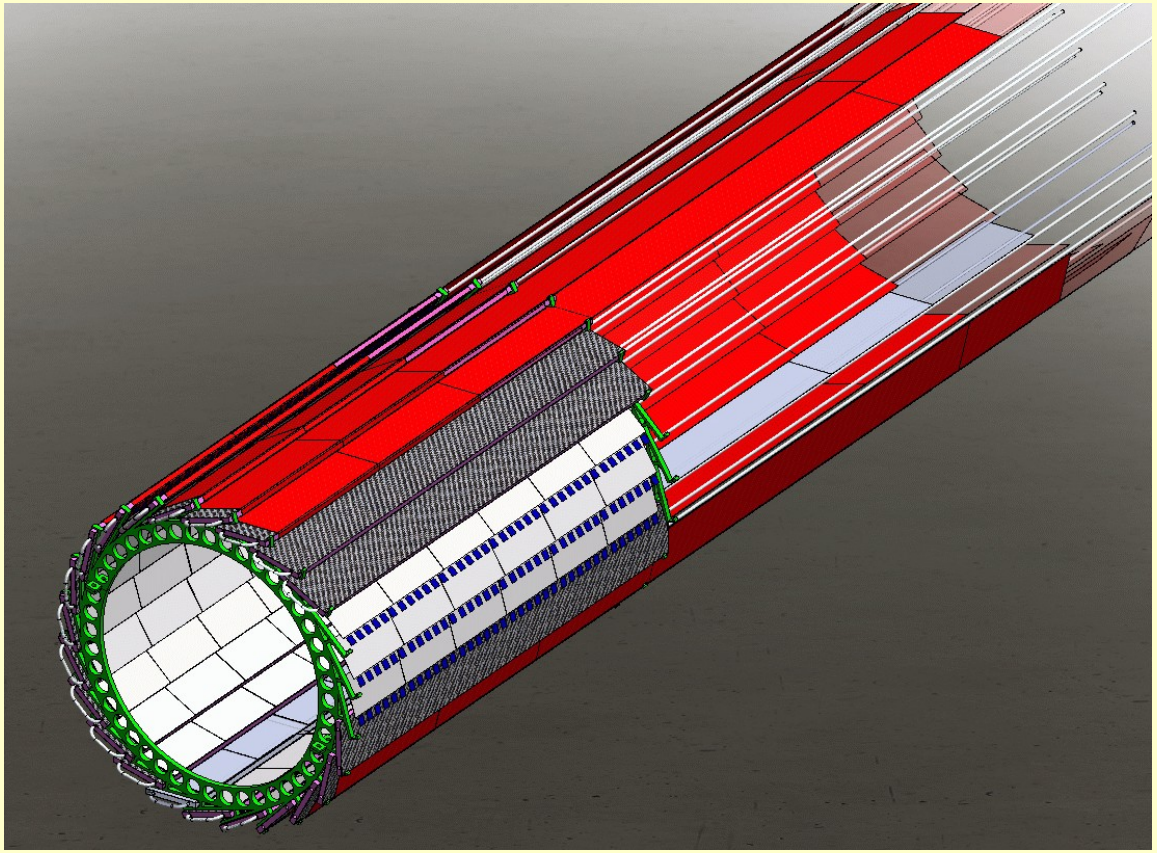
IST Prototype Sensors

IST introduction
Experimental requirements
Sensor and readout chip
Prototype specifications
Quotation

Gerrit van Nieuwenhuizen
IST Prototype production review
BNL, January 26, 2011

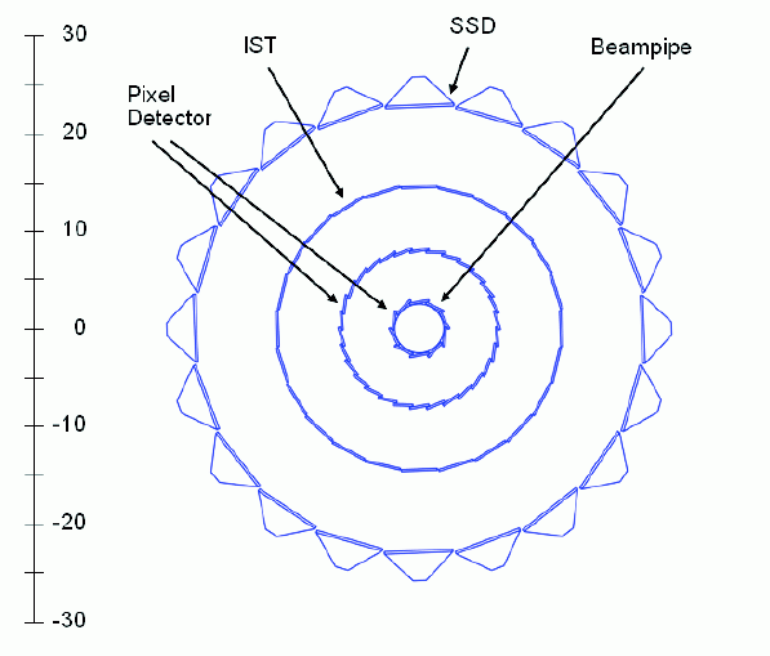
IST Overview



Radius	14 cm
Length	50 cm
ϕ Coverage	2π
$\lvert\eta\rvert$ Coverage	≤ 1.2
Number of ladders	24
Number of hybrids	24
Number of sensors	144
Number of readout chips	864
Number of channels	110592
R-ϕ resolution	172 μm
Z resolution	1811 μm

