

Open bottom and charm production at ATLAS

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on behalf of the ATLAS Collaboration

Physics at LHC

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- Detector and triggers
- $D^{*\pm}$, D^\pm and D_s^\pm mesons
- B^\pm , B_d and B_s mesons
- b-jet cross-sections



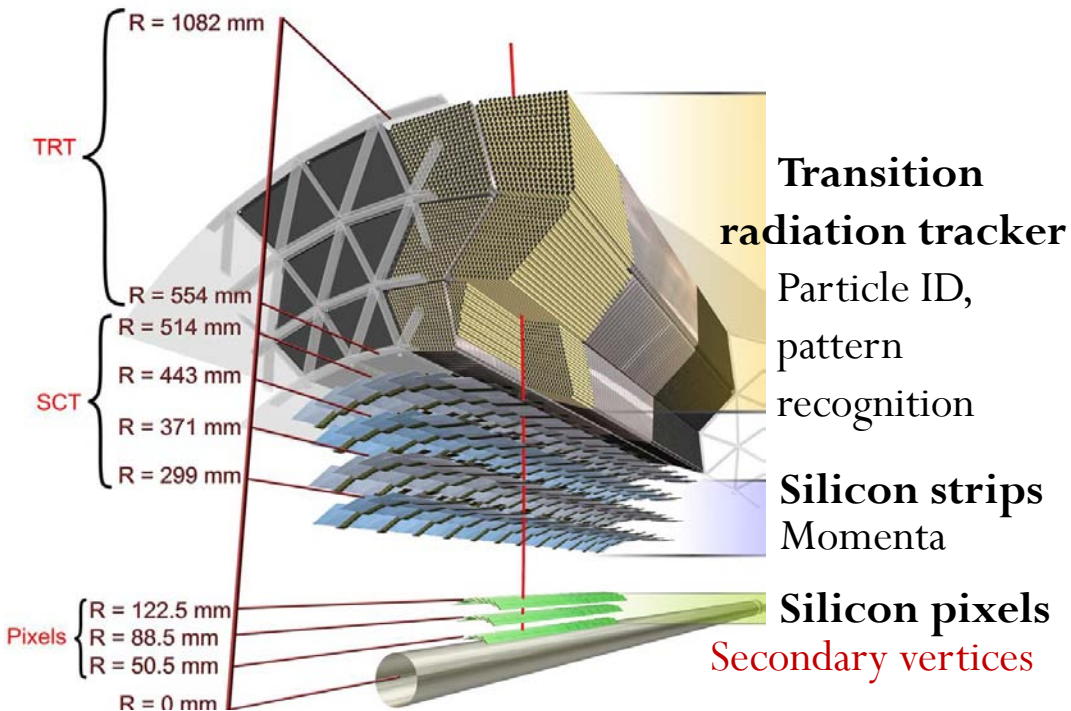
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SOCIETY

The ATLAS detector for B physics

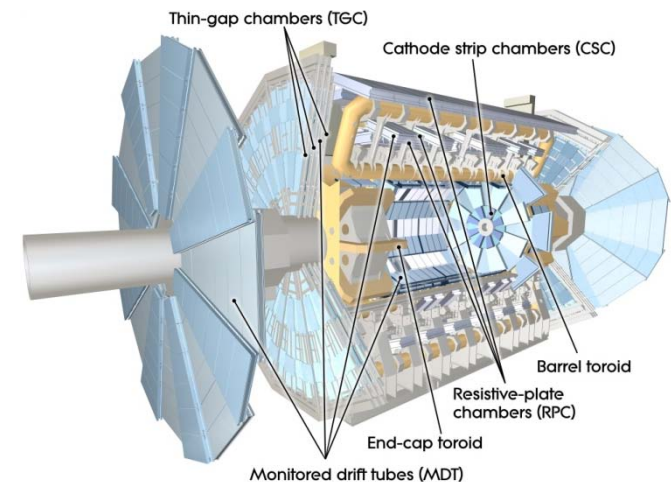
Inner detector



- Covers $|\eta| < 2.5$
- Solenoidal B-field, 2T
- $\sigma/p_T \sim 3.4 \times 10^{-4} p_T \oplus 0.015$ for $|\eta| < 1.5$

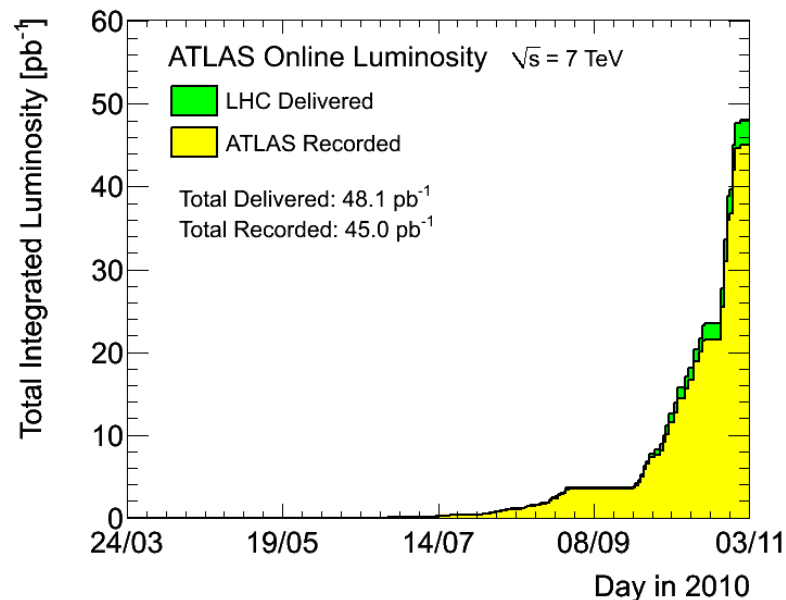
Muon system

- Precise tracking chambers and trigger chambers
- $|\eta| < 2.7$
- Toroidal B-field, $\sim 0.5 \text{ T}$
- $\sigma/p_T < 10\%$ up to $\sim 1 \text{ TeV}$



