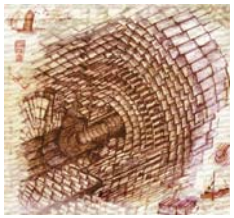
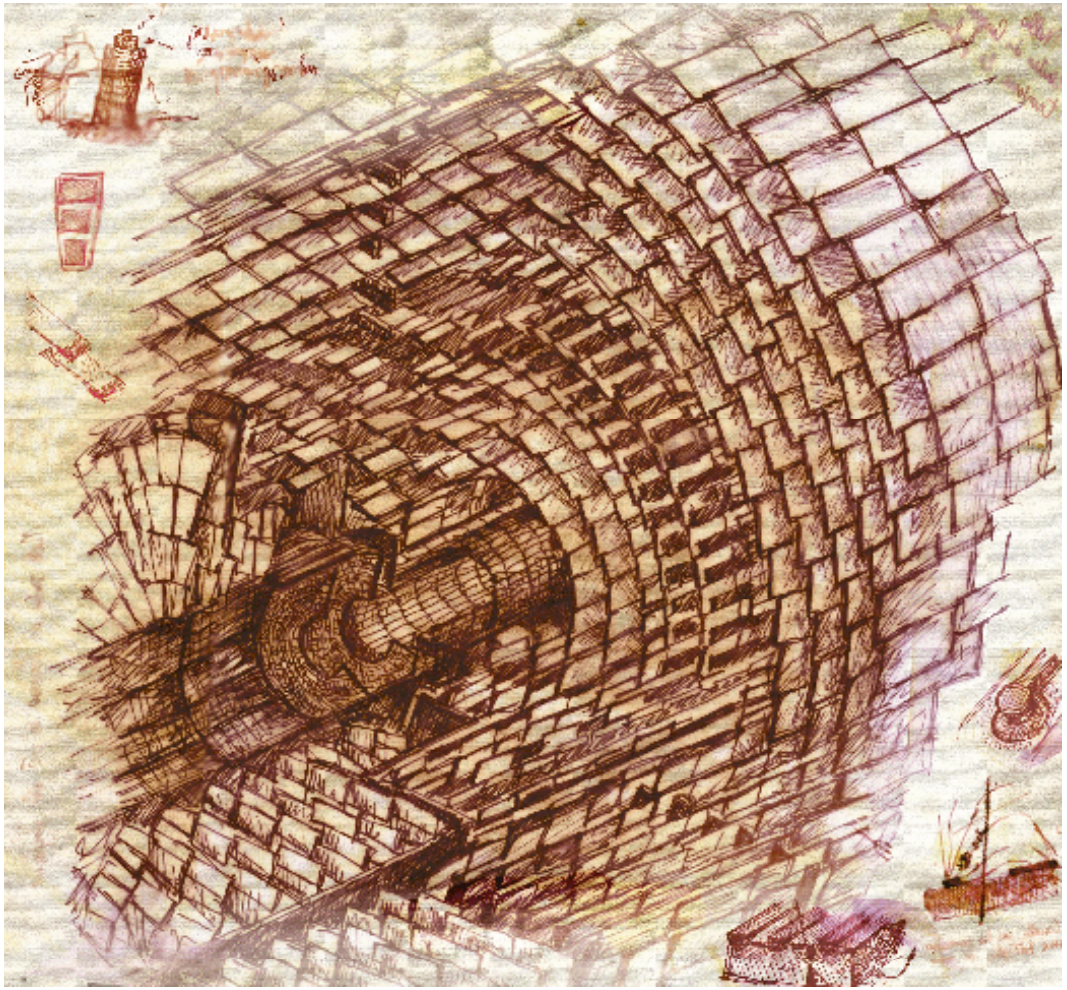
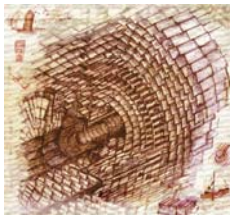


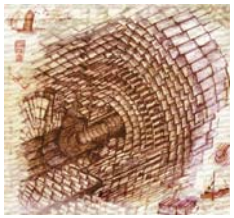
CMS SLHC Tracker Thin Sensor R&D with HPK





Outline plan of work for Sensors

- **Phase I: Targeted R&D** **~ 2008 - 2012**
  - Establish required sensors characteristics & basic specifications
- **Phase II: Preproduction and Qualification** **~ 2012 - 2014**
  - Finalize detailed specifications and QA protocols
  - Qualify for large scale production
- **Phase III: Large Scale Production** **~ 2014 - 2016**
- **Market Survey to identify Additional Industrial Partners for Phases II and III**
  - Producers qualified according to this MS may take part in Phase II
  - Production contingent on Phase II success



Outline plan of work for Sensors

- **Phase I: Targeted R&D** **~ 2008 - 2012**
  - Establish required sensors characteristics & basic specifications
  - Funds available and Cost for HPK order now match
  - Negotiating Single Source HPK order with CERN
  - Layout still being finalized…
- **Phase II: Preproduction and Qualification** **~ 2012 - 2014**
  - Finalize detailed specifications and QA protocols
  - Qualify for large scale production
- **Phase III: Large Scale Production** **~ 2014 - 2016**
- **Market Survey to identify Additional Industrial Partners for Phases II and III**
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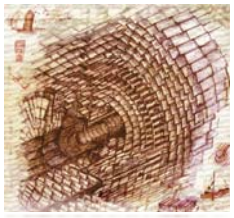
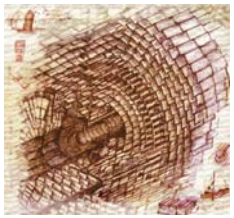


