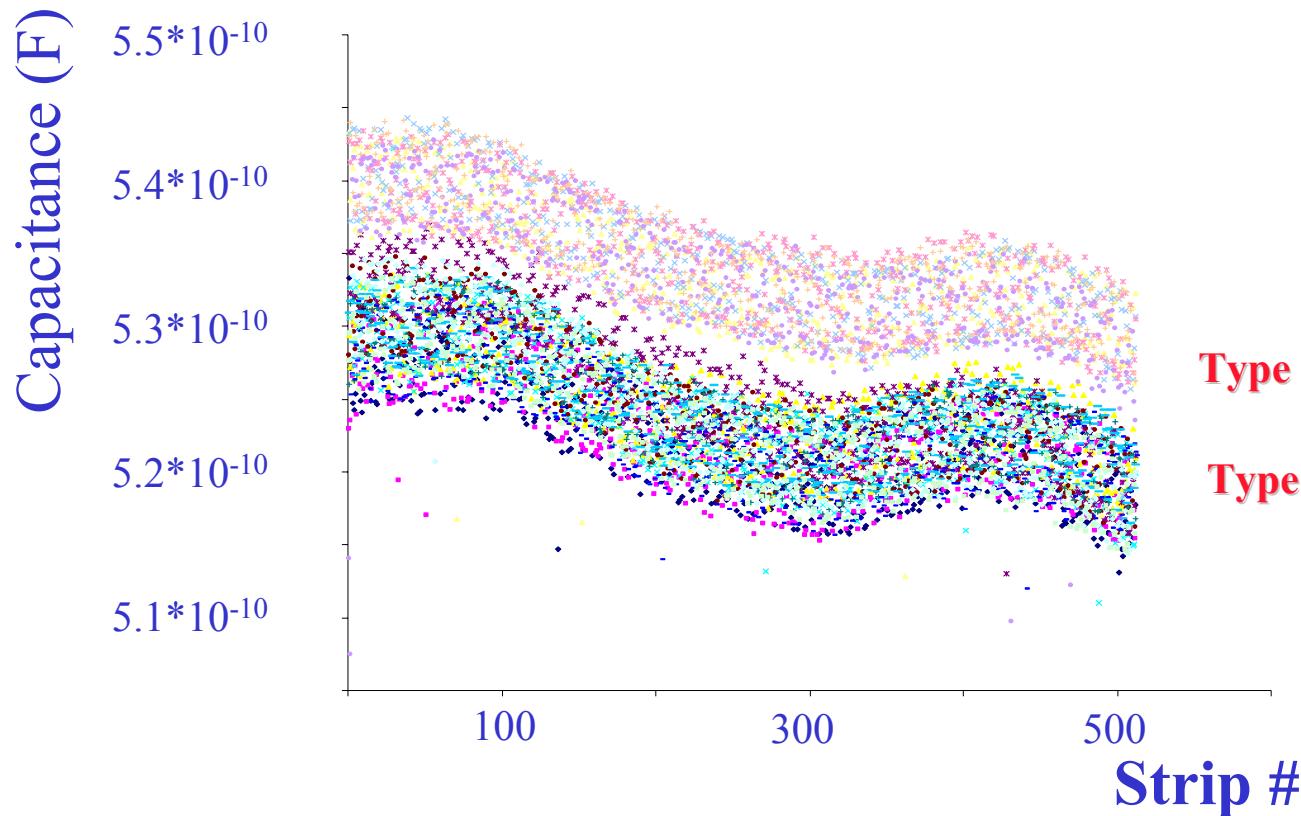


- No breakdown up to 550V
- $I(450V) \sim 25\text{pA/cm}^2$ well within sensor specifications ($I < 200\text{pA/cm}^2$)



