

Extracting longitudinal shower depth from calorimetry plus tracking

David Brown (LBL), Jelena Ilić (Warwick), Gagan Mohanty



TILC09, Sim/Rec/Opt Session

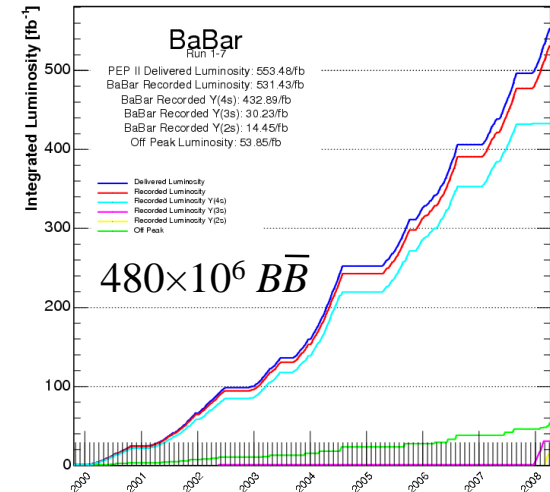
19 April 2009

Talk Outline

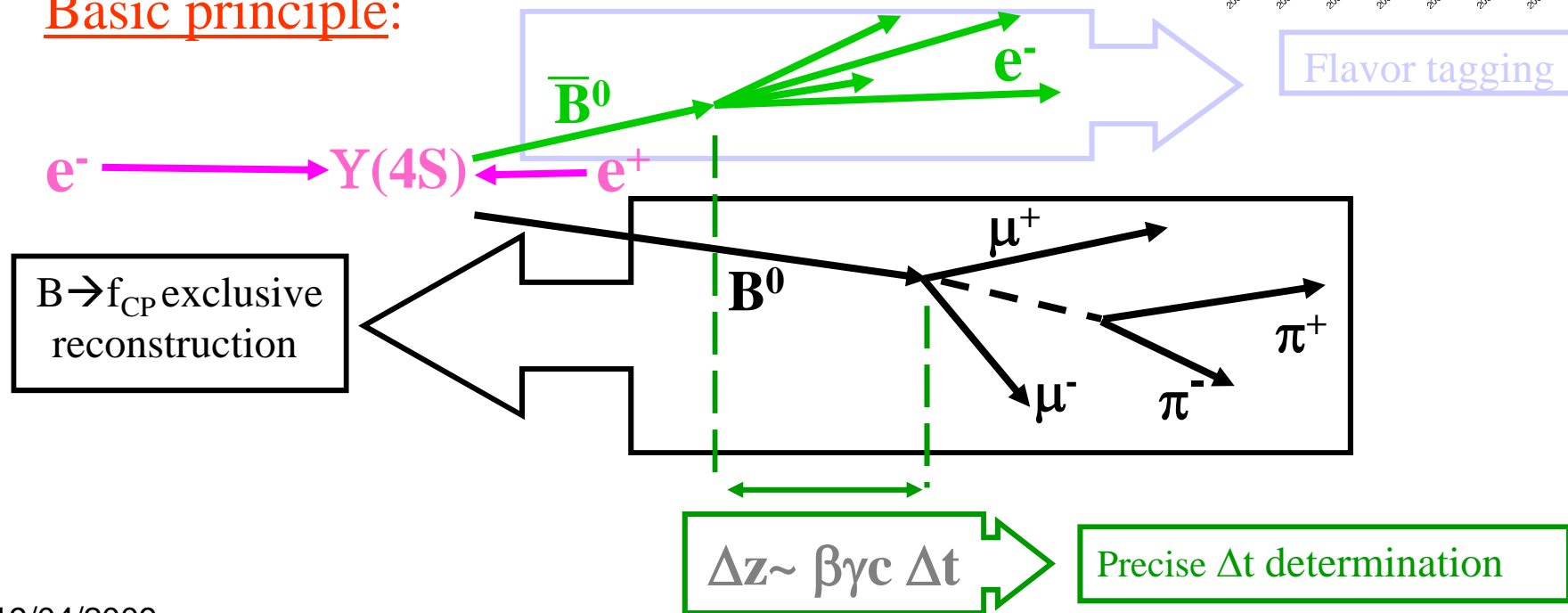
- Introduction to BABAR
- Definition of Shower Depth
- Particle ID Performance
- Log-dependence on Energy
- Relevance to Linear Collider
- Closing Remarks

