APEX Status: Big Picture

B. Wojtsekhowski, for the APEX collaboration

- Scientific goals and motivation of the experiment
- Interest of the JLab physics community
- Proposal approval status
- Proof of experiment concept (the test run)
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Interest of the JLab physics community

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i) Direct search, as done for VMs, Z, W, top, Higgs

ii) Deviation in some well-understood observable, such as Θ_W

The parameter space: the mass and the coupling constant.
Direct search often covers a limited range of mass and
could be very sensitive to small coupling.

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The LHC found Higgs, so far a Great Desert beyond SM
The focus is shifting to Dark Matter: WIMPs, A', Z_d … Dark forces

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Proposal approval status

The APEX proposal was submitted to PAC35
http://www.jlab.org/exp_prog/proposals/10/PR12-10-009.pdf

PAC35: A very strong physics case.
Conditional approval

Proposal PR12-10-009: Several recent popular extensions of the Standard Model envision the existence of a relatively light vector boson that couples very weakly to ordinary charged particles through its small mixing with the photon. Motivation for such a particle stems from astrophysical observations as well as theoretical considerations of dark matter models. The mass for this particle, sometimes called "the dark photon", is expected to be in the MeV to GeV range, a region accessible to JLAB experiments. Indeed, it appears that high intensity electron scattering experiments can be sensitive to extremely small couplings over a broad mass range of such hypothetical particles. They could either significantly constrain their properties or discover them. The PAC believes that JLab provides a unique opportunity to pursue such measurements. The high impact on the global physics scene of such measurements makes this experiment of high priority. Much work is still required as set out in the detailed report. This experiment is Conditionally Approved.

Proposal approval status

Issues:
The measurements proposed cover a very interesting range with a large potential for discovery which can change the picture of interactions and our understanding of physics beyond the Standard Model. Even if a signal is not seen, the experiment will constrain the plane of new boson mass and coupling allowed and so provide important limits on the domain of possible new physics.

However, running conditions push the detector performances to the extreme in terms of relative angular resolution (positioning of spectrometers), acquisition rate, particle identification. The feasibility of the measurements relies on a detailed understanding of the experimental conditions as well as on the proper background estimates.

Taking into account the very high requirements on the detectors and strong dependence of the obtained results on the understanding of very high background, the PAC recommends tests of as many elements of the proposed setup as possible as well as detailed study of the calculated background and comparison with measurements. *The PAC strongly encourages the collaboration to continue the development of the proposal.*

suggestion for a TEST RUN

Proposal approval status

Proposal: PR12-10-009

Scientific Rating: A
Recommendation: Approval

The PAC approves the proposal contingent on a successful solution of the radiation issue. The PAC feels that the experiment should be carried out as early as possible (ideally before the 6 GeV shut down in 2012).

Title: "Search for new Vector Boson *A'* Decaying to e^+e^-"

Spokespersons: R. Essig, P. Schuster, N. Toro, B. Wojtsekhowski

Motivation: The proposal is to search for a vector boson *A'* with weak coupling of about 10^{-3} e or smaller to electrons in the mass region 65-525 MeV. The proposed search is motivated by recent developments of models trying to explain inconsistencies observed in astrophysical data and dark matter search experiments. Such a vector boson would couple to charged leptons as it will mix with photon. If *A'* is produced by radiation off an electron beam, it would decay producing very narrow resonance in the invariant mass e^+e^- spectrum.

The proposal is very interesting and has the potential to make an important discovery. There are not many places where such measurement can be done, as it requires very high integrated luminosity and good control of the electromagnetic background. Part of the plane of coupling constant *versus* mass of the boson has already been excluded, but the region available for the proposed experiment coincides with the domain of greatest theoretical interest, for example explaining the deviation from SM expectations observed in the latest *g-2* experiment.

Proposal approval status

As you know, your experiment has been conditionally approved in the category C1. This means that it must meet the designated technical requirements to obtain approval from laboratory management.

