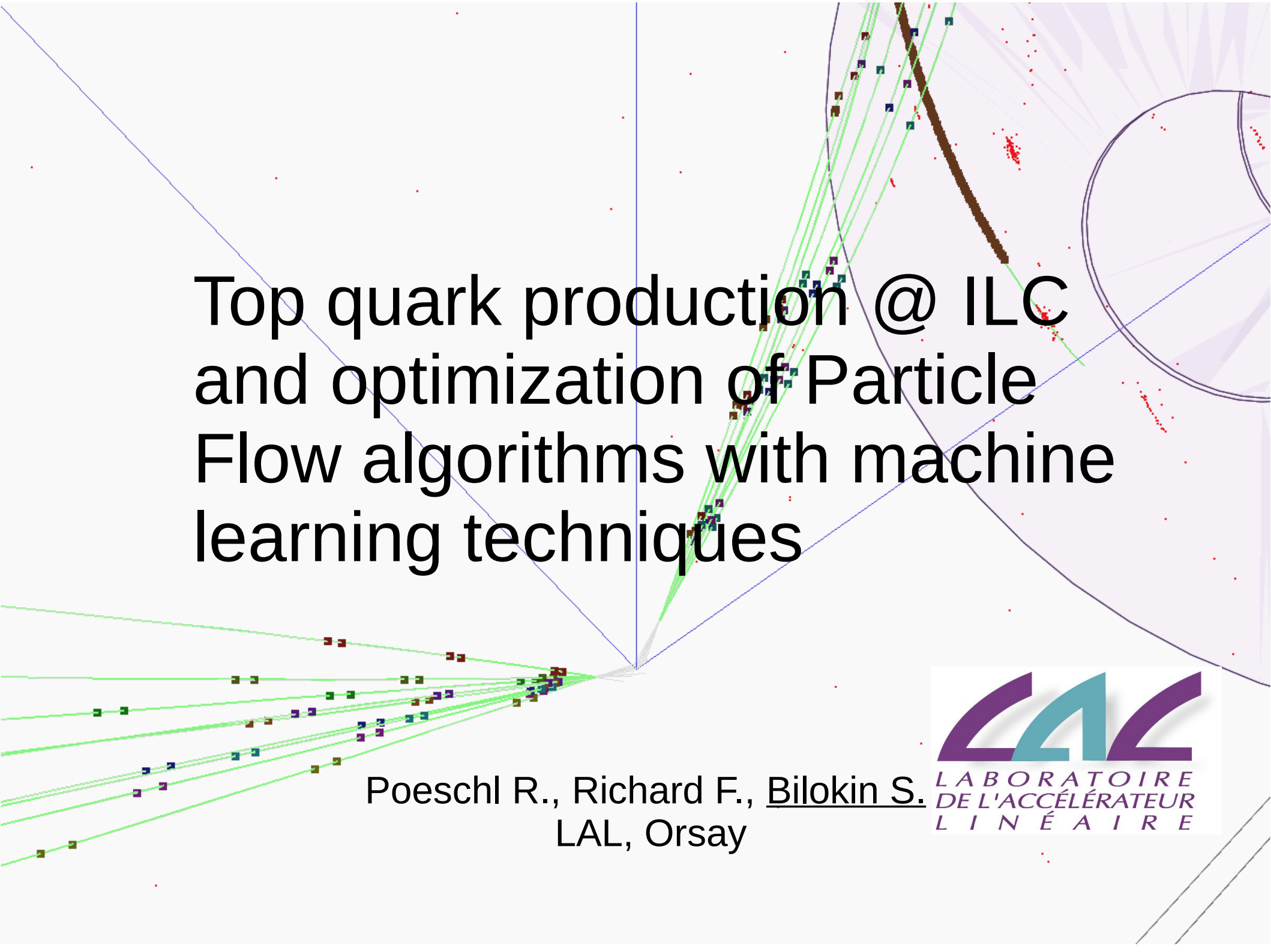

Top quark production @ ILC and optimization of Particle Flow algorithms with machine learning techniques

Poeschl R., Richard F., Bilokin S.
LAL, Orsay

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

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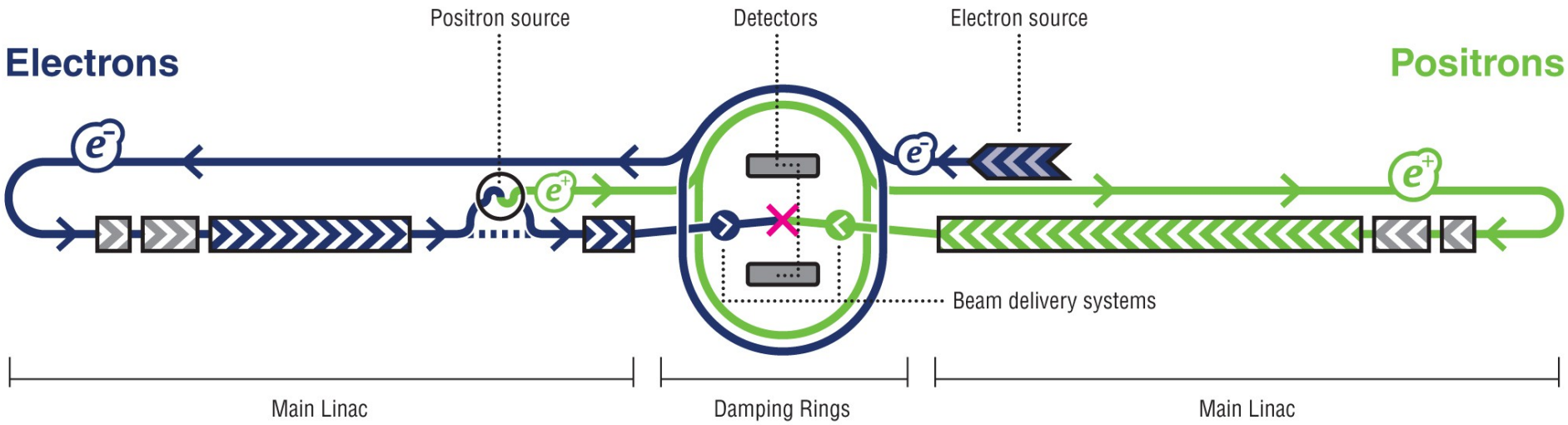
- International Linear Collider project
- International Large Detector description
- Optimization of Particle Flow algorithms in Electromagnetic calorimeter prototype for ILC
- Optimization of top-quark asymmetry calculation using b-jet charge

