PID summary

J. Va'vra, SLAC

Talks

- Jerry Va'vra:

  FBLOCK initial design.
- Douglas Roberts:

  Geant4 simulation of the FDIRC.
- J. Va'vra:

  FDIRC in CRT: update on the waveform electronics performance.
- Ch. Beigbeder:

  100ps-TDC-based proposal for barrel electronics.
- Flavio Dal Corso:

  Status of SiPM studies in Padova
- J. Va'vra:

  Forward TOF: update on photocathode choice and the waveform electronics performance.
- Dominique Breton:

  Progress on the characterization of analog memories for TOF picosecond measurement.
- Nicolas Arnaud:

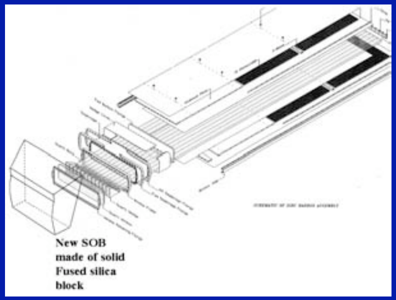
  Possible mechanical design for the TOF detector.

Barrel PID:
Development of FBLOCK

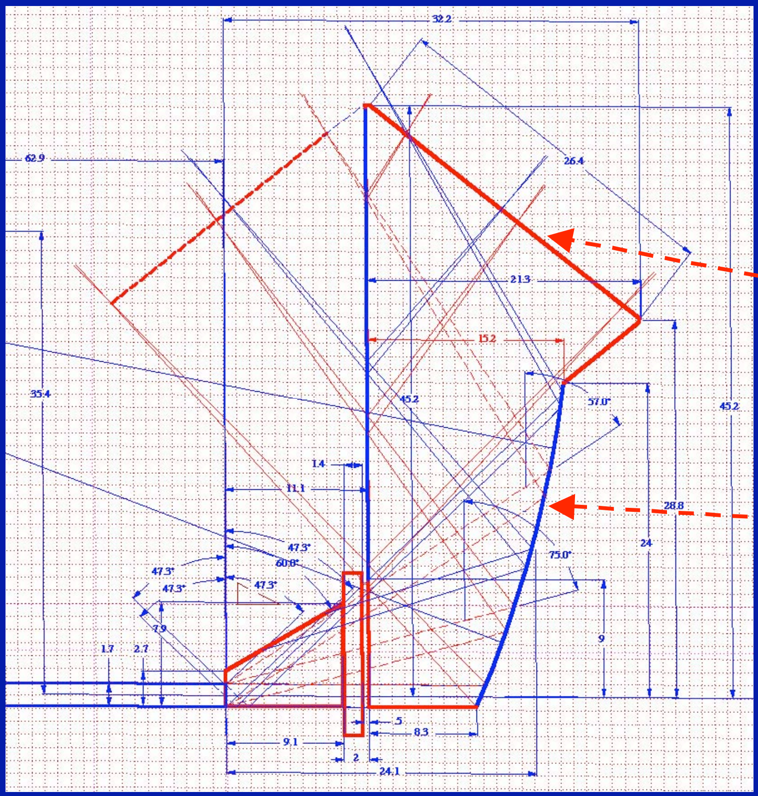
- Ray tracing to start the design
- Geant 4 MC simulation
- Drawings for biding
- Mechanical support
- Electronics development

FBLOCK design #3

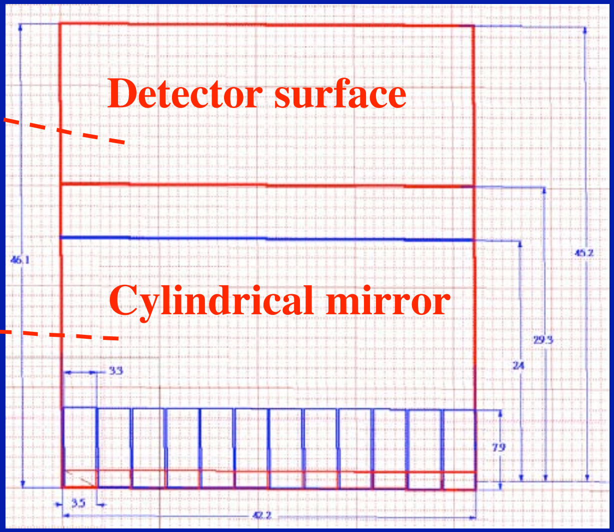
Va'vra, SLAC-PUB-13763



Side view:



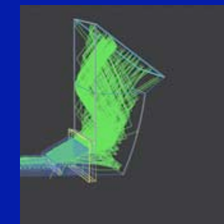
Back view:



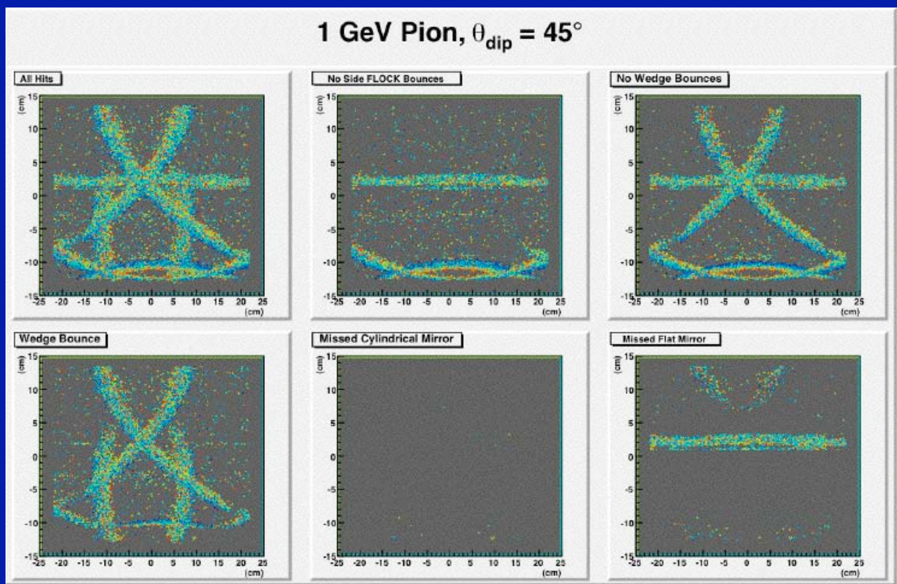
- Design FBLOCK that same way as the FDIRC prototype: using manual ray tracing.
- Verify it with a computer ray tracing, and later with a G4 MC.
- Focal plane is formed as a focus of two parallel rays coming off the bar without bouncing off the wedge included surfaces.
- Other things in the talk: worry about too masny reflections, mirror height, partial polish of sides, etc.

