@twhyntie

The Science of CERN@school

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GridPP34, Queen Mary University of London

Thursday 30th April 2015

CERN@school

Bringing CERN into the classroom

- Engage teachers with real research equipment and data to support their teaching.
- Engage students with real research equipment and data to enthuse them about physics and equip them with the skills needed to go on to a STEM career.
- To develop research based learning as part of students' experience of physics and part of the experience of being a scientist.

http://cernatschool.web.cern.ch

Overview of the talk

- The Timepix detector
- The CERN@school Detector Network
- The demonstration experiments & Eclipse 2015
- Data management with the DAQMAP and the grid
- The LUCID experiment
- CERN@school, MoEDAL and the Zooniverse
- Publications
- Summary and conclusions

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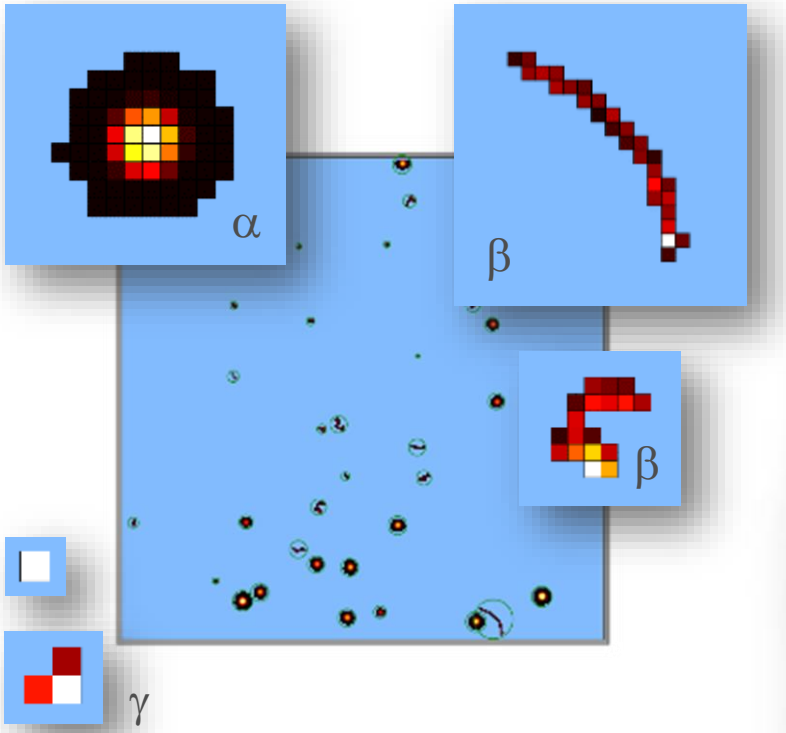
The Timepix hybrid silicon pixel detector

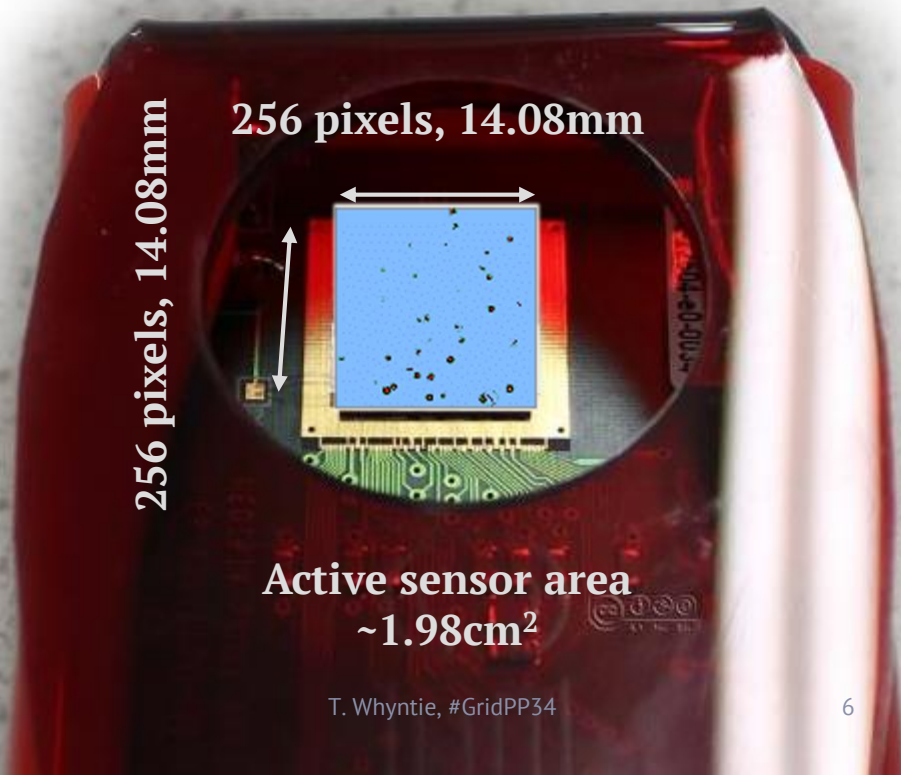
CERN@school is based around the Timepix hybrid silicon pixel detector:

- Developed by the Medipix2 Collaboration [Llopart et al. 2007].
- 300 μm thick silicon sensor bump-bonded to a Timepix readout chip.
- 256 × 256 pixels of pitch 55 μm provide 65,536 readout channels from the 1.98cm^2 sensor element.
- It can be used to detect ionising radiation, make energy measurements (when calibrated) and perform particle identification (to an extent).

Huge thanks to Michael Campbell et al.

The Timepix hybrid silicon pixel detector





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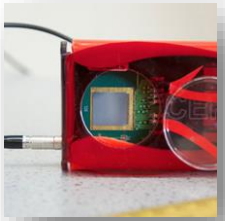
The CERN@school detector network

Science & Technology Facilities Council

Since the SEPnet pilot, STFC have funded 35 detectors and laptops for deployment nationwide. Currently ~50 nodes in the CERN@school detector network.

SEPnet South East Physics Network

JABLOTRON CREATING ALARMS



IOP Institute of Physics

- Detectors are managed regionally by IOP Physics Network Coordinators (PNCs) and SEPnet outreach officers;
- These network "hubs" are trained to use the detectors. They then have the freedom to design their own delivery programme.
- Also deployed to UK national laboratories at RAL and Daresbury for public engagement/demonstration purposes.

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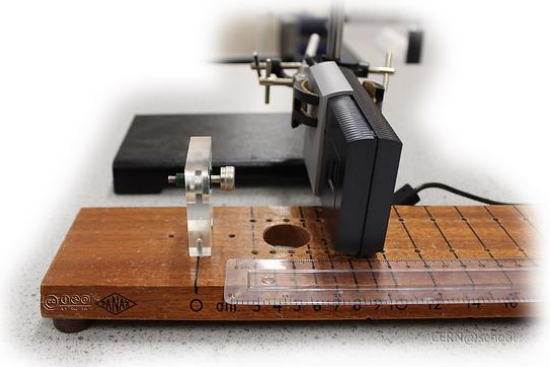
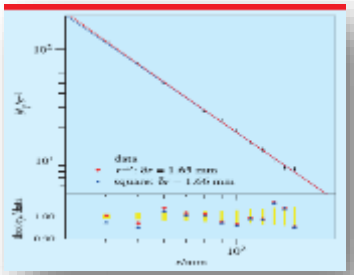
Demonstration experiments

Huge thanks to J. Wilson for supervising 3rd year projects.

The inverse square law

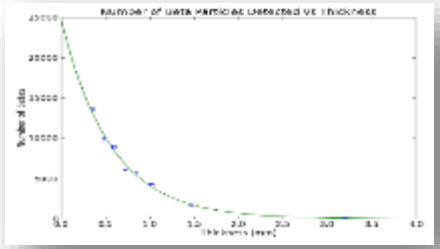


T. Whyntie & B. Parker, Phys. Educ. 48 344 2013

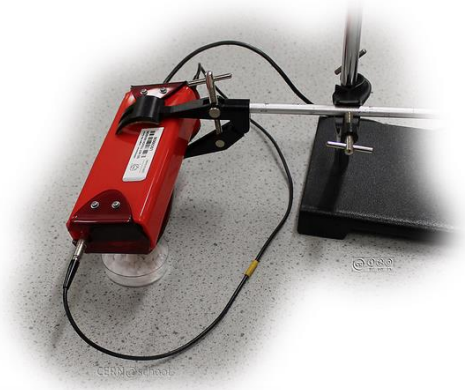


Attenuation of beta radiation

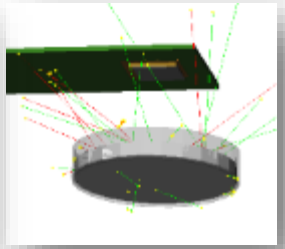
A. Coupe, SEPnet summer student 2013 (accepted)



