FDIRC - towards TDR

J. Va'vra, SLAC

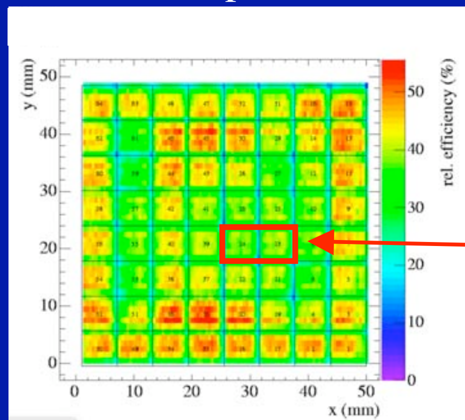
Status of FDIRC

- Can we still tweak the FBLOCK optics ?
- Photodetector choice.
- Detector matrix on the FDIRC camera
- Magnetic shielding.
- Specifications and drawings for final bidding of quartz optics.
- Remote viewing of mechanical drawings.
- Start thinking about TDR.

Photodetector choice

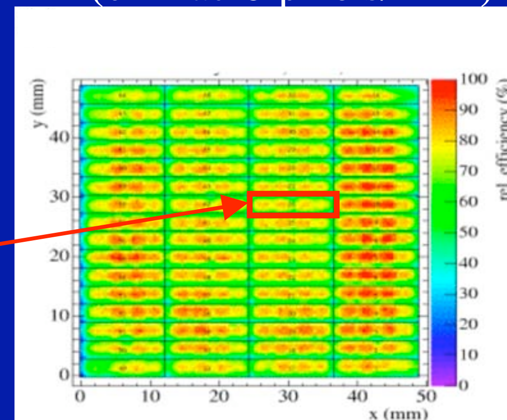
H-8500

(32 macro-pixels/PMT)



H-9500

(64 macro-pixels/PMT)



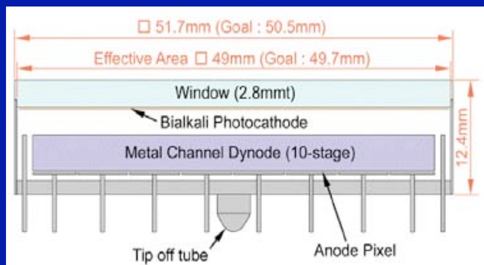
Macro pixels

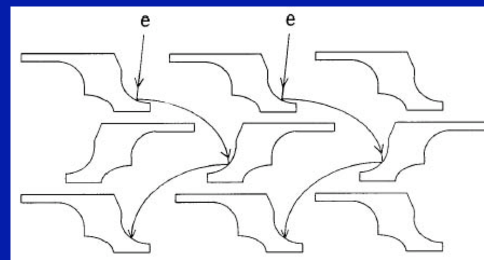
- **<u>Our choice #1:</u>**
  - No problem with delivery of 700 pcs
  - Lower cost of tube and electronics (~$3k/tube for a quantity of 700 pcs)
  - Available with enhanced QE of 24%
  - Medical people use H-8500 for imaging and prefer it over H-9500 !!
  - Total system would have 18,432 pixels.
  - **FDIRC detector would have a similar performance as BaBar DIRC**

- **<u>Our "less likely" choice:</u>**
  - HPK: We are sorry, but we cannot send a quotation for the H9500 at a large quantity at the moment because the production yield of the tube is bad. The maximum quantity we can offer is 200 pcs and we need at least one year to deliver these 200 tubes. Cost is higher than H-8500 as the yield is lower.
  - Not available with the enhanced QE !
  - Total system would have 36,864 pixels.
  - **FDIRC would gain ~0.5-1 mrads in resolution, if we use this tube.**

