

# Online software and controls for VMM SRS

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# About ESS



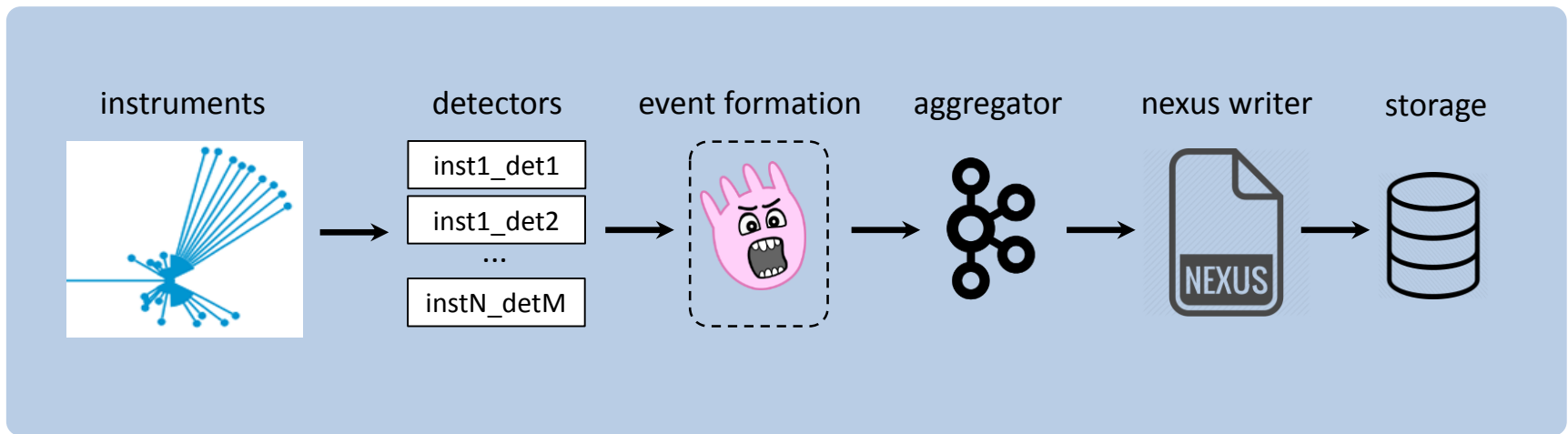
- Multidisciplinary research facility
- Powerful pulsed neutron source, Lund, Sweden
- Joint effort of 17 european countries
- Operational from 2023 with (initially) 15 instruments
- Everything is built from scratch
  - Instrument hardware
  - Detectors
  - Readout electronics
  - Data processing and management software

# Relation to RD51

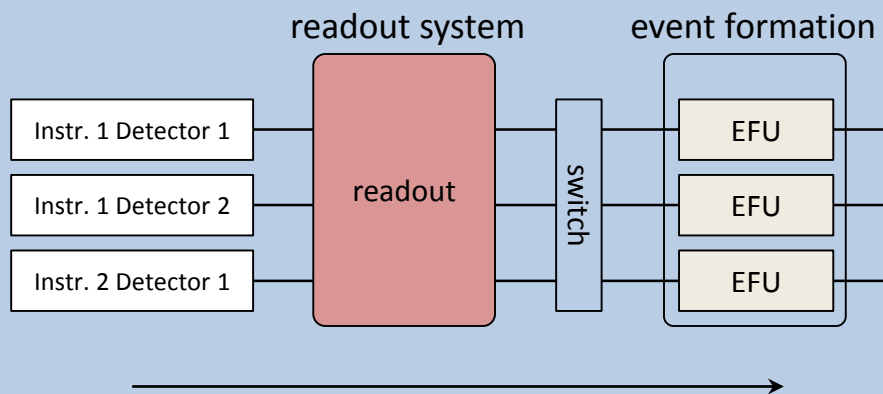
- Three detectors will cover 5(6) of the new instruments
  - Multigrad x2 (x3)
  - Multiblade (x2)
  - Gd-GEM
- All three detectors will use VMM3 for electronic readout
- Gd-GEM currently uses SRS

- Data Management and Software Centre
  - Situated in Copenhagen, Denmark
- Responsible for all software related to data
  - Acquisition, event formation, aggregation, storage and analysis
- Focus on early integration
  - Early info on data formats, rates, processing requirements
  - Collaboration with ESS Detector Group

