



University of Athens

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The CREATIONS project and Educational programs and opportunities at CERN and Greece

- European and International efforts/resources
- National Masterclasses
- CERN expositions
- Science fairs in Greece
- Teacher resources in the framework of CREATIONS
- The HYPATIA tool for University students

The HEP main challenge

**How can we provoke students' curiosity for HEP?
(which in most countries is absent from the national curriculum)**

- So far a lot activities for high school students; IPPOG's International Masterclasses, mini-masterclasses, virtual visits to the experiments, Quarknet, etc etc)
- The students get engaged in hands-on experimentation directly connected to **top-level real-time research** and discoveries
- EU outreach projects developed a lot of material which is ready to be used in **the duration of a school lesson**
- **At University level enhance labs with research tools**

European/International efforts

- EU outreach programs
- IPPOG Masterclasses
- Beamline for schools
- Quarknet
- Non-accelerator masterclasses

Past project: Content of Discover the COSMOS

Discover the COSMOS Repository

The Discover the COSMOS Repository contains educational material in the form of **educational content** (photos, videos, animations, exercises, graphs, links) and of **learning activities** (structured lesson plans organized according to specific pedagogical models such as inquiry based Learning and Guided Research). Users can search for the educational materials in the "Explore Discover the COSMOS" section or to upload their own materials to the Discover the COSMOS Repository, using the "Share your Content" section.

Explore Discover the COSMOS

Search for Educational Content (90205)

Search for Learning Activities (625)



Share your Content

Upload Educational Content

Upload Learning Activities



moCERN

The Discover the COSMOS Repository goes mobile! Now, Discover the COSMOS Educational Content is available for mobile and handheld devices. Visit MoCERN and explore the HEP resources and MoCO and explore the Astronomy repository through your mobile phone.



Visit the DISCOVER the COSMOS Camp in Second Life! Explore the Universe, the ATLAS Detector and numerous other contents of the Repository through a unique immersive experience in a realistic context. From here you can download and install Second Life Viewer which is used for entering the Discover the COSMOS Camp in Second Life. Teleport to Discover the COSMOS Camp.

Discover the COSMOS Tutorials



The Discover the COSMOS consortium has produced a series of video tutorials on astronomy, astrophysics and high energy physics subjects. To access these tutorials click here.

Repository

~ 95,000 items in Educational content
~ 630 educational scenarios (HEP/Astronomy)

HEP tool-box

- HYPATIA
- MINERVA
- CAMELIA
- CERNland
- LHCgame

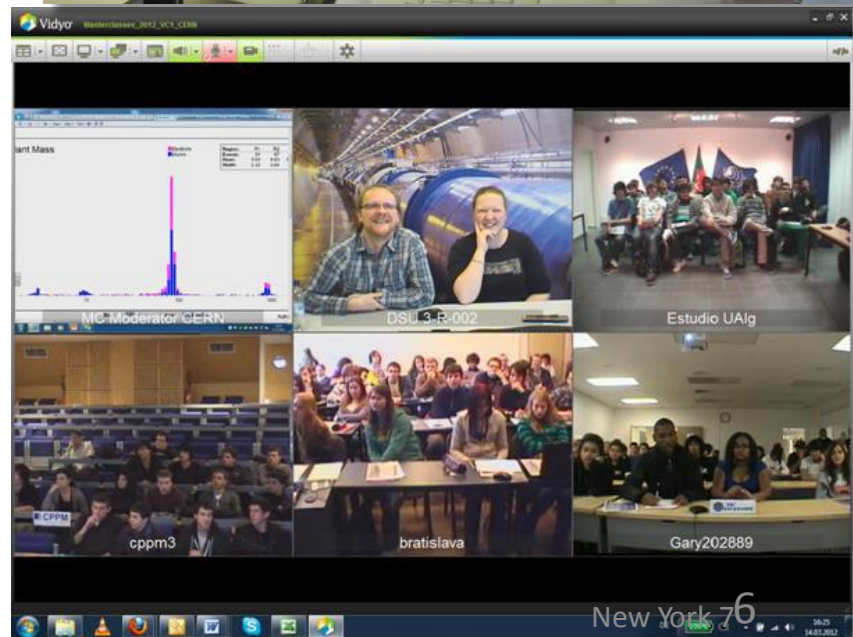
5,000 teachers and
31,000 students reached
850 impl. activities in schools
2,000 schools and continuing

A Horizon 2020 European outreach project to Develop an Engaging Science Classroom

- Will last till 30/9/2018
- Main objective: to improve skills of youngsters in STEM subjects
- HEP partners are UoA/IASA, UoBirmingham, Art@CMS, STFC
- **Many teachers' and students' activities/resources (masterclasses, workshops etc)**

IPPOG's International Masterclasses

- High school students (15 – 19) are scientists for one day
- Get invited to a research institute or university
- Introductory talks
- 2h measurement with LHC data (ATLAS, CMS, ALICE, LHCb) + New also with Icecube data
- International video conference (2– 5 inst. + CERN/Fermilab)



International Masterclasses 2017



1.3. - 11.4.2017

50 countries involved



Coord.: QuarkNet / TU Dresden



- 43 institutes (43)
- 50 Masterclasses (48)
- 35 CMS (33)
- 15 ATLAS (15)



- 173 institutes (169)
- 264 Masterclasses (227)
 - 45 ATLAS W (42)
 - **93 ATLAS Z (83)**
 - 52 CMS (49)
 - 45 LHCb (34)
 - 24 ALICE SP (15)
 - 5 ALICE R_AA (4)

IPPOG masterclasses in Greece (2017)

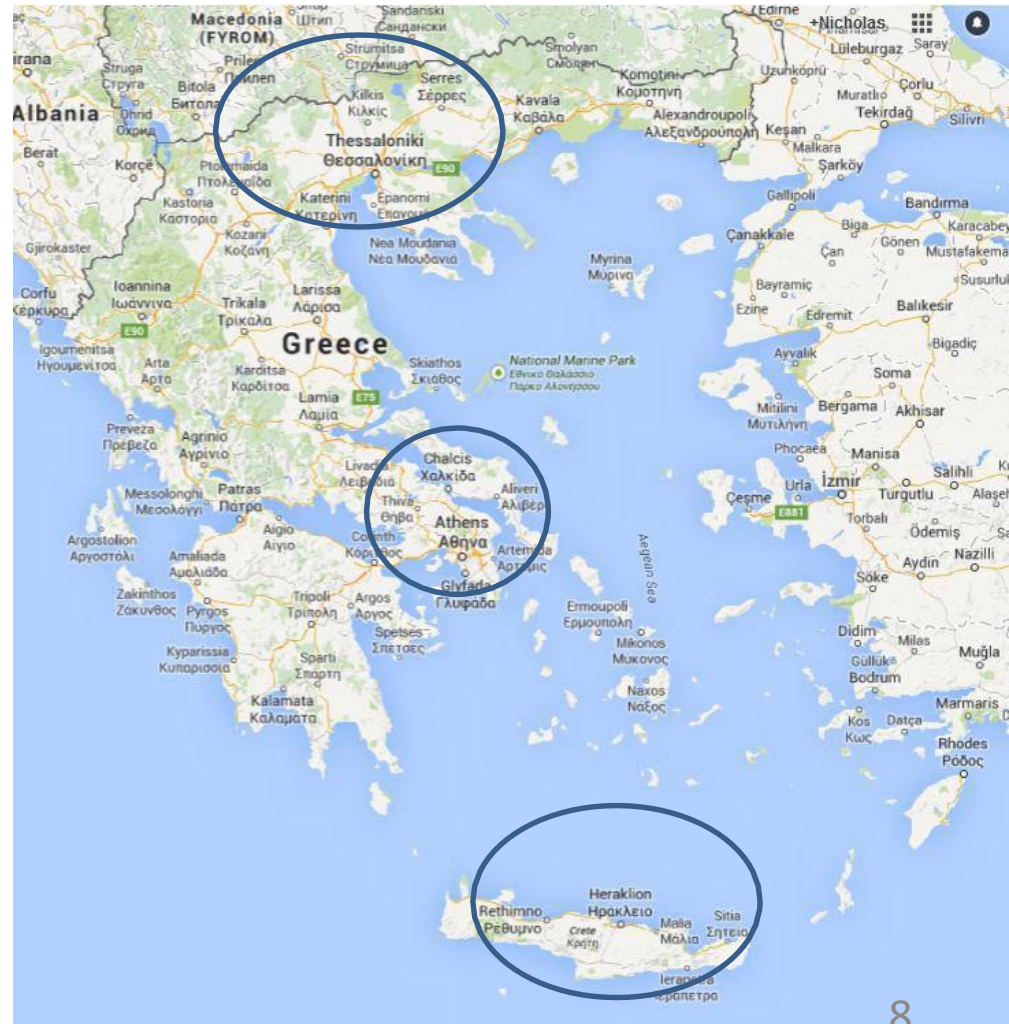
Athens (3)

- Athens University
- N.R.C. Democritos
- NTUA

Applications from 74 schools (~370 students)
for 220 places (+ 35 teachers)

- **Thessaloniki University (AUTH)**
Applications from 70 schools (~350 students)
for 100 places

- **Crete University**
100 students from 16 schools (+18 teachers)

