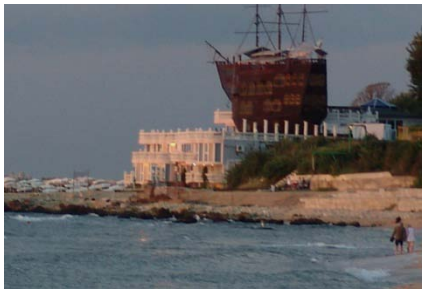


CMS Standard Model Physics Results

Frank-Peter Schilling (KIT, Karlsruhe)

14th Annual RDMS CMS Collaboration Conference

Varna (Bulgaria), 07/09/2010

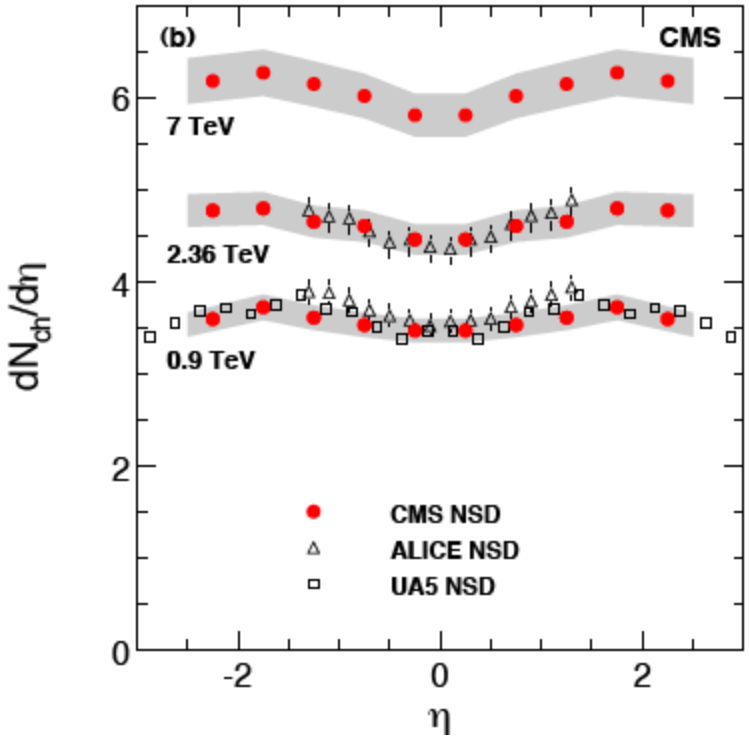
Outline

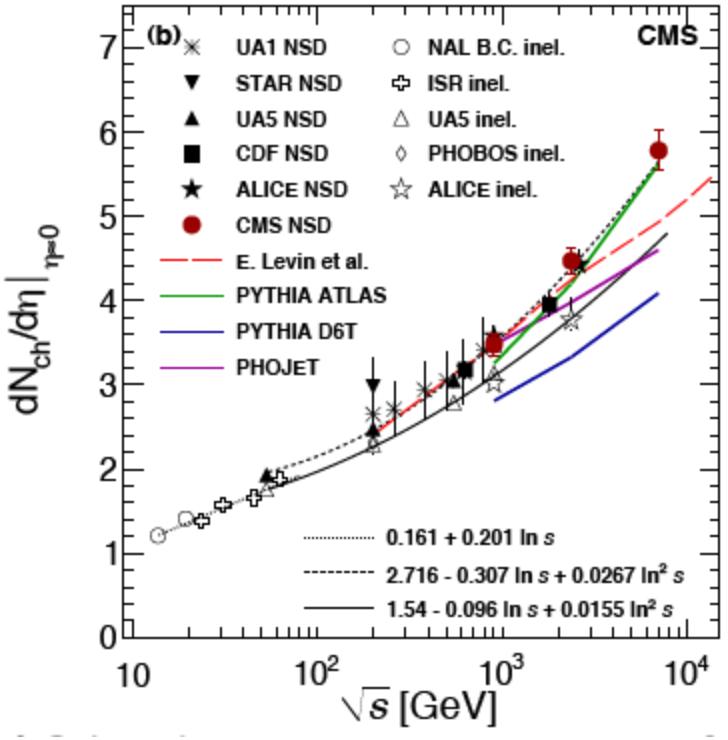
CMS presented many SM results with 7TeV data at ICHEP
Few updates with more recent data also covered here

- Soft QCD and Underlying Event
- Jet Physics
- J/Psi and Y cross sections
- b cross section
- W and Z production
- Top Quarks

Charged Hadron Spectra (QCD-09-010 and QCD-10-006)

- First CMS publications !
- Charge particle density and <Pt> for sqrt(s)=0.9, 2.36 and 7 TeV
  - Three methods: Pixel hit counting, PX tracklets, full tracking, Pt>=100 MeV

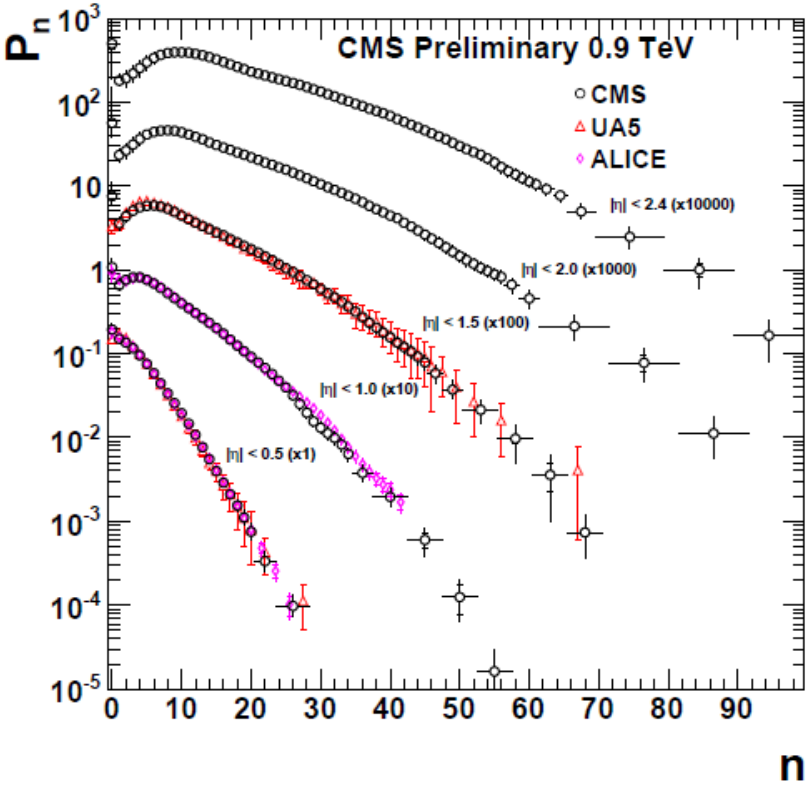


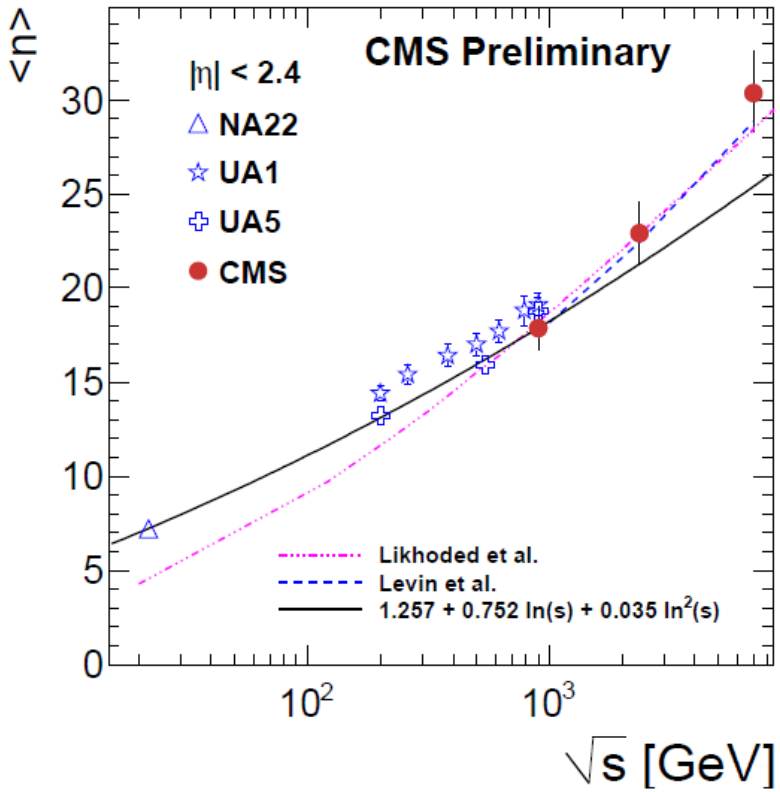


$dN/dEta|_{eta=0}$ = 5.78+/-0.01(stat)+/-0.23(syst.)
at 7TeV for NSD events (higher than most predictions)

Charged particle Multiplicity (QCD-10-004)

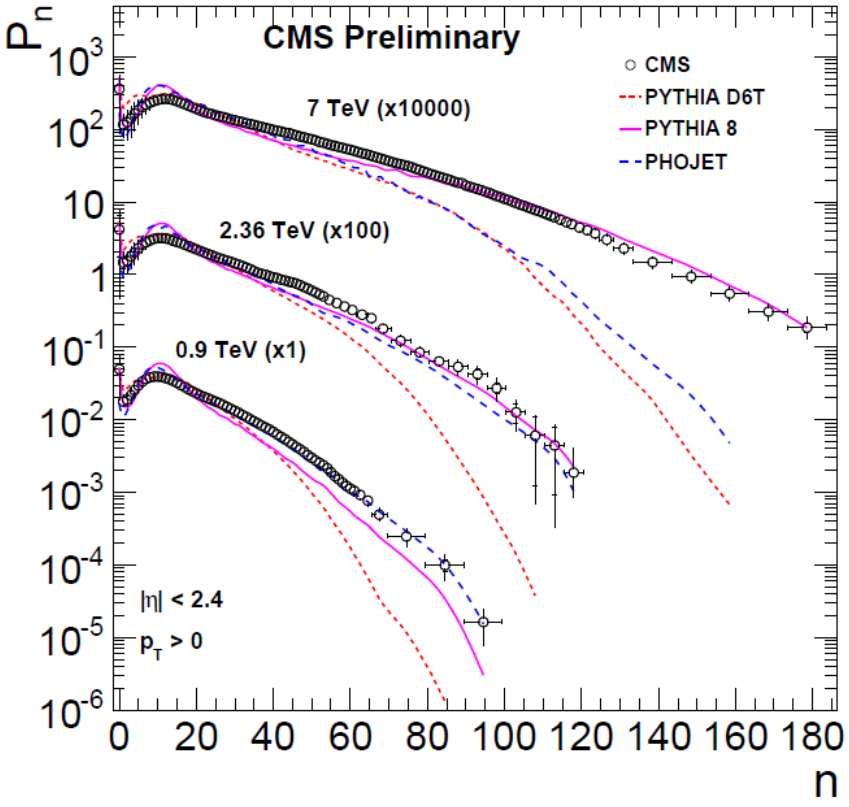
- Measurement at 0.9, 2.36 and 7 TeV for Pt>100MeV (extrapolated to zero)
  - 900GeV data consistent with previous experiments
  - 7TeV data higher than extrapolations from lower energies



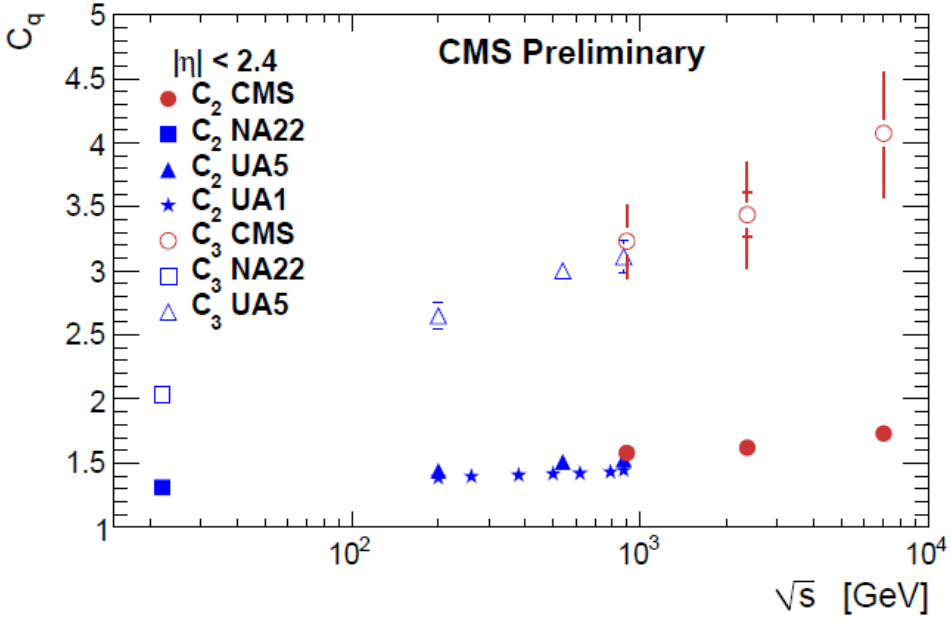


Charged particle Multiplicity (QCD-10-004)

- Comparison with models
  - All (incl. those descrining lower energy data) have problems to reproduce energy dependence

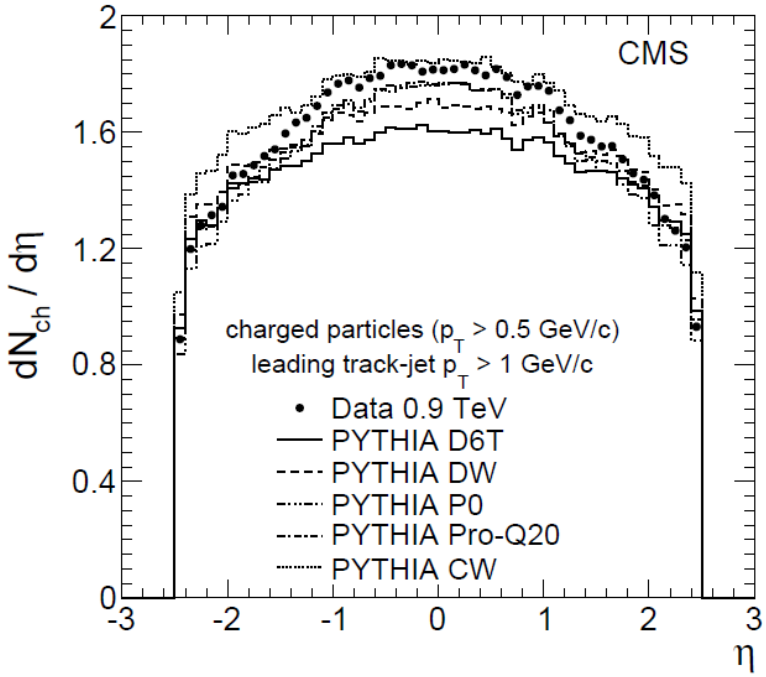


- Violation of KNO scaling confirmed
  - KNO: normalized multiplicity moments Cq=<n^q>/<n>^q independent of s

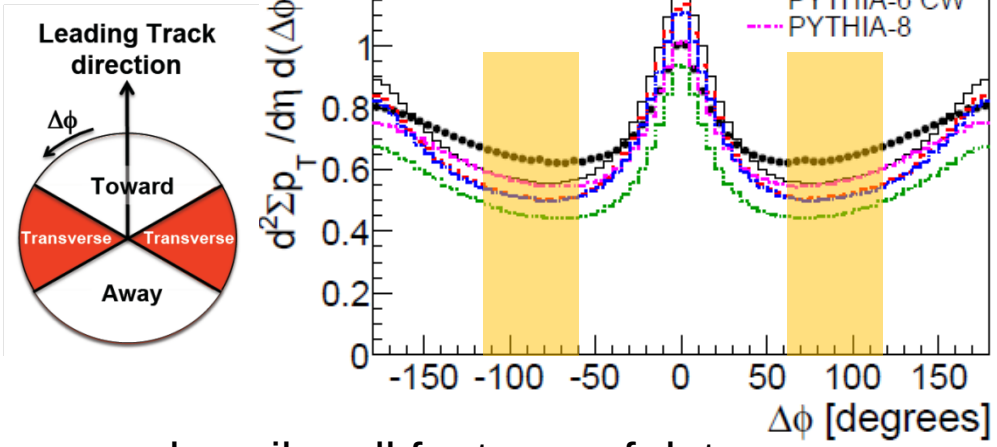


Underlying Event at 0.9 and 7 TeV (QCD-10-001 and QCD-10-010)

- Average charged particle multiplicity N(ch) vs eta
  - 0.9 TeV, events with leading track-jet Pt>1GeV



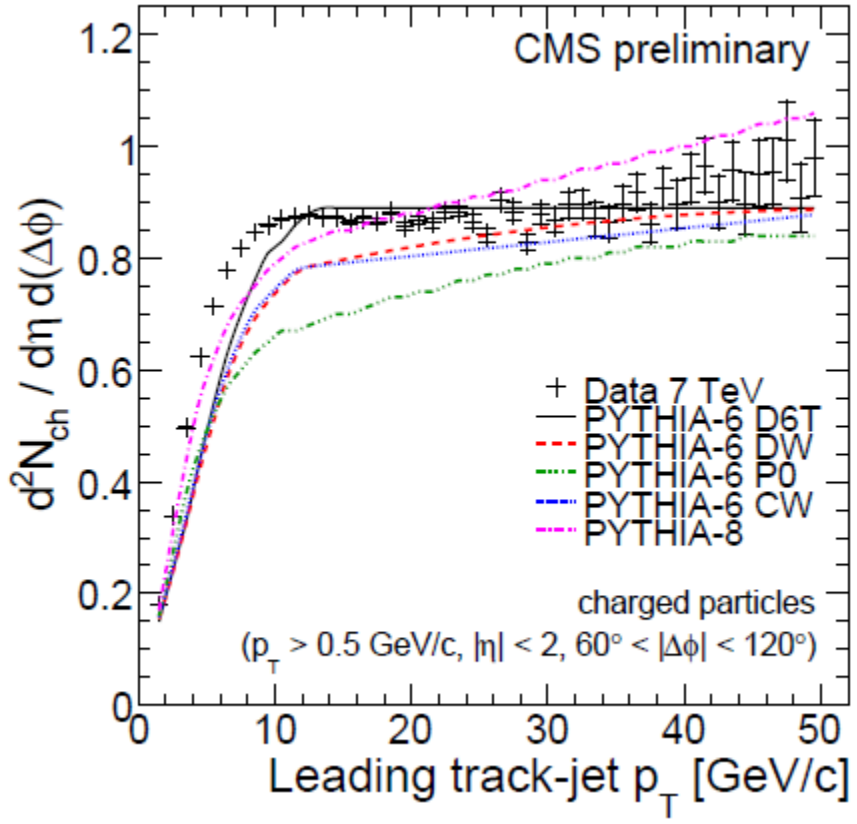
- Average Sum[Pt(ch)] per unit area
  - 7 TeV, events with leading track Pt>2GeV

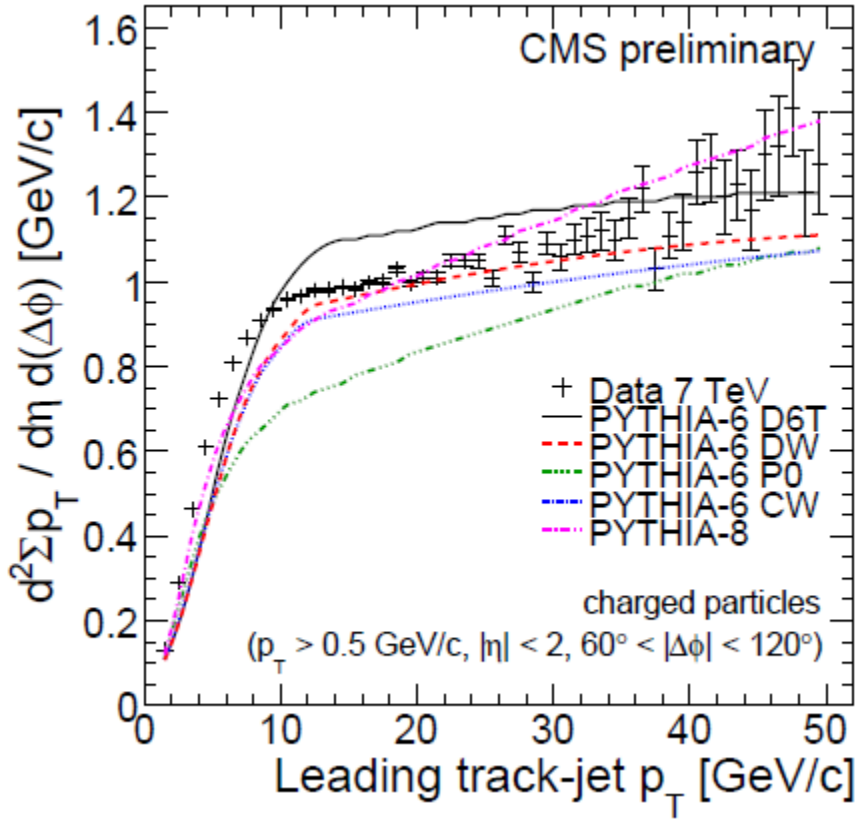


None of the tunes can describe all features of data
To study UE, look in particular at transverse region …

