



Data Acquisition Software Pipeline for the Commissioning of the LoKI Small Angle Neutron Scattering Instrument

PRESENTED BY JENNY WALKER

2022-10-18

Agenda



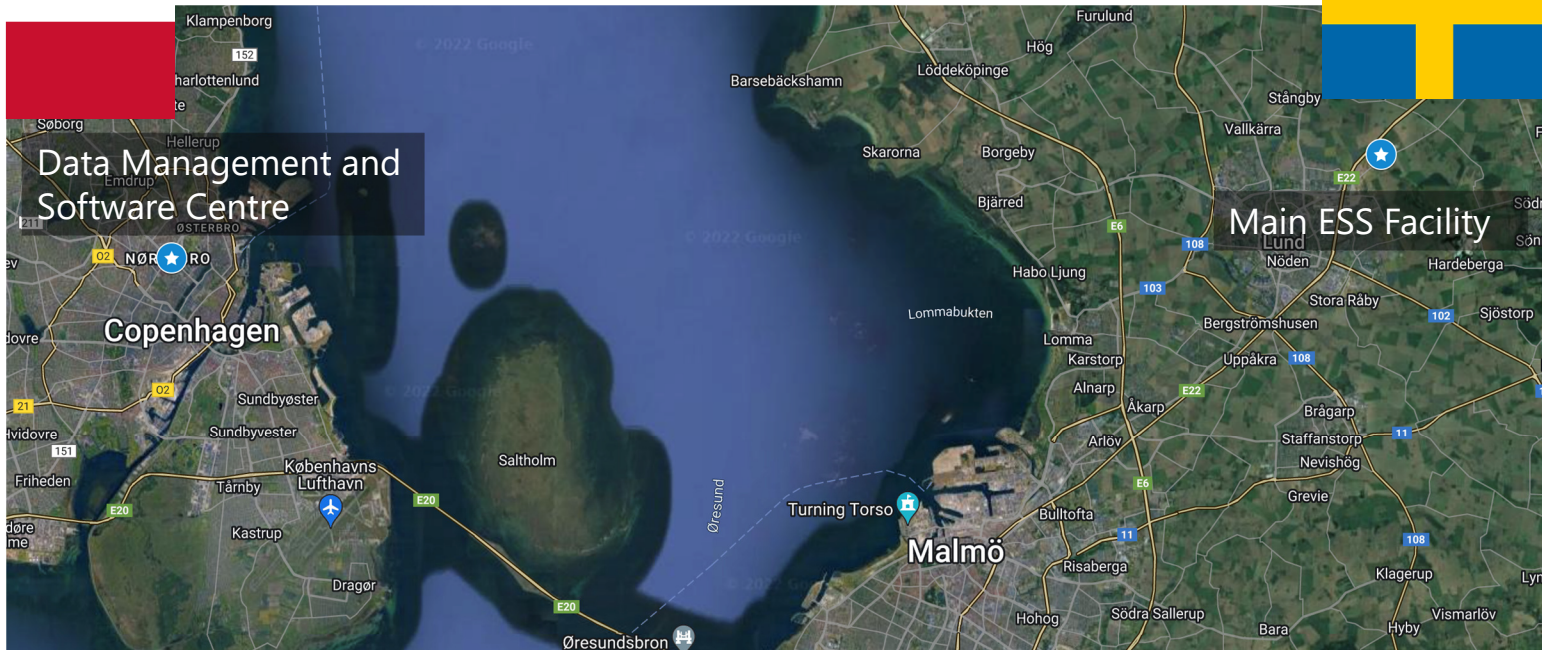
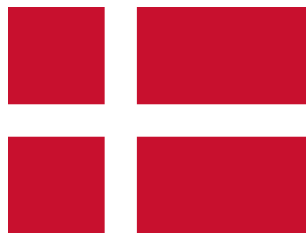
- 1 What is ESS?
- 2 Data Acquisition at ESS
- 3 LoKI Test at ISIS in March 2022

1

ESS, European Spallation Source



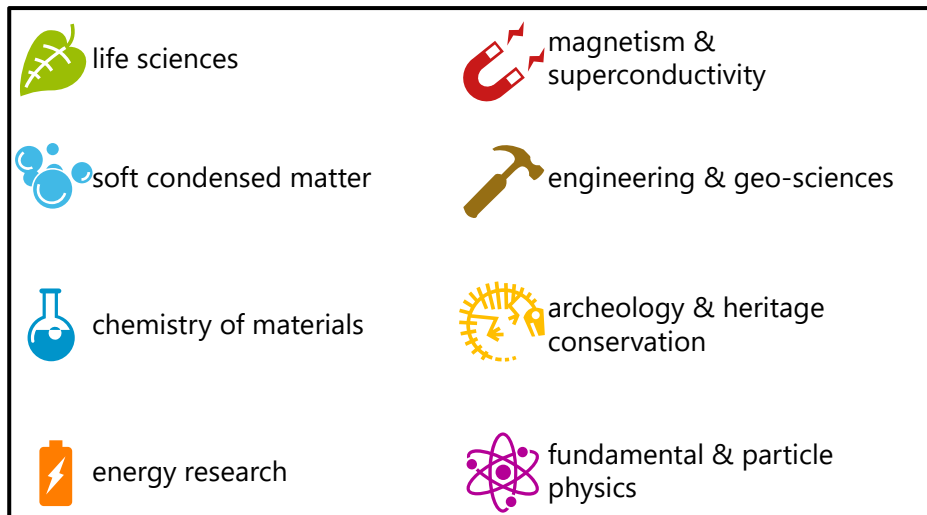
Where is ESS?



Neutron Source Facility in Lund, Sweden



- The facility is being built by 13 member countries and partners
- Once in operation, it will contribute to research in



