Modules for the Mighty Tracker

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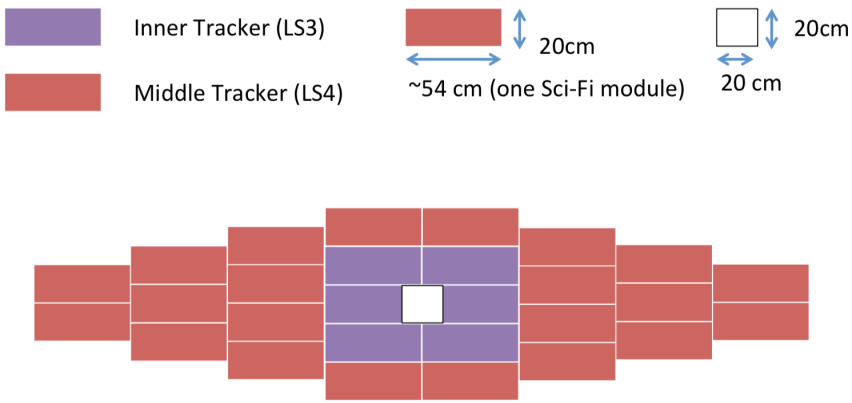
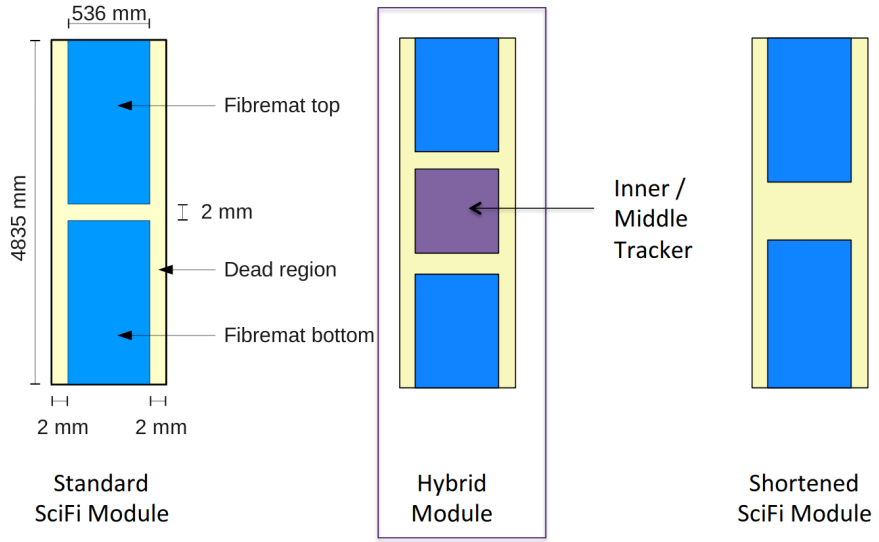
Overview

Replace central region of tracker with silicon





- Integrated with SciFi panels
- Central region built from nominally identical modules
- Exact dimensions to be optimised, constrained by SciFi in x and z
  - Initial dimensions: 535 mm $\times$ 200 mm $\times$ 40 mm

Module design influences

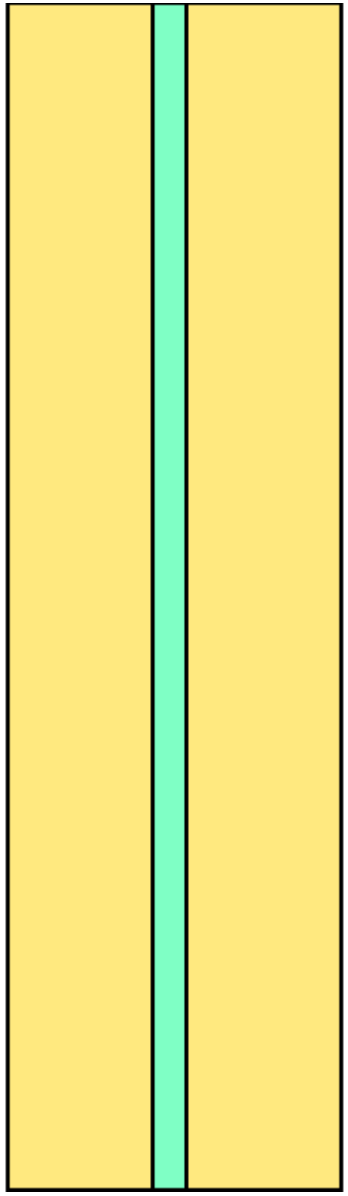
Constraints on module from several directions

