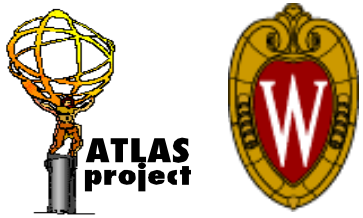
Higgs->ZZ->4e with full ATLAS simulation

S.Armstrong B.Mellado, S.Paganis, Sau Lan Wu

University of Wisconsin



ATLAS Higgs WG, CERN, Dec/1 2003

Outline

- LAr electron energy linearity, resolution and comparison with TestBeam:
  using TestBeam results in a Higgs analysis

- H->ZZ->4e analysis with TDR cuts.
  - Higgs Mass resolution 130,150,180,200,300 GeV
  - 4e Efficiencies vs Background Rejection
  - Effects of the new layout to the signal
  - Comparison with TDR studies.

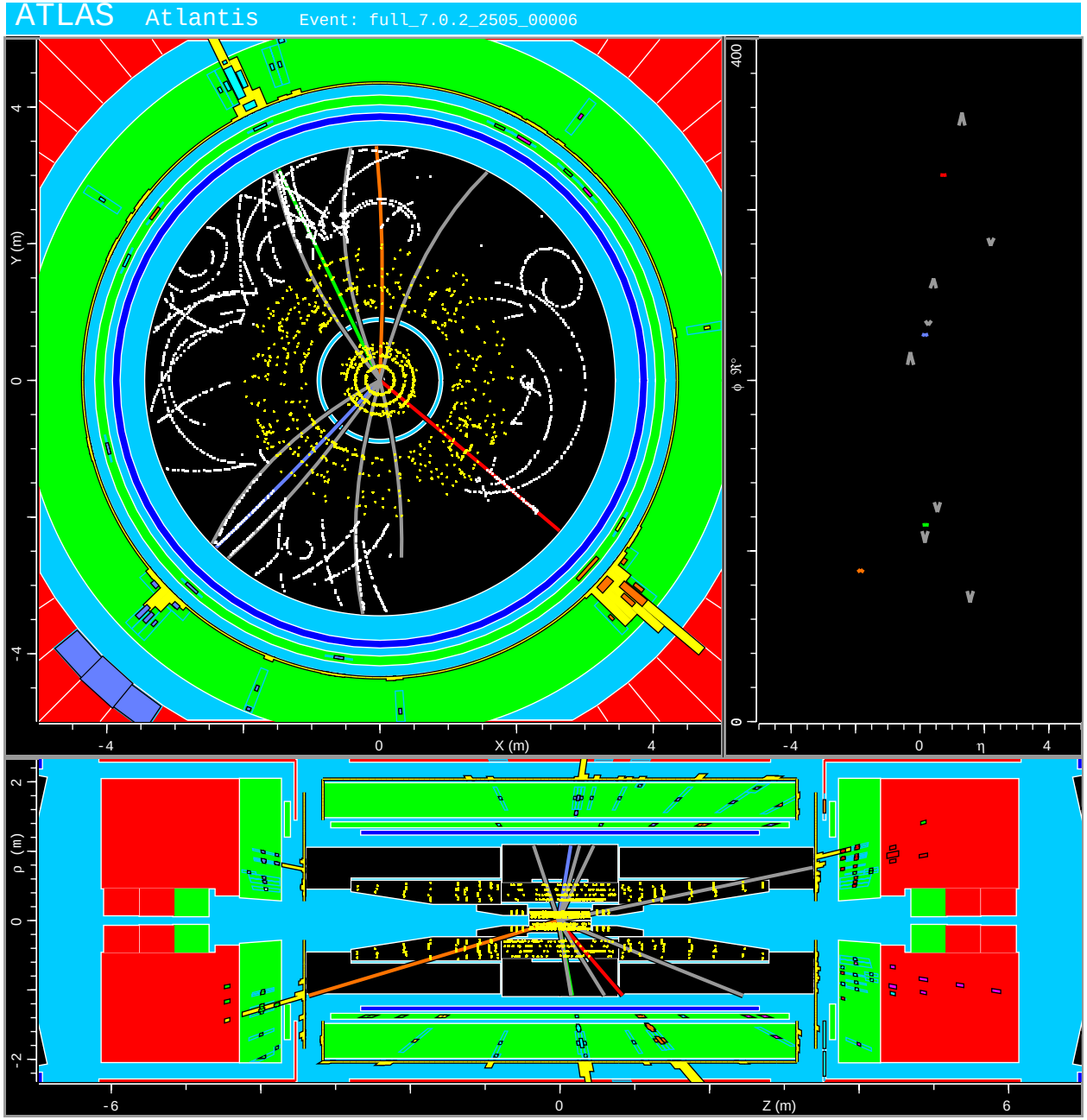
- Application of EM-cluster weights based on the cluster nature to recover Higgs signal loss

Monte-Carlo Samples (A. Stradling and B. Mellado)

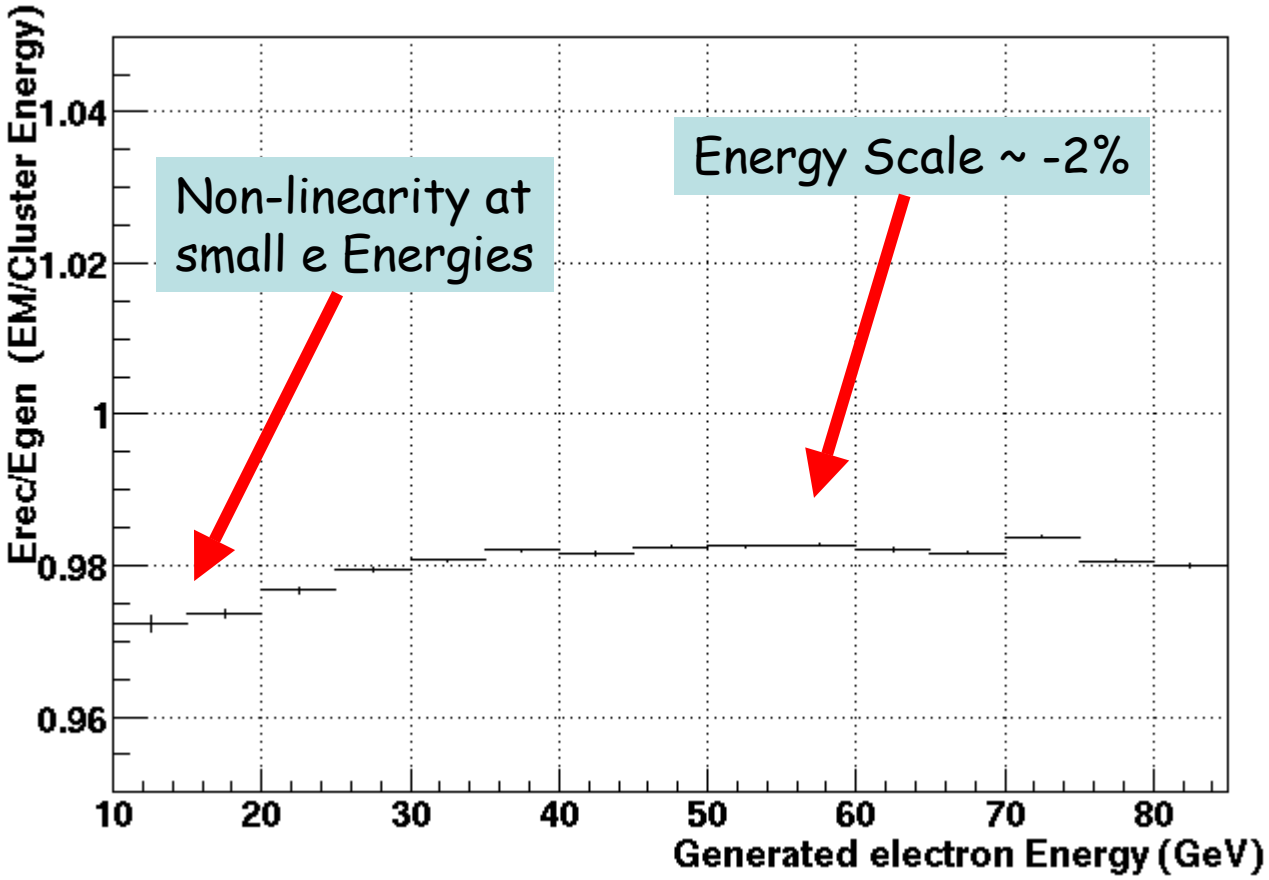
- 5x70k events H->ZZ->4e:
  M_{Higgs}=130, 150, 180, 200, 300 GeV
  Pythia 6.203, Recon Offline Release 6.0.3
  pt(e) > 4GeV, $|\eta| < 2.7$
- 43k events ttbar->4e (MC@NLO)
- 15k events pp->ZZ->4l Pythia
- DC1 samples
- No Zbb and $\tau\tau$ll backgrounds yet!

