Vertex Detector and Tracker Mechanics and Materials

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Outline of Vertex Detector Work for DBD

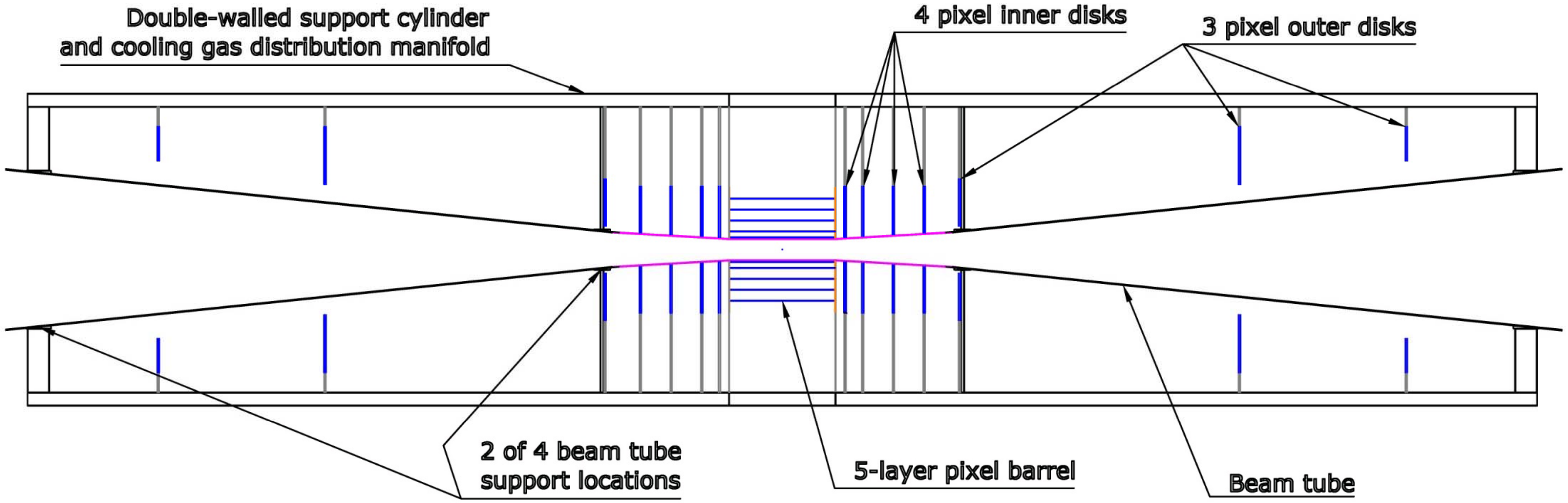
- Sensor R&D
- Power delivery and distribution R&D
  - Test LHC DC-DC converter: January 2010 – September 2010
  - Test serial power scheme: April 2010 – March 2011
  - Design pulsed power system: January 2011 – September 2011
  - Fabricate and test pulsed power system: June 2011 – September 2012
- Support R&D
  - Design, fabricate, and measure test support cylinder
    - October 2010 – March 2011
  - Design, fabricate, and measure module support test structures
    - June 2010 – December 2011
  - Thin ladder R&D
    - Fabricate and measure thin ladders
    - January 2010 – June 2012
  - Alignment monitoring system
    - Fabricate and test alignment monitoring system
    - March 2010 – September 2012

Outline of Tracker Mechanical Work for DBD

- Power delivery and distribution R&D
  - Design pulsed power system: January 2011 – August 2011
  - Determine locations of power conditioners: November 2010 – August 2011
  - Develop air flow paths for cooling the power conditioners: April 2011 – August 2011
  - Fabricate and test an R&D prototype with power sources and air flow: September 2011 – December 2011
- Mechanical Stability
  - Evaluate impact of power cycling: June 2010 – March 2011
  - Test vibrational stability of cylinders and test pulsed power system: April 2011 – August 2011
- Alignment with vertex detector
  - Continue development of FSI: January 2010 – December 2011

