

CMS Data Analysis

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Available Data Sets

- 2000 di-muon events around the J/ψ
- 2000 di-electron events around the J/ψ
- 2000 di-electron events around the Υ
- 100,000 di-muon events in the invariant mass range 2-110 GeV
- 100,000 di-electron events in the invariant mass range 2-110 GeV
- 500 di-electron events around the Z boson
- 500 di-muon events around the Z boson
- 500 events of W to $e\nu$
- 500 events of W to $\mu\nu$
- 13 Higgs candidate events: H to $\gamma\gamma$, $4e$, $2e2\mu$, 4μ
- ~ 50 1/pb single muons for top quark analysis (508,561 events)

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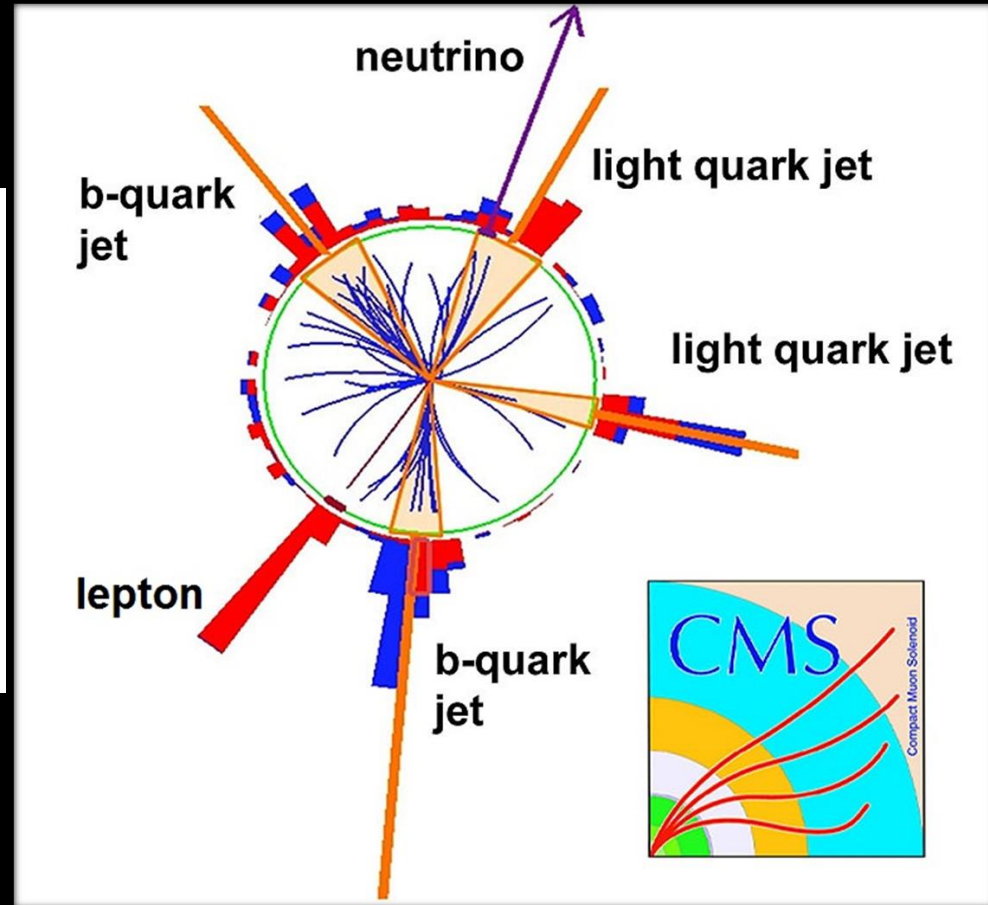
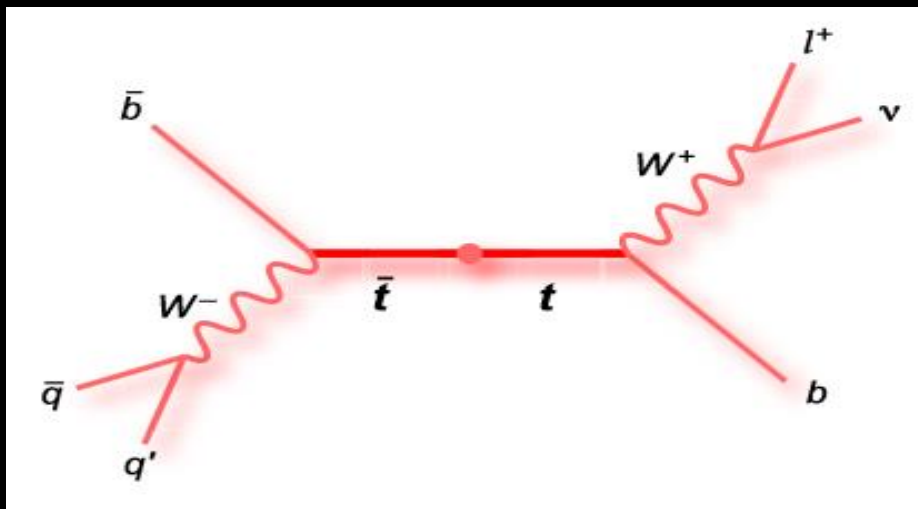
Why the $t\bar{t}$ Data Set?

- Reasons for choosing the $t\bar{t}$ data set:
 - well-designed accompanying activity
 - activity requires use of simulated data to determine cuts and efficiencies
 - provides an opportunity to learn Linux, C++, and ROOT

Preparatory Activity

- We downloaded data and several example programs to our local Linux machine
 - created individual accounts for each member of the group
- We used MobaXterm to give us virtual terminals on that machine to access the data
- We studied C++ for two weeks before starting work with ROOT

