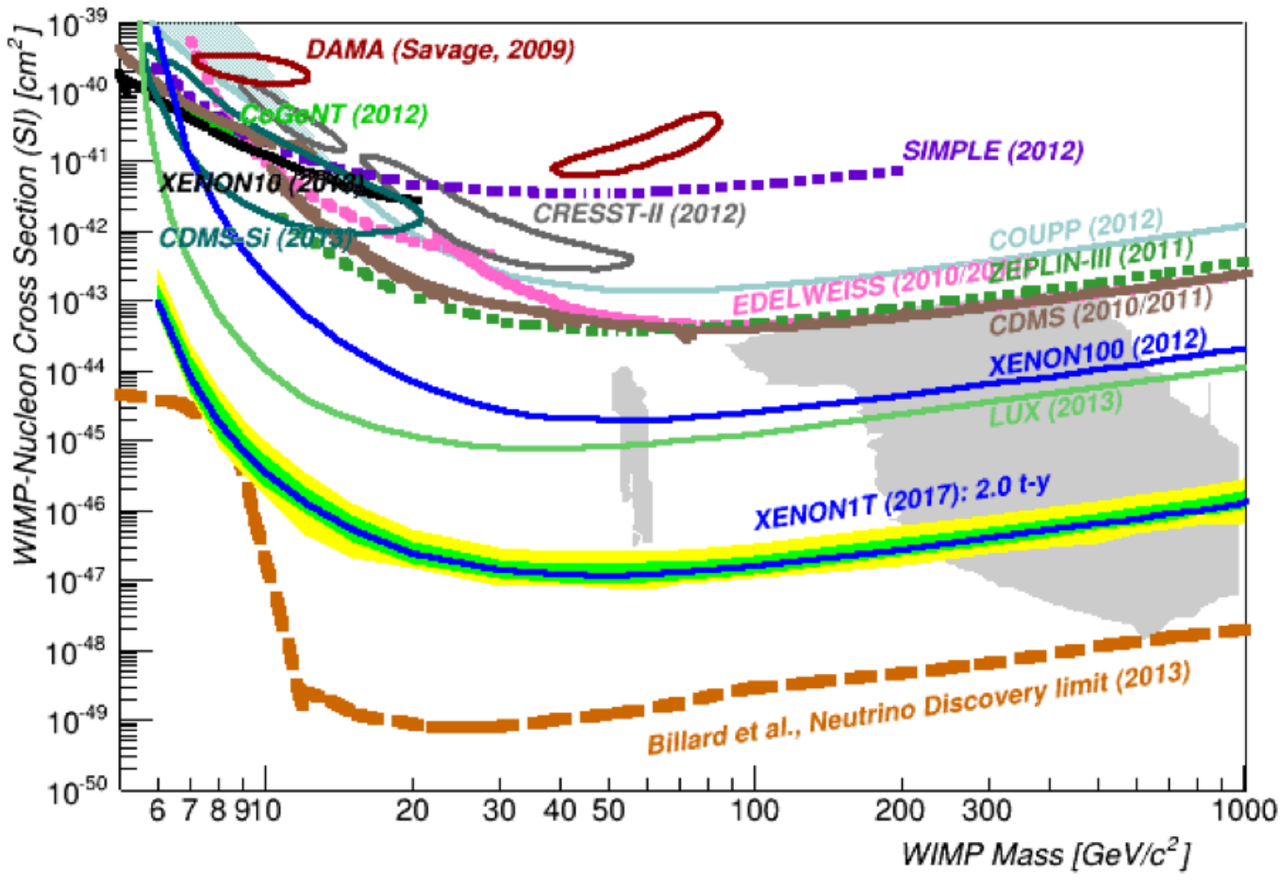
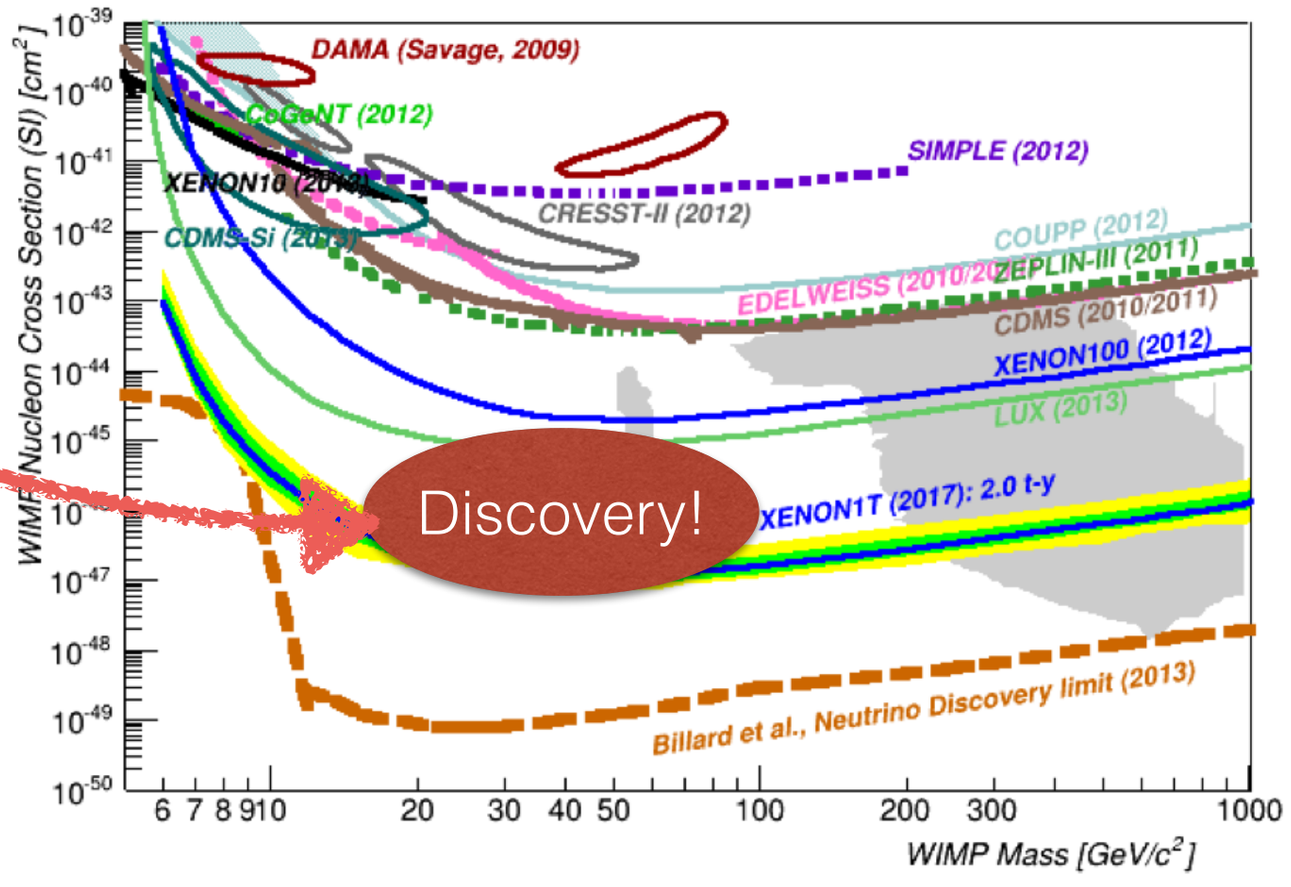
XENON1T
DAQ to analysis:
“klein maar fijn”

Christopher Tunnell

Nikhef Jamboree ‘15


DAMA (Savage, 2009)
CoGeNT (2012)
SIMPLE (2012)
XENON10 (2013)
CRESST-II (2012)
CDMS-Si (2013)
COUPP (2012)
EDELWEISS (2010/2011)
ZEPLIN-III (2011)
CDMS (2010/2011)
XENON100 (2012)
LUX (2013)
XENON1T (2017): 2.0 t-y
Billard et al., Neutrino Discovery limit (2013)
WIMP-Nucleon Cross Section (SI) [cm^2]
WIMP Mass [GeV/c^2]
10^{-39}
10^{-40}
10^{-41}
10^{-42}
10^{-43}
10^{-44}
10^{-45}
10^{-46}
10^{-47}
10^{-48}
10^{-49}
10^{-50}
6 7 8 9 10 20 30 40 50 100 200 300 1000

1. Save interesting data
2. Reconstruct data
3. Analyze data



1. Save interesting data

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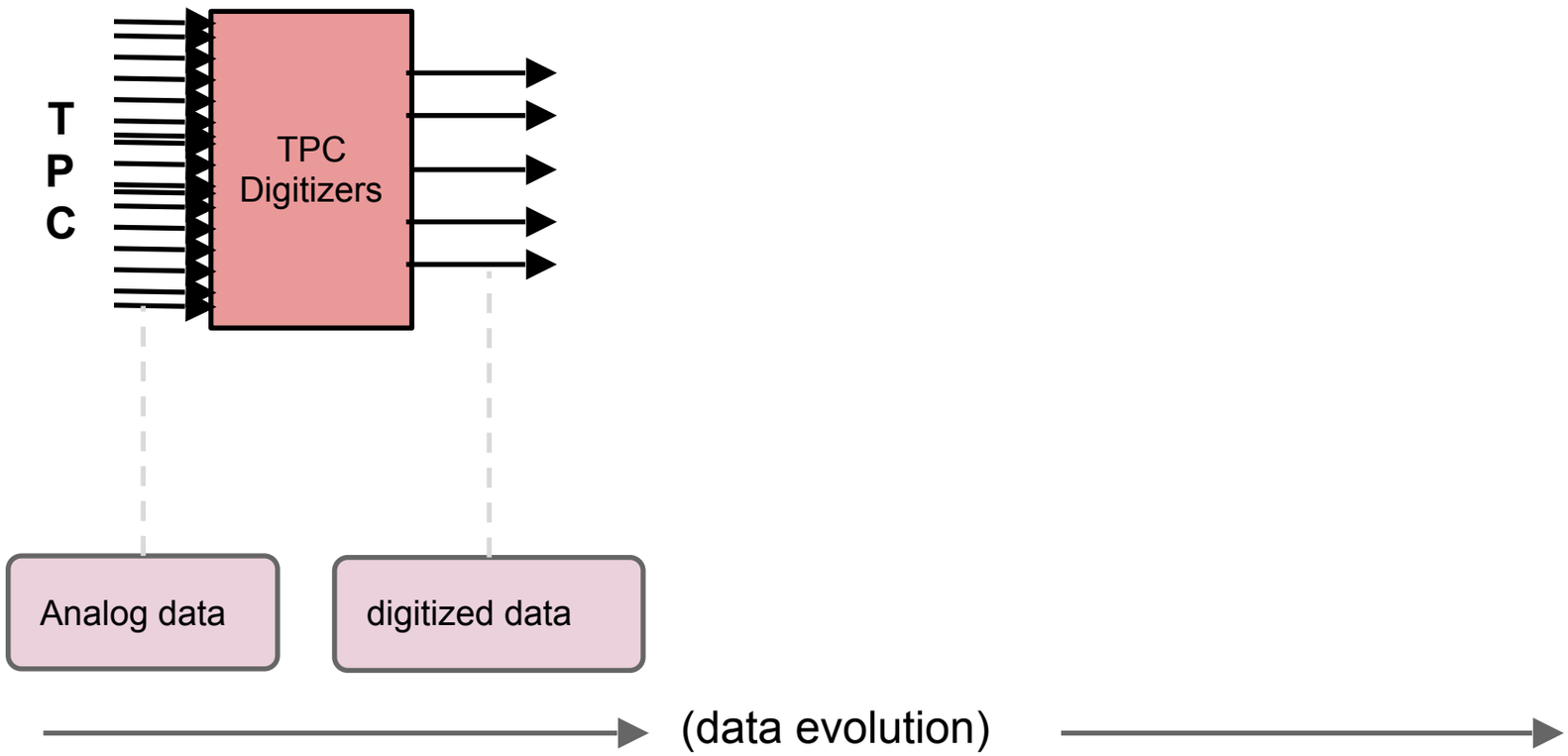
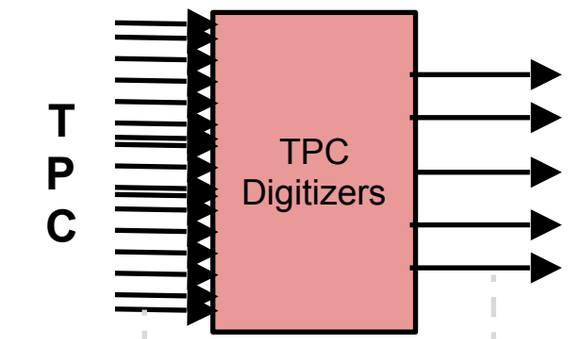
Hardware and Software Components