Strip scan - coupling capacitance Hamamatsu pre-production

Measured at 100 Hz, between dc and ac pads



Acceptance Criteria
 $413\text{pF} < C_{\text{ac}} < 620\text{pF}$

Type W6A
Type W6B

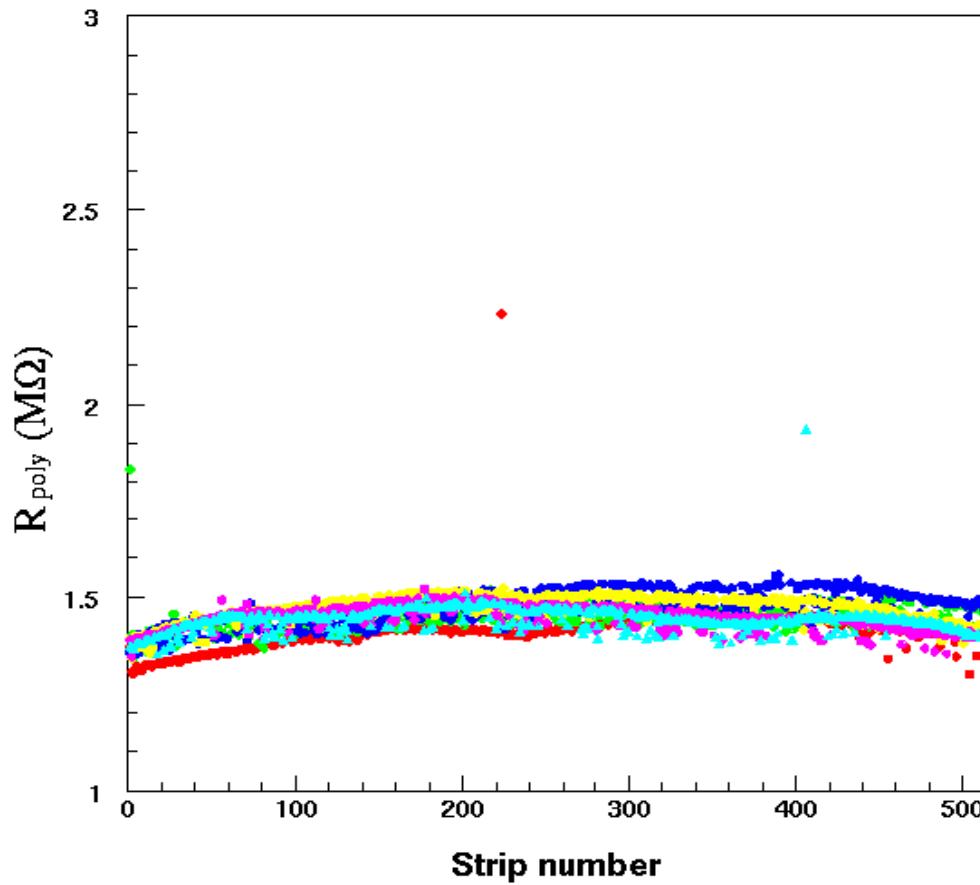
Two different geometries
~4% spread inside a batch



