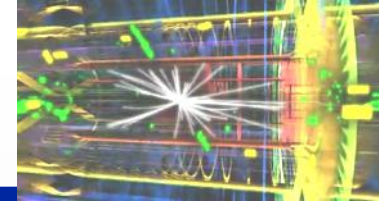
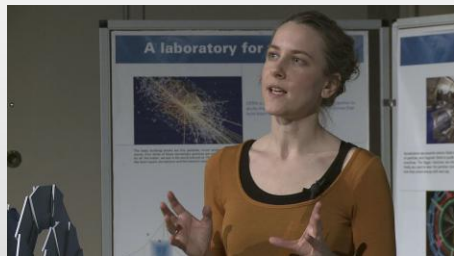


Master Classes 2010 in Norway *From LEP to LHC and from Universities to Science Centers*

**Maiken Pedersen, Eirik Gramstad, Magnar Bugge, Vanja
Morisbak, Farid Ould-Saada**
University of Oslo



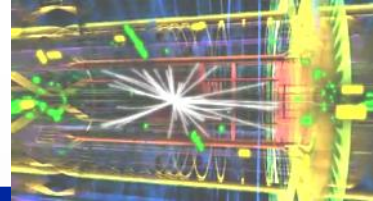
- ⊙ Exercises with LEP data
 - ⊙ Physics day in Bergen ~300 students → MC 120 students
 - ⊙ Oslo: 130 students



