Physics
Hall D
WBS 1.5

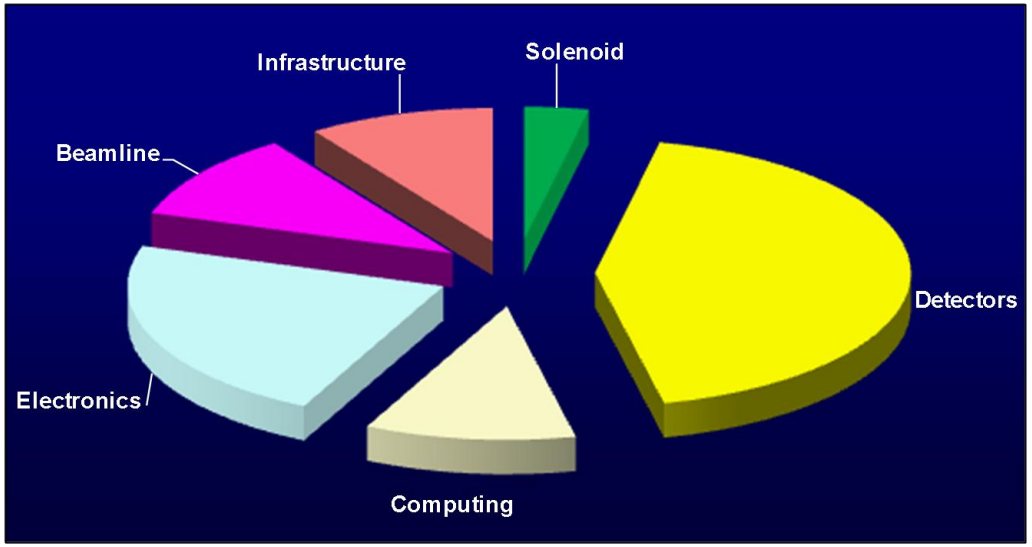
Eugene Chudakov

Independent Project Review of 12 GeV Upgrade
Jefferson Lab
September 22-24, 2009

Outline

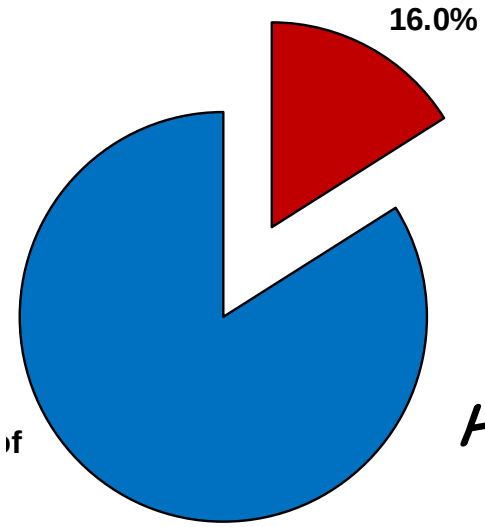
- Introduction to Hall D
  - Scope description
  - Cost summary, changes since 2008
  - Physics goals, technical solutions
- Project Status
  - Progress with the subsystems PED/Construction
  - Design Reviews
  - Schedule
  - APPs
  - Labor
  - MOUs
  - Risk Management
- Summary

1.5 Cost Construction



Construction

WBS	System	FY09$k Direct
1.5.1	Solenoid	1231
1.5.2	Detectors	12217
1.5.3	Computing	2954
1.5.4	Electronics	6210
1.5.5	Beamline	3086
1.5.6	Infrastructure	3429
1.5	Total	29127



Hall D construction: 16% of total

Hall D Cost Delta

WBS	Hall D	FY09$K Direct IPR 2008 Costbook *	IPR 2009 Costbook **	Delta	Reasons for Changes
1.5.1	Solenoid	902	1,232	331	*magnet controls added*
1.5.2.	Detectors	11,862	12,217	354	Scintillating Fibers (-$111k)
1.5.3.	Computing	2,954	2,954	0	
1.5.4.	Electronics	6,211	6,210	0	*procurement drawings*
1.5.5.	Beamline	2,900	3,086	186	
1.5.6.	Infrastructure	2,622	3,429	806	*Work Coordinator*
1.5.	**Total**	**27,451**	**29,127**	**1,676**	Manpower plan revised

* IPR 2008 Costbook, dated June 30, 2008

** IPR 2009 Costbook, dated June 30, 2009

Contract Awards since June 30, 2009:

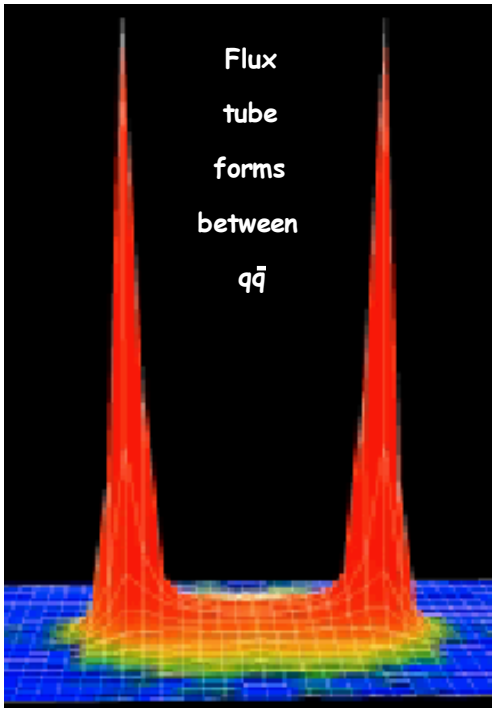
+ $148k University of Regina-BCal Fab (CR09-043)

Hall D Introduction

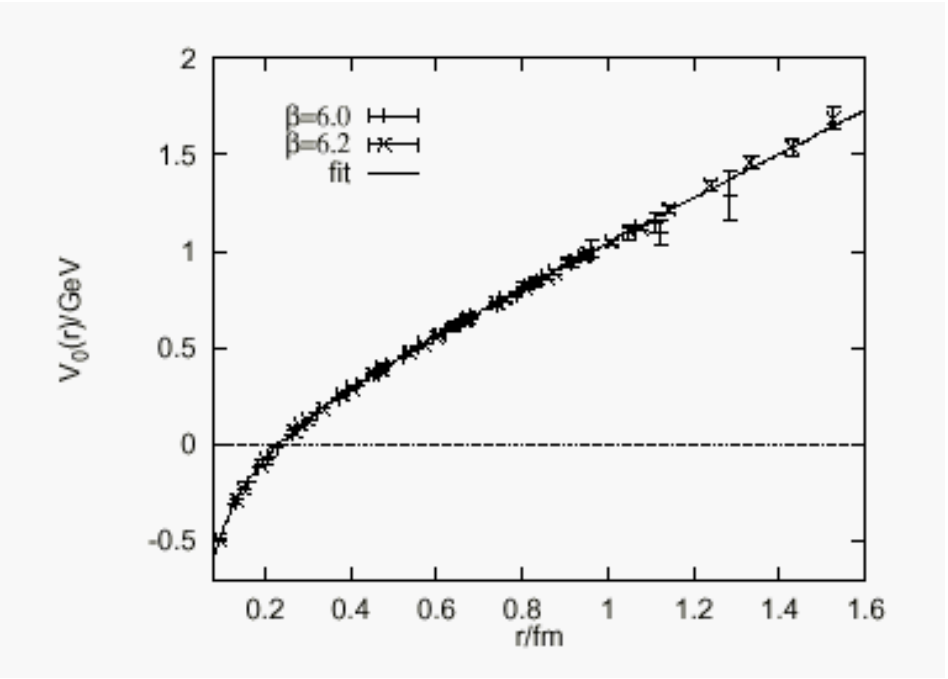
- **Mission:**
  - Search for gluonic excitations in the spectra of light mesons (predicted in QCD)
- **Scope – new beamline and experimental hall:**
  - Tagged photon beam, linearly polarized at ~ 9 GeV
  - Detector:
    - nearly hermetic for charged particles / photons
    - good momentum/energy resolution
    - pipeline readout electronics, high DAQ rate ~ 200kHz

Physics: QCD

- Concept of color flux tube is supported by LQCD

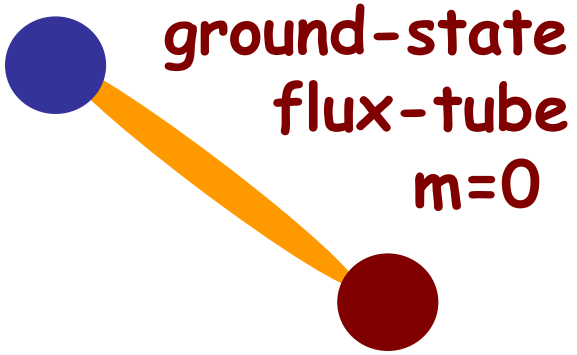


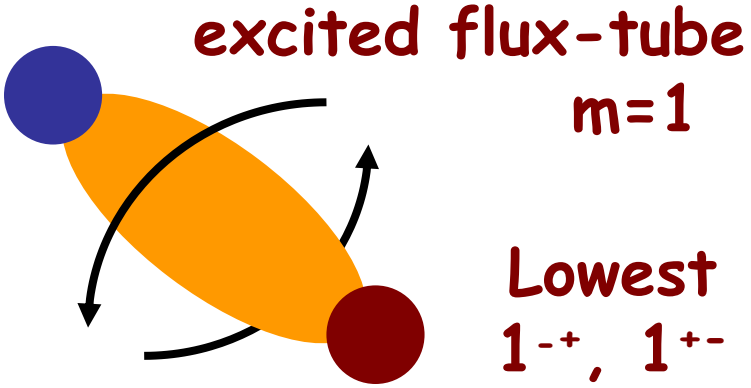
LQCD



Explanation of confinement

Physics: Flux Tube Signature





Conventional mesons **Hybrid mesons**

Regular quantum numbers

0^{-+} : π,η,K 1^{--} :ρ,ω,K^* 1^{++} 1^{--}

1^{+-} : h_1,b_1,K_1 0^{++} : a_o,f_o,K^*_o

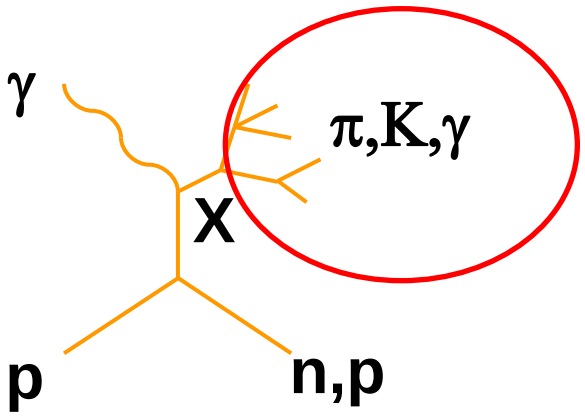
Exotic quantum numbers

1^{-+} 2^{+-} 0^{+-}

Hybrid mass spectrum → QCD probe

Search for QCD Exotics-Hybrid Mesons

Photoproduction



$\pi_1\ \eta_1\ \eta'_1$ 1^{-+} $b_2\ h_2\ h'_2$ 2^{+-} $b_0\ h_0\ h'_0$ 0^{+-}

$\eta_1 \rightarrow a^+_1\pi^- \rightarrow (\rho^o\pi^+)(\pi^-) \rightarrow \pi^+\pi^-\pi^+\pi^-$

$h_0 \rightarrow b^o_1\pi^o \rightarrow (\omega\pi^o)\gamma\gamma \rightarrow \pi^+\pi^-\gamma\gamma\gamma\gamma\gamma\gamma$

$h'_2 \rightarrow K^+_1K^- \rightarrow \rho^o K^+ K^- \rightarrow \pi^+\pi^-K^+K^-$

Exotics vs regular:

π^-p: ≈ 1%

γp: ≈ 10%

γ can be linearly polarized!

helps to identify the quantum numbers

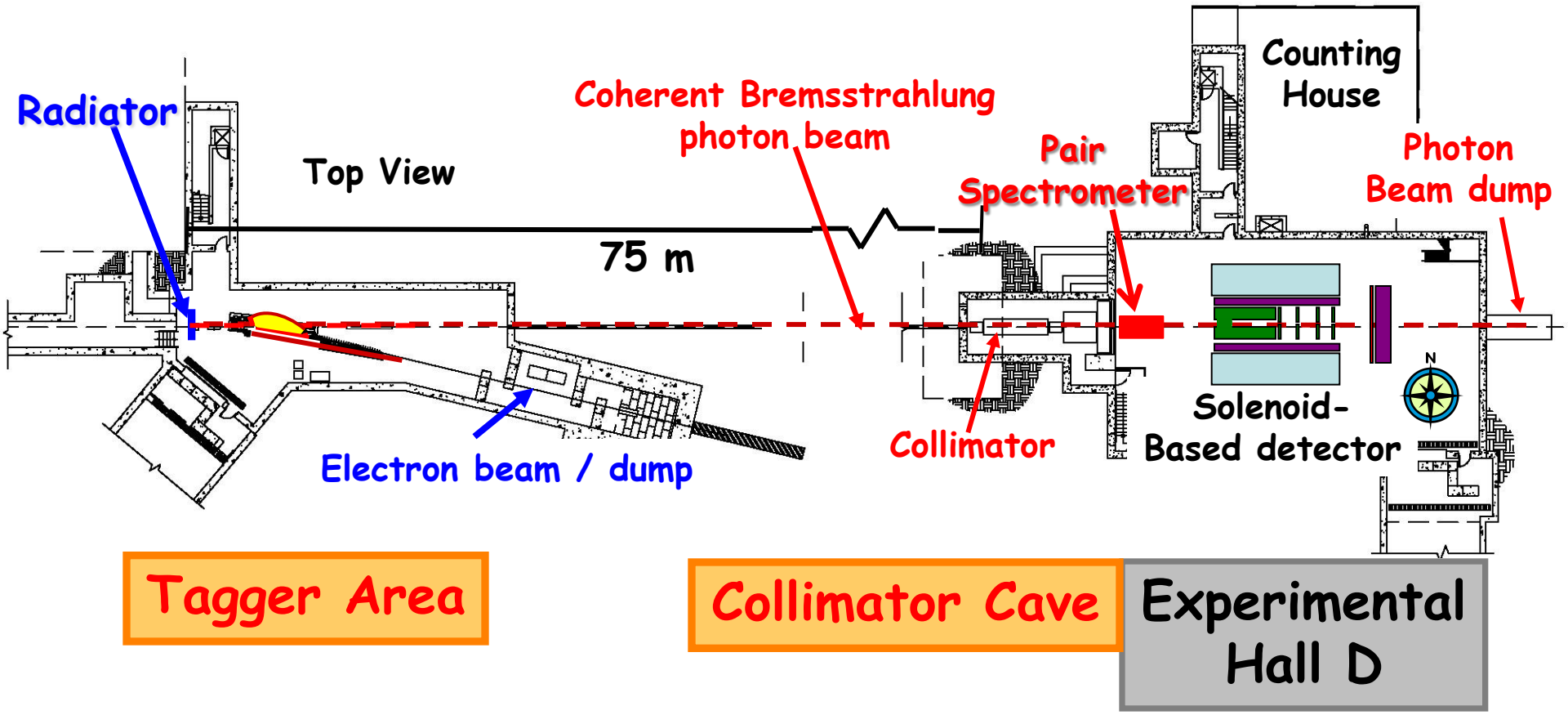
Multiparticle final states:

$\pi^\pm\ K^\pm\ \gamma\ p\ \ n\ K_L$

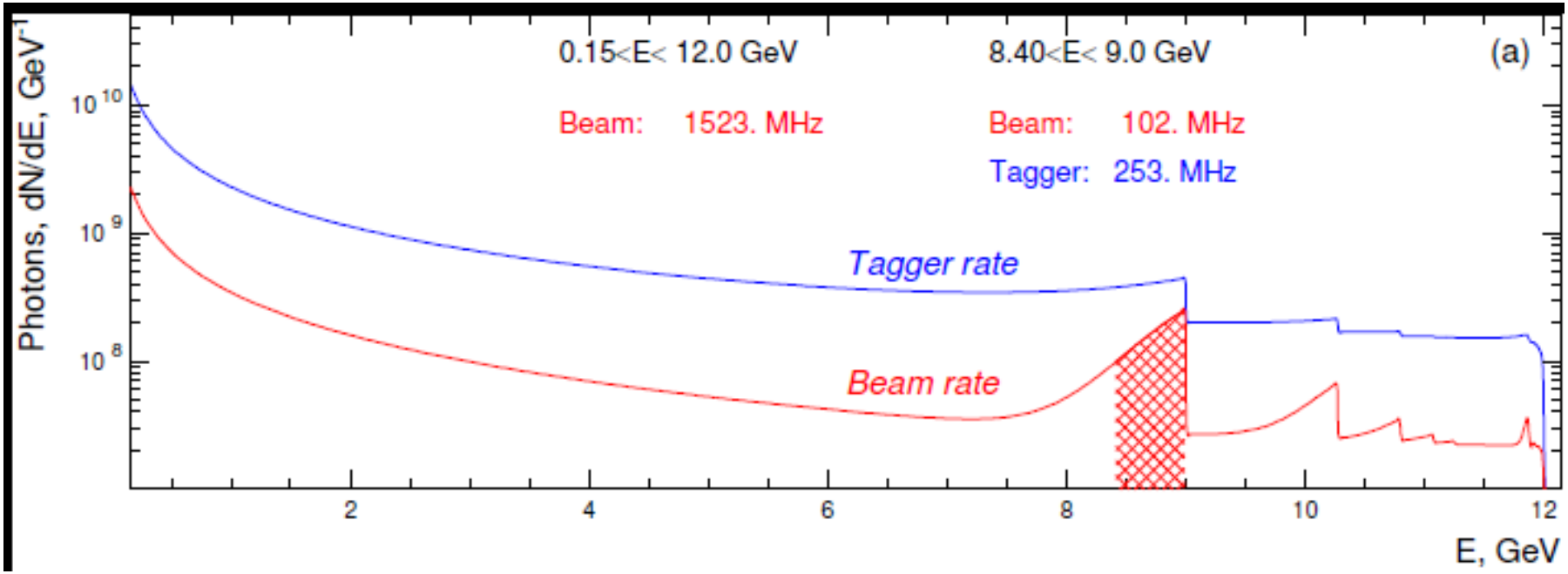
A Detector for Spectroscopy

- Requirements:
  - Experimental Program: light meson spectroscopy
    - photon beam of ~ 9 GeV/c, linearly polarized
      - sensitivity to masses < 2.5 GeV/c
      - sweet spot for high luminosity and polarization
      - linear polarization → access to parity
    - Detector requirements:
      - nearly hermetic detector for charge particles and photons
      - medium resolution: momentum (~ 1-4%), energy (2-20%)
      - identification of charged particles and π^0
      - high luminosity → high rate DAQ
- Design solutions
  - Solenoidal magnet
  - Drift chambers, electromagnetic calorimeters, TOF
  - Pipeline front-end electronics and DAQ

Photon beam and experimental area

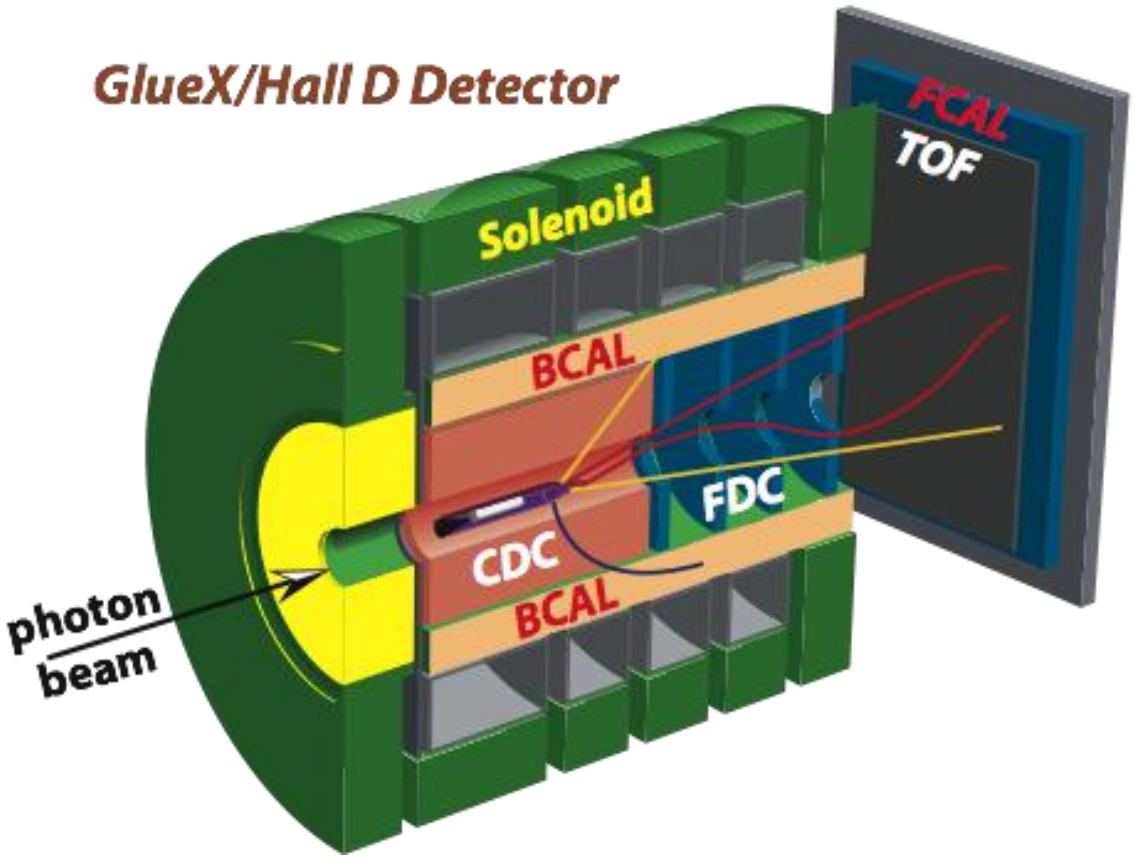


Linearly Polarized Photon Beam



- 12 GeV electron beam
- diamond radiator 20 μm accurately aligned
- coherent Bremsstrahlung: 8.4 – 9 GeV at <25 μrad
- collimation d=3.5mm at 75m, peak area:
  - 40% linear polarization
  - 100 MHz photons at 2.2 μA

