ATLAS Pix3 based tracker demonstrator discussions

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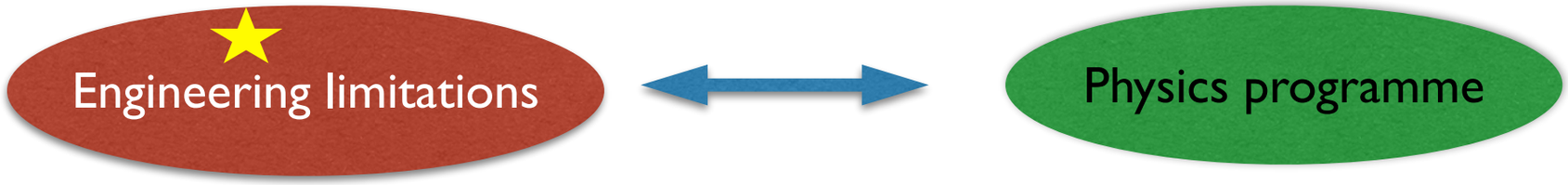
Second UK workshop on HV-CMOS tracker for e+e- colliders, 1-June-2020

Starting point

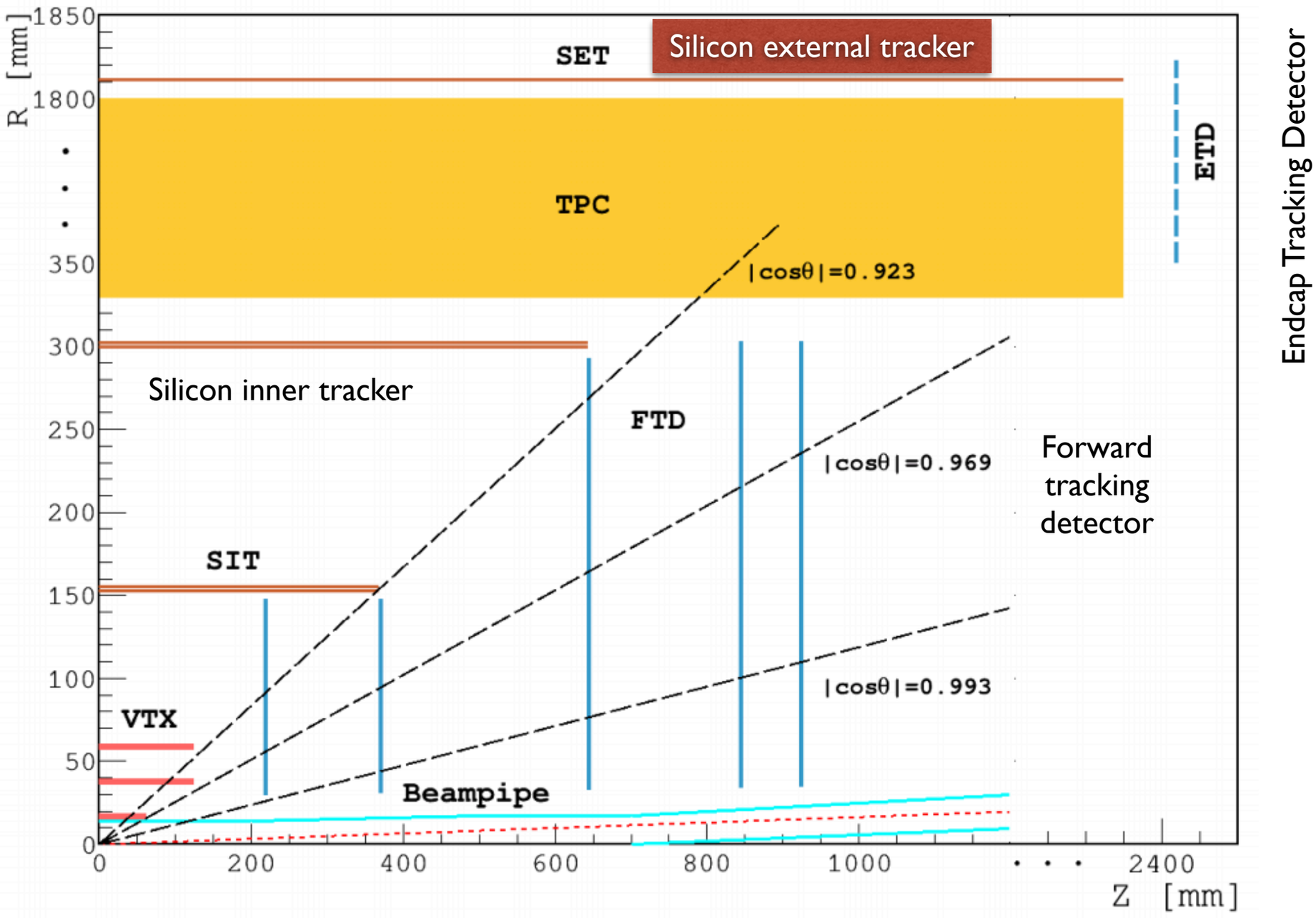
- There is essentially NO specifications on the tracker
  - A wishlist can be found via the CDRs from various proposals



