Silicon Vertex Tracker

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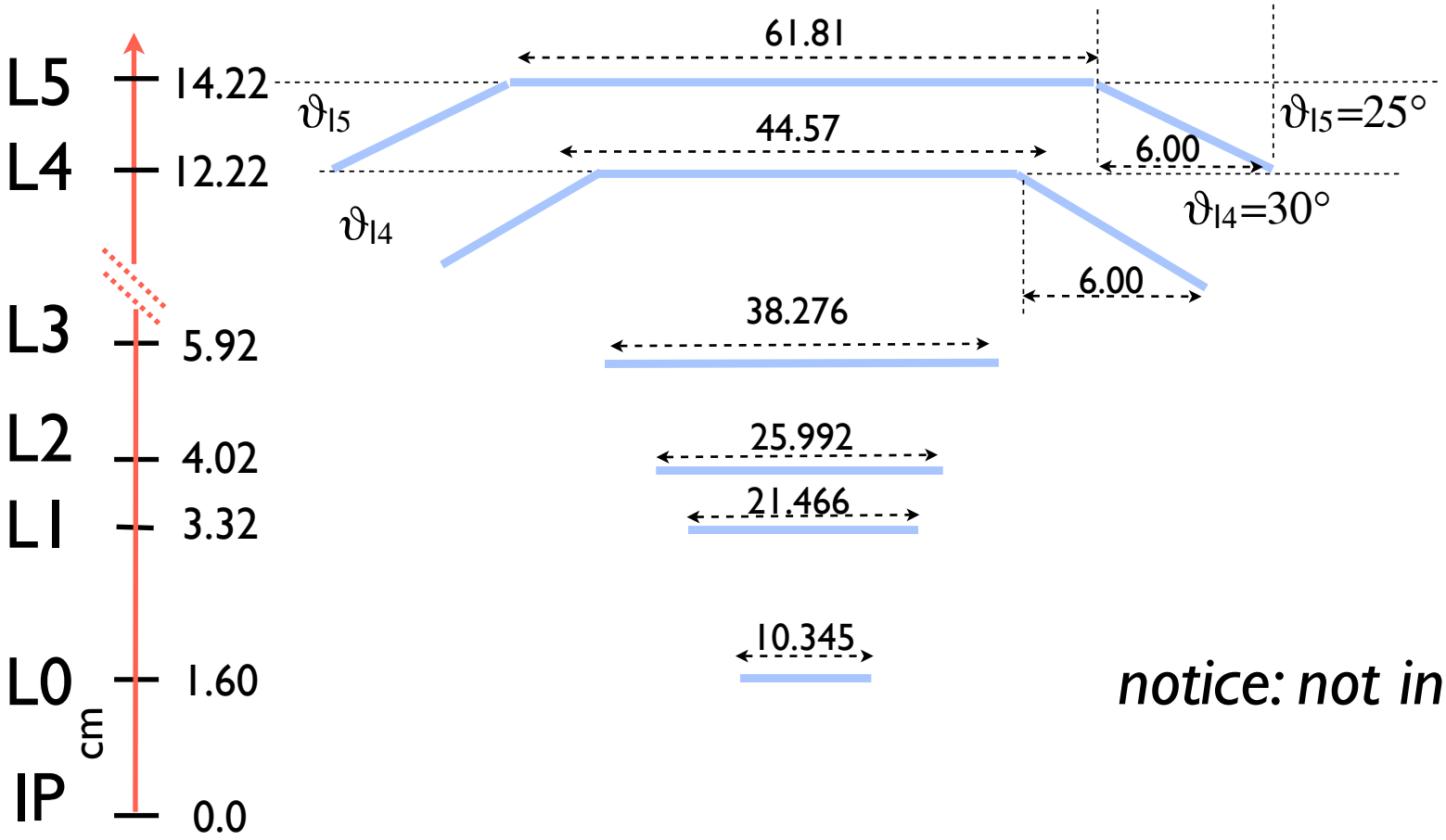
Outline

- Introduction
- Update on L_0 strategy
- Bkg and performance studies
- Summary of SVT parallel sessions

1. SuperB baseline:

- SVT baseline: L0 + L1-L5 (300 μm) strip detectors, ±300 mrad angular coverage in Lab frame;
- additional L_0 required for maintaining adequate proper time resolution for B^0 time-dependent measurements.



