APEX Experiment Status

B. Wojtsekhowski, for the APEX collaboration

- Scientific goals and motivation of the experiment
- APEX rating by PAC35 and PAC41
- Experiment Readiness Review
- Experiment preparation status
- Run schedule
- Collaboration efforts

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.
Dark matter is the most important problem of physics.

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

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.

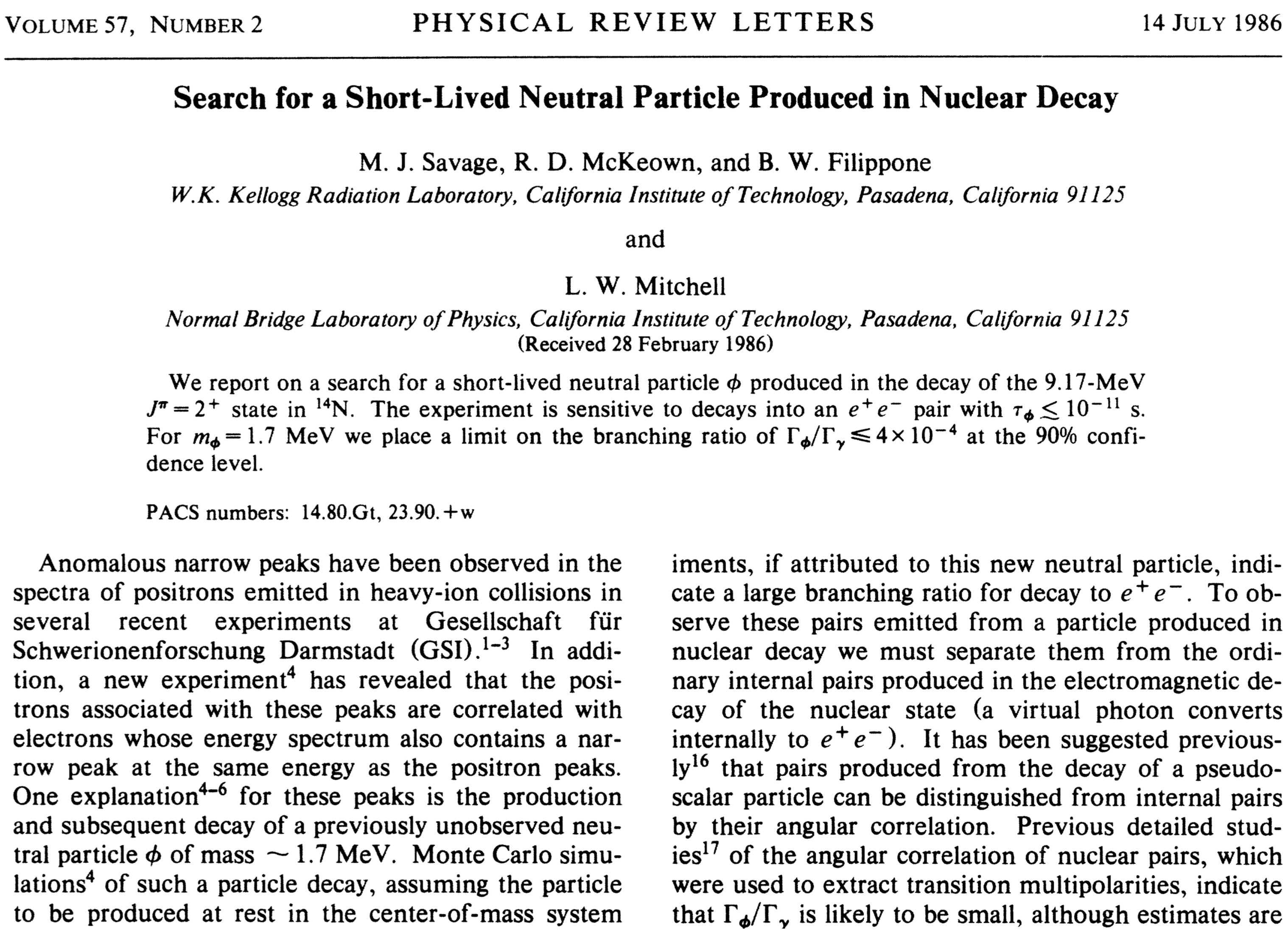
- Our nuclear physics lab has the only 100% duty factor high energy high intensity electron accelerator existing in the U.S.

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. test of Special Relativity

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

Why do a search for new physics at JLab?



VOLUME 57, NUMBER 2 PHYSICAL REVIEW LETTERS 14 JULY 1986

Search for a Short-Lived Neutral Particle Produced in Nuclear Decay

M. J. Savage, R. D. McKeown, and B. W. Filippone
W.K. Kellogg Radiation Laboratory, California Institute of Technology, Pasadena, California 91125
and
L. W. Mitchell
Normal Bridge Laboratory of Physics, California Institute of Technology, Pasadena, California 91125

(Received 28 February 1986)

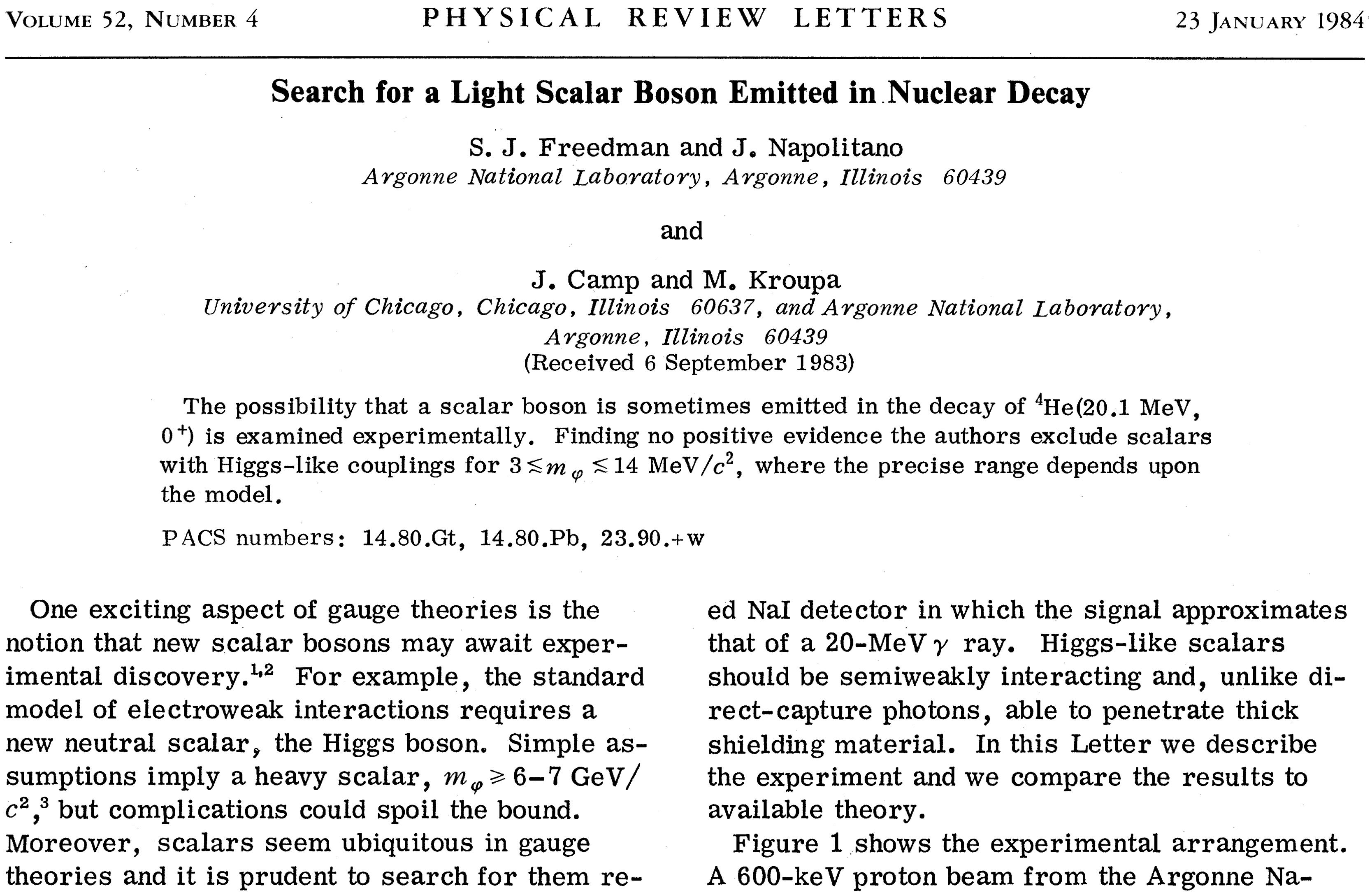
We report on a search for a short-lived neutral particle ϕ produced in the decay of the 9.17-MeV $J^\pi = 2^+$ state in ^{14}N. The experiment is sensitive to decays into an e^+e^- pair with $\tau_\phi \lesssim 10^{-11}$ s. For $m_\phi = 1.7$ MeV we place a limit on the branching ratio of $\Gamma_\phi/\Gamma_\gamma \leqslant 4\times10^{-4}$ at the 90% confidence level.

PACS numbers: 14.80.Gt, 23.90.+w

Anomalous narrow peaks have been observed in the spectra of positrons emitted in heavy-ion collisions in several recent experiments at Gesellschaft für Schwerionenforschung Darmstadt (GSI).[1–3] In addition, a new experiment[4] has revealed that the positrons associated with these peaks are correlated with electrons whose energy spectrum also contains a narrow peak at the same energy as the positron peaks. One explanation[4–6] for these peaks is the production and subsequent decay of a previously unobserved neutral particle ϕ of mass ~ 1.7 MeV. Monte Carlo simulations[4] of such a particle decay, assuming the particle to be produced at rest in the center-of-mass system

iments, if attributed to this new neutral particle, indicate a large branching ratio for decay to e^+e^-. To observe these pairs emitted from a particle produced in nuclear decay we must separate them from the ordinary internal pairs produced in the electromagnetic decay of the nuclear state (a virtual photon converts internally to e^+e^-). It has been suggested previously[16] that pairs produced from the decay of a pseudoscalar particle can be distinguished from internal pairs by their angular correlation. Previous detailed studies[17] of the angular correlation of nuclear pairs, which were used to extract transition multipolarities, indicate that $\Gamma_\phi/\Gamma_\gamma$ is likely to be small, although estimates are

Why do a search for new physics at JLab?



