

INTERNATIONAL MASTERCLASSES HANDS ON PARTICLE PHYSICS

Uta Bilow, TU Dresden
Ken Cecire, Notre Dame

10th IPPOG meeting, CERN
05.11.2015



What is a Masterclass?



Countries in IMC



Possible candidates

- Mozambique
- Madeira
- Russia
- India
- Venezuela
- Bangladesh
- Mongolia
- Korea
- Albania

What is a Masterclass like? What do students do?



News from W-Path

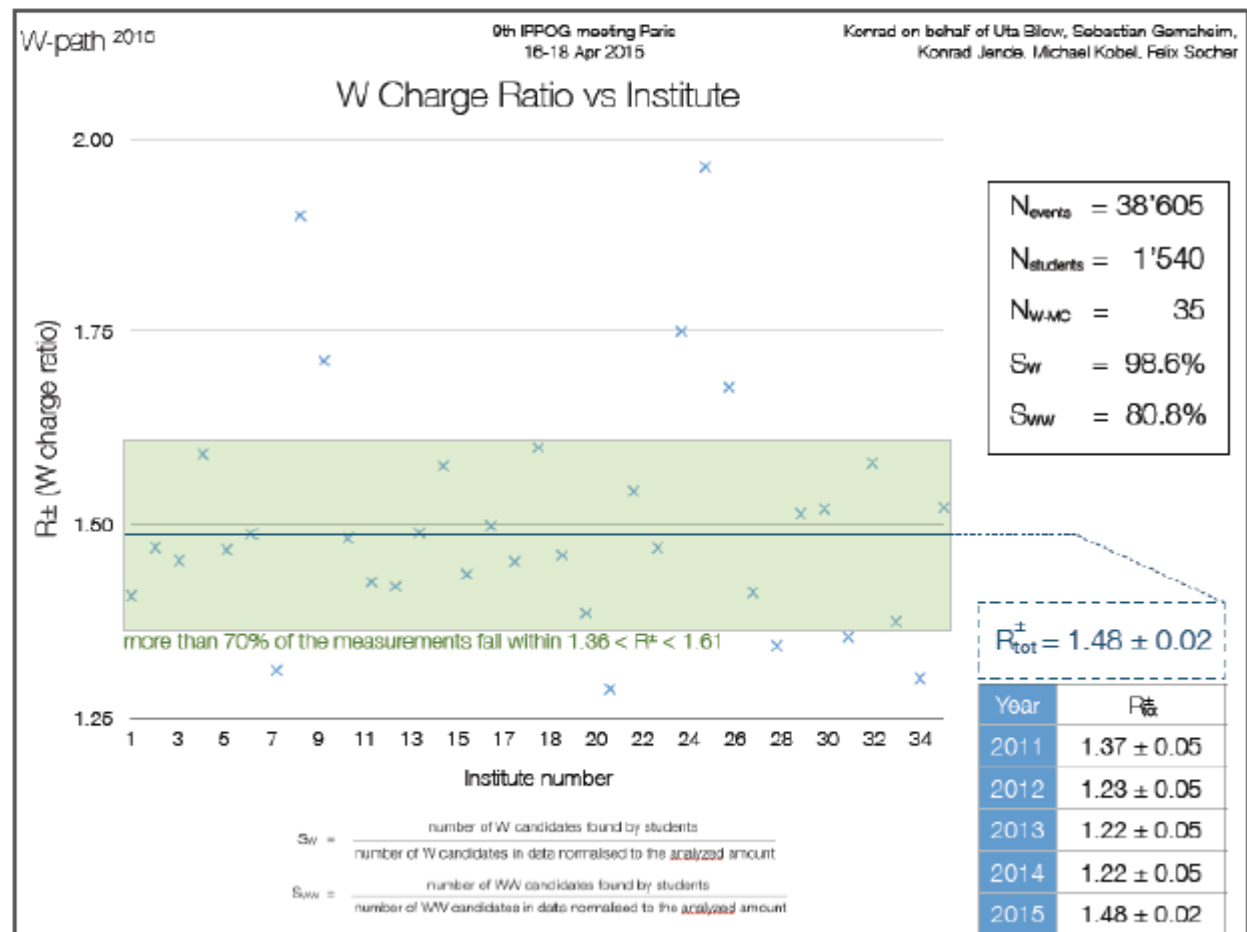
- W-path had a major update last year:
 - more events (then 6000 now 12000 data events)
 - overhauled selection, better comprehensible information
 - we used the year to test the outcome

