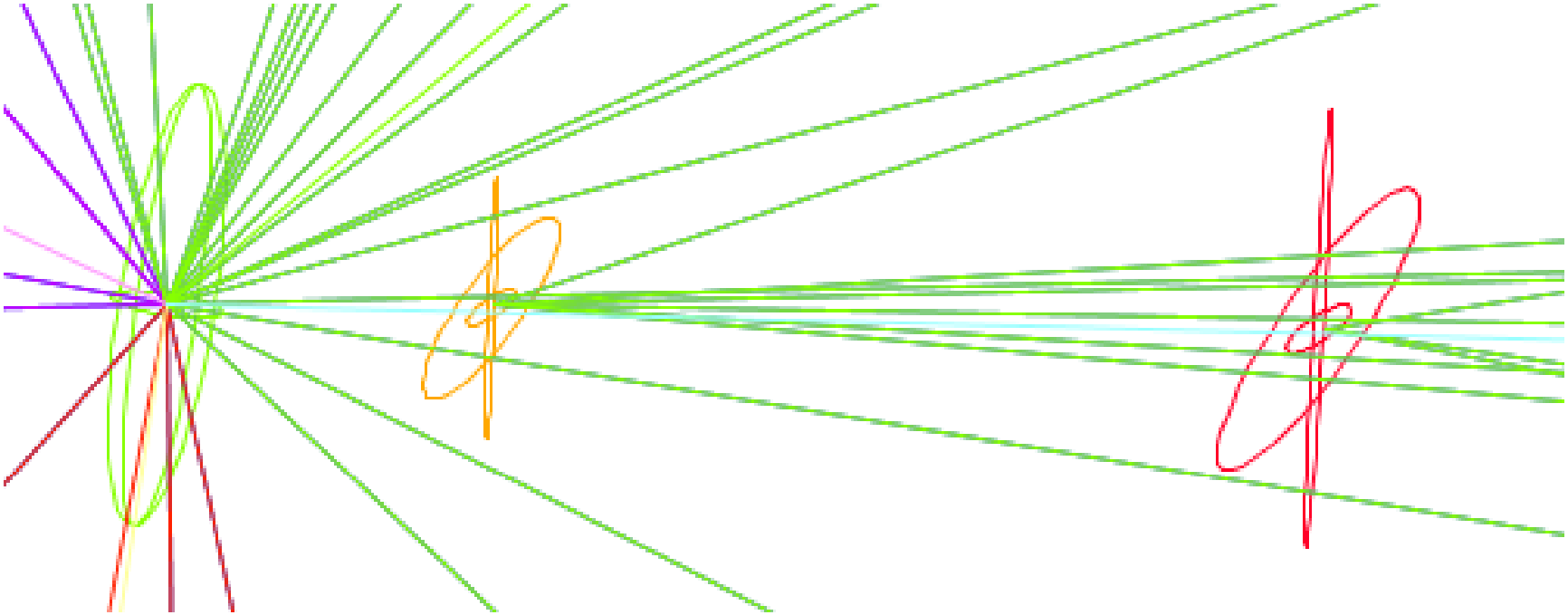
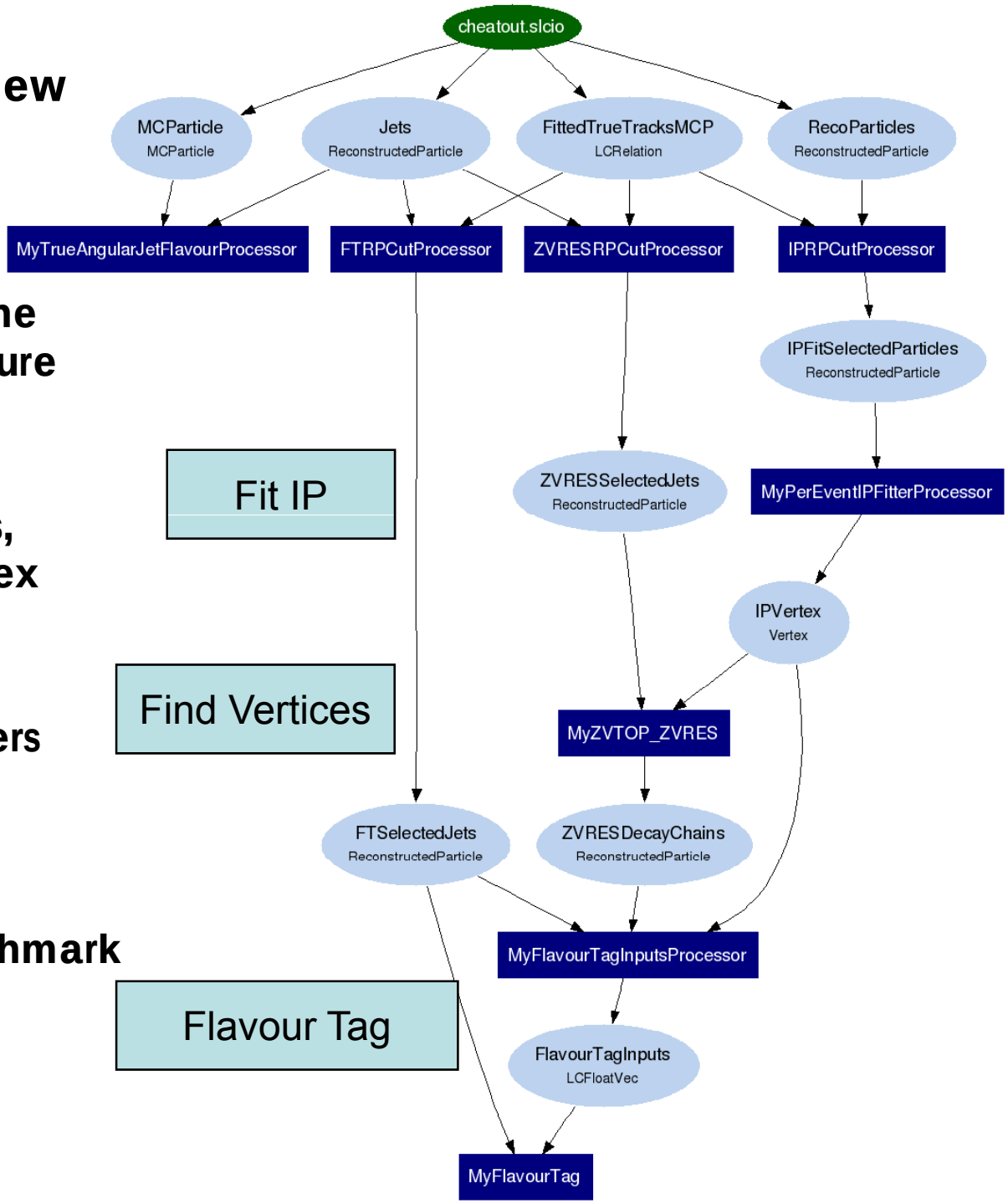


LCFI Vertex Software Update

Ben Jeffery
Oxford University
(on behalf of the LCFI collaboration)

Vertex Package Overview

- **Set of 10 processors for the Marlin Framework with pure LCIO interfaces**
- **Two vertexing algorithms, flavour tagging and vertex charge measurement**
- **Active development, users from 3 different software frameworks**
- **Now being used in benchmark studies**



What's in the package?

