Z'→ee searches with early ATLAS data

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Overview

- Introduction
- Motivations for Z' searches
- Present Z' limits
- ATLAS Z' searches potential in early data
  - Using standard electron selection
  - Using EM calorimeter only electron selection
- Conclusion

Searches for New Physics

- Searches are motivated by BSM physics
  → a model can predict several signatures

Theorist!

e.g. ED models:
Graviton exchange: deviations in dilepton cross-sections
or Graviton emission: jet/γ + Missing Energy signatures

- Analysis: start with experimental signature
  → one signature can constrain several models

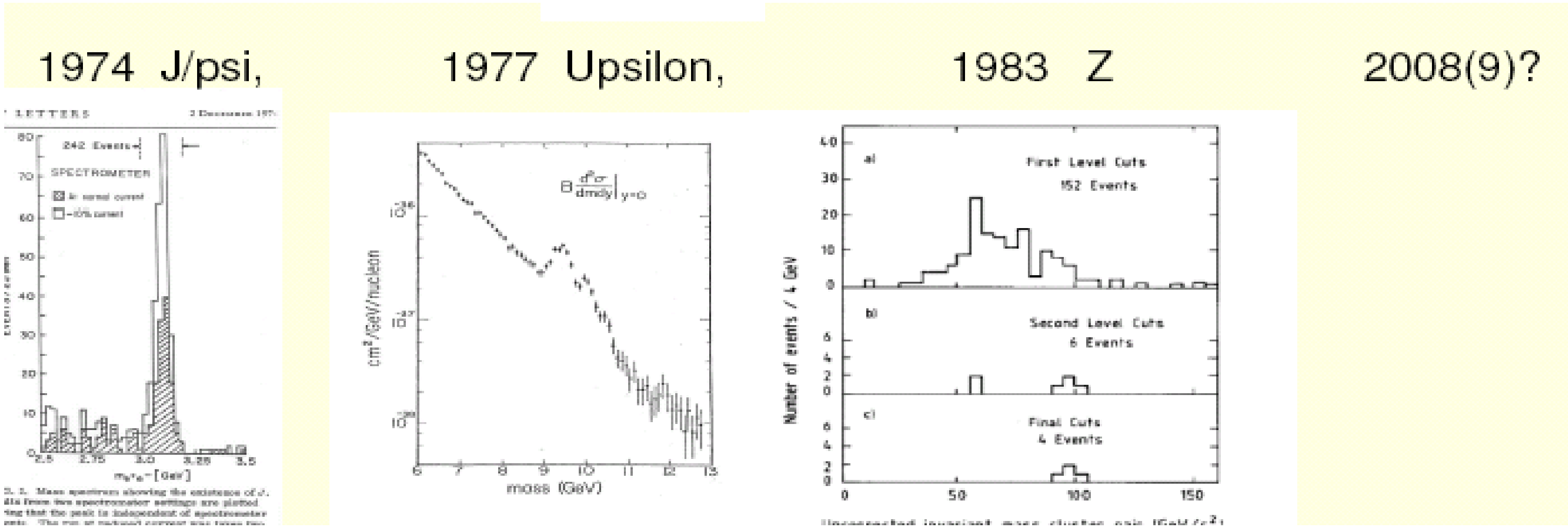
Experimentalist!

e.g. deviations in ee cross-section:
Z’,
ED models: RS, ADD …

ATLAS lepton+X group presently organised such that volunteer for a PhD topic & model!

New Physics in ee Channel

- Dilepton resonances have a history for discovery:
  J/Ψ,Y Z
  - 2 leptons in the final state: clear signature
  - Search for new physics: peak on the Drell-Yan spectrum



- Motivations continues at higher energy….

Models predicting Z'

A Z'-like object at the TeV scale in Drell-Yan is a very common prediction in many BSM scenarios:

- Extended SUSY-GUT groups
- R-Parity violating SUSY
- String constructions/intersecting branes
- Little Higgs models
- Hidden Valley/mediation models
- Extra dimensions: gauge & graviton KK's
- String excitations
- Unparticles

hep-ph/ 0610104

Models predicting Z'

3 "traditional" models based on GUTS:

Symmetry-breaking of larger gauge group to SM groups generates additional U(1) gauge groups → Z' bosons

- Effective Rank-5 models

  $E_6 \to SO(10) \times U(1)\psi$

  $\to SU(5) \times U(1)\chi \times U(1)\,\psi \to SM \times U(1)_{\theta(E6)}$

  Models frequently studied are Z'_ψ Z'_χ Z'_η

- Left-Right symmetric models

  $SO(10) \to SU(3) x SU(2)_L x SU(2)_R x U(1)_{B-L}$

  Models frequently studied are $Z'_{L,R}$

- Sequential Standard Model

  uses the SM Z couplings $\to Z'_{SM}$

  (Not gauge invariant but good for comparisons)

Mass eigenstates

$Z'(\theta) \to Z'_\psi \sin\theta + Z'_\chi \cos\theta$

θ : mixing angle: determines the coupling

$$\theta = \arctan\left(-\left(\frac{5}{3}\right)^{\frac{1}{2}}\right)$$

$$\alpha_{LR} = \sqrt{\frac{c_W{}^2 g_R{}^2}{s_W{}^2 g_L{}^2} - 1}$$

Experimental motivation to search for a Z'

Long lasting 3.2σ discrepancy in the electroweak precision fits from A_{LR} and A^b_{FB}

If interpreted as a hint of new physics, could be explained by mixing of the SM Z with a heavier Z'
(M. Chanowitz)

arXiv:0806.0890v2 [hep-ph]

Current Limits on Z'

- Direct Search (Tevatron)
  - reconstruct a dilepton invariant mass "bump"
- Indirect Search (LEP)
  - forward-backward asymmetry, or σ_{ll}, σ_{qq}

Z' Model	Indirect Searches (GeV)	Direct Searches (GeV)	
		e^+e^- Colliders	p^+p^- Colliders
Z'_χ	680	781	864
Z'_ψ	481	366	853
Z'_η	619	515	933
Z'_{LRSM}	804	518	–
Z'_{SSM}	1787	1018	966

Table 1: 95% C.L. limits on various Z' models.

CDF II preliminary $L = 2.3\ \mathrm{fb}^{-1}$

Model	Mass Limits, 95% CL (GeV/c^2)
Z' (SM)	1030
Z' (η)	975
Z' (χ)	892
Z' (ψ)	878
Z' (N)	861
Z' (I)	789
Z' (sq)	754

Now exceeded by CDF $Z' \to \mu\mu$ 2.3 fb^{-1} search

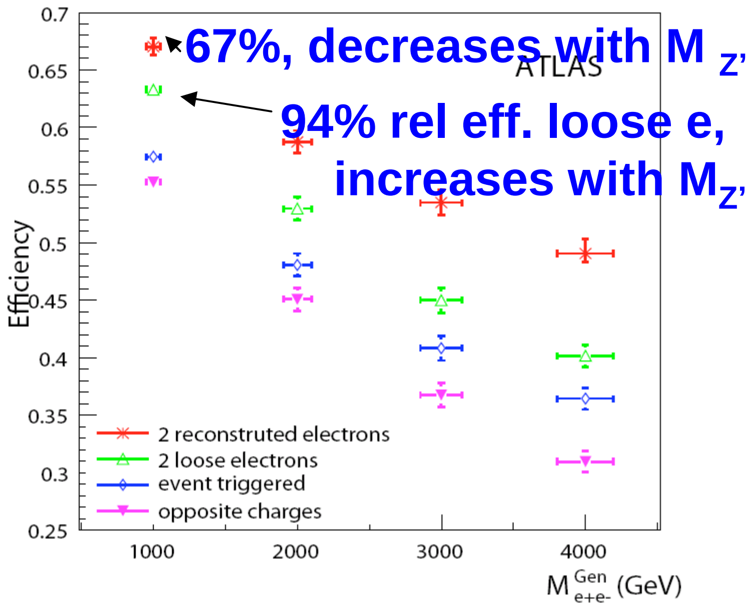
ATLAS Z' Discovery Potential

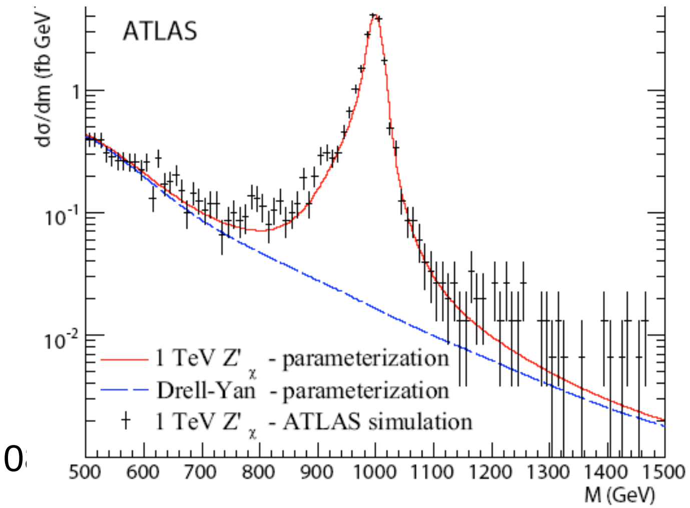
Fully simulated Z'_χ with 1,2 and 3 TeV

$M_Z \pm 4\Gamma_{Z'}$

Selection	Signal at 1 TeV	DY at 1 TeV	Signal at 2 TeV	DY at 2 TeV	Signal at 3 TeV	DY at 3 TeV
	347	3.56	14.7	0.16	1.22	0.015
2 generated $e^\pm$, $\|\eta\| < 2.5$	299	3.07	13.7	0.15	1.16	0.013
2 clusters with a track	201	2.06	8.0	0.09	0.62	0.009
2 *loose* electrons	190	1.96	7.2	0.08	0.52	0.008
At least one $p_T > 65$ GeV	190	1.96	7.2	0.08	0.47	0.008
Event triggered	173	1.77	6.6	0.07	0.43	0.007
2 opposite charges	166	1.70	6.2	0.07	0.41	0.007

e55 trigger: 90.8 % per event





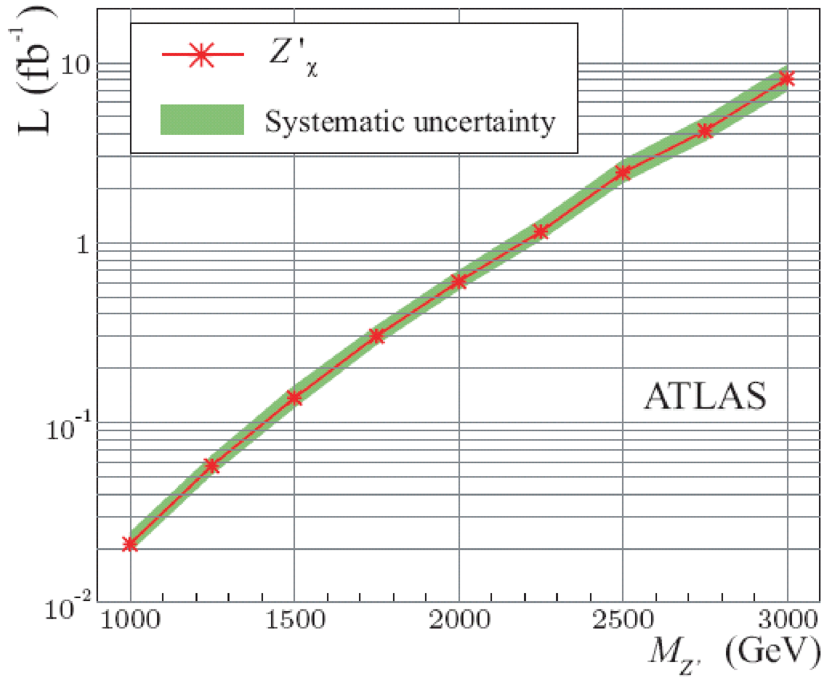
To calculate the significance for Z' models a parameterisation of both Drell-Yan and Z's was used

ATLAS Z' Discovery Potential

Main systematics

– ± 3.6% to ± 0.6% uncertainty on event selection
– Theoretical uncertainties: e.g. higher order corrections and PDF uncertainties on DY cross section ± 8.5% to 14 %

→ Combined uncertainties on the luminosity needed to discover a 1, 2, 3 TeV Z' is: $^{+9}_{-10}$%, $^{+14}_{-10}$%, $^{+15}_{-13}$%

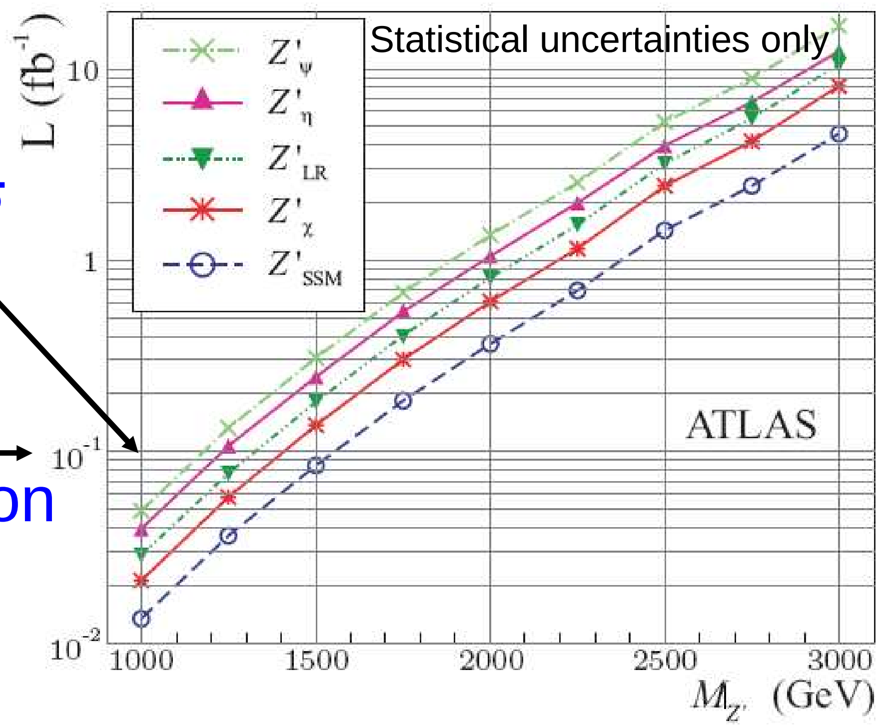


- Uncertainty from DY ~ 1%
- Uncertainty on the energy resolution affects the luminosity needed for discovery is $^{+5}_{-2}$%, independent of $M_{Z'}$

ATLAS Z' Discovery Potential

- Sensitivity to exotic dilepton resonances:
  - Z' →ee, 15 to 50pb^{-1} for 5σ discovery of Z'$_{\chi,\eta,\psi,LR,SSM}$

Z' Discovery Potential



- 100 pb^{-1} are sufficient to discover Z' beyond the Tevatron limits:

  1.2 TeV < $m_{Z'}$ <1.6TeV

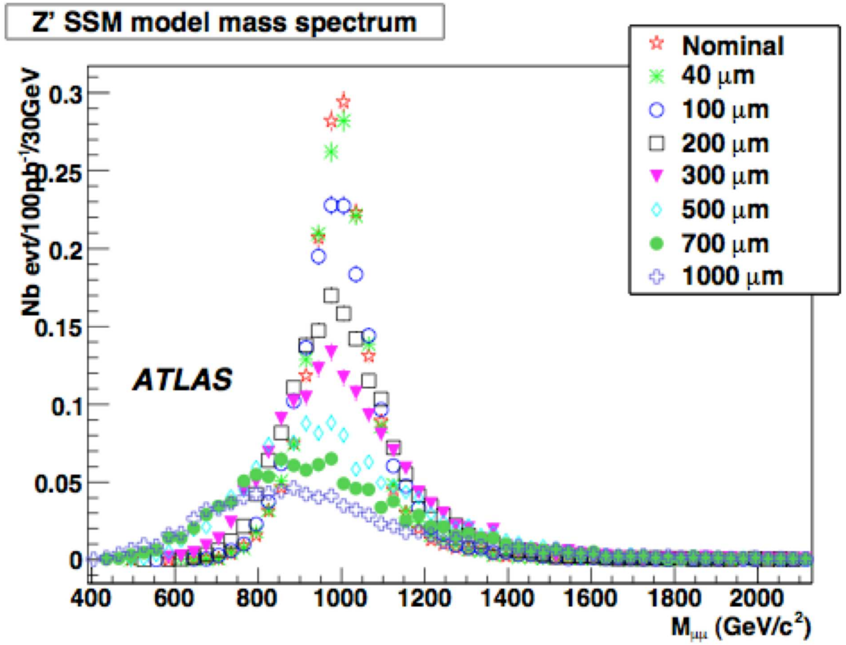
- Early discoveries potentially possible!

