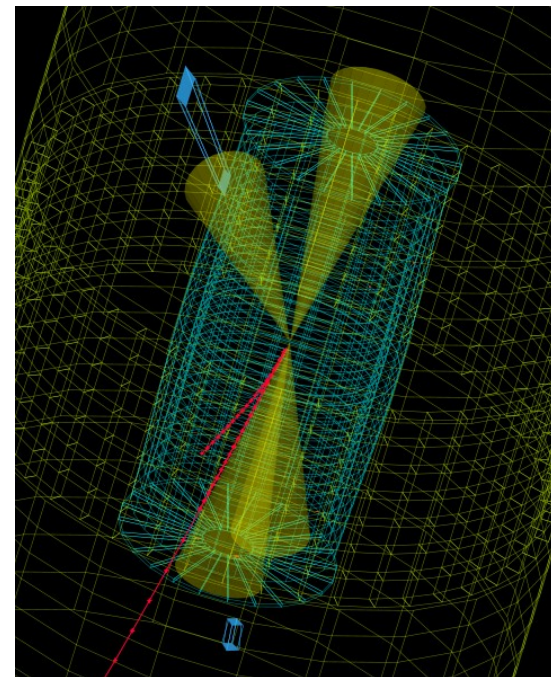# CMS Masterclass 2011

Ken Cecire

University of Notre Dame/QuarkNet

kcecire@nd.edu

Items to Report

- Website
- Event display
- Student investigations
- Results
- Observations
- Ideas for development

CMS Masterclass Website

- http://leptoquark.hep.nd.edu/~kcecire/mc/cms.html on local Notre Dame QuarkNet server

- http://www.physicsmasterclasses.org → Navigate to Physics/CMS.

- Try to keep to simple html and simple presentation where possible.

- Save most of physics for masterclass presentations outside website.

- Introductory videos (English only for 2011) on front page

- 6 languages: DE, EN, FR, IT, SP, 日本語

"Hands on Particle Physics"
International Masterclasses

HOMEPAGE   INTRODUCTION   J/Ψ EXERCISE   EVENTS   LIBRARY

CMS International Masterclasses

Join us on a journey to study the smallest building blocks of matter! Data samples from the CMS Experiment at CERN's Large Hadron Collider (LHC) are ready. Make your own measurements. Follow the menu buttons above: the current J/Ψ Exercise for Masterclass 2011 and the W/Z Exercise to be released later. Students will find information in the Library and videos. Explore...and then let's do some 21st century particle physics!
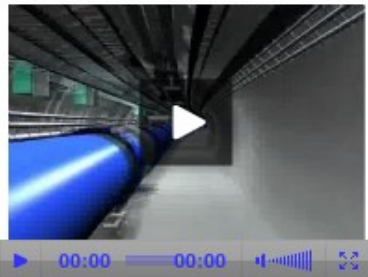
LANGUAGES

DE EN FR IT SP 日本語

LINKS

Hands on Particle Physics

WHAT ARE CERN AND THE LHC?

00:00   00:00

CERN in 3 minutes, courtesy CERN

WHAT IS CMS?

00:00   00:00

Don Lincoln, Fermi National Accelerator Laboratory

WHAT ARE THE BIG QUESTIONS?

00:00   00:00

Kevin Lannon, University of Notre Dame

WHAT IS THE MASTERCLASS?

00:00   00:00

Laura Alvesson, Mills Godwin High School

CURRENT EVENTS

- US/LHC Event of the Week
- interactions.org
- CERN Courier
- CMS Times

IPPOG Spring Meeting
14 April 2011

"Hands on Particle Physics"
International Masterclasses

International Masterclasses — **Hands on Particle Physics**

HOMEPAGE   INTRODUCTION   J/Ψ EXERCISE   EVENTS   LIBRARY

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LANGUAGES

DE EN FR IT SP 日本語

LINKS

Hands on Particle Physics

CERN

CMS

ATLAS

Explain how to use event display.

Technical requirements

WHAT IS ... LHC?

WHAT IS CMS?

CERN in 3 minutes, courtesy *CERN*.

