HiSPARC in the Classroom

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Goal of HiSPARC

- Special outreach project

  Get students to experience real science and research

  - More physics students (also girls)
  - Improve opinion of science
  - Improve scientific literacy
  - etc

Research questions

Questions from researchers and students

- Both large and small

Examples:

- What is the origin of cosmic radiation?
- How does it get its energy?
- Is there a maximum to the energy?
- What forces in de universe influence the path of cosmic radiation and how?
- What happens in our atmosphere?
- Does the weather on earth affect airshowers?
- What is the composition of airshowers?
- What do the HiSPARC detectors measure?

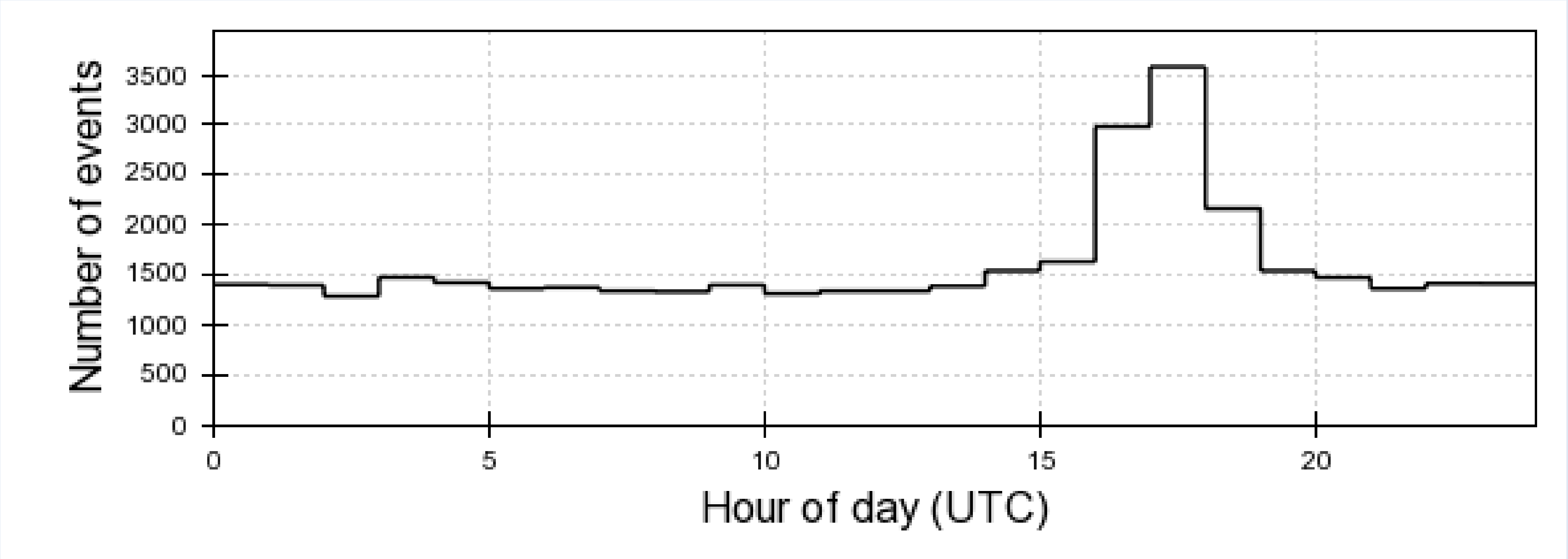
Examples in this presentation

- Weather effects
- Gerasimova-Zatsepin effect
- Detector efficiency
- Teaching materials
- Work from students symposium 2012
  - Airshowers and atmospheric conditions
  - Particle detection
  - Angle reconstruction

Weather effects

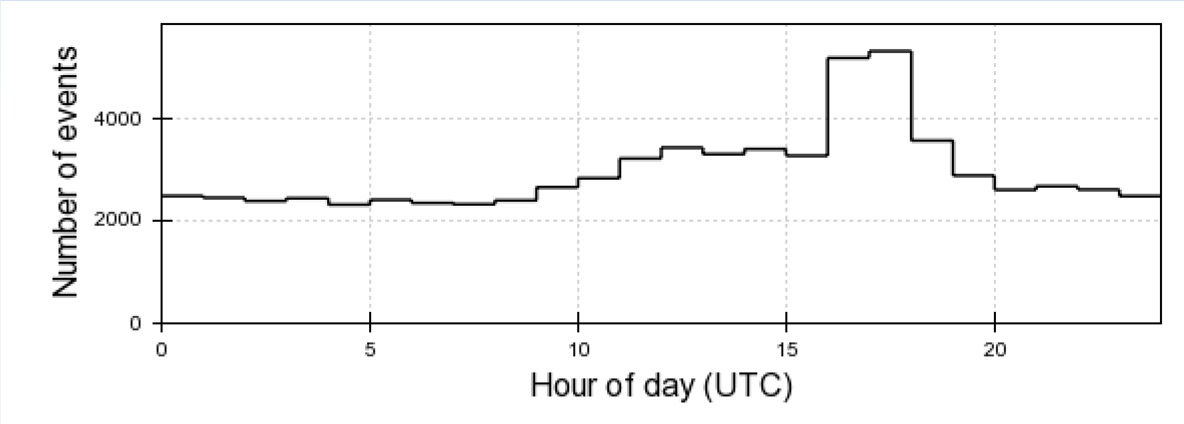
Students regularly inspect data for abnormalities

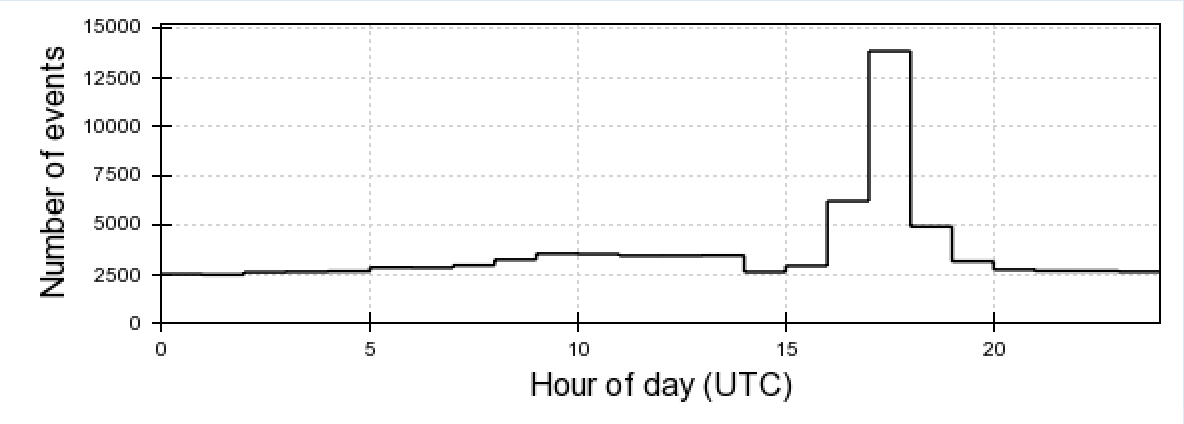
Sint Joris College Eindhoven 14 Jul 2010



Weather effects

- Check with other stations in region
  - Also at university and in Tilburg (~30 km away)

