

COSMICWATCH

LOCATION: GEOGRAPHICAL SOUTH POLE
DATE: Nov. 29TH 2018.

Detecting Cosmic Rays at home & Building your own version of the Large Hadron Collider

Why everyone here should have a banana in their astro kit!

Dr Andrew Thornett

Photo reproduced with permission CosmicWatch



Does your astronomy feel increasingly like this?



*Think
outside of
your
telescope's
box*

*A form of astronomy that you can still
do when rains or snows*

**Before I go further...all of these
are supposed to prevent
successful radio astronomy**

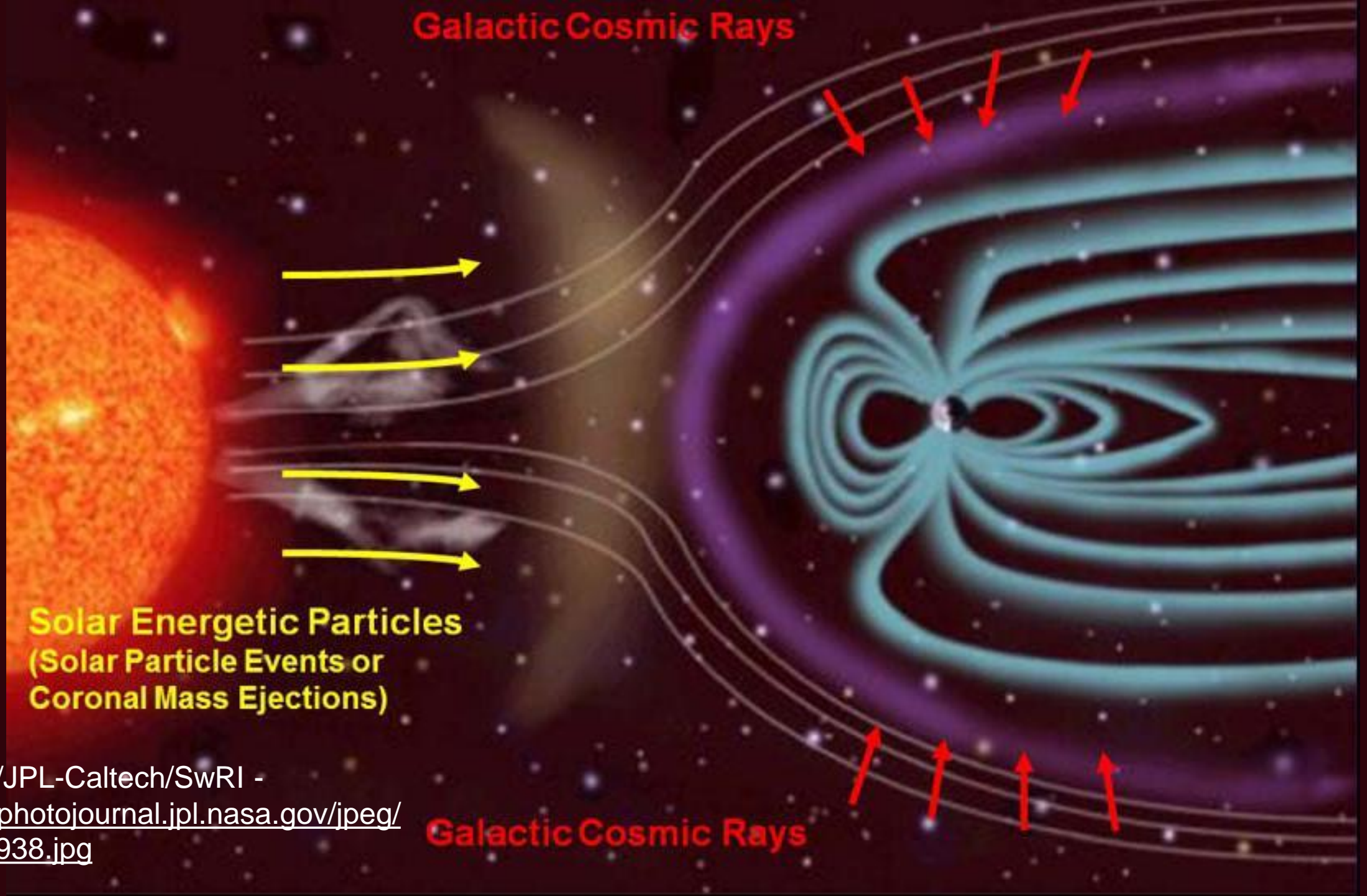
- I live in a moderate sized town 400m from large supermarket
- I do NOT have enormous garden
- I DO experience lots of radio interference!



Your own particle collider at home

- Make use of natural 20km collider above our heads.
- Build or buy your own detector.
- Use same physics as professional observatories.
- For < price good quality eyepiece.

