APEX Status: Big Picture

B. Wojtsekhowski, for the APEX collaboration

- Scientific goals and motivation of the experiment
- APEX rating by PAC41
- Experiment preparation status
- Funding of the experiment
- Run schedule: What we do and don't know
- Collaboration efforts
- Technical publications and reports

APEX: A Search for Dark Photons in Hall A

Why do a search for new physics at JLab?

- It is the most interesting thing that a physicist can do.

- Our nuclear physics lab has the only 100% duty factor high energy high intensity electron accelerator existing in the U.S.

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There are a few ways to search for new physics:

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

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

iii) Test of fundamental symmetries, e.g Special Relativity

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

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

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- The heavy photon is a window which our electromagnetic community has a chance of opening. It is like the searches for new physics with the Qweak and Moller experiments.

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APEX: PAC41 results

Why do a search for new physics at JLab?

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.

APEX: PAC41 results

Why do a search for new physics at JLab?

PAC Days
Boldface = days designated High Impact
Parentheses = days not counting toward High Impact total

PAC41 "High Impact" Selection

Row Color
Yellow = High Impact
Green = backup expt

Exp#	Exp name	Hall	Run Group/ Days	PAC Days	PAC grade	Comments
	TOPIC 1 : SPECTROSCOPY					
E12-06-102	**GlueX** : Mapping the Spectrum of Light Quark Mesons and Gluonic Excitations with Linearly Polarized Photons	**D**		(120) approved **★90**	A	GlueX - assumed half commissioning/half physics **★plus (30) commissioning days**
	TOPIC 2 : FORM FACTORS					
E12-06-101	Measurement of the Charged **Pion Form Factor** to High Q2	**C**		**52**	A	Requires fully commissioned SHMS
E12-07-109	**GEp/GMp** : Large Acceptance Proton Form Factor Ratio Meas's at 13 and 15 (GeV/c)2 Using Recoil Polarization Method	**A**		**45**	A-	Requires SBS and high power cryo target
E12-11-106	High Precision Measurement of the **Proton Charge Radius**	**B**		**15**	A	Non-CLAS12 experiment, Prad
	TOPIC 3 : PDFs					
E12-06-113	**BONuS** : The Structure of the Free Neutron at Large x-Bjorken	**B**	F/40	(40) approved **★21**	A	Requires BONuS Radial TPC upgrade

APEX: PAC41 results

Why do a search for new physics at JLab?

E12-11-003	**DVCS CLAS–D(UU,LU)** : DVCS on the Neutron with CLAS12 at 11 GeV	B	B/90	(90) approved	A	Requires D target; central neutron detector ready in 2016 **★Backup GPD-E meas if HDIce delayed**
TOPIC 5 : NUCLEAR						
E12-13-005	**Bubble Chamber** : Measurement of 16O(³,±)12C with a bubblechamber and a bremsstrahlung beam	**INJ**		**14**	A-	Our guess: 2017
E12-11-101	**PREx-II** : Precision Parity-Violating Measurement of the Neutron Skin of Lead	**A**		**35**	A	Requires septum, Pb target, 1% Moller polarimetry
E12-06-105	**SRC–hiX** : Inclusive Scattering from Nuclei at $x > 1$ in the quasielastic and deeply inelastic regimes	**C**		**32**	A-	
E12-11-112	**SRC–Tritium** : Precision measurement of the isospin dependence in the 2N and 3N short range correlation region	**A**	Tritium target group/61	**19**	A-	
TOPIC 6 : FUNDAMENTAL SYMMETRIES						
E12-11-006	**HPS** : Status of the Heavy Photon Search Experiment at Jefferson Laboratory (Update on PR12_11_006)	**B**	H/180	(155) approved **★39**	A	non-CLAS12 experiment, HPS **★25 pre-CLAS engr + 14 physics @ 4.4 GeV**
E12-10-009	**APEX** : Search for new Vector Boson A1 Decaying to e+e-	**A**		**34**	A	Requires new septum and target system

<<< SUMMARY of "HIGH IMPACT" DAYS >>>

by Topic	**1**	**2**	**3**	**4GT**	**5**	**6**	**total post-commissioning**
	90	112	78	190	100	73	643
by Hall		**A**	**B**	**C**	**D**	**INJ**	
		224	195	120	90	14	643

APEX: A Search for Dark Photons in Hall A

Why do a search for new physics at JLab?