Jefferson Lab is revisiting the experimental readiness review process in preparation of the 12-GeV startup. The resulting document, expected to be released soon, will give the guidance for running experiments in the 12 GeV era. The document guidelines ask, among others, a) to calculate and document Experiment Operating Envelope (EOE) for all combinations of beam conditions and target planned; b) write a formal Radiation Safety Assessment Document (RSAD) for the experiment that explicitly includes the calculations of the EOE and addresses the EHS&Q issues it raises. Specifically, assessing the amount of radiation being generated in the hall by the experiment and implementing measures to reduce it as well as assessing its impact on the experiment equipment and running efficiency are now a requirement for every experiment and they are part of the Experiment Readiness Review leading to scheduling and running an experiment. In essence, this requirement is identical to the condition imposed by the PAC for running APEX except that now this requirement applies to every experiment. So, APEX no longer has a special condition attached to it. Now, like all other experiments, it needs to demonstrate that if fulfills the above requirements and it is subject to the same procedures than the other experiments.

Therefore there is no need to appoint a separate review committee now for your approval process.

Sincerely,

Patrizia Rossi

April

Proposal approval status

From: Bob McKeown

To: Philip Schuster, Rouven Essig, Natalia Toro, Bogdan Wojtsekhowski

Cc: Cynthia Keppel, Hugh Montgomery, Rolf Ent, Susan Brown

Dear Philip, Natalia, Rouven, and Bogdan,

As you have requested, I have reviewed the history and technical issues related to the disposition of APEX as a conditionally approved experiment. The justification for conditional approval was the PAC concern that the issue of radiation damage in Hall A be addressed. Subsequently, the Experimental Physics Division has implemented a policy that radiation damage assessment be part of the Experiment Readiness Review process. Following the implementation of this policy the conditional approval for APEX is redundant and unnecessary. In particular, I note that PREX (at a later PAC) had similar concerns from the PAC but received full approval. (In fact, the radiation damage issues for APEX and PREX are very similar as the beam current, target thickness, and running time are comparable.)

So at this point we have decided that APEX should be considered as a fully approved proposal. We will update the lab website in the near future (Susan is away on medical leave for a few weeks).

I look forward to working with you to make APEX successful in the future.

Best regards,
Bob

APEX: A Search for Dark Photons with HRSs

Jefferson Lab Program Advisory Committee 41

Science Topic: **1 [ ] 2 [ ] 3 [ ] 4G [ ] 4T [ ] 5 [ ] 6[x]**

[The PAC has distributed experiments by six science categories, but has split science category 4 into two parts: related to GPDs (4G) and to TMDs (4T)]

Experiment Number: E12-10-009

Experiment Title: **Search for new Vector Boson A' Decaying to e+e-**

Spokespersons: *Rouven Essig, Philip Schuster, Natalia Toro, and Bogdan Wojtsekhowski*

Rating: *A*

Days: *34*

Hall: *Hall A*

PAC #: *PAC 37*

Run Group #: *May be able to run in a run group with CREX*

Run Group Days: *34 APEX (+ 45 CREX ?)*

Stage I/II: Stage I experiment [ ] Stage II experiment [x]

[List here if a Stage I (resources need to be identified/obtained) or a Stage II (resources are essentially available) experiment]

Equipment and Beam Requirements:

[For "Description" list any equipment needs beyond foreseen CD-4B base equipment (i.e. HRS, CLAS12, HMS/SHMS, GlueX), beam specification needs beyond the day-0 beam parameters, infrastructure needs beyond what is already available, and any further assumptions, line by line. For "Year Complete" list the year in which the requirement is expected to be complete]

Description	*Year Complete*
a. Requires new septum magnet (construction underway)	2014
b. Specialized beampipe/vacuum through septum	2014
c. Requires installation of the specialized target system	2015
d. Requires mitigating measures to prevent radiation damage to equipment due to running with thick targets (8% r.l.) with a current of 80 μA at 3.3 GeV beam energy for 7 days and with a current of 60 μA at 4.4 GeV beam energy for 14 days.	
e. Required beam energies are 1.1, 2.2, 3.3, and 4.4 GeV (no polarization required).	