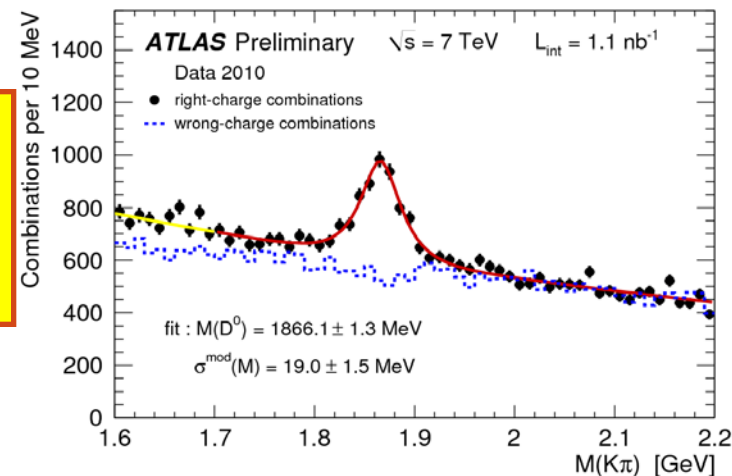
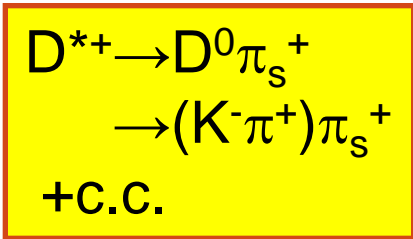
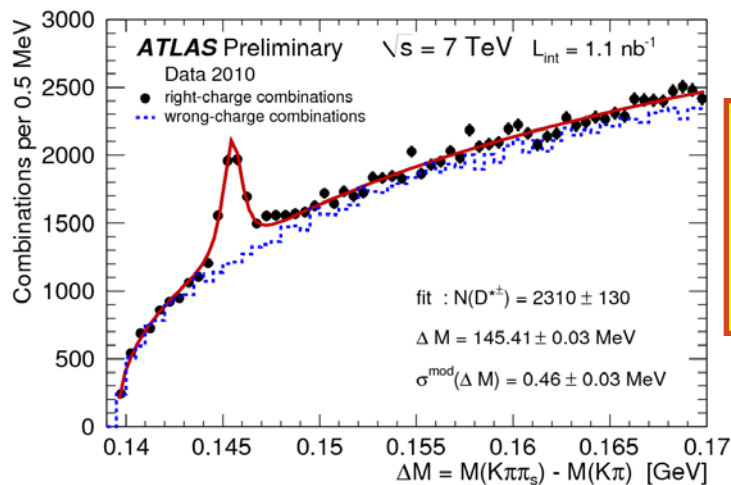
Triggers

- All analyses presented here use 2010 data
- Integrated luminosity increased steadily and some early triggers were prescaled
- A variety of triggers used for these analyses
 - D mesons: **minimum bias** and **random**
 - Fully efficient, prescaled beyond first data
 - B mesons: **single muon** and **dimuon**
 - Thresholds 0-10 GeV
 - b-jet cross-section: **min. bias** and **jet**
 - Thresholds chosen to be fully efficient for each p_T bin



D mesons

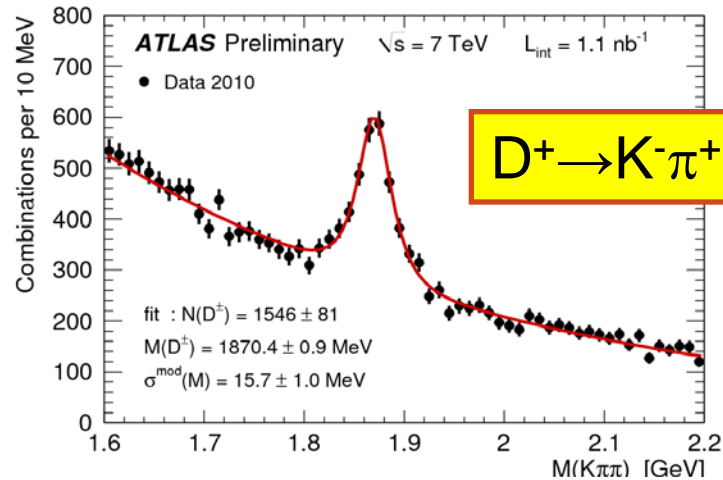
- Charmed mesons produced in c and b quark hadronisation
- High cross-sections, clear signatures
- Validate tracking and vertex reconstruction
- Test **NLO QCD** predictions



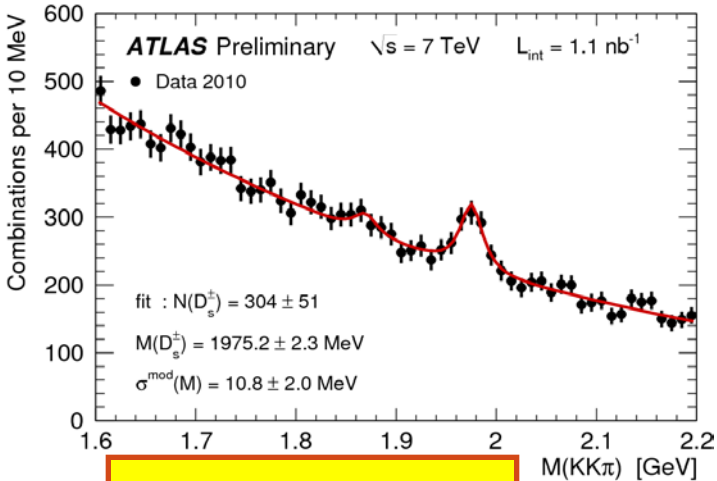
- Hard production and fragmentation \rightarrow cuts on $p_T(D^*)$, $p_T(K, \pi)$, $p_T(D^*)/\Sigma E_T$

- Charge constraints $q(K) = -q(\pi, \pi_S)$
- Vertex reconstruction $D^{*\pm}, D^0$
- Decay length $L_{XY}(D^0) > 0$

D meson cross-sections



- Cross-section uncertainties from
 - Track reconstruction and selection
 - D meson selection
 - Model dependence of acceptance
 - Signal fits
 - Luminosity and branching ratios