- Result:

- more consistent results
- more satisfactory for students

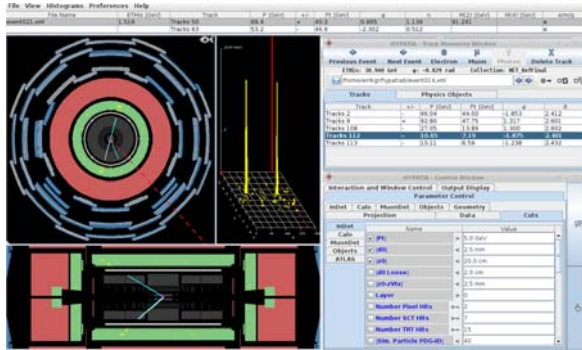
- Future Plans:

- better web-hosting for W-path files
- only minor improvements foreseen for this year



ATLAS Z path <http://atlas.physicsmasterclasses.org/en/zpath.htm> 2015 Zpath

1) Identify events: ll , $4l$, $\gamma\gamma$



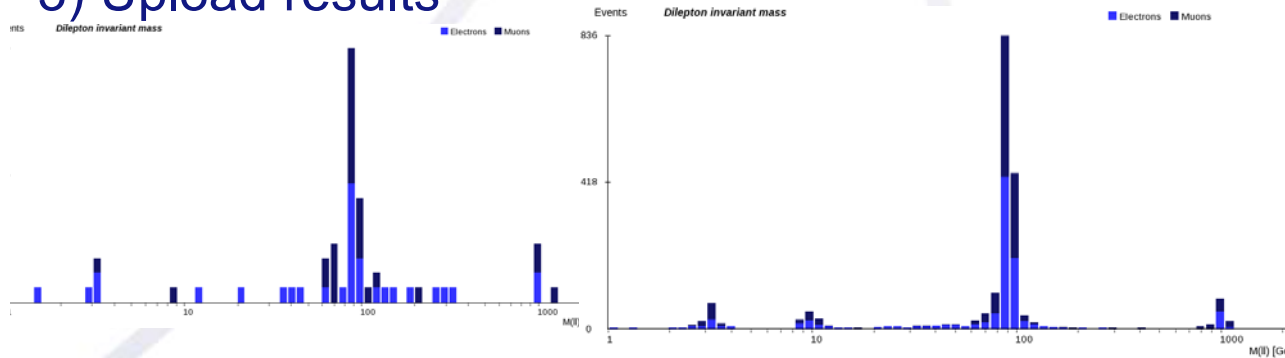
2) Calculate invariant mass

4) Combine results, discuss, interpret

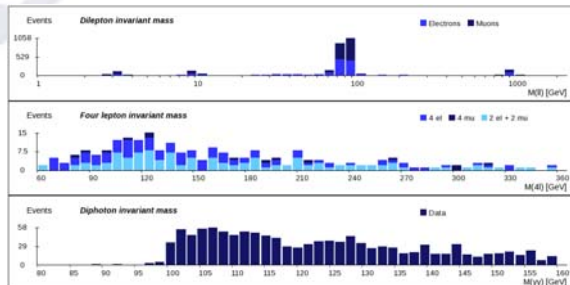
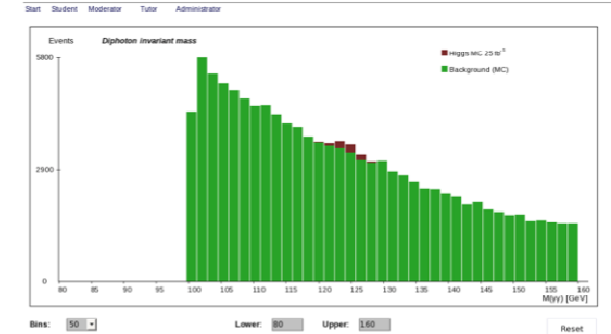
3) Upload results