CMS SLHC Tracker Thin Sensor R&D with HPK

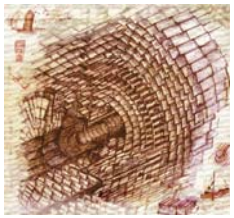
- **Aim for:**
  - **Single Technology for Outer Tracking Layers**
  - **Single Technology for Inner Pixel Layers**
    - This will be an important consideration in defining Radial Boundary between these two Regions
- **For the region above ~ 22cm, currently occupied by the Strip Tracker, a program of measurements is proposed, addressing**
  - **Thin Single-Sided p-on-n vs n-on-p sensors on FZ vs MCZ**
- **Based on results obtained, aim to identify Radial Regions where these technologies can be deployed**



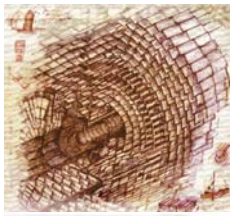
CMS SLHC Tracker Thin Sensor R&D with HPK

nb active thickness ~ physical thickness - 20um

substrate type & physical thickness	FZ 200um carrier	MCZ 200um thinning	FZ 120um carrier	epi 100um	epi 60um	FZ 320um	Total
P-on-N Production	6	6	6	6	6	14	44
N-on-P Production p-spray	6	6	6	6	6	14	44
N-on-P Production p-stop	6	6	6	6	6	14	44
2'nd metal production P-on-N	6						6
2'nd metal production N-on-P p-stop	6						6
Total	30	18	18	18	18	43	145



Backup Slides

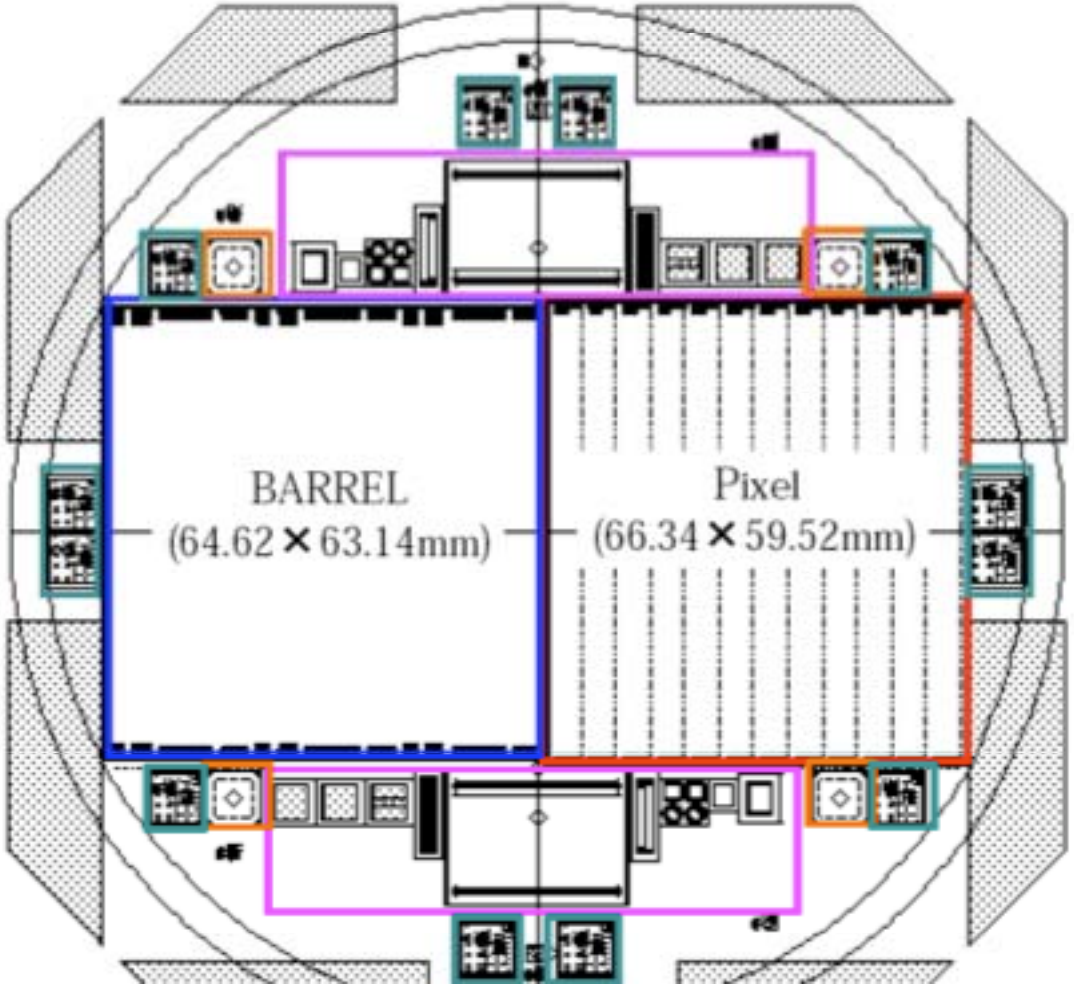


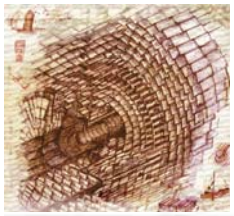
CMS SLHC Tracker Thin Sensor R&D with HPK

