Workshop on High School Cosmic Ray Experiments

https://indico.cern.ch/event/596002/

1st day – 15th of February 2017, Rome, Centro Fermi

Minutes (Barbora Bruant Gulejova)

Introduction by Charles Timmermans

Goals of the workshop

•Community building: Get to know each other

•Making an inventory of the different projects on cosmic rays

•Learning from experiences

•Prospects for further cooperation

•Benefit of coordination of activities

There are different outreach activities on cosmic rays with different scales and aims (from experimenting in the classroom using small detectors, through large scale experiments (Hispark, EEE) collecting data continuously, to extremely large scale experiments combining data from continuous setups (CREDO)). We are aiming towards the worldwide network of cosmic rays detectors.

Welcome by Luisa Cifarelli

She introduced and described Centro Fermi, who is very happy to welcome the workshop and IPPOG, she proposed that the next meetings/workshops are also hosted by Centro Fermi.

Extreme Energy Event Project (EEE) – leading project of Centro Fermi, bringing science inside the schools. Mission is the dissemination. This project is a collaboration of Centro Fermi, CERN, INFN, MIUR (Italian ministry…), etc. First idea was to build sophisticated detectors inspired by those at CERN, and get the scientific instruments which would allow for scientific publications.

- In 2016 there are 52 EEE telescopes, from which 46 in high schools (clusters of detectors), in 28 cities covering the whole territory of Italy, providing to students 35 billion of muons as data

Aim: to provide not only Masterclasses but also access to data for analysis for wider public, also those teachers and students who do not have their detector.

HISPARK by Kasper van Dam

High school project on astrophysics research with cosmic rays, which offers high school students the opportunity to contribute to real scientific research

There are 40 stations, based in Netherlands (most of them), UK and Denmark.

HISPARK station is composed of multiple detectors - scintillators, detecting particle showers, measuring coincidence and single rates, 400 MHz (2,5ns) + GPS. There are 2 types of stations, with 2 or 4 detectors.

Science Park Array = different stations in one city (10 meters away), connected to local PC and one can reconstruct energy information; local data storage (real data, signal in time, event properties), data reduction. There is also weather station using Rasphery Pi.

Responsibility for maintenance is in hands of schools.

Data access: freely available on the internet public database, but also Application on programming interface to allow everybody to use the database without programming. They provide also SAPPHIRE (HISPARK analysis framework based on Python). But normally one just goes to the website and download and work.

Experiments to do: measuring coincidences and single rates, identifying if hits are from the same shower. You ca also do azimuth angle and zenith angle measurements to get direction reconstruction between detectors. This can be done also between different stations and you get nice energy reconstruction (which Kasper wants to optimise).

Overview: 140 stations, 6 billion of events, open data system, analysis framework, online programming environment, 10 years of experiences, no thinning CORSIKA simulations, Muon tomography. Cost: 10 000 euros – financed by schools themselves, local funding agencies, ministries, sponsors (big companies).

HISPARK symposium – competition for students – the winners go to CERN.

HISPARK in UK - by Bob Van Eijk

Since 2012, 50 schools, private to comprehensive, 3 schools received grants from Royal Society, 20 detectors in schools.

Detectors are built by schools/students themselves guided by scientists/teachers.

Research: Day/night variation of cosmic rays; Investigating link between certain weather factors (pressure, temperature) and cosmic rays; Link between solar cycle and cosmic rays

Annual HISPARK conference at one of the leading universities – for students, where they present the work to audience of academies, teachers and other students.

HISPARK analysis - by Niek Schulteis

Reconstruction game can be used from age of 12-14 years. It shows the capabilities of HISPARK, facilitates interactive reconstruction of energy; presents detector data.

Python programming is used to interpret /analyse the HISPARK data – easy introduction of Python into classes is realised with interactive Jupiter notebooks, these are flexible and enable pupils to discover self – formulated solution / interpretation methods.

Data processing uses SAPPHIRE (simulations and Analysis Programme package for HISPARK research and education).

Pupils from age of 15 are shown simple programming examples, they develop programming skills from scratch; introduction of lists, dictionaries, arrays; modelling using functions; creating plots/histograms; editing notebook templates.

For university level students: building specialised modules/classes, writing test procedures.

Experiments by teachers in research: unique geometry of HISPARK facilitate unique experiments:

-correlation of single rate (1 detector), events (1 station), local coincidences (subcluster-several stations), long distance correlations (with network)

- air-shower development depends on atmospheric parameters, weather;

-detection on the Earth depends on magnetic fields I the solar system: Massive solar flares

-ionisations due to air-showers triggers lightning discharges

Summary: Notebooks are successfully introduces at teachers workshops; HISPARK data is interpreted using tested Phyton modules, HISPAK notebooks, based on these modules are used for research within NIKHEF and at schools from 2015; software is available if HISPAK GITHUB.

Remark: Valid for both EEE and HISPARK – important is to provide materials in English! Because for the moment it is in Italian and Dutch. Maybe teachers can do the translation when they come and work on it… But it is important that at schools one needs to teach in the national language. Python is very nice programming tool written in English, so if students go to learn about it, they need to work in English.

Dutch Teacher in Research program - by Jan Van Holten

HISPARK- research and education program for teachers, students, since 2003 coordinated by NIH+KHEF; 100 detectors stations in Netherlands, 20 in UK and Denmark, build by high school students and teachers.

Goal: use research as a tool to improve science education at high schools.

Data are collected at special server at NIKHEF.

The LIO programs: 5-6 teachers have opportunity to participate at research in cosmic rays for 1 day a week (compensated by funding agencies), - around 50 days per year. Every year successful projects collected in annual reports, which can be downloaded at HISPARK website, Lot of publications in various journals (teachers are encouraged to write a paper and get it published by Dutch Physical Society).

Analysis using cross-section of detector, Monte Carlo simulations for several angles, primary energies; reconstruction of energy flux, energy spectrum; not only experiments observing primary particles, but ne project is also about lightening - whether it has some correlation with cosmic rays/air showers (collaboration with meteorological institute to get data from lightening events).

