Searches for new physics with diboson final state

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LAPP Annecy

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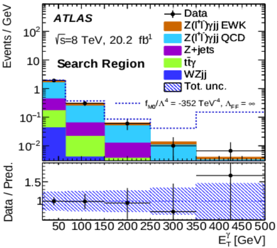
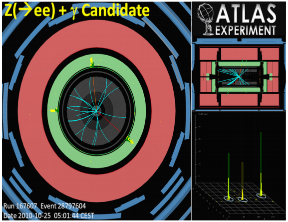
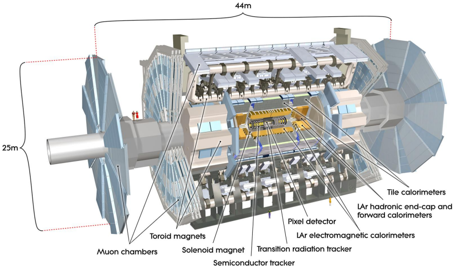




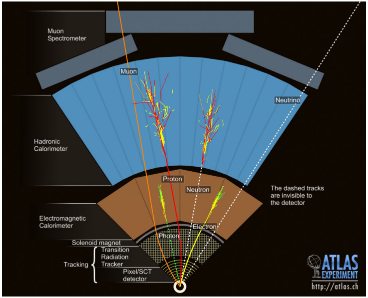
Outline

ATLAS detector



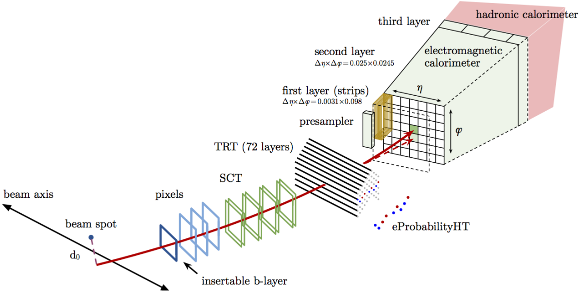
- Multipurpose detector
- Study of p-p collisions at LHC
- Run2 (2015-2018), $\sqrt{s} = 13$ TeV
- Aim is Luminosity $\geqslant 120 fb^{-1}$

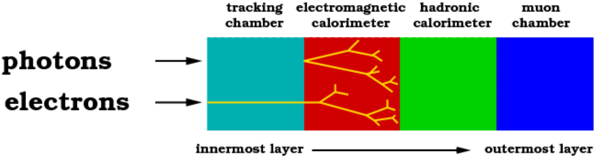
- Patterns of energy deposits that allows the identification of different types of particles produced in collisions.



Electron & photon reconstruction

- Electron: track & cluster in electromagnetic calorimeter
- Photon:
  - Unconverted: only cluster in electromagnetic calorimeter
  - Converted: Clusters with conversion vertex and tracks





Electron identification

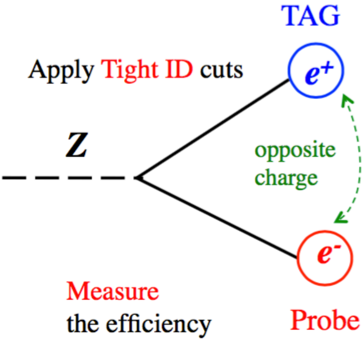
- Different sets of cuts are used to deliver a very good separation between electrons and fake electrons (ex. misidentified jets).
- (The fake electrons are called "background".)
- 3 main operating points with increasing background rejection power have been defined for electrons → loose,medium,tight.

Measuring the identification & reconstruction efficiency using data, requires a clean and unbiased sample of electrons.

