Introducing High Energy Physics Computing to the Secondary Classroom

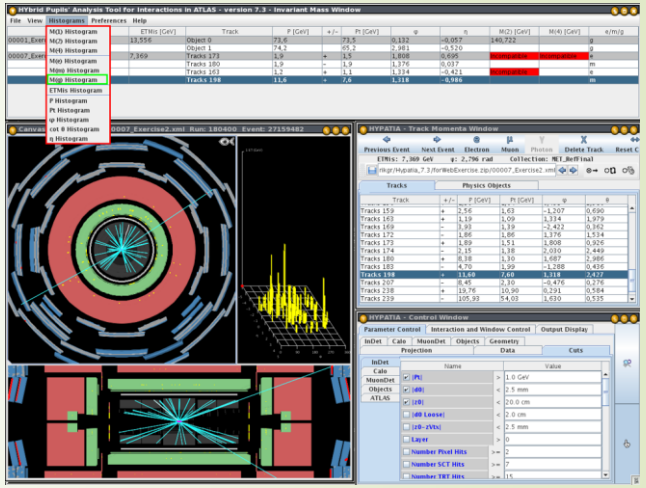
Group 4: Javier Cifuentes, Anshul Gupta, Radja Khatir, Slavoljub Mitic, Hoi Yan Chan

Key ideas

- Design of colliders and other facilities at CERN;
- Simulation of high energy physics and designing the experiments;
- Automated safety controls to protect human life;
- Extracting, storing and analysing all data obtained;
- Collaboration and communication across a very large international network.

Curriculum & classroom connections

- Dataloggers
- Data analysis



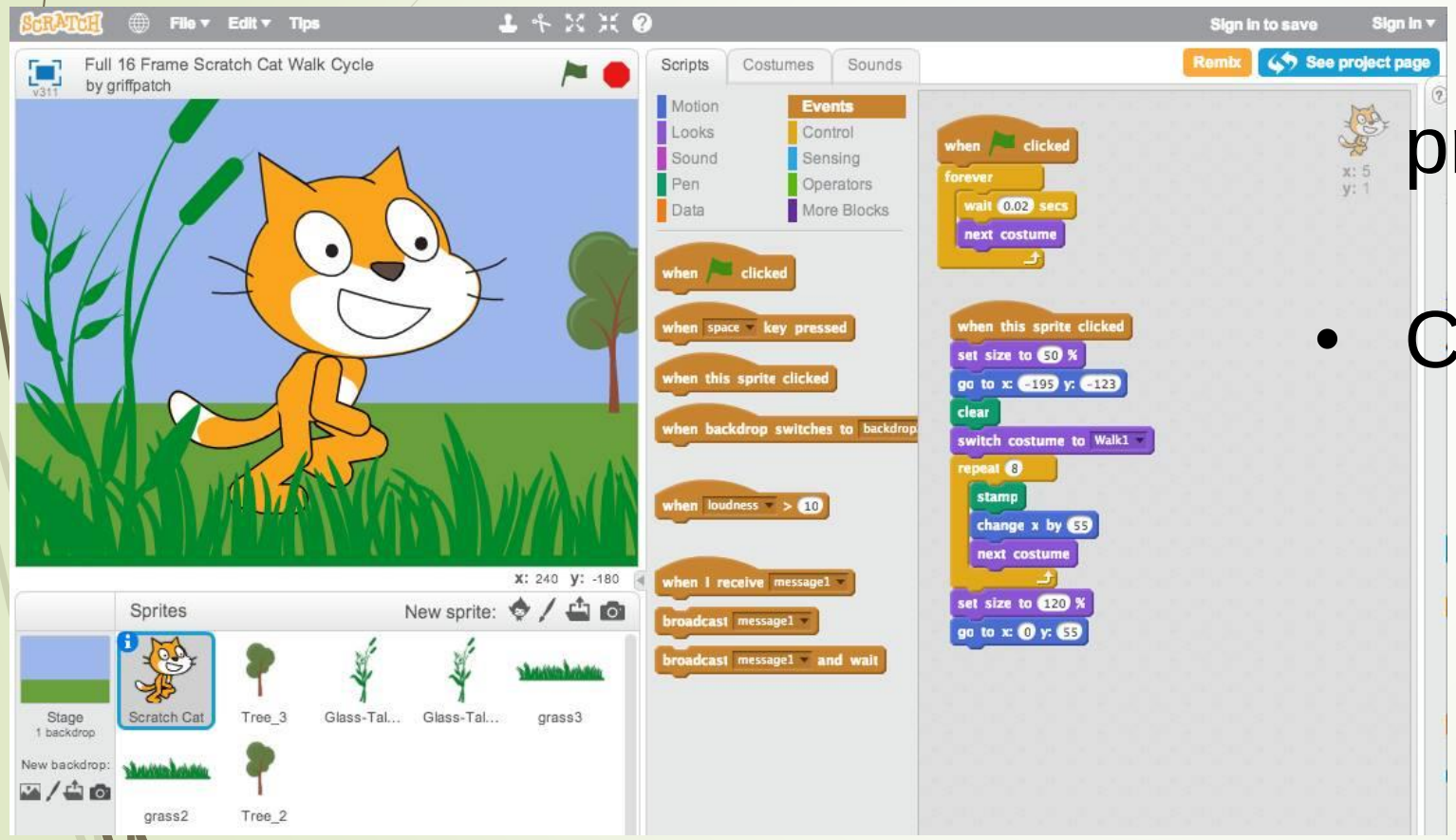
- Simulations for particle interactions
- Mathematical modelling and statistical distributions
- Databases

Potential student conceptions & challenges

- Computing is a difficult!
- Perception of scale of data collected
- Understanding that 99.99% of data is filtered out!
- "What even is data?"
- Assumptions made

