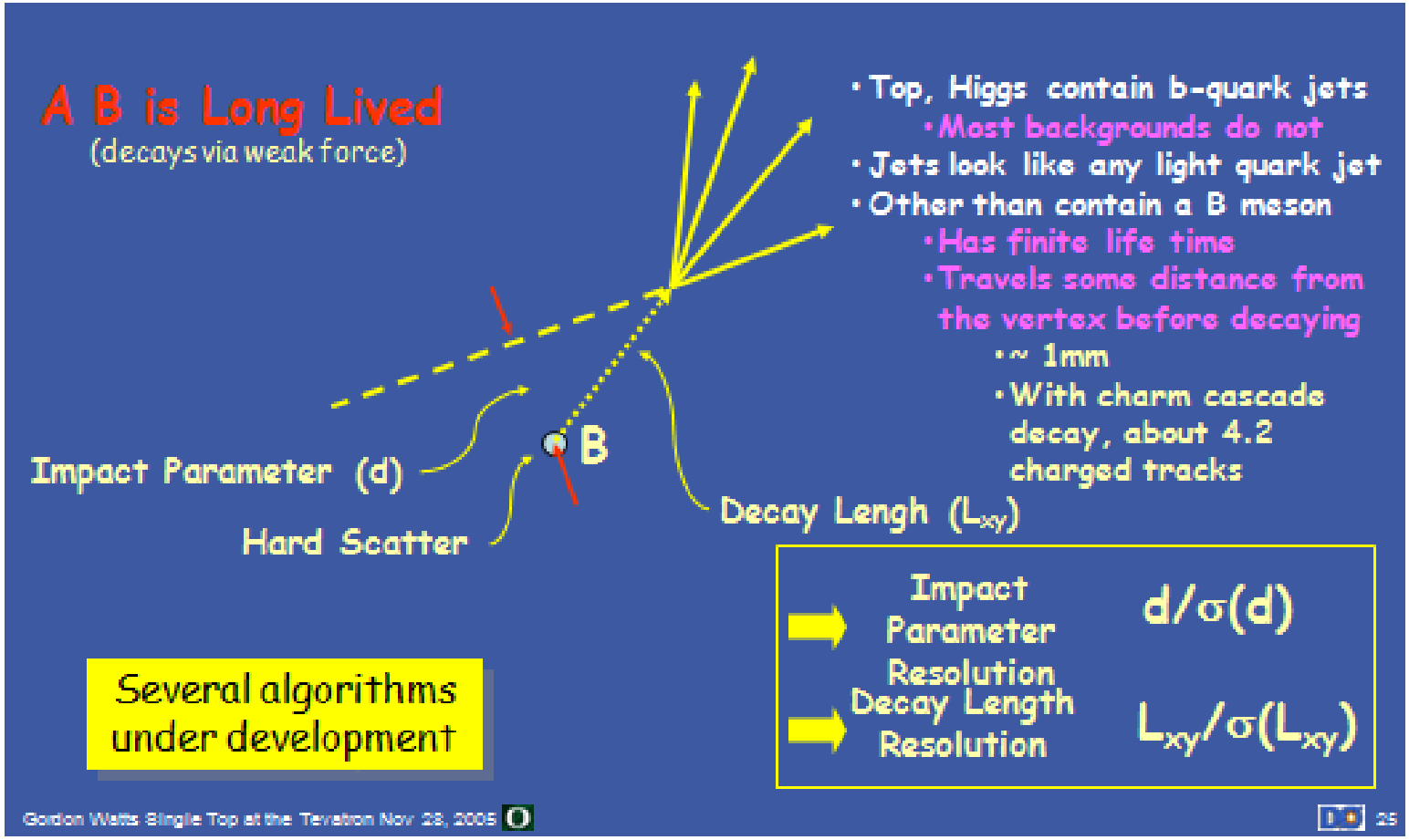
BTAGGING AT ATLAS

G. Watts (U Washington – Seattle/CPPM – Marseille)

Anatomy of a B-Hadron Decay



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Tagging Algorithms

- Impact Parameter
  - Displaced vertices generate displaced tracks
    - Large impact parameters
  - Rely on impact parameter significance (IP$/\sigma_{IP}$).
  - Likelihood fit or straight out cut
- Secondary Vertex
  - Attempt to reconstruct the bottom-quark's decay vertex.
  - Cuts on track quality, L_{xy}, $L_{xy}/\sigma_{L_{xy}}$, etc.
- Soft Lepton Tagger
  - Look for muon/electron from B or $B \rightarrow D$ cascade decay
  - Rate is low. Very difficult to do electron tagger

Combined Algorithms

- Use the results of the previously mentioned algorithms