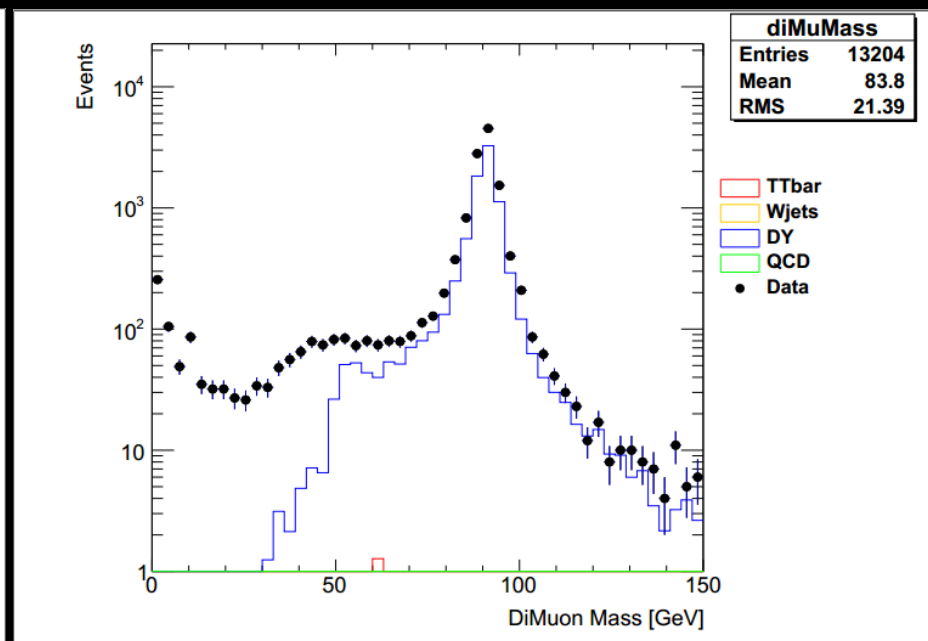
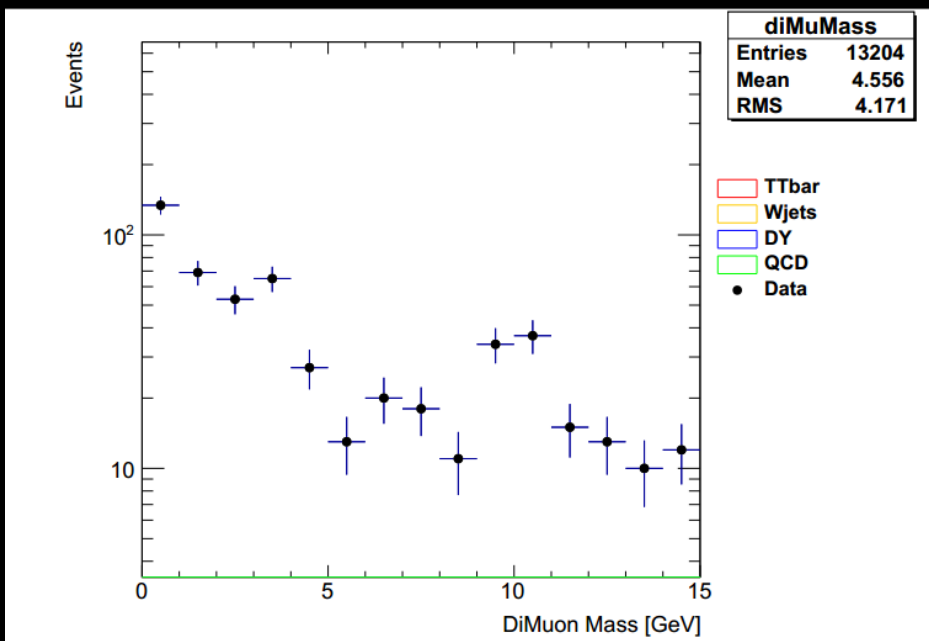
$t\bar{t}$ Events



Preliminary Plots

1. Diagnostic Plots

2. DiMuon Mass Plots



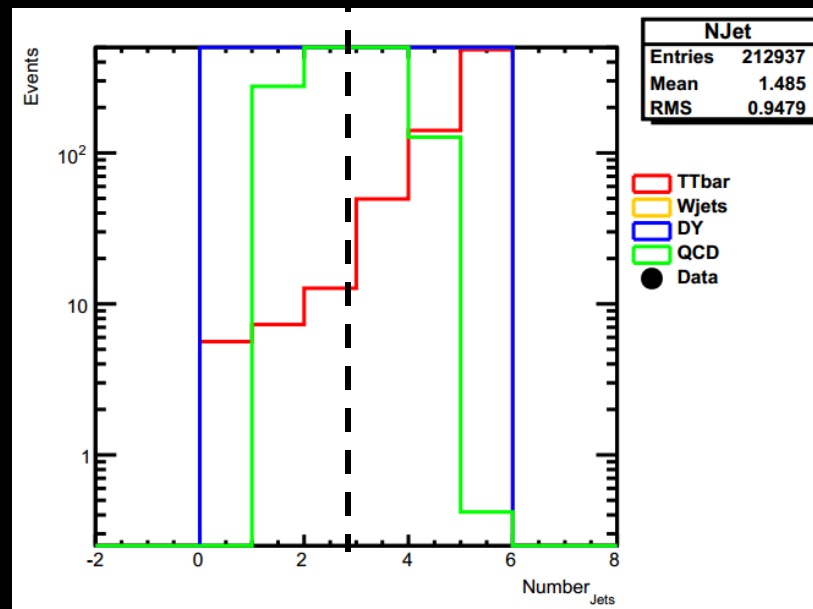
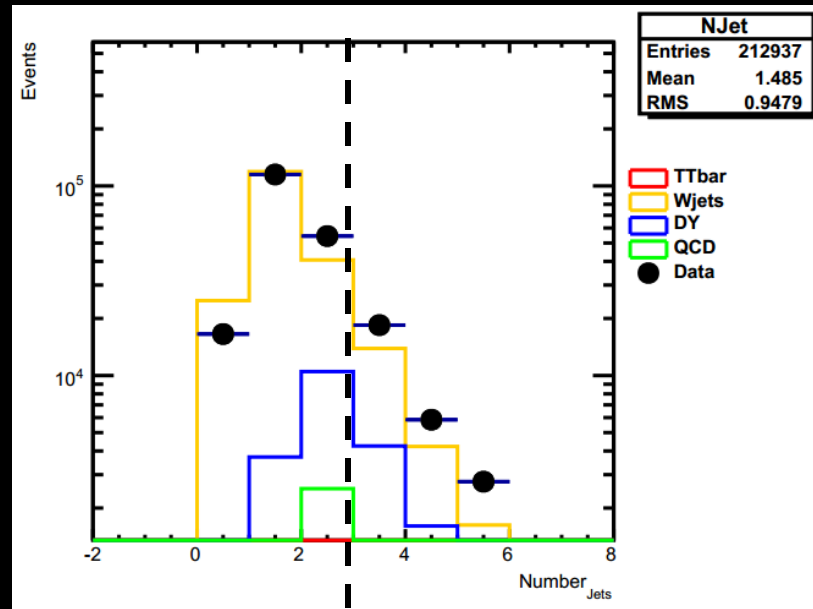
Enriching the Top Content of the Data

Sample: Strategy

- Identify measured quantities that allow us to distinguish between $t\bar{t}$ events and expected background
- Number of simulated events
 - $t\bar{t}$: 383,167 (signal)
 - Drell-Yan: 109,656 (background)
 - $W + \text{Jets}$: 76,196 (background)
 - QCD: 137 (background)
 - total: 569,156