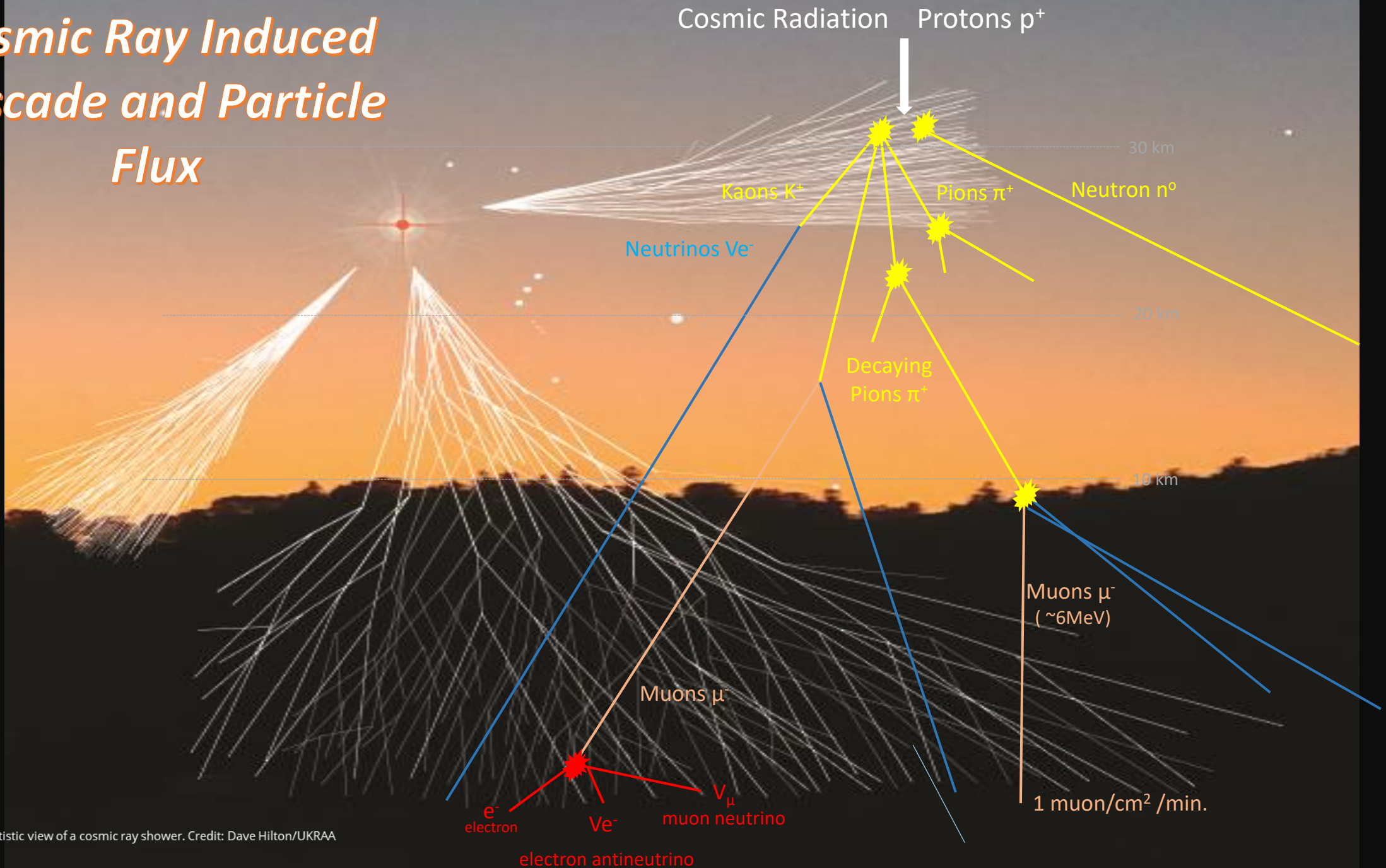
Galactic Cosmic Rays



**Solar Energetic Particles
(Solar Particle Events or
Coronal Mass Ejections)**

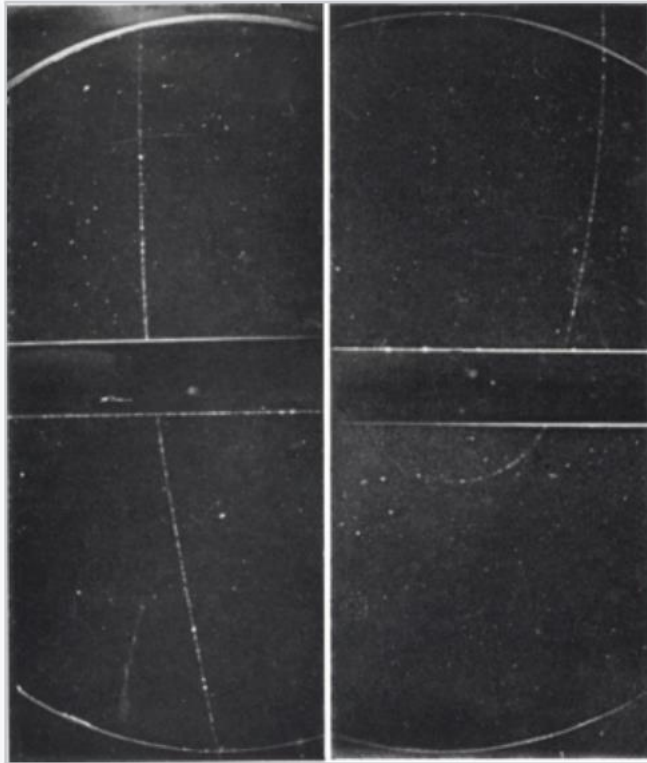
Galactic Cosmic Rays

Cosmic Ray Induced Cascade and Particle Flux



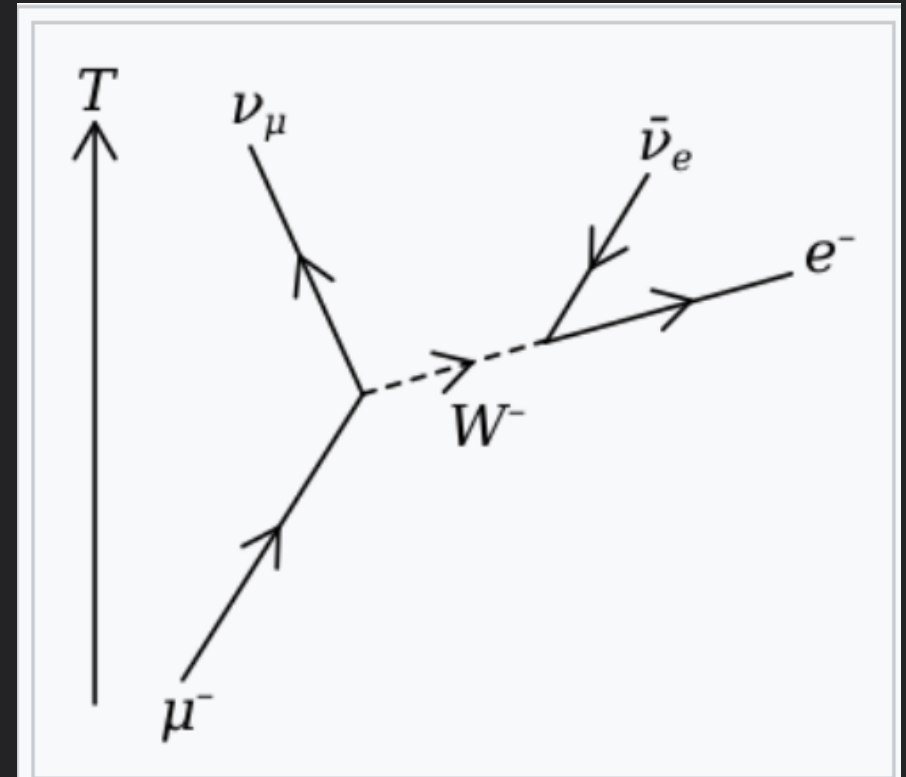
Artistic view of a cosmic ray shower. Credit: Dave Hilton/UKRAA

