(Di-)Boson WW Production Research in ATLAS Experiment

Presentation des doctorants du CPPM de premiere annee

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Outline

- Di-Boson WW Production in ATLAS Experiment
- Current Work: First W/Z Observation background estimation using ABCD method for W
- Previous Work: Material Mapping in front of the EM calorimeter using showershape variables from b→e
- Prospects and Future Work

Introduction:
Motivation for WW Production Study

* Fundamental test of Standard Model, especially the non-Abelian gauge group structure of the electroweak sector
* Probing the triple gauge-boson coupling(TGC) vertices, WWγ and WWZ, which provide important contributions to the pp→WW production Xsection
* Irreducible background of Higgs→WW search, which is an important discovery channel at LHC

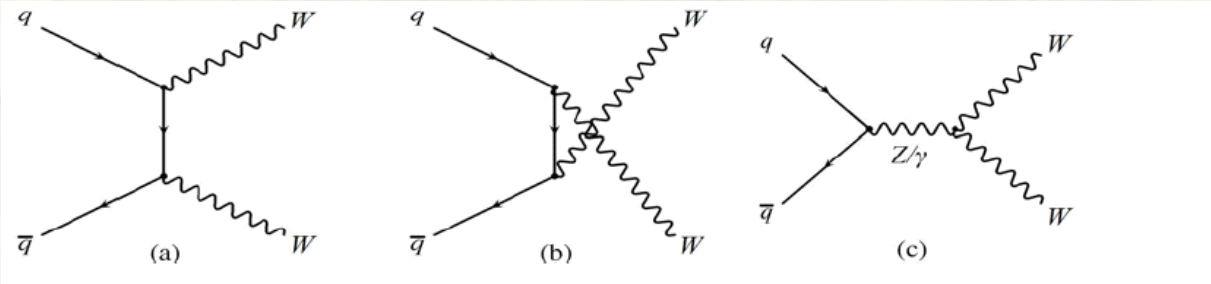


Figure 1: The Standard Model leading order Feymann Diagrams for WW production through quark-antiquark initial state

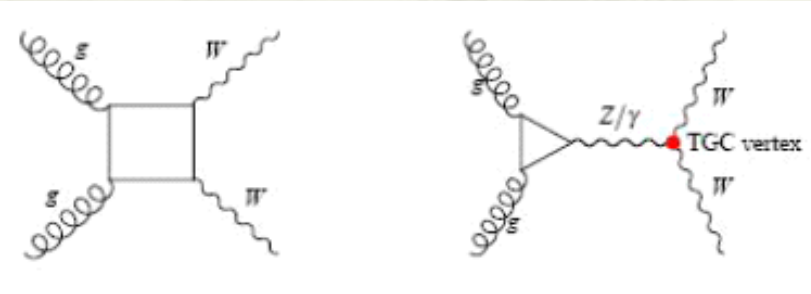


Figure 2: gluon-gluon fusion (~4% contributions to signal, not considered)

Introduction:
Signal and Background

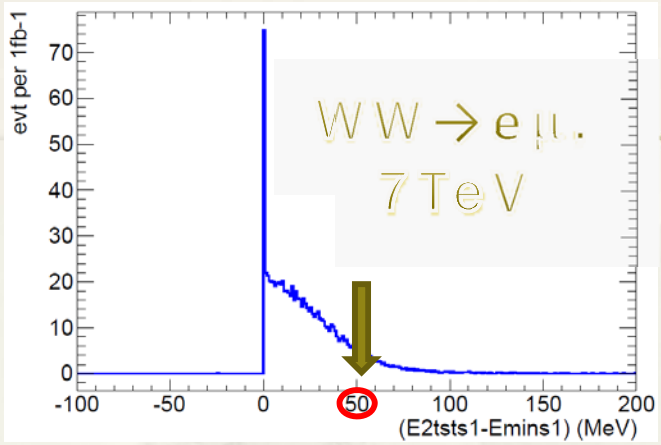
- **Signal**: (using 7TeV MC Samples, MC@NLO and Herwig/Jimmy)
  (assume the Xsec to be 0.51pb respectively, normalized to 1 fb^{-1})
  - $W^+W^- \rightarrow e^+\nu e^-\nu$ (Currently Focusing on!)
  - $W^+W^- \rightarrow \mu^+\nu\mu^-\nu$
  - $W^+W^- \rightarrow e^+\nu\mu^-\nu$
  - $W^+W^- \rightarrow \mu^+\nu e^-\nu$

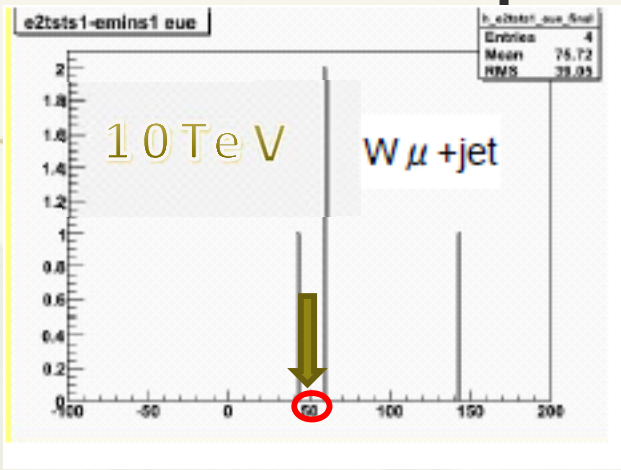
- **Major Background:**
  (10TeV samples to be shown, 7TeV on-going)
  - $W^{\pm}Z$ with undetected leptons (MC@NLO and Herwig/Jimmy)
  - $ZZ \rightarrow ll\upsilon\upsilon$ (MC@NLO and Herwig/Jimmy)
  - ttbar (MC@NLO and Herwig/Jimmy)
  - single top Wt (AcerMC)
  - Drell-Yan (Pythia)
  - W+jets with jets fake leptons (Pythia)
  - W+photon with photon fake lepton (Pythia)
  - $WW \rightarrow \tau$+ e /μ/ τ (MC@NLO and Herwig/Jimmy)

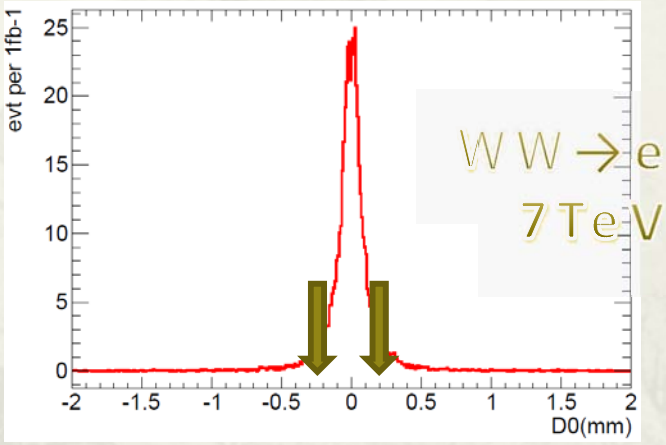
Event Selection

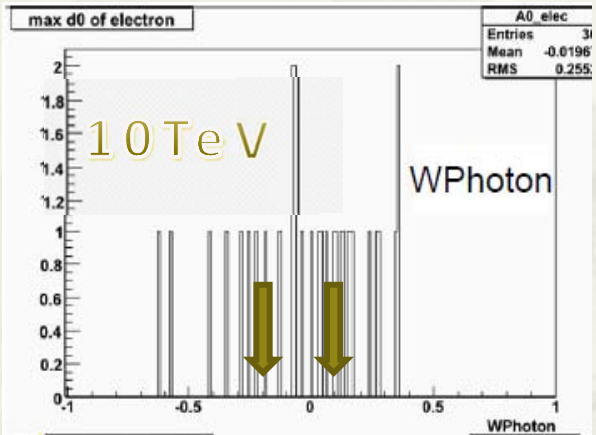
WW→ee	WW→eμ	WW→μμ	Background suppression
two opposite charge leptons(veto if >2)			
dR > 0.5			
veto Jets with: pT>30GeV, |η|<5, dR>0.5 from electrons with pT>20GeV			ttbar
METRefFinal>30GeV	METRefFinal>20GeV	METRefFinal>35GeV	Drell-Yan
qT<25GeV (vector sum of the (px,py) of the 2 leptons and MET)			ttbar
METRefFinal>45GeV if |Mee–Mz|<15GeVMz	METRefFinal>35GeV if dϕ(leptons , met) <2.6 or dϕ(e,μ)>2.9	|Mμμ–Mz|>15GeV	Drell-Yan, ZZ→llνν
lepton pairs invMass>15GeV			

