Electron identification performance in the ATLAS detector & SUSY search with 2 OS leptons in final state

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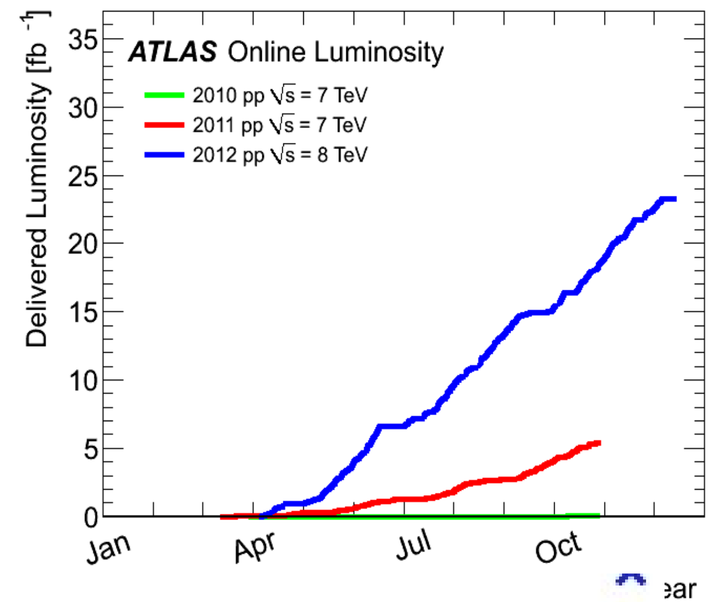
ATLAS detector

- ATLAS record the LHC collision data since 2010.
  - ~5 fb^{-1} recorded at 7 TeV in 2011
  - ~21 fb^{-1} recorded at 8 TeV in 2012

- Composed of a series cylindrical sub detectors

- For electrons, tracker and EM calorimeter are used

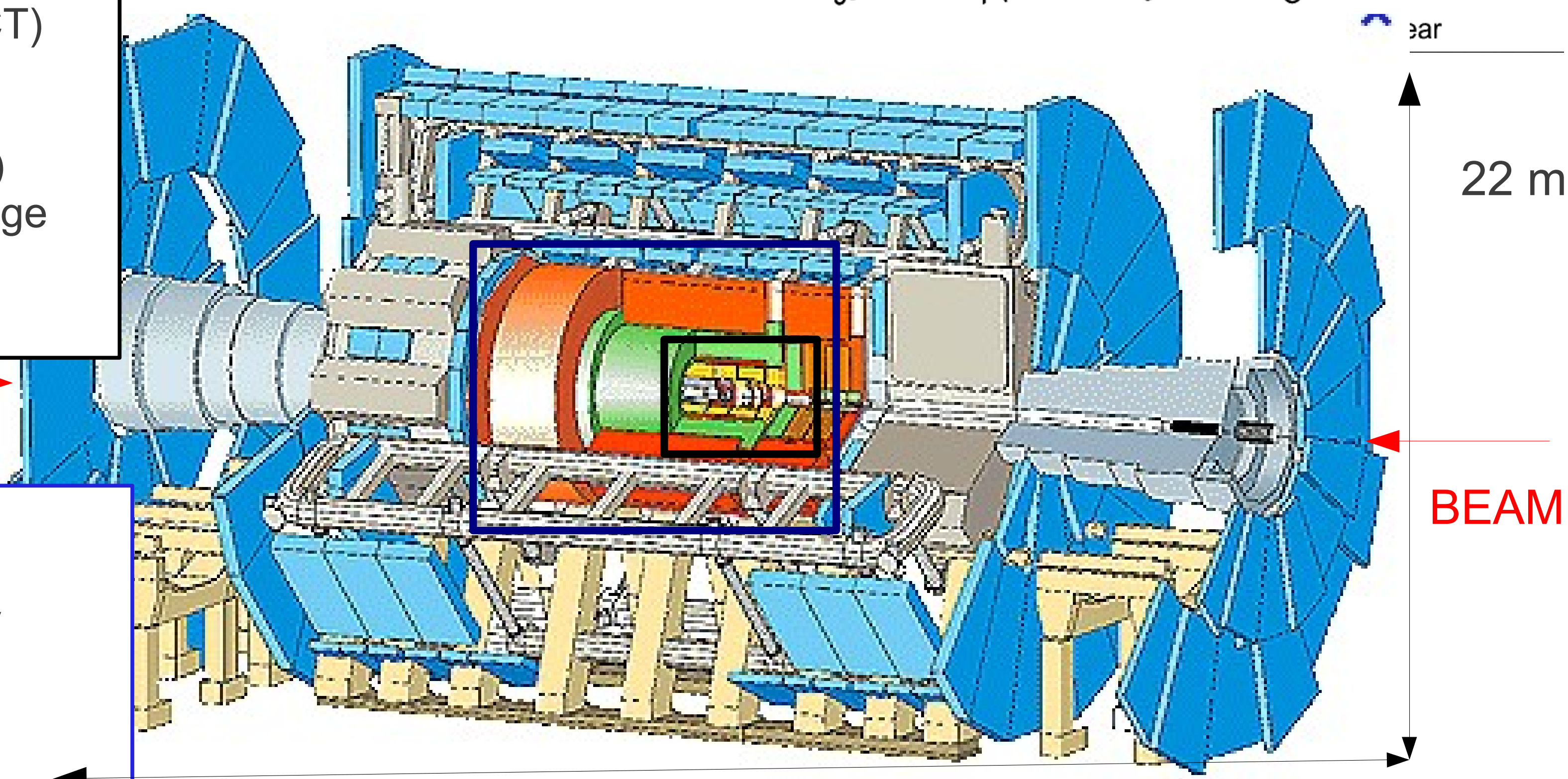


1- Tracking

Si detector (Pixels and SCT)
=> 7 space points

Transition Radiation (TRT)
=> 36 hits on the average

Solenoid (B = 2 T)