What if the detector is not perfect immediately!/Experimental Issues!

Spectrometer and tracker not aligned, Calorimeter calibration not optimal …

Mis-alignment of muon spectrometer downgrades the mass resolution

- for Z'→μμ most important systematic.
- Affects the reconstruction efficiencies and sensitivities



Misalignment (μm)	Nominal	40	100	200	300	500	700	1000
Relative loss	0.984	0.984	0.984	0.98	0.973	0.948	0.918	0.877

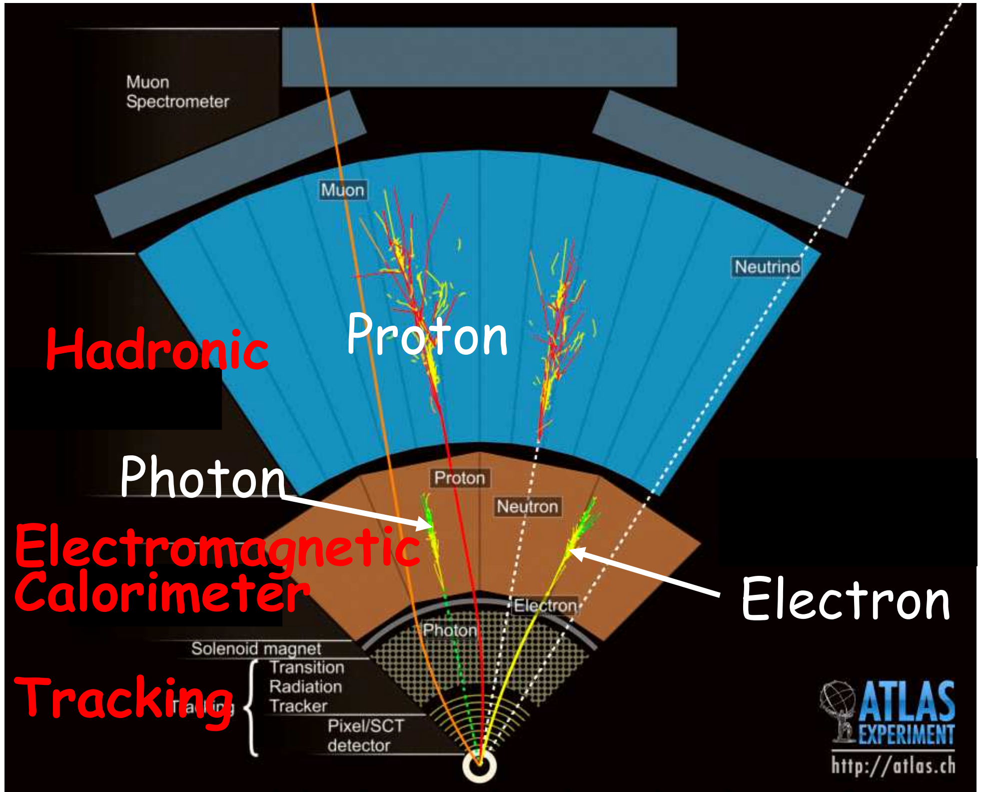
What is the impact of a realistic detector on the Z'→ee discovery potential?

Electron Identification/Background Rejection

- Usually involved matching a EM cluster with a track to distinguish from γ
- What if the tracker is misaligned?

- To reject background from jets
- Electron ID usually includes a Had/EM cut

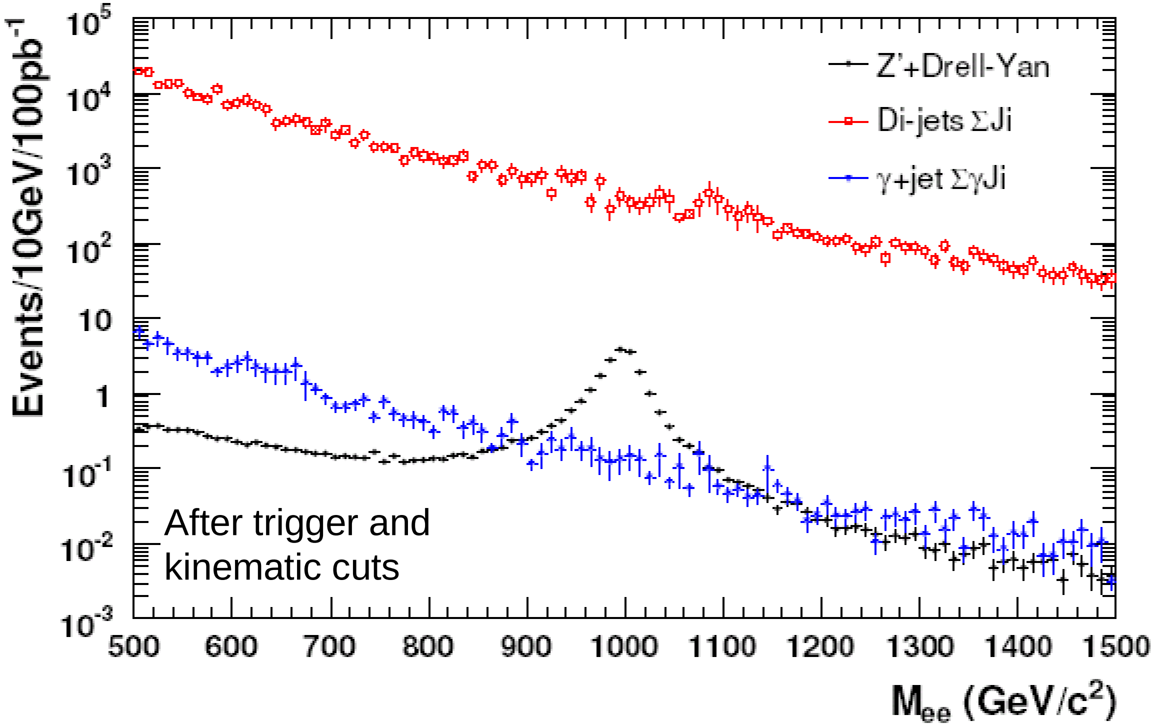
- Can the EM calorimeter be used in a stand-alone way?
- i.e. not include the tracker or the HAD calorimeter?



The EM calorimeter is expected to operate smoothly from the beginning of data taking, even if the rest of the ATLAS detector is not operating smoothly – tested for 10 years and in situ

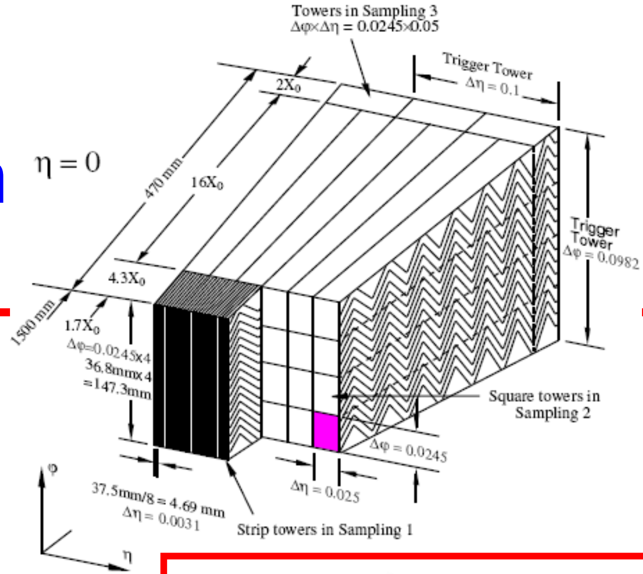
Can the EM calorimeter be used in a stand-alone way?

Challenge!

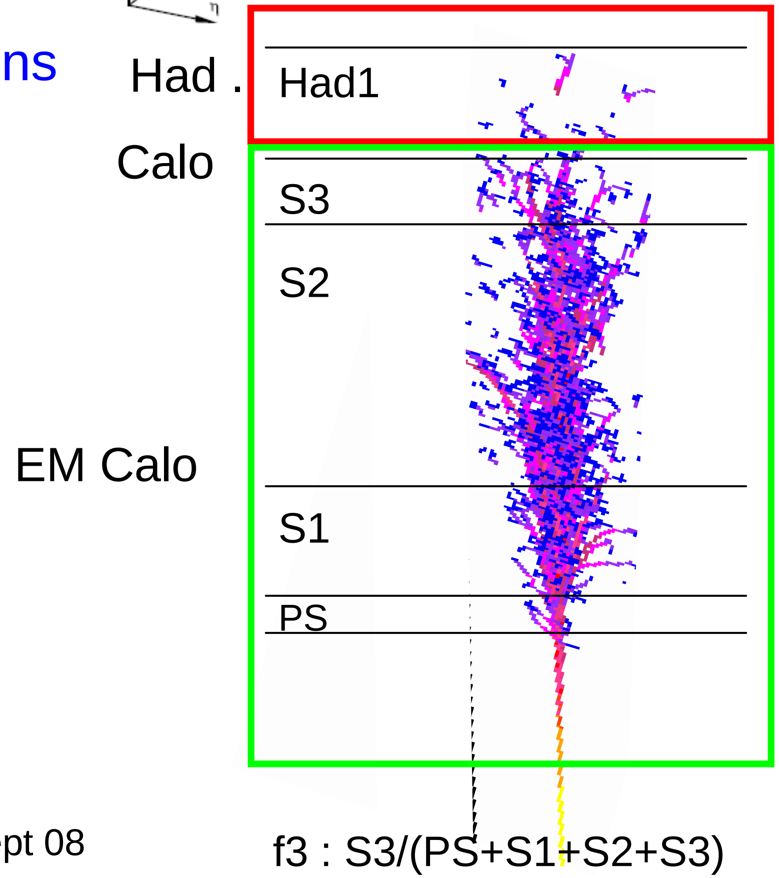


- **Developed 3 simple and robust cuts :**
  - Based on EM calorimeter only
  - η-independant cuts

Electron identification/QCD rejection



- **Taking advantage of EM shower specifics :**
  - The longitudinal shape : fractions of energy in S1,S2,S3
  - The lateral shape : energy distributions for different cluster sizes in S1,S2,S3

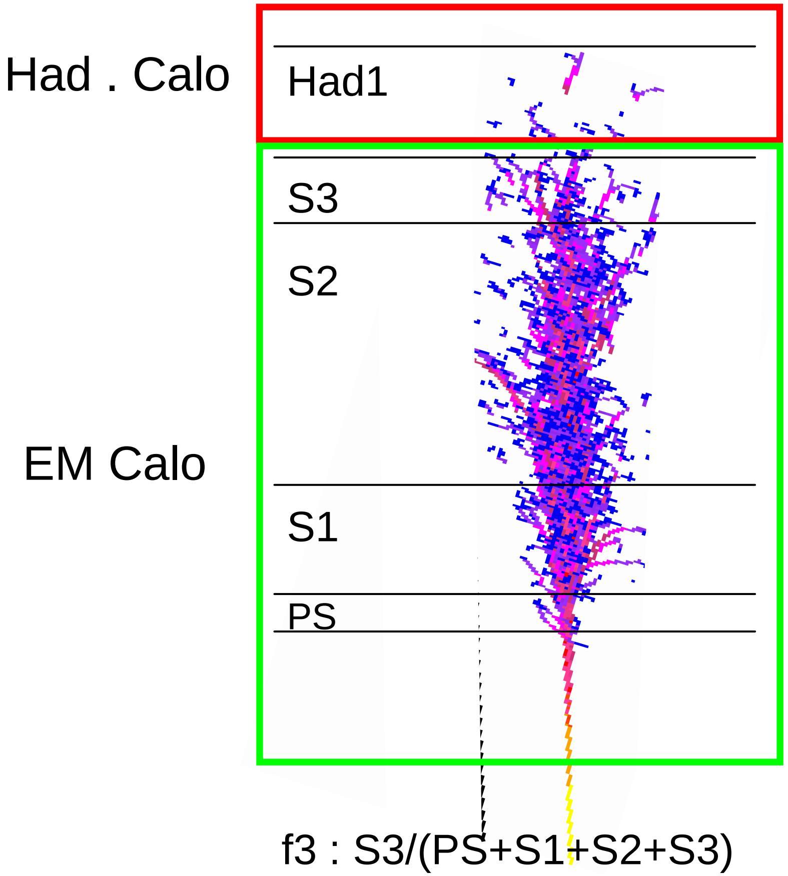


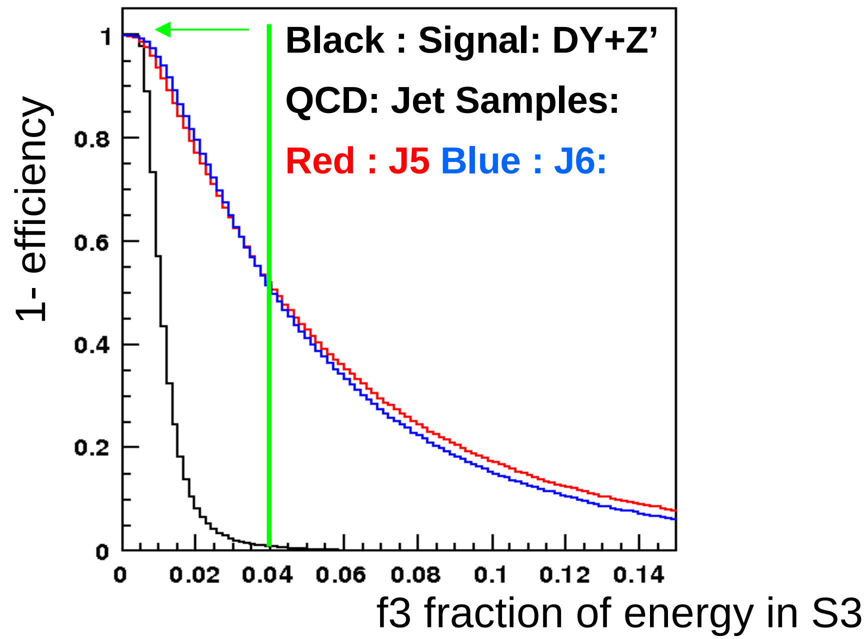
- **3 main differences between a jet-induced EM-cluster and an e one:**
- i) energy fraction deposited in S3 (f3) is higher
- ii) Energy deposited in a core region S2 is less dense
- iii) Shower width in S1 is wider for a jet-induced cluster

f3 : S3/(PS+S1+S2+S3)