Muon lifetime and other classroom experiments in Amsterdam - by Frank Linde

Muon lifetime measurements: scintillator – measuring pulses and having statistics for 100-200 evets and measure muon lifetime. About 20 students per year. Let them play with it and week later they get more data – 1000 events to make better results. Schools and research institutes buy these detectors (scintillators are not very cheap – 2000 euros). Students decide themselves what they want to measure/analyse.

Build your own laser interferometer: measure index of refraction, building kit (79 euros) – hundreds sold, 5-10 students per year at NIKHEF.

Build your own cloud chamber: even using radioactive sources. Kit for cloud chamber. Note: there is one very good also in Microcosm and in SCOOLAB at CERN with hand on workshops to build it.

Cosmic Arch: measuring the angles of cosmic rays

Spark chamber…

Popular Dutch websites: natuurkunde.nl (1000 000 visitors per year, age 14-18); science space (age 11-14, 300 000 visitors/year);

Outreach in Finland - by Kai Krister Loo

Outreach started in 2010, discussing with teachers, how to develop the visit program for students so that it's interesting for them.

EMMA experiment – in the mine, measure muons underground, 11 stations in total

C14 experiment – measuring of radiocarbon content in liquid scintillator samples

Cloud chamber observations, building of cloud chamber - very popular

APPEC - by Antonio Masiero (chair) – he didn't upload his slides on the website, maybe you can put them…

APPEC: Astroparticle physics European Consortium http://www.appec.org/ Before it was ASPERA?

APPEC is a consortium of 17 funding agencies, national government institutions, and institutes from 14 European countries, responsible for coordinating and funding national research efforts in astroparticle physics.

Structure: APPEC General Assembly, Joint Secretariat, Scientific Advisory Committee and Functional Bodies

The APPEC General Assembly gathers heads of agencies around Europe and observers from international organizations such as CERN, ESO and JINR, to create a forum where future actions are discussed and common endeavours emerge.

Scientific Advisory Committee: 19 experts from all world, who are consulting APPEC, examines and reports on issues of strategic scientific importance., proposes programms…

APPEC Functional centres: The main activities of APPEC are distributed over a limited number of 'functional centres' hosted in different participating institutions, each functional centre having its own leader and dedicated staff. APPEC is currently organized in four functional centres:

- AstroParticule et Cosmologie (APC) Paris, France
- Deutsches Elektronen-Synchrotron (DESY) Hamburg, Germany

- INFN Laboratori Nazionali del Gran Sasso (LNGS) L'Aquila, Italy
- LSC, Laboratorio Subterráneo de Canfranc, Spain

Roadmap: 7 fields in astronomy and astroparticle physics- characteristic actions of APPEC: "magnificent 7": HE gammas, HE neutrinos, HE cosmic rays, Gravitational waves, Dark matter, neutrino mass, neutrino mixing

In Mai 2017 in Brussels: official launch of new Astroparticle physics European roadmap – new thing about it is that it will be "resource aware", meaning that it is a realistic plan: trying to understand what is the investment of institutes in APPEC today in Astroparticle physics and trying to extrapolate this for future and combine it into the roadmap – a policy for AP physics in Europe. At the moment it seems that the resources are not enough. There are 2 new subjects on the top of 7 magnificent: Dark energy, Cosmic Microwave Background (unknown inflation etc.). There is 20 years plan till 2035 (see slide!).

Nowadays in general there is a phenomenon of concentrating to huge projects - Big Science: Too big to fail. But the recommendation is: Beware to go to only big projects! Also small projects are very important.

Recently APPEC put a lot of accent to Education and Outreach. There are several centres of APPEC on E&O. In the new roadmap it is important as well.

APPEC in cooperation with IPPOG encourages… (see slide!)

In last 30 years there have been a lot of great discoveries in AP and cosmology field. There is bright future ahead- for next 20 years, the development of the new sector: multi-messanger astronomy, dark matter, inflation, dark energy, neutrino masses, number and CP violation and their interplay with cosmology.

Extreme energy events: physics program and perspectives - by Francesco Noferini

Project launched at 2004 at CERN as collaboration of Centro Fermi, CERN, INFN, MIUR, SIF.

46 telescopes in high schools + 2 telescopes at CERN + 4 telescopes in INFN Bologna = network of 52 telescopes distributed in clusters in Italian territory in 28 cities + Geneva, installed at schools and maintained by teachers and students: Italian students come to CERN for 1 week and they build the detectors. Goal is to involve young students;

EEE MRPC (multigap resistive plate chamber) uses the same technology as ALICE-TOF detectors, they are built by HS students at CERN; GPS for positioning

Data collection in central site in Bologna (IFNF-CNAF) + statistics: 37 billion of cosmic rays (muon tracs), 5-10TB per year expected.

Measurements:
- EEE telescopes collect secondary muons coming from primary cosmic rays of over 10^{11} eV; coincidences allow to select primary energies above 10^{15} eV.
- Multi-telescope analysis – cluster of telescopes in some cities, distance 10-100 m, allow to select high energy cosmic rays, reconstruct the direction of wave front of shower and correct for delays.
- Galactic Cosmic Ray Decrease due to solar activity

-Rate vs Distance

- Upgoing events (electrons coming from muon decays)

- Cosmic ray isotropy at sub-TeV scale

Next step: goal to reach 100 schools in network, from 2-telescope coincidence to 3-telescopes coincidence, larger distances, different cities; add multi-track telescope analysis in the search, test pointing capabilities of telescopes…

EEE Open Data project: so far Data monitor services provided at CNAF (www.centrofermi.it/eee/monitor); Tablets to 75 EEE High Schools (50 with + 25 without telescope); Remote & continuous monitor of EEE telescopes and access to data even for Schools without telescopes.

Next step: provide basic framework for Masterclasses within the EEE Project; descriptions (metadata) and tools (macro) for data analysis; content for educational courses for High School students

They expect to benefit from IPPOG experiences.

Luisa: The raw data today are not available, but for educational purposes yes, they are willing to collaborate with HISPARK, put the data and select data. Like CERN who provides the data which are worked out already, elaborated , not for people to do discoveries, but for educational purposes.

Extreme energy events: Impact on didactics and science awareness - by Ivan Gnesi

The EEE observatory was born in 2004 with a the challenging scope of both Studying the Cosmic Radiation at extreme energies never observed before and Addressing phenomena related to cosmic radiation (environment and climate; life; solar and interplanetary effects)

-unprecedented and very welcome case of online EEE schools, 43 schools + growing

Didactic and research activities: group of 4 students, 1-2 teachers, come to CERN and build telescope and learn, study, try and understand deeply; then these students take responsibility to maintain experiments; they do also data taking and shifting like researchers.