Events in CASTOR available to the ATLAS collaboration

- No noise
- No pile-up
- No PHOTOS FSR

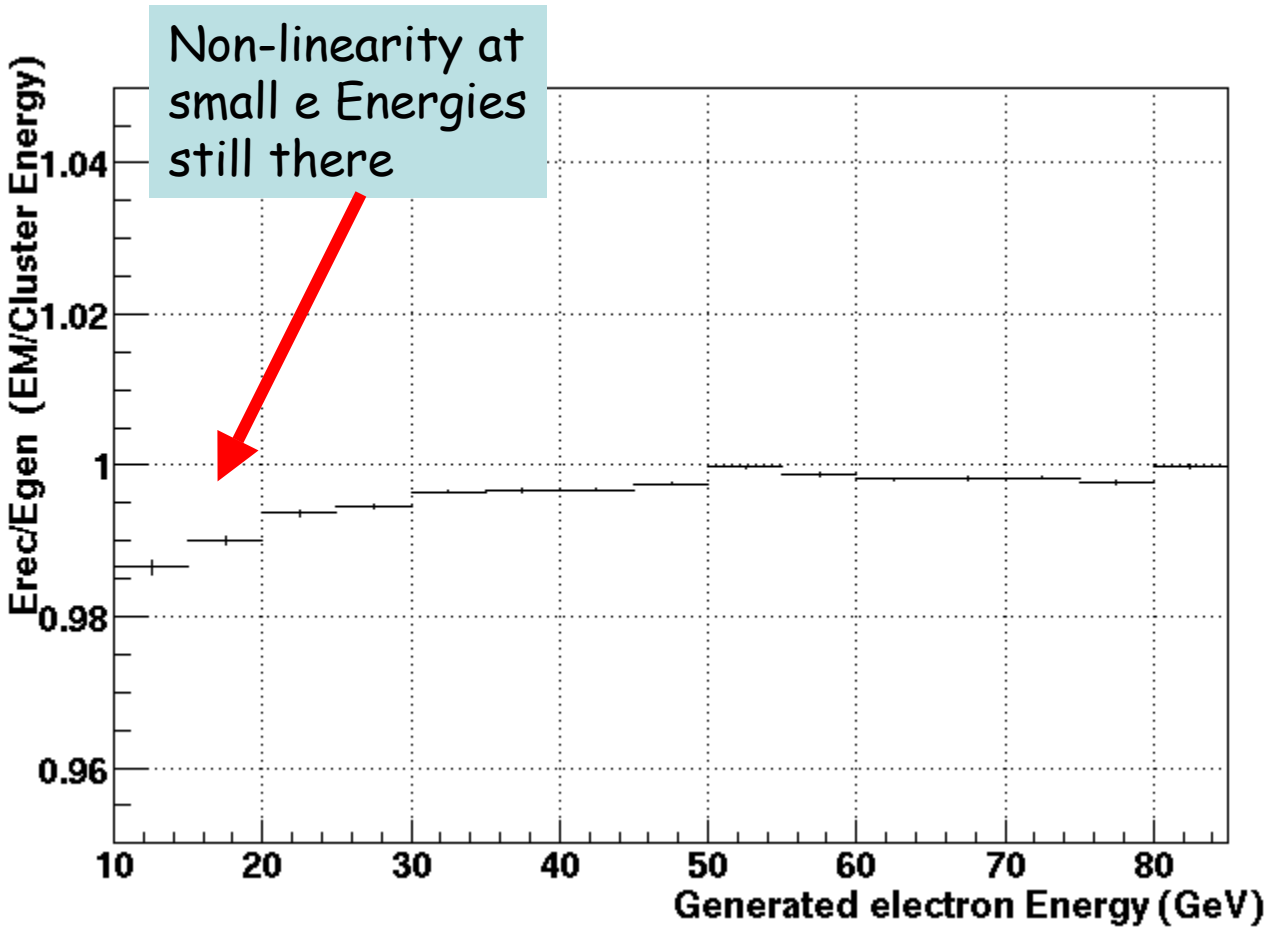


EM cluster energy corrections

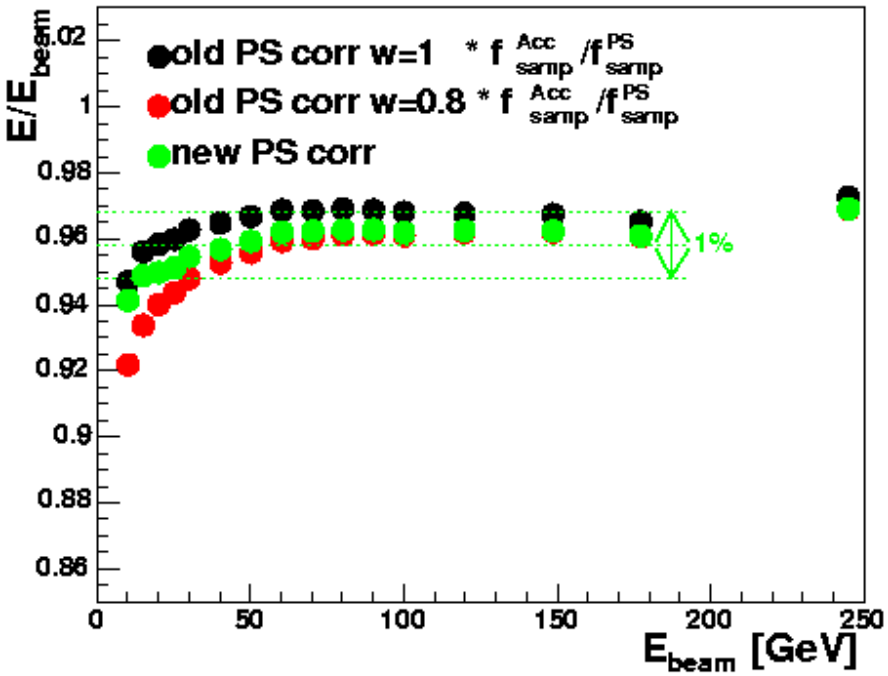


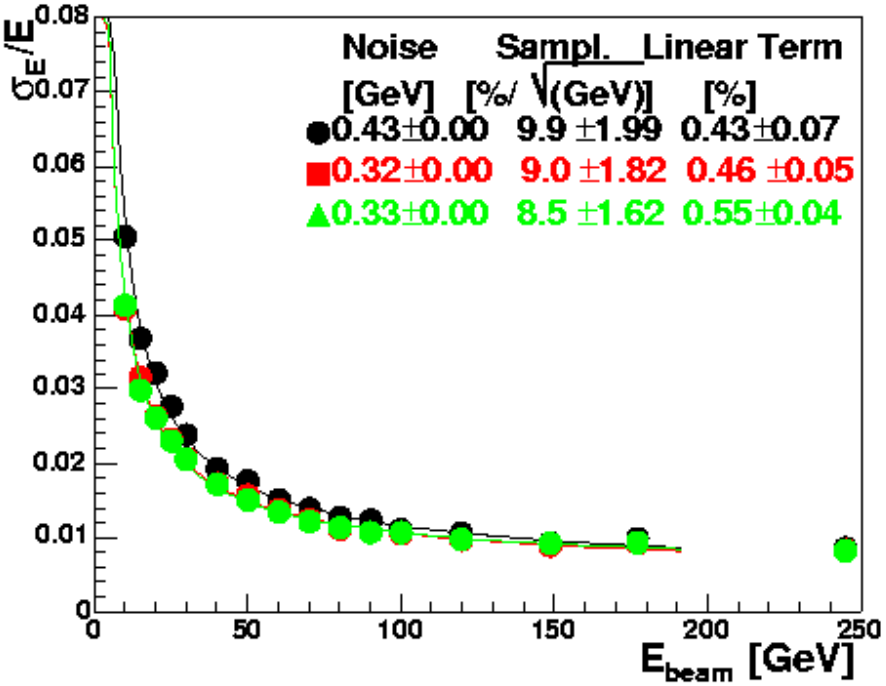
We performed a fit to obtain an η dependent Escale correction

Result of an EM Escale correction as a function of η



Test-Beam Data: the presampler correction is not constant (Tancredi Carli et al, Nov/03)