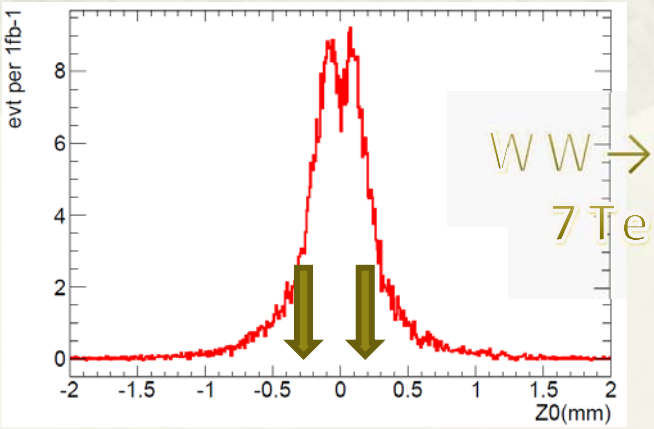
Background Suppression
(take some of the discriminant variables as examples)

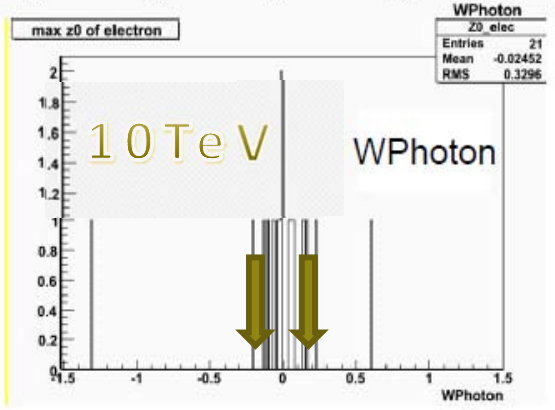




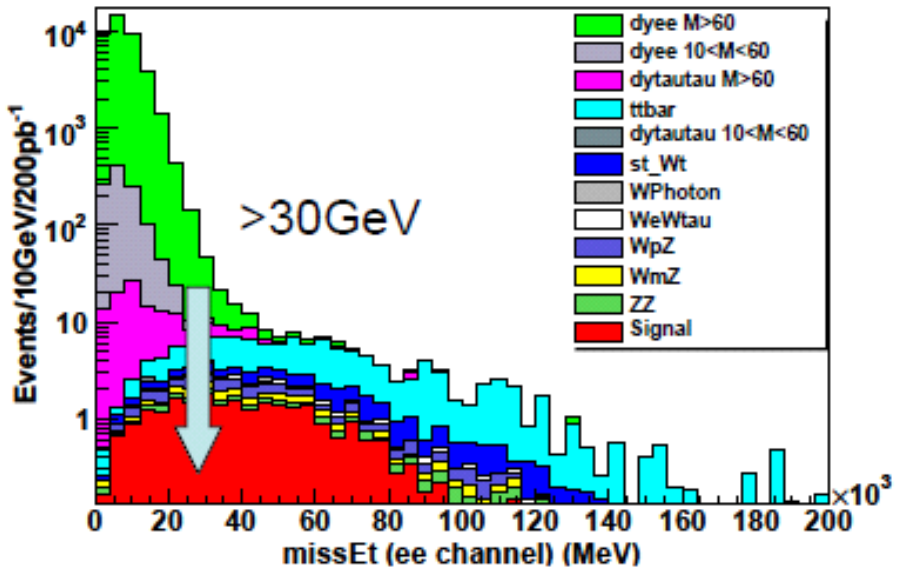


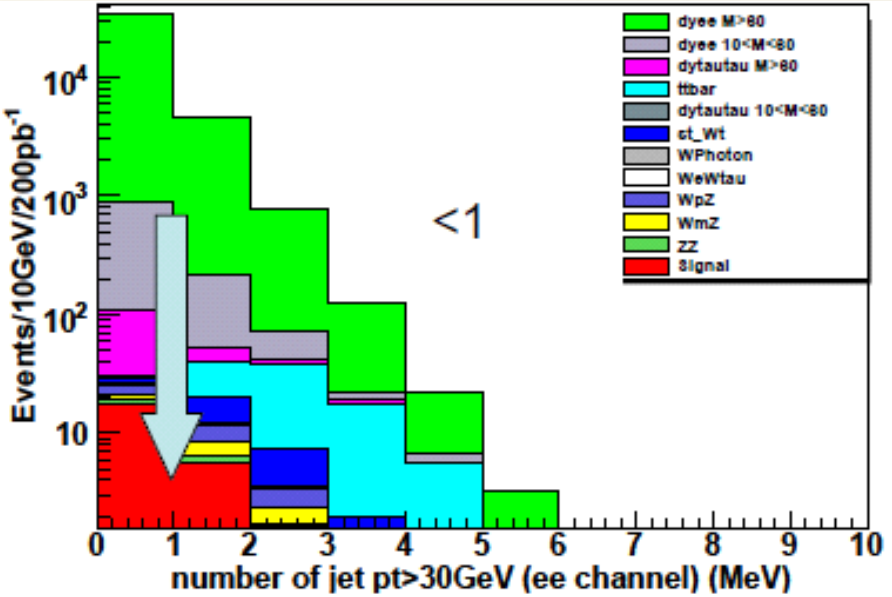


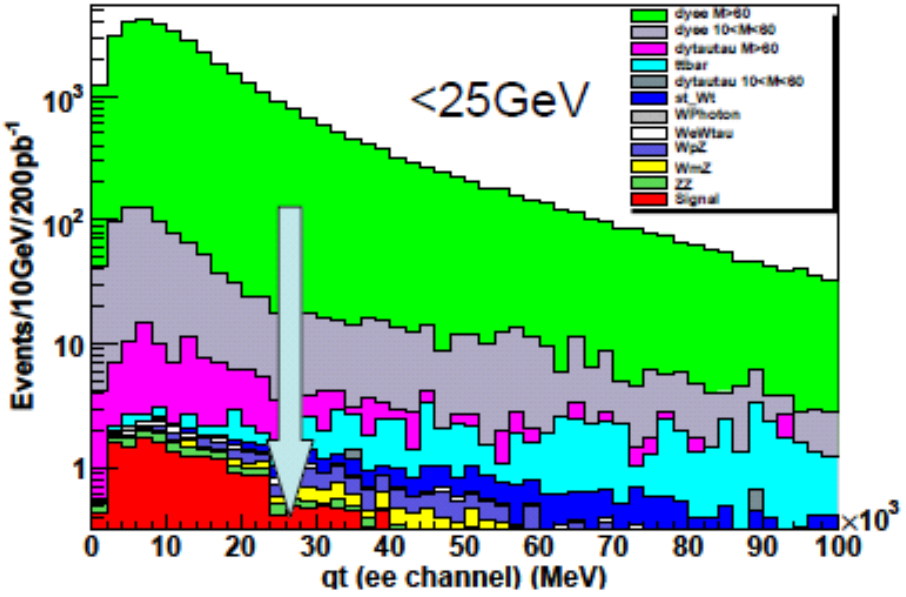


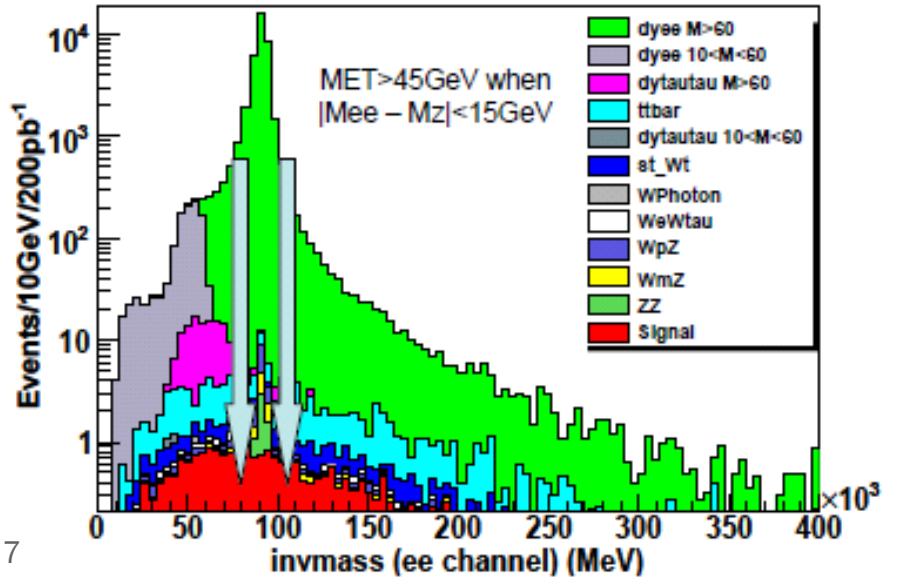


WW→ee 10TeV


dyee M>60
dyee 10<M<60
dytautau M>60
ttbar
dytautau 10<M<60
st_Wt
WPhoton
WeWtau
WpZ
WmZ
ZZ
Signal
>30GeV
Events/10GeV/200pb⁻¹
missEt (ee channel) (MeV)
×10³


dyee M>60
dyee 10<M<60
dytautau M>60
ttbar
dytautau 10<M<60
st_Wt
WPhoton
WeWtau
WpZ
WmZ
ZZ
Signal
<1
Events/10GeV/200pb⁻¹
number of jet pt>30GeV (ee channel) (MeV)


dyee M>60
dyee 10<M<60
dytautau M>60
ttbar
dytautau 10<M<60
st_Wt
WPhoton
WeWtau
WpZ
WmZ
ZZ
Signal
<25GeV
Events/10GeV/200pb⁻¹
qt (ee channel) (MeV)
×10³


dyee M>60
dyee 10<M<60
dytautau M>60
ttbar
dytautau 10<M<60
st_Wt
WPhoton
WeWtau
WpZ
WmZ
ZZ
Signal
MET>45GeV when
|Mee – Mz|<15GeV
Events/10GeV/200pb⁻¹
invmass (ee channel) (MeV)
×10³

