Increasing the Energy Jets with Ws and Zs at LHCb

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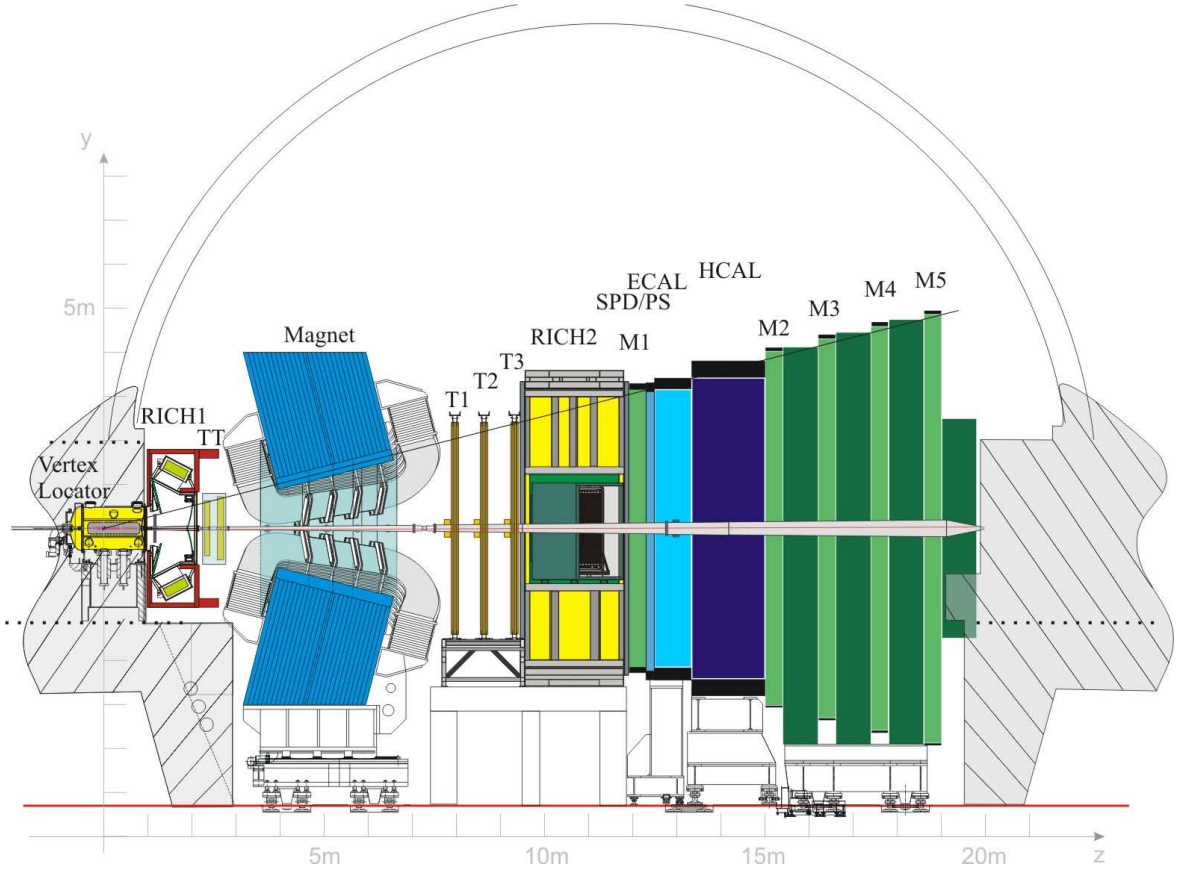
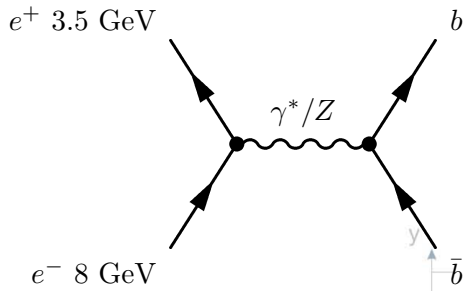
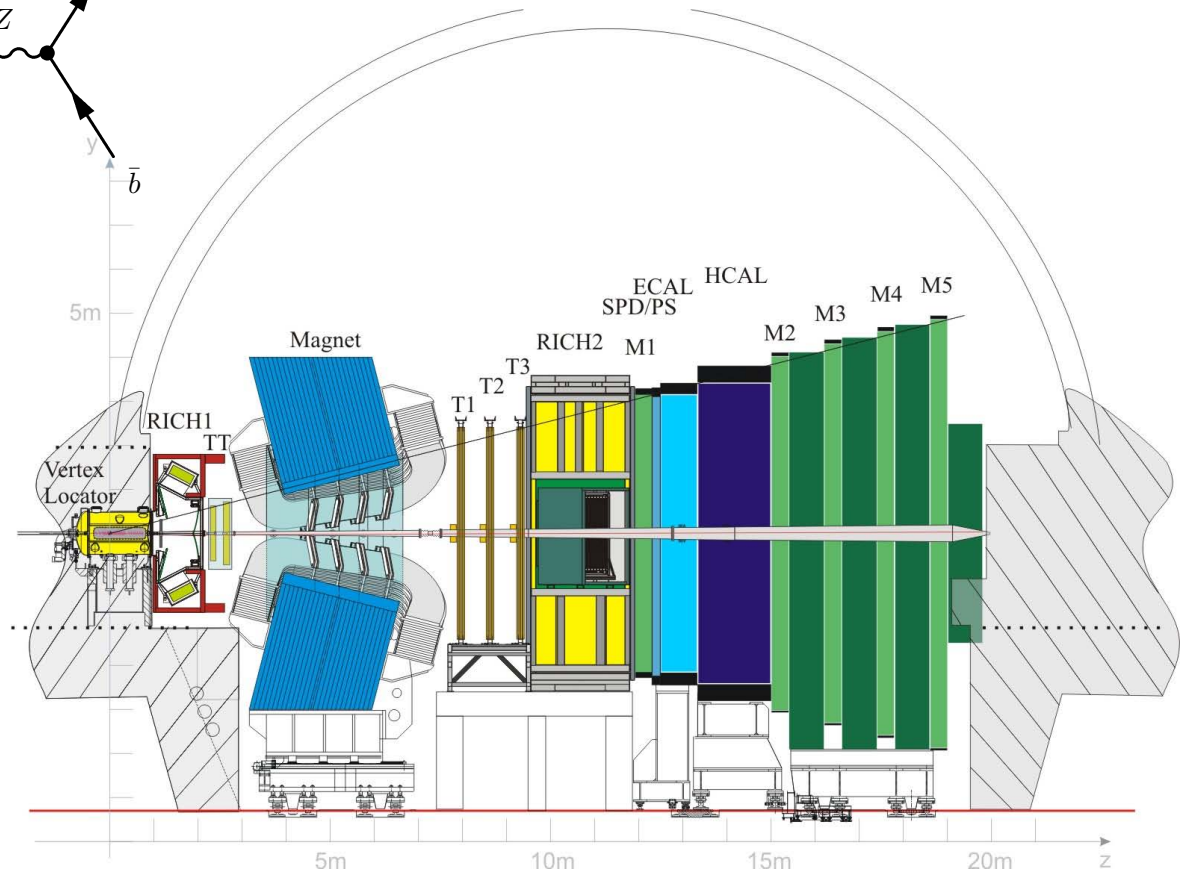
Overview



The LHCb Detector



KEKB (Belle)



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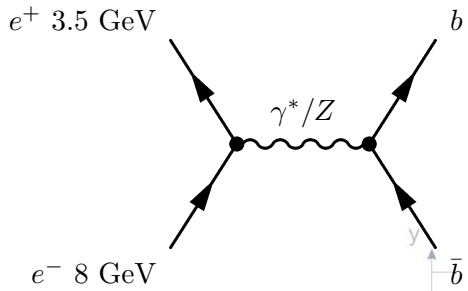

