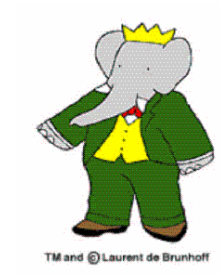
“Fast Simulation” of the Dirc



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Outline

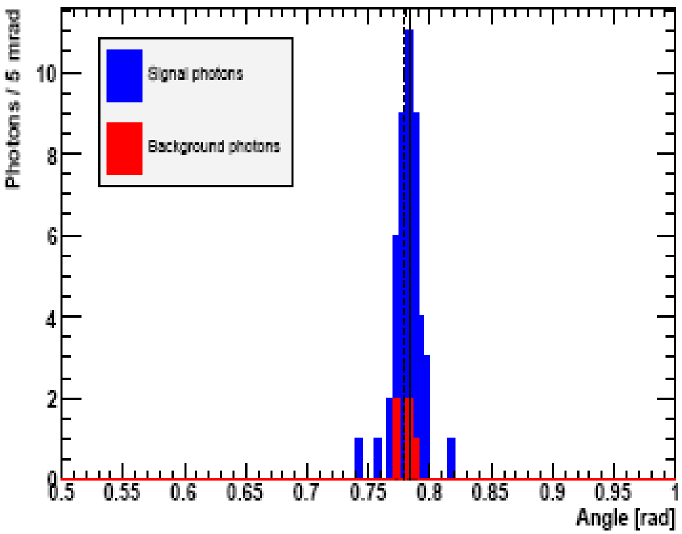
- Overview
- Performance cf Babar G4
- Configuration options
- Programming interface
- Known Problems
- Plans

Overview of Algorithm : Ring generation

- PacBaBarDrcModel generates a number of photons based on track momentum and type from BaBar ring dictionary
- Photons are stored as (θ_c,ϕ_c) pairs with respect to track momentum.
  - θ_c's are generated with a Gaussian distribution around the nominal Cherenkov angle, with errors from the DIRC geometry and quartz achromaticity.
  - ϕ's are generated uniformly within the range for which internal reflection will occur.

Overview of Algorithm : Ring generation

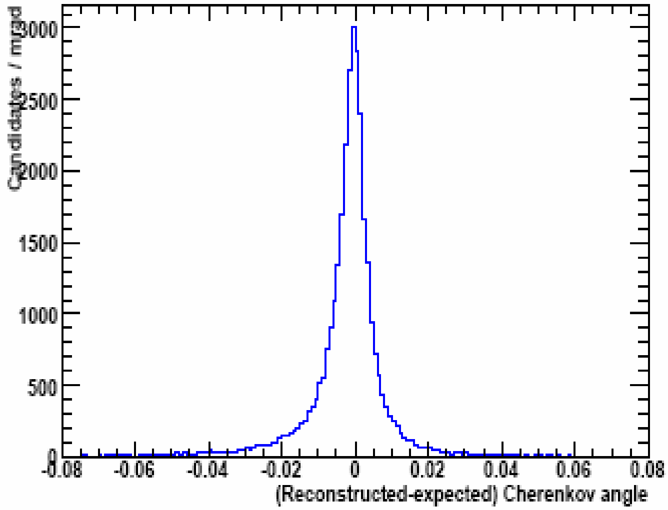
- Various Effects – justified on basis of experience with the Babar Dirc are included:
  - An additional, large error is applied to some tracks;
  - 50% of photons are generated with respect to the outgoing track momentum, to account for errors from scattering
  - Background photons are generated uniformly in a window around the nominal Cherenkov angle.



Distribution of Cherenkov photons for a single track. The solid line indicates the true Cherenkov angle, the dashed line is the reconstructed angle. Notice that the 25-mrad window includes all photons for this track.

Overview of Algorithm : Reconstruction

- Given angles with respect to true momentum, PacDircFitter calculates angles with respect to reconstructed momentum.
- Reconstructed Cherenkov angle θ_c is the arithmetic mean of the θ_c for individual photons
- Outlying photons are excluded by means of a sliding window. A window of width 25 mrad is moved across the distribution of Cherenkov angles θ_c, and only those falling within the most populous window are used.



Program Features : Configuration Options

- All conguration parameters can be found in PacDetector/DircConfig.xml. These include
  - QuantumEfficiency given in units of the BaBar quantum eciency.

    Raise it to 1.05, get 5% more photons. Default is 1.
  - ExtraScatterProb and ExtraScatterSize govern the additional Gaussian applied to some photons.

