FToF Design and Status Report

CLAS Collaboration Meeting

12 GeV Upgrade
Future Science at Jefferson Lab

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UNIVERSITY OF SOUTH CAROLINA

University of South Carolina

Requirements and result driven design,
construction and quality assurance,
man power, time effort, and timeline

FTOF Design Overview and Requirements

- CLAS12 FTOF system designed to measure flight time for charged particles that pass through DC system.

  Primary system for charged hadron id for momenta up to 2.6 GeV in forward direction.

  Used for particle id up to 5.3 GeV.

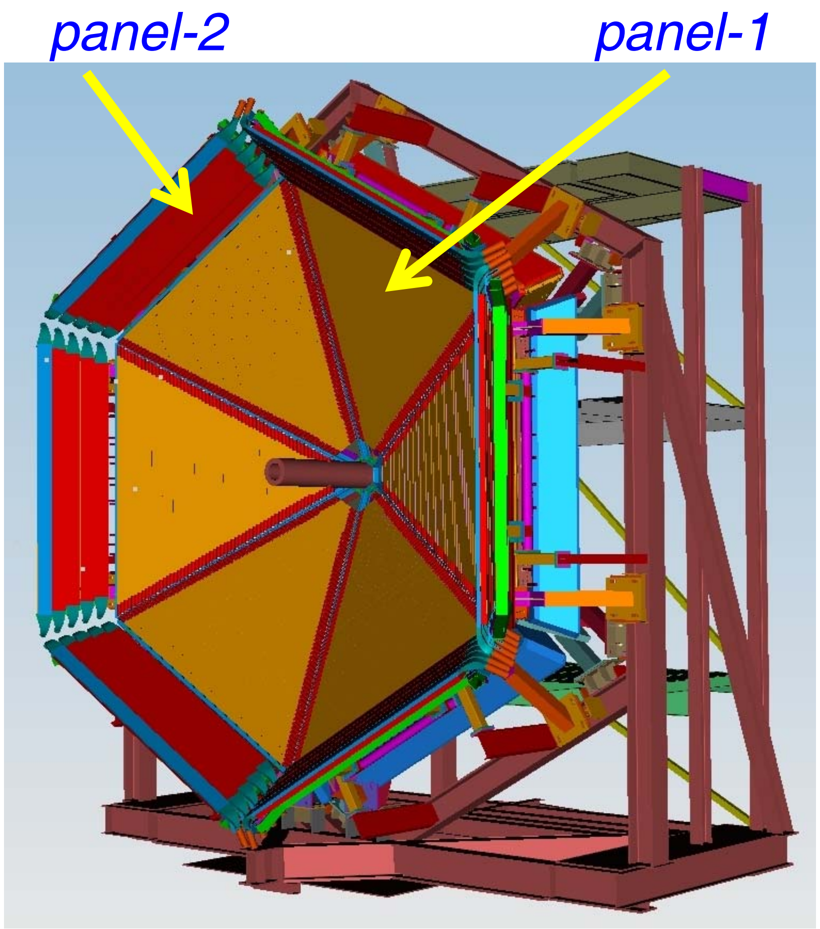
- FTOF consists of 3 scintillator panels in each CLAS12 sector.

  Panel-1a: original CLAS panel-1

  Panel-1b: new counters with better time resolution (combined 80 ps)

  Panel-2: original CLAS panel-2

- Average flight path from target to FTOF system is 650 cm.



FTOF Design Overview and Requirements

- The inactive elements of the FTOF system (dividers, PMTs, cables, supports) must be fully in the shadow defined by the torus cryostats and drift chambers.

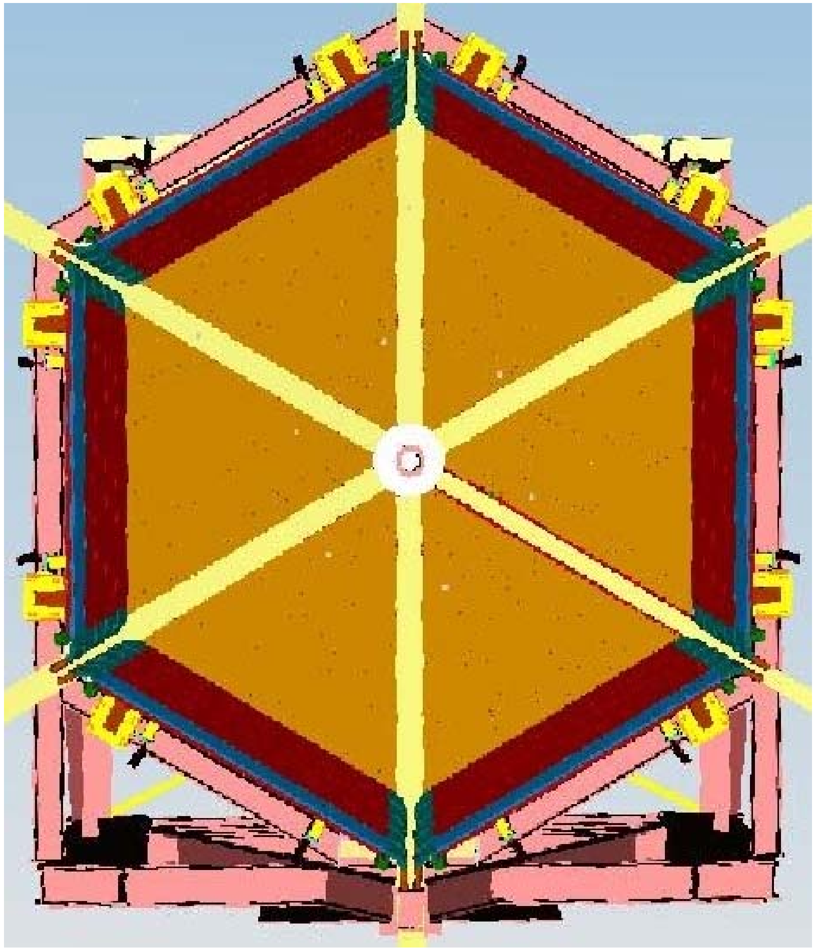
- ϕ coverage of FTOF must match that of drift chambers.

  Large ϕ coverage at small θ is critical for the physics program.

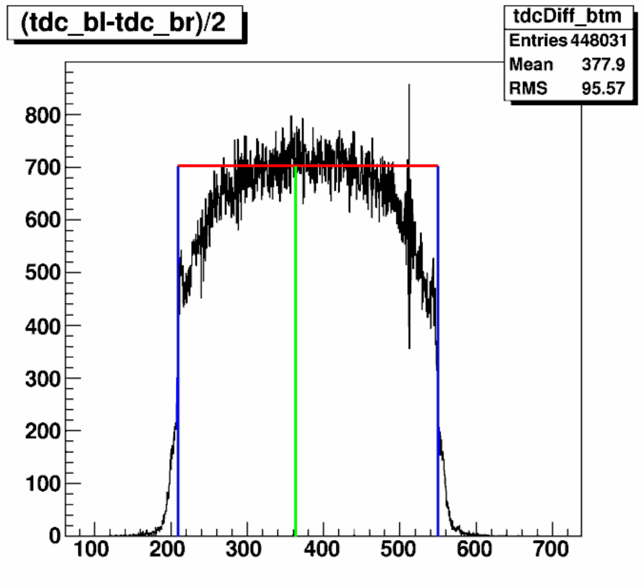
  Specification is 50% coverage at $\theta = 5^o$.

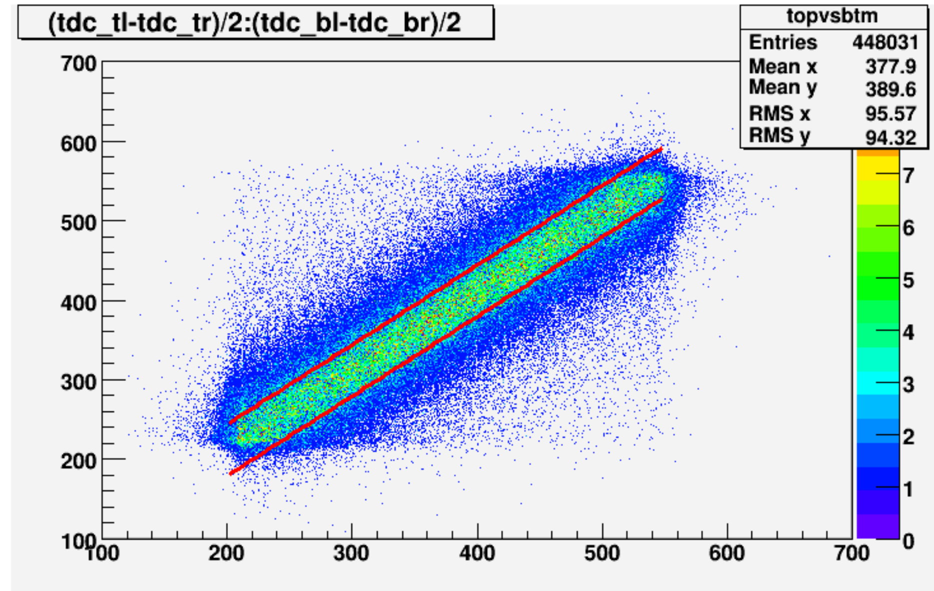
- Average flight path from target to FTOF system is 650 cm.

Shadow Definition



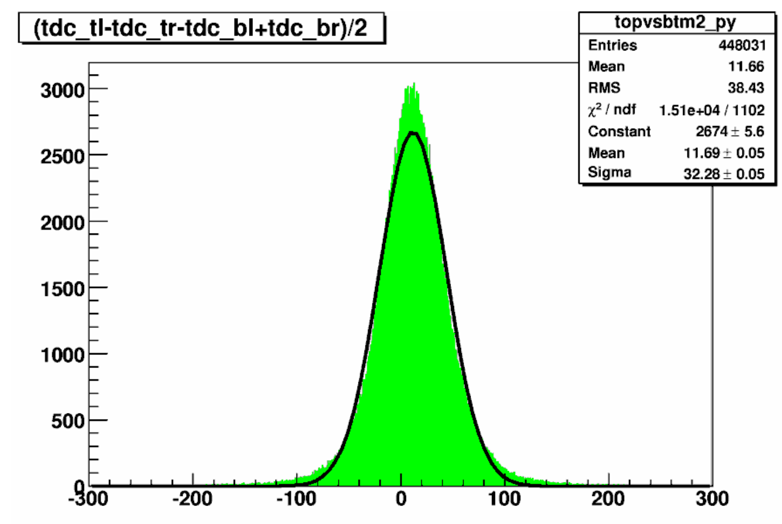
Automated Software Development





Determines left and right edges of TDC differences distribution

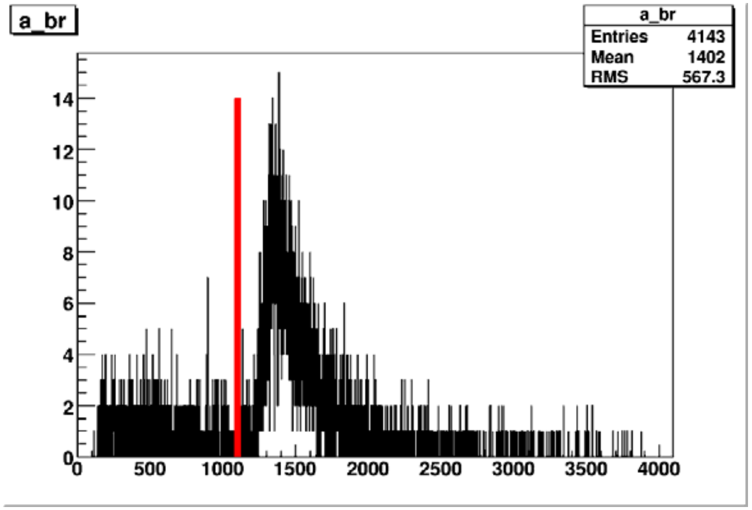
Fits difference of TDC differences and applies 1 σ cut



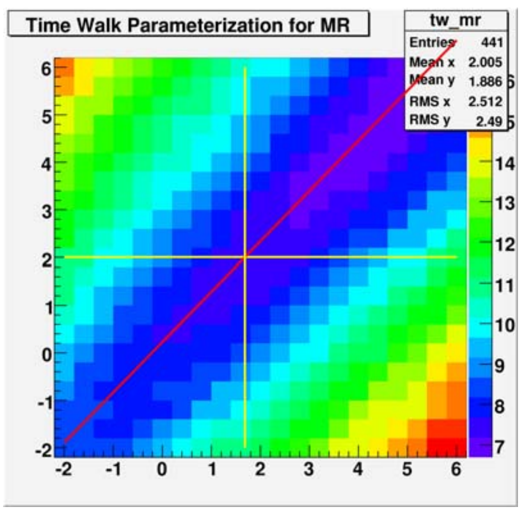
Applies 1 σ vertical cut and divides the scintillation bar into equidistance segments by choosing approximately equistatistical TDC difference bins