KCl: measurements vs. MC studies

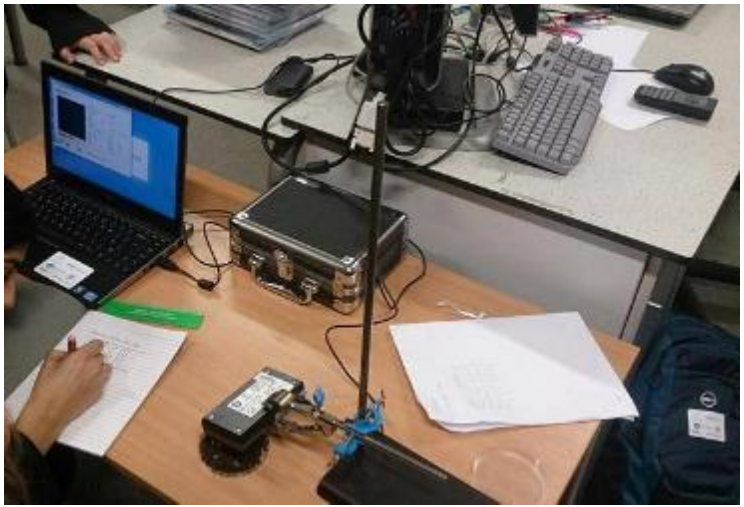


R. Fickling, QMUL project student 2013-14 (accepted)



Eclipse 2015

- On Friday 20th March 2015, the UK experienced a partial solar eclipse.
  - Suggestion from IOP PTN – would it affect background radiation levels measured by Timepix?
- Resulted in the first large-scale simultaneous measurement:
  - ~25 Timepix detectors running;
  - Data on the grid (via DAQMAP);
  - Students analysing…



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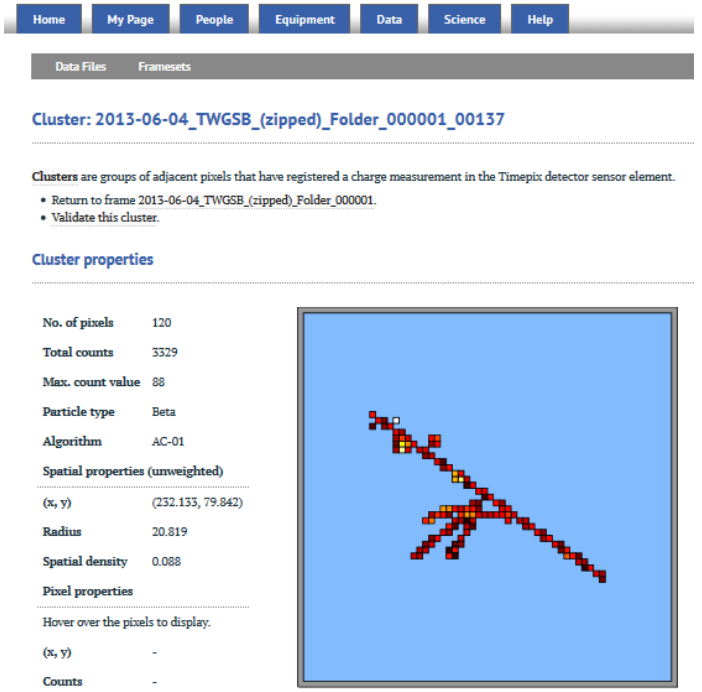
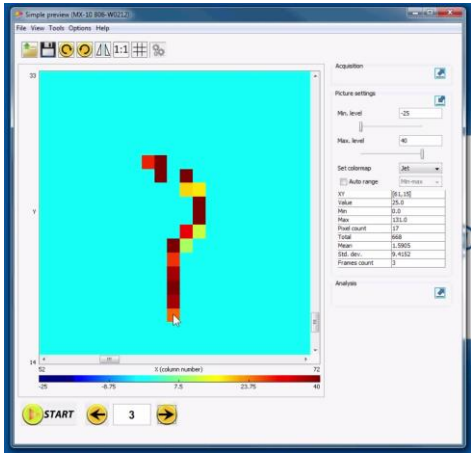
Data on the DAQMAP and the grid

The Data AcQuisition, Management, Analysis and Presentation system:

- Based on the same technology as **Galaxy Zoo** – Ruby on Rails app (Hobo gemset) running on an AWS Ubuntu 12.04 LTS server (Phusion Passenger deployment);
- Users organised into research groups. Functionality also available for monitoring usage, Support Tickets, reporting and equipment inventories;
- Data uploaded from the detector via zip files. Uploaded to the grid via DIRAC. Accessed from Storage Elements via http;
- Removes the need for a grid certificate for every student (though can provide where necessary).