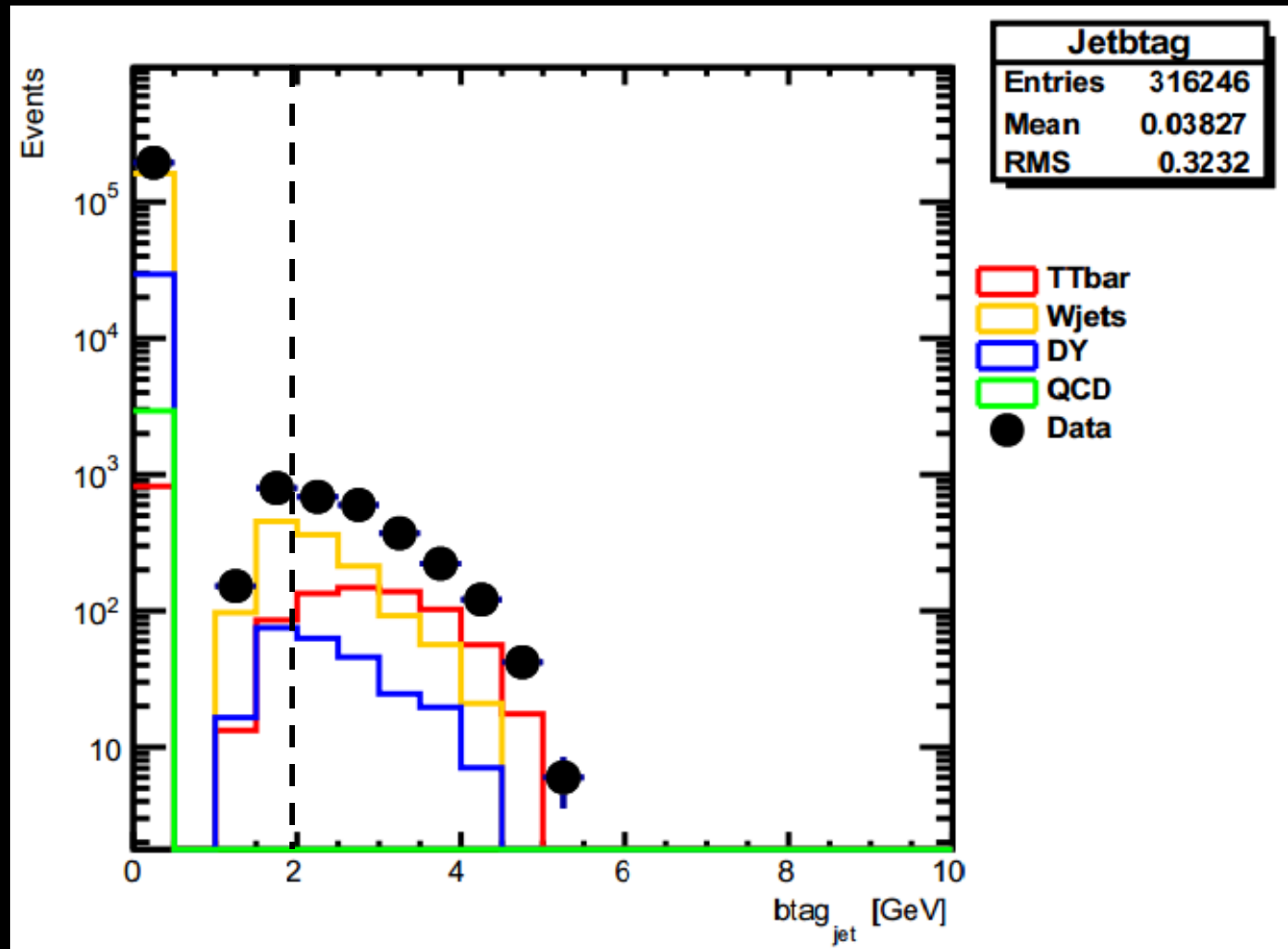
Enriching the Top Content of the Data Sample

- NJets



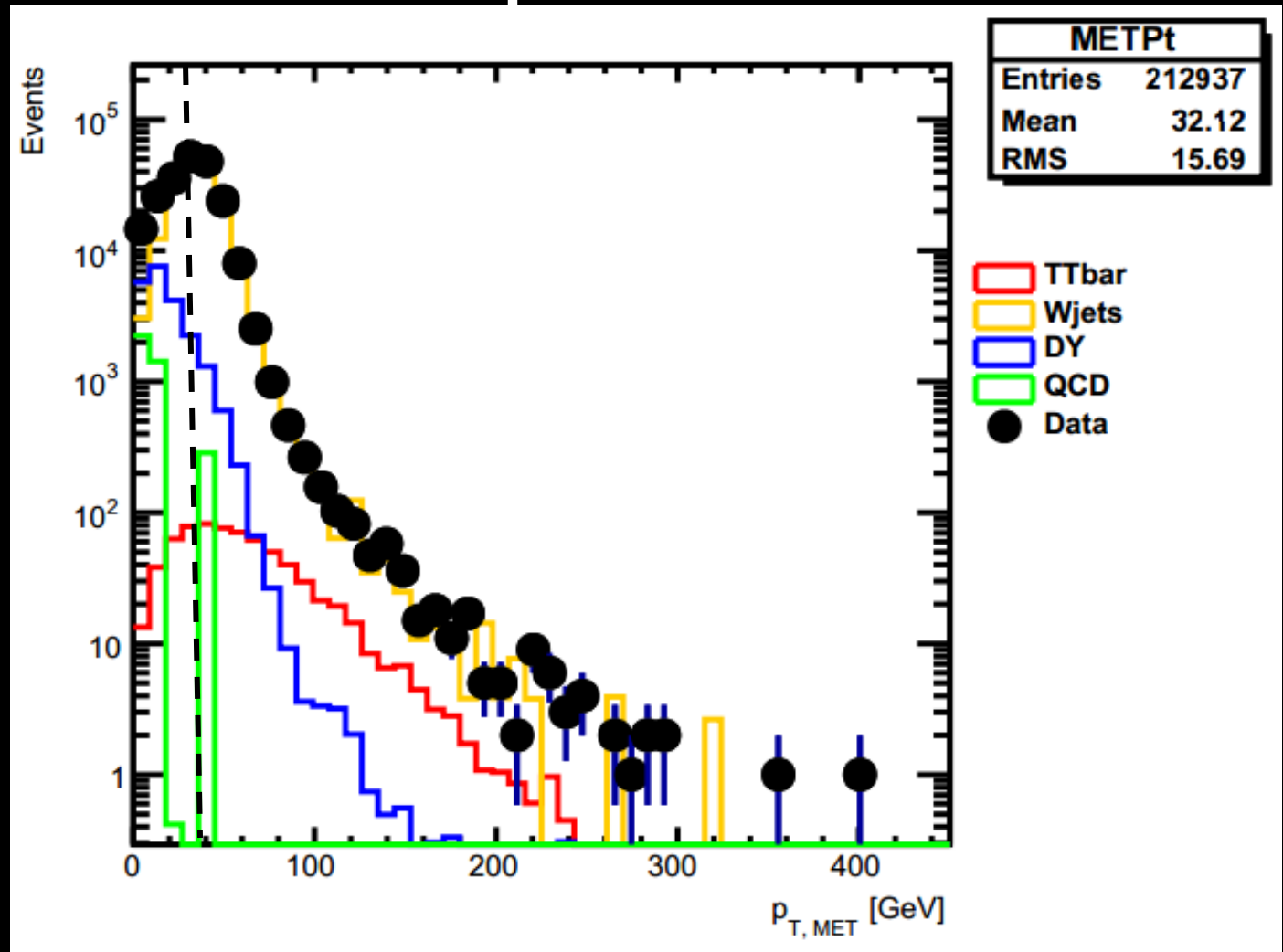
Enriching the Top Content of the Data Sample