2- Calorimetry

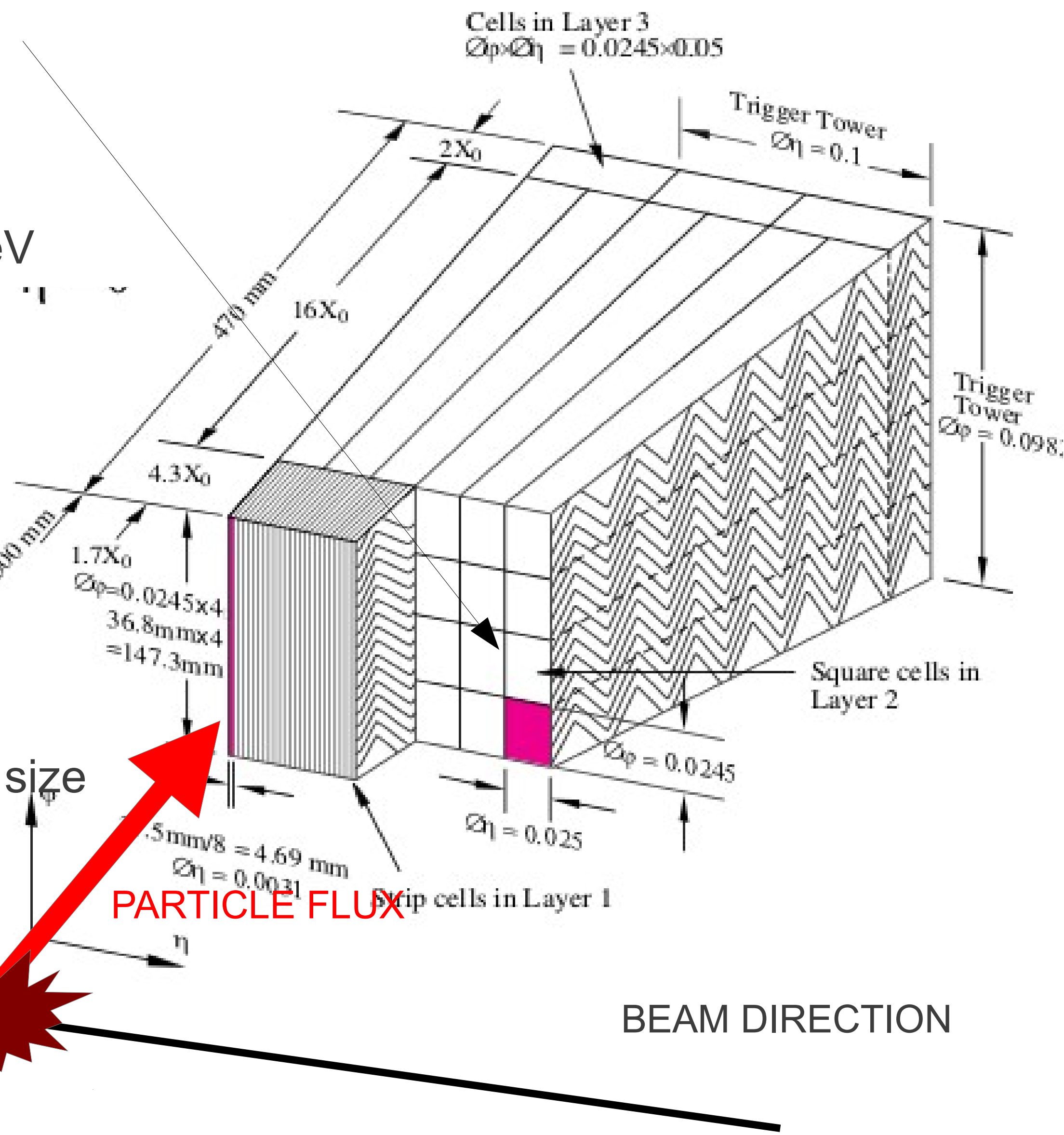
EM Calorimetry (LAr):
=> accordion geometry
=> high granularity

Hadronic Cal (LAr & Tile)
Forward Cal (LAr)

Electron reconstruction

- EM clusters with sliding window algorithm
    - Window of (3 × 5) in units of pink square
    - Slides along 2nd layer of calorimeter
    - Identify EM seed clusters with $E_T >$ 2.5 GeV
- Track extrapolation to EM clusters
    - Tracks are reconstructed in Si detectors
    - Extrapolated and matched to EM clusters
- Electron clusters
    - if EM cluster + track, extend cluster lateral size
    - Form final e cluster to compute e energy

LAr MODULE (|η| < 1.5)



Electron identification

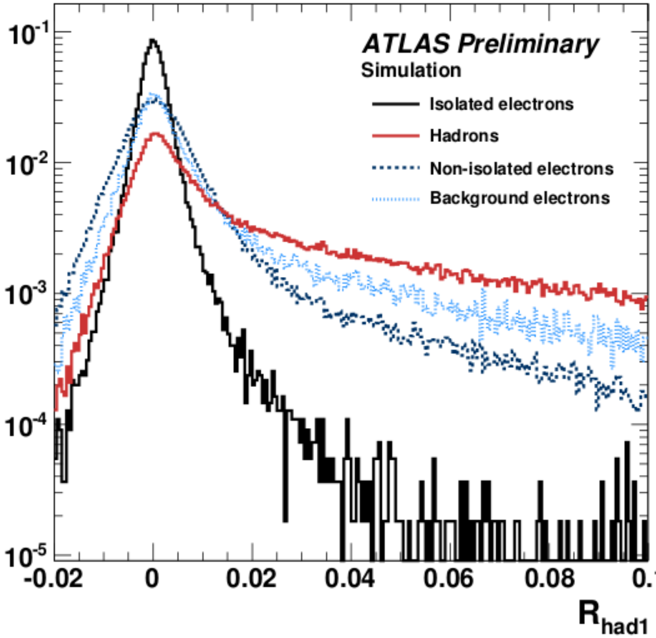
- Aim is to **separate "good" electrons from jets**

- cut-based selection on :
  - => calorimeter shower shapes : hadronic leakage, shower width
  - => tracking variables : Number of hits in Si and TRT,impact parameter
  - => combined variables tracking/EMCal : E/p, track matching to EM cluster

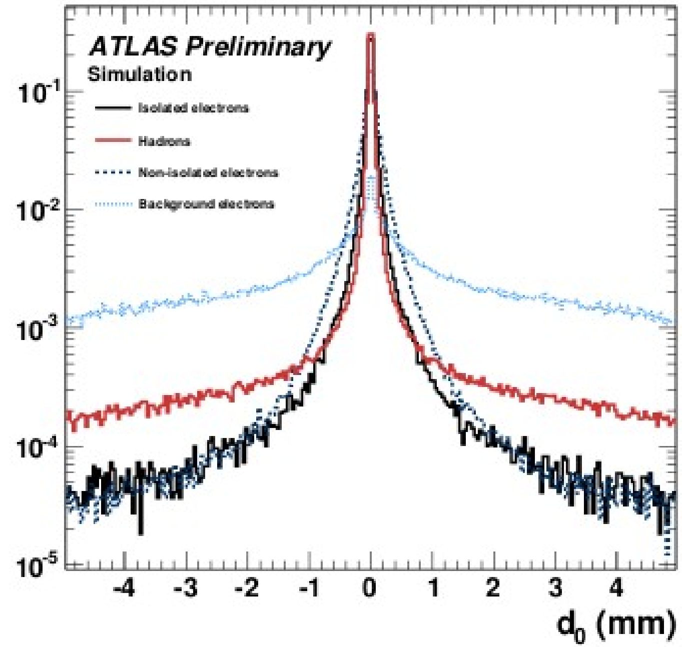
- ID Menu

loose	medium	tight
Highest efficiency	Average efficiency and rejection	Highest rejection
shower shapes	track characteristic	E/p

