University of Athens

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EU educational projects: Go-lab and ISE Introducing HEP to students through web based simple hands-on analysis

Introduction: High school activities

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

The HEP main challenge:

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

- So far a lot activities for high school students (IPPOG's International Masterclasses, mini-masterclasses, virtual visits to the experiments, 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 interval of a school lesson**

The running EU outreach projects + CREATIONS

- **Go-Lab (Nov. 2012 - Nov.2016, 19 partners)**

❖**Online science laboratories for the large-scale use in schools**

http://www.go-lab-project.eu/

GO-LAB

- 161 on-line labs
- 152 Inquiry Learning Spaces
- 34 Apps (tools)

In all STEM curricula subjects in 10 languages

- **Inspiring Science Education (ISE) (April 2013 + 40mo, 31 partners)**

❖**eLearning tools for 5,000 schools in 14 countries**

inspiring SCIENCE education

http://inspiring-science-education.org/

- 120 Demonstrators (in all STEM curricula subjects)
- +Harvested existing repositories with 278,000 educational resources (mainly ODS and DtC)
- **In two years has reached 2750 schools**

Content of Discover the COSMOS repository/Activities

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 astronomy, astrophysics and high energy physics subjects. To access these tuto click here.

~ 95,000 items in Educational content
~ 630 educational scenaria (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 continuing

HEP applications
The main tool: HYPATIA
Best practice

- **Offline version** used by IPPOG's **Z-path** http://hypatia.phys.uoa.gr/
- **Online version** http://hypatia.iasa.gr/

has been used since 2010 in about 100 Greek schools across the country

Local Masterclasses, e-Masterclasses & Virtual Visits

Students learn "how actually science works" (half day)

- Listen to lectures
- Follow a virtual visit to ATLAS control room
- Analyse events with the HYPATIA on-line tool

Example of **four HYPATIA lesson plans (ILSs)** developed for **Go-lab** using the full Inquiry Based path :

Orientation, Conceptualization, Investigation, Conclusion, Discussion

1) **Conservation of momentum**

http://www.golabz.eu/spaces/conservation-momentum-particle-colisions

2) **Measurement of the magnetic field using the giant ATLAS detector**

http://www.golabz.eu/spaces/measurement-magnetic-field

3) **Hunt for the Higgs boson**

http://www.golabz.eu/spaces/discover-higgs-boson

4) **Discover the Z boson**

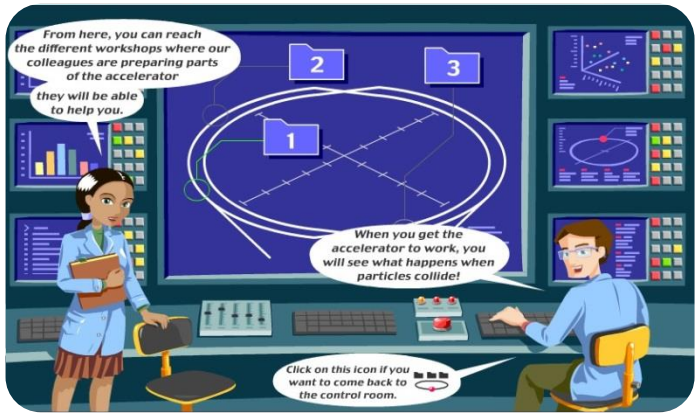
http://www.golabz.eu/spaces/discover-z-boson

