

# UK SILICON REPORT

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*LCUK Liverpool*

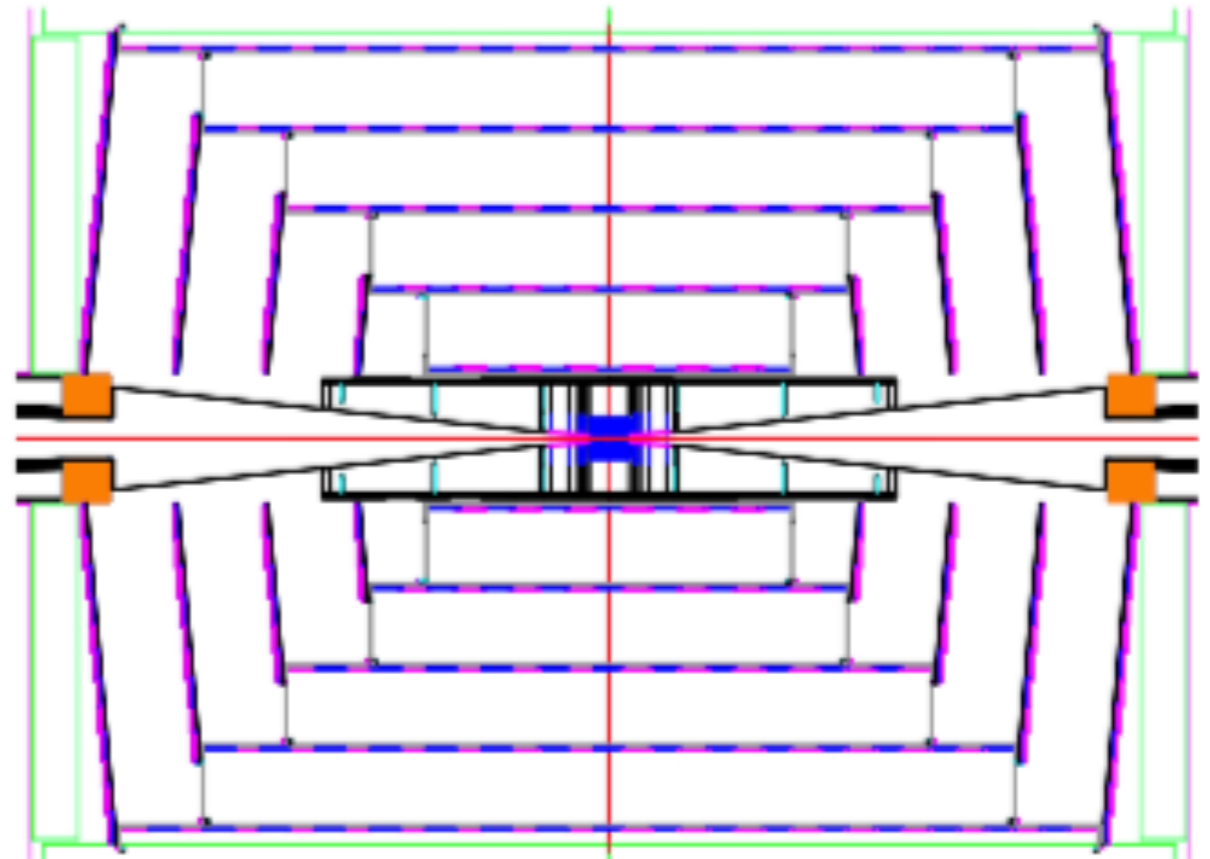
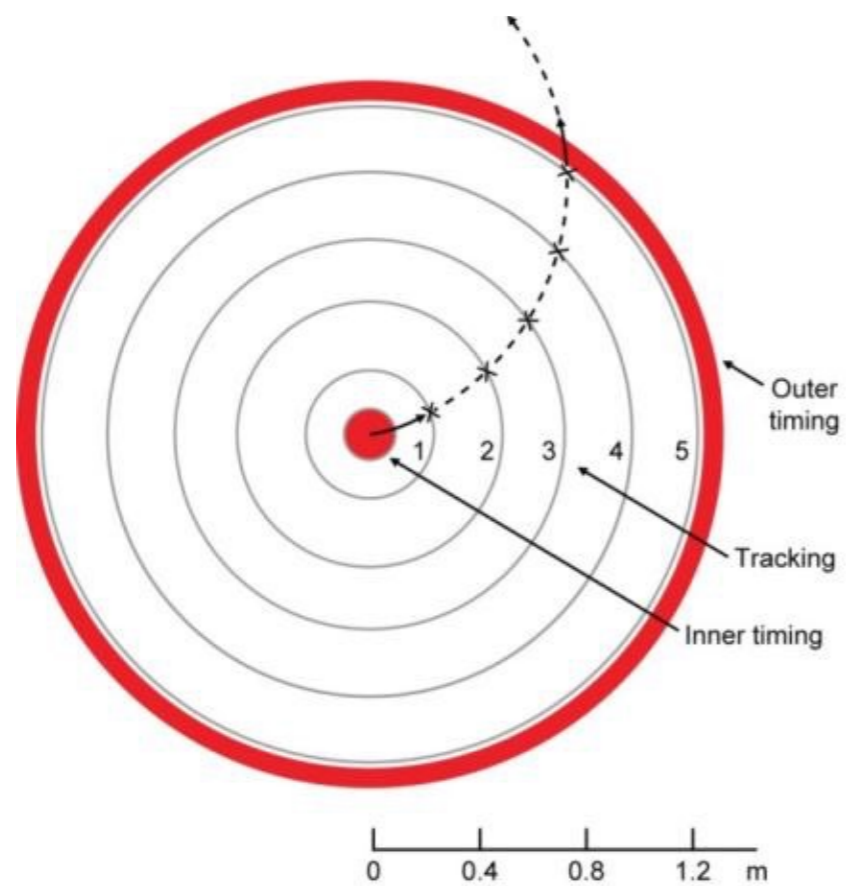
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# Overview

- \* Decided to focus on pixel tracker for 2014 proposal
- \* Strong UK expertise and opportunity for leadership
- \* First meeting in Bristol in November 2014
- \* Monthly(ish) meetings in 2015, mainly remote
- \* Interest and activities from many institutions:
  - \* Bristol, Edinburgh, Glasgow, Lancaster, Liverpool, Manchester, OU, Oxford, QMUL, RAL
- \* Broadly organised into three activities:
  - \* Systems, Simulations, Engineering
- \* Overview of work in next few slides...