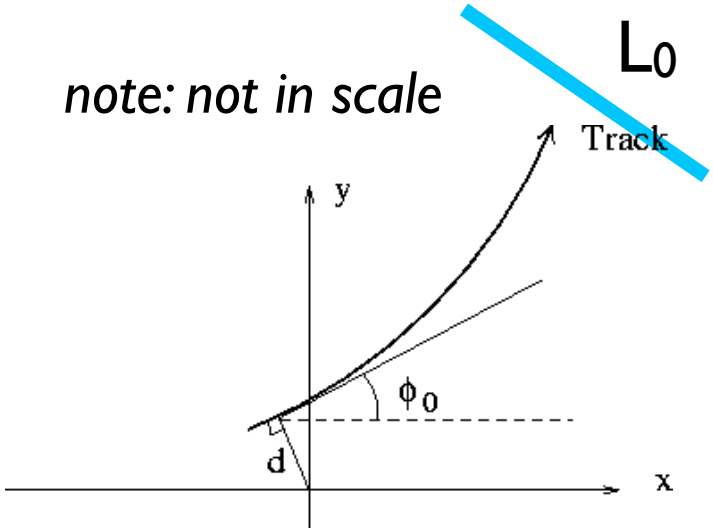
Coverage down to 300 mrad FW and BW

L_0 requirements

- L_0 requirements (some numbers):
  - capable to operate close to the IP (1.5-2.0 cm);
  - low material budget (<1% X_0);
  - good signal over noise (>20);
  - high efficiency (> 95%)
  - hit resolution (<15 mum)
  - radiation hardness (>10 MRad);

$$\sigma_{m.s.}(d) \propto r_{L_0} \cdot \frac{\sqrt{x/X_0}}{\beta c p}$$

d = track impact parameter
x/X_0 = tot. radial material at L_0
m.s. = multiple scattering



L_0 possible options

technology	material X_0 (%)	signal/noise	efficiency	hit rate capability
striplets	~0.4%	>20	99%	<100MHz/cm^2
Hybrid Pixel	~1.0%	>>20	99%	>100MHz/cm^2
Maps	~0.4%	>20	90-95%	>100MHz/cm^2

Depending on bkg level, detector occupancy might be an issue for striplets. Hybrid Pixel and Maps are more robust due to the higher detector granularity.
High occupancy can degrade efficiency and hit resolution.

from Giuliana Rizzo talk

Layer0 options vs background

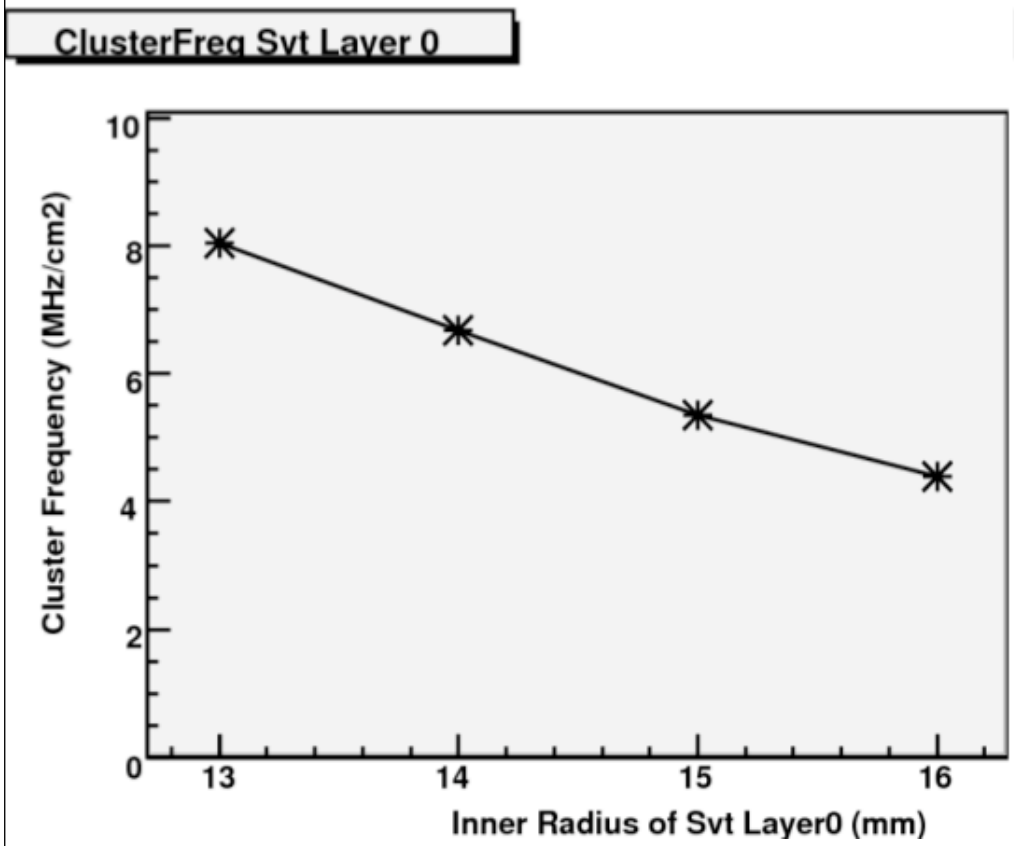
- In CDR background track rate ~5 MHz/cm2 (was not final, cluster multiplicity not included) + safety → hit rate ~ 50 MHz/cm2:
  - Striplets viable solution, MAPS pixel option under development.
- Since then background rate raised significantly (full simulation, more sources…) → striplets no longer considered robust enough!
- End of 2008 (approval of TDR project) R&D on MAPS was promising but not mature for TDR timescale (2010)

