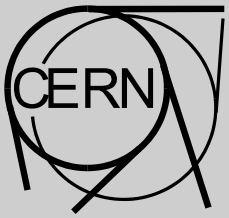

Progress in H->2e2m Analysis

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University Of Wisconsin

Higgs WG 12/May/04

Introduction-Reminder

- H->ZZ(*)->4l with full Atlas Simulation has been extensively studied
  - see past Higgs meetings since Sept/03
  - H->4lepton ATLAS note very close to completion.
- Electron-based calibration
  - First provided to Atlas by the 4e Higgs group analysis
  - Barrel only, η dependent, offset included
  - Calibration (constants) used by collaborators (M.Schaefer, W.Quayle, etc.)
  - ATLAS note is ready for submission.
- Electron (muon) detector information can improve the analysis
  - We used EM shower information, cluster/track matching, impact parameter, ...

Motivation

- What we know (focus at low mass):
  - Low H->ZZ*->4l Br. Ratio ~2.10^{-4} (130GeV)
  - Narrow ZZ* Invariant mass peak
  - Background free final state if leptons are isolated, track matched objects (see plots in this talk)
  - But ... low efficiency mainly due to isolation criteria
- Our Goal:
  - Attempt to carefully relax isolation (+more) cuts to allow some more signal to pass, for an acceptable background increase
  - To do this, exploit detector information concerning the four final state leptons (example: EM shower shapes)
  - Algorithms can be applied in any multi-lepton final state channel (but optimizations are particular to the channel).

Calibration Performance
(report on behalf of Martina Schaefer)

the ATLAS Experiment

$Z' \rightarrow e^+e^-$

Martina Schäfer

Higgs meeting

12 may 2004

study at the *LPSC* (Grenoble)