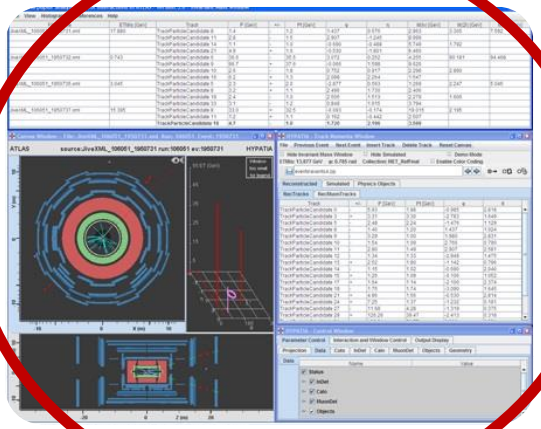
Direct relation with school curricula

Analysis: Big Ideas of Science

the continuity

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



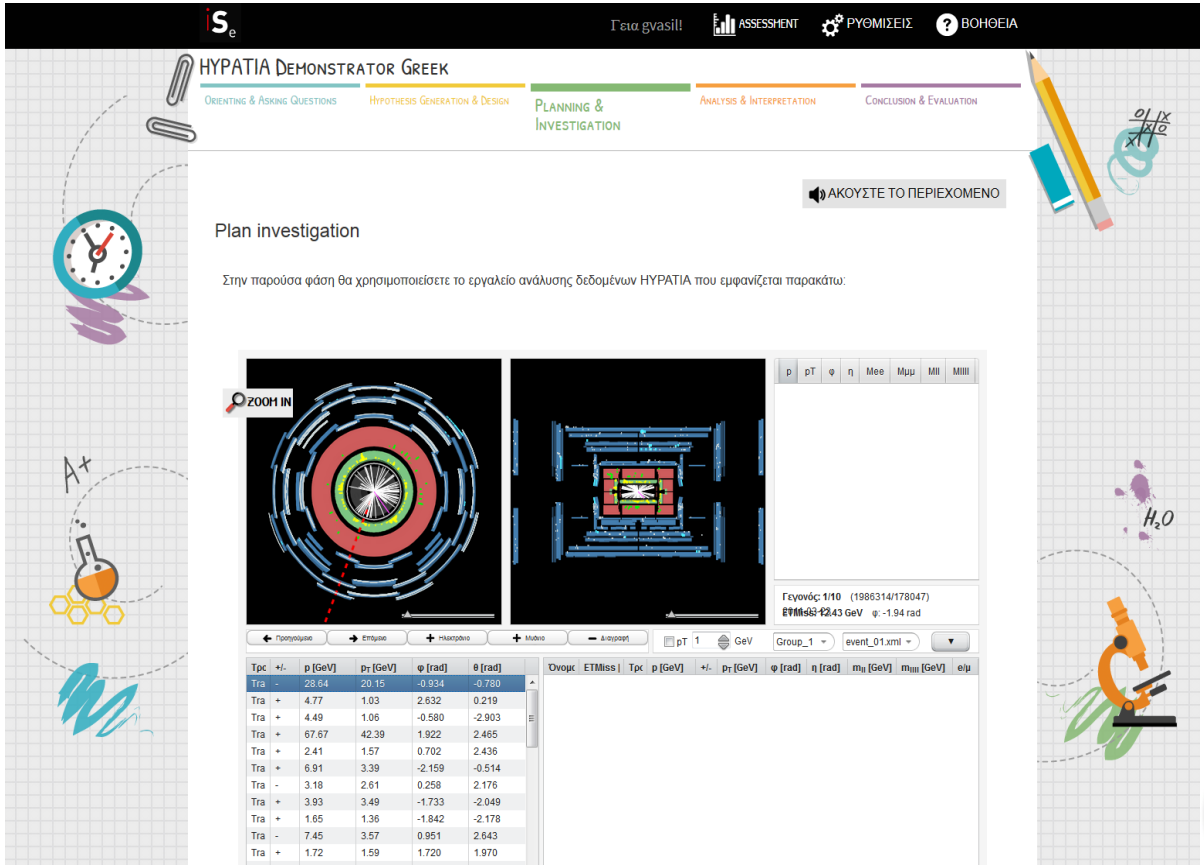


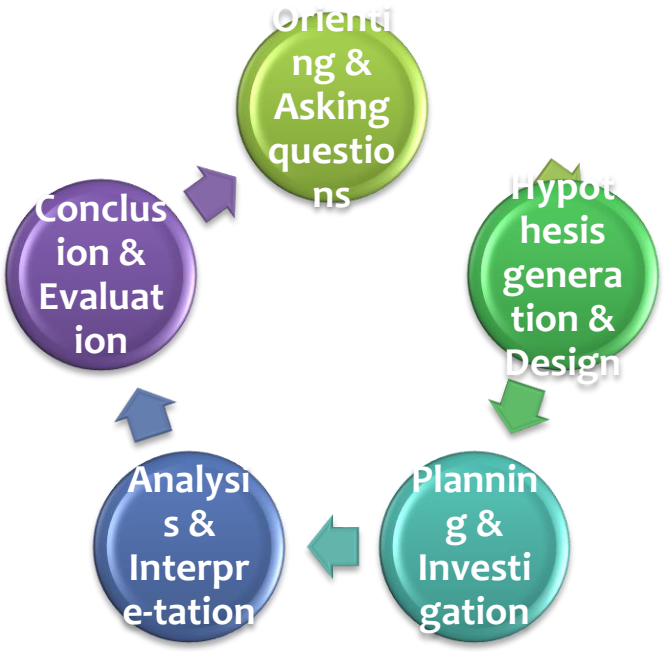
CERN Land
6-9, 9-12

LHC Game
12-15

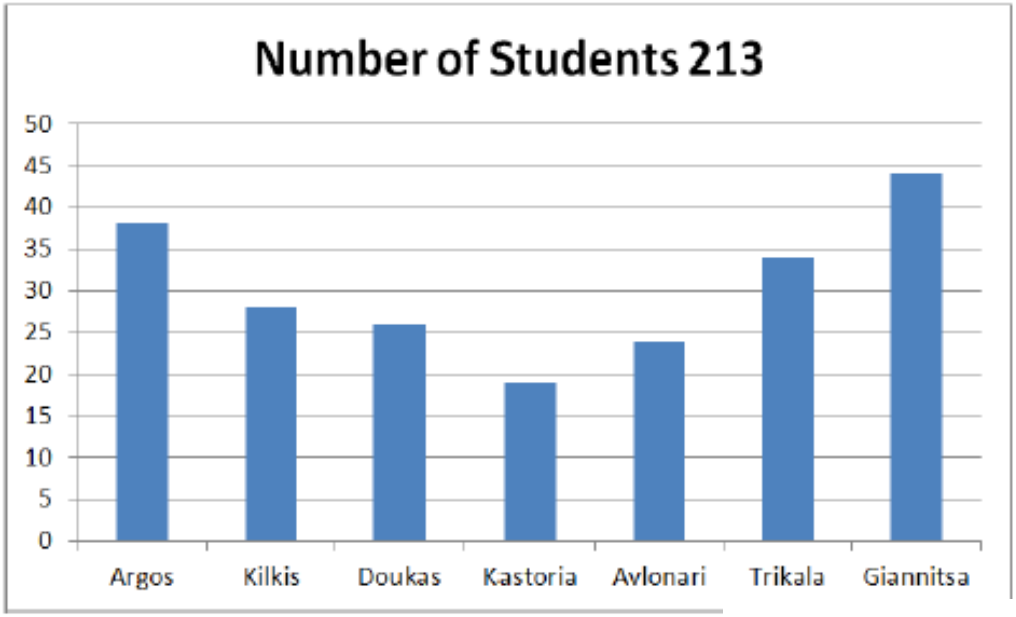
Hypatia
15-18

ISE HYPATIA demonstrator +PISA assessment questions

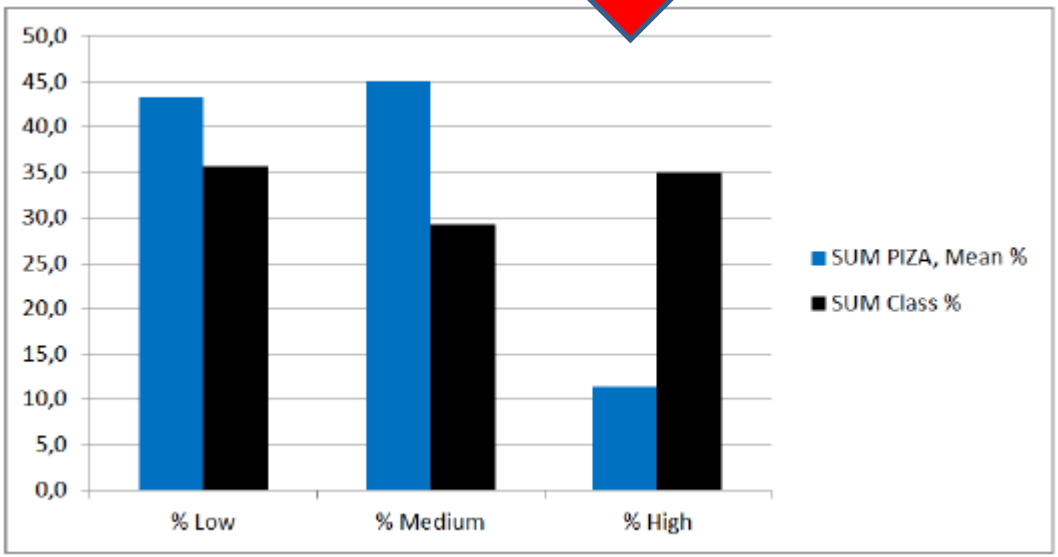




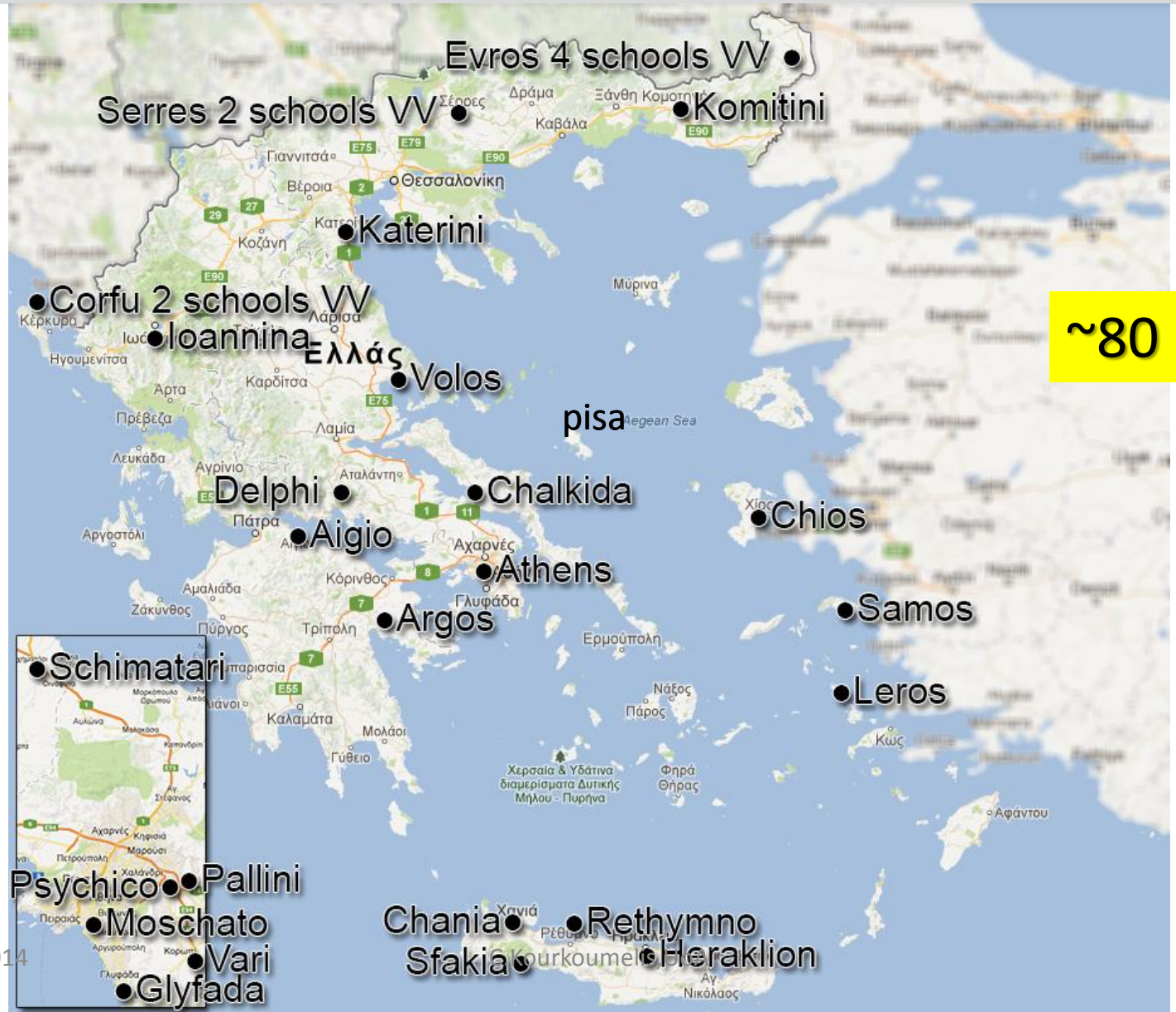
Tested demonstrator (February 2015-July 2015) in 26 schools at seven different locations



Problem solving competence
-> Higher than “PISA”



Masterclasses and VV in Greece (last two years)



BUT most developed material is for high school ages

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 is using small set of ATLAS data
- Need experimental data (real and MC)
- Multiple groups have shown interest in obtaining larger datasets
- So an effort was launched by a **ATLAS Outreach Data and Tools group** to define the data and get approval for larger datasets (an ATLAS note under preparation)

University Student analysis using HYPATIA (1)

Use the large datasets to process events in batch mode for:

- for teaching data analysis strategies such as selection optimization, histogramming and statistics
- detector and accelerator physics

