# Forward backward asymmetry measurements in $e\text{-}e^{+} \rightarrow b\bar{b}$ at ILC@500GeV

## *Update since the ILD Benchmarking days*

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**QQbar Analysis Meeting,**
18/04/2019

# Git & Note status

- ILDbench git repository https://github.com/ILDAnaSoft/ILDbench_QQbar is used for documentation and link to the group repository
- Our group Git repository is mostly up to date. https://github.com/QQbarAnalysis
  - Tracking restoring tools
  - Reco-Truth tools
  - Kaon ID tools
  - QQbarProcessor (bb, tt) + Offline analysis scripts
  - Instructions to merge developments (push requests) https://github.com/QQbarAnalysis/QQbarAnalysis/issues
- Branch: **QQbarAnalysisBranch2018**
  - up to date for Kaon ID, bbbar (Adrian) and ttbar (Yuichi) analysis
  - VertexRestorer proccessors to be updated (beam IP smearing)
  - VertexRecoTest (TrashProccessor, etc) are in the same status that S. Bilokin left them.
  - ttbar_bb4j from S. Amjad have been just forked here.

# Technical details

- **Detector models: l5, s5**
  - /cvmfs/ilc.desy.de/sw/ILDConfig/v02-00-02/StandardConfig/production/Gear/gear_ILD_l5_o1_v02.xml
  - /cvmfs/ilc.desy.de/sw/ILDConfig/v02-00-02/StandardConfig/production/Gear/gear_ILD_l5_o1_v02.xml
- **Software + reconstruction**
  - /cvmfs/ilc.desy.de/sw/x86_64_gcc49_sl6/v02-00-02
- **Physics case**: $b\bar{b}$ forward backward asymmetry for 500 GeV interaction.
  - We show only **pure left polarization results**.
  - Samples: /pnfs/desy.de/ilc/prod/ilc/**mc-opt-3**/ild/dst-merged/**500-TDR_ws/2f_Z_hadronic/ILD_s5_o1_v02**/v02-00-01/rv02-00-01.sv02-00-01.mILD_s5_o1_v02.E500-TDR_ws.I250114.P2f_z_h.eL.pR.n001.d_dstm_10409_1.slcio
  - **Total simulated luminosity: 46fb-1** per detector model
  - Beam bkg included.

# Revertexing, jet clustering

- I reprocess the vertexing and the b-tagging using latest LCFIplus version, scripts and weight files
- **ILD benchmarking days**: DurhamVertex (+ UseBeamJets=0)
  - Durham stands for the well known durham algorithm
  - Vertex stands for the LCFIPlus feature of using full vertex info as input for the jet algorithm.