Vertex Detector

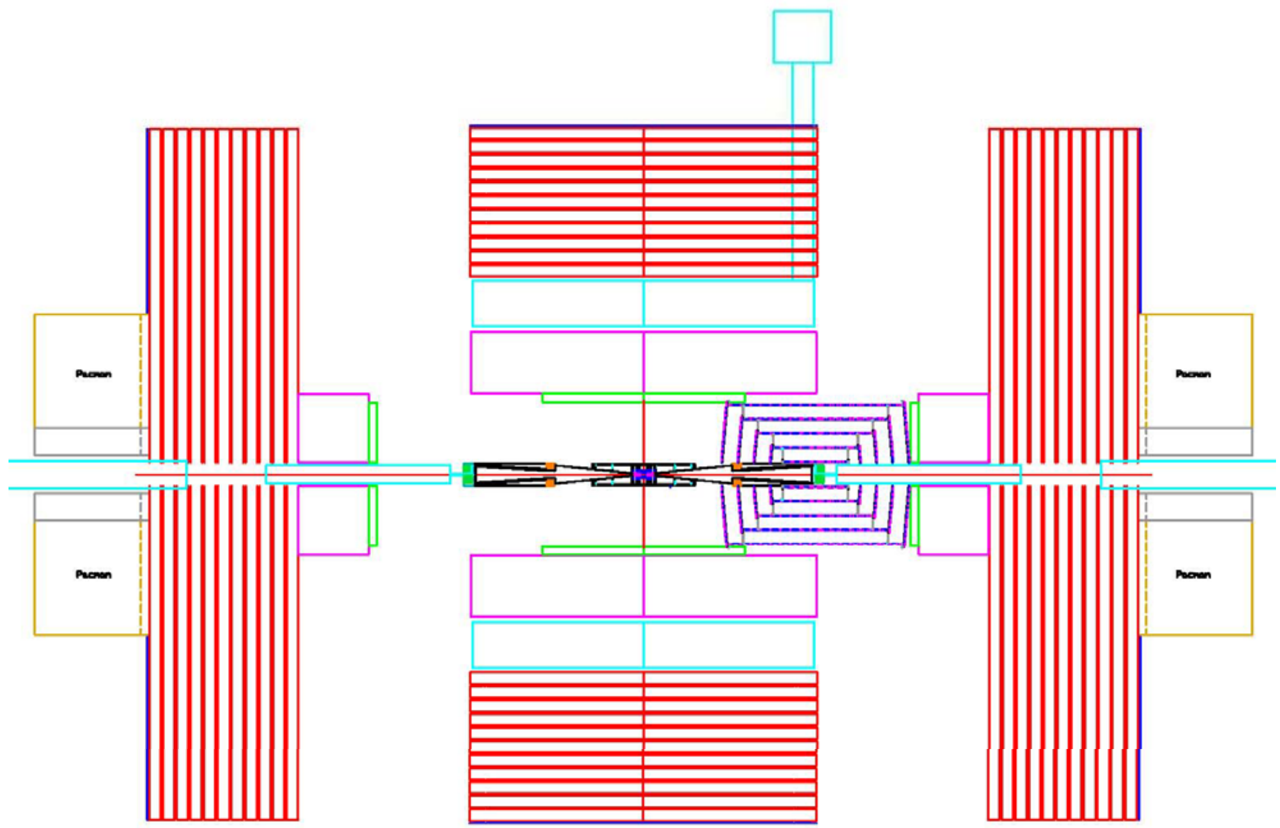
- The present arrangement of the vertex detector is shown below.



- The vertex detector is assumed to be made in top and bottom halves, which are clamped around the beam pipe.
- The vertex detector outer support cylinder maintains beam straightness of the beryllium portion of the beam pipe.