# Previously...

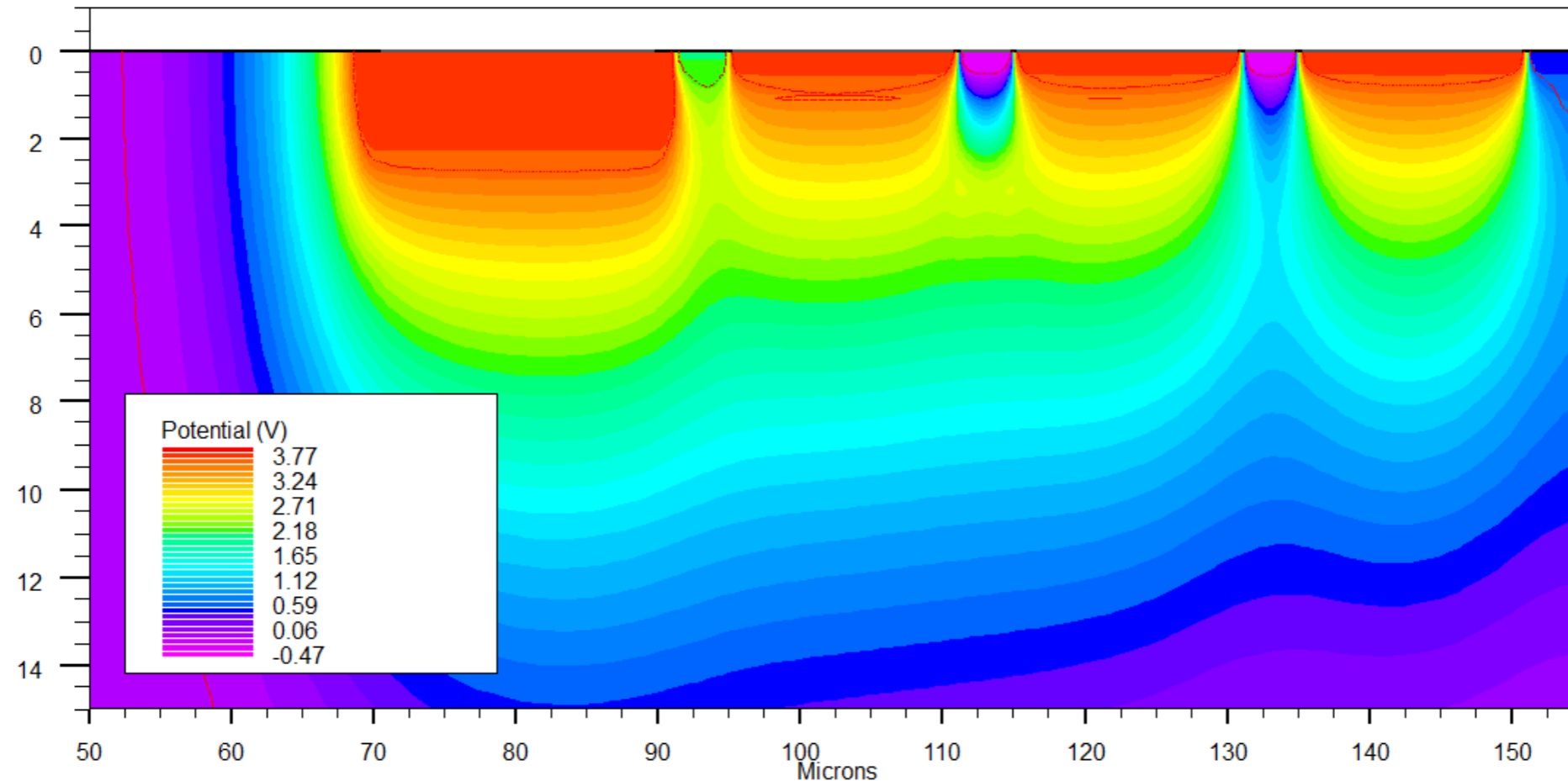
- \* SiD Strip Tracker
- \* SPT Concept



# Systems

- \* List of requirements and operating parameters
  - \* Physics drivers, power estimates etc.
  - \* <https://wikis.bris.ac.uk/display/lcsi/Tracker+Requirements>
- \* Definition of straw man design
  - \* Silicon module design
  - \* Overall layout
  - \* <https://wikis.bris.ac.uk/display/lcsi/Straw+Man+Design>
- \* Keeping informed on sensor technologies
  - \* Developed for other applications
  - \* UK and elsewhere