Gleb

Automated Software Development

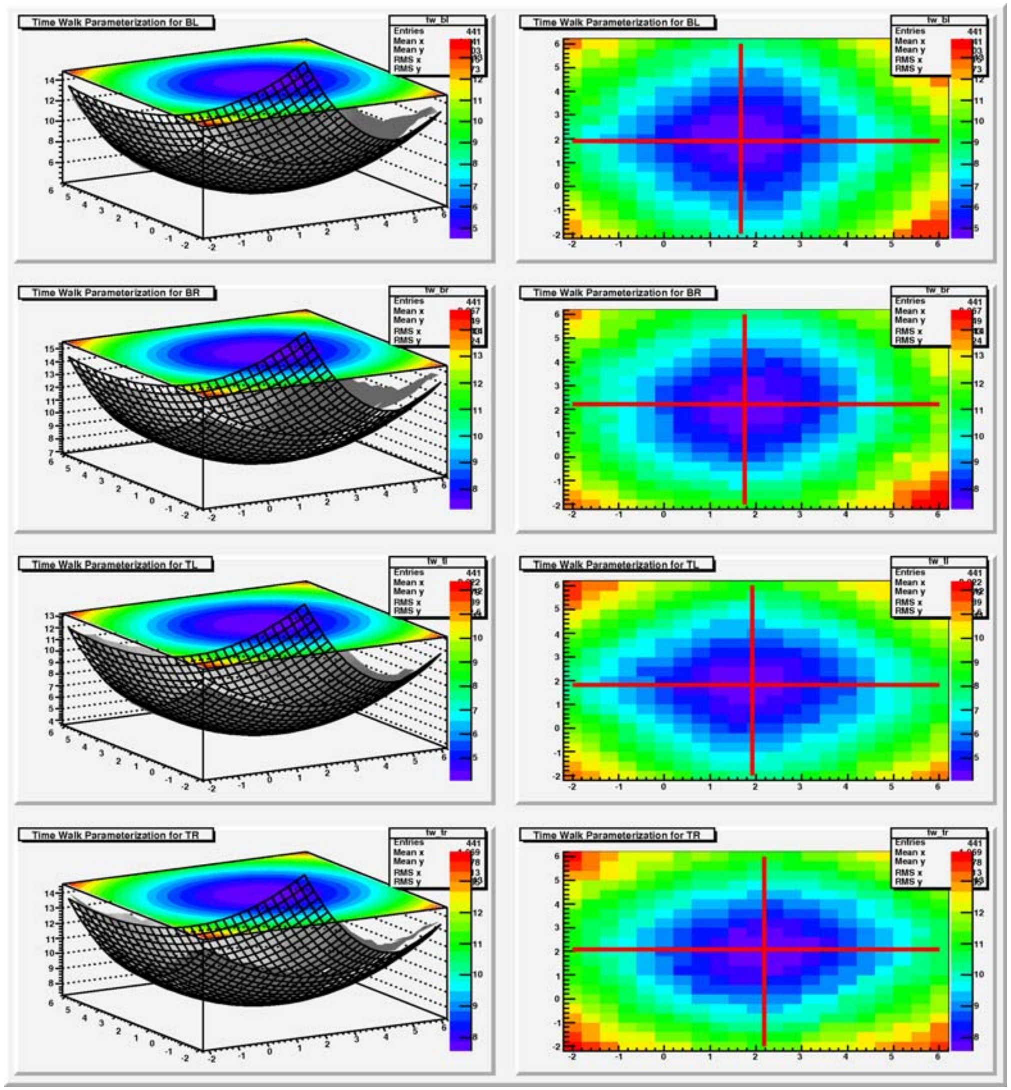


ADC distribution in individual bin with ADC cut



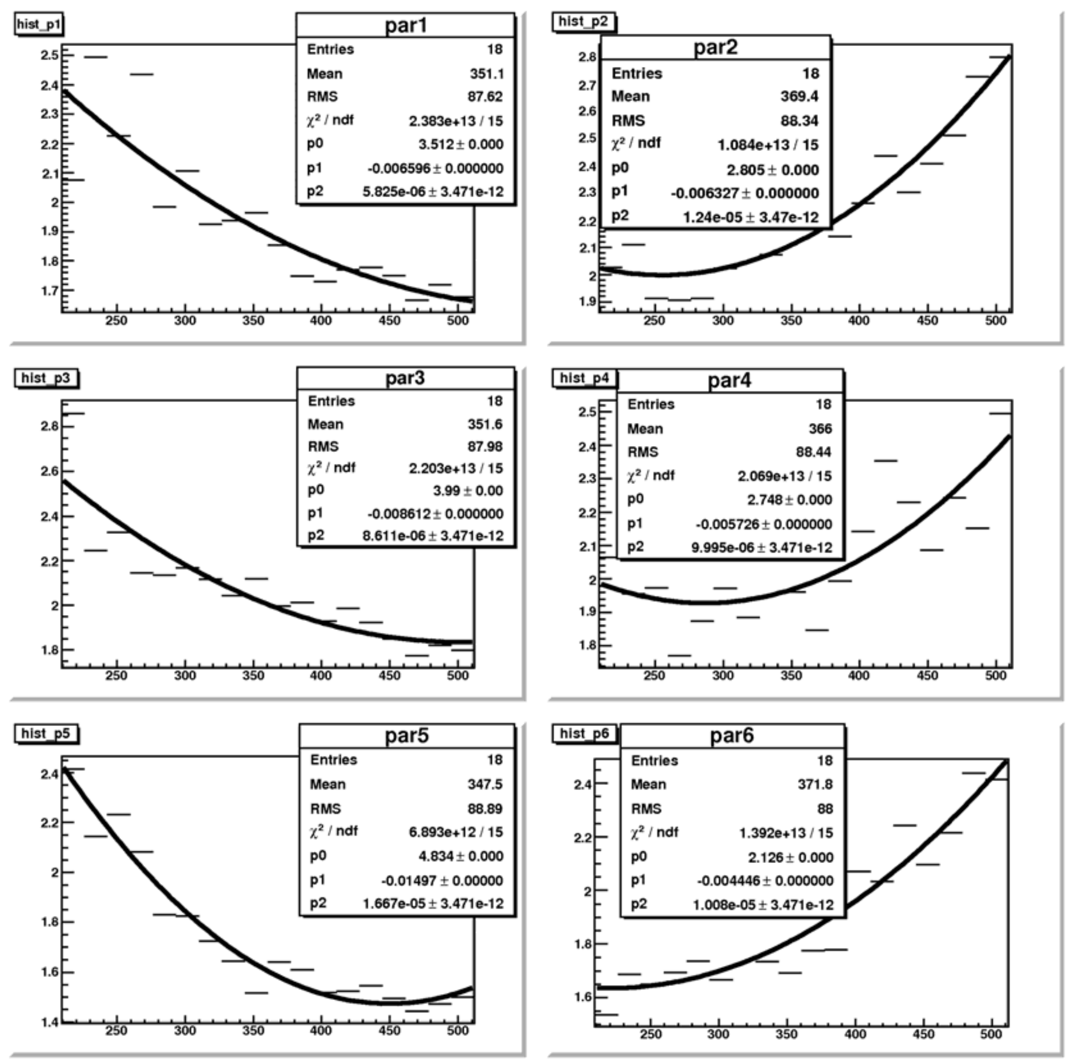
Gleb

Time-walk parameter for reference scintillator

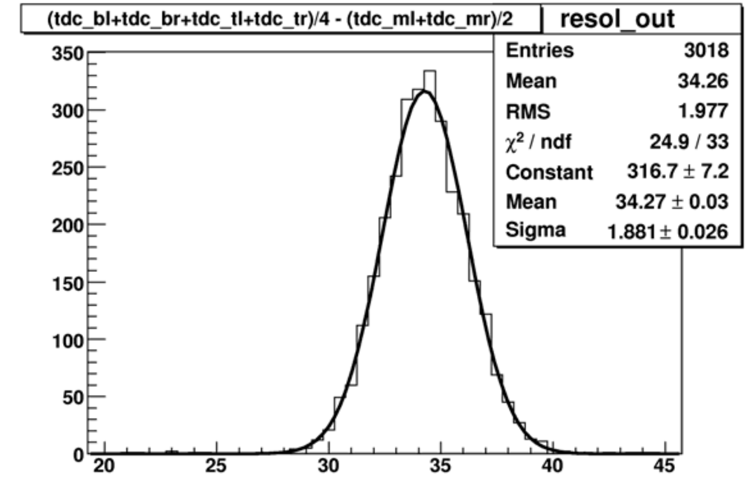


Determines time-walk parameters for best corrections

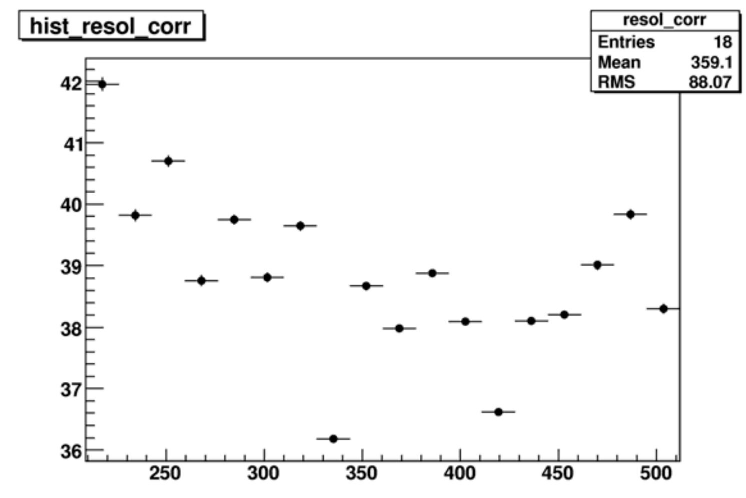
Automated Software Development



Fits time-walk parameters vs. TDC difference for 6 PMTs



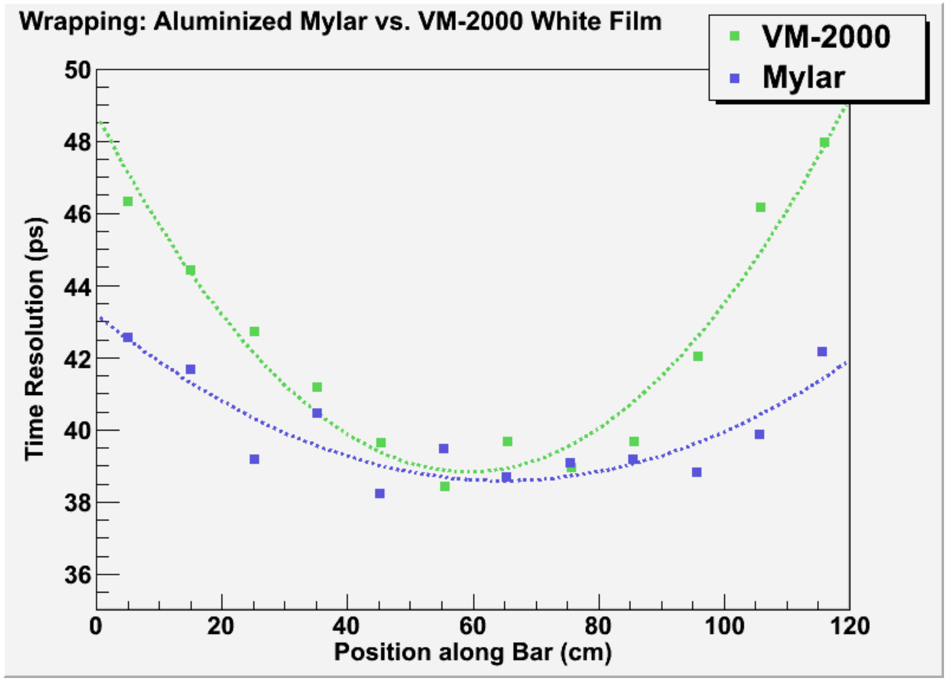
Time resolution in one TDC difference bin

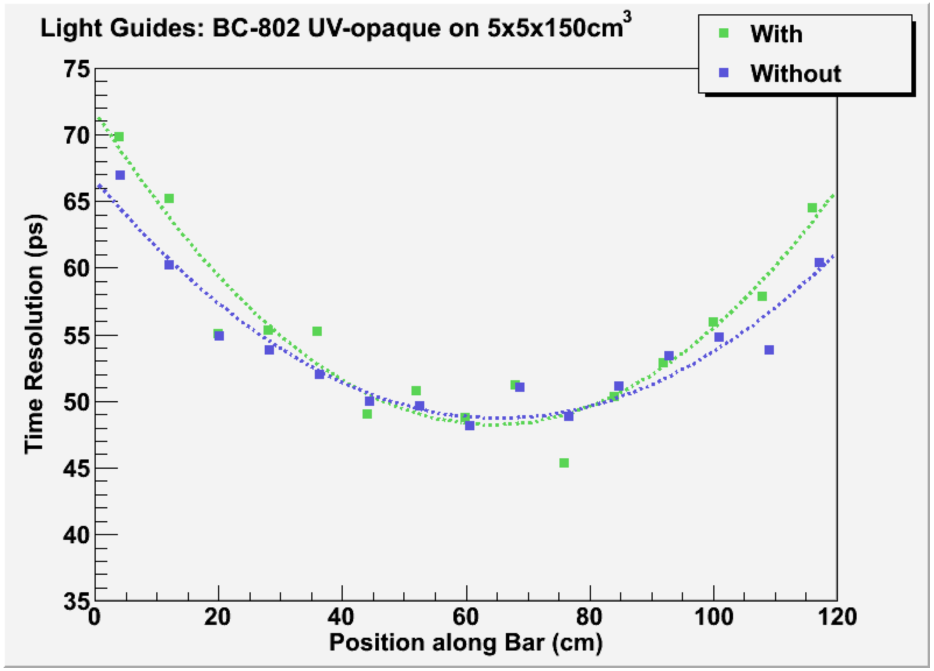


Time resolution vs. TDC difference

Gleb

Wrapping and Light Guides



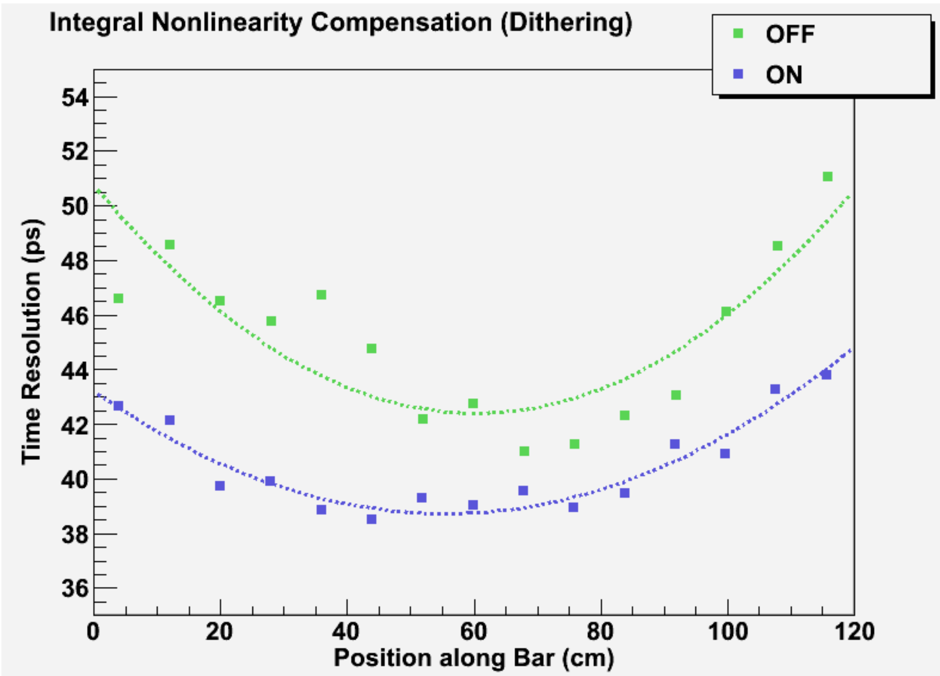


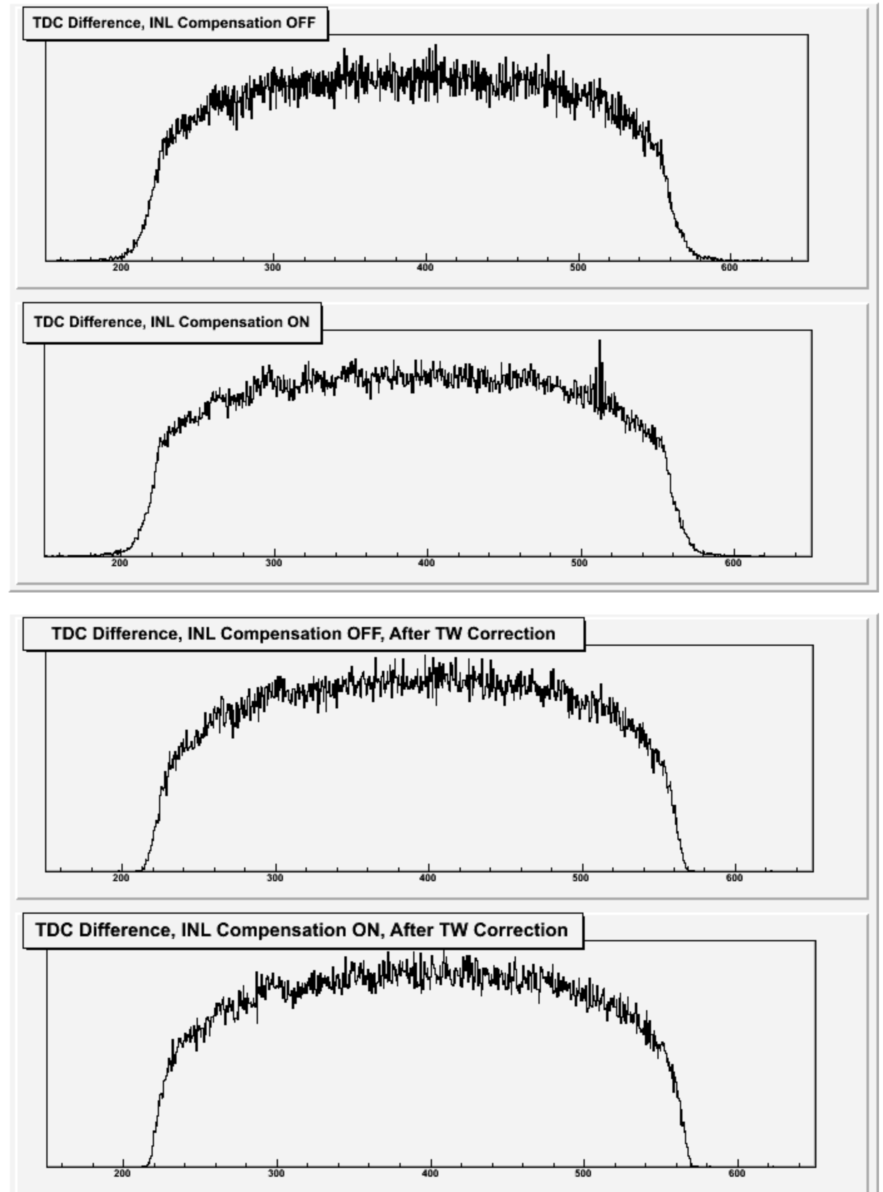
Aluminized Mylar outperforms VM-2000 in preserving photon statistics

