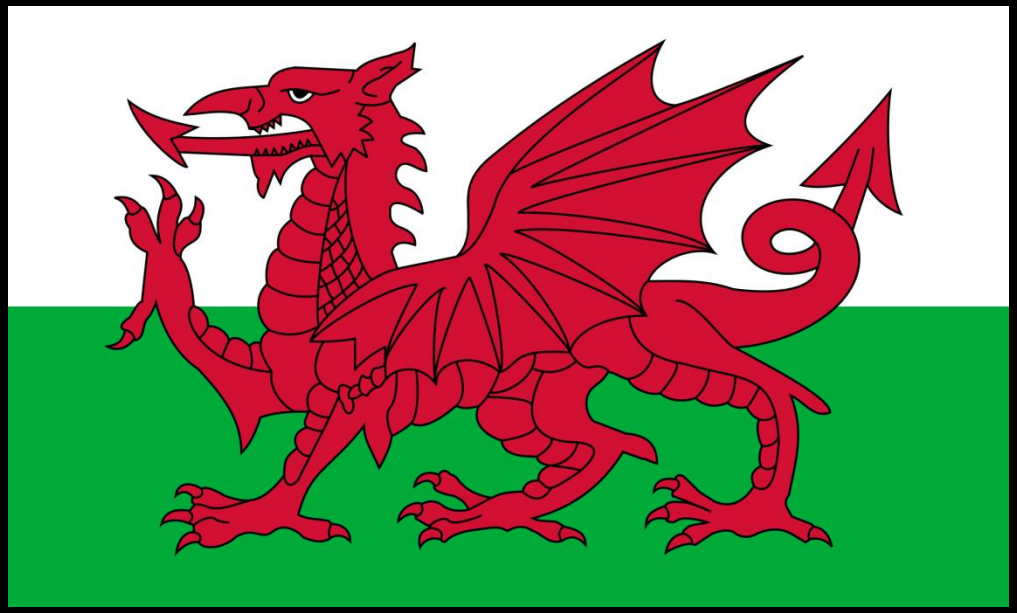
# Quarknet Cymru

## Cosmic ray detection and particle physics in Wales

**Fraser Lewis (on behalf of Paul Roche, Sarah Roberts)**
**Faulkes Telescope Project**
**National Schools' Observatory**
**Liverpool John Moores University**
**The Open University**

# Based in Cardiff, Wales

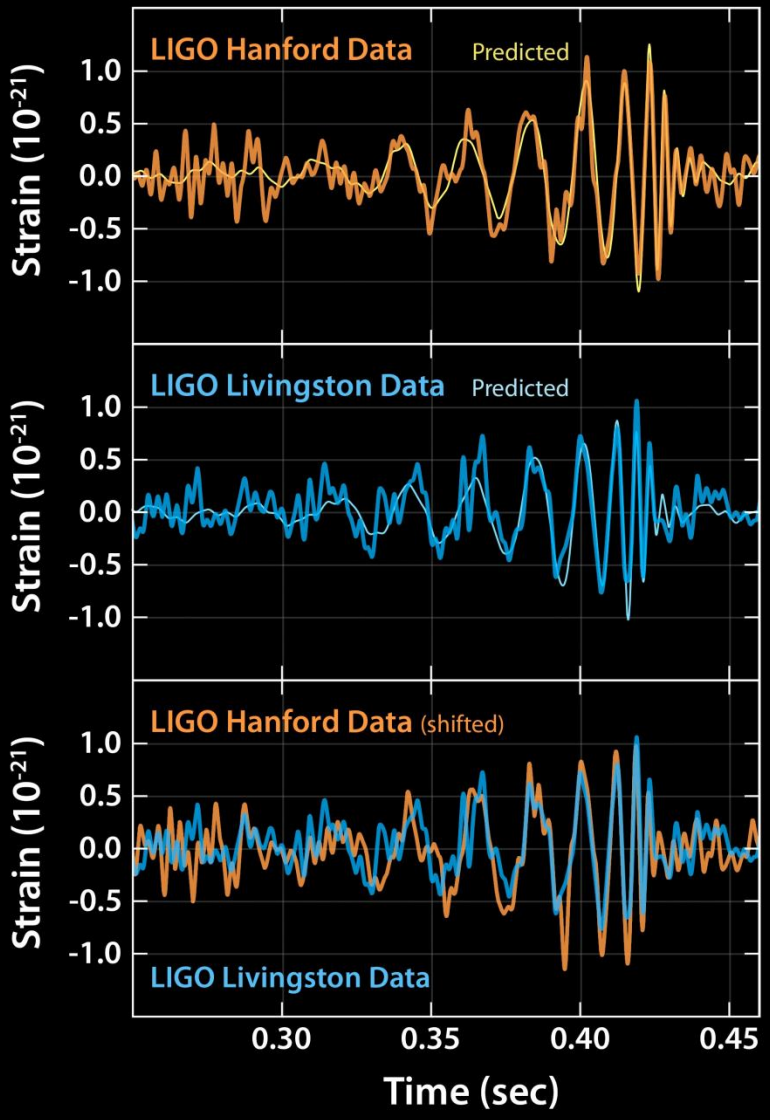
# The Home of Football !



POLICE BOX


Stagecoach
IT'S NEW.
IT'S FAST.

# Cardiff University

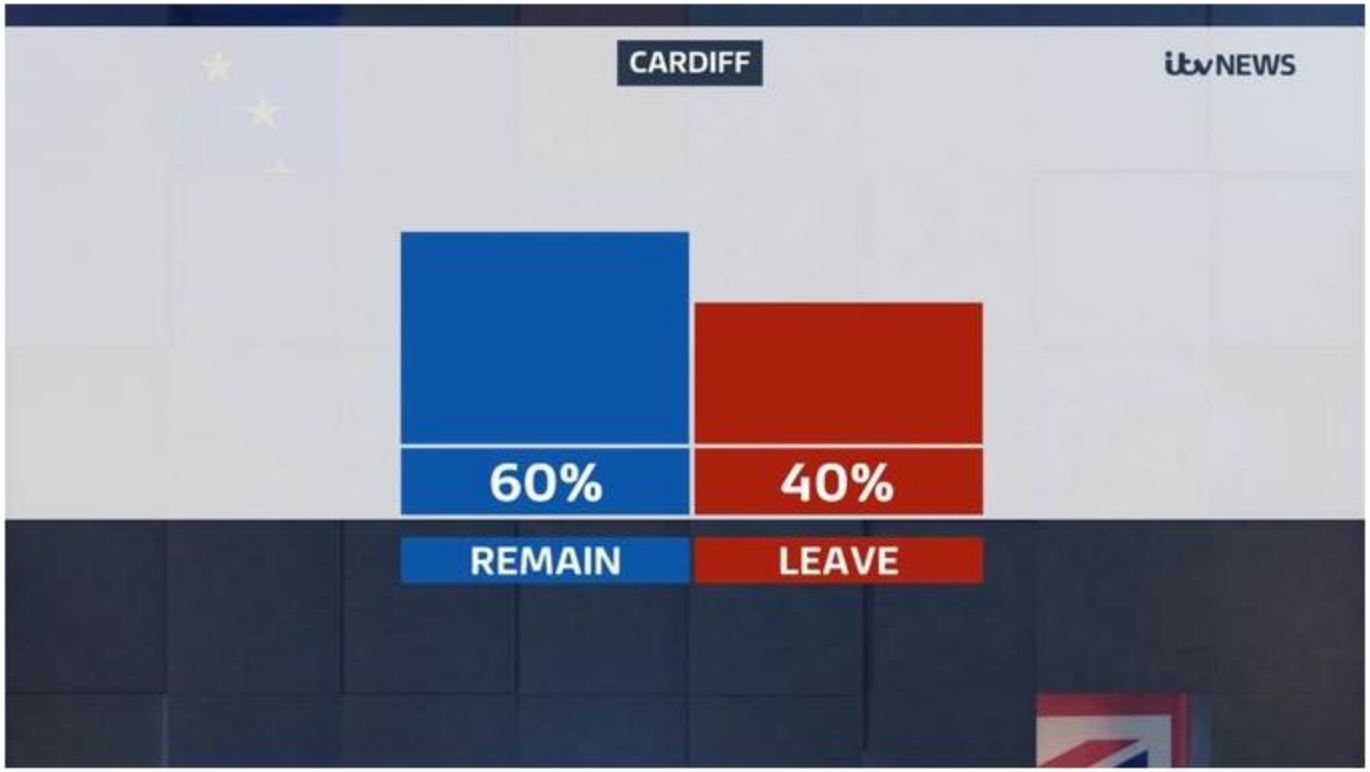



http://www.astro.cardiff.ac.uk/research/gravity/tutorial/

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

24 June 2016 at 4:01am

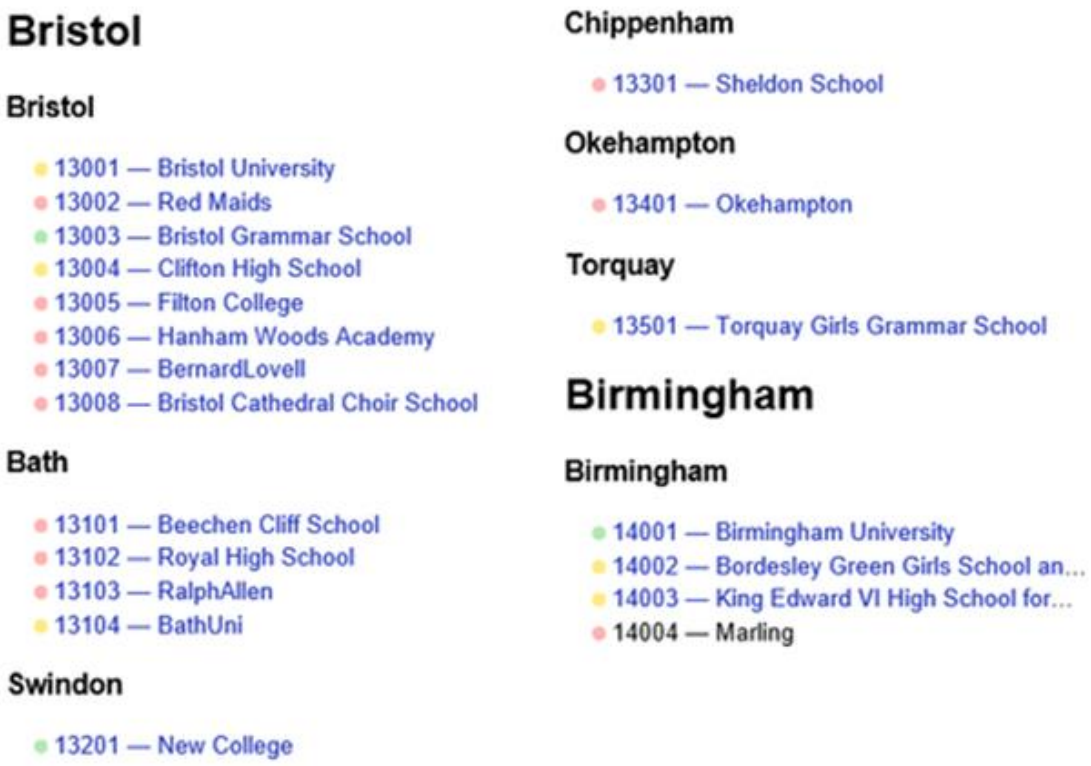
# Cardiff votes to remain in the EU with 60% of the vote




Cardiff voted in favour of staying in the EU with 101,788 (60%) votes. 67,816 (40%) voted to leave. Turnout was 69.6%.