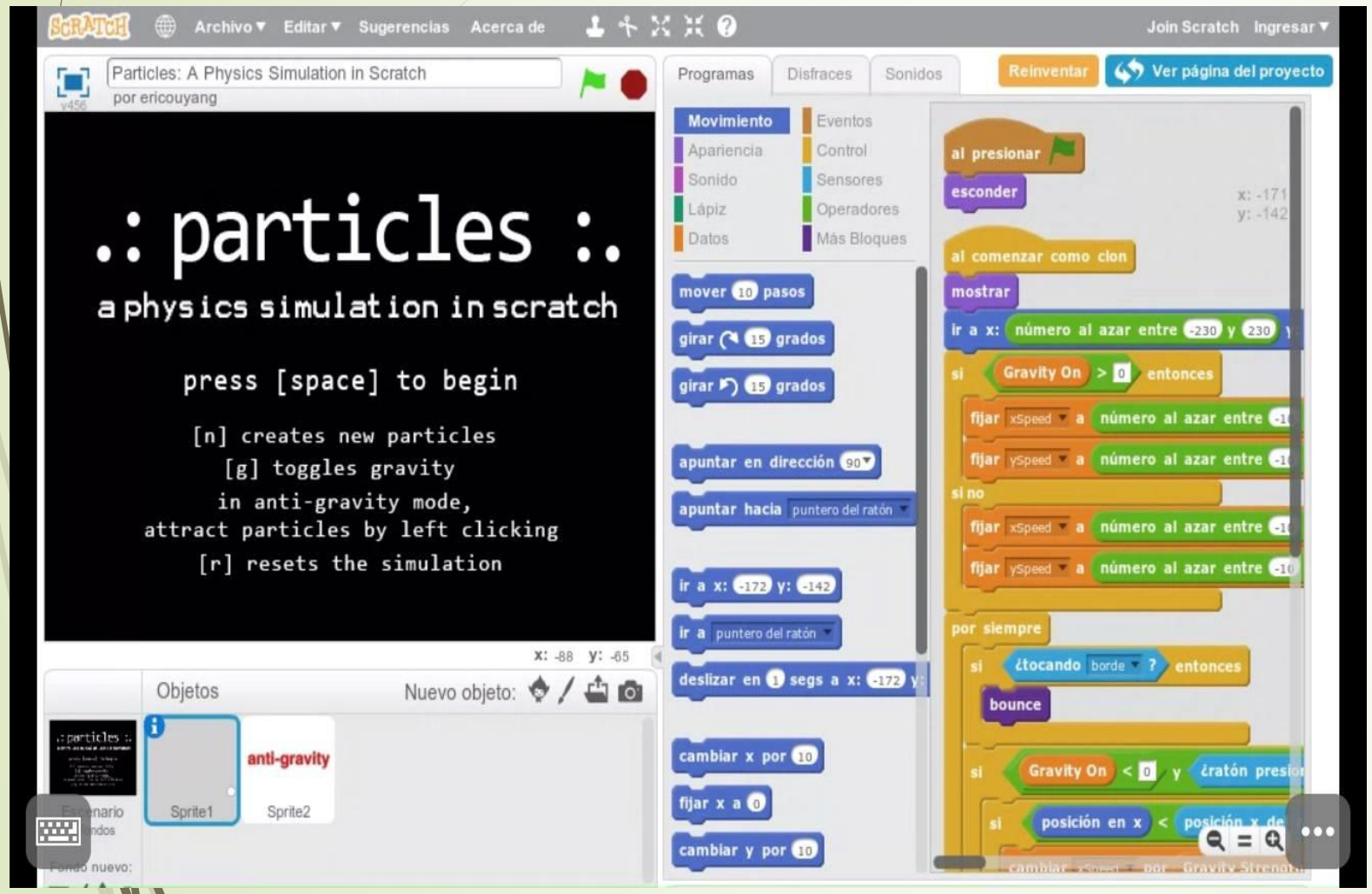
Scratch

STRATEGY 1: TEACHING STUDENTS HOW THE HIGGS WAS DISCOVERED WITH COMPUTERS USING SCRATCH AS A PROGRAMMING TOOL



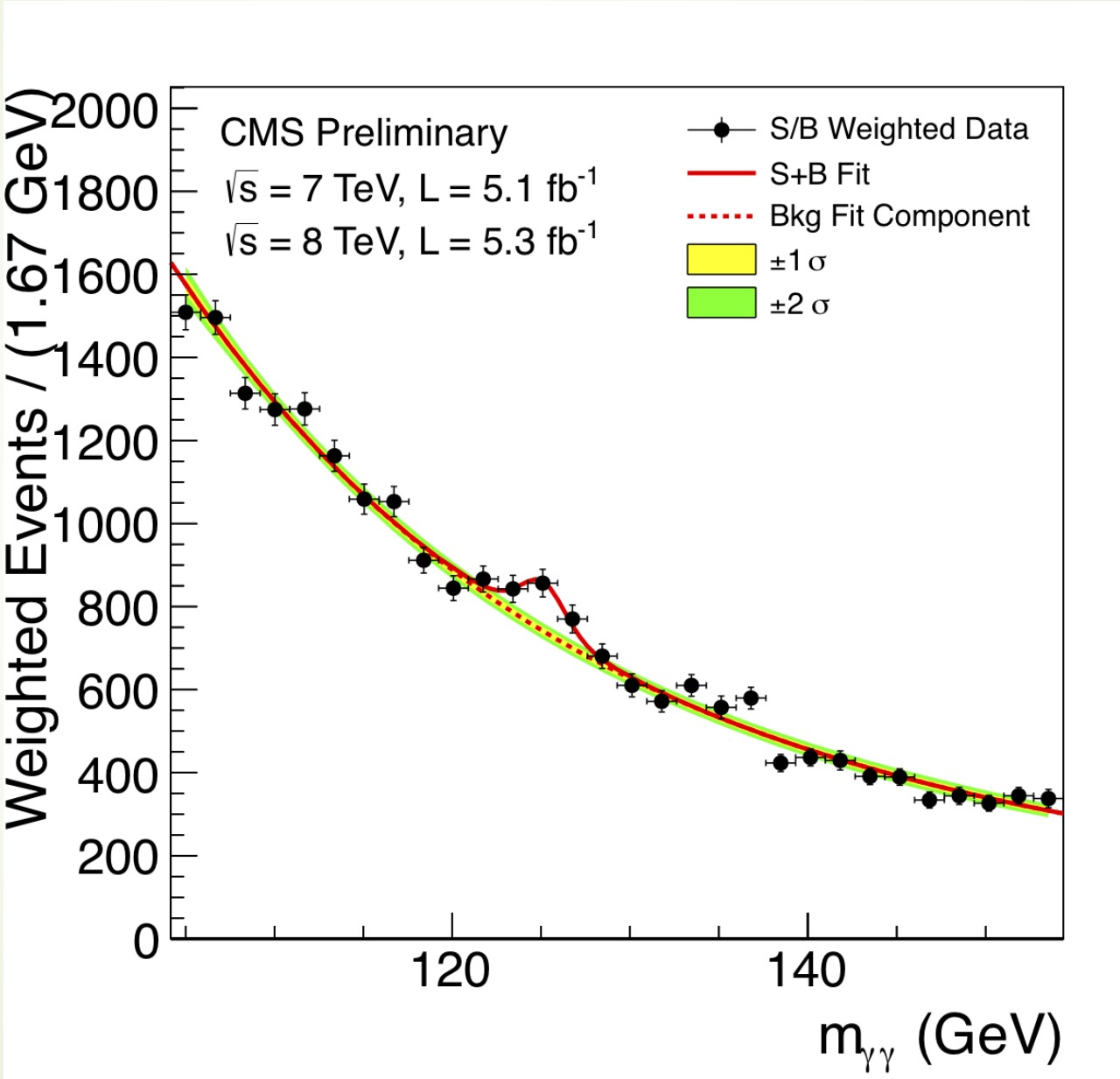
- Ideal for novice programmers
- Code condensed to blocks