  → hybrid pixel baseline option (accelerate R&D to reduce pitch and material for support and cooling)
- Nov 2009: after SLAC (where back. was really too much even for pixel, due to a bug discovered recently) the expected track rate back to ~ 4 MHz/cm2 (R = 1.6 cm) but further checks on cluster multiplicity gives significantly higher hit rate ~10-40 MHz/cm2 (still x 5 safety to be included!)
  - While the background was on the low side we started to reavaluate the striplets option

Bkg studies

Riccardo Cenci

New results after bug fix: B field was not activated in beampipe region.
Dominating source of bkg for L_0 is $e^+ e^- \rightarrow e^+ e^- e^+ e^-$ process.

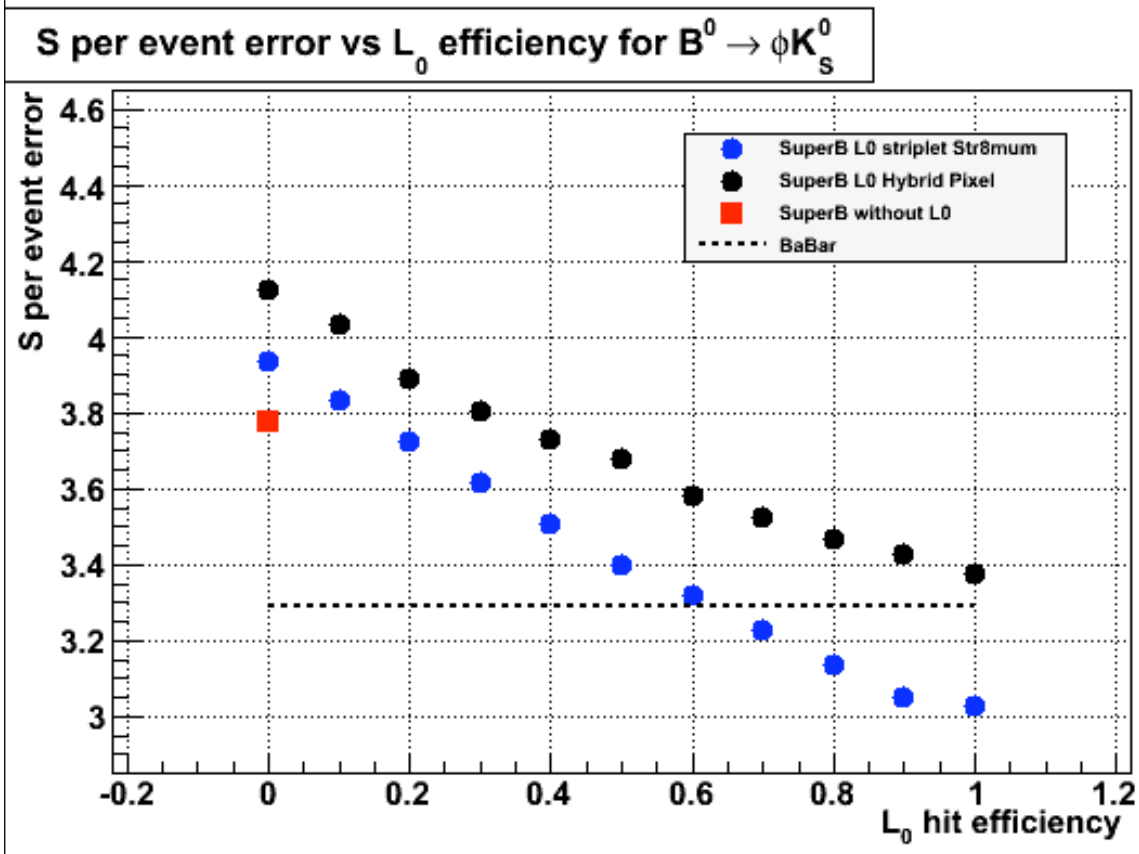


- Hit rate = cluster rate × cluster multiplicity.
- Cluster multiplicity depends on L_0 solution: e.g. thickness of active sensor, charge sharing among pixel (strips), discriminator threshold.
- Work in progress to determine this number for different L_0 solutions.
- Preliminary results suggest cluster multiplicity could be a relevant factor.

Cluster/hit rate is reducing going far from IP. It needs to be studied at larger L_0 radius.

Physics studies

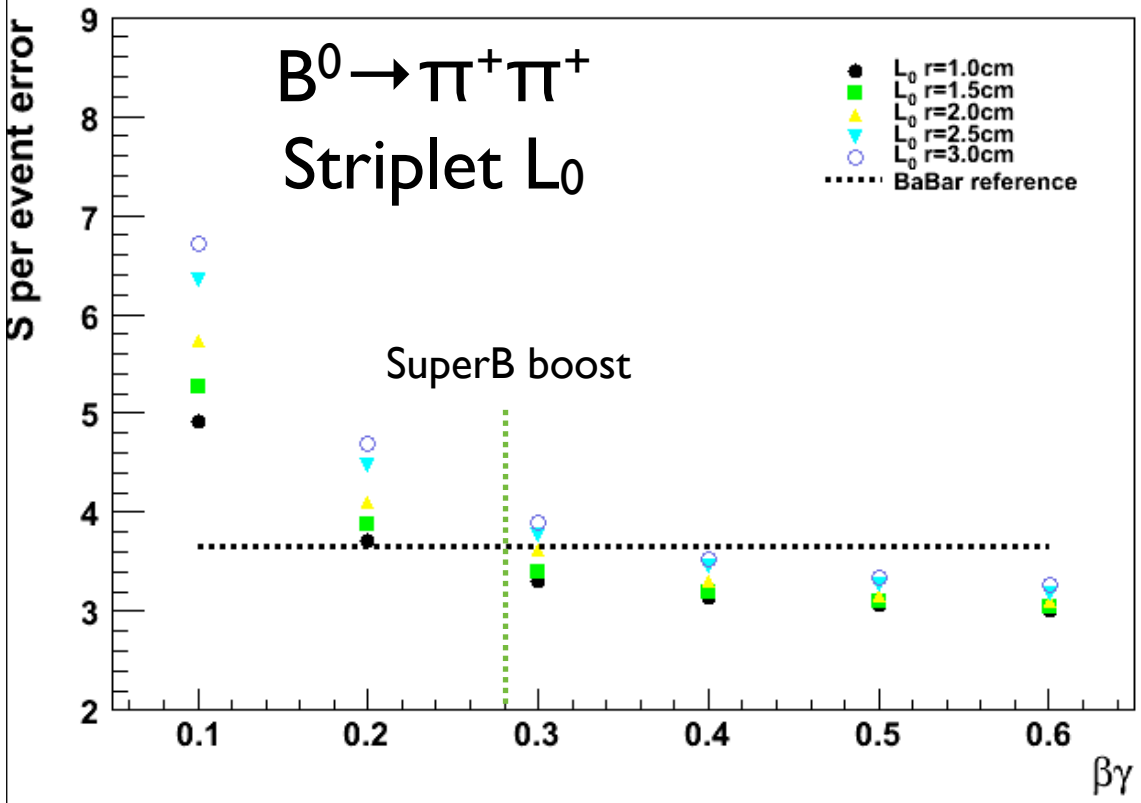
N.N.



- L_0 radius = 1.60 cm and $\beta\gamma$=0.28.
- Sensitivity study for S (sin2β) shows better performance for striplets wrt hybrid pixel due to lower material budget, i.e. reduced multiple scattering effect on charged tracks.
- Striplets can afford reduced efficiency while maintaining good S sensitivity compared to BaBar reference.