# System data flow



# Detector to EFU

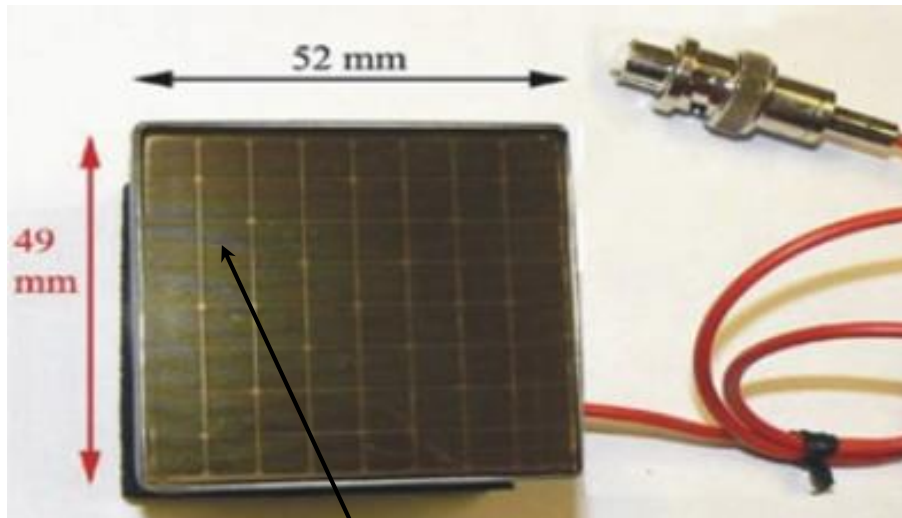
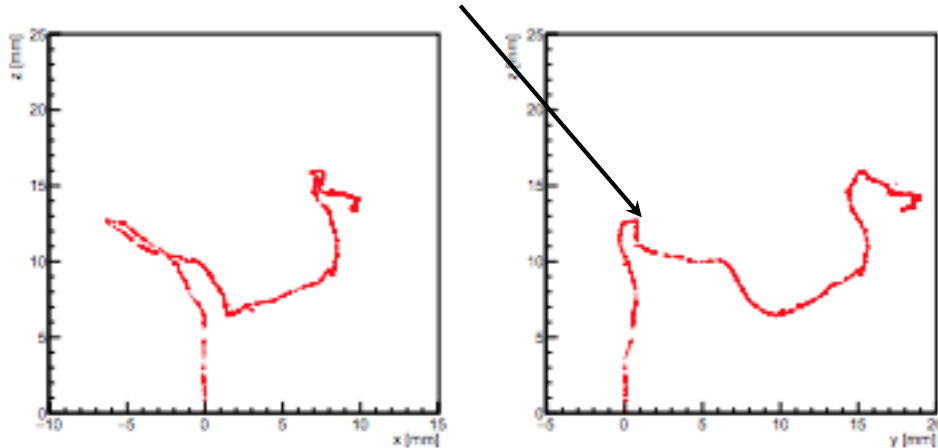


# Event Formation Unit (EFU)

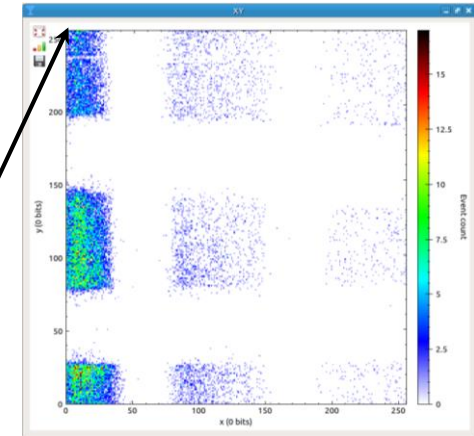
- Main function
  - receive detector data
  - calculate detector position (pixel)
  - generate events <t, pixel>

# Pixels: from complex to simple

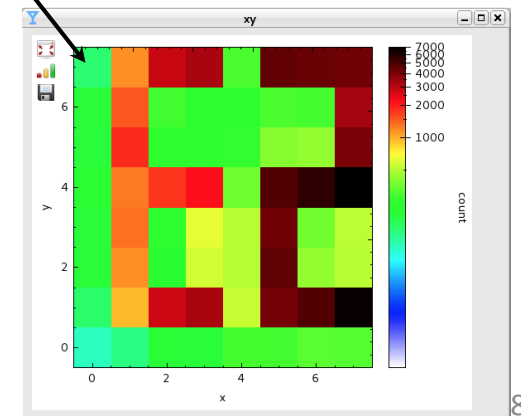
(fec, asic, channel, TOF, adc)



