



VETENSKAPENS HUS

Cosmic Ray outreach in Stockholm

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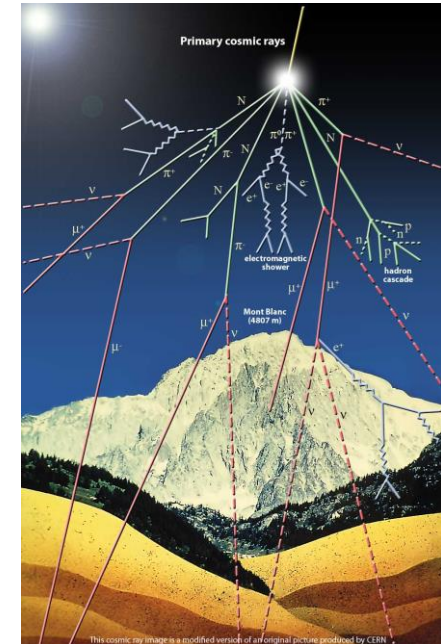
- Owned by KTH and Stockholm University
- Aims to inspire young adults and increase interest for science and technology
- Connection to front-line research is important. Possibility for collaboration with active researchers
- Provide access to equipment unavailable to schools
- 70000 visitors during 2015
- Physics, chemistry, biology, mathematics and technology
- 100 school programs (39 physics, one on cosmic rays)
- School classes visit for 1.5-3 hours
- Longer project work during last year of high school
- Teacher training courses and public events



High school projects in Stockholm

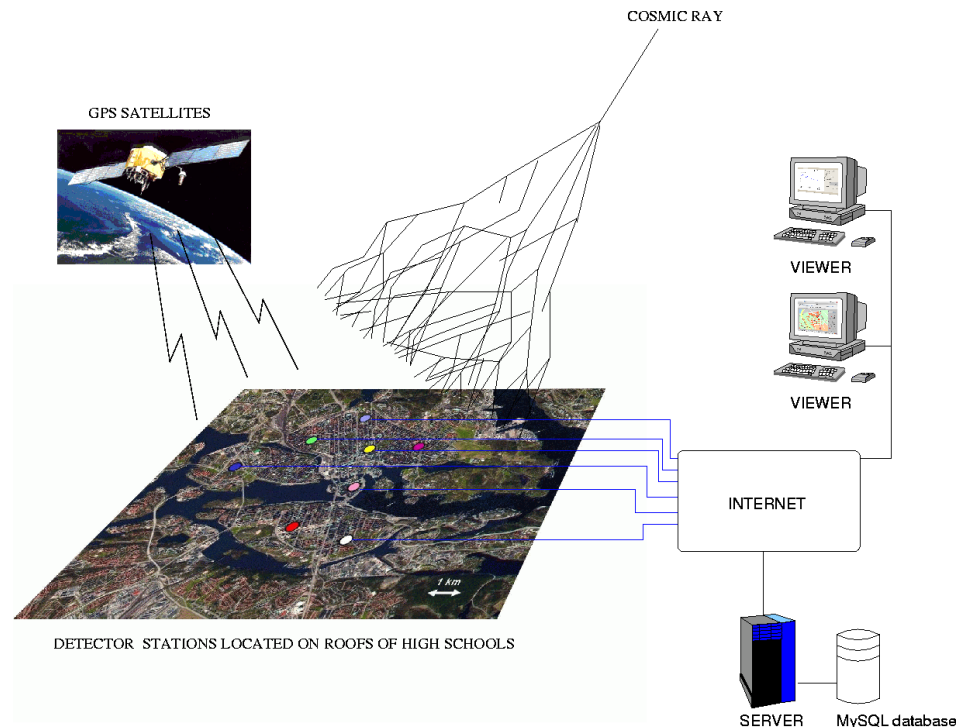


- Project work during the last year of upper secondary school (18 – 19 years of age)
- A collaboration between the Department of Physics at KTH and Stockholm House of Science.
- Pupils are introduced to an interesting and current research field and learn how to work scientifically.
- 20 – 25 students per year for 12 years