    The first (defaults to 20%) is the probability of a photon being extra scattered; the second (defaults to 0.02) is the amount added to the Gaussian sigma, in radians.
  - WindowWidth is the size of the sliding window used in the reconstruction, in radians. Default is 25 mrad.
  - BkgWindow and BkgAmount are used in generating background photons. Background photons are generated uniformly;

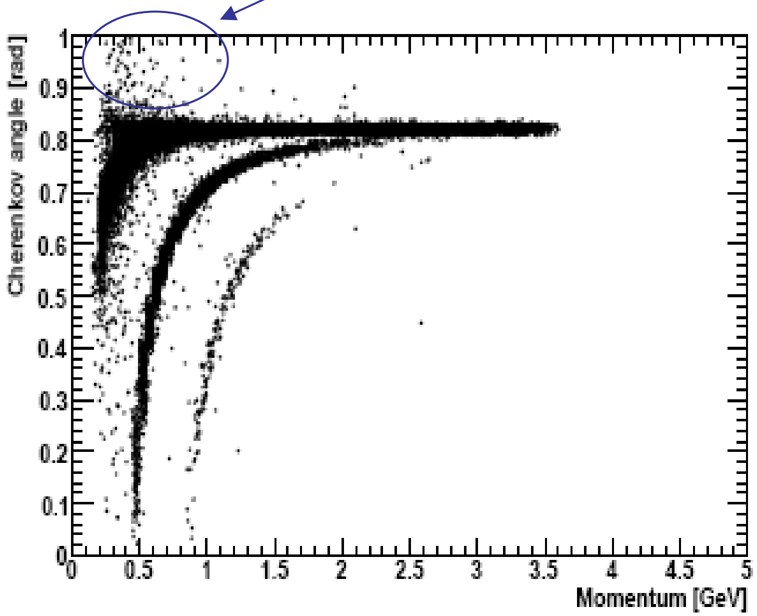
    BkgWindow is the extent in either direction from the nominal Cherenkov angle. BkgAmount is number about which background photons are Poisson-distributed. By default the values are 20 mrad and 4.
  - AchromConstant and GeometricError are the size of the per-photon errors in Cherenkov angle, in radians;

    Defaults are 4.2 mrad and 4 mrad.

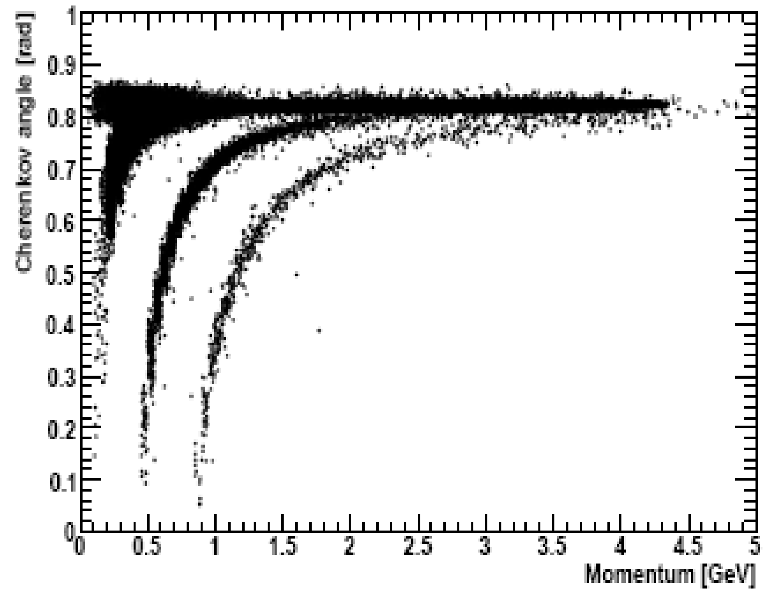
Comparison with Geant4 (Babar)

e^- – perhaps δ-rays

θ_c



θ_c



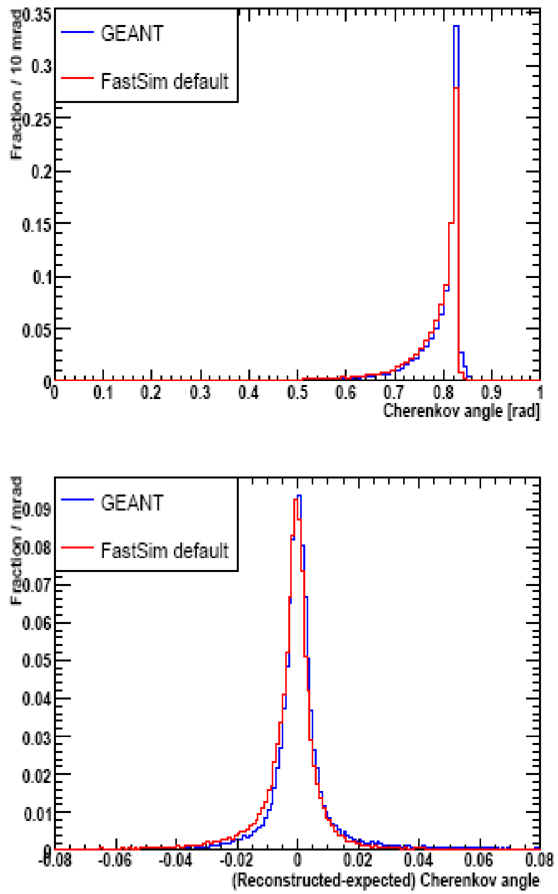
Momentum (GeV/c)