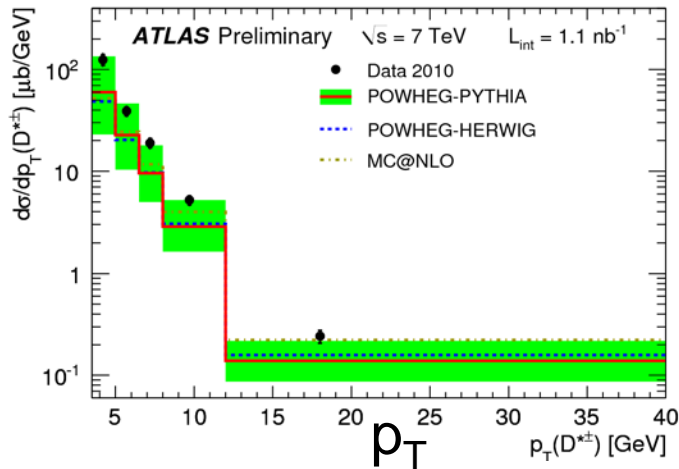
$$\sigma^{\text{vis}}(D^{*\pm}) = 285 \pm 16(\text{stat.})_{-27}^{+32}(\text{syst.}) \pm 31(\text{lum.}) \pm 4(\text{br.}) \mu\text{b}$$

$$\sigma^{\text{vis}}(D^{\pm}) = 238 \pm 13(\text{stat.})_{-23}^{+35}(\text{syst.}) \pm 26(\text{lum.}) \pm 10(\text{br.}) \mu\text{b}$$

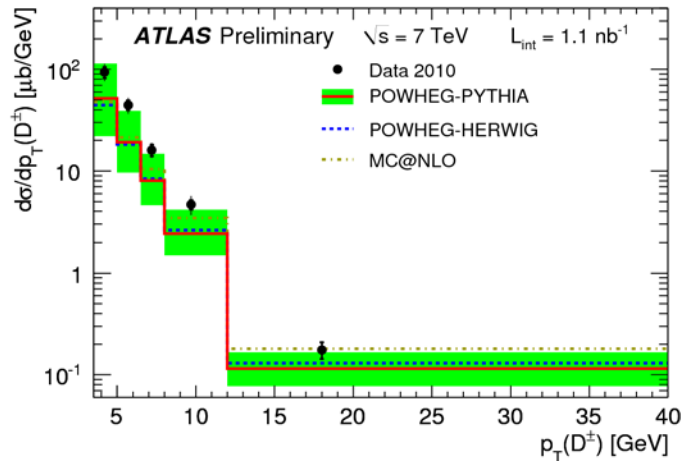
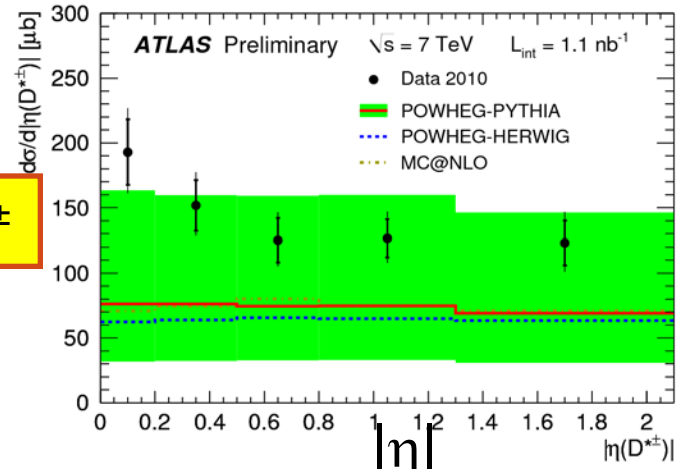
$$\sigma^{\text{vis}}(D_s^{\pm}) = 168 \pm 34(\text{stat.})_{-25}^{+27}(\text{syst.}) \pm 18(\text{lum.}) \pm 10(\text{br.}) \mu\text{b}$$

$$p_T(D^{(*)}) > 3.5 \text{ GeV and } |\eta(D^{(*)})| < 2.1$$

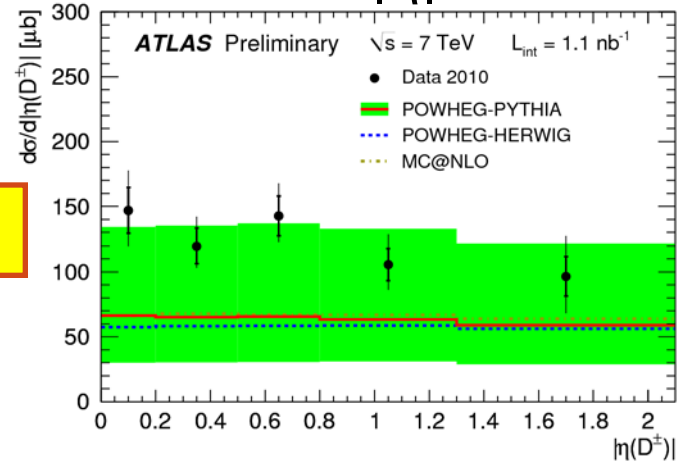
D meson differential cross-sections



$D^{*\pm}$



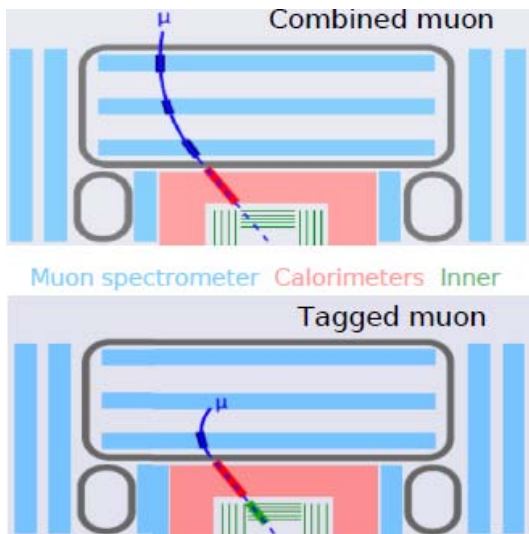
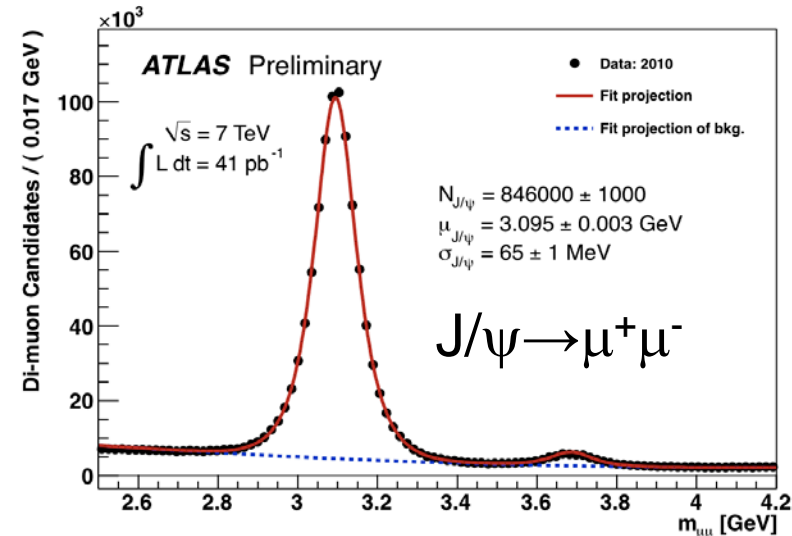
D^{\pm}