(asic, channel, TOF)



pixel 1

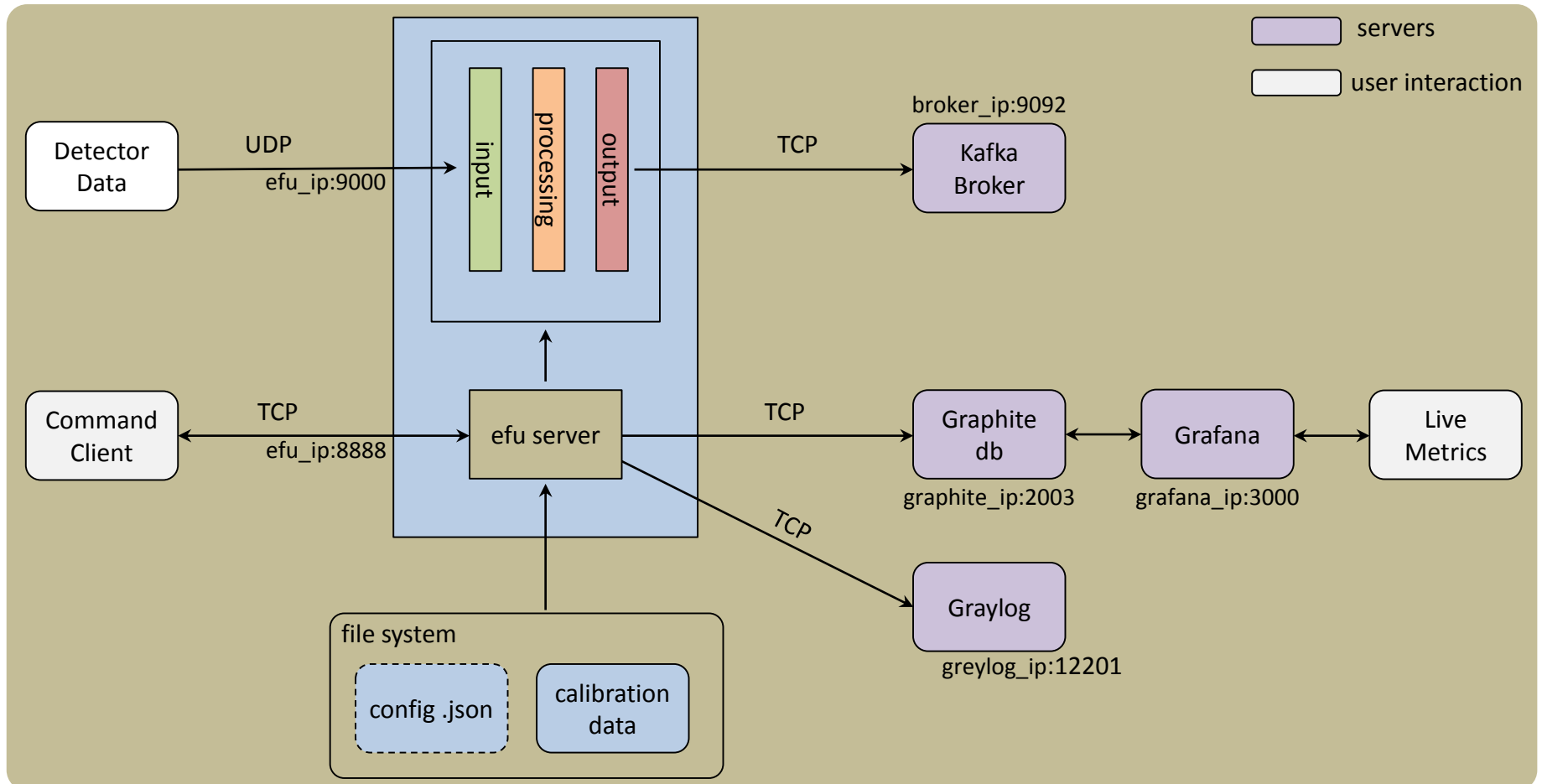




# Event Formation Unit (EFU)

- Main function
  - receive detector data
  - calculate detector position (pixel)
  - generate events <t, pixel>
  - forward events to scalable storage
- Multi threaded C++ application
  - Linux (Ubuntu and CentOS) and Mac
- Detector Framework
  - Loading and launching processing pipelines
  - Publish realtime metrics/counters with Graphite
  - Logging with Graylog
  - Command line API for remote operation
  - Streaming of event data with Kafka
- Custom detector processing plugins can be added

# EFU Framework



# EFU as VMM/SRS DAQ

- Software bundle on single workstation



- Readout software
  - RD51 VMM Slow control



- Event Formation Unit
  - Parser for SRS/VMM data format
  - Clustering and Event formation implementation
  - Software ‘hook’ to write readout data to disk



- Kafka
  - Data aggregation



- DAQuiri
  - Detector image visualization from Kafka topics
  - Histograms, particle track samples, TOF spectra, ...