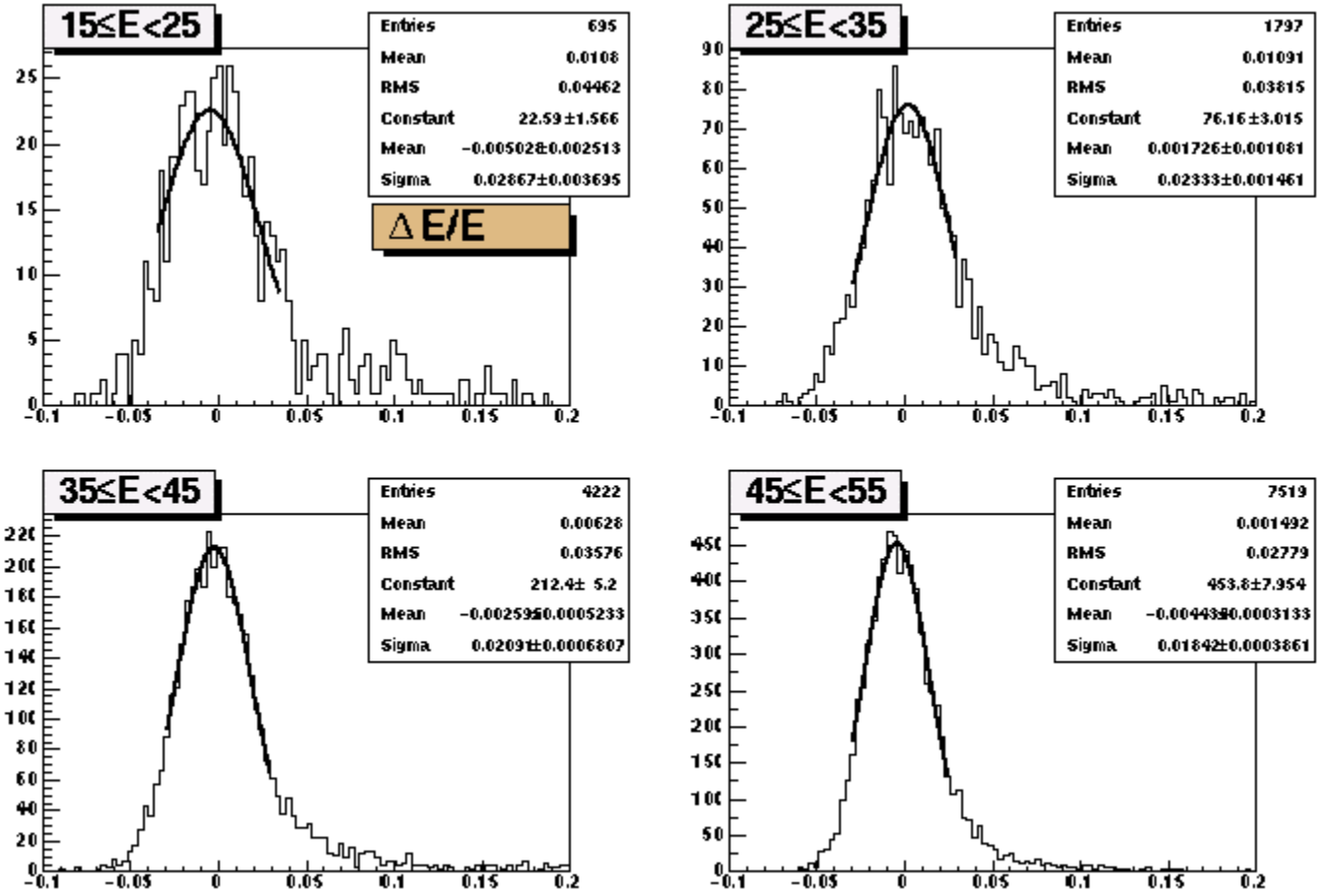




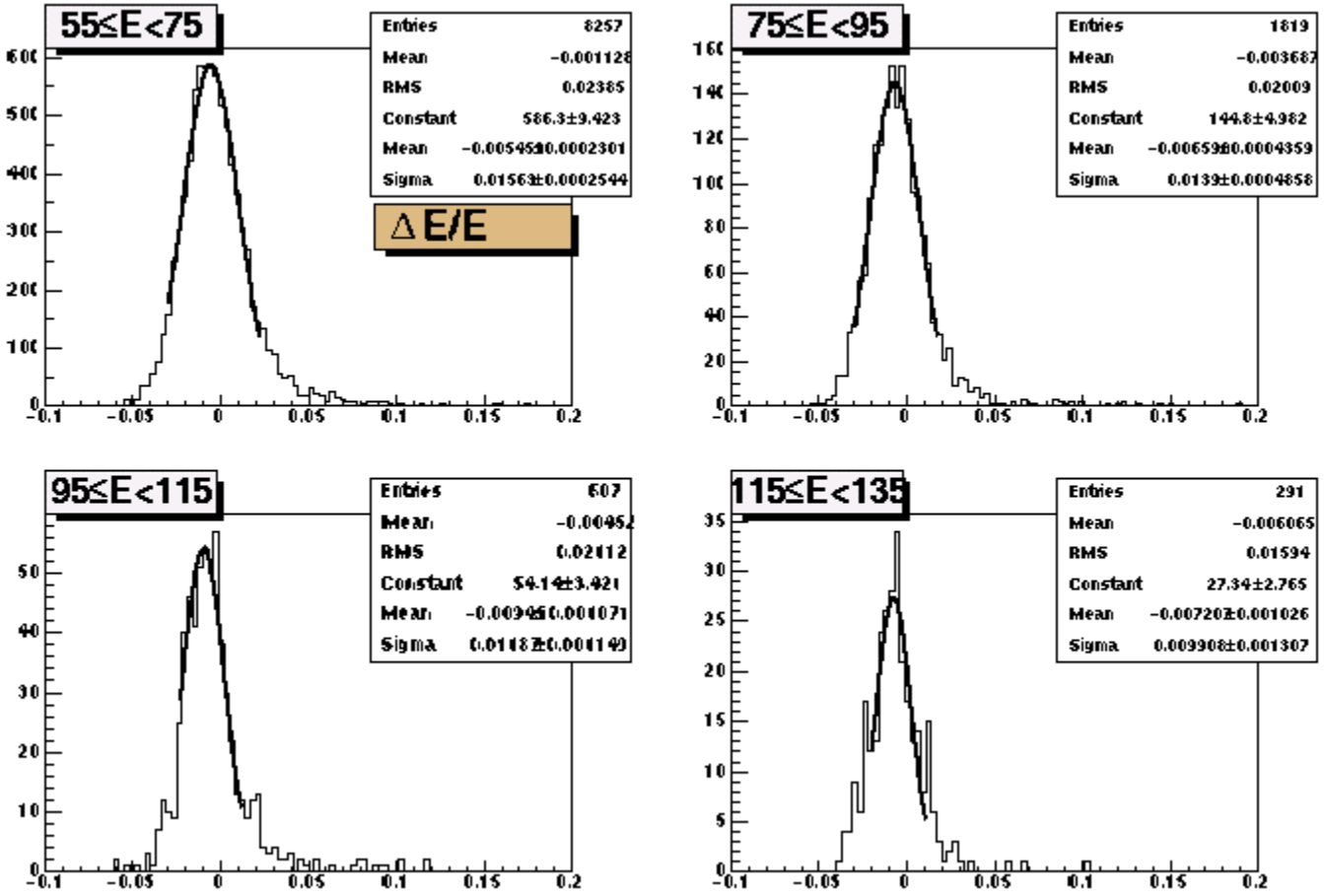
The Ansatz: $f_{samp}^{PS}(E_{PS}) = \dfrac{E_{PS}}{a + b\,E_{PS}}$ gives good linearity and resolution !

We perform an η dependent MINUIT fit using the above parametrization on top of the DC1 (existing) calibration.

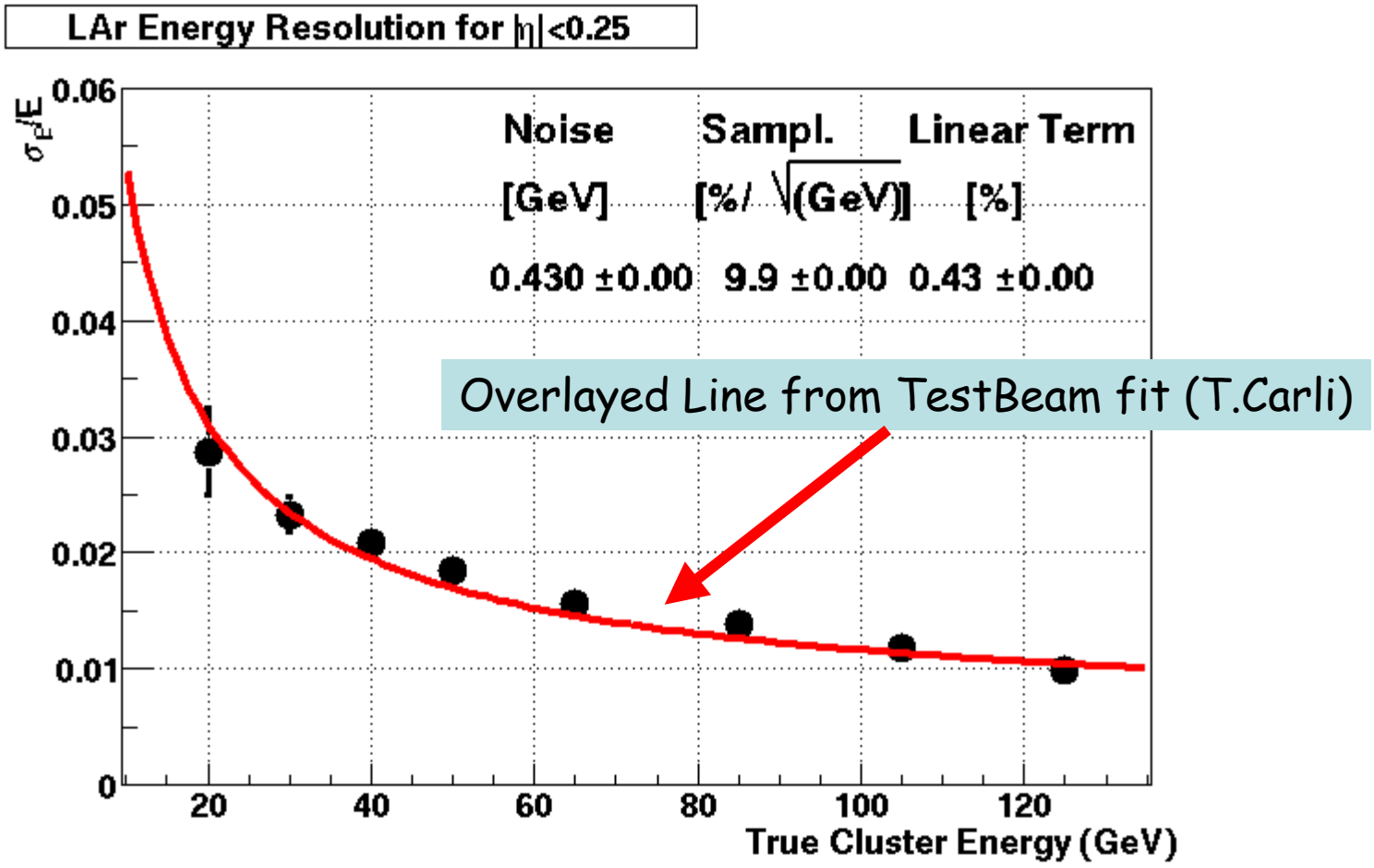
Energy Resolution after corrections (lower Energy)
$|\eta| < 0.25$