Underlying Event at 7 TeV (QCD-10-010)

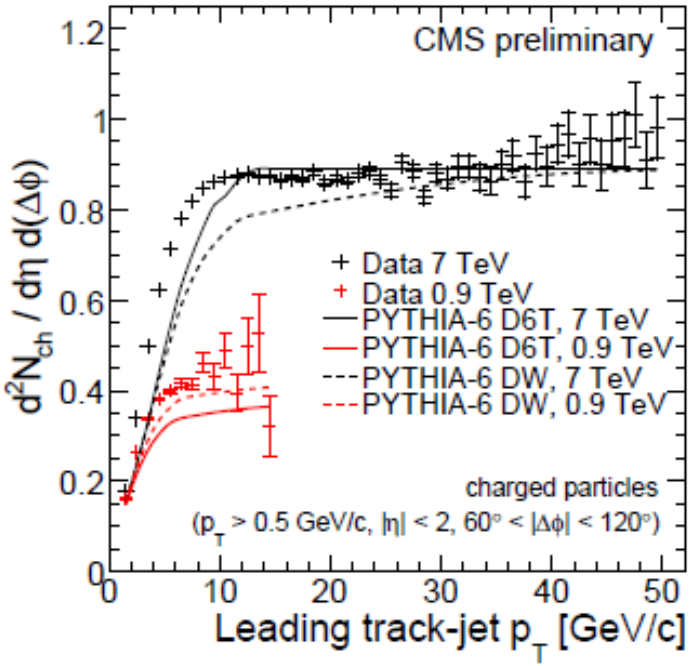
- Strong increase in transverse region with Pt(jet), followed by shallow rise
  - Average N(ch) vs Pt(leading track-jet)
  - Average Sum(Pt,ch) vs Pt(leading track-jet)





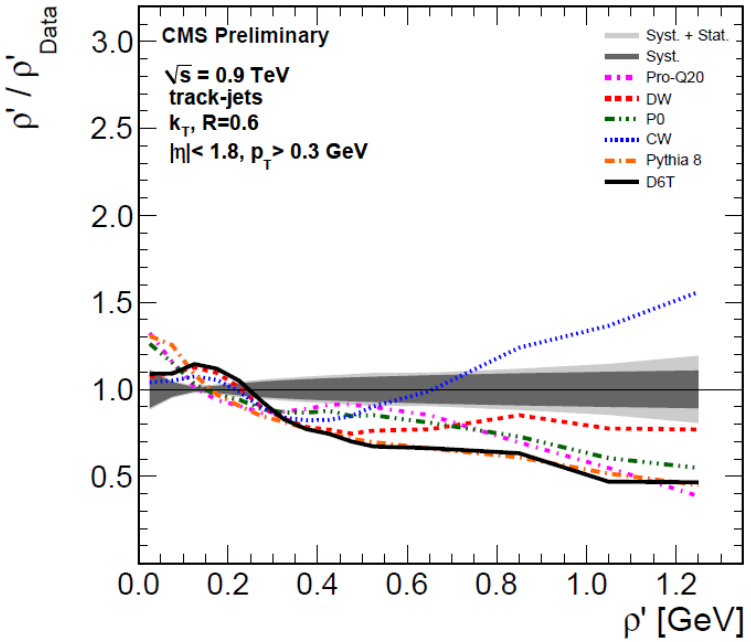
Underlying Event (QCD-10-001 and QCD-10-005)

- Energy dependence not well described by models which are consistent with Tevatron data
  - Esp fast rise at low jet Pt



- QCD-10-005: New approach (Cacciari, Salam, Sapeta)
  - Median of jet Pt / jet area

$$\rho' = \underset{j \in \text{physical jets}}{\text{median}} \left[\left\{ \frac{p_{Tj}}{A_j} \right\} \right] \cdot C$$

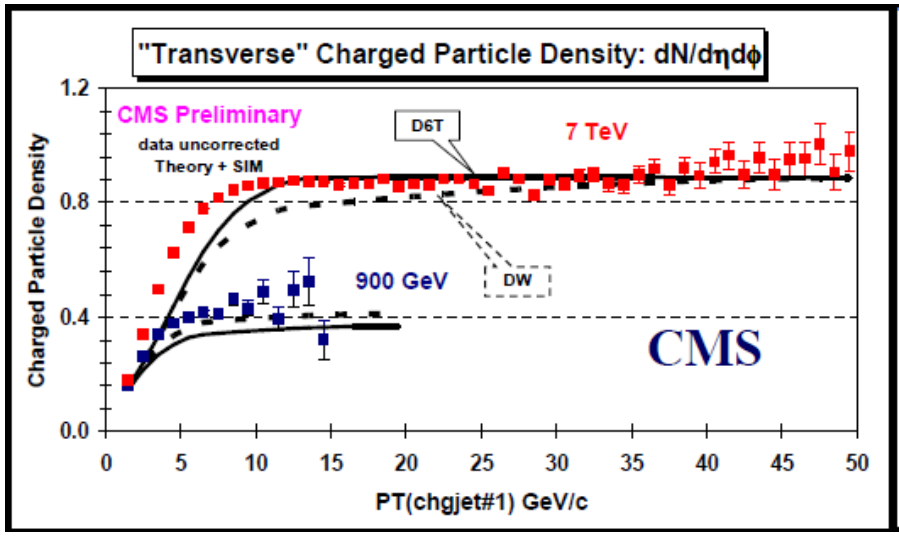


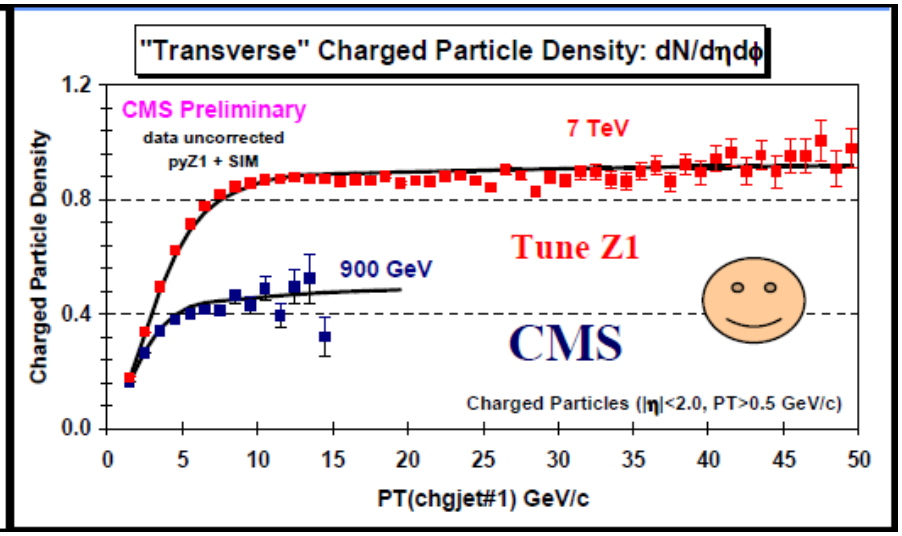
Need for new Tune, better consistent with our data

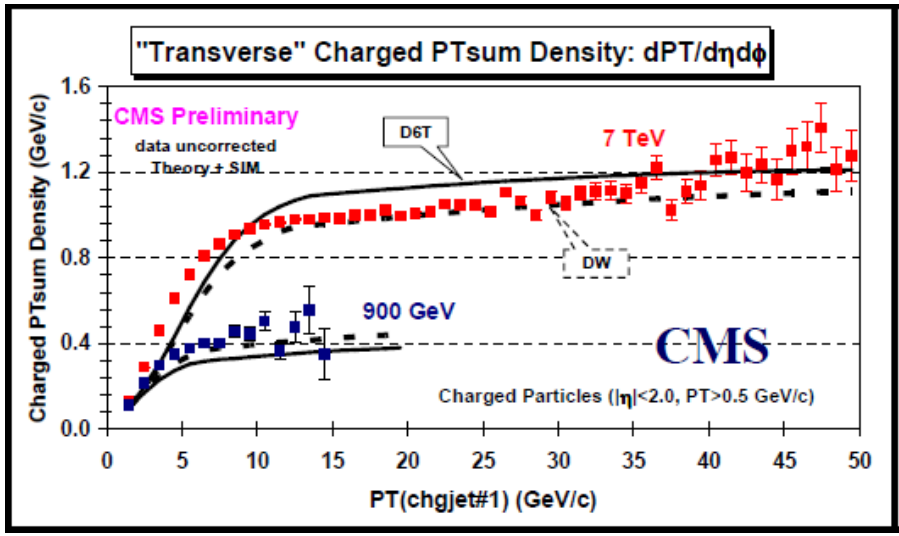
New Phythia 6 Tune Z1 (Rick Field)

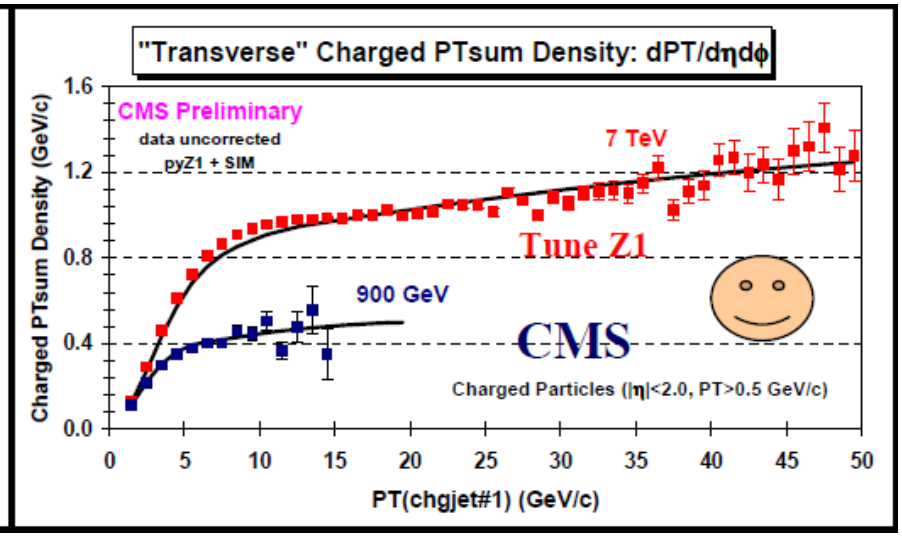
- Native Pythia 6.4 tune
  - Pt ordered showers, new MPI model
  - previous tunes (e.g. D6T, DW) were obtained using Q2 ordered showers
- Similar to ATLAS tune AMBT1, but
  - Using CTEQ5L instead of LO*
  - Varied PARP(82) and PARP(90) [MPI parameters] to best fit CMS UE data at 0.9 and 7 TeV
- However, slightly overestimates CDF 1.96 TeV data

New Phythia 6 Tune Z1



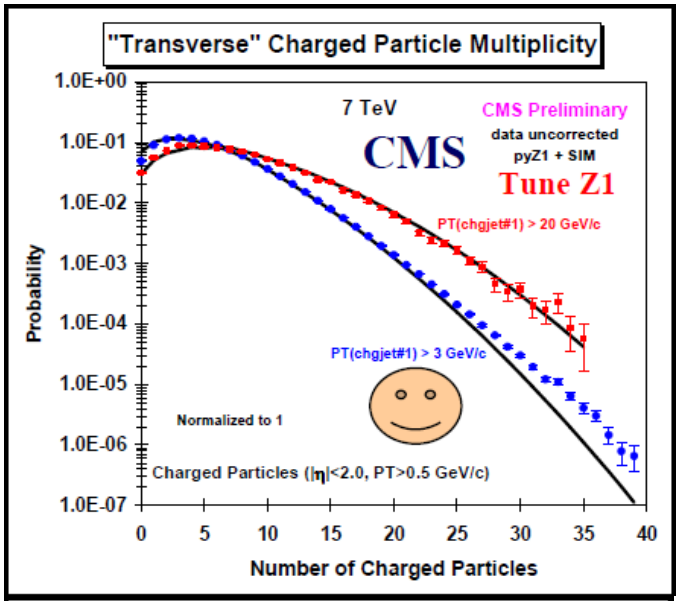


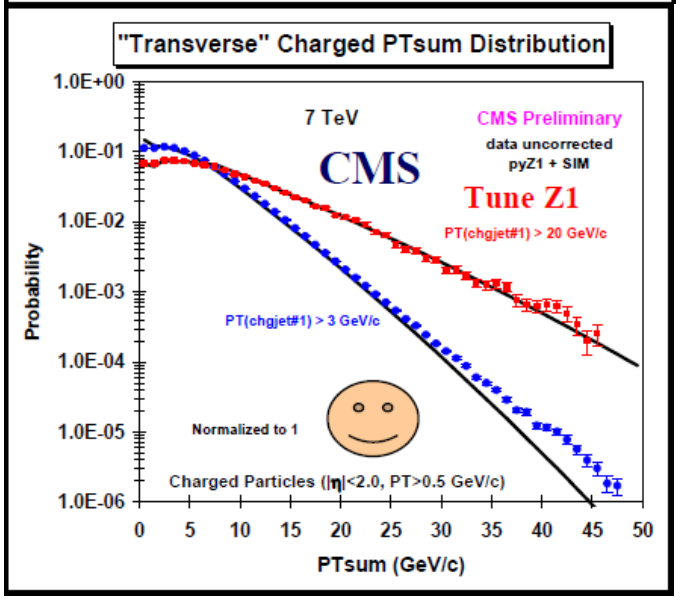




New Phythia 6 Tune Z1

- Interesting Excess of events with large transverse multiplicity / Sum(Pt) at low scales





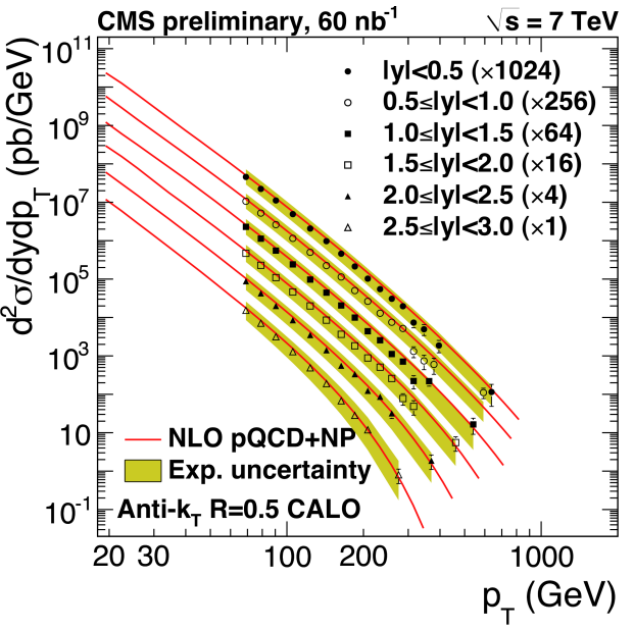
Next steps:

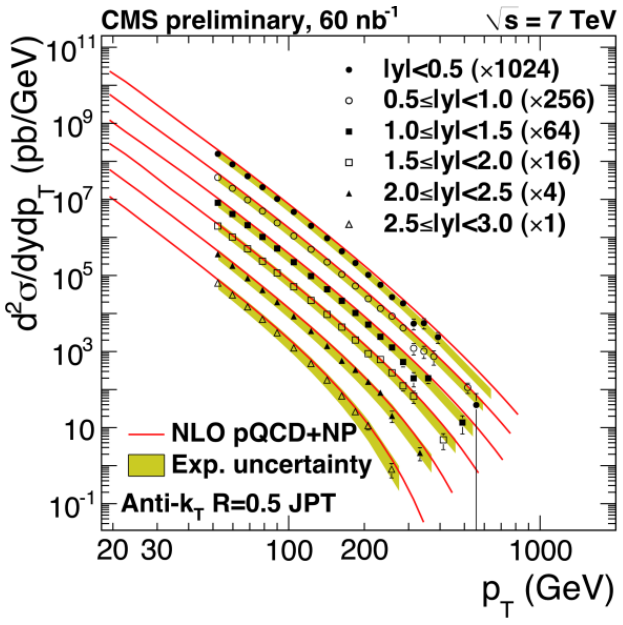
•Tune Z2 (use CTEQ6) – used as basis for next big MC production

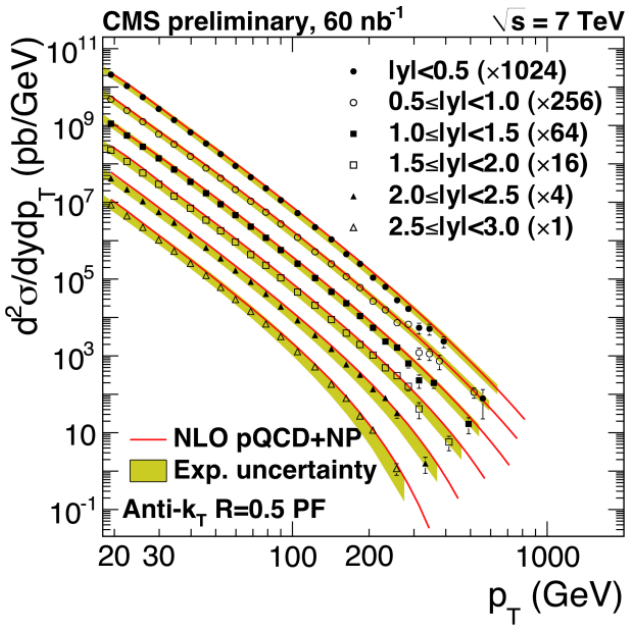
•Corrected UE data for use outside CMS / in global fits

Inclusive Jet Cross section (QCD-10-011)

- L=60nb-1, measure cross section in various rapidity bins for Pt=18 … O(500) GeV, using three jet types
  - Calorimeter only, Jet-plus-tracks, particle flow
- Good agreement between methods, and with NLO QCD
  - NLOJET++

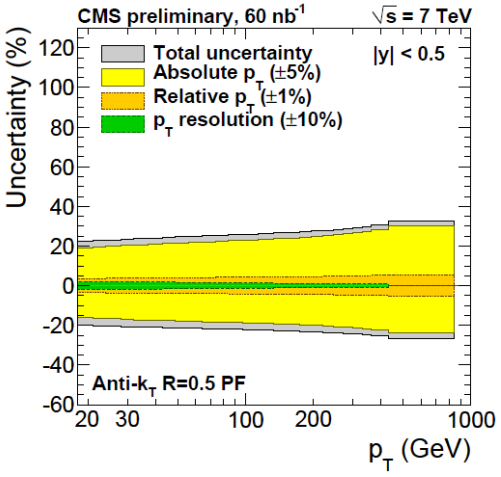


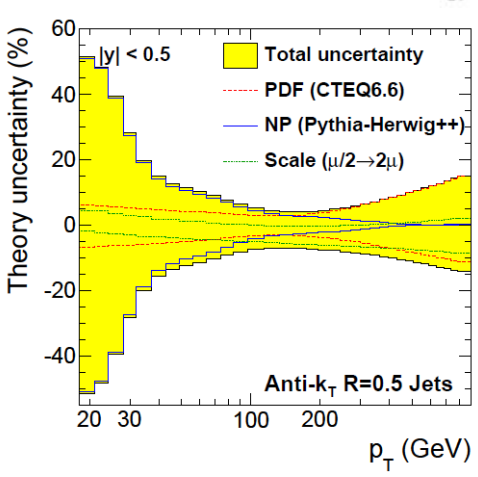


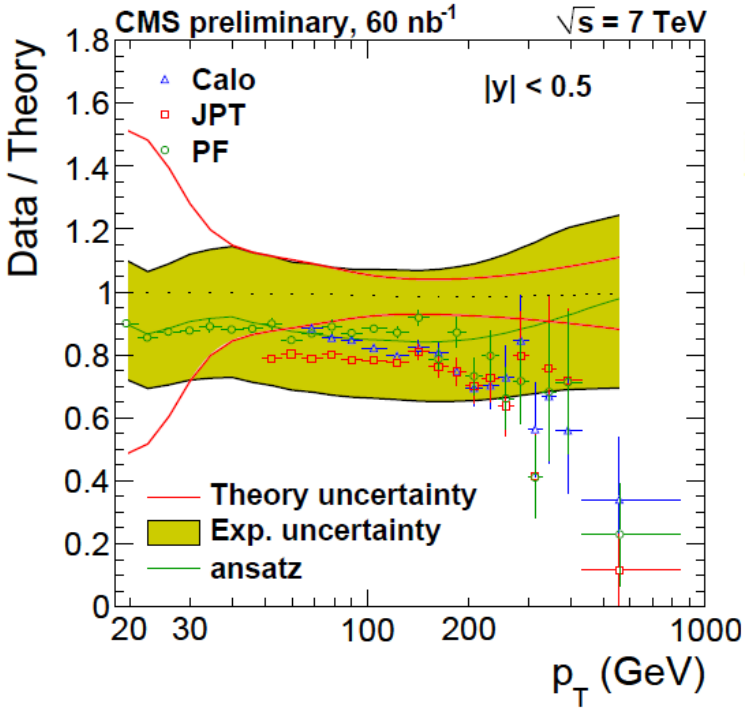


Inclusive Jet Cross section (QCD-10-011)