Expected Signal Statistics @1fb^{-1} and uncertainty evaluation

Channel		WW→ee Challenging!	WW→ μμ	WW→eμ
#Signal Events		17.66	36.58	63.28
W+jets 95% upper limit	#Bgd Events	31.10	17.87	44.23
	S/B	0.57	2.05	1.43
	Stat Uncertainty	39.5%	20.2%	16.4%
	Total Uncertainty	53.5%	23.6%	22.8%
No W+jets	#Bgd Events	12.84	17.87	21.51
	S/B	1.38	2.05	2.94
	Stat Uncertainty	31.3%	20.2%	14.6%
	Total Uncertainty	35.3%	23.6%	17.7%

Next Step

- Cut flow more intensive study using SM/Electroweak WG baseline cuts
- Quickly get 7TeV background reprocessed and collision data tested (on-going)
- Various data format validation
- Cut optimization
- Etc.....

Current work: (Still on-going)
background estimation for first W/Z Observation using ABCD method

- **Motivation:**
  - Investigate the quantities of background components in current W→ev candidates
  - Trying to evaluate the systematics due to the EGamma WG recommended cuts

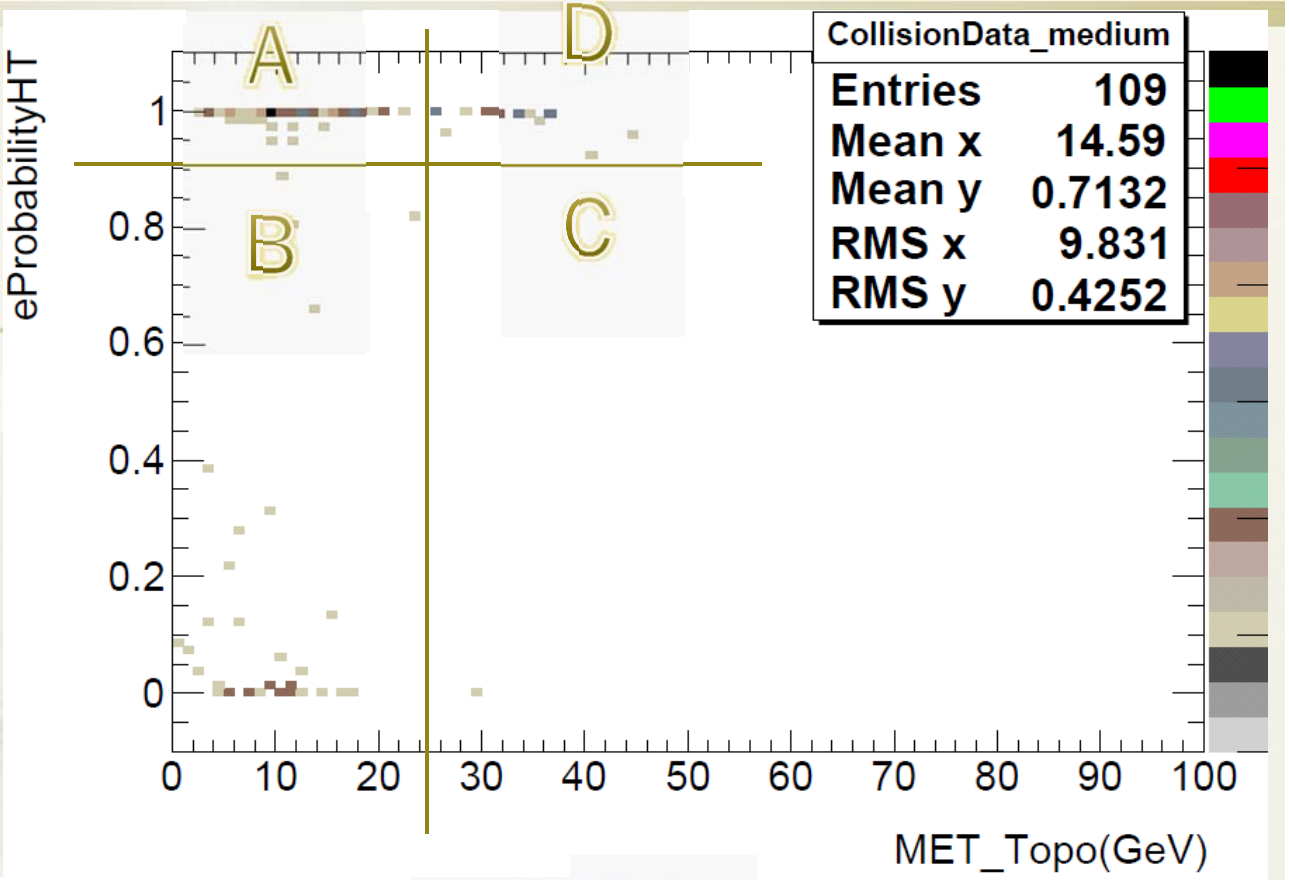
  - **To implement the compartmentalization of ABCD region:** (several variables tested)