Continuous exchange with social networks

They save all the data in electronic logbook, where all schools are searchable.

Students measure fundamental parameters for data analysis

Teachers and Students often take in charge activities according to their specific courses.

"Telematic " school activities: remote and shifting on existing telescopes by remote access; using portable cosmic rays detectors

EEE Monitor – powerful tool, anyone can see data from each telescope - open data quality monitor, information on fraction of good tracks, cluster multiplicity; anyone have access to these data and do some analysis, including Monte-Carlo simulation generating shower.

EEE Masterclasses: involved in real experiment, telescope shifting, high energy cosmic showers, extreme events on sun, looking for telescope coincides…

Scientific collaboration works Symposia organised 2-3 times a year – present their own analysis + Open analysis meetings

Next plan: Building a wide outreach network in science – need to find new ways how to teach the physics and science the teachers and students, real experiments are really important!

Science awareness in Society is a fundamental aspect of research itself because of the strong economic impact of Science, the role of Society in taking decision on Science is growing. Importance of direct contacts between Science and Society (industry, school, communication, welfare), new ways of teaching and making Science (pushing on the need for interdisciplinarity).

Real experiments directly involving Society are the most effective way of getting many of these requirements opening for new.

Proposal: A beautiful idea of Science as the real Global Community can be reached working together for a connected net of experiments; open data; web portals for direct Science Communication; Scientific Events for citizens; Updates for Science teaching; distributed repository

Cosmodetecteur and COSMIX and e-PERON - by Nicolas Arnaud

Sciences a l'Ecole: project of French ministry of education promoting science in high schools – part of it: COSMOS a l'ecole – goal to provide detectors to schools, 30 detectors being used by 1700 pupils, teachers get them for at least 3 years and they can also train their colleagues, circulate to other schools; also trainings for teachers: CERN French teacher program, CPPM week training, website, CNRS/IN2P3 scientists like mentors.

Detectors: 3 scintillator plates with photomultiplier + DAQ system- students detect muons - in addition there is plexiglass radiator to see Cherenkov light and scintillator to measure muon lifetime.

Educational activities: raw muon angular distribution, lifetime of muons, study radioactivity of rocks with detectors on the of it, showers

Nationwide network, organising common taking data days and sharing…

COSMIX detector: more recent, same principle but more portable, compact, light, you just switch it on, to power and start taking data 'plug and play'- around 2500 euros

2 kind of experiments/data-taking modes: single rate and coincidence (when mobile part is used); GPS also included

Measuring cosmic rays rates vs altitude – take it on trip to mountains

Circulation of COSMIX detector: more than 1000 students in 15 High schools, more underway (in 2017 10 more cases), also in CERN S'Cool Lab, etc..

COSMIX is more simple to distribute, because it's physicists taking care, but for the first project one needs the safety certificate if another teacher wants to use it…

e-PERON: project on the top of mountain in Pyrenes, where e-peron (particle?) was discovered.

e-PERON virtual lab : The data are available for experiments, joint collaboration between various labs, 60 kiloeuros budget, started 2 years ago… some data are already used locally at universities and groups of around 20 teachers are using it for high schools.

For the moment the website is only in French (therefore it is called national activity), but otherwise it's available freely to all the world

Cosmic ray outreach in Stockholm – on the ground and in the air - by Tanja Kramer-Nymark

The project of cosmic ray outreach was initiated by Mark Pearce 15 years ago – goal to inspire school children located at Stockholm House of Science; school visits of laboratories; experiments in physics, technology, biology, chemistry…; teacher training courses also to students who are becoming teacher.

In Sweden there is a compulsory project which everybody must do to get an exam – so they proposed projects also on cosmic rays

SEASA – Stockholm Educational Air Shower Array – network of 5 schools in Stockholm area – students build detectors but it is difficult to maintain due to lack of manpower and funding

Detectors: *Cosmic Rays Telescope* – portable but not easy; *Gigantos* - 3 scintillator plates, quite large, mobile (can turn), but not portable; *The "flux" PFD* – Swedish astronaut took with him to space a little detector and did measurements, now they have access to these data, when back, detector went to the space station and it's still there…

School programs 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-liife

Project work for HS students for last year of their HS; 5-6 meetings for 2 hours' time, students come during 6 months; lectures by scientists, tutoring and then they take detectors with them, take it to mountains or elsewhere and do the analysis.

Examples: What influences the flux of Cosmic Rays (pressure, etc)? How can we improve the muon detector to make the measurements more reliable? How does the muon flux depend on latitude and altitude?

PADMe = Particle Demonstrator Monitoring Extension: show number of registered particles on a display; do time-limited measurements; transmit data to computer

How does the muon flux depend on latitude? They brought detector to different placed in Sweden.

How does the muon flux depend on altitude? Flying detector on a weather balloon upto 3300 m. Future plans: one flight per year aiming to get even higher. The detector must be probably put into thermostatic box, because with temperature it can react differently.

The open outreach educational project "Showers of Knowledge" - by Victoria Tokareva

Project Showers of Knowledge consist of distributed facility "Rusalka" (meaning mermaid) – unique interactive internet portal: http://livni.jinr.ru – aim is to bring worldwide internet users to the analysis of data constantly accumulated in the course of real experiment in the field of cosmic rays research; objectives to make fundamental science more popular and encouraged by society…

Audiences: middle and high school students interested in physics, university undergraduate physics students, any keen internet users.

Why cosmic rays: Why cosmic rays? They are relevant for introduction into a wide range of trends in modern fundamental science; they make it possible to constantly accumulate big stats with minimal expenses for hardware and comparatively simple software for the analysis; it is simple enough to understand the idea and perform first experiments.

Educational tasks: Physics, Astrophysics, Mathematics, Technology

Scientific tasks: Monitoring of broad atmospheric showers; Search for space or time correlated showers (nuclear dissociation, interaction with cosmic micro-objects like dust or meteorites, etc.)