- bTags



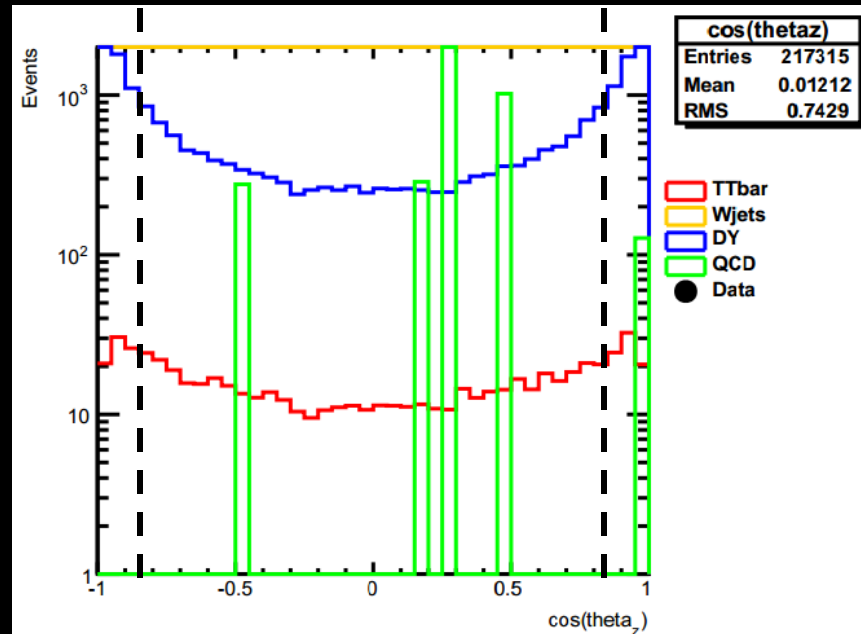
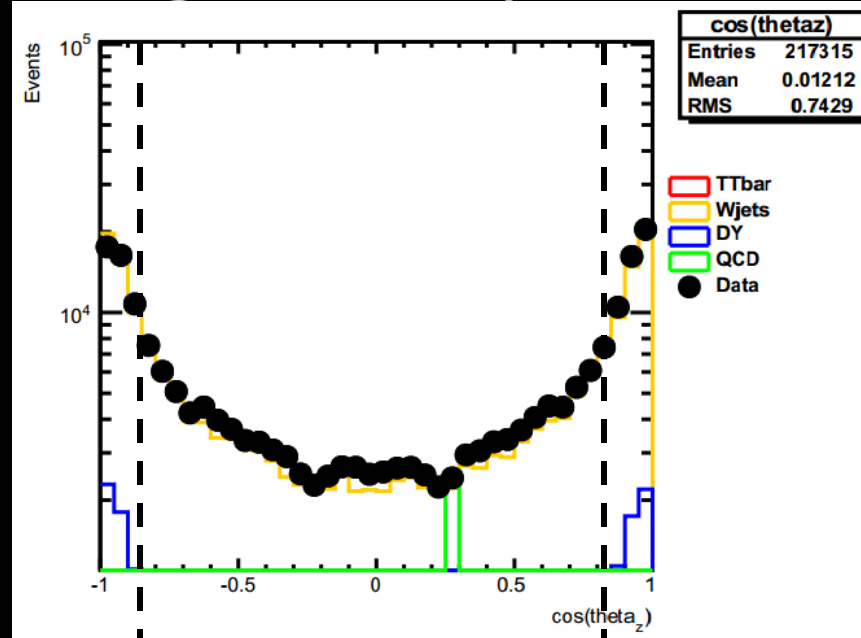
Enriching the Top Content of the Data Sample

- MET

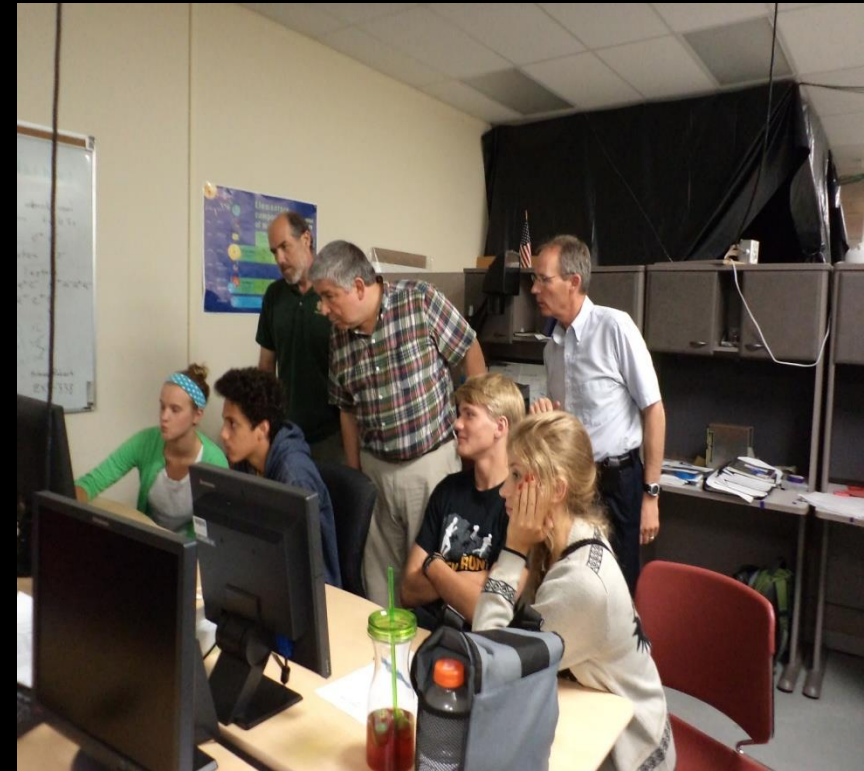
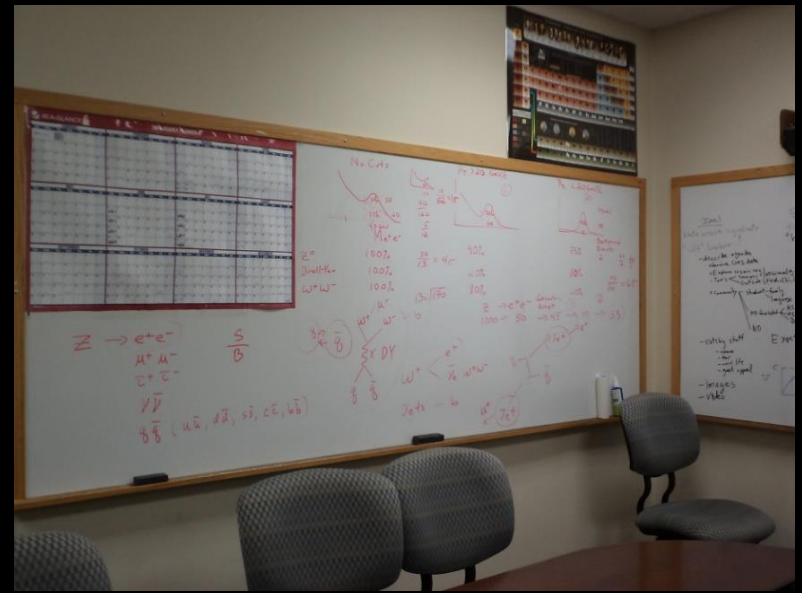