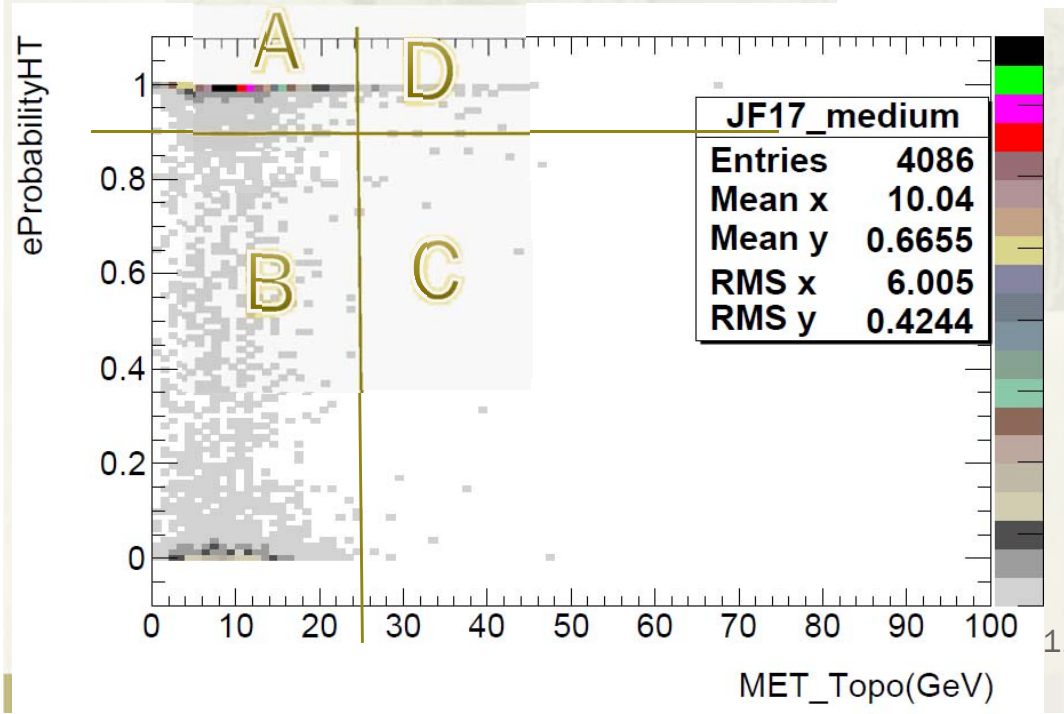
✓ Electron TRT High Threshold Probability Vs MET

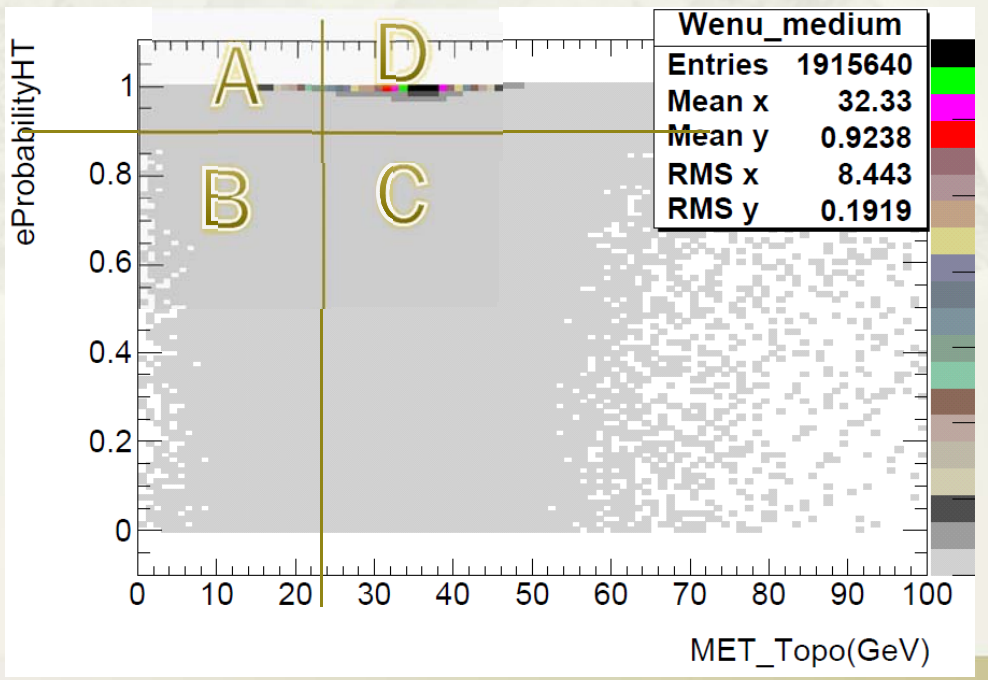
✓ TRT High Threshold Ratio Vs MET

✓ Calorimeter Isolation Vs MET

eProbabilityHT Vs MET after preCuts with isEM medium applied (Not Normalized)