What is a muon?



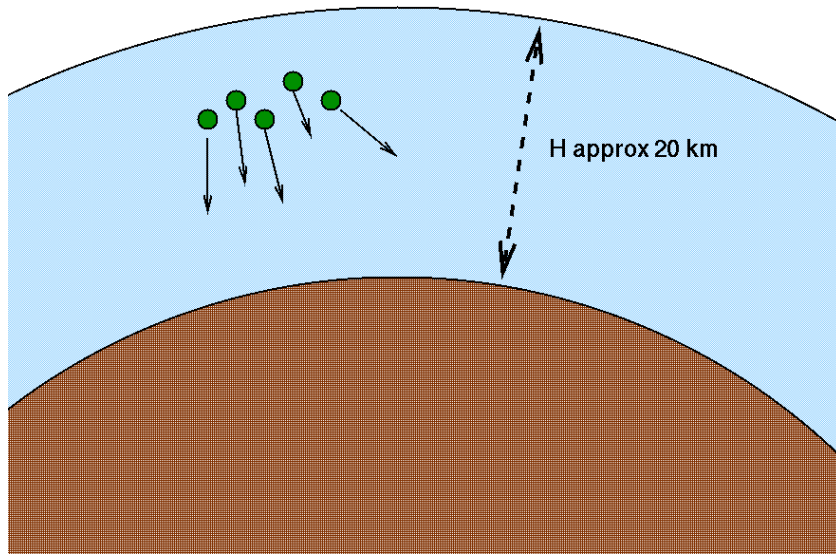
Cosmic ray muon passing through lead in cloud chamber

Muons are unstable elementary particles and are heavier than electrons and neutrinos but lighter than all other matter particles.



The most common decay of the muon

Muon Life Expectancy



Muons also can be created in laboratory, where their lifetime has been measured:

$$\text{muon lifetime } t = 2 \times 10^{-6} \text{ seconds}$$

No real "edge" to the Earth's atmosphere.

Cosmic ray collisions occur at about 20km height..

How can we detect muons from Cosmic Rays at Sea Level?

- Muons can be detected at sea level due to **time dilation** that occurs as result of Einstein's Special Theory of Relativity.
- Muons travel close to speed of light -- relative to the Earth and people on the ground – as result of relativity their clocks run slowly; that means that their lifetimes will be extended, long enough to reach the ground.
- Therefore, detecting muons with your detector gives evidence to support Einstein's Theory.

Muon Detection available to amateurs

- Development of new detectors available to amateurs
- CosmicWatch kit
- UKRAA produce version of these in UK – available as kit (if you feel confident with soldering iron) OR as fully made and tested device (which is what I bought)
- Ideally have two for concidence.
- *UKRAA is a charitable incorporated organisation (CIO) which operates as a not-for-profit company. Our activities are carried out by volunteers with the Trustees freely giving their time and expertise.*

Building your own Muon Detector using CosmicWatch plans (buying own components)


Not secure | www.cosmicwatch.lns.mit.edu/detector#steps

CosmicWatch About the project News! Detector Start measurement Forum FAQ Downloads

Step-by-step instructions for the latest version of the detector (v2) including SD card reader and coincidence connection, can be found here.
Below, you can find the instructions for v1.

- Introduction
- Purchasing components
- Arduino
- Main PCB
- SIPM PCB
- Scintillator
- Assembling the detector
- Electronics ▾
- Calibration
- Recording data
- Troubleshooting

Introduction



Free software that works well!

The screenshot shows a GitHub repository page for 'spenceraxani / CosmicWatch-Desktop-Muon-Detector-v2'. The repository is public and has 63 forks and 214 stars. The main content is a file list for the 'py2 and py3' branch, showing various folders and files with their commit dates. The right sidebar contains sections for 'About', 'Releases', and 'Packages', all of which are currently empty or show no published content.

Product ▾ Solutions ▾ Open Source ▾ Pricing

Search or jump to...

spenceraxani / CosmicWatch-Desktop-Muon-Detector-v2 Public Notifications Fork 63

Code Issues 65 Pull requests Actions Projects Security Insights

master 1 branch 0 tags Go to file Code

spenceraxani py2 and py3 69dbb5 on Jan 26 47 commits

Arduino	adding Gerber file with larger snapp-off connections for JLCPCB	2 years ago
CAD	.DS_Store banished!	6 years ago
Datasheets	.DS_Store banished!	6 years ago
Enclosure_Files	updated instructions	5 years ago
PCB_Files	updating PCB to include a reflective plane.	2 years ago
Pictures	fixing typos	4 years ago
Recording_Data	py2 and py3	last year
.gitignore	.DS_Store banished!	6 years ago
Instructions.pdf	Updating OLED info	5 years ago
Purchasing_List.xlsx	updated purchasing list	last year
README.md	adding paper	5 years ago
ThePhysicsPaper.pdf	Updating Physics Paper	5 years ago

