Timepix status

For far backward working group meeting, 8th Dec 2022

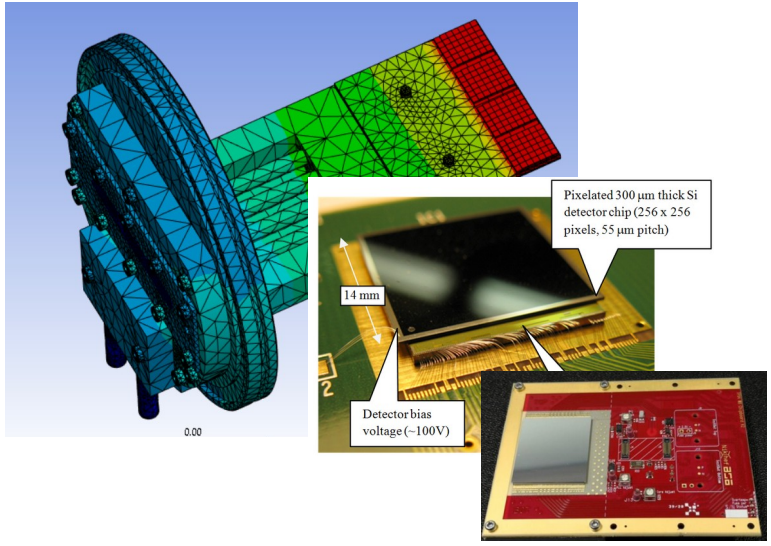
UK EIC Consortium

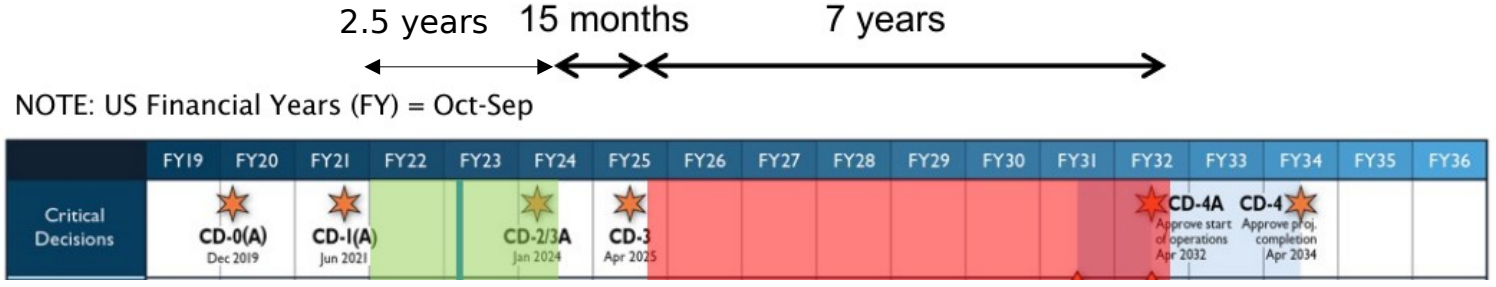
Current Project

2.5 years. R & D. **£3M**

WP1 MAPS, Central Det (Bham, DL, + ...)
WP2 **Timepix** (Glasgow, DL)
WP3 Polarimetry (York)

WP2 Timepix
Is there a role for Timepix at EIC ?
D1. Report by Xmas ... summarised here.





