Benchmarking Tracking & Vertexing

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This Presentation

to discuss with tracking group

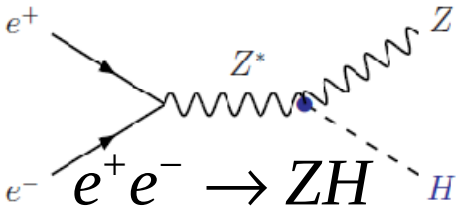
- Benchmarking physics processes
  - For Tracking
  - For Vertexing
- Status of Tracking tools
- Benchmarking and optimization for tracking

Tracking

ZH Recoil Mass Resolution

$\sqrt{s} = 350\ GeV$

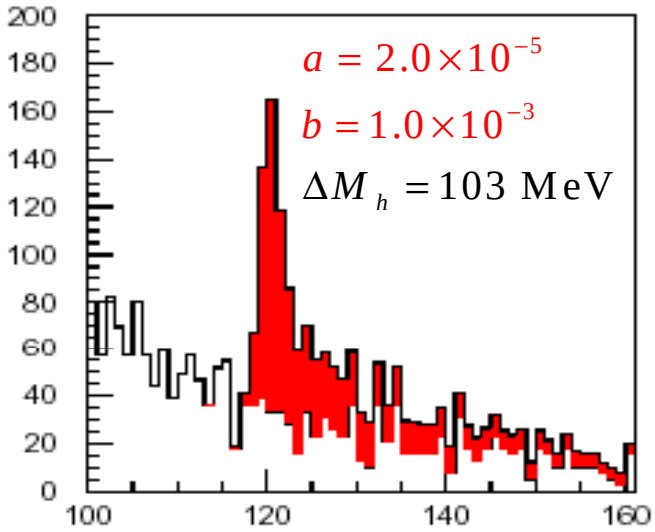
$L = 500\ fb^{-1}$

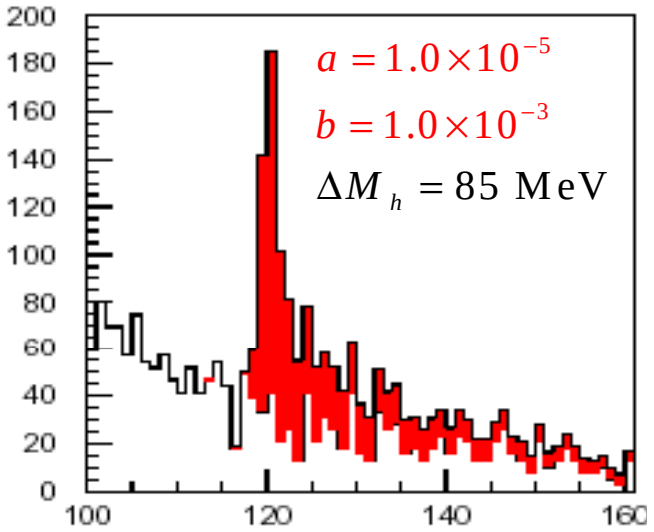


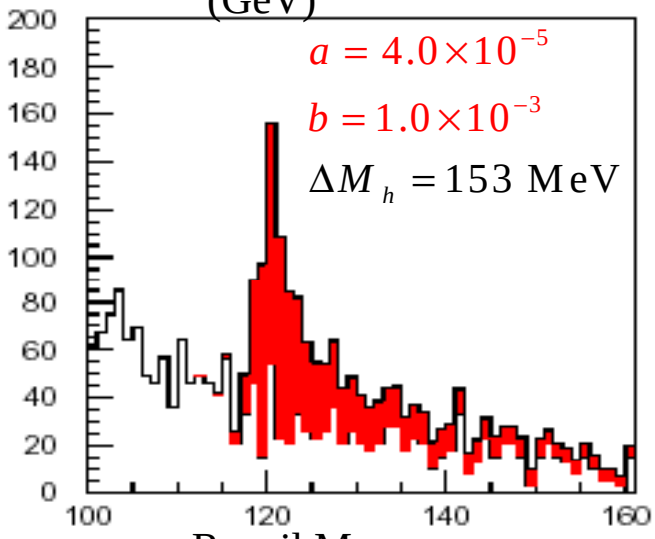
$e^+e^- \rightarrow ZH$

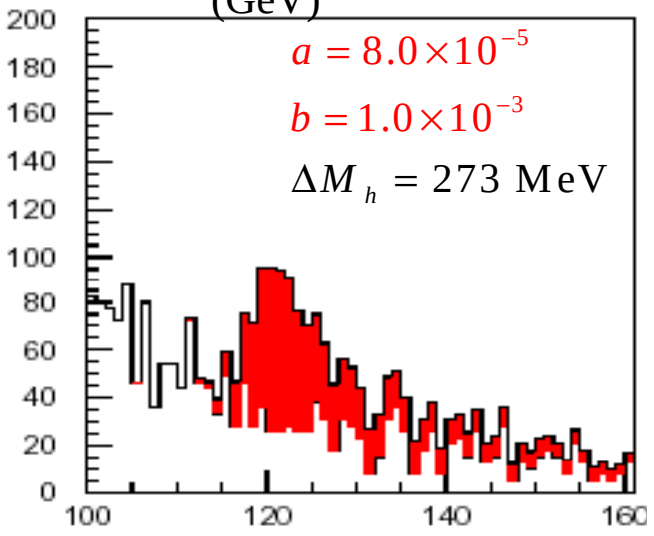
$\rightarrow \mu^+\mu^- X$

- Model independent approach – does not depend on Higgs decay mode
- Resolution quickly deteriorates with momentum resolution
- Also studies by Norman using SLIC