Physics studies

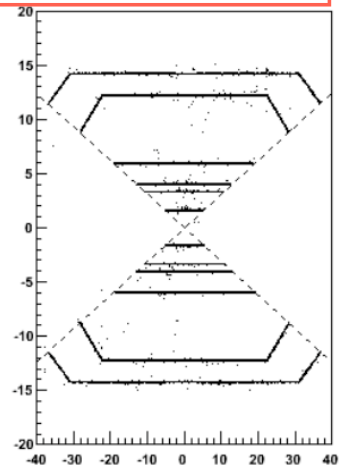
N.N.



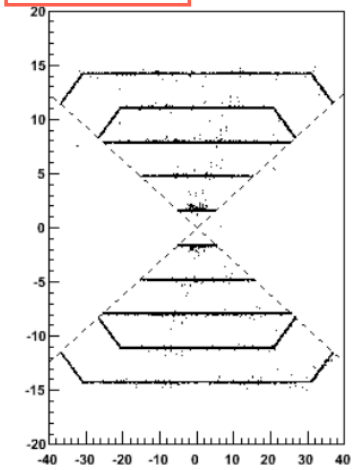
- L_0 striplet solution offers some margins, in terms of radial distance from the IP, to use if hit rate level at 1.6 cm radius needs to be reduced; true down to a boost of ~0.28
- L_0 at 2.0 cm gives comparable performances for S sensitivity wrt BaBar reference.
- Bkg hit rate at 2.0 cm needs to be studied. If it reduces by a factor ~2 wrt 1.6 cm bkg rate, it is sustainable for striplet solution (including x5 safety factor).

External layer configuration

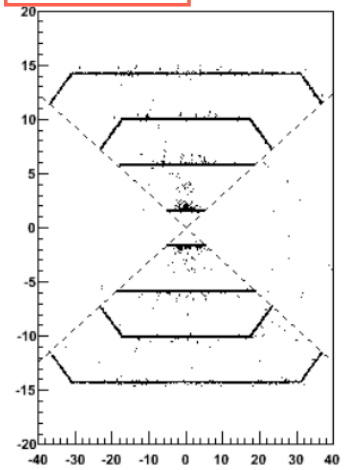
6 layers: nominal



5 layers

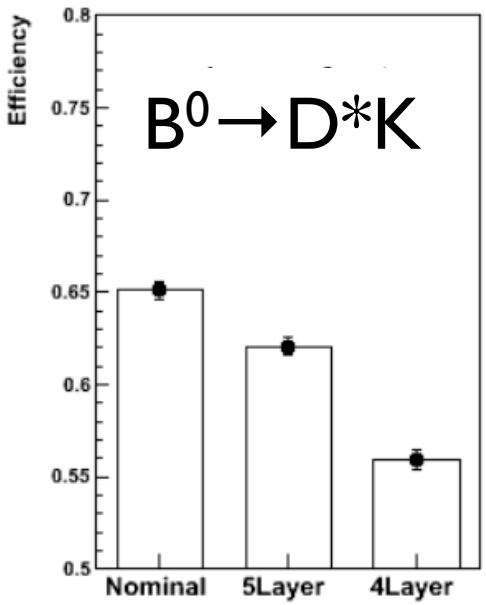


4 layers



J. Walsh

Efficiency: imperfect detector



- Gains in tracking performance in going to 4- or 5-layer device almost negligible.
- Efficiency for tracks and B reconstruction is reduced for the 4- or 5-layer devices.
- It appears that the current 6-Layer design is superior to the alternatives investigated.

Ongoing R&D

FSSR2 chip

- Candidate readout chip for strip and striplet detectors
- R&D just started for optimizing the chip for readout of L_0 (short strips but high bkg rate) and external layers (long strips and higher noise).

FSSR2 optimization

V. Re

External layers (long strips)

- **Better capacitive matching**

Optimize input NMOS gate width W

(FSSR2 was optimized for C_D = 20 pF)

- **Reduce channel thermal noise**

  Increase drain current I_D

  (power dissipation constraints?)