e ID & QCD Rejection

1) Longitudinal shape in EM calo



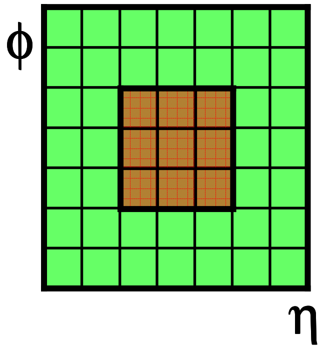


Cuts	ID Eff.	J5 Rejection	J6 Rejection
f3 < 0.04	99.1%	2	2

→ 50% of QCD background is removed

e ID & QCD Rejection

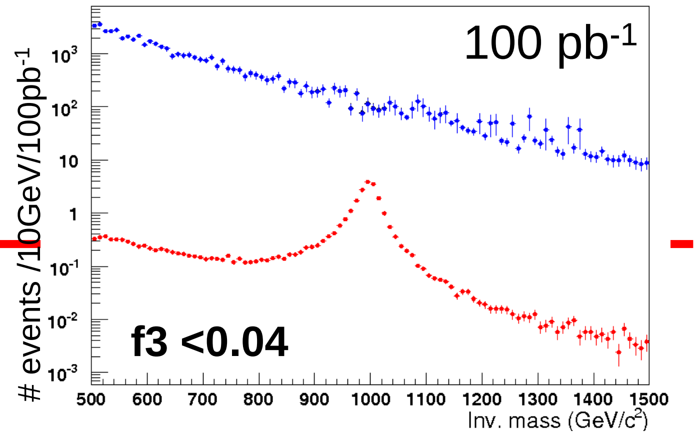
2 & 3) Lateral shape in EM calo

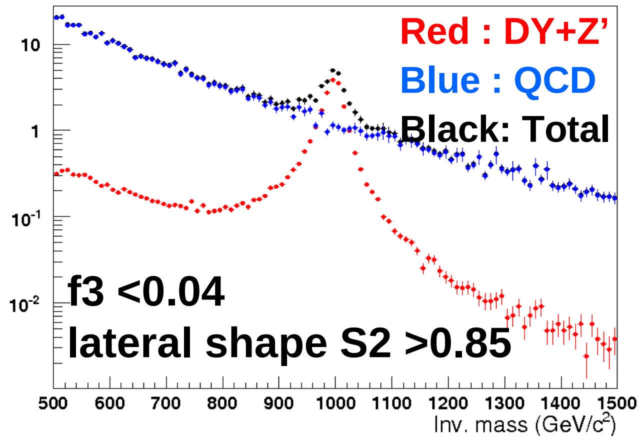


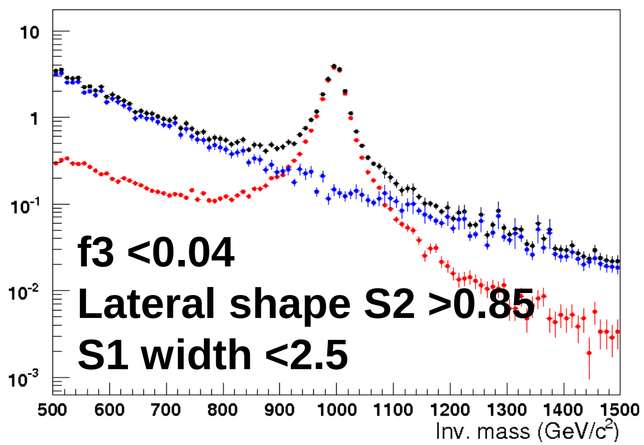
Energy mainly deposited in S2
→ Ratio: E(3x3)/E(7x7)

Granularity is higher in S1
→Width of EM Shower in S1

Cuts	ID Eff.	J5 Rejection	J6 Rejection
f3 < 0.04 (1)	99.1%	2	2
(1) + S2 >0.85 (2)	98.5%	18	9
(1) + (2) + S1<2.5 (3)	96.5%	48	31







3 simple, η independent cuts:
significantly decrease the QCD background

Signal extraction with EM calo

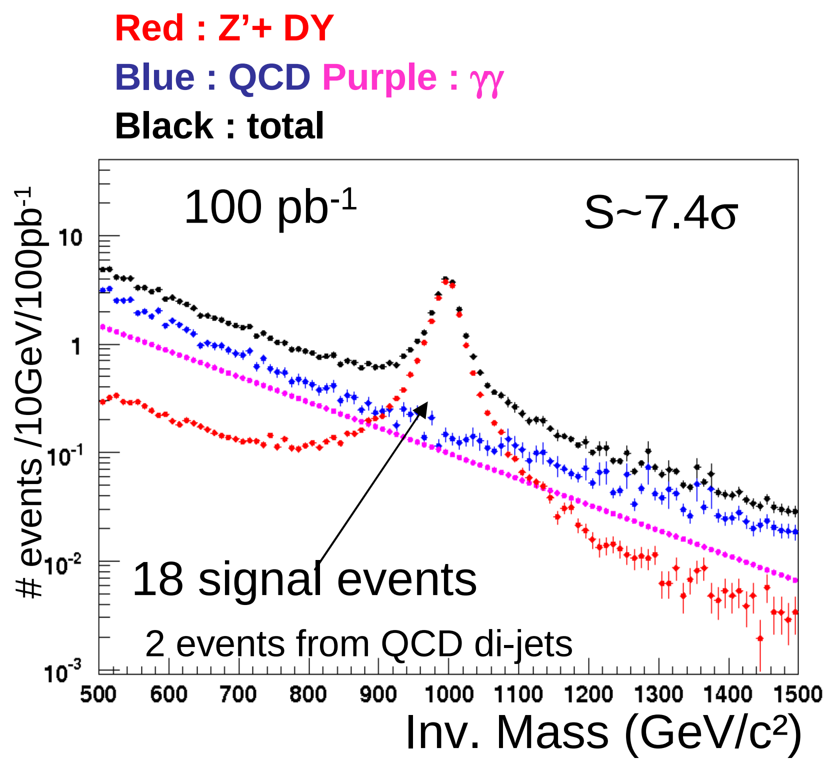
- So far, only EM Calo cuts on Clusters
- No photon rejection
    - $\gamma\gamma$ background : is ~5 times DY

Using the EM calorimeter only

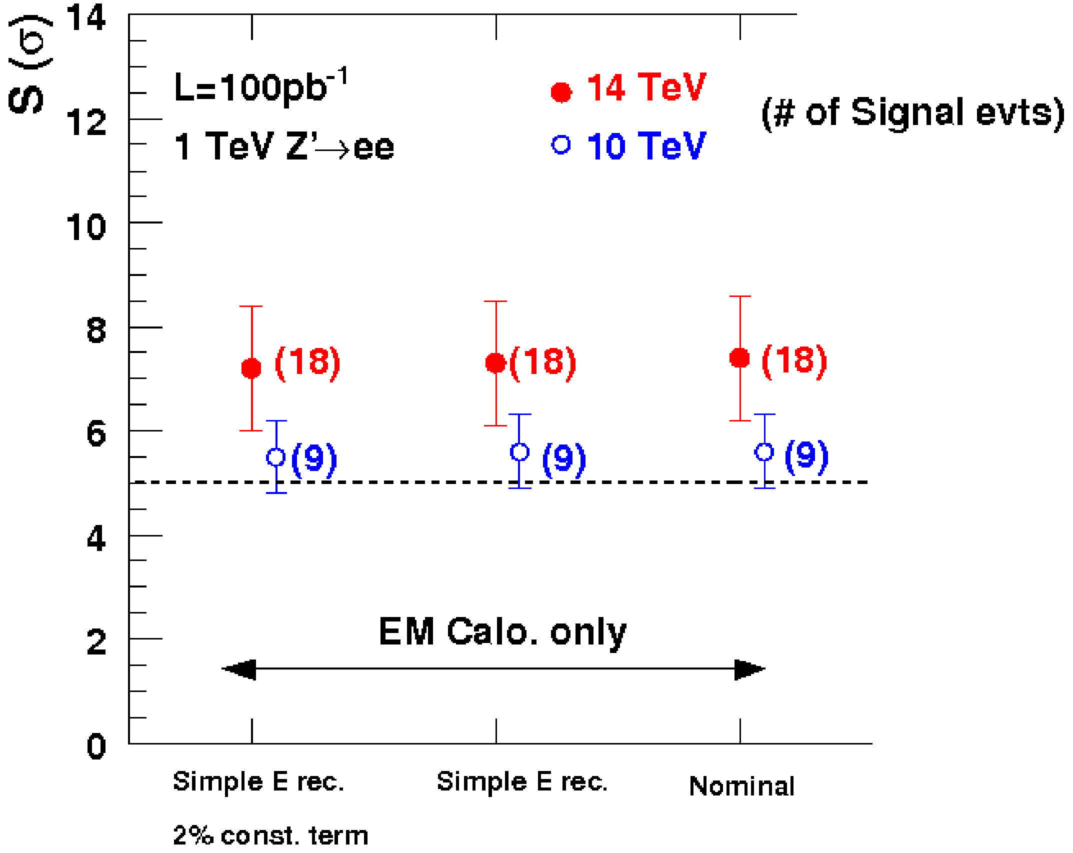
QCD background is dominant,
$\gamma\gamma$ contributes significantly

Significance :

$$S = \sqrt{2 \times \left((Sig + B) \times \ln\left(1 + \frac{Sig}{B}\right) - Sig \right)}$$



Z' Early Discovery
Using calo-only e ID



- EM calo performance does not alter the discovery potential
- EM Calo alone sufficient to discover Z' at 100 pb^{-1}
- Can use tracker to confirm signal and discriminate ee/$\gamma\gamma$ resonance

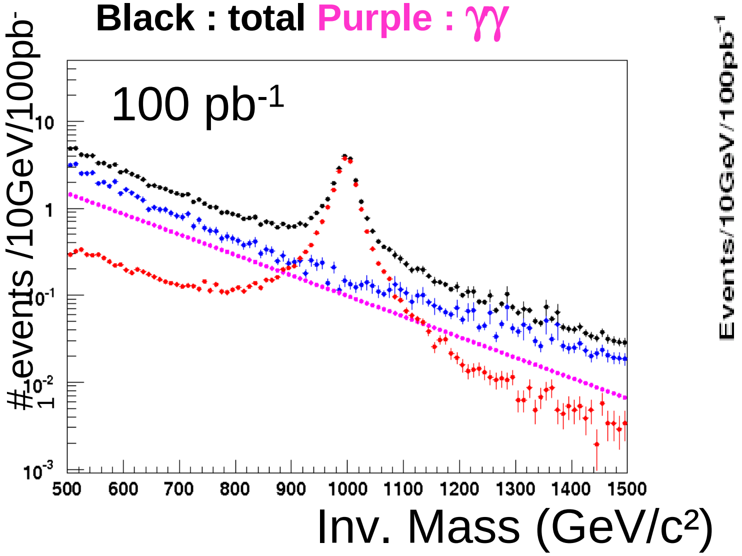
5σ discovery possible with 40 pb^{-1} using the EM calo. only

Including more of the detector..

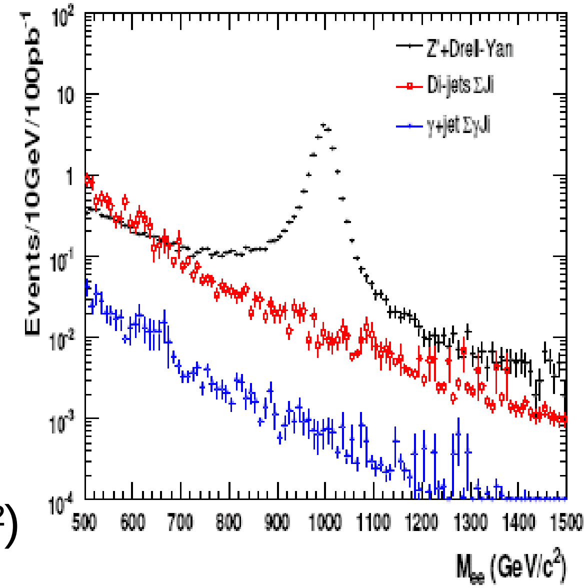
EM Calorimeter Only

Red : Z'+ DY **Blue : QCD**

Black : total **Purple : $\gamma\gamma$**



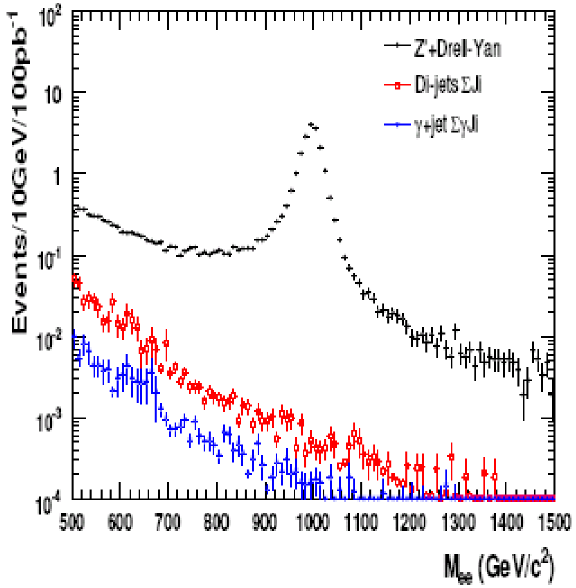
Including the Hadron Calorimeter



Remove the f3<4% cut

Add a hadronic leakage cut < 1%

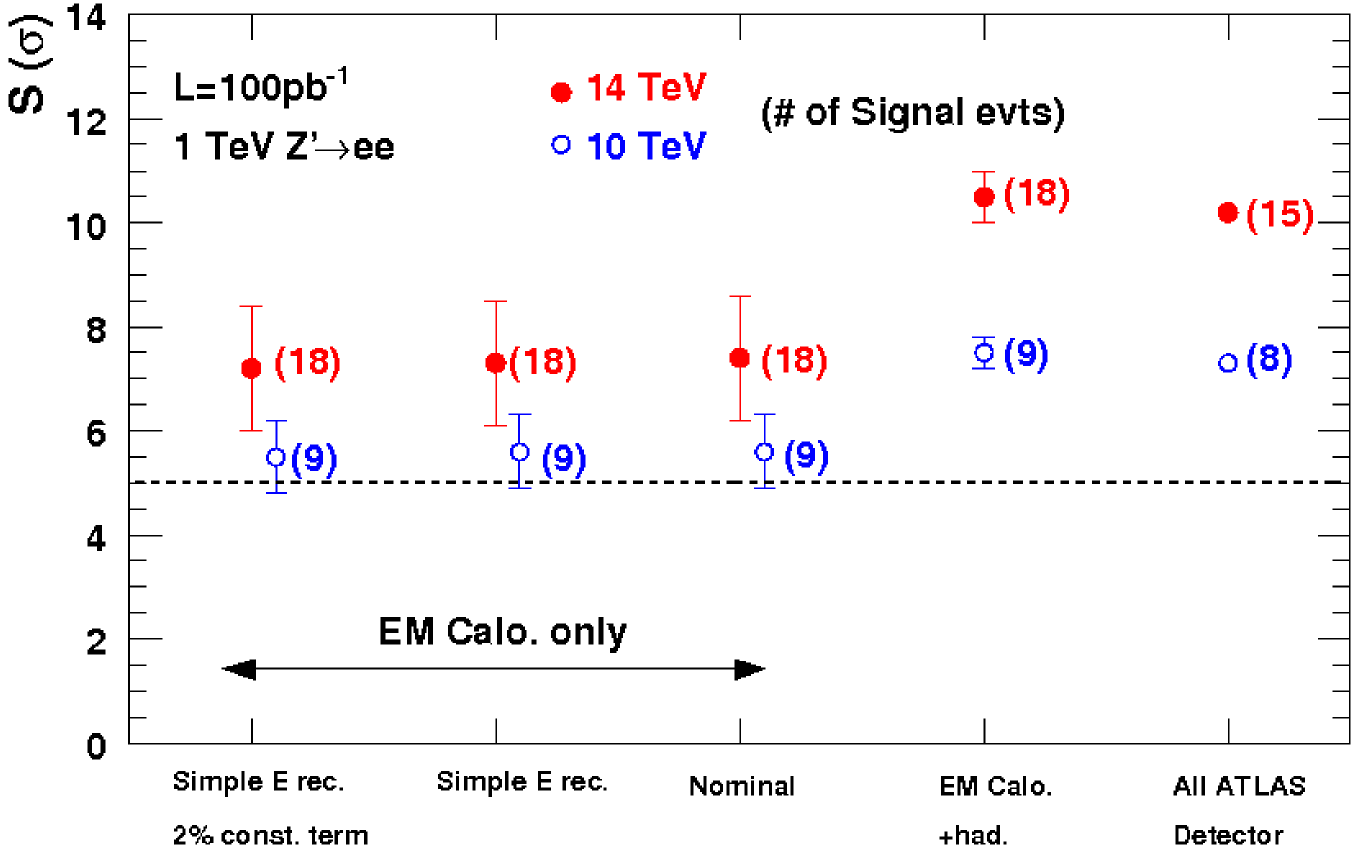
Including Tracking



Then add loose matching between EM cluster and a track

Dominant Background: **QCD** **$\gamma\gamma$** **DY**

Z' Early Discovery
Using calo-only e ID



5σ discovery possible with 40 pb^{-1} using the EM calo. only

Conclusions

- Even without a perfect detector – we still have an opportunity to discover new physics
  Using the EM calorimeter only:
  - 5σ discovery of $Z'_{\chi} \rightarrow ee$ possible with 40 pb^{-1}