Ten modular parts (Processors in Marlin):

In run order:

- **TrueJetFlavour** - Determine MC flavour and charge of reconstructed jets
- **RPCut** - Select ReconstructedParticles based on Track parameters, number of hits etc.
- **PerEventIPFitter** - Find the event IP
- **ZVTOPZVRES** - Find secondary vertices topologically
- **ZVTOPZVKIN** - Find secondary vertices kinematically
- **FlavourTagInputs** - From vertices and tracks calculate discriminating variables for the neural net
- **FlavourTag** - Calculate network output (tag value)
- **VertexCharge** - Calculate charge of decaying hadron *(next release)*
- **LCFIAIDAPlot** - Create AIDA file with many diagnostic plots *(next release)*
- **NeuralNetTrainer** - Train networks

The example steering files combine these to make the Hawking's bc tagging procedure *(LC-PHSM-2000-021)* parameters for these from previous Brahms study.

Documentation is in "LCFIVertex/doc" in the form of doxygen generated web pages, the Processor class pages are a good starting point. There are also several extra pages of explanatory prose under "related pages"
Code and docs at: http://ilcsoft.desy.de/portal/software_packages/lcfivertex/index_eng.html

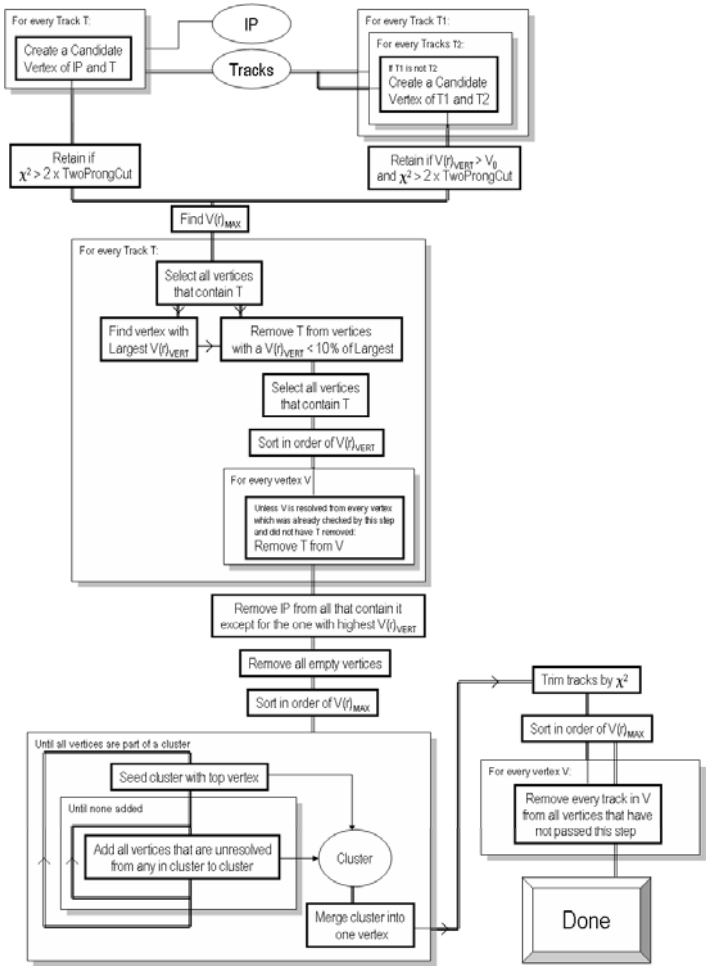
Recent Developments and Features

- **Now at version v02-02, core algorithms stable.**
- **Development focuses on secondary tools to remove dependence on MC information and provide a tuned set of code parameters**

Increase realism – proper treatment of effects added by full MC

- **Recently Added**
  - **Diagnostics**
  - **Kalman Fitter**
  - **Full MC Impact parameter fitting**
  - **Material Interactions**

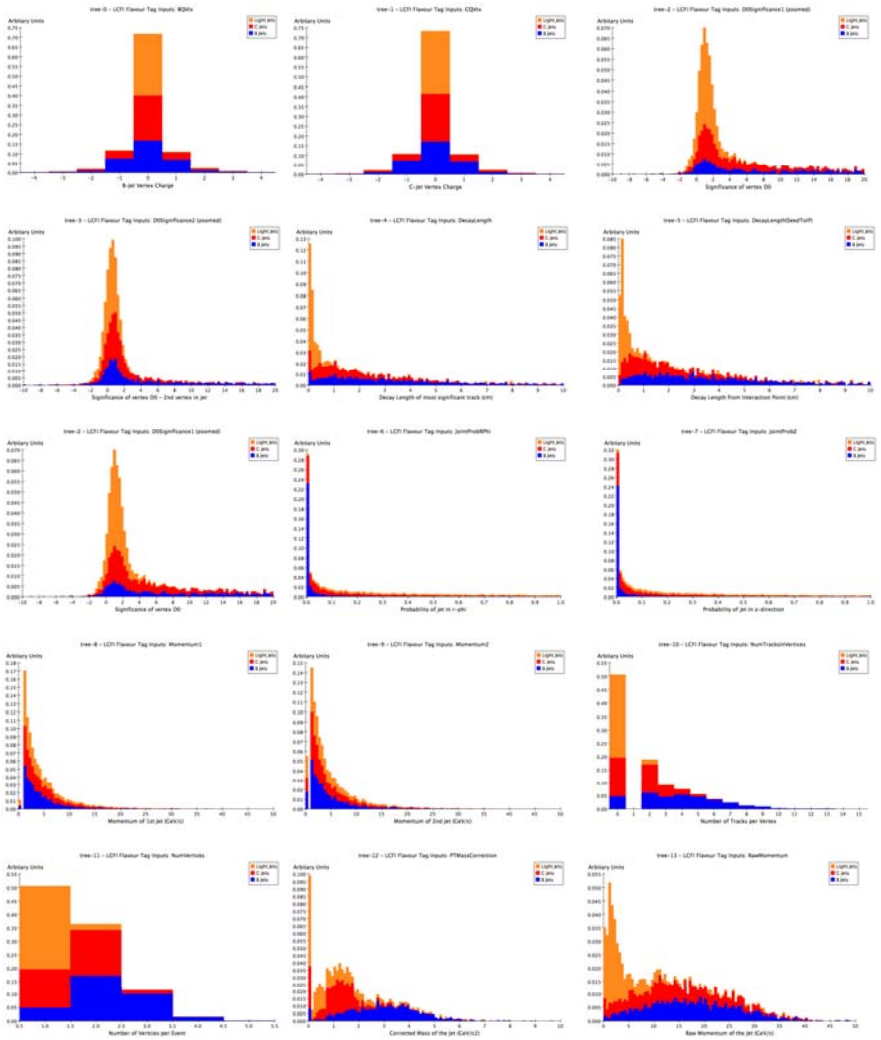
- **Upcoming:**
  - **Removal of K_S, Λ and photon conversions**
  - **Parameter Tuning**
  - **Training of flavour tag based on full MC**
  - **Additional documentation** →
  - **Paper describing package**