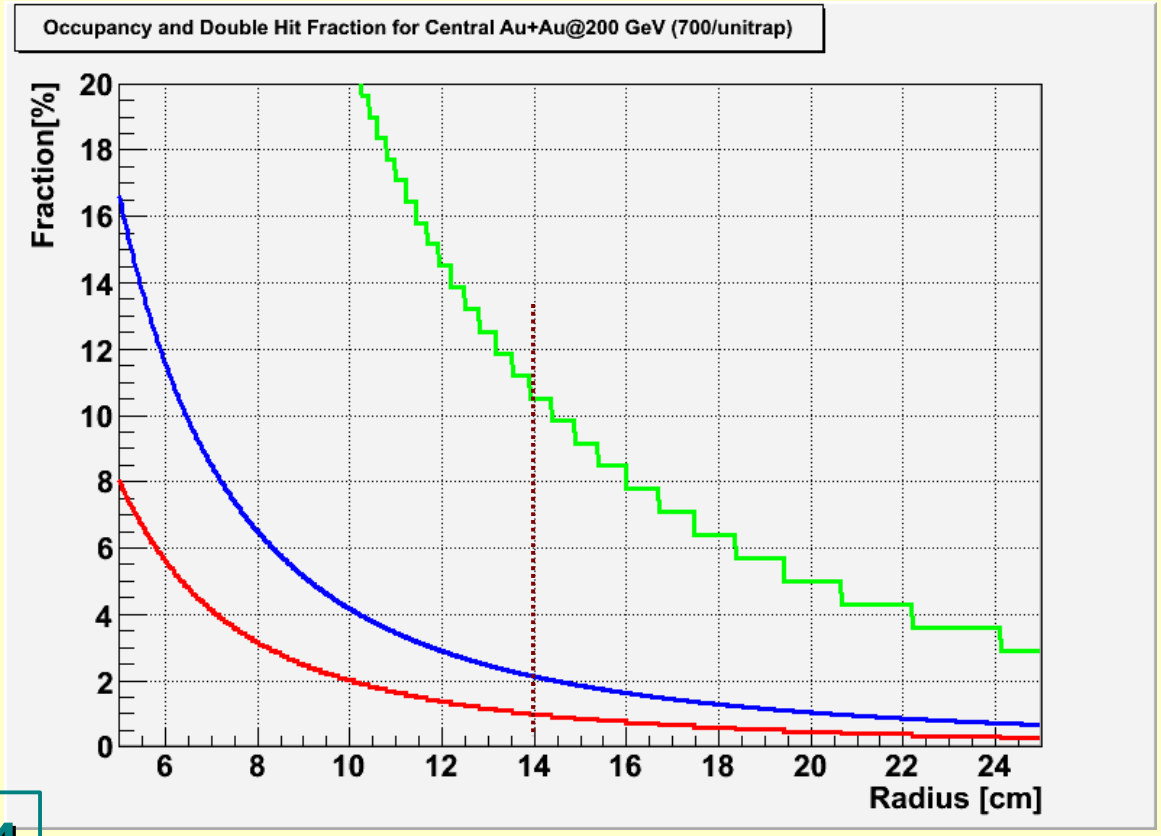
IST Requirements

- Pointing resolution in r-phi of about 200um
- Hit efficiency > 95%
- Live channels > 97%
- Occupancy on few % level
- Double hit probability on few % level
- Withstand 30kRad/year for 10 years



IST Strips?

