ILC Vertex Detector Mechanical Studies

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LCFI Collaboration

ALCPG, 30th August 2007

LCFI

- Linear Collider Flavour Identification

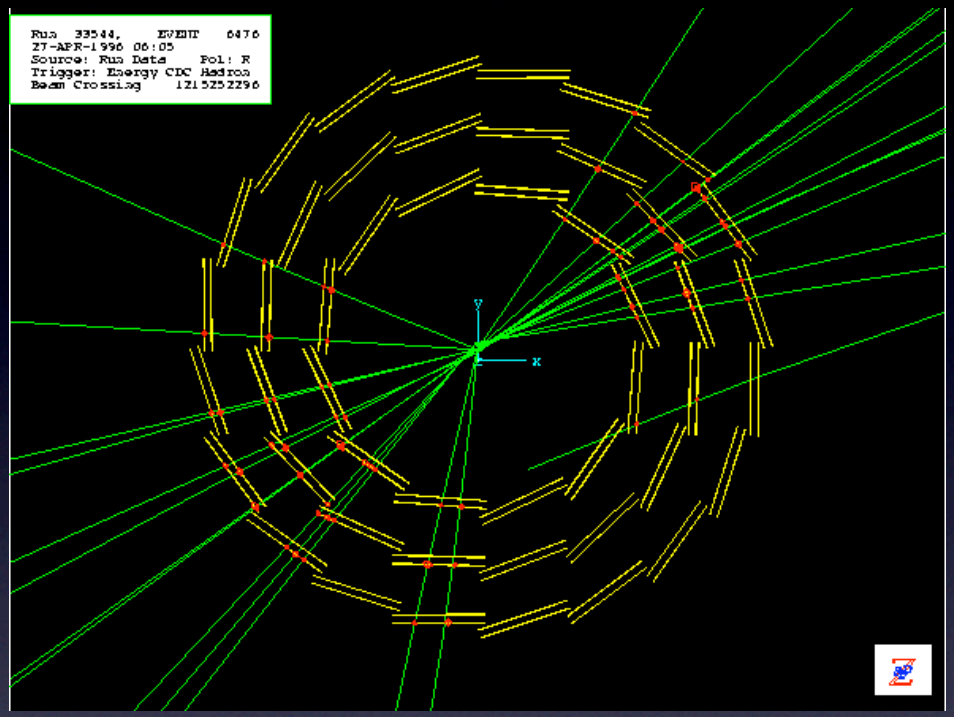
  - Bristol
  - Edinburgh
  - Glasgow
  - Liverpool
  - Nijmegen
  - Oxford
  - RAL

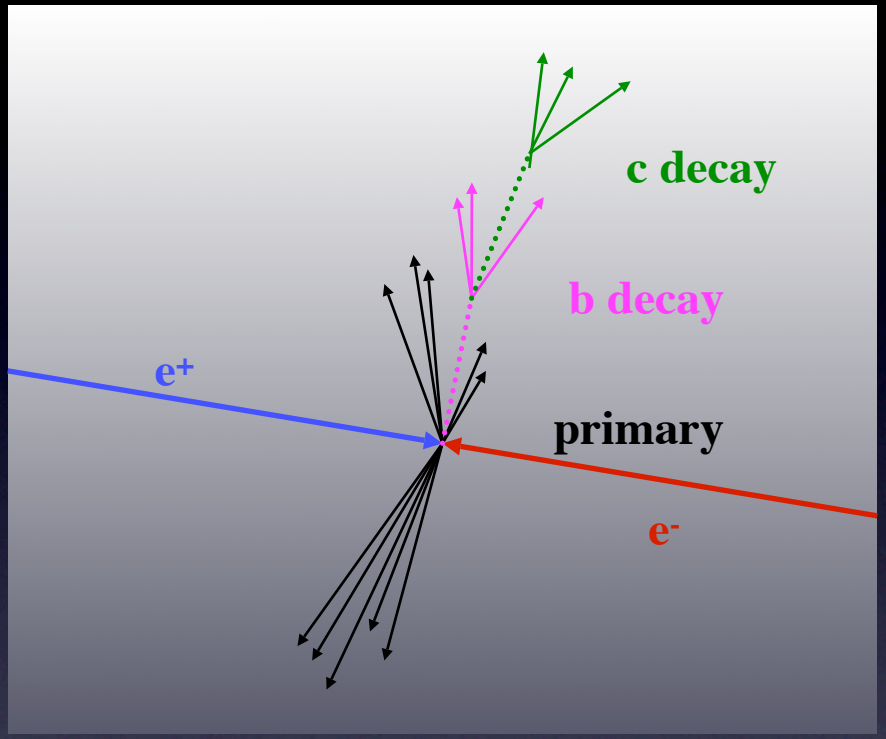
  – Sensors
  – Readout
  – Mechanics
  – Software
  – Physics

Outline

1. Physics Motivation
2. Mechanical Requirements
3. Sensor Support Technologies
4. Conceptual Design
5. Cooling Studies

Flavour Physics

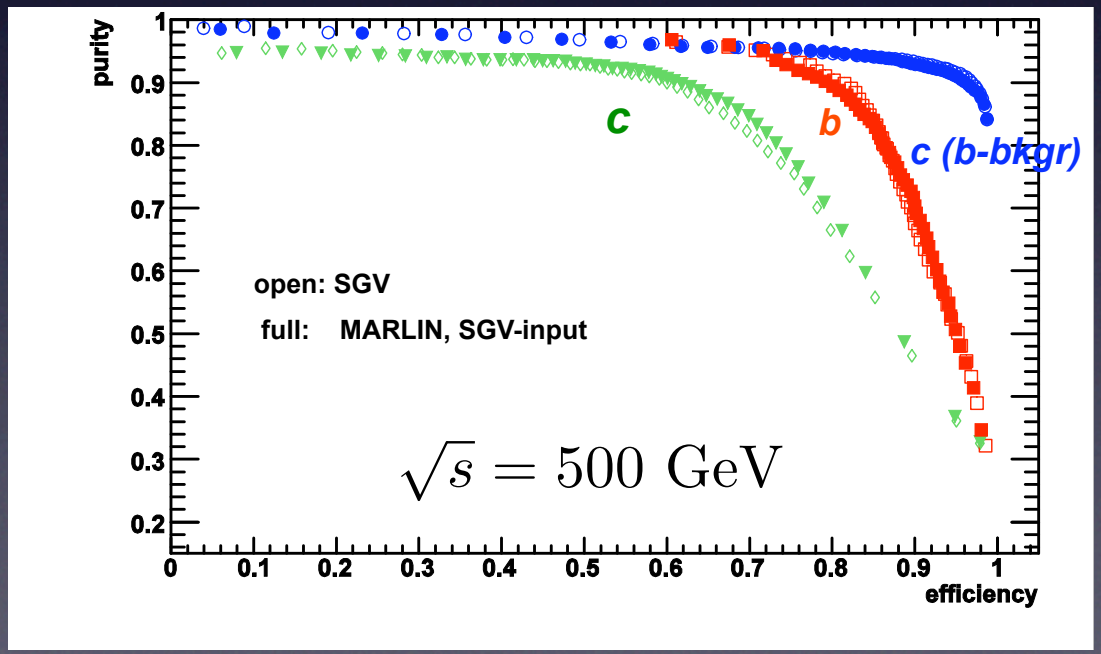


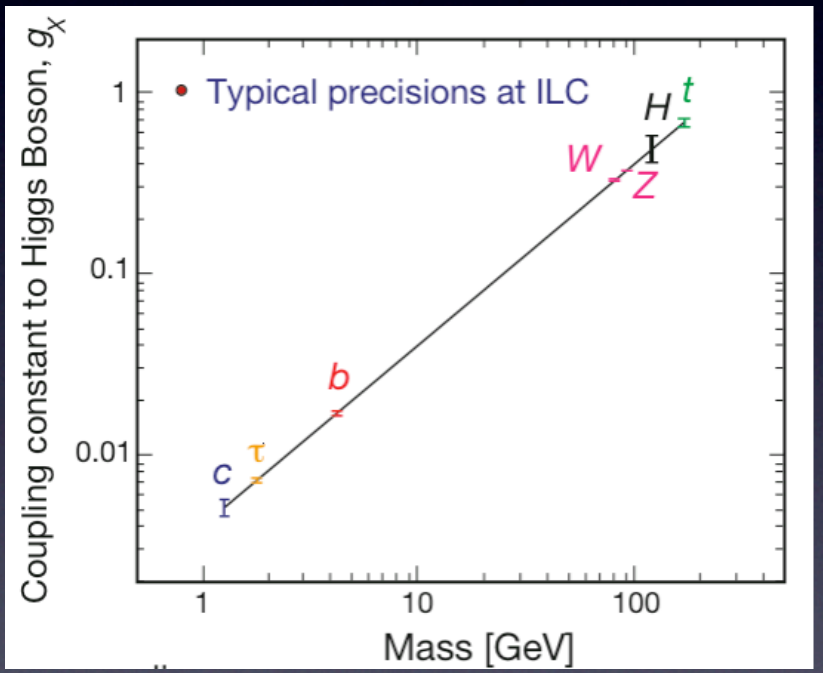


- Precision detectors close to interaction point
- Distinguish tracks from secondary vertices
  - Identify, separate *b*, *c* quarks and τ leptons
  - Measure charge