- Sensor
  - Must support the sensor
  - Allow it to operated as designed
- Integration
  - Must be compatible with the SciFi
- Physics
  - Low scattering required
- Complex optimisation problem

Sensor constraints

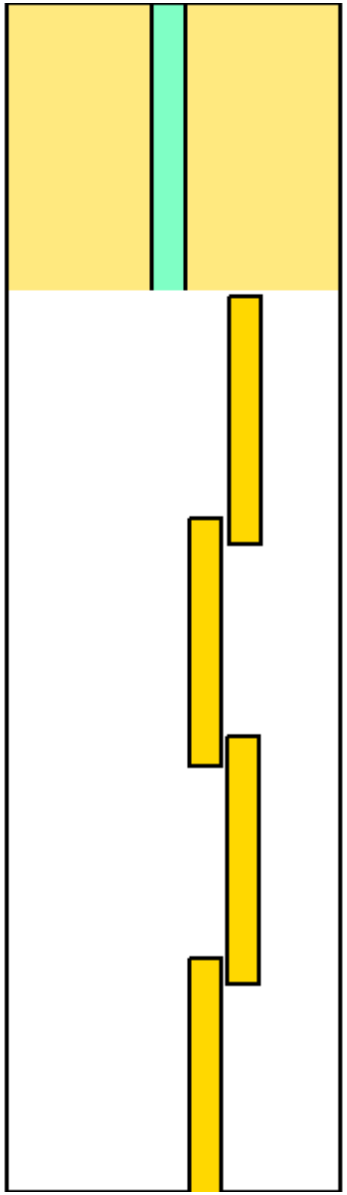
- Size: 20 mm$\times$20 mm
  - Module must contain integer number or sensors
- Dead area: All on one edge, $\mathcal{O}(5\%)$
  - Module must compensate for this with sensor arrangement
- Power consumption: $\sim$ 0.1 W/cm^2
- Operating temperature: Room temperature
  - Module must cool sensor