Z-path world wide

- 86 different institutes, in total 100 Z-path events
- in 24 countries
- on 5 different continents
- distributed on 19 days (between February 25th and April 1st)



OPlot - MasterClass - Combination for all institutes on 2013-03-15



$ll \rightarrow$ Measure mass and width of known particles: $Z^0, J/\psi, Y$

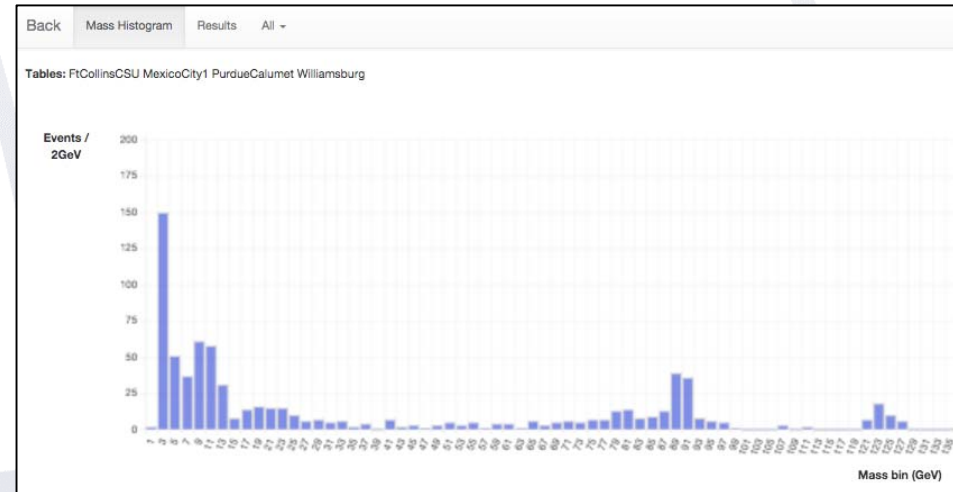
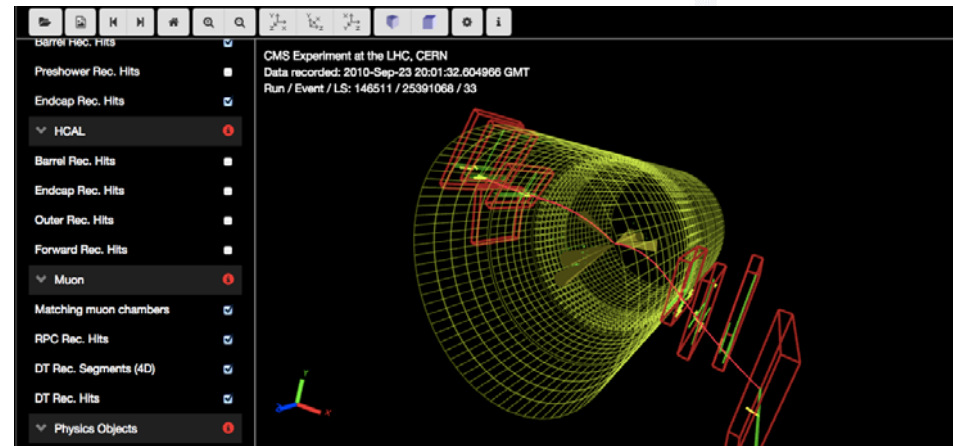
\rightarrow Search for new force / new gauge boson – Z'

$4l, \gamma\gamma \rightarrow$ Provide insight into the process of discovering the Higgs at CERN

\rightarrow Explain concepts of statistics, modeling, signal significance

CMS WZH measurement

- Students characterize W, Z, and Higgs candidates
- Create mass plot of standard model particles that decay into 2 leptons, plus Higgs
- Ratios W^+/W^- , e/μ
- 3000 events – with misfits, surprises, interpretation
- New: WebGL event display
- Website adding 12th language for 2016