Enriching the Top Content

- Angular Distribution



Quarknet

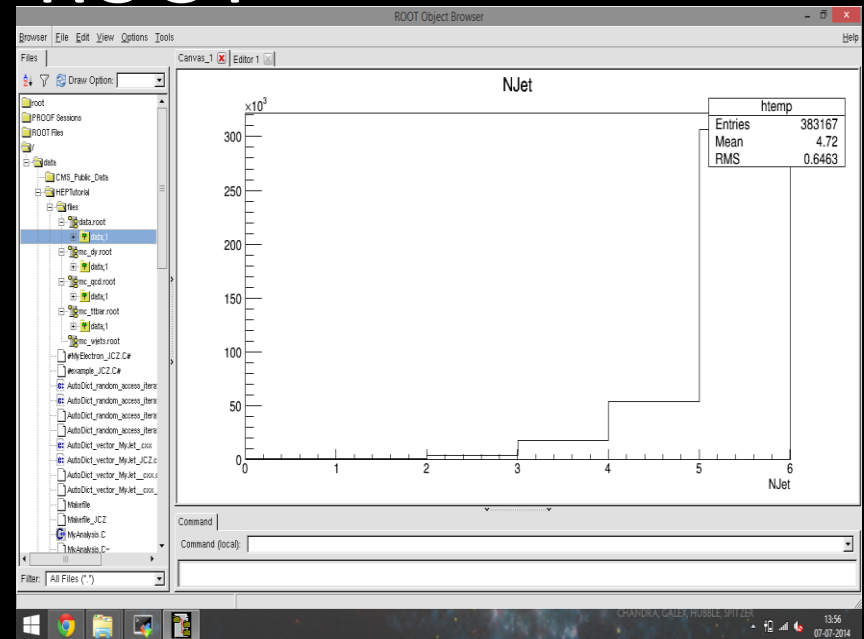


Quarknet

CMS Data Group



ROOT



C++

```
BuildEvent();

// cout << "Muons: " << endl;
// for (vector<MyMuons>::iterator it = Muons.begin(); it != Muons.end(); ++it) {
//   cout << "pt, eta, phi, iso, charge: " << it->Pt() << ", " << it->Eta() << ", " << it->Phi() << ", "
//   << it->GetIsolation() << ", " << it->GetCharge() << endl;
// }

// Fill d1Mass into histogram
// require at least two isolated muons and trigger bit
//

if (MMuon > 1 && triggerIsolu24) {
  for (int io=0; io<MMuon-1; io++) {
    if (Muons.at(io).IsIsolated() && Muons.at(io).Pt() > 24) {
      for (int ii=io+1; ii<MMuon; ii++) {
        //if (Muons.at(ii).IsIsolated() && Muons.at(ii).Pt() > 24 && Muons.at(io).GetCharge() != Muons.at(ii).GetCharge()) {
        if (Muons.at(ii).IsIsolated() && Muons.at(ii).Pt() > 24) {
          mass_mumu=(Muons.at(io) + Muons.at(ii)).M();
          h_d1Mass->Fill(mass_mumu, EventWeight);
        }
      }
    }
  }
}

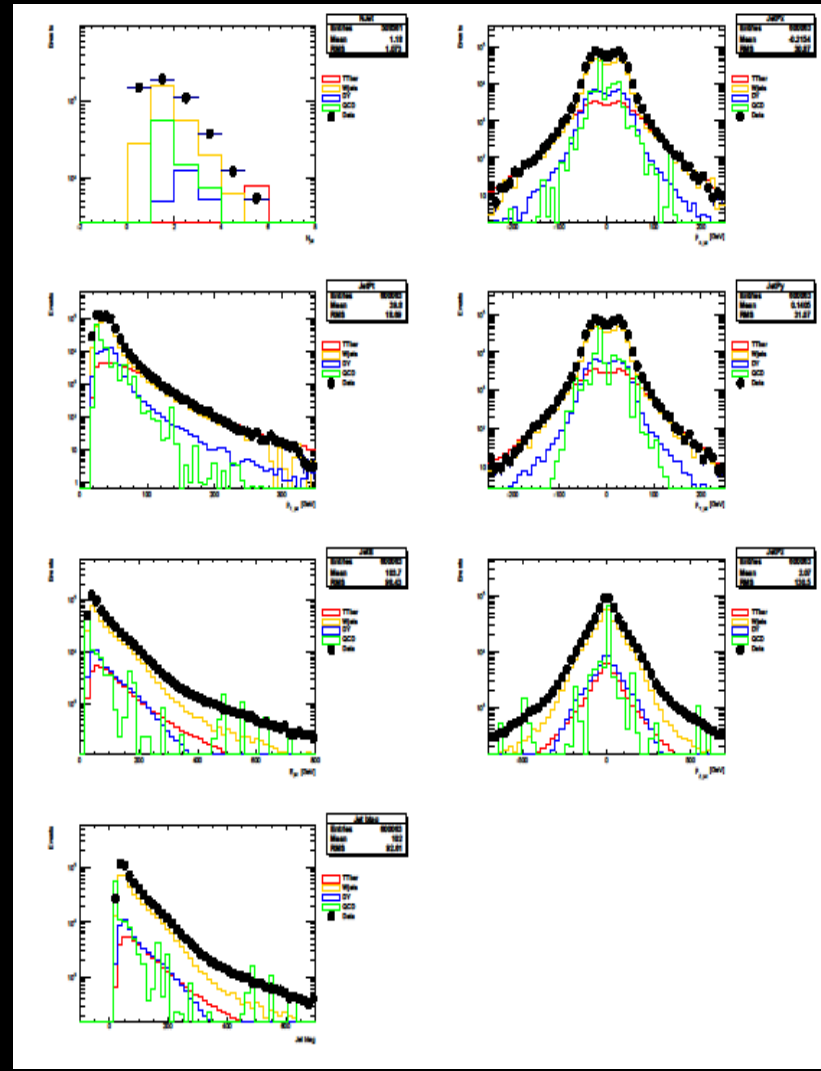
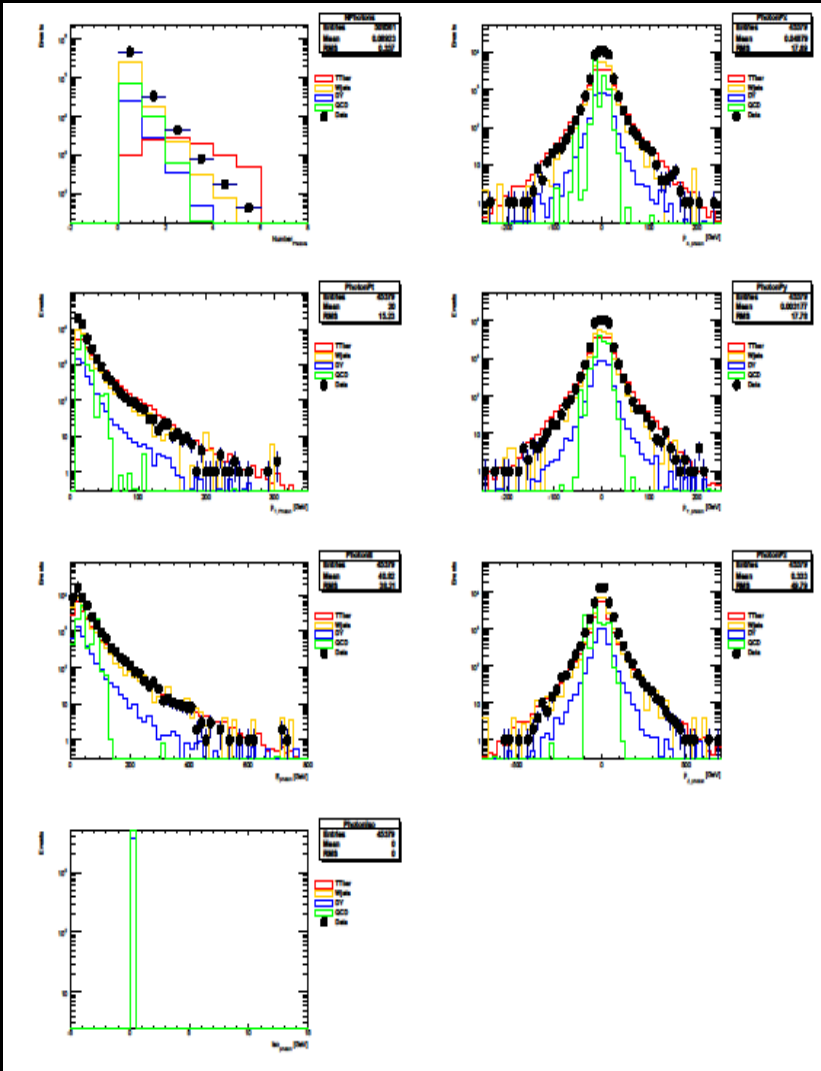
return KTRUE;
}

void MyAnalysis::SlaveTerminate() {
// The SlaveTerminate() function is called after all entries or objects
// have been processed. When running with PROOF SlaveTerminate() is called
// on each slave server.
}

MyAnalysis d1Mass.C 28x1127 (23x) / hbrau
```