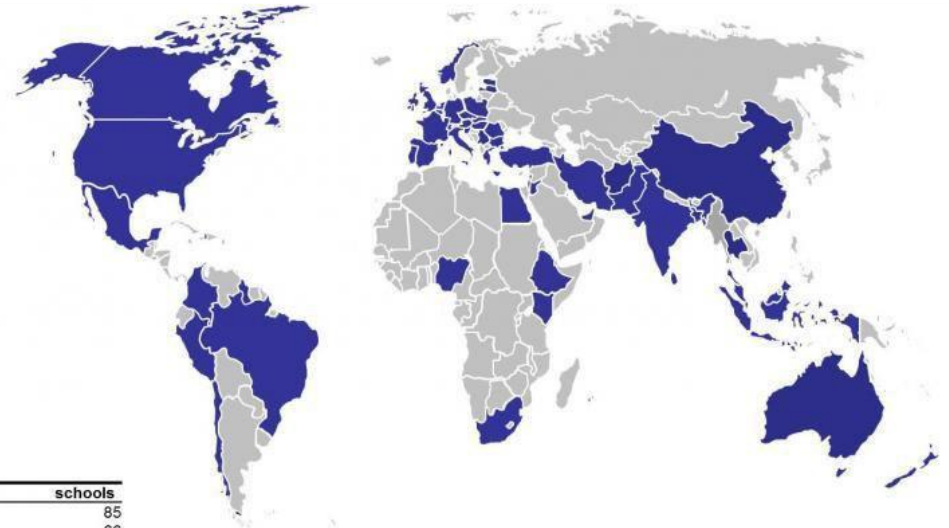


Competition: a beam line for schools

IPPOG acts as local contacts to schools in many countries.

IPPOG members take responsibilities for multiple countries to ensure that language barriers will not be an insurmountable hurdle.

The Beamline for Schools competition 2018 is now open!



Country	schools				
Italy	85				
Spain	66				
United States	45	Netherlands	6	Egypt	3
United Kingdom	43	Singapore	5	Slovakia	3
India	28	South Africa	5	New Zealand	2
Greece	19	Indonesia	4	Czech Republic	2
Germany	17	Hungary	4	Brazil	2
Canada	13	Austria	4	Norway	2
Poland	10	Mexico	4	Serbia	2
Switzerland	8	Ireland	4	Slovenia	2
France	7	Iran	3	Bulgaria	2
Portugal	7	Colombia	3	Australia	2
Romania	6	Estonia	3	Afghanistan	2
Turkey	6	Thailand	3	Lebanon	1
				Jordan	1
				Mauritius	1
				China	1
				Kuwait	1
				Nigeria	1
				Malaysia	1
				Ethiopia	1
				Haiti	1
				Pakistan	1
				Guyana	1
				Peru	1
				Latvia	1
				Belgium	1
				Sri Lanka	1
				Cyprus	1
				Malta	1
				Qatar	1
				UAE	1
				Israel	1
				Chile	1
				Bangladesh	1
				Kenya	1
				Total	455



First Competition 2014
 (to celebrate 60th anniversary)
Winner a Greek team!!

New York 10

Outreach activities at Frascati

A representative list of the HEP activities

- Beam Tests at the Facility
- Measurements at Synchrotron Light source

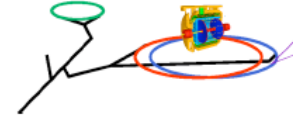
- Slow Control by Arduino
- Electronic circuits for HEP: Planck constant

- SiPM and scintillator materials
- Cloud chamber construction
- Cosmic Ray detection and μ speed calculation

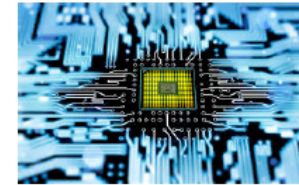
- D^0 life time measurement through LHCb data

- Theory: Modern Physics

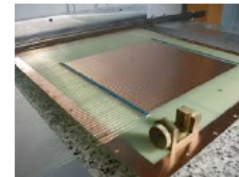
accelerators



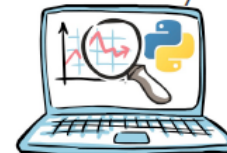
electronics



detectors



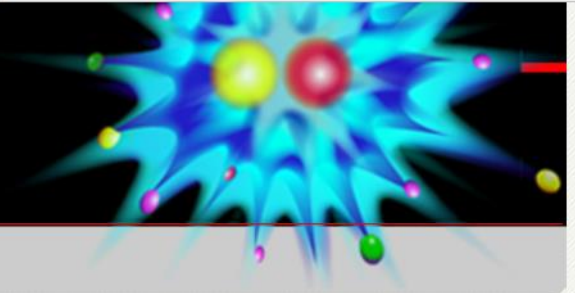
data analysis



Quarknet@Fermilab

QuarkNet

Helping Develop America's Technological Workforce



[Home](#)

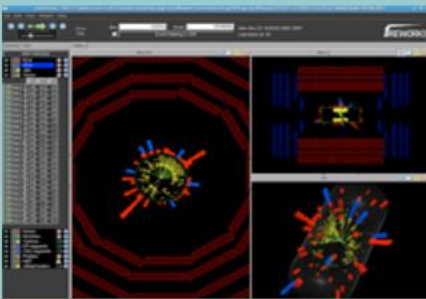
[Data Portfolio](#)

The Opportunity: "Your program rejuvenates my soul. It connects me with a cadre of intelligent and excited educators. It reinvigorates my teaching and provides me avenues to extend and enliven the projects that I can offer my students. Without the Quarknet program I am sure that I would have left teaching years ago."

The Players: High school students, teachers and physicists working together on physics research projects exploring the hidden nature of matter, energy, space and time.

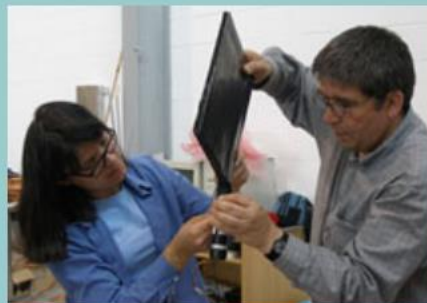
The Questions: What are the origins of mass? Can the basic forces of nature be unified? How did the universe begin? How will it evolve?

Project Overview



LHC & Fermilab Links

QuarkNet Stories



For Teachers



For Students

Expanding to Astroparticle physics – discussions and pilot tests ongoing

IceCube Masterclass

<http://icecube.wisc.edu/masterclass/home>

International Muon Week

Quarknet

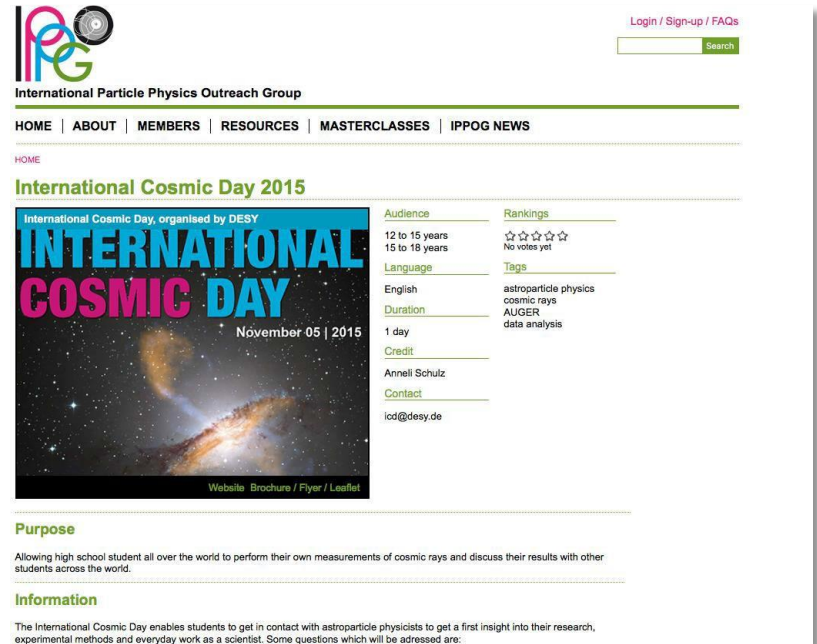
<http://Internationalmuonweek.org>

International Cosmic Day

<http://icd.desy.de>

Auger Masterclass

<http://auger.colostate.edu/ED>
Pilot tests in German Netzwerk
Teilchenwelt



The screenshot shows the IPPOG website with a navigation menu and a featured event page for International Cosmic Day 2015. The event page includes details such as audience (12 to 15 years, 15 to 18 years), language (English), duration (1 day), and contact information (Anneli Schulz, icd@desy.de). It also features a 'Purpose' section explaining the event's goal and an 'Information' section with a brief description.

International Particle Physics Outreach Group

HOME | ABOUT | MEMBERS | RESOURCES | MASTERCLASSES | IPPOG NEWS

HOME

International Cosmic Day 2015

International Cosmic Day, organised by DESY

INTERNATIONAL COSMIC DAY

November 05 | 2015

Website / Brochure / Flyer / Leaflet

Audience	Rankings
12 to 15 years 15 to 18 years	☆☆☆☆☆ No votes yet
Language	Tags
English	astroparticle physics cosmic rays AUGER data analysis
Duration	
1 day	
Credit	
Anneli Schulz	
Contact	
icd@desy.de	

Purpose

Allowing high school student all over the world to perform their own measurements of cosmic rays and discuss their results with other students across the world.

