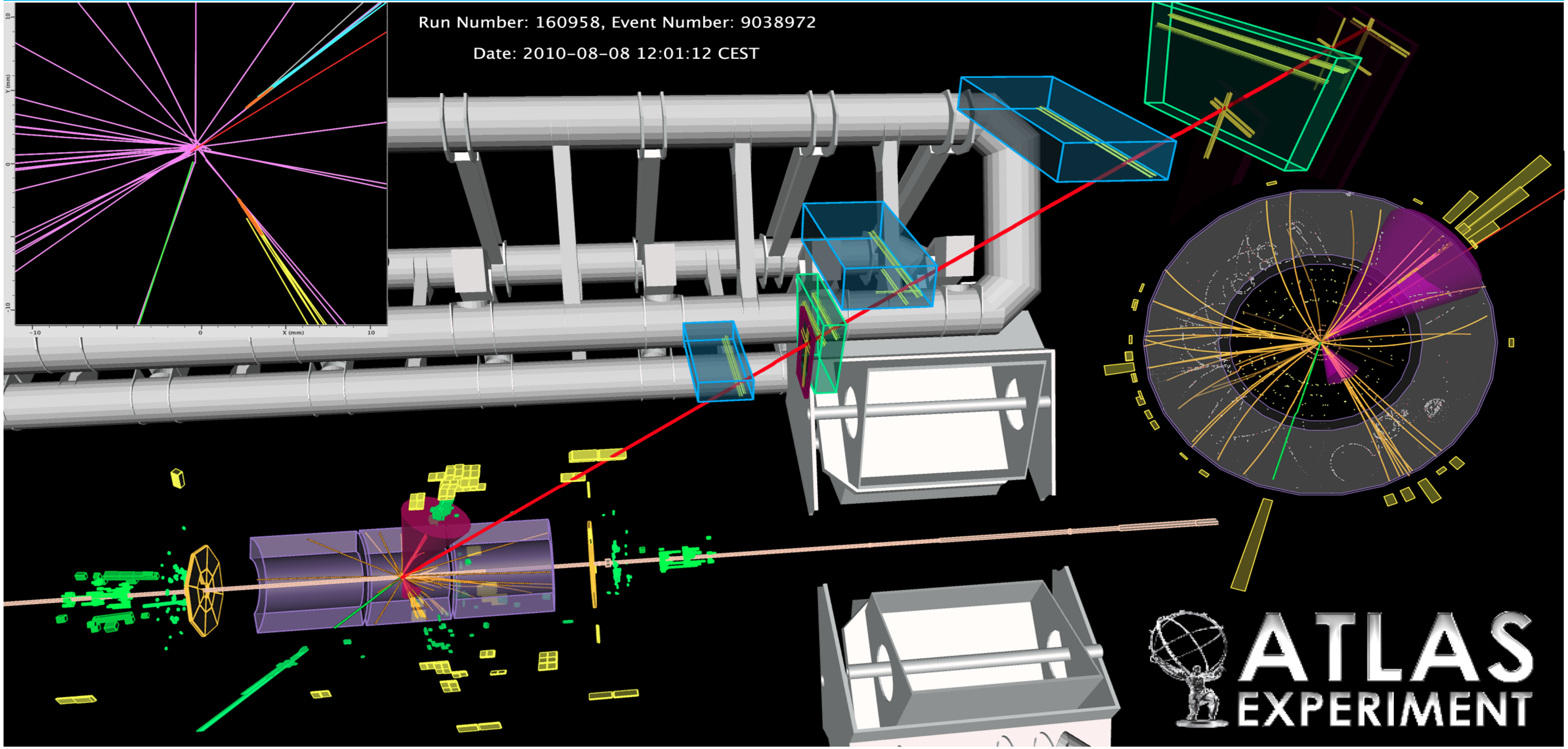
Recent results on jet and top physics from ATLAS