Strip scan - Biasing resistor ST Microelectronics pre-production



Bias resistor strip scan

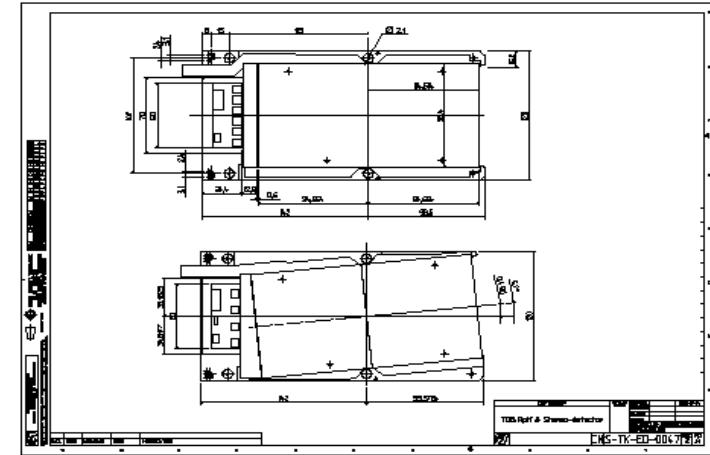
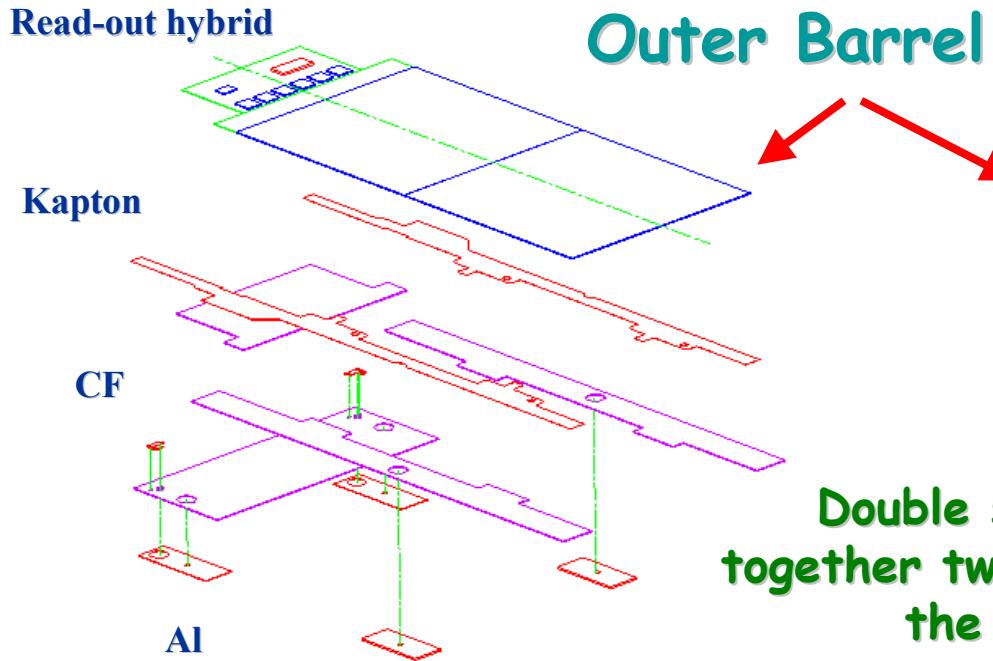


Good uniformity over both strips and sensors inside a production batch

Reference values:
 $1.2 \text{ } M\Omega < R < 1.8 \text{ } M\Omega$



Tracker modules



Double sided modules are achieved joining together two mechanically independent detectors, the $r\text{-}\emptyset$ and the stereo detectors

The module consists essentially of three elements:

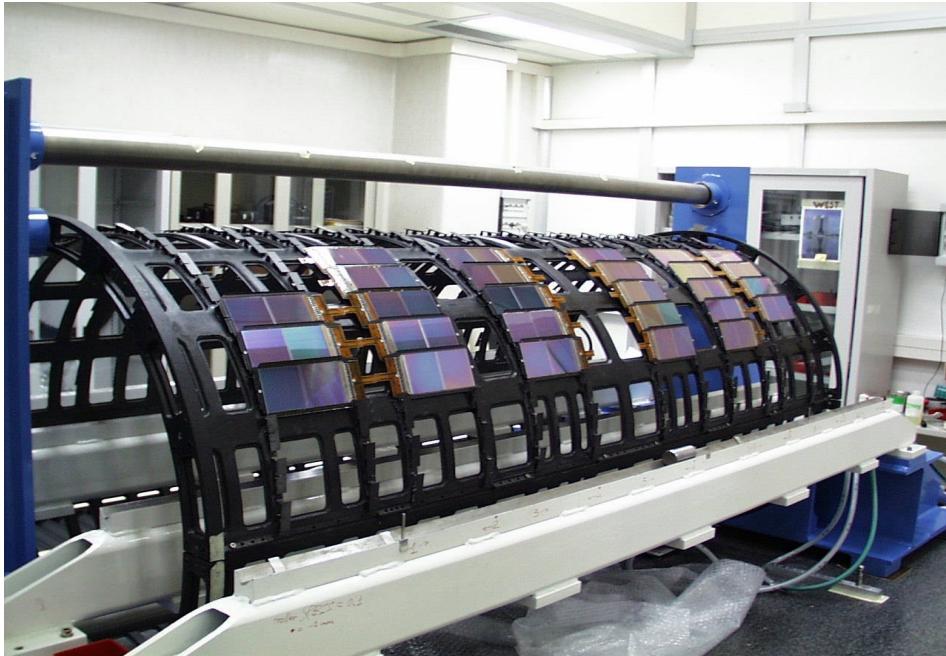
- the silicon sensors
- the mechanical support structure and heat transport elements
- the read-out hybrid

Strip length ranges from 12 cm (inner barrel) to 20 cm (outer Barrel).
Pitch ranges from 80 μ m to 200 μ m.