- Data higher than NLO predictions, but within large theoretical (scale) uncertainties

Exclusive B meson reconstruction

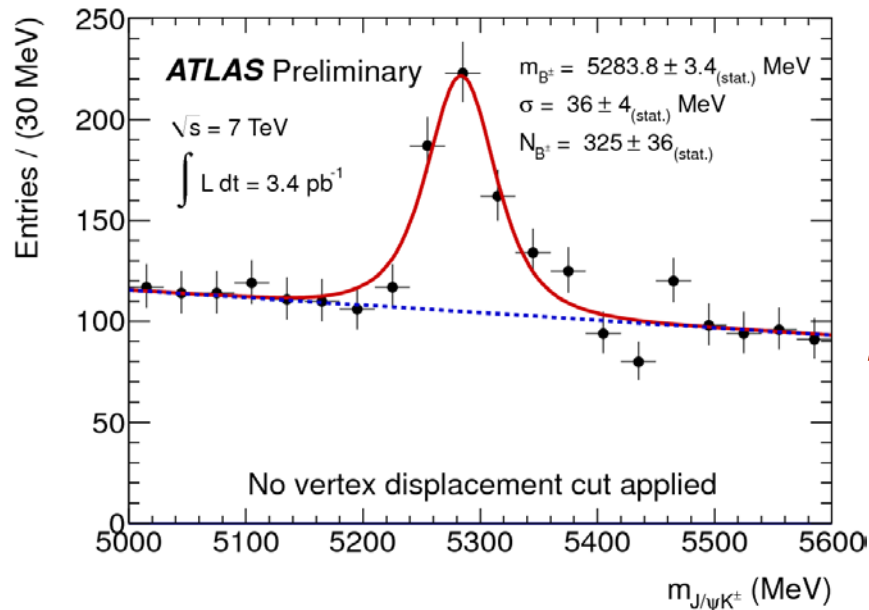
- Aim to study flavour tagging, mixing, CP violation, branching ratios
- Initial studies test detector and trigger performance
- Use $B \rightarrow J/\psi(\mu^+\mu^-) + X$ decays



- Muon reconstruction
 - Combined muons: match inner detector and muon **tracks**
 - Tagged muons: match inner detector tracks to muon **segments** (low p_T)
- Require ≥ 1 combined muon for J/ψ

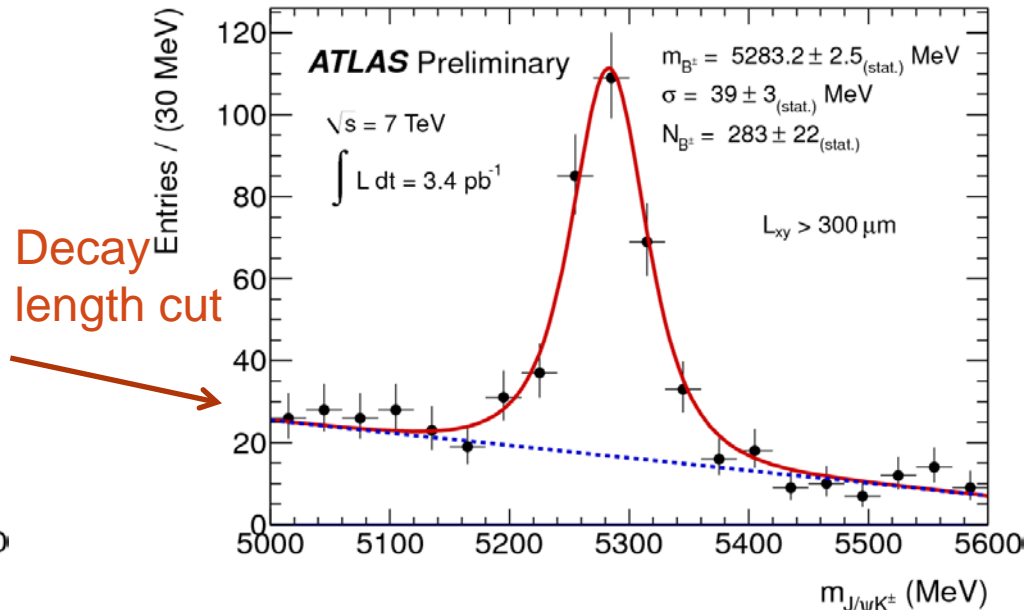
Observation of $B^\pm \rightarrow J/\psi(\mu^+\mu^-)K^\pm$

- Select additional track, assign **kaon mass**
- Fit 3-track vertex; constrain $\mu^+\mu^-$ to $M(J/\psi)$
- Unbinned max. likelihood fit : **Gaussian signal, linear background**
- Enhance signal with **transverse decay length cut**