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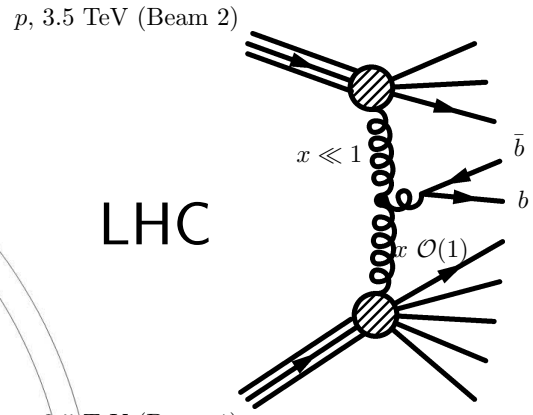
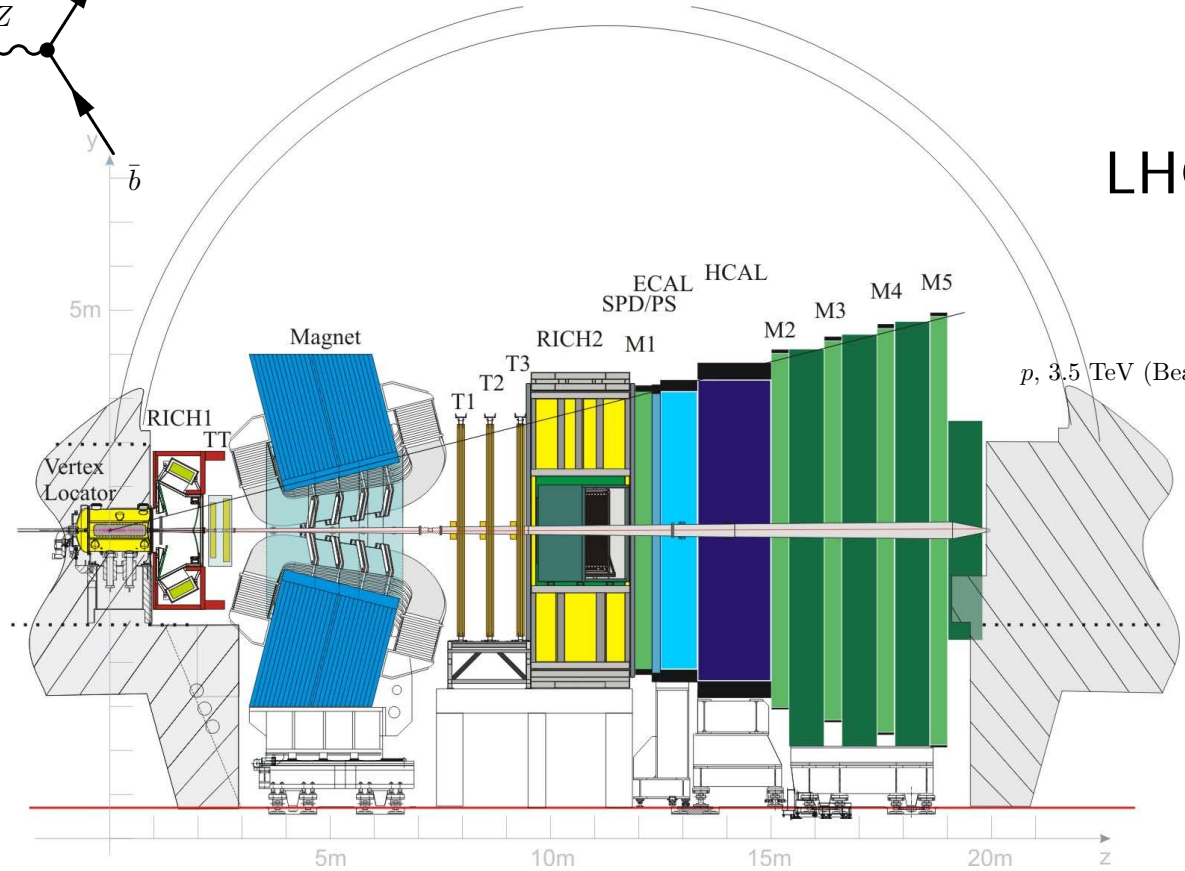


LHC



The LHCb Detector

Beautiful western honey bee (Apis Mellifera) carrying pollen.

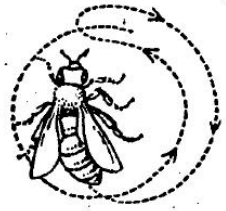


Abb. 5. Der Rundtanz. Beim *Rundtanz* läuft die Biene in *Kreisen*, wobei sie sich manchmal schon nach einem halben Kreisbogen, meist erst nach ein bis zwei vollen Kreisen nach der entgegengesetzten Richtung wendet und so in stetigem raschen Wechsel rechts herum und links herum tanzt.

Beim *Schwänzeltanz* beschreibt sie einen *Halbkreis* nach einer Seite, rennt dann geradlinig zum Ausgangspunkt zurück, läuft einen Halbkreis nach der anderen Seite, wieder geradlinig zurück und so fort. Während des Geradelaufes erfolgt jedesmal das für diese Tanzform typische Schwänzeln mit dem Hinterleibe.

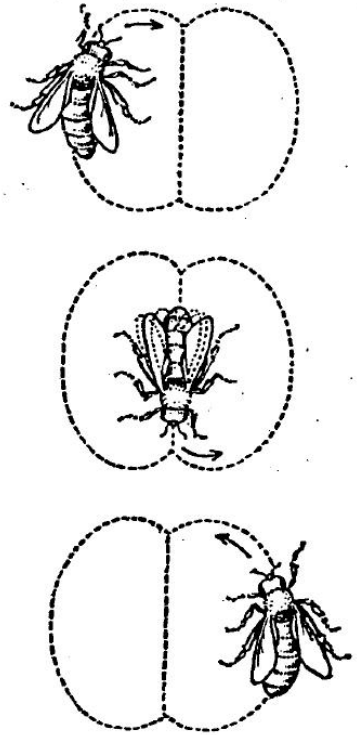
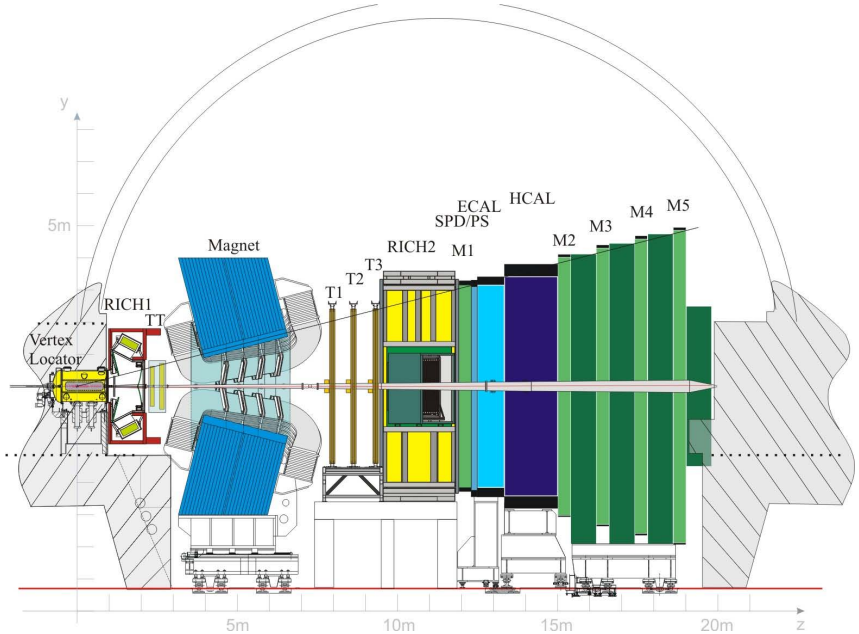
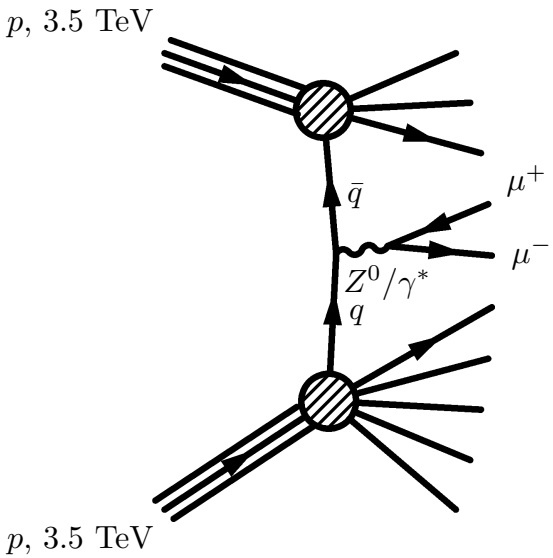


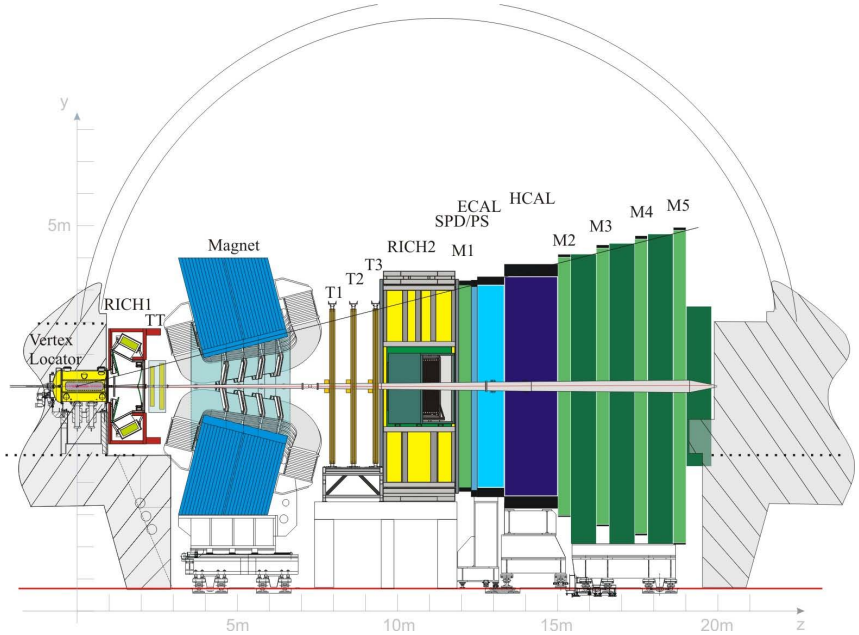
Abb. 6. Der Schwänzeltanz in drei aufeinanderfolgenden Phasen.

