PROGRESS ON THE FOCUSING DIRC R&D

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Accompanied by talk by J. Schwiening

Introduction

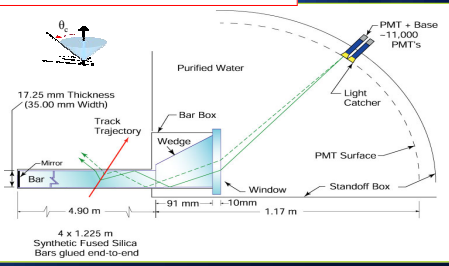
BABAR-DIRC has been a very successful particle identification (PID) system
- crucial to success of SLAC B-Factory
- very reliable, robust, easy to operate
- π/K separation ≥ 2.7σ up to 4.2GeV/c

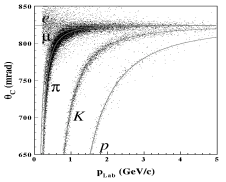
Potential DIRC for PID at future experiments?
- Super B-Factory
- Linear Collider
- Hadron spectroscopy (GlueX at JLab)
- Nuclear physics (PANDA at GSI)

In many future applications, need to further improve momentum coverage and make DIRC more background resistant

→ Improve single photon timing and angular resolution, decrease size of Cherenkov ring expansion region

→ SLAC R&D for a fast Focusing DIRC, measure performance of prototype in test beam at SLAC



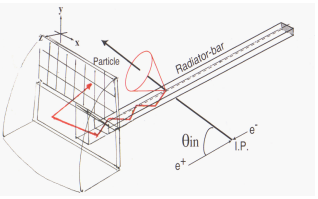


This plot shows one of the variables (θ_c) the DIRC uses to identify particles. Another variable is the number of photons detected.

NEXT GENERATION DIRC

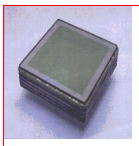
Improve single photon Cherenkov angle resolution
- use smaller photon detector pixels
- correct chromatic production term via precise timing
- use focusing optics to decrease bar size term

Decrease size of expansion region
- smaller expansion region will decrease background rate (caused by conversion of few-MeV accelerator-induced photons in expansion region)

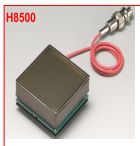


PHOTON DETECTOR SELECTION

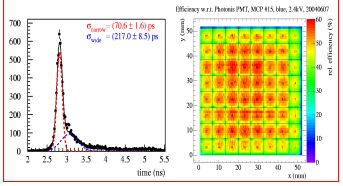
- Timing resolution : timing resolution σ_t < 200ps required for chromatic correction.
- Pixel size: small pixels allow reduction of size of expansion region without compromising angular resolution .
- Single photon efficiency: need quantum efficiency ~20- 30% and >70% packing efficiency to keep DIRC photon yield.

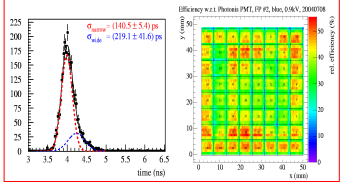


Burle 85011-501 MCP-PMT
- bialkali photocathode
- 25μm pore MCP
- gain ~5×10⁵
- timing resolution ~70ps
- 64 pixels (8×8), 6.5mm pitch



Hamamatsu H-8500 Flat Panel PMT
- bialkali photocathode
- 12 stage metal channel dynode
- gain ~10⁶
- timing resolution ~140ps
- 64 pixels (8×8), 6.1mm pitch





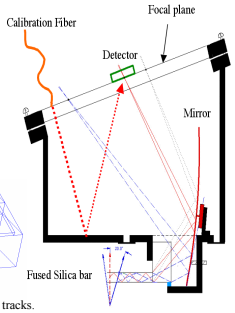
FOCUSING DIRC PROTOTYPE

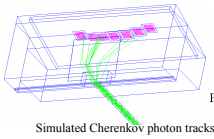
Radiator
- use 3.7m-long bar made from three spare high-quality BABAR-DIRC bars
- use same glue as BABAR-DIRC (Epotek 301-2), wavelength cut-off at 300nm

Expansion region
- use smaller stand-off distance (30% of BABAR-DIRC)
- coupled to radiator bar with small fused silica block
- filled with mineral oil (KamLand experiment) to match fused silica refractive index
- include optical fiber for electronics calibration
- would ultimately like to used solid fused silica block

Focusing optics
- spherical mirror from SLD-CRID detector (focal length 49.2cm)

Photon detector
- use array: 2 Hamamatsu flat panel PMTs and 3 Burle MCP-PMTs in focal plane
- readout to CAMAC/VME electronics

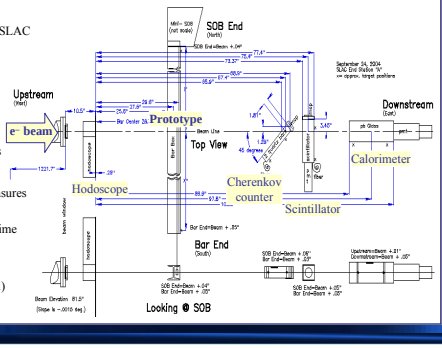




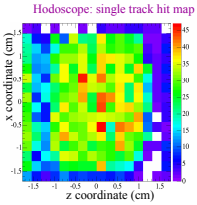
Simulated Cherenkov photon tracks.