1. Save interesting data

Hardware and Software Components

Digitizers

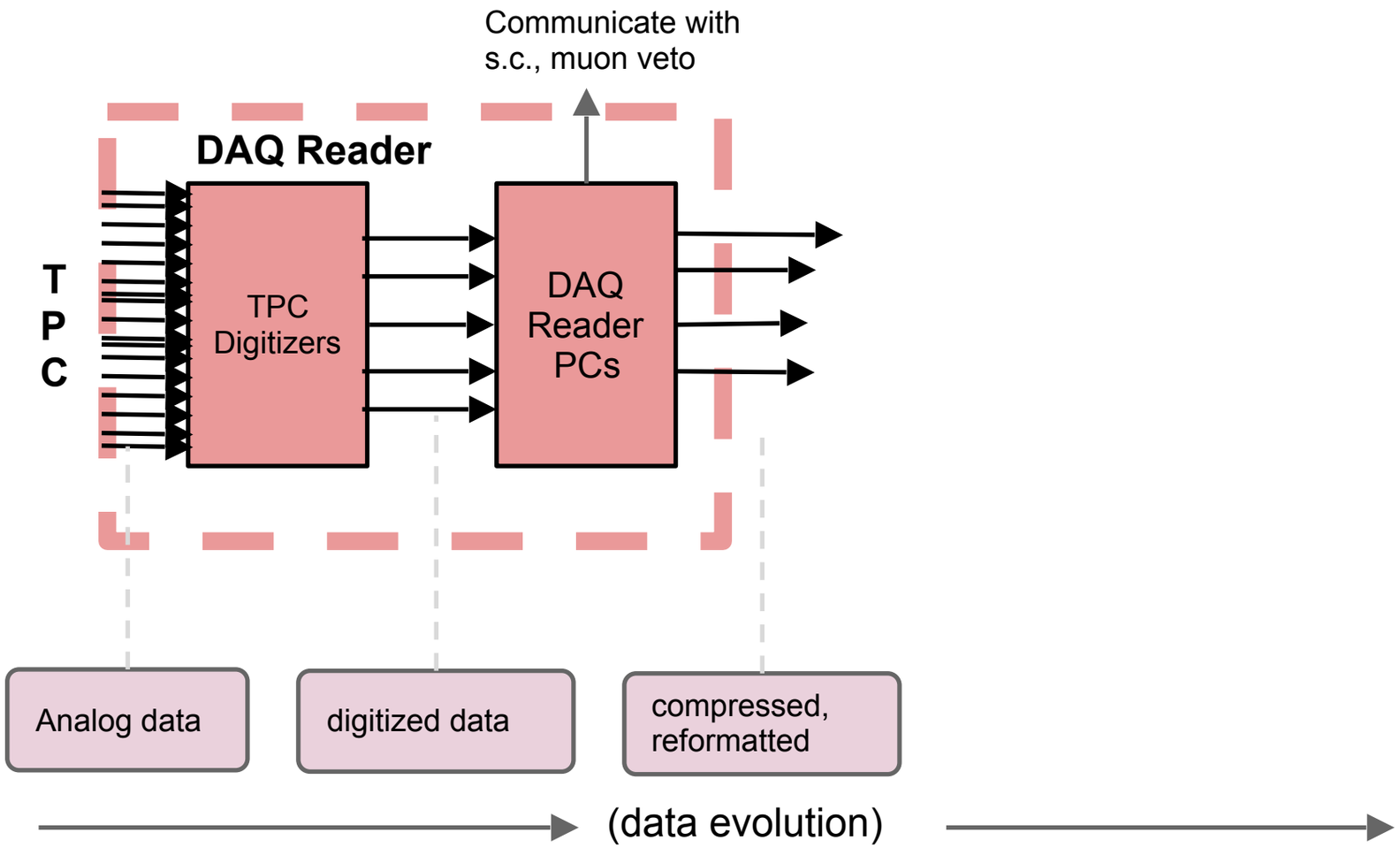


- **Off the shelf**
- CAEN V1724 - same as in XENON100
- New firmware for XENON1T
  - Triggerless readout
- 8 channels, 100 Ms/sec, 14-bit samples

(data evolution)

1. Save interesting data

Hardware and Software Components



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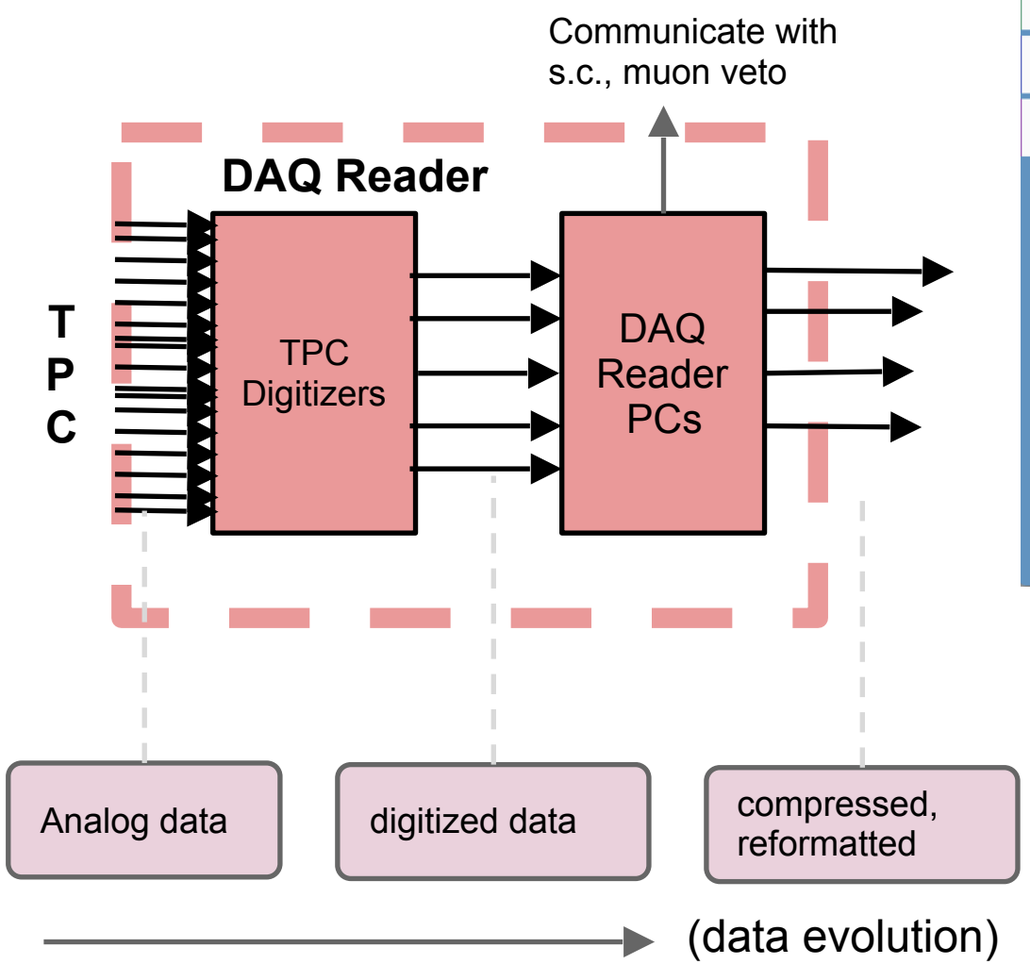
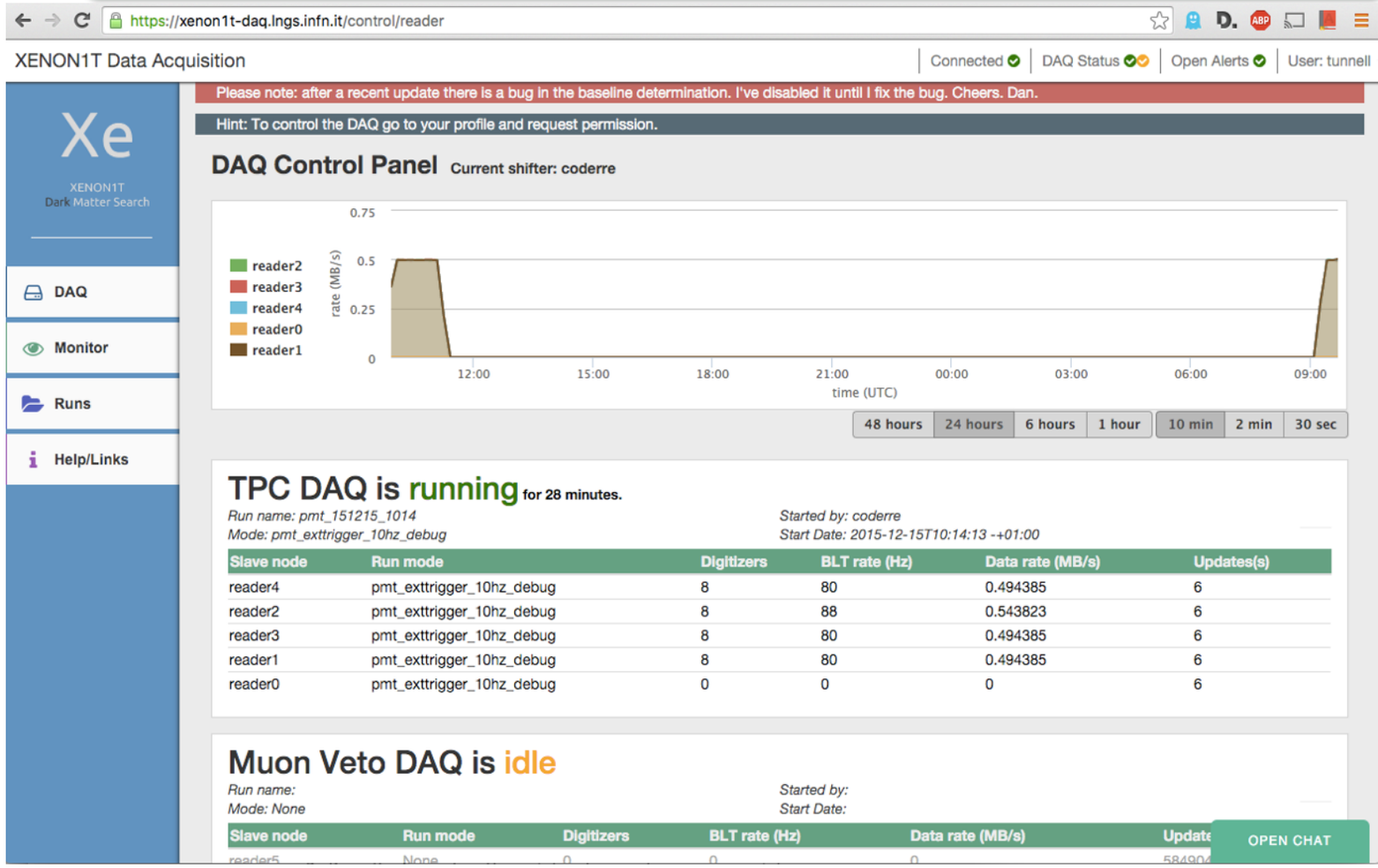
Hardware and Software Components