Quarknet

Photons



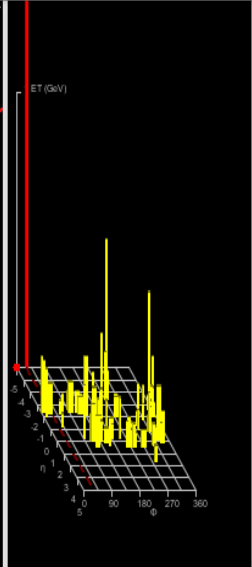
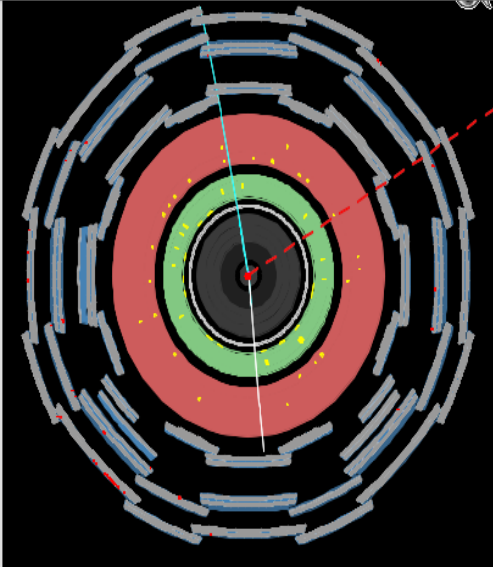
Quarknet

Masterclass Hypatia

Hybrid Pupils' Analysis Tool for Interactions in ATLAS - version 7.4 - Invariant Mass Window

File View Histograms Preferences Help

File Name	ETMis [GeV]	Track	P [GeV]	+/-	Pt [GeV]	ϕ	η	M(2) [GeV]	M(eeee) [GeV]	M(eemm) [GeV]	M(mmmm) [GeV]	e/m/g
event002.xml	23,199	Tracks 76	93,3	+	42,9	1,779	1,413	94,165				m
		Tracks 0	217,0	-	42,6	-1,479	2,310					m



ETMis: 23,199 GeV ϕ : 0,516 rad Collection: MET_RefFinal

C:\Users\DanielaAmbar\Documents\Hypatia\groupA\zip\event002.xml

Tracks Physics Objects

Track	+/-	P [GeV]	Pt [GeV]	ϕ	θ
Tracks 0	-	216,96	42,63	-1,479	0,198
Tracks 76	+	93,33	42,90	1,779	0,478

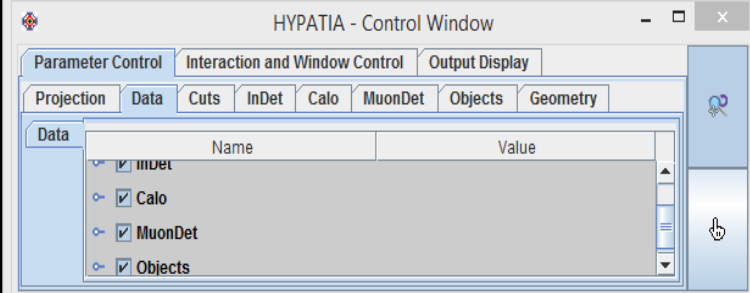
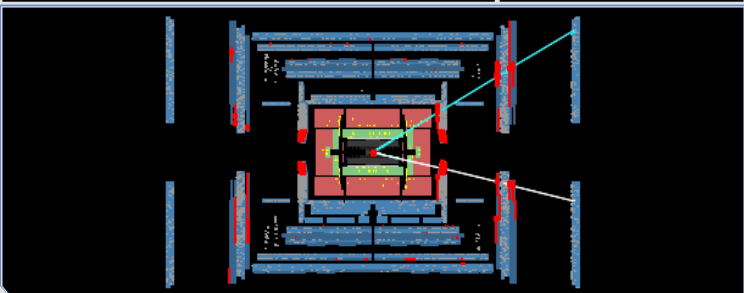
HYPATIA - Control Window