- Goal of this demonstrator
  - Establish what can be achieved using the state-of-the-art solutions
    - We simply do not have resources (mostly limited by staff time) to do further
  - Define the challenges and directions for future R&D with more funding/staff time
  - At the end (~end of 2022), we will have a credible, UK unique, and flexible programme
    - Suitable for large area application for any e+e- collider experiment
- What drive the key considerations for demonstrators?
  - Large area applications: low power, scalable, and modular
  - A long-term UK strategy on the HV-CMOS program

The "Baseline" Tracker in CDR

Caveat: baseline is really just a starting point, fresh physics and R&D program are ongoing to redefine this



Endcap Tracking Detector

Except FTD 1+2, all use 2 layers of back-to-back mounted single-sided strips at an stereo angle

Sensor: 10 × 10 cm², pitch 50μm, Thickness <200μm

Strip design with ~300-400 μm thickness per layer alone gives 0.3-0.4% X_0

Effective silicon area for strip: 160m² , pixelated design reduces to 80m²

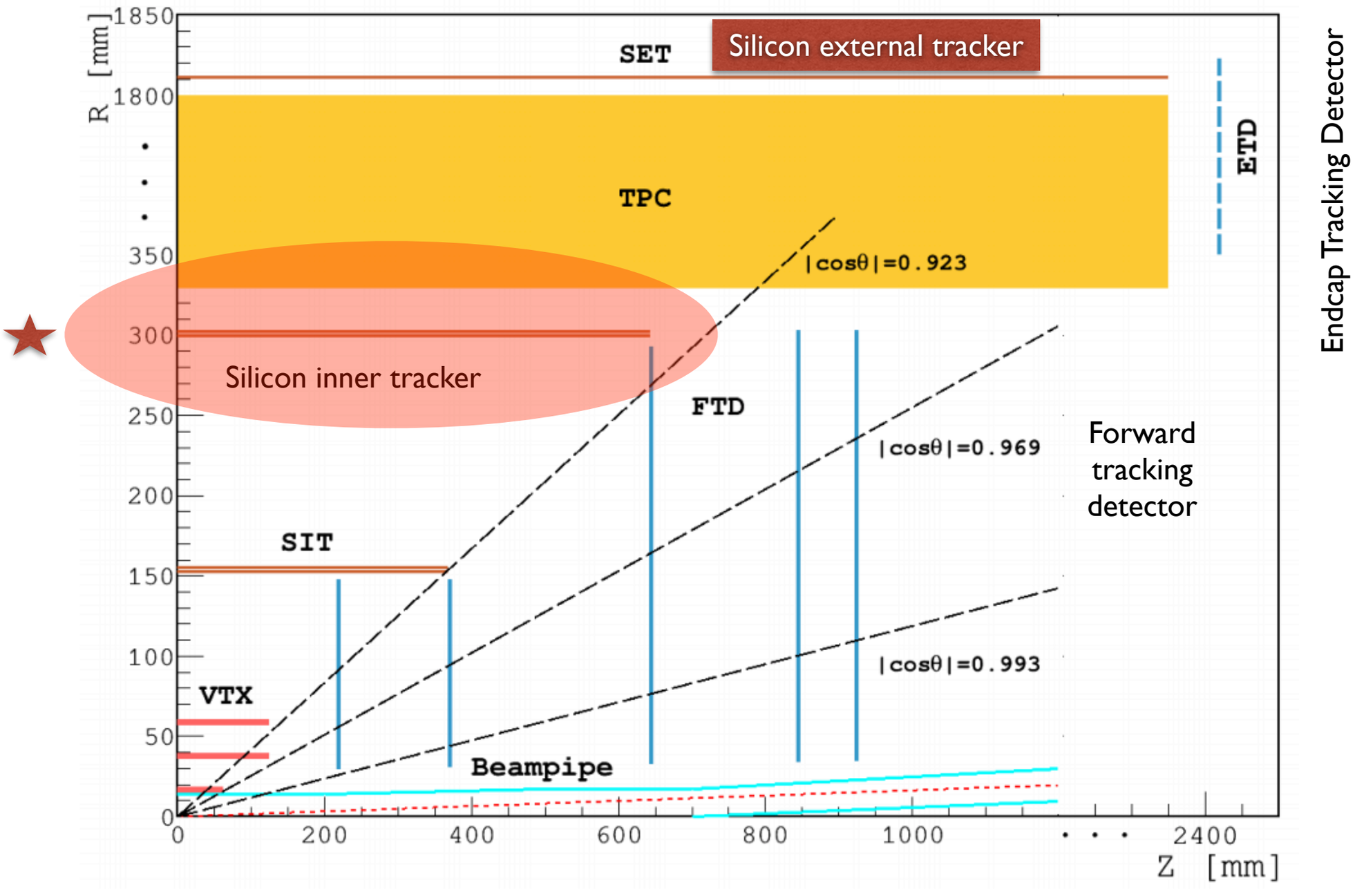
Closer look

	With TPC	All silicon
Barrel	SIT-L1: R=0.15m, L=0.75m → A=0.7m² SIT-L2: R=0.3m, L=1.33n → A=2.5m² SET: R=1.8m, L=4.7m → A=53m²	?
