Imperial College London

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LZ and SoLid computing

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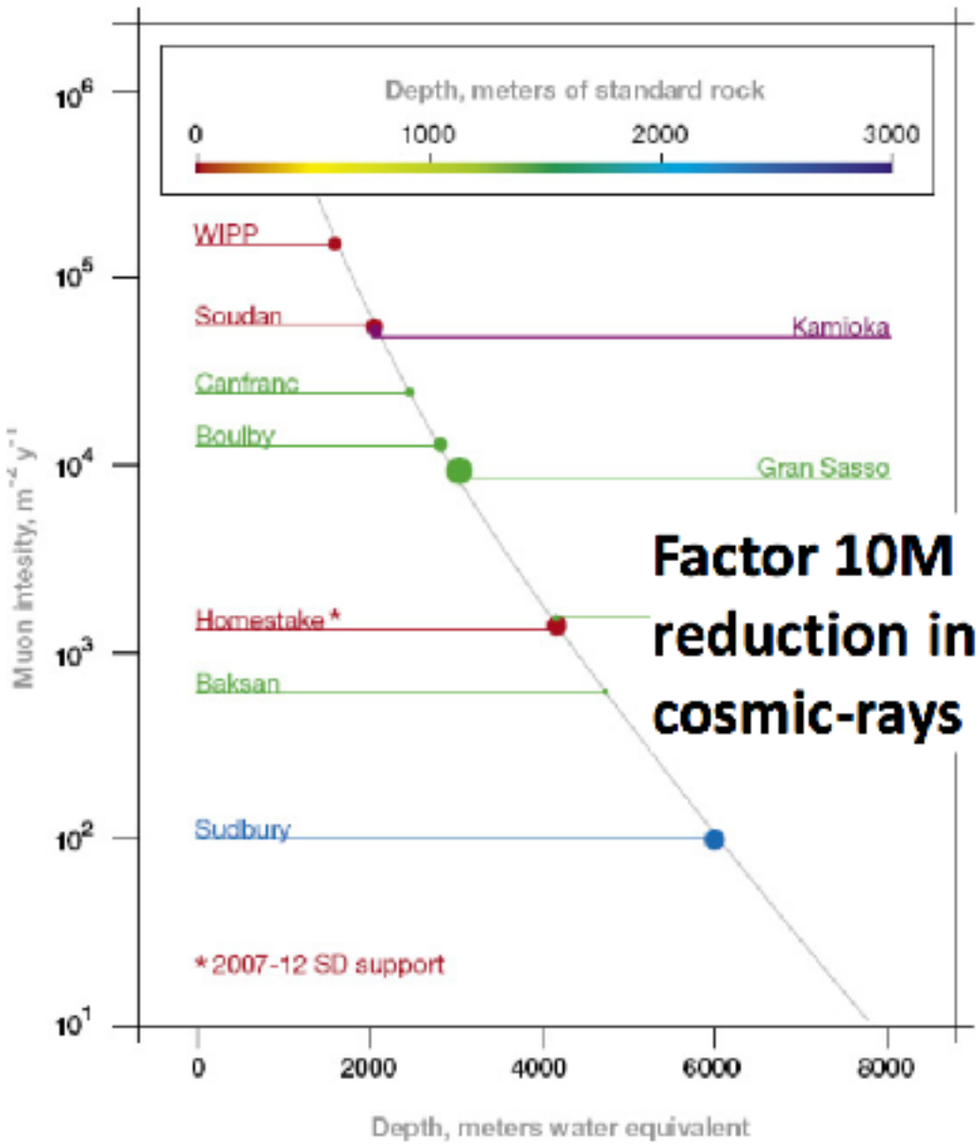
GridPP meeting
Brighton, 07 April 2017

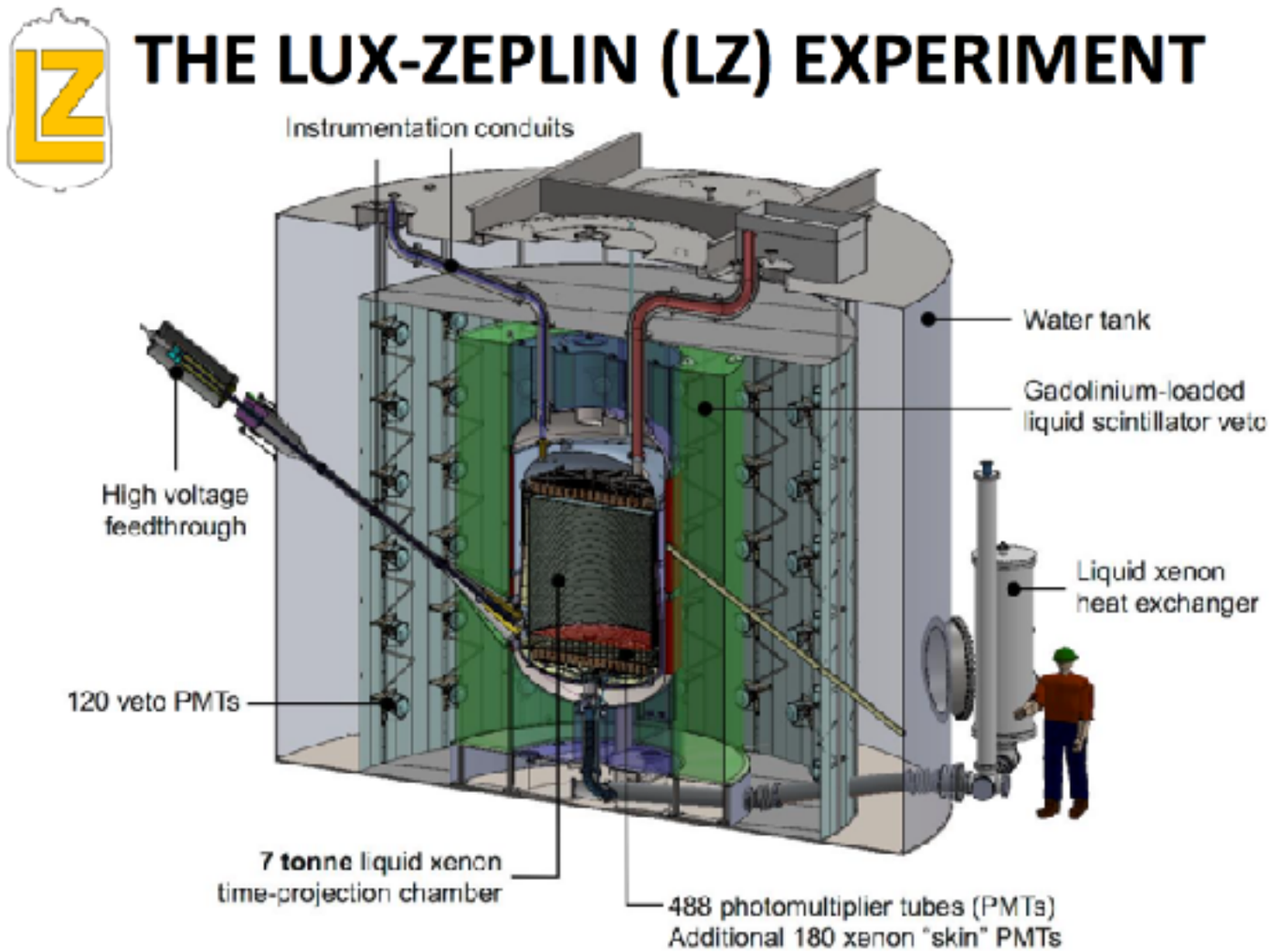
SoLiд

Outline

- LZ dark matter experiment
  - data centers and computing activities
- SoLid very short baseline neutrino experiment
  - computing scheme
- Summary