Vertex Algorithm Flow Diagram

Diagnostics

(Victoria Martin)



Purity of reconstructed track-vertex association (%)

MC track origin	Reconstructed track-vertex association: Two-vertex case			Three-vertex case			
	Pri.	Sec.	Iso.	Pri.	Sec.	Ter.	Iso.
Primary	90.5	1.61	27.7	97.2	4.66	2.43	46.5
B decay	7.2	48.6	35.1	1.91	74.9	9.99	24.5
D decay	2.28	49.8	37.2	0.935	20.5	87.6	29

- **Plot Processor produces AIDA file of vertexing and IP fitting results, flavour tag input distributions and outputs**
- **Tables of purity of track to vertex allocation**

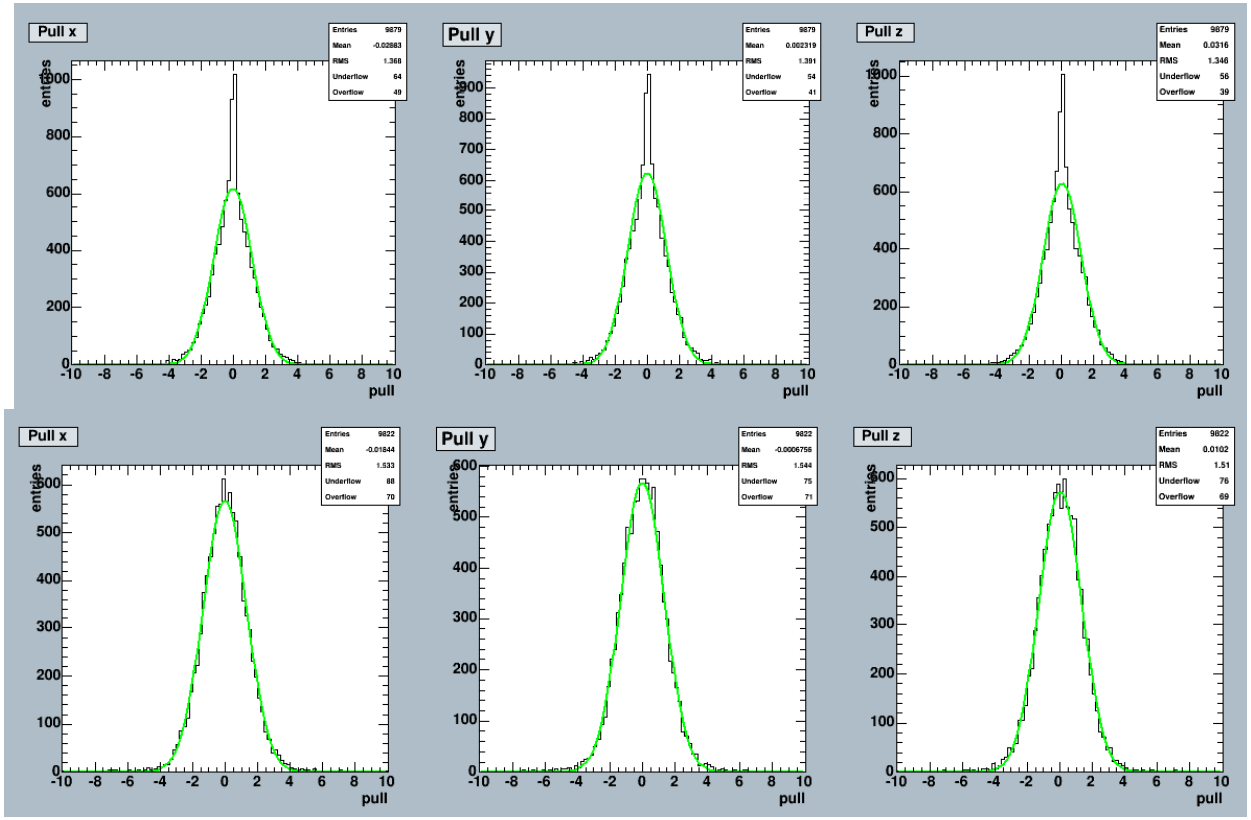
Kalman Fitter

(Tomáš Laštovička)

- **Original vertex fitter was quickly developed and intended to be a placeholder.**
- **New Kalman filter based on one developed for the CBM experiment**
  (S. Gorbunov and I. Kisel, CBM-SOFT-note-2006-001)
- **Orders of magnitude faster!**
- **Better looking pull distributions.**
- **Now default for IP Fitting**

Original

Kalman



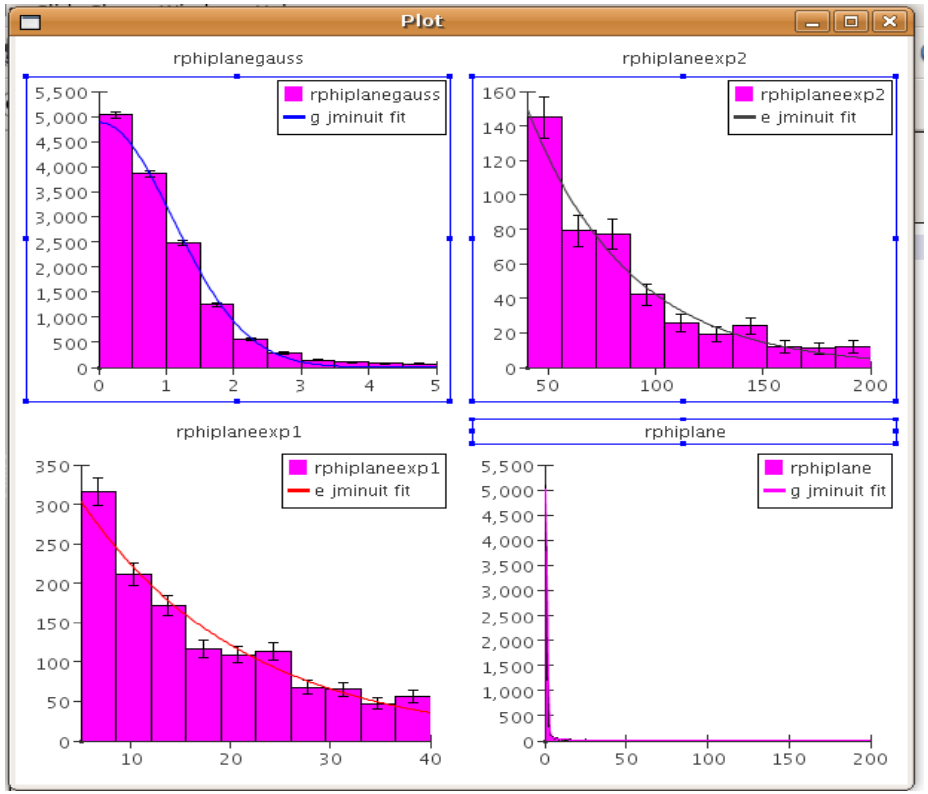
Impact parameter fitting

(Erik Devetak)