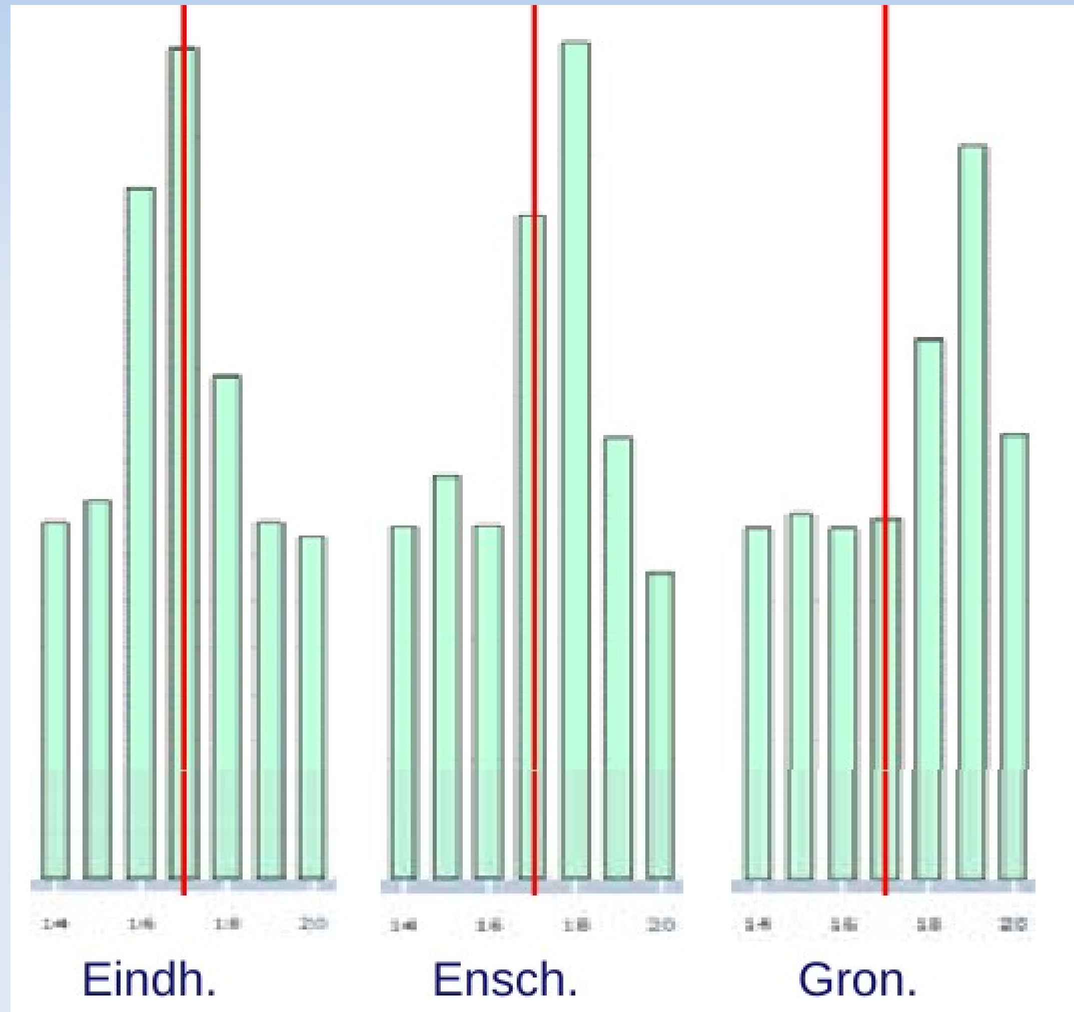




Weather effects

Gather all the data and look for explanations

- Multiple stations
- No 'bad' data
- Clear pattern



South ~150 km ~150 km North

Weather effects

What happened on 14th of July?

Weather on 14 July

http://www.youtube.com/watch?v=uewixfetzHg

Extreme heavy weather with lots of thunder

Weather effects

Literature study

Science, 2005

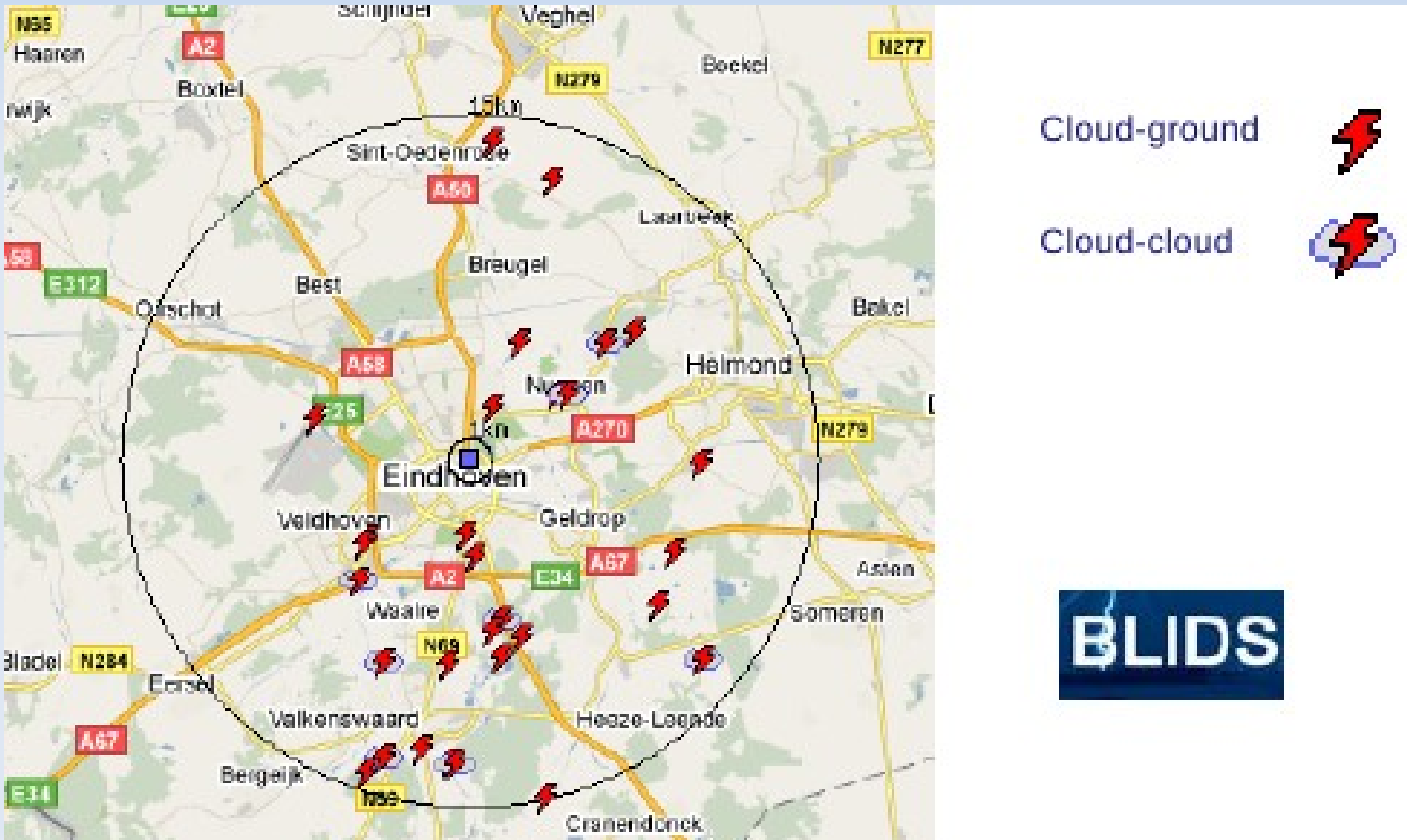
Terrestrial Gamma-Ray Flashes Observed up to 20 MeV

David M. Smith,[1*] Liliana I. Lopez,[2] R. P. Lin,[3]
Christopher P. Barrington-Leigh[4]

Terrestrial gamma-ray flashes (TGFs) from Earth's upper atmosphere have been detected with the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) satellite. The gamma-ray spectra typically extend up to 10 to 20 megaelectron volts (MeV); a simple bremsstrahlung model suggests that most of the electrons that produce the gamma rays have energies on the order of 20 to 40 MeV. RHESSI detects 10 to 20 TGFs per month, corresponding to ~50 per day globally, perhaps many more if they are beamed. Both the frequency of occurrence and maximum photon energy are more than an order of magnitude higher than previously known for these events.

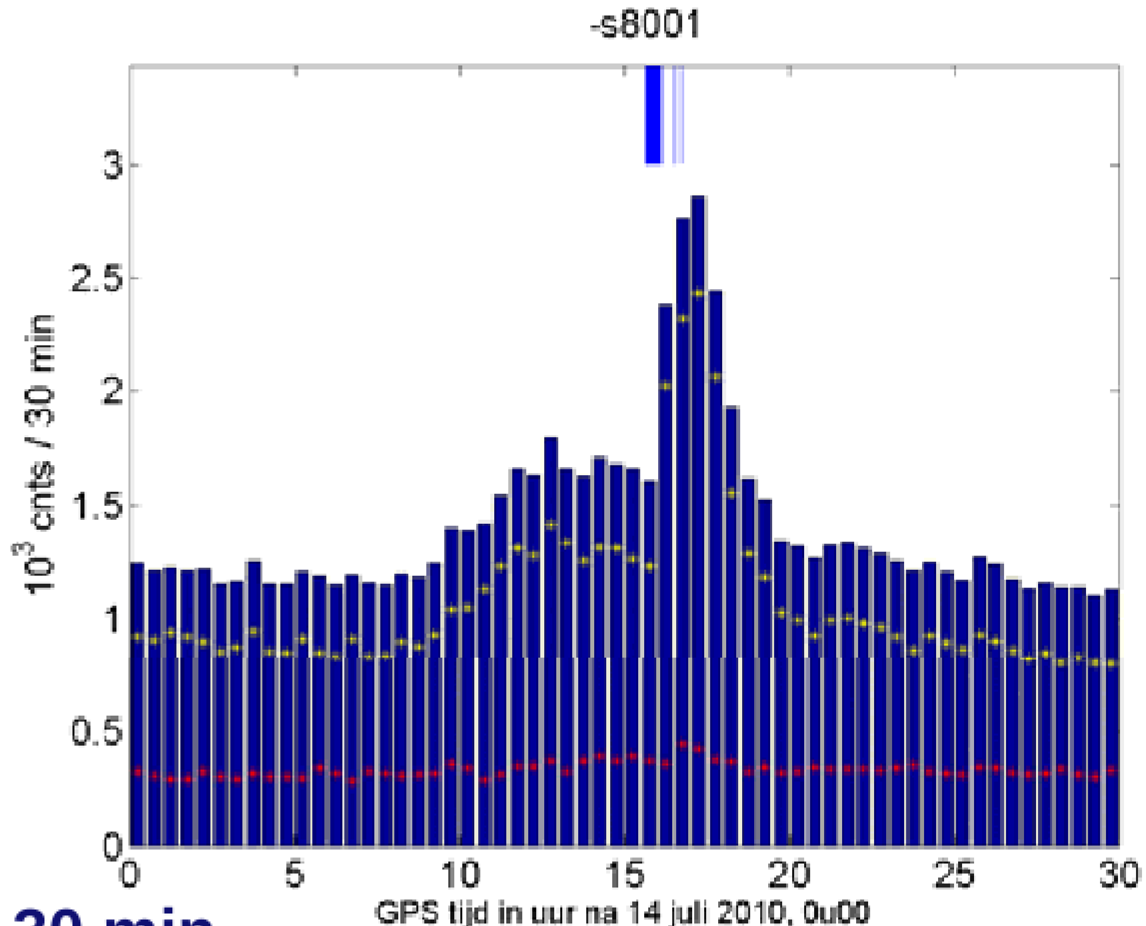
Weather effects

Correlate data



Weather effects

Time difference!



