LCFI Mechanical Studies

Snowmass 2005, VTX WG

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For the LCFI Collaboration

LCFI Mechanical Studies

1. Thin Ladder Mechanics

- **Materials and designs for $\Delta T \approx 100K$**
- **Preference for uniform material in tracking volume**
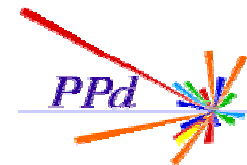- *CCDs routinely thinned to epitaxial layer*

2. Global Design

- **Ensure ladder designs practical**

3. Cooling

- **Gas cooling has always been assumed…**

Mechanical Options

Target of 0.1% X_0 per layer
(100μm silicon equivalent)

1. Unsupported Silicon

- Longitudinal tensioning provides stiffness
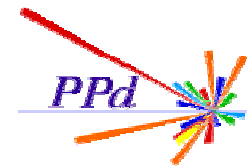- No lateral stability
- Not believed to be promising

2. Thin Substrates

- Detector thinned to epitaxial layer (20μm)
- Silicon glued to low mass substrate for lateral stability
- Longitudinal stiffness still from tension
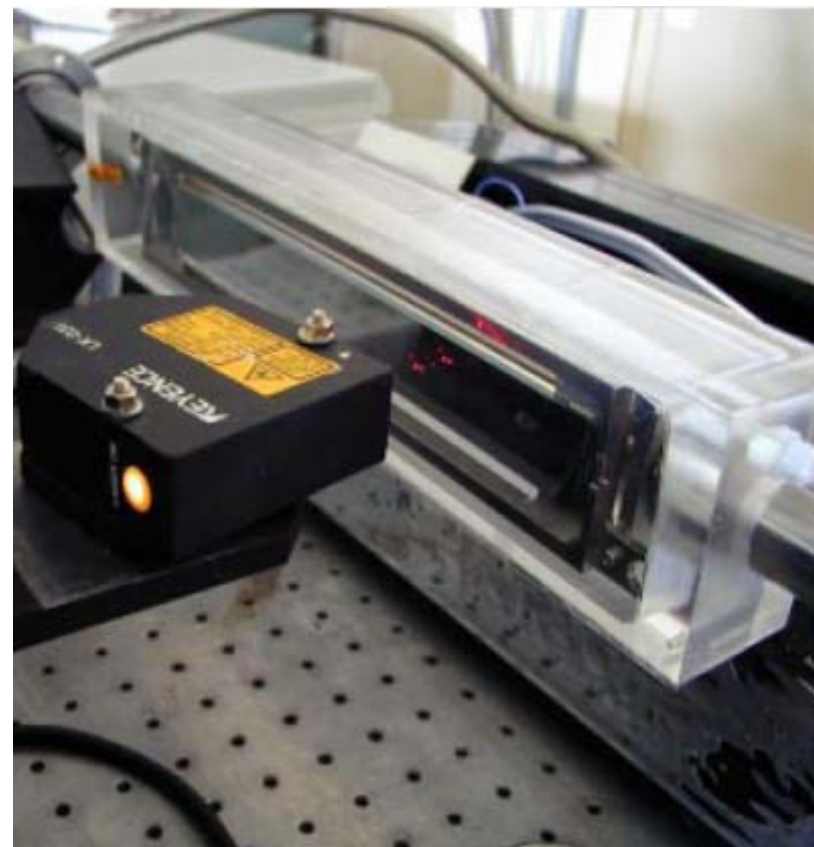- Beryllium has best specific stiffness