Information

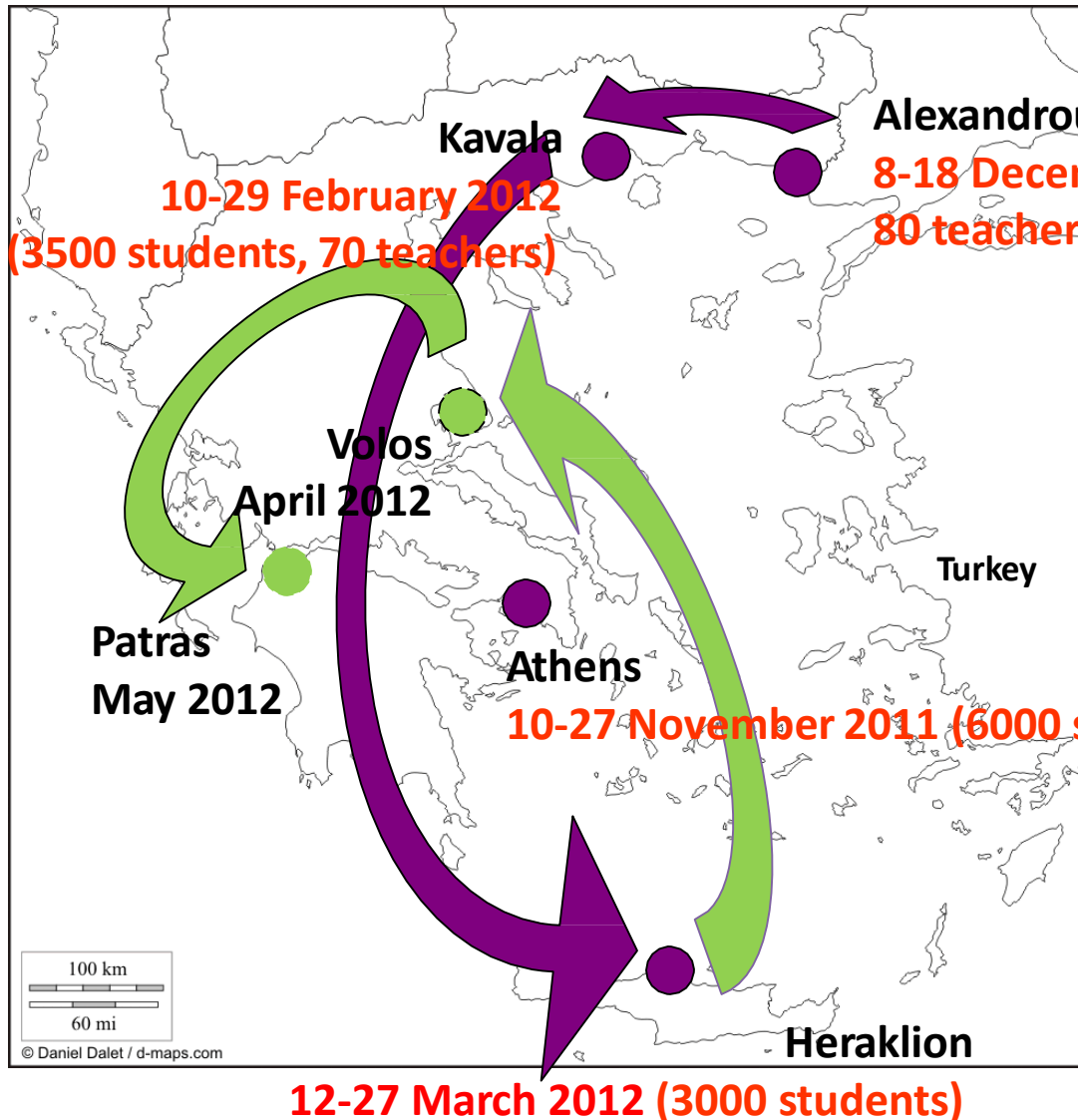
The International Cosmic Day enables students to get in contact with astroparticle physicists to get a first insight into their research, experimental methods and everyday work as a scientist. Some questions which will be addressed are:

CERN exhibitions in Greece

Science fairs in Greece

CERN in Greece mini expo (2011-2012)

8 cities in 8 months



~22,000 students visited
~750 teachers trained in concurrent workshops

Accelerating science CERN exhibition in Athens

April 12 – May 31 2014 at Eugenides Foundation
(science museum housing a planetarium)

Goal: To familiarize the Greek public with CERN, its activities and scientific achievements

Target group

- School students 9-17 → **4014 students from 92 schools**
- Teachers → **trained 115 in 6 dedicated seminars**
- University students
- General public → **11,238 visitors (!!)**
- Families interested in engaging their children with science



The children of EA school singing the Higgs song

Science Fair in Chania (Crete) for five consecutive years in the premises of the Sailing Club (next door) Activities

Experiments (by courtesy of M.Bardeen):

- Conservation of momentum
- Rolling with Rutherford
- Probe matter
- Quark workbench
- W signatures

Masterclasses : ATLAS, ALICE

Puzzles, books, card games etc



Science Events organized by Conf 12 conference last summer

➤ Veroia 27/8

➤ Thessaloniki 28/8



Format was similar to the Chania one
Public lecture by E.Tsesmelis

National masterclasses



Intoduction: High school activities

How can we attract students interest in science education (STEM and STEAM)?

(Their interest is decreasing with age)

In general:

- Train teachers in intergrading IBSE in the classrooms
 - > gradually change their teaching approach
- Promote use of existing ICT, new methodologies and new eLearning tools ready to be used in the classroom
- Resources should be linked to the curricula
- Build teacher communities
- Engage learner in scientifically oriented questions

Scenaria: Big Ideas of Science

the continuity

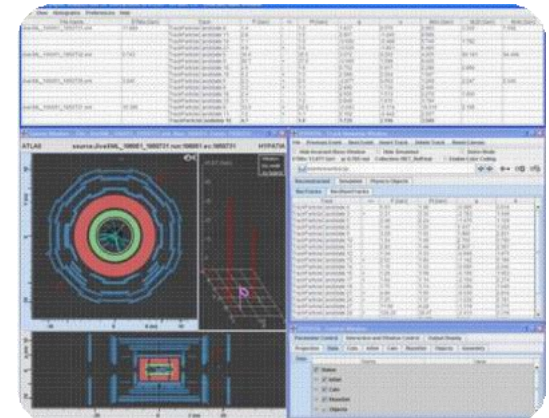
#1. All material in the Universe is made of very small particles



CERN Land
6-9, 9-12



LHC Game
12-15



Hypatia
15-18

Some examples of resources/scenaria

1) Let's accelerate particles (LHC game)

<http://tools.inspiringscience.eu/delivery/view/index.html?id=c4e9fd501dce4f6290d35f8dcb9dcf1d&t=p>

Ages
12-15

LET'S ACCELERATE PARTICLES

ORIENTING & ASKING QUESTIONS

HYPOTHESIS GENERATION
& DESIGN

PLANNING & INVESTIGATION

ANALYSIS & INTERPRETATION

CONCLUSION & EVALUATION

2) All that MATTERS (make atoms, make nucleons)

<http://tools.inspiringscience.eu/delivery/view/index.html?id=02afe7b3264f4848bf59c42a6b07e3cf&t=p>