LZ in a nutshell





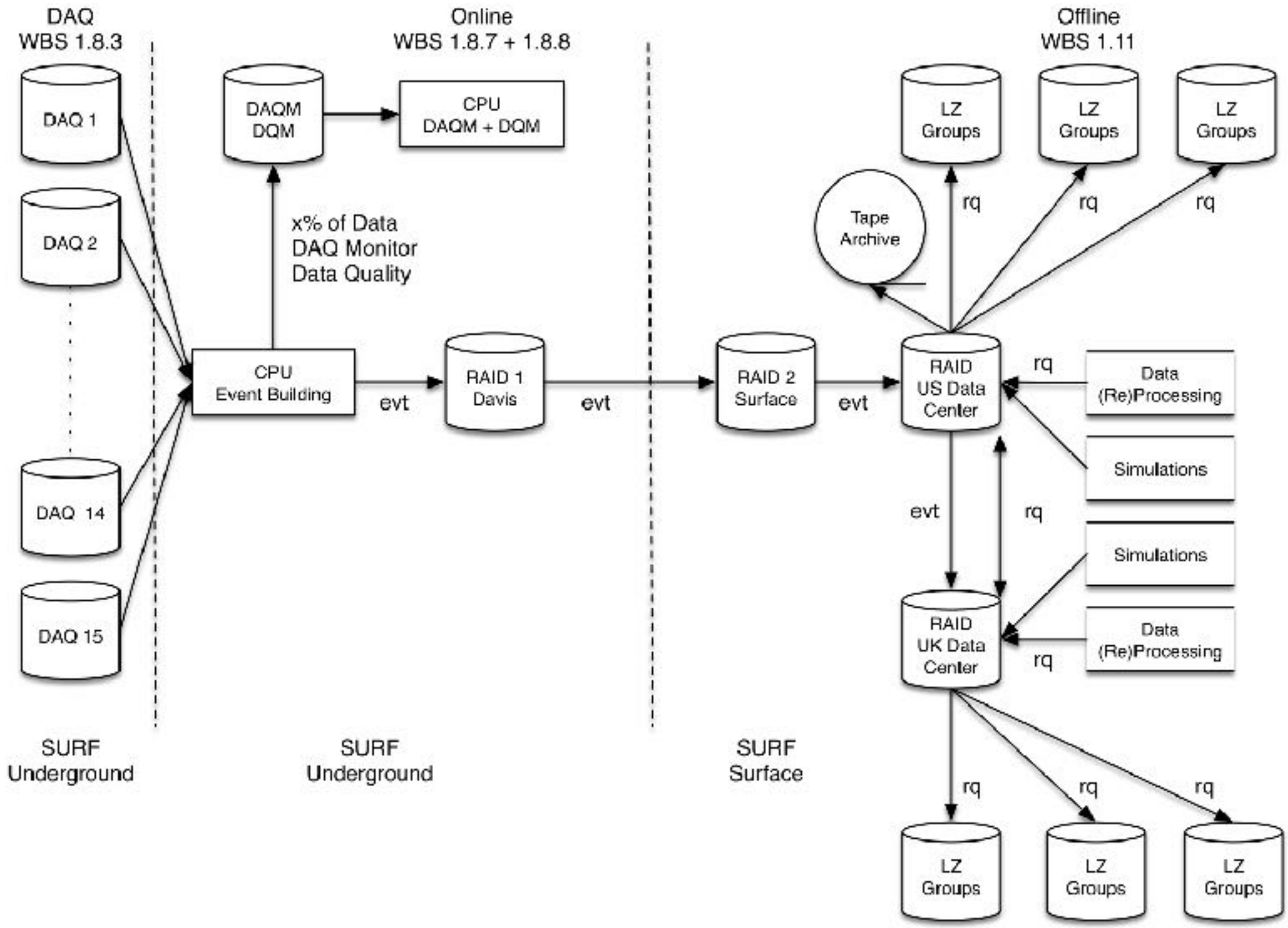
LZ COLLABORATION

220 scientists from 37 institutes in the US, UK, Portugal, Russia & South Korea

University of Alabama ◊ Black Hills State ◊ University Brookhaven National Laboratory ◊ Brown University ◊ University of California, Berkeley ◊ University of California, Davis ◊ University of California, Santa Barbara ◊ Center for Underground Physics (Korea) ◊ Edinburgh University ◊ Fermilab National Laboratory ◊ ***Imperial College London*** *◊ Kavli Institute for Particle Astrophysics and Cosmology (KIPAC)* ***◊ Lawrence Berkeley National Laboratory*** *◊ Lawrence Livermore National Laboratory ◊ LIP-Coimbra, Portugal ◊ University of Liverpool ◊ MEPHI-Moscow, Russia ◊ University of Massachusetts ◊ University of Maryland ◊ Northwestern University ◊ Pennsylvania State University ◊ Oxford University ◊ University of Rochester ◊ Rutherford Appleton Laboratory ◊ SLAC National Accelerator Laboratory ◊ SD School of Mines & Technology ◊ Shanghai Jiao Tong University ◊ University of Sheffield ◊ University of South Dakota ◊ SUNY University at Albany ◊ Texas A&M University ◊ University College London ◊ Washington University ◊ University of Wisconsin ◊ Yale University*

32

Data centers in LZ



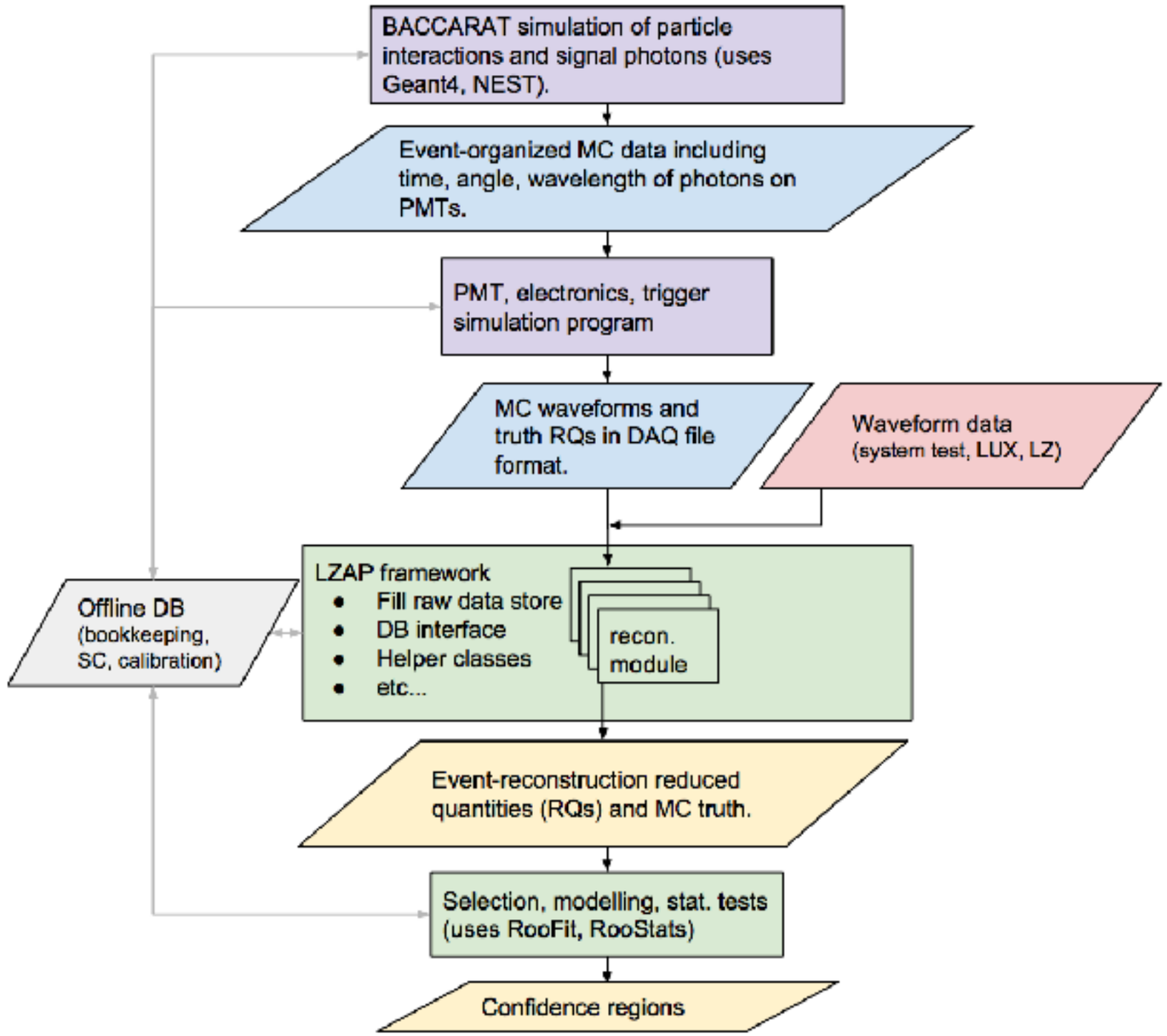
CPU and storage needs

FY	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
Raw data	–	–	–	–	–	560	1680	2800	3920	5040	6160	
Calibration data	–	–	–	–	–	160	480	800	1120	1440	1760	
Simulation data	40	80	80	100	100	200	200	200	200	200	200	
Processed data	20	40	40	50	50	172	316	460	604	748	892	
User data	20	40	40	50	50	55	134	213	292	371	451	
Total data	80	160	160	200	200	1147	2810	4473	6136	7799	9463	
USDC: Disk space	40	220	220	220	220	1360	3360	5360	7360	9360	11360	TB
USDC: CPU cores	–	–	175	350	350	390	830	1270	1710	2150	2590	
UKDC: Disk space	150	220	220	270	650	1597	3260	4923	6586	8249	9913	TB
UKDC: CPU cores	150	175	350	350	350	390	830	1270	1710	2150	2590	

- ~1.4 PB total data generated per year of running (starting 2020)
- steady increase of CPU needs in 2018-2020 period and between 2x and 8x over data taking period
- 40 Hz data stream, assuming 1evt/s, 440 cores can reprocess 1 year of data in 1 month
- total storage capacity needed is ~ **10 PB** including all raw data
- Numbers based on full production of MC