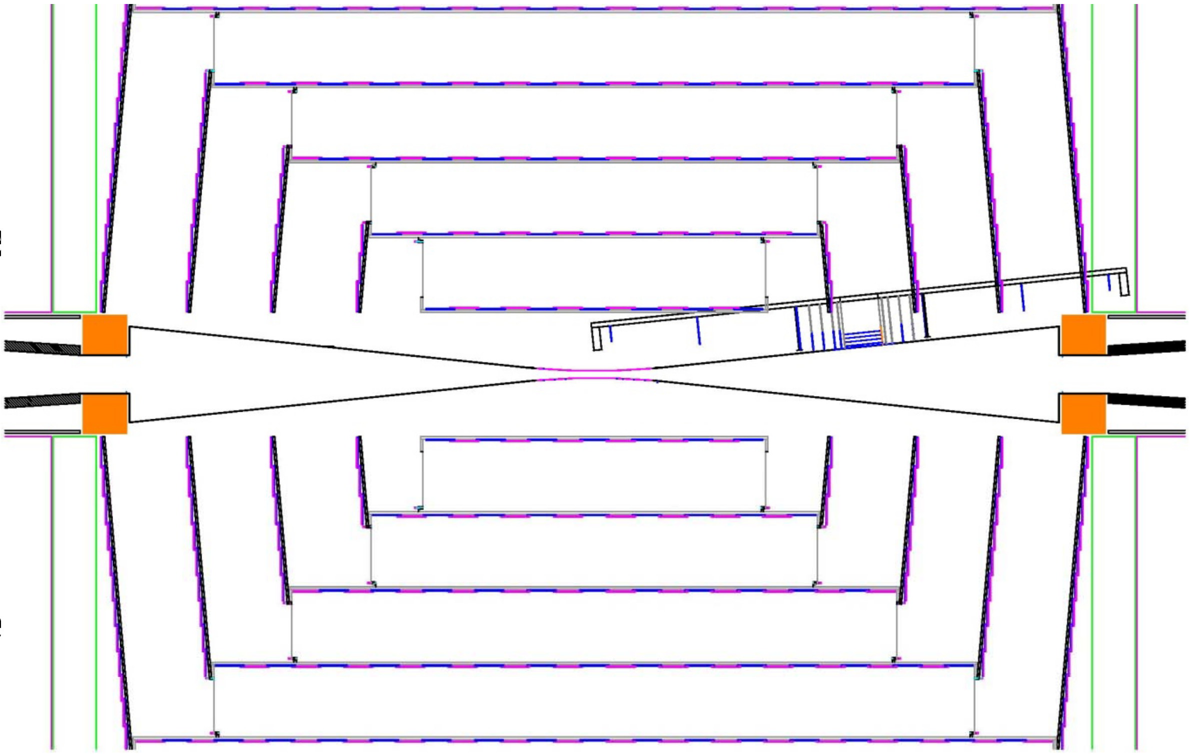
A reminder

- The figure from the LOI associated with vertex detector servicing is shown below.
- The detector would be opened, tracker cables would be removed from one end, and vertex detector cables from one or both ends.
- The vertex detector would then be fully accessible.



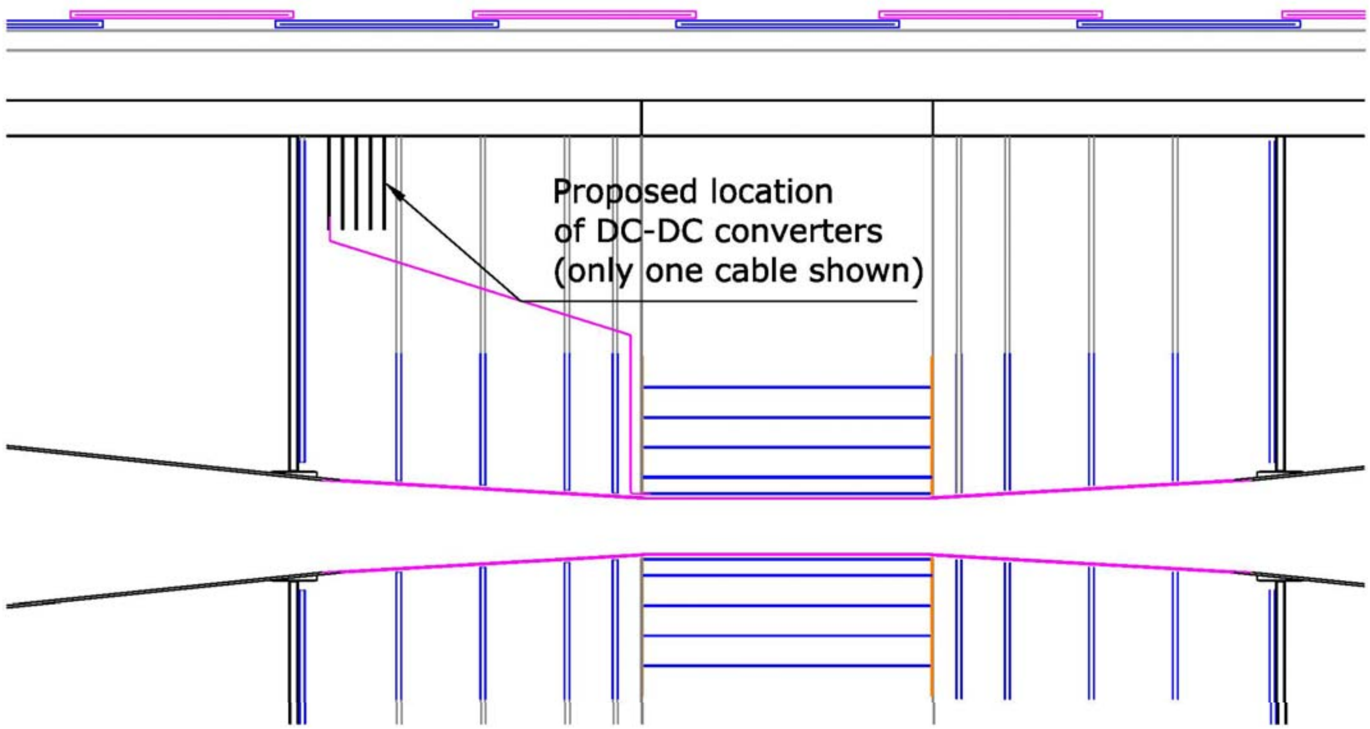
Vertex Detector

- Some time ago, I was asked if installation of the vertex detector could follow the method used by CMS rather than withdrawing the tracker to expose the vertex detector region.
- That doesn't work for SiD.
- It might be possible for CLIC, provided constraints on tracker and vertex detector geometry are taken into account.
- Risks are likely to be greater due to limitations in ability to observe and control the vertex detector / beam pipe interface.