BaBar G4

FastSim

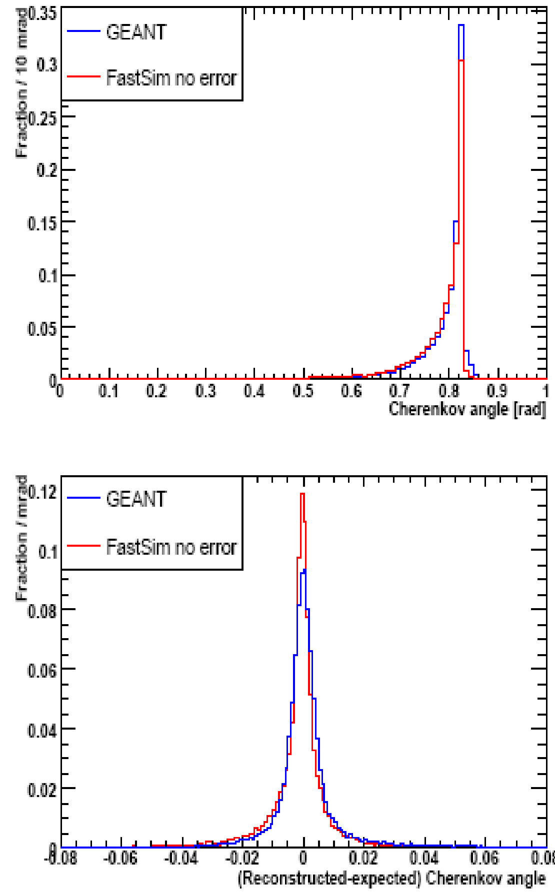
Comparison with Geant4 (Babar)

Default



Default distributions.

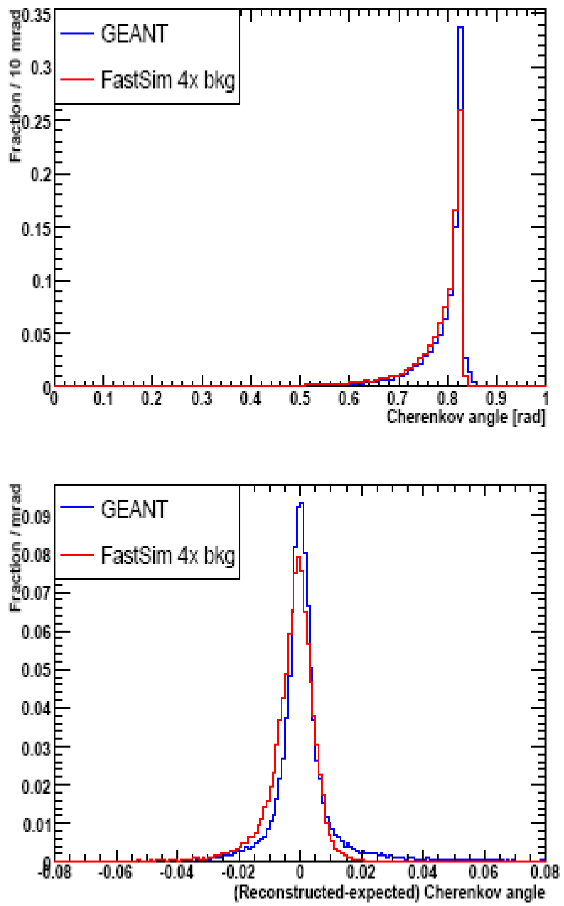
No error



No errors - geometric, achromatic, and extra error terms all set to zero.

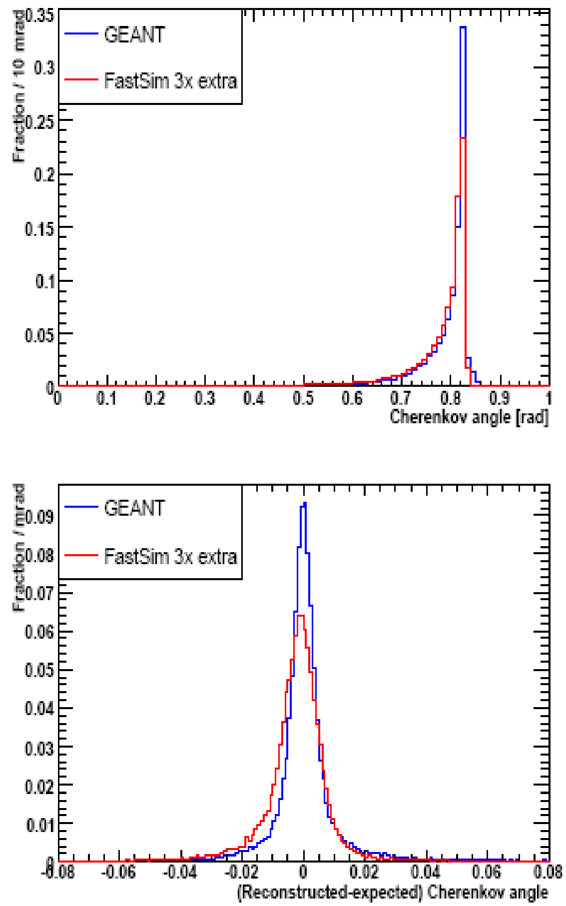
Comparison with Geant4 (Babar)

4 x Background



Background increased by factor 4.