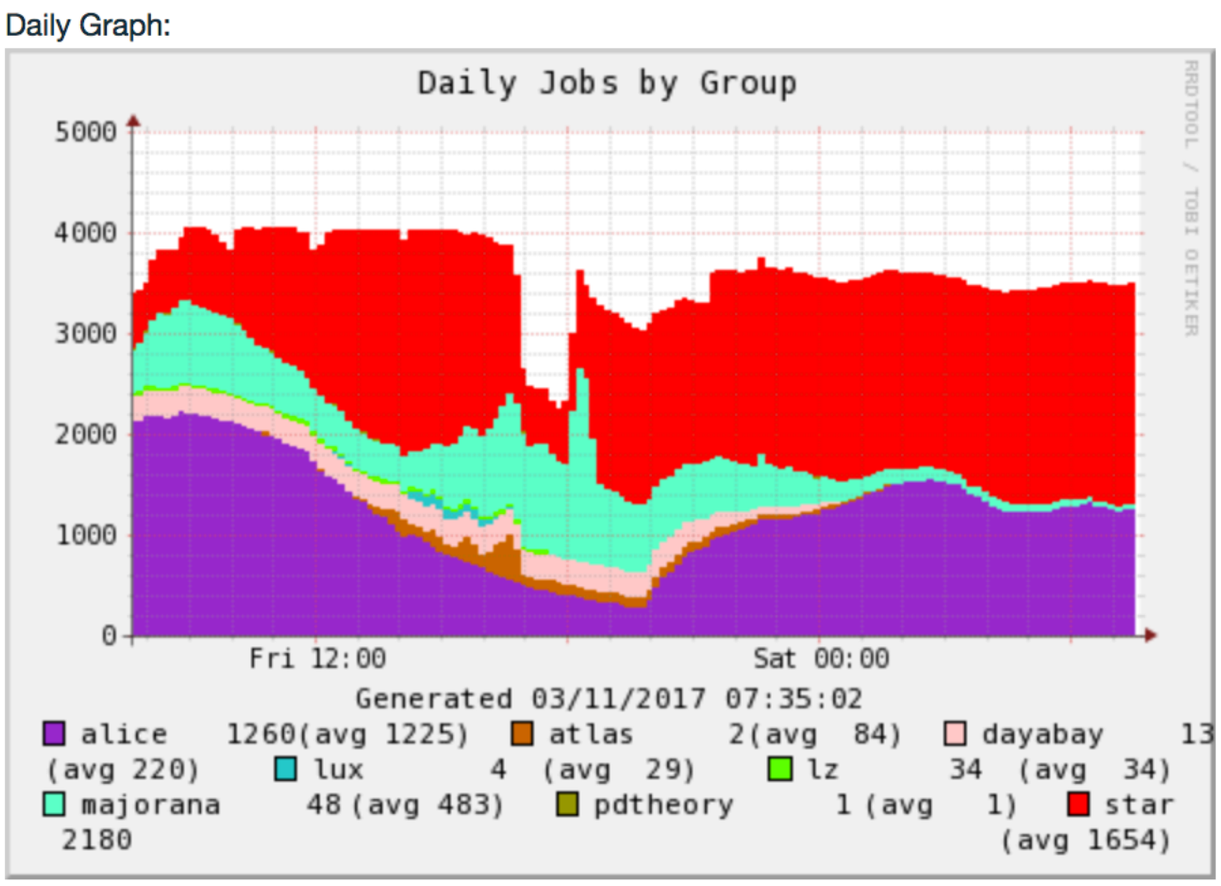
LZ MC & Analysis Software

- Software is based on Geant-4 and Gaudi packages
- Simulation requires large number of optical photons to be tracked in complex vessel geometry
  - already exploring what can be done with GPUs



NERSC is US data center

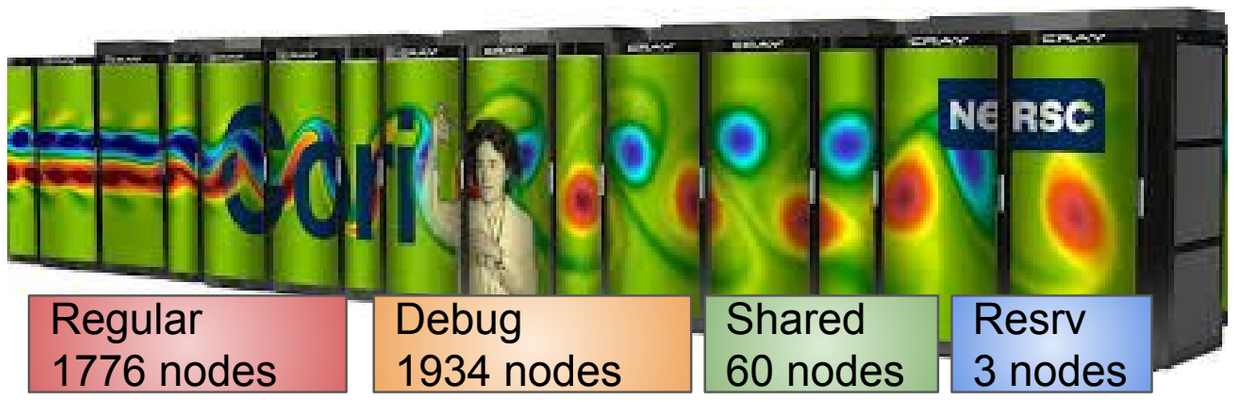
- ESnet & NERSC DOE-ASCR national facilities
- PDSF (~4000 SLC vcores)
  - **LZ 230 fairshare job slots + opportunistic**
- NGF (8.2 PB disk)
  - **LZ 220 TB on /project & /projecta**
- HPSS (150 PB tape)
  - ERCAP allocation model. No cost to LZ.
- Free: DTNs, Data Gateways, 24/7 Operations, Networking, Account Mgt, Security, …



Many-core HPC

- PDSF to be phased out in not too distant future
- USDC has been testing processing on NERSC emerging many-core machines
- looking into where and how Cori/HPC resources complement PDSF & UKDC.

NERSC CRAY Machine(s)



Cori

2,004 Xeon "Haswell" nodes

- 32 cores + 120 GB RAM

9,300 Xeon Phi "Knight's Landing" nodes (KNL)

- 68 cores +96+32 GB RAM

Edison

5586 "Ivy Bridge" nodes:

- 24 cores
- 61 GB RAM

Using Linux container ~ Thin VM

Shifter: Containers for HPC

Challenge and Opportunity

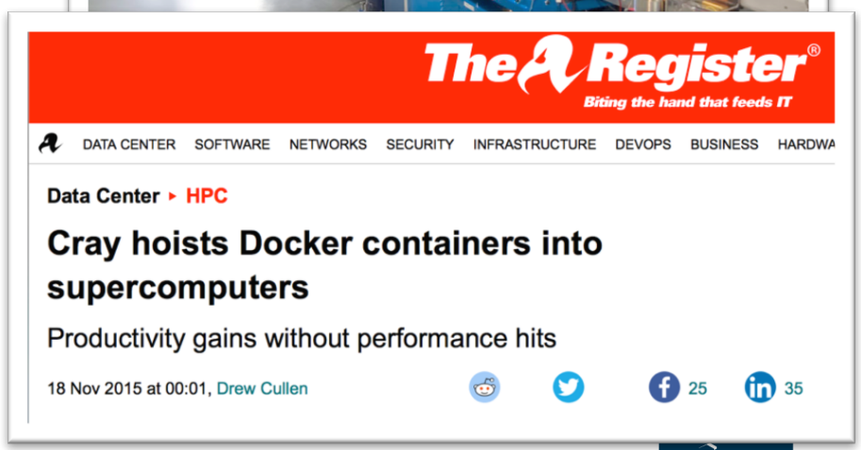
- Data Intensive computing often require large, complex software stacks
- Docker becoming standard package to run applications.

Innovation

- Shifter is a NERSC R&D effort, in collaboration with Cray, to support User-created Application images.
- Shifter provides “Docker-like” functionality for HPC

Impact and Early Successes

- Shifter has enabled multiple projects to quickly make use of NERSC (e.g. LCLS, LHC)
- Shifter can improve job-startup times and application performance (e.g. Python)
- Shifter will be supported by Cray and is under evaluation by other HPC centers



UK data center

E. Korolkova, V. Kudryavtsev, R. Taylor , A. Vacheret
GridPP: D. Bauer, D. Colling, S. Fayer, A. Richards

- UK data center is hosted at Imperial College London and leverage on **GridPP resources**
- Servers (nodes & disk), network, software supported by non-LZ admins and developers
- UKDC team responsible for writing LZ scripts on top and running jobs
- LZ VO supported currently at 8 UK sites (Brunel, ICL, Lancaster, RAL-PP, Sheffield, Liverpool, Manchester, QMUL)
- Storage allocated as needed at Imperial Tier 2
- CPU allocated by fair share algorithm