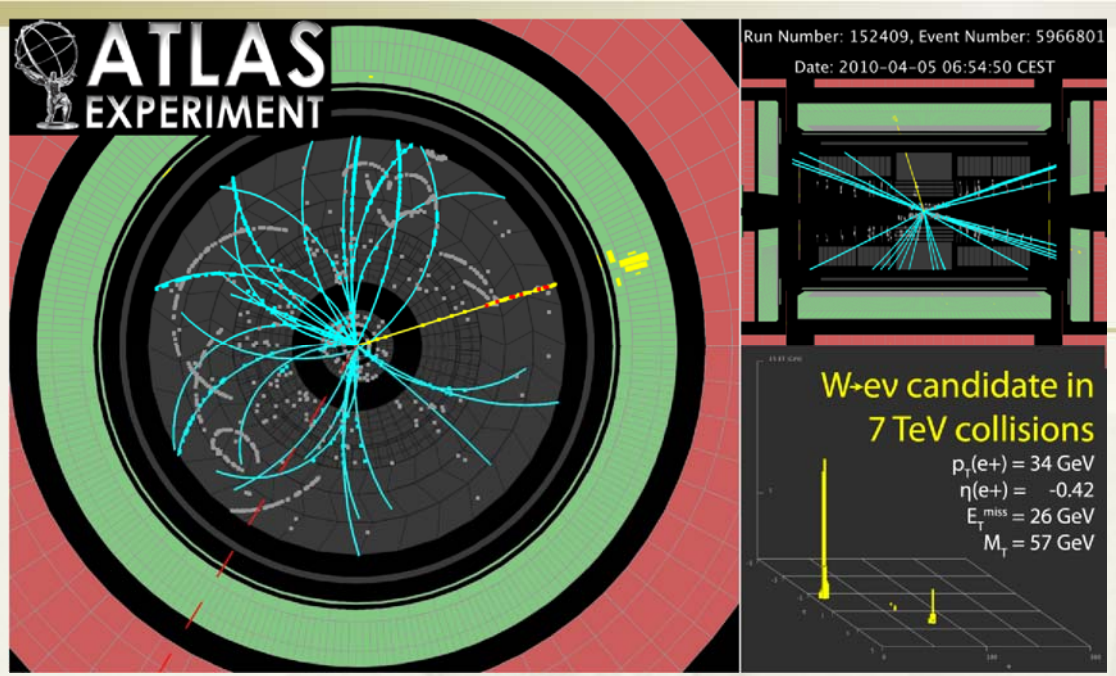


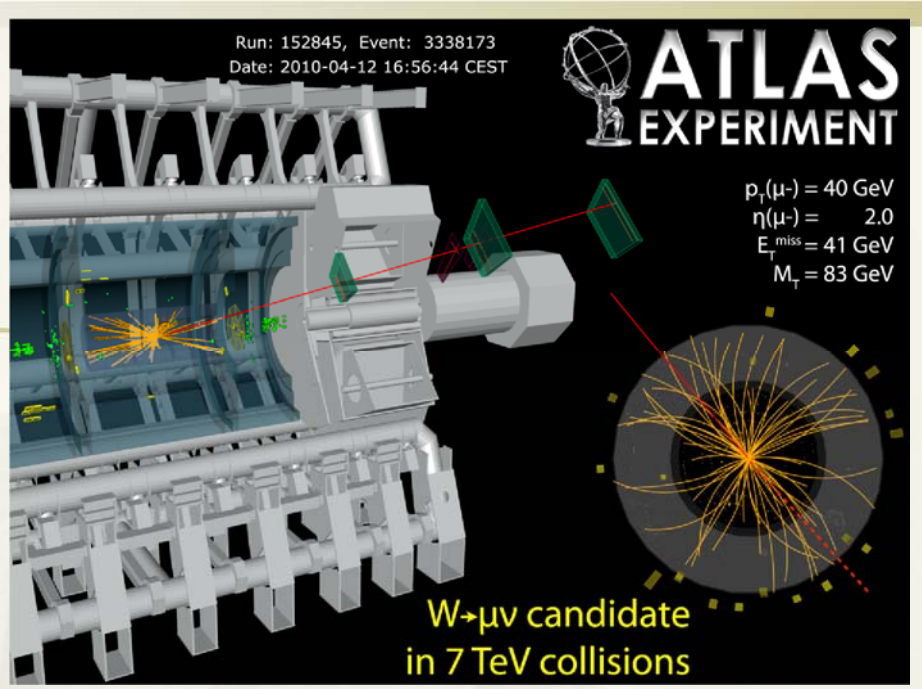




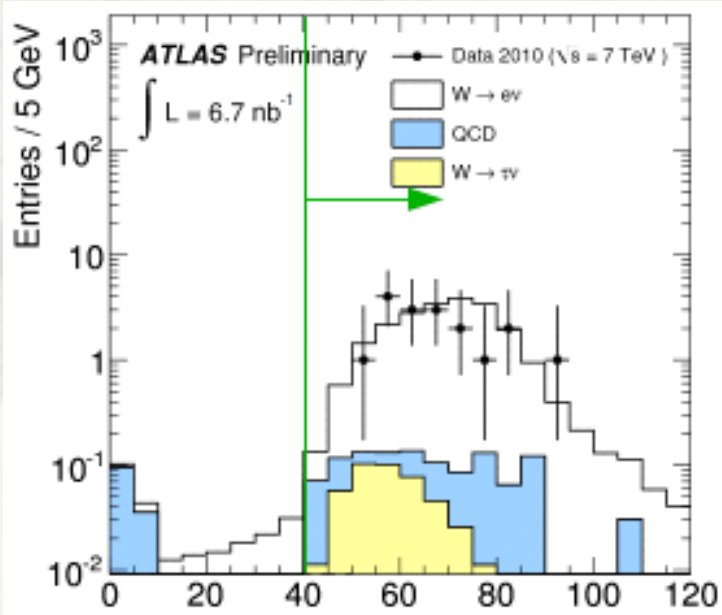
Next Step

- Verify the assumption for this method to be carried on from MC intensively
- Further investigate the current variables in use and try with more variables which may be discriminant
- Merge with more collision data increasing very quickly
- Systematics evaluation



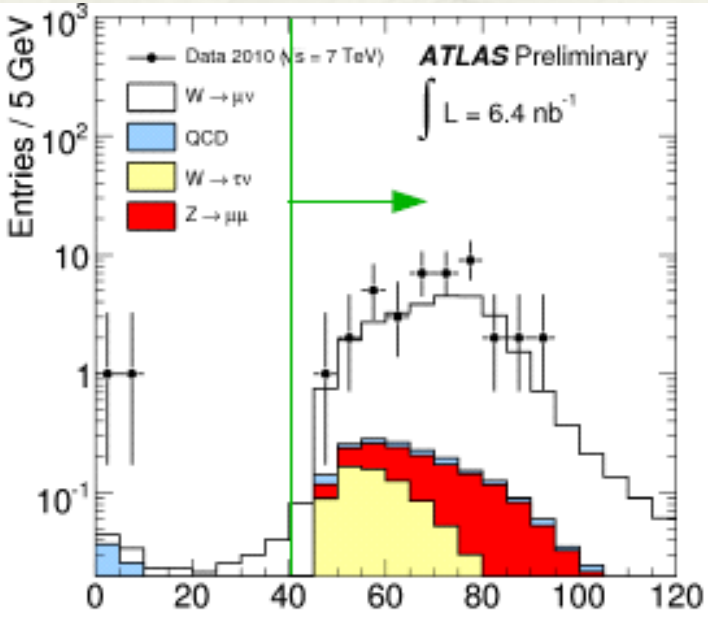


Electron



➔ 17 candidates
(11 e^+, 6 e^-)

Muon



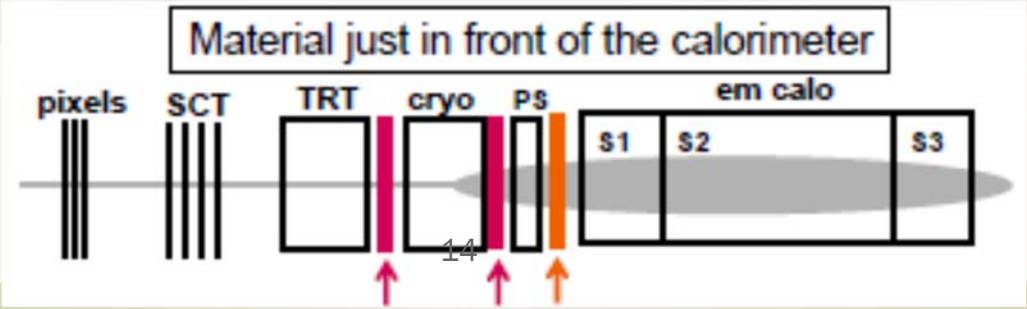
➔ 40 candidates
(25 μ^+, 15 μ^-)