Efficiency Measurement Methodology, with data

Tag & Probe method

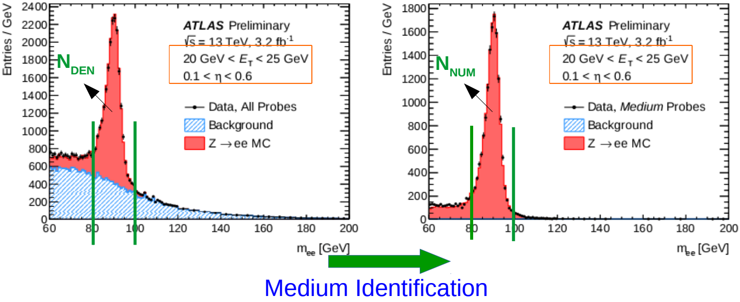
- use of the characteristic signatures of Z $\rightarrow$ ee and J/ψ $\rightarrow$ ee decays
- Z $\rightarrow$ ee decay $\rightarrow$ rather clean sample of electrons



- **tag** electron $\rightarrow$ strict selection criteria
  probe electron$\rightarrow$ used for the efficiency measurements
- Z selection:
  - Zmass & ZIso method $E_T > 15$ GeV
  - radiative decays of the Z 10 GeV $< E_T <$ 15 GeV
- Background subtraction of probes:
  - Probes with $E_T > 25$ GeV are usually clean sample.
  - For lower E_T, care should be taken

Method I: Zmass

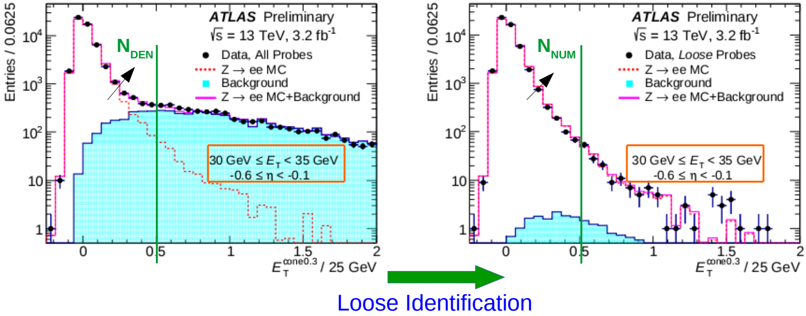
- use the invariant mass of the tag and the probe as discriminating variable
- provides electron identification efficiencies for electrons with E_T 15-200 GeV



- To compute the efficiency, we take the ratio after the background subtraction $\epsilon = N_{NUM}/N_{DEN}$.
- SF=$\epsilon_{data}/\epsilon_{MC}$

Method II: ZIso

- use the probe isolation as a discriminating variable against the background



- To compute the efficiency, we take the ratio after the background subtraction $\epsilon = N_{NUM}/N_{DEN}$.
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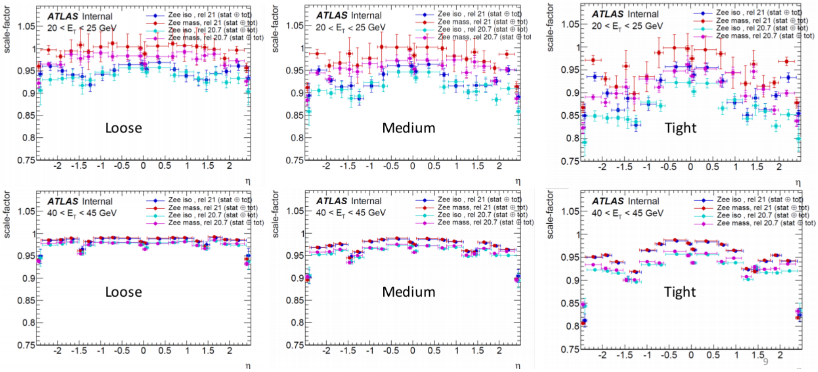
Results: Zmass & ZIso (full 2016 data)

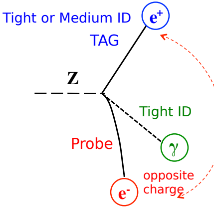
Two different "Releases" of the ATLAS software (20.7 and 21)



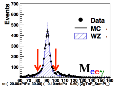
- Releases 20.7 and 21 give coherent results.
- The 2 methods give coherent results, small difference in low $E_T \rightarrow$ is going to be understood.
- Results using 2017 data have also been produced.