T. Suehara told me about a bug on this in LCFiPlus… is it fixed??

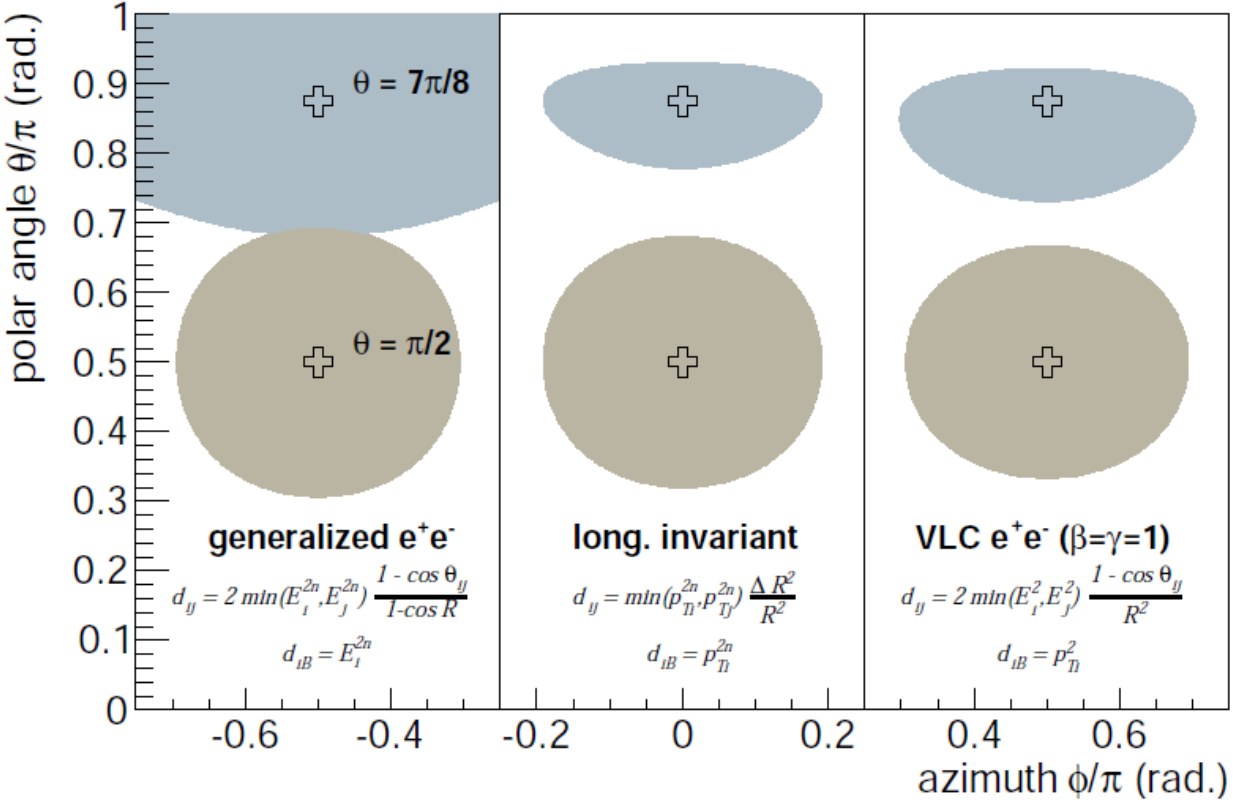
  - UseBeamJets is for the beam rejection. In case of using kT or Valencia algorithm, the particle-beam distance (diB) is defined in the algorithm. In the case of the Durham, a new distance has been proposed by LCFIPlus developers:

$$d_{iB} = \frac{2\,E_i^2}{E_{vis}^2}\left(1-\cos\left(\theta_{iB}\right)\right)\alpha^2$$

  - The rejection of beam jets needs of an optimization of the “alpha”parameter.

# Revertexing, jet clustering: update after ILD Bench. days

- The Vertexing issue is is solved?
  - I didn't reprocess anything.
- I use ValenciaVertex (+ UseBeamJets=1, R=1.4).
  - VLC is well suited for perturbative calculations (as Durham)
  - VLC is also suited for beam rejection, using the transverse momentum the long-kT. (the R=1.4 is a reasonable value, according to M. Vos)




- Vos et al, arxiv:1607.05039

# Revertexing, b-tagging

- Flavour tagging:
  - Weight prefix *6q500_v04_p00_ildl5 (or s5)*
  - D0ProbFileName *d0probv2_ildl5_6q500.root (or s5)*
  - z0ProbFileName *z0probv2_ildl5_6q500.root (or s5)*
- For the final analysis I use the same values for the selection than in 250GeV DBD:
  - Btag1>0.9, btag2>0.2