Vertex Detector

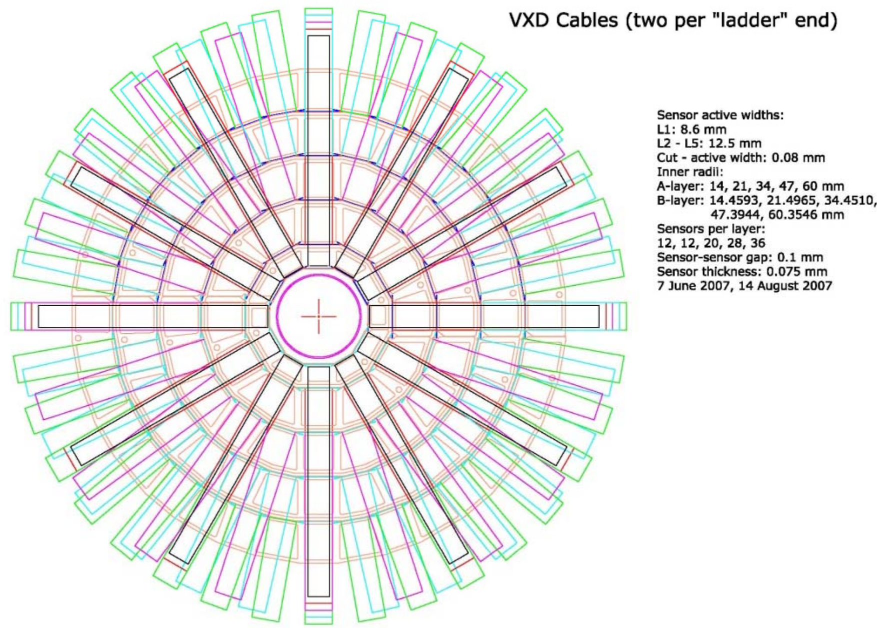
- Cables and power delivery will take substantial effort and testing.



- In the US, Satish Dhawan has made substantial progress on DC-DC conversion (~80% efficiency with commercial parts).
- Some degree of serial powering may also be necessary.

Vertex Detector

- Though cable layouts have been proposed, the cable requirements depend on the sensors.



- Once those requirements are known better, cables can be made and tried.
- Fiber optics are a clear alternative for signals, but cables appear to be necessary for power delivery.
- In principle, cable motion from pulsed power is calculable, but the predictions should be checked.

Vertex Detector “Ladders” and Support

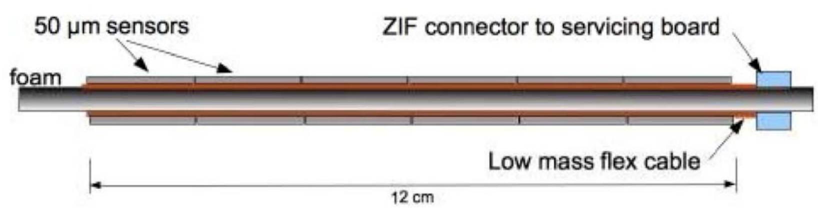
- The development of low-mass structures has been stimulated by the development of specific sensor designs.
- That development will likely continue independent of the ILC and CLIC, but SiD and CLIC should remain sources of motivation.

LCWA 2009,
Rita De Masi

Only a few examples are shown to suggest areas of effort.
My apologies for not including a wider variety of possible examples.

The PLUME project

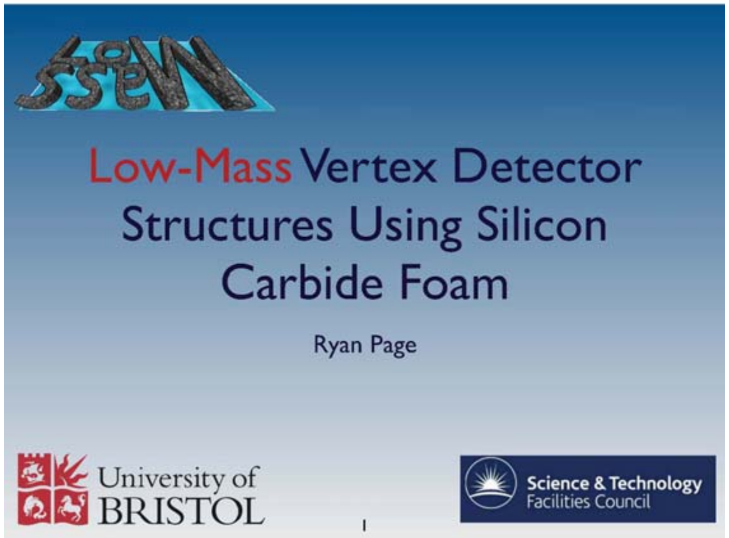
- Pixel Ladder with Ultra-low Material Embedding.
- Double sided ladder equipped with 2x6 M26 (TDR 2012).
- 0.2-0.3 % X_0.
- Explore feasibility, performances and added value of double-sided ladders.
- Allows for improved time resolution (outer layer with larger and fewer pixels).
- First prototype (reduced scale) to be tested in SPS beam next November.
- Full scale prototype expected in 2010.

