b-JETS AT LHCb

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(*on behalf of LHCb collaboration)*

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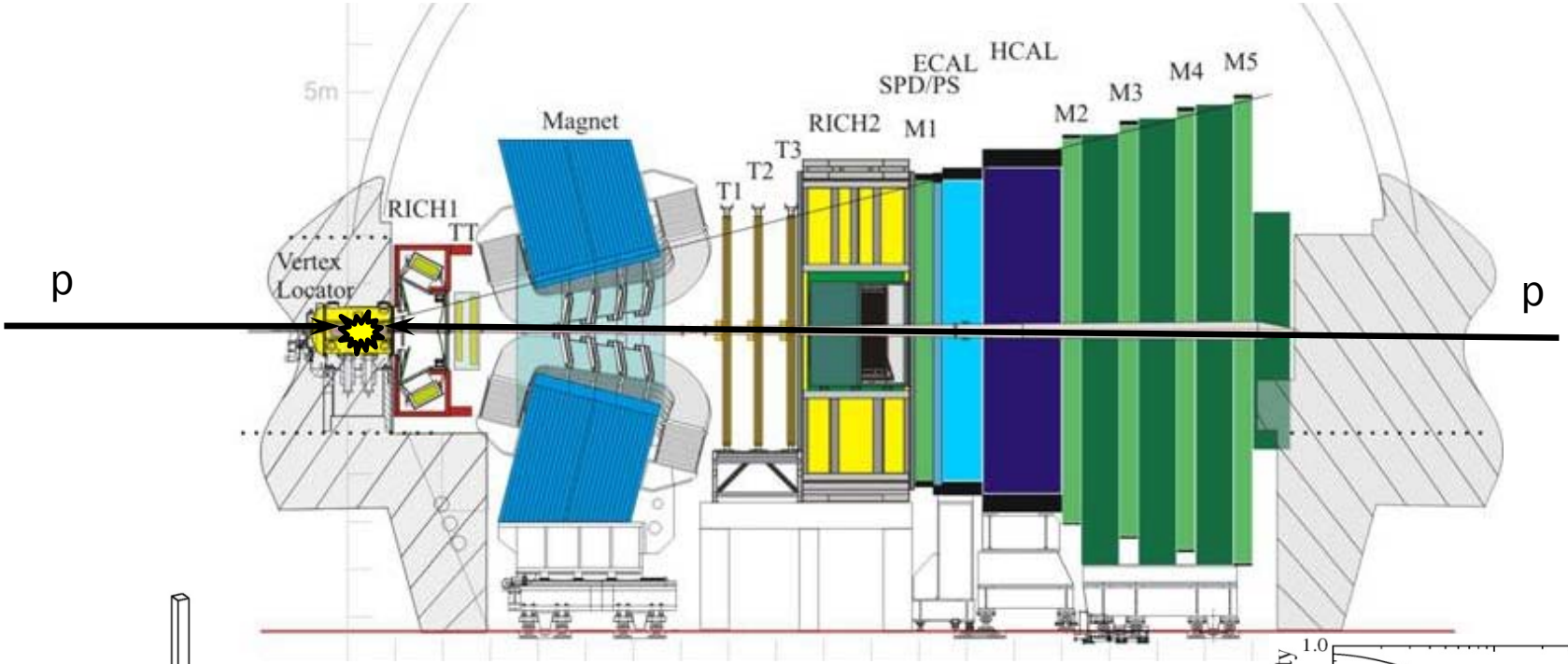
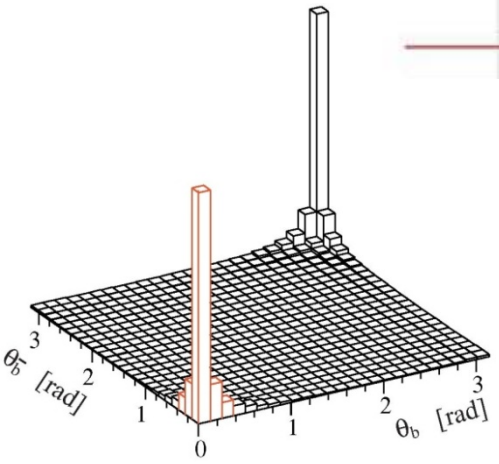
LHCb OVERVIEW

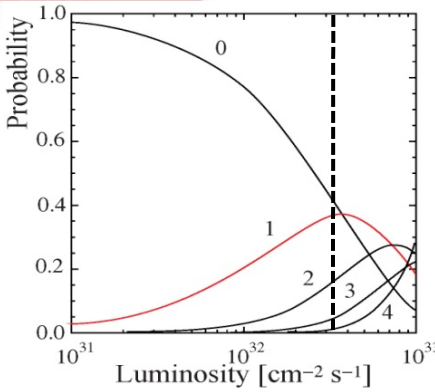
LHCb is an LHC experiment dedicated to ~~CP~~ measurements and B rare decays





Nominal luminosity $2\times10^{32}cm^{-2}s^{-1}$

About 10^{12} $b\bar{b}$ pairs per year, one nominal LHCb year ($2fb^{-1}$)



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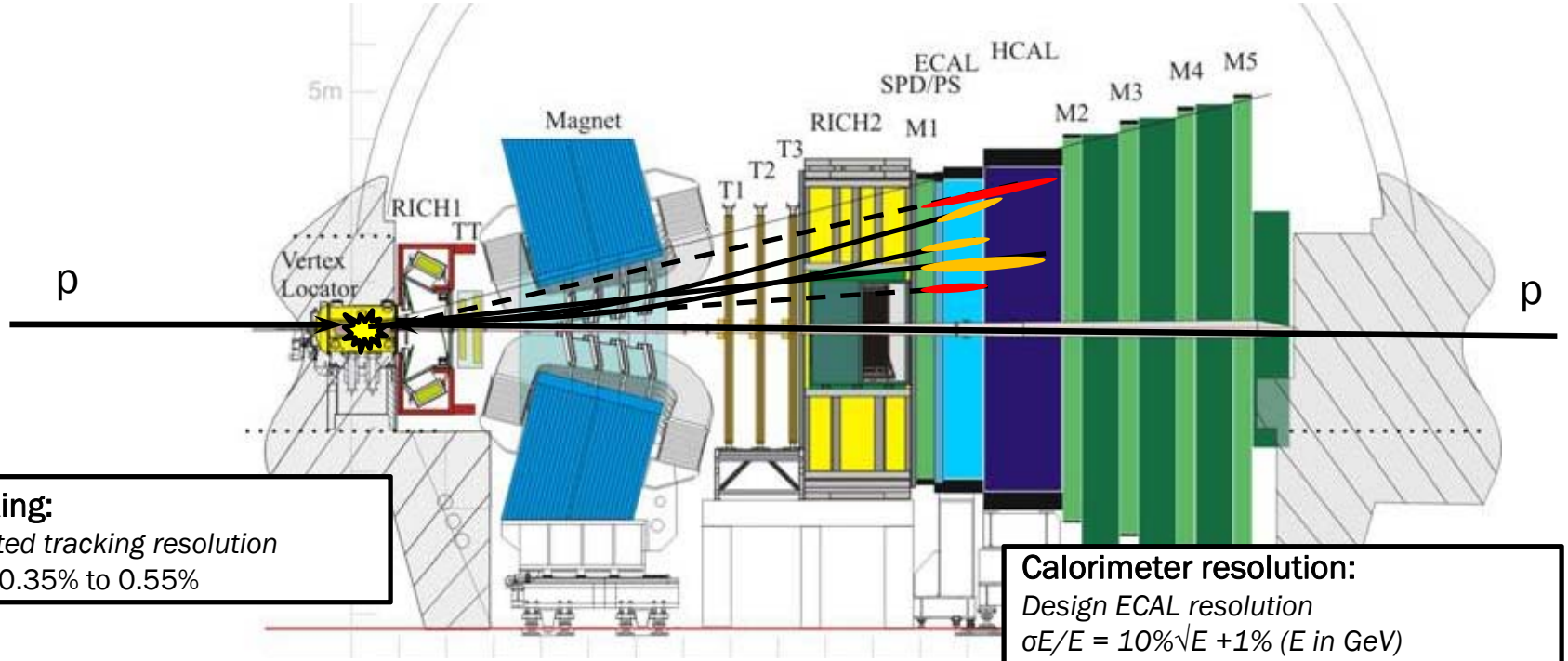


