

Introduction to Analysis Example tutorial

D. Greenwood

For P. Skubic

Email: pskubic@ou.edu

Who we are

- We are **DOSAR: Distributed Organization for Scientific and Academic Research**
<http://www.dosar.org/>
- You are welcome to join our bi-weekly video (Vidyo) meetings. Send request to be added to DOSAR email list to Prof. Greenwood:
greenw@phys.latech.edu
- If you want long-term grid access, you can request membership in the **DOSAR VO**

Typical data analysis steps in particle physics

- Step 1: create files containing simulated data
- Step 2: analyze simulated data
- Step 3: collect real data from detector
- Step 4: analyze real data
- Step 5: compare simulation with real data
 - If there is good agreement, limits can be set on existence of new physical states (i.e. particles)
 - If there is disagreement, further study is needed
 - Possible mistake?
 - Possible new discovery?
- We will illustrate steps 1 and 2 today

Notes

- In particle physics software tools such Madgraph or Isajet (event generators) and GEANT (to simulate our detector response) are used in Step 1
 - We will use a simple random generator of Gaussian distribution in Root
- Typically (almost) the same reconstruction software is used for Step 4 and Step 2
- Root is a powerful tool to read and analyze large amounts of data

Root Documentation

- Web page: <http://root.cern.ch>
- It is useful to click on: Documentation and then select: Reference Guide
- From there you can look at the documentation and source code for all the Root classes in any version of Root

Condor submission script

```
universe=grid
grid_resource=gt2 osgitb1.nhn.ou.edu/jobmanager-condor
executable=run-root.sh
transfer_input_files = run-root.C
transfer_executable=True
when_to_transfer_output = ON_EXIT
log=run-root.log
transfer_output_files = root.out,t00.root,t01.root
output=run-root.out.$(Cluster).$(Process)
error=run-root.err.$(Cluster).$(Process)
notification=Never
queue
```

Step 1: Create simulated data by running Root on the Grid

- Contents of execution script: **run-root.sh**

```
#!/bin/bash
```

```
/usr/local/bin/root -b < run-root.C > root.out
```

This command executes Root in batch mode using macro **run-root.C** and routes output to file **root.out**

Step 1: Create simulated data by running Root with macro **run-root.C**

- Create TFile 0 for “run 0” (t00.root)
- Create TTree object (“t0”) to store data in Root
 - Generate 100 “events” each with Gaussian distributed “Energy”
 - Fill TTree branches for each event
- Write TFile 0
- Close TFile 0
- Repeat above steps to create TFile 1 for “run 1” (t01.root)

Step 2: make TSelector

```
TFile f("t00.root"); //open file  
t0.MakeSelector("s0"); //create TSelector "s0"  
f.Close(); //close file
```

This creates two files with code: `s0.C` and `s0.h`

We will modify these files to add a histogram of the Energy variable and use them to process the simulated data on the Grid

Conclusion

- After completing Steps 1 and 2 you are in principle ready to scale up and make TTree's with hundreds of variables and create and analyze thousands of files
- If time permits you can try adding your own features to the existing example by adding variables and histograms, etc.
- Good luck and have fun!!

Z-boson Plot

- A Z-boson is particle that only lives for a very short time before decaying. We can observe a Z-boson by looking at its decay products. The decay modes of the Z are here

<http://pdg.lbl.gov/2012/tables/rpp2012-sum-gauge-higgs-bosons.pdf>

- It decays to two muons and two electrons 3.4% of the time.

readEvents.C

- Macro from Heather to calculate the invariant mass of the first muon pair in each event and then plot the invariant mass in a histogram.
- Only looks at events which contain at least two muons where both muons have transverse momentum, $p_t > 20$ GeV.
- The two selected muons have opposite charge.

Determination of the Z boson mass

- readEvents.C uses the following:
 - The TLorentzVector class (<http://root.cern.ch/root/html/TLorentzVector.html>) is very powerful.
 - If you have two particles and want to know the properties of the particle which produced them, you can simply add them together:
 - TLorentzVector Particle1;
 - TLorentzVector Particle 2;
 - // set up the properties of particle 1 and particle 2
 - TLorentzVector MotherParticle = Particle1 + Particle2;

More Information

- ROOT website: <http://root.cern.ch/drupal/>
- Intro to ROOT: <http://root.cern.ch/drupal/content/discovering-root>
- Tutorials:
<http://root.cern.ch/root/html/tutorials/>
- Invariant mass:
- Reference guide for all classes: <http://root.cern.ch/root/html534/ClassIndex.html>
- ATLAS Z cross-section:
<http://arxiv.org/pdf/1010.2130v1.pdf>