<http://www.fys.uio.no/publikum/handsoncern/>

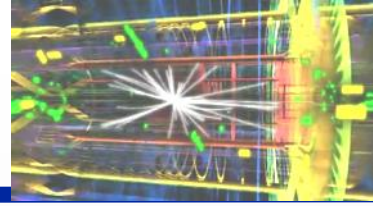


- ⊙ Next Steps
 - ⊙ Real Data from LHC
 - ⊙ Involvement of Science centres

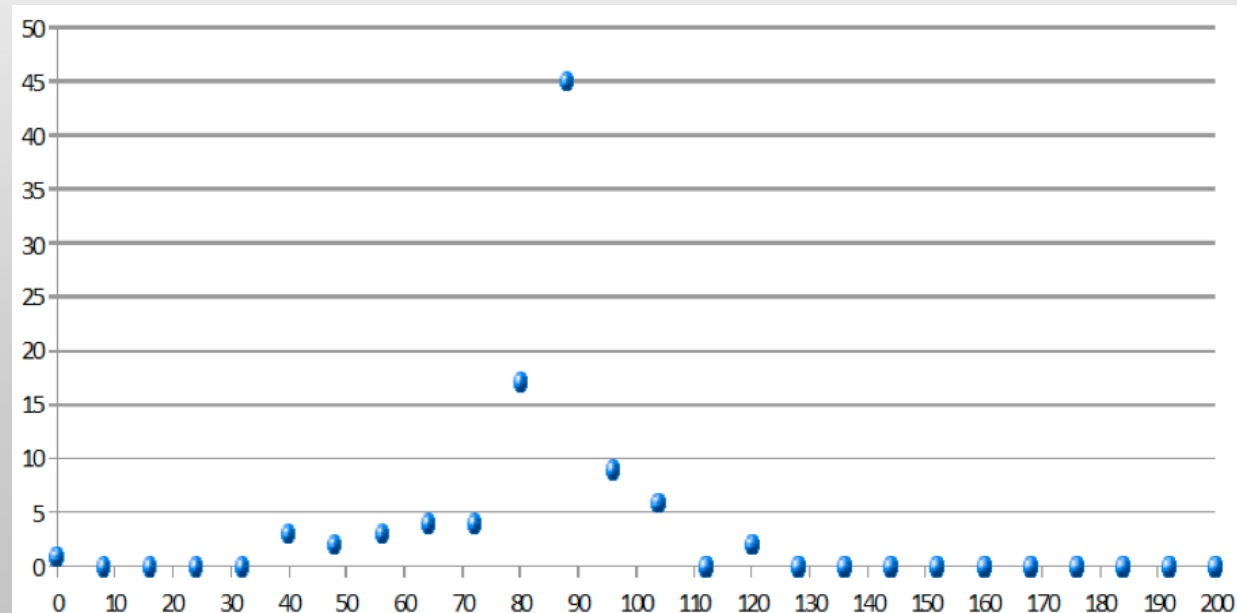


- ◉ Goal
 - ◉ Offer national Master Classes several times a year
 - ◉ Participate in EPPOG MC through Science Centres
 - ◉ From LEP to LHC data
- ◉ Proof of concept
 - ◉ UiO and Technical Museum 28.09.2010
 - ◉ 25 students followed lecture and introduction to invariant mass technique
 - ◉ Practice with ATLANTIS: Z, W, QCD and Higgs MC events (Minerva event catalogue)
 - ◉ **Rediscover Z at LHC!**

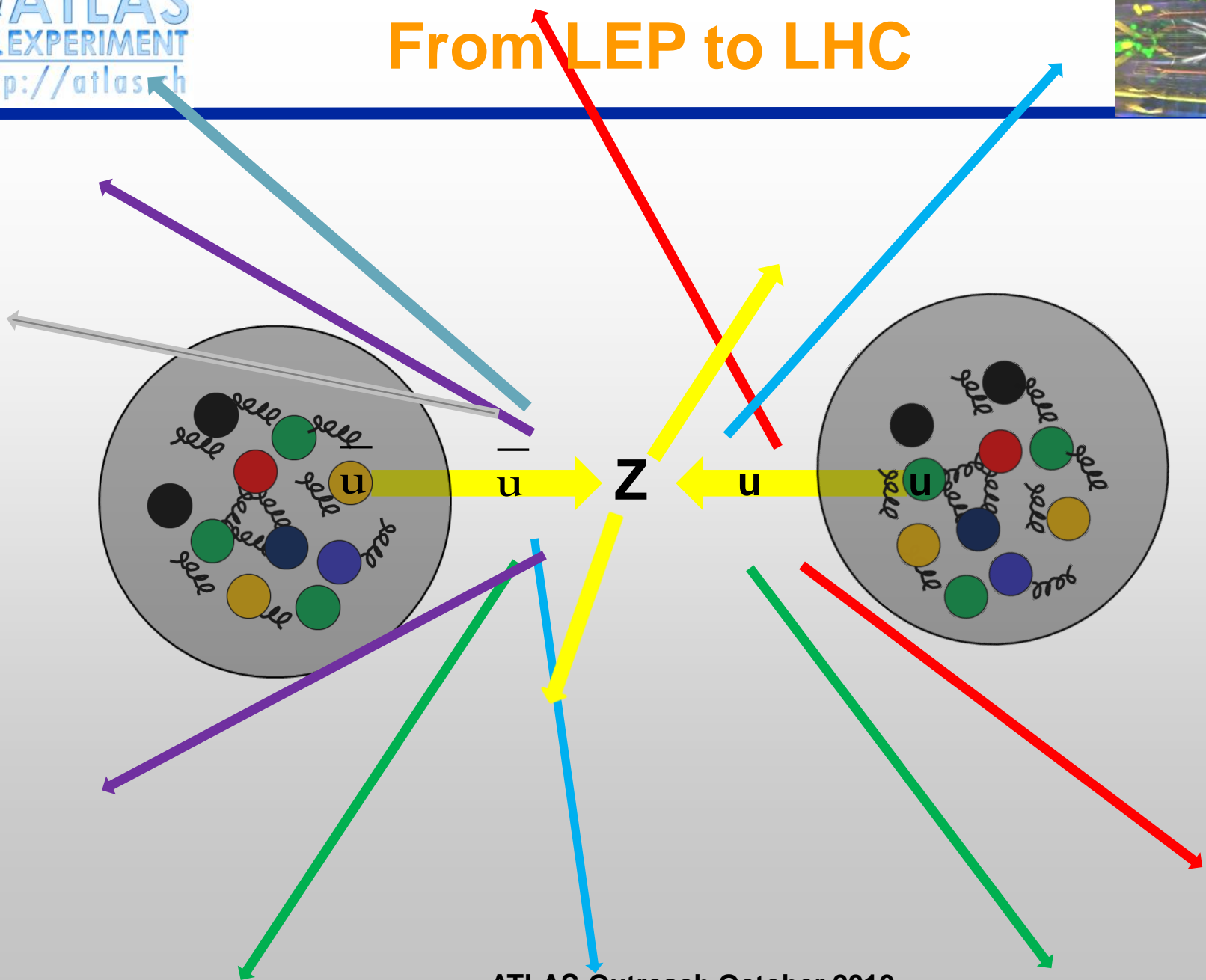
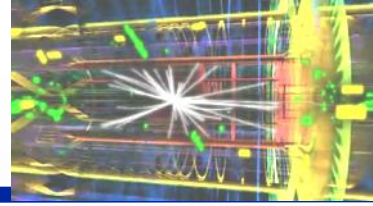