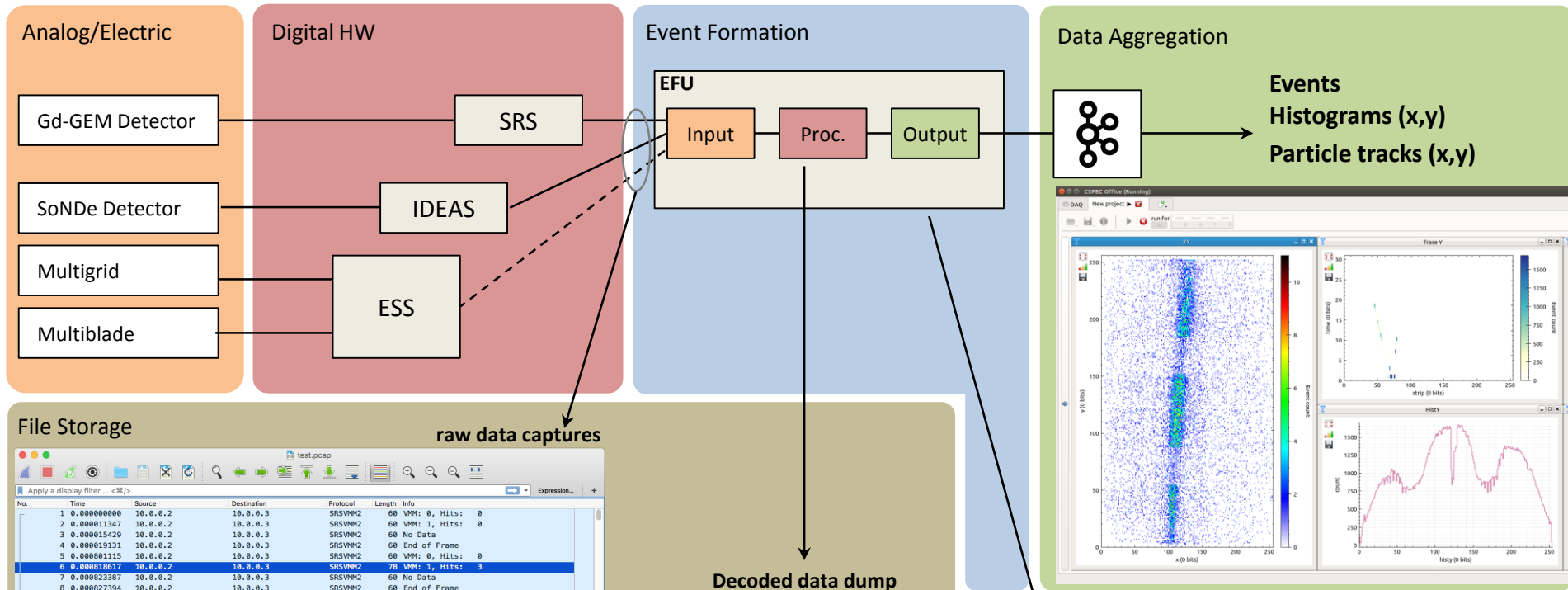


- Graphite/Grafana
  - Visualizing EFU time series data



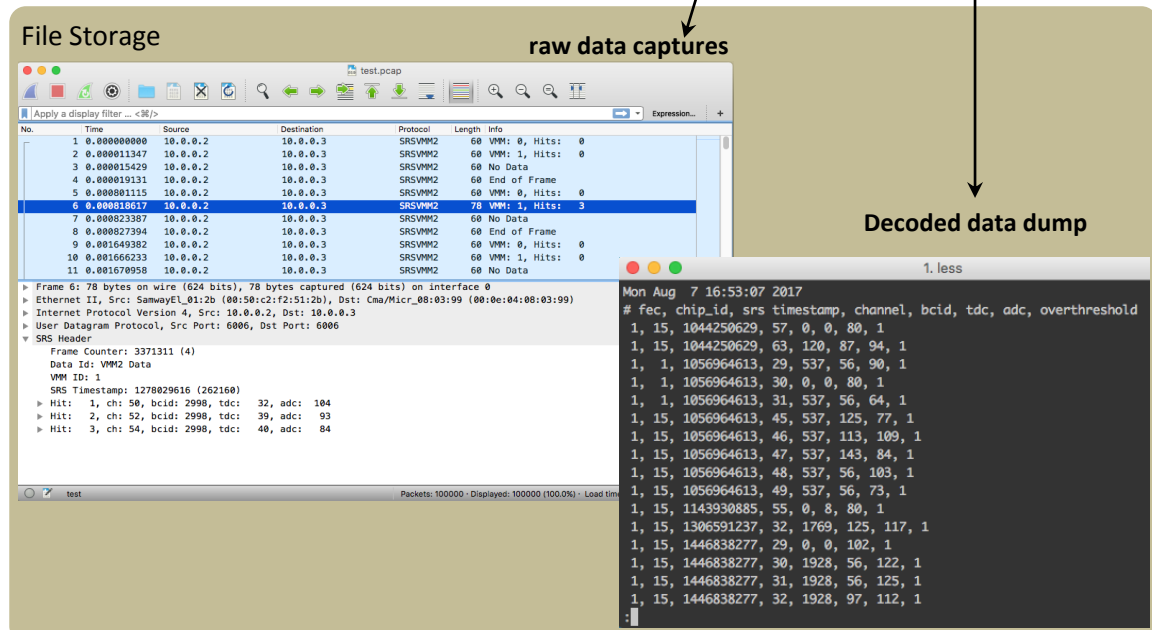
- Wireshark
  - Raw readout data capture, low level readout inspection

