XENON1T Computing Model

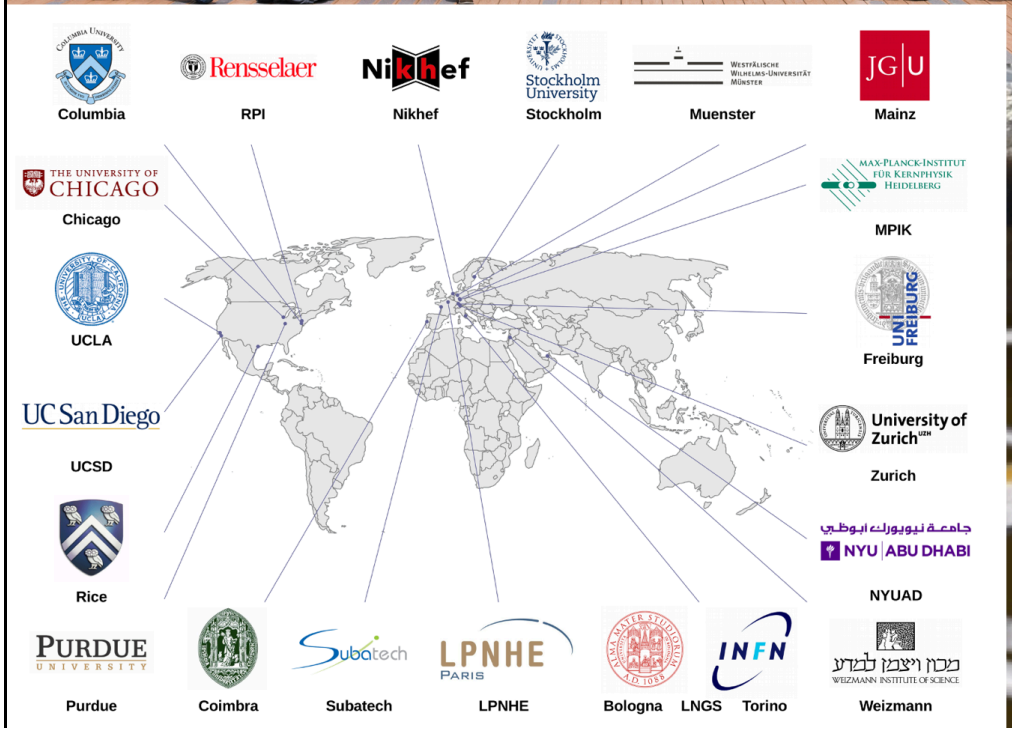
Marco Selvi (INFN Bologna)
for the XENON Collaboration

... with special thanks to Luca Grandi (UChicago),
Luca Scotto Lavina (LPNHE Paris) & Alfio Rizzo (Columbia),

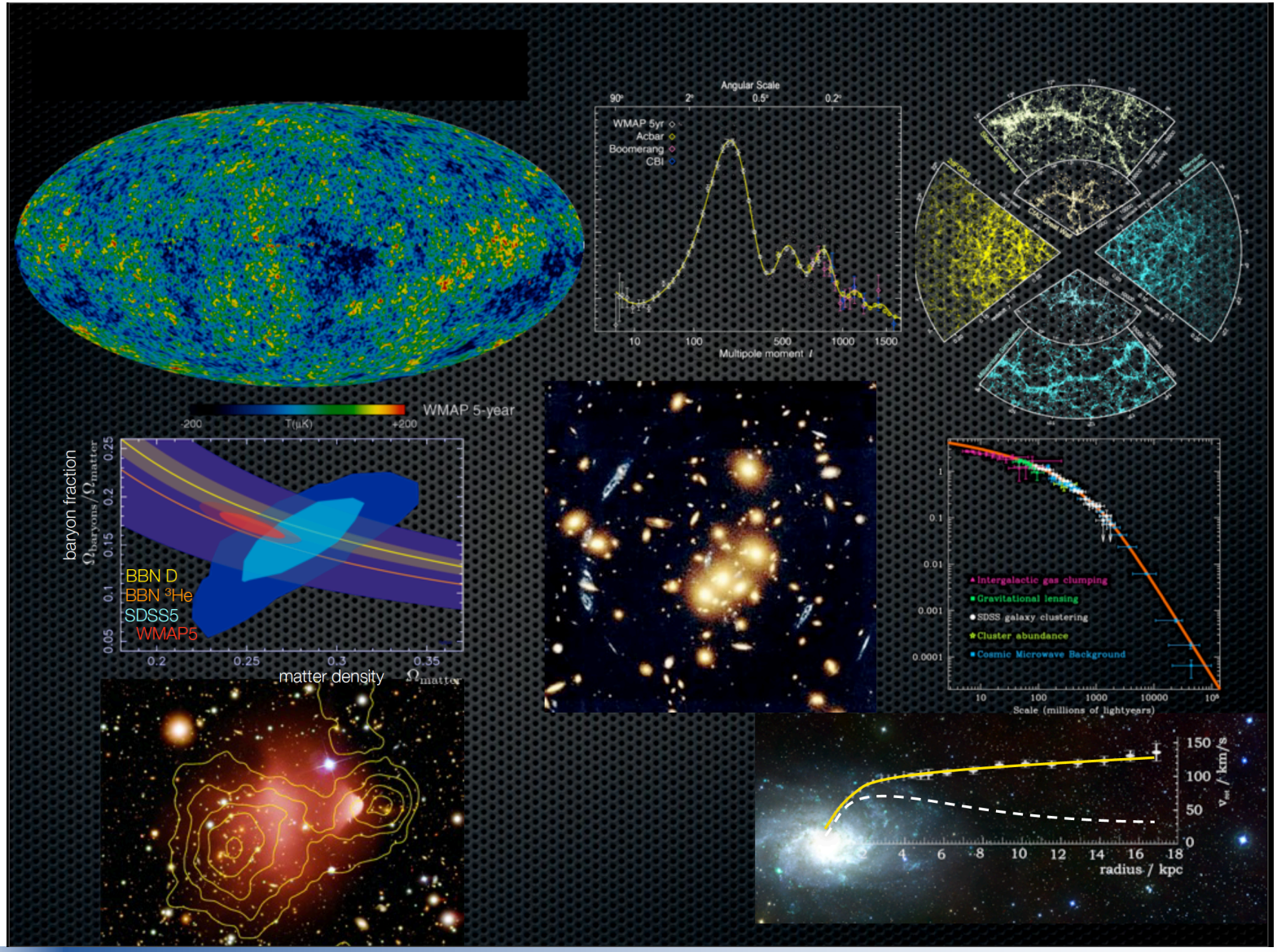
and to the LNGS Computing Team !

