Boron Coated Straw Tubes for LoKI

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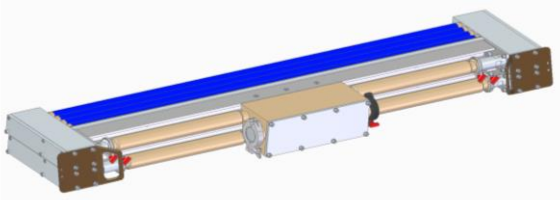
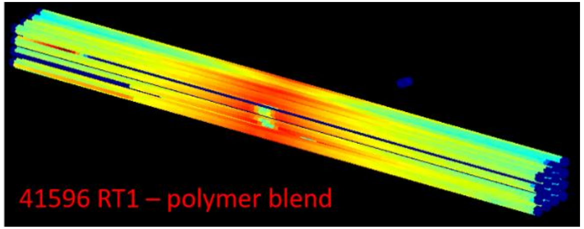
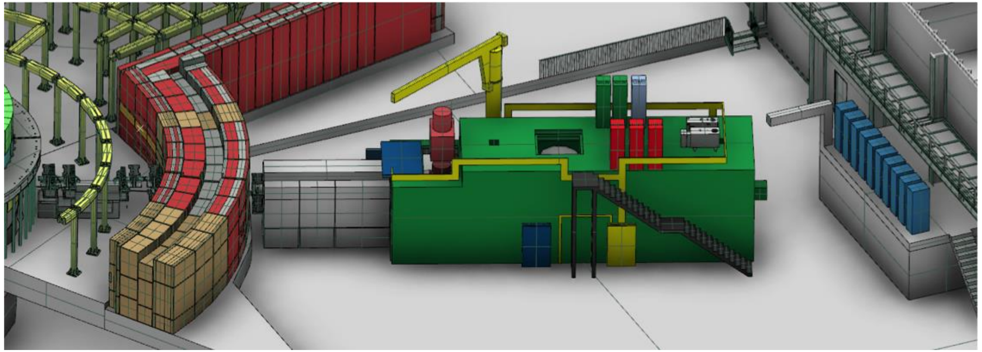
27/10/2019





Outline

- LoKI introduction
- Detector technology description
  - Detector module
  - Performance
- Readout
  - Multiplexing
  - ADC and signal processing
- SANS test on Larmor



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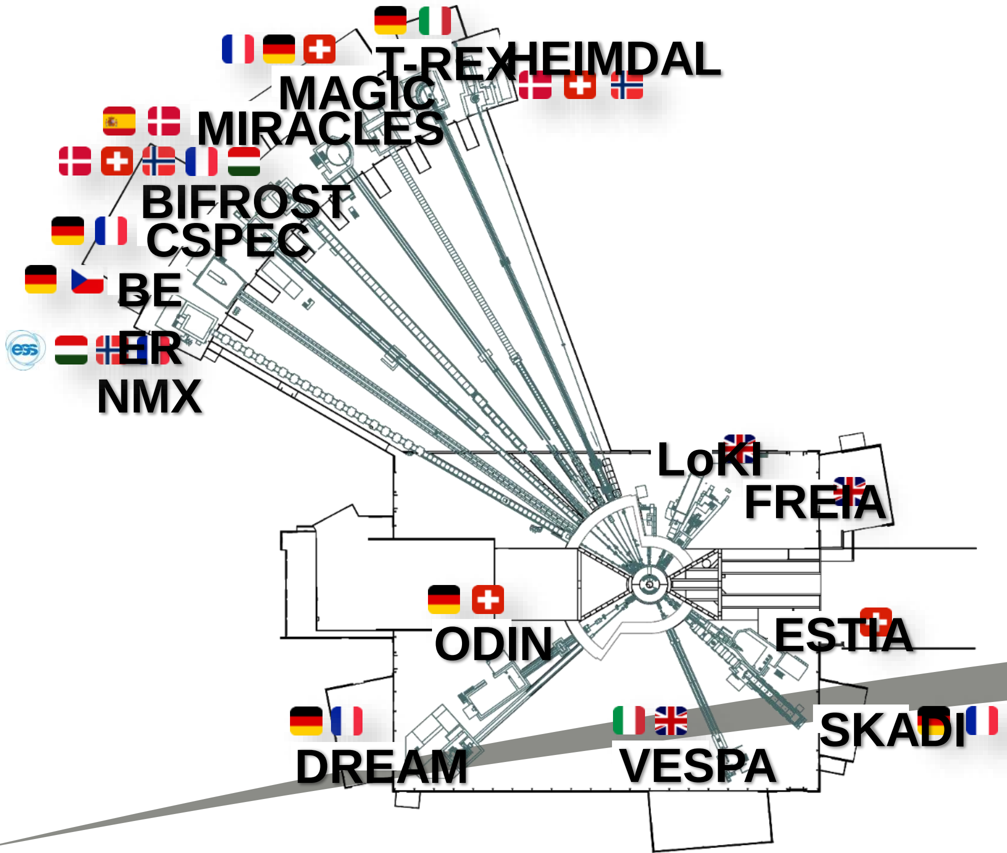
ESS beamlines



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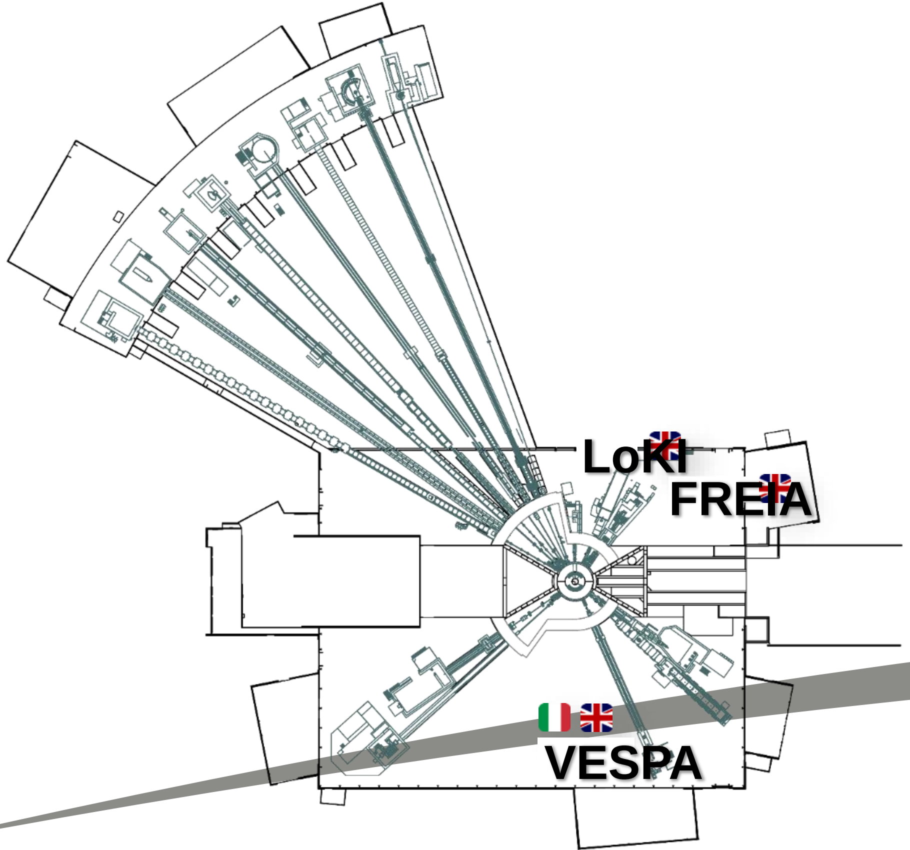
ESS beamlines