- **Important input to flavour tag is "joint probability" roughly the probability that all tracks originate at the IP.**
- **Need to know the impact parameter distribution of tracks truly from the IP.**

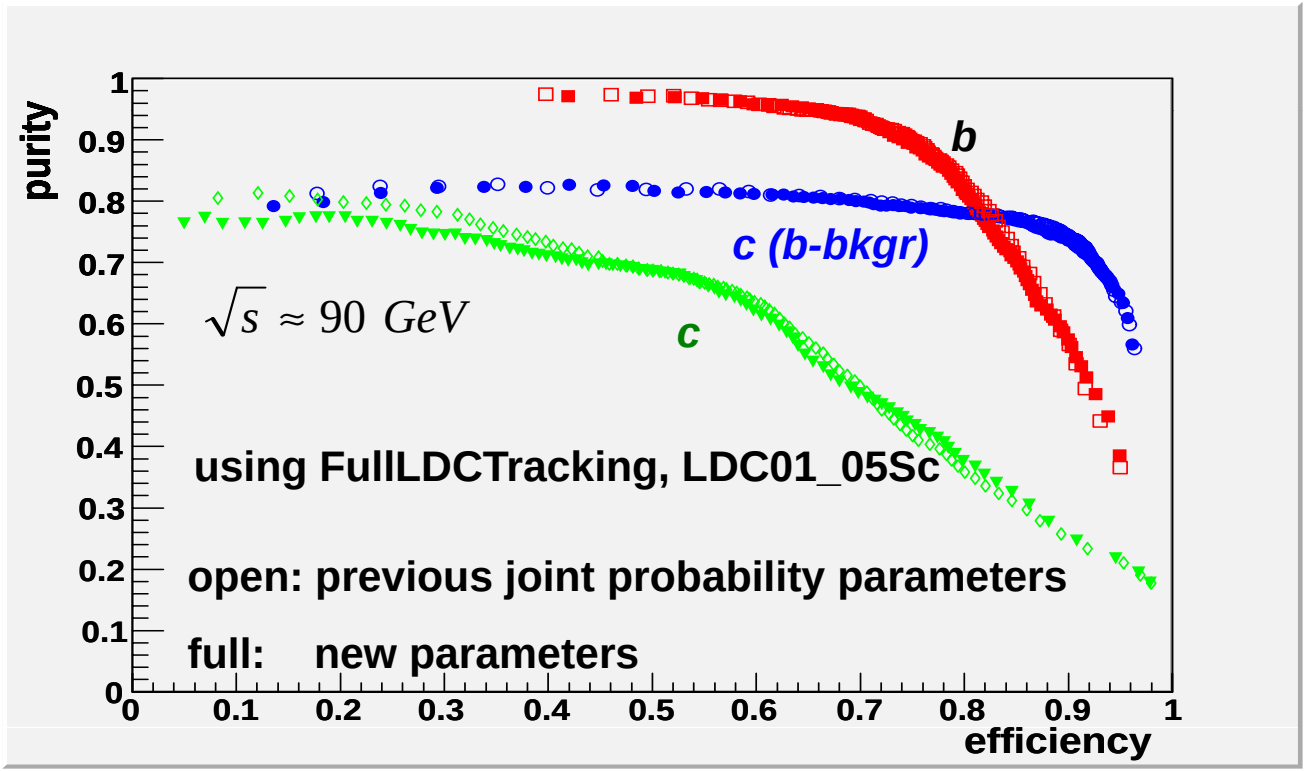
- **Results so far have used hard-wired distributions from Fast MC**

- **New processor developed to derive parameters from fit to a set of jets**



Impact parameter fitting

- **Performance unchanged but flavour tag needs to be retrained to see full effect.**

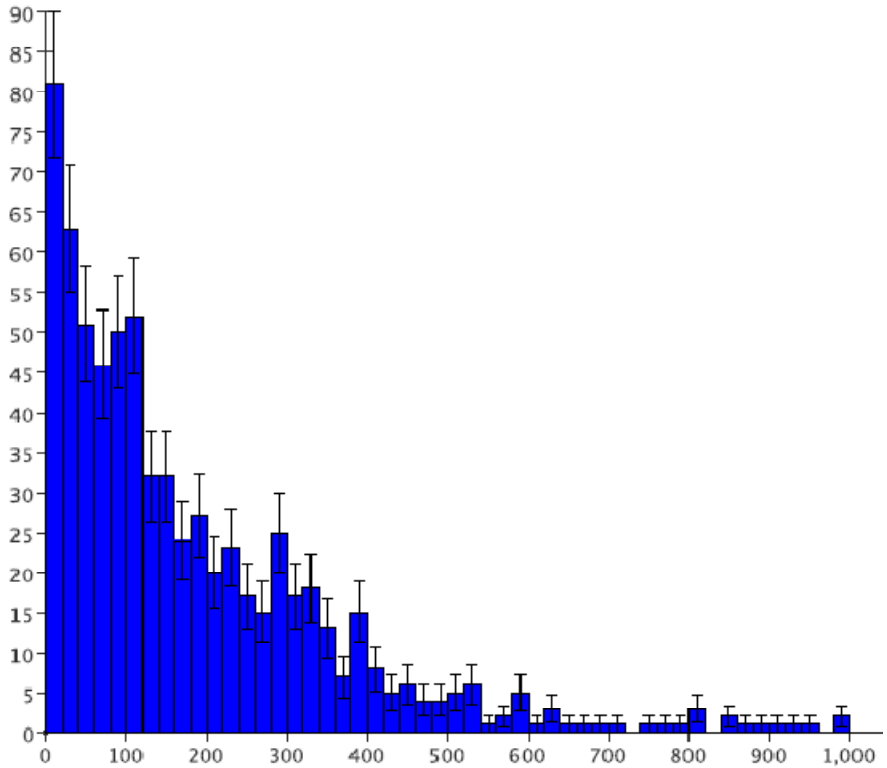


K_S, Λ and photon conversions

(Kristian Harder)

- **Need to be removed before vertexing**
- **For initial testing photon conversions deactivated in simulation and K_S, Λ products removed by checking MC PDG of parent.**
- **Processor to reconstruct and remove tracks from both sources in development**