GlueX/Hall D Detector



BCAL - barrel calorimeter
FCAL- forward calorimeter

CDC - central drift chamber
FDC - forward drift chambers

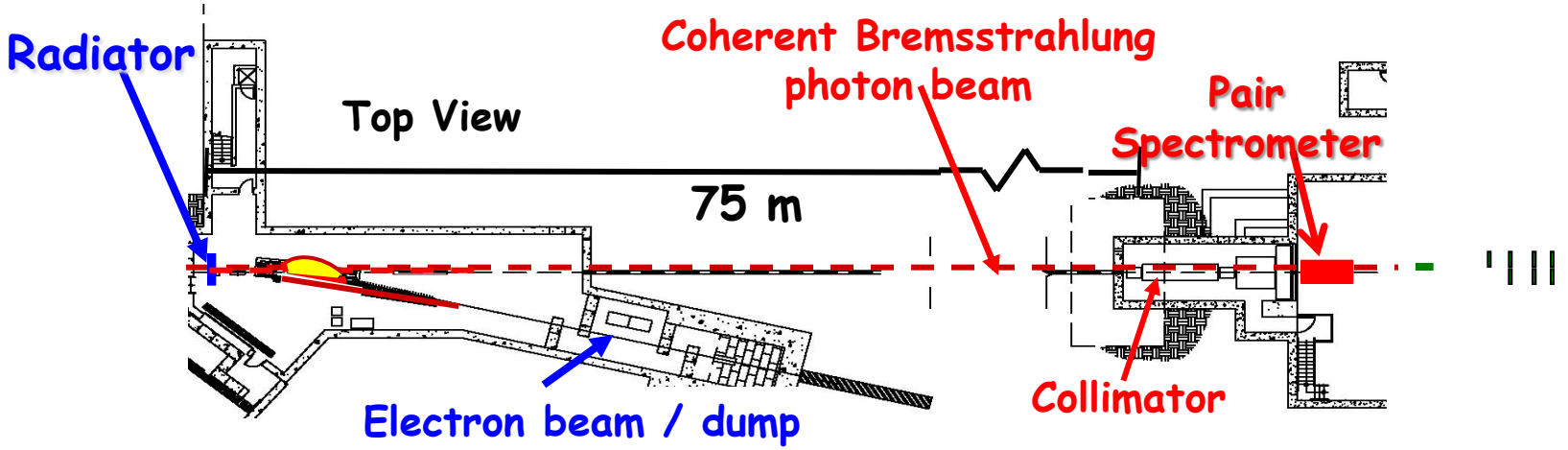
TOF - time-of-flight

Reviews

2008 IPR – *no open recommendations*

Date	Convened	Title of the review	Total	Open
2004 Oct	JLab	Hall D Detector		0
2006 Jan	JLab	Hall D Tagging spectrometer		0
2007 Mar	JLab	Hall B/D Drift Chambers		0
2008 Feb	Hall D	Hall D FDC mini	0	0
2008 Feb	JLab	Hall D Calorimeter	3	1
2008 Mar	JLab	Hall D Drift Chamber and PID	0	0
2008 May	JLab	Hall B/D Systems	0	0
2008 July	DOE	IPR Lehman review	0	0
2008 Oct	JLab	Hall D Beamline and Tagger	0	0
2009 Feb	JLab	Hall D Installation	3	1
2009 July	Hall D	Hall D Tagging Magnet	9	9
2009 July	Hall D	Hall D BCAL Readout	2	2

Beamline Elements

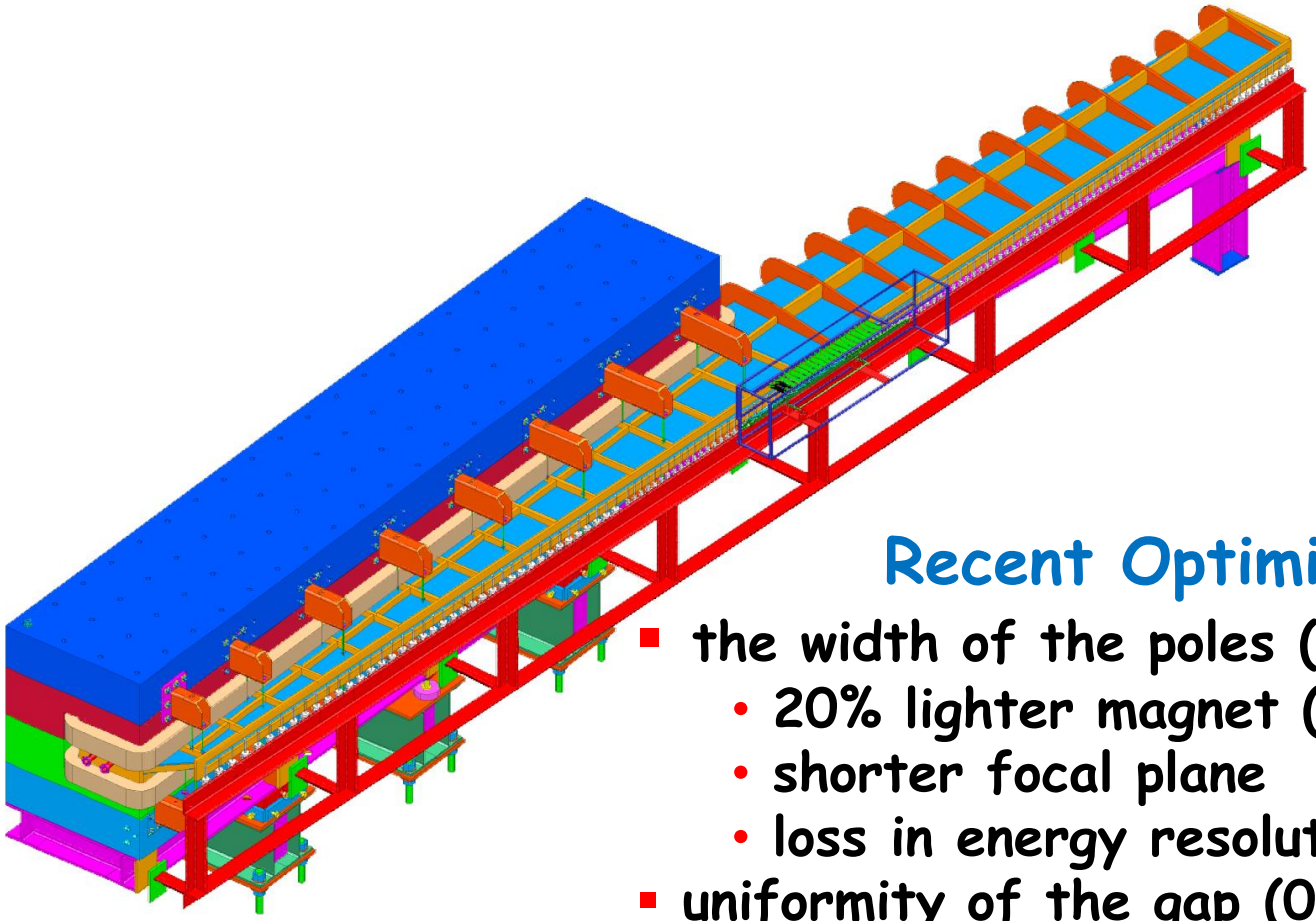


- **Tagger:** measure momenta of radiated electrons: σE(γ) ~ 0.1%
  - Dipole magnet: 6m x 1.5T, 12 GeV bend 13.5°, FY11-12
  - Fixed 140 counters + PMTs, 3-11.6 GeV, FADC+TDC, FY12
  - Movable 124 counters + SiPMs, 8.4-9 GeV, FY12
- **Diamond radiator:** 20 μm thick, FY11-12
- **Pair spectrometer:** measure E_γ after the collimator
  - Magnet 6x30x70" from BNL, FY11-12
  - Hodoscope 40 counters with PMTs, FY12
- **Miscellaneous:** collimators, beam diagnostics, FY12

Reviews of the Beamline Components

- Beamline and Tagger final design review, Oct 2008:
  - Findings:
    - 2 tagger magnets replaced by 1 magnet - endorsed
    - Pair Spectrometer concept - validated
  - Recommendations: none
- Tagger magnet, Hall D convened review, July 2009:
  - Charge:
    - evaluate the specifications
    - recommend on procurement (build-to-print or performance)
    - evaluate the ES&H considerations
  - Recommendations (9 in total):
    - improve the magnetic field specification - *in progress*
    - update mechanical requirements - *in progress*
    - consider calibration with particles
    - finish the drawing package on-site

Tagger Magnet: Response to the review



Recent Optimization

- the width of the poles (400mm→340mm)
  - 20% lighter magnet (80t → 64t)
  - shorter focal plane
  - loss in energy resolution (0.02%→0.1%)
- uniformity of the gap (0.2mm→1.0mm)
  - ease of fabrication
  - mechanical measurements required

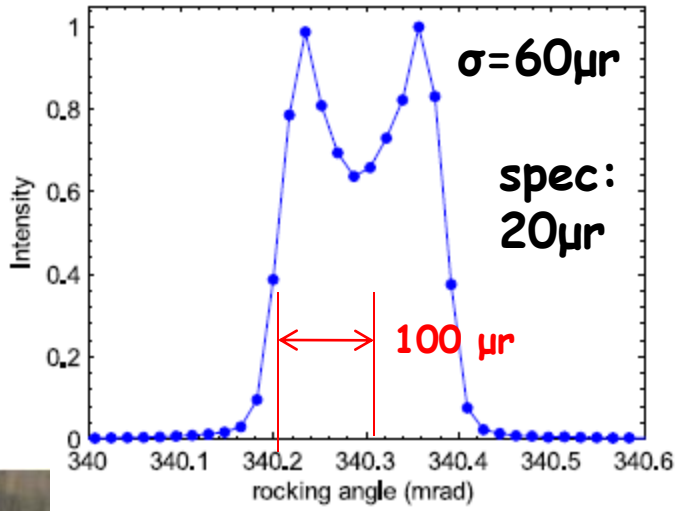
More details on the design: next talk by Tim Whitlatch

Diamond Radiator

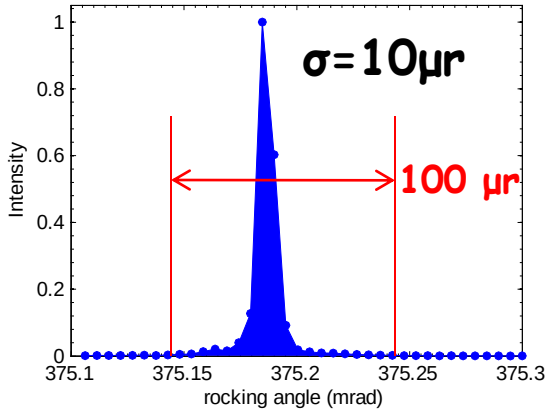
- CVD 4x4x0.4 mm^3 diamond - OK!
- Test at CHESS 2009: holder's vibration
  - redesign the holder (no wires/more wires)
  - Michelson interferometer for checking the holder stability and diamond shape
- Heat load is being analyzed (holder design)
- Diamond thinning by ablation:
  - 248 nm excimer laser at UConn - not used for 10 years - testing needed

Rocking curves

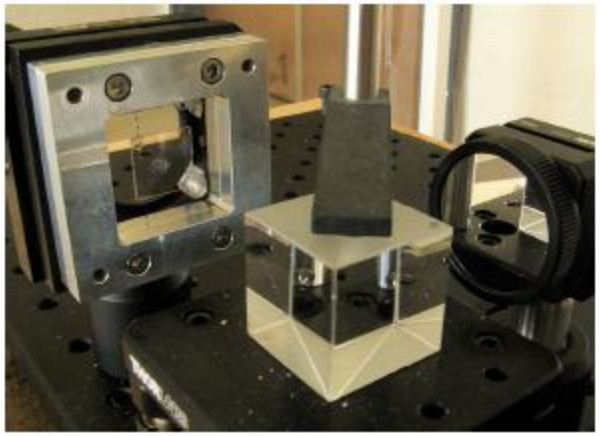
Vibration of the holder



Vibration fixed



Interferometer



Excimer laser

Procurement of diamonds: FY11

Major Detectors Subsystems

- Solenoidal magnet: ID=200cm, B=2 T, L=400cm *FY09-12*
  - The magnet from LASS – is being refurbished (operations)
  - New field configuration – optimization of the yoke elements
- Central Drift Chambers (CDC) *FY09-12*
  - Barrel L=150cm, 28 layers of straw tubes
  - Resolution ~0.15mm, dE/dx
- Forward drift chambers (FDC) *FY10-12*
  - 4 units x6 planes, readout: anode drift, cathode amplitude
  - Resolution ~0.20mm, spatial points in each plane
- Barrel Calorimeter (BCAL) *FY09-12*
  - "SPACAL" 48 modules 4m long, readout from both sides
- Forward Calorimeter (FCAL) *FY10-12*
  - 2800 lead glass blocks 4cm x 4cm
- TOF – 88 plastic scintillators x 2 PMT *FY12*

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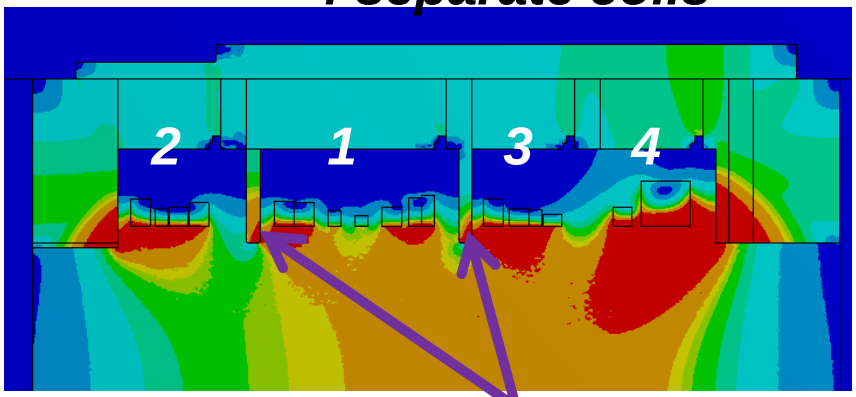
Solenoid



Coil refurbishing on BIA (operations)

- Coil 1 (Jlab) : short fixed, the coil is reassembled
- Coil 3 (IUCF) : new LN2 shield is being installed
- Coil/yoke configuration modified - reevaluation of the forces
  Minimizing the forces and mitigation of potential problems:
  - coils 1 and 2 are swapped
  - steel baffles added to the yoke
  - reinforcement of coil 2 is being evaluated
- Equipment for the controls is being purchased (*12 GeV CR09-27*)
- Preparations for individual coil testing in FY10

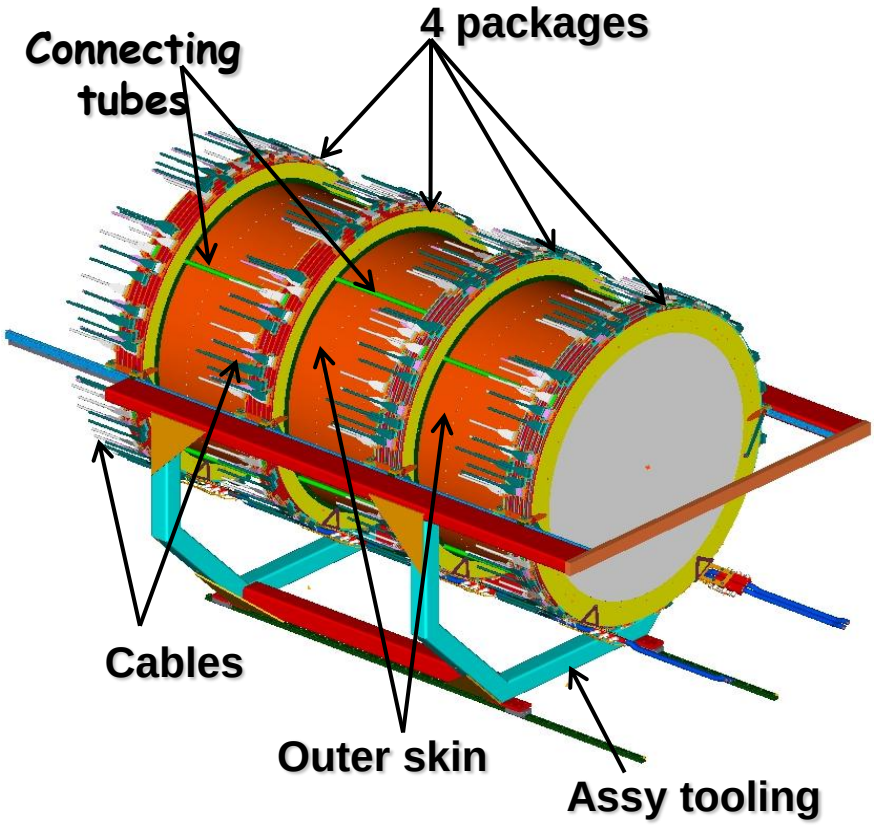
Reviews of Tracking Detectors

- FDC technology review, Feb 2008:
  - Endorsed:
    - wire & cathode readout
    - the design level of details
  - Concerns (no official recommendations):
    - importance of building a full-scale prototype
      - *construction prototype is being built*
    - transition from PED to construction
      - *detailed documentation in progress*
- Drift chambers and PID, Mar 2008:
  - Findings:
    - the design meets the physics requirements
    - the fabrication plans are realistic (manpower a concern)
    - kaon identification will require a Cherenkov detector
  - Advice (no official recommendations):
    - continue pre-production testing - *in progress (CR09-27),*
    - pay attention to coordination and integration
      - *addressed in the Installation Review*

Tracking: Forward Drift Chamber

Forward Drift Chamber

Angular Coverage: 1° – 30°
Gas Mixture: 40:60 Ar/CO_2
Readout: wire timing,
cathode strips amplitudes
– combining projections
Resolution: 200 μm



Status:
small scale prototype has been tested
construction prototype underway
(added by CR09-27)
MC: no staggering needed
(would have changed the design)

Design review 2007 recommendation:
reduce material (closed March 2008)
Final design of the frames:
a sandwich of 2 G10 skins and rohacell foam
cathode: Cu 5μm→2μm on 25 μm Kapton
1 package: 6 planes, active area 0.5%→0.3% RL

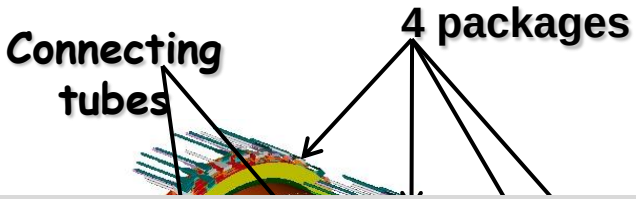
Tracking: Forward Drift Chamber

Forward Drift Chamber

Angular Coverage: 1° – 30°

Gas Mixture: 40:60 Ar/CO_2

Readout: wire timing,



Resolutio

Status:
small scal
construct

Design rev

Final des
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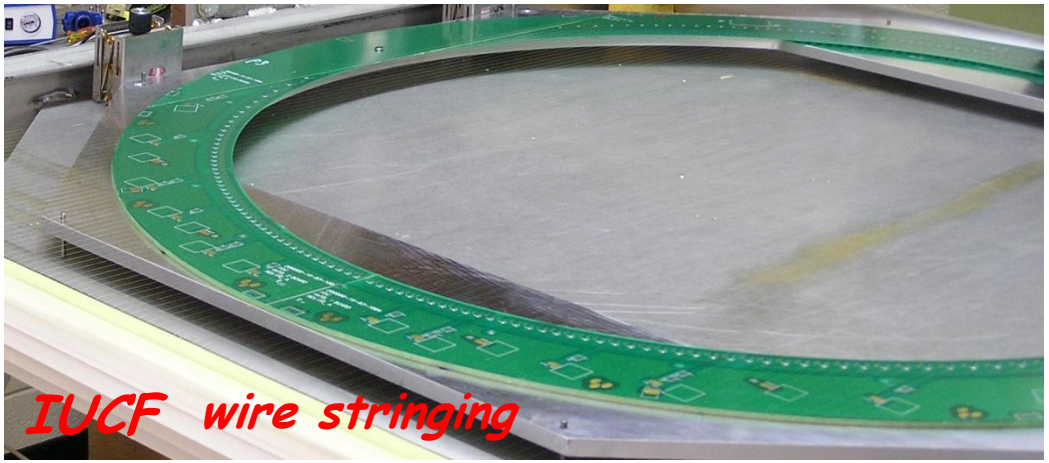
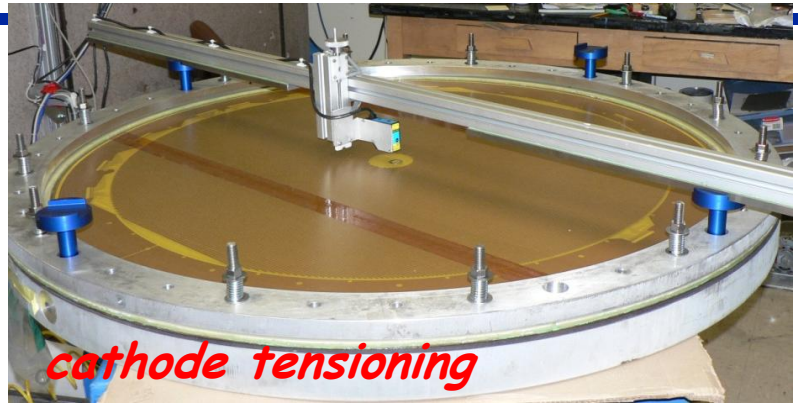
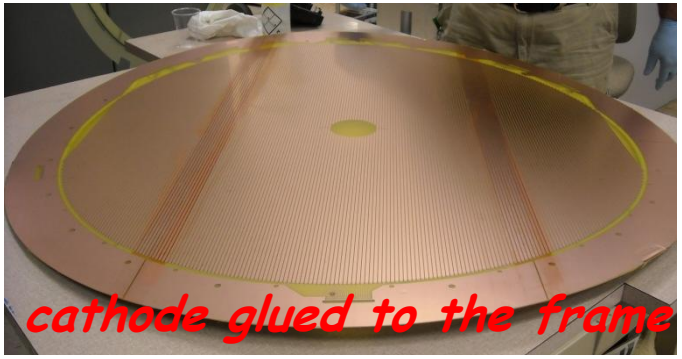
- Setup:
  - cathode strip chamber
  - 4 packages each 24 planes;
    ground- cathode-wire-spacer-cathode
  - 96 sense + 97 field wires & 216 cathode strips/plane
    - total: 12672 channels
  - wires; u-v strips +/- 75° to wires
  - diameter: 1.2m
- Readout / Electronics:
  - Preamp. boards based on ASIC
  - cathodes: 125 MHz FADCs (72 ch) → 144 modules
  - anodes: 125ps F1-TDC (48 ch) → 48 modules
- HV
  - 384 channels
- main procurements in FY10-11

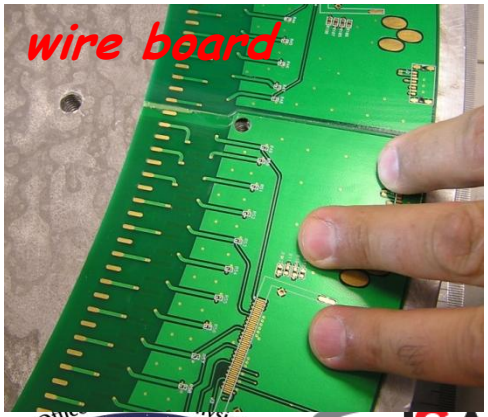
FDC progress: construction prototype

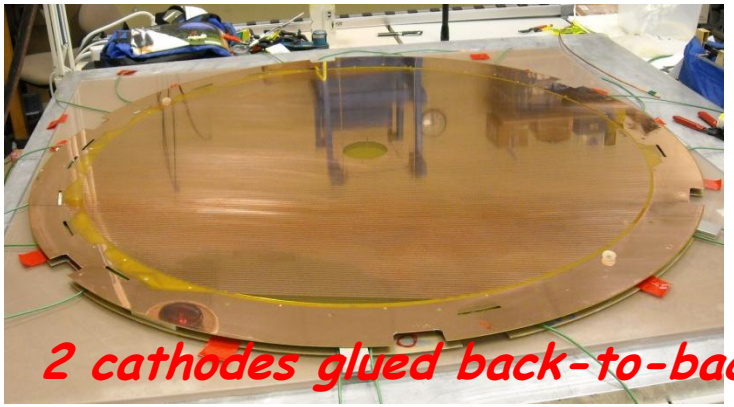
- 4 planes of full scale
- cathodes: Cu 2 μm and 5 μm
- finalizing construction procedures