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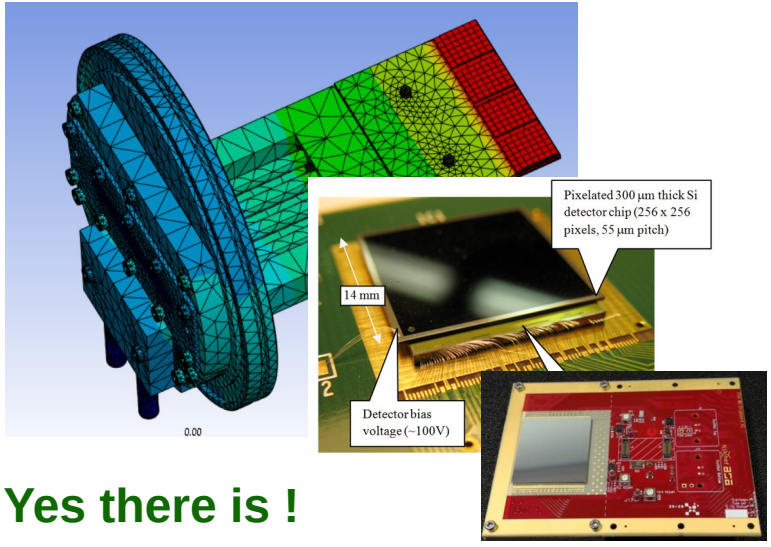
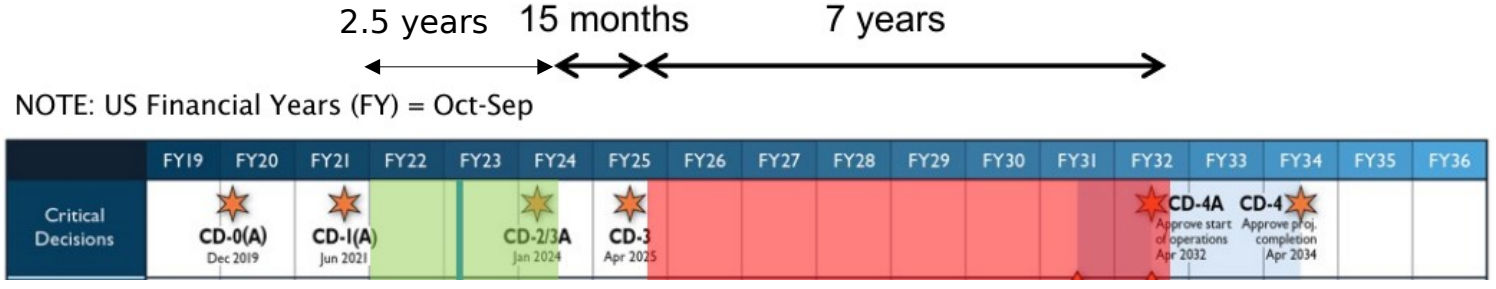


Yes there is !



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New proposal

7 years. Design and Construction. **£35M**

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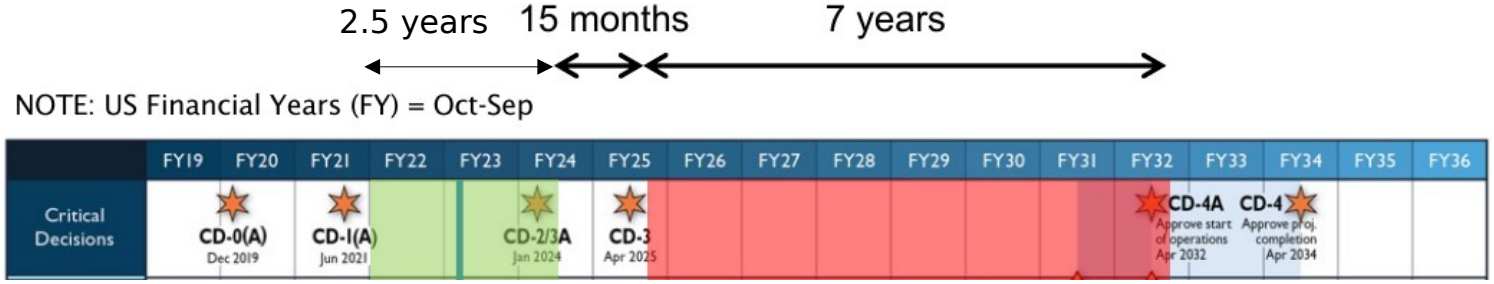
WP3 Polarimetry (York)
WP4 Accelerator (Cl, DL, + ...)

WP2 Low Q^2 Tagger / Timepix
Design and build Low Q^2 Tagger (tracker)

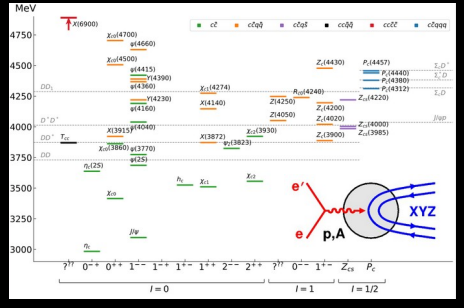


WP2 – Timepix

Glasgow: Simon Gardner, Derek Glazier, Ken Livingston, Dima Maneuski, ,Ross McGarrie
Daresbury: Mos Kogimtzis, James Lawson, Carl Unsworth

- Can we find a role for Timepix at EIC? Yes we can. It's the **Far Backward Tagger** (Low Q^2 Tagger).