STEP 1: UNDERSTANDING THE BASIC LAWS THAT GOVERN PARTICLE COLLISIONS



- Simulate particle collisions
- Students put their understanding of conservation laws into practice

STEP 2/3: BACKGROUND AND SEARCHING FOR NEW PARTICLES



International Masterclasses

International Masterclasses Spring each year – take part!
http://www.physicsmasterclasses.org/index.php

IPPOG website – great place to get resources for teaching and organising particle physics events
http://ippog.org/

International Masterclasses

This year more than 13000 high school students in 52 countries participated in this project.

http://physicsmasterclasses.org/

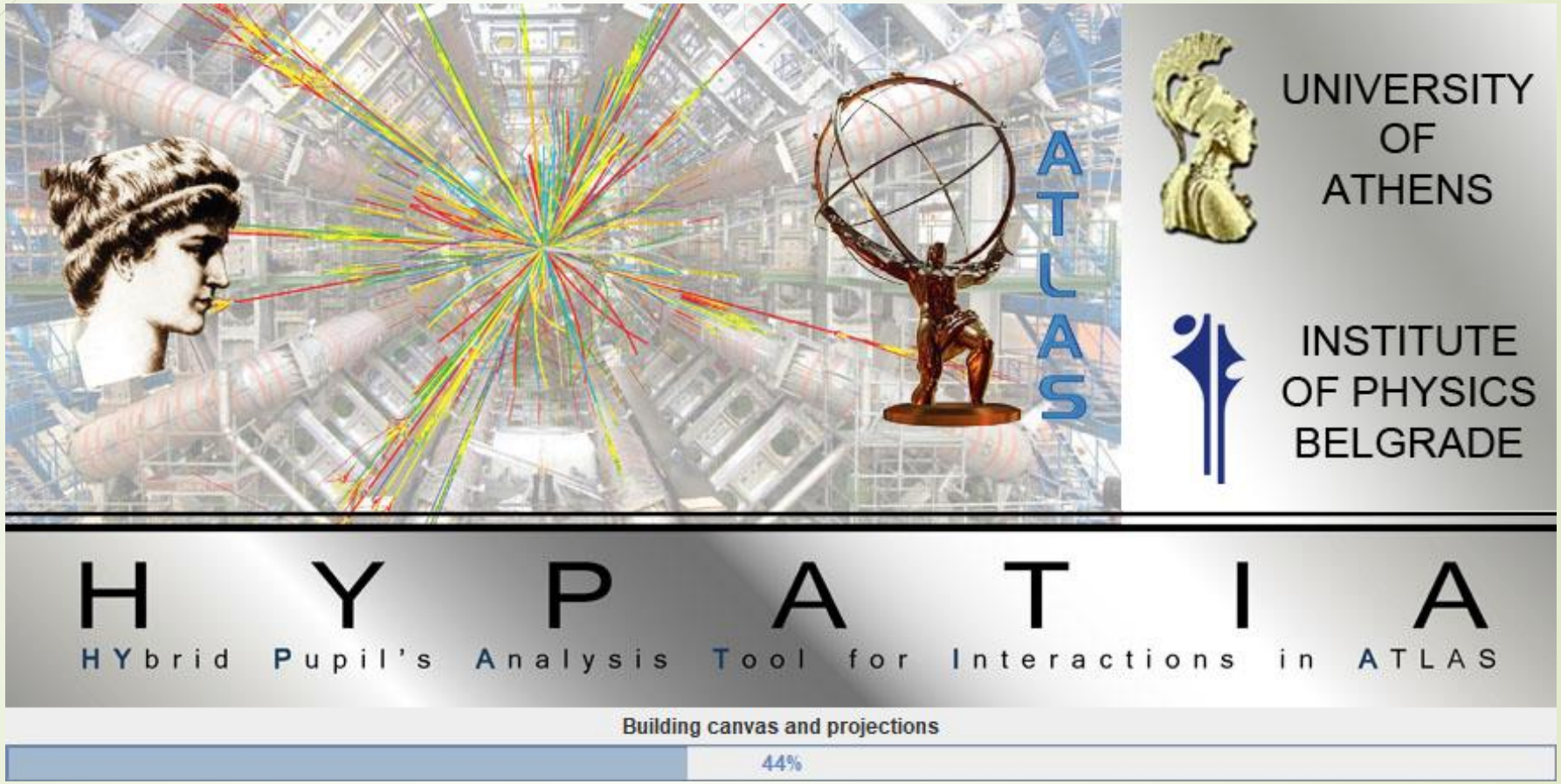
http://atlas.physicsmasterclasses.org/en/index.htm

- Students 15-19;
- Every March;
- Discover the world of particle physics.

Activities:

- Lectures
- Measurements on real CERN data
- Video conference with students from other countries - collaboration

Hypatia - analyze real data rom ATLAS and try to discover the elementary particles.



