

PRad Implementation Plan

(suggested installation and run)

A. Gasparian

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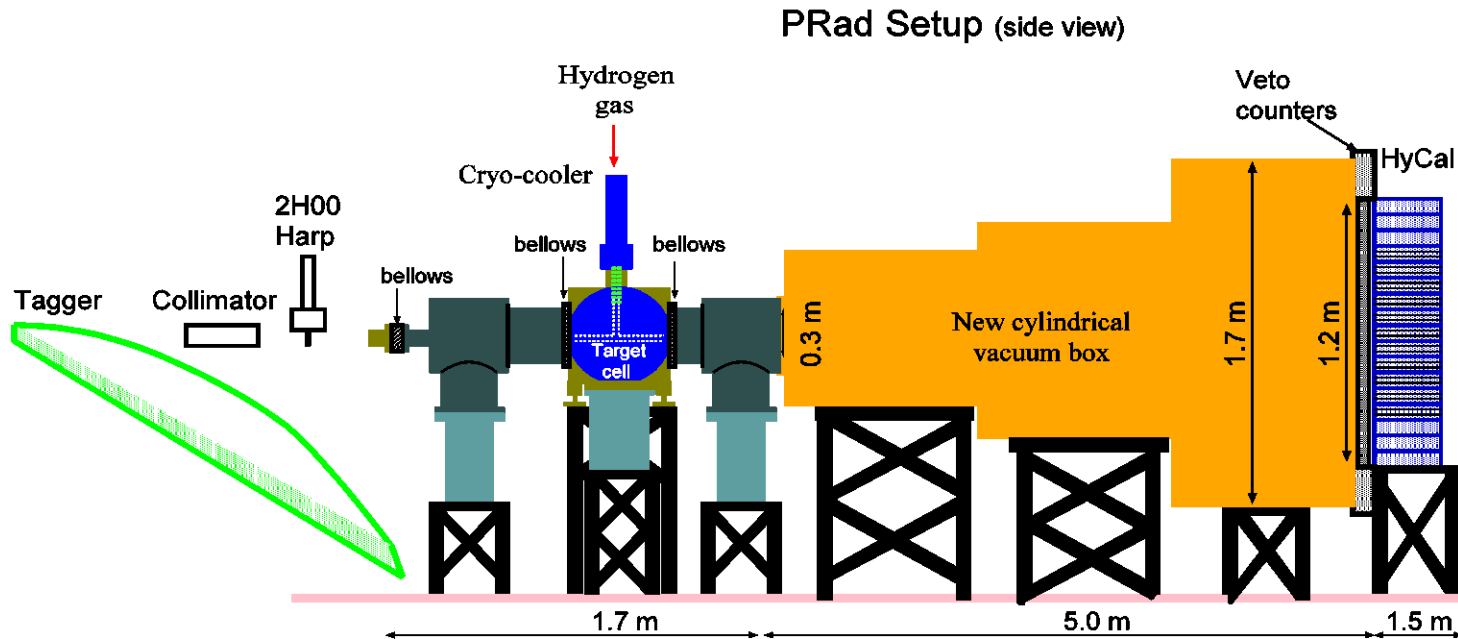
for the PRad collaboration

Outline

- PRad experimental setup
- Installation plan in Hall B
- Suggested engineering and physics runs
- Time schedule and manpower

PRad Experimental Setup

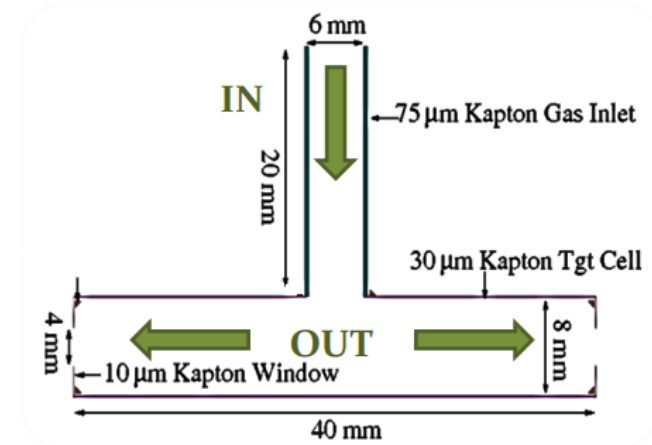
- Main detectors and elements:
 - Windowless H₂ gas flow target
 - High resolution, large acceptance PrimEx HyCal calorimeter
 - Vacuum box with one thin window at HyCal end only (~ 5 m long, from H₂ target to HyCal)
 - X,Y – scintillating veto counters
- Beam line equipment:
 - Photon Tagger facility for calibrations
 - Standard beam line elements for low intensity e⁻ beam current (0.1 – 10 nA)
 - Collimator box (with 2 mm collimator for photon beam and 6 mm for e⁻ beam halo “clean-up”)



Windowless H₂ Gas Flow Target

Target cell:

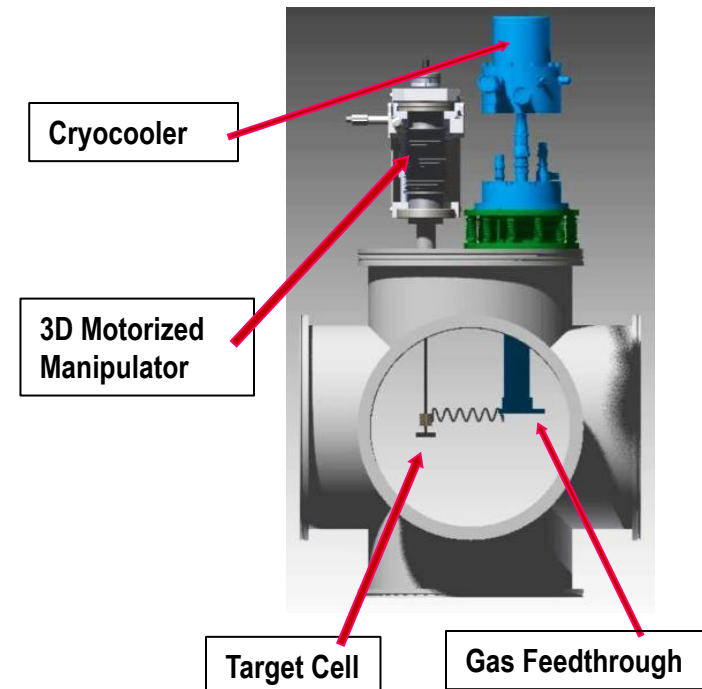
- cell length 4.0 cm
- cell diameter 8.0 mm
- cell material 30 μm Kapton
- input gas temp. 25 K
- target thickness 1×10^{18} H/cm²
- average density 2.5×10^{17} H/cm³
- gas mass-flow rate 6.3 Torr-l/s \approx 430 sccm



