Egamma Tutorial

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Detector Understanding with First LHC Data
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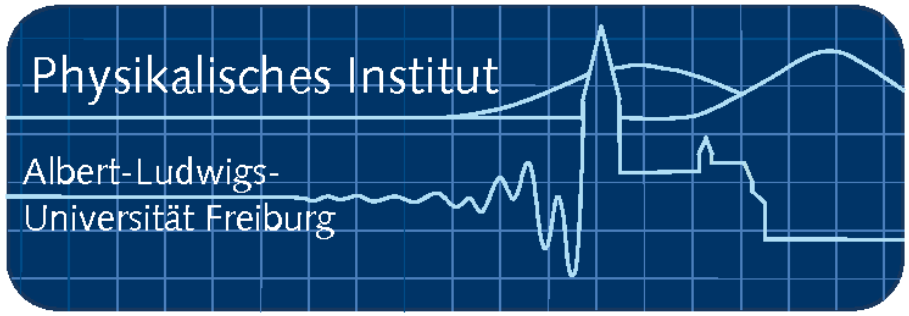


Overview

This tutorial is based on a tutorial from Nicolas Kerschen!

We will look at FDR2 pseudo data from the egamma stream. We will do the following:

- plot the dielectron mass spectrum
- plot isEM variables around the Z peak
- make some cuts to reduce the background
- implement a "tag and probe" method to determine the isEM efficiency from (pseudo) data

The TWiki for this tutorial is:
https://twiki.cern.ch/twiki/bin/view/AtlasProtected/TutorialsDU09EGamma

Getting Started

Setup your Athena release:

```
source ~/cmthome/setup.sh -tag=15.1.0,local
cd ~/atlas/testarea/15.1.0
```

Get the code and compile it:

```
cp -r /afs/naf.desy.de/user/j/jhartert/public/EgammaTutorial .
cd EgammaTutorial/cmt
cmt config
make
```

When compiling next time use

```
make QUICK=1
```

Now run the electron study:

```
cd ../python
athena elecstudy.py
```

While it's running let's have a look at the code....

Looking at the code: job options

The code is compiled C++ used in combination with the steering file (`elecstudy.py`). In the python file you may want to change the following lines[1]:

```
evtMax = 5000
inputFileList="input_FDR.txt"
```

We will stick to the FDR2 data, but if you want to look at MC as well, the following inputs are available:

`input_Zee.txt` ($Z \rightarrow e^+e^-$ - 106050)
`input_JF17.txt` (filtered QCD dijets - 105802)
`input_Hgg.txt` ($H \rightarrow \gamma\gamma$ - 106384)

[1] The files of the chosen FDR2 run contain about 90k events corresponding to a luminosity of roughly $0.36\,\mathrm{pb}^{-1}$

Looking at the C++ code: ElectronStudy.cxx

The main method: `run()`:

- loops events:

```
for (unsigned int jentry = 0; jentry<nEventsToProcess ; jentry++)
```

- call cut methods:

  `Convert(...)` - converts ElectronContainer to std::vector

  `EtaEtCuts(...)`

  `IdCuts(...)`

- reconstructs the Z peak

This is where you should later implement the tag and probe method.

Things you should (try to) understand

In the `convert()` method:

```
(*inputElectrons)[i]->author(egammaParameters::AuthorElectron)
```

This means that the electron was reconstucted by the cluster based algorithm. Also a track based electron algorithm exists:

`egammaParameters::Softe`.