- Using all of the ATLAS detector:
  - 15 to 50pb^{-1} for 5σ discovery of $Z'_{\chi,\eta,\psi,LR,SSM} \rightarrow ee$
  - 100 pb^{-1} are sufficient to discover Z' beyond the Tevatron limits: 1.2 TeV < $m_{Z'}$ <1.6TeV
  - Ultimate ATLAS reach for Z' 4 to 5 TeV (300 fb^{-1})

- But good to see we can look for evidence of new physics early on in data-taking.

- We look forward to collision data!

CSC dilepton/diphoton Note
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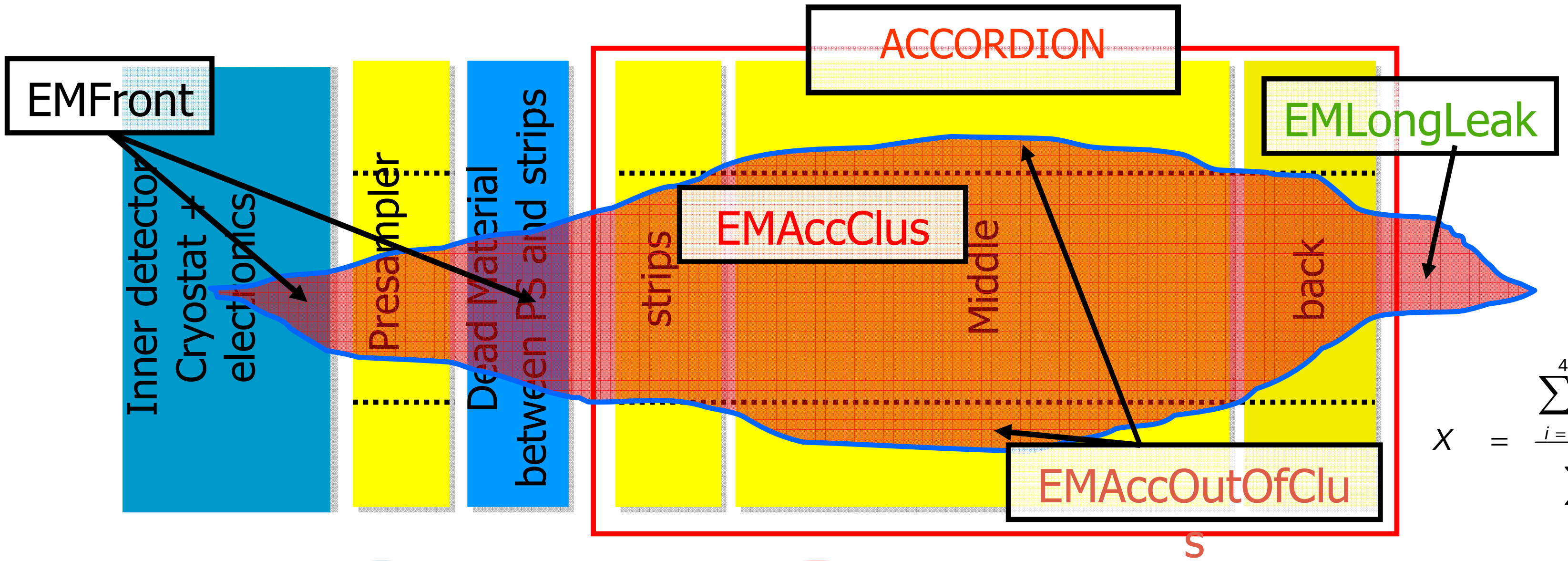
CalibHits based egamma calibration

- Compute corrections for each effect (from Monte Carlo) correlating each energy depositions to a measurable quantity
- Different parameterizations of the different corrections have been used (please refer to previous talks for more details)
- **Default calibration method from release 14.**



$$X = \frac{\sum_{i=1}^{4} E_i^{LAr} X_i}{\sum_{i=1}^{4} E_i^{LAr}}$$

$$E^{reco} = F(E^{reco}_{acc}, \eta) \cdot E^{cl\, lAr}_{ps} + S_{acc}(X,\eta) \cdot \left(\sum_{i=1}^{3} E_i^{cl\, lAr}\right) \cdot (1 + C_{out}(X,\eta)) \cdot (1 + f_{leak}(X,\eta))$$

Energy deposited in front of calo

Energy deposited into the cluster

Energy deposited out of cluster

Energy deposited behind calo

13.0.3 CSC Data samples

→ Z_χ' of 1 TeV + Drell-Yan in same sample
→ ~100k events of Z_χ' AND DY (extract ~82k Z_χ' from fit)

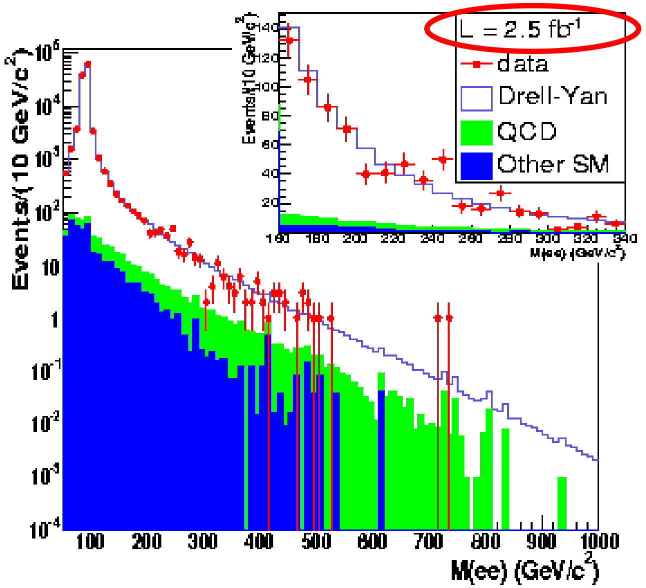
	CSC Sample	P_t range (GeV)	σ (nb)	# of events	Luminosity (pb^{-1})
Signal	5605	M_{ee}>500	376.5 10^{-6}	82k	217000
dijets J3	5012	70-140	588	1101k	1.87
dijets J4	5013	140-280	308	383k	1.24
dijets J5	5014	280-560	12.5	330k	26
dijets J6	5015	560-1120	0.36	306k	850
dijets J7	5016	1120-2240	5.71 10^{-3}	155k	27132

Samples generated with Pythia

Simu version : 12.0.6; reco version : **13.0.3** ; Geometry : CSC-01-02-00

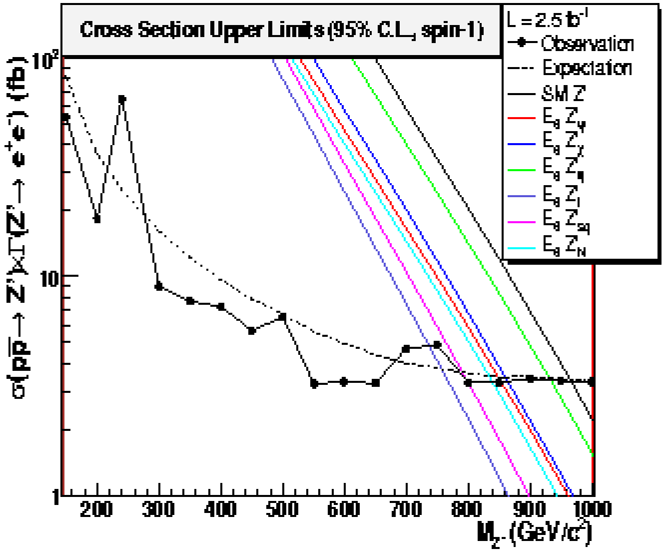
CDF High Mass ee Spectrum: Limits on Z' Bosons

CDF Run II Preliminary



Limits set with SM couplings and in E6 model

CDF Run II Preliminary



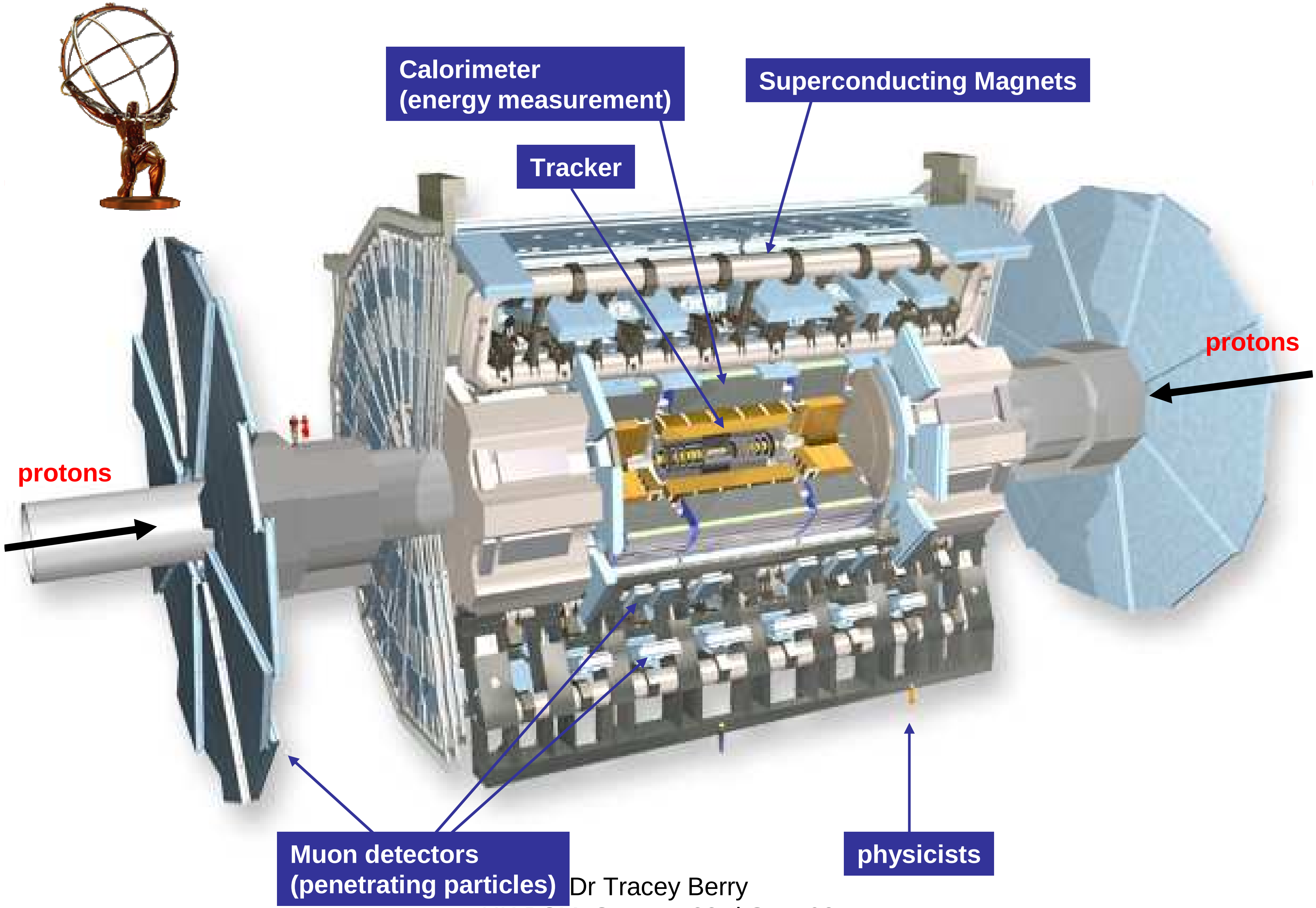
- Largest excess at M_{ee} = 228 – 250 GeV/c^2
- -> P-value= 0.6 % to see such an excess in 150-1000 GeV/c^2
- The 0.6% probability stands for a 2.5 sigma significance.
- D0 observed no excess

95 % C.L. Mass Limits

Model	Z'_{SM}	Z'_{Ψ}	Z'_{χ}	Z'_{η}	Z'_{I}	Z'_{sq}	Z'_{N}
Exp	965	849	860	932	757	791	834
Obs	966	853	864	933	737	800	840

Systematic uncertainties

- Systematic uncertainties:
  - Renormalization/factorization energy
  - PDFs: 5% @ 1TeV, 11% @ 3TeV
  - Efficiencies: 1%(e), 5% (μ,τ)
  - Energy scale: 1%(e), 5% (μ,τ)
  - Resolution: 20% e, 45% τ
  - Luminosity: 20% @100 pb^{-1}, 3% @ 10fb^{-1}
  - CSC dilepton Note


Calorimeter
(energy measurement)
Superconducting Magnets
Tracker
protons
protons
Muon detectors
(penetrating particles)
physicists

isEMLoose Selection Criteria

- i) no energy leakage in the first sampling of the hadronic calorimeter
- Ii) narrow lateral shower shape and width in the EM calorimeter second sampling
- Iii) a (loose) matching between the EM cluster and the reconstructed track

PLAN

1. Can we use the EM calorimeter only?

2. Impact of a realistic EM Calorimeter :

- Energy reconstruction at cell level

Checked *in situ* with cosmics data

  - Are confident in signal reconstruction over whole calorimeter coverage (*)
  - Absolute Scale ok within a few % at very low energy (**)
  - Saturation effects?
- Energy reconstruction at cluster level
- Constant term
- Trigger effects