Target parts:

- pumping system (all parts at Jlab)
- cryocooler (at Jlab)
- motorized Manipulator (at Jlab)
- chillers for pumps and cryocooler (at Jlab)
- Target and secondary chambers (early May, 2014)

Kapton cell: work in progress

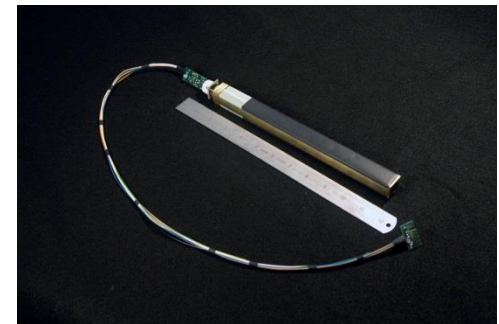
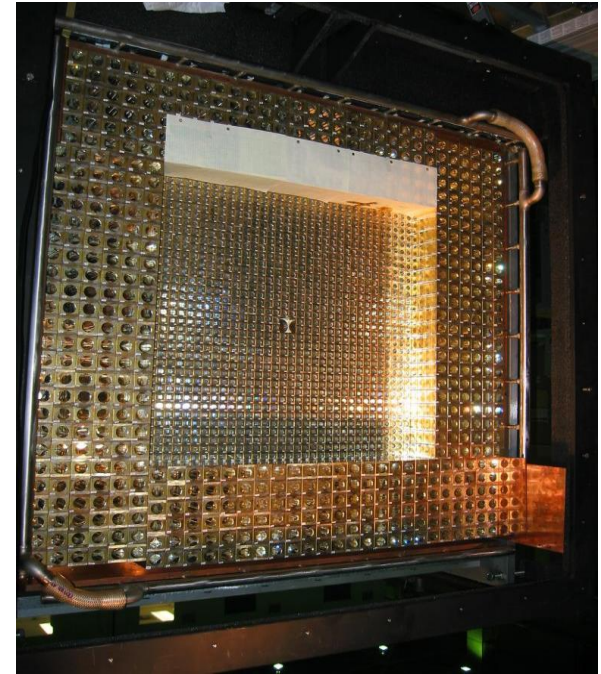


PrimEx Hybrid Electromagnetic Calorimeter (HyCal)

- Combination of PbWO_4 and Pb-glass detectors ($118 \times 118 \text{ cm}^2$)
- 34×34 matrix of $2.05 \times 2.05 \times 18 \text{ cm}^3$ PbWO_4 shower detectors
- 2×2 PbWO_4 modules removed in middle for beam passage
- 5.5 m from H_2 target ($\sim 0.5 \text{ sr}$ acceptance)

- Resolutions:
 - for PbWO_4 shower detectors
 - ✓ energy $\sigma/E = 2.6 \% / \sqrt{E}$
 - ✓ position: $\sigma_x = 2.7 \text{ mm} / \sqrt{E}$
 - for Pb-glass shower detectors
 - factor of ~ 2.5 worse

- Work in progress to add X,Y-coordinate detectors on front of HyCal
 - factor of **>10 improvements in coordinate resolutions**
 - Similar improvements in Q^2 resolution (**very important**)
 - unbiased coordinate reconstruction (including transition region)
 - increase Q^2 range by including Pb-glass part of HyCal (**important**)



Beam Quality Requirements

Quality	Value
Energy	1.1 and 2.2 GeV
Beam current	0.1 – 10 nA
Luminosity	$\sim 10^{28} \text{ cm}^{-2}\text{s}^{-1}$
σ_x, σ_y	$\sim 100 \text{ }\mu\text{m}$
Position stability	$\sim 100 \text{ }\mu\text{m}$
Beam halo	$< (1 \times 10^{-7})^*$
Divergence	$< \text{mrad}$
Emittance (ϵ_x, ϵ_y)	$8 \times 10^{-10} \text{ m-rad}$