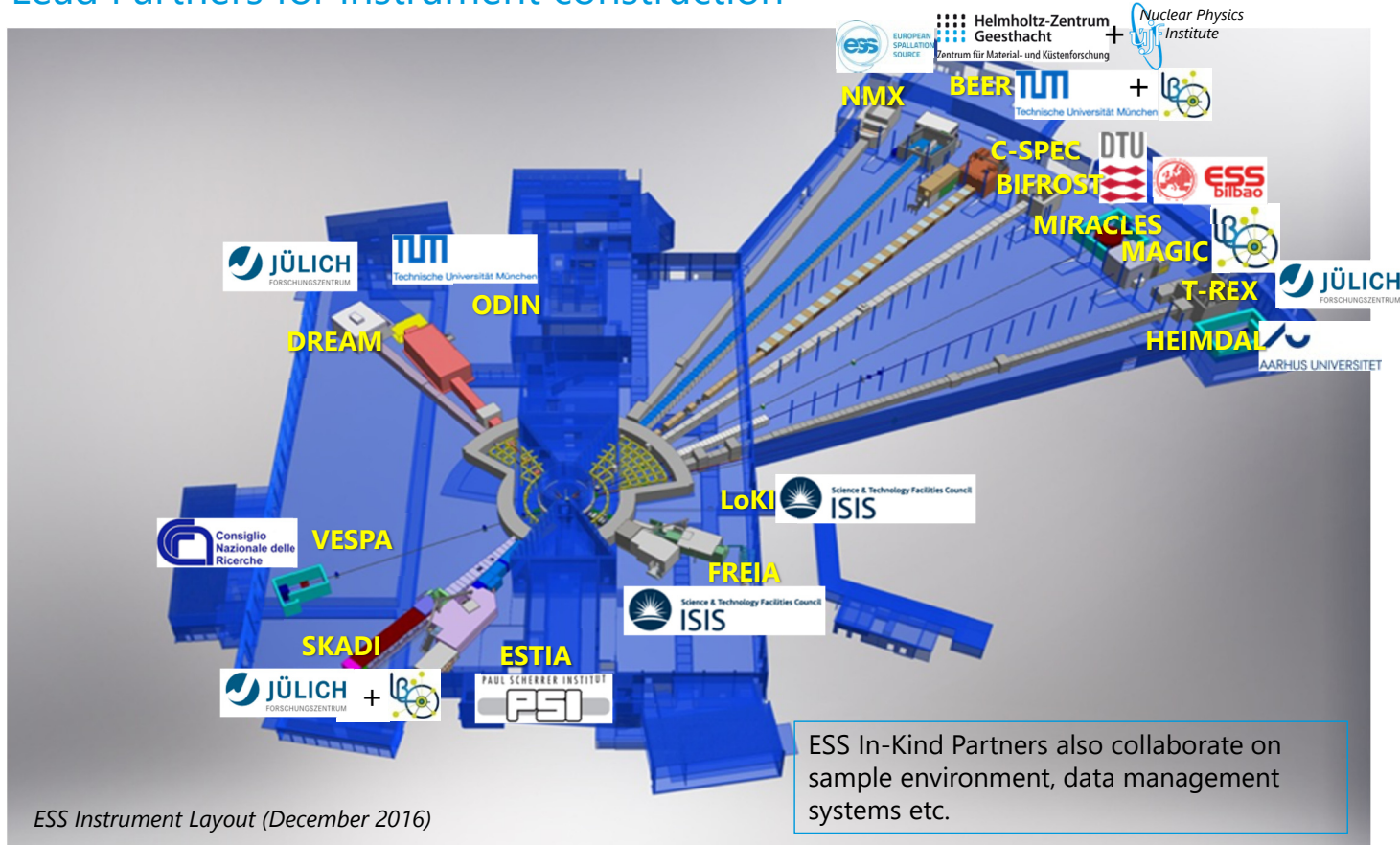
The construction project

Accelerator, Target & Experimental Halls



Different instruments for different science

ESS Lead Partners for instrument construction

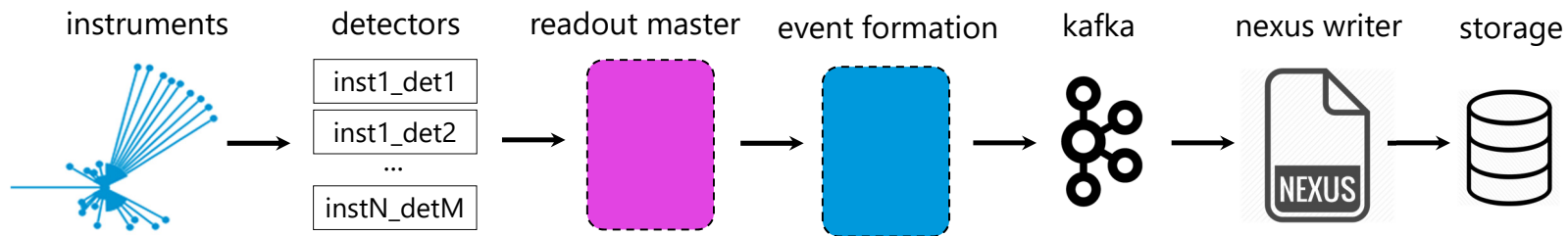


ESS Instrument Layout (December 2016)

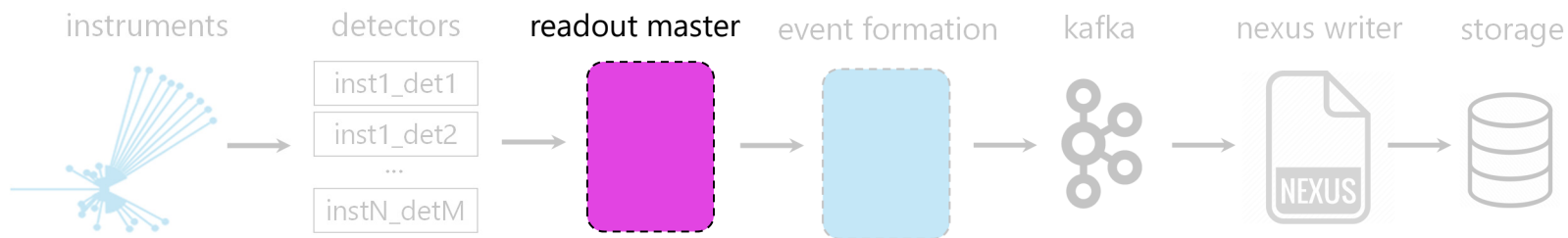
2

Data Acquisition at ESS

Data Acquisition Pipeline



Data Acquisition Pipeline



Forwards timing signals to detector hardware

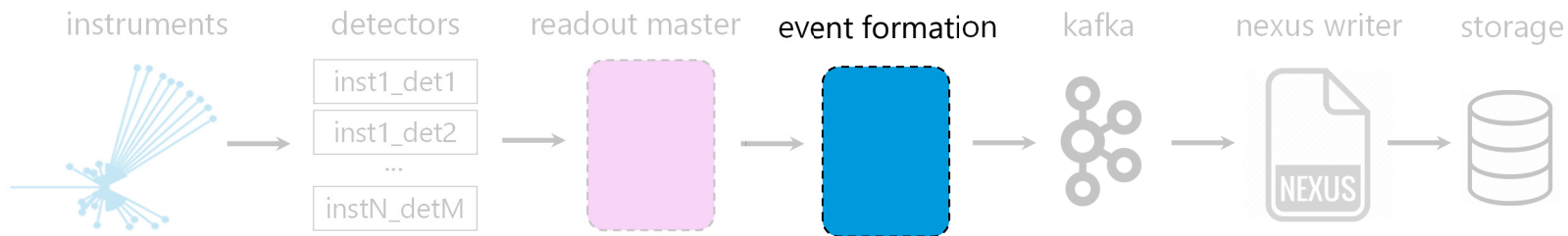
Communicates with EPICS IOCs

Creates UDP packets for event formation

header			
0	1	2	3
		Padding 0x00	Version 0
Cookie		Type / SubType	
'E'	'S'	'S'	
Length		OQ ID	TimeSrc
Pulse time HI			
Pulse time LO			
Prev. Pulse time HI			
Prev. Pulse time LO			
Sequence Number			

readouts		
Ring ID	FEN ID	Length
Time HI		
Time LO		
OM 1	TUBE	DataSeqNo
Ampl A		Ampl B
Ampl C		Ampl D