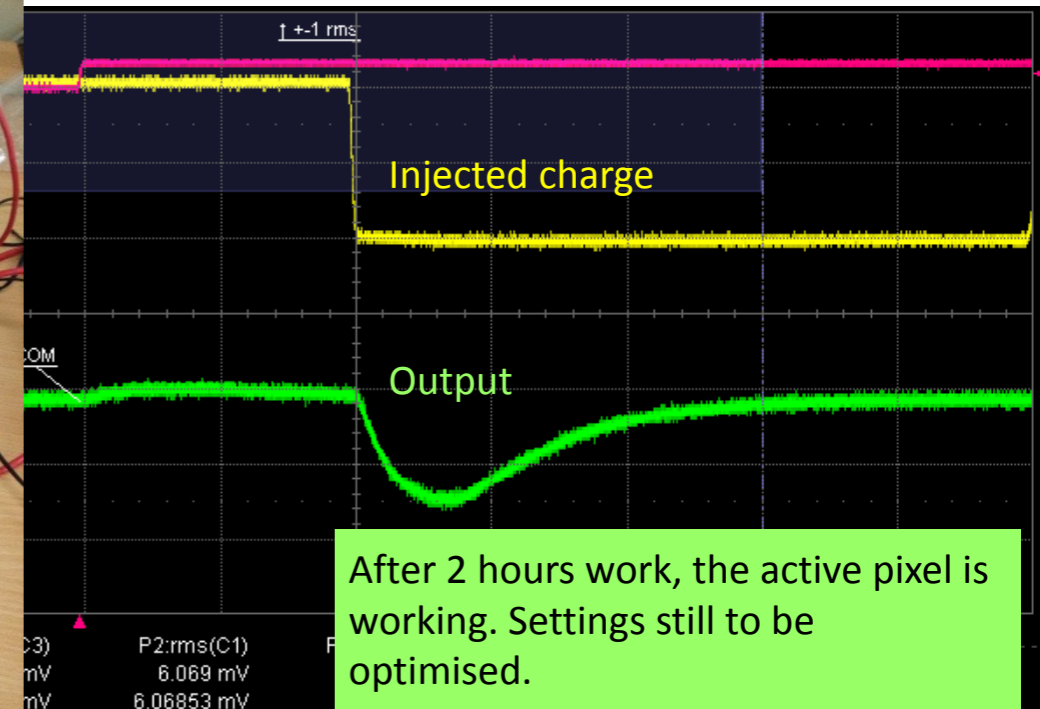
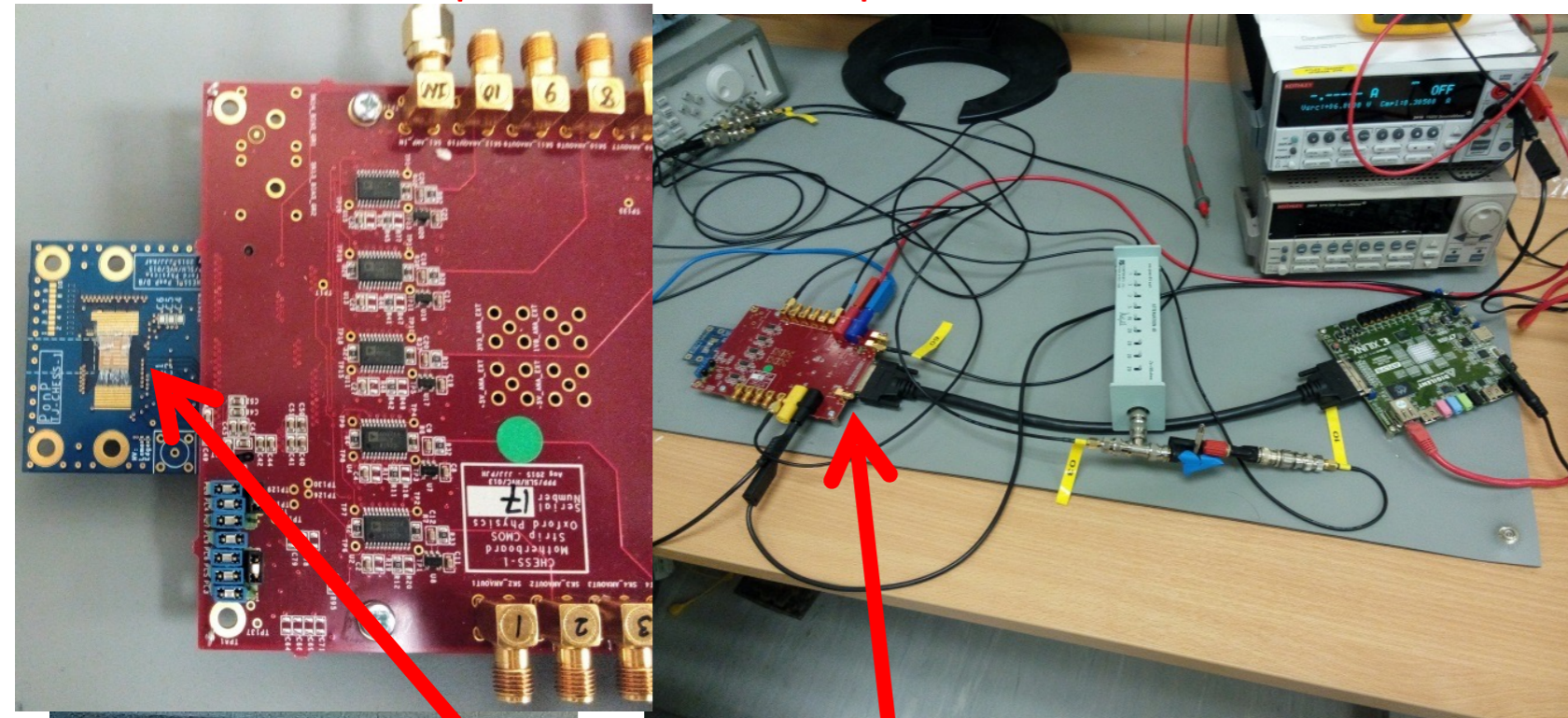
# Sensor R&D



- \* Fully-depleted HV/HR-CMOS MAPS
- \* Capacitively-coupled HV-CMOS
- \* HR-CMOS

# HR-CMOS MAPS – OverMOS1

- First HR-CMOS chips tested Tuesday 26<sup>th</sup> January 2016
  - 25  $\mu\text{m}$  epi High Resistivity split version 40  $\mu\text{m}$  x [40,80,400,800]  $\mu\text{m}$  pixels.
  - 18  $\mu\text{m}$  epi HR version split should arrive today.
  - 4 other splits still to be diced.
  - Roughly 20 structures of 5x5 pixels on each: passive pixels, active pixels, isolated amplifiers, different pixel sizes and shapes.



min	394 mV	6.069 mV	330 mV	225 $\mu\text{V}$
max	409 mV	6.069 mV	353 mV	1.8 mV
sdev	3.15 mV	---	4.26 mV	604 $\mu\text{V}$
num	296	1	296	5
status	✓	✓	✗	✗

C1	AVG ACTM	C2	A F DC1M	C4	DC1M
5.00 mV/div	5.00 V/div	200 mV/div			
14.000 mV	14.800 V	-2.4700 V			
296 #	296 #				

Timebase	-2.04 $\mu\text{s}$	Trigger	C2
	1.00 $\mu\text{s}/\text{div}$	Stop	950 mV
	50.0 kS	Edge	Positive