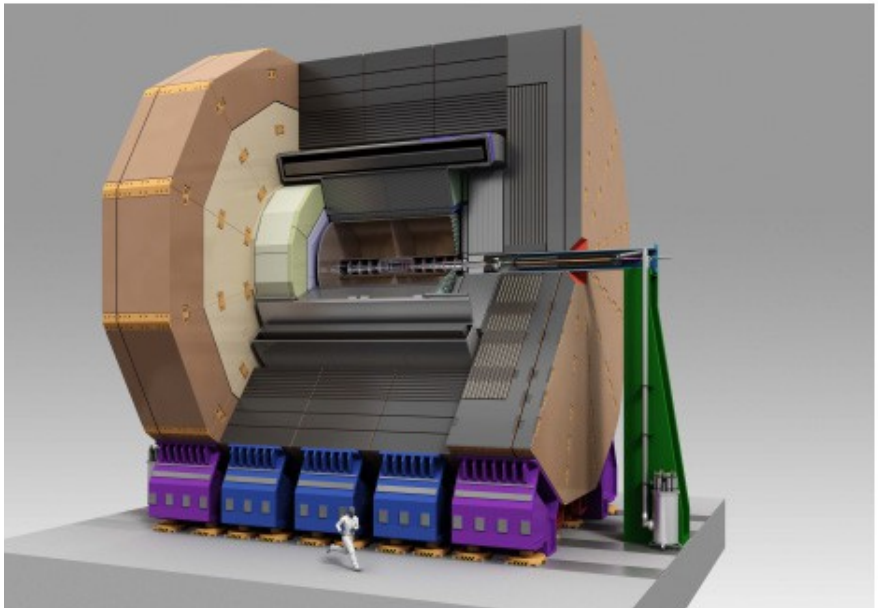
ILC project

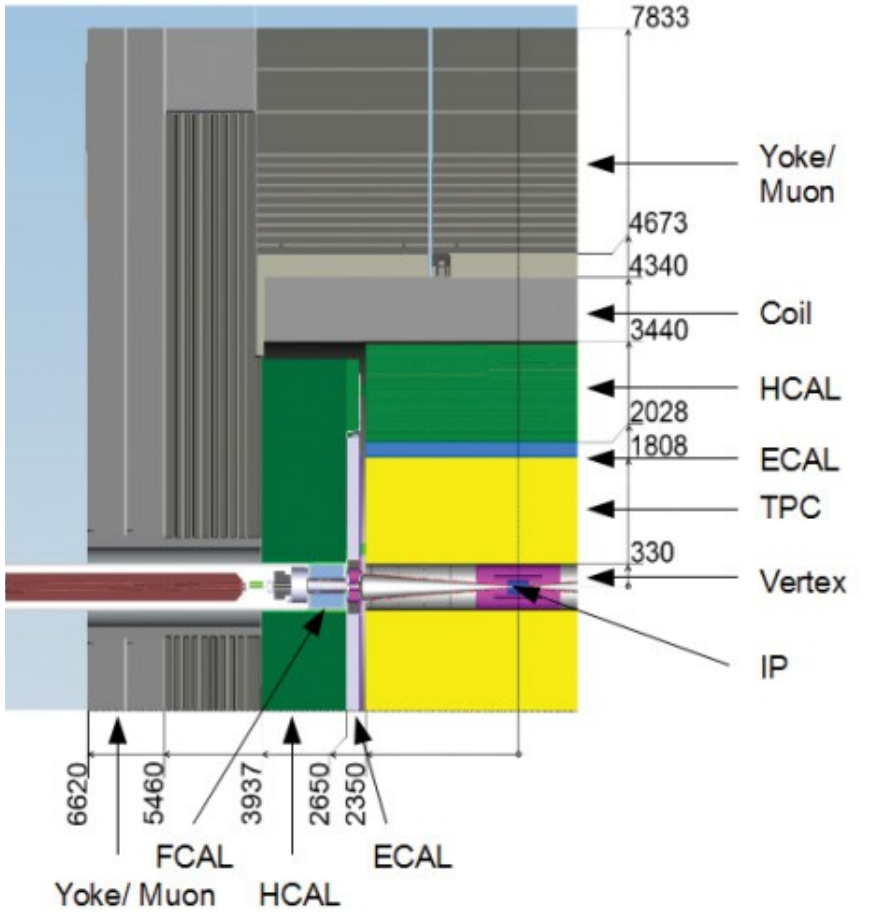


- Polarized electron and positron beams
- Center-of-mass energy of 250 – 500 GeV with a 1000 GeV upgrade option
- Two detectors, SiD and ILD
- Well known state of initial particles, low machine background
- Main goals:
  - Precision measurement of Standard Model parameters
  - Direct and indirect searches of Beyond Standard Model particles