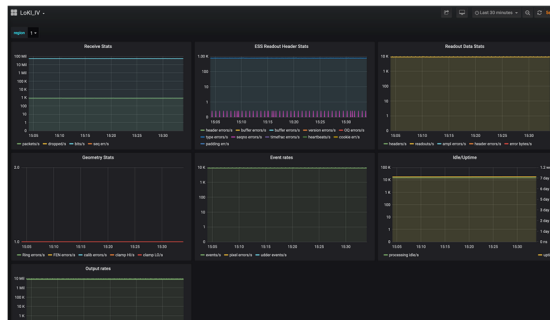
Data Acquisition Pipeline



Linux server C++ application
running as a constant service

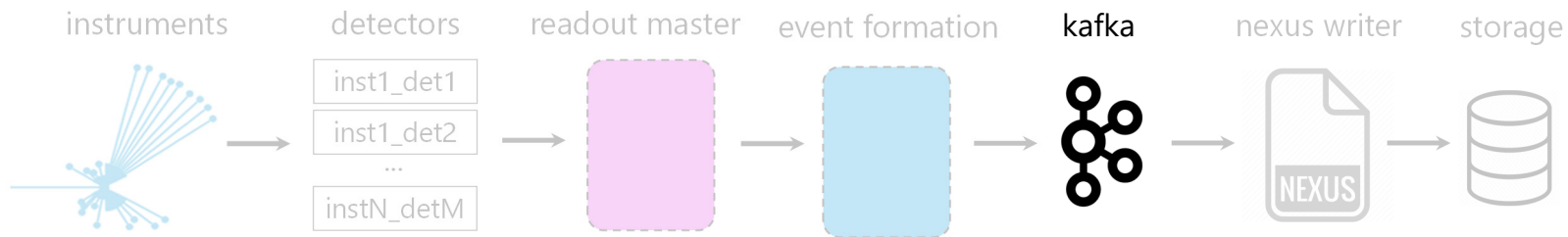
Processes detector readout
data into distinct events,

For 2D and 3D detectors,
clusters and matches
readouts in different planes



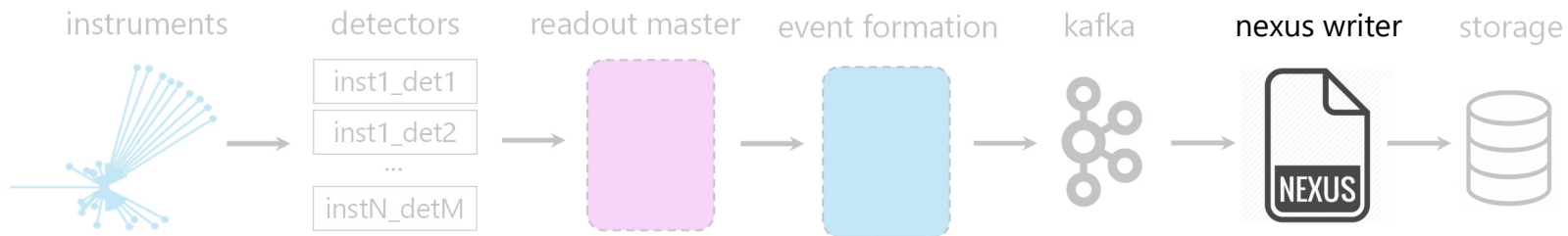
Field Name	Type	Description
source_name	string	Field identifying producer, commonly detector name
message_id	ulong	Consecutive numbers, used to check order of messages
pulse_time	ulong	Nanoseconds since Unix epoch of given pulse time
time_of_flight	uint	Nanoseconds since pulse for given event
detector_id	uint	Pixel ID, identifying where neutron was detected

Data Acquisition Pipeline



Broker for event messages,
allows for multiple services down the chain to use event information