Previous Test Structure

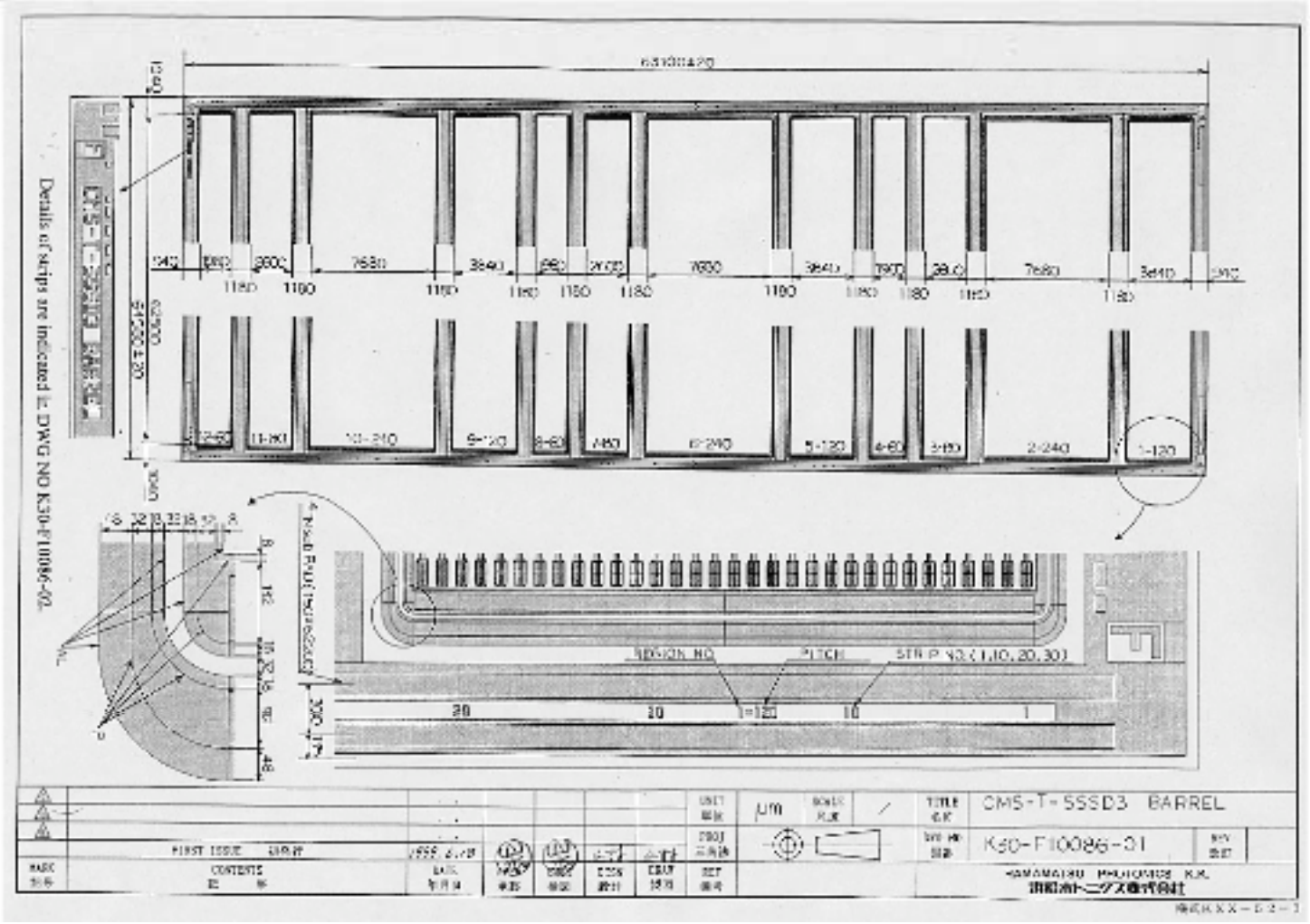
Monitor Diode

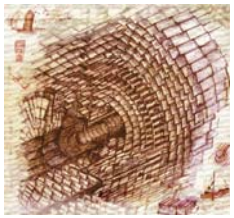
HPK Test structure





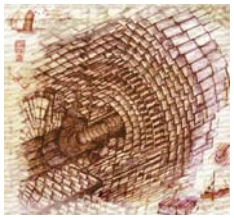
Multi-Geometry Strip Sensors



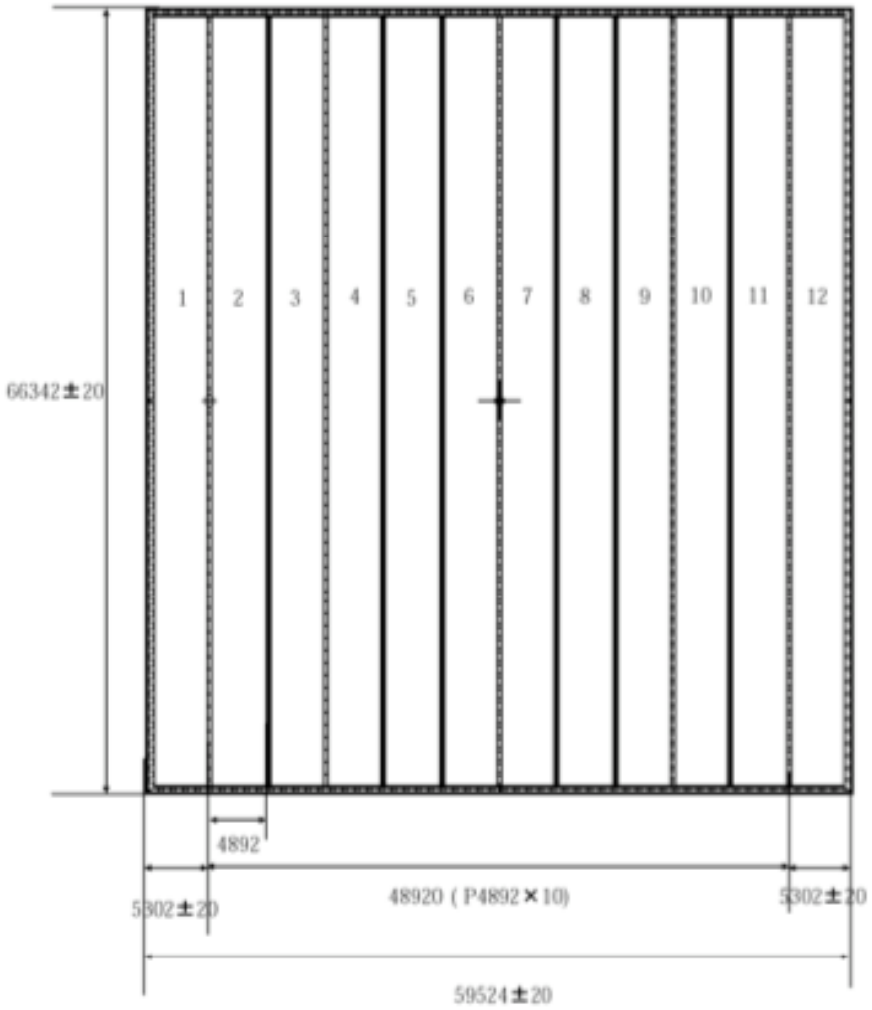


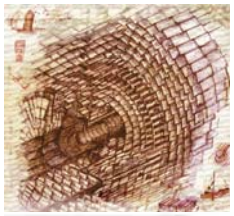
Multi-Geometry Long Pixel Sensors

- Pixel pitch: 120um
- Pixel implant width / pixel pitch: 0.25
- Metal overhang: 8 um
- Pixel separation, along pixel length: 60um; 90um; 120 um