- **Read out data**
- Control everything via *django* and web
- Compress on fly with *snappy* from Google

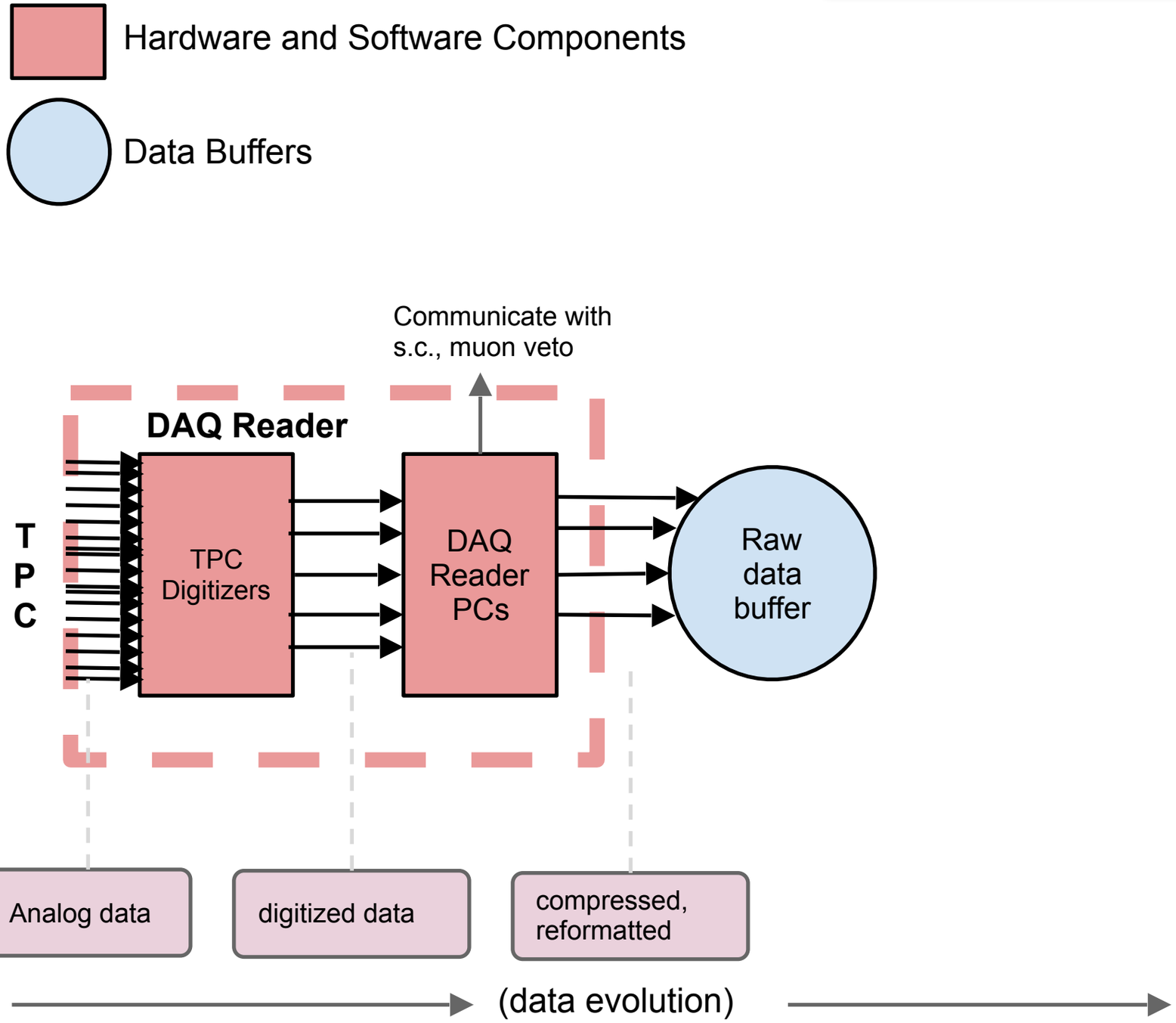
django

d3.js

jQuery
write less, do more.

Google

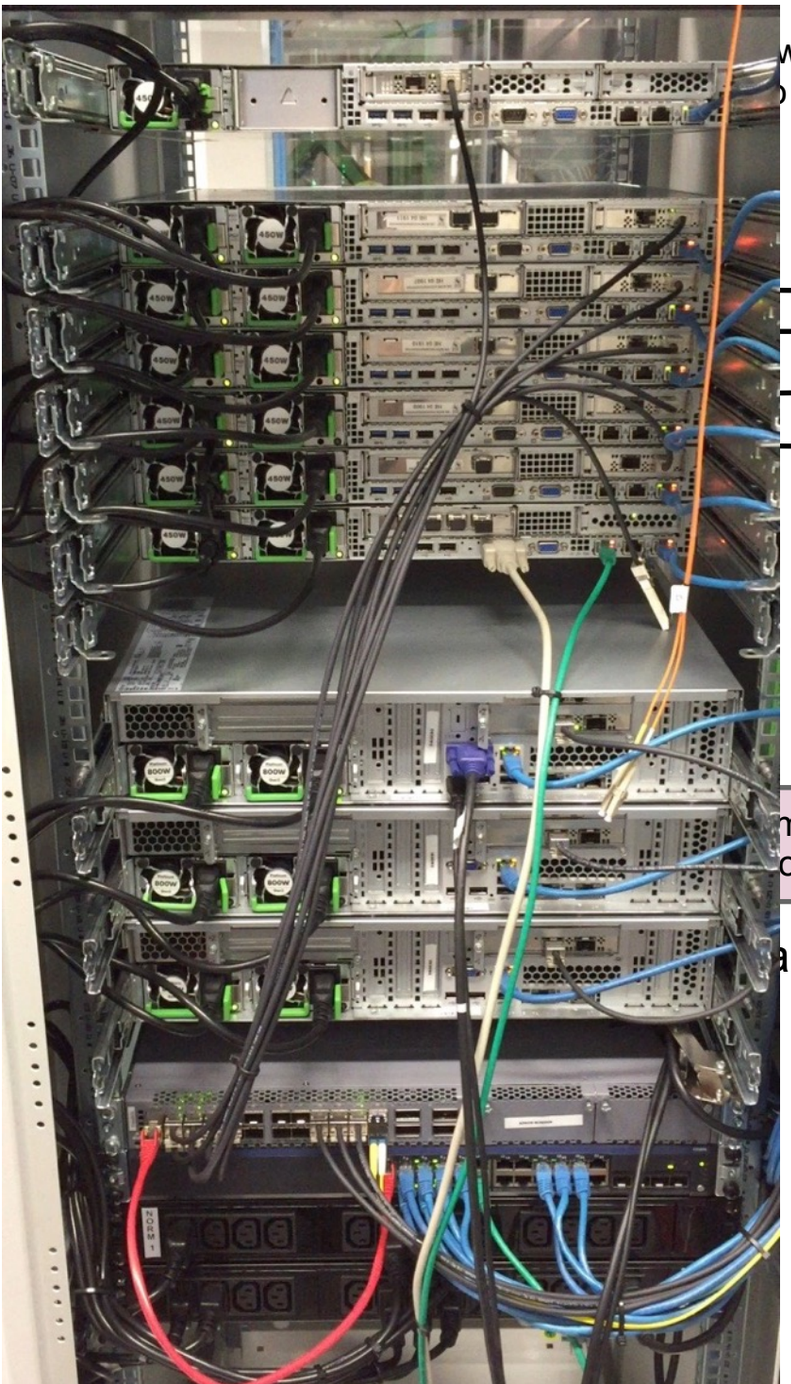
1. Save interesting data



1. Save interesting data

Hardware and Software Components

Data Buffers



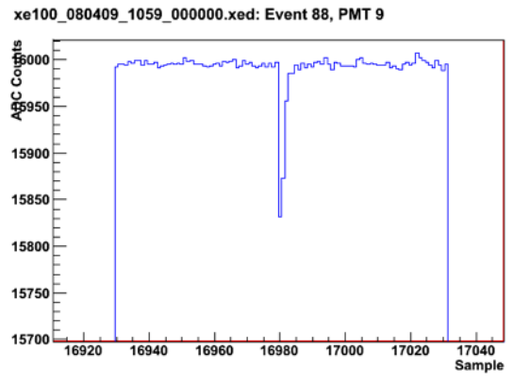
with

Raw data buffer

mpressed, ormatted

a evolution)

