XENONnT
Analysis software:
Analysis software in the wider HEP/nuclear community

XENON

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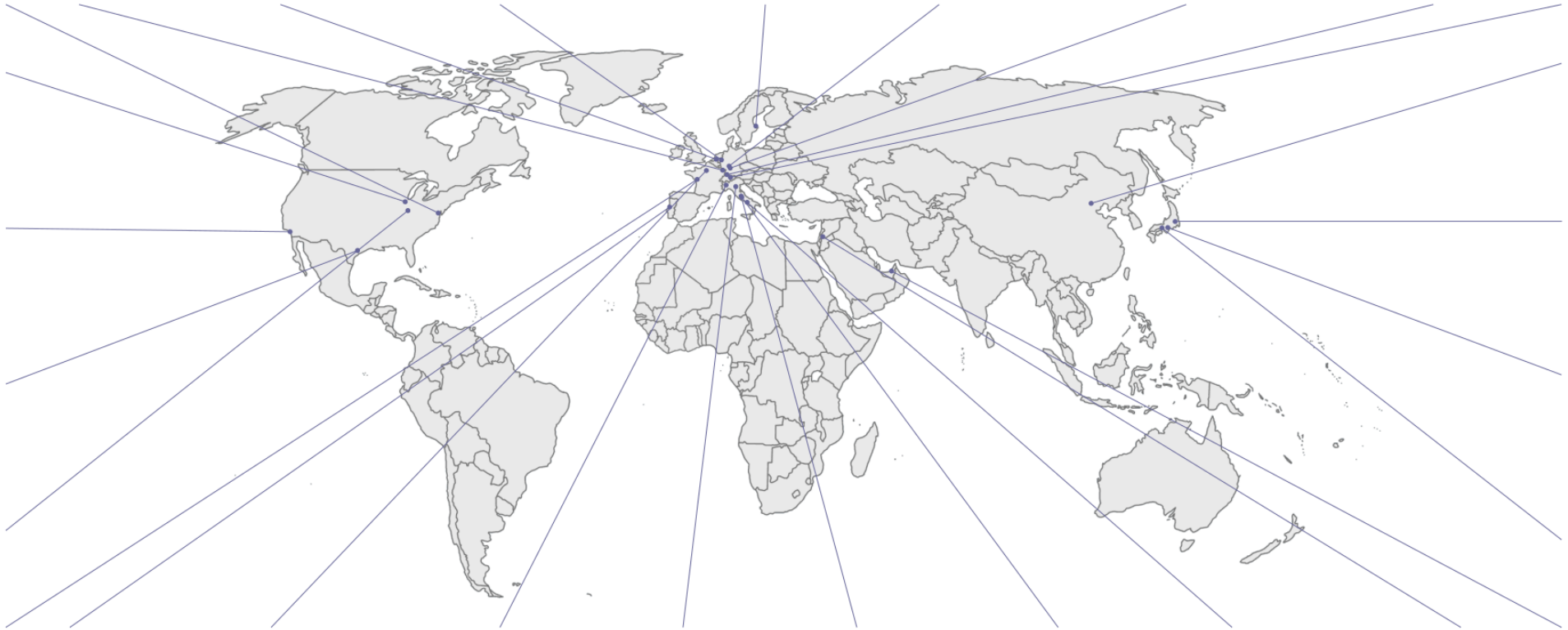
Nikhef

GRAPPA

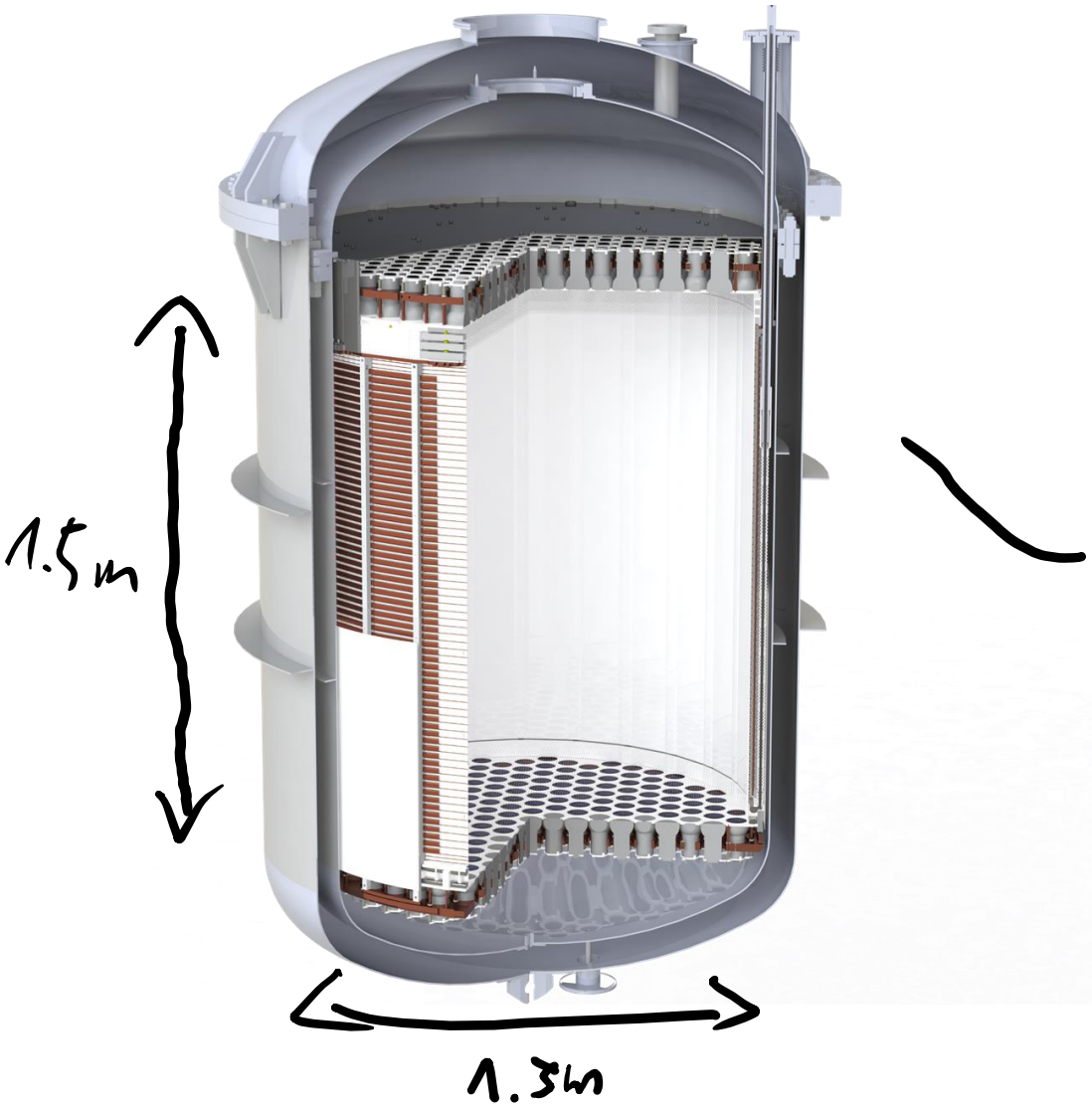
GRavitation AstroParticle Physics Amsterdam

XENON Family:



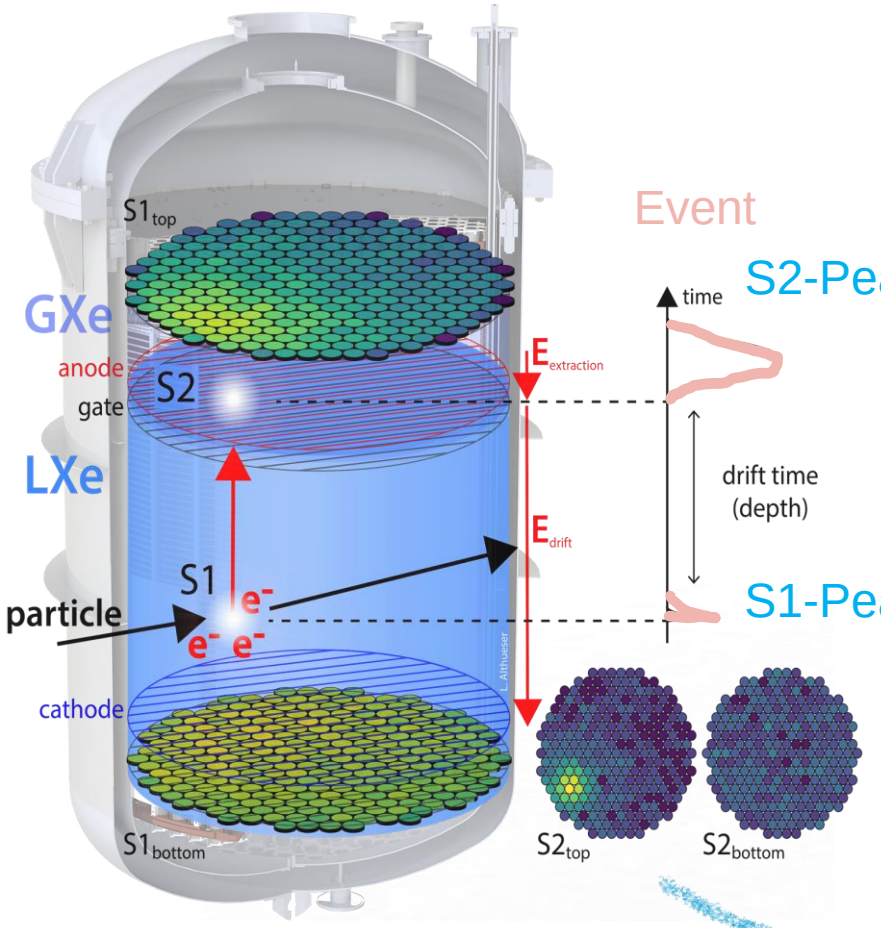
Columbia
KIT
Nikhef
Muenster
Stockholm
Mainz
MPIK, Heidelberg
Freiburg
Zurich
Chicago
Tsinghua
UCSD
Tokyo
Rice
Nagoya
Purdue
Kobe
Subatech
Coimbra
LPNHE
Torino
Bologna
L'Aquila
LNGS
Napoli
Weizmann
NYUAD

The XENONnT Experiment:



XENONnT Analysis software

The XENONnT Experiment:

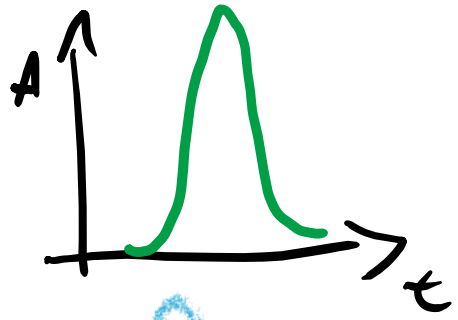


Event

S2-Peaks

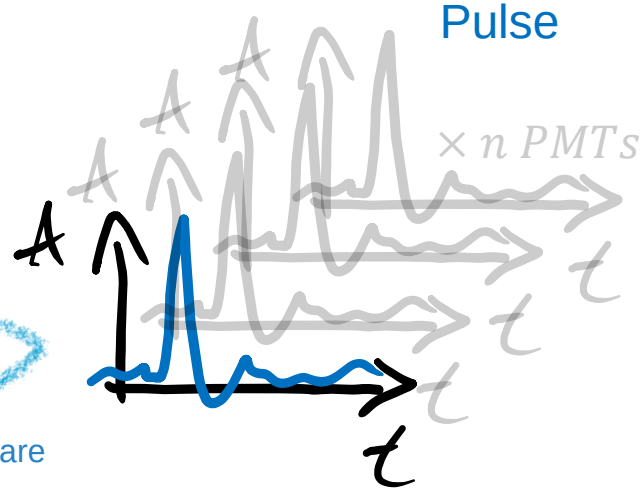
S1-Peaks

S1/S2-Peak



Sum over all PMT signals

Pulse



Selftriggered, 10 ns binned data

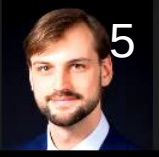
redax: 50 MB/s

LZ: 98.3 MB/s(1) (triggered)

Atlas: 340 MB/s(2) (triggered)

XENONnT Analysis software

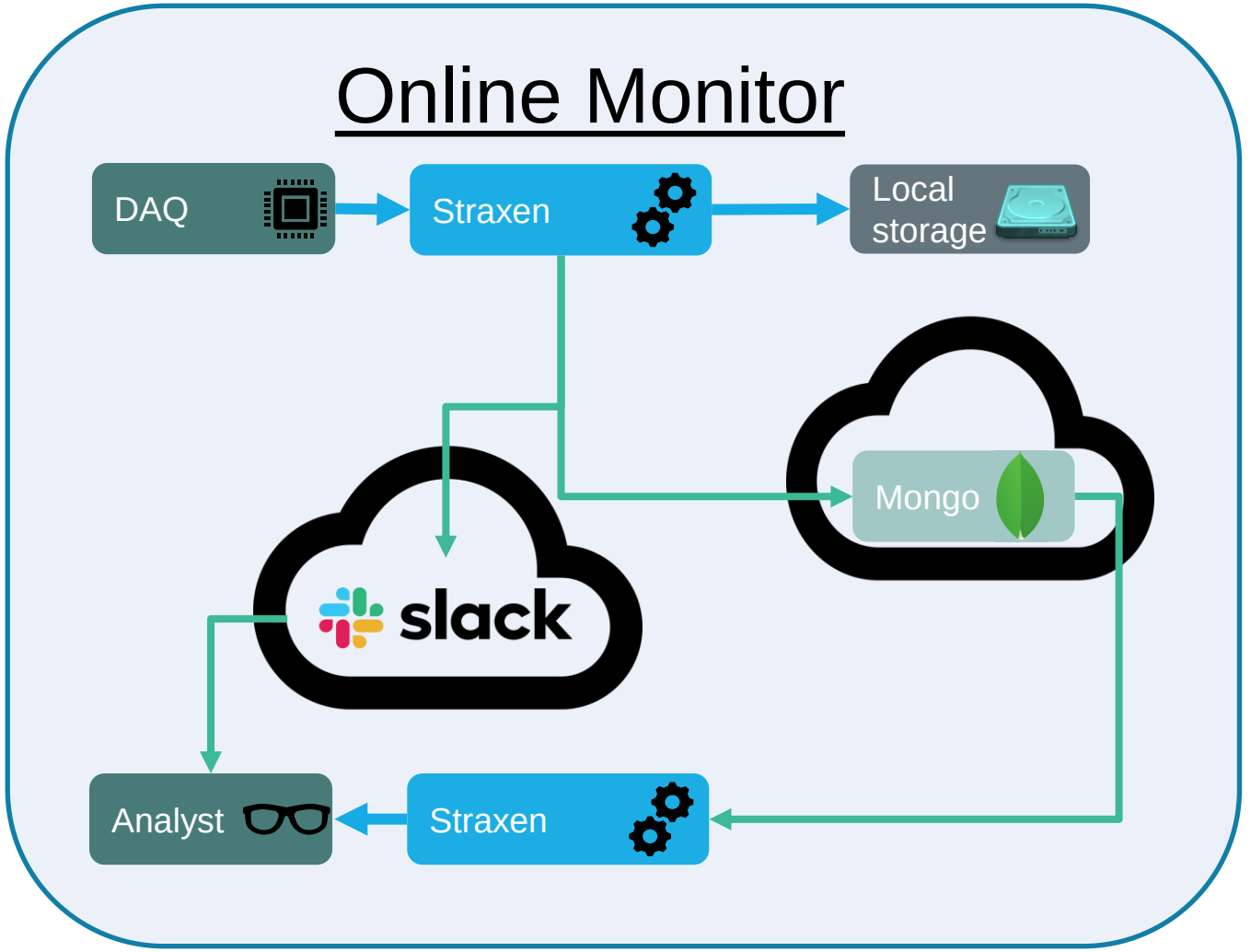
(1) LZ technical design Report, LZ Collaboration
arxiv:1703.09144
(2) ATLAS Fact Sheer, Atlas Collaboration



Demo:

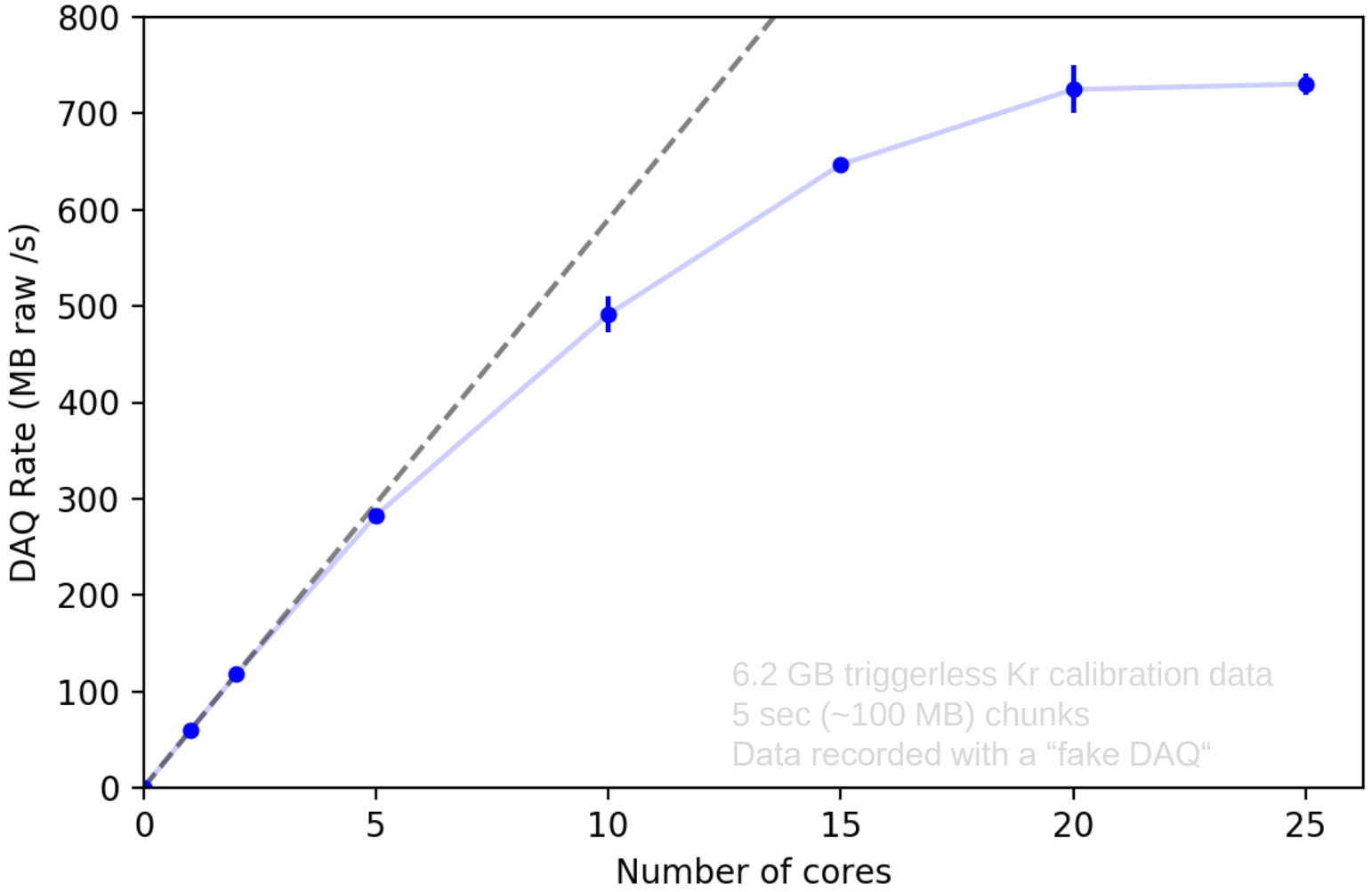
Online processing

- Full event reconstruction at the DAQ on triggerless data
  - Baselining
  - Hit-finding
  - Peak-finding
  - Position-reconstruction (3 neural nets)
  - Corrections
  - etc
- Events available within ~30 s
- Fully integrated into slack messaging platform



Performance:

- From XENON1T→ **XENONnT**
- pax → **strax**
- 0.2 MB/s/core → **60 MB/s/core**



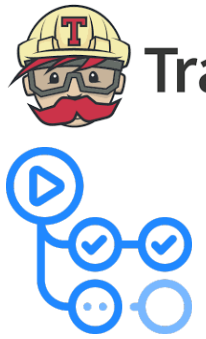
How does this work?