Rings & resolution

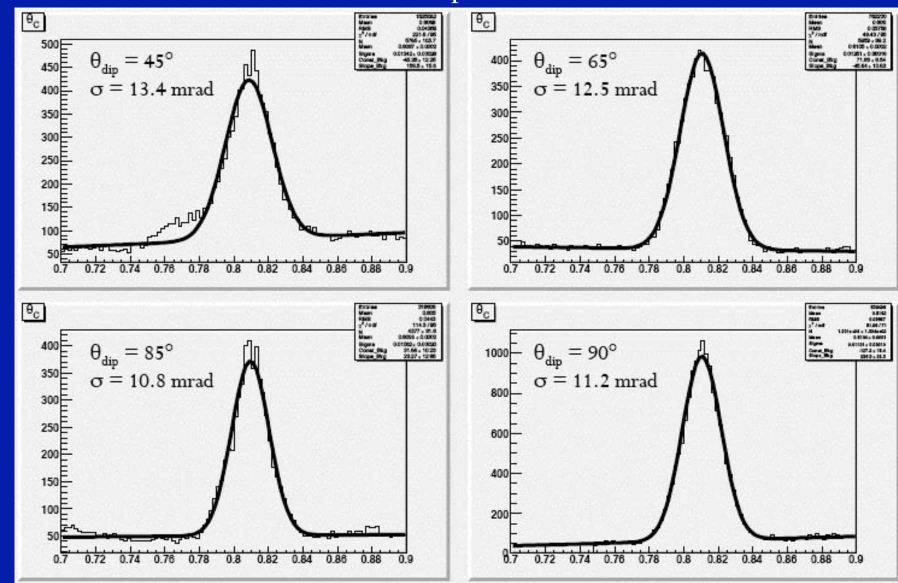
D. Roberts



Ring image is complex due to many reflections



Resolution = f(θ_{dip}) for 3mm pixels

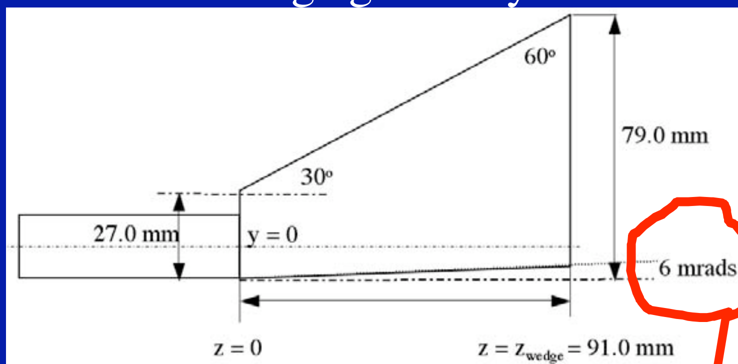


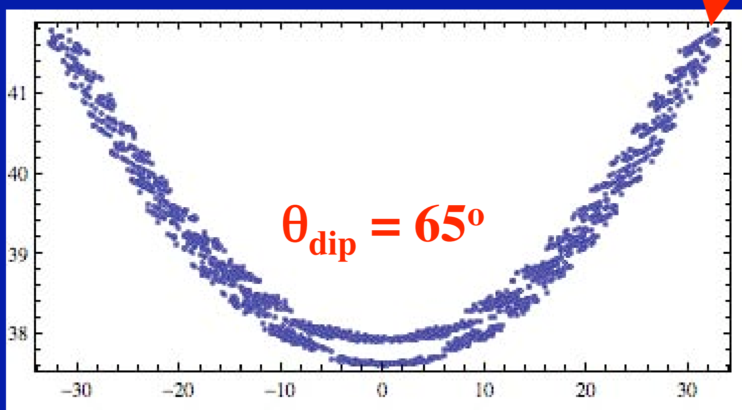
- **Wedge and FBLOCK side reflections complicate image.**
- **Wedge botom inclided surface is a likely culprit to broaden the resolution.**
- **A resolution of $\sigma_{\theta c}$ = 10.5 -13.5 mrads is much worse than what was obtained with the FDIRC prototype with 3 mm pixels ($\sigma_{\theta c}$~ 8 mrads) or the BaBar DIRC ($\sigma_{\theta c}$~ 9.6 mrads). Why ? Wedge may work with only pin hole focusing.**
- **Dough will check it next week by removing the botom wedge reflections.**

Wedge complicates image - can we correct it ?

Va'vra, Perugia PID session, New SOB design, page 13, http://agenda.infn.it/conferenceDisplay.py?confId=1161

Wedge geometry





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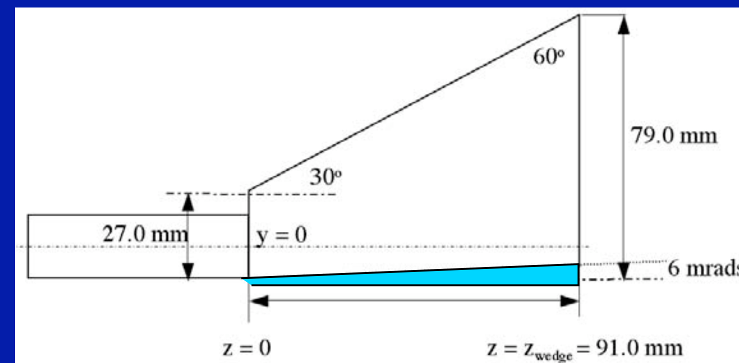
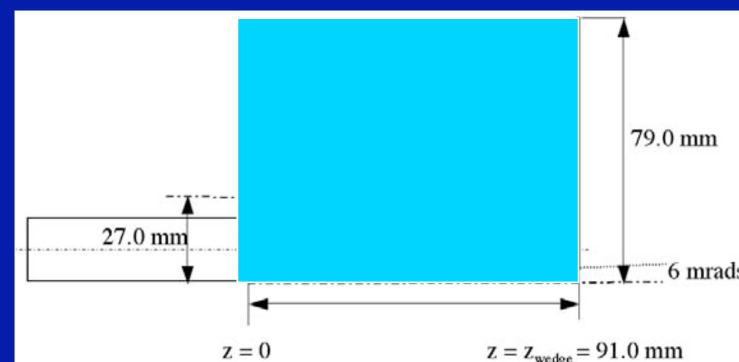
Bar box modification ?

a)