# Detector data taps



### File Storage

#### raw data captures



No.	Time	Source	Destination	Protocol	Length	Info
1	0.00000000	10.0.0.2	10.0.0.3	SRSVM2	60	VMM: 0, Hits: 0
2	0.00011347	10.0.0.2	10.0.0.3	SRSVM2	60	VMM: 1, Hits: 0
3	0.00015429	10.0.0.2	10.0.0.3	SRSVM2	60	No Data
4	0.00019131	10.0.0.2	10.0.0.3	SRSVM2	60	End of Frame
5	0.00080115	10.0.0.2	10.0.0.3	SRSVM2	60	VMM: 0, Hits: 0
6	0.00081517	10.0.0.2	10.0.0.3	SRSVM2	70	VMM: 1, Hits: 3
7	0.00082387	10.0.0.2	10.0.0.3	SRSVM2	60	No Data
8	0.000827394	10.0.0.2	10.0.0.3	SRSVM2	60	End of Frame
9	0.001649382	10.0.0.2	10.0.0.3	SRSVM2	60	VMM: 0, Hits: 0
10	0.001666233	10.0.0.2	10.0.0.3	SRSVM2	60	VMM: 1, Hits: 0
11	0.001678958	10.0.0.2	10.0.0.3	SRSVM2	60	No Data

Frame 6: 78 bytes on wire (624 bits), 78 bytes captured (624 bits) on interface 0  
 Ethernet II, Src: SamwoyE1\_01:2b (00:15bc:c2:f2:51:2b), Dst: Cma/Micr\_08:03:99 (00:0e:04:08:03:99)  
 Internet Protocol Version 4, Src: 10.0.0.2, Dst: 10.0.0.3  
 User Datagram Protocol, Src Port: 6006, Dst Port: 6006

SRS Header  
 Frame Counter: 3371311 (4)  
 Data Id: VM2 Data  
 VMM ID: 1  
 SRS Timestamp: 1278029616 (262160)  
 Hit: 1, ch: 50, bcid: 2998, tdc: 32, adc: 104  
 Hit: 2, ch: 52, bcid: 2998, tdc: 39, adc: 93  
 Hit: 3, ch: 54, bcid: 2998, tdc: 48, adc: 84

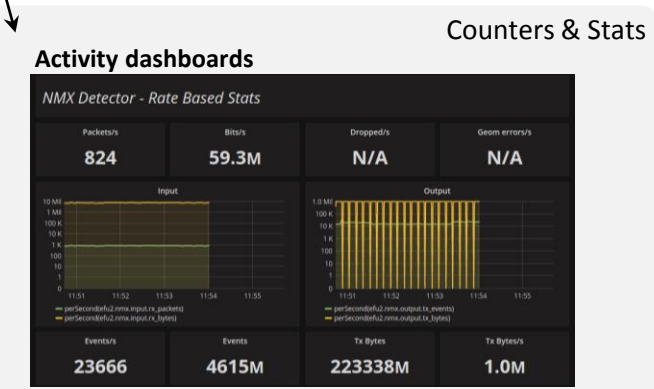
#### Decoded data dump

```

1. less
Mon Aug 7 16:53:07 2017
# fec, chip_id, srs timestamp, channel, bcid, tdc, adc, overthreshold
1, 15, 1044250629, 57, 0, 0, 80, 1
1, 15, 1044250629, 63, 120, 87, 94, 1
1, 1, 1056964613, 29, 537, 56, 90, 1
1, 1, 1056964613, 30, 0, 0, 80, 1
1, 1, 1056964613, 31, 537, 56, 64, 1
1, 15, 1056964613, 45, 537, 125, 77, 1
1, 15, 1056964613, 46, 537, 113, 109, 1
1, 15, 1056964613, 47, 537, 143, 84, 1
1, 15, 1056964613, 48, 537, 56, 103, 1
1, 15, 1056964613, 49, 537, 56, 73, 1
1, 15, 1143930885, 55, 0, 8, 80, 1
1, 15, 1306591237, 32, 1769, 125, 117, 1
1, 15, 1446838277, 29, 0, 0, 102, 1
1, 15, 1446838277, 30, 1928, 56, 122, 1
1, 15, 1446838277, 31, 1928, 56, 125, 1
1, 15, 1446838277, 32, 1928, 97, 112, 1
  