Tracking:
Expected tracking resolution
δp/p=0.35% to 0.55%

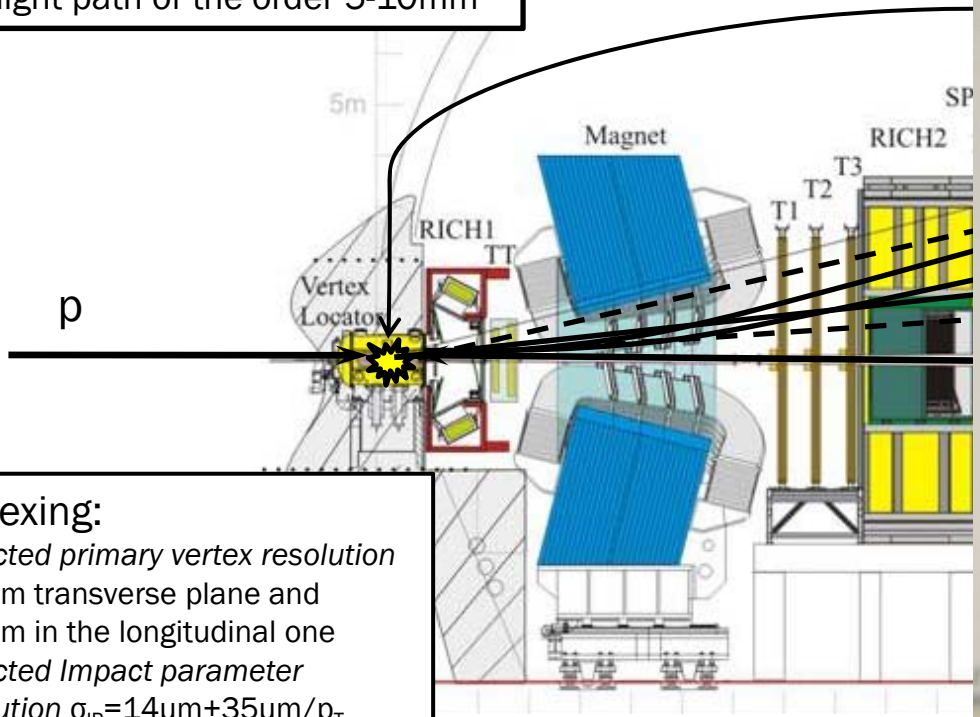
Calorimeter resolution:
Design ECAL resolution
σE/E = 10%√E +1% (E in GeV)
HCAL resolution from test-beam data
σE/E = (69±5)%√E+ (9±2)% (E in GeV)

Requirements for measurements in B hadrons system are:
good particle identification, excellent tracking and vertexing

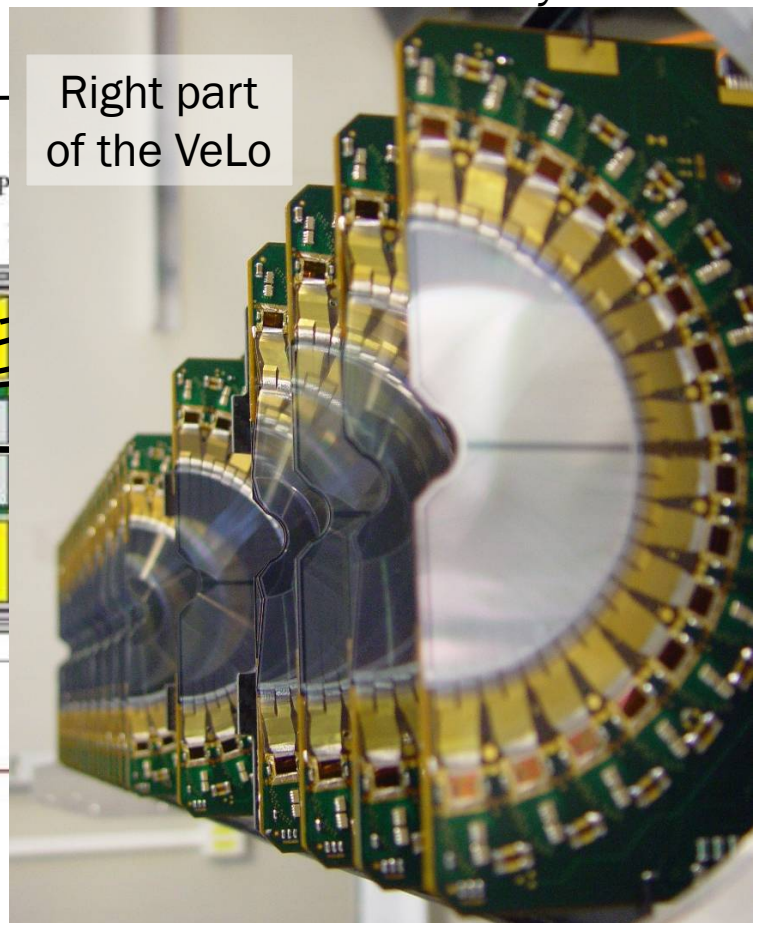
LHCb OVERVIEW

LHCb is an LHC experiment dedicated to ~~CP~~ measurements and B rare decays

B flight path of the order 5-10mm



Vertexing:
Expected primary vertex resolution
~10μm transverse plane and
~60μm in the longitudinal one
Expected Impact parameter resolution σ_{IP}=14μm+35μm/p_T



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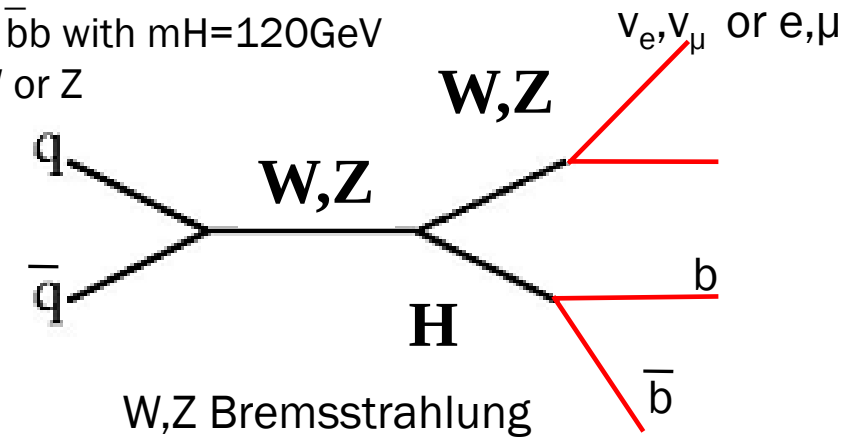
b-Jets reconstruction and identification

Generator level Study – 4 Momenta

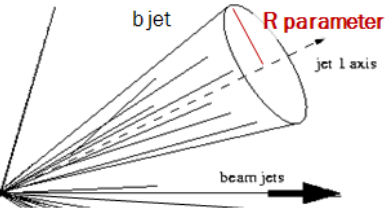
As a textbook case we use SM Higgs decaying to $\bar{b}b$ with mH=120GeV in association with e or μ from W or Z