* for $R > 3 \text{ mm}$ from the beam center

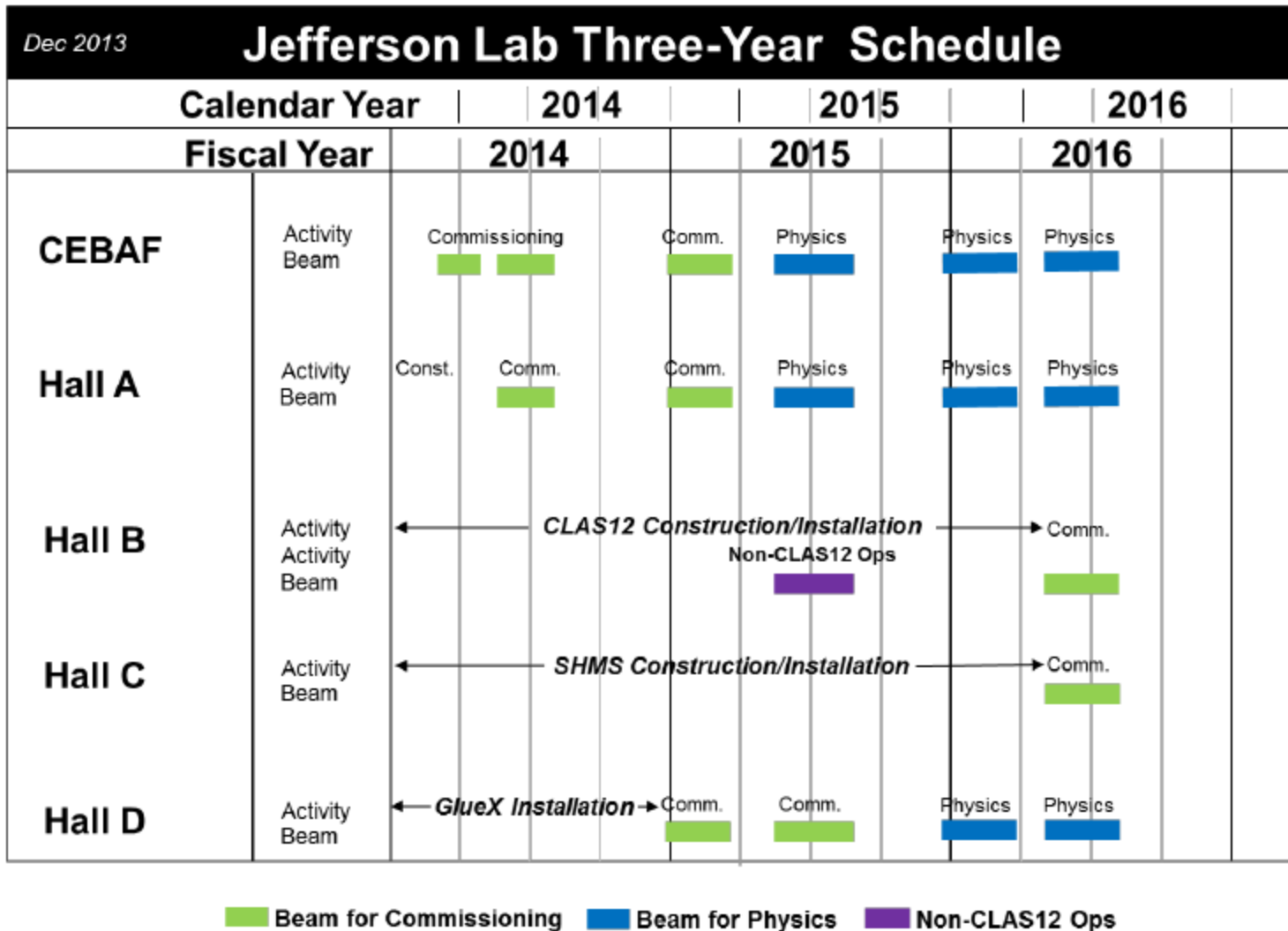
PRad Run Proposal

- Engineering/commissioning run (first part of 2015)
 - PRad is a “stand-alone” experiment with new detectors and engineering systems:
 - ✓ new windowless H₂ gas flow target
 - ✓ refurbished 1750 channel hybrid calorimeter
 - ✓ new DAQ and slow control system
 - ✓ new fADC-based electronics
 - To check:
 - ✓ all systems check-out with an electron beam
 - ✓ background rates in HyCal trigger
 - ✓ effectiveness of 6 mm “clean-up” collimator in real beam conditions
 - ✓ new target system in real beam conditions
 - Estimated 14 calendar days with beam (not included in PAC39 approved days)
 - Beam energy: 2.2 GeV and/or 1.1 GeV
 - Beam quality: same as for the physics run or best available by that time

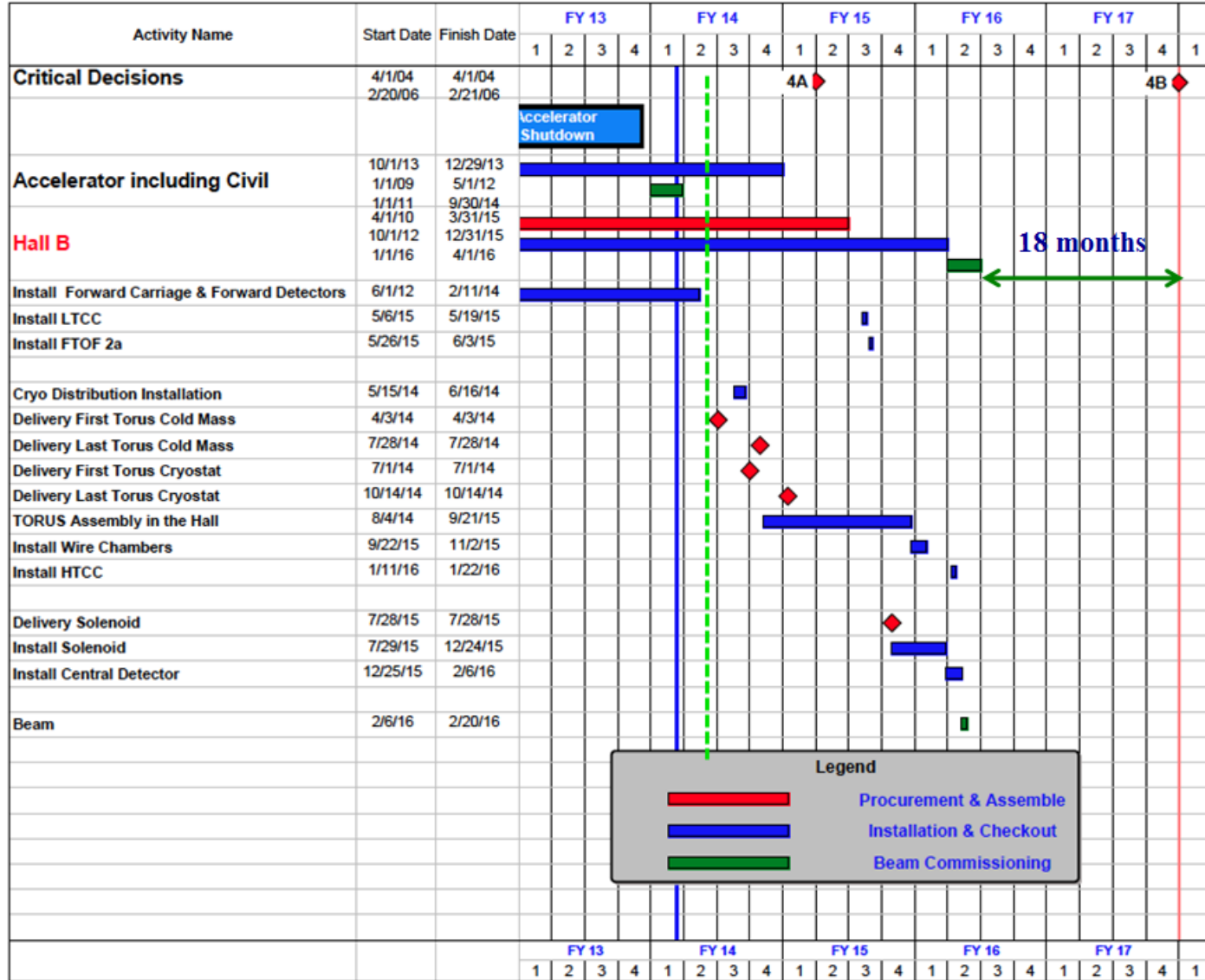
- Physics/production data taking run (2-3 months after engineering run)
 - Beam energy: 1.1 GeV and 2.2 GeV
 - Beam quality: as requested in proposal
 - Beam time: 15 PAC days