Ages
10-12



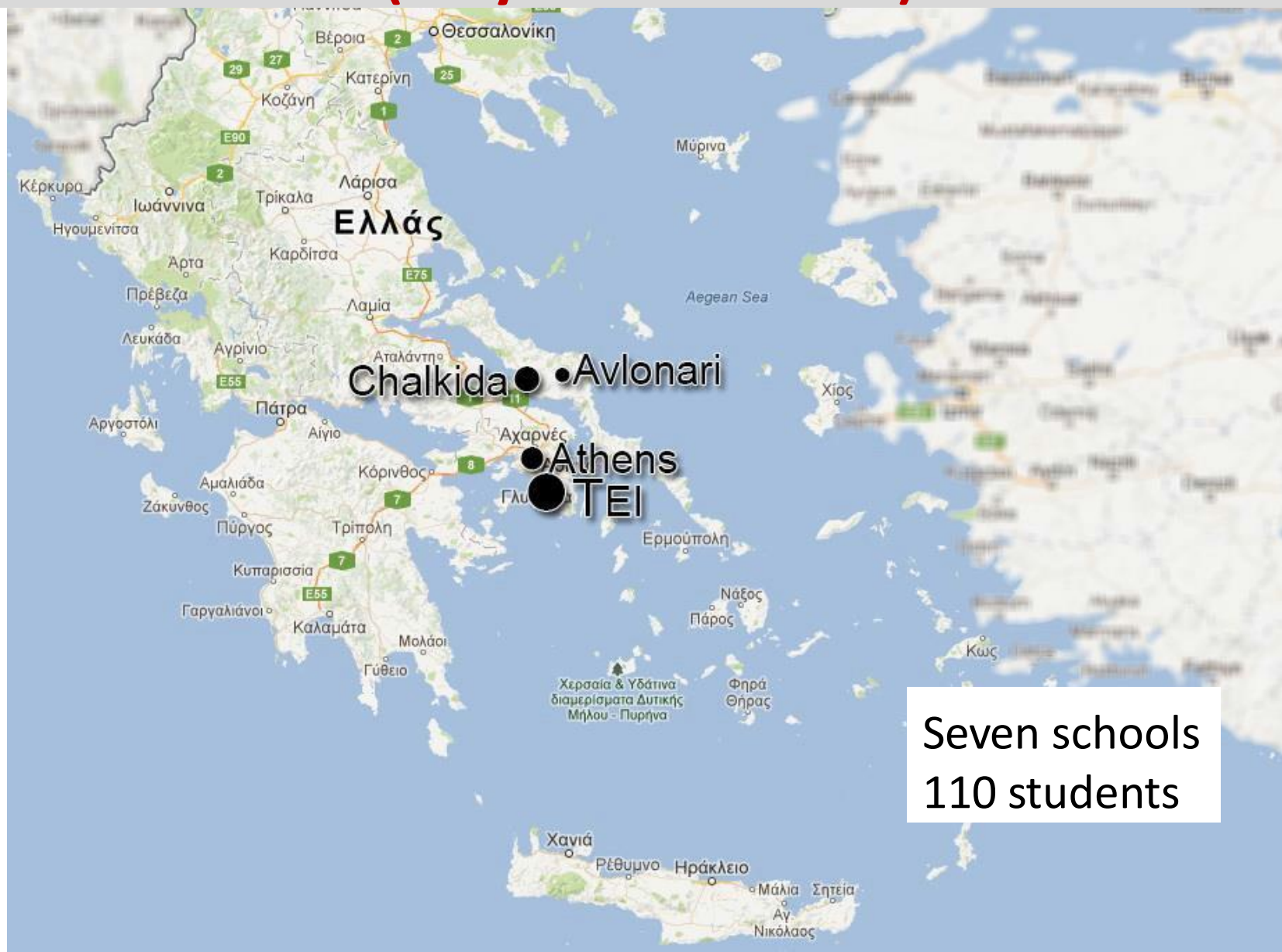
1/9/2016



C.Kourkoumeis, 00A

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Masterclasses for younger ages in Greece (only in six months)

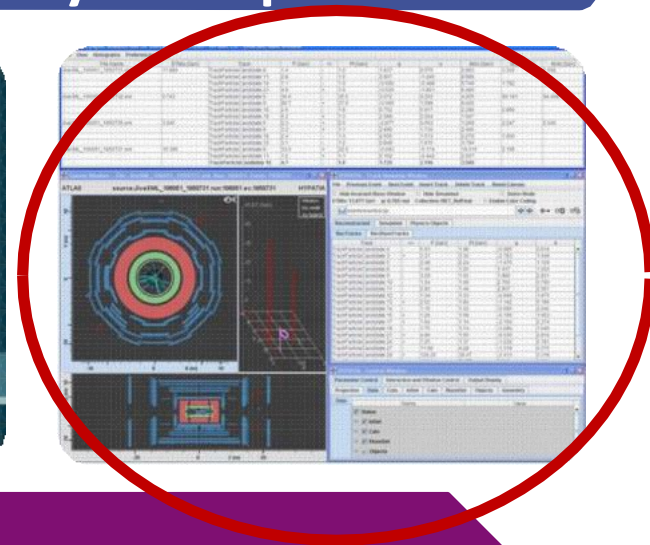


Seven schools
110 students

Scenaria: Big Ideas of Science

the continuity

#1. All material in the Universe is made of very small particles




CERN Land
6-9, 9-12

LHC Game
12-15

Hypatia
15-18

Scenarios/masterclasses based on the HYPATIA ATLAS Event Display

– Online HYPATIA analysis  (which won the “**best visualized experiment award**” by the online labs IEEE consortium). Fully developed <http://hypatia.iasa.gr/> has been used since 2010 in about 150 Greek schools across the country

- **Offline version** used by IPPOG’s **Z-path masterclasses 93 in 2017 across the world**
- <http://hypatia.phys.uoa.gr/>



A successful local Masterclass (half-day) in a school involves:

➤ Introduction and analysis of events with HYPATIA online, embedded in an educational scenario with the circle of learning phases



➤ Combined with a Virtual Visit to an LHC experiment

➤ Followed by long Q&A session

Impact Evaluation with:


“Pisa like” assessment questions at each phase

Indicators on the success of the event analysis (# of Z's found, # of Higgs found, e-pair/ μ -pair, etc.)

Pre and post creativity questionnaires



ISE HYPATIA demonstrator +PISA assessment questions


 Γεωργιάσι! ASSESSMENT ΠΥΘΜΙΣΕΙΣ ΒΟΗΘΕΙΑ

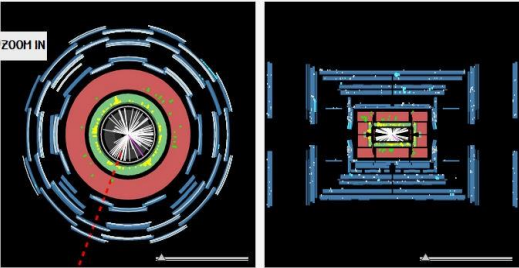
HYPATIA DEMONSTRATOR GREEK
 ORIENTING & ASKING QUESTIONS | **HYPOTHESIS GENERATION & DESIGN** | PLANNING & INVESTIGATION | ANALYSIS & INTERPRETATION | CONCLUSION & EVALUATION

ΠΛΗΡΗΣ ΟΡΓΑΝΙΣΜΟΣ

ΑΚΟΥΣΤΕ ΤΟ ΠΕΡΙΕΧΟΜΕΝΟ

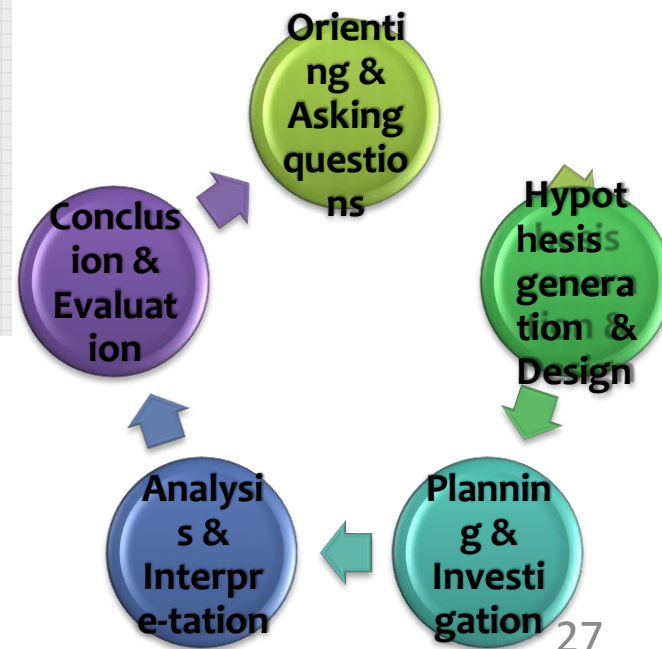
Plan investigation
 Στην παρούσα φάση θα χρησιμοποιήσετε το εργαλείο ανάλυσης δεδομένων HYPATIA που εμφανίζεται παρακάτω.

ZOOM IN



Γεγονός: 110 (1986314178047)
 ΕΥΡΕΣΗ: 42.43 GeV φ: -1.94 rad

Τρc	+	-	p [GeV]	p _T [GeV]	φ [rad]	θ [rad]
Tra	-	28.64	20.15	-0.934	-0.780	
Tra	+	4.77	1.03	2.632	0.219	
Tra	+	4.49	1.06	-0.580	-2.903	
Tra	+	67.67	42.39	1.922	2.465	
Tra	+	2.41	1.57	0.702	2.436	
Tra	+	6.91	3.39	-2.159	-0.514	
Tra	-	3.18	2.61	0.258	2.176	
Tra	+	3.93	3.49	-1.733	-2.049	
Tra	+	1.65	1.36	-1.842	-2.178	
Tra	-	7.45	3.57	0.951	2.643	
Tra	+	1.72	1.59	1.720	1.970	



Assessment tool #1:

“Pisa like” assessment questions
Had 39 runs with ~520 students
answering all 2*4 questions