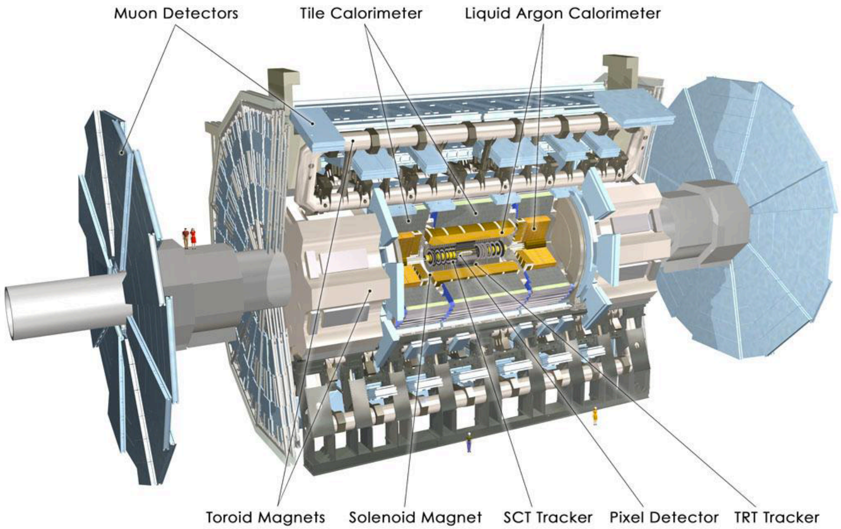


Hongbo Zhu

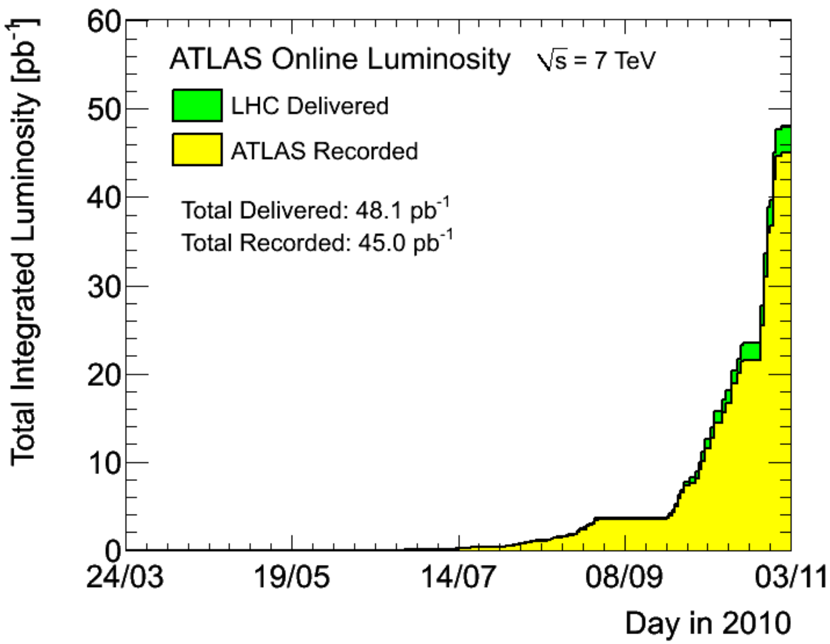
LHC Physics Discussion

21.03.2010

Introduction



- ATLAS collected ~45 pb^{-1} data at $\sqrt{s}$=7 TeV in 2010



Inner Tracking Detectors			Calorimeters				Muon Detectors			
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	CSC	TGC
99.1	99.9	100	90.7	96.6	97.8	100	99.9	99.8	96.2	99.8

Luminosity weighted relative detector uptime and good quality data delivery during 2010 stable beams in pp collisions at $\sqrt{s}$=7 TeV between March 30th and October 31st (in %). The inefficiencies in the LAr calorimeter will partially be recovered in the future.

Lumi. uncertainty ~3.4%

DESY

Part I: Jet

- Jet reconstruction and performance
  - Reconstruction and calibration
  - Energy scale uncertainty and validation in-situ
- Jet physics results
  - Inclusive jet and di-jet cross-section (*in approval*)
  - Multi-jet cross-section
  - Di-jet production with a jet veto
  - Measurement of di-jet azimuthal decorrelations (*arXiv:1102.2696*)

Jet reconstruction and calibration

- Calorimeter cells calibrated to electromagnetic scale
- 3D topological clusters (nearest neighbor energy significance to localize showers in the calorimeter, efficient noise suppression)
- Jets are reconstructed using the anti-kt algorithm with size parameter R 0.6 (0.4)

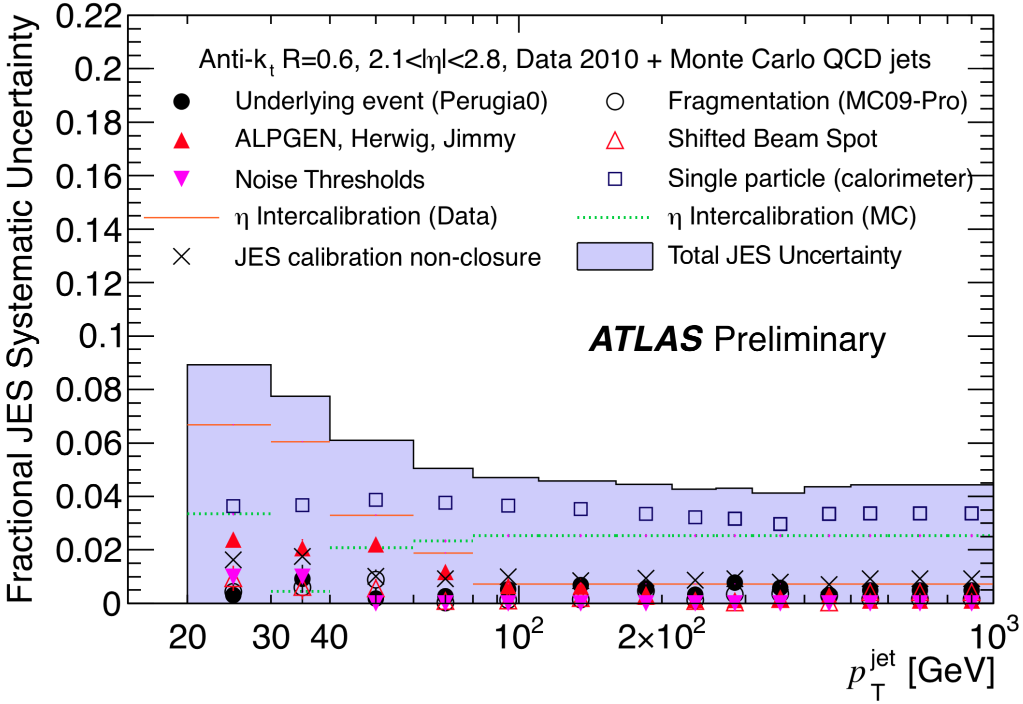
- Energy and momentum of jets measured in the calorimeter are corrected using kinematics of Monte Carlo truth jets as reference
- EM+JES schema – simple default Monte Carlo based calibration
  - (η, p_T) dependent correction factor E_{calo}^{EM}/E_{truth}

Jet energy scale uncertainty

ATLAS-CONF-2011-028

- Evaluated from combination of measurements and Monte Carlo
  - response and uncertainty of single hadrons measured in data and propagated to jets using MC, assessed up to |η|=4.5, using di-jet balance measurements, uncertainties from systematic variations of MC
  - evaluated from in-situ Monte Carlo, obtained systematic uncertainties in agreement with JES from single hadron response