Base: 1.3k / 30 min

Weather effects

Report findings to community:

- On 14th of July HiSPARC measured increased activity

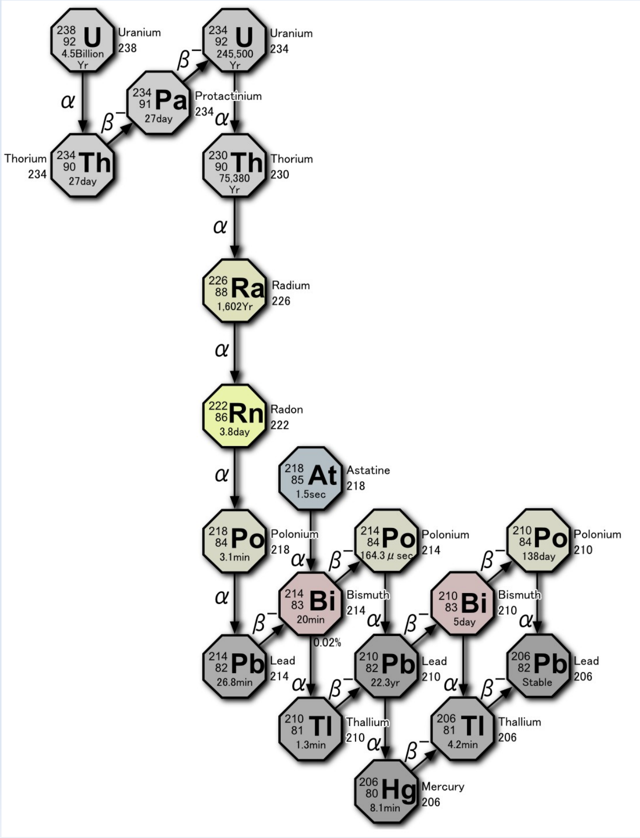
Possible explanation: Heavy thundercloud

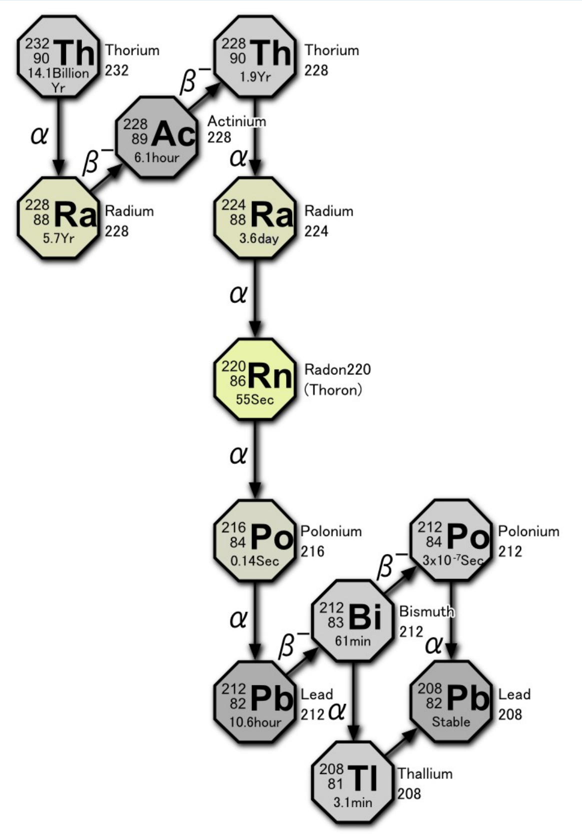
- Delayed response of ~1 hour
- Sometimes sharp peak, not always
- No explanation for coincidences
- Still under investigation

Weather effects

Different theory - Radon daughters in the atmosphere

- Variations in outdoor radiation levels in the Netherlands. Blauwboer et. al. 1996





Weather effects

Model to explain results:

Rain collects underneath the detectors

- Uncorrelated emission of radiation
- But creates (large) increase in background radiation
- More random coincidences
- Visible in data (more events with high Δt)
- Time delay consistent with $t_{1/2}$ of ^{214}Pb and ^{214}Bi

Weather effects

Two models, which one is correct?

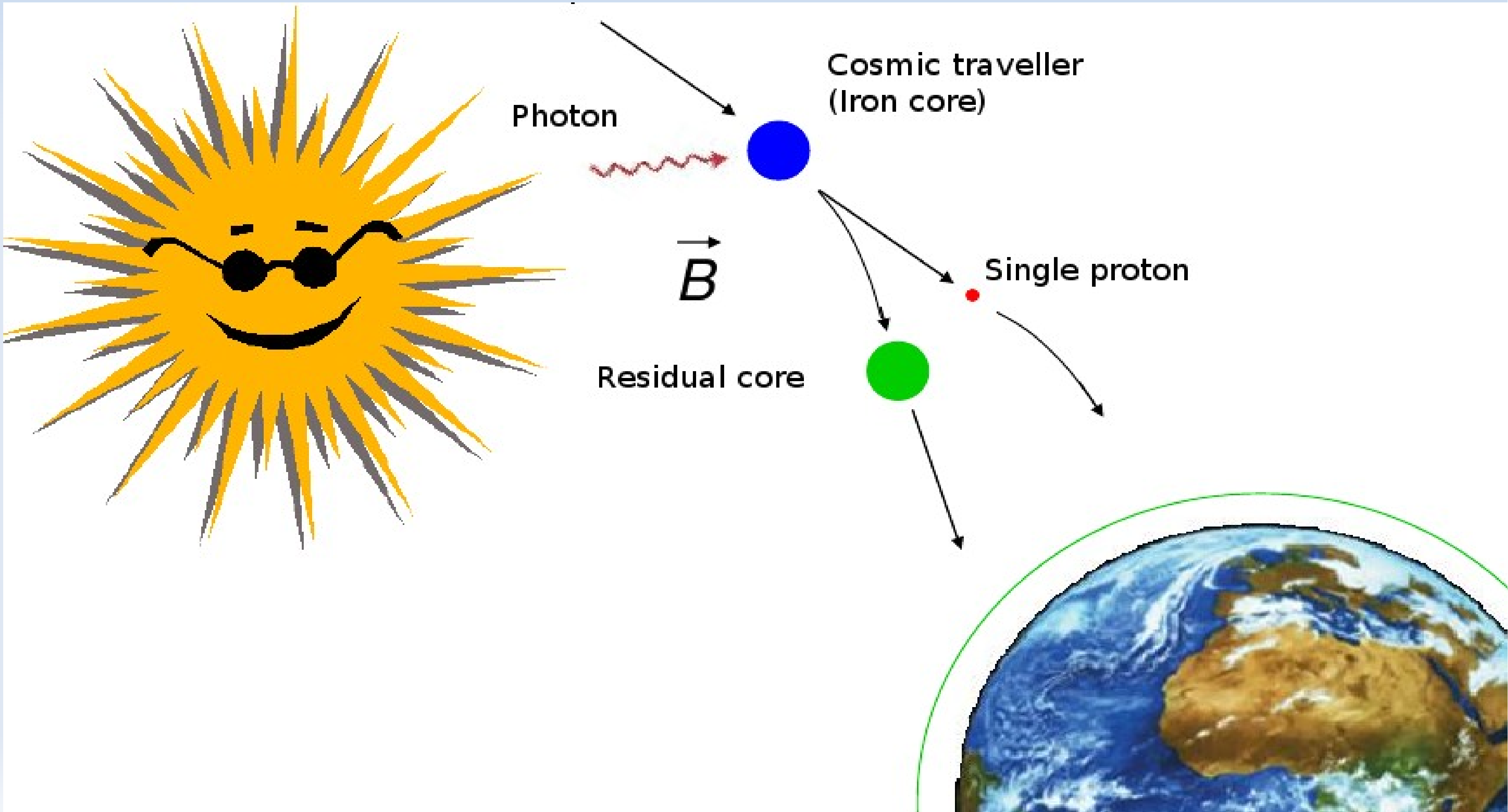
Obtained new information about detector network

- Network might be used to register thunder
- Natural background radiation fluctuates and might influence readings
- Time difference between plates might give usefull information (other than shower angle)