CCR Workshop, 22nd May 2017, LNGS

XENON collaboration



Dark Matter exists

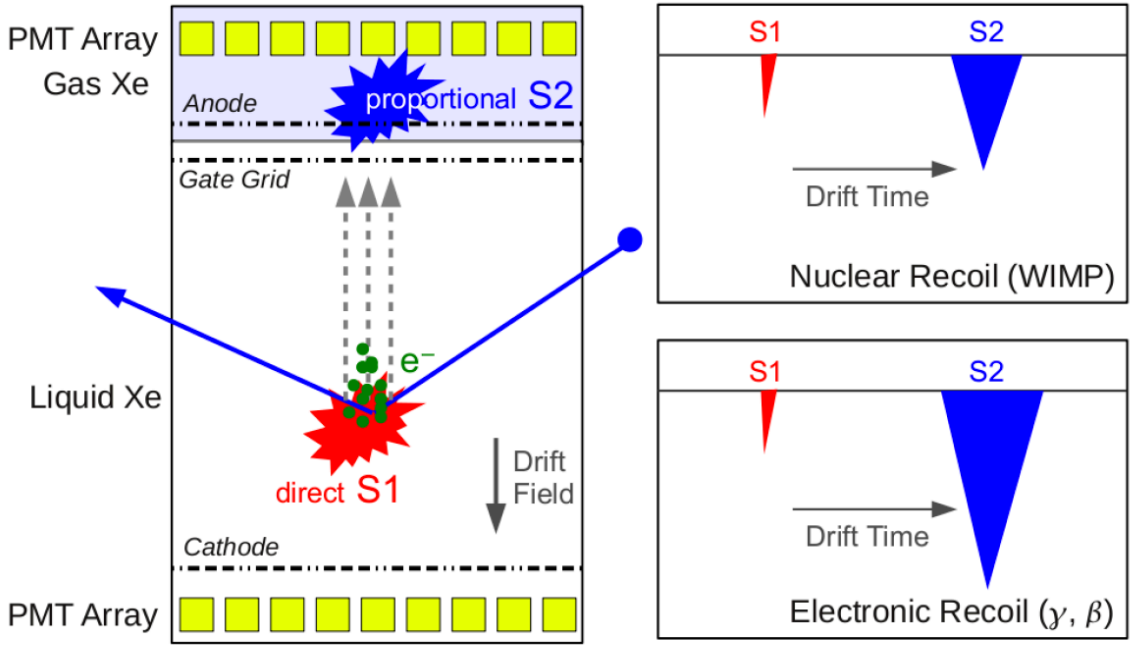


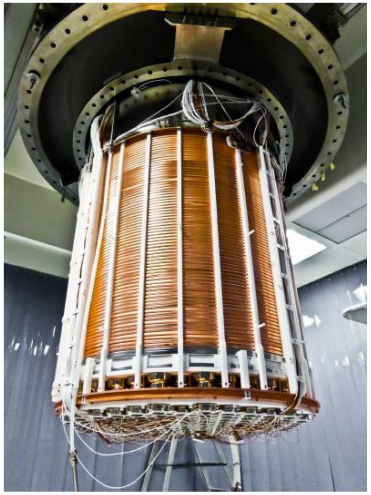
XENON1T in Hall B @ LNGS

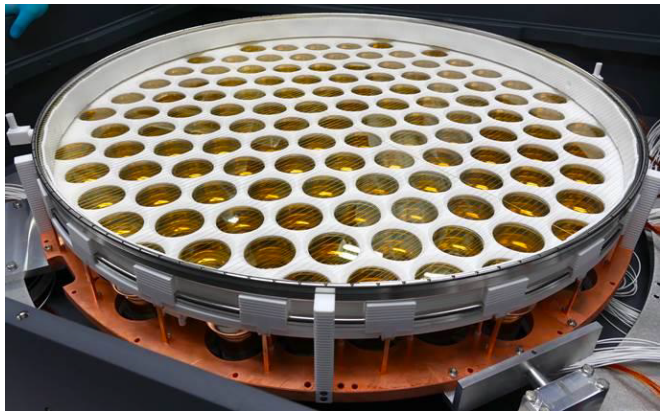
Dual-phase TPC

- **Immediate scintillation light S1**
- **Ionization electrons** drift to the top of the TPC
- Strong field extracts electrons to gas phase
  - proportional amplification → **charge signal S2**

- **X, Y position** → S2 hit pattern
- **Z position** → electron drift time
- **Energy** → S1, S2 integral
- **Electronic/Nuclear recoil discrimination** → S2/S1
  - **WIMPs** (NR), **background** (mostly ER)