Rusalka consists of 11 workstations, inside JINR building and area of 0.5 km diameter; best for te shower registration. Each workstation – 2 scintillator counters, GPS receiver or GLONAS, DAQ system. All data stored on server, users can access them; there is a web interface to run jobs with data, figures etc.

Project statistics: portal was launched in 2010; 571 registered users, more than 300 000 site views, more than 10 000 executed jobs; several languages, all materials are in Russian and English.

Outreach work: INR University; JINR Science Museum; "Poisk" (Search) school centre; Summer school "Modern Physics"; JINR Science Festival; Videoconference with students of Moscow schools

Perspectives: more than 100 schools, more than 10 clusters, global super detector for rare showers of super-high energies > 10^{19} eV

Cooperation: Joint institute of Nuclear Research DUBNA, Russia; Partnership with Callio Lab in Finland

Educational portals - by Sofoklis Sotiriou

Examples and Practices: Up to now it has been shown what is being done at e=various places, now it will be shown how the efforts could be brought together globally: Tools and Data Repositories; Educational Portals and Content Aggregators; Search Mechanisms; Community Support Environments; Authoring and Content Enrichment Tools; Users support; Monitoring and Impact Assessment

Strategy: Unification of existing tool and online materials; organised according to the scientific curriculum; access to rea data; advanced infrastructures; high quality content; user generated content; developed accordingly commonly used educational approaches; organised in meaningful activities; tested in real environments;

Goal: idea is to support teachers to provide their own tools, scenarios;

COSMOS project: about 10 years ago there were many Astronomy observatories, and they organised resources for teachers and then offered the interface for teachers to work with data.

Demanding job is to organise the curricula of different countries and create the common curricula which would help teachers to orient and find right resources – organise all in meaningful activities for the full classes.

Tool repository: example: "Discovery space" project; bring network of telescopes together and give teachers opportunity to make own observations.

Educational portal "Discover the Cosmos" http://portal.discoverthecosmos.eu - not only tools and experiments, but the opportunity to develop their own materials, scenarios; 629 educational scenarios and 92709 educational resources brought together in astronomy and HEP field.

Content Aggregator: "Open Discovery Space" (http://portal.opendiscoveryspace.eu): >80 000 resources, >1200 communities, >2500 schools, 12 000 teachers, 165 activities.

If data are not stored in one central location, but in different locations, million resources, 10 000 teachers from different countries organising their own communities – more complicated

Search mechanism: “Discover the Cosmos”: search by keyword, educational content: language, age groups, school curriculum, educational level -> classifications, user assessment opportunity;

Authoring and Content enrichment tools: creating and uploading own tools, inquiry based-models (inspiring science, GoLab), 5 phases of IBSE educational scenario: orienting and asking questions; Hypothesis generation and design; Planning and investigation; Analysis and Interpretation; Conclusion and Evaluation.

Embedding virtual e-science applications; Online Assessment (Assessing Problem Solving Skills and Knowledge Items);

Community support environments: community building is important, teachers work together and exchange in network best practices, information…(Open Discovery Space Community Support Environment:>1200 online communities as of now http://portal.opendiscoveryspace.eu/communities)

Users support: Training academies; inspiring science different training courses (ESEA, ISE…), example of teacher training activity “Building cloud chamber”

Monitoring and Impact Assessment: impact on community building and support mechanism.

Example of ISE Community portal: more than 10 000 STEM students; > 5000 educational scenarios created; implemented in > 5000 schools. Majority of teachers believe that the ISE Solutions (i.e. IBSE Methodology, e-Learning Tools, Educational Scenarios) have a high or very high Impact on their Teaching Practices and their Professional Development, on the Motivation of their Students and even on the School Curriculum for Science Education; very low Bounce Rates and high number of Returning Visitors further indicate the suitability and acceptance of the ISE portfolio of educational offers.

- 20% of users remain after 20 clicks, what kind of resources are being uploaded with time spent…
- Sophisticated monitoring and analysis tools – for our project maybe later…

How it works: 1h20 is average lesson, which is developed in 5 phases by teacher, it actually allows to do extra-curriculum and out-of-school activities to the classes. It could be applied for example also to Masterclasses – enabling them to be in the classroom like a lesson plan. All kinds of special interfaces can be embedded into the platform. It works as a social platform, schools are registered by school headmasters who give the certification to teachers, so we trust them that they will upload correct good quality materials, therefore there is no need of editing. Teachers are producing metadata files, they must obligatory fill in the IP rights data (creative commons principles) and have responsibility for data they upload. There is a possibility to report incorrect content and comment on other contributors.

Conclusions:

**Educational Portals* can host and effectively facilitate the use of different experiments. Through their services, users can upload and download data, share educational content, search and use e-science applications of their interest.

*Effective search mechanisms allow users to find the resources, lesson plans and e-science applications of their interest efficiently.

*Educational Portals can host a community support environment for exchange of practices and content between users. A high number of Teachers consider the ODS online communities as a sufficient basis to exchange practices and use the portal's tools for sharing Open Educational Resources.

*The Concept of Training Academies for Teacher Professional Development has been thoroughly tested and proven to be successful.

*Portals provide coverage in different languages and provide connection with the social media, thus ensuring their high visibility and outreach potential.

*Portals can provide authoring tools with a solid metadata scheme in order for teachers to create their own IBSE based educational scenarios.

*A solid strategy for portal use validation has been operated and proven to be effective.

IPPOG - by Steven Goldfarb

IPPOG (International Particle Physics Outreach Group), is a group of particle physicists, science communicators and education specialists, developing & sharing ideas, best practices, material & projects and international programmes to convey the value and excitement of particle physics to a global audience.

IPPOG is a Collaboration of representatives from Nations, Laboratories and Experiments agreeing to MoU, sharing of resources in order to guarantee sustainability, expand our reach, support new initiatives.

Expanding IPPOG Scope:

*International reach: Members from Australia to South Africa to Italy to…; Particle Physics Masterclasses in 46 Countries

*Particle Physics Facilities: LHC, IceCube, LIGO, Auger, …; High School Rooftops? (cosmic rays detectors)

*Outreach Themes: W, Z, Higgs, CP Violation, Neutrinos, Gravitational Waves,..; Cosmic Rays?