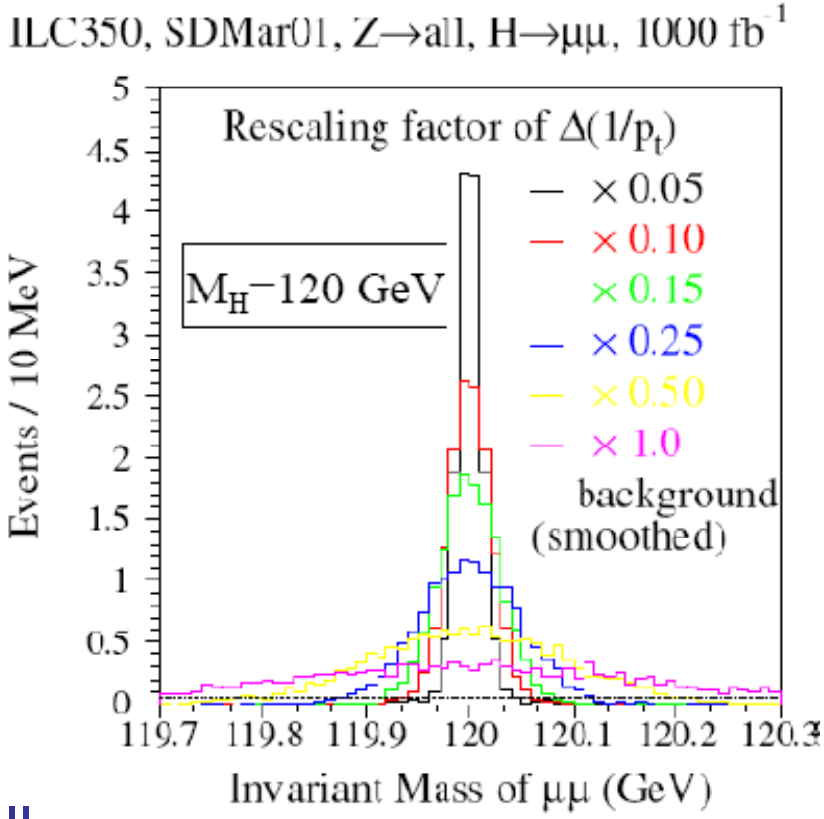




$$\frac{\delta p_t}{p_t^2} = a \oplus \frac{b}{p_t \sin\theta}$$

H→ μμ and ee→μμ

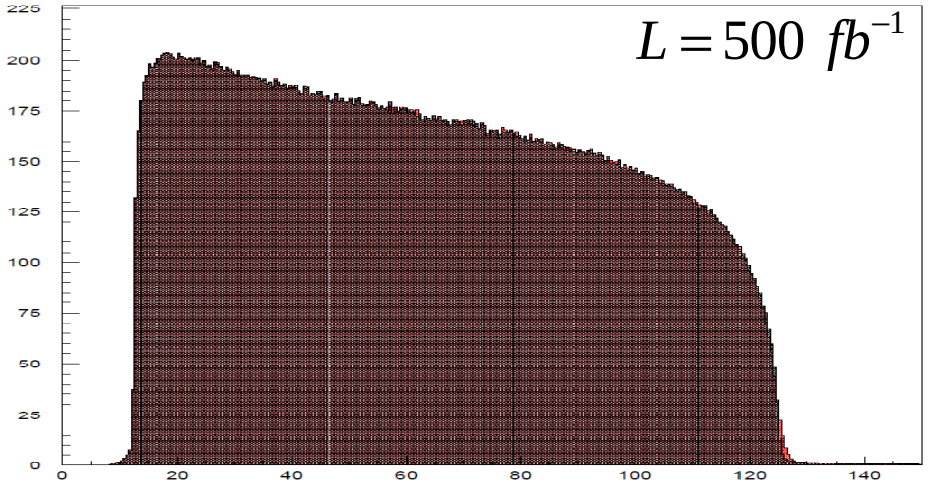
- Br H→ μμ
  - Studies by Haijun Yang and Keith Riles (U.Michigan)
  - Very sensitive to momentum resolution
- ee→ μμ
  - Energy reconstruction through luminosity weighted center-of-mass energy. Need