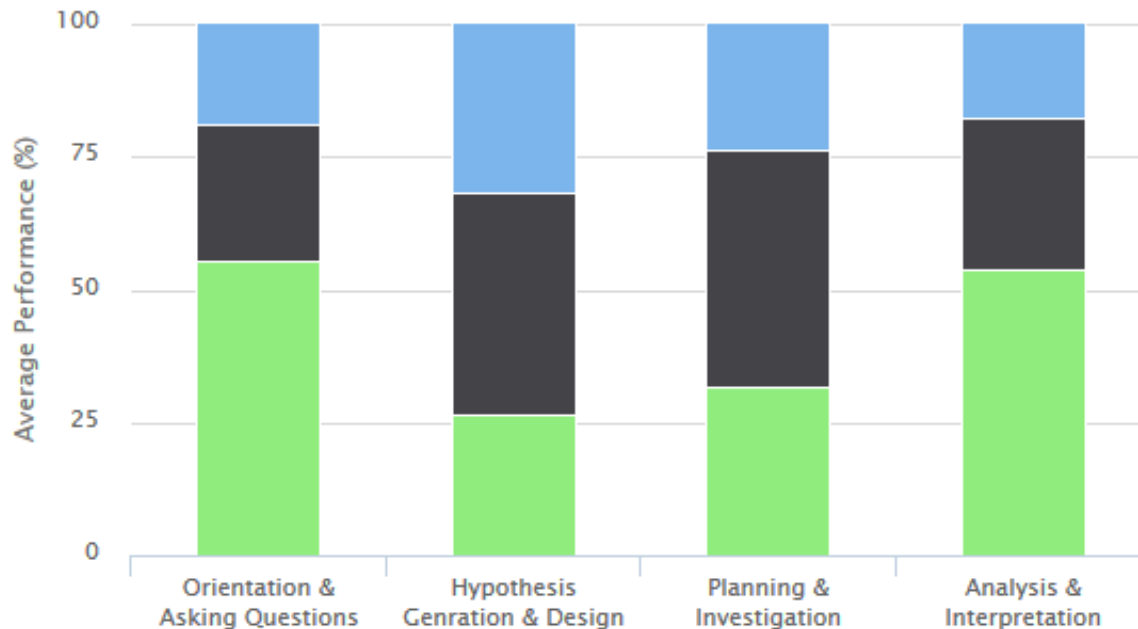
Class Profile

Sample 518 students' groups

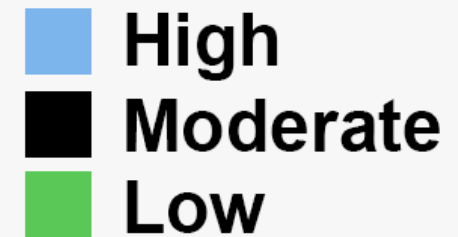
General information

Total runs:	39
Run Avg. Duration:	1:27:20
Students Participated:	709
Students Completed PSQ:	518 (73.1%)
Period From:	02/05/2015
Period To:	03/11/2017

Number of replies Percentage (%)

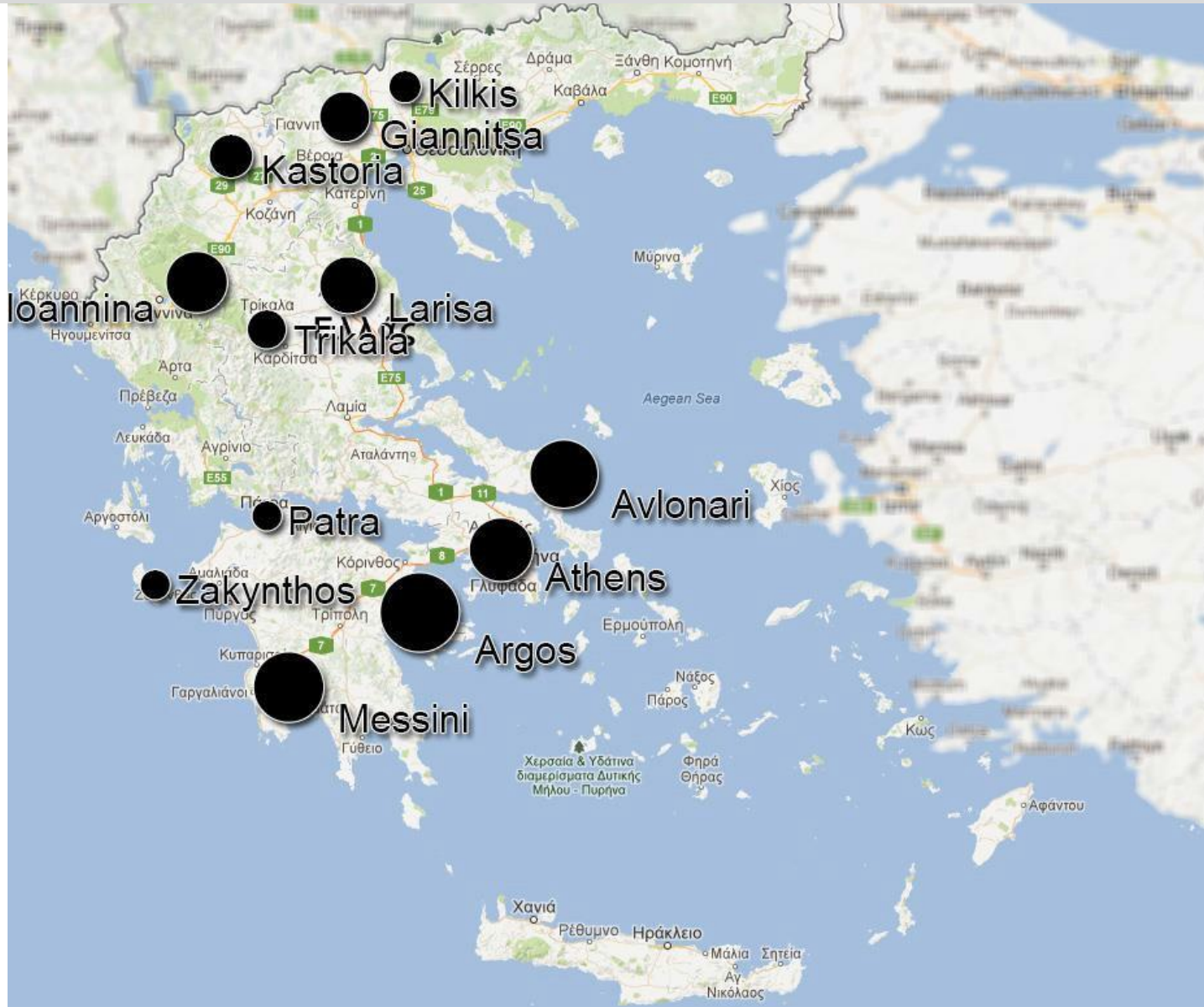


Results/phase



Students
outperformed
the OECD
averages

Masterclasses and Virtual visits in Greece during the last two years



In addition developed material for University students since most resources were addressed to high school students

Decided to target University students

- Up to now very few universities had such lab courses addressed to their students
- University of Athens has been one of the few, BUT was using small set of ATLAS data
- Need experimental data (real and MC)
- **ATLAS released 1fb^{-1} of Run I data about a year ago**
- Have developed a batch process event analysis **which optimizes cuts for the $Z \rightarrow 2\text{lepton}$ and $\text{Higgs} \rightarrow 4\text{lepton}$ search**
 - To teach analysis strategies such as selection optimization, histogramming and statistics
 - To get familiar with detector and accelerator physics

University Student analysis using HYPATIA

Method:

- Maximize the significance

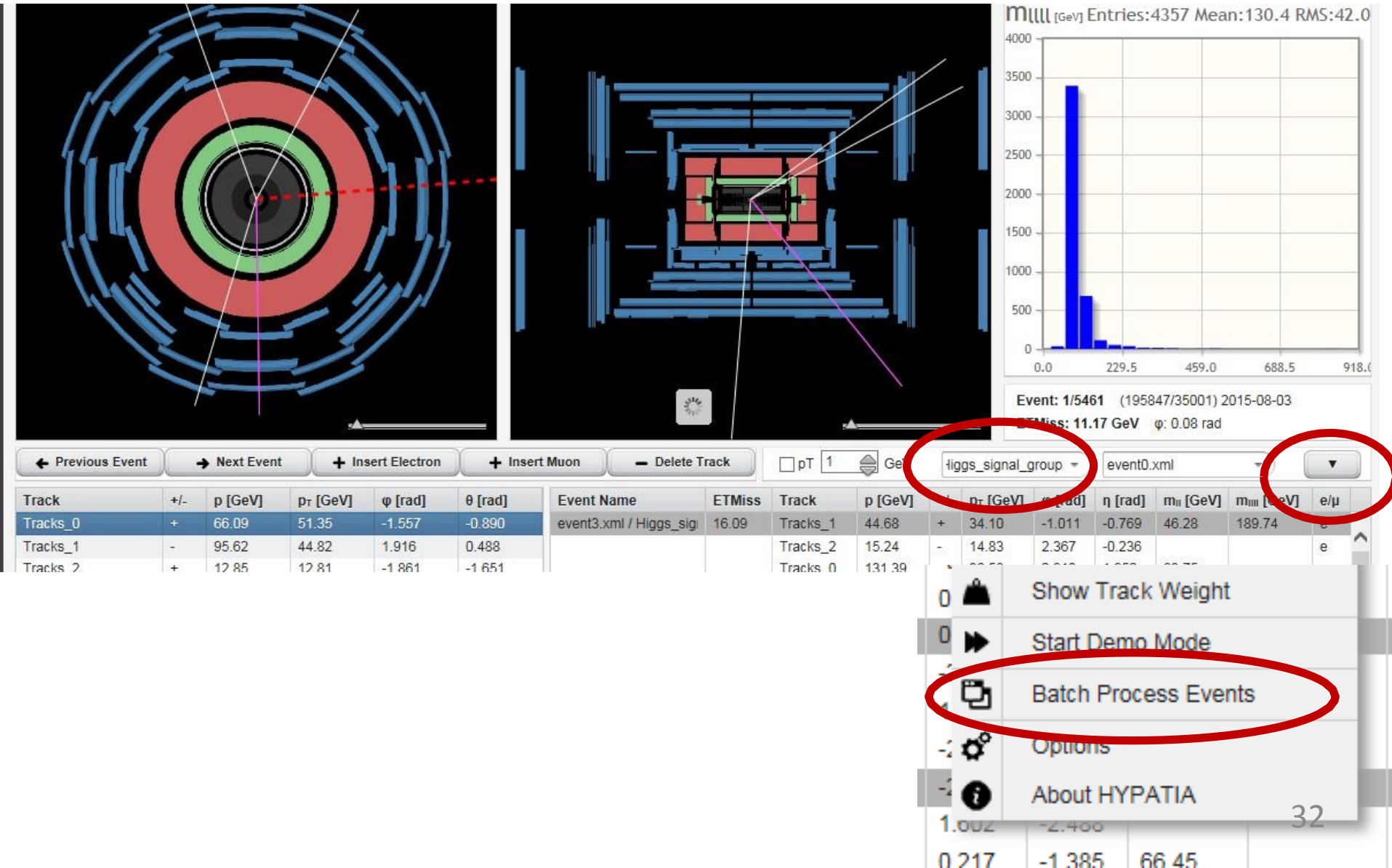
$$\text{significance} = \sqrt{2 * \left((S + B) * \ln \left(1 + \frac{S}{B} \right) - S \right)}$$