VOLUME 52, NUMBER 4 PHYSICAL REVIEW LETTERS 23 JANUARY 1984

Search for a Light Scalar Boson Emitted in Nuclear Decay

S. J. Freedman and J. Napolitano
Argonne National Laboratory, Argonne, Illinois 60439

and

J. Camp and M. Kroupa
University of Chicago, Chicago, Illinois 60637, and Argonne National Laboratory,
Argonne, Illinois 60439

(Received 6 September 1983)

The possibility that a scalar boson is sometimes emitted in the decay of ^{4}He(20.1 MeV, 0^+) is examined experimentally. Finding no positive evidence the authors exclude scalars with Higgs-like couplings for $3 \lesssim m_\varphi \lesssim 14$ MeV/c^2, where the precise range depends upon the model.

PACS numbers: 14.80.Gt, 14.80.Pb, 23.90.+w

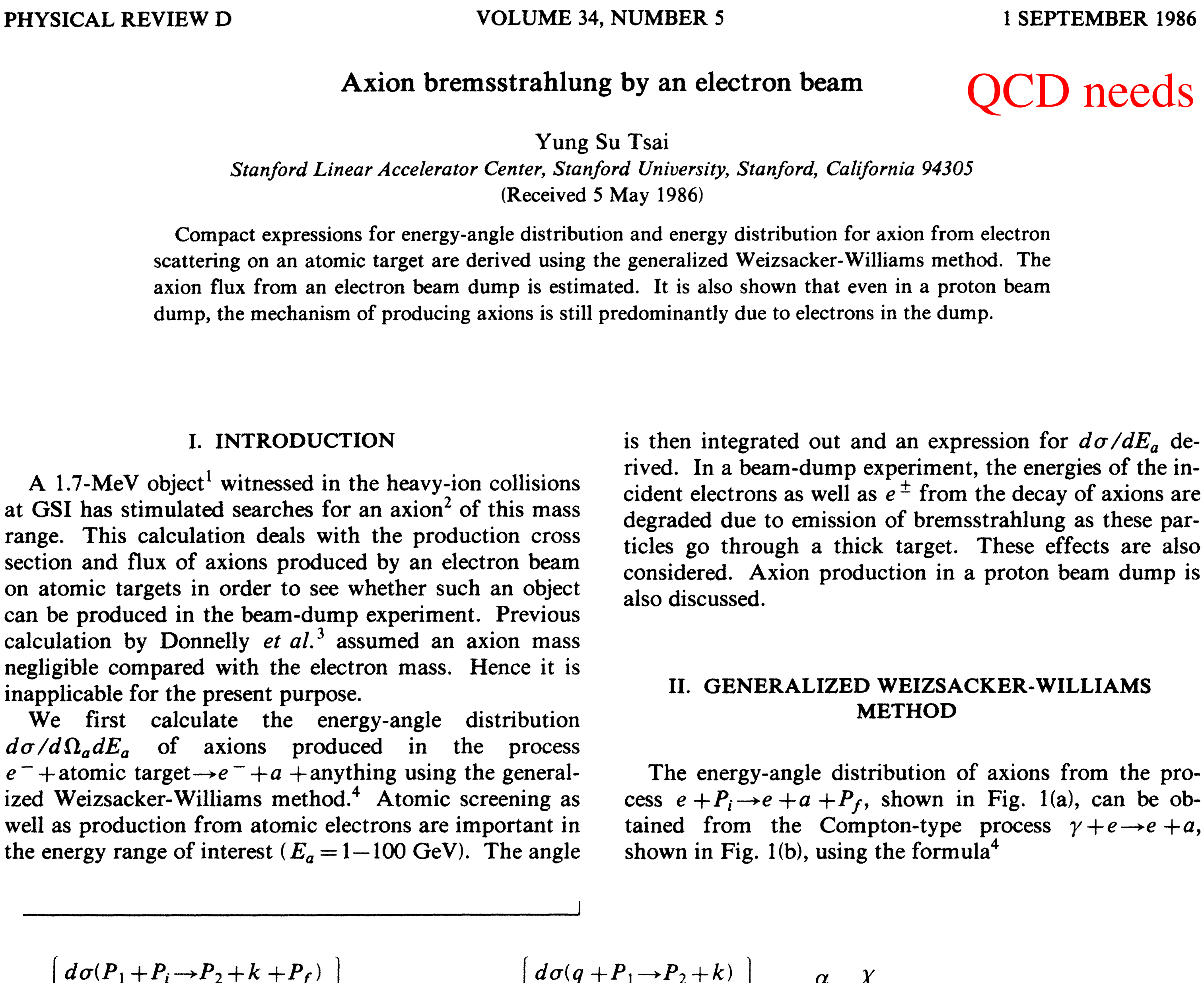
One exciting aspect of gauge theories is the notion that new scalar bosons may await experimental discovery.[1,2] For example, the standard model of electroweak interactions requires a new neutral scalar, the Higgs boson. Simple assumptions imply a heavy scalar, $m_\varphi \gtrsim 6-7$ GeV/c^2,[3] but complications could spoil the bound. Moreover, scalars seem ubiquitous in gauge theories and it is prudent to search for them re-

ed NaI detector in which the signal approximates that of a 20-MeV γ ray. Higgs-like scalars should be semiweakly interacting and, unlike direct-capture photons, able to penetrate thick shielding material. In this Letter we describe the experiment and we compare the results to available theory.

Figure 1 shows the experimental arrangement. A 600-keV proton beam from the Argonne Na-

Why do a search for new physics at JLab?

QCD needs an axion!



PHYSICAL REVIEW D VOLUME 34, NUMBER 5 1 SEPTEMBER 1986

Axion bremsstrahlung by an electron beam

Yung Su Tsai
Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305

(Received 5 May 1986)

Compact expressions for energy-angle distribution and energy distribution for axion from electron scattering on an atomic target are derived using the generalized Weizsacker-Williams method. The axion flux from an electron beam dump is estimated. It is also shown that even in a proton beam dump, the mechanism of producing axions is still predominantly due to electrons in the dump.

I. INTRODUCTION

A 1.7-MeV object[1] witnessed in the heavy-ion collisions at GSI has stimulated searches for an axion[2] of this mass range. This calculation deals with the production cross section and flux of axions produced by an electron beam on atomic targets in order to see whether such an object can be produced in the beam-dump experiment. Previous calculation by Donnelly *et al.*[3] assumed an axion mass negligible compared with the electron mass. Hence it is inapplicable for the present purpose.

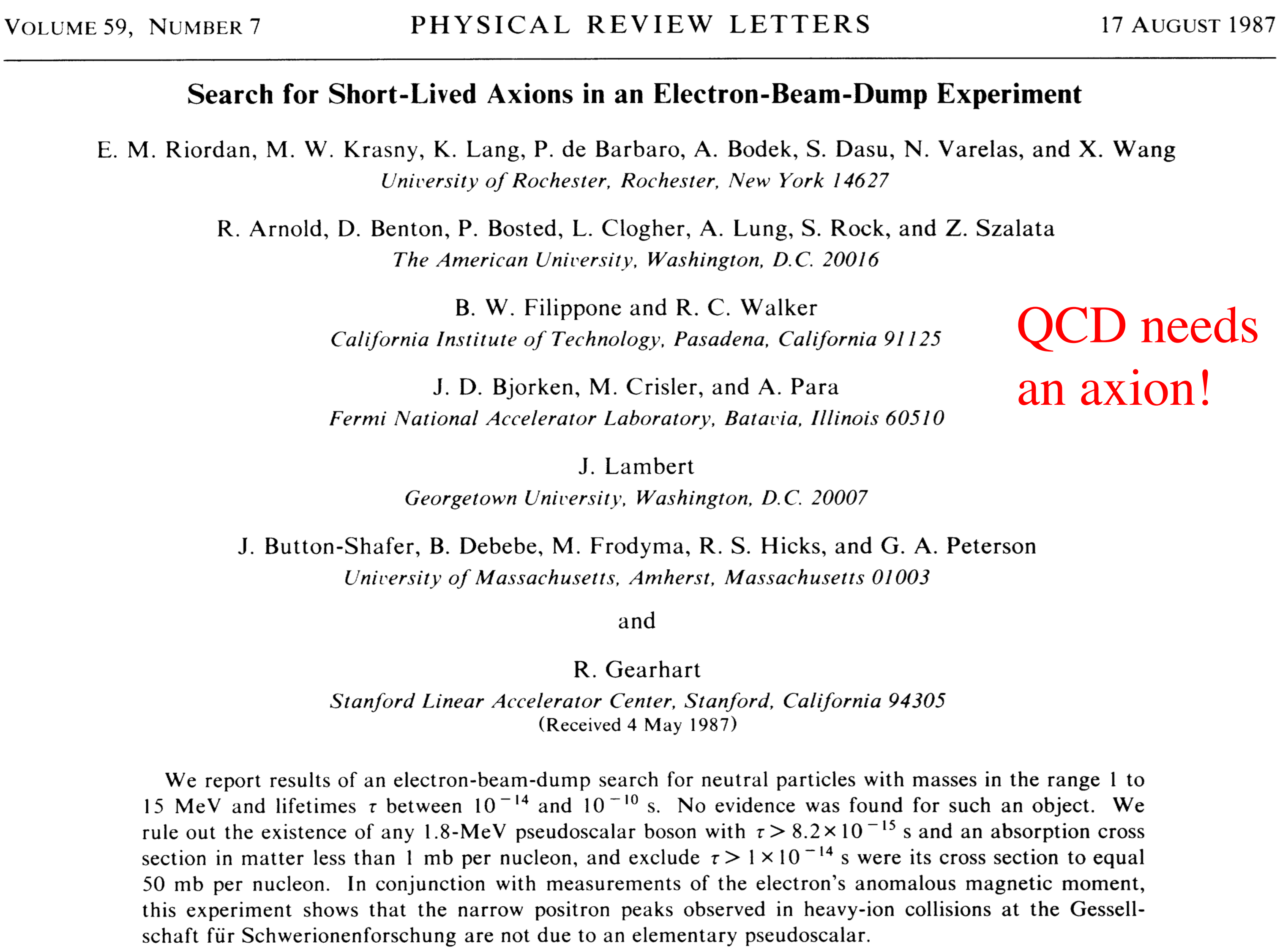
We first calculate the energy-angle distribution $d\sigma/d\Omega_a dE_a$ of axions produced in the process $e^- +$atomic target$\to e^- + a +$anything using the generalized Weizsacker-Williams method.[4] Atomic screening as well as production from atomic electrons are important in the energy range of interest ($E_a = 1-100$ GeV). The angle is then integrated out and an expression for $d\sigma/dE_a$ derived. In a beam-dump experiment, the energies of the incident electrons as well as $e^\pm$ from the decay of axions are degraded due to emission of bremsstrahlung as these particles go through a thick target. These effects are also considered. Axion production in a proton beam dump is also discussed.