Don Lincoln, Fermi National Accelerator Laboratory

▶ 00:00 ———— 00:00 ◀⊣‖‖‖ ⤢

WHAT ARE THE BIG QUESTIONS?

WHAT IS THE MASTERCLASS?

▶ 00:00 ———— 00:00 ◀⊣‖‖‖ ⤢

▶ 00:00 ———— 00:00 ◀⊣‖‖‖ ⤢

Kevin Lannon, University of Notre Dame

Laura Akesson, Mills Godwin High School

CURRENT EVENTS

- US/LHC Event of the Week
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IPPOG Spring Meeting
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"Hands on Particle Physics"
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International Masterclasses   Hands on Particle Physics

| HOMEPAGE | INTRODUCTION | J/Ψ EXERCISE | EVENTS | LIBRARY | → to QuarkNet Masterclass Library |

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Explain how to use event display.

Technical requirements

Interpretation of events

How to combine and understand results

WHAT IS THE LHC?

WHAT ...

CERN in 3 minutes, courtesy CERN

Don Lincoln, Fermi National Accelerator Laboratory

WHAT ARE THE BIG QUESTIONS?

00:00 — 00:00

Kevin Lannon, University of Notre Dame

WHAT IS THE MASTERCLASS?

00:00 — 00:00

Laura Akesson, Mills Godwin High School

LANGUAGES

DE EN FR IT SP 日本語

LINKS

Hands on Particle Physics

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14 April 2011

"Hands on Particle Physics"
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International Masterclasses — Hands on Particle Physics

HOMEPAGE   INTRODUCTION   J/Ψ EXERCISE   EVENTS   LIBRARY

CMS Masterclass Event Display

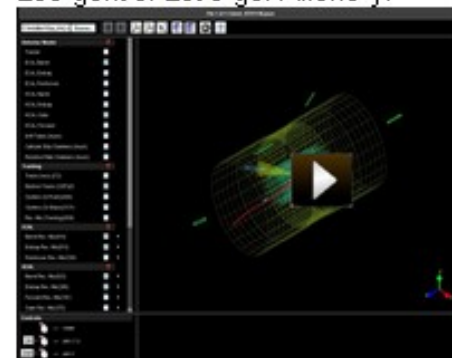Home:
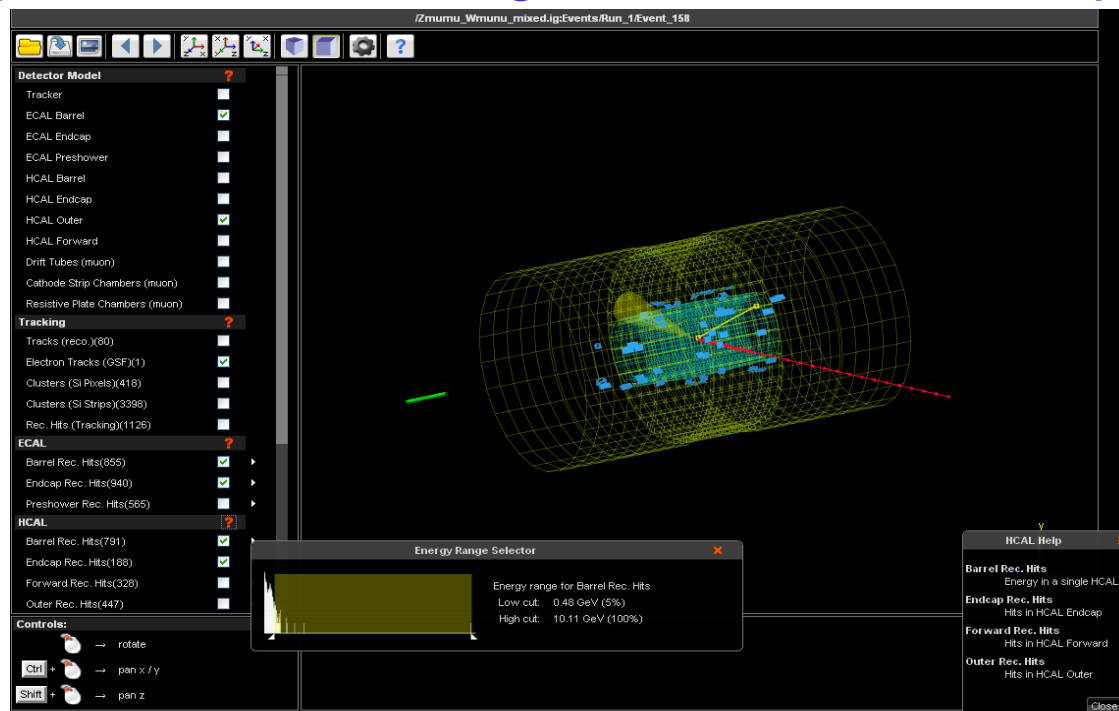DE EN FR IT SP 日本語