ILD project

- Designed for Particle Flow algorithms that allow to reconstruct individual particles inside ILD
- Tracking system:
  - Vertex Detector composed of 3 double layers of silicon pixels
  - Time Projection Chamber with particle identification capabilities
  - Other devices
- Calorimeters:
  - High-granular silicon-tungsten Ecal (SiW Ecal)
  - Hcal with iron absorber
- 3.5T Solenoid
- Muon trackers
- Full GEANT4 simulation





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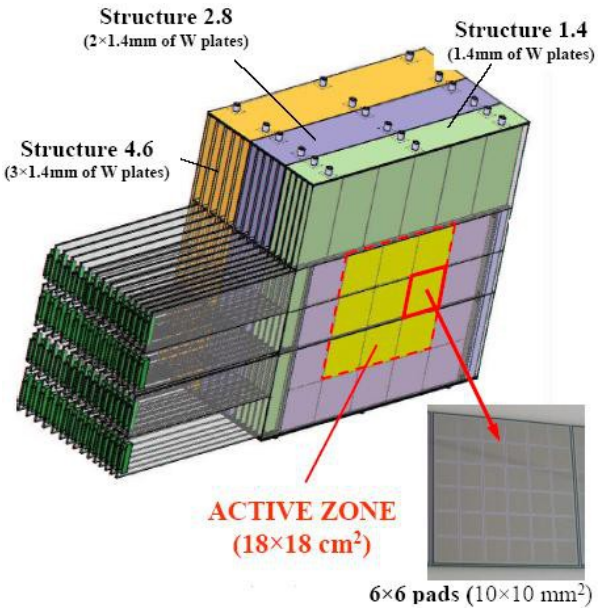
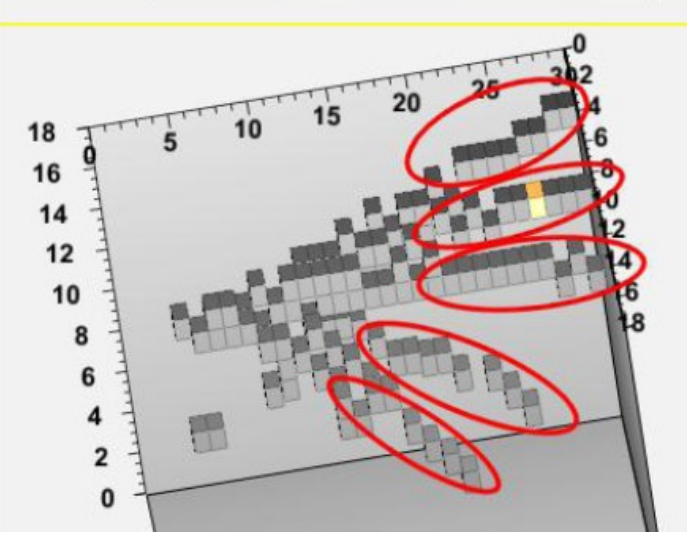
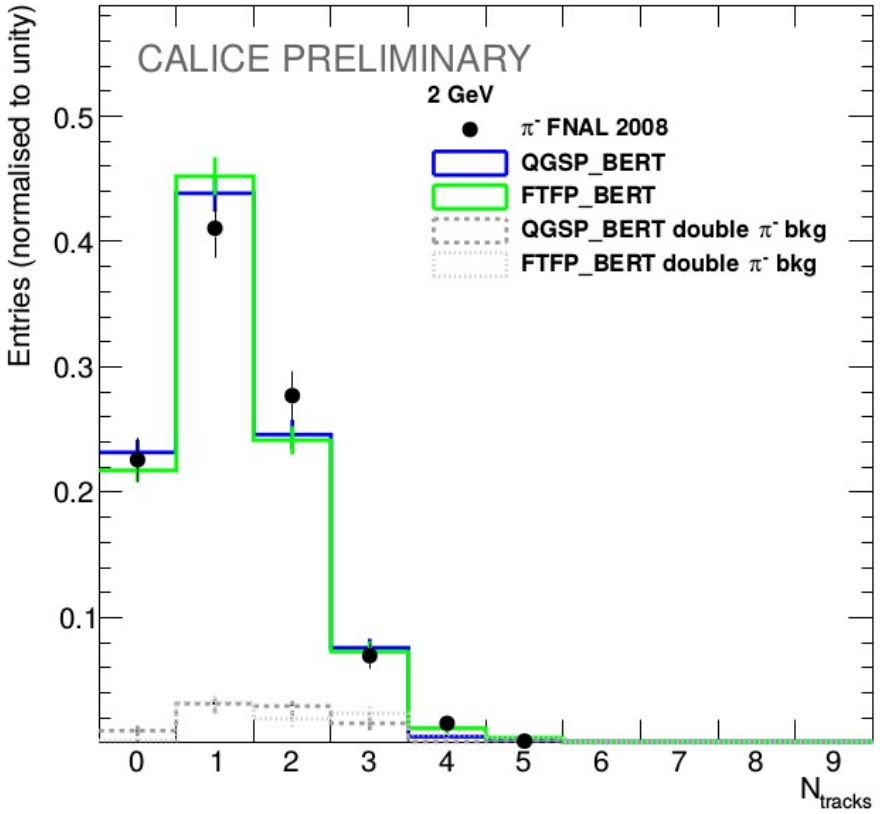
Outlook I