Light guides negatively impact time resolution, especially at the ends of long scintillators

Evan and Felician

Integral Nonlinearity Compensation

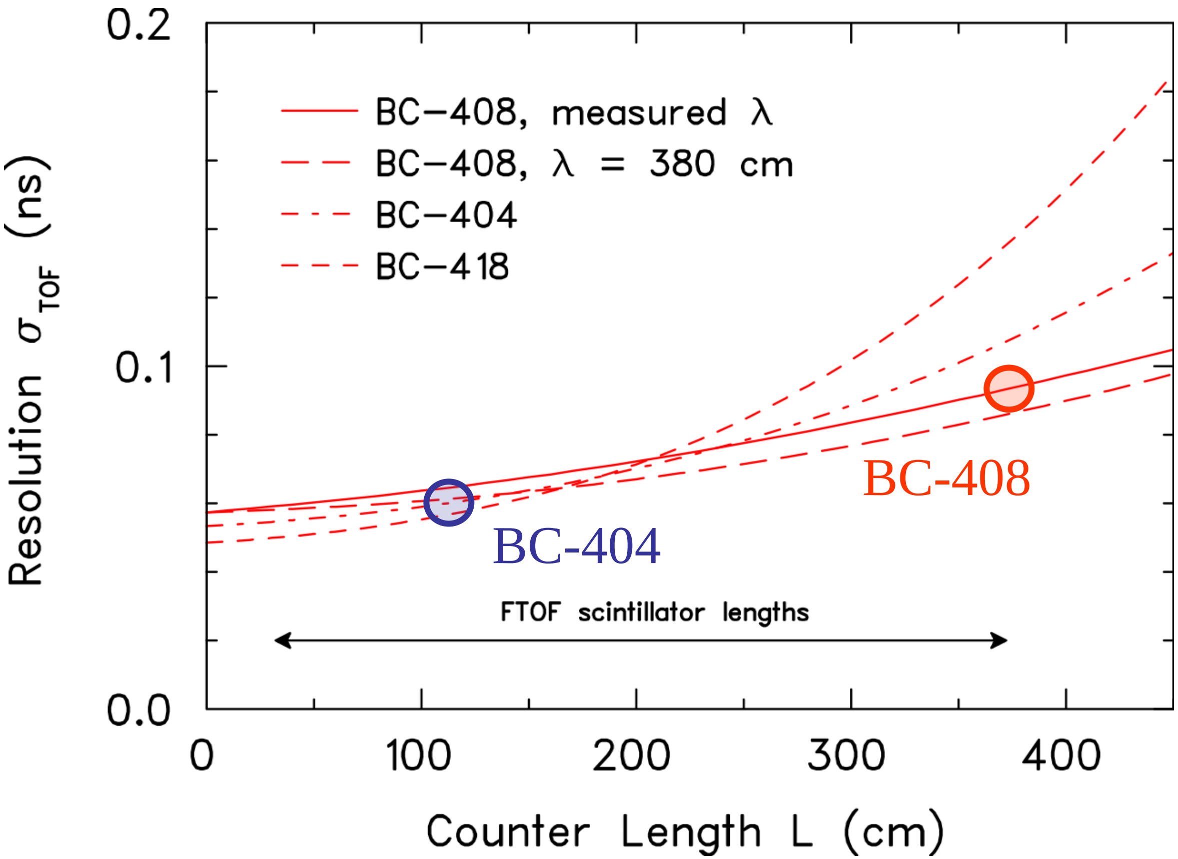




CAEN V792N TDC features integral nonlinearity compensation that improves time resolution

Evan and Felician

Light Attenuation Length

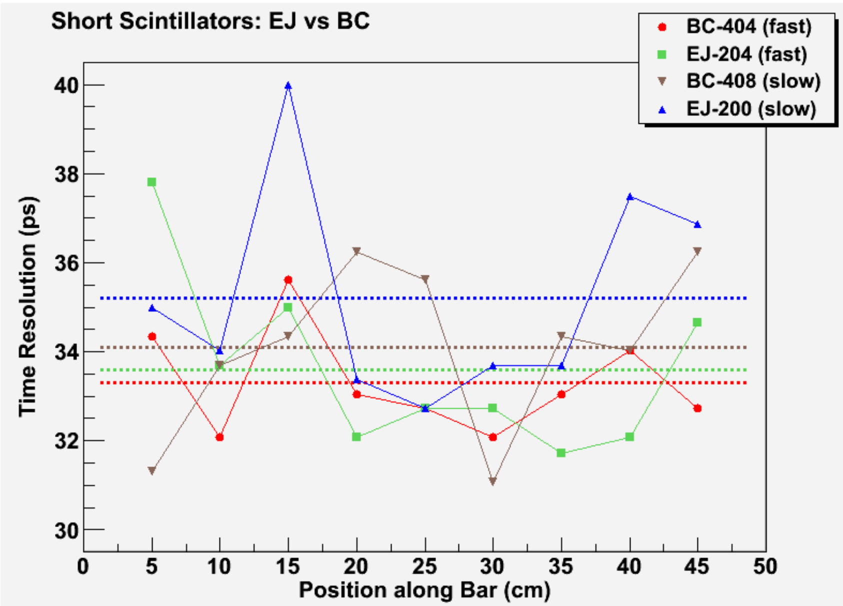


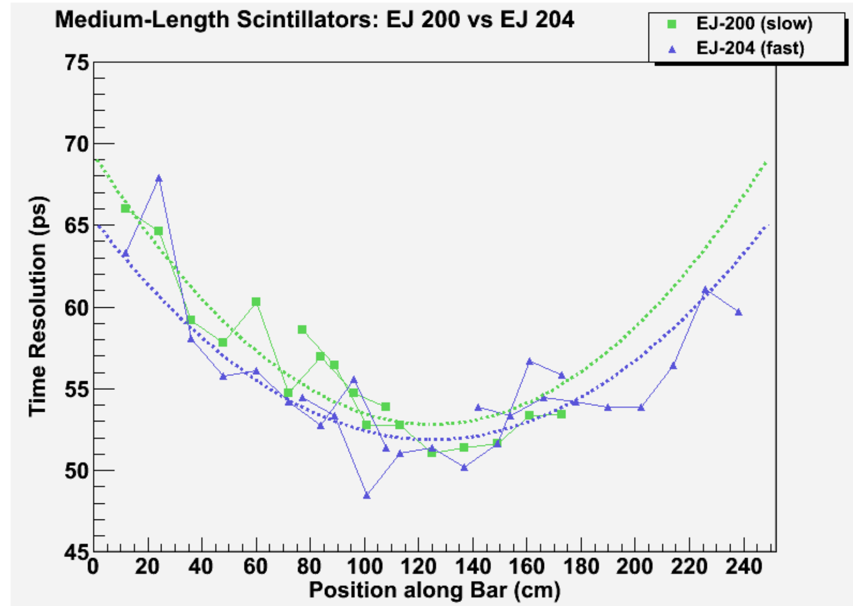
Scintillator	Bulk λ (cm)	τ (ns)
BC-408	380	2.1
BC-404	160	1.8
BC-418	100	1.4

BC-404 with λ = 160 cm (Saint Gobain) but ~325 cm (measured)

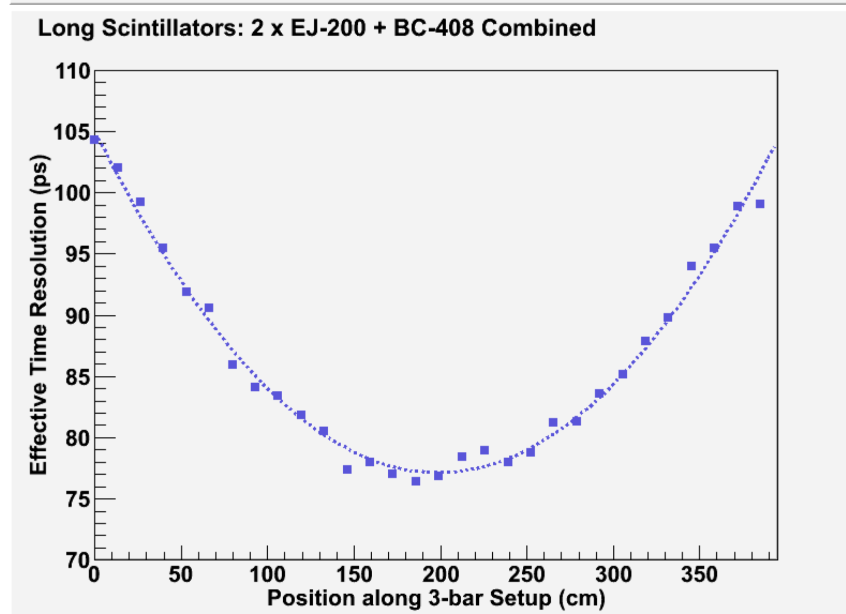
BC-408 with λ = 380 cm (Saint Gobain) but ~262 cm (measured)

Scintillation Material



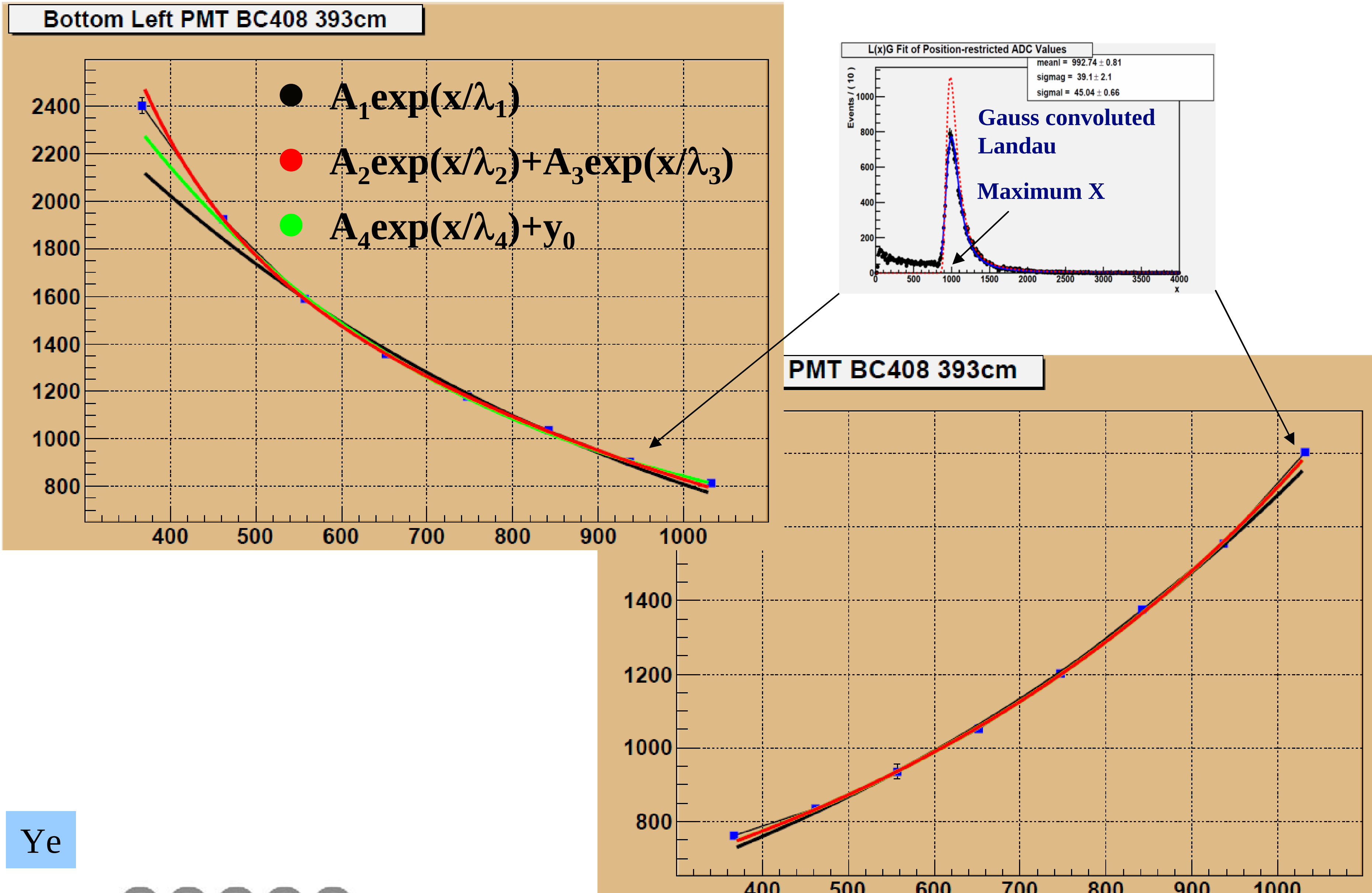


	50cm	250cm	375cm
BC-404	33.3ps	N/A	N/A
EJ-204	33.6ps	56ps	N/A
BC-408	34.1ps	N/A	86ps
EJ-200	35.2ps	58ps	