  - Combined with other input variables
  - Use MVA techniques
  - Can see gains of 20% or so
  - Calibration will be very difficult!!

Variables We Care About To Tag

- Track Parameters
  - In particular the impact parameter significance!
  - 2D and 3D parameters
- SV Parameters
  - Decay length in particular
- Soft electron, muon
- Sum of track pT's
- Jet specific variables
  - Total energy, E_T, etc.
- Count of 2-track vertices in jet
- # of tracks in the jet
- Vertex Mass

These are all per-jet variables!
Are there Wb/Wbb variables that could be used to enhance this?

Rejection

Efficiency

Exactly what you would expect:

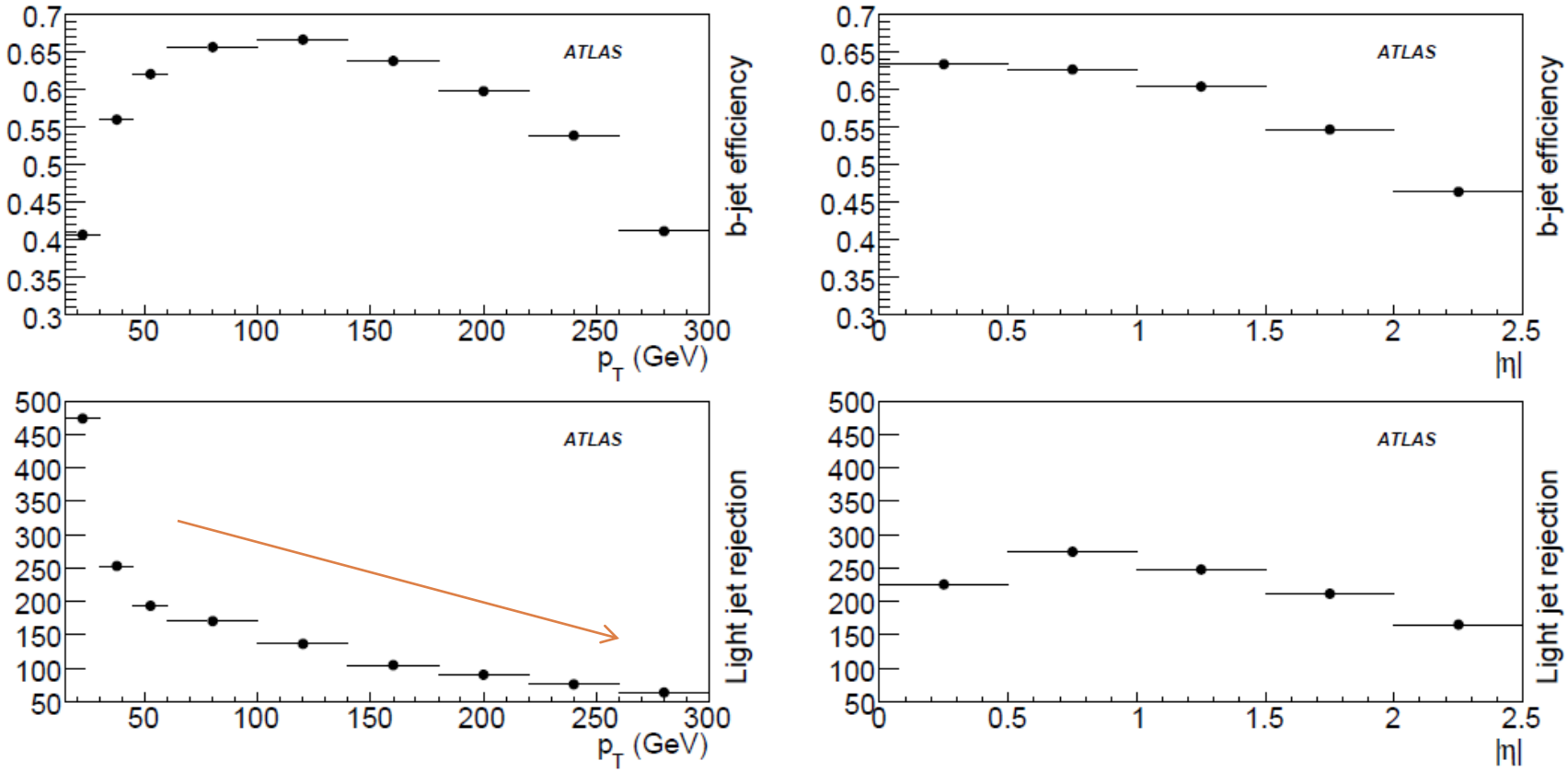
$$\frac{\text{\# of b-jets tagged}}{\text{\# of b-jets}}$$