IPPOG perspective for this Cosmic Ray Workshop:

Perfect example of activity IPPOG supports; sharing of innovative ideas started independently; goal to identify and develop commonalities; Project with far-reaching scope; Potential to reach many schools / students; Reasonable requirements for resources; Potential for a long-term sustainable program; Hands-on example of particle physics research; Detector Installation, Operation, Maintenance, DAQ and Computing; Physics Analysis; International Collaboration

Hope & Commitment

Hope for outcome of workshop: Sharing of ideas, projects, material, plans; Identification of commonalities & best practices; Plans for consolidation, when appropriate; First ideas for a globally connected program

IPPOG Commitment: Source of material, ideas from other projects; Platform for sharing cosmic ray material (not sure how this is meant…?); Forum for ongoing discussion; Support for communication & network building; Coordination with APPEC

Comment from public: We should be more aggressive by trying to get the funding in order to succeed.

Barbora: Important to understand, that IPPOG is giving a structure but project as this is going to apply for funding with support of big bodies, like IPPOG and APPEC.

Also, among others there was a misunderstanding in the public, that MC are heavily financed by IPPOG…

2nd day – 16th of February 2017, Rome, Centro Fermi

Minutes (Danielle De Gruttola)

Gamma Ray Hunters – by Sebastian Grinschpun

www.cazadoresderayosgamma.com

-invitation for students in Spain

- start working with MAGIC data (high time resolution air Cherenkov telescope)

- masterclass in astrophysics built from this work

web application:

- videos pictures explanations
- environment to make analysis (Python)

- 1 Challenge: do your own analysis about the Crab Pulsar (most important gamma rays source)

- 1 Prize: visit the MAGIC telescopes (spending one night there for observations)

Why Python? Easy to setup, easy debug

Why Jupyter Notebooks? Interactive programming on the web

Why Flask? Integrating Jupyter Hub with custom HTML pages

Why Digital Ocean? Cloud computing service. Security

Some analysis done for outreach:

- list of reconstructed events is provided (time, energy, space, particle infos)

- learn about statistical analysis

- cut criteria

- light curves (time analysis)

- noise vs signal, significance

How data are used?

- play at home

- tool for teachers in the school

- tool for workshops in research centers

Website online since October 2016

- 2500 unique visitors, 400 registered users

- Comments and interactions with users

- Very low maintenance requirements

- 4 workshops at IFAE with students & teachers

- Attracted some press

Online example:

-interactive cartoon

-links to information and explanations

-library included (python) that can be used by users

Questions:

1) how long to see a result?

Less than an hour

2) why you called it game?

Each night you learn something and it is directed to you…it's an interactvie challenge, as an adventure game…

Starting with really simple data and analysis, than you go ahead with the challenge…

3) only in spanish, plans to translate it?

Yes

4) connections with classroom activity?

Important point: learn how to programm and apply to new items. Diffcult link to real school curriculum

Comment by speaker: produce platform to make new cosmics on other items

key point is the combination between narrative (explanations) and programming with python

DETECTA - by Sebastian Grinschnup

Last year a student built a Cherenkov detector

Project not meant for real science

- STEM education: physics & electronics & programming

- Engage the students in the scientific process

- Interdisciplinary working group

- Design a particle detector → versatile, modular

- Testing and characterisation by students

- Teachers involvement in the process

- Education & Outreach material

- Analysis proposed & performed by students

MWPC

Students are building the single wires

No funding agencies found → they say that it is too expansive (1000 euro….)

Ad-hoc electronics

Arduino electronics tirgger, ADC, reco → students?

Software → students?

Analysis foreseen

- Cosmic rays

- Fundamental Physics with Gammas, Alphas, & Betas spectrum, Bragg peak, Landau Distribution, tracks, energy deposition

- Tomography

R&D moment

questions

1) why such a difficult detector?

The group was involved in this technology

Cosmic- Ray Extremely Distributed Observatory (CREDO) – a tool to explore uncharted realm of science - by Petr Homola

don't call it outreach → call it citizien science…..

involve other itmes: ASTRO; GEO; BIO; FISHING (HUNTING FOR UNEXPECTED)

GEO:

can cosmic rays predict earthquakes? Why not?

There are research and papers

Add sismic detectors, satellite projects for effect on ionosphere…

Auger saw a correlation with earthquake in Chile in 2010

BIO

How cosmic rays affect us on the earth?

Why not to look for correlations with hills?

FISHING

Cat the global cosmic ray net

CITIZIENS SCIENTISTS

New affiliation for papers: amateur astronomers

ASTRO/COSMO

Study cascades

Millions of photons spread over a very large area (indirect DM search)

Slide 11/12 for the physics process*

The conclusion now is: exotic (Dark Matter) scenarios severely constrained

But this assumes single photon!!... → slide 15

*Process:

pre-shower:

Photon interacts iwth magnetosphere -> conversion to e+e- -> synchrotron radiation -> shower in atmoshpere

-> (super)preshower

classification in slide 17

let's look for events like central one in slide 19 and 20

road map in slide 21

slide 25

look for clusters in time, instead of space (look for detectors hit at the same time, even not one close to each other)

CREDO guarantee of success:

ocean of opportunities / synergy generator under one roof (project) slide 31

<u>Discussion:</u>

1)standard preshower foreseen should look different and we don't see them, but if the process starts very earlier the shower is spread and

2)how can this kind of reasearch work? What are you doing in CREDO?

We started this study in Auger – **40 people working on this**

3)is there any ready insfastructure to put all data together?!!

Something very simple is going to be proposed

Big data wise…

ACC Cyfronet AGH-UST: computing center to host a global cosmic-ray initiative – by Marek Magrys

established in 1973

provides free computing resources for scientific institutions

- TOP500 ranked supercomputers/clusters

Prometheus 2.4 PFLOPS and ZEUS 375 TFLOPS

- Storage

Disk 20+ PB and Tape 30+ PB

- Cloud for scientific resources

- high bandwidth national and regional network

- 2140 TFLOPS in CPUs + 256 TFLOPS in GPUs

- 2232 nodes, 53568 CPU cores, 279 TB RAM

- 10 PB usable disk space @ 180 GB/s

Questions

1)do you offer the infrastructure?

yes

Citizens science potential in a global cosmic-ray project: hands-on exercises with CREDO/Dark universe – by Sulek Mateusz

project: mark luminosity of the stars for planet hunting

link on the presentation

https://www.zooniverse.org/projects/credo/dark-universe-welcomecredo.science

Quarknet: Cosmic Rays studies I – by Marge Bardeen

50+ centers at universities and labs across the U.S.

