Time-of-Flight (TOF) for GlueX

Institute for HEP (Protivino, Russia) and Indiana University

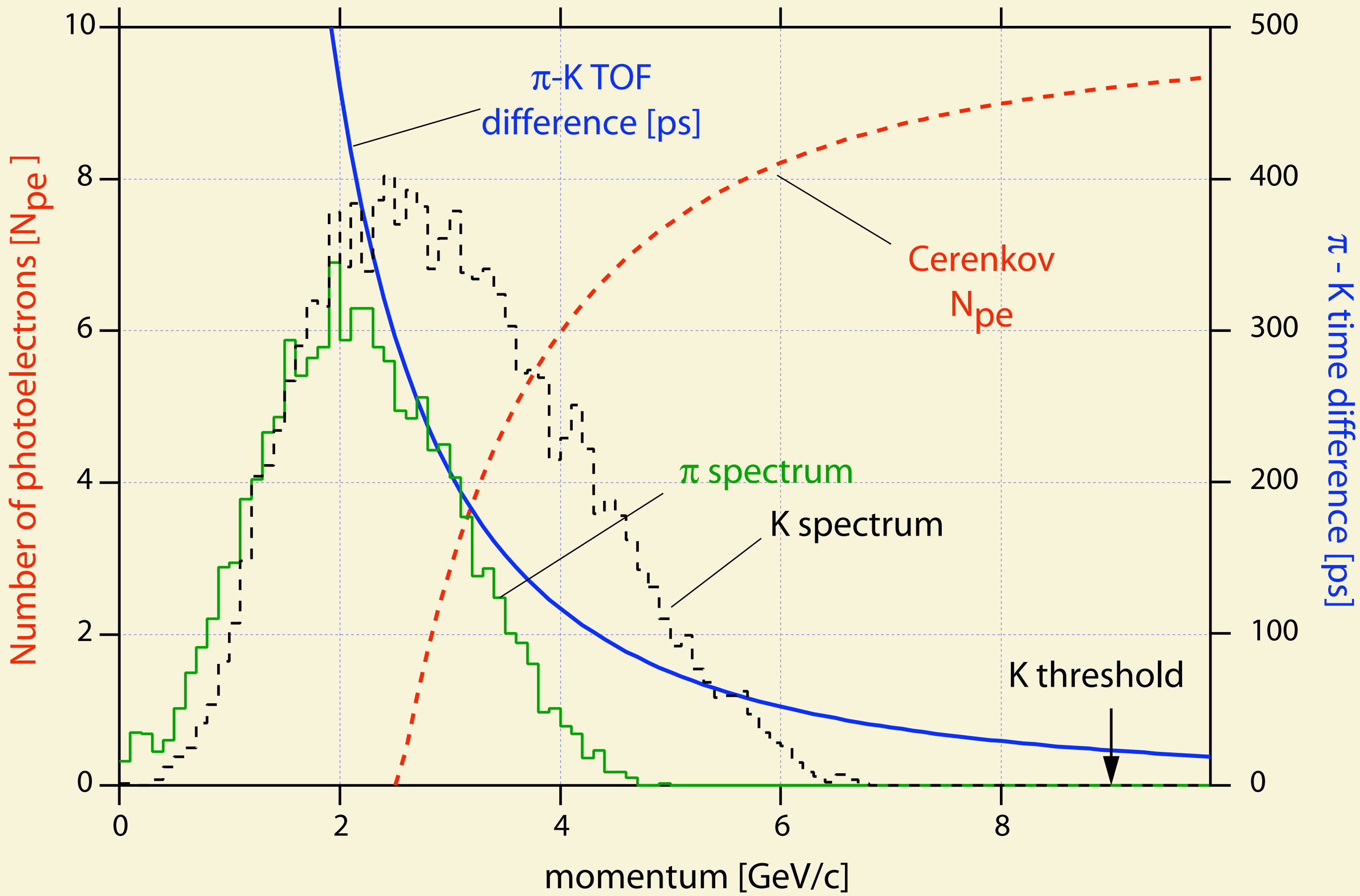
- Separate π from K up to 3 GeV/c - time resolution of 70 ps
- Two planes of scintillation counters: each 6 cm x 1.25 cm x 2 m
- Each bar read out with 2 XP2020 PM's: 140 channels total
- Each PM will be read out with:
  CFD (constant fraction discriminator) FADC and F1 TDC
- TOF will also produce: multiplicity count for level-1 trigger