F.Ledroit (UJF-CNRS Grenoble) *DEIR*

and *Th.Müller* (Universität Karlsruhe) *Diplomarbeit*

LPSC Grenoble

UNIVERSITE JOSEPH FOURIER
SCIENCES. TECHNOLOGIE. MEDECINE. GRENOBLE - ALPES

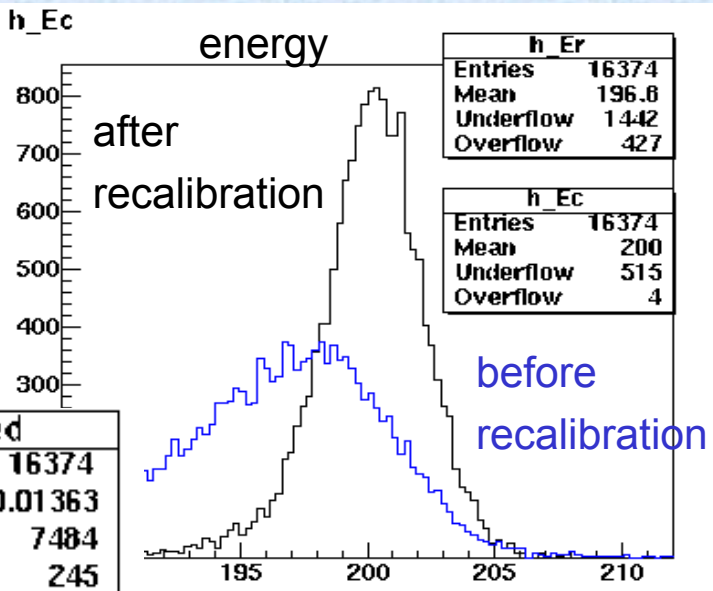
IEKP

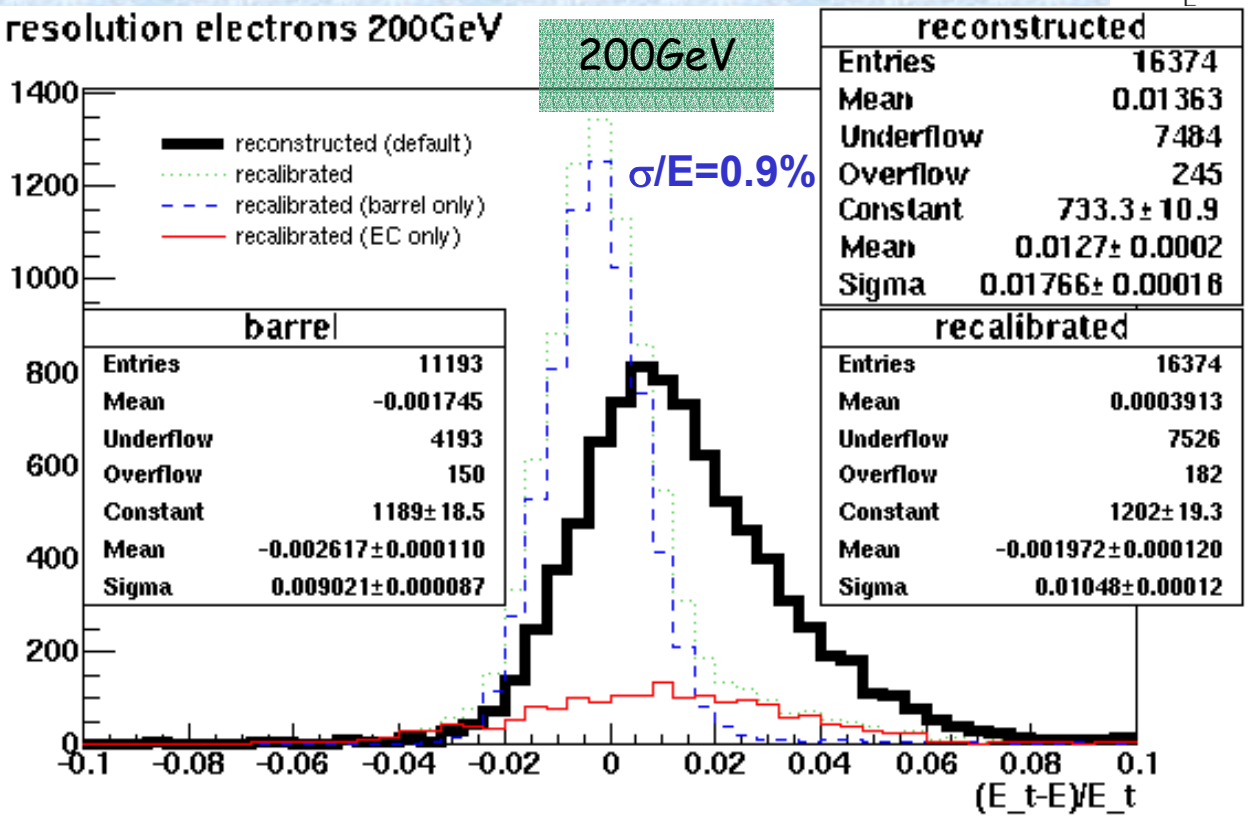
Universität Karlsruhe (TH)

Calibration (1)

- "standard" calibration : photons
- de-calibration
- re-calibration
- only barrel

} Stathes Paganis





$\sigma(E)/E$ (E=200GeV)
$= 9.5\% \sqrt{E}^{-1} + 0.45\%$
$\approx 0.8\%$ ok

Calibration (3)

Results on the Z' (SSM 1.5TeV), electrons at about 750GeV

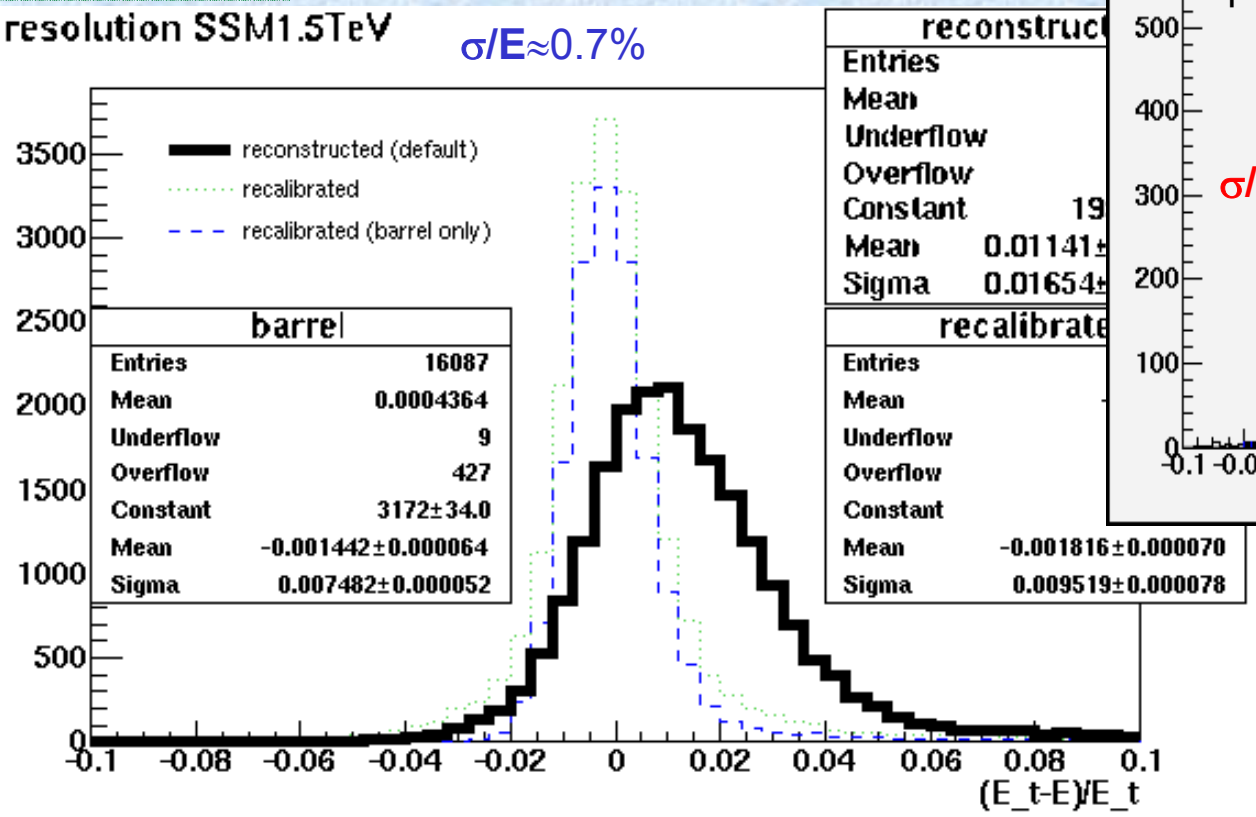
$\sigma(E)/E$ (E=750GeV)

