

The XENON1T

Data Distribution and Processing Scheme

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Sofia/Bulgaria

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The XENON1T Collaboration



What are we doing:

Looking for particle Dark Matter with 3.5 tons of liquid xenon in a dual phase time projection chamber (TPC)

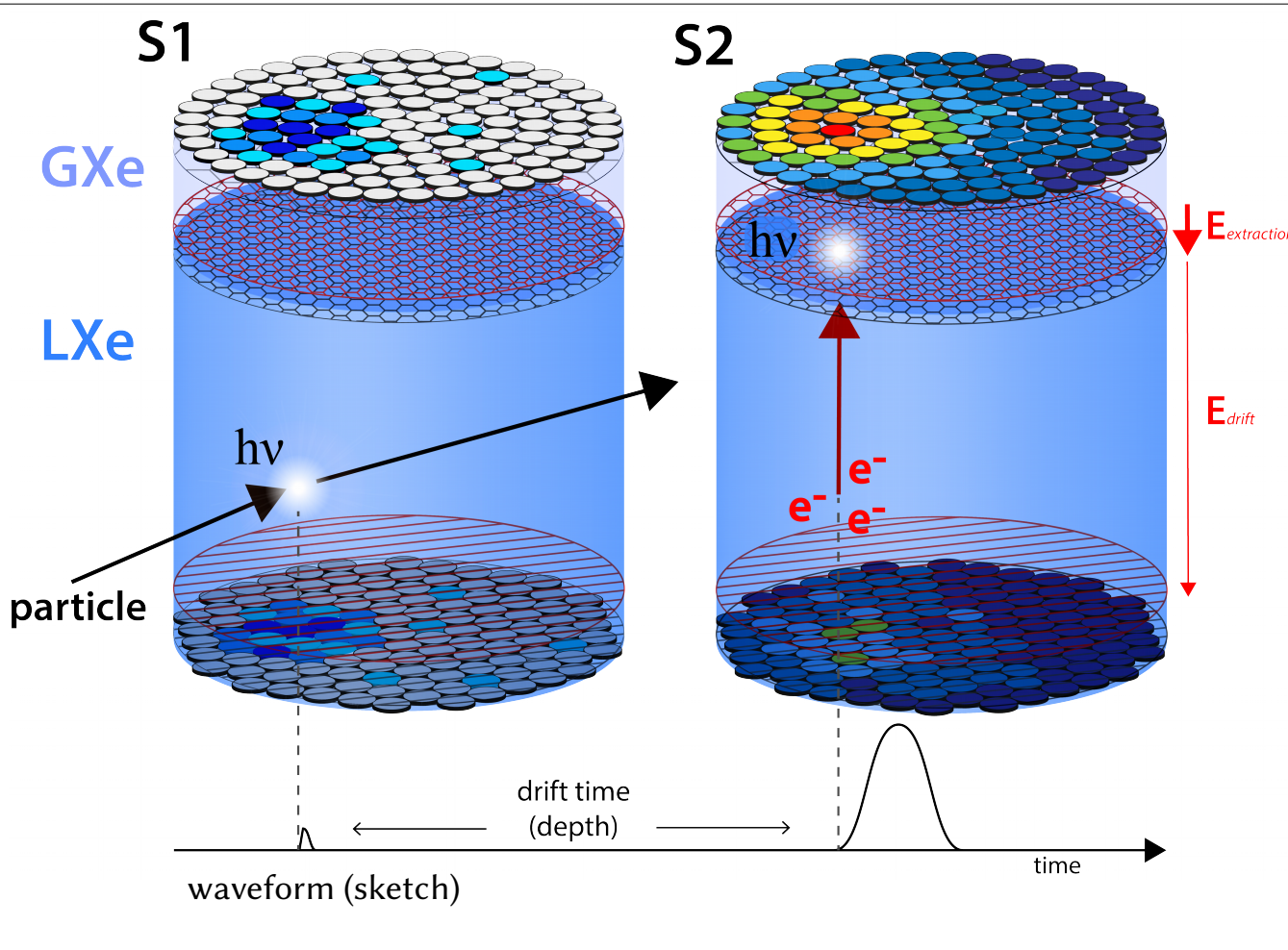
A worldwide collaboration:*

- 25 institutes
- >150 members



Collaboration Meeting in January 2018 (Florence)

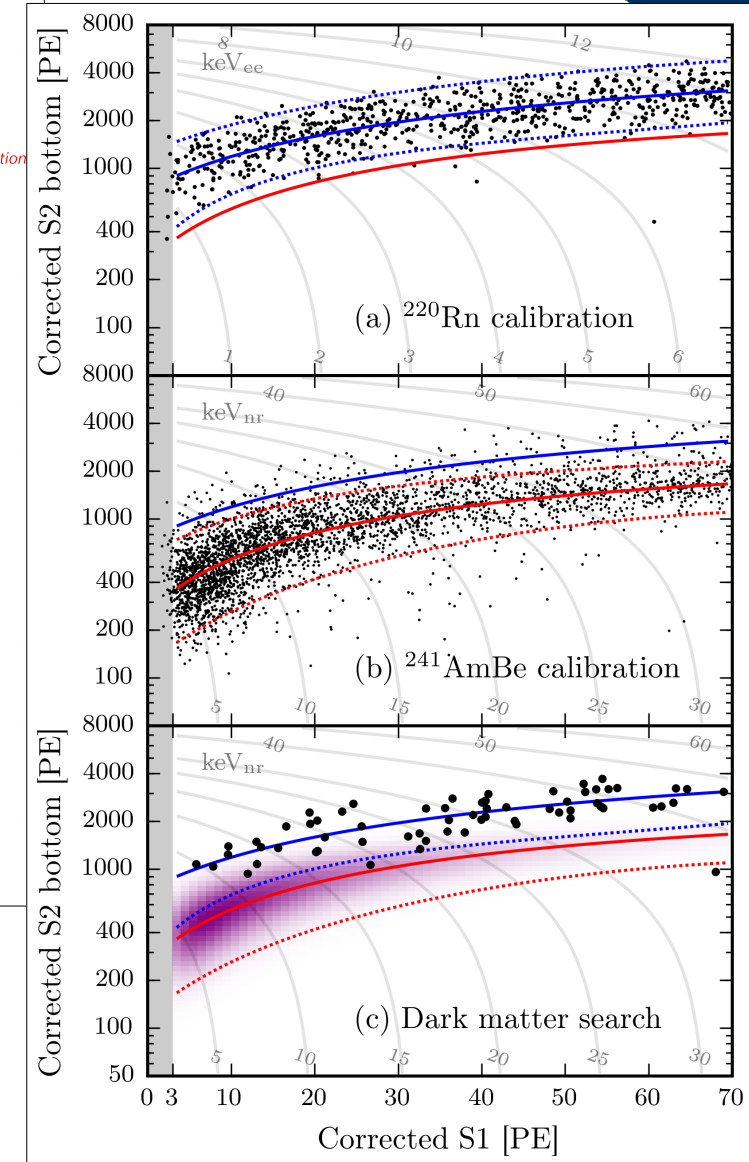
Dark Matter Detection with Liquid Xenon (I):