R&D carried out using cosmic rays and hadron beam at IHEP
  Bars of various thickness tested
  Various PM's tested as well

An 8-element test will be carried out in April 2005

TOF requirements

$$\gamma p \rightarrow Xp \rightarrow K^* \bar{K}^* p \rightarrow K^+ \pi^- K^- \pi^+ p$$



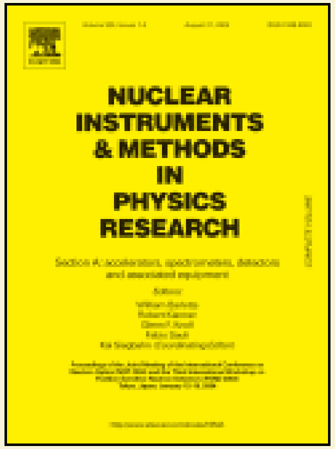
$$\frac{dN_{pe}}{dx} = N_0 \left(1 - \frac{1}{\beta^2 n^2}\right)$$

$$\Delta t \approx \frac{L}{2c} \frac{m_K^2 - m_\pi^2}{p^2} = \frac{1870}{p^2}\ ps$$

$C_4F_{10} : L = 80\ cm;\ n = 1.0015;\ N_0 = 90\ cm^{-1}$

$L = 5\ m$

$at\ 3\ GeV/c\ \Delta t = 210\ ps$ $\quad 95\%(3\sigma) \Rightarrow \sigma_\tau = 70\ ps$



A478 (2002)

Timing characteristics of scintillator bars

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A494 (2002)

Characteristics of the TOF counters for GlueX experiment

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A595 (2004)

Systematic studies of timing characteristics for 2 m long scintillation counters

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in press (2004)

Studies of magnetic shielding for phototubes☆

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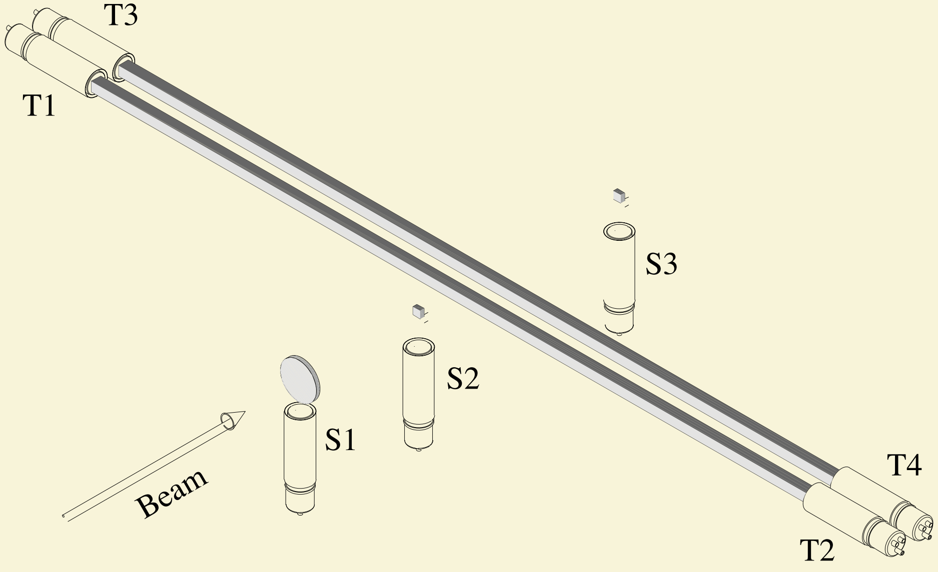
Cosmic Ray Testing