Data Acquisition Pipeline

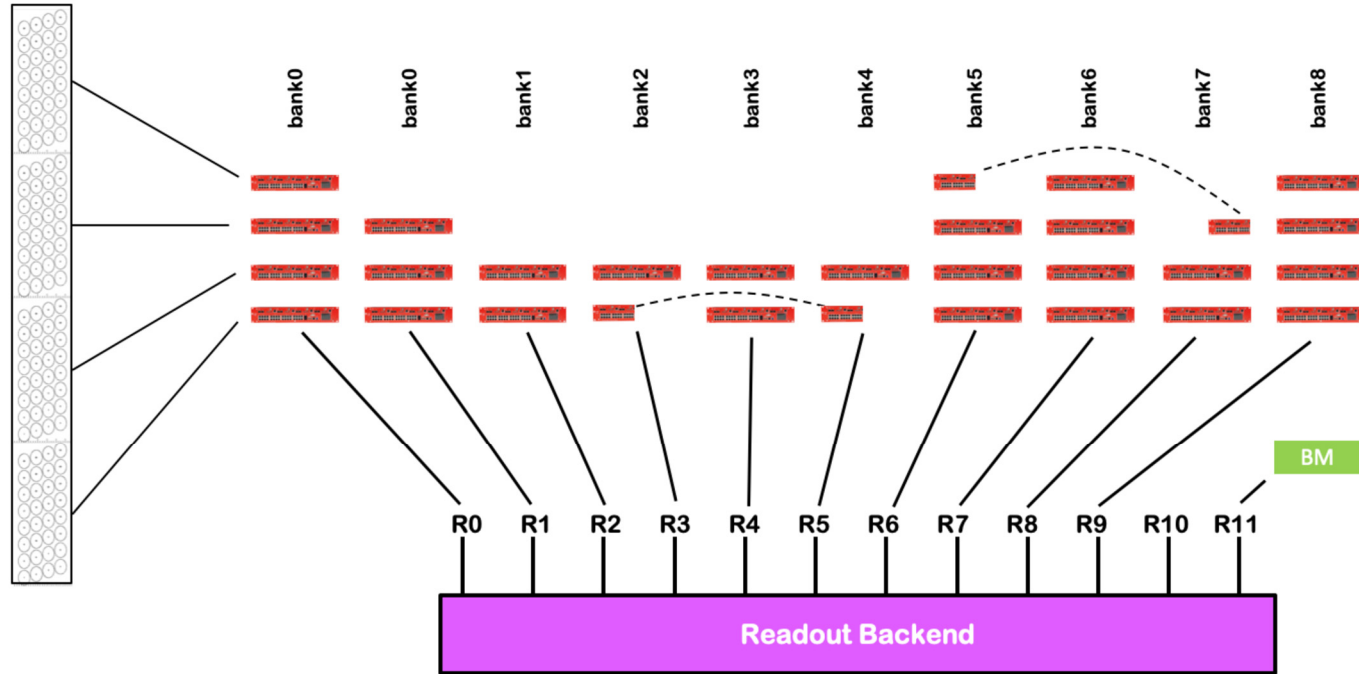


Writes NeXus files

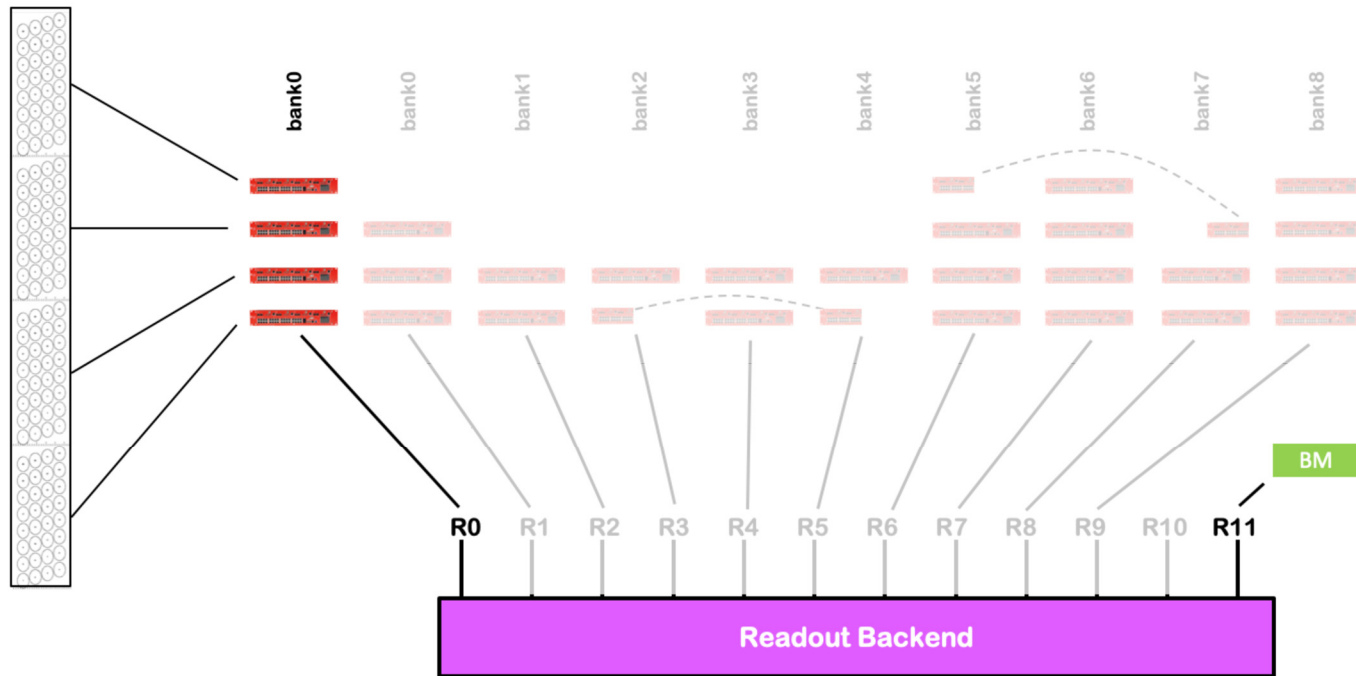
Neutron experiment data format

Name	Description	Type
60376-2022-03-04_0405.nxs		
entry		
end_time	["My exp..."]	NXentry
experiment_description	"2032-0..."	string
experiment_identifier	["this is a..."]	string
experiment_identifier	["pt234"]	string
instrument		
larmor_detector		NXdetector
depends_on	["entry/i..."]	string
detector_number	1D data	int32
larmor_detector_events		NXevent_data
cue_index		uint32
cue_timestamp_zero		uint64
event_id	1D data	uint32
event_index	1D data	uint32
event_time_offset	1D data	uint32
event_time_zero	1D data	uint64
pixel_shape		NXcylindrical_geometry
cylinders	[[0 1 2]]	int32
vertices	2D data	float32
transformations		NXtransformations
trans_1	[4.4821]	float32
x_pixel_offset	1D data	float32
y_pixel_offset	1D data	float32
z_pixel_offset	1D data	float32

Detector Readout Electronics



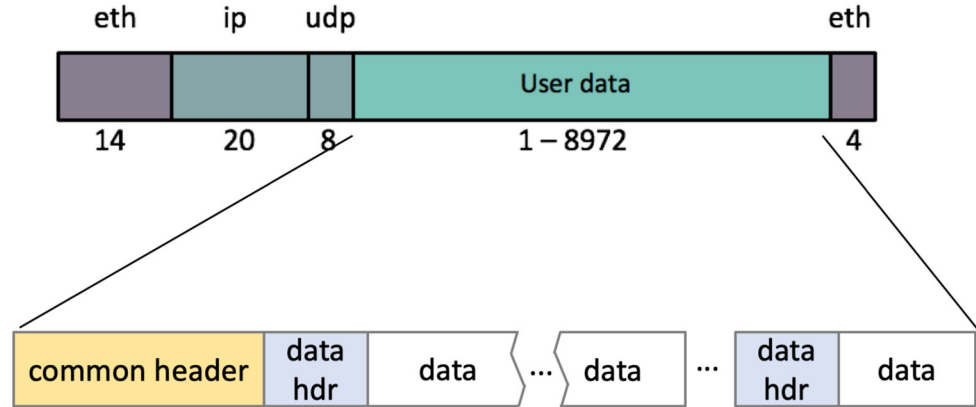
Detector Readout Electronics



Ethernet transmission



0	1	2	3	byte/address
		Padding 0x00	Version 0	0 - 1
Cookie			Type / SubType	2 - 5
'E'	'S'	'S'		
Length		OQ ID	TimeSrc	6 - 9
Pulse time HI				10 - ##
Pulse time LO				14 - ##
Prev. Pulse time HI				18 - ##
Prev. Pulse time LO				22 - ##
Sequence Number				26 - ##
Ring ID	FEN ID	Length		
Time HI				
Time LO				
OM 1	TUBE	DataSeqNo		
Ampl A		Ampl B		
Ampl C		Ampl D		
Ring ID	FEN ID	Length		
Time HI				
Time LO				
OM 1	TUBE	DataSeqNo		
Ampl A		Ampl B		
Ampl C		Ampl D		
Ring ID	FEN ID	Length		
Time HI				



