Experiences in QCD PAG during early 2011 data taking

Suvadeep Bose

University of Nebraska Lincoln

April Trigger/Physics Jamboree

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Outline

- Low p_T QCD
  - UE measurement using Drell-Yan with 2011 data
    - Effect Pile up

- QCD Photons
  - Photon efficiency studies using Z->ee (Tag & probe)
  - Study of isolation variables to understand impact of Pile up

- High p_T QCD
  - Jet Triggers in 2011 data
  - Jet ID in 2011
  - Data-MC comparisons:
    - basic kinematic variables
    - data quality variables
  - Analyses examples:
    - Dijet mass, Dijet angular distributions (χ)
    - Effect of pile up

Report from QCD Low p_T subgroup

(Monika Jindal)

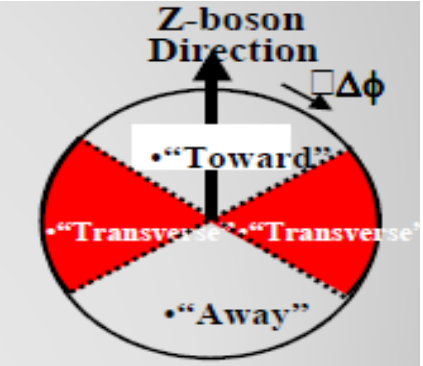
UE measurement using Drell-Yan

- Underlying Events: Multiple Parton Interaction (MPI), Beam-Beam remnant (BBR). ISR and FSR also included (not possible to separate).

- Drell-Yan (muonic final state) is experimentally clean and theoretically well understood process.
- Hard interaction can be easily separated by identifying two muon with large transverse momentum.
- The region of di-muon invariant mass around Z region, $60 < M_{ll} < 120$ GeV, has small contamination from background process.
- Lowest event scale is set by invariant mass of muons, increases with transverse momentum of di-muon system.
- Transverse and towards region both are sensitive for UE measurement.

Data:

- Muon primary datasets have been used for both 2010 and 2011 data.
- 2010 data ~ 36.1 pb^{-1} of integrated luminosity.
- 2011 data ~ 11.6 pb^{-1} of integrated luminosity.



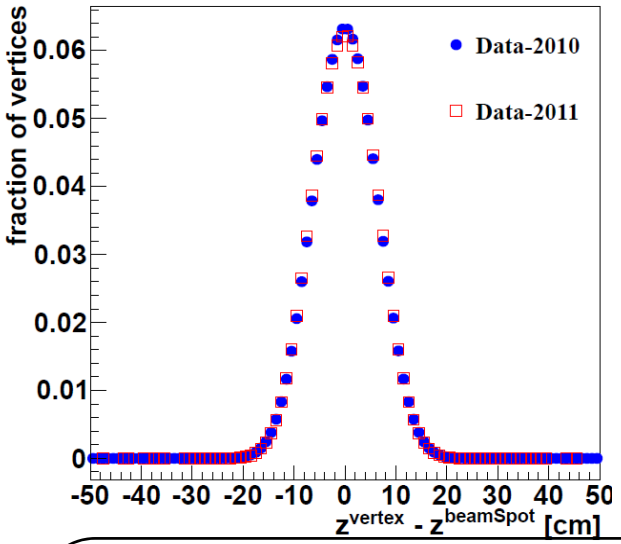
Event selection

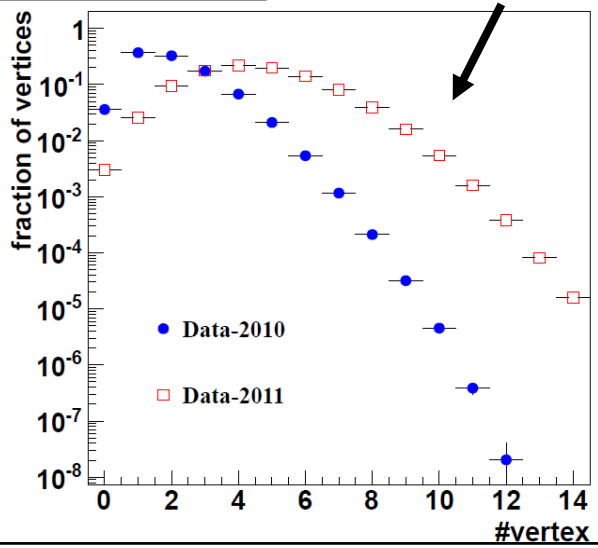
- Real vertex, ndof > 4
- |z(vtx)-z(beamspot)| < 18 cm
- rho < 2 cm
- event with atleast one good vertex
- Leading vertex is taken as signal vertex

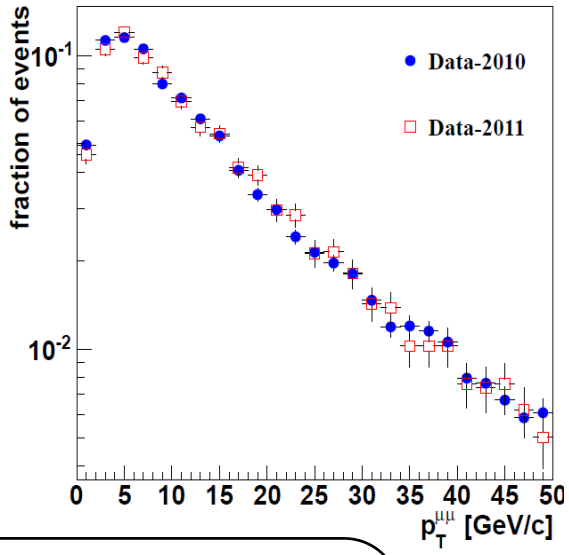
Trigger:

2010 data: HLT_Mu9, Mu11, Mu15 depending on the run range
2011 data: HLT_Mu15

Difference due to PU







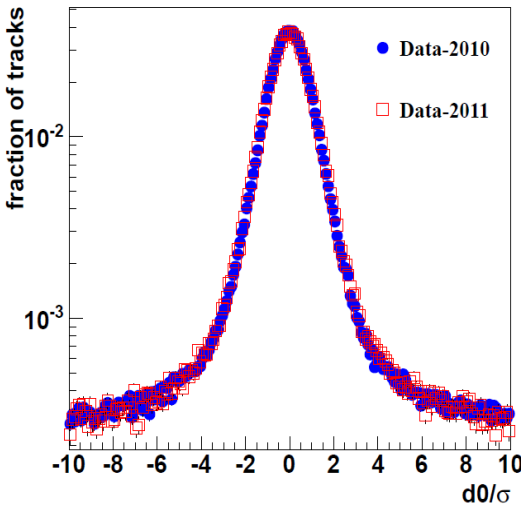
❑ Z candidate selection:

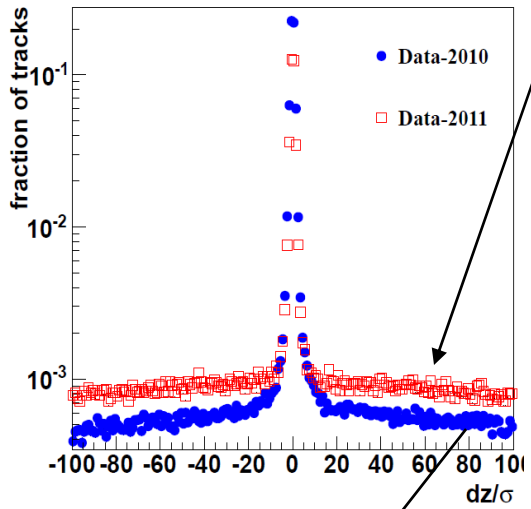
- Atleast two global muons, atleast one of them matching to trigger object, Passes Muon ID criteria, relative combined isolation < 0.15 (dR < 0.3).
- Leading two muons with p_T > 20 GeV and opposite charge.
- Invariant mass of muon pair in window 60-120 GeV
- To reduce the effect of PU, both muons are associated to selected signal vertex

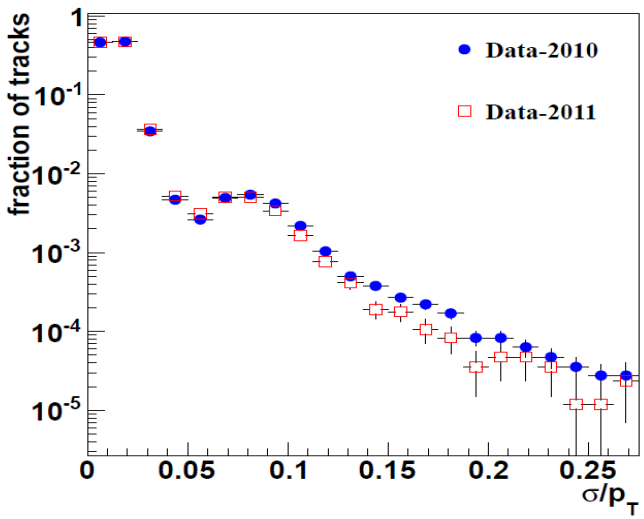
Track selection and validation

- Excluded muons tracks: dR , $dp_T/p_T < 0.01$
- Only tracks with High Purity flag
- Tracks with $p_T > 0.5$ GeV, $|\eta| < 2$
- Longitudinal and transverse IP (w.r.t. *Signal vertex*) required to be less then 3 times of respective uncertainty
- Relative p_T error required to be less then 5%

High tail in 2011data due to increased PU







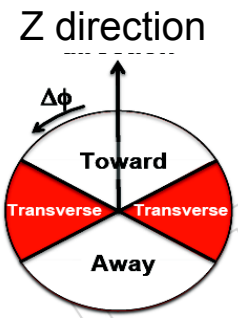
Selection	Data-2010	Data-2011
not a muon	98.14	99.01
high purity	86.98	83.88
pt>0.5 GeV	54.79	52.64
eta<2.0	82.75	82.72
$d_0/\sigma(d_{xy}) < 3.0$	80.89	81.41
$d_z/\sigma(d_z) < 3.0$	59.23	33.62
$\sigma(p_T)/p_T < 0.05$	97.75	97.96

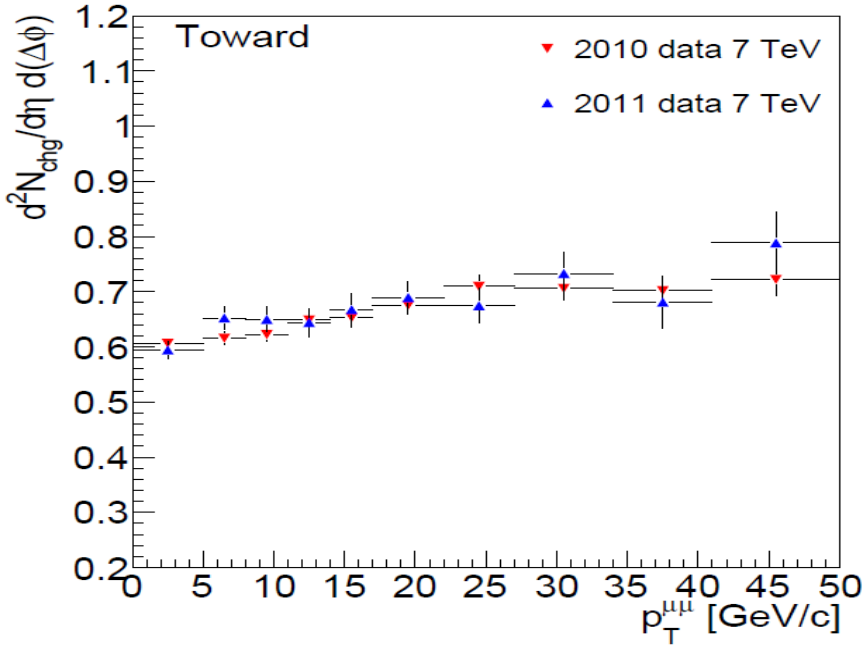
Due to increased background tracks from PU

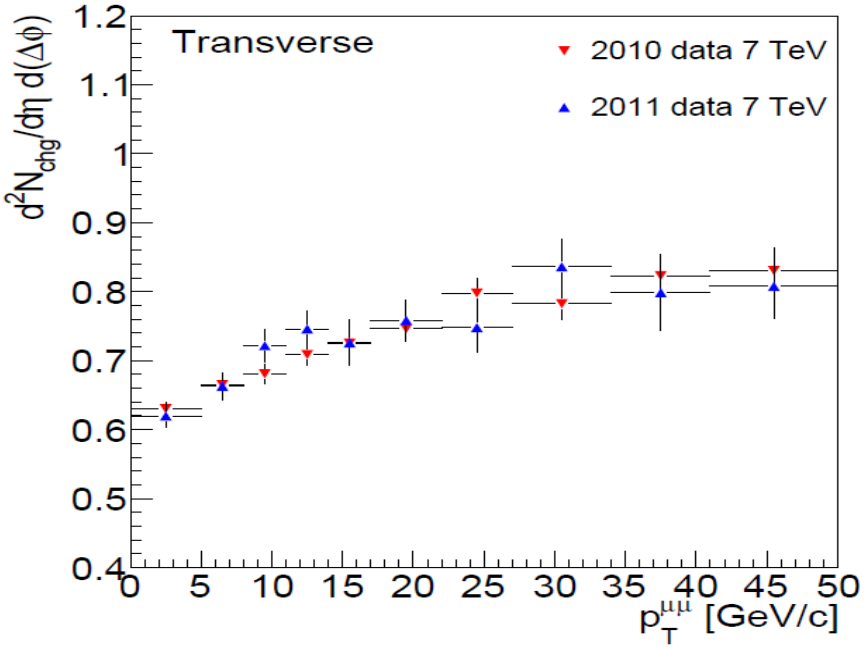
No unexpected feature is observed in 2011 data

$\langle N_{chg} \rangle$ Profile Distributions

- Average number of charged particles per unit pseudorapidity per unit azimuth $d^2N/d\eta d\phi$

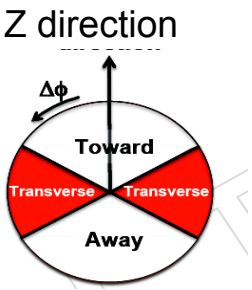




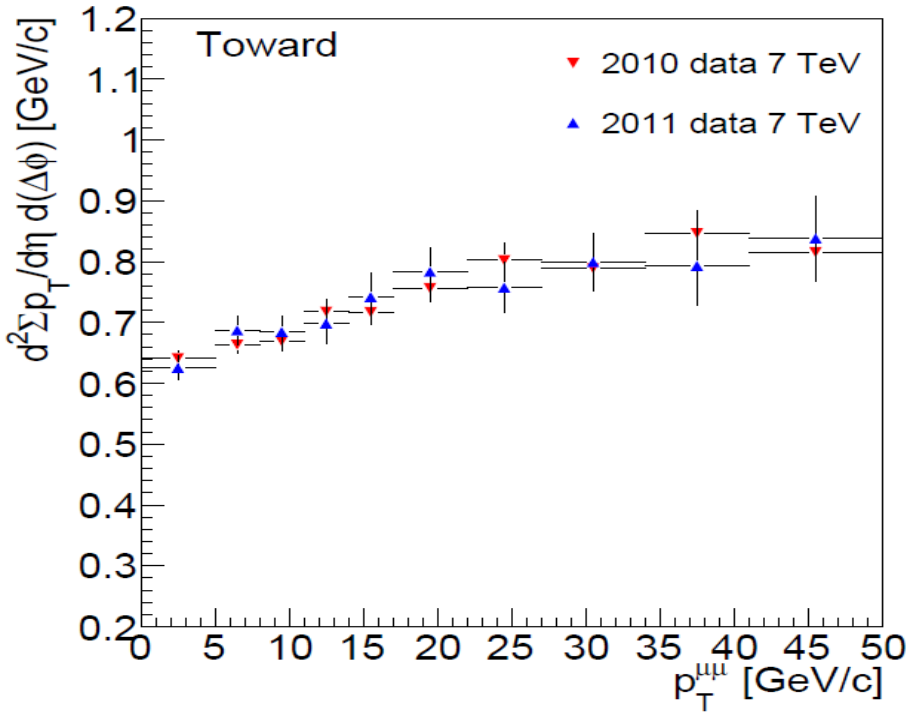


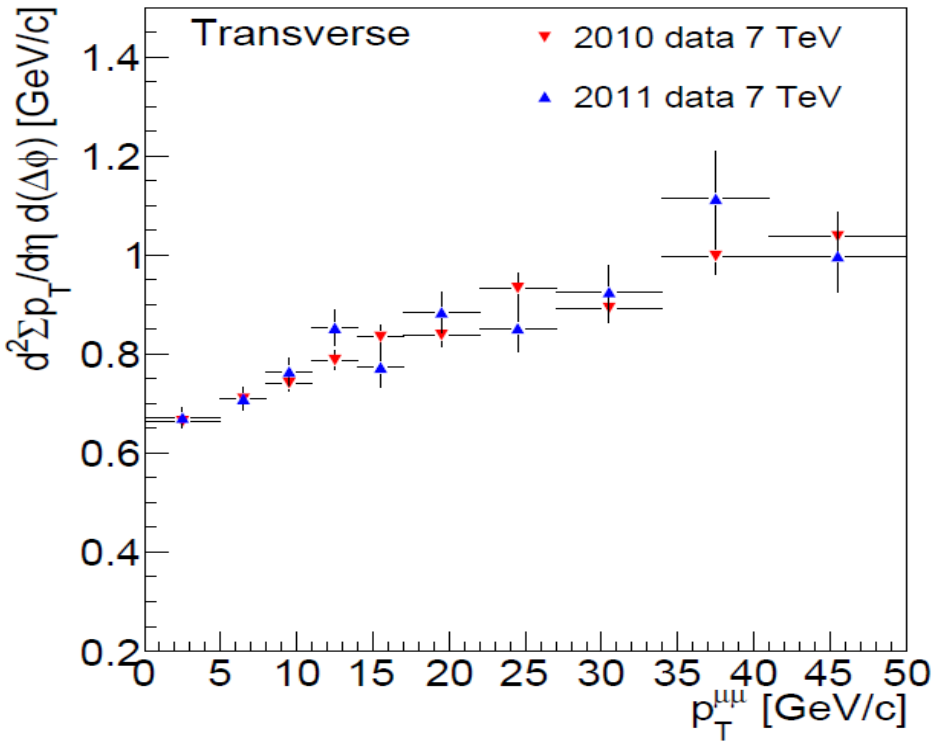
- Same trend in 2010 and 2011 data
- UE activity in 2011 data is higher by 1-2% because of pile-up.