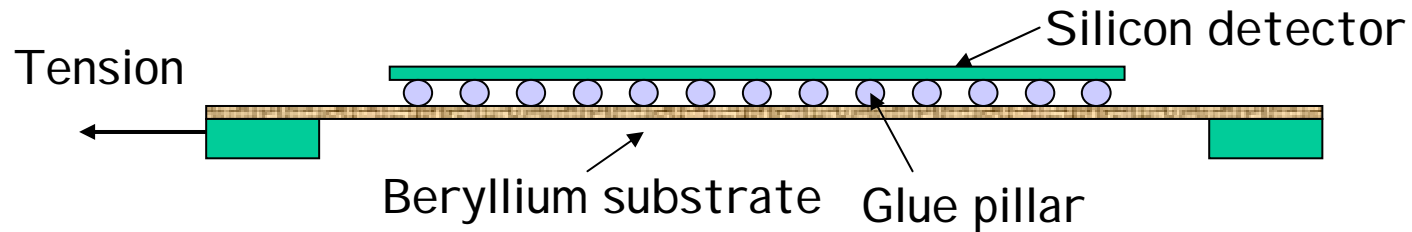## 3. Rigid Structures

Laser Survey System

- **Laser displacement meter**
  - Z precision ~ 1 μm
- **2D motorised stage**
  - X-Y precision < 1 μm
- **Ladder in cryostat:**
  - ΔT ~ 100°C
- **Fast:**
  - 1D scan < 1 minute
  - Scan during cooling

Mechanical Studies of Be-Si

Tension

Silicon detector

Beryllium substrate   Glue pillar

FEA Simulations

~160 µm ripples at -60°C

Physical Prototyping

Plot showing deviation of 30 micron thick silicon with respect to temperature change

Deviation (microns)

length (mm)

- 5 degrees C
- 4 degrees C
- 3 degrees C
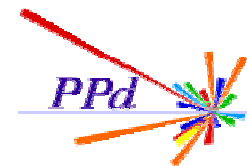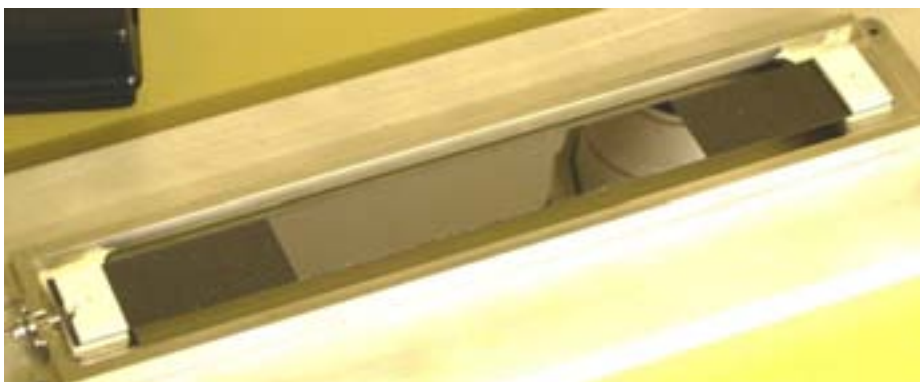- 0.5 degrees C
- 0 degrees C
- -7 degrees C
- -10 degrees C
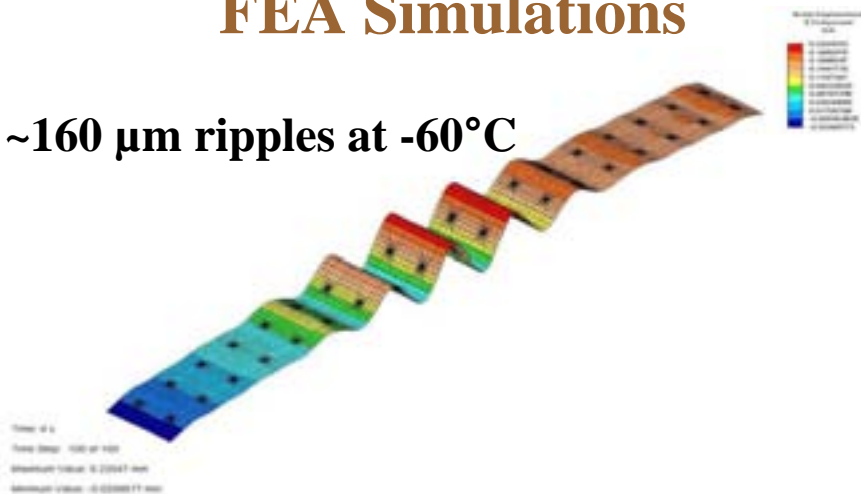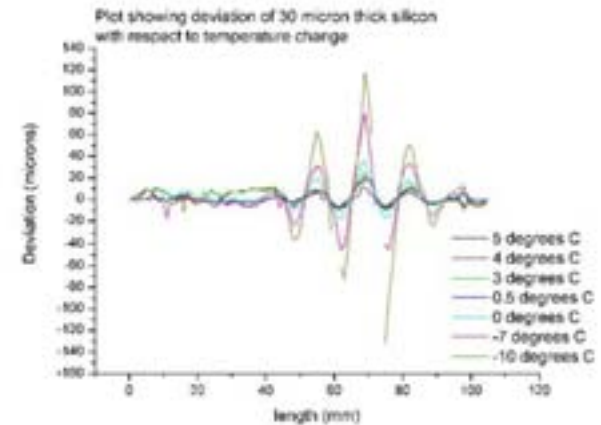
- **Good qualitative agreement**