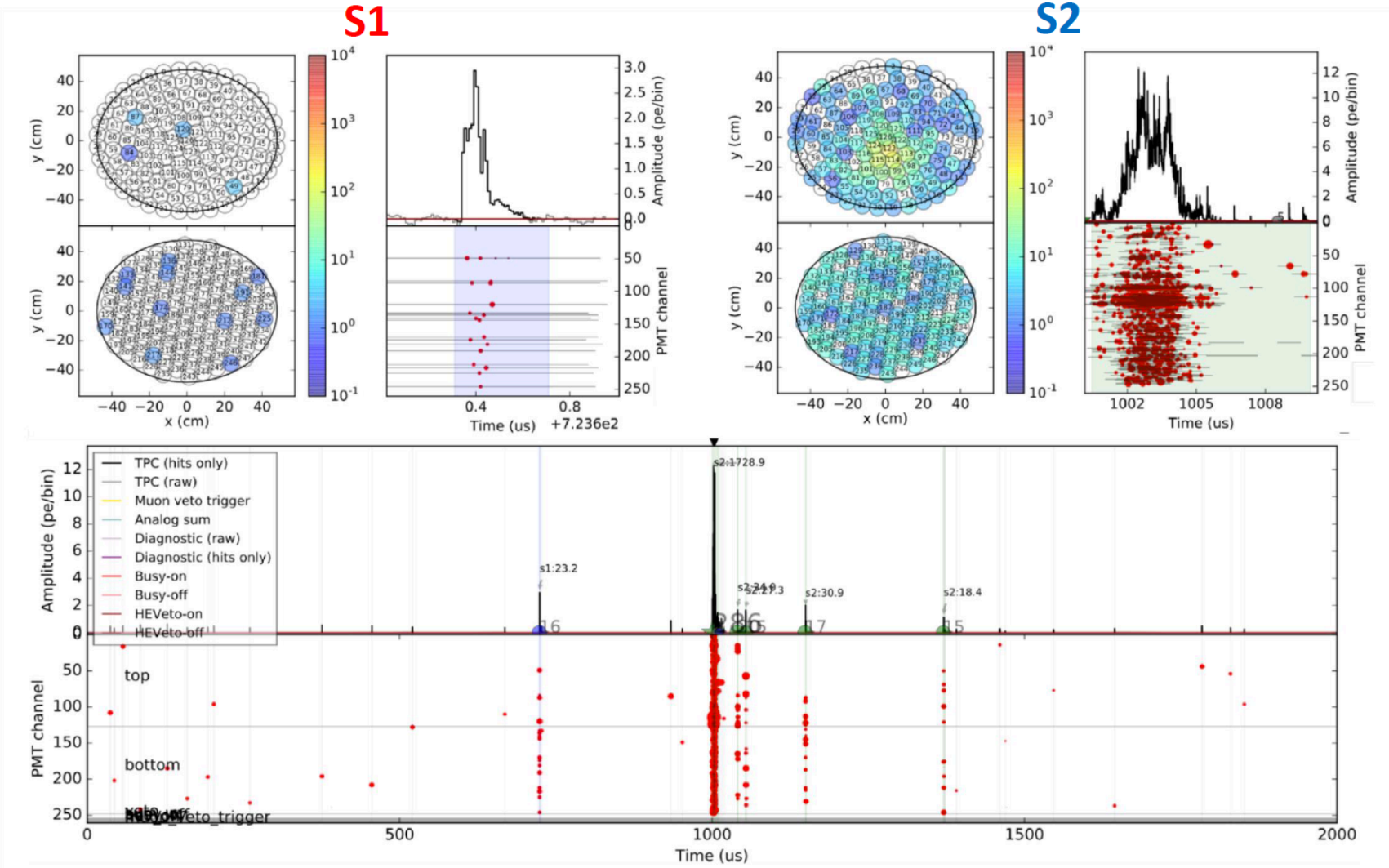




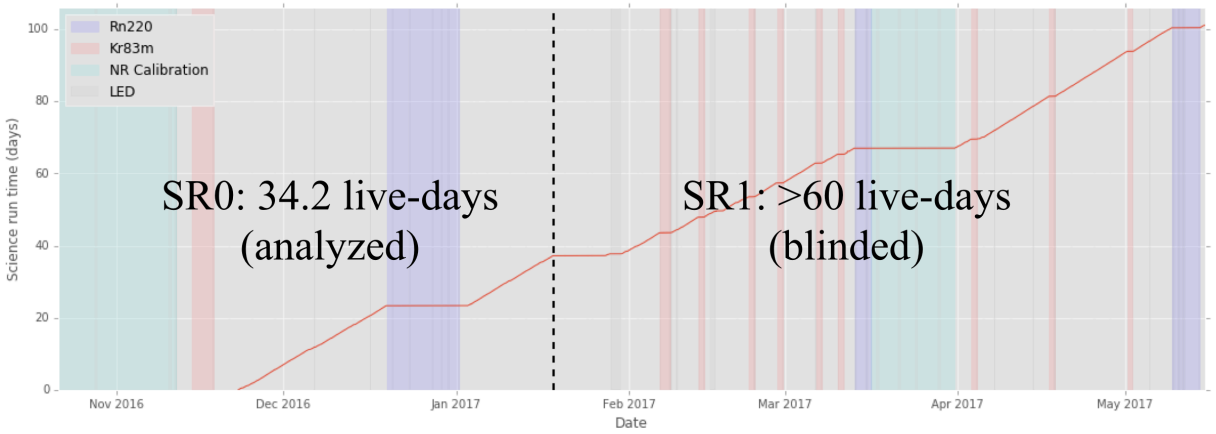


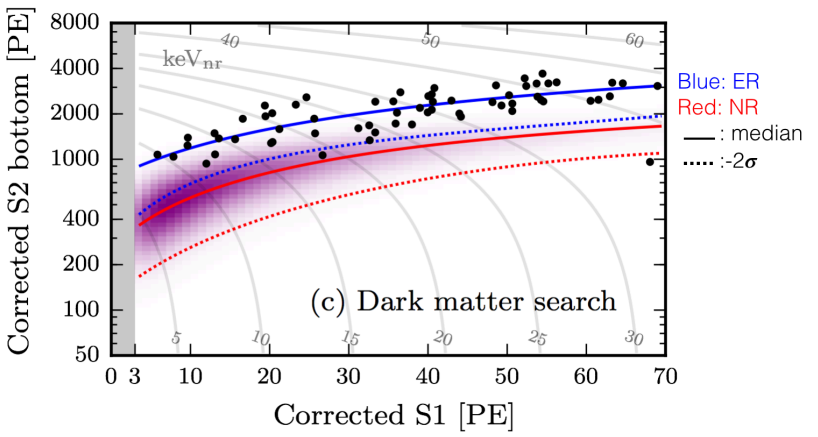
- 248 PMTs in the TPC
- + 84 in the Muon Veto