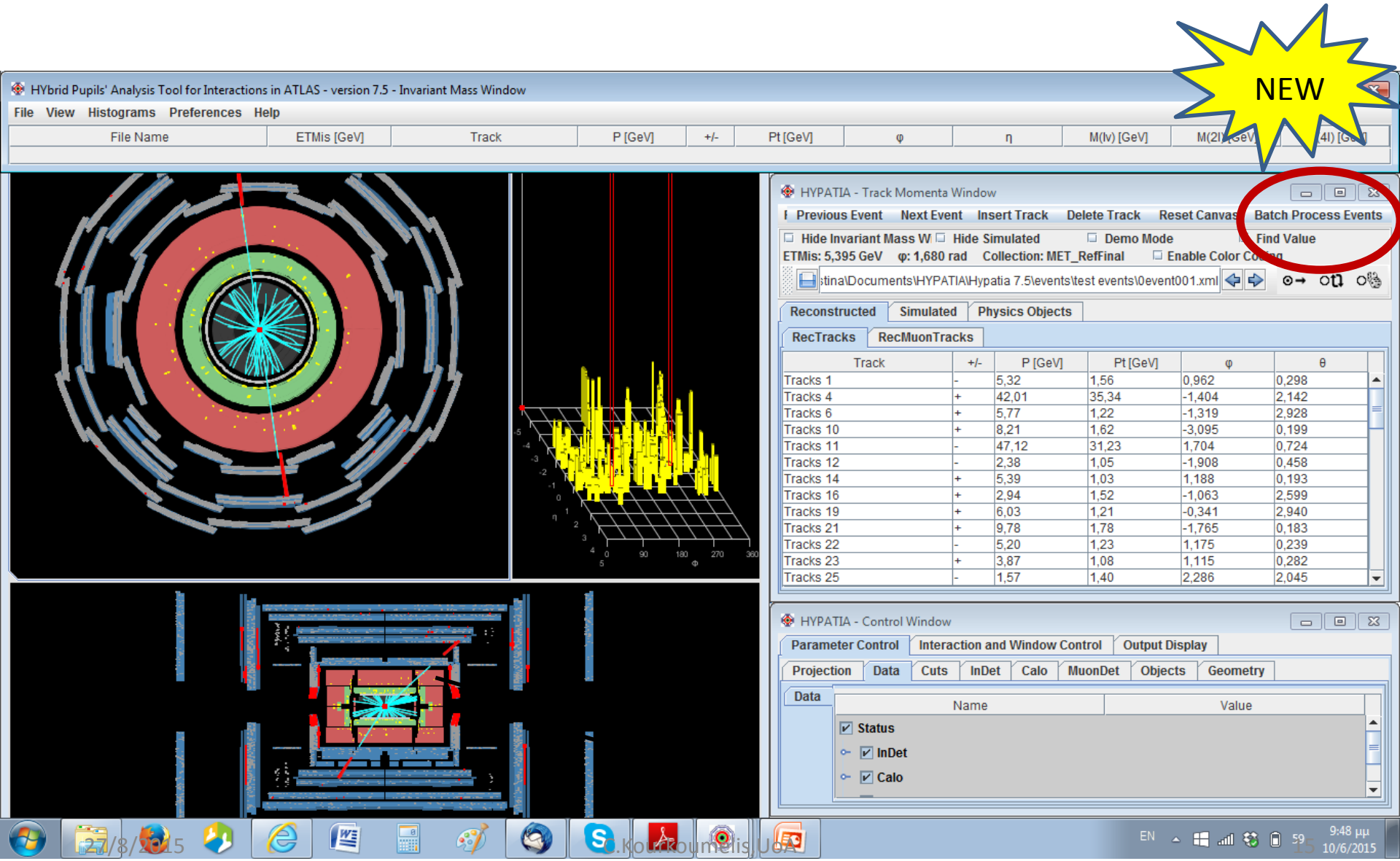
HYPATIA has been running on event-by-event display mode ->modification to run large datasets

University Student analysis using HYPATIA (2)

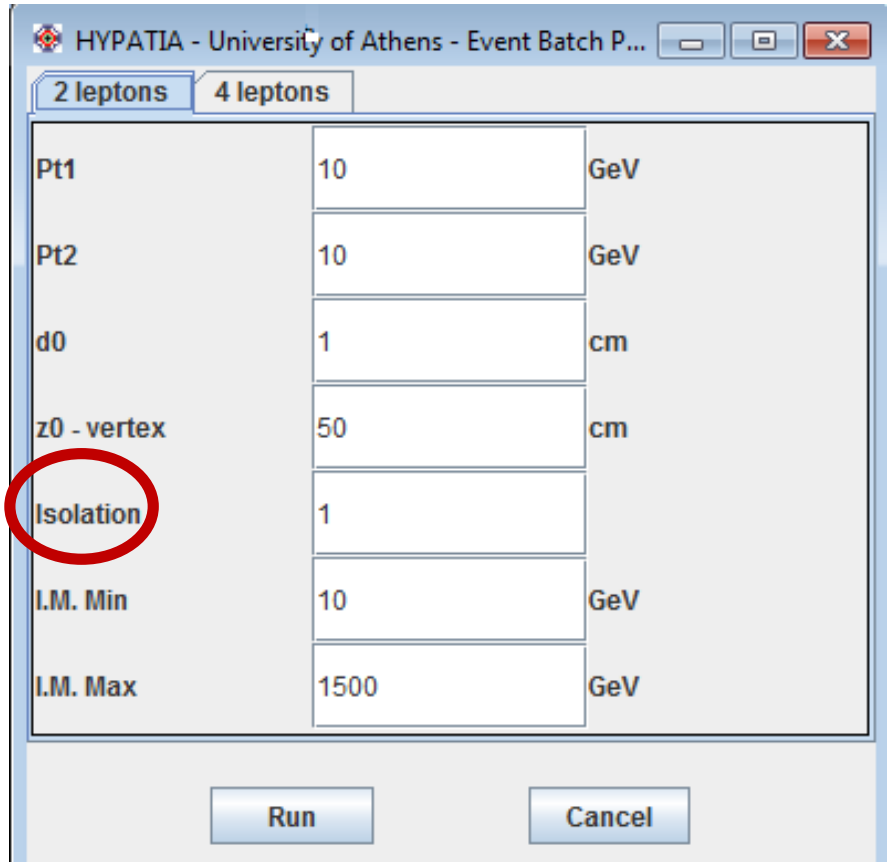
After **visually** inspecting some events

- Process many events in **batch jobs** (which have some minimum defaults cuts)
- A GUI opens to set manually **cuts** like p_T, d0, |z0-vrtx|, isolation , invariant mass range
- Inspect histos (signal/real data and MC) ->rerun, etc
  - **Run on 2 leptons (look for J/ψ, Υ, Z, Z')**
  - **Run on four leptons (Higgs)**

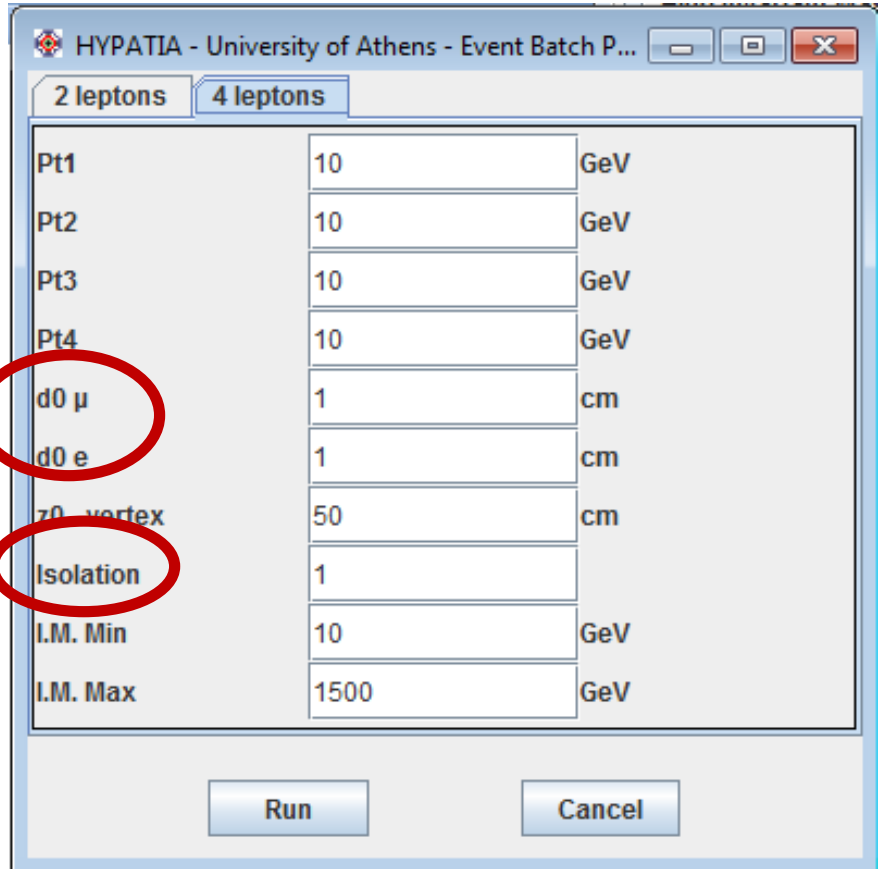
1) “Standard” version of offline HYPATIA