1.

Ansehen! Watch! Regardez!

Guarda! ¡Mira! 見てください！

**2.**

Los geht's! Let's go! Allons-y!

Si parte! ¡Vamos! 始めよう！

Event Display

- Based on iSpy, runs online (not IE)
- Javascript by I2U2 programmer Mihael Hategan
- Modified for DVD by Phong Nguyen
- 3D, rotates, zooms, options, more
- http://www18.i2u2.org/elab/cms/event-display/

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Event Display→Data→Investigation

- 2000 dimuon events, 2-5 GeV invariant mass
- Prepared by Tom McCauley
- Looking for J/Ψ mass plot
- Students rate events 0-3.
  - 0 – no chance (like charge muon tracks)
  - 1
  - 2
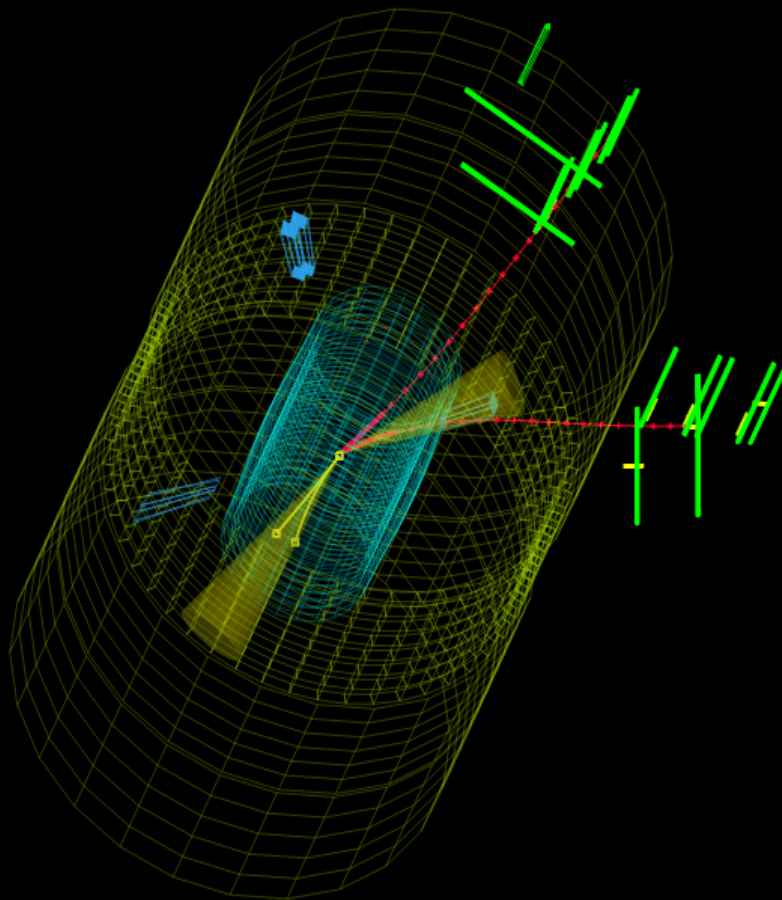 - 3 – good candidate (two global muons, opposite charge)