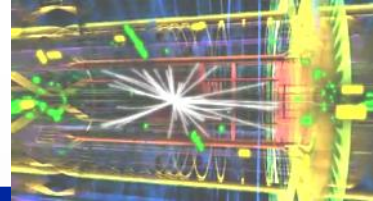
- Feature
 - Real LHC events (ATLAS Z^0 events)
 - Bonus: some 1-TeV Z' -events mixed
- Students scanned through PNG files of Z candidates and used the kinematics of the Z^0 leptonic decay products (provided) to calculate the invariant mass and fill in a histogram
- Students result
 - Z^0 mass $\sim 90\text{GeV}$!
 - This is known!
- Discussion
 - High mass peak (not shown here)?
 - Z' !
 - A way to discover new particles



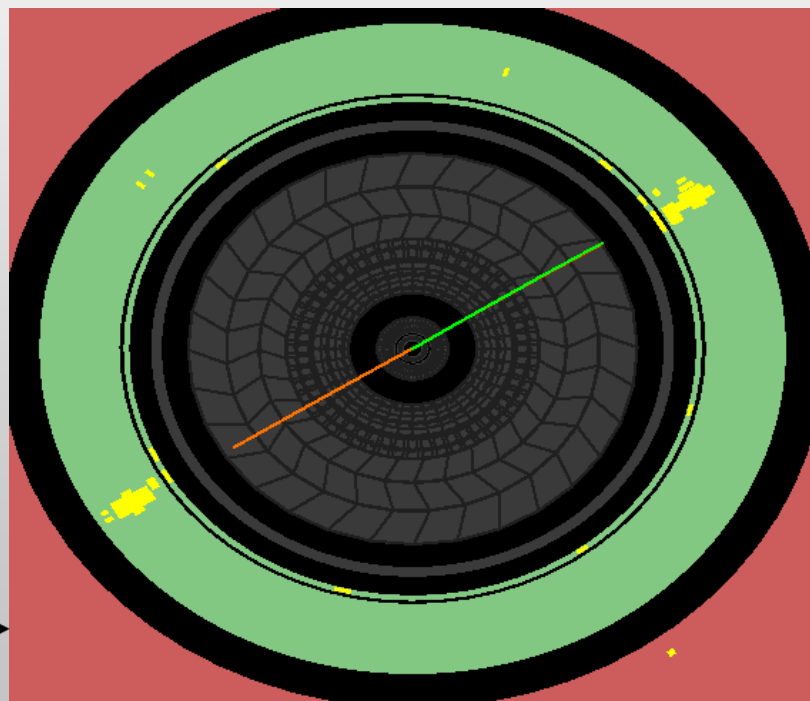
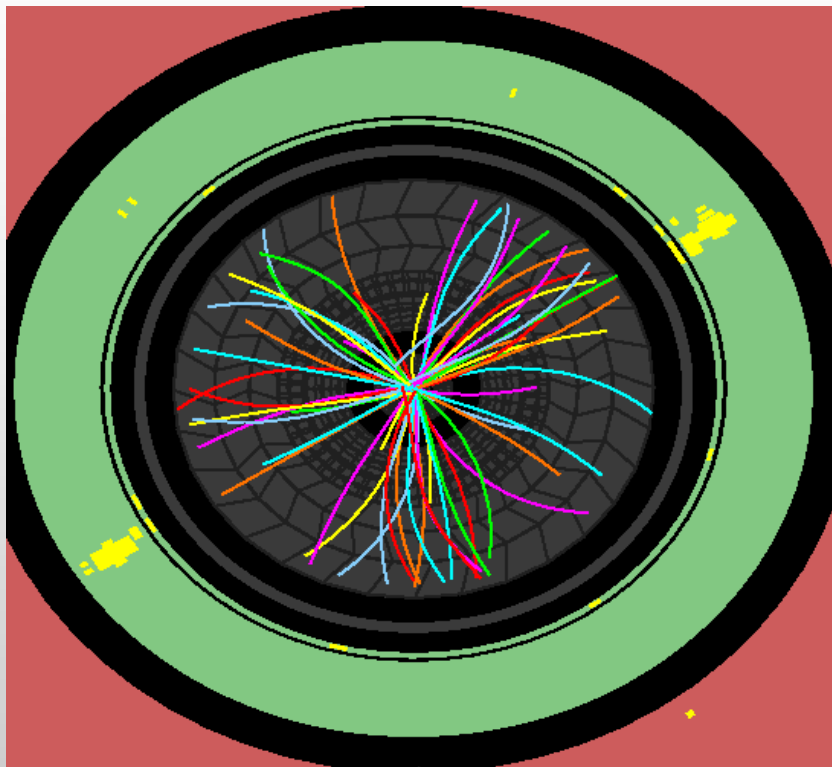
From LEP to LHC