to know well momentum, angle and acceptance. Studied by Tim Barklow



Scalar Muon Mass

$\sqrt{s} = 500\ GeV$

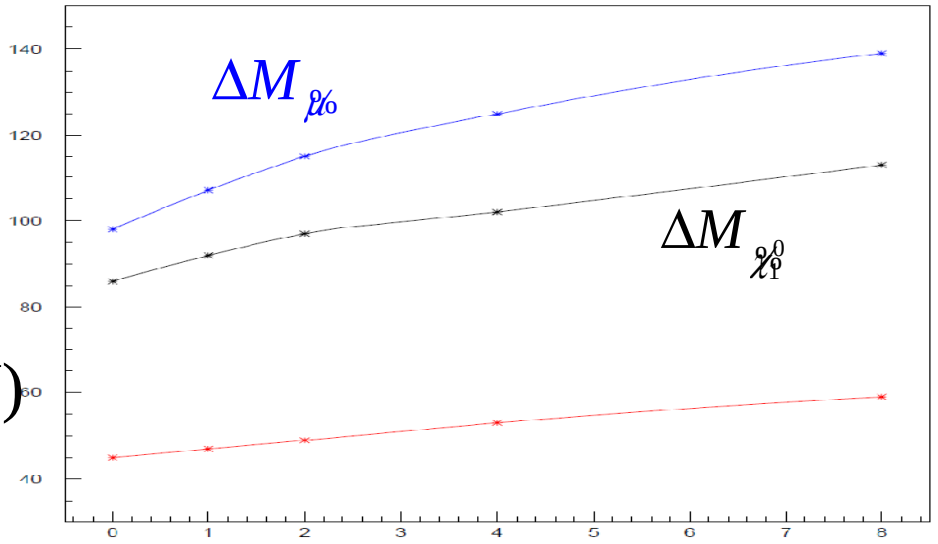
$e^+e^- \to \tilde{\mu}^+\tilde{\mu}^- \to \mu^+\mu^-\tilde{\chi}^0_1\tilde{\chi}^0_1$



Muon Energy (GeV)

- Two body decay of smuon
- Mass is measured by edges in muon energy spectrum
- Threshold scan