- 100Gbit/s Ethernet
- Jumbo frames (8972 bytes user data)
- UDP/IP
- 1.38 M packets/s
- $\sim 5.13 \times 10^8$ readouts/s

EFU Configuration

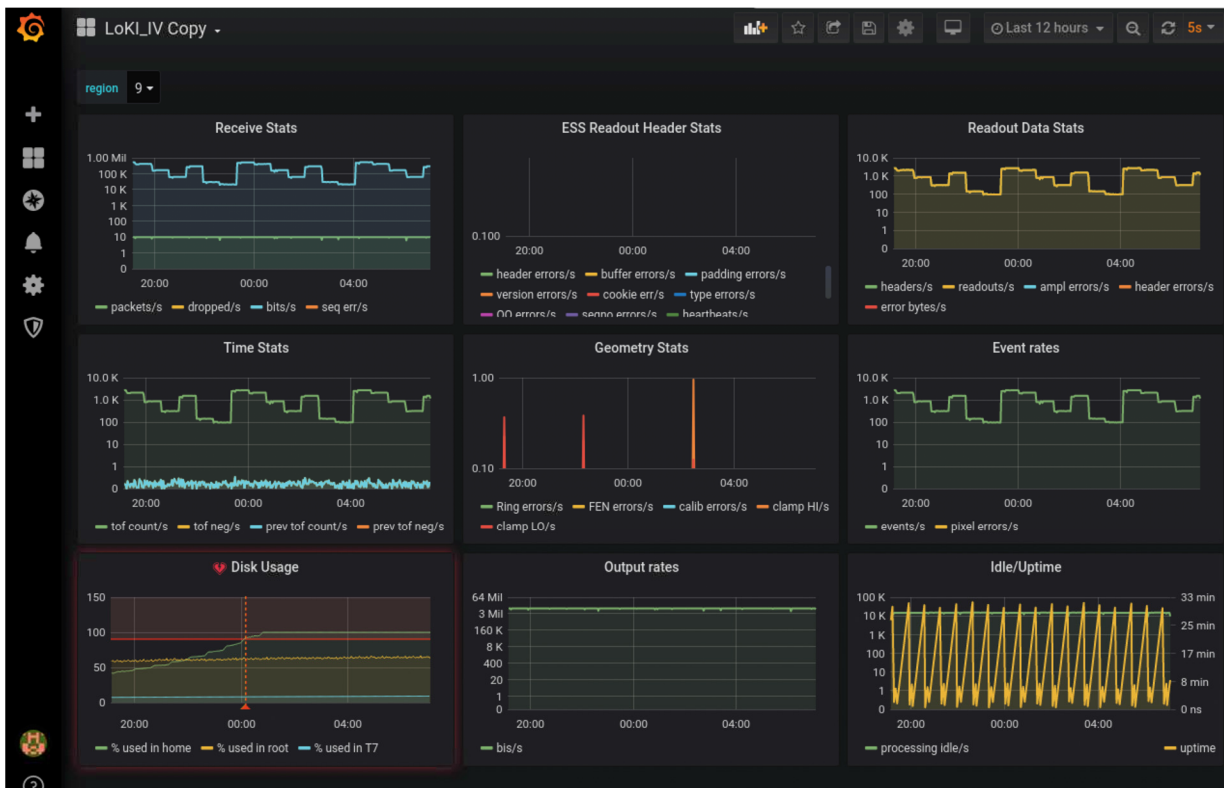


JSON based configuration files

```
1 {
2   "Detector": "LoKI",
3   "StrawResolution" : 512,
4   "PanelConfig" : [
5     { "Bank" : 0, "Vertical" : false, "TubesZ" : 4, "TubesN" : 32, "StrawOffset" : 0 },
6     { "Bank" : 0, "Vertical" : false, "TubesZ" : 4, "TubesN" : 24, "StrawOffset" : 896 },
7     { "Bank" : 1, "Vertical" : false, "TubesZ" : 4, "TubesN" : 16, "StrawOffset" : 1568 },
8     { "Bank" : 2, "Vertical" : true, "TubesZ" : 4, "TubesN" : 12, "StrawOffset" : 2016 },
9     { "Bank" : 3, "Vertical" : false, "TubesZ" : 4, "TubesN" : 16, "StrawOffset" : 2352 },
10    { "Bank" : 4, "Vertical" : true, "TubesZ" : 4, "TubesN" : 12, "StrawOffset" : 2800 },
11    { "Bank" : 5, "Vertical" : false, "TubesZ" : 4, "TubesN" : 28, "StrawOffset" : 3136 },
12    { "Bank" : 6, "Vertical" : true, "TubesZ" : 4, "TubesN" : 32, "StrawOffset" : 3920 },
13    { "Bank" : 7, "Vertical" : false, "TubesZ" : 4, "TubesN" : 20, "StrawOffset" : 4816 },
14    { "Bank" : 8, "Vertical" : true, "TubesZ" : 4, "TubesN" : 32, "StrawOffset" : 5376 }
15  ]
16 }
```