II. GENERALIZED WEIZSACKER-WILLIAMS METHOD

The energy-angle distribution of axions from the process $e + P_i \to e + a + P_f$, shown in Fig. 1(a), can be obtained from the Compton-type process $\gamma + e \to e + a$, shown in Fig. 1(b), using the formula[4]

$$\left[d\sigma(P_1 + P_i \to P_2 + k + P_f) \right] \quad \left[d\sigma(q + P_1 \to P_2 + k) \right] \quad \alpha \quad \gamma$$

Why do a search for new physics at JLab?



VOLUME 59, NUMBER 7 PHYSICAL REVIEW LETTERS 17 AUGUST 1987

Search for Short-Lived Axions in an Electron-Beam-Dump Experiment

E. M. Riordan, M. W. Krasny, K. Lang, P. de Barbaro, A. Bodek, S. Dasu, N. Varelas, and X. Wang
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R. Arnold, D. Benton, P. Bosted, L. Clogher, A. Lung, S. Rock, and Z. Szalata
The American University, Washington, D.C. 20016

B. W. Filippone and R. C. Walker
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J. D. Bjorken, M. Crisler, and A. Para
Fermi National Accelerator Laboratory, Batavia, Illinois 60510

J. Lambert
Georgetown University, Washington, D.C. 20007

J. Button-Shafer, B. Debebe, M. Frodyma, R. S. Hicks, and G. A. Peterson
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and

R. Gearhart
Stanford Linear Accelerator Center, Stanford, California 94305

(Received 4 May 1987)

We report results of an electron-beam-dump search for neutral particles with masses in the range 1 to 15 MeV and lifetimes τ between 10^{-14} and 10^{-10} s. No evidence was found for such an object. We rule out the existence of any 1.8-MeV pseudoscalar boson with $\tau > 8.2\times10^{-15}$ s and an absorption cross section in matter less than 1 mb per nucleon, and exclude $\tau > 1\times10^{-14}$ s were its cross section to equal 50 mb per nucleon. In conjunction with measurements of the electron's anomalous magnetic moment, this experiment shows that the narrow positron peaks observed in heavy-ion collisions at the Gesellschaft für Schwerionenforschung are not due to an elementary pseudoscalar.

QCD needs an axion!

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.

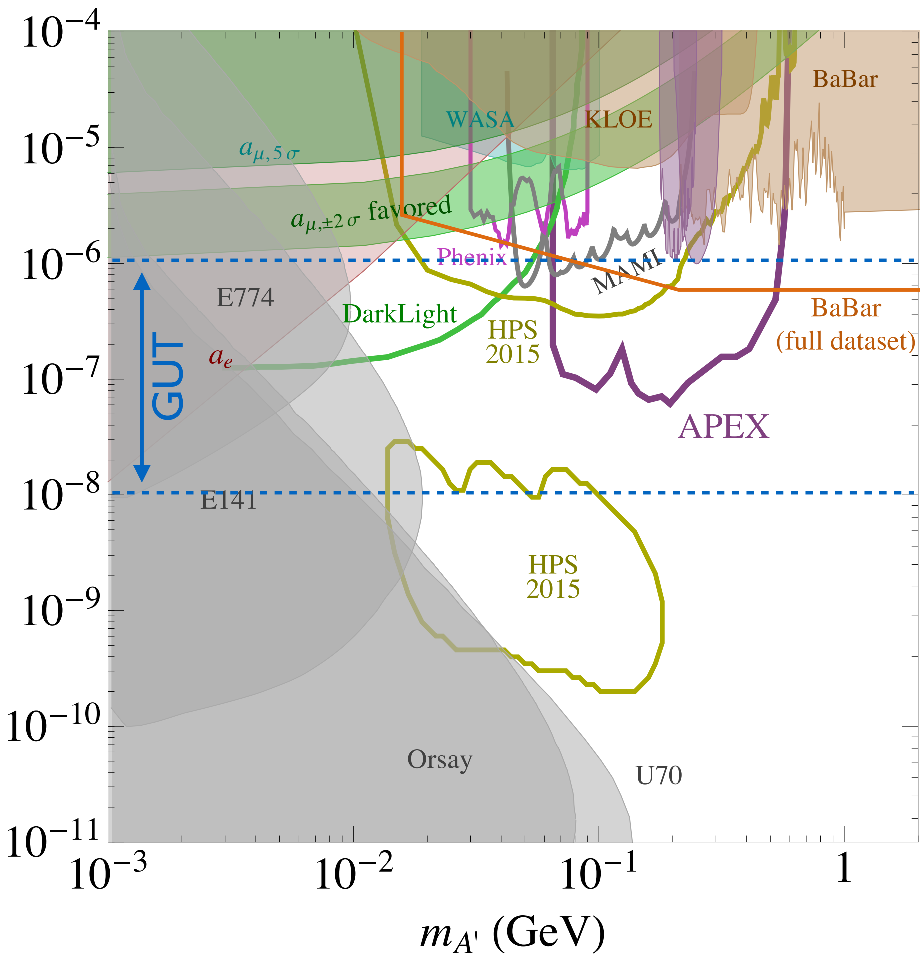
- Our nuclear physics lab has the only 100% duty factor high energy high intensity electron accelerator existing in the U.S.

- 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.

APEX

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

The APEX parameter space is motivated by:



- Theory:

  simple Standard Model extensions have

  $$\epsilon^2 \sim 10^{-8} - 10^{-4}$$

  $$m_{A'} \sim \sqrt{\epsilon}\, m_W \sim 10 - 1000 \text{ MeV}$$

  if Standard Model forces unify in a GUT,

  then expect $\epsilon^2 \sim 10^{-8} - 10^{-6}$

  APEX first to explore deep into this region

- Dark Matter:

  Cosmic-ray e^+, e^- excess (PAMELA, Fermi, AMS-02), if explained by DM, prefer

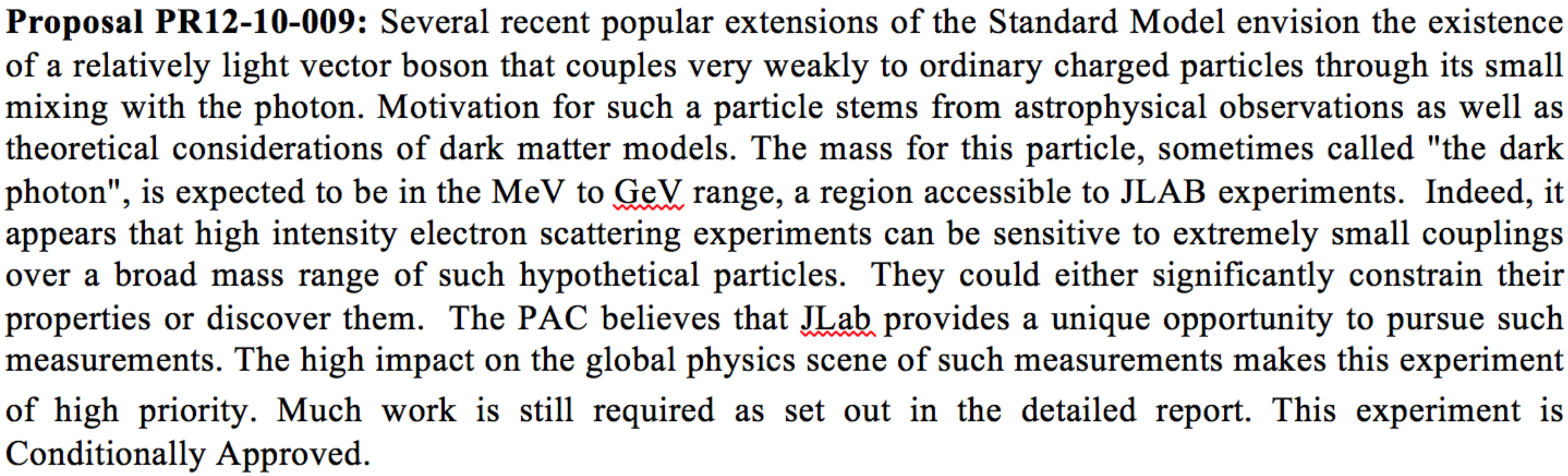
  $m_{A'} \sim 100 - 1000 \text{ MeV}$, where APEX has unique and world leading sensitivity