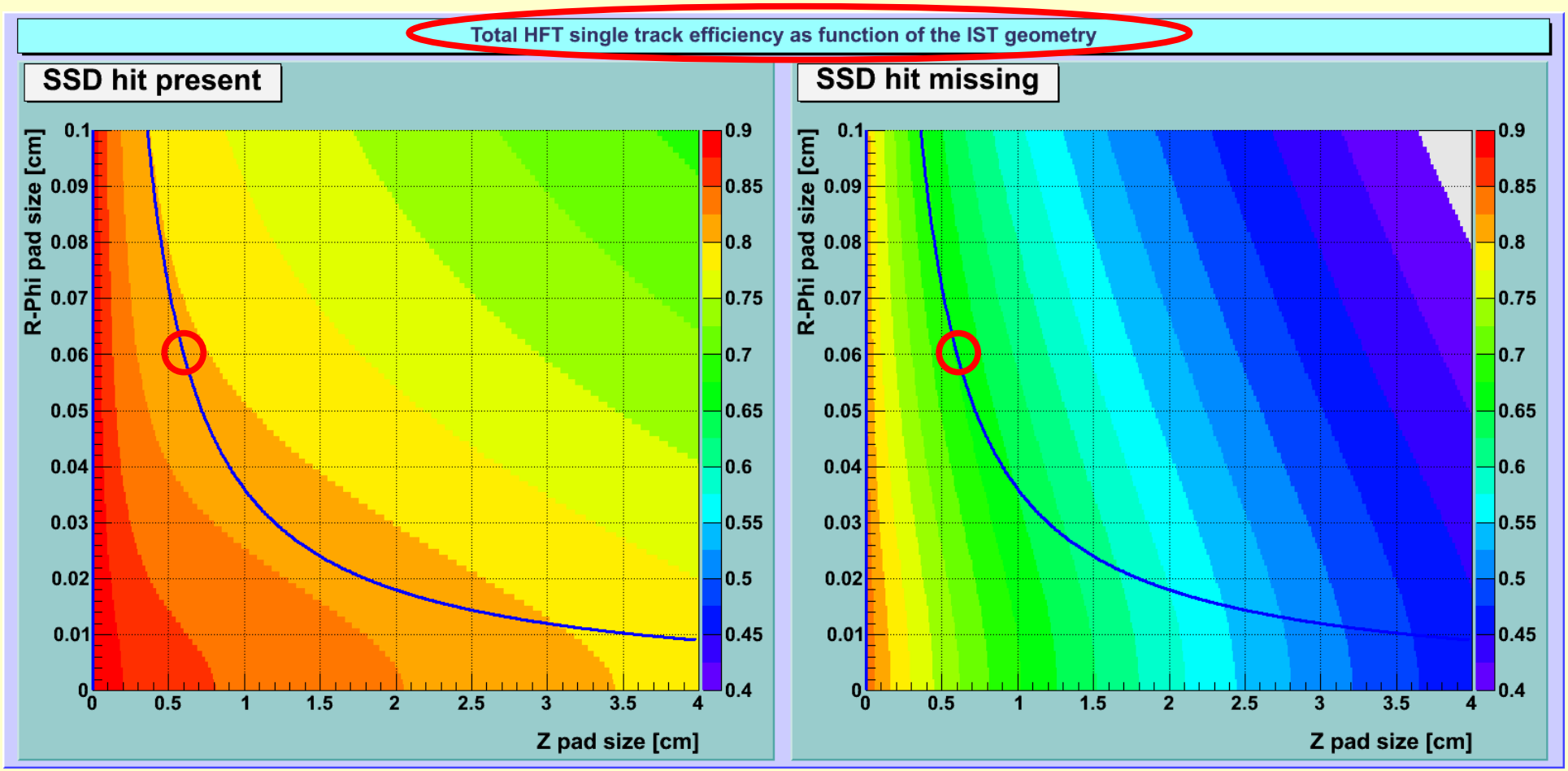
- 200GeV Au+Au can lead to about 1 charged particle/cm^2
- channels per sensor determined by readout chip density
- strips will give unacceptable high double hit probability



- 768 strips or pads
- ~ 4cm X 8cm sensor (r-phi X Z)
- 50um strips
- 600um X 6000um pads
- ~550um search ellipse (r-phi from tracking)

Strips not an option

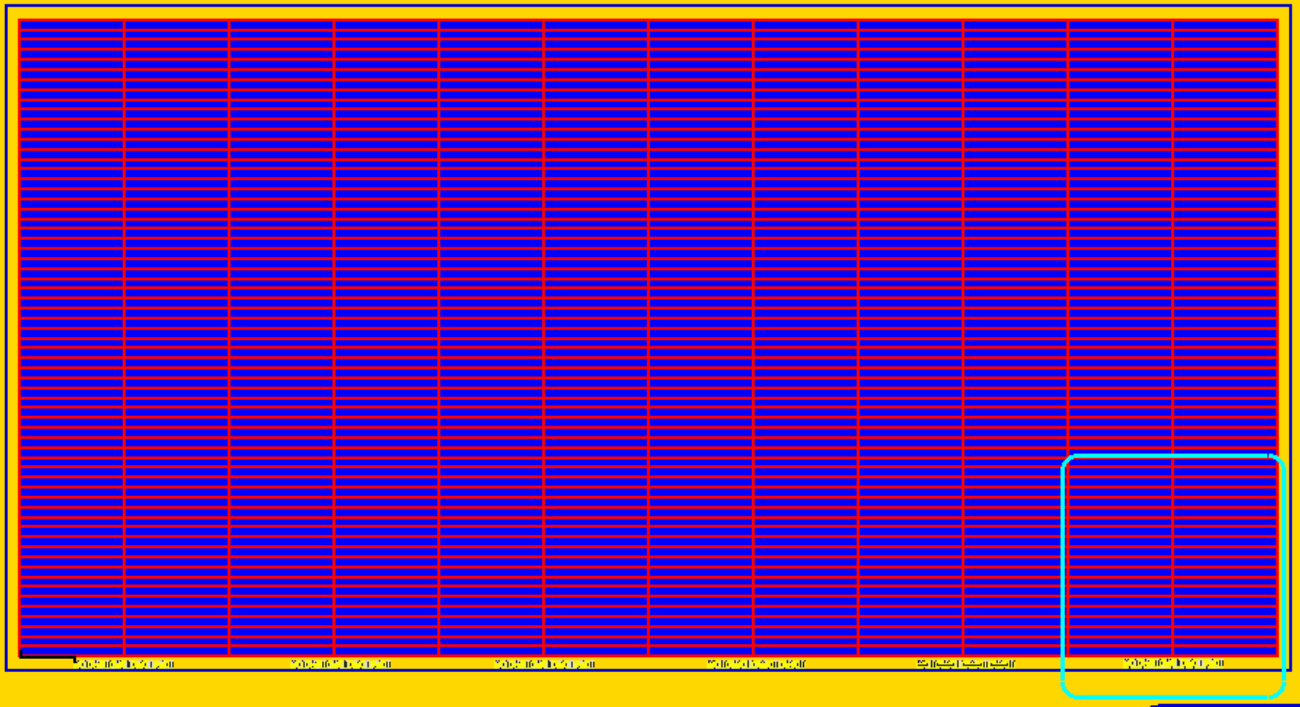
IST Pad Geometry



- We can conveniently fit 768 channels in the readout chips
- 600um X 6000um can comfortably be laid out on the sensor
- Efficiency of 83% with SSD hit, 73% without SSD hit
- Efficiency sufficient for Heavy Flavor program
- IST and SSD deliver redundancy