All authors are defined in egammaParamDefs.h[2]:

```
const unsigned int AuthorUnknown=0x0;
const unsigned int AuthorElectron=0x1;
const unsigned int AuthorSofte =0x2;
const unsigned int AuthorPhoton=0x4;
const unsigned int AuthorFrwd=0x8;
const unsigned int AuthorRConv=0x16;
```

[2] http://alxr.usatlas.bnl.gov/lxr-stb4/source/atlas/Reconstruction/egamma/egammaEvent/egammaEvent/egammaParamDefs.h?v=release_15_1_0

Things you should (try to) understand (2)

In the `IdCuts()` method:

The shower variables are stored in an `EMShower` object which is obtained like this:

```
const EMShower* shower =
inputElectrons[i]->detail<EMShower>("egDetailAOD");
```

From that you can get the shower variables in the following ways:

```
float ethad = shower->ethad();
```

or

```
float ethad = shower->parameter(egammaParameters::ethad);
```

The available variables are documented in
https://twiki.cern.ch/twiki/bin/view/AtlasProtected/EgammaAOD.

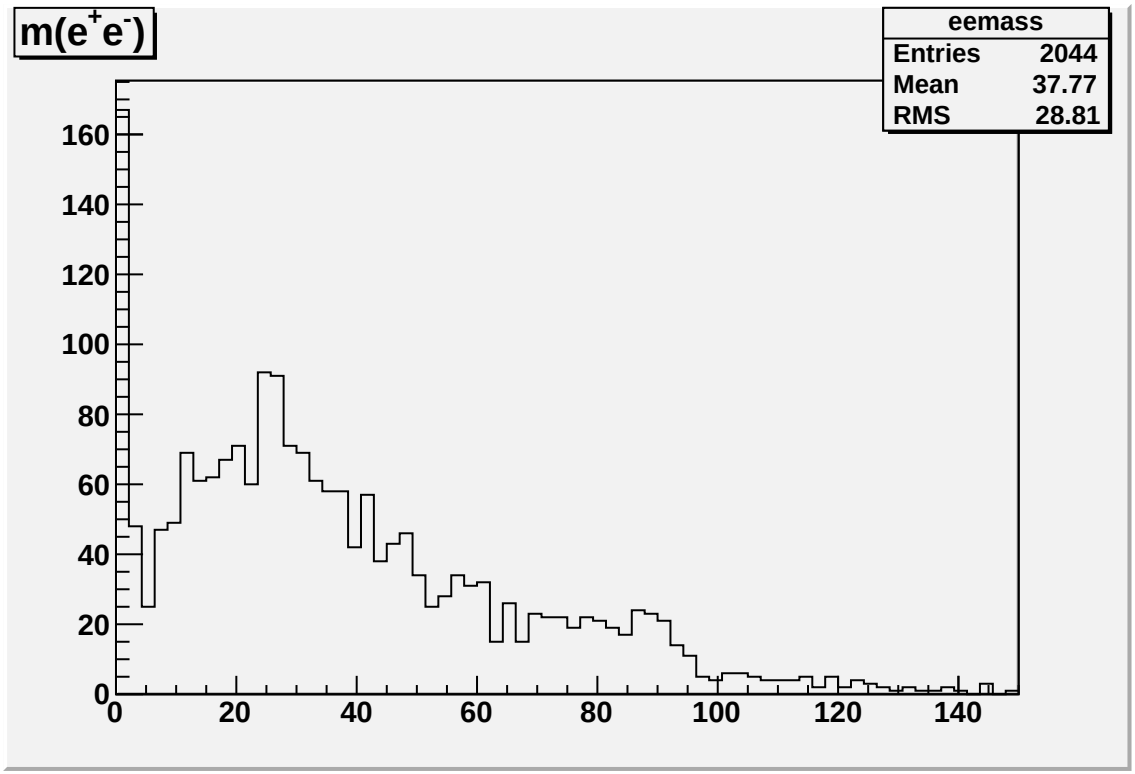
Also note the usage of the standard electron ID via the isEM bit mask, which we will use later:

```
inputElectrons[i]->isem(egammaPID::ElectronLoose) == 0
```

Spotting the Z peak

When your job is finished, have a look at the output file
`ElectronStudy.root`
The histogram `eemass` shows the e^+e^- invariant mass distribution.

Do you see the Z peak? But this is whitout any electron ID!