Jaya John (Oxford) m/  
board (CHESS) and d/  
board

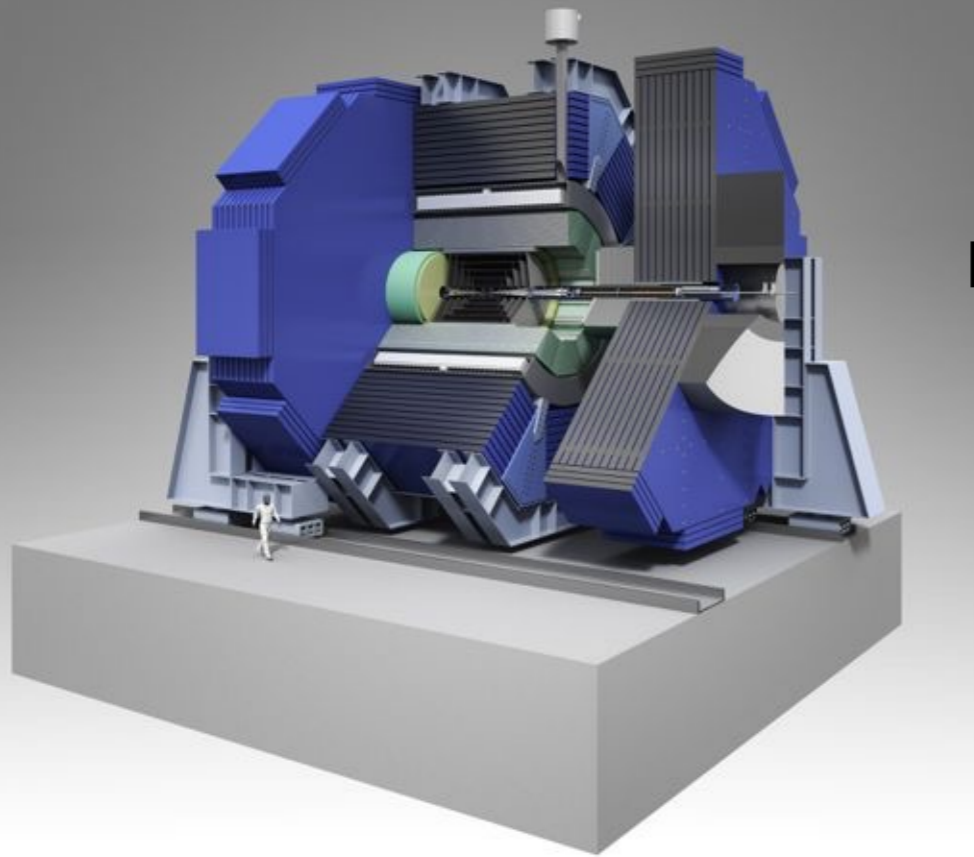
OverMOS 1

Starting this week: lasers (TCT and back illumination), neutron irradiation, x-ray irradiation, ... Samples being sent to interested partners as fast as we can.

# Simulation

- \* Simulations critical to answer important questions
  - \* Pattern recognition → readout speed → power → cooling
- \* So far using SiD framework
  - \* Not always optimal
  - \* Poorly supported
  - \* *SiD is now switching to DD4HEP*
- \* Glasgow making good progress nevertheless...

# Tracker studies for SiD



SiD LOI: Tracker consists of vertex detector  
+ 5 strip tracker layers

Developing pixel tracker concept  
in context of LCUK

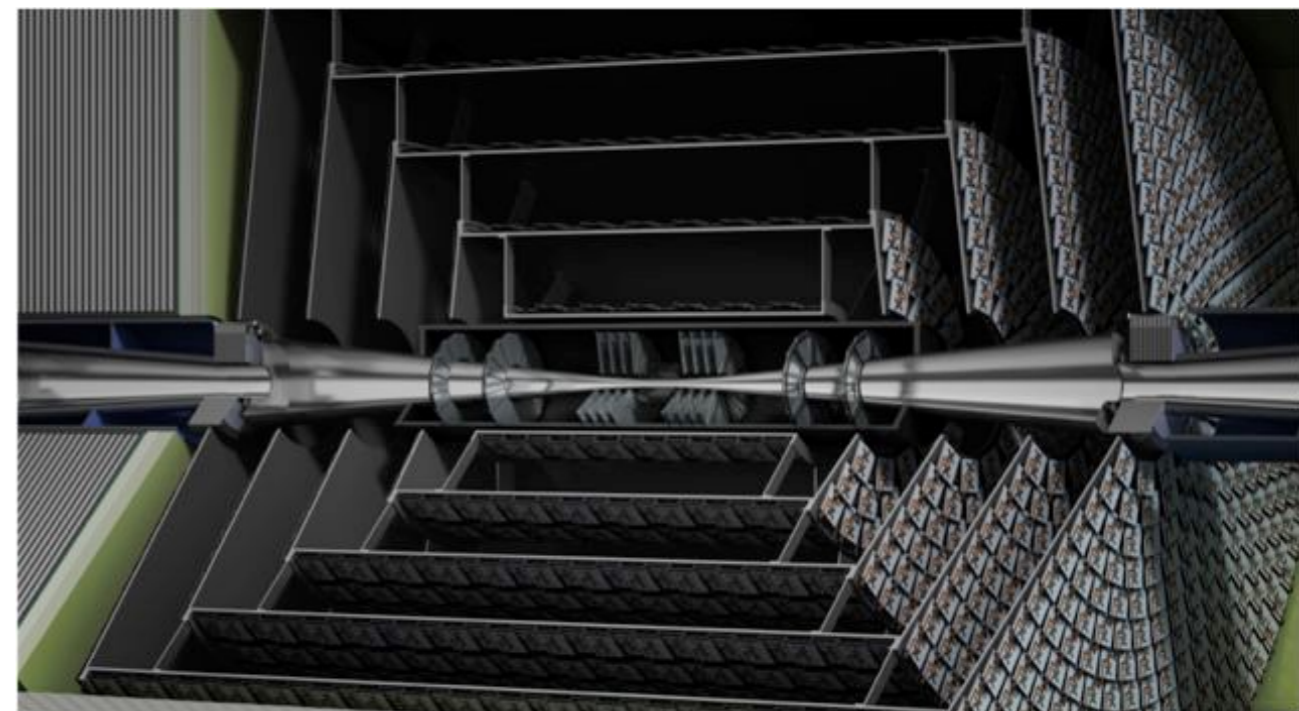
**LOI 2009 -> TDR 2018?**

Glasgow: Aidan Robson,  
Dan Protopopescu,  
Neil Warrack (UG student)

Using existing SiD SLIC simulation  
(not new DD4HEP simulation – see this afternoon)

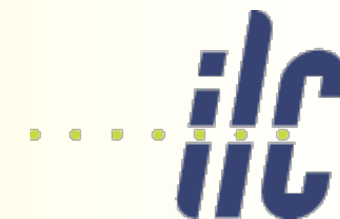
Starting from SiD LOI3 model  
(used for LOI physics studies)

- ◆ Removing tracker layers
  - stability of efficiency / resolution?
- ◆ Pixellating strip layers in tracker
  - effect on resolution?
- ◆ Benchmarking with single muons and with t-tbar events
  - first isolated particles, then busy events