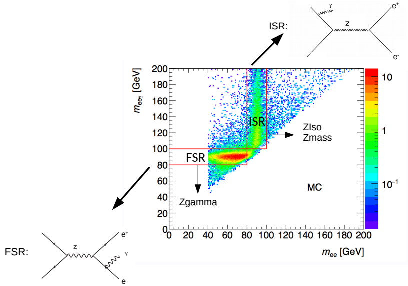
Method III: Zγ method

- probe electrons with E_T between 10 GeV & 15 GeV are selected from Z$\rightarrow$ eeγ decays in which an electron has lost much of its energy due to final state radiation(FSR).
- the invariant mass of the 3 objects is used as a discriminating variable.



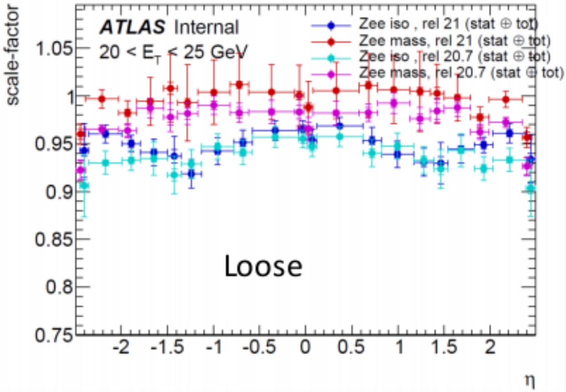
To identify the event require:
v.good e & **v.good γ** & **unbiassed e**
$|M_{ee\gamma}-M_Z|$ < 15 GeV



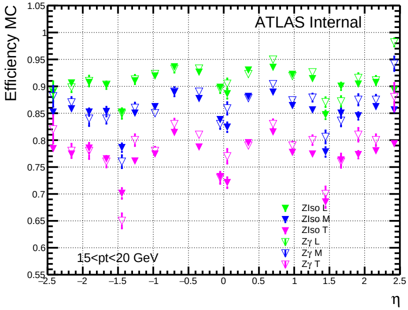


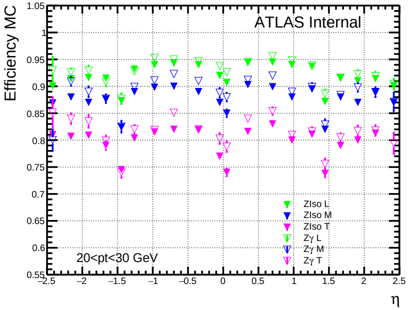
Motivations

- at low E_T (10-15), this topology has less background than Z$\rightarrow$ ee decays
- understanding the difference in ScaleFactor between Zmass & ZIso method in the low E_T bin.



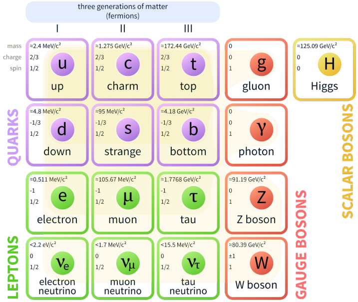
Efficiency achieved using the $Z\gamma$ method





- Only statistical uncertainty is shown.
- ZIso & $Z\gamma$ methods are in agreement.