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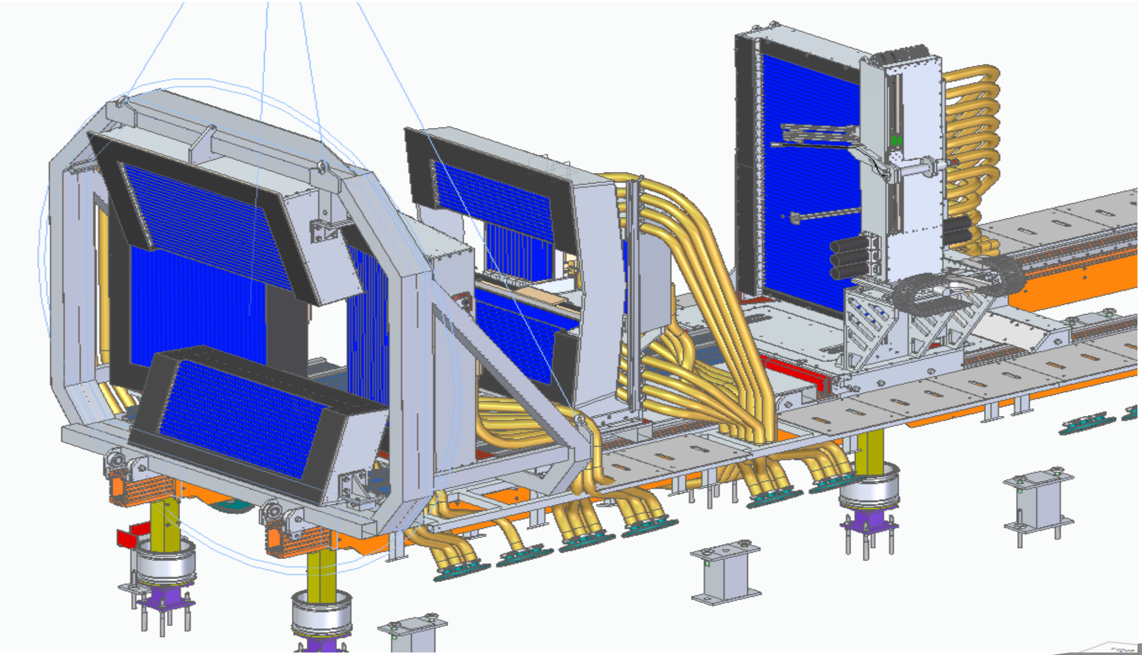
LoKI detector array



~9m^2 detector area

9 panels

5 panel on day 1

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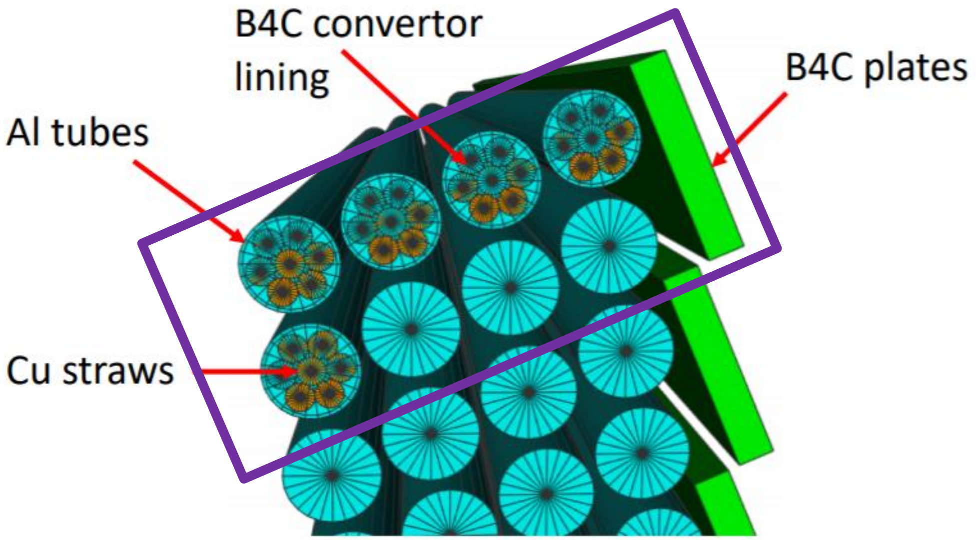
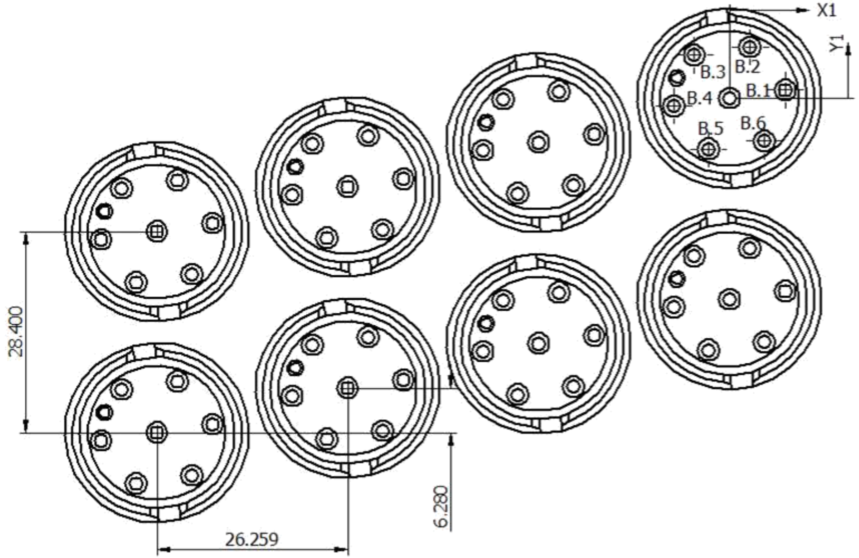
Boron Coated straw tubes