2 leptons (J/ψ, Υ, Z, Z')

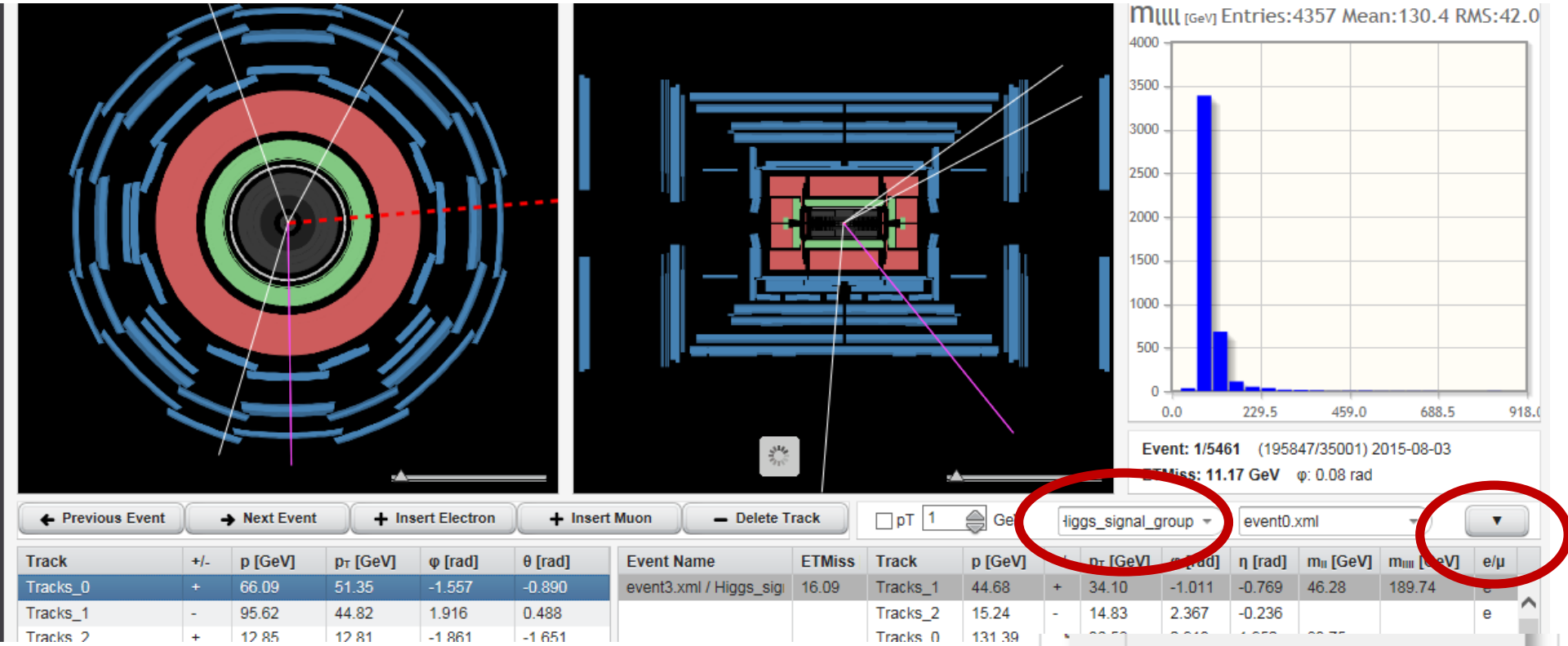


4 leptons (Higgs)



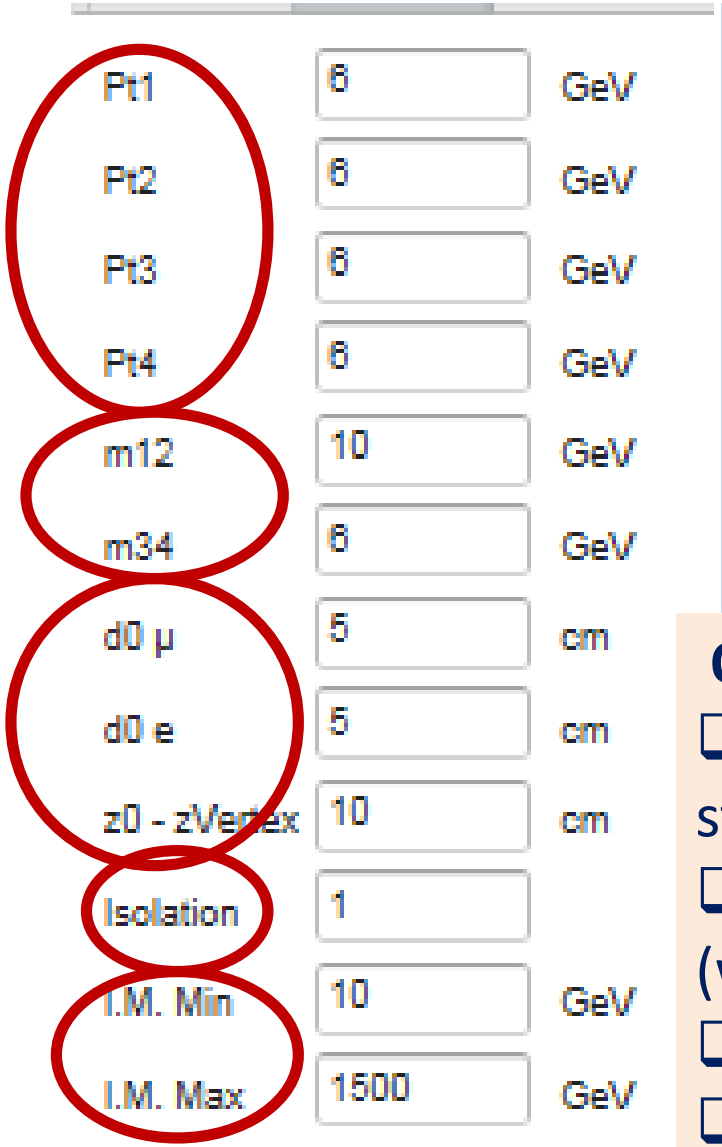
- Needs xml files (big)
- Can process any .xml file
- ATLANTIS is slow in loading events