- Pixel length: 1mm; 2mm; 3mm; 4mm



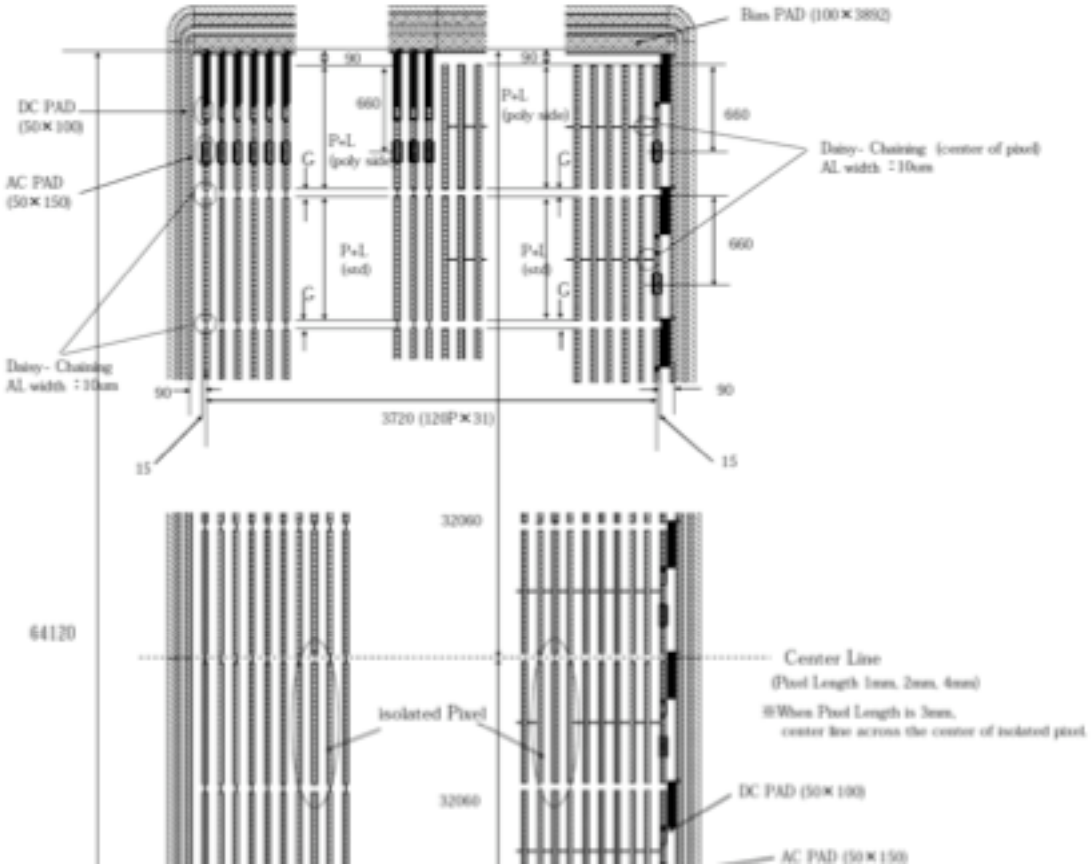
Multi-Geometry Long Pixel Sensors

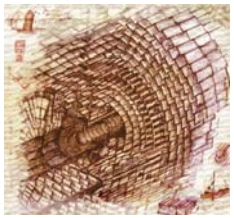




Multi-Geometry Long Pixel Sensors

Pixel Length(s) = (P+ Length + (Gap))		1000			2000			3048			4000		
	Number of pixel/row	64			32			21			16		
G	Gap	60	90	120	60	90	120	60	90	120	60	90	120
P+ L (std)	P+ Length (std)	940	910	880	1940	1910	1880	2988	2958	2928	3940	3910	3880
P+ L (poly side)	P+ Length (poly side)	980			1940			2980			3940		