Evan and Felician

Light Attenuation Length

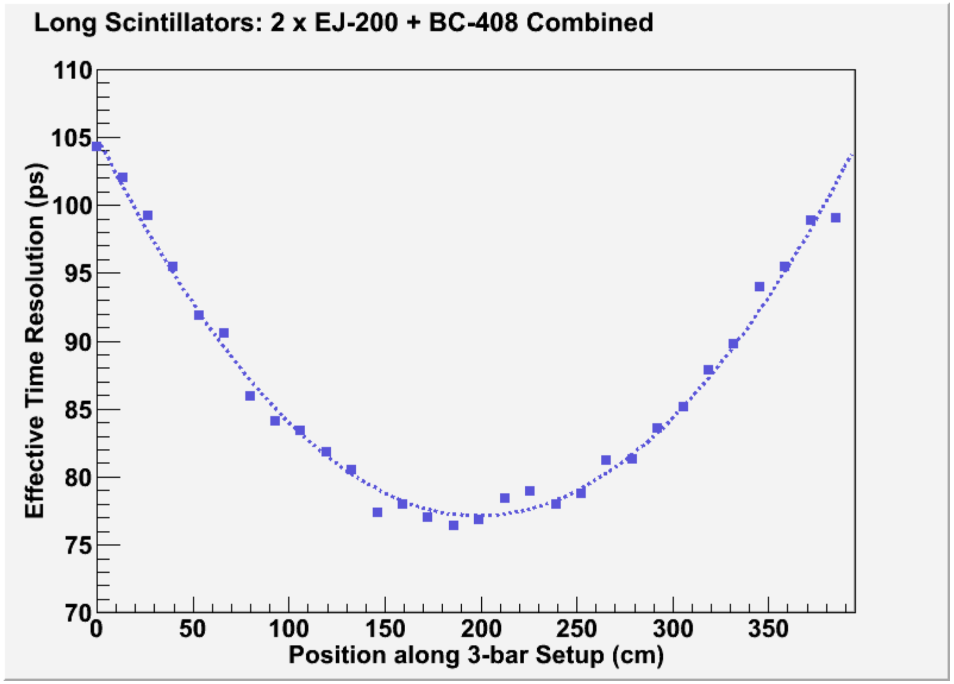


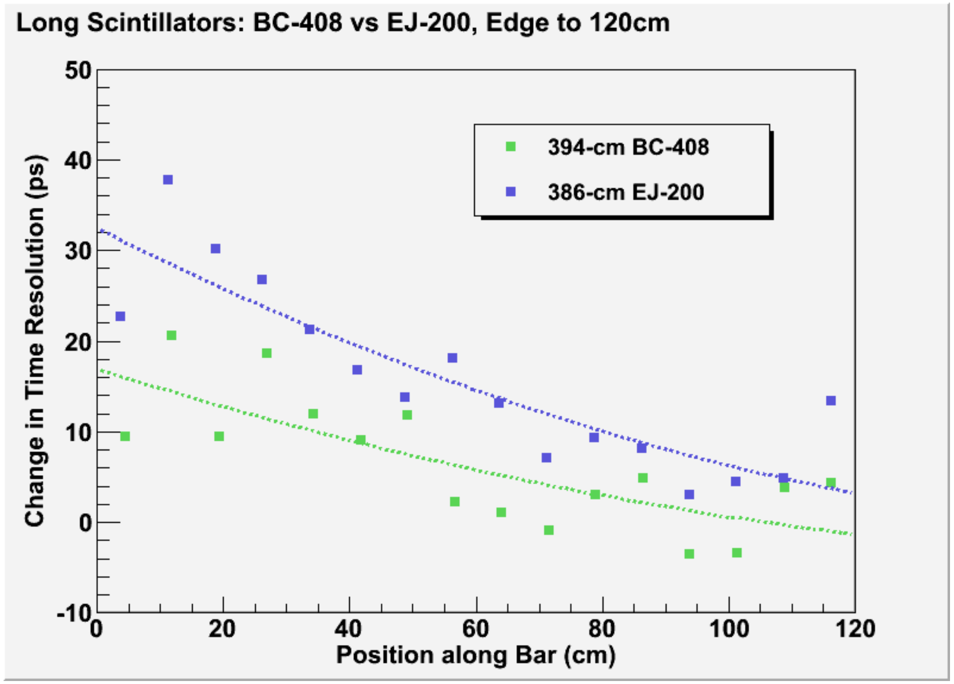
Ye

Light Attenuation Length

$A_1 exp(-x / \lambda_1)$	λ_1(cm)	Ratio λ (cm)
Top Left (EJ200 373cm)	**232.96 ± 0.76**	**180.45**
Top Right (EJ200 373cm)	**244.59 ± 1.96**	**191.22**
Middle Left (EJ200 386cm)	**188.02 ± 1.70**	**182.19**
Middle Right (EJ200 386cm)	**214.63 ± 4.37**	**197.47**
Bottom Left (BC408 393cm)	**256.98 ± 4.74**	**247.24**
Bottom Right (BC408 393cm)	**295.34 ± 7.98**	**277.29**

Scintillation Material and Attenuation Length





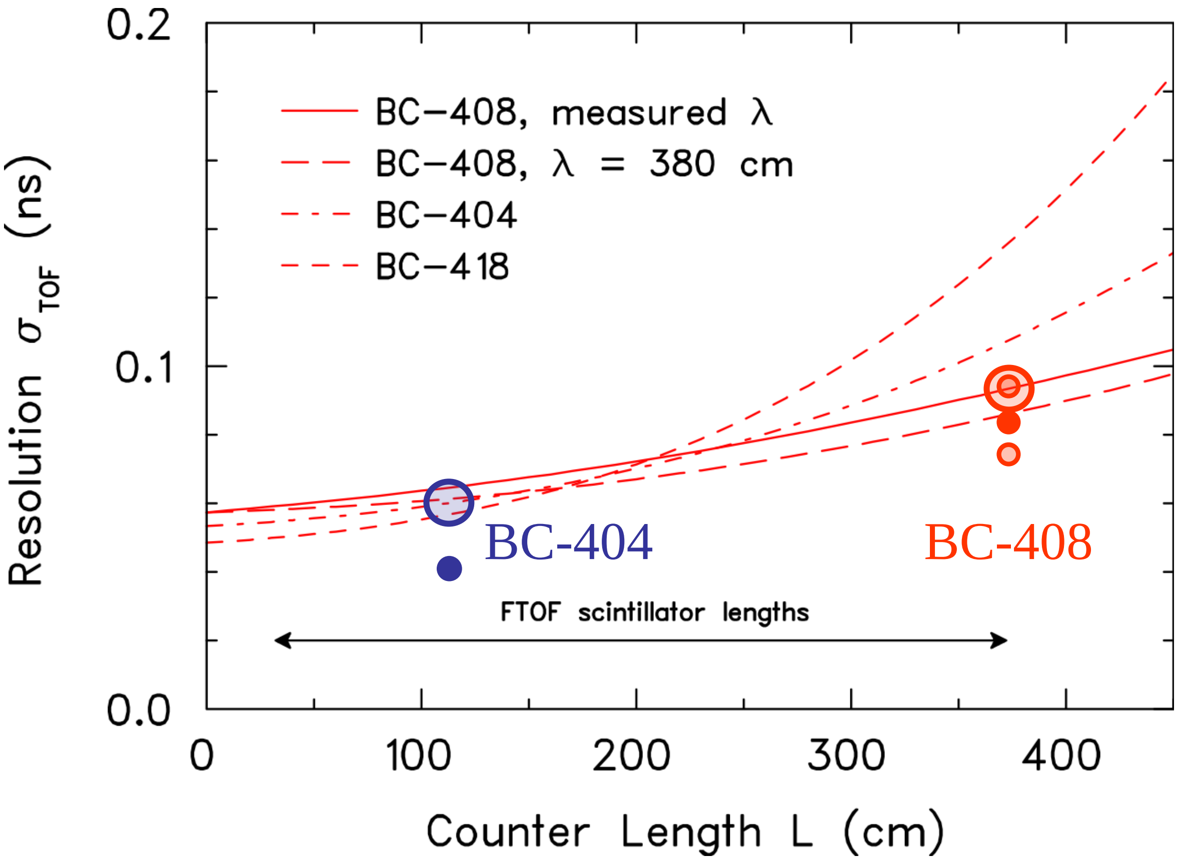
	50cm	250cm	375cm
BC-404	33.3ps	N/A	N/A
EJ-204	33.6ps	56ps	N/A
BC-408	34.1ps	N/A	97ps
EJ-200	35.2ps	58ps	113ps

λ = 262.26cm (BC-408)

λ = 187.83cm (EJ-200)

Evan, Felician, and Ye

Light Attenuation Length



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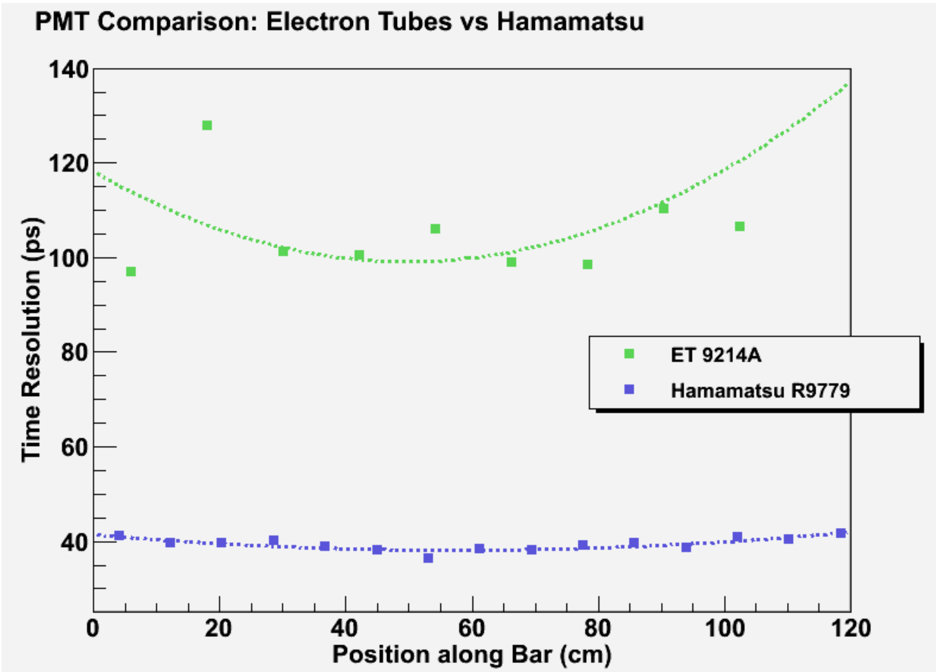
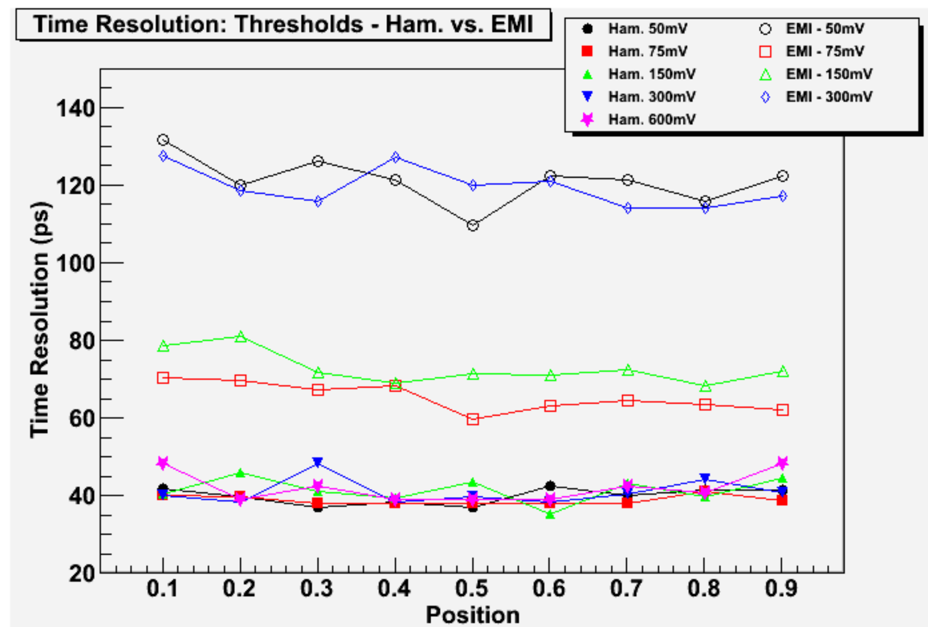
PMT and Threshold Dependencies

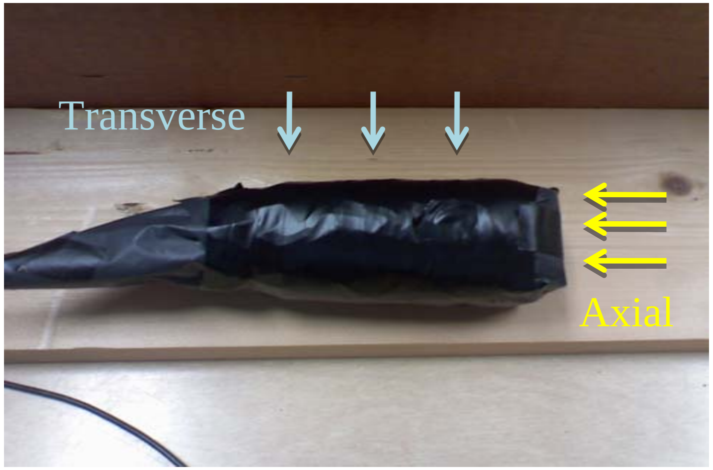


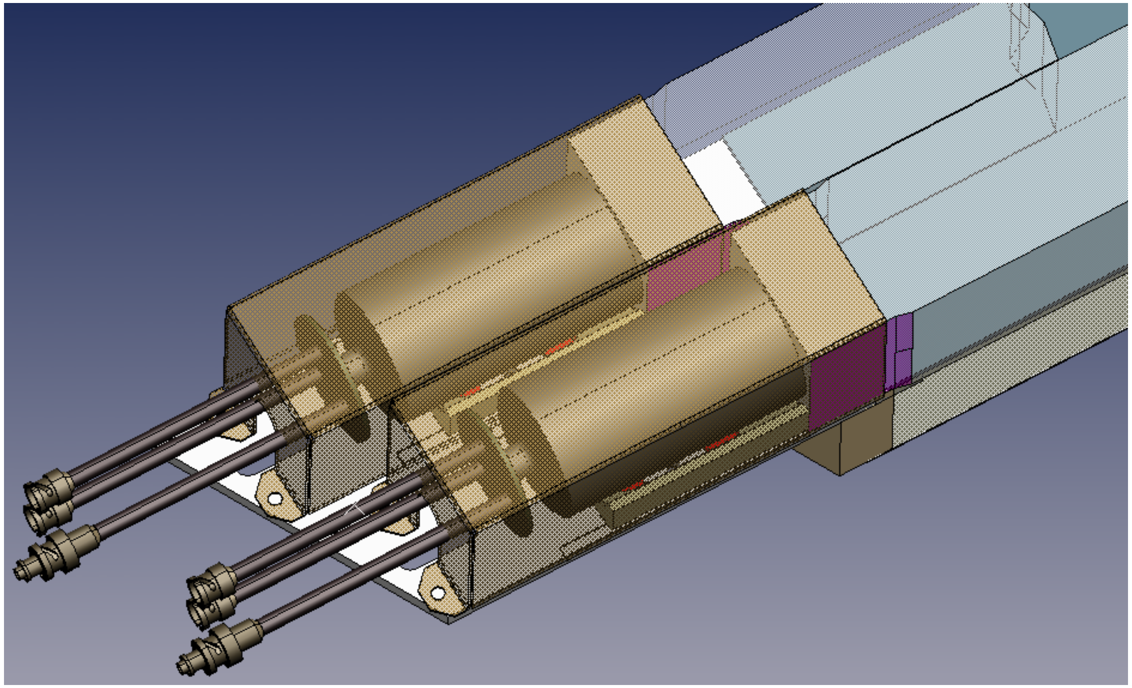
Hamamatsu R9779 PMT:
- superior time resolution
- time resolution is insensitive threshold
- extremely compact



Evan and Felician

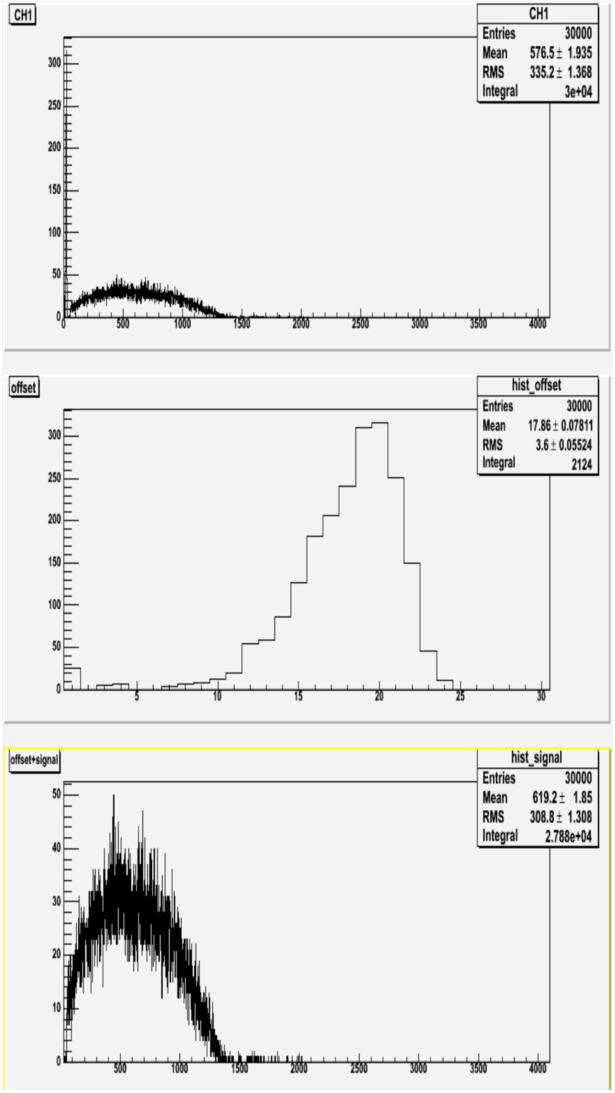
Mu-Metal Shielding against Magnetic Fields