Integration constraints



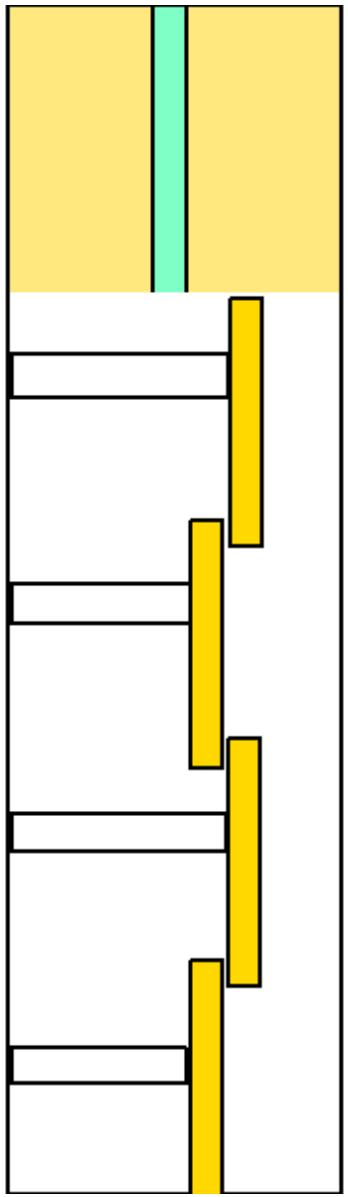
Integration constraints

- Replace fibres with silicon sensors



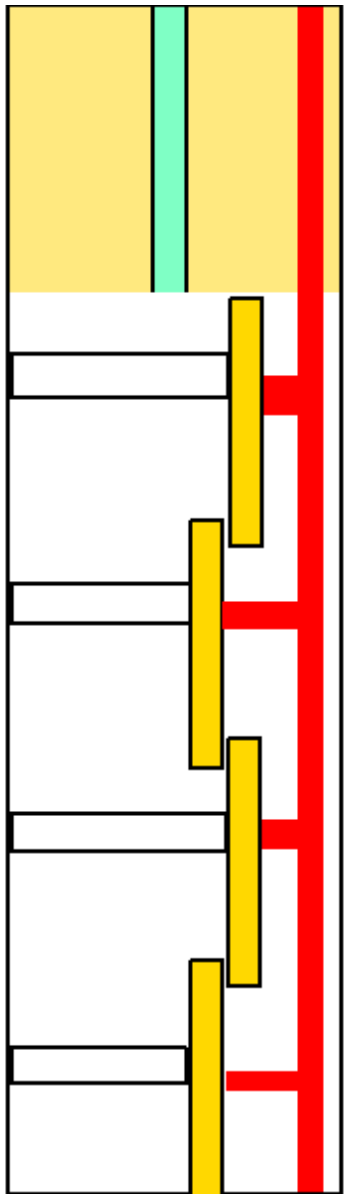
Integration constraints

- Replace fibres with silicon sensors
- Must be supported