- Produced by Proportional Technology (US)
- Large application in homeland security
- Seven boron coated straws inside a 1” aluminium tube
- Resistive wire as the ^{3}He detector used on most SANS instruments around the world
- Four layers to reach an efficiency comparable to the 8 mm ∅ ^{3}He detectors

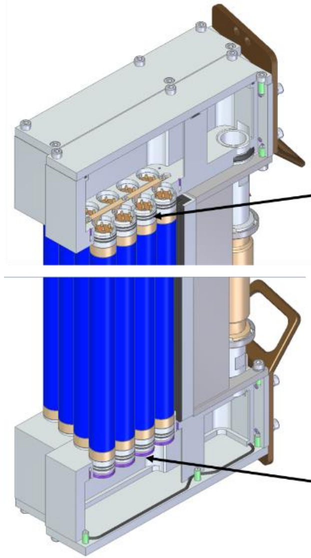


1” Tubes in a module



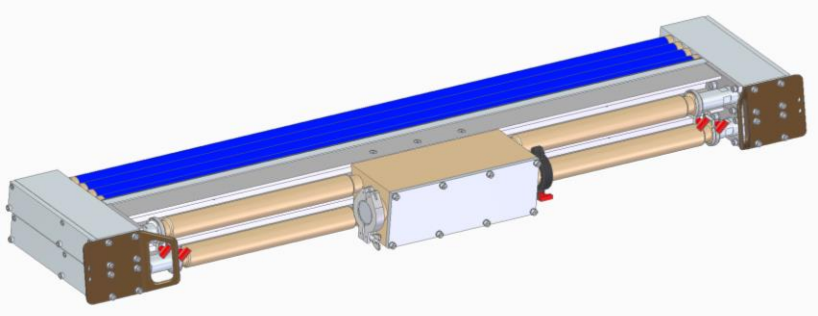
HOLE TABLE		
HOLE	X	Y
B.1	7.67	1.14
B.2	2.85	7.21
B.3	-4.82	6.07
B.4	-7.67	-1.14
B.5	-2.85	-7.21
B.6	4.82	-6.07

Detector Module

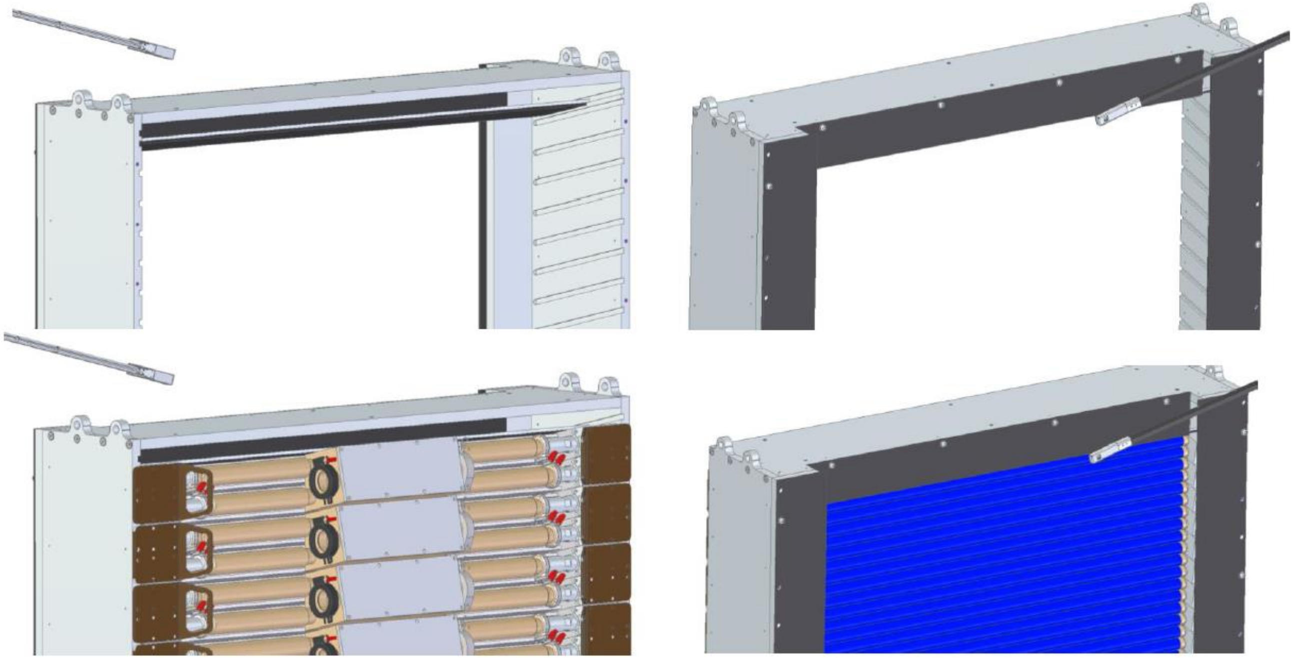


Tube end features:
- Double O-ring seals maintain vacuum boundary
- Rotation location provides know straw positioning
- Chamfer assists assembly

Double conductive O-ring stack (shown in purple) provides flexibility to absorb assembly tolerances and maintains electrical contact between the imaging tubes and air boxes.