Introduction to the Experiment

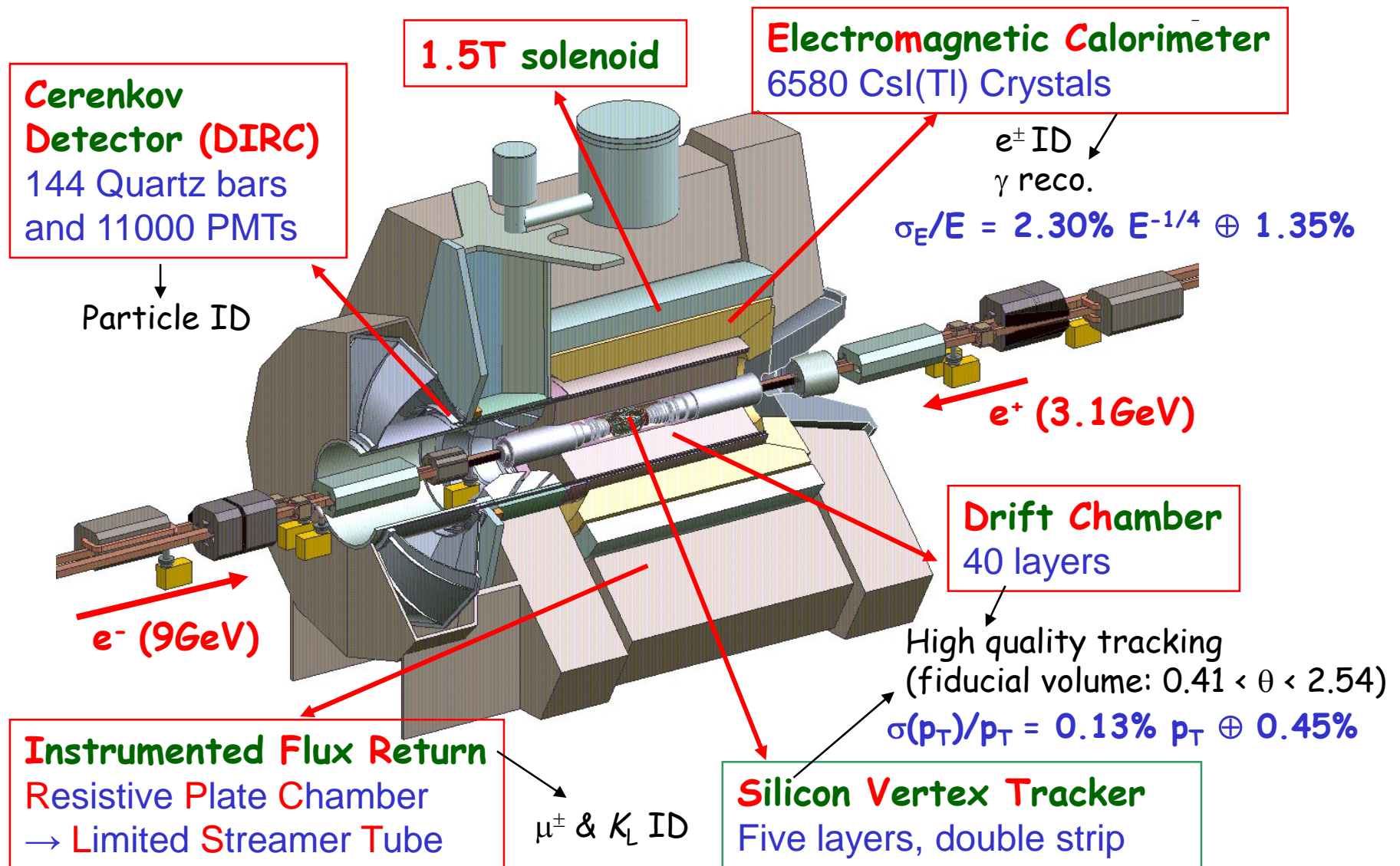
- ✓ Designed to verify the Kobayashi-Maskawa paradigm of CP violation in decays of B mesons, copiously produced near the $Y(4S)$ resonance
- Data taking from May 1999 till April last year
- Led (along with Belle) to half the 2008 Nobel prize in Physics awarded to Profs. Kobayashi and Maskawa



