Higgs to 4 leptons in Athena with eventView

Stathes Paganis
University of Sheffield
(Collaboration with Saclay/R.Nikolaidou,
Max Planck/N.Benekos)

ATLAS UK meeting at UCL, 19-Sep-05

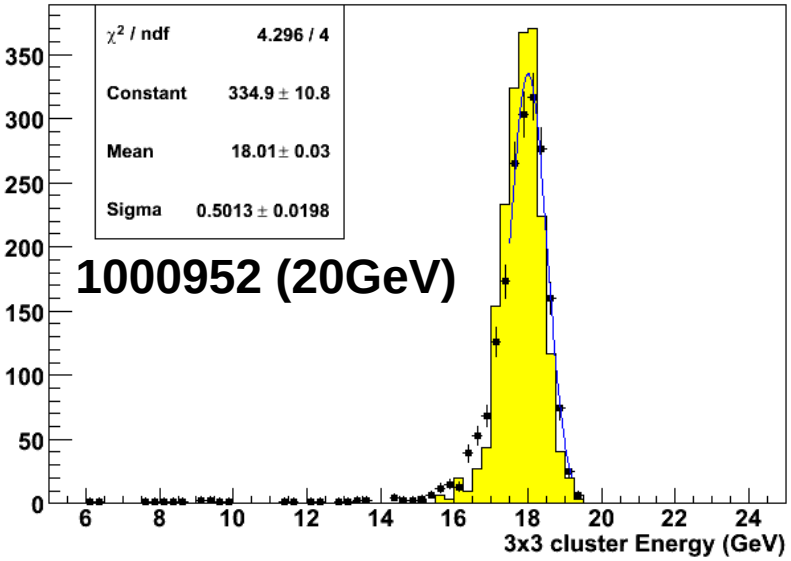
Outline

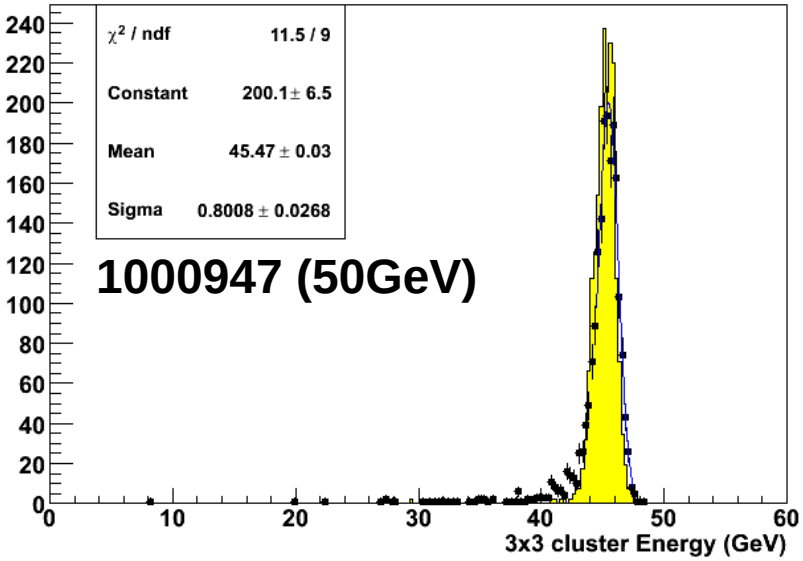
- H->4l: it's all about Performance
  - Electron efficiency after preselection vs (pt, eta)
  - Linearity/Uniformity, Resolution, tails, shower shapes
  - We must understand all this reasonably well before we can look for the Higgs. How we do this in the complex ATLAS environment?
  - Muons: work in progress with Saclay/MPI
- Why eventView: new algo EV_Hto4l
  - EV_Hto4l structure
  - EV_Hto4l tools
  - First Results (examples)
  - Plans