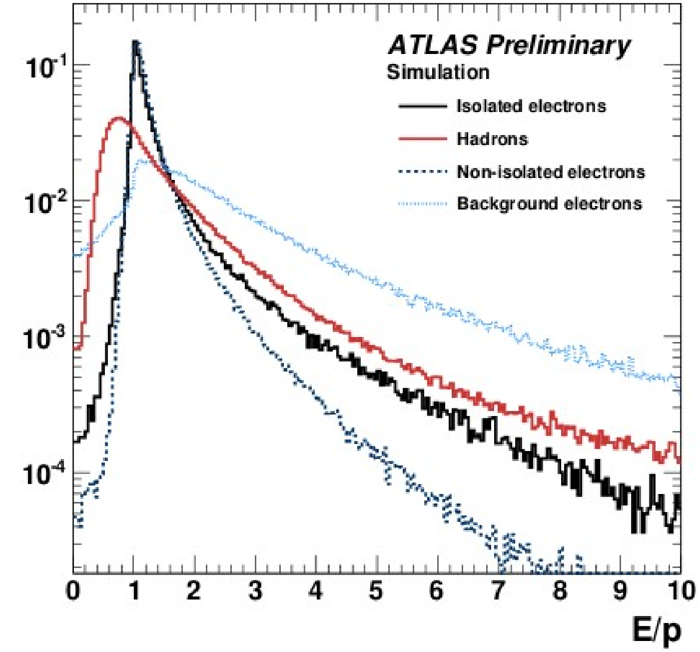
Hadronic leakage



Impact parameter



Energy / momentum



Tag & Probe method

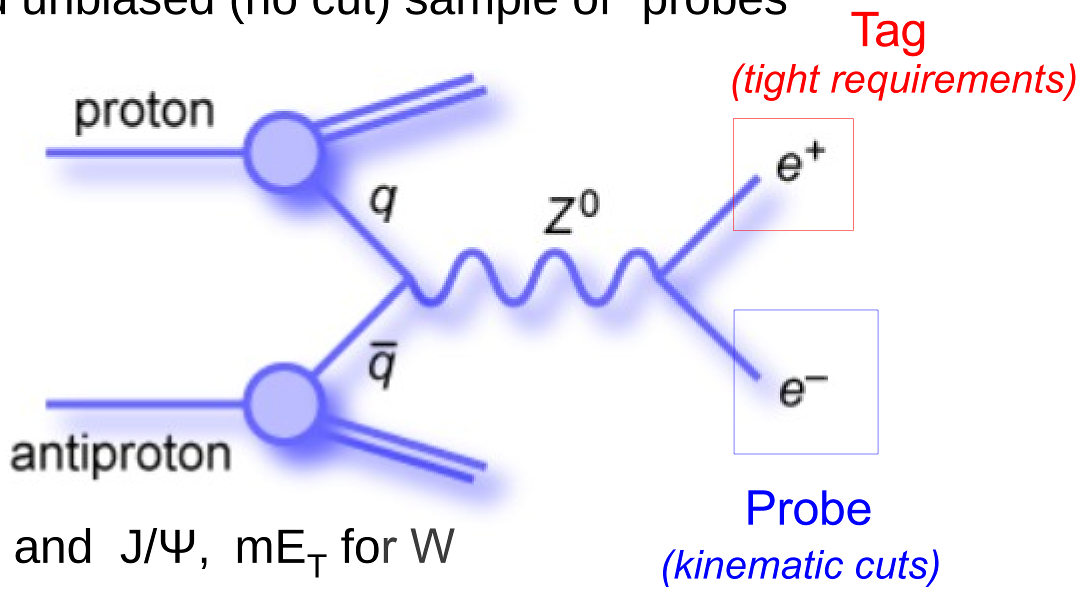
- Tag & Probe :

  - Need Data driven method to measure **cut/Reco/Id efficiencies**

  - Aim : select a clean (no background) and unbiased (no cut) sample of "probes"

  - Using well known decays

  $W \rightarrow e + \nu_e$, $Z \rightarrow ee$, $J/\Psi \rightarrow ee$



- Probe Selection :

  - No jets faking electrons :

    => Tag with tight requirements => e for Z and J/Ψ, mE_T for W
    => using a discriminating variable to improve S / B ratio

- Background subtraction :

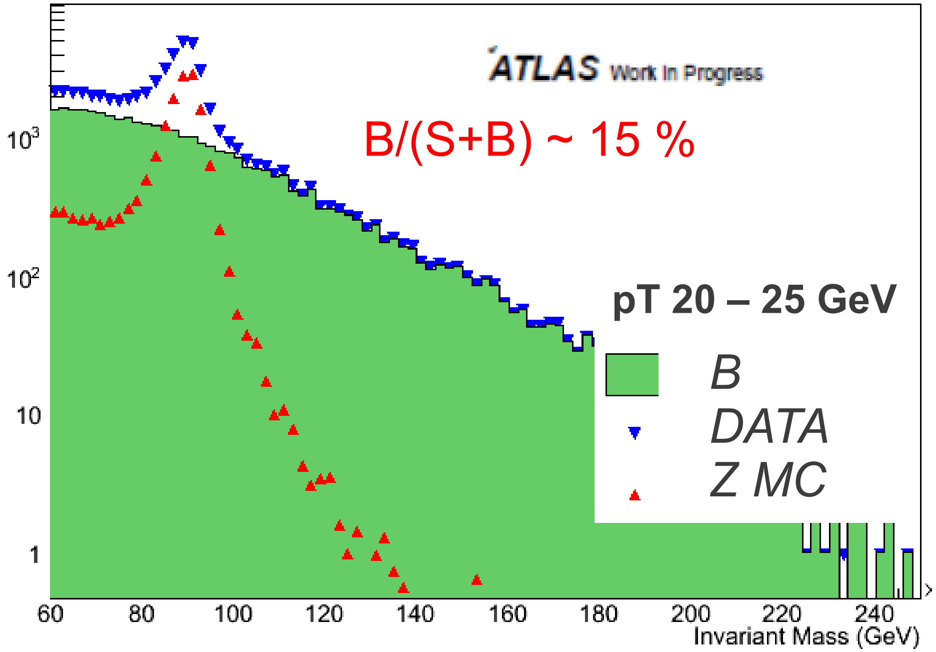
  - Background still remains in probe sample => need a method to subtract it
    => **key of the efficiency measurement**