  - Hold the sensors
  - Compensate for removed honeycomb



Integration constraints

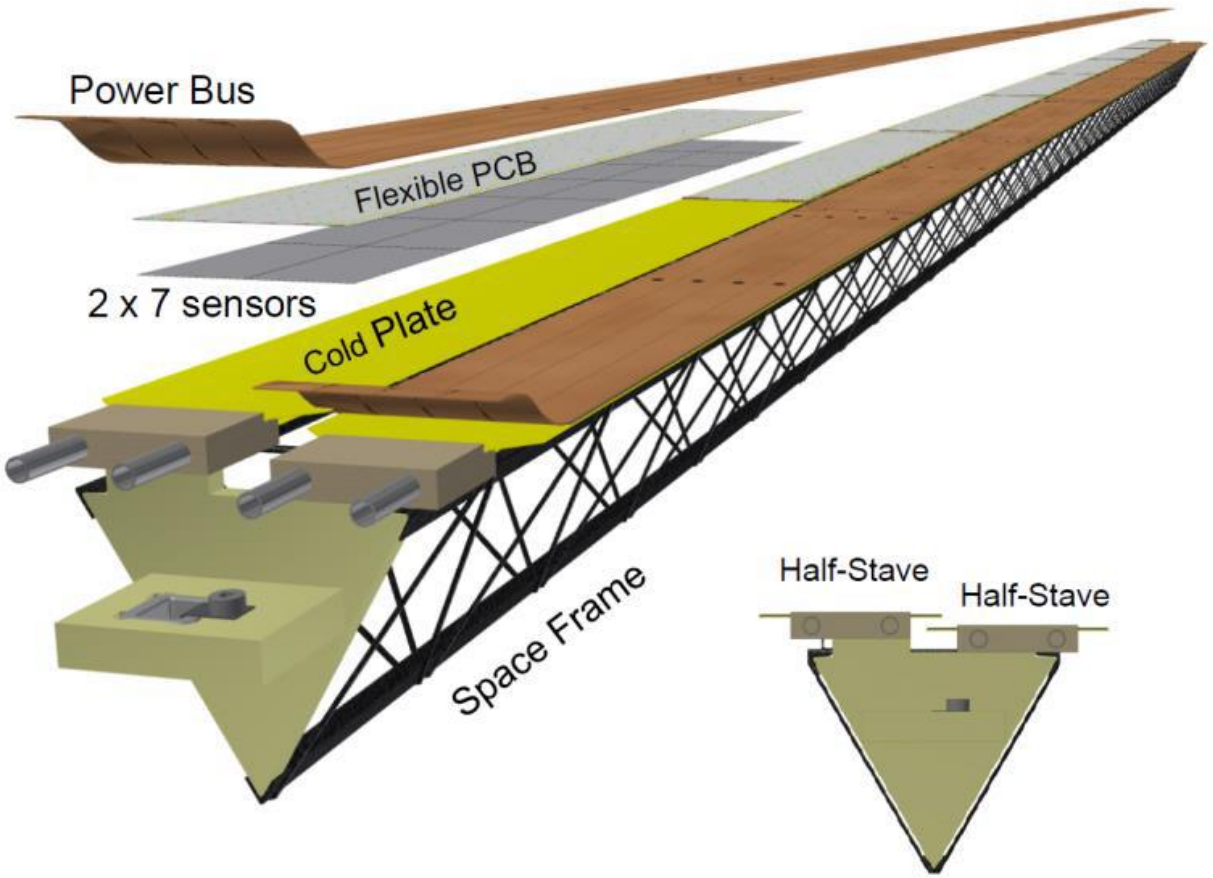
- Replace fibres with silicon sensors
- Must be supported
  - Hold the sensors
  - Compensate for removed honeycomb
- Needs power, cooling, readout