Hamamatsu H-8500 & H9500 Flat panel MaPMTs

Based on Hamamatsu data





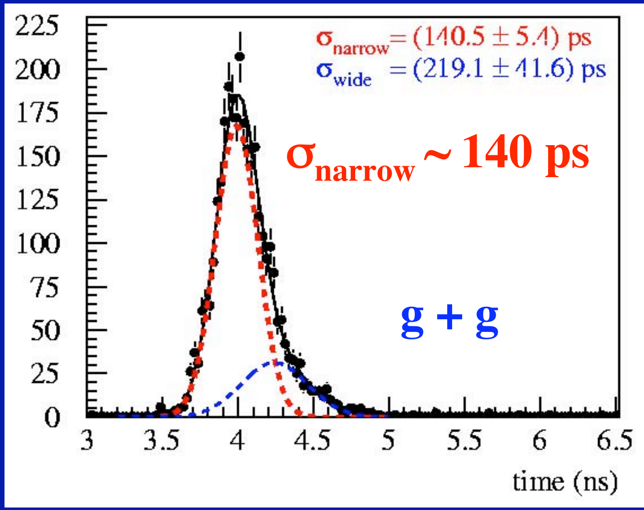
Parameter	Value
Photocathode: Bi-alkali QE at 420nm	20 % (-> 24%) *
Geometrical collection efficiency CE of the 1-st dynode	75% (-> 80%) *
Geometrical packing efficiency (dead space around boundary)	89%
PDE = Total fraction of "in time" photoelectrons detected	~ 13% (->16-17%) *
Photocathode uniformity	1:1.5 to 1:2.5
Number of dynodes	12
Total average gain @ -1kV	$\sim 10^6$
Fraction of photoelectrons arriving "in time"	~95%
σ_{TTS} - single electron transit time spread	~ 140-150 ps
Matrix of pixels (H8500 & H9500)	8 x 8 & 16 x 16
Number of pixels (H8500 & H9500)	64 & 256
Pixel size (H8500 & H9500)	5.8 x 5.8 & 2.9 x 2.9 [mm^2]

* - now available with a Super QE (24%) and better collection efficiency (80%)

Single electron timing response

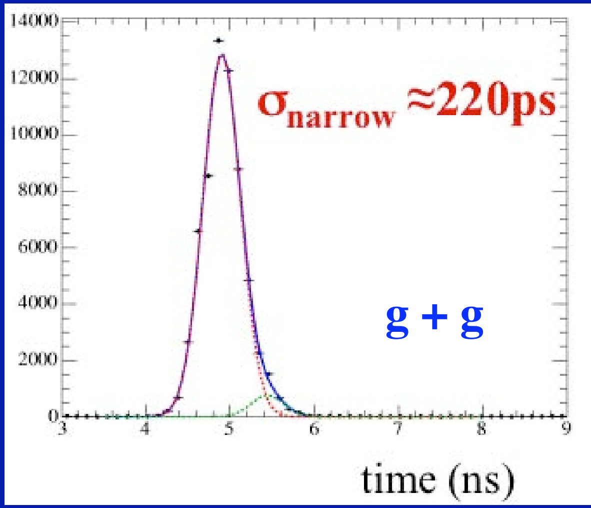
J. Va’vra et al., SLAC-PUB-12236, 2007

H-8500 TTS distribution:



(Measured with a 635 nm PiLas laser)

H-9500 TTS distribution:

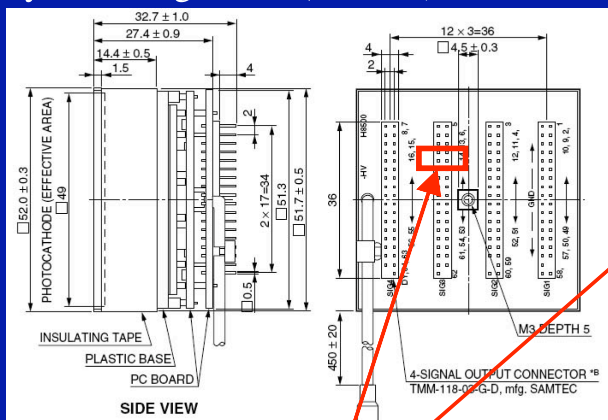


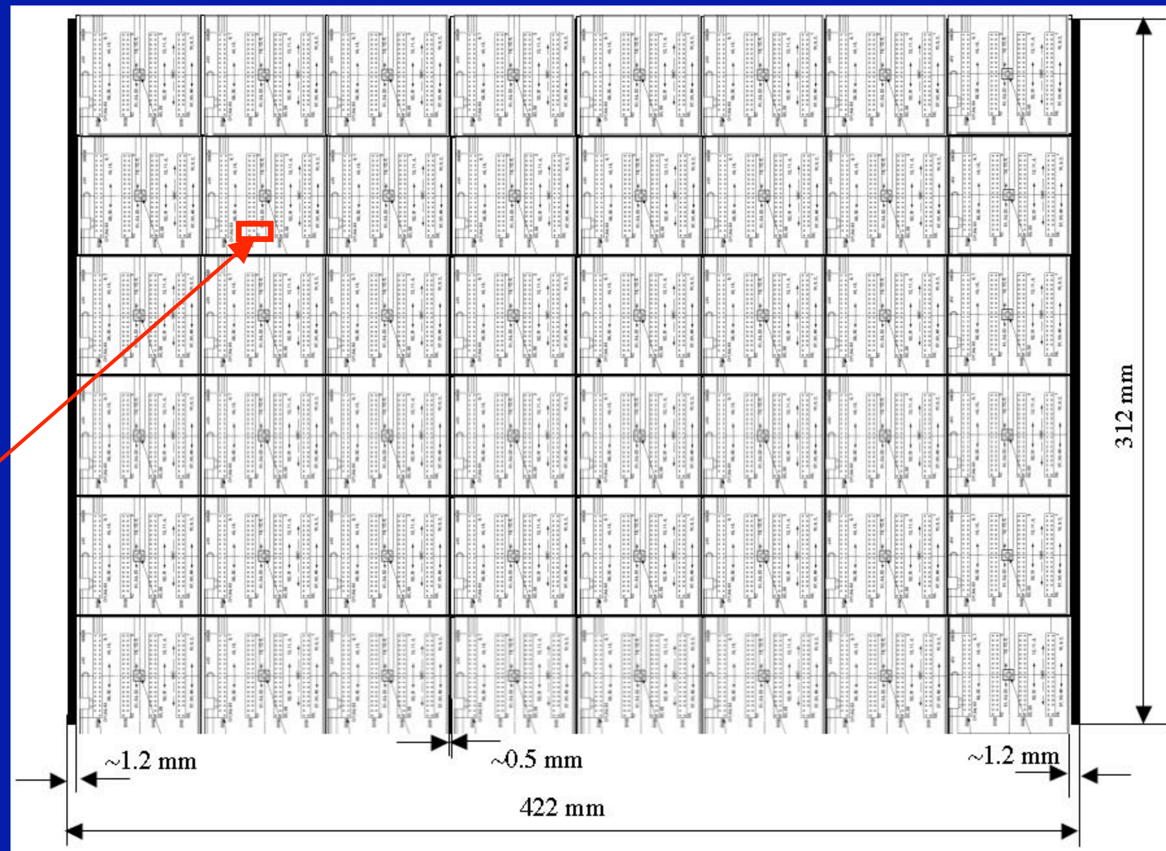
(Measured with a 407 nm PiLas laser)

- **H-8500 has a slightly better TTS resolution than H-9500.**
- **MaPMTs have smaller timing tail compared to MCP-PMTs.**
- **This resolution is good enough to do the chromatic corrections, but not good enough to do a TOF detector.**

Detector matrix in one camera

Detector precision is determined by a holding screw (H-8500):