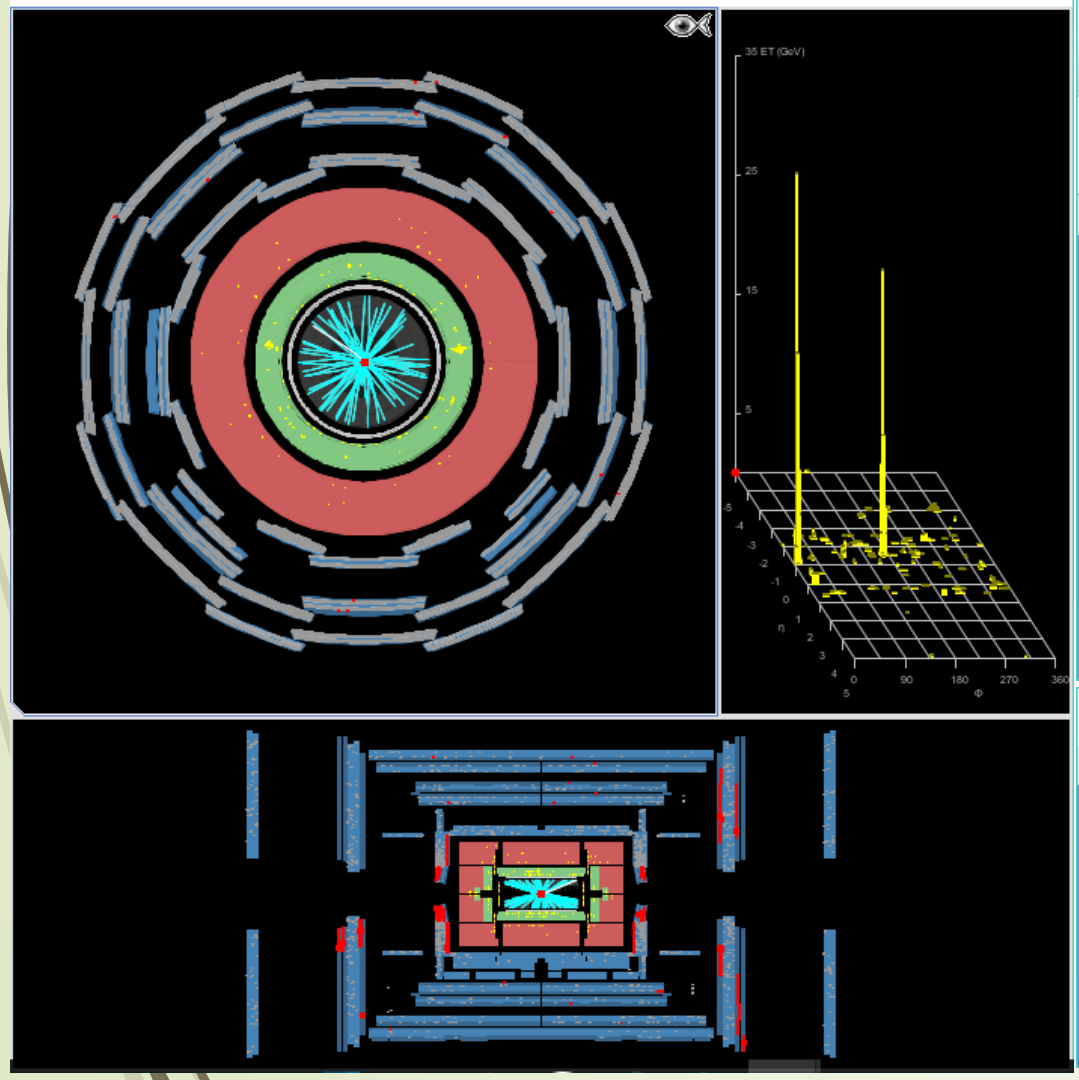
Interactive laboratory environment - events recorded in proton-proton-collisions

HYbrid Pupils' Analysis Tool for Interactions in ATLAS - version 7.4 - Invariant Mass Window

File View Histograms Preferences Help

File Name	ETMis [GeV]	Track	P [GeV]	+/-	Pt [GeV]	φ	η	M(2) [GeV]	M(eeee) [GeV]	M(eemm) [GeV]	M(mmmm) [GeV]	e/m/g
00001_Exercise2.xml	13.556	Tracks 4	7.6	+	1.5	-1.729	-2.299	4.322	20.977			e
		Tracks 5	2.5	-	2.3	-2.396	-0.399					e
		Tracks 6	5.2	+	1.0	-1.432	2.315	3.012				e
		Tracks 15	**6.2**	**-**	**2.2**	**2.412**	**1.674**					e

Canvas Window - File: 00001_Exercise2.xml Run: 186721 Event: 1100319



HYPATIA - Track Momenta Window

File Previous Event Next Event Electron Muon Photon Delete Track Reset Canvas

ETMis: 13.556 GeV φ: -2.942 rad Collection: MET_RefFinal

C:\SM\CERN\Hypatia_7.4_Masterclass\exercise2\00001_Exercise2.xml

Tracks | Physics Objects

Track	+/-	P [GeV]	Pt [GeV]	φ	θ
Tracks 4	+	7.60	1.51	-1.729	2.941
Tracks 5	-	2.54	2.35	-2.396	1.960
Tracks 6	+	5.22	1.02	-1.432	0.197
Tracks 7	-	1.26	1.13	2.854	1.110
Tracks 11	+	6.90	2.01	0.033	0.296
Tracks 13	+	3.72	1.15	2.471	2.827
Tracks 15	**-**	**6.20**	**2.25**	**2.412**	**0.371**
Tracks 16	-	2.61	1.19	1.906	0.473
Tracks 17	-	3.43	1.02	0.532	2.840
Tracks 19	+	1.56	1.54	3.032	1.738
Tracks 32	+	1.30	1.10	-1.218	2.126
Tracks 33	+	1.59	1.57	1.763	1.698