First look at a module

- Needs to compensate for sensor dead area
  - Overlap between adjacent sensors
- Allow cooling and services
- Must provide support inside SciFi
- Must be low material
- Can take inspiration from two similar projects
  - ALICE inner tracker
  - ATLAS ITk

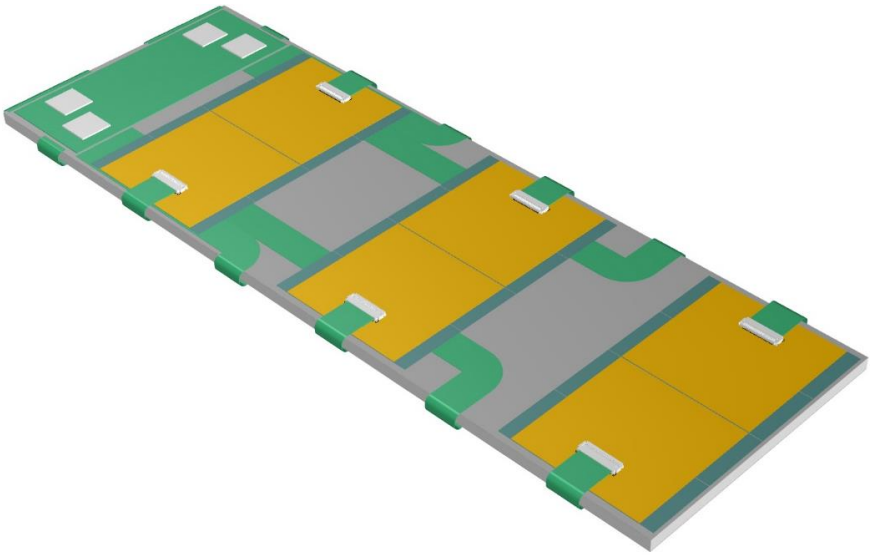
Inspiration – ALICE inner tracker

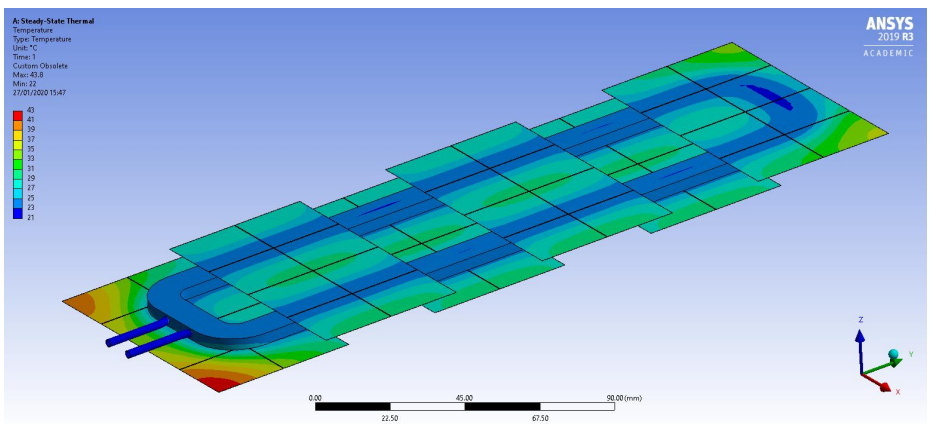


- Integrated services
- Low material budget
- Very different geometry

Several meetings with the ALICE team take place

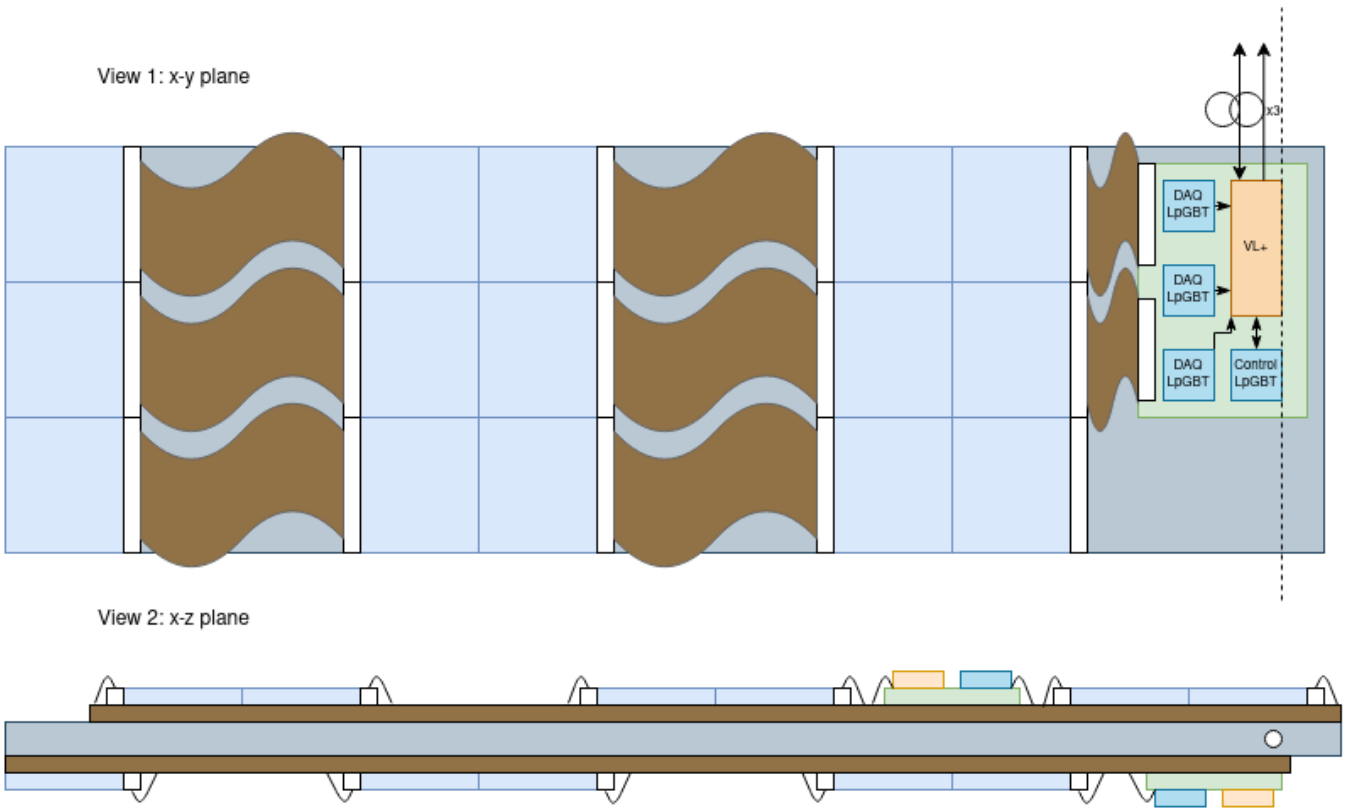
Inspiration – ATLAS ITk test module





- Similar geometry
- Similar sensor
- $\sim 1/8$ the size of a module
- Mature estimates of power/cooling to extrapolate
- Tight bends in kapton cable

MT initial concept



- Modification to ATLAS design
  - Can borrow cooling strategy
  - No bending of kapton cable

Cooling

Cooling requirements not scary, but difficulty is providing cooling within acceptance

- 200 W per module
- Operate just above cavern dew point $\sim$ 15 °C
- Initial concept water cooled
  - Extrapolation from ATLAS prototype $\sim$ 3 l/min