# HiSparc in the UK

## Co-ordinated by Universities of Birmingham, Bristol and Bath (SW region)



# What is QuarkNet Cymru?

A pilot project to help engage students with particle physics

Provision of cosmic ray and particle detectors for schools

Supported by Cardiff and Swansea - the two largest universities (and cities) in Wales

# Funding (~£100 K)

From National Science Academy
(Welsh Government)

STFC (UK Science Funding Body)

Royal Astronomical Society

# Plans for Wales

Support for GCSE/AS/A level Physics
Establish HiSparc network in Wales
(in schools and universities)

Creating website to share resources, upload data and provide curriculum links



http://www.researchinschools.org/ http://www.researchinschools.org/CERN/home.html

# Curriculum links

Limited before 17 – 18 year olds who can do ‘extended projects’ with some examining boards

Some links at earlier years with radioactivity, standard model, the Sun, supernovae (life cycle of stars)

School system extremely ‘exam-driven’

QuarkNet Cymru has purchased **4** rooftop HiSPARC detectors, plus a range of desktop equipment for loan to schools

One each in Swansea and Cardiff Universities, one in a public Science Centre in Swansea and a 4th to be deployed to a local school

# 7 Muon Observatories

Desktop muon detectors to be loaned to schools

One set up in Oriel Science Centre, Swansea

Two being used by Cardiff University u'grad and MSc students (projects to count CRs and to track objects)

ORIELSCIENCE

Oriel Science is a Swansea University project.
With thanks to our sponsors:

Swansea University Prifysgol Abertawe · BID · S4C · technocamps · QuarkNet Cymru · Science & Technology Facilities Council

# More Portable Kit

6 Geiger Counters

4 Cloud Chambers

3 MX10

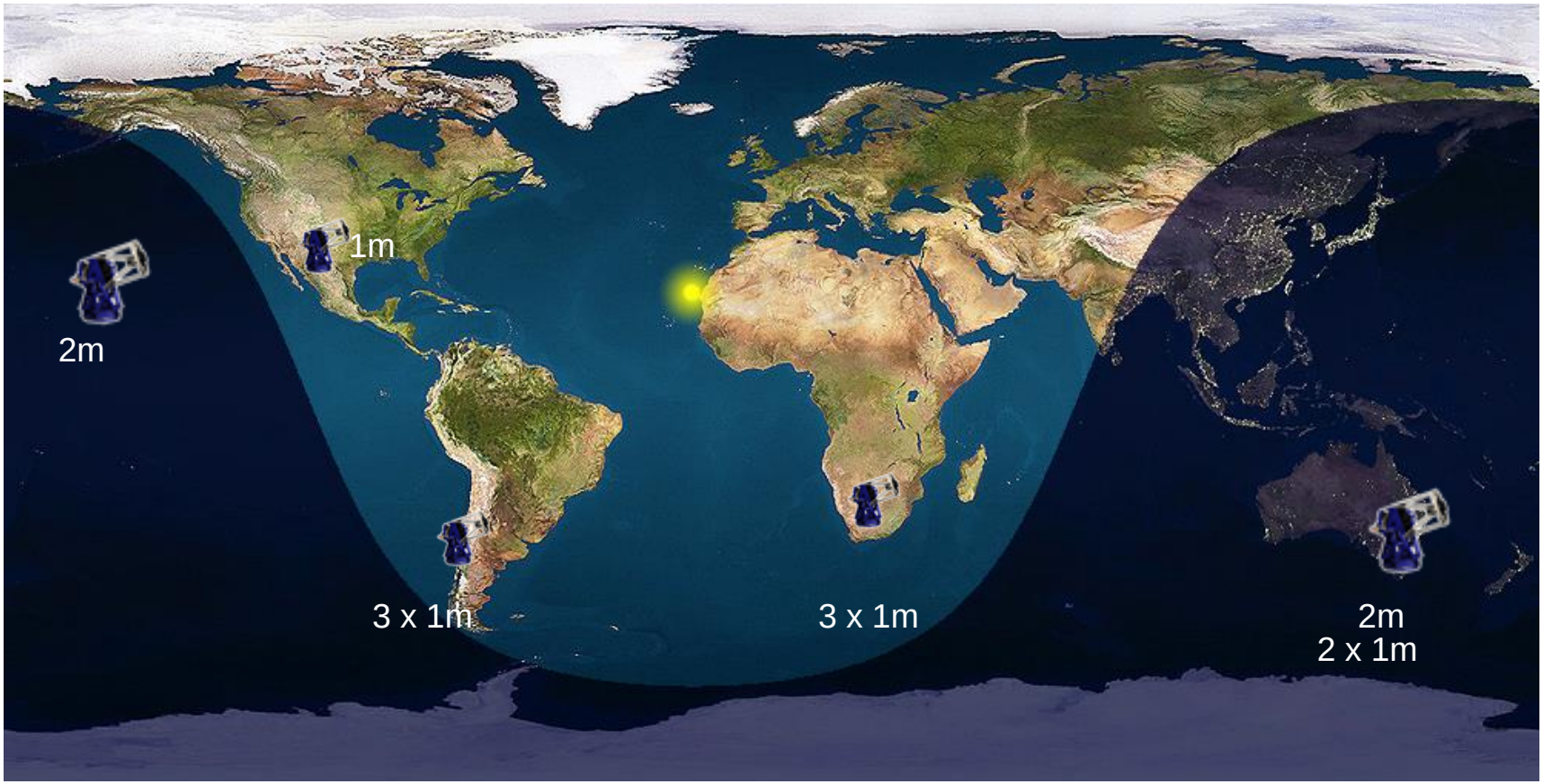
(one on the Institute of Physics “Lab in a Lorry” to tour Wales…)

# Our Other Projects

Faulkes Telescope Project

VR/AR material via RAL, Gaia, ISS

# 2 * 2-metre, 9 * 1-metre (5 more soon)
# 3 * 0.4 metre telescopes




# 360 degree Tours

CERN

Surface of Mars
Fall in to a black hole
Telescopes
Universities

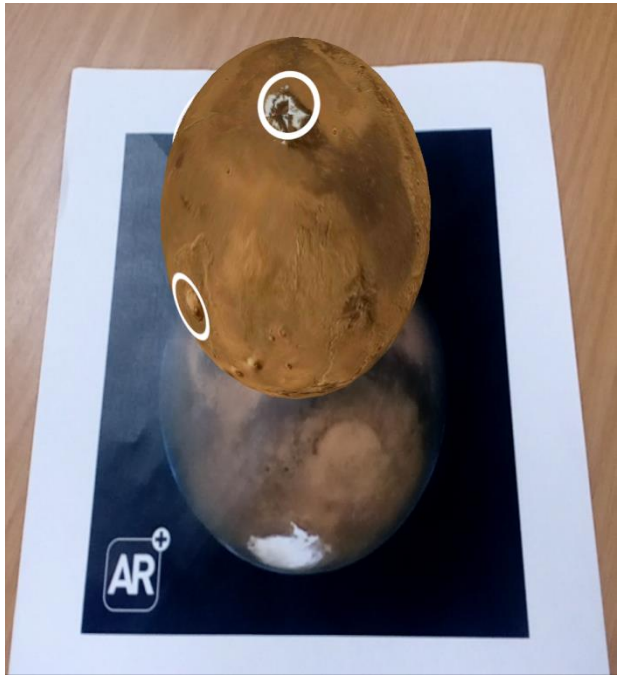
Live 360 talks
Labs
Museums
Science centres
Hospitals