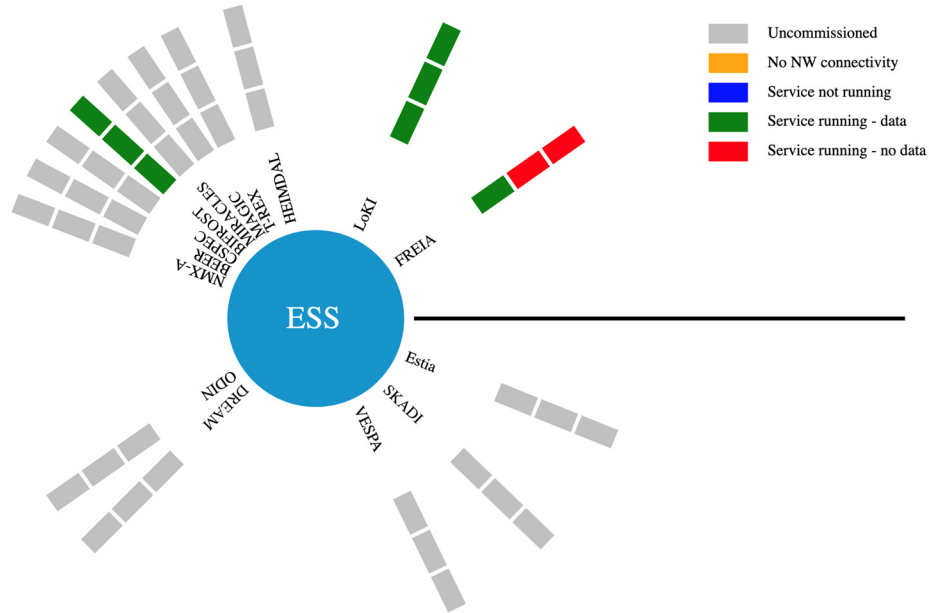
```
1 {
2   "LokiCalibration" : {
3     "ntubes" : 8,
4     "nstraws" : 7,
5     "resolution" : 512,
6     "polynomials" : [
7       {"c" : [0, 0.0, 0.0, 0.0, 0.0]},
8       {"c" : [1, 0.0, 0.0, 0.0, 0.0]},
9       {"c" : [2, 0.0, 0.0, 0.0, 0.0]},
10      {"c" : [3, 0.0, 0.0, 0.0, 0.0]},
11      {"c" : [4, 0.0, 0.0, 0.0, 0.0]},
12      {"c" : [5, 0.0, 0.0, 0.0, 0.0]},
13      {"c" : [6, 0.0, 0.0, 0.0, 0.0]},
14      {"c" : [7, 0.0, 0.0, 0.0, 0.0]},
15      {"c" : [8, 0.0, 0.0, 0.0, 0.0]},
16      {"c" : [9, 0.0, 0.0, 0.0, 0.0]},
17      {"c" : [10, 0.0, 0.0, 0.0, 0.0]},
18      {"c" : [11, 0.0, 0.0, 0.0, 0.0]},
19      {"c" : [12, 0.0, 0.0, 0.0, 0.0]},
20      {"c" : [13, 0.0, 0.0, 0.0, 0.0]},
21      {"c" : [14, -5.27184, -0.0134901, -3.49317e-05, 1.69815e-07]},
22      {"c" : [15, 28.3162, -0.114629, -3.79167e-05, 1.86055e-07]},
23      {"c" : [16, 50.2752, -0.223065, 9.49951e-05, 1.30951e-08]},
24      {"c" : [17, 49.1083, -0.236256, -8.05768e-06, 1.64068e-07]},
25    ]
26  }
```

EFU Status Monitoring - Grafana



YMIR

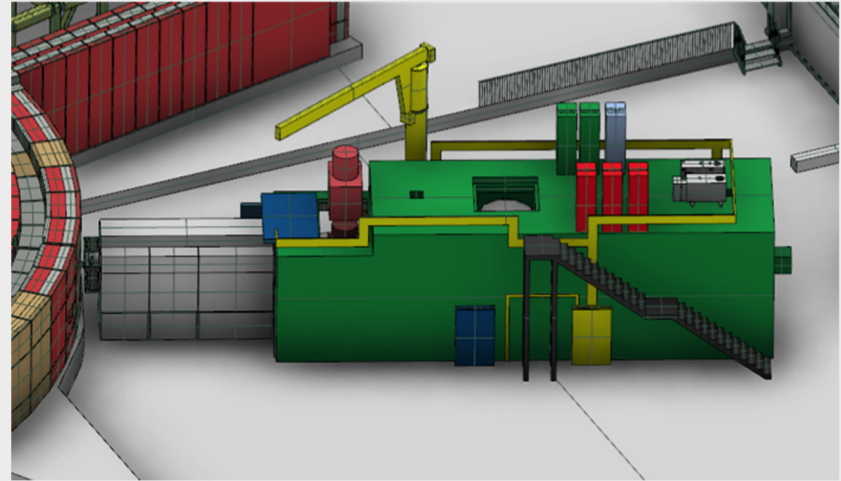
carbon	
grafana	
AKHQ	
graylog	



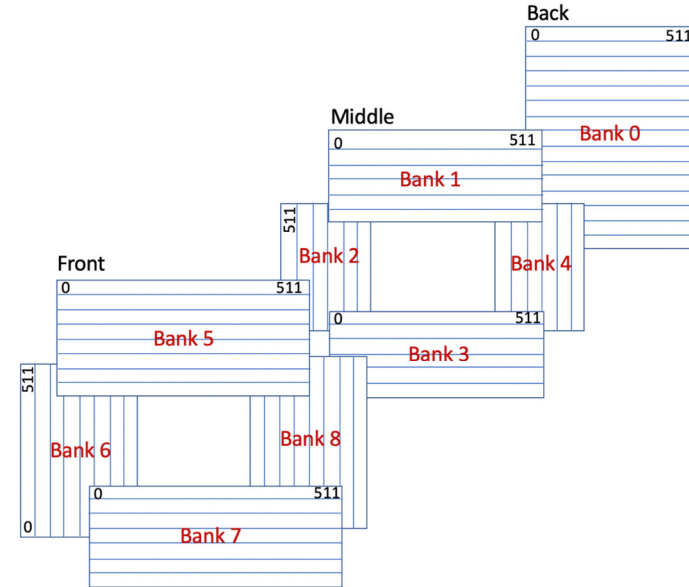
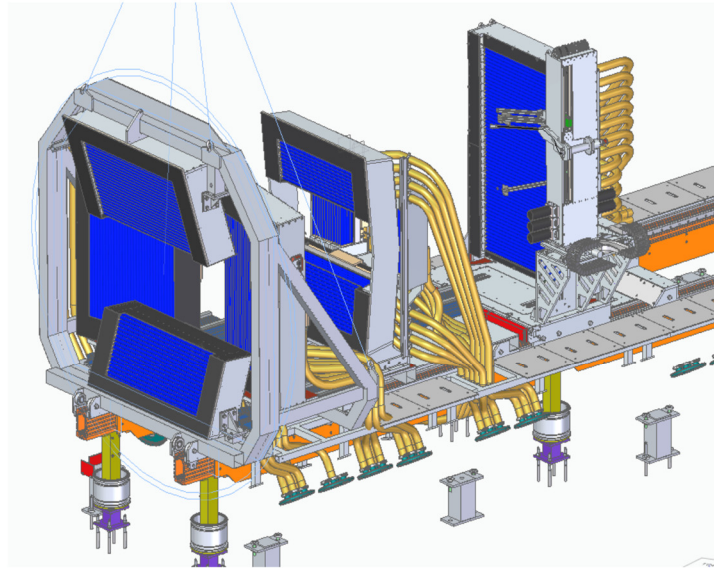
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3