  Recent X-ray line at 3.5 keV and GeV γ-ray excess also compatible with A′/dark matter physics

- Muon g-2:

  APEX probes muon g-2 region for A' visible branching ratio as low as 0.1-1%

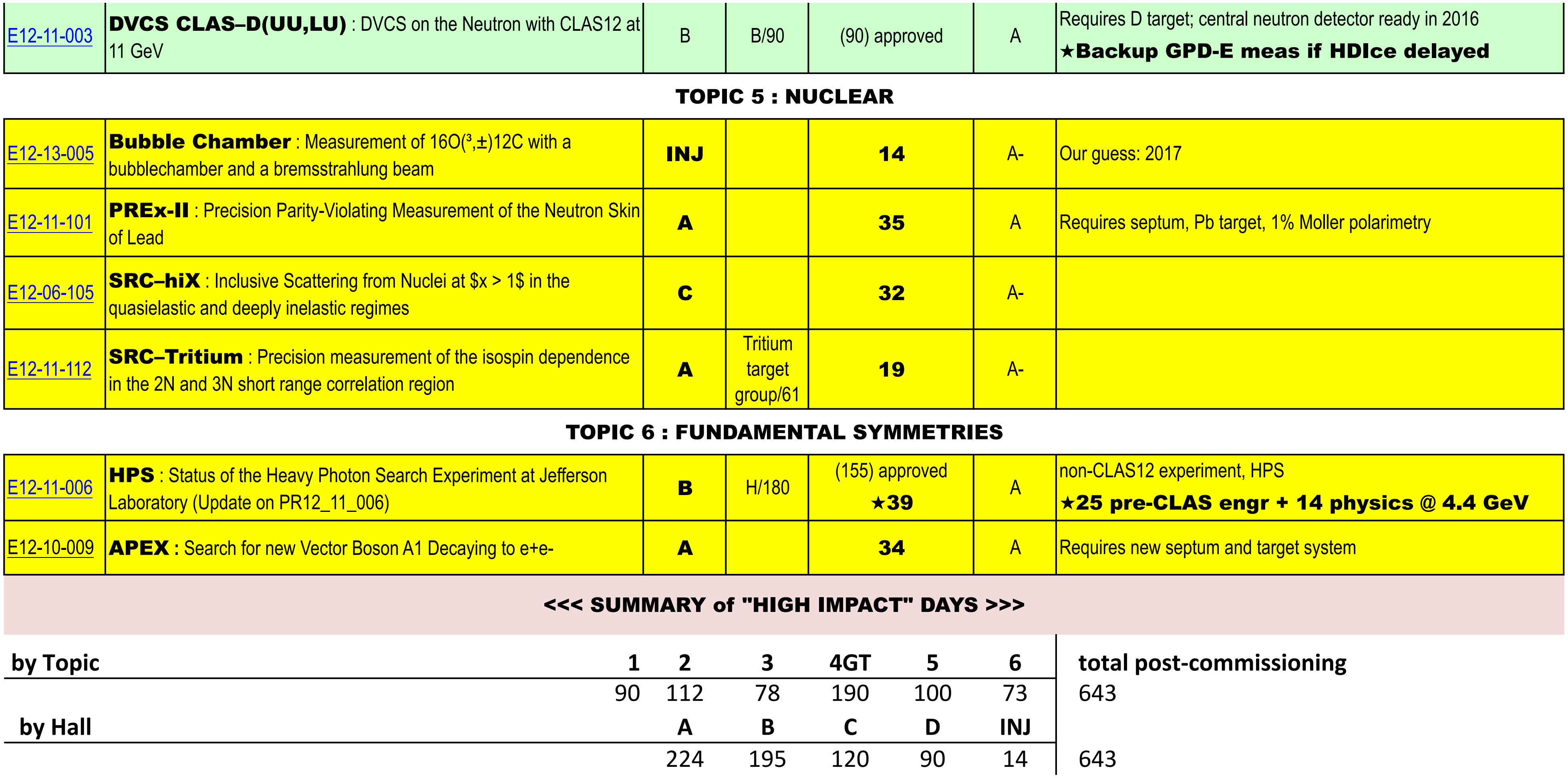
PAC35 report



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.

APEX: PAC41 results

Why do a search for new physics at JLab?



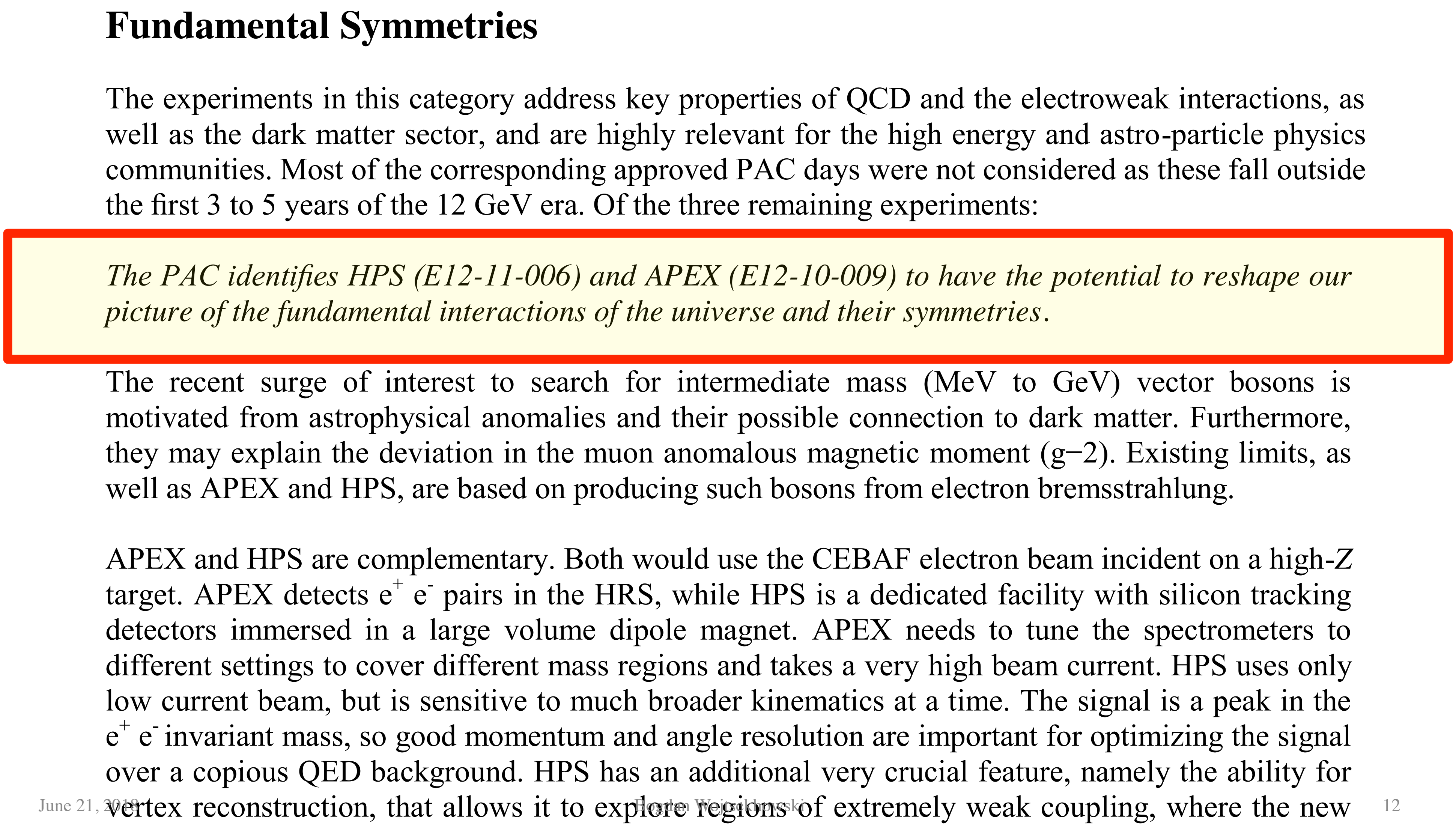
E12-11-003	**DVCS CLAS–D(UU,LU)** : DVCS on the Neutron with CLAS12 at 11 GeV	B	B/90	(90) approved	A	Requires D target; central neutron detector ready in 2016 **★Backup GPD-E meas if HDIce delayed**
			TOPIC 5 : NUCLEAR			
E12-13-005	**Bubble Chamber** : Measurement of 16O(³,±)12C with a bubblechamber 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:

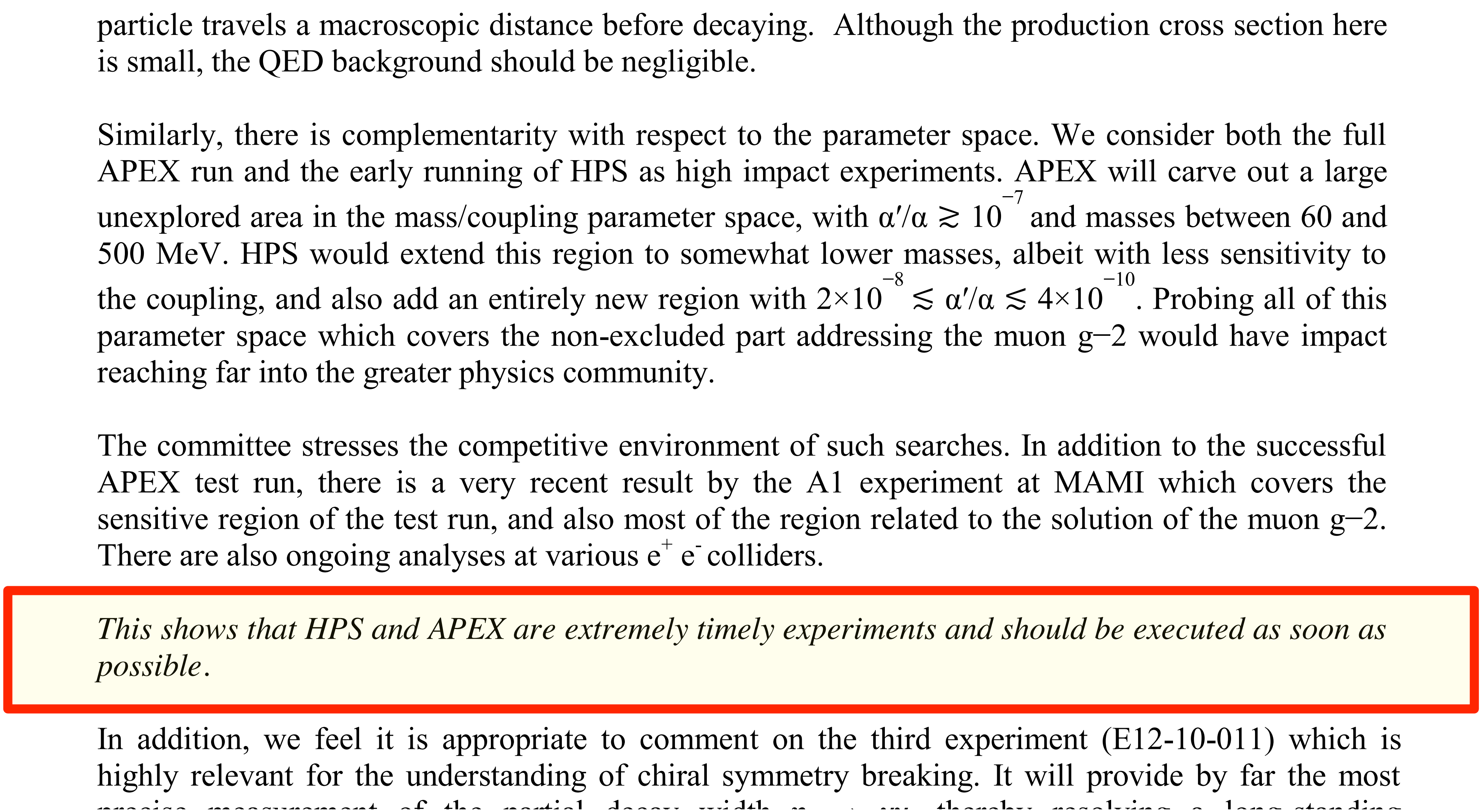
The PAC identifies HPS (E12-11-006) and APEX (E12-10-009) to have the potential to reshape our picture of the fundamental interactions of the universe and their symmetries.

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.

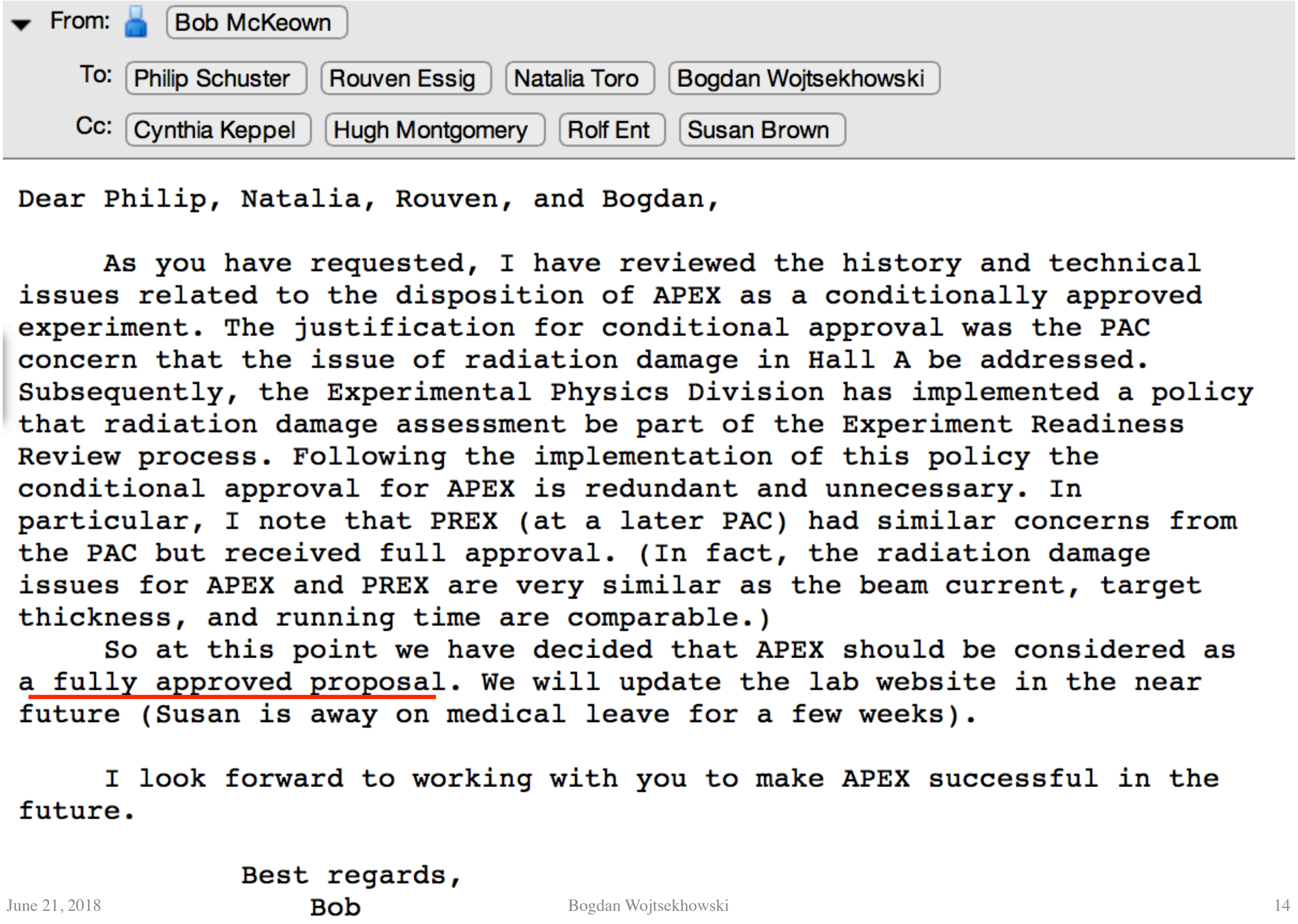
Similarly, there is complementarity with respect to the parameter space. We consider both the full APEX run and the early running of HPS as high impact experiments. APEX will carve out a large unexplored area in the mass/coupling parameter space, with $\alpha'/\alpha \gtrsim 10^{-7}$ and masses between 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

APEX: A Search for Dark Photons in Hall A



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,

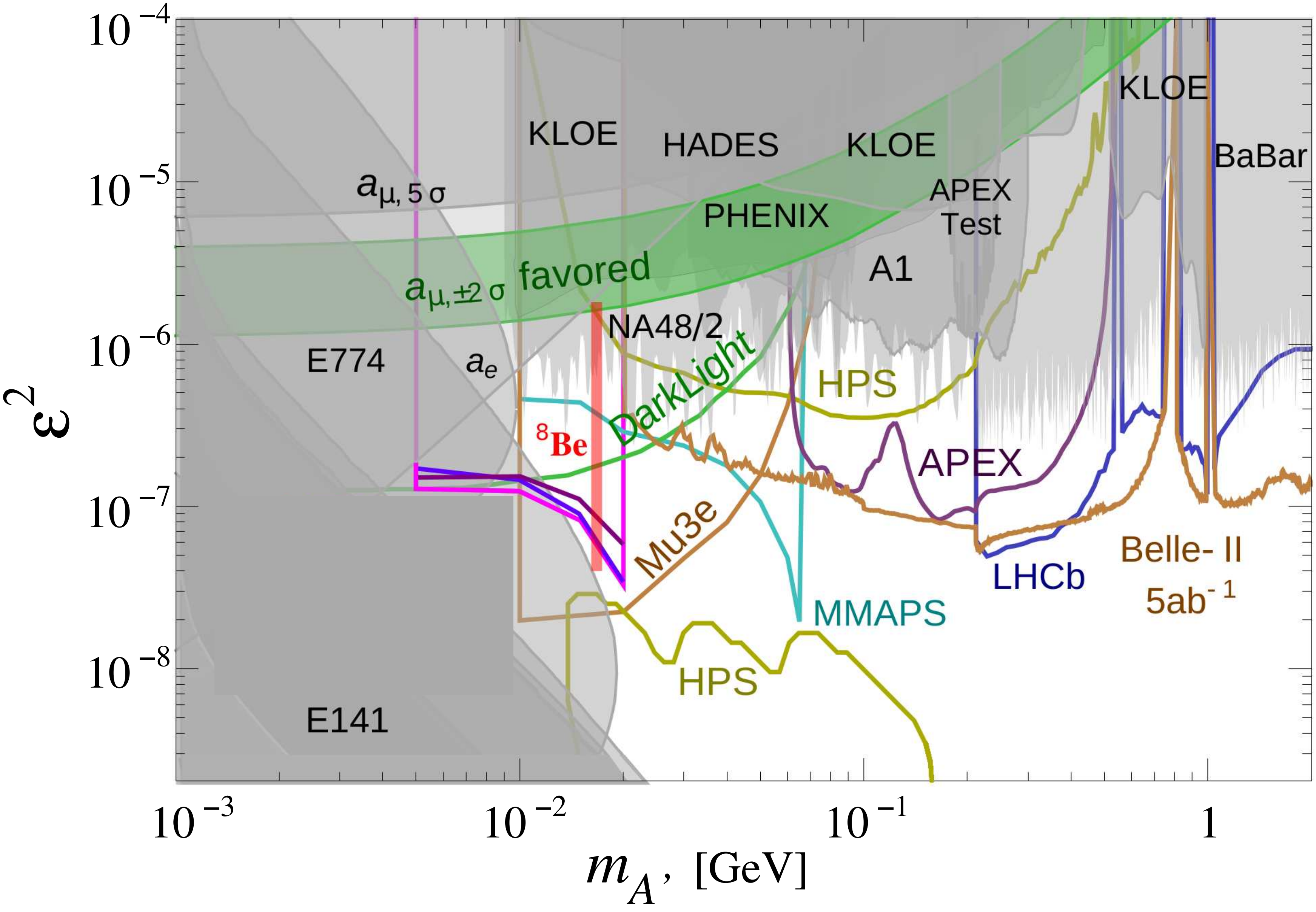
As you have requested, I have reviewed the history and technical issues related to the disposition of APEX as a conditionally approved experiment. The justification for conditional approval was the PAC concern that the issue of radiation damage in Hall A be addressed. Subsequently, the Experimental Physics 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

2018 phase space of A' searches



APEX Experiment Readiness Review

ERR meeting in April 2016 was organized by P. Rossi.
The review committee: V. Burkert (chair), P. Degtiarenko,
E. Folts, C. Keith, B. Manzlak, Q. Sun, K. Welch.