$M(\text{PDG}) = 5279.17 \pm 0.29 \text{ MeV}$

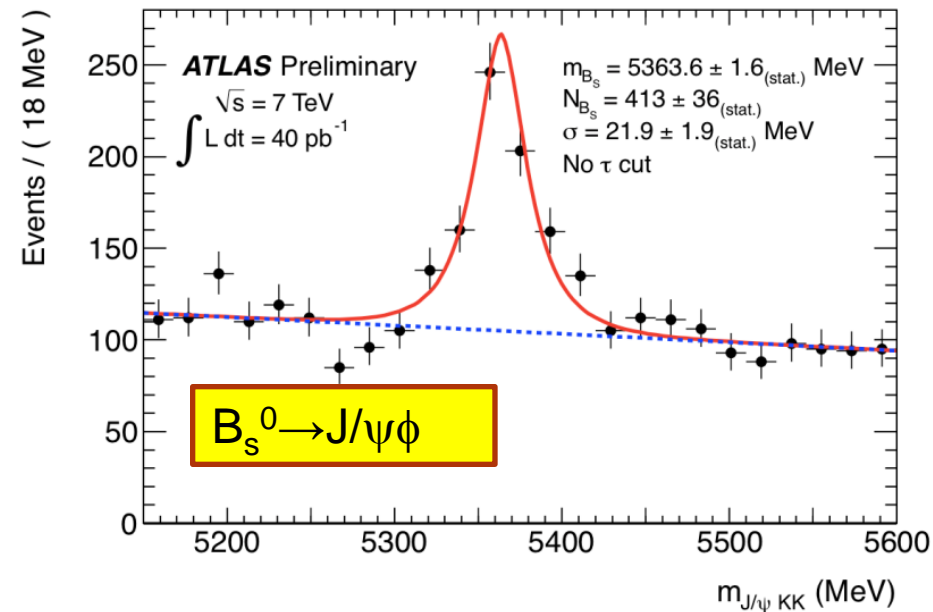
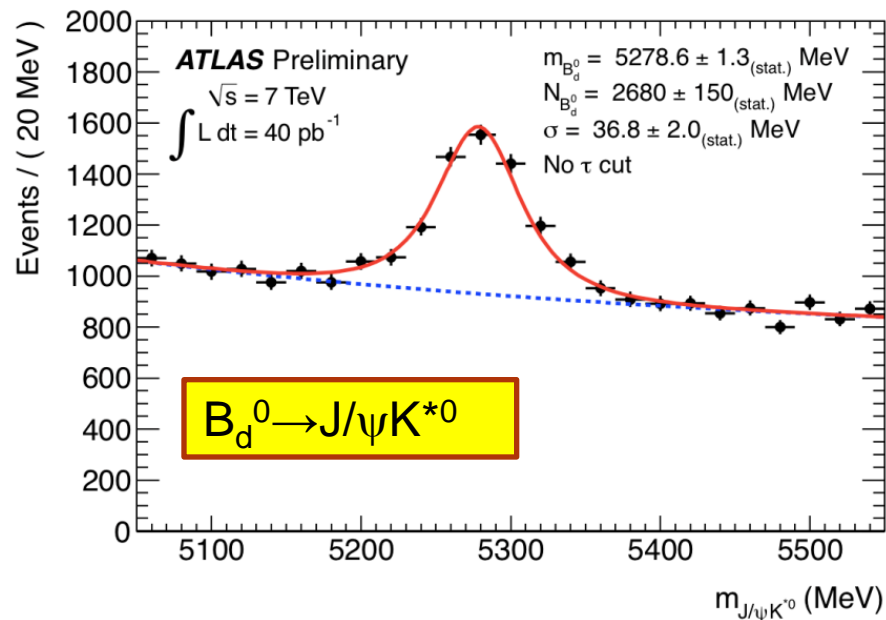
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Consistent results for B^+ and B^-

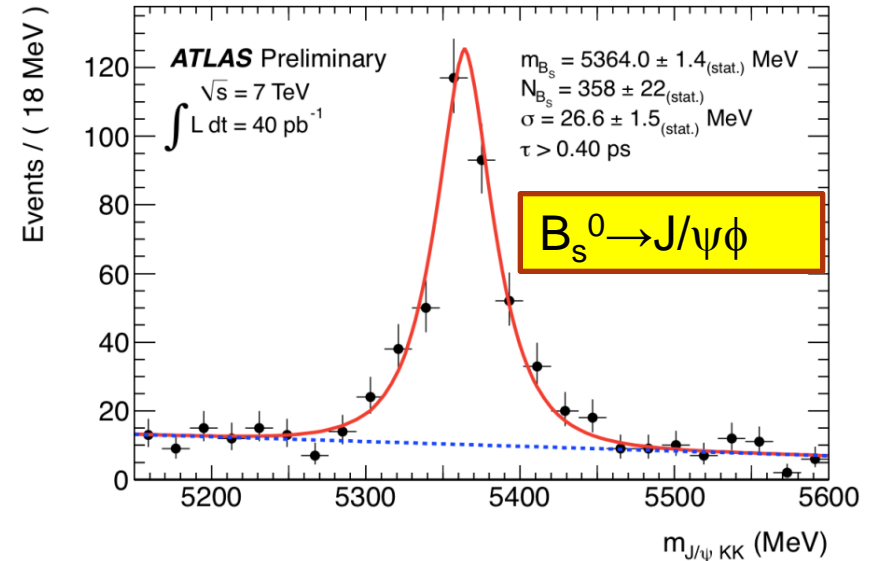
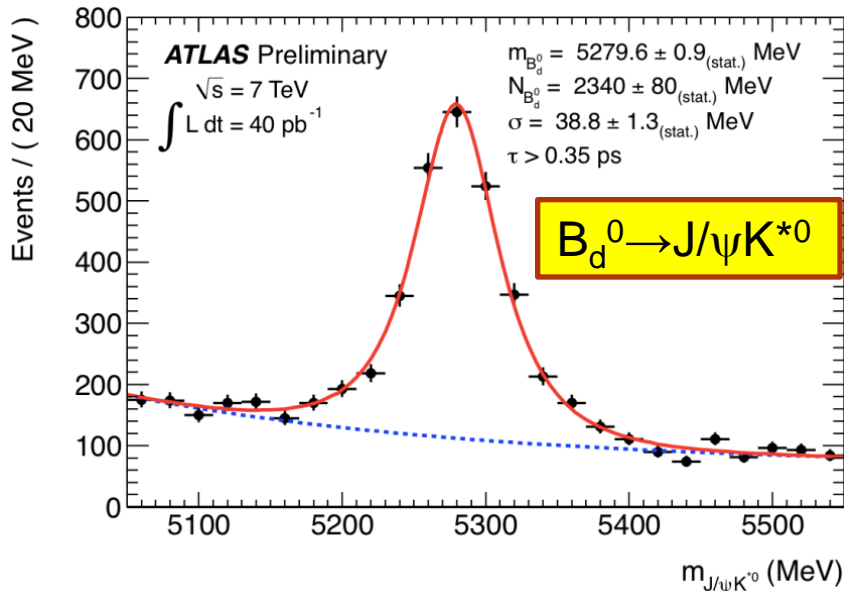
Observation of $B_d^0 \rightarrow J/\psi K^{*0}$, $B_s^0 \rightarrow J/\psi \phi$