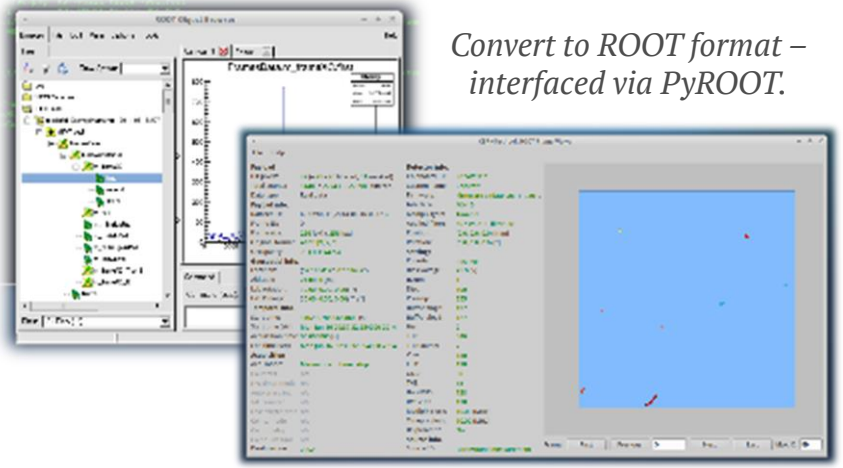


Coding with CERN@school

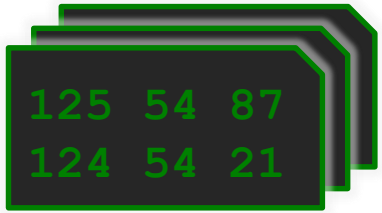


Data capture performed with **Pixelman** software [S. Pospíšil et al. 2006]

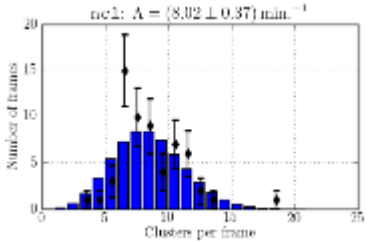
Output: ASCII text files.



Convert to ROOT format – interfaced via PyROOT.



Process with Python and matplotlib



GitHub

All of our software and code is available on our GitHub page: http://github.com/CERNatschool

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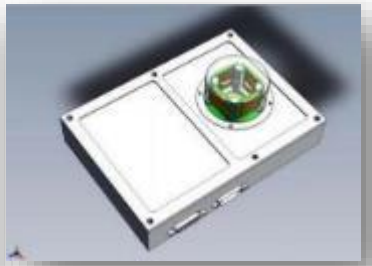
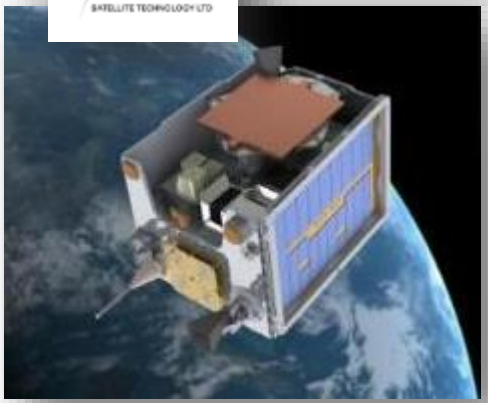
The LUCID experiment

The Langton Ultimate Cosmic ray Intensity Detector (LUCID) experiment:

- 5 Timepix detectors in an open-faced cube, housed in a ~0.68 mm aluminium "dome" (not pictured), to measure the Low Earth Orbit radiation environment.
- Launched aboard Surrey Satellite Technology Limited's TechDemoSat-1 on Tuesday 8th July 2014.
- Science goals: measure particle intensity, energy, directionality in outer electron belts, SAA, at ~635km.

Huge thanks to D. Cooke, S. Sahand, E. Brownbill, S. Wokes, D. Garton et al.





The LUCID experiment

SSTL's TechDemoSat-1

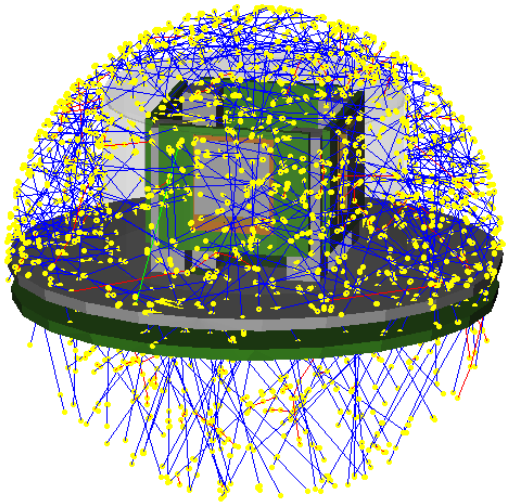
LUCID is under here

TechDemoSat-1 launched from Baikonur aboard a Soyuz 2 rocket on Tuesday the 8th July 2014.