Insert "occurrences" into DB, these are data quanta



Unstructured data buffer

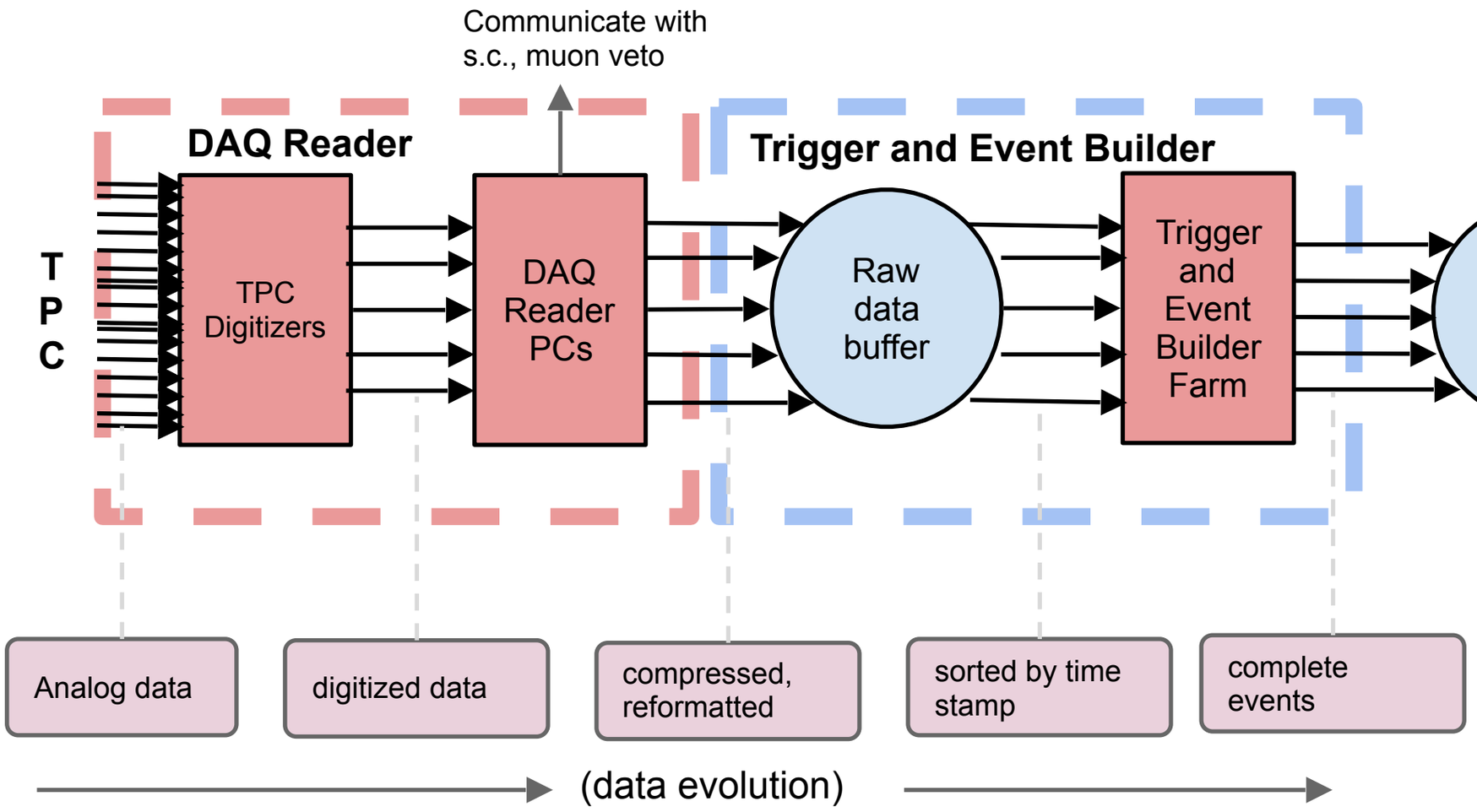
- **Readout is CAEN -> MongoDB convertor**
- OTC MongoDB database
  - Fast
  - Simple
  - Scalable
  - Supported (beyond physics!)
    - CMS, Guardian, Orange, etc
- Need fast network too, HFT switch (left)
- Queryable:
  - **"Give me all data over a one-second time window"**

Thanks Tristan!

1. Save interesting data

Hardware and Software Components

Data Buffers



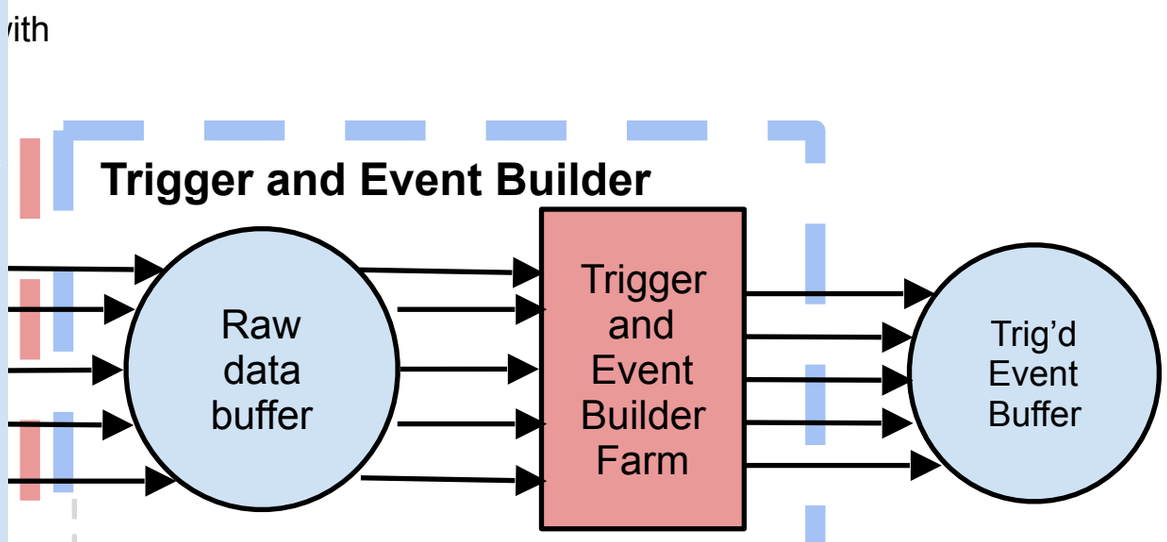
1. Save interesting data

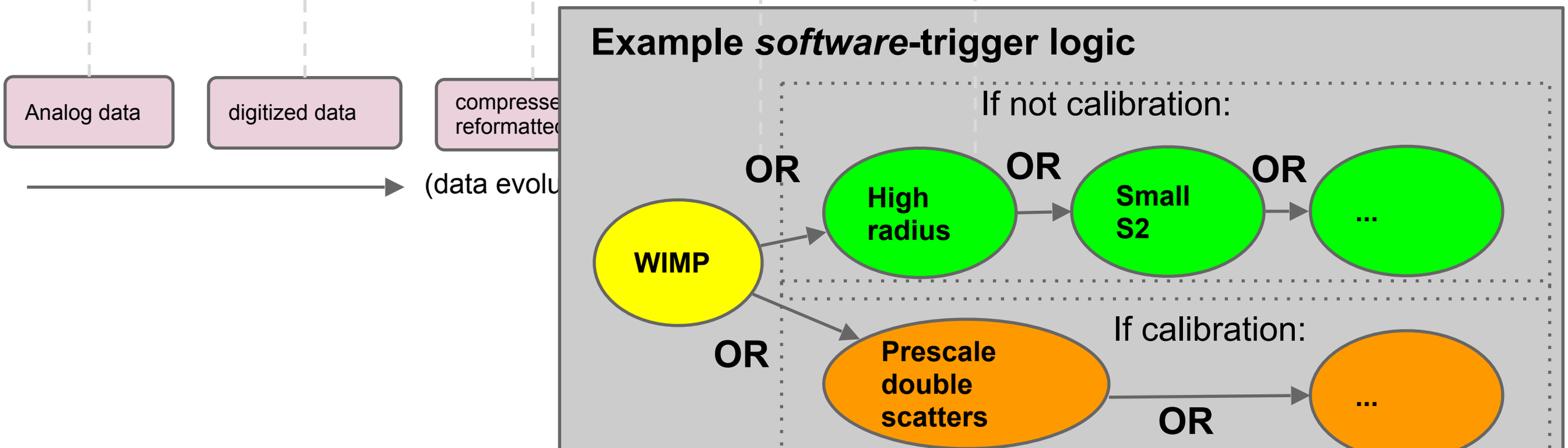
Hardware and Software Components

Data Buffers

Implementation:

- Software high-level trigger
- Uses 120 cores
- Process live
- Data stored in MongoDB backend