< Σp_T > Profile Distributions



- Average scalar sum of transverse momentum of charged particles per unit pseudorapidity per unit azimuth $d^2\Sigma p_T / d\eta d\phi$





- Same trend in 2010 and 2011 data
- UE activity in 2011 data is higher by 1-2% because of pile-up

Report from QCD Photon subgroup

(Vasundhara Chetluru)
on behalf of
O. Bondu, H. Brun, S. Gascon-Shotkin, M. Lethuillier, Kadir Olcan

Single photon HLT Triggers

- **Available single photon triggers**
  - HLT_Photon30_CaloIdVL_IsoL (Prescaled)
  - HLT_Photon30_CaloIdVL (Prescaled)
  - HLT_Photon125_NoSpikeFilter (Prescaled)
  - HLT_Photon50_CaloIdVL_IsoL
  - HLT_Photon75_CaloIdVL_IsoL
  - HLT_Photon75_CaloIdVL
- Working points
  - CaloIdVL
    - H/E < 0.15 (0.10)
    - Shower Shape < 0.024 (0.040)
  - IsoL
    - Ecal ET < 5.5 + 0.012*ET
      Hcal ET < 3.5 + 0.005*ET
      Trk PT < 3.5 + 0.002*ET

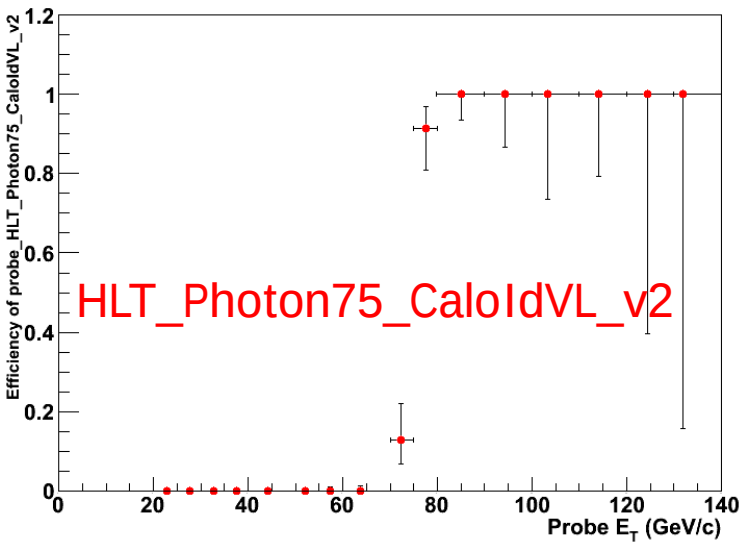
❑ **Double photon triggers:**

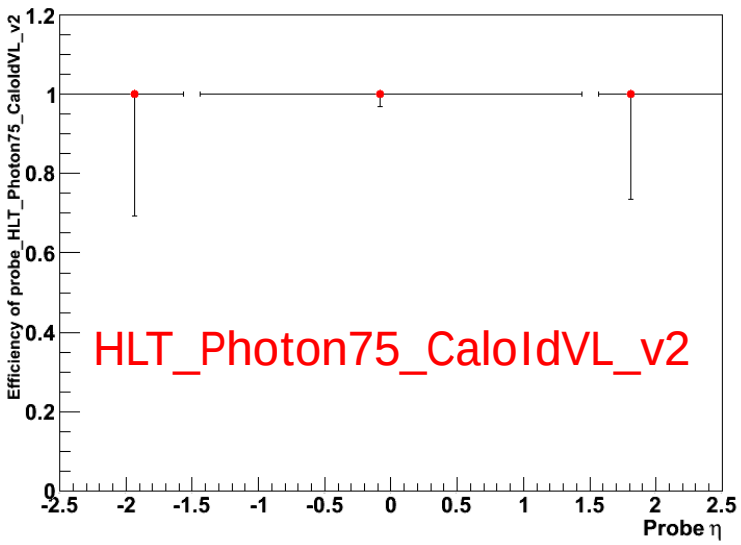
- **HLT_DoublePhoton33_v2**
- **HLT_DoublePhoton5_IsoVL_CEP_v1**
- **HLT_Photon20_R9Id_Photon18_R9Id_v2**
- **HLT_Photon26_CaloIdL_IsoVL_Photon18_CaloIdL_IsoVL_v2**
- **HLT_Photon26_CaloIdL_IsoVL_Photon18_R9Id_v1**
- **HLT_Photon26_CaloIdL_IsoVL_Photon18_v2**
- **HLT_Photon26_IsoVL_Photon18_IsoVL_v2**
- **HLT_Photon26_IsoVL_Photon18_v2**
- **HLT_Photon26_Photon18_v2 (Prescaled)**
- **HLT_Photon26_R9Id_Photon18_CaloIdL_IsoVL_v1**

https://twiki.cern.ch/twiki/bin/viewauth/CMS/QCDPhotonsTrigger2011

Photon Efficiency studies using Z->ee

- Efficiency measurements of the HLT single photon paths in **2011A data** by using the Tag & Probe package.
  - CMSSW version: CMSSW_4_1_3_patch2
  - 2011A data: /Photon/Run2011A-PromptReco-v1/AOD
  - Corresponding luminosity: **~11.9/pb**
  - Json: Cert_161079-161352_7TeV_PromptReco_Collisions11_JSON_noESpbl_v2.txt
- **Using Tag & Probe:**
  - Tag: electron passing a standard electron ID selection (VBTF WP80)
  - Probe: photon passing isolation template selection:
    - h/e < 0.05
    - $\sigma_{i\eta i\eta}$ < 0.013 (EB)
    - $\sigma_{i\eta i\eta}$ < 0.03 (EE)





We use the binnings:
-- probe_et: 50 & 75 – Inf.
-- probe_eta: -2.5, -1.56, -1.44, 1,44, 1.56, 2.5
* Exclude the transition gap between barrel (EB) and endcap (EE)

Trigger Efficiency studies using Tag & Probe

- Counting and Fitting methods are used to measure the efficiencies for the unprescaled paths.

Isolation Template		Fitting Method			Counting Method		
Path Name	ET (GeV)	- Endcap	Barrel	+ Endcap	- Endcap	Barrel	+ Endcap
HLT_Photon50_CaloIdVL_IsoL_v1	50 - 55	88.9+-7.4	89.2+-6.6	94.4+-9.0	88.9+-10.0	87.1+-2.3	84.2+-10.8
HLT_Photon50_CaloIdVL_IsoL_v1	55 - Inf.	100+-0.1	94.6+-1.2	91.2+-4.6	92.1+-5.7	94.5+-1.3	91.7+-6.0
HLT_Photon75_CaloIdVL_IsoL_v2	75 - 80	100+-30.1	75.5+-11.6	100+-30.1	100+-30.1	73.7+-12.4	100+-30.1
HLT_Photon75_CaloIdVL_IsoL_v2	80 - Inf.	80.1+-17.2	92.9+-3.5	100+-13.3	80.0+-24.6	92.9+-4.4	100+-13.2
HLT_Photon75_CaloIdVL_v2	75 - 80	100+-30.1	89.5+-7.0	100+-30.1	100+-30.1	89.5+-9.5	100+-30.1
HLT_Photon75_CaloIdVL_v2	80 - Inf.	100+-15.4	100+-1.6	100+-13.3	100+-15.4	100+-1.6	100+-13.3

- Remarks:

- Need to have more statistics
- MC efficiency & 2010A/B data comparisons are on the way
- Working on the efficiency measurements for the prescaled single photon HLT paths

https://indico.cern.ch/getFile.py/access?contribId=8&resId=1&materialId=slides&confId=128108

Comparison with 2010 Data

- data 2011 : prompt reco with latest Json file≃5.8 pb-1
  - `Json file = OR of Cert_160404-161216_7TeV_PromptReco_Collisions11_JSON.txt and Cert_161079-161352_7TeV_PromptReco_Collisions11_JSON_noESpbl.txt`
- data 2010 : all 2010 runB, 4 th nov reReco 33 pb-1
  - so without laser correction like in 2011 prompt reco
- Event Selection
  - no scrapping + good vertex filter HLT_Photon75_CaloIdVL trigger in 2011 data
  - no trigger in 2010 data

Photon selection :

	EGM 006 Loose
no Pixel Seed	yes
trackerIso	< 2
ecalIso	< 4.2
hcalIso	< 2.2
pt	<80
$\sigma_{i\eta i\eta}$	0.01(EB) 0.03(EE)
HoE	0.05
η-Gap	removed

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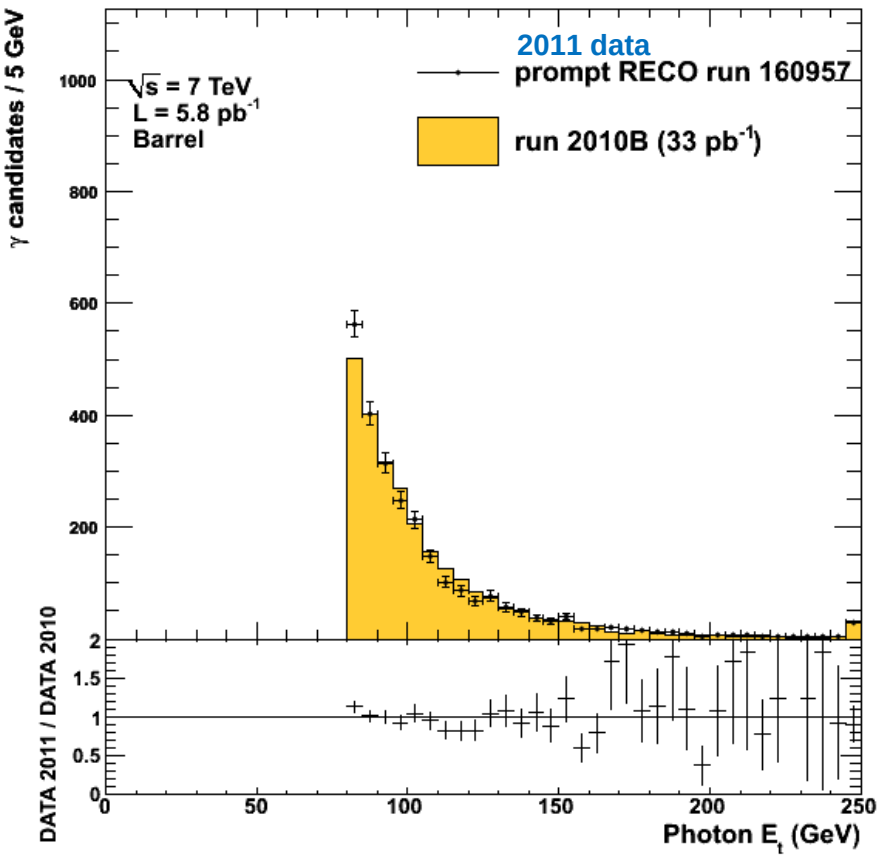
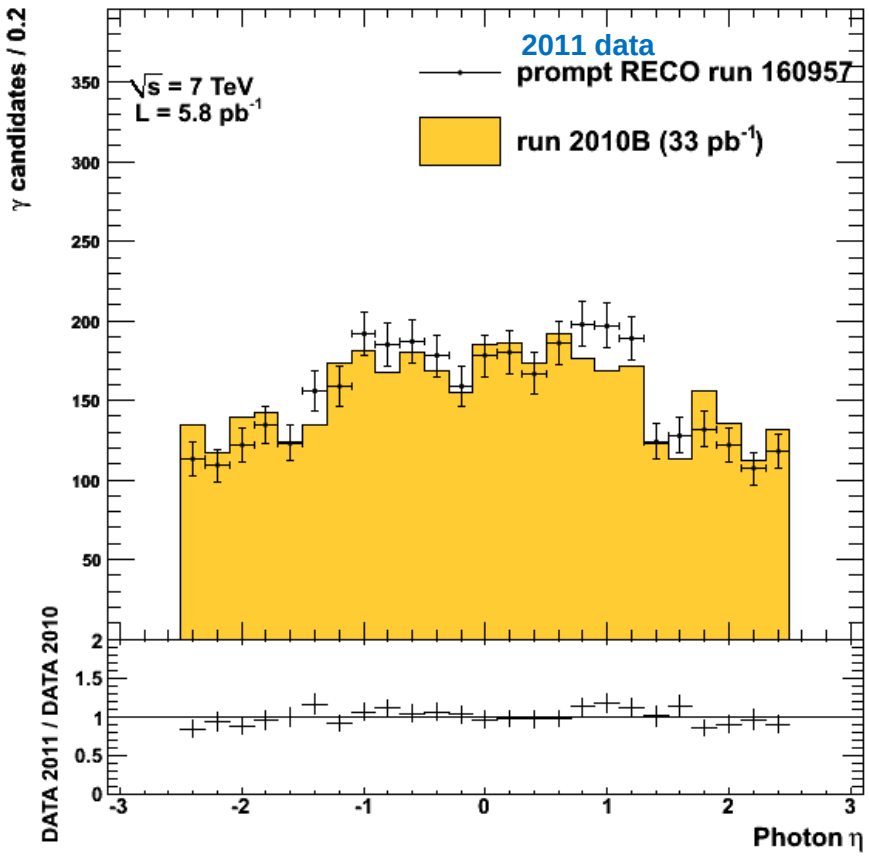
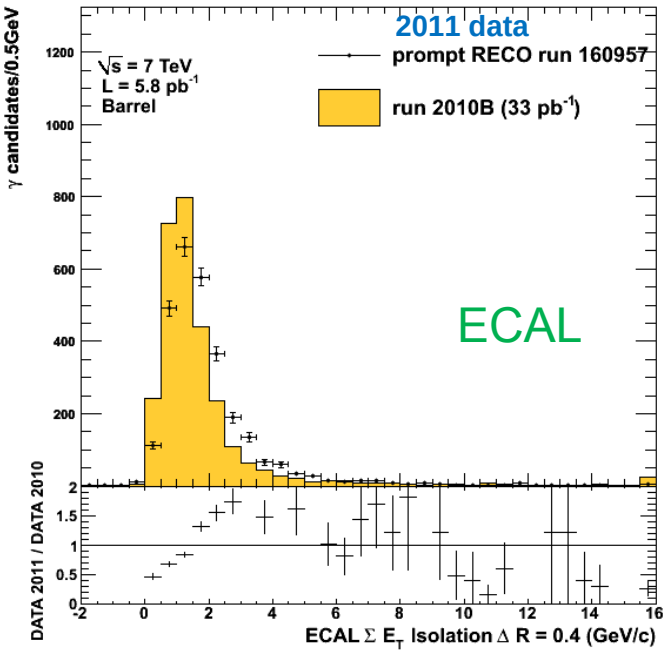
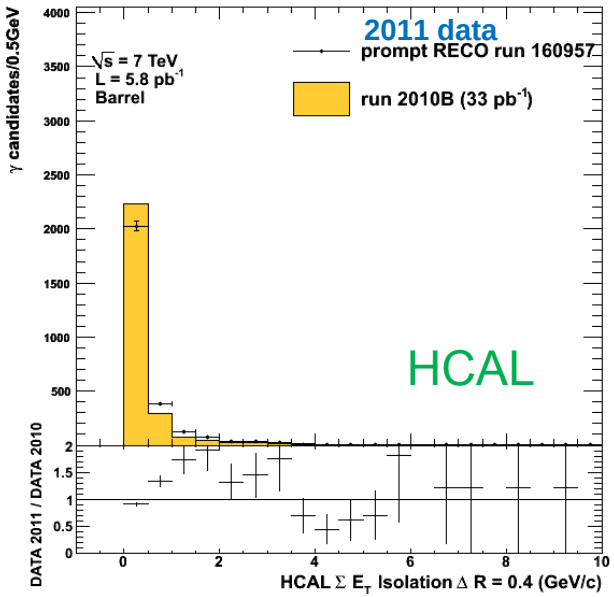
Photon E_T, η

