Ideas for LC mechanics

(we will work on sensors as well –
particular CMOS)

Current Oxford activities on composite structures

- Oxford is contributing to the R&D for the ATLAS strip tracker upgrade
- We are involved in the development of the local supports: barrel strip staves
  - UHM CF/honeycomb structures with carbon foam (Allcomp) cooling channels with embedded thin-wall Ti tubes
  - Kapton/Cu flex circuits co-cured with CF skins
- And the design of the global CF support structure for the barrel strip system

Cu/Kapton tape co-cured with K13C2U

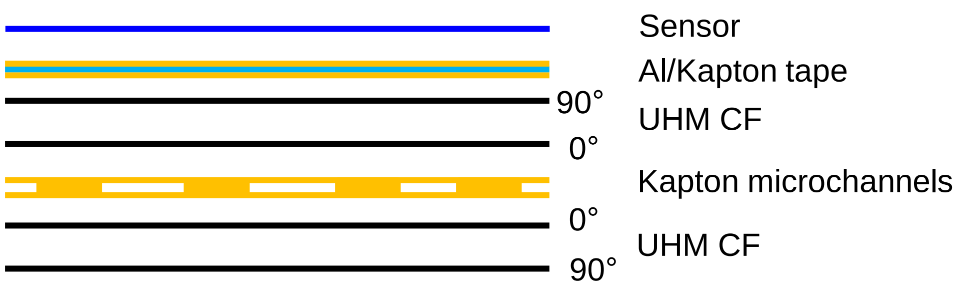
Our vision for future large trackers

- Future sensor technologies (thinned down MAPS) promise material down to a few ‰ of a radiation length
  - Structures and services need to match this
- We do have a strong preference for liquid (evaporative) cooling
  - Gas cooling is not a robust technology (difficult to predict)
  - Gas cooling has limited capacity (might be ok for linear collider, but not much more)

→ Challenge: Is 0.5% X_0/tracking layer with evaporative cooling possible for a large ((2-3m)^3) tracker?

  - For comparison: ATLAS phase II >2.5% X_0, LC TDR ~1% X_0
  - Support/service sandwich layer:
    - Structural: UHM fibre (e.g. K13C2U, 4 layers of 45gsm)
    - Cooling: Microchannel Kapton cooling
    - Electrical services: Al/Kapton multilayer cables
    - All the above are co-cured (this saves glue)
  - Sensors: Thinned down to 50µm (MAPS)
  - This would be a layer less than 1mm thick

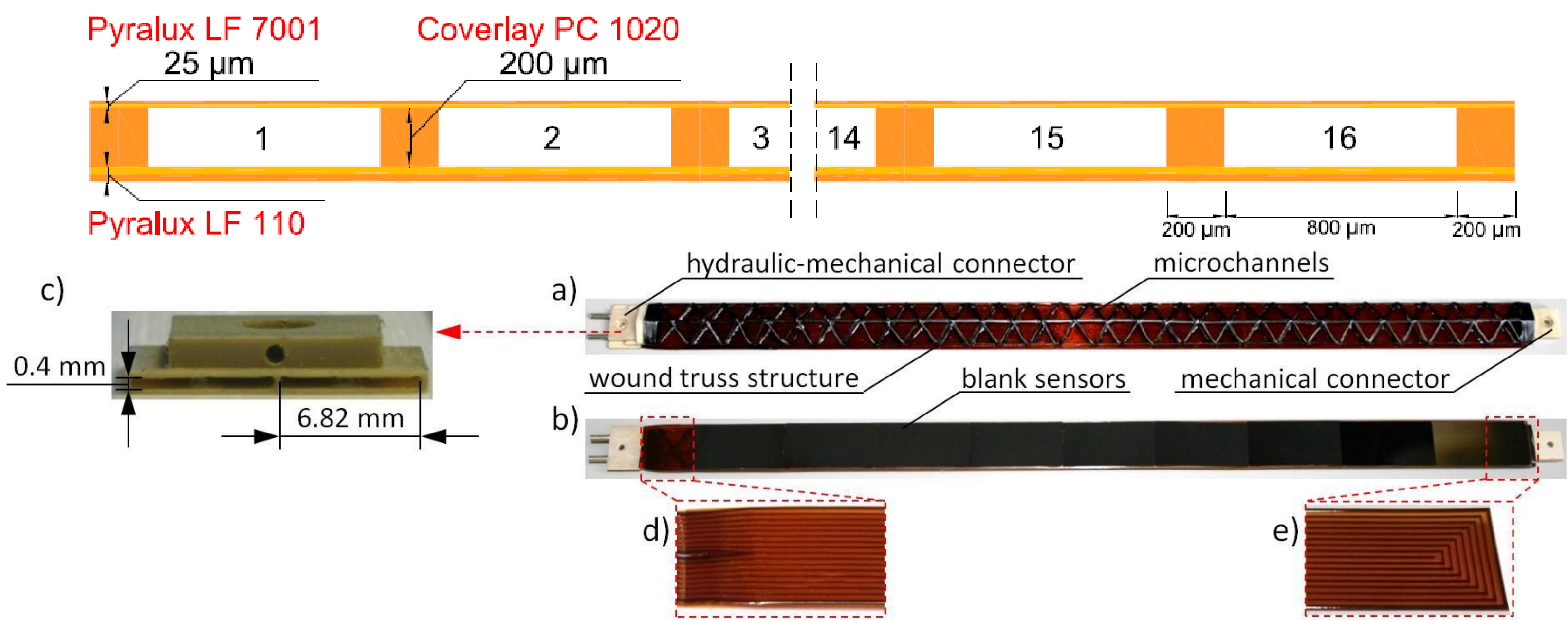
	Material	X0 [mm]	thickness [mm]	Scattering material [X0]
Skin	CF	273	0.25	0.09%
Cooling channel	Kapton	286	0.09	0.03%
Coolant	C4F10	224	0.05	0.02%
Tape	Al	89	0.05	0.06%
	Kapton	286	0.05	0.02%
Glue	SE4445	120	0.05	0.04%
Silicon		94	0.05	0.05%
Total				0.31%