 - Expected result:
 - ✓ high accuracy, most model independent extraction of R_p (total error 0.6%)

JLab Three-Year Run Plan

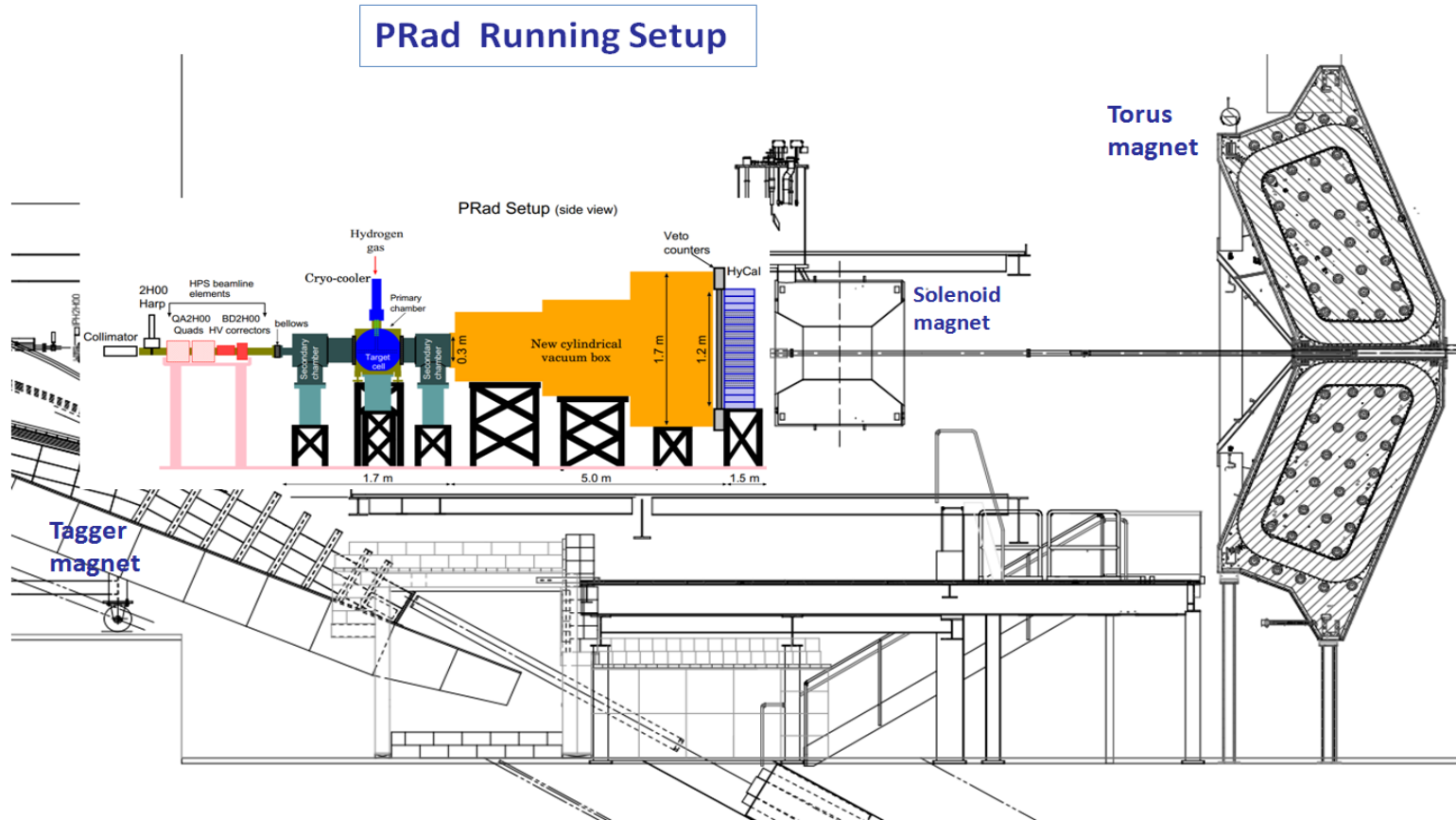


Hall B Installation Schedule



Proposed PRad Running Configuration in Hall B

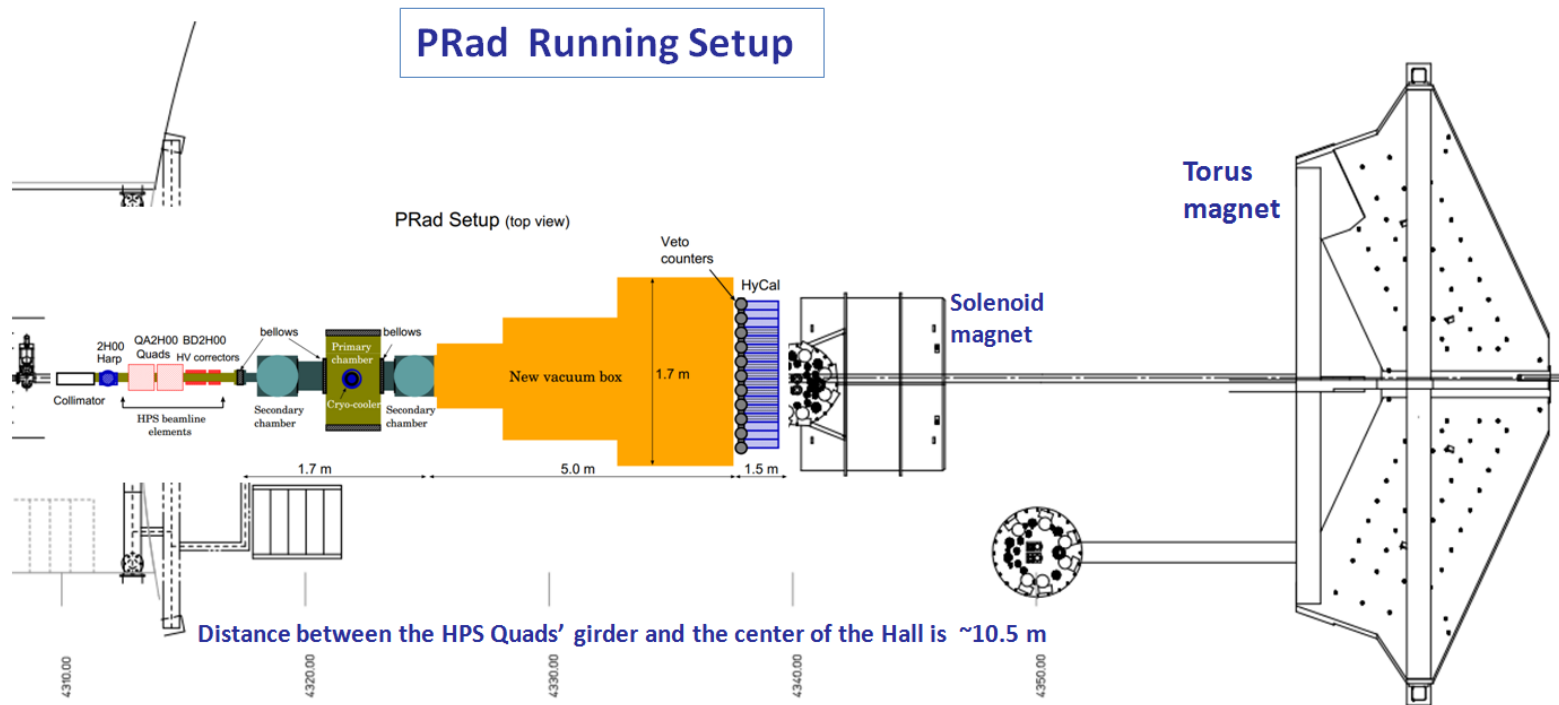
- Footprint of PRad setup: $\sim 8.2 \times 1.7 \text{ m}^2$