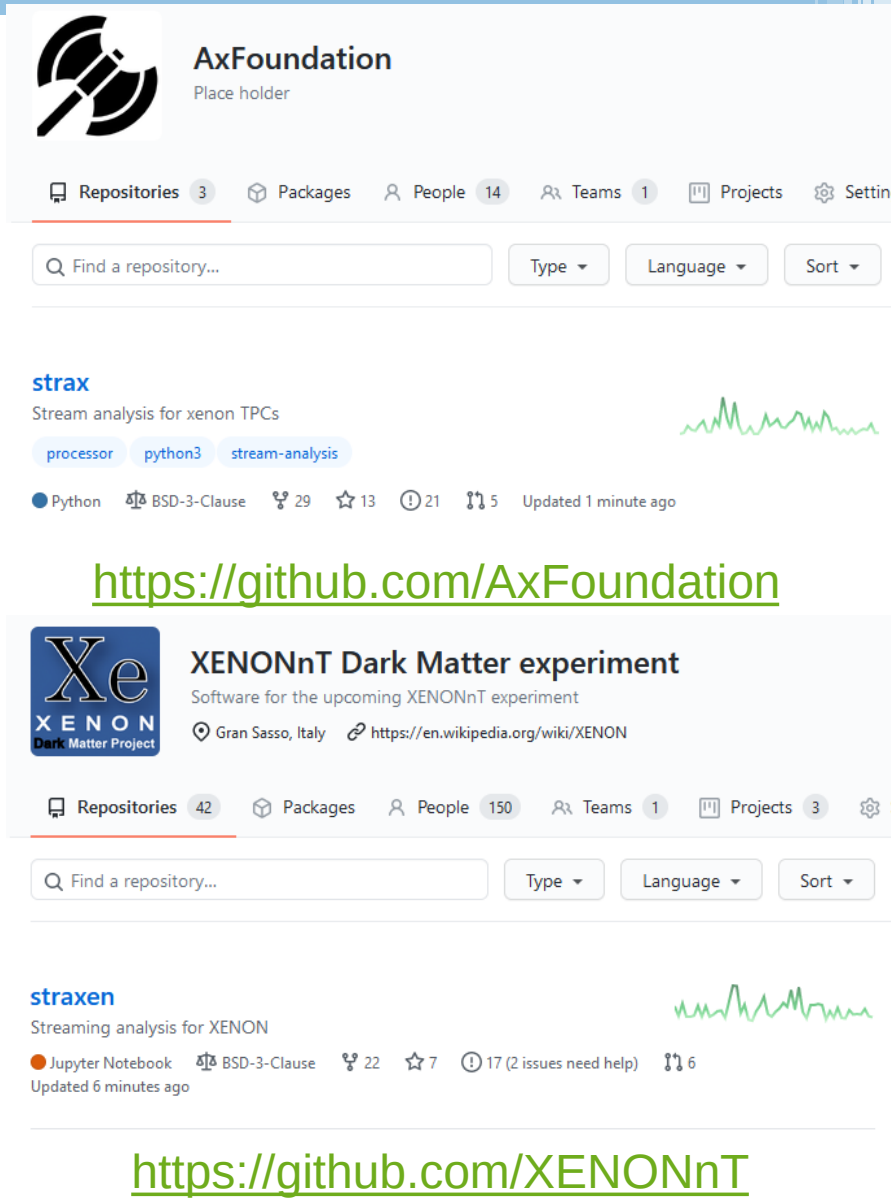
Strax:

Streaming analysis for xenon

Software:

- Split between:
  - general & optimized code (strax)
  - detector specific software (straxen)
- Continuous integration for testing:
  - Travis-ci
  - Github actions
  - Many more
- The core code is public
- Analyses & detector conditions private



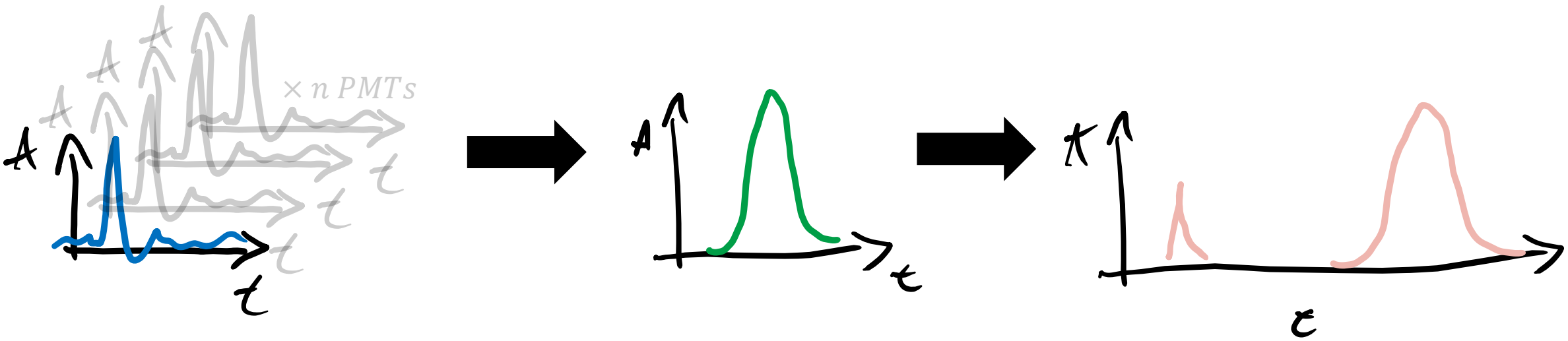


Pulse-Peaks-Events in no time:

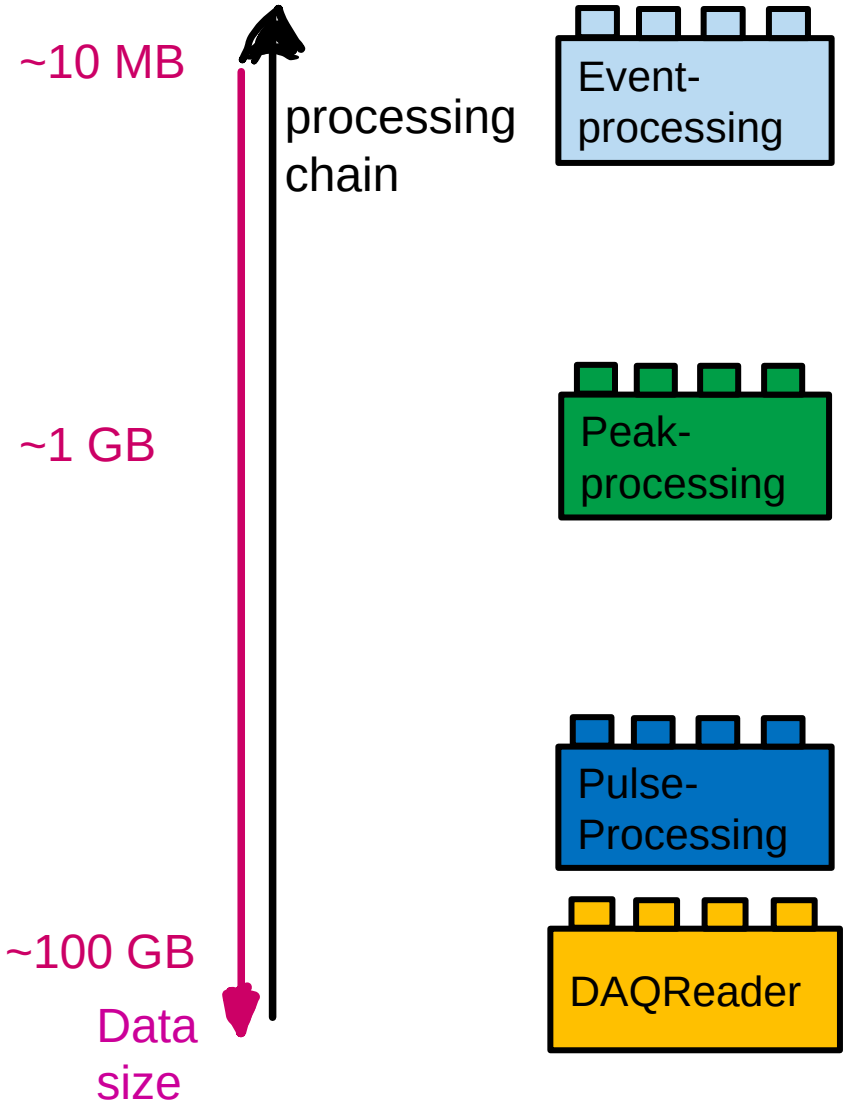
Pulse

Peak

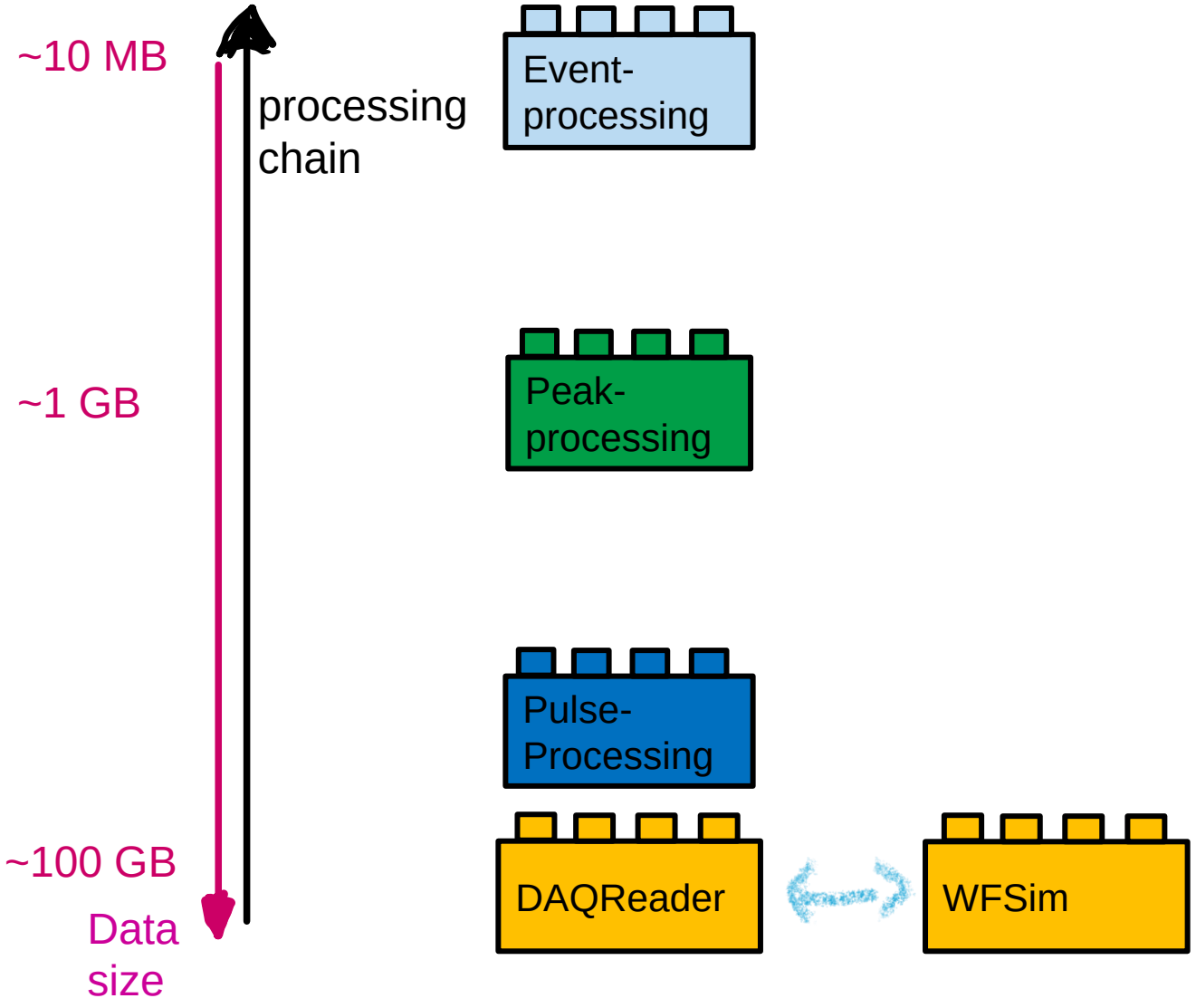
Event



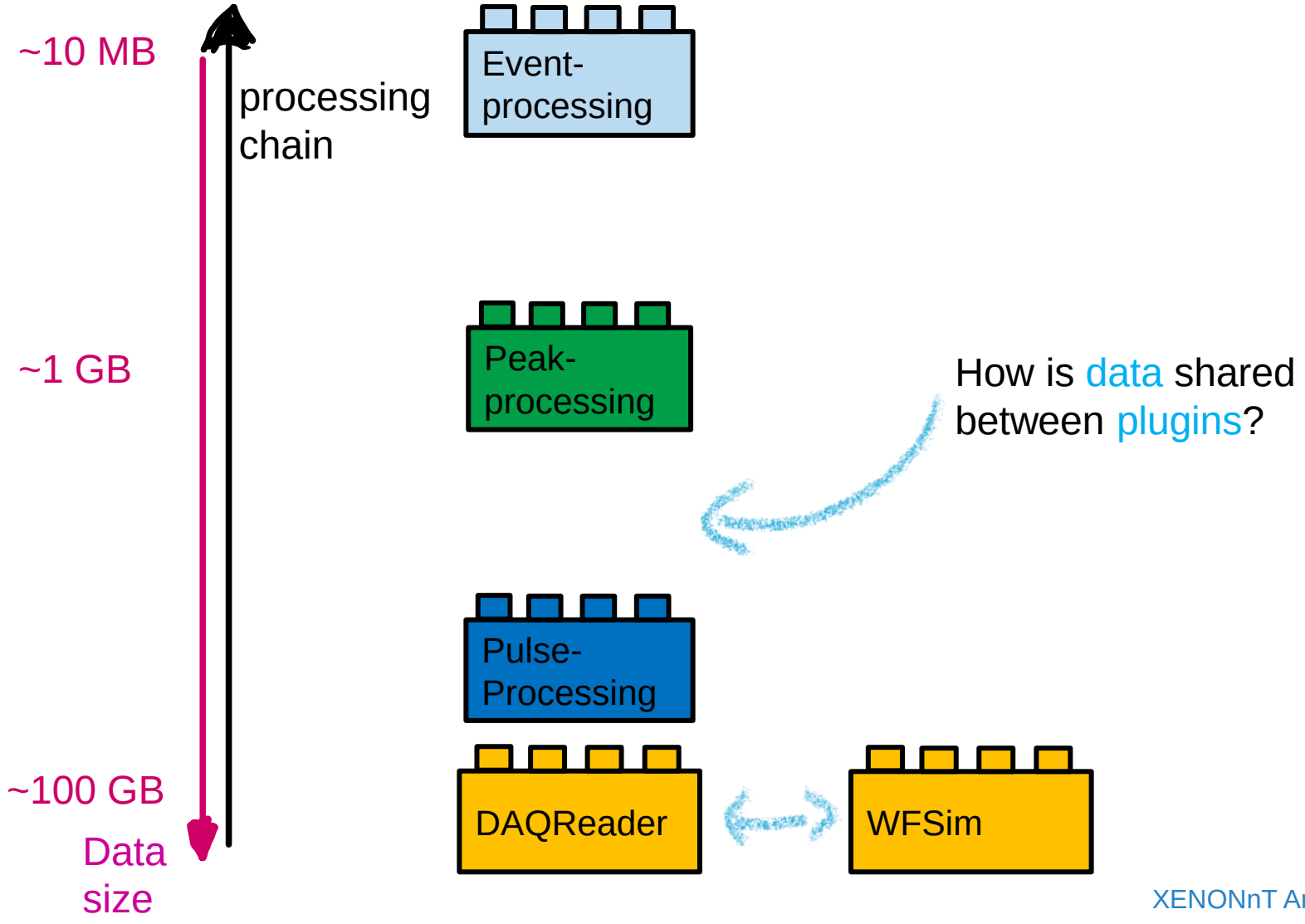
Strax Plugins:



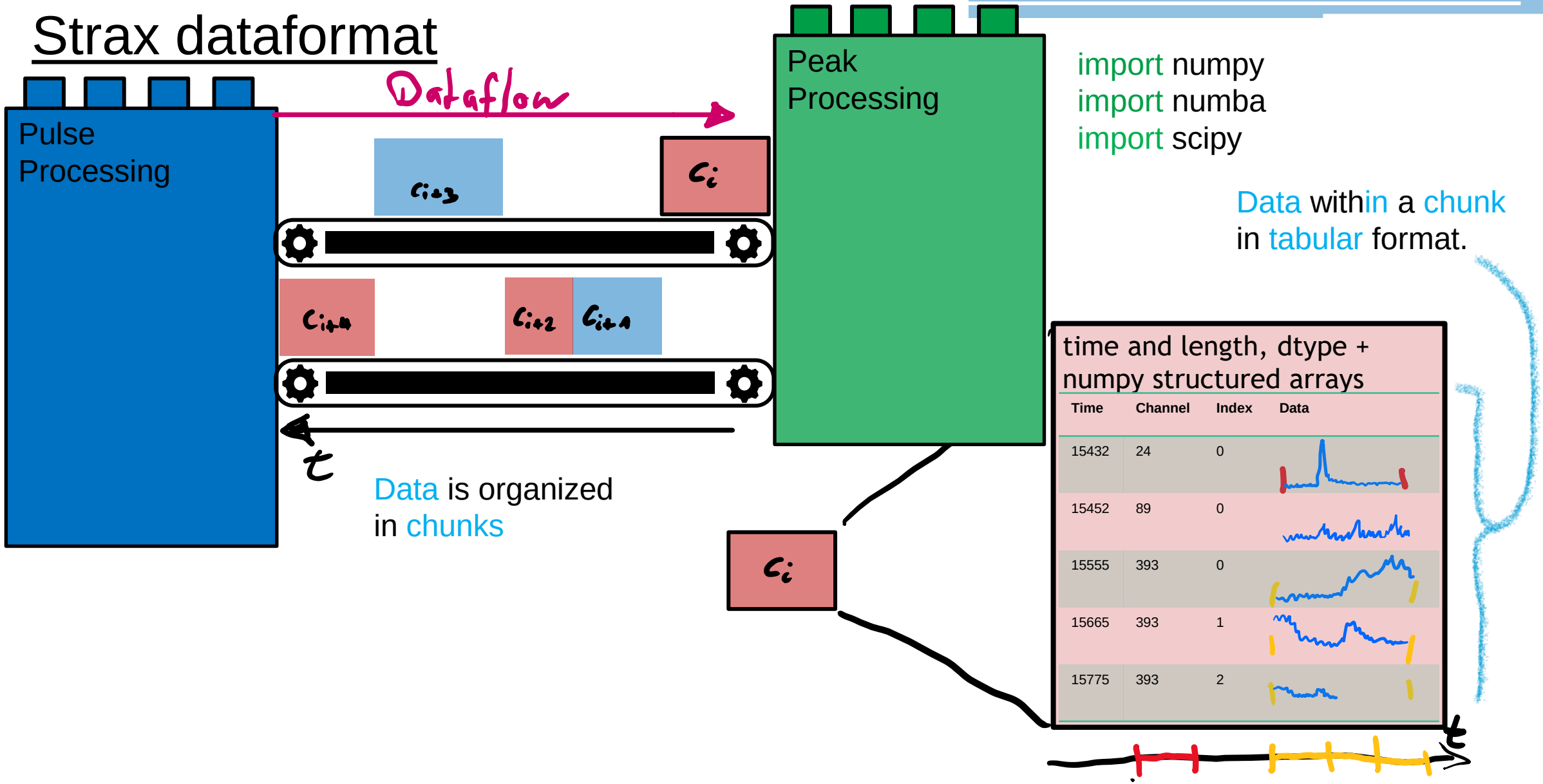
Strax Plugins:



Strax Plugins:



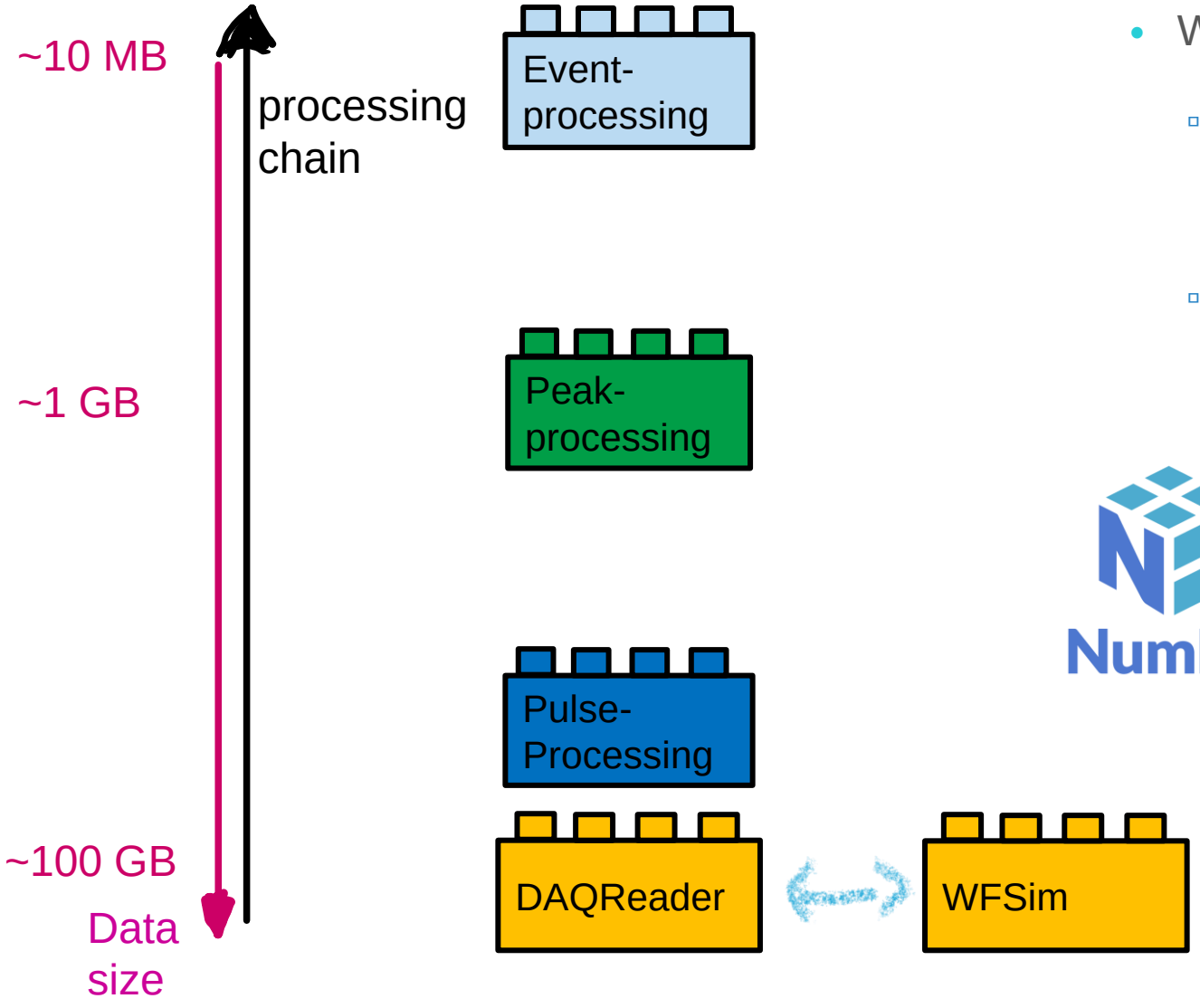
Strax dataformat




```
import numpy
import numba
import scipy
```

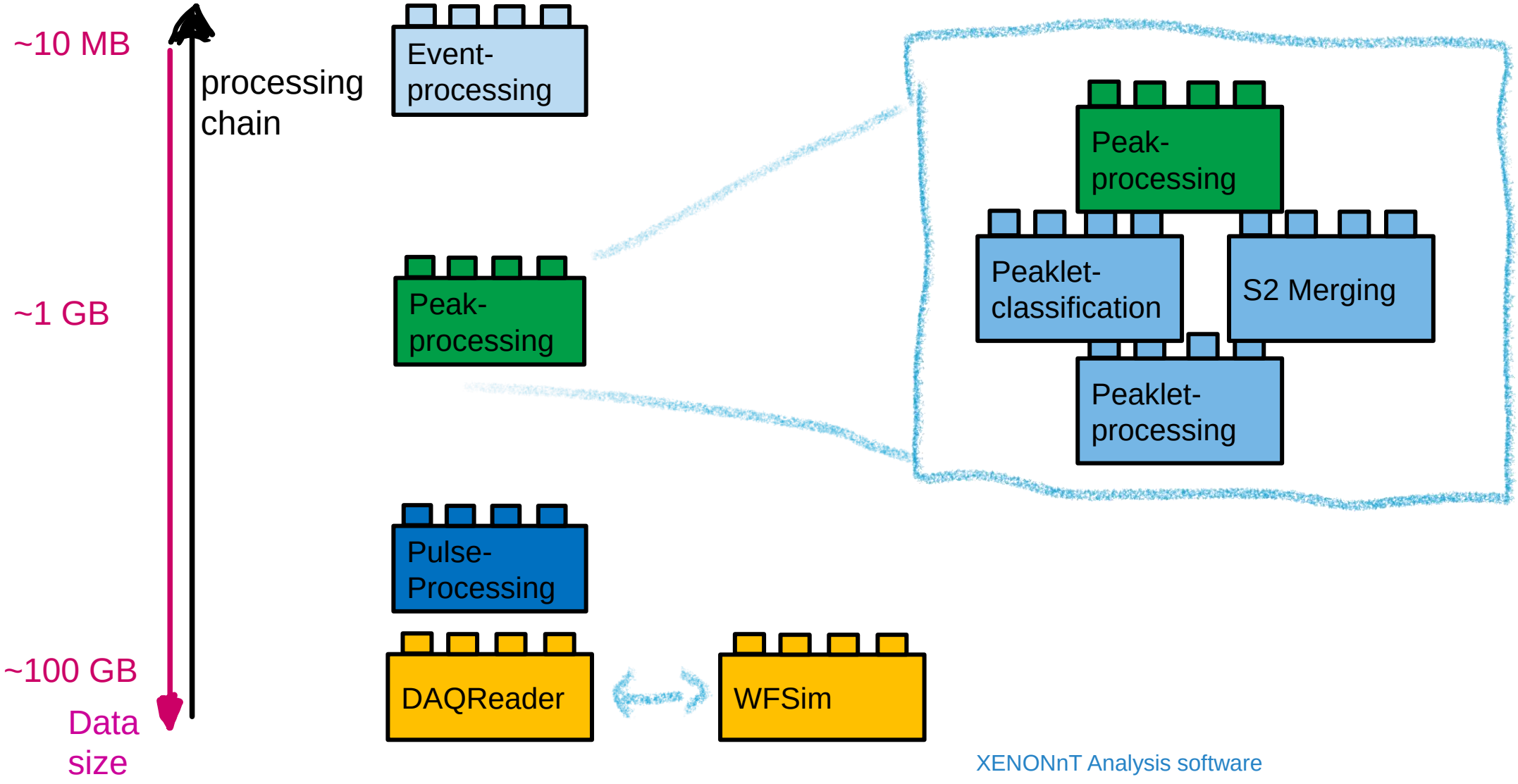
Data within a chunk in tabular format.

Strax Plugins:

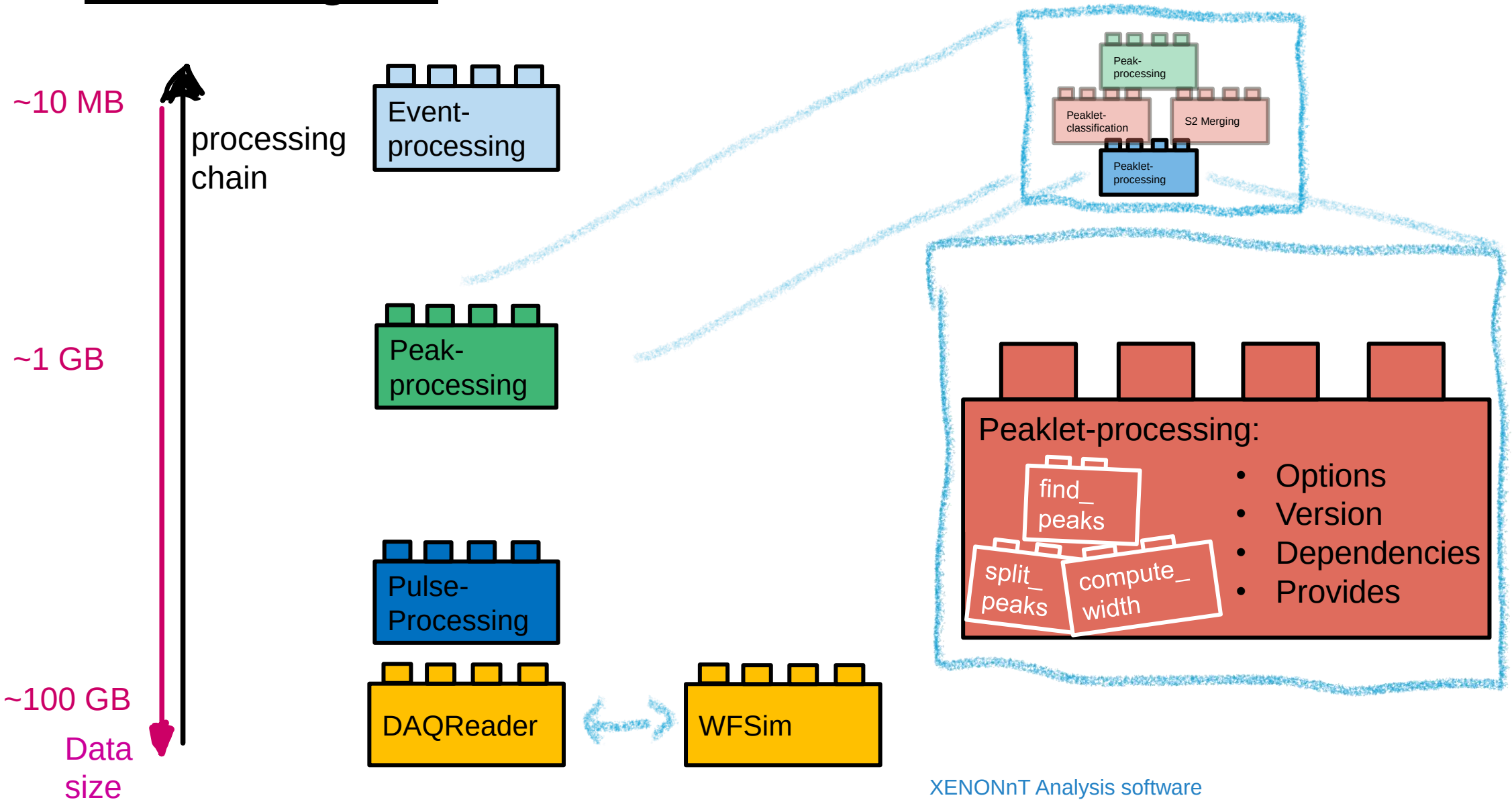


- We chose Python
  - numba & numpy make it fast
    - just-in-time compilation
  - cast data in tabular shape
    - tabular data allows autovectorization

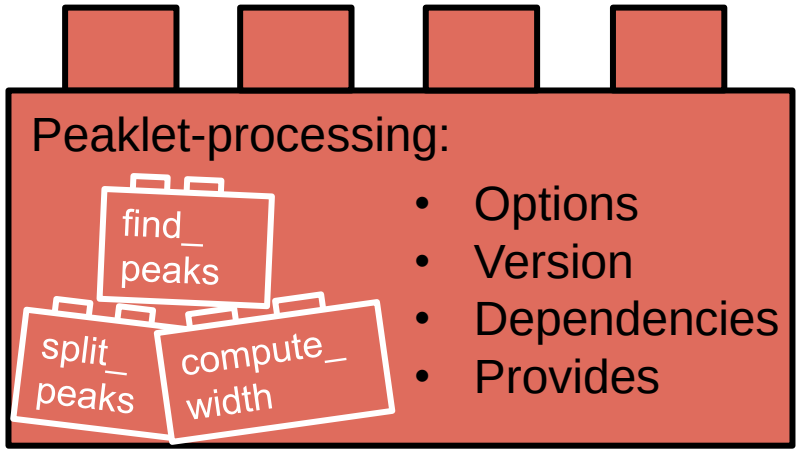
Strax Plugins:



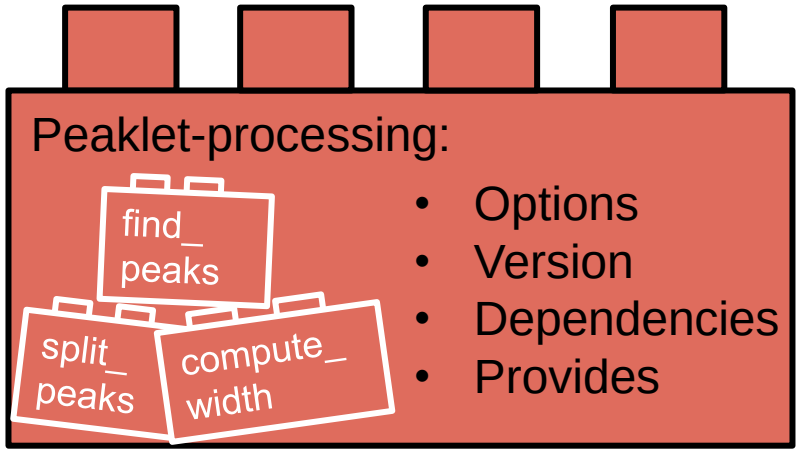
Strax Plugins:



Lineage Hash, reinventing the wheel



Lineage Hash, reinventing the wheel




```
import json
import hashlib
```

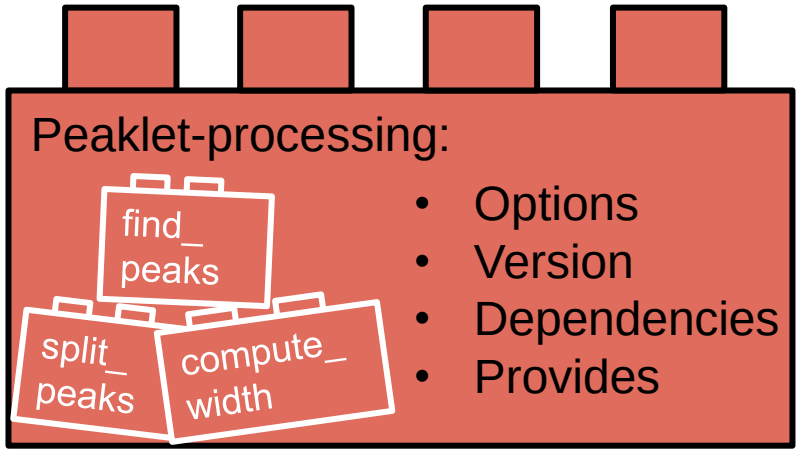
Run_id

009566-peaklets-vihtx27i3g

009566-peaklets-wzhznivfds

009566-peaklets-zle65opplt

Lineage Hash, reinventing the wheel




```
import json
import hashlib
```

Lineage hash:

```
'peaklets':
                ('Peaklets',
                 '0.3.5',
                 {'n_tpc_pmts': 494,
                  'gain_model':
'records':
                ('PulseProcessing',
                 '0.2.2',
```

Run_id

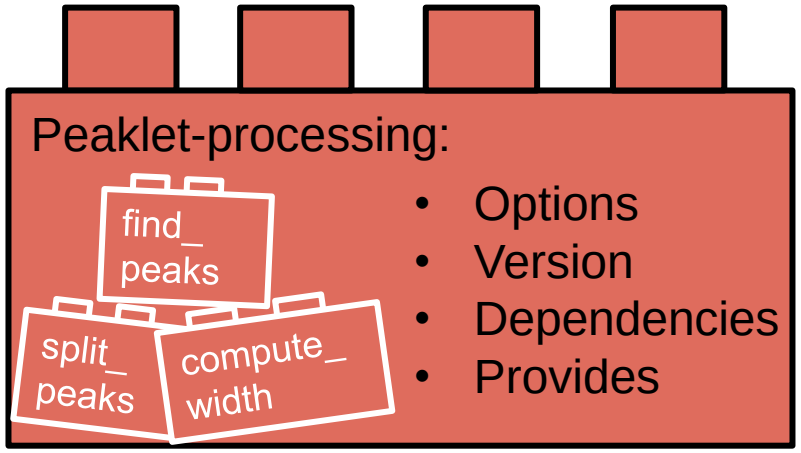
009566-peaklets-vihtx27i3g

009566-peaklets-wzhznivfds

009566-peaklets-zle65opplt

- Strax keeps track of your data

Lineage Hash, reinventing the wheel




```
import json
import hashlib
```

Lineage hash:

```
'peaklets':
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                 '0.3.5',
                 {'n_tpc_pmts': 494,
                  'gain_model': ...},
'records':
                ('PulseProcessing',
                 '0.2.2',
```

Plugin Version

Plugin Options

Run_id

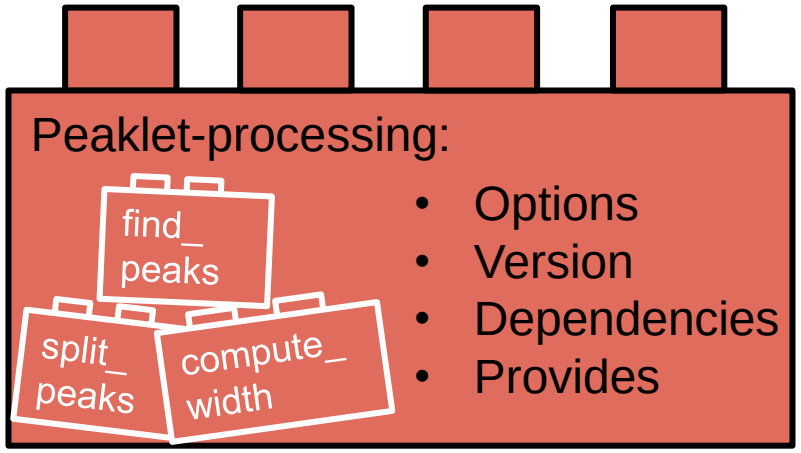
009566-peaklets-vihtx27i3g

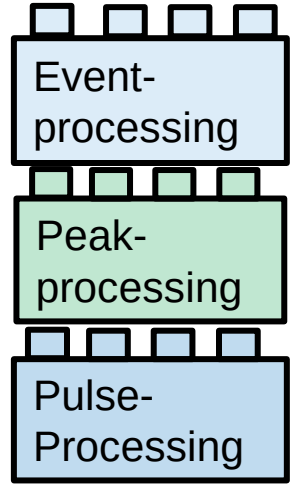
009566-peaklets-wzhznivfds

009566-peaklets-zle65opplt

- Strax keeps track of your data

Lineage Hash, reinventing the wheel



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```

Lineage hash:

```
'peaklets':
            ('Peaklets',
             '0.3.5',
             {'n_tpc_pmts': 494,
              'gain_model': ...},
'records':
            ('PulseProcessing',
             '0.2.2',
```

Plugin Version

Plugin Options

Same for all dependencies

Run_id

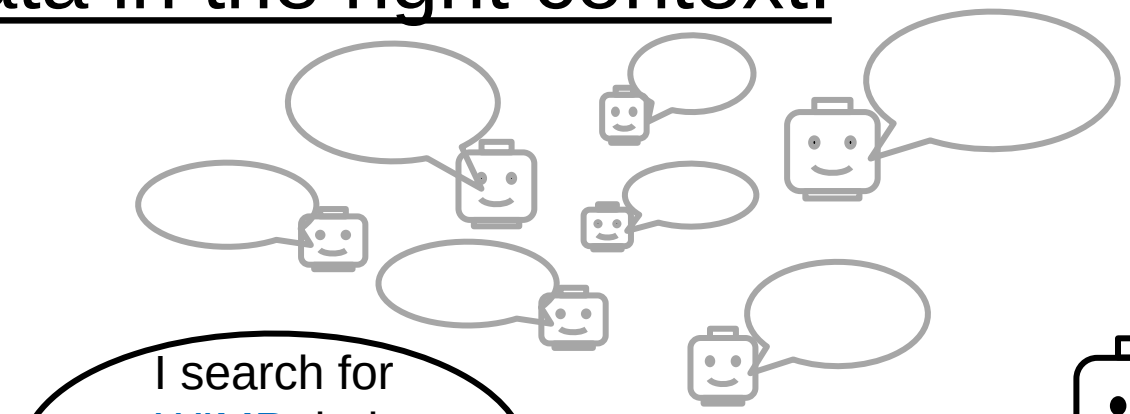
009566-peaklets-vihtx27i3g

009566-peaklets-wzhznivfds

009566-peaklets-zle65opplt

- Strax keeps track of your data
- Lineage allows partial reprocessing

Put your data in the right context:



I search for WIMP dark matter with XENON1T.