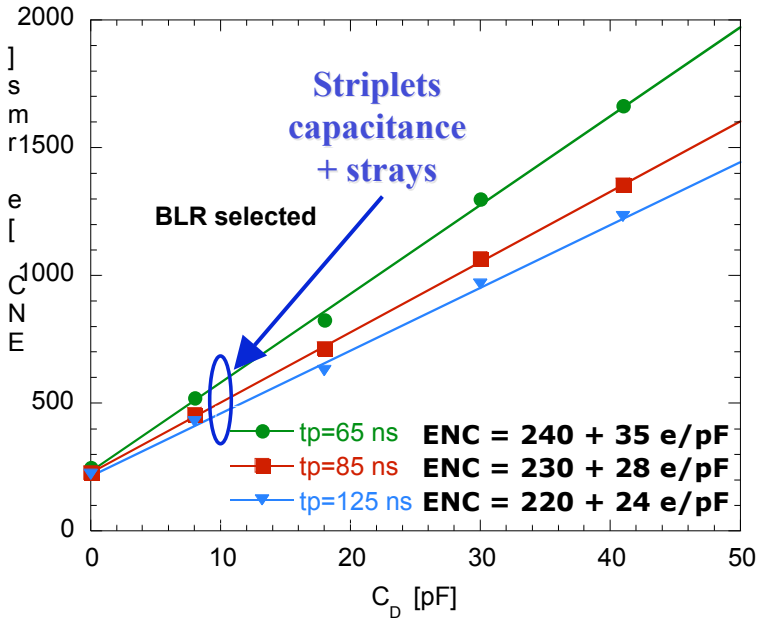
- **Increase signal peaking time t_P**

  (occupancy constraints?)

After a first optimization
S/N = 26 at t_P = 1 μs
looks reasonable

L_0 striplet (high bkg rate)

To handle with background rates, can be necessary to decrease the present FSSR2 peaking time of 65 ns