- Other options under investigation
  - Parasitic with SciFi cooling
  - Air cooling

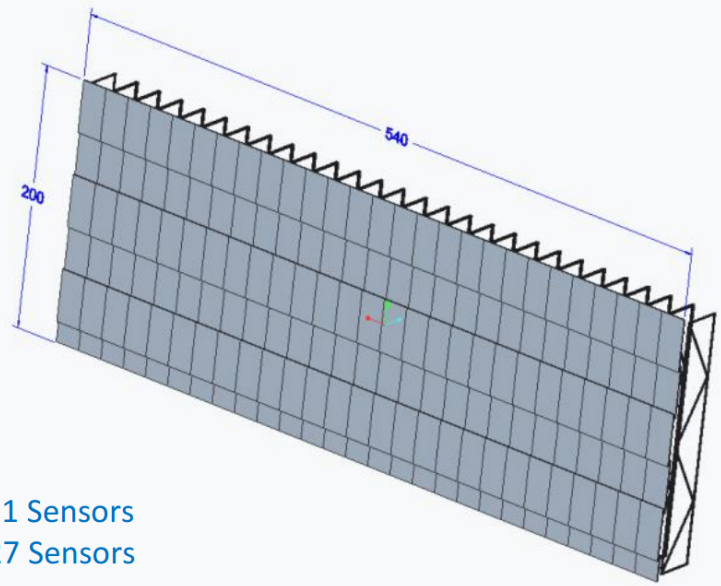
Integration

Three potential integration schemes under investigation

- Full **(Nominal)**
  - All sensors and support structure contained within the SciFi modules
- Partial (backup 1)
  - Sensors and support structure mostly contained within the SciFi modules, but some space outside used
- Independent (backup 2)
  - Essentially everything outside the SciFi modules, but mounted to them

Initial integration designs

- Light carbon fibre structure to support sensor/cooling structure
- Supported between SciFi carbon fibre skins



Some questions still need to be answered before design moves forward

Integration – open questions

Acceptable dead area between SciFi and CMOS?

- Can the U-V fibre layers cover this region sufficiently?
  - If not, will need an overlap between the fibres and silicon in X layers

How to deal with the beam pipe

- Do we need multiple module types?
- Can panels be rotations of each other?

How early in the SciFi assembly does the integration need to happen?