82 physicists as volunteer mentors

563 active teachers & their students

+International outreach

data on slides 5 6

High school students develop their own research

questions, conduct investigations, analyze data &

reports results.

Materials Include:

- Hardware – portable & configurable
- Data Analysis Tools – online, browser-based
- Cosmic Ray e-Lab – instructional tool for teachers
- Professional Development – workshops & help desk

California: sea level up to mountain..

Slide 16

Large circles are places where teachers can meet students

Small circles are the activities of the students

Students can write documents -> teachers can comment

Questions:

1)81k files, where do they come from?

Students

Quarknet: Cosmic Ray Studies II – by Mark Raymond Adams

net spread around the world

e-lab data

analysis from students:

flux -> rate vs time

shower -> correlate events from different DAQs

muon lifetime

tof -> relative time between counters, speed of muons

link to dataset: select DAQ, date and run analysis

you can set parameters

various examples

their level of data is useful to experimenters outside of QuarkNet

With a common format,

studies of any user with any other

user's data would become much easier. A better shared

logbook would need to be implemented.

Imagine a world

-wide network of detectors that high school

students can:

1.Monitor for rare events.

2.Mine for rate variation around the world.

3.Explore effects of latitude or pressure versus altitude.

4.Monitor the entire celestial sphere for cosmic ray variation.

Questions:

1)you are **not in a stable configuration**; if you do this, students will not be free as now..

students are the prioriy

3)different analysis -> different sites?

usually students use their own data

4) size of the detectors?

25x30 cm^2 in different configurations

Quarknet Cymru – by Fraser Lewis

mostly involving schools already in HiSparc UK. (supported by Cardiff and Swanse Univ.)

- they plan to create a website for sharing resources and get in touch with teachers.
- they bought 4 rooftop module from HiSparc and installed in 2 University, 1 Research Center and 1 schools
- they (Swanse Unviersity) also build 7 portable muon telescopes for university and schools
- 6 geigers + 4 cloud chambers
- 3 MX10 (1 of this is mounted on a lorry going around UK)
- they give access to Faulkes telescope to students
- Virtual Reality tours (additional activities related to Faulkes telescopes)
  * 360 degrees tours: Mars, falling into a BH, Labs Museum, also Hospital, Dinosaurs etc. and they want to add Cosmic Rays Virtual visit
  * using Intern. Space Station Data + Gaia Data (SN, BH ...)

Reflections on Cosmic Ray Project work in UK schools – by Kevin Mosdale (Radley College (Oxford))

4 years old program
Involves 12 students for 2h a week for 6 years.
-Intro to CR
- They Set Up a home made detector
- Finding the plateau
- Performance study
- CR flux studies

SkyView – by Julian Rautenberg

Wuppertal University

Detectors SkyView (liquid scintillator tank (20 keuro)). Too coslty for schools, then used for university labs.
CosMO Detector was developed for schools (3 cm of liquid scintillator + PMTs), to be used in clusters of 4 module.
  - first version with GPS + 100 MHz resolution, again too expensive
  - second v. uses Quarknet (800 MHz TDC + GPS) --> working for schools (3 keuro)
They measure direction, no energy, developing user friendly sw, developing Excel Masterclasses for Auger.

Cosmic@web and International Cosmic Day – by Carolin Schwerdt

Astroparticle Outreach in DESY

CosmicLab: a project for supporting teachers and students in teaching physics with internships for students (followed by phD students) and updating activities at schools for teachers.
They also provide portable detectors to schools and activities to be done with the detectors.
5000 students/year, 250 in advanced stage, 60 at CERN workshops, 300 teachers.
Detector projects:
- Build your own Cloud chamber
- CosMO : Cosmic Muon Observer, 3 scintillator counter 20x20 cm (readout using MPPC + Quarknet)
- Portable Cherenkov water counters (size: thermos for coffe)
- sw for measurements (muon half-life, pressure correlation ....)
Events:
- they also provide Masterclasses for Auger
- International Cosmic Day: after introduction on CR physics each school perform data analysis using a Masterclass and then results are discussed via conference calls

Final Discussion: A common open data portal and analysis tools? - convened by Charles Timmermans

HW issues:
-classroom detector
Problems: different nations have different security rules
-Big Muon Counters and telescopes
Also measures direction and timing (EEE).
Not easy to compare data from different setup (scintillator vs MRPCs and others....)
-Airshower arrays
-world wide arrays

SW issues:
- web portals to be implemented
  - data sharing
  - tool sharing
  - learning programs

Question to be discussed:

- do we want to share data, tools, find a common format?

Answers:

on detector subject:

+ For school is better to participate to a world wide project because it's easier for asking funds
- A big enterprise means a detector inside the school but often is not used for teaching activity
+ a Big detector in a wide experiment needs to be monitored daily and this is a huge set of activities to be done which can be interesting for students.
+ people like to have also a role in big enterprises but also having a private detector (e.g. smartphone). This engages people.

on sharing data and tools:

+ sharing data: it is important but it is not possible to share the whole data, which remains a property of the collaboration.
+ Open Data for citizen science is different from those shared data for a scientific purposes, where clear agreements have to be defined.
+ different ways of opening data to citizens:
  --completely open data
  --open on demand
+ might think about really opening data to public for real science (e.g. Long Distance Correlation) because important scientific results could be lost if data are closed
+ real data from experiments cannot be analyzed by people because they are too complex
+ if data are formatted in a clever way, people can give real contribution to scientific results.
+ a proposal is to share a fraction of the data from the different collaborations as a starting point for testing the outreach capabilities

+ building complex detectors is also an enriching activity
+ exchange students among nations is also educative
+ it might be important asking to teachers and students which are the items they feel important.
+ might be useful to move the focus to the kind of audience addressed:
    - students in classrooms
    - students at a Masterclass
    - citizens involved in Science
and ask them questions
+ also ICD could be a way of "sharing data" for outreach, since students can share what they did in a specific experiment/masterclass to other students
+ we could also use the approach of developing webportals with contents in science, without focusing on data.
    -- this approach requires for each topics and masterclass several "difficulty levels" being differents the levels of students and schools connected to the portals.
    -- using games and assigning prices via scientific travels and exchange the net of schools and students would increase and motivate.