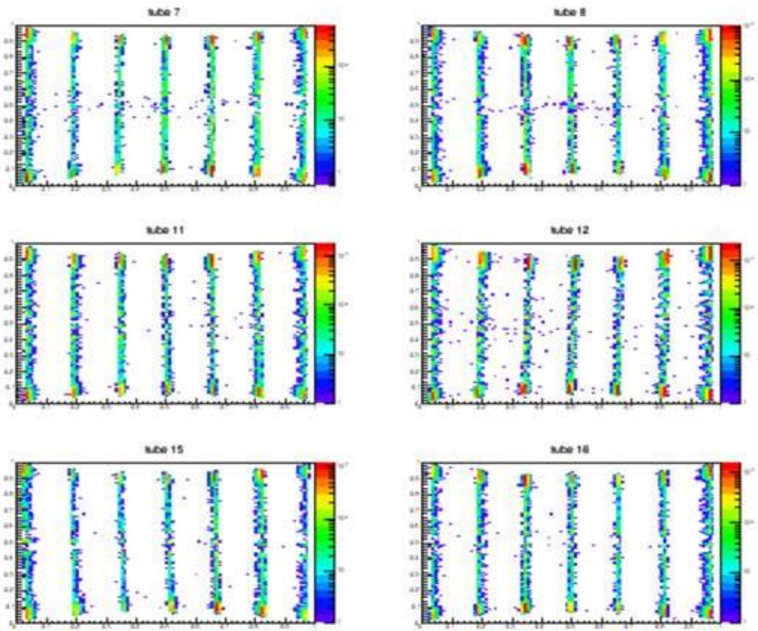


Modules in the detector array



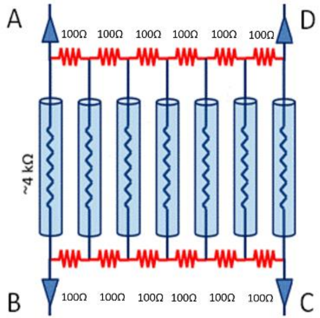
Multiplexing

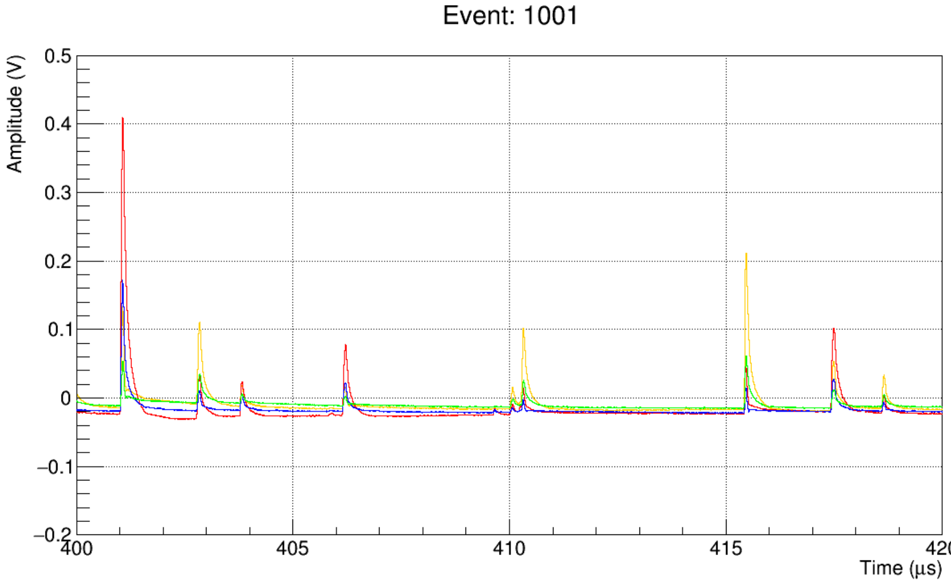
- Reduce the number of readout channels
- *x* to identify the straw
- *y* gives the position along the straw
- 100Ω resistance, optimised for straw ID
- It fits inside the ends of the tube
- Leaps to guarantee that they all sit at the same height/good connection with the HT boards
- Pogo pins to connect to the HT board
- Sockets to connect to the straws



Analog Signals (A-B-C-D)

Raw signals





EMMA
1m long straws
HT=1100V
at y=0.3m from the centre
Rate ~400 kHz/1" tube

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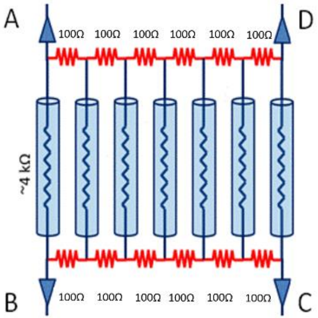
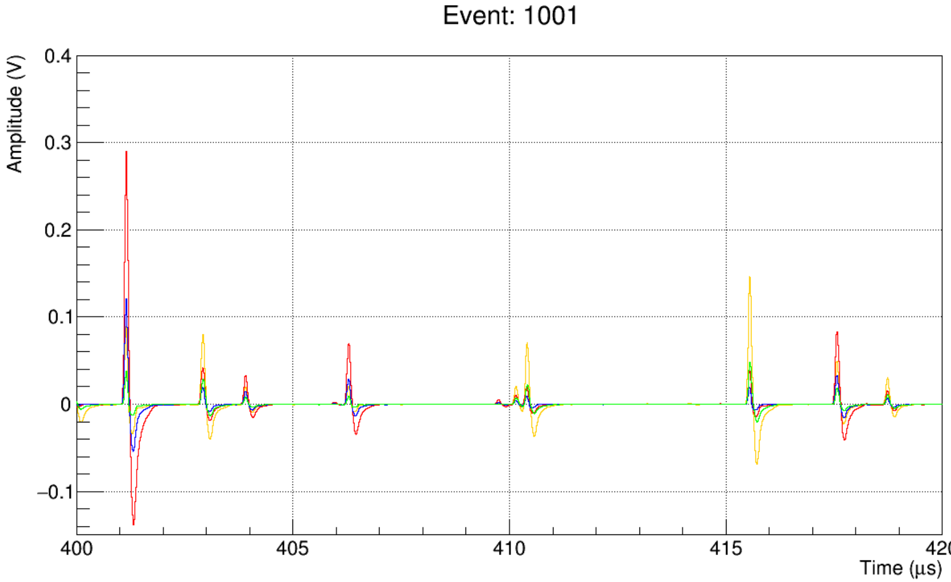
Analog Signals (A-B-C-D)

3 integration stages (3x48ns)

1 differentiation stage (1x144ns)