Arjun, Robert, Designers

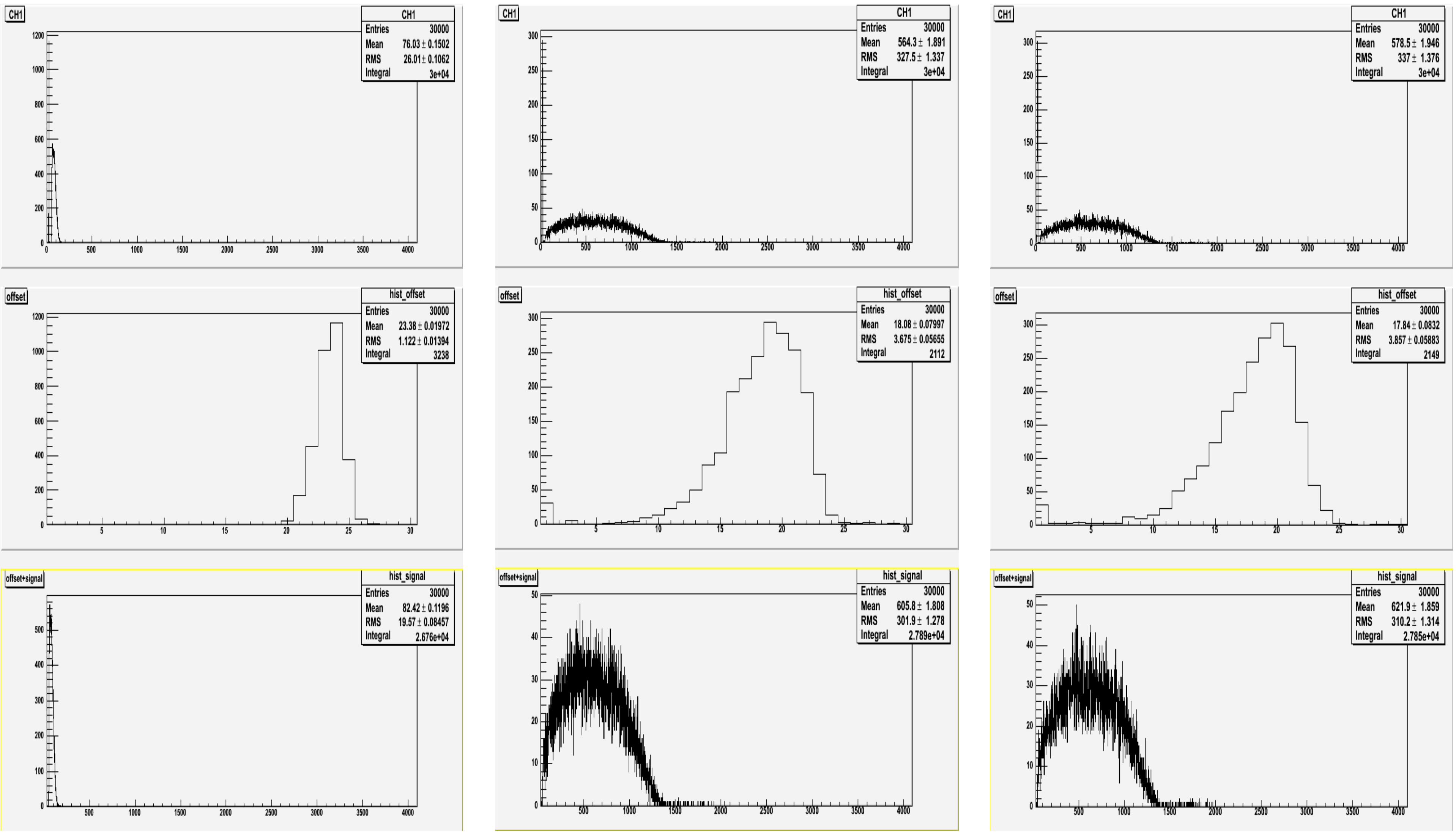
No Magnetic Field



Arjun

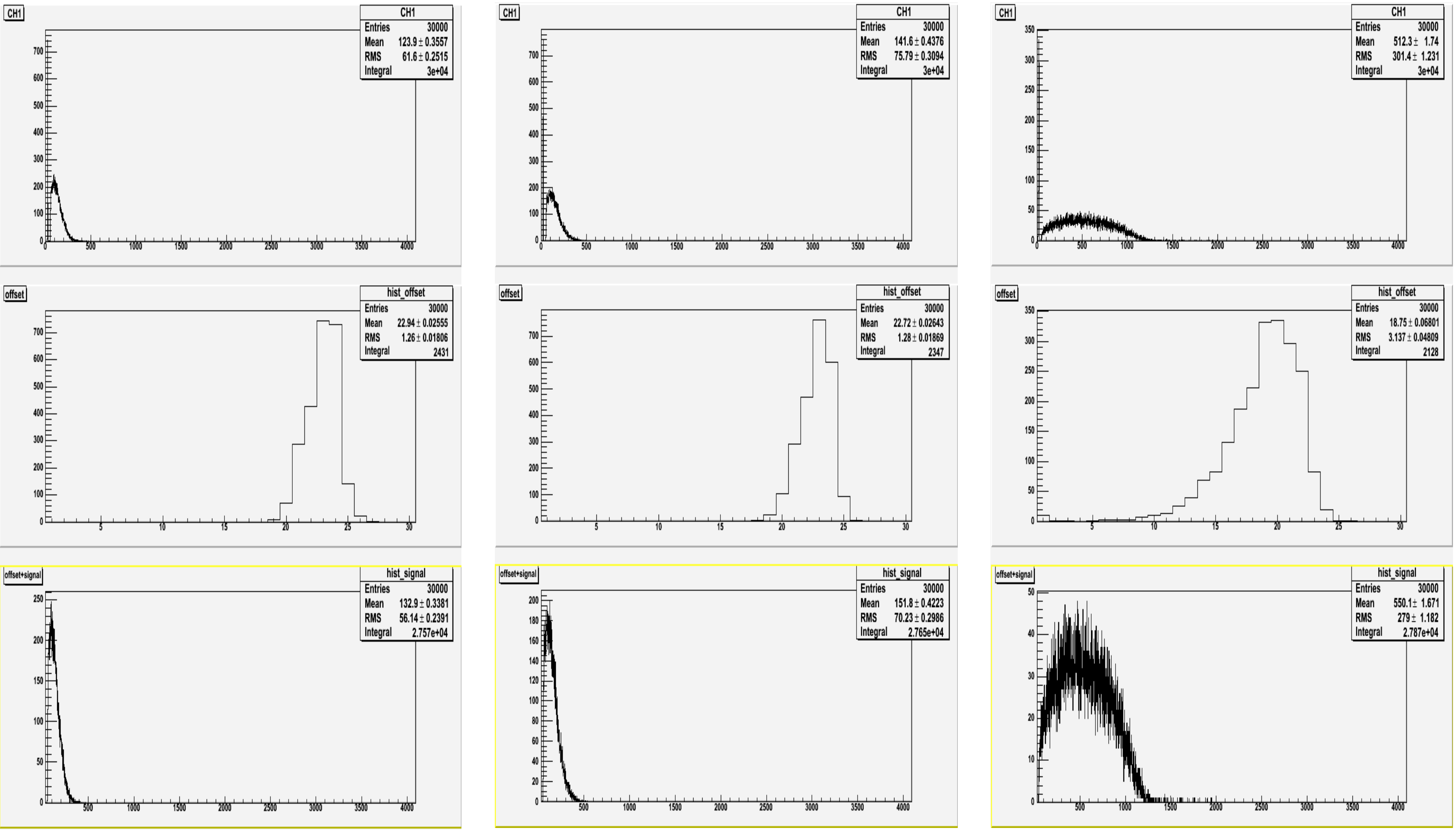
30 Gauss Transverse Field

No shielding | With shielding (0cm) | With shielding (3cm)



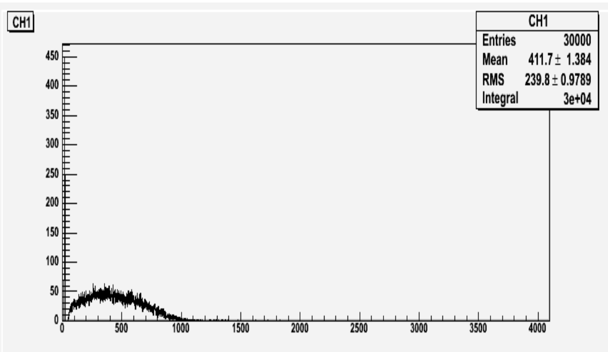
30 Gauss Axial Field

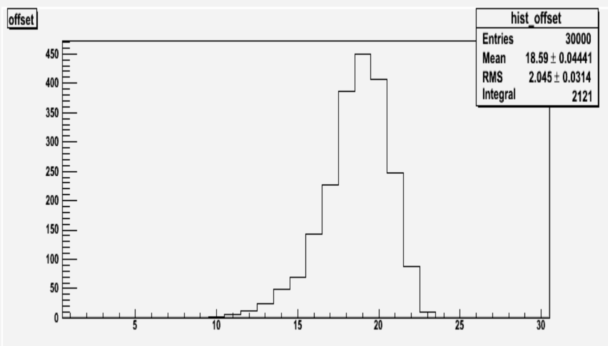
No shielding | With shielding (0cm) | With shielding (3cm)

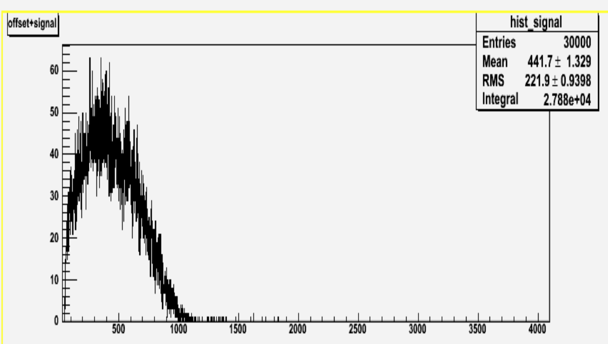


10 Gauss Axial Field

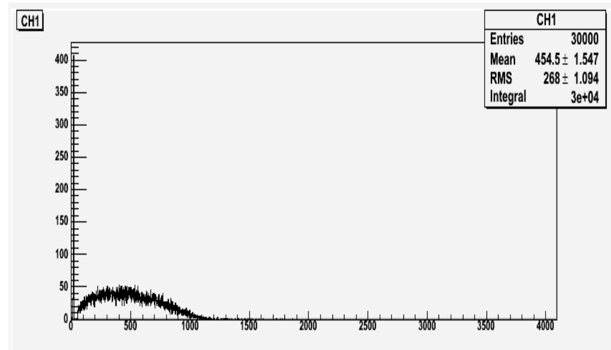
No shielding

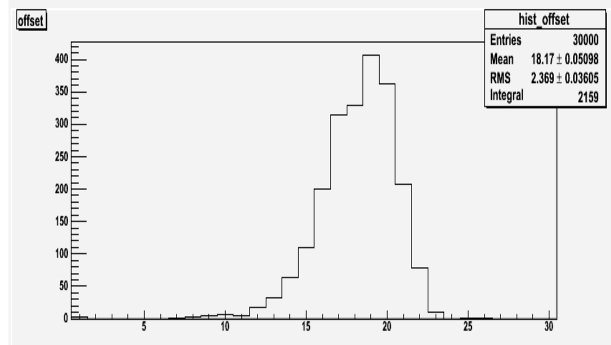


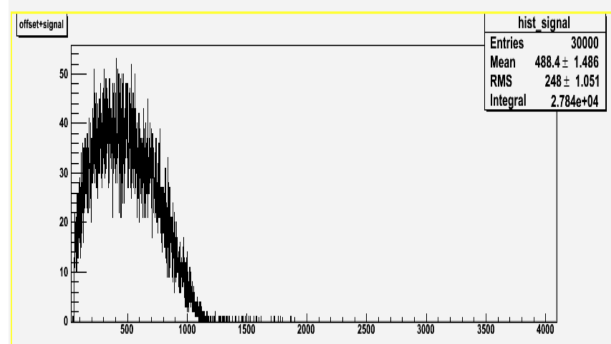




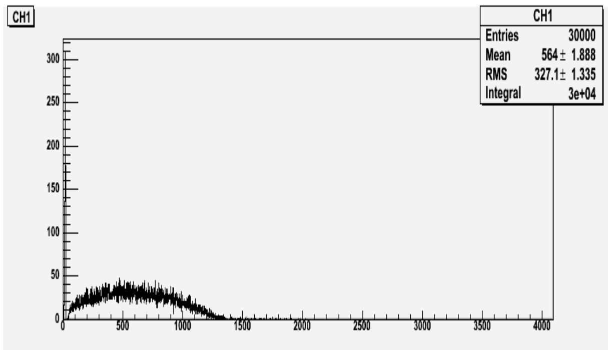
With shielding (0cm)

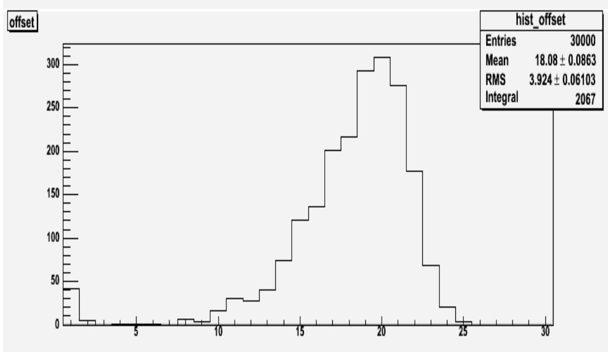


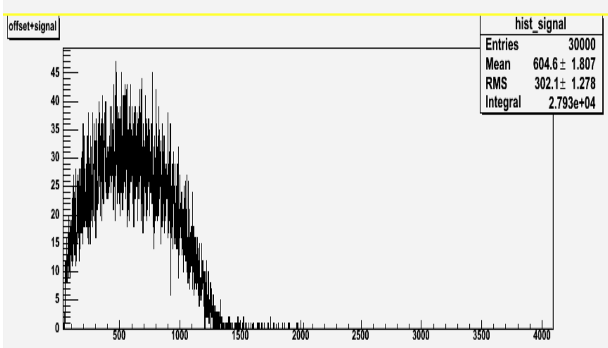




With shielding (3cm)