About
The CosmicWatch Desktop Muon Detector supplementary material

- Readme
- Activity
- 214 stars
- 25 watching
- 63 forks

Report repository

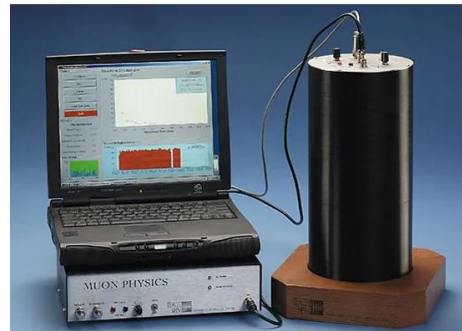
Releases
No releases published

Packages
No packages published

Muonpi – Similar detector, Community network of detectors

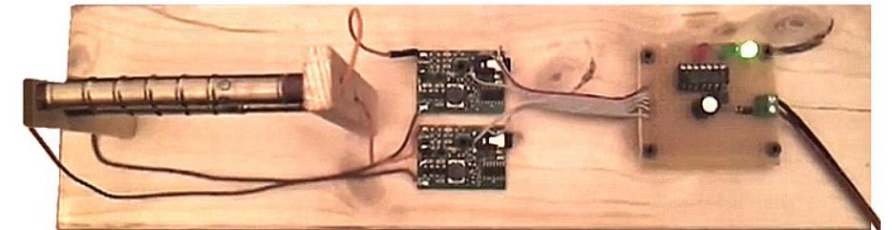
- Website: www.muonpi.org
- You can offer to host a detector by emailing support@muonpi.org

Other providers



- Measure Muon Lifetime
- Demonstrate Relativistic Time Dilation
- Measure Local Muon Flux
- Measure Sea Level Muon Charge Ratio
- Convenient Source of Genuinely Random Numbers
- Create Simulated "Muons" and Measure their Lifetime
- Study Processing of Photomultiplier Signal

Coincidence detector



This is the detector of coincidences of Alessio, You can see it work in this video:

<http://www.youtube.com/watch?v=82oifYjycoo>

Documentation and notes for using the coincidence detector:

[CosmicRaysDetector_ITA.pdf](#)

[CosmicRaysDetector_ENG.pdf](#)

Other information on the detectors in coincidence, cosmic rays and muons, here:

<http://hardhack.org.au/book/export/html/2>

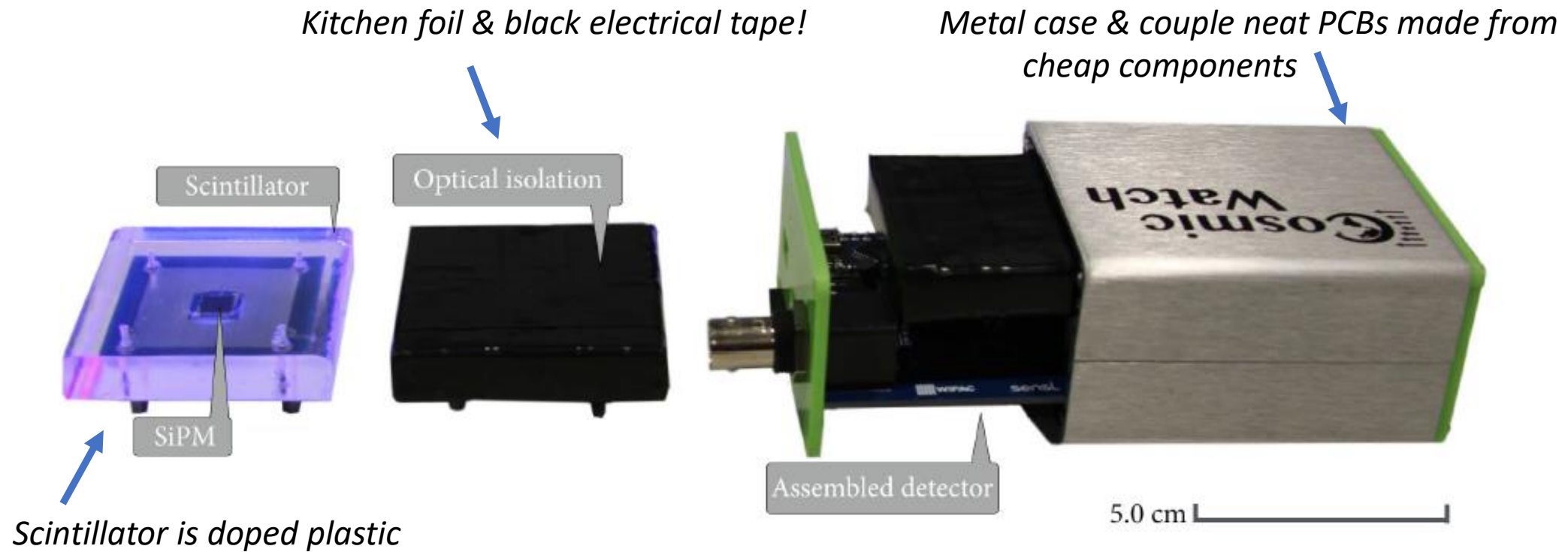
The scheme is simple and can be assembled in five minutes even on a Breadboard. If you connect the outputs to a Master you can count regardless of the three channels by configuring the input Pin as simple Counter. You do not need to set the pins like FastCounter, because the number of events per minute is very low.