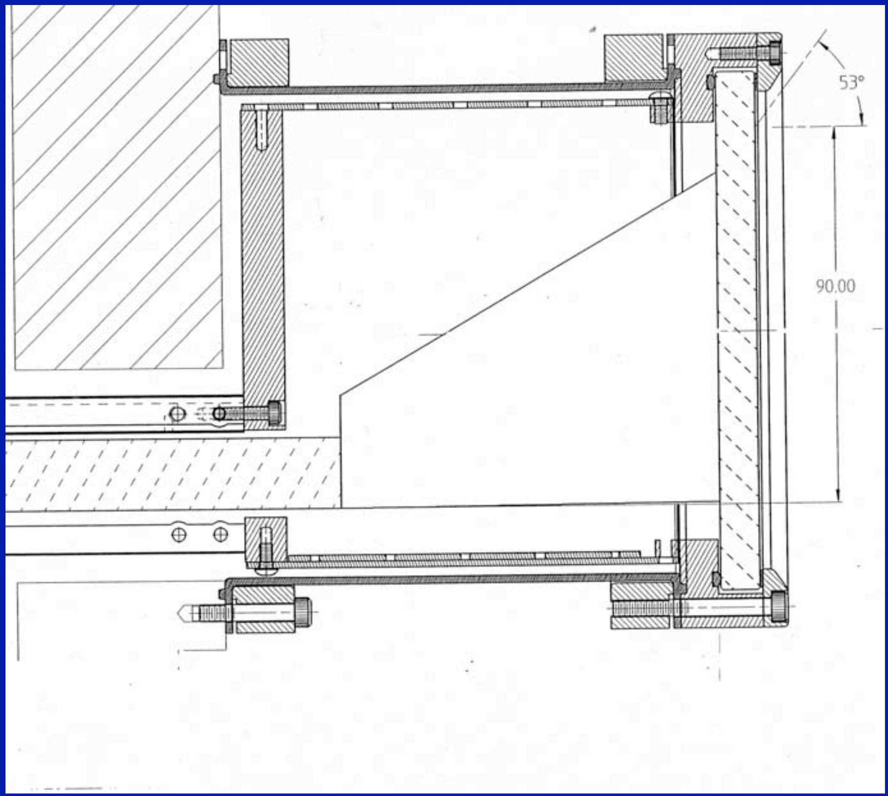


b)



- **Wedge botom reflection creates a double wission with FDIRC optics.**
- **Wedge was designed for a pin hole optics and will not work well with focusing, I am afraid.**
- **Can we glue corrective thin wedge on the bottom surface ?**
- **Or, should we remove wedge entirely and replace it with a simple blocks, as we have in the FDIRC prototype ?**
- **Modification like this is highly nontrivial.**

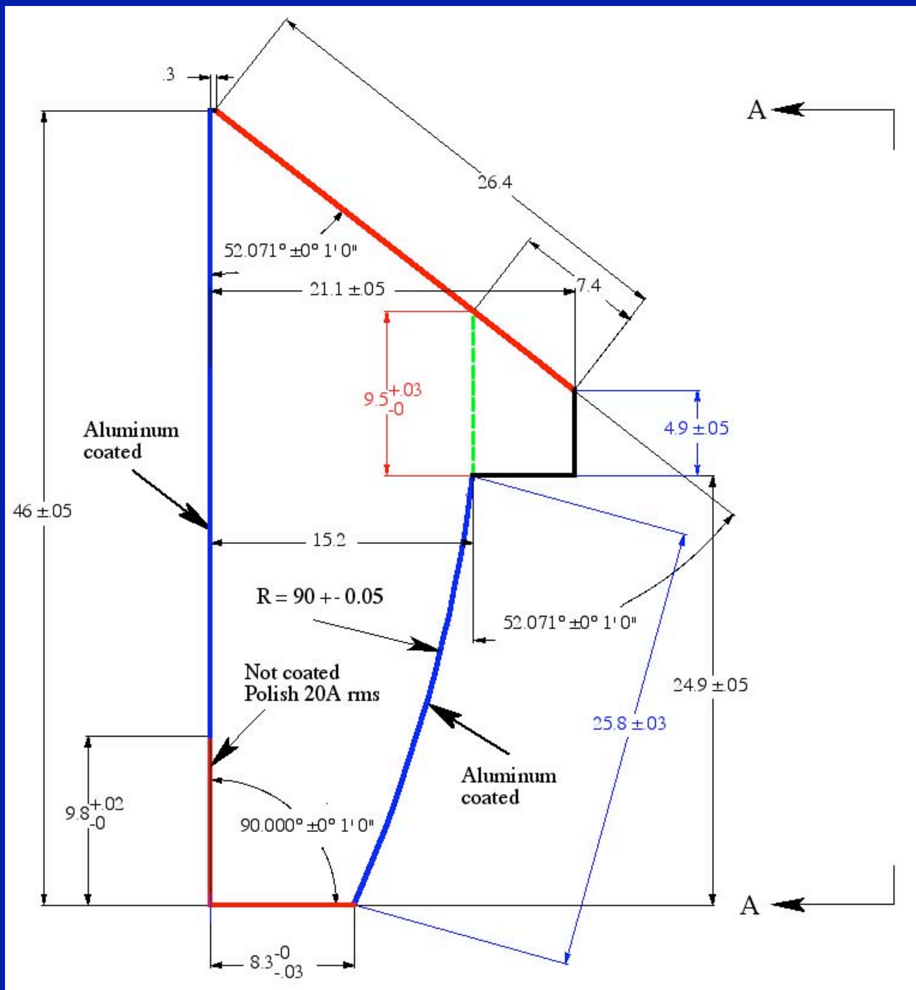
How to do it ?



- To install the correcting wedge, one has to open a portion of the bar box.
- Not trivial. But Matt McCulloch is still talking to me, after I mentioned it…

Going for preliminary quotes to get a feel for the cost and a difficulty to make it