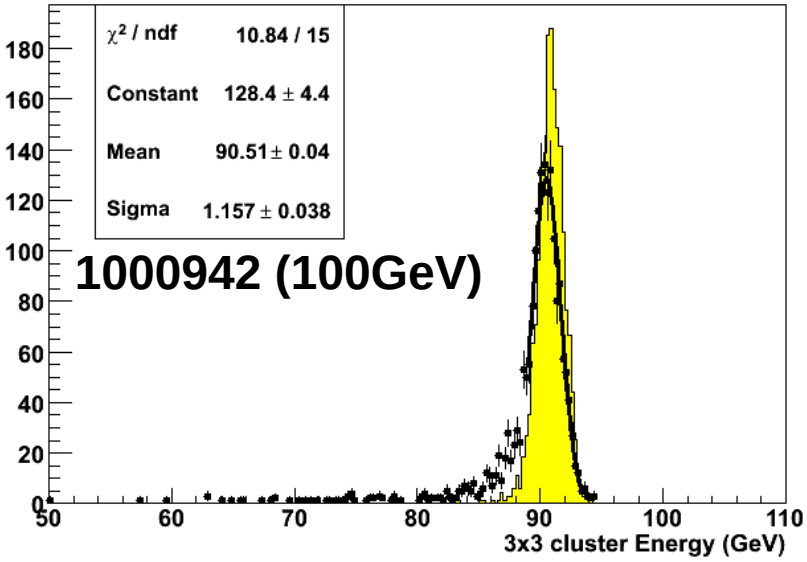
H->4l : critical items

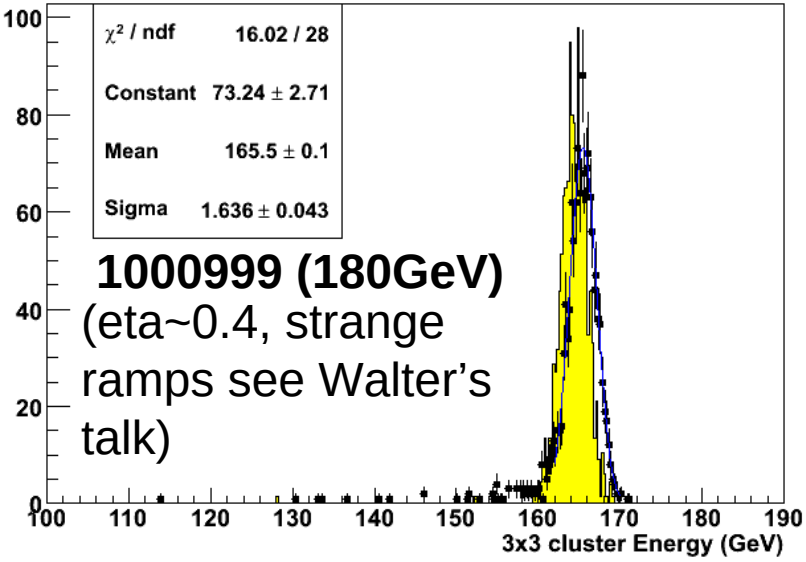
- Backgrounds from ttbar and Zbb must be reduced by large factors (ttbar Rejection: 10^3) with no more than 30-40% loss of Higgs signal.
- Single Electron/Muon efficiencies before isolation cuts must be kept high (92% for electrons).
- Electron (muon) linearity/uniformity and resolution must be contolled to the TDR levels (electrons: 10%sqrt(E) and 0.1% linearity/uniformity would do).
- Non-Gaussian tails? a problem not only due to the upstream material but also due to bremsstrahlung, clustering and miscalibrated cells.
- Finally a problem never addressed: background extraction under the Higgs peak, and its systematic error.

CTB04: (see my talk at LArWeek Sep/05)
Resolution Plots without cluster corrections









ATLAS: how do we determine the cluster corrections?

- The cluster corrections are based on MC. So
  - the knowledge of material distribution upstream the LAr calorimeter is crucial (problems already in how to do that in our CTB04)
  - Geant4 must be checked against data. We don't want shower shapes to be different in real life because we use them in isolation cuts!
- Data can be used for cell-to-cell or region-to-region calibration (aka intercalibration). For example Z decays to ee, muons, MIP pions etc.
- Data will definitely be used to get the true energy scale right.