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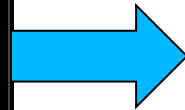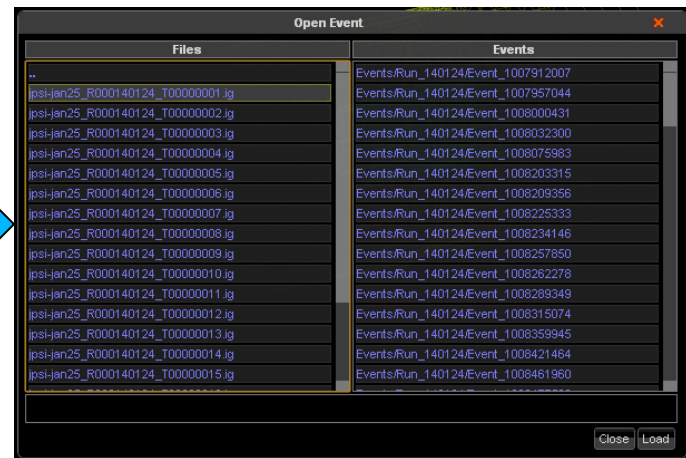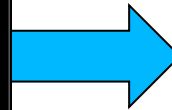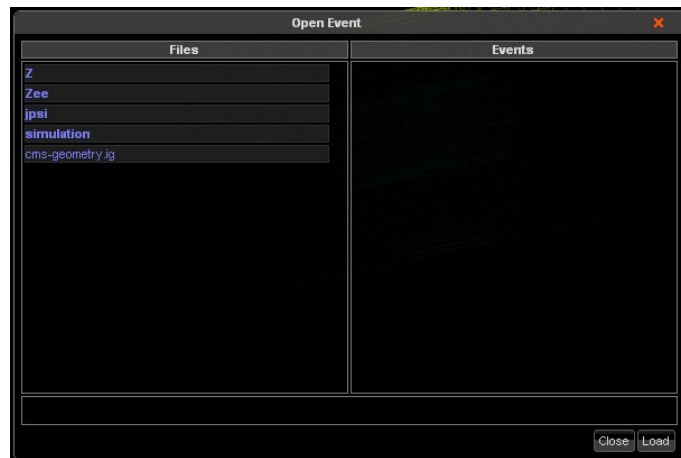
Tracks (reco.)(91)
Electron Tracks (GSF)(2)
Clusters (Si Pixels)(450)
Clusters (Si Strips)(3478)
Rec. Hits (Tracking)(1223)
ECAL ?
Barrel Rec. Hits(1527)
Endcap Rec. Hits(763)
Preshower Rec. Hits(318)
HCAL ?
Barrel Rec. Hits(828)
Endcap Rec. Hits(221)
Forward Rec. Hits(178)
Outer Rec. Hits(381)
Muon ?
DT Rec. Hits(63)
DT Rec. Segments (4D)(6)
CSC Segments(0)
RPC Rec. Hits(7)
CSC Rec. Hits (2D)(0)
Particle Flow ?
Physics Objects ?
Tracker Muons (Reco)(2)
Stand-alone Muons (Reco)(2)
Global Muons (Reco)(2)
Calorimeter Energy Towers(297)
Jets(9)