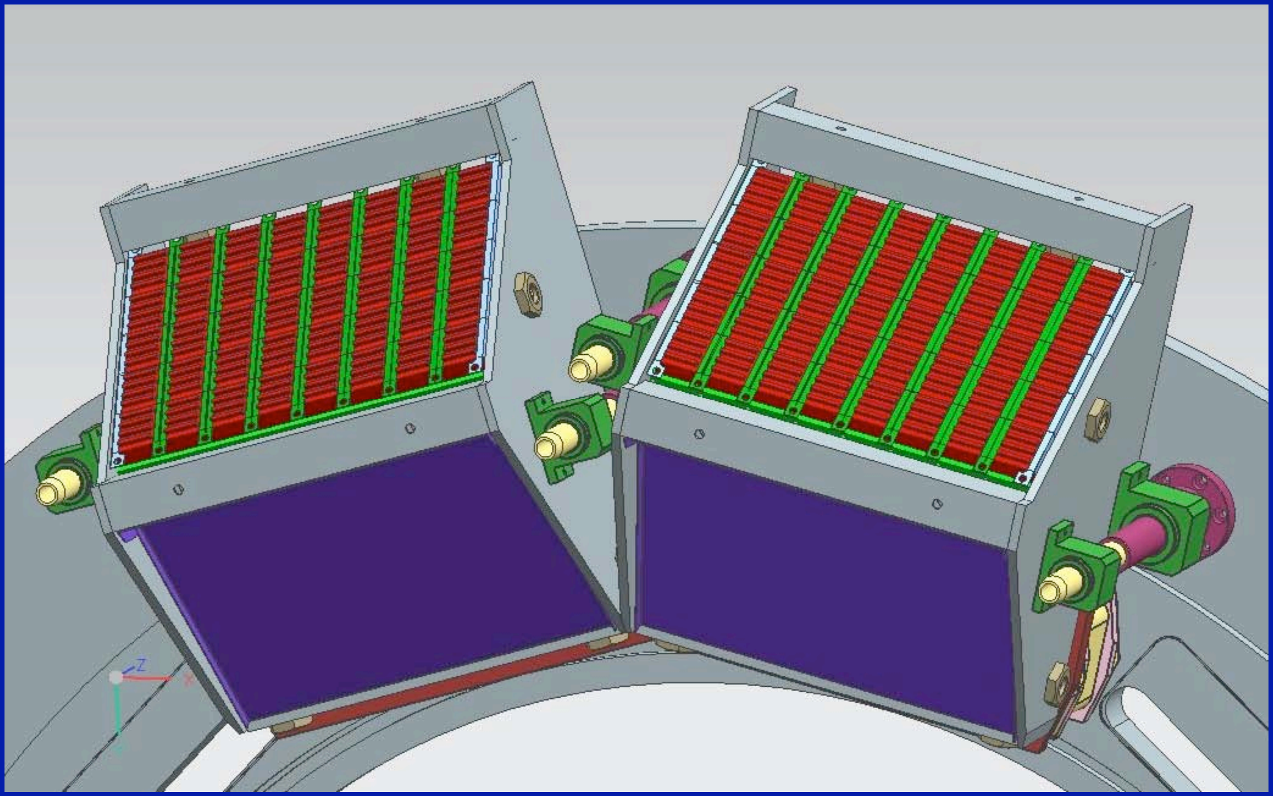
J. Va'vra



- **Contacted seven companies, two rejected the bid, five are considering it presently.**
- **So far, all companies want to make it out of two parts. The green line suggests the split. This is also "convenient" from the gluing point of view.**

3D drawings of the mechanical support

Massimo Benettoni

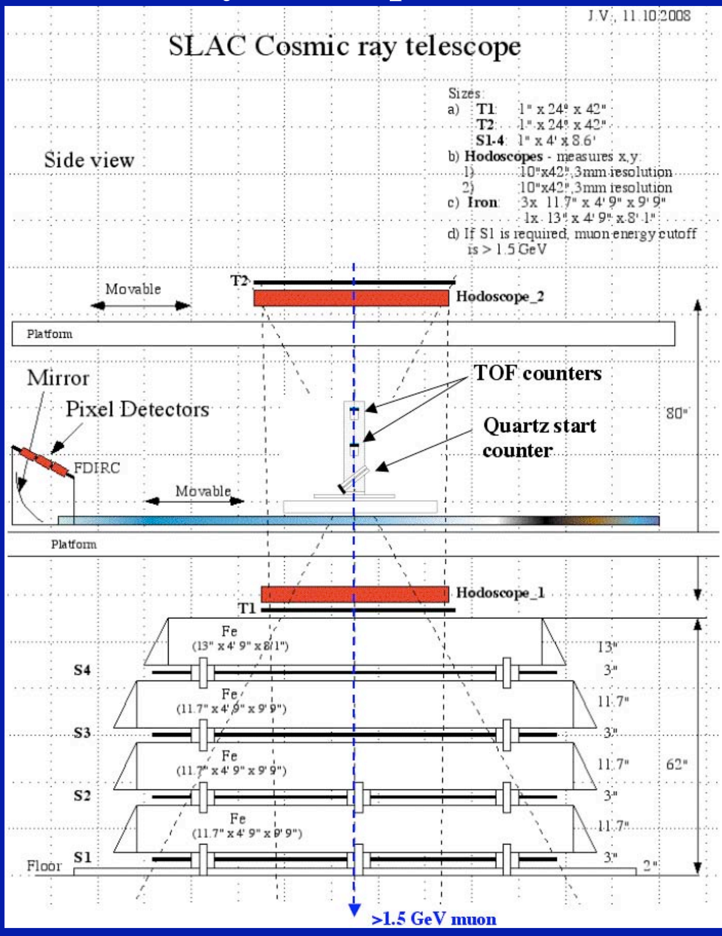


- **Initial concept of the mechanical support.**
- **Bottom, face and side of the FBLOCK should be aligned with bars to ~ 0.25 mrad. The support MUST be reproducible around the azimuth.**

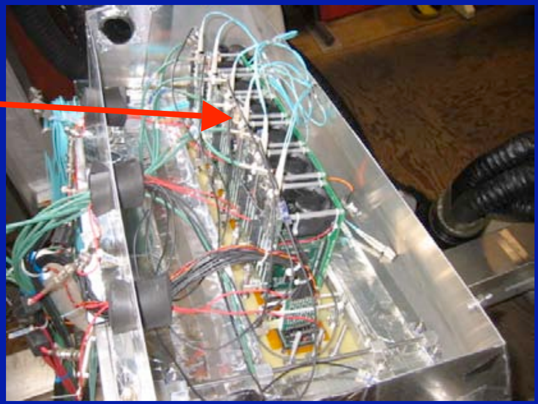
Test of BLAB2 electronics with FDIRC prototype in CRT

J. Va'vra

Cosmic Ray Telescope (CRT):

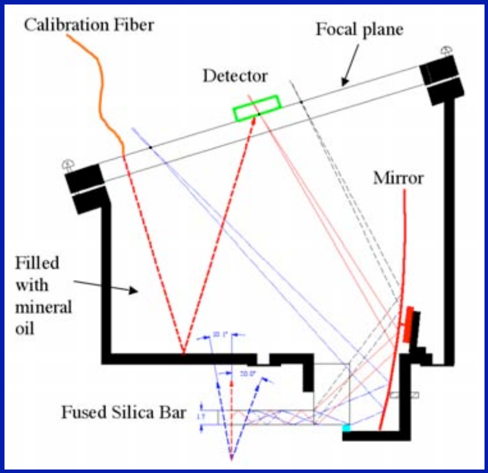


BLAB2 electronics



MaPMT
64 pixels
6mm x 6mm
400 ps/bin

FDIRC prototype:

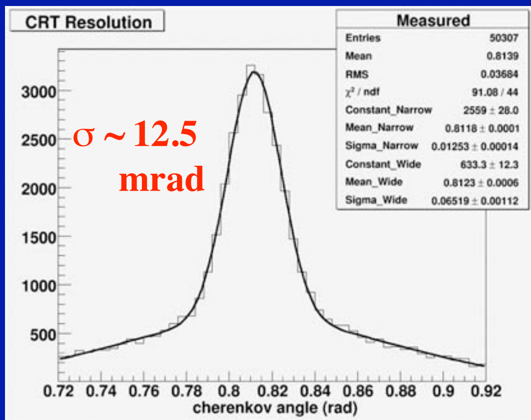


- **Trigger rate of muons with E_{muon} > 1.6 GeV & small spot on the bar is ~ 6k/day.**
- **BLAB2 is a 2.5 GSa/s waveform digitizing electronics measureing a time and pulse height of each photon. The test is running all the time. We have a huge amount of data.**

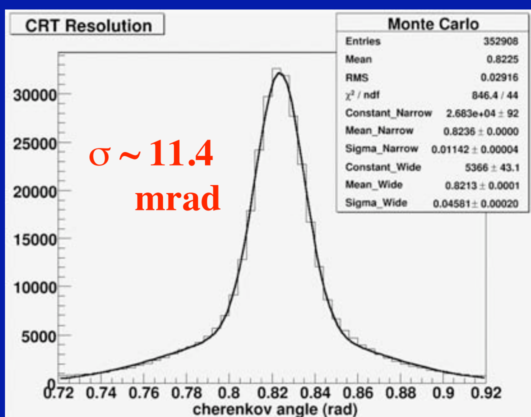
Cherenkov angle resolution with BLAB2 chip