Endcap	FTD D1-D5: 1.8 m² ETD: R_{out}=1.82m, R_{in} =0.42m → A=20 m²	
$\sigma_{SP\ (r\phi)}$	7 μm	
$\sigma_{SP\ (Z)}$	Very loose ~ 100 μm	
Timing	25 ns	
Max* Occupancy	SIT-L1: 0.6%, SIT-L2: 10^{-3}, SET: 10^{-4}	
Radiation	TID ~< 1kRad/year, NIEL ~< 10^{10} 1 MeV neq /cm². year	
dE/dX	-	2-3% @ pT [2-10]
X/X_0	0.65% Barrel 0.5-0.65% Endcap	?

- SET+ETD: 73 m² out of the total area of 78 m²
  - Given the large difference w.r.t. the rest, we may end up with different technologies
  - What are the realistic target we should aim for in this demonstrator?

**Assumption: Pixel dimension: 50 μm × 350 μm, readout time: 10us, Cluster size: 9 hits per track*

The "Baseline" Tracker in CDR



December 2019 discussions (in RAL)

- Tracker prototype deliverables (2 Year plan)
  - A local support structure with sensors on
- Short-term milestones
  - 2-3 Quads with Zif connectors?
  - CF space frame - Hongbo
  - Cold plate
- Long-term R&D considerations
  - New sensor/chips
  - Chinese fab
  - Aluminium flexes?
  - Copper (1oz/ft^2, 35um thick) is about 0.2% radiation length
- Impact of the alignment on the overall tracker design
- Full size support for the outer layer