ATLAS-CONF-2011-007



ATLAS-CONF-2011-014

- In-situ calibration
  - multi-jet balance
  - calorimeter jet-track balance
  - direct gamma jet balance
  - photon balance using missing transverse momentum projection

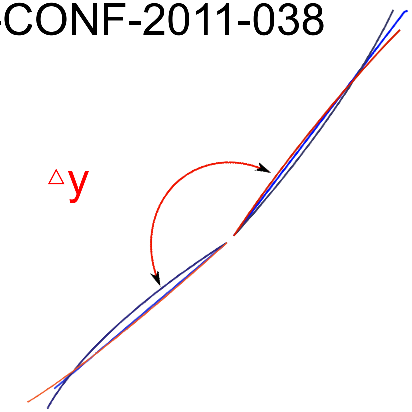
Jet energy resolution

- default calibration: EM+JES, simple jet (η, pT) approach on top of EM scale
- advanced calibration (% improvement):
  - global sequential calibration
  - global cell energy density based weighting
  - local cluster property based weighting
- Jet energy resolution measured in-situ with di-jets using di-jet balance and bi-sector techniques

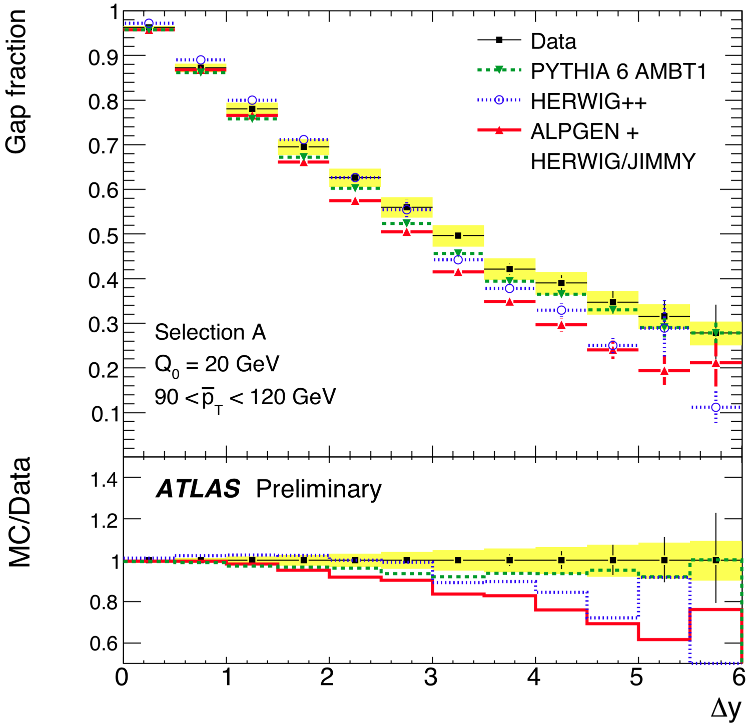
Di-jet production with a jet veto

ATLAS-CONF-2011-038

- Jet activity in rapidity gap between forward-backward jets (wide angle soft gluon radiation, color exchange ...)
- Gap events are identified as the subset of events that do not contain an additional jet with pT> Q0, using Q0=20 GeV