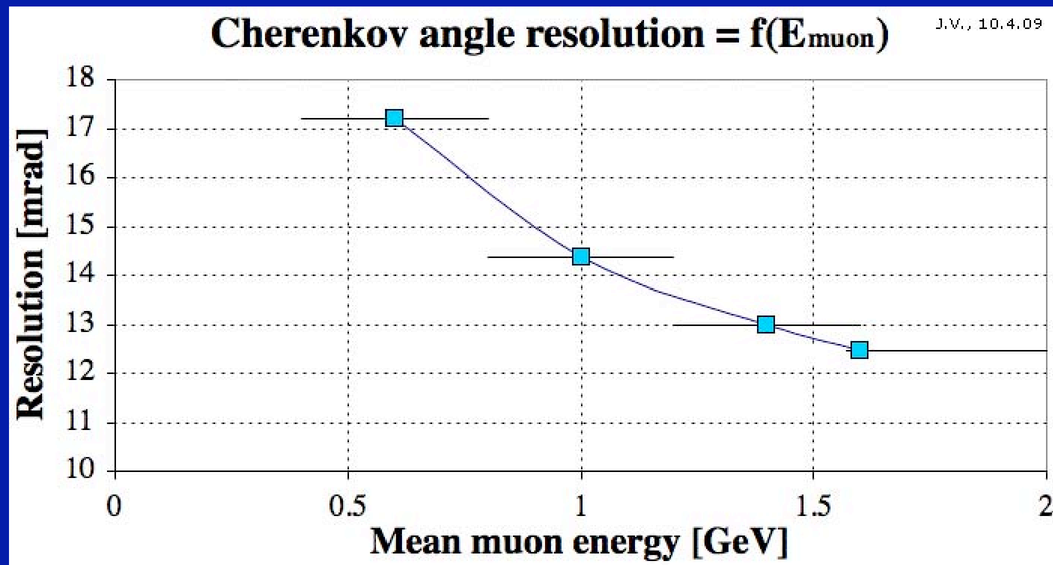
J.Va'vra

Data:



G4 MC:



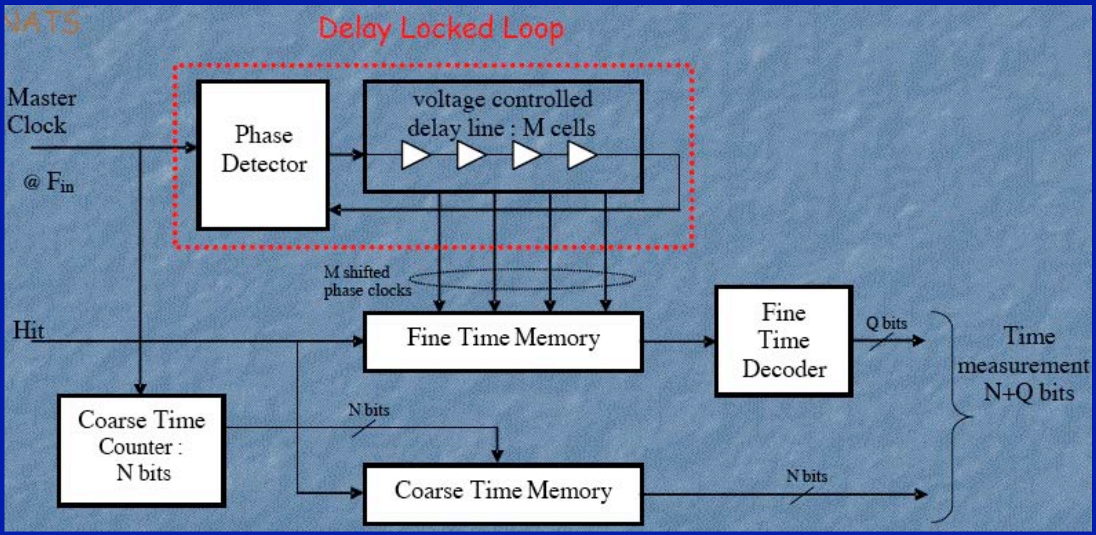


- **In the 10 GeV e- test beam we measured ~ 10 mrads under similar condition.**
- **θ_c resolution deterioration understood - the iron stack is not thick enough.**
- **Waveform digitizing electronics using the BLAB2 chip, designed by Gary Varner, works. However timing is still a problem as the resolution is only ~1 ns. A firmware fix is ready and will be installed in December. At that point will be ready for 3D chromatic corrections.**

Orsay TDC/ADC electronics

D. Breton, Ch. Beigbeder

Principle of time stamper:



- **Circuit isd based on Super Nemo "SNATS" circuit.**
- **Normal TDC measures time between START & STOP.**
- **A principle of time stamper: record absolute hit time.**
- **Measured time to ~70 ps resolution (for Barrel FDIRC we require 100ps).**
- **Will use this circuit on the FDIRC prototype in CRT in future.**
- **Will need an ADC to correct for pulse height variation. A CFD circuit is difficult to implement on a chip.**

FDIRC expected rates at Super-B

Va'vra, see similar argument in my talk at SuperB workshop in Elba, 2008

- **BaBar empirical scaling law for DIRC PMT rate:**

  Sector 3: PMT rate/kHz ~ 5.3 I_{LER} / A + 19.2 I_{HER} / A + 22.2 LUMI / 10^{33}

- **We know that Belle does not have a LUMI term.**

- **We will assume that Super-B LUMI term is 10% of the BaBar LUMI term.**

- **Simple method to estimate the pixel rate for the option 3 (H8500 MaPMT):**

  a. BaBar DIRC 1" dia. PMT rate at L ~ 10^{34}: Measured rate ~200 kHz/PMT
  b. Scale pixel sizes using a total pixel count => Factor ~ 30000/10000 ~3
  c. FDIRC FBLOCK is smaller for at Super-B => Factor ~ 6000 liters / (18*12 liters) ~25

=> Expected pixel rate ~ 200 kHz * 100 / (10 * 25 * 3) ~ 25 kHz / pixel

BaBar PMT; Scaling to 10^{36}; LUMI term; SOB volume; Pixel ratio

- This seems to be a very comfortable situation, provided that (a) LUMI term is not much bigger, and (b) we keep FBLOCK much smaller than BaBar SOB.