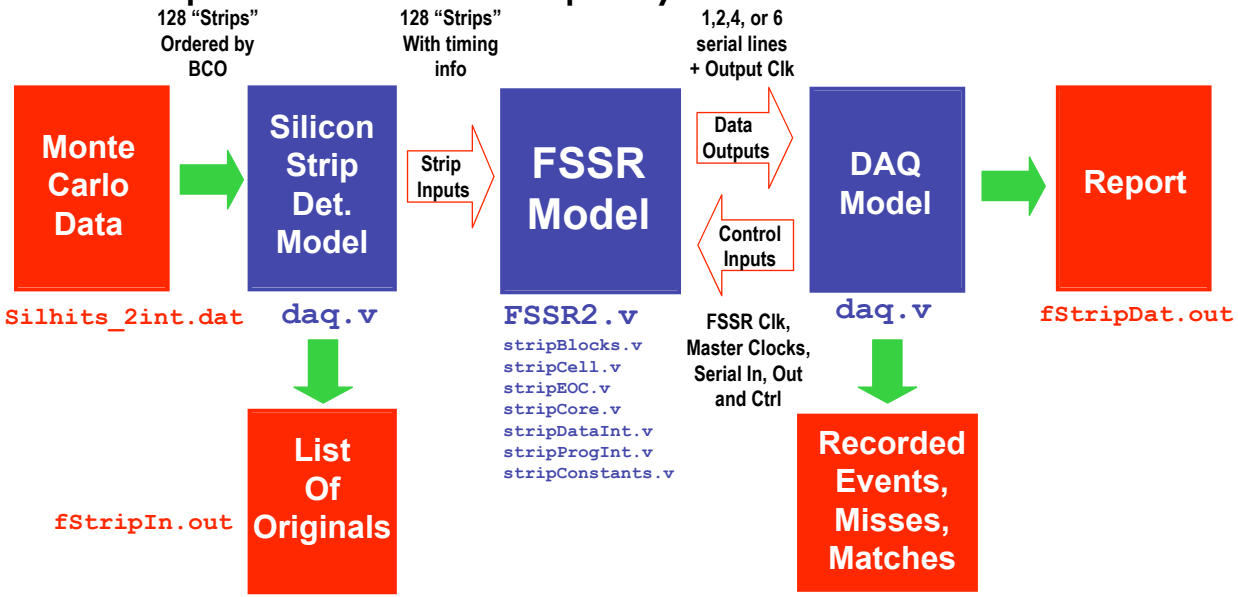
(Si 200 um thick),

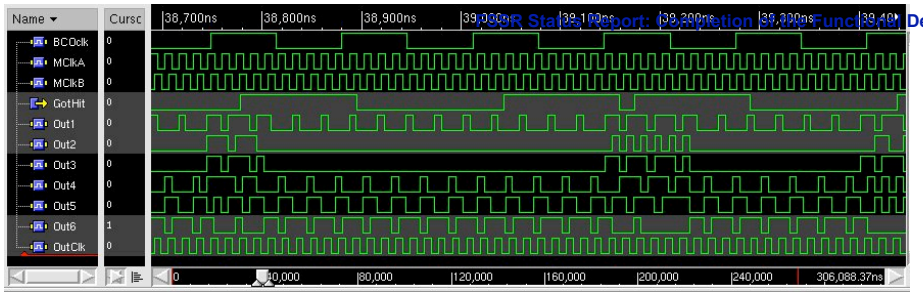
S/N ~ 20 at t_P = 25 ns

FSSR2 readout efficiency

M. Manghisoni

- FSSR2 efficiency with high occupancy might be an issue for L_0 striplets.
- uccessful start of studies, using verilog model, for the efficiency of the readout chip vs detector occupancy.





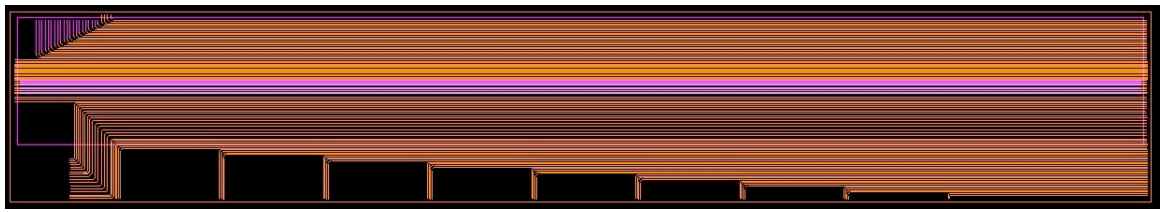
Design Phase Hoff, J.R.; Mekkaoui, A.; Yarema, R.

Very preliminary results
88% efficiency with 3% occupancy
striplets might have ~10% occupancy

Pixel module interface

Mauro Citterio

- Aluminum data bus for MAPS and Hybrid Pixels.



The prototype (1.8 x 11.2 cm) after several delays were delivered last Friday