EMMA
1m long straws
HT=1100V
at y=0.3m from the centre
Rate ~400 kHz/1” tube

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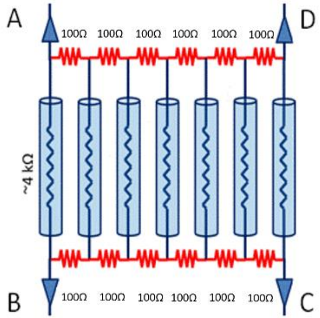
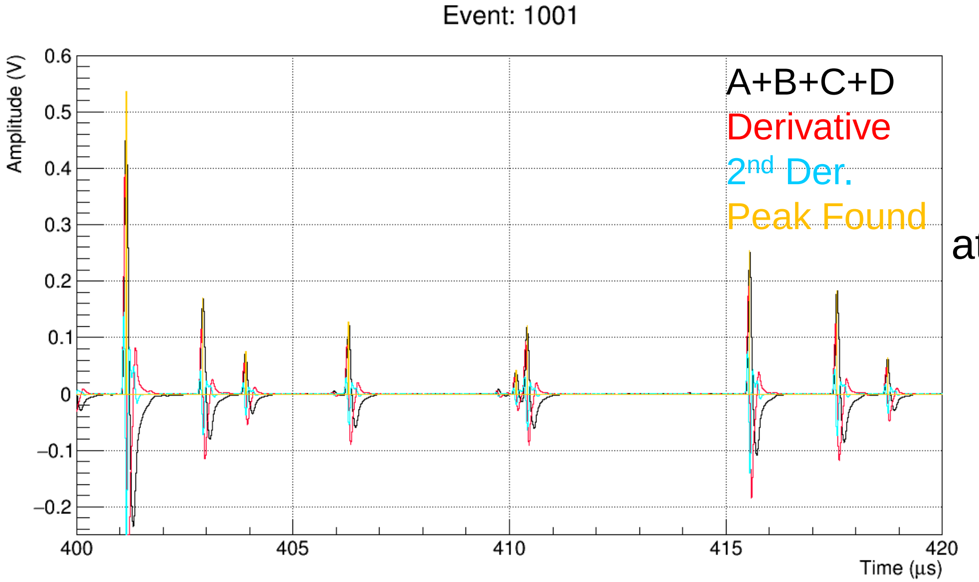
Sum Signals

3 integration stages
(3x48ns)

1 differentiation stage
(1x144ns)

A+B+C+D





EMMA
1m long straws
HT=1100V
at y=0.3m from the centre
Rate ~400 kHz/1” tube

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Signal Processing

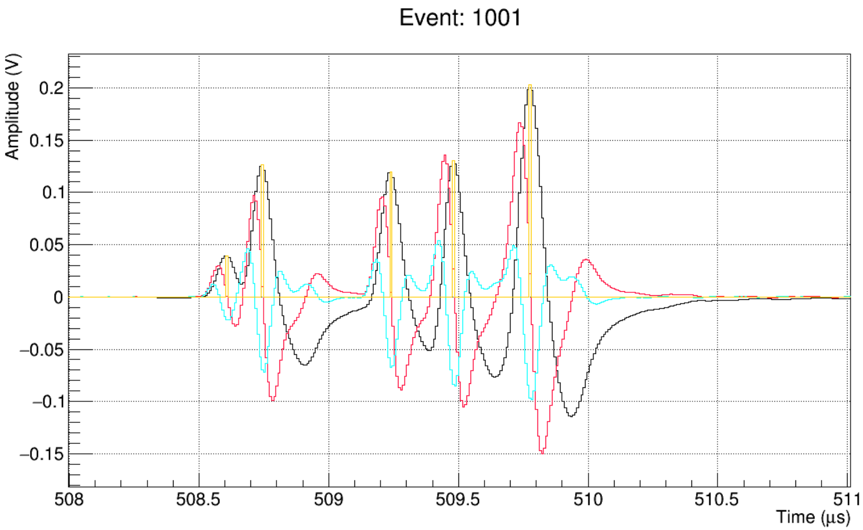
- 3 integration stages (3x48ns)
- 1 differentiation stage (1x144ns)

1. Trigger on 2nd derivative
2. Peak at zero crossing on the derivative
3. End of the signal at 2nd der. zero crossing

- Amplitudes on A,B,C and D at the time of the peak of the sum

$$x = \frac{A+B}{A+B+C+D}$$

$$y = \frac{A+D}{A+B+C+D}$$



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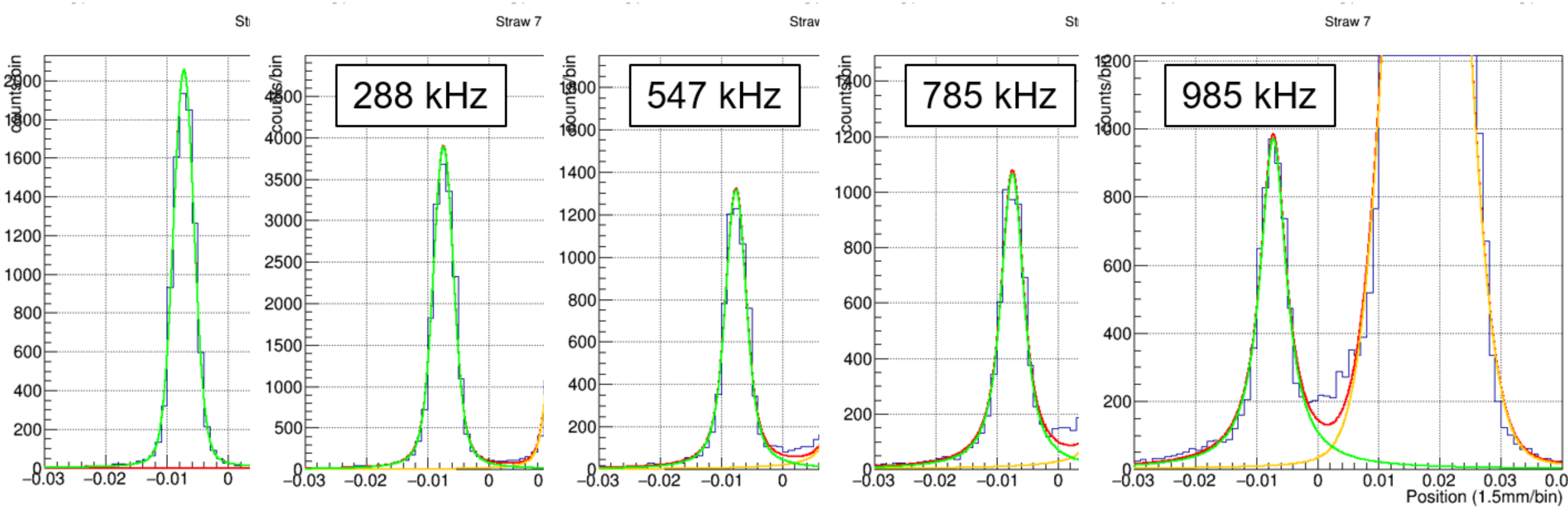
Position Resolution vs Rate