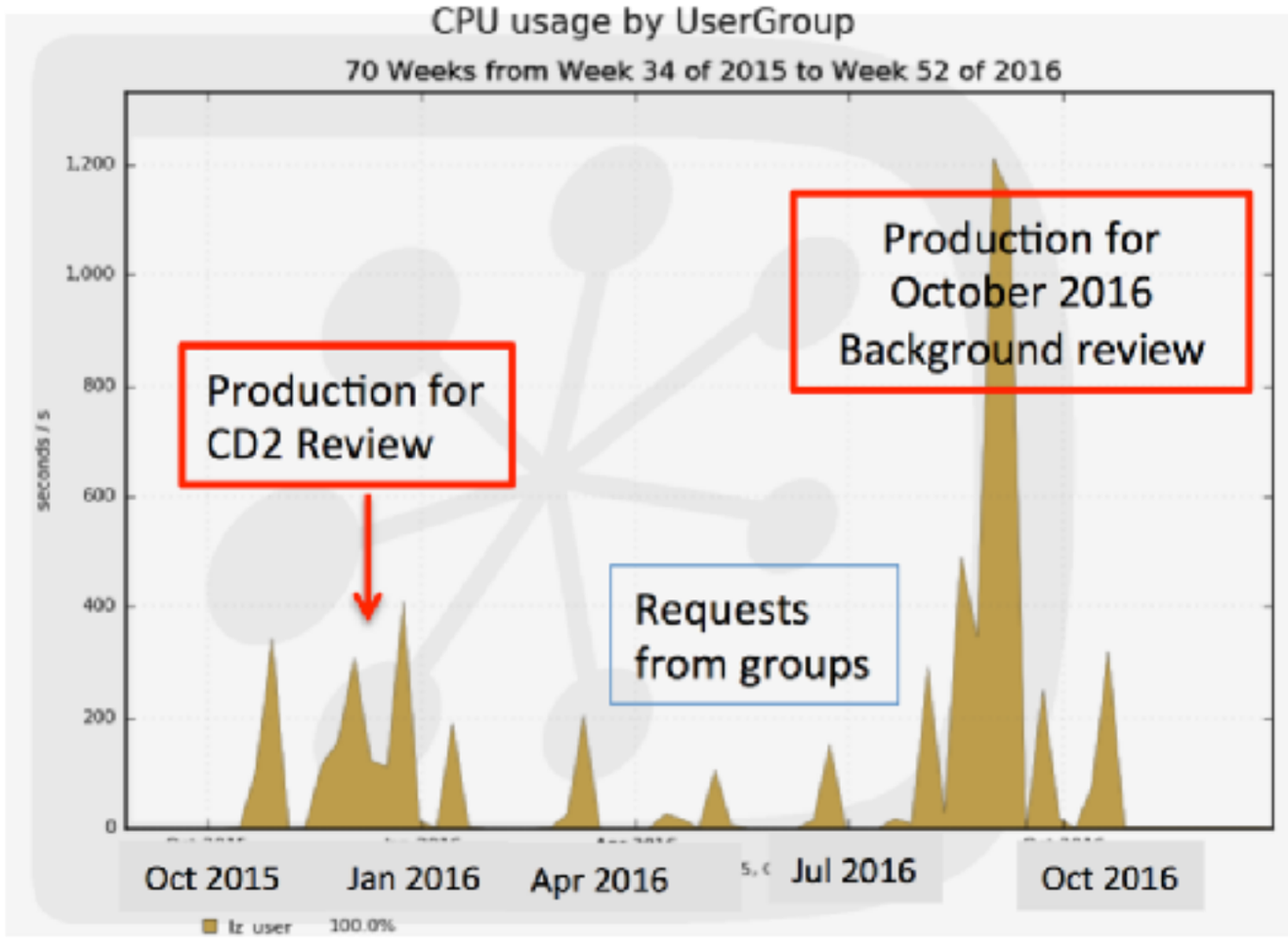
Production for October Background Review (2016): final TDR numbers

Generated:

- 262 macros
- 6×10^{10} events

- All data volume:
  - 117 TB (UKDC)
- Reduced data
  - 10 TB (UKDC and PDSF)

CPU time: 640K CPU hours



- UK Data center achievement has been highly praised by other collaborators at a recent internal design review

- gridPP support was central to this success

MC production for October Background Review (2016)

- Additional components simulated and more statistics (compared to CD2 production)
- Realistic geometry synchronised with LZ Solid Model (CAD)
  - Top PMT array, Outer Detector and Skin design
- Increased statistics → reduced uncertainty in cases where previously only upper limits were set
- fastNEST: S1/S2 fast response based on latest TPC and Skin design
- Chain LUXSim (GEANT4.9.5-based, v.4.3.3) energy deposits → fastNEST (v.3.0.2)→ analysis cuts mimicking data (TDRAnalysis v. 3.13.1)
- CPU resources at 5 UK GridPP LZ-affiliated sites (Imperial, Sheffield, RALPP, Brunel, Lancaster)

Tools developments

- The UK data center is developing a web-based **large scale production** UK-DC **job submission system**
  - aim to simplify handling of requests for large scale submission of MC and data processing on the grid
  - remove the need for filling web-based spreadsheets
  - reduce manual operations to complete jobs
  - data access from anywhere

MC production table

File Edit View Insert Format Data Tools Add-ons Help

View only

imperial.richards@gmail.com

Share

	Requester (not just initials)	Date of request (MM/DD/YY)	Description	Source types and stats	Detector components	LUXSim/ BACCARAT/... ver.	Sim lead (not just initials)	Job submission tab	Status	Date complete (MM/DD/YY)
25	Hugh L.	2/22/17	Energy depositions in the skin	Xe131m decays in skin?	LiquidXenonSkin comp	BACCARAT new release				
24	Hugh L.	2/22/17	Multiple scattering simulation for LZap developmer	200 keV gammas might be doable - 1000? on a FNAL machine it's 39060 seconds per event	LiquidXenon, PMT Pho	BACCARAT new release				
23	Cees C.	11/30/16	Kr-83 sims for DER validation	100 events made with the following mac	LiquidXenon, PMT Pho	POSTPONED UNTIL NEXT RELEASE OF DER	Do not use DER release-1.0.4 and LUXSim release-4.4.6_geant4.9.4			
22	Jim Dobson	10/09/16	Check of full optical sims for LZAP for BACCARAT	0-10 keV ER, 0-30 keV NR, uniform in f	LiquidXenon	BACCARAT/release (0.X.X, POSTPONED TILL	Maria Elena	BACCARAT v0.2.1 ER and NR full sims for LZap	2) LUXSim/macros complete	
21	Maria Elena	10/26/16	Full optical sims (ER+NR) for LZap validations	0-10 keV ER, 0-30 keV NR, uniform in f	LiquidXenon	LUXSim/release-4.4.6 DER/release-1.0.4	Maria Elena	LUXSim v4.4.6 ER and NR full sims for LZap	6) Jobs completed	
20	Melih S.	10/07/16	Full neutron sims for the latest OD design+Water	Bckg U_earlyfate/Th neutrons + Water	All components used i	Will use a forthcoming release of LUXSim after	Melih S.	LUXSim v4.X.X NR and ER with updated OD geom	5) Jobs submitted	
19	Maria Elena	09/27/26	Full stats for Xe131m, uniform in TPC (and RFR)	Xe131m decays uniform in LXe volume	LXe (TPC+RFR)	LUXSim/release-4.3.3 TDRAnalysis/release-3..	Maria Elena	LUXSim v4.3.3 Xe131m e-deposit sims	6) Jobs completed	
18	Steve W.	09/23/16	Full optical sims for DER background deliverable	0-10 keV betas uniform in the LXe volun	LiquidXenon	LUXSim/release-4.4.4 reduction LUXSim/releas	Maria Elena	LUXSim v4.4.4 ER full sims for DER	6) Jobs completed	10/28/16
17	Tyana S.	09/18/16	BG sims for BACCARAT validation using Geant4	U_earlyfate/Th neutrons + gammas	neutrons for TPC PMTs	BACCARAT/0.2.0 TDRAnalysis/release-3.13.1	Tyana S.	BACCARAT v0.2.0 BG sims for G4.9.5 validations	6) Jobs completed	
16	Henrique A.	30/08/16	BG sims for assessing alternative materials for gr	U/Th/60Co/34Sc gammas + Neutrons fr	All grids separately (bo	LUXSim/release-4.3.3 TDRAnalysis/release-3..	Tyana S.	LUXSim v4.3.3 BG sims for Oct. review	6) Jobs completed	
15	Tyana S.	8/20/16	BACCARAT v0.2.0 validation sims for g4decay gar	U238 and Th232 gammas	Vessels and TPC PTFE	BACCARAT/0.2.0	Tyana S.	BACCARAT v0.2.0, g4decay gamma BG checks	6) Jobs completed	
14	Jim D.	08/18/16	BG sims for Oct. backgrounds review	U_earlyfate/Th neutrons + gammas	Initially limited set of components, will be increased once checked		Elena K.	LUXSim v4.3.3 BG sims for Oct. review	6) Jobs completed	
13	Peter S.	08/12/16	Full optical for saturation study (~1000 events per	131m/xe at radii in range (~50 cm – ~75 cm) and z=0			Asher K./Jim D.	LUXSim v4.3.3 Xe131 sims for saturation study	4) Job tab filled	
12	Jim D.	07/27/16	BG sims of key components for collaboration mee	U_earlyfate/Th neutrons + gammas	TPC PMTs, PTFE wall	LUXSim/release-4.3.2 TDRAnalysis/release-3..	Elena K.	LUXSim v4.3.2 key BG sims for testing	6) Jobs completed	
11	Matthew S.	06/21/16	ER and NR events for LZAP development	1e4 ER unif(2,5), 1e4 NR unif(5,10)	LiquidXenon	LUXSim/release-4.3.2 ElectonicsSimulation/rel	Maria Elena	LUXSim v4.3.2 ER and NR for DER	6) Jobs completed	08/16/16
10	Jim D.	06/14/16	Additional BG sims for components missed during	U_earlyfate/Th neutrons + gammas + I	1) OD tank, 2) OD Liqu	LUXSim/3.7.0	Elena K.	LUXSim v3.7.0	6) Jobs completed	
9	Melih S.	05/09/16	Repeat TDR neutron sims for candidate OD geometry	U_earlyfate/Th neutrons (TDR stats)	All components used fi	LUXSim/MS-CaseL-6122cd76	Melih S.	LUXSim MS-CaseL-6122cd76, stats for OD-rate st	5) Jobs submitted	