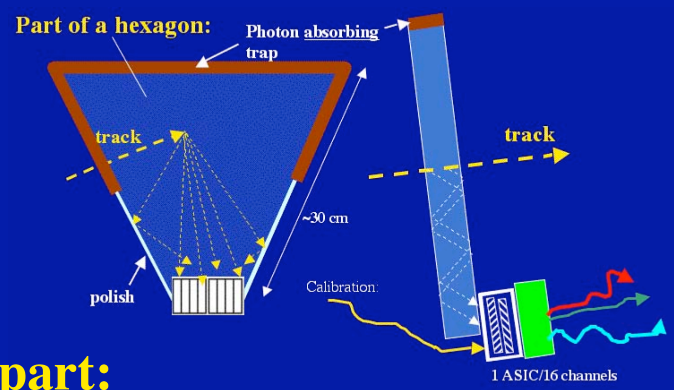
Forward PID:
TOF or ArRICH

- TOF:
  - Concept selection
  - Mechanical support ideas
  - Electronics ideas/development
- ArRICH:
  - Latest news from Novosibirsk

Geometry selection

J. Va'vra

DIRC-like TOF



Bad part:

a) **Must be sensitive to single photoelectrons**

b) Detector has to work at **high gain** (>5x10^5).

c) Detector operates at higher rate. Therefore, the rate and aging problems are a concern. **May segment more if necessary.**

e) Chromatic effects could be important for large photon paths.

f) More complicated data analysis.

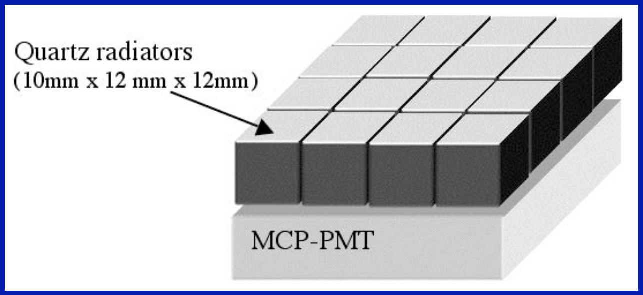
g) Quartz radiator needs a complicated & perfect **photon trap**. Without a photon trap it may act as a optical resonator !! Very crucial to success !!

Good part:

a) **VERY small number of photo-detectors (~ 50 detectors !!)**

b) Thin & uniform radiator in front of the calorimeter

Pixilated TOF



Bad part:

a) **Large number of photo-detector needed.**

b) **Too much mass in front of the calorimeter.**

c) Low gain operation => worse S/N ratio. Offset by thick radiator.

d) Expemsive.

Good part:

a) **Low gain operation (~2x10^4) - small rate of aging.**

b) **Detector "does not" see single photoelectron background.** The detector is sensitive only to tracks. Therefore the detector operates at much lower rates. Therefore, the rate and aging problems are easier to solve.

c) **Simple data analysis.**

d) The chromatic effects are not important at all.

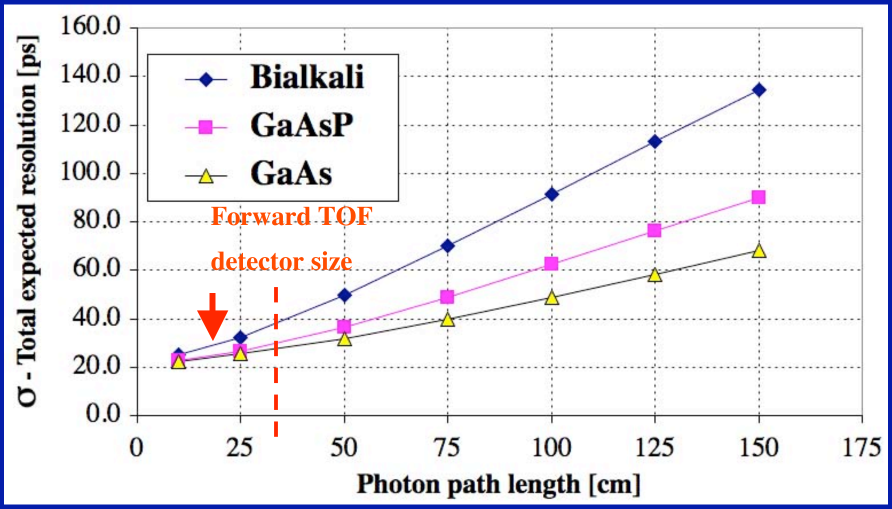
Large "DIRC-like" TOF detector

J. Va'vra

$$\sigma_{Total} \sim \sqrt{[\sigma^2_{Electronics} + (\sigma_{Chromatic} / \sqrt{(\varepsilon_{Geometrical\_loss} * N_{pe})})^2 + (\sigma_{TTS} / \sqrt{\varepsilon * N_{pe}})^2 + \sigma^2_{Track} + \sigma^2_{detector\ coupling\ to\ bar} + \sigma^2_{to}]}$$

$\sigma_{Electronics}$ - electronics contribution ~ 10 ps
$\sigma_{Chromatic}$ - chromatic term = f (photon path length) ~ 5-45 ps for path lengths 10-50 cm
σ_{TTS} - transit time spread ~ 35 ps
σ_{Track} - timing error due to track length L_{path} (poor tracking in the forward direction) ~ 5-10 ps
$\sigma_{detector\ coupling\ to\ bar}$ - timing error due to detector coupling to the bar ~ 10 ps
$\sigma_{t\,o}$ - start time dominated by the SuperB crossing bunch length ~ 15 ps
$\varepsilon_{Geometrical\_loss}$ - loss due to a geometrucal acceptance ("reject" bad photons) ~ 10%