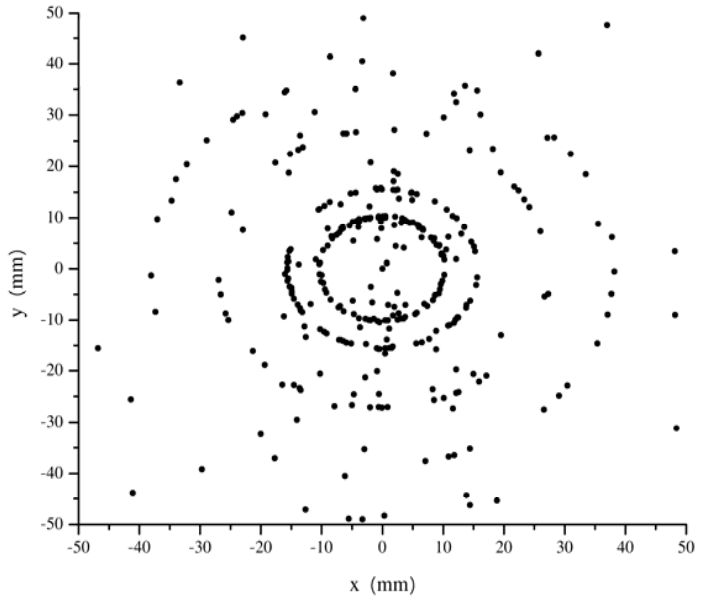
- **Fit all opposite charge track pairs**
- **Select based on chi-squared and kinematic fit**



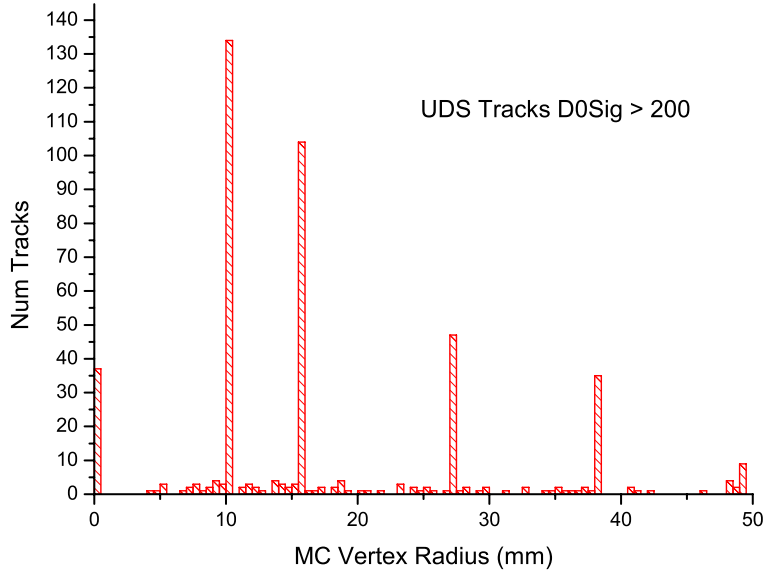
K_S Decay Length

Material Interactions

- **Material interactions need to be suppressed**
- **Not yet a full treatment – but allows impact to be quantified**
- **Currently achieved by cut on track production point**
- **Quick-fix hardwired cut now replaced by cut from GEAR xml detector description**
- **Not ideal –**
  e.g. can't cope with vertex detector end caps in SiD
  but possible to modify GEAR to cope with this