Karl von Frisch Österr. Zool. Z. 01:(1948) – Nobel Price 1973



The LHCb Detector





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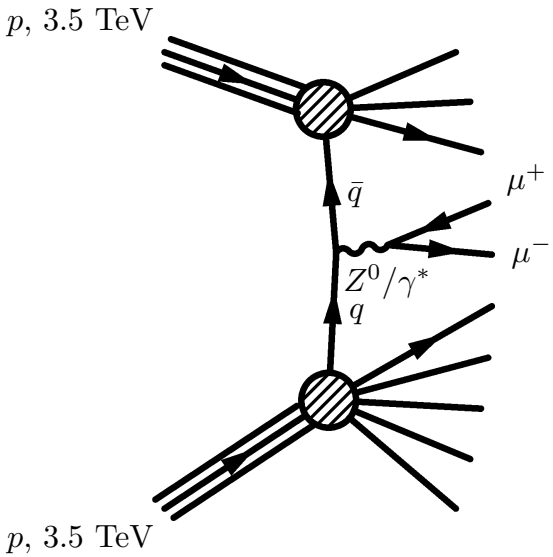
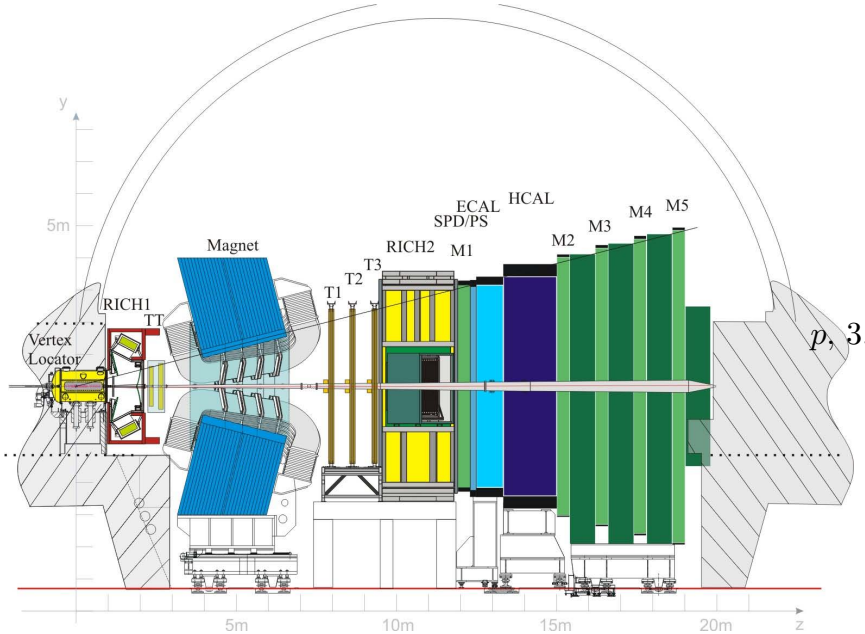
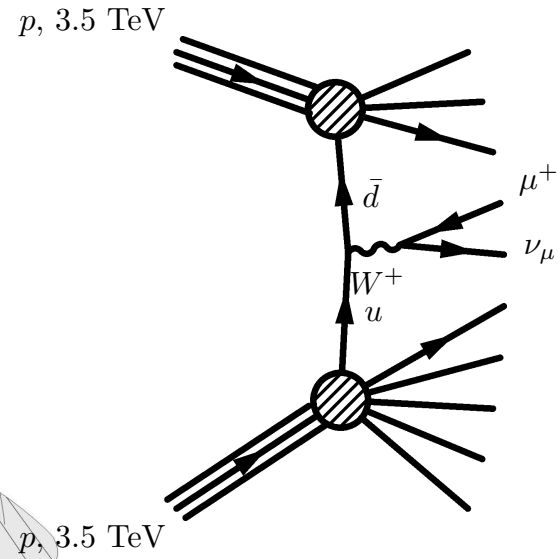
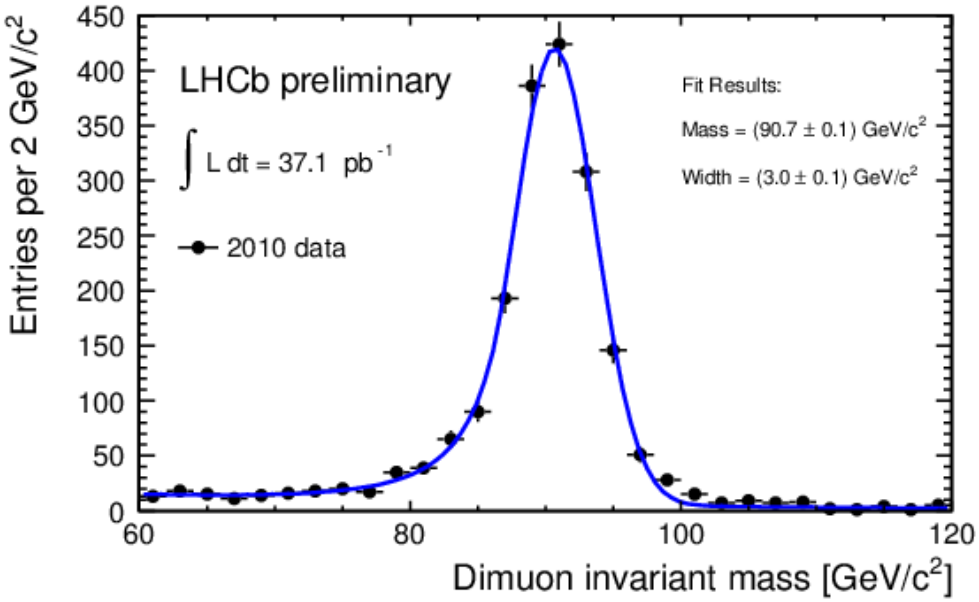






The LHCb Detector

Z Selection



- $p_T > 20 GeV$
- $2 < \eta_\mu < 4.5$
- 60 GeV $< m_{\mu\mu} <$ 120 GeV
- track quality

Single μ trigger $p_T > 10$ GeV

1966 Candidates

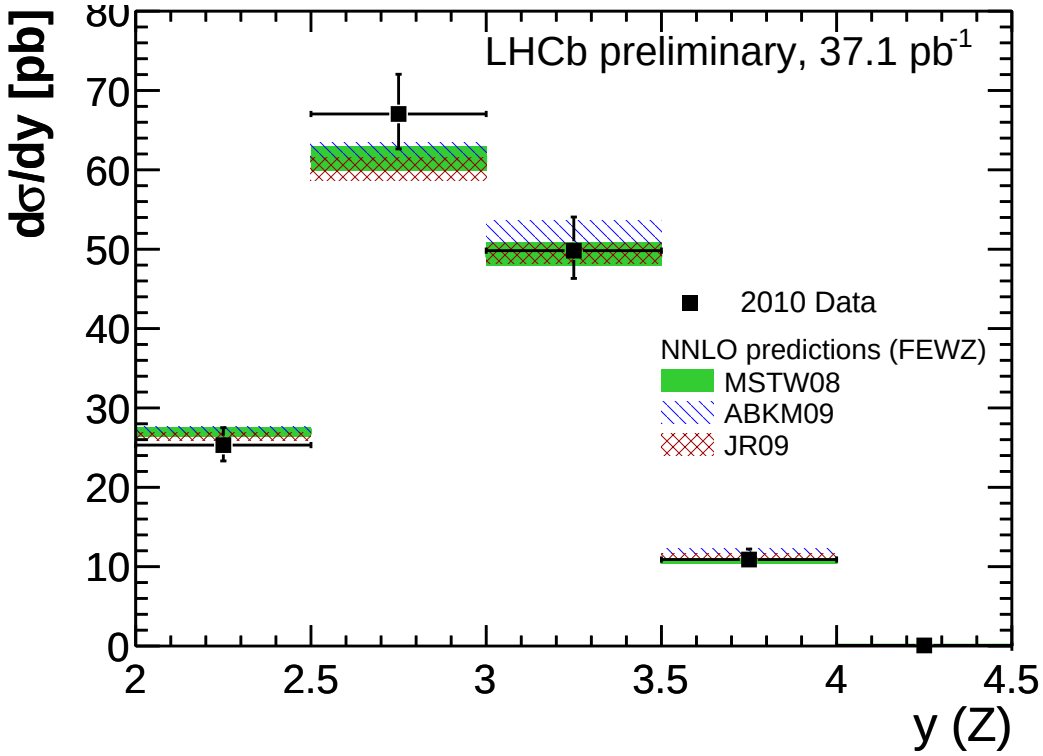
Backgrounds

Heavy Flavour 4.3 ± 3.0 (data)

mis ID < 1 (data)

$Z \to \tau\tau$ 0.6 ± 0.2 (MC)

Z Rapidity distribution



$$
\begin{aligned}
& p_{T,\mu} && > 20 \text{ GeV} \\
60 \text{ GeV} < \quad & m_{\mu\mu} && < 120 \text{ GeV} \\
2 < \quad & \eta_{\mu} && < 4.5
\end{aligned}
\qquad \sigma = \frac{N}{\mathcal{L}\varepsilon}
$$

References

FEWZ - arXiv:1011.3540v1 (hep-ph)
MSTW08 - [arXiv:0901.0002 (hep-ph)]
ABKM09 - [arXiv:0908.2766 (hep-ph)]
JR09 - [arXiv:0810.4274 (hep-ph)]

Efficiencies from data!