Concerns or Equipment Conflicts:

[There may be cases where spokespersons have special worries about beam or cryogenic need compatibility with experiments in other Halls, or foreseen incompatibilities with other equipment (requiring removal of spectrometer magnets or detectors). Please list such concerns here, line by line]

Description
a. Two non-standard energies 1.1 and 3.3 GeV.

Specific Experiment Requirements:

[List here a tabular form of the running conditions of the experiment with the required energies and PAC days. Explicitly indicate here also, for instance, if the experiment requires non-standard energy (no multiple of 2.2 GeV/pass), or list specific torus magnet values and polarity, with the associated PAC approved days. In the end, we need to be able to cross-correlate this table to your high-level science goals and Hall/run group compatibility.]

Experiment Requirement	*PAC days*			
	Settings A	B	C	D
Beam energy (GeV)	2.2	4.4	1.1	3.3
Beam current (μA)	70	60	50	80
Target thickness (X_0)	4%	8%	0.7%	8%
Beam on target (hrs)	162	306	162	162
Time Requested (hrs)	166	314	170	170
Time Requested (days)	**7**	**13**	**7**	**7**

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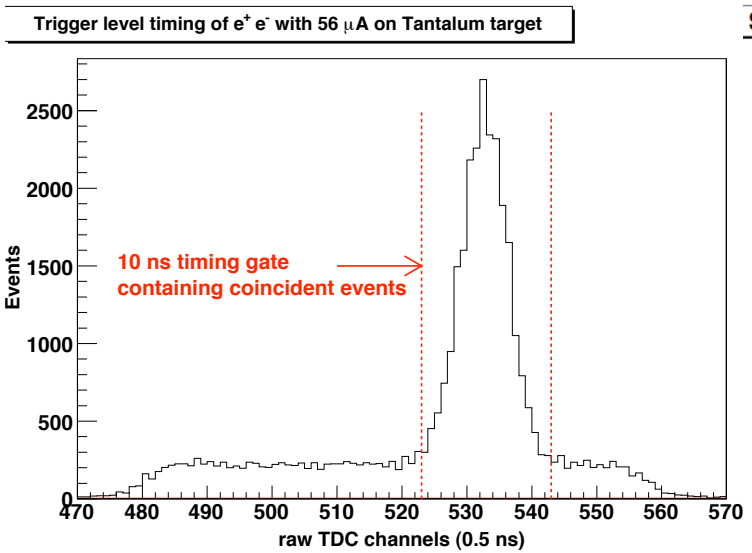
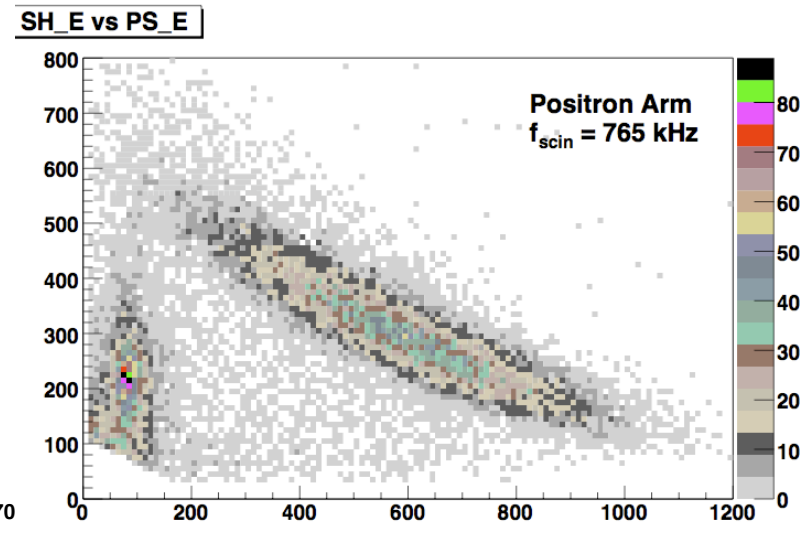
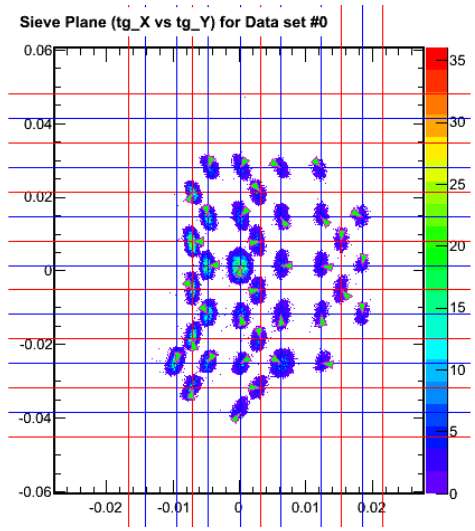
The Test Run