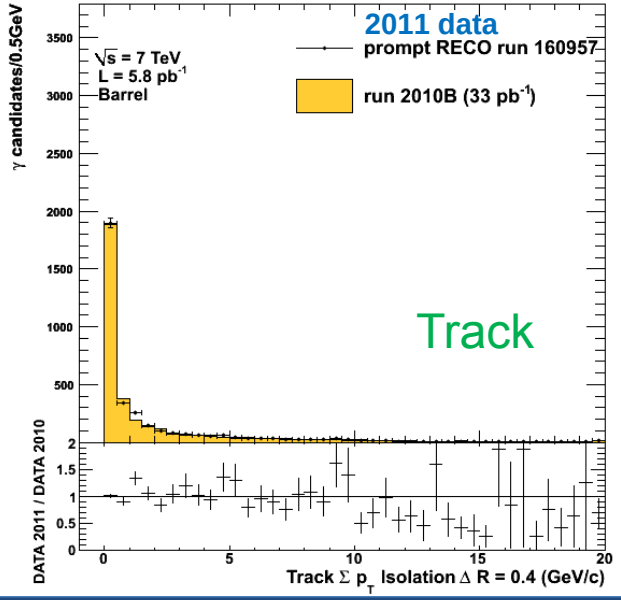

2011 data
prompt RECO run 160957
run 2010B (33 pb^{-1})
$\sqrt{s}$ = 7 TeV
L = 5.8 pb^{-1}
Barrel
γ candidates / 5 GeV
DATA 2011 / DATA 2010
Photon E_t (GeV)


2011 data
prompt RECO run 160957
run 2010B (33 pb^{-1})
$\sqrt{s}$ = 7 TeV
L = 5.8 pb^{-1}
γ candidates / 0.2
DATA 2011 / DATA 2010
Photon η

Isolation distributions

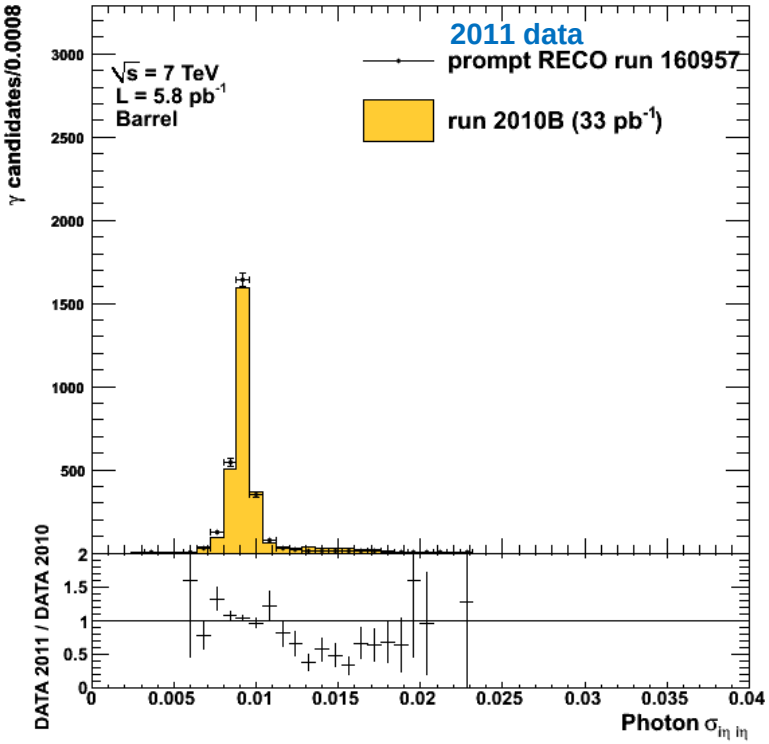


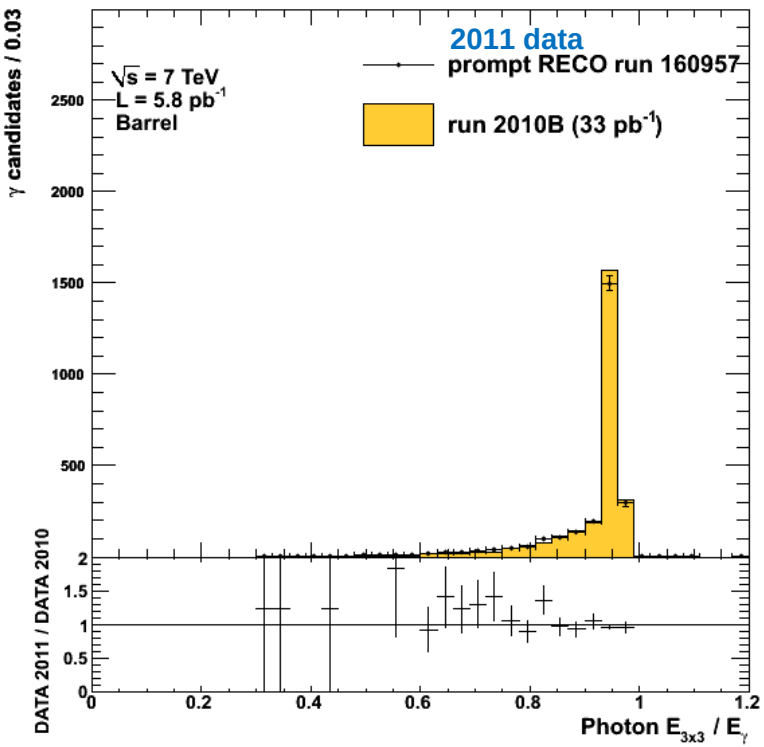




- ECAL Isolation is the most sensitive pileup and track isolation is the least sensitive to pileup

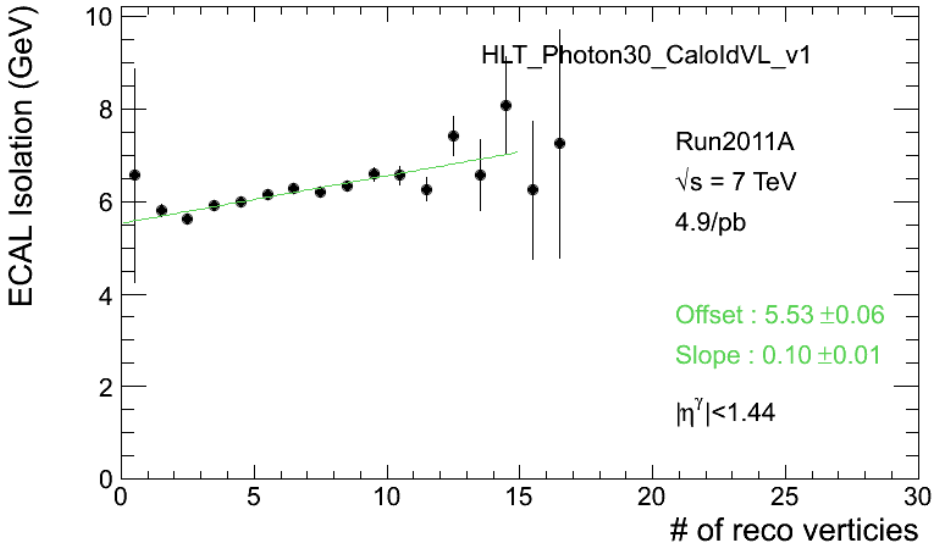
Shape variables

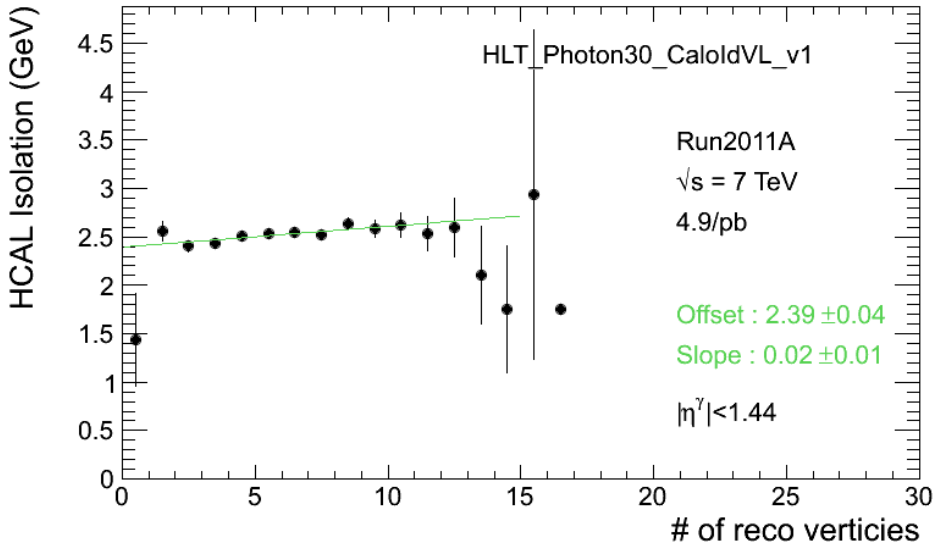


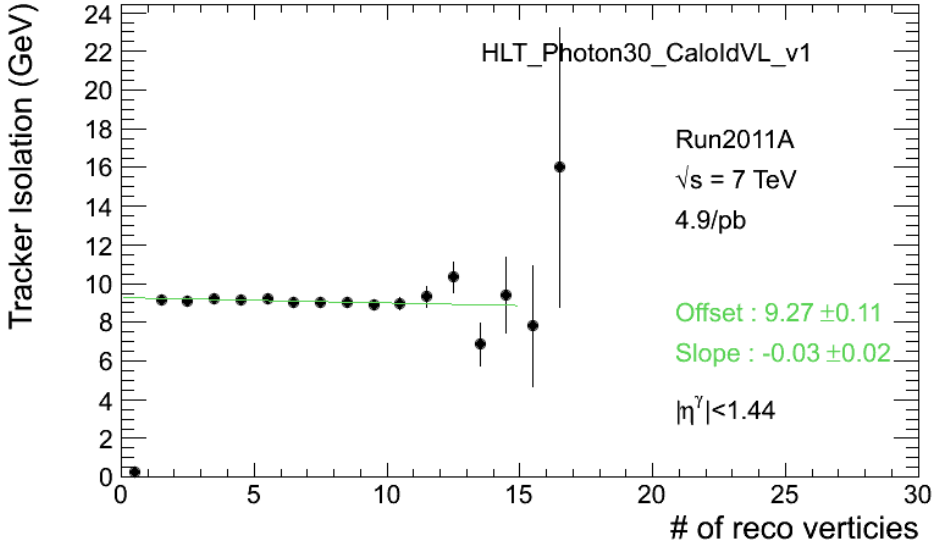


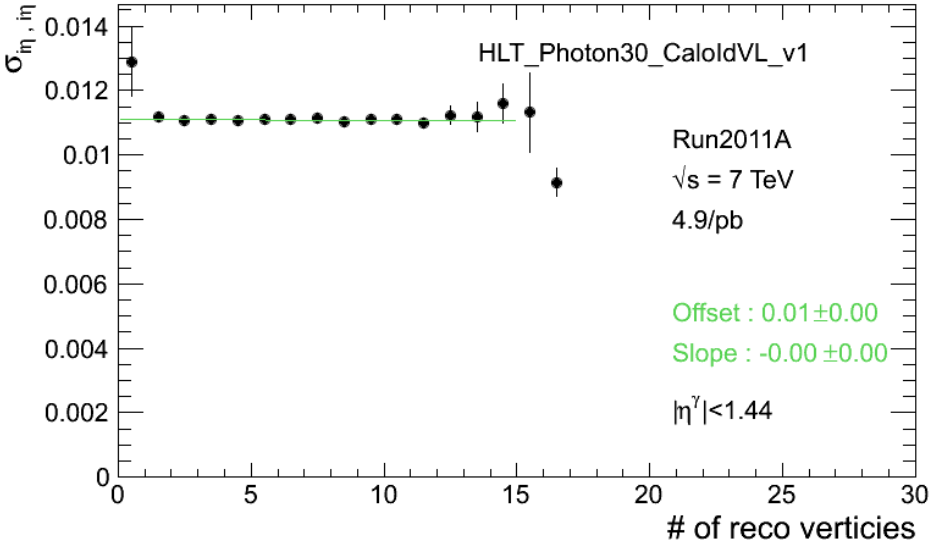
- Shape variables show a good comparison between the 2010 and 2011 data.
  - They are less sensitive to pile-up

Effect of pile-up









Report from QCD High p_T subgroup

(Suvadeep Bose)