Physics case - established



Design – well underway

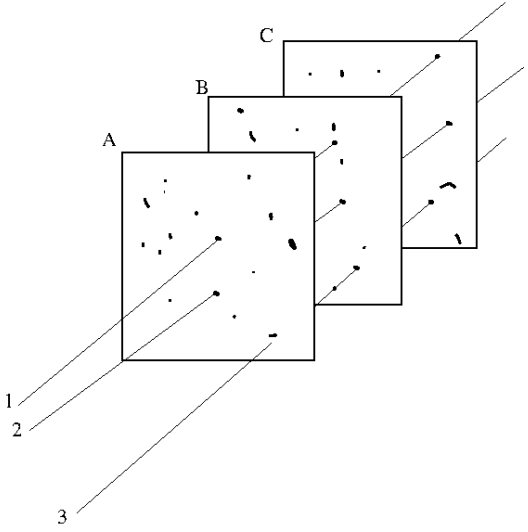
Timepix4 for tracking

X. Llopart et al 2022 JINST 17 C01044

B. Bergmann, et al. NIM A, 2020. 978:164401

WP2 – Timepix

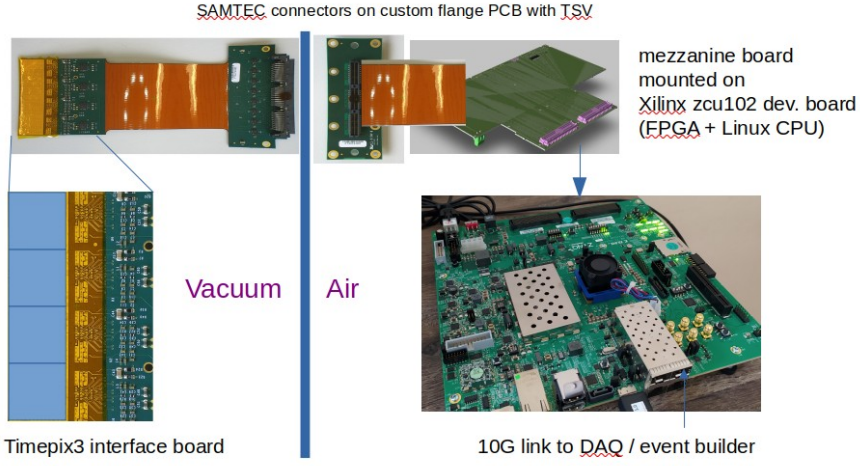
- **Calorimeter not required for Low Q^2 Tagger** – removed from simulation and design
- **What's required** of a pixel tracker?
- **Position resolution** good enough for physics needs (~50um adequate)
- **Segmentation** good enough to separate out tracks. (~50x50um pixels)
- **Vacuum compatibility**. Cooling. Readout. Beam impedance.
- **Rate capability**.
  - In a bunch crossing:
  - **~10 electrons tracks** from the interaction point almost all brem.
  - These are unrejectable! Need physics - exclusivity, kinematics …
  - 12ns between bunches => **pixel hit rate per layer = 2.5 GHz**
  - Assume same rate from synchrotron BG.
  - Total rate per layer = **5GHz**. At 64 bits per pixel = **320 Gb/s**. Very big. Timepix4 + SPIDR4 can do this.



  - Use **FPGA based clustering** to find MIPS. Store only MIPS clusters (x, y, time, energy, width) = 80 bits
  - 2 tagger, 4 layers, Trigger Rate 500kHZ => **Rate to DAQ = 3.2 Gb/s**. Very manageable.

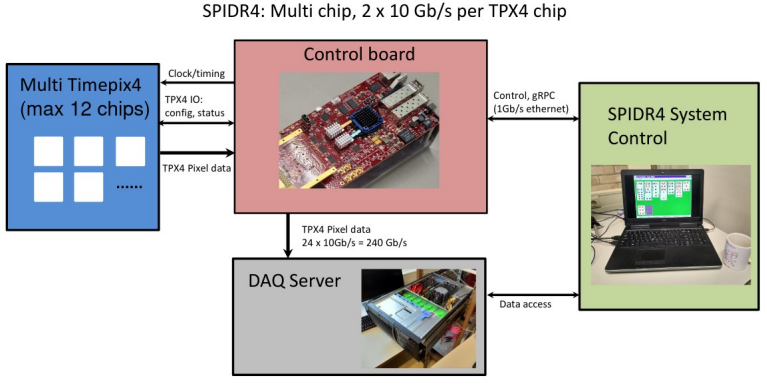
WP2 – Timepix

Timepix3



Developed by:
Glasgow Group: Ken Livingston, Dima Manuelski, Simon Gardner
Daresbury Group: Mos Kogimtzis, James Lawson, Carl Unsworth