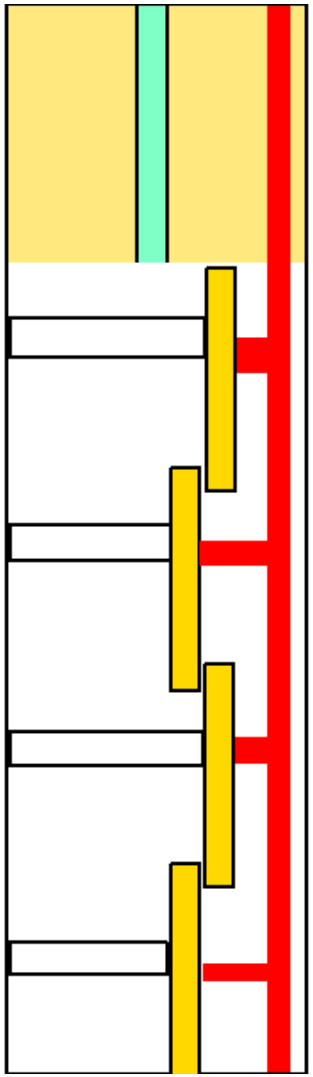
Could we extend outside a SciFi panel if needed?

- Probably not needed

Service routing

Two potential service paths investigation

- Integrated **(Nominal)**
  - Runs within the SciFi modules
- Outside (backup)
  - Runs on outer surface of SciFi modules



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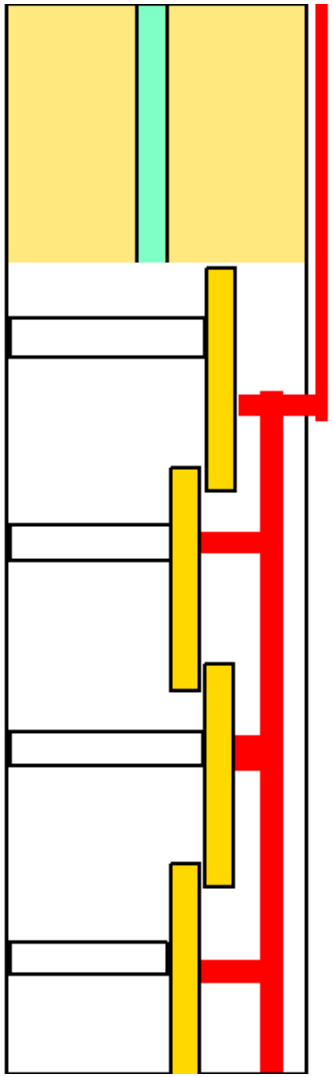


Services – open questions

How much cooling is required?

- Studies of the ATLAS module suggest water is plausible

How many fibres

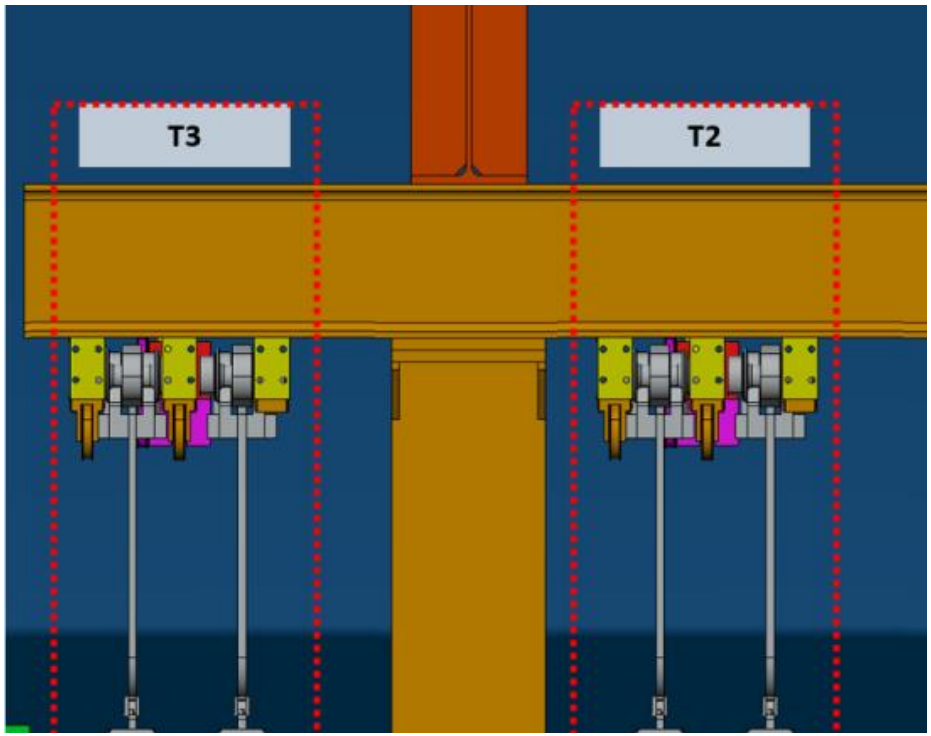
- Current DAQ estimates suggest $\sim$ 200 fibres per module