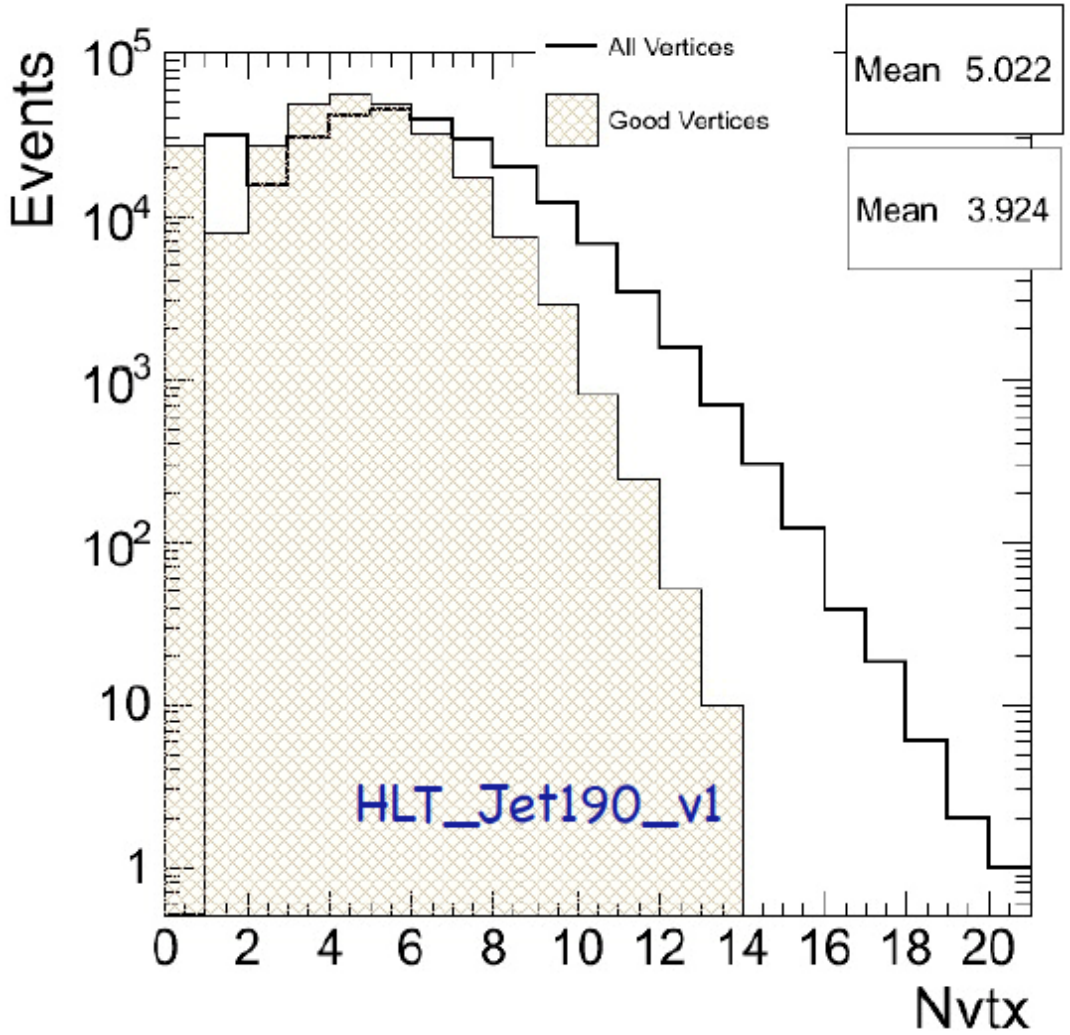
Jet Triggers in 2011 data

HLT Path	L1 Seed	L1 Prescale	HLT Prescale	Eff. Lumi
HLT_Jet30_v1	L1_SingleJet16	1588	16.45	0.8 nb^{-1}
HLT_Jet60_v1	L1_SingleJet36	7.75	309	8.4 nb^{-1}
HLT_Jet80_v1	L1_SingleJet52	1	212	0.10 pb^{-1}
HLT_Jet110_v1	L1_SingleJet68	1	46.3	0.44 pb^{-1}
HLT_Jet150_v1	L1_SingleJet92	1	10.3	2.0 pb^{-1}
HLT_Jet190_v1	L1_SingleJet92	1	2.3	8.8 pb^{-1}
HLT_Jet240_v1	L1_SingleJet92	1	1	20.2 pb^{-1}
HLT_Jet370_v1	L1_SingleJet92	1	1	20.2 pb^{-1}

- Jets are corrected both at L1 and at HLT
- The prescale values are the weighted average over the different trigger menus
- Total bandwidth allocated to the single-jet triggers: **~8 Hz**

K. Kousouris

Effect of pile up



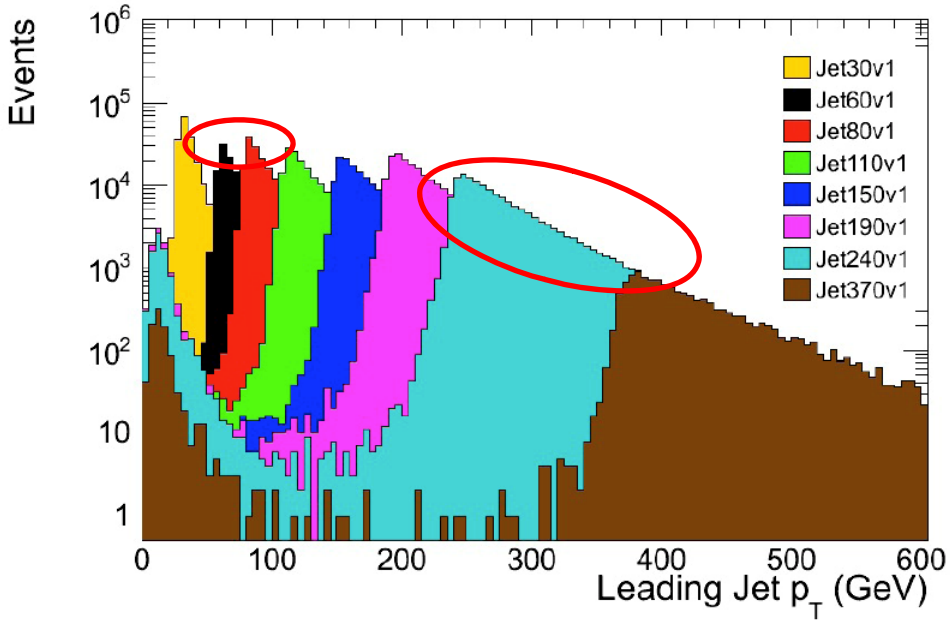
- Good vertex definition:
  |z| < 24 cm
  ndof >= 4
- Already more pile-up than 2010

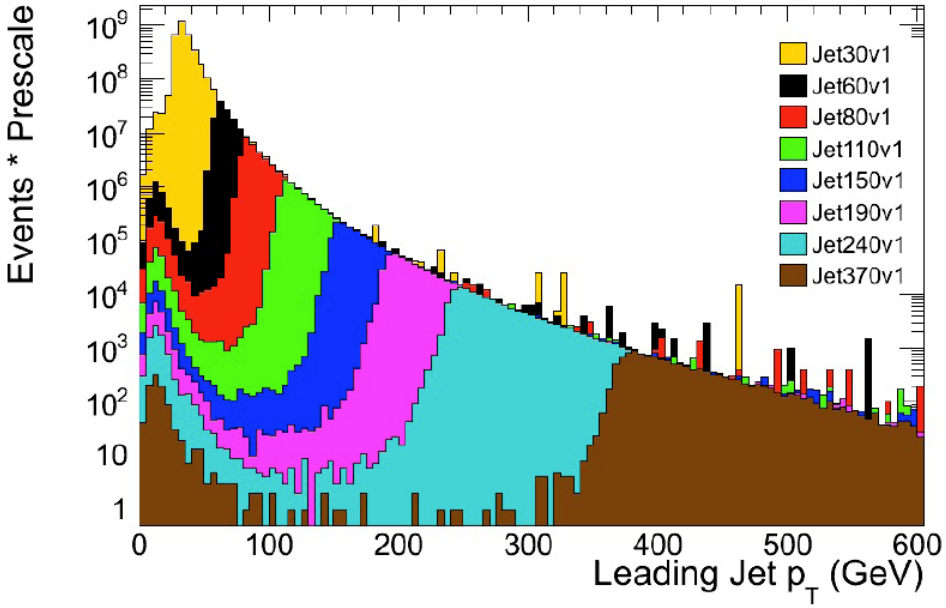
K. Kousouris

Trigger yield vs CaloJet p_T

- The single-jet triggers appear to be well behaved in general

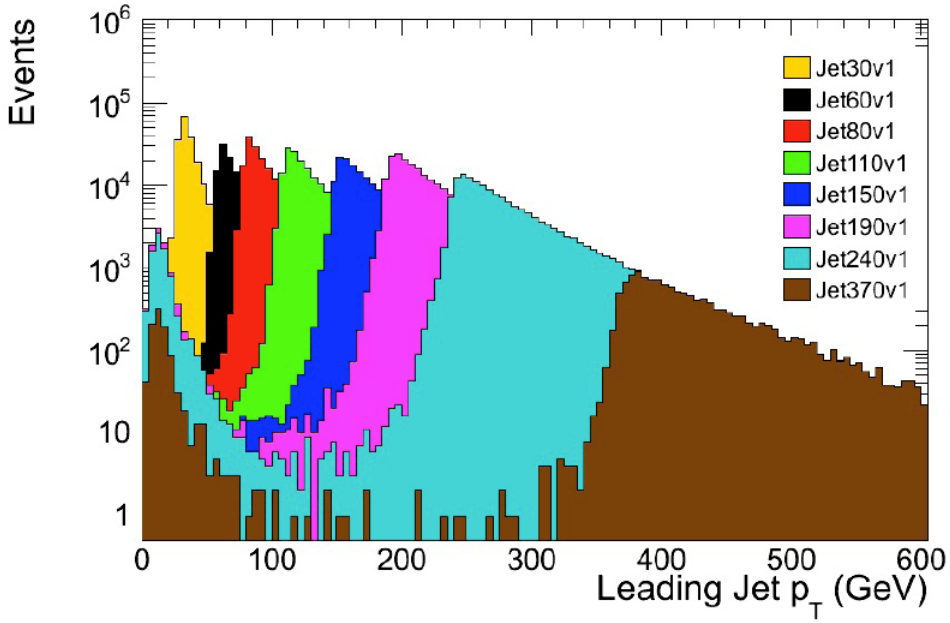
K. Kousouris

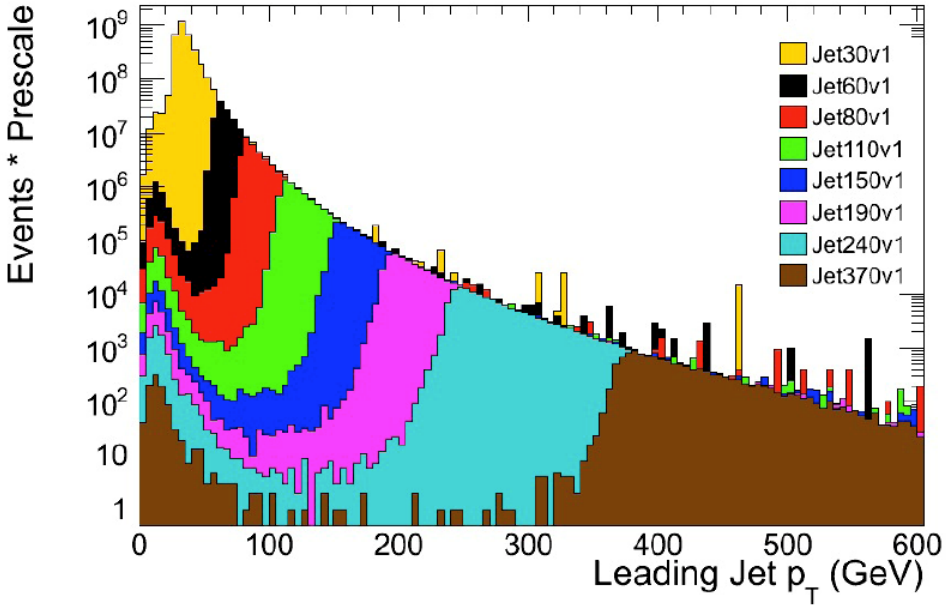




- Some issues observed:
  - The trigger thresholds are not optimal (not in equal distance)
  - ➡ the Jet60 is too close to the Jet80
  - ➡ if the Jet240 gets significant prescale, the Jet370 is too far
- Actions:
  - Add HLT_L1SingleJet16 L1 pass-through path
  - Add a new single jet threshold @p_T=300 GeV
  - Update HLT_DijetAve path to use corrected jets

Trigger yield vs PFlowJet p_T





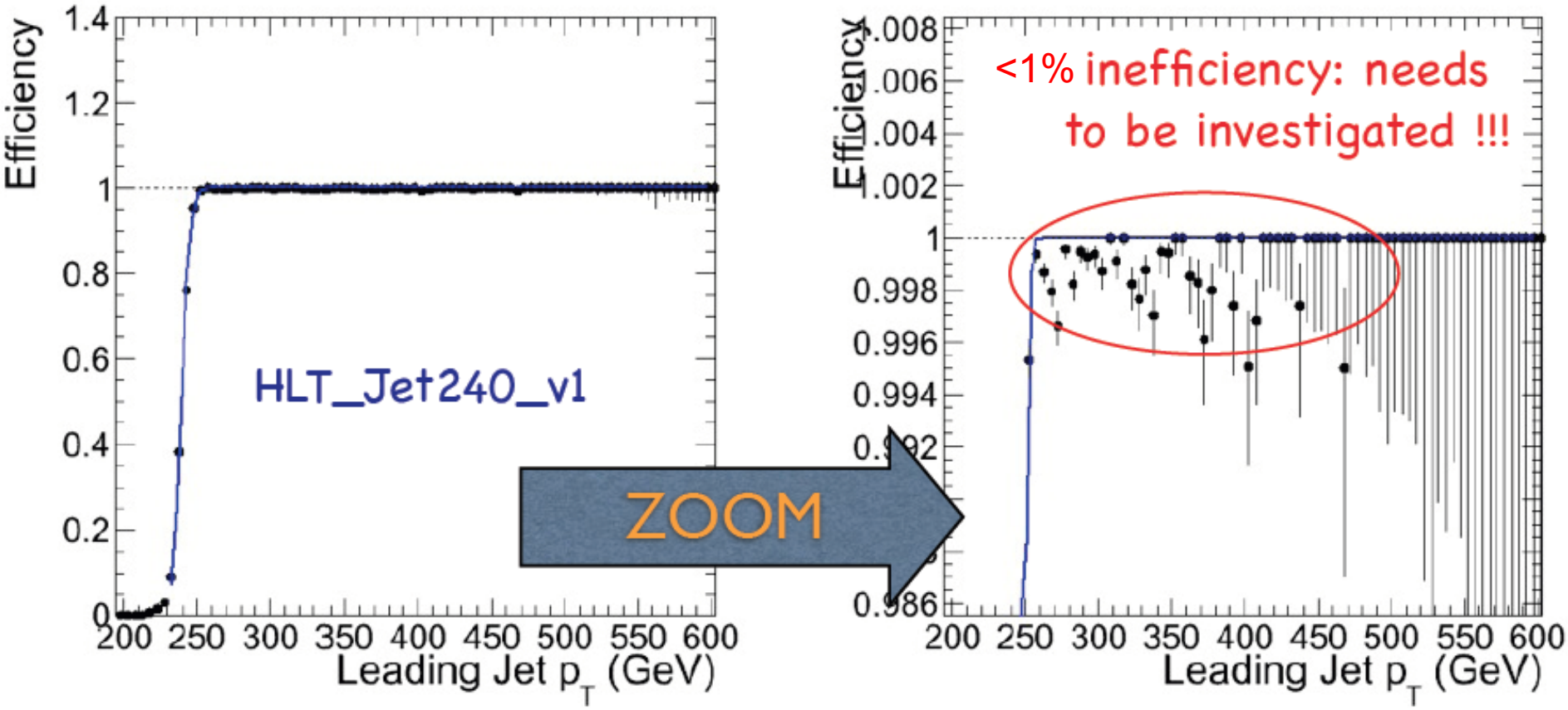
- Observation:

The turn-on of the single-jet triggers isslower for PFJets than for CaloJets (expected because the trigger uses CaloJets)

K. Kousouris

Trigger inefficiency vs. CaloJet p_T

Efficiency of the un-prescaled trigger Jet240 = $\frac{\text{Jet190 \&\& Jet240}}{\text{Jet190}}$