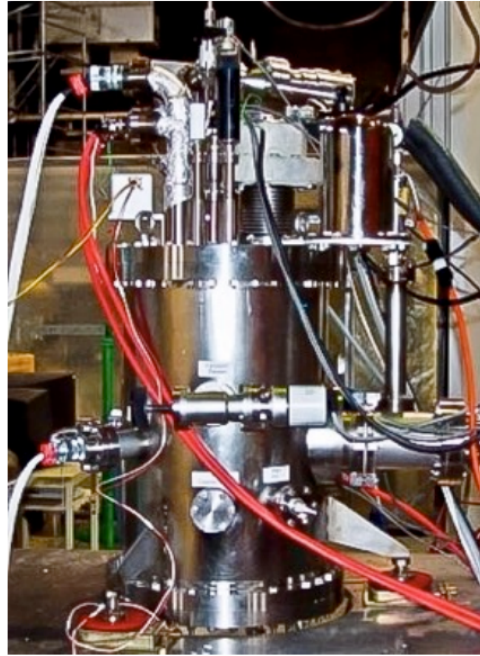
Probe and distinguish for different recoil types

- Electron recoil (ER)
- Nuclear recoil (NR)

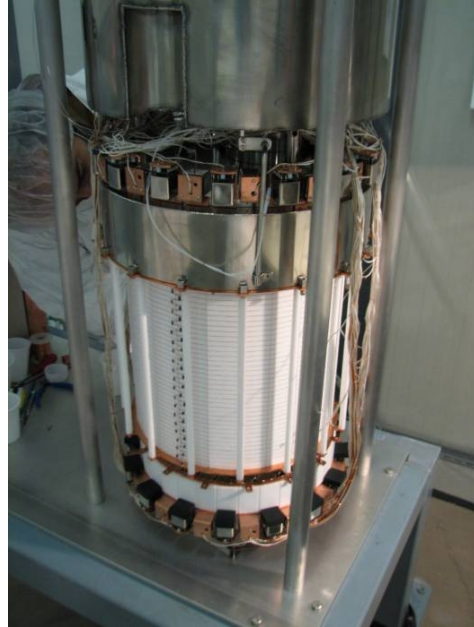
Expected from Dark Matter interaction:
--> Single scatter NR-like recoil type



Dark Matter Detection with Liquid Xenon (II):



XENON10

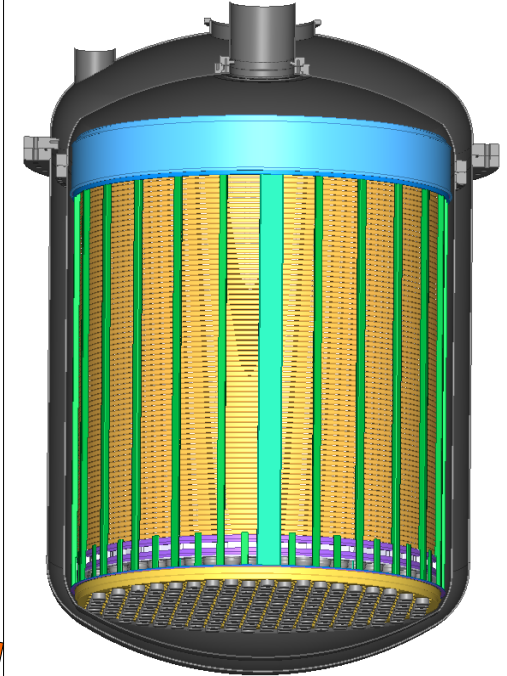


XENON100



XENON1T

First "light"
February 2016



XENONnT

Lifetime: 2005-2007

Mass: 25 kg

Height: 15 cm

PMTs: 89

2008-2016

161 kg

30 cm

242

2012-2018

3200 kg

100 cm

248

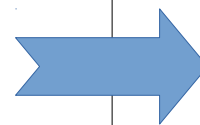
2019-20??