The committee reviewed the APEX experiment and experimental equipment as proposed by the APEX collaboration according to the documentation available and based on the presentations given to the committee. The committee commends the collaboration for the excellent presentations and the preparatory work that entered into them.
The presented material was reviewed to address the **nine charge items** given to the committee and the presenters prior to the review.
The answers to the charges are presented below and separated into **Answer, Findings, Comments, and Recommendations.**

Hall A

Beam parameters:

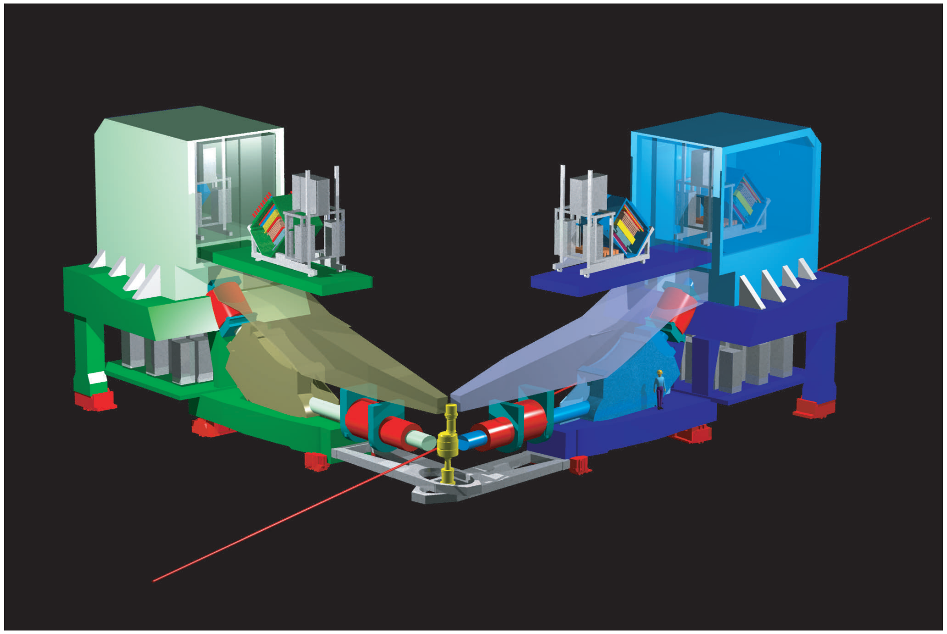
energy up to 11 GeV
intensity up to 180 μA
polarization 85%
pol. flip systematic 10^{-9}
time structure 2(4) ns

Luminosity: 10^{39} cm^{-2}/s

Detector systems: **HRSs**

Polarized targets:
^{3}He: $L \sim 10^{36}$ cm^{-2}/s
NH_3/ND_3: $L \sim 10^{35}$ cm^{-2}/s

Hall A Eletron and Hadron Arms



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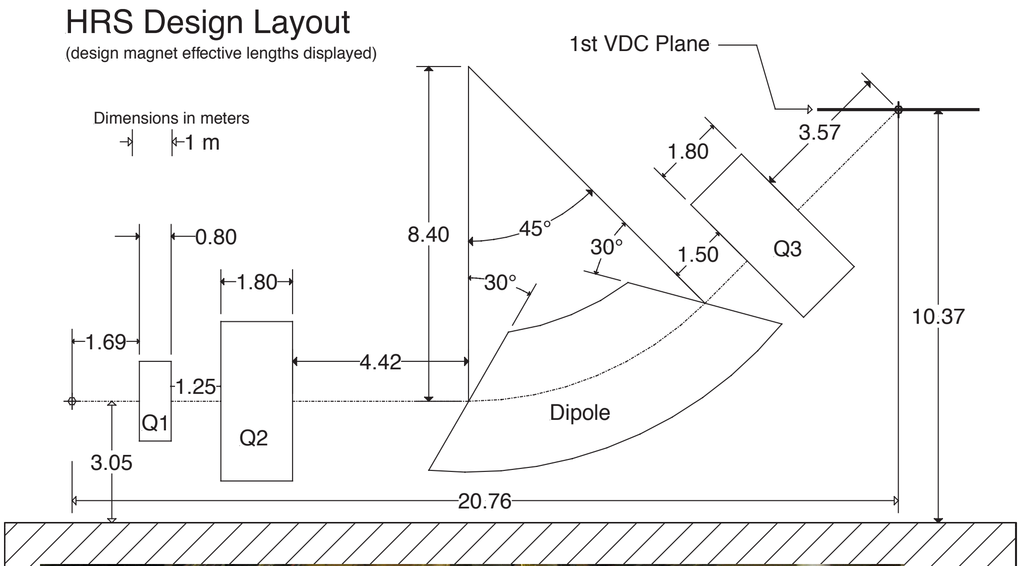
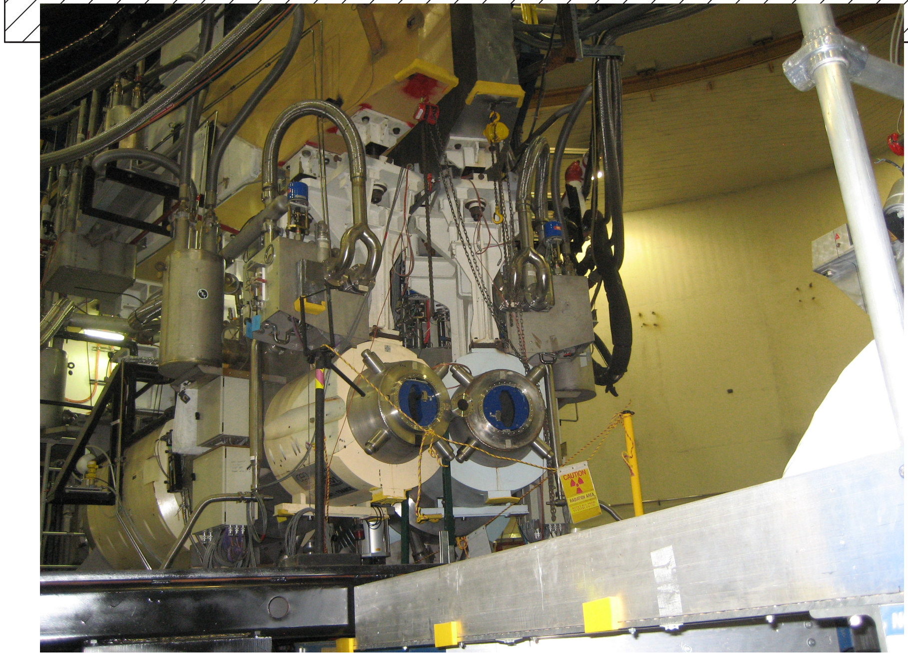
momentum up to 4.3 and 3.2 GeV/c

The HRS spectrometers





Two HRS Spectrometers

$0.3 < p < 4.0$ GeV/c

$-4.5\% < \Delta p/p < 4.5\%$

6 msr at $12.5° < \theta < 150°$

4.5 msr at $\theta = 6°$ with septum

$-5\text{cm} < \Delta y < 5\text{cm}$

Optics: (FWHM)

$\delta p/p \leq 2 \cdot 10^{-4}$ (achieved)