Basic principle:



The BABAR Detector



BABAR Calorimeter

- Each CsI(Tl) crystal

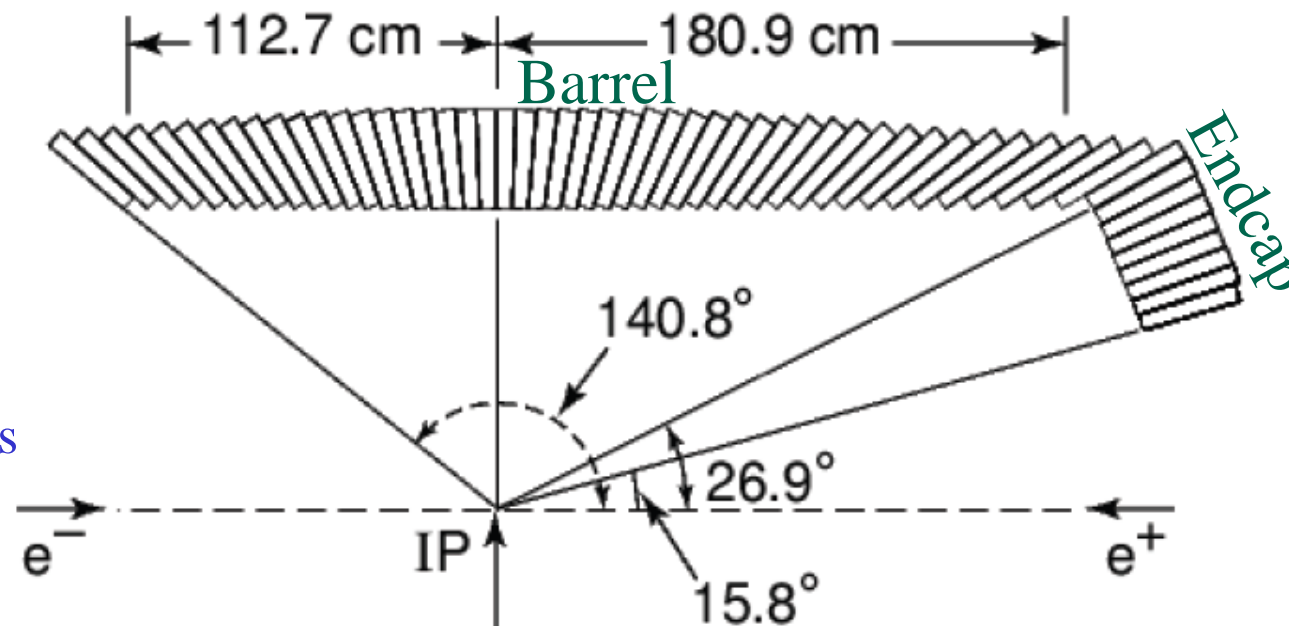
$L \sim 17X_0$ (31.5cm)

