

Education and Outreach Activities in Norway

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The R-ECFA Visit to Norway

October 2, 2015

Outline

- why?
- the International Masterclasses - particle physics to high school students
- beyond masterclasses - more particle physics to high school and university students
- ATLAS@Home
- visiting and exchanging with CERN
- outreach activities, popular science articles and material



Why Outreach?

- explaining and reaching out your field of research is a critical necessity for everyone to engage in
- essential for continued support from
 - decision makers (i.e politicians and funding agencies)
 - young students
 - the young students of today are the potential researchers of tomorrow
 - broad public
 - the tax payer deserve to know where their money goes

The International Masterclasses (IMC)

- the International Masterclasses is a particle physics outreach program run by the International Particle Physics Outreach Group (IPPOG)
- F.Ould-Saada member of the IMC Steering Committee
- aim is to provide an opportunity for 15- to 19-year old school students to discover particle physics through hands-on measurements with **real** LHC data
- several measurements from the various LHC experiments are available:
 - W -path } ATLAS
 - Z -path } ATLAS
 - W, Z, H measurements } CMS
 - J/ψ measurements } CMS
 - Looking for strange particles } ALICE
 - The Nuclear Suppression Factor } ALICE
 - Measuring the D^0 lifetime } LHCb



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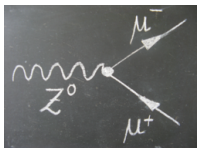
⇒ Z -path has been developed in Oslo



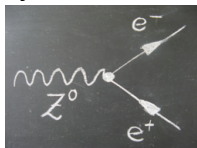
The Z-path[†]

- high-school students spend one full day at their local university
 - ① lectures covering introduction to particle physics theory and experiments
 - ② practical measurements at computer labs
 - ③ discussion of results and video conference with CERN and other participating institutes
- the Z-path introduces the invariant mass technique and explains how one can learn about short lived particles by studying their decay products
- focus on the following particles and their decays:

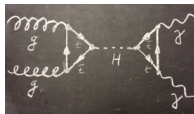
Z-decays



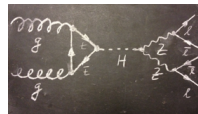
di-lepton



Higgs decays



di-photon



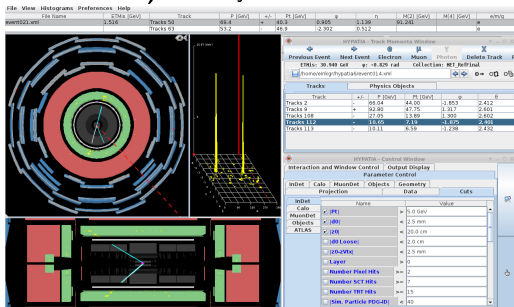
four-lepton

some “surprises” are also included to show the strength of the invariant mass technique for distinguishing different particles and discover new ones.

[†] M. Pedersen, F. Ould-Saada, E.G. M. Bugge, V. Morisbak, <http://atlas.physicsmasterclasses.org/en/zpath.htm>

The Z-path

1) Identify events

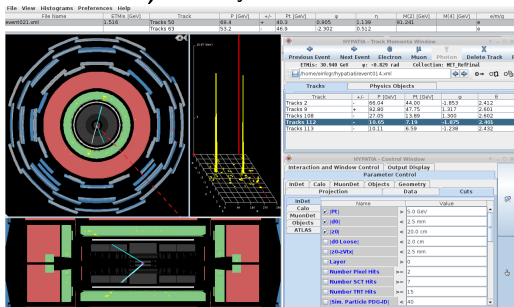


2) Calculate invariant mass

94.16460730838116 m
1212.603027475931 m
100.33432042478175 g
944.1019598663026 m
120.88966037775438 4me
88.23451507198037 m
21.23697880757043 e
64.92651268101835 m
130.1915607084978 g
90.93023501521859 m
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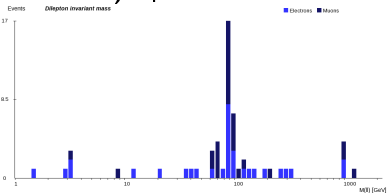
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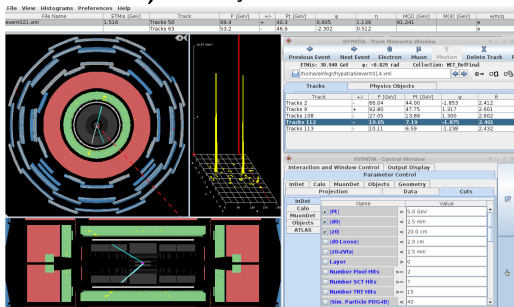
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3) Upload results