# Tracker studies for SiD

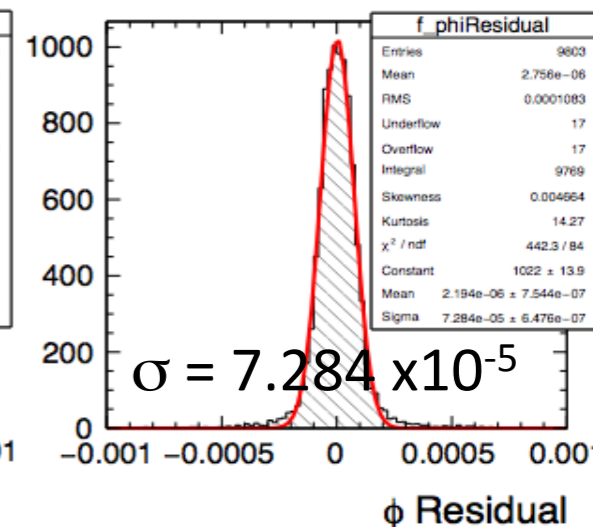
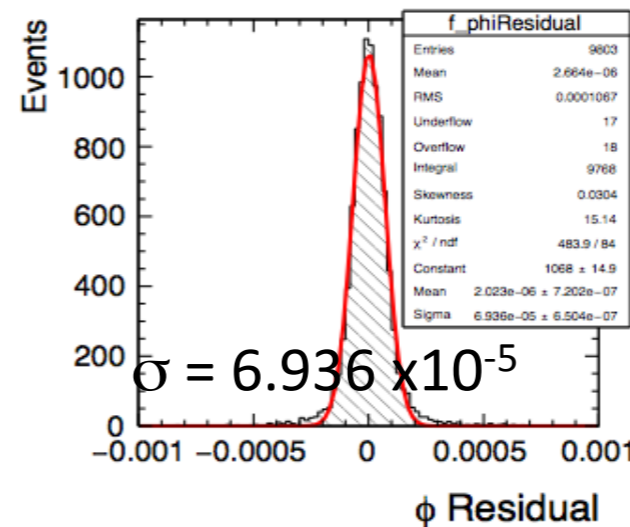
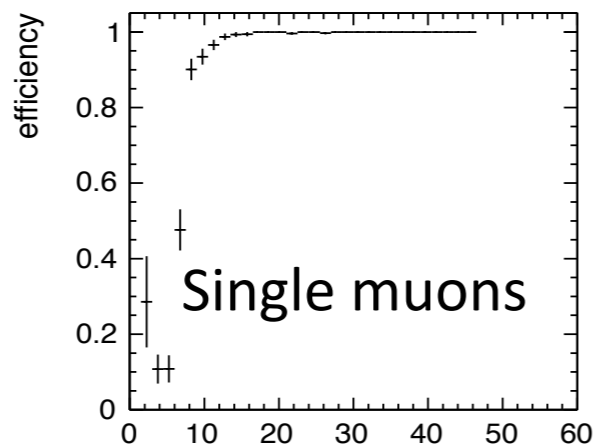
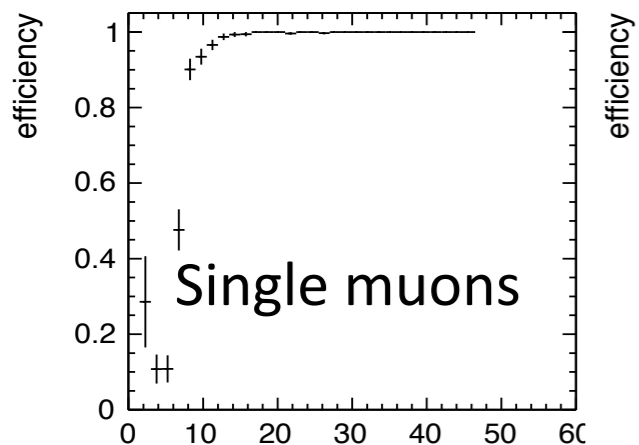


original layout

tracker layers  
3 & 5 removed

original layout

tracker layers  
3 & 5 removed



Single muons: overall track-finding efficiency found **robust** against losing outside layers...

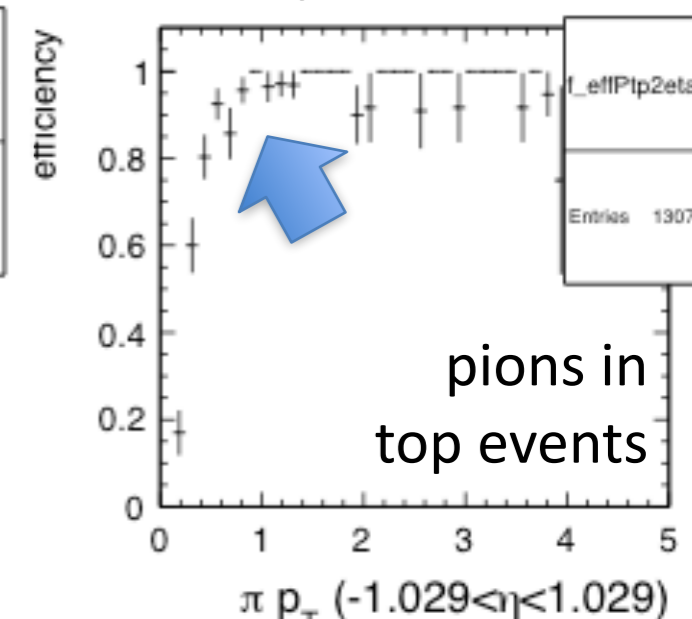
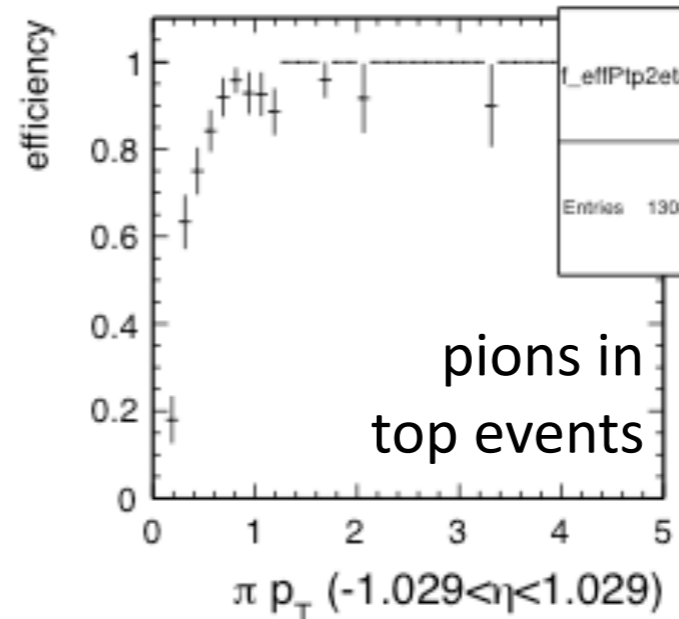
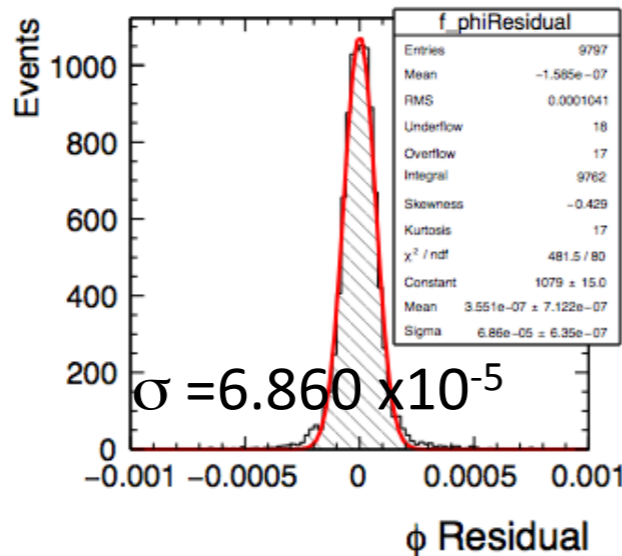
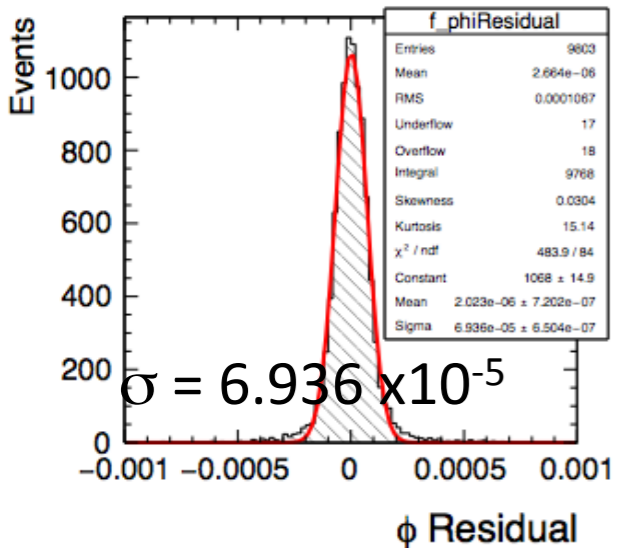
(as expected) → ...but resolution degraded.