Fundamental Symmetries

The experiments in this category address key properties of QCD and the electroweak interactions, as well as the dark matter sector, and are highly relevant for the high energy and astro-particle physics communities. Most of the corresponding approved PAC days were not considered as these fall outside the first 3 to 5 years of the 12 GeV era. Of the three remaining experiments:

The PAC identifies HPS (E12-11-006) and APEX (E12-10-009) to have the potential to reshape our picture of the fundamental interactions of the universe and their symmetries.

The recent surge of interest to search for intermediate mass (MeV to GeV) vector bosons is motivated from astrophysical anomalies and their possible connection to dark matter. Furthermore, they may explain the deviation in the muon anomalous magnetic moment (g−2). Existing limits, as well as APEX and HPS, are based on producing such bosons from electron bremsstrahlung.

APEX and HPS are complementary. Both would use the CEBAF electron beam incident on a high-Z target. APEX detects e^+ e^- pairs in the HRS, while HPS is a dedicated facility with silicon tracking detectors immersed in a large volume dipole magnet. APEX needs to tune the spectrometers to different settings to cover different mass regions and takes a very high beam current. HPS uses only low current beam, but is sensitive to much broader kinematics at a time. The signal is a peak in the e^+ e^- invariant mass, so good momentum and angle resolution are important for optimizing the signal over a copious QED background. HPS has an additional very crucial feature, namely the ability for vertex reconstruction, that allows it to explore regions of extremely weak coupling, where the new

APEX: PAC41 results

Why do a search for new physics at JLab?

particle travels a macroscopic distance before decaying. Although the production cross section here is small, the QED background should be negligible.

Similarly, there is complementarity with respect to the parameter space. We consider both the full APEX run and the early running of HPS as high impact experiments. APEX will carve out a large unexplored area in the mass/coupling parameter space, with $\alpha'/\alpha \gtrsim 10^{-7}$ and masses between 60 and 500 MeV. HPS would extend this region to somewhat lower masses, albeit with less sensitivity to the coupling, and also add an entirely new region with $2\times10^{-8} \lesssim \alpha'/\alpha \lesssim 4\times10^{-10}$. Probing all of this parameter space which covers the non-excluded part addressing the muon g−2 would have impact reaching far into the greater physics community.

The committee stresses the competitive environment of such searches. In addition to the successful APEX test run, there is a very recent result by the A1 experiment at MAMI which covers the sensitive region of the test run, and also most of the region related to the solution of the muon g−2. There are also ongoing analyses at various $e^+ e^-$ colliders.

This shows that HPS and APEX are extremely timely experiments and should be executed as soon as possible.

In addition, we feel it is appropriate to comment on the third experiment (E12-10-011) which is highly relevant for the understanding of chiral symmetry breaking. It will provide by far the most precise measurement of the partial decay width $\pi^0 \to \gamma\gamma$, thereby resolving a long standing

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APEX: A Search for Dark Photons in Hall A

- HRS electronics upgrade, the beam test was performed in 2014, 2015
- Septa magnet designed, ordered, delivered in 11/2014, test is under way
- Power supply for 2 kA, 650kW (SBS) delivered, accepted
- Scintillator Fiber hodoscopes constructed, new electronics tested
- Vacuum chamber design is completed, 2/3 ordered
- Corrector magnet design is in the detail stage

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  - Radiation analysis and improvements
  - The detector preparation and testing, Q1 repair/replacement
  - New calibration detector, SciFi with fADC
  - The collaboration to prepare, run, analyze data