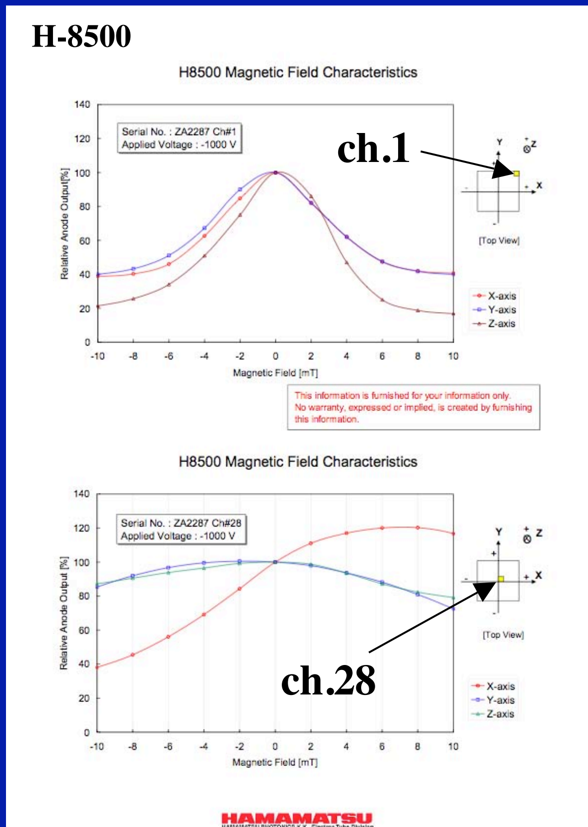




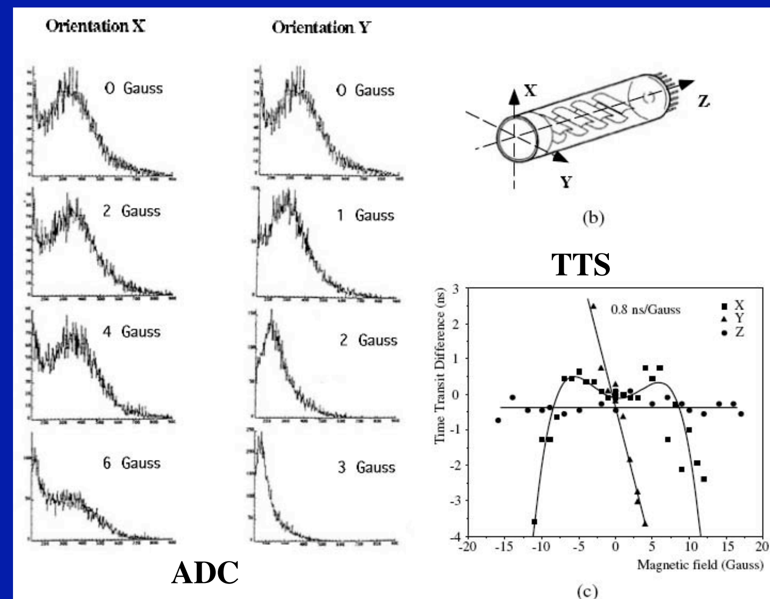
Shorting of two pads

- **Number of H-8500 detectors: 48 = 8 x 6 per camera**
- **Total number of detectors: 576 = 48 x 12 per entire system**
- **Total number of pixels (H-8500): 18,432 = 12 x 48 x 32 per entire system**
- **If we short two neighboring pads, it has to be done via an equal delay path.**
- **Detectors must be oriented right way for shorting of pads to work properly.**

H-8500 sensitivity to magnetic field



DIRC tube (from NIM paper):



- **DIRC PMT tube was much more sinsitive to magnetic field (~1 Gauss is a very visible effect).**
- **H-8500: edge pixels are more sensitive than center pixels:**
  up to ~20% amplitude loss at ~20 Gauss; up to ~60% amplitude loss at ~50 Gauss
- **We will need a magnetic shield, but it may not need to be as massive as in BaBar.**
- **We may be able to tollerate a field up to ~10 Gauss, so we may have gained a factor of ~10x.**

Present FDIRC predicted performance

Dough Roberts

Table 1: FDIRC performance simulation by Geant 4 MC.