Rejection

$$\frac{1}{\dfrac{\text{\# of non-b/c -jets tagged}}{\text{\# of non-b/c-jets}}}$$

Easy to get fooled by large changes in the rejection – which are small changes in the actual tag rate!

Performance (IP3D+SV1)



(a) versus jet p_T

(b) versus jet $|\eta|$

B-Tagging Shaping…

Just like any other section cut there is a turn-on.

We are less sensitive to low pT b's than higher pT b's.

We are less sensitive to very high pT b's!

Physics signal with lots of low pT jets? Acceptance wouldn't be all that good!!

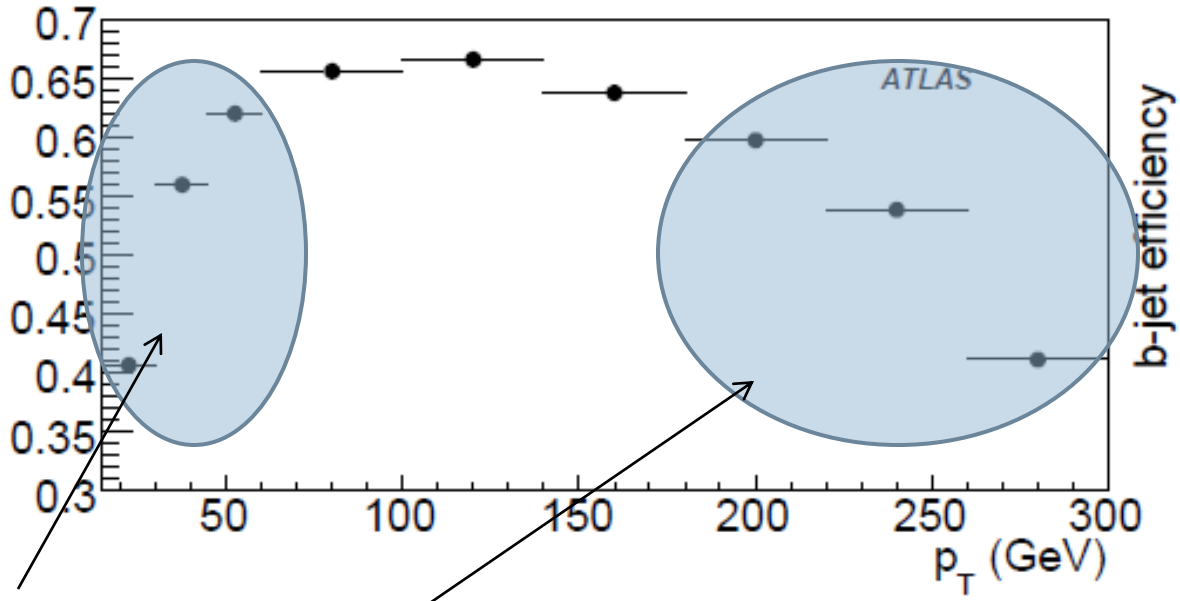
Calibration

Hornet's nets: what is a b-jet in MC?!