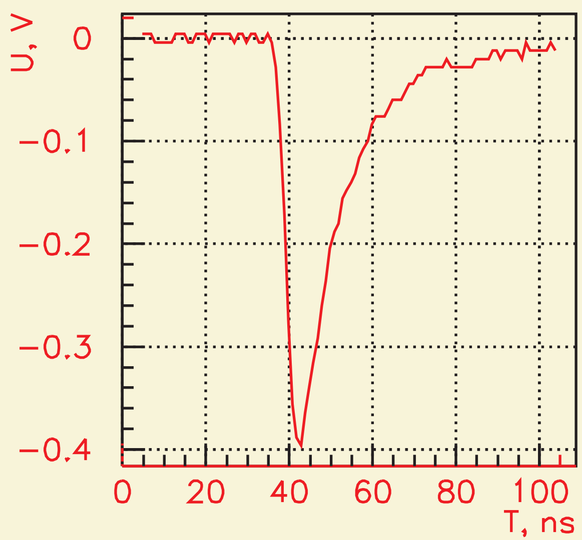
Black box for testing 2-m bars using cosmic rays

Helmholtz coils (200 G max) for shielding studies

Test Setup at IHEP

5 GeV/c hadron beam





Typical pulse from XP2020 from a 2-m bar after passing through 40-m delay cable

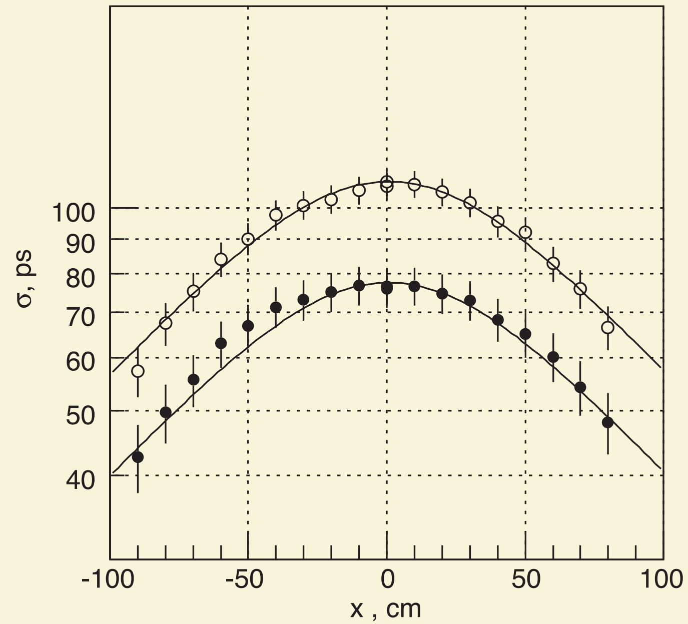


Fig. 6. The time resolution for one (◦) and two (•) 1.25 × 6.0 cm^2 bars viewed by XP2020 PMTs.

Issues - raised by Simon Taylor - answers by IU/IHEP

Q: Scintillator dimensions: what is the optimum thickness and transverse size of each paddle? I see you have gone with 1.25 cm thick paddles

A: Choice is based on occupancy studies (6 cm dim), match to the XP2020 photocathode and results in low enough mass presented to LGD and reasonable number of channels. Issue of radius of LGD wall - 2.5 m?

Q: Scintillator material: BC-404 or Eljen EJ-200? Bicron used to have other variants such as BC-408, which I seem to recall was used for the TOF in CLAS. Have you decided upon the material yet?

A: BC404 or LG-200 is a good choice - reasonable characteristics reasonable low cost and gain in resolution is only 10% improvement with more expensive scintillator. But there is concern about attenuation length of BC404.

	BC-404	BC-408	EJ-200
Light Output, %Anthracene	68	64	64
Rise Time, ns	0.7	0.9	0.9
Decay Time (ns)	1.8	2.1	2.1
Pulse Width, FWHM, ns	2.2	~2.5	~2.5
Wavelength of Max. Emission, nm	408	425	425
Light Attenuation Length, cm	140	210	
Bulk Light Attenuation Length, cm	160	380	~400

Q: Wrapping material. I believe there are alternatives to Tyvek and aluminum foil available.