# Preselection cutFlow, IDR large vs small

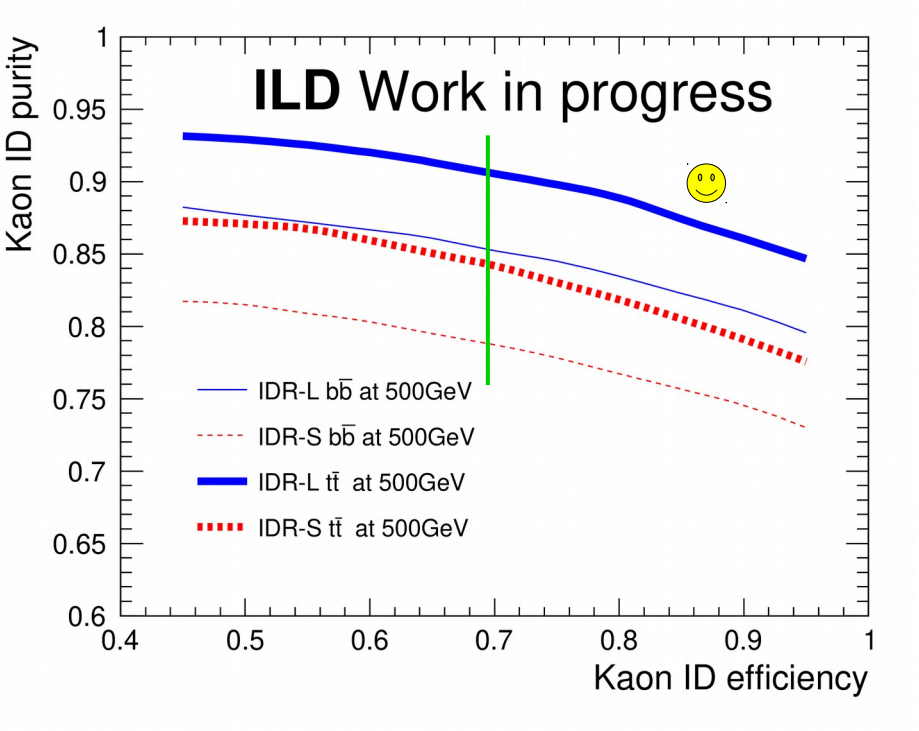
| | 500 GeV, eLpR, l5 model | | |
|---|---|---|---|
| | | B/S | |
| | **Signal** | qq | Radiative Z |
| *Sample* | 100.0% | 2322.9% | 508.5% |
| *btag cut* | 70.2% | 2.6% | 230.0% |
| *+inv mass cut* | 67.2% | 1.1% | 3.0% |
| *+y23 cut* | 64.4% | 1.2% | 2.5% |
| *+Ey cut* | 61.7% | 1.1% | 0.7% |

| | 500 GeV, eLpR, s5 model | | |
|---|---|---|---|
| | | B/S | |
| | **Signal** | qq | Radiative Z |
| *Sample* | 100.0% | 2328.3% | 509.5% |
| *btag cut* | 70.1% | 2.7% | 231.5% |
| *+inv mass cut* | 67.1% | 1.1% | 2.8% |
| *+y23 cut* | 64.4% | 1.1% | 2.3% |
| *+Ey cut* | 61.3% | 1.1% | 0.6% |

- There are no noticeable differences between both models.
- Cuts explained in the backup.

IDR doc. benchmarking tables

# Kaon ID

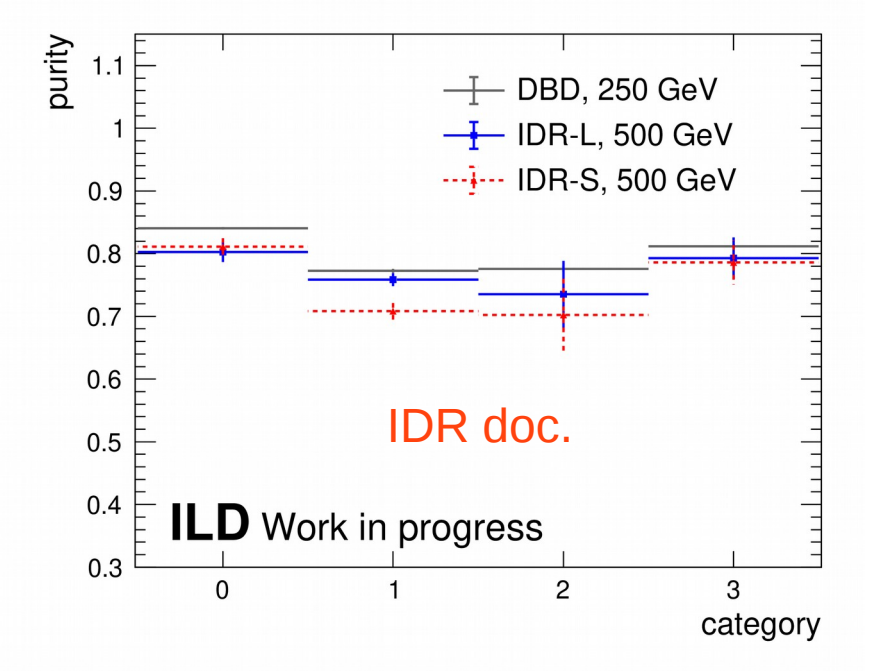



- Working points: calculated for all tracks in secondary vertexes in tt (or bb) events before btagging+selection.