# Our Other Projects

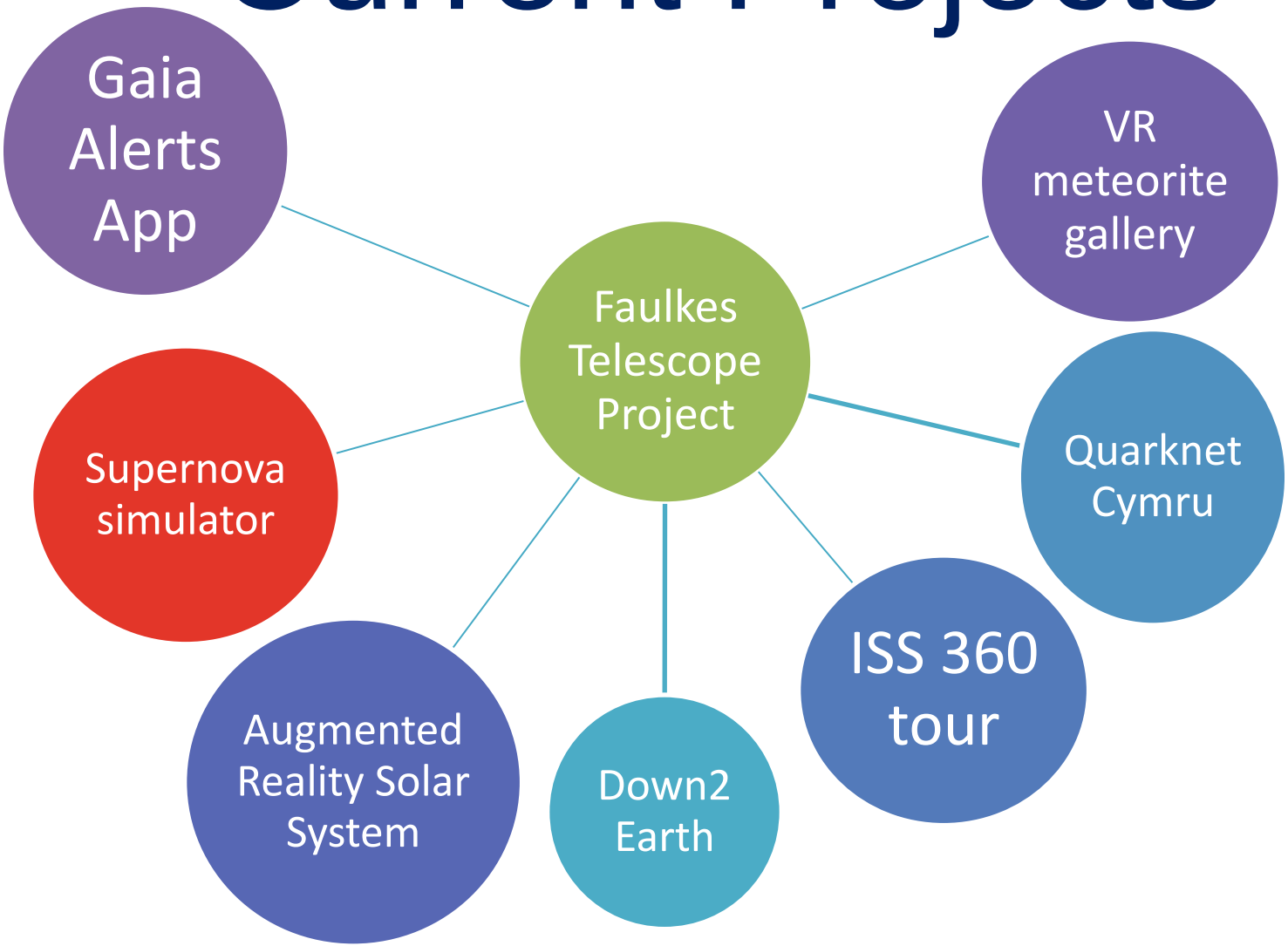
## Faulkes Telescope Project

## VR/AR material via RAL, Gaia, ISS





# Current Projects



Faulkes Telescope Project

Prosiect Telesgôp Faulkes

national museum wales amgueddfa cymru

Noddir gan Lywodraeth Cynulliad Cymru
Sponsored by Welsh Assembly Government

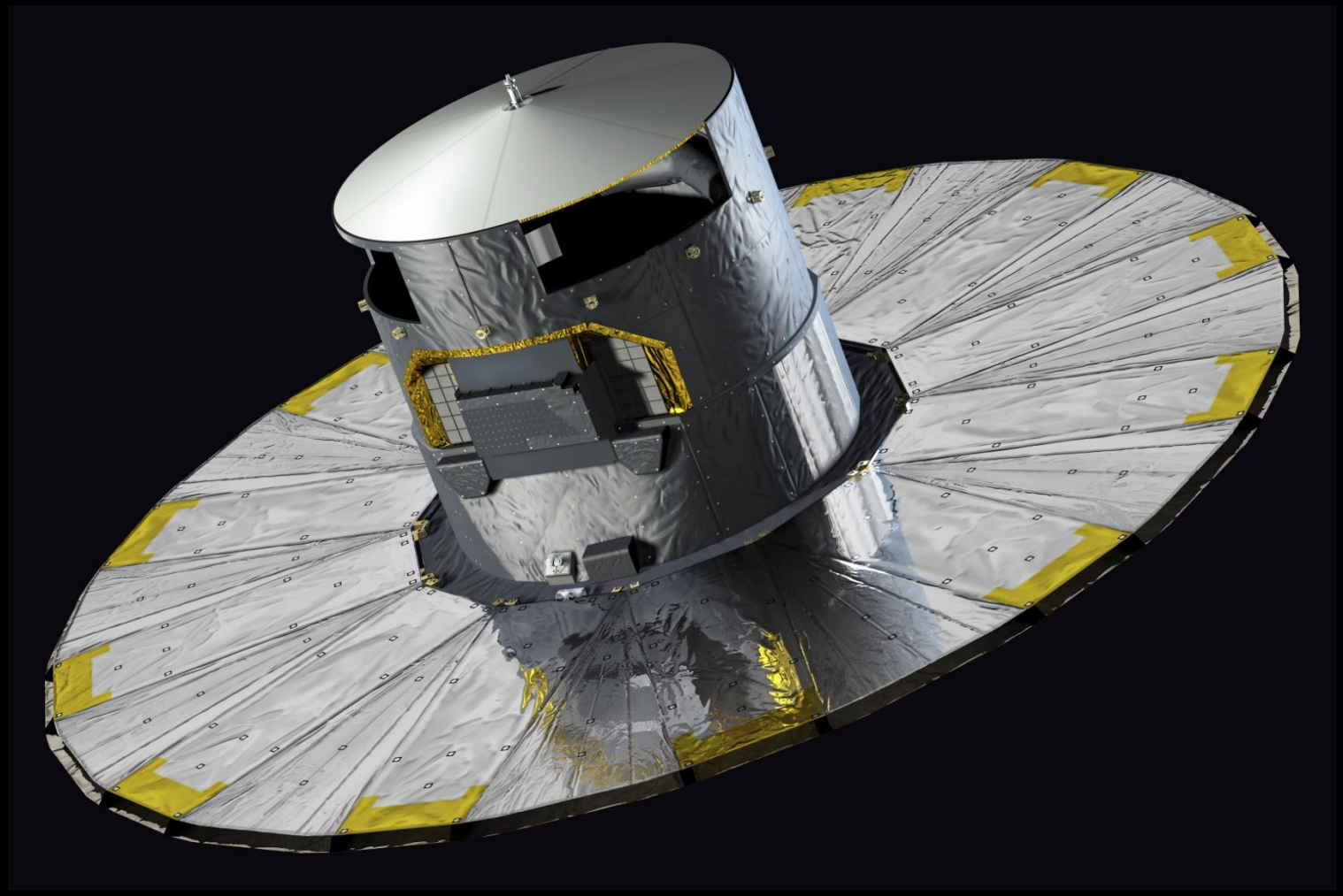
# Down2Earth

Joint project FTP and NMW

Ages 11-16 years



# Gaia Transient Follow-up



http://gsaweb.ast.cam.ac.uk/alerts/alertsindex

# Spotting a Supernova

Background Material

## Gaia Science Alerts

***The detection of transient astronomical objects in real-time***

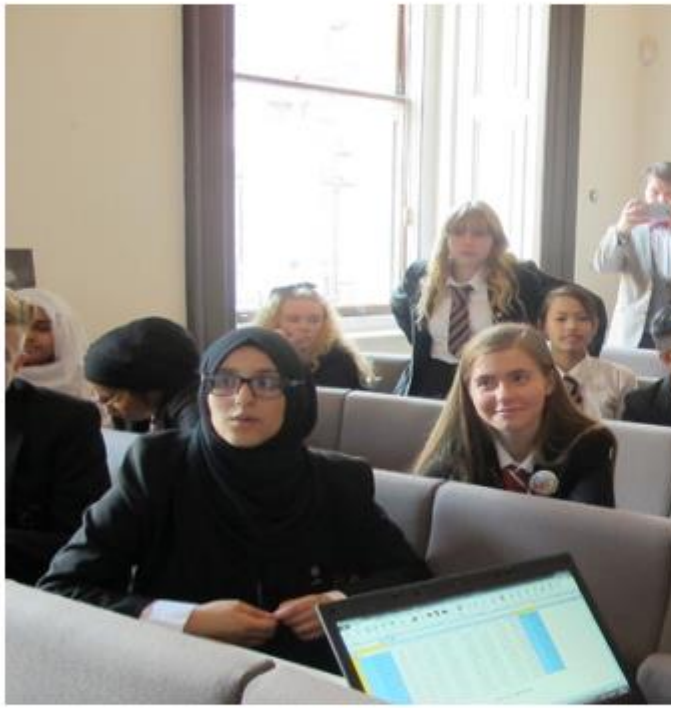
Not all stars emit light with a constant brightness and radiation output, many of them **change in brightness very suddenly** and often unexpectedly, over a variety of timescales. We call these objects **transients**.

Every day, the Gaia team announces several **science alerts** which indicate new discoveries of transient objects. The discoveries themselves are made in Cambridge University at the data processing centre at the Institute of Astronomy. Here, they lead the UK's involvement within the Gaia Data Processing and Analysis Consortium (DPAC).

As most transients – and indeed stars – that Gaia sees are so far away from us and appear so faint, we are unable to see them with the naked eye alone. Gaia is mapping one billion stars, whereas fewer than ten thousand stars are bright enough to be seen with just the naked eye – and most of those only with very dark sky conditions!) However, these objects can be seen from the ground by harnessing the power of **robotic telescopes** such as the Faulkes Telescopes. Gaia's science alerts (GSA) provide accessible data that **schools** and amateurs can use to make their own follow-up observations to confirm these transient objects and gather more information about their **properties and characteristics.**

http://resources.faulkes-telescope.com/course/view.php?id=144

# Eastbury Community Sch
# a lesson in how to plot a
# the Royal Astronomical S



Eastbury Community School students in action.

Megan Greet (Head of physics), Jamie Paton (teac
School were delighted to be invited to the Royal A
that teenagers really can carry out genuine scienti
Research in Schools, led by Becky Parker, Eastbury were selected as the pilot school to analyse data from the Gaia project. This is a wonderful opportunity to enhance the enrichment work being

**Eastbury Physics**
@EastburyPhysics

Follow

Us giving presentation @RoyalAstroSoc on supernovae found in data from #GaiaMission provided by @ResearchInSch

# Black Holes In My School (with Rosa Doran, Nuclio, Portugal)

"It's black, and it looks like a hole. I'd say it's a black hole."




The Astronomer's Telegram
Post | Search | Policies
Credential | Feeds | Email

15 Feb 2017; 13:44 UT





[ Previous | Next ]


## Optical brightening of Swift J1753.5-0127 observed with the Faulkes Telescope North


ATel #10075; *Ahlam Al Qasim, Aisha AlMannaei, David M. Russell (NYU Abu Dhabi), Fraser Lewis (Faulkes Telescope Project & Astrophysics Research Institute, LJMU), Guobao Zhang, Joseph D. Gelfand (NYU Abu Dhabi)*
*on **14 Feb 2017; 14:39 UT***
*Credential Certification: David M. Russell (dave.russell5@gmail.com)*


Subjects: Optical, X-ray, Binary, Black Hole, Transient



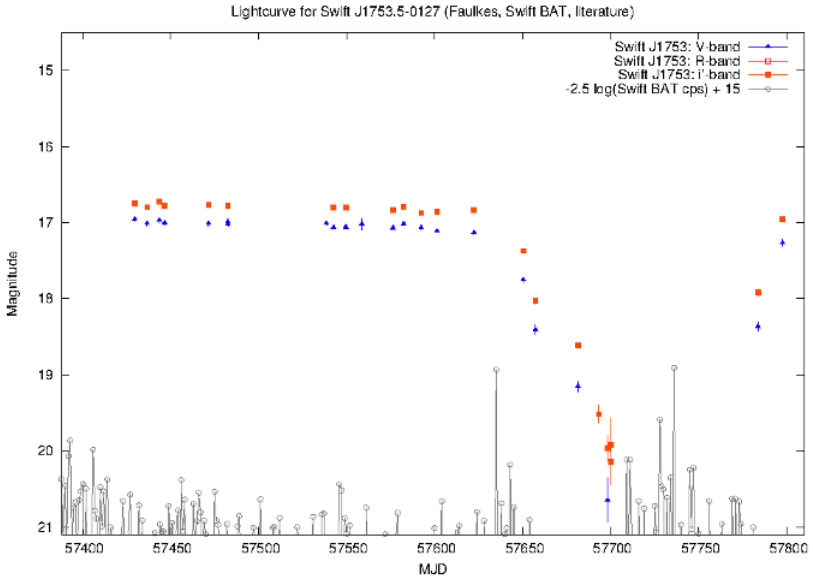

We have continued monitoring Swift J1753.5-0127, the black hole candidate X-ray binary, with the 2-m Faulkes Telescope North after it became once again visible from the ground. Last year, we reported an optical fading of the source towards quiescence (ATel #9708, #9739). Follow-up radio (ATel #9765), X-ray (ATel #9735) and optical (ATel #9741, #9758) observations confirmed the source was very faint compared to the last 11 years.

We report our new magnitudes of the object in the i'-band and the V-band as follows. V = 18.37 +- 0.06; i' = 17.92 +- 0.05 on 30 January 2017 (MJD 57783.7) and V = 17.27 +- 0.05; i' = 16.95 +- 0.02 on 13 February (MJD 57797.6). The latest magnitudes are similar to that before the fading in August 2016; we observe that it is now as bright as it was during July 2016. During the recent brightening, the V-i' color of the source seems to have shifted back to what it originally was before fading away, getting bluer as it has brightened, probably due to an increase in temperature of the accretion disc. The source is 4.0 magnitudes brighter in V-band since it was detected at V = 21.25



**Related**

| | |
|---|---|
| 10075 | Optical brightening of Swift J1753.5-0127 observed with the Faulkes Telescope North |
| 9765 | A Deep Radio Limit on the 2016 Decay of Swift J1753.5-0127 from the Very Large Array |
| 9758 | Optical/UV follow-up observations of Swift J1753.5-0127 |
| 9741 | Detection of a very red source at the position of SWIFT J1753.5-0127 |
| 9739 | Follow-up optical observations of Swift J1753.5-0127 as it fades into quiescence |
| 9735 | Swift J1753.5-0127 no longer detected by Swift |
| 9708 | Swift J1753.5-0127 is heading to quiescence after an 11-year outburst |
| 8782 | Swift J1753.5-0127 has returned to the hard state |
| 7813 | Optical observations of Swift J1753.5-0127 |
| 7697 | SWIFT J1753.5-0127 shows the lowest optical flux since 2005 |
| 7216 | Increased soft X-ray activity but no optical response in Swift J1753.5-0127 |
| 7196 | Unusual hard X-ray decrease in Swift J1753.5-0127 observed by MAXI and Swift |
| 4056 | X-ray spectral softening of Swift J1753.5-0127 |

# Summary

QuarkNet Cymru will have access to national/international HiSPARC network

Rooftop detectors in Cardiff and Swansea universities

Equipment for loan to schools in Wales

Links with CERN@School, Institute for Research In schools

# Thanks for listening


Please come find me or
e-mail me your ideas

fraser.lewis@
faulkes-telescope.com

http://faulkes-telescope.com

http://resources.faulkes-telescope.com

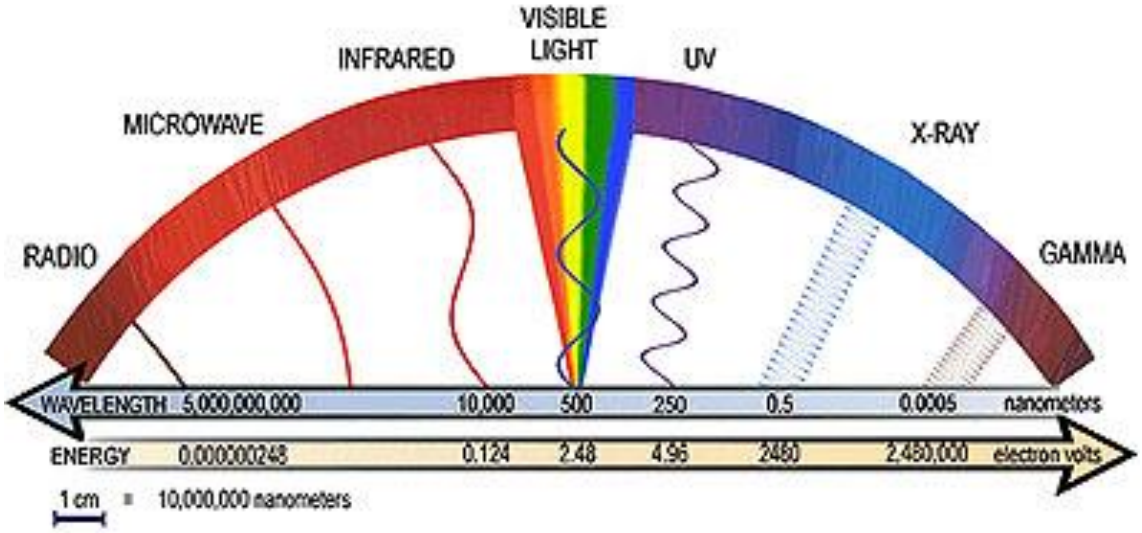
http://education.down2earth.eu

@QuarknetCymru

@faulkestel

# Traditional v “new” astronomy…

Traditional – photonic, EMR




Non-Traditional – astroparticle physics, gravity waves

# Astronomy without EMR?

- What can we detect that is ***non-photonic***?