~8000 kg

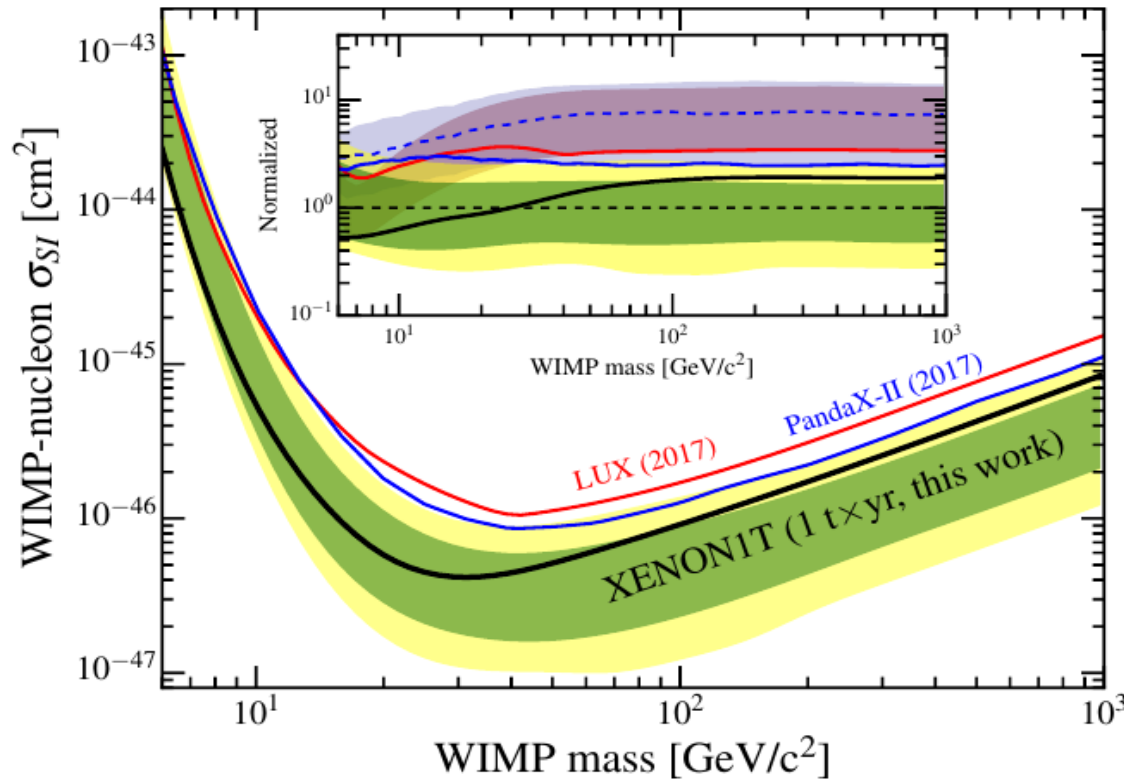
144 cm

476

Raw data storage, processing, tape
and analysis at the LNGS

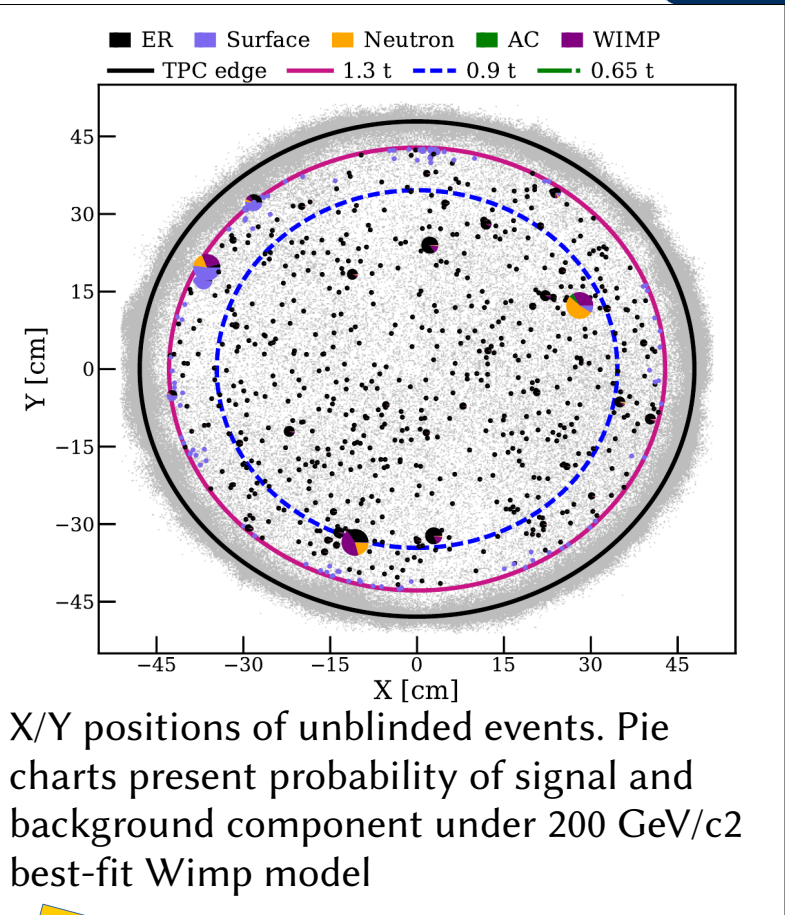


- Storage and processing at several computing facilities (worldwide, GRID)
- Research Computing Center (RCC) for analysis in Chicago



Dark Matter Search Results from a One Tonne×Year Exposure of XENON1T (arxiv:1805.12562)

- 278.8 life days
- Fiducial mass: 1.3 t
- Electron recoil background rate of 82 events/(t×yr×keVee)
- No significant excess over background is found
- Exclude above $4.1 \times 10^{-47} \text{ cm}^2$ at 30 GeV/c² (C.L. 90%, SI)



Usually the talk ends here!

Source	Size per Event (MB)	Total Events per year ($\times 10^6$)	Storage (PB/year)	Data Type
Background	2.01	139	0.279	Science
^{83m}Kr	0.78	66	0.051	Calibration
^{220}Rn	0.67	145	0.097	Calibration
Neutron Generator	2.71	4.5	0.013	Calibration
LED	0.12	192	0.023	Calibration
Total		546.5	0.463	

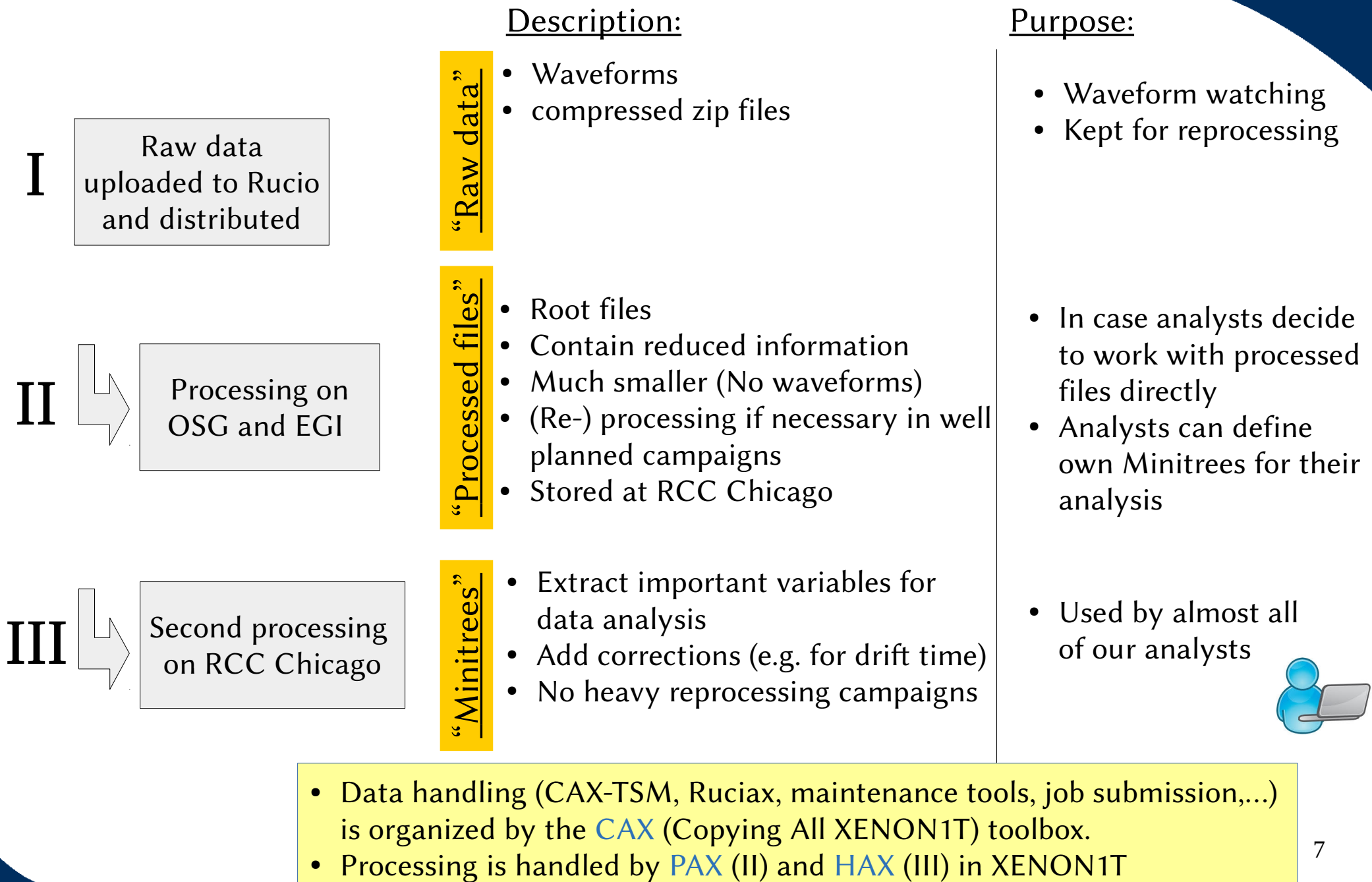
Storage Usage in XENON1T as of 26th of March 2018