Energy Resolution after correction (higher Energy)
$|\eta| < 0.25$

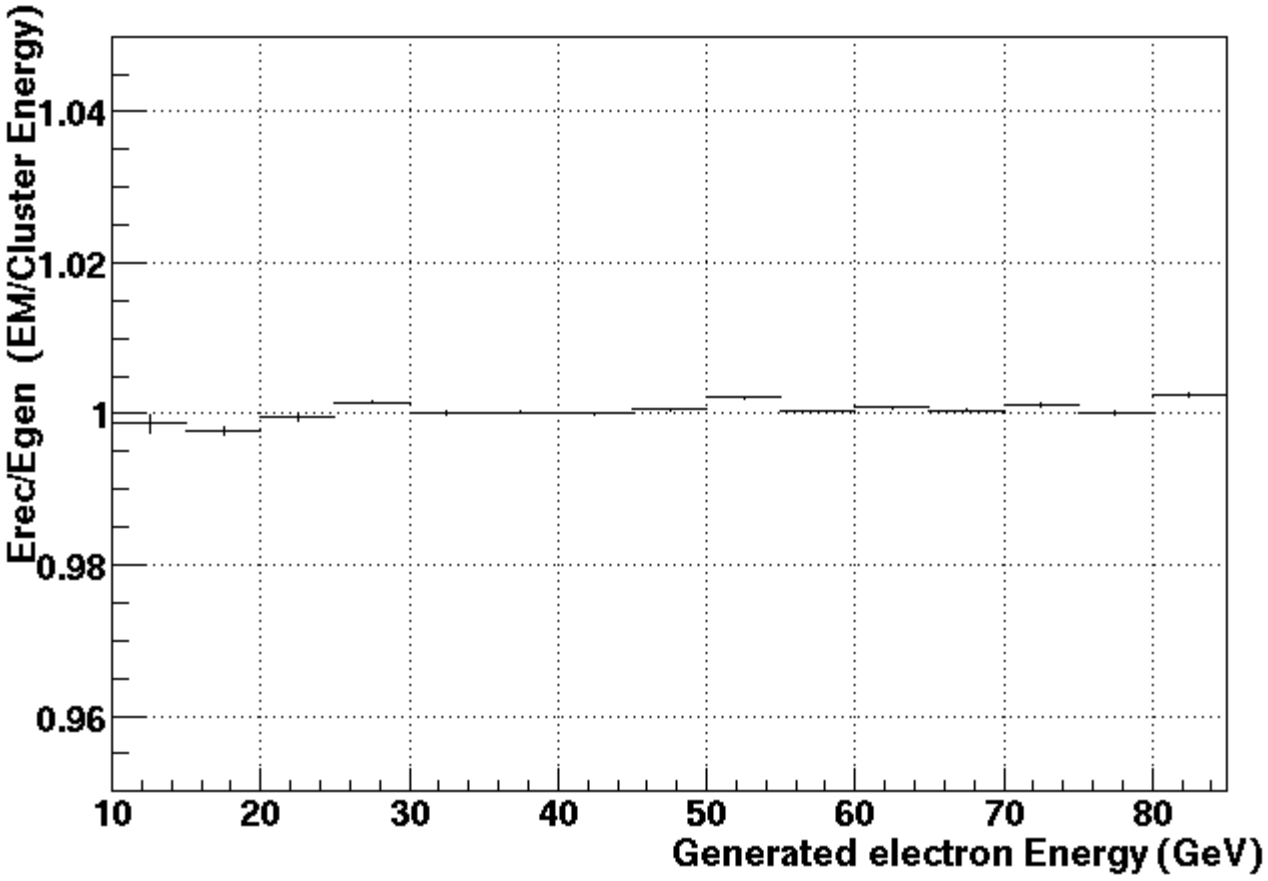


Comparison of Atlas LAr Full-Sim with TestBeam results

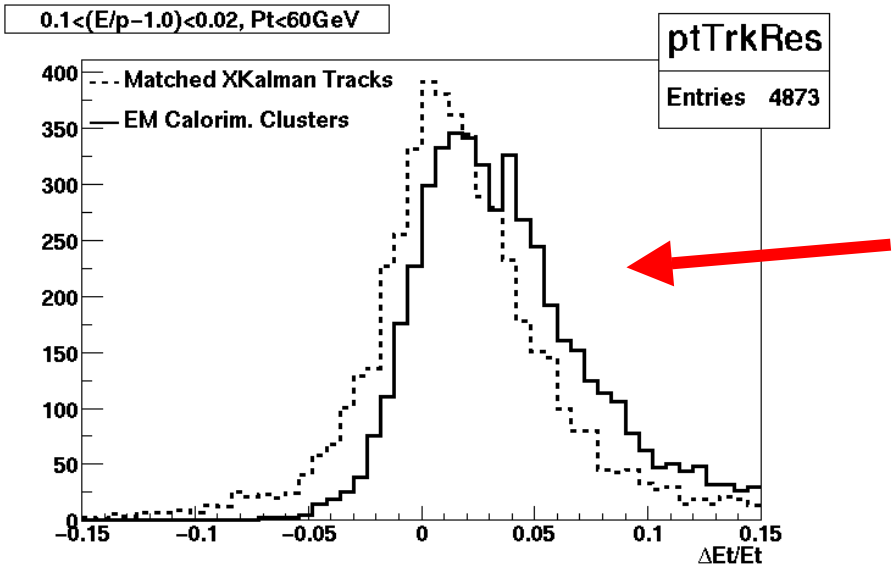


But … MC has no noise, >2X0 and TBeam has noise and 1.2X0.

Linearity after Presampler Correction



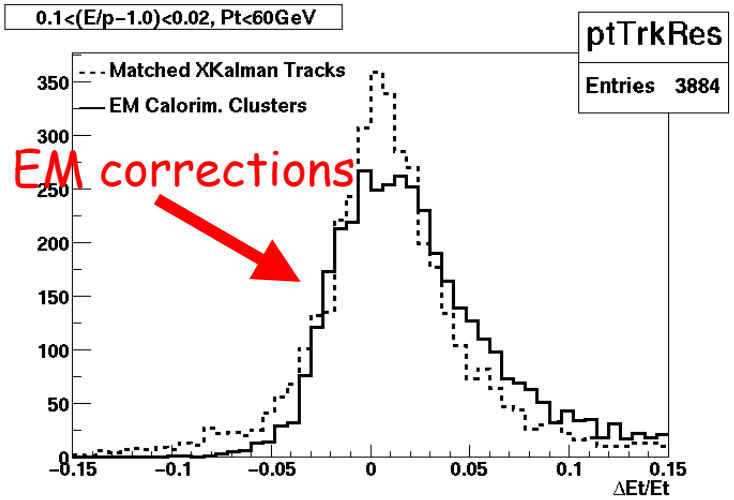
Combine ID with LAr to improve Et



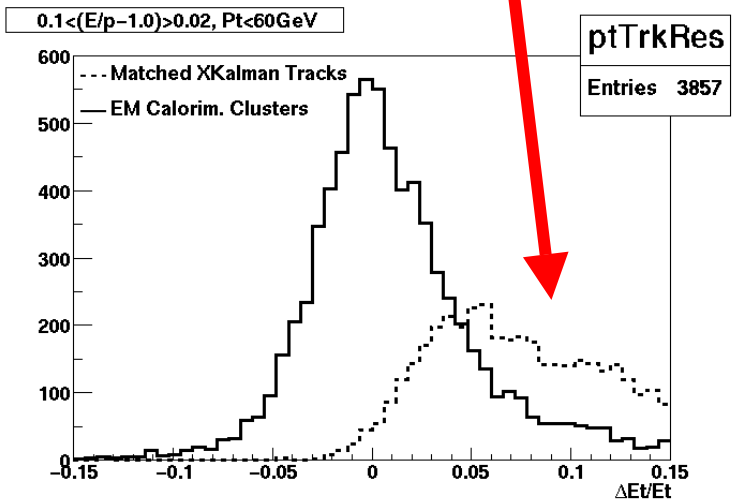
Tracks/Clusters with E/p~1 come most likely from tracks that either did not radiate, or radiated late.