- Not in SiD short list



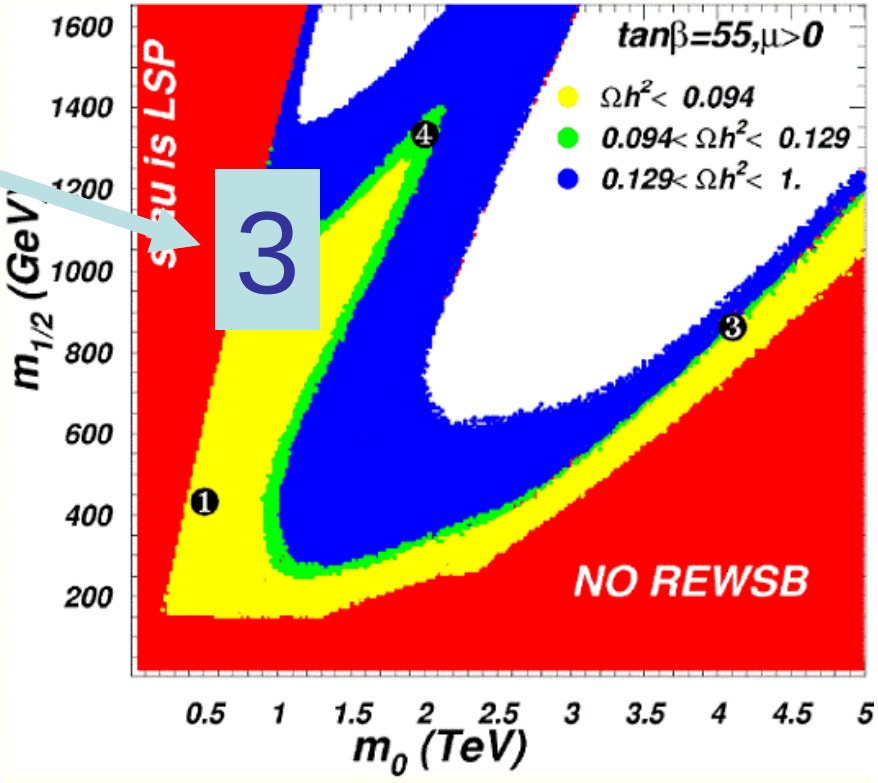
$a \times 10^{-5}$

$\Delta M_{\tilde{\mu}}\ ,\ \Delta M_{\tilde{\chi}}\ (\mathrm{MeV})$

$$\frac{\delta p_t}{p_t^2} = a \oplus \frac{b}{p_t \sin\theta}$$

Soft Tracks

- ee→stau stau → ττ MET
- So called SUSY Point 3: Δm=9 GeV ➔ soft tracks
  - Δm is allowed to be even smaller