Presented at 2011 symposium

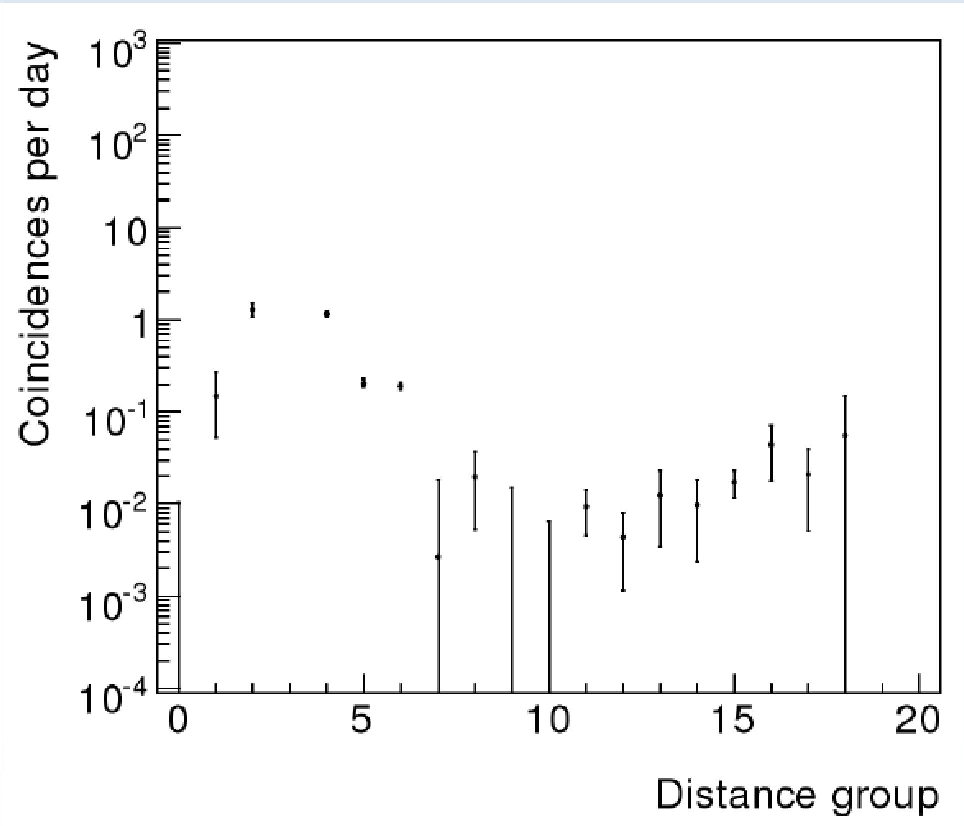
Gerasimova-Zatsepin effect

Two showers, correlated in time and space



Gerasimova-Zatsepin effect

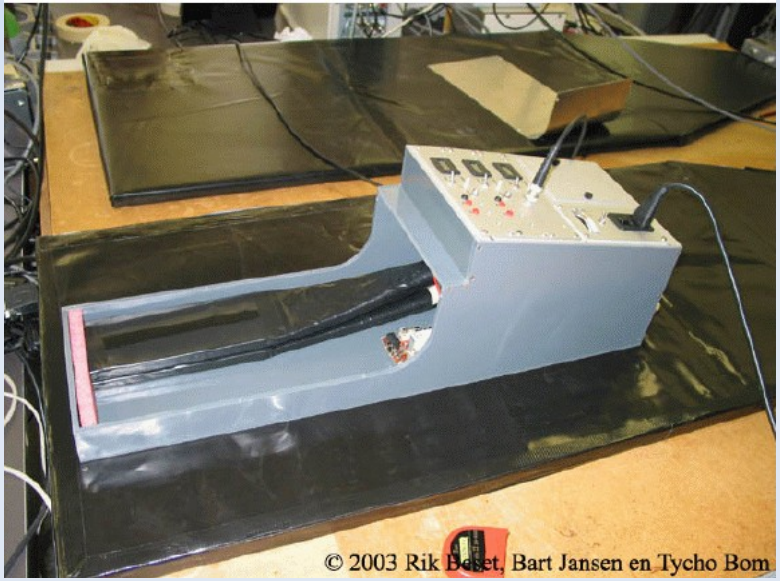
- Clear indication of Gerasimova-Zatseping effect at small distances
- Software (and support) available for students to continue search at larger distances
- Expanding array to make this possible