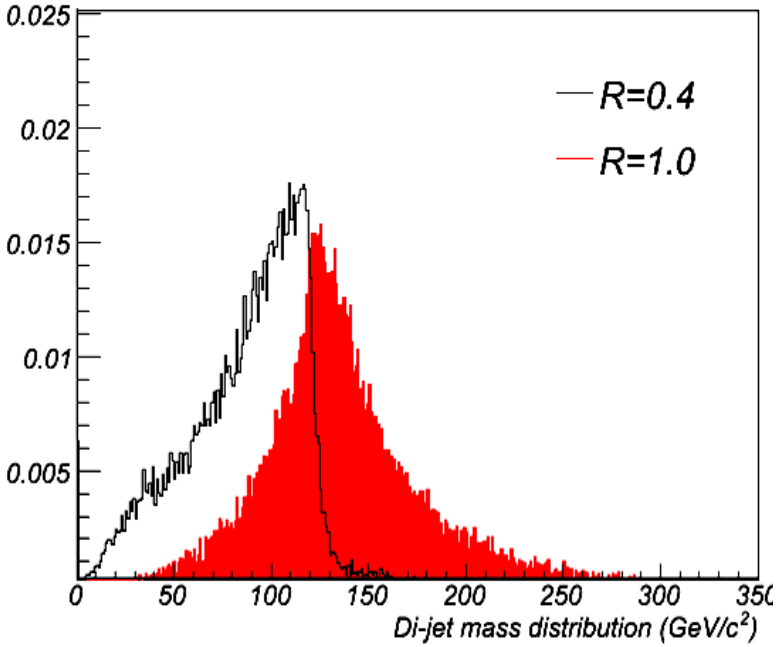


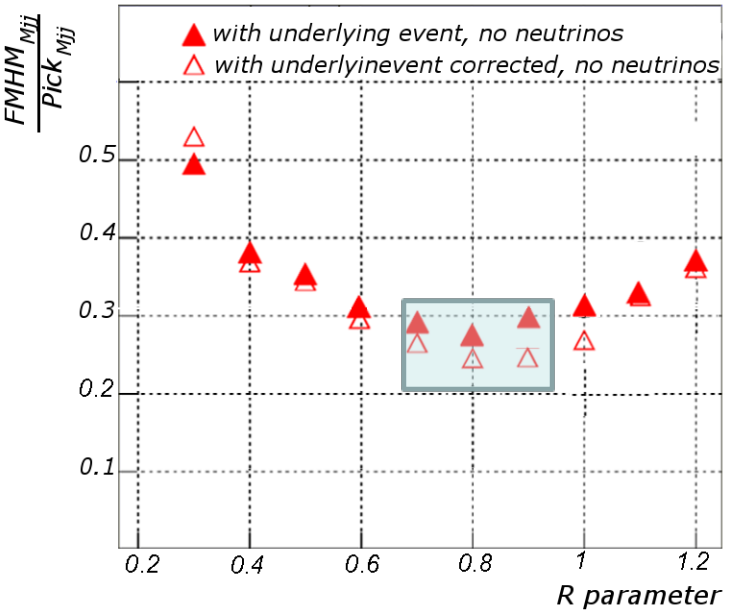
W,Z Bremsstrahlung

Comparison of Cone algorithm with seed and Kt shows similar results in terms of di-jet mass resolution for this study. In the following Kt is used.

4 momentum study all Higgs with η>0



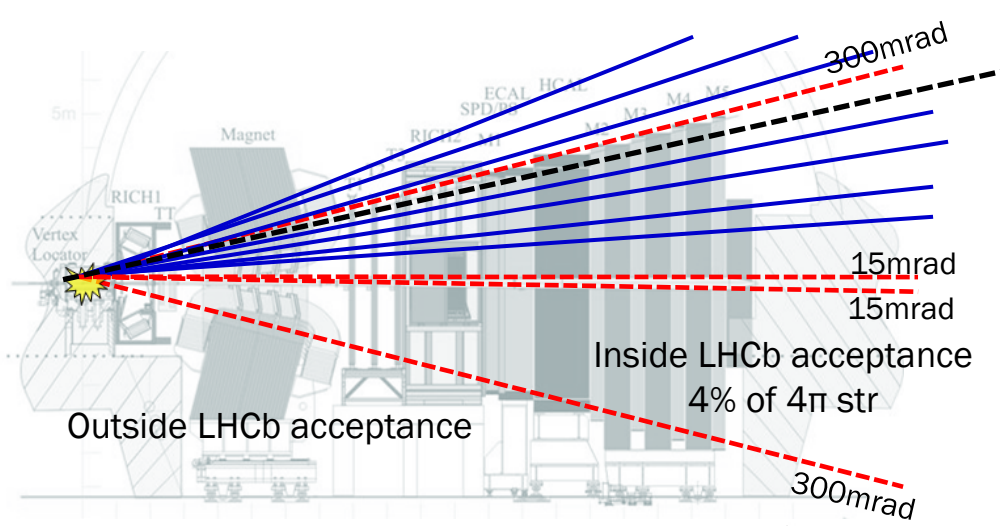


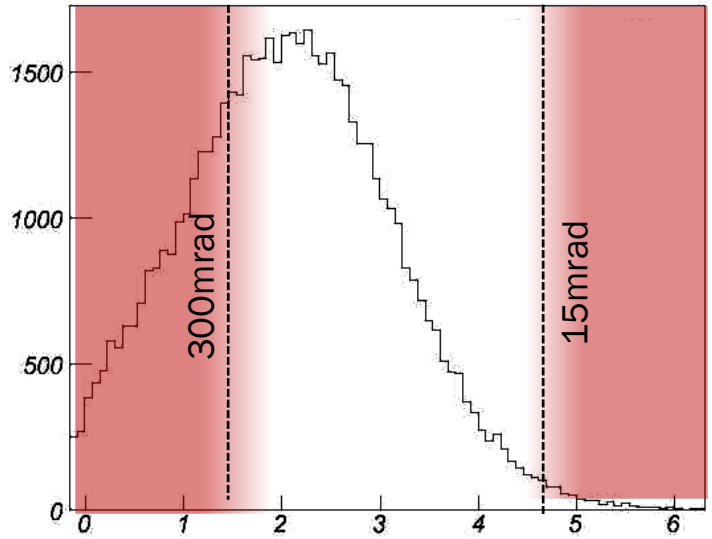


Optimal R value is 0.7<R<0.9

b-Jets reconstruction and identification

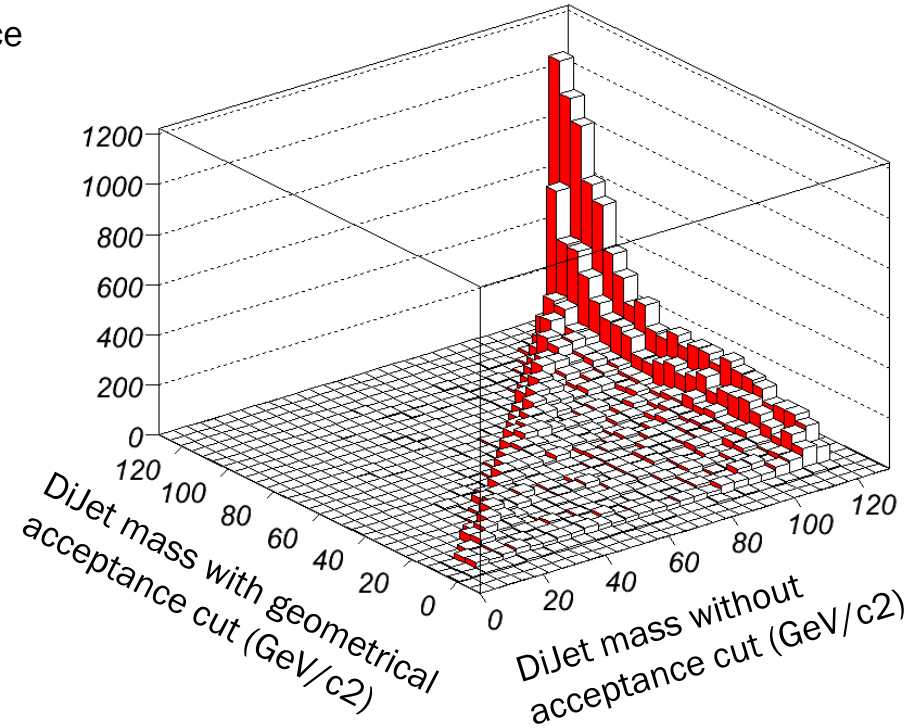
Detector acceptance study at generator level