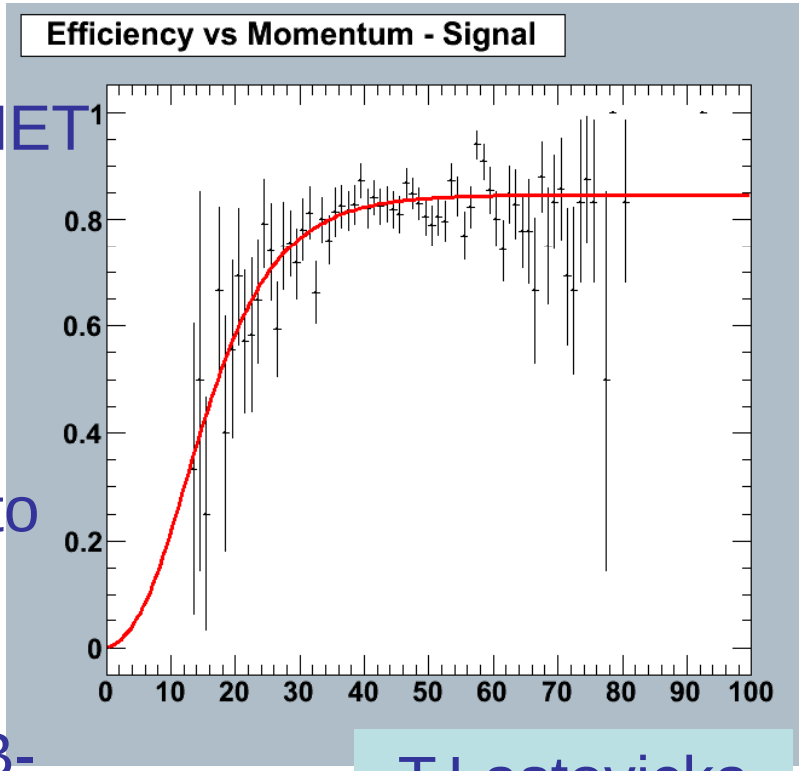


Soft Taus

- 85% of tau decays are single prongs
- Reconstruction of soft tracks is hard
- Tagging of taus is hard as well
  - Tag taus using Tracking/Vertexing
  - Use tau lifetime (=impact parameter) to tag?
  - c tau = 87 micron

More Soft Jets and Tracks

- Similarly
  - ee→sbottom sbottom → bb MET
  - ee→stop stop → cc MET
- Tagging of soft bottom and charm is hard
  - Standard b-tagging eff starts to fall down at 20-30 GeV
  - At smaller energies: just collection of soft tracks from B-hadron decays – similar to B-physics
  - Nobody really studies this yet



T.Lastovicka

Forward Tracking

- Anomalous couplings in ee→bb, ee→cc
- Observable, FB asymmetry, is most sensitive in forward region
  - Need to distinguish quark and antiquark
- Asymmetry is measured using jet vertex charge
  - Single tracks matter – can flip the vertex charge

Vertexing

Benchmarking Vertexing

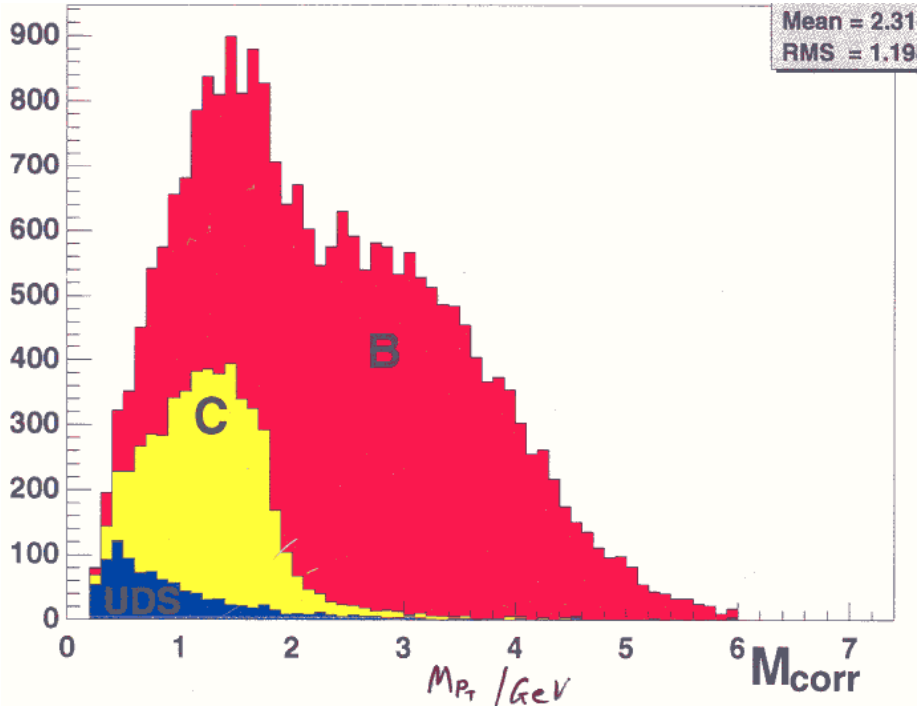
- bb and cc two fermion production
- Br H→bb, cc, tau tau