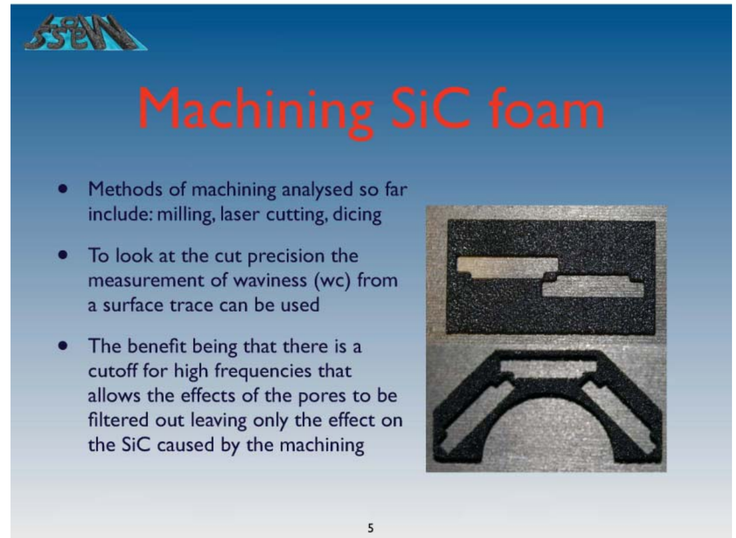


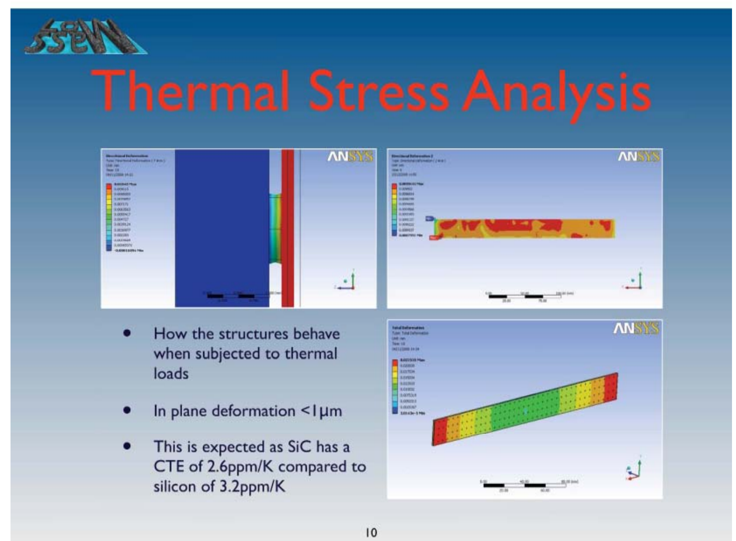
LCWA 2009 9

Vertex Detector “Ladders” and Support

- LCWA2009, Ryan Page

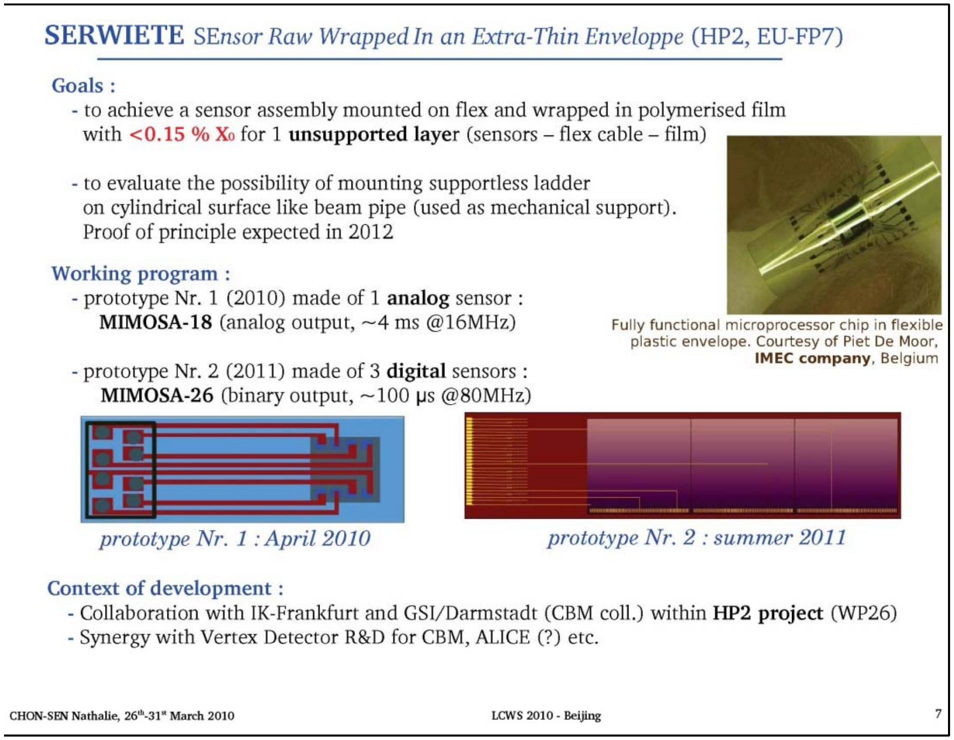


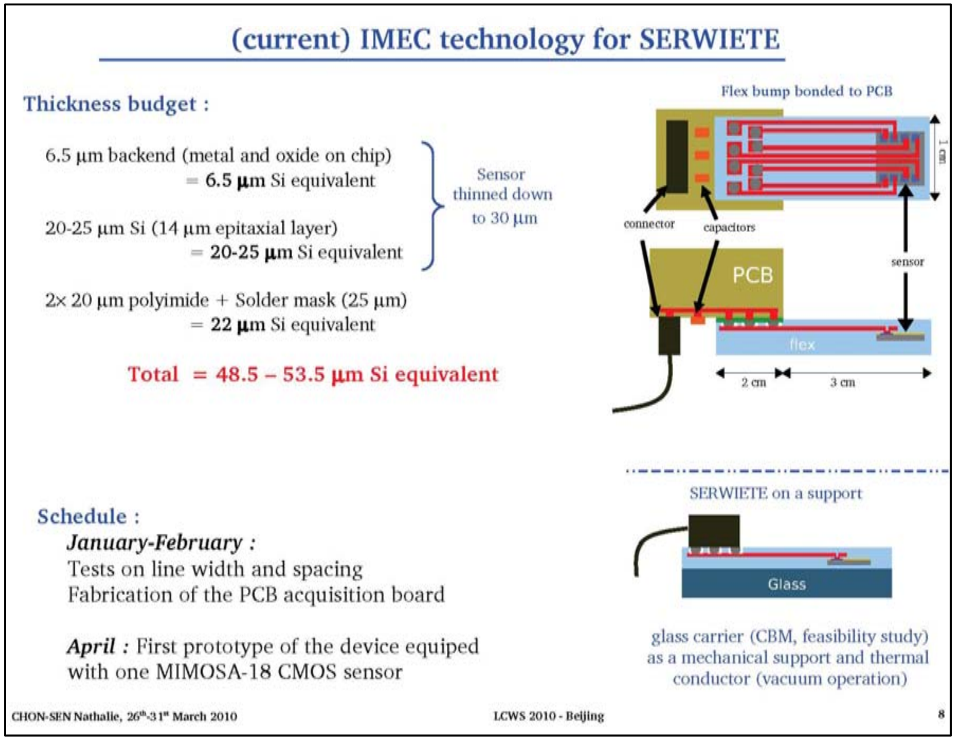




Vertex Detector “Ladders” and Support

- Beijing2010, Nathalie Chon-Sen



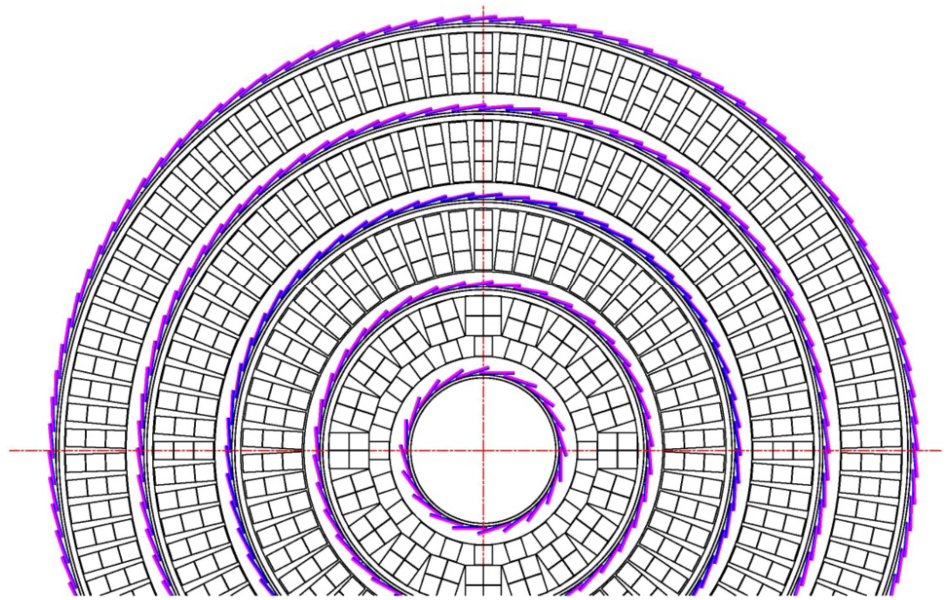


Cooling

- Though not on the list of work proposed for the DBD, both the vertex detector and the outer tracker would benefit from studies to understand cooling gas delivery paths.
- For the vertex detector, some effort should go towards understanding how the gas is delivered at an appropriate, low temperature.
  - That could involve heat exchangers from “liquid” to gas near the ends of the silicon region or within the vertex detector support cylinder.
  - Augmented local cooling may allow a wider range of sensor varieties to be considered.
  - Evaporative CO2 cooling may be appropriate to limit material.
    - That ties to R&D in progress for LHC upgrades and other experiments.