Number of Files	2.03×10^6
Number of Datasets	19877

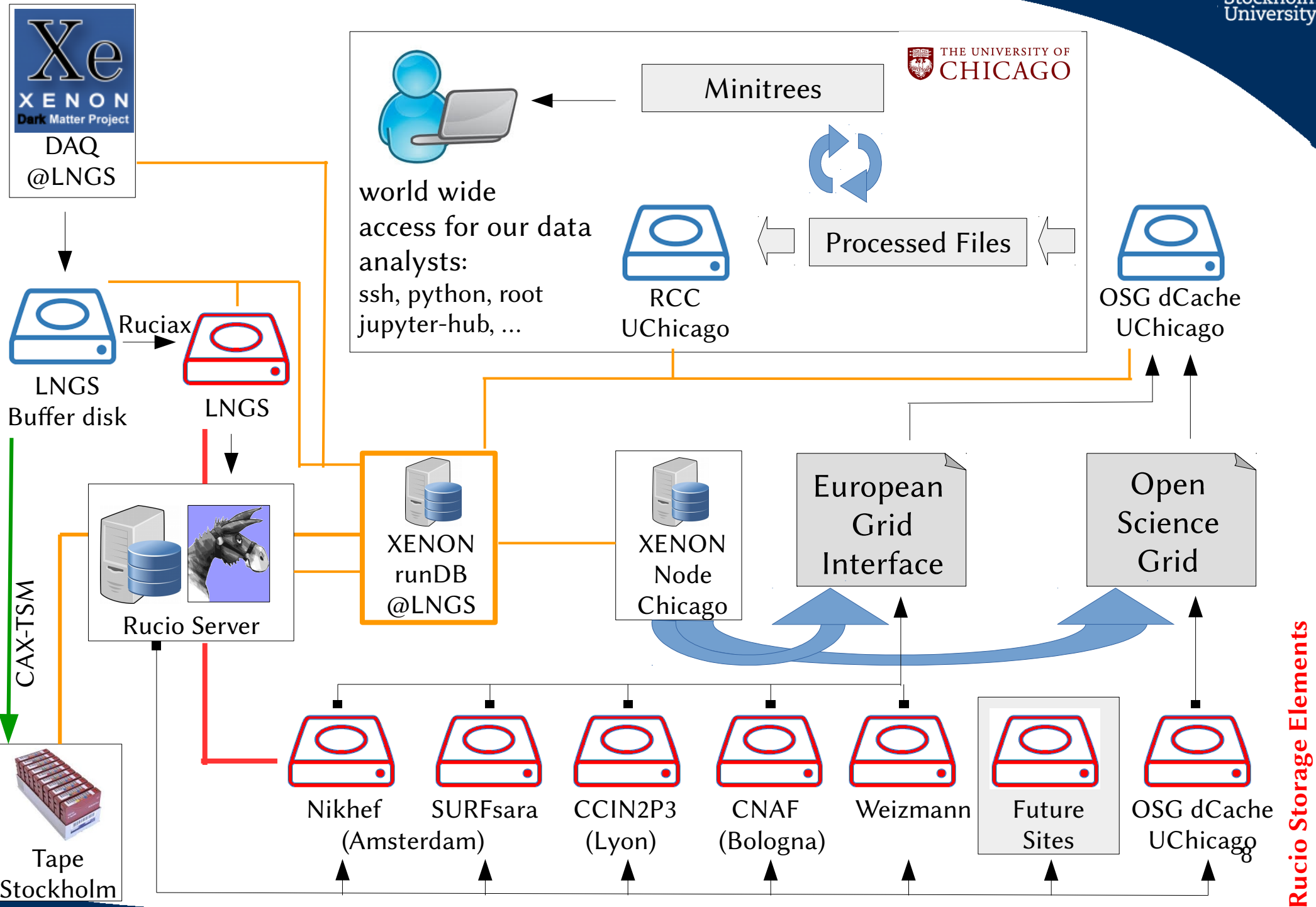
Use [Rucio](#) for data distribution:



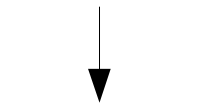
- Developed by the ATLAS collaboration
- XENON integrated Rucio in its workflow (Ruciax)
- Advantage: highly flexible in usage
 - Add GRID storage easily
 - Data distribution is done only within Rucio



The XENON1T Data Distribution Scheme:



The XENON1T Data Distribution Scheme:



LNGS
Buffer disk

CAX-TSM



Tape
Stockholm

Ruciatx

LNGS



world wide

Ruciatx

A Rucio server (VM) handles raw data transfers to several Rucio Storage Elements (RSE)

But data handling needs also Ruciatx:

- Developed by the XENON collaboration and provided by CAX
- Upload and download raw data
 - Uploads run from LNGS only
 - Analysts download small junks of raw data
 We “hide” Rucio command line interface from analysts
- Set and change transfer rules for many raw data sets if necessary
- Update the XENON runDB (@LNGS) regularly



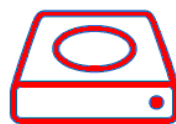
Rucio Server



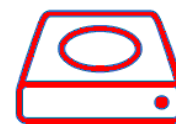
Nikhef
(Amsterdam)



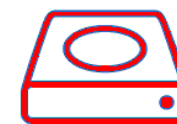
SURFsara



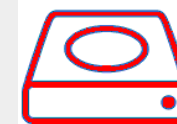
CCIN2P3
(Lyon)