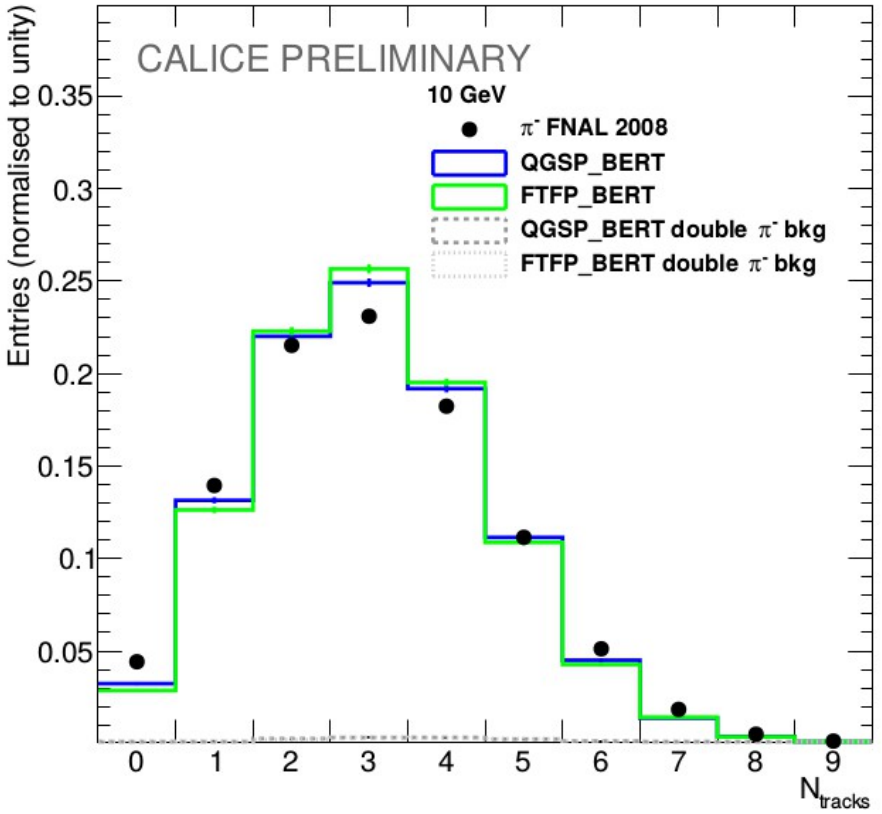
- CALICE Ecal physics prototype has 30 layers of silicon 1x1 cm pixels detectors with tungsten absorber plates in between
- Developed by LAL, LLR and LPNHE groups, and tested at CERN, Fermilab and DESY facilities
- High-granular structure of the Ecal prototype allows to reconstruct tracks from secondary particles emerged from hadron interactions
- We compare various GEANT4 Monte Carlo models to the data using new set of observables from our track finding algorithm





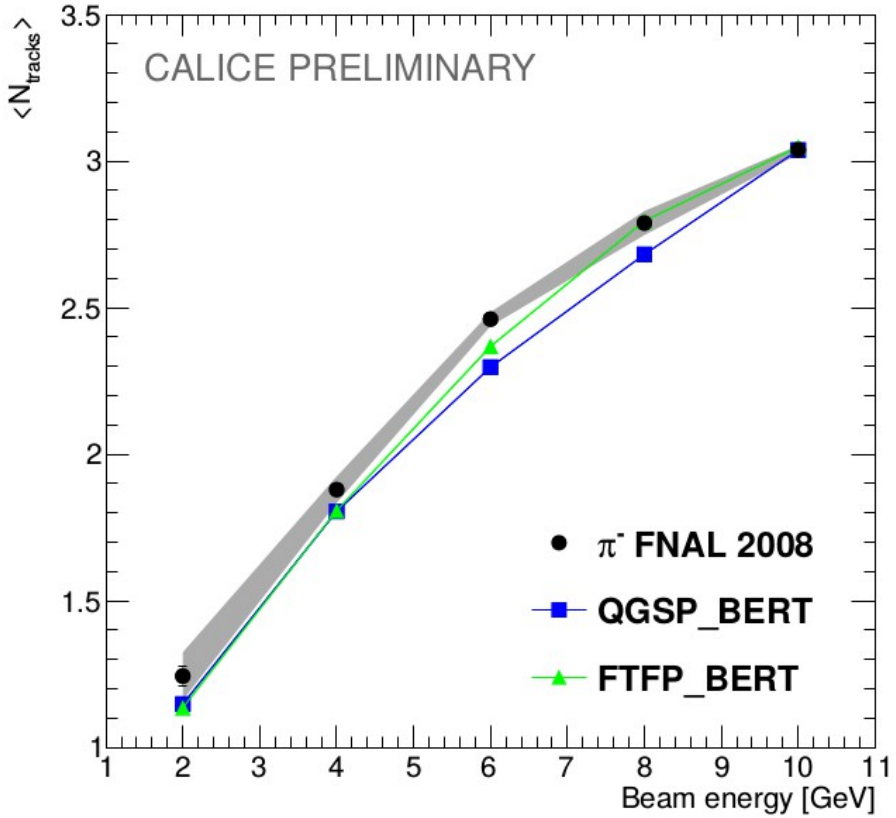
Tracking algorithm in the Ecal





- Number of secondary tracks for 2 and 10 GeV pion data and two Monte Carlo simulations. Both simulations agree with the data