2) Implemented in the online HYPATIA



- Event files are built-in (converted from xml) but much smaller
- Only works with the built-in event files
- Runs VERY fast

Higgs 4l analysis (MC signal and bkg files)



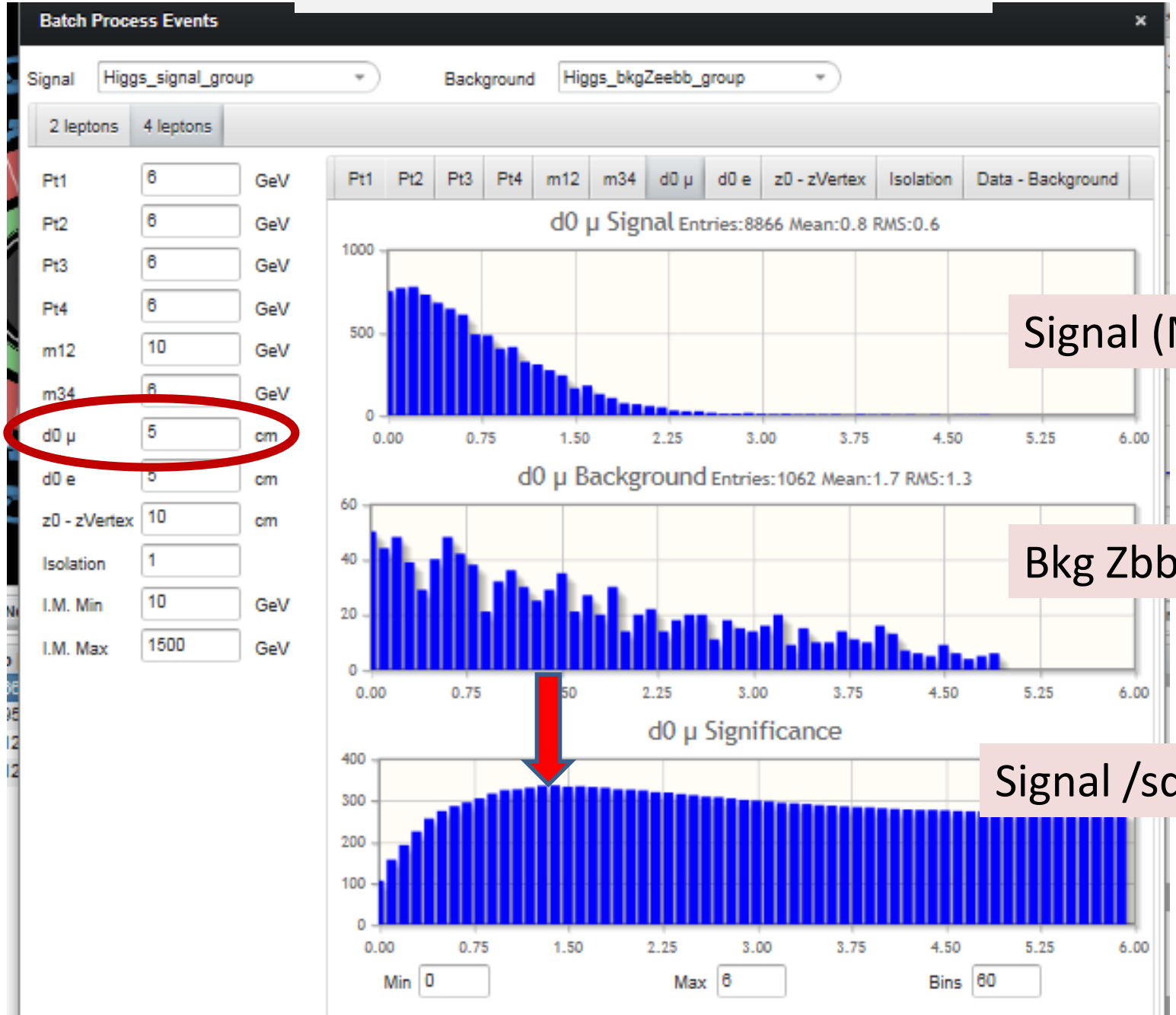
Possible cuts (as in real analysis)

- $P_{T1,2,3,4}$
- m_{12} 1st pair closest to Z mass
- m_{23} 2nd pair closest to Z mass
- Impact parameters for muon, electron (d_0) and z_0
- Isolation of each lepton
- Minimum (and maximum) invariant mass of 4 leptons

Optimize cuts by "N-1" method

- ❑ Apply all cuts except the one under study and plot its distribution
- ❑ Determine the optimum cut value (where significance is max)
- ❑ Iterate for all cuts
- ❑ Plot invariant mass of 4 leptons and try to maximize signal/bkg