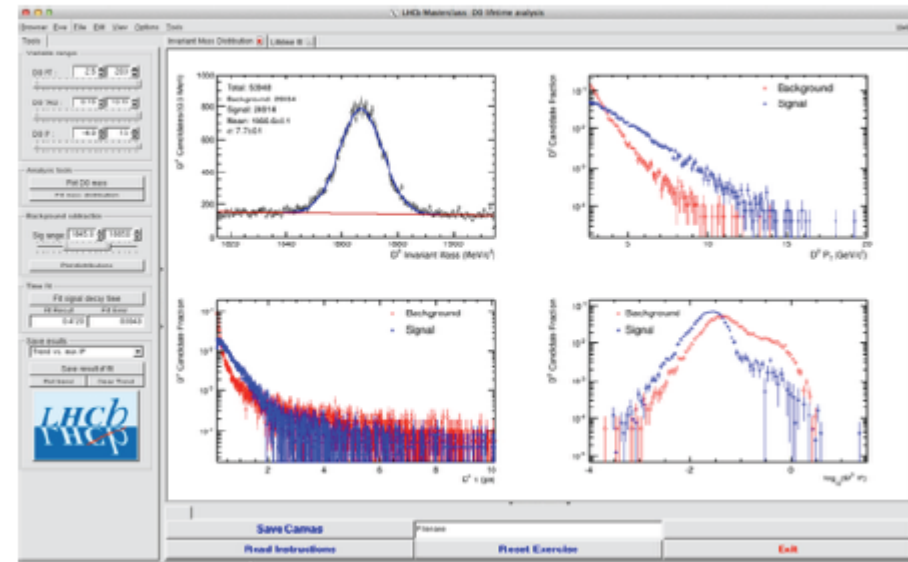
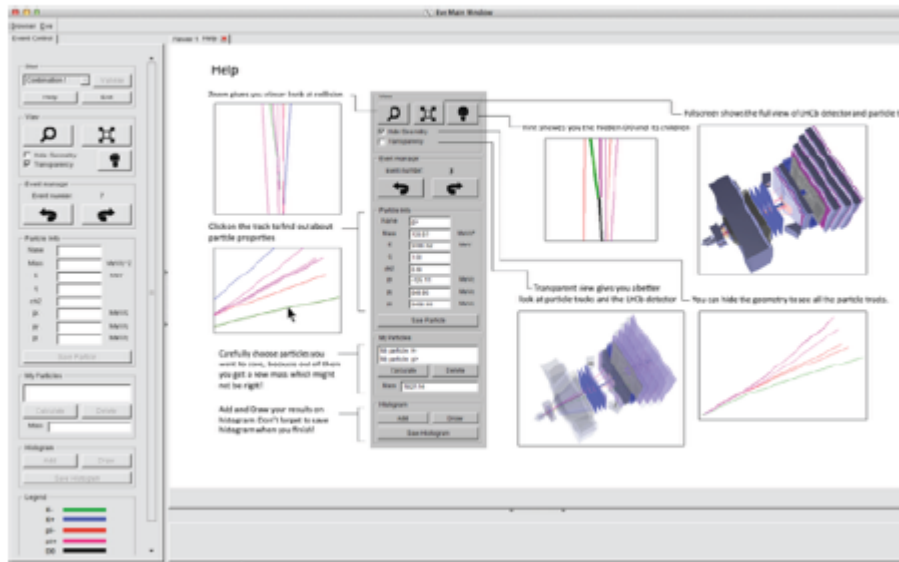




- LHCb experience has > 20 institutes involved, EU and US for 2015/2016.

- The experience is twofold:
 - The students search for the $D^0 \rightarrow K\pi$ decay using an event display.
 - The students also perform a lifetime measurement at the 1% level.