IST Sensor Design I

IST silicon pad sensor design for Hamamatsu quote



This area A is enlarged in another picture

Silicon sensor size: 76.900mm x 40.000mm

Active area pitch: 6275um x 596um
Edge structure left & right: 800um
Top edge structure: 800um
Bottom edge structure: 1056um
12 columns x 64 rows

HamamatsuDesign_13May2010

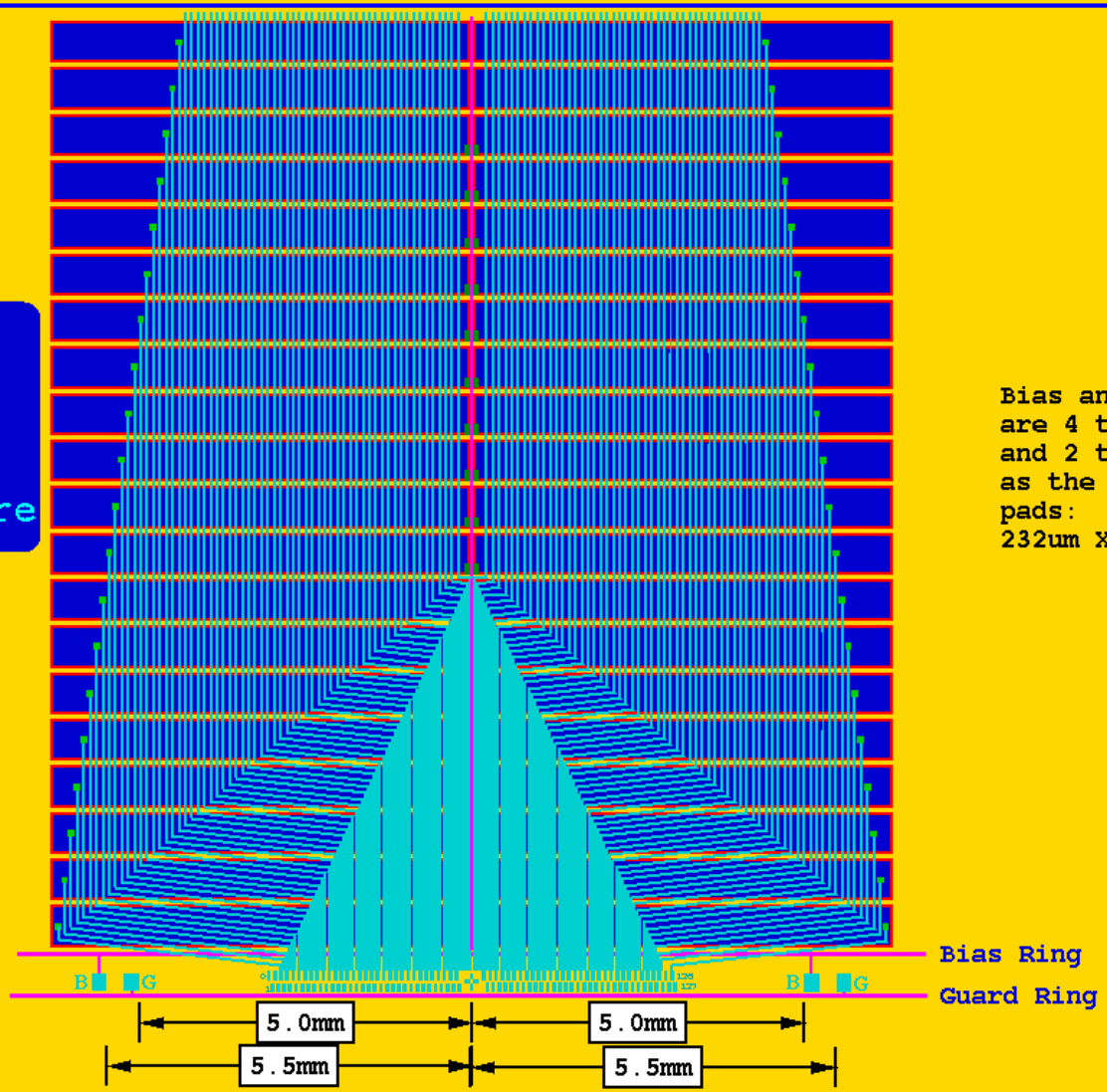
Latest Revision: 07/12/2010

IST Sensor Design II

IST sensor: detail bonding pads

Enlarged Area A

Area B around center signal bonding pads enlarged in another picture



Bias and guard pad are 4 times as wide and 2 times as high as the signal bonding pads:
232um X 272um