We would like to improve the Et resolution for low Et by using ID

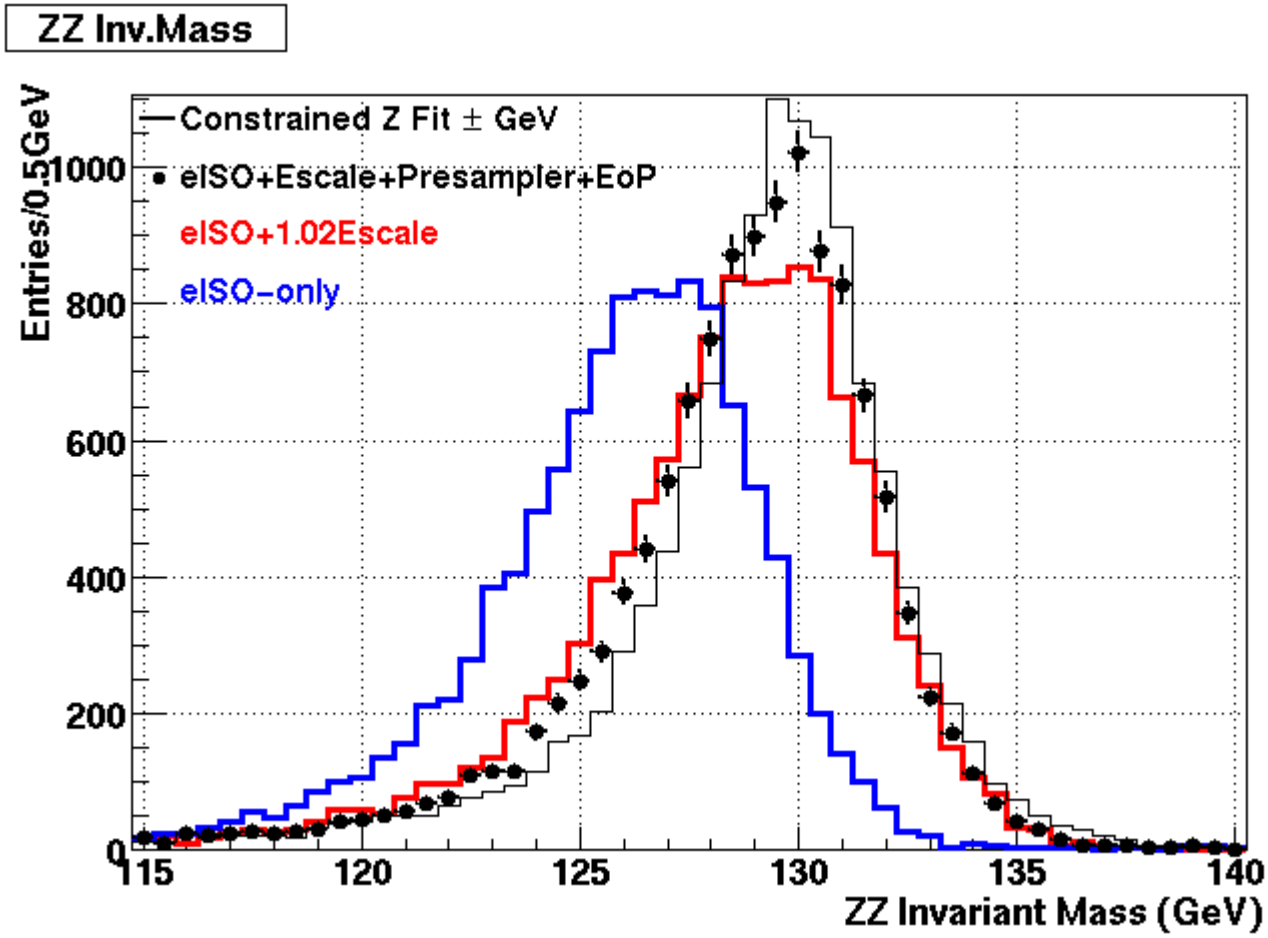
After EM corrections



Look outside the E/p cut



Higgs(130)->4e mass after corrections

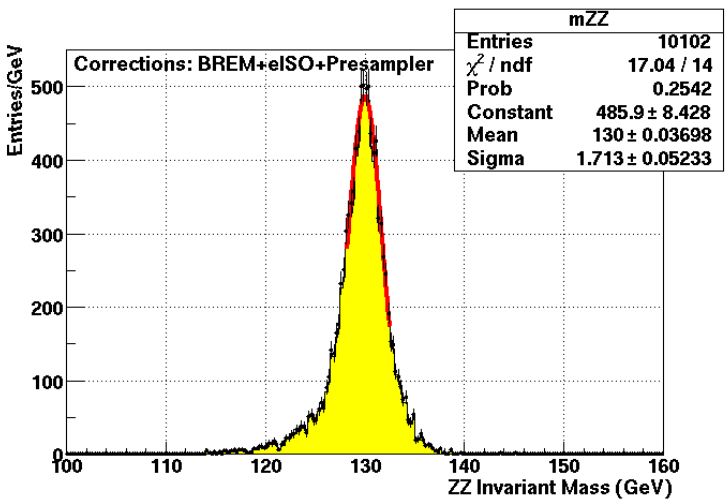


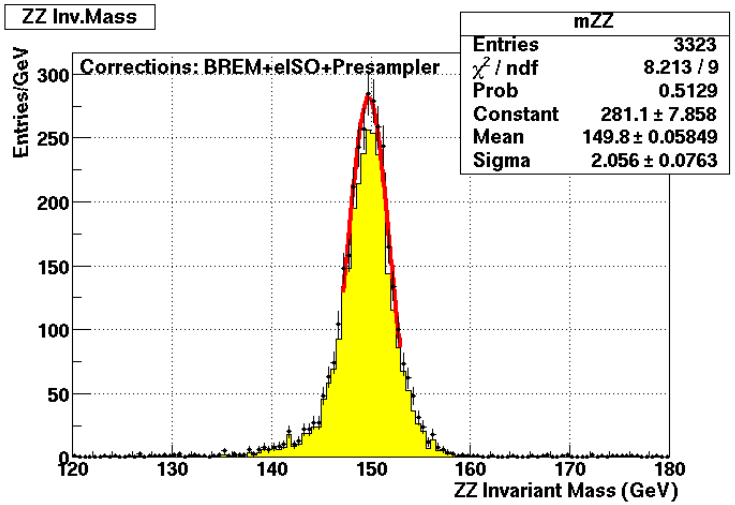
Corrections improve (10-15% here) resolution and signal yield