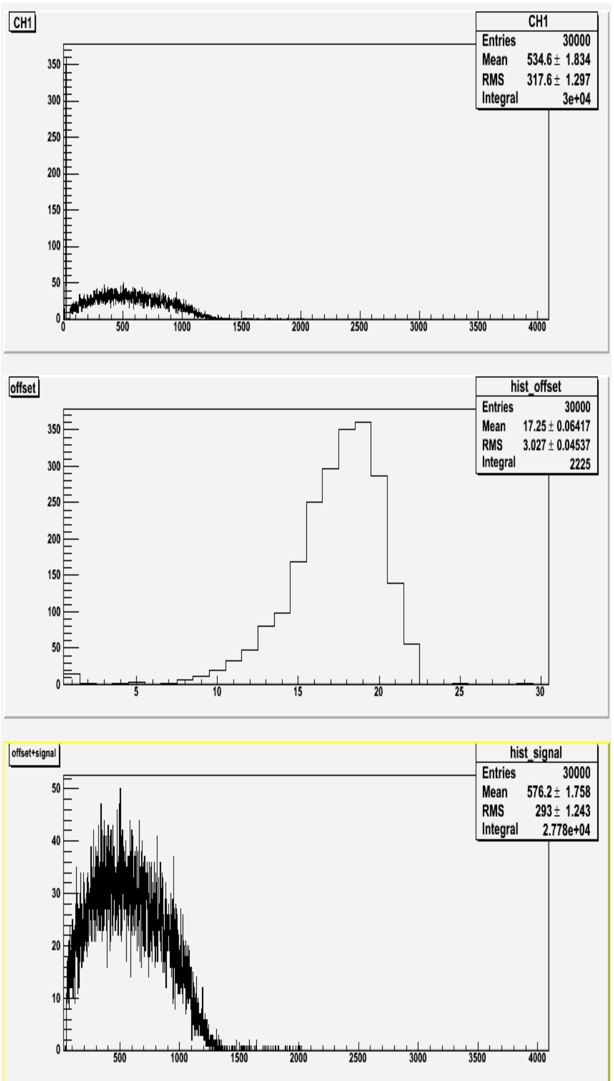




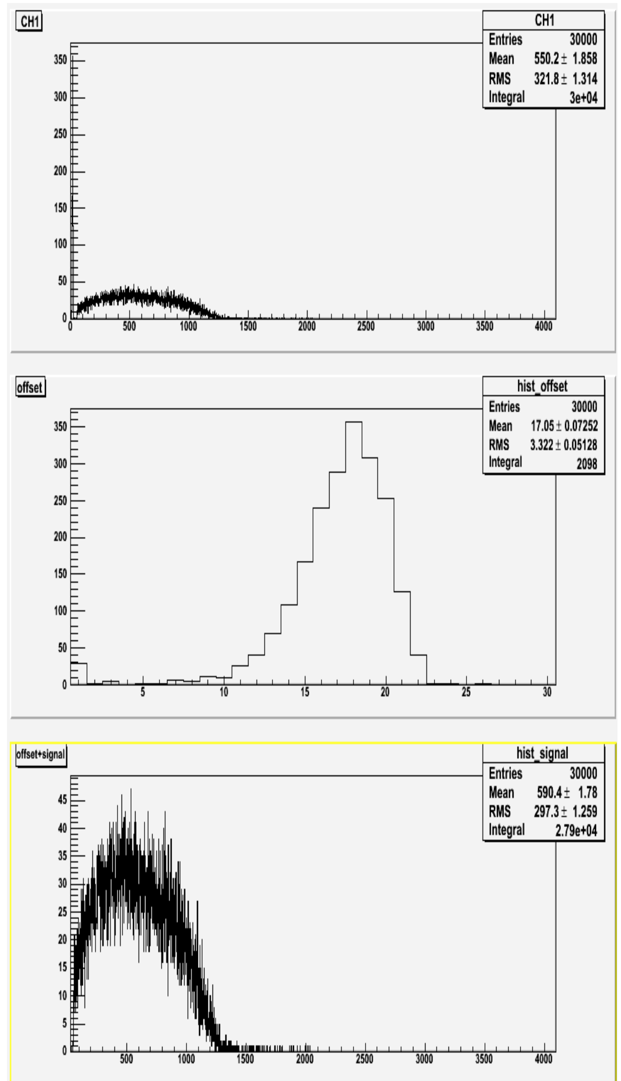


5 Gauss Axial Field

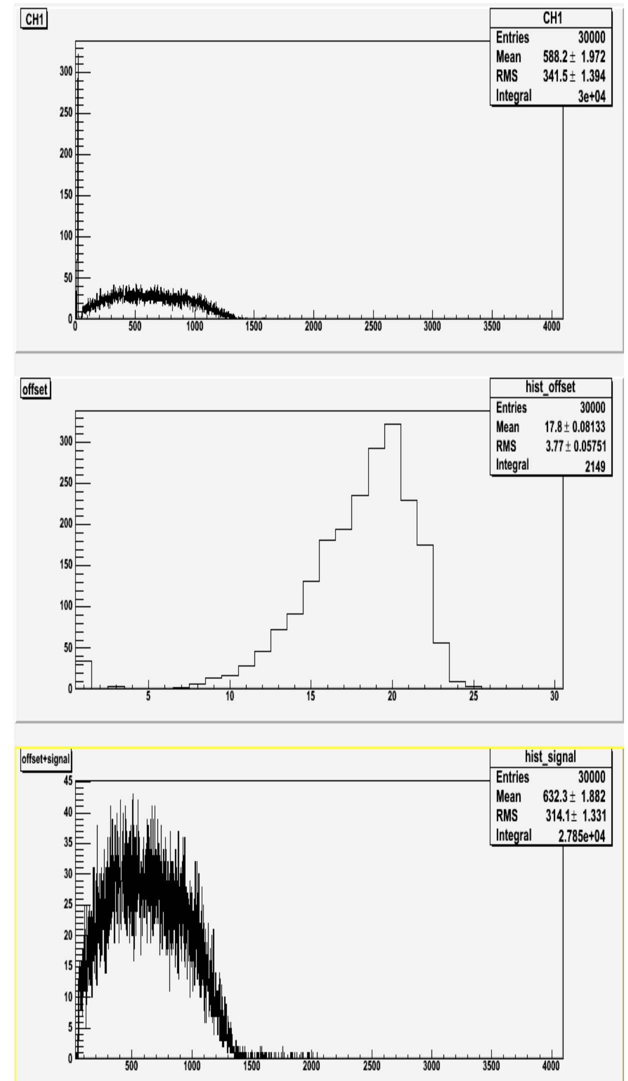
No shielding



With shielding (0cm)



With shielding (3cm)

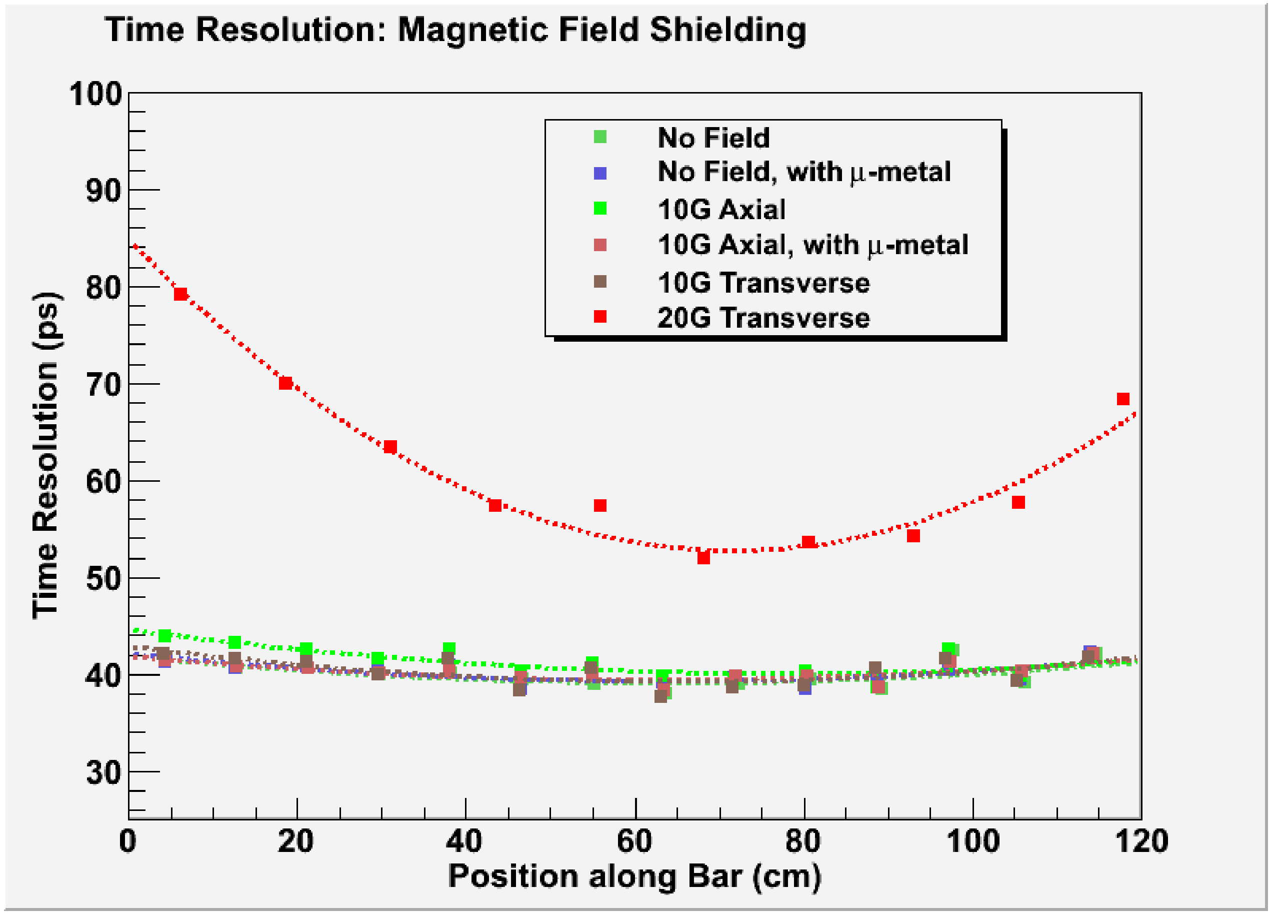


Mu-Metal Shielding against Magnetic Fields

	No Shielding	With Shielding (0 cm depth)	With Shielding (3 cm depth)
No B field	594 +/- 35	594 +/- 35	594 +/- 35
5 Gauss	T: 587 A: 558	T: 585 A: 573	T: 610 A: 614
10 Gauss	T: 600 A: 423	T: 600 A: 470	T: 609 A: 586
15 Gauss	T: 563 A: 272	T: 588 A: 338	T: 590 A: 594
20 Gauss	T: 509 A: 203	T: 573 A: 235	T: 570 A: 568
25 Gauss	T: 295 A: 156	T: 594 A: 176	T: 636 A: 526
30 Gauss	T: 59 A: 110	T: 587 A: 129	T: 604 A: 531

Arjun

Time Resolution in Magnetic Fields

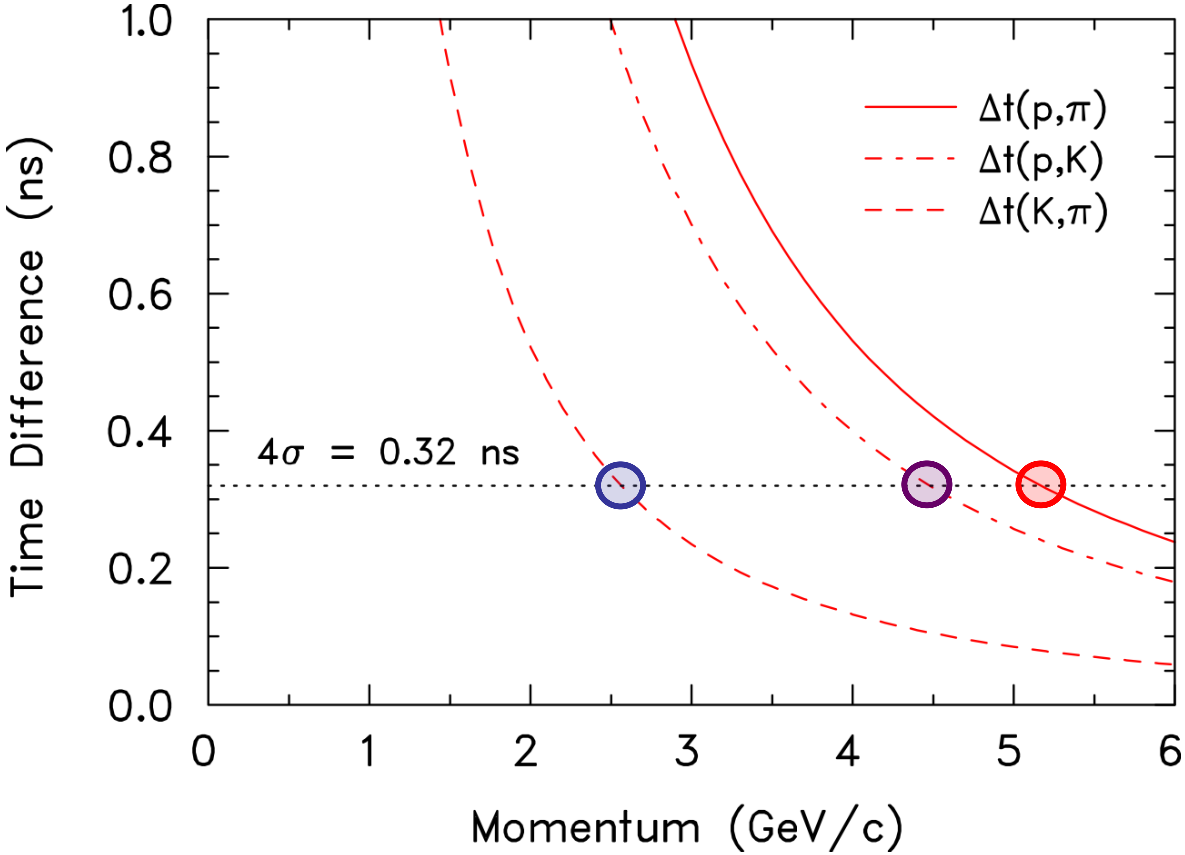


Hamamatsu R9779 PMT:

- superior time resolution
- time resolution is insensitive to signal degradation and threshold
- extremely compact
- built-in shielding effective in transverse magnetic fields