Detector efficiency

Yearly task for students

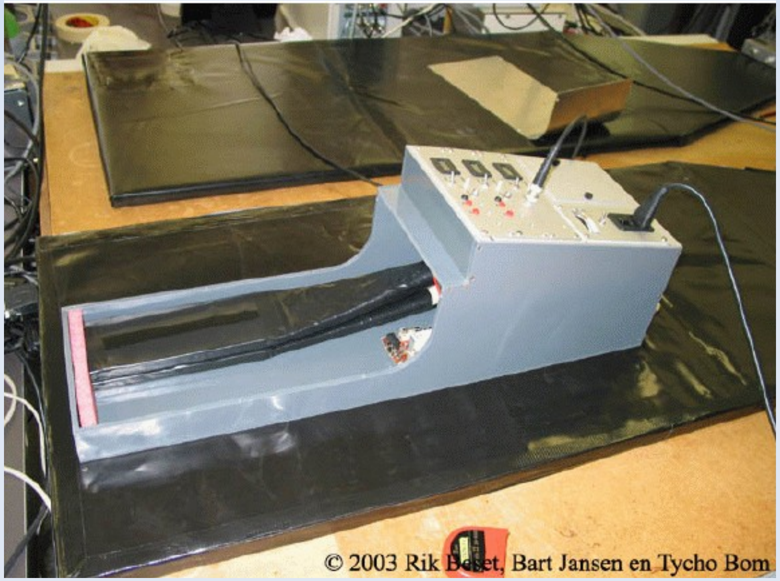
- Calibration

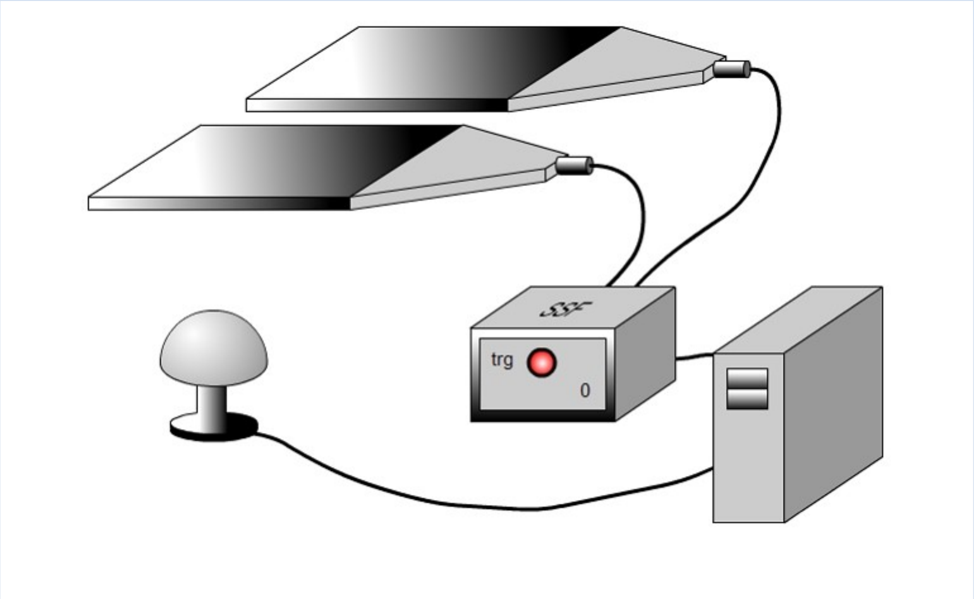


Detector efficiency

Yearly task for students

Calibration and monitor efficiency

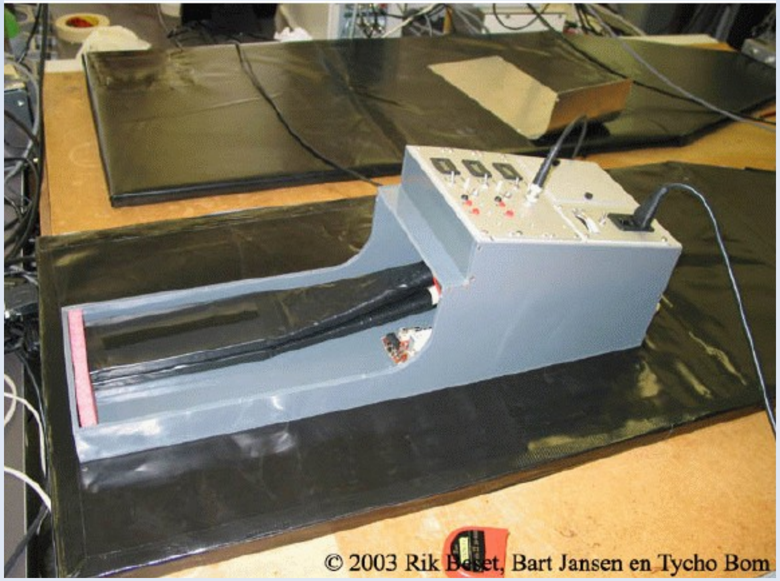




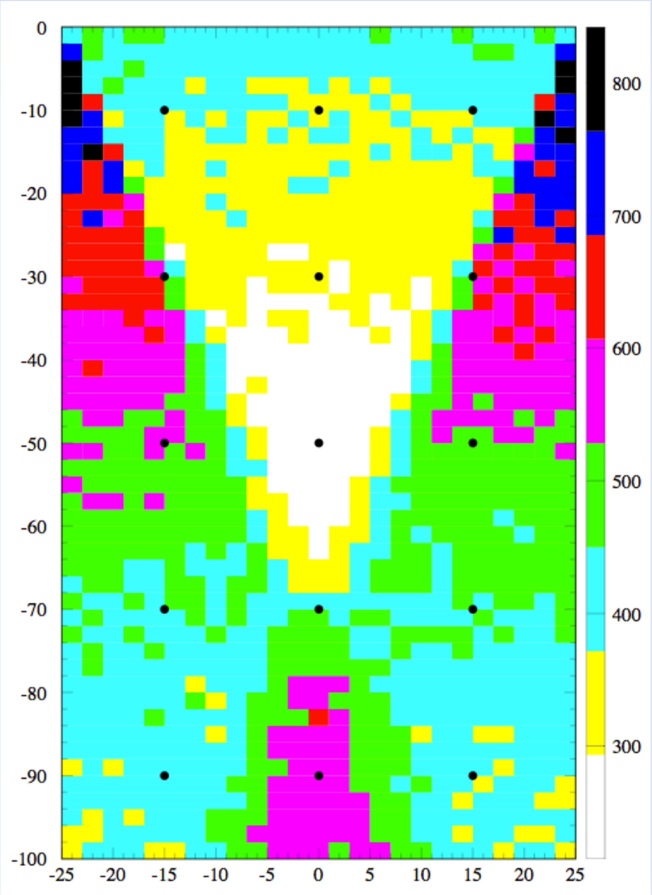
Detector efficiency

Yearly task for students

Calibration



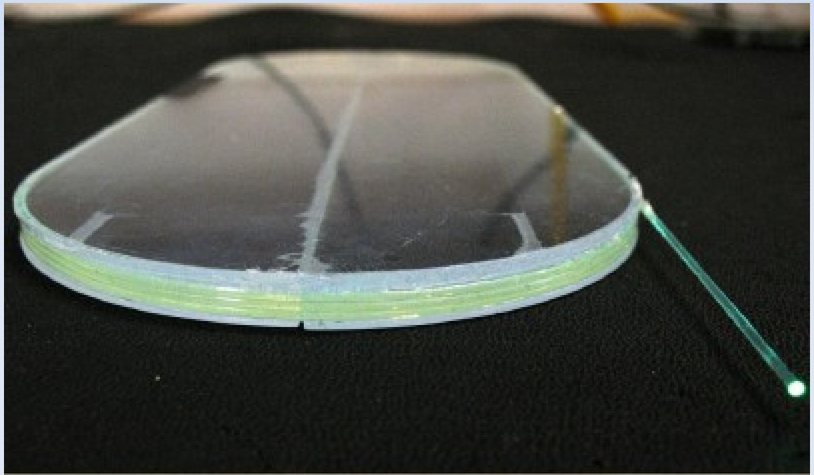
and monitor efficiency

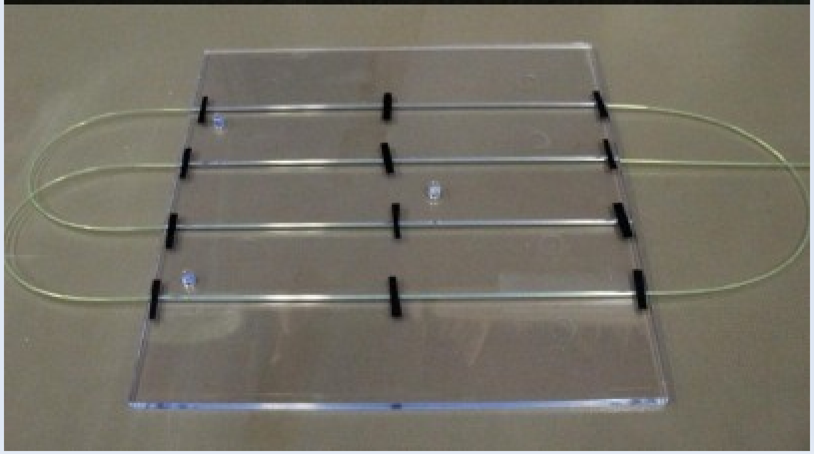


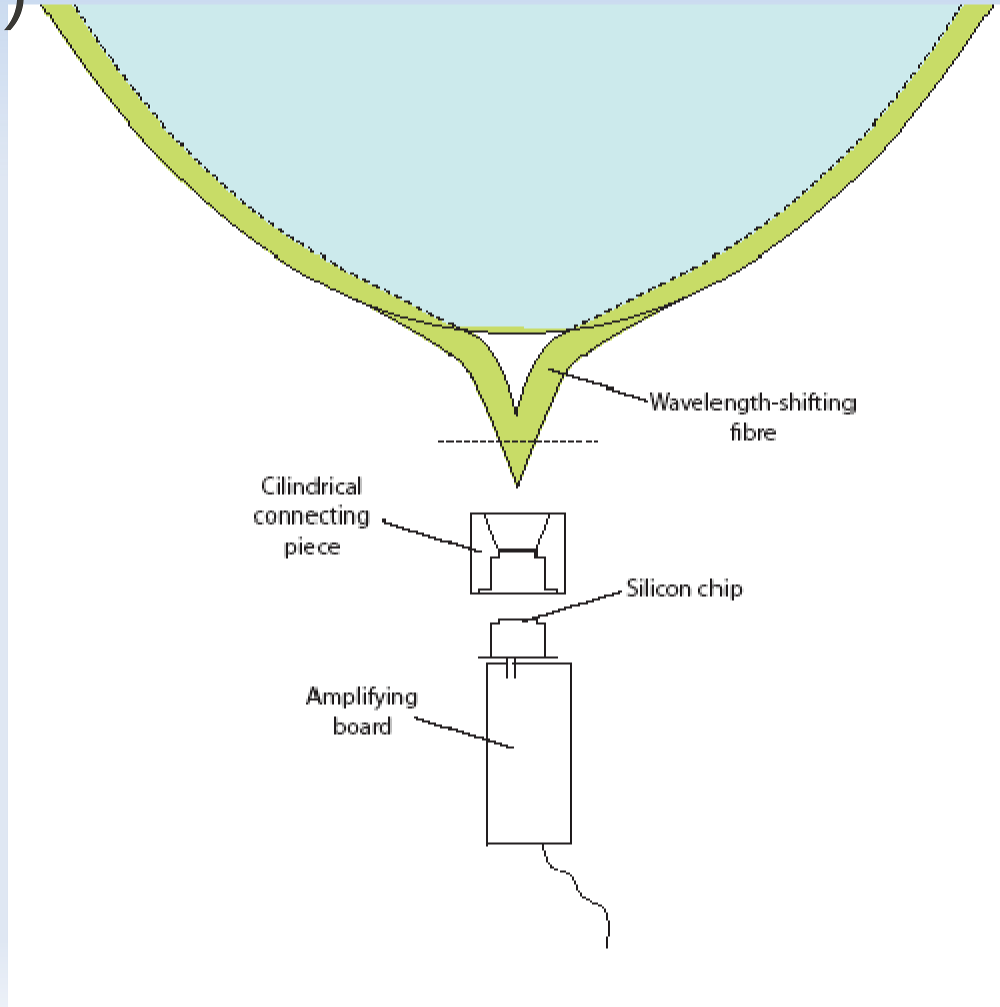
Detector efficiency

Possible new design

- Research done by 17 year old student at Cavendish Laboratory (Cambridge)