Of course, we have ignored a few things, but we think 0.5% is a conceivable aspiration…

Kapton microchannel cooling

- Developed for ALICE by CERN:



G. Fiorenza et al., 5th IEEE International Workshop on Advances in Sensors and Interfaces (IWASI), 2013, p. 81-85, 10.1109/IWASI.2013.6576065.

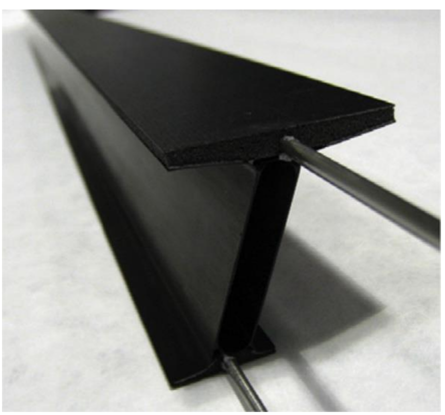
- Tested to $10bar_a$ with water and C_6F_{14} monophase cooling
- Requires scaling to large tracker size, can we achieve higher pressures
- At Oxford we have started to look into similar photo-etched and machined structures…

First attempts

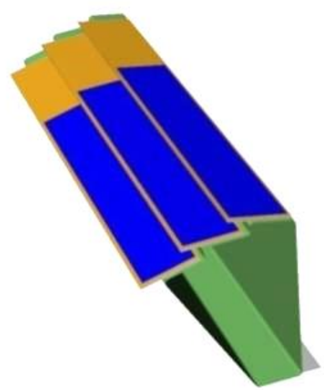
- Prototypes of 40×100mm^2
- Machined (milled with a tool at 45°)
- Photo-etched as ALICE
  - One prototype has achieved 10bar$_a$ (two channels delaminated at 5bar$_a$, but ultimate failure at 10bar$_a$)
- Next step is to co-cure a sample with CF

How can we achieve stiffness?

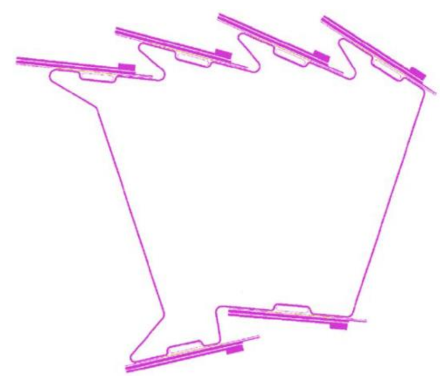
- The key is **design for large moment of inertia** (together with high modulus)
  - Ladders are poor
  - Large cylinders are better
    - But: hoop stiffness is now the challenge
    - Also: integration of large cylinders has many disadvantages
      - Large, valuable objects – difficult to move/transport
      - Technologies get challenged late in the integration
- Can one make smaller units which are clever structurally?
  - Yes, exploit the mouldability of CF (and Kapton-based service elements)!
  - Examples exist for vertex/pixel systems, need to scale by 10 in size