Things such as:

***Magnetic fields***

***Gravity fields***

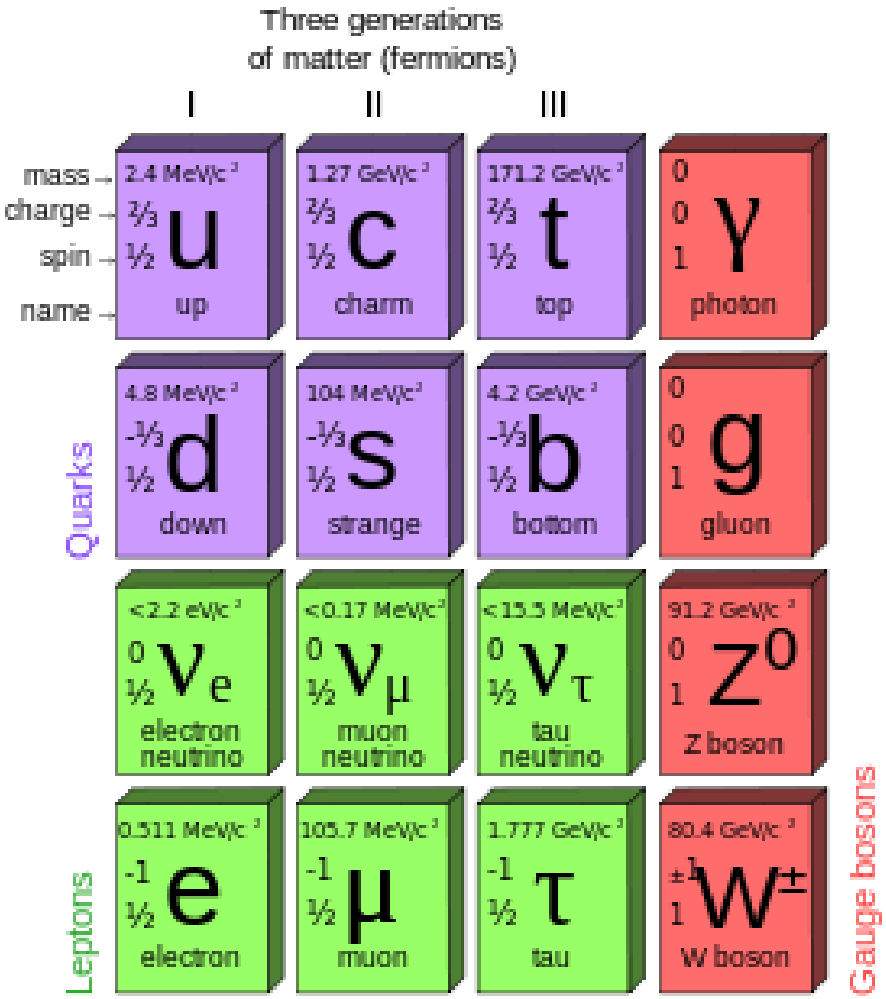
***Particles*** → Cosmic rays, Neutrinos

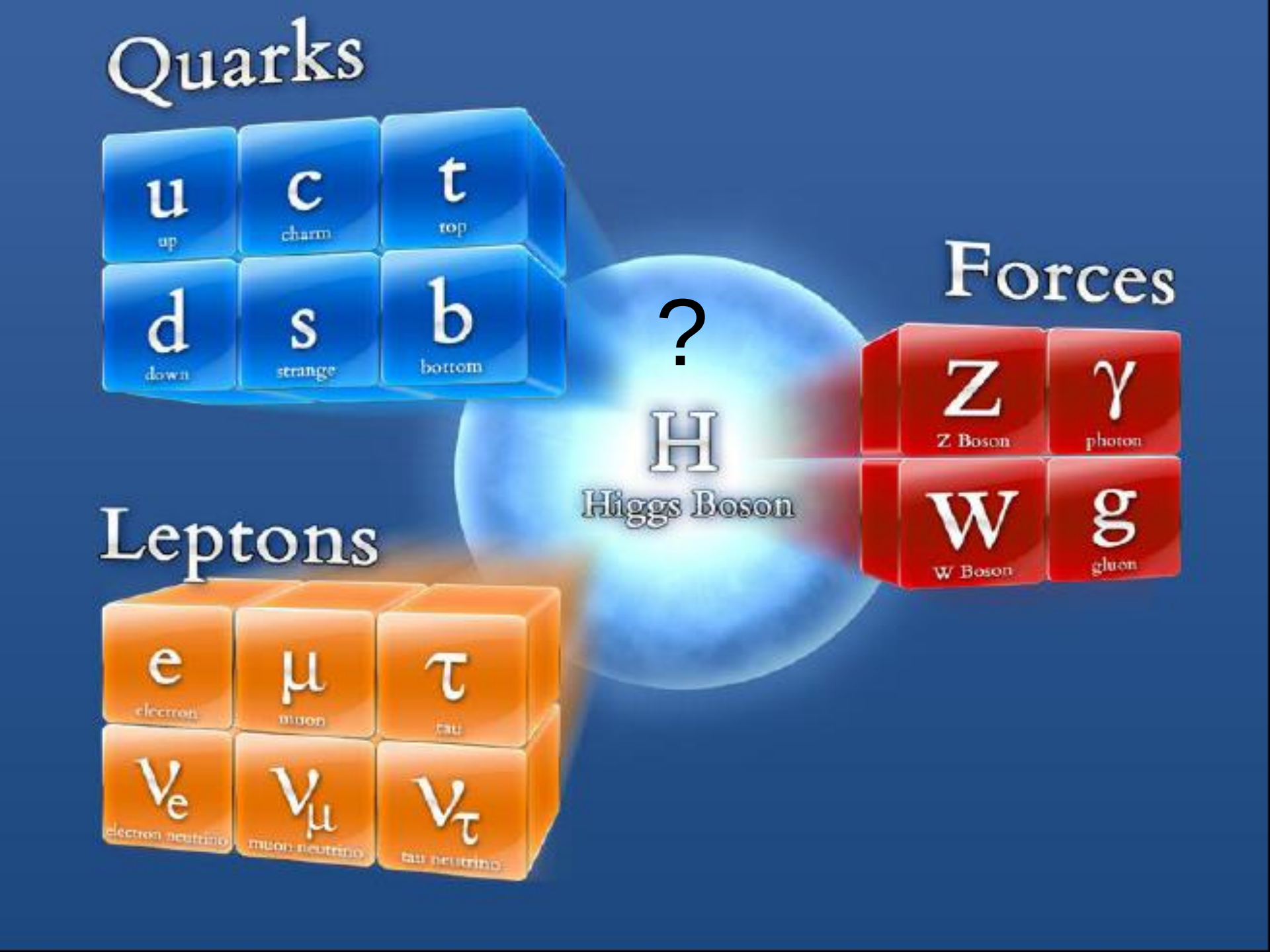
***Gravity waves***

# What is astroparticle physics?!

- "Traditional astronomy" – ***EMR***, detecting ***photons***
- Other forms of astronomy look for ***non-photonic*** things…
- Astroparticle physics – observing protons, electrons, muons, neutrinos etc.

# Standard Model




Quarks
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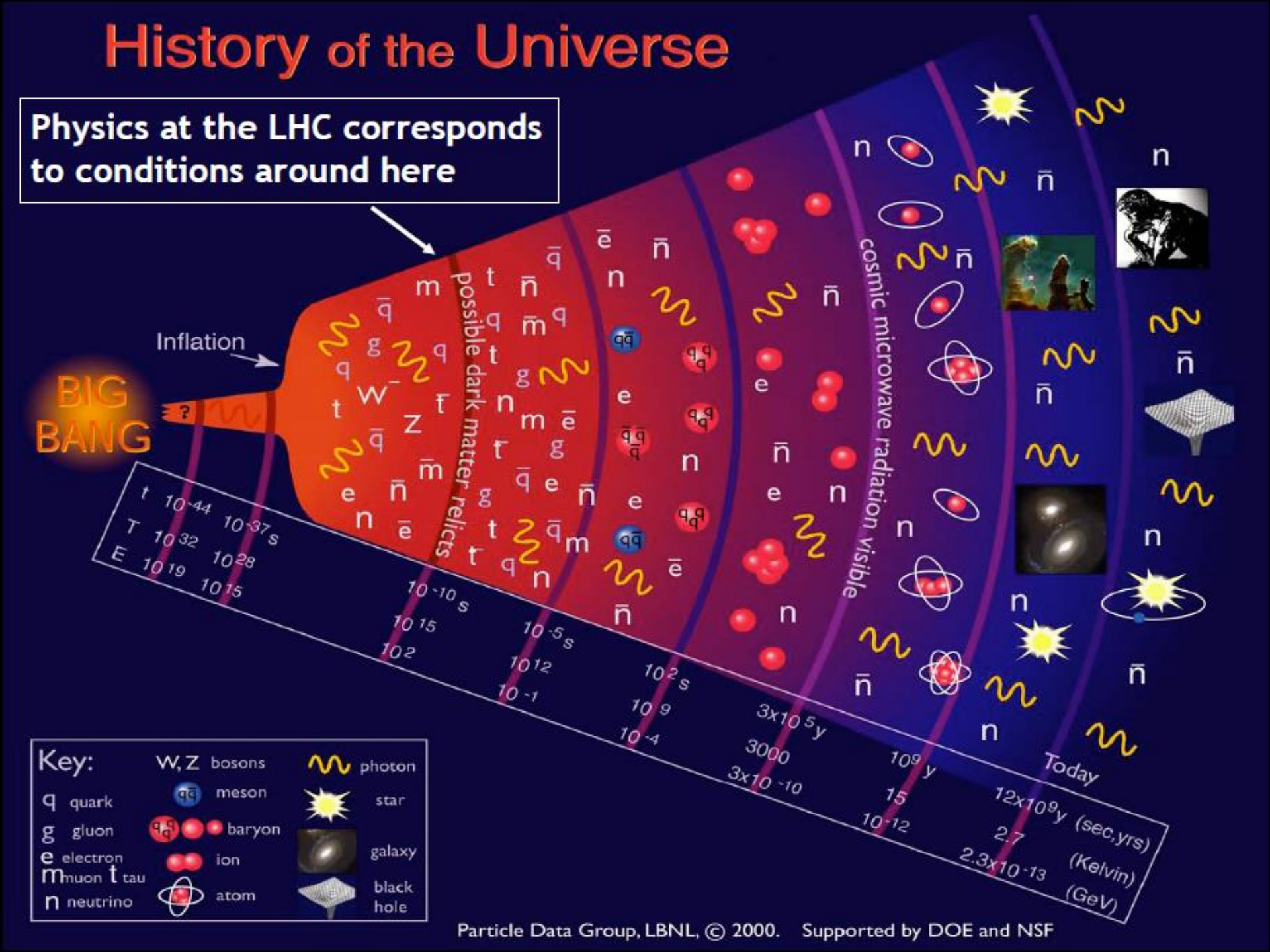
electron neutrino
νμ
muon neutrino
ντ
tau neutrino