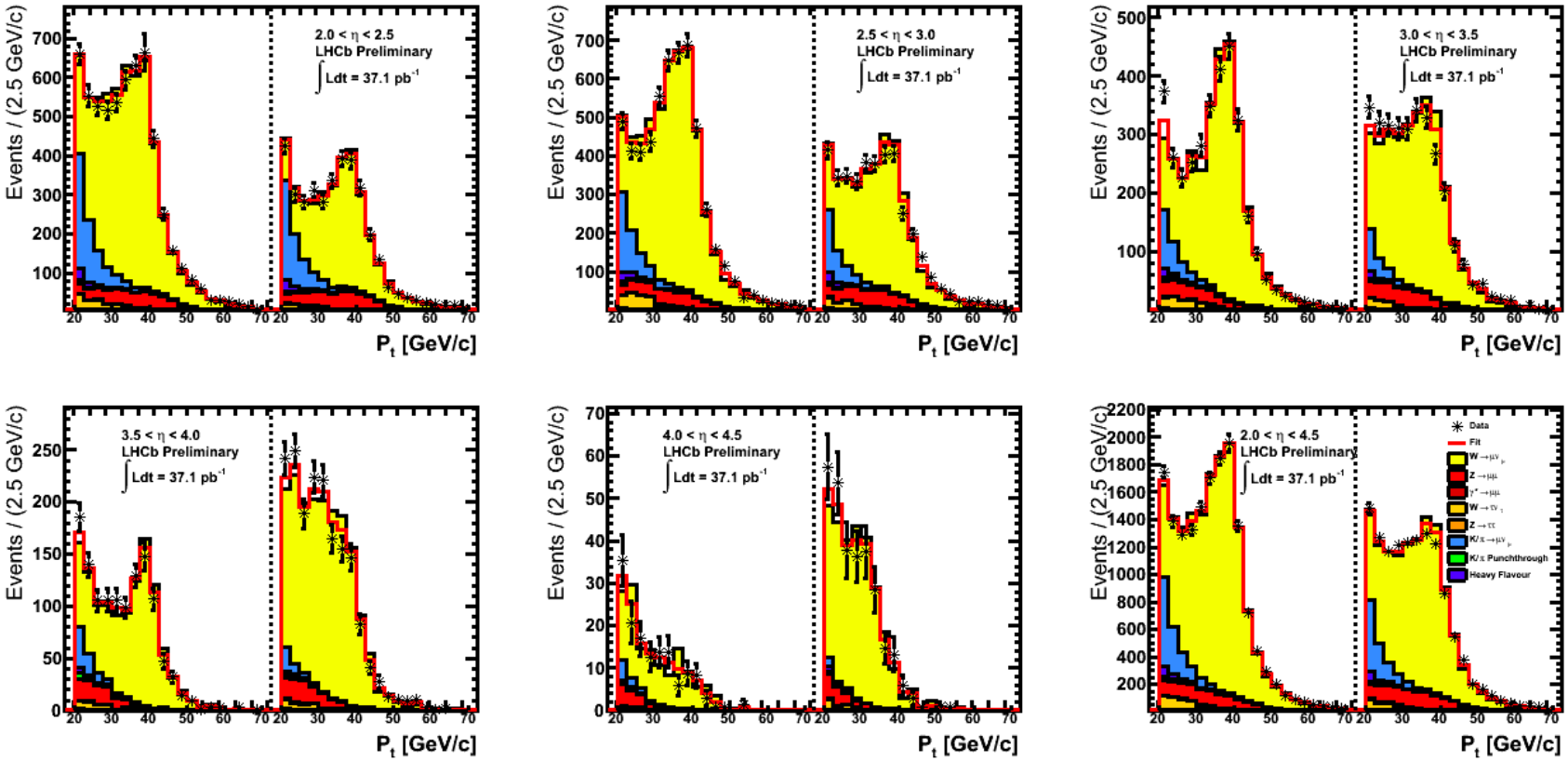
W Selection

W Candidates are good, exclusive, isolated, high–momentum muons from the primary vertex with low hadronic interactions well inside the acceptance.

good	Hits in all three tracking stations and $P(\chi^2, ndof) > 1\%$
exclusive	No second muon with $p_T > 5$ GeV
isolated	Transverse momentum of tracks and CALO clusters in $\Delta_R < 0.5$ cone smaller than 5 GeV
high–momentum	$p_T > 20$ GeV
from the primary vertex	Impact parameter smaller than 40 μm
low hadronic interactions	$E/p < 4\%$
acceptance	$2 < \eta < 4.5$

The tracking and muon ID selection is much tighter than it is for the $Z \to \mu\mu$ events.

W Fit – Binned in Pseudorapidity



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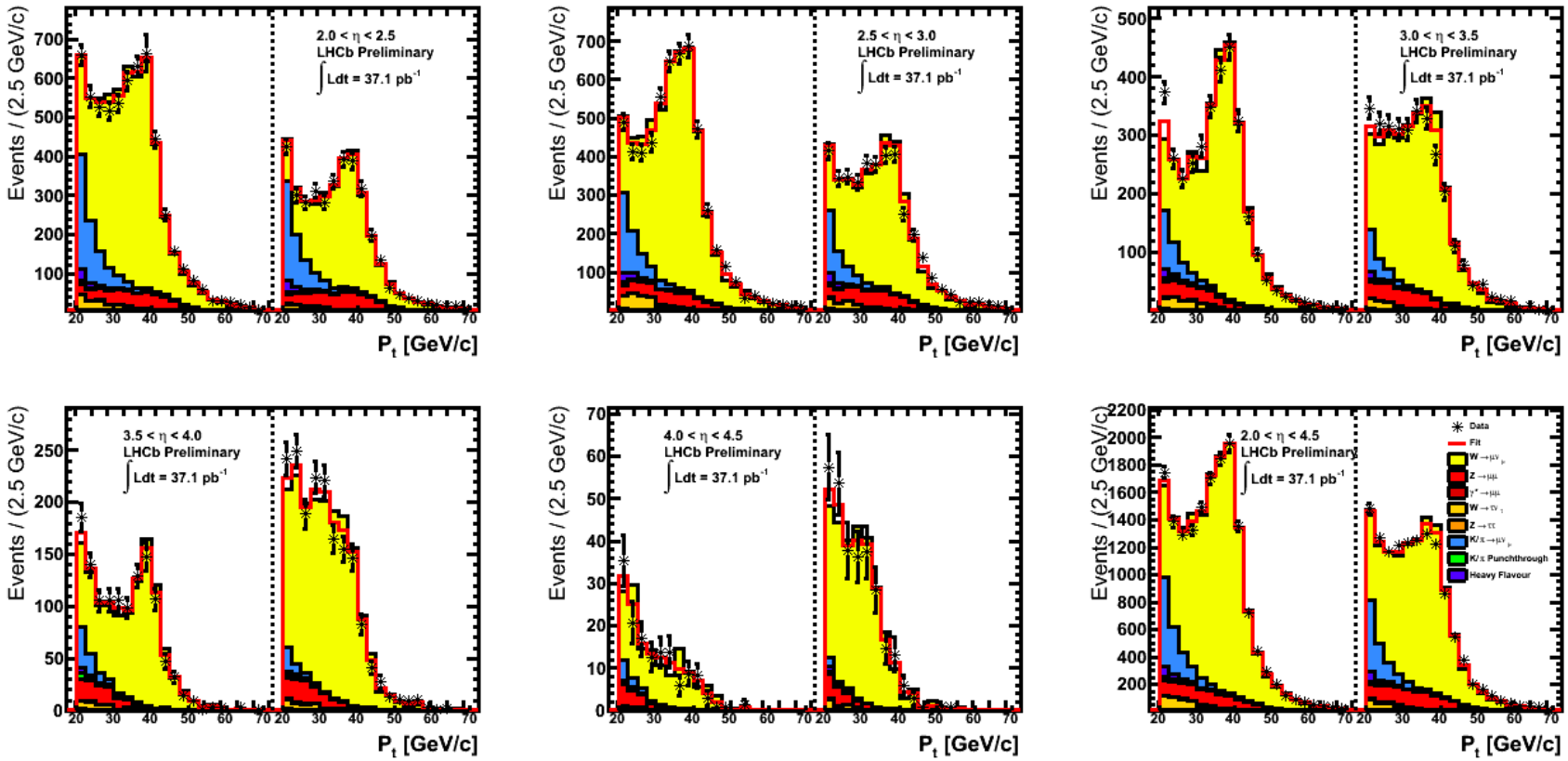
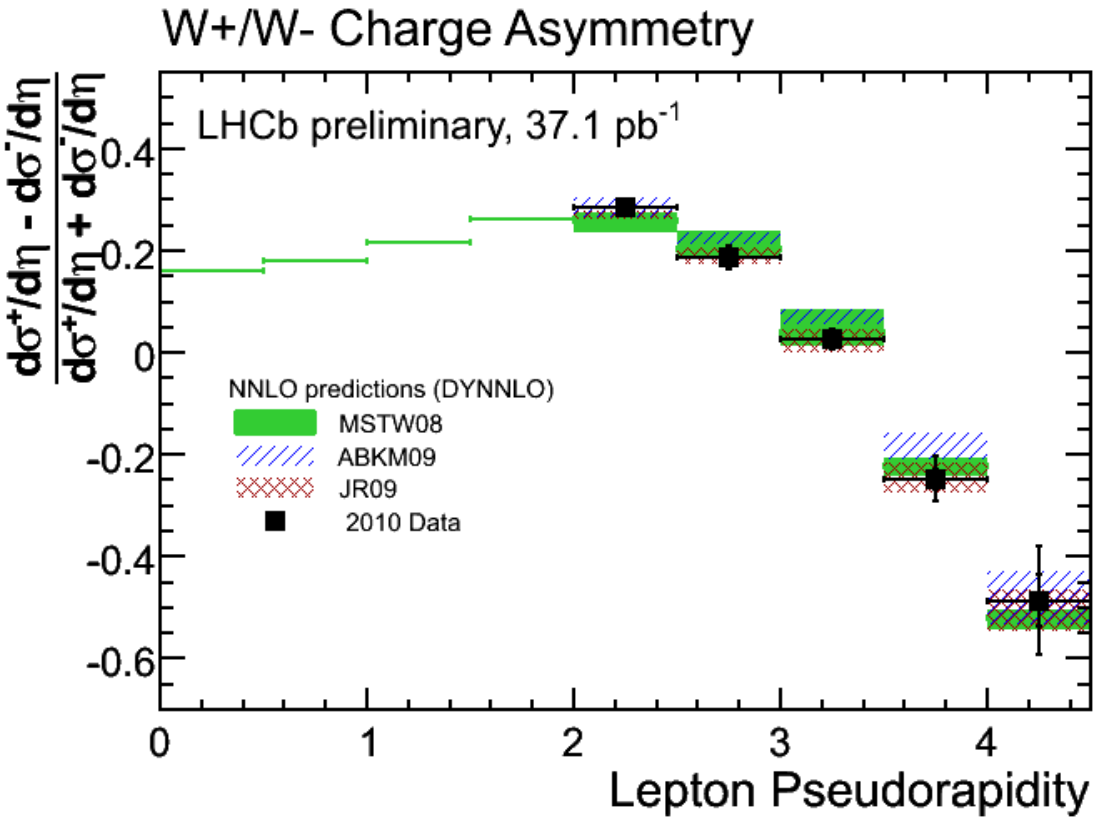