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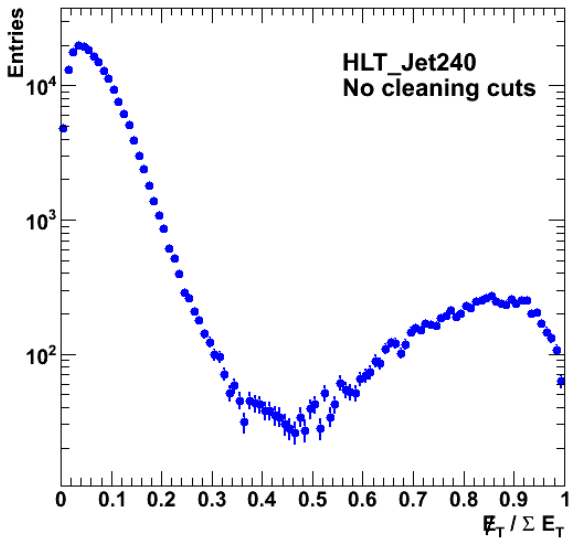
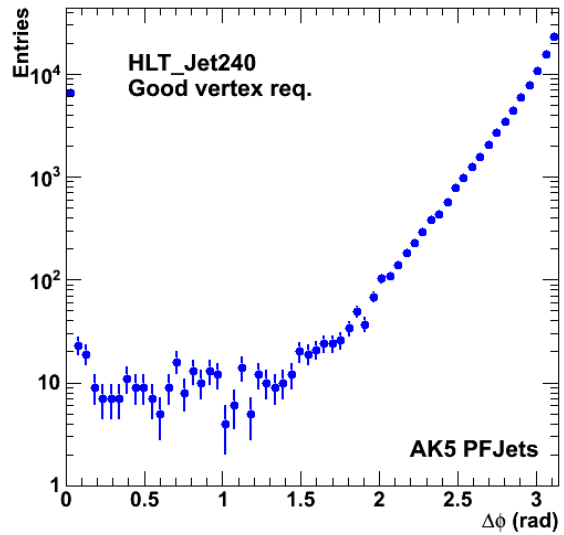
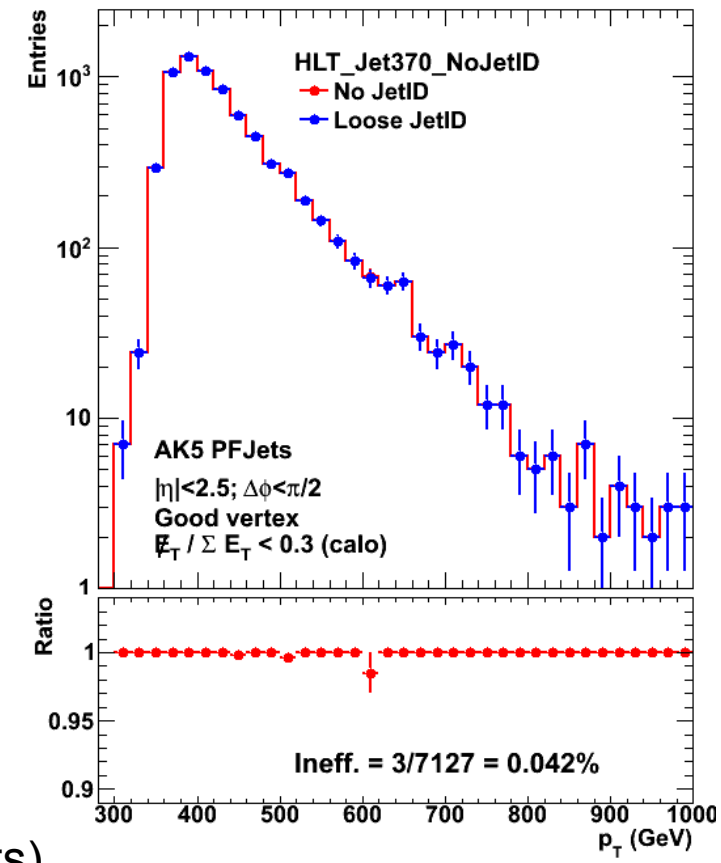
Offline JetID efficiency







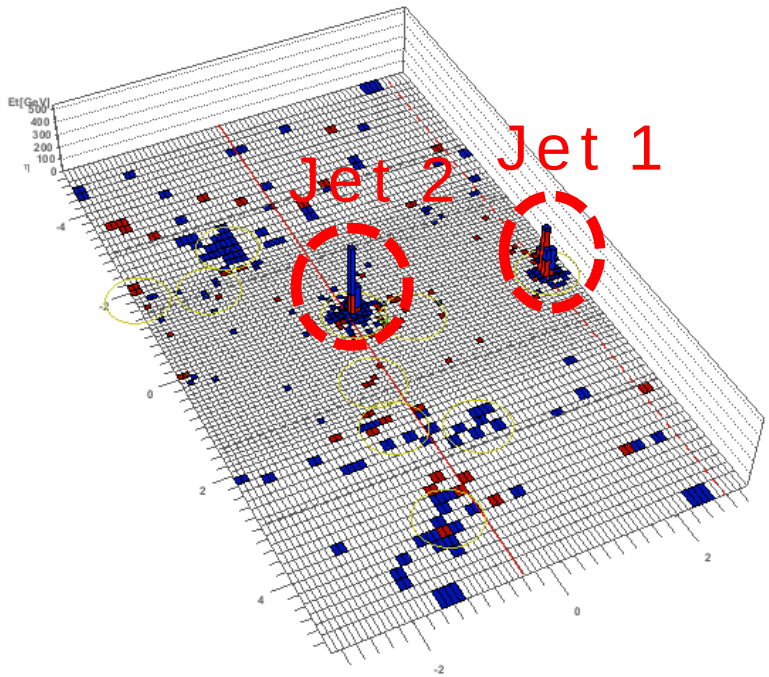
- Event Cuts:
  - HLT_Jet370_NoJetID trigger
  - HLT jet |η| < 2.5 (suppress noise from HF)
  - Missing E_T / SumE_T < 0.3 (calculated from CaloJets)
  - Δφ (jet1, jet2) > π/2
  - Good Vertex
- Particle Flow jets:
  - P_T > 300 GeV ; |η| < 2.5

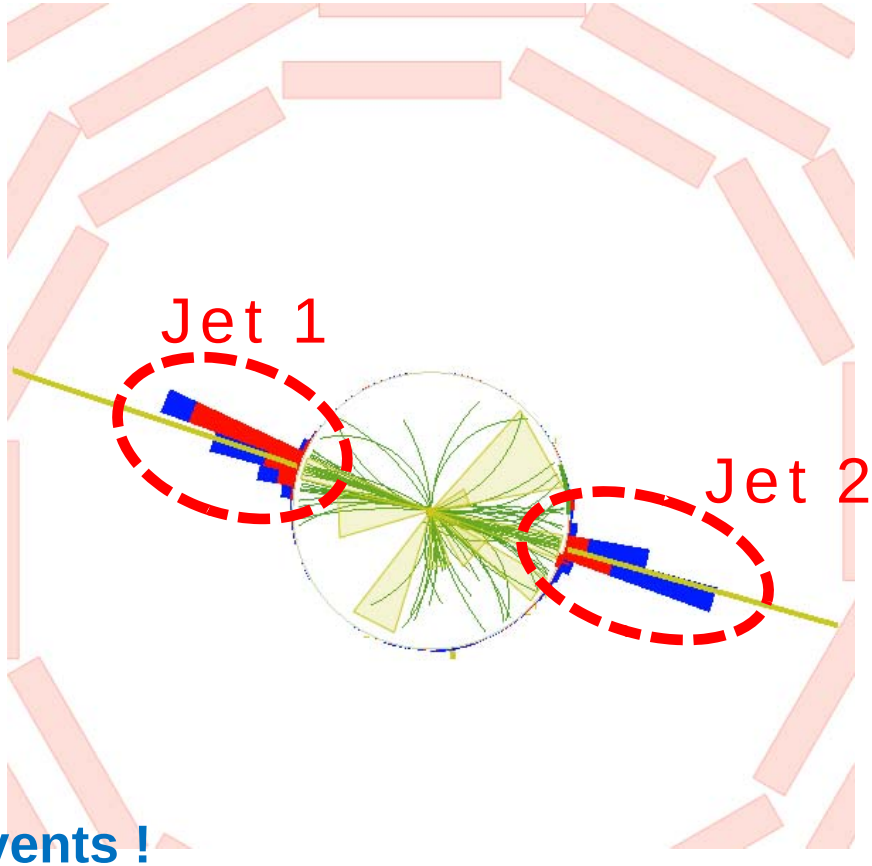
L. Apanasevich

Highest dijet mass event

C. Jeong

Run : 161311
Event : 101019991





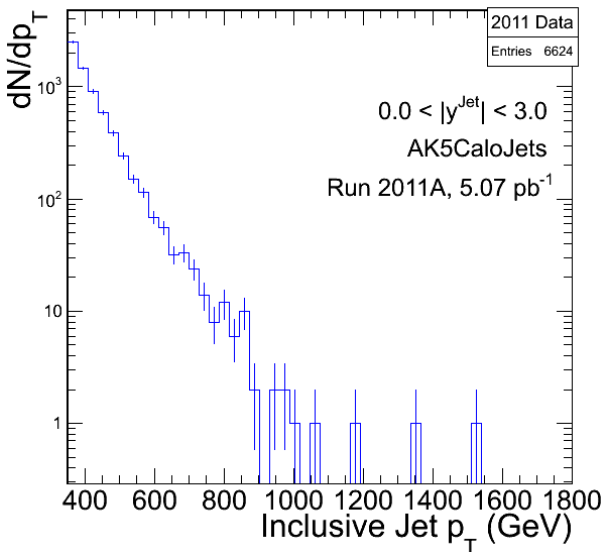
Higher than any 2010 dijet events !

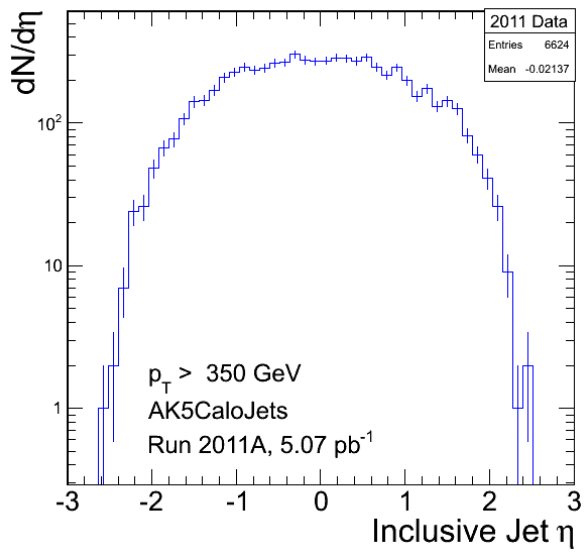
Dijet Mass = 2.700 TeV, MET = 60 GeV

Jets	CorP$_T$ (TeV)	η	Φ	n90hits	emf	nTrkCalo	fHPD	fRBX	met/sumet
Jet1	1.349	0.3	2.8	45	0.59	26	0.19	0.36	0.02
Jet2	1.261	-0.1	-0.3	47	0.30	20	0.38	0.65	7

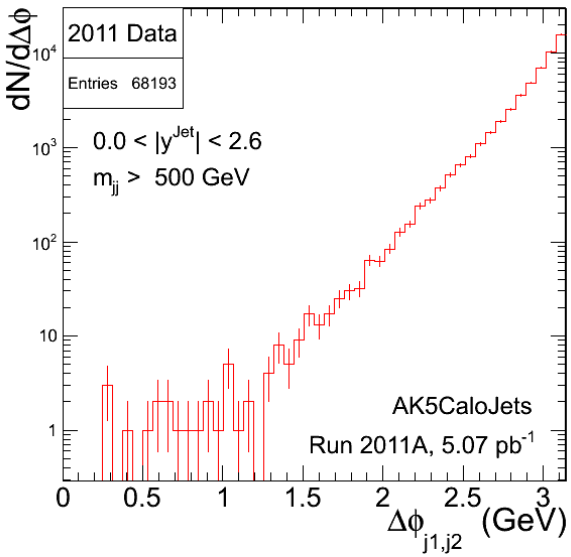
Basic kinematic distributions with 2011 data

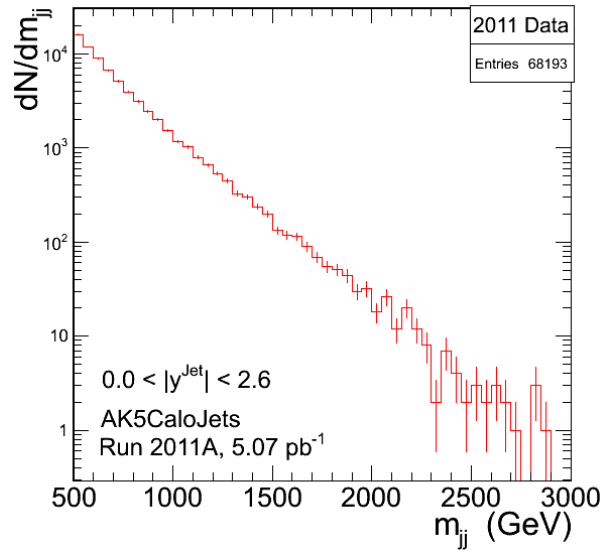
K. Rose





- JEC is version 10
- No L1 correction applied

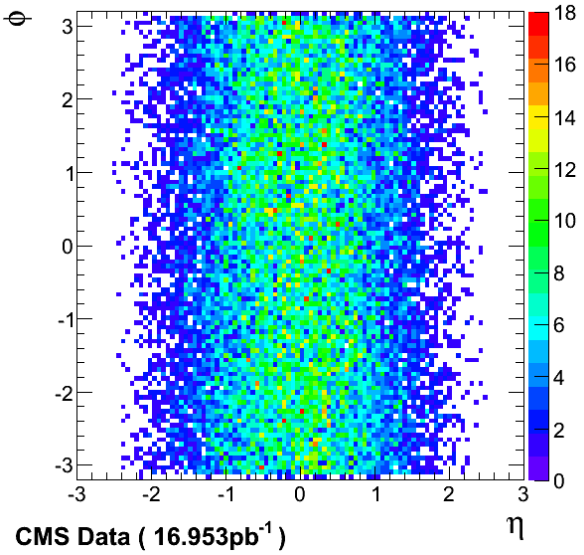


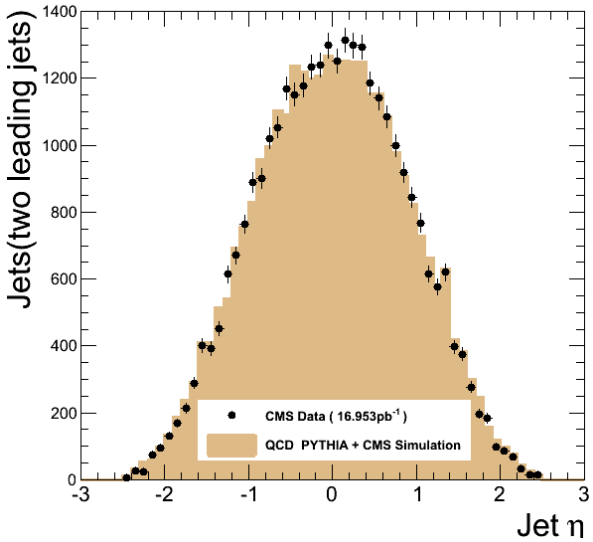


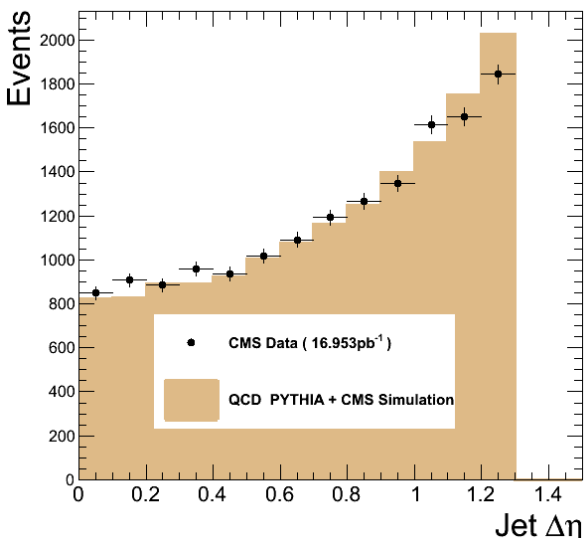
❖ There are not any unusual surprises.