Pseudorapidity of b-quarks coming from H(120GeV)
(high pt lepton in the acceptance)

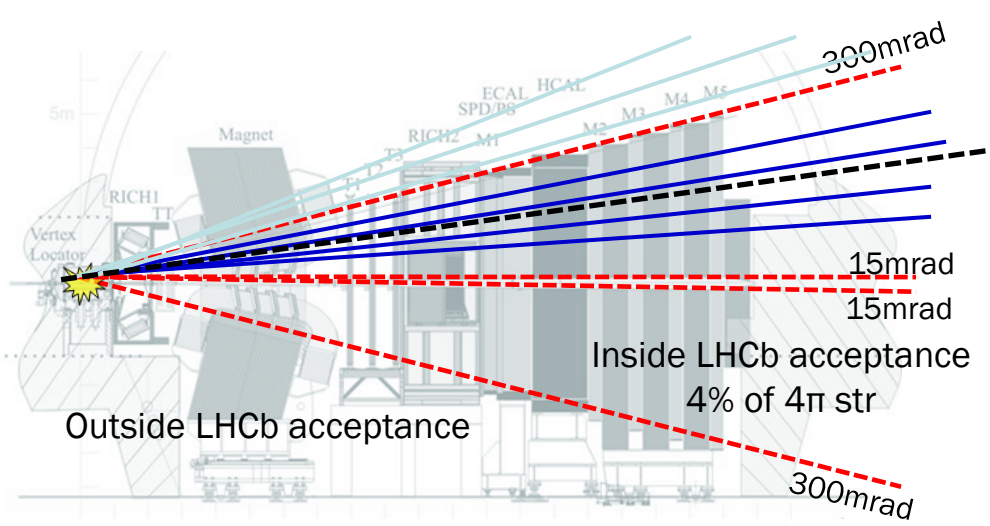
Acceptance losses disturb the partonic picture of the event

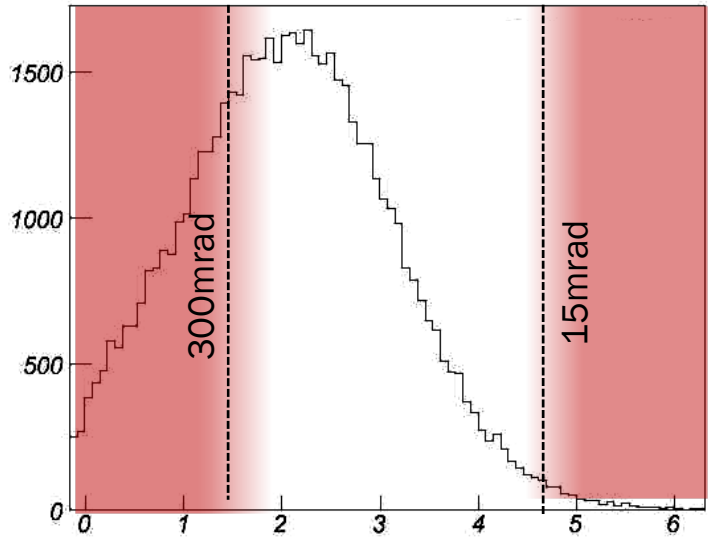


⇒ Dijet mass resolution is affected

b-Jets reconstruction and identification

Detector acceptance study at generator level





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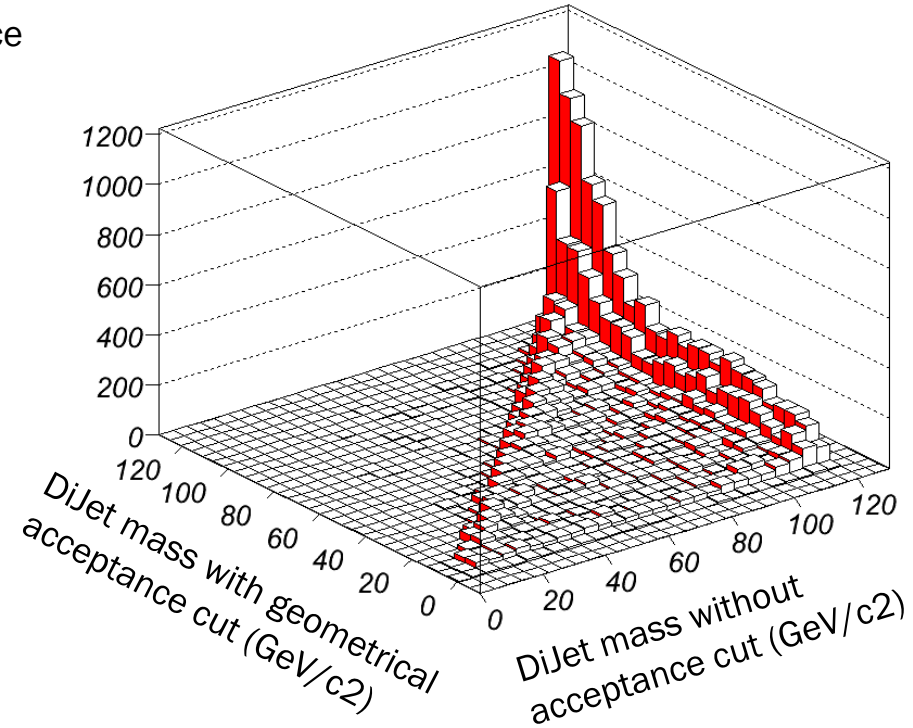

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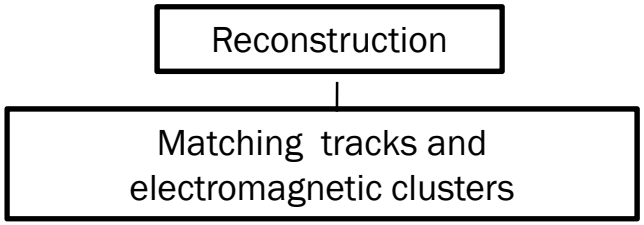
b-Jets reconstruction and identification

LHCb strategy for jet reconstruction



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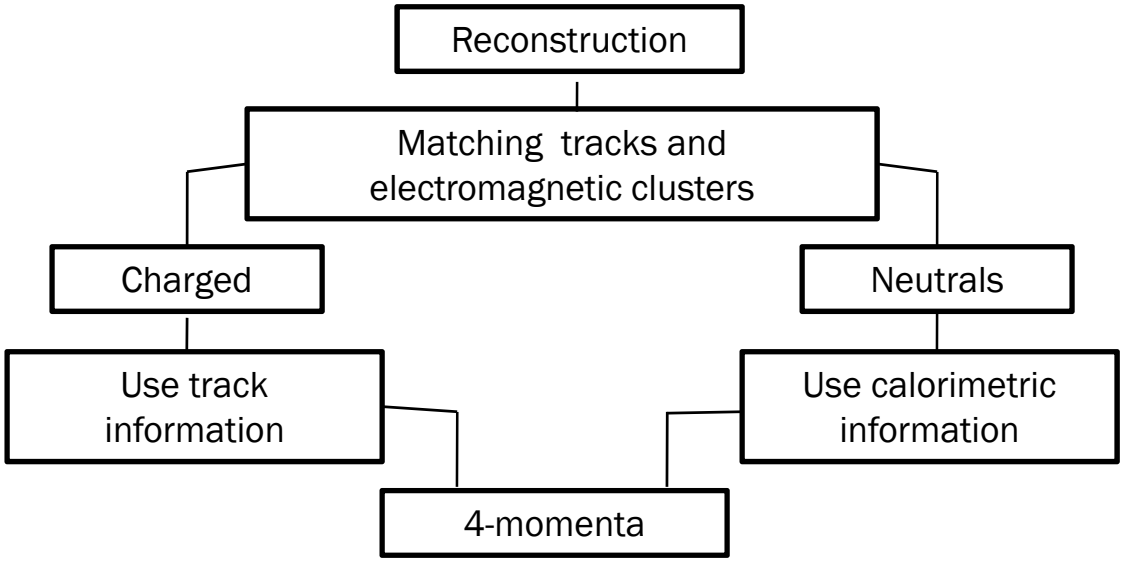