Evan and Robert

Design Requirements



To achieve

Proton-Pion separation up to 5.3 GeV/c

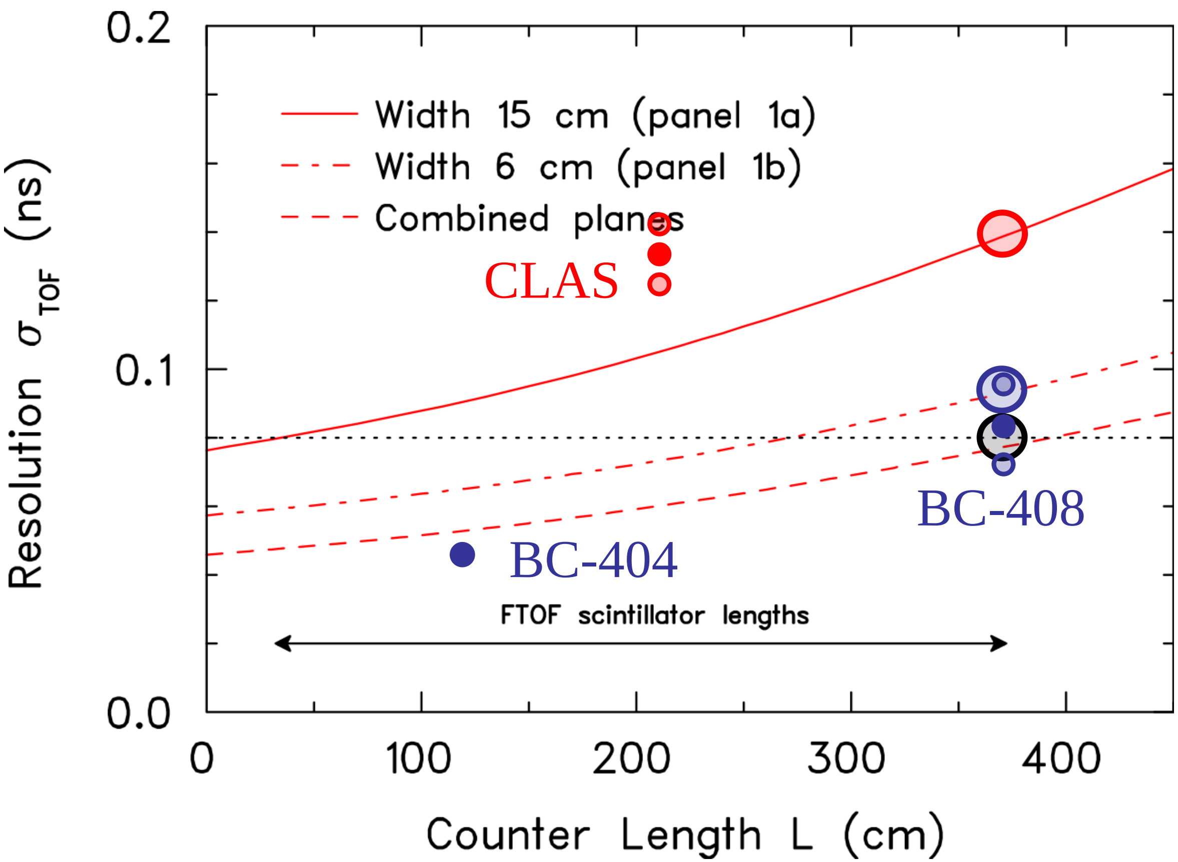
Proton-Kaon separation up to 4.5 GeV/c

and

Kaon-Pion separation up to 2.6 GeV/c

an improved timing resolution of $\sigma \sim 80$ ps is needed

Design Requirements and Results



With a resolution for the longest scintillators of

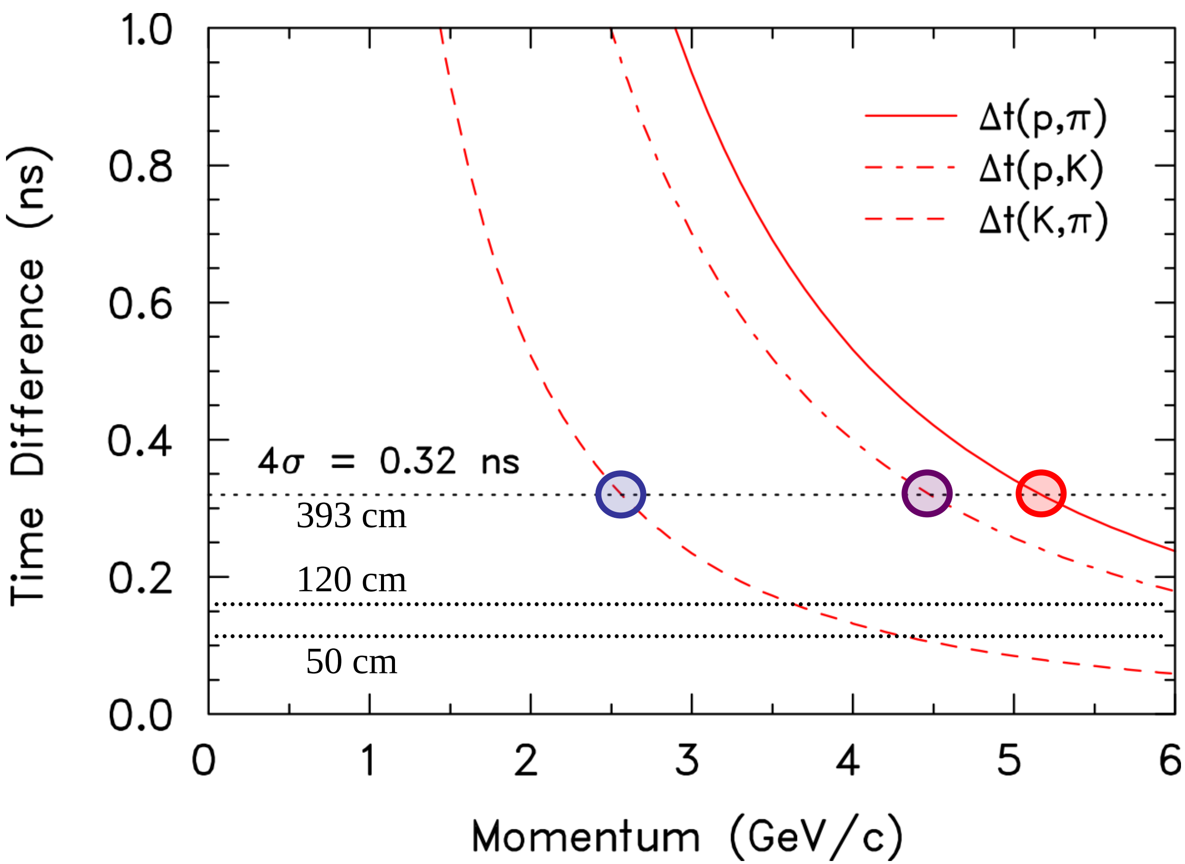
better than ~150 ps for the current FTOF panel

and

better than ~95 ps for the new FTOF panel

a combined timing resolution of σ ~ 80 ps can be accomplished

Design Requirements



To achieve

Proton-Pion separation up to 5.3 GeV/c

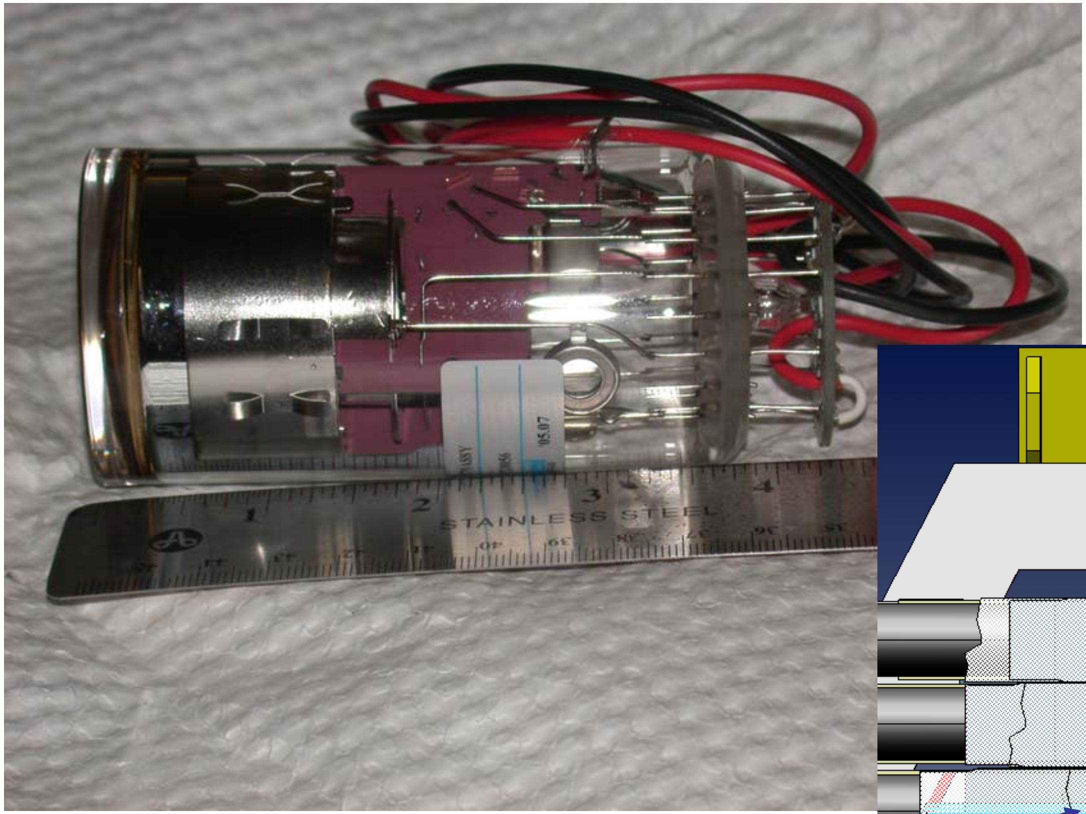
Proton-Kaon separation up to 4.5 GeV/c

and

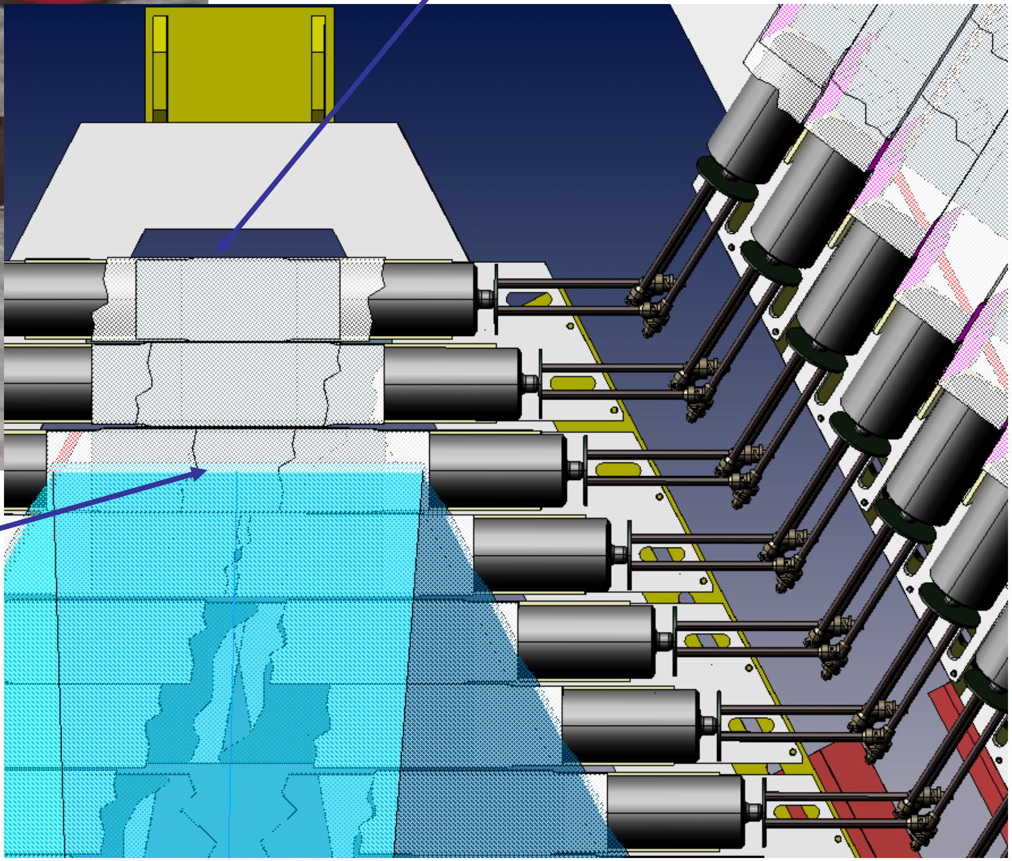
Kaon-Pion separation up to 2.6 GeV/c

an improved timing resolution of σ ~ 80 ps is needed

Small Angle Coverage



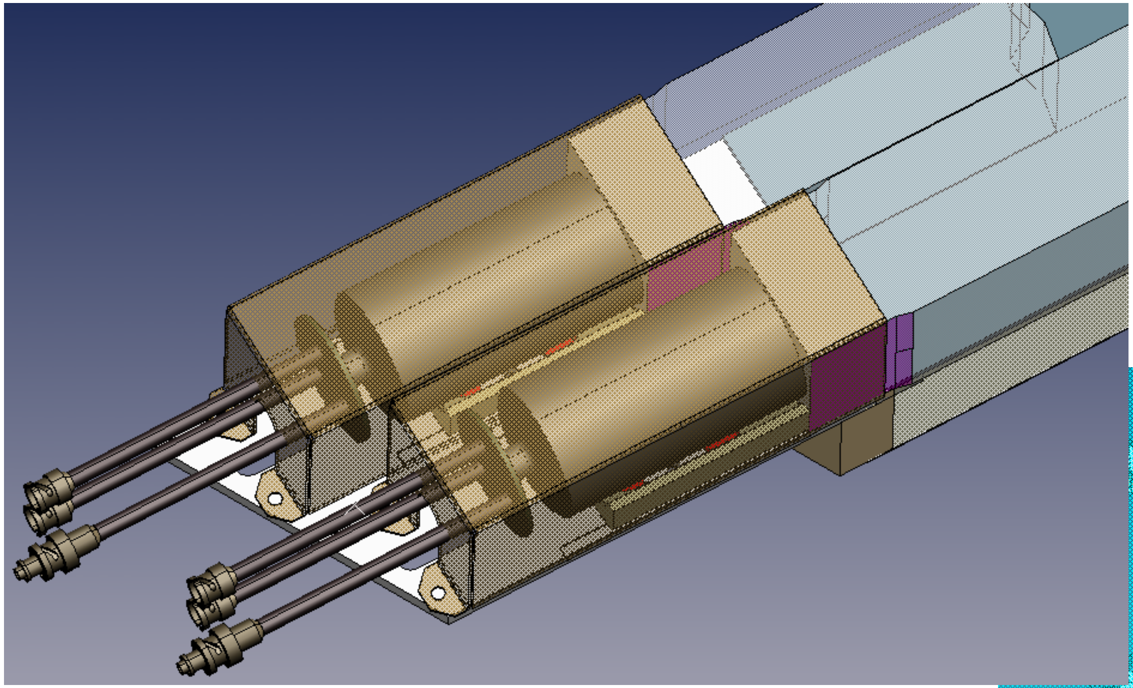
Increased acceptance for in-bending particles

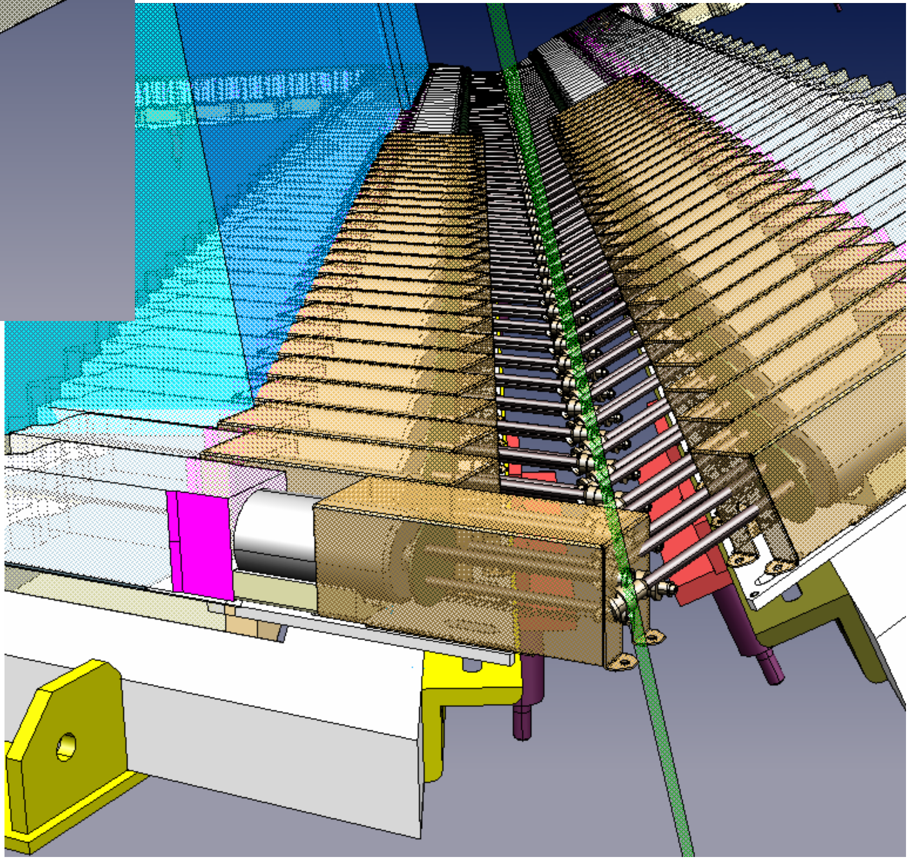


5^{o} straight line shadow

Jlab Designers

Magnetic Fields and Shielding

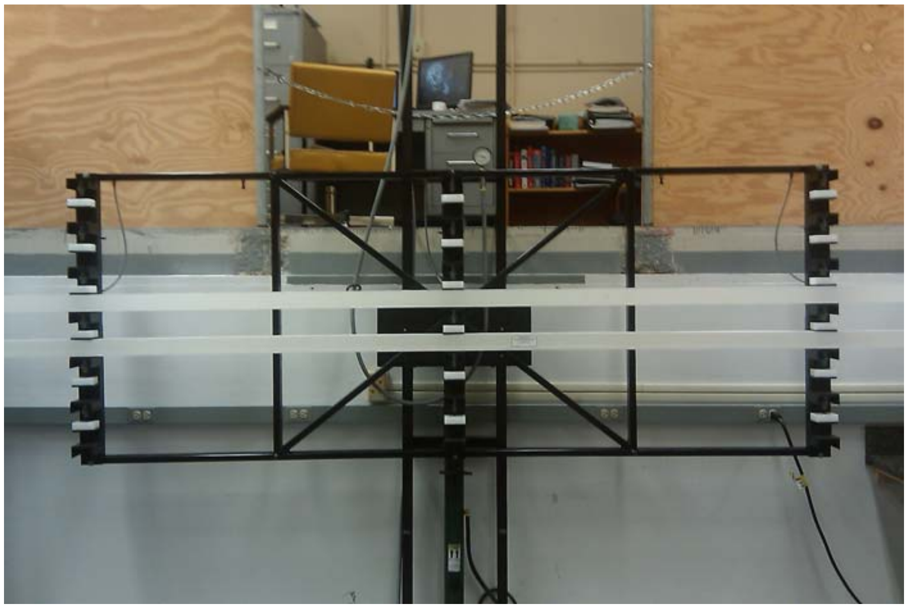




Jlab Designers

FTOF Preconstruction Details

- Prototype backing structure and support frame have been studied at USC to finalize how panel-1b counters will be supported and to finalize the counter lengths.