<https://www.theremino.com/en/hardware/inputs/radioactivity-sensors#geiger>

Methods that use smartphones as detectors of interactions with cosmic ray muons

- US Distributed Electronic Cosmic-Ray Observatory, DECO.
- Poland-based Cosmic-Ray Extremely Distributed Observatory, CREDO

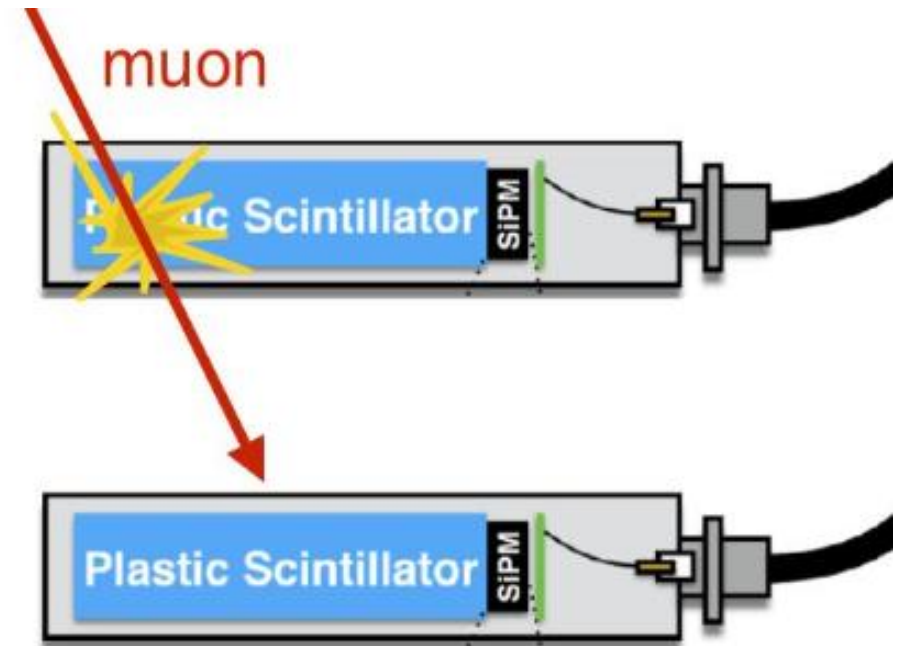
Components of Desktop Muon Detector



Coincident measurements (Master/Slave Configuration)

- Using a coincident measurement we can reduce the background.
- We can also get directional information this way.
- We can also go deep underground to eliminate the muons and only have the background.

Direction of travel

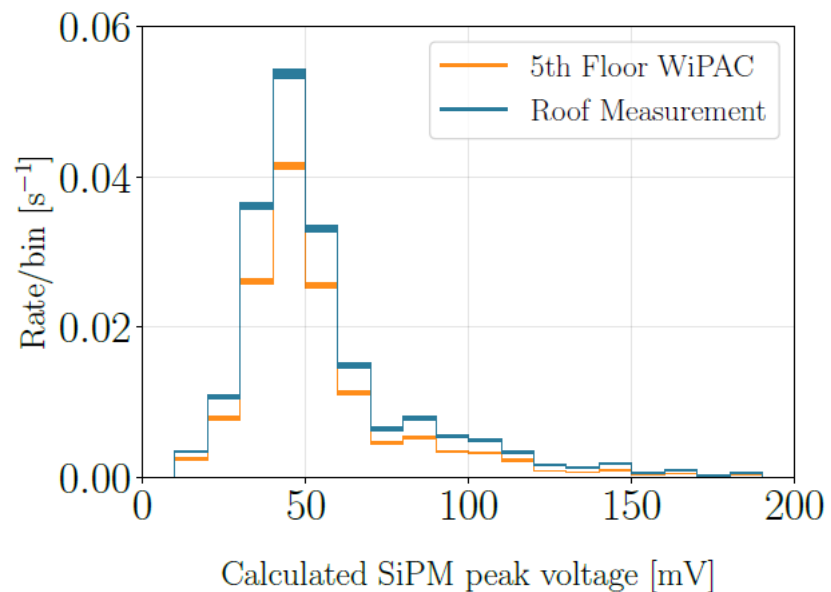


Height from ground and rate of muon detection

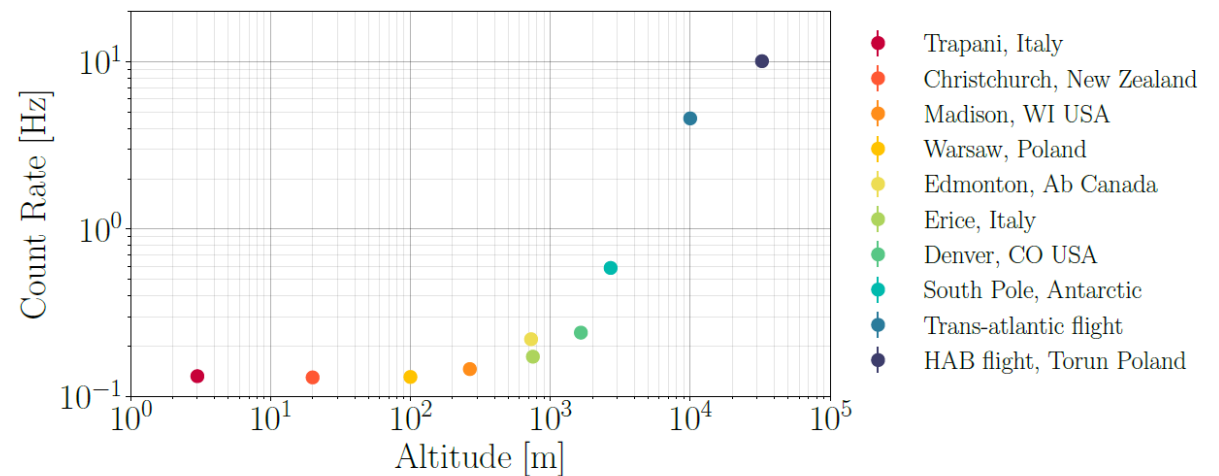
NEARSPACE2018
HIGH ALTITUDE BALLOON MISSION
ALTITUDE: 107,000FT