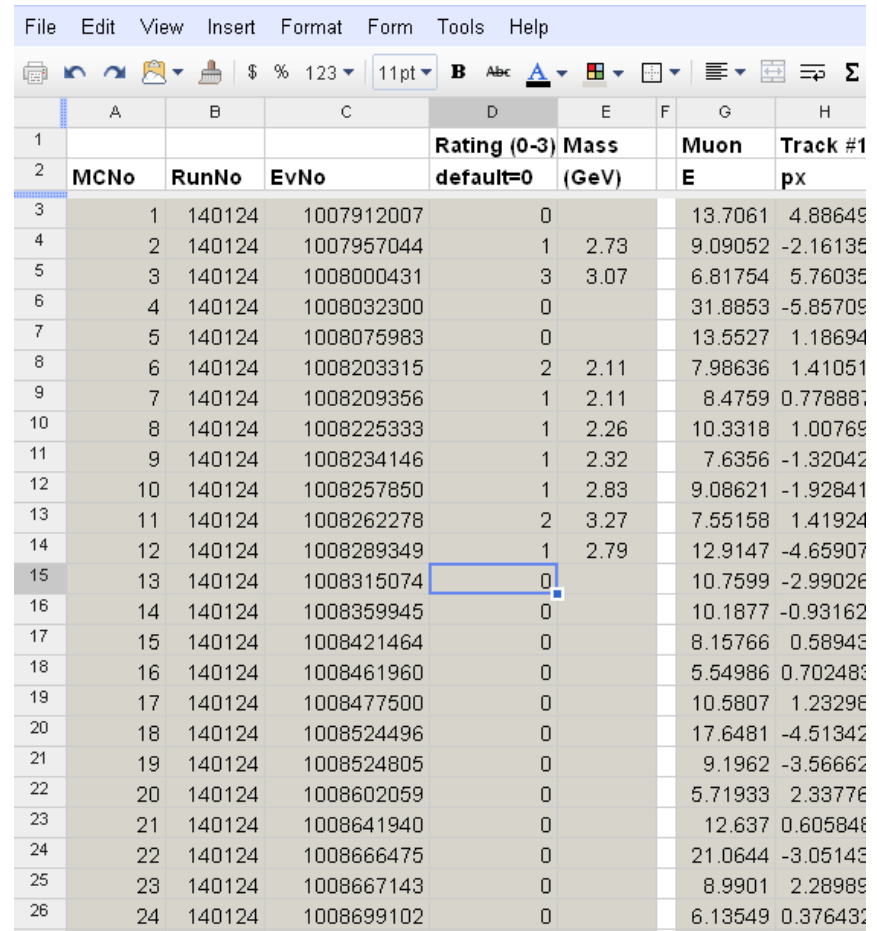**Controls:**

→ rotate

Ctrl + → pan x / y

Shift + → pan z

IPPOG Spring Meeting
14 April 2011

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Rate this event 0-3.

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International Masterclasses

CMS J/Ψ Investigation

- Rate the events 0-3.

- 2 students: 100 events

- Transfer ratings to spreadsheet, which reveals invariant mass.

- Mentor leads group to create mass plot; must decide which ratings to use.
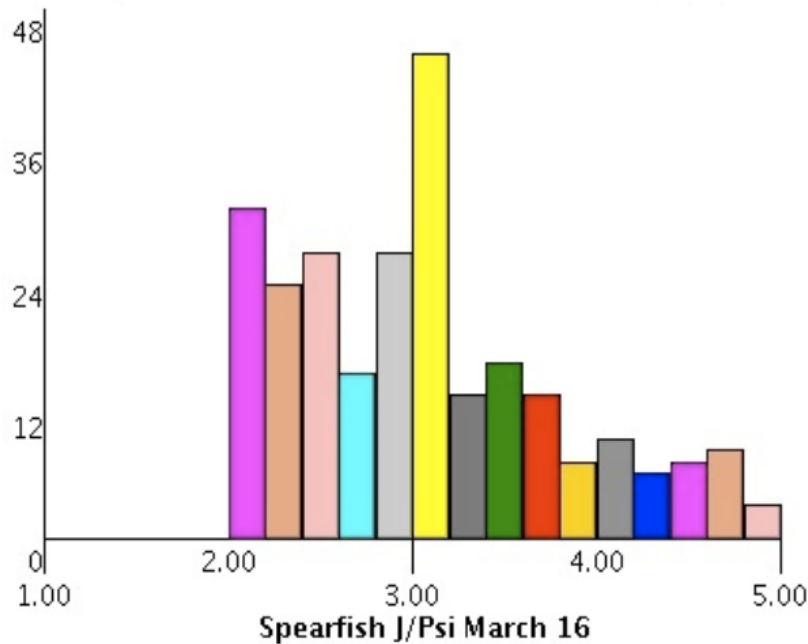
- Upload for videoconference.