Flavour Tagging

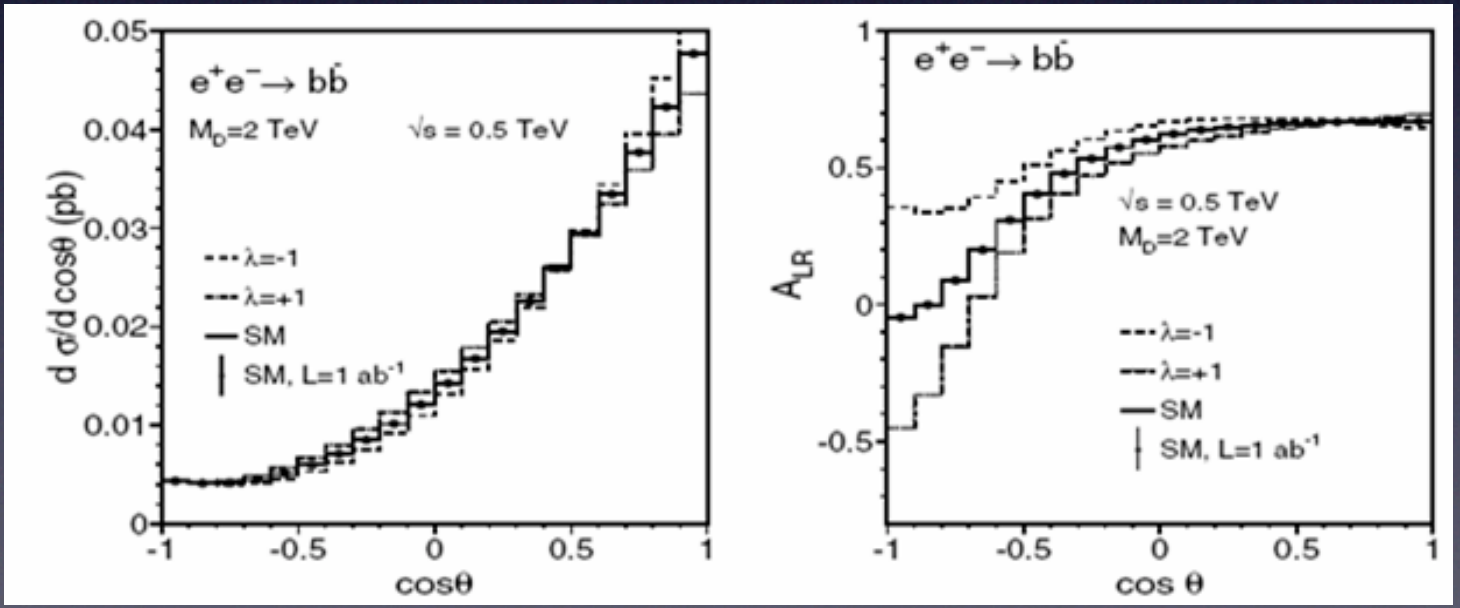
- *b*-tagging fairly robust at the ILC
- c-tagging more detector dependent
  - Measure Higgs branching ratios
  - . . .





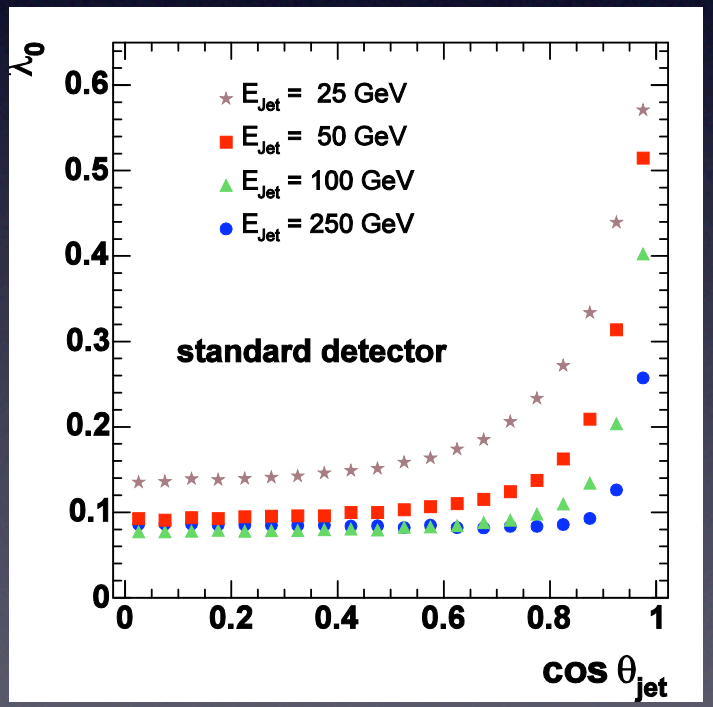
Vertex Charge

- Add charge of all tracks associated to vertex
- Identify charge of flavoured hadron
  - Can distinguish quark from antiquark
  - Asymmetries → LEDs, . . .

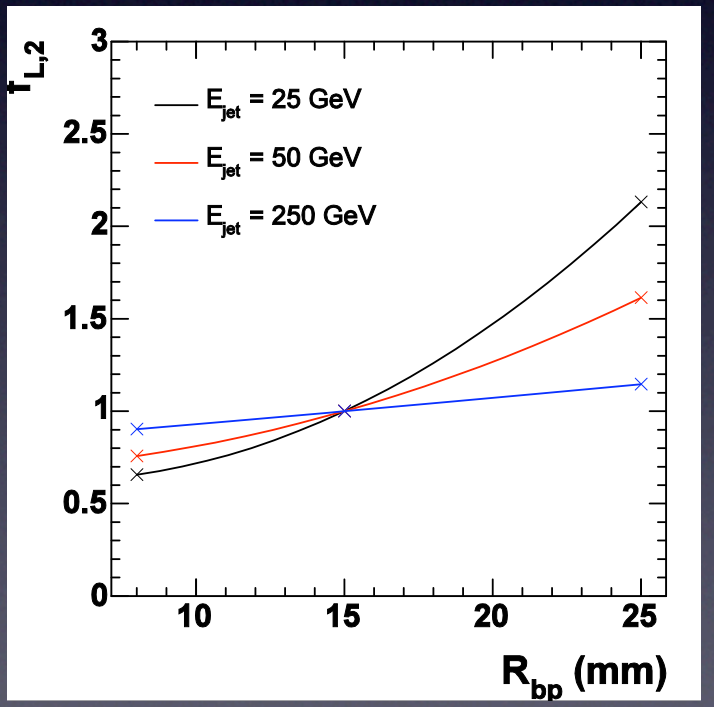


Leakage Rates

- Single missed track causes leaks, e.g. $B^0 \rightarrow B^+$
- Sensitive to detector parameters