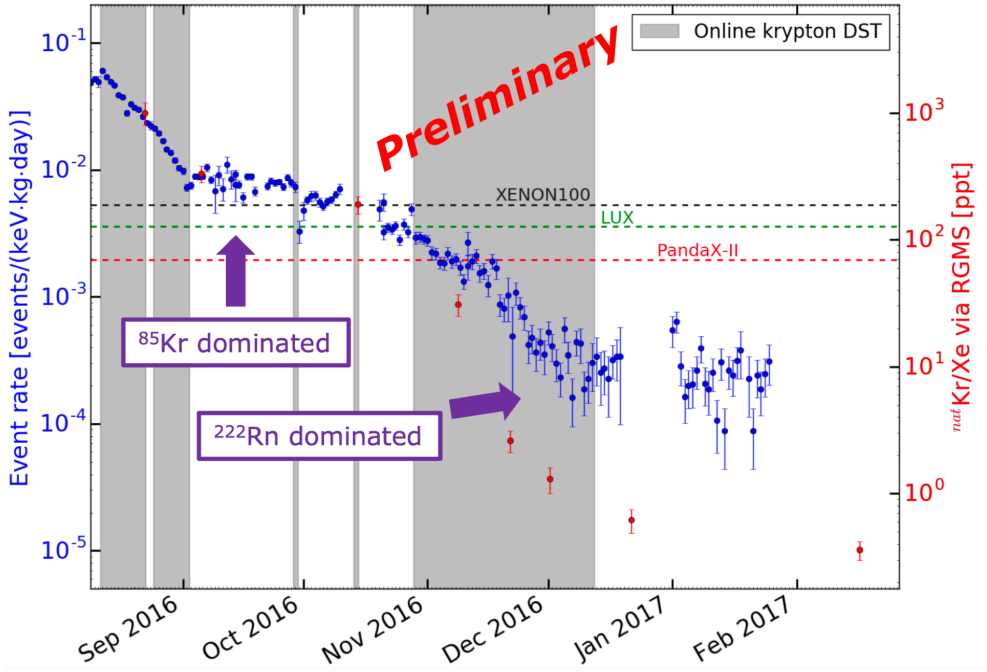
A typical waveform

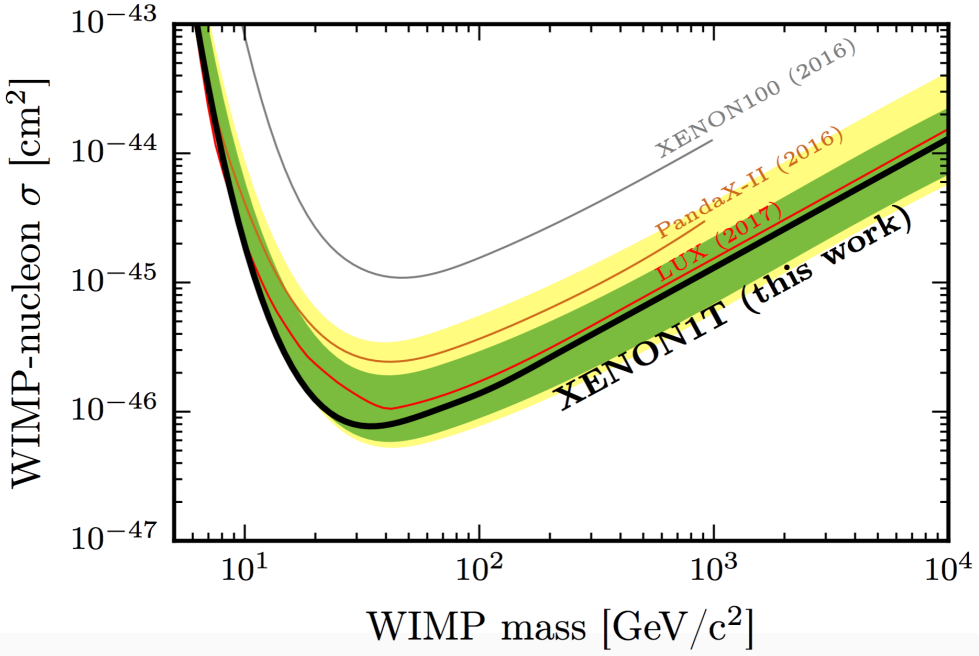


First XENON1T results, arXiv:1705.06655









XENON1T computing

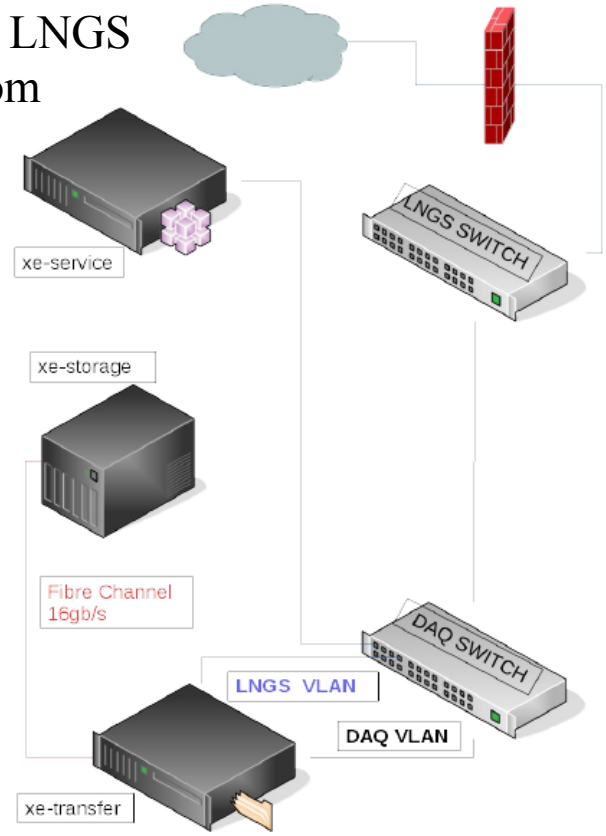
- XENON1T data taking for commissioning started on May 2016
- XENON1T science run started on Nov 2016
- Data consists in:
  - raw data from DAQ
  - processed data
  - Monte Carlo production
- Data rate for science runs: ~1 TB/day
  calibration runs: ~7 TB/day
- Total expected yearly rate: 1 PB/year (~300 TB for science runs)

Computing resources

- Raw data temporary stored in a 50 TB local buffer located in the LNGS computing room.
- Automatic raw data transfer from LNGS to:
  - European and US GRID storages
  - Backup facility with tapes (Stockholm)
- Raw data processed on US GRID (Open Science Grid)
- Processed data files made available to the entire Collaboration through the Analysis Facility at UChicago (Jupyter Hub infrastructure)
- MC simulation @ EGI (including CNAF) and OSG