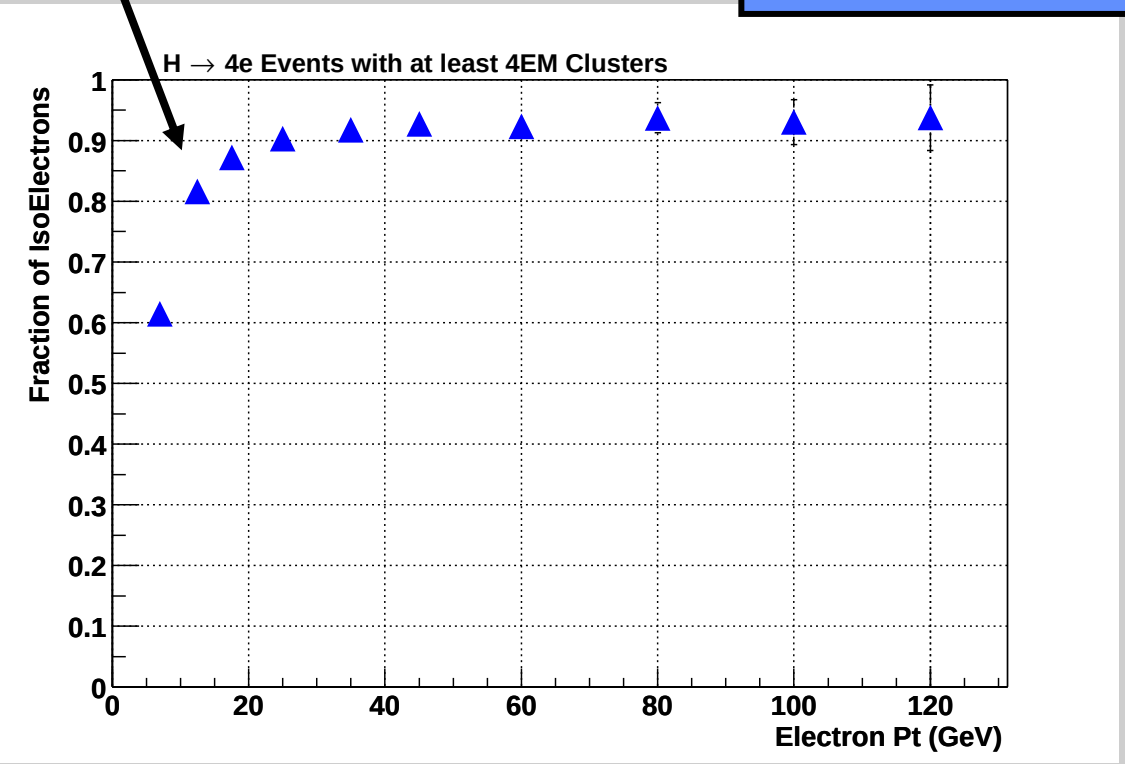
Higgs->4lepton: typical cut flow

Cut Name	Efficiency
Restrict to |eta|<2.5	65%
Require 4 electrons with matched tracks	70%
2e pt>7GeV 2e pt>20GeV	92%
Calorimeter Isolation	65%
Tracking Isolation	90%
Impact Parameter	90%

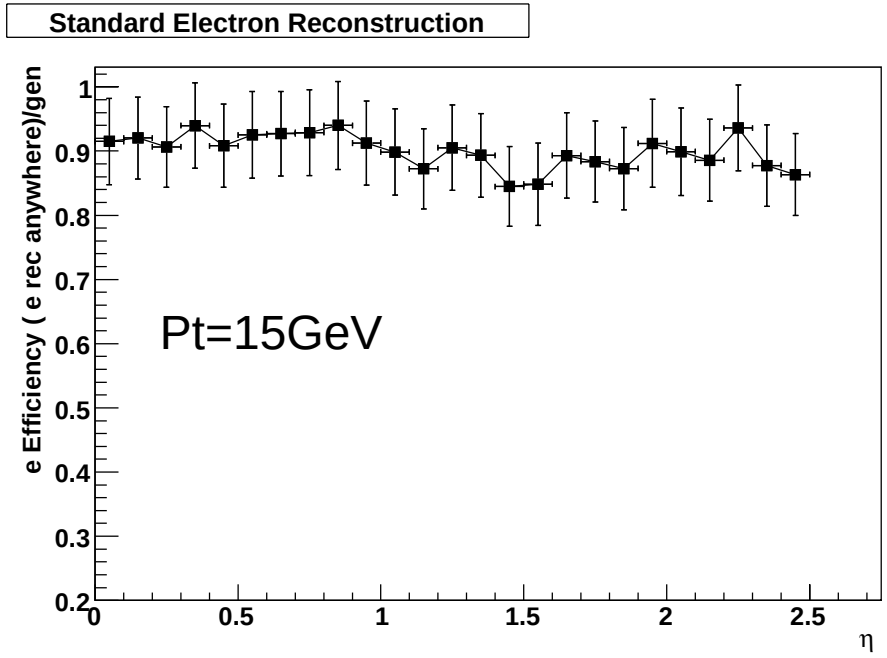
Electron Isolation efficiency (DC1)

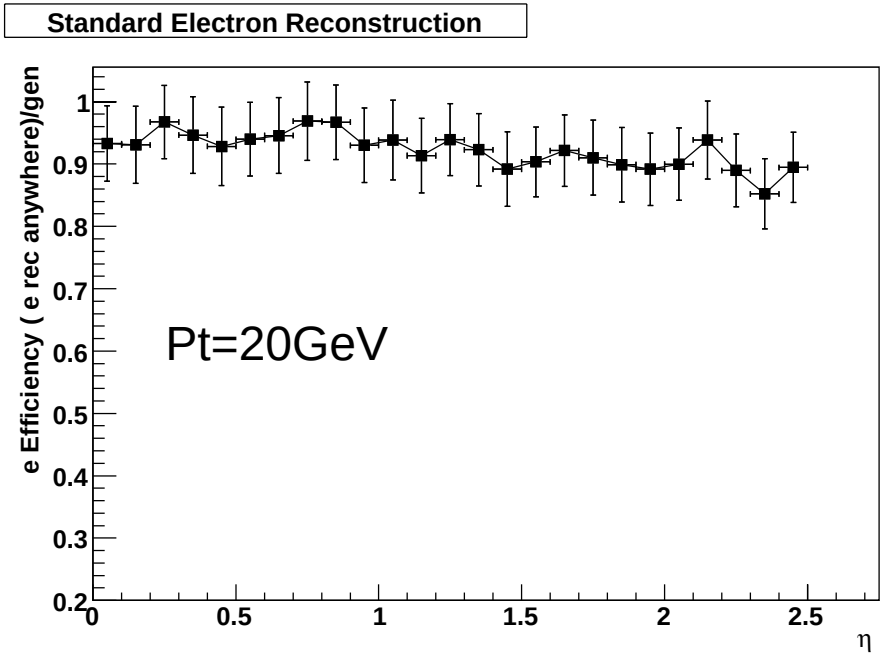
Signal: Loss of efficiency at low Pt<20GeV