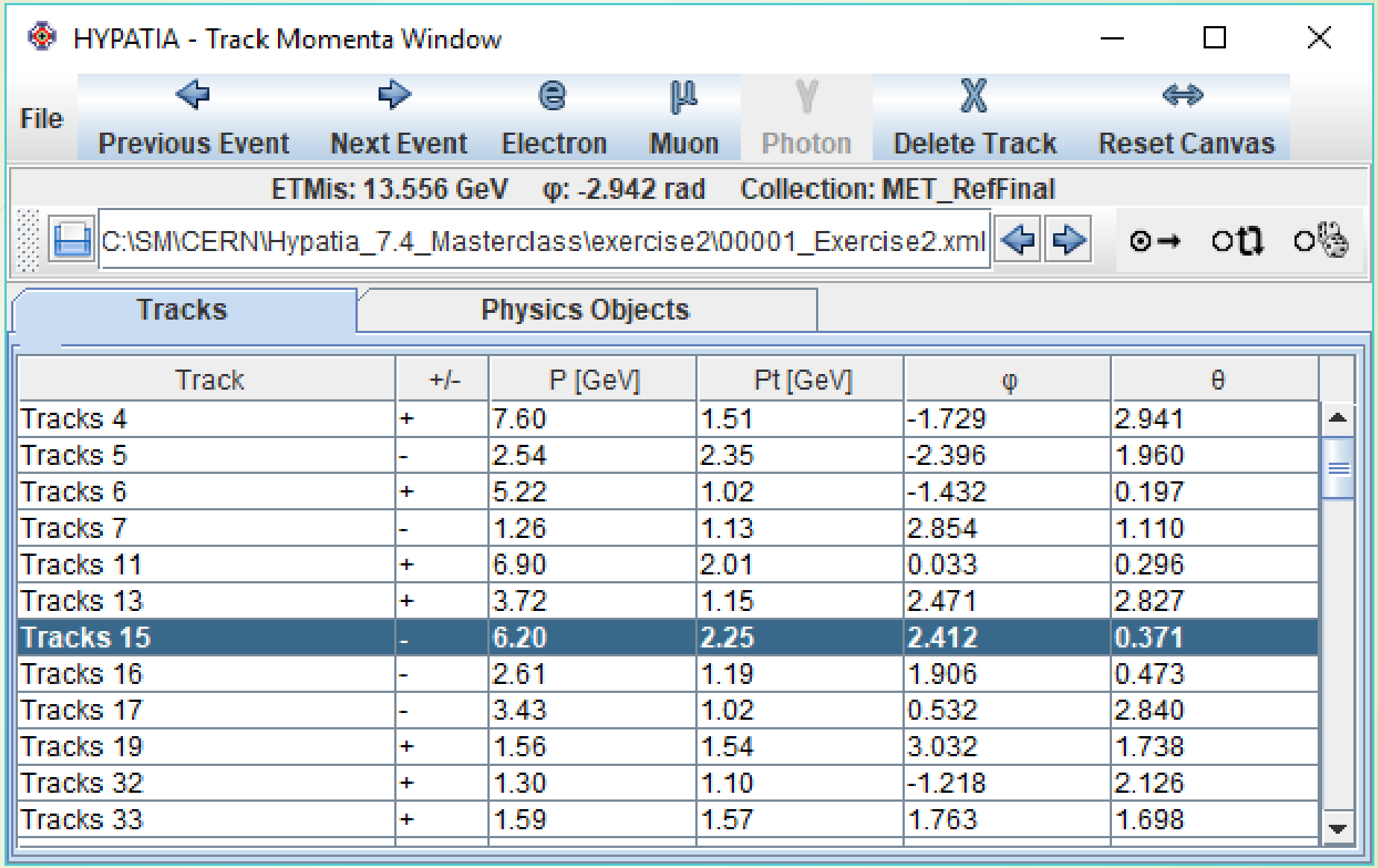
HYPATIA - Control Window

Parameter Control | Interaction and Window Control | Output Display

Projection | Data | Cuts | InDet | Calo | MuonDet | Objects | Geometry

Event Info | X'Z | Y'Z | 3DBox | LegoPlot | Residual | YX | Φη | ρZ | Φρ | ΦZ

Name	Value
View	Standard
Summed LAr binning	0.1x0.1
Summed HEC binning	0.2x0.2



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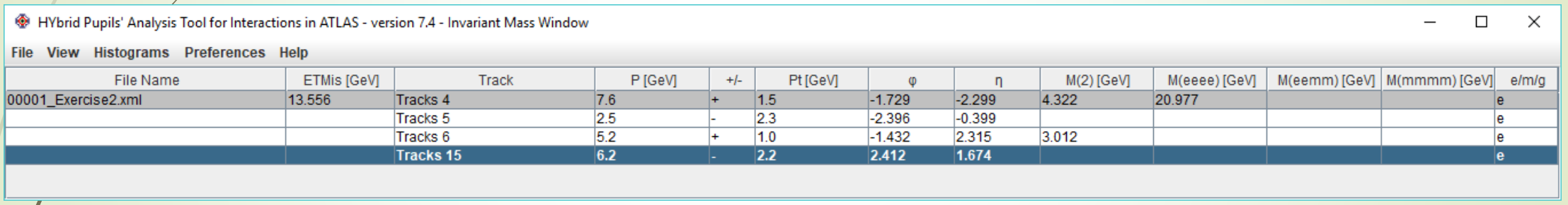
Track Momentum Window -
loading and reviewing events