Tracker

- As in the vertex detector, power distribution will need attention.
- The present assumptions are that power conditioning boards would be on the rings which connect barrels to one another and cables would bring power to individual sensor modules.
- The layout below isn't optimized but gives an idea of the space available with 50 wide x 56 mm tall power conditioning cards.
- It assumes that conditioners for a barrels 2-5 are inboard of their respective barrels and conditioners for barrel 1 are outboard of barrel 1.
- Power conditioning for disks will also be needed.
- We should include an update on tracker modules and their mounting.

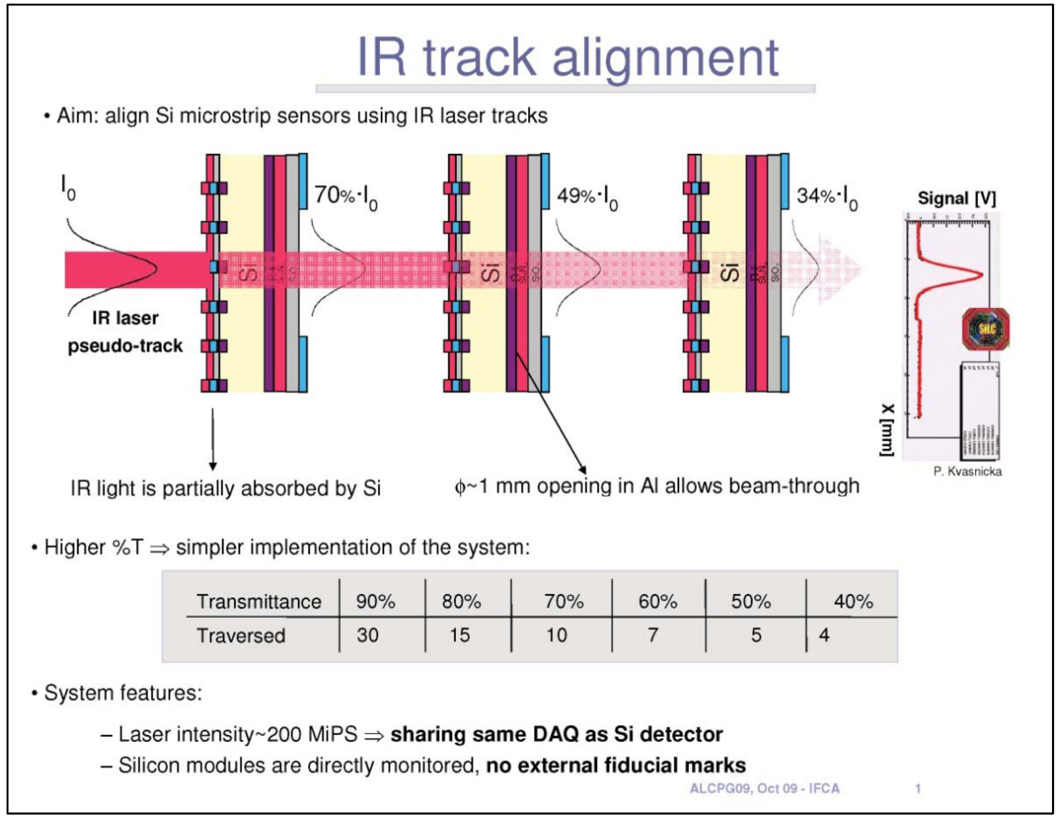


Vibration

- It is better to measure to measure vibrations of cables and support structures due to power pulsing and other mechanisms rather than try to calculate them.
- A suitable magnet and support structures are needed.
- We had hoped to fabricate a vertex detector outer support cylinder and at least one tracker barrel support cylinder.
- Fabricating a vertex detector support cylinder seems realistic in the not too distant future.
  - Cylinder dimensions wouldn't be exactly those assumed in the design, but would approximate them well enough for stiffness and vibration studies.
  - Gas flow and distribution via the support cylinder could also be checked.
  - The vertex detector support cylinder would serve as a test of the support cylinders for the outer tracker barrels.