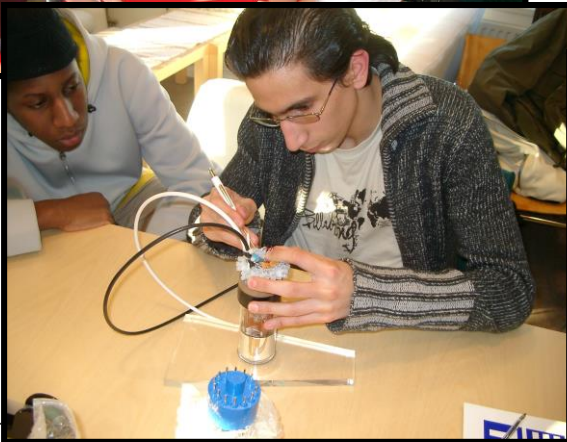


SEASA – Stockholm Educational Air Shower Array

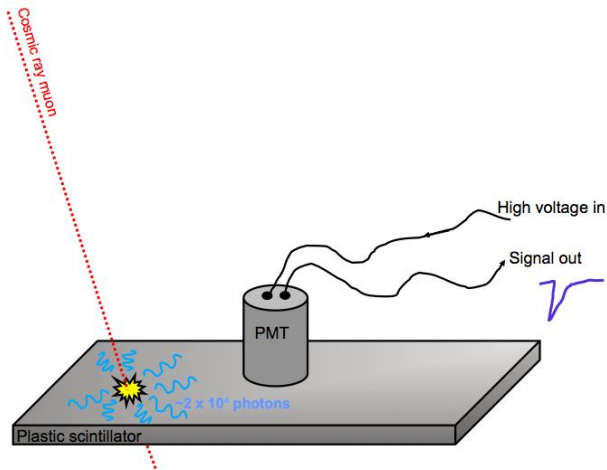
- Planning started 2002
- Construction and testing 2003-2005
- Collaboration with 5 schools in the Stockholm area
- High school students involved in building detectors 2005/2006
- Operational 2006-2010
- Became difficult to maintain due to lack of manpower



High-school students building detectors



New approach – detectors of different sizes made available to high school students



Cosmic Ray Telescope



Cosmic ray outreach in Stockholm



Gigantos



Cosmic ray outreach in Stockholm

The "Flux" PFD



School program on cosmic rays

- School classes visit for 1.5 – 3 hours
- Lecture on cosmic rays
- Study films from cosmic ray measurements at the International Space Station
- Measure muons on ground
- Determine muon half-life

Project work for high school students – How does it work?

- Scientific investigation during last year of high school
- Pose a question and make a hypothesis
- Plan the measurements
- Make the measurements and analyze the data
- Summarize and present