Invariant Mass Window -
shows the invariant mass of the selected particle



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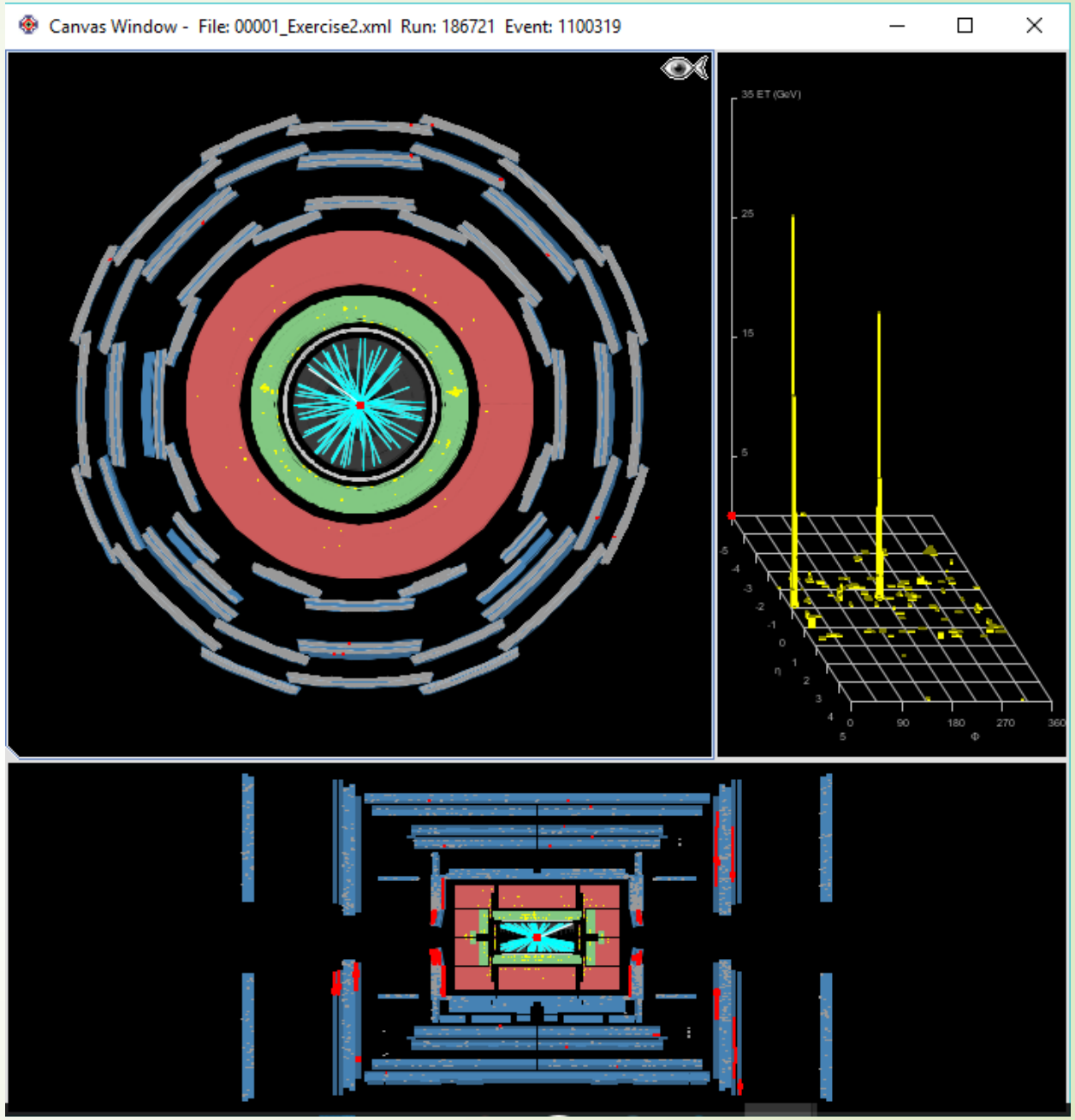
		Tracks 15	**6.2**	-	**2.2**	**2.412**	**1.674**					e

Canvas Window -
visual display of Atlas detector
cross section
side view

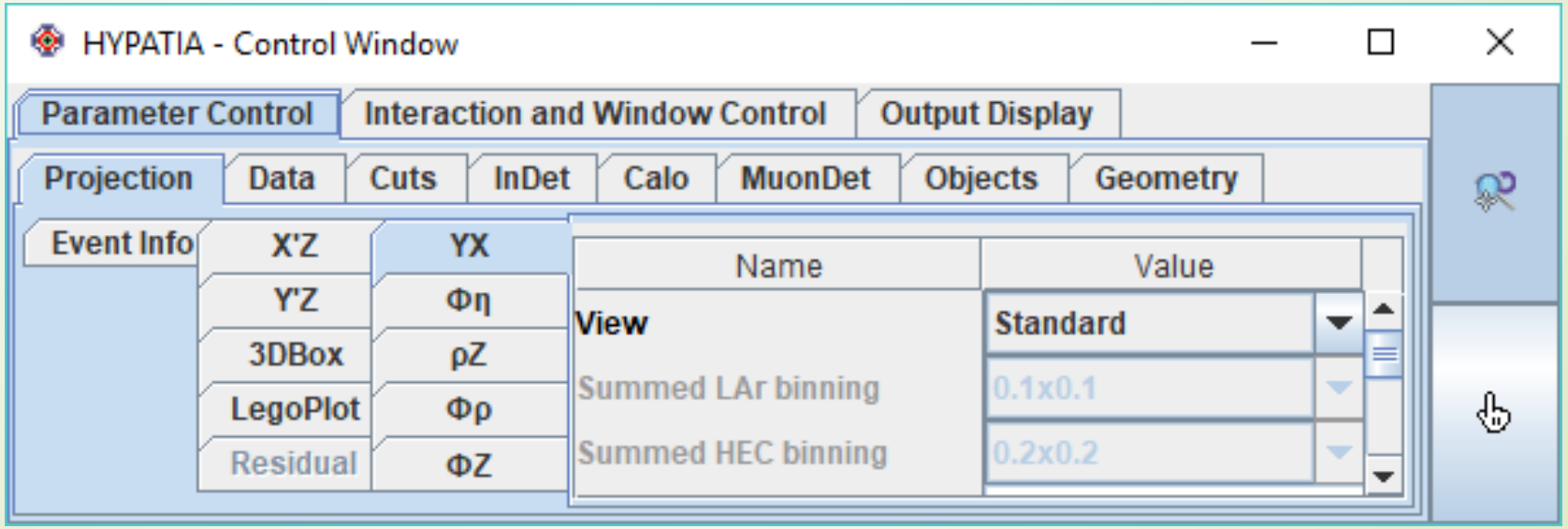


Control Window -

Parametar Control - turn on and off the event view, change color...