Local resources @ LNGS

Located in the LNGS computing room



xe-transfer.lngs.infn.it (PROXMOX)
Access via LNGS VPN
1GB and 10GB connections VMs:

100 (xe-boxmgnt)
102 (xe-offlinemon)
103 (xe-mongodb)
104 (xe-mysql)
106 (xe-oasis)

xe-service.lngs.infn.it (PROXMOX)
Access via LNGS VPN
1GB and 10GB connections
Vms:
- will contain the wiki
- will act as a backup in case of issues with xe-transfer

- XENON1T has become part of the pool of experiments allowed to use **LHCONE** network to improve data transfer through Atlantic. We are working with the **LNGS IT** on its implementation. Nikhef and UChicago are already on board.

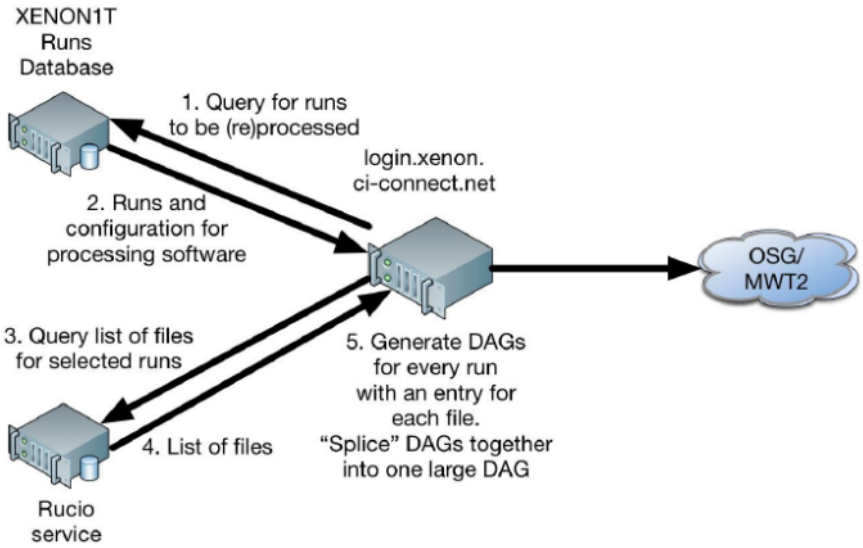
- Occasional, but very efficient use of the **ULITE** facility @LNGS, for test MC and data processing.

Data management

Setup a distributed data management system using **Rucio**
(data management system developed and used by ATLAS) and FTS at BNL.
The product has been adapted to XENON1T needs by Stockholm group and UChicago IT.