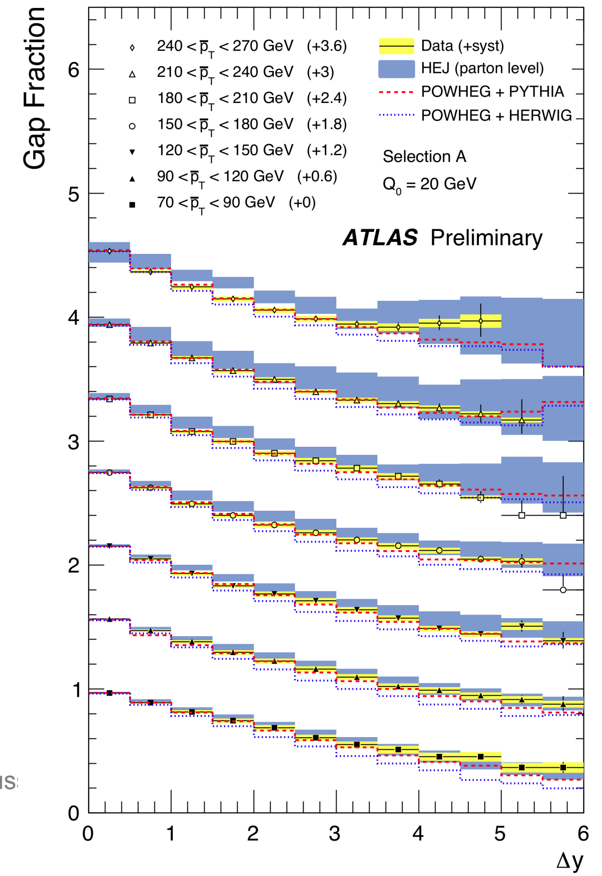


probability of no jets with pT> 20 GeV in the gap



LO: good agreement with PYTHIA, ALPGEN+HERWIG overestimation

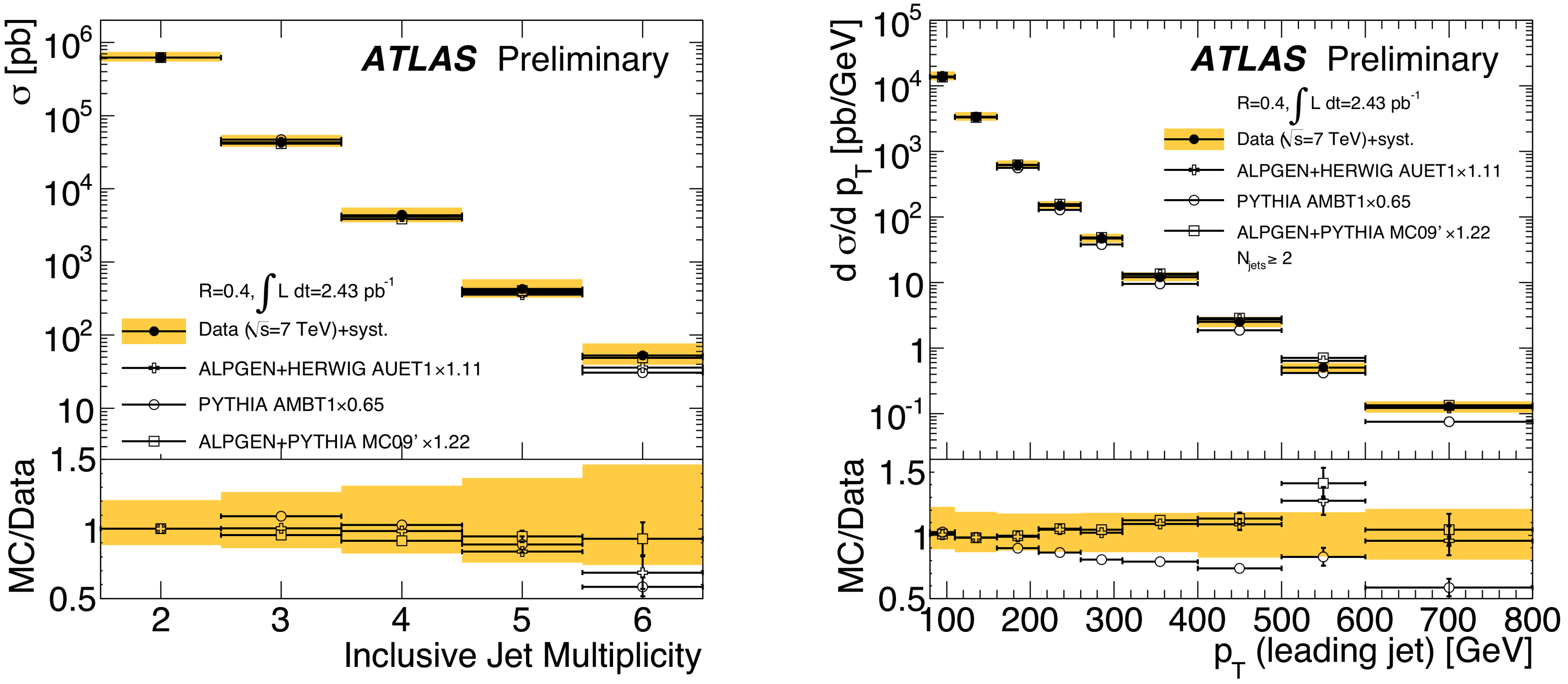
- HEJ predicts too little activities at large pT
- POWHEG(NLO) +PYTHIA gives the best description (but too much activity at large Δy)
- POWHEG+HERWIG predicts too much activity



Multi-jet cross section

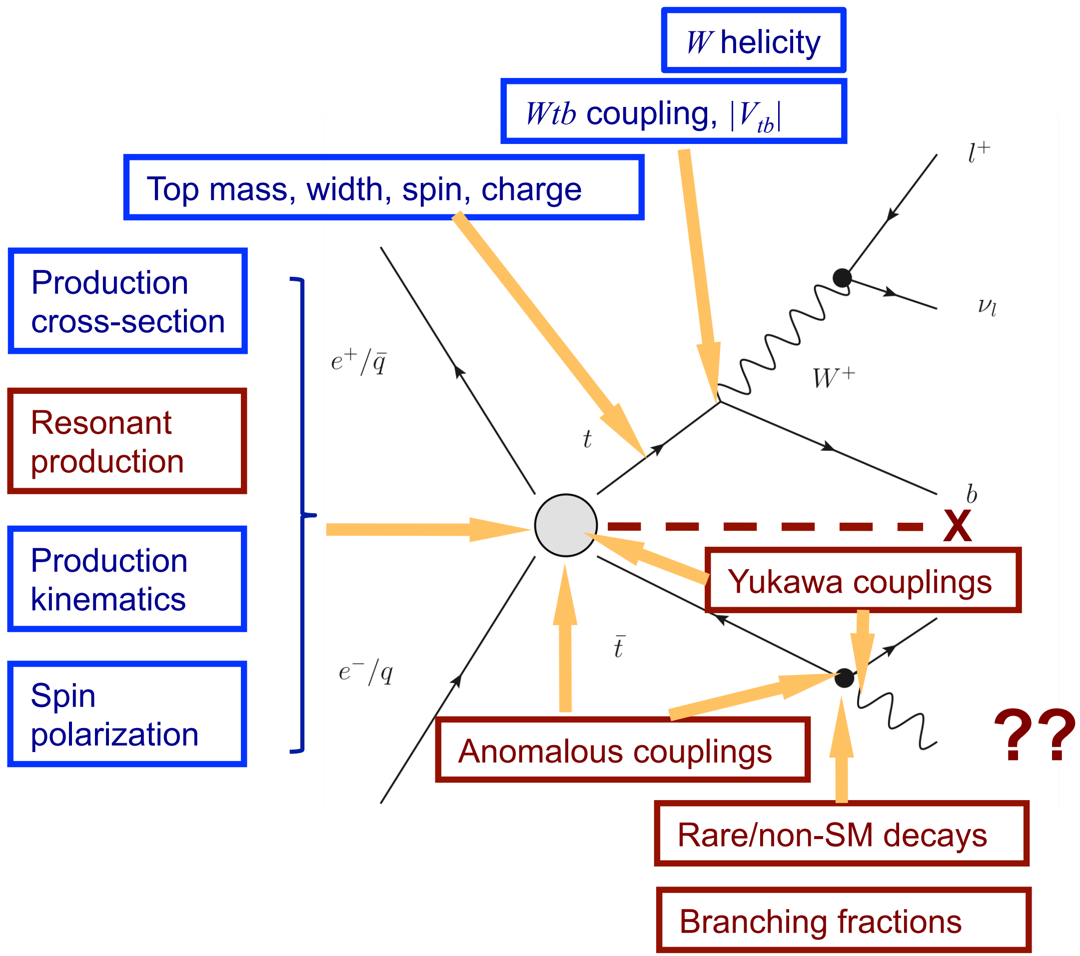
ATLAS-CONF-2011-043

- Jet multiplicity up to 6, with pT>60 GeV, leading jet pT>80 GeV
- Uncertainties on the differential cross section 20-40%