Front: $4.7 \times 4.7 \text{ cm}^2$

Back: $6.0 \times 6.0 \text{ cm}^2$

- Finely segmented in the plane transverse to incoming particles

- No longitudinal segmentation

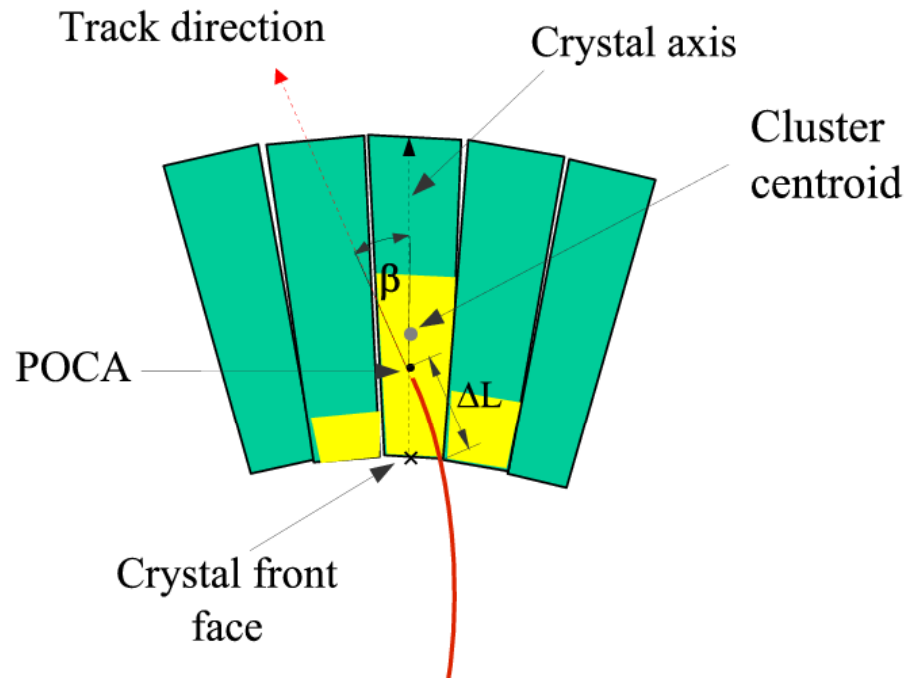


No direct measurement of longitudinal shower development

❑ Main goal of the study is to extract an effective longitudinal shower depth by using a precise extrapolation of the track into the calorimeter

Definition of Shower Depth

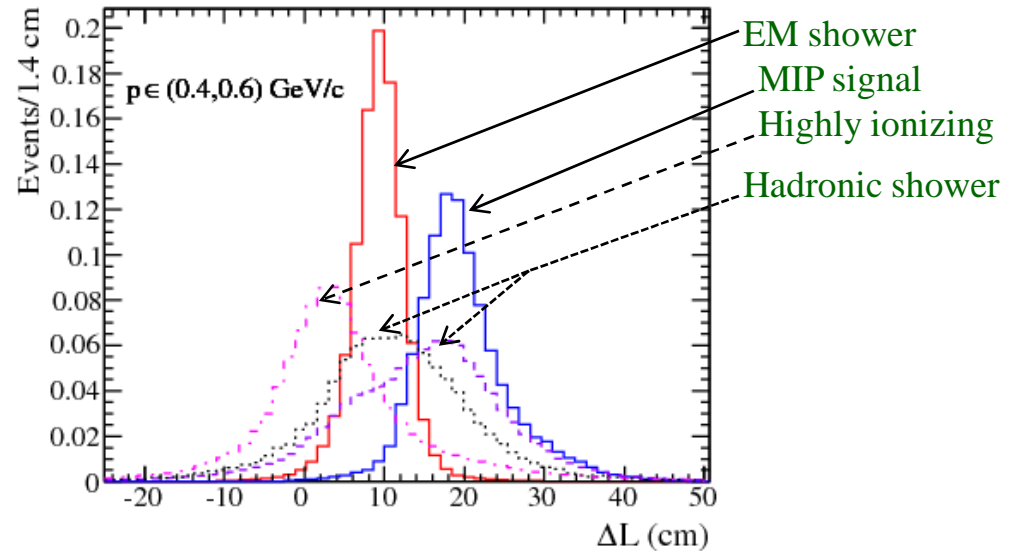
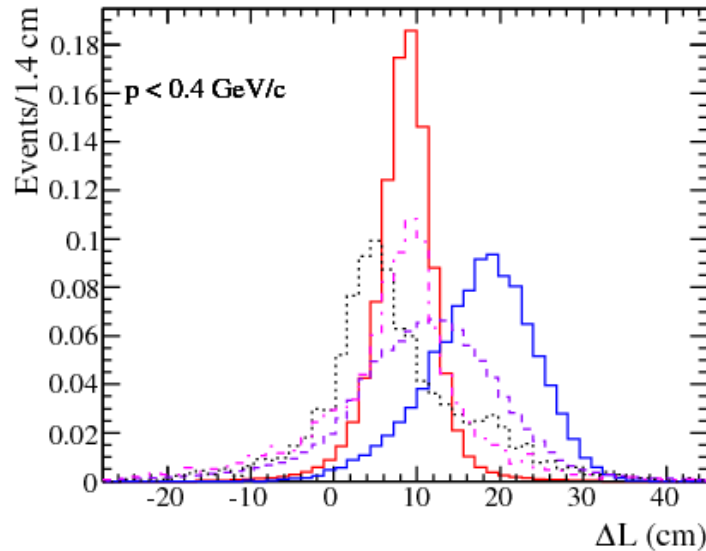
NIM A592, 254 (2008)