Templates for the considered backgrounds were fit to the spectrum. This was done separately in bins of η

W Charge Asymmetry Distribution



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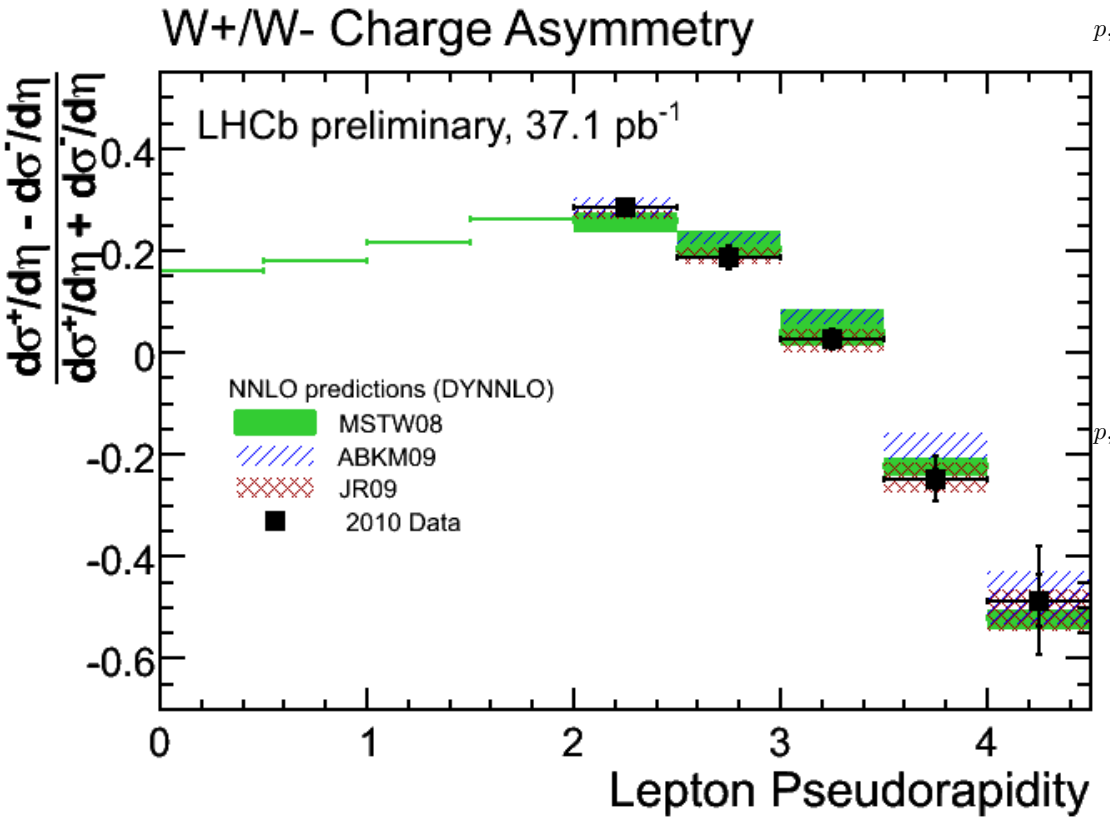
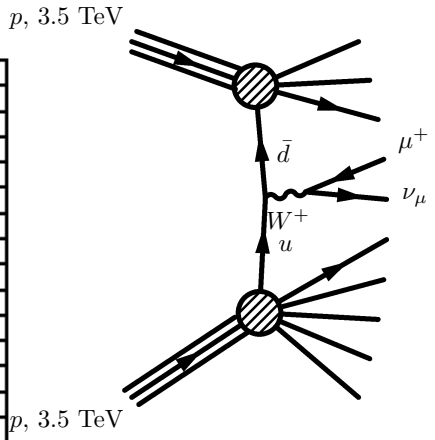
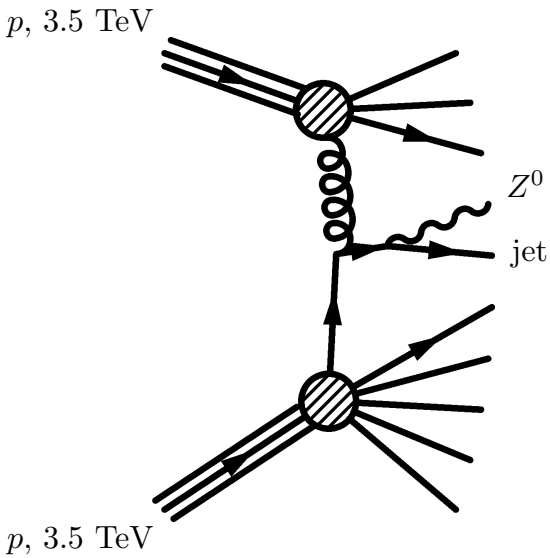


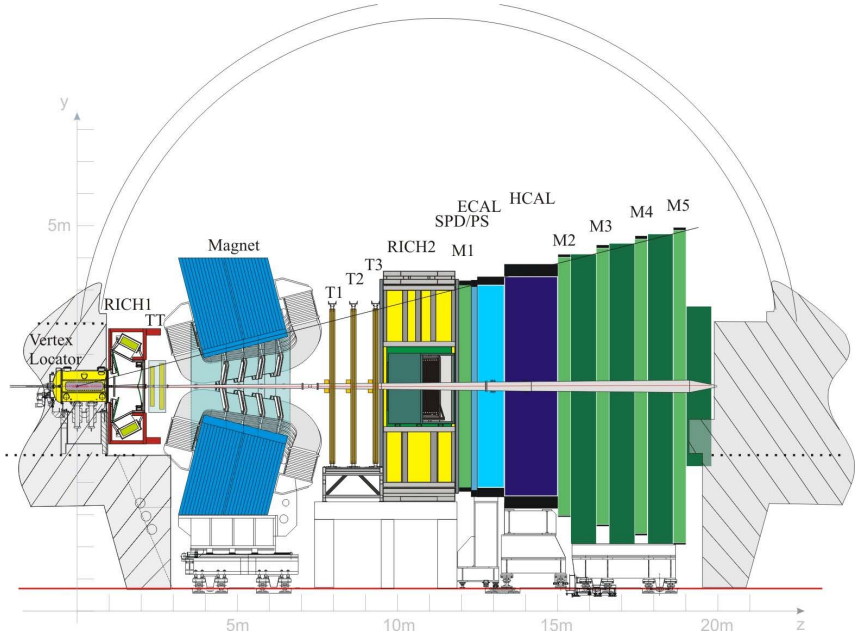


Electroweak Physics in its full glamour!