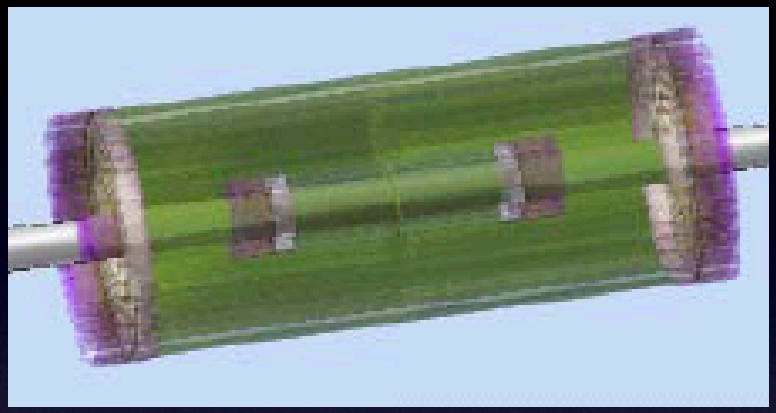


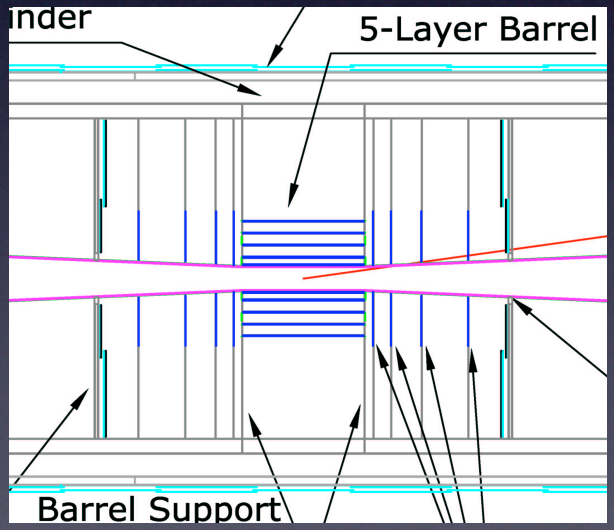
- inner radius
- point resolution
- coverage
- material



Optimisation

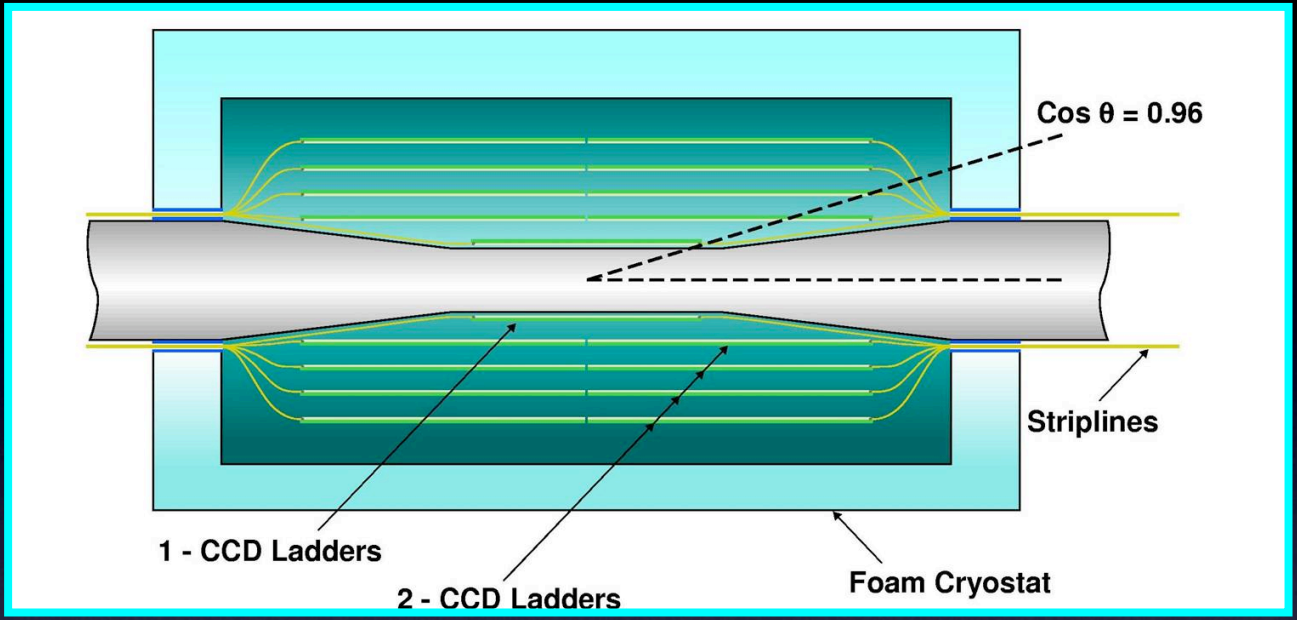
- Layout - barrel vs endcaps
- Material in active volume
- Material outside
  - May depend on sensors, electronics etc.
    - material, temperature. . .
  - Needs input from simulations and studies
    - tools becoming available





Bill Cooper

ILC Vertex Detector



- 800M 20×20μm^2 pixels
- 5 layers, inner radius ~ 1.5 cm
- Gas cooling
  - 0.1% X_0 per layer
  - Uniform material distribution

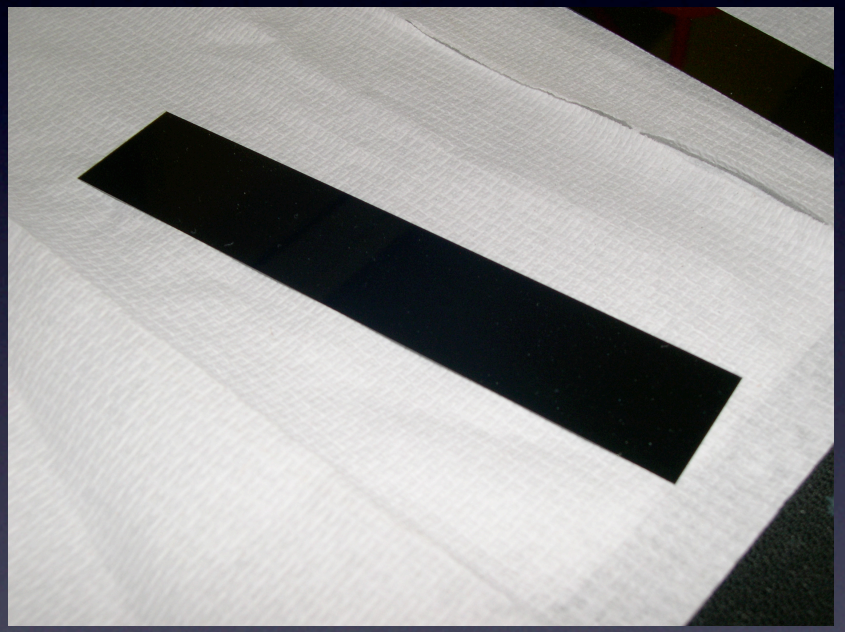
LCFI Mechanical Work

1. Support Prototyping
   - RVC and SiC Foams
   - Carbon Fibre
   - Shells
2. Conceptual Design
   - Check Compatibility
3. Cooling studies
   - Test Rig and Simulations

Support Options

Material target equivalent to 100 µm silicon

- Thinning silicon to 50-100 µm becoming routine
- Thinning to epitaxial possible