$\delta\vartheta = 0.5$ mrad, $\delta\varphi = 1$ mrad

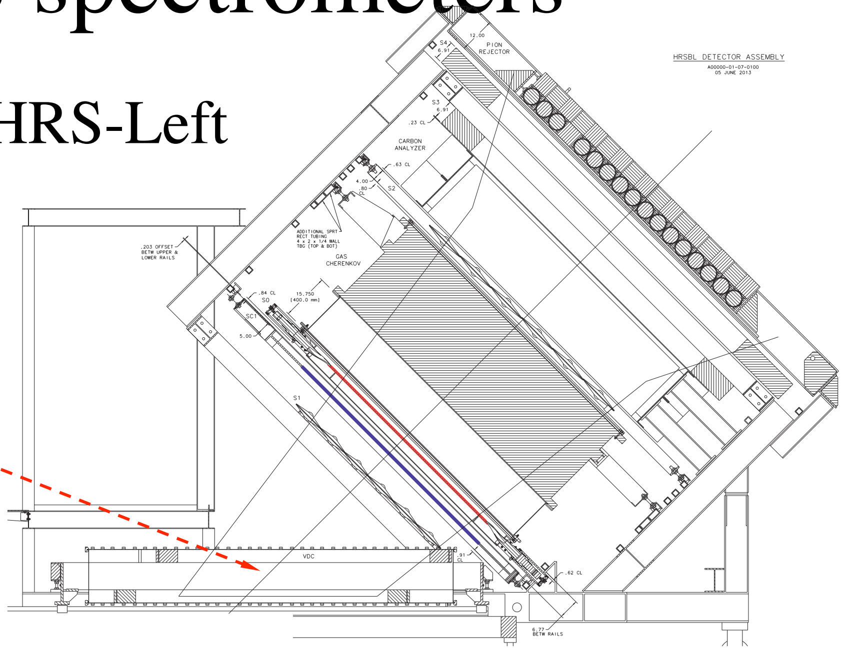
$\delta y = 1$mm

Luminosity ~ 10^{39} cm^{-2}s^{-1}

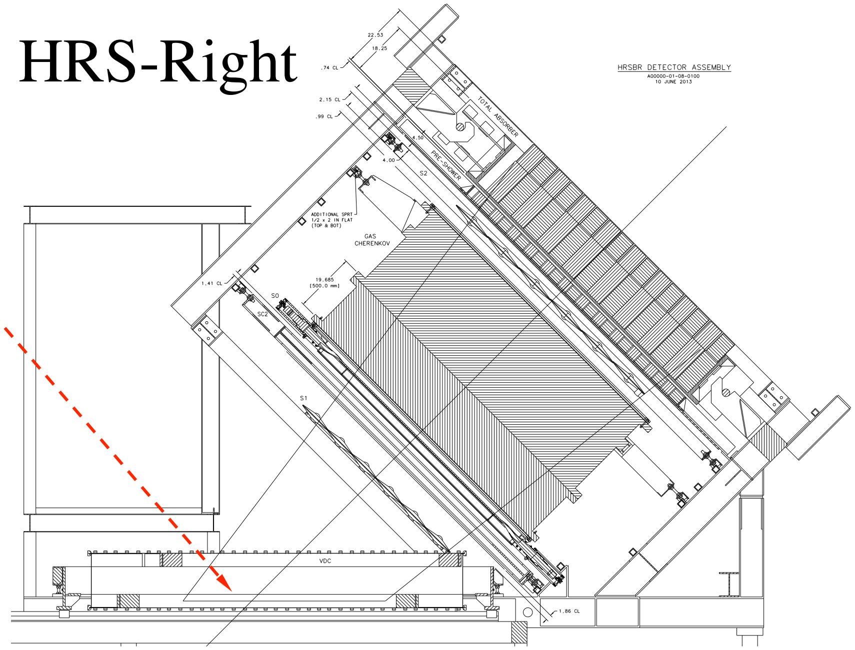
Detectors of the HRS spectrometers

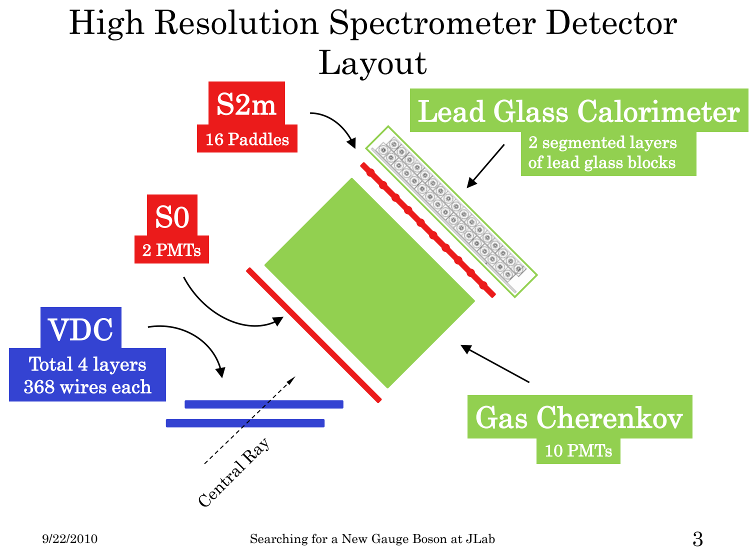
VDC tracker
S0 plane
S2 hodoscope
Gas Cherenkov
Lead-glass calorimeter

HRS-Left



HRS-Right





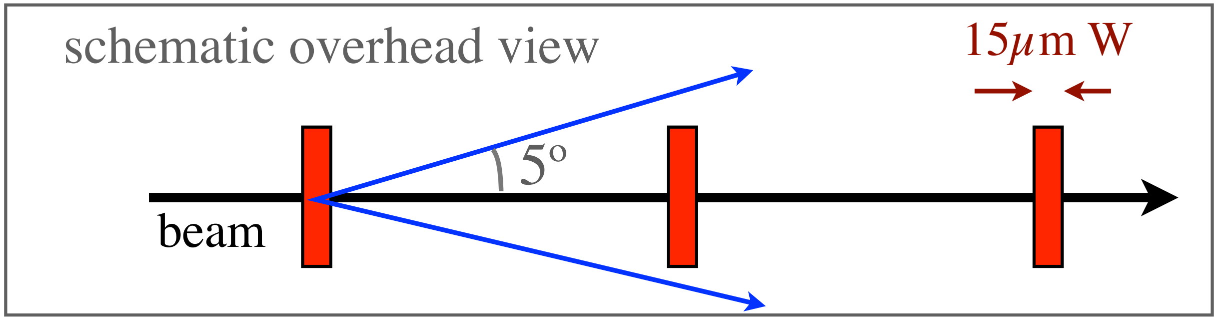
High Resolution Spectrometer Detector Layout

9/22/2010 Searching for a New Gauge Boson at JLab 3

Specialized APEX target

Goals:

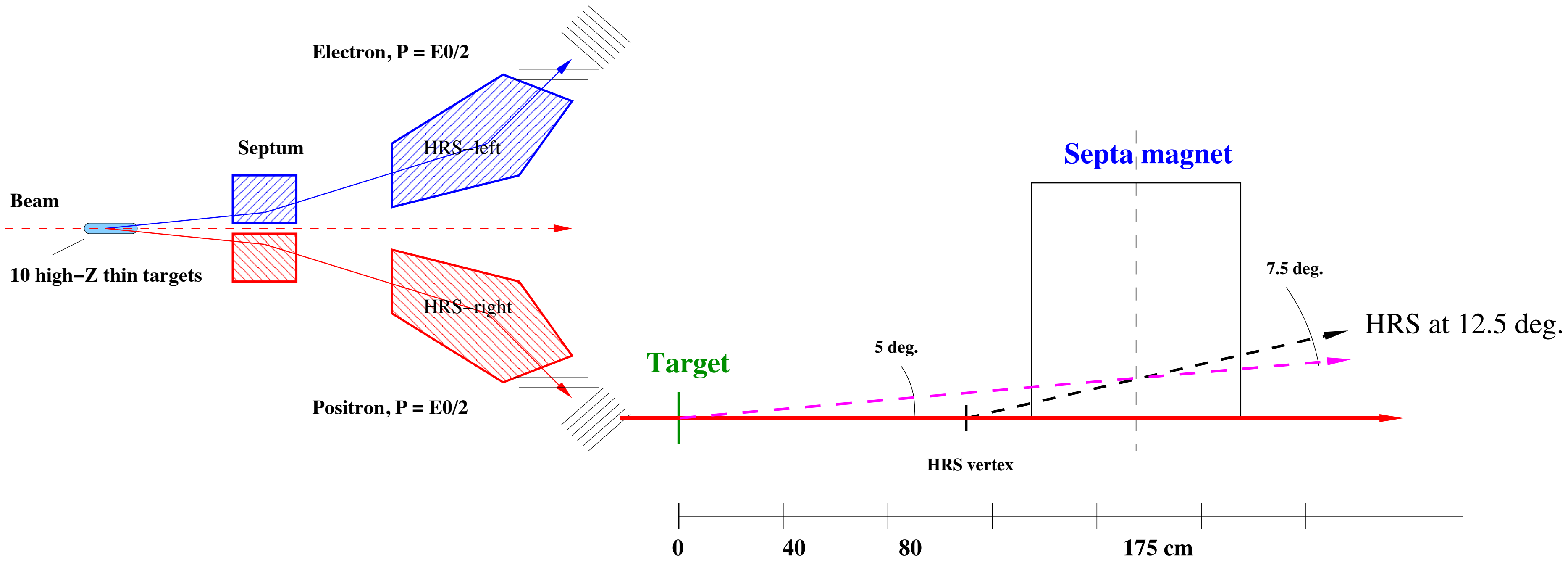
- $\sigma(\theta)_{\text{mult scat}} \leq 0.5$ mrad
  $\Rightarrow$ typical e^+e^- pair must only go through 0.3% X_0 (2-pass)
- Target thickness 0.7–8% X_0 (depending on E_{beam})



- High-*Z* target (reduce π yield for given QED rates)
- Stable under currents up to ~100 μA

A wide mass range with one beam energy setting!