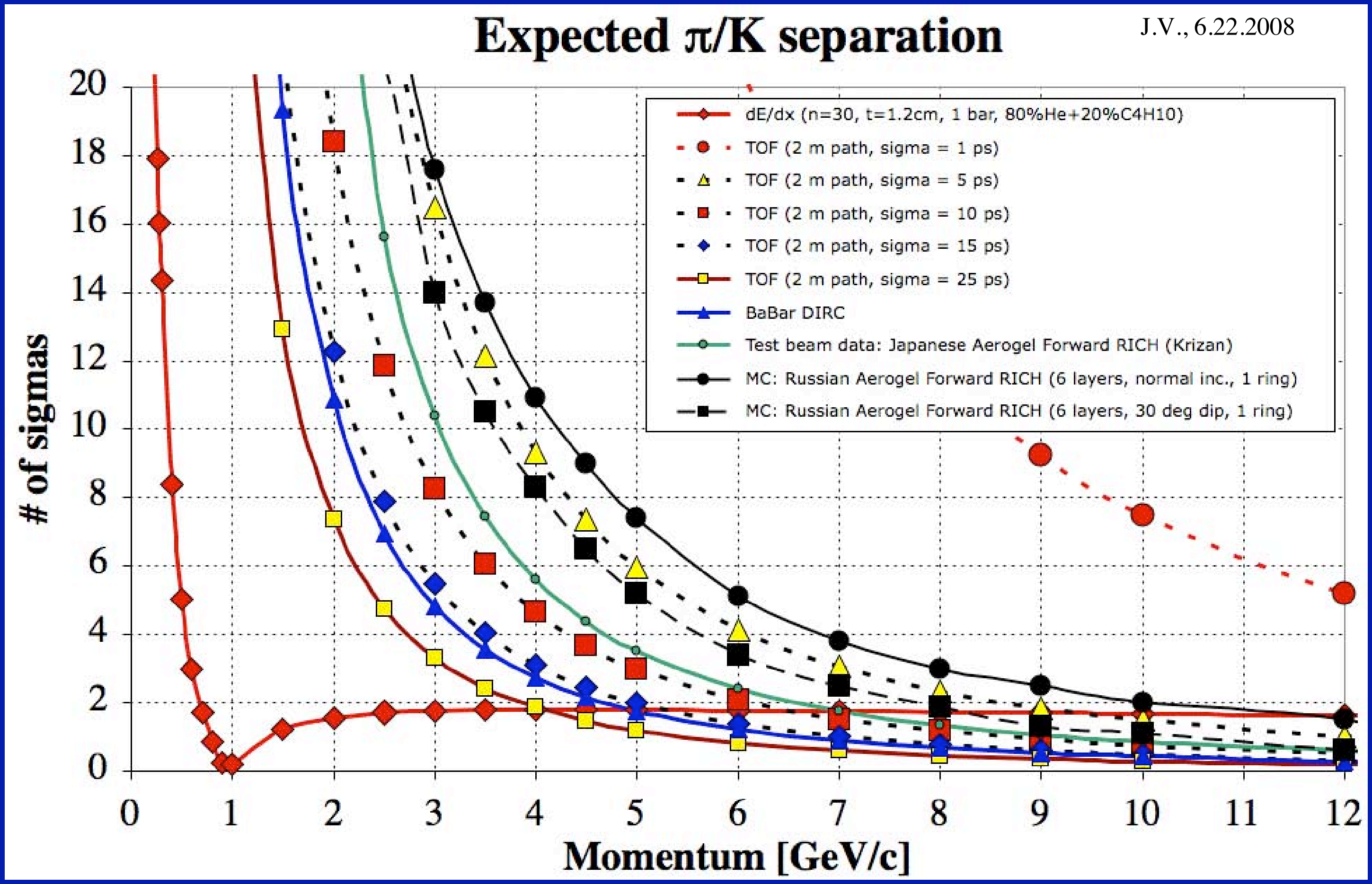
Expected final resolution:



- **Bialkali photocathode will have σ_{ave}~ 30ps, with GaAsP ~ 25ps.**
- **For such a small size counter it is not worthwile to go for GaAsP photocathode. Bialkali is fine.**

Comparison of PID methods in SuperB geometry

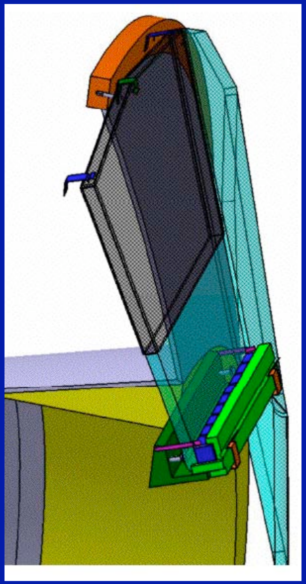
J. V., dE_dx = f(beta_gamma) study.xls

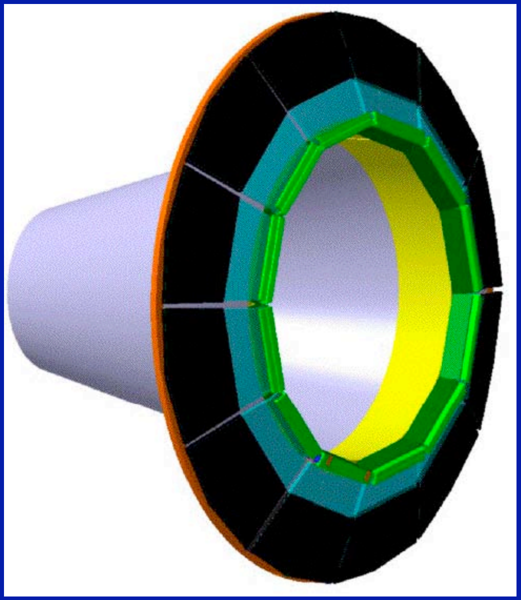


- **If a DIRC-like TOF would achieve σ ~ 30ps, it will be useful up to ~ 2.0 GeV/c.**

Mechanical support concept of DIRC-like TOF

N. Arnaud





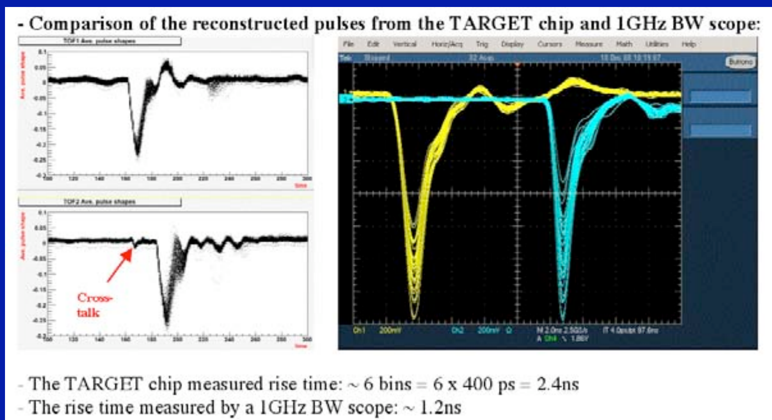
- Very clean design.
- Drawings made by LAL mechanical engineers S. Wallon and F. Bogart
- Quartz plates should be inclined to produce as many forward photons as possible.

Is this a useful timing method ?

J. Va'vra

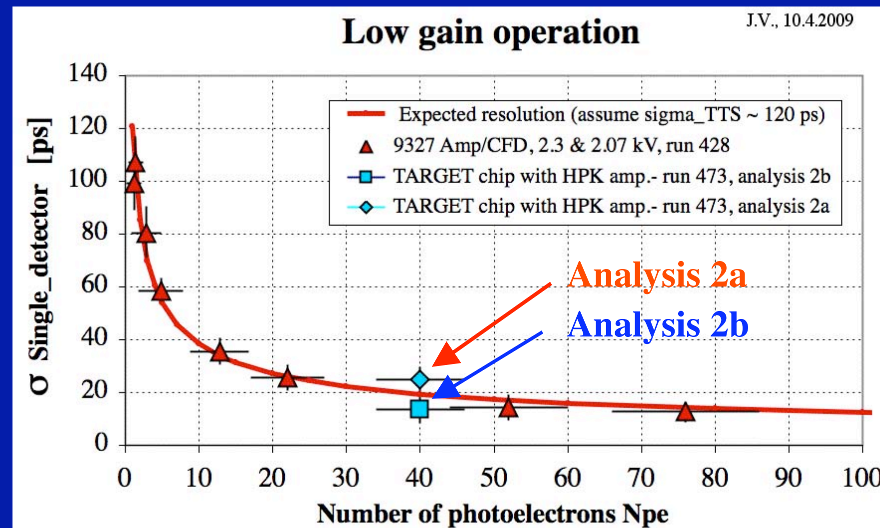
I call the new timing method as:

"Mismatched BW timing method".