- Assumed for DBD samples (bb) (Too optimistic?)

# Purity of the charge measurement

- After the preselection we proceed to the final selection in which the charge of the b-jets is measured.
- We only accept events with at least two compatible charge measurements.
- For that we separate the events in different categories and we determine the purity of the charge measurement for each category independently.
  - Cat 0, only vertex info
  - Cat 1, only kaon info
  - Cat 2, both types of info in but in different jets
  - Cat 3, both types of info in one jet
- I had a bug in the plot of the ILD benchmarking days: the Kaon ID output was used wrongly, giving poor purities for cat 1-3.



# Final selection efficiency

| 250 GeV, eLpR, DBD model | |
|---|---|
| Cat 0 | 12,8 % |
| Cat 1 | 6,8 % |
| Cat 2 | 4,2 % |
| Cat 3 | 9,5 % |
| *total* | *33,3 %* |

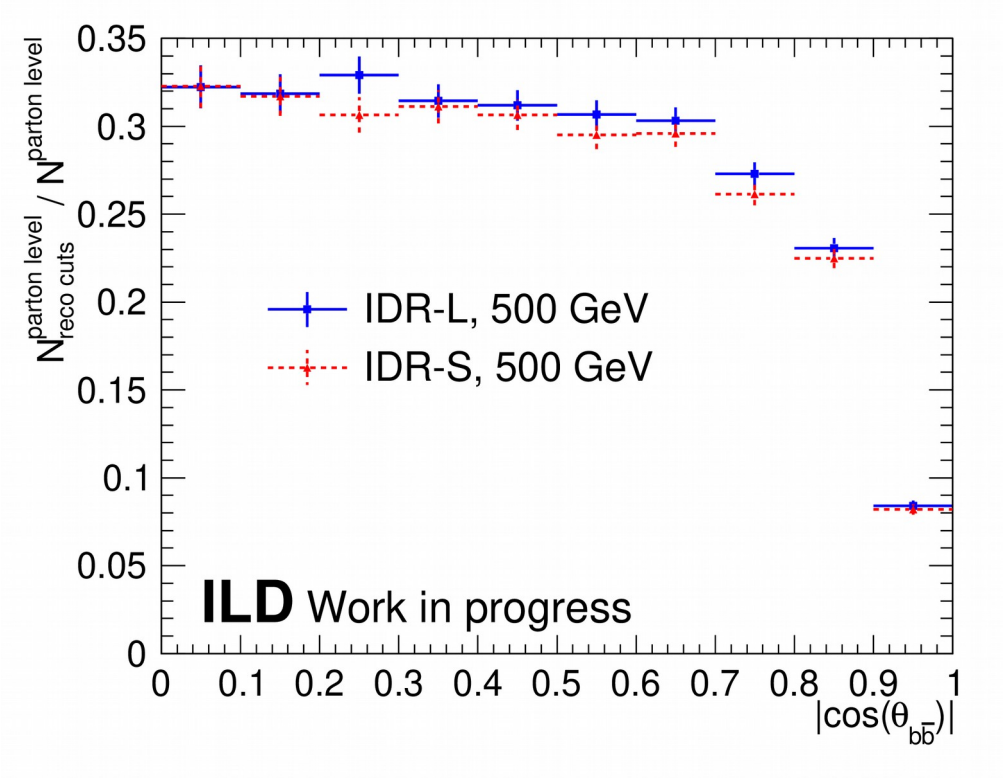
| 500 GeV, eLpR, l5 model | |
|---|---|
| Cat 0 | 11.9 % |
| Cat 1 | 4.2 % |
| Cat 2 | 3.7 % |
| Cat 3 | 7.1 % |
| ***total*** | ***26.9 %*** |

| 500 GeV, eLpR, s5 model | |
|---|---|
| **Cat 0** | **11.8 %** |
| Cat 1 | 3.7 % |
| Cat 2 | 3.5 % |
| Cat 3 | 6.9 % |
| ***total*** | ***25.9 %*** |

IDR doc.

- The better performance of l5 wrt the s5 is due to the kaon selection.