large scale job submission system

LZ Production Requests

ganga up DIRAC up Admins

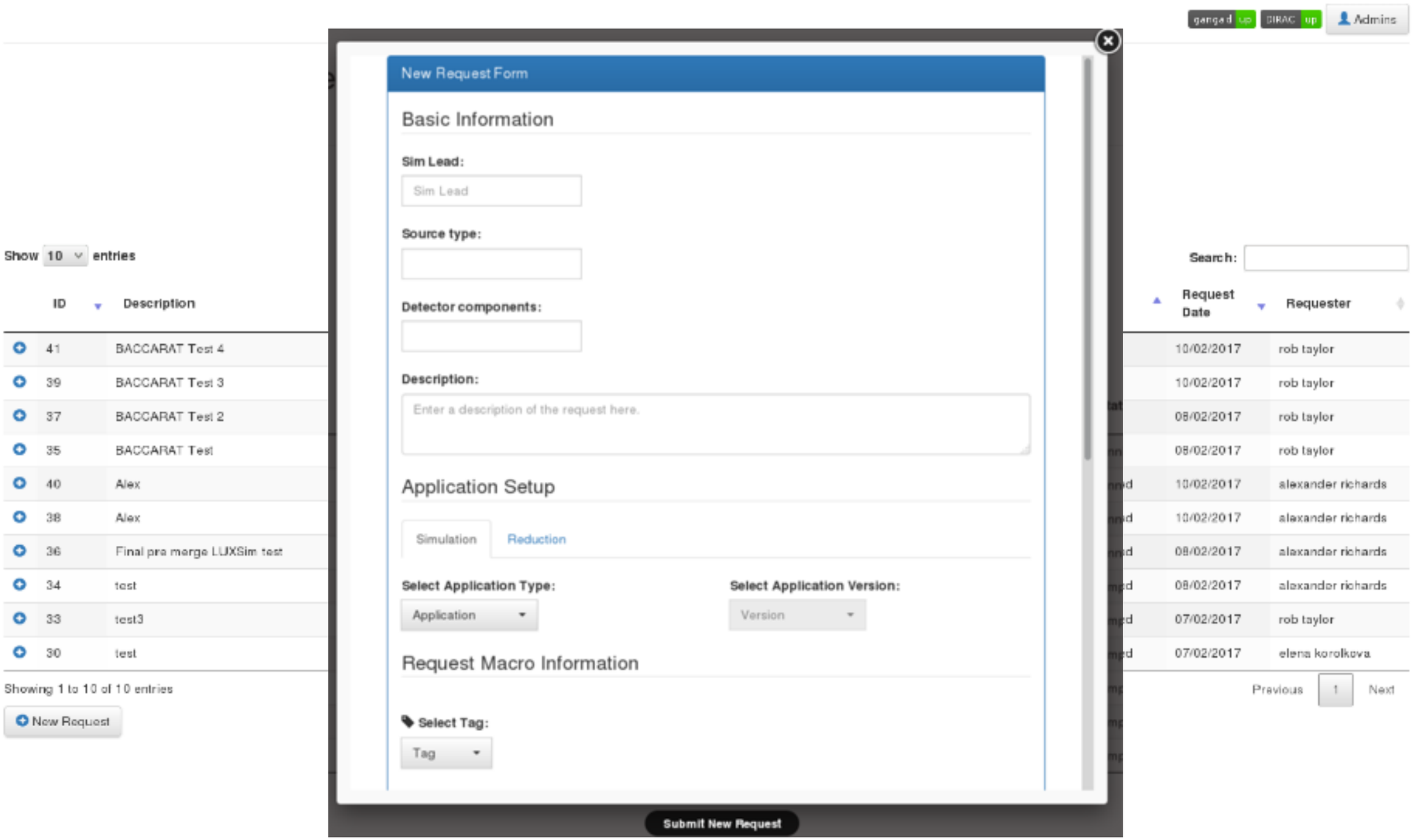
Show 10 entries Search:

	ID	Description	Sim Lead	Status	Request Date	Requester
⊕	41	BACCARAT Test 4	Rob	Running	10/02/2017	rob taylor
⊕	39	BACCARAT Test 3	Rob	Running	10/02/2017	rob taylor
⊕	37	BACCARAT Test 2	Rob	Running	08/02/2017	rob taylor
⊕	35	BACCARAT Test	Rob	Running	08/02/2017	rob taylor
⊕	40	Alex	Alex	Completed	10/02/2017	alexander richards
⊕	38	Alex	Alex	Completed	10/02/2017	alexander richards
⊕	36	Final pre merge LUXSim test	Alex	Completed	09/02/2017	alexander richards
⊕	34	test	Alex	Completed	09/02/2017	alexander richards
⊕	33	test3	Rob	Completed	07/02/2017	rob taylor
⊕	30	test	EK	Completed	07/02/2017	elena korolkova

Showing 1 to 10 of 10 entries Previous 1 Next

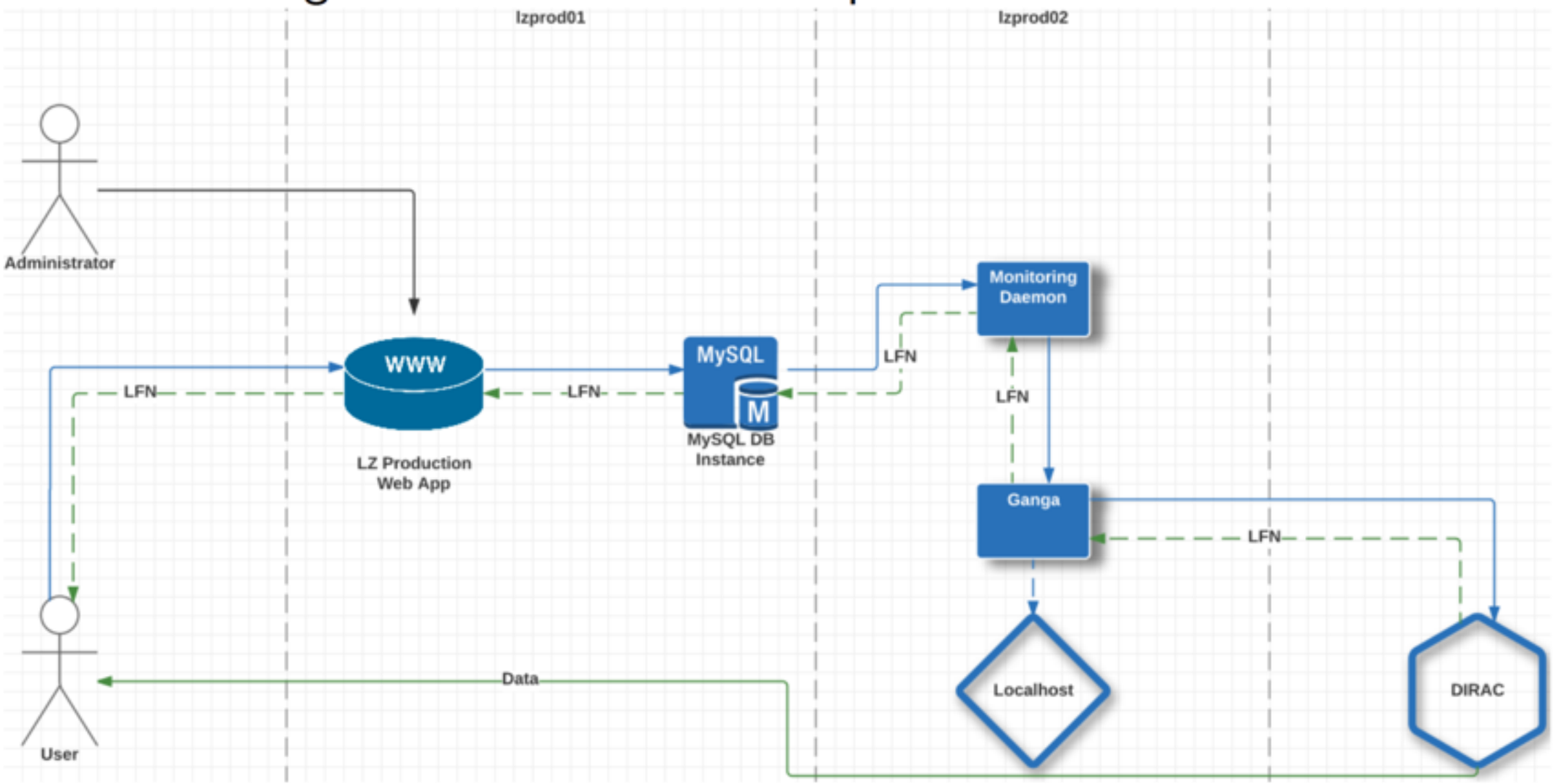
⊕ New Request

large scale job submission system



Behind the scene

- MySQL DB bridges frontend web app and submission backend.
- Lightweight cherrypy webserver for web app frontend.
- Monitoring daemon submits new requests from DB to Dirac.