A: It was shown in first NIM paper that wrapping is not important.

Q: Light guides? Coupling (grease or glue)?

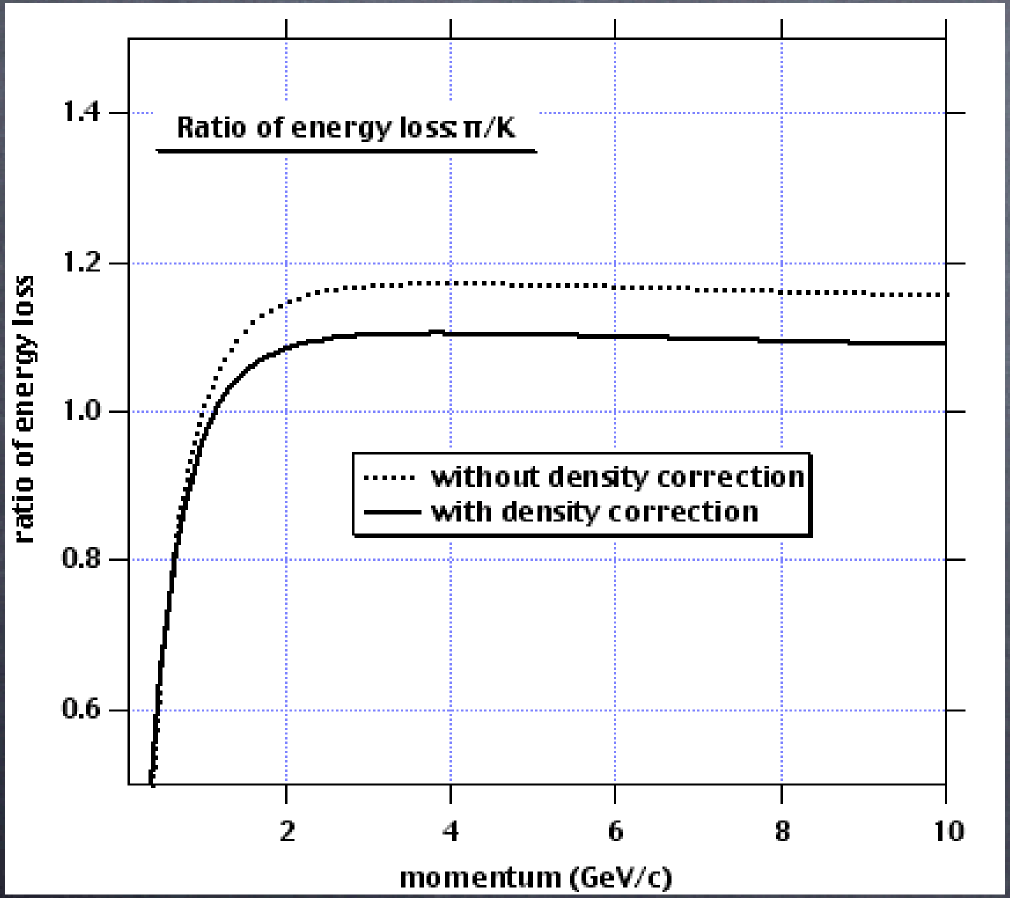
A: Tests show that time resolution with or without light guides is approximately the same - so light guide choice will be driven by magnetic shielding considerations. No decision yet on glue or grease.

Q: Magnetic shielding - how will 1-diameter extension be accommodated?

A: See above - light guide issue or notching scintillator.

Q: Discriminators: CFDs vs. leading edge (ADC measurement needed). CLAS uses the leading edge technique. The time-walk correction is not exactly the same as the one described in your NIM article. Do we gain anything by making dE/dx measurements with the TOF?

A: Use leading edge discriminator with ADC - maybe use dE/dx - information will be there.



Q: TDC's - F1?

A: Denisov mentioned the HPTDC with a least count of 25 ps - not clear to Paul if this will work with the pipeline architecture.

Q: Calibration and monitoring?

A: Denisov proposes a system similar to what they used in D0 for a 5000-counter system based on LED's.