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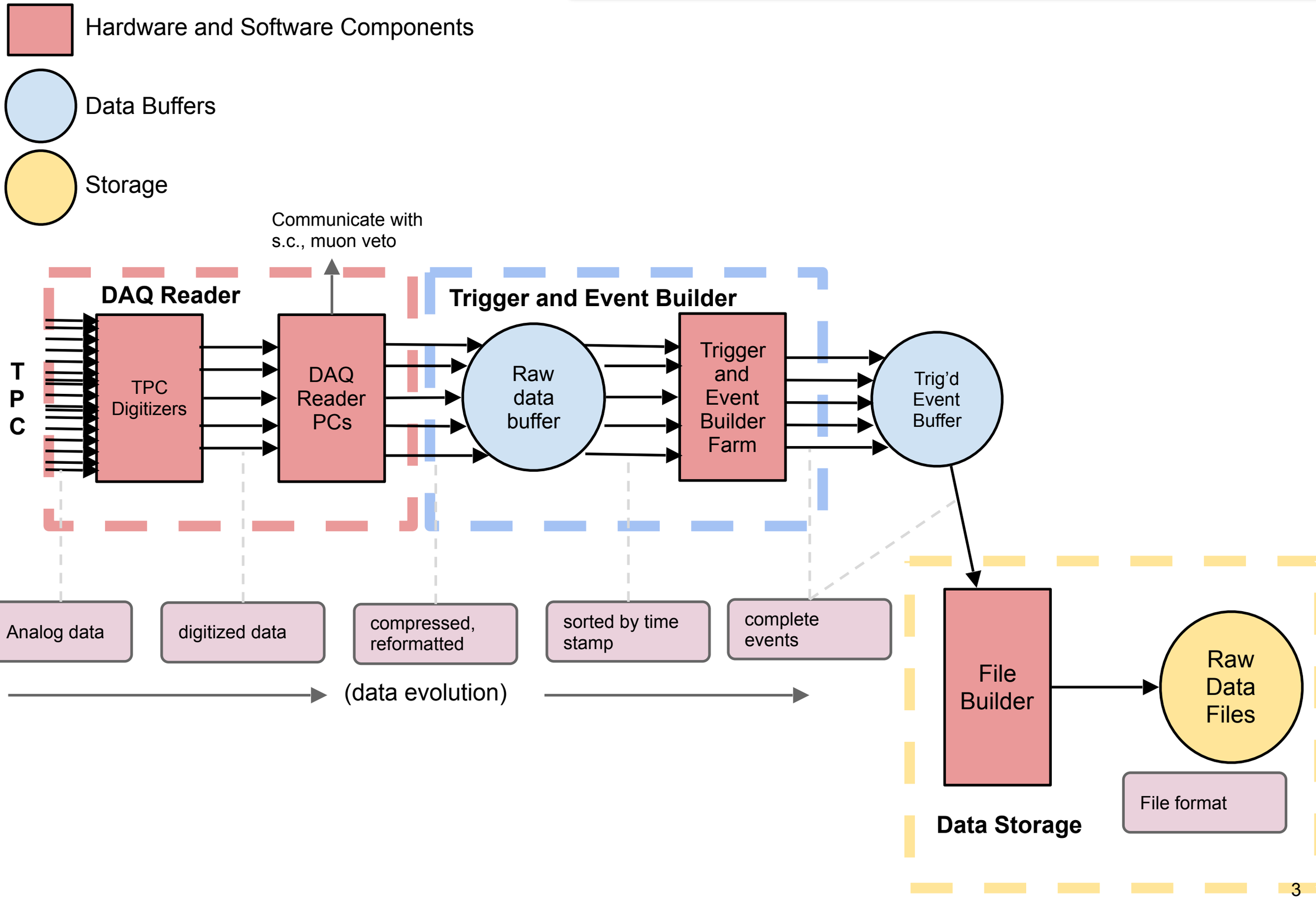
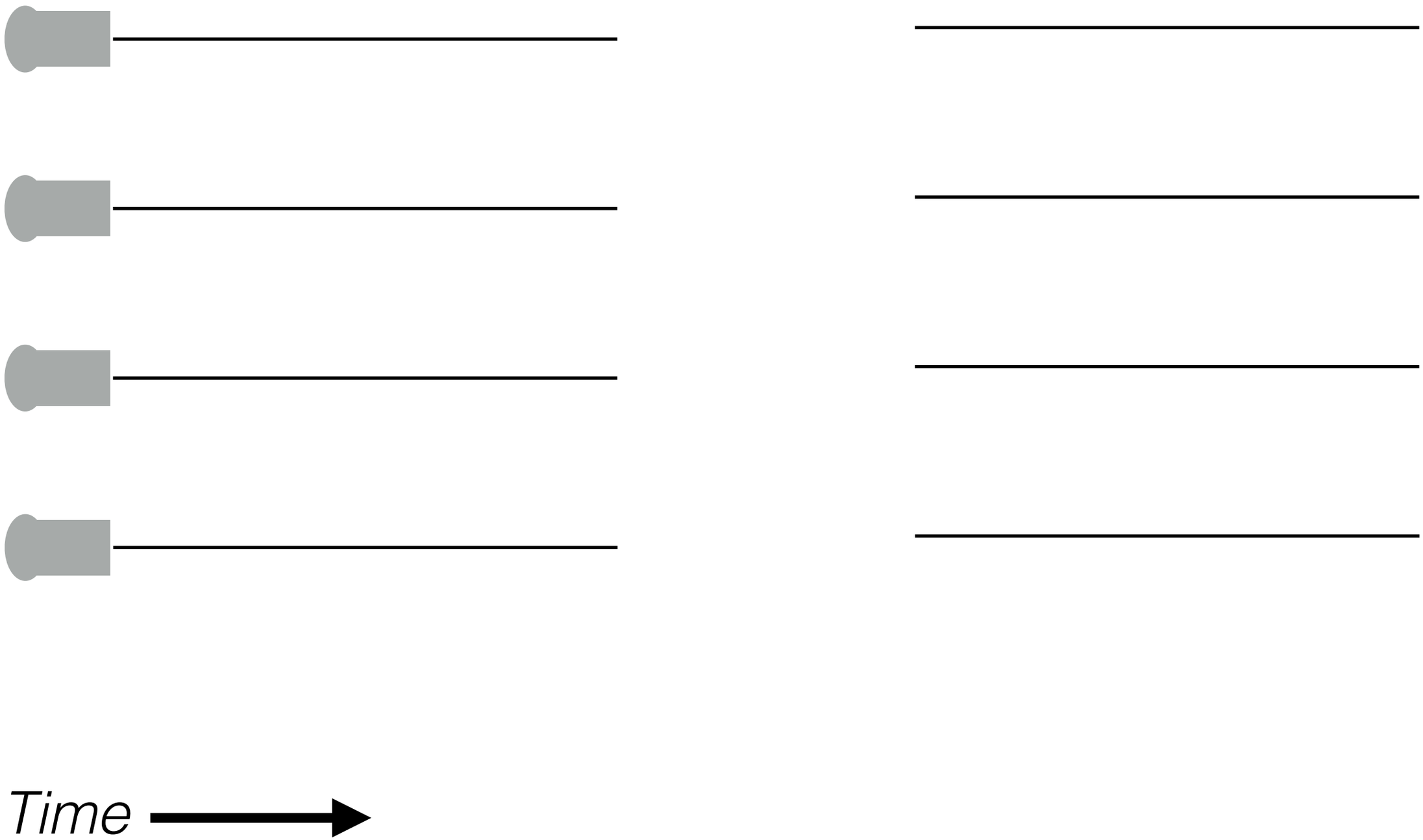


1. Save interesting data

Who	Purpose	Experience
mongoDB.	Offload data handling and processing to database	Positive, but high rate of change: gets quicker but yearly API changes
CAEN Tools for Discovery Electronic Instrumentation	Digitizer and read out signals	Works but frequent driver problems and a pyCAEN would help testing.
django	Run DAQ	Usability of DAQ increased using web… also less work for us
CONTINUUM ANALYTICS	Write trigger routines in Python that are faster than C++	Refactoring easy and allows online processing, but requires good testing

2. Reconstruct data



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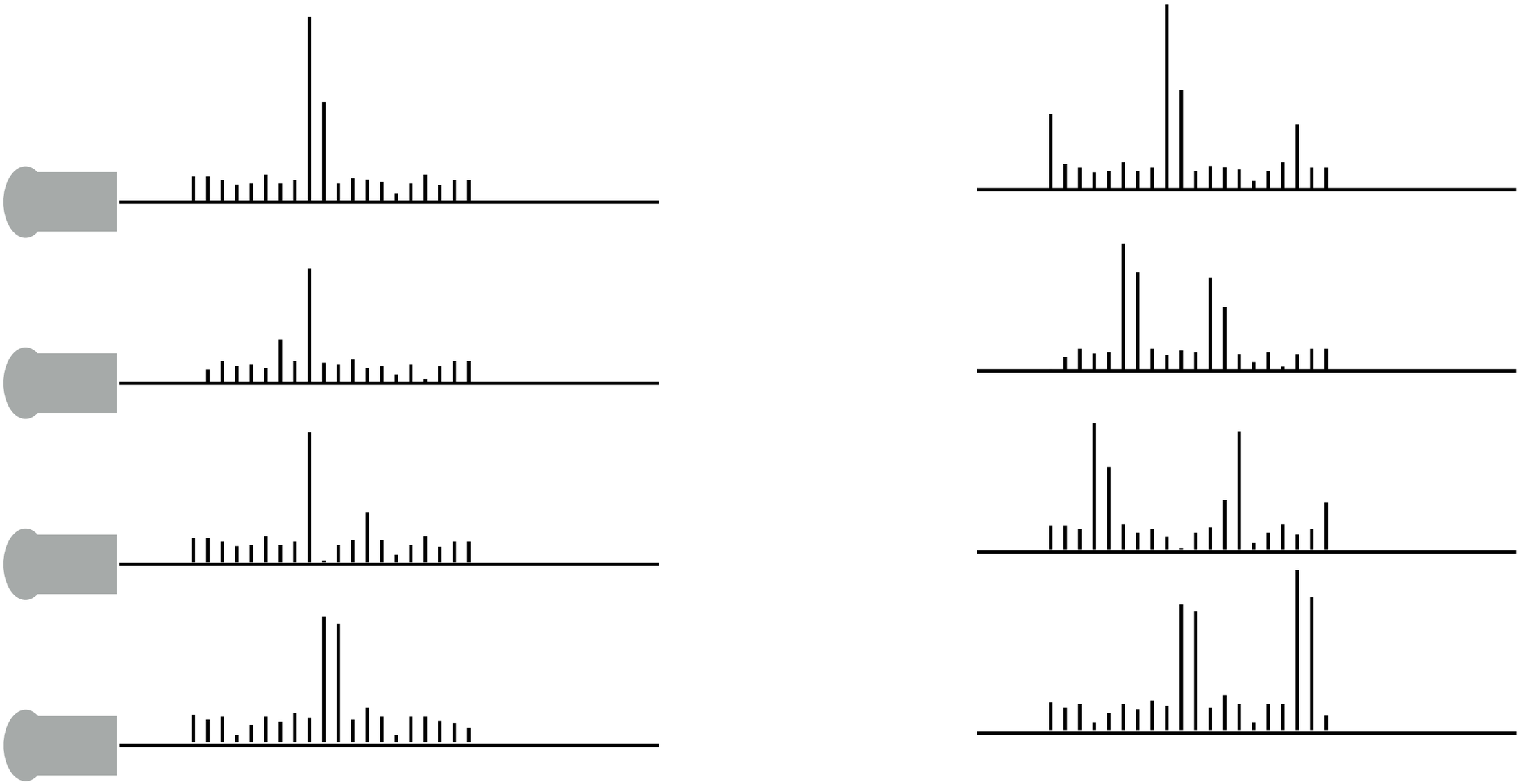
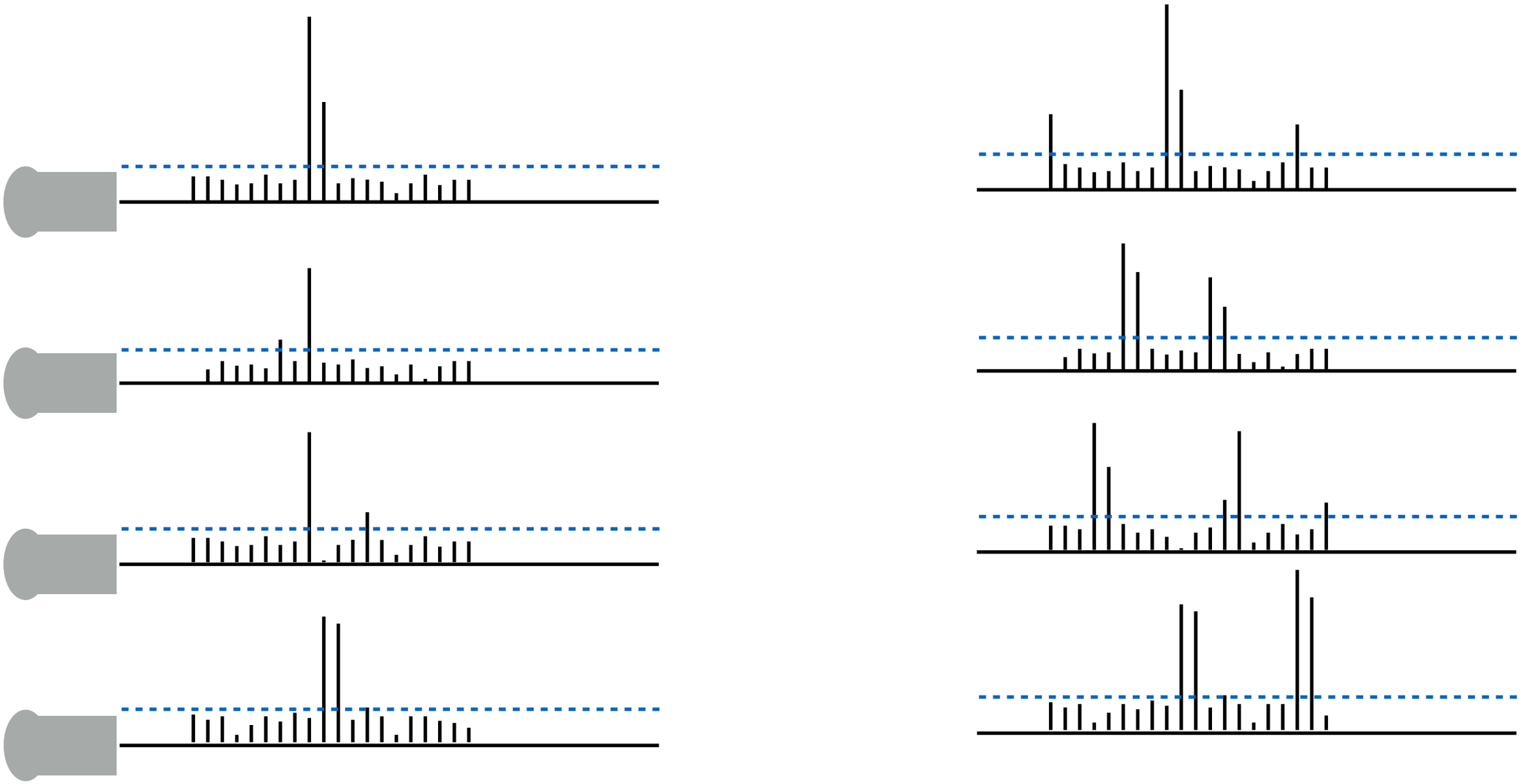