3 x Background



Extra scatter probability set to 60%.

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Program Interface: Extracting Information

- Basic information like reconstructed Cherenkov angle is contained in PacMicroAdapter object and can be extracted just as in old BaBar code.
- The underlying information of individual photon angles is stored in PacDircResponse.
- PacDircResponse has three public methods for extracting information:
- To get the PacDircResponse associated with a track, use PacDircMaps class:

```
static PacDircResponse* get (const PacSimTrack* tr);
static PacDircResponse* get (const BtaCandidate* tr);
```

Return lists of the individual photon angles, with respect to the true momentum.

Zero ϕ_c lies along the cross product of the track momentum and the z axis.

```
std::vector<double> getBkg () const;
```

List of the apparent Cherenkov angles of the background photons. This is with respect to the reconstructed

Momentum, hence no ϕ_c angle is given.

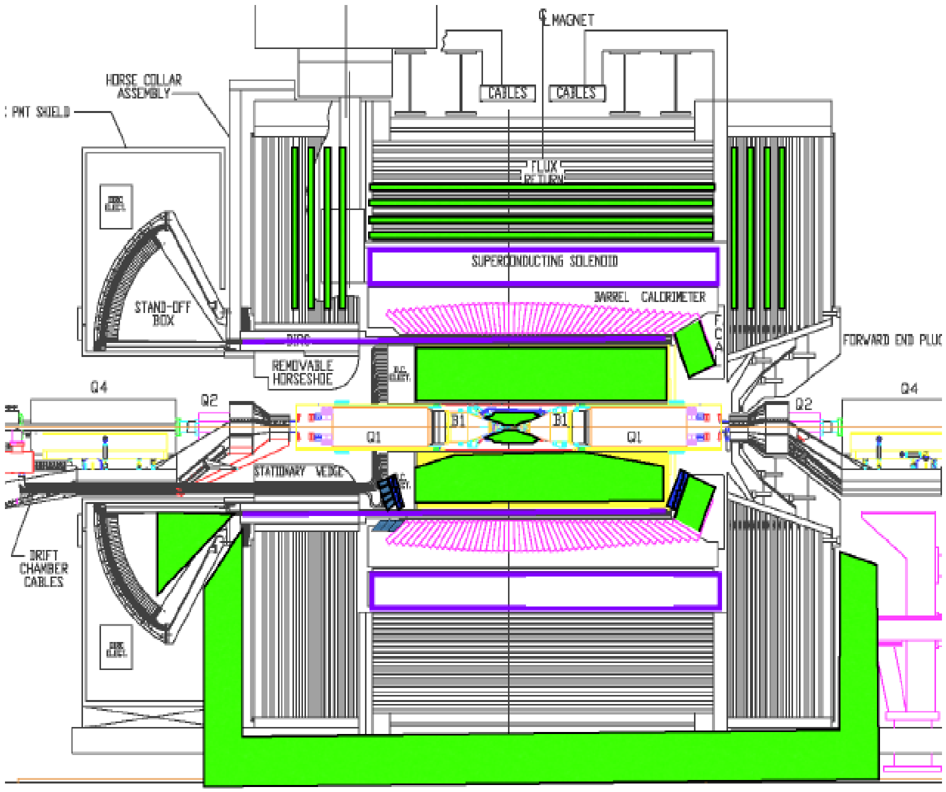
Program Interface: Adding Features

- New DIRC models (for creating Cherenkov rings) may be added as follows:
  - Write a class extending PacMicroAdapter (defined in PacDircModel.hh).
  - Edit initialisation code in PacAbsDircModel::getModel to include:

```
static bool initialised = false;
if (!initialised) {
  initialised = true;
  addModel(defaultModel, &PacBaBarDrcModel::create);
  // addModel(''MyModelName'', &MyModel::factoryFunction);
}
```

  - Change parameter DircModel in DircCong.xml to “MyModelName"
- New models must implement a getDircResponse method which returns a PacDircResponse object containing a list of photon angles.
- Changes to the reconstruction algorithm must be done by changing the PacDircFitter class.