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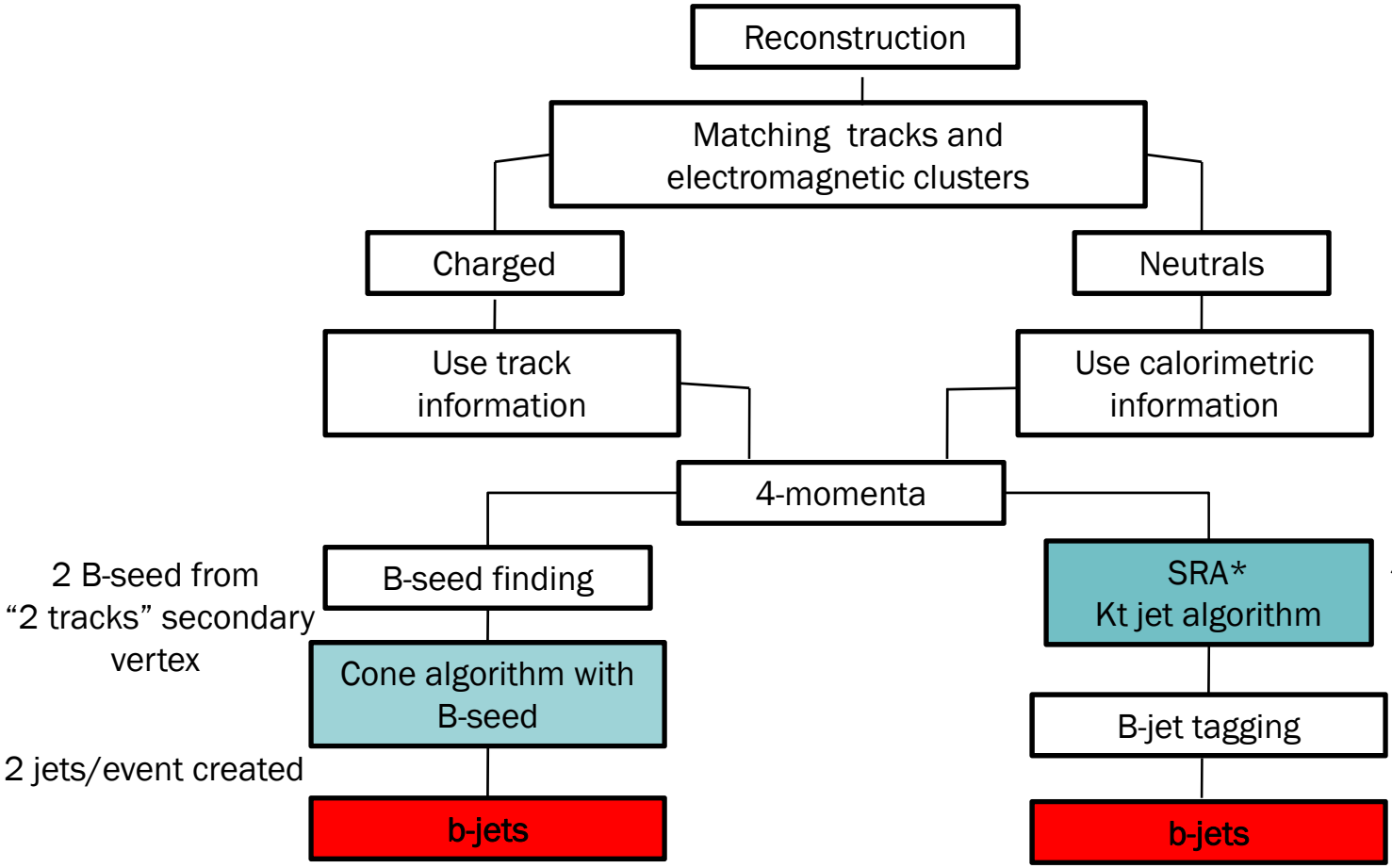


2 B-seed from "2 tracks" secondary vertex

2 jets/event created

For R=0.7
~15 jets/event reconstructed
¼ of them have pt>5GeV/c with mean number of particles: 13

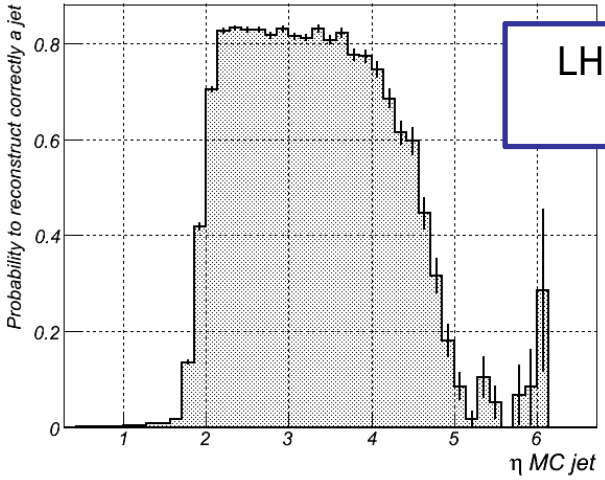
Ideally 2 jets/event

*SRA: sequential recombination algorithm

b-Jets reconstruction and identification

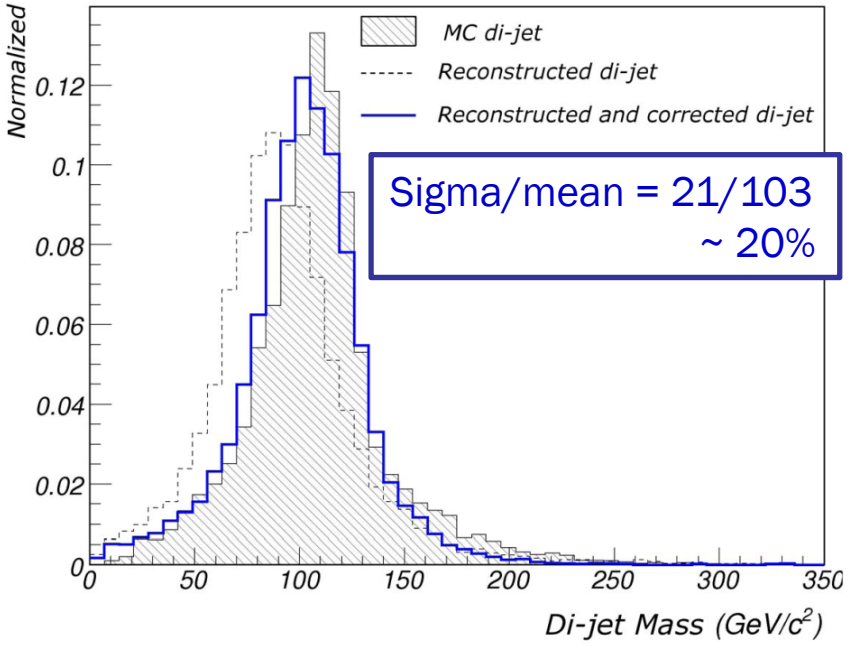
b jets Reconstruction and Correction in full simulation

Only the jets that are well inside the acceptance and known to be b-jets are considered here