- Select 2 additional tracks, assume $K^{*0} \rightarrow K^+ \pi^-$ or $\phi \rightarrow K^+ K^-$
- Fit 4-track vertex; constrain $\mu^+ \mu^-$ to $M(J/\psi)$
- Apply cuts on $M(\phi)$ or $M(K^{*0})$
- Unbinned max. likelihood fit : Gaussian signal, linear background



Observation of $B_d^0 \rightarrow J/\psi K^{*0}$, $B_s^0 \rightarrow J/\psi \phi$

- Add **decay time** cut on fitted secondary vertex

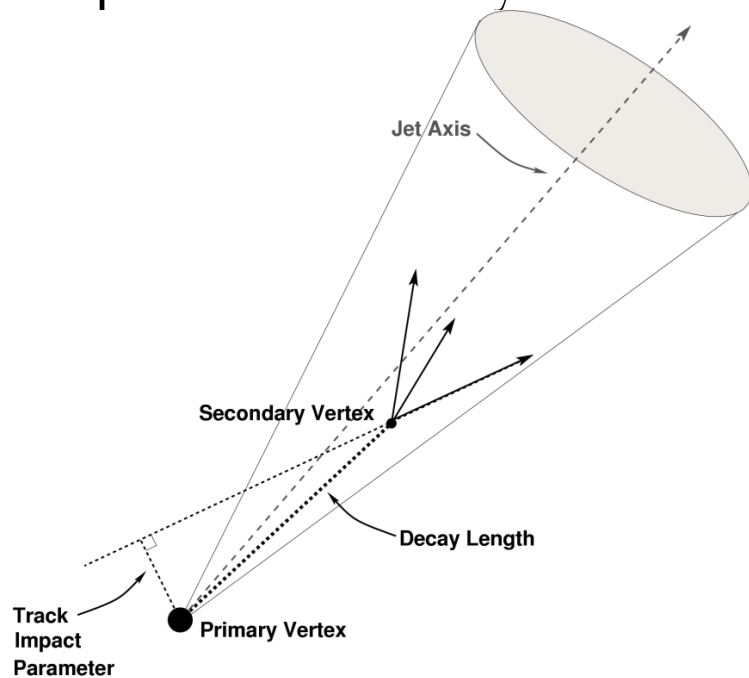


		m_B	σ_m	N_{sig}	N_{bkg}
B_d^0	no τ cut	5278.6 ± 1.3 MeV	36.8 ± 2.0 MeV	2680 ± 150	10280 ± 110
	with τ cut	5279.6 ± 0.9 MeV	38.8 ± 1.3 MeV	2340 ± 80	1330 ± 60
B_s^0	no τ cut	5363.6 ± 1.6 MeV	21.9 ± 1.9 MeV	413 ± 36	764 ± 17
	with τ cut	5364.0 ± 1.4 MeV	26.6 ± 1.5 MeV	358 ± 22	90 ± 7

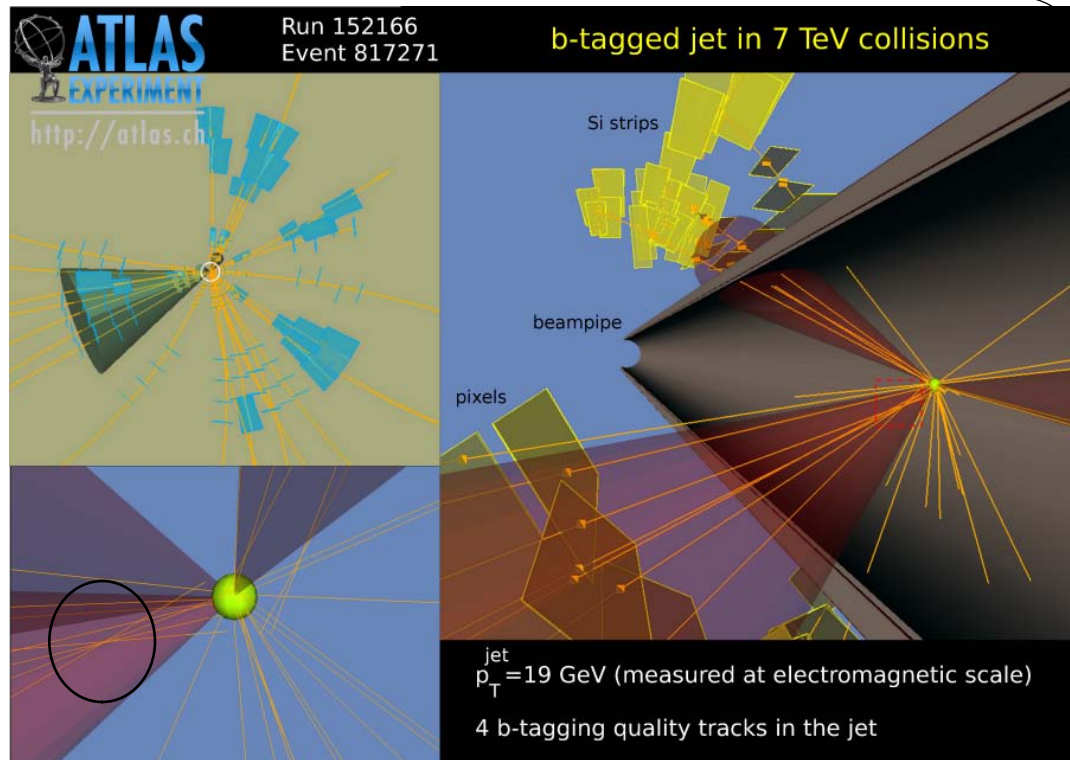
Consistent with PDG masses

b-jet tagging

- Reconstruct jets using calorimeter clusters
 - Anti- k_t jets, $R=0.4$
- Enrich b-jet content with displaced secondary vertex