Timepix4

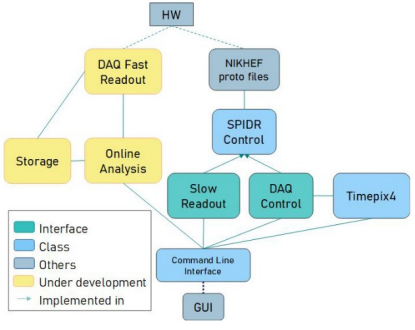


Martin Fransen (martinfr at nikhef.nl), Gridpix brainstorm April 2020 18

Availability of Timepix4 for tracking applications is driving hardware and software development.

SPIDR4 + DAQ tools look set to be the de facto standard
Closest to *off-the-shelf* technology

Build your own DAQ



You can use this software also with a hardware read-out system different from SPIDR4.
You only have to write the following 4 methods to:

- Read a Timepix4 Register
  - Operations to read a register through SC/I2C
  - Takes register address and returns vector of bytes
- Write a Timepix4 Register
  - Operations to write a register through SC/I2C
  - Takes register address and vector of bytes
- Configure the DAQ
  - Operations to configure the control board
  - Flexibility: desired configuration as xml file
- Read DAQ Monitoring Information
  - Operations to read back the control board
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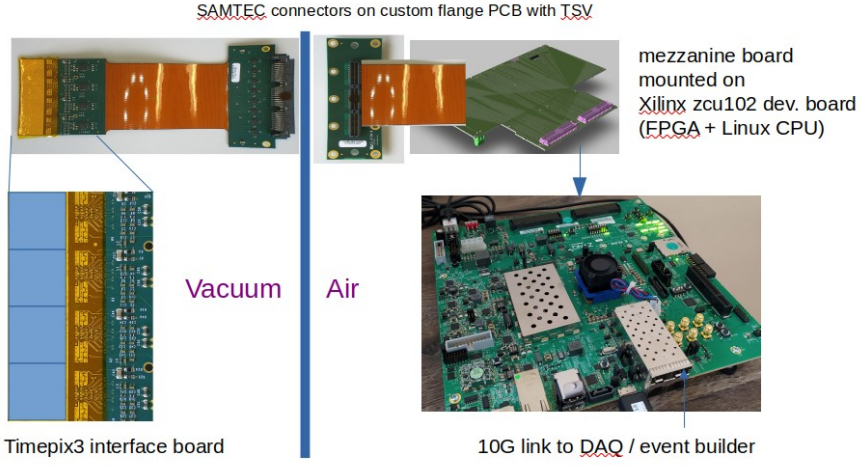
N.V. Biesuz - Development of Readout Software for Timepix4-based Detectors - 16th November 2022 8

WP2 – Timepix

Timepix3



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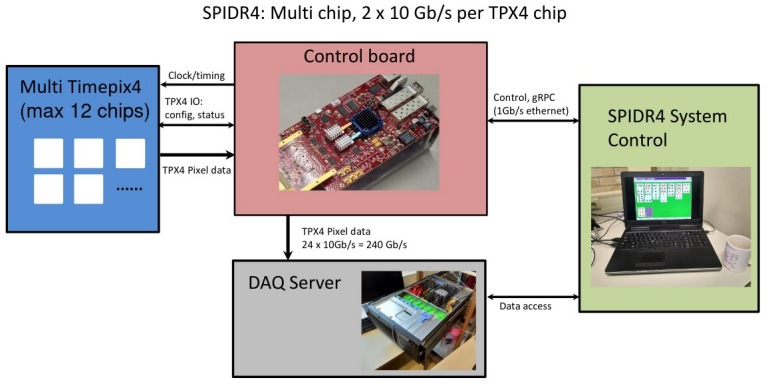
Timepix4



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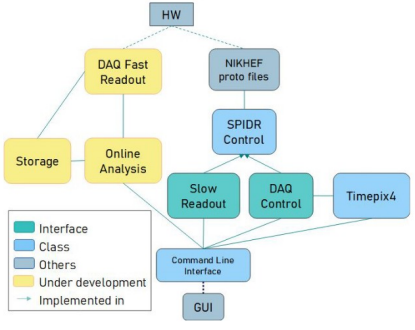

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N.V. Biesuz - Development of Readout Software for Timepix4-based Detectors - 16th November 2022 8

WP2 – Timepix ….. or something else

An attempt to compare apples with bananas ….
… please let me know better.