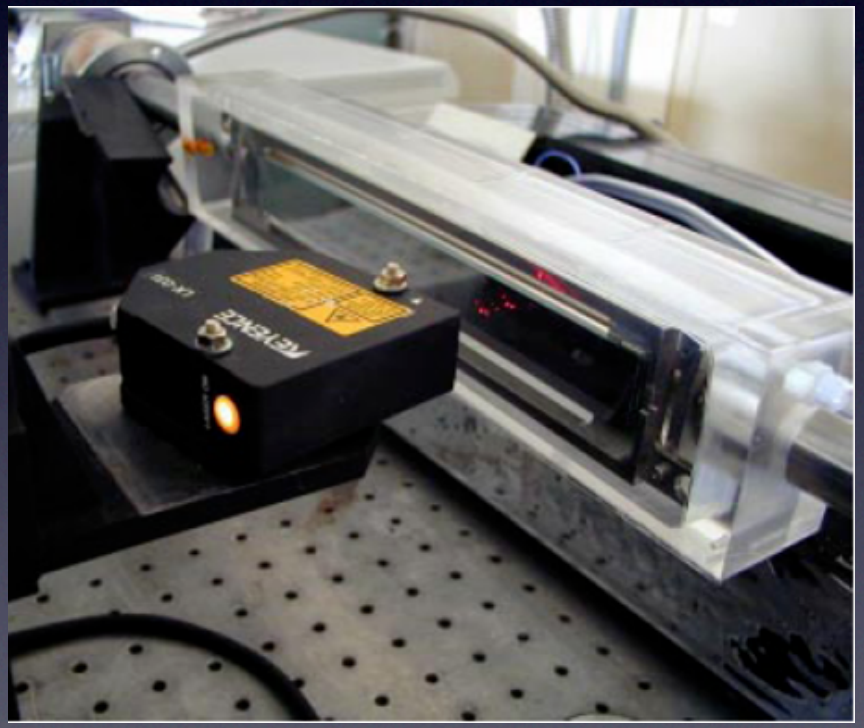


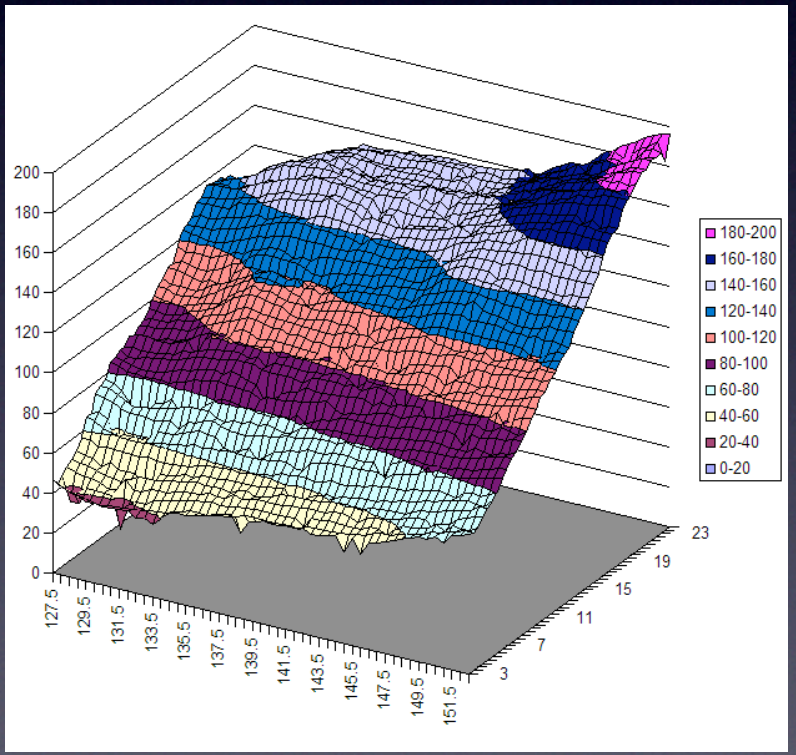
- *Ladders with bulkheads*

1. Unsupported silicon
   - can't control lateral curl
2. Laterally stiffened silicon
3. Rigid structures

Metrology

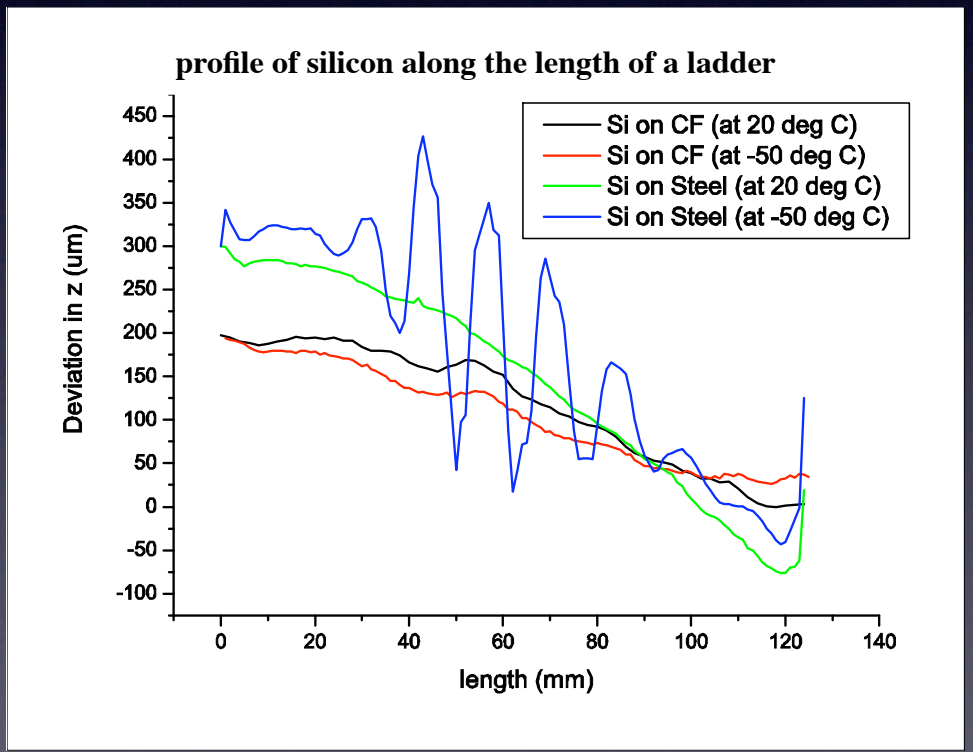
- 2D scanning system based on Keyence LK-3010M
- Gas-cooled cryostat capable of ~180K





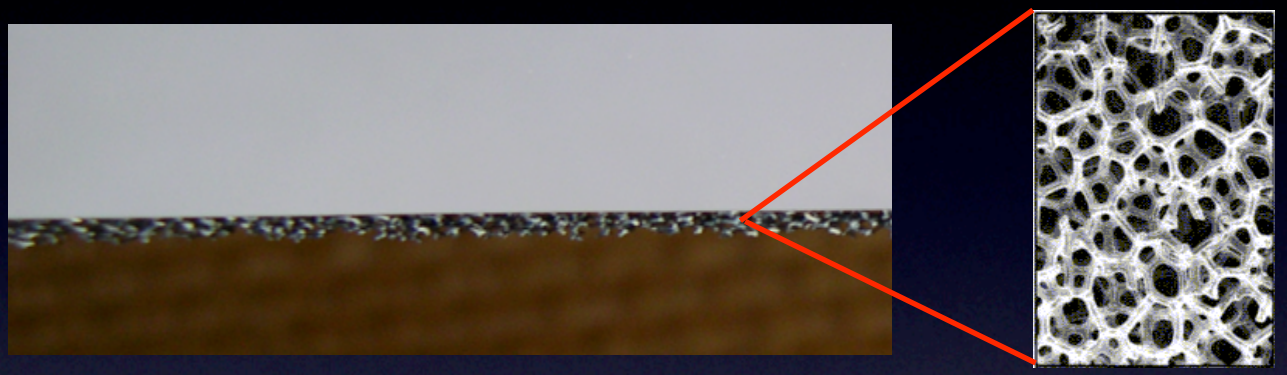
Thin Substrates

- Longitudinal stiffness from tensioning
- Lateral stiffness from thin substrate
  - Beryllium: good specific stiffness but bad CTE
  - Carbon fibre good candidate
    - 0.09% X_0 test model
    - laterally stability insufficient