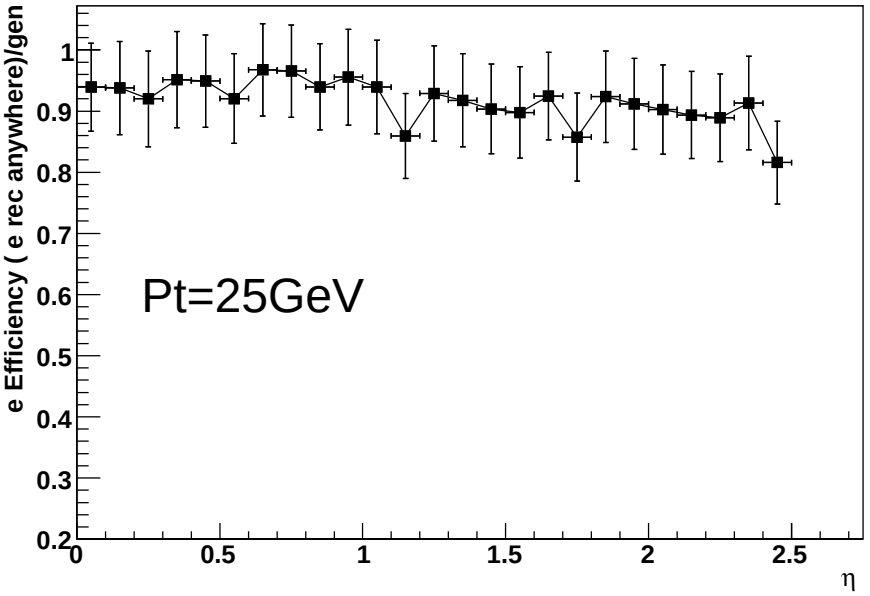
Plateau reached for Pt>30GeV



e Efficiency vs eta (DC1) track-matched clusters



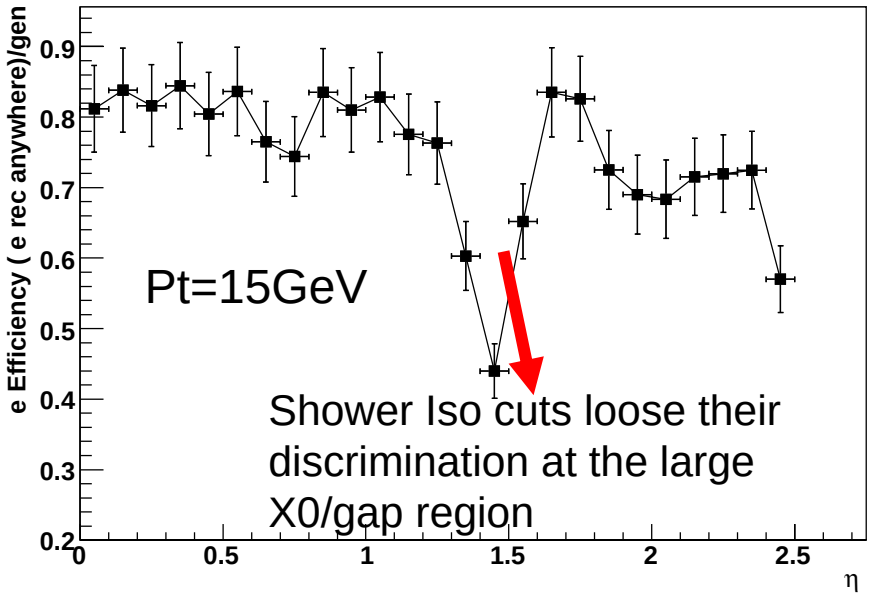




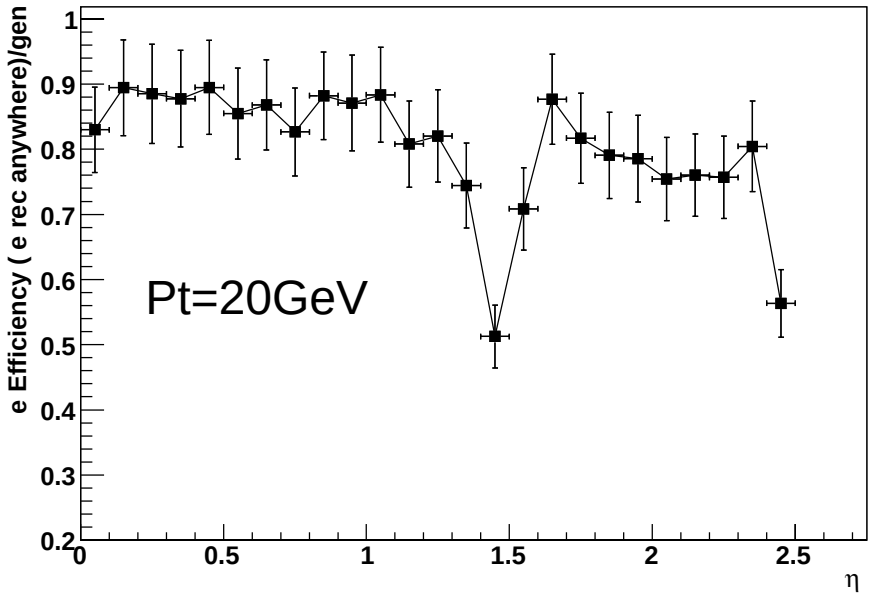
FEE noise and
Pile-up included