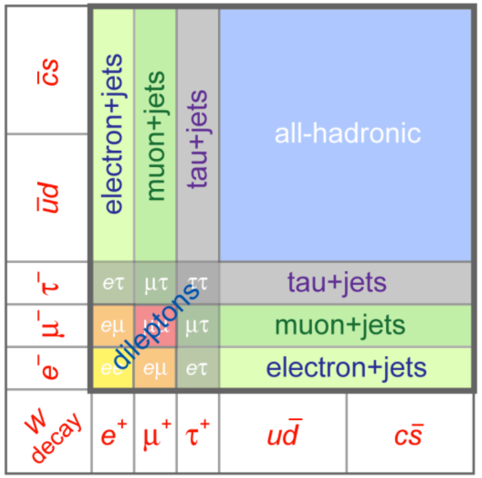


Part II: Top physics

- Production cross section (35 pb-1)
  - Single lepton pre-tag
  - Single lepton b-tag
  - Di-lepton (in approval)
  - Combination (in approval)
  - Single top
- Properties (35 pb-1)
  - top mass
  - W helicity
  - $t\bar{t}$ anomalous E_T^{miss}



Event selection



Electron
- Good isolated electron
- $E_T > 20$ GeV
- $|\eta| \in [0, 2.47]$ excluding [1.37, 1.52]

Muon
- Segments in tracker and muon detector
- Isolated track
- $p_T > 20$ GeV
- $|\eta| < 2.5$

ETmiss
- Vector sum of calo energy deposits
- Corrected for identified objects

Jet
- Topological clusters
- Anti-kT (R=0.4)
- MC-based calibration
- pT > 25 (20) GeV
- $|\eta| < 2.5$

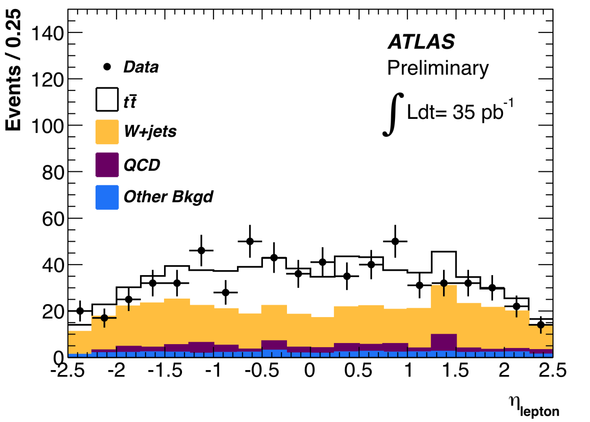
b-Jet
- Displaced tracks or secondary lepton
- SV0: reconstructed sec. vertex
- JetProb: track/jet compatibility with PV

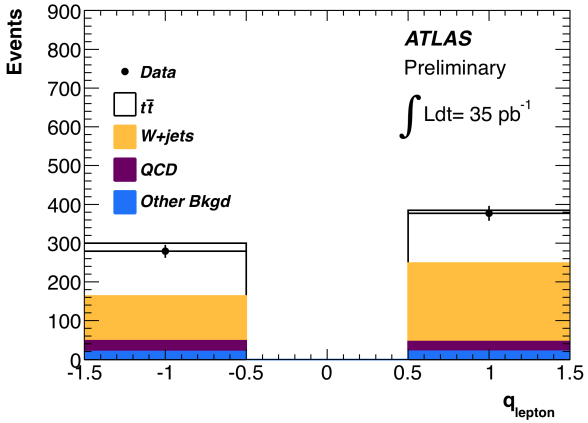
Event cleaning
- Good run conditions
- PV at least 5 tracks
- Bad jet veto
- Cosmic veto

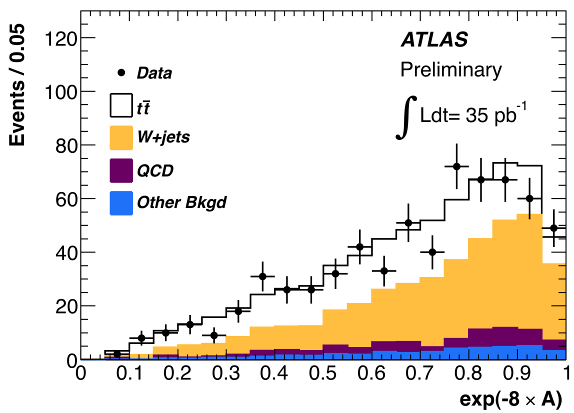
σ_{tt} Single lepton (without b-tagging)