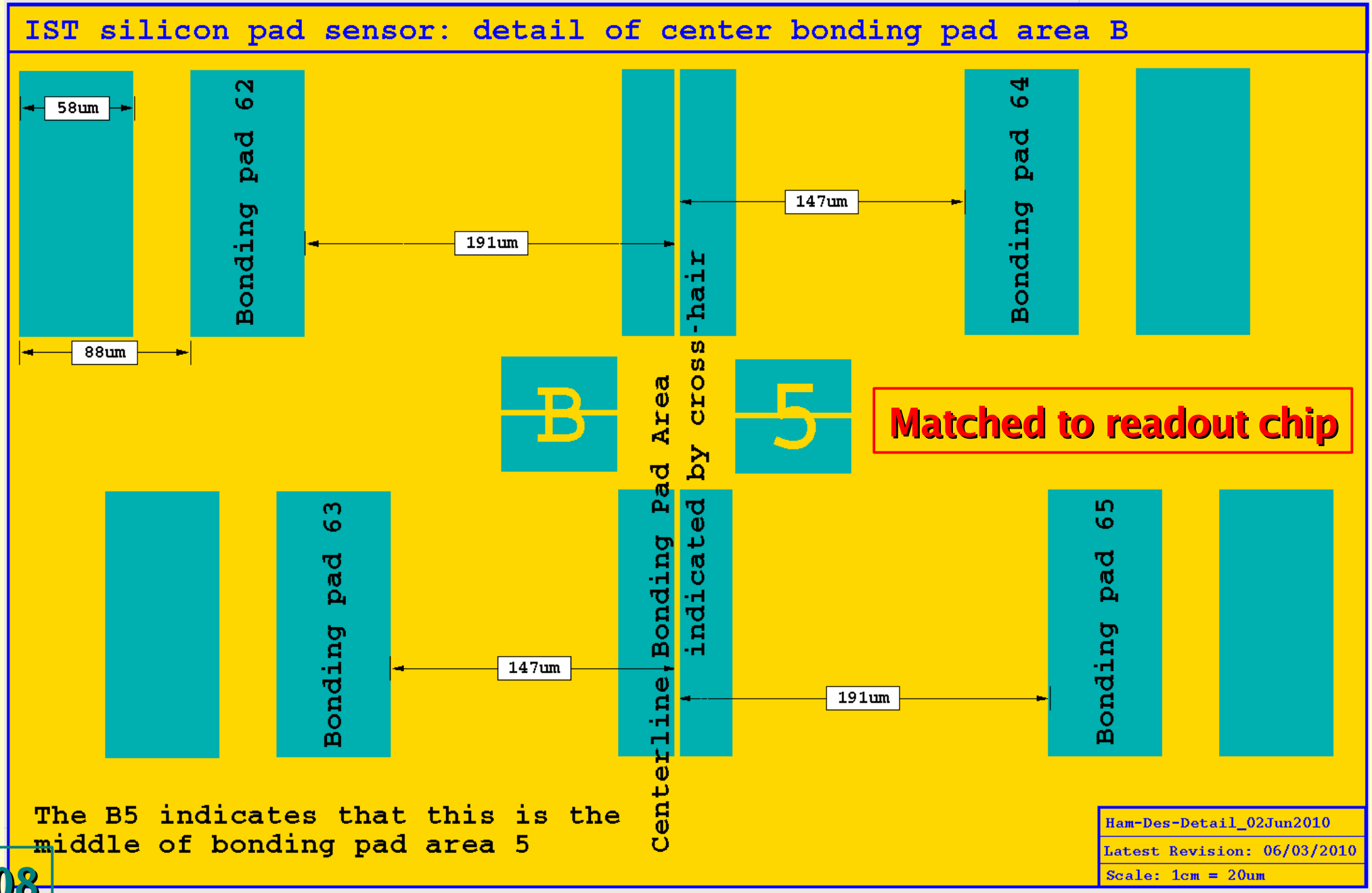
Distances to bias and guard bonding pad edges measured from the center of the signal bonding pad area.
Note: each signal bonding pad area will have 2 bias and 2 guard bonding pads to facilitate flexibility in assigning corresponding similar pads on the hybrid