(*) ATL-LARG-PUB-2008-01

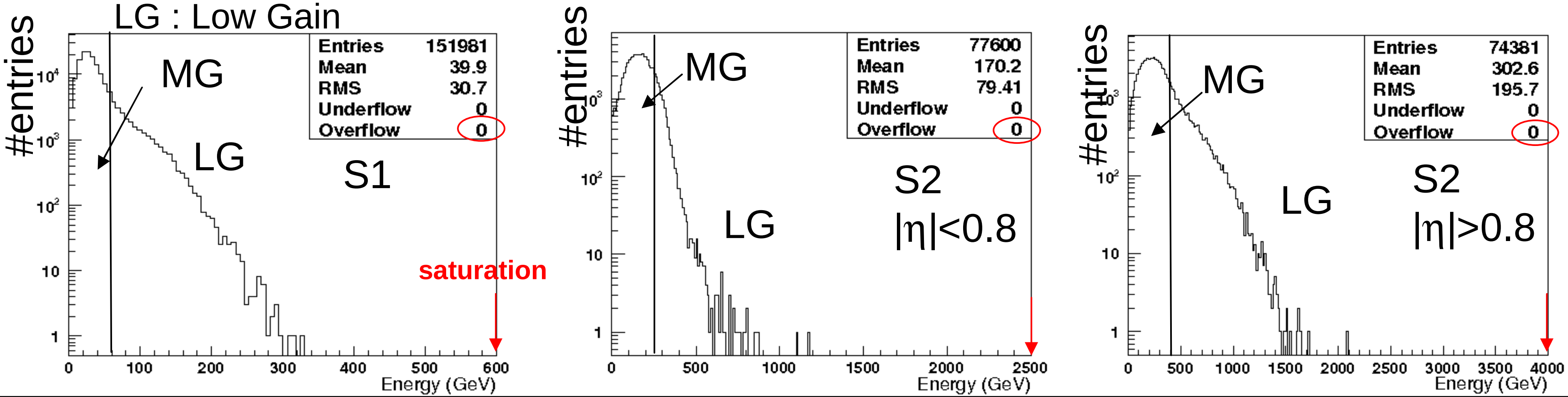
(**) ATL-LARG-PUB-2007-13

Saturation

- EM calorimeter has been designed to be able to see a Z'
- 3 electronic gains allow an energy reconstruction with a large dynamic range : from few tens of MeV to few TeV electrons

MG : Medium Gain
LG : Low Gain

Maximum energy cell in cluster



→ For 1 TeV Z', ATLAS is not affected by saturation

→ Extrapolation : 5% of S1 and S2 (|η|<0.8) cells will saturate for a 6 TeV Z'

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Energy reconstruction

- The calibrated energy reconstruction sums the weighted energies of clusters in the PS and the 3 layers.

$$E = \lambda\left(a + w_0 E_0 + E_1 + E_2 + w_3 E_3\right)$$

Link to material in front of the calo.

Link to longitudinal leakage

where λ, a, w_0, w_3 are η-dependant

λ, a, w_0, w_3 are determined from MC

- At the beginning of data taking, MC may (will) not fit correctly data.

Using a naive energy reconstruction:

$$E = (E_0 +) E_1 + E_2 + E_3$$

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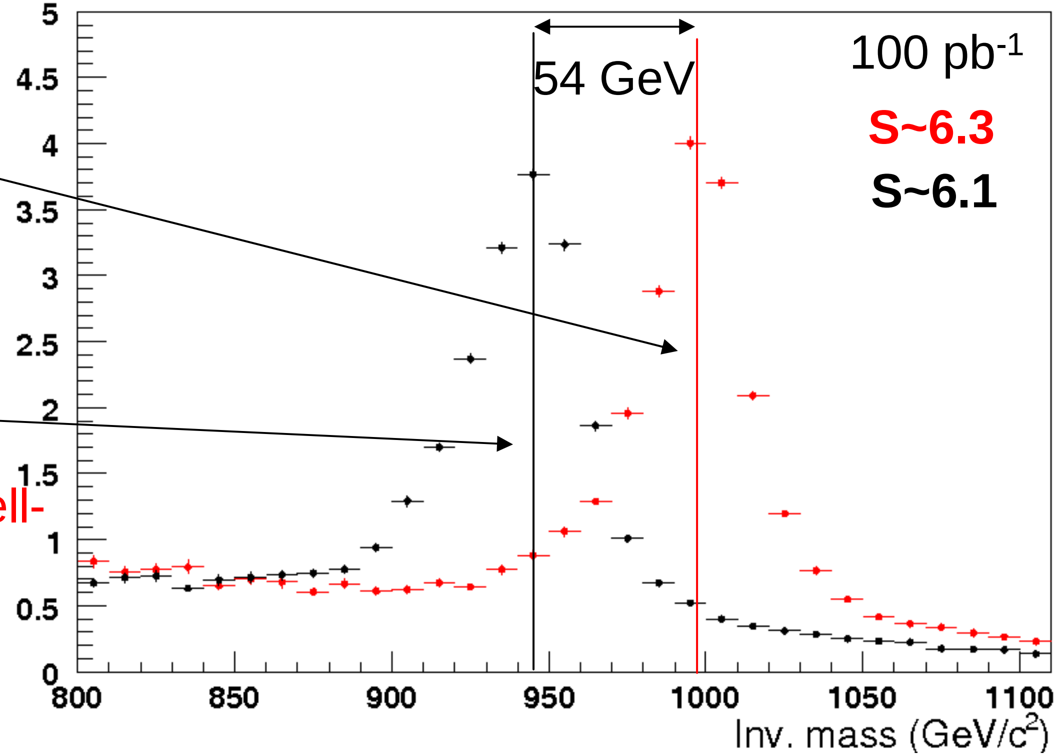
Calibration effects

Invariant mass spectra after our 3 EM calo simple identification cuts

~16 signal events
in [μ-3σ,μ+3σ]

~14 signal events
in [μ-3σ,μ+3σ]



Red: energy is reconstruted with well-tuned MC calibration coefficients

Black: energy is reconstructed with the simple sum of cluster energies

➔ Underestimate the resonance mass by 5.4%

➔ Do not loose significance with basic reconstruction

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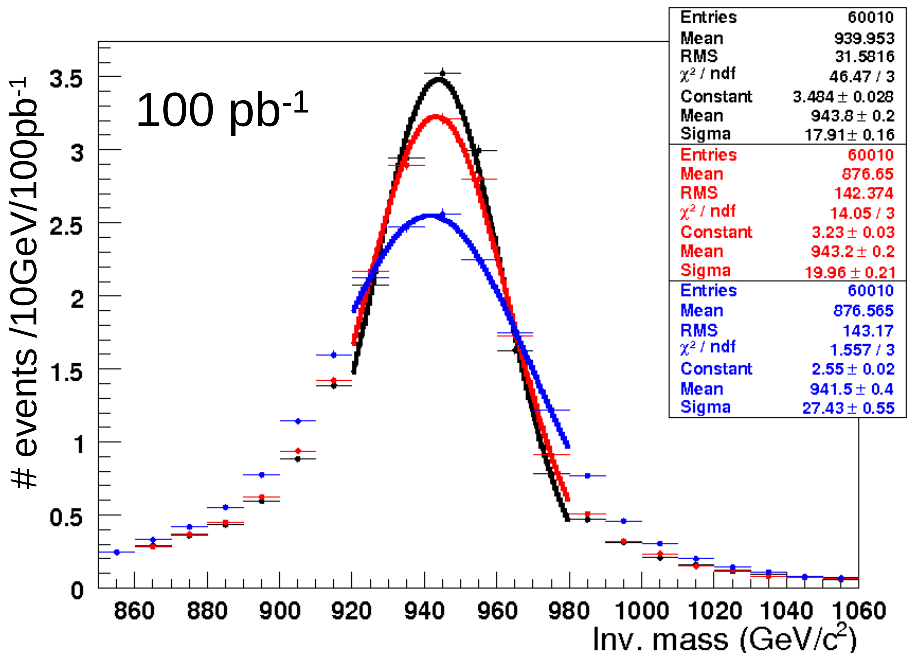
Energy Resolution: Constant term effects

- Constant term dominates resolution at high energy

$$\frac{\sigma}{E} = \frac{a}{\sqrt{E}} \oplus \frac{b}{E} \oplus c$$

- Has been carefully measured <1% in standalone beam test for 15% of modules (*)
- **But now, more modules, *in situ*, with matter in front of it …effects?**



Black : Default Constant term

Red : Constant term of 2%
(realistic at beginning?)

Blue : Constant term of 5%
(unrealistic case, CMS?!)

➔ Even in a realistic case, doesn't affect significantly the significance

(*) NIM A582 (2007) 429
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Trigger

→ At the beginning of data taking, only L1 Calo trigger used

→ Should not be a problem if L1 is well understood,

→ It is currently commissioned (connection, energy calibration…)

Trigger	Efficiency in full mass range	Efficiency in mass range [900;1100] GeV
L1_2e15	99.9%	100%
L1_2e15i	40.3%	32.5%
L1_e25i	82.4%	80.3%
L1_e100	**99.7%**	**99.96%**

Isolation not suited for high pt electrons

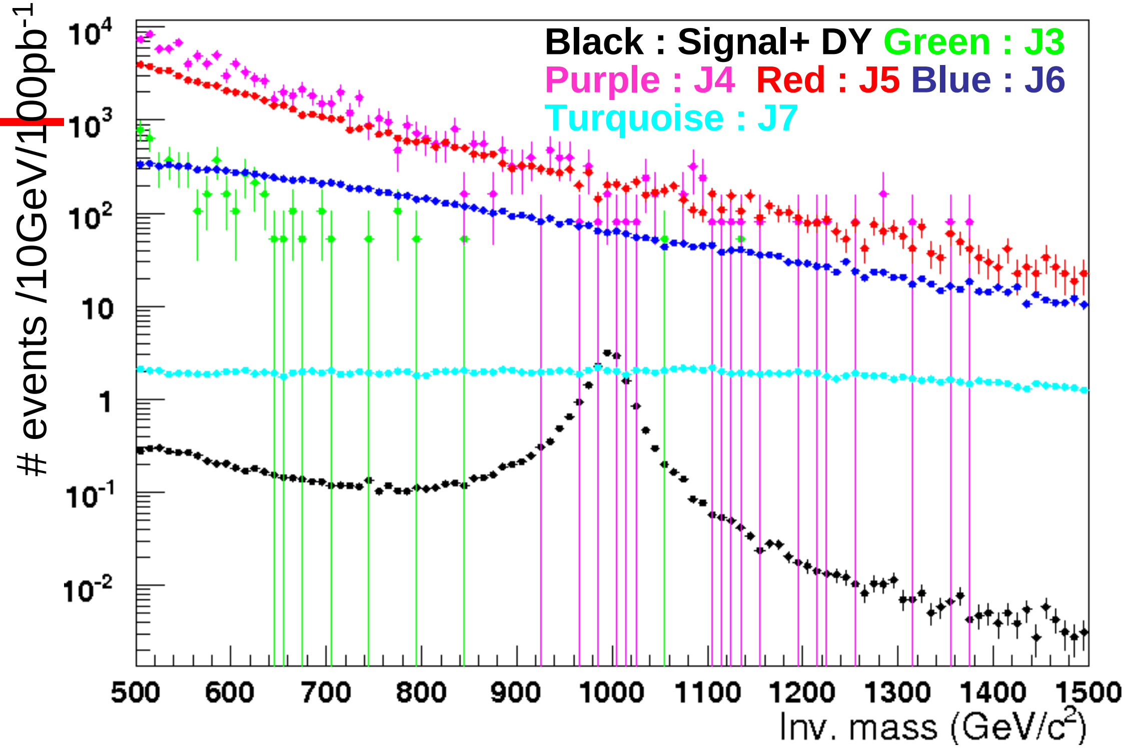
→ L1_e100 Trigger has a very good efficiency and may be used at the very beginning of data taking.

QCD Rejection (1)

<u>EM Clusters</u>

~~sliding window algorithm~~

- 2 highest Pt clusters
- Pt >15 GeV
- |η| < 2.47
- Large exclusion around EM calo crack (1.3 <|η| < 1.6)



→ 3 orders of magnitude between signal and QCD background *

Challenges :

Can we reject it by a factor 1000 only with EM Calo?

Can we do it keeping a good efficiency? (signal limited search)

(*) In the following, rejection does not exclude real electron in QCD background

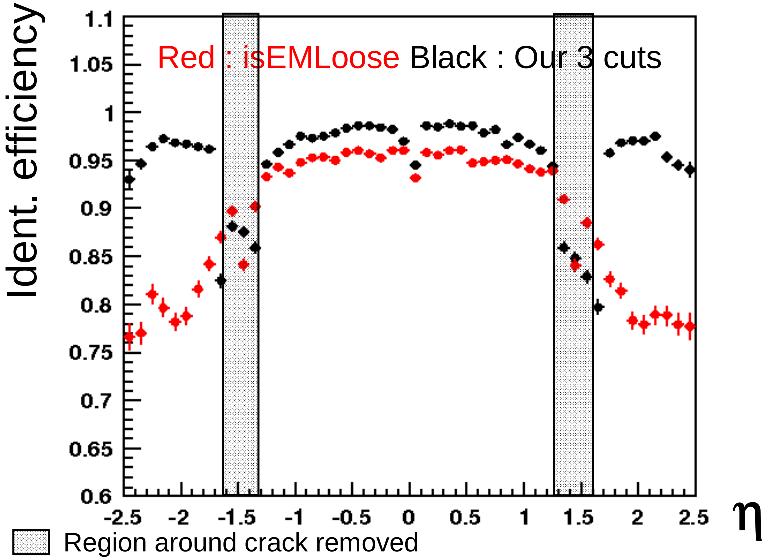
QCD Rejection Summary

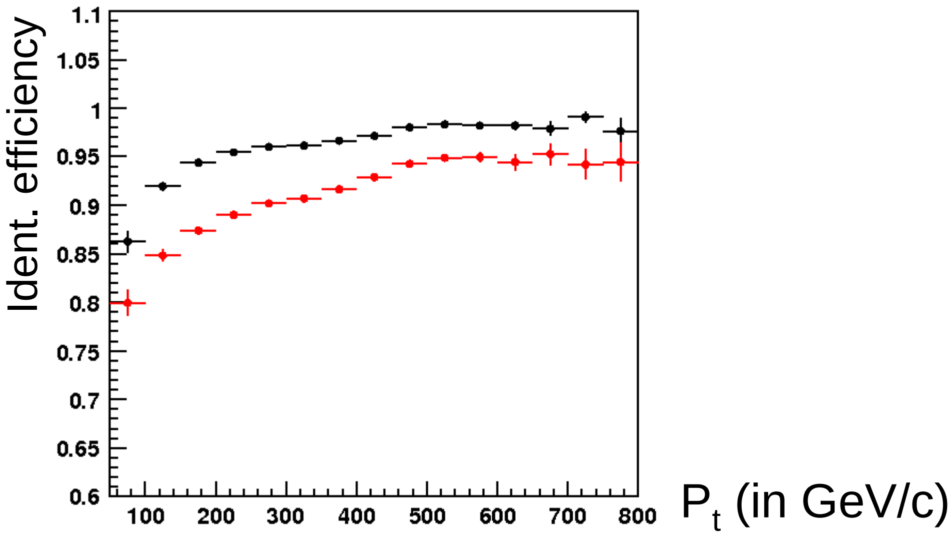
3 simple, calorimeter based, η-independant cuts :

→ Fraction of energy in S3 <0.04, >85% of energy in a 3x3 cluster, Width in S1 < 2.5

Cuts	Ident. Eff.	J5 Rejection	J6 Rejection
Our 3 cuts	**96.5%**	**48**	**31**
IsEmLoose Selection	**91.5%**	**40**	**54**