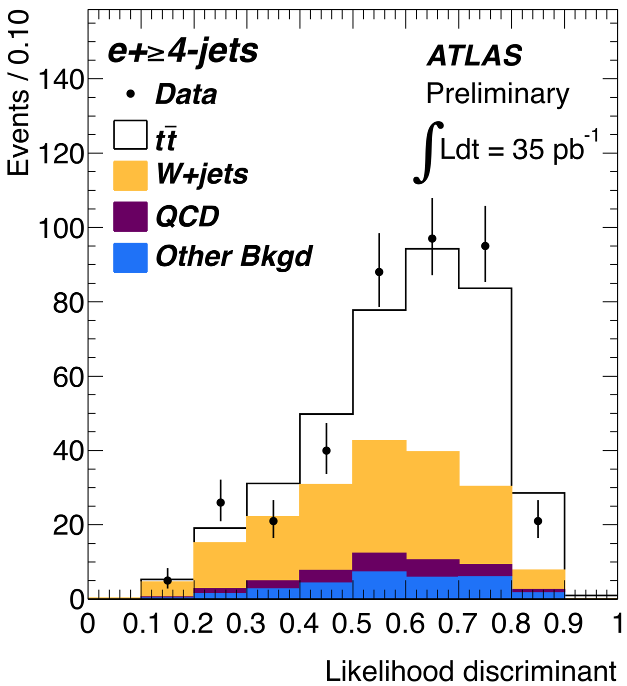
ATLAS-CONF-2011-023

- Project likelihood based on three discriminating variables









$$\sigma_{t\bar{t}} = 171 \pm 17(\text{stat.})^{+20}_{-17}(\text{syst.}) \pm 6(\text{lumi.})\ \text{pb}$$

syst. source	uncertainty %
Jet energy scale & resolution	-6.1/+5.7
ISR/FSR	-2.1/+6.1
QCD normalization	3.9
QCD shape	3.4
Parton shower & hadronization	3.3
Total	-10.2/+11.6

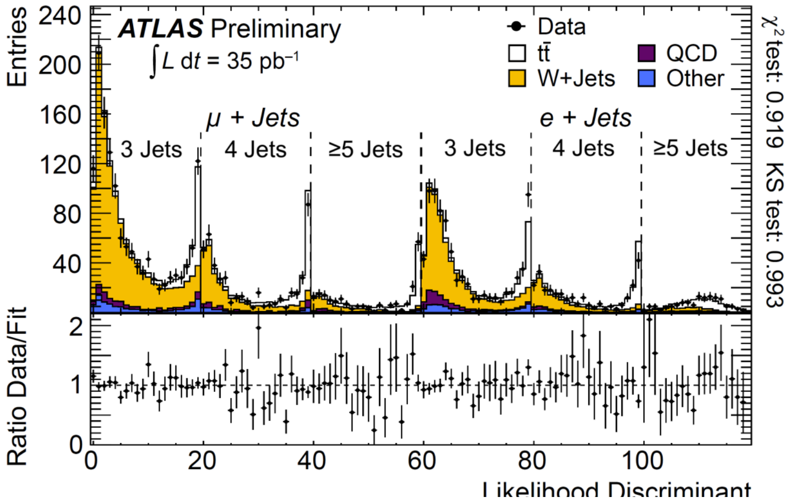
Binned maximum likelihood to 4 channels (3-jet, ≥4-jet; e,μ)

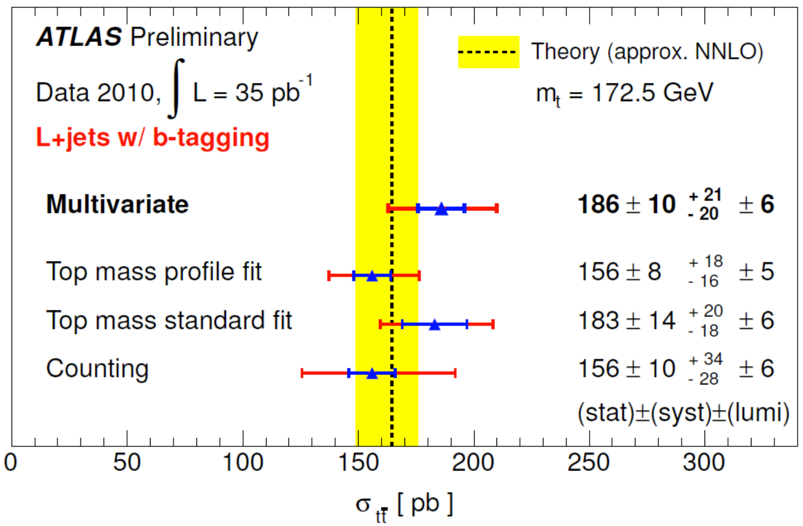
σ_{tt} Single lepton (with b-tagging)

baseline analysis from DESY & Goettingen

ATLAS-CONF-2011-035

- Project likelihood with 4 input variables: lepton η, aplanarity, $H_{T,3p}$, b-tag weight, in 6 channels (3-jets, 4-jets, ≥5-jets, e & μ)
- Profile likelihood fit to extract the cross section (and syst. uncertainties)





$$\sigma_{t\bar{t}} = 186 \pm 10(\text{stat.})^{+21}_{-20}(\text{syst.}) \pm 6(\text{lumi.})\ \text{pb}$$

Statistical Error (%)	**+5.3**	**-5.2**
Object selection (%)		
Jet energy scale	+3.8	-2.8
Jet reconstruction efficiency	+4.2	-4.2
Jet energy resolution	+0.8	-0.2
Electron scale factor	+1.2	-0.8
Muon scale factor	+0.5	-0.6
Electron smearing	+0.3	-0.2
Muon smearing	+0.6	-0.4
Background modeling (%)		
Wjets HF content	+7.2	-6.3
Wjets shape	+1.5	-1.5
QCD shape	+1.0	-1.0
$t\bar{t}$ signal modeling (%)		
ISR/FSR	+4.0	-4.0
NLO generator	+0.5	-0.7
Hadronisation	+0.0	-0.6
PDF	+1.7	-1.7
Others (%)		
b-tagging calibration	+7.5	-6.3
Simulation of pile-up	+1.5	-0.6
Templates statistics	+1.6	-1.5
Total Systematic (%)	**+11.5**	**-10.5**