original layout

high granularity  
layers 3 & 5

original layout

high granularity  
layers 3 & 5



Increased tracker granularity improves resolution ...and improves efficiency for pions in top events

– first steps in overall optimization

# Tracker studies for SiD



Lots of unexpected technical problems along the way...

- running full simulation and reconstruction
  - with modified model
  - and verifying that the hits in the modified layers were really being used
    - ...was non-trivial

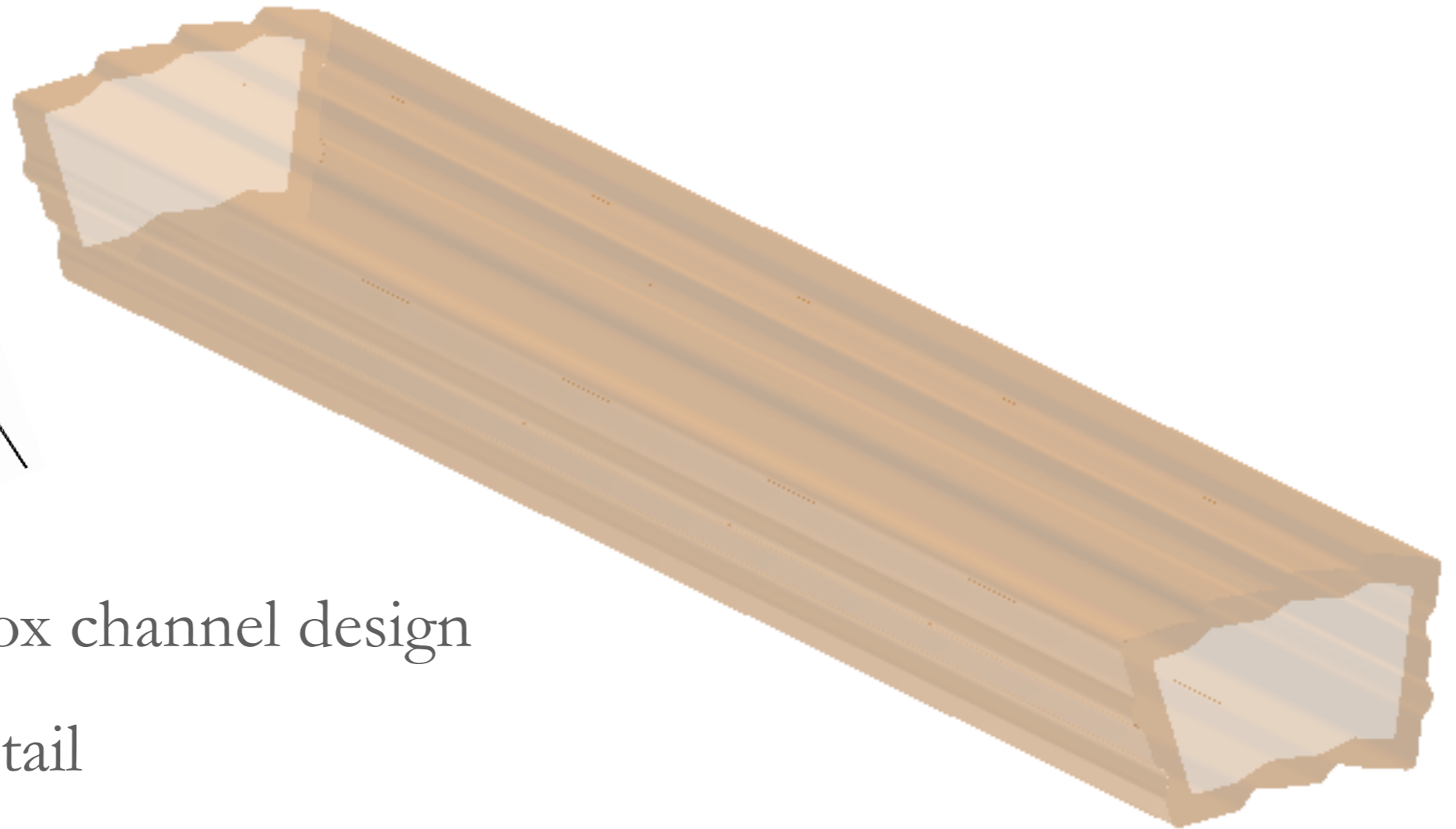
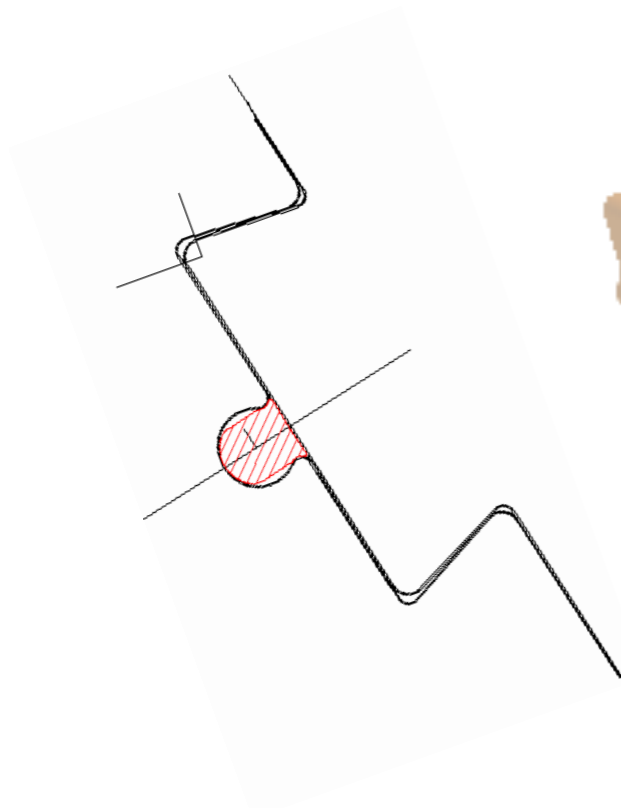
We started now to get some results.