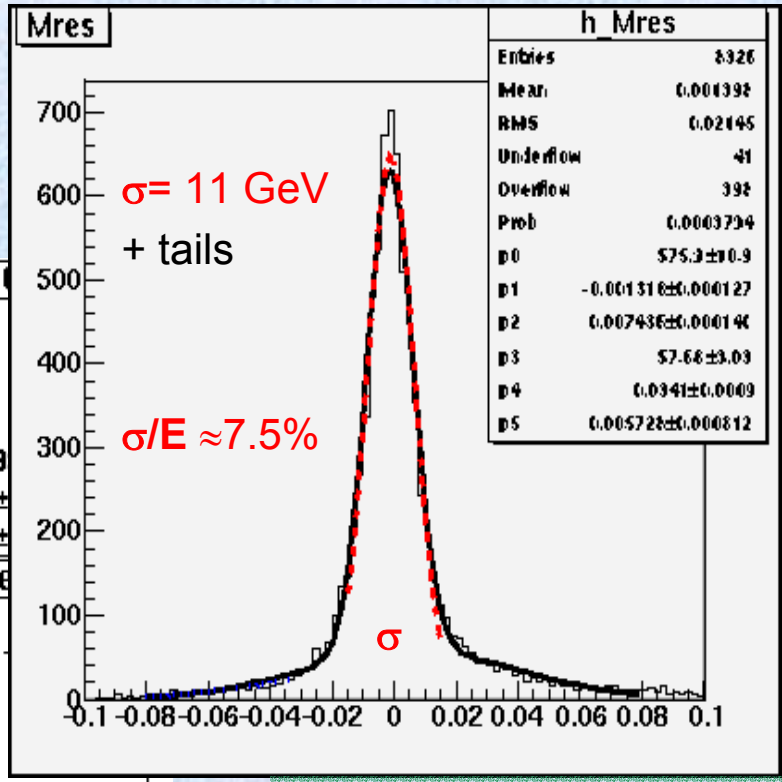
$= 9.5\% \sqrt{E}^{-1} + 0.45\% \approx 0.6\%$ ok

$\sigma(M)/M$ (M=1.5TeV)

$= \sqrt{2}\ \sigma(E)/E \approx 0.8\%$ ok

resolution of electrons (Z' at 1.5TeV)