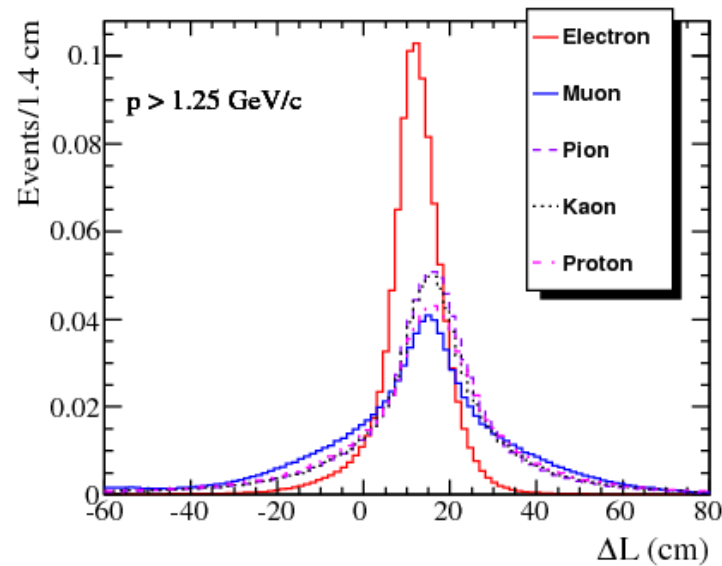
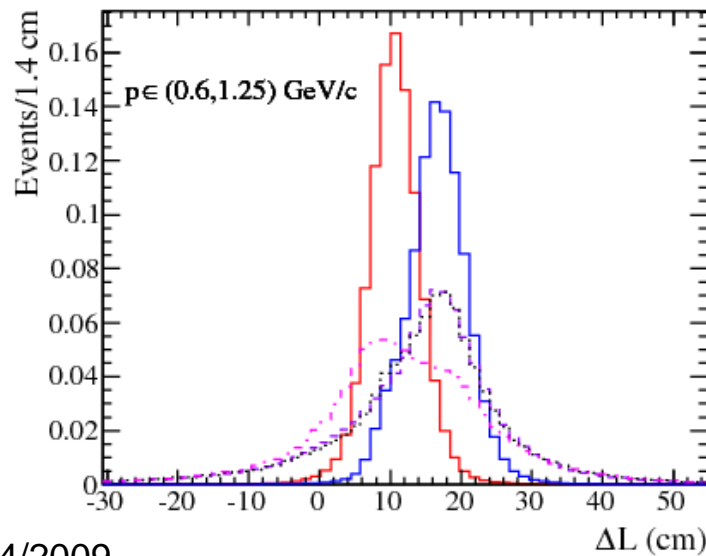
$$\Delta L \equiv \frac{(\vec{r}_{\text{POCA}} - \vec{r}_{\text{Front}}) \cdot \hat{r}_{\text{Cluster}}}{\cos \beta}$$

- Physically, ΔL is the distance along the flight path of the track between where it enters the calorimeter and energy-weighted average shower position
- Exploits the fact that the track and the cluster are two independent 2D projections of the shower position
- The track direction and the crystal axes are not collinear
 - ❑ Magnetic field bends the track
 - ❑ The crystals do not point back exactly to IP
 - ❑ The IP has a finite width in the beam direction