COSMICWATCH
DESKTOP MUON DETECTOR



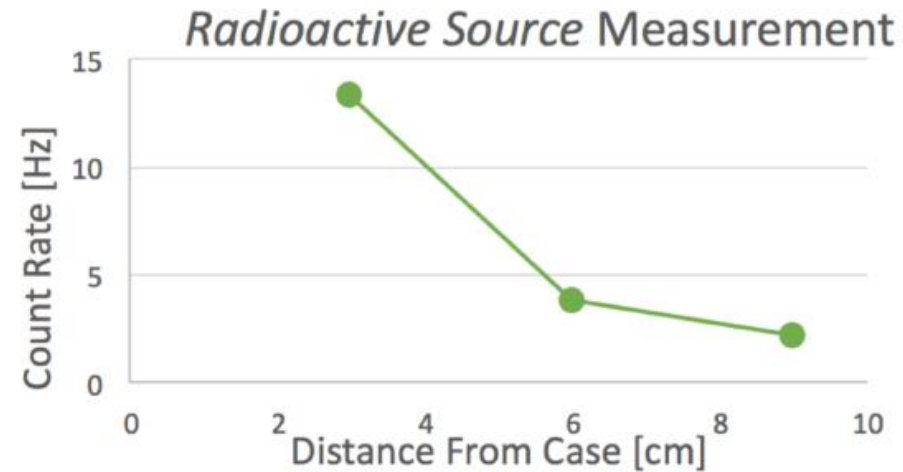
The calculated SiPM peak voltage on the roof of the WiPAC building compared to on the 5th floor.



The coincident detector count rate at various locations throughout the world. The trans-Atlantic flight rate was measured at 30,000ft

Graphics and photo reproduced with permission CosmicWatch

Radiation sources and rate of detection



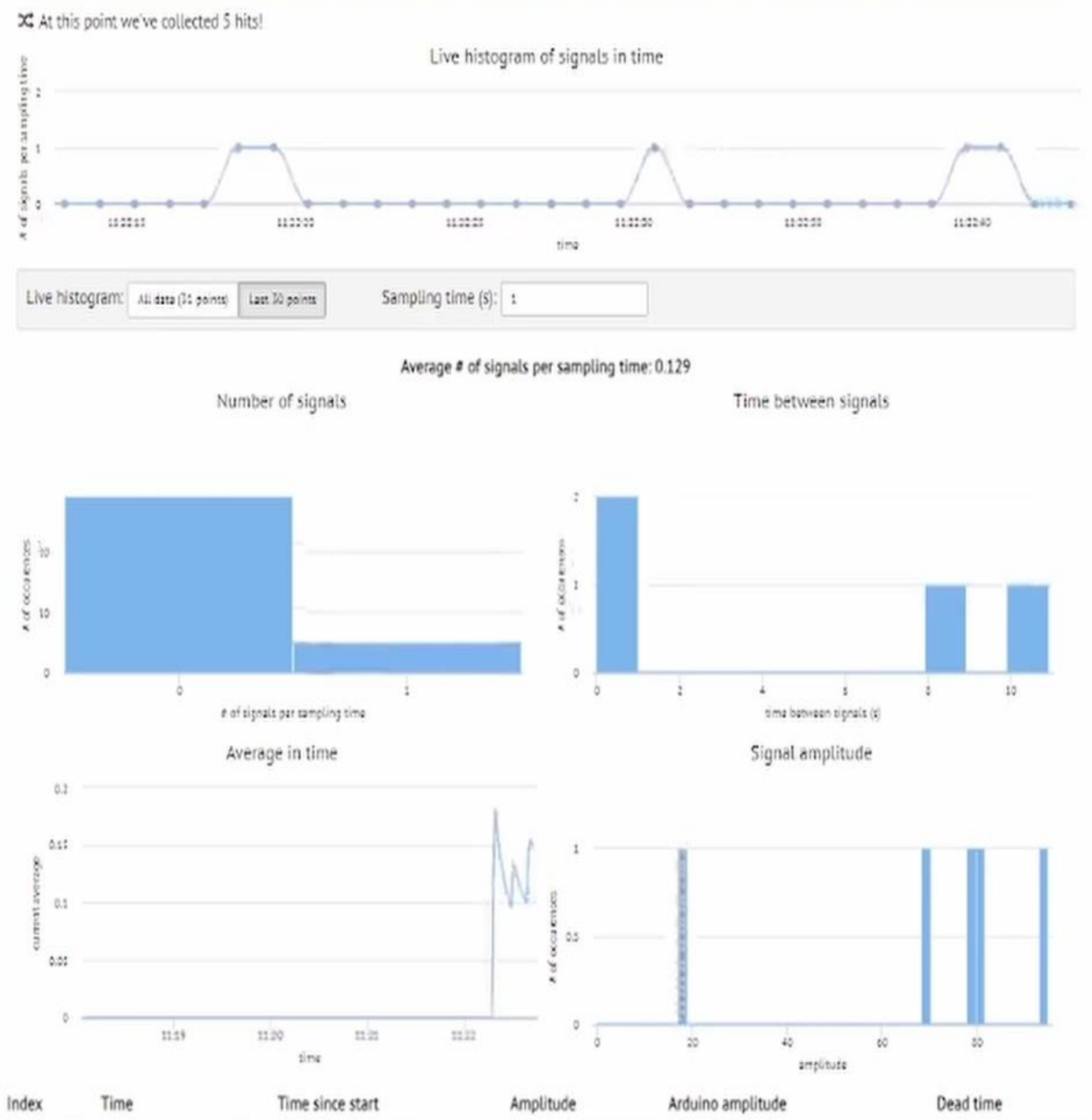
The measured trigger rate as a function of distance between using a rock containing uranium and a detector.

LRO Muon Detectors – note my notes on side enclosures to tell me what to do!