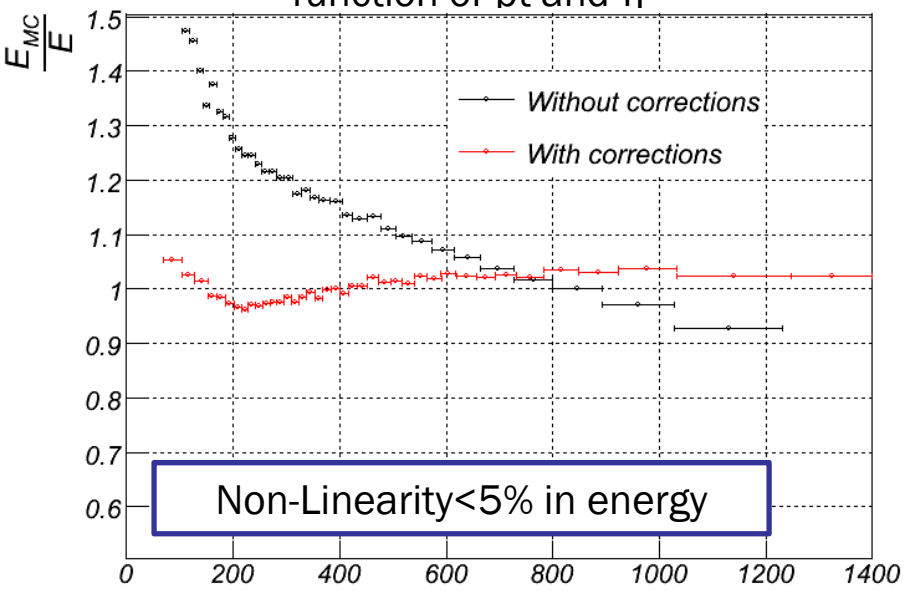
LHCb allow reconstruction of b-jet in the range $2 < \eta < 4$

Kt with R=0.75



Sigma/mean = 21/103 ~ 20%

Absolute corrections are determined as function of pt and η



Non-Linearity<5% in energy

Mass pick is displaced 120→103GeV, mainly because of neutral hadron and neutrino losses

Improvement expected by adding HCAL information

b-Jets reconstruction and identification

b jets identification in full simulation

Jet is defined as b jet if it has:

pt>5GeV, 4 tracks and 2% of charged energy (primary cut)
+ NNSel>-0.2

NNSel is a neural net trained to discriminate b jets from lights and c jets. Made from variables:

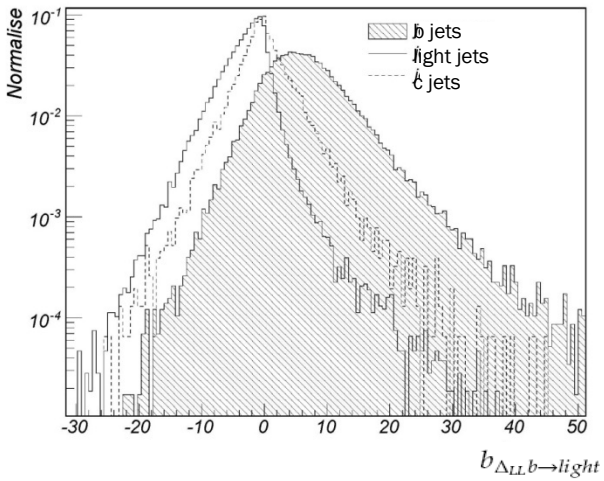
-Number of particles in jet
-Number of tracks with σ_{IP}>4
-Percentage of energy of from tracks with σ_{IP}>4
-Percentage of energy of from charged particles
-Percentage of energy in a cone of R=0.4 around the jet axis
-jet area and pt flux

And two weight defined as:

$$b_{\Delta_{LL}b\to light} = \sum_{constituents} \ln\left(\frac{pdf_b(\chi^2_{IP}, IP, PT)}{pdf_{light}(\chi^2_{IP}, IP, PT)}\right)$$

and

$$b_{\Delta_{LL}b\to c} = \sum_{constituents} \ln\left(\frac{pdf_b(\chi^2_{IP}, IP, PT)}{pdf_c(\chi^2_{IP}, IP, PT)}\right)$$



Taking into account only jets that pass primary cut in some tt events

b-jets selection: 70%
Rejection of:
- b-jets partially in acceptance: 93.5%
- Non b-jets: 96.5%
- Composed of:
  - light-jets: 97.5%
  - All c-jets: 95%
  - Hard c-jets: 85%

No explicit vertex reconstruction, and no semi-leptonic B-decays were used

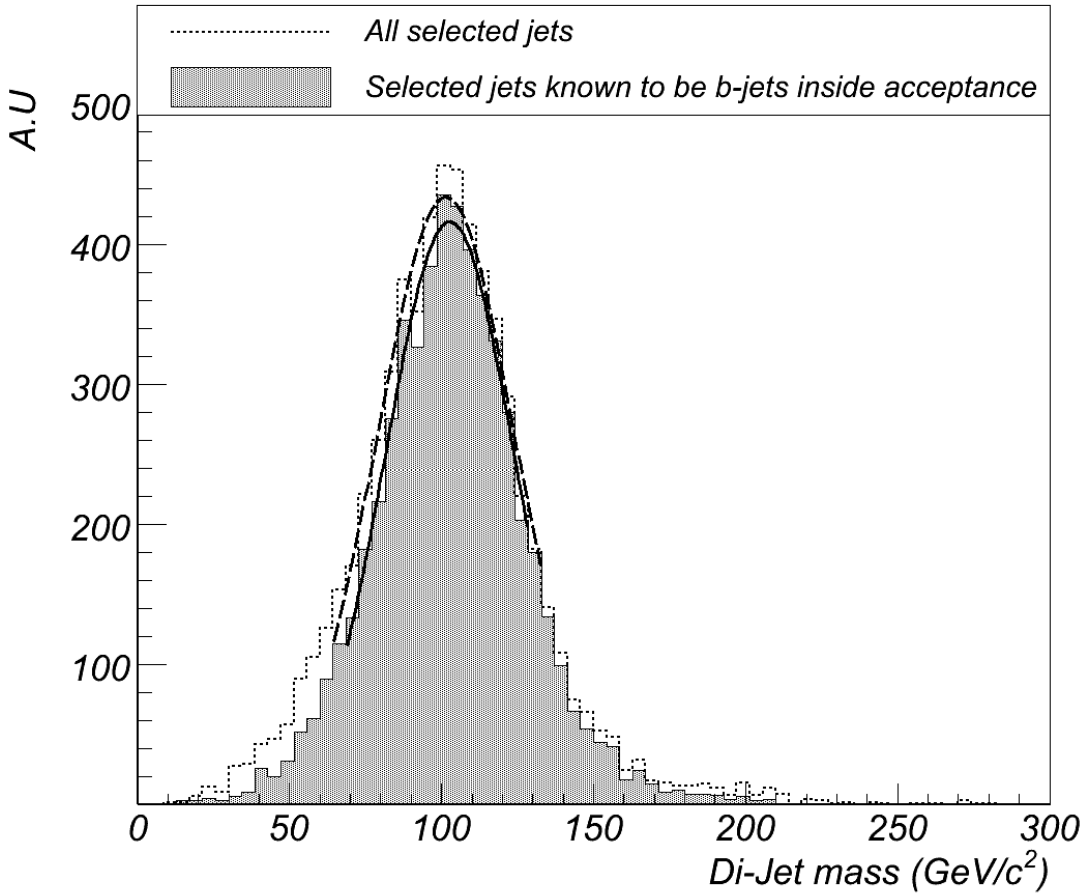
⇒ *Still room for improvement (especially for c-jets rejection)*

b-Jets reconstruction and identification

Influence of acceptance in full simulation

Only the jets that pass the b-jet selection are considered here

Kt with R=0.75



In gaussian approximation:

Considering only b-jets well inside acceptance.

Sigma/mean = 21/103 ~ 20%

Considering all selected jets:

Sigma/mean = 23/101 ~ 22%

On which 8% of di-jets contains one jet that is not a b jet well inside the acceptance.

With b jet selection, about 50% of the reconstructed di-jet events are selected

Which physics can we do?

Of course light SM Higgs decaying into $b\bar{b}$ in association with high transverse momentum lepton would be a (very) nice measurement.