Similar rejection of QCD background





→ Better efficiency with our 3 cuts (Mainly in End-caps) than with isEMLoose

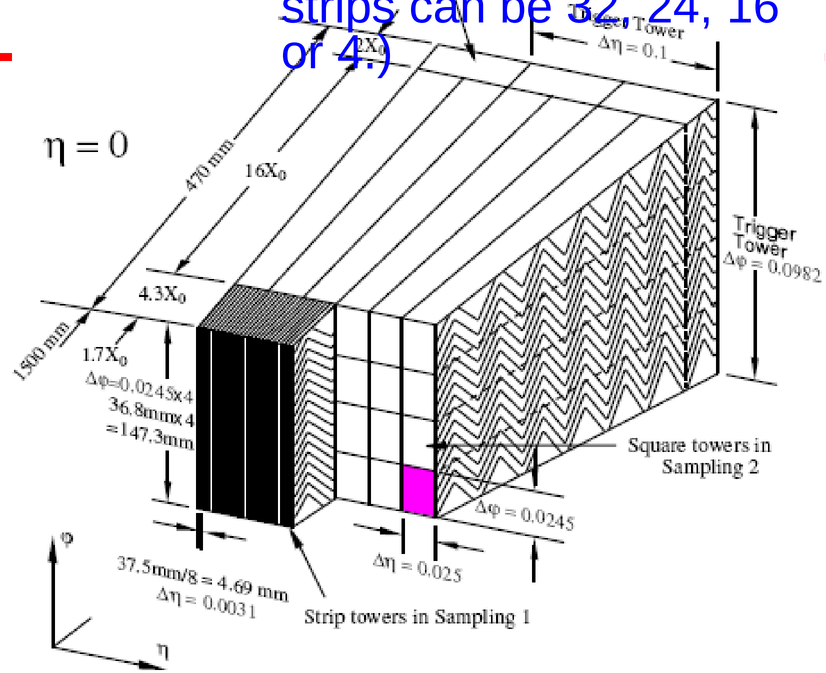
→ Important for discovery as search is mainly signal limited

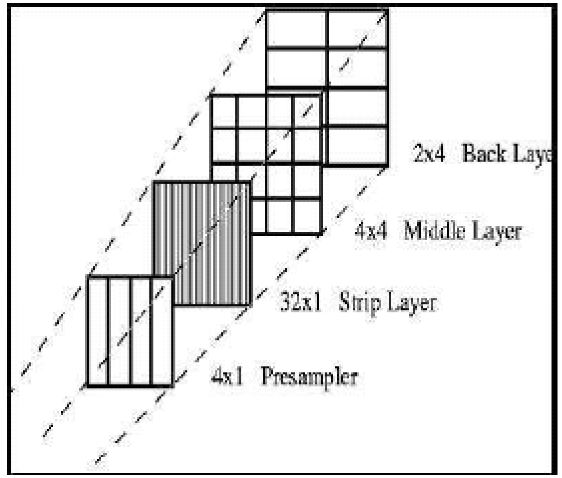
→ Similar cuts for Z signal extraction at start-up

Electromagnetic Calorimeter Granular

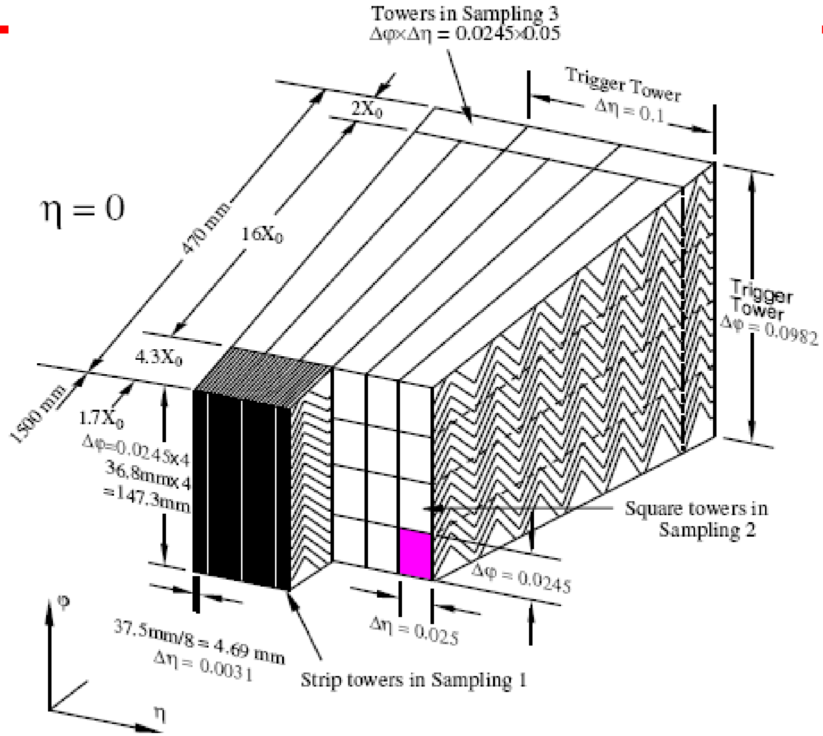
- Sketch of $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$ region of the EM calorimeter with different layers in depth. In the endcaps, the number of strips can be 32, 24, 16 or 4.)

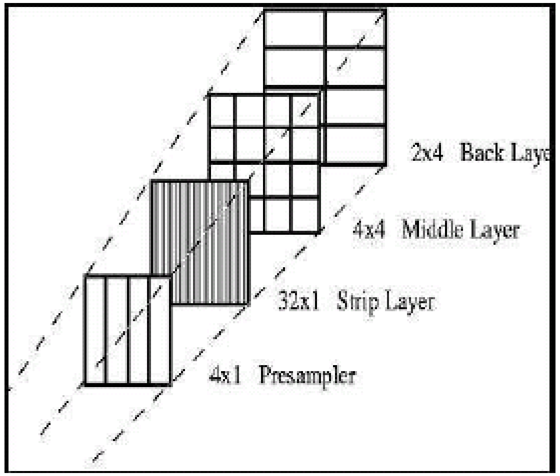
- ATLAS precision region $|\eta|<2.5$
- Excluding $1.4< |\eta|< 1.5$
- The EM cal. is divided in depth in 3 projective compartments: S1, S2, S3
- (It is segmented into 170 000 read-out channels)
- A thin presampler (PS) detector of 0.1X0 is also present for $|\eta|<1.8$ with the η granularity of S2 and the ϕ granularity of S1.
- There is a “crack” region between the EM barrel and endcap: $1.37 <|\eta|<1.52$. (So energy reconstruction will be challenging in this region – conservatively extend this region to $1.3< |\eta|<1.6$.)





Electromagnetic Calorimeter Granularity

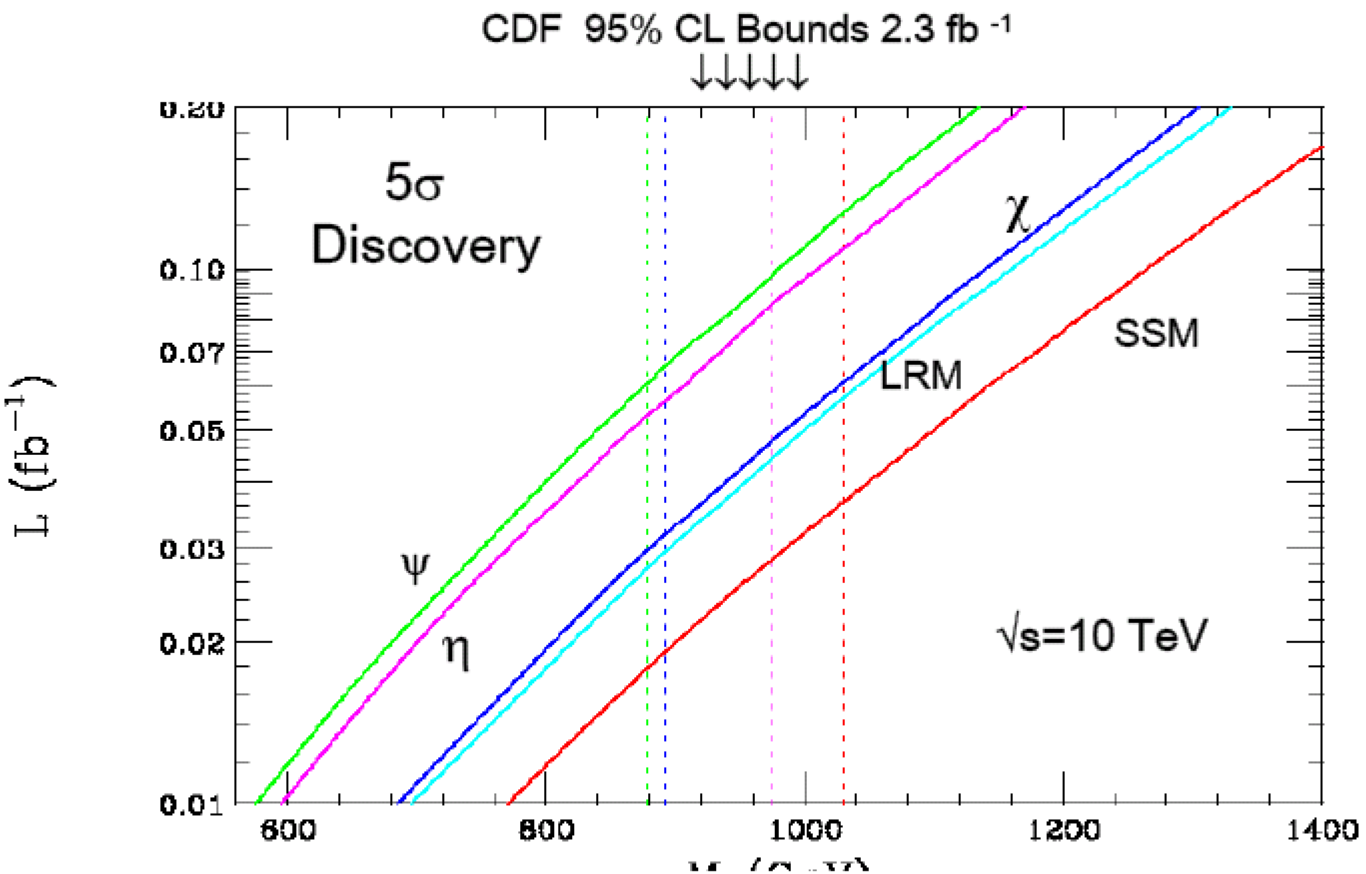




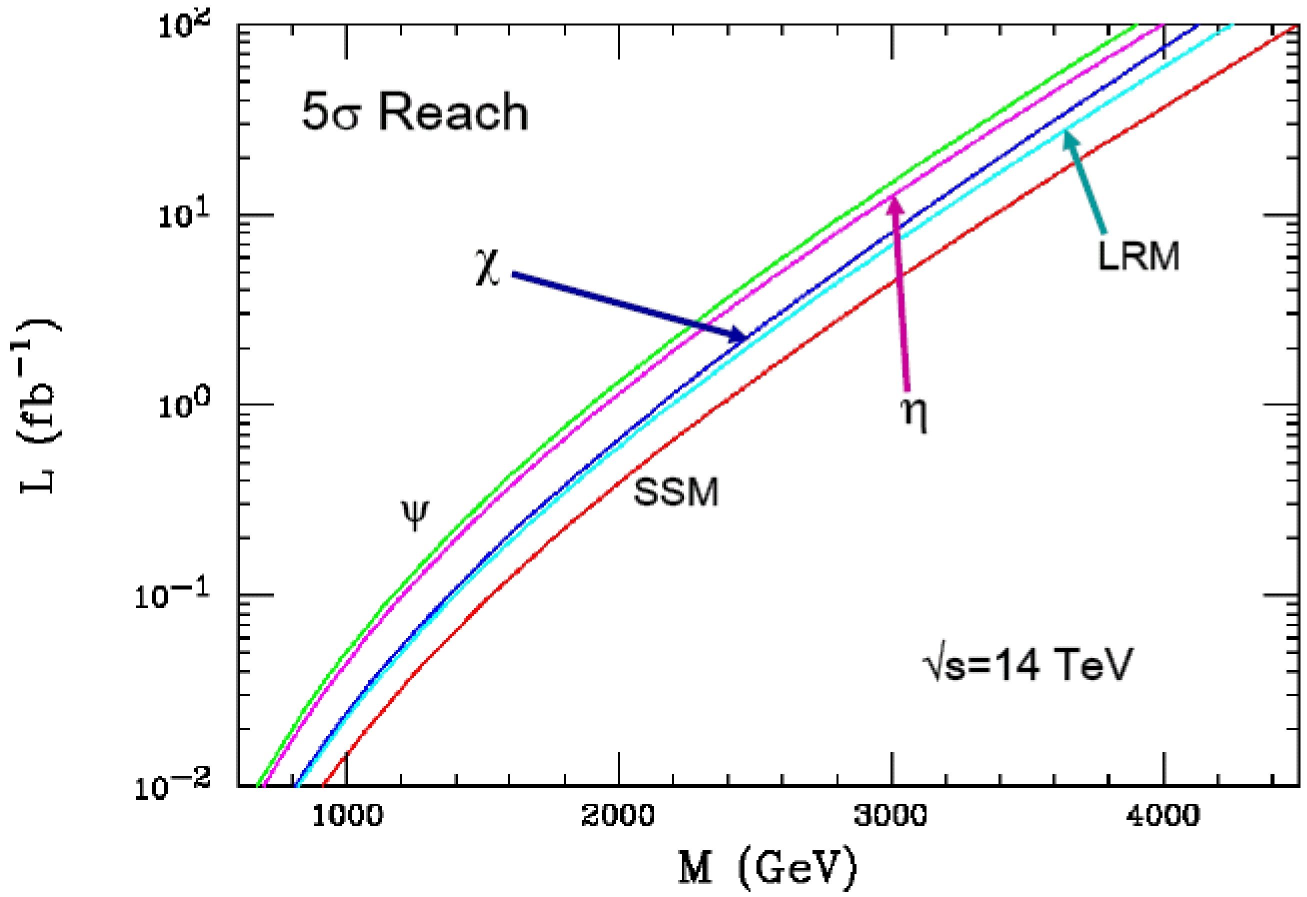
Region	Compartments ($\Delta\eta \times \Delta\phi$)			
	PS (0.025×0.1)	S1 ($0.025/n^* \times 0.1$)	S2 (0.025×0.025)	S3 (0.050×0.025)
Barrel	112×64	896×64	112×256	54×256
Endcaps	24×64	424×64	80×256	40×256
Total	8704	84480	49152	24064

Table 4: *Number of cells ($\eta \times \phi$) in the precision region of the EM calorimeter, $|\eta| < 2.5$, without the zone $1.4 < |\eta| < 1.5$ around the crack. *n=1, 4, 6, 8, depending on* η.

Z'→ leptons is a very clean mode and may provide the first signal of new physics to be observed at the LHC…*even* with √s=10 TeV and a low integrated luminosity…



Eventually the Z’ 5σ reach will extend up to 4 TeV and beyond for `conventional’ GUT-inspired models once sufficient lumi is accumulated….