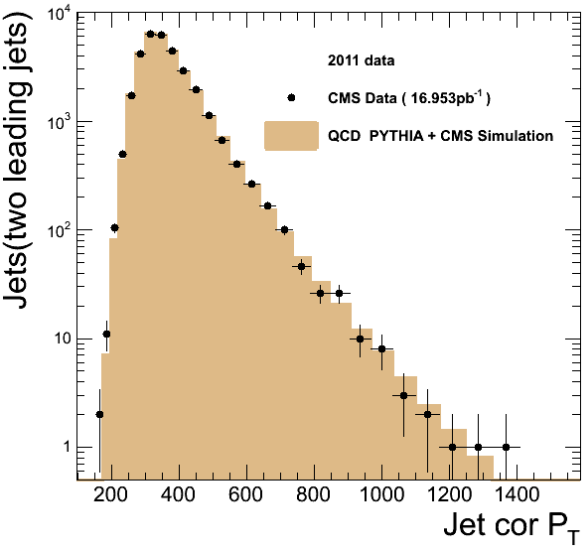
Basic kinematic distributions: Data('11)-MC

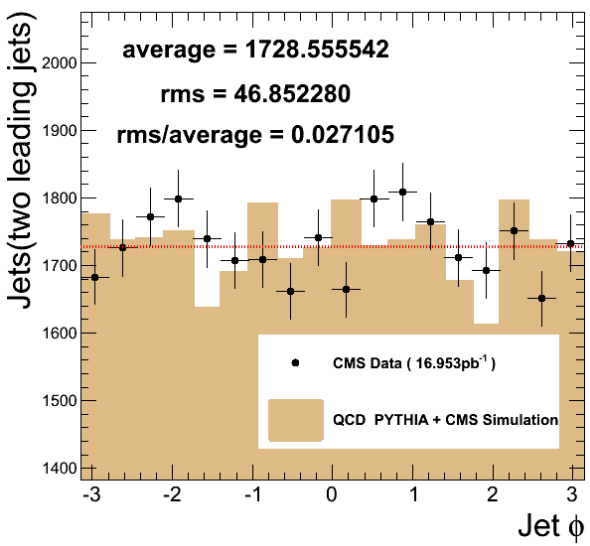
C. Jeong

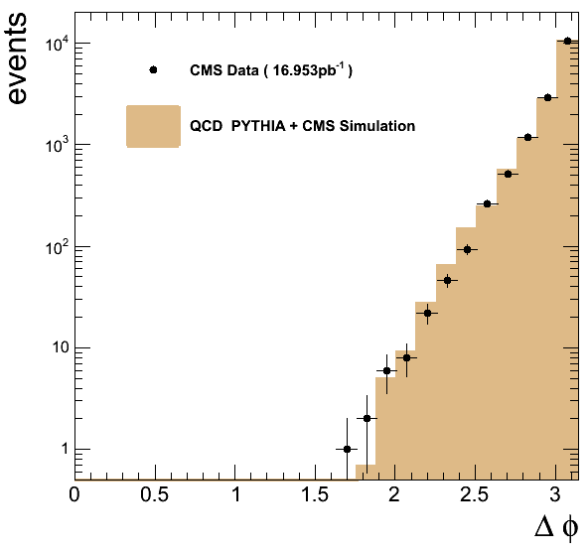








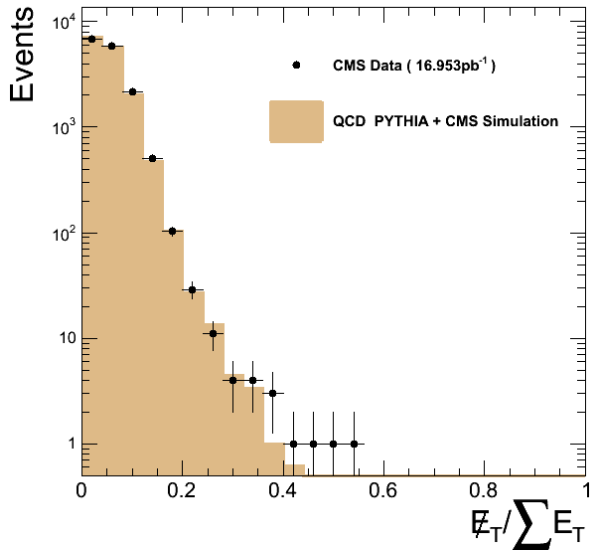


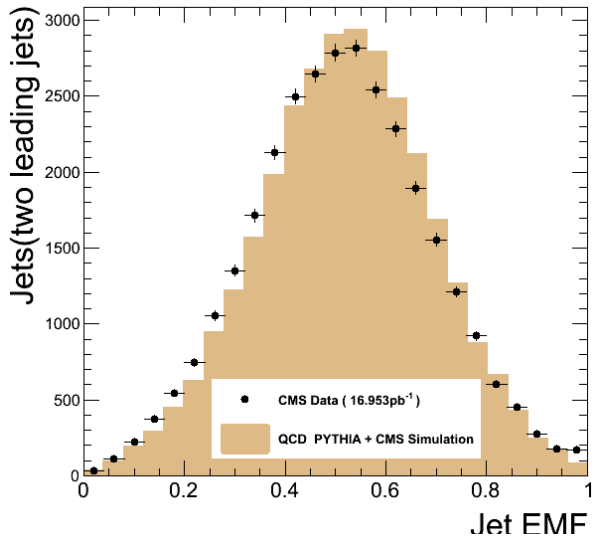


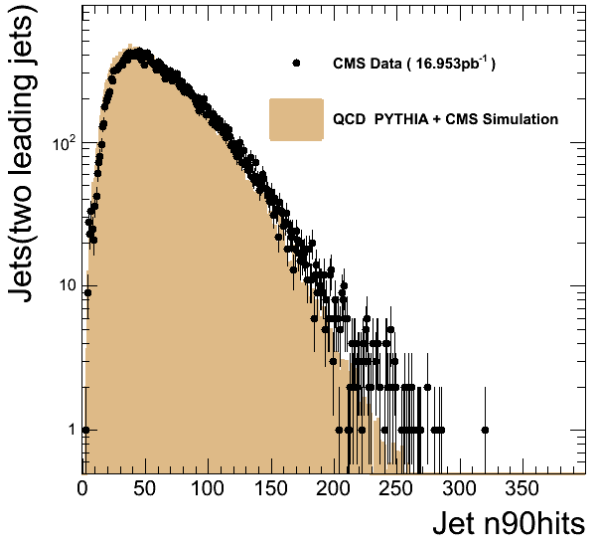
JEC: L1Offset, L2 ,L3 L1L2L3Residual

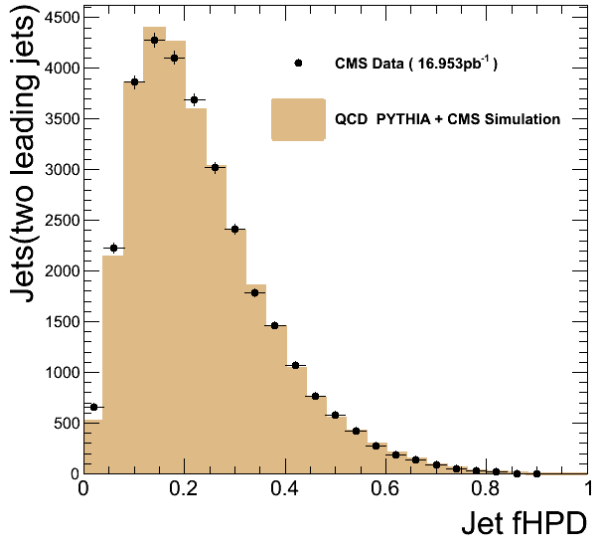
Basic Data quality plots: Data('11)-MC

C. Jeong



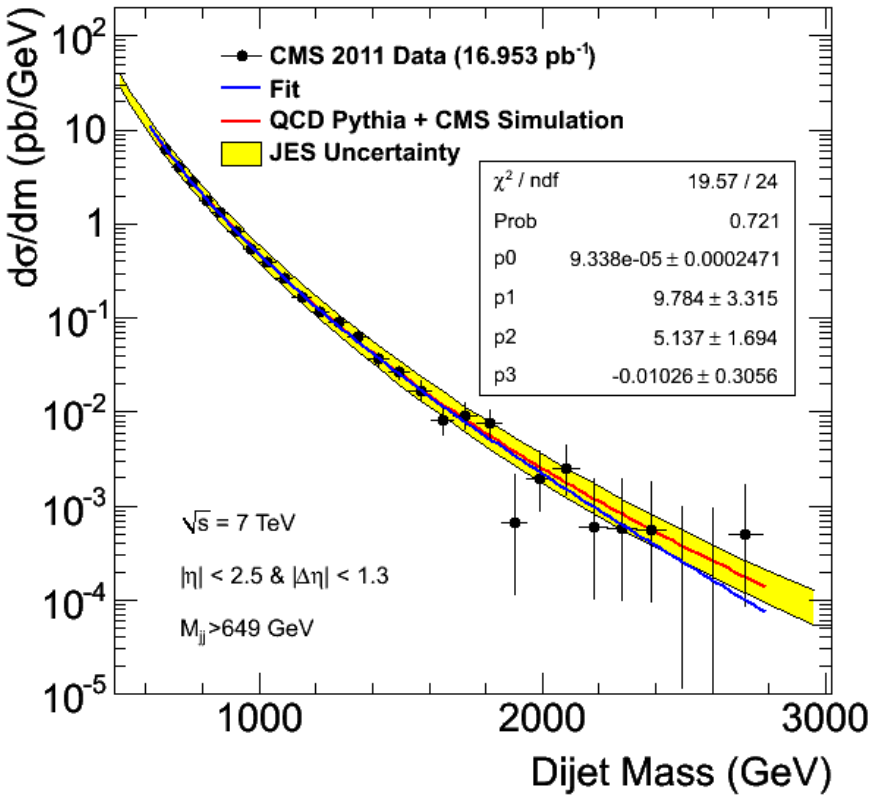


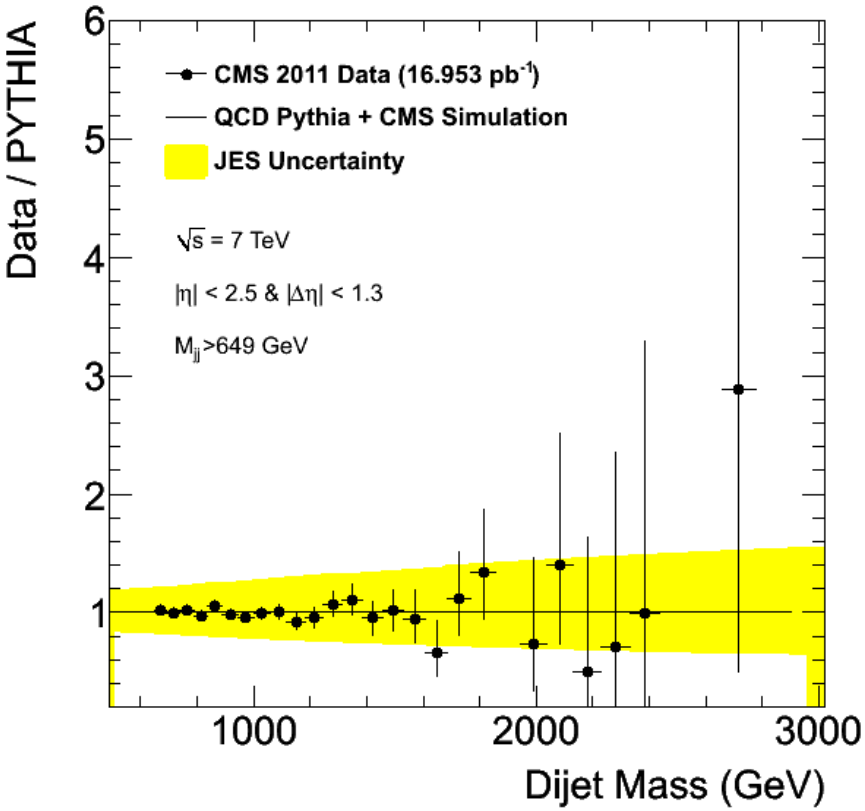




Dijet mass distribution with 2011 data

C. Jeong



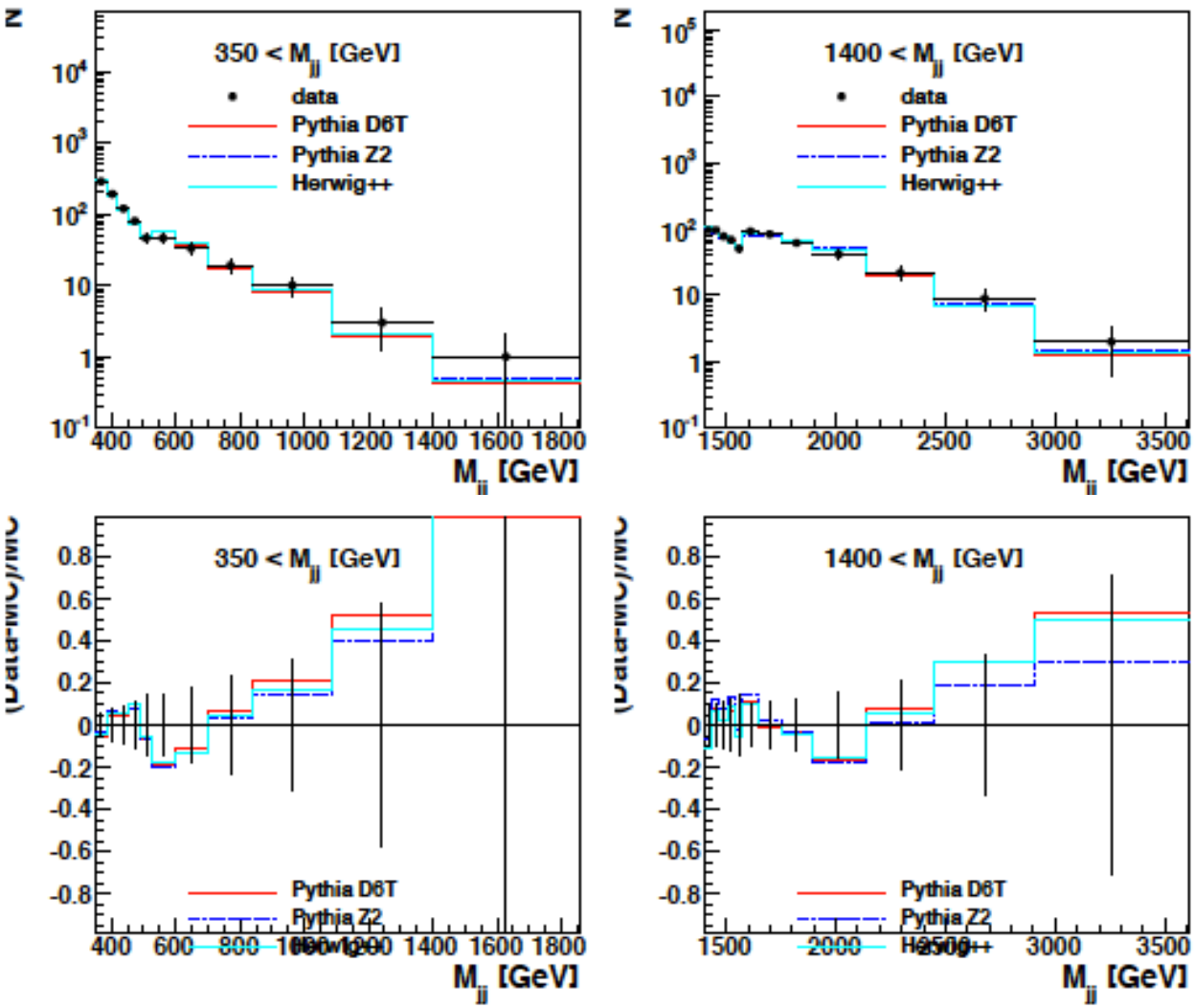


- The 2011 data is in good agreement with the full CMS simulation of QCD from PYTHIA.