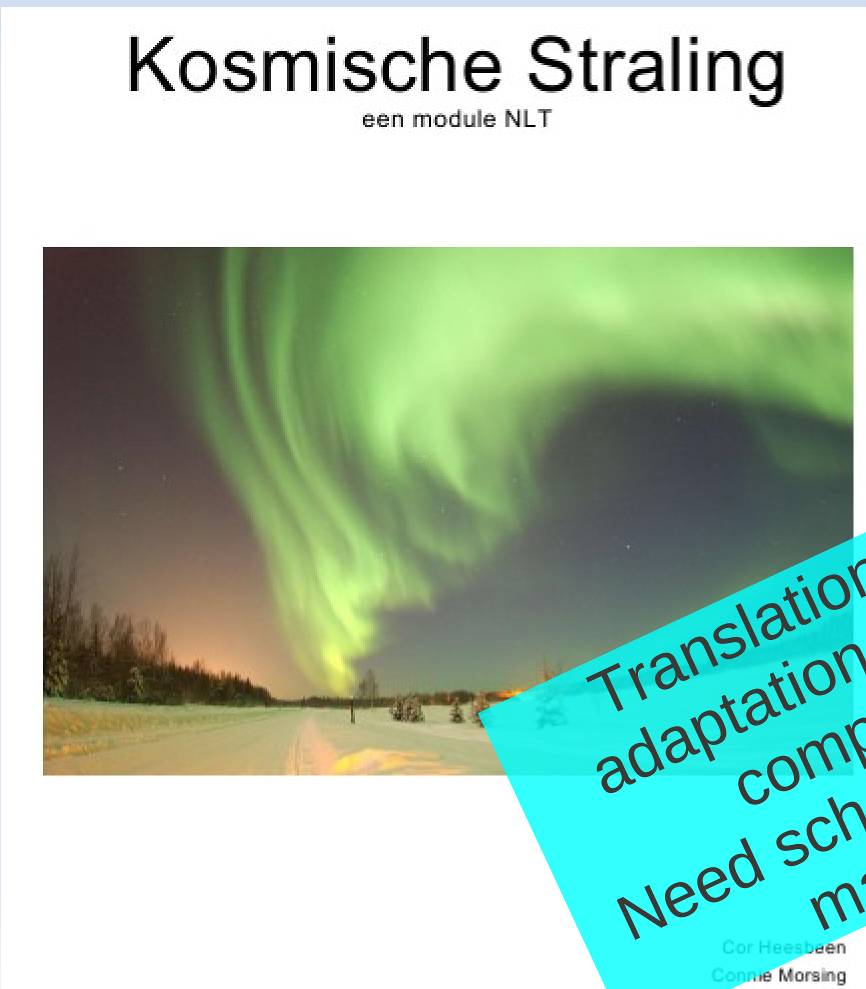


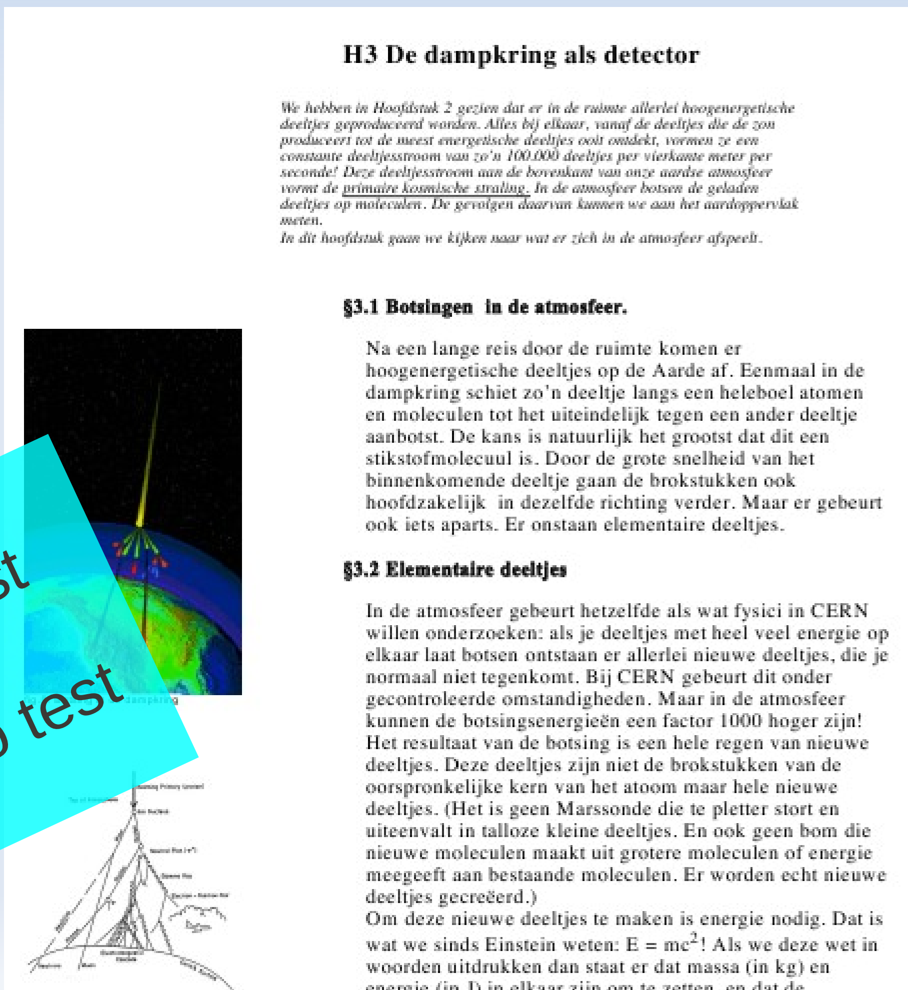
Teaching materials

Teaching materials

Book to get students started

Aimed at small (~15 hours) practical research assignment





H3 De dampkring als detector

We hebben in Hoofdstuk 2 gezien dat er in de ruimte allerlei hoogenergetische deeltjes geproduceerd worden. Alles bij elkaar, vanaf de deeltjes die de zon produceert tot de meest energetische deeltjes ooit ontdekt, vormen ze een constante deeltjesstroom van zo'n 100.000 deeltjes per vierkante meter per seconde! Deze deeltjesstroom aan de bovenkant van onze aardse atmosfeer vormt de primaire kosmische straling. In de atmosfeer botsen de geladen deeltjes op moleculen. De gevolgen daarvan kunnen we aan het aardoppervlak meten.
In dit hoofdstuk gaan we kijken naar wat er zich in de atmosfeer afspeelt.

§3.1 Botsingen in de atmosfeer.

Na een lange reis door de ruimte komen er hoogenergetische deeltjes op de Aarde af. Eenmaal in de dampkring schiet zo'n deeltje langs een heleboel atomen en moleculen tot het uiteindelijk tegen een ander deeltje aanbotst. De kans is natuurlijk het grootst dat dit een stikstofmolecuul is. Door de grote snelheid van het binnenkomende deeltje gaan de brokstukken ook hoofdzakelijk in dezelfde richting verder. Maar er gebeurt ook iets aparts. Er onstaan elementaire deeltjes.

§3.2 Elementaire deeltjes

In de atmosfeer gebeurt hetzelfde als wat fysici in CERN willen onderzoeken: als je deeltjes met heel veel energie op elkaar laat botsen ontstaan er allerlei nieuwe deeltjes, die je normaal niet tegenkomt. Bij CERN gebeurt dit onder gecontroleerde omstandigheden. Maar in de atmosfeer kunnen de botsingsenergieën een factor 1000 hoger zijn! Het resultaat van de botsing is een hele regen van nieuwe deeltjes. Deze deeltjes zijn niet de brokstukken van de oorspronkelijke kern van het atoom maar hele nieuwe deeltjes. (Het is geen Marssonde die te pletter stort en uiteenvalt in talloze kleine deeltjes. En ook geen bom die nieuwe moleculen maakt uit grotere moleculen of energie meegeeft aan bestaande moleculen. Er worden echt nieuwe deeltjes gecreëerd.)
Om deze nieuwe deeltjes te maken is energie nodig. Dat is wat we sinds Einstein weten: $E = mc^2$! Als we deze wet in woorden uitdrukken dan staat er dat massa (in kg) en

Translation and adaptation almost complete
Need schools to test material

Teaching materials

Lesson book for project on radiation in Key Stage 3

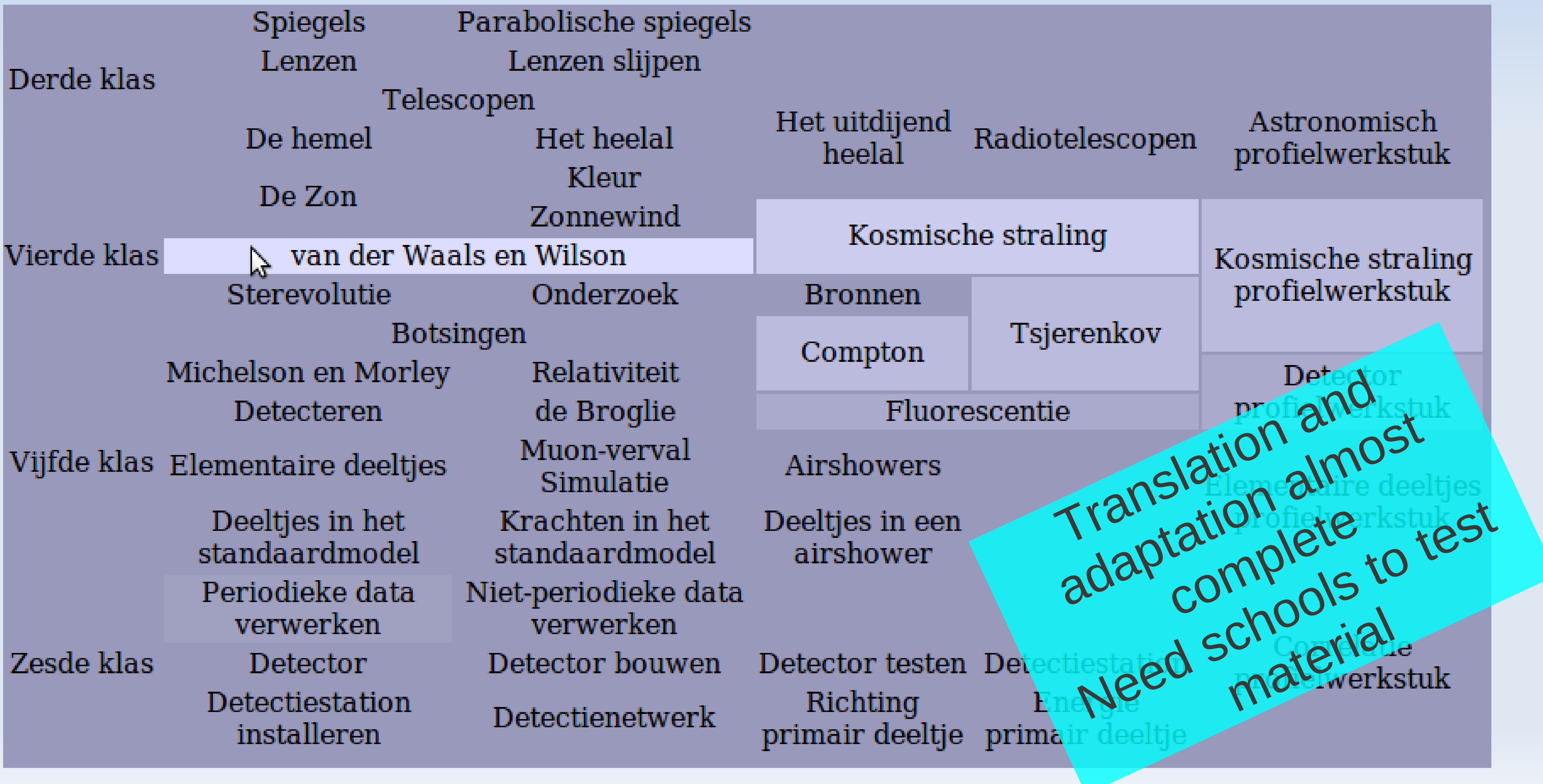
Subjects include:

- Waves
- Particles
- Magnetism
- Orders of magnitude

Also aimed at practical work

Teaching materials

- Lesson letters forming a route of knowledge
  - Can be used by students without help from teacher



Teaching materials

Routenet contains letters about:

- Telescopes and optics
- Relativity
- Compton scattering
- Cherenkov radiation
- The Standard Model
- Muon decay
- De Broglie
- Building detector
- Testing detector
- Inner workings of detector
- Analysing data
- Using Excel
- Detection network

Teaching materials

Routenet example

2 Cherenkov

Pavel Alekseyevich Cherenkov (1904-1990) was a Sovjet physicist who shared the Nobel Prize in Physics in 1958 with Ilya Frank and Igor Tamm for the discovery of Cherenkov radiation made in 1934.