Tracking algorithm in the Ecal



- Mean number of secondary tracks as a function of beam energy for data and two Monte Carlo simulations. There is a nice correspondence between data and Monte Carlo models

Conclusion I

- We have developed and tested a simple algorithm that finds the secondary tracks in hadronic interactions in the Si-W ECAL physics prototype. Both simulations (physics lists) show a good performance in terms of tracking observables
- The largest discrepancy found in energy fraction and radius of the interaction region - up to 15% difference
- The systematic effects of the algorithm and double pion background events are studied and taken into account
- The results are summarized in the CALICE note CAN-055
- Further work:
  - Apply this analysis to new GEANT4 v10 physics lists
  - Paper publication
  - Apply machine learning algorthms in collaboration with AppStat group at LAL

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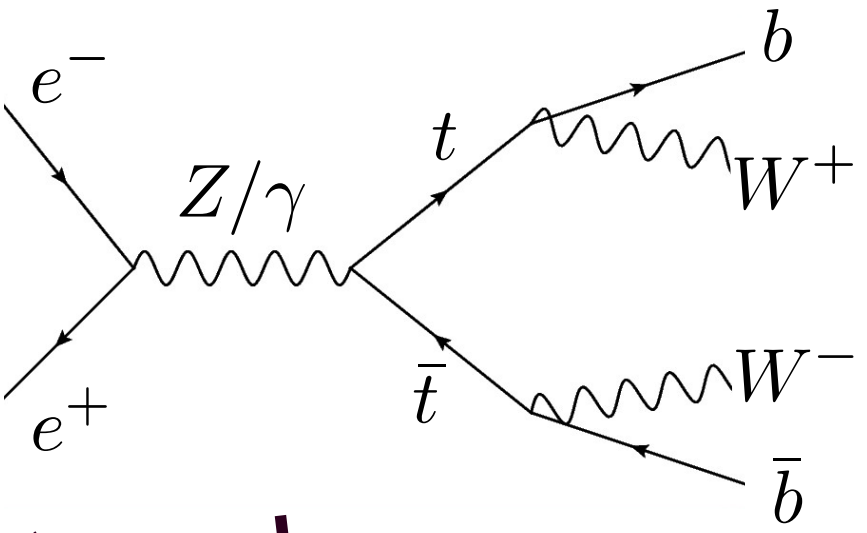
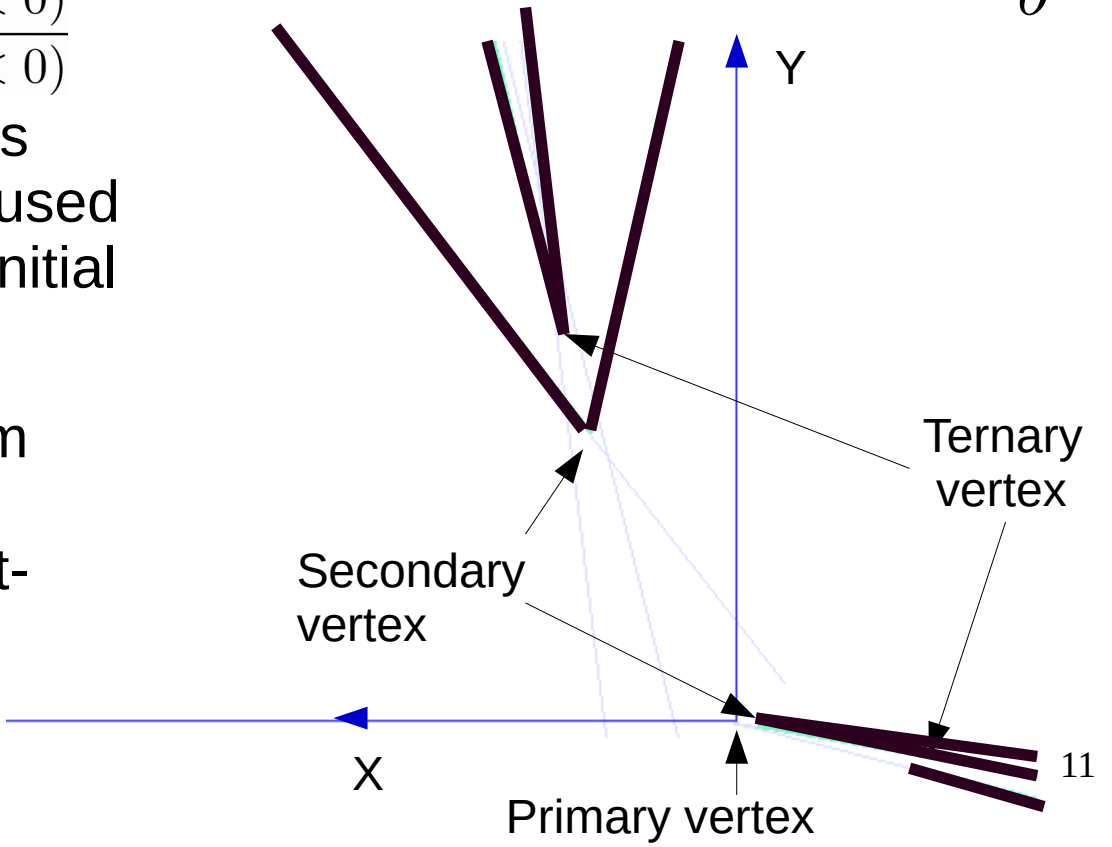
Outlook II