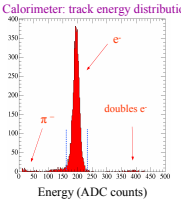
TESTBEAM SETUP

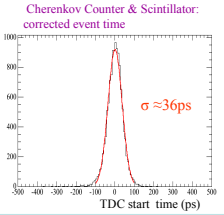
- Prototype located in beam line in End Station A at SLAC
- Accelerator delivers 10 GeV/c electron beam (e^-)
- Beam enters bar at 90° angle.
- 10 Hz pulse rate, approx. 0.1 particle per pulse
- Beam enters through thin aluminum foil windows
- Bar can be moved along long bar axis to measure photon propagation time for various track positions
- Trigger signal provided by accelerator
- Fiber hodoscope (16+16 channels, 2mm pitch) measures 2D beam position and track multiplicity
- Cherenkov counter and scintillator measure event time
- Lead glass calorimeter selects single electrons
- All beam detectors read out via CAMAC (LeCroy ADCs and TDCs, Philips TDC, 57 channels in total)



BEAM DETECTORS: Event Selection & Start Time

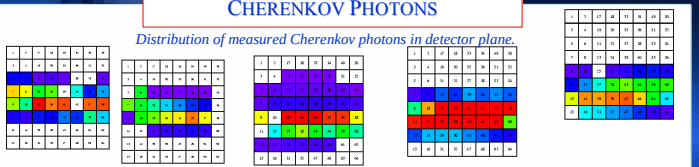


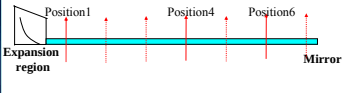




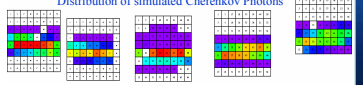
CHERENKOV PHOTONS

Distribution of measured Cherenkov photons in detector plane.

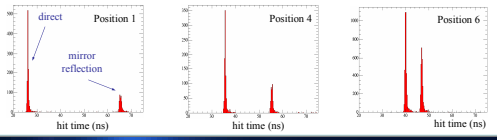




Distribution of simulated Cherenkov Photons



Hit time distribution for single PMT pixel in three positions.



PRELIMINARY RESULTS

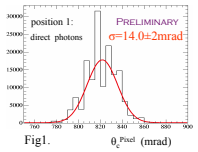


Fig1.

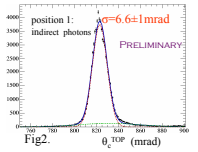


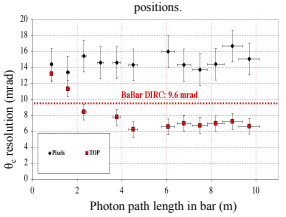
Fig2.

Fig.1 Shows one of our measurement of θc using pure geometry. Fig.2 shows our indirect measurement of θc. This requires a measurement of the wavelength of the photon which is then converted into an angle through the theoretical correlation function:

$$\theta_c^{TOP} = \cos^{-1}\left(\frac{1}{\beta n(\lambda)}\right)$$

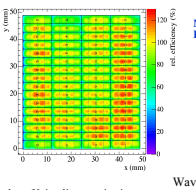
β=1 for our energetic electrons. The graph to the right shows the θc resolutions for different beam positions as a function of the average photon path length.

Cherenkov Angle Resolution for different positions.



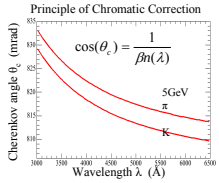
OUTLOOK

- Another beam test planned for 2006 to include new PMTs from Hamamatsu and Burle (256 channel and 1024 channel), for improved angular granularity.
- Better Calibration of our detectors is expected to improve the timing resolution.
- Accounting for chromatic effects using our TOP measurement will yield another set of θc measurements with resolutions better than the geometric measurements.



New Hamamatsu H-9500 Flat Panel Multianode PMT
- bialkali photocathode
- 12 stage metal channel dynode
- gain ~10⁶
- typical timing resolution ~220ps
- 256 pixels (16×16), 3 mm pitch
- custom readout board – read out as 4×16 channels

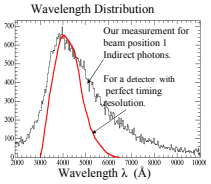
Principle of Chromatic Correction



LEFT: Lack of knowledge of λ implies a projection of the curves onto the θ axis thereby joining the two particles. With a measurement of λ, the two particles will be separated. In reality the curves are weighted (with a maximum at about 4000 Å) according to the production mechanism of Cherenkov photons as well as wavelength dependent efficiencies of the detectors.

RIGHT: This histogram shows our current measurement of the wavelength of Cherenkov photons for beam position 1 indirect photons. The red curve shows the expected distribution for an ideal detector.

Wavelength Distribution



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