Adding selfmade electron ID

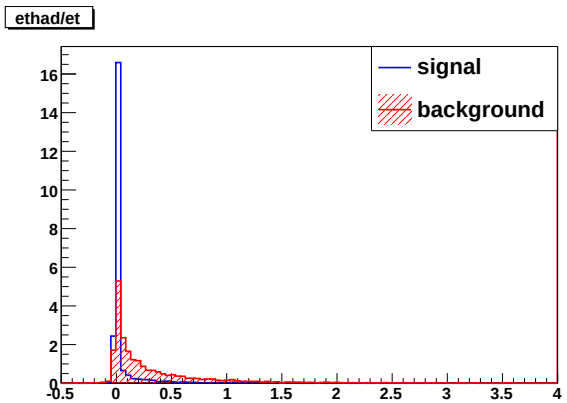
Now try to improve this by:

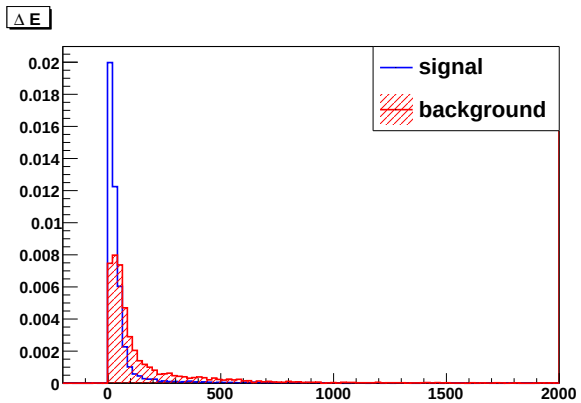
- adding a p_T cut (e.g. 10 GeV)
- apply cuts on the following variables:
  - ethad/et
  - e237/e277
  - weta2
  - emax2-emin
  - f3core
  - etcone30/et

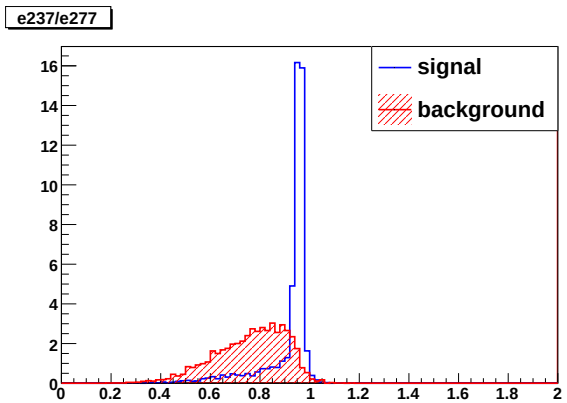
To safe some time, those variables are already implemented. The following plots may help you to find appropriate cuts...

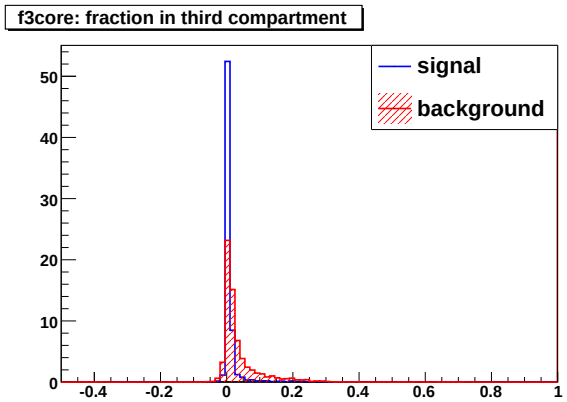
Distributions of some isEM variables

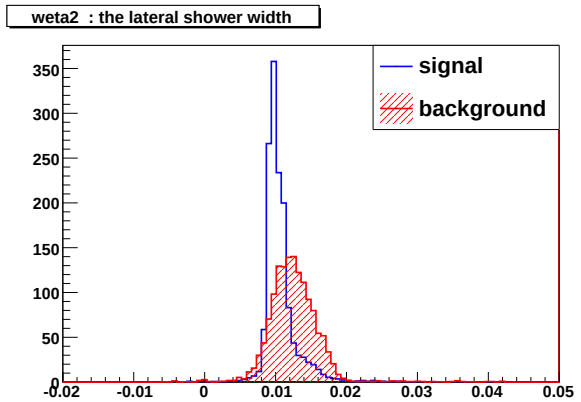
Signal: $Z \longrightarrow e^+e^-$
Background: filtered dijets