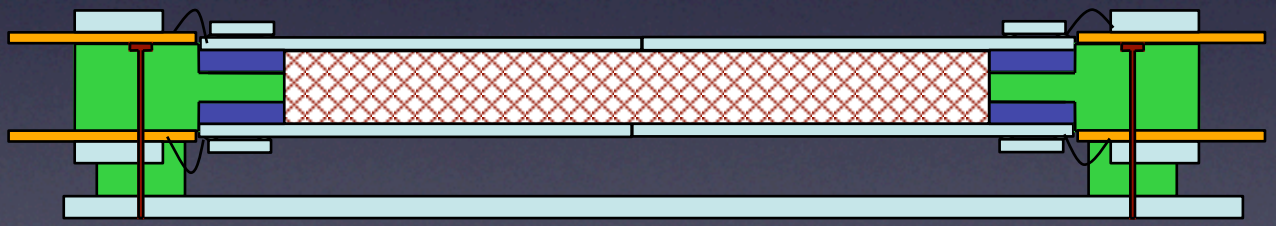


Foam Ladders

- 25 micron silicon on 1.5mm 8% SiC
  - Very rigid
  - Achieved 0.14% X_0

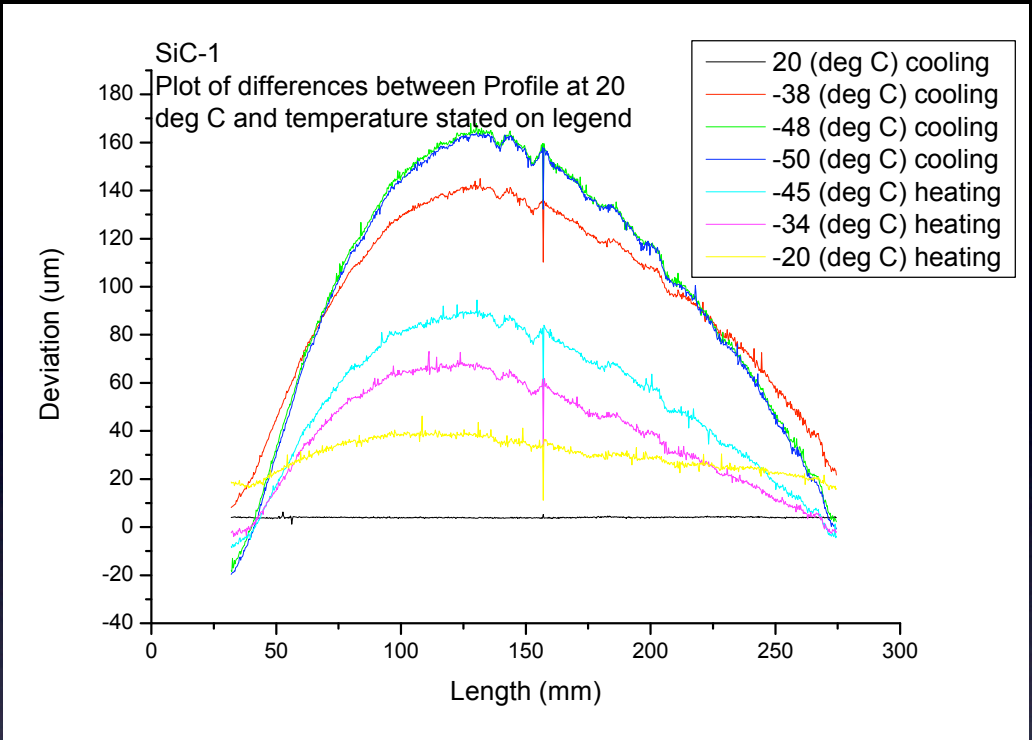


- 20 micron silicon sandwiching 1.5mm 2% carbon
  - Could be double-sided
  - Achieved 0.07% X_0



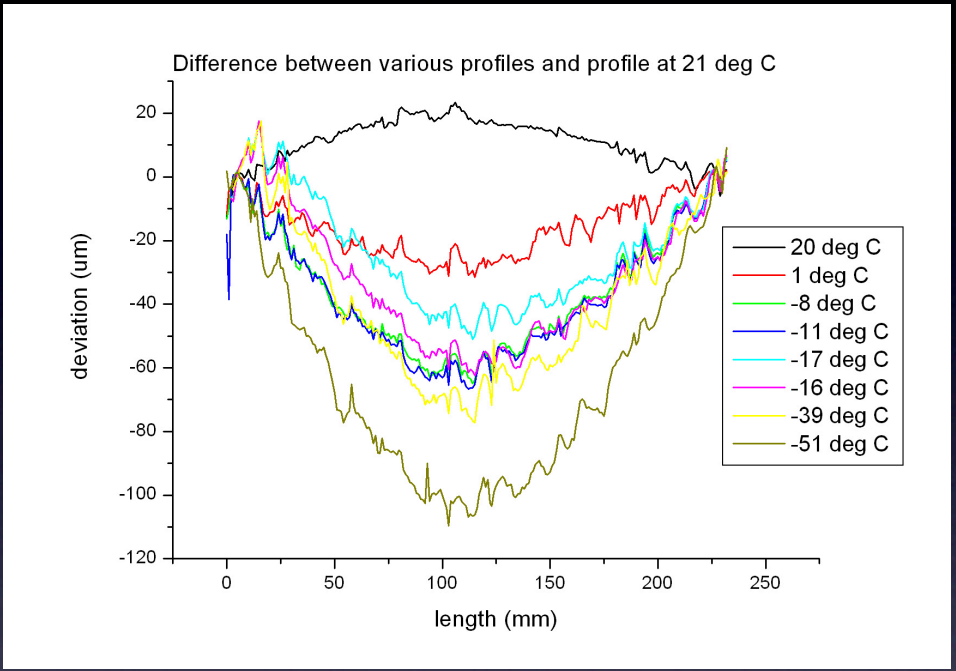
More exotic rigid structures possible

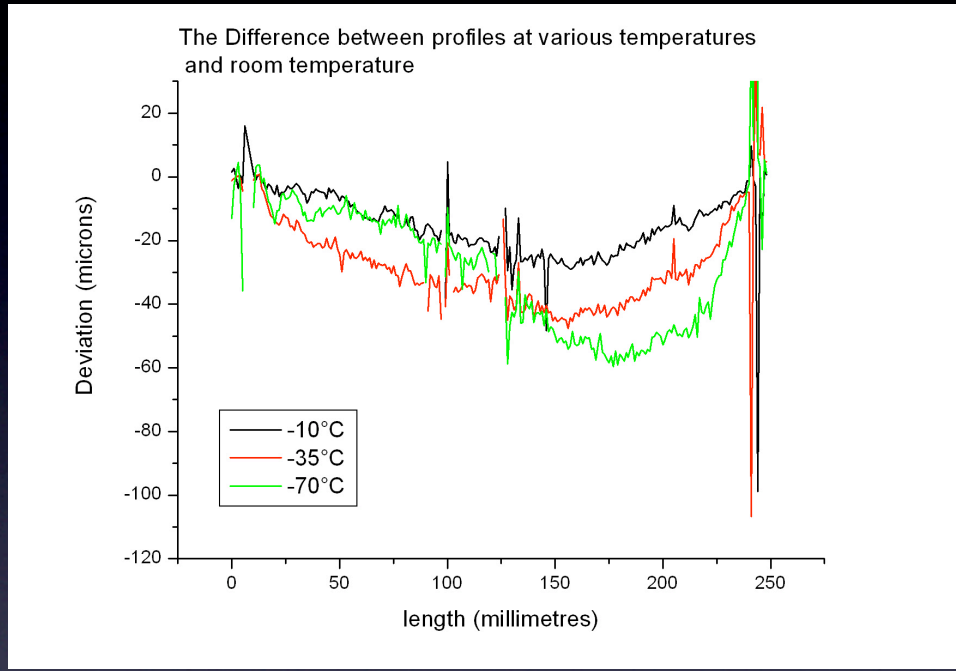
Silicon Carbide



- Samples of 8% and 6% relative density obtained
  - Lower density believed possible
  - Processing techniques being investigated