- 1500 mm long straws
- HT=1100V
- 3x48ns int.time
- 144ns diff.time
- 1.5mm Cd Slit

Position Resolution vs Rate

- 1500 mm long straws
- HT=1100V
- 3x48ns int.time
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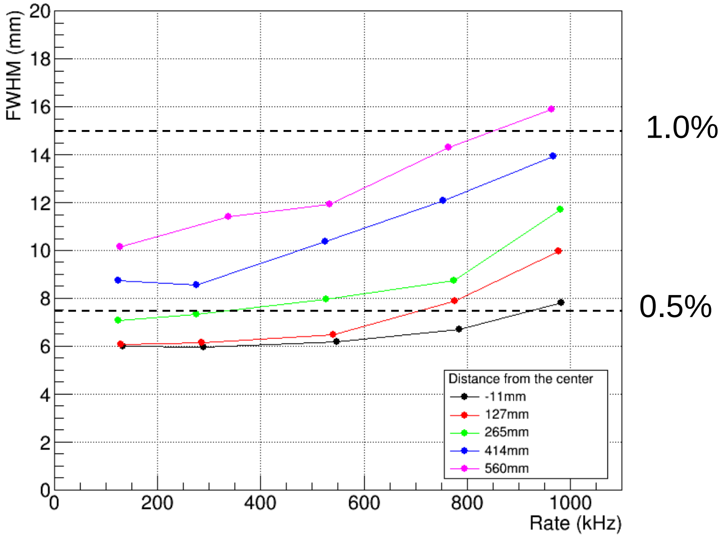

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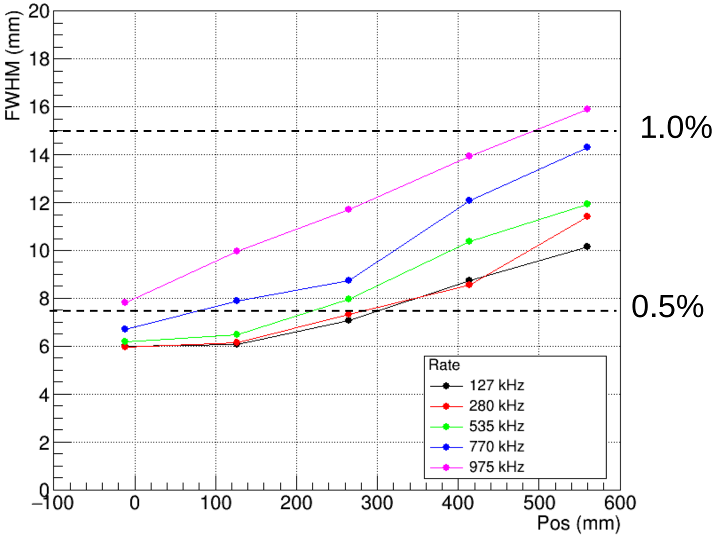
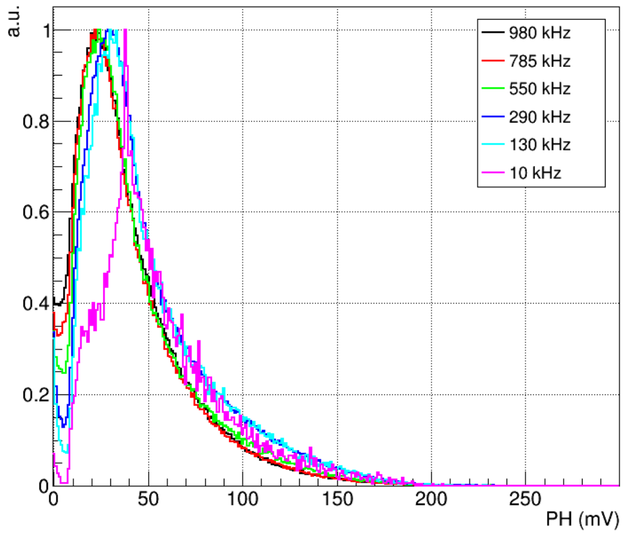
Position Resolution vs Position

- 1500 mm long straws
- HT=1100V
- 3x48ns int.time
- 144ns diff.time



PH vs Rate

- 1500 mm long straws
- HT=1100V
- 3x48ns int.time
- 144ns diff.time



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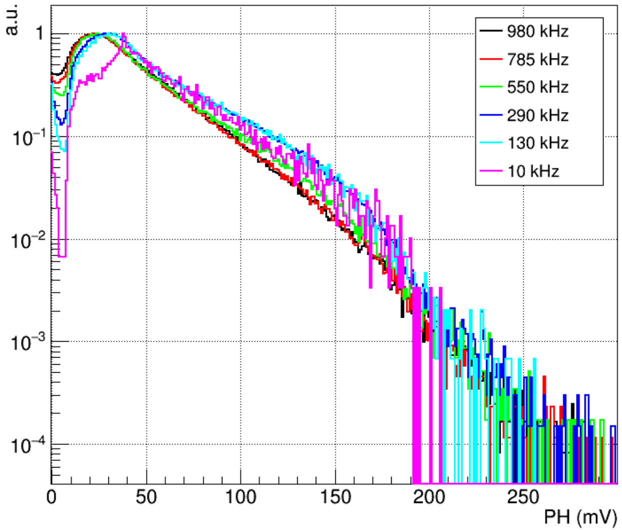
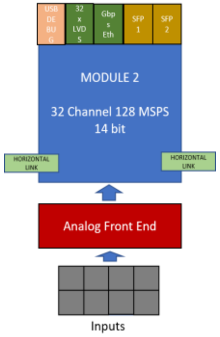
PH vs Rate

- 1500 mm long straws
- HT=1100V
- 3x48ns int.time
- 144ns diff.time



ADC

- CAEN/NI R5560 with Xilinx Zynq Z-7035 FPGAs
- 128 input Channels
- Digitise the signals (125MHz)
- Open FPGA
- Signal processing
- Straw ID
- Position Calculation
- Time Stamp
- Create a data package
- Transmit data to the back end electronics
- Visualisation of analogue signals