- **Minimum thickness ~ 0.15% X_0**

Carbon Fibre Substrates

- **Carbon fibre has better CTE match than beryllium**

profile of silicon along the length of a ladder

Legend:
- Si on CF (at 20 deg C)
- Si on CF (at -50 deg C)
- Si on Steel (at 20 deg C)
- Si on Steel (at -50 deg C)
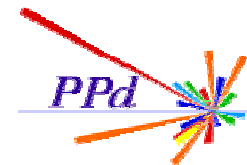
Y-axis: Deviation in z (um)
X-axis: length (mm)

- **Prototype ~ 0.09% X_0**
  - **No rippling down to < 200K**
  - **Lateral stability insufficient**
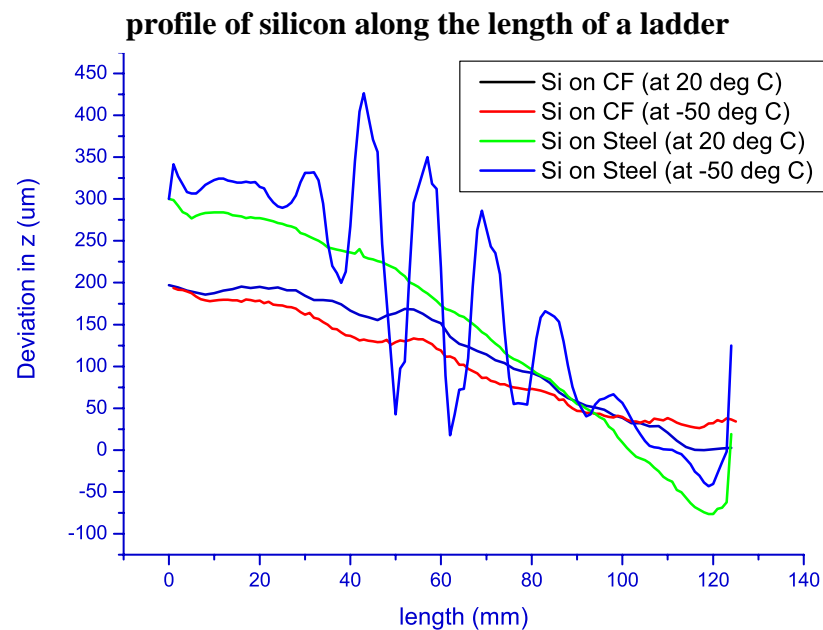
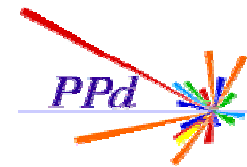# Other Thin Substrates