```

### Activity dashboards

#### Counters & Stats



**NMX Detector - Rate Based Stats**

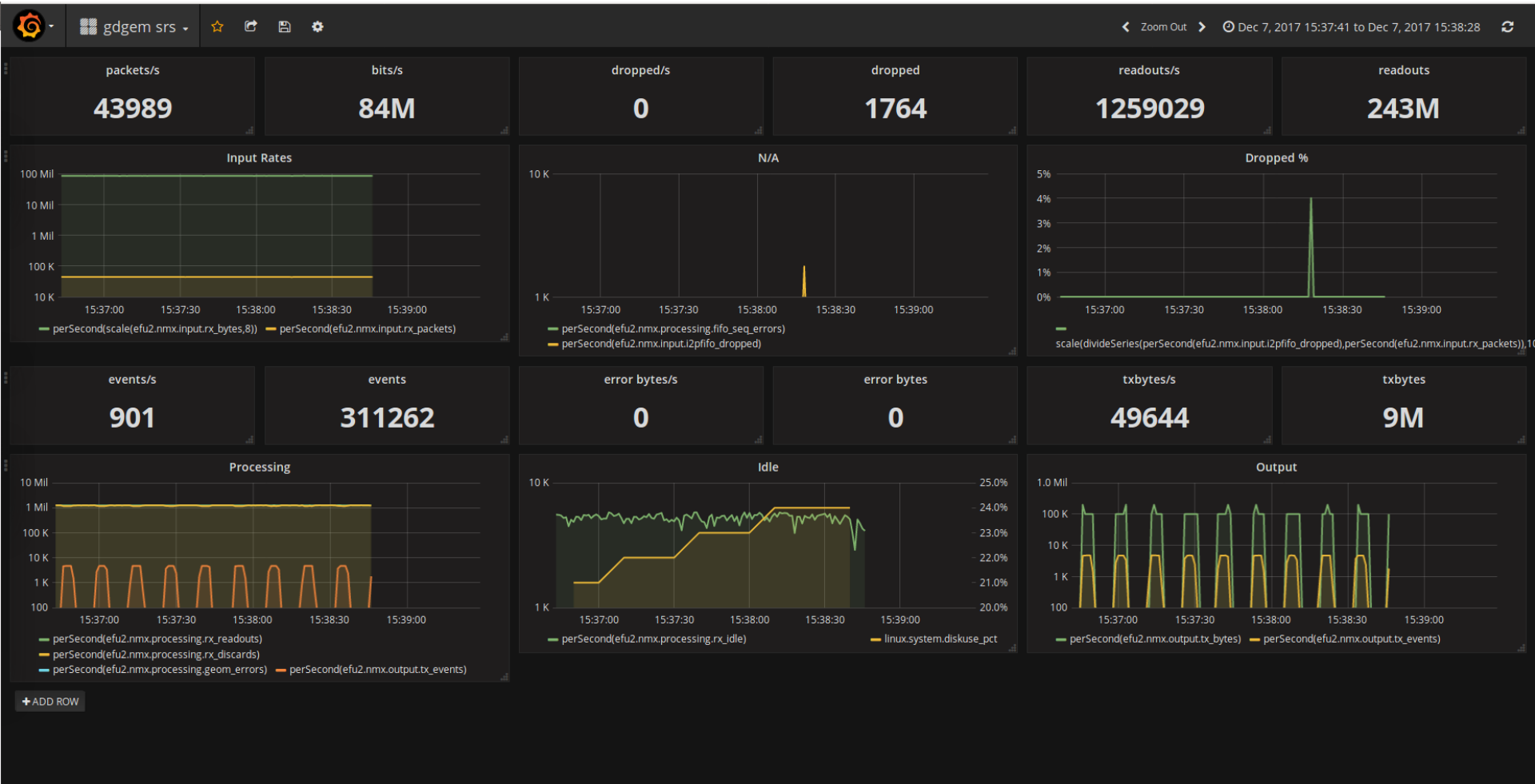
Packets/s	Bits/s	Dropped/s	Geom errors/s
824	59.3M	N/A	N/A