Leading edge of the waveform from the TARGET chip saturates.

Comparison with the same laser test with the Ortec 1GHz BW CFD/TAC/ADC electronics:



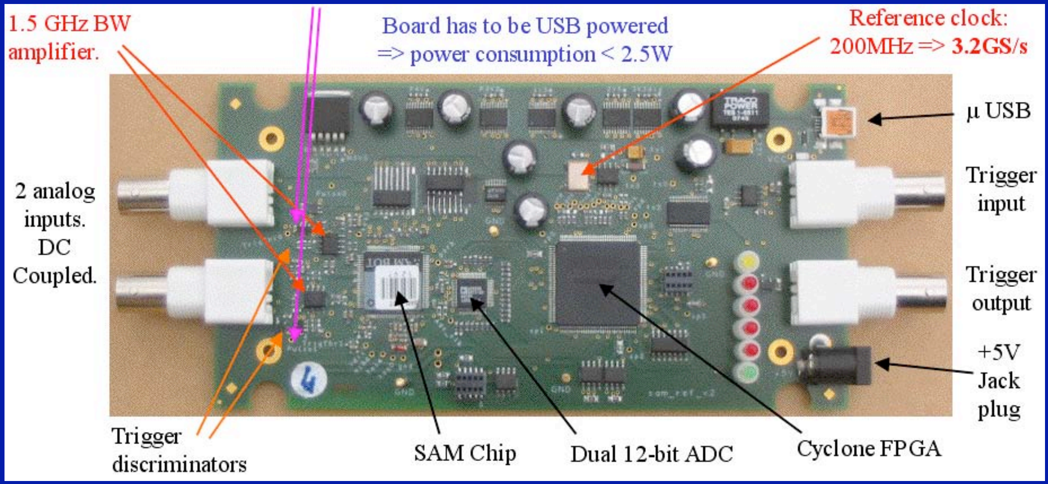
Note: σ_{TTS} ~ 120 ps because of the low gain

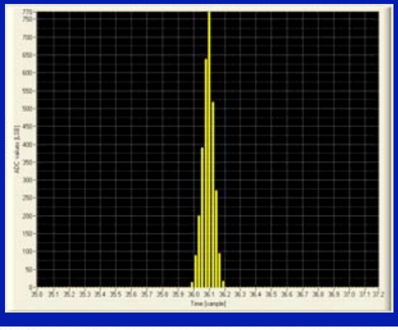
- **TARGET chip was given to me by Gary Varner to learn how it works…**
- **Low gain operation to reduce the aging rate.**
- **MCP-PMTs with 10μm holes** used during the Fermilab beam test (obtained σ ~ 14ps).
- **A discovery: A combination of fast detector and fast 1.6 GHz BW amplifier & 0.25GHz BW front end of TARGET chip gives equal or better result than a 1 GHz BW Ortec CFD/TAC/ADC electronics !?!?!**
- **Is this trick going to be useful in future timing methods ? One should try it on single pe's.**

"USB waveform catcher"

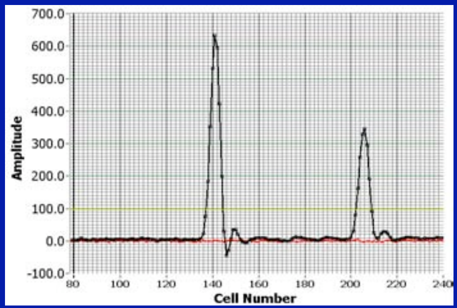
D. Breton

~0.5GHz BW, 3.2 GSa/s



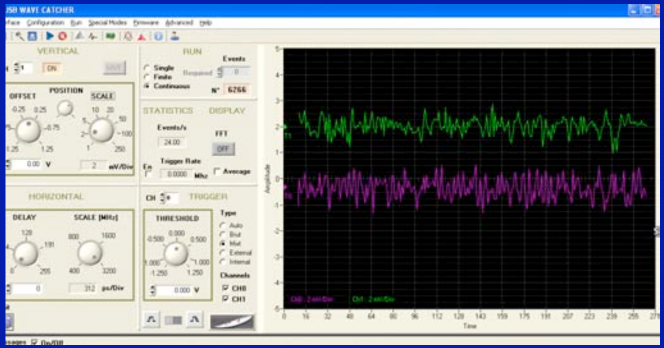


Measured resolution:
$\sigma_{electronics}$~ 10 ps rms



2ns FWHM consecutive pulses, separated by 22ns

Jihane Maalmi running a wave catcher software

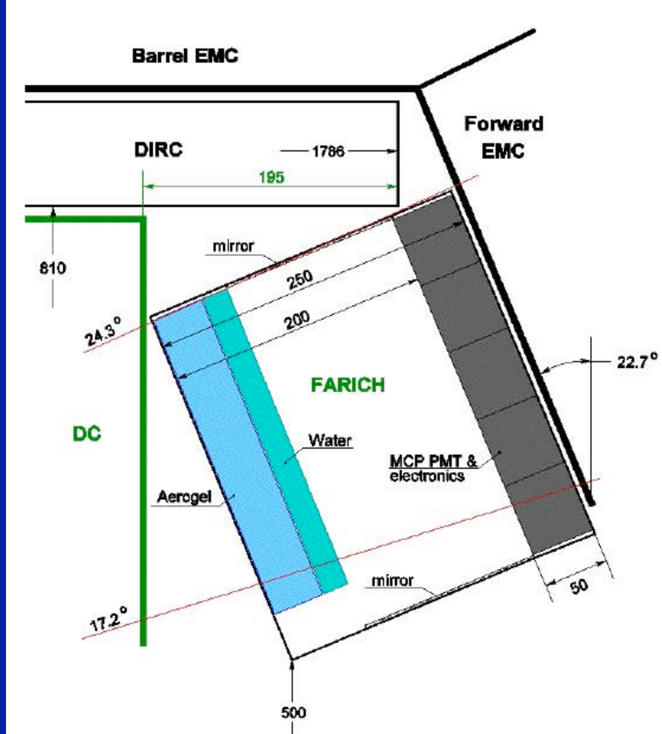


..and instaling it on my MAC

- **We spent some time in my lab and took data with a laser and the TOF counter setup. Data ready for analysis. The Wave Catcher software also now runs on my MAC.**

Aerogel RICH

E. Kravchenko



- Expansion gap 200 mm
- Burle MCP PMT with 3.2x3.2 mm pixels (16x16 matrix), photoelectron collection efficiency 70%, geometrical factor 85%
- 3-layer focusing aerogel, n_{max}=1.07, total thickness 30 mm
- Number of PMTs ~ 450
- Number of channels ~ 115000
- Amount of material, (X_0) = 3.5%(aerogel)+ 2.5%(water)+ 14%(MCP PMT)+8% (support, electronics, cables) ~ 28%

- **Clearly ArRICH is a better PID device than TOF.**
- **However, the complexity is non-trivial. This device is more complex than the Barrel FDIRC, I would say.**
- **A lot of mass in front of calorimeter.**
- **Beam test is being prepared.**