Would we be interested in a big shared database

also discussing which kind of data requiring from a detector:
+ time resolution?
+ full ADC?
+ several layer of ToT (ICECUBE)?

HISTORY OF THE PROJECT "Cosmic Ray going global"

From report from 9th IPPOG meeting in Paris, April 2015:

(Full report here: https://indico.cern.ch/event/354555/)

4.1. PANEL: COSMIC RAY BECOMING GLOBAL

Participants: *Marge, Nicolas, Sasha, Michael, Despina, Hans-Peter*

IDEA FOR THIS NEW INITIATIVE:

- Cosmic ray educational/outreach programs offer a huge opportunity for IPPOG to create an umbrella for cosmic ray educational programs
  - bring many existing programs together
  - exchange of ideas and experiences made
  - allow teachers / schools across the globe to participate and engage in cosmic ray educational programs
  - share interesting (unique) datasets on website- raw data, data taking procedure, logbook, analyzed data (possibly, if deemed useful)
  - gather information about the cosmic muon flux on Earth - angular dependance, energy spectrum, charge ratio, composition, etc.
  - build detector and collect own data would have an advantage that students can detect and collect their own data life and not only work with old data (from ATLAS etc. as during MC), which is not really so interesting as taking data themselves
- Started discussions APPEC who expressed mutual interest and possible funds (tried in 2010, kick-off meeting at CERN, nothing happened, but now real interest?)

PANEL DISCUSSION: What exists, what can be done, what are the issues?

HISPARK, Netherlands, Sasha

- Detector (5000 euros) - box with scintillator, photomultiplier, read-out
- 100 stations installed in schools in Netherland, several also in GB, Denmark
- schools buy it from Nikhef, students build and install station, analyse data - correlate with T,p or other stations, students can do measurements with these stations
- Nikhef + commercial development, data collected on webpage, Hispark webpage – good database

TEILCHENWELT, Germany, Michael

- Teilchenwelt Netzwerk- connecting students, scientists and teachers at 22 places in Germany, PP (Dresden), AstroPP (DESY, Zeuthen), for the moment everything in german language
- Cosmic ray projects in Germany: Teilchenwelt Netzwerk organises Auger MC, International Cosmic Day, participates in IceCube MC, Int.Muon Week, Kascade Cosmic Ray Data Center

- Cosmic@Web: webinterface for data taken over the years from several instruments (detectors, scintillators,...) - starting mid 2015
- Detector: CosMO detectors –(plastic scintillators to measure muons of air showers, 15 places in Germany, 32 new detectors sets build right now), Kamiokannen (Cherenkov light of Muons)
- Teachers/schools in Germany can get detector for one week/month from one of the institutes of Teilchenwelt under the condition, that they would use it for teaching programs
- German company sells expensive detectors (7000 €), if angular distribution we need at least 2!

COSMIX, France, Nicolas

2 types of educational cosmic detectors in France

- CNRS/IN2P3 and « Sciences à l'Ecole » (ministry of education) joint project; 32 detectors loaned to teams of high-school teachers (for usually 2-3 years), teachers selected and trained
- COSMIX - designed and built in the Bordeaux IN2P3 lab (CENBG),
  - mobile and basic detectors: loans are a few weeks long
  -18 detectors produced in 2014; 27 more in 2015, bought mostly by IN2P3 labs
  - data in ascii files, simple to download and upload and work with it
  - educational brochure in French - supporting document for high-school teachers

EXTREME ENERGY EVENTS (EEE), Italy, Despina

- Cosmic ray physics experiment to study extended air shower from high energy cosmic rays by detecting muon component of the shower (since 11 years)
- Network of muon telescopes (Large area Muon detectors MRPCs) has been installed in 41 high schools distributed all over Italy + 6 muon stations at CERN, INFN and universities (students and teachers build muon detectors themselves)

QUARKNET, US, Marge

- High school teachers from (or not) QuarkNet network receive detector kit (4 counters, photomultiplier tubes, power box, DAQ, GPS antenna, T sensor) for use in their class-rooms
- Quarknet has grant, they can loan DAQ detector for 700 dollars for 5 years
- The e-Lab for all US and international teachers provides tools needed to guide students through cosmic rays investigations, downloadable files for excel or google docs
- 2015: 775 DAQs worldwide (250 with QuarkNet), 65 000 data files uploaded, 16 000 plots saved

International Cosmic Day, Marge

- 39 participants, 8 October 2014

TO DO: Promote participating in ICD in your countries and encourage physicists and students to do measurements, plots (ALL)

International Muon Week

- 51participansts, 9-13 February 2015
- ran by teachers vs. MC ran by physicist

TO DO: Promote participating in IMW in your countries and encourage physicists and students to do measurements, plots. Make connections with teachers. (ALL)

TO DO: Provide information for others to distribute. (Marge)

DISCUSSION OUTCOMES

Depending on feedback from APPEC consider the following:

1) Create the common webpage for cosmic rays:
- collect everything that is available today (links to networks) and translations. Important to make the idea and information visible to people.
- including construction plans for detectors, information on how detector can be obtained by school (what detectors, from where, for how much, how long…)
- inspiration for this webpage from: CERN@SCHOOL event (STFC), MEDIPIX (good webpage- there is very well explained how detector is used, etc., Mozilla Global Day for Science...

2) Create a leaflet about muons that we could see on Earth and highly energetic muons which are detected- as a nice joint initiative of IPPOG and APPEC

TO DO: Put together 2 pages of what is available (also including info from CERN@SCHOOL in GB) and present it to APPEC, confront them and see whether they would like to provide funding… (**Marge**)

ISSUES:

Teachers training: challenge to think about how motivate teachers to go through learning process, maybe also would be good to do some online training?

Which detectors to use?

- We need standardised detector low-cost, detectors offered should be standardised
- Geiger counter (500 euros) + laptop (500 euros) = > read-out: you can do quite a bit
- Next step: correlate muons, pointing resolutions, higher level of experiment – 5000 euros
- Or use the commercially available instruments to detect fluxes (some cameras), but question whether there is some science to be studied?