Input: 10 M, 1 M, 100 K, 10 K, 1 K, 100, 10, 1

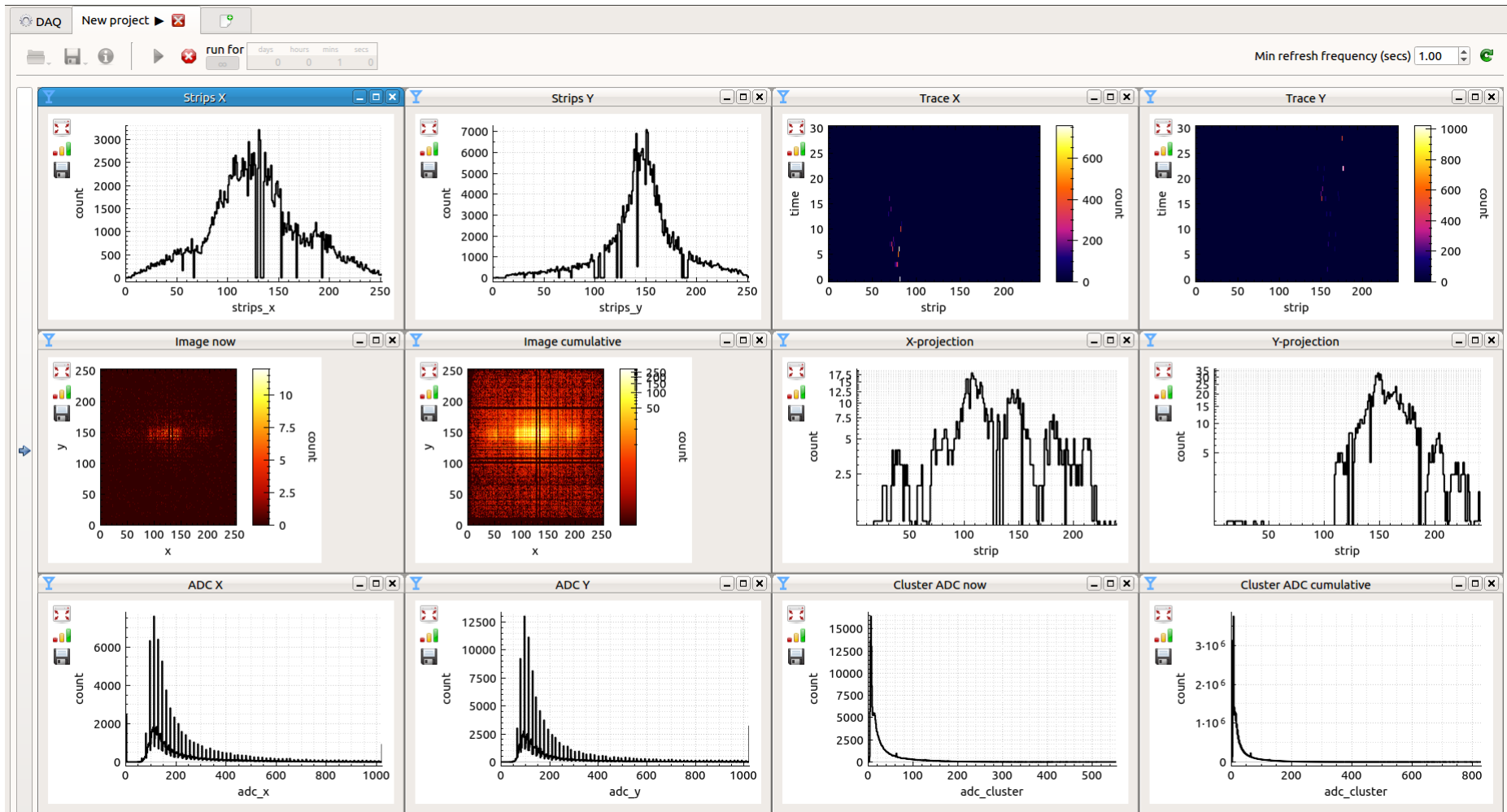
Output: 1.0 M, 100 K, 10 K, 1 K, 100, 10, 1

Events/s: 23666, Events: 4615M, Tx Bytes: 223338M, Tx Bytes/s: 1.0M

# VMM/SRS readout stats



# VMM data visualization



# Performance

- Recent experiments on real ESS detector readout data
  - Linux
  - Xeon E5-2620 v3 @ 2.40GHz CPU
  - 1G Ethernet
  - using two cores: input and processing

detector	packets/s	bits/s	dropped	events/s	geomerrors/s
Multiblade	83k	957M	5%	2.4M	3.7M
Multigrad	13k	117M	0%	2.7M	56k
SoNDe	94k	949M	0%	23.2M	n/a
Gd-GEM	239k	78M	0%	10k	n/a?