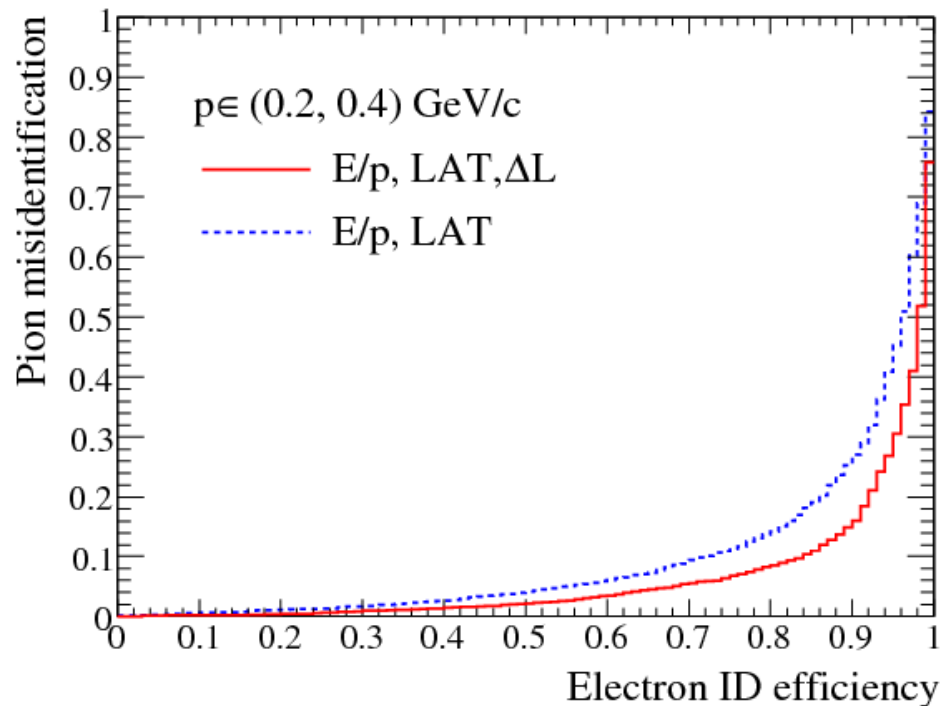
Distributions of various particles



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Electron ID Performance



- Test the impact of ΔL while added to two standard variables: (E/p) and LAT

$$\frac{\sum_{i=3}^N E_i r_i^2}{\sum_{i=3}^N E_i r_i^2 + E_1 r_0^2 + E_2 r_0^2}$$

- Improvement in the performance for the barrel region, not so much in endcap – discrimination power decreases with increasing energy

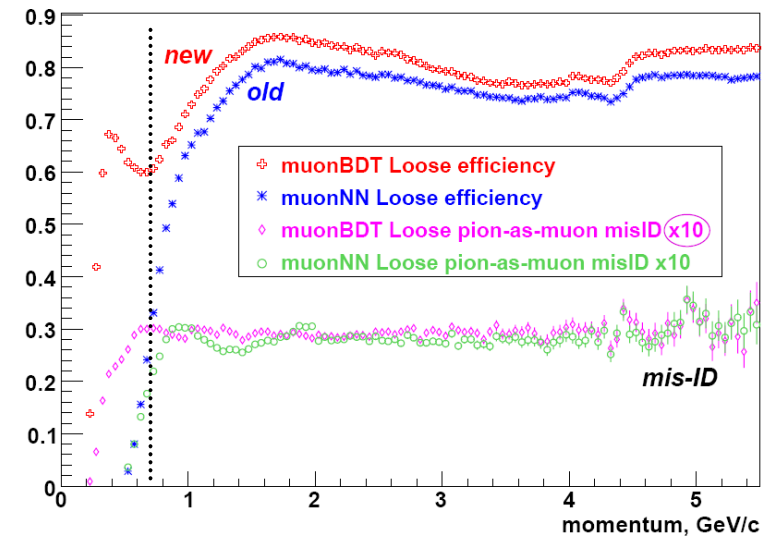
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Pion misidentification probabilities at 90% electron ID efficiency