Time →

2. Reconstruct data



Time →

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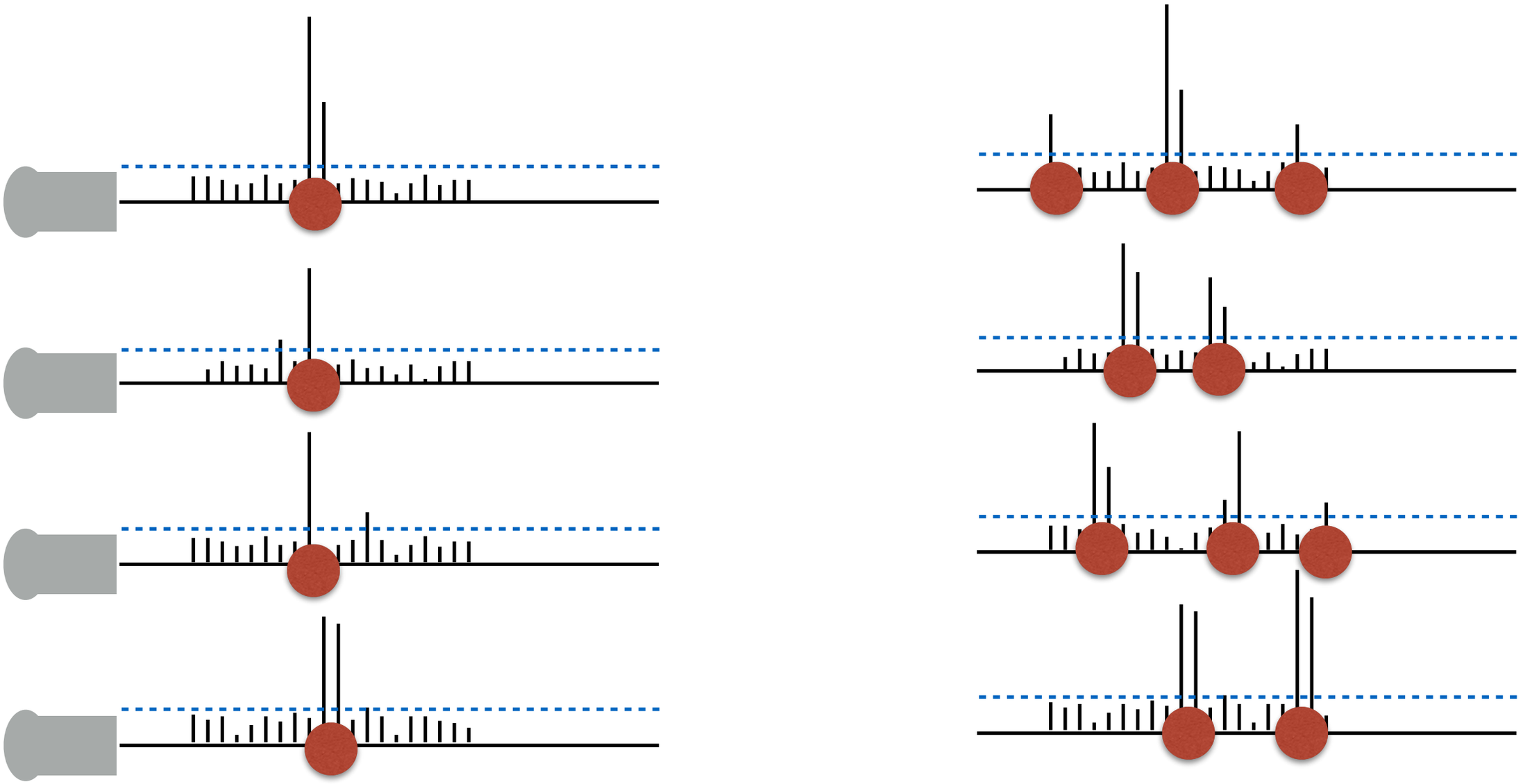

Time →

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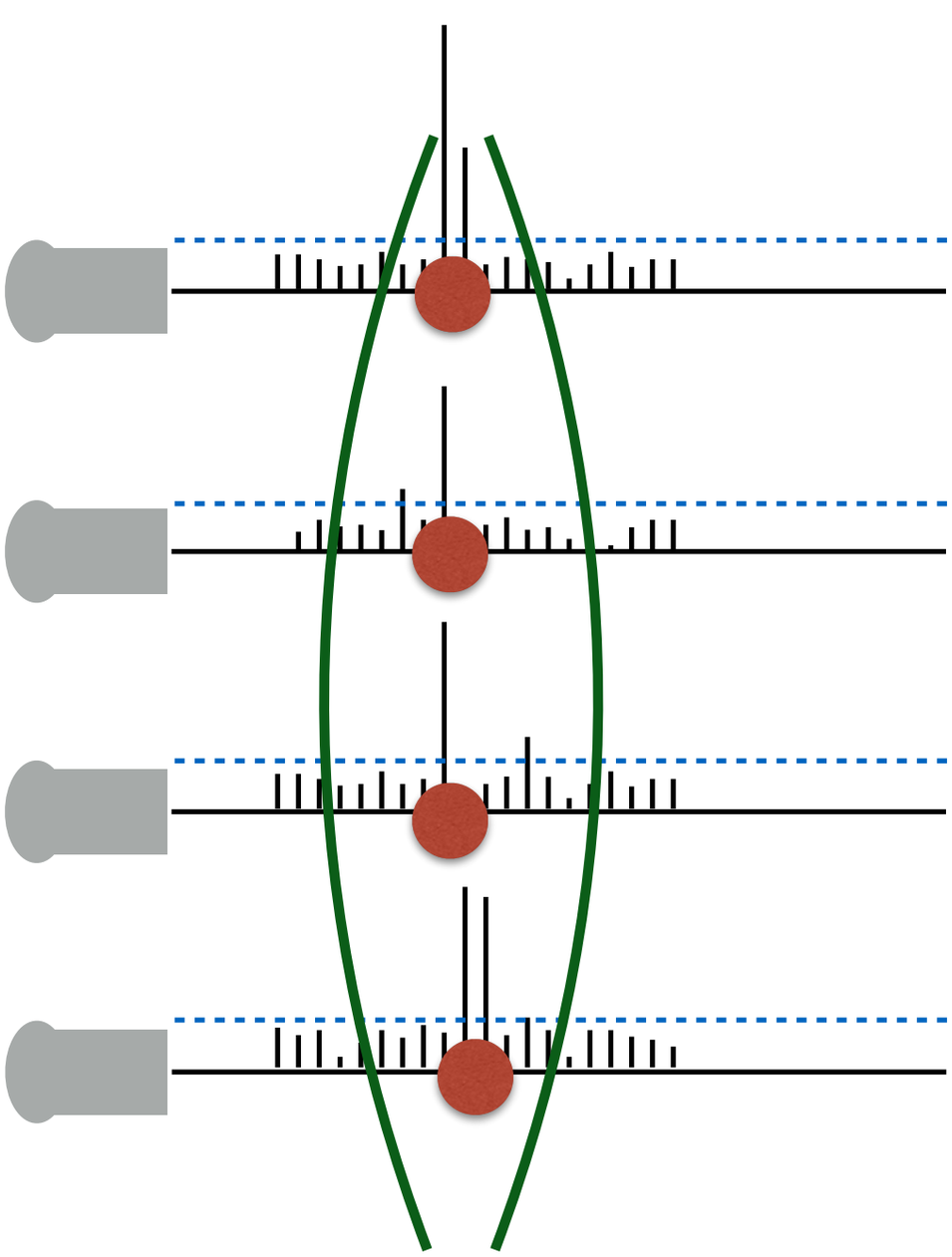