But generator level study shows that $t\bar{t}$ background is difficult to remove

Backgrounds: $b\bar{b}$ inclusive (reduced by high pt isolated lepton)

$t\bar{t}$, Z+2b, W+2b

ZZ, ZW

Under study…

The development of a framework for b-jets studies in LHCb open other possibilities

- At LHC start … measurements of Z production decaying into $b\bar{b}$

- Models beyond SM, involving **several b-jets** and **highly displaced vertices**, are studied
  - -Hidden Valley Models
  - -SUSY models with neutralinos with finite lifetime

Interesting process for LHCb

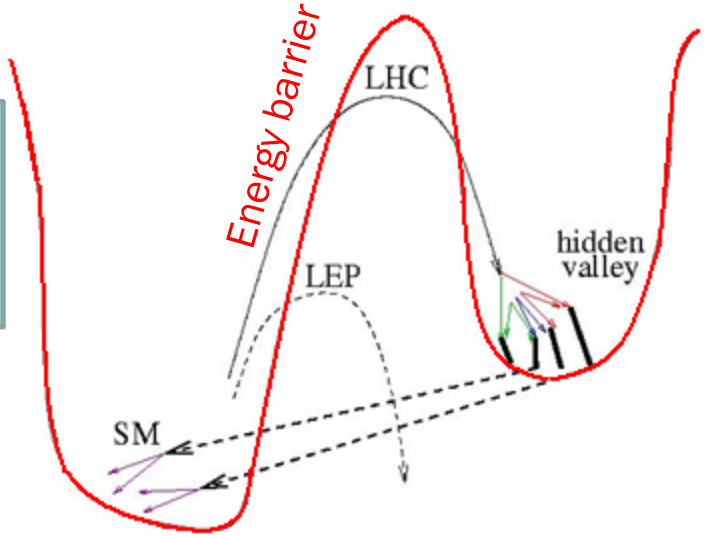
Hidden Valley

It is a class of phenomenological models which
- appear to be consistent with data and well motivated
- arise in many models
- appear to be consistent with most methods for solving the hierarchy problem

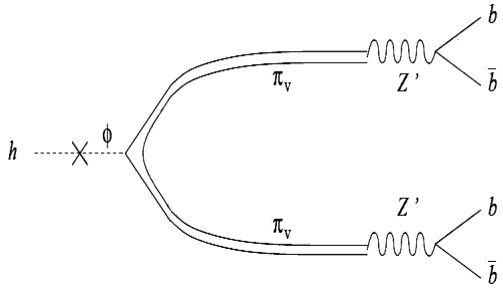
Extend the SM gauge group G_{SM} with non-abelian group G_v
High dimension ***operators at TeV scale*** allow ***interactions between SM and new particles***
Some neutral v-hadrons can decay into gauge-invariant combinations of SM-particles, **with observable lifetimes** (from zero to infinity)

Matthew J.Strassler& Kathryn M.Zurek
hep-ph/0604261 **"Echoes of Hidden Valley at HadronColliders"**
hep-ph/0605193 **"Discovering the Higgs through highly-displaced Vertices"**

"...Indeed it is possible that the LHCb experiment is ideally suited for detecting and studying such states."



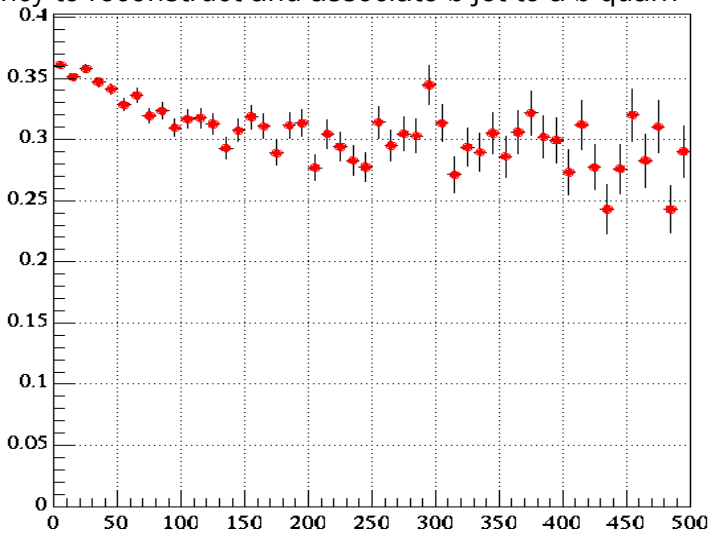
$H_0 \rightarrow 2\pi_v \rightarrow 4b$

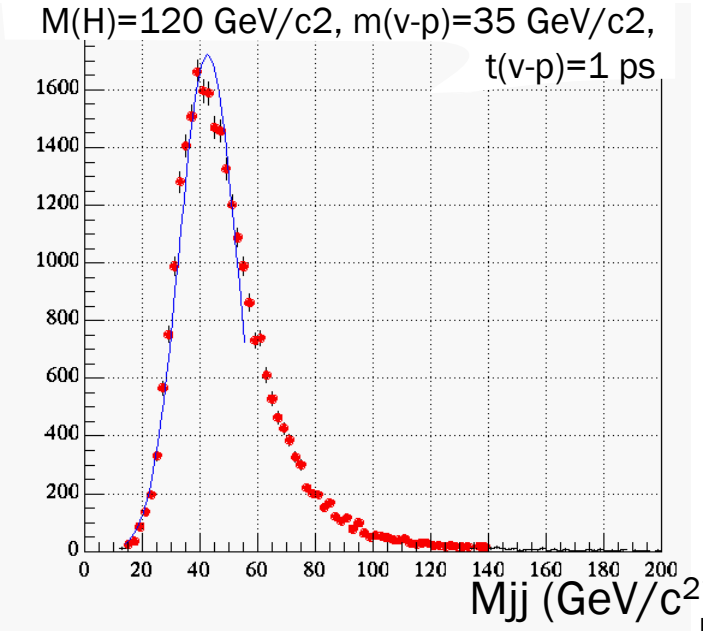


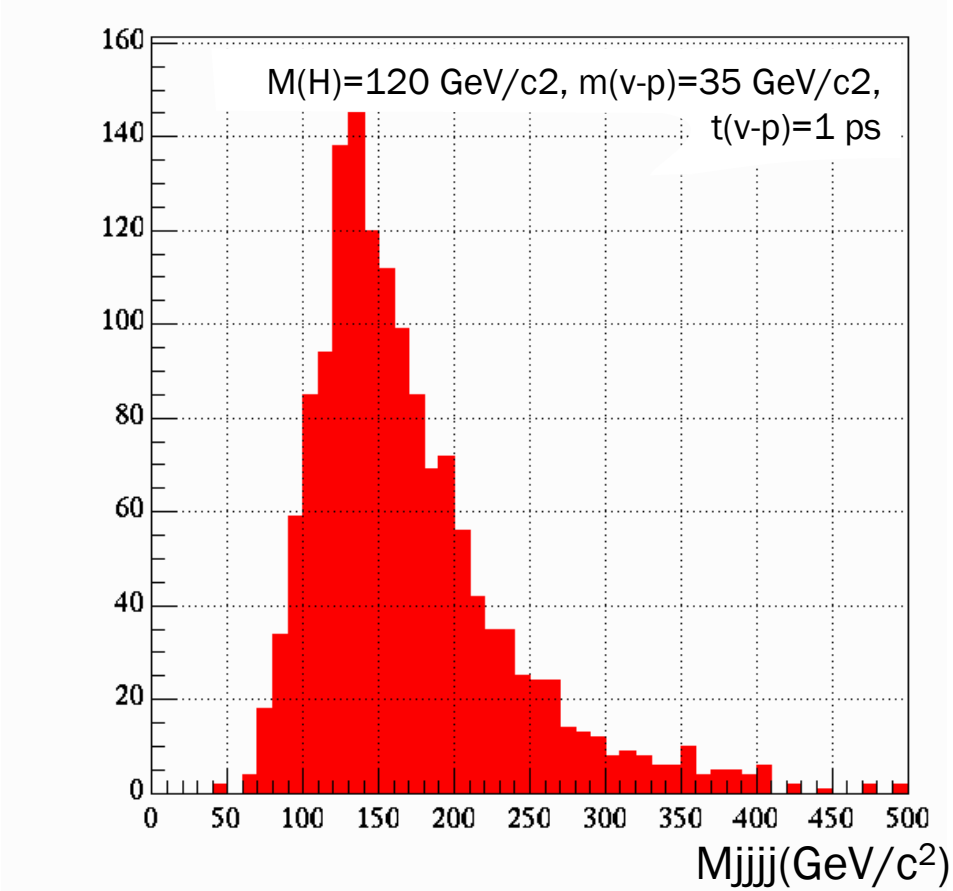
Interesting process for LHCb

Hidden Valley

Efficiency to reconstruct and associate b-jet to a b-quark







Thanks to vertex detector we might be able to reconstruct b jets until lifetime of the order of 50cm

There is potential to reconstruct multi b jets events coming from long life time new particles

Interesting process for LHCb

Susy Neutralino with finite lifetime

MSSM/MSUGRA with R-parity violation, baryon number violation and non-unified gaugino masses.
Light Higgs decays mainly into lightest neutralinos with finite lifetime.