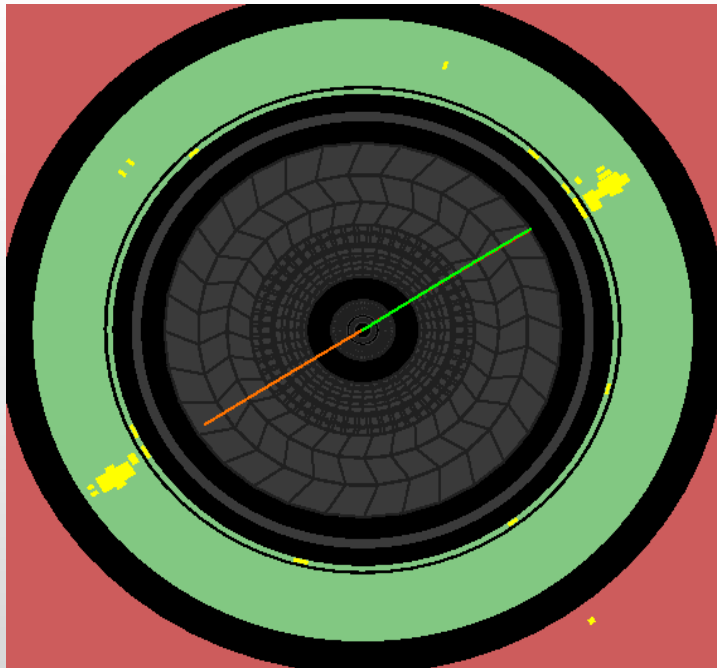
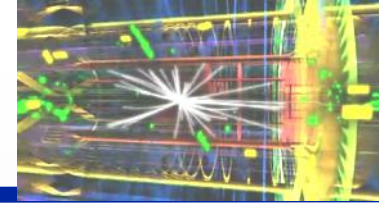
Z⁰ – from LHC to “LEP”



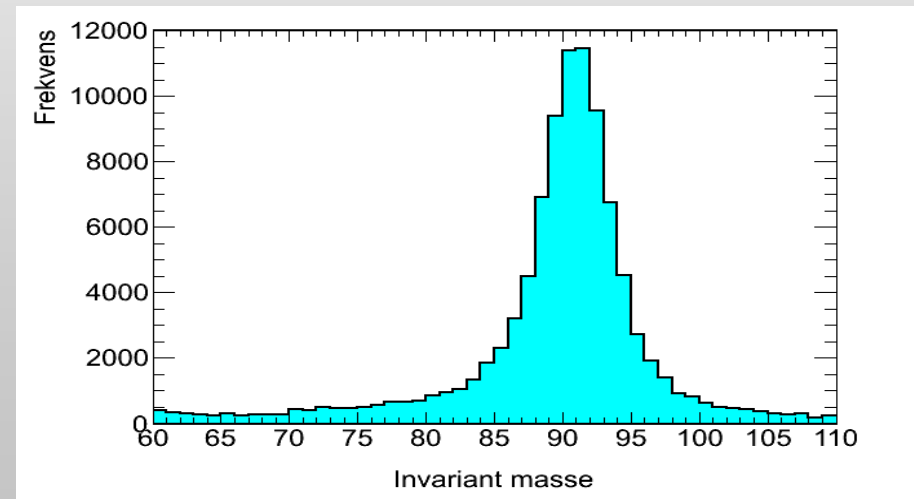
- Study high p_T collisions
 - “Ignore” low p_T particles
 - Identify 2 leptons of opposite charges: e^+e^- or $\mu^+\mu^-$