How many copper services

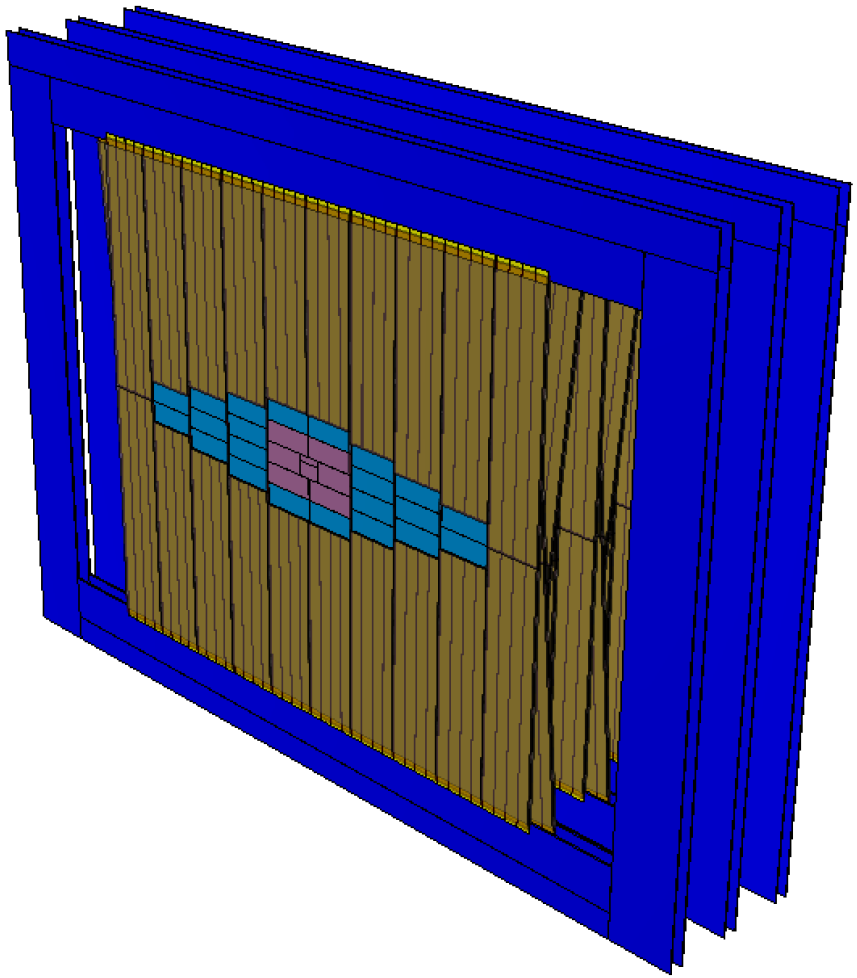
- Can make reasonable assumptions from the ATLAS modules

What does it mean to extend beyond the SciFi modules?

- $\sim$ 30 mm between layers
  - Would prefer not to reduce inter-layer space
- As only using X layers could
  - Use $-$ve z at front of station
  - Use $+$ve z for back of station
- Would still need to be careful of pillars and RICH 2



Simulation



- DD4HEP geometry implemented
- Support material being included
- Soon can be used to optimise module design

Summary

- Plausible initial concepts for module
- Several options for integrating with the SciFi being investigated
- Needed services being investigated
- Simulation advancing well
- In good state to advance module design

Backup