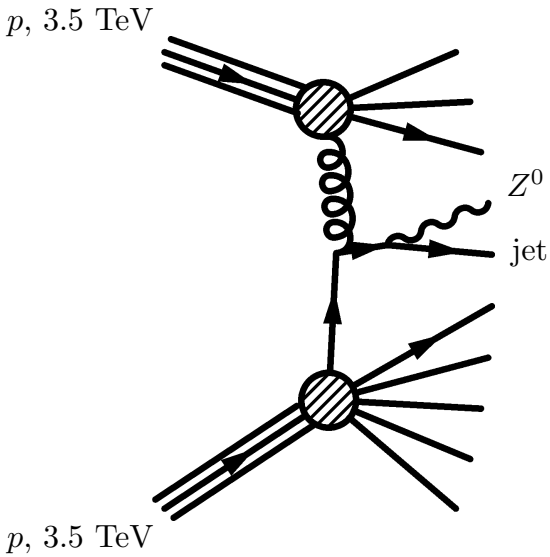
Jets with W

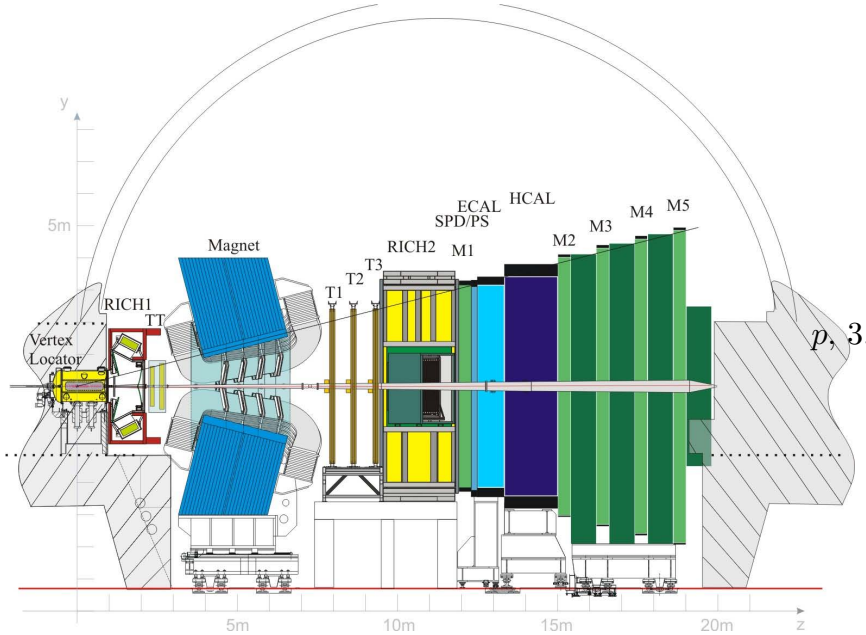
Heavy A-10 Thunderbolt II "Warthog" carrying hazards.

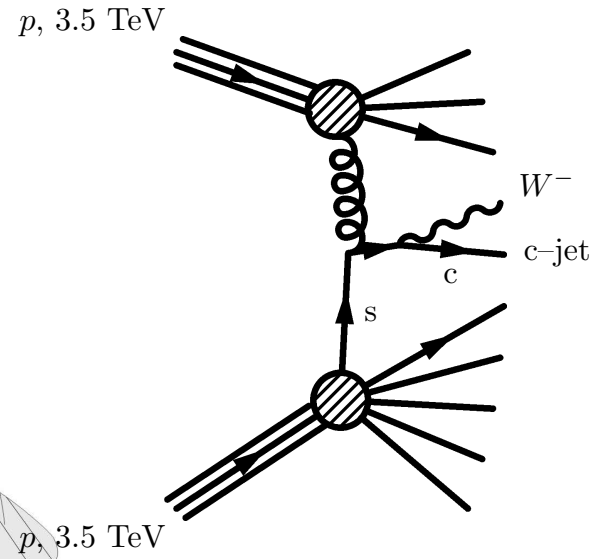




The LHCb Detector







The LHCb Detector

Jets with Z in 2010 data

$Z \to \mu\mu$ candidates are

- Two muons above $p_T > 15$ GeV
- $m_{\mu\mu} > 70$ GeV
- $\chi^2/ndf < 5$ for both muon tracks

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- $\sigma_P/p < 20\%$

clustered with *anti*-k_T algorithm ($\Delta_R = .5$).

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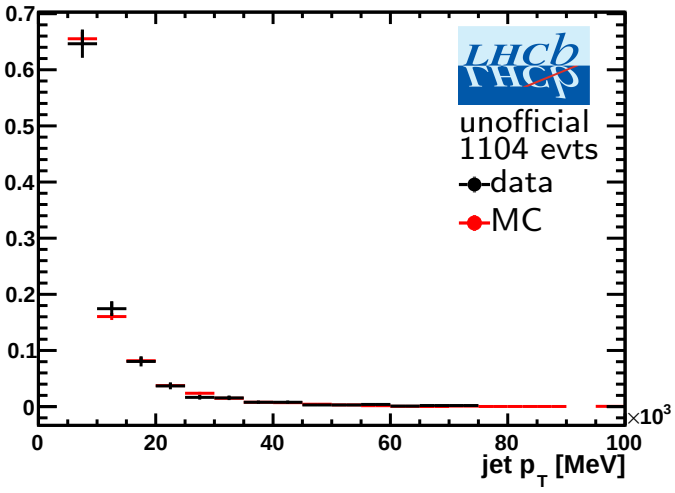
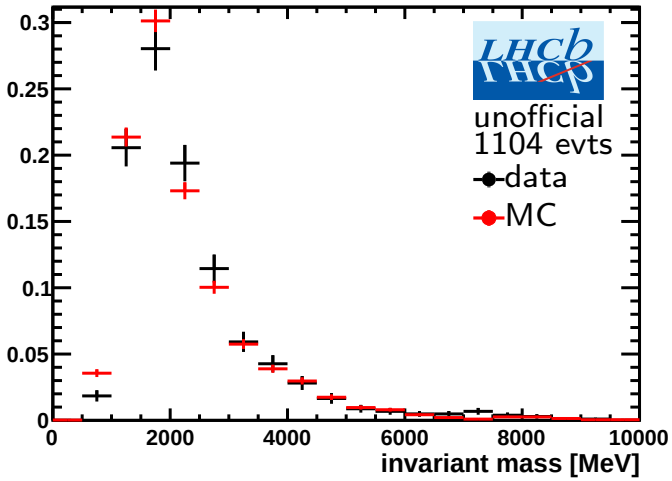
Additional Selection

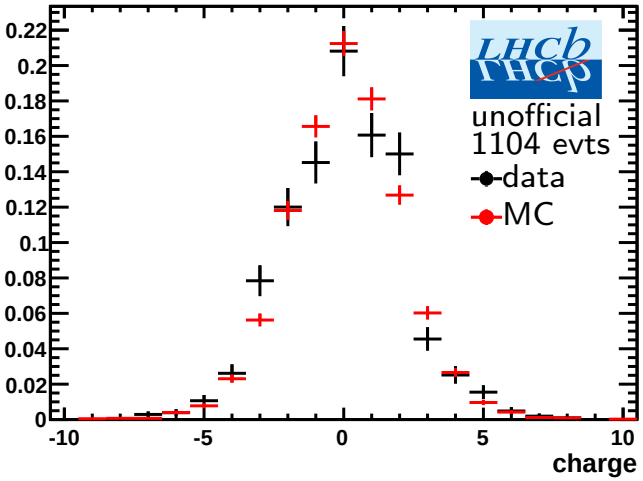
- $max(p_T)/p_T < 90\%$
- At least 3 particles in the jet
- $p_T > 5$ GeV (uncorrected)

SingleMuonTrigger $p_T > 10$ GeV
1104 Events in part of 2010 data ($16.5 pb^{-1}$).