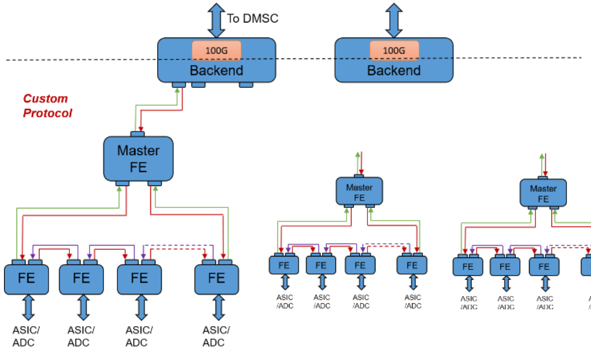


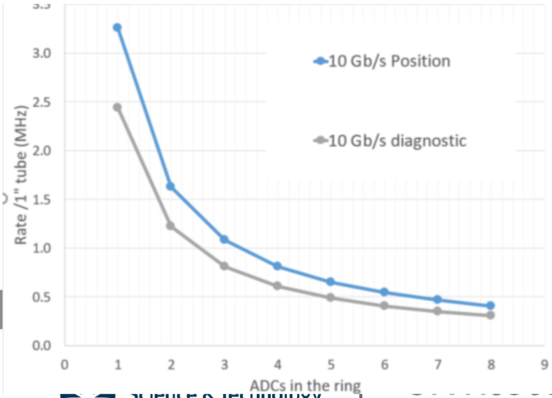
ADC to BackEnd electronics

- 18 ADCs → 6 rings → 3 ADCs/ring
  - it is enough for the foreseen neutron rate
  - it will allow to keep the same configuration when the full detector coverage will be available
  - Still using 1 back end electronics board
- Time stamp precision requirement ~100µs
  - 64 bit precision 14ns
  - 52 bit precision 57.3µs
- 32 bits packet transmission around the ring

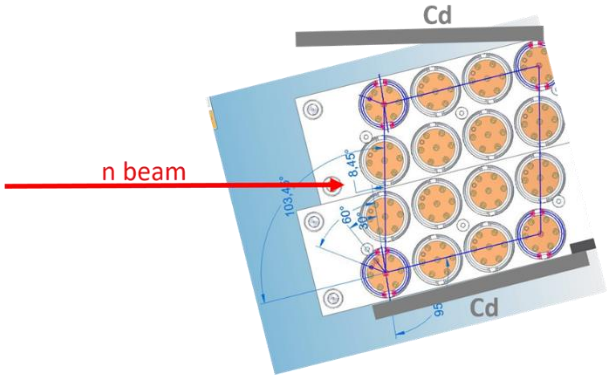
- Communication between neighbour FPGA possible via fast link – firmware to be done

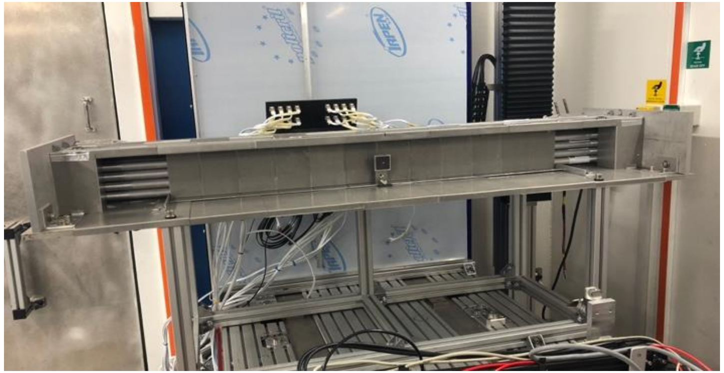
- Interface the ADC with the FEA and the Backend Electronics together with STFC TD



