



# SuperB SVT

## Update on sensor and fanout design in Trieste

Irina Rashevskaya, Lorenzo Vitale, Carlo Stella, Luciano Bosisio

Erik Vallazza, Michela Prest\*

INFN-Trieste e Università di Trieste

\* INFN-Milano e Università dell'Insubria



## Update on activities in Trieste

- Microstrip Sensor design for Layers 1 - 5
  - Definition of ladder composition, sensor models and dimensions, strip pitches
- z-side Fanout design for Layers 1 - 5
  - Evaluation of strip connection schemes (ganging/pairing)
  - Definition of fanout technology
  - Preliminary fabrication tests
- Not covered here:
  - Analysis of 2011 Beam-Test data
  - Evaluation of background from  $e^+e^-$  pairs (Carlo Stella)



## Layer 1-5 - Sensor dimensions

- We assume the layer dimensions given by Filippo
  - the  $r$ - $\phi$  cross-section remains the same as in BaBar
  - the length of the barrels is increased by a factor of  $\sim 1.5$
  - the wedge sensors retain the same size as in BaBar
- We minimize the number of sensors in each ladder, with the following constraints:
  - a) 8 different sensor models, fitting within a 150 mm wafer (a dedicated sensor for each barrel ladder type, plus the wedge sensor)
  - b) Even number of sensors in each ladder, allowing symmetric forward-backward readout



# Sensor geometry table in the TDR

Physical dimensions, number of strips and pitches for the nine different sensor models.

Sensor Type	0	I	II	III	IVa	IVb	Va	Vb	VI
Dimensions (mm)									
$z$ Length (L)	104.0	111.7	66.5	96.4	114.5	119.9	102.2	106.0	68.0
$\phi$ Width (W)	13.9	41.3	49.4	71.5	52.8	52.8	52.8	52.8	52.8-43.3
Thickness	0.20	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
PN junction side reads	$u$	$z$	$z$	$\phi$	$\phi$	$\phi$	$\phi$	$\phi$	$\phi$
Strip Pitch ( $\mu\text{m}$ )									
$z$ ( $u$ for Layer 0)	50	50	50	55	105	105	105	105	105
$\phi$ ( $v$ for Layer 0)	50	50	55	50	50	50	50	50	50 $\rightarrow$ 41
Readout Pitch ( $\mu\text{m}$ )									
$z$ ( $u$ for Layer 0)	50	100	100	110	210	210	210	210	
$\phi$ ( $v$ for Layer 0)	50	50	55	100	100	100	100	100	100 $\rightarrow$ 82
Number of Readout Strips									
$z$ ( $u$ for Layer 0)	1536	1104	651	865	540	565	481	499	318
$\phi$ ( $v$ for Layer 0)	1536	799	874	701	512	512	512	512	512

Active area is:

- 0.7 mm inside the physical sensor area in Ly 1 – 5 (300  $\mu\text{m}$  thick)
- 0.6 mm inside the physical sensor area in Ly 0 (200  $\mu\text{m}$  thick)



# Sensor geometry table in the TDR

Number of the different sensor types per module, and total required number of sensors, including one spare module per module type (two for layer 0).

Sensor Type	0	I	II	III	IVa	IVb	Va	Vb	VI	All
Layer0	1	-	-	-	-	-	-	-	-	1
Layer1	-	2	-	-	-	-	-	-	-	2
Layer2	-	-	4	-	-	-	-	-	-	4
Layer3	-	-	-	4	-	-	-	-	-	4
Layer4a	-	-	-	-	4	-	-	-	2	6
Layer4b	-	-	-	-	-	4	-	-	2	6
Layer5a	-	-	-	-	-	-	6	-	2	8
Layer5b	-	-	-	-	-	-	-	6	2	8
Total	8	12	24	24	32	32	54	54	68	308
Total w/Spare Modules	10	14	28	28	36	36	60	60	76	348

For layers 1 – 5 :