Tells us what this effect actually is

And allows us to "deconvolute" it from our actual trigger efficiencies

Why?



Multiple Scattering!

Collimated jets – much denser core, so increased tracking errors, more fragmentation tracks… and… out of range!!!

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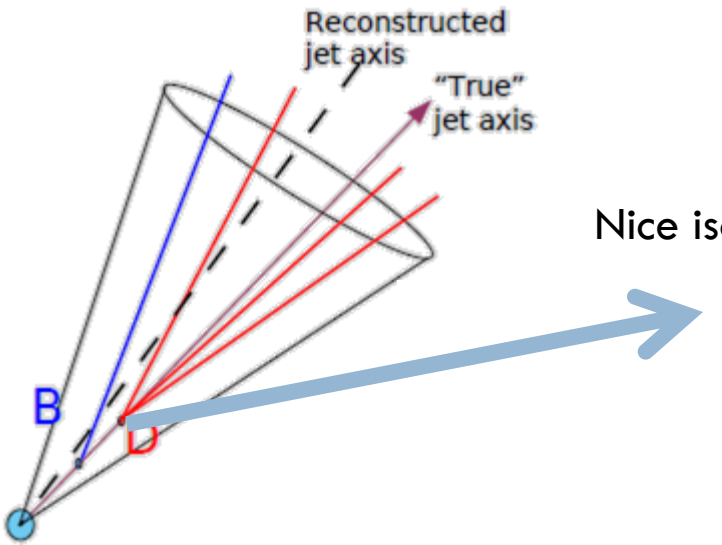
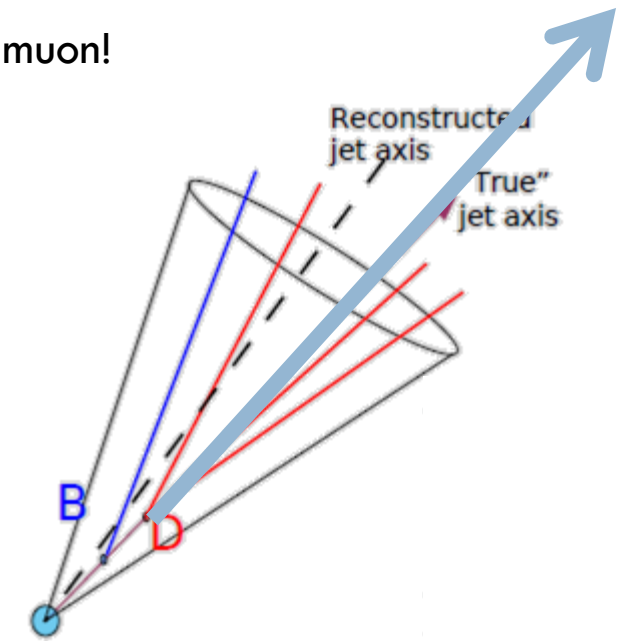
	$R_B > 2.9$ cm	$R_B > 5.1$ cm
all E_T	9.0%	2.8%
$E_T > 100$ GeV	12.2%	3.9%
$E_T > 200$ GeV	21.1%	7.9%

Side Note About Semileptonic Decays



Nice isolated muon!

If you miss the jet you get an isolated lepton and missing E_T.



Theorist should ignore: these are detector effects and we have a very hard time (or impossible time) simulating them

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Gluon Decay's

When we calibrate we do it be jet pT and eta

Implicit in this is the assumption that the B hadron pT is strongly correlated with the jet pT!

Correlation clearly does not work when we have gluon splitting in the same jet!

On average a B hadron from gluon splitting in a jet will have about half the pT of a b from the same pT jet if it was from the hard scatter.