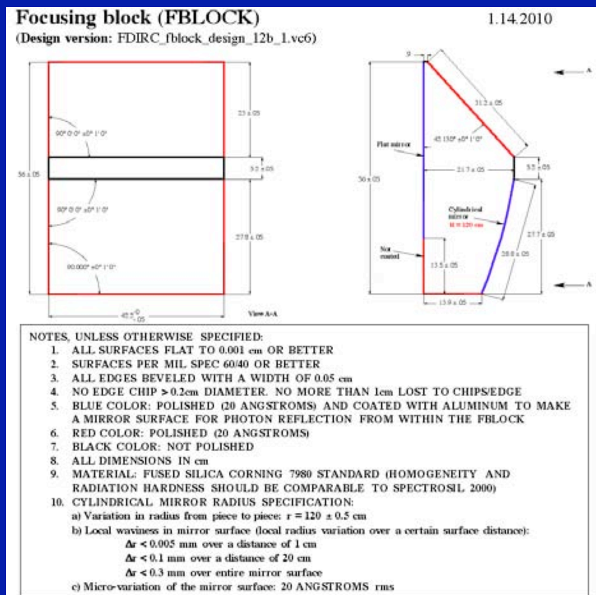
Design	Option	θ_c resolution [mrad]
1	FDIRC with 3 mm x 12 mm pixels with a micro-wedge	8.1
2	FDIRC with 3 mm x 12 mm pixels & no micro-wedge	8.8
3	FDIRC with 6 mm x 12 mm pixels with a micro-wedge	9.0
4	FDIRC with 6 mm x 12 mm pixels & no micro-wedge	9.6

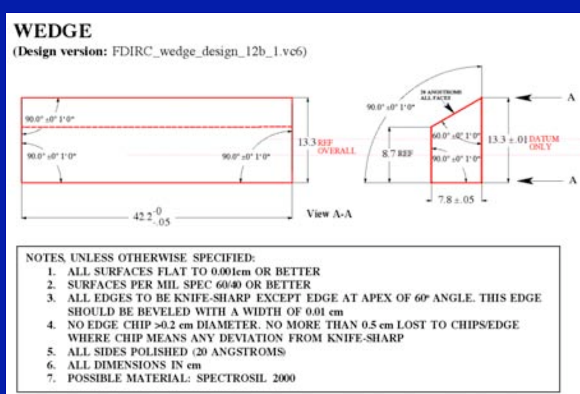
Note: BaBar DIRC resolution for di-muons: ~9.6mrads

- **The most conservative decision, which is a design #4, would give a similar performance as the BaBar DIRC (~9.6 mrads).**
- **However, one should point out that FDIRC will correct out the chromatic error by timing, at least partially, which would reduce the error by 0.5-1 mrads, assuming that we do mess up timing resolution.**

Drawings for final bidding process

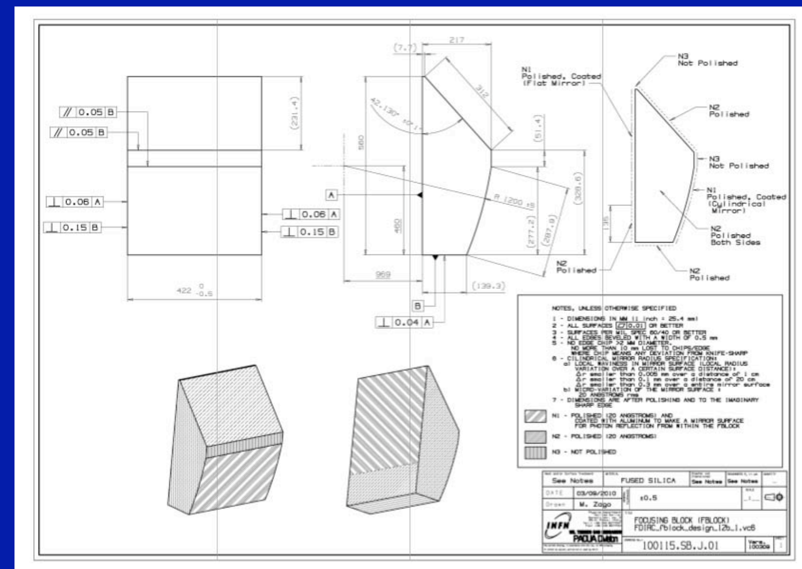
Drawings for preliminary bid (J.V.):