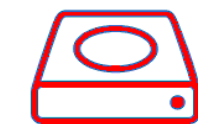
CNAF
(Bologna)



Weizmann

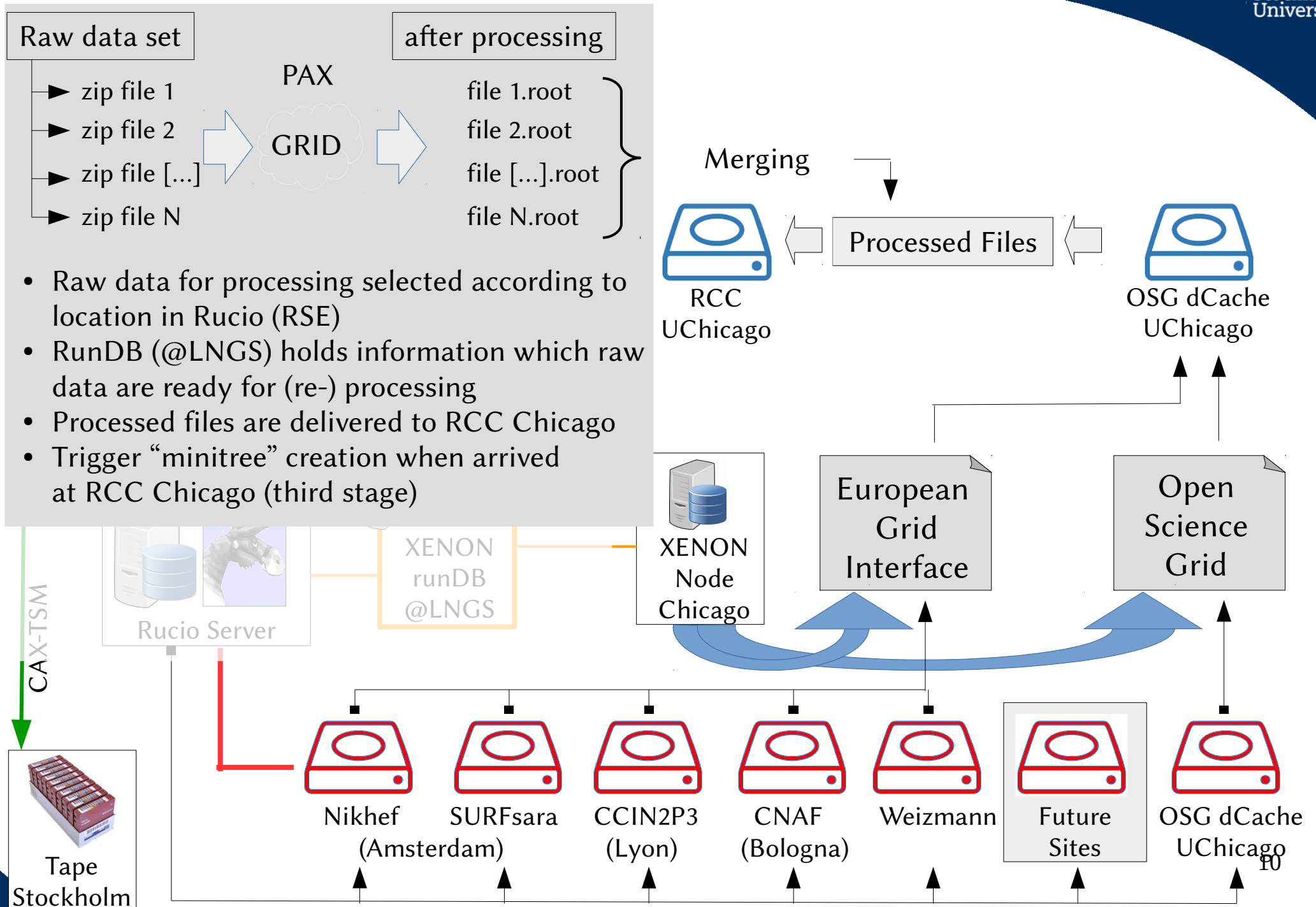


Future
Sites

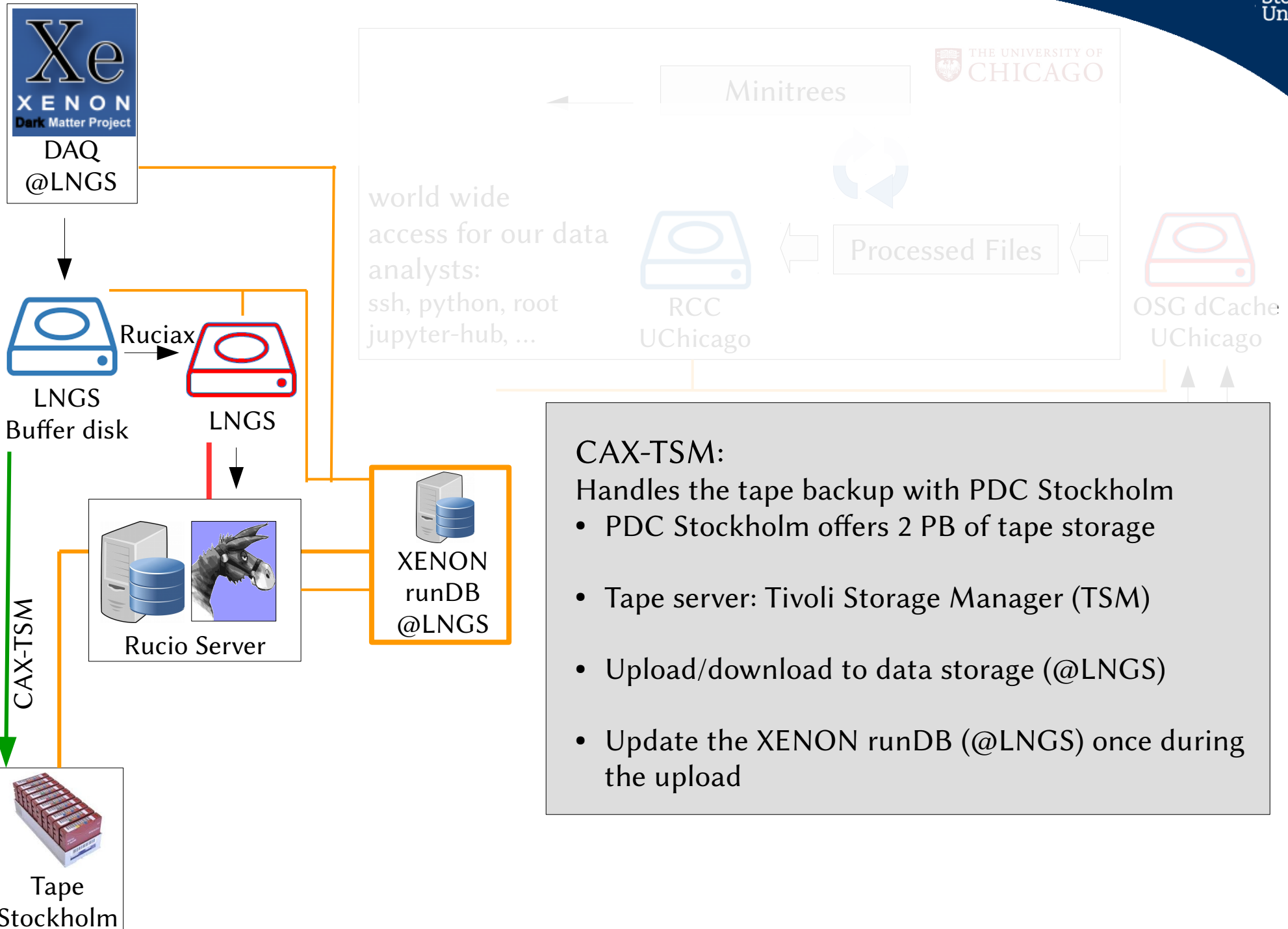


OSG dCache
UChicago

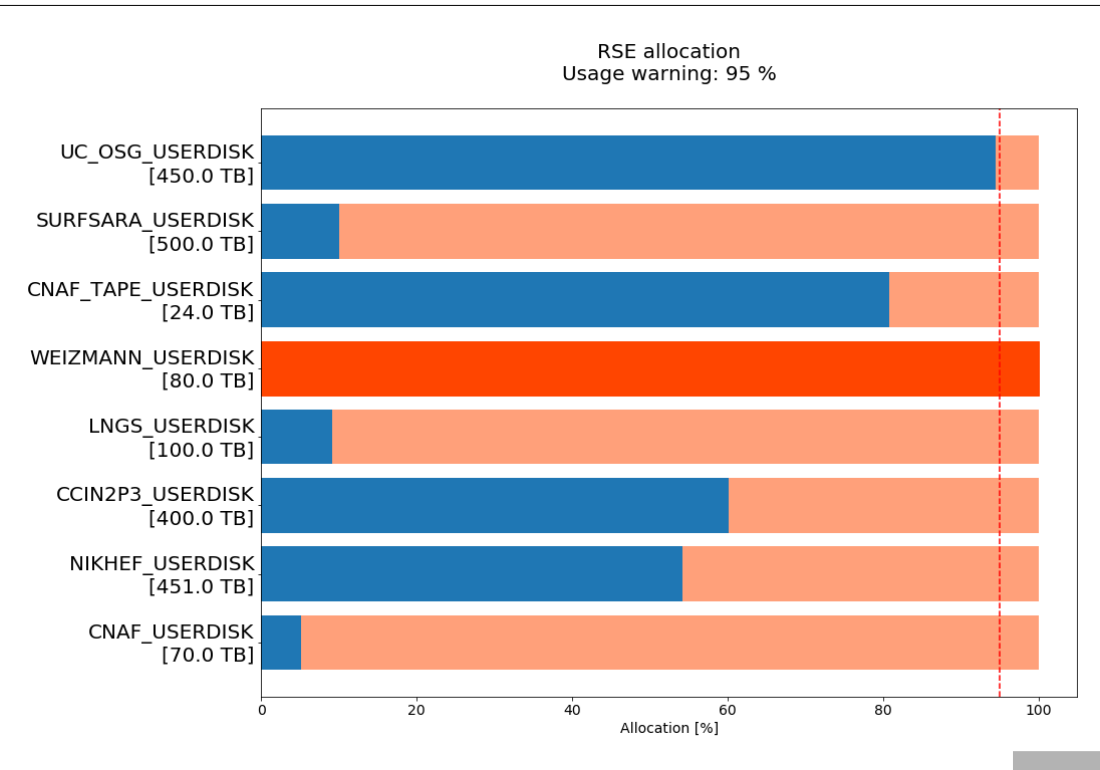
The XENON1T Data Distribution Scheme:



The XENON1T Data Distribution Scheme:



The XENON1T Disk Allocation and Requirements



- Data have two copies:

New data:

- US: OSG dCache at UChicago (hold only relevant data)
- Europa: One of several computing centers

Old data:

- Two RSEs in Europe

- Tape copy in Stockholm --> Independent of Rucio



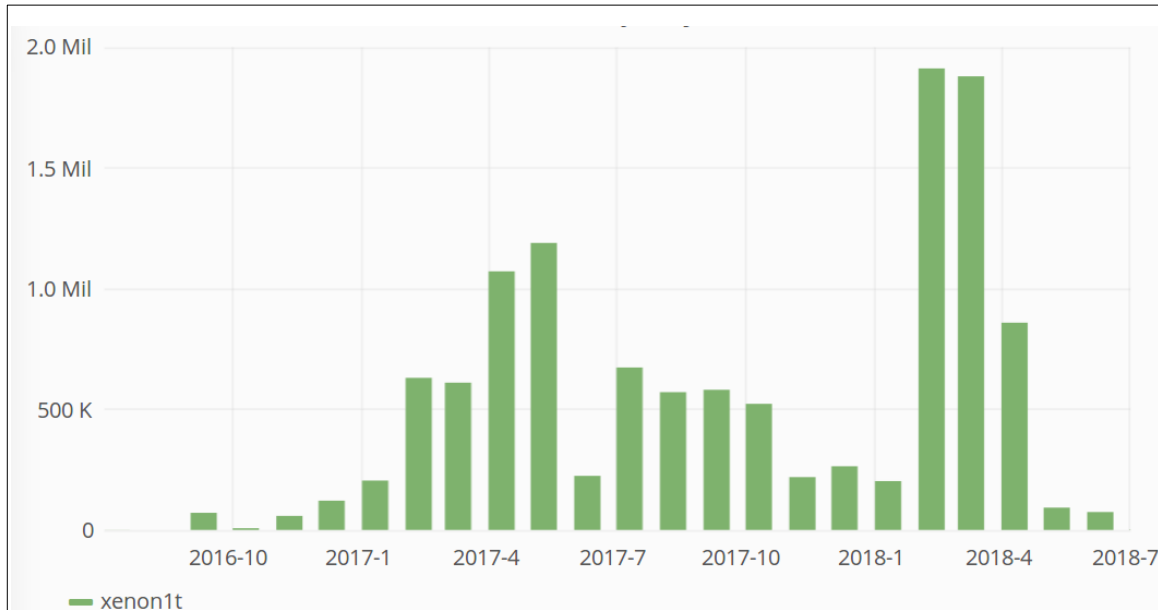
In total:

- Rucio: ~1.5 / 3.5 PB
Main contributors: CNAF & CCIN2P3
- Tape only: 2 PB (Stockholm)
- 155 TB (RCC Chicago)

Location	Diskspace
CCIN2P3 (Lyon)	1100 TB
CNAF (Bologna)	1070 TB
Weizmann	80 TB
NIKHEF/SURFsara (Amsterdam)	775 TB
OSG (Chicago)	475 TB
Total	3.5 PB

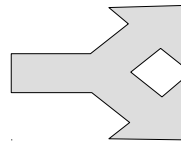
Tape & Disk

Successful GRID job submission since October 2016:



Wallhours in XENON1T

- Job submission is implemented in [CAX](#) (developed by the XENON collaboration)
- Use OSG GlideinWMS infrastructure
- Job submission to:
OSG, EGI, NSF Supercomputer COMET (SanDiego), RCC (Chicago)

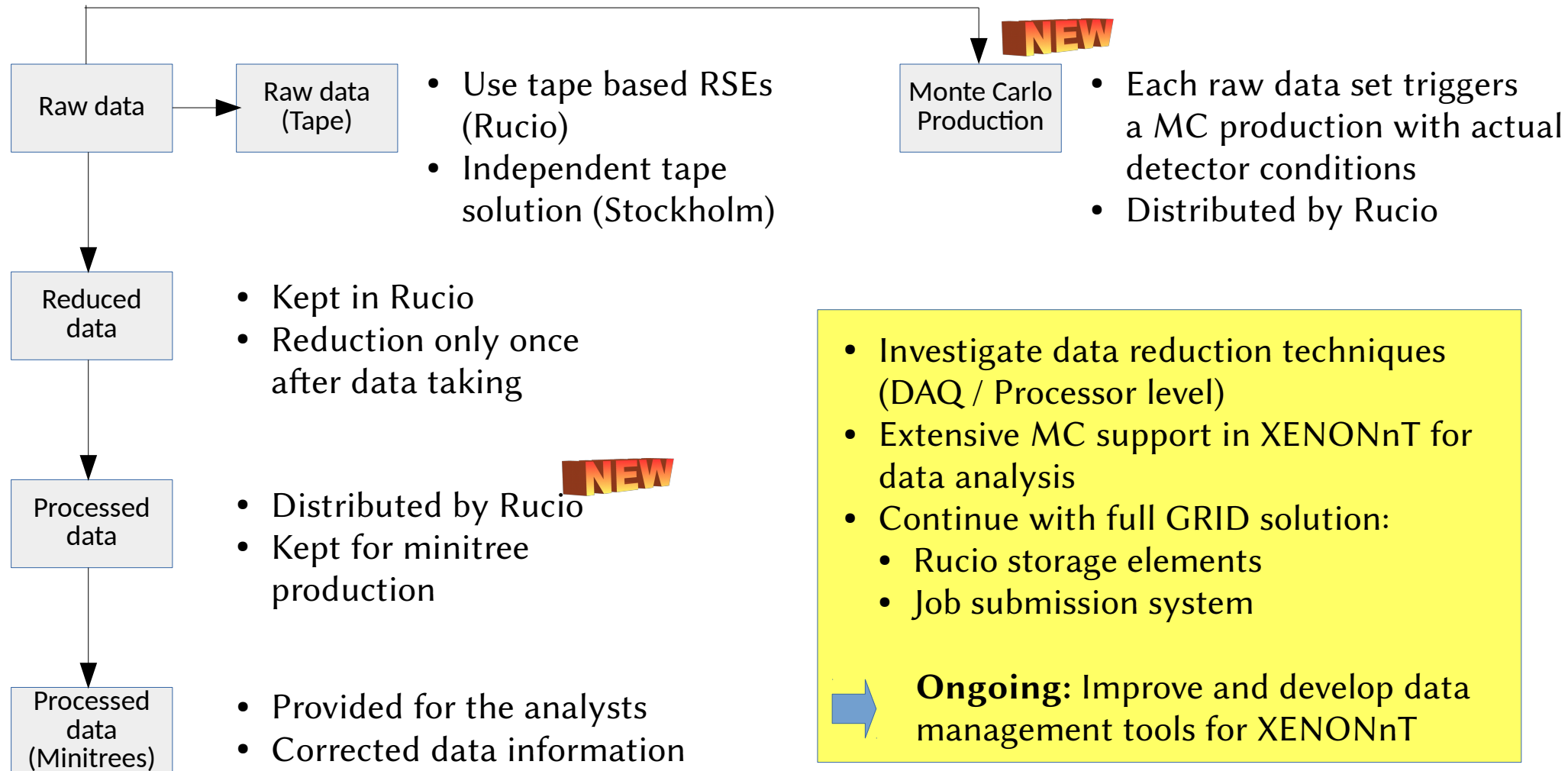


- Constant processing of raw data
- Reprocessing if necessary

Montecarlo simulations on GRID allow a full XENON1T simulation (e.g. different calibration sources)

Most important:

- Based on the XENONnT design we expect at least twice as much data!
- Detectors: TPC, MuonVeto, NeutronVeto **NEW**
- Schedule for mid 2019 (data taking)



XENON1T

- RUCIAX, CAX-TSM, CAX as part of the [CAX toolbox](#)
 - handling several tasks regarding data management and processing
 - Allocated disk space at the moment ~ 1.5 PB
 - multiple copies, 6 RSEs worldwide
 - Data taking continues!
 - Science data (“Science run 2” everything after 01.02.2018)
 - ^{37}Ar calibration
 - Further physics analysis are ongoing
 - e.g. event rate modulation, double electron capture
-

XENONnT

- Continue with GRID infrastructure for
 - Data distribution with Rucio
 - Processing of raw data
 - New: full detector MonteCarlo simulations
- Introduce an intermediate level of data (reduced raw)
- Improve and develop tools (a “new” CAX):
 - Upload/Download/Transfer in Rucio
 - Job submission
- Data reduction is under investigation

Backup Slides...



Backup: XENON1T Bookkeeping

The XENON runDB (@LNGS) keeps track on meta information:

- Trigger information
- Time stamps
- Calibration source
- Data locations and transfer status
- ...