- Experimental uncertainties:
  - JES (10% for calo, 5% for JPT/PF), plus 2%*|eta| (size of residual correction)
  - Luminosity 11%
- Theoretical uncertainties:
  - Scale uncertainty mur=muf=Pt/2…2Pt
  - Non-perturbative effects (Pythia vs Herwig)
  - PDF (CTEQ6.6 error sets)



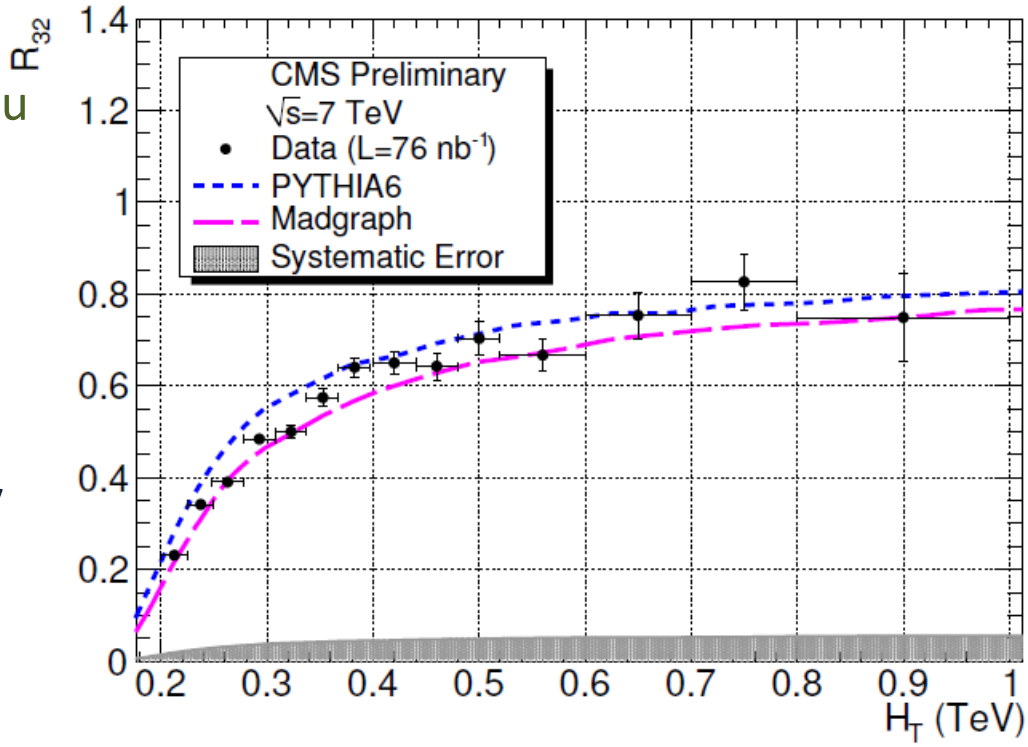




Agreement Data-Thory within 20%

3/2 jet ratio (QCD-10-012)

- R3/2 measured vs HT for HT up to 1TeV
  - Cancellation of systematics
  - Sensitivity to alpha-s in plateau regime
- Consistent with PYTHIA and MADGRAPH within present uncertainties (dominated by stat.)
- Future: use to extract alpha-s

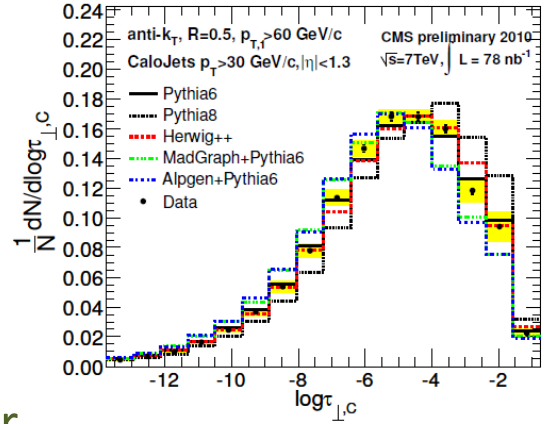


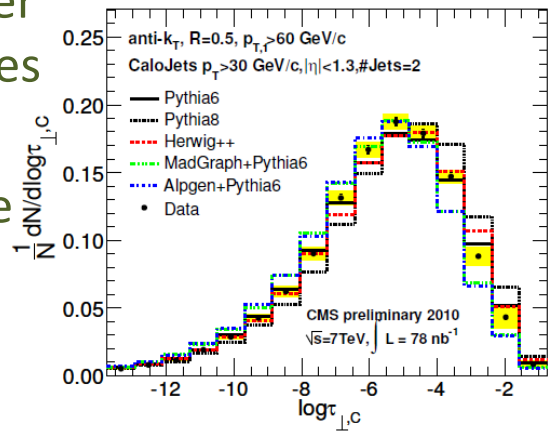
Event shapes (QCD-10-013)

- 7TeV data, 80nb-1
- Event shapes not affected by JES uncertainty (only indirectly due to jet counting)
- Model comparisons
  - Best agreement with PYTHIA6 and HERWIG++
  - ALPGEN/MADGRAPH more peaked at dphi=180, smaller R3/2 -> shift of event shapes to smaller values
  - Difference P6-P8 cannot be accounted for by shower model

Central transverse thrust

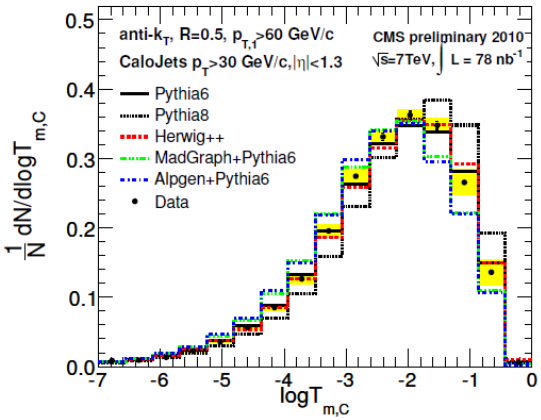
$$T_{\perp,\mathcal{C}} \equiv \max_{\vec{n}_T} \frac{\sum_{i\in\mathcal{C}} |\vec{p}_{\perp,i} \cdot \vec{n}_T|}{\sum_{i\in\mathcal{C}} p_{\perp,i}}$$

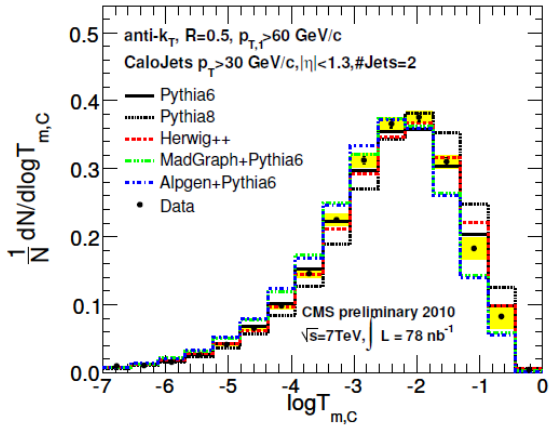




Central thrust minor

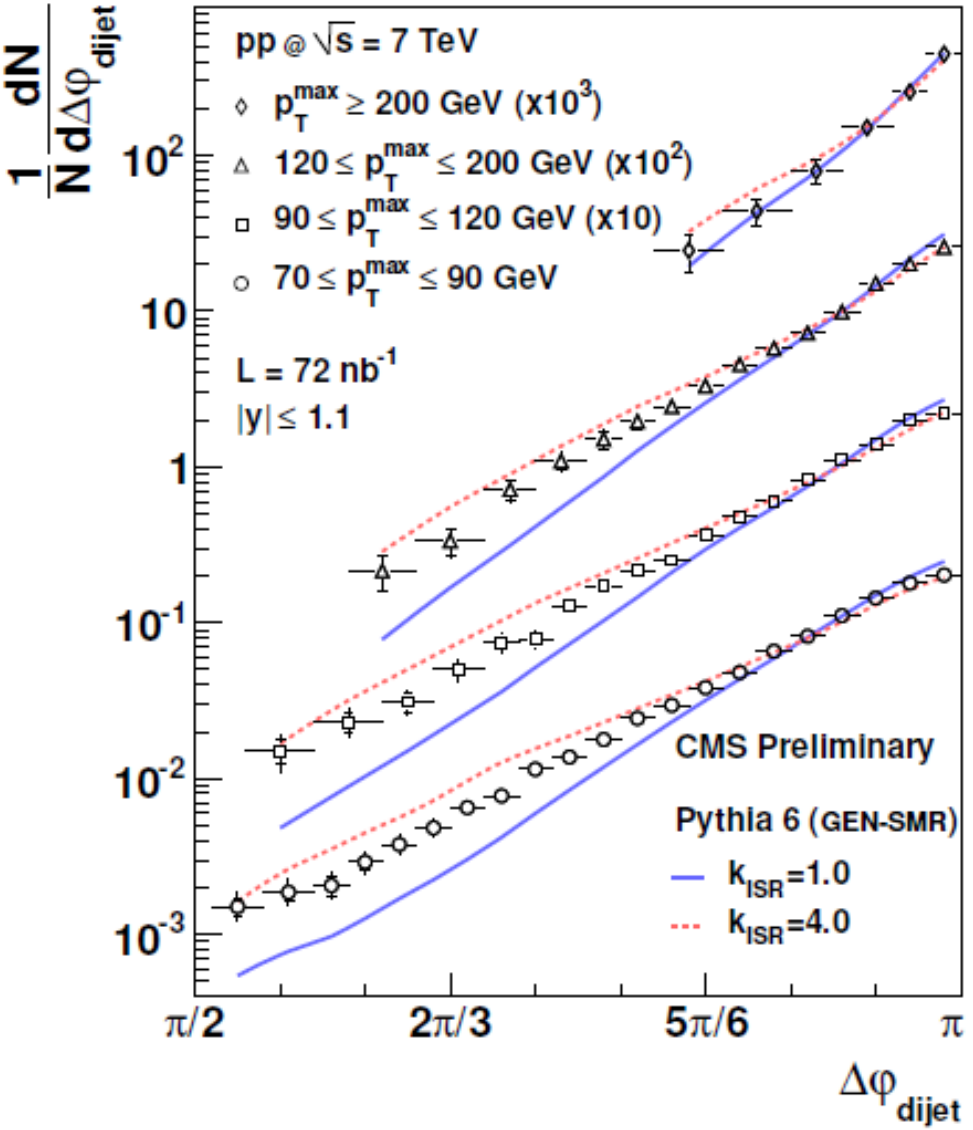
$$T_{m,\mathcal{C}} \equiv \frac{\sum_{i\in\mathcal{C}} |\vec{p}_{\perp,i} \times \vec{n}_{\mathrm{T},\mathcal{C}}|}{\sum_{i\in\mathcal{C}} p_{\perp,i}}$$





Dijet Azimuthal Decorrelations (QCD-10-015)

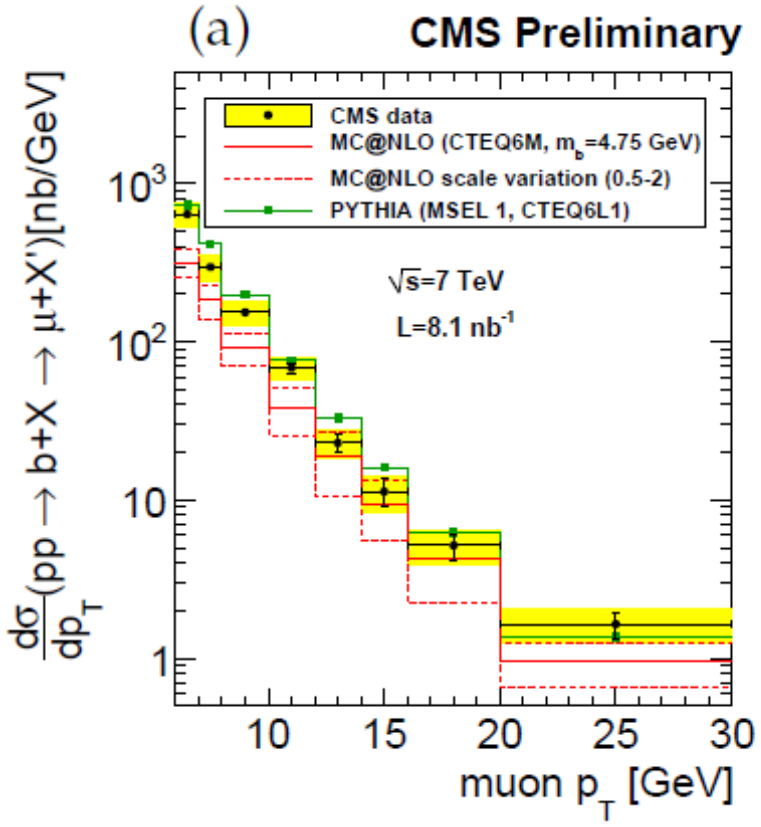
- Dijets, Pt>30 GeV, |y|<1.1
- Measured in various Pt(max) intervals
  - PYTHIA/HERWIG++ in agreement with data
  - Madgraph has ~20% less decorrelation
- Sensitive to higher order effects / ISR
  - Useful for MC tuning

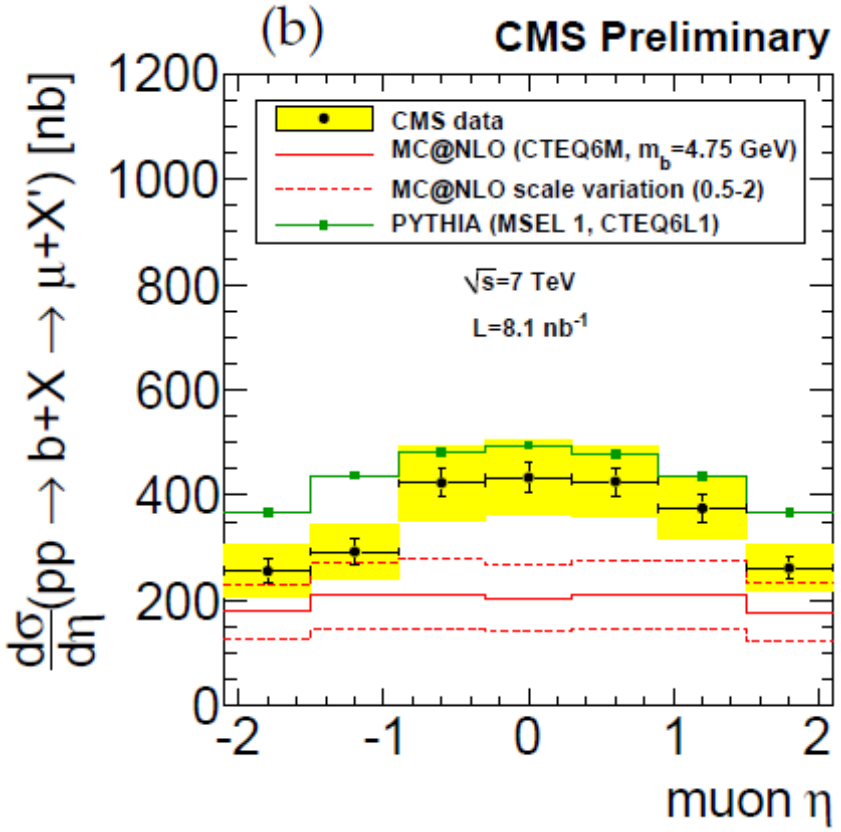


b-cross section with muons (BPH-10-007)

$$\sigma(pp \to b + X \to \mu + X', p_{\perp}^{\mu} > 6\,\mathrm{GeV}, |\eta^{\mu}| < 2.1)$$

Cross section from template fits to Pt-rel(mu) distributions

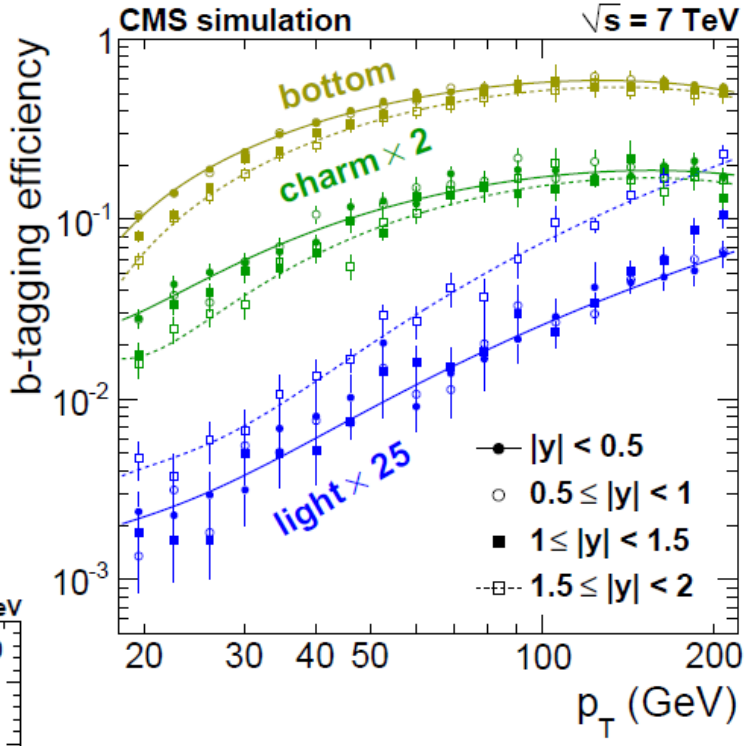


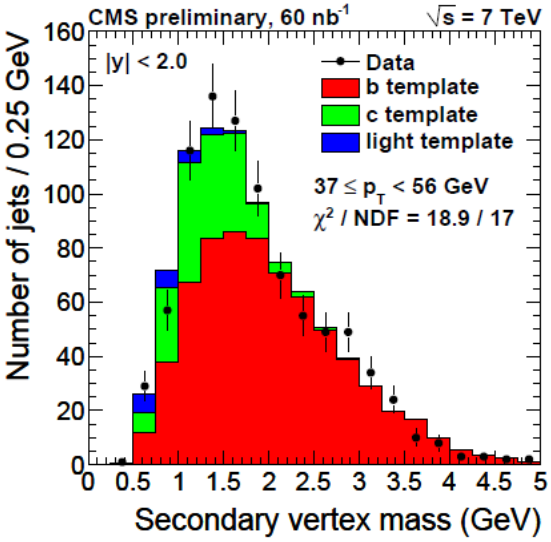


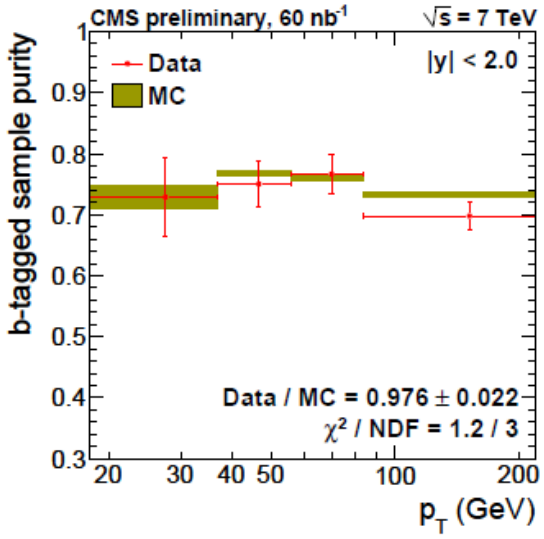
Data above MC@NLO calculation
Also different rapidity shape ovserved

Inclusive b cross section with b-tagging (BPH-10-009)