# Detector acceptance



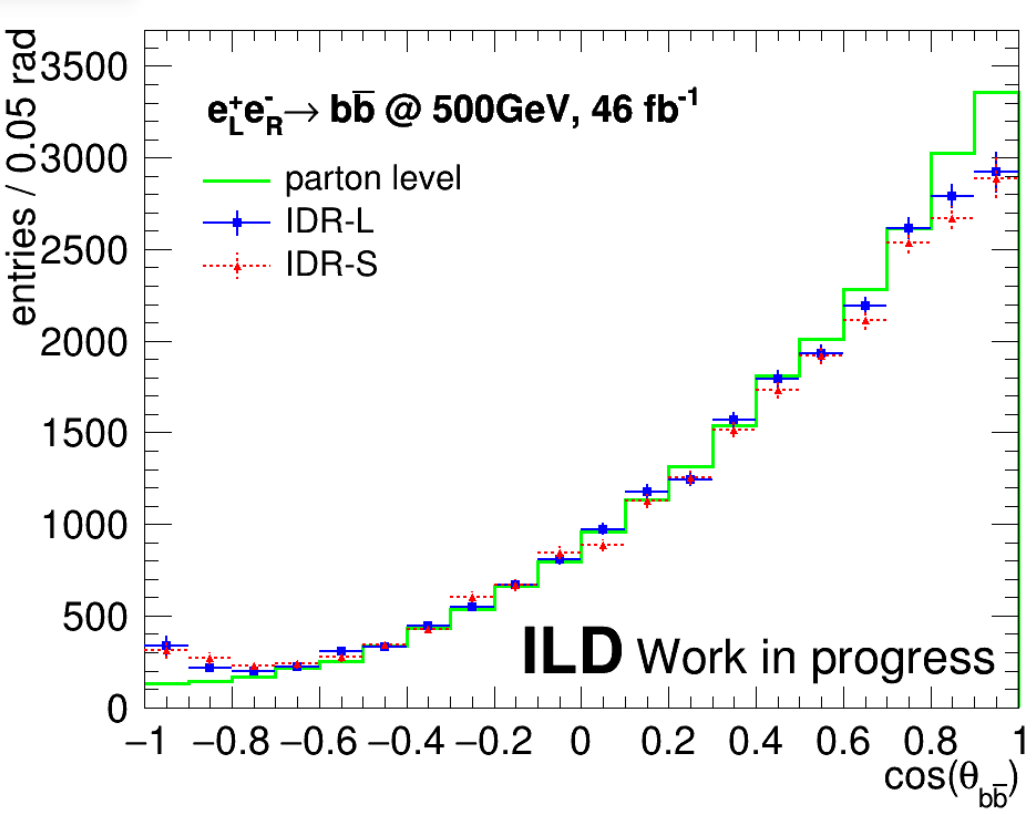

- The acceptance is mainly associated to btagging & tracking
- L5 seems better than s5 but the statistical uncertainties are large

IDR doc.

# Results

- Distribution after charge correction (“data driven”) and acceptance correction (MC fudge factor).
- Fit restricted to -0.8,0.8

IDR doc.




$dA_{fb}^{reco+corrected} = 2.2\%,$ $\frac{A_{fb}^{reco+corrected}}{A_{fb}^{parton}} = 97.6\%$

$dA_{fb}^{reco+corrected} = 2.3\%,$ $\frac{A_{fb}^{reco+corrected}}{A_{fb}^{parton}} = 96.1\%$

# Summary

- The differences in performance between 250GeV and 500GeV are quantitatively smaller than before.
  - We don't need to show both in the IDR note…
- The size of the sample (46fb$^{-1}$) makes difficult to extract further conclusions on the results or to do further improvements
  - i.e. the p-q correction is not done differentially due to the low amount of events.

# TO DO List

- Few hours of work:
  - Launch the revertexing+jet clustering +btag again when the issue on the JetClustering+Vertexing is resolved.
  - Use the PFOs for the jet direction reconstruction. We are using the tracks as in 250GeV. The PFO -angle problem seems to be solved in the IDR samples and it has much better resolution (~5% instead of ~20%)
- I might be able to find some time to prepare a naive estimation of the impact of the TOF…
  - difficulty? Unknown… If it is too difficult to have it for next meeting, I might drop it for the moment.
- Add the z0 info in the VertexRecovery… ??