- started also next steps:
  - one layer missing compensated by higher-granularity layer
  - splitting by eta and pt etc

Plenty of effects are not (yet) taken into account:

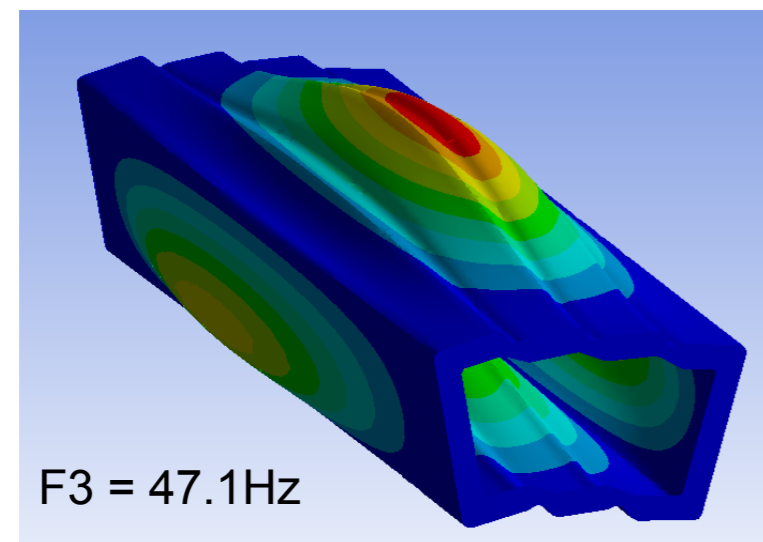
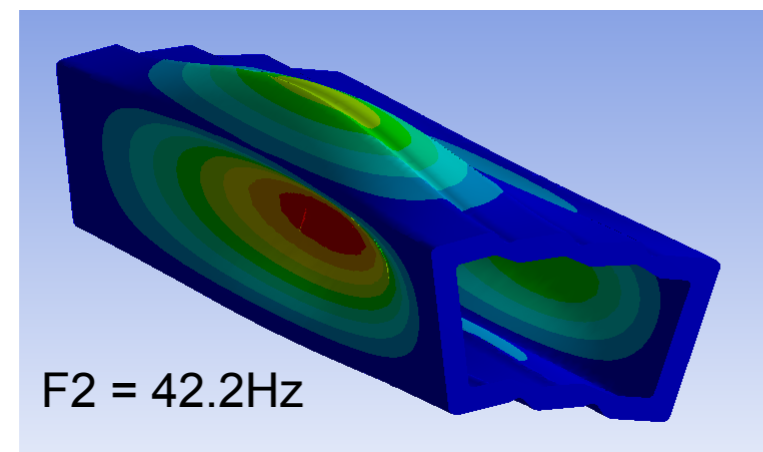
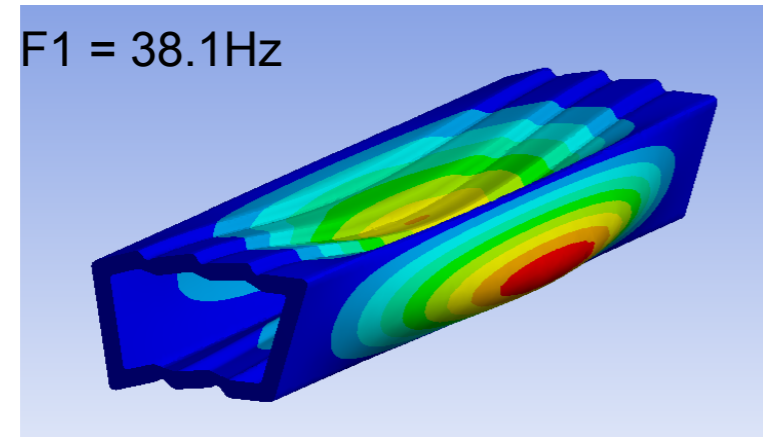
- layers with extra granularity have same material as strip layers
  - material needs to be more realistic
- timing information is not included