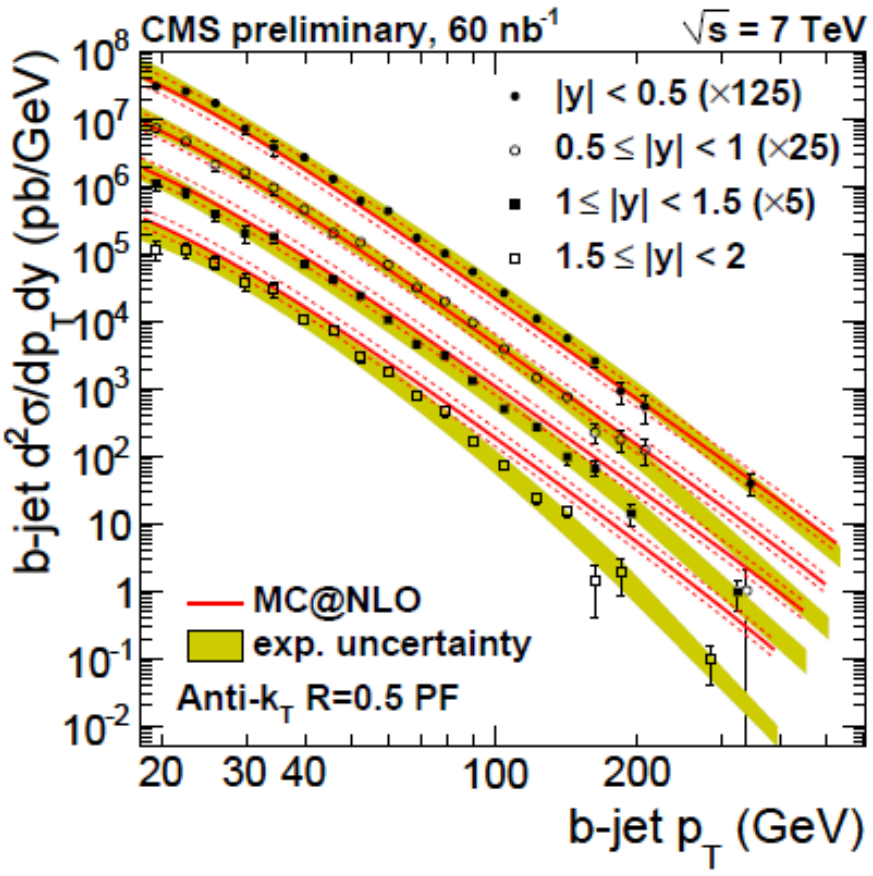
- Use secondary vertex b-tagger (>= 3 tracks)
- Sample purity from MC b-tagging/mistag rates
  - Cross checked using SV mass template fits

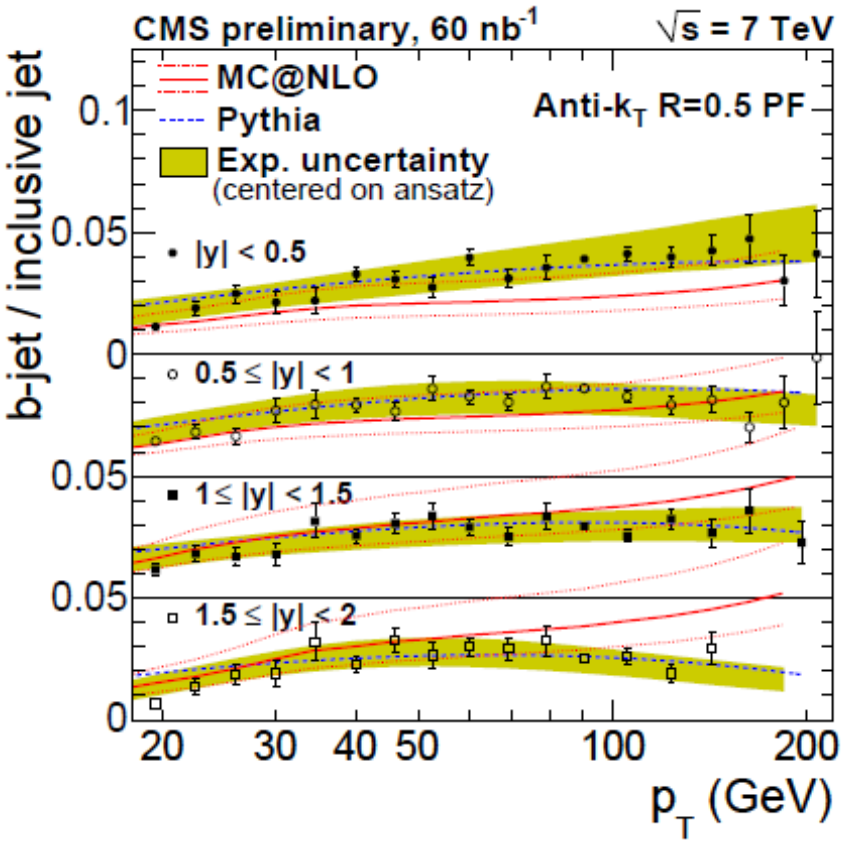






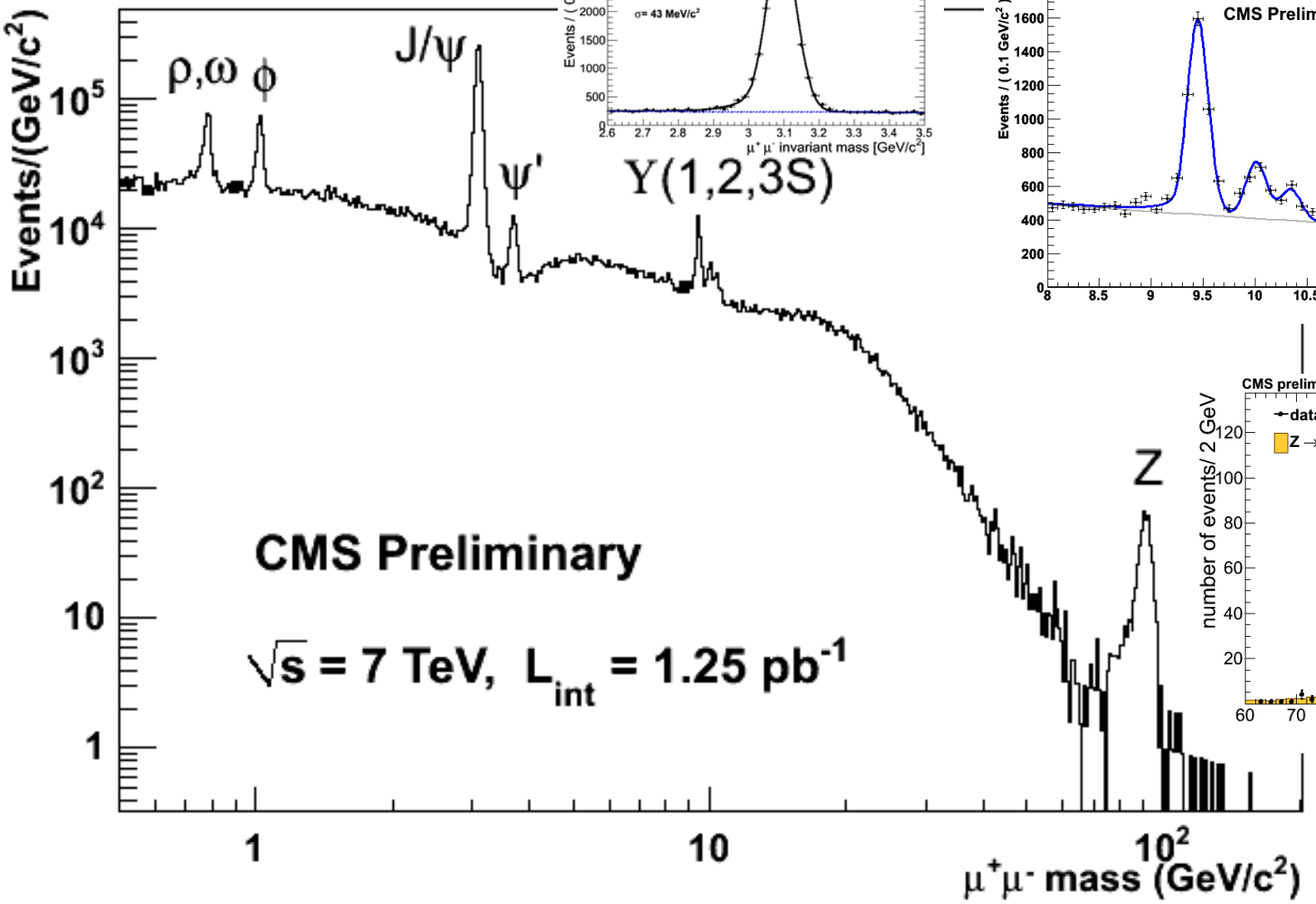
BPH-10-009 (cont.)

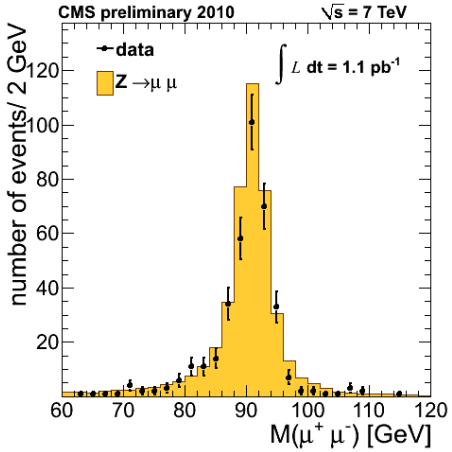




Good agreement with PYTHIA for Pt>30 GeV
MC@NLO describes overall fraction of b-jets, but with significant differences in shape

Di-Muon Mass Spectrum





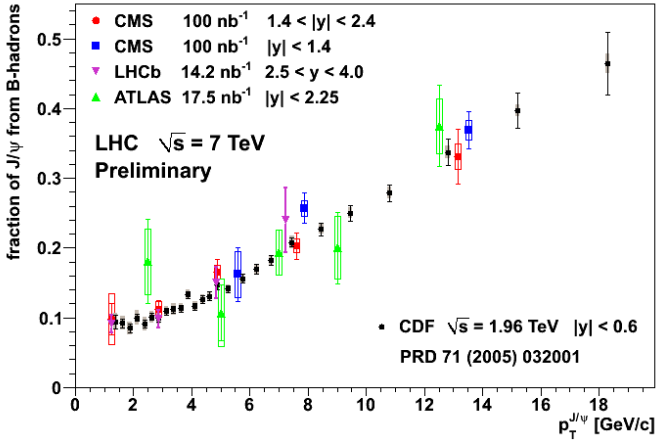
J/Psi cross section (BPH-10-002)

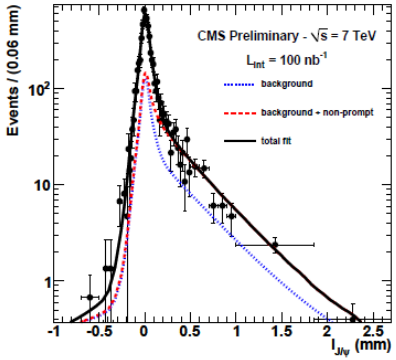
- Inclusive measurement:

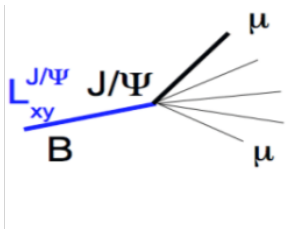
$$BR(J/\psi \to \mu^+\mu^-) \cdot \sigma(pp \to J/\psi + X) =$$
$$(289.1 \pm 16.7(\text{stat}) \pm 60.1(\text{syst}))\ \text{nb}$$

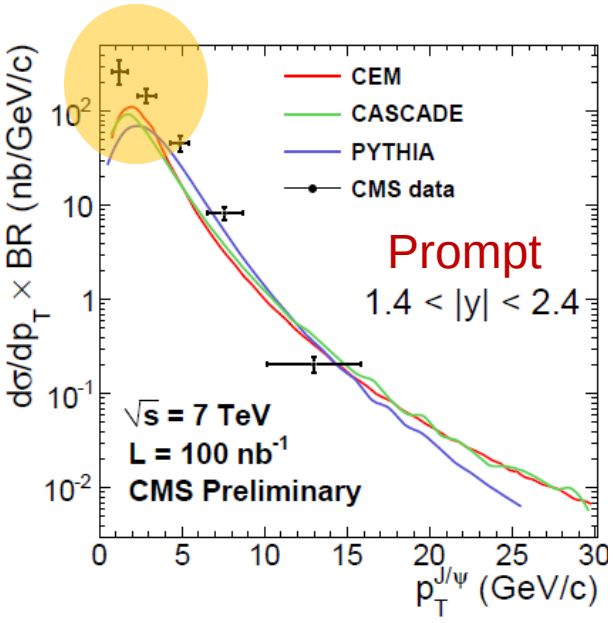
- Prompt and non-prompt contributons from fit to transverse decay length

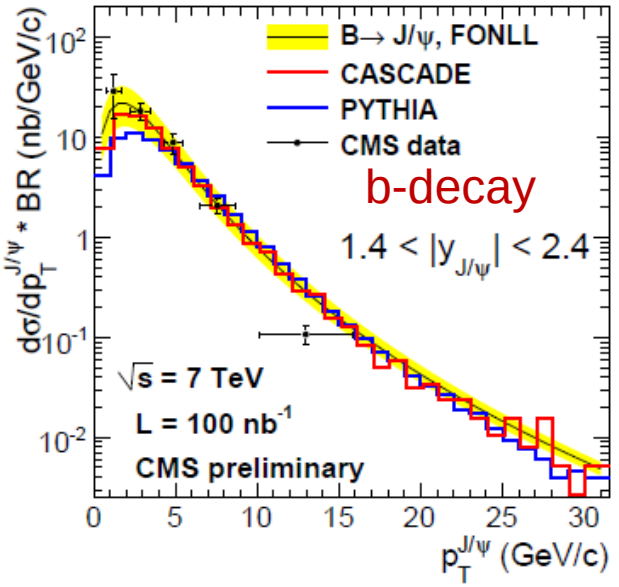
Fraction of J/Psi's from B-hadrons agrees well with other Expt's







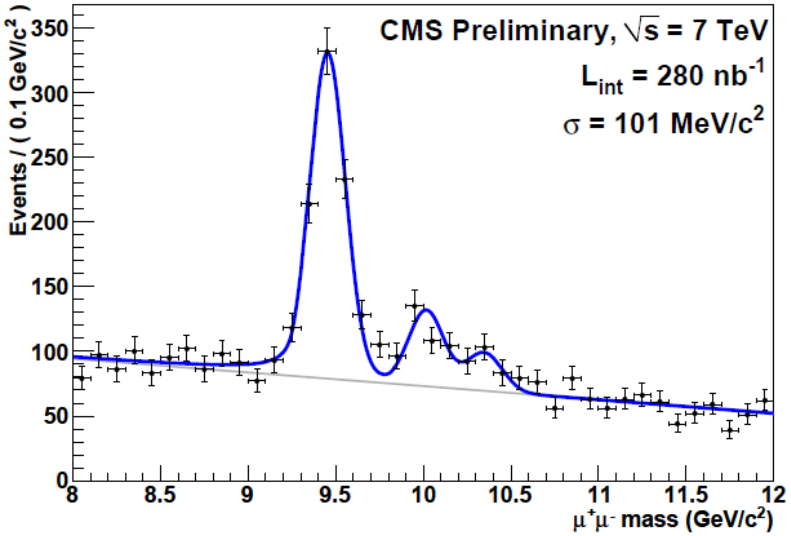




Y(1S),Y(2S),Y(3S) (BPH-10-003)

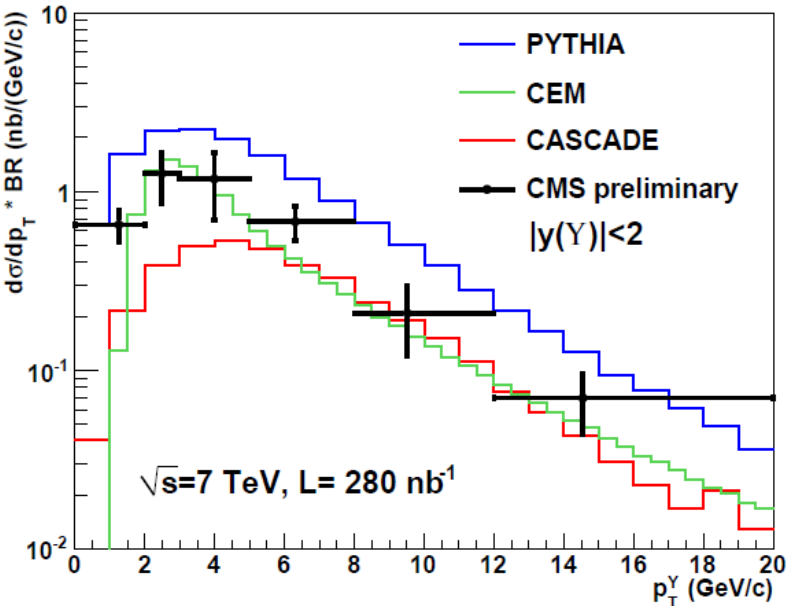
- Inclusive Y(1S) cross section at 7 TeV

$$\sigma(pp \to \Upsilon(1S)X) \cdot \mathcal{B}(\Upsilon(1S) \to \mu^+\mu^-) = (8.3 \pm (0.5)_{\text{stat.}} \pm (0.9)_{\text{lumi.}} \pm (1.0)_{\text{syst.}})\ \text{nb}$$



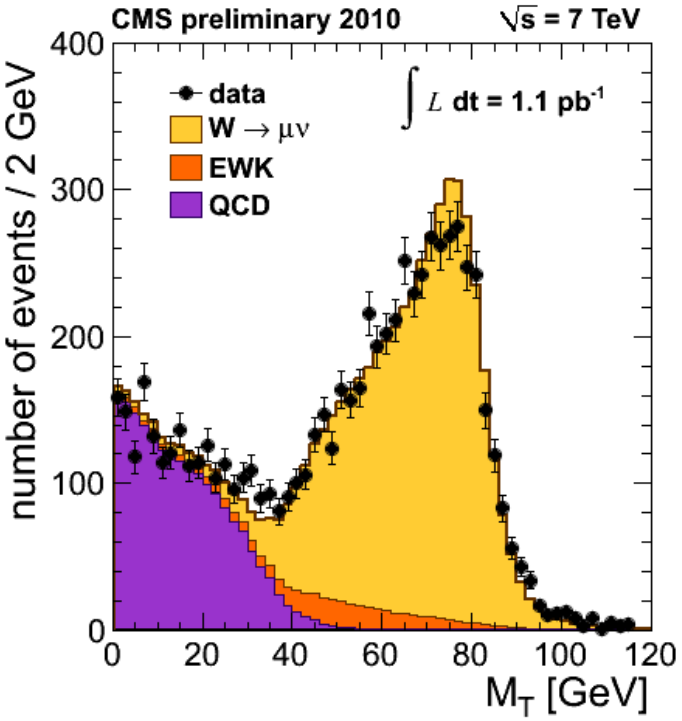
- Ratio R=[Y(2S)+Y(3S)]/Y(1S)

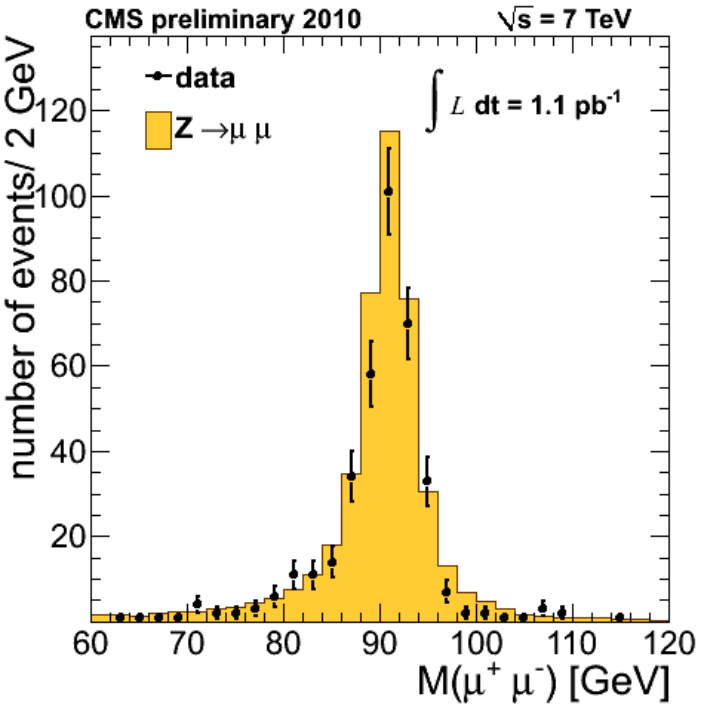
$$R = 0.44 \pm 0.06 \pm 0.07$$



W/Z to muons (EWK-10-002)

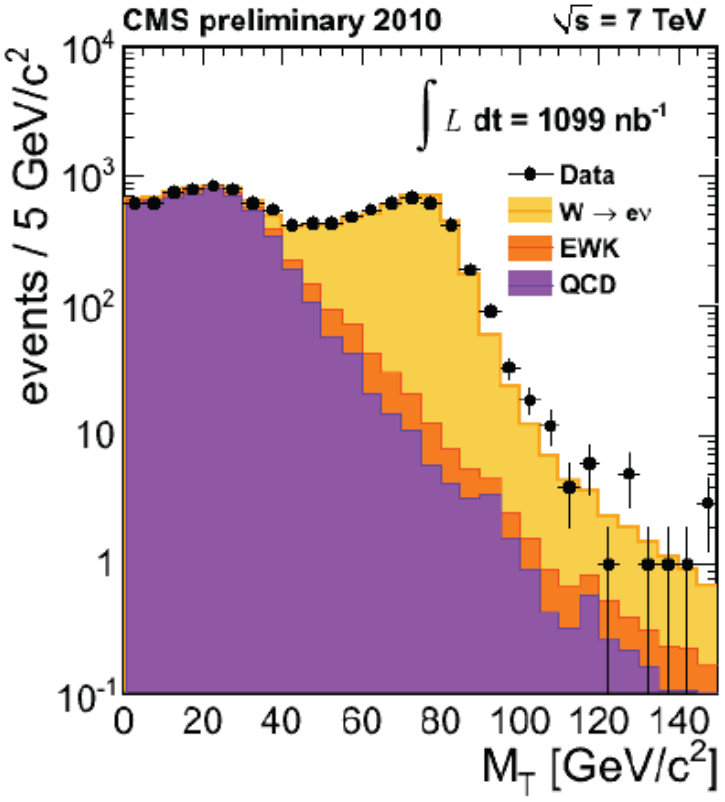
- W selection & signal extraction
  - Isolated muon, Pt>20 GeV, |eta|<2.1, PF or TC MET
  - N(W) from template fit to MT distribution (DD for QCD)
- Z selection & signal extract.
  - Looser ID for 2nd muon
  - Low background: N(Z) from cut & count