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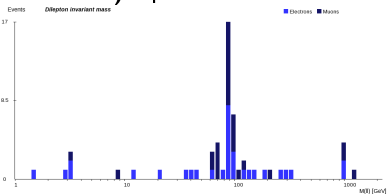
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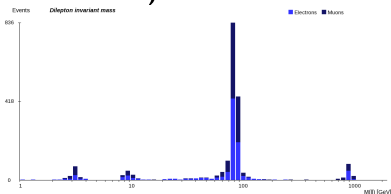
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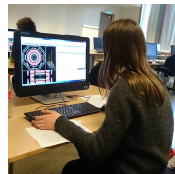
4) Combine



The Z-path - numbers in 2015

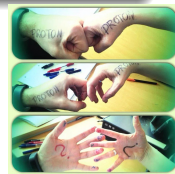
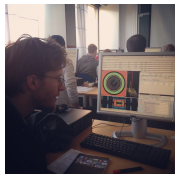
Z-path world wide

- 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)



Z-path in Norway

- ~ 400 students
- from 23 high schools
- in 9 different municipalities
- distributed on 2 days

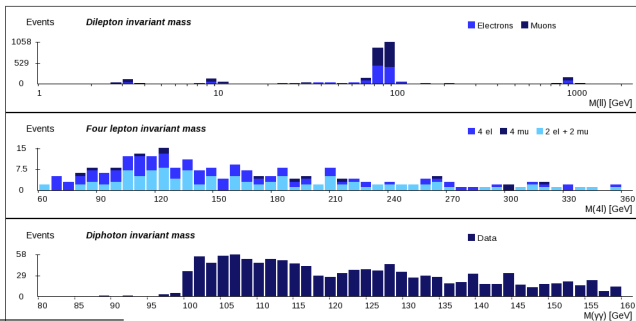


The OsloPlottingTool (OPloT)

- OPloT[†] is an interface used for studying and combining the results
- each pair of students analyze at least 50 unique collision events and upload their results to OPloT
- results are easily combined with
 - all students at the each institute
 - all students at all the participating institutes (final results)
- final results discussed in video conference with CERN

result from IMC
March 3rd 2015 with

- Oslo (NO)
- DESY (DE)
- Vyskov (CZ)
- Siegen (DE)
- Amsterdam (NL)



[†]<http://cernmasterclass.uio.no/OPloT/index.php>

More advanced tools - beyond IMC^{††}

- LHC collision data used for Z-path is available in CERN Data Portal as
 - XML-files - readable by event display programs (HYPATIA[†]) and by batch analysis code (e.g. `python`)
 - ROOT mini NTuples - readable in ROOT (`python`, `C++`)
- plan is to make 10% of the 2012 8 TeV data available
 - with single lepton skim (≥ 1 tight lepton with $p_T > 25$ GeV), GoodRunList and Trigger applied
- extend also to MC samples with simulation of
 - Standard Model backgrounds
 - Gravitons decaying into di-leptons, di-photon and di-weak bosons
 - heavy gauge bosons (Z') decaying into leptons
 - supersymmetry with missing transverse energy and leptons
- note under construction: <https://cds.cern.ch/record/2034188>

[†]<http://hypatia.phys.uoa.gr/>

^{††}F.Ould-Saada, E.G. M.Bugge

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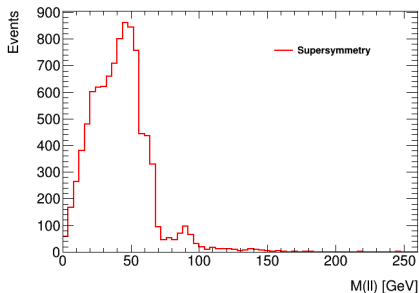
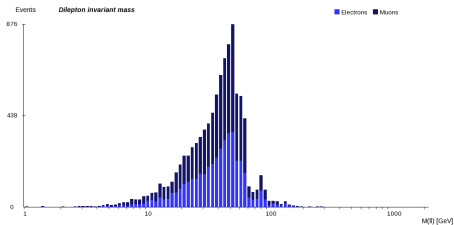
⇒ only defining a few variables (missing transverse energy, invariant mass)
students can look for many new-physics scenarios