Results for 2010 data



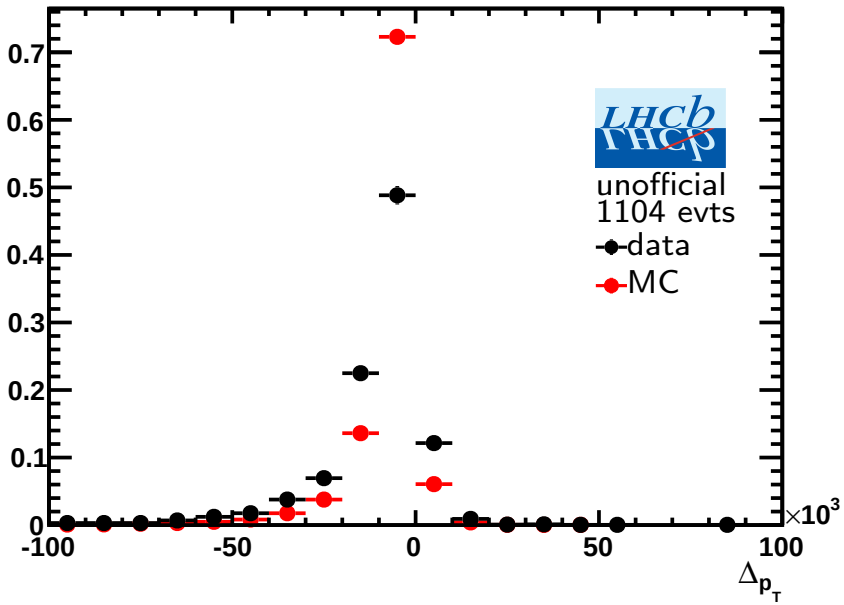


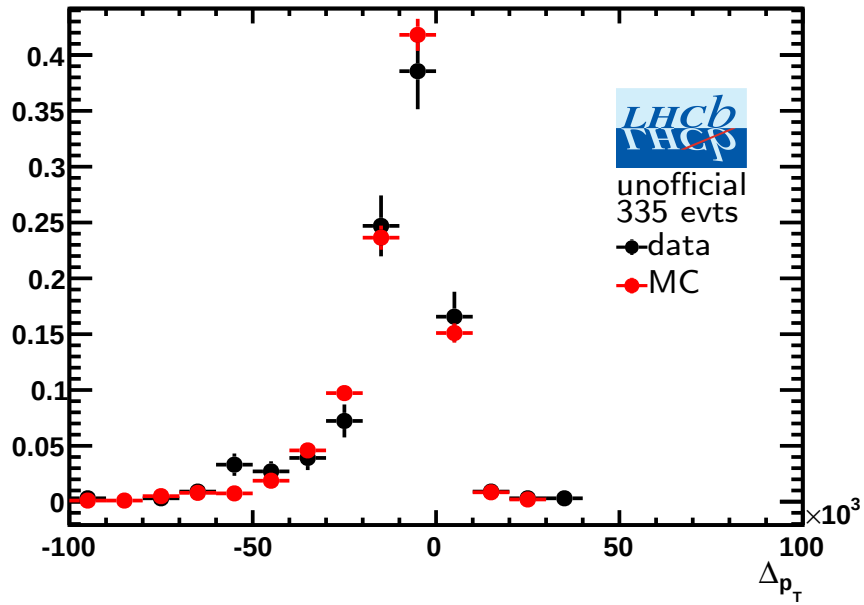


Reasonable agreement between data and simulation

The distributions shown correspond to reconstructed MC

Results for 2010 data





Inclusive Z plus jet candidates with the previously shown selection.

Exclusive Z plus jet candidates with additional selection:
$|\Delta_\phi| > 2$ and $2 < \Delta_R < 4$

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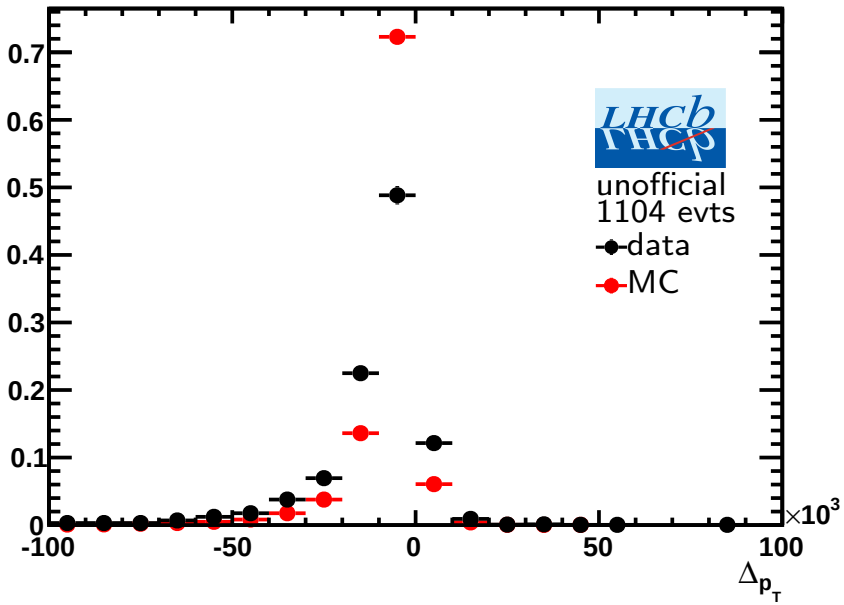

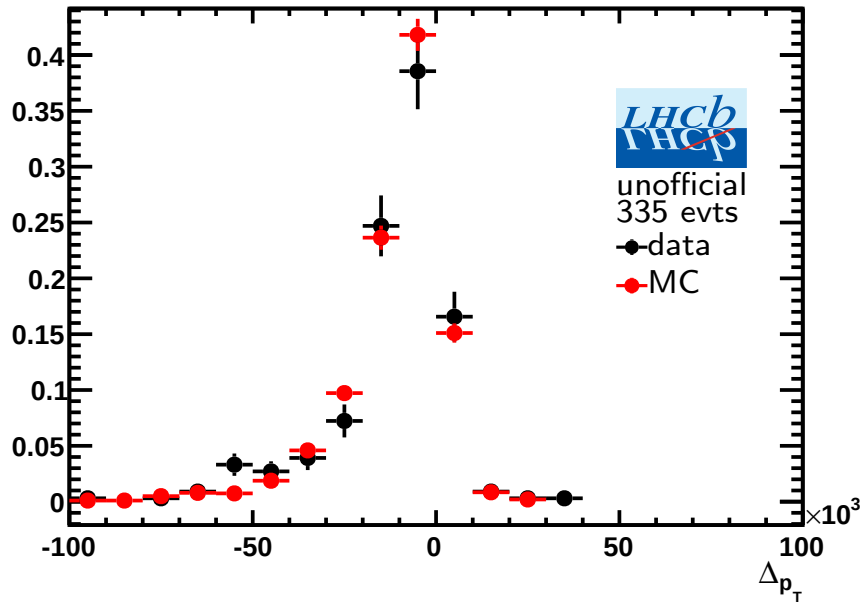

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$|\Delta_\phi| > 2$ and $2 < \Delta_R < 4$

$Z \to \mu\mu$ plus jet events are visible in 2010 data!

A proper measurement should be possible with 2011 data.

Towards a Boson plus Jet Measurement

I started to cluster jets from tracks and to select Z plus jet events in October 2010.

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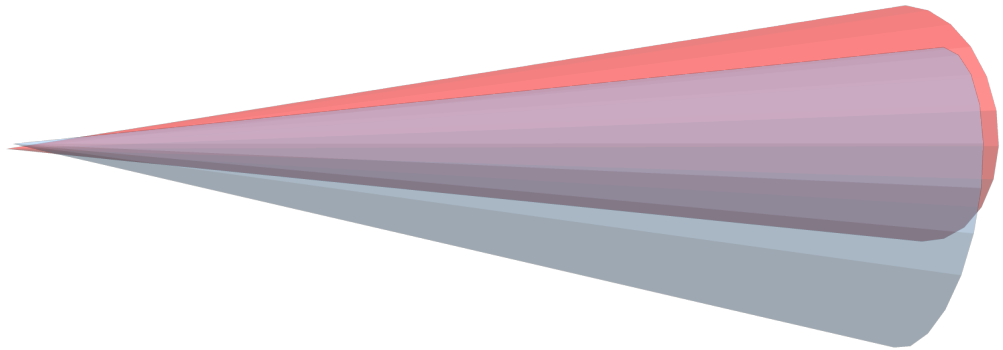
Now there is a little group in LHCb analysing and defining jets.

Matching Jets

- Jet Energy Scale corrections can be derived from simulation
- Jets can be clustered from simulated particles and compared to the reconstructed particles
- It must be known which MC jet corresponds to which simulated jet



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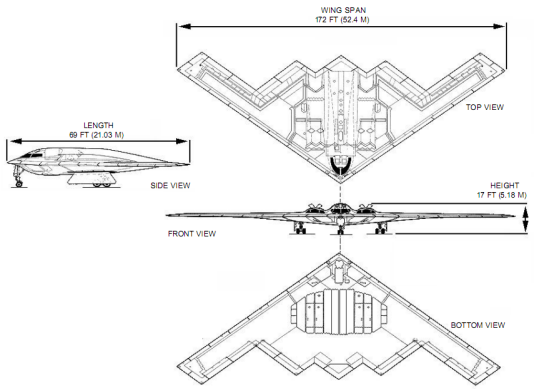

Simulated Jets are clustered from $\pi^{\pm}, K^{\pm}, \gamma, e^{\pm}$ *and* $\mu^{\pm}$ with p_T >150 MeV. This is chosen to match the requirements of the offline selection.