- When writing to disk, speeds are lower

- Using the anticipated infrastructure for early detector experiments we
  - get early validation of the implementation
  - obtain a common understanding of the interface
  - establish early collaboration across the organization
  - Identify processing bottle necks for later improvement
- Providing tools for live data and statistics visualization
  - Efficient use of beam time
  - Expert views can be customized for prototype detectors
  - Processing algorithms can be quickly tested and validated



## Event Formation Unit

<https://github.com/ess-dmsc/event-formation-unit>

## DAQuri

<https://github.com/ess-dmsc/daquri>

## Grafana

<https://grafana.com/> or run in Docker container

<https://github.com/ess-dmsc/utils>

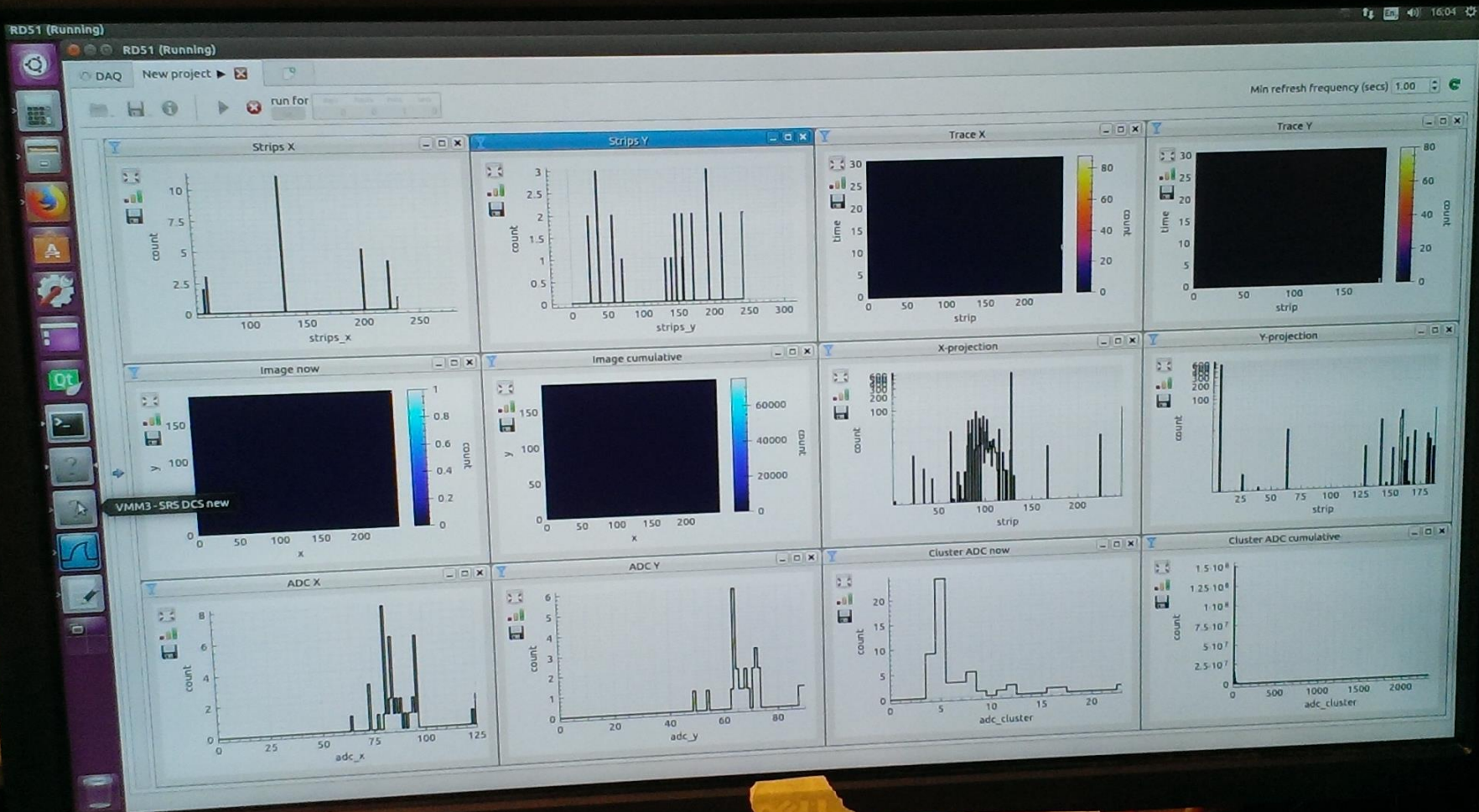
## Apache Kafka

<https://kafka.apache.org/>

## Graylog

<https://www.graylog.org/>

We can provide detailed installation instructions – get in touch



IFE 1.49.4253

R2D2

SLOW CONTROL

WIRESHARK

EFU