Optimization of each cut



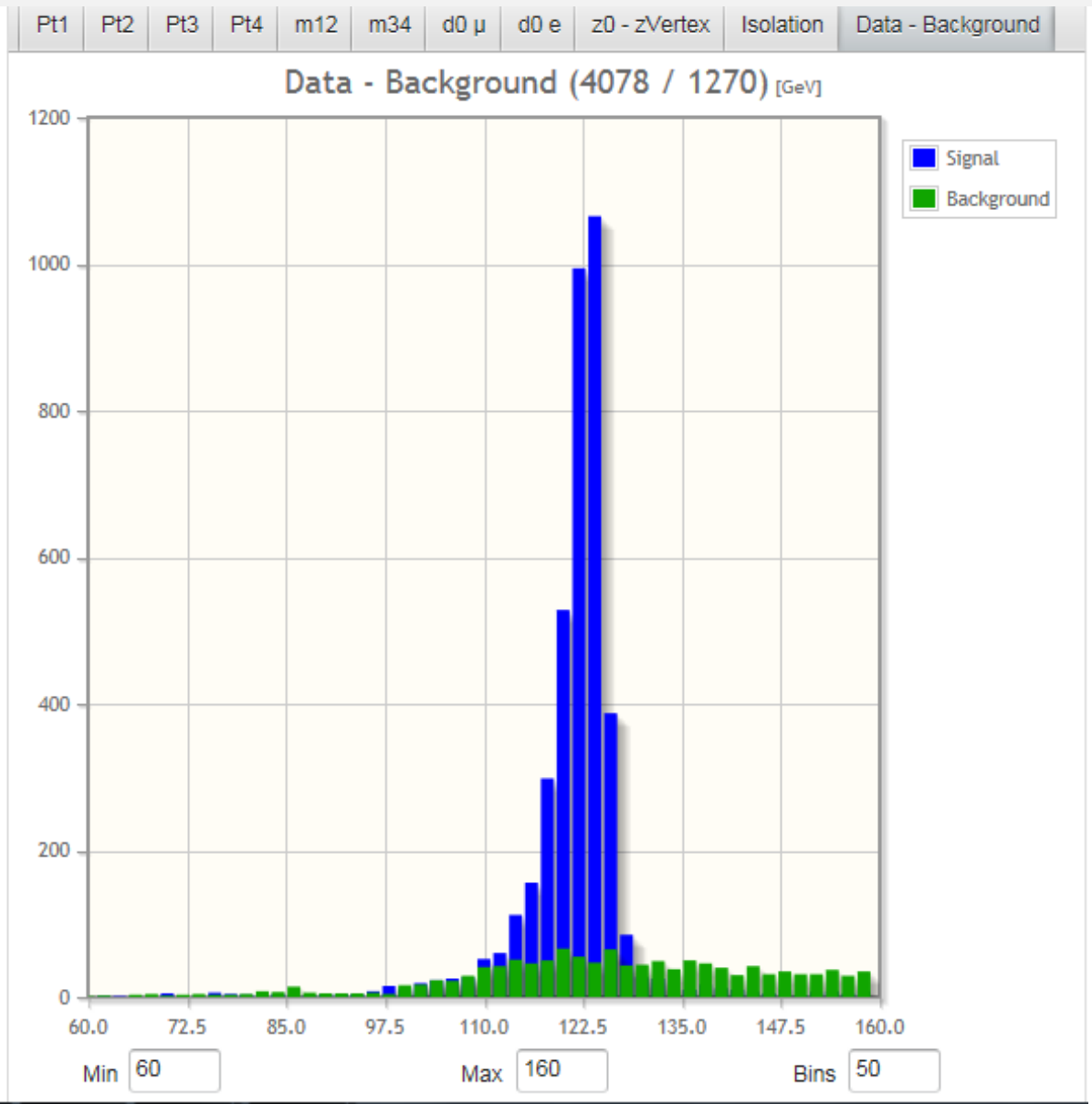
Signal (MC)

Bkg Zbb

Signal /sqrt(Bkg)

How the four lepton invariant mass looks after imposing some cuts

Pt1	6	GeV
Pt2	6	GeV
Pt3	6	GeV
Pt4	6	GeV
m12	10	GeV
m34	6	GeV
d0 μ	5	cm
d0 e	5	cm
z0 - zVertex	10	cm
Isolation	1	
I.M. Min	10	GeV
I.M. Max	1500	GeV



Horizon 2020

Call: H2020-SEAC-2014-1

Topic: SEAC-1-2014

Proposal acronym: CREATIONS

Developing an Engaging Science Classroom

- 36 months
- 1,8ME
- 7 WPs
- Coordinator: University of Bayreuth

16 Partners (CERN, UoB, IASA, STFC etc) + Quarknet

CONCLUSIONS

- ❑ **A lot of resources for introducing HEP already available**
- ❑ **Number of labs/resources for University students increasing**
- ❑ **EU very interested in funding outreach projects for STEM (school of tomorrow..)**
- ❑ **New calls coming (ex. science with and for Society)**

- ❖Tomorrow there is a public event/science fair in Chania
- ❖H-P Beck is ready to answer all questions !!
- ❖And lectures for the public in the evening (in Greek)

Back-up

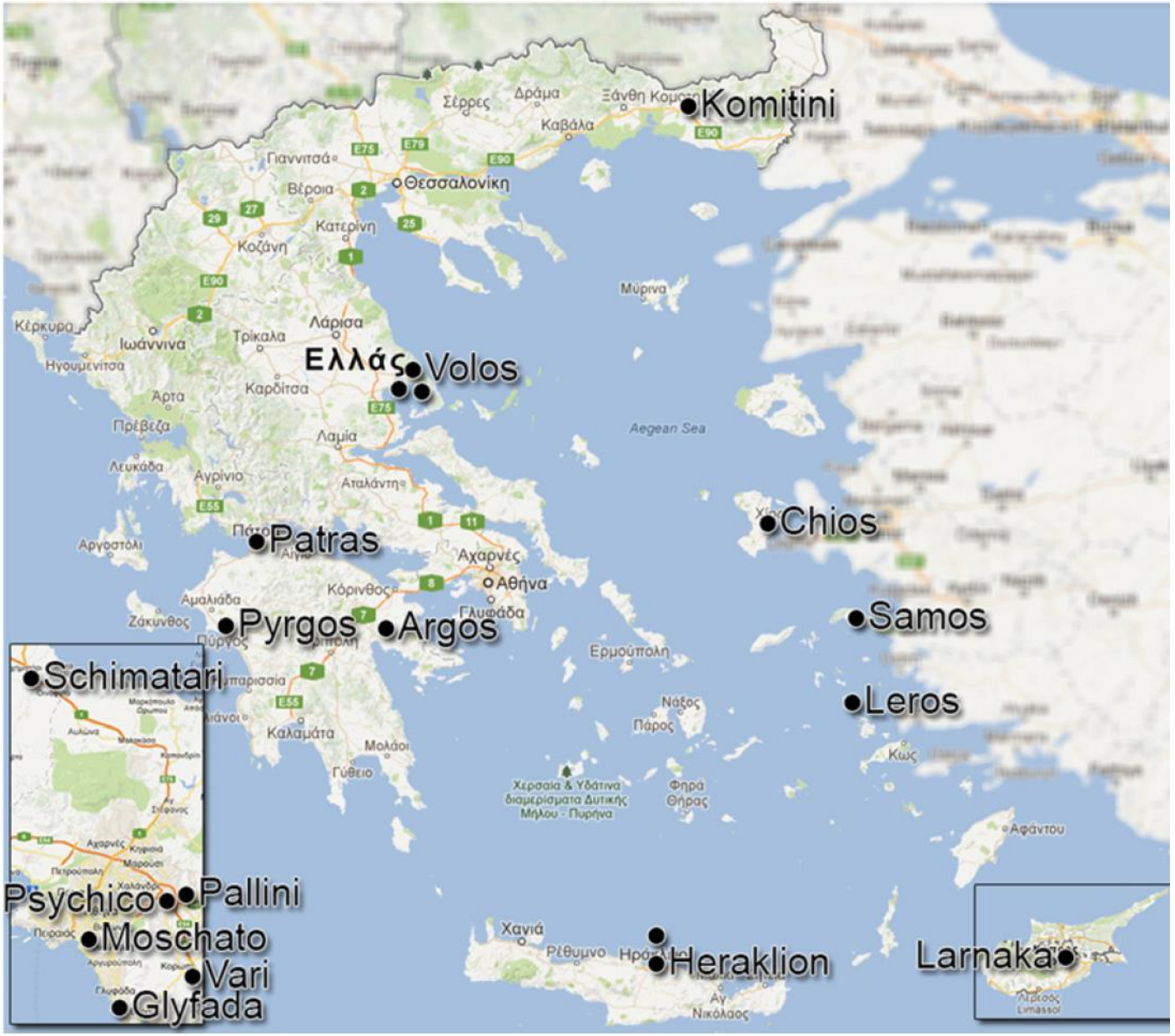
Best practices:
Local Masterclasses, e-Masterclasses & Virtual Visits