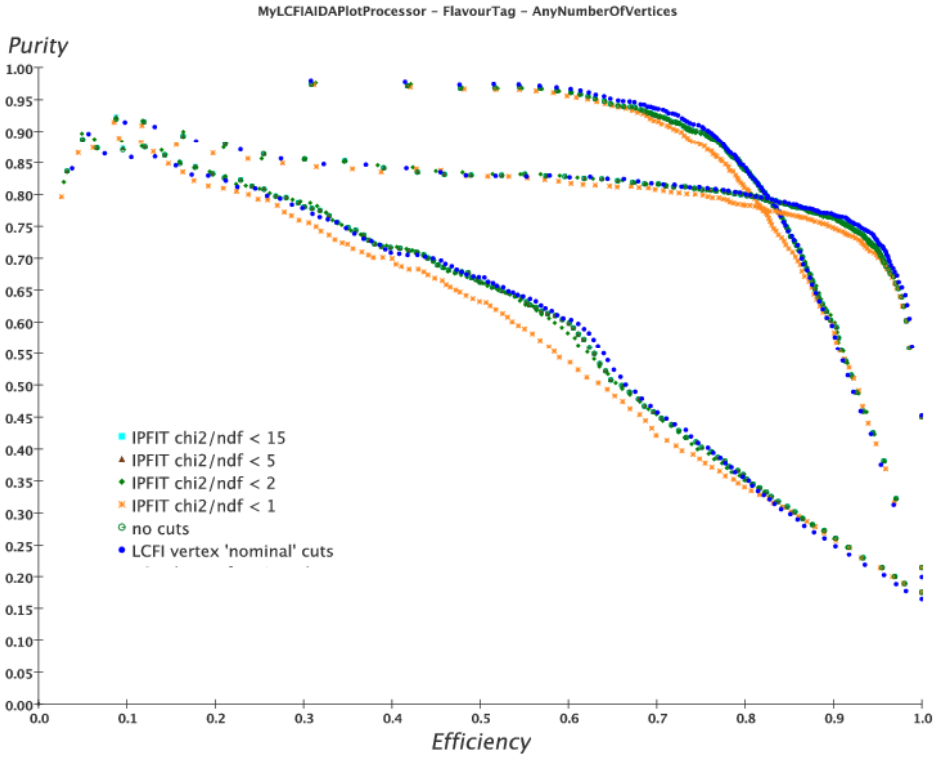
Track production points in UDS events

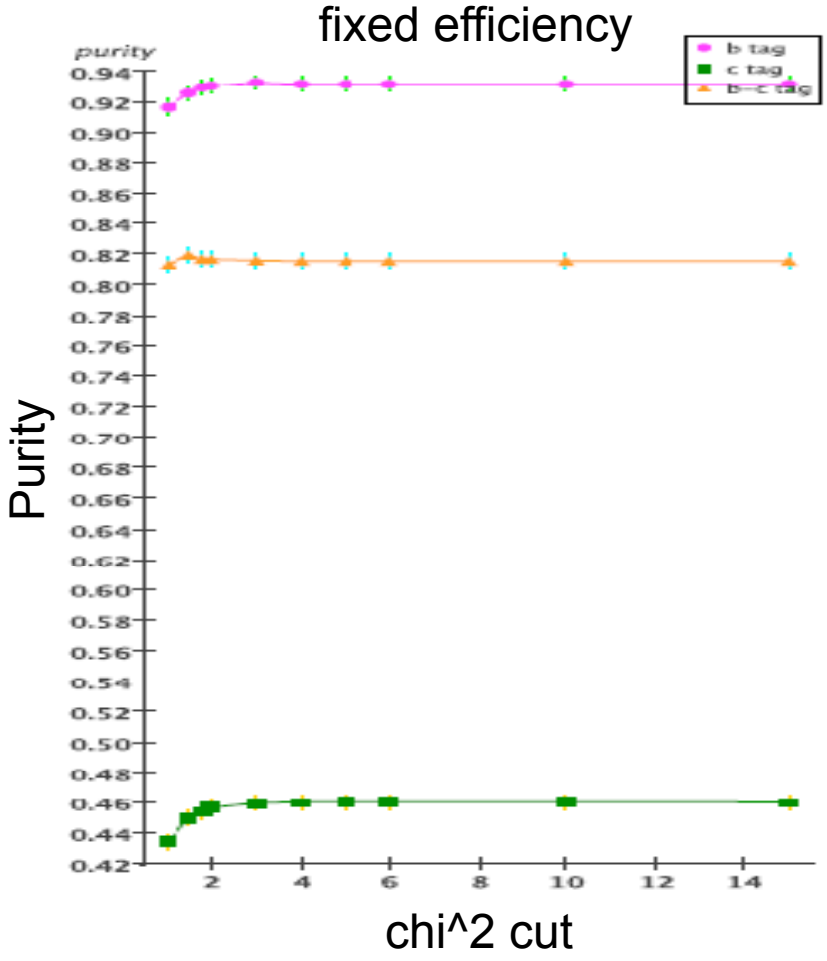


Parameter Tuning

(Roberval Walsh)

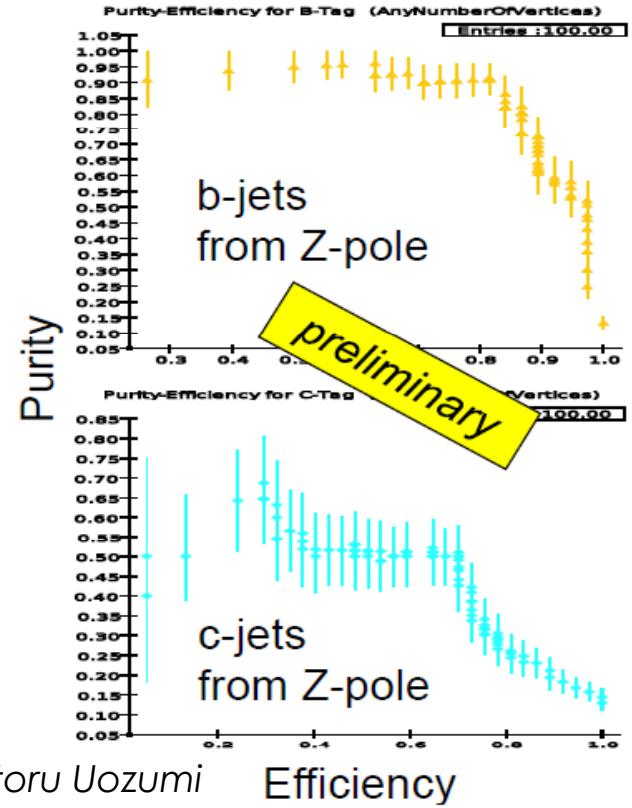
- **18 cut values + 5 vertex finder parameters + other parameters**
- **Defaults from Fast MC and GEANT3 based BRAHMS MC used so far**
- **Detailed exploration of parameter space underway, initially concentrate on tagging performance as a function of individual parameters.**
- **Preliminary results for IP fit track selection produced so far**





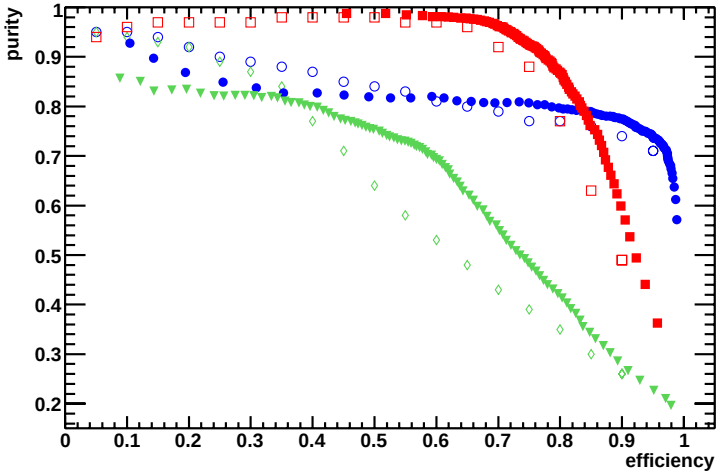
Cross concept

- **Package currently runs only in the Marlin (ILD/EU) framework**
  - **Usage direct from Java/org lcsim (JNI) on hold due to loss of JNI expert.**
- **But through the magic of LCIO can be driven with input from org lcsim (SID/US) and Jupiter (ILD/Asia)**



Jupiter input

- **Possible as geometry information is limited to description of material location for fiducial cut.**



MarlinReco input

Using the package with input from org lcsim

- **Only need to install Marlin + LCFIVertex (MarlinReco not needed)**
  - **Easiest with install script –**
    - **http://www-zeuthen.desy.de/lc-cgi-bin/cvsweb.cgi/ilcinstall/?cvsroot=ilctools**

- **Currently only tested with org.lcsim.mc.fast.tracking.MCFastTracking and perfect PFA**
- **Use head version of org.lcsim - generates LCRelations needed to use MCParticle information**

Minimal changes to example steering needed:

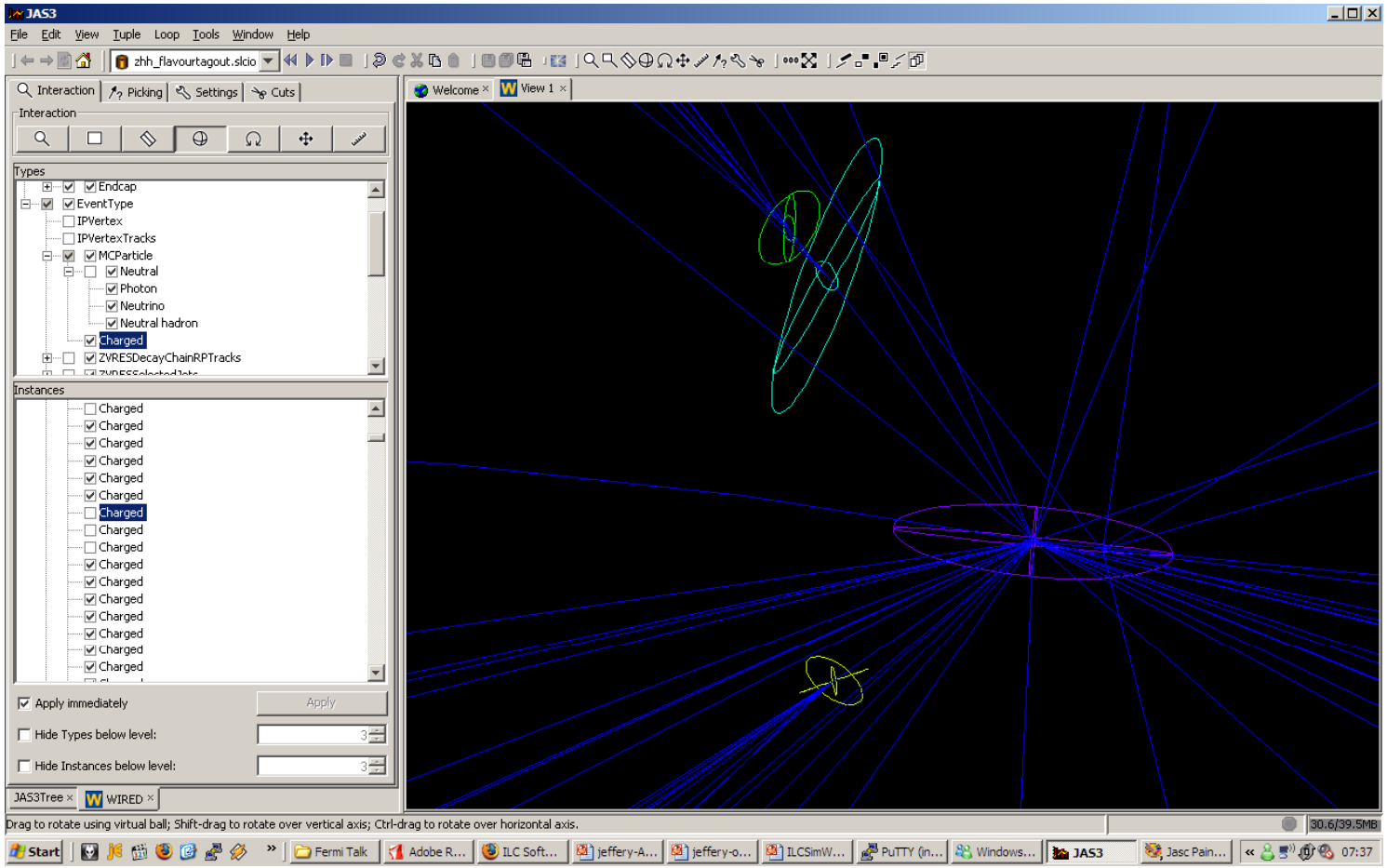
- **Rename input collections to match those generated by org.lcsim**
- **Supply GEAR file for fiducial cut (barrel only ☹)**

- **Examples of steering for org lcsim and GEAR file at: http://www-pnp.physics.ox.ac.uk/~jeffery/sid_steering**

- **SiD support not as tested and extensive as that for ILD. But guaranteed to improve as some package developers are performing SiD analyses!**

Vertex display

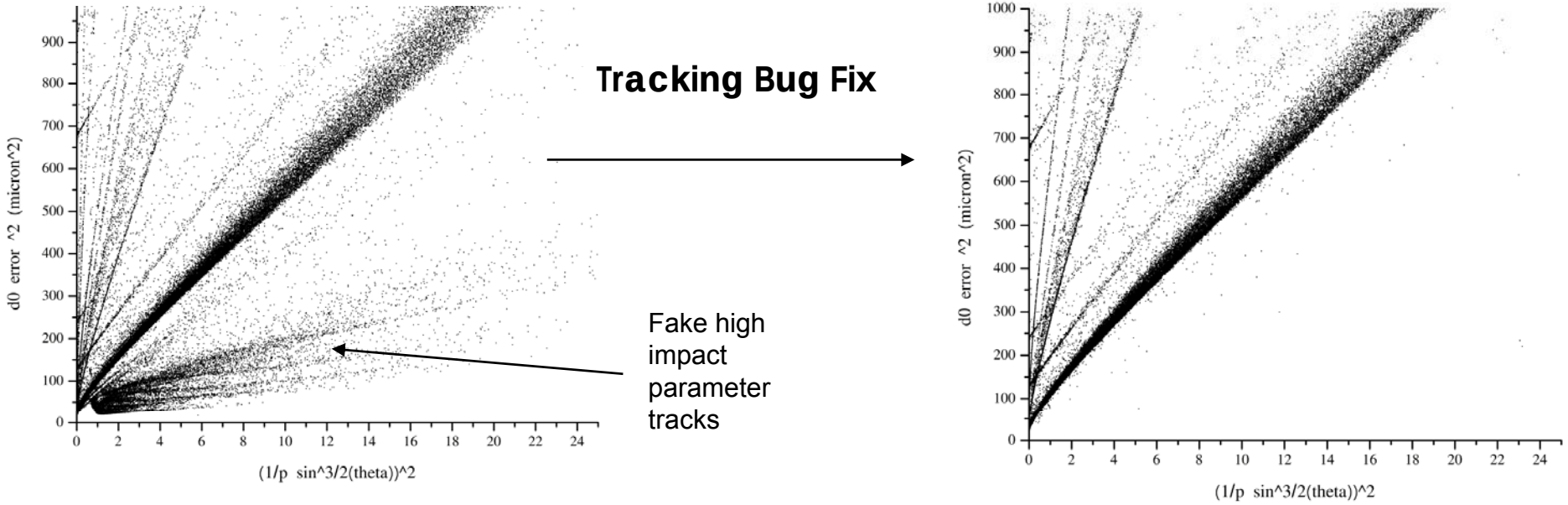
- **Whether the reconstruction was performed in org.lcsim, Marlin or a mix the physics analysis can be performed in JAS and visualised using WIRED4:**



org.lcsim tracking/Marlin vertexing vertices in the most recent release of WIRED4

Future Developments

- **Looking forward to using full realistic tracking with SiD**
- **Full tracking should "drop in"**
- **Experience from MarlinReco integration shows that adequate time and effort working closely with tracking experts may be needed**



Summary and Benchmarking studies

- **Package maturing and ready for benchmark studies**

- **Several benchmarking studies with SiD and the vertex package are underway some of which will be presented tomorrow.**

- **These push the package into challenging 6-jet and soft jet events**

- **t tbar W_{tb} anomalous coupling**
- **Higgs self coupling**
- **Sbottom production**

Asymmetry study

6. $e^+e^- \to c\bar{c}, b\bar{b}$, at $\sqrt{s}$=0.5 TeV;