Future Plans



Options for forward PID and re–design of DIRC photon detectors are still to be explored

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All of SuperB will contribute to PID:

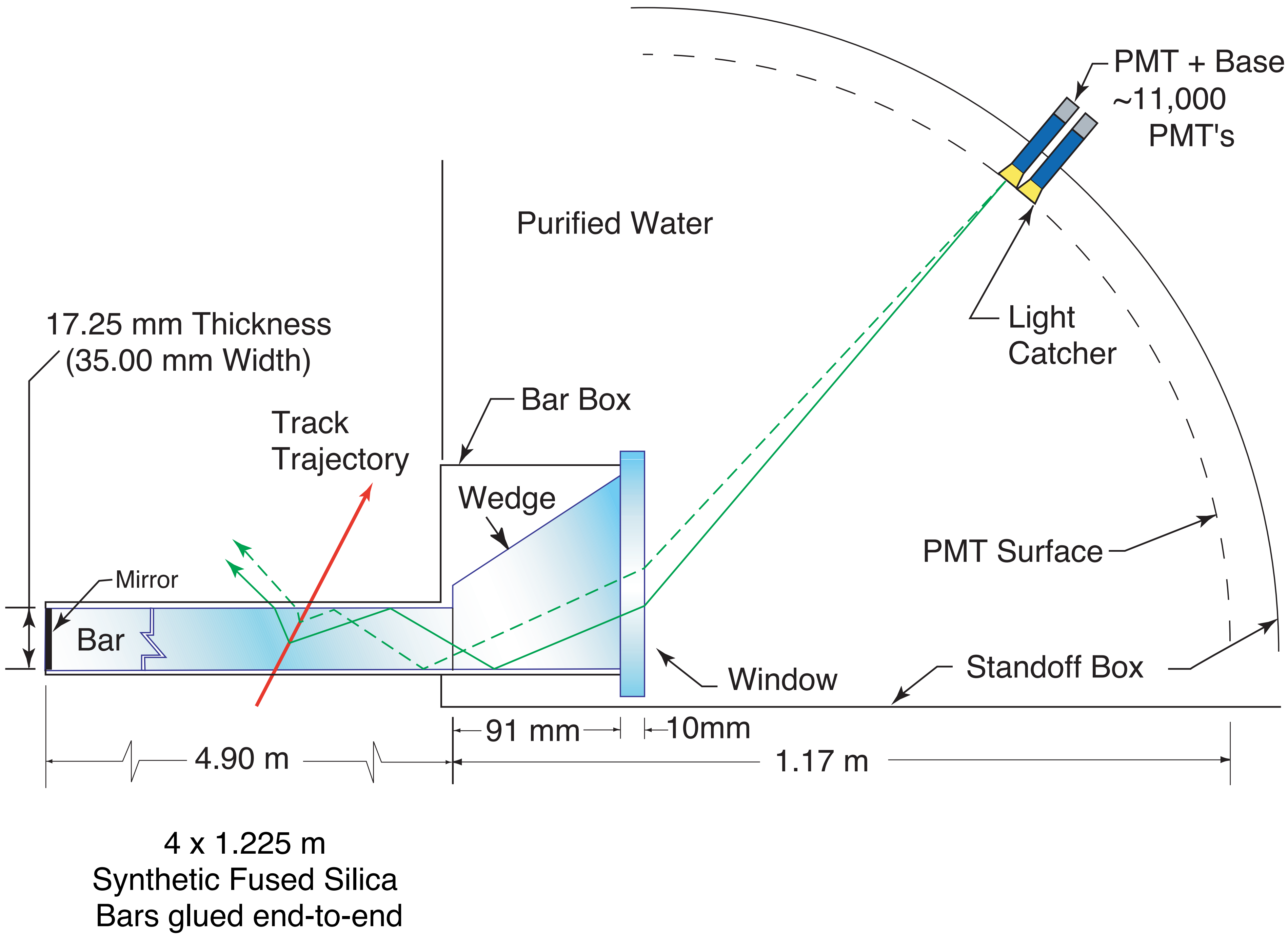
- SVT — dE/dx
- DCH — dE/dx
- DIRC — Cherenkov radiation
- EMC — EM shower (electron signature)
- IFR — penetrating particles (muon signature)

- Hadrons also interact in material, giving different shower shapes in EMC.
- Muons only lose energy by dE/dx in EMC.