- **Considerations for other materials**
  - **CTE match**
  - **thickness**
  - **financial**

- **Ceramics, advanced materials….**
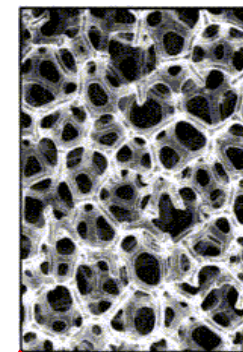
- *Diamond samples in hand*

Rigid Structures
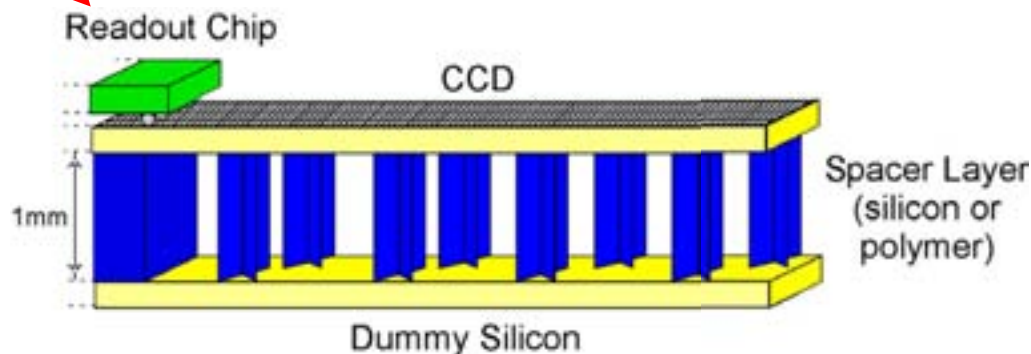
Foam: substrate or sandwich core

- **Macroscopically uniform**

- **No tensioning needed**

Other approaches exist

RVC foam (foam thickness 1.5 mm)

Silicon Carbide foam (foam thickness 1.5 mm)

Readout Chip

CCD

1mm

Spacer Layer (silicon or polymer)

Dummy Silicon

Foom Prototypes

- **3% RVC**
  - **Sandwich**
  - **0.09% X_0**
  - **Mechanically unsatisfactory**
  - **Working on glue application**