using samples of signal and background MC events

- Change one cut at a time, optimize, iterate
- Apply the optimized cuts on a sample of REAL events from the **1 fb⁻¹ ATLAS Open data**

(<http://opendata.atlas.cern/>)

Implemented in the online HYPATIA



“Cuts” available for optimization

2 leptons 4 leptons

$P_{T1} >$ 6 GeV

$P_{T2} >$ 6 GeV

$d_0 <$ 15

Isolation $<$ 2

Calo. Iso. $<$ 2

I.M._{min} $>$ 10 GeV

I.M._{max} $<$ 150 GeV

Insert signal into IMT

Y axis logarithmic scale

Default Values

2 leptons 4 leptons

$P_{T1} >$ 20 GeV

$P_{T2} >$ 15 GeV

$P_{T3} >$ 6 GeV

$P_{T4} >$ 6 GeV

$m_{12} >$ 50 GeV

$m_{34} >$ 2 GeV

$d_{0\mu} <$ 15

$d_{0e} <$ 15

Isolation $<$ 2

Calo. Iso. $<$ 2

I.M._{min} $>$ 50 GeV

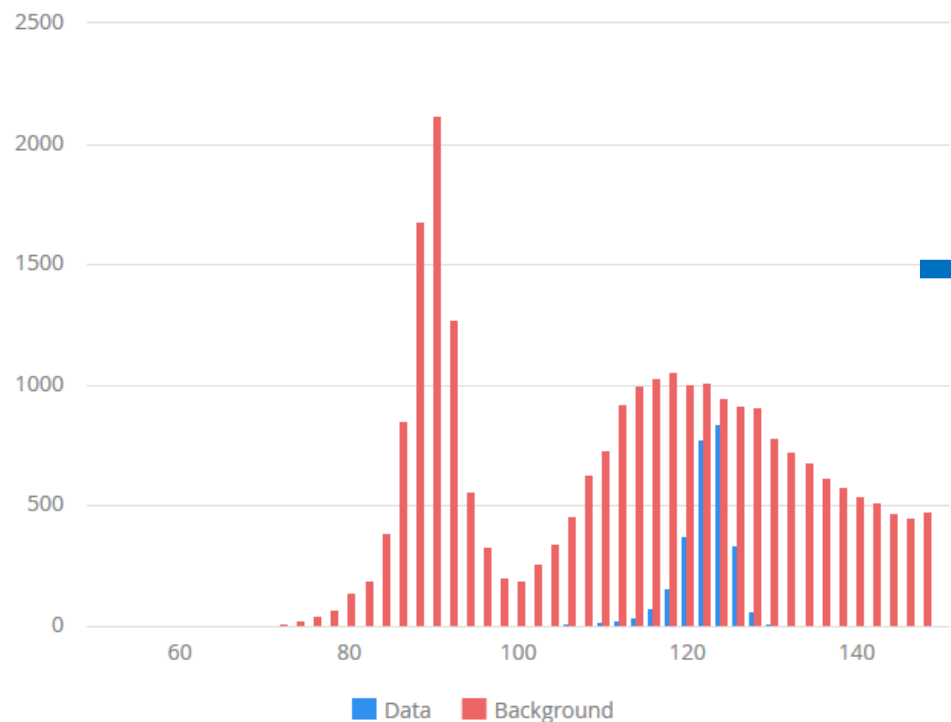
I.M._{max} $<$ 500 GeV

2 leptons (J/ψ , Υ , Z , Z')

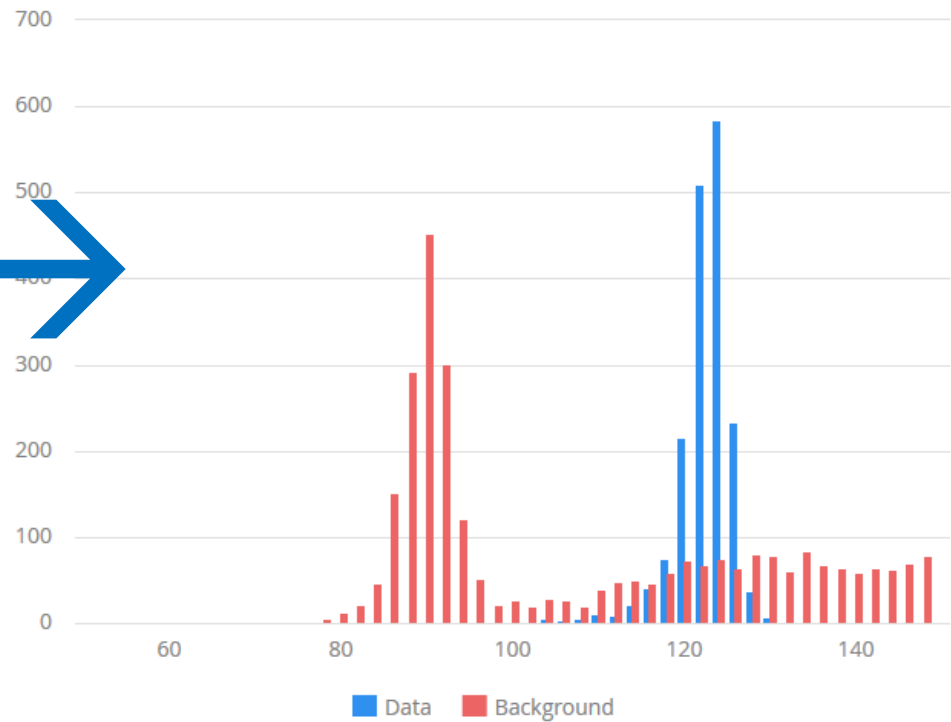
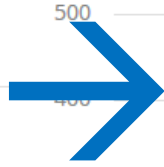
4 leptons (Higgs)

Result before/after cut optimization on MC signal/background samples

Data - Background (2759 - 25157 / 82.5% - 28.2% / 11.0%)_[GeV]



Data - Background (1766 - 2893 / 52.8% - 3.2% / 61.0%)_[GeV]



Conclusions

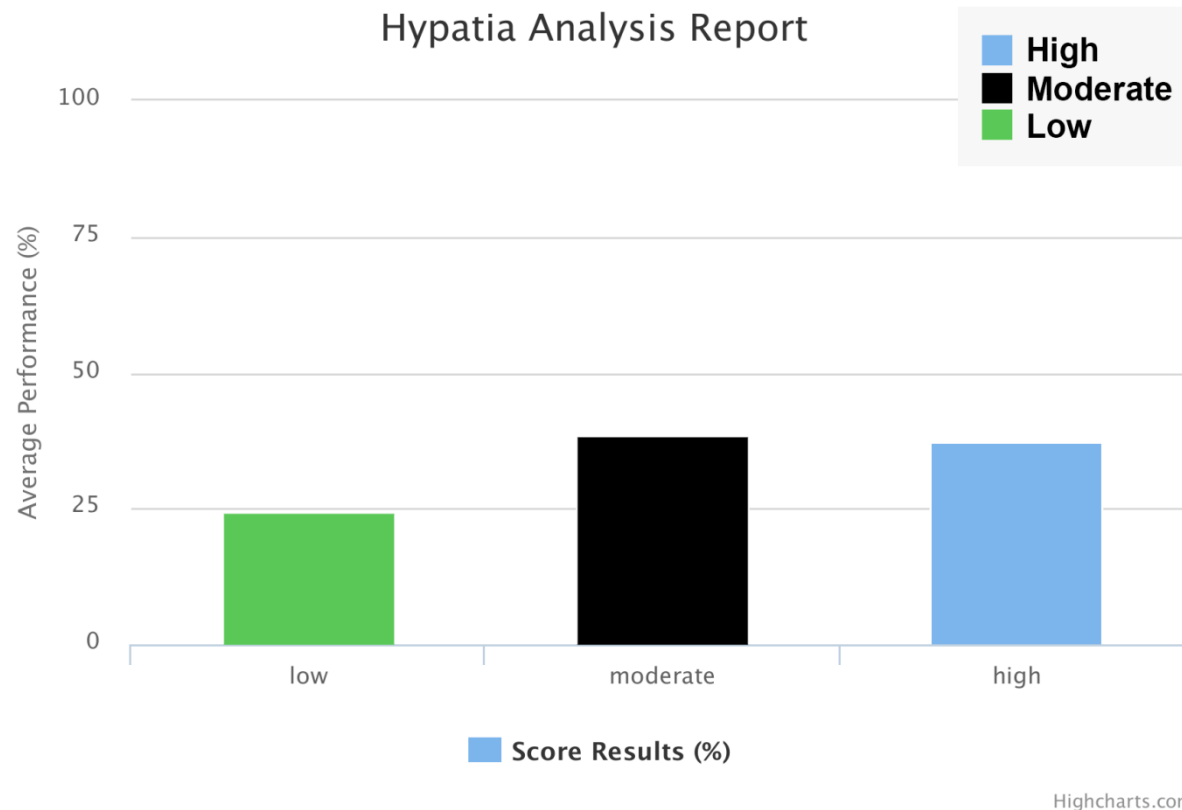
A plethora of outreach activities in Greece, CERN and other national labs