Seicento ragazzi con Masterclass



ALICE : Looking for strange particles

Search for **strange particles** from their **V0-decays**
Visual identification of V0s from their decay pattern
Invariant mass calculation

First part : visual analysis of ~ 15 events per group
Merging of results

Second part:

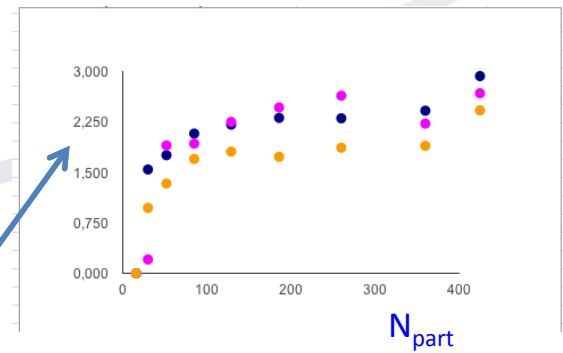
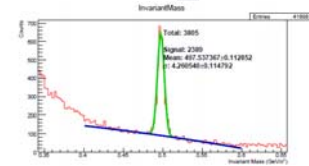
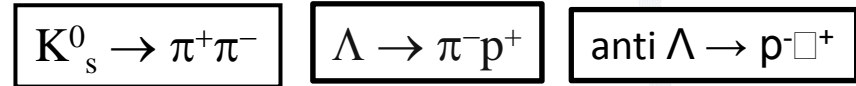
Calculation of numbers of Ks, Λ , anti Λ from invariant mass distributions (fit gaussian/polynomial to peak/background; subtract background) for **different centrality regions** in lead-lead collisions

Concepts conveyed : **invariant mass; centrality of PbPb collisions; background**

results : **observe strangeness enhancement in Pb-Pb collisions comparing with pp collisions**

Use ROOT-based simplified ALICE event display

Strangeness enhancement: the particle yield normalised by the number of participating nucleons in the collision N_{part} , and divided by the yield in proton-proton collisions



ALICE: nuclear modification factor

- ALICE: heavy-ion experiment at the LHC

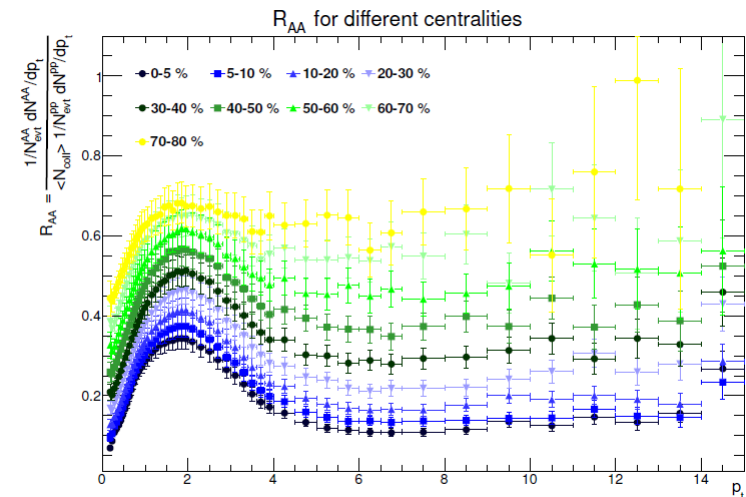
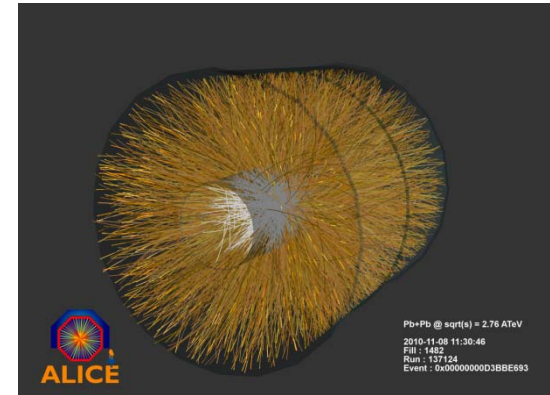
- study properties of deconfined matter: the Quark-Gluon Plasma
- Pb-Pb collision \neq independent pp collisions

- nuclear modification factor $R_{AA} = \frac{yield(Pb-Pb)}{\langle N_{coll} \rangle yield(pp)}$

- ratio of transverse-momentum distributions of charged particles in Pb-Pb and pp collisions, taking into account the collision geometry
- $R_{AA} < 1$ implies jet suppression in the QGP

- students' measurement

- necessary concepts: measurement of
 - charged particle momentum
 - collision centrality
- event-display based visual analysis
 - R_{AA} simply via counting of tracks
- ROOT based large scale analysis
 - R_{AA} as a function of momentum in various Pb-Pb centrality classes
 - students discover jet suppression!