- **8% Silicon Carbide**
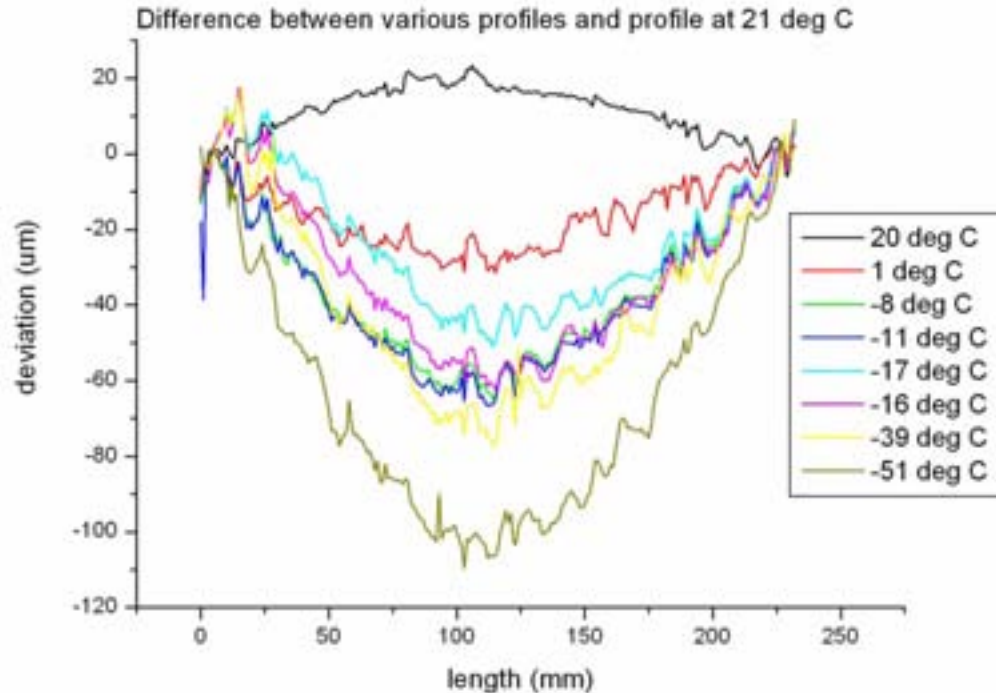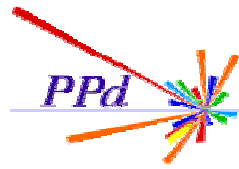 - **Single-sided**
  - **0.14% X0**
  - **3-4% believed possible**
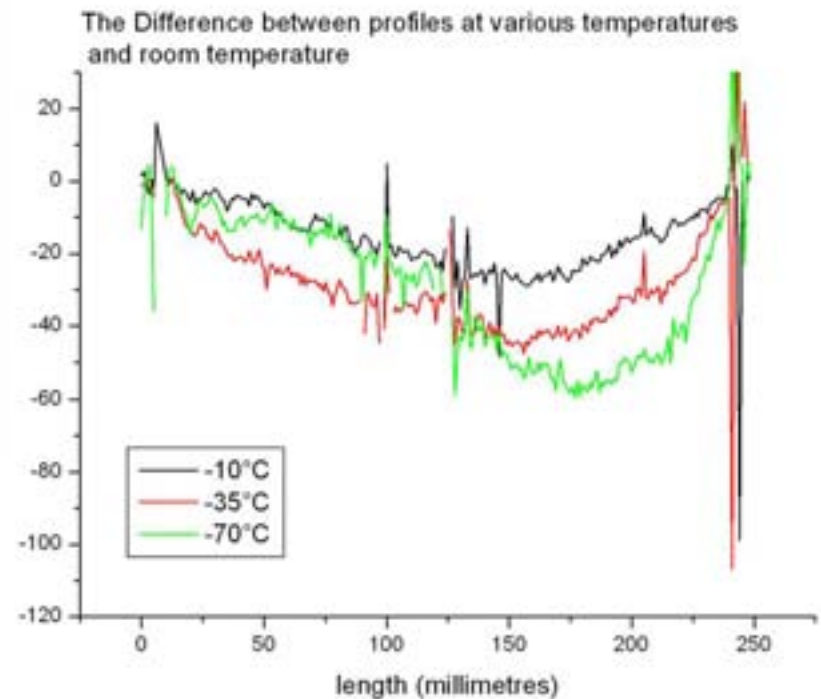
20 μm silicon

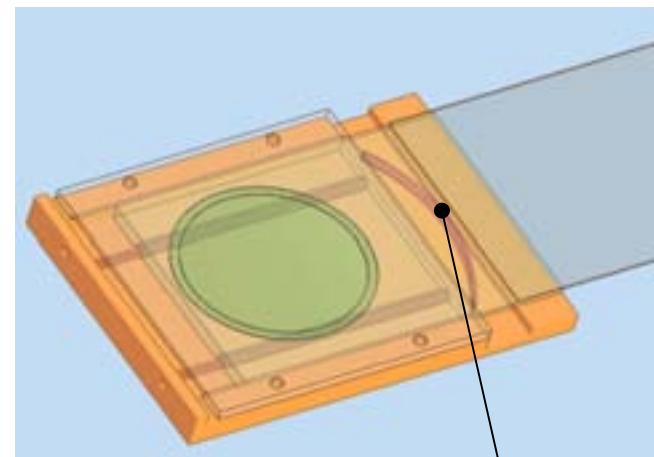**1.5 mm silicon carbide**

Silicon Carbide Foam

Difference between various profiles and profile at 21 deg C

deviation (um)