- ✓ Use of the Gas Cherenkov in trigger, timing – proposed 20 ns, demonstrated 10 ns
- ✓ Operation of the VDC at 5 MHz track rate – demonstrated up to 8 MHz
- ✓ Operation of the positron arm PID – demonstrated up to 0.8 MHz (more than needed)
- ✓ Operation of trigger/DAQ – demonstrated total dead time of 8% at full luminosity

- Also checked: optics calibration, singles rates in the HRS spectrometers, signal to background in trigger and offline analysis, a thin Ta foil with 150 μA beam.
- Accumulated about 2 million true e+e- coincidence events & optics data for a new physics result for mass range around 200 MeV.







The Test Run

Detailed reports were presented at the 2010 workshop:

http://www.jlab.org/conferences/boson2010/index.html

Boson2010

Searching for a New Gauge Boson at JLab
September 20-21, 2010
Thomas Jefferson National Accelerator Facility
Newport News, VA

Announcement

Various dark matter related anomalies have lead to theoretical models proposing that there are new gauge bosons (A') with masses in the MeV to GeV range, which act as force carriers between dark matter particles. Fixed-target experiments with electron beams are a powerful probe of such A's. The goal of the workshop is to review the A' search experiments proposed at Jefferson Lab in order to further inform a decision at the laboratory on which experiments to pursue in detail. The workshop will focus on the technologies of each proposed measurement, and the issues perceived as potentially standing in the way of conclusive results. The workshop will identify R&D/technology development, background measurements and modeling that would be useful in preparing these experiments. The relevance of each of the proposed experiments will be discussed, as well as the degree of overlap and complementarity.

the reports are posted:
http://www.jlab.org/conferences/boson2010/program.html

The Test Run

What are the results of the 2010 test run?

- Validation of every item of the experiment concept
- Full approval by PAC with recommendation to run ASAP
- PRL paper with a significant advance of the exclusion zone
- 2 PhD degrees

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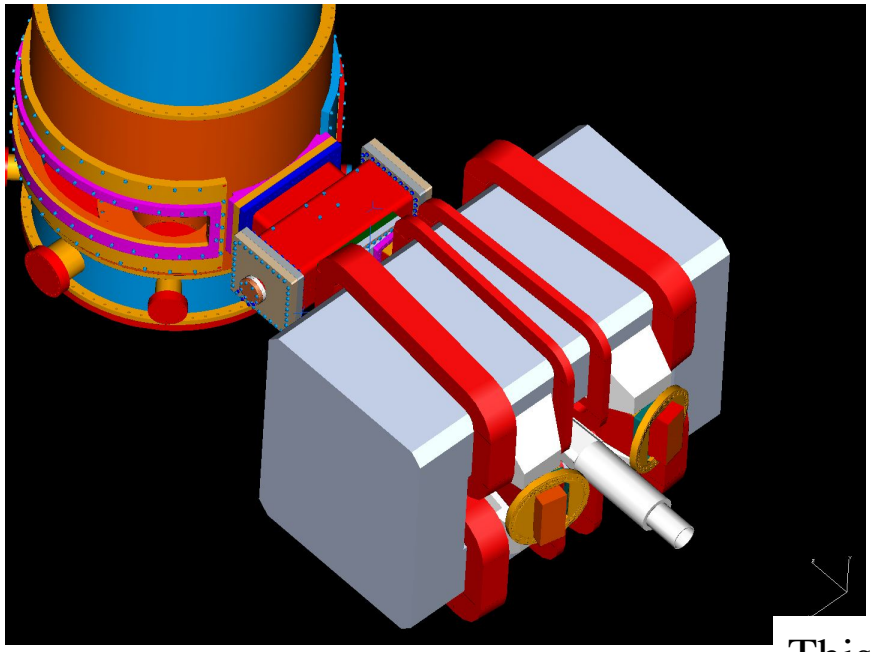
Equipment preparation