Status

- 11.2. – 23.3.2016
- Registration started 22.10.2015
- Signed up so far (numbers from 2015):
 - ATLAS W: 30 (37)
 - ATLAS Z: 81 (84)
 - CMS WZH: 42 (46) ◆ CERN videoconference
 - LHCb: 30 (28) ◆ Fermilab videoconference
 - ALICE: 14 (18)
 - CMS WZH: 13 (28)
 - ATLAS Z: 0 (14)
- Uta → Ken/QuarkNet/ND in Oct

What do Masterclass moderators do?

Video conference International Masterclasses with moderators Julia and Kate

Analysis

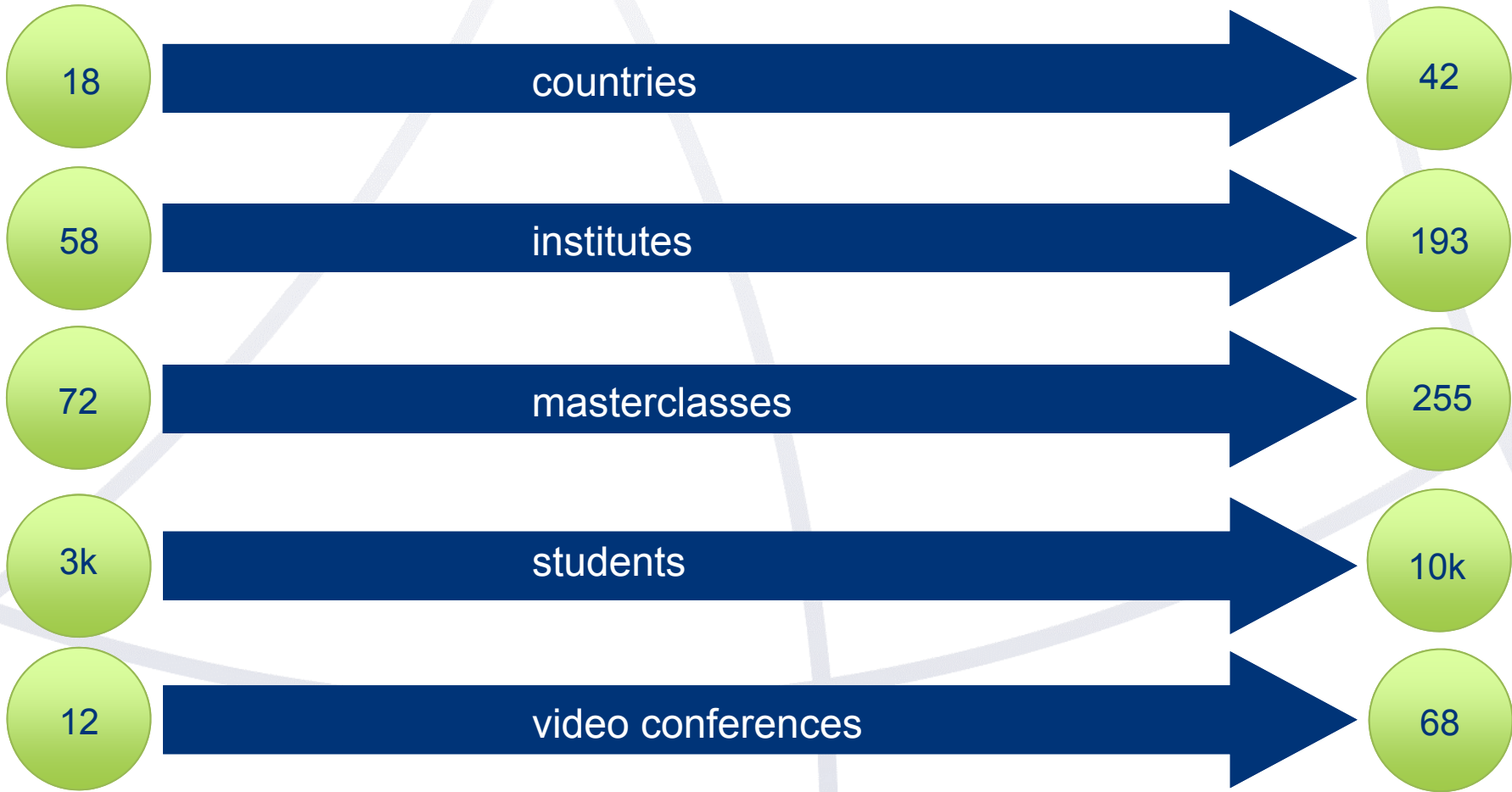
| Total # | W → ... + ν | | | | Background | WW |
|---------------------------|----------------|----------------|----------------|----------------|-----------------|------------|
| | e ⁺ | e ⁻ | μ ⁺ | μ ⁻ | | |
| Hraga | 89 | 51 | 60 | 38 | 740 | 41 |
| Erlangen | 58 | 56 | 75 | 55 | 525 | 34 |
| Presov | 109 | 97 | 109 | 89 | 531 | 79 |
| Strasbourg2 | 31 | 22 | 25 | 27 | 306 | 24 |
| Total | 287 | 226 | 269 | 209 | 2102 | 178 |
| $\Sigma W^+ / \Sigma W^-$ | $ W^+ $ | 556 | $ W^- $ | 435 | $ W^+ + W^- $ | 991 |
| Ratio | $ W^+ / W^- $ | | 1.28 | | ± | 0.08 |