HamamatsuDesign_Detail_14May2010

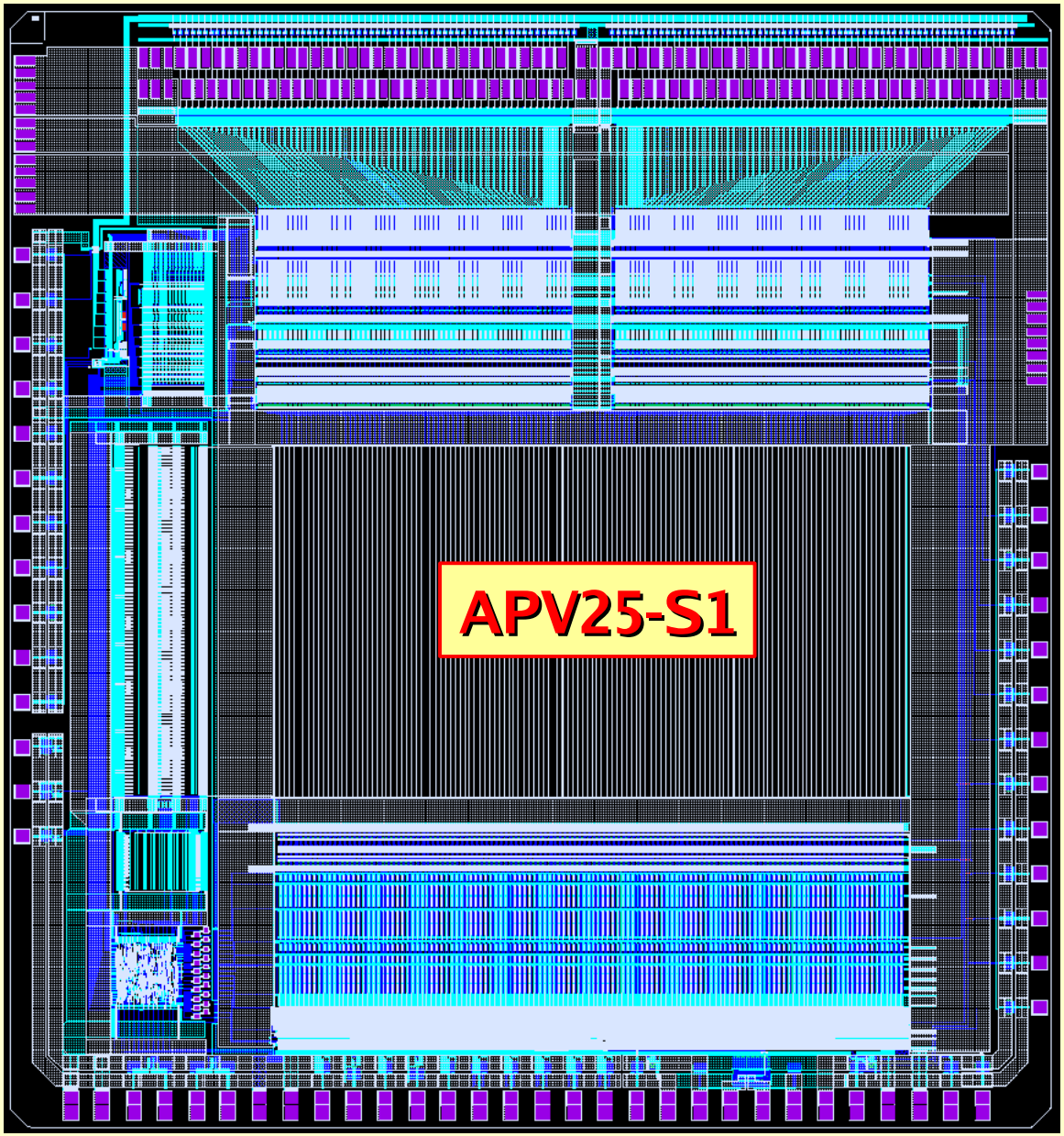
Latest Revision: 05/27/2010

Scale: 1cm =

IST Sensor Design III



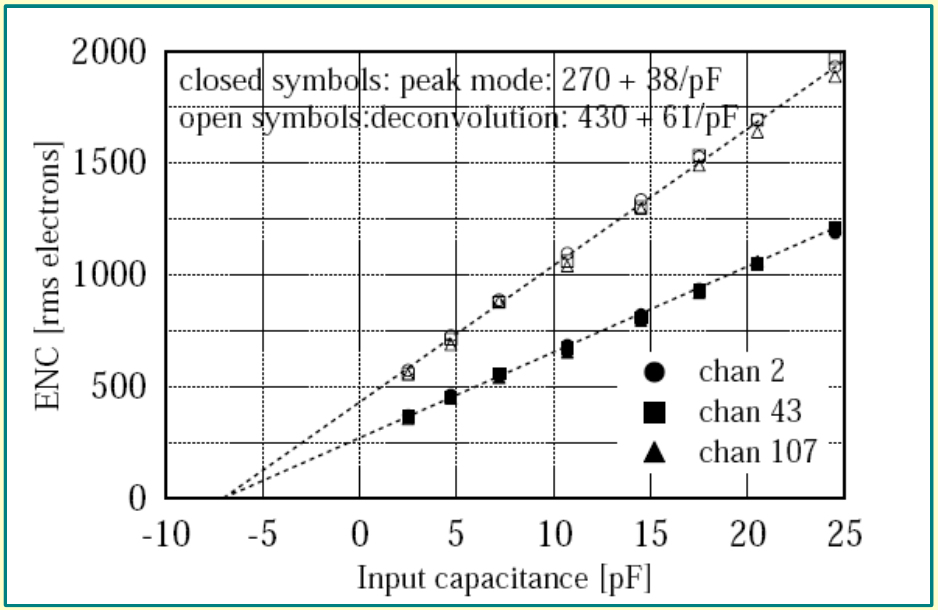
IST Readout Chip



Front End Pad Layout

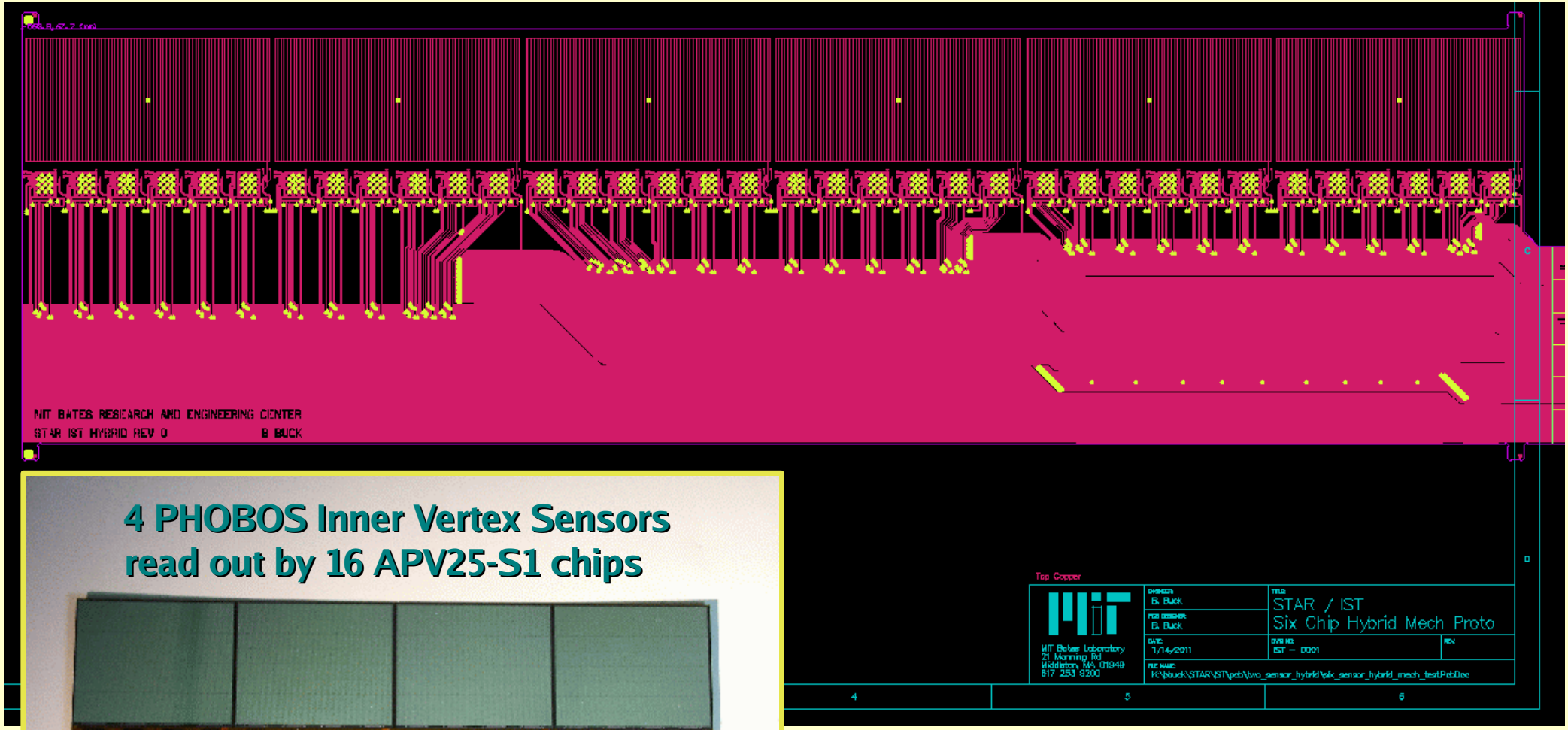
The 128 analogue inputs are grouped into 2 sections. The sections are arranged in two staggered rows with even numbered pads on the outside and odd numbered pads on the inside. The first section contains