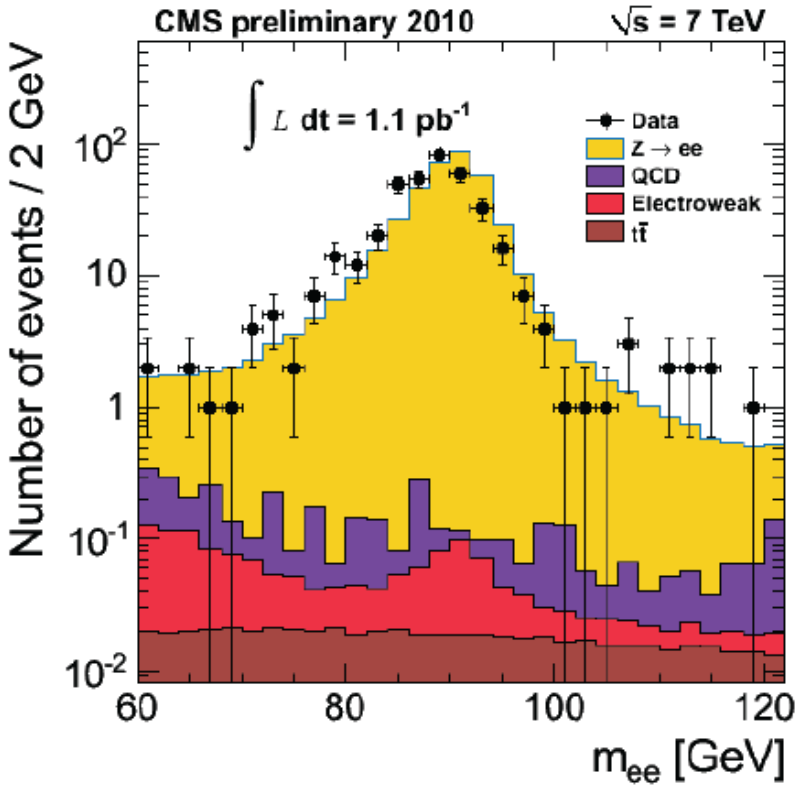




W/Z to electrons

- Electron
  - Et>20 GeV, |eta|<2.5, isolated, conversion veto
- Signal extraction
  - similar to muon channel





Systematics

Muon channels

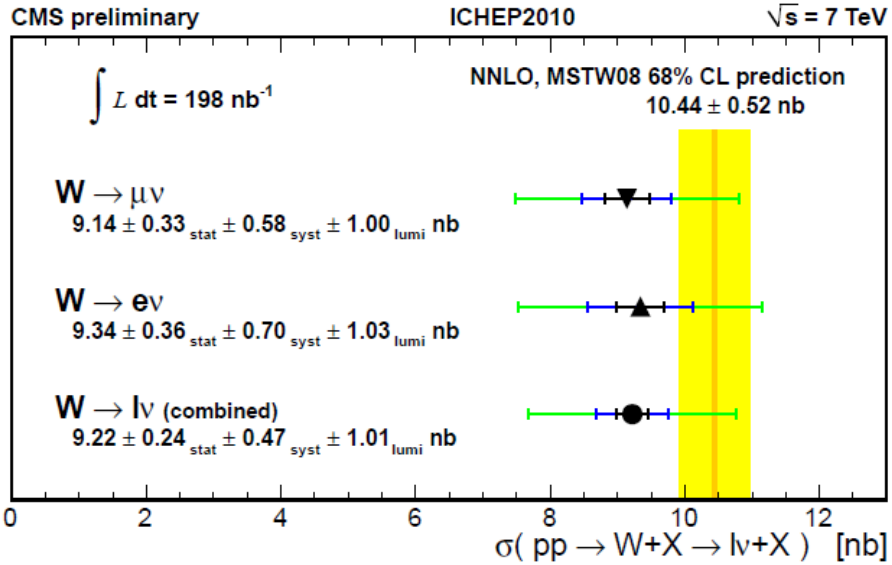
Source	W channel (%)	Z channel (%)
Muon reconstruction/identification	3.0	2.5
Trigger efficiency	3.2	0.7
Isolation efficiency	0.5	1.0
Muon momentum scale/resolution	1.0	0.5
$\not\!\!E_T$ scale/resolution	1.0	-
Background subtraction	3.5	-
PDF uncertainty in acceptance	2.0	2.0
Other theoretical uncertainties	1.4	1.6
TOTAL (without luminosity uncertainty)	6.3	3.8
Luminosity	11.0	11.0

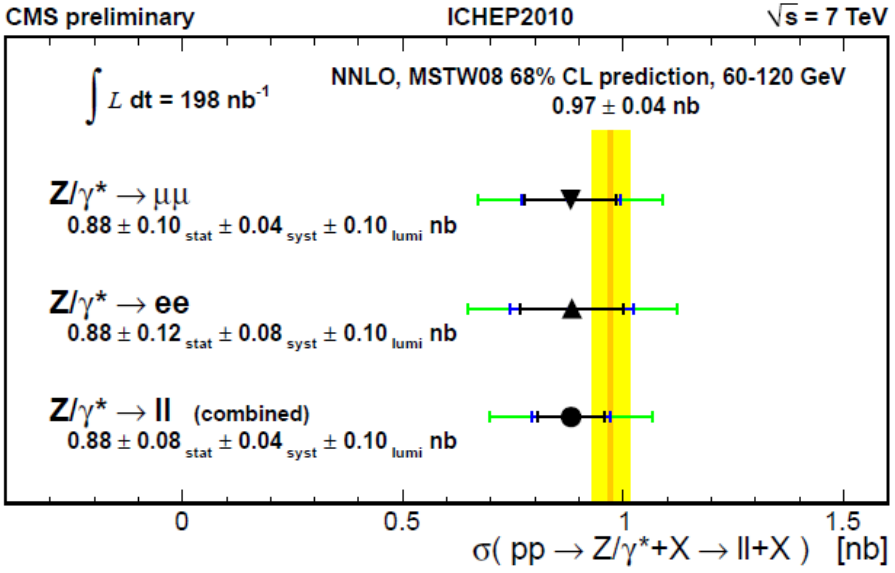
Electron channels

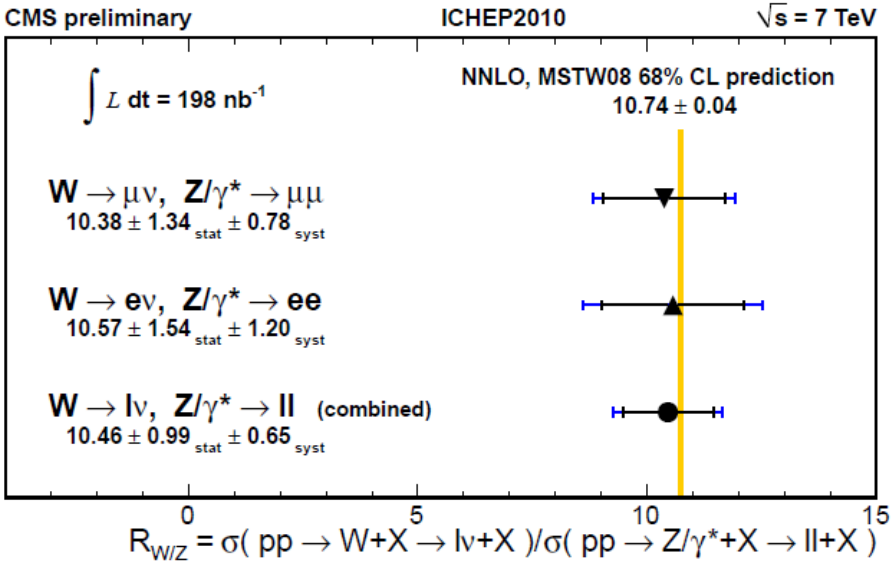
Source	W channel (%)	Z channel (%)
Electron reconstruction/identification	6.1	7.2
Trigger efficiency	0.6	-
Isolation efficiency	1.1	1.2
Electron momentum scale/resolution	2.7	-
$\not\!\!E_T$ scale/resolution	1.4	-
Background subtraction	2.2	-
PDF uncertainty in acceptance	2.0	2.0
Other theoretical uncertainties	1.3	1.3
TOTAL (without luminosity uncertainty)	7.7	7.7
Luminosity	11.0	11.0

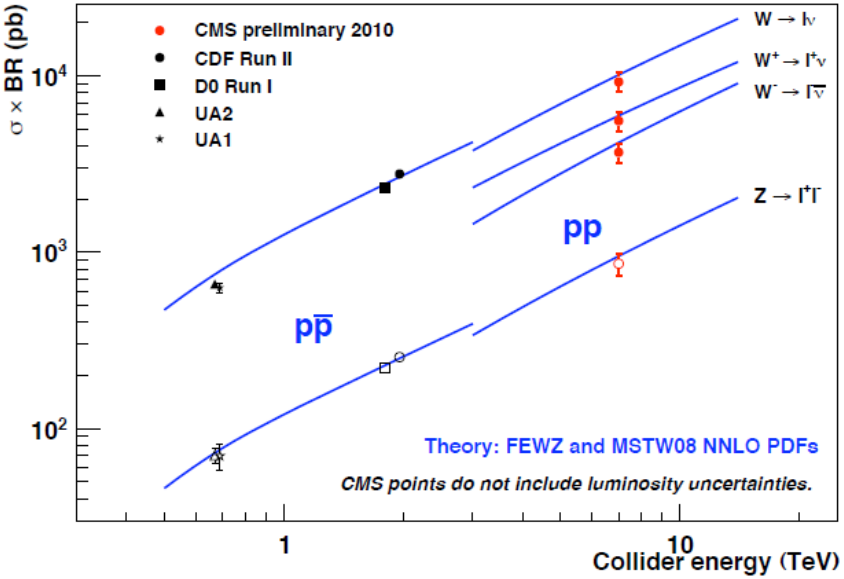
Dominant uncertainties:
W->mu: bg subtraction (templates) dominating
else: lepton reco/id/isol eff. (from samples used for T&P to derive MC SF)

W/Z cross section results

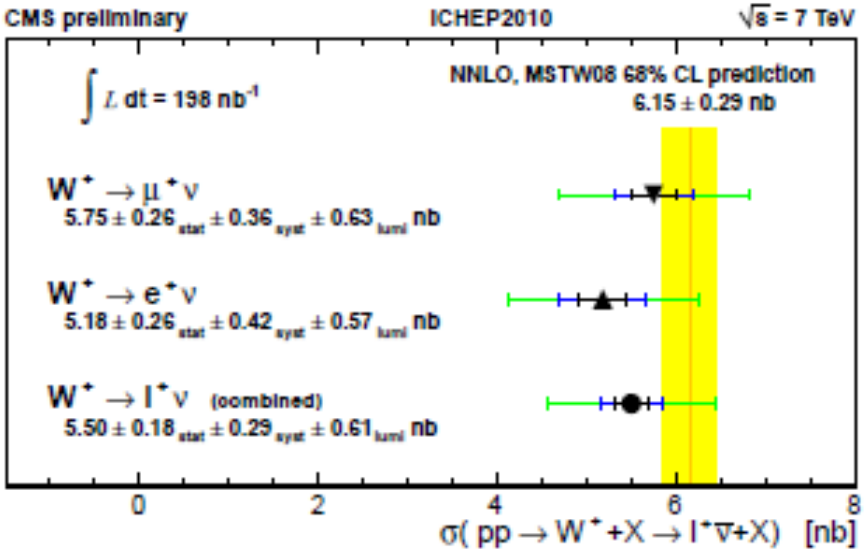


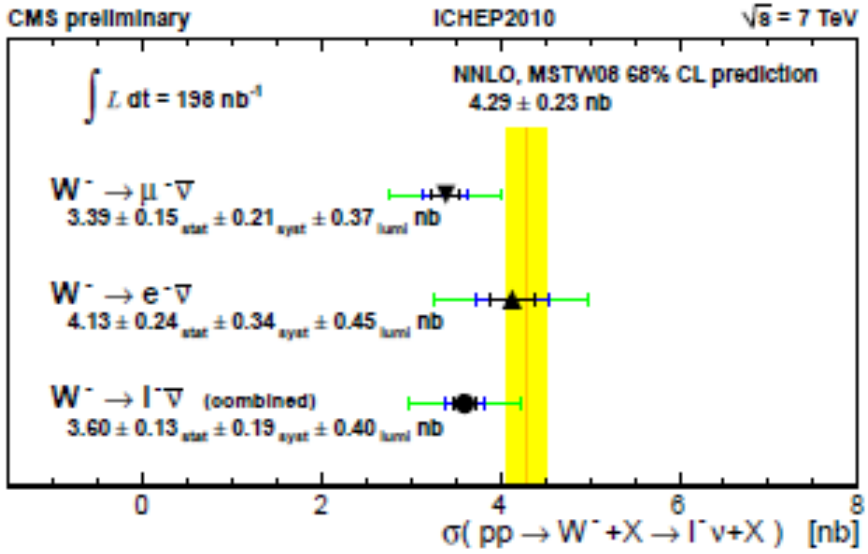


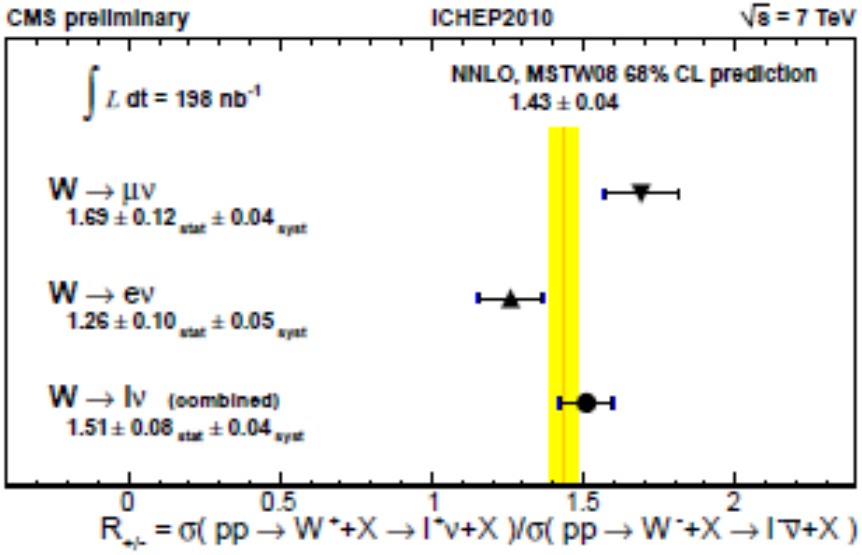




W+/W- cross sections and ratio



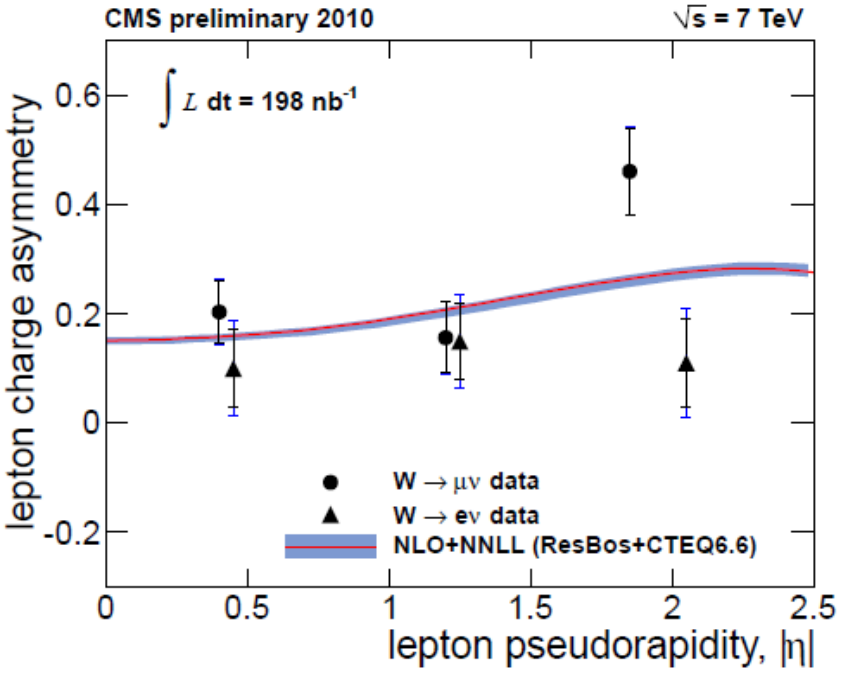




Lepton charge asymmetry and forward-backward asymmetry

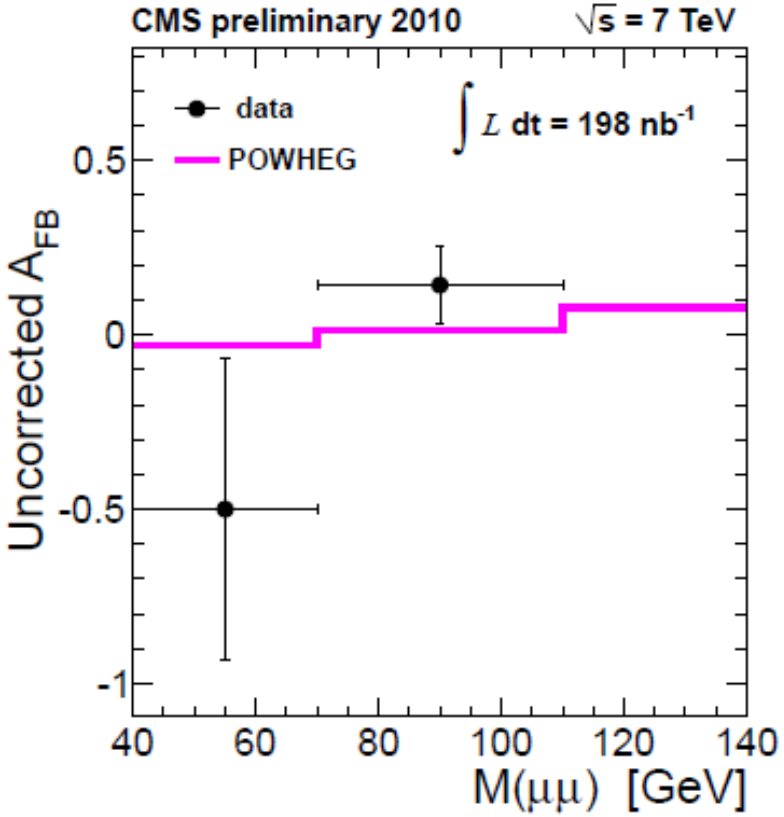
- W lepton charge asymmetry

$$A(\eta) = \frac{d\sigma^{(+)}/d\eta_l - d\sigma^{(-)}/d\eta_l}{d\sigma^{(+)}/d\eta_l + d\sigma^{(-)}/d\eta_l}$$