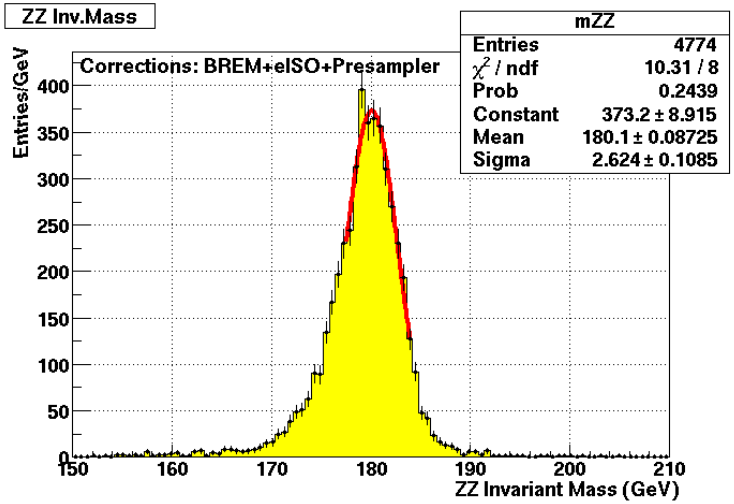
H->ZZ->4e analysis

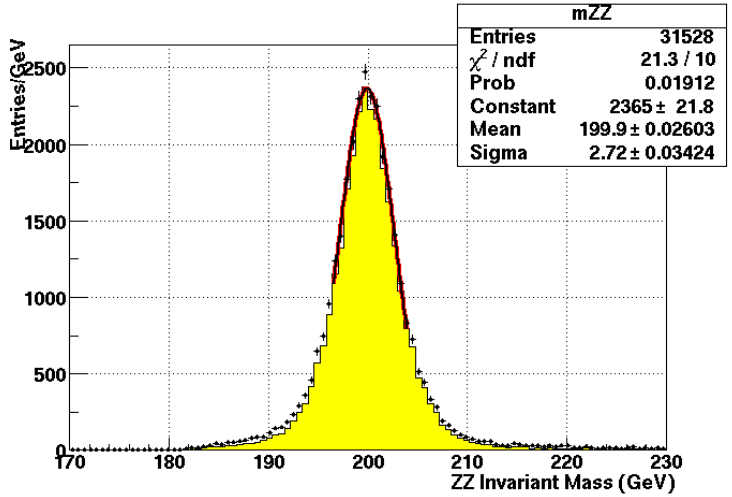
- Apply EM corrections
- Use Et from LAr, η, ϕ from tracks and combine ID with LAr for tracks with 0.1<E/p<1.02
- Apply TDR-like cuts (use TDR cross-sections)
  - 4 electrons with pt(1,2)>20, pt(3,4)>7GeV with $|\eta|$<2.5 units
  - EM isolation cuts (low mass only)
  - ID isolation cuts (low mass only)
  - Impact Parameter cut (low mass only)
- Study possibility of enhancing signal yield without increasing the reducible backgrounds, using EM cluster information.

H->4e Mass Resolution

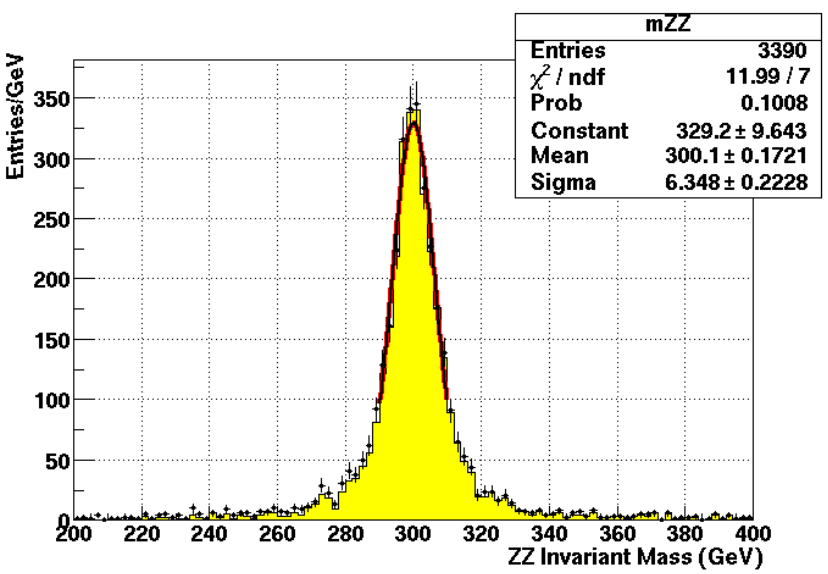


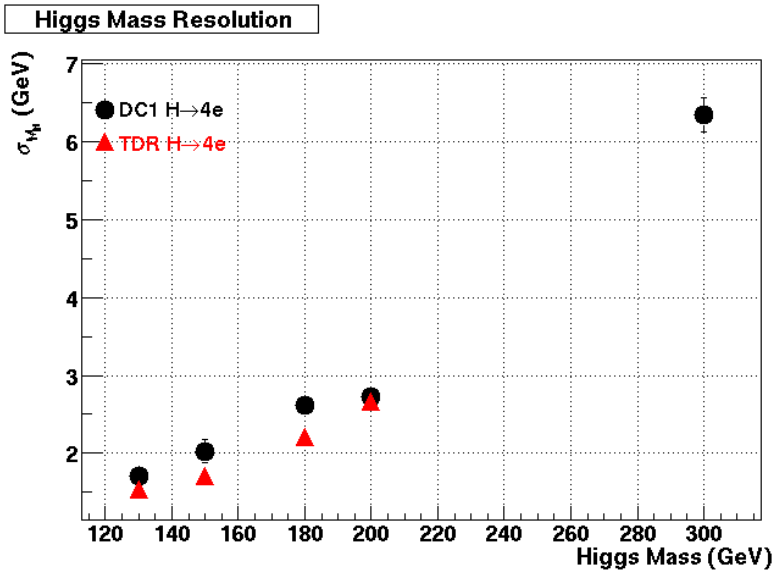






Comparison with TDR





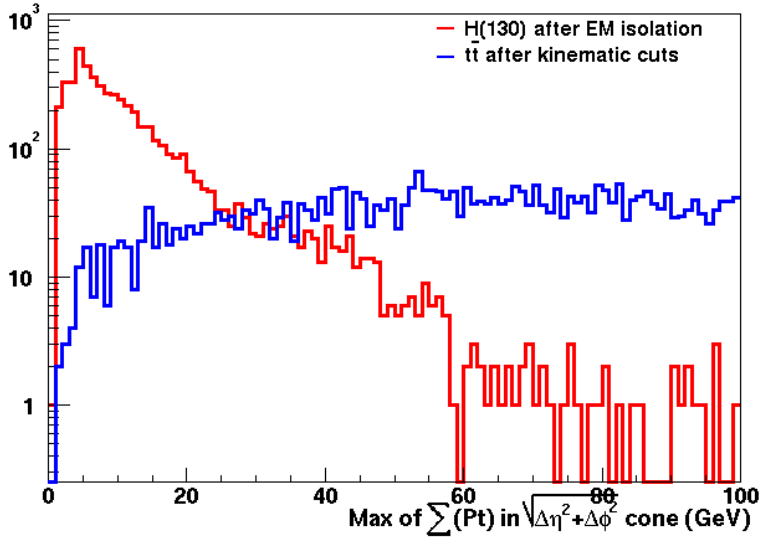
- Small degradation for low masses (10-20%)
- For real ZZ and after constrained Z->ee fit, there is no degradation.

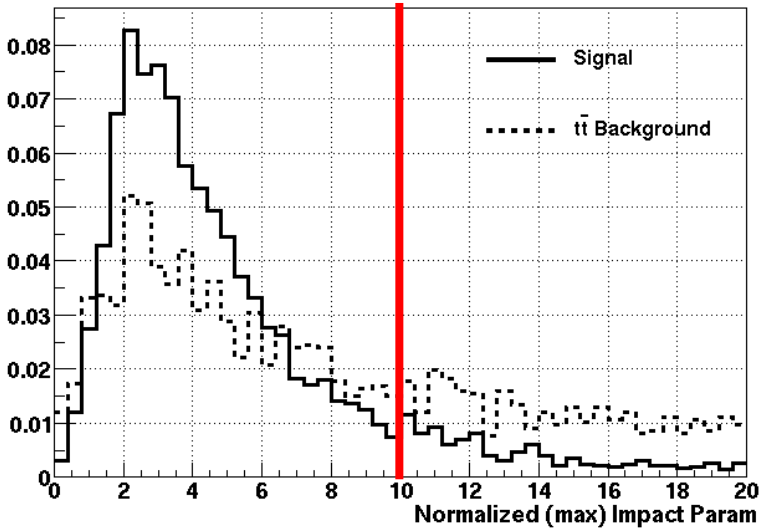
Electron isolation

1. Hadronic Calorimeter Leakage cut (η dependent)
2. 2nd LAr sampling cut: e237/e277 > cut(η)
3. 1st LAr Sampling cuts

(all of the above implemented in "qejflag" within ATHENA)

- Cut on the maximum (among all 4e) summed pt within a cone around the electron track.
- Cut on the normalized maximum impact parameter (a0Vert variable)





Rejection vs H(150)->4e Efficiency with new Atlas layout

Cut	ttbar->4e (Rejection)	H->4e efficiency
EM LAr		
Hac+2S+1S	123+/-10	0.61
Hac+2S	59.5+/-3.3	0.73
Hac-only	11	0.86
Inner Detector		
ID SumPt<10GeV	45+/-2	0.81
ID SumPt<12GeV	33+/-1.4	0.84
Combined		
EM(H+2+1)+ID	418+/-61	0.55
EM+ID+ImpPar.	1155+/-280	0.46

Efficiencies with new Atlas layout

Higgs Mass (GeV)	130	150	180	200	300
Acceptance (filter)	0.64	0.65	0.72	0.73	0.77
4e Recon Eff	0.65	0.70	0.73	0.74	0.75
Pt and η cuts	0.84	0.92	0.96	0.96	0.96
EM+ID isolat.	0.54	0.55	0.57	No	No
ImpParam cut	0.91	0.84	0.85	No	No
Z mass cuts	0.68	0.67	0.70	0.60	0.65
M_{Higgs} Window	0.92	0.92	0.89	0.88	0.90
Total	0.096	0.12	0.15	0.27	0.328

TDR H->4e	0.01097

H->4e Signal vs TDR (used TDR cross sections)