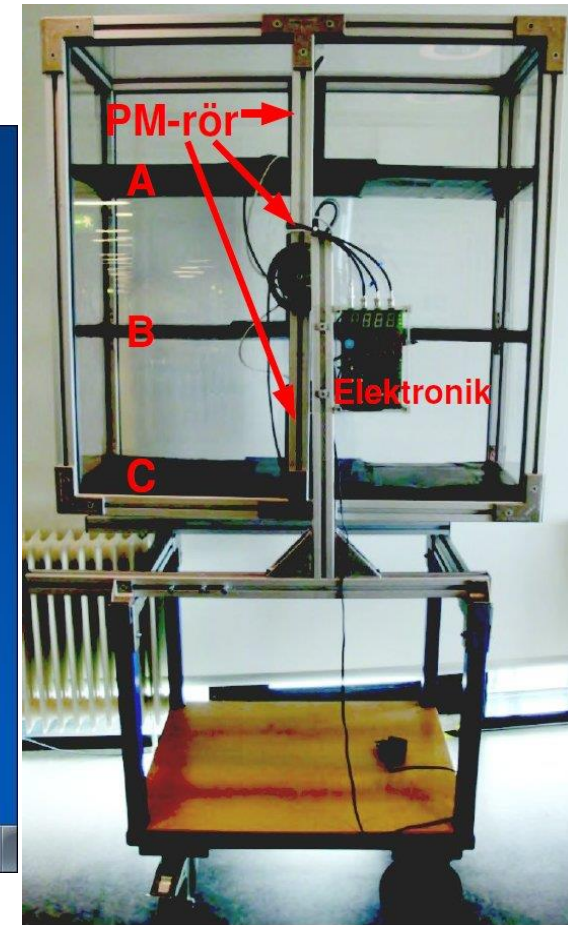
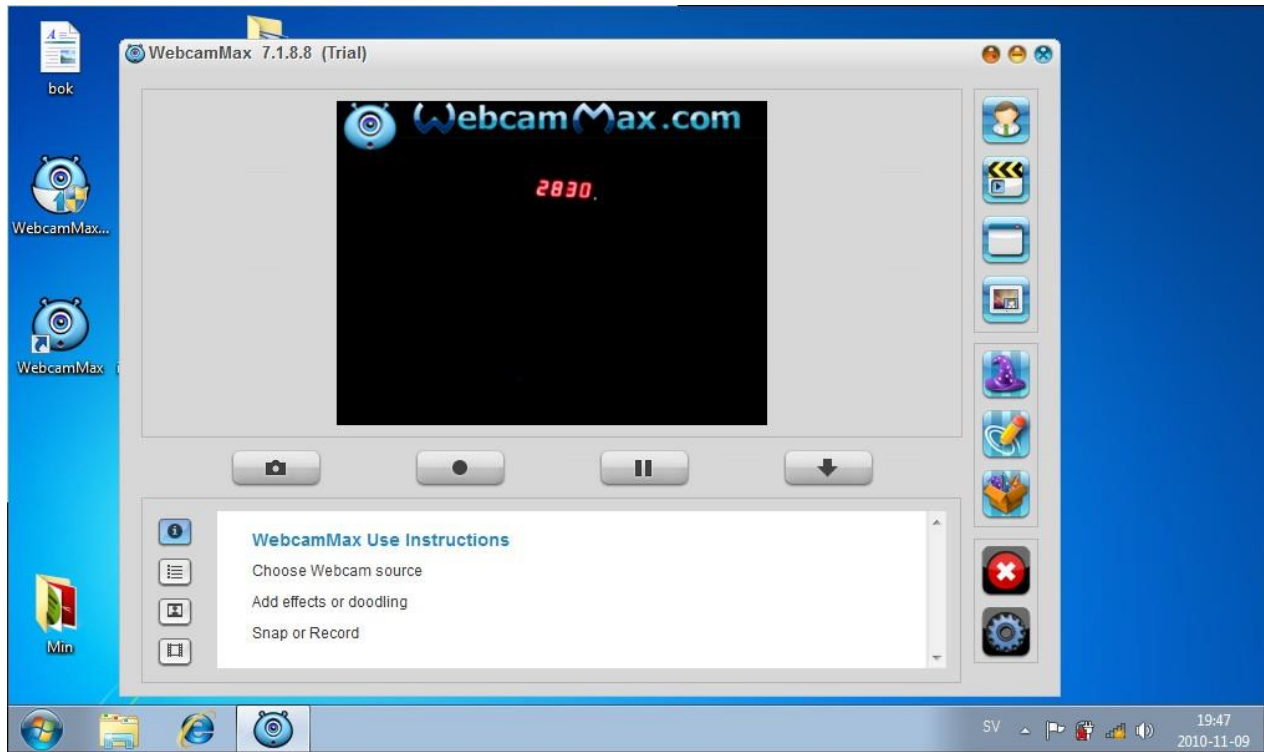
Project works – How do we help?

- 5 – 6 meetings, 2 h/meeting
- Lectures by scientists, demonstrations and assistance with data analysis. Tutoring.
- The pupils can borrow the muon detectors to do measurements at home, or come to our labs.

Examples:

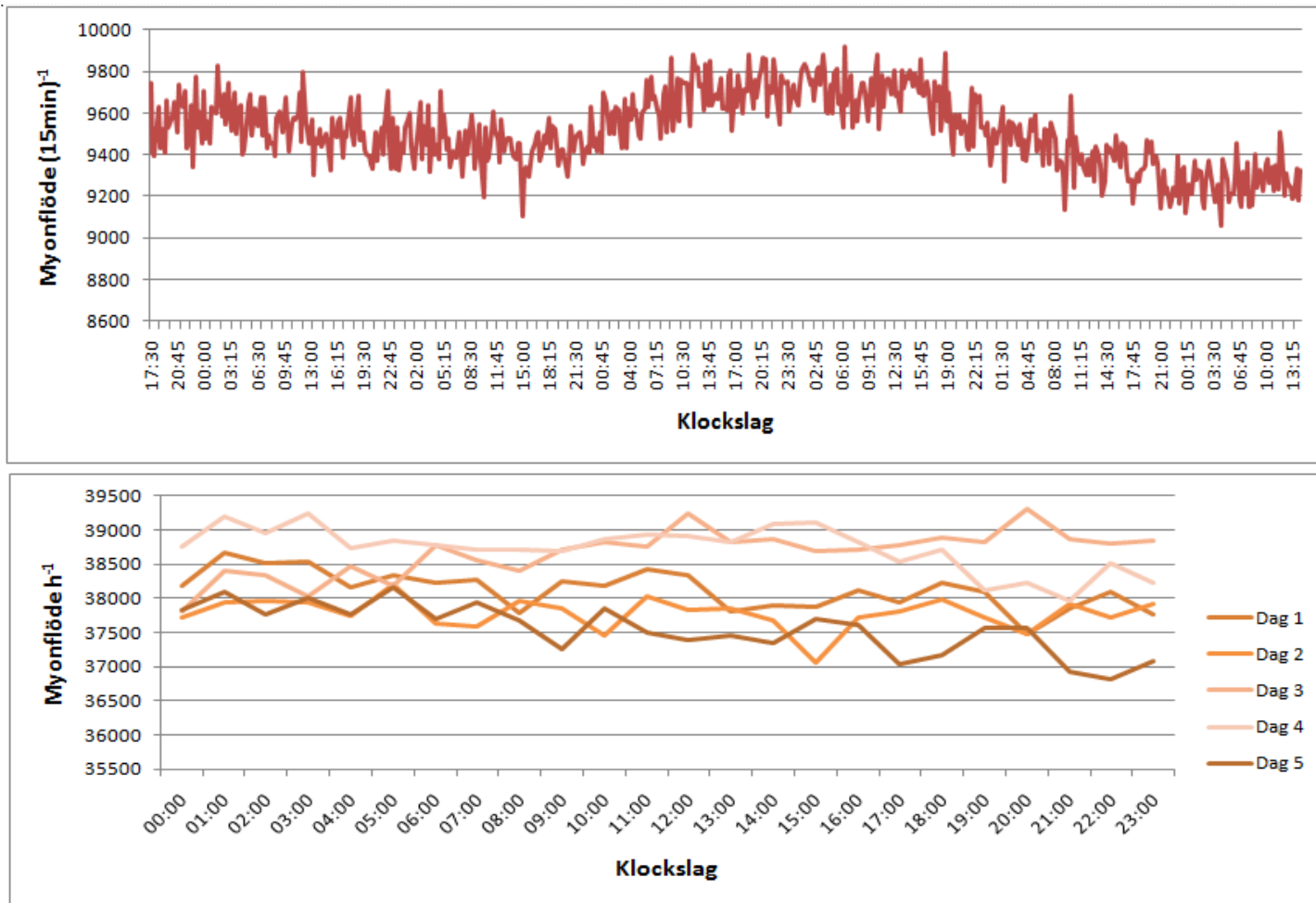
- What influences the flux of Cosmic Rays? (Dennis Alp, 2011)
- How can we improve the muon detector to make the measurements more reliable? (Gustav Dänssel, Agnes Gårdebäck, Jacob Stuart, 2012)
- How does the muon flux depend on latitude and altitude? (William Andersson och Anton Palm Ekspong, 2013)

*What influences the flux of Cosmic Rays?
Does the flux depend on the time of the day?*