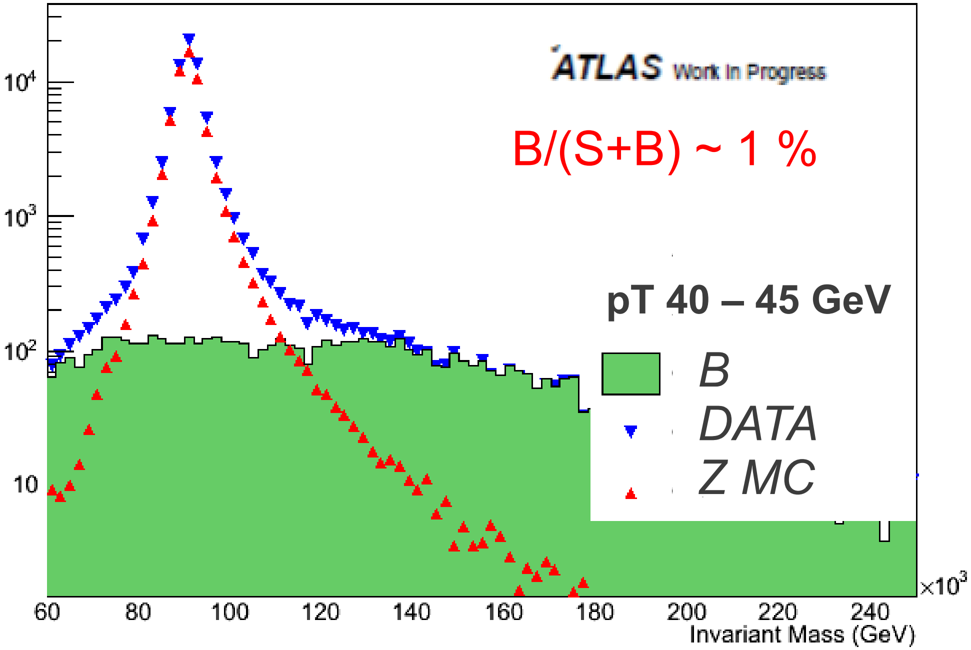
Z Tag&Probe

- Z -> ee produced in ATLAS : 4 millions in 2011, 18 millions in 2012

- Discriminant variable : m_{ee} (Z mass)

- Use for reconstruction and identification efficiency measurement in ATLAS





- **Background amount and shape depends on pT and η** => 50 bins in η and 7 bins in pT

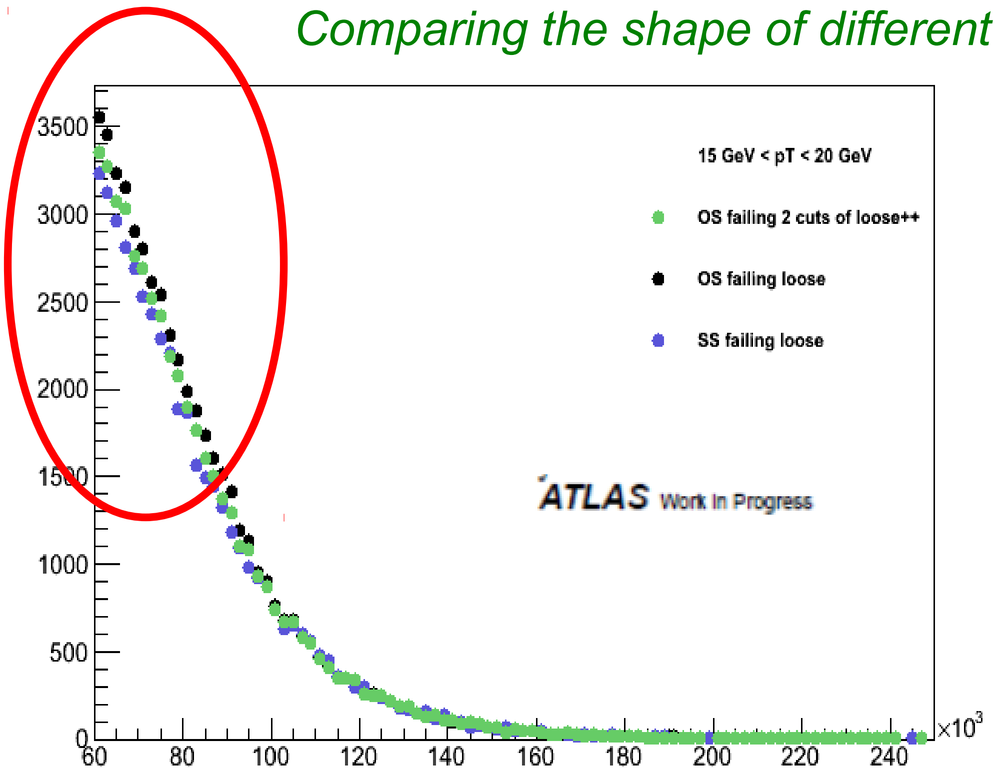
Background shape

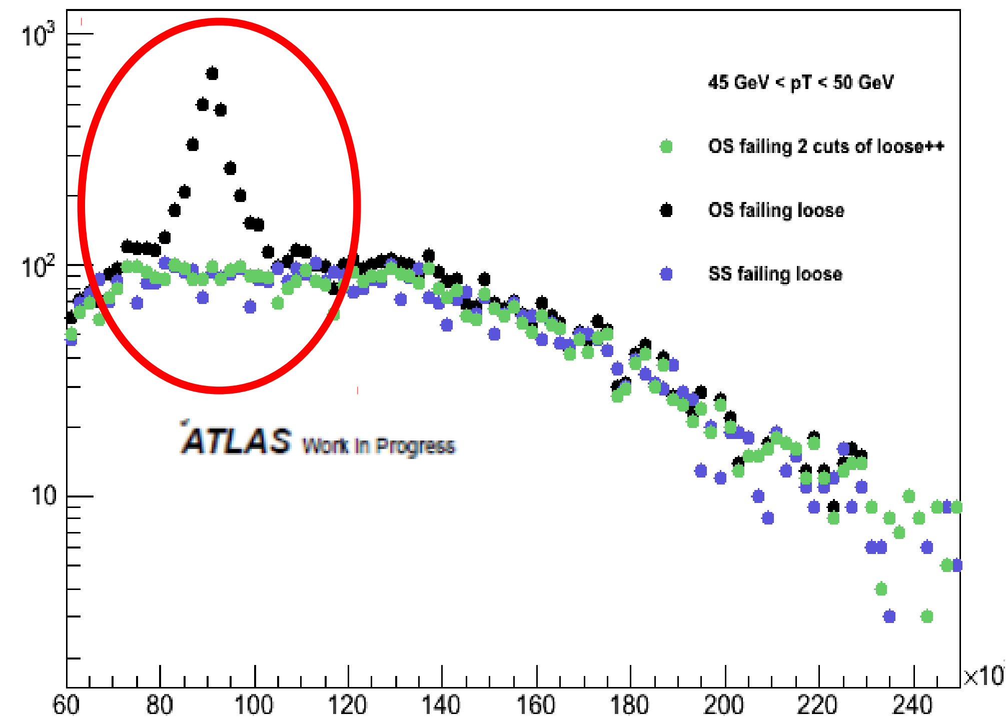
- To know the background shape, build background template by reverting the ID cuts