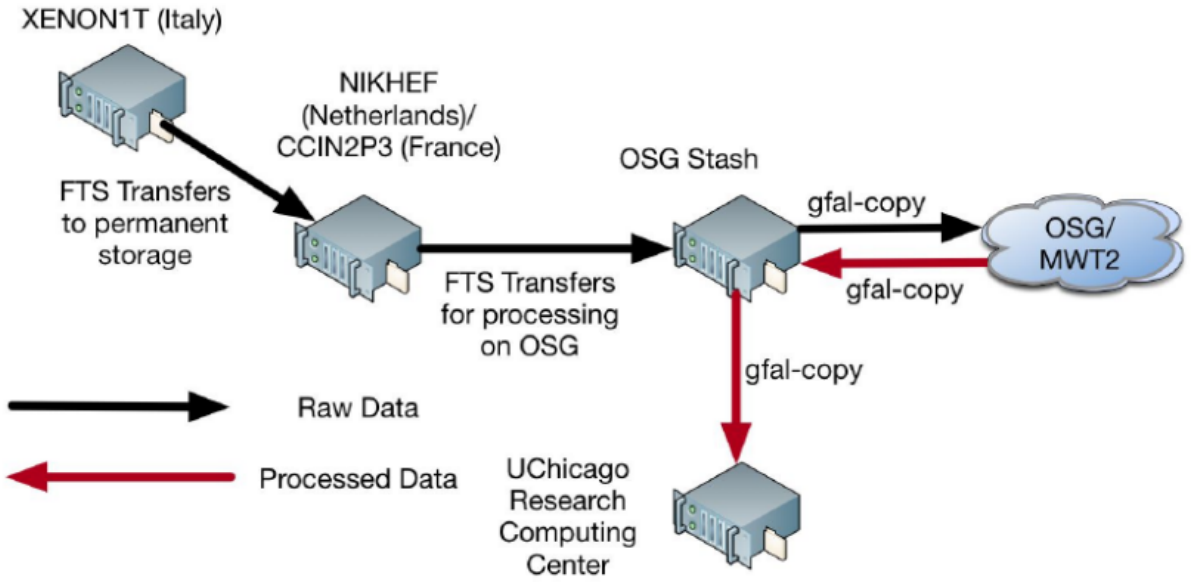
- Rucio: File catalog service, subscription "rule" model for automatic data placement and deletion, etc.
- FTS: Reliable file transfer
- Currently 5 storage facilities have become Rucio endpoints
  (Nickhef, UChicago, CC-IN2P3 Lyon, Weizmann and LNGS).
  CNAF might become a Rucio endpoint if enough storage will be granted (minimum 200 TB !).
- A policy of at least 1 copy on tape and 1 copy on storage is enforced.

Data processing workflow

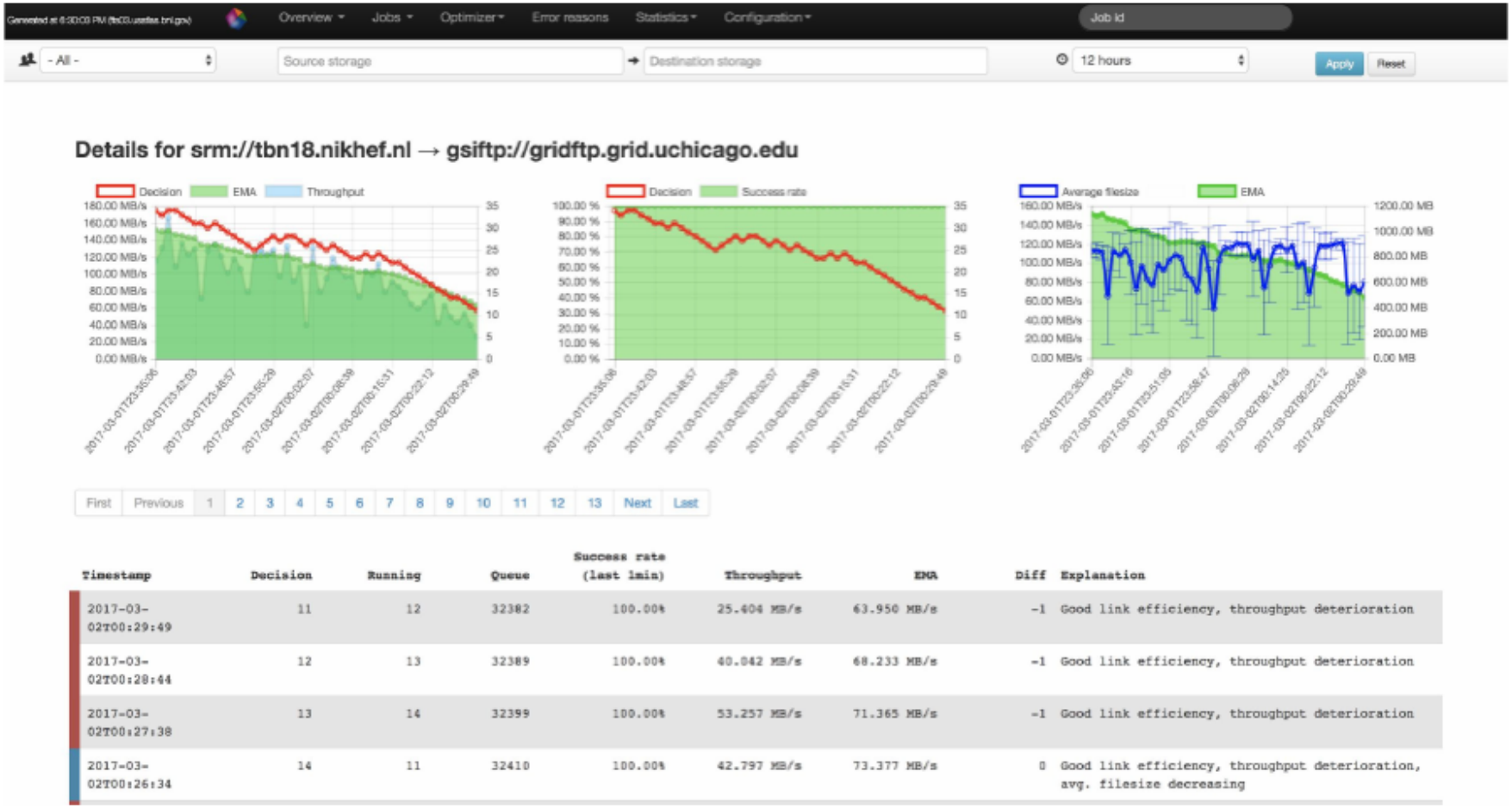


Data flow for processing

- Both **real time** and **massive-reprocessing** happens on OSG.
  For massive reprocessing raw data copies in Europe are automatically and temporary pre-staged on UChicago Rucio End Point
- Demonstrated capability of processing through OSG in 4 days about 98% of raw data corresponding to ~40 days of background data plus few weeks of high rate calibration (Remaining 2% are outliers)
- We are testing the implementation of OSG glide in, **allowing OSG to make use of EGI CPUs**, allowing to extend the use of EGI to raw data processing as well (at the moment only used for MC)