I am working on detector simulation

I'm searching for dark matter with XENONnT-data

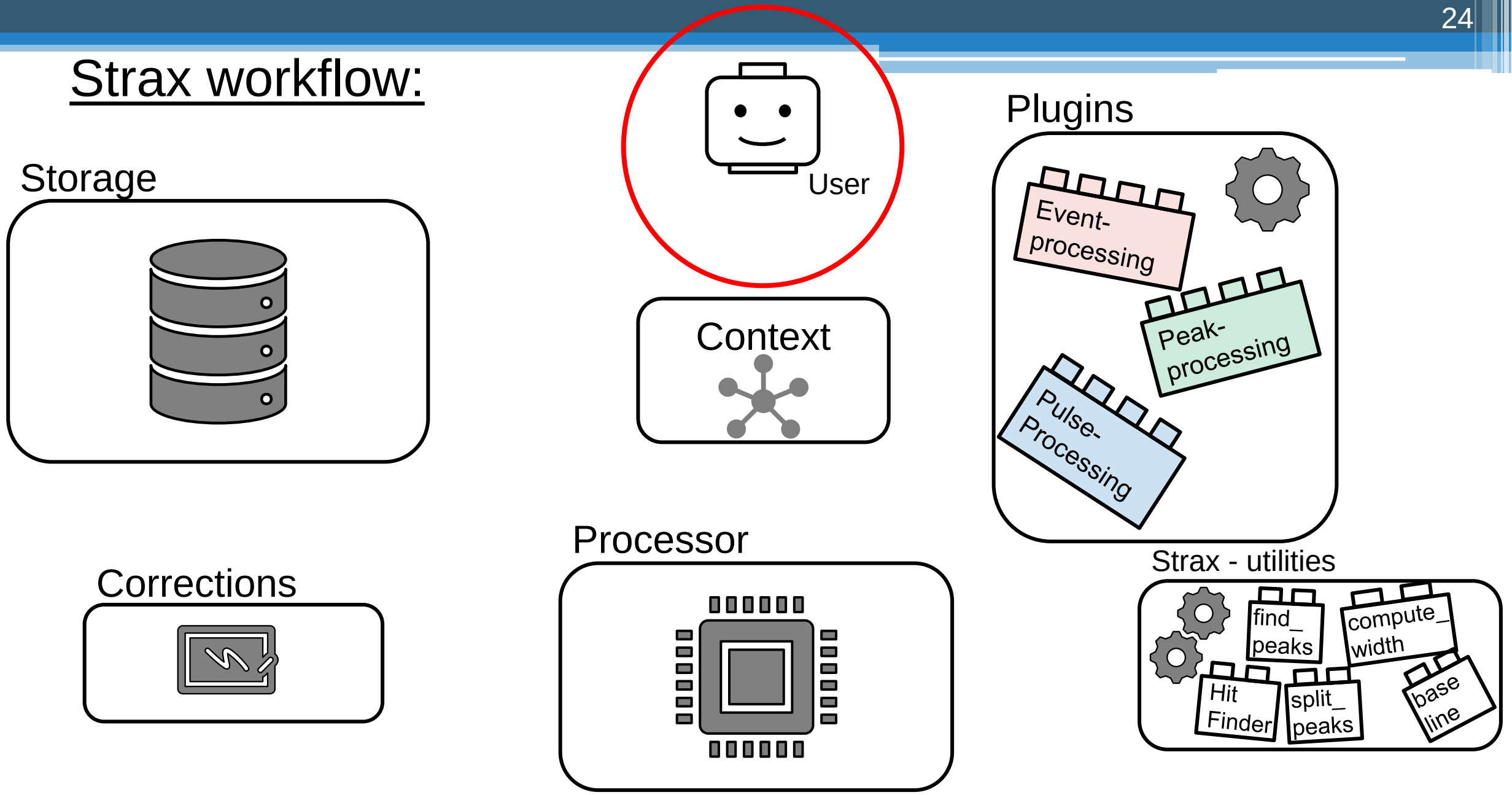
I'm working on XENONnT position reconstruction

I'm also working on XENONnT, we are sharing the same **context**.

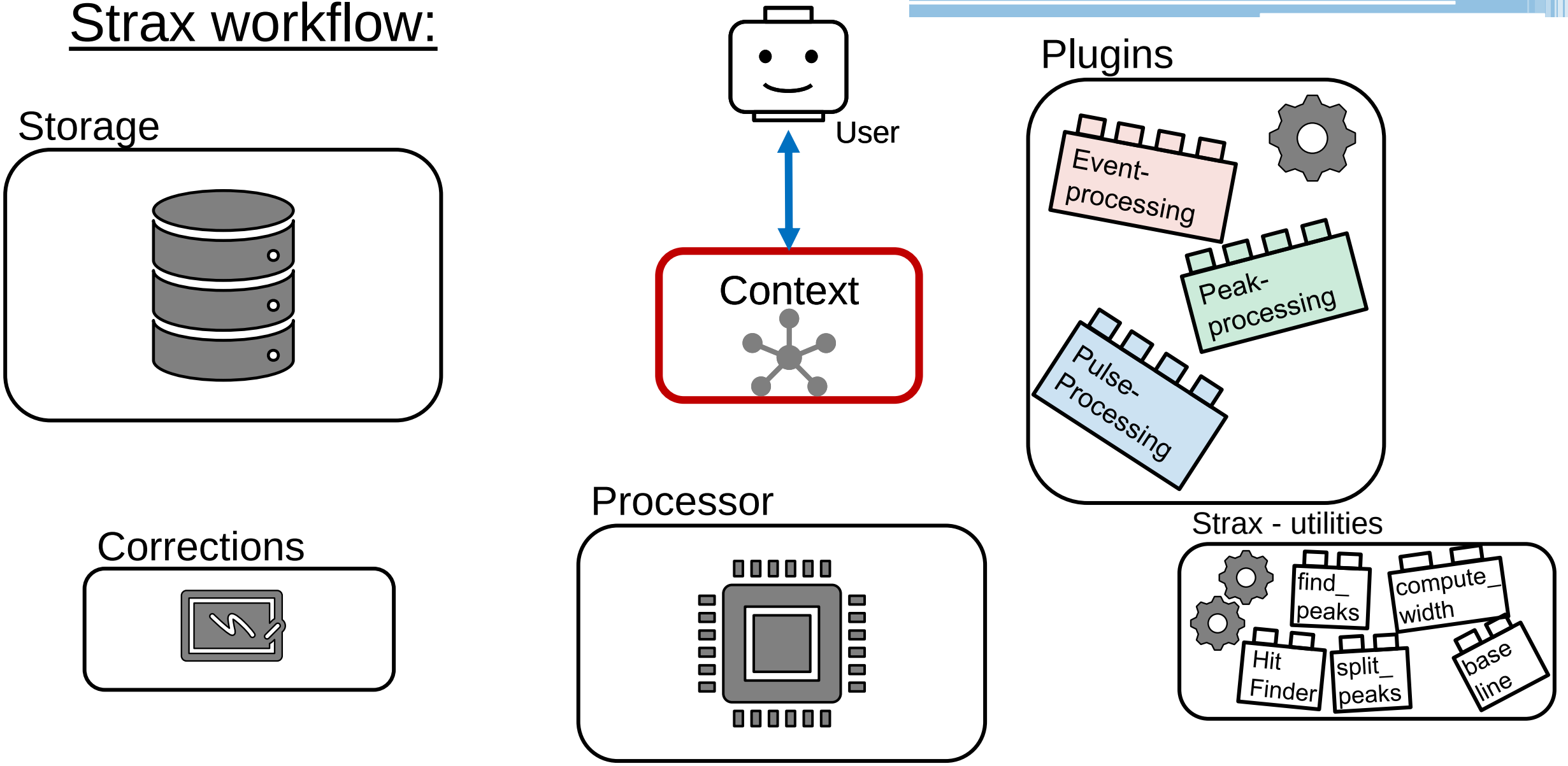
Limited computing developers, but many different needs.

User and processing team should use the same tool.

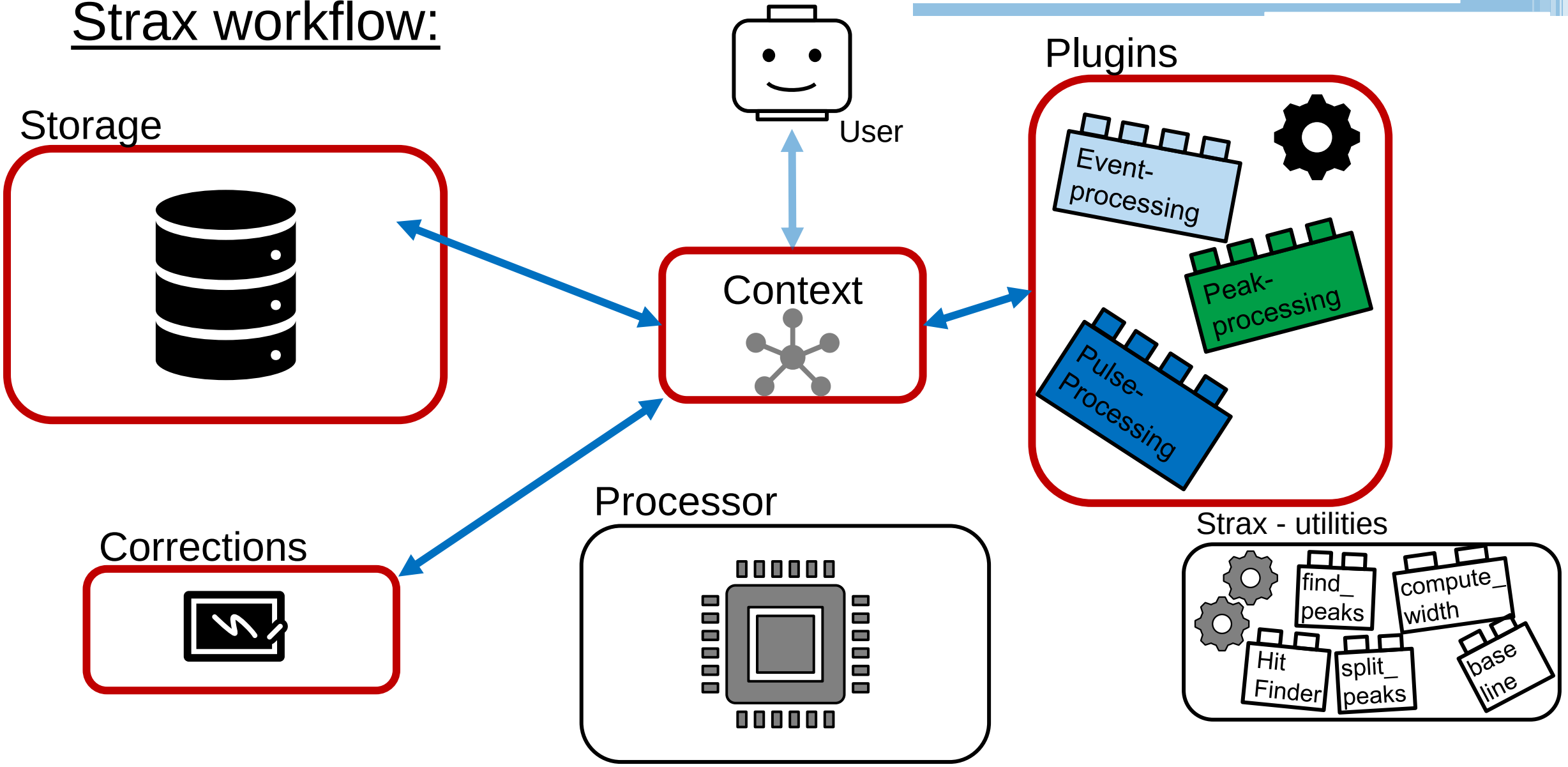
Strax workflow:



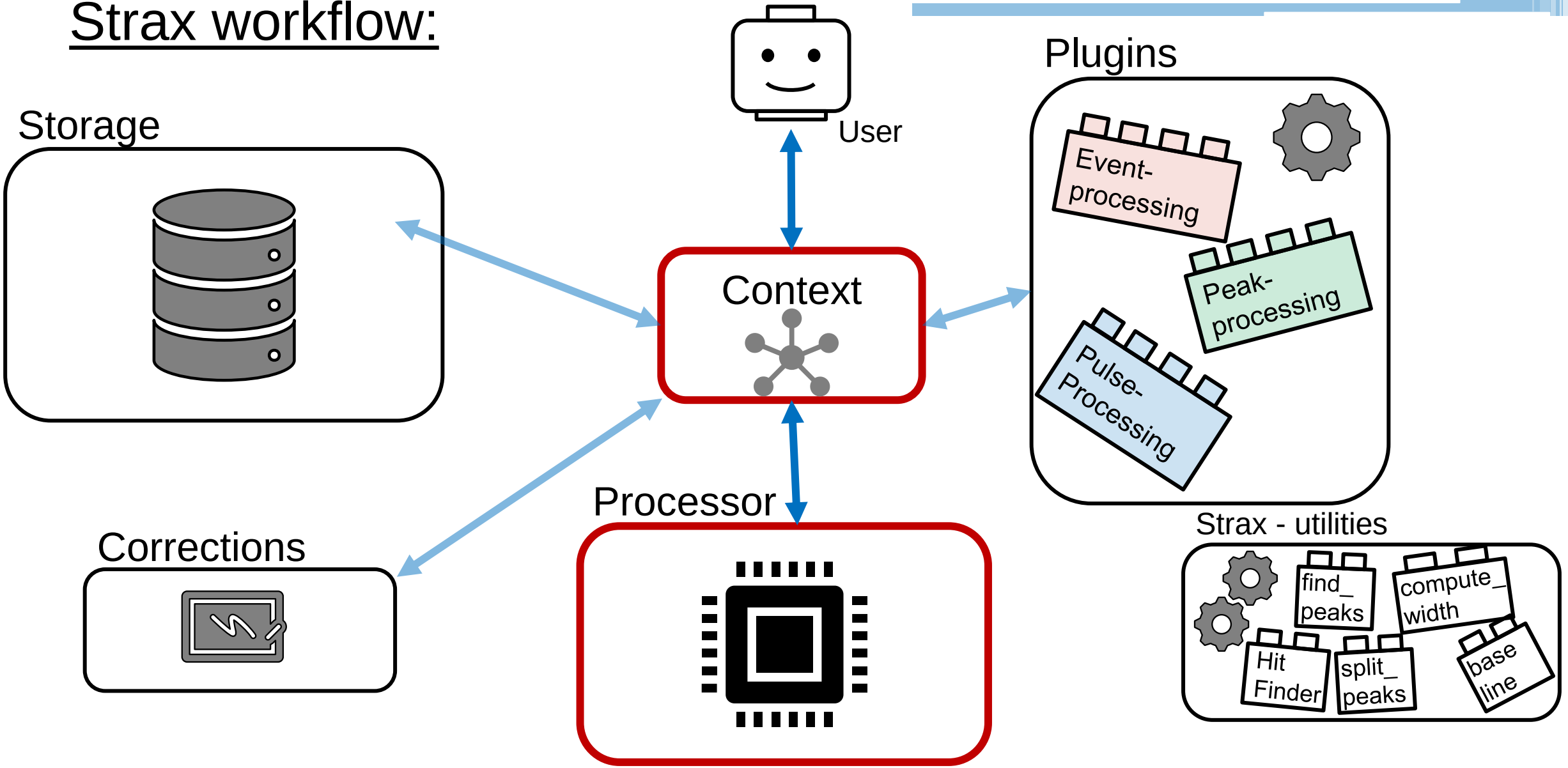
Strax workflow:



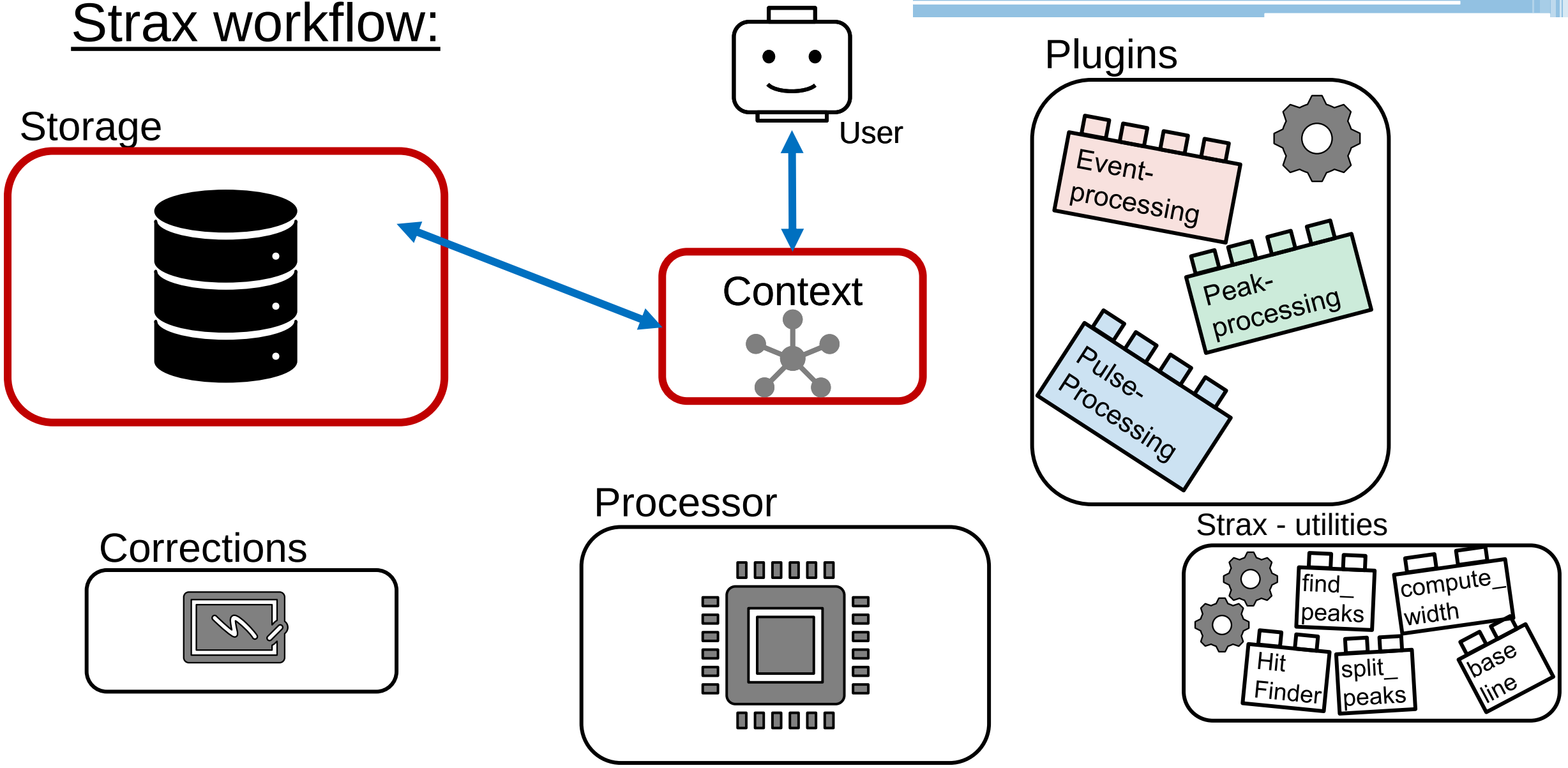
Strax workflow:



Strax workflow:

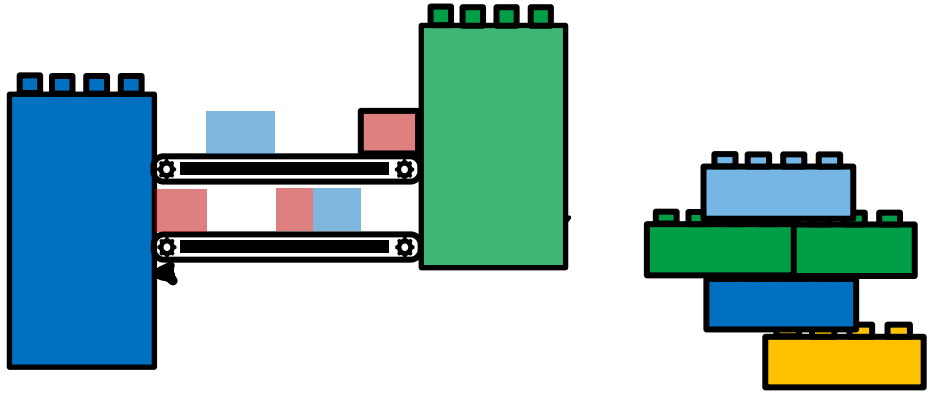


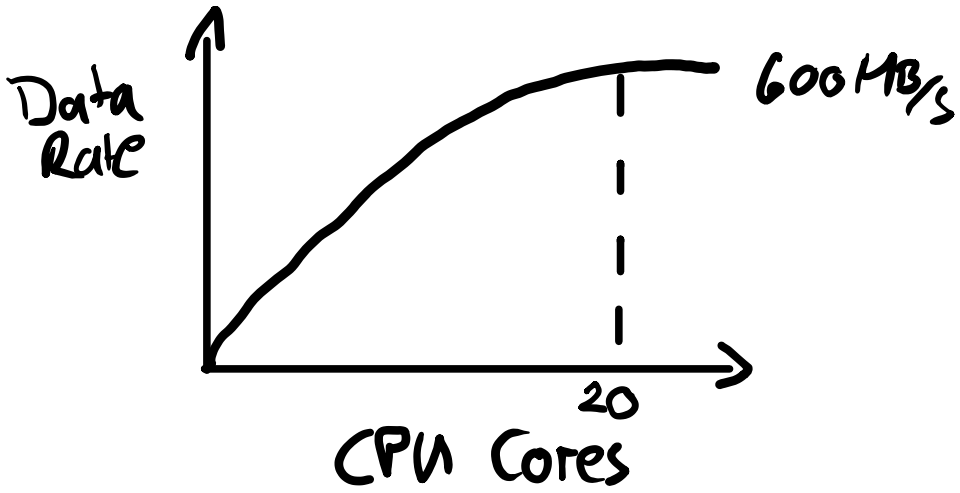
Strax workflow:



XENONnT analysis software:

- Data: chunks and tabular
- Processing: modular
- Patrial processing due to lineage
- From PMT signals to event in no time
- Not limited to TPCs





Check out strax and straxen on github