# History of the Universe

**Physics at the LHC corresponds to conditions around here**

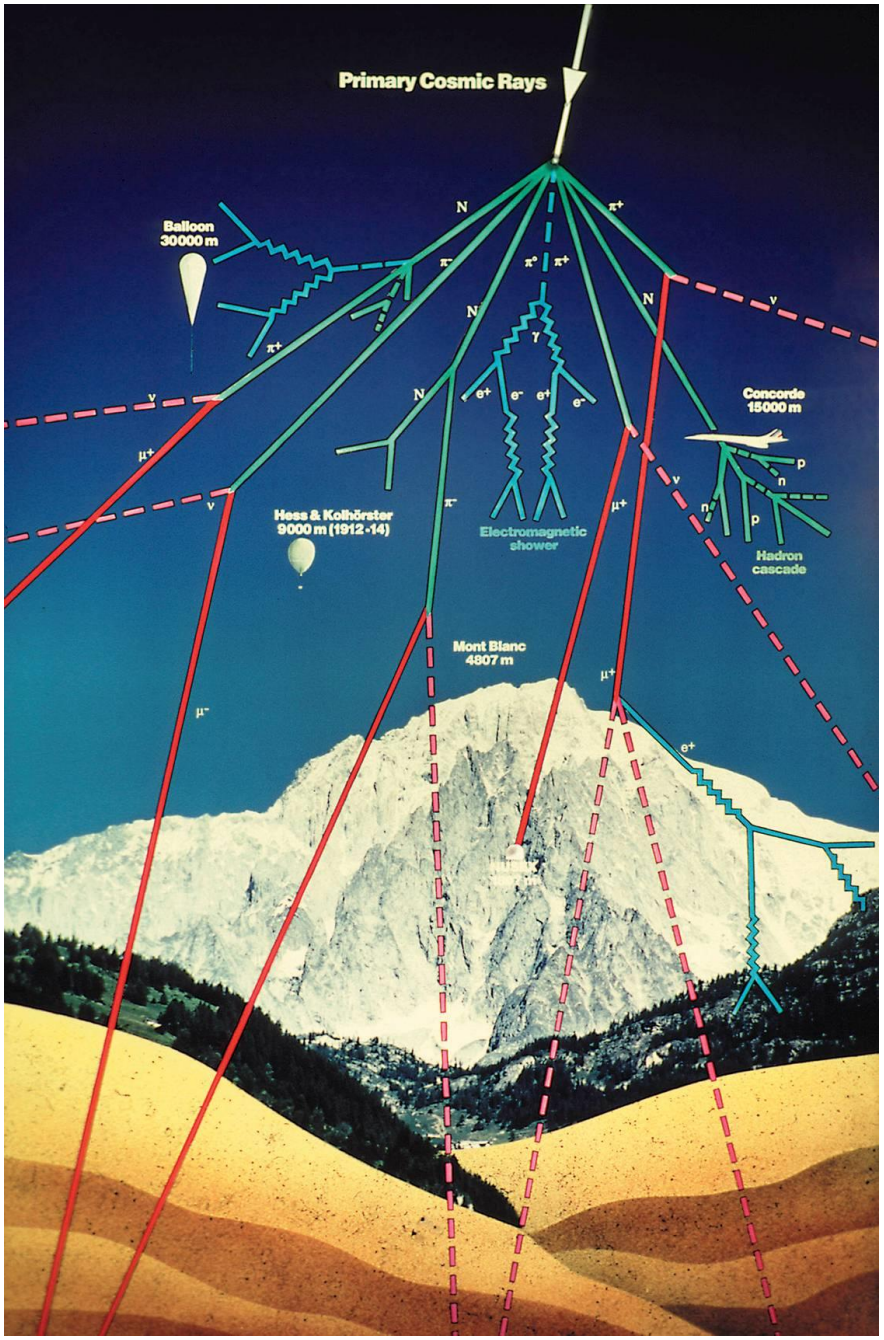


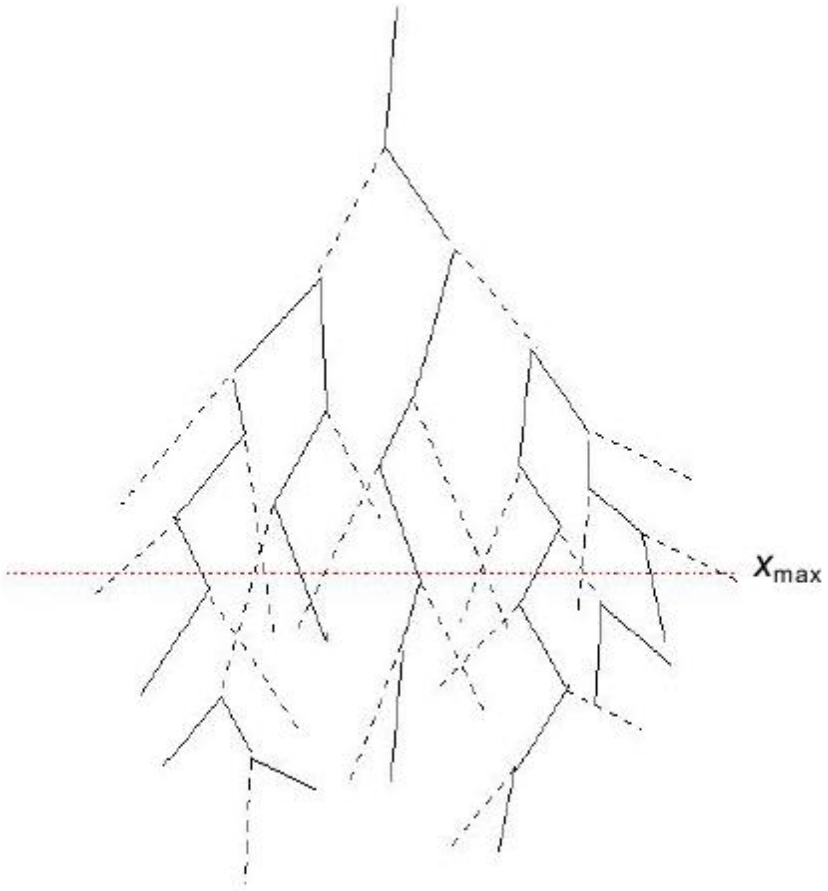
# Muons

- Every second, each $m^2$ of the Earth is hit by ~100 particles originating from cosmic radiation

- Most of these are **muons** produced in the uppermost part of the atmosphere, where even more energetic particles collide with air molecules

Cosmic rays from outer space - at ground level, mainly **muons (200x $m_e$)**



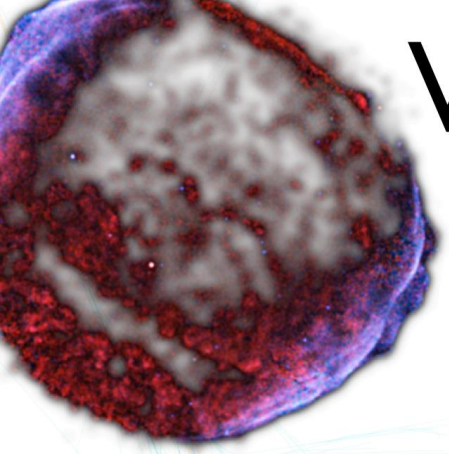


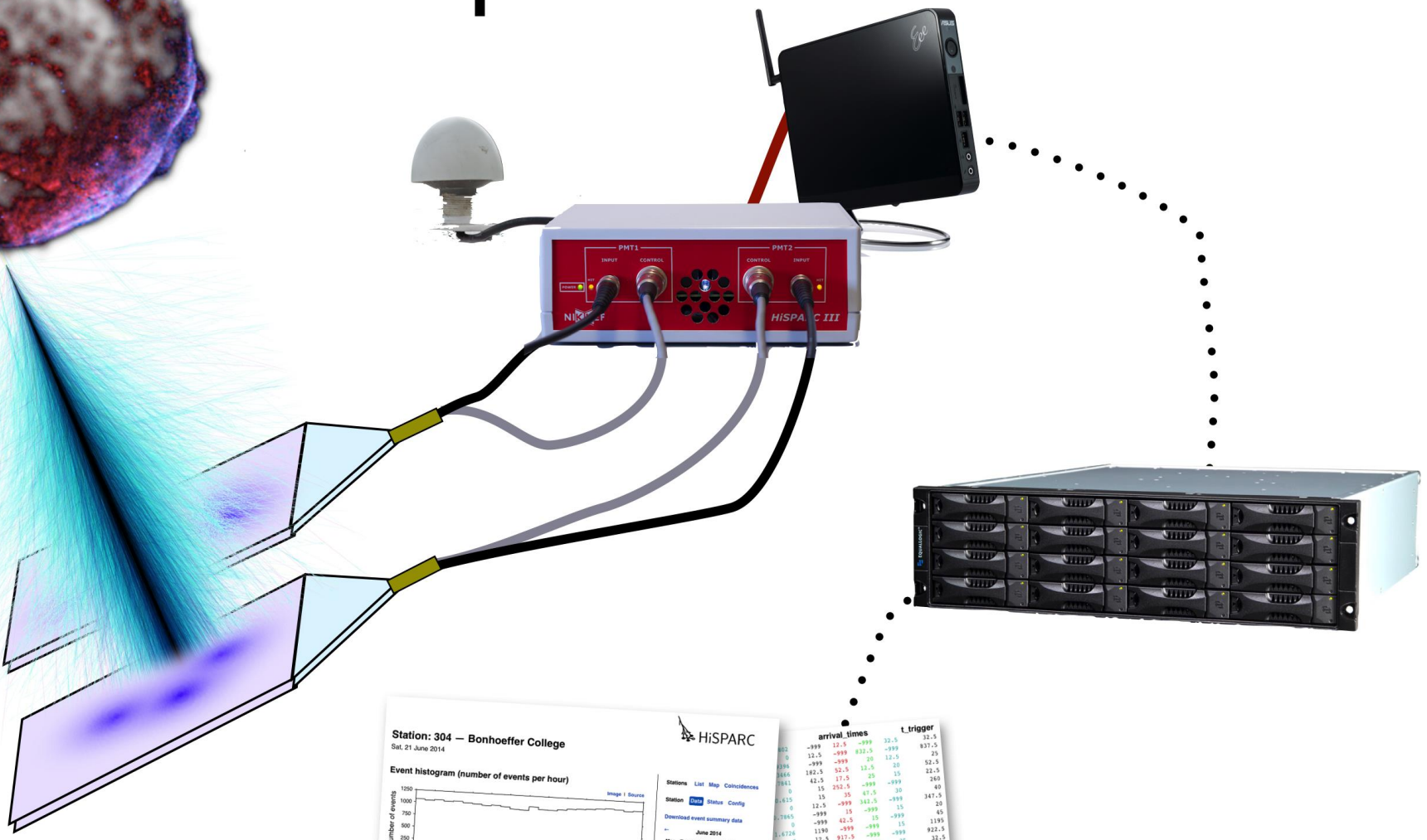

Schematic representation of development of an air shower. Highest particle density is at a depth $x_{max}$ inside the atmosphere, measured from the starting point of the shower

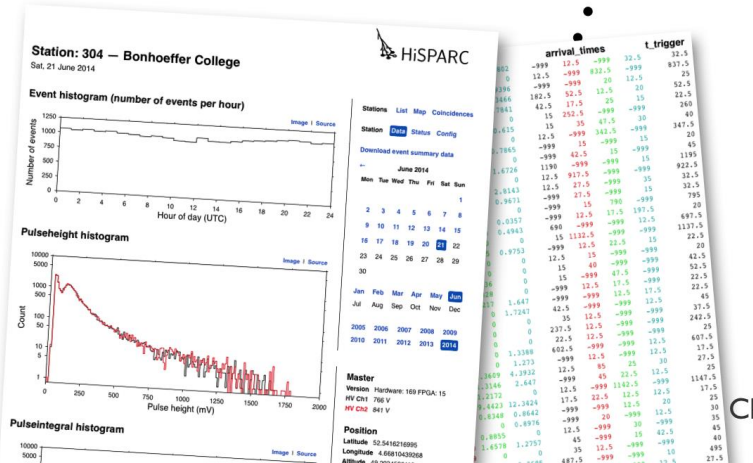
# Muons

- Muons occur as both positively and negatively charged particles
- A muon is **~200x** heavier than an electron
- Muons are unstable with a half-life of **2.197 μs**