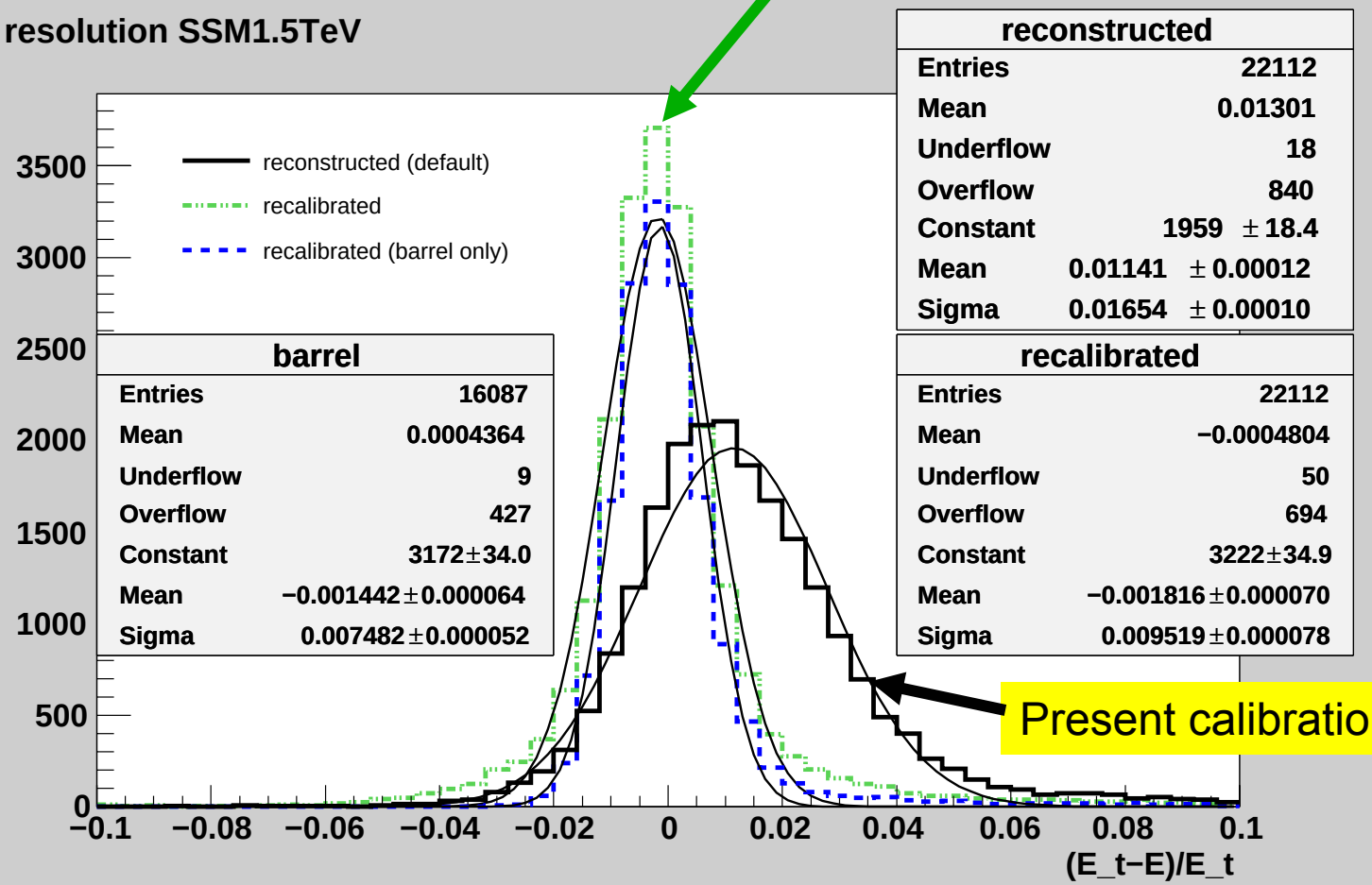


resolution on the mass (for 1.5TeV)

Electron Calibration for Z'(1.5TeV)->e+e-

plot from Martina Schaefer (Grenoble)

Our e-based calibration



Present calibration Athena

(electron True Energy – Recon Energy) / True Energy

Electron Calibration (cont)

- Good news here is that we used low energy electron samples (E<150GeV) to get the calibration constants.

- This is a hint that the energy dependence of the calibration constants (**due to the presence of upstream material**) may be small at high energies and significant only at low energies. This problem is partially fixed by the "offset" parameter which plays no role at high energies (**T.Carli**)

$$E_{rec} = \lambda\left(b + W_0 E_{pres} + E_1 + E_2 + E_3\right)$$

Offset

Standard (TDR) H->4l Analysis Reminder

- Recalibrate EMB, (EMEC: simple escale factor)
- Lepton trigger pt1,pt2>20GeV, pt3,pt4>7GeV
- Electron clusters always matched to tracks
- Electron pt<60GeV combination (ID and EMC)
- EMB,EMEC+InnerDetector isolation cuts for electrons
- ID-only isolation for muons (no EMC noise)
- Impact Parameter cuts
- Z, Z(*) mass cuts (TDR)
- Count signal in a ZZ mass window (TDR)

H->ZZ->2e2μ Analysis (TDR cuts)

Higgs Mass (GeV)	130	150	180	200	300
Full Cross-section(fb)	20750	16350	12040	10070	5400
Xsection*BR (fb)	2.1	3.57	1.82	6.94	4.38
Signal (fb)	0.18	0.423	0.269	1.1306	0.7485
pp->ZZ->2e2μ (fb)	0.037	0.031	0.1418	0.5	0.207
ttbar->2e2μ (fb)	<0.002	<0.002	<0.002	<0.002	<0.002
Zbb->2e2μ (fb)	0.011	0.0053	<0.003	<0.003	<0.003
2*30 fb^{-1} Signal	10.8	25.38	16.14	67.84	44.4
2*30 fb^{-1} Bgnd	2.88	2.16	8.51	30.0	12.42
Significance	4.6	9.24	4.26	9.76	9.15