The TechDemoSat-1 “Selfie”

Simulation of the LUCID experiment

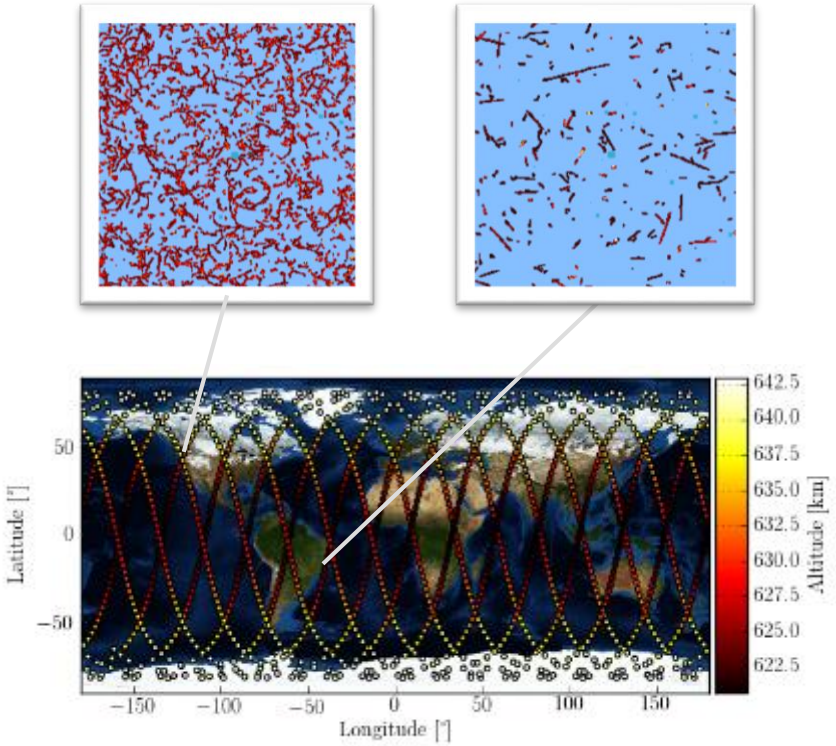
GridPP resources are used run GEANT4 simulations of the LUCID experiment with Allpix (J. Idarraga, M. Benoit). Monte Carlo datasets are used by students to study expected performance in SAA/outer electron belts and to compare with real data when it arrives.



Allpix simulation of the LUCID experiment (Al dome not shown), 40 MeV proton GPS source.

Typical MC run: 500 points in LUCID's orbit, 5M particles per point.

Frames shown from SAA and northern electron belt.



Papers published in CHEP '13, iWORID '14 proceedings.

Data from the LUCID experiment

Abstract submitted to the National Astronomy Meeting 2015

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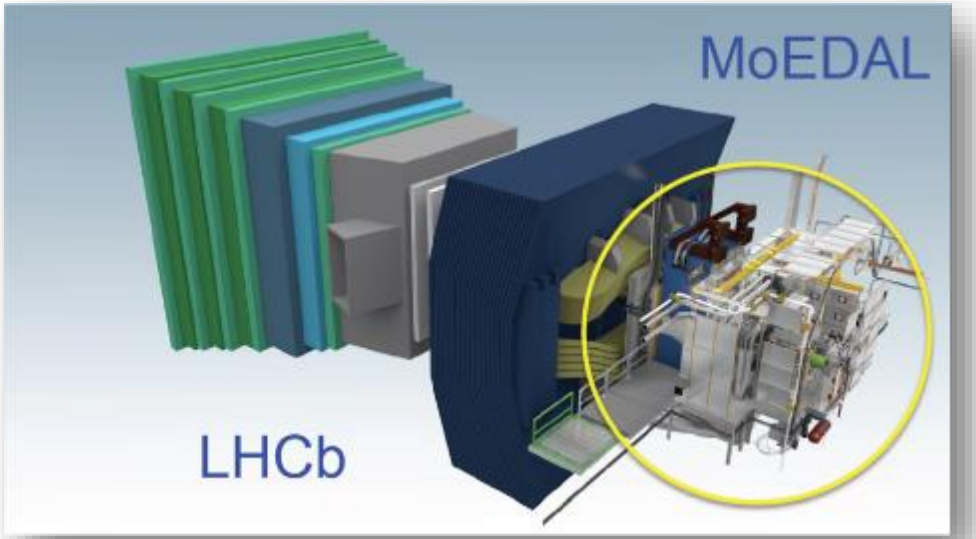
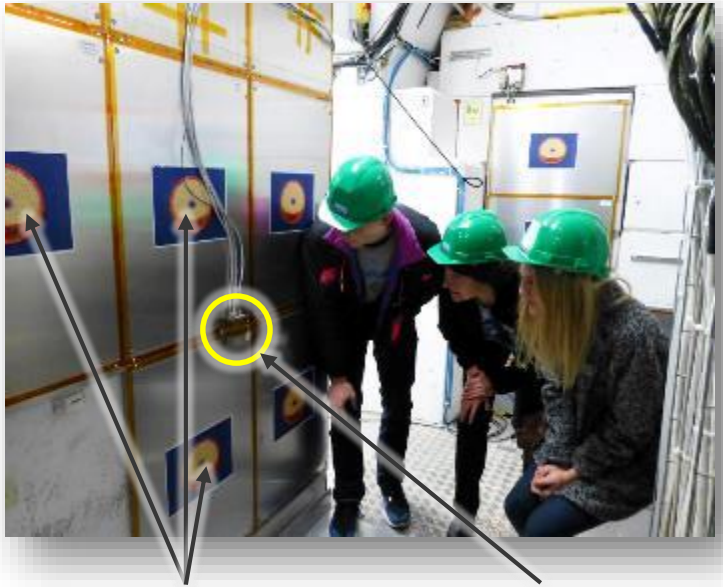
The MoEDAL experiment