(PYTHIA prediction is normalized by 1.53)

Data(2011) - MC comparisons

A. Hinzmann



Data-MC/MC

- Good agreement with 2010 jet resolution smeared MC

Study of QCD-10-016 with 2011 data

A. Hinzmann

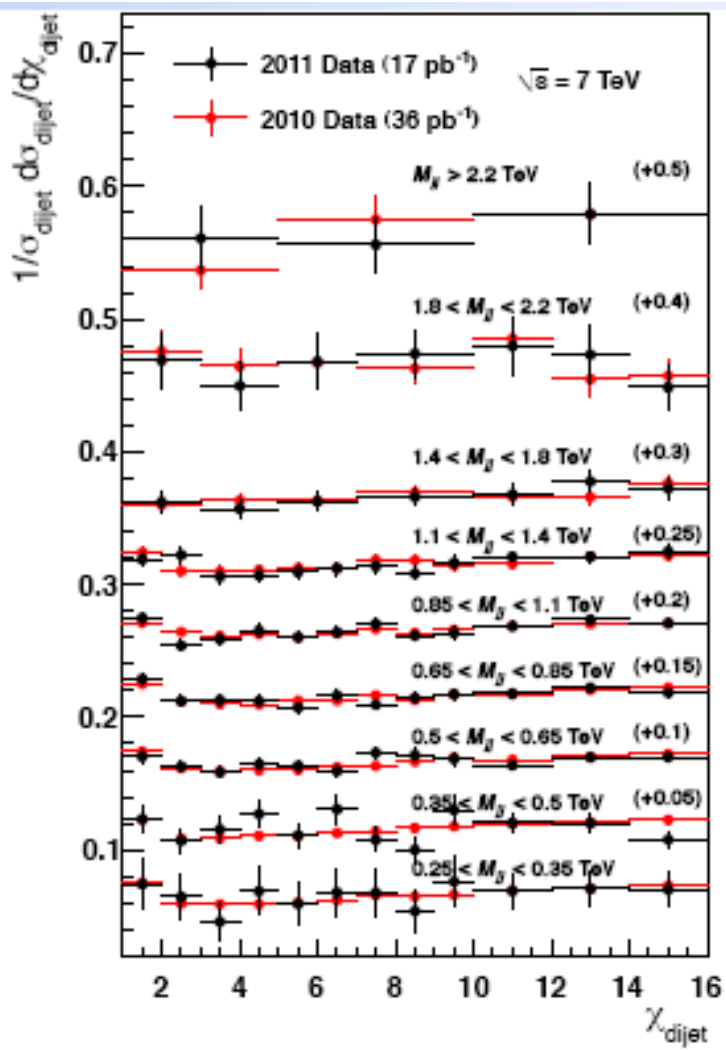
- /Jet/Run2011A-PromptReco-v1/AOD
- 17/pb of certified data:

`Cert_160404-161312_7TeV_PromptReco_Collisions11_JSON`

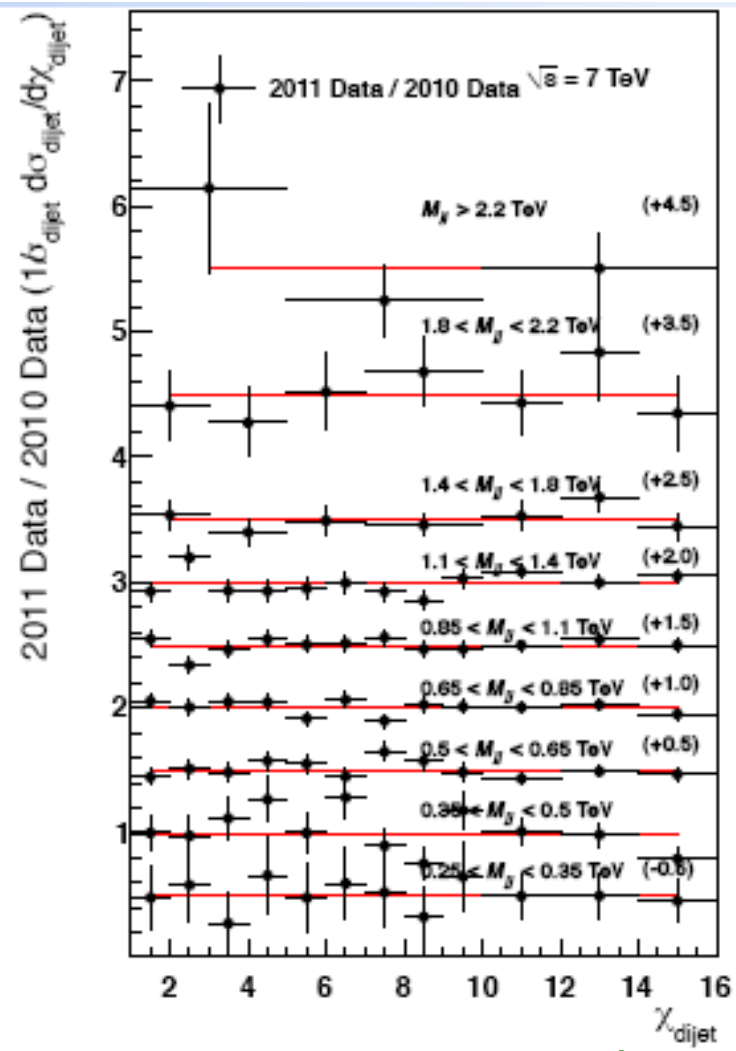
`Cert_161079-161352_7TeV_PromptReco_Collisions11_JSON_noESpbl_v2`

- Triggers, luminosities, massbin:
  - Jet30_v1: 0.00072/pb (250-350)
  - Jet60_v1: 0.011/pb (350-500)
  - Jet80_v1: 0.061/pb
  - Jet110_v1: 0.30/pb (500-650)
  - Jet150_v1: 1.4/pb (650-800)
  - Jet190_v1: 5.0/pb (800-1100)
  - Jet240_v1: 17/pb (1100-)
  - Jet370_v1: 17/pb
- Triggers chosen by quick look at trigger turn on. Will study more thoroughly

2010 vs 2011 data (QCD-10-016): χ



Ratio

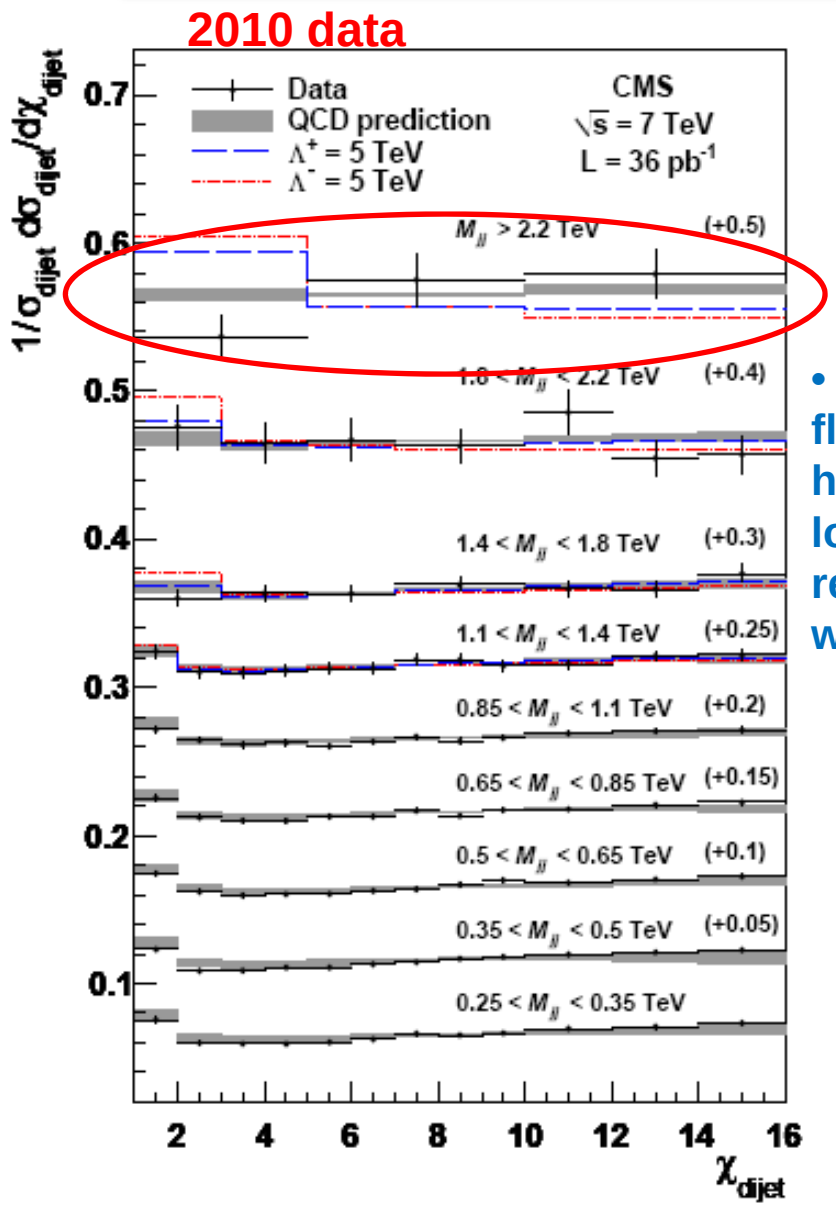


A. Hinzmann

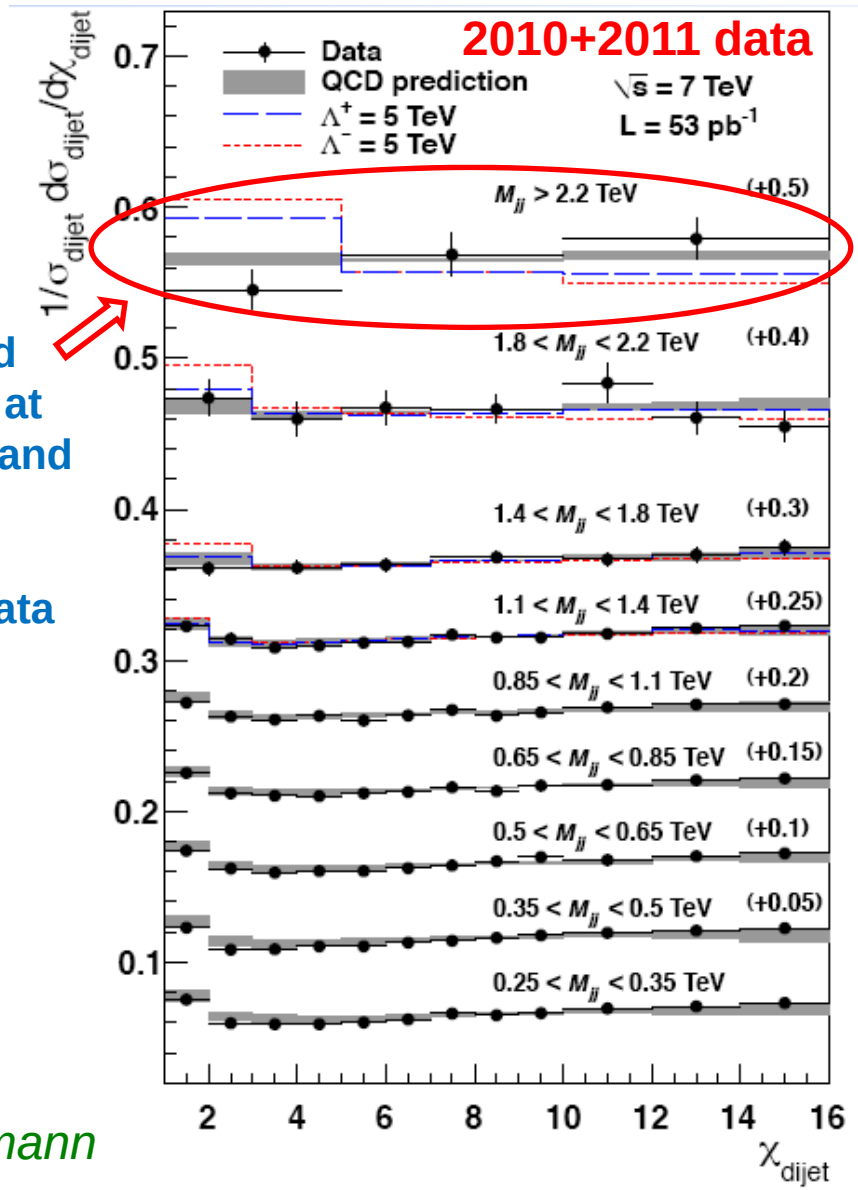
- Comparison of 2011 and 2010 data looks promising..

❑ Analysis seems insensitive to the expected effects in this data: (i) Wrong MC jet energy scale, (ii) Pileup, (iii) Lumi scans.

Combination of 2010+2011 data: χ



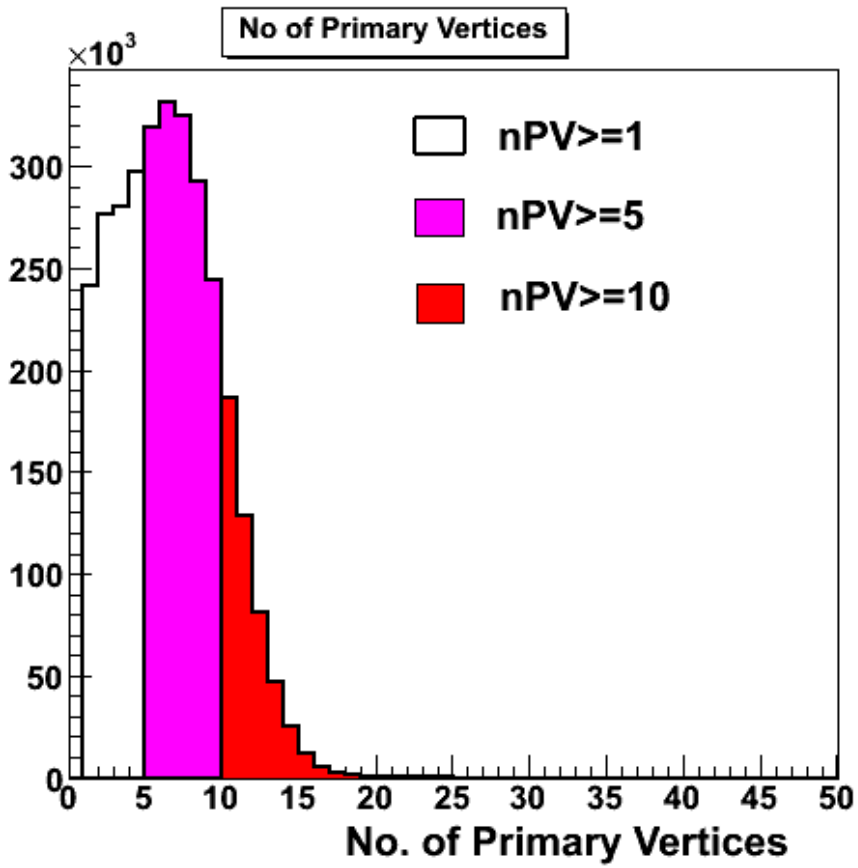
- Downward fluctuation at high mass and low chi is reduced with new data



A. Hinzmann

Study of Pile up

- MC Sample looked at:
- `/QCD_Pt_15to3000_TuneZ2_Flat_7TeV_pythia6/Spring11-E7TeV_FlatDist10_2011EarlyData_50ns_START311_V1G1-v1/GEN-SIM-RECODEBUG`