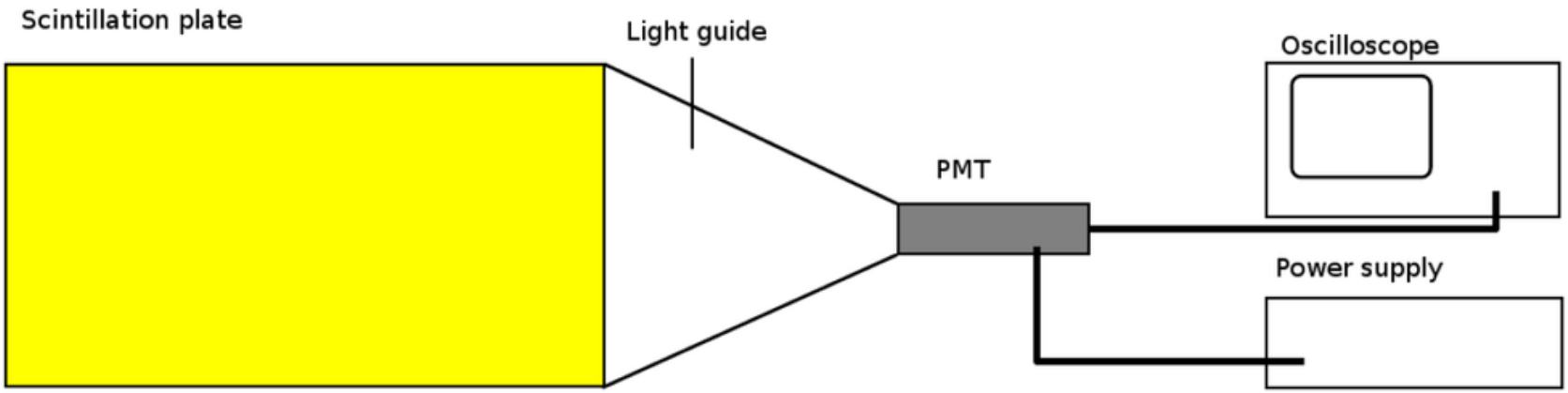
# Van supernova tot data



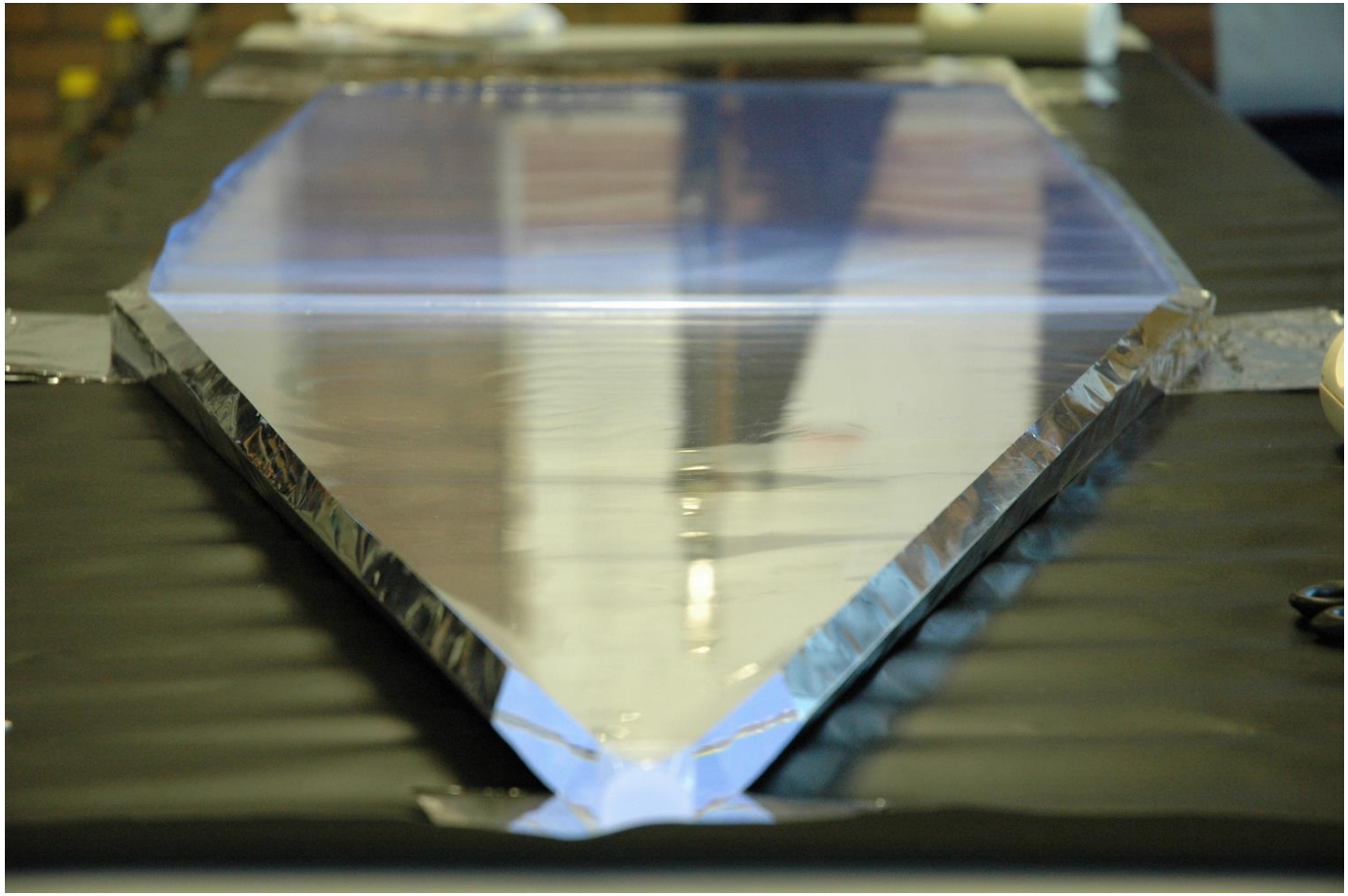


# The HiSPARC detector



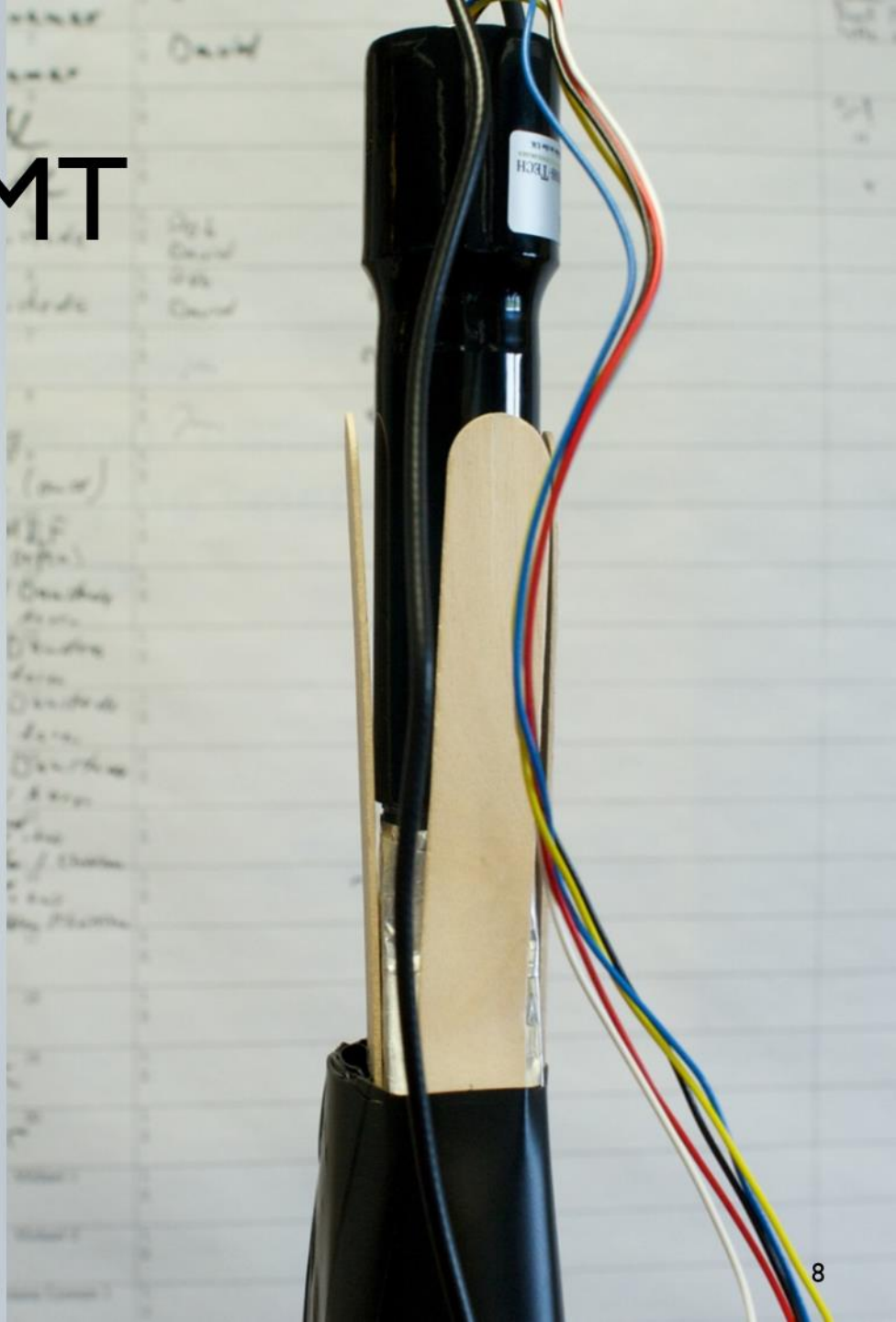
# Scintillator and light guide



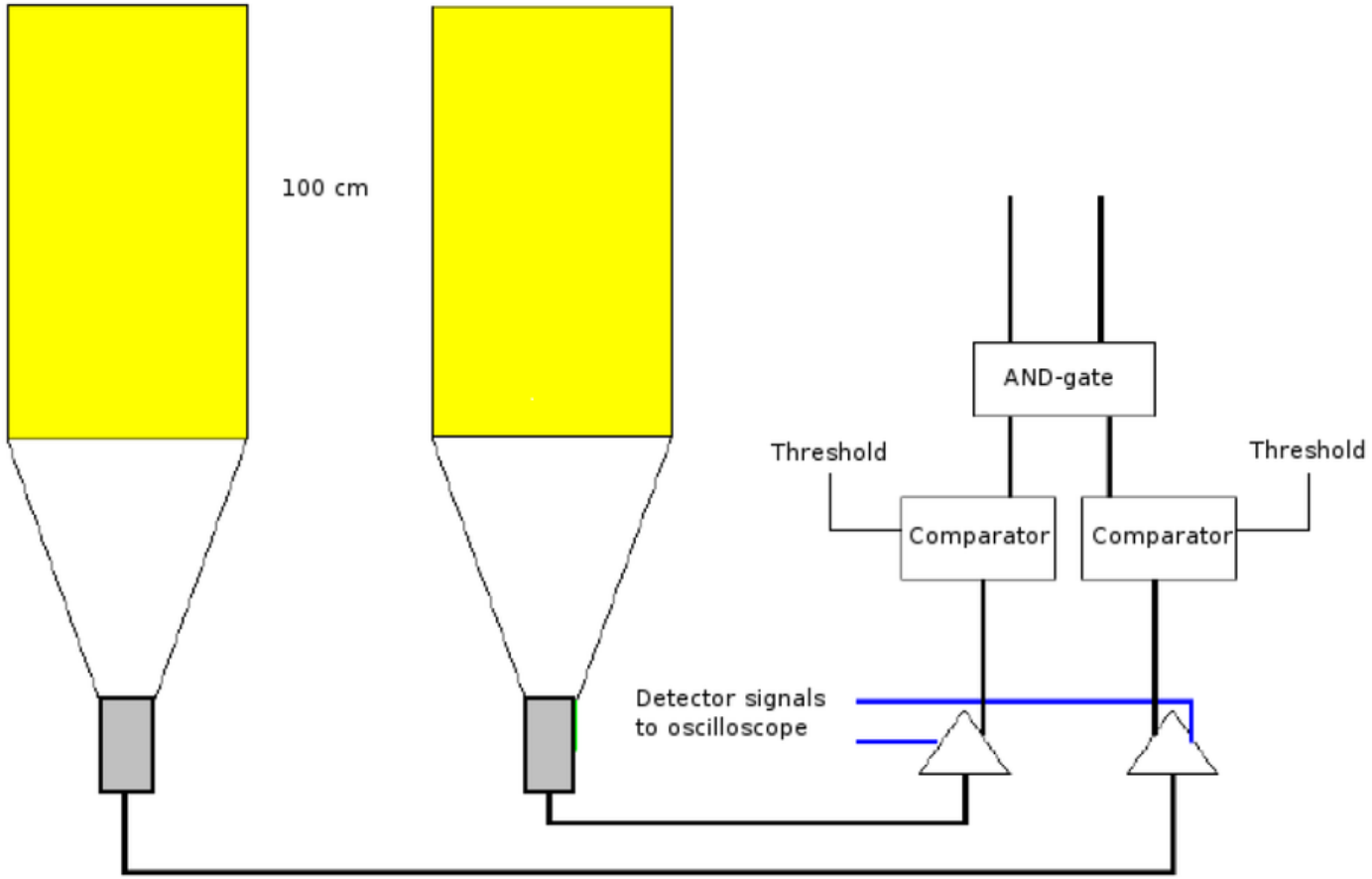
HiSPARC sensitive area is a scintillating plate (plastic) 1.0 m by 0.5 m with a light guide leading to a PMT

# PMT

Fotonen naar electrisch signaal



# HiSPARC layout




Schematic representation of a two plate HiSPARC detector station and processing electronics

# Muon Observatory – shower mode

- Shower recorded as coincidence event from **3** GMTs arranged in a triangle
- This geometry ensures that no single particle can be detected in all **3** tubes

Production of showers may be facilitated by allowing the radiation to pass through something that is slightly "thicker" than air - steel plates

# Muon Observatory – telescope mode

- If a muon passes through all tubes, a pulse is output from coincidence box

Placing steel plates between the tubes ensures that only very high-energy radiation is recorded

# MX10 Particle detectors

- Manufactured by Jablotron (Czech Republic)