Efficiency: isolated track-matched clusters

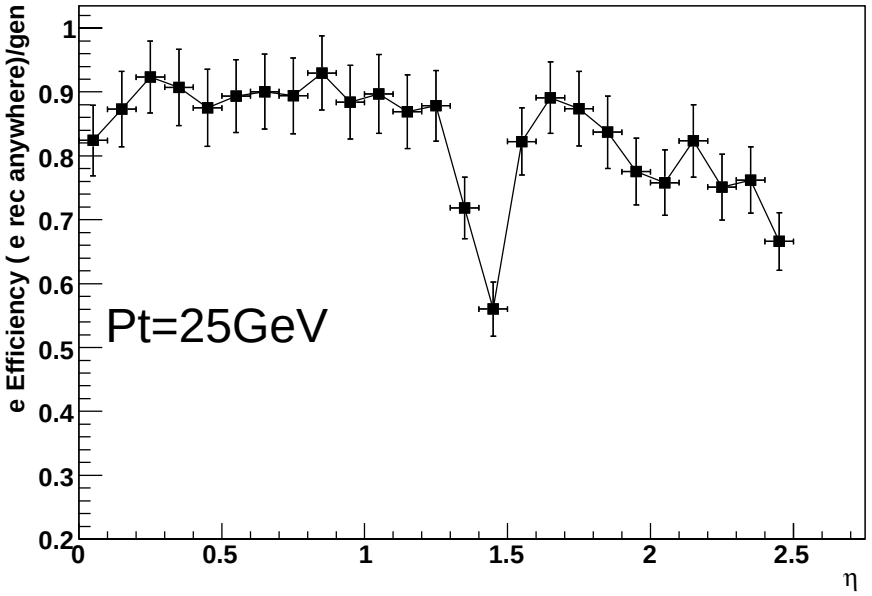
Standard Electron Reconstruction



Standard Electron Reconstruction



FEE noise and Pile-up included



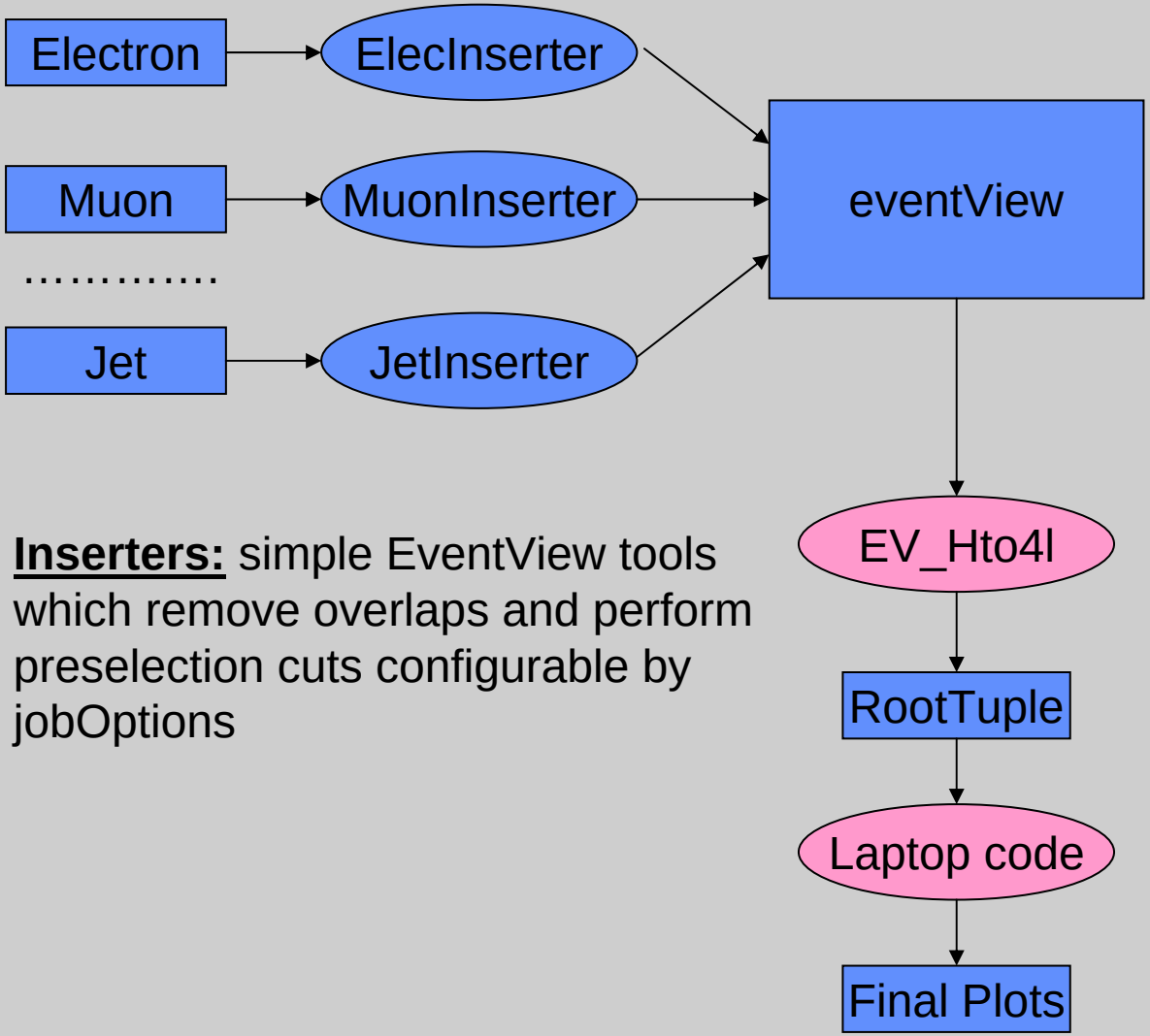
Things I would like in the Higgs analysis