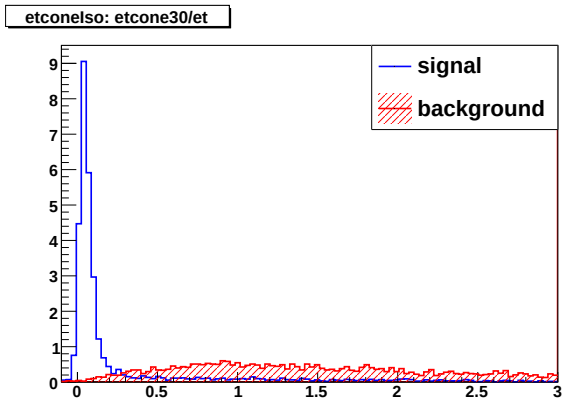






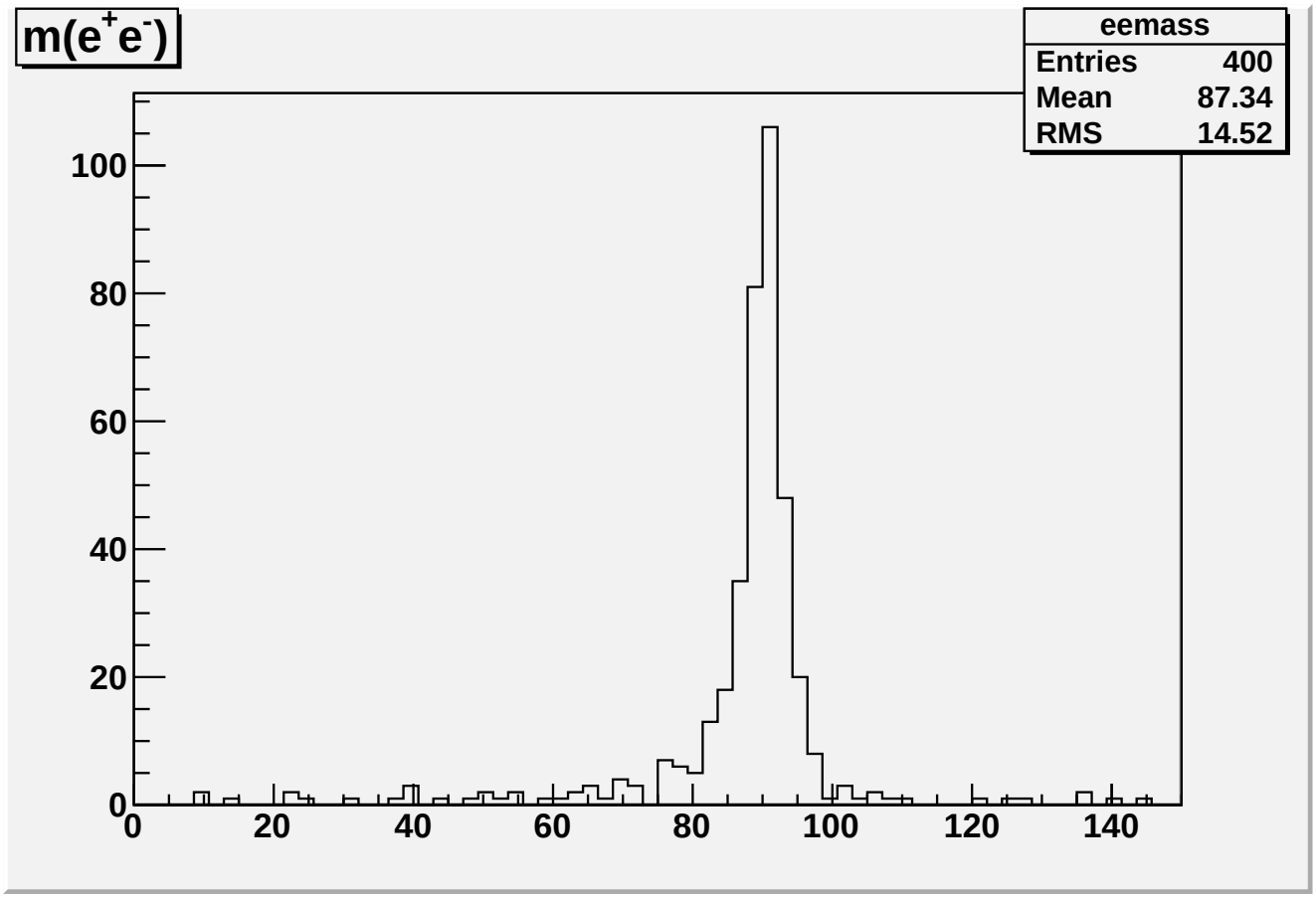






Spotting the Z peak (2)

Do you see a clear Z peak now?



Using isEM mask (1)

Instead of applying your own cuts lets use the pre-defined electron ID:

```
inputElectrons[i]->isem(egammaPID::ElectronLoose) == 0
```

For a bunch of variables default cuts are defined (binned in η and p_T) and for each variable a bit is set to true/false (not passed/passed). When using `isem(egammaPID::ElectronLoose)` the bits of a certain set of variables are taken into accout.

The variables are described in the CSC book:
http://cdsweb.cern.ch/record/1125884
and extracted here:
https://twiki.cern.ch/twiki/bin/viewfile/AtlasProtected/TutorialsDU09EGamma?rev=2;filename=isEMVarsElectrons.pdf

Using isEM mask (2)

For the cut values look in the job options (of the release that was used in reconstruction):

release $<$ 14.4.0: EMPIDBuilderBase.py

http://alxr.usatlas.bnl.gov/lxr-stb3/source/atlas/Reconstruction/egammaRec/python/EMPIDBuilderBase.py?v=release_14_2_0

release $\geq$ 14.4.0: egammaElectronCutIDToolBase.py

http://alxr.usatlas.bnl.gov/lxr/source/atlas/Reconstruction/egamma/egammaPIDTools/python/egammaElectronCutIDToolBase.py