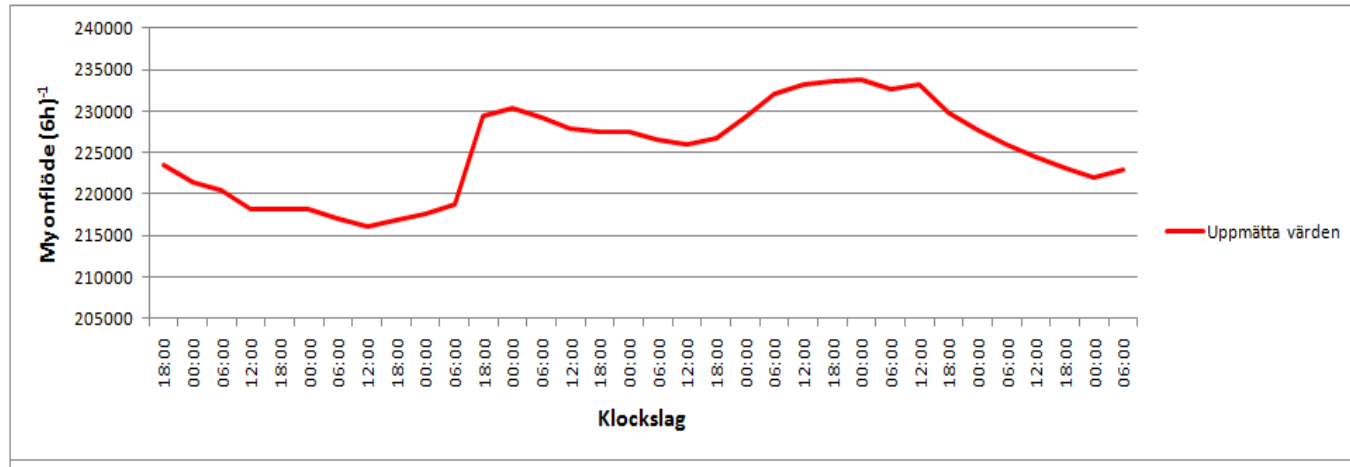
Dennis Alp, Enskilda gymnasiet, 2011

Cosmic ray outreach in Stockholm



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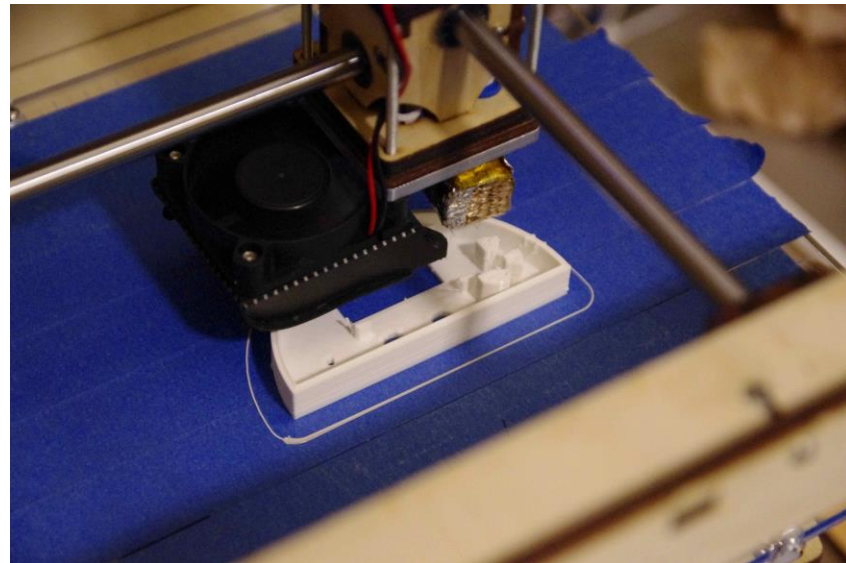
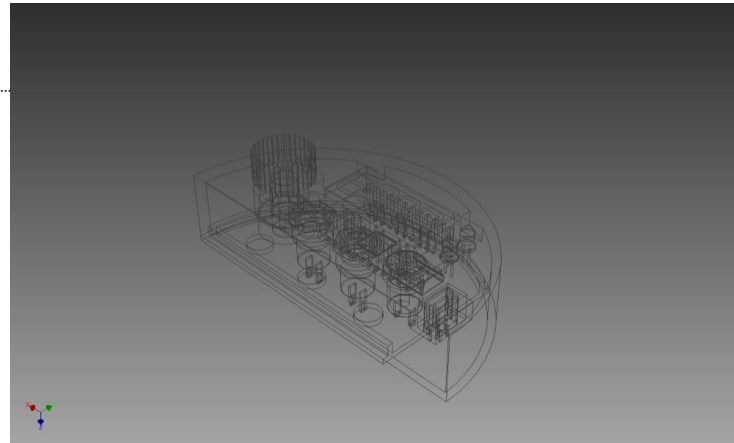
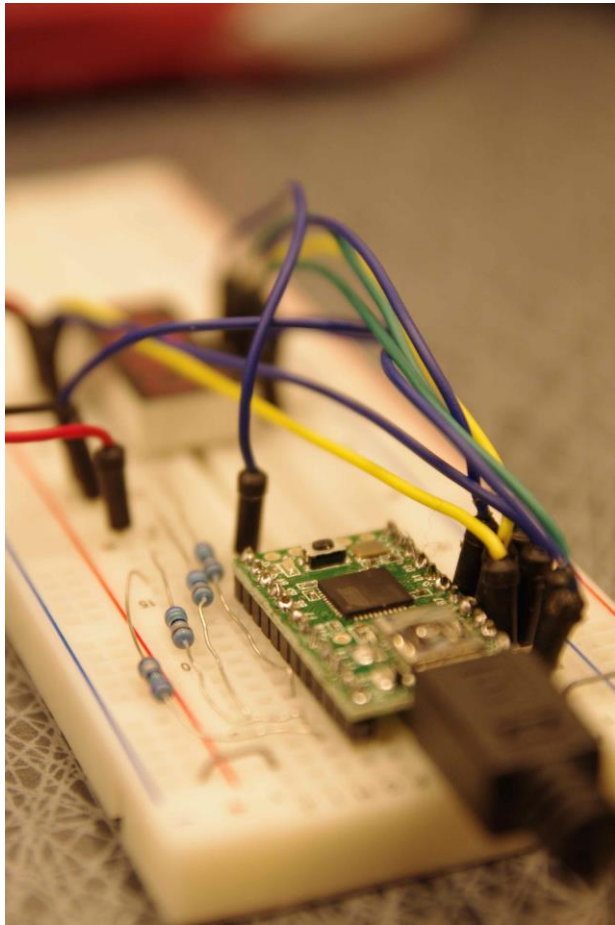
PADME = PArticle Demonstrator Monitoring Extension