The Langton Star Centre has joined MoEDAL (Monopole and Exotics Detector at the LHC) due to students' experience with Timepix detectors.

Nuclear Tracking Detector (NTD) sheets for monopole detection.

One of the Timepix detectors used for radiation monitoring.

The Zooniverse

- World-leading Citizen Science:
  - https://www.zooniverse.org/
  - "Real Science Online"
- Led by Prof. Chris Lintott (Uni. Oxford, BBC Sky At Night).
- 1,301,214 users as of 13:49 GMT Wednesday 18th March 2015.
- Started in astrophysics, now covers many disciplines (including particle physics – see Higgs Hunters).
- Powered by Amazon Web Services.

CC BY-SA 3.0: Image credit

ZOONIVERSE

Panoptes – Zooniverse for All

- The Zooniverse team are developing a tool to allow anyone to assemble their own Citizen Science projects: **Panoptes**
  - Panoptes (API): https://github.com/zooniverse/Panoptes
  - Front End: https://github.com/zooniverse/Panoptes-Front-End/
- Requirements for setting up a project:
  - **Subject sets** – images classified by the Zooniverse Users (ZUs);
  - **Workflow** – series of questions and tasks to be performed by ZUs resulting in a "classification" for each subject;
  - **Science case** and **background material** to provide context.
- ***The aim: use Panpoptes to classify odd Timepix clusters***