Interaction and Window Control – zoom, change the frame

Output Display - more detailed information about the selected object



Invariant Mass Window

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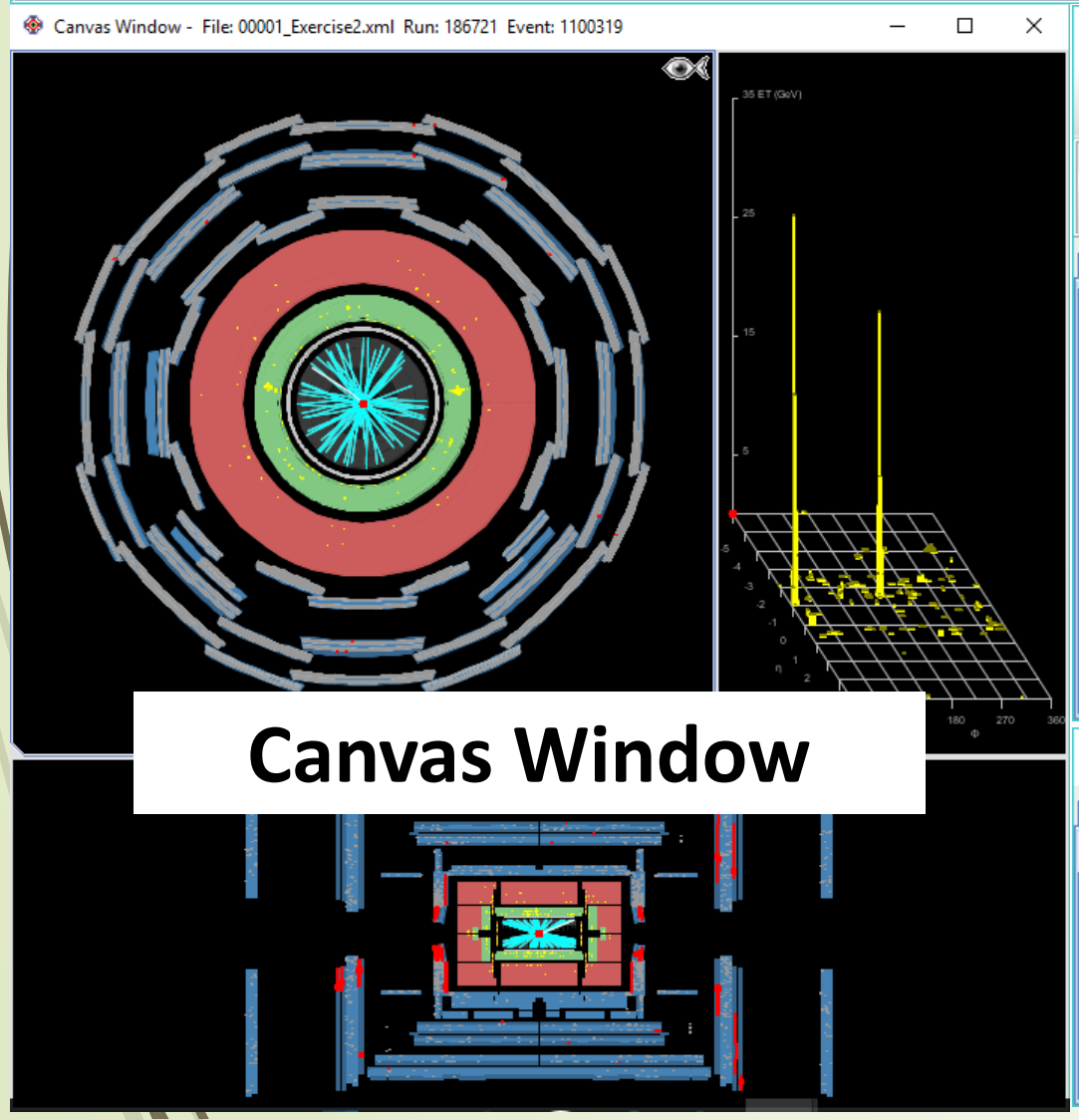
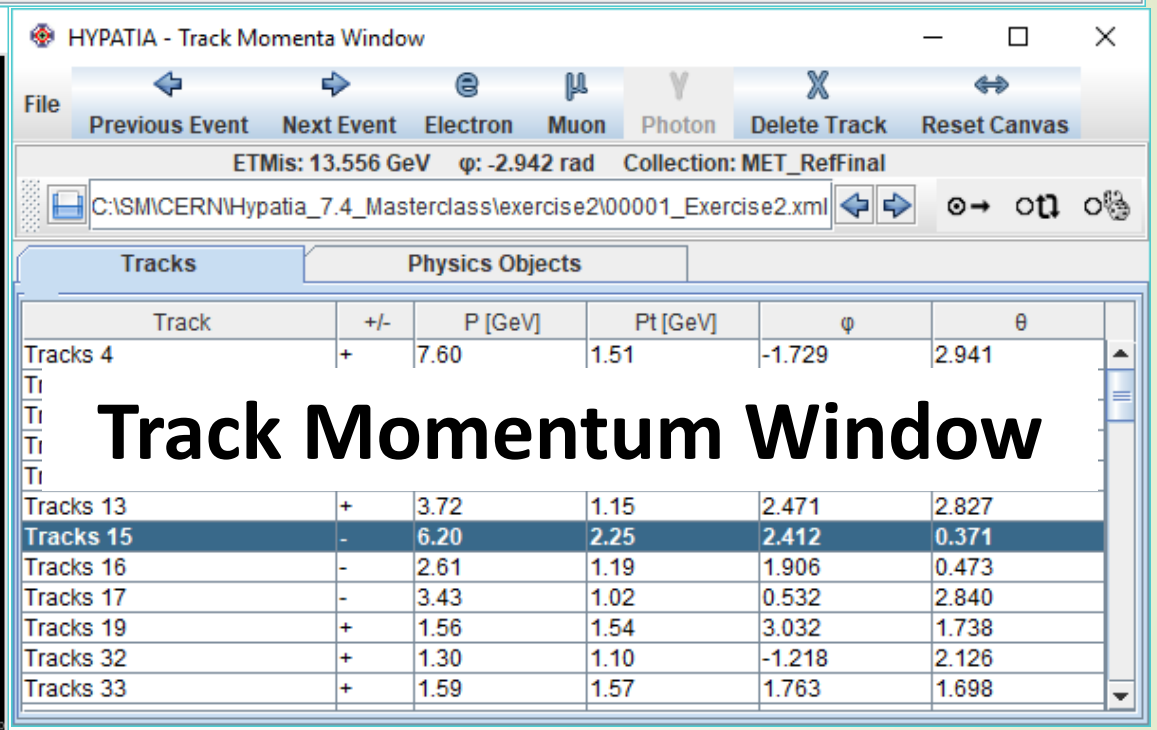
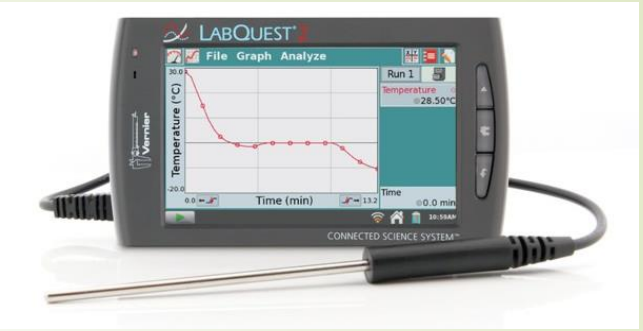