pads 0-63, and the second pads 64-127. The two groups are separated by a set of GND pads. These supply the preamplifier and shaper stages. GND.1 supplies the preamplifier input FET and GND.2 supplies the inverting stage of the preamplifier. The power pads contain passivation openings on the same pitch as the input pads. Analogue inputs have diode protection to VSS and VDD.

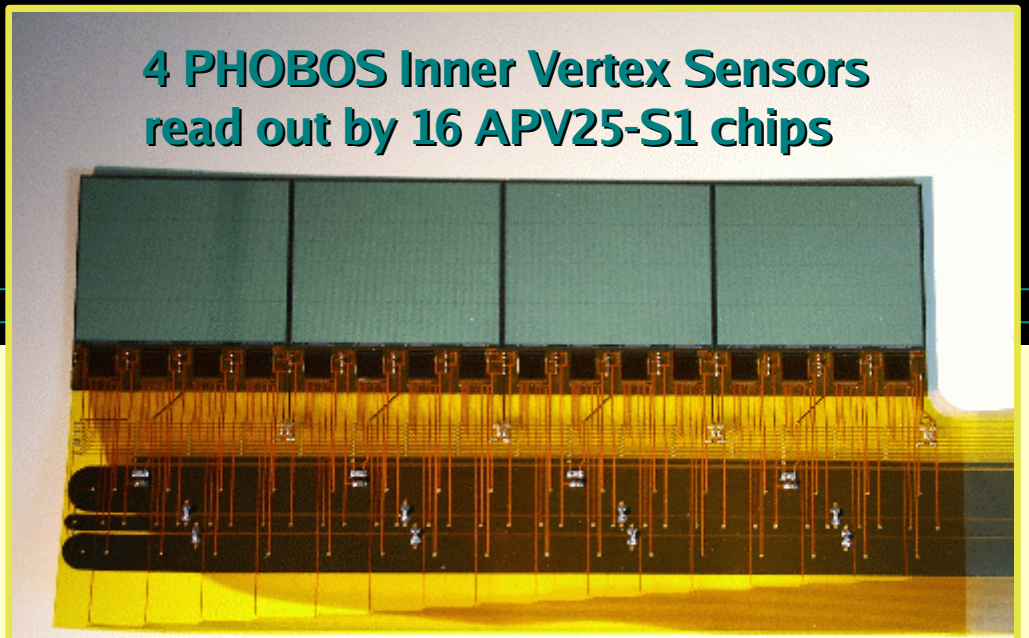
- Pad Size and Pitch
- Size 136 x 58um
- Pitch 44um