- Easy/Clean access to “other” electrons. If I can combine softElectrons (softMuons) with the regular egamma electrons (and reg. muons), I may be able to increase efficiency which is mainly lost at low pt.
- Ability to combine 3 isolated electrons with 1 “less” isolated.
- Ability to combine “non track” electrons to reach outside the eta=2.5 region (LAr goes out to 3.2).
- Combine tracks with clusters and write my own variables that can move around my tools and go to an ntuple.

H->4l outside Athena

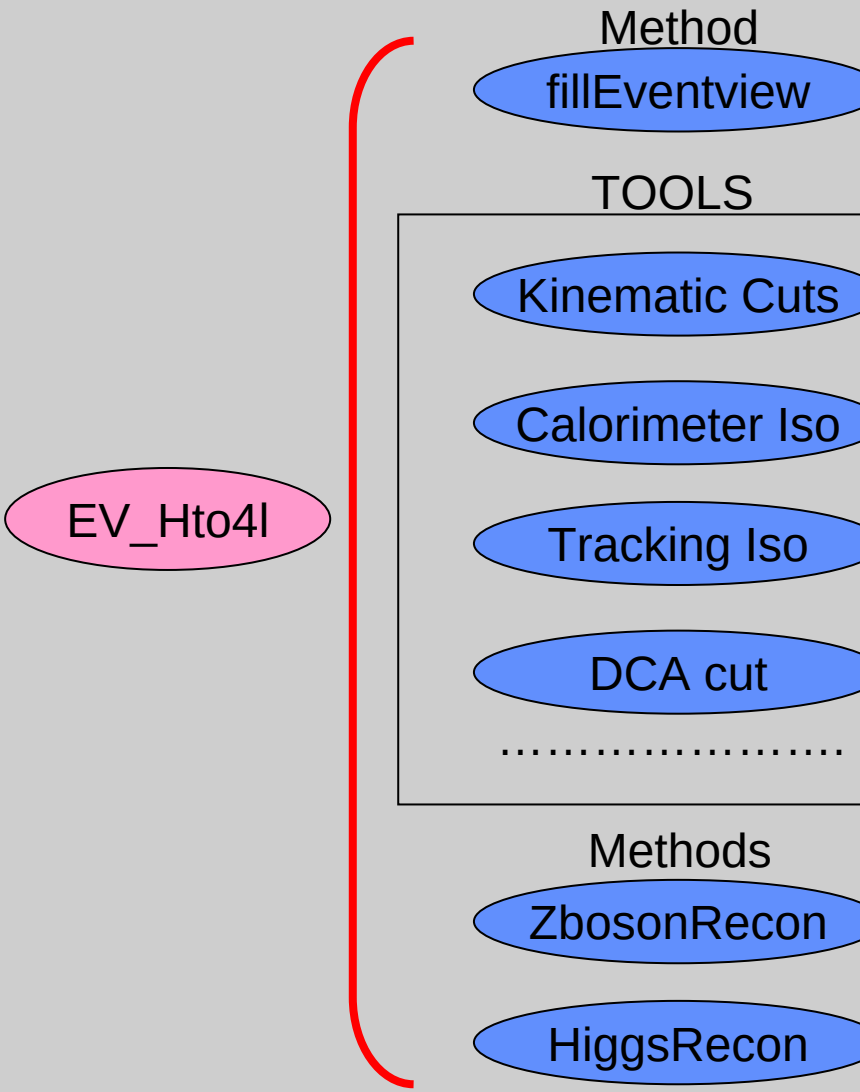
- It was very difficult to write a flexible piece of C++ code with all necessary tools that can cleanly go beyond the std TDR analysis (trivial)
- I tried to do the same in Athena, but the std AOD analysis examples do not really simplify the problem (although in principle it can be done)
- On the other hand I needed access to Athena tools and the particle objects (including truth). I soon found the easiest way to do all this:
  the **eventView**...

Structure (simplified+what I have tried)



Inserters: simple EventView tools which remove overlaps and perform preselection cuts configurable by jobOptions

EV_Hto4l algorithm and its tools



Fills the eventView with user variables/objects. These end-up in the output-rootTuple

Do we need all these tools?

No, we just wrote one (simple) tool and use N instances of it.