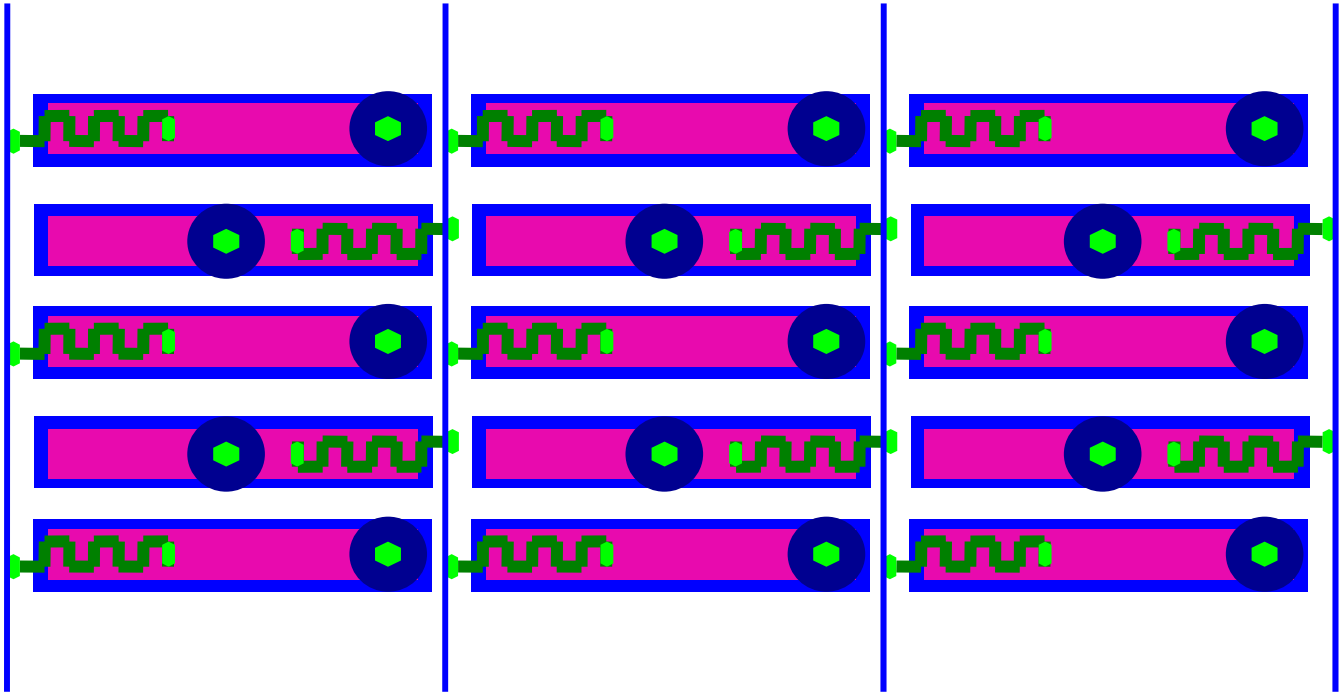
Long Pixels
Biasing Scheme i

Pixel Implants:

Length 1 ~ 4mm
Pitch ~ 120um
Width ~ 30um
Gaps ~ 90um

Vias:

Metal – Poly
Poly – Implant
Metal - Implant

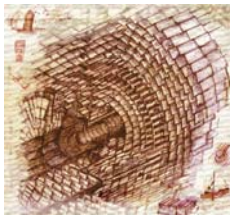


Poly Bias Resistors:

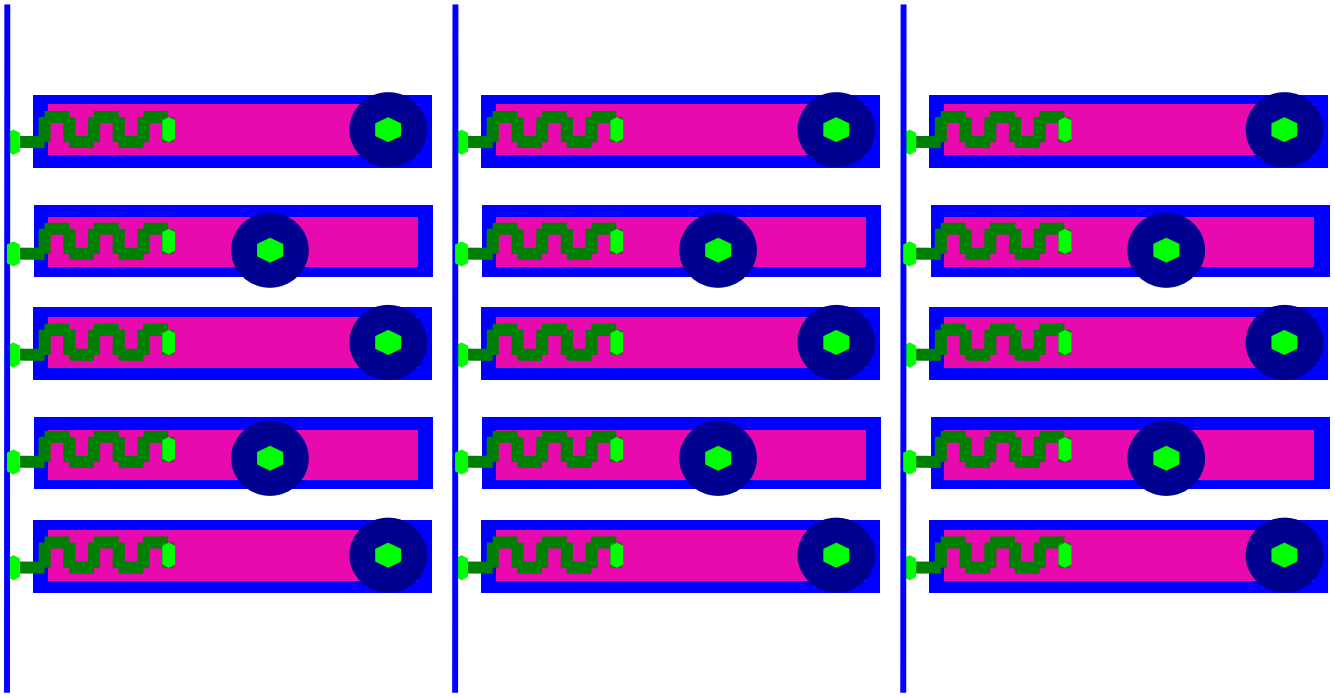
~ 1MOhm

Metal Layer:

Bump min. pitch ~ 240um
Bump Diameter ~ 50um
Bias Line Width < 10um



Long Pixels
Biasing Scheme ii



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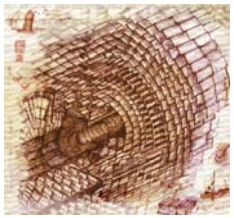
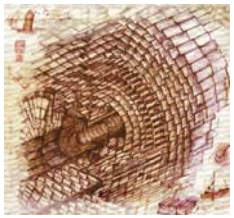
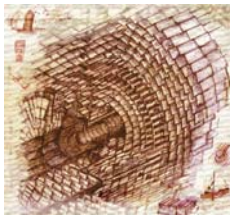


More Backup slides

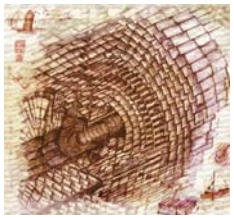


- The charged hadron fluence has a strong radial dependance; the neutral hadron fluence, in particular above about 60cm has little radial dependence
- For radii below 60cm, the fluence is dominated by charged pions; at about 70cm, the fluence of charged pions and neutral hadrons are approximately equal
  - This motivated the TIB/TOB thin/thick sensor transition
- There is factor of almost 6 reduction in total fluence going from 22cm to 58cm radius
- There is a further factor of about 2 in going from 58cm to 115cm radius
- The fluence at 4cm radius is almost 20 times higher than at 22cm radius



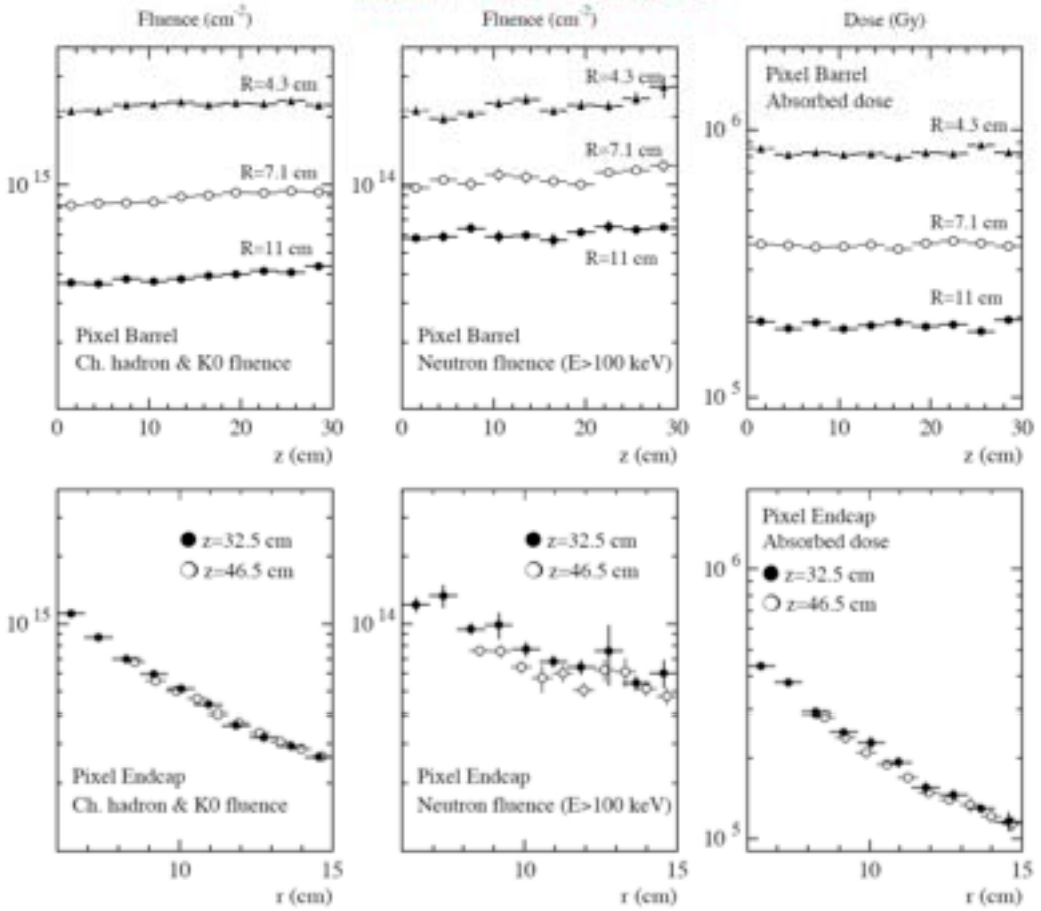
- At the SLHC, the fluence at the innermost radius of TIB (22cm) will be about half as much as at the innermost Pixel layer at full LHC luminosity

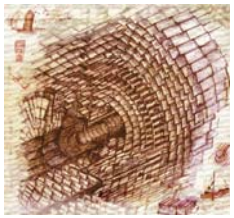
- At the SLHC, the fluence at the innermost (outermost) radius of the TOB will be about 2.5 (1.1) times higher than at innermost radius of TIB at full LHC luminosity