DESY

Di-lepton, combined and extract mass from cross-section

- Conference notes are still in the pipeline of approval ...
- Main contribution from us to the note “extracting mass from cross-section measurements”

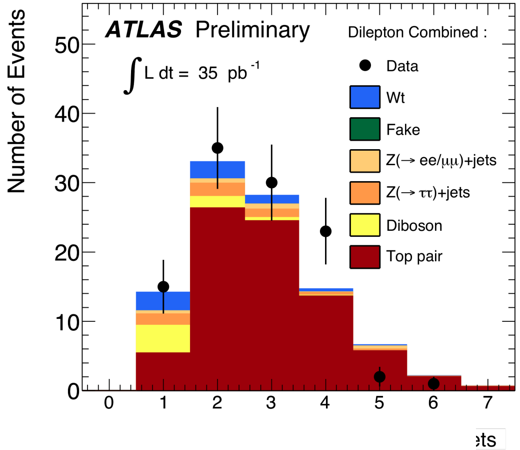
Di-lepton: ATLAS-CONF-2011-034

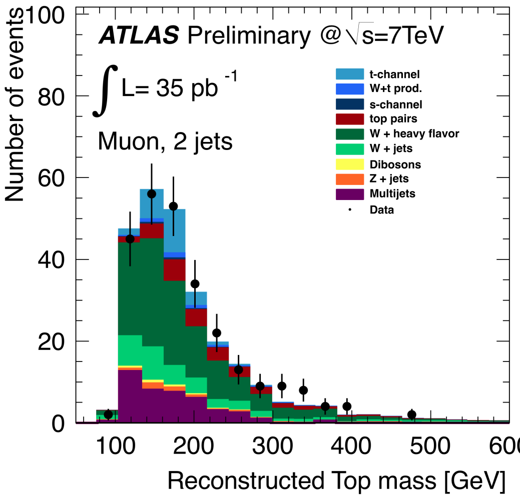
Single top: t- and Wt-channel

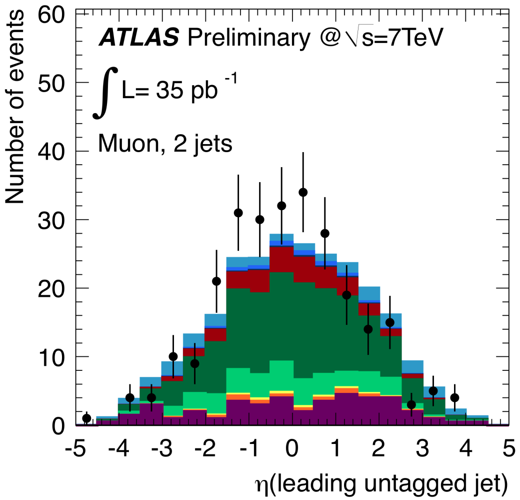
ATLAS-CONF-2011-027

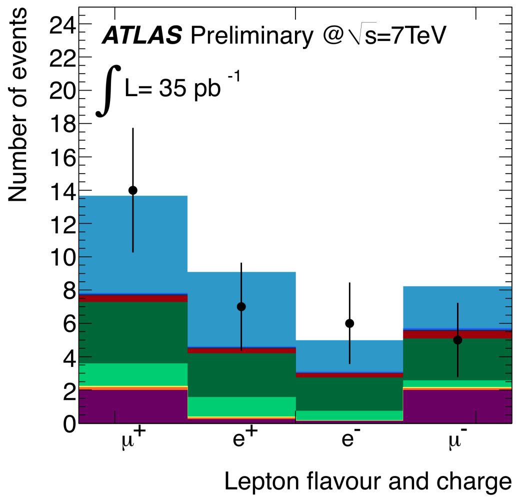
- t-channel: cut-based (cross-checked with likelihood method)
  - 1 lepton, 1 b-jet, 1 light-jet, Etmiss
  - Bkg: QCD multi-jet, W+jets
  - Final cut mtop (130, 210 GeV), |light-jet| > 2.5

$$\sigma_t = 53^{+27}_{-24}(\text{stat.})^{+38}_{-27}(\text{syst.}) = 53^{+46}_{-36}\ \text{pb}$$









- wt-channel: cut-based
  - l+jets: 2-4j jets, exactly 1 b-jet,
  - dilepton: data driven Z+jets, fakes, tt (from Njets >1)
  - combined channels, expect