Constraints on PDFs from ~10pb-1

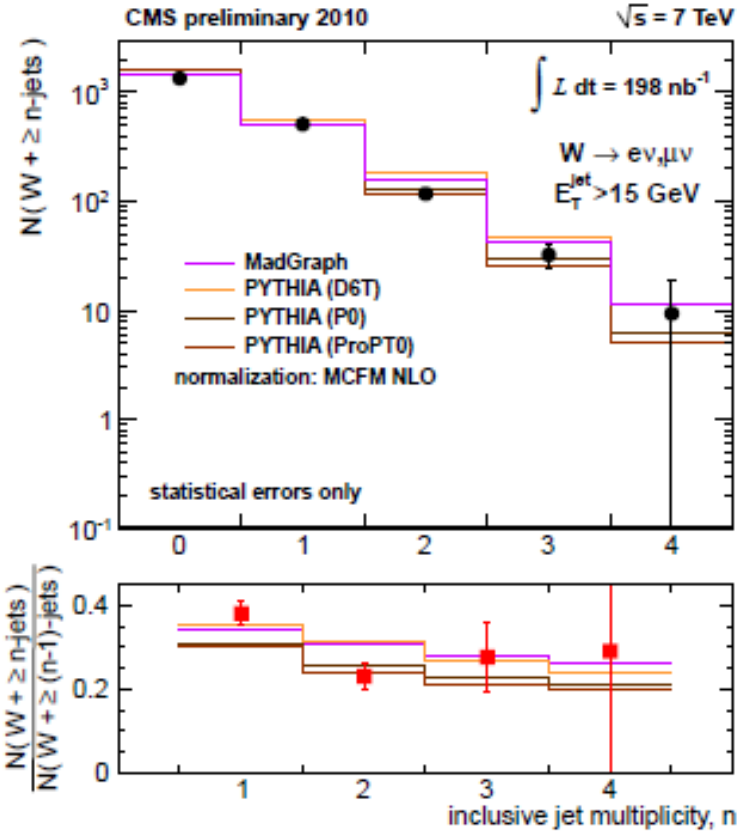
- Di-muon forward-backward asymmetry

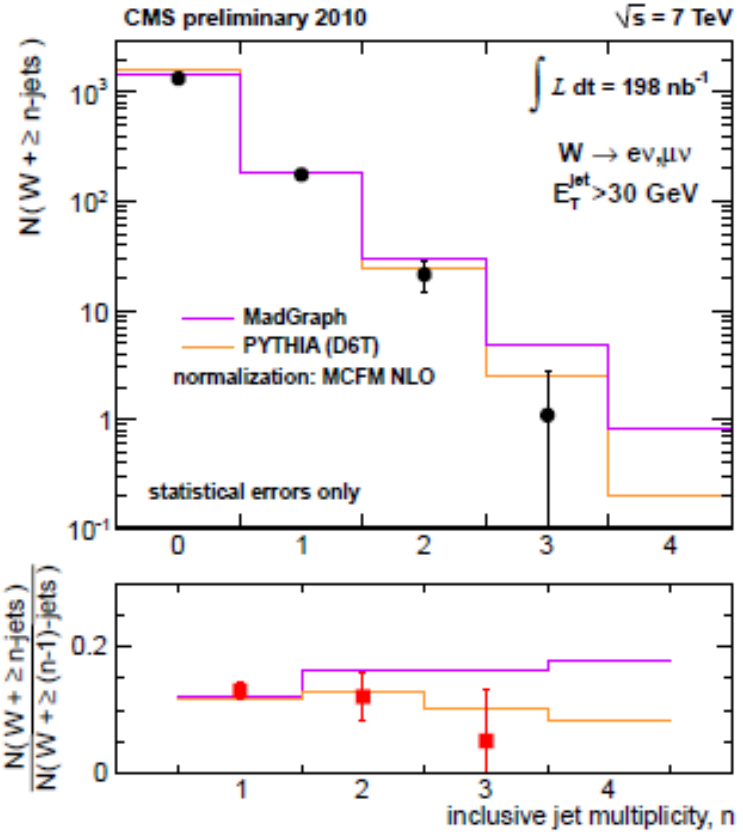


Expect deviations from SM in presence of new neutral gauge boson

W+jets

- BG subtracted (MT fit) jet multiplicity in W events
  - MC normalized to MCFM NLO cross section

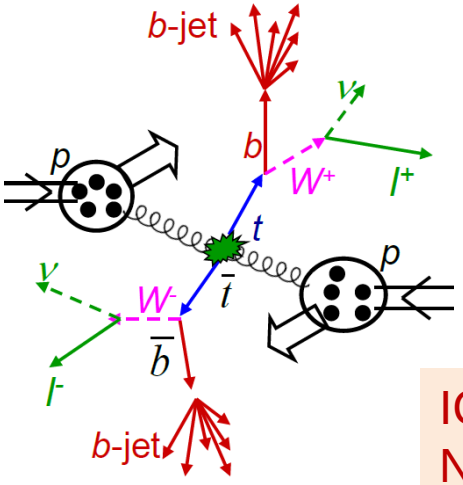




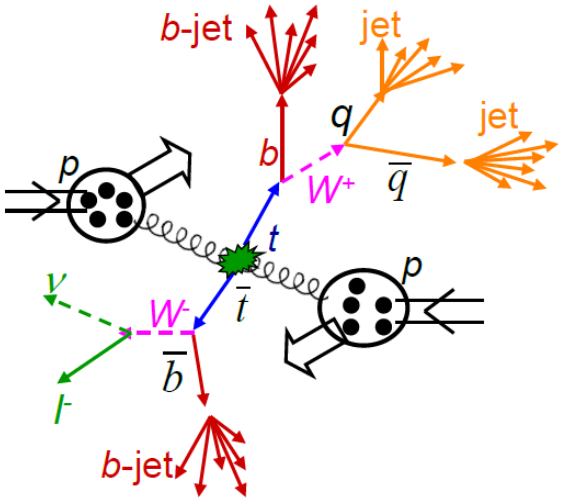
Agreement with simulation within stat. errors

Top (TOP-10-004 + HCP update)

- Dilepton
  - 2 isolated, opposite charge leptons, Pt>20 GeV, Z-Veto
  - Jets with Pt>30 GeV (expect >=2 for Top)
  - tcMET>30 (20) GeV in ee,mumu (emu)
  - >=2 JPT jets, Pt>30 GeV



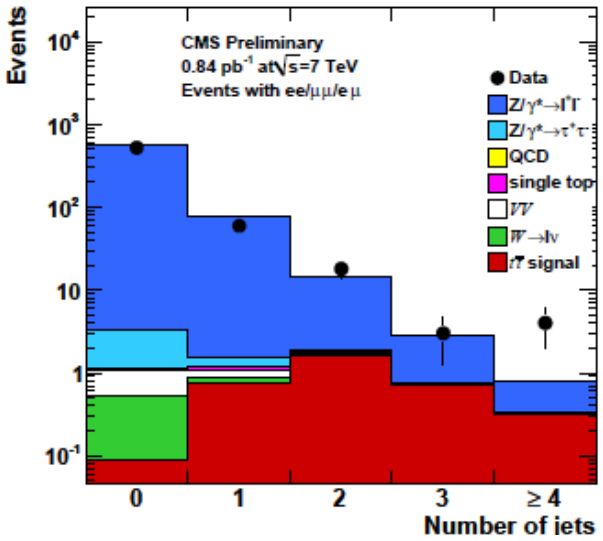
- Lepton+Jets
  - One isolated high pt e (Pt>30 GeV) or mu (Pt>20 GeV)
  - Jets with Pt>30 GeV (expect >=4 for Top)

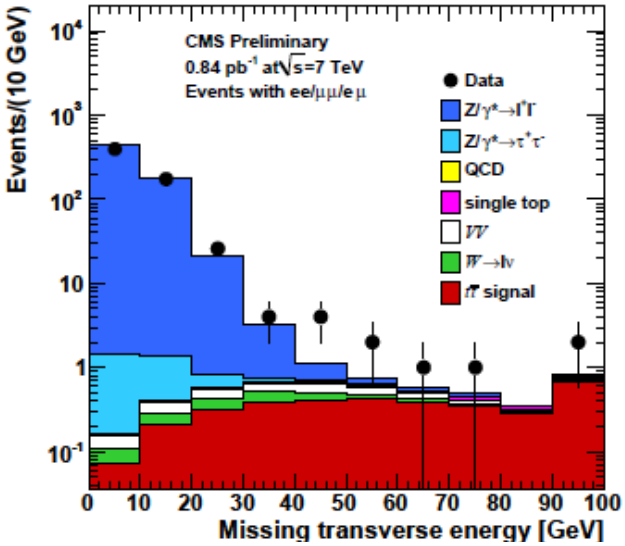


ICHEP results: L=0.25pb-1
New: Update with L=0.84pb-1 for HCP

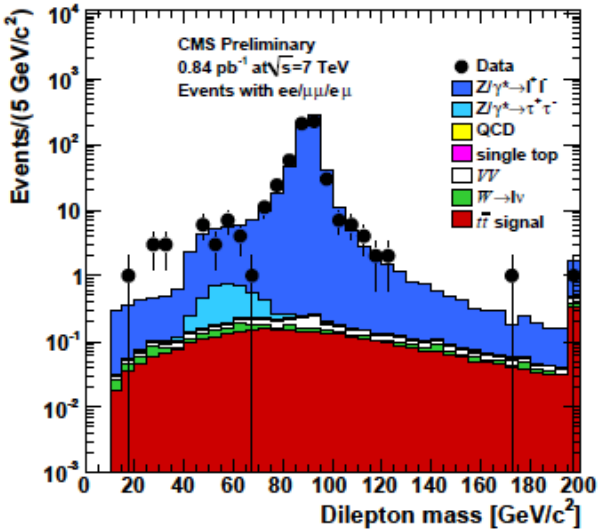
Dilepton yields (relaxed selection)

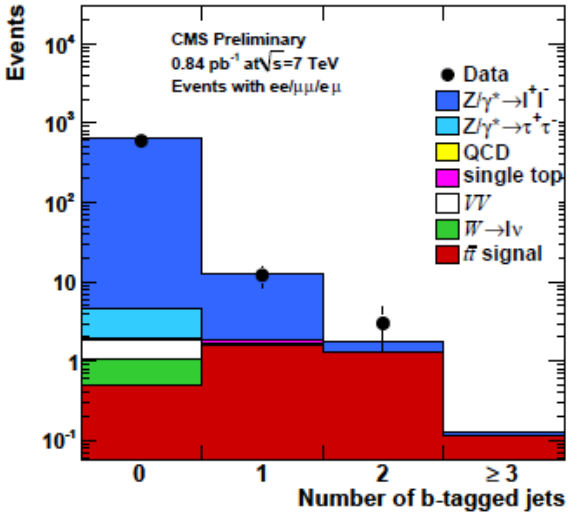
- No Z-veto, no MET, no N(jets) requirements





L=0.84pb^{-1}





Rightmost bins contain overflow

Dilepton yields: tighter selection

- Z-veto, N(jets)>=1

$L=0.84pb^{-1}$

Sample	ee	$\mu\mu$	$e\mu$
Dilepton $t\bar{t}$	$0.63 \pm 0.09 \pm 0.12$	$0.70 \pm 0.11 \pm 0.13$	$1.70 \pm 0.26 \pm 0.32$
VV	0.05 ± 0.03	0.05 ± 0.03	0.12 ± 0.06
Single top - tW	0.04 ± 0.02	0.05 ± 0.03	0.12 ± 0.06
Drell-Yan $\tau\tau$	0.08 ± 0.04	0.13 ± 0.07	0.19 ± 0.09
Drell-Yan $ee, \mu\mu$	4.2 ± 1.1	5.0 ± 1.2	0.04 ± 0.02
Non-dilepton $t\bar{t}$	0.02 ± 0.01	0.003 ± 0.002	0.03 ± 0.02
W+jets	0.06 ± 0.03	$0.000\ ^{+0.002}_{-0.000}$	0.07 ± 0.04
QCD multijets	$0\ ^{+10}_{-0}$	$0\ ^{+10}_{-0}$	$0\ ^{+10}_{-0}$
Total simulated	5.1 ± 1.1	5.9 ± 1.2	2.3 ± 0.4
QCD data-driven	$0.0\ ^{+0.1}_{-0.0}\ ^{+0.1}_{-0.0}$	$0.0\ ^{+0.2}_{-0.0}\ ^{+0.2}_{-0.0}$	$0.0\ ^{+0.1}_{-0.0}\ ^{+0.1}_{-0.0}$
W+jets data-driven	$0.2\ ^{+0.2}_{-0.0}\ ^{+0.1}_{-0.0}$	$0.0\ ^{+0.4}_{-0.0}\ ^{+0.2}_{-0.0}$	$0.0\ ^{+0.4}_{-0.0}\ ^{+0.2}_{-0.0}$
Drell-Yan data-driven	$3.6 \pm 0.6 \pm 1.8$	$4.3 \pm 0.7 \pm 2.1$	N/A
Data	6	6	2

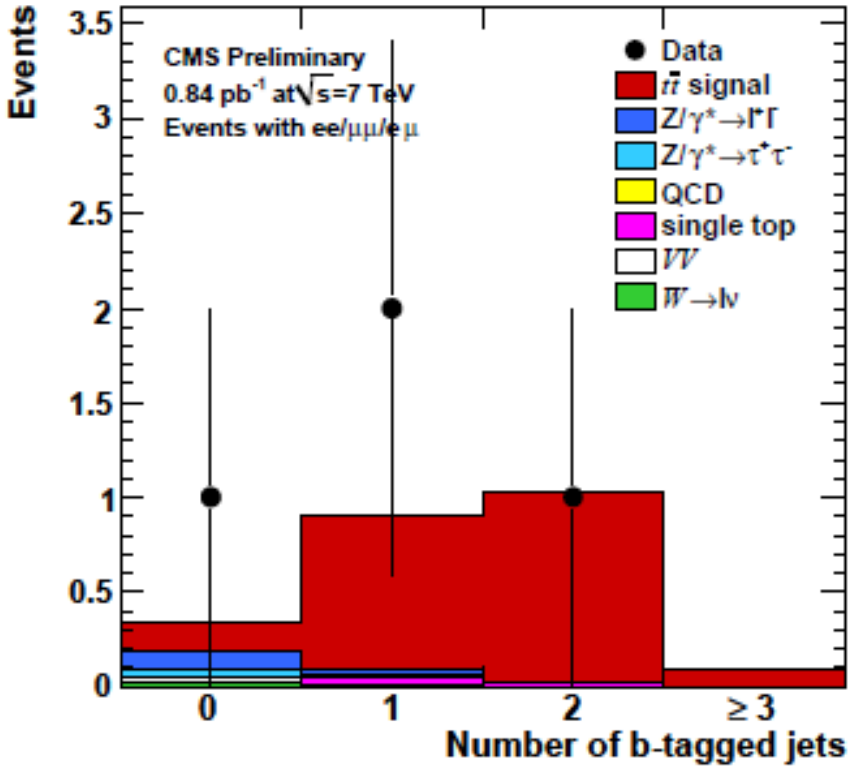
Systematics:
- Signal and DY: 15% acceptance (conservative), 15% theory, 11% lumi
- Other backgrounds: 50% (conservative)
- Data-driven backgrounds: DY,Wjets: 50%; QCD: 100%

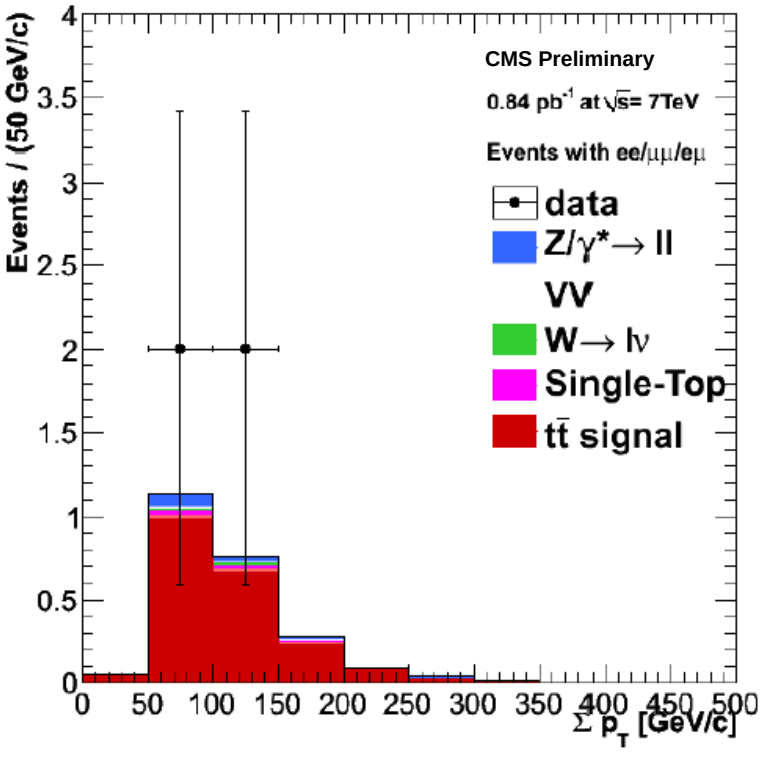
Good agreement observed!

Dilepton: full selection

- All cuts applied: Z-Veto, MET, N(jets)>=2

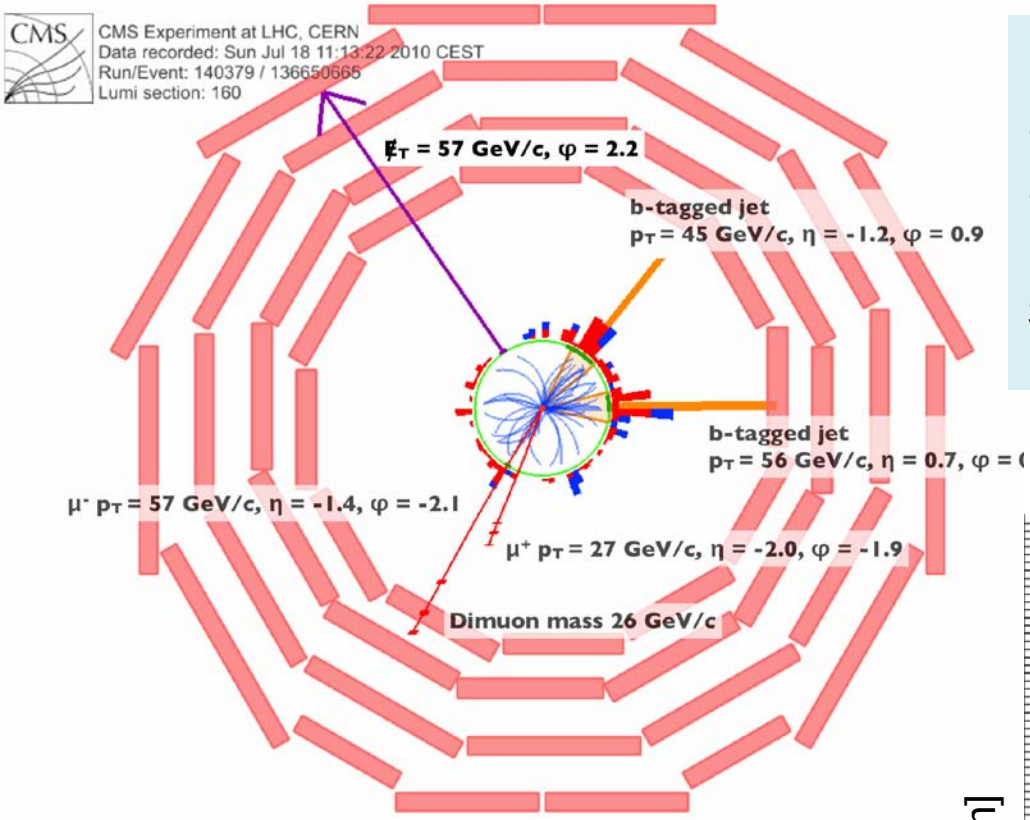
L=0.84pb^{-1}





4 clean ttbar candidates observed
~2.1 signal events expected

Dimuon event with 2 b-tags

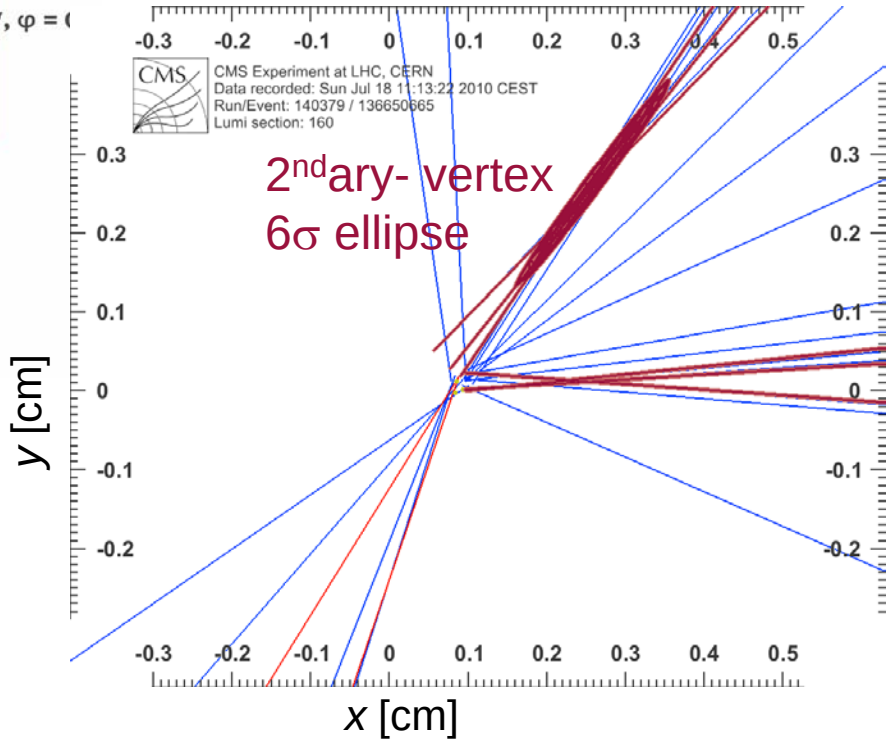


Event passes full selection:

2 muons with opposite charge

2 jets, both w/ good/clear *b*-tags (and secondary vertices!)

significant MET (>50 GeV)