~16000 modules in the Tracker.....



Silicon Tracker Mechanics



TIB (Tracker Inner Barrel) 4 layers
with thin ($320\mu\text{m}$) detectors assembled
in a shell mechanics



TOB (Tracker Outer Barrel) 6 layers with
thick ($500\mu\text{m}$) large area detectors
assembled in rod mechanics



CMS Microstrip Tracker Read-out

- **Front end**

- **APV25 final chips produced**

- **Optical link**

- **Procurement starting**

- **DAQ interface**

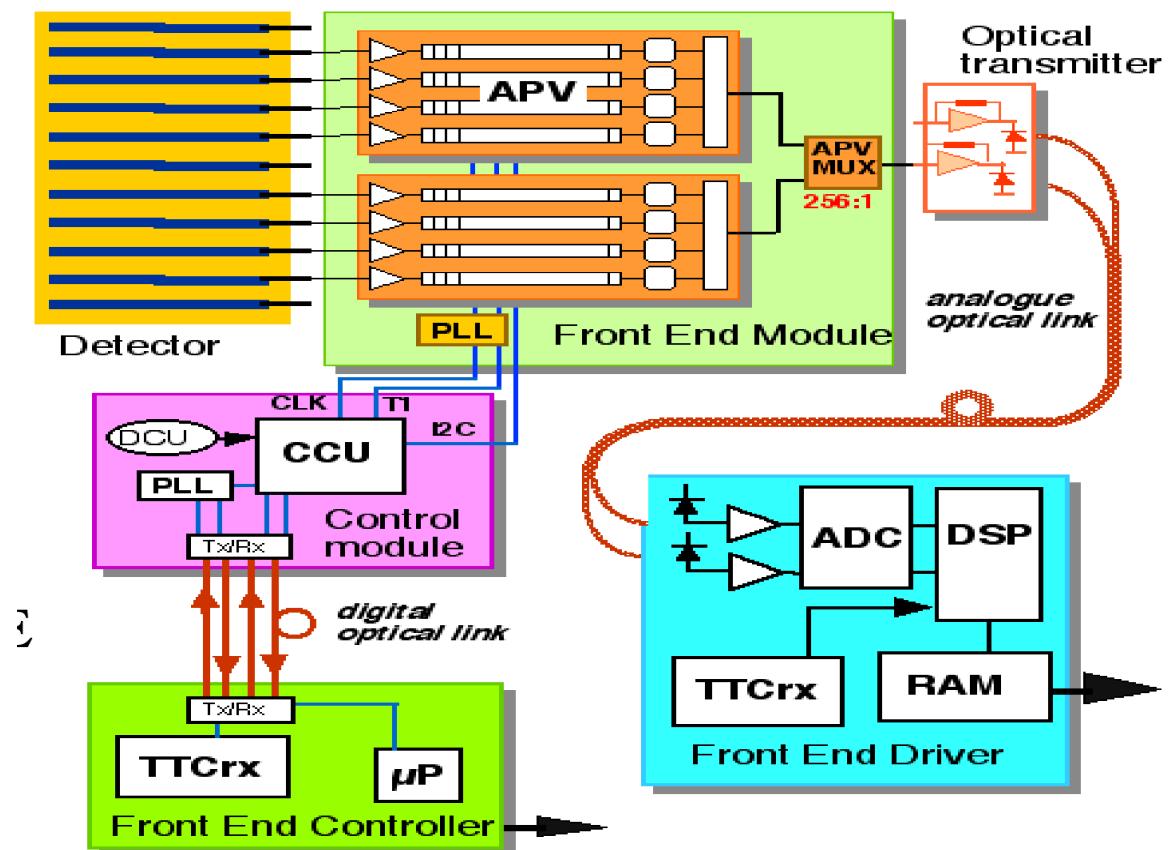
- **PMC FED (ADC) in beam tests
final version being designed**