Monitoring automated FTS transfer



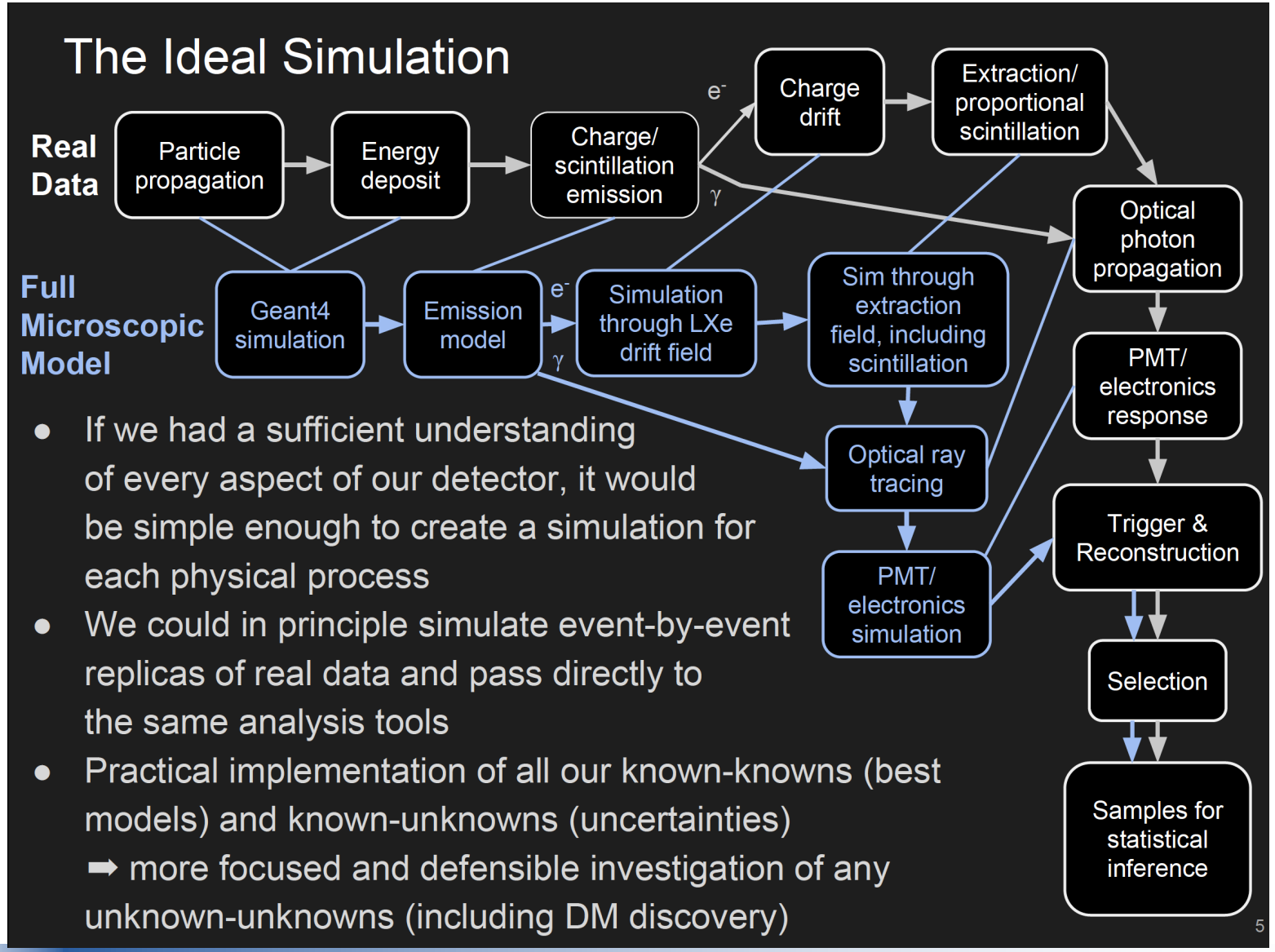
Timestamp	Decision	Running	Queue	Success rate (last 1min)	Throughput	EMA	Diff	Explanation
2017-03-02T00:29:49	11	12	32382	100.00%	25.404 MB/s	63.950 MB/s	-1	Good link efficiency, throughput deterioration
2017-03-02T00:28:44	12	13	32389	100.00%	40.042 MB/s	68.233 MB/s	-1	Good link efficiency, throughput deterioration
2017-03-02T00:27:38	13	14	32399	100.00%	53.257 MB/s	71.365 MB/s	-1	Good link efficiency, throughput deterioration
2017-03-02T00:26:34	14	11	32410	100.00%	42.797 MB/s	73.377 MB/s	0	Good link efficiency, throughput deterioration, avg. filesize decreasing

Monte Carlo workflow

- Implemented using **Pegasus** workflow manager to handle running jobs and errors
- Submit to OSG or EGI sites using a switch at runtime

```
mc_process.py --flavor G4 --config optPhot --source-macro
run_optPhot_fullvolume.mac --batch-size 10000 --events 1000
--mc-version v0.1.7 --pax-version v6.2.1 --grid-type osg
```