# Backup slides

# Jet clustering in LCFIPlus

## FastJet Definitions

### Durham (or ee_kt)

```
JetDefinition jet_def(ee_kt_algorithm);
```

$$d_{ij} = 2\min(E_i^2, E_j^2)(1-\cos\theta_{ij})\,.$$

### Generalized ee_genkt

```
JetDefinition jet_def(ee_genkt_algorithm, R, p);
```

$$d_{ij} = \min(E_i^{2p}, E_j^{2p})\frac{(1-\cos\theta_{ij})}{(1-\cos R)}\,,$$

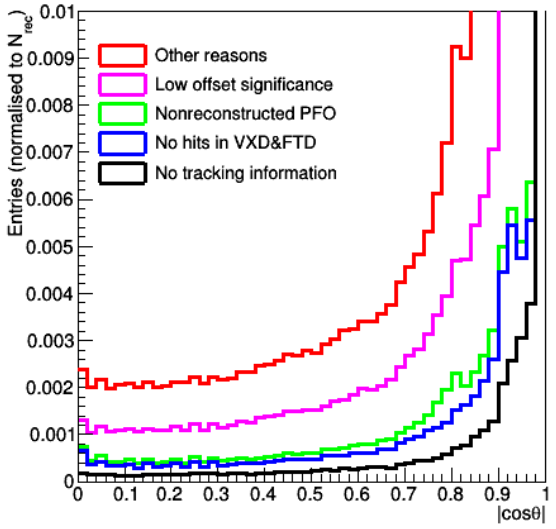
$$d_{iB} = E_i^{2p}\,,$$

## LCFIPlus definitions

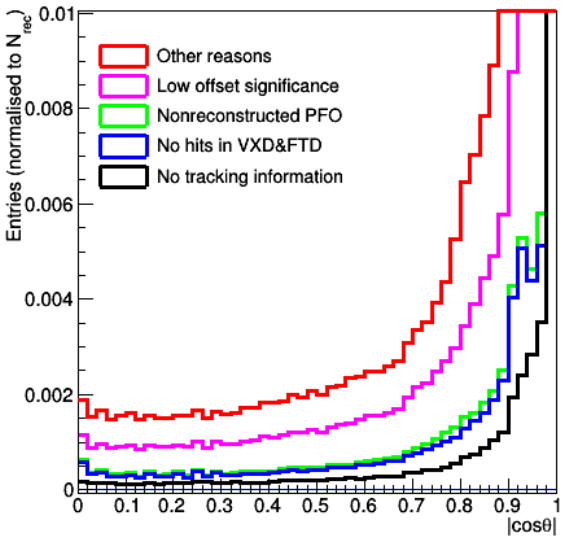
- **Durham**:
  - is the same but divided by $E^2_{vis}$ (visible energy).
  - $d_{ij} \rightarrow y_{ij}$
- **Durham + Beam Distance** (beam bkg rejection)
  - CosR=0.5, p=1
  - Both distances divided by $E^2_{vis}$ too.
  - $$d_{iB}=\frac{2E_i^2}{E_{vis}^2}(1-\cos(\theta_{iB}))\alpha^2$$
  - α=1 by default