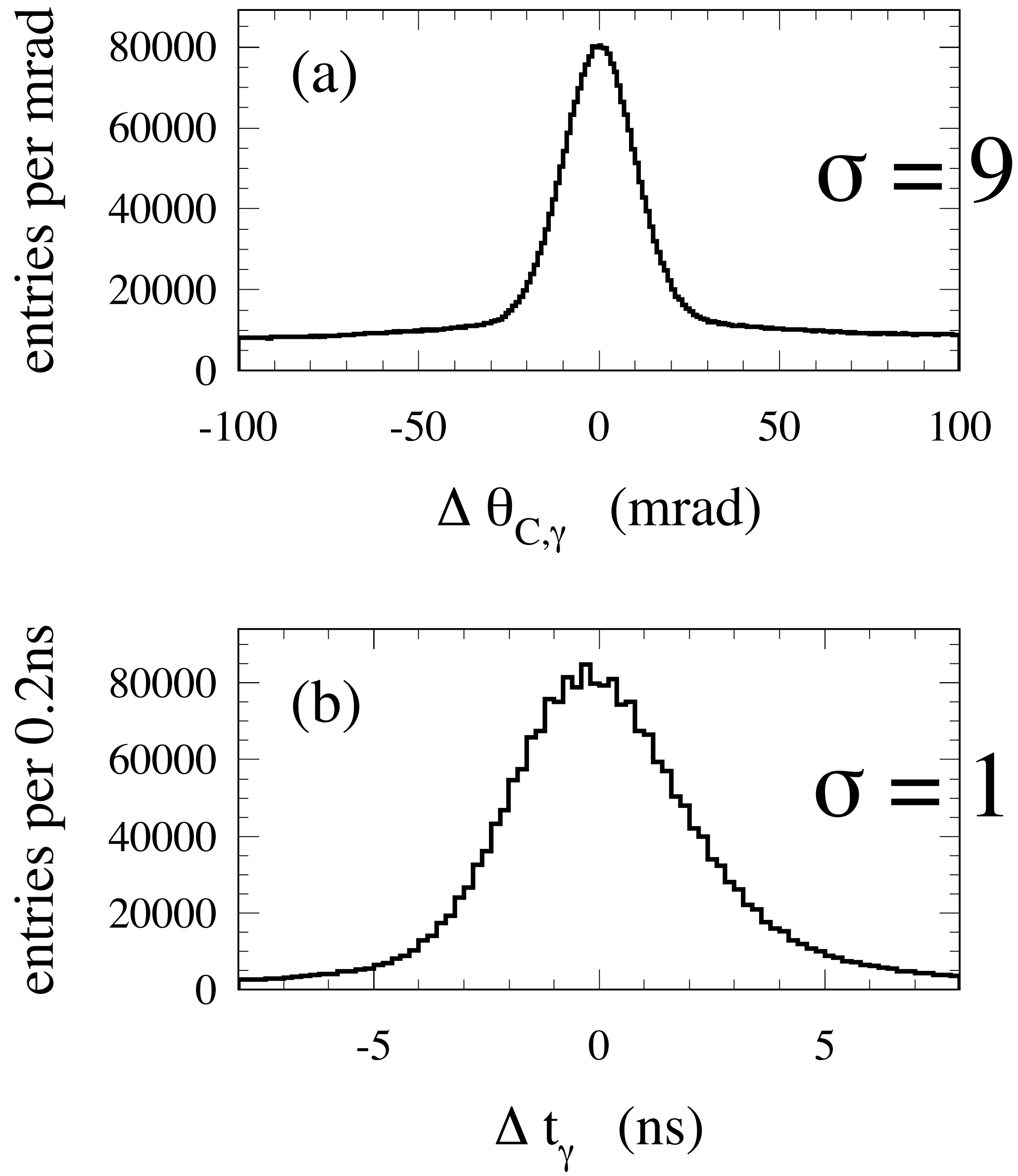
Only DIRC is not satisfactory for physics studies

- SVT — spec of dE/dx performance needed
- DCH — spec of dE/dx performance needed
- DIRC — measurement of ϑ_c ✔

- Selectors are needed to combine information. Simplicity is good, no need for neural nets &c.
- Volunteer(s) are very welcome to work on these topics!



- Many ray ambiguities: up/down, left/right, forward/ backward, wedge/no-wedge
- Typically only 2—3 sensible solutions