Isolation cuts applied in the full range

3+1 Analysis Algorithm example

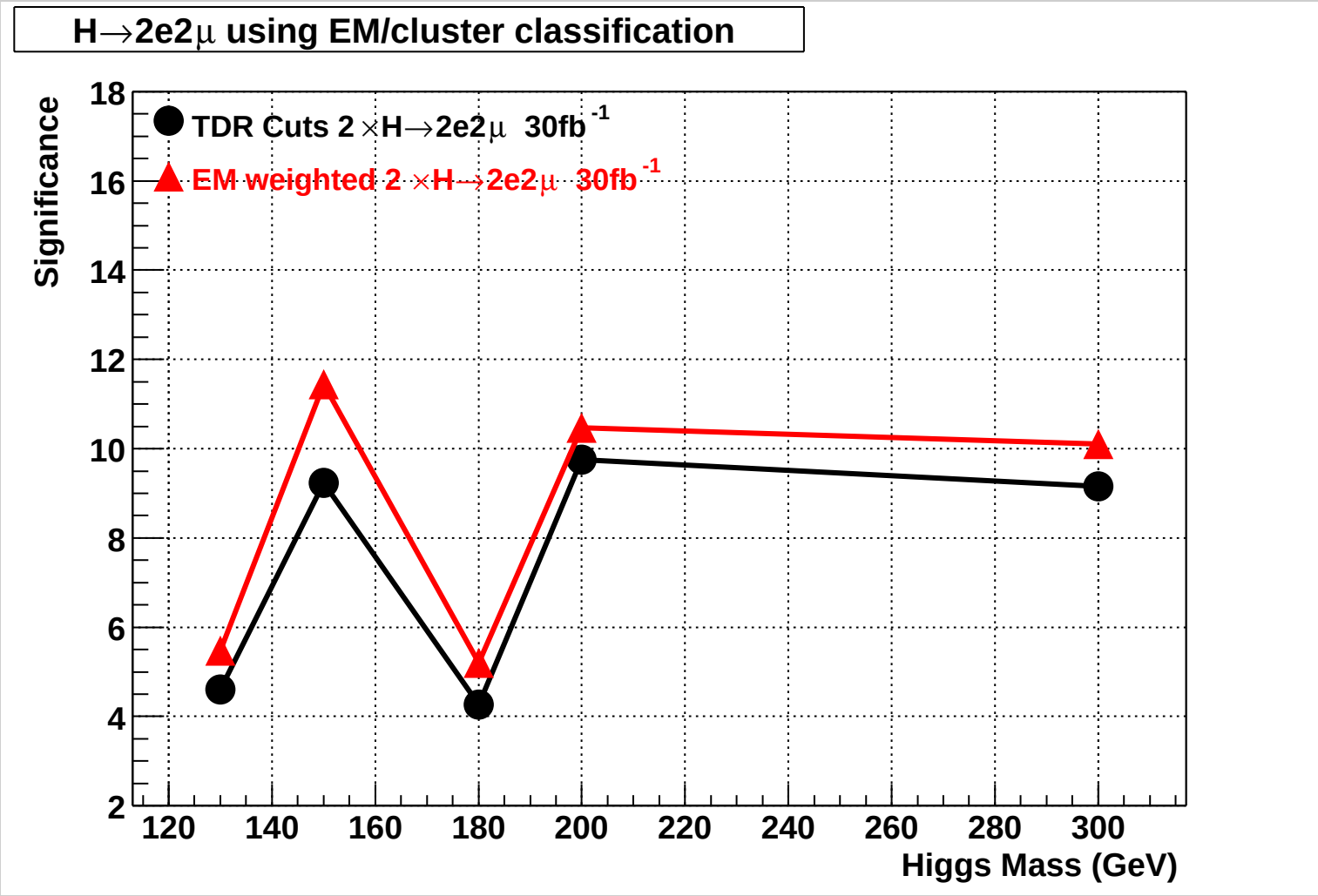
- Require 3 isolated leptons
- Allow for 1 non-isolated electron
  - Electron must be matched to a track
  - EM shower must be longitudinally contained in EMC
  - Electron must pass ID isolation cuts
- If there are 4 isolated leptons allow for a cluster without a match to an ID track
- Impact Parameter cuts are still used and optimized for best performance
- Select the leading 4-lepton candidate from those which pass all cuts