# Track Recovery performance

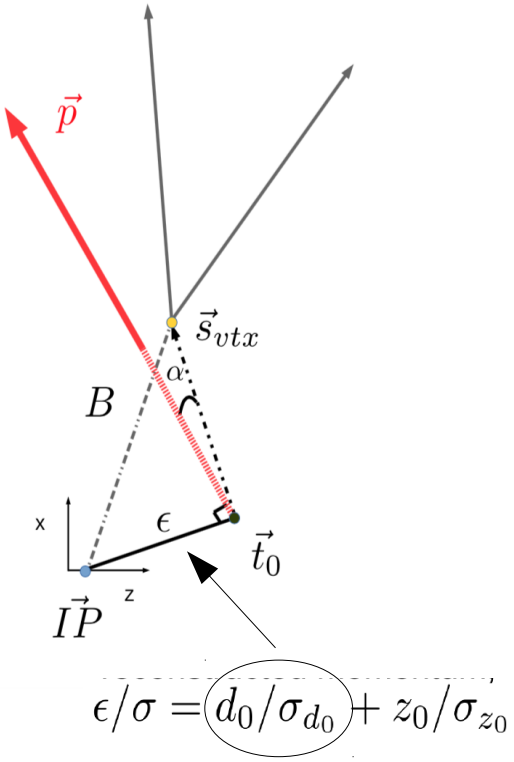
**IDR, l5**



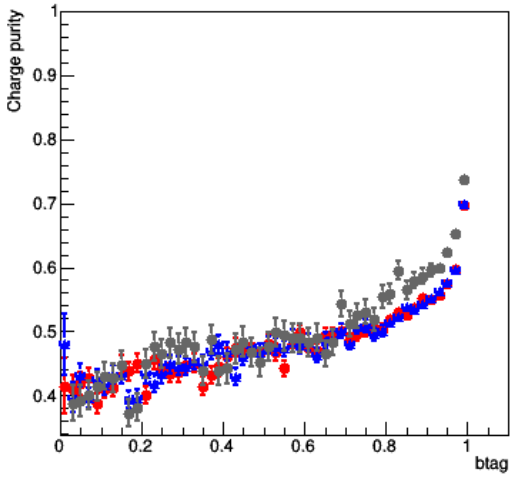

Before Recovery

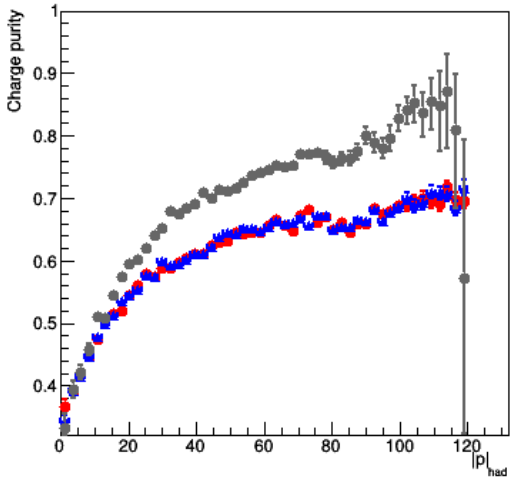


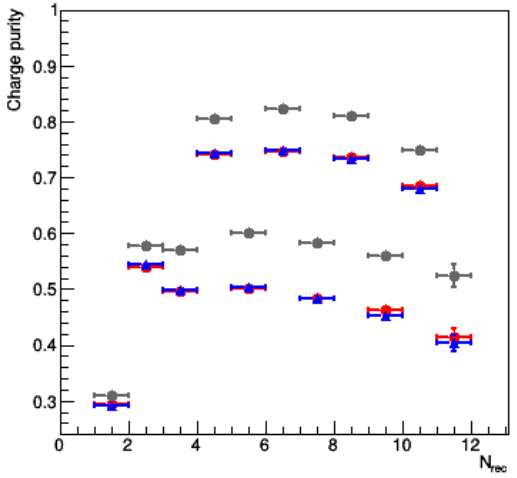

After Recovery

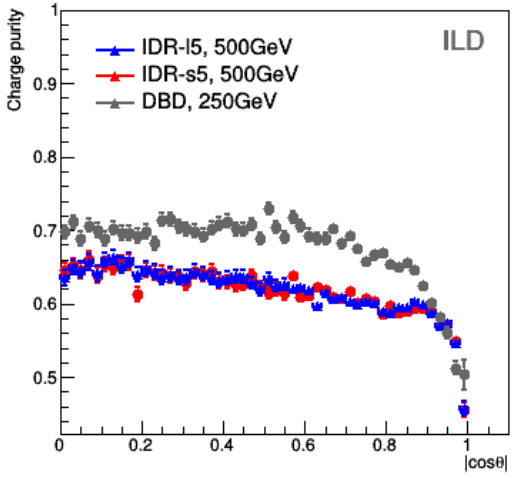



- The “other reasons” are associated to fitting problems.
  - This issue does not appear in DBD samples without IP smearing (even before restoring).




- Both IDR models show similar performance.

- The purity on b-quark charge measurement using vertex charge measurement is much better for 250GeV (DBD samples/software)
  - Different kinematics.
  - The track restoring was developed and optimized for DBD reconstruction.
  - We believe that there is still some room for improvement in the IDR… how much?

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