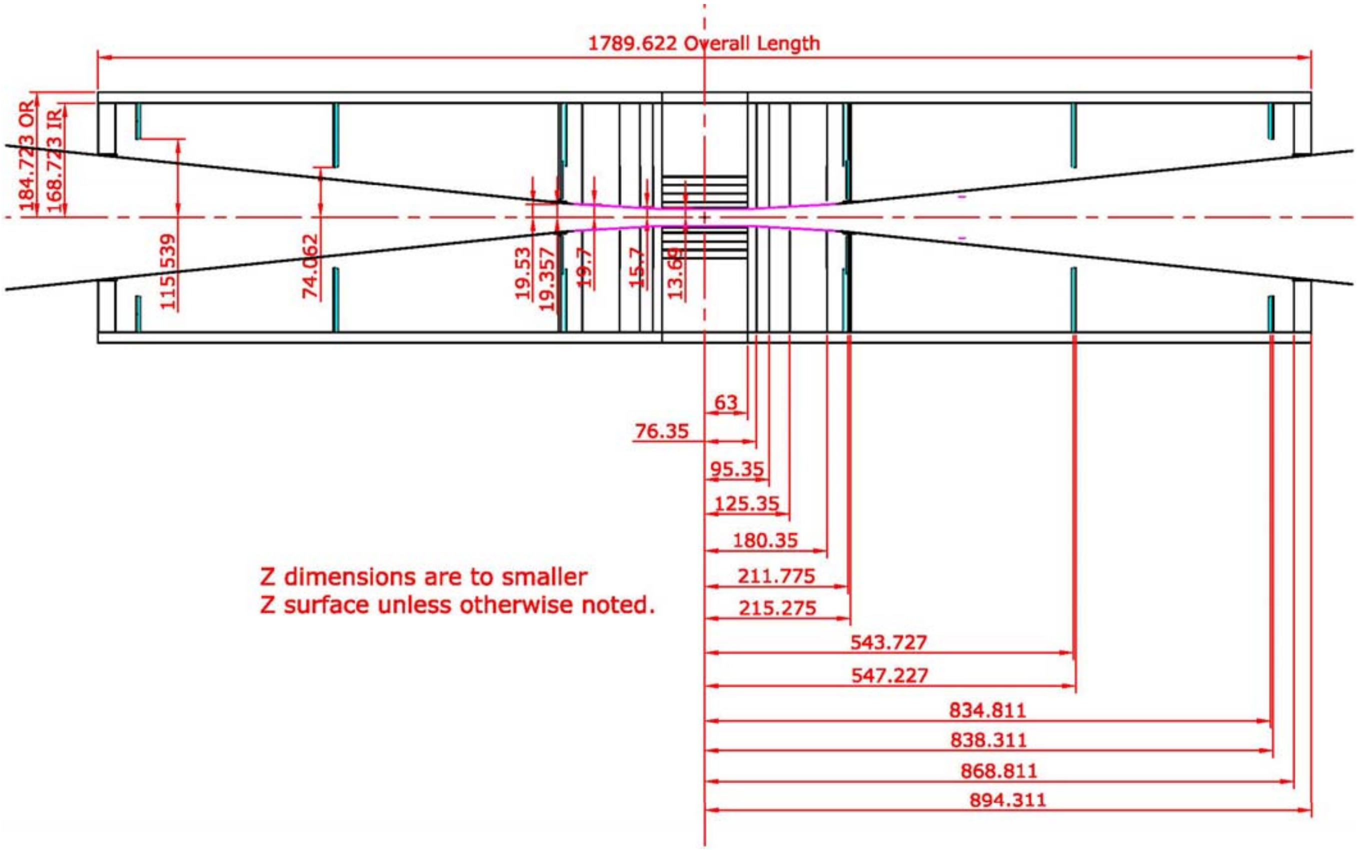
Measurement Methods

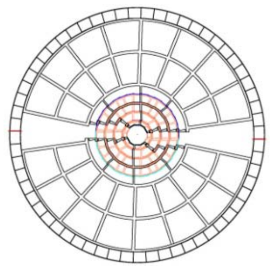
- We've been counting on FSI (as developed by Keith Riles, U. of Michigan) as a tool to measure vibrations and monitor alignment.
  - Renewed support for Keith's work would be important.
- Another approach to alignment monitoring has been under development by Alberto Ruiz Jimano and colleagues.
- It depends on shining a laser through overlapping sensor regions which are free of metallization.



Vertex Detector Support Cylinder

- Drawings have been ready since spring 2008.
  - Recently updated for current beam pipe geometry





Material Properties

- Measurements of carbon fiber electrical conductivity were begun early this year in conjunction with CMS tracker upgrade needs.
- Similarly, measurements of carbon fiber thermal conductivity are beginning.
- Both sets of properties are affected by the carbon fiber ply lay-up.
- In principle, measurements are available with a quasi-isotropic lay-up, though agreement of published results is not very good.
- We need results for high-modulus fiber (not so well studied by others) and for specific ply lay-ups which optimize the use of material.
- We should be careful about ground paths which extend from one detector end to the other.
- Such paths, plus a magnetic field, could lead to requirements regarding ground isolation of pulsed power sources at the two detector ends.
- Will an electrical break be needed at Z=0?

Resources

- Tight, at best

		2010		2011		2012	
		Need	Have	Need	Have	Need	Have
VTX	Staff	3	1.8	3	1.8	3	1.8
	Postdoc	2	0	2	0	2	0
	Engineering	0	0	0	0	0	0
	Student	0	0	0	0	0	0
	M&S (K$)	410	225	380	200	330	200
Tracker	Staff	1.25	0.5	1.25	0.5	1.25	0.5
	Postdoc	0.5	0	0.5	0	0.5	0
	Engineering	0	0	0	0	0	0
	Student	0	0	0	0	0	0
	M&S (K$)	50	0	50	0	50	0

- R&D on mechanics is sufficiently generic that resources may come from related efforts with common goals, for example, resources for measurements of material properties, cooling performance, alignment, and vibrations.