Visual inspection: quality and uniformity is high, received 20 pieces

CERN Technology Stackup made of: Aluminum, polimide and glue

Various traces on the same structure to compare simulation and actual BUS

To test the technological limits in term of frequency (signal up to 160 MHz, 32bit BUS)

Yellow: injected signal
Green: signal at the receiving end

First test already started:

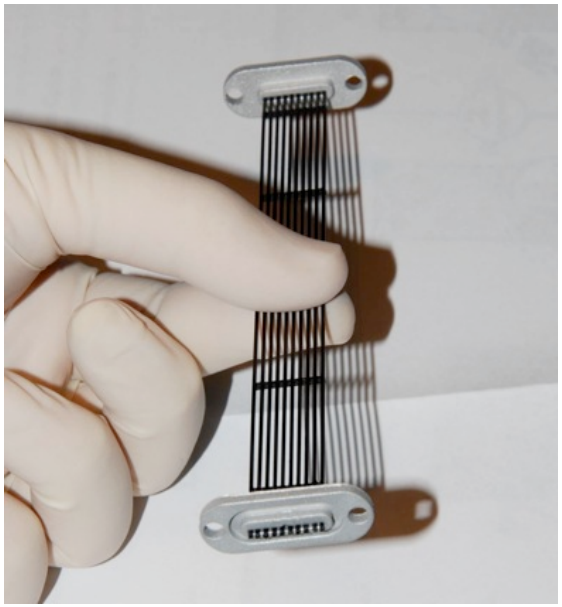
-example of signal integrity measurement;

-first impedance measurements are encouraging.

F. Bosi

Cooling for L_0 & beampipe

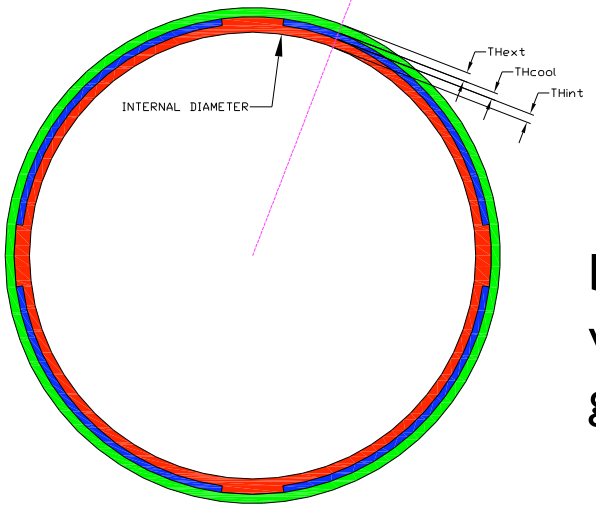
Net Module is a micro-channel support with vacancy of tubes in the structure



First Prototype produced !