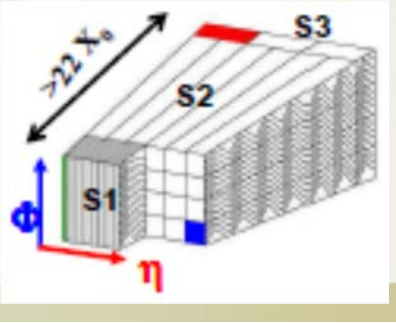
Previous Work:
Shower shape based Material mapping using electrons from b→e

- Motivation:
  - To obtain better and controlled Electron/Photon Reconstruction performance (1% radiation length precision for the material mapping in front of the EM Calo)
  - Significant contribution and striking signature of the high pT isolated Electrons to the first physics study in ATLAS Project(Zee Xsection, discovery, Wenu products etc.)
  - Abundant low pT b/c prompt electrons for smaller φ region material mapping and non-uniformity investigation (better than W→eν due to its larger statistics in data especially when luminosity is limited)
- Material impact principally:

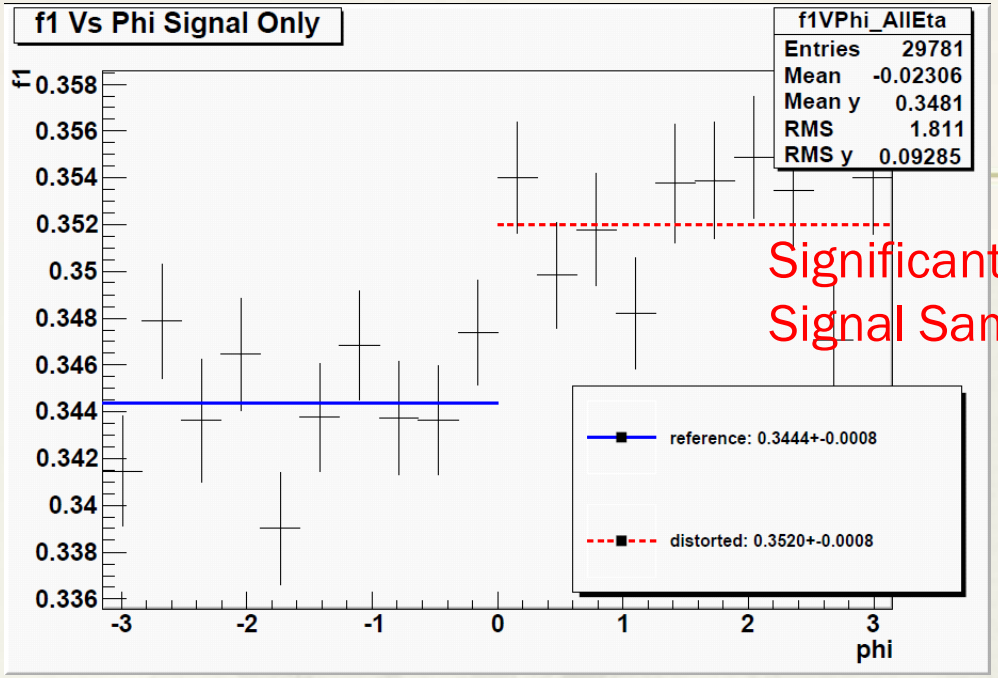
the shower starts earlier when material is added:

- ✓ Energy fraction in S1: f1 should be larger (which will be taken for instance afterward)
- ✓ Width along η in S1:weta1 should be larger
- ✓ Etc……

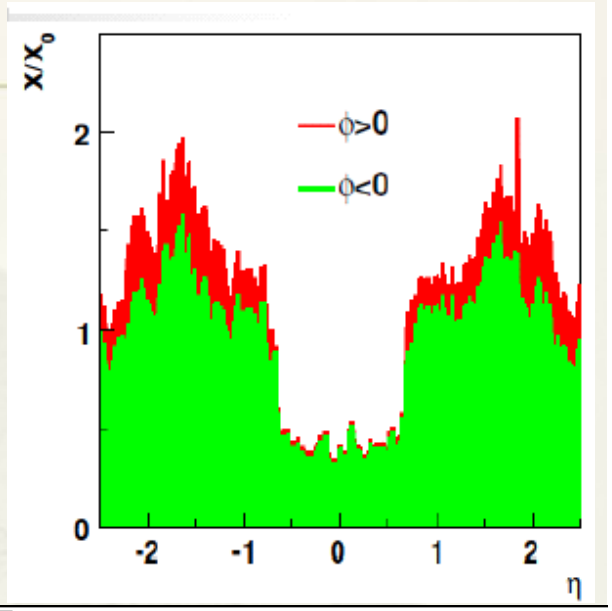




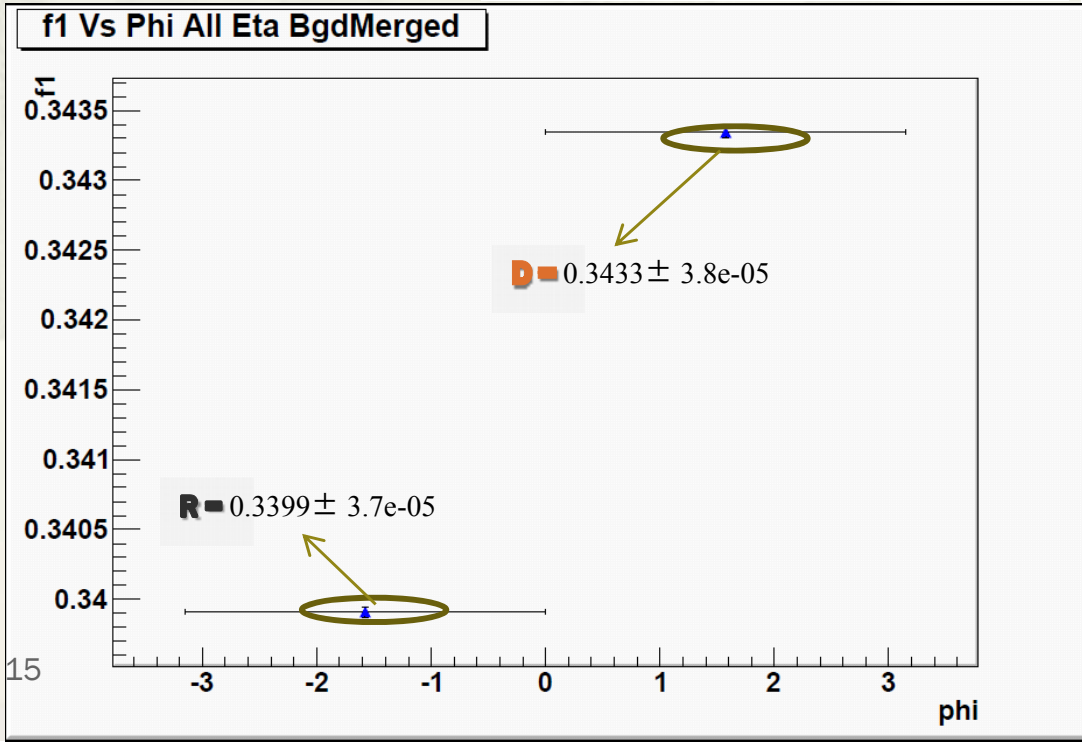
f1 Profile and Histogram showing the material impact:



Significant Material Impact in Signal Sample! Not Normalized



Still appeared to be when merged with background, (compatible with W electron samples. See backup for more!)