- Distance between HPS “quads girder” and Hall B center (Solenoid magnet area): $\sim 10.5 \text{ m}$
- Installation in parallel with CLAS12 work/assembly in Hall B
- Engineering and Physics runs during evenings/nights and over weekends



Distance between the HPS Quads' girder and the center of the Hall is $\sim 10.5 \text{ m}$

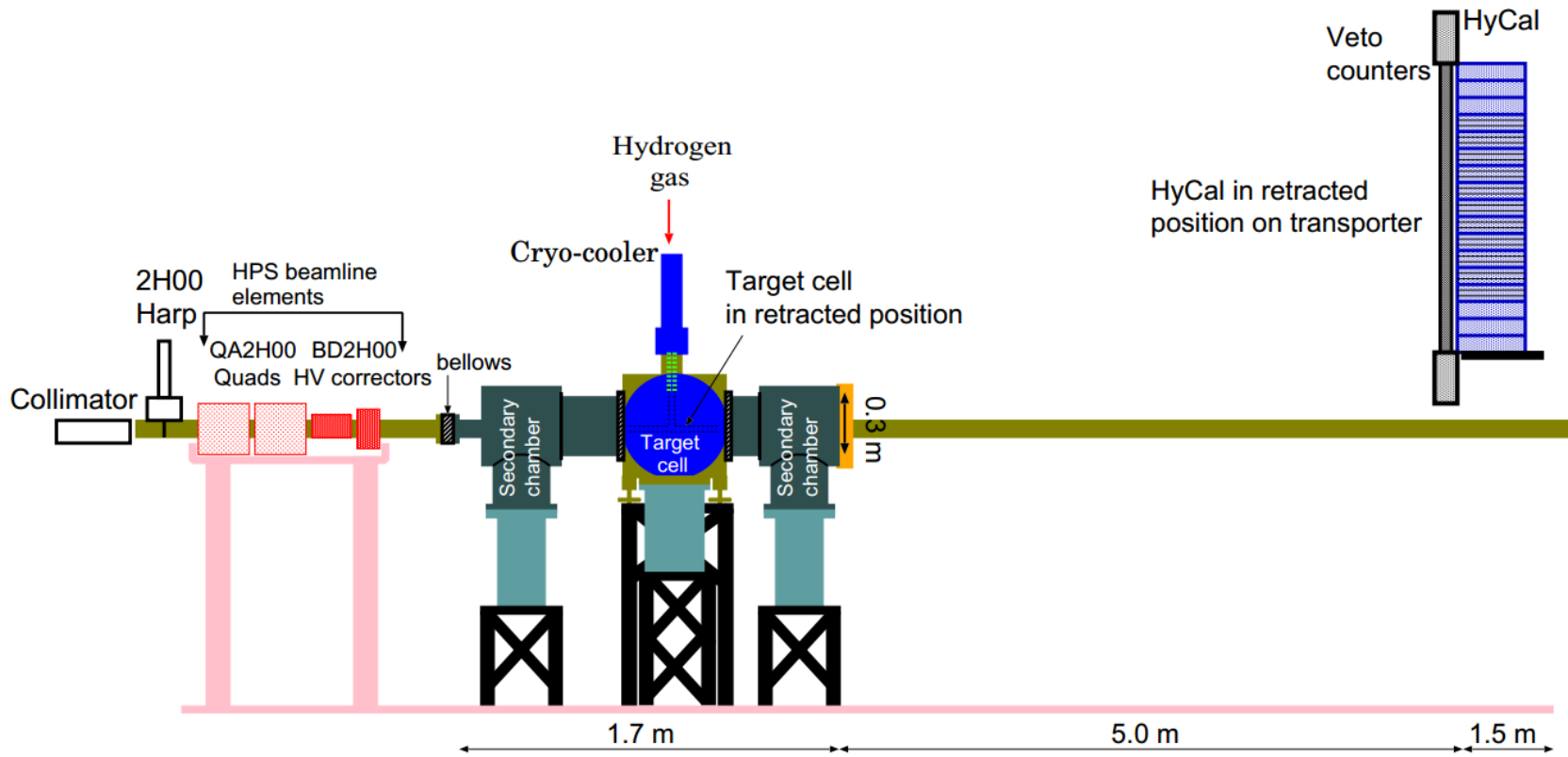
Proposed PRad Running Configuration in Hall B (top view)