- On the context of the CREATIONS EU program
- On the context of IPPOG
- On the context of conferences

- ❑ Students from **in urban, sub-urban and rural areas** of Greece get to know about HEP research .using hands-on interactive tools
- ❑ Most advanced HEP analysis techniques are introduced at the University level

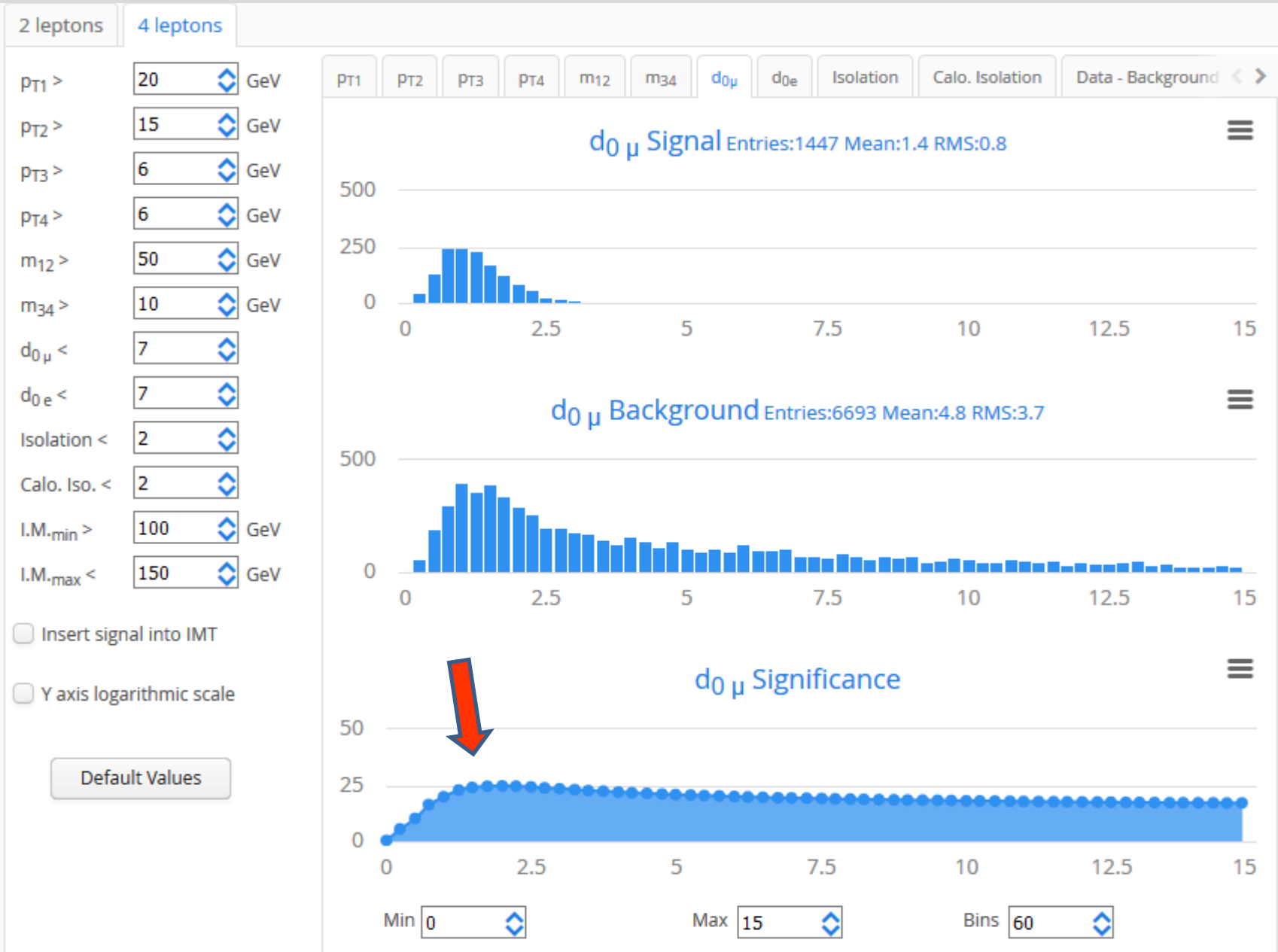
BACK-UP

Final overall evaluation of HYPATIA indicators

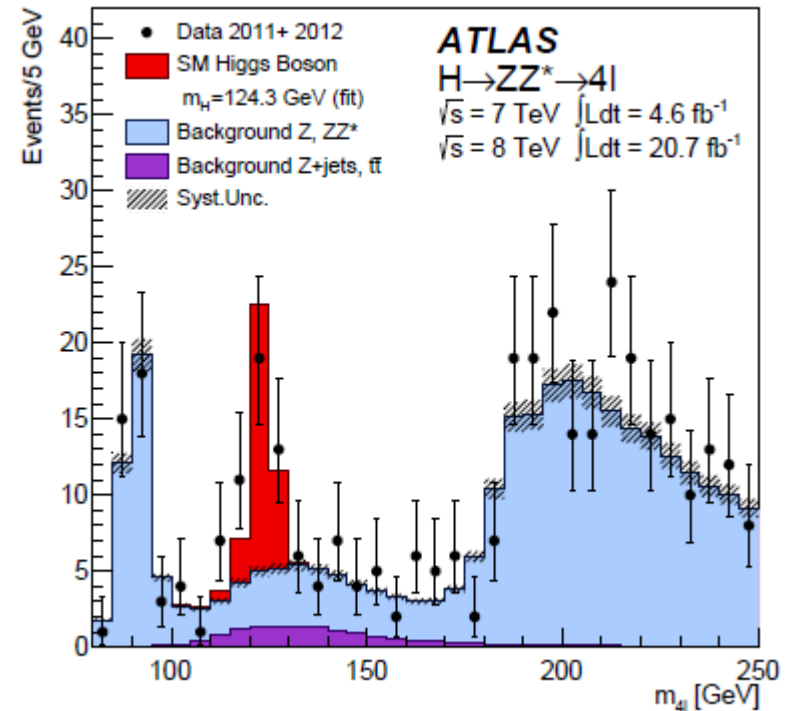
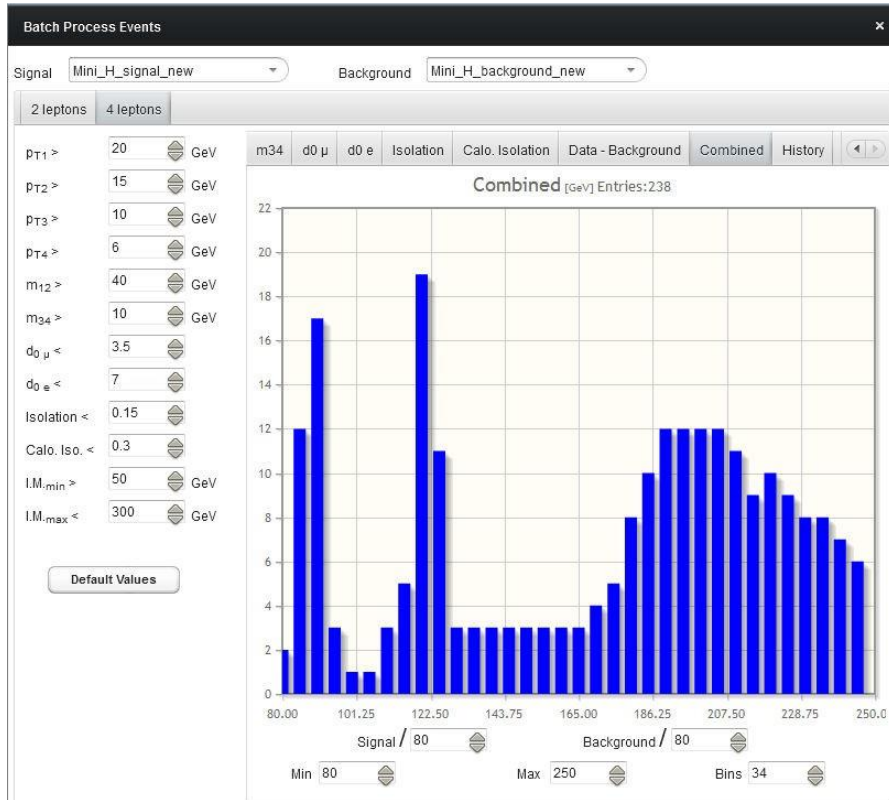