Cherenkov was researching the radiation emitted by nuclear reactors containing water which is used both as a cooling agents as well as a neutron moderator. [1]

As we have seen with the Geigercounter, moving particles can knock away electrons from a medium. The electron can jump to a higher energy state within the atom or be made completely free from the atom (also a form of higher energy state). With Cherenkov radiation the electron immediately returns to its ground state, emitting its excess energy in the form of a photon. If this happens in water then photon won't have the the speed of light in vacuum, but it will move slower $c_{medium} = \frac{c}{N_{medium}}$. The particle that knocked the electron into a higher energy state could have had a higher velocity than c_{medium}.

[1] A moderator is a medium that reduces the speed of fast neutrons inside nuclear reaction. This deceleration is necessary to maintain the nuclear reaction. Without the moderator the fast neutrons will escape the reactor vessel without interacting with other nuclei. This will cause the reactor to shut down. Too many slow neutrons is also a problem. This is rapidly increase the number of nuclear reactions causing overheating, if this is not stopped soon enough the reactor could be damages by a melt-down (Harrisburg and Chernobyl).

Teaching materials

Routenet example

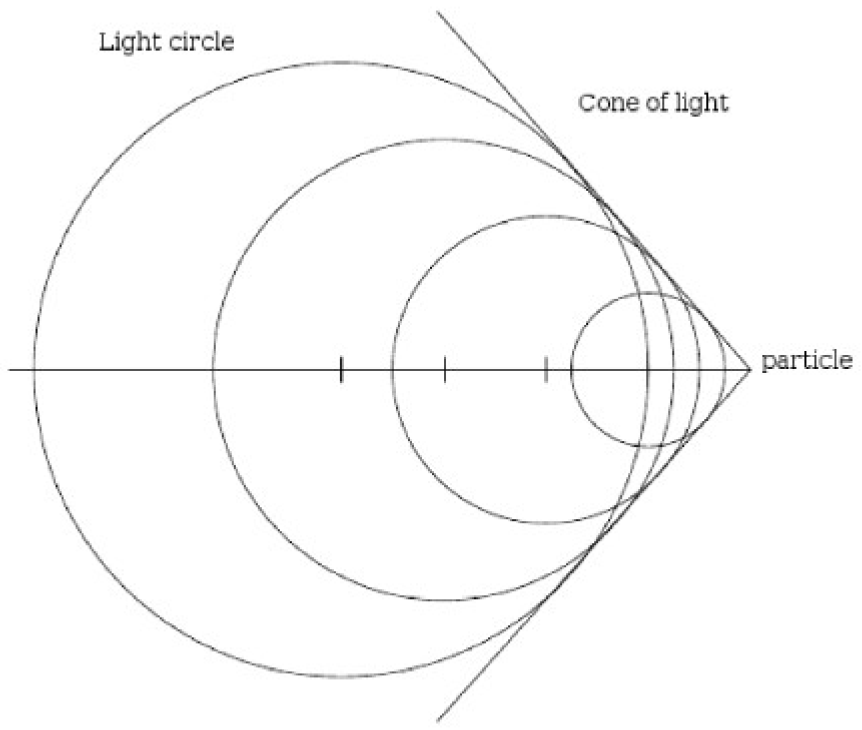


Figure 1: Schematic representation of the emission of Cherenkov radiation.

Student work symposium 2012

- Robin de Vries
  - Correlation Airshowers and atmosferic conditions
- Luciano van der Veekens & Dylan Cruz
  - Built their own Cloud Chamber
- Gijs Bouman, Sam Huizing & Cees de Wit
  - Angle reconstruction

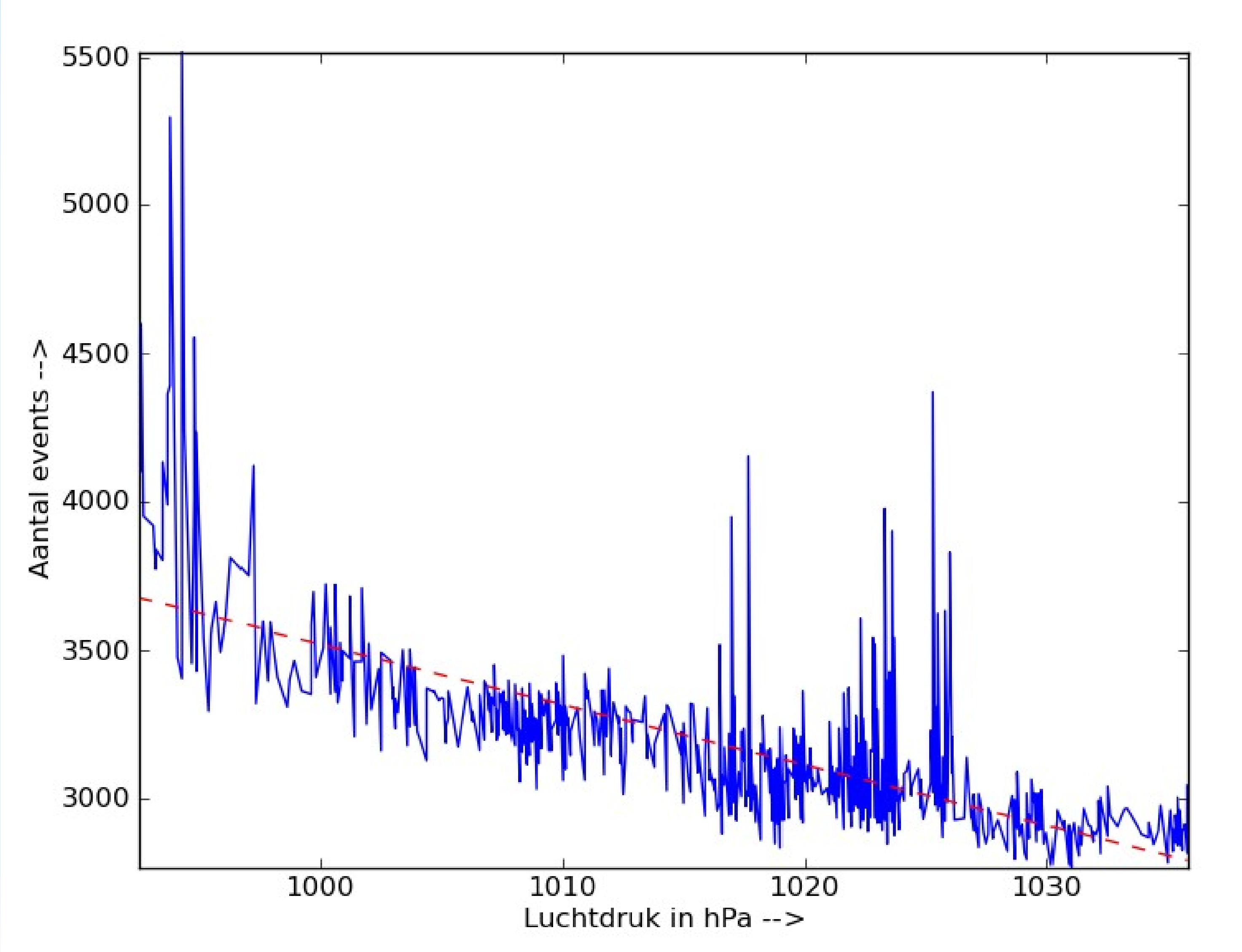
Airshowers and atmospheric conditions

Robin de Vries wrote his own software to import data from data-website and schools weather station

```
# import the libraries
import csv
import urllib2
from pylab import *

#download weather
weatherurl = "http://www.stmichaelcollege.nl/weersmc/data/jan-11.csv"
file = urllib2.urlopen(weatherurl)
r = csv.reader(file,delimiter=";")
data = [row for row in r]
pressure = [float(r[3]) for r in data]


#set event url without day number
eventurl = "http://data.hisparc.nl/django/show/source/eventtime/101/2011/1/"

#january 2011 has 31 days, in range 1-32
for i in range(1,32):
    # i is an integer, but we use it as a string
    url = eventurl + str(i) + "/"
    file = urllib2.urlopen(url)
    r = csv.reader(file,delimiter=";")
    data = [row for row in r][7:-1]
    tmp = [int(r[1]) for r in data]
    #print i
    #print tmp

    if(i == 1):
        nevents = tmp
    else:
        nevents.extend(tmp)

#combine the data
data = zip(pressure,nevents)
```