H->ZZ->2e2μ Analysis (EM/cluster classification)

Higgs Mass (GeV)	130	150	180	200	300
Full Cross-section(fb)	20750	16350	12040	10070	5400
Xsection*BR (fb)	2.1	3.57	1.82	6.94	4.38
Signal (fb)	0.2967	0.806	0.4021	1.3604	0.9167
pp->ZZ->2e2μ (fb)	0.0692	0.086	0.2345	0.64	0.2631
ttbar->2e2μ (fb)	0.004	0.004	<0.002	<0.002	<0.002
Zbb->2e2μ (fb)	0.0264	0.0252	<0.003	<0.003	<0.003
2*30 fb^{-1} Signal	17.8	48.36	24.126	81.624	55.0
2*30 fb^{-1} Bgnd	5.976	6.912	14.07	38.4	15.786
Significance	5.47	11.44	5.2	10.468	10.11

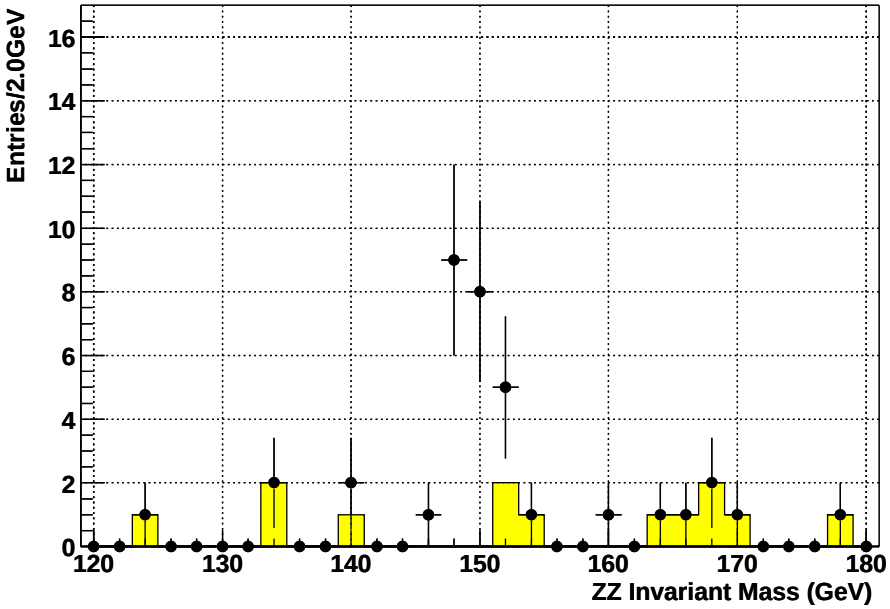
Notice: Signal increase >50%

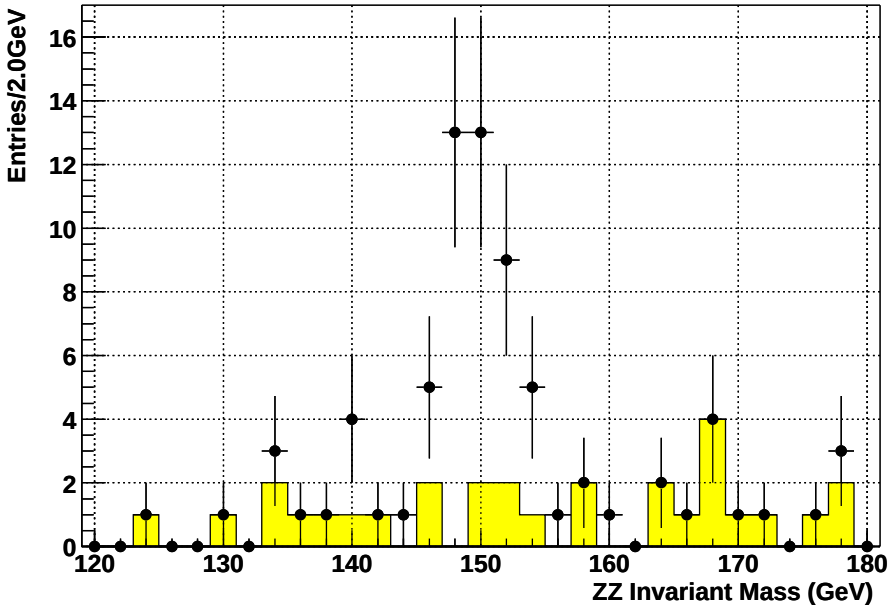
Higgs->ZZ->2e2μ



Higgs(150GeV)->4e, 2e2μ (30fb^{-1})