Monte Carlo workflow



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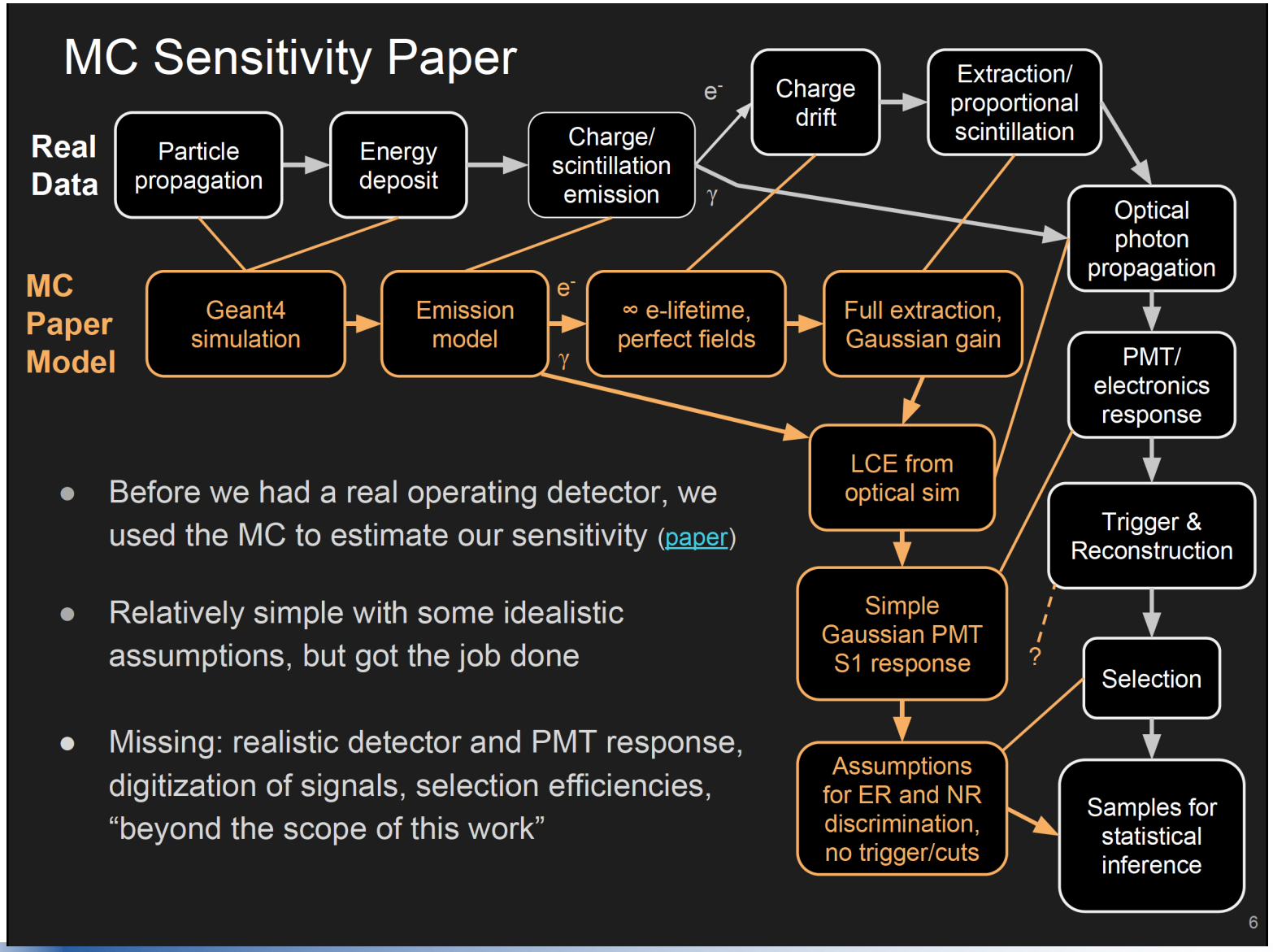

Computing Resources and Requests

Pledge of the current year (2017)

Experiment Name	Where		CPU [HS06]	DISK [TB]	TAPE [TB]
XENON	Tier1		700	110	0
	Elsewhere		**6160**	**945**	**1000**
	Nikhef		120	200	
	Lyon		740	225	
	Stokholm			100	1000
	WIS		500	80	
	US OSG		1000	250	
	US Midway		3800	90	

Proposed 2018 Pledges

Experiment Name	Where		CPU [HS06]		DISK [TB]		TAPE [TB]	
			Δ	New pledge	Δ	New pledge	Δ	New Pledge
	Tier1		300	1000	90	200	1000	1000
	Elsewhere							

Future needs and new ideas

- More CPUs: we want to integrate the data processing between OSG and EGI. Need skilled manpower (CNAF ?) to work together with the Uchicago IT. So far CNAF is used for MC only.

- More disk: use also CNAF as a storage point for the real data (so far, only MC).

- Tapes: we have a full copy of the data in Stockholm. INFN asked to have an additional clone in Italy -> we ask 1000 TB / y at CNAF (if possible also from 2017)

New ideas:

- GPUs used in the (near) future for
  - Bayesian MC to reconstruct the physics and detector model from calibration
  - Position reconstruction (Neural network, machine learning)
  - Optical simulation (CHROMA in addition to GEANT4)

- XENONnT in 2019 : a factor x3 x4 larger than XENON1T

Summary

- XENON1T data taking and processing is going on:
  - GRID nodes storage capacities increasing as from requests according to needs
  - Rucio services is working in stable conditions

- Transfer speeds between EU sites and US can vary greatly, under investigation

- Xenon has been formally accepted into the LHCONE
  (Large Hadron Collider Open Network Environment) networking organization
  (peering for LNGS into LHCONE in progress)

- We (INFN) would like to be more involved in
  the near future in the Computing business.
  Support from CNAF ?

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First XENON1T results out last week.
A great effort also on the computing side !