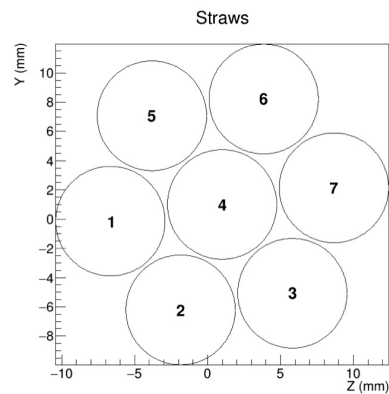
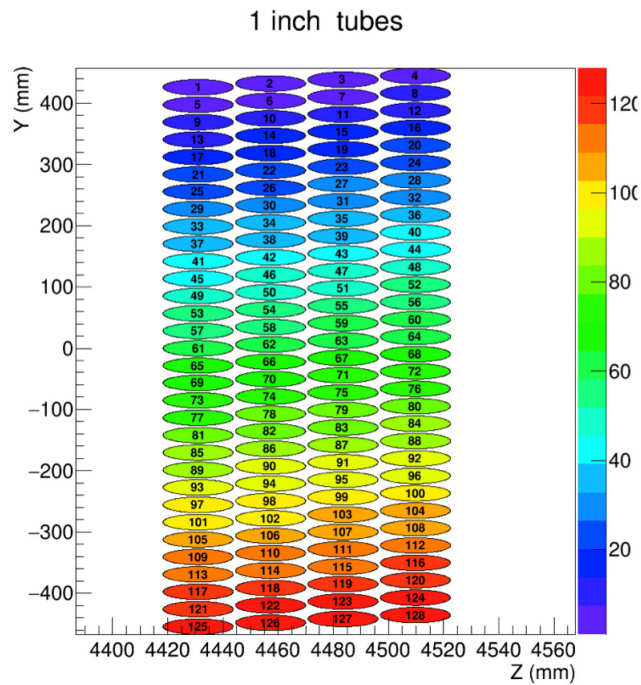
LoKI test at ISIS in March 2022



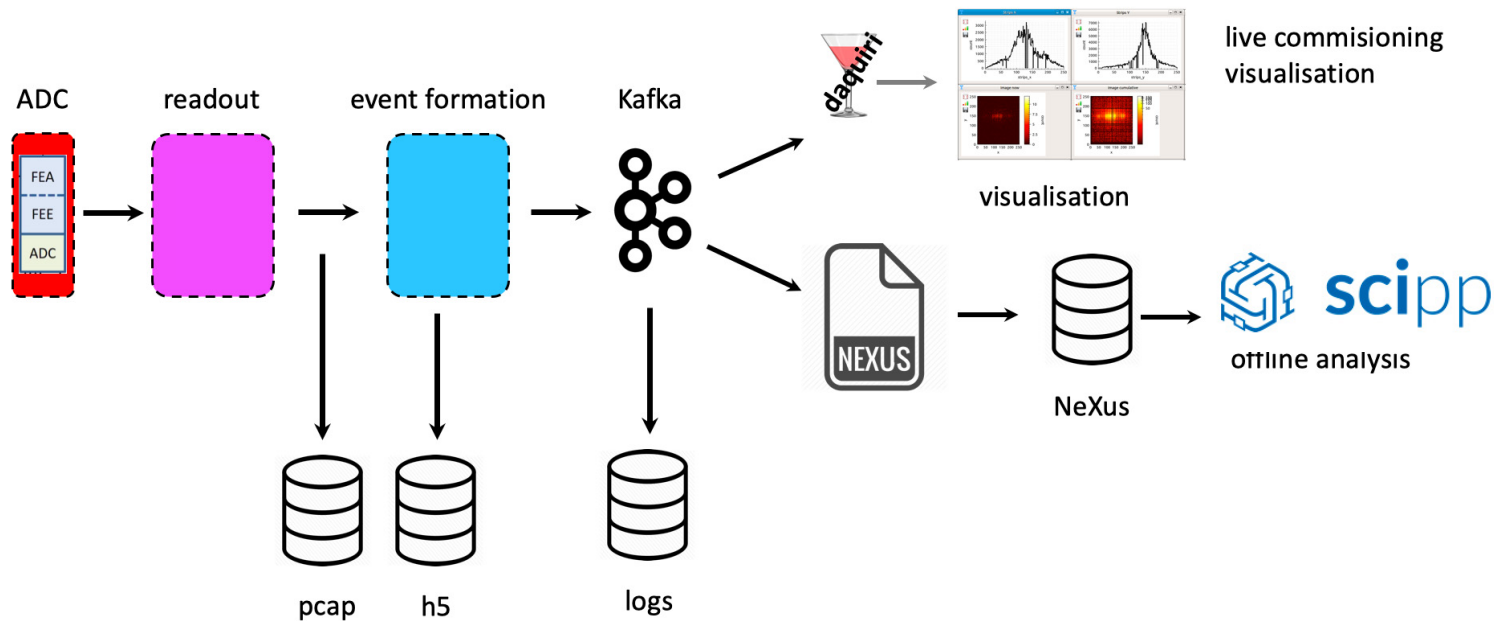
LoKI SANS Instrument & Detector



LoKI SANS Instrument & Detector



LoKI data pipeline



LoKI event formation



0	1	2	3	byte/address
		Padding 0x00	Version 0	0 - 1
Cookie 'S'		'S'	Type / SubType	2 - 5
Length		OQ ID	TimeSrc	6 - 9
Pulse time HI				10 - ##
Pulse time LO				14 - ##
Prev. Pulse time HI				18 - ##
Prev. Pulse time LO				22 - ##
Sequence Number				26 - ##
Ring ID	FEN ID	Length		
Time HI				
Time LO				
OM 1	TUBE	DataSeqNo		
Ampl A		Ampl B		
Ampl C		Ampl D		
Ring ID	FEN ID	Length		
Time HI				
Time LO				
OM 1	TUBE	DataSeqNo		
Ampl A		Ampl B		
Ampl C		Ampl D		

- Identify Bank and Section from Ring and FEN ID
- Identify Tube from Tube ID
- Identify straw and position along straw from amplitude values