Airshowers and atmospheric conditions

And then looked at different possible correlations

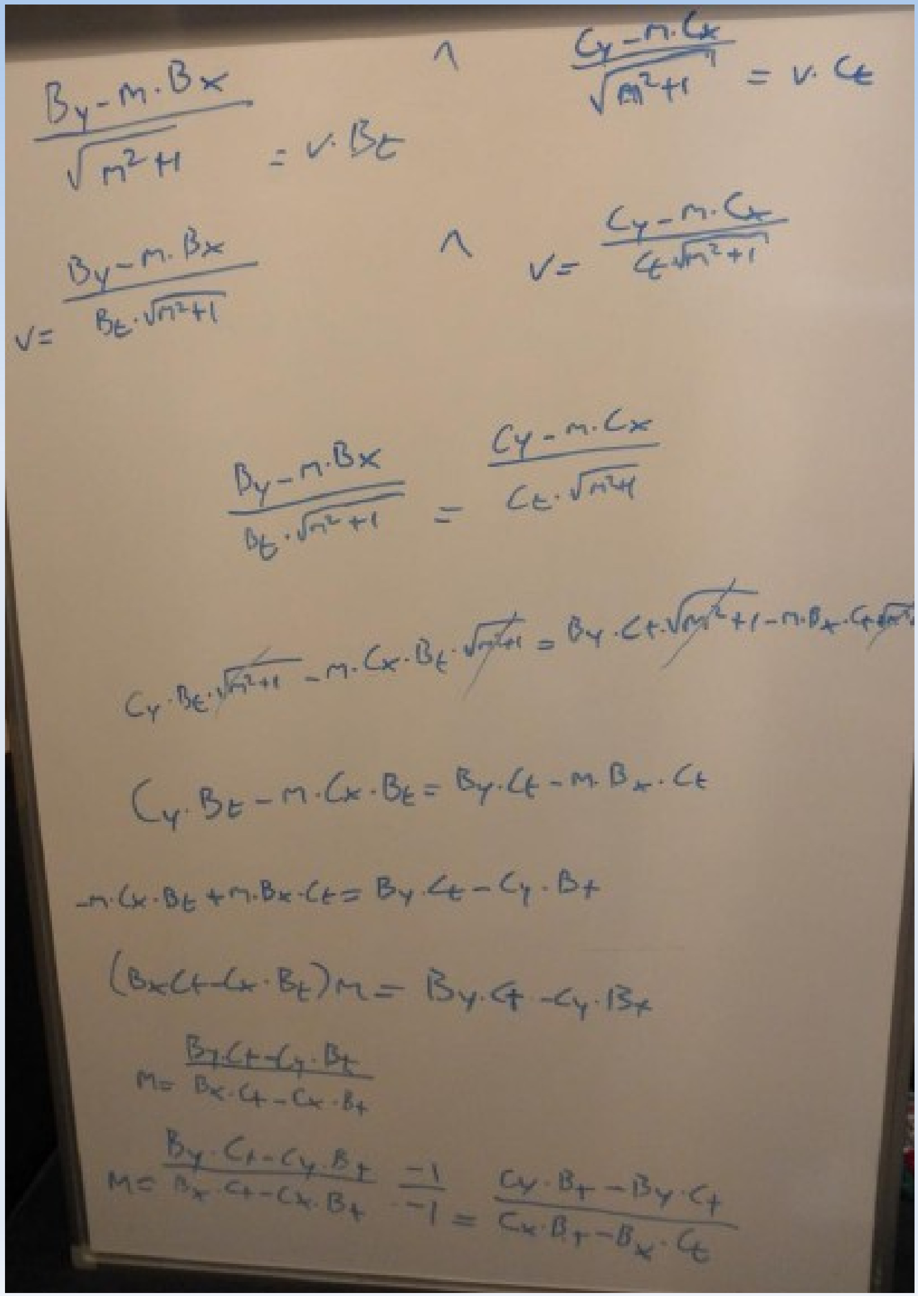


Building your own particle detector

Luciano van der Veekens & Dylan Cruz built their own Cloud Chamber

Angle reconstruction

Gijs Bouman, Sam Huizing, and Cees de Wit started with lots of formulas



Angle reconstruction

Ended up with a simple to use Excel sheet

	A	B	C	D	E	F	G	H	I	J
1										
2	hoek t.o.v. N	5					invoer			
3							relatieve tijden en de volgorde die daaruit volgt			
4							coördinaten			
5	detector	tijden (ns)	rel. tijden (s)	volgorde			coördinaten relatief aan detector 1			
6	1	999	9,77E-07	4			coördinaten A, B en C zonder translatie			
7	2	30	7,50E-09	3			coördinaten A, B en C met A(0,0,0)			
8	3	22,5	0,00E+00	1			uitkomsten m, v, φ en θ			
9	4	25	2,50E-09	2						
10										
11	Coördinaten									
12		x	y	t						
13	1	0	0							
14	2	-0,5031718918	-5,7512810408							
15	3	-5,7357643635	-8,1915204429							
16	4	4,2261826174	-9,0630778704							
17										
18	A	-5,7357643635	-8,1915204429	0						
19	B	4,2261826174	-9,0630778704	2,50E-009						
20	C	-0,5031718918	-5,7512810408	7,50E-009						
21										
22	A	0	0	0						
23	B	9,9619469809	-0,8715574275	2,50E-009						
24	C	5,2325924717	2,4402394021	7,50E-009						
25										
26	m	-0,2050403901								
27	v	4,59E+08								
28										
29	φ	-101,58734706								
30	θ	34,6475326208								
31	hoek t.o.v. N oostwaarts	191,58734706								

Impression symposium

Impression symposium

Impression symposium

Impression symposium

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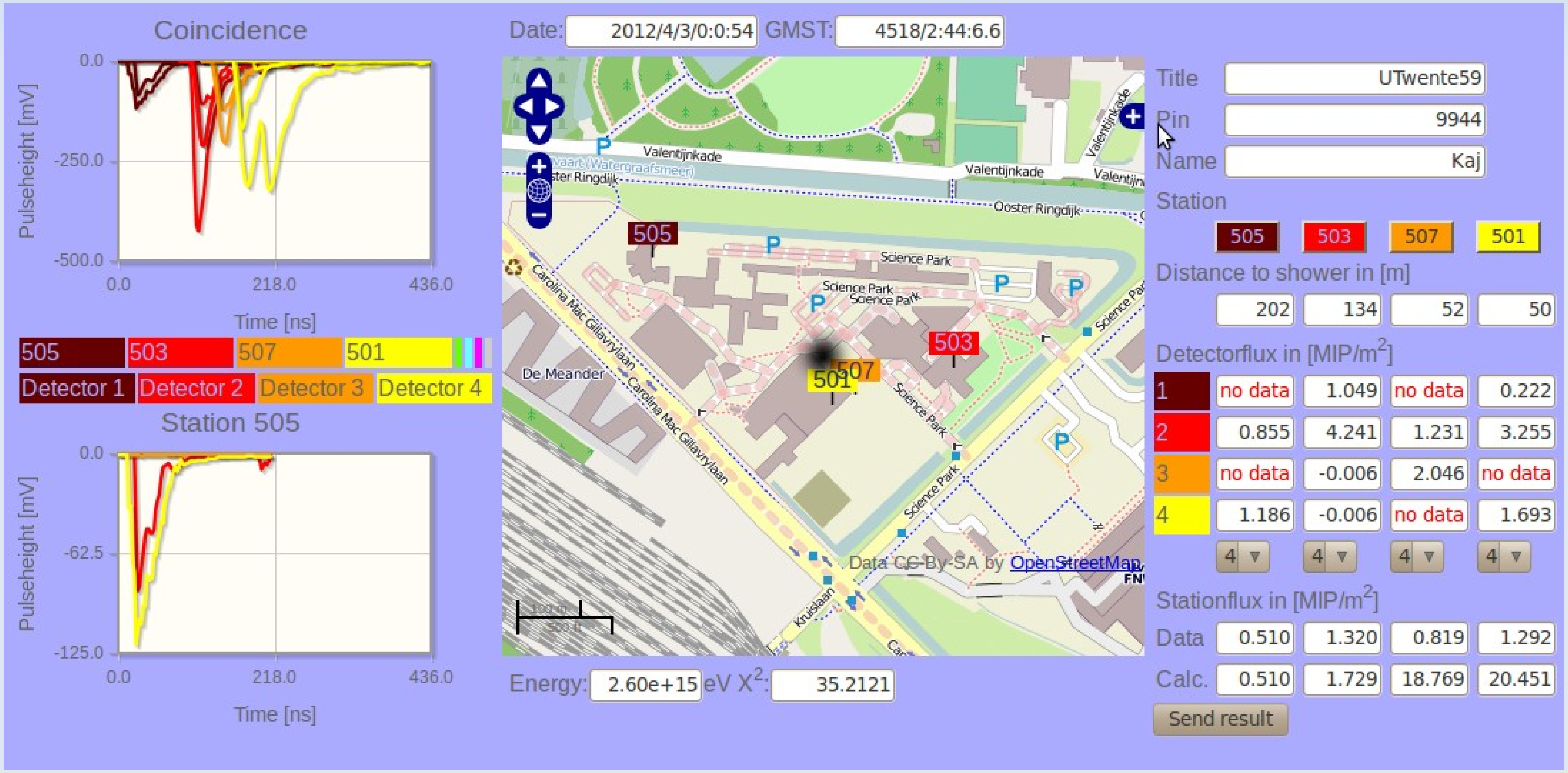
Shower location and energy

JSparc

Competition between students



http://www.hisparc.nl/en/hisparc-data/jsparc/

Does not work in Internet Explorer