One Experiment 30fb^{-1}



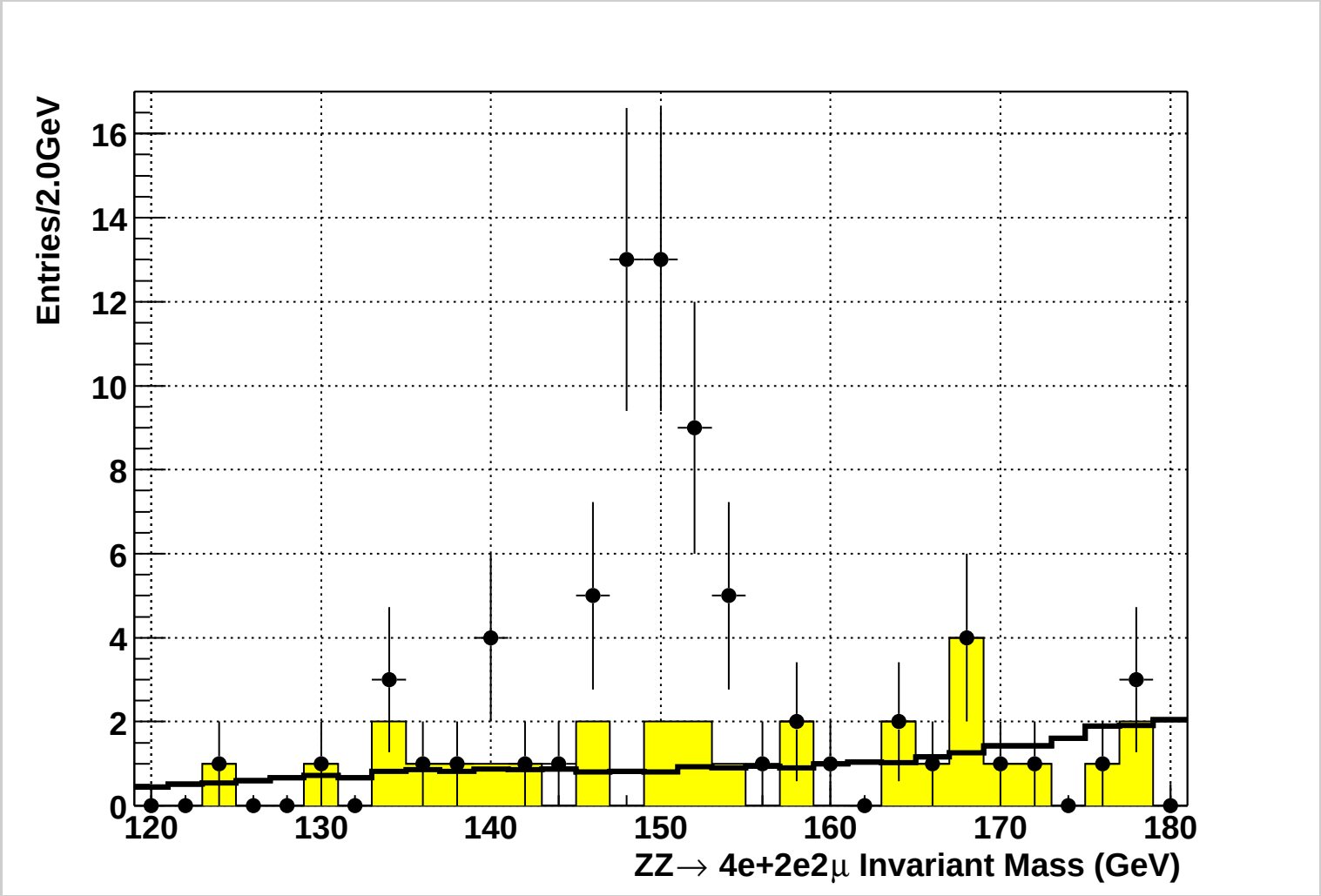


TDR Analysis

EM/cluster classification (3+1)

- One 30fb^{-1} experiment for the 4e and 2e2μ channels
- Left: Background (in yellow) is very low for TDR analysis
- Right: Background increases; but the signal increases giving higher sensitivity

Higgs(150GeV)->4e, 2e2μ (30fb^{-1})