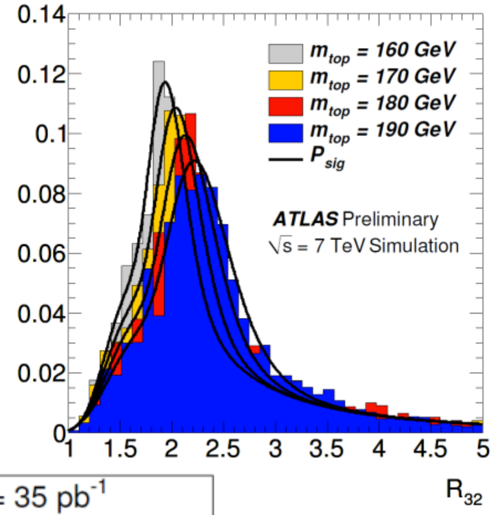
$$\sigma_{Wt} < 94\ \text{pb}$$

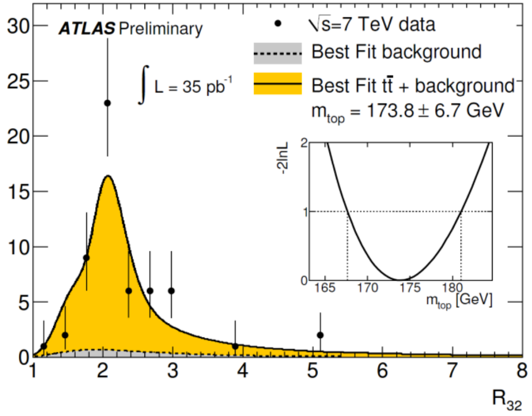
Top quark mass

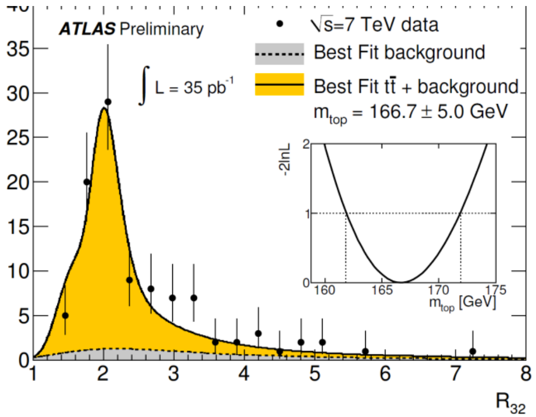
ATLAS-CONF-2011-033

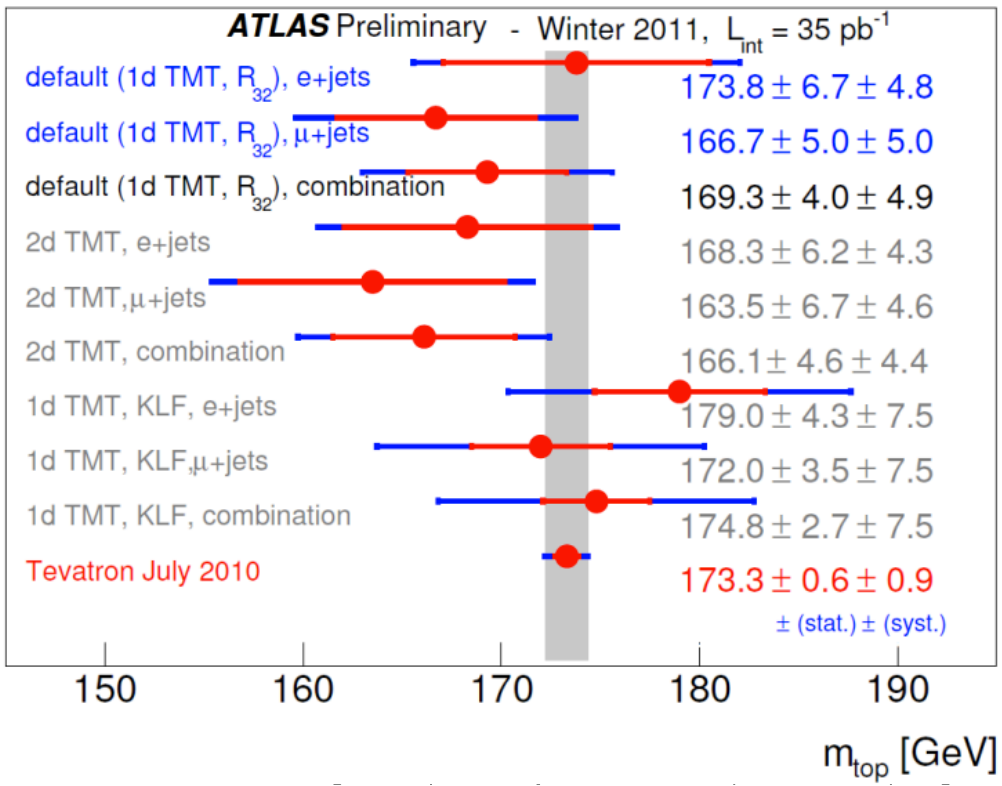
- Template in $R_{32} = m_{jjb}(t) / m_{jj}(W)$
- Cross checks: kinematic fit templates, 2D templates with JES scaling

$$m_{top} = 169.3 \pm 4.0(\text{stat.}) \pm 4.9(\text{syst.})\ \text{GeV}$$









More top physics analyses

- tt + anomalous Etmiss: ATLAS-CONF-2011-036
- W helicity in top decays: ATLAS-CONF-2011-037

Conclusion

- Recent results on jet and top from ATLAS have been presented. With the 2010 data, we have improved the jet calibration and looked into several jet physics. With 35 pb-1, we have already measured top production cross-section, mass, single-top and several properties.
- 2011: further improved understanding of the detector (reduced systematic uncertainties) and the year of top precision measurement (together with significantly more data)

Definition of input vairables

Lepton pseudorapidity $\eta = -\ln(\tan(\theta/2))$, cluster η for electrons

Aplanarity A: 1.5 times smallest eigenvector of momentum tensor $M_{ij} = \frac{\sum_{k=1}^{N'_{\text{objects}}} p_{ik} p_{jk}}{\sum_{k=1}^{N'_{\text{objects}}} p_k^2}$
→ transformed to exp[–8×A]

$H_{T,3p}$: transverse momentum of all but the leading two jets, divided by sum of absolute values of all longitudinal momenta in the event (neutrino p_z from solving event kinematics and taking solution with smallest p_z)

$$H_{T,3p} = \frac{\sum_{i=3}^{N_{\text{jets}}} |p_{T,i}^2|}{\sum_{j=1}^{N_{\text{objects}}} |p_{z,j}|}$$

→ transformed to $\exp[-4 \times H_{T,3p}]$

Continuous b-tagging weight w_{JP} from JetProb tagger → transformed to $-\log_{10}(w_{JP})$

Our choice: mean of two highest b-tagging weights (expect two b-jets in $t\bar{t}$ signal)