ID efficiency from data

Now lets try to extract the ID efficiencies from (pseudo) data. For that we use the "tag and probe method":

1. require a tight electron (tag electron)
2. try to find a second electron candidate (probe electron) which is consistent with coming from a Z boson decay
3. for the probe electron count, how often is passes the ID cuts

The method and its results are described in more detail in the CSC book: http://cdsweb.cern.ch/record/1125884 (p. 88 ff)

ID efficiency from data (2)

For the tag and probe, you can for example try to use the following requirements:

tag electron

- hardest electron candidate
- `egammaPID::ElectronTight`
- $p_T > 25\,\text{GeV}$

probe electron

- $p_T > 15\,\text{GeV}$
- $\Delta\phi(e^+e^-) > 3/4\pi$
- $80\,\text{GeV} < m(e^+e^-) < 100\,\text{GeV}$

The results of the CSC studies are listed here:

https://twiki.cern.ch/twiki/bin/viewfile/AtlasProtected/TutorialsDU09EGamma?rev=4;filename=TagAndProbeResultsCSC.jpg

Addon: Looking into photons

If you have a lot of time (and motivation ;-)) left, you may also look into photons.

Use the PhotonStudy.cxx and photonstudy.py.

The photons from the $H \rightarrow \gamma\gamma$ MC sample are a good source of high p_T isolated photons.