Instructions and materials for work

http://atlas.physicsmasterclasses.org/en/index.htm
https://indico.cern.ch/event/507180/contributions/2154507/attachments/1308441/1956712/IPPOG_Masterclasses.pptx
http://kjende.web.cern.ch/kjende/en/index.htm
http://physicsmasterclasses.org/
http://www.physicsmasterclasses.org/exercises/hands-on-cern/hoc_v21en/index.html
https://indico.cern.ch/event/318730/contributions/737355/attachments/613361/843833/KoJe-Masterclasses-2014-HST.pdf
http://hypatia.phys.uoa.gr/Downloads/

Datalogging



- To introduce automated and large scale data collection
- To understand the need for collaboration

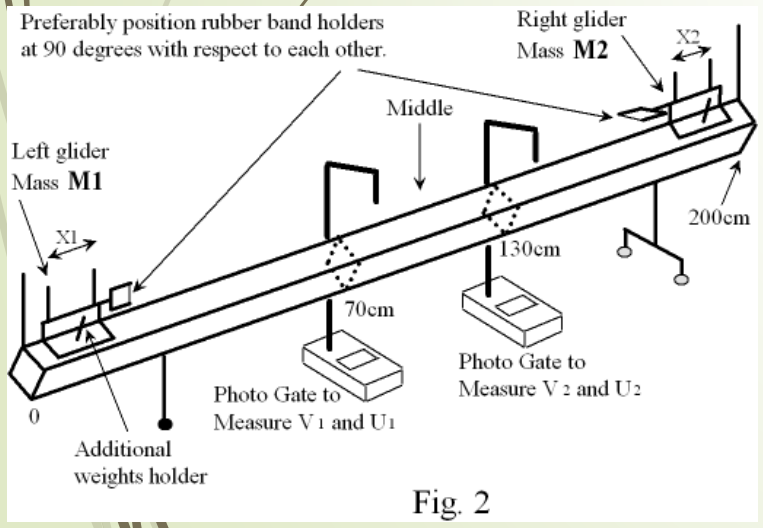


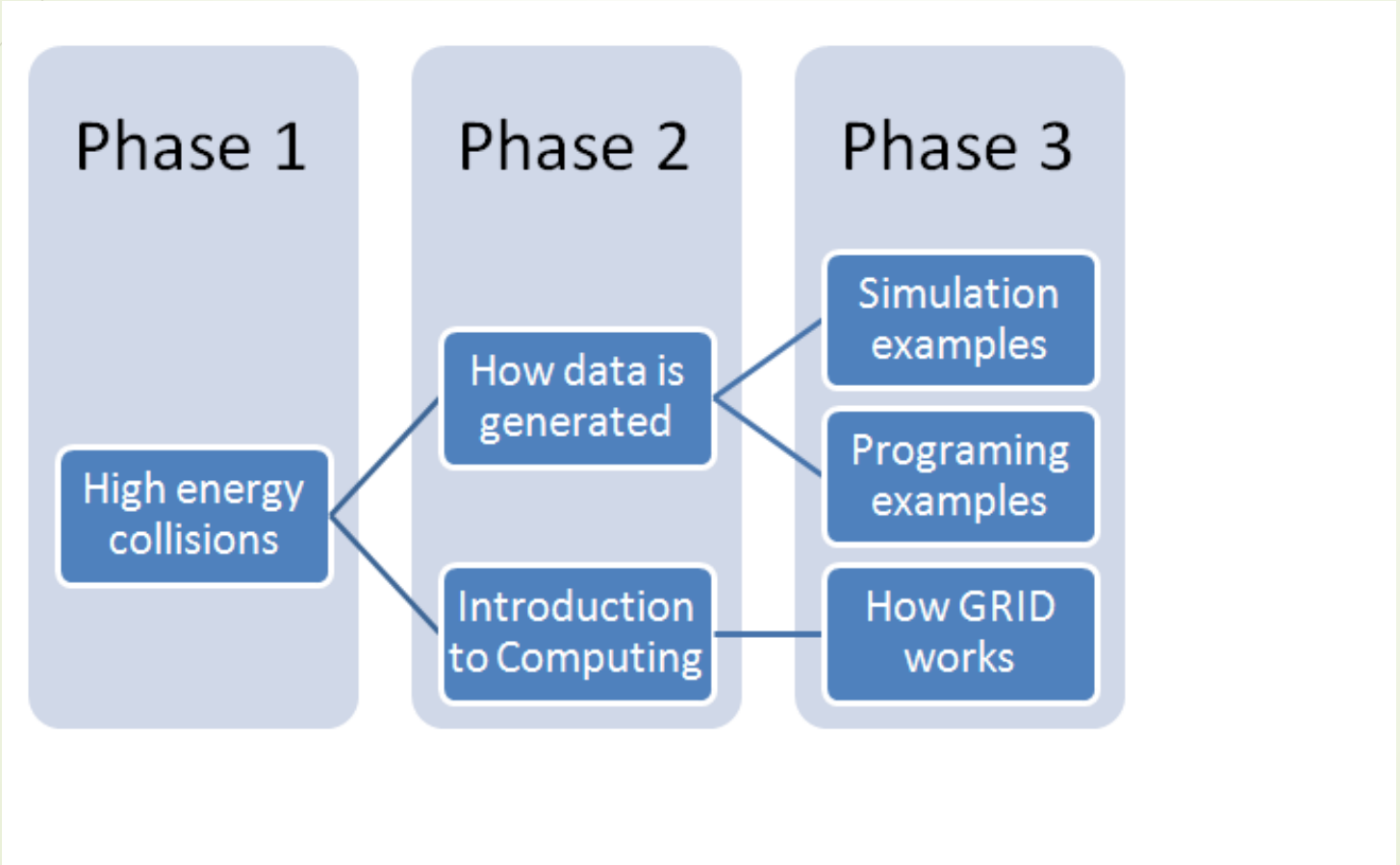
Fig. 2

- Students carry out experiment into energy in linear collisions of particles by modelling with air track gliders
- Discuss the need to obtain many data points to observe possible energies and relate to particle collisions

The Grid we are concerned with.....

- The Worldwide LHC Computing Grid (**WLCG**)
- More than 170 computing centres
- 42 countries
- To provide global computing resources ~50 Petabytes of data in 2017, generated by LHC @ CERN
- Task is too Store Distribute and Analyse.

How we can proceed.....



Anshul Gupta, Slavoljub Mitic, **Jeff Wiener**, Javier Cifuentes

Radja Khatir, Hoi Yan Chan (Group 4 – 5 + **1**)