- Maximum horizontal size of PRad setup: 1.7 m (diameter of Vacuum Box)



PRad Non-Running Configuration in Hall B

- Target chamber will be the **only element** left in Hall B beam line:
 - ✓ Vacuum box removed from the beam line
 - ✓ HyCal with coordinate detectors and veto counters lifted up on the transporter
 - ✓ No residual material in the beam line



PRad Options in Other Halls

- PRad requires **low current electron beam** ($I_e \leq 10$ nA):
 - ✓ beam stability is highly important
 - ✓ controlled beam halo ($< 10^{-7}$ level) is critical
 - **NOT available for Halls A and C (Hall D has photon beam)**
- HyCal calorimeter requires:
 - ✓ very low intensity tagged photon beam for direct check-out and calibration
 - ✓ high precision Transporter frame for movement
 - **Ready to use in Hall B, NOT available in other Halls**
- Hall B is practically the only Hall for PRad

Setup Implementation and Installation Schedule

Task	Manpower	Time & Effort	Compl. Time
1) Windowless H₂ Target:			
a) All parts to JLab	PRad		May, 2014
b) Development, assembly, tests	Tgt Grp.+PRad		Sep, 2014
c) Design, constr. of support stands	Hall B Engg. Grp.	15 days	Dec, 2014
d) Target system ready	Tgt Grp.+PRad		Dec, 2014
e) Installation in Hall B	Tgt Grg.+Hall B Tech. Grp.	7 days ^(b)	Jan, 2015
2) HyCal Calorimeter:			
a) Clear bldg. 98 to get to HyCal	Hall B Tech. Grp.	3 days ^(b)	Jun, 2014
b) Mods second work deck for level 2	Hall B Tech. Grp.	5 days ^(b)	Jun, 2014
c) Move Transporter parts to Hall B	Hall B Tech. Grp.	2 days ^(b)	Jun, 2014
d) Reassemble Transporter, test movement	Hall B Tech. Grp.+Prad	10 days ^(b)	Jun, 2014
e) Move/install cart to/in Hall B	Hall B Tech. Grp.	2 days ^(b)	Jun, 2014
f) Move HyCal to Hall B and install on Trans.	Hall B Tech. Grp.	5 days ^(b)	Jun, 2014
g) Inspect all mech. electrical, optical parts	PRad		Jul, 2014
h) Plug signal, HV cables, fix broken chnls	PRad		Jul, 2015
i) Inspect the LMS, fix it	PRad		Jul, 2014
j) Plug Chiller, test it	PRad+Hall B Tech. Grp.	1 day ^(b)	Aug, 2014
k) Devel., assembly readout elec. and DAQ	PPad+Hall B staff		Aug, 2014
l) Test HyCal with LMS and cosmic rays	PRad		Sep, 2014

^(b) “days” are for “duration of work” = x4 manpower resources for crane/forklift/rigging operations

Setup Implementation and Installation Schedule (cont'd)

Task	Manpower	Time & Effort	Compl. Time
3) Vacuum Box:			
a) Conceptual design	Hall B Engg. Grp.+PRad	30 days ^(c)	Jun, 2014
b) Engineering design	Hall B Engg. Grp.	18 days ^(c)	Jul, 2014
c) Construction	Hall B+PRad	50 days	Dec, 2014
d) Installation in Hall B	Hall B Tech. Grp.	2 days ^(b)	Jan, 2015
4) Veto Counters:			
a) Move veto counters to Hall B	Hall B Tech. Grp.	2 days ^(b)	Aug, 2014
b) Inspect and fix mechanical parts	PRad		Aug, 2014
c) Inspect and fix optical parts	PRad		Aug, 2014
d) Assemble new horizontal veto counters	PRad		Sep, 2014
e) Test with cosmic rays	PRad	2 days ^(b)	Sep, 2014
f) Install veto counters on HyCal	PRad+Hall B Tech. Grp.		Sep, 2014
5) Setup ready for first test beam			Jan, 2015

^(b) "days" are for "duration of work" = x4 manpower resources for crane/forklift/rigging operations

^(c) Hall B Engineering Group + designers from Accelerator Division

Technical/Manpower Support from JLab

Task	Manpower	Time & Effort	Compl. Time
1) Windowless H₂ Target:			
a) Design, constr. of support stands	Hall B Engg. Grp.	15 days	Dec, 2014
b) Installation in Hall B	Tgt Grp.+Hall B Tech. Grp.	7 days ^(b)	Jan, 2015
2) HyCal Calorimeter:			
a) Clear bldg. 98 to get to HyCal	Hall B Tech. Grp.	3 days ^(b)	Jun, 2014
b) Mods second work deck for level 2	Hall B Tech. Grp.	5 days ^(b)	Jun, 2014
c) Move Transporter parts to Hall B	Hall B Tech. Grp.	2 days ^(b)	Jun, 2014
d) Reassemble Transporter, test movement	Hall B Tech. Grp.+Prad	10 days ^(b)	Jun, 2014
e) Move/install cart to/in Hall B	Hall B Tech. Grp.	2 days ^(b)	Jun, 2014
f) Move HyCal to Hall B and install on Trans.	Hall B Tech. Grp.	5 days ^(b)	Jun, 2014
g) Plug Chiller, test it	PRad+Hall B Tech. Grp.	1 day ^(b)	Aug, 2014
3) Vacuum Box:			
a) Conceptual design	Hall B Tech. Grp.	30 days ^(c)	Jun,2014
b) Engineering design	Hall B Eng. Grp.	18 days ^(c)	Jun, 2014
c) Construction (~ \$35K +\$20K)	Hall B+PRad	50 days	Dec, 2014
d) Installation in Hall B	Hall B Tech. Grp.	2 days ^(b)	Jan, 2015
4) Veto Counters:			
a) Move veto counters to Hall B	Hall B Tech. Grp.	2 days ^(b)	Aug, 2014
b) Install veto counters on HyCal	PRad+Hall B Tech. Grp.	2 days ^(b)	Sep, 2014
Total Time & Effort from JLab		154 days	

^(b) “days” are for “duration of work” = x4 manpower resources for crane/forklift/rigging operations