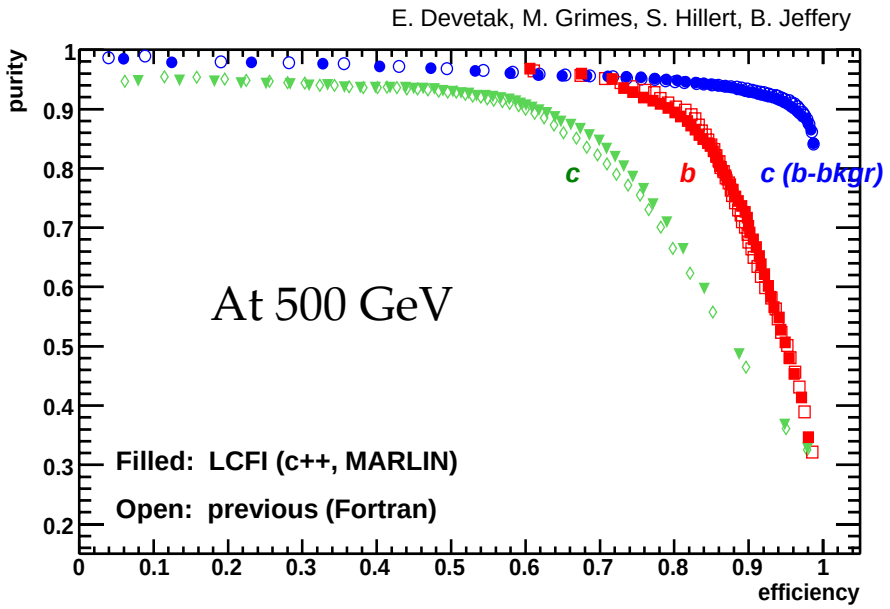
- ZHH (or ttbar) 6-jet final states need highly efficient *b*-tagging
  - significant heavy flavour multijet background
  - dense, collimated jets

- 3-prong vertexing for collimated tau decays

Flavour Identification

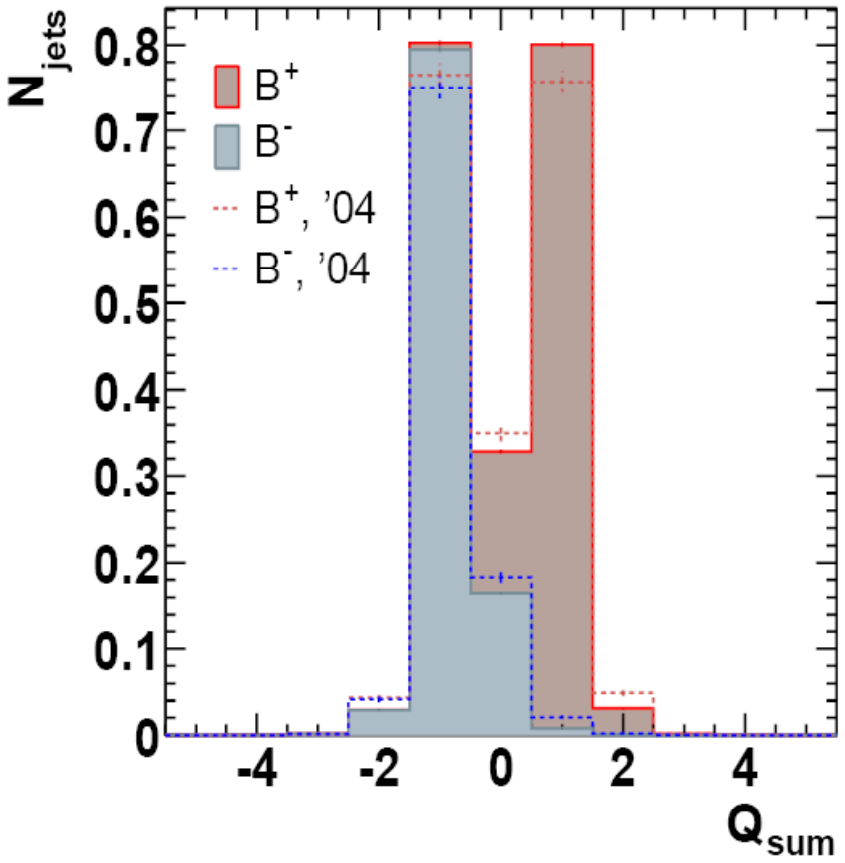
- Combine several variables into Neural Net
  - **Vertex mass**
  - Vertex momentum
  - Decay length
  - Decay length significance
  - Jet Probability
- Main contributors are Vertex Mass and Jet Probabilit