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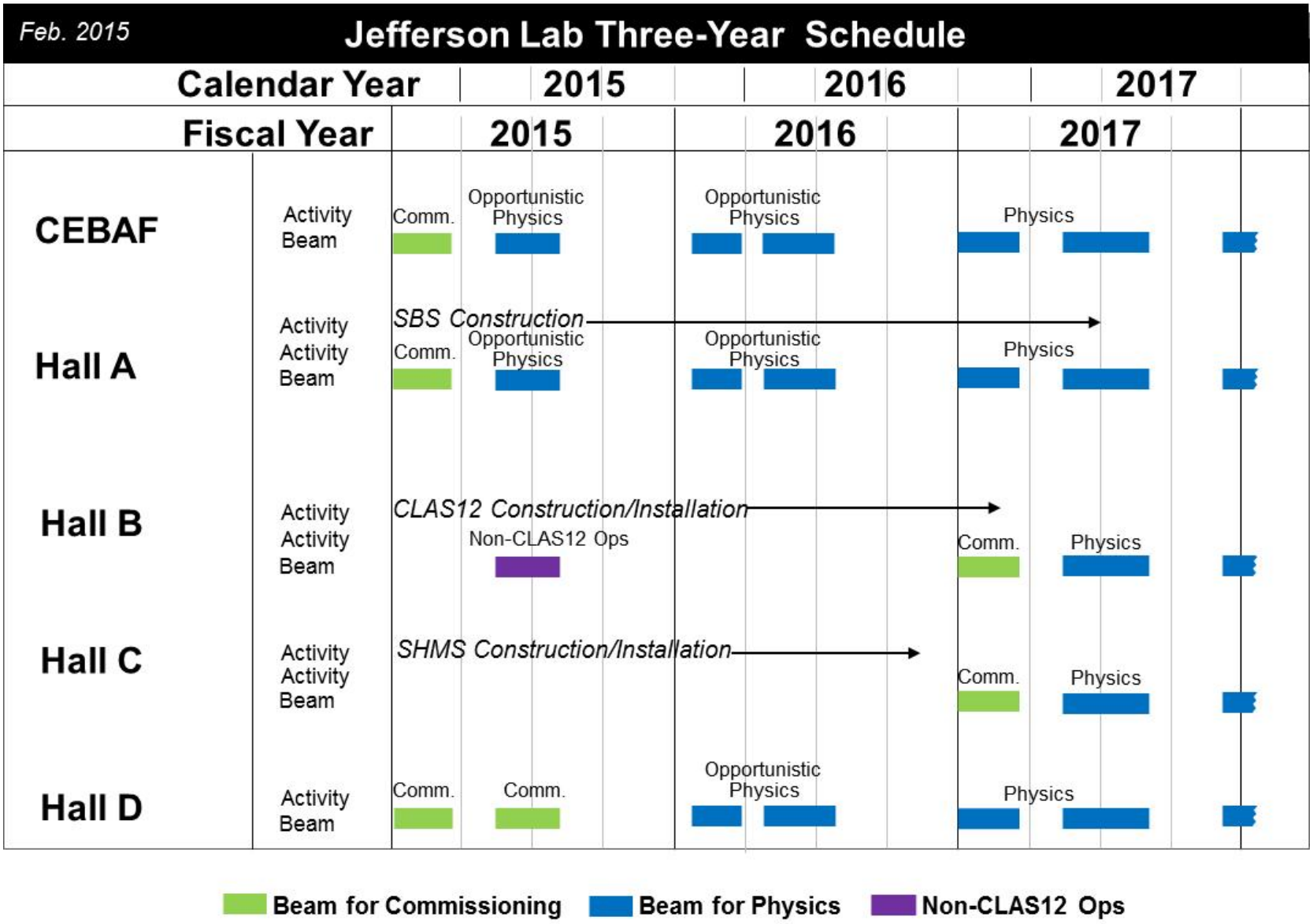
APEX: A Search for Dark Photons



APEX: A Search for Dark Photons

7. Most of the Fall 2015 running period is expected to be dedicated to accelerator commissioning and development. Useful beam for physics is expected to be limited.

8. For Hall B, HPS is expected to take data during Fall 2015 only if and when consistent with both the 12 GeV project installation schedule and the accelerator development.

9. If the Hall A DVCS and GMp experiments reach the goals agreed with the hall leader during calendar year 2015, APEx may take their place for the Spring 2016 run period.

10. The Spring 2016 program for Hall B is still To Be Determined (TBD). Experiments HPS or PRad are being considered if consistent with the hall 12 GeV project installation schedule.

11. The physics program for the last week of operations during Spring 2016 is To Be Determined (TBD). It will be set later on based on Accelerator performance, hall availability and physics impact.

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APEX: Collaboration efforts

- APEX collaboration in 2010 test run
- Ph.D. students
- Significant growth in the last year, regular meetings
- Funding resources from the collaboration, DOE, JLab
- Current status, Ph.D. students

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APEX: Technical publications and reports

- APEX proposal: JHEP 1102 **(2011) 009,** [arXiv:1001.2557]
- Data from test run reported in 2010 workshop
- PRL paper got 120+ citations
- Sophisticated bump search procedure, unpublished
- New hardware development: septa and SciFi, unpublished
- Progress with the DAQ readout speed, unreported
- New MC results, need to be published

APEX Status: Welcome

- Welcome to students
- Welcome to postdocs
- Welcome to data taking crews
- Welcome to Hall A designers
- Welcome to Hall A technical experts
- Welcome to CEBAF beam crews
- Welcome to the supporters
- Welcome to JLab and Hall A management