	Requirement	Timepix4	AC-LGAD	MAPS
Readout	—	SPIDR4	EICROC	Direct ?
Pixel Size (μm)	$\sim 50 \times 50$	55×55	500×500	20×20
Sensor thickness (μm)	—	100	50	20
Detector size (pixels)	—	512×448	64×64	?
Detector area (cm^2)	—	6.94	10.24	?
Layer Area (cm^2)	~100	83 (3x4 Timepix4)	92 (3x3)	?
Power consumption (W/cm^2)	As low as possible	1.0	0.4	0.15
Timing resolution (ns)	< 12	0.2	0.03	9
Minimum threshold (fC)	—	1.2	2.0	0.48
Individual pixel thresholds	—	Yes	Yes	No
Pixel hits in MIPS cluster	—	3	30	5 ?
Rate (various units)				
Hits/pixel/s (max)	$\sim 7 \times 10^3$	$\sim 10.7 \times 10^3$	?	?
Hits/detector/s (max)	$\sim 1.7 \times 10^9$	$\sim 2.5 \times 10^9$	?	?
Bits/detector/s (max)	$\sim 27.0 \times 10^9$	$\sim 160 \times 10^9$	?	?
Bits/layer/s (integrated)	$\sim 320 \times 10^9$	$> 240 \times 10^9$	?	

Used elsewhere in ePIC

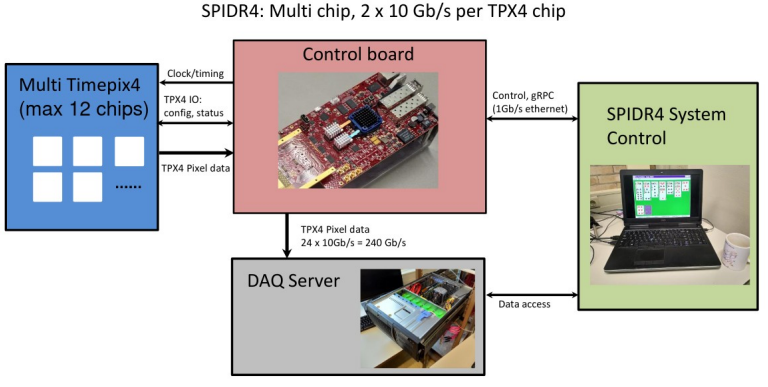
MAPS: for Central Tracker.
Great pos. resolution, very application specific, poor timing, Rate capability? Low power. **Much development needed**.

AC-LGAD for Roman Pots
Very good timing, good pos resolution, big clusters, Rate ? Medium power. **Much development needed**.

Timepix4 + SPIDR4

Adequate timing, good pos resolution, good cluster size, high rate, high(ish) power. **Available already.**
Hybrid upgrade sensor from standard Si to Inverse LGAD (<30ps).

Timepix4



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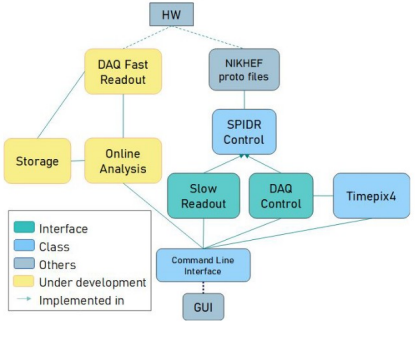