- ID cuts don t have an efficiency of 100%, so template is contaminated by signal

- Goal is to have a template with low signal contamination and high background efficiency

Comparing the shape of different possible background templates

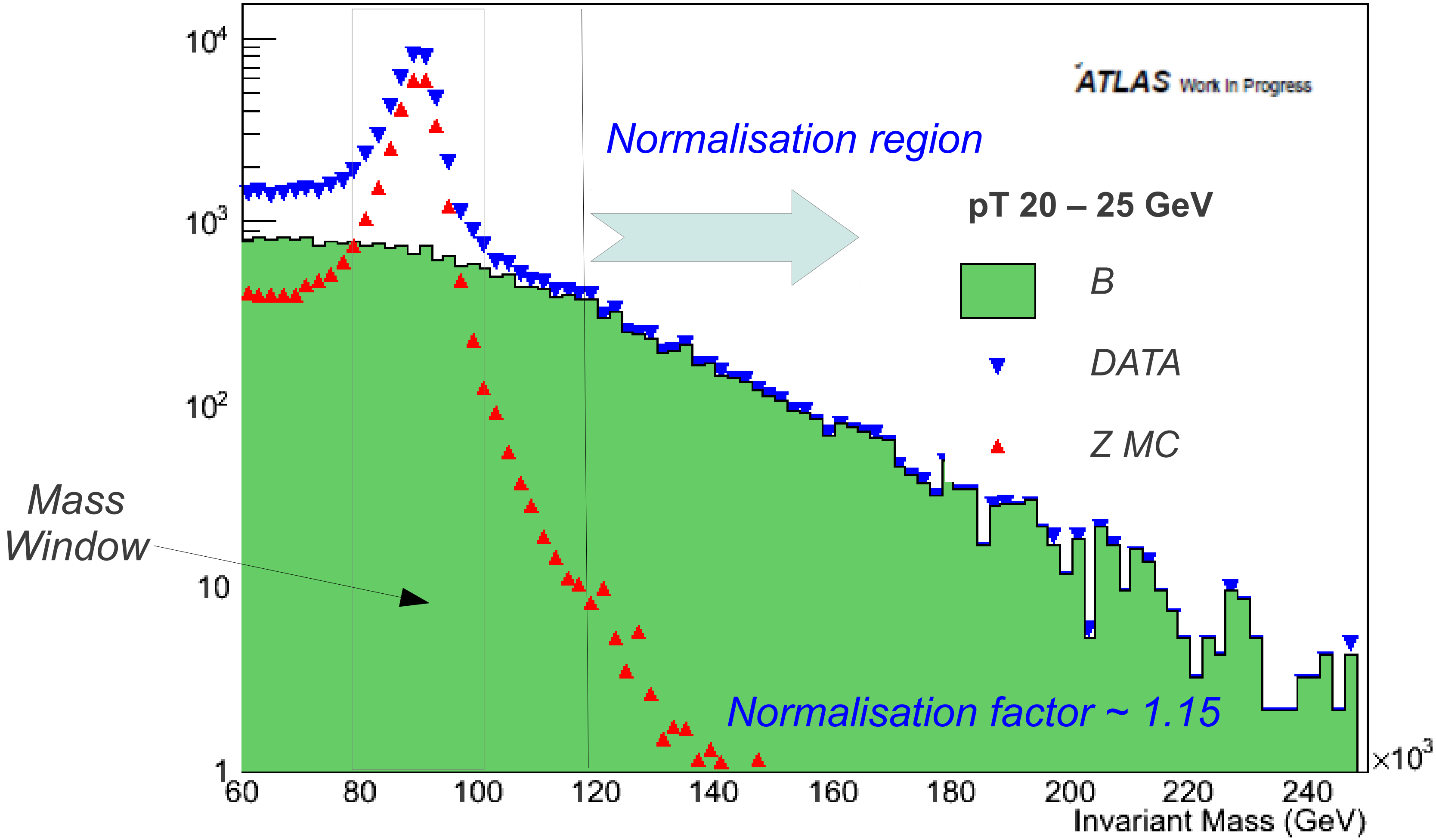




- Template with probes failing at least 2 cuts of ID loose = best compromise

Background normalisation

- Good background shape but not good normalization
- Background Template scaled in signal region at M_{ee} > 120 GeV (background only region)
- efficiency is then computed in Z window mass