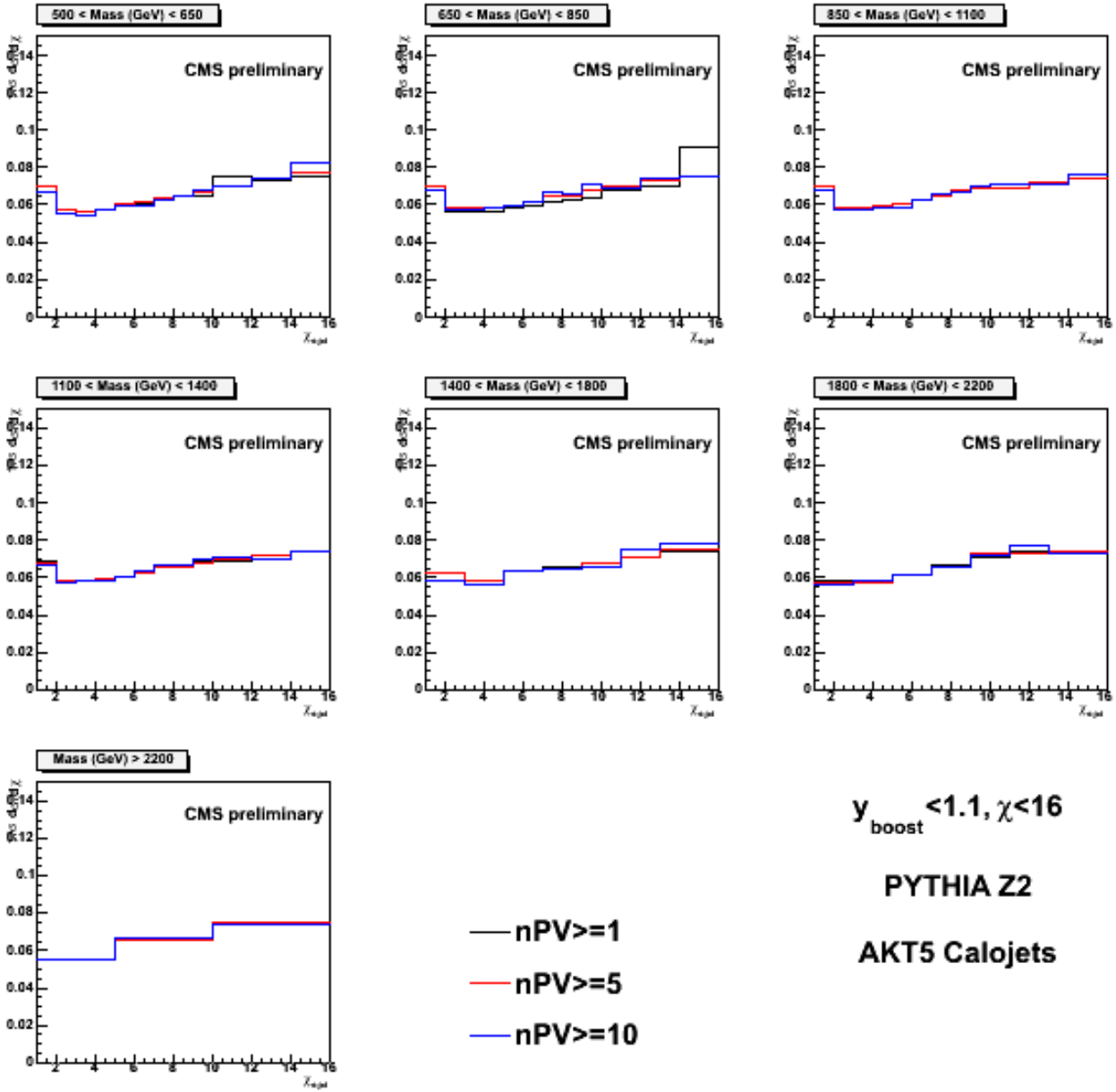
- Jet reconstruction:
  - Anti-kT R=0.5 CaloJets
  - Apply L2+L3+L2L3Residual JEC
- Event selection:
  - not fake, ndof>4, z<24cm, ρ<2cm
  - Leading 2 jets in event pass loose JetID
- Restrict measurement within |y|<2.5

$y_{boost} = 0.5*(y_1+y_2) < 1.11$

$y^* = 0.5*|y_1-y_2| < 1.39$ (or $\chi<16$)

S.B.

Effect of PileUp on χ



QCD-10-016

y_{boost}<1.1, χ<16

PYTHIA Z2

AKT5 Calojets

- No significant effect of Pile up

S.B.

Conclusions and Plans

- **Experience with the 2011 so far:**

  2011 data look to be in good agreement with MC and follow same characteristic properties as the 2010 data.

  New HLT Jet trigger efficiencies studied.

- **Comparison to the 2010 performance:**

  Comparison of basic distributions as well as final observables look reasonable. Most of the high pt analysis are not much influenced by the new features of the 2011 data.

- **Understanding the effect of huge pile-up:**

  Low p_T: the UE activity in 2011 data is higher by 1-2%

  Photons: ECAL isolation is the most sensitive, track isolation is least sensitive

  High p_T: No significant effect due to high p_T regime

✧ More studies needed from the analysis groups who finished with the 2010 data.

❖ Thanks to all the contributors for making the plots in such quick time.

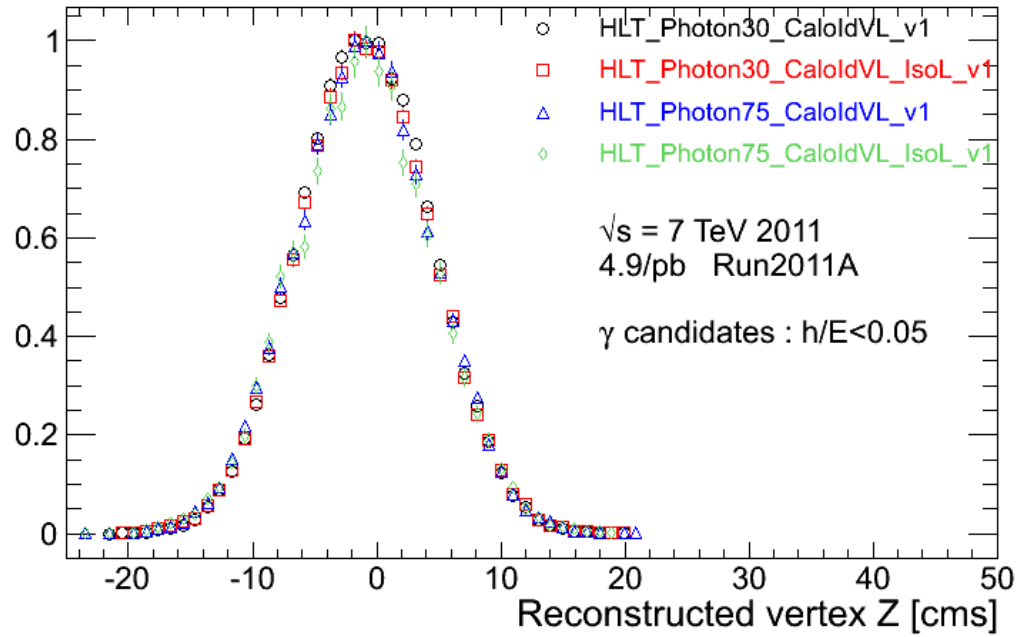
Back up slides

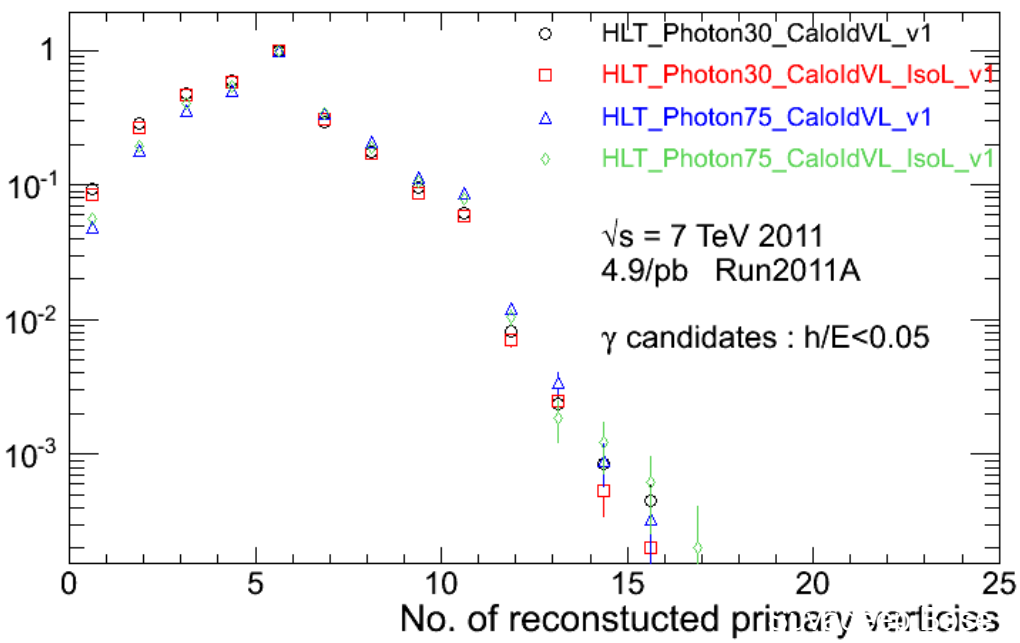
Data-sets etc for pileup studies

- CMSSW version: CMSSW_4_1_3
- 2011A data:
  - /Photon/Run2011A-PromptReco-v1/
- Json: [json_DCSONLY.txt_160404-161312]

Reconstructed Vertex

- Reconstructed vertex distribution looks similar for different triggers

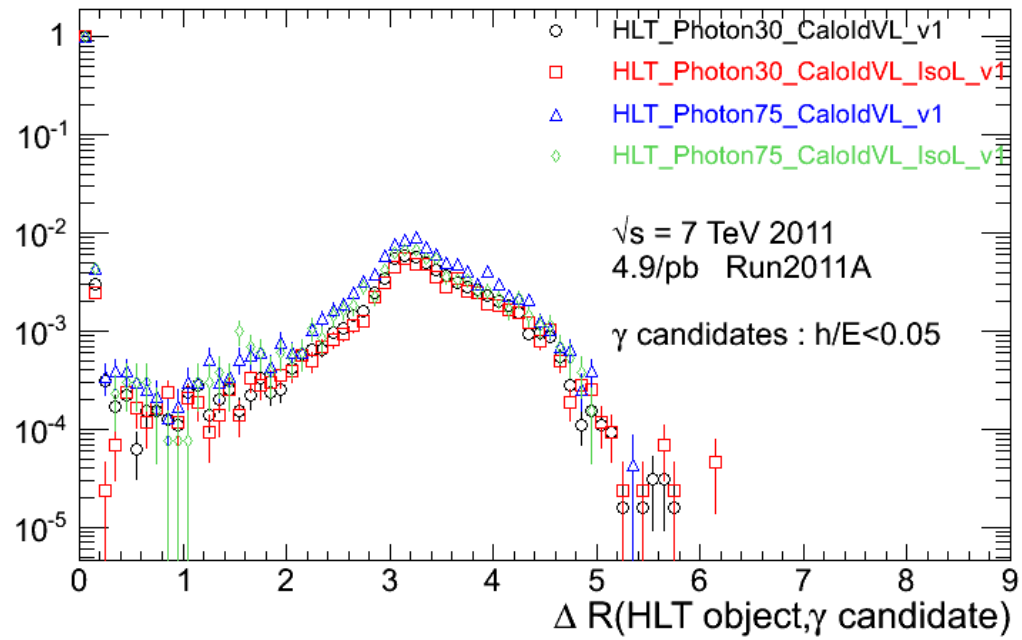


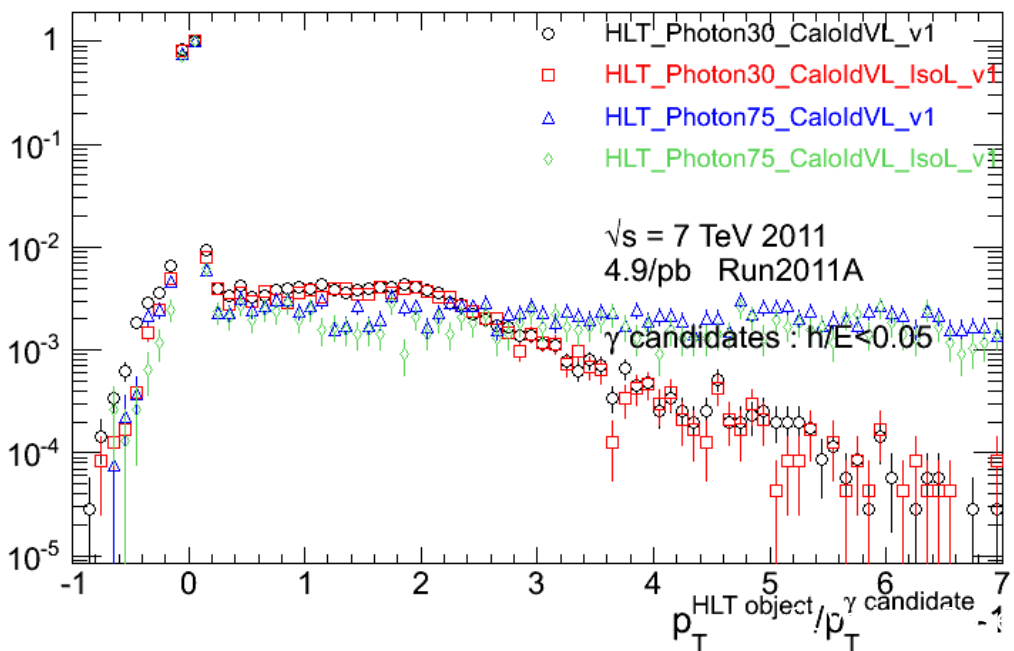


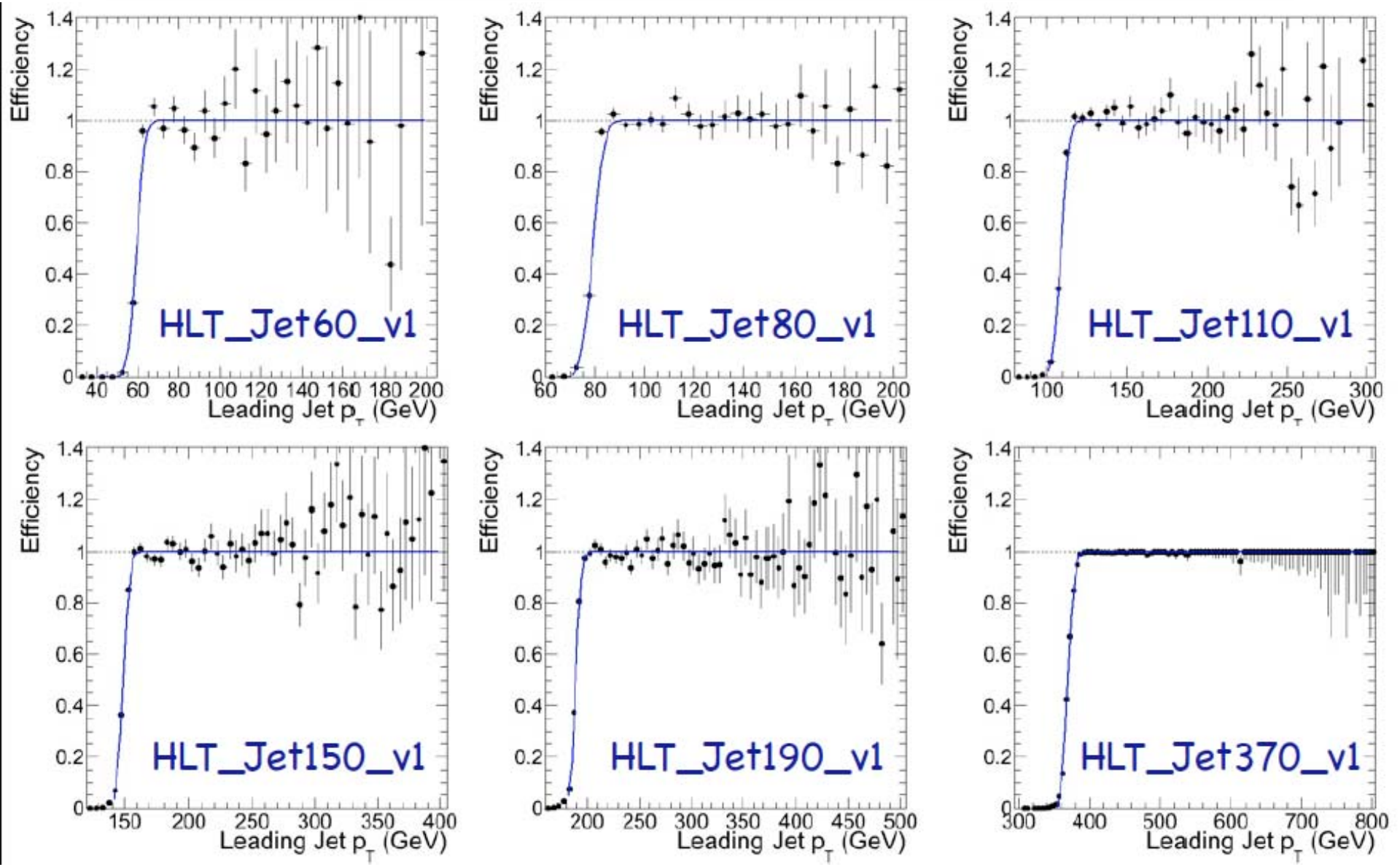
- Average number of reconstructed vercies
  - 2011 – ~5.4
  - 2011 – ~2.92

HLT Object and Reco Object

- Offline recommended delta R cut between the HLT object anc offline reco-object is 0.3. Works well.





- Long tail in the delta pt distribution is due to the very loose H/E cut in the endcap

Trigger inefficiency vs. CaloJet p_T