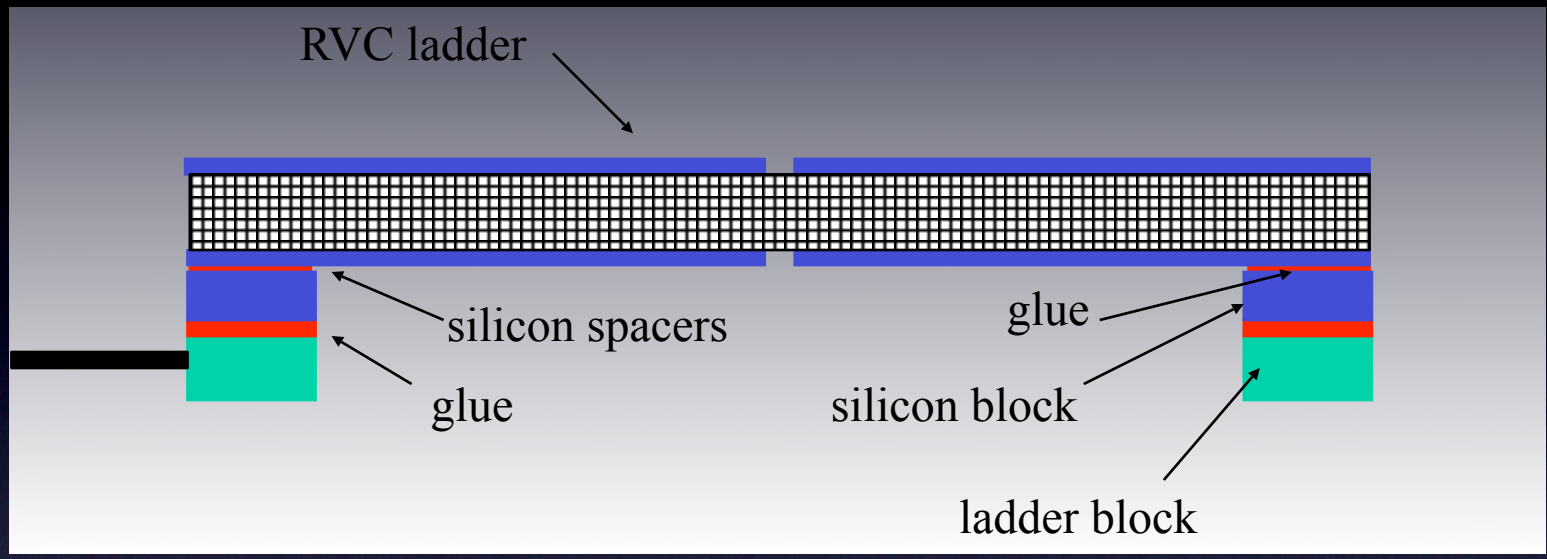
Glue Placement



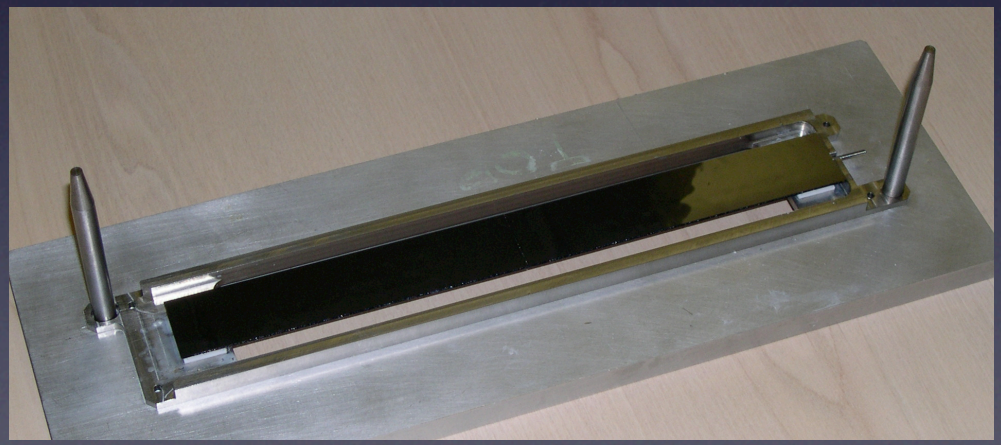


- Silicon and SiC substrate in contact
- Silicon and SiC spaced by 200 microns of silicone

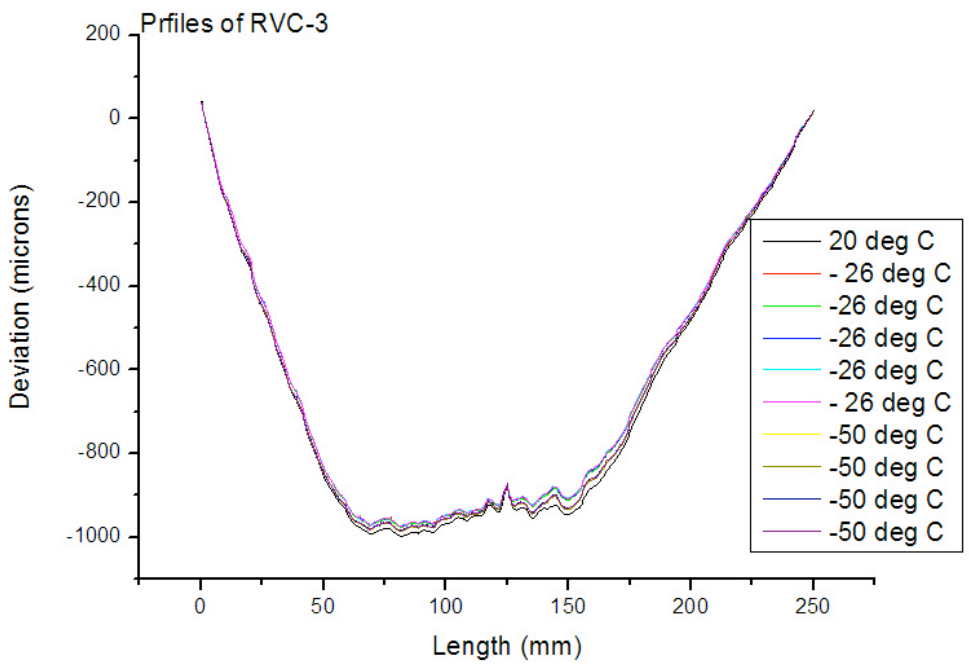
RVC Foam

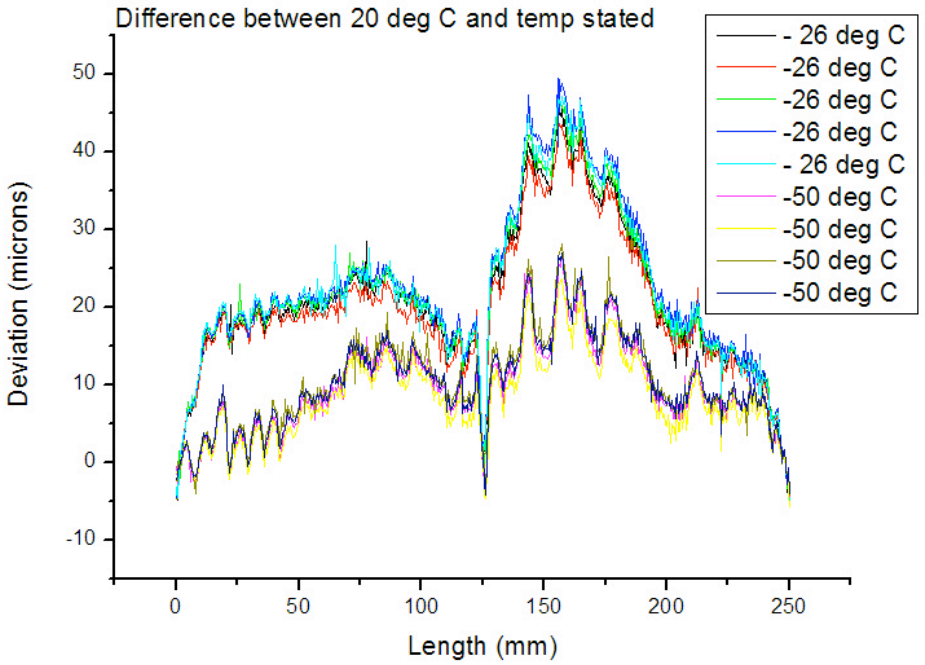


- Reticulated Vitreous Carbon
  - 2-3% relative density
  - Not stiff enough for one-sided