This is a great way to study in detail efficiencies (they keep their own names/counters)

EV_Hto4l jobOptions (1)

```
#
# Setup Dlls for analysis and set algorithm options
#
theApp.Dlls   += ["AnalysisTools" , "TruthParticleAlgs"]
theApp.Dlls   += ["UserAnalysis"]
theApp.TopAlg += ["EV_Hto4l/higgs"]
higgs=Algorithm("higgs")

#
# Top Algorithm (I call it "higgs")
#
#higgs.OutputLevel=VERBOSE
higgs.OutputLevel=ERROR

#
# The higgs analysis factory tools (order matters)
#
higgs.Hto4lTools=[
                "EV_Hto4lPreselectionTool/fourEMLArClusters",
                "EV_Hto4lPreselectionTool/fourTrkMatchClusters",
                "EV_Hto4lPreselectionTool/fourTrkQualClusters",
                "EV_Hto4lPreselectionTool/threeIsoEMLArClusters",
                "EV_Hto4lPreselectionTool/fourIsoEMLArClusters",
                "EV_Hto4lPreselectionTool/fourIsolatedTracks",
                "EV_Hto4lPreselectionTool/fourLowImpParamTrks"
                ]
```

EV_Hto4l jobOptions (2)

```
#
# Preselection Tools:
#
Hto4l = Service( "ToolSvc" )
Hto4l.fourEMLArClusters.cutName            = "fourEMLArClusters"
Hto4l.fourEMLArClusters.etaMax             = 2.5
Hto4l.fourEMLArClusters.ptLow              = 7.0*GeV
Hto4l.fourEMLArClusters.ptHigh             = 20.0*GeV
Hto4l.fourEMLArClusters.useIsEM            = False
Hto4l.fourEMLArClusters.outputLevel        = ERROR

Hto4l.fourTrkMatchClusters.cutName         = "fourTrkMatchClusters"
Hto4l.fourTrkMatchClusters.useTrackMatch   = True
Hto4l.fourTrkMatchClusters.outputLevel     = ERROR

Hto4l.fourTrkQualClusters.cutName          = "fourTrkQualClusters"
Hto4l.fourTrkQualClusters.useTrkQualIsEM = True
Hto4l.fourTrkQualClusters.useTRT           = False
Hto4l.fourTrkQualClusters.outputLevel      = ERROR

Hto4l.threeIsoEMLArClusters.cutName        = "threeIsoEMLArClusters"
Hto4l.threeIsoEMLArClusters.useCaloIsEM    = True
Hto4l.threeIsoEMLArClusters.nCaloNonIsoEle = 1 #num of allowed Non-Isolated electrons (3+1)
Hto4l.threeIsoEMLArClusters.outputLevel    = ERROR

Hto4l.fourIsoEMLArClusters.cutName         = "fourIsoEMLArClusters"
Hto4l.fourIsoEMLArClusters.useCaloIsEM     = True
Hto4l.fourIsoEMLArClusters.nCaloNonIsoEle  = 0
Hto4l.fourIsoEMLArClusters.outputLevel     = ERROR
```