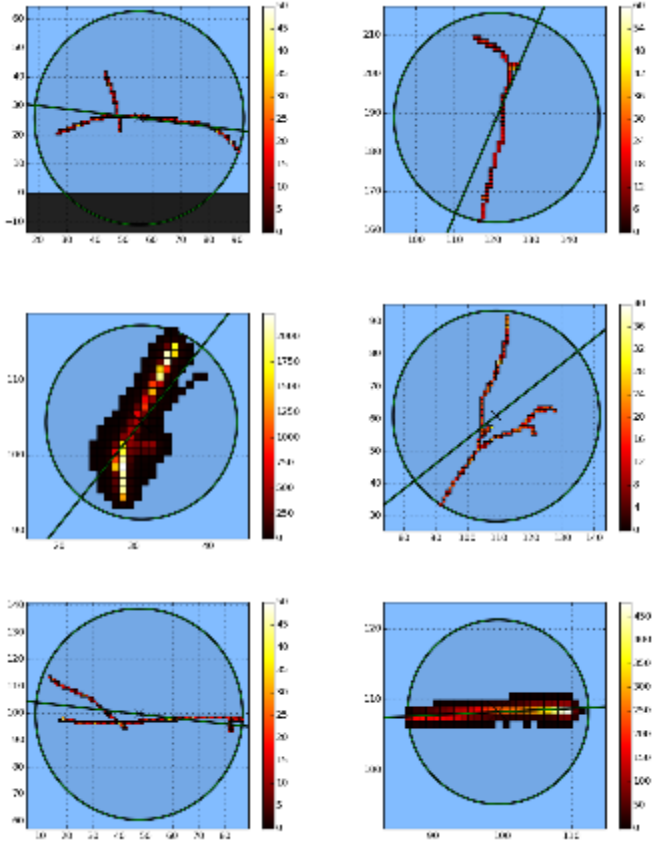
The Timepix datasets

Run ID	Frames	Size [B]	Start time	Δ *T* [s]	Δ *t* [s]	δ *t* [s]	File name
F03-W0098_2012-02-22-174731	264124	3015160620	Wed Feb 22 17:47:31.000000 2012	47 days, 20 hours, 30 mins.	15.65	10.0000	tpx01_20120222_Background_LT_10s_1000.root
F03-W0098_2012-04-10-142403	42803	2294918579	Tue Apr 10 14:24:03.000000 2012	2 days, 20 hours, 51 mins.	5.79	0.1000	tpx01_20120410_2012_Operation_LT_0.1s_1000.root
F03-W0098_2012-04-13-111927	3087067	11455473062	Fri Apr 13 11:19:27.000000 2012	201 days, 17 hours, 21 mins.	5.65	0.0010	tpx01_20120413_2012_Operation_LT_0.001s_1000.root
F03-W0098_2012-11-28-154345	683691	1081386053	Wed Nov 28 15:43:45.000000 2012	45 days, 2 hours, 28 mins.	5.70	0.0010	tpx01_20121128_2012_Operation_LT_0.001s_1000.root
F03-W0098_2013-01-15-095630	537408	484531408	Tue Jan 15 09:56:30.000000 2013	35 days, 3 hours, 28 mins.	5.65	0.0010	tpx01_20130115_2012_Operation_LT_0.001s_1000.root
F04-W0098_2012-02-22-174731	264479	1791754186	Wed Feb 22 17:47:31.000000 2012	47 days, 20 hours, 31 mins.	15.63	10.0000	tpx02_20120222_Background_LT_10s_1000.root
F04-W0098_2012-04-10-142404	43137	488212354	Tue Apr 10 14:24:04.000000 2012	2 days, 20 hours, 51 mins.	5.75	0.1000	tpx02_20120410_2012_Operation_LT_0.1s_1000.root
F04-W0098_2012-04-13-111929	3094134	7062753596	Fri Apr 13 11:19:29.000000 2012	202 days, 15 hours, 20 mins.	5.66	0.0100	tpx02_20120413_2012_Operation_LT_0.01s_1000.root
F04-W0098_2012-11-28-154343	686623	740489626	Wed Nov 28 15:43:43.000000 2012	45 days, 2 hours, 28 mins.	5.68	0.0100	tpx02_20121128_2012_Operation_LT_0.01s_1000.root
F04-W0098_2013-01-15-095628	575000	427892329	Tue Jan 15 09:56:28.000000 2013	37 days, 14 hours, 17 mins.	5.65	0.0100	tpx02_20130115_2012_Operation_LT_0.01s_1000.root

- The IEAP (CTU, prague) Timepix detectors took data for over a year during the LHC Run 1 (details above). Data stored in ROOT format at the IEAP.
- Huge thanks to Petr Benes (IEAP) for giving us access – we have now converted these to the Mafalda (J. Idarraga, CERN) ROOT format for grid processing.

Example subject set

- We have prepared a sample dataset of clusters from the Feb. 2013 dataset (acq. time 0.001 s).
- "Triggering":
  - First 100 frames containing a cluster with size > 100 pixels;
  - Then selected clusters with size > 50 pixels, radius > 10 pixels.
- Aim to pick out large clusters; more systematic studies also being done.

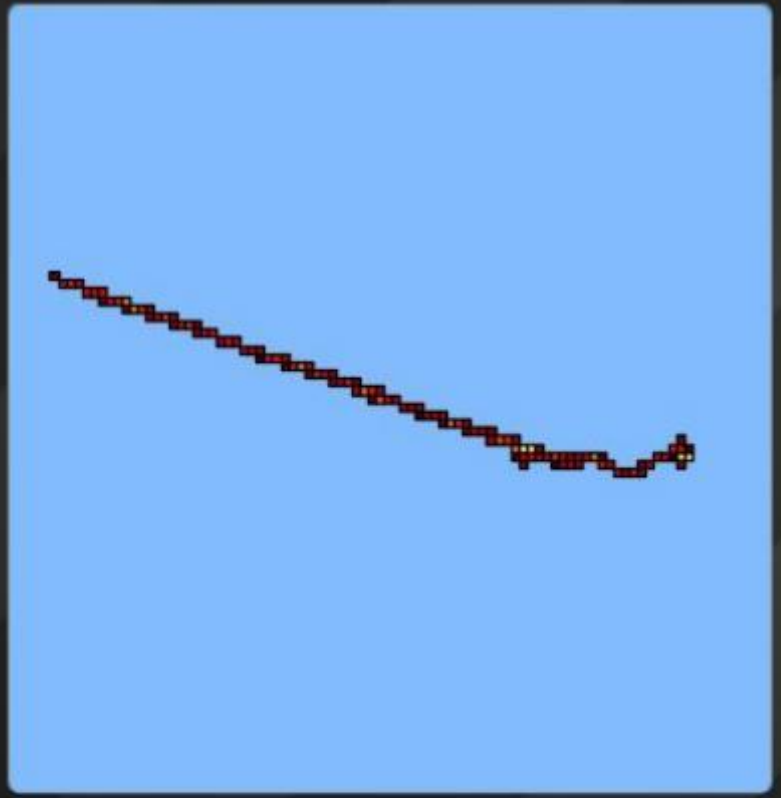


Using the grid

- Using the cernatschool.org VO for the moment:
  - moedal.org VO creation in progress.
- Timepix IEAP datasets uploaded to the grid.
- Datasets put into the Mafalda ROOT format using CERN@school software conversion tools (CernVM-FS) and the Imperial DIRAC server.
  - Data (and metadata) managed via DFC and Python API;
  - Subject sets harvested from datasets on the grid;
  - Have also used grid jobs to create “time profiles” over the run.