[†]<http://hypatia.phys.uoa.gr/>

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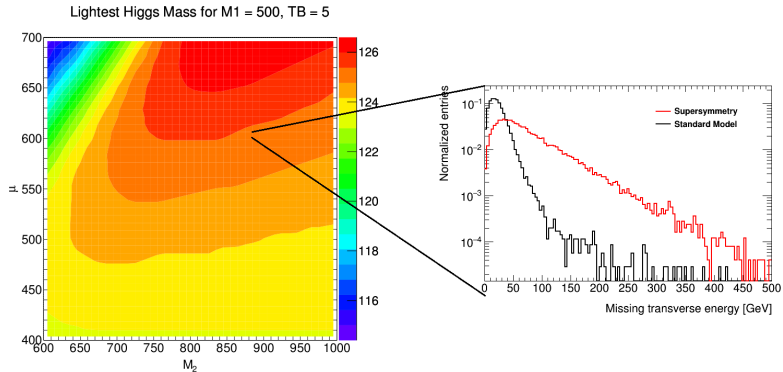
- getting ready for bringing new discoveries to the class room
 - di-lepton invariant mass edge in a simulated SUSY scenario
- distributions obtained from XML files and directly analyzed in OPlOT (left) or ROOT (right)



- Z-path is introduced in two courses, FYS3510 (Subatomic Physics) and FYS4560 (Advanced Particle Physics) at UiO
 - adds the feeling of working with fresh, real data
 - larger statistics allow beautiful *textbook* hands-on activities

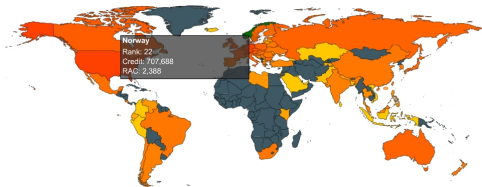
More advanced tools - beyond IMC

- student doing a 3-month project as part of the bachelor course Research project I at UiO[†]
- Topic: Search optimization with ATLAS and sharing discoveries with students
- using IMC dataset comparing with some carefully chosen SUSY scenarios
- done using event-display formats and python scripts



[†]Alex Cameron (Supervisors: F.Ould-Saada, E.G); *Supersymmetry at the Large Hadron Collider - Search optimisation and simulated $\tilde{\chi}_2^0 \tilde{\chi}_1^\pm$ production events in the ATLAS detector*

- volunteer computing: people all over the world offer their PCs to scientific communities for computation
- ATLAS@Home: ATLAS simulation jobs are running on personal computers world wide
- not only about getting free computing resources, but also getting the public involved in ATLAS
 - volunteers want to know more about the project they're participating in
- D.Cameron (UiO) is a key responsible for ATLAS@Home
 - based on ARC Control Tower (see Jon Nilsen's talk)



<https://atlasphysathome.web.cern.ch/>

Visits to CERN

- yearly visits to CERN for students at the Subatomic Physics and Advanced Particle Physics courses at UiO



- Norwegian mini-winter school at CERN for bachelor students in physics at UiB and UiO (<http://indico.cern.ch/event/342304/>)
- visits span typically over ~ 3 -4 days and covers a huge variety of topics
 - particle and nuclear physics, Higgs, Heavy ions, accelerators, antimatter, CERN, detectors, GRID computing etc.
 - included visits to ATLAS, CLIC, Linac, LHC Control Room, ALICE, AMS, Compass, ISOLDE, AEGIS etc.
- ~ 20 -25 participants
- several Norwegian CERN guides take care of Norwegian high school students visiting CERN

Exchanging with CERN

- Bergen University College (HiB)[†] sends many students to the Technical Student Programme at CERN
 - a practical training period or a place to complete your final project in applied physics, engineering or computing
 - spend 4-12 months at CERN during Bachelor or Master studies



Anders Mikkelsen at CERN

- Institutt for Data og Realfag at HiB has had an extensive exchange program with CERN over many years
 - based on this success Institutt for Elektrofag at HiB has also started an exchange program
 - 6 participating students (2 female, 4 male) over the past three years

[†]J.Alme and H.Helstrup

Popular Science Articles and Interviews

- a selection of popular science articles and interviews the last ~year
 - scientists within each field are actively reporting on news, updates and discoveries to the public