	A	B	C	D	E	F	G	H
1				Rating (0-3)	Mass		Muon	Track #1
2	MCNo	RunNo	EvNo	default=0	(GeV)		E	px
3	1	140124	1007912007	0			13.7061	4.88649
4	2	140124	1007957044	1	2.73		9.09052	-2.16135
5	3	140124	1008000431	3	3.07		6.81754	5.76035
6	4	140124	1008032300	0			31.8853	-5.85709
7	5	140124	1008075983	0			13.5527	1.18694
8	6	140124	1008203315	2	2.11		7.98636	1.41051
9	7	140124	1008209356	1	2.11		8.4759	0.778887
10	8	140124	1008225333	1	2.26		10.3318	1.00769
11	9	140124	1008234146	1	2.32		7.6356	-1.32042
12	10	140124	1008257850	1	2.83		9.08621	-1.92841
13	11	140124	1008262278	2	3.27		7.55158	1.41924
14	12	140124	1008289349	1	2.79		12.9147	-4.65907
15	13	140124	1008315074	0			10.7599	-2.99026
16	14	140124	1008359945	0			10.1877	-0.93162
17	15	140124	1008421464	0			8.15766	0.58943
18	16	140124	1008461960	0			5.54986	0.702483
19	17	140124	1008477500	0			10.5807	1.23298
20	18	140124	1008524496	0			17.6481	-4.51342
21	19	140124	1008524805	0			9.1962	-3.56662
22	20	140124	1008602059	0			5.71933	2.33776
23	21	140124	1008641940	0			12.637	0.605848
24	22	140124	1008666475	0			21.0644	-3.05143
25	23	140124	1008667143	0			8.9901	2.28989
26	24	140124	1008699102	0			6.13549	0.376432

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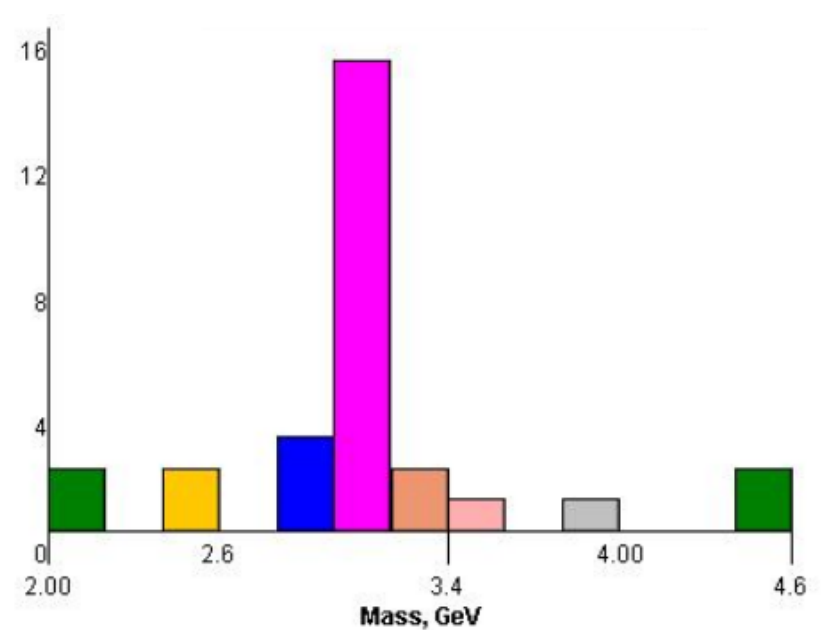International Masterclasses

CMS J/Ψ Investigation Results

Masterclass Institute: **Spearfish**
Experiment: **CMS**

Mass plot: *2's and 3's*   Mass plot: *3's only*

Spearfish J/Psi March 16


Mass, GeV

"Hands on Particle Physics"
International Masterclasses

Observations

- High satisfaction reported by mentors
- Good stuff:
  - Excitement about real LHC data
  - Enthusiasm over event display
  - Realistic data analysis
  - Students discuss like physicists.
  - Simulates physicist decisions on cuts, triggering, etc.
- Room to improve:
  - Richness of data in LEP missed by some physicists and teachers (but the students were fine)
  - DVD version not quite as versatile as online version
  - Combination of results not smooth