Job submission system status

- Framework in place
- Security
  - encrypted https protocol using apache as reverse proxy
  - access based on X509 grid certificate (and LZ VO)
    - DN checks against user in DB (also recognise admin and normal users for request management)
- currently working towards usability for first mock data challenge this summer
  - various processing options being developed
- develop the design to process on US clusters
- Improve re-usability of the interface for deployment in other experiments (e. g. SoLid)

SoLid

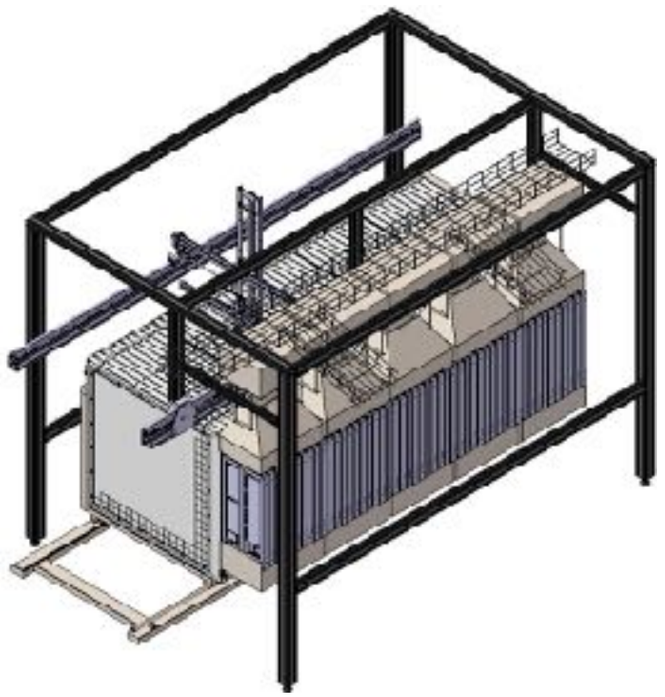
ArXiv:1703.01683

SoLid

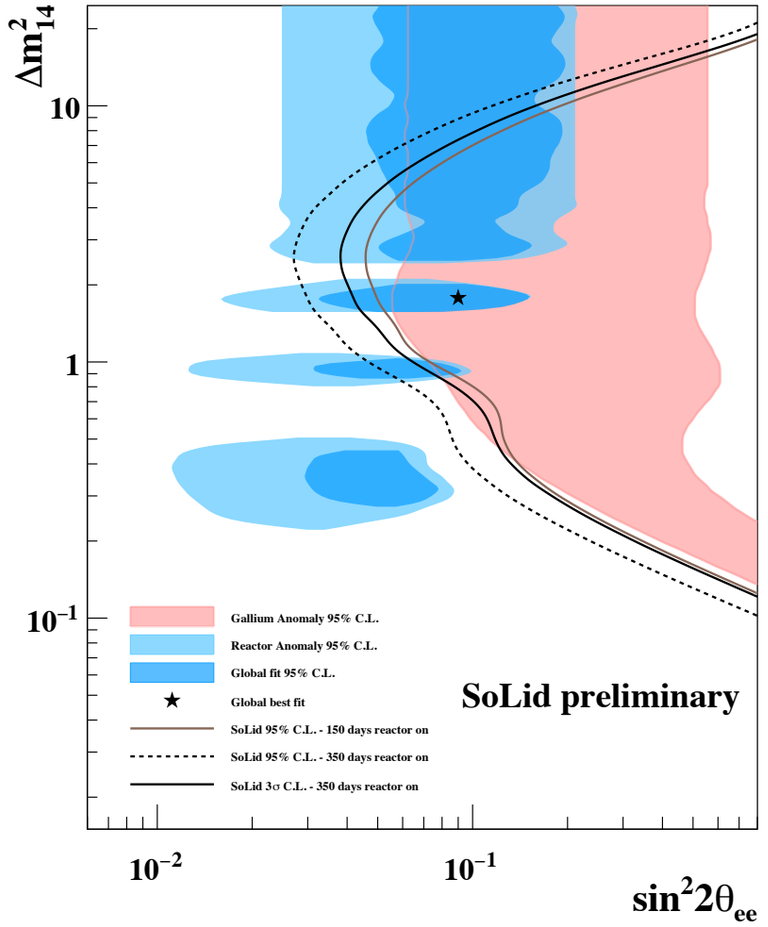
PI A. Vacheret
CoG 682474 SOLID

- SoLid baseline : 6-9m from the BR2 MTR reactor at SCK•CEN mol, Belgium
  - 5-6x movable modules on rail system 1.6-2 tonnes fiducial mass
  - External shielding based on H_20 bricks and PE slabs.
- Experiment data taking in 2017-2021 period