# Engineering



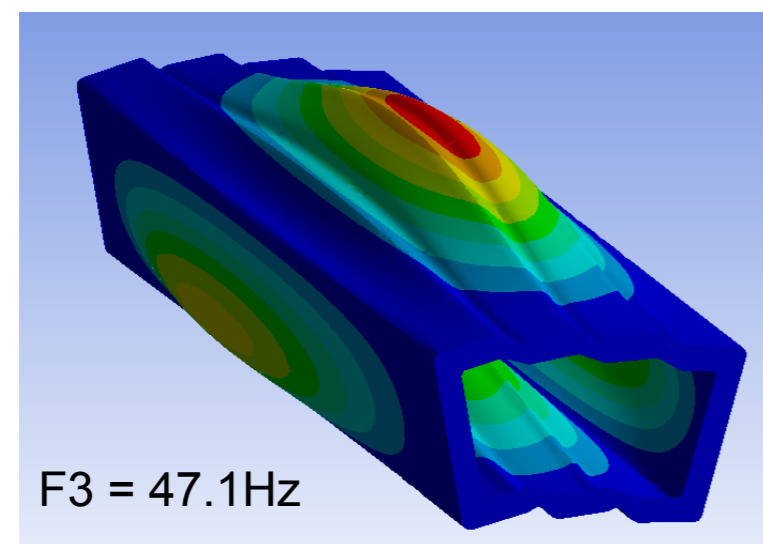
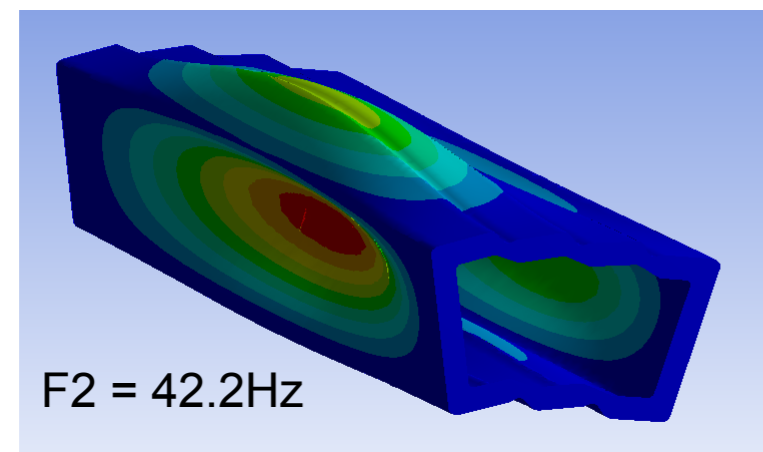
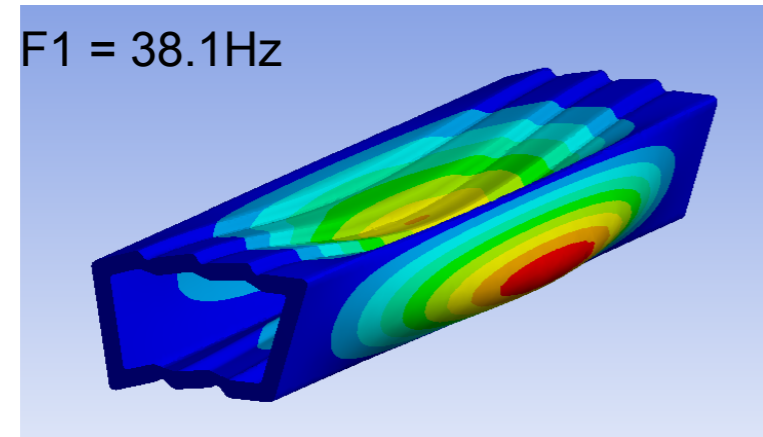
- \* Focusing on box channel design
- \* Joined by dovetail
- \* Inherently stiff
- \* Channels cooling airflow

# Studies



- \* FEAs performed
- \* Results very promising
- \* Need to prototype
- \* Need to test heat transfer

# Studies



- \* FEAs performed
- \* Results very promising
- \* Need to prototype
- \* Need to test heat transfer
- \* Need cash (~20k)

# Mechanical Prototyping of Support Structures for Future Low Mass Trackers

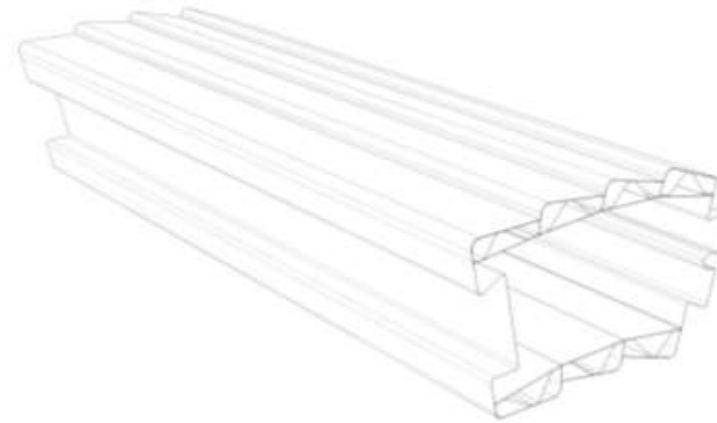
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Peter Cooke, Tim Jones, Wing Lau, Georg Viehhauser

21/12/15

## Introduction

A candidate design of the mechanical support structure for a low-mass high precision barrel-region tracking system builds on the on-going developments for the ATLAS Tracker upgrade. We envision a multi-module structure which runs the full length of the barrel tracker and supports detector modules of facets on two opposing faces of the structure. An assembly of 14 such modules will form two measurement layers. The figure below shows a 1m long section of a box-structure.



## Proposed Programme

The key aspects of the proposed programme are to;

1. Investigate the extent to which connecting neighbouring structures along their length enhances the overall structural stiffness allowing a lower mass solution to be developed for a certain material budget.

We intend to manufacture three simple box-sections (i.e. without cooling channels) which exploit a cam-lock system which is intended to high-friction interface between neighbouring box-sections. Estimated cost £3,020.

2. Investigate the efficiency of removing the heat generated by the active components by air cooling via linear duct-work which can form part of the overall mechanical structure.

We intend to develop the tooling to manufacture 1.5m long cooling channels and to manufacture 10 of these from CFRP. Two cooling channels will be used for thermal evaluations and 7 will be used to assembly a full box-section.

# Summary

- \* Silicon pixel tracker now technologically possible
  - \* Could offer several advantages
- \* UK establishing itself as leader
  - \* Utilising related technology development
  - \* Simulations (in software old and new)
  - \* Novel engineering concepts
- \* Aiming for coherent proposal in  $\sim 1-2$  years

# Summary

- \* **Simulations**

- \* Baseline plus options

- \* Determine requirements (granularity, #layers...)

- \* **Engineering**

- \* Mechanical design concept

- \* **Systems**

- \* Power, cooling, electronics etc.

- \* Ongoing technology work

- \* Maintenance of documentation

- \* **Cross-feed essential**