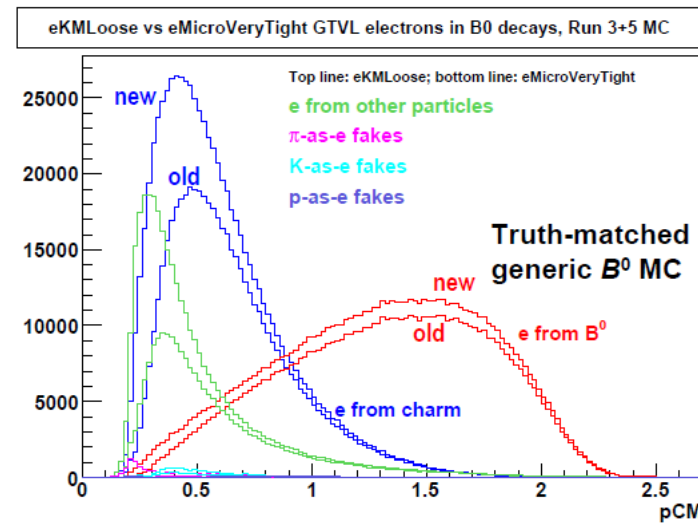
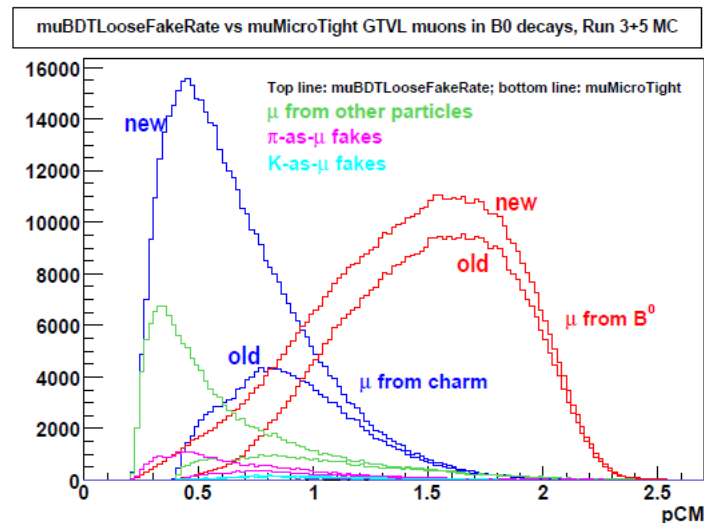
p in GeV/c	Backward barrel (%)		Forward barrel (%)		Endcap (%)	
	With	Without	With	Without	With	Without
[0.2, 0.4]	25	34	16	27	5	7
[0.4, 0.6]	19	25	14	22		
[0.6, 0.8]	6	11	8	15		
[0.8, 1.0]	2	3	3	5		
[1.0, 2.0]	2	3	2	3	2	3
> 2.0	3	3	2	2		

Improved Muon ID and B Tagging

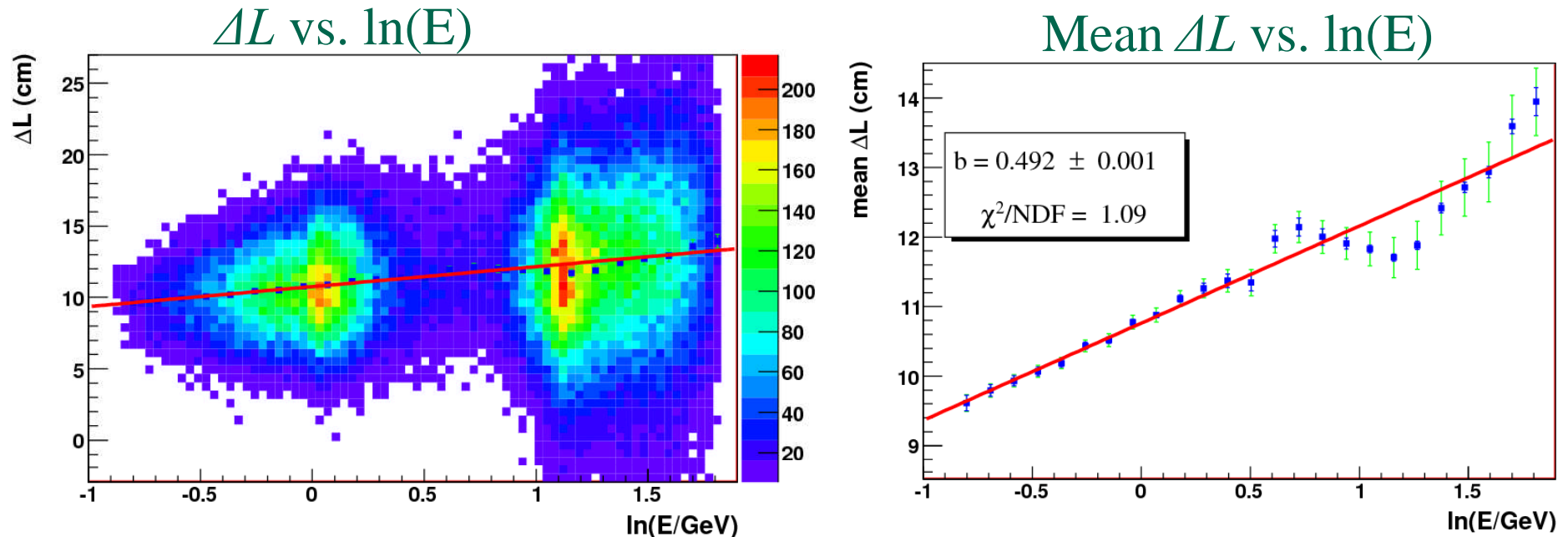
- Find significant improvement in the muon identification at low momentum
- Increase in the detectable muon minimum momentum from 800 to 270 MeV/c