Current status

- Panoptes now functioning.
  - Can create projects, workflows and subject sets;
  - Still creases to iron out but getting there!
  - Huge thanks to the Zooniverse team:
    - https://github.com/zooniverse/Panoptes-Front-End/issues
- We have created a demo project for Timepix data.
  - Front End: http://demo.zooniverse.org/panoptes-front-end
  - View the test project “Monopole Quest 003” live here!
  - Click on “Classify Clusters” to start classifying.



What can you see in the cluster?

- One or more tracks
- One or more blobs
- Multiple shapes (not just tracks or blobs)

Need some help?

Back | Next

Please use the track tracer, blob marker, and polygon tool to trace the shapes you can see

Track Tracer (1)

Blob Marker (2)

Polygon Tool

Need some help?

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Publications

- [1] The MoEDAL Collaboration, "*Timepix cluster classification schema for the MoEDAL experiment*", Nucl. Instr. Meth. A (in prep., 2015);
- [2] The CERN@school Collaboration, "*The LUCID experiment*", Nucl. Instr. Meth. A (in prep., 2015);
- [3] T. Whyntie et al., "*CERN@school: demonstrating particle physics with the Timepix detector*", Contemporary Physics (accepted for publication May 2015);
- [4] T. Whyntie et al., "*CERN@school: bringing CERN into the classroom*", Nucl. Phys. B (Proceedings of ICHEP 2014, Valencia, submitted for publication 25/10/14);
- [5] T. Whyntie & M. A. Harrison, "*Full simulations of the LUCID experiment in the Low Earth Orbit radiation environment*", JINST **10** C03043 (2015) - proceedings of IWORID 2014
- [6] T. Whyntie & M. A. Harrison, "*Simulation and analysis of the LUCID experiment in the Low Earth Orbit radiation environment*", J. Phys. Conf. Ser. **513** 022038 (2014);
- [7] T. Whyntie & B. Parker, "*Investigating the inverse square law with the Timepix hybrid silicon pixel detector: a CERN@school demonstration experiment*", Phys. Educ. **48** 344 (2013).

Research Symposium 2014

- **WELCOME LECTURE**
- **STUDENT WORKSHOPS**
- **TEACHER WORKSHOPS**
- **LUNCH**
- **PLENARY SESSION** with 10th International Conference on Position Sensitive Detectors (PSD10):
  - Keynote address: Medipix and Timepix: introducing young people to nuclear and particle physics - Michael Campbell
  - Introduction to CERN@school - Becky Parker, Langton Star Centre
  - The LUCID experiment - Matt Harrison
  - The MoEDAL experiment at the Large Hadron Collider - Katherine Evans
  - Radiation Around You (RAY) – Simon Langton Grammar School for Boys, Kent
  - F.A.I.R - Kettering Buccleuch Academy, Northamptonshire
  - An investigation into water-based radiation shielding - Pate's Grammar School, Gloucestershire
  - Development of a 3D radiation scanner - The Thomas Hardye School, Dorset
  - Collaborating with your local university - Dave Cotton, Cardinal Newman College
- **BREAK AND POSTER SESSION**
- **CLOSING SESSION**

  Presentation of participation certificates - Prof. John Womersley, Chief Executive, STFC


StarCentre
Science & Technology
CERN@school Joint Session
SEPnet


Preliminary Experiments


South China Sea
South Atlantic Anomaly
University of Houston, ISAP Project, NASA


UNIVERSITY OF
SURREY

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Summary and conclusions

- CERN@school has a rich and ever-expanding research programme in place, offering school students and teachers the chance to do real research:
  - Detectors in schools, in space and now the LHC;
  - Building a CERN@school Collaboration publication record;
  - Look back at GridPP30, GridPP32 talks… achieved all and more!
- Computing and analysis made possible by GridPP:
  - Processing and data storage not possible in schools;
  - Developments with the CernVM to come…

Thanks and acknowledgments

- **Medipix2 Collaboration**: M. Campbell et al.
- **SSTL (LUCID)**: D. Cooke et al.
- **Zooniverse**: C. Lintott and Panoptes dev. team.
- As ever, the **GridPP community**!
  - DIRAC: the Imperial team – providing a production level service for our research.
  - CernVM-FS: Catalin (RAL STFC) – software distribution.
  - Tier-2 sites: Sam S., Dan T., (Chris W,) Steve J.

Thank you for listening! Further information:

http://cernatschool.web.cern.ch

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