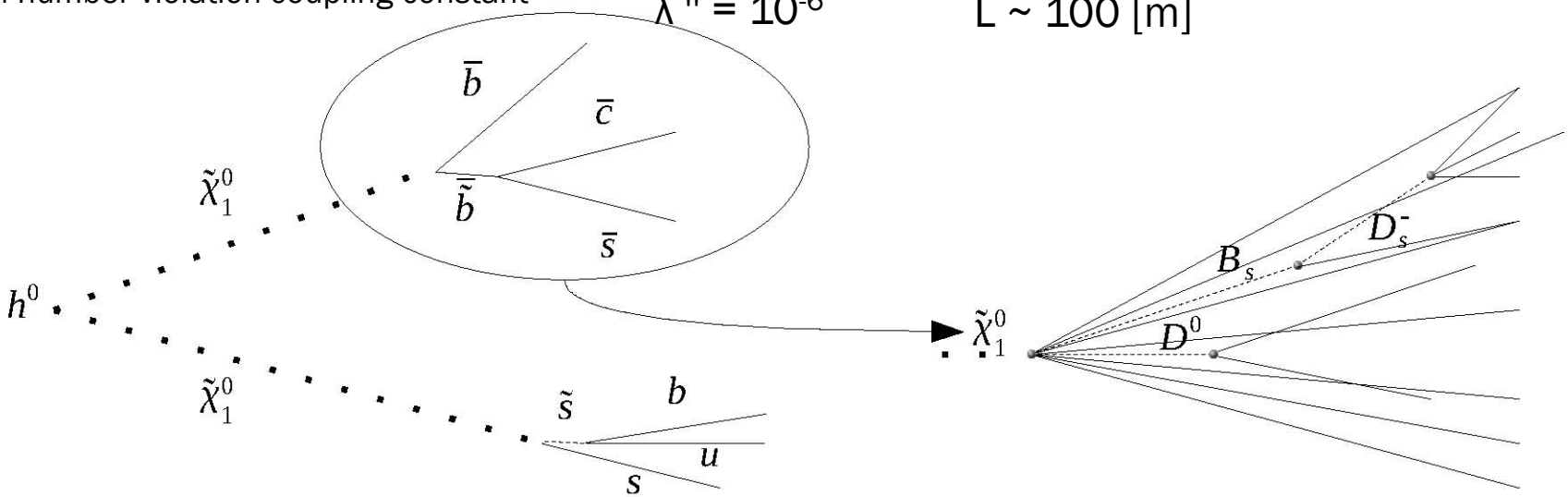
D.Kaplan, L.Carpenter, E.-J.Rhee
hep-ph/0607204 **Reduced Fine-Tuning in Supersymmetry with R-parity violation**
D. Kaplan, K. Rehermann, arXiv:hep-ph/0705342 v2
Proposal for Higgs and Superpartner Searches at the LHCb Experiment

$$L \;\alpha\; \frac{1}{\lambda''^{2}}$$

Baryon number violation coupling constant

$\lambda'' = 10^{-3}$	L ~ 100 [μm]
$\lambda'' = 10^{-4}$	L ~ 10 [mm]
$\lambda'' = 10^{-5}$	L ~ 1 [m]
$\lambda'' = 10^{-6}$	L ~ 100 [m]

Might be detected at LHCb



Aim is to find 4 displaced vertices (2 from χ_0 and 2 from B or D daughters) with high number of track

Interesting process for LHCb

Susy Neutralino with finite lifetime

m_χ=50 GeV/c^2 m_{h0}=115 GeV/c^2 $\lambda''=10^{-4}$

Generator level study with vertex smearing
Only charged tracks are used

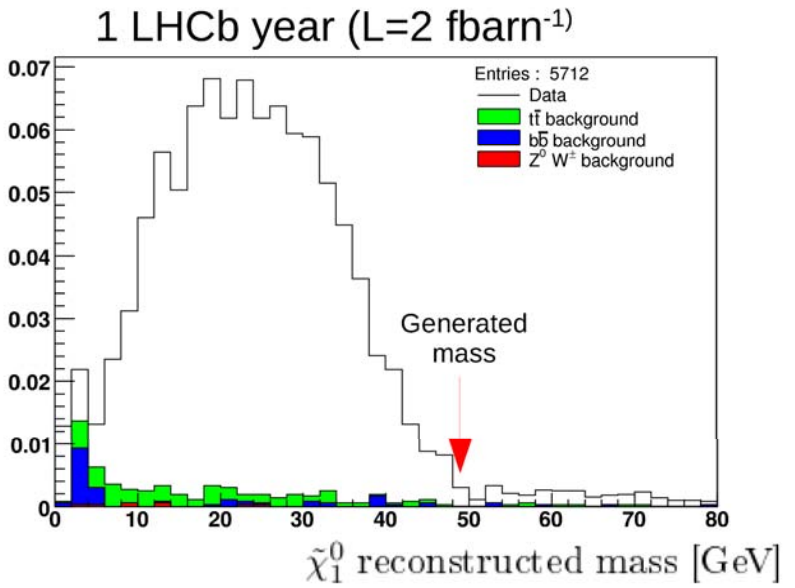
Study is based on topological selection of displaced vertices for χ_0, B and D

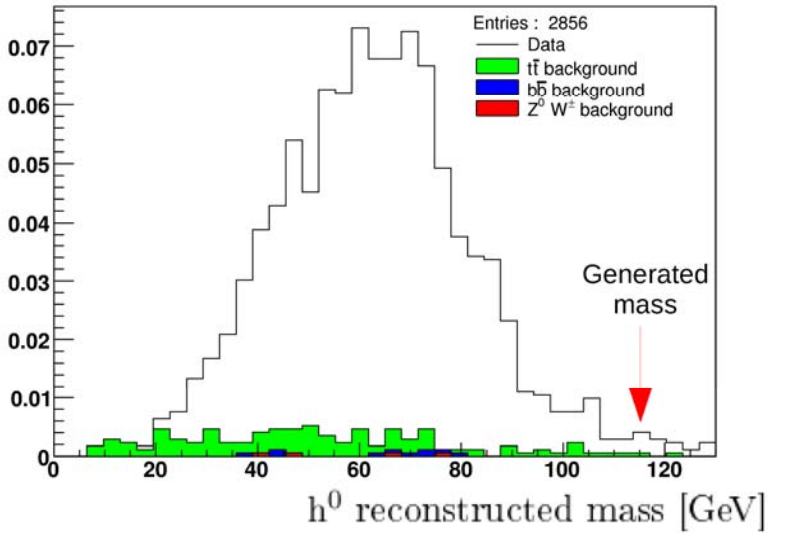
Displaced vertex are collected two by two to identify a χ_0 decay and then two χ_0 are by events required to build h_0

1 LHCb year

σ_h = 62.7 pbarn
nb of evts = 5000 – 100'000
nb of evts in accept. = 1000 – 25'000
nb of evts after trigger = 800- 20'000

Potential to detect massive displaced vertices with high number of tracks (> 6)





Summary

Tools are developed to ***reconstruct b-jets in LHCb***

Reconstruction is effective within $2<\eta<4$

b-jet identification benefits from high resolution vertexing

Possibility of detecting ***highly displaced vertices*** *from* ***new physics*** *processes*

Beside important B physics measurements

LHCb has potential to observe New Physics processes

in high rapidity region