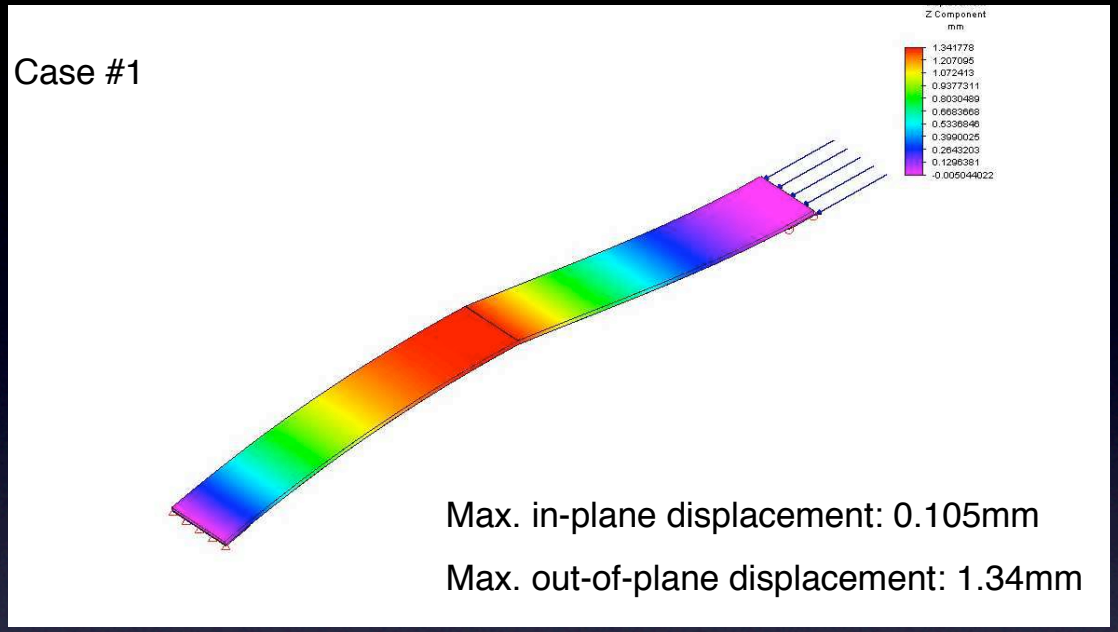
RVC Results



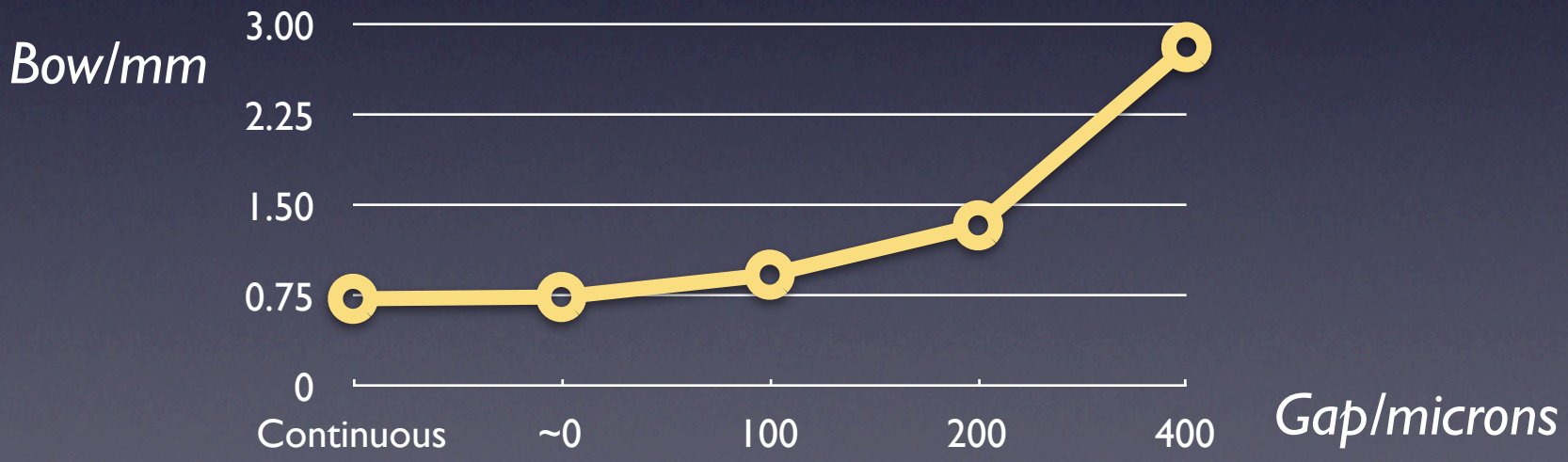


- Overall bow due to asymmetry in production
  - New fixturing being made
- Several features not understood

FEA Study of RVC

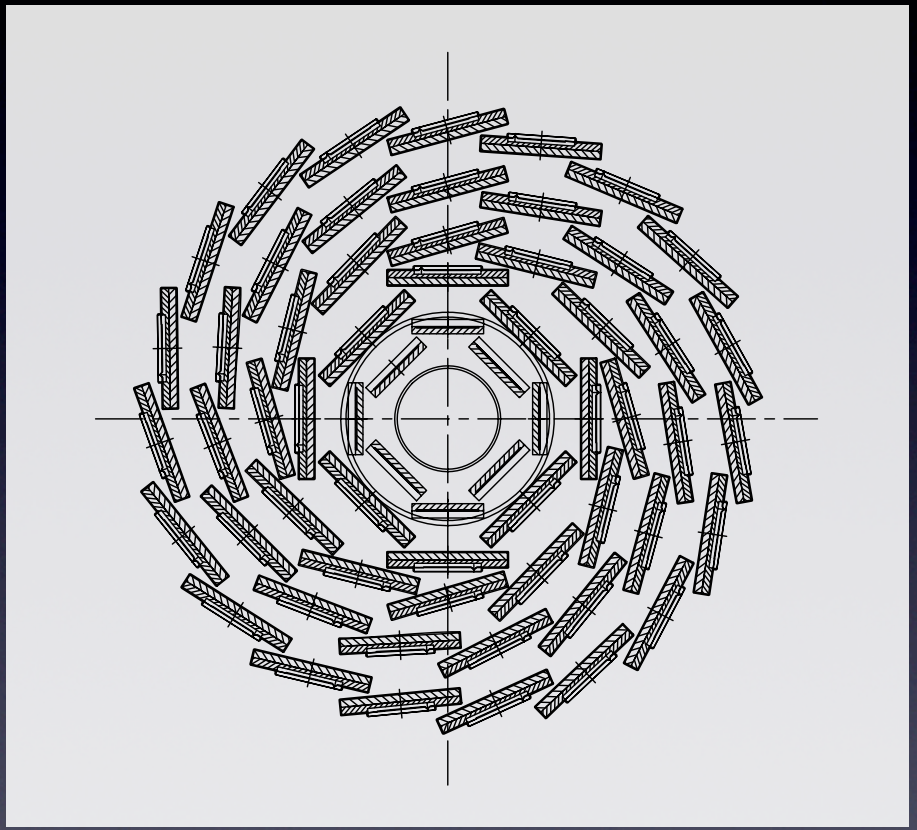


- Effect of gap size
  - 7.5N compression
  - 70 degree cooling



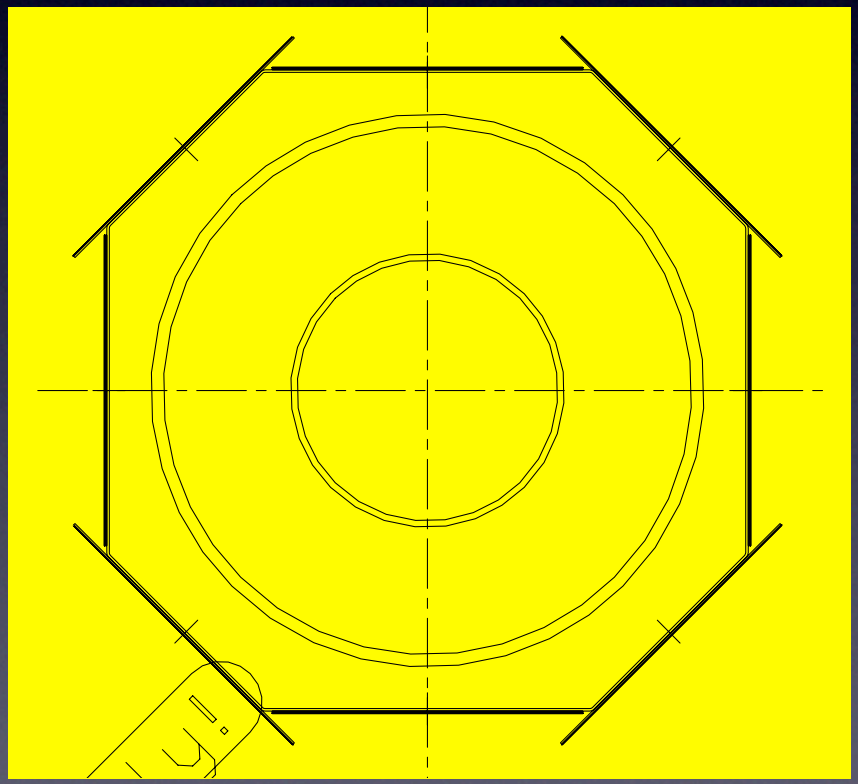
Conceptual Design

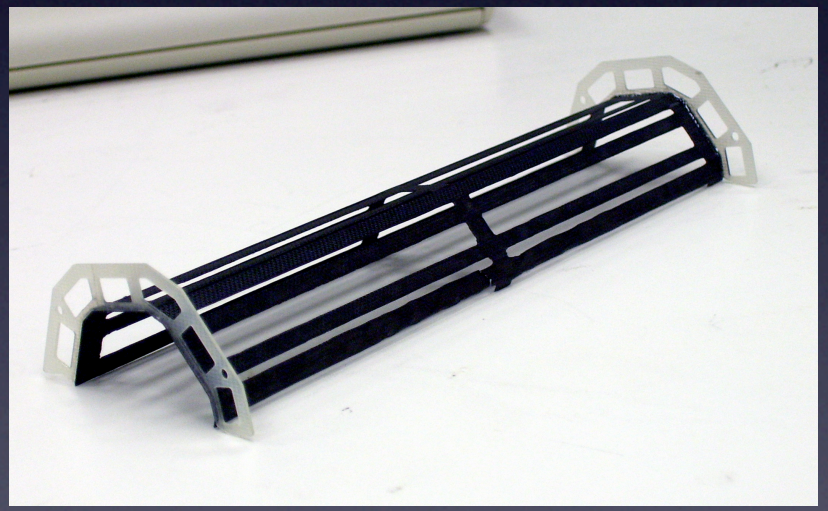
- Checking feasibility
- Thick foams not easy
  - Layers 1&2 crowded
    - Double-sided layers...?
    - CF shells...?
    - …