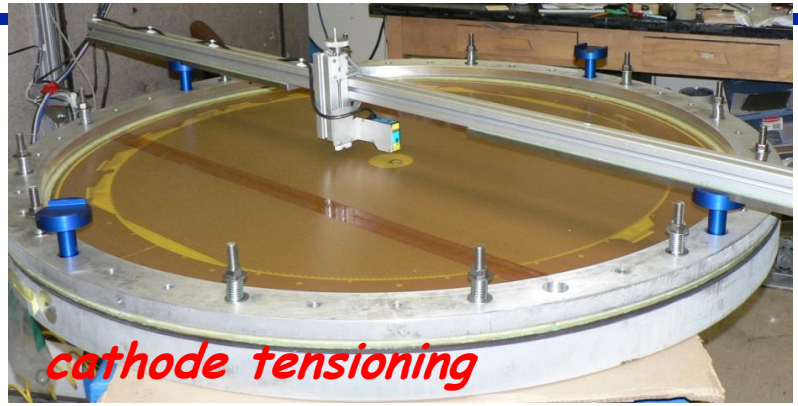


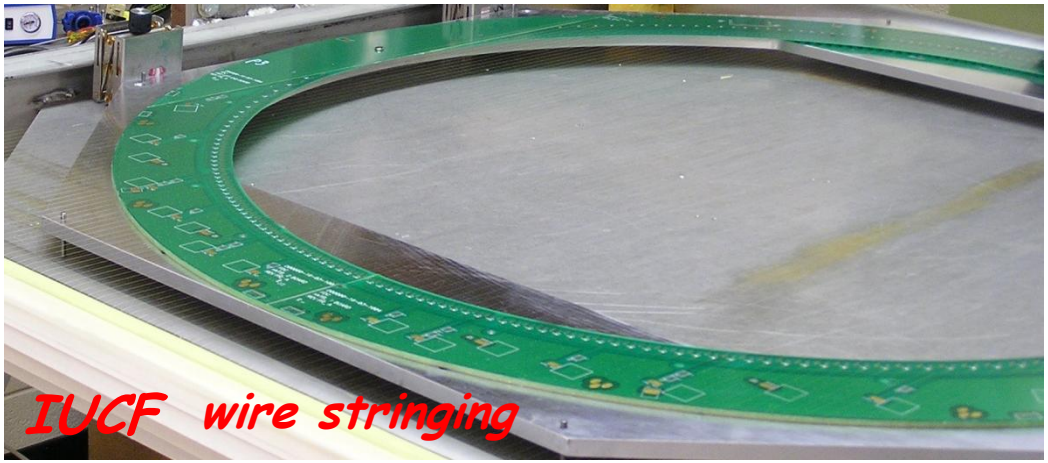


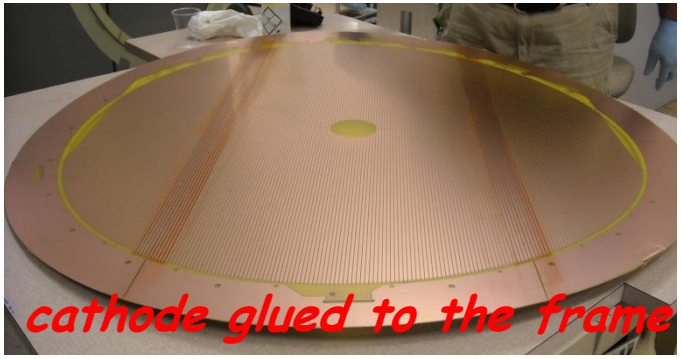


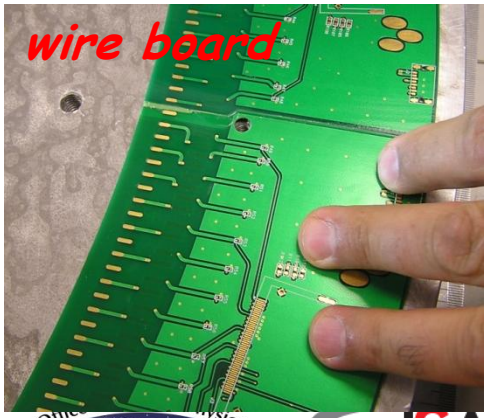
FDC progress: construction prototype

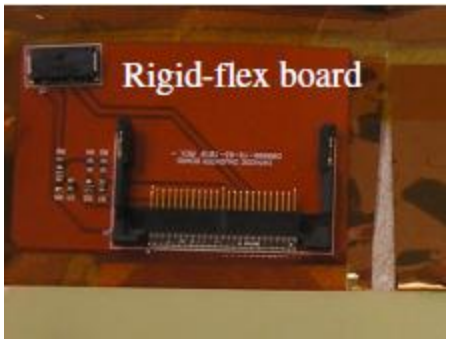
- 4 planes of full scale
- cathodes: Cu 2 μm and 5 μm
- finalizing construction procedures







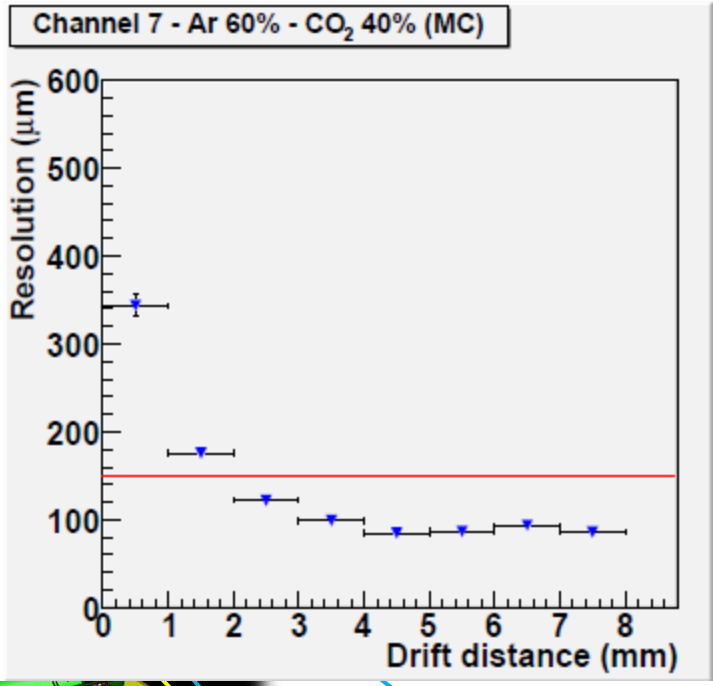


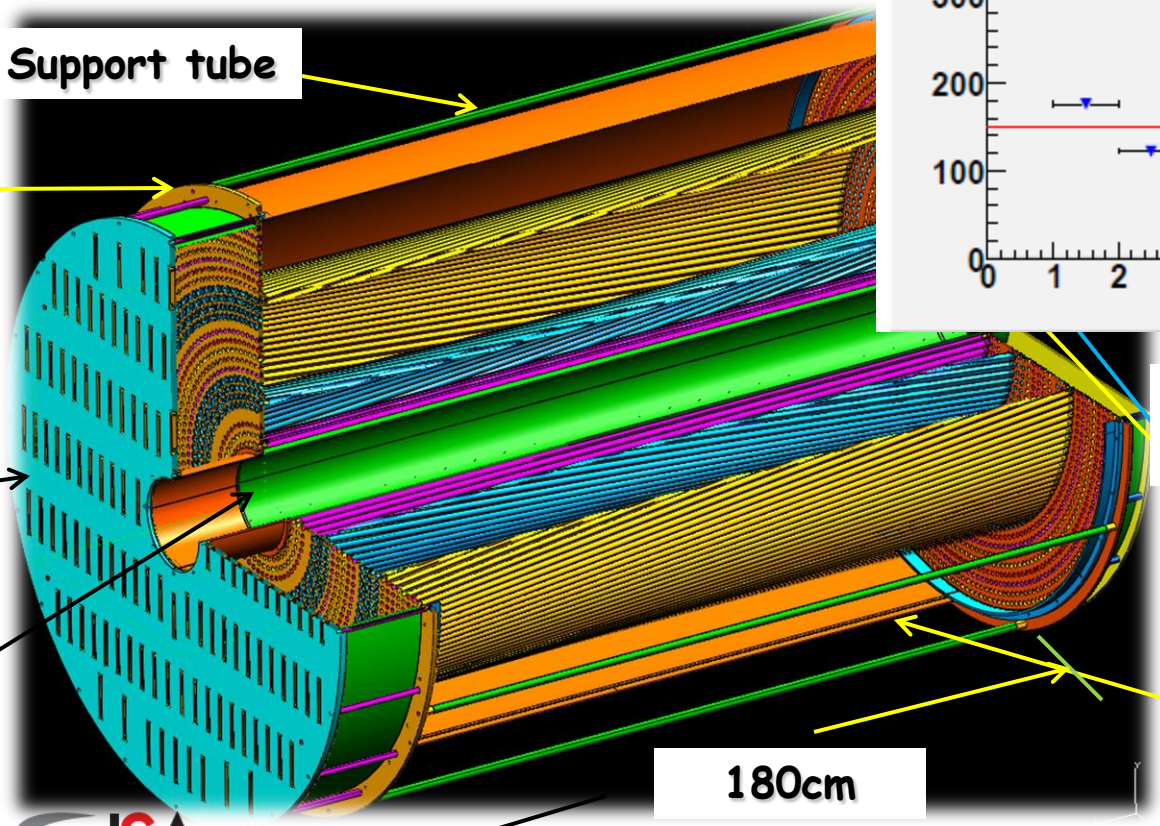


Central Drift Chambers

dE/dx for p < 450 MeV/c
Gas mixture: ~60/40 Ar/CO_2
Angular Coverage: 6°-155°
Resolution:
$\sigma_{r\phi}$ ~ 150 μm, σ_z~1.5 mm

Developed at CMU, JLab





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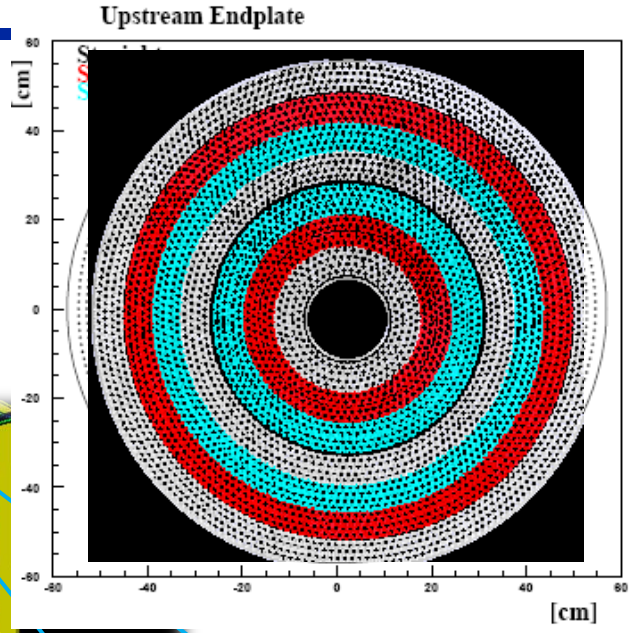
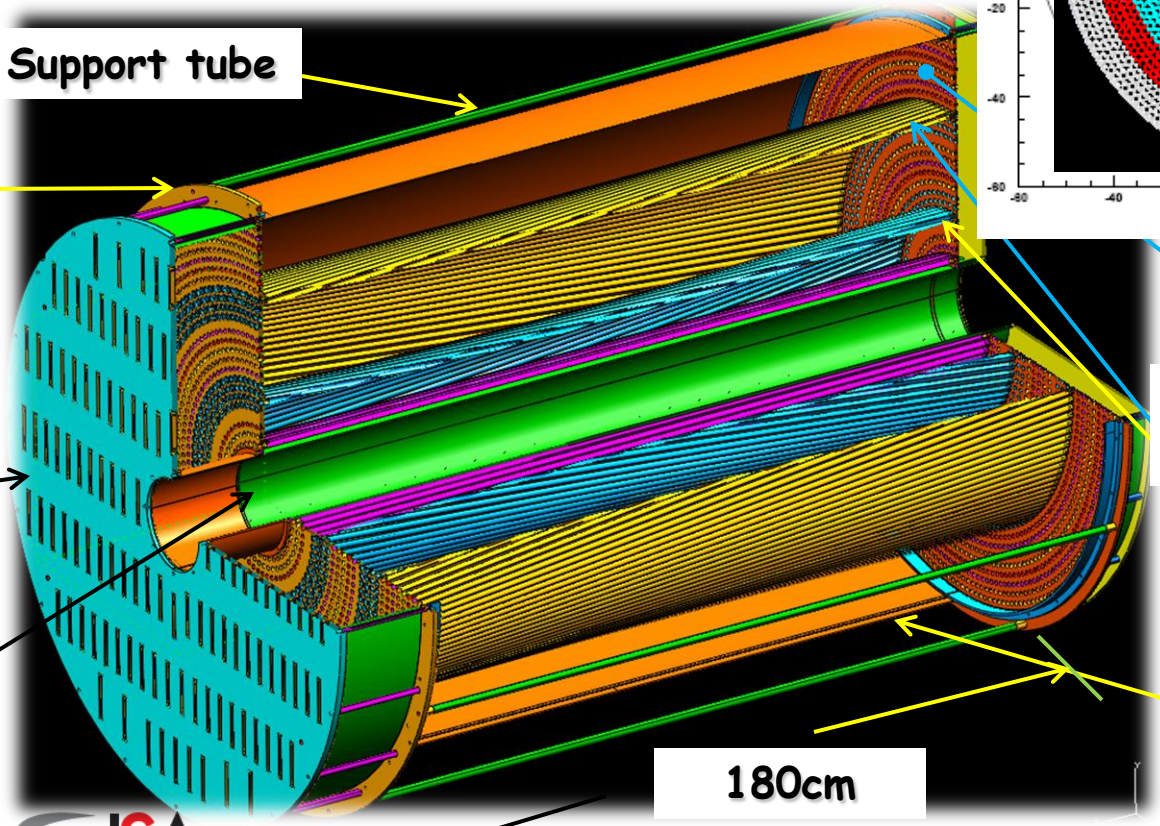
$\sigma_{r\phi}$ ~ 150 μm, σ_z~1.5 mm

Developed at CMU, JLab

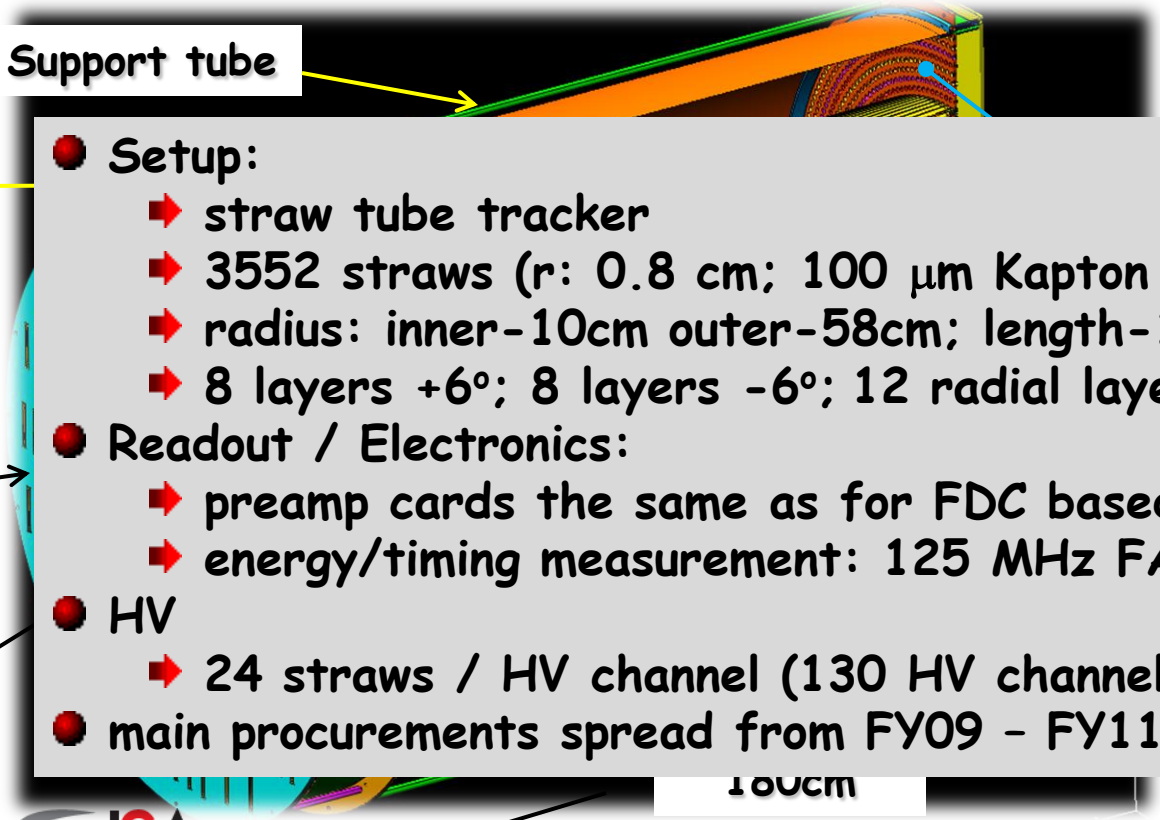




Central Drift Chambers

dE/dx for p < 450 MeV/c
Gas mixture: ~60/40 Ar/CO_2
Angular Coverage: 6°-155°
Resolution:
$\sigma_{r\phi}$ ~ 150 μm, σ_z~1.5 mm

Developed at CMU, JLab

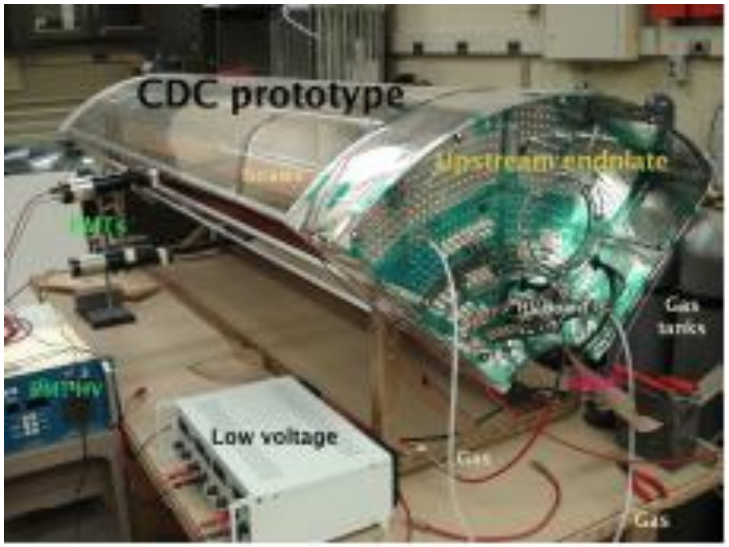


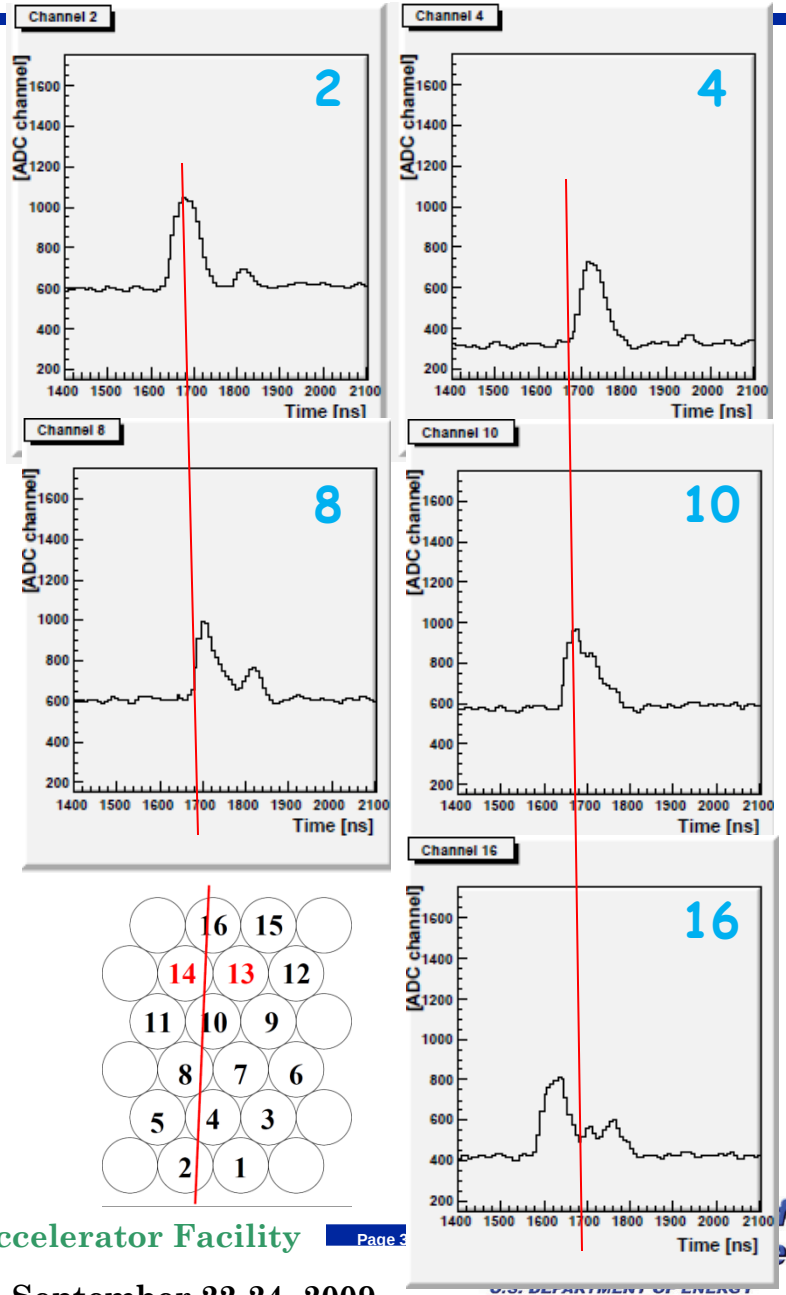
- Setup:
  - straw tube tracker
  - 3552 straws (r: 0.8 cm; 100 μm Kapton >9 μm Al)
  - radius: inner-10cm outer-58cm; length-1.5m
  - 8 layers +6°; 8 layers -6°; 12 radial layers
- Readout / Electronics:
  - preamp cards the same as for FDC based on ASIC
  - energy/timing measurement: 125 MHz FADCs (72ch)
- HV
  - 24 straws / HV channel (130 HV channels)
- main procurements spread from FY09 – FY11