Future Work

- To continue with previous performance work expecting for a mature and decent conclusion
- Hopefully a few WW events at the end of this year, so am trying to catch up with the timetable to show some preliminary results and expect for more interesting issues next year at $1fb^{-1}$
- Going to take some LAr data quality shifts and learn more about hardware monitoring and expertise

Spare

WW Object Level Selection: Electrons

- **Cut Flow:**
  - With Good Track fit quality, measured perigee, Calo Cluster and EM Shower Info (PreCuts)
  - IsEM Medium applied
  - Author Electron Only
  - $|\eta| \leq 2.5$ without crack region
  - $pT \geq 20GeV$
  - $Etcone40 \leq 8GeV$
  - Track pT sum within 0.4cone $\leq 8GeV$
  - Nucone40<5
- **Event Selection:**
  - $|d0|<0.2mm$, $|z0|<0.2mm$ (Wγ suppression)
  - Second largest strip E: $\Delta E = e2tsts1 - emins1 < 50MeV$ (W+jets suppression)

WW Object Level Selection: Muons

- StacoMuon
- With Good measured perigee and Track fit quality for both ID and muon spectrometer (PreCuts)
- $|\eta| \leq 2.5$
- $pT \geq 20GeV$
- $Etcone40 \leq 5GeV$
- $Nucone40 < 4$
- $Ptcone40 \leq 5GeV$
- Track Match Probability ≥ 0.0001

Assumption for 7TeV WW Xsection mesurement uncertainty study

- So as to evaluate the effect of the systematics, we assume ATLAS will have similar uncertainties as those from Tevatron experiments:
  - 6% uncertainty on luminosity L
  - 20% background estimated uncertainty δ_B/B
  - 3% uncertainty on acceptance A
  - 3% uncertainty on event selection efficiency $\varepsilon=\varepsilon_p\varepsilon_s$

ABCD Region Compartmentalization

- ✓ Method 1.

Assume ABCD regions have similar ratio over each other for those background components of each region in the data:

$$bgd_A/bgd_B=bgd_D/bgd_C$$

So as to extract the signal component in “D” while removing the estimated background in it. (Should be verified based on MC)

- ✓ Method 2.

Assume ABCD regions have similar ratio over each other for both signal and bgd between data and Monte Carlo:

$$b_{1i}+b_{2i}+s_i=N_i, \quad i=A,B,C,D$$

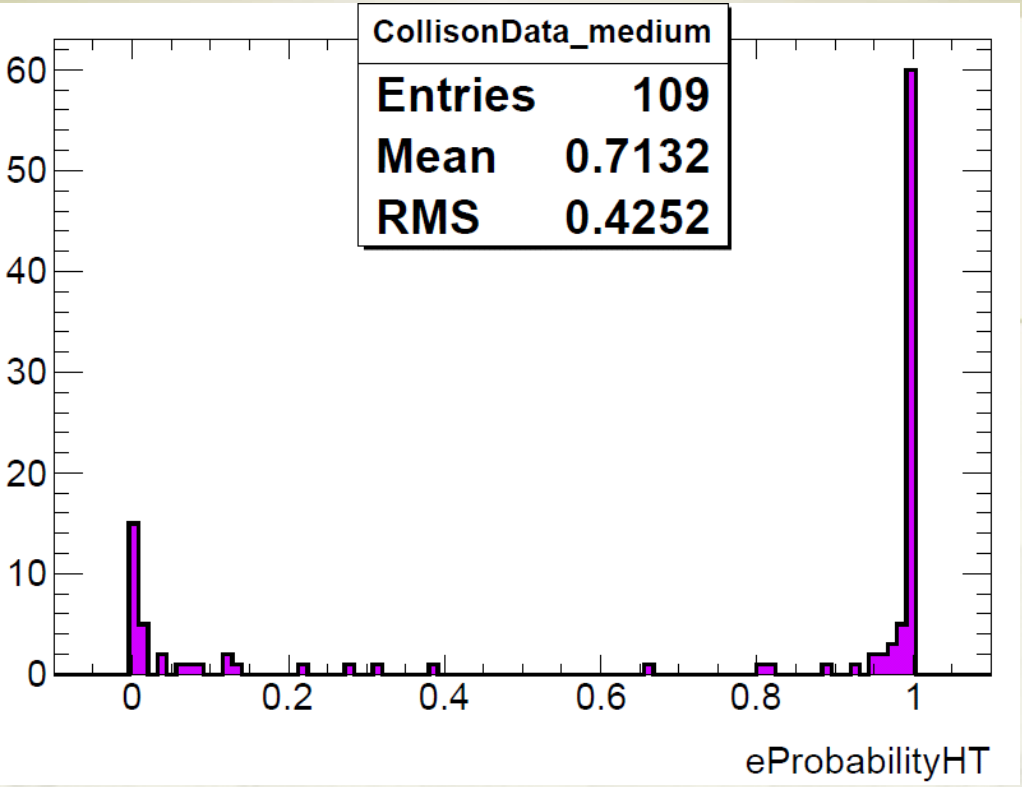
- b_{1i}: 1_{st} kind of background (JF17), b_{2i}: 2_{nd} kind of background (filtered_MinBias)

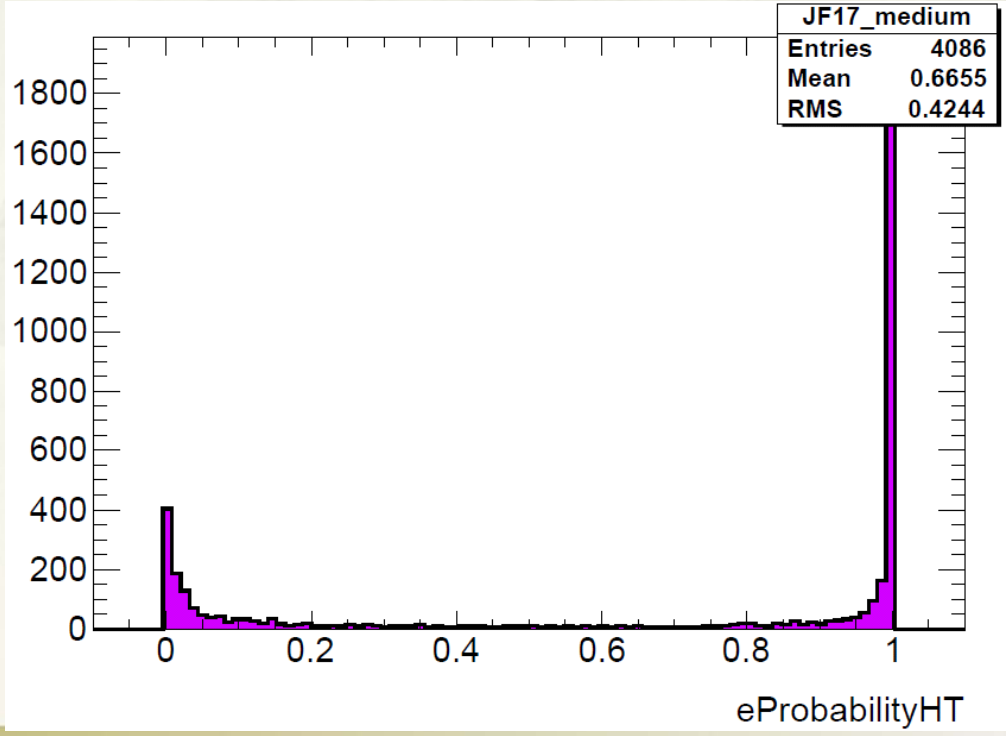
  N_i: Expected from data
- s_i/s_i, b_{1i}/b_{1j}, b_{2i}/b_{2j} in data should be consistent with MC
- 3 equations and 3 unknown variables