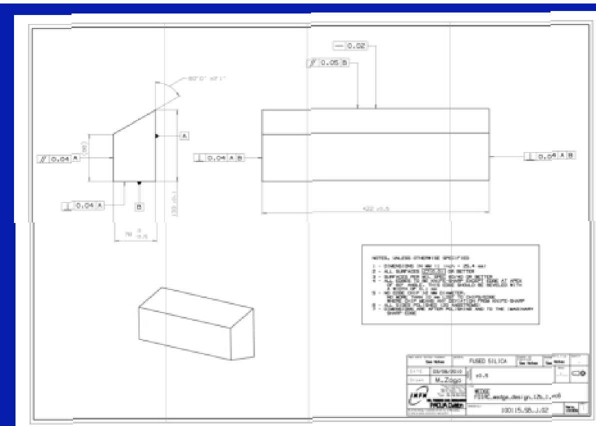




Many iterations between JV and Massimo

Drawings for a final bid (Massimo B.):



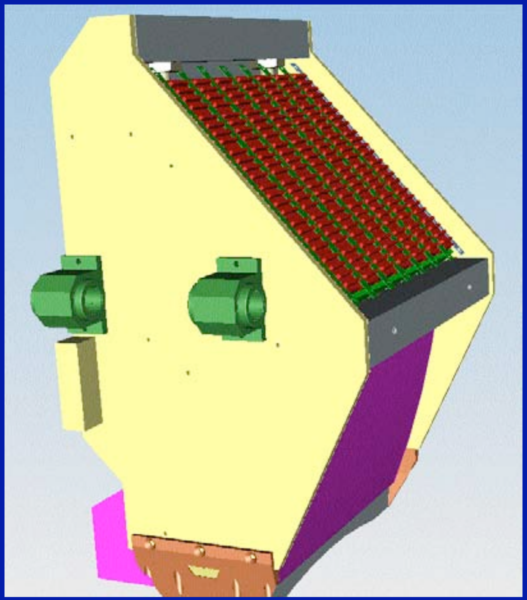


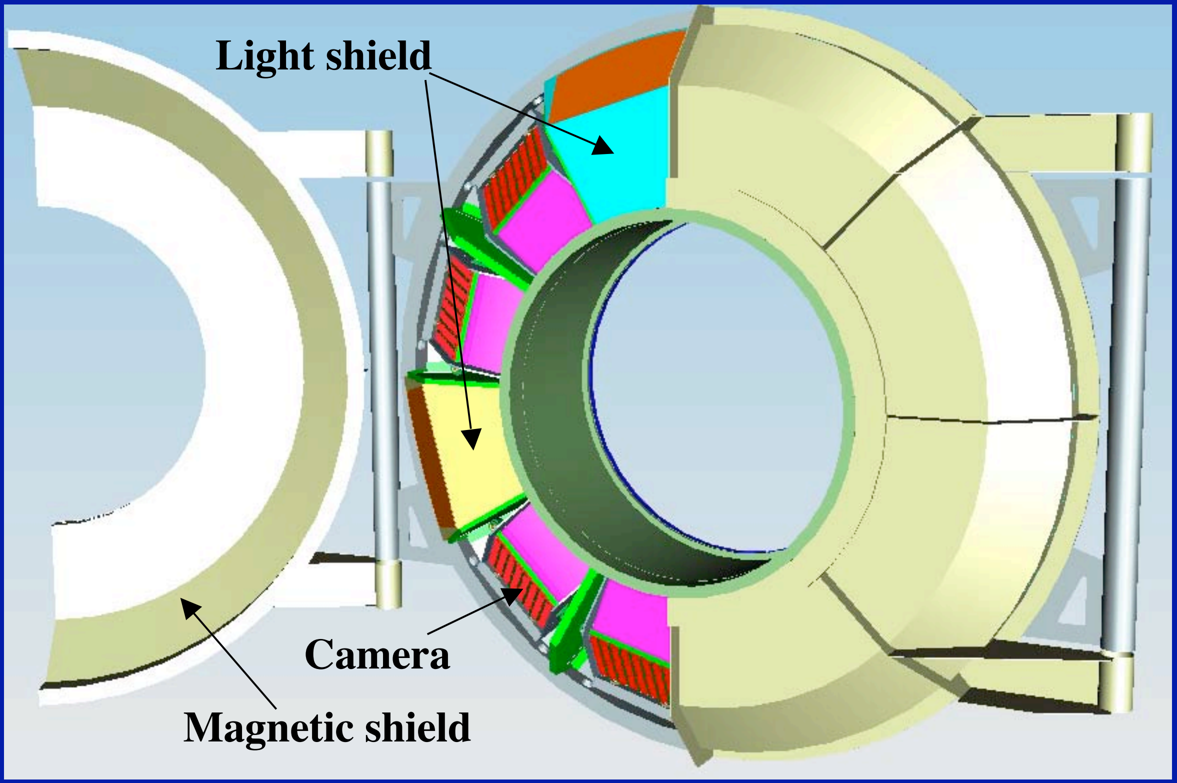
- In addition we have a specification for a raw quartz material from Corning.