CF Shells

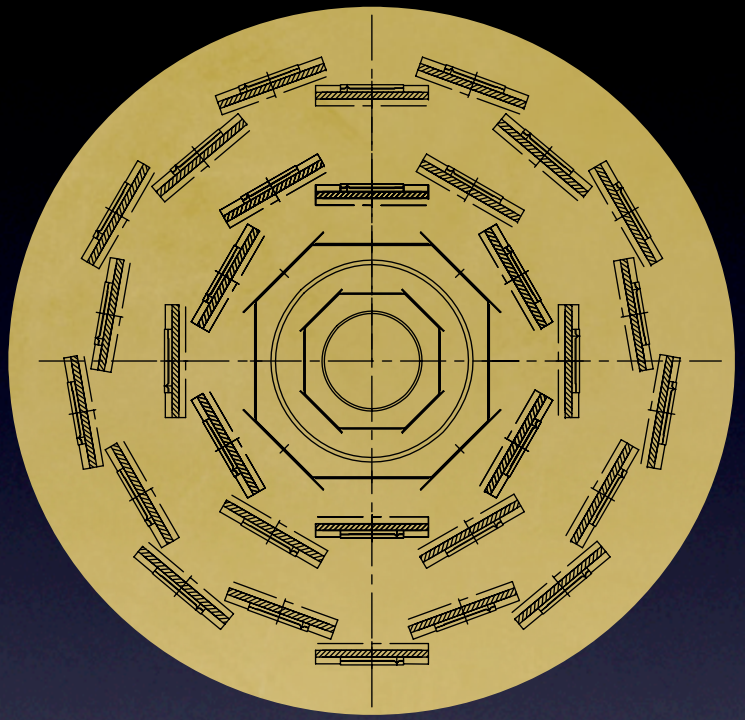
- CDF and DZero innermost silicon layers
- Prototyping 25cm long ILC structure





UWashington

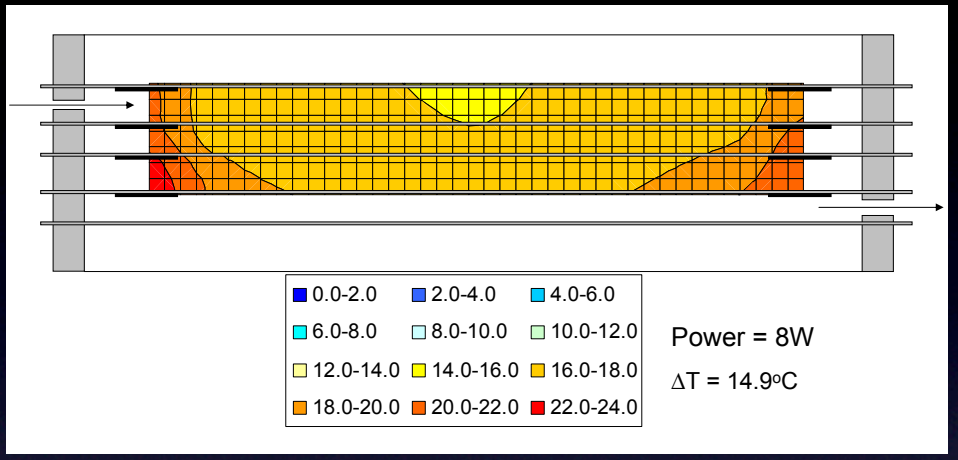
Other Concepts

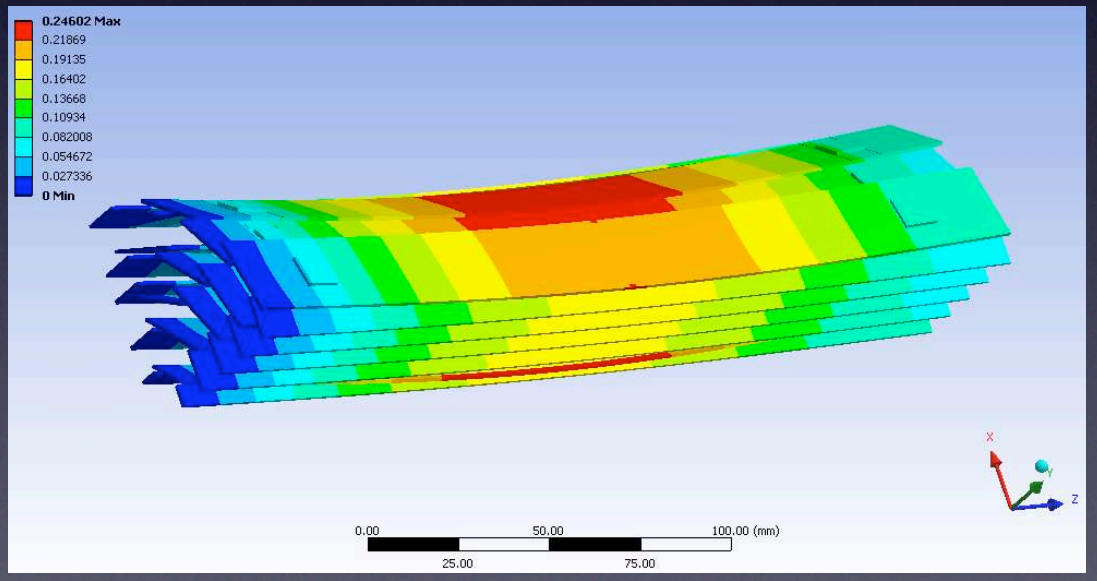


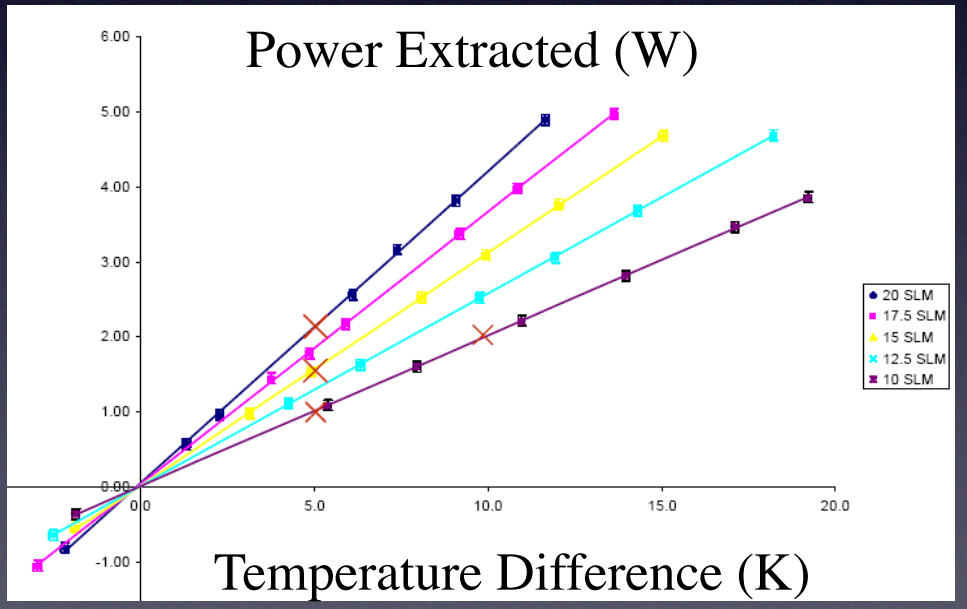
- Combine technology
  - e.g. 2 layers CF shell, 2 double-sided foam
- Complete foam structure
- . . .

Cooling Studies

- Model of 1/4 barrel
  - Can extract >30W at reasonable flow rates
- Calibrating CFD and FSI tools







International Meetings

- Regular inter-R&D group video meetings
  - VXD Mechanics Meetings
  - Tuesdays at 17:00 RAL/11:00 FNAL

    ILC-VXD-MECHANICS@listserv.fnal.gov

Summary

- Mechanical constraints challenging
  - Driven by physics goals
  - Need simulation and electronics input
- Several candidate technologies
  - LCFI focusing on foam ladders, CF shells
- Regular collaborative meetings