Comparison with results of the ATLAS collaboration (from 2011):
 Measurement of the W → lν and Z(lνν) → ll production cross sections in proton-proton collisions at sqrt(s) = 7 TeV
 with the ATLAS detector*) and Search for the Standard Model Higgs boson in the H → WW(lν) → lνν decay

Topics:
 Aims/Tasks
 Identifying pa
 Identifying Pa
 Measurement
 Analysis
 For modera
 Supporting

History and Statistics

2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015



What is a Masterclass like? Is it difficult?



Report from SG meeting

- Social media
 - IMC twitter account – will open on Fri evening – follow us!
 - Adam Davis (Quantum Diaries) will cover IMC this year
 - Other initiatives?
- New countries
 - WG will meet today
 - Initiatives with International Schools and IB
 - African School of Fundamental Physics
- World Particle Day
 - If we do this, Oct or Nov 2016
- TOTEM Masterclass
 - Start small in 2016

How much Masterclass is enough?



05.11.2015

10th IPPOG meeting, CERN



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How much Masterclass is enough?

- We have so far failed to find an upper limit.

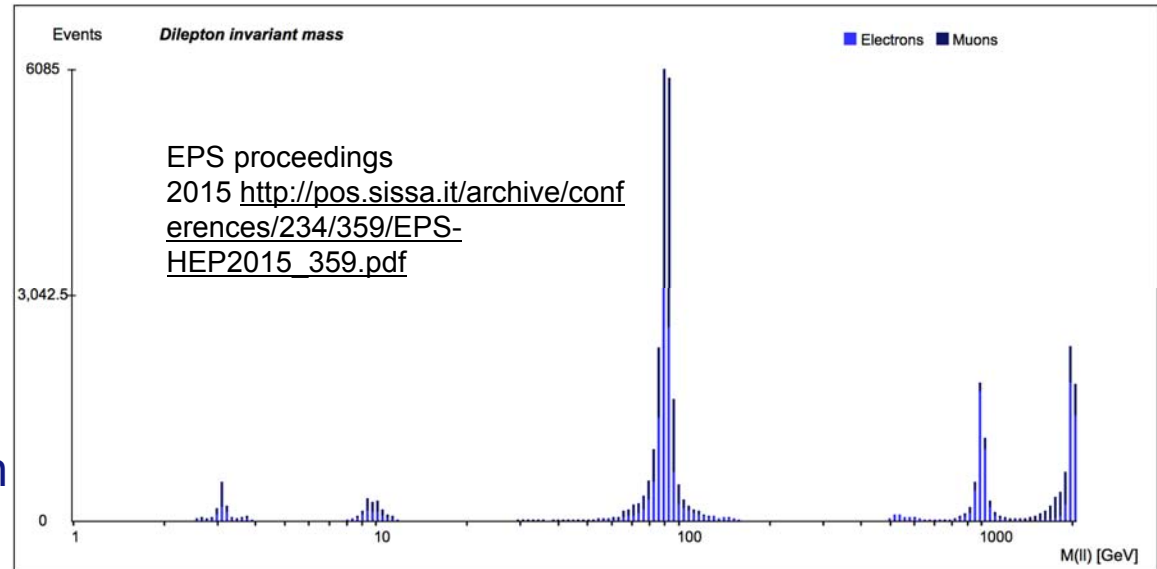


Back-up slide

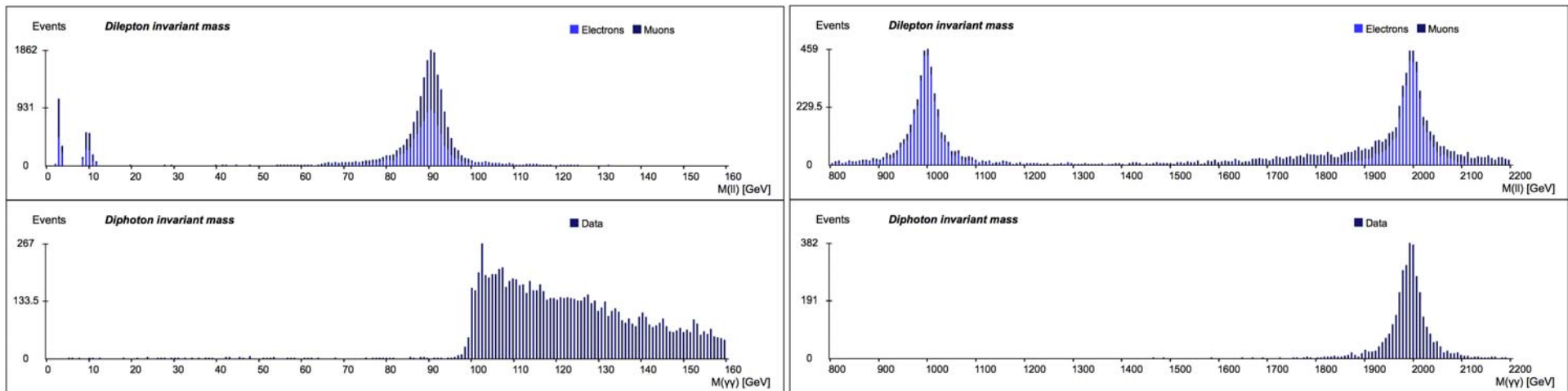
Zpath Near future

New features – implemented!

- Batch analysis after display of 50 events
- Graviton \rightarrow $\ell\ell$, $ZZ/4\ell$, $\gamma\gamma$
- Dark Matter, Supersymmetry with missing transverse energy and leptons
- And whatever to be discovered at LHC



Invariant mass of di-leptons. In addition to the bumps shown in Figure (J/ψ , Y , Z and Z') a graviton resonance is added at 2 TeV, as well as a Supersymmetry contribution just below the Z mass.



The invariant mass distribution for di-leptons (top, shown in Figure) features the real data (J/ψ , Y and Z) (left), a simulated 1 TeV Z' and a simulated 2 TeV graviton resonance (right). The di-photon distribution (bottom) shows no Z , but the Higgs data (left, a 100 GeV selection cut was applied). A 2 TeV graviton is visible, but no Z' at 1 TeV as the Z' (and Z) cannot decay into di-photons (right).