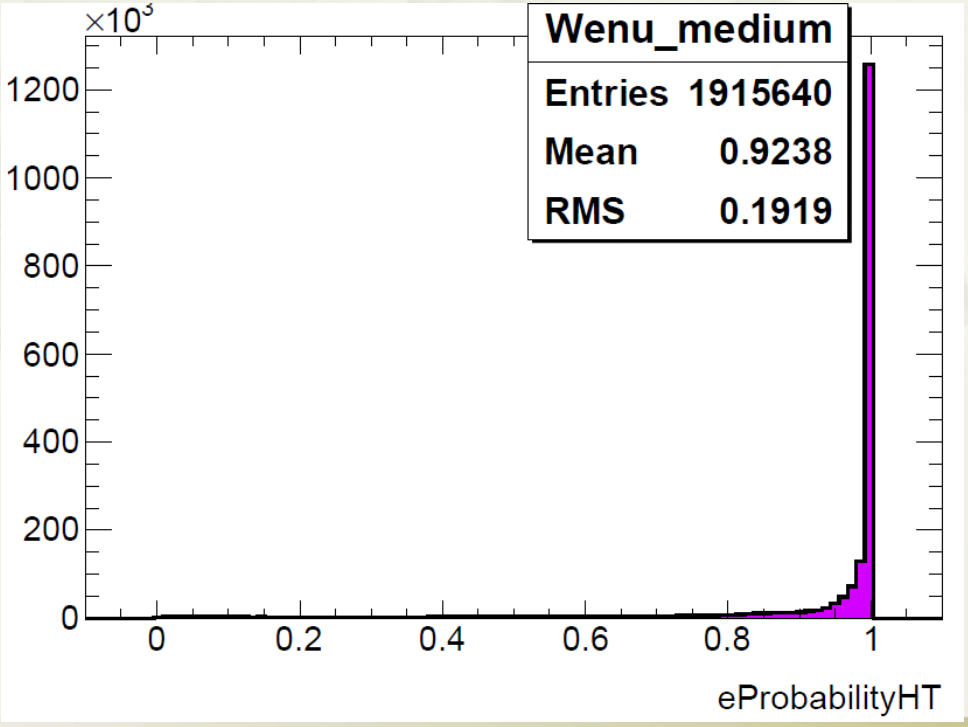
Electron Probability for TRT High Threshold(variable named ePROBABILITYHT) Vs MET_Topo

* ePROBABILITYHT Vs MET_Topo
* • A: MET_Topo <= 25GeV, ePROBABILITYHT >= 0.9
* • B: MET_Topo <= 25GeV, ePROBABILITYHT < 0.9
* • C : MET_Topo > 25GeV, ePROBABILITYHT <= 0.9
* • Signal Region D:
* MET_Topo > 25GeV, ePROBABILITYHT > 0.9

ePrabilityHT distribution after preCuts with isEM medium applied (Not Normalized)







isEM Loose
(Not Normalized)

Region Sample /data	A	B	C	D
Wenu (7M)	305964	57413	254392	1332229
JF17 (10M)	4323	7347	33	92
Data (~14M)	95	163	1	20

A/B=D/C doesn't agree

Very tight

isEM Medium
(Not Normalized)

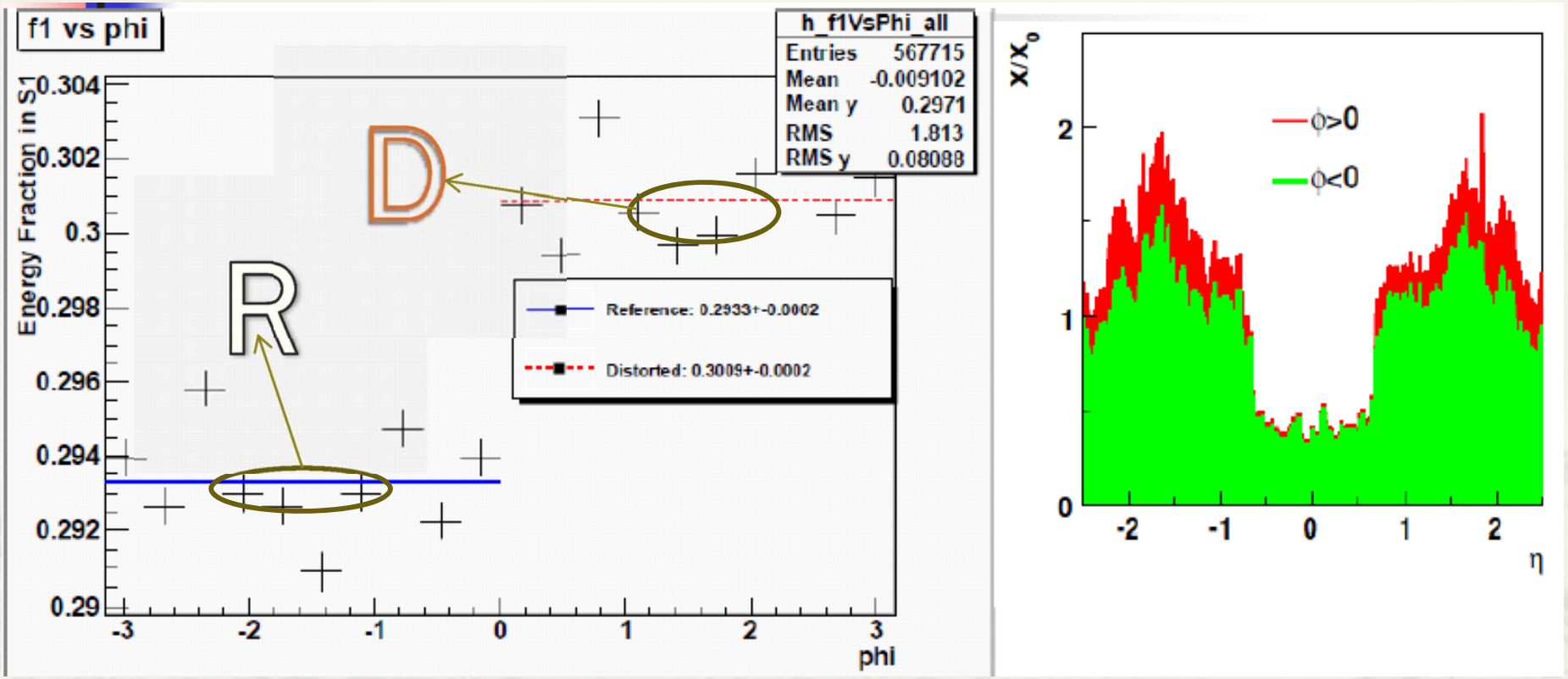
Region Sample /data	A	B	C	D
Wenu (7M)	299627	56346	250544	1309123
JF17 (10M)	2268	1721	17	80
Data (~14M)	54	35	1	19

A/B=D/C doesn't agree

Very tight

Material Distortion Detail

* **GeoTag:** ATLAS-GEO-06-01-00, take f1 variable for instance



(Using old W electron selection criteria to more significantly verify the Geometry)

Define: Estimator = Distorted "D" / Reference "R"

See:

http://indico.cern.ch/contributionDisplay.py?contribId=10&confId=77965

For more

Comparison of Estimator Significance

Sample/Selection	Significance of Estimator deviating from 1. (Estimator = "D" / "R")
	All η Region
W→ev / Original (Signal only)	38.9
W→ev / NewCut (background merged)	25.3
b→e / Original (Signal only)	58.5
b→e / Recomm Cut (background merged)	64.4
b→e / TMVA 20% (background merged)	52.1