Higgs Mass (GeV)	130	150	180	200	300
Xsection*BR TDR (fb)	0.74	1.38	0.81	3.1	2.35
Signal TDR (fb)	0.092	0.22	0.164	1.117	0.75
Signal now (fb)	0.071	0.184	0.133	0.915	0.634
pp->ZZ now	0.019+/- 0.005	0.021+/- 0.005	0.04+/- 0.006	0.325	0.146
ttbar->4e (fb)	<0.005	<0.005	<0.005	0.118	0.071
Zbb (TDR)	0.001	0.0015	0.0015	0.05	
4*30fb-1 Signal	8.52	22.08	15.96	109.8	76.08
4*30 fb-1 Bgnd	2.4	2.7	4.98	59.16	26.04
Significance	**3.93**	**8.09**	**5.25**	**11.6**	**11.22**

Comparison with TDR (events)

Higgs Mass (GeV)	130	150	180	200	300
Signal TDR (4l)	11.4	26.8	19.7	134	90
Bgnd TDR (4l)	2.61	2.98	3.1	74	31
4*30fb-1 Signal	8.52	22.08	15.96	109.8	76.08
4*30 fb-1 Bgnd	2.4	2.7	4.98	59.16	26.04
Significance (*)	**3.93**	**8.09**	**5.25**	**11.6**	**11.22**

(*) calculated with UW MadTools software

Direct comparison was only possible for H->4e:

H(130)->4e TDR: ε=0.69x0.335x0.57x0.833 = 0.1097 or 9.74 events

H(130)->4e this analysis: 8.52 events

Drop in the yield due to some reduction on 4e efficiency and isolation efficiency (expect to improve -> impact parameter)

H->4e with Pythia6.2 cross sections

Higgs Mass (GeV)	130	150	180	200	300
Xsection*BR TDR (fb)	1.05	1.785	0.91	3.47	2.19
Signal (fb)	0.1	0.237	0.149	1.023	0.590
pp->ZZ (fb)	0.033	0.034	0.065	0.276	0.108
ttbar->4e (fb)	<0.005	<0.005	<0.005	0.118	0.071
ttbar (no window)	0.024+/-0.01	0.024+/-0.01	0.005+/-0.005	0.05	-
Zbb (TDR)	0.001	0.0015	0.0015	0.04	0.0
4*30 fb-1 Signal	12	28.44	17.88	122.76	70.8
4*30 fb-1 Bgnd	4.08	4.26	7.96	52.08	21.48
Significance	**4.37**	**8.75**	**4.97**	**13.33**	**11.2**

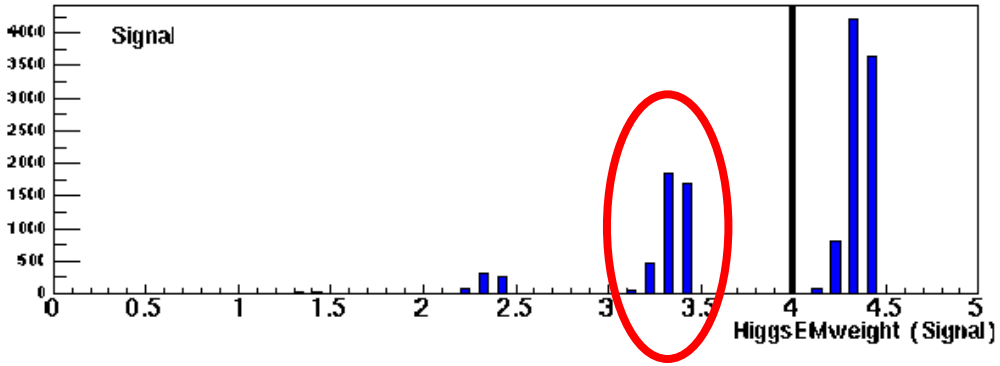
Classification of EM-clusters

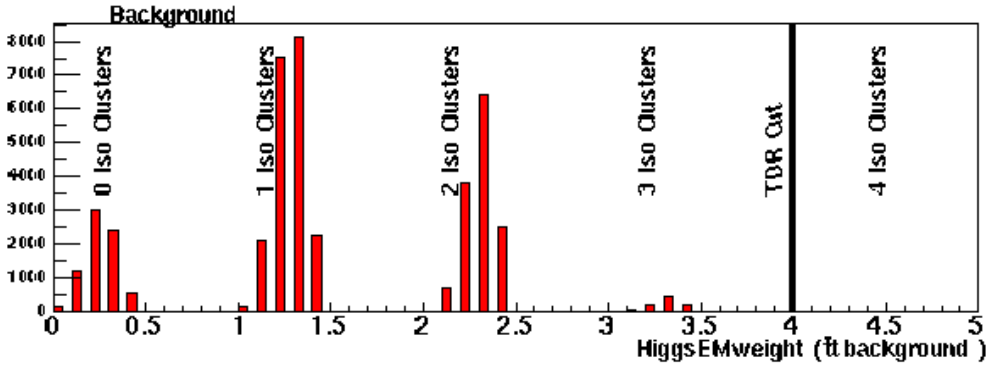
Classify EM Clusters. EXAMPLE:
- 1.0 for each Isolated Electron
- 0.1 for each Track/Cluster match
- 0.01 for eta in the LAr crack
- more…

ttbar background has typically up to 2 isolated electrons

Most of the signal loss involves events with 3 isoE + 1 non-isoE

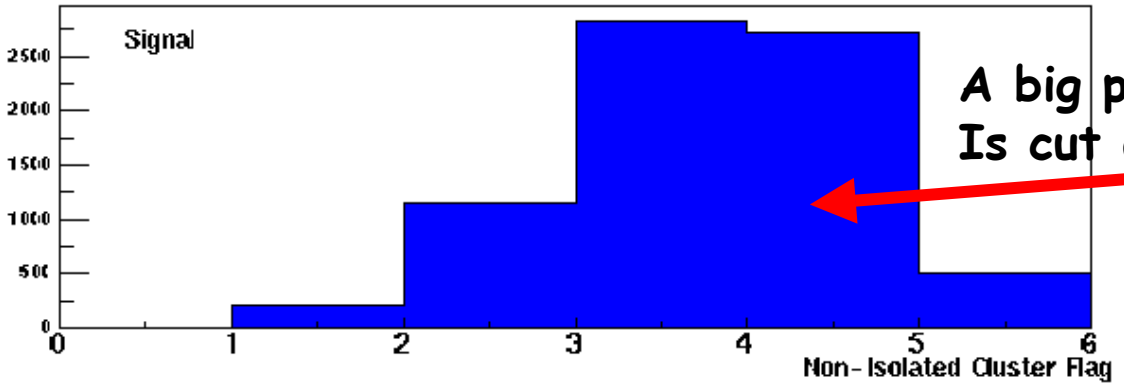
Still Background is HUGE… Jet rejection is also a problem if we relax the 4-isoE requirement!



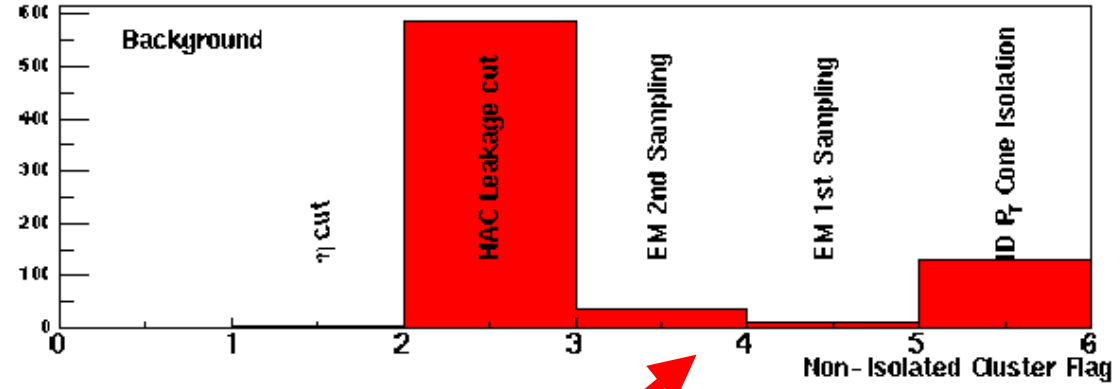


There is more info: the step at which the isolation criteria failed!