CDC progress

Status:

- full scale prototype - 16 straws fully instrumented





CDC progress

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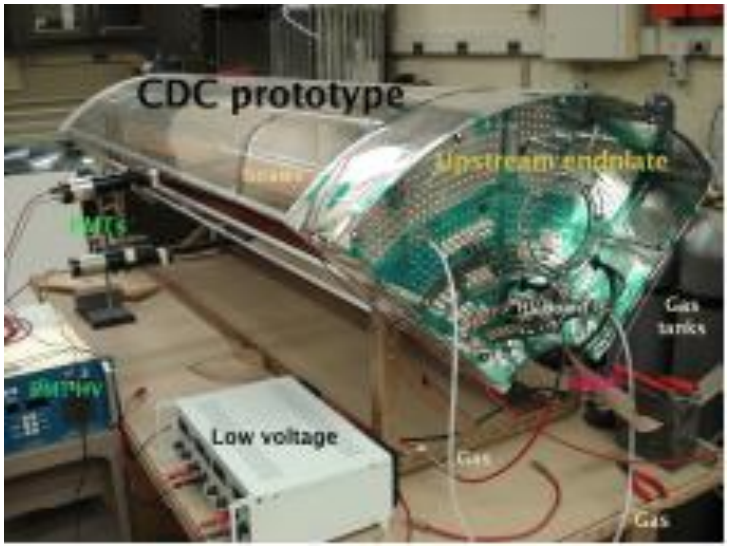
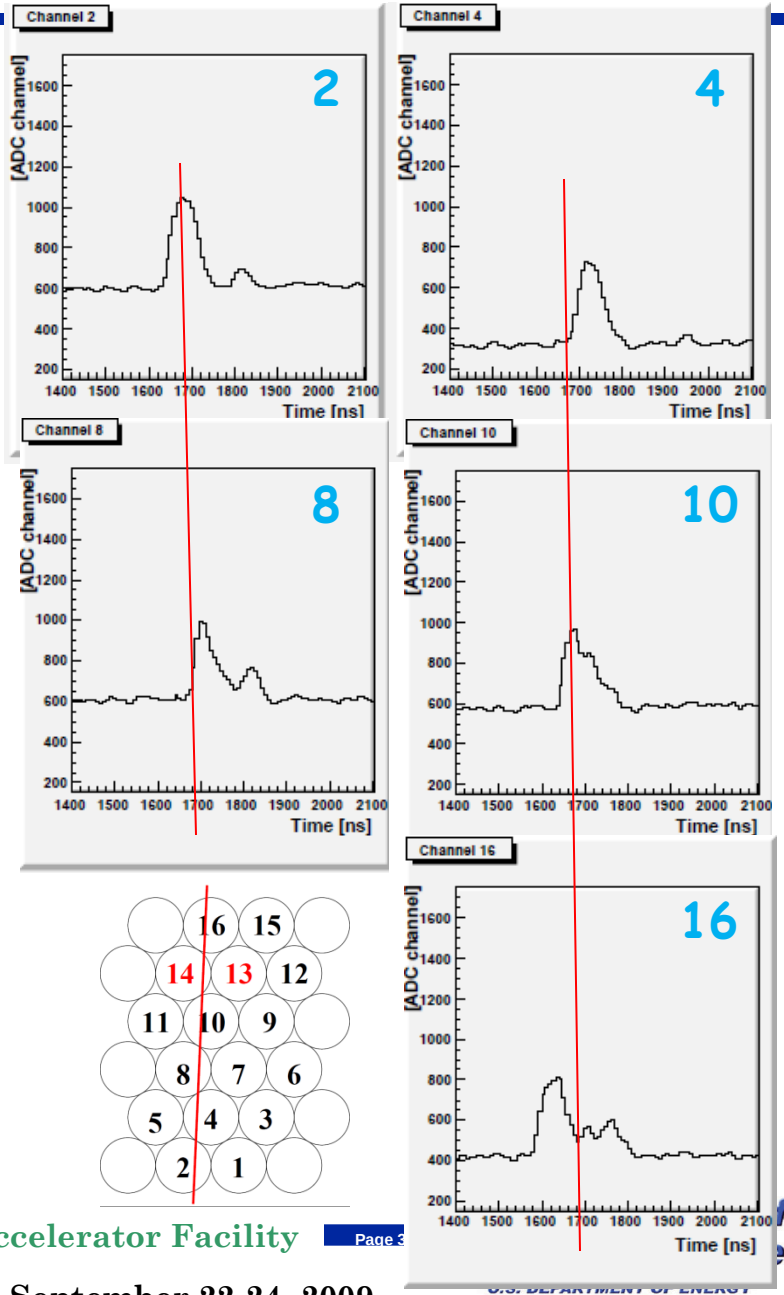


- vendor selection (straws): radiation test under way
- tolerances finalized
- endplates - contract awarded
- feedthroughs - open solicitation



Reviews of Calorimeters

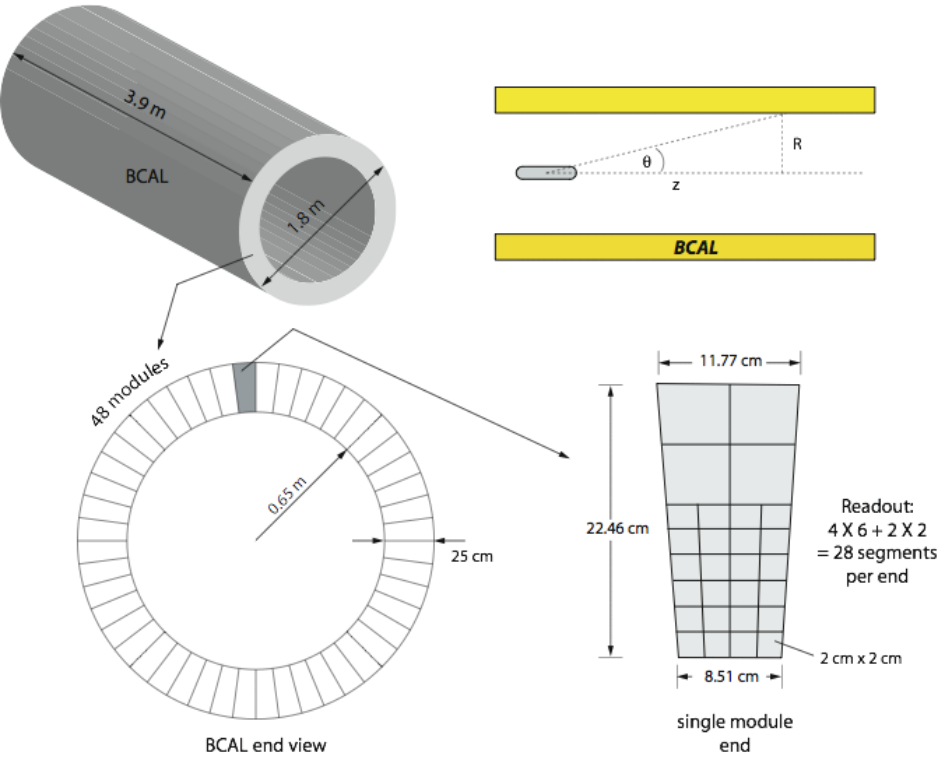
- Calorimetry, Feb 2008:
  - Findings:
    - the design meets the specifications
    - the reviewers provided many suggestions and comments
  - Recommendations:
    - address logistics of BCAL module construction
      Closed. Contract awarded to Regina
    - develop a backup plan for SiPM readout
      Closed by July 2009 review (fine-mesh PMT)
    - full characterization of SiPMs: *continuous progress*
- BCAL readout, July 2009 (two solutions presented):
  - Comments/suggestions:
    - Fine-mesh PMT (FMPMT) provide a viable backup plan
    - use either SiPMs or FMPMTs - avoid hybrid solutions
  - Recommendations (SiPM solution seems more promising):
    - develop a plan for characterization of SiPM prototypes
    - select SiPM/FMPMT only after the previous step

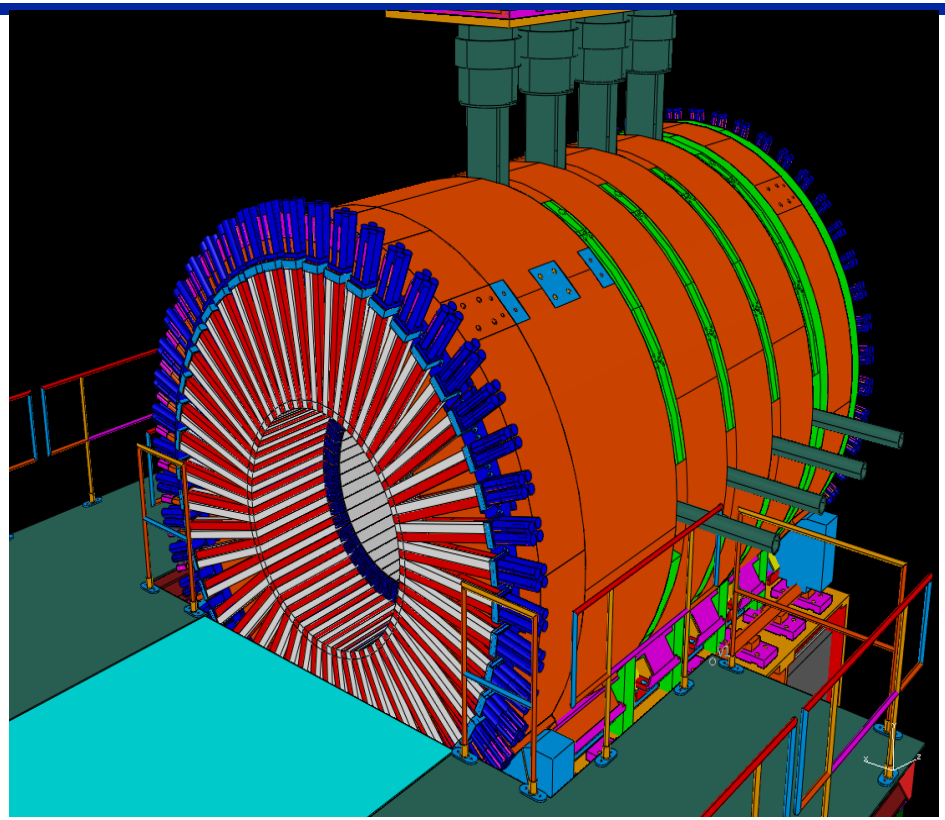
Final decision by Jan 2010

Barrel Calorimeter (BCAL)

BCAL design modeled after KLOE EMC;

48 modules (phi sectors)





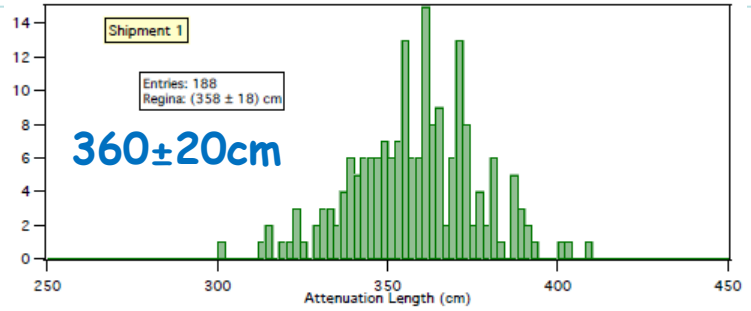
Module: 191 layers
Pb/Sc/Glue 37/49/14

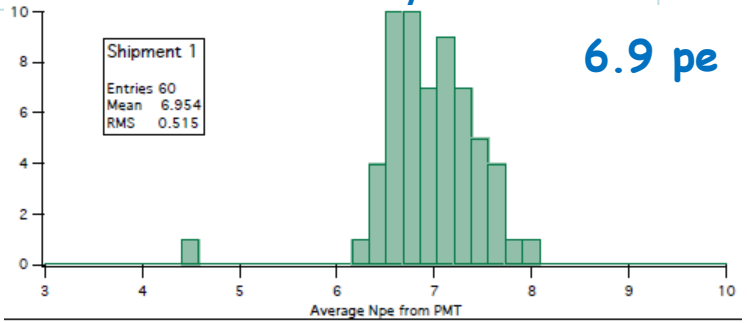
- Fibers: contract awarded (Kuraray)
- Lead: contract awarded

BCAL: Scintillating Fibers QA

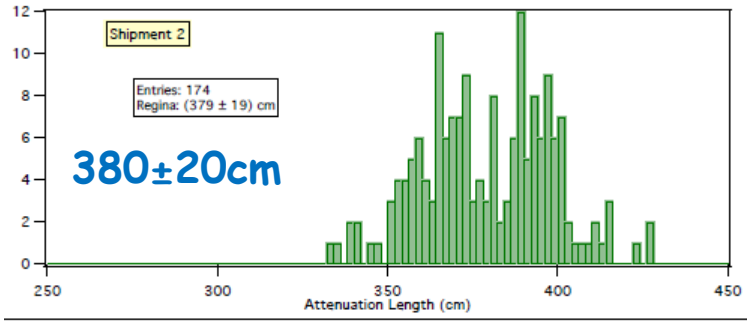
Kuraray (SCSF-78-MJ): 4 shipments so far ~ 20% of total

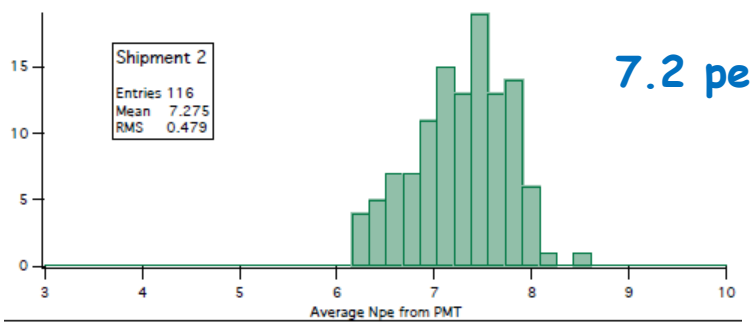
Meet or exceed the specifications: L_{atten}>300cm, N_{pe}>3.5





shipment 1





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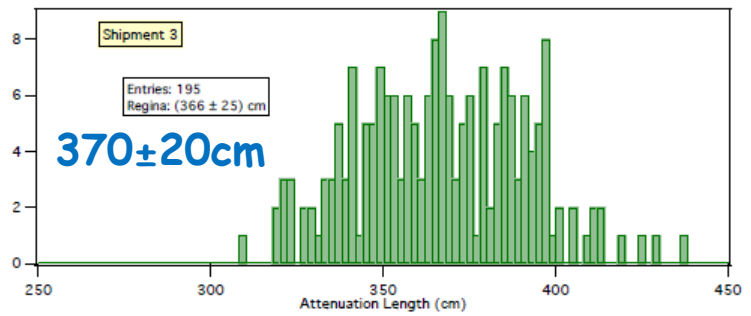
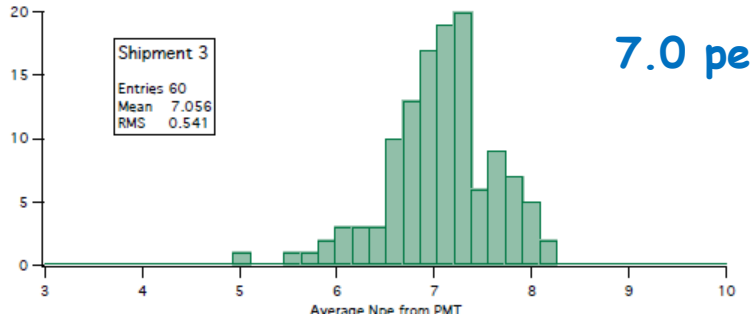


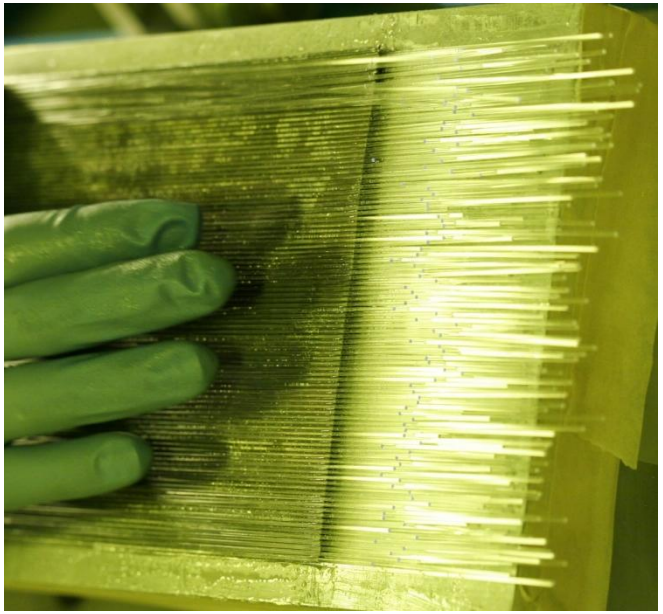


3

BCAL: Modules Construction

- Contract awarded to University of Regina
- Construction prototype is being built
  - >70% complete (140 layers out of 190)

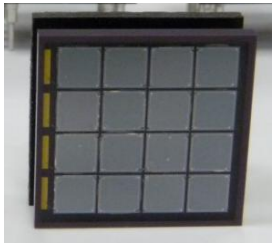
Summer 2009



BCAL: Light sensors

SiPMs

- Two companies: Hamamatsu and SensL
- Arrays (4x4) of $3x3mm^2$ cells
- Size ~ 1.2 x 1.2 cm^2
- Gain > 10^6
- Insensitive to B-fields
- Dark rate ~ 100 MHz
- Operation depends on temperature

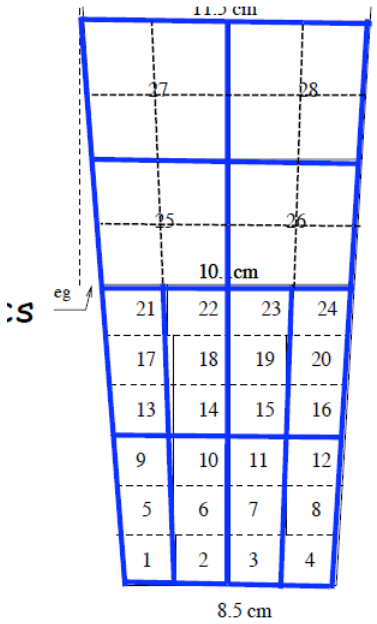


Fine Mesh PMTs

- Hamamatsu H8409-70
- 1.5" PMT: R7761-70
- Photocathode D = 27mm
- 19 stages
- Max. anode I = 10μA
- Gain ~ $3x10^6$ (0.5 T)
- Dark rate ~ 0.5 kHz

BCAL: Readout Comparison

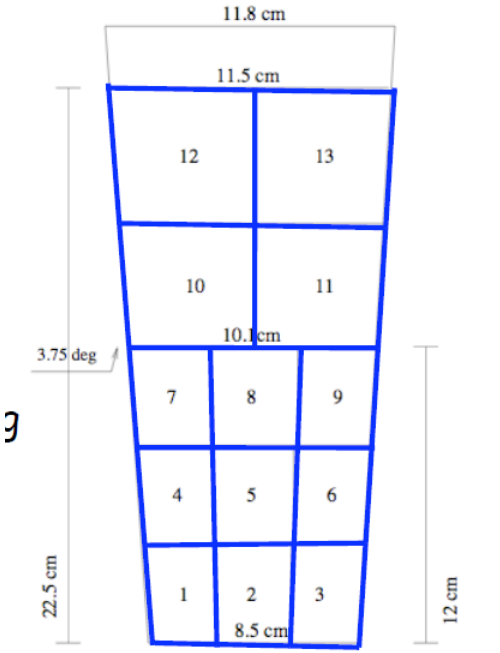
SiPMs



Conceptual layout for inner readout with SiPM

- 3840 SiPMs
- 1152 FADC250 channels
- Summing boards (3,4)

Fine Mesh PMTs



Conceptual layout for readout with fine-mesh pmts H8409-70

- 1248 FMPMT
- 1248 FADC250 channels

BCAL: Readout Comparison

SiPMs

+ Short light guides
  Acceptance loss ~ 10.5-11°
+ Minimum energy ~ 50 MeV

- Saturation effects >4 GeV
- Needs cooling/stabilization
- Radiation hardness <40Gr
- Unproven at large scale
- Combining 3-4 SiPM→readout

Early tests of SenSL arrays - not meeting specs

- too high noise (unless cooled)
- poor uniformity

Fine Mesh PMTs

- Long light guides (losses)
  Acceptance loss ~ 9.5-11°
- Minimum energy ~60 MeV

- Poor time resolution at low E
- Long light guides - mechanical complexity

Viable backup option

BCAL: Readout Comparison

SiPMs

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  Acceptance loss ~ 10.5-11°
+ Minimum energy ~ 50 MeV

- Saturation effects >4 GeV
- Needs cooling/stabilization
- Radiation hardness <40Gr
- Unproven at large scale
- Combining 3-4 SiPM→readout

New Arrays: vendors promise to remove deficiencies

- SenSL - improved technology
- Hamamatsu - needs only thermal stabilization (no cooling)

Fine Mesh PMTs

- Long light guides (losses)
  Acceptance loss ~ 9.5-11°
- Minimum energy ~60 MeV

- Poor time resolution at low E
- Long light guides - mechanical complexity

Viable backup option

BCAL: Readout Comparison

SiPMs

+ Short light guides
  Acceptance loss ~ 10.5-11°
+ Minimum energy ~ 50 MeV

- Saturation effects >4 GeV
- Needs cooling/stabilization

- Delivery of 10 final samples by Oct 15, 2009:
  - SENSL
  - Hamamatsu
- Tests (complete by Jan 2010):
  - Noise/gain/PDE
  - Uniformity
  - Radiation hardness