- **Masterclasses @schools ("mini" ones)**
  - **~ 80 schools all over Greece (Komotini to Crete)**
    - Students learn how actually science goes"
    - Listen to lectures
    - Follow a virtual visit to ATLAS control room
    - Analyse events with the HYPATIA on-line tool

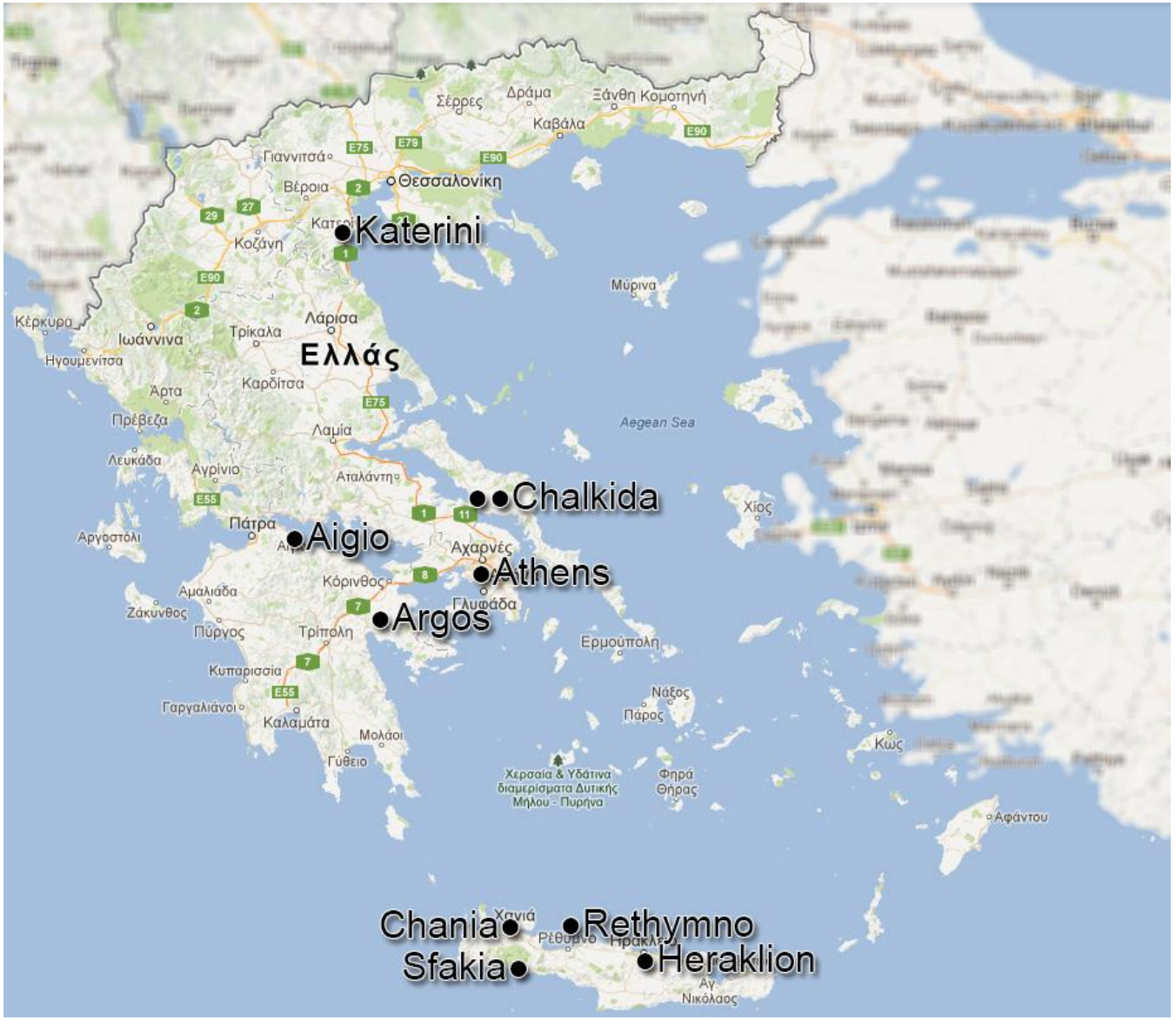
- **e-Masterclasses**
  - **Dutch (9) & Polish (43) students (Nov12)**
    - "Learn how actually science goes"
    - Teachers' role (e.g. HST12 participants)
    - Targeting extended group visits
    - **Synergies with local-level MCs**
    - + CERN Hangouts (Polish students)
    - + CERN Mini Expo (Santiago de Compostela

- **VV with a cluster of schools**
  - **CMS (10), ATLAS (10+2 from Cyprus)**

Implementation in Greek schools 2012-2013



Implementation in Greek schools 2013-2014



Implementation in Greek schools 2014-2015