Tag Rate is Lower

There are two of them

Tag Rate is higher

Tevatron: about 15% lower than expected

So we are going to mis-calibrate those unless we account for them!

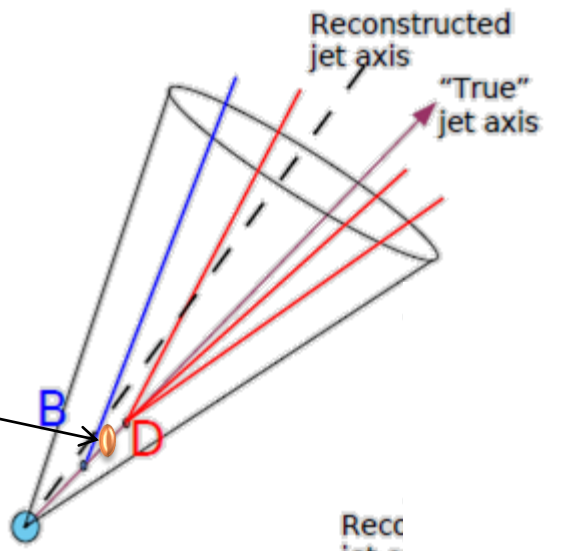
Technique could be used for finding 2 b's in same jet

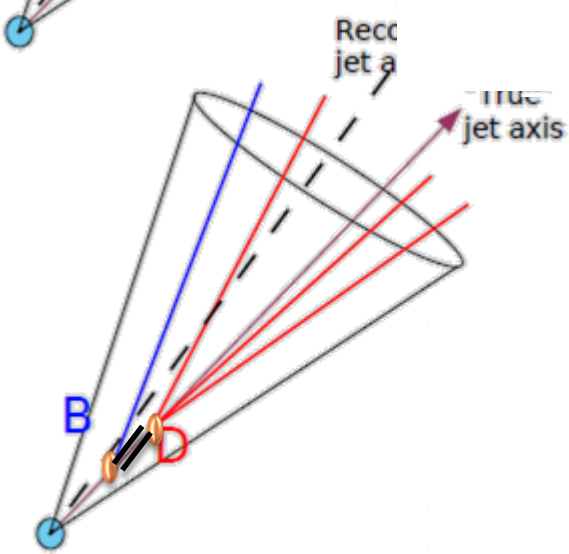
Vertex Fitting – At The Next Level

Based on the ghost-track algorithm first implemented in SLD

Regular fit hypothesizes a single vertex in the jet.

Try two vertices, with a ghost track from the B to the D vertex.





Currently the best performing single tagger in ATLAS' arsenal.

A similar technique could be used for gluon splitting

ATLAS (and others) need to know how important this is.

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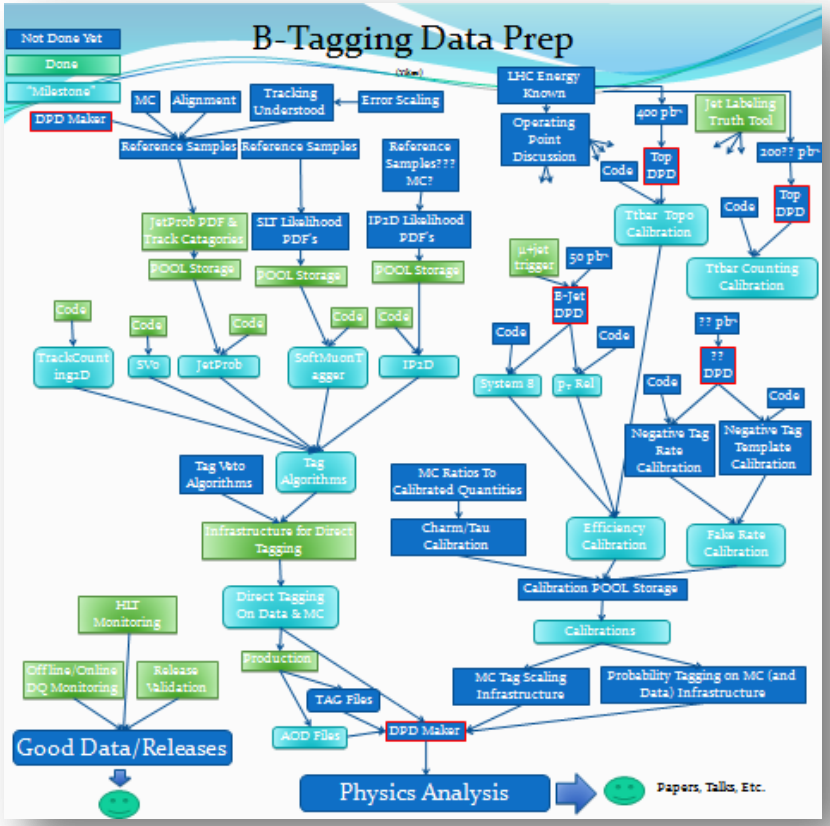
Schedule – What will be ready when?