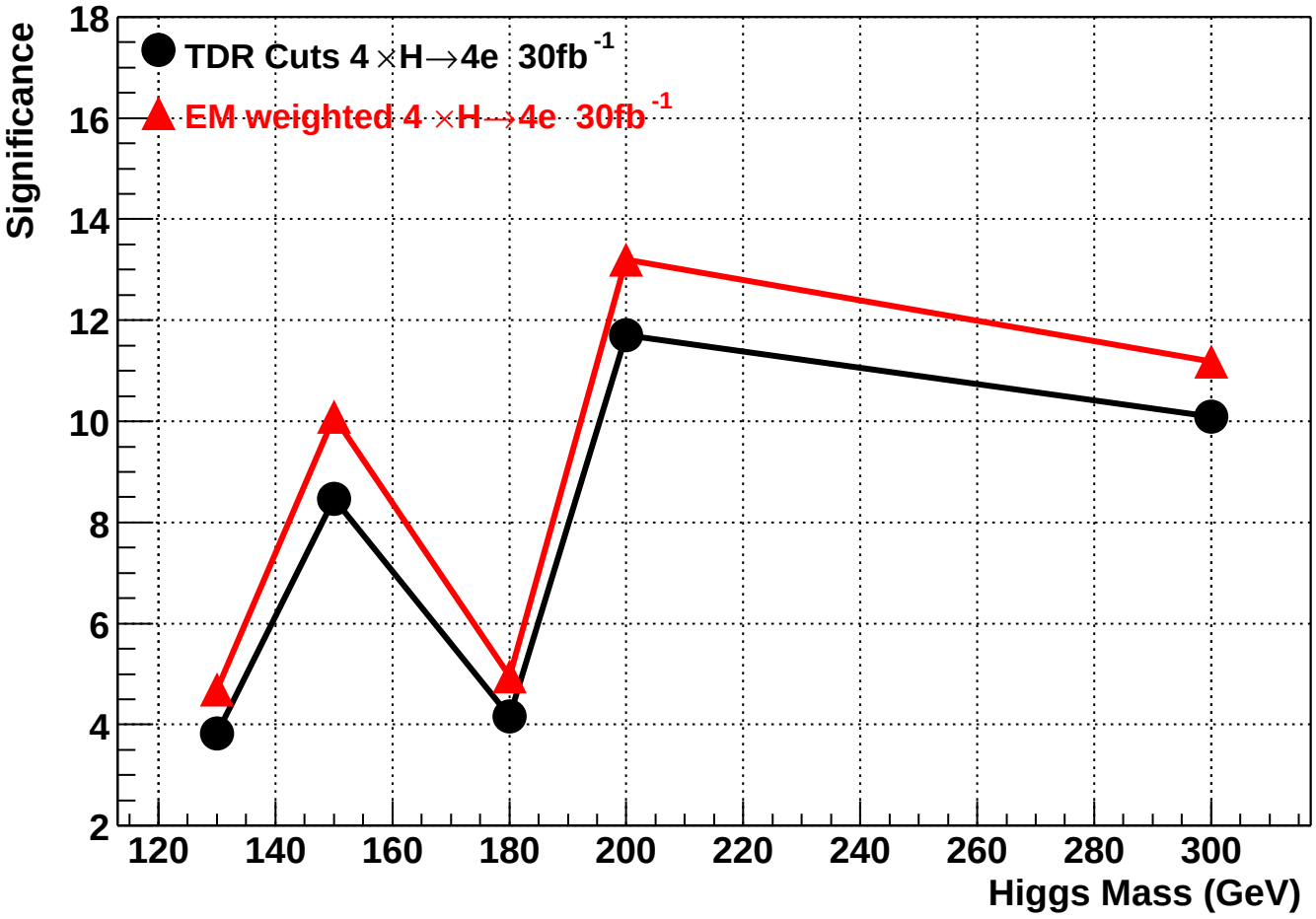
Caveat: Results may significantly change

- Atlas Recon software is in its early stages
  - Vertex impact parameter determination is improving
  - Tracking is improving
  - Brem Recovery is improving
- Still no noise in our samples
  - Will affect isolation with the EMC
- Our Samples include underlying event (Pythia) but:
  - Effects from the underlying event (like EM contained pions) have not been checked.
  - Increase of hard pions etc affect 3+1 type algorithms
- Pile-up ?

Summary

- We briefly reviewed the application of a lepton object classification algorithm (aka 3+1) in the H-> ZZ->2e2μ analysis
  - Increases in signal yield and significance observed in the 4e channel were also found in the 2e2μ channel
  - Inclusion of the 4μ channel (where 3 muons are found in the muon chambers and 1 in the ID – see Quayle's talk HWG Apr/04) could lead up to an overall ~20% increase in Significance.
- Caution: Algorithms sensitive to reconstruction underlying event, pile-up, noise and more
- Atlas Notes (H->4l and Calibration) very close to submission

Higgs->ZZ->4e


Significance
TDR Cuts 4 ×H→4e 30fb -1
EM weighted 4 ×H→4e 30fb -1
18
16
14
12
10
8
6
4
2
120
140
160
180
200
220
240
260
280
300
Higgs Mass (GeV)