~75,000 used in CMS tracker

IST Hybrid





Prototype Hybrid

Full ladder hybrid (50cm long)
6 sensors
4x12 APV25-S1 chips

IST Request for Quotation I

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Request For Preliminary Quotation.
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We would appreciate it if you could give us separate preliminary quotations
on the following items:

        8  prototype  silicon pad sensors
        192 production silicon pad sensors


The geometry of the sensor is defined in the attached drawings:

        HamamatsuDesign_13May2010_GIF.gif
        HamamatsuDesign_Detail_14May2010_GIF.gif
        HamamatsuDesign_Detail_Middle_Pads_02Jun2010_GIF.gif


(Note: Although both dimensions and strip counts for the sensor are
            pretty much fixed there could still be some small changes
            when fine tuning the designs. We definitely will have to add
            some aligning markers in Metal-2 still. These could be
            separate markers or be incorporated in existing structures
            like the guard ring(s).)
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IST Request for Quotation II

We would like to propose the following specifications:

1) high resistivity silicon (>= 4 kOhm.cm)
2) float zone
3) <111> or <100> crystal
4) thickness 325um +- 15um
5) thickness uniformity 10um max
6) detector flatness +-30um
7) 2.0 +- 0.5 MOhm polysilicon biasing resistors
8) AC coupled with coupling capacitance > 100 pF/mm^2
9) all metal >= 1.5um
10) leakage current at full depletion at 21 degrees Celsius ~ 50nA/cm^2
11) coupling capacitor >= 200 Volt breakdown voltage
12) radiation hard
13) < 1% broken channels, randomly distributed
14) cutting accuracy +- 10um with respect to the nominal dicing line

Note A: Please specify the expected breakdown voltage of the sensors.

Note B: We would like to minimize the inactive area of this sensor.
Could you please specify the width of a mnimized guard ring structure
that you still feel comfortable with.

Note C: Please specify the Metal-2 line widths and distances.

Note D: Please specify delivery times after receiving the order.

IST Hamamatsu specs I

1) high resistivity silicon (>= 4 kOhm.cm)
   Judging from the wafer procurement, it should be >=3.5k ohm. Please confirm.

2) float zone

3) <111> or <100> crystal ===> <100>

4) thickness 325um +- 15um ===> It should be 320um+/-15.

5) thickness uniformity 10um max

6) detector flatness +-30um ===> The flatness should be 100um

7) 2.0 +- 0.5 MOhm polysilicon biasing resistors

8) AC coupled with coupling capacitance > 100 pF/mm^2

9) all metal >= 1.5um ===> Both 2 metal is 0.6um thickness.

10) leakage current at full depletion at 21 degrees Celsius ~ 50nA/cm^2

11) coupling capacitor >= 200 Volt breakdown voltage

12) radiation hard
    We will use the process which has experience for high energy physics application. But we can't evaluate it at our side.

13) < 1% broken channels, randomly distributed

14) cutting accuracy +- 10um with respect to the nominal dicing line
    Although the actual value seems to be less than 10um, what we can specify is +/-20um.

IST Hamamatsu specs II

Note A: Please specify the expected breakdown voltage of the sensors.
We basically guarantee upto 200V in the case of standard design. If the customer request over 200V, please let us know the requested Vb.

Note B: We would like to minimize the inactive area of this sensor. Could you please specify the width of a minimized guard ring structure that you still feel comfortable with.
The size of inactive area is depending on the design of the requested breakdown voltage. In the case of standard design, the width of inactive area is 750um each side.

Note C: Please specify the Metal-2 line widths and distances.
Width and distance is 8um minimum.

Note D: Please specify delivery times after receiving the order.
We need 2 months for design. It takes 5 months after receiving the approval of the design.

7 months + Our approval time

IST Hamamatsu Preliminary Quotation

Hi Gerrit,

It is good to hear all of the proposed specs are acceptable.
Pricing for this detector is as mentioned below.
Regarding payment, we typically invoice the completed
parts as they are shipped from NJ (net 30 days).
As for the NRE fee I am checking with the factory
when that portion of the order would need to be paid.

When first shipment arrives

As for your comments regarding lead time,
I am asking the factory if they think they can improve
the lead time to meet your schedule and I will let
you know there comments asap.

Nope

NRE fee: $67,500.00
6-8 pcs.: $5,475.00 ea.
192 pcs.: $1,742.00 ea.

$43,800 + $67,500 = $111,300

Please let me know if you need an official quote.

Requested Jan. 17, waiting.....

Best regards,
Norm

Norm Schiller
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