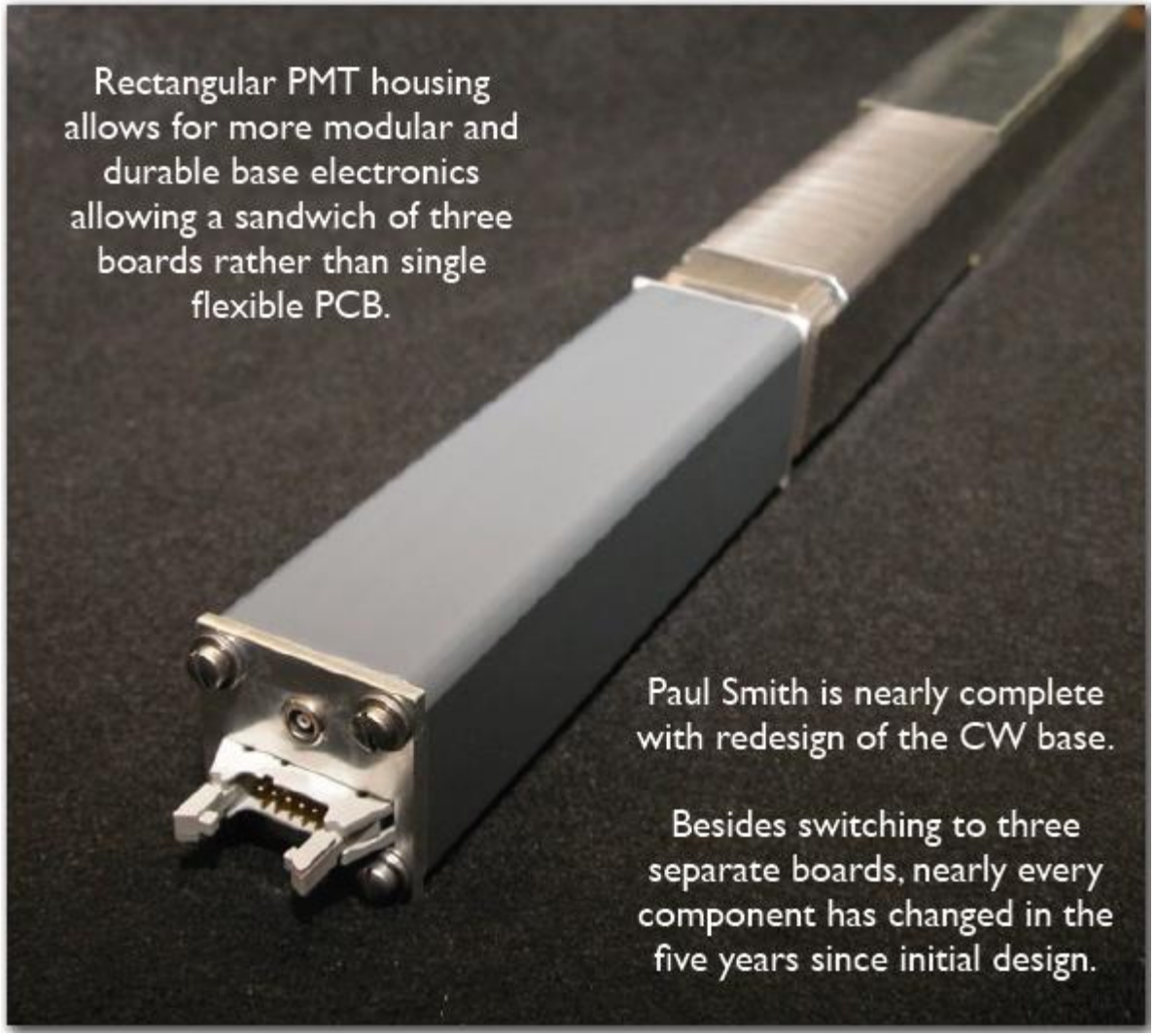
Fine Mesh PMTs

- Long light guides (losses)
  Acceptance loss ~ 9.5-11°
- Minimum energy ~60 MeV

- Poor time resolution at low E
- Long light guides - mechanical complexity

Viable backup option

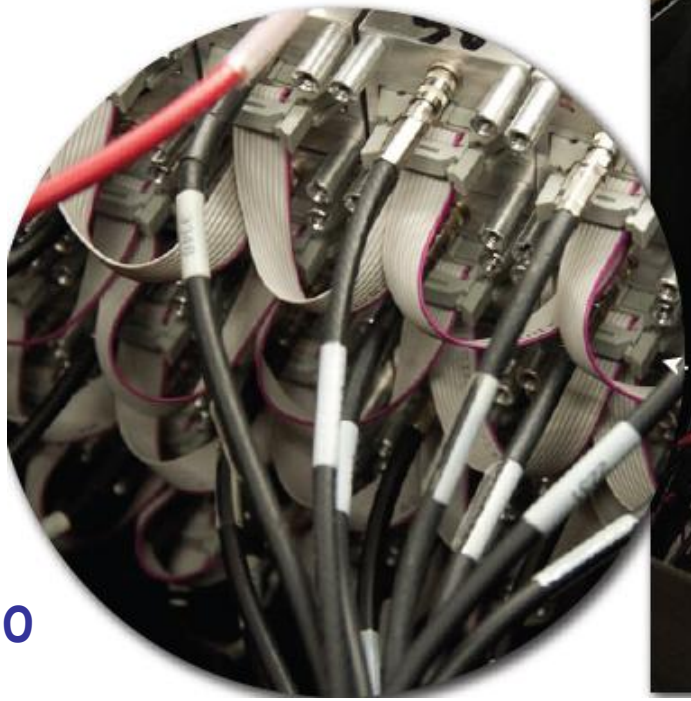
FCAL module: LG, PMT, shield, base



FCAL Progress (Indiana)

- Mechanical design nearly final
- Magnetic shielding being tested
- New CW base design: almost complete (10 prototypes Jan 2010)
- CAN control system is progress
- Progress with radiation tests of lead glass
- 64-module prototype:

32 modules are loaded and operational



Ethernet-CAN gateway

Construction starts in FY10

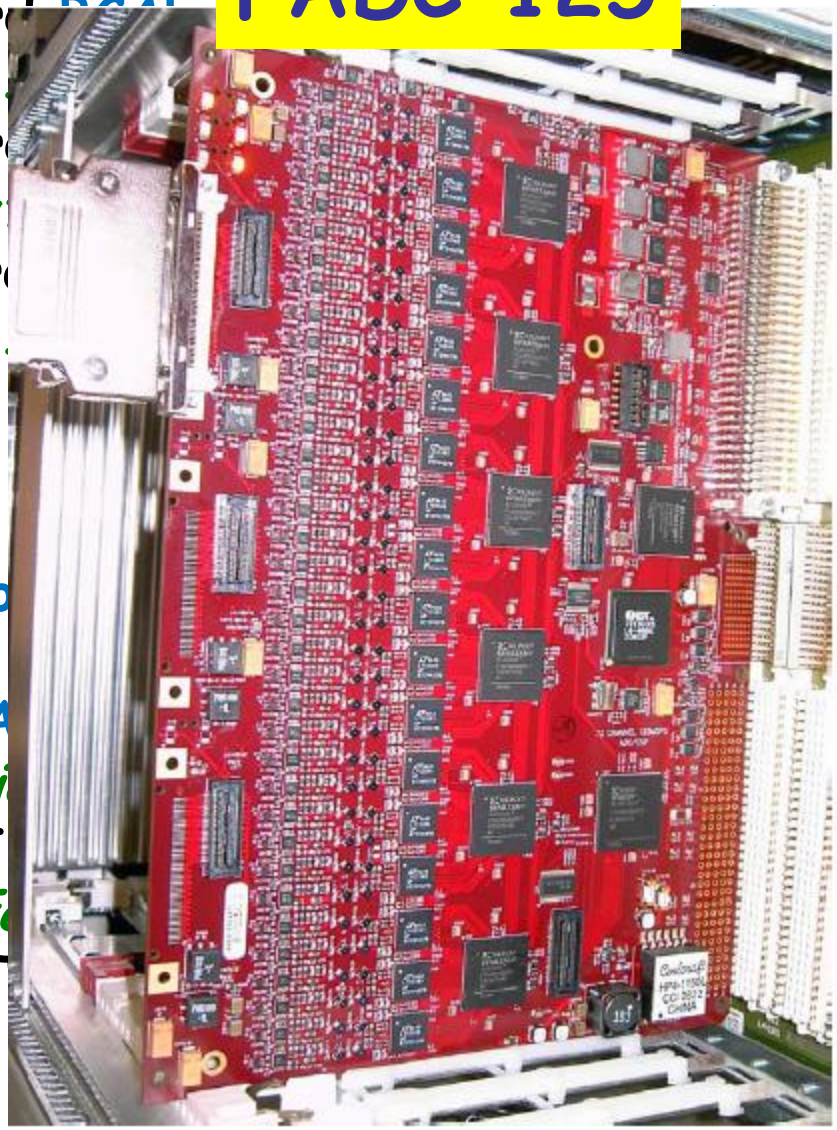
Readout Electronics

- FADC 250 MHz 12 bit 16 ch/board BCAL,FCAL,TOF,hodoscopes
  extensively tested, newer chips - small modifications needed
- FADC 125 MHz 12 bit 72 ch/board CDC,FDC(cathodes)
  prototype is being tested - evaluation by Nov 2009
- F1 TDC 60-120 ps 32 ch/board FDC(anodes),TOF,BCAL,hod.
  extensively tested, newer chips - small modifications needed
  All F1 chips purchased
- ASIC preamps 24 ch/card FDC,CDC
  prototype cards are being tested, evaluation by Sep 2009
- LE Discriminators TOF,BCAL, hodoscopes
  off-shelf from CAEN, or existing module from JLab
- CTP (Crate Trigger Processor) BCAL/FCAL crates
  tested, newer chips - small modifications needed
- SSP (Sub-System Processor), GPT (Global Trigger Processor)
  prototypes in FY10 (not much different from CTP)
- Auxilliary modules: SD-*complete*, TI - *1-st revision tested*,
  TI - *under development*

Readout Electronics

FADC 250

FADC 125



- FADC a… 6 ch/boar… PG4…
  exten… hips - …
- FADC … h/boar…
  proto… evalua…
- F1 TD… h/boar…
  exten… hips - …
  All F1…
- ASIC … h/card
  proto… ested,
- LE Dis… …, hodo…
  off-s… xisting
- CTP (… or) BCA…
  teste… modifi…
- SSP (Sub-System Processor), GPT…
  prototypes in FY10 (not much diffe…
- Auxilliary modules: SD-*complete,* …
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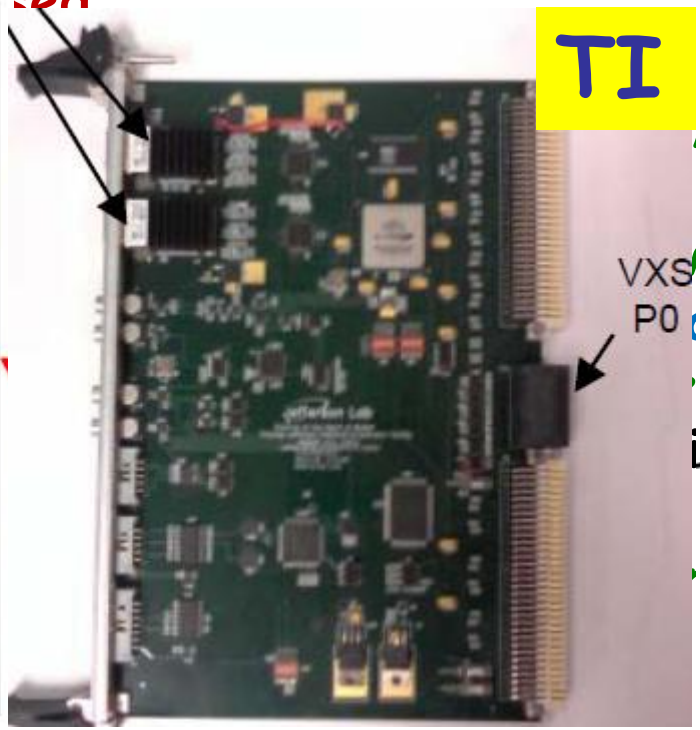
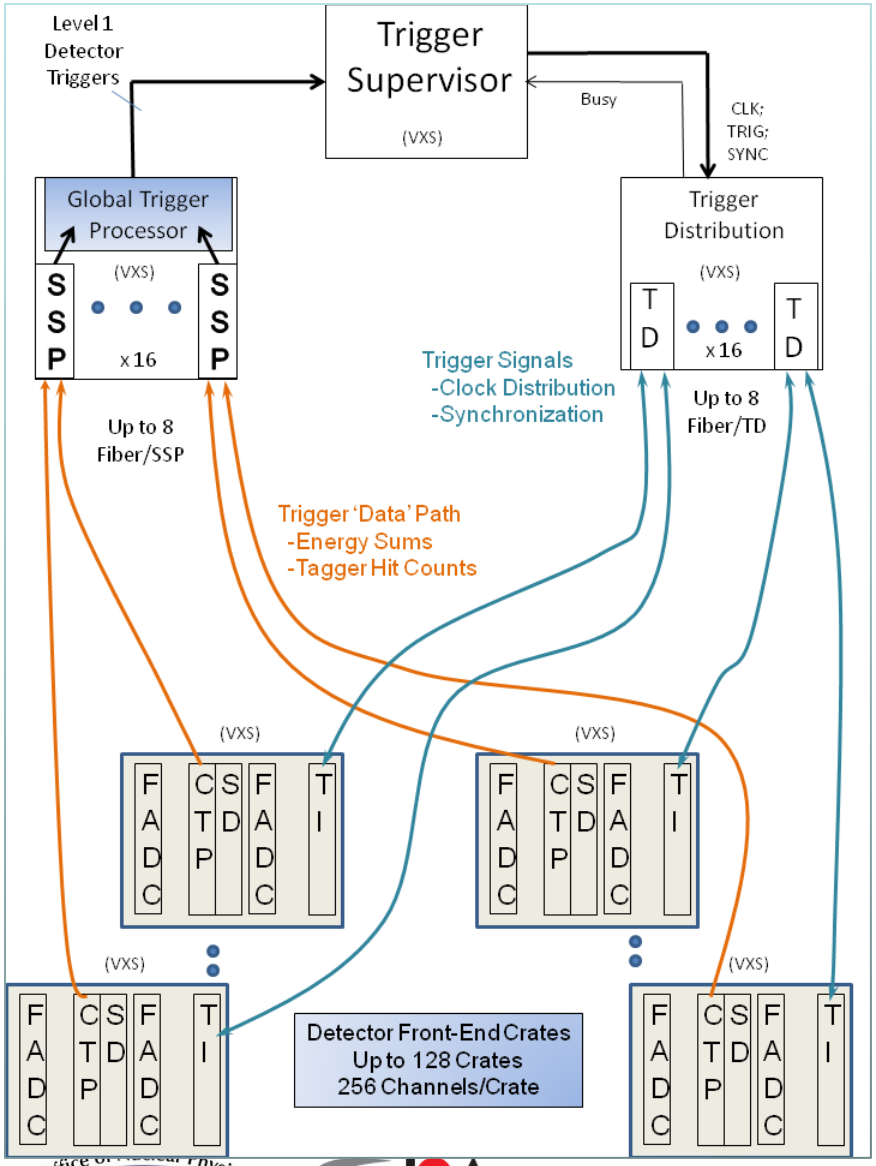


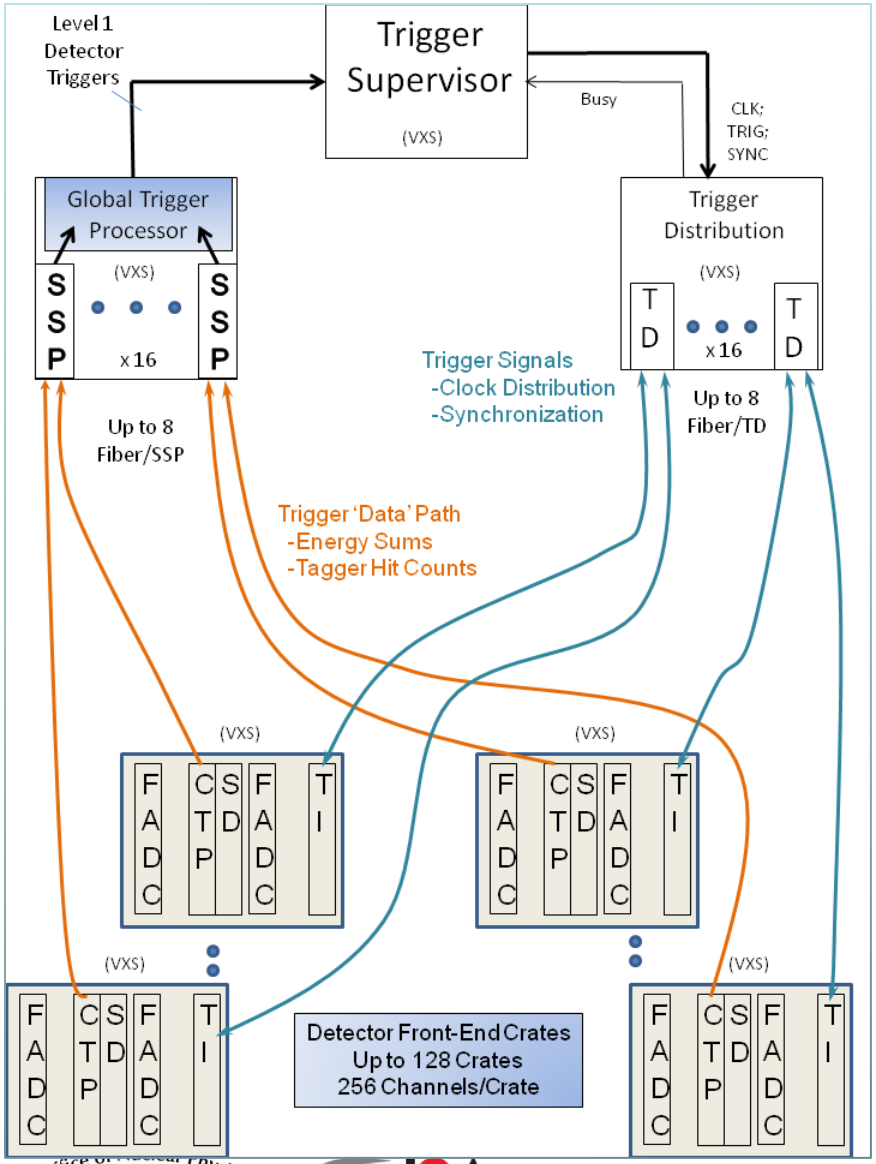
Trigger: progress since IPR-2008



Realistic test of the concept is completed with existing modules

- 2 crates with FADC, CTP etc
- Simplified SSP, trigger: $\Sigma_{A>x}$
- Trigger distribution
- Readout:
  - full readout of 4ns samples
  - charge integration in FPGA
- Reached trigger rates:
  - 175 kHz full readout
  - >200 kHz limited readout
  - *very close to the specs*

Trigger: progress since IPR-2008



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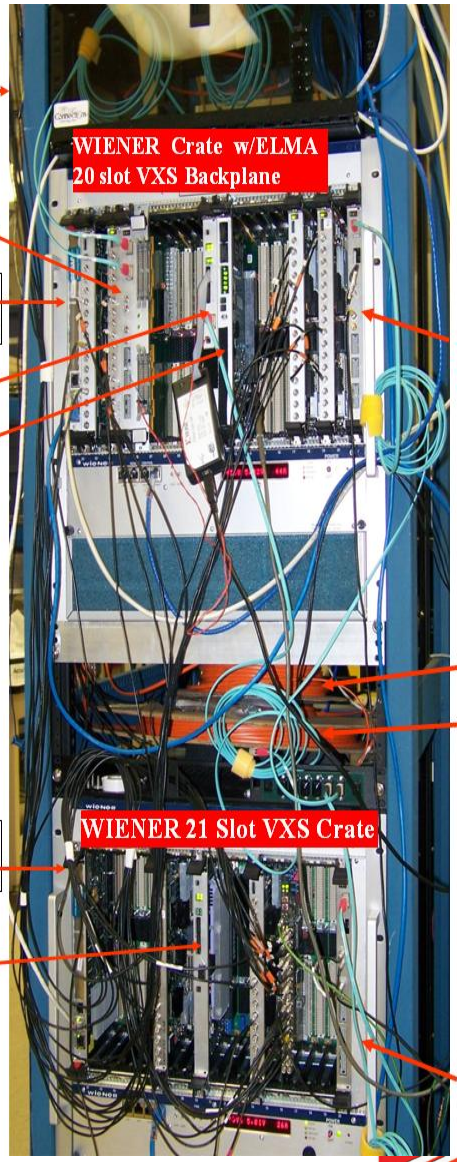


WBS 1.2.3 PED

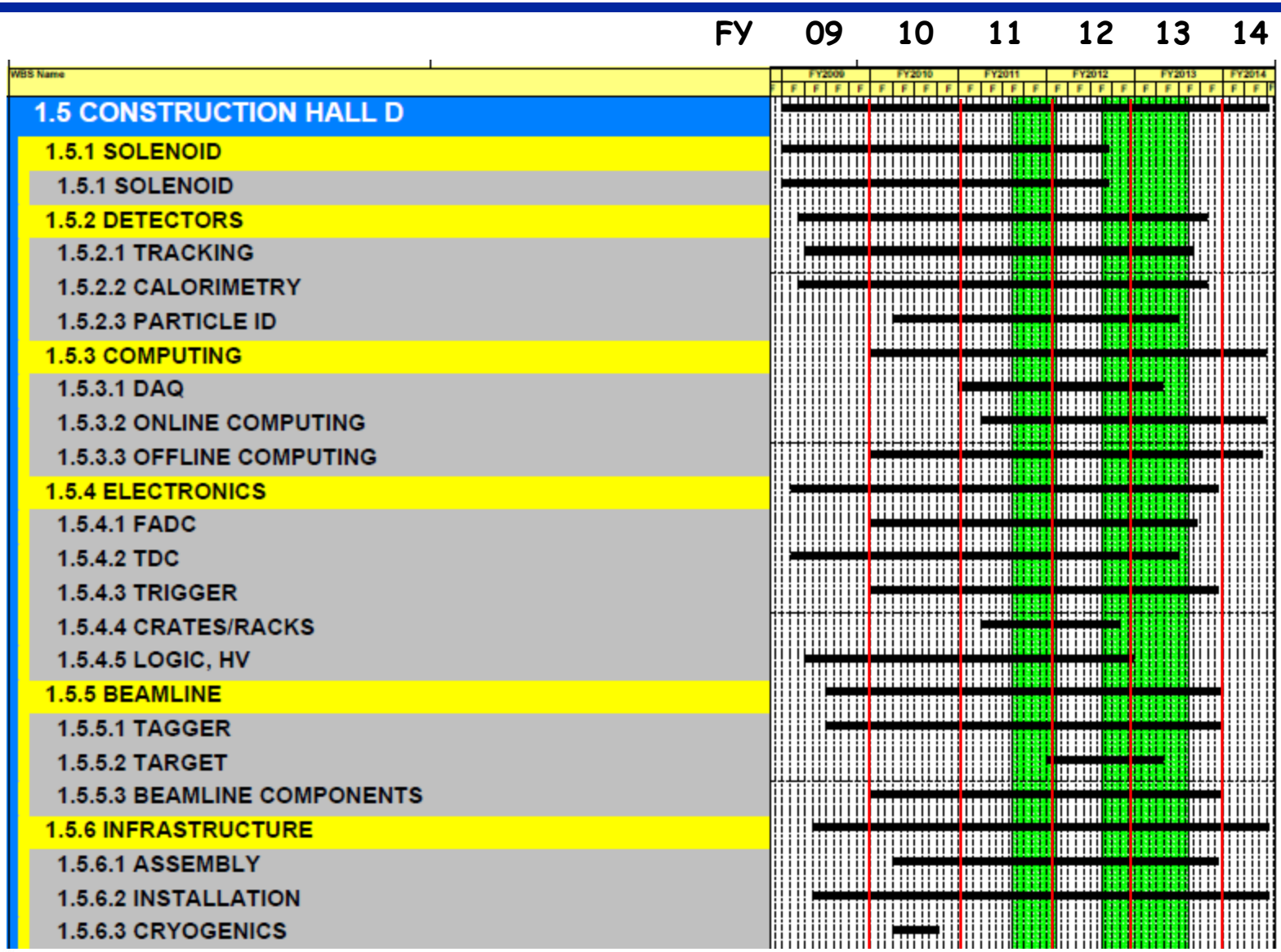
- ~98% finished by mid-September 2009
- Ongoing PED:
  - ASIC tests, to be finished by Oct 1 (the end of P6 PED)
  - some fabrication drawings need input before completion
- Two outstanding tasks:
  - Final characterization Silicon PMT samples
  - Tagger magnet review recommended to produce the fabrication drawings for this magnet in-house (this can be viewed as part of a construction task, does not affect PED)