- Show the number of registred particles on a display
- Do time-limited measurements
- Transmit data to a computer
- External electricity source

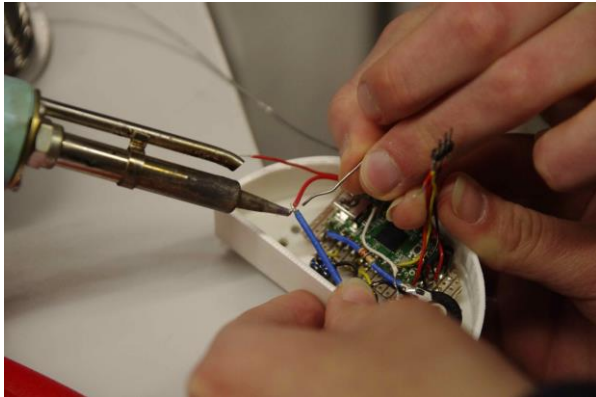
Agnes Gardebäck, Gustav Dänzel & Jacob Stuart, Nacka gymnasium, 2012

Cosmic ray outreach in Stockholm



Agnes Gardebäck, Gustav Dänzel & Jacob Stuart, Nacka gymnasium, 2012

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Agnes Gårdebäck, Gustav Dänzel & Jacob Stuart, Nacka gymnasium, 2012

- *How does the muon flux depend on the latitude?*

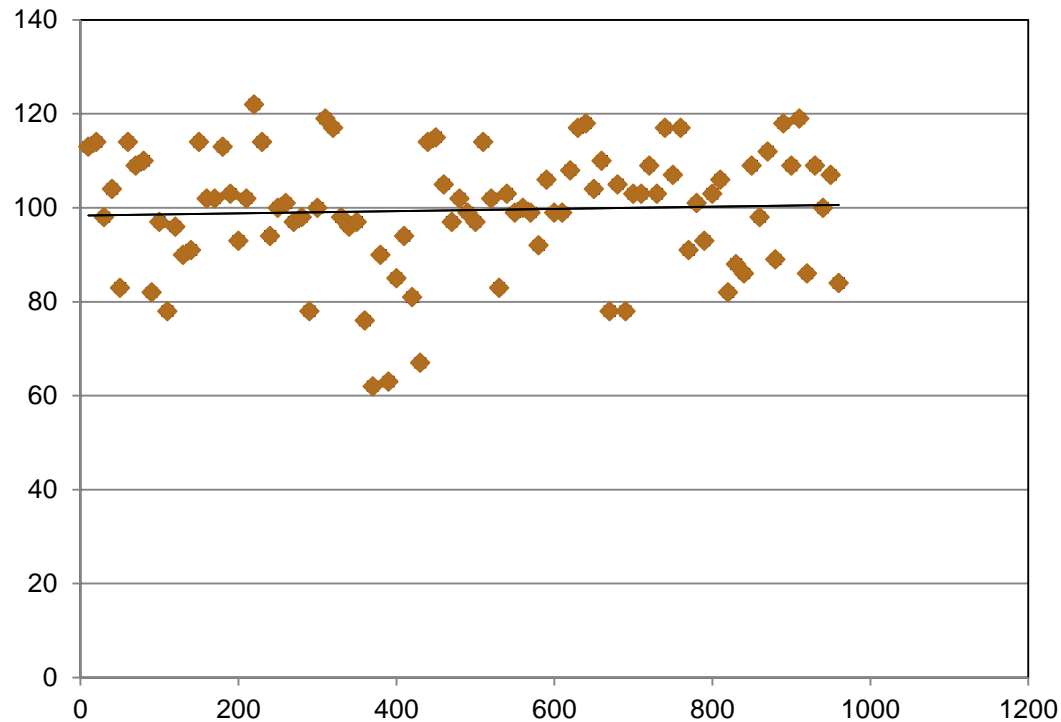
Influence of the magnetic field.

- *How does the muon flux vary with altitude?*

Influence of the atmosphere.