- The Tagging Algorithms
  - Most are fully coded and working well on MC now
  - Some require likelihood calibrations to work at their best (derived from data)
- Calibration
  - This is the weakest part – not much is production quality yet
- Infrastructure
  - Good at the 80% level



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Good To Go for First Data

An Analysis!

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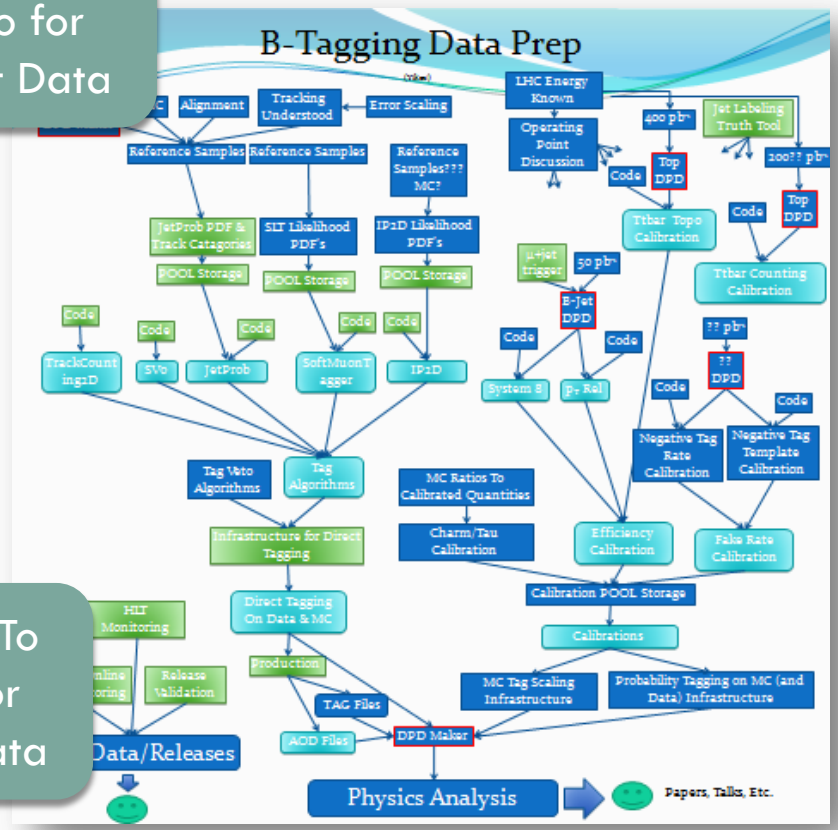

Should be ready – but perhaps best not to make it a show-stopper!

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Early Data

- Performance likely much worse than what I've shown.
- But… we can re-run on early data and improve the performance as we improve our understanding of the detector
  - If b-tagging misses the first results, it will be there for the second results – even if no further data is taken

Last Slide

- You can find out almost everything we know in ATLAS from the CSC exercise public document
  - http://arxiv.org/abs/0901.0512