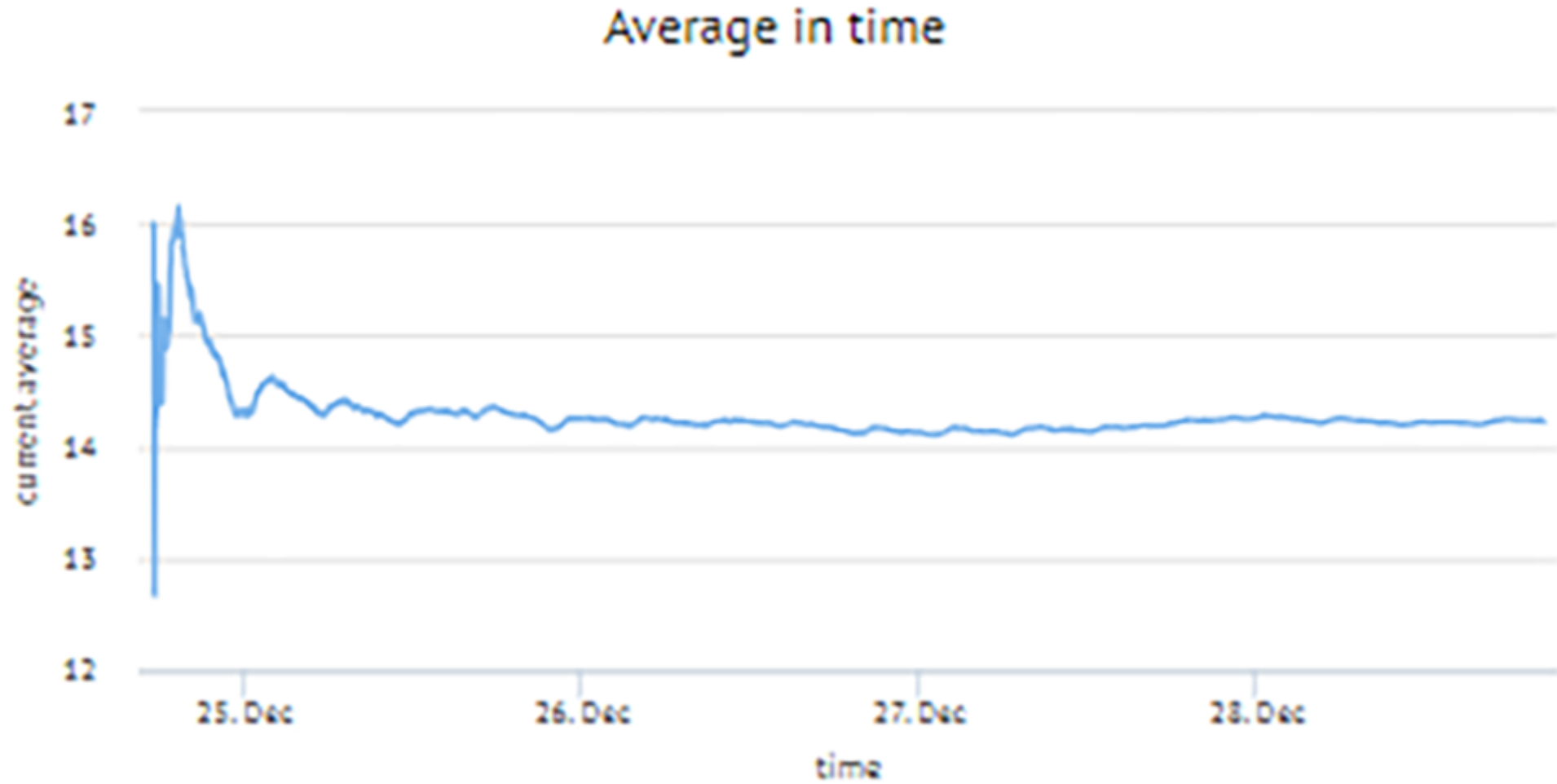


You can see the real thing downstairs on BAA stand

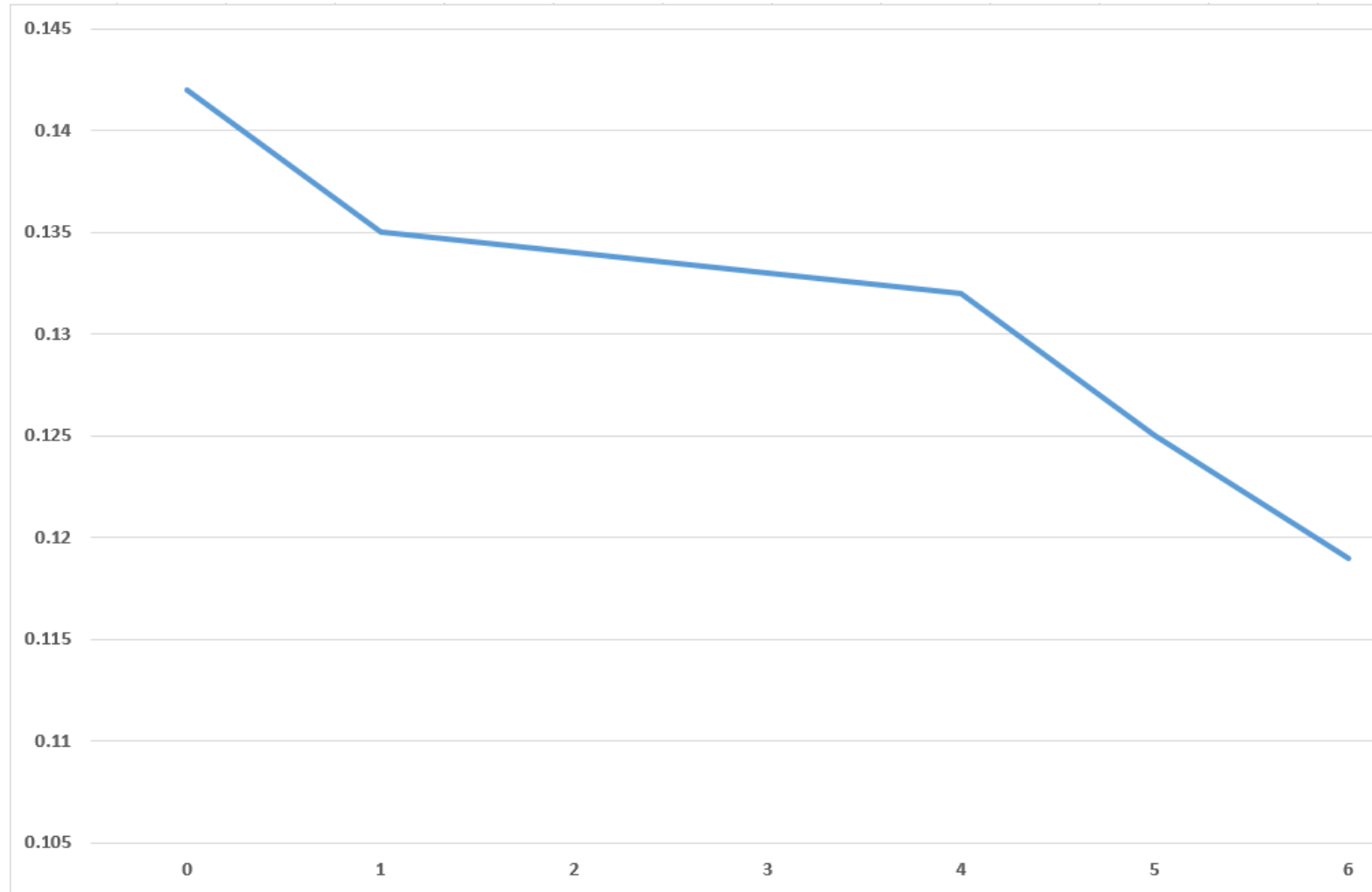
Charting muon data via Cosmic Watch website (LRO Data)