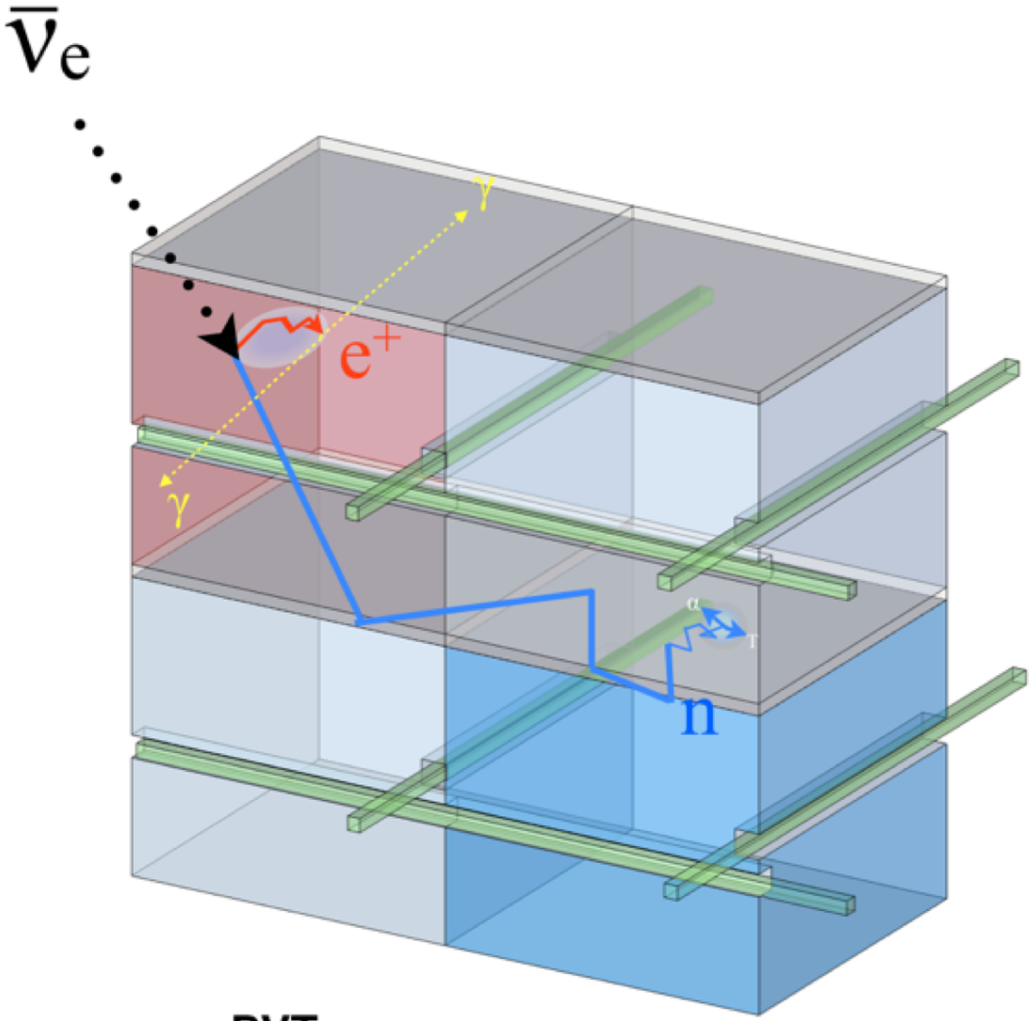
Geant4 model of SoLid at BR2

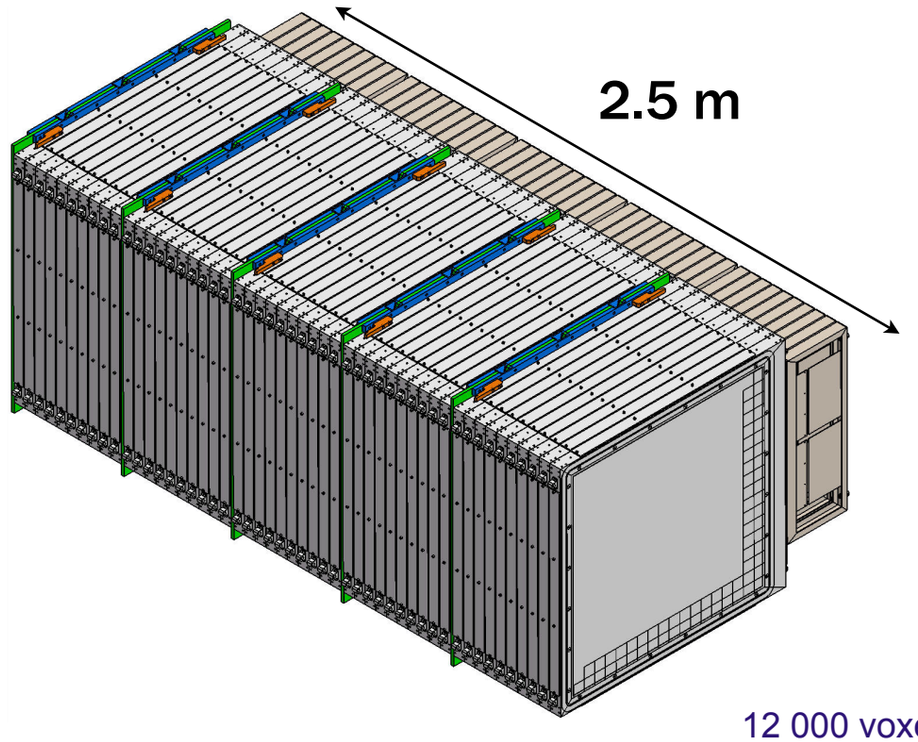


Detector Modules and rail
CROSS source calibration robot

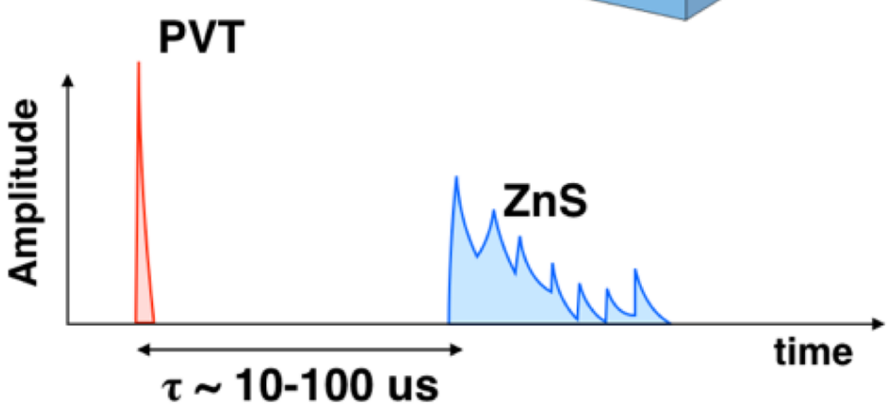


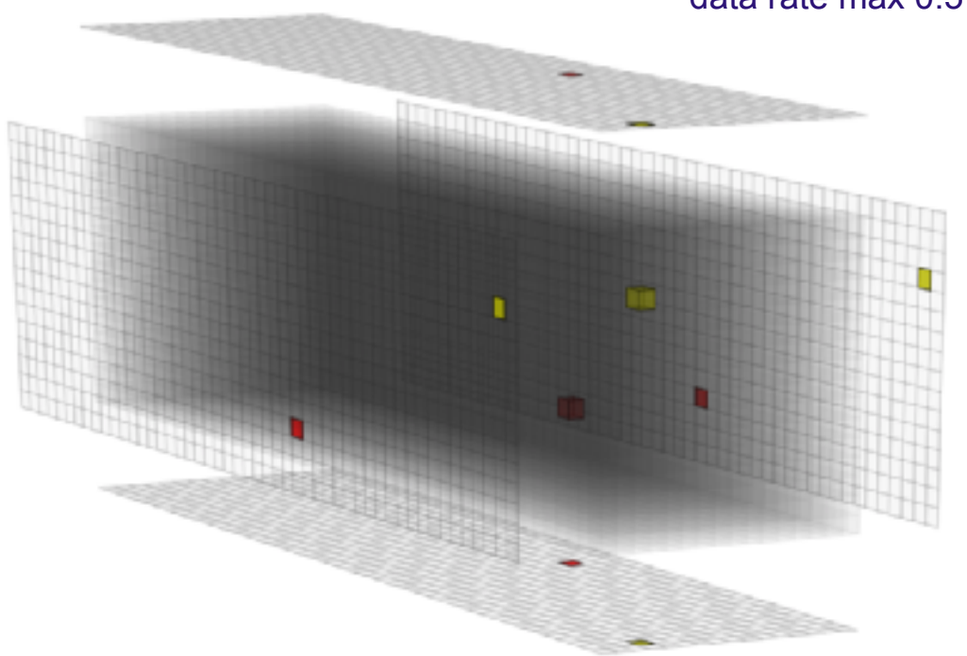
Detector technology





12 000 voxels,
3 200 read out channels
data rate max 0.5 TB/day





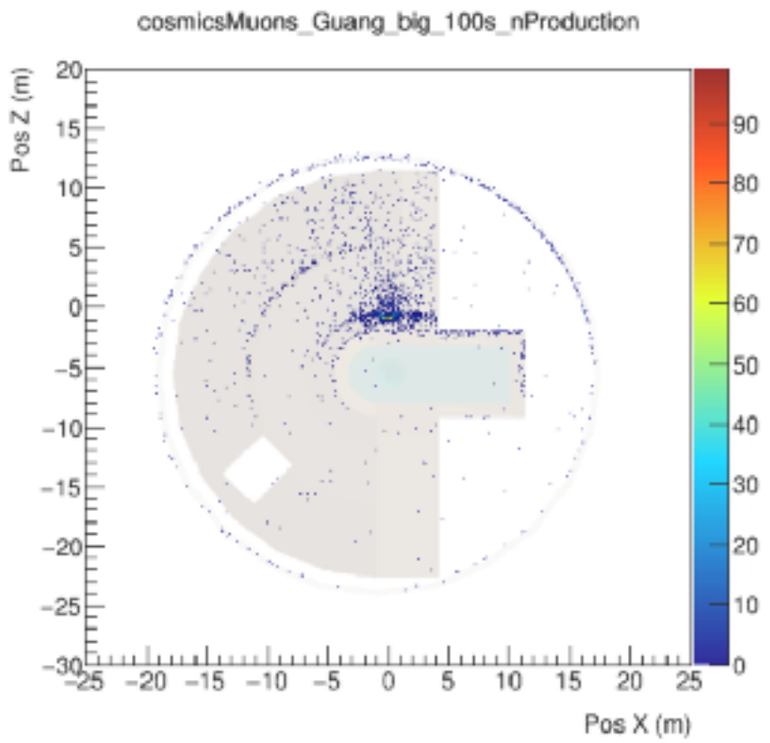
SoLid collaboration

- 4 countries, 11 institutes, ~ 50 people

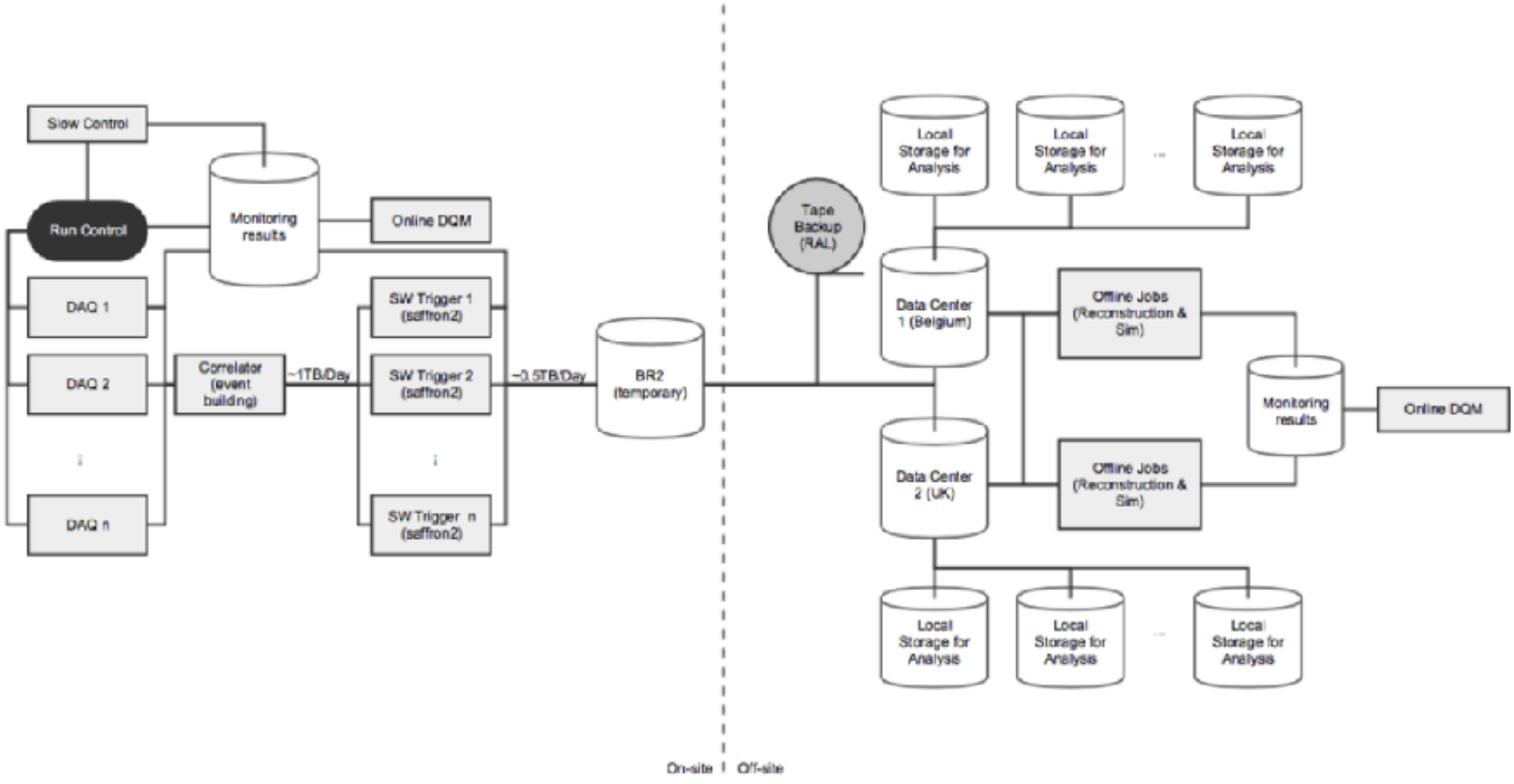
SCK•CEN
Universiteit Antwerpen
Vrije Universiteit Brussel
UNIVERSITEIT GENT
LAL LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE
lpc caen
Subatech
Imperial College London
University of BRISTOL
UNIVERSITY OF OXFORD
VirginiaTech Invent the Future

SoLid computing challenges

- **Precision measurement neutrino experiment on the surface**
  - Large statisitical sample of antineutrino
- **Large scale simulation and processing required for background model and physics sensitivity**
  - muons from atmosphere
  - Fast neutrons
  - Internal background
- **Reactor evolution code for each reactor cycle with variable resolution in time**
  - CPU and memory intensive especially for fine time resolution on burn up
- **Development of deep learning algorithms**
  - will require processing on GPUs especially for architecture optimisation



SoLid Computing scheme



- Data processing and simulation in UK and Belgium as baseline
- Reactor evolution calculations performed at Lyon computing center in France