- 20 deg C
- 1 deg C
- -8 deg C
- -11 deg C
- -17 deg C
- -16 deg C
- -39 deg C
- -51 deg C

length (mm)

Thin glue layer

Glue "pillars"

The Difference between profiles at various temperatures and room temperature

- -10°C
- -35°C
- -70°C

length (millimetres)

Detector layout:

Option 1

Option 2
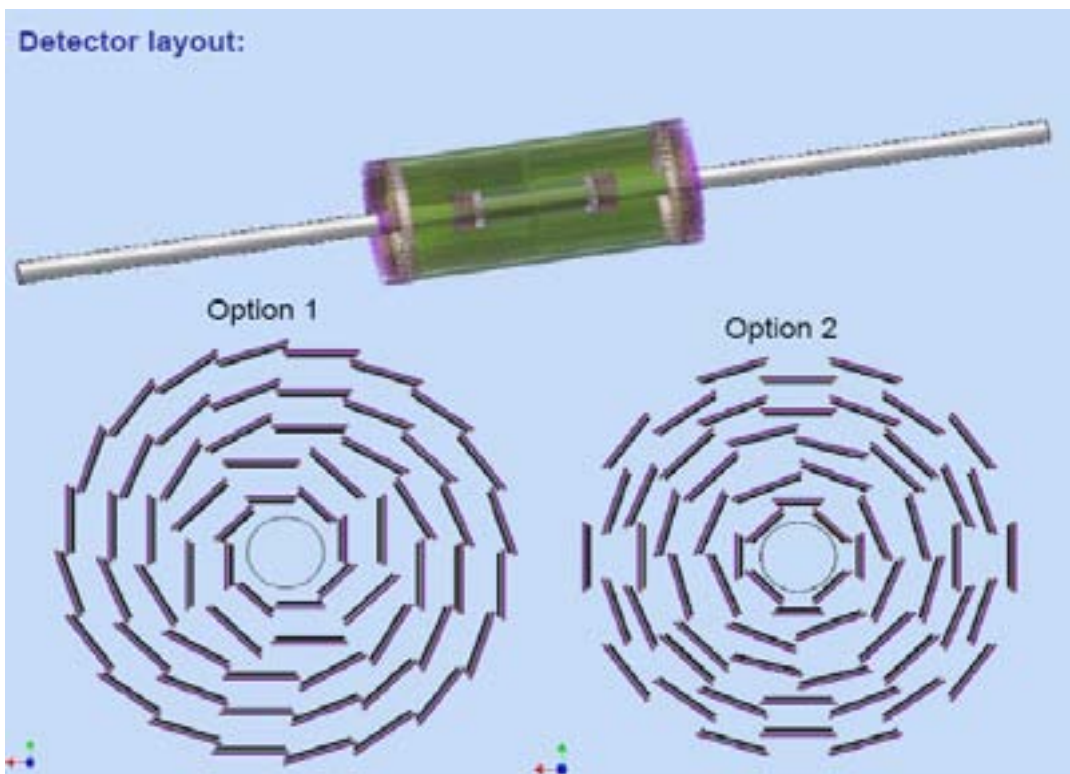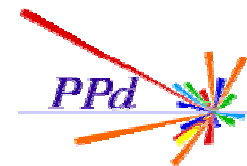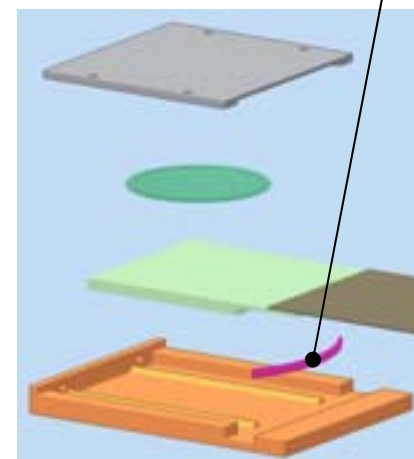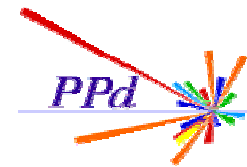
Ladder end with leaf spring