A sample of 86 students (new assessment)

Example of “vertex displacement” optimization Higgs→4l



Indicative results:



Indicative results:

Batch Process Events

Signal: Mini_H_signal_new Background: Mini_H_background_new

2 leptons 4 leptons

PT1 > 20 GeV
PT2 > 15 GeV
PT3 > 10 GeV
PT4 > 6 GeV
m12 > 50 GeV
m34 > 12 GeV
d0 μ < 3.5
d0 e < 6.5
Isolation < 0.15
Calo. Iso. < 0.15
I.M.min > 50 GeV
I.M.max < 500 GeV

Insert signal into IMT

Default Values

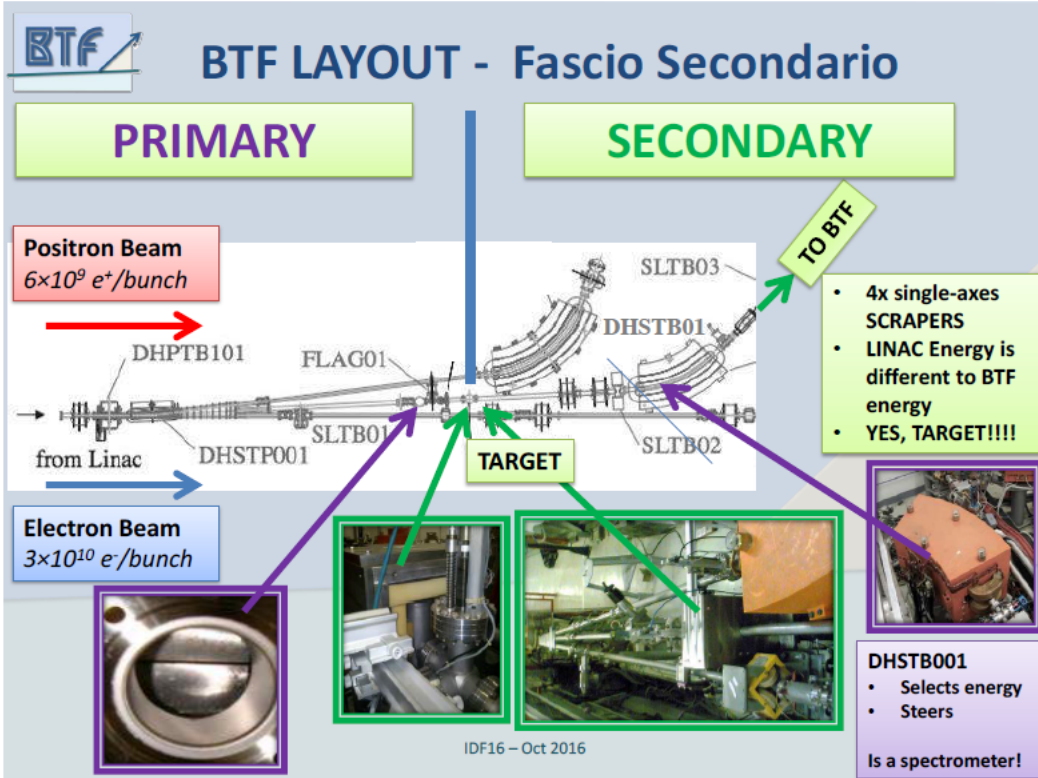
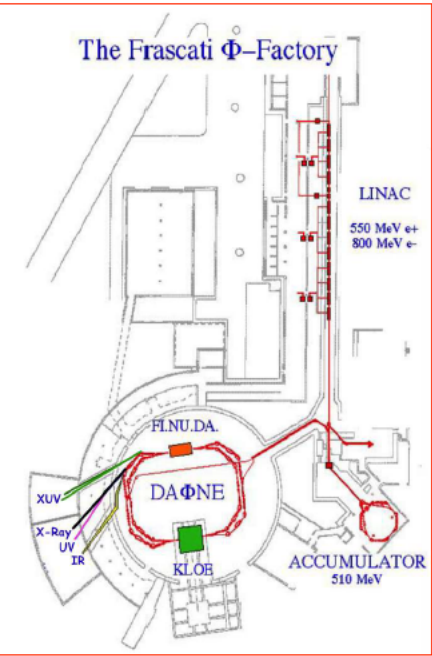
m34		d0 μ		d0 e		Isolation		Calo. Isolation		Data - Background			Combined	History
PT1	PT2	PT3	PT4	m12	m34	d0 μ	d0 e	Iso.	C.Iso	IM_min	IM_max	Signal	Backg.	Sign.
20	15	6	6	50	2	15.0	15.0	2.00	2.00	50	500	2759	50046	12.22
20	15	16	6	50	2	15.0	15.0	2.00	2.00	50	500	1933	28360	11.35
20	15	16	6	50	10	15.0	15.0	2.00	2.00	50	500	1808	25084	11.28
20	15	16	6	50	10	15.0	15.0	0.20	2.00	50	500	1630	22738	10.68
20	15	16	6	50	10	15.0	15.0	0.20	0.20	50	500	1527	21037	10.40
20	15	10	6	50	10	15.0	15.0	0.20	0.20	50	500	2081	23813	13.30
20	15	10	6	50	12	15.0	15.0	0.20	0.20	50	500	2026	23005	13.17
20	15	10	6	50	12	3.5	6.5	0.20	0.20	50	500	1992	22268	13.16
20	15	10	6	50	12	3.5	6.5	0.15	0.15	50	500	1766	20753	12.09

Run Close

An example of test beam use

Beam Test Facility

Extracted beam from the Dafne linac (up to 510 MeV)





The educational programs

- Winter stage in Italian (9 x 4h) 110 participants
- Winter stage in English (1 week) 50
- Masterclasses (1 week) 60
- Summer stage (2 or 3 weeks) 120
- Incontri di Fisica - Meetings for Physics (3 days) 300
- Matinee + experiment (7 x 1 morning) 120
- Divulcation Seminars (10 /yr) 300
- Physics Lessons (10 x1 afternoon) 200
- *School-Work Alternation* (80 h per student)
- *e-learning portal (LifeLongLearning)*

- Formation paths in high schools of the territory
- Guided tours including a seminar ~3000
- Open day (once a year) ~2500 (+110 students)
- European Research Night ~500
- Career day

Many of these initiatives are on streaming and on the LNF
YouTube channel

Education

High school students and teachers

- 70 000 school children visit CERN every year
- 10 000 teachers have been trained at CERN since 2006 impacting more than a million students
- 4000 school students each year perform hands-on experiments on modern physics at CERN S'Cool LAB
- 200-300 teams from schools around the world engages in "Beamline for Schools" competition
- 15000 pupils in 46 countries analyse real LHC data through "International Masterclasses"



Fantastic setting!!!



Space filled with people and activities set-up on several two meter long benches+ smaller tables)



Space filled with people and activities set-up on several two meter long benches+ smaller tables)



Science Event for the Public
with the participation of
researchers from the
"large experiments" of

CERN

Thessaloniki

12th International Conference
"Quark Confinement and the Hadron Spectrum"

Speaker: Emmanuel Tsesmelis
Soprano: Kalliopi Petrou

Programme

- 18:00 Introduction to Cern, Exhibiton
- 18:45 Theatrical play by high school students
- 19:30 First part of musical performance
- 19:45 Public lecture
"CERN and search for new physics"
- 20:30 Second part of musical performance
- 20:45 Questions and discussion with the public

Free Entrance

Sunday 28 August 2016, Time: 18:00 - 21:00
Thessaloniki, New Town Hall, Auditorium "M. ANAGNOSTAKIS"

Welcome Reception

Welcome the Conference Participants, Monday 29 August 2016
New Town Hall, Open Amphitheater



indico.cern.ch/e/conf12



Science Event for the Public
with the participation of
researchers from the
"large experiments" of

CERN

Veroia

12th International Conference
"Quark Confinement and the Hadron Spectrum"

Organisers:
Yiota Foka, Christina Kourkoumeli

Morning Science Event
Presentation and Projections
of CERN Experiments

Evening Science Event

19:00 First part of musical performance
19:15 Public lecture
"CERN and search for new physics"
20:00 Second part of musical performance
20:15 Questions and discussion with the public
Speaker: Emmanuel Tsesmelis
Soprano: Kalliopi Petrou

Public Library, Time 11:30 - 14:00

Cultural Center, Time 19:00 - 20:30

Free Entrance

Veroia, Saturday 27 August 2016



indico.cern.ch/e/conf12