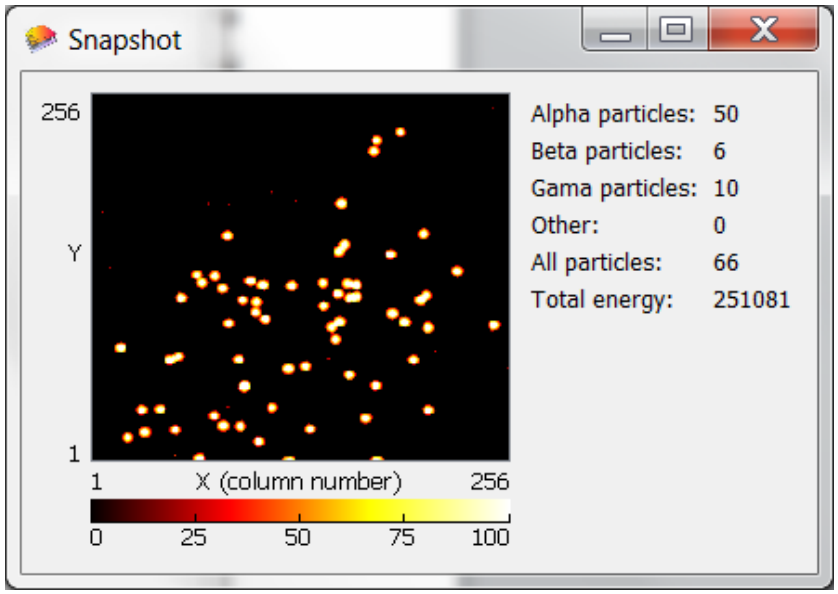
*“The MX-10 Digital particle camera is a state-of-the-art educational tool for demonstrating radiation and analyzing radioactive sources”*

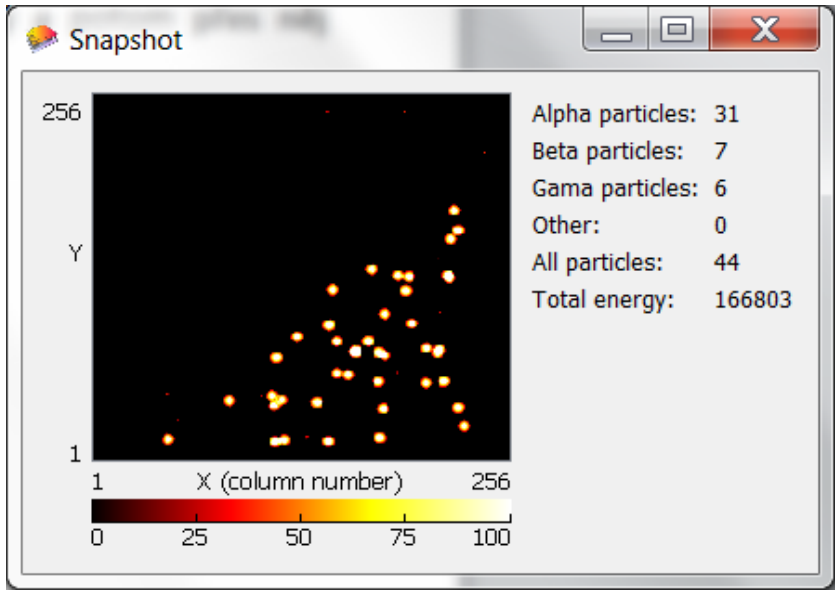
| | | | | |
|---|---|---|---|---|
| Chip | Pixelated 300 µm Si detector chip (256 x 256 pixels, 55 µm pitch) by **Medipix2 Collaboration** | | | |
| Software | Pixelman version 2.2.3 or higher licensed by **IEAP CTU in Prague** | | | |
| Detection ability | **Particle Type** | **Energy Level** | **Efficiency** | **Comment** |
| | Heavy charged particles | > 1 MeV | ~100 % | Alpha, etc. |
| | Electrons (beta) | > 10 keV | ~100 % | |
| | MIP particles | > 1 MeV | ~100 % | Under specific angle, e.g. muons from cosmic rays |
| | X-rays | 6 keV - 10 keV | ~100 % | |
| | X-rays | 20 keV | ~25 % | |
| | X-rays | 60 keV | ~1 % | |
| | Gamma-rays | > 1 MeV | ~0.1 % | |

# Educational activities

- Comes with a variety of activities

e.g. Absorption of alpha particles in paper

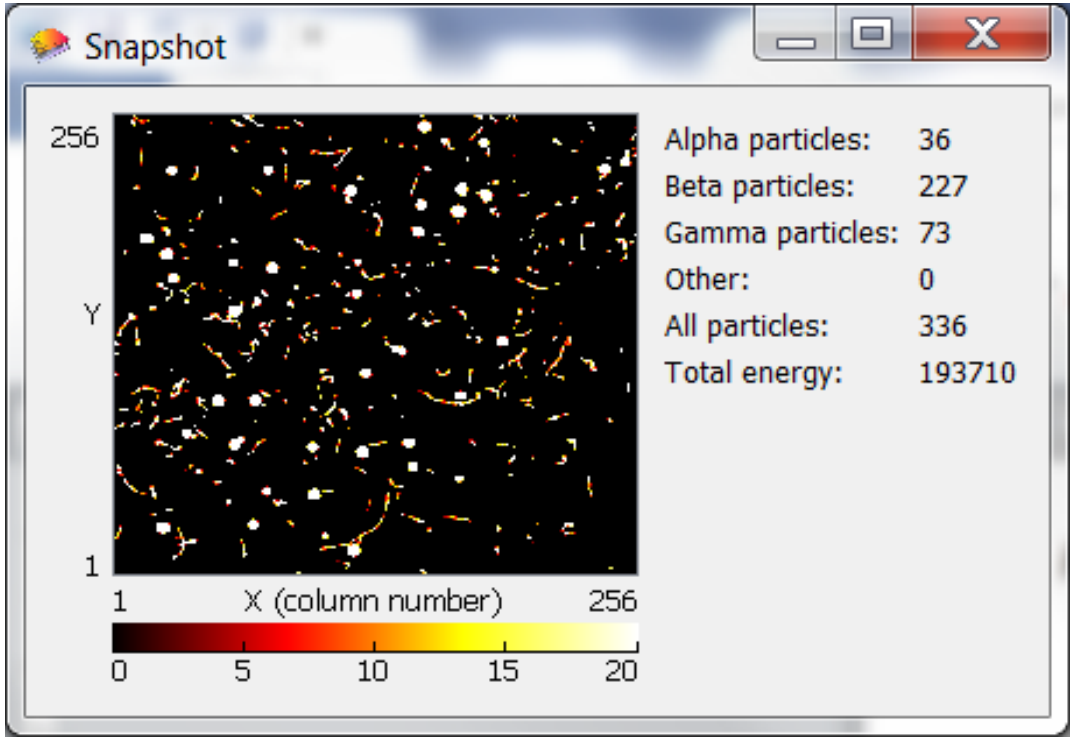


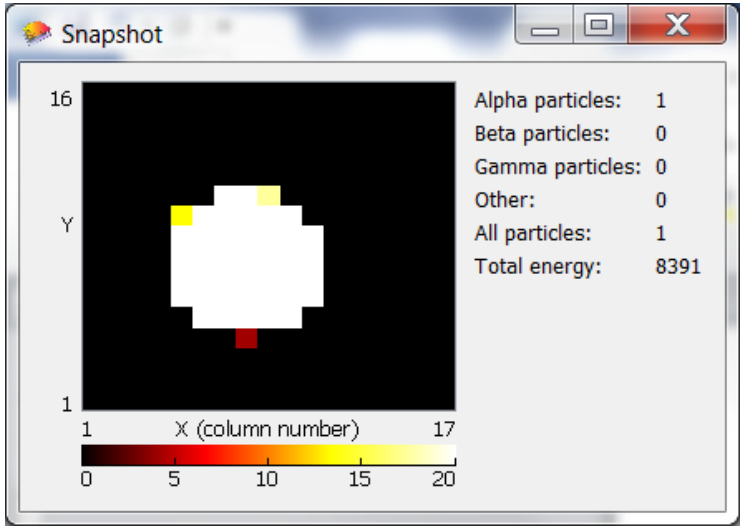




http://www.particlecamera.com/index.php/support-camera-mx-10/experiments-with-mx-10