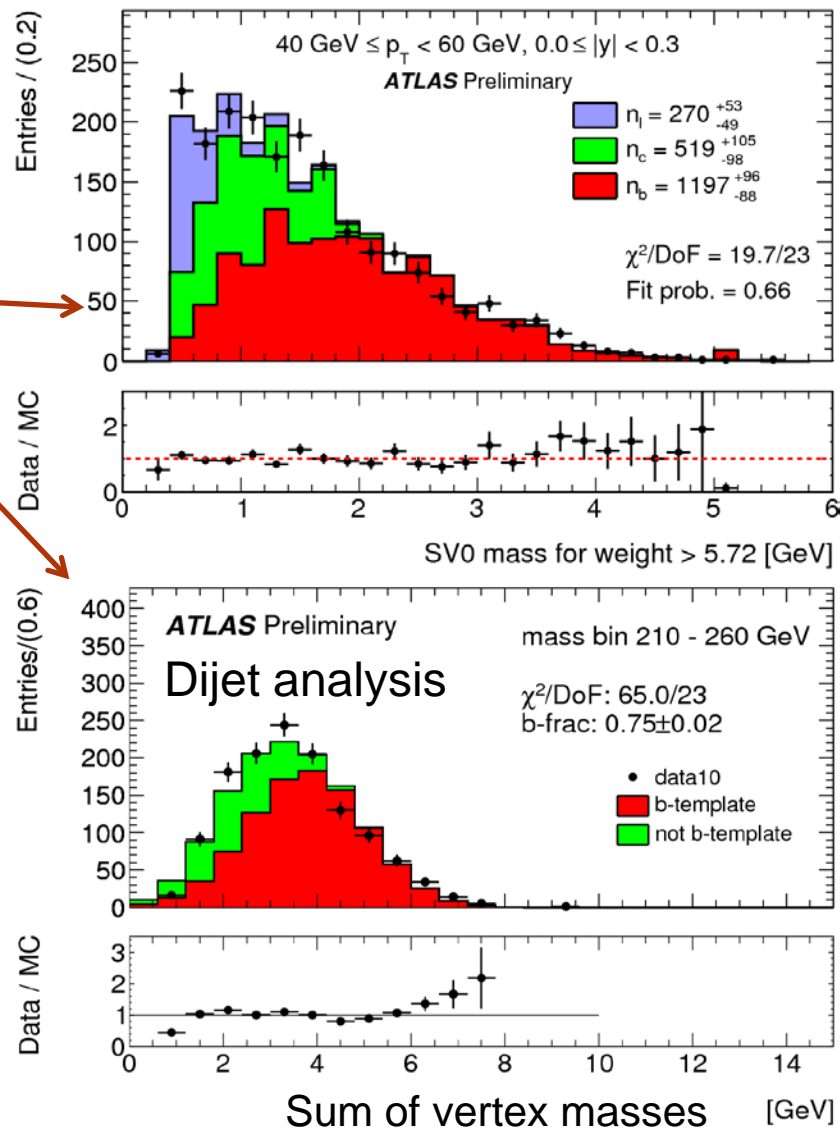
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- SV0 b-tagging algorithm takes tracks
 - $\Delta R < 0.4$ from jet axis
 - With track quality requirements
- Merge tracks into common vertex
- Cut on decay length significance: L/σ_L

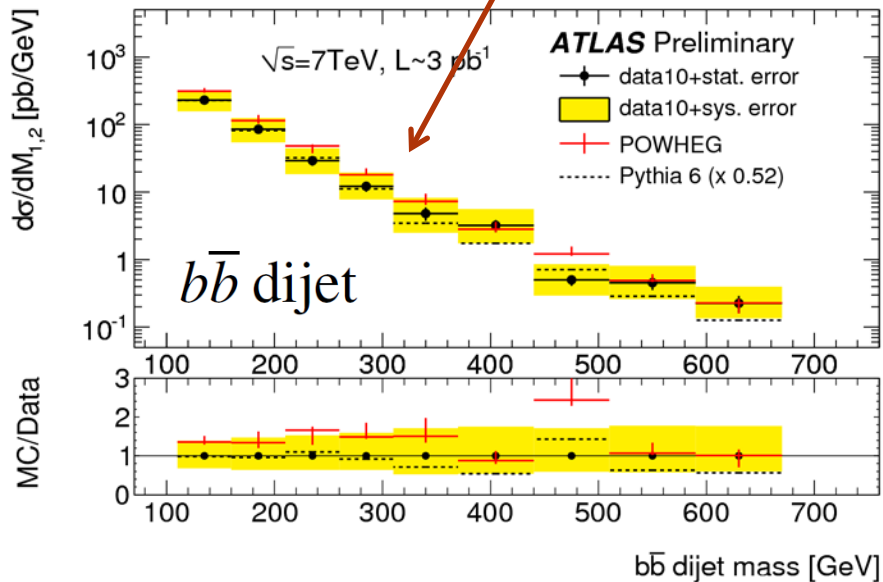
b-jet cross-section evaluation

- Identify b-jets with *SV0 tagging*
- b fraction obtained from binned likelihood fit to *vertex mass* distribution, using MC templates
 - for bins of jet p_T and jet rapidity
 - calculate differential cross-sections
- Efficiency correction from alternative tagger
- Bin-by-bin corrections for detector effects