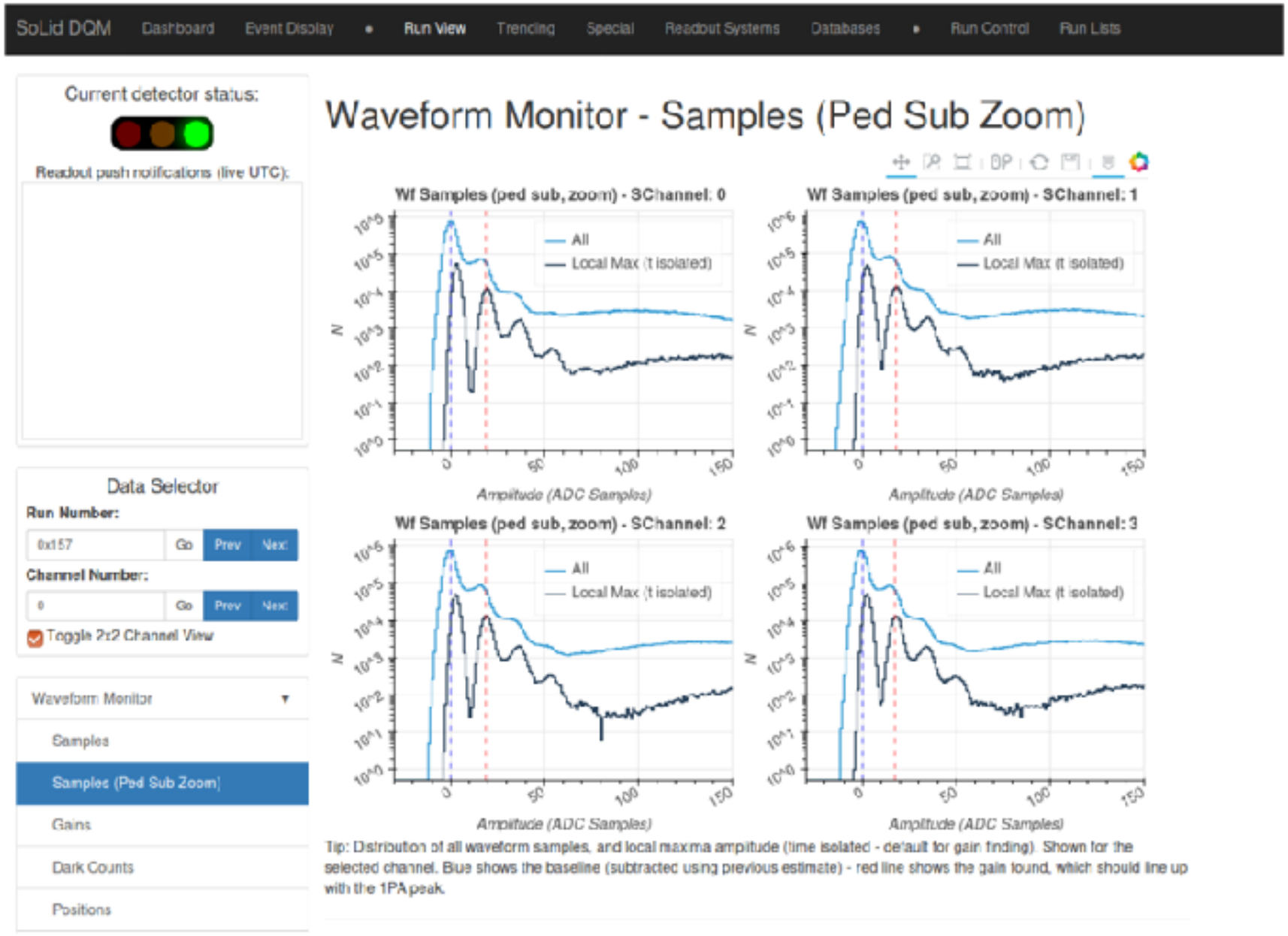
SoLid computing needs and status

Data Type	/Day (GB)	Total 5 Years (TB)
Physics raw files	$\mathcal{O}(100)$[1]	$\mathcal{O}(100)$
Physics reduced files	$\mathcal{O}(0.1)$	$\mathcal{O}(0.1)$
Calibration	$\mathcal{O}(100)$	$\mathcal{O}(100)$
Simulation	$\mathcal{O}(100)$	$\mathcal{O}(100)$
Total	< 1	< 1000

- Recently started SoLid VO and developing CVMFS based software
- Discussion plans for where custodial copy will be held
  - expect UK to contribute significantly
- Main task in the UK is to prepare software for data processing and data monitoring
- Simulation currently ran at Brussels Tier-2
  - Simulation tasks in the UK to ramp up as we shift from construction this summer
- UK gridPP support key for delivering on the processing side of the experiment

SoLid Data Quality Monitor

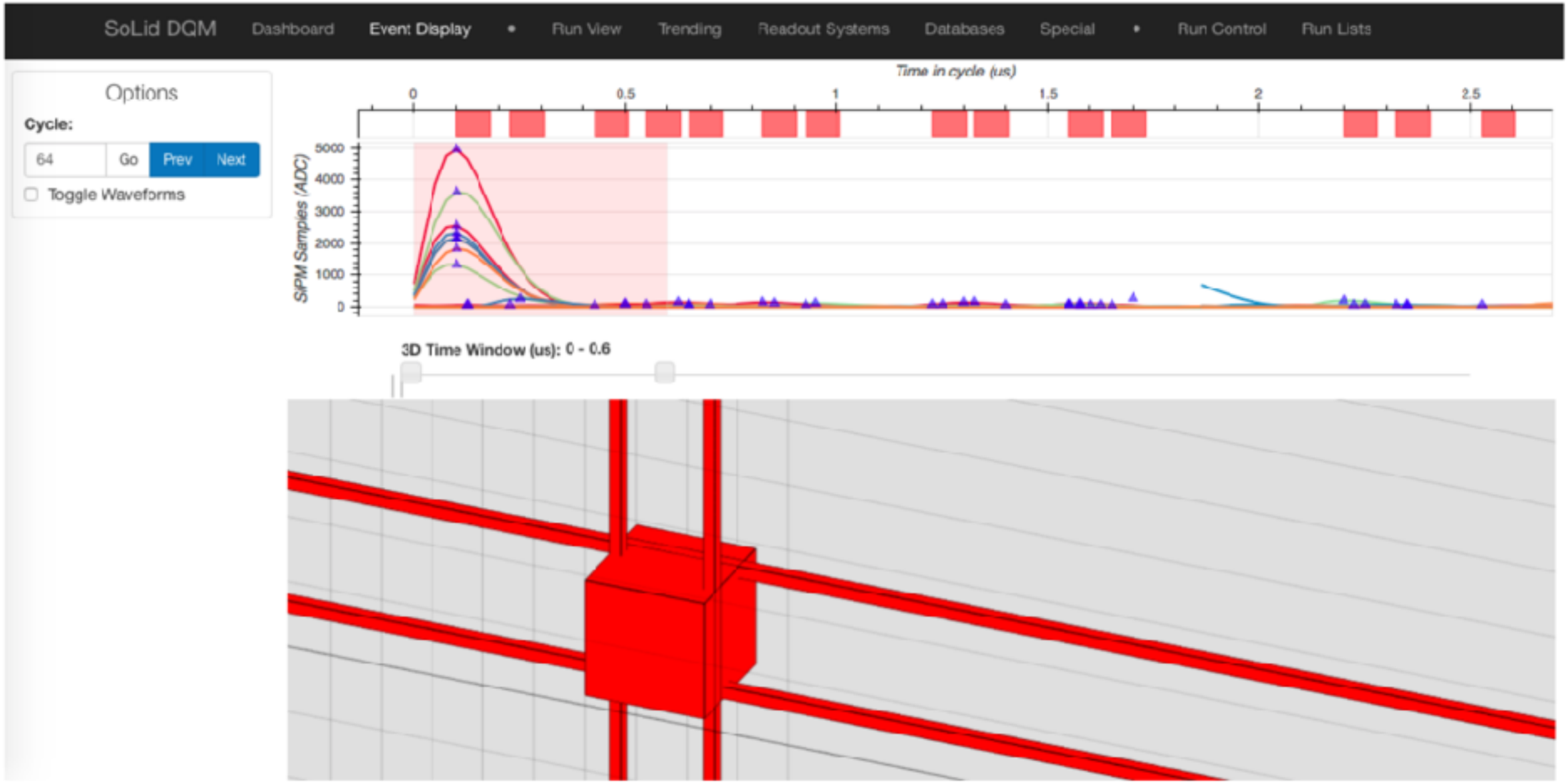
- HTML based web monitoring.
  - Python backend using Flask & Bokeh (charts).
- Runs at detector site.
  - Remote access.
  - Users access via web browser (port forwarding for security).
- Interface with on-site databases for calibration and run book-keeping.
- Run control.



- Online oriented monitoring but preparing for integrating the data processing part of the experiment too

Web-based Event Display

- Three js graphics library.
- Visualise dynamic time window for viewing events.



Summary

- **LZ**
  - Data centers are on track to enable the processing and storage of LZ raw data and MC simulation
  - UK Data center has played a key role in CD milestones
  - UK very active with new job submission system for management of large scale production
  - Progress in US towards testing containers on Cori
- **SoLid**
  - Computing needs around x10 smaller than LZ but some challenges for
  - Experiment currently developing plan for data taking pahse later this year
  - Leverage on LZ job submission system for deeper integration
- **gridPP support is key for UK institutes to play a leading role in non-LHC experiments**
- Interesting development on interface built on top of grid middlewares
- Machine learning is getting big and some groups are going to move heavily on it