Kinematic cuts

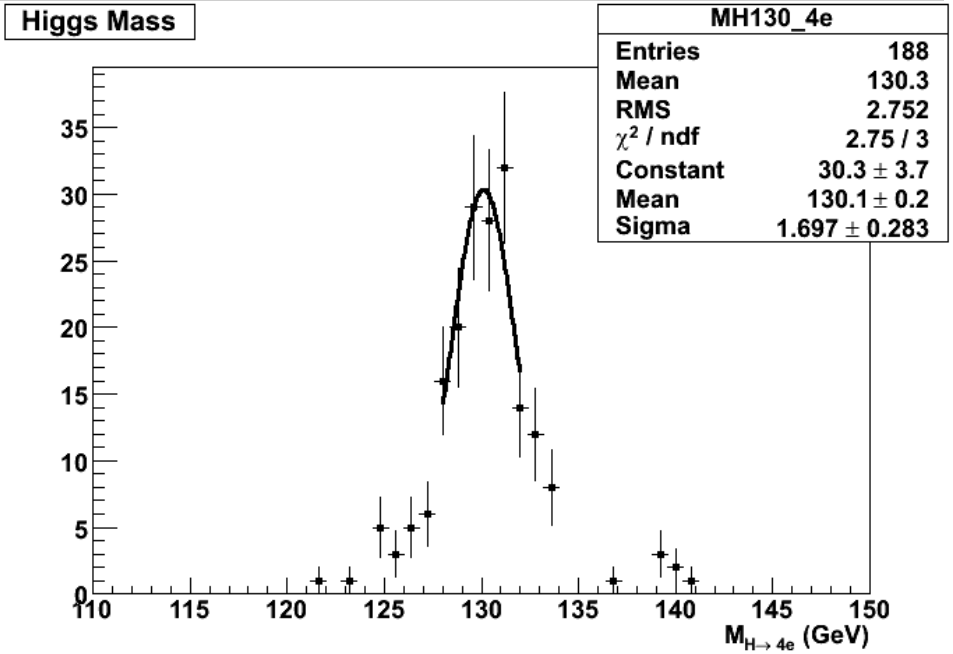
LAr Isolation cuts

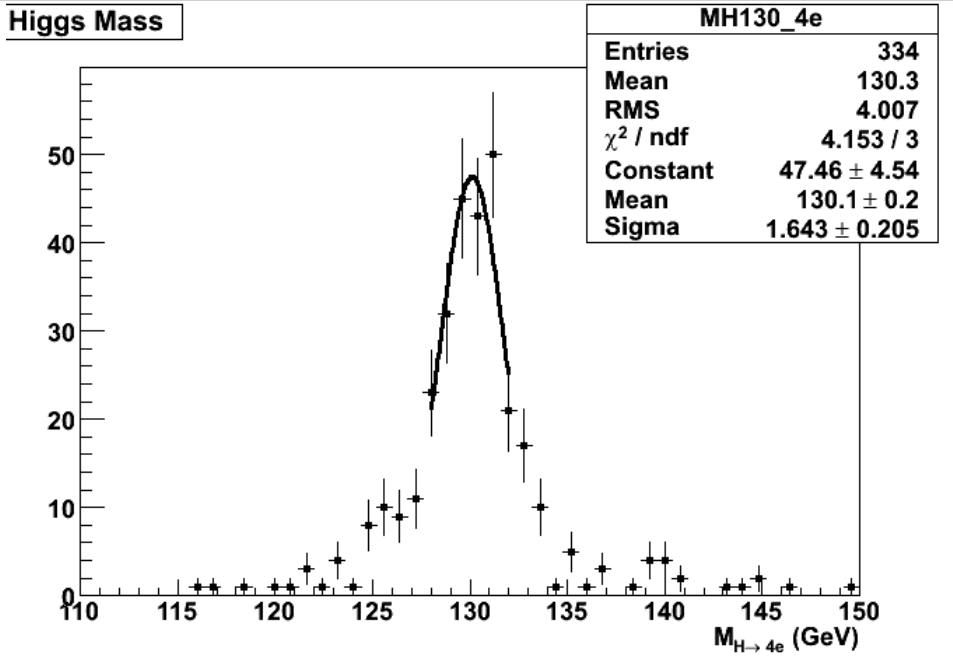
H->4e efficiency tables from EV_Hto4l

	Total	Passed	Efficiency	TotalEff
fourEMLArClusters	10069	928	0.0922	0.0922
fourTrkMatchClusters	928	928	1.0000	0.0922
fourTrkQualClusters	928	797	0.8588	0.0792
fourIsoEMLArClusters	797	334	0.4191	0.0332
fourIsolatedTracks	334	308	0.9222	0.0306
fourLowImpParamTrks	308	253	0.8214	0.0251
ZeeReconstruction	253	253	1.0000	0.0251
HtoZZ4eReconstruction	253	188	0.7431	0.0187
Total				0.0187

	Total	Passed	Efficiency	TotalEff
fourEMLArClusters	10069	928	0.0922	0.0922
fourTrkMatchClusters	928	928	1.0000	0.0922
fourTrkQualClusters	928	797	0.8588	0.0792
threeIsoEMLArClusters	797	624	0.7829	0.0620
fourIsolatedTracks	624	540	0.8654	0.0536
fourLowImpParamTrks	540	453	0.8389	0.0450
ZeeReconstruction	453	451	0.9956	0.0448
HtoZZ4eReconstruction	451	334	0.7406	0.0332
Total				0.0332

Invariant masses (AOD-Rome Input)





Four Isolated electrons

Three Isolated electrons

This simple example shows how one can start studying signal losses/gains vs background rejections as a function of the various cuts (and their parameters)

Zbb->4e background increases by 10x !

********** Cut Efficiency Summary **********				
	Total	Passed	Efficiency	TotalEff
fourEMLArClusters	94513	10745	0.1137	0.1137
fourTrkMatchClusters	10745	10745	1.0000	0.1137
fourTrkQualClusters	10745	9099	0.8468	0.0963
fourIsoEMLArClusters	9099	93	0.0102	0.0010
fourIsolatedTracks	93	45	0.4839	0.0005
fourLowImpParamTrks	45	14	0.3111	0.0001
ZeeReconstruction	14	14	1.0000	0.0001
HtoZZ4eReconstruction	14	5	0.3571	0.0001
Total				0.0001

	Total	Passed	Efficiency	TotalEff
fourEMLArClusters	94513	10745	0.1137	0.1137
fourTrkMatchClusters	10745	10745	1.0000	0.1137
fourTrkQualClusters	10745	9099	0.8468	0.0963
threeIsoEMLArClusters	9099	942	0.1035	0.0100
fourIsolatedTracks	942	201	0.2134	0.0021
fourLowImpParamTrks	201	80	0.3980	0.0008
ZeeReconstruction	80	80	1.0000	0.0008
HtoZZ4eReconstruction	80	35	0.4375	0.0004
Total				0.0004

However partial isolation on the 4th electron may keep Zbb under control

Plans

- Implementation of 2e2mu, 4mu analyses
- Make CVS package (or become part of one)
- Address eventView issues:
  - Remember eventView is under construction
  - Speed issues related to the output file writing?
  - Have the option to write only events that pass the cuts (fast)
  - Have C++ vectors as user data types (done!)
- Develop Performance tools for single leptons as part of the EV_Hto4l package.