Shizuoka
18 March 2011

"Hands on Particle Physics"
International Masterclasses
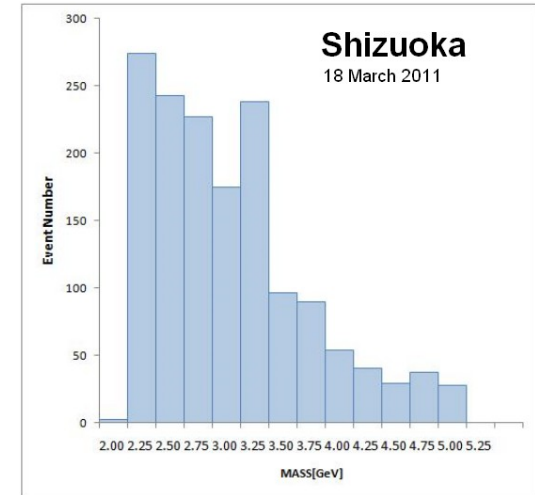
Ideas for Development

- Data
  - Adding dielectron data
  - Not difficult to expand to upsilon
  - Seek to design W/Z exercise with data promised by CMS.
  - Rollout by autumn 2011?

- Event display refinements
  - Show invariant mass calculation.
  - Select track and display data.
  - DVD version: data grouping
  - Link to analysis tools.
  - Learn from best features of HYPATIA and MINERVA but keep iSpy-online functionality.

"Hands on Particle Physics"
International Masterclasses
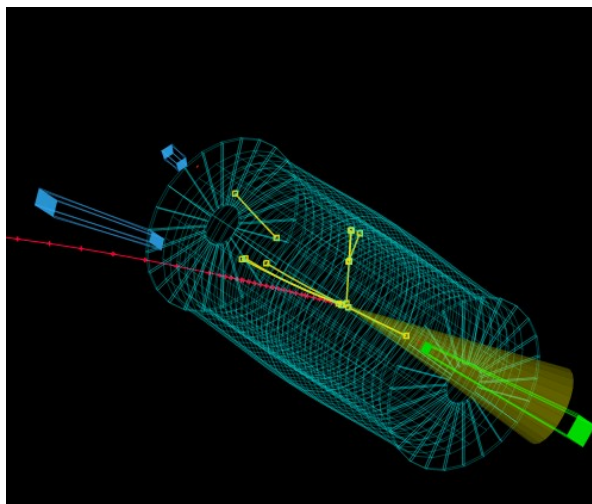
Ideas for Development

COS'E' UNA MASTERCLASS?
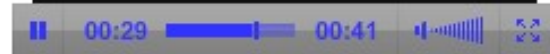
Laura Akesson, Mills Godwin High School (in inglese)

Hephy Vienna

- Combination of results
  - Alt 1: Google forms, histogram
  - Alt 2: Use e-Lab tools.
  - Alt 3: …
  - Website use
  - Make investigation flow from student analysis to group discussion to videoconference.
- Website
  - More languages (which?)
  - Translate and/or create videos.
  - More investigations
  - Interactive with data analysis
  - Work out glitches.

"Hands on Particle Physics"
International Masterclasses

Collaborators

- Mihael Hategan (UC Davis)
- Phong Nguyen (FNAL)
- Marge Bardeen (FNAL)
- Liz Quigg (FNAL)
- Tom McCauley (FNAL)
- Don Lincoln (FNAL)
- George Alverson (NEU)
- Hector Mendez (UPRM)
- Laurenz Widhalm (HEPHY)
- Pierre Van Hove (IN2P3)
- Catia Peduto (INFN)

- Daniela Bortoleto (Purdue)
- Fabrizio Margaroli (Purdue)
- Taku Nakamura (Shizuoka-kita HS)
- Mike Fetsko (Godwin HS)
- Laura Akesson (Godwin HS)
- Dave Trapp (Sequim Science)
- Mike Wadness (Medford HS)
- Shane Wood (Irondale HS)
- Kevin Lannon (ND)
- Jamie Antonelli (ND)
- Tom Loughran (ND)
- Dan Karmgard (ND)

. . . and others!

"Hands on Particle Physics"
International Masterclasses