$\sigma = 9.6$mrad

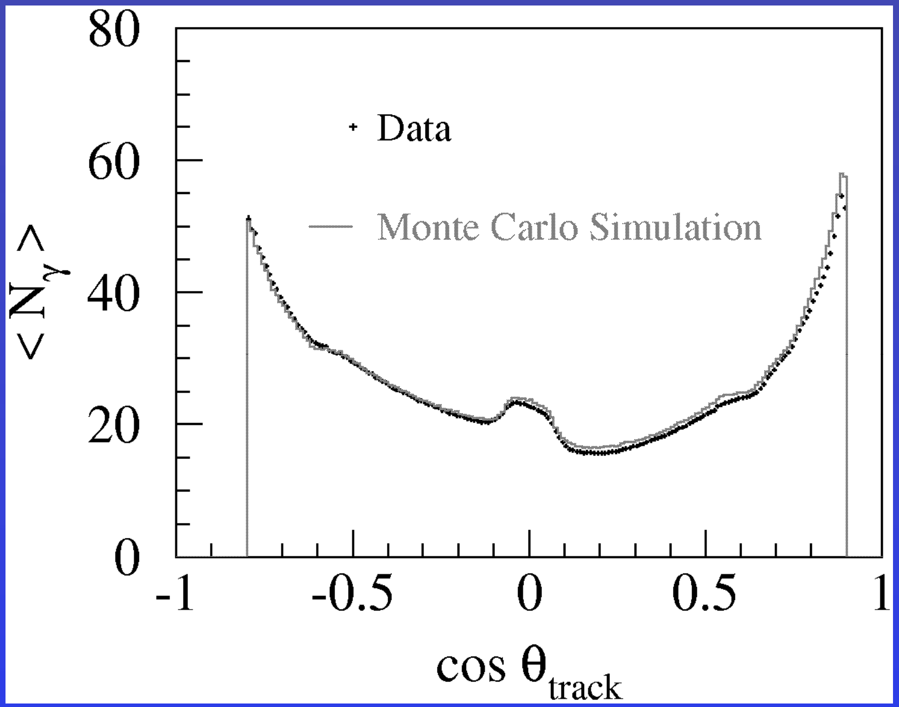
~7mrad bar/PMT size
5.4mrad dispersion

$\sigma = 1.7$ns

Single photon performance from di-muon events

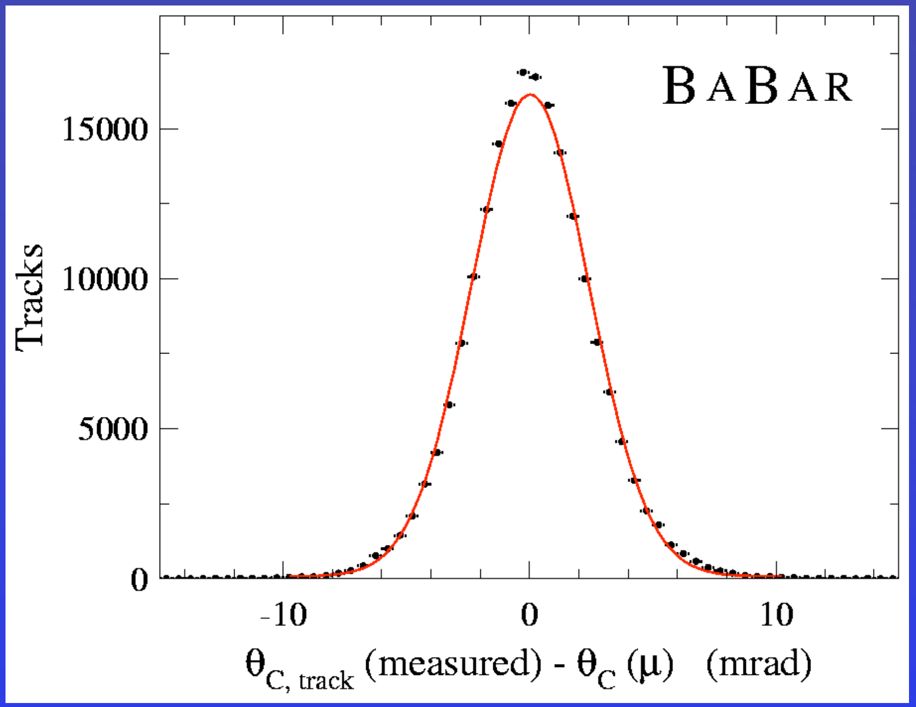
DIRC PERFORMANCE

Number of Cherenkov photons per track (di-muons) *vs*. polar angle:



Between 20 and 60 signal photons per track.

Resolution of Cherenkov angle fit per track (di-muons):



$\sigma(\Delta\theta_c) = 2.4$ mrad

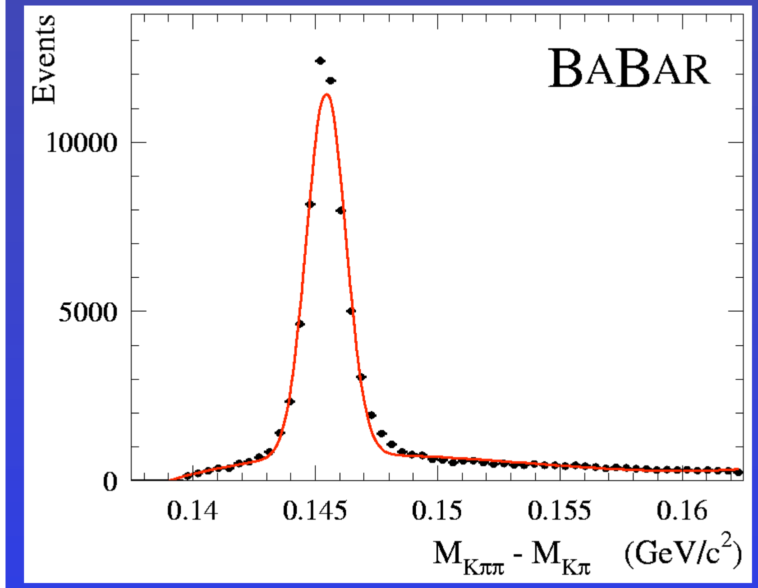
Very useful feature in BABAR environment:
higher momentum correlated with larger polar angle values
→ more signal photons, better resolution ($\sim 1/\sqrt{N}$)