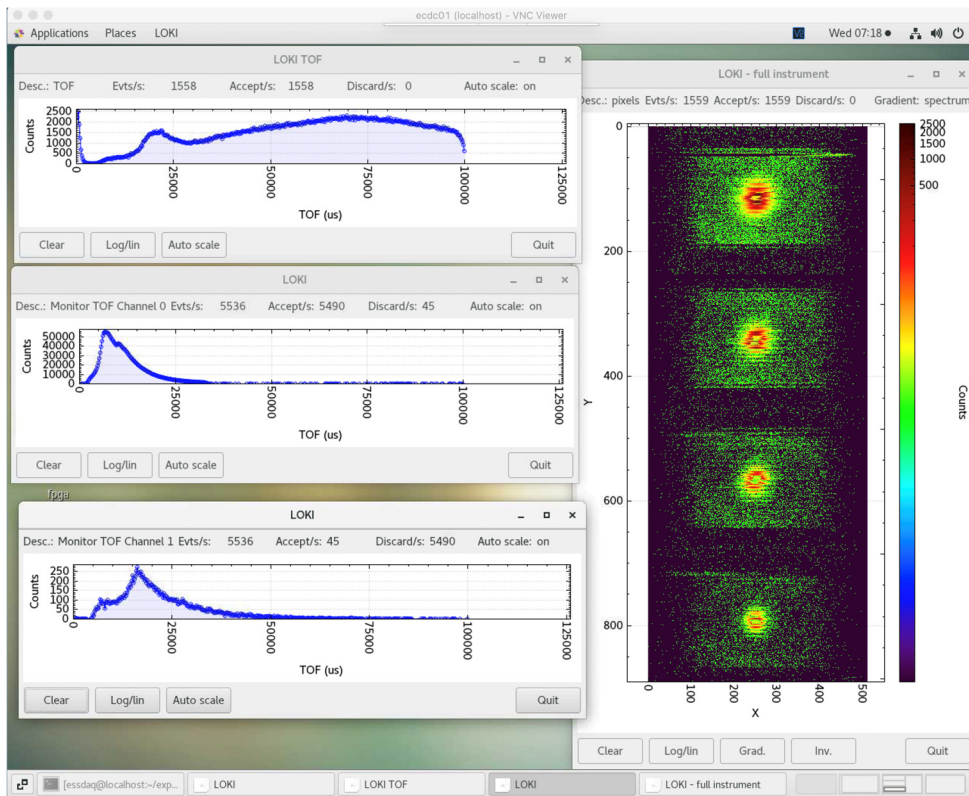
Ring ID	FEN ID	Length
Time HI		
Time LO		
OM 1	TUBE	DataSeqNo
Ampl A		Ampl B
Ampl C		Ampl D

$$Straw = \frac{B + D}{A + B + C + D} 6$$

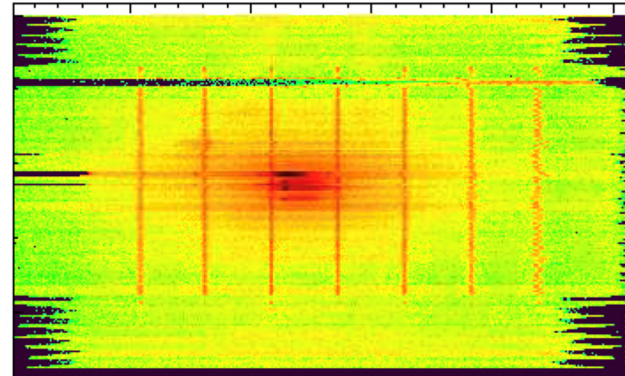
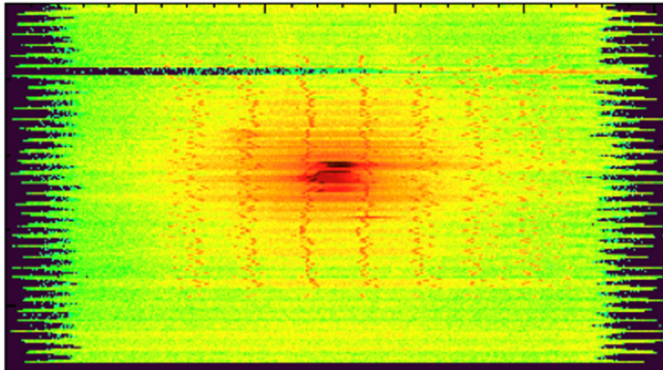
$$Pos = \frac{A + B}{A + B + C + D} (2^N - 1)$$

LoKI Detector test at Larmor



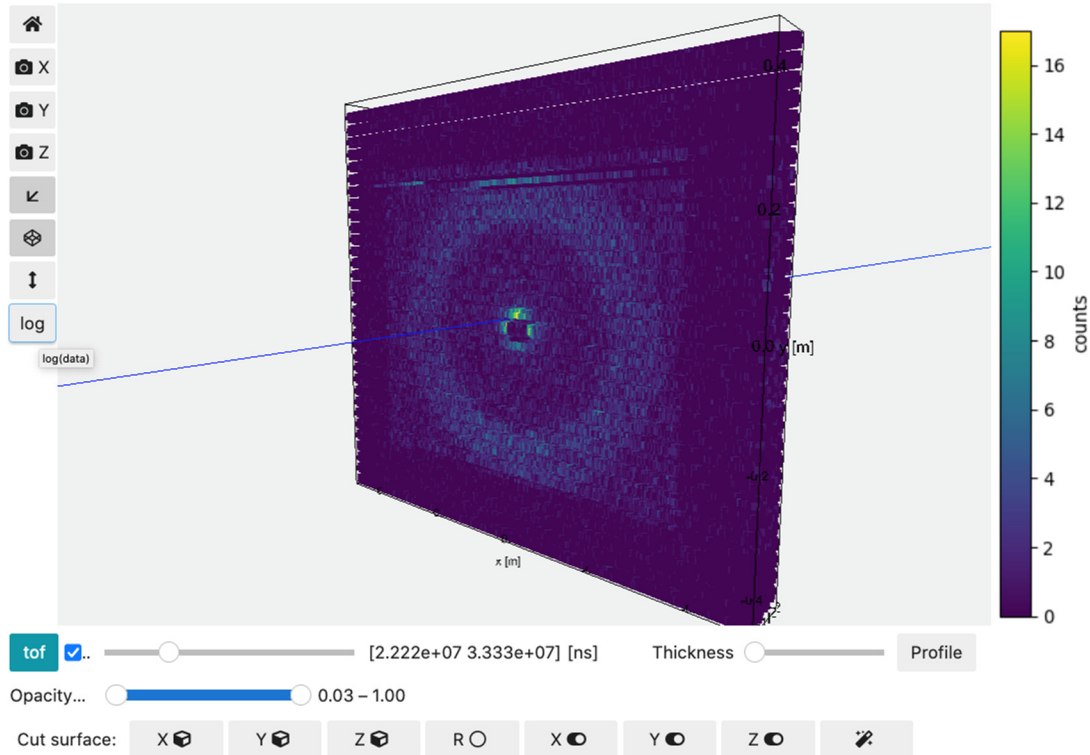


Straw Calibration



LoKI Detector test at AMOR

Data visualisation and analysis in scipp





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