- Main purpose of this work is to detect the charge of top and antitop quarks. This is crucial for reconstruction of top polar angle in $t\bar{t}$ process at ILD
- Forward-backward asymmetry :

$$A_{fb} = \frac{N(cos\theta_t > 0) - N(cos\theta_t < 0)}{N(cos\theta_t > 0) + N(cos\theta_t < 0)}$$

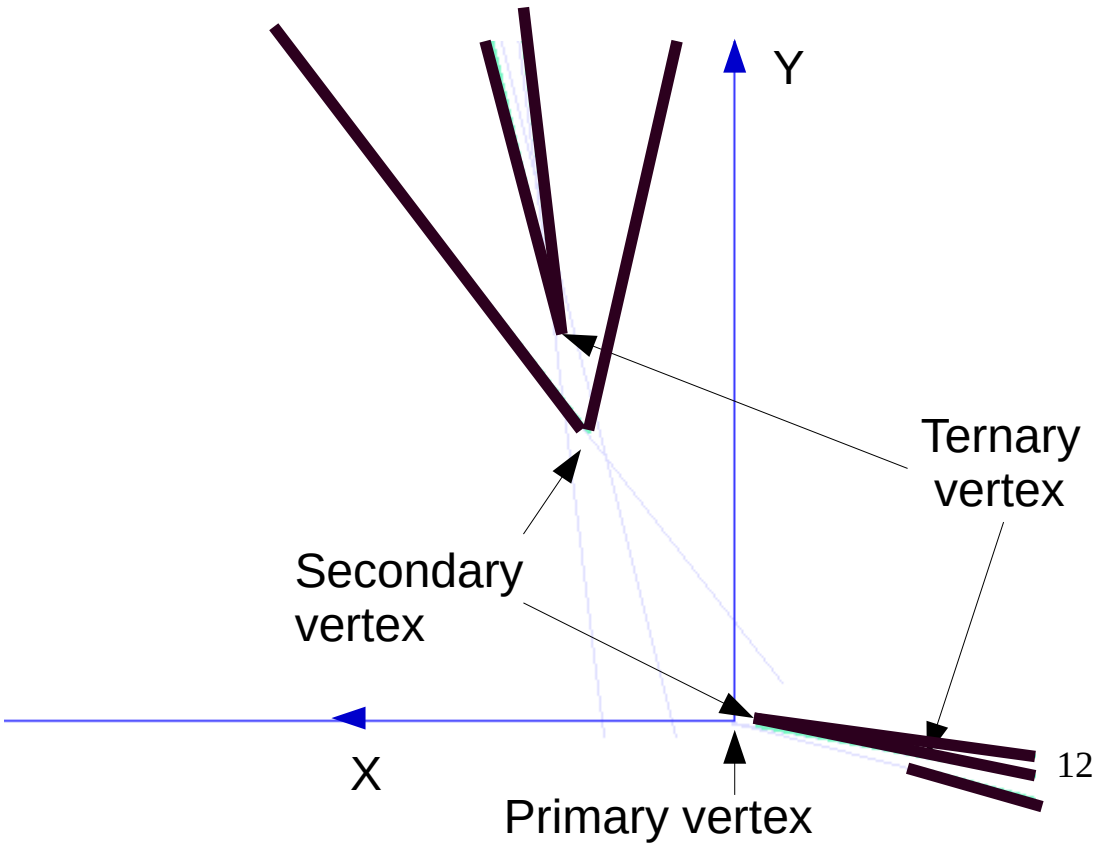
- Properties of decay products from the B-hadrons can be used to determine the charge of initial t-quark
- The charge of K-meson from ternary vertex is directly connected to the charge of t-quark



