Mack comments on TDR draft
9/8/15

General:

Well written for the most part.

Surprisingly hand-waving on capabilities of existing TOF. You don't want to leave a reviewer with the impression that we'd rather tackle an expensive, difficult, and high-risk upgrade before 1) documenting TOF PID capabilities interpreted optimistically, or 2) considering a low-risk, low-cost, brute force TOF upgrade like increasing the scintillator thickness by 50%.

Font is too small.

My view of the overall situation: The physics is approved. You are preparing to go to DOE for the majority of funding for the FDIRC, but perhaps only a superficial technical review took place just before PAC 42. (I am still trying to track down those documents. As far as I remember, Rolf didn't send that proposal to our Independent Technical Review committee.) You are now asking me to comment on a 95% clean TDR draft. The importance of improved PID to the physics program is clear, and I believe you will make the FDIRC work. I am worried about something slipping thru the crack in between: mainly *requirements*. If you get a question about requirements from a real reviewer that you cannot adequately address, or that suggests fuzzy logic, that could delay you a year until the next review.

I. Introduction:

An appendix containing a chronological list of web links leading up to PAC 42 approval might be a helpful supplement to the Introduction. (See below.) Phase IV came into being organically, and Physics Division records aren't very user friendly, so it took me half an afternoon to make sense out of it from the PAC web archives.

2012 (PAC 39):

GlueX proposal
PR12-12-002 "An initial study of mesons and baryons containing strange quarks with GlueX"
https://www.jlab.org/exp_prog/proposals/12/PR12-12-002.pdf

PAC 39 report containing conditional approval (at C2 rank)
https://www.jlab.org/exp_prog/PACpage/PAC39/PAC39%20Final_Report.pdf

2013 (PAC 40):

Updated GlueX proposal
PR12-13-003 "An initial study of mesons and baryons containing strange quarks with GlueX"
https://www.jlab.org/exp_prog/proposals/13/PR12-13-003.pdf

PAC 40 report containing full approval for 200 days for the so-called Phase IV running period following commissioning (base equipment PID) https://www.jlab.org/exp_prog/PACpage/PAC40/PAC40_Final_Report.pdf

2014 (PAC 42*):

"New" proposal based on enhanced PID available from an FDIRC
C12-12-002 (PAC 42) "A study of decays to strange final states with GlueX in Hall D using components of the BaBar DIRC" https://www.jlab.org/exp_prog/proposals/14/C12-12-002.pdf

PAC42 report including full approval for 220 days (with FDIRC upgrade)
https://www.jlab.org/exp_prog/PACpage/PAC42/

See also the JLab guidelines for proposals including non-standard equipment such as FDIRC
https://www.jlab.org/exp_prog/PACpage/guidelines.html

(comment: If FDIRC construction and installation occurs in a timely manner, these 220 days may overlap the previously awarded 200 days from PAC 40.)

*PAC 41 took place earlier the same year but was dedicated to prioritization of already approved proposals.

II. **Requirements**:

You should be more precise and quantitative about existing capabilities. The sentence, "The current PID system provides sufficient proton identification; however, K-pi separation is only possible up to momenta of about 2 GeV." perhaps should be something like "Currently, CDC based dE/dx provides sufficient identification for the majority of recoil protons. However, 3sigma K-pi separation in the forward direction is only possible up to momenta of about 2 GeV."

My toy simulation for the TOF detector used a conservative 100 ps resolution. However, given that the TOF already exists, it seems appropriate to be hopelessly optimistic and assume two statistically independent measurements of 70 ps resolution. (Single-ended bars are a complication, but still the combined resolution should be in the range 50-70 ps.) That may raise the K-pi separation of TOF to at least 2.5 GeV. I realize the inferior PID capability of TOF is implicitly buried in your reconstruction efficiency and purity results, but *you should be prepared to whip out a slide that shows the TOF won't work and can't be made to work.*

One of the highest level analyses of the FDIRC capability (somehow linked to the 3sigma K-pi separation requirement) appears to be the efficiency and purity results tabulated in Table IV of the proposal. I find the multiple IV's in this table confusing. What matters is the final error bar, and if the statistical error dominates, then you can define a figure of merit (FOM) which helps you estimate the statistically optimal/unique combination of efficiency and purity. Since the absolute yields aren't available, I suspect the appropriate FOM to use is Efficiency*Purity^2 (see slide 2 of http://argus.phys.uregina.ca/cgi-bin/private/DocDB/ShowDocument?docid=2639) then I can recast the proposal's Table IV as follows:

	Figure of Merit (warning: not useful for comparing one meson to another)							
	Eta1'		H2'		Phi3		Y(2175)	
Purity	base	FDIRC	base	FDIRC	Base	FDIRC	base	FDIRC
0.90	0.292	**0.389**	0.267	**0.480**	0.543	0.599	0.373	**0.527**
0.95	0.162	0.299	0.144	0.307	0.551	**0.614**	0.181	0.496
0.99	0	0.049	0	0.078	0.176	0.372	0.029	0.274

The maximum FOM in each case is indicated in bold. Hopefully I didn't introduce any typos in my rush. What preliminary conclusions can I draw from this, based on the signal yield and width and backgrounds that went into the simulation?

- We always win with the FDIRC. The optimum is less than a factor of 2 over baseline though.
- There is a big FOM penalty in going to 99% purity*. (It may be useful for systematics studies.)
- In some cases, the optimal configuration may lie below 90% purity.

*I don't follow the argument for the need for 99% purity at the end of section V.B in the proposal. Perhaps I could be persuaded by a few lines of algebra in a well-chosen notation. But I feel there may be no way to evade the above FOM argument without introducing the issue of systematic errors.

III. FDIRC Design

A.

"however, the optical joints in the bars…"→ "however, the glue joints in the bars…"

B.

Figure 8 axes aren't labelled.

In a couple of places in the TDR there are references to "dispersion" wrt mirrors. Do you really mean "diffusivity"? The former might be some SuperB jargon that we've picked up.

C.

"into a resolution on the Cherenkov angle" → "into a Cherenkov angle"

What are the dark rates of these multi-anode pmts? Given the high signal rate, thermionic emission seems unlikely to be a significant source of additional noise in your reconstruction, but I didn't see it mentioned anywhere.

A background source that can be reliable simulated is scattered particles hitting the MA-PMTs.

A background source which may also be important is (n,alpha) on boron in the glass window of the PMTs. It would probably be difficult to simulate. Most of the neutrons would probably come from the air mass downstream of the target.

VIII. Project Details

This looks like an honest cost estimate, which means it might only be low by 50%-100%. After the project people get their hands on it, they will add labor costs for design and engineering. They will also add overhead and contingency.

I doubt Fernando's labor estimate includes thorough testing of the PMT's. If that could be done by students it would save the cost of a loaded FTE.

IX. Summary

This is a cost-effective PID upgrade which increases the FOM for strange decays by ~50% (channel dependent).

The FDIRC will permit .geq. 3sigma K-pi separation in the 2-4 GeV/c range for a wide ranging fixed target program of strange meson and baryon measurements.

This is a bleeding edge PID detector drawing on BaBar DIRC bars, Super B R&D, and JLab electronics.