More on the construction drawings - in the next talk by Tim Whitlatch

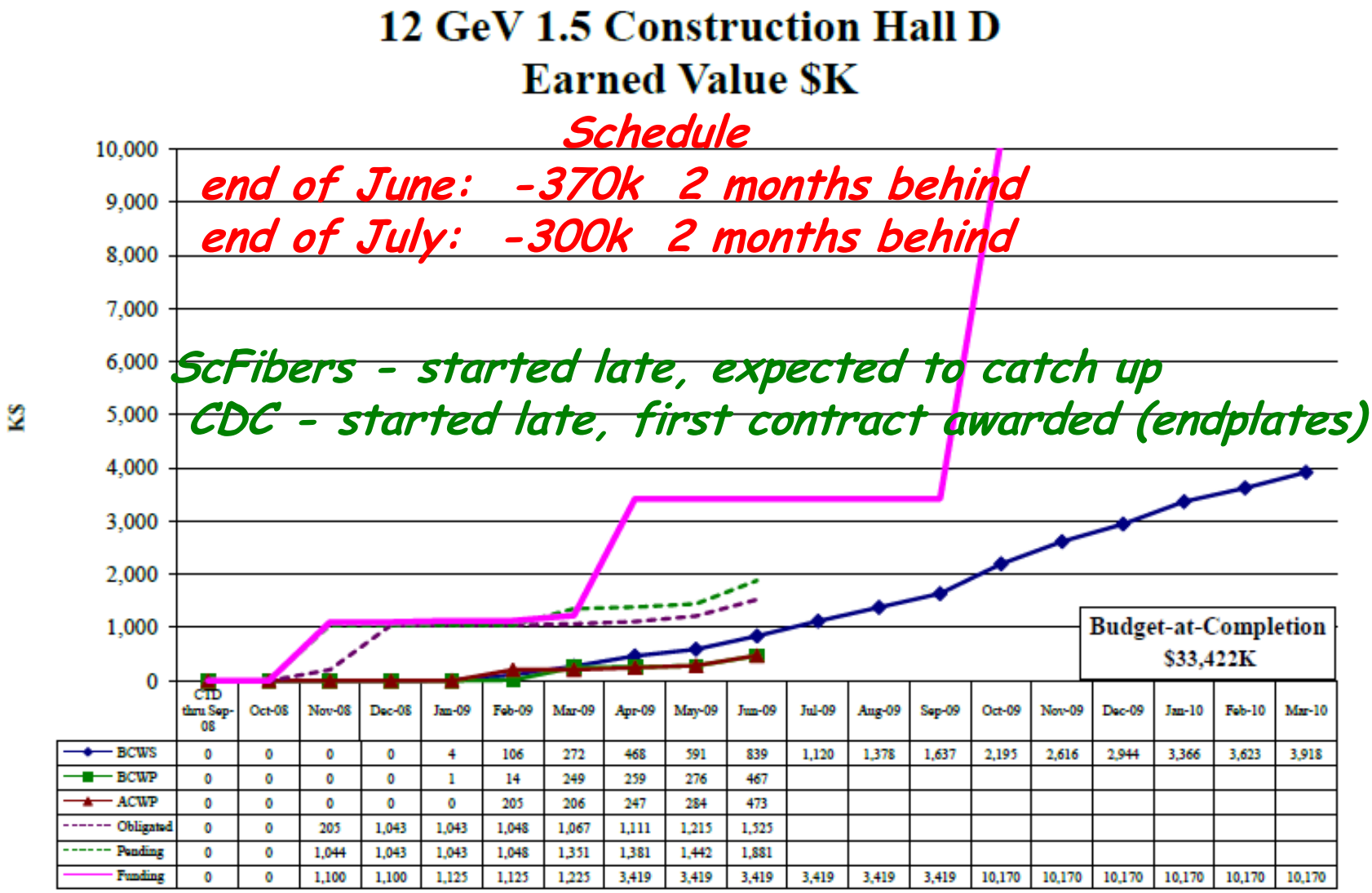
Summary of Tracked Recommendations

- D-Det08:
  - 1: *Logistics of BCAL construction:* contract awarded - *closed*
  - 2: *Backup plan for SiPM readout:* FMPMT endorsed - *closed*
  - 3: *Full characterization of SiPM:* finish by Dec 09 - *open*
- D-Inst09:
  - 1: *Hire Work Coordinator:* CR09-27, started Sep 1- *closed*
  - 2: *Installation staging area:* plan developed - *closed*
  - 3: *Work Coord. - reevaluate the plans:* started - *open*

Construction Schedule



1.5 Hall D Construction Earned Value



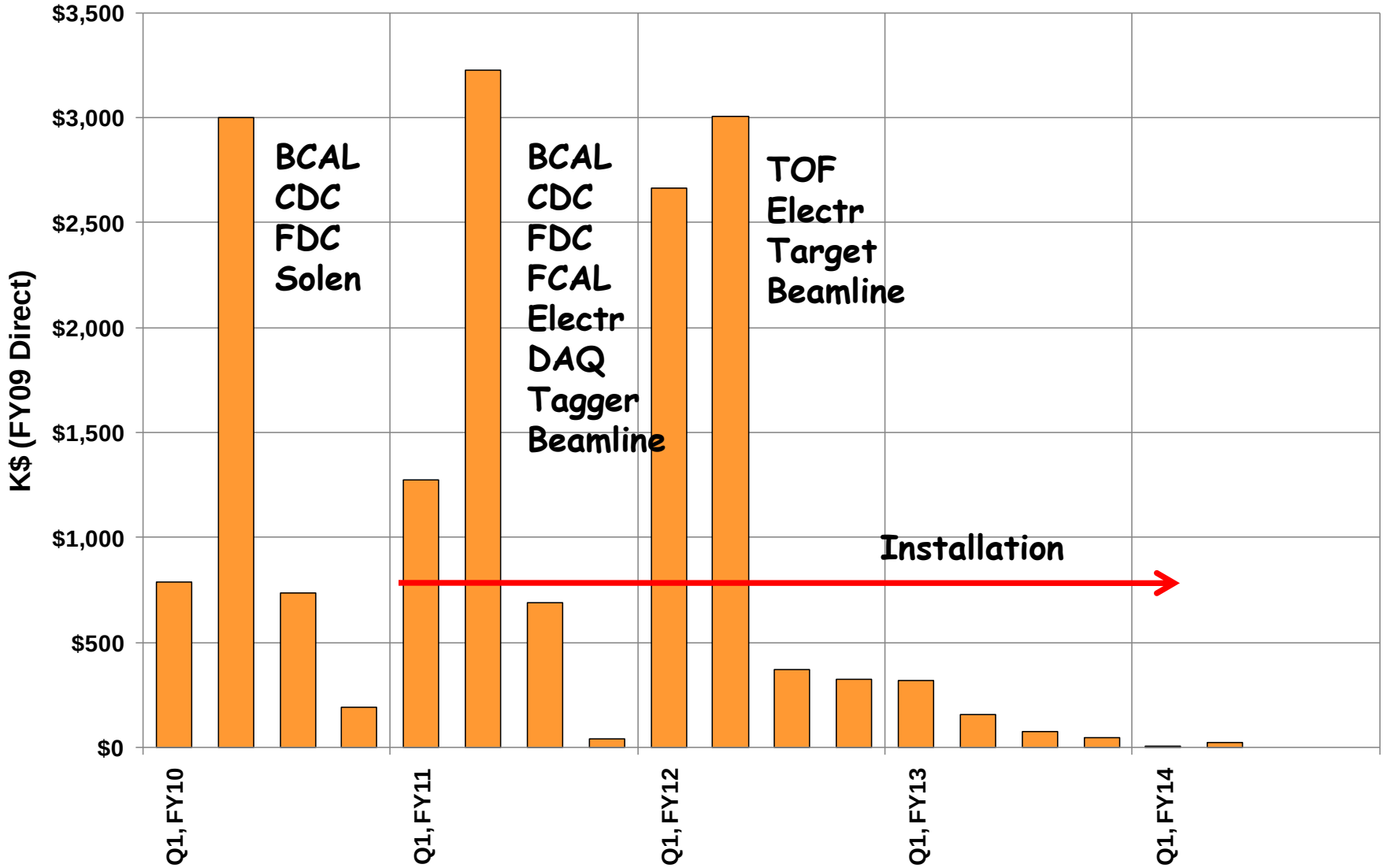
	CTD thru Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10
BCWS	0	0	0	0	4	106	272	468	591	839	1,120	1,378	1,637	2,195	2,616	2,944	3,366	3,623	3,918
BCWP	0	0	0	0	1	14	249	259	276	467									
ACWP	0	0	0	0	0	205	206	247	284	473									
Obligated	0	0	205	1,043	1,043	1,048	1,067	1,111	1,215	1,525									
Pending	0	0	1,044	1,043	1,043	1,048	1,351	1,381	1,442	1,881									
Funding	0	0	1,100	1,100	1,125	1,125	1,225	3,419	3,419	3,419	3,419	3,419	3,419	10,170	10,170	10,170	10,170	10,170	10,170

WBS 1.5 Major Procurements 1-SEP-09 Status

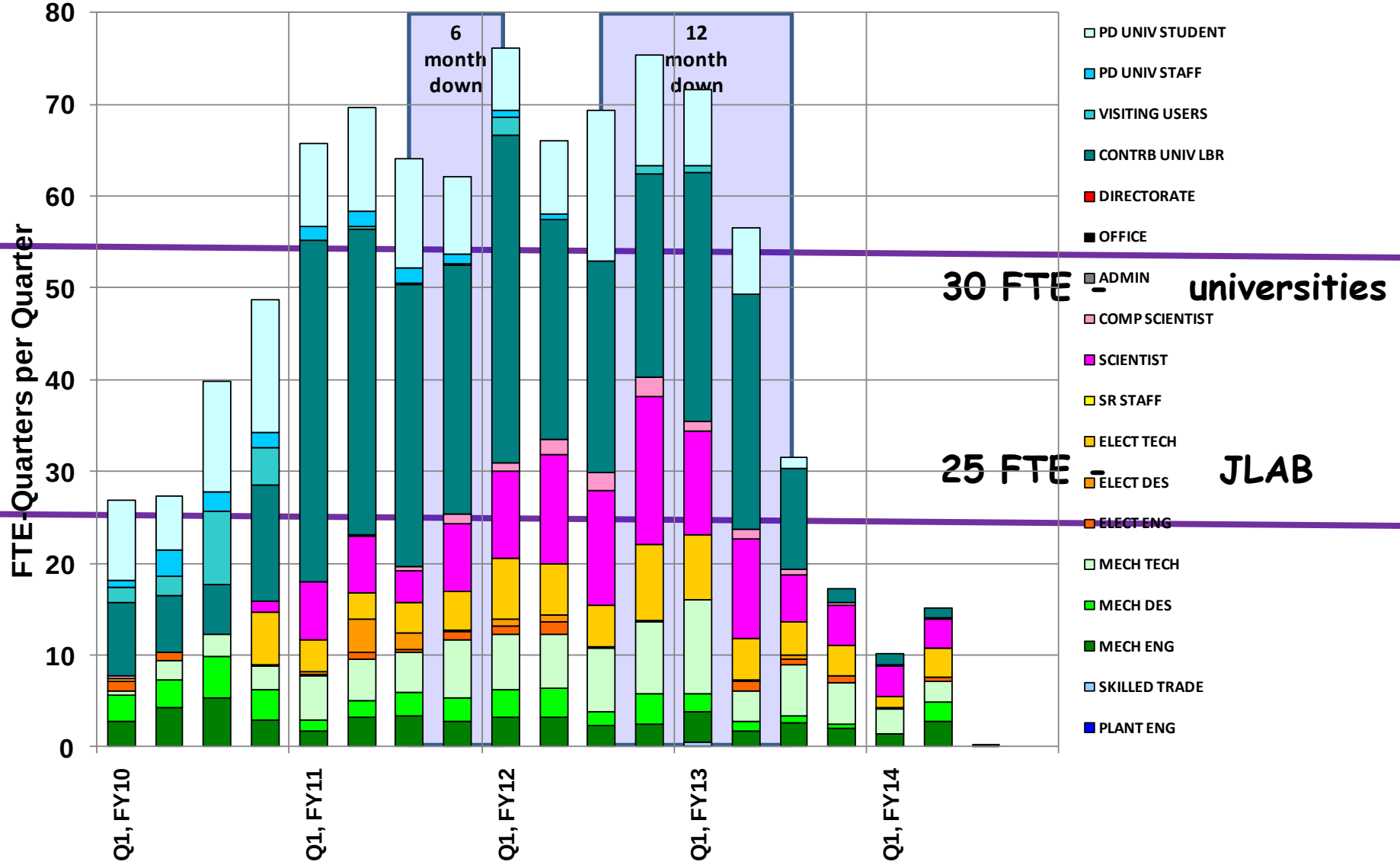
WBS	CONTRACT	PHASE	STATUS
1.5.2	Hall D Barrel Cal Fibers	Phase 1 of 3	**Awarded**
1.5.2	Hall D Barrel Cal Fabrication	Phase 1 of 4	**Awarded**
1.5.2	Hall D Procure SiPMTs	-	Advanced Procurement Plan In Progress
1.5.2	Hall D Central Drift Chamber	Phase 1 of 3	Specification Complete *
1.5.2	Hall D Forward Calorimeter	Phase 1 of 4	**Open Solicitation**

* Endplates - contract awarded
Feedthroughs - PR submitted
CMU contract - PR submitted

Hall D Procurement/Expense Obligation Profile



WBS 1.5 Total Labor by Skill



Active collaboration/MOU Status

University	MOU type	year	WBS	status/update
Regina	construction	2009	BCAL	active
CMU	construction	2009	CDC	active
Indiana U	construction	2009	FCAL	active
FSU	collaboration	2003	TOF	active/in progress
FIU	collaboration	2003	Start Counter	active/in progress
SMU (Chile)	collaboration	2007	BCAL	active
CNU	JLab	2009	electronics	active
Catholic	collaboration	2004	Tagger FA	active
Connecticut	collaboration	2003	Tagger MA, radiator	active
Athens	collaboration	2003	Monitoring for calor.	active
UMass	collaboration	2009	Target, electronics	in progress
NCUW	construction	2009	Pair spectrometer	in progress
NCA&T	collaboration	2009	Beam line	in progress

new

Risk Management

WBS Item	Description		Risk Rating	Likelihood Assessment			Impact Assessment		
				Technical	Cost	Schedule	Technical	Cost	Schedule
1.5	Construction Hall D								
1.5.1	Solenoid		Low	Low	Low	Low	Low	Low	Low
1.5.2	Detectors		Low	Low	Low	Low	Low	Low	Mod
1.5.3	Computing		Low	Low	Low	Low	Low	Low	Low
1.5.4	Electronics		Low	Low	Low	Low	Low	Mod	Low
1.5.5	Beamline		Low	Low	Low	Low	Low	Low	Low
1.5.6	Infrastructure		Low	Low	Low	Low	Low	Low	Mod

Risk mitigation plan is updated at least twice a year

Overall risk ratings are low

- 1.5.2 Contributed manpower was a concern, mitigated by CR09-27
  BCAL readout decision by Jan 2010
  Tracking the cost as low risk since June 2009
- 1.5.4 New densely populated electronics (FADC-125 72) under tests
  Mitigation: produce less-dense modules
- 1.5.6 Mitigation: Work coordinator hired; detailed installation plans are being developed

Hall D Cost Methodology

Basis of Estimate (BOE):

• Costed	1%	*F1 chips*
• Obligated	11%	*Sc.Fibers, BCal*
• Quotes from vendors	0%	
• Catalog price	4%	
• Estimates from vendors/ consultants	33%	
• Previous JLab experience	25%	
• Information from other labs, Universities, etc.	6%	
• Engineering judgment	20%	

SUMMARY

- **PED:**
  - *expected to be finished in Sept 2009*
  - *Outstanding issue:*
    - *Characterization of the SiPM by Jan 2010*
- **Construction:**
  - *BCAL: fibers/lead - contracts awarded, modules construction - contract awarded, ordering the light sensors - Feb 2010*
  - *CDC, FCAL - open solicitations, procurements started*
  - *FDC - construction prototype - Dec 2009*
  - *Tagger - package for "build-to-print" - Oct 2010*
  - *Electronics: F1 chips purchased, trigger scheme tested*

SUMMARY (continued)

- **Manpower:**
  - *Hired: Hall leader, Work coordinator*
  - *Interviewing:*
    - *2 scientists, started interviewing*
    - *1 engineer, advertised*
    - *2 techs, started interviewing*
  - *Collaboration growing: UMass, NCUW, NCA&T*

Appendix

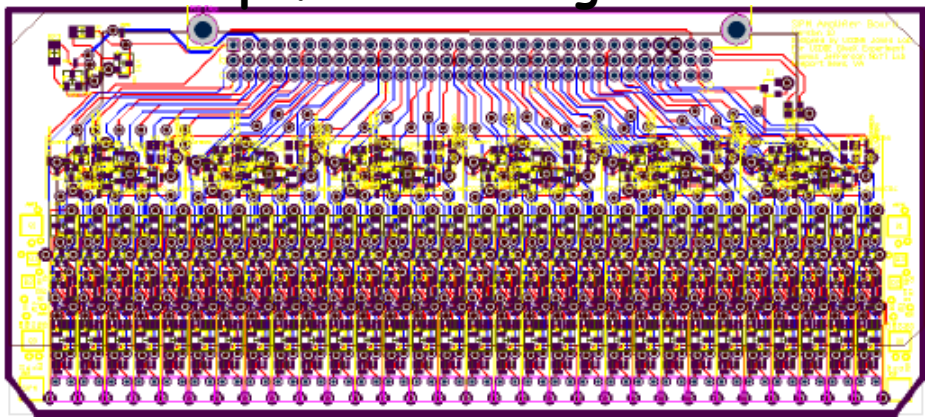
Hall D: Detector Design Parameters

Capability	*Quantity*	*Range*
Charged particles	Coverage	$1^o < \theta < 160^o$
	Momentum Resolution (5^o-140^o)	$\sigma_p/p = 1 - 3\%$
	Position resolution	$\sigma \sim 0.15$-0.20 mm
	dE/dx measurements	$20 < \theta < 160^o$
	Time-of-flight measurements	$\sigma_{ToF} \sim 60$ ps; $\sigma_{BCal} \sim 200$ps
	Barrel time resolution	$\sigma_t{}^{\gamma} < (74/\sqrt{E} \oplus 33)$ ps
Photon detection	Energy measurements	$2^o < \theta < 120^o$
	FCAL energy resolution (E > 60 MeV)	$\sigma_E/E = (7.3/\sqrt{E} \oplus 3.5)\%$
	BCAL energy resolution (E > 40 MeV)	$\sigma_E/E = (5.54/\sqrt{E} \oplus 1.6)\%$
	FCAL position resolution	$\sigma_{x,y,} \sim 0.64$ cm$/\sqrt{E}$
	BCAL position resolution	$\sigma_z \sim 0.5$cm $/\sqrt{E}$
DAQ/trigger	Level 1	< 200 kHz
	Level 3 event rate to tape	~ 15 kHz
	Data rate	300 MB/s
Electronics	Fully pipelined	250 / 125 MHz fADCs, TDCs
Photon Flux	Initial: 10^7 γ/s for 8.4<E<9.0 GeV	Final: 10^8 γ/s

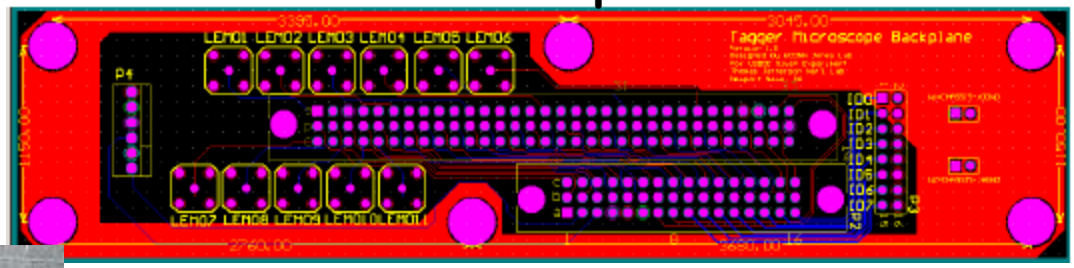
Tagger: Scintillator "microscope"

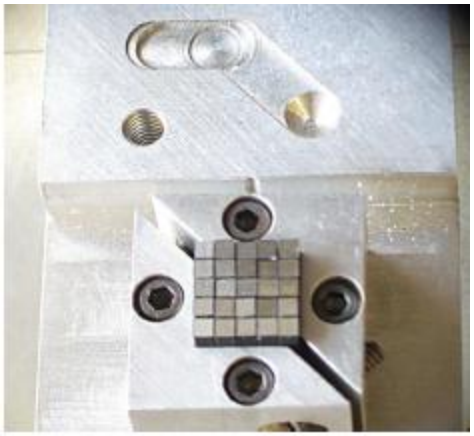
- Amplifier board: design complete
  - Up to 30 SiPM 2x2 mm^2
  - 2-stage fast amplifiers
  - Summing circuitry
  - Health sensors (<0.5°C)
- Control board: design complete
  - FPGA
  - Ethernet
  - V_{bias} via DAC: 14 bits 32-chan
  - Health sensors
- Test in Hall B: March 2010
- Construction: FY12