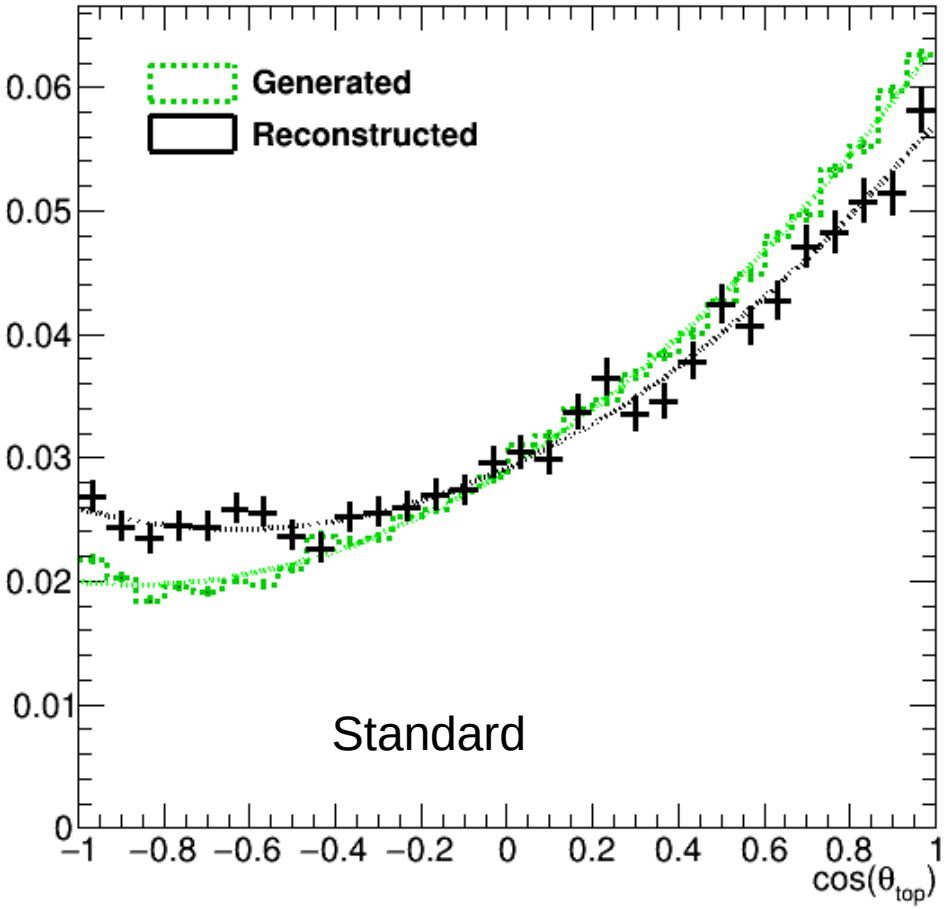


Overview

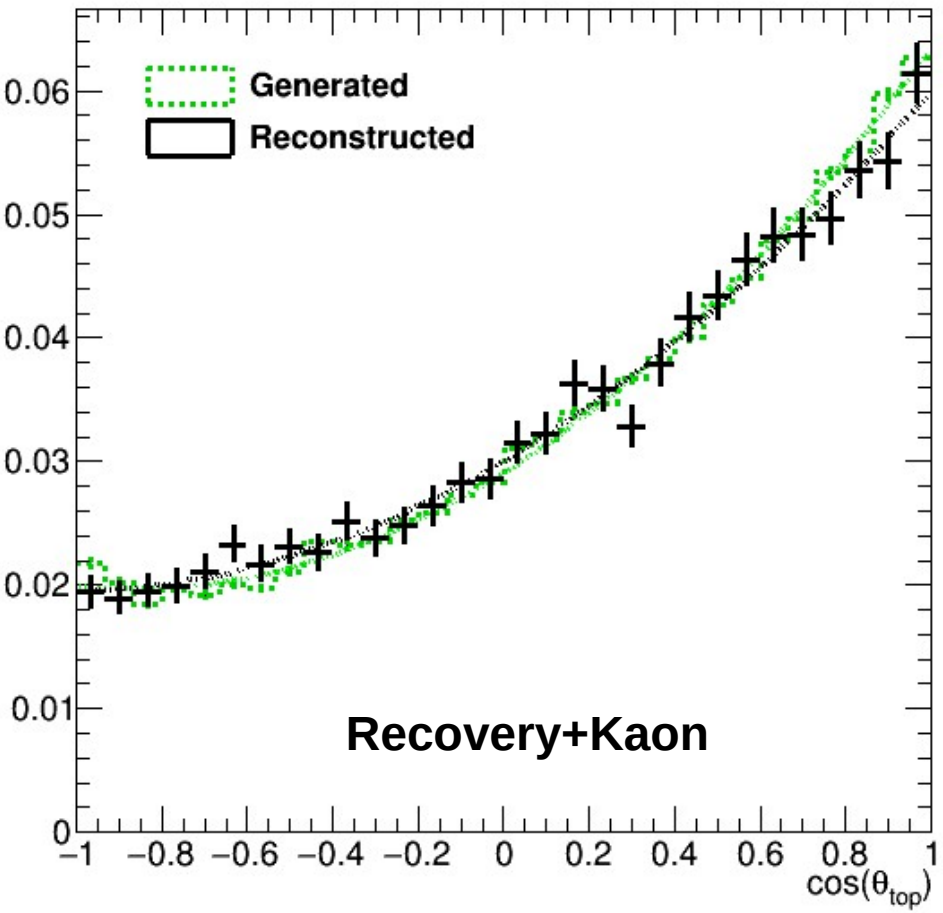
- Was developed TruthVertexFinder - an algorithm that finds generated vertices from B hadrons, detects all charged secondary particles, B-Bbar oscillations etc.
- Vertex reconstruction algorithms can lose a secondary or ternary tracks from a reconstructed vertex
- VertexChargeRecovery designed to improve the b-charge purity by adding tracks to reconstructed secondary and ternary vertices
- The K-meson from ternary vertex can be detected by using energy deposition information from TPC



Overall top polar angle improvement



72% precision on Afb



94.4% precision on Afb

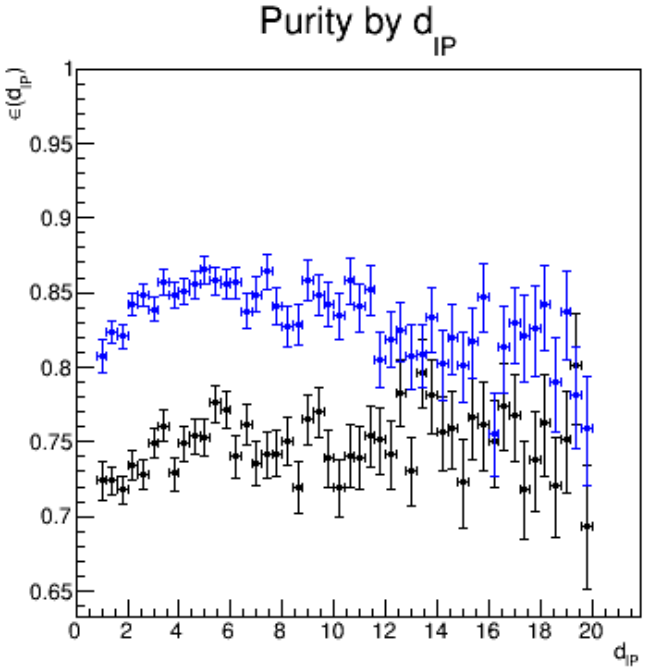
- Top polar angle reconstruction. Standard vs Kaon charge + new recovery