Parameter Control Interaction and Window Control Output Display

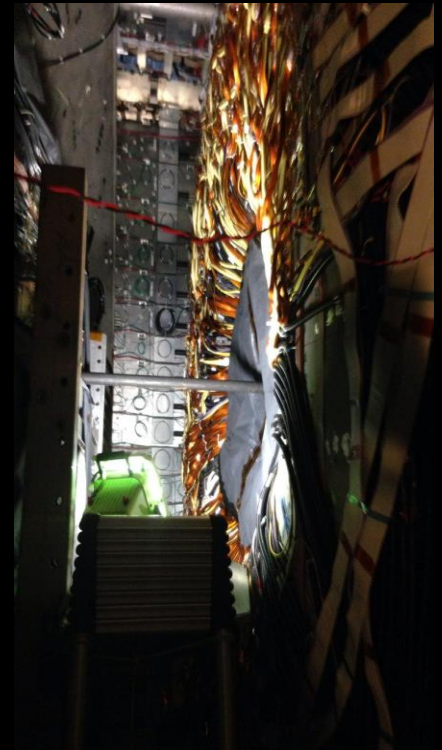
Projection Data Cuts InDet Calo MuonDet Objects Geometry

Data

Name	Value
<input checked="" type="checkbox"/> InDet	
<input checked="" type="checkbox"/> Calo	
<input checked="" type="checkbox"/> MuonDet	
<input checked="" type="checkbox"/> Objects	

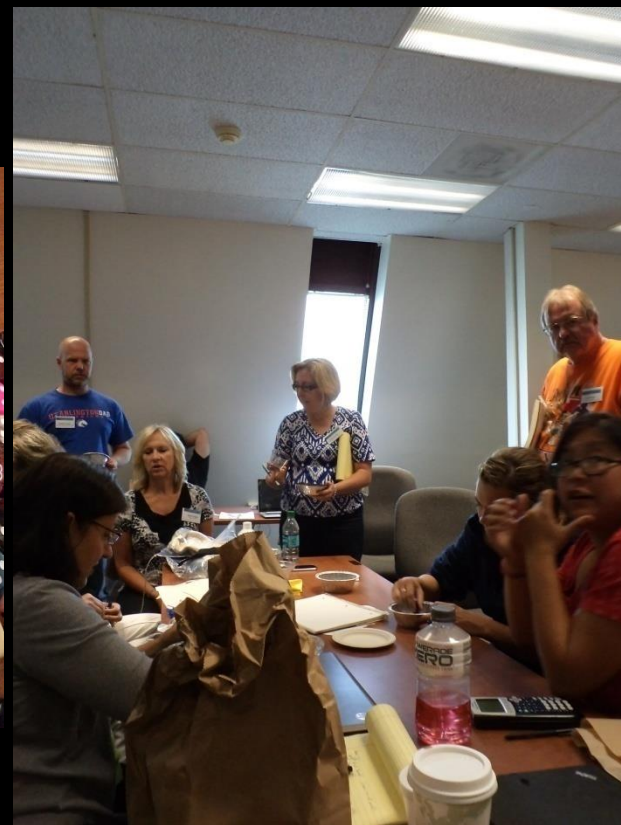
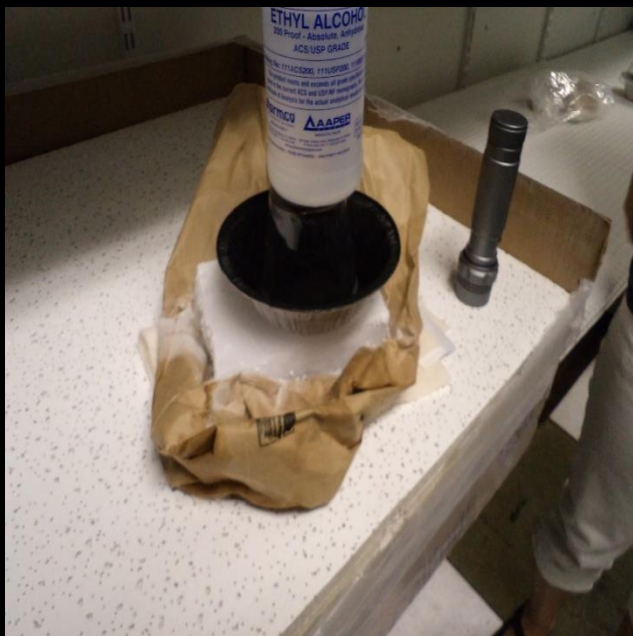