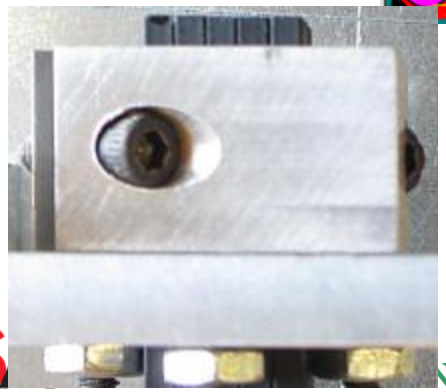
Amplifier/Summing Board



Backplane





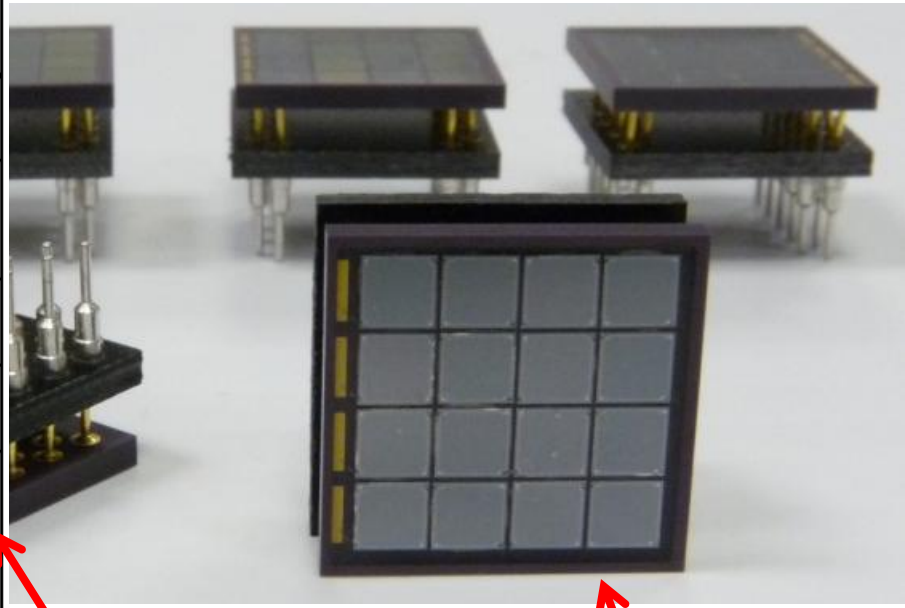


Fiber cutting and polishing

Digital Control Board

BCAL SiPM options

	SensL	Hamamatsu
Pixel size (μm)	35	50
N_{pixels} / cell	3640	3600
PDE	10-20%	> 20%
Fill Factor	59%	61.5%
Dark Rate (per cell)	8Mhz	5-6 Mhz
V_{op}	30 V	70 V
Gain	$> 10^6$	$> 10^6$
Eff. Area	75%	89%

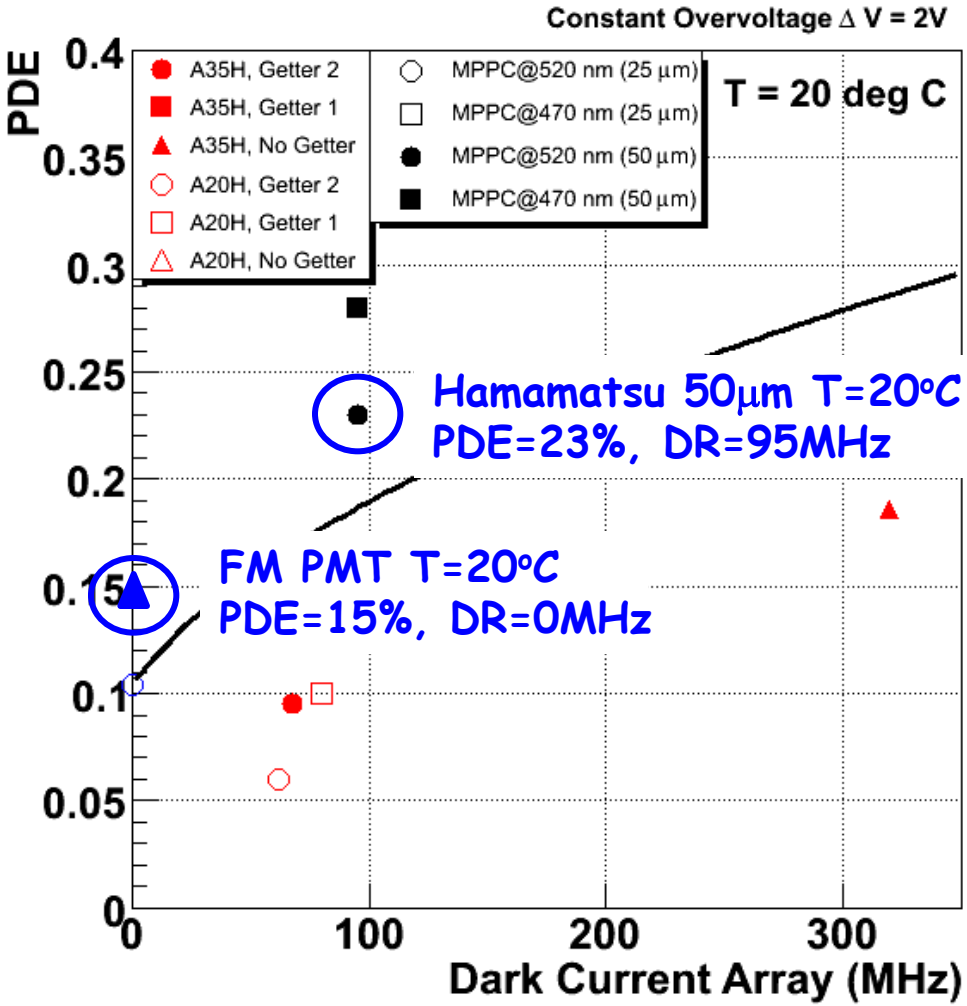


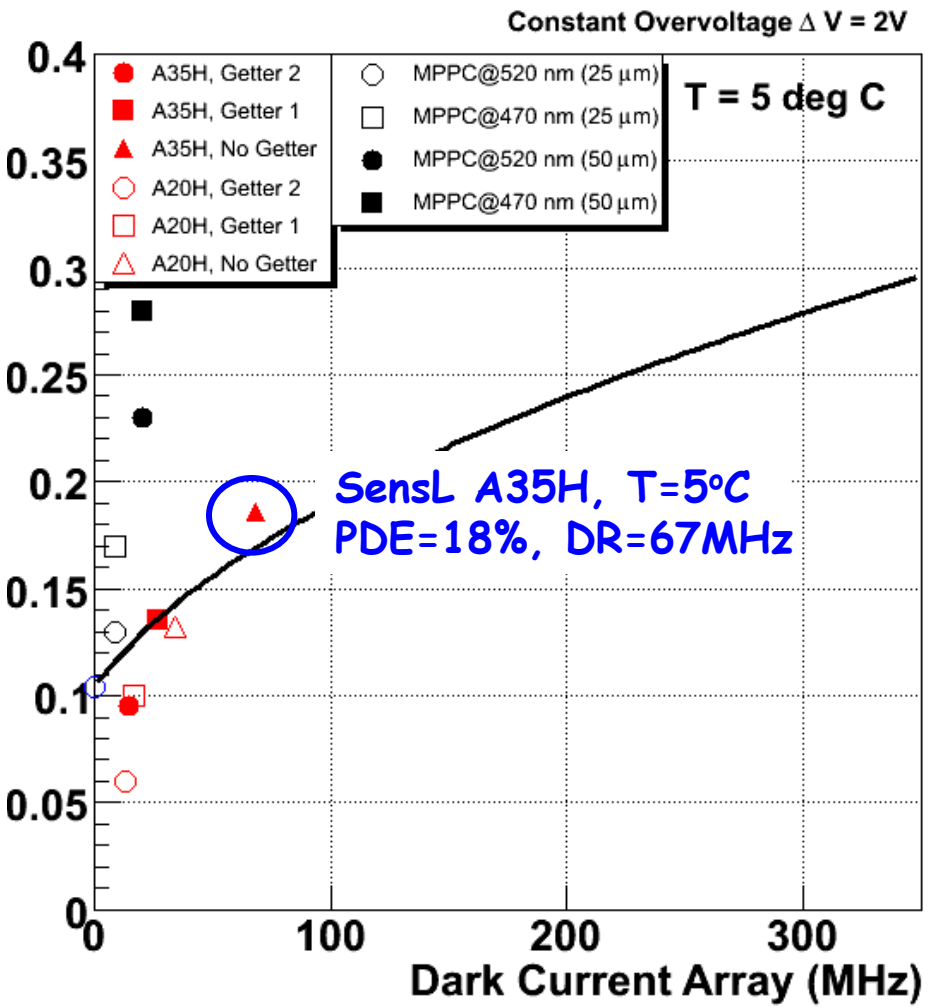
Temperature dependent

SensL Array

BCAL SiPM: PDE vs Dark Current

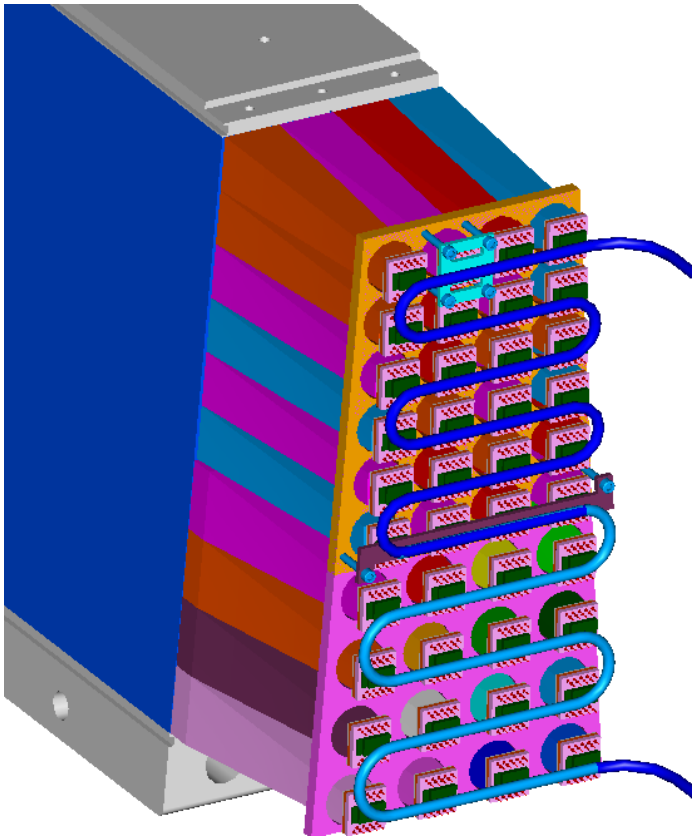
$$DR(T) = DR(20^o)\, e^{0.103\,(T-20)}$$



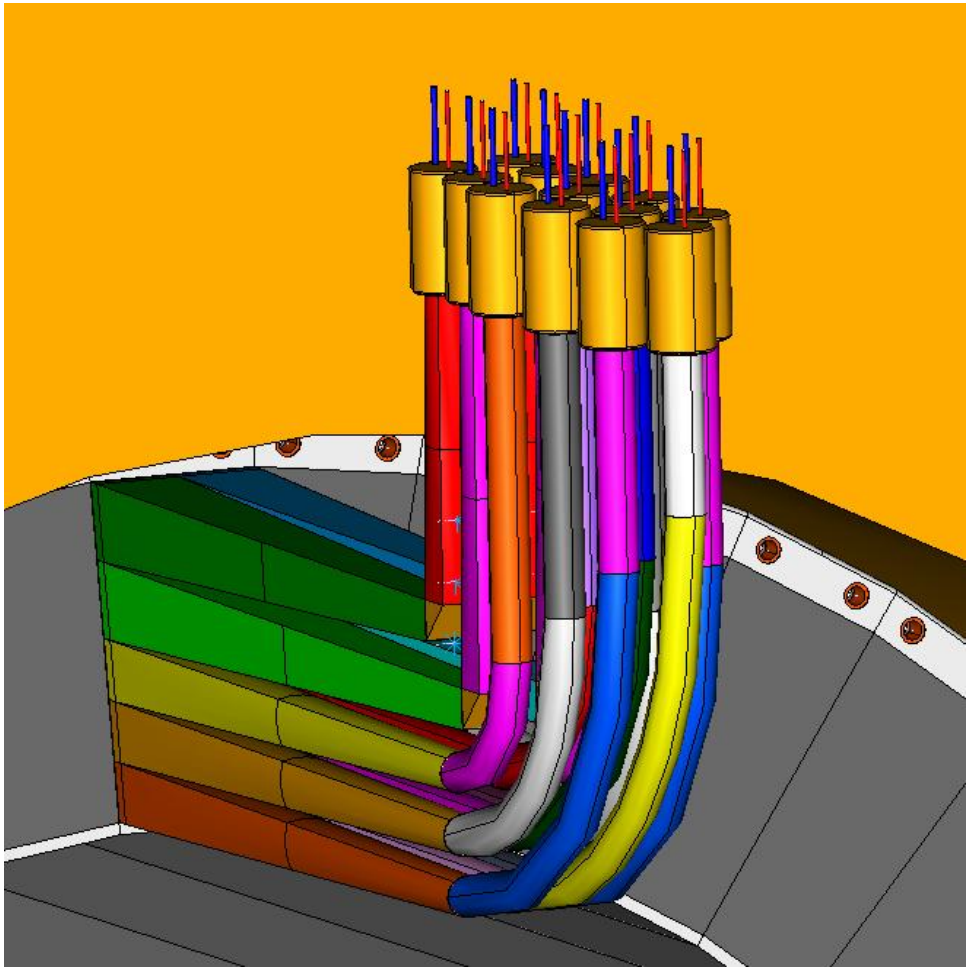


BCAL: Two Readout Schemes

- SiPM



- FMPMT



Alternative geometry might improve collection

Suggestion:
Place FM PMTs at 30° relative to Field
Btot < 0.2 T

Ref: Pedro Toledo
GlueX-doc-1291

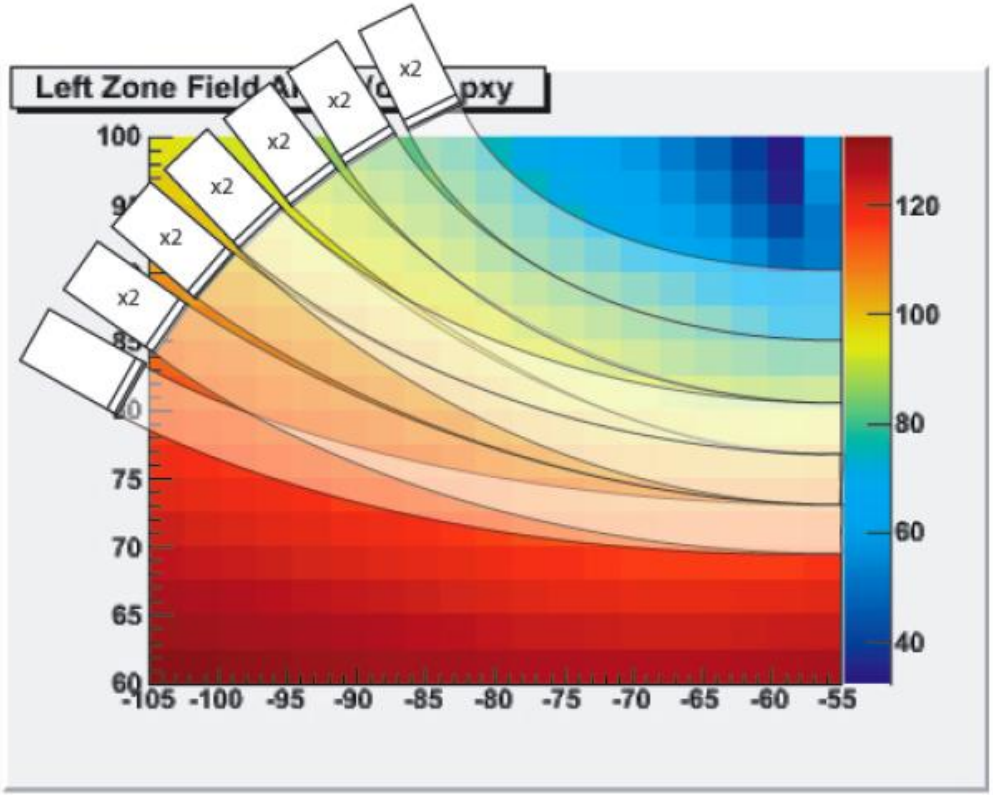
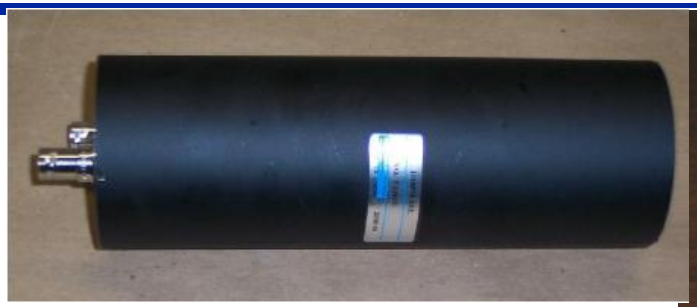


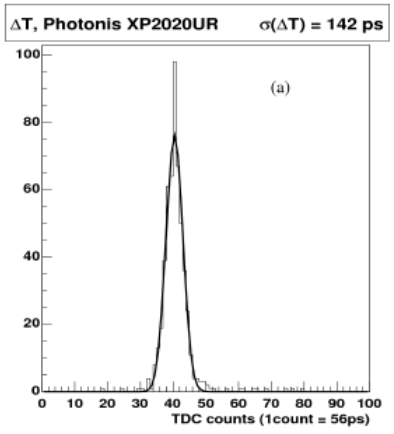
Fig. 8. **FMPMT at sugested position** The figure shows the 13 FMPMT deployed at the available space with the orientation needed to have 30[deg] respect to the magnetic field. The FMPMT with the label "x2" specifies that in the axis Y there will be 2 FMPMT with the same orientation

TOF Progress

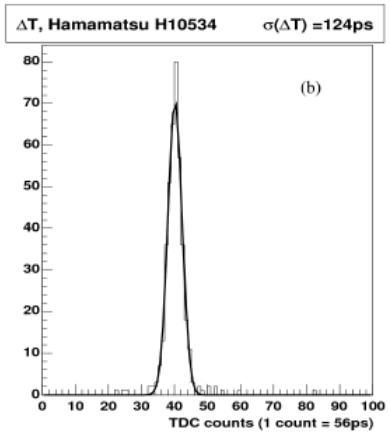


- PMT: Hamamatsu H10534 vs XP2020
  - Timing resolution: slightly better
  - Lower gain: use an amplifier?
  - Lower cost
- Light guides optimization
- Timing resolution measurements: progress
- Construction: FY12

Timing resolution: XP2020UR vs H10534



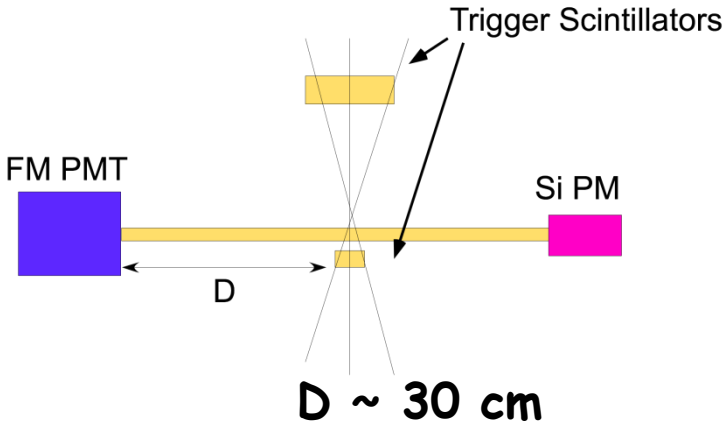
Photonis: 142 ps at 2300 V
(~300 V below nominal HV)

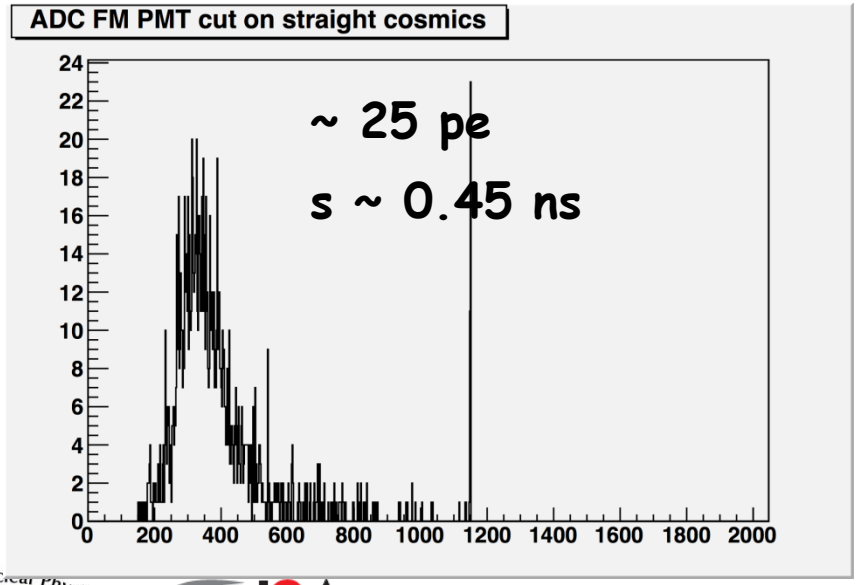


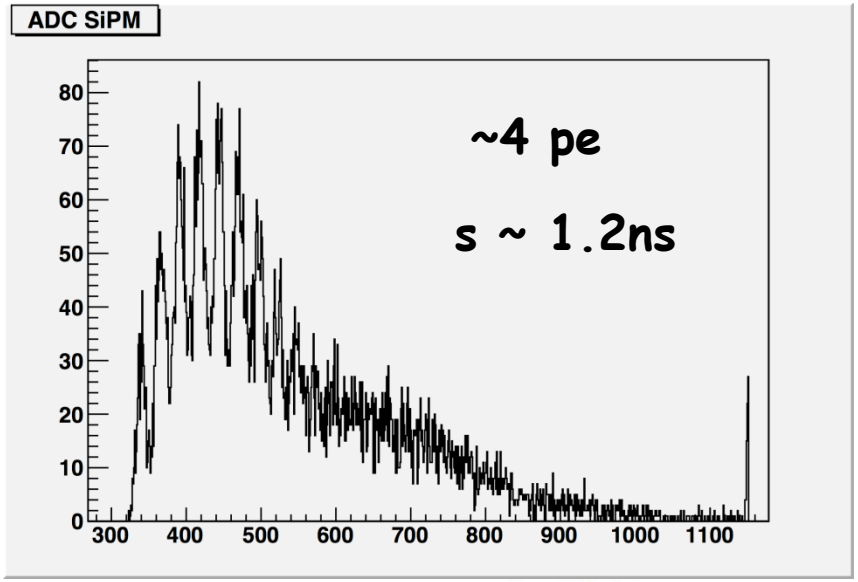
Hamamatsu: 124 ps at 1750 V
(at nominal HV)

Start Counter Progress

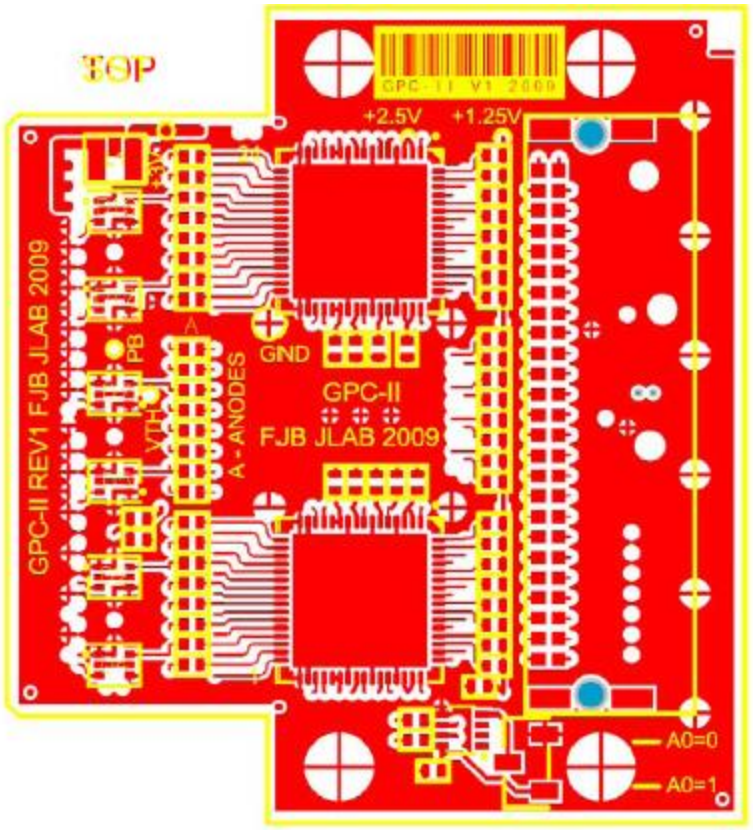
- Plastic scintillator 3x10x600 mm^3
- Measured attenuation length ~240 mm
- Comparison
  - SiPM (3x3mm, SENSL) 1.2 ns
  - FM PMT 0.45 ns
  - Need 0.35ns for bunch identification
- Light guides, better SiPM, WLS fiber?
- Construction: FY12







GAS-II ASIC



- GAS-II ASIC chips 8 channels/chip (prototype GAS-I - extensively tested)
- ~100 chips received June 2009
  - Preliminary tests - OK
  - Gain settings:
    - Cathodes: 6 mV/fC, Q <120 fC
    - Anodes: 1.2 mV/fC, Q <600 fC
    - Anode discriminators: 3.2 fC
  - Bonding missing for channel #3 will be fixed for production
- Preamplifier PCB: 3 ASICs
  - Finish testing by Oct 1
  - Package 40 chips with the bond fixed
  - Use for the FDC testing
- Procurement schedule: June 2010

Checkout/Commissioning

Commissioning Period One: General Checkout (without Beam)

Hall D Objectives:

Test base functionalities of the detectors, magnets, and target during early phase of the Hall D installation, with testing of the superconducting magnet performed well in advance of the further detector assembly and installation.