Topic	Title	Where/WWhen	Who	Link
AEGIS	Faller antimaterie oppover?	<i>Aftenposten</i> , Jan 28 th 2015	H.M.Holmestad	↗
Cherenkov Telescope Array	Jakten paa den mørke materien	<i>Bergens Tidene</i> , March 23 rd 2015	T. Buanes	↗
LHC	Big Bang-maskinen smadrer rekorder	<i>Bergens Tidene</i> , June 14 th 2015	T. Buanes	↗
	CERN: Vilddyret har vaaknet!	<i>Aftenposten</i> , June 4 th 2015	E.Gramstad	↗
	Talking about the start-up of LHC	Ekko NRK P2, May 22 nd 2015	L. Smestad	↗
	Physics of early universe with the atlas at the CERN's Large Hadron Collider	<i>META magazine</i> , January 2014	F.Ould-Saada	↗
CERN	Hallo, noen vaakne paa CERN?	<i>Kollokvium</i> , August 15 th 2014	L. Smestad	↗
	Interview with Fabiola Gianotti	Ekko NRK P2, September 1 st 2014	L. Smestad	↗
	CERN girer opp til ny runde med nye oppdagelser	<i>Forskning.no</i> , March 3 rd 2015	F.Ould-Saada	↗
	Mysteriet Higgs	<i>Bergens Tidene</i> , December 08 th 2013	H.Sandaker, A.Lipniacka, B.Stugu	↗
	Snart kan forskerne finne svar paa gaaten mørk materie	<i>Aftenposten</i> , April 12 th 2015	H.Sandaker	↗
	Finding the subatomic needle in the haystack	<i>Forskning.no</i> , October 2015	F.Ould-Saada	↗

Popular Science Lectures/Material

Title	Where/When	Who	Link
101 pretty interesting things you probably didn't know about the LHC (and CERN)	seminar for UiO students, May 28 th 2015	A. Raklev	-
Symmetry & Physics	lecture at Trondheim Katedralskole, March 17 th 2015	A. Raklev	-
What is the Higgs Boson, and why is it important?	video on youtube	A. Read	↗
Everything you need to know about Higgs in (little more than) five minutes	video on youtube	B. Samset, A. Raklev	↗
Stuff I don't know	lecture on youtube	A. Raklev	↗
REALfrokost (breakfast) with Torstein Bringmann	Realistforeningen, November 25 th	T. Bringman	↗

- the 4th International Conference on New Frontiers in Physics, Crete, 23-30 August 2015[†] has an extensive outreach and education program
 - lectures for students in different fields of physics
 - outreach public lecture in English (this year devoted to the centenary of Einstein's Theory of Relativity)
 - Masterclass presentations within the conference
 - special event devoted to the Year of Light
 - children's Science Exhibition



[†]L. Bravina et al., <https://indico.cern.ch/event/344173/>

- FameLab is a communications competition designed to engage and entertain by breaking down science, technology and engineering concepts into three minute presentations
- 27 countries + CERN participated in 2015
- Lillian Smestad won the “national” final at CERN and was sent to the international final in Cheltenham, UK
 - won a shared second place in the final
 - contribution: *what happens when you fall into a black hole?*[†]



[†]<https://cds.cern.ch/journal/CERNBulletin/2015/24/News%20Articles/2022358?ln=en>

Conclusions

- even though we are all mainly doing research there's a wide variety of education and outreach activities going on in parallel
- outreach and education is important in many perspectives
 - recruiting young people to the field
 - making the public aware of the hot topics in science
 - it's fun



Particle Collision in an outreach context

- sharing the excitement of scientific discoveries with the public is part of our duty as researchers!

BACKUP

Details of the Z-path data set

Event type	Number of events	Fraction in mixture
$Z \rightarrow l^+l^-$	18.500	50%
$J/\Psi \rightarrow l^+l^-$	1.850	5%
$\Upsilon \rightarrow l^+l^-$	1.850	5%
$Z' \rightarrow l^+l^-$	1.850	5%
Four lepton	40 [†]	5%
Two photon	1.850	30%

[†] Replicated many times

Publications on IMC/Z-path

- M. Pedersen, F. Ould-Saada, and M. K. Bugge, Sharing ATLAS data and research with young students, Tech. Rep. ATL-OREACH-PROC-2015-001, CERN, Geneva, Feb, 2015.
<https://cds.cern.ch/record/1984338>
- Bugge, Magnar K., Gramstad, Eirik, Morisbak, Vanja, Ould-Saada, Farid, Pedersen, Maiken, and Raddum, Silje H., ATLAS Masterclasses W and Z path physics and presentation of the Z path measurement, EPJ Web of Conferences 71 (2014) 00024.
<http://dx.doi.org/10.1051/epjconf/20147100024>
- Ould-Saada, Farid et al., LHC Discoveries an particle physics concepts for education, EPS-HEP 2015, Vienna. <https://indico.cern.ch/event/356420/session/7/contribution/523/attachments/1131928/1618157/EPS2015-NewConcepts4Education-V02.pptx>
- Ould-Saada, Farid, Bringing LHC data into the Classroom, PoS ICHEP2012 (2013) 559, Melbourne.
http://inspirehep.net/record/1257275/files/ICHEP2012_559.pdf

More on BOINC

- simulation jobs on BOINC (ATLAS@Home)