Link to discussion google doc

Goal for today's discussions

- We hope to converge on a set of essentials and desirables in the following 4 areas
  - Sensor and chips
  - Electrical and system
  - Readout and DAQ
  - Mechanical support structure

Sensors and chips

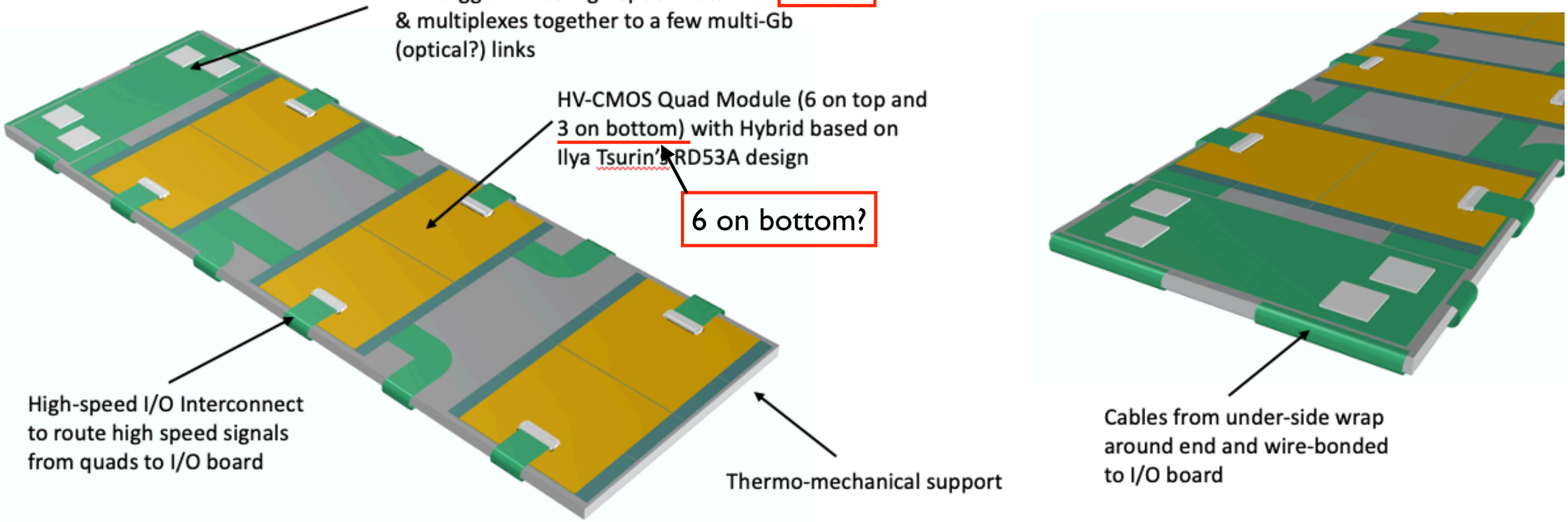
- Essential
  - ✓ ATLAS Pix3
- Desirables
  - Contribute to the subsequent engineering runs and submissions

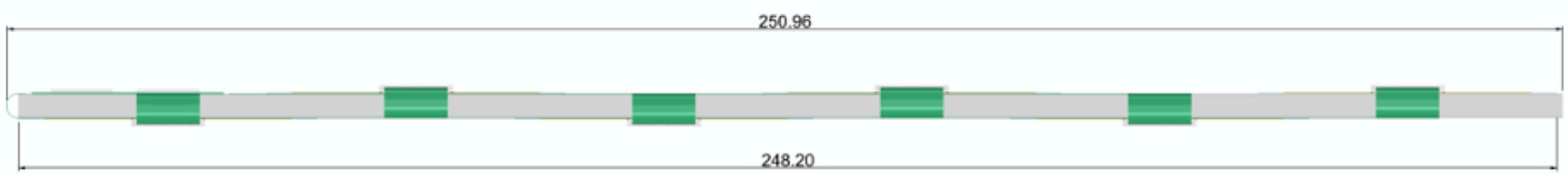
Electrical system: Tile concept proposed by Tim Jones