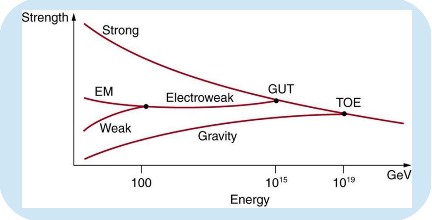
The Standard Model and the Electroweak interaction



Standard Model(SM):

- describes the interaction of fundamental particles
- 3 kinds of interactions:
  - electromagnetic
  - weak
  - strong

\+ (gravitational)



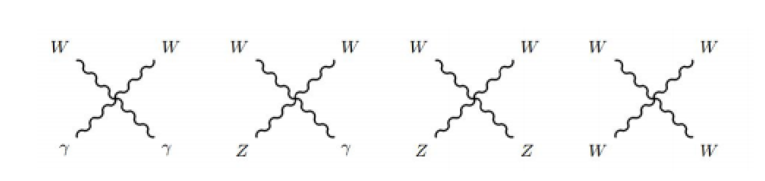
Electromagnetic & Weak:

- above certain energy these two forces merge into a single electroweak (EWK) interaction.

Vector Boson Dynamics

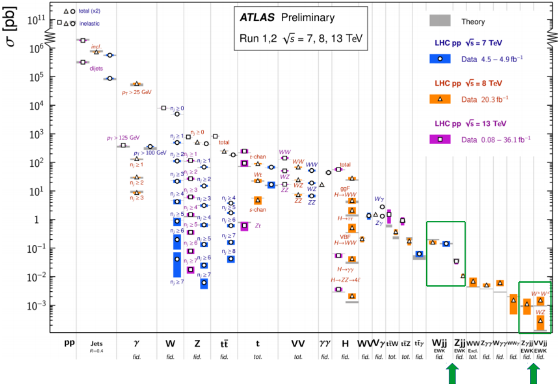
- the SM predicts self-interactions between the electroweak gauge bosons.
- these self-couplings can involve either 3(triplet, TGC) or 4(quartic, QGC) gauge boson at a single vertex.

QGC in SM (VBS):



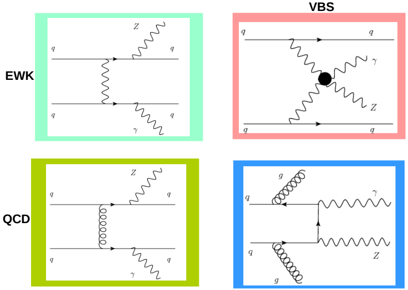
- VBS purely EWK process with small cross-section

VBS Motivation



- measurement of the production of multiple EWK gauge bosons represents an important test of the SM & a good candidate to search for physics beyond the SM.
- Complementary to Higgs boson property studies

Zγjj production

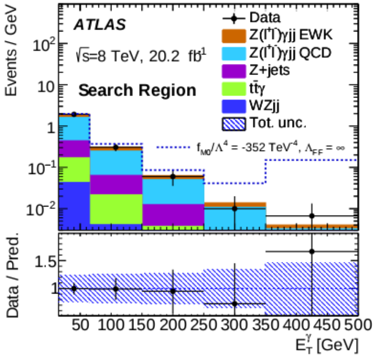


- Main (irreducible) background

  $\downarrow$

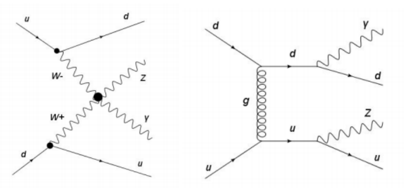
  QCD production of the same diboson states + jets

- Our channel of interest: pp$\rightarrow$ Zγjj, Z $\rightarrow$2l



QCD/EWK Interference

- QCD & EWK production of Zγjj have an identical final state.
- Therefore they can interfere with one another.
- The interference was estimated at the 8 TeV to be $\leqslant 10\%$.



- I am using MadGraph5 event generator to revisited this interference at 13 TeV, producing 3 different samples:
  - Only the EWK component.
  - Only the QCD component.
  - The combination of QCD & EWK.

Other Activities & Future Plans

- ATLAS Software Tutorial
- Monte Carlo School, Hamburg
- 60 hours of French courses
- Calo/FWD shift at ATLAS Control Room

Future Plans:

- Poster about electron ID in the Physics Workshop at CERN, December2017.
- Adding the $Z\gamma$ method in the Electron ID paper, spring 2018.
- VBS $Z\gamma$ analysis.
- More French courses