Relative gain in the B tagging efficiency ($\Delta Q=4\%$)



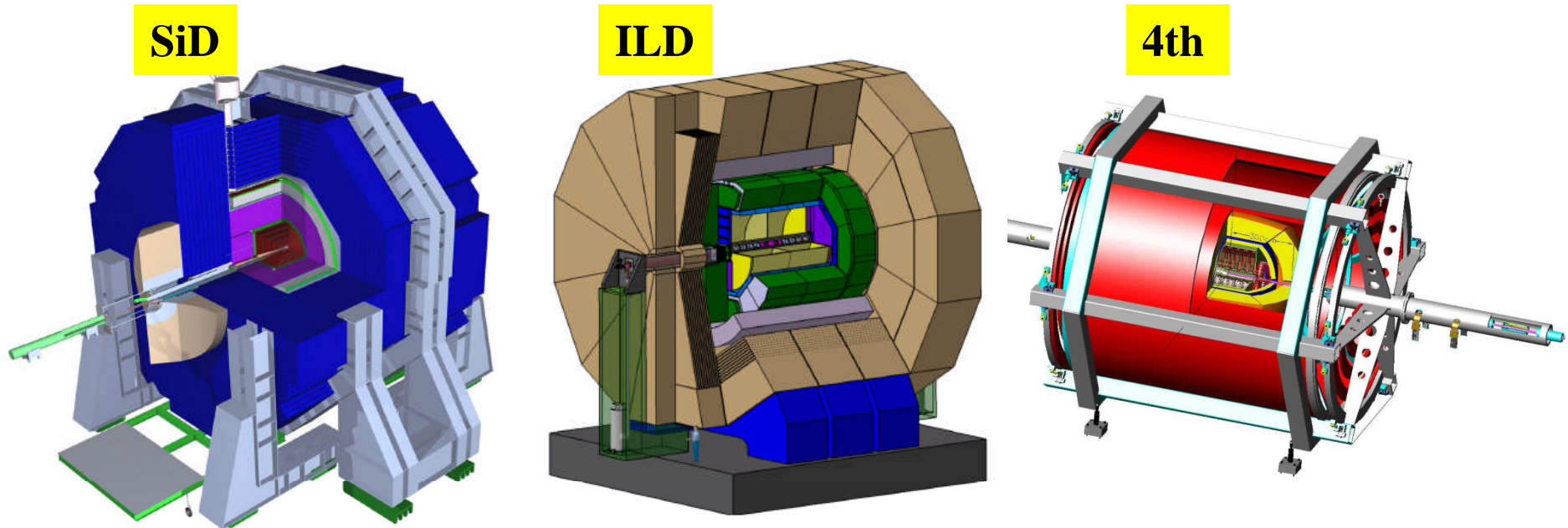
Is it really Shower Depth?



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- Follows a logarithmic dependence on the energy of showers generated by incident electrons
- Fitted material-dependent shower scale factor 'b' is consistent with the expectation for a CsI(Tl) crystal calorimeter

Relevance to ILC Detectors



- Complementary approach
 - ❑ Tracking: pure silicon tracker in SiD, TPCs combined with silicon vertex detectors for other two
 - ❑ Calorimetry: particle flow calorimetry for first two while 4th follows a different philosophy with compensating calorimetry
- Would be nice to see if the marriage of two can be extended to improve information on longitudinal shower development

Closing Remarks

- BABAR has been one of the most successful collider-based HEP experiments (close to 500 publications in about ten years)
- At its core, the basic strategy was (still continues) to foster new ideas and to successfully implement them
 - ❑ One such was the theme of this talk
- Hope the linear collider experiments to take the lead of innovation in near future after the LHC