FDIRC mechanical design

Massimo Benettoni

Camera:





- **I can use a 3D viewer 10,000 miles away and discuss the details with Massimo. This is a real progress compared to what we had in previous experiments.**

FDIRC: towards TDR

- **Tweak camera optics ?** Yes, but we will become less and less flexible because of the consequences on other things (mechanics, electronics, etc.).
- **MC simulation:** (a) number of photoelectrons per ring = f(dip angle), (b) Cherenkov angle resolution per track, (c) chromatic correction = f(timing resolution, photon path length), (d) Can we gain the resolution if we do not use the hits on the Cherenkov wings, etc.
- **Micro-wedge:** Shall we go for it, or we give up this idea ? Is it worth of a ~0.7 mrad inprovement in resolution ? I would argue that it is not worth of the risk.
- **Photodetector choice:** H-8500 vs H-9500. I argue for H-8500.
- **Magnetic shielding:** Need it to bring the field bellow ~10 Gauss. Do we trust Hamamatsu data or do we need to make more tests in the magnet ?
- **Electronics concept:** What tests do we need to make to decide ? We have on-going test of the FDIRC prototype in CRT where we plan to compare two options. There are also test bench setups. Based on the experience with the waveform electronics so far in CRT, I would argue for a TDC/ADC concept.
- **Photodetector holder:** Do we glue detectors to FBLOCK surface with RTV ? What is a detector removal procedure if we do glue them ? Needs to be tested before we write it down. Can we afford ~ 8% photon loss, if we decide not to glue ?

FDIRC: towards TDR

- **Laser Calibration:** (a) laser calibration proved to be essential to correct the chromatic error by timing in the FDIRC prototype in the test beam; (b) where do we put a laser diode entrance ?; (c) how many laser diode inputs should we have (I argue for 2-3/camera) ?
- **Mechanical design of the new camera:** (a) how we are going to put the FBLOCK, New Wedge together ? Do we glue the New wedge to FBLOCK first (right now preffered), or do we glue the New Wedge to the bar box window first ?; (b) do we glue in the extended position where the bar box is partially removed ?; (c) design details of the precision rail-based mechanics to prevent stress build up; (d) details of mechanical support, (e) earthquake risk analysis; (f) light tightness; (g) easy maintenance of electronics, etc.
- **D&D:** (a) bar box removal from BaBar, (b) if we decide to add micro-wedges, the bar boxes have to travel to the clean room, (c) inspect glue joints optically before and after removal from BaBar, (d) bar box storage at SLAC, (e) bar box transport to Italy, (f) bar box storage in Italy, etc.
- **Real engineering budget.**
- **Should we worry about fall back positions ?:** (a) FDIRC with mineral oil a'la FDIRC prototype, (b) non-focusing DIRC