No discernable change muon flux day vs night (LRO Data)



Muon Count @ LRO/sec. with varying amounts lead under detectors (coincidence mode) (cm)

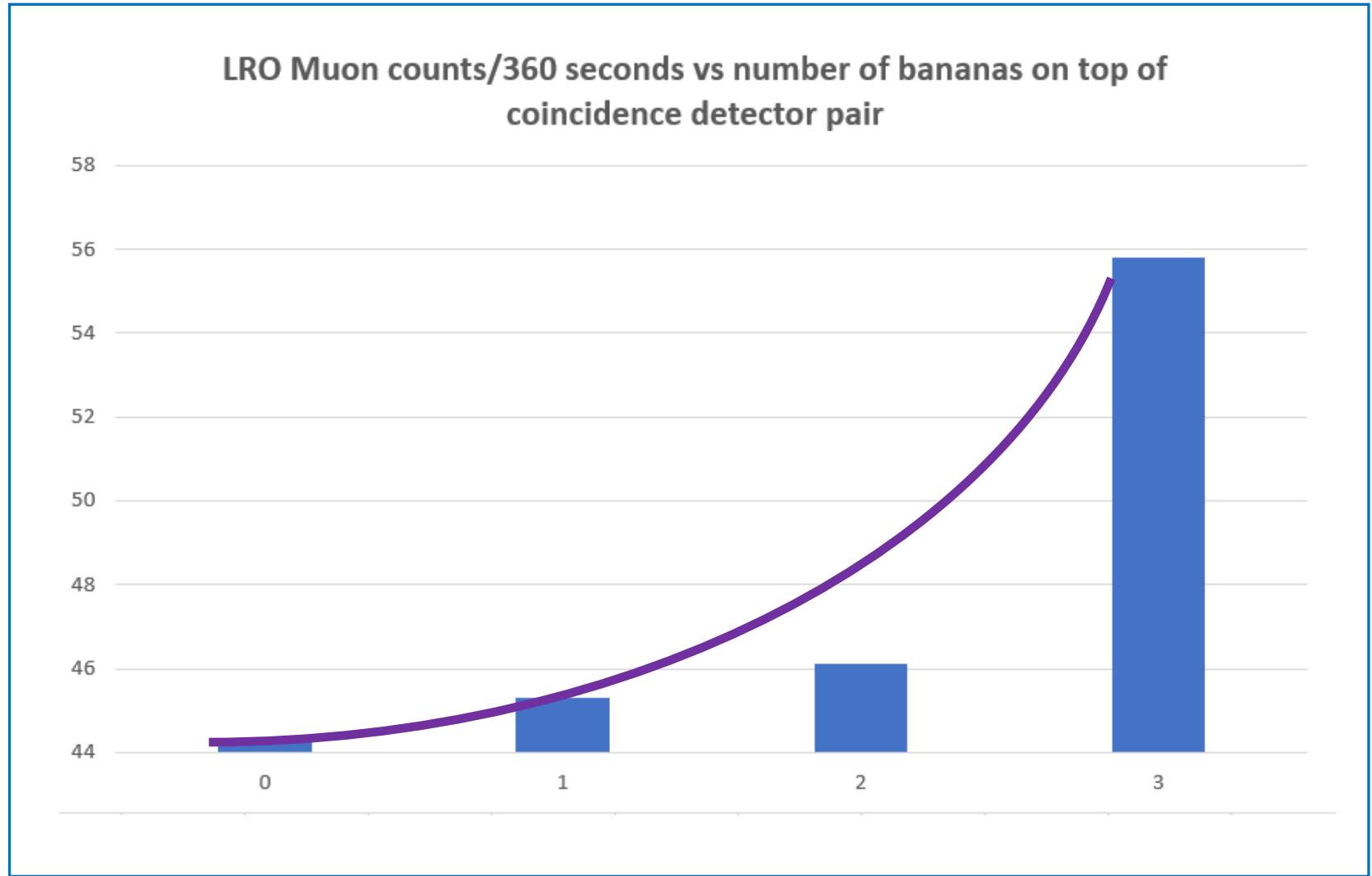


Unit of radiation used for next
experiment = The Banana





In the name of good science, I tasted these afterwards to ensure they were real bananas!



6kg of scrap lead roof flashing

My next project...

Breaking ground on the Lichfield
Ridiculously Small Neutrino Detector

I've got to dig 1km down...!

**Many thanks to following for
their graphics that I have used in
this talk:**

**Graphic and photos from CosmicWatch website and
papers used with kind permission.**

**Muons hitting atmosphere and associated graphics:
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Talks for clubs

*I would to hear
About what you are
doing*