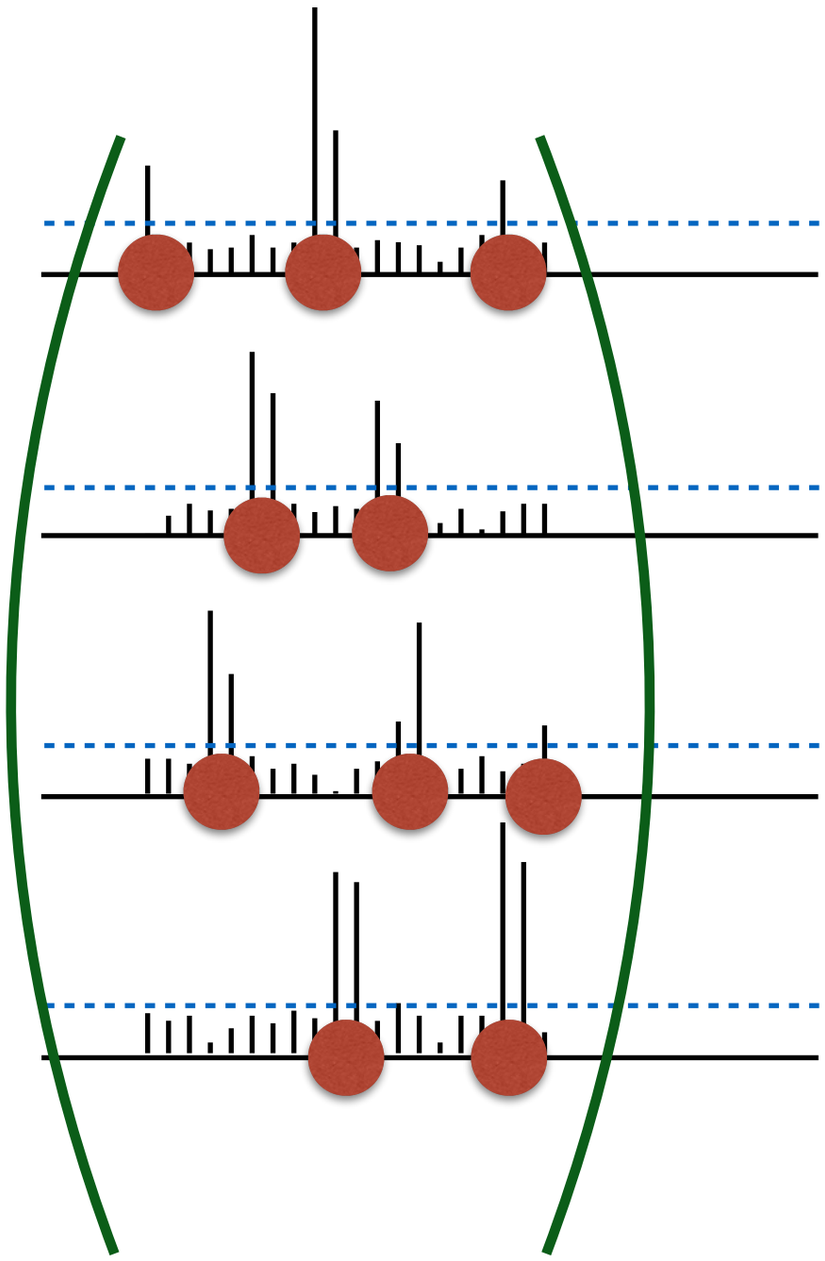

Time →

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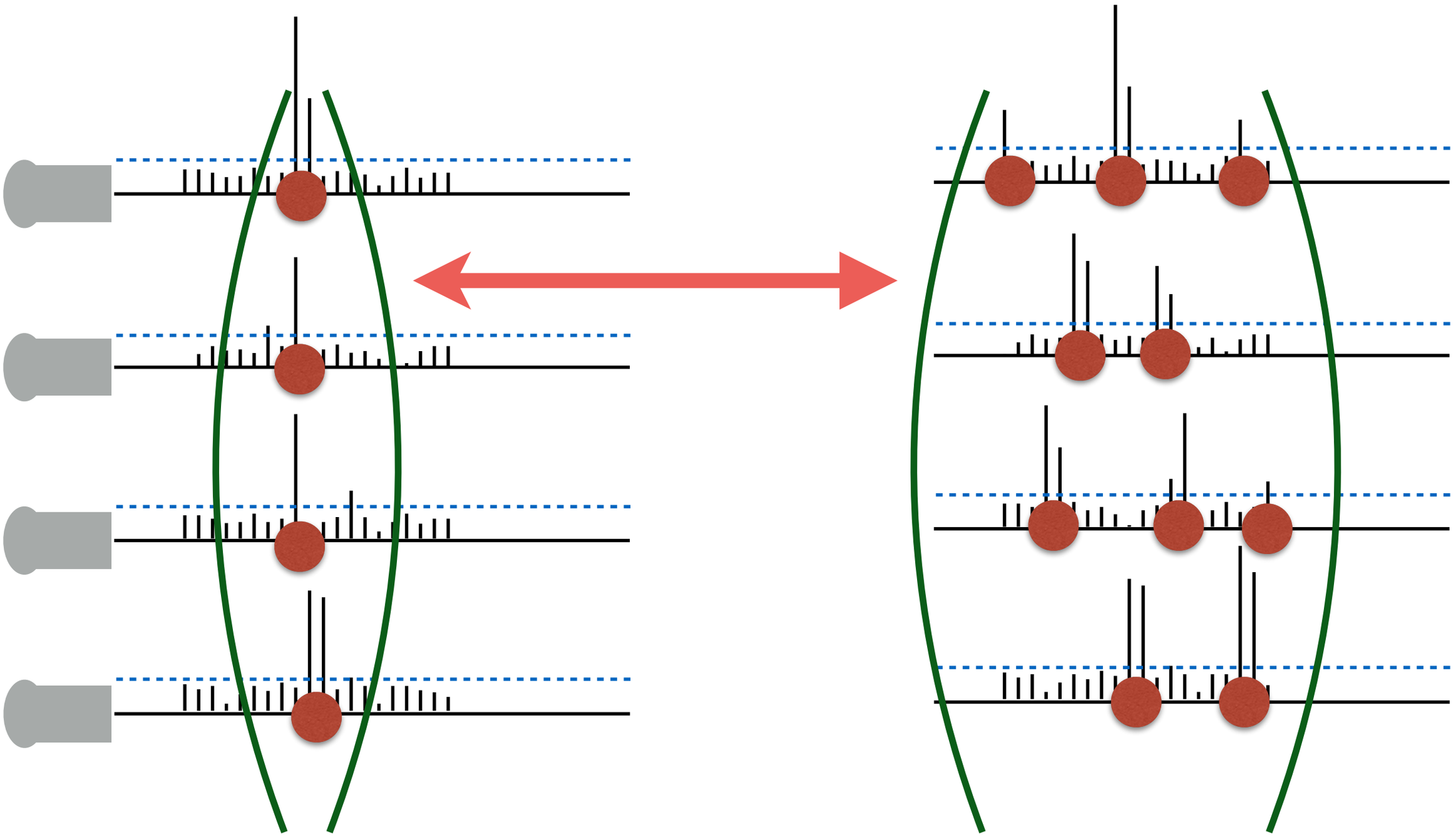
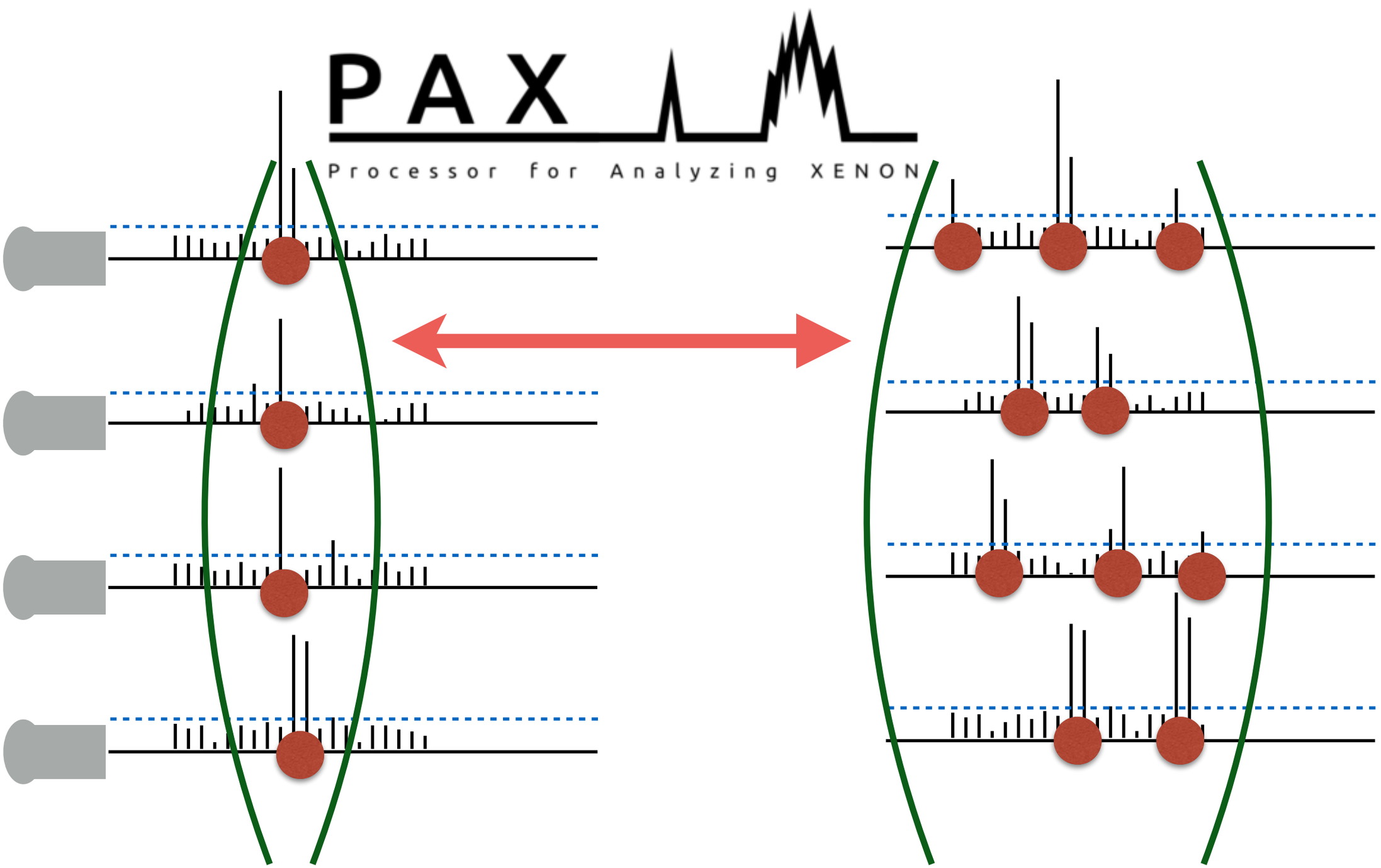


Time →

2. Reconstruct data

PAX

Processor for Analyzing XENON



Time →

2. Reconstruct data

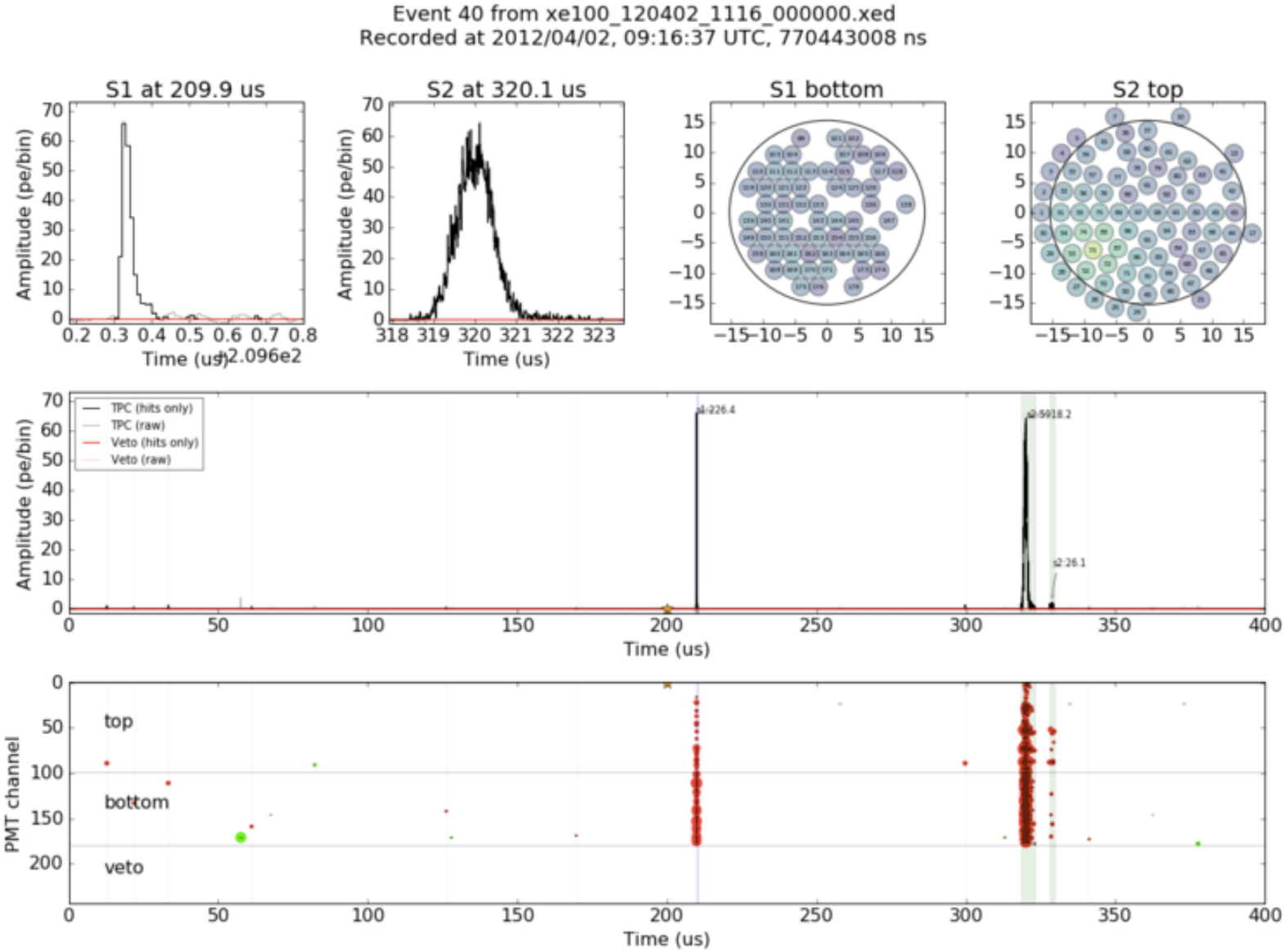
GitHub, Inc. [US] https://github.com/XENON1T/XeAnalysisScripts/blob/master/PaxROOTExample/analysis_basics.ipynb