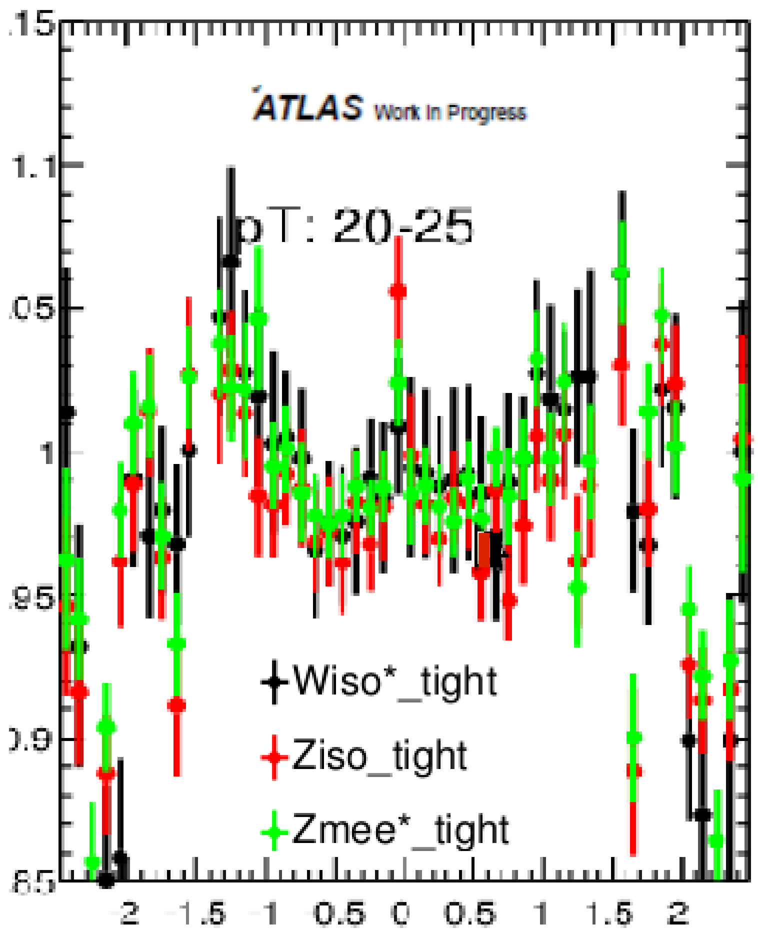


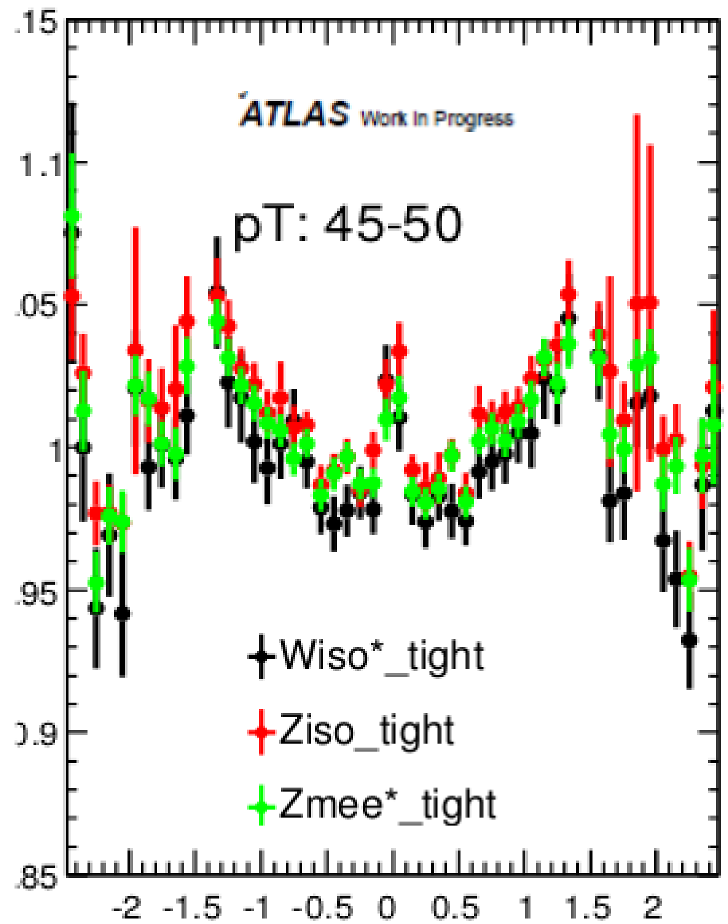
2011 results

- Final results is a combination between W T&P and Z T&P

- All physics analysis involving electrons use scale factors $\quad SF = \frac{\epsilon_{DATA}}{\epsilon_{MC}}$

- Errors dominated by systematic on background subtraction





Uncertainties

- Systematic uncertainty on the background estimation :

pT bin / uncertainties	statistical	systematic
15 GeV – 20 GeV	1 %	1.5 %
45 GeV – 50 GeV	0.7 %	0.3 %

- To estimate systematics, RMS of variations on :

  - Signal Range : 75 – 105 GeV, 80 – 100 GeV , 85 – 95 GeV

  - Signal Contamination in OS template : OS + !(2 cuts of loose) + reverse isolation

  - tag requirements : medium ++, Tight ++, Isolated

- Statistical uncertainty :

$$\delta N^{S2} = \underbrace{N^{OS}_{peak} - N^{B}_{peak}}_{\text{N Probes}} + \frac{(N^{OS}_{hightail} - N^{B}_{hightail})^2}{N^{B\,2}_{hightail}} N^{B\,2}_{peak} \left(\underbrace{\frac{1}{N^{B}_{peak}}}_{\text{N Background}} + \underbrace{\frac{1}{N^{B}_{hightail}} + \frac{1}{(N^{OS}_{hightail} - N^{B}_{hightail})}}_{\text{Normalization factor}} \right)$$

Pile up

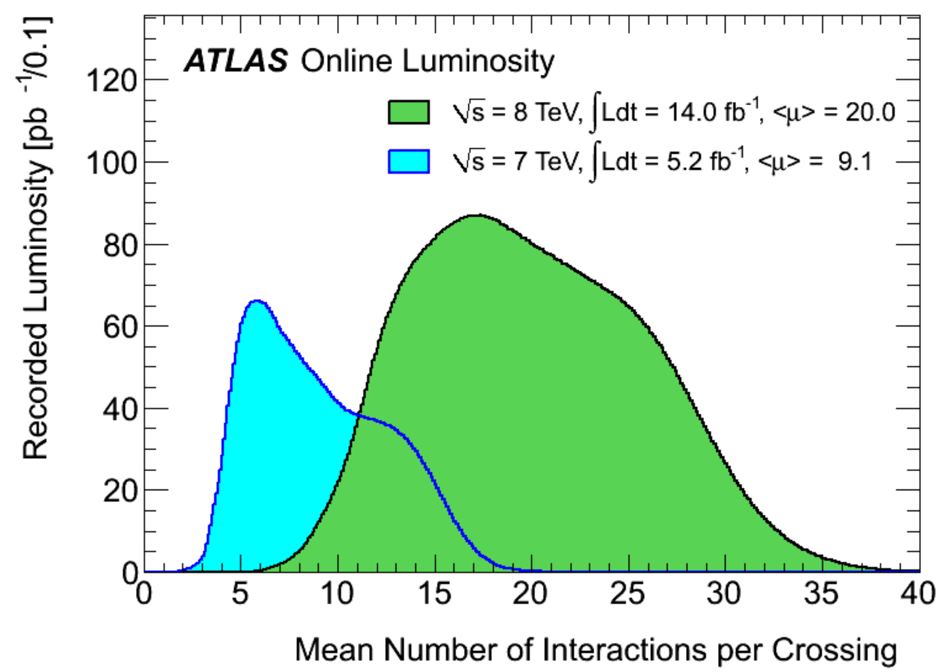
- Pile up = 2012 challenge :

- Pile up = more than just 1 pp per bunch crossing.

- ATLAS instant luminosity goes up with time

- so does the Pile up !