A web interface allows us to check for:

- Data transfers status (Rucio and non-Rucio)
- Data processing status



Storage

Comments

JSON

Raw data

xe1t-datamanager

Type: raw Status: transferred

Location: /data/xenon/raw/180224_0427

tsm-server

Type: raw Status: transferred

Location: /data/xenon/tsm/180224_0427

rucio-catalogue

Type: raw Status: transferred

Location: x1t_SR001_180224_0427_tpc:raw [LNGS_USERDISK, UC_OSG_USERDISK]

Processed data

login

Type: processed Status: transferred

Pax version: v6.8.0

Location: /xenon/xenon1t_processed/pax_v6.8.0/180224_0427.root

midway-login1

Type: processed Status: transferred

Pax version: v6.8.0

Location: /project2/lgrandi/xenon1t/processed/pax_v6.8.0/180224_0427.root

```
{
  "location": "x1t_SR001_180224_0427_tpc:raw",
  "checksum":
    ":1204afbb:aaddddb3:b0cfa37c:3f5648b7:6a16339",
  "creation_time": {
    "$date": 1519452310627
  },
  "status": "transferred",
  "host": "rucio-catalogue",
  "rse": [
    "LNGS_USERDISK",
    "UC_OSG_USERDISK"
  ],
  "type": "raw",
  "rule_info": [
    "LNGS_USERDISK:2018-03-01_07:49:03",
    "NIKHEF_USERDISK:STUCK",
    "UC_OSG_USERDISK:valid"
  ]
},
```

Example from the web interface

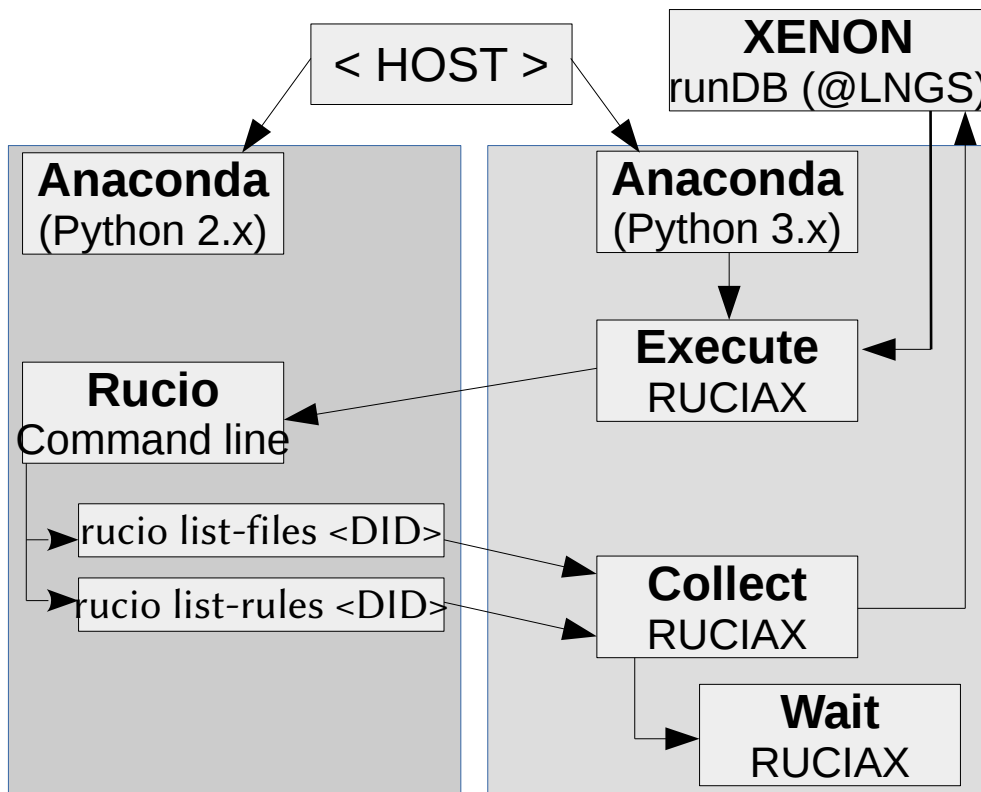
RUCIAX, CAX-TSM are

- Part of the same toolbox CAX ([Github](#))
 - > Several experts develop different parts
- Serve different purpose based on “tasks” (CAX) or applications (RUCIAX, CAX-TSM)
- Language: Python 3.4
- But: Rucio is Python 2.6

We needed to overcome the “language barrier” to talk to Rucio with RUCIAX



Python 2.6 vs. Python 3.4



Several configurations but:

- Mounted: cvmfs at several hosts to provide all our software tools
- Anaconda manages different Python versions and offers:
 - Data management and processing tools (e.g. CAX, RUCIAX, CAX-TSM, Rucio)
 - Analysis tools:
e.g. root, python, jupyter-hub, serveral
 - software developed for XENON1T

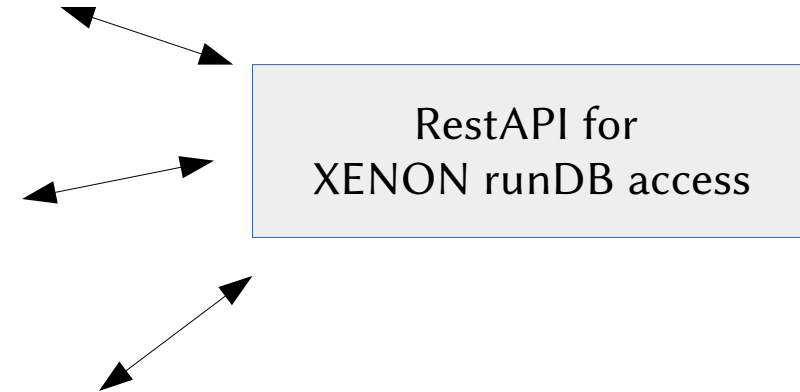
For example:

RUCIAX is executed to update XENON runDB locations

Heavy usage of Rucio command line interface (CLI)

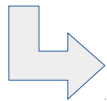
Update: Software

- Independent tool to handle:
 - the extended data structure (reduced and processed data in Rucio)
 - RucioAPI instead of CLI
 - If new Rucio server is in Python 3.x
 - The tape storage (CLI for TSM)
- Independent tool for job submission
 - Job submission is adjusted according to reduced and processed data sets
- CAX to handle tasks (similar to XENON1T)



Update: Requirement on data safety (& tape)

- Keep latest raw data in Rucio on dedicated tape storage.
- Move older raw data to PDC/Stockholm



Allow quick first level reprocessing if necessary

Source	Size per Event (MB)	Total Events per year ($\times 10^6$)	Storage (PB/year)
Background	3.62	278	0.502
83mKr	1.4	198	0.277
220Rn	1.21	145-436	0.194-0.528
Neutron Generator	1.21	4.5-135	0.054-0.164
LED	0.24	192	0.046
Total		817.5-1239	1.073-1.517

Estimated sizes for XENONnT raw data