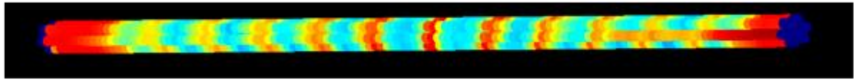


SANS test on Larmor

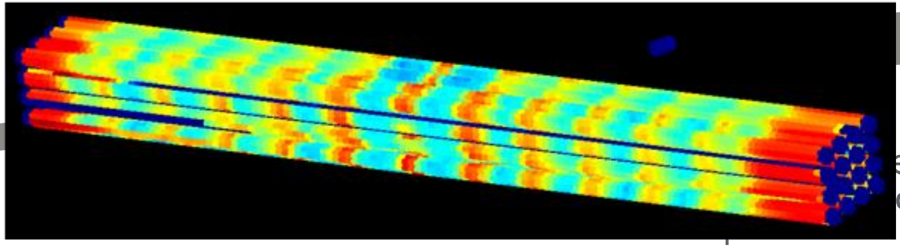




(i) Single tube containing 7 BCSs

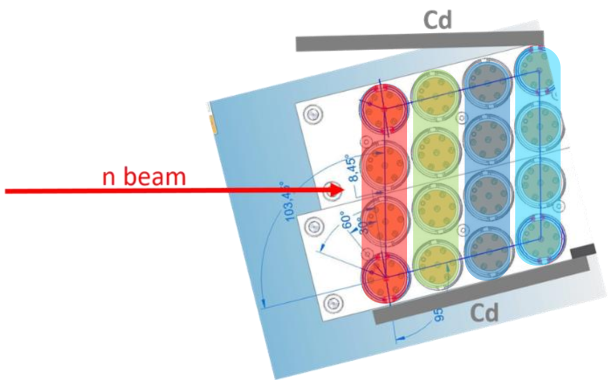


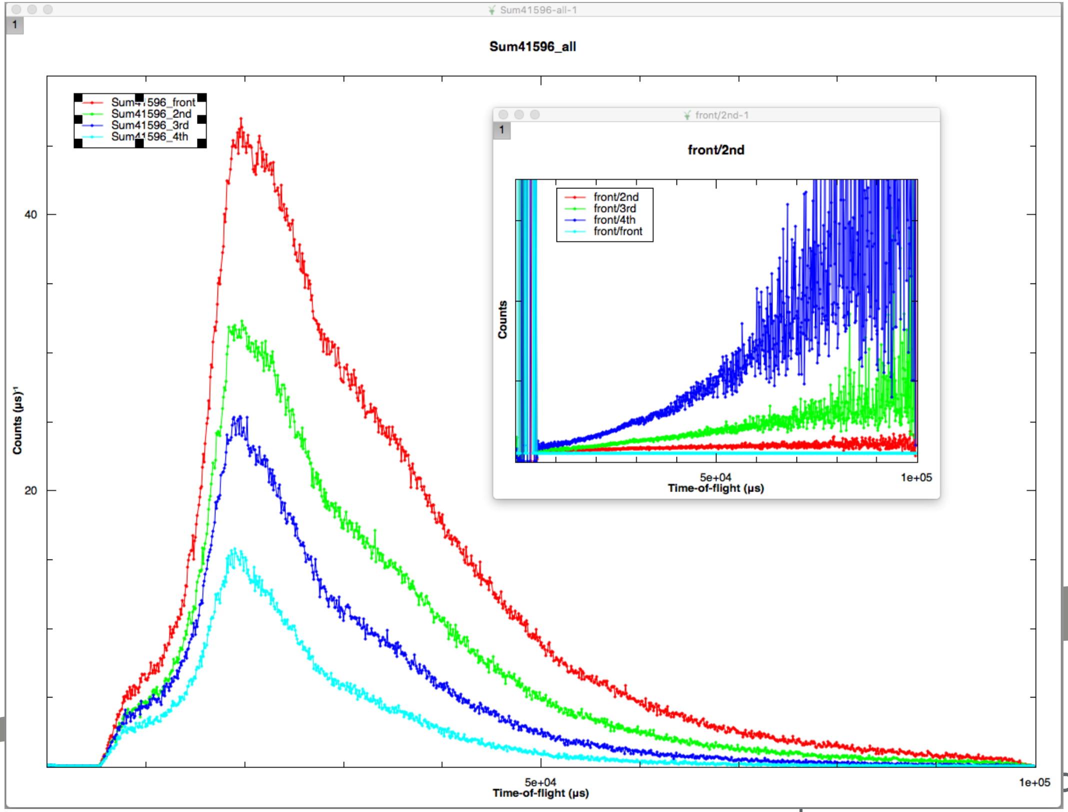
(ii) 16 tubes



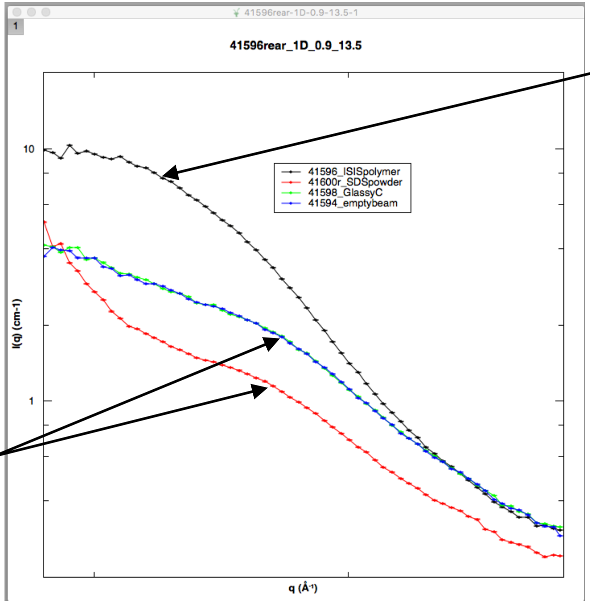
- 1.5 m long straws
- HT=950V
- ADC in diagnostic/event mode
- Ethernet readout
- Calibration mask for position corrections
- Data corrected and Transformed in histogram mode and loaded in Mantid

SANS test on Larmor





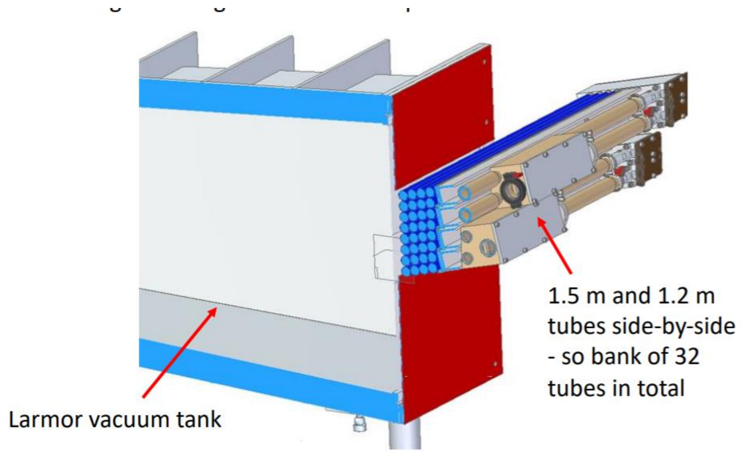
SANS test on Larmor

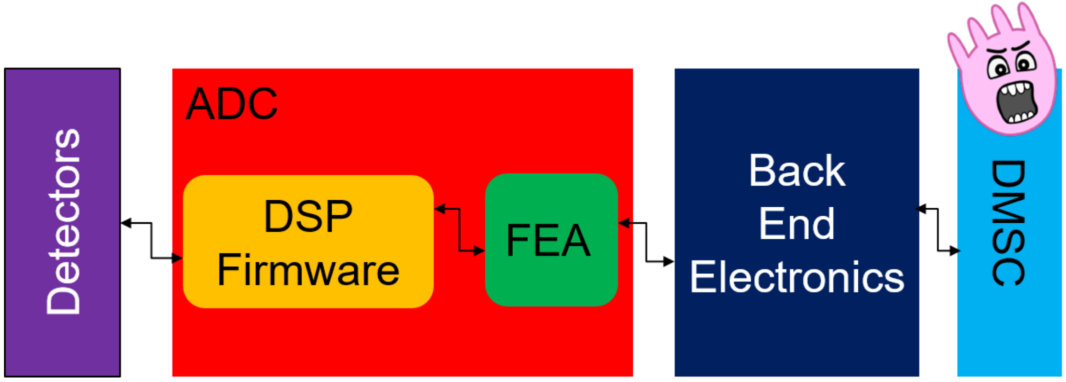


Polymer SANS pattern as expected

This bump likely comes from air

Next steps


1.5 m and 1.2 m
tubes side-by-side
- so bank of 32
tubes in total
Larmor vacuum tank


Detectors
ADC
DSP
Firmware
FEA
Back
End
Electronics
DMSC