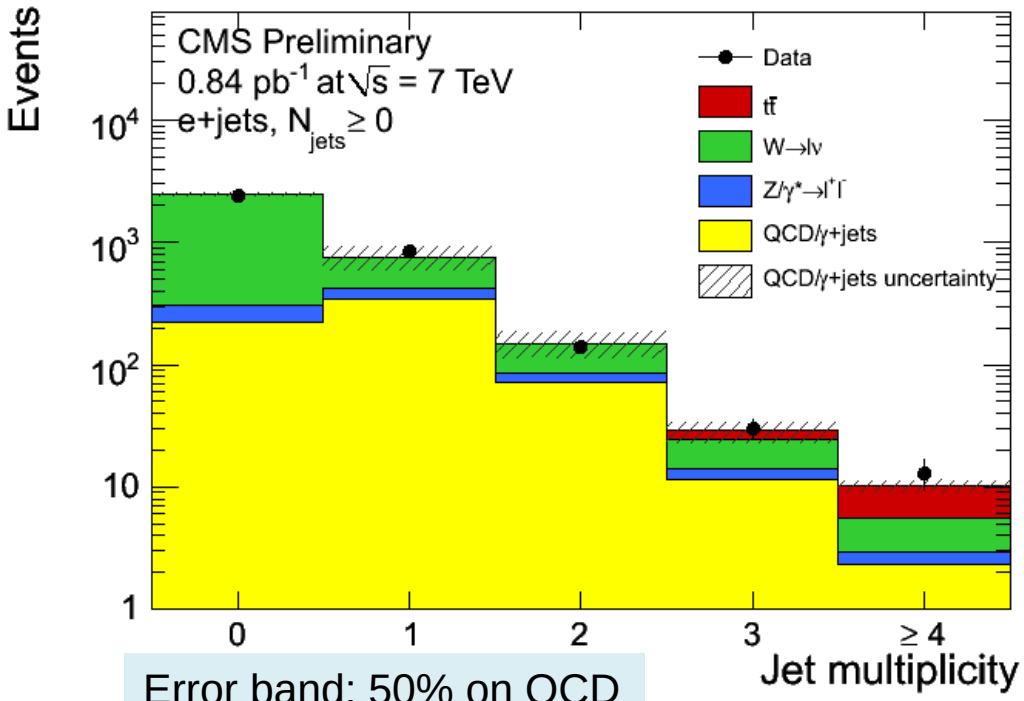


Preliminarily reconstr. mass in the range 160–220 GeV/c^2

Electron+Jets

No b-tagging, no MET cut applied

Jet multiplicity	ttbar	single top	W+jets	Z+jets	QCD	Sum MC	Data
$N_{jets} \geq 0$	12 ± 2	3.4 ± 0.4	2619 ± 317	180 ± 21	658 ± 73	3472 ± 326	3434
$N_{jets} \geq 1$	12 ± 2	3.1 ± 0.4	419 ± 77	92 ± 11	436 ± 62	962 ± 99	1022
$N_{jets} \geq 2$	11 ± 2	1.9 ± 0.3	74 ± 18	19 ± 5	85 ± 22	191 ± 29	183
$N_{jets} \geq 3$	8.9 ± 1.8	0.70 ± 0.14	13 ± 4	3.3 ± 1.0	14 ± 5	40 ± 7	43
$N_{jets} \geq 4$	4.8 ± 1.2	0.21 ± 0.06	2.6 ± 1.1	0.60 ± 0.23	2.3 ± 1.1	11 ± 2	13



Error band: 50% on QCD

MC Uncertainties (table):

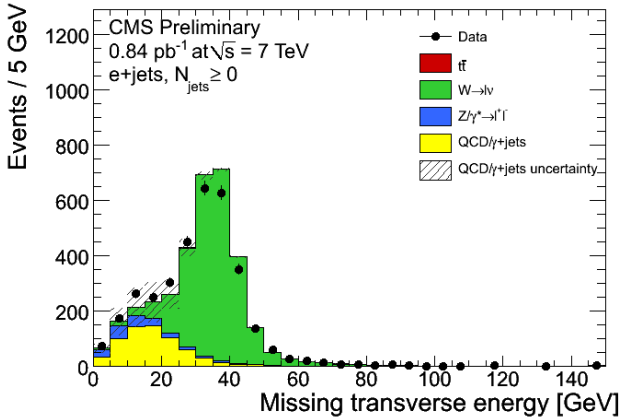
- Jet energy scale (known to 10%)
- Luminosity (known to 11%)
- Cross section unc. (scale,PDF)

$L=0.84pb^{-1}$

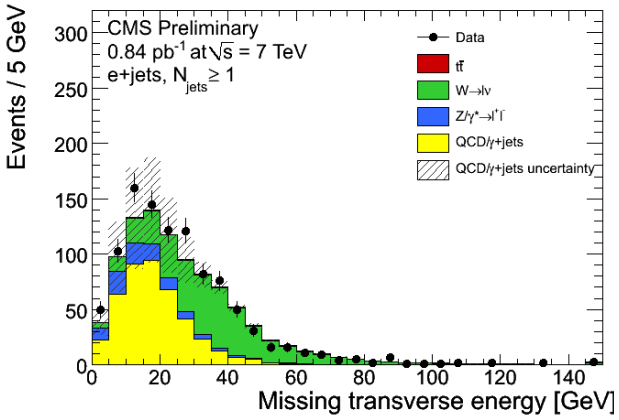
Good agreement observed in all Jet bins!

e+jets in various jet bins

N(jets)>=0

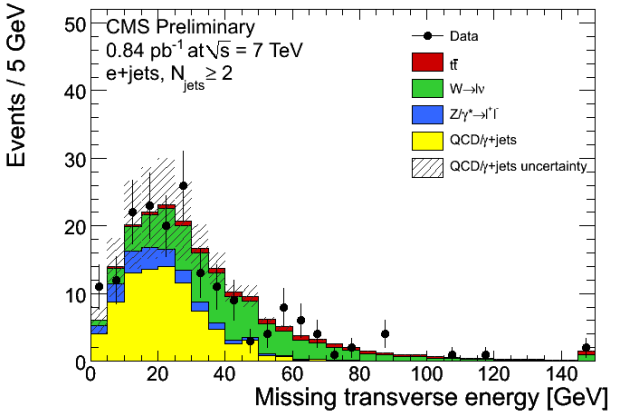


N(jets)>=1

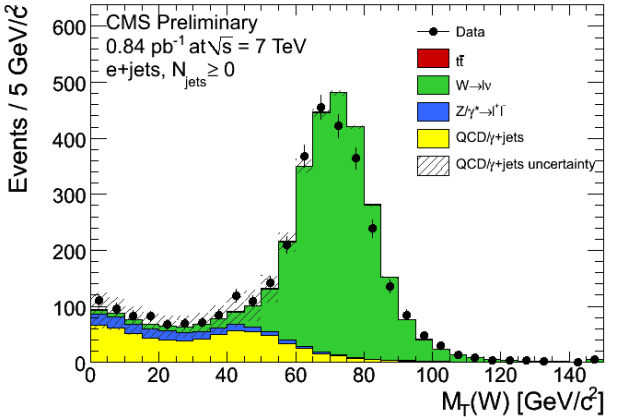


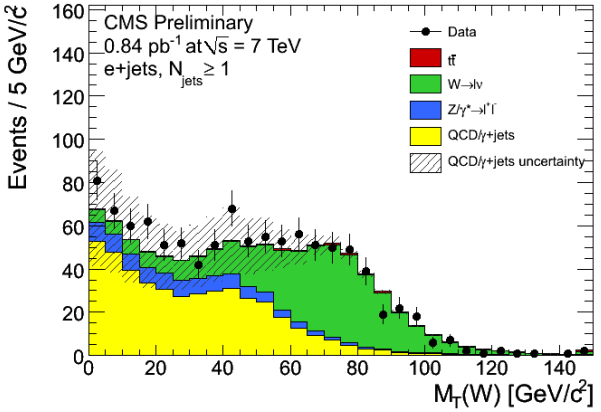
N(jets)>=2

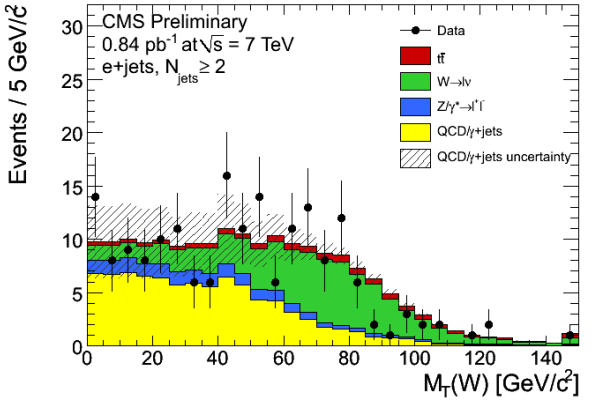
L=0.84pb^{-1}



Missing ET (hard to get right, important for any top quark measurement)







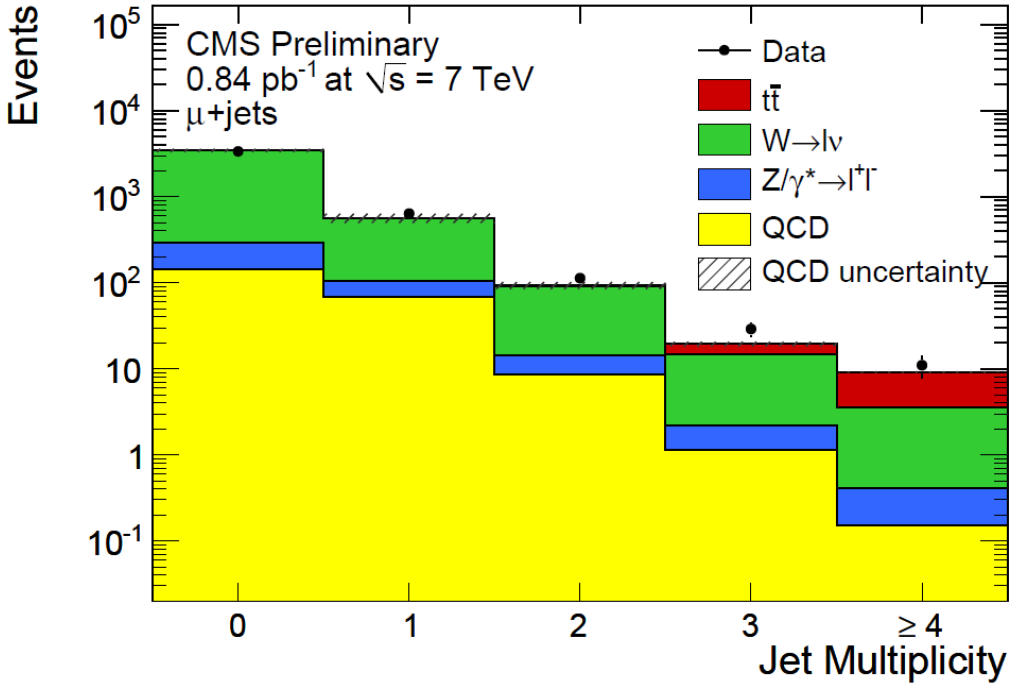
M_T(W): transverse W mass (calculated from lepton+MET)

Good agreement Data-Simulation! QCD background important in e+jets!

Muon+jets

No b-tagging, no MET cut applied

Jet multiplicity	ttbar	single top	W+jets	Z+jets	QCD	Sum MC	Data
$N_{jets} \geq 0$	13 ± 3	4.2 ± 0.4	3708 ± 448	192 ± 29	223 ± 25	4140 ± 450	4142
$N_{jets} \geq 1$	13 ± 3	3.9 ± 0.4	552 ± 106	42 ± 12	79 ± 17	690 ± 108	789
$N_{jets} \geq 2$	13 ± 2	2.3 ± 0.3	92 ± 24	7.1 ± 4.4	10 ± 3	124 ± 25	153
$N_{jets} \geq 3$	10 ± 2	0.82 ± 0.15	16 ± 5	1.3 ± 0.9	1.3 ± 0.5	29 ± 5	40
$N_{jets} \geq 4$	5.6 ± 1.4	0.24 ± 0.06	3.1 ± 1.2	0.25 ± 0.18	0.15 ± 0.07	9.3 ±1.9	11

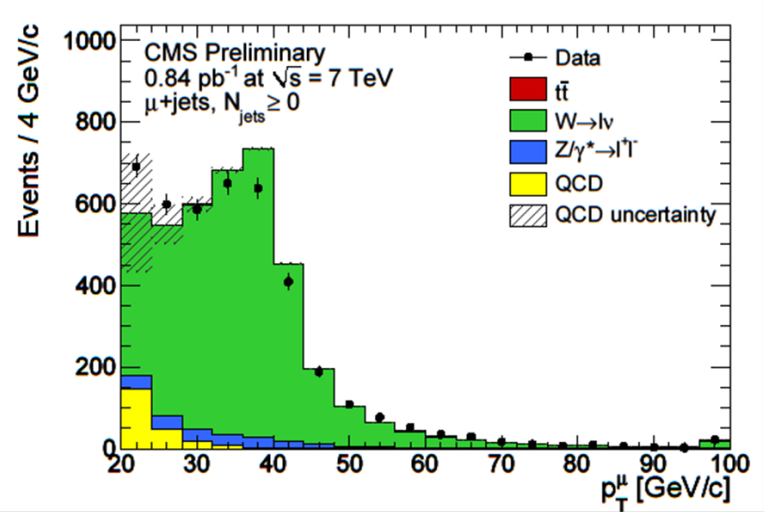


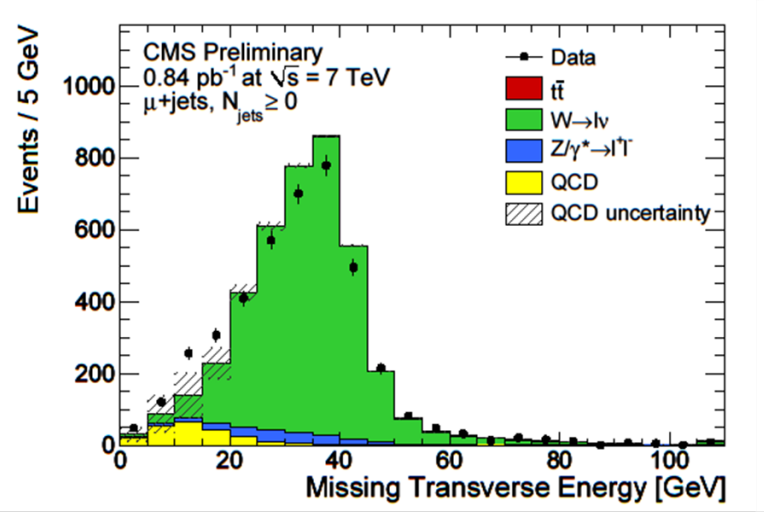
MC Uncertainties (table):
- Jet energy scale (known to 10%)
- Luminosity (known to 11%)
- Cross section unc. (scale,PDF)

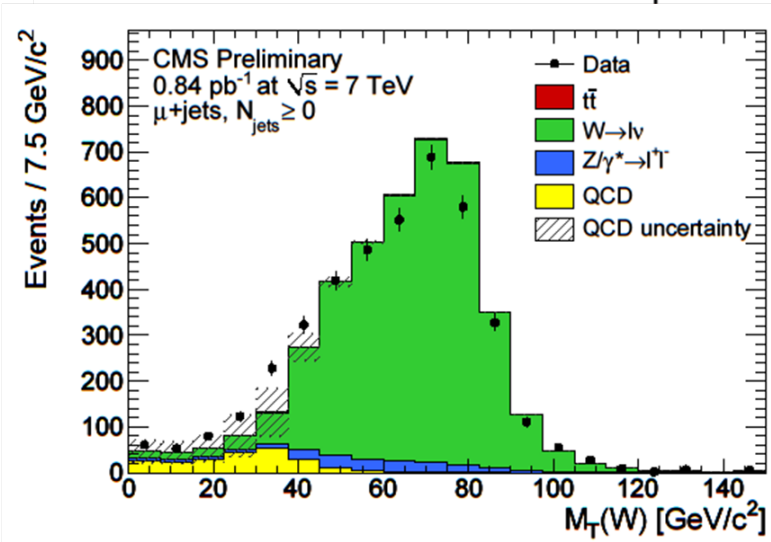
$L=0.84pb^{-1}$

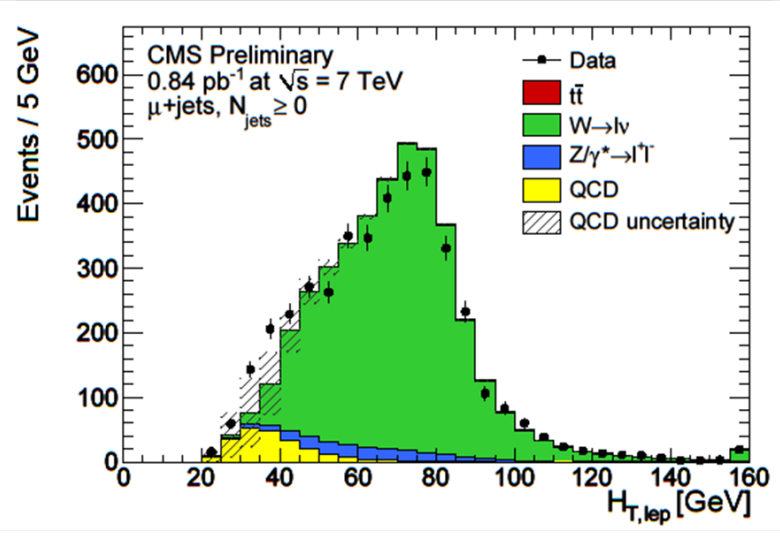
Good agreement observed in all Jet bins!

mu+jets, N(jets)>=0





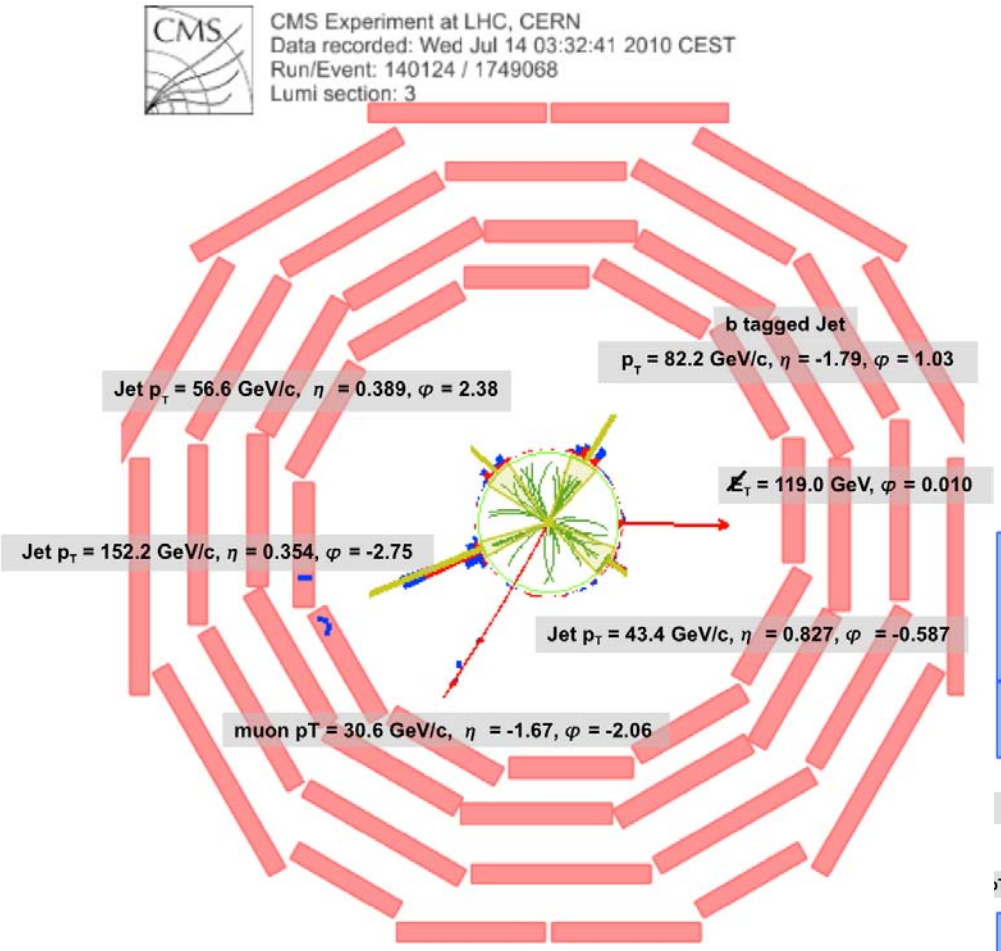




Excess observed in data at low Pt(mu), MET, MT and HT
Consistent with QCD MC being factor ~2 too low

Error band: 100% on QCD
(from data-driven methods)