PRad Collaboration Institutional List

- Currently 15 collaborating universities and institutions
 - Jefferson Laboratory
 - NC A&T State University
 - Duke University
 - Idaho State University
 - Mississippi State University
 - Norfolk State University
 - Argonne National Laboratory
 - University of North Carolina at Wilmington
 - University of Kentucky
 - Hampton University
 - College of William & Mary
 - Tsinghua University, China
 - Old Dominion University
 - ITEP, Moscow, Russia
 - Budker Institute of Nuclear Physics , Novosibirsk, Russia
- Open for new collaborators and institutional groups

Collaboration Manpower

(from leading Universities)

Institution	Senior Researcher	Postdoc	Graduate student	Others
Duke Univ.	H. Gao (40%)	1 FTE* (2 x 50% each)	1.5 FTEs (1 x100% + 1x50%)	1 Technician (2 weeks), 1 Visiting Scientist (4 weeks)
Mississippi State Univ.	D. Dutta (50%) 6 months at JLab (first part of 2015)	0.5 FTE, starting from fall, 2014 located at JLab	1 FTE located at JLab	
Idaho State Univ.	M. Khandaker (75%)		1 FTE fall, 2014	
NC A&T SU	A. Gasparian (75%)		0.5 FTE (1 M.S.) located at JLab	1 Visiting Scientist (4 months)
TOTAL	2.4 FTE	1.5 FTE	4 FTE	~1 Visiting Scientist (~6 months)

* for senior personnel the percentage is estimated from the research time

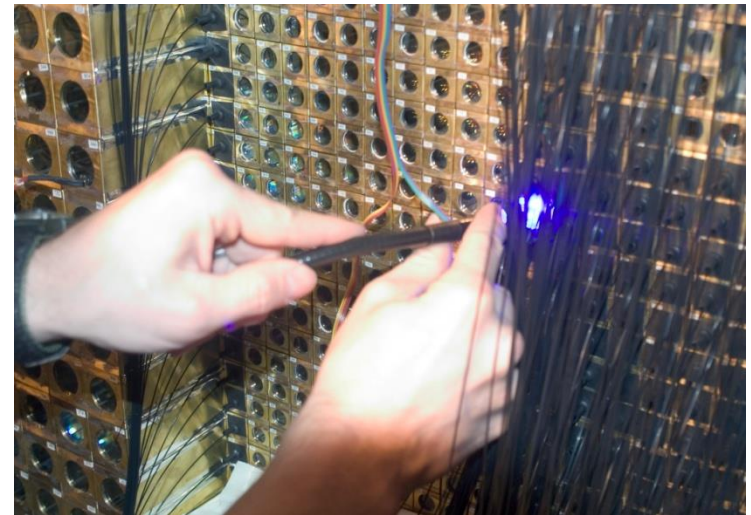
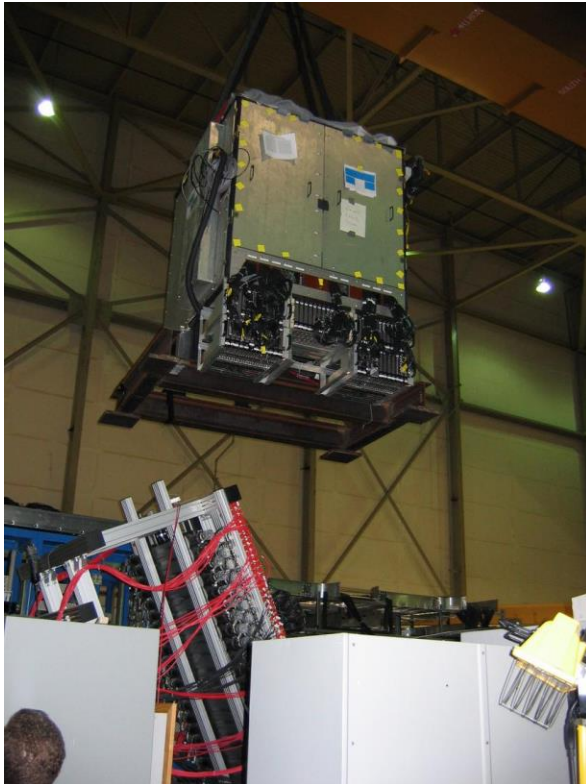
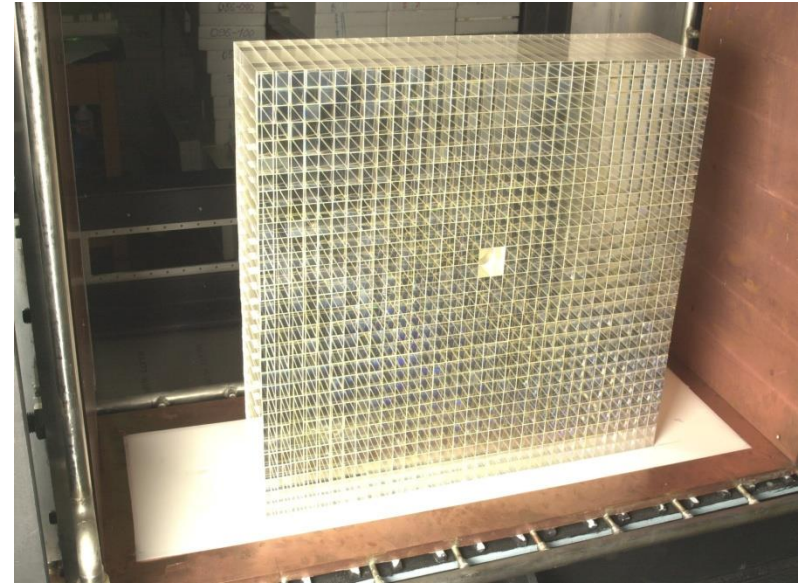
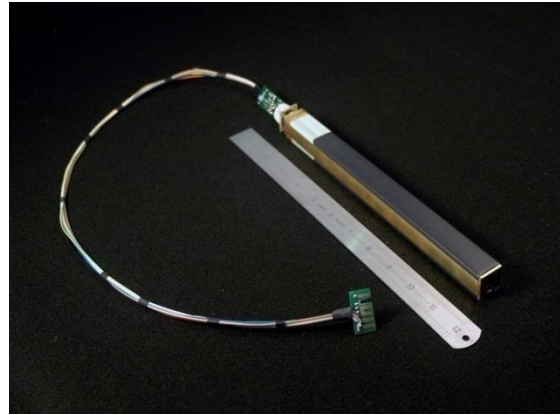
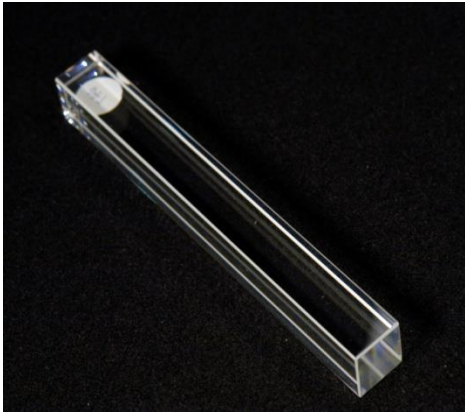
- A. Gasparian is currently looking into options to be located at JLab for 2015