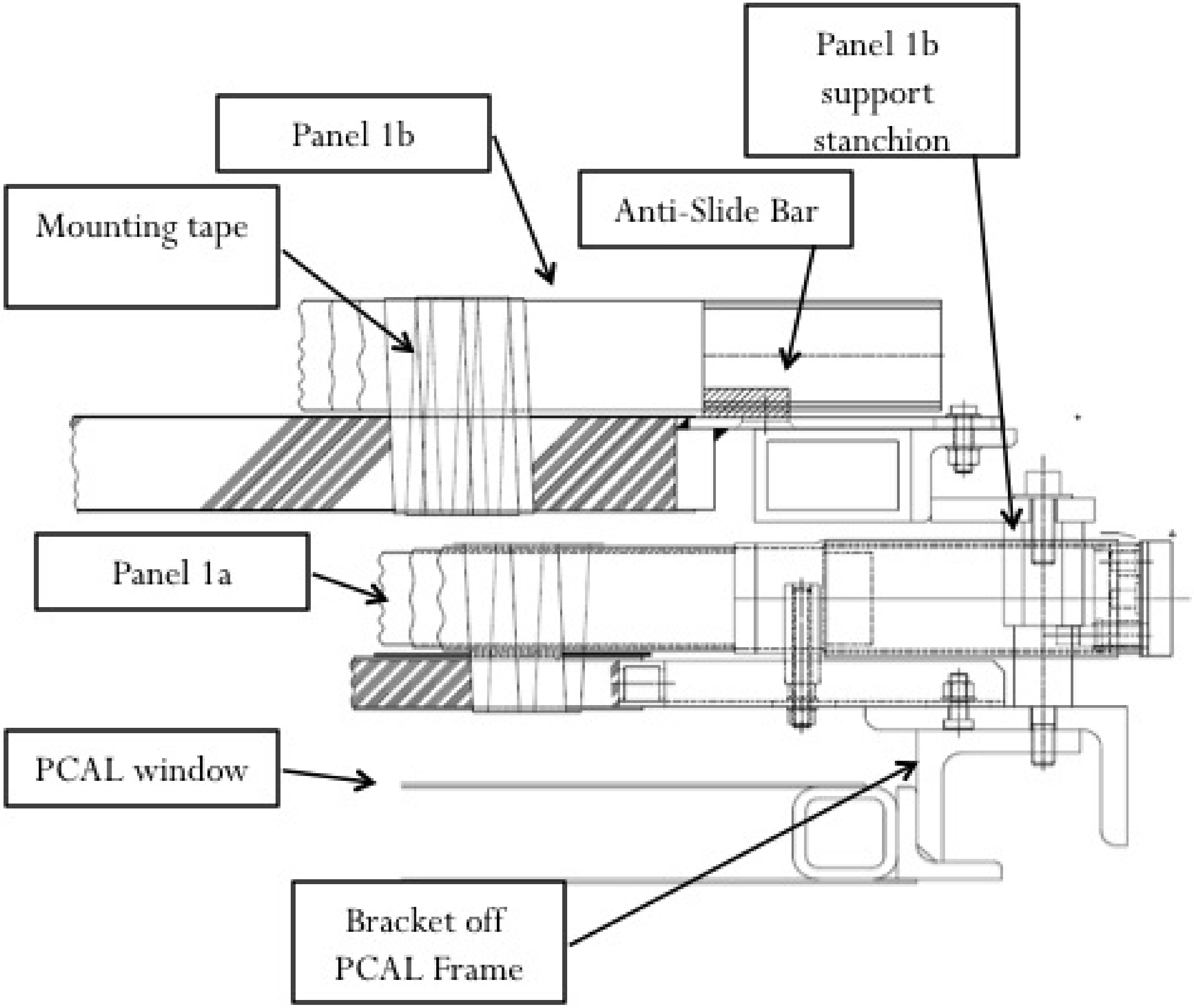


Counter Construction "Windmill"

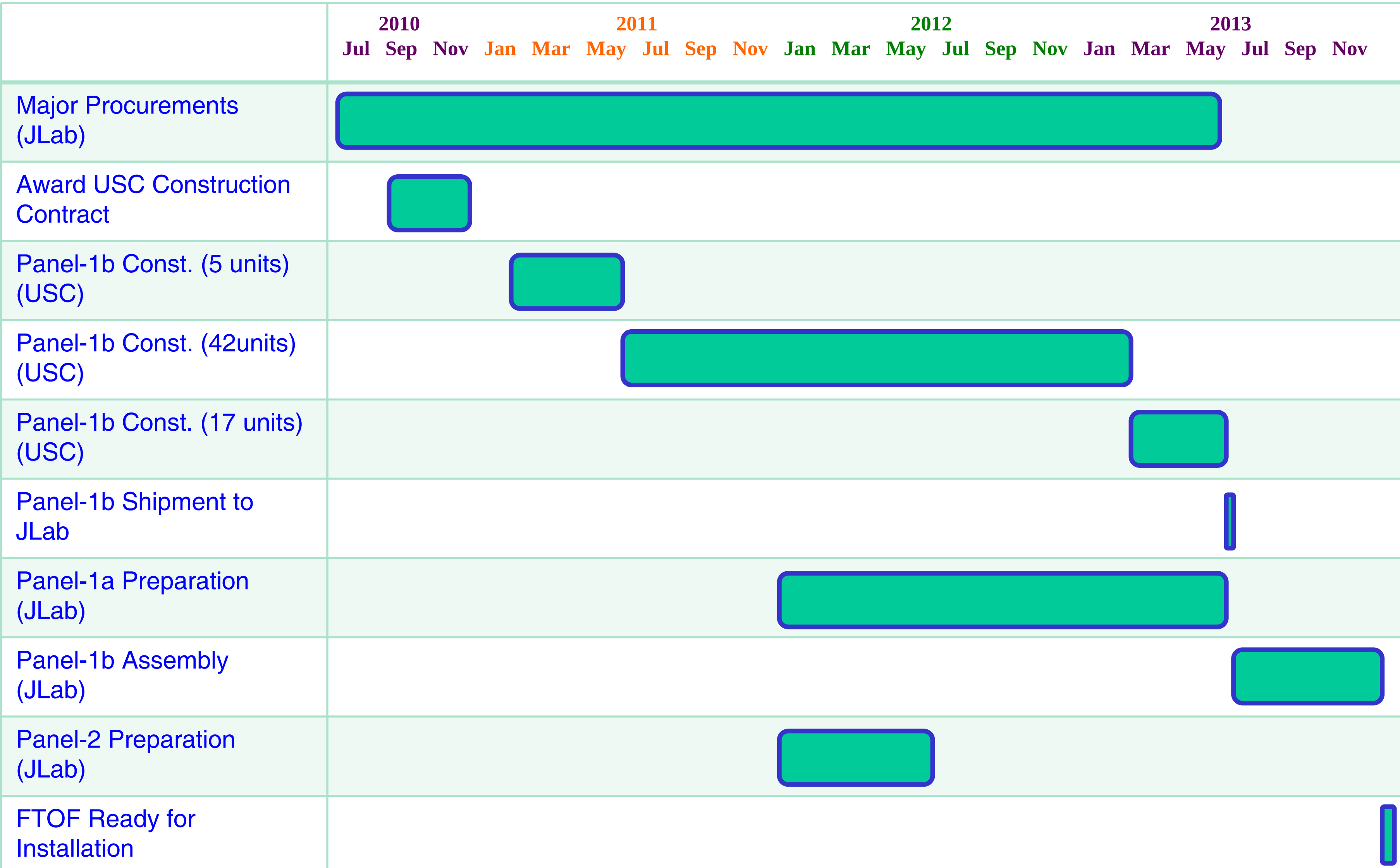
Backing structure & frame prototype

- USC preparing manpower and equipment for mass-production of the Panel-1b counters. Lab space also being prepared for production and storage.

Panel-1a/1b Mounting



FTOF Construction Schedule

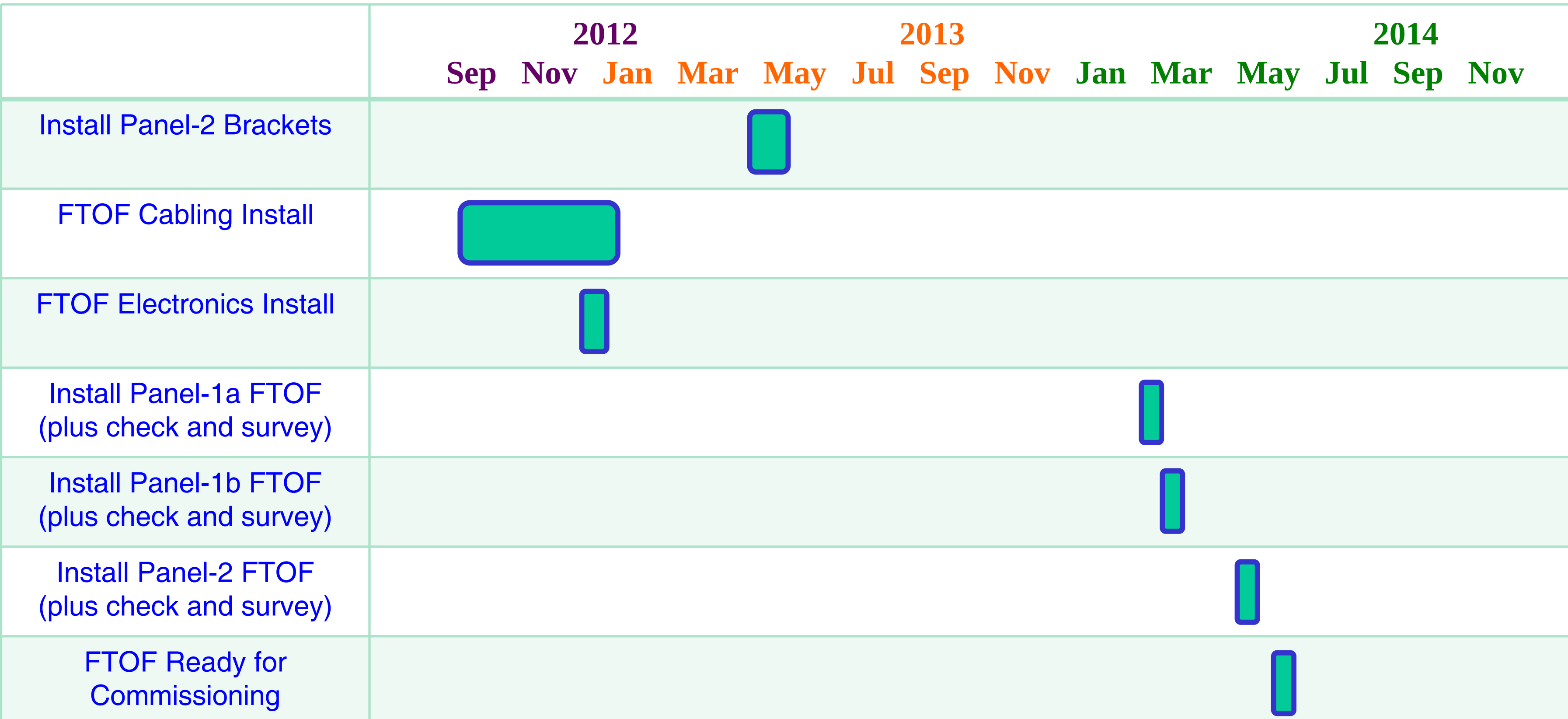


FTOF Major Procurements

Procurement	Status
PMT / Divider Assemblies Panel-1b	Contract with Hamamatsu in place; first article testing First production shipment due 2/1/11.
Scintillation Material Panel-1b	Contract with Saint-Gobain in work; first article testing First production shipment due 2/1/11.
Backing Supports	Procurement preparation in progress.
High Voltage Cables	Procurement preparation in late 2012.
Signal Cables	Procurement preparation in late 2012.
Support Frames	Procurement preparation in late 2012.
Divider Adaptors	Procurement preparation in late 2012.
Panel-1a/2 Modifications	Procurement preparation in early 2012.

Total FTOF Budget	**$2,429,109**
Procurements (Major)	$1,647,300 ($520,000 costed, $1,283,600 obligated)
JLab Labor	$353,473
USC Contract	$387,336
Misc.	$41,000

FTOF Installation Schedule



FTOF Construction

- The construction MOU with the University of South Carolina is nearly in place. Awaiting final signatures.
- The construction contract for the panel-1b counters assembly and construction is nearly in place. Negotiations ongoing with the University of South Carolina. Contact expected to be in place by the end of October.
- Major procurements are nearly in place for the panel-1b PMTs, dividers, and scintillation bars. Procurements for backing structures for panel-1b now underway.
- Panel-1b scintillation bar assembly begins in February 2011 at USC.
- Careful review and update of FTOF costs and schedules completed in May 2010.

FTOF Responsibilities & Manpower

University of South Carolina:

Responsible for panel-1b counter assembly and testing at USC and panel-1b panel assembly and testing at JLab. Will assist CLAS12 Collaboration with commissioning activities.

- Ralf W. Gothe – FTOF principal investigator
- Gleb Fedotov, Slava Tkachenko – postdoctoral researcher
- Graduate Students (4)
- Undergraduate Students (8)

Jefferson Laboratory:

Responsible for design of panel-1b system and support, panel-1a and 2 modifications and support. Responsible for major procurements, deinstallation, reconfiguration, and testing of panel-1a,2. Will assist with panel-1b assembly and testing at JLab. Responsible for installation.

- Daniel Carman – FTOF group leader
- Dave Kashy – Lead engineer
- Sergey Boyarinov – DAQ scientist
- Mechanical and electrical technicians