- Total sensor area 1.51 m<sup>2</sup>
- Total number of sensors 300
- Total number of wafers 254 (two wedge sensors can fit in a 150 mm wafer)



## Three options had been considered

Option	Sensors fit within	Nr. of sensor models	Nr. of sensors	Nr. of 150 mm wafers	Nr. of 150 mm mask sets	Nr. of 100 mm wafers	Nr. of 100 mm mask sets
(a)	150 mm Wafers	6	270	236	6		
(b)	150 mm Wafers	8	288	254	8		
(c)	100 mm Wafers	6	432	219	5	432	6

- The cost of the various options is difficult to evaluate.
- We feel that the differences would not be large ( $\pm 15\%$  ?).
- Option (c) on 100 mm wafers is likely the most expensive, on 150 mm wafers the least expensive.
- We think that we should favour the efficiency of testing and assembly, and the performance of the detector (minimize dead regions).  
 $\Rightarrow$  option (a) is preferred, or option (b) if we require a symmetric forward/backward readout.
- The chosen solution is (b).s



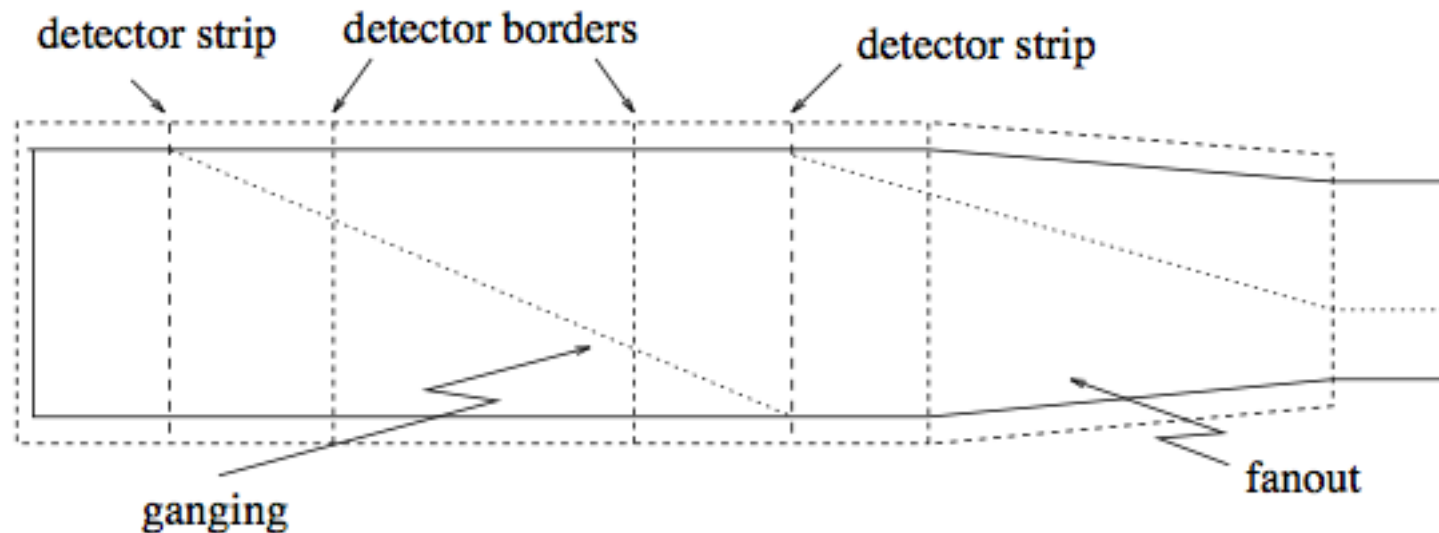
## Sensor Suppliers

- Possible suppliers of double-sided sensors on 150 mm wafers:
  - Micron
    - 200  $\mu\text{m}$  and 300  $\mu\text{m}$  thickness OK
    - 5 mm minimum clearance from wafer edge
  - Sintef
    - 300  $\mu\text{m}$  thickness only
    - 8 mm minimum clearance from wafer edge
  - Hamamatsu
    - 320  $\mu\text{m}$  minimum thickness
    - 5 mm minimum clearance from wafer edge
  - CiS (Erfurt, D) presently only 100 mm, 150 mm within 2013 (?)
  - FBK-irst (Trento) presently only 100 mm, 150 mm within 2014 (?)
  - E2V (UK) is evaluating the possibility to fabricate DSSD.