Specialized APEX hardware: Septa magnet



Septa works well for Δp/p << 1. In HRS Δp/p is of 0.09
Required field integral is 0.44 Tesla-m per 1 GeV/c
APEX is approved to run with 1.1, 2.2, 3.3, and 4.4 GeV beam energies,
which requires 0.55, 1.1, 1.65, and 2.2 GeV in HRS

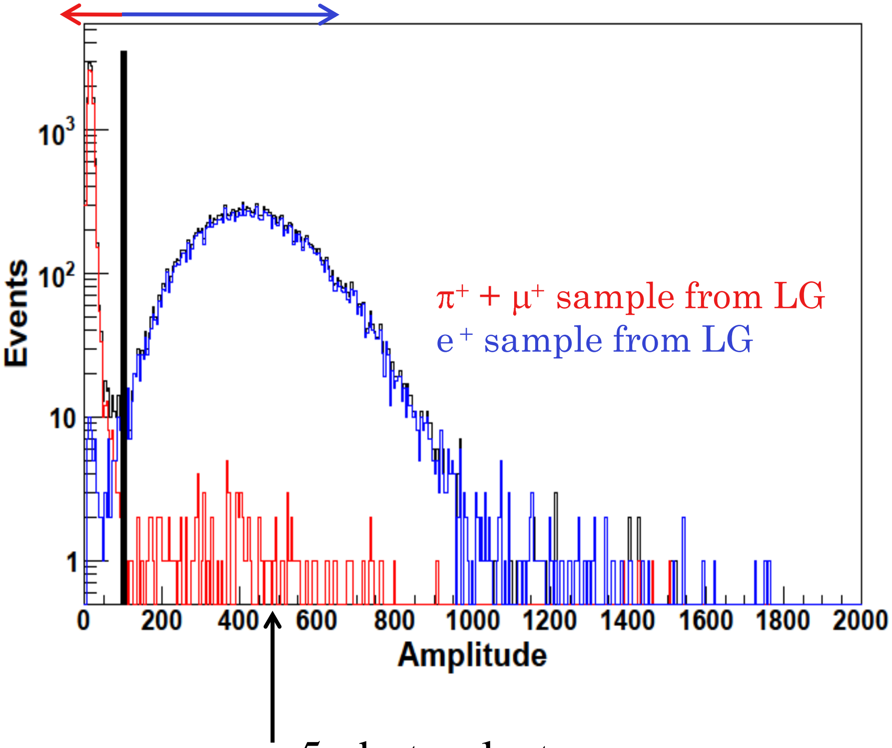
This concept was used in two previous septa magnets and well tested

Detectors of the HRS spectrometers

Currently (2018): 15 photo-electrons per electron track

From the test run (2010) analysis

$\pi^+ + \mu^+$ sample e^+ sample



5 photo-electrons

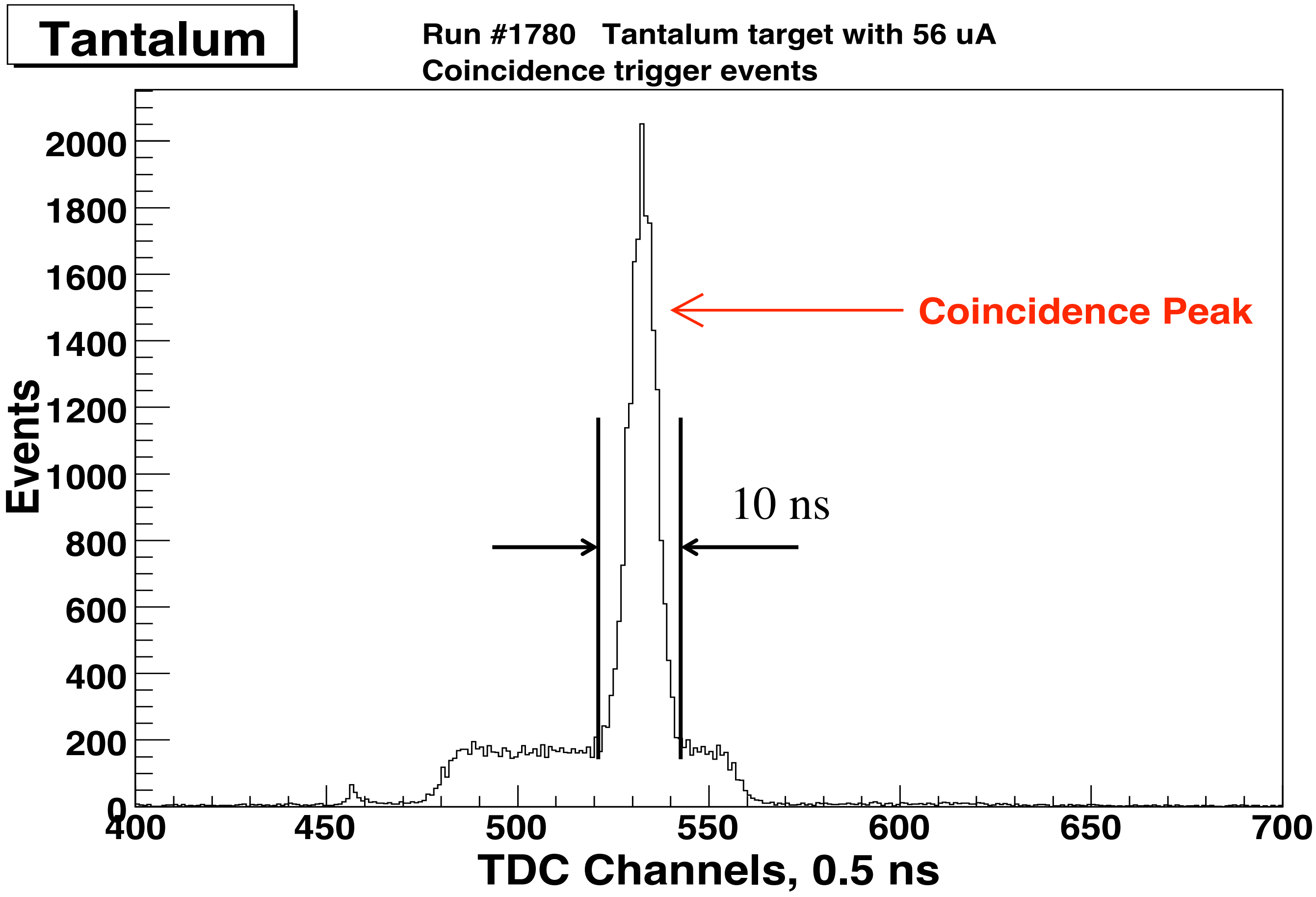
Electron detection eff.	0.995
Pion rejection eff.	0.987

Meson background rejected by a factor of 75

Detectors of the HRS spectrometers

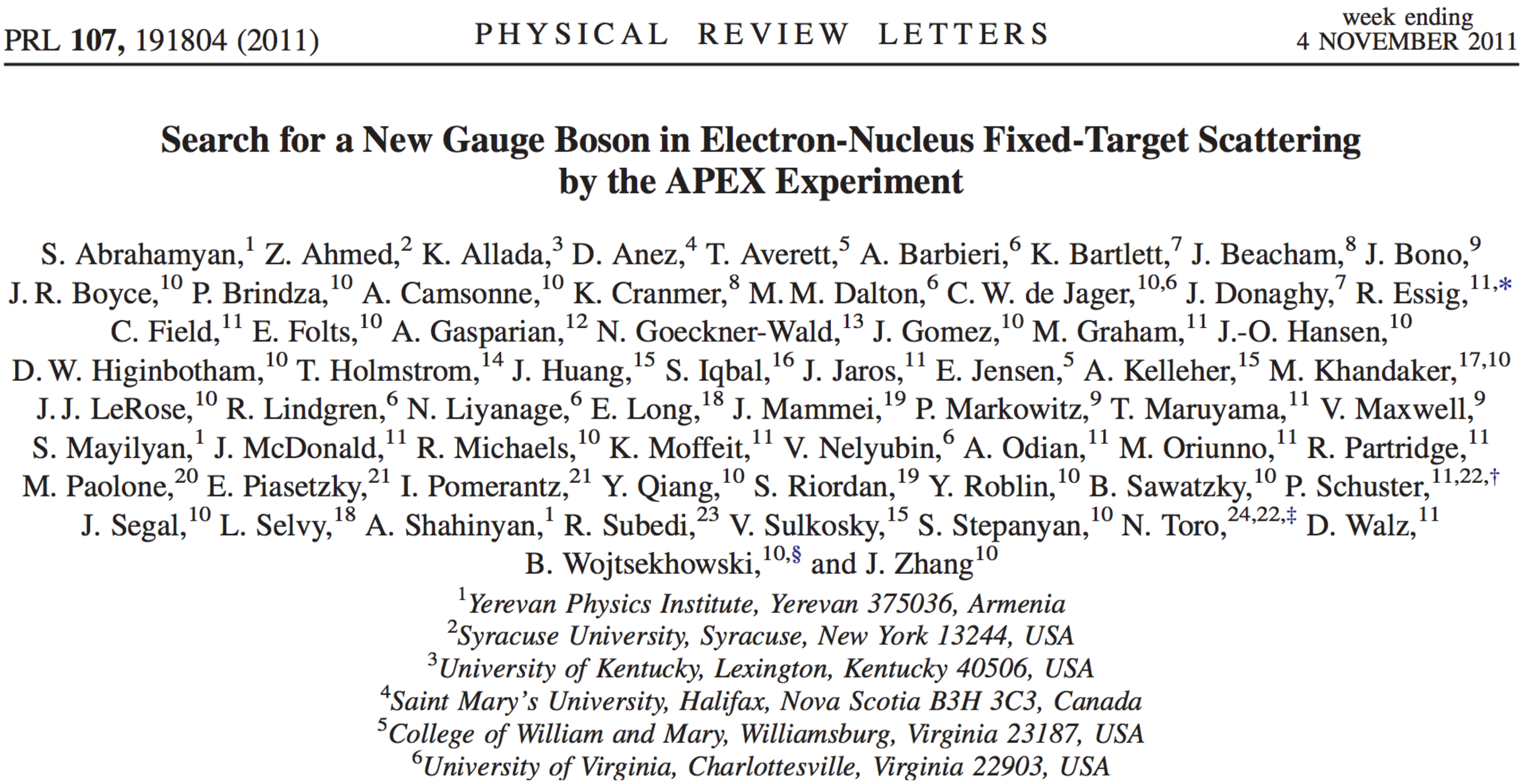
DAQ trigger is a triple coincidence of the Gas Cherenkov (e+ arm) and Scintillator hodoscopes of two arms

From the test run (2010) analysis



APEX Test-Run paper

236 citations



PRL 107, 191804 (2011) PHYSICAL REVIEW LETTERS week ending 4 NOVEMBER 2011

Search for a New Gauge Boson in Electron-Nucleus Fixed-Target Scattering by the APEX Experiment

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