Fermilab



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Activities



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ZeePreview - Excel

ARCHIVO INICIO INSERTAR DISEÑO DE PÁGINA FÓRMULAS DATOS REVISAR VISTA Iniciar sesión

Pegar Fuente Alineación Número Estilos Celdas Modificar

AE7 94

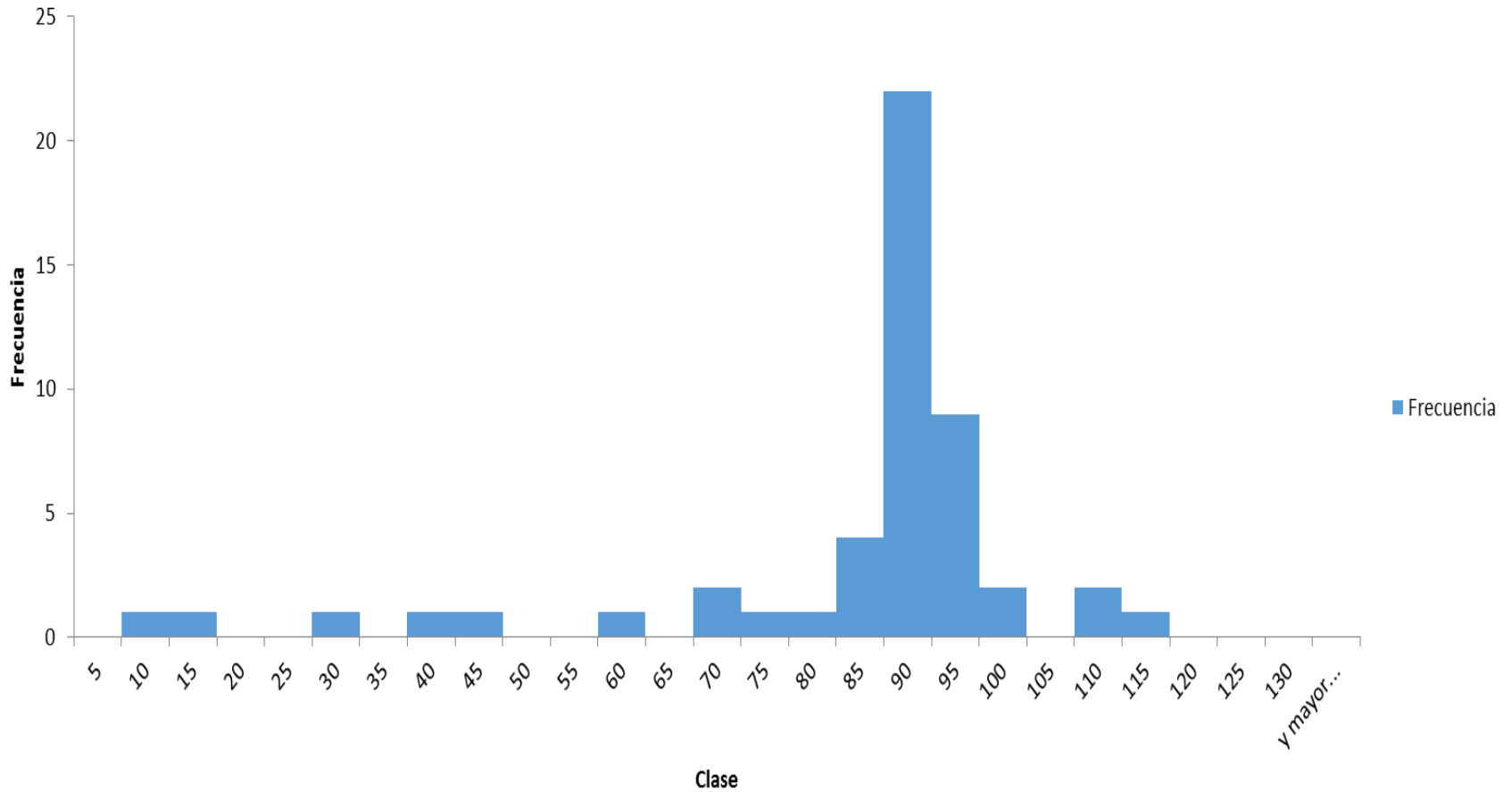
	U	V	W	X	Y	Z	AA	AB	AC	AD
1	$px1+px2=px$	$py1+py2=py$	$pz1+pz2=pz$	$px(sqr)+px(sqr)+px(sqr)=p(sqr)$	$E1+E2=E$	$E(sqr)$	$E(sqr)-p(sqr)=m(sqr)$	m		91,2
2	-1,044127	-6,20034234	-296,9211434	88201,69984	310,0711595	96144,12395	7942,424109	89,12027889	5	
3	32,367401	-4,64740721	-432,3885579	188029,112	442,5815827	195878,4573	7849,345301	88,59653098	10	
4	-6,59838911	2,19702369	-287,5703775	82745,08767	300,3215933	90193,0594	7447,971735	86,30163228	15	
5	-8,40864701	3,83583063	-78,73163955	6284,090007	115,8657721	13424,87715	7140,787139	84,50317828	20	
6	39,7497876	18,27716183	510,0005053	262014,6157	520,7390907	271169,2006	9154,584918	95,6795951	25	
7	-39,75355388	1,29289285	0,02668332	1582,01733	99,61480204	9923,108785	8341,091456	91,32957602	30	
8	-1,17797811	-4,55343383	-35,8422495	1306,788241	93,89745921	8816,732846	7509,944605	86,65993656	35	
9	1,99758123	6,48148364	27,04837443	777,6145203	97,12952113	9434,143875	8656,529355	93,0404716	40	
10	11,35085473	1,6297373	436,7284355	190863,2243	444,2788269	197383,676	6520,451711	80,74931399	45	
11	2,55747231	-5,98058492	188,2318789	35473,54831	208,4203517	43439,04298	7965,494672	89,24962001	50	
12	6,951807269	5,02673334	-117,7433175	13937,08449	151,6451555	22996,25319	9059,168701	95,17966538	55	
13	7,3986607	0,49836682	106,7506461	11450,68899	138,1004685	19071,73941	7621,050414	87,29862779	60	
14	-0,18315789	-5,38069844	-62,68757951	3958,718087	106,0788864	11252,73014	7294,01205	85,40498844	65	
15	5,382629681	-2,06427893	-10,23611363	138,011972	90,21937306	8139,535275	8001,523303	89,45123422	70	
16	1,136651521	8,75455279	-18,79052695	431,0180743	109,4152329	11971,69318	11540,67511	107,4275342	75	
17	-18,72561785	8,96143297	309,3941393	96155,68945	329,6137843	108645,2468	12489,55735	111,7566882	80	
18	10,55958399	1,36741819	-188,8792421	35788,74274	209,4740114	43879,36146	8090,618717	89,94786666	85	
19	-19,42470632	24,87911293	-20,13415515	1401,673679	38,3891936	1473,730185	72,05650615	8,488610378	90	
20	24,77334289	-23,62866186	-171,9850567	30750,89189	177,2220044	31407,63884	656,7469463	25,62707448	95	
21	1,47062861	-3,76084604	-44,09336909	1960,531909	98,16644399	9636,650726	7676,118816	87,61346253	100	
22	-21,36618574	4,20501775	-19,08267832	838,3446791	94,79700298	8986,471774	8148,127095	90,26697677	105	
23	6,828056699	0,33611363	77,37211607	6033,179676	118,8660555	14129,13915	8095,959472	89,97754982	110	
24	10,18449157	0,90043611	141,2684728	20061,31606	167,0546667	27907,26166	7845,945592	88,57734243	115	
25	11,66580756	3,9796145	-42,40410578	1950,036585	97,4984809	9505,953778	7555,917193	86,92477894	120	

Hoja8 Hoja7 Sheet 1

LISTO CHANDRA, HUBBLE 22:51 15-09-2014

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Histograma



How about in Chile?

- Classes to learn about Hadronic structure and Collider and particle physics.
- Classes using software hypatia.
- Connect relativity with particle physics through calculations of Z mass.
- Make videos about Quark Workbench.
- Watch and discussed movies about relativity and particle physics, for example Interstellar.

Plans for Next Summer

- Continue $t\bar{t}$ analysis
 - Develop a set of cuts
 - Determine efficiencies
 - Create $t\bar{t}$ mass plots
 - Calculate $t\bar{t}$ cross-section and mass

Conclusions

- We've made substantial progress toward analyzing CMS data in its native format
- We are in a good position to finish the $t\bar{t}$ analysis by the end of next summer
- We are better poised to access and analyze CMS data in general
- In October 2014 LHC Collaborations released portions of their datasets for education and research purposes at: <http://opendata.cern.ch/>