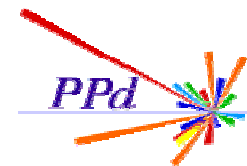• **Enough detail for ladder design "sanity check"**

Plans

- **Continue work on ladder designs**

  – **Foams looking promising**

  – **Settle on favoured technology ~ 2 years**

  – **Start looking at production issues**
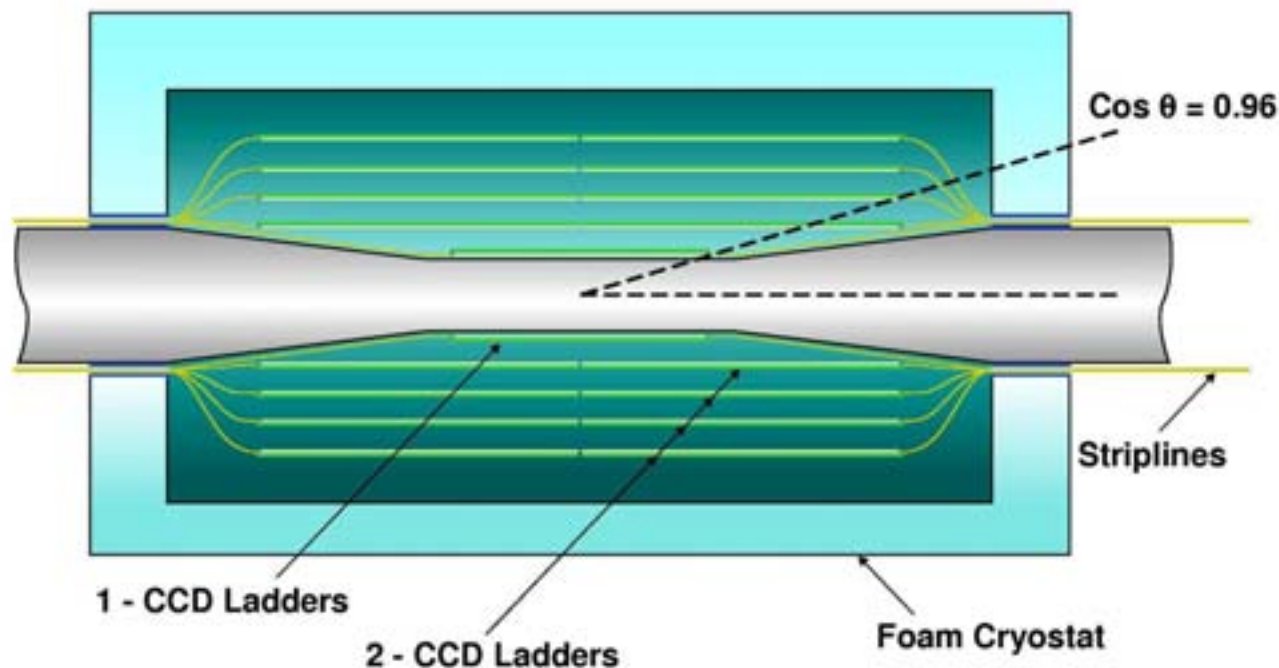
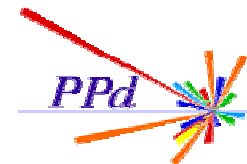- **Increase effort on global and cooling design**

Backup Slides

Baseline Vertex Detector

- **800 Mchannels of 20×20 μm pixels in 5 layers**
- **Optimisation:**
  - **Inner radius** **(1.5 cm?)**
  - **Readout time** **(50 μs?)**
  - **Ladder thickness (0.1% X_0?)**