Events with 3isoElectrons + 1 non-isoElectron

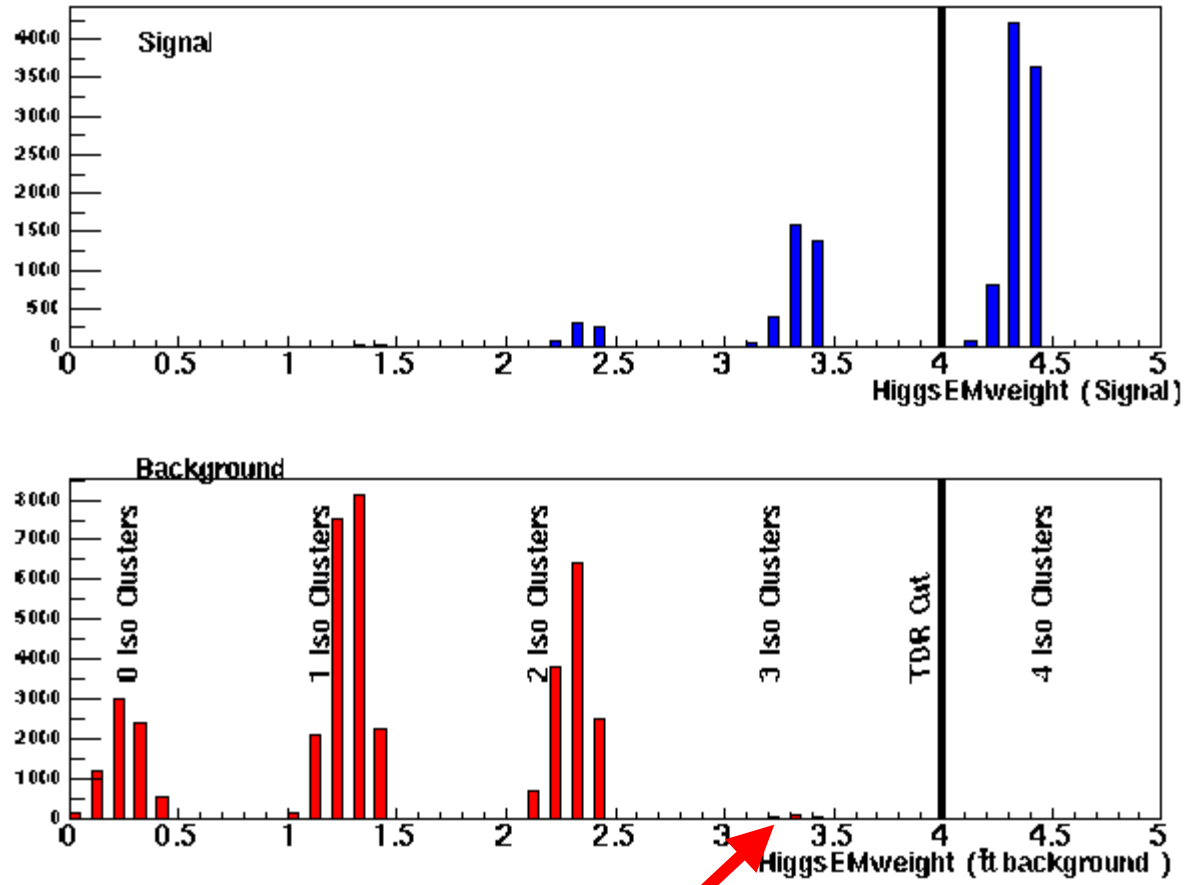


A big part of the signal Is cut at the LAr Samp.



Very little background (for these events) is cut at the LAr Samplings!

Example: use only HAC-leakage as a requirement on the non-isolated cluster



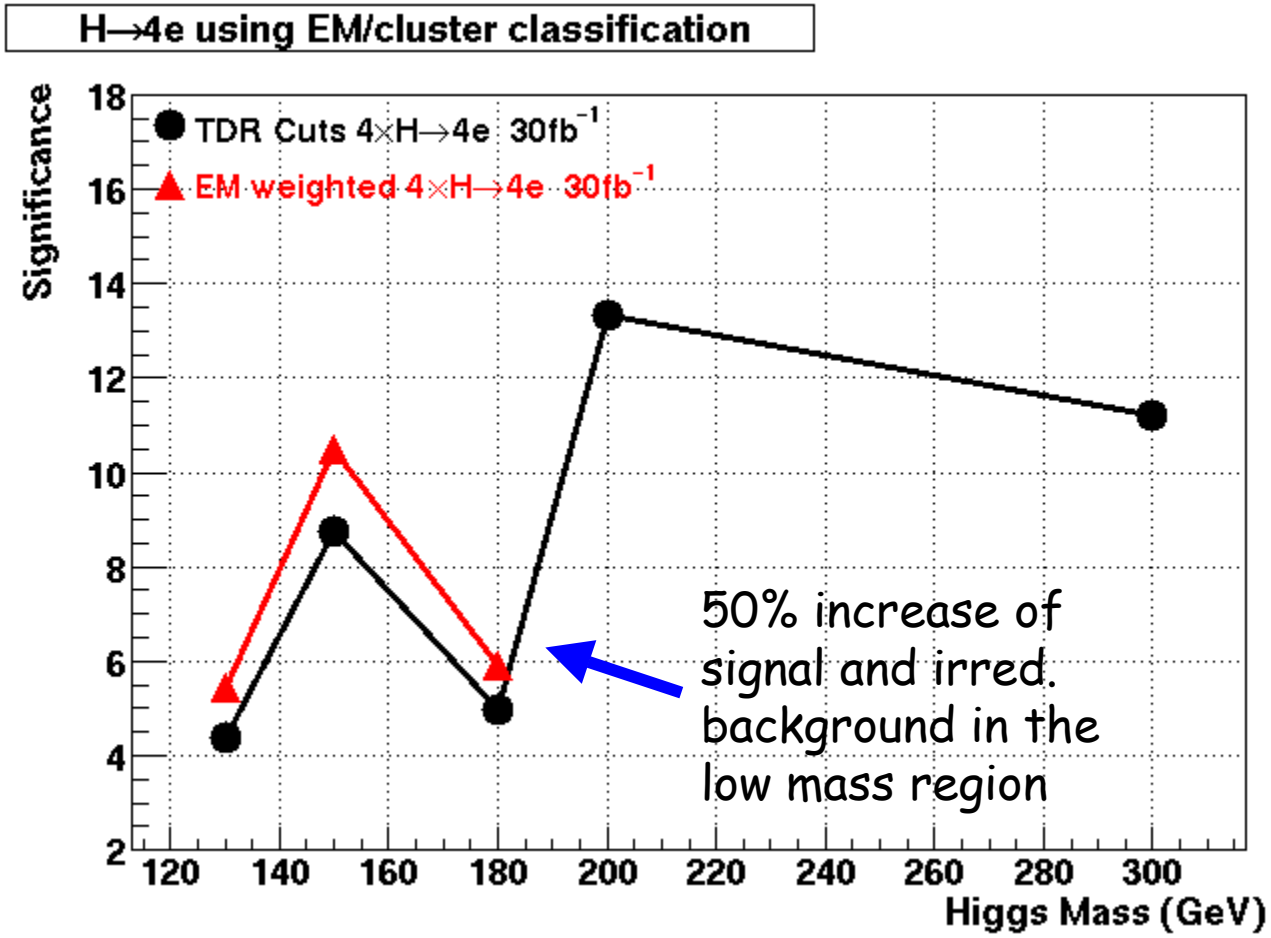
H->4e using EM-classification

Higgs Mass (GeV)	130	150	180	200	300
Xsection*BR TDR (fb)	1.05	1.785	0.91	3.47	2.19
Signal (fb)	**0.16**	**0.36**	**0.218**	**0.992**	**0.572**
pp->ZZ (fb)	0.0568	0.045	0.099	0.268	0.107
ttbar->4e (fb)	<0.005	0.01+/-0.007	<0.005	0.0142	0.0
ttbar (no window)	0.1+/-0.03	0.047+/-0.015	0.005	-	-
Zbb (TDR)	0.001	0.003	0.0015	0.005	0.0
4x30 fb-1 Signal	19.2	43.2	26.16	121	68.64
4x30 fb-1 Bgnd	6.92	6.96	12.06	34.46	12.84
Significance	**5.46**	**10.49**	**5.89**	**14.97**	**12.69**

Example: use LAr cluster information to improve Higgs significance

Higgs Mass (GeV)	130	150	180	200	300
4x30 fb-1 Signal	12	28.44	17.88	122.76	70.8
4x30 fb-1 Bgnd	4.08	4.26	7.96	52.08	21.48
Significance	**4.37**	**8.75**	**4.97**	**13.33**	**11.2**
4x30 fb-1 Signal EM weights	19.2	43.2	26.16	121	68.64
4x30 fb-1 Bgnd EM weights	6.92	6.96	12.06	34.46	12.84
Significance	**5.46**	**10.49**	**5.89**	**14.97**	**12.69**

Classification of EM-clusters



Summary

- First attempt to perform Test-Beam inspired LAr EM corrections in the low mass Higgs Analyses: Linearity is improved, resolution is not far from TestBeam fits.

- H->ZZ->4e analysis with TDR cuts and cross-sections and the new ATLAS layout leads to a small degradation ~10%

  This due to (1) drop of the 4e efficiency (~5%) and (2) reduction of the efficiency after isolation cuts (a better impact parameter determination will help)

- Exploiting the wealth of information from the LAr and ID helps increase the yield of signal while keeping the reducible background low:
  - A 20-25% increase in the significance of the Higgs signal is seen with a proposed simple EM object classification scheme
  - The irreducible background still remains: one must look into physics to reduce it