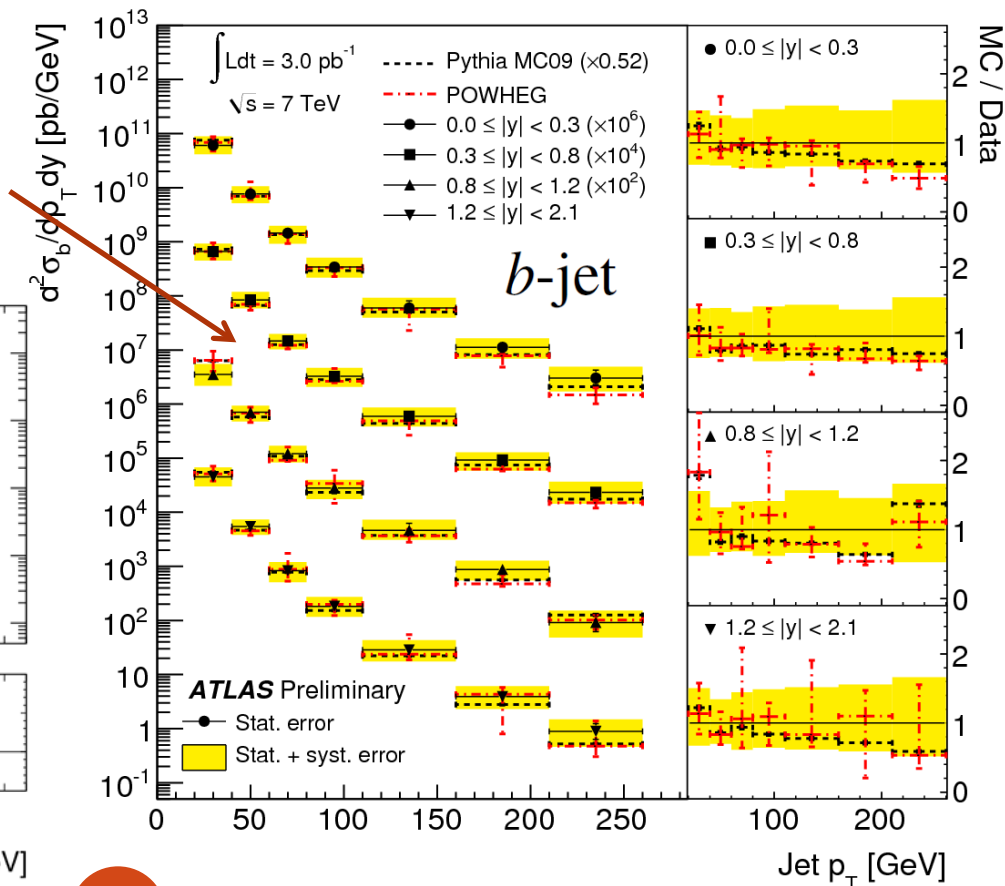


Inclusive b and bb cross-sections

- Systematics dominated by b-jet energy scale, b-tagging efficiency and purity determination
- PYTHIA (LO+LL) describes shapes reasonably, but not normalisation
- **POWHEG (NLO)** shows steeper drop with p_T than data and higher dijet cross-section

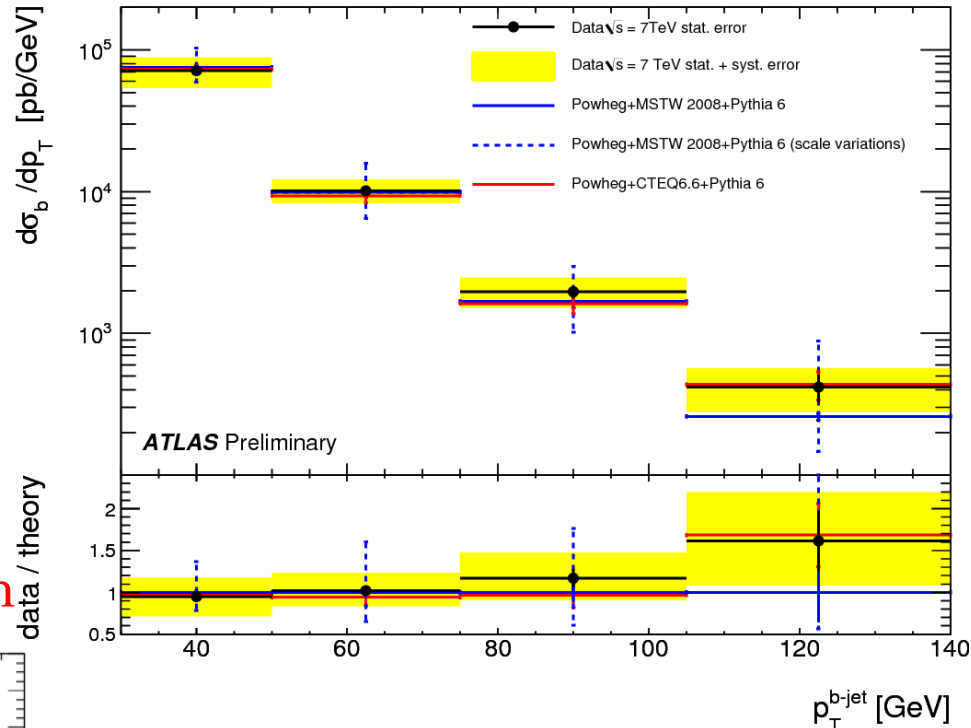
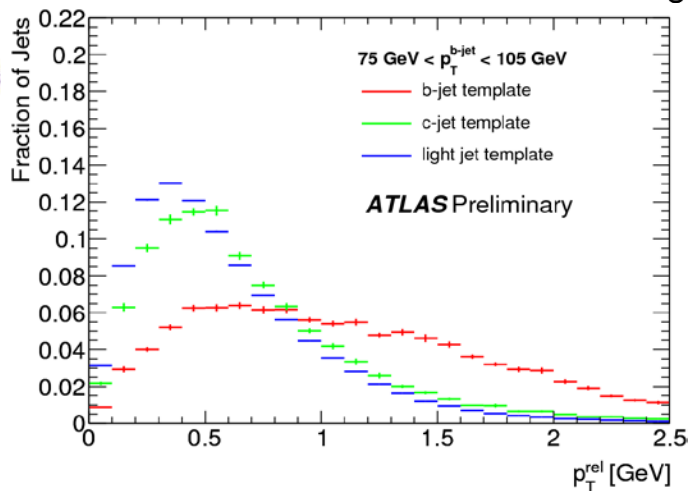
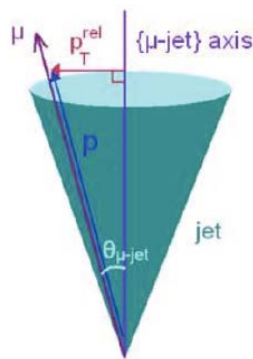


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b-jet cross-section using muons in jets

- Select a sample of jets containing soft muons
 - Anti- k_t jets, $R=0.4$
 - Muons $\Delta R < 0.4$ from jet axis
- Fit distribution of muon momentum relative to jet axis, p_T^{rel} , using templates \rightarrow **b fraction**



- Largest uncertainties from **light jet templates**
- **POWHEG (NLO)** agrees within uncertainties
- Consistent with secondary vertex results

Summary

- Many interesting results from the first year of data in ATLAS
 - Integrated and differential cross-sections for $D^{(*)}$ mesons
[ATLAS-CONF-2011-017](#)
 - Observation of B mesons: $B^{\pm} \rightarrow J/\psi K^{\pm}$, $B_d^0 \rightarrow J/\psi K^{*0}$, $B_s^0 \rightarrow J/\psi \phi$
[ATLAS-CONF-2010-098](#), [ATLAS-CONF-2011-050](#)
 - Inclusive b-jet and dijet cross-sections using vertex tagging and muons in jets
[ATLAS-CONF-2011-056](#), [ATLAS-CONF-2011-057](#)
 - Details on <https://twiki.cern.ch/twiki/bin/view/AtlasPublic>
- Updates and new analyses with more data are in progress