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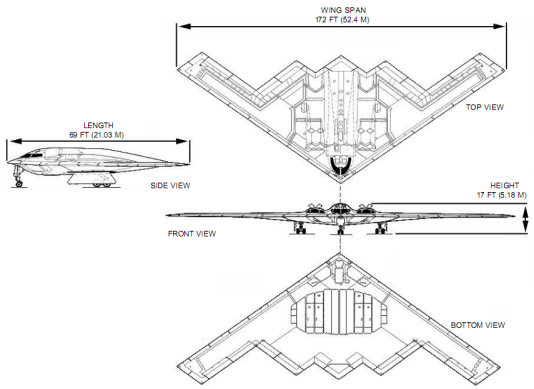

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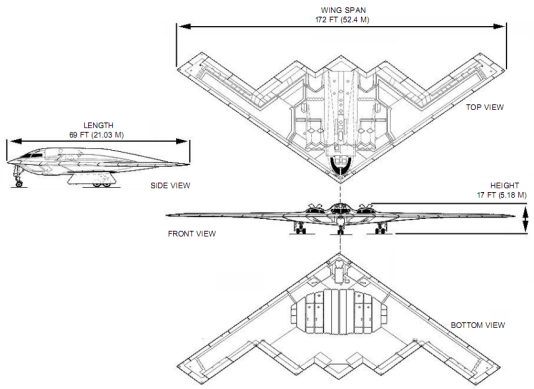

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Jet algorithm is *anti*-k_T algorithm and cone size is 0.5. The dominance cut and the minimal number of particles requirement have been dropped to study their behaviour.
Input selection is currently refined in LHCb and will be changed to an approach inspired by CMS' ParticleFlow.

Matching Methods

MC Matching:

1. loop over all reconstructed particles in a given Rec jet i.

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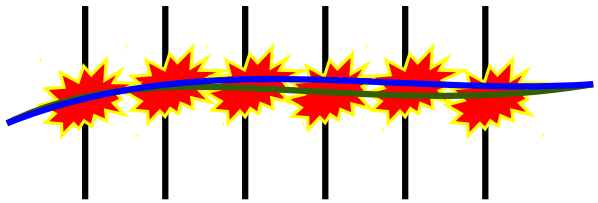

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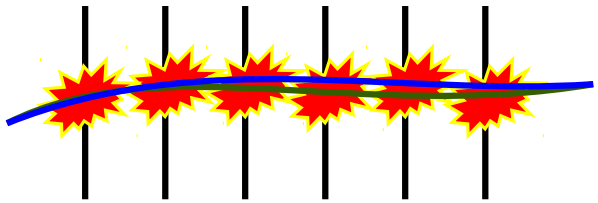

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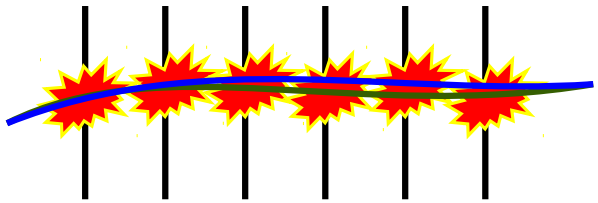

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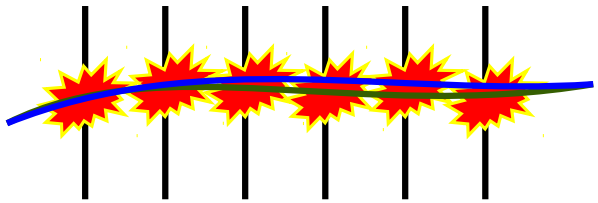

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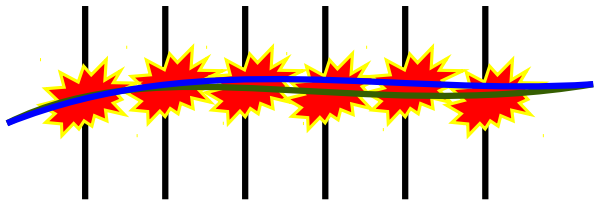

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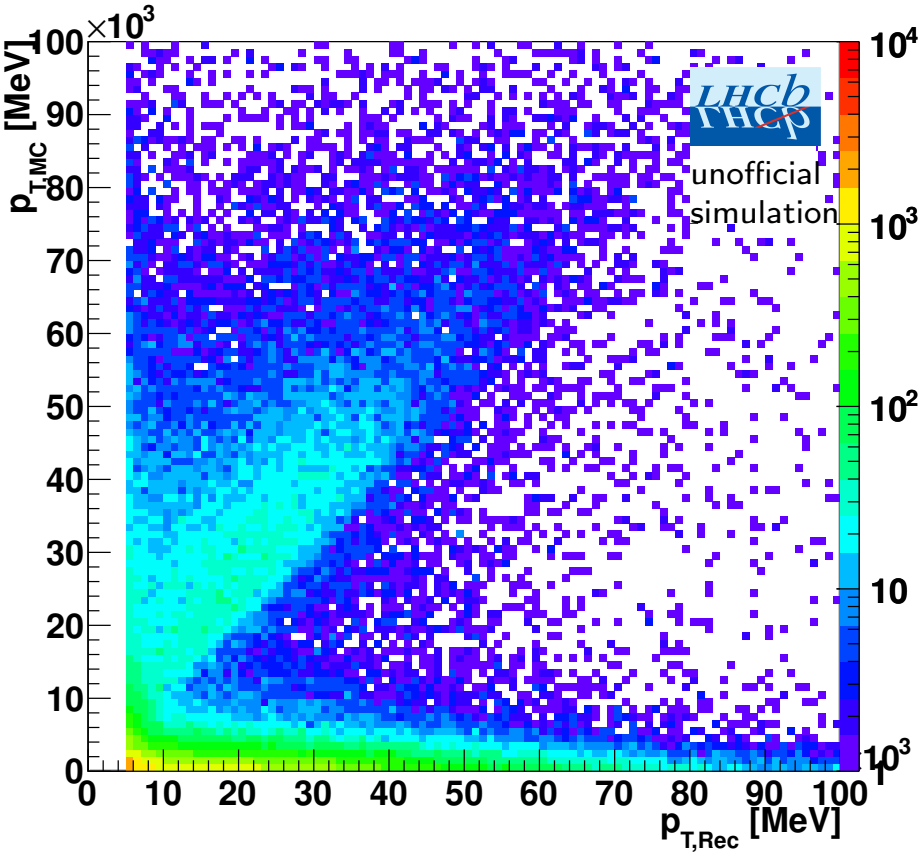
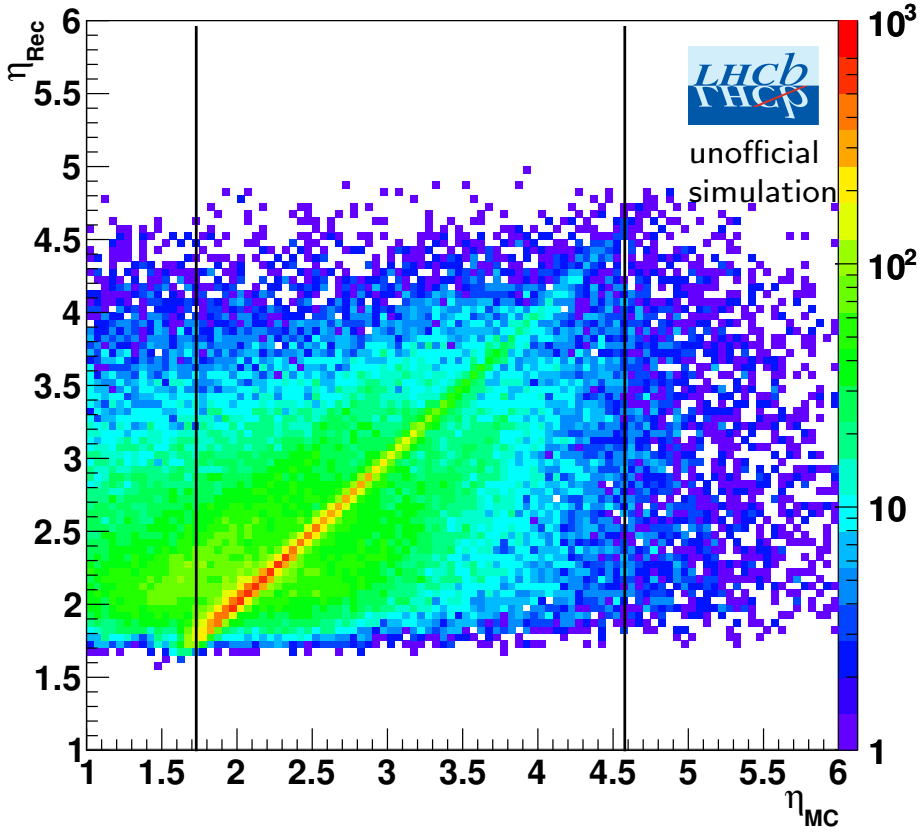
$\Delta_R = \sqrt{\Delta_\eta^2 + \Delta_\phi^2}$ can be used as a distance measure as well. But this would hide the problem explained on the next slide.

Matching Results not yet conclusive



Rec jet p_T vs. matched p_T (MC)



Rec jet η vs. matched η (MC)

Conclusion

- W and Z bosons have been measured in a unique region of phase space
- W and Z plus jet measurements are possible in LHCb
- Jet energy calibration in LHCb is being prepared
- Flavour tagging of the W plus jets is the ultimate goal of this analysis
- With such a measurement s pdfs could be constrained

Thank you for your attention