William Andersson & Anton Palm Ekspong, Blackebergs gymnasium, 2013

How does the muon flux depend on the latitude?

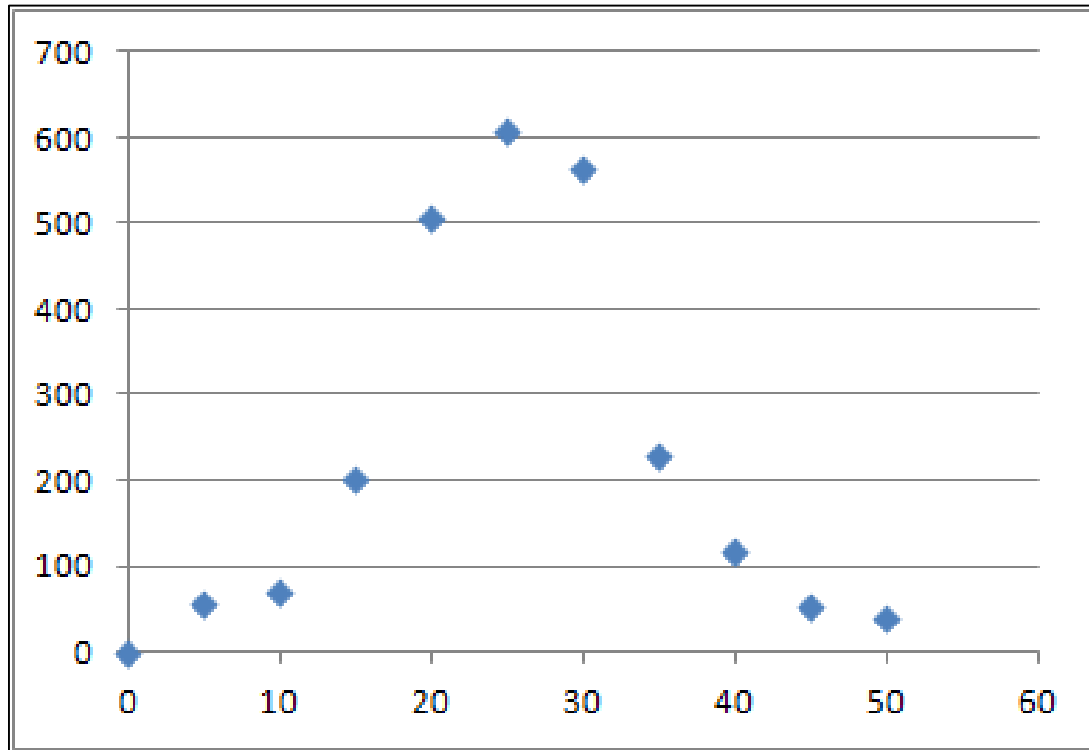


Measurements in
Gothenburg, Stockholm and
Kiruna.

Trip by train
Gällivare – Stockholm.

William Andersson & Anton Palm Ekspong, Blackebergs gymnasium, 2013

How does the muon flux vary with altitude?



Trip by airplane
Gothenburg - Stockholm
Maximum height: 7600 m

William Andersson & Anton Palm Ekspong, Blackebergs gymnasium, 2013

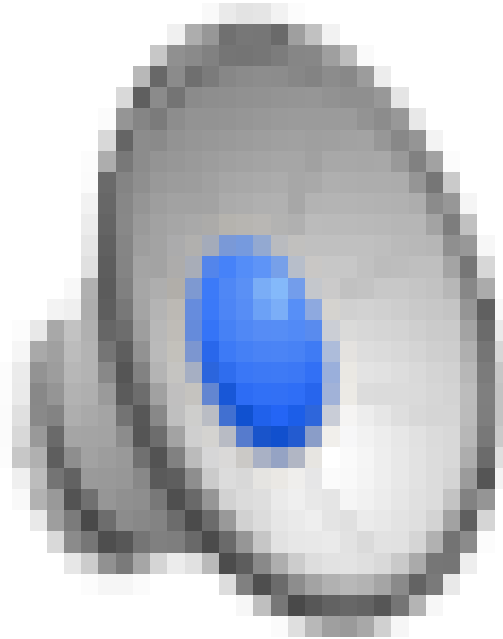
How does the muon flux vary with altitude? – going higher...

Flying a detector on a weather balloon

- FluxLite-1, October 2013 – reached an altitude of 25000 m, but no muondata
- FluxLite-2, March 2015 – altitude of 27000 m, no muondata above 15000 m
- FluxLite-3, October 2015 – altitude of 35000 m, reliable data up to 25000 m
- FluxLite-4, October 2016 – altitude of 33000 m – good data!