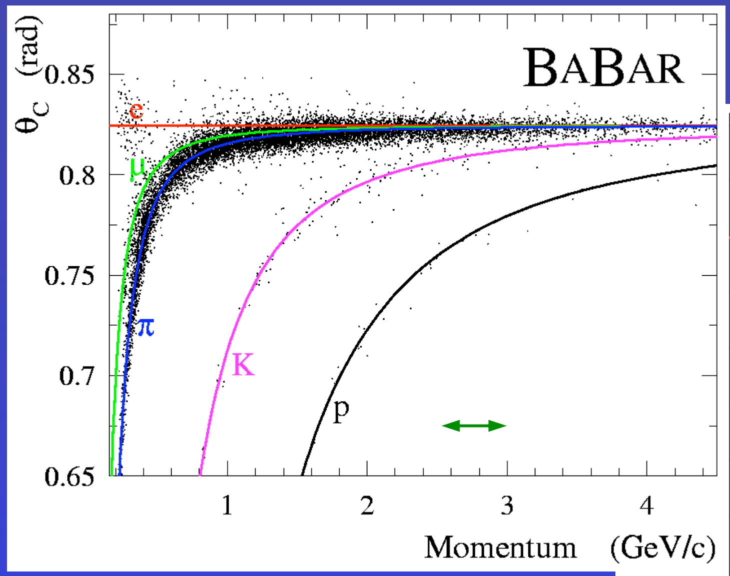
Track Cherenkov angle resolution is within ~10% of design.

Should improve with advances in track- and DIRC-internal alignment.

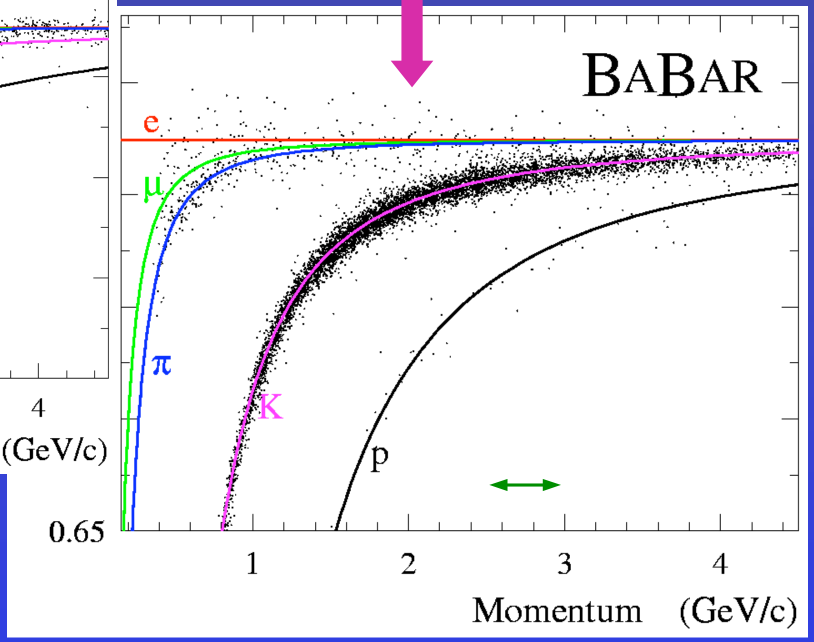
DIRC PERFORMANCE

$D^{*-} \rightarrow D^0 \pi^-$
$\hookrightarrow K^- \pi^+$

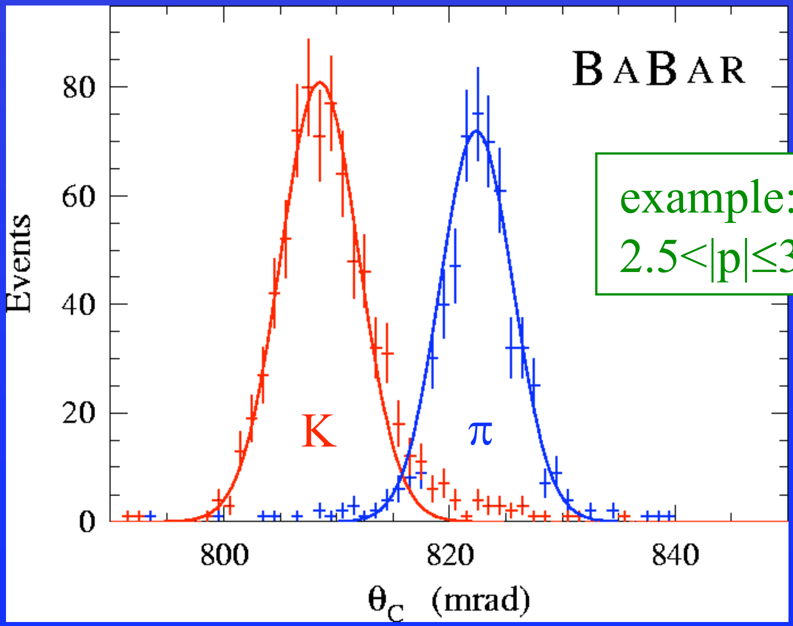




kinematically identified
π and K



- Select D^0 candidate control sample with mass cut (±0.5 MeV/c^2)
- π and K are kinematically identified
- calculate selection efficiency and mis-id
- Correct for combinatorial background (avg. 6%) with sideband method.



example:
2.5<|p|≤3GeV/c