Others issues:

- What is the data format? Which are the important data? Do we need the common data format?
- To translate part of the existing educational material to English
- To encourage teachers to participate to international events -Language is likely to be an issue/a showstopper for some teachers
- Publicity through MC, Int. Cosmic day, Int. Muon Week
- People register to those events, put their flag, but don't upload the plots, don't finish their job
- How to train teachers to participate in Int. Muon Week or Int. Cosmic Day

IPPOG Newsletter 1
http://ippog.org/sites/ippog.web.cern.ch/files/IPPOG_Newsletter_September_2015.pdf

Cosmic rays becoming global

We propose to establish a 'universal' portal through which successful cosmic ray studies programmes can reach out to teachers and students around the world. This common webpage on cosmic rays would contain all the resources available today, including background information, data, analysis tools, an educational framework for students' investigations, a place to post results, and more. Teachers and students will learn how to build, borrow or purchase a detector for use in the classroom and the translations are also envisaged.

Possible new IPPOG activity…

Educational/outreach programmes present an excellent opportunity for IPPOG to set up an umbrella structure. Many such programmes exist in a number of countries, so there is no need to re-invent the wheel, but this is an opportunity to take advantage of being a network to bring the existing programmes together with a view to exchanging ideas and experience. The aim would be to allow teachers /schools across the globe to participate and engage in cosmic ray educational programmes.

Partnership with APPEC in the pipeline

Following the ASPERA meeting on cosmic ray detectors for education held at CERN in 2010, several high school cosmic ray project representatives expressed an interest in working together to develop a common website and data format so that teachers and students worldwide, with or without a detector, could design and conduct studies using data from one or more projects. At the April 2015 IPPOG meeting, a panel representing five of the original cosmic ray projects (COSMIX, Extreme Energy Events, HISPARC, QuarkNet and Teilchenwelt Netzwerk) presented a brief overview of their projects and discussed renewing collaboration talks. IPPOG members made a number of suggestions and expressed an interest in participating if the initiative goes forward.

In the meantime, Hans Peter Beck and Marge Bardeen have discussed a possible partnership between IPPOG and APPEC with APPEC representatives, who expressed an interest and raised the possibility of releasing funds for the joint project. IPPOG hopes that official collaboration will prove possible, and the discussions are continuing.

From report from 10th IPPOG meeting at CERN, November 2015:

(Full report here: http://indico.cern.ch/event/440711/)

4.2. COSMIC RAYS GOING GLOBAL

- Idea to establish universal portal for cosmic rays through which successful cosmic rays studies programs can reach out to teachers and students worldwide, including data, analysis tools, detectors to be borrowed/purchased) - See more details in the newsletter N1, page 3.
- Following the last meeting where this initiative was discussed and well received by IPPOG, Hans Peter had further conversation with APPEC director Frank Linde, who is very much in favour of closer ties with IPPOG, which could be beneficial for defining new projects and asking for European money (which should not be limited to Europe only...). In the meantime the APPEC outreach office moved from Paris to London and new London based outreach officer is going to be hired, therefore we are waiting for him/her to be found and settled in to push forward.
- **Design workshop** has been proposed to be organised for all the possible stakeholders in order to determine together the structure and all the requirements of the project (get inspiration from existing webpages, like Teilchenwelt and others)– possibilities: next International Cosmic Rays Conference ICRC, July 2017, South Korea (too far in the future), ICHEPP 2016 in Chicago

IDEAS: - Web portal accessible for everybody with helpdesk and forum
- Different ways how to process data: 1) Get data and analyse them
  2) Get data out of the hardware through remote access and analyse them
  3) Measure own data with the detector
- Like in normal collaboration students/schools would share the date
- Possibility of remote running of detector (detector available at CERN, CMS visitors site – Wojciech Bialas, bld.27, detector has ability to turn on remotely, good if students cannot come to CERN)

OPEN QUESTIONS: - Do we want to have a common data format?
- How do we incorporate trainings for teachers?

LIST OF EXISTING PROJECTS: CERN@school (UK), COSMIX (France), COSMOS à l'ECOLE (France), CZELTA (Czech Republic), Extreme Energy Events (Italy), HELYCON@education (Greece), HISPARC (Netherlands, Denmark, Germany and UK), QuarkNet (US and worldwide), Teilchenwelt Netzwerk (Germany).

NEW POSSIBLE PARTNERS / Other interested projects:
- ***University of Geneva***: contact Leila Haegel

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1) COSMIC PI- low cost educational and open source cosmic rays detector, small scintillator 15x10 cm, 500 dollars, just connect to internet cable, Raspberry Pi computer for data storage and online analysis... (prototype in IdeaSquare at CERN?)
2) Muon life time experiment in laboratory, not heavily used, can be made available for students

- ***CERN*** – scintillator from CMS visitors site (mentioned above) – contact Wojciech Bialas

- ***NUCLIO***, ***GALILEO TEACHERS***, ***HANDS ON UNIVERSE***, ***OPEN DISCOVERY SPACE***, ***INSPIRING SCIENCE***, ***GO LAB*** , ***ESA***, ***Faulkes Telescope*** (University of South Wales, UK) - contacts through Barbora

TO DO: Pursue conversation/negotiation with APPEC (H-P, Marge)
TO DO: Put together already now little website, where what exists could be put together (Rasmus can try to use it – as HST)
TO DO: Define goals/needs from the point of view of the teacher (Rasmus); Marge will loan him a detector from QuarkNet
TO DO: Organise a design workshop (Marge?)
TO DO: Follow up with all new contacts of possible partners

From report from 11th IPPOG meeting in Krakow, May 2016:

(Full report here: https://indico.cern.ch/event/513681/)

5.2 Enabling cosmic rays globally – Charles Timmermans

- Issues were identified such as:
  - Analysis of the differences and similarities between experiments;
  - How to share data (Open Cosmics initiative from Achintya) and how to improve the data (VISPA tool);
  - Additional groups (Belgium interests and Denmark: 9 quarknet detectors).

- The idea to use a professional database was mentioned in order to make such data useful for the teachers (ex.: Neutrino database). The importance of the format of downloaded files had been pointed out;
- Teacher projects: 52 high-schools are working on data at the moment using one detector.