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FluxLite-4

Successful flight – reached an altitude of 33 000 m

Data analysis ongoing. High school students involved in analysis and interpretation.

Will be repeated and improved.....



Titel

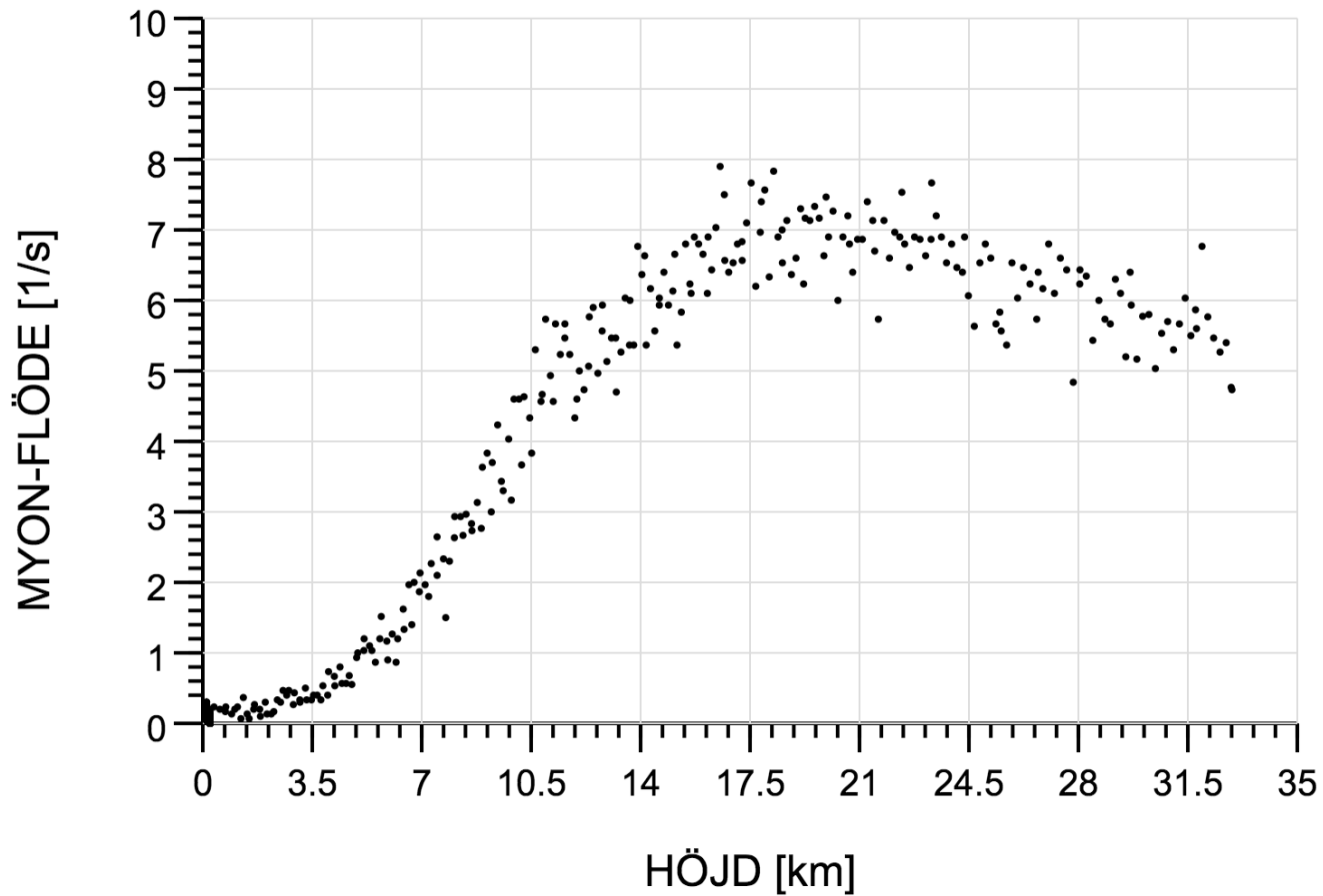


Titel



Results October 2016

MYON-FLÖDE BEROENDE PÅ DETEKTIONSHÖJD



Future plans

- One flight per year – aim to go even higher
- Data available online
 - <http://teleskop.vetenskapenshus.se/fluxlite/>
- If possible - synchronising balloon flights across Europe

”We got to measure real particles high in the atmosphere – and it worked! It felt so distant but we could do it!”

Thank you!