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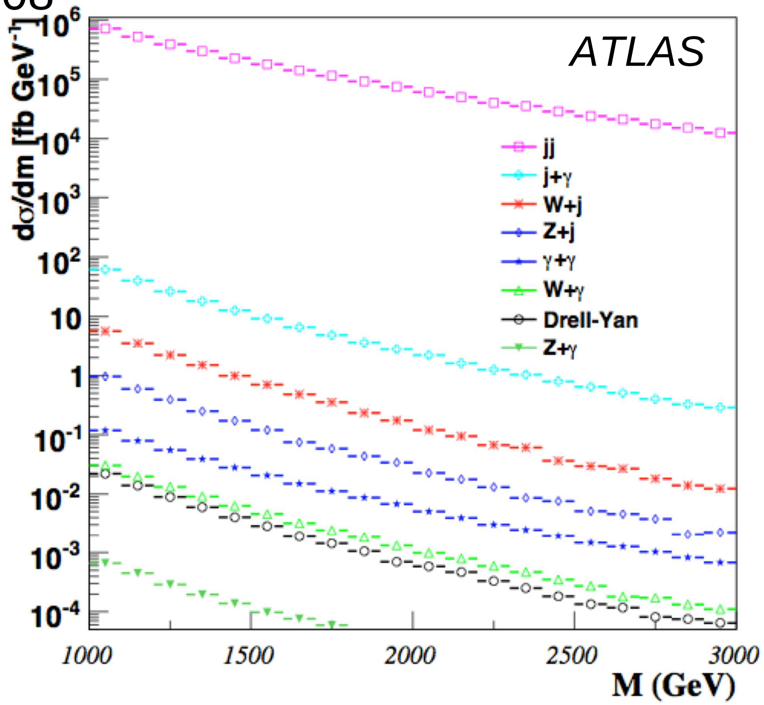
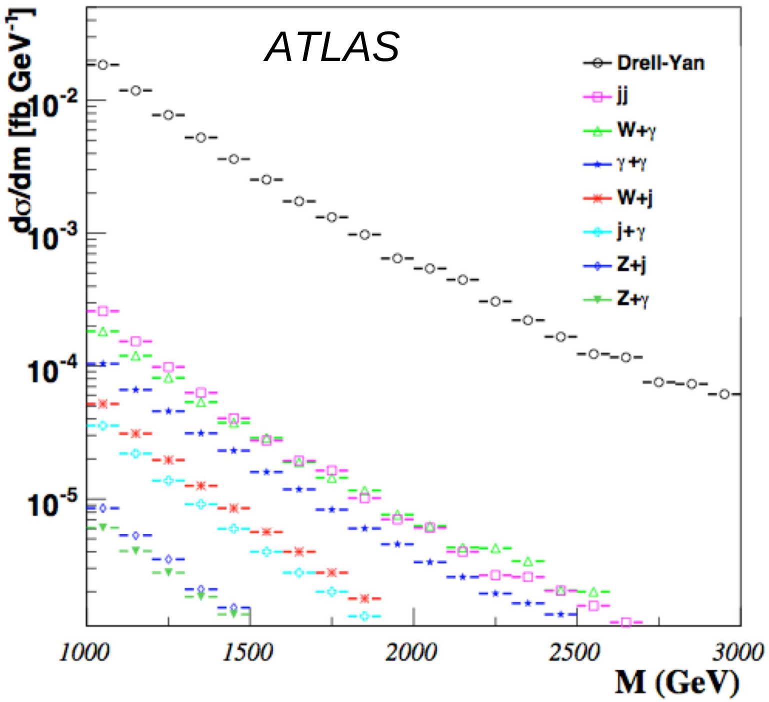
Standard Model: backgrounds





- Source of (ir) reducible background: (non $\tau\tau$)
  - Drell-Yan
  - Jet→e, γ→e contamination
  - e and μ production from Z and W decay
- Cuts:
  - $R_{e\text{-jet}}=10^4$, $R_{e\text{-gamma}}=10$, Pt and pseudorapidity ($R_{e\text{-jet}}$ & $R_{e\text{-gamma}}$ varied by a factor 2)
  - The Drell-Yan is the dominant background
- Muons are cleaner & $\tau\tau$ studied separately (see below)

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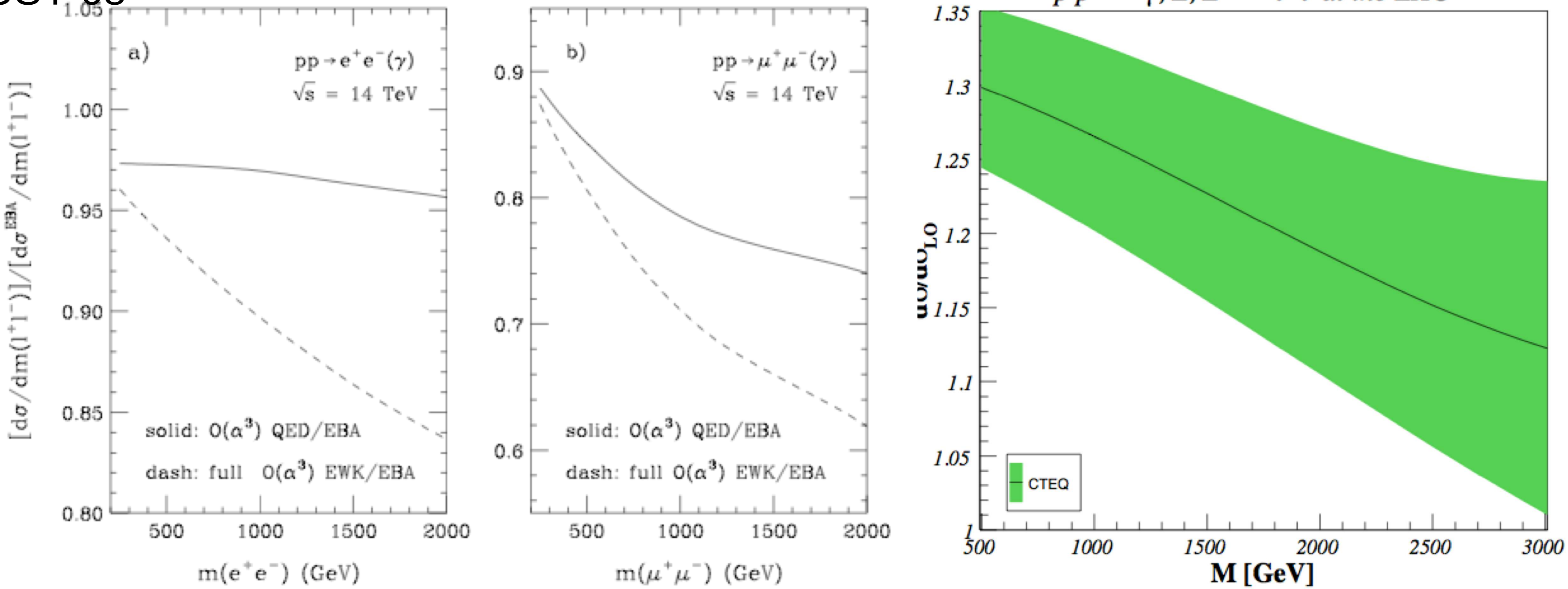
Standard Model: NLO corrections



- 2 independent studies: γ,Z,Z' and γ,Z
- ee and μμ studied separately
- EW corrections -12to-18% for ee, -4to-16% for μμ
- QCD corrections using MC@NLO
- Combination QCD/QED re-summation

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Conclusion

- Sensitivity to exotic dilepton resonances:
  - $Z' \rightarrow ee$, 15 to 50pb^{-1} for 5s discovery of $Z'_{\chi,\eta,\psi,LR,SSM}$
  - $Z' \rightarrow \mu\mu$, 20pb^{-1} for 5σ discovery of Z'_{χ}
  - $Z' \rightarrow \tau\tau$, 1fb^{-1} gives 3.4 σ for $m_{Z'}$=600GeV
  - $G^* \rightarrow ee$, 5σ dicovery @ 1fb^{-1}: up to m_{G^*}=1.5 TeV
  - TC$\rightarrow$mumu, 5σ discovery @ 1fb^{-1}: up to m_{TC}=600GeV
- 10 to 100 Pb^{-1} are enough to go beyond the Tevatron limits for most of dilepton resonances

CDF Excess – p value

- To estimate the probability of observing an excess equal to or greater than the maximum observed excess anywhere in the search range of 150-1,000 GeV/c2, we run 100,000 background only simulated events. The maximum -2log&lambda anywhere in the search range is recorded in each simulated event. The probability of observing an equal or greater excess anywhere in the 150-1,000 GeV/c2 mass range is defined as the fraction of simulated events with an equal to or greater than maximum -2log&lambda that shown in real data, which is 14.38 in this analysis and it is found to be 0.6%. The 0.6% probability stands for a 2.5 &sigma significance.

- http://www-cdf.fnal.gov/physics/exotic/r2a/20080306.dielectron_duke/pub25/duke.html

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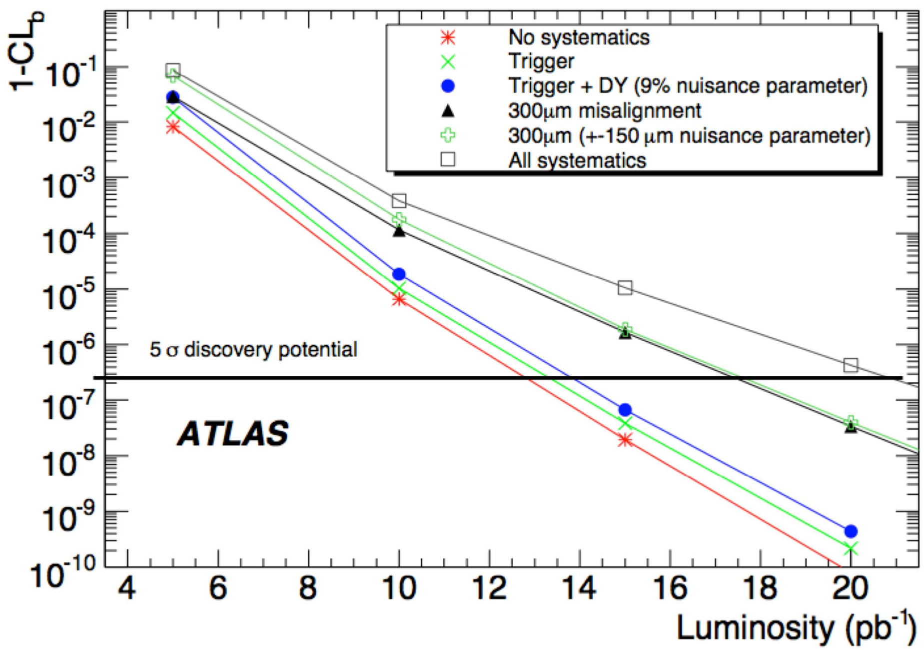
Exotics: Z'→mu-mu

- Complement to Z'→ee, ~~especially when the~~ designed rejections are not reached.
- SSM and χ models investigated of 1 & 2 TeV
- Sensitivity computed using FFT
- Systematics (5σ discovery):
  - Standard uncertainties has modest effect:
    - 13 → 14 pb^{-1} @ $m_{Z'}$=1 TeV
  - Alignment is the main source of degradation:
    - 14→ 20 pb^{-1} @ $m_{Z'}$=1 TeV

Sample	Z' (1 TeV SSM)	Z' (2 TeV SSM)	Z' (1 TeV χ)	Drell-Yan ($M \geq 800$ GeV)
Generated	508.6	23.8	380.6	13.5
$\lvert\eta\rvert \leq 2.5$	366.8	18.1	271.5	10.8
$p_T \geq 30$ GeV	364.0	17.9	270.1	10.7
Muon identification	342.3	17.0	256.0	10.0
Trigger	325.2	16.2	243.2	9.5
Opposite charge	324.8	16.2	243.0	9.5



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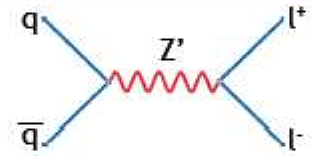
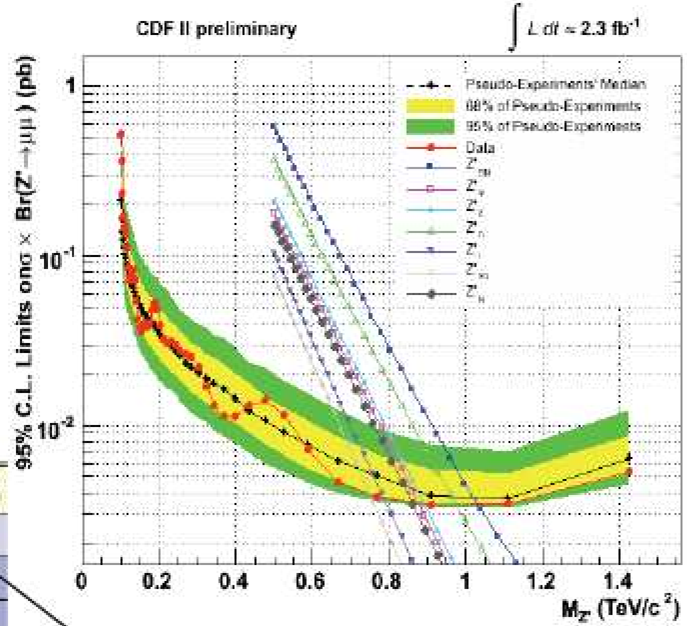
High Mass $\mu\mu$ Spectrum - Limits on Z' Bosons



- Limits set with SM couplings and in E6 Model
- Approaching kinematic limit for some models

CDF II preliminary $L = 2.3\ fb^{-1}$

Model	Mass Limits, 95% CL (GeV/c^2)
Z' (SM)	1030
Z' (η)	975
Z' (χ)	892
Z' (ψ)	878
Z' (N)	861
Z' (I)	789
Z' (sq)	754

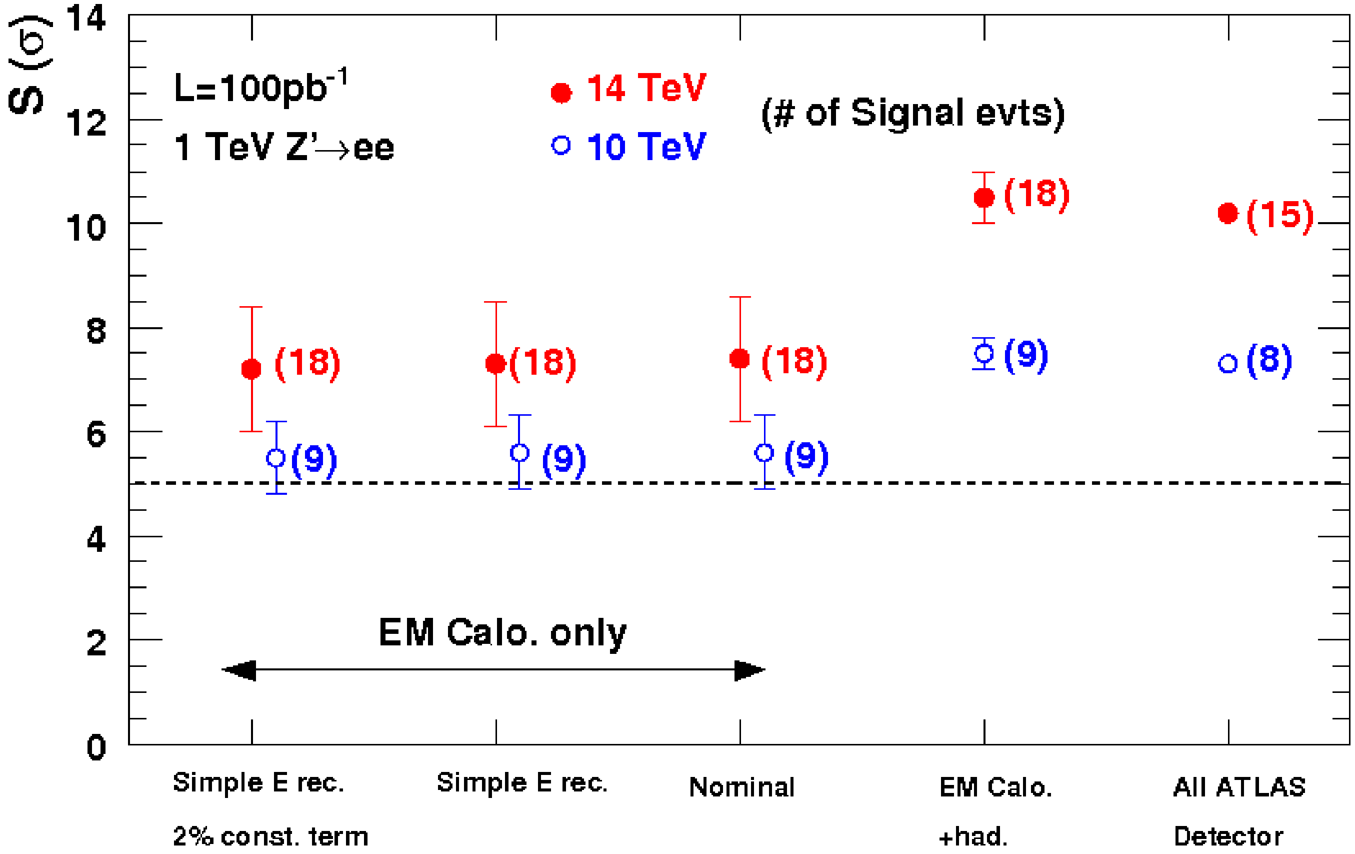


- For the first time beyond the one TeV mark

...world's best limit

Z' : Early, calo-only discovery

Pierre-Simon Mangeard, F. Hubaut, P. Pralavorio
(CPPM/IN2P3)