X= 0.17 % X_0

Legenda:
Green: External Pipe
Red: Internal Pipe with pillars
Bleu: Micro-channels



beryllium
water
gold

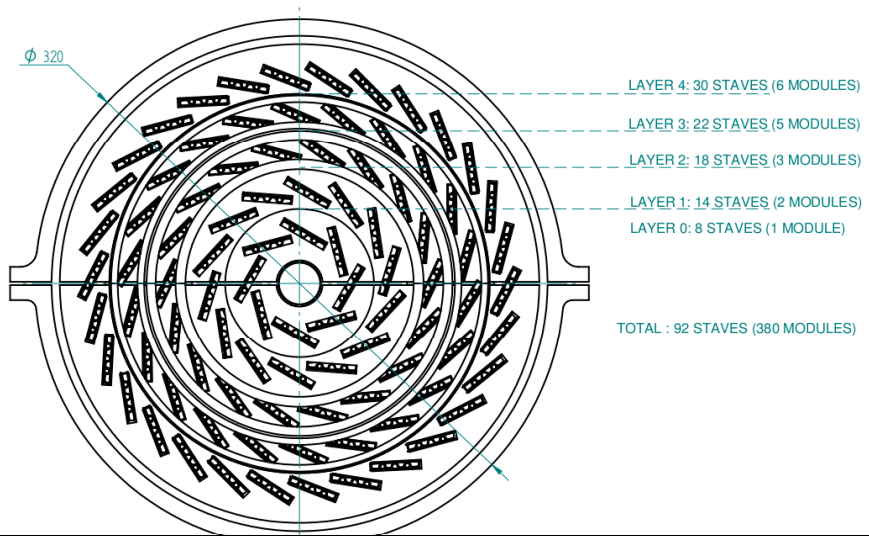
	min	max
% X_0	$0.23 + 0.12 = \mathbf{0.35}$	$0.32 + 0.12 = \mathbf{0.44}$

Consistent with values considered for FastSim

Thermal and mechanical studies are fine.

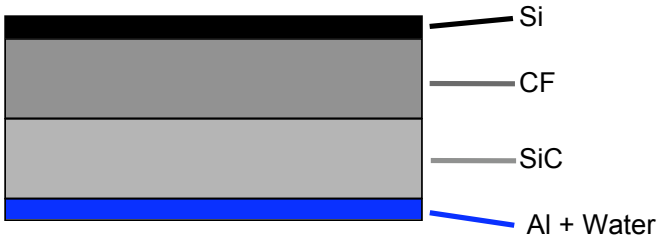
UK proposal for SVT *A. Bevan*

- Very interesting and well advanced MAPS technology from UK (Queen Mary, RAL).
- Presented a new proposal for a complete MAPS based detector. A very conservative and initial estimate of material budget is 1.14% X_0 per layer (strip detectors are 0.5% X_0). It can be reduced.
- Physics studies show comparable proper time resolution to the SuperB configuration with L_0 Hybrid pixel. More general tracking studies are on going also for low momentum particles.



Material	Radiation length, D_0 (mm)	$\%X_0$
CFRP	240	0.730
Al Alloy	89	0.069
SiC FOAM	1000	0.181
Silicon	94	0.053
Coolant (Water)	360	0114
	TOTAL	1.146%

(Material thickness averaged over section of stave)



Conclusions

- Striplet solution for L_0 gives sizable improvements wrt hybrid pixels in terms of vertex resolution and sensitivity in time-dependent (TD) analyses.
- There is margin to move a striplet L_0 detector at larger radius reducing the bkg rate and maintaining comparable performance for TD analyses wrt BaBar.
- Striplet solution can be considered as baseline solution for TDR.
- Intense R&D activity should continue to develop thin pixel (hybrid pixel with reduced material and MAPS).
- Very important to proceed with pixel R&D to be used in a second phase of the experiment when reached nominal or even higher luminosity.
- Interesting new proposal from UK for a complete MAPS SVT detector has been presented and received lots of interest.