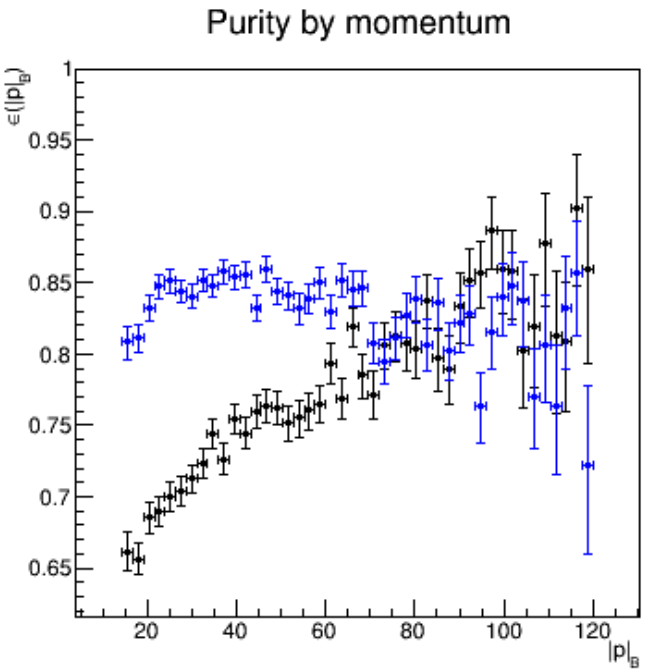
Conclusion II

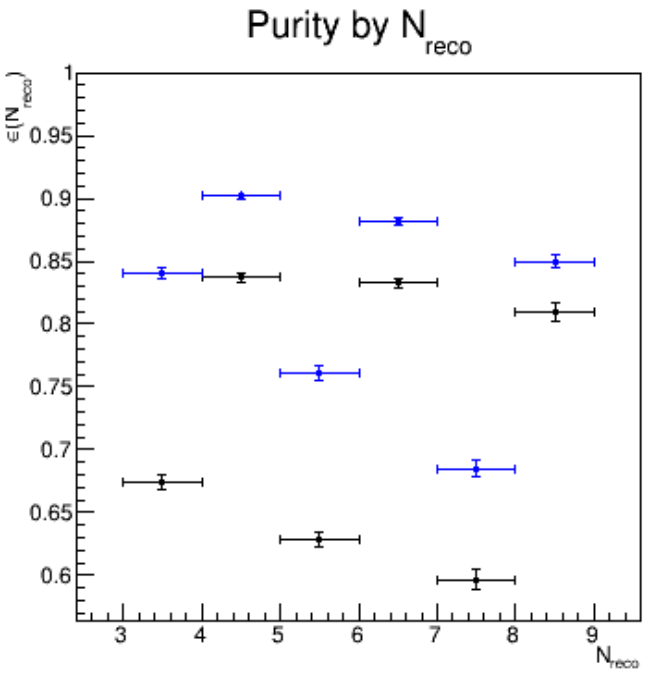
- We have developed two algorithms that are included in ilcsoft repository:
  - TruthVertexFinder for finding generated b-vertices
  - VertexChargeRecovery to recover reconstructed vertices
- The standalone B-charge reconstruction quality is improved by 10%
- Application of kaon charge makes possible to use fully hadronic decays of the top pair
- Further work:
  - Increase the method efficiency
  - Apply this analysis to fully hadronic top decays
  - Apply this method to b-bbar process at ILC

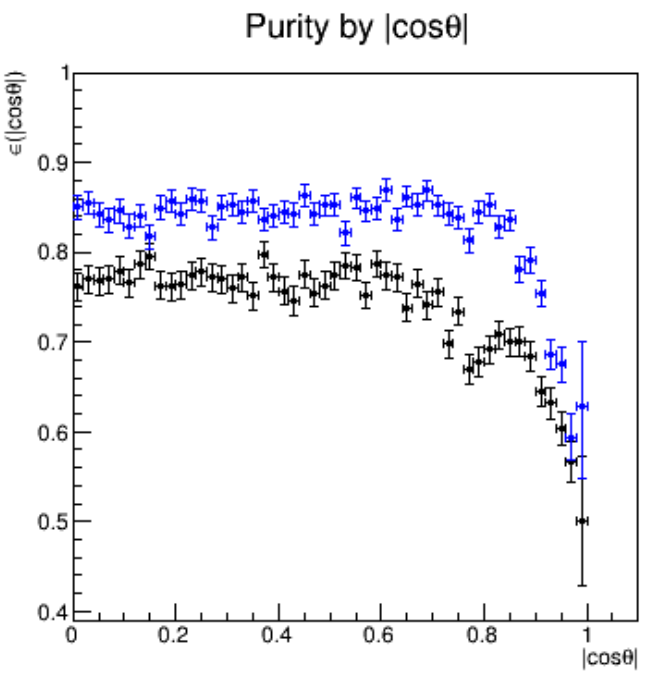
Thank you!

Overall purity improvement









- B-meson charge purity.

Minivector + recovery
DBD