Summary

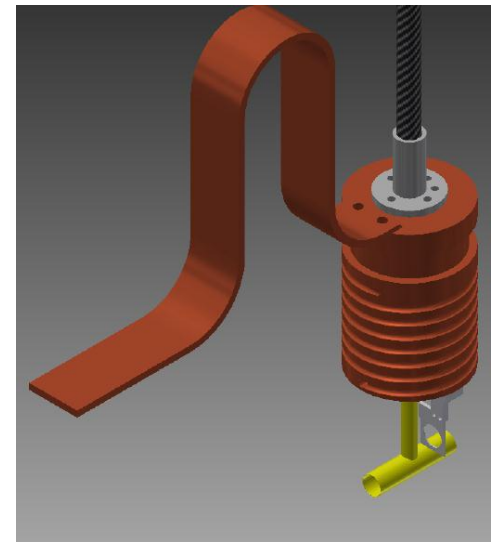
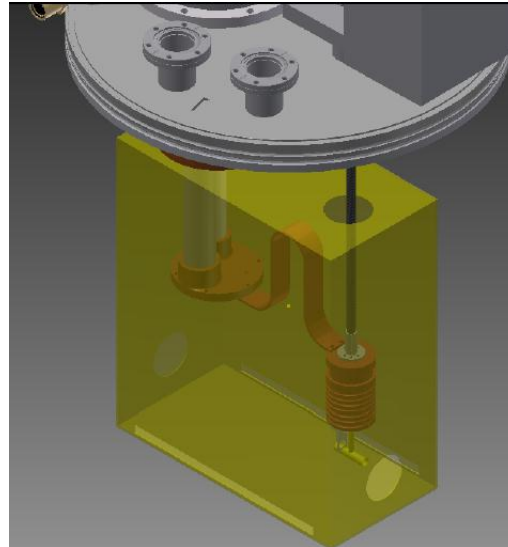
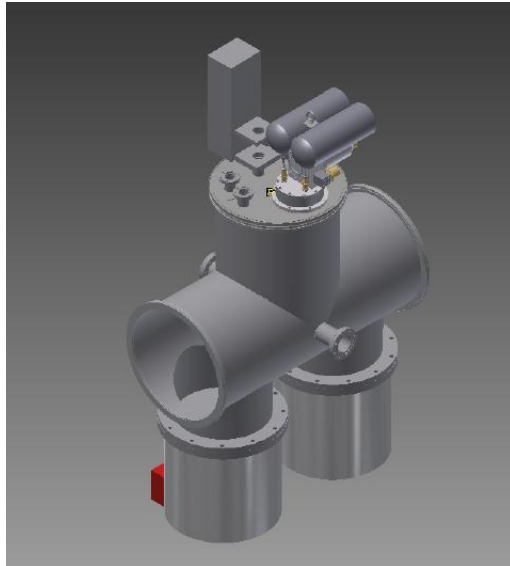
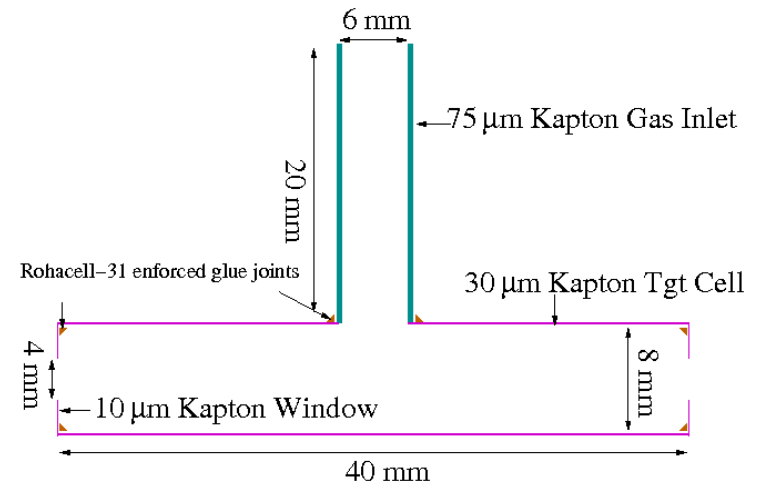
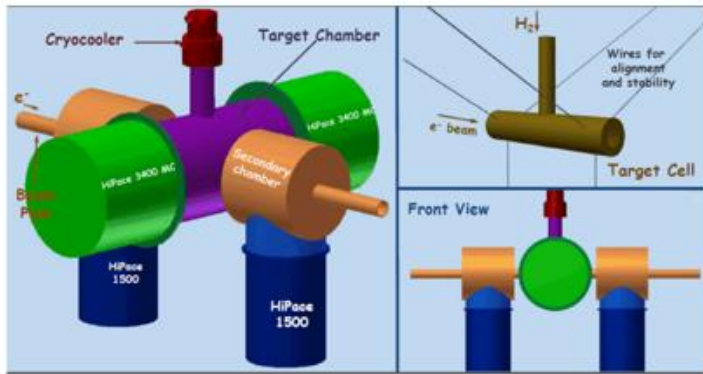
- PRad experimental setup with JLab's support will be ready for installation in January, 2015.
- Suggested PRad installation scheme is compatible with CLAS12 assembly and HPS installation and run.
- We request an Engineering Run in beginning of 2015 and Physics Run few months later.
- Expected high impact physics result for "*proton radius puzzle*"

Thank You!

Electromagnetic Calorimeter (HyCal)



Windowless H₂ Gas Flow Target



Target development well underway

Windowless H₂ Gas Flow Target