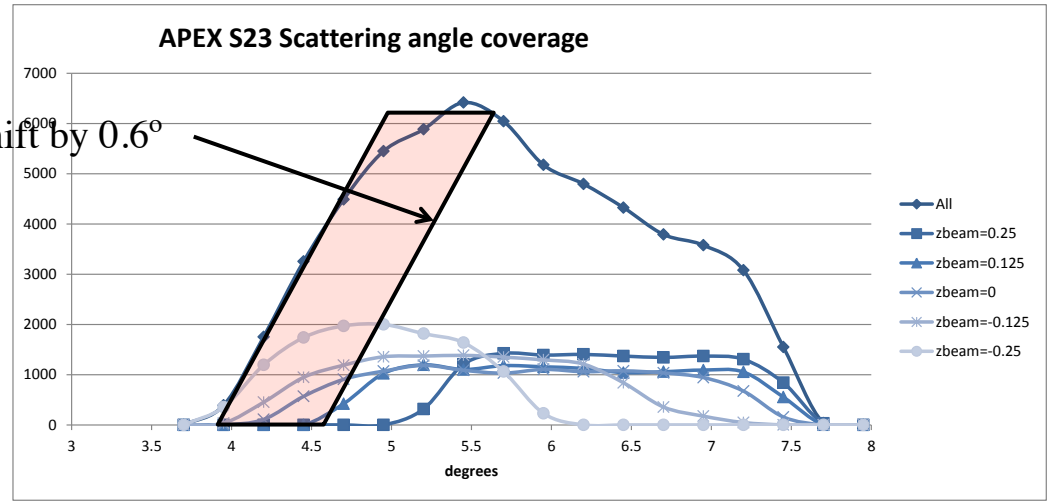
- HRS electronics upgrade, the beam test was performed a month ago
- Septa magnet designed, ordered, will be delivered by July 2014
- Power supply for 2 kA, 650kW (SBS), delivery in summer 2014
- Scintillator Fiber hodoscopes, constructed, need commissioning
- Vacuum chambers/corrector, design is proceeding
- Target hardware and controls, need commissioning

Equipment preparation

- Septa:

1) A new design of the magnet: shielded beam; simple high current coils, acceptance from 3.7 degree scattering angle, larger momentum reach
Collaboration funding for design ($16k) and construction ($134k)
2) Delivery by July 2014.





This septa has acceptance from min angle of 3.7° in APEX mode and 3.4° in CREX mode for 2.2 GeV momentum

Equipment preparation

What are the cost of preparation and the sources of funding?

- The total cost of APEX equipment was estimated to be $250k.
- The collaboration funded the magnet design + construction ($150k)
  NCCU, UW, SBU, CMU, CSULA
- Remaining design work for the vacuum chambers, correctors, support