- **Control system**

- **FEC & 0.25 μ m chip set exist**

- **System**

- **System test ongoing**

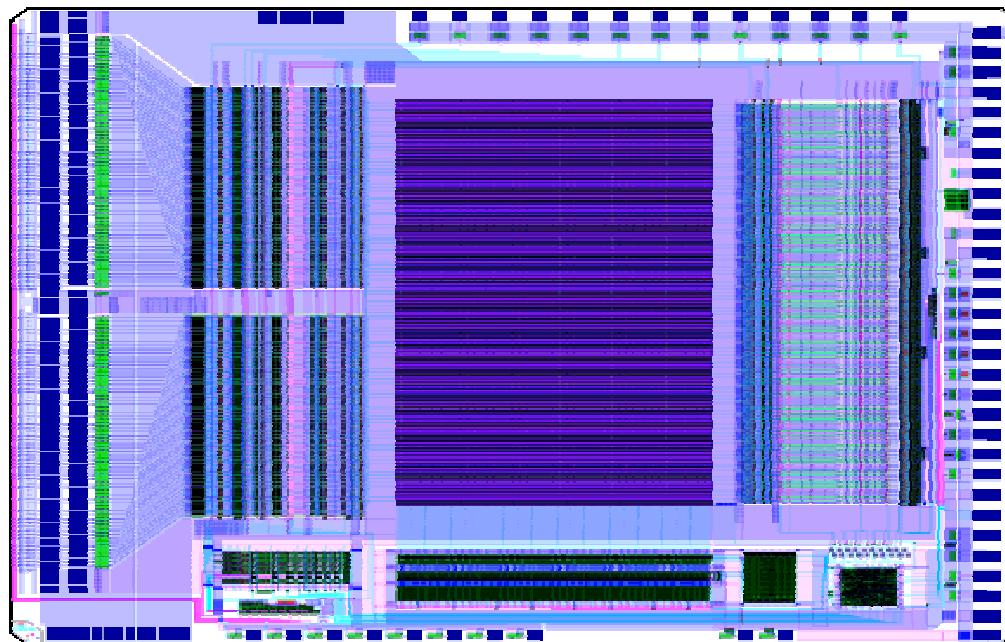
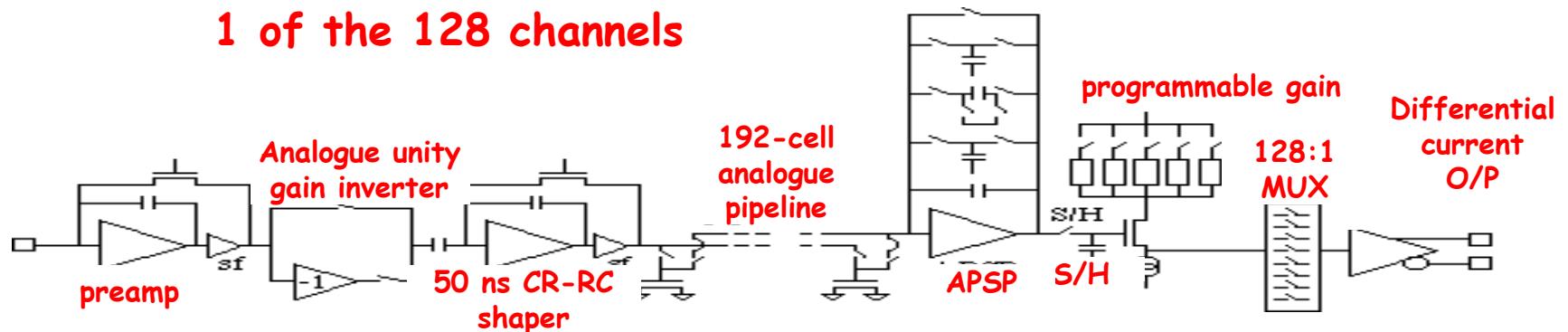




APV25 0.25 μ m CMOS



1 of the 128 channels



Intrinsic Radiation Tolerant

APV25-S1 (Aug 2000)

Chip Size 7.1 x 8.1 mm

Final



Conclusions

- The design and choice of materials for the CMS Silicon Sensors are well suited for running the Silicon Microstrip Tracker up to **10 years** at LHC.
- The CMS Silicon Tracker Collaboration has completed the R&D program and it is entering the **production phase**.
- **Detector module** construction for the pre-production is underway.
- We believe that a **powerful and robust** Silicon Tracker can be built to cope with the hostile LHC environment.