BNL, doi:10.1016/j.nima.2013.07.005



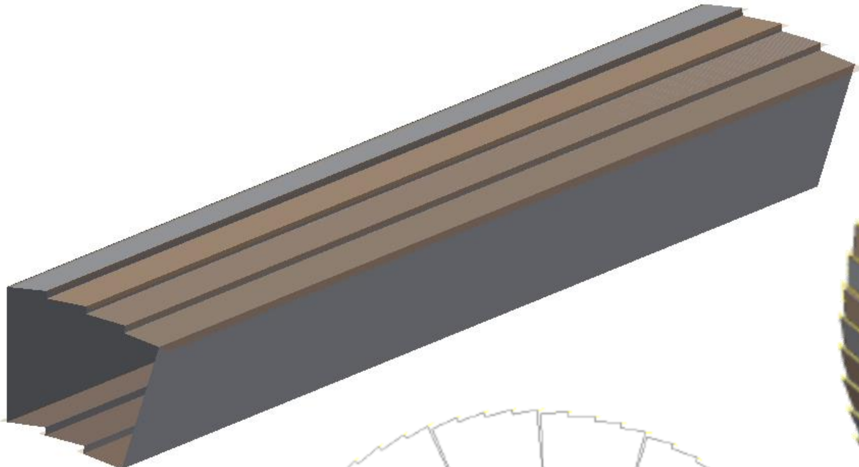
STAR, doi:10.1016/j.nima.2010.12.006

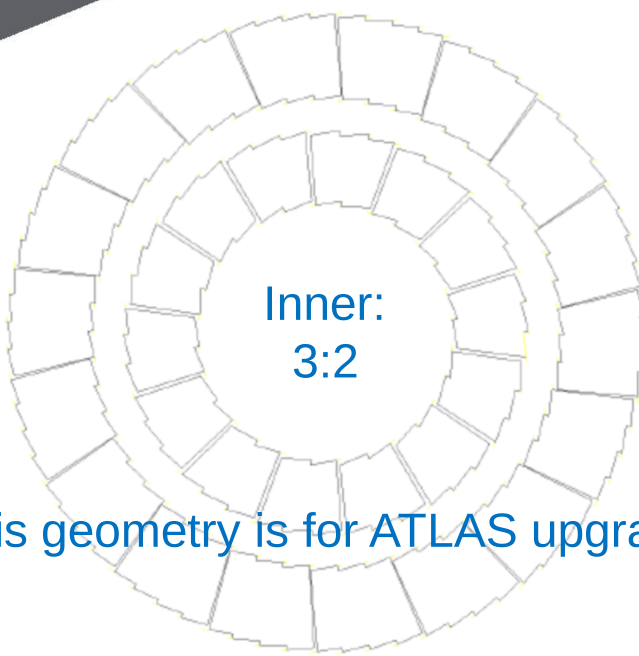


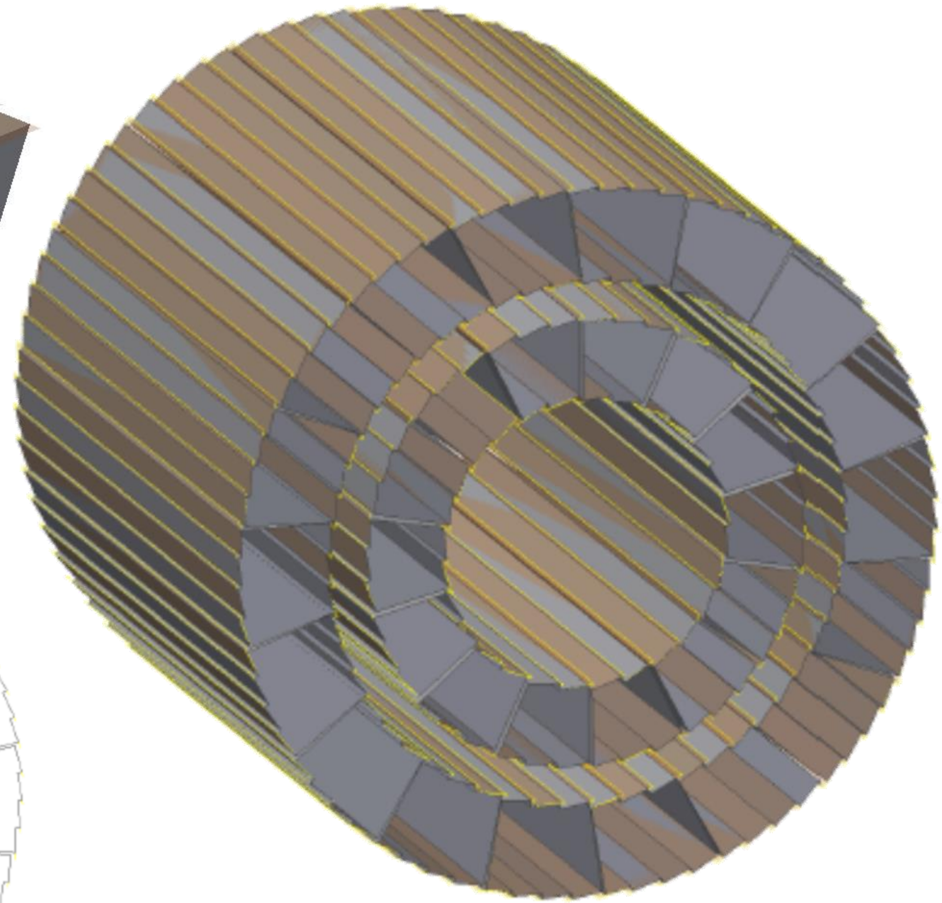
ALICE, doi:10.1016/j.nima.2006.04.093

- And, with 50μm sensors, the structures do not need to be flat…

How could this look like?







This geometry is for ATLAS upgrade dimensions, but you get the picture