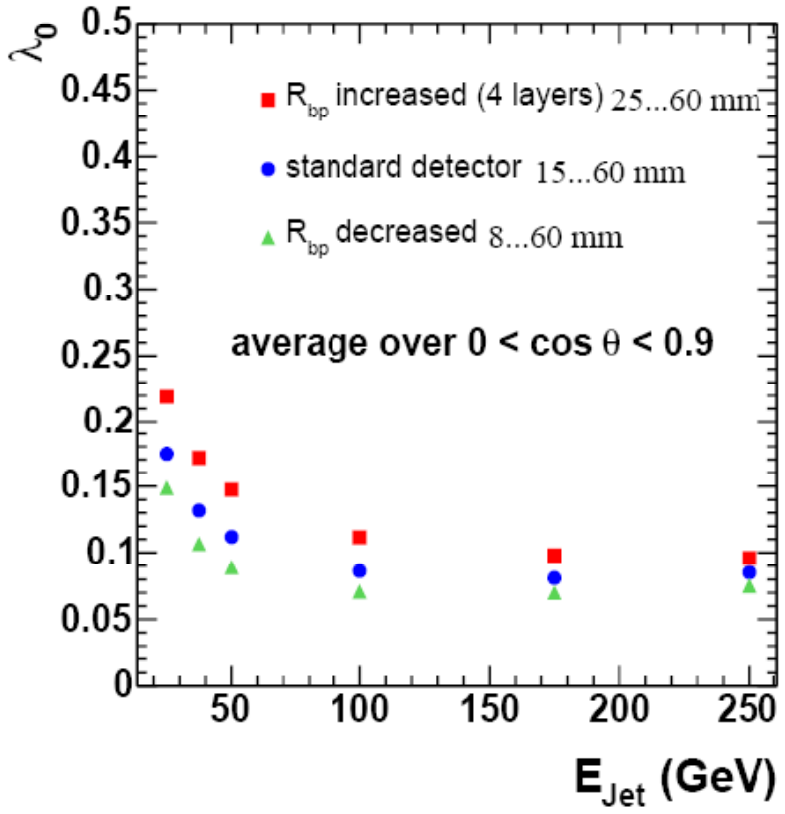


Vertex Charge

- Total charge of tracks associated with a secondary (+tertiary) vertex
  - Binary behaviour : a lost or wrongly assigned track changes the charge → every track is important
- LCFI Vertexing Package does flavour tagging and vertex charge



Optimization of Beampipe Radius



By S.Hillert in 2005

- Compared several beampipe radii
- Calculated corresponding ‘luminosity factors’ based on efficiency deterioration
  - Strong dependence: 70% more luminosity needed for 50 GeV jets if R increased from 15 mm to 25 mm
- Need R as small as possible

Tracking Tools

- I am not aware of any pattern recognition code that is ready to be use for analysis
  - I hope to learn more about it today
- Current options: Fast MC and PPFA
- PPFA has some tracking intelligence
  - Keep track of secondaries
  - Decides between reconstructable and un-reconstructable particles (pt cut, # of hits etc)
- FastMC and PPFA have usable error matrices
  - Tested with LCFI vertexing package (so far through reflection off Marlin and back to org.lcsim)
- It looks like PPFA could account for all material effects but without pattern recognition

Questions

- When will we have some usable pattern recognition?
- What do we need to optimize the Tracker? (well, which aspect of the Tracker, see next question)
  - fastMC?
  - PPFA?
  - Full MC
- What can be optimized without full MC?
  - Geometry? (acceptance, number of layers, barrel vs endcal split)
  - Various tracking algos and their combinations?
  - Tolerable bkg levels for pattern recognition?
- What do you have in mind for a set of subsystem benchmarking plots
  - Tracking efficiency, fake rate vs pt, angle
  - IP resolution vs pt, angle, IP
  - V0 reconstruction efficiency vs raduis, pt
  - V0 invariant mass vs pt
  - …