A beautiful mu+jets candidate



Event passes all cuts of full selection

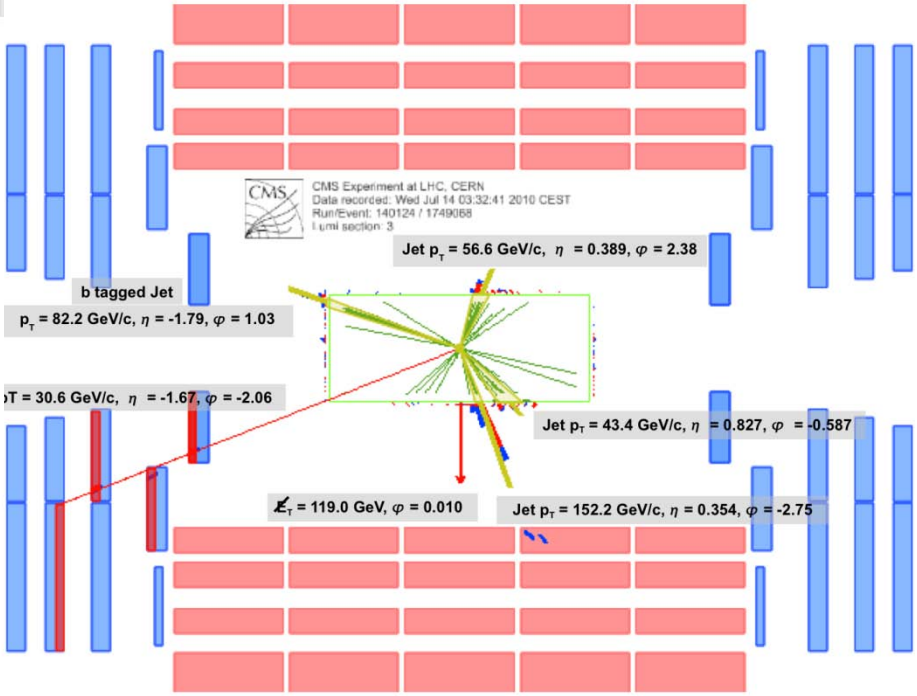
1 high-momentum muon

significant MET>100GeV

m_T(W) = 104 GeV/c^2

4 high-p_T jets,

one of which with good *b*-tag

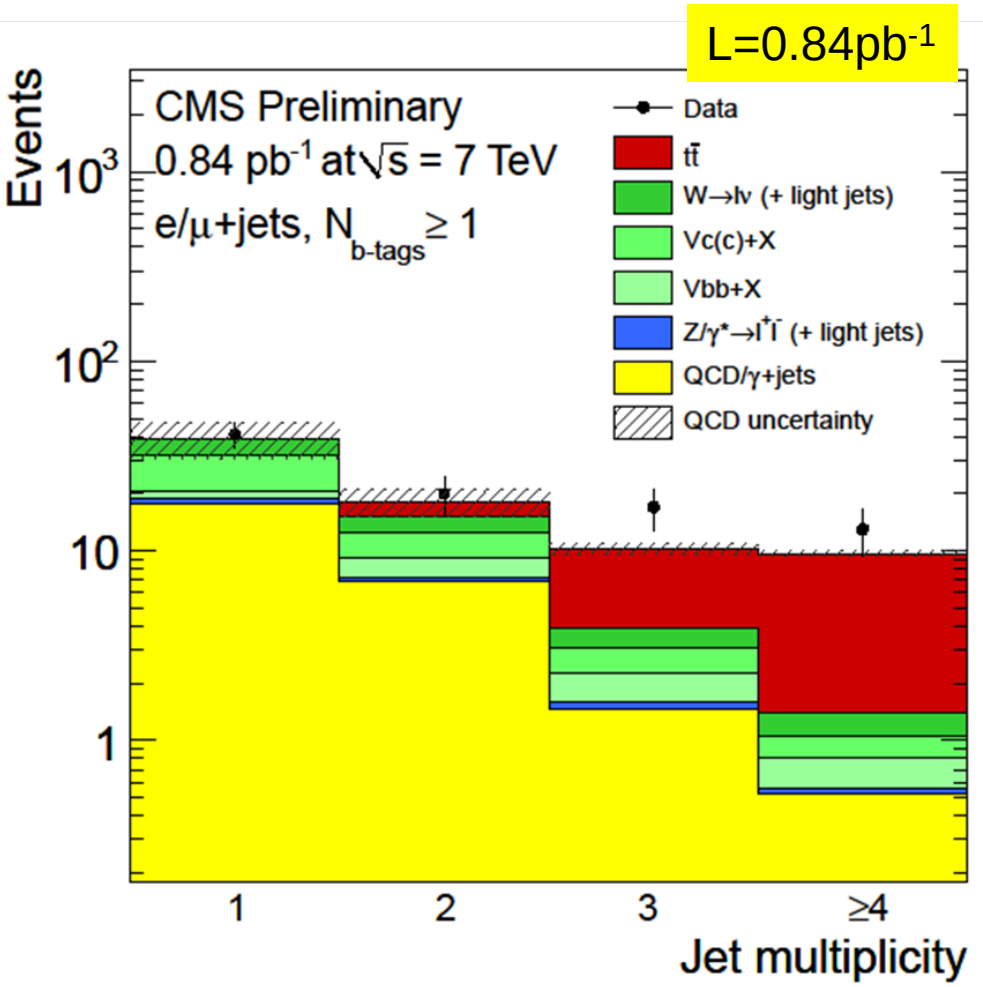


reconst. top mass around 210 GeV/c^2

masses of 2 untagged jets (3 possible comb.): 104, 105, 151 GeV/c^2

e/mu+jets with b-tagging

- e/mu+jets combined
- Secondary vertex tagger (working point with high efficiency and ~1% fake rate)
- For N(jets)>=3:
  - Observed N(data)=30
  - Prediced background N(BG,MC)=5.3



Seeing ttbar events at a rate roughly consistent with NLO cross section, considering experimental (JES,b-tagging) and theoretical (scale, PDF, HF modelling, …) uncertainties

Conclusions

- Borad range of Standard Model measurements being performed by CMS, and presented at ICHEP
  - Soft QCD und underlying Event
  - Jet Physics
  - Quarkonia and b-Production
  - Electroweak physics (W and Z)
  - First glimpse at the Top
- Most using <250nb-1, now have already >3 pb-1 recorded
- Exceptionally well working and understood detector, already at this “early” stage
- SM measurement are really the groundwork for new Physics searches
- Expect much more soon (e.g. first Top cross section!)

Backup

SM Physics for ICHEP

- QCD
  - QCD-09-010 Charged hadrons @ 0.9/2.36 TeV [pub.]
  - QCD-10-006 Charged hadrons @ 7 TeV [pub.]
  - QCD-10-004 Charged particle multiplicities
  - QCD-10-003 Bose-Einstein Correlations [pub.]
  - QCD-10-001 Underlying Event @ 0.9TeV [pub.]
  - QCD-10-010 Underlying Event @ 7 TeV
  - QCD-10-005 Underlying Event from JetArea/Median
  - QCD-10-002 Cluster properties from two-particle angular correlations
  - QCD-10-007 Strangeness production
  - QCD-10-011 Inclusive Jets
  - QCD-10-012 3-to-2 jet ratio
  - QCD-10-013 Event shapes
  - QCD-10-014 Jet transverse structure
  - QCD-10-015 Dijet azimuthal decorrelations

SM Physics for ICHEP (cont.)

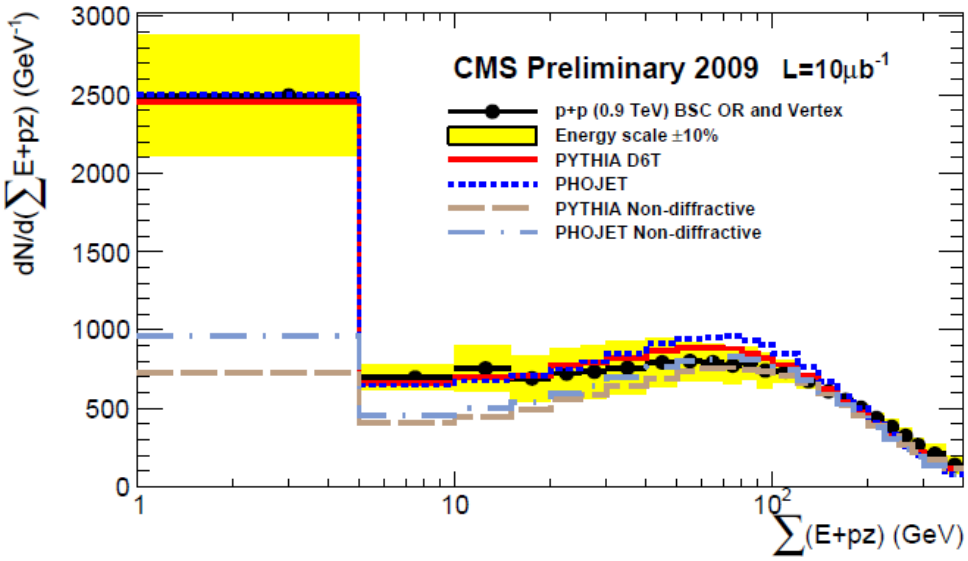
- Forward Physics
  - FWD-10-001 Observation of Diffraction
  - FWD-10-002 Forward Energy Flow
- B-physics / Quarkonia
  - BPH-10-002 J/Psi cross section
  - BPH-10-003 Upsilon cross section
  - BPH-10-007 Open beauty with muons
  - BPH-10-009 b-jet cross section
- Electroweak Physics
  - EWK-10-002 W/Z cross section and more
- Top physics
  - TOP-10-004 Top selection and candidates

Post-ICHEP updates

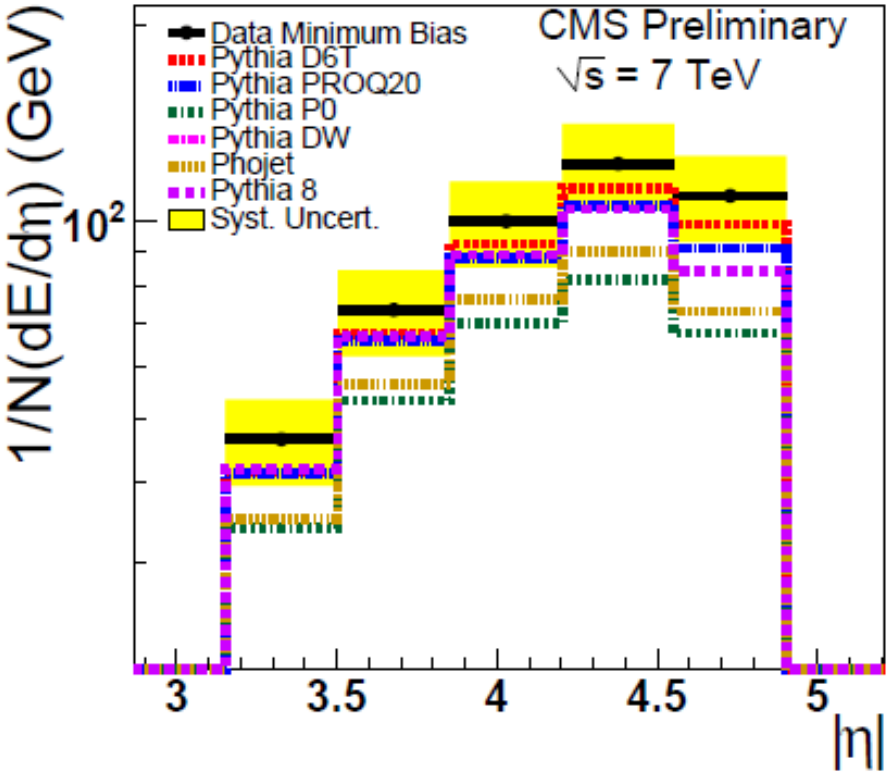
- QCD
  - QCD-10-008 Charged hadron Pt spectra
  - Z1/Z2 PYTHIA Tunes Rick Field
- TOP
  - Updated public plots for 840nb-1 for HCP/PIC
- PAG Jamboree Sept 01-02 (CMS internal)
  - http://indico.cern.ch/conferenceDisplay.py?confId=105457

Forward Physics

- FWD-10-001
  - Observation of diffraction in min. bias events
  - Sum(E+Pz) calculated from calo towers (incl. HF)
    - Proportional to p momentum loss

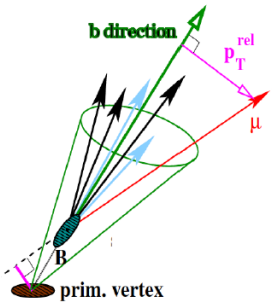


- FWD-10-002
  - Forward (HF) energy flow in MB and dijet events



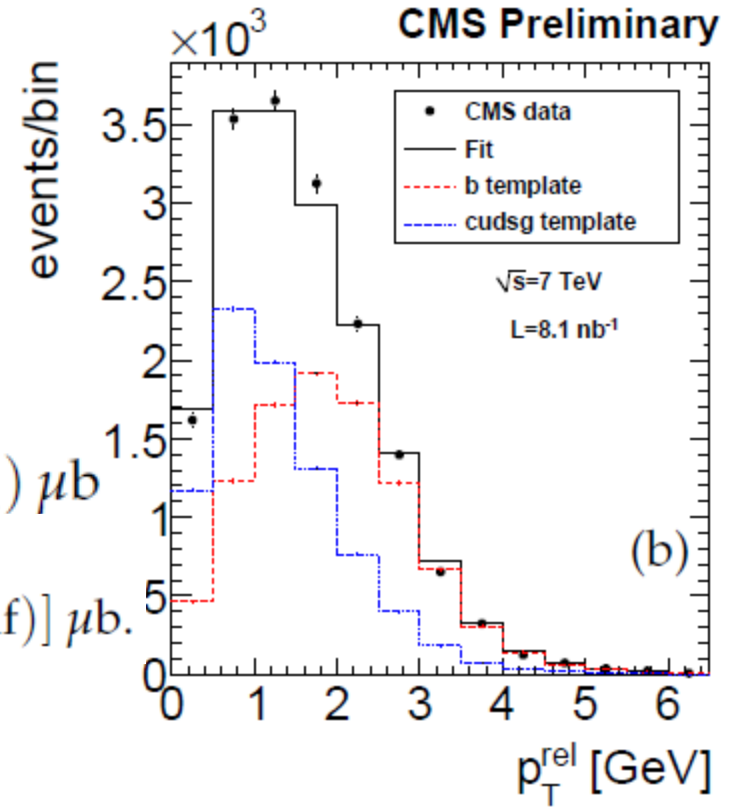
Inclusive b cross-section with Muons (BPH-10-007)

$$\sigma(pp \to b + X \to \mu + X', p_{\perp}^{\mu} > 6\,\mathrm{GeV}, |\eta^{\mu}| < 2.1)$$



- Cross section measured by fitting templates to Pt(rel) distribution in Pt/Eta bins

$$\sigma = (1.48 \pm 0.04_{\mathrm{stat}} \pm 0.22_{\mathrm{syst}} \pm 0.16_{\mathrm{lumi}})\ \mu\mathrm{b}$$
$$\sigma_{\mathrm{PYTHIA}} = 1.8\ \mu\mathrm{b},$$
$$\sigma_{\mathrm{MC@NLO}} = [0.84^{+0.36}_{-0.19}(\mathrm{scale}) \pm 0.08(m_b) \pm 0.04(\mathrm{pdf})]\ \mu\mathrm{b}.$$



Dilepton Event Yields

- Relaxed selection:
  - No Z-veto, no MET, N(jets) requirements

$L=0.84 pb^{-1}$

Process	ee	$\mu\mu$	$e\mu$
Dilepton $t\bar{t}$	$0.84 \pm 0.13 \pm 0.16$	$0.94 \pm 0.14 \pm 0.17$	$1.75 \pm 0.26 \pm 0.33$
VV	0.23 ± 0.12	0.25 ± 0.13	0.35 ± 0.18
Single top - tW	0.06 ± 0.03	0.07 ± 0.03	0.13 ± 0.07
Drell-Yan $\tau\tau$	0.6 ± 0.3	0.7 ± 0.4	1.3 ± 0.7
Drell-Yan $ee, \mu\mu$	298 ± 74	343 ± 86	0.1 ± 0.1
Non-dilepton $t\bar{t}$	0.02 ± 0.01	0.004 ± 0.002	0.03 ± 0.02
W+jets	0.3 ± 0.1	0.01 ± 0.01	0.3 ± 0.2
QCD multijets	$0\ ^{+10}_{-0}$	$0.00\ ^{+10}_{-0}$	$0\ ^{+10}_{-0}$
Total simulated	300 ± 74	345 ± 86	4.0 ± 0.8
Data	305	294	6

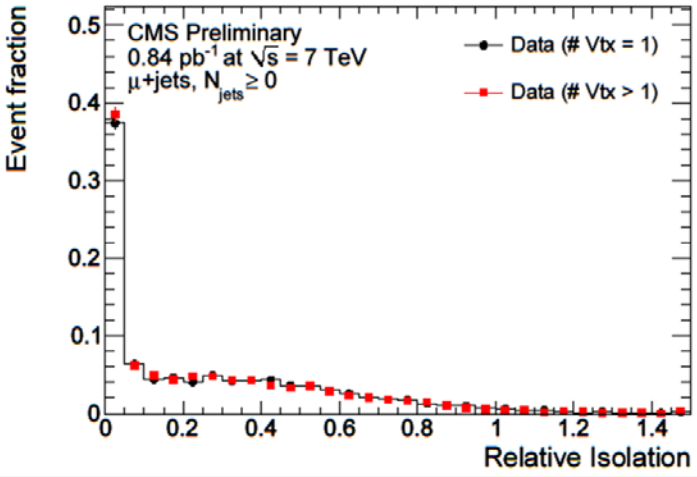
Systematics:
- Signal and DY: 15% acc*eff (conservative), 15% theory, 11% lumi
- Other backgrounds: 50% (conservative)

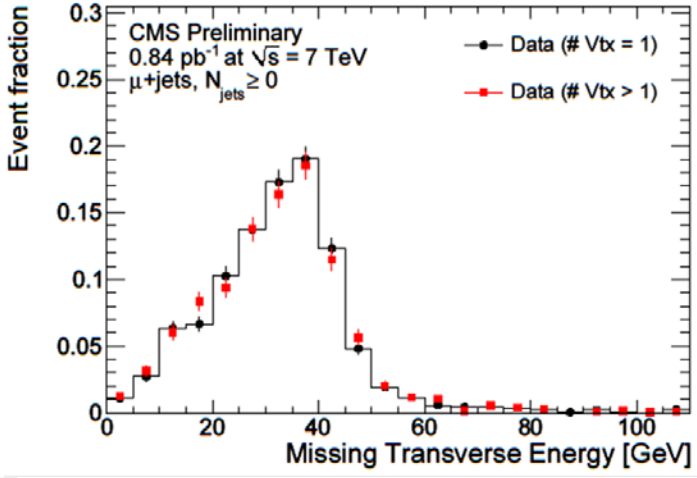
Good agreement observed!

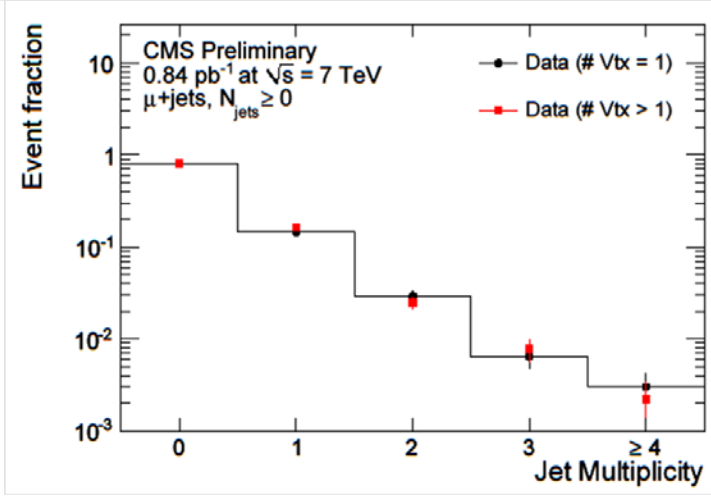
Are we sensitive to Pile-up?

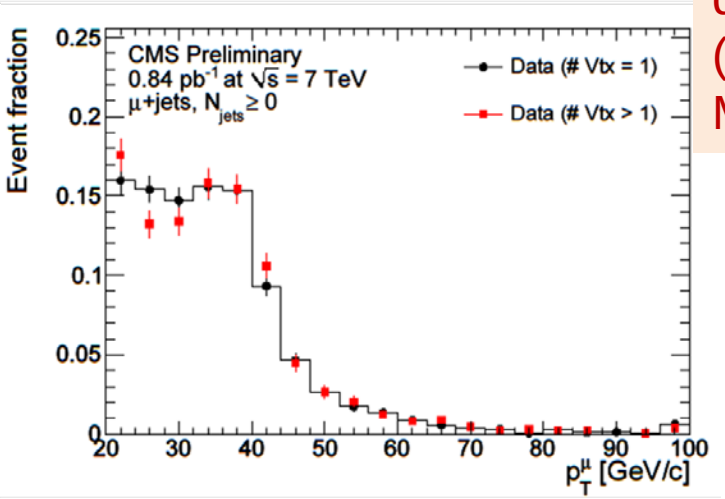
Do have non-negligible pileup in recent data <N>~0.9
Simulation is without pileup
Compare data with one vertex vs data with >=1 vertex

L=0.84pb^{-1}









So far little effect on sensitive distributions (e.g. isolation, MET)