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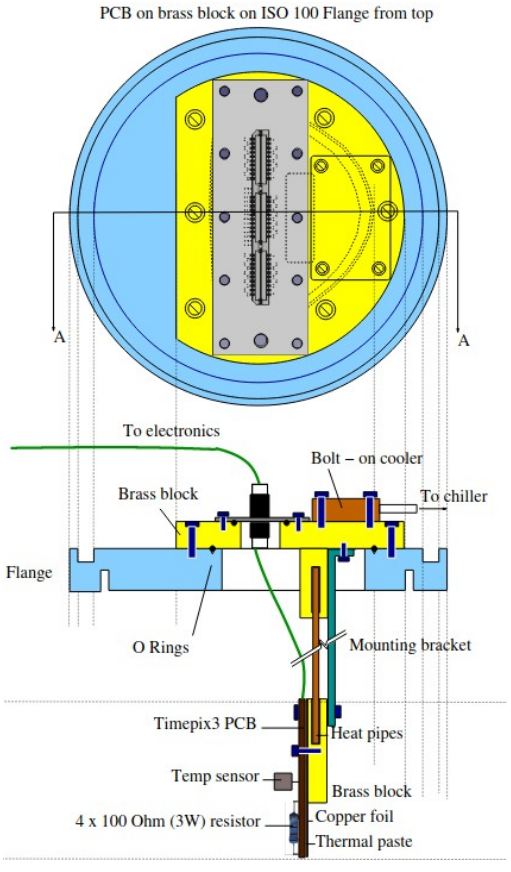
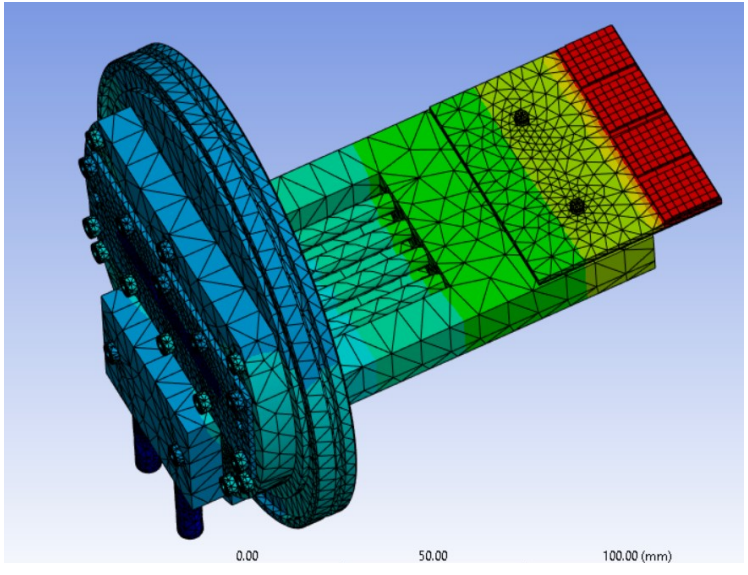
WP2 – Timepix

.. but timepix3 DAQ readout and test rig still essential for development



Real **connectors**, vacuum **feedthroughs**, **heat pipes**
PCB with **temp sensors**. **Resistors** to mock up ASIC heat.
Developed in CAD as **special flange** for ISO 100 mount.
Currently in Glasgow workshop.

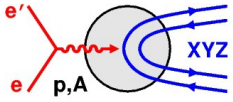
To be tested in 10-5 mbar with **external mounted chiller**.
Cooling **modelled in ANSYS**.



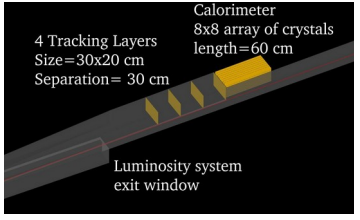
WP2 – Timepix

Summary

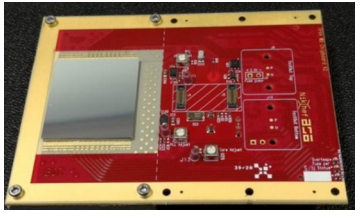
Strong physics case for low Q^2 tagger.



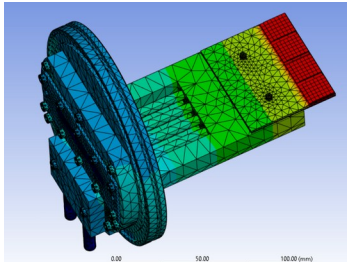
Design implemented needs more simulation and adjustment



Timepix4 + SPIDR4 looks like the best solution (but other options still being evaluated)



Development for structure, cooling, beamline
Continue with Timepix3 setup.



Links / Refs
Timepix4: X. Llopart et al 2022 JINST 17 C01044
SPIDR4: http://www.nikhef.nl/~s01/SPIDR4-MF-GP-apr2020.pdf
SPIDR4 DAQ: https://indico.cern.ch/event/1215762/contributions/5137274/

Timepix status

UK EIC Consortium

Deadline 10th Feb 2023

We hope to say:

Far Backward Tagger is now part of the design.

We will lead the development of the pixel based tracker, working with Far Backward Group.

Cost and design based on Timepix4 + SPIDR4

New proposal

7 years. Design and Construction. **£35M**

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