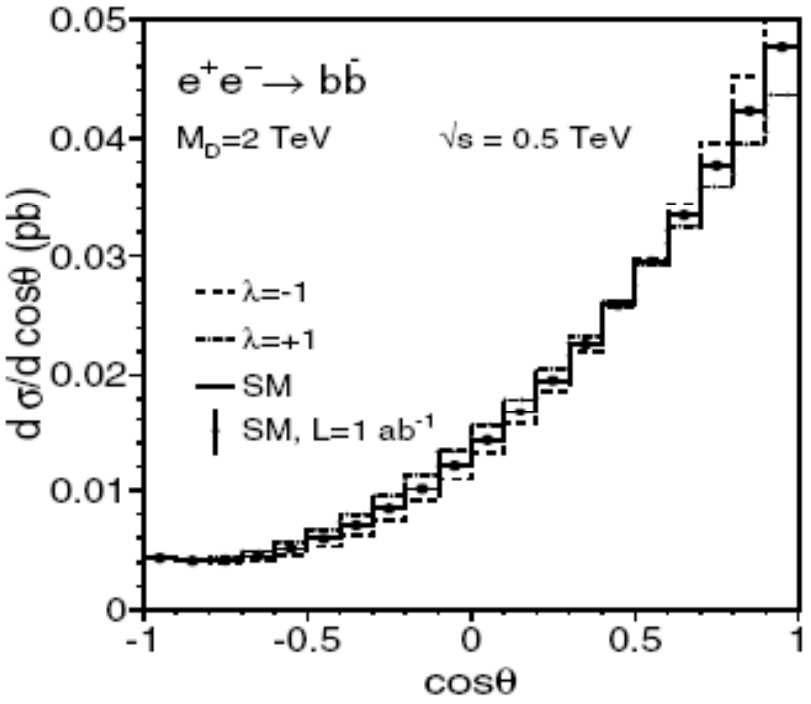
$A_{FB}^{LR}(c)$ & $A_{FB}^{LR}(b)$

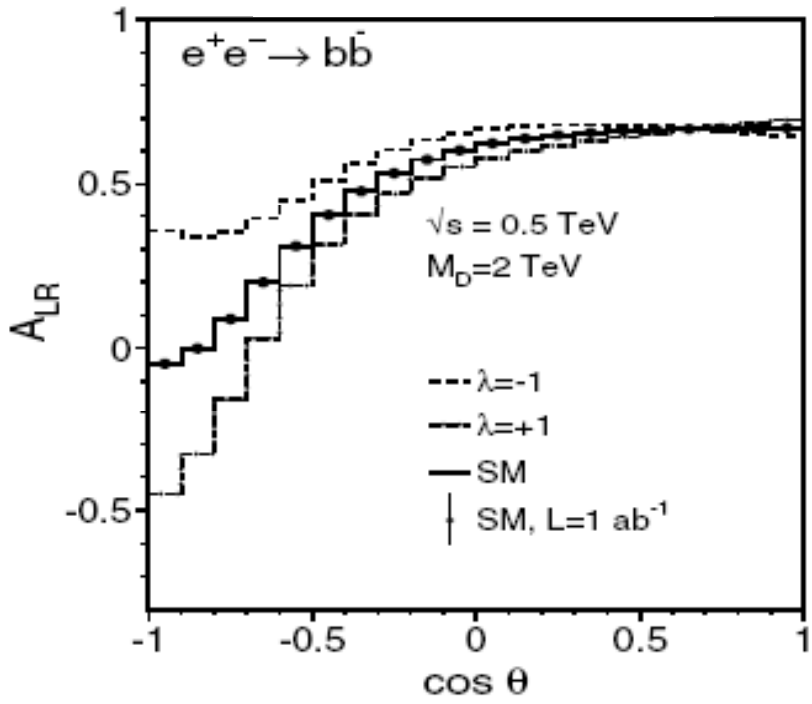
Benchmark Process

Sensitive to Z', leptoquarks, R-parity violating scalar particles, and extra spatial dimensions - *S.Riemann (LC-TH-2001-007*)

- **Requires good c and b tag, plus quark charge to unfold cross sections**

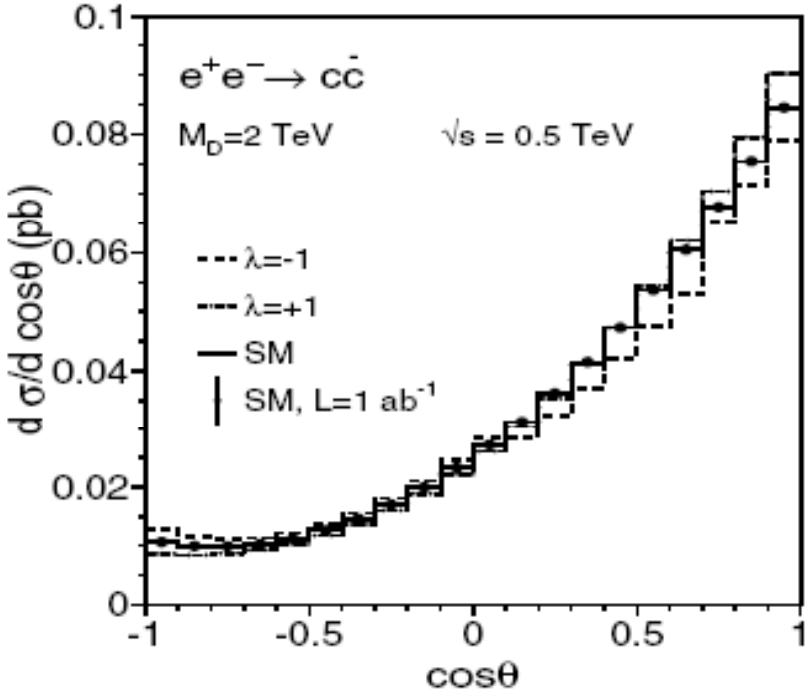
$$A_{LR} = \frac{\sigma_L - \sigma_R}{\sigma_L + \sigma_R}$$

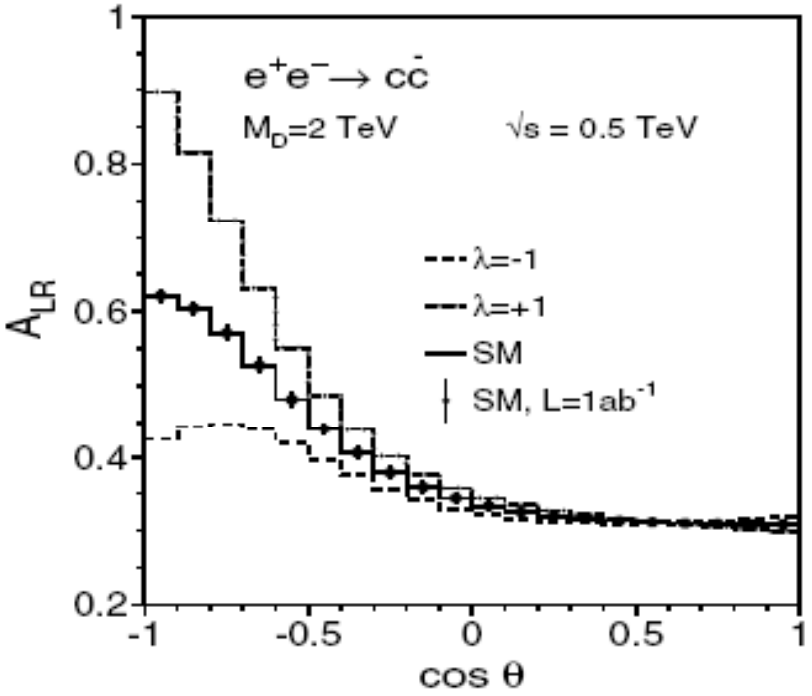




Example sensitivity to large extra dimensions, λ is a model parameter

Asymmetry study





Note the sensitivity is at large θ – very vertex detector geometry dependant

Status:

Extra dimensional model set up in WHIZARD

Setting up asymmetry calculation and fitting using MC level input