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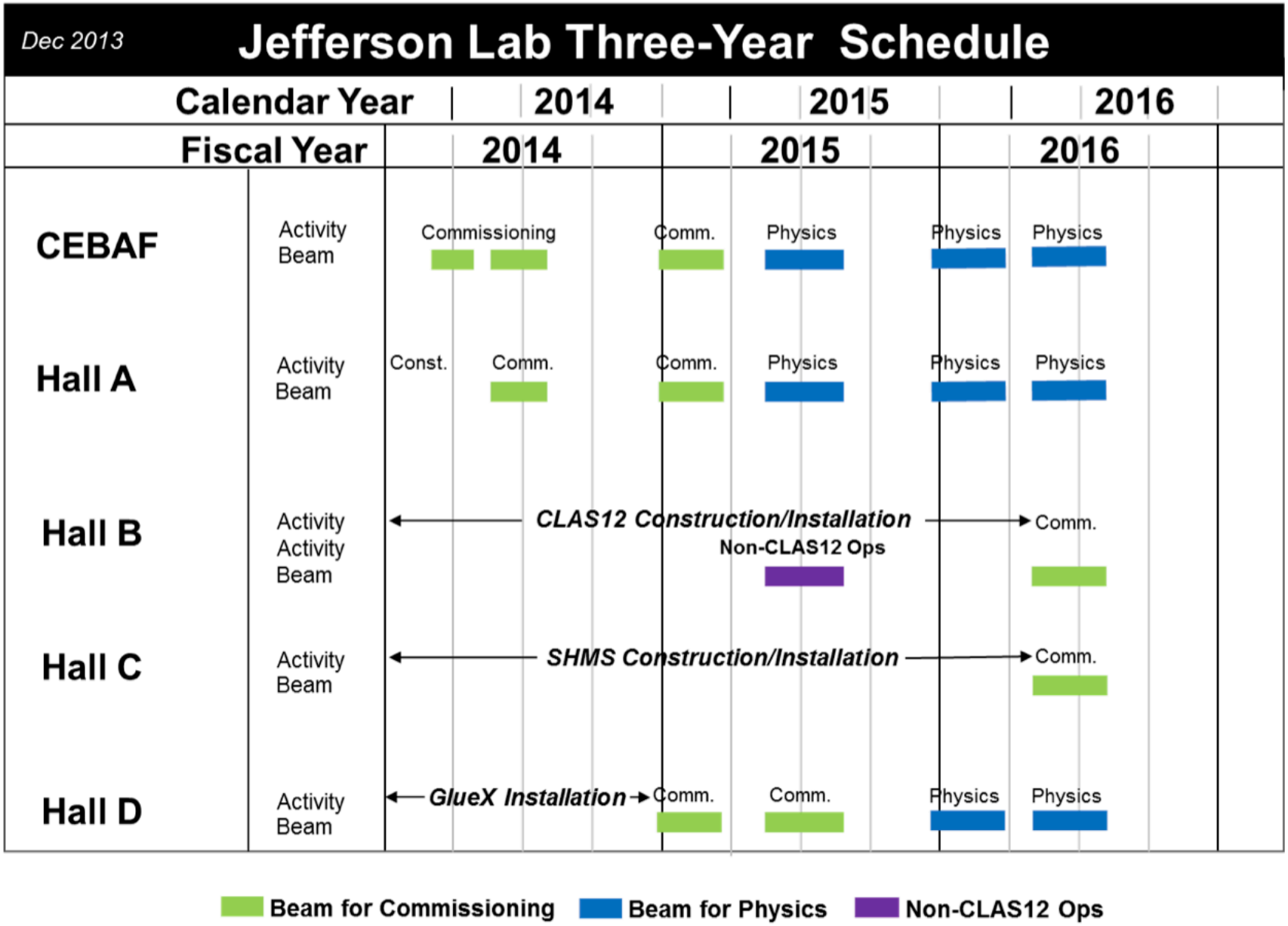
Beam time schedule



APEX Status: Big Picture
Summary

- Experiment is fully approved and approaching the data taking run.
- Collaboration made key contributions to the test run, new septa, SciFi.
- There are new ideas for additional experiments with APEX equipment.
- The main part of equipment preparation cost is funded.
- The remaining work on APEX which needs to be done includes:

APEX Status: Big Picture
Summary

- The remaining work on APEX which needs to be done includes:
  - commissioning of the equipment:
    - the septa
    - the SciFi
    - the target
  - development of the software for:
    - the SciFi DAQ
    - the optics calibration
    - the high rate data analysis
    - the bump search simulation
  - the radiation shielding design/review/construction
  - the experiment readiness review
  - the data taking run (30/0.5x3.5x3 = 630 shifts)