- See talks by Tim in the last UK meeting Link to Tim's talk

Tile Conceptual Design

Overall: 8cm × 35cm





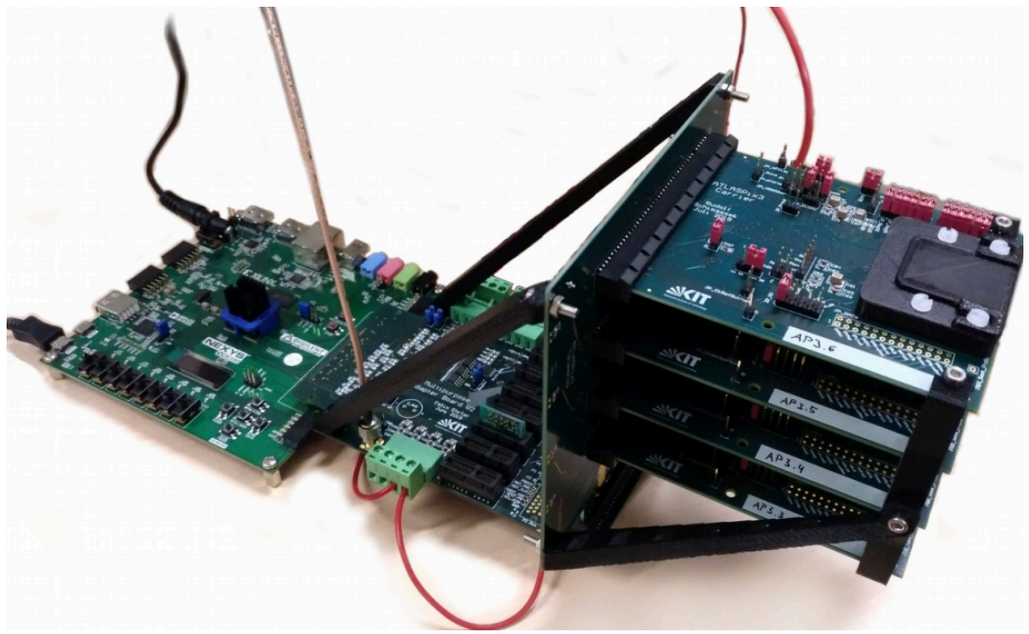
Electrical system

- We will start with charactering 1-2 quads
- Shall we aim to readout all 48 chips simultaneously
  - What can we gain in comparison to the 1-2 quad electrical modules
    - System design
    - First glimpse of potential service routing
    - Identify the "limit" of a modular design
- Essential electric solutions
  - Quad flex from Milano, see recent talks in this link by Attilio Andreazza
  - Bus-tapes
  - Is serial powering essential?
- Desirables:
  - Optical solution using GBTx or LpGBTx

Readout DAQ

- The KIT GECCO readout system
  - See Rudolf Schimassek's talks
    - Link to CEPC tracker meeting talk
    - Link to UK e+e- collider HV-CMOS mtg
  - Find out the max chips this can be configured
  - ✓ PCBs have been ordered

- YARR
  - Hardwares ready
    - Non-trivial firmware adaptation
- Caribou system
  - ATLAS Pix3 solution in principle ready
  - RD50 collaboration is organising purchase for the next version
  - Most UK institutes do not have yet the expertise



Mechanical support - essentials

- Support structure
  - 8cm × 66.6cm structure to be made for the intermediate tracker layer (SIT-L2 in CDR)
  - This can in principle host two tiles
  - Cold plate
- Cooling
  - Foam with Ti cooling and facesheet
    - Liverpool FEI4 demonstrator or the Strip stave might be a good starting point
  - Graphite (this was already explored in the UK Ring-0 prototype, see Jon's talk above)

Mechanical support - desirables

- Support structures
  - Space-frame like truss
- Cooling
  - Micro-channel