CMS

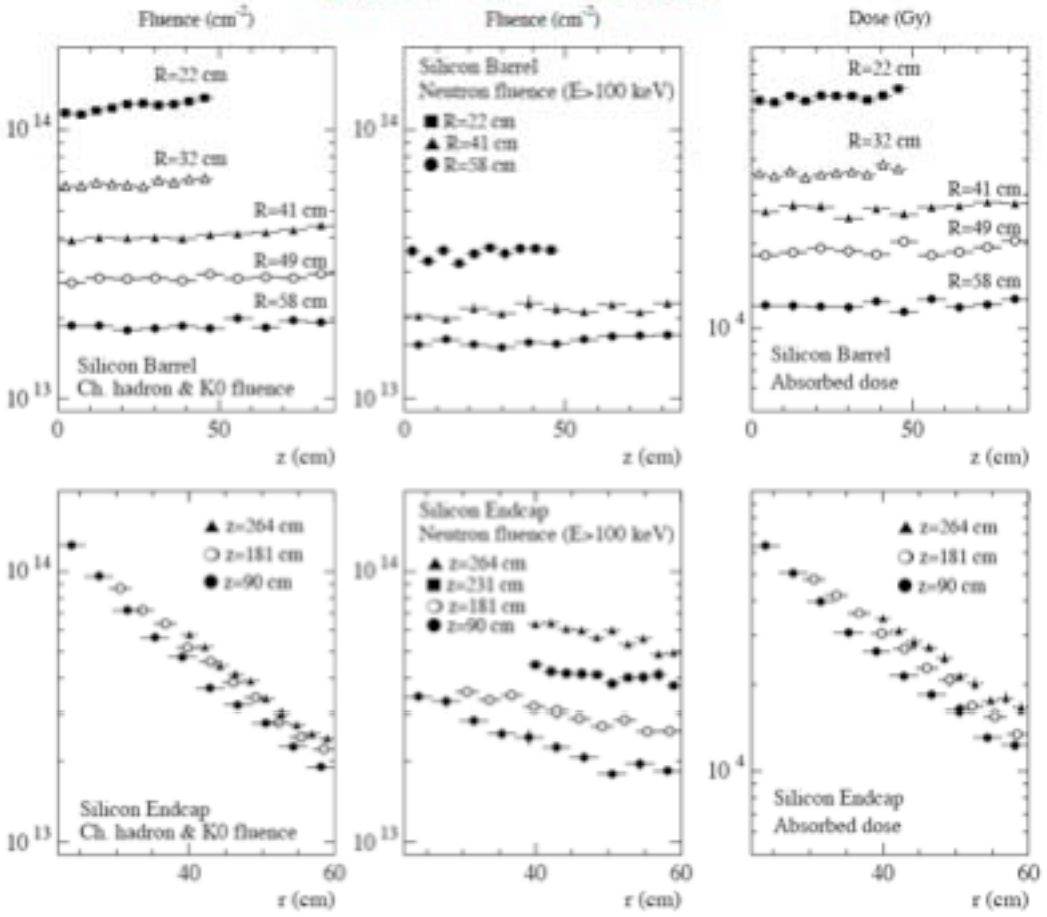
4cm < R < 11cm

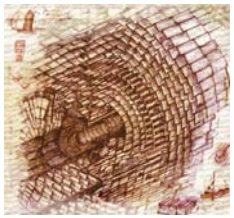

Fluence (cm⁻²)
R=4.3 cm
R=7.1 cm
R=11 cm
Pixel Barrel
Ch. hadron & K0 fluence
z (cm)
Fluence (cm⁻²)
Pixel Barrel
Neutron fluence (E>100 keV)
Dose (Gy)
Pixel Barrel
Absorbed dose
z=32.5 cm
z=46.5 cm
Pixel Endcap
Ch. hadron & K0 fluence
r (cm)
Pixel Endcap
Neutron fluence (E>100 keV)
Pixel Endcap
Absorbed dose