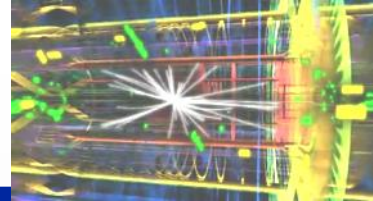
Invariant Mass: Z^0 signal



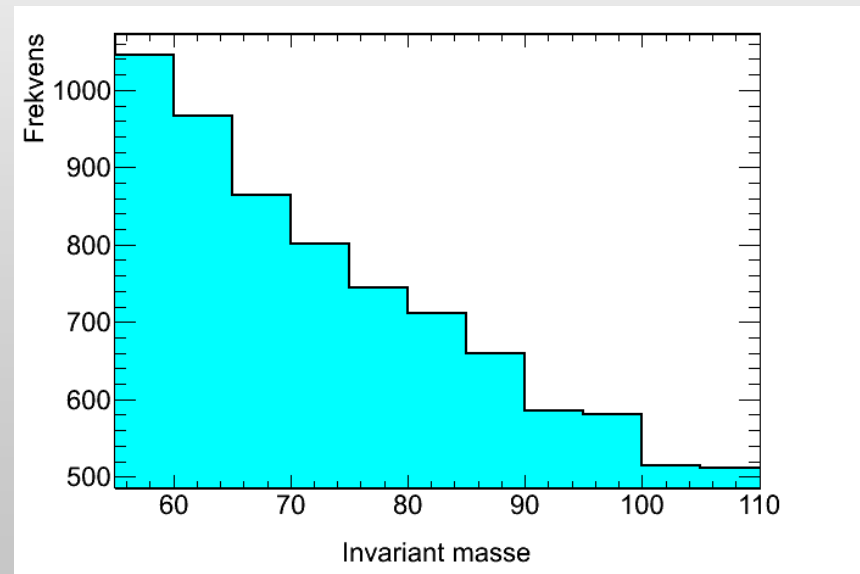
- Calculate invariant mass for combinations of high p_T e^+e^- or $\mu^+\mu^-$
- Fill in histogram
 - Accumulate statistics
 - After many Z^0 candidate events, you should see a signal similar to this:



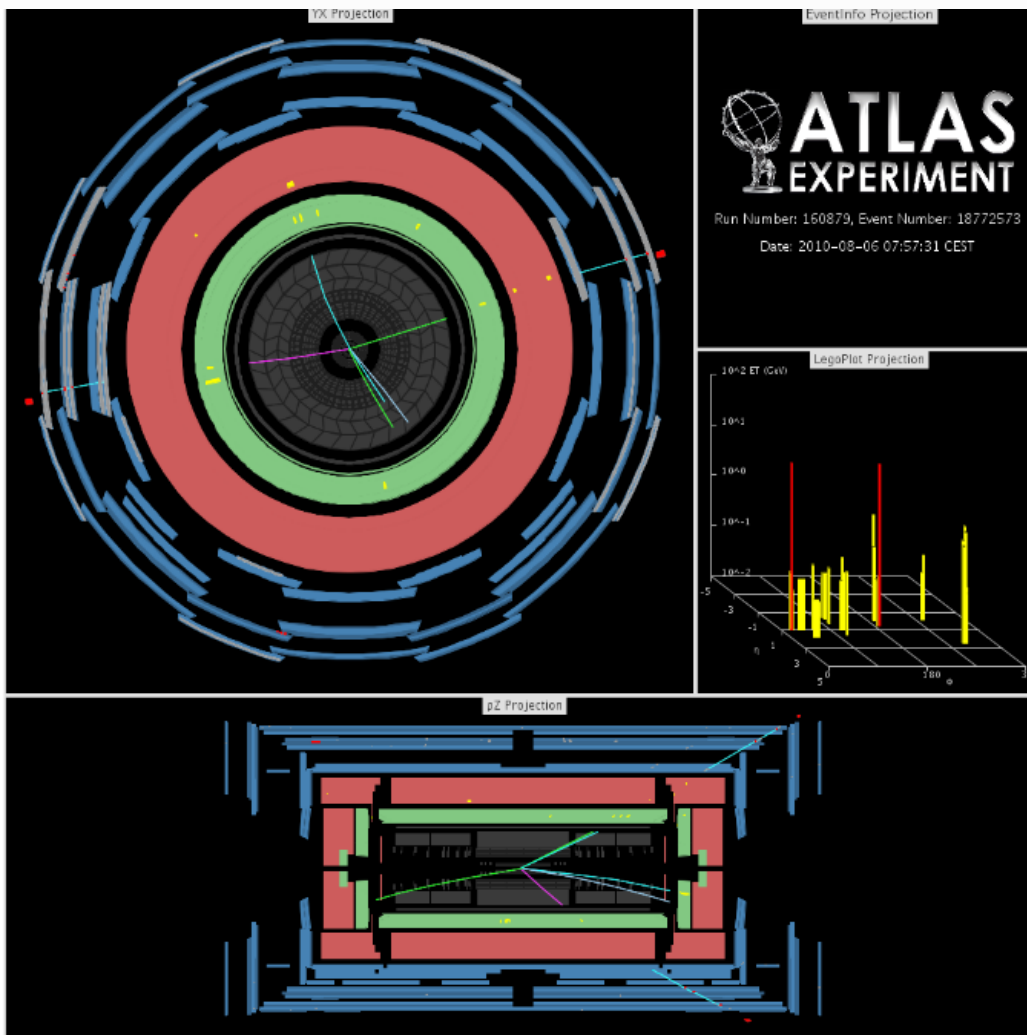
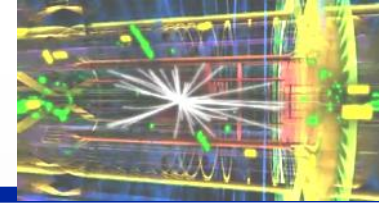
Invariant Mass: “Background”



- Calculate invariant mass of electron and muon combinations
- Fill in histogram
 - Accumulate statistics
 - After many events
- No sign of heavy particle decaying to 2 particles!



Details and links



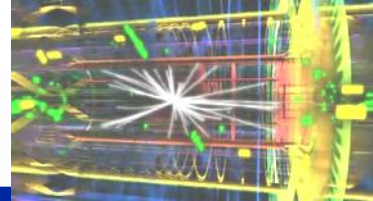
RUN: 160879

[Forrige](#) **EVENT #** [Neste](#)
[\(7609530\)](#) **18772573** [\(36005944\)](#)
 (7/22)

partikkel #	1	2
pt [GeV]	20.04	16.18
η	0.96	0.55
φ [grader]	17.00	189.20

- ⊙ CD distributed, contains
 - ⊙ Introduction to Particle physics, detection, invariant mass, ...
 - ⊙ Event catalogue
 - ⊙ Preselected Z candidates and info about kinematics
 - ⊙ 1-TeV Z' mixed
 - ⊙ Invariant mass calculator
 - ⊙ Spread sheet

<http://folk.uio.no/maikenp/MasterClass/mcvitensentrene>



- Next Steps
 - Real Data from LHC:
 - fine tuning
 - distribute (to teachers?) necessary basic introductions (kinematics, ...) before MC days
 - Involvement of Science centres: Tromsø, Oslo, Bergen, ...
 - National “MC”
 - EPPOG MC
 - Introduce exhibitions, poster sessions,