- more than 10 collisions per event



- PU robust ID :

- the goal for 2012 : an identification menu which is not affected by pile up

- mandatory to reconstruct H → 4 leptons event

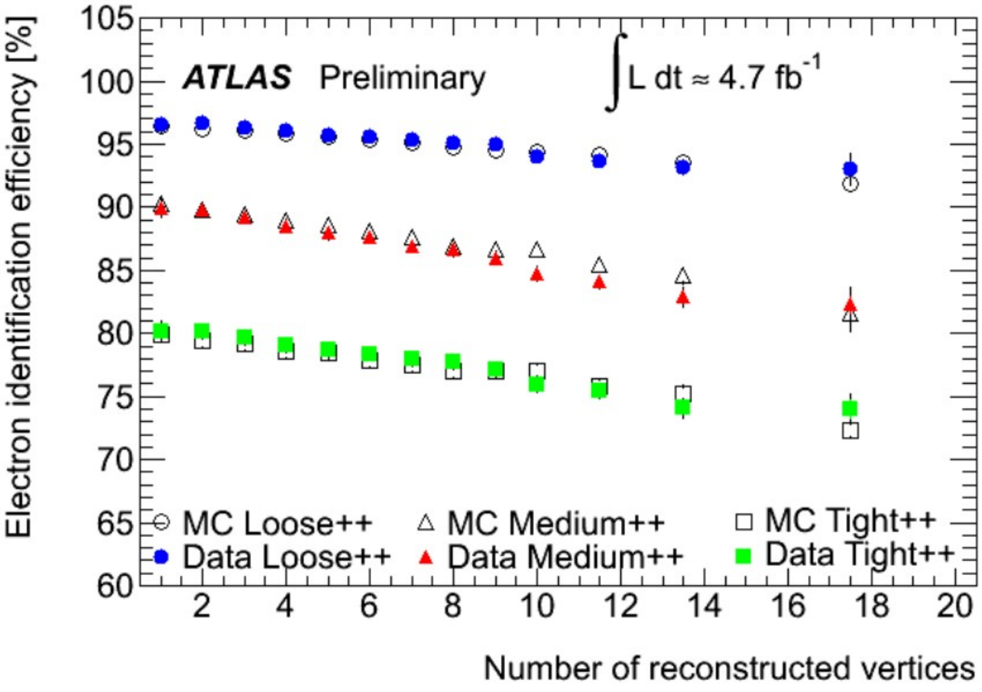
- Basic idea : The higher the volume sampled by a cut, the higher it will be affected by pileup

Efficiencies vs PileUp before optimisation

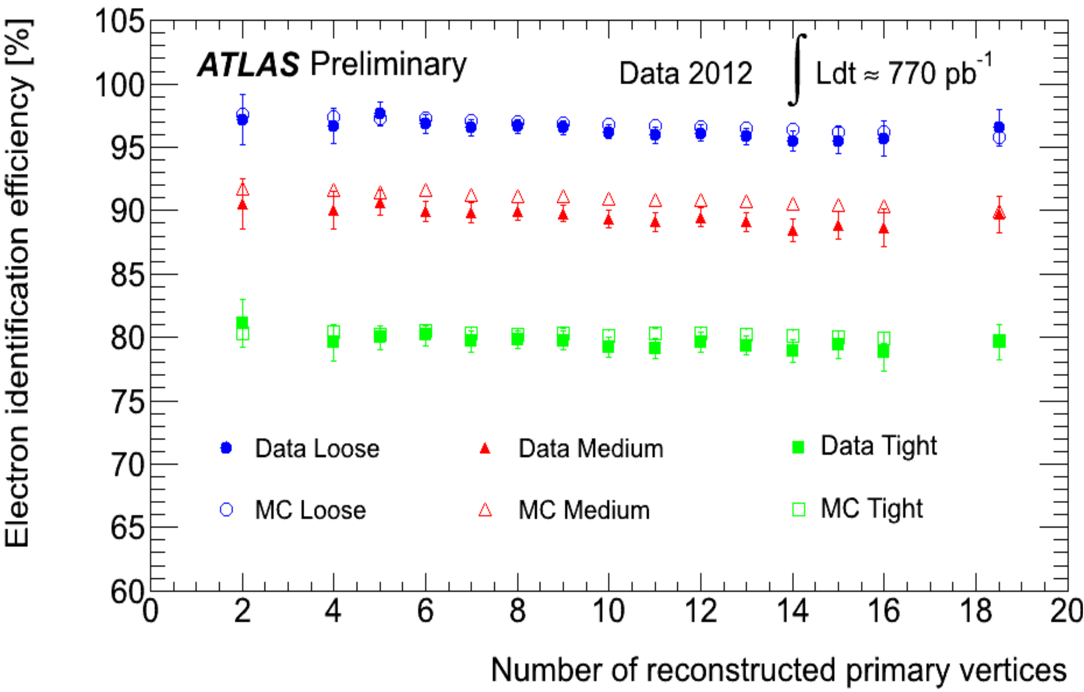
- H → Z (→ e^+e^-) Z* (→ e^+e^-) 4 electrons in final states