- Identify types of radioactivity

e.g. decay of Thorium to produce alpha, beta and gamma

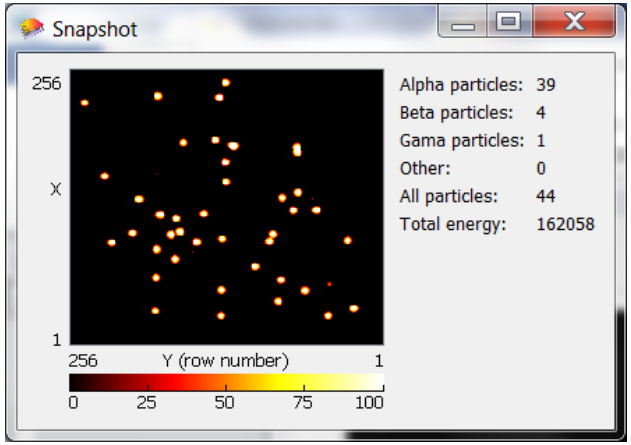


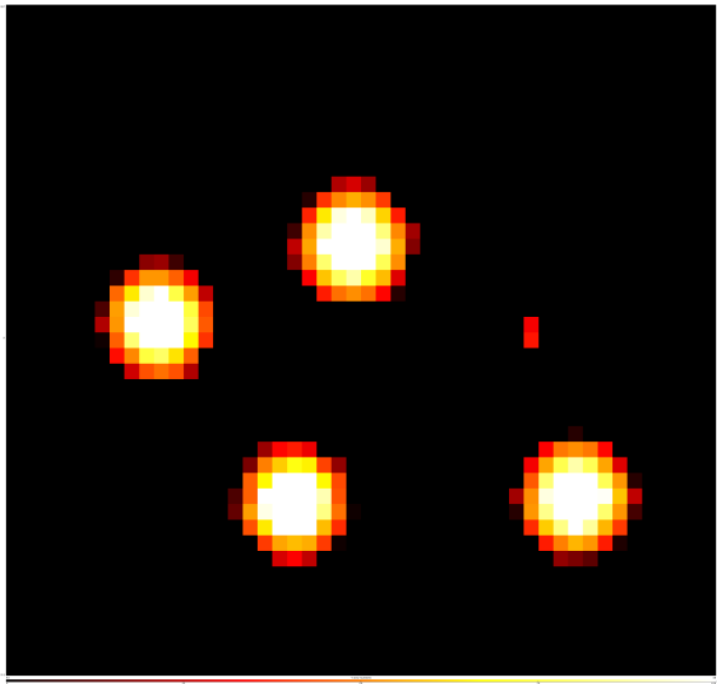



# Alpha particles

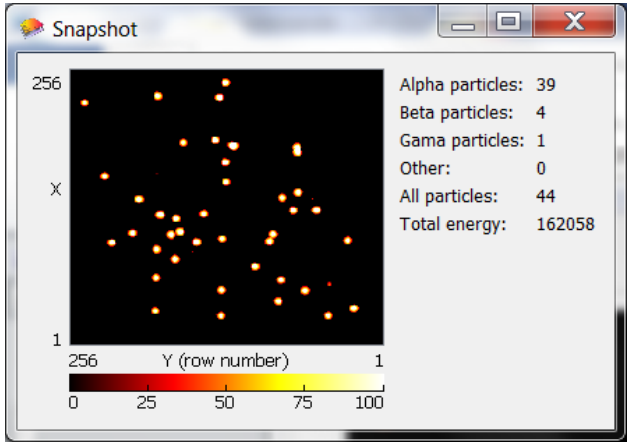
Alpha particles are displayed as large round “blobs“ (>40 pixels) and the energy captured by the detector is high (usually 3000 to 4500 units per particle).

The “blob” edges are red (lower absorbed energy) and the centres are white (higher energy).



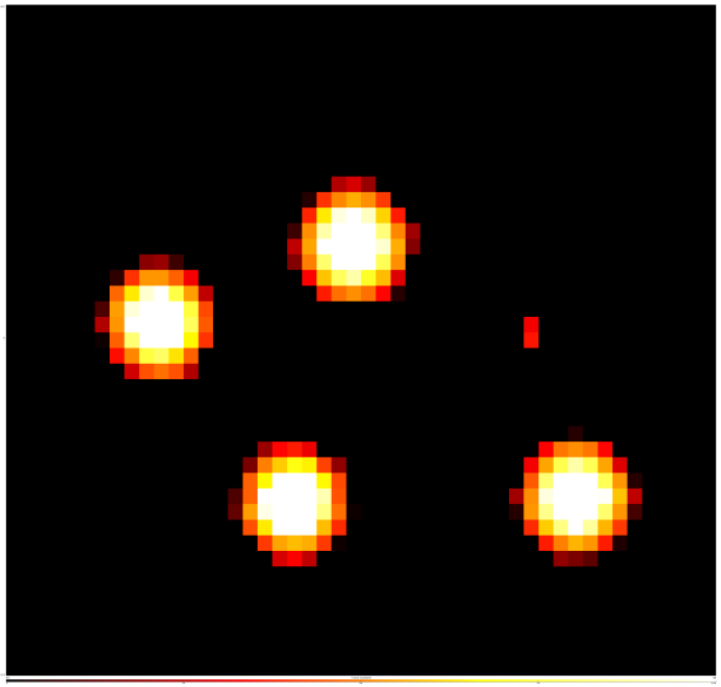



# Alpha particles

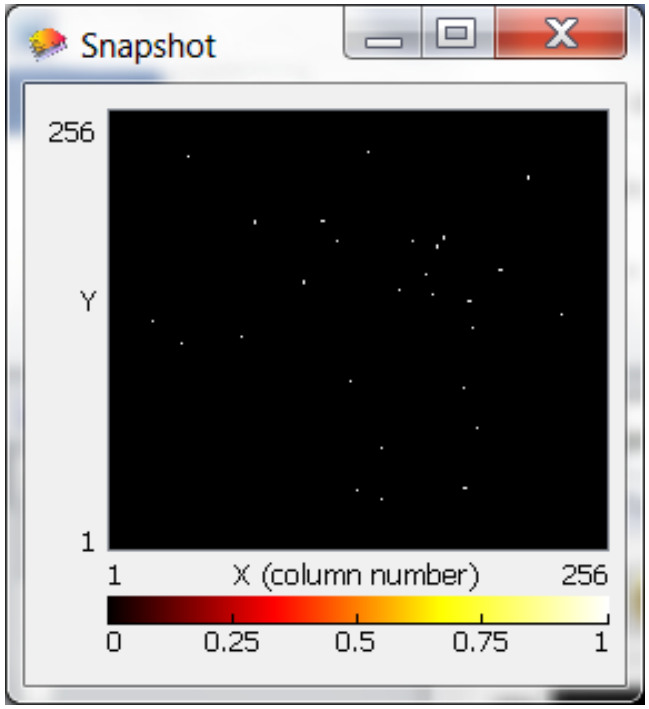


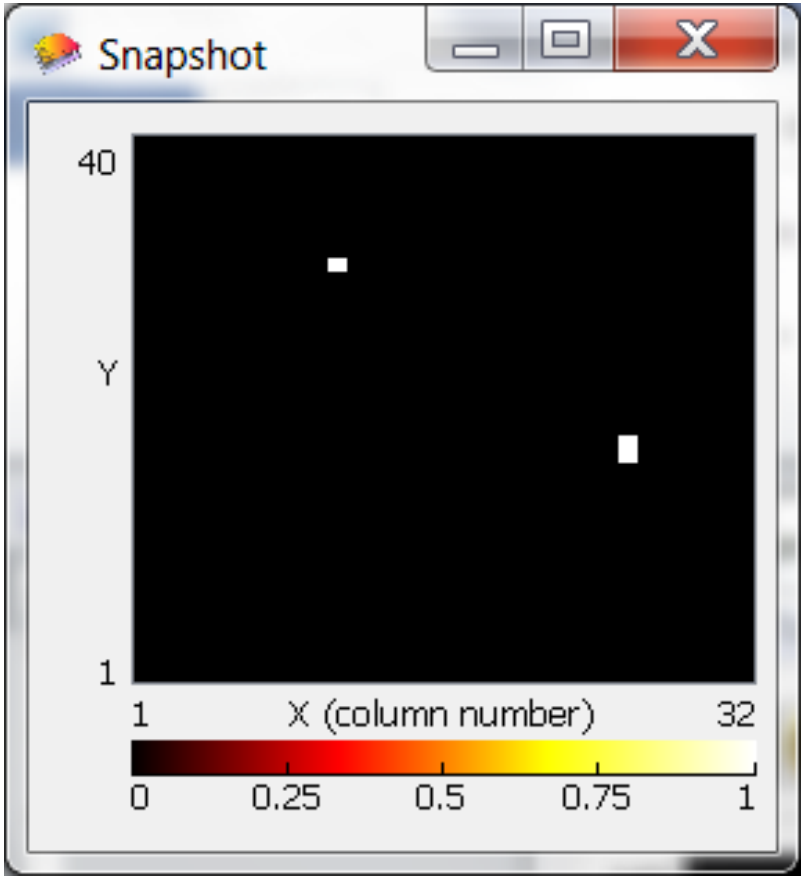

An alpha particle leaves its whole energy in the detector and is completely stopped.

Small traces (usually one or two pixels) are caused by gamma photons.



# Gamma-rays




Majority of the traces are one-pixel or two-pixels

# HiSPARC

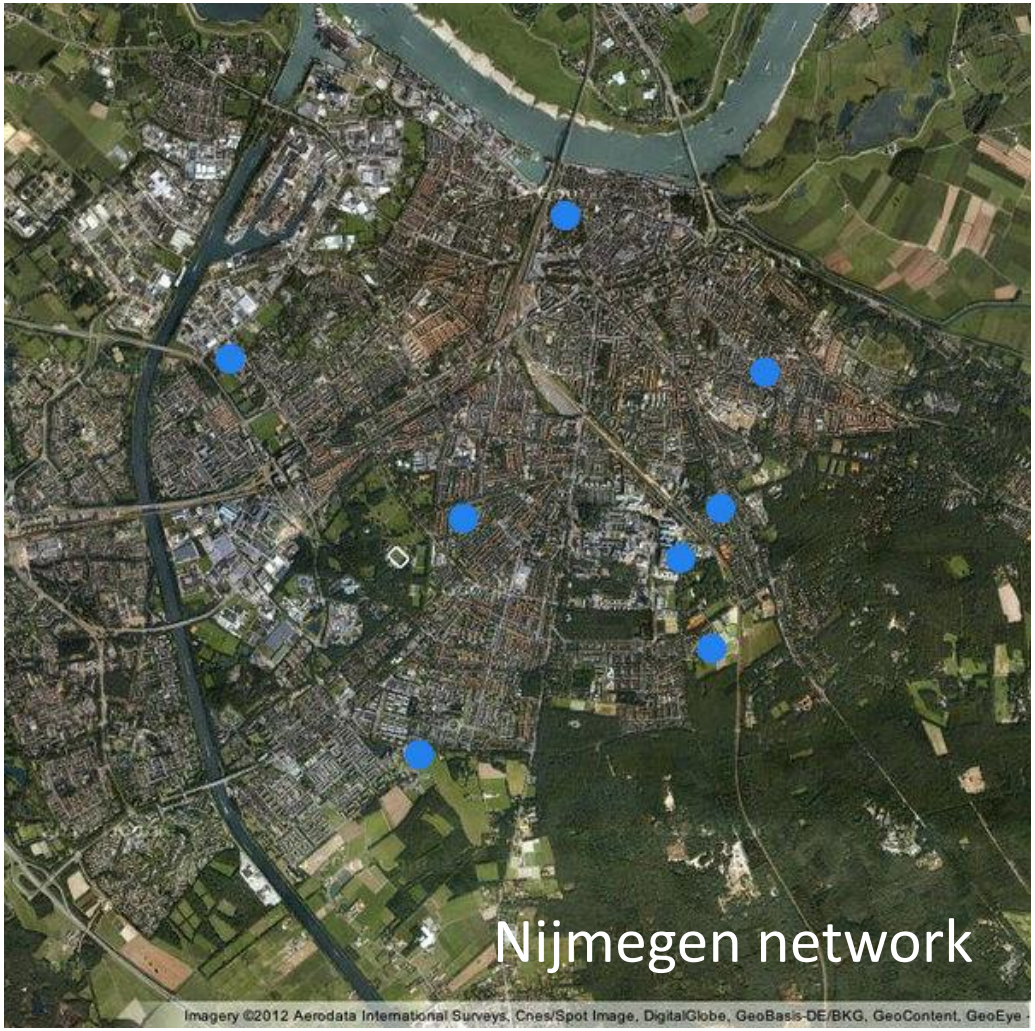
- Network of detectors across Netherlands


http://www.hisparc.nl/en/about-hisparc/

# History

- Started 2003, Radboud University (Nijmegen)
- Rooftop detector at university, engagement with local schools
- Soon became a national project
- **Hi**gh **S**chool **P**roject on **A**strophysics **R**esearch with **C**osmics (HiSPARC)

- Now **>100** detectors in **7** clusters around the Netherlands, and expanded internationally




http://data.hisparc.nl/show/stations_by_country/