## z-side readout: ganging of strips

- Number of readout strips exceeds the available amplifier channels => at least a part of the readout channels must be connected to more than one strip.
- In BaBar we choose to gang together two *far apart* strips:



- In the SuperB SVT the increased length of the modules will force us to gang together up to three strips in Ly 4 & 5, with a further increase in capacitance and noise.



## An alternative option: 'pairing' of strips

- At small theta angles (large incidence angles) the track traverses several z-strips (up to 9 in the inner layers!) and the signal becomes proportional to the strip pitch.
- This suggests to bond two or more *adjacent* strips to a single fanout trace, effectively increasing the strip pitch and the signal into a readout channel, with only a modest increase in capacitance.
- This gives better S/N and efficiency at small theta angles compared to non-paired strips. The improvement is more important when compared to ganging, for which the strip capacitance is proportional to the number of strips ganged together. Moreover, in the pairing scheme the fanout capacitance too is lower, because of the doubled trace pitch.
- In addition, at small theta angles pairing is not expected to have a significant impact on spatial resolution.

## Next steps

- An evaluation of strip pitches and ganging/pairing schemes for the various layers is ongoing.
- We plan to measure the capacitance of different pairing configurations on a BaBar Model II sensor.
- The final design should be based on a realistic evaluation of S/N and spatial resolution, obtained through an *ad hoc* MC simulation of the detector response.



## Fanout prototyping for Layers 1-5

- The plan is to produce the SVT fanouts at the CERN PCB workshop, with a similar technology as for BaBar, but with lower costs, higher turnaround, better yield.
- Automatic optical inspection (detecting opens and shorts) will be made by CERN before delivery. No electrical test is foreseen.
- A first sample has been fabricated using a BaBar layout, in order to check the technology.
- A macro for the automatic layout generation of the new Ly 4-5 fanouts has been prepared.
- Minimum trace pitch is  $\sim 40 \mu\text{m}$ , with minimum gap of  $15 \mu\text{m}$ .



# Backup Slides



# Sensors fitting on 150 mm wafers

## *Eigth different sensor models*

Sensors fitting on 150 mm wafers -- 8 different models												
Layer	Nr. of Ladders	Sensor width W	Target Barrel Length	Model	Sensors per Ladder	Sensor length L	Clearance to wafer edge	Obtained Barrel Length	Barrel Length Difference	Model	Nr. of Sensors	Sensor Area
		(mm)	(mm)			(mm)	(mm)	(mm)	(mm)			(m <sup>2</sup> )
1	6	41.3	214.78	I	2	107.39	17.5	214.78	0.00	I	12	0.053
2	6	49.4	262.78	II	2	131.39	4.8	262.78	0.00	II	12	0.078
3	6	71.5	385.70	III	4	96.43	15.0	385.70	0.00	III	24	0.165
4a	8	52.8	457.95	IV a	4	114.49	12.0	457.95	0.00	IV a	32	0.193
4b	8	52.8	479.42	IV b	4	119.86	9.5	479.42	0.00	IV b	32	0.203
5a	9	52.8	613.04	V a	6	102.17	17.5	613.04	0.00	V a	54	0.291
5b	9	52.8	635.84	V b	6	105.97	15.8	635.84	0.00	V b	54	0.302
Each barrel layer has its own dedicated sensor										VI	68	0.222
<ul style="list-style-type: none"> <li>even number of sensors in each ladder (=&gt; symmetric forward/backward readout possible).</li> </ul>										All	288	1.508
<ul style="list-style-type: none"> <li>254 wafers (150 mm)</li> <li>8 mask sets</li> </ul>										Nr. of wafers	254	