- need a **pile up robust identification** to reconstruct it with same rejection

2011 results



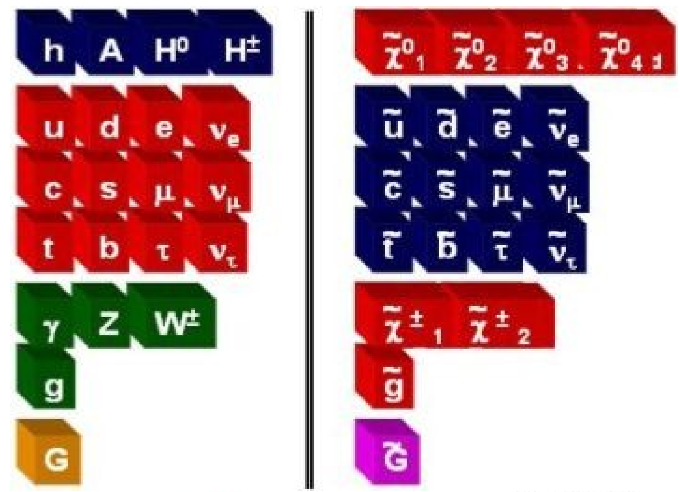
2012 results, reoptimized ID



- **efficiency flat vs n_pvx**

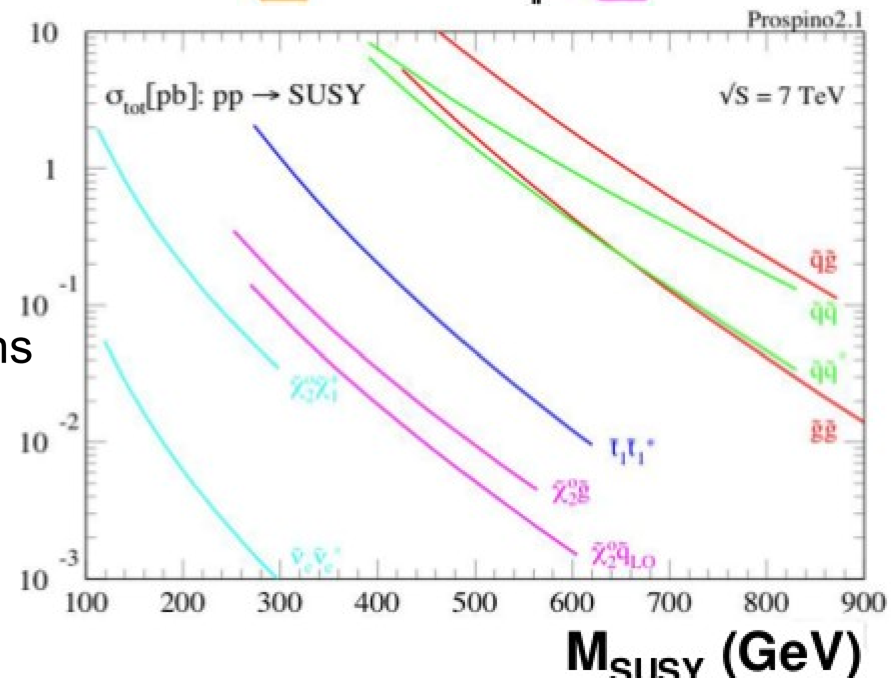
MSSM : a minimal SUSY model

- Supersymmetry add a new symmetry to SM
- each standard particule has a supersymmetric partner
- only the spin differs by 1/2
- protect the Higgs mass and solve the hierarchy problem



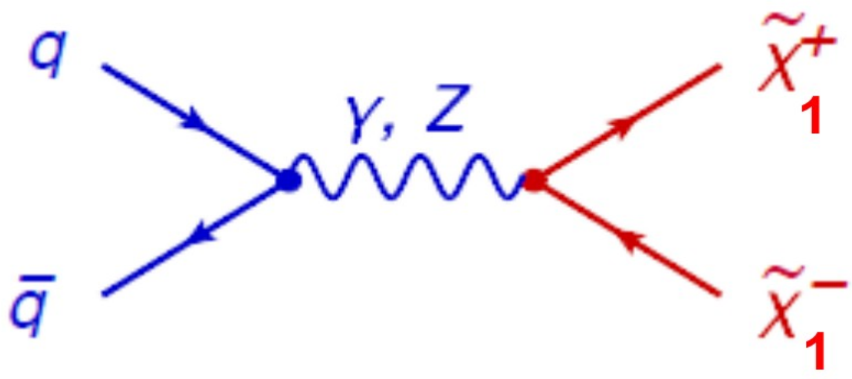
- MSSM = minimal supersymmetric extension to SM
- Coloured sparticles can be heavier than non-coloured
- Can explain why we don t see gluino so far
- Largest XS for weak production of gauginos or sleptons

$$XS(\chi_{1(100\ GeV)}\chi_{1(100\ GeV)}) = 100 * XS(\tilde{g}_{(1TeV)}\tilde{g}_{(1TeV)})$$



- **charginos in this scenario can be the first SUSY visible particle at LHC**

Direct chargino production



- Motivations :

=> No optimised signal region for now

=> Simple channel with only 1 new particle

=> ATLAS had no sensitivity until now

=> No intermediate sleptons hypohesis

Gravity-like decay [LSP= χ_1^0 =O(GeV)] : $\chi_1^+ \chi_1^- \rightarrow$ **W+** χ_1^0 **W-** χ_1^0

GGM-like decay [LSP = $\tilde{G}$ =O(eV)]: $\chi_1^+ \chi_1^- \rightarrow$ **W+ $\tilde{G}$ W- $\tilde{G}$**

- Considering the 2 W(*) decays leptonically

=> 2 OS leptons in final state, different flavors (suppress Z background)

=> jet veto

=> Background :

- SM WW, H → WW : MET cuts, kinematics cuts : ΔΦ(ll), pt(ll)
- tt : jet veto
- WZ, ZZ, gammaZ ...

Conclusion & prospects

PhD 1st year : Electron ID

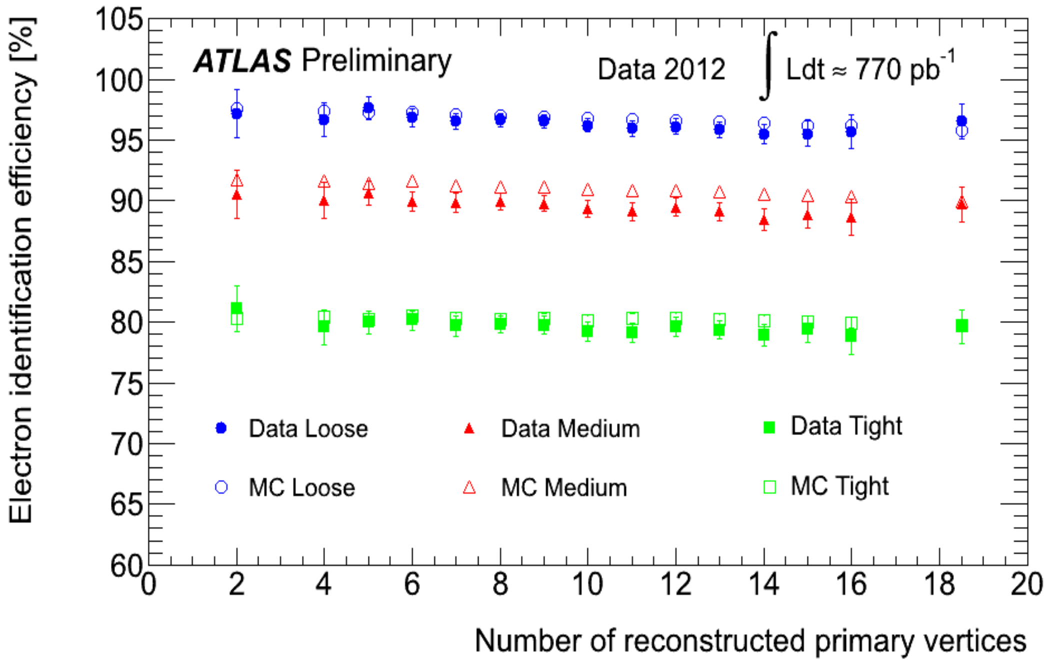
=> Measure efficiency and SF of electron ID with Zee method

=> Role in the Higgs discovery

=> Developed a new B subtraction

- more efficient at low pT

- lower systematics



Prospects for 2nd year :

=> Analysis on direct charginos production with 2 W in the decay

=> new and challenging signal region

=> aiming EPS (2013 conference)