- checkout the solenoid; cryo-system, quench test, run to full field, magnetic field measurements
- tagger checkout; power supplies, interlock systems, magnetic field measurements, run magnet at full field
- checkout individual detector components for basic functions
- tests of liquid hydrogen target interlock system
- test all electronic modules for full functionality in separate test stand prior to integration in DAQ

Checkout/Commissioning

Commissioning Period Two: Integrated Checkout (Hot Checkout)

Hall D Objectives:

the purpose of the detector checkout without beam is to ensure that all detector components are functional and cabled correctly. During this period a full check of the data acquisition and slow control system is performed. A test of all the interlock system for running with beam is also performed, to ensure the safety of the equipment during beam operation.

- checkout of HV and LV systems before and after they are cabled to the detectors.
- test of slow-control and alarm system
- test of FDC and CDC with integrated pulser system; test of calorimeters and ToF with gain monitoring system
- check detector responses with pulsers and led systems and magnetic field turned on
- check all the detectors with cosmics to determine gain, … test monitoring software and trigger logic.

Checkout/Commissioning

Commissioning Period Three: Full Commissioning (with beam)

Hall D Objective:

Transport an electron beam with an energy of at least 10 GeV, average current of at least 2 nA, and emittance < 20 nm-rad at tagger radiator (CD4B-VIII).

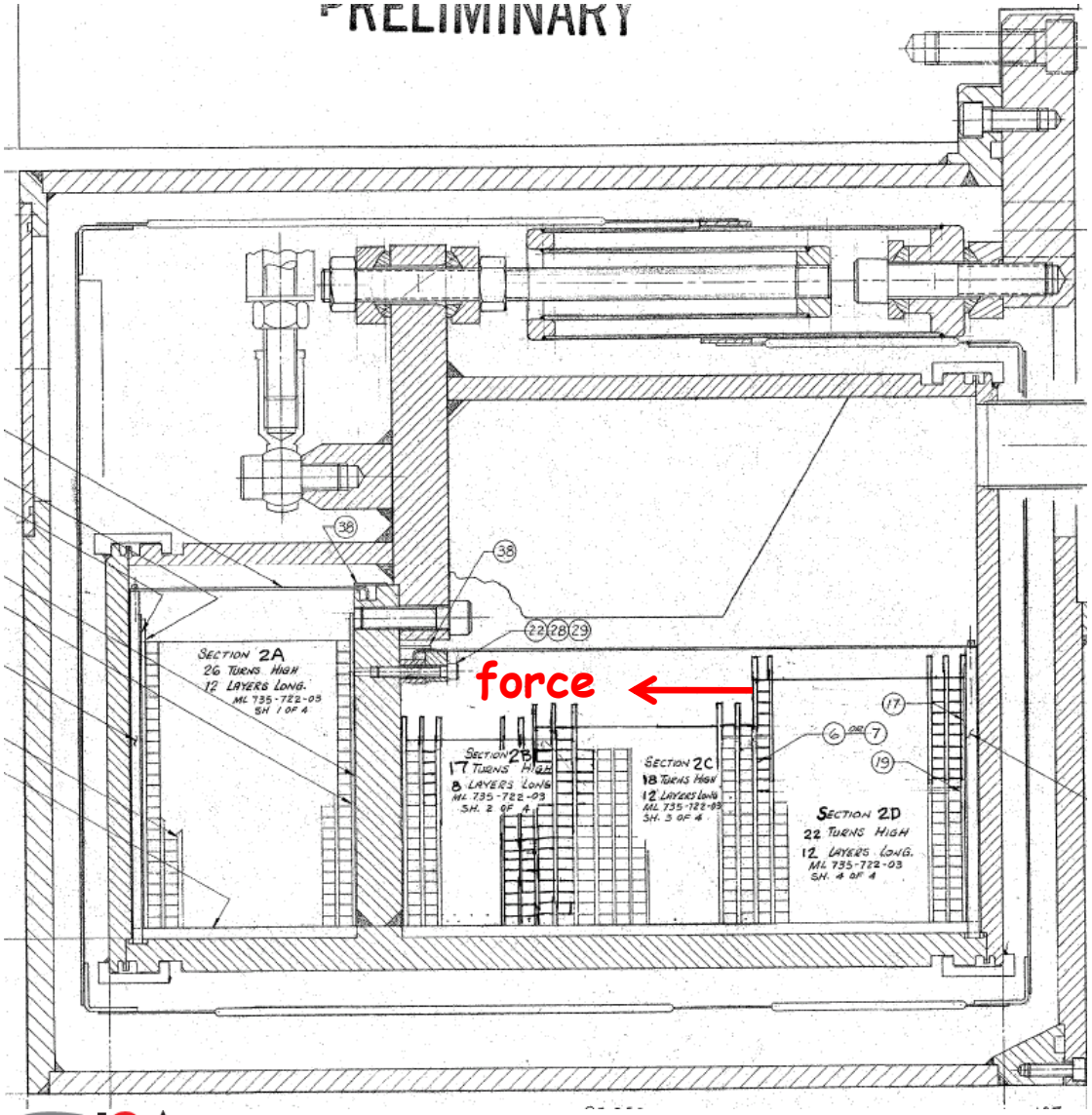
- Transport photons from the tagger radiator through a collimator to a target within the Hall D spectrometer.
- checkout of individual detector components with photon beam
- checkout the trigger logic for real events.
- checkout all slow-control and monitoring software
- write full events to tape

Backup

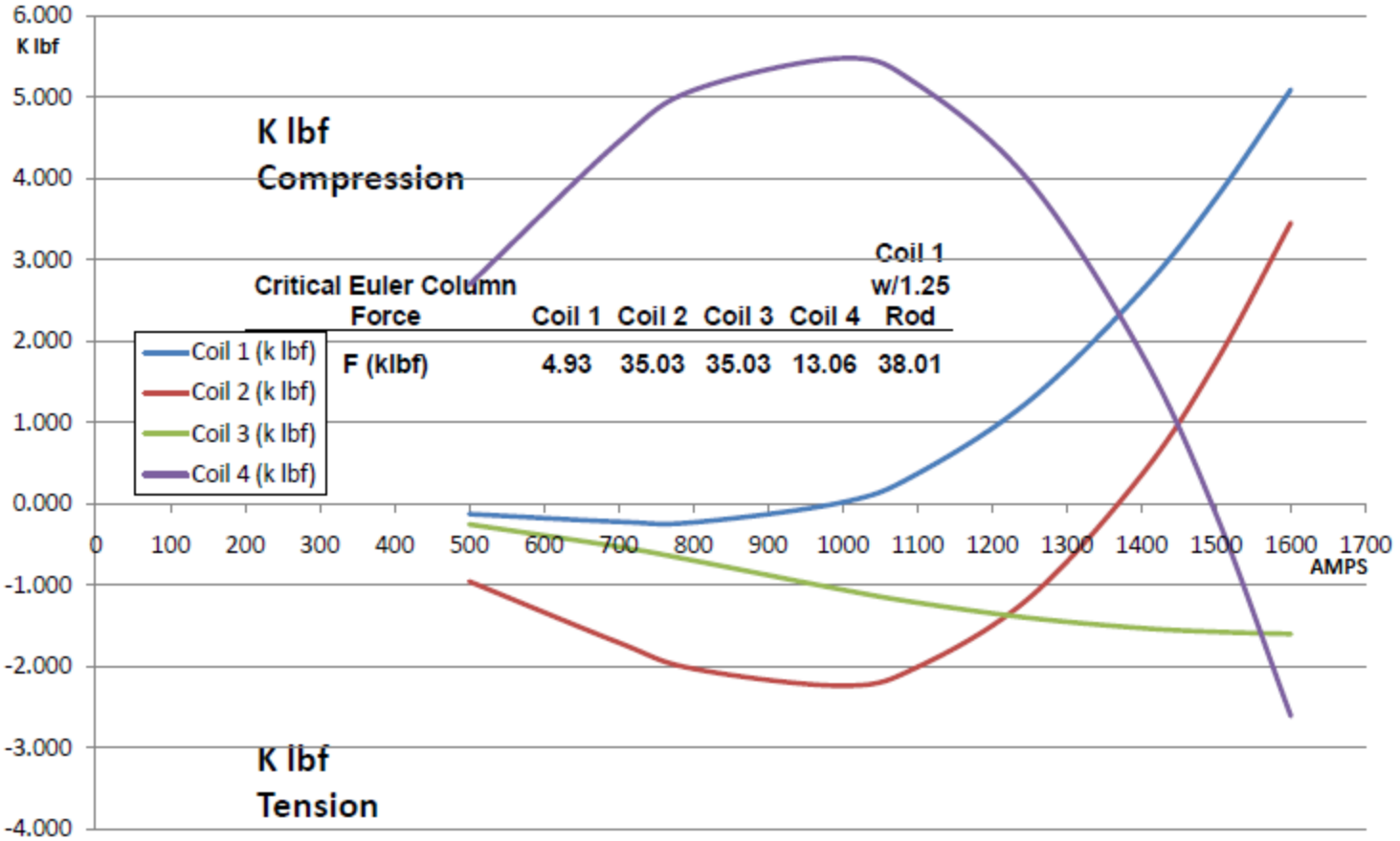
Solenoid Coil Refurbishment Status

Coil	LN2 Circuit	LHe Vol.	Coil Structure	Electrical Shorts
1	OK	OK	OK	OK Ready to close-up at JLab
2	OK	OK	Subcoil D needs structural support	OK
3	New stainless shields delivered to IUCF	OK	OK	OK
4	OK	OK	OK	OK

Solenoid: Coil 2

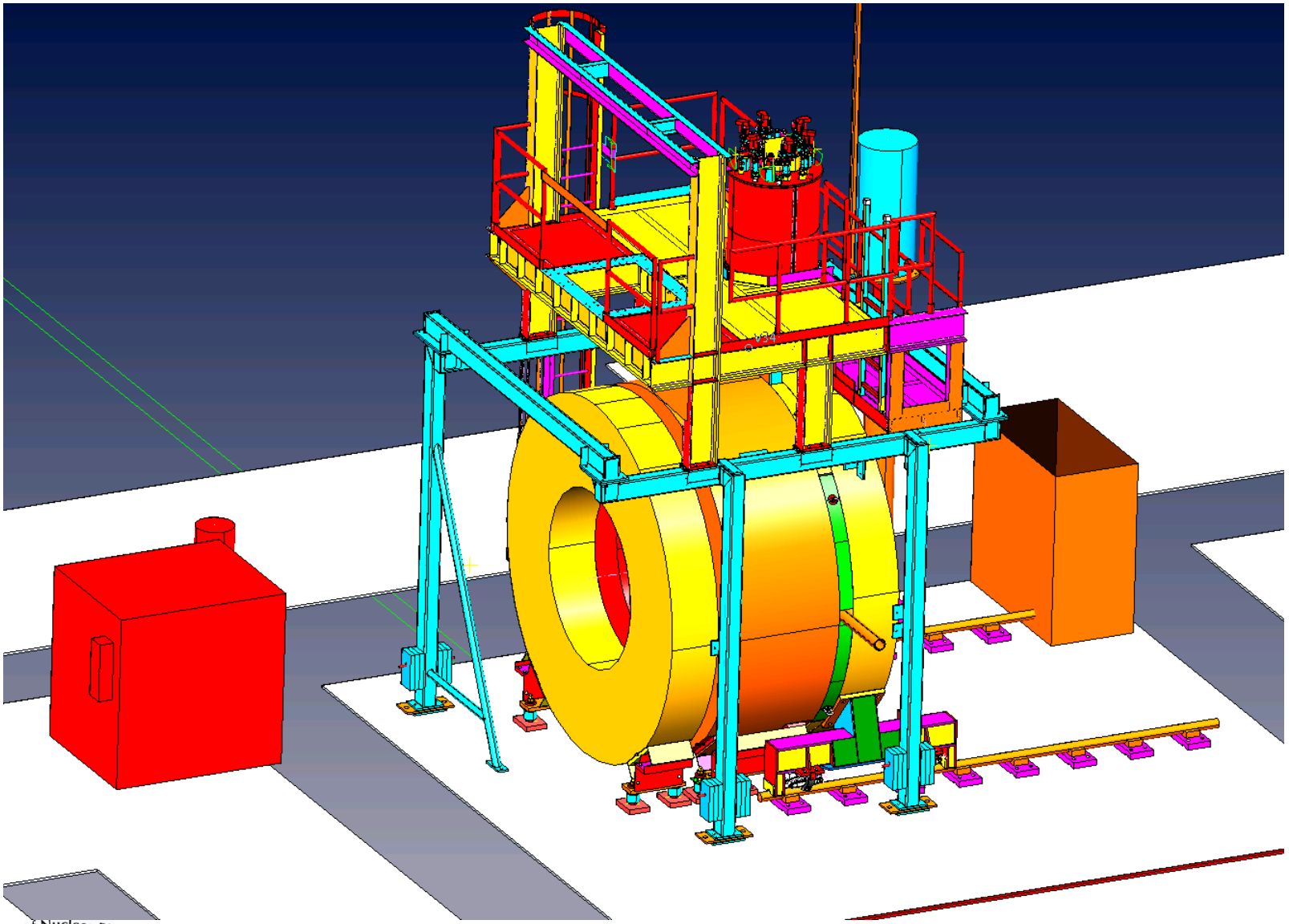


Solenoid: Axial Forces per Column

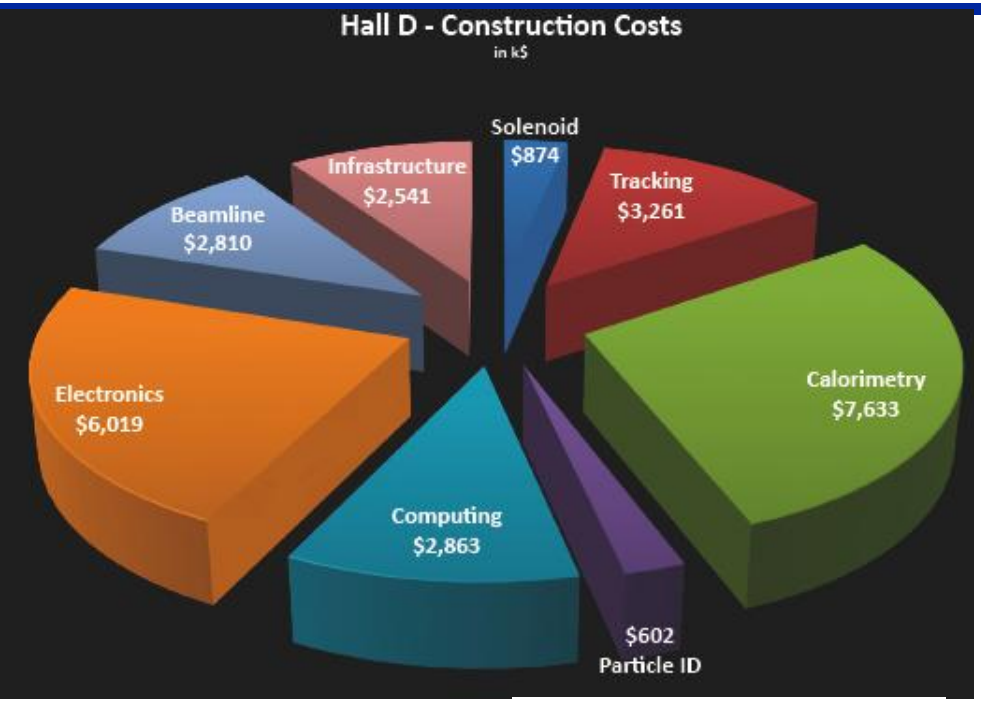


Critical Euler Column Force	Coil 1	Coil 2	Coil 3	Coil 4	Coil 1 w/1.25 Rod
F (klbf)	4.93	35.03	35.03	13.06	38.01

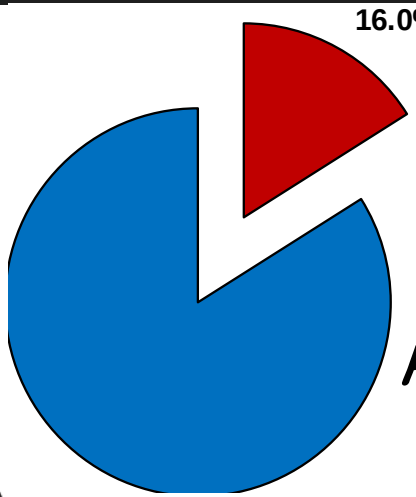
Solenoid: Planned Test of Coil 1



1.5 Cost Construction



Old picture

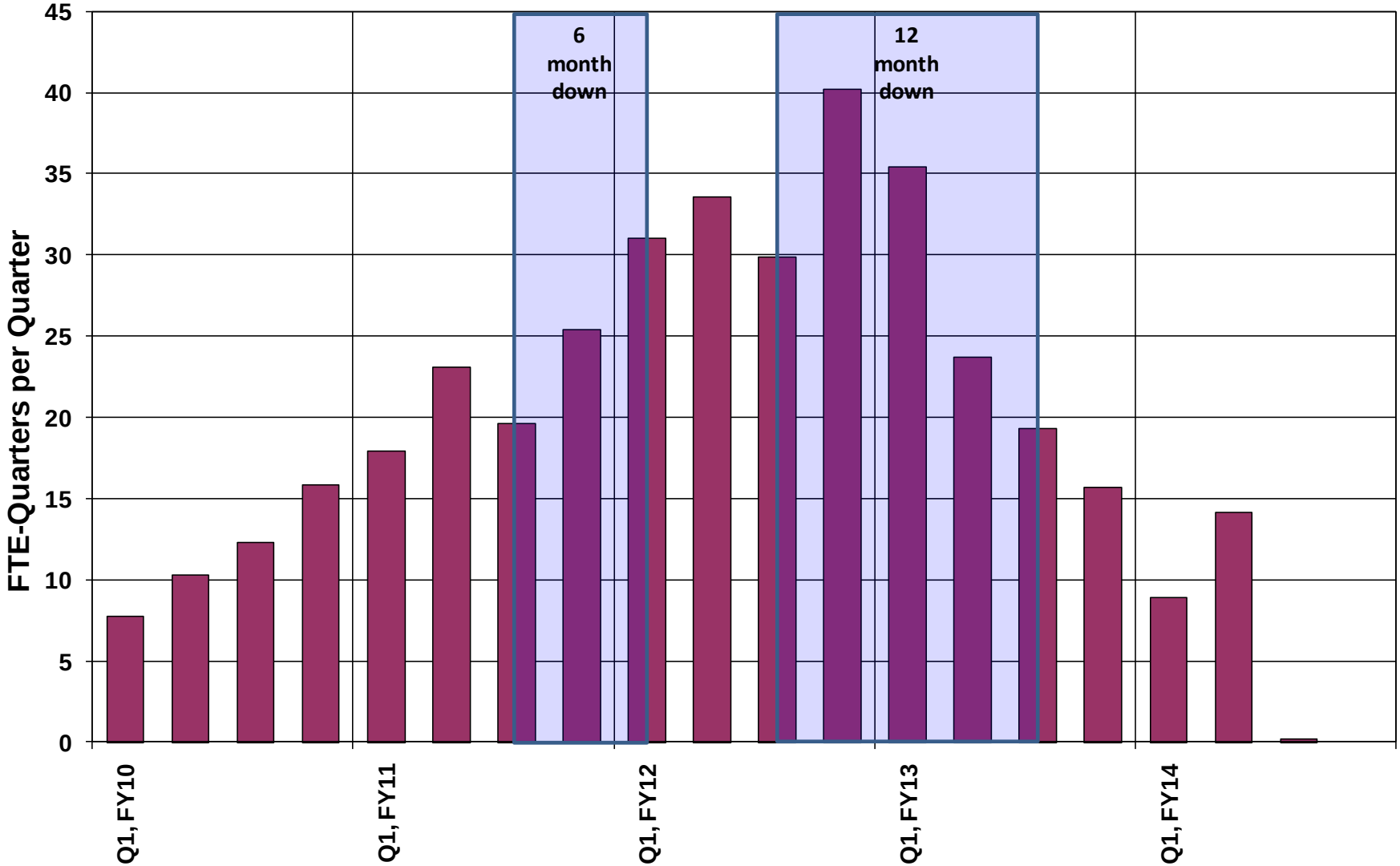


Hall D construction: 16% of total

Construction

WBS	System	FY09$k Direct
1.5.1	Solenoid	1231
1.5.2	Detectors	12217
1.5.3	Computing	2954
1.5.4	Electronics	6210
1.5.5	Beamline	3086
1.5.6	Infrastructure	3429
1.5	Total	29127

Hall D JLab Labor Profile



Construction Schedule