Inspect waveforms

This fetches data from GRID

```
In [135]: inspect_event(dfs['ambe'].iloc[0])
```

```
WARNING:ReadXED:input_name /var/folders/m3/zg5yhg3d24x6tqtfqcwtz7800000gn/T/tmpo8_wkpke does not en
d with the expected file extension xed
Event:   0%|          | 0/1 [00:00<?, ?it/s]
https://tbn18.nikhef.nl/dpm/nikhef.nl/home/xenon.biggrid.nl/archive/data/xenon100/run_10/xe100_1204
02_1116/xe100_120402_1116_000000.xed
```



Thanks PDP!

2. Reconstruct data

Who	Purpose	Experience
netherlands eScience center	**Allow *Big Data* tools (e.g. pandas, MongoDB) in a "ROOT" world**	**NLeSC delivers expert *niche* help and should listen to them!**
GitHub	Software Project Management	Necessary for maintainable project and better than alternatives
Travis CI	Continuous testing on Linux and OS X	Prevents code stink. Otherwise, how know broken?
CONTINUUM ANALYTICS	Just-in-time compiling for Python and packaging	Key speed gains made project success. Packaging means usable.
GITTER	Day to day chatting	Quite nice, even for operations and analysis

Each has given some level of financial support

3. Analyze data

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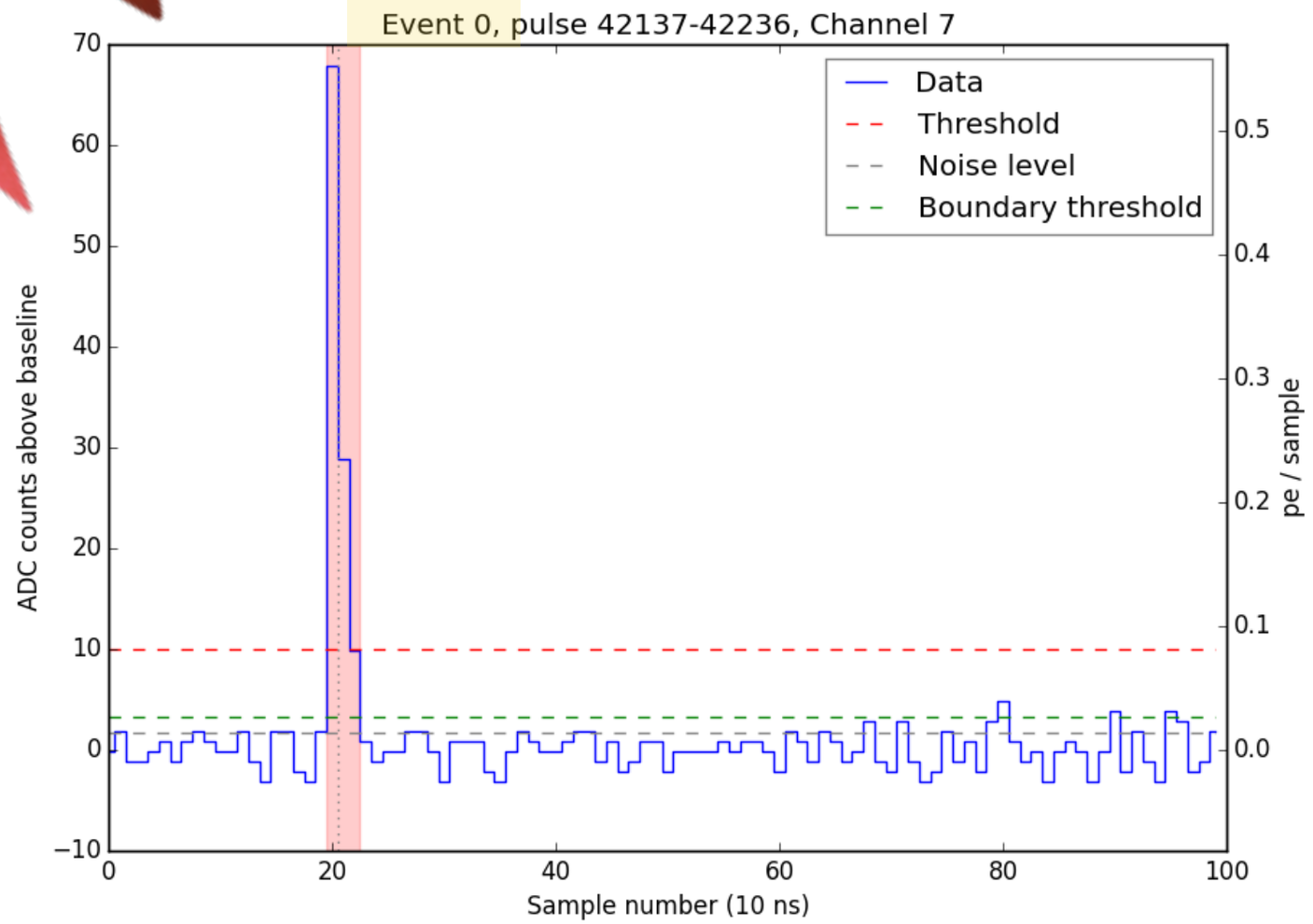
IP[y]: matplotlib

NumPy

scikit learn Spark

3. Analyze data

First light



See xenon1t.org for more

3. Analyze data

netherlands eScience center

GitHub

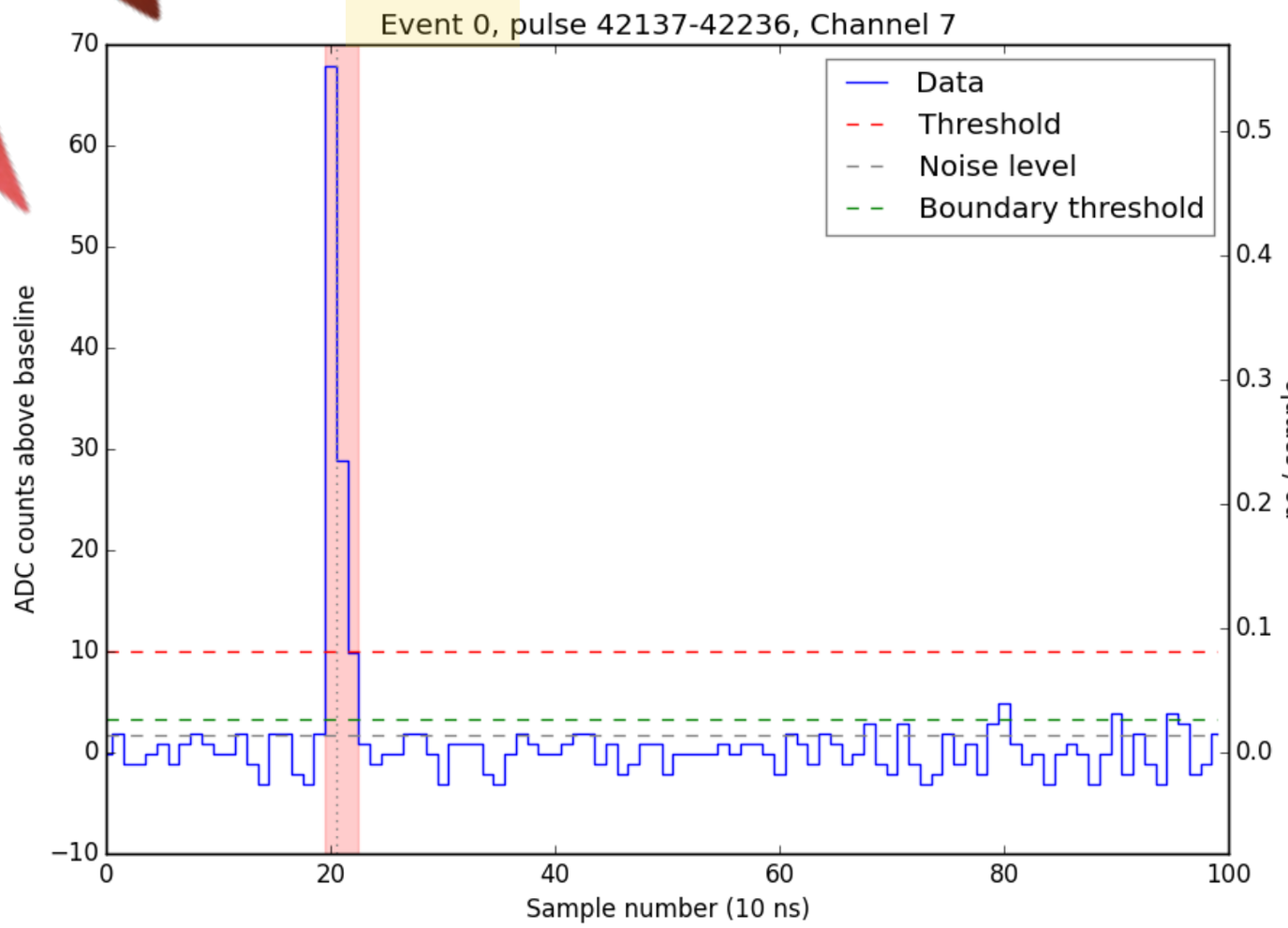
Travis CI

CONTINUUM ANALYTICS

GITTER

CAEN Tools for Discovery Electronic Instrumentation

First light



django

d3.js

jQuery write less, do more.

Google

mongoDB

See xenon1t.org for more

IP[y]: matplotlib

NumPy

scikit learn Spark