CMS

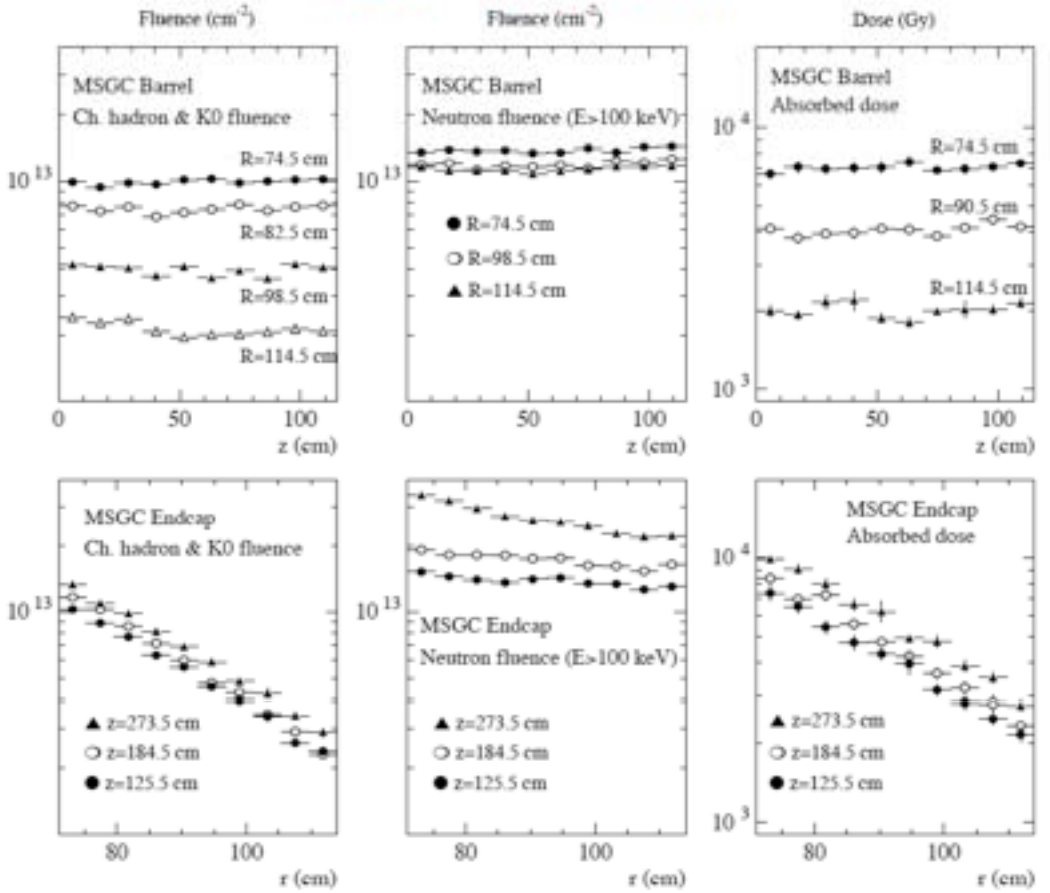
20cm < R < 60cm

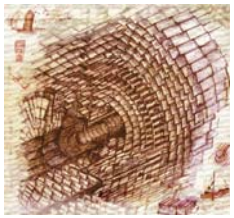

Fluence (cm^{-2})
Fluence (cm^{-2})
Dose (Gy)
R=22 cm
R=32 cm
R=41 cm
R=49 cm
R=58 cm
Silicon Barrel
Ch. hadron & K0 fluence
Silicon Barrel
Neutron fluence (E>100 keV)
Silicon Barrel
Absorbed dose
z (cm)
z=264 cm
z=231 cm
z=181 cm
z=90 cm
Silicon Endcap
Ch. hadron & K0 fluence
Silicon Endcap
Neutron fluence (E>100 keV)
Silicon Endcap
Absorbed dose
r (cm)




CMS

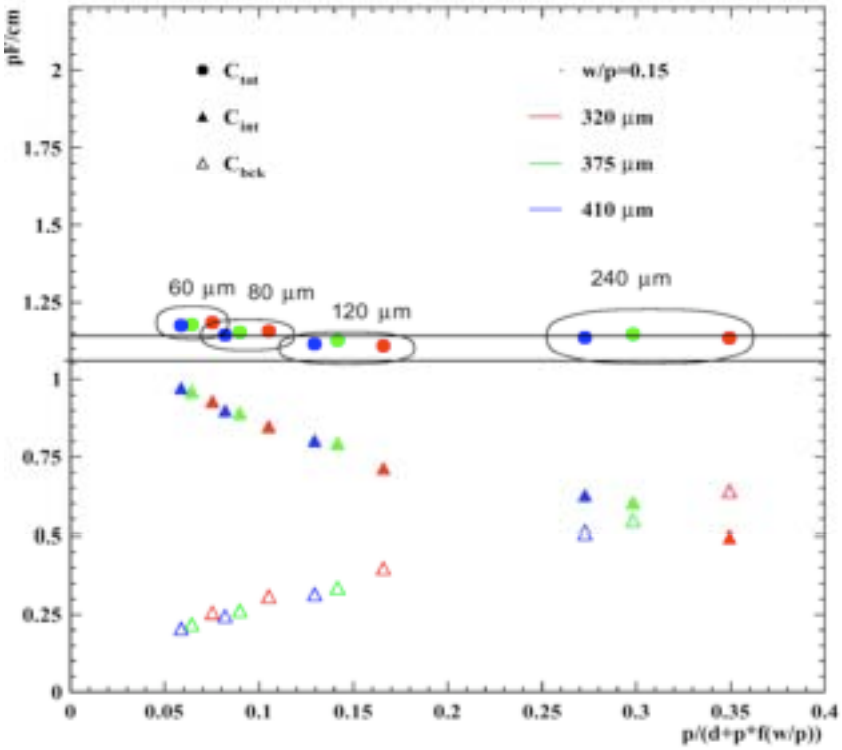
75cm < R < 115cm


Fluence (cm^{-2})
MSGC Barrel
Ch. hadron & K0 fluence
R=74.5 cm
R=82.5 cm
R=98.5 cm
R=114.5 cm
10^{13}
0
50
100
z (cm)
Fluence (cm^{-2})
MSGC Barrel
Neutron fluence (E>100 keV)
R=74.5 cm
R=98.5 cm
R=114.5 cm
10^{13}
0
50
100
z (cm)
Dose (Gy)
MSGC Barrel
Absorbed dose
R=74.5 cm
R=90.5 cm
R=114.5 cm
10^{4}
10^{3}
0
50
100
z (cm)
MSGC Endcap
Ch. hadron & K0 fluence
z=273.5 cm
z=184.5 cm
z=125.5 cm
10^{13}
80
100
r (cm)
MSGC Endcap
Neutron fluence (E>100 keV)
z=273.5 cm
z=184.5 cm
z=125.5 cm
10^{13}
80
100
r (cm)
MSGC Endcap
Absorbed dose
z=273.5 cm
z=184.5 cm
z=125.5 cm
10^{4}
10^{3}
80
100
r (cm)



Total Strip capacitance is the main contribution to electronic noise
It is a function of w/p only, Independent of pitch and thickness

Ctot ~ 1.2pF/cm for w/p = 0.25



Noise ~ 430e- + 75e- * strip length cm