- **Updated results**
- **Study documented in ATL-PHYS-INT-2008-020**

For earliest data
Consider simple
Calorimeter only
electron identification

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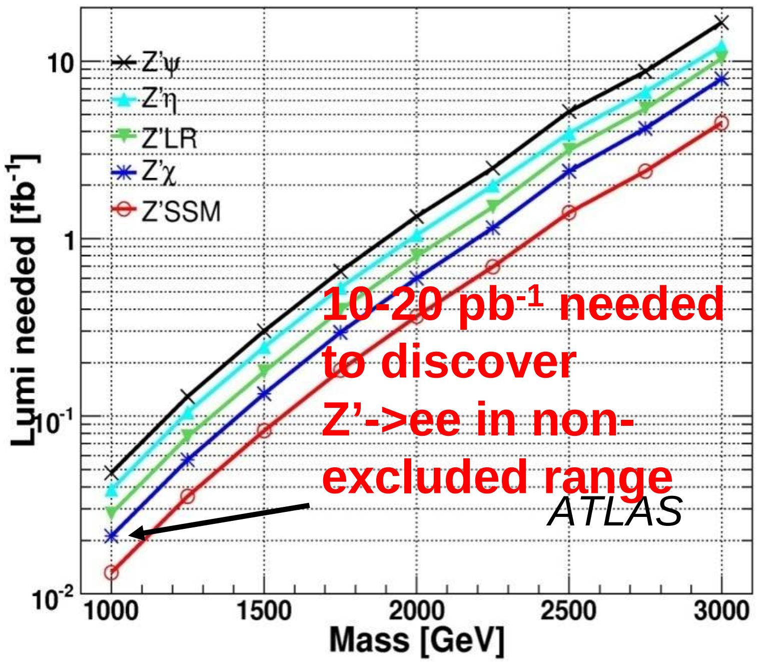
ATLAS Z' Discovery Potential

Selection	Signal at 1 TeV	DY at 1 TeV	Signal at 2 TeV	DY at 2 TeV	Signal at 3 TeV	DY at 3 TeV
	347	3.56	14.7	0.16	1.22	0.015
2 generated $e^{\pm}$, $\lvert\eta\rvert < 2.5$	299	3.07	13.7	0.15	1.16	0.013
2 clusters with a track	201	2.06	8.0	0.09	0.62	0.009
2 *loose* electrons	190	1.96	7.2	0.08	0.52	0.008
At least one $p_T > 65$ GeV	190	1.96	7.2	0.08	0.47	0.008
Event triggered	173	1.77	6.6	0.07	0.43	0.007
2 opposite charges	166	1.70	6.2	0.07	0.41	0.007

- Fully simulated Z'_χ with 1,2 and 3 TeV
- Mass spectrum generation for ψ, η, χ, LR and SSM models:
  - Parameterisation of both Drell-Yan and Z's
  - Width Z' resonances
- FFT methods used: DY<1%
- Uncertainties on the DY have negligible effect
- 100 pb^{-1} are sufficient to discover Z' beyond the Tevatron limits:

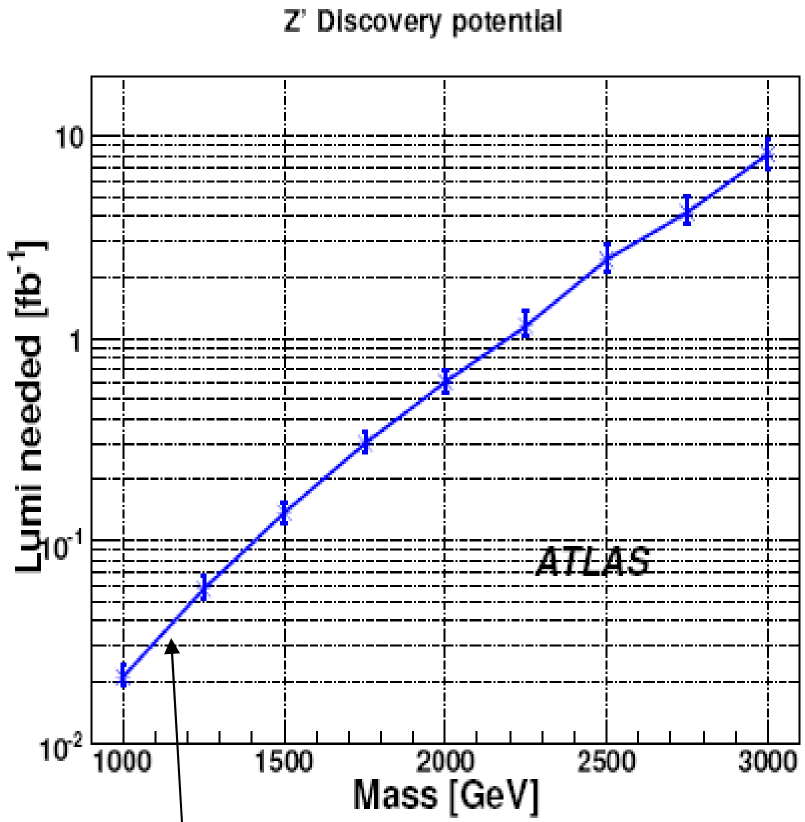
  1.2 TeV < $m_{Z'}$ <1.6TeV



10-20 pb^{-1} needed to discover Z'->ee in non-excluded range

Lepton Searches in Early Data

- Early discoveries possible in simple channels
  - Benchmark Z'->ee as "easy case"
- Main systematics
  - Electron ID ~ 3.5% uncertainty on event selection
  - Higher order corrections and PDF uncertainties on DY cross section ~8.5%



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Julien Morel
Fabienne Ledroit

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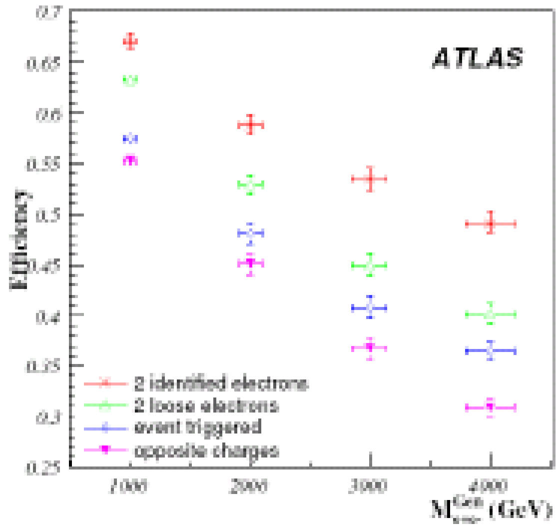

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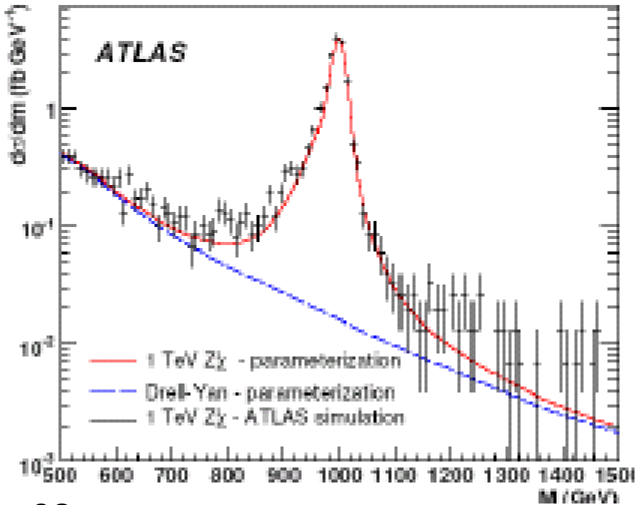
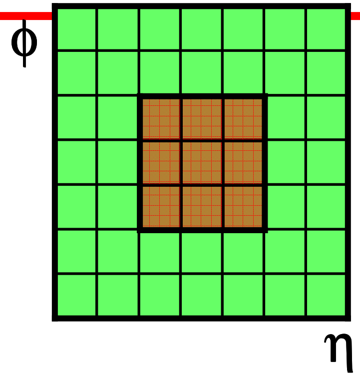
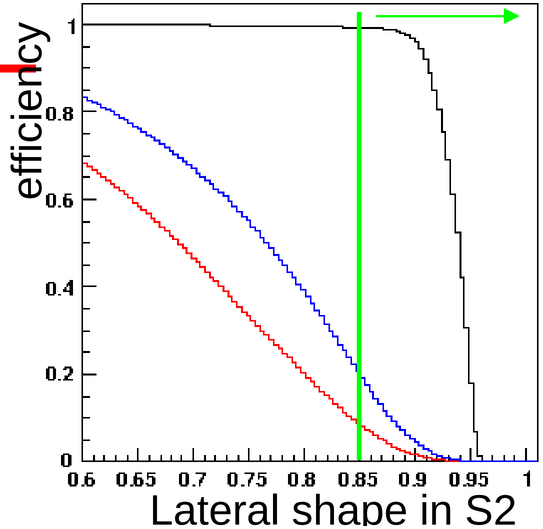


QCD Rejection

Black : Signal Red : J5 Blue : J6

2 & 3) Lateral Shape in EM calo





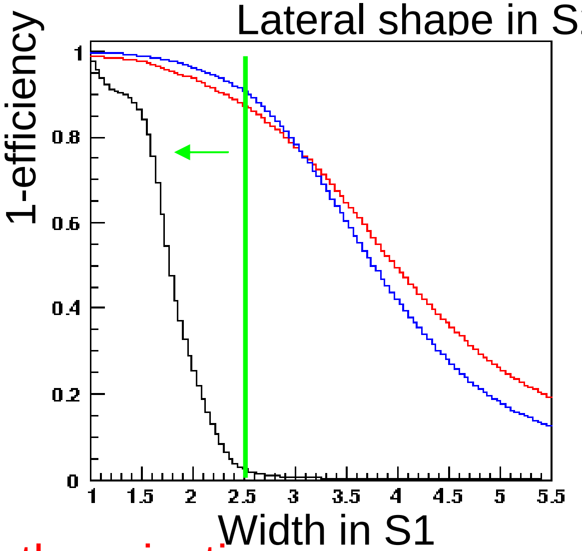
Energy mainly deposited in S2

→ Ratio: E(3x3)/E(7x7)

Granularity is higher in S1

→Width of EM Shower in S1

$$w_{tot} = \sqrt{\sum_{i=1}^{40} E_i \times (i - i_{\max}) / \sum_{i=1}^{40} E_i}$$



Cuts	ID Eff.	J5 Rejection	J6 Rejection
f3 < 0.04 (1)	99.1%	2	2
(1) + S2 >0.85 (2)	98.5%	18	9
(1) + (2) + S1<2.5 (3)	96.5%	48	31

η independant cuts on lateral shape increase significantly the rejection

QCD Rejection

- 3 simple, calorimeter based, η-independant cuts :

→ Fraction of energy in S3 <0.04, >85% of energy in a 3x3 cluster, Width in S1 < 2.5

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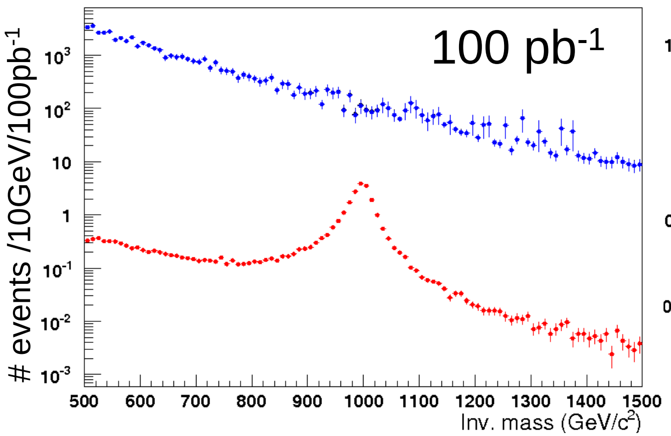
Similar rejection of QCD background

→ Better efficiency with our 3 cuts than with isEMLoose

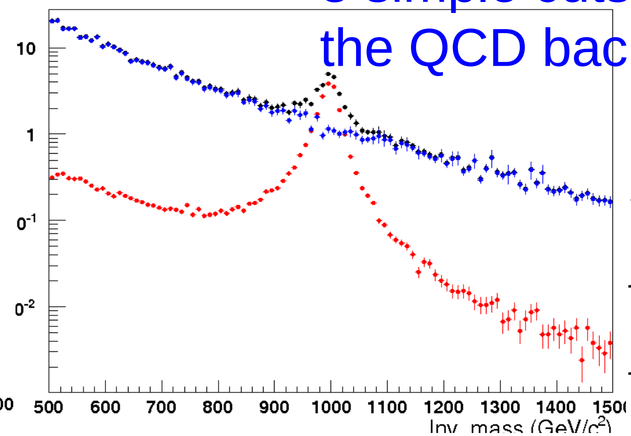
→ Important for discovery as search is mainly signal limited

Red : Z'+ DY Blue : QCD Black : total

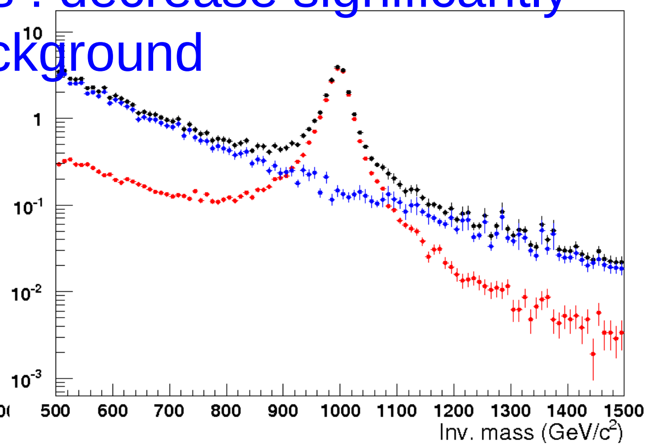
3 simple cuts : decrease significantly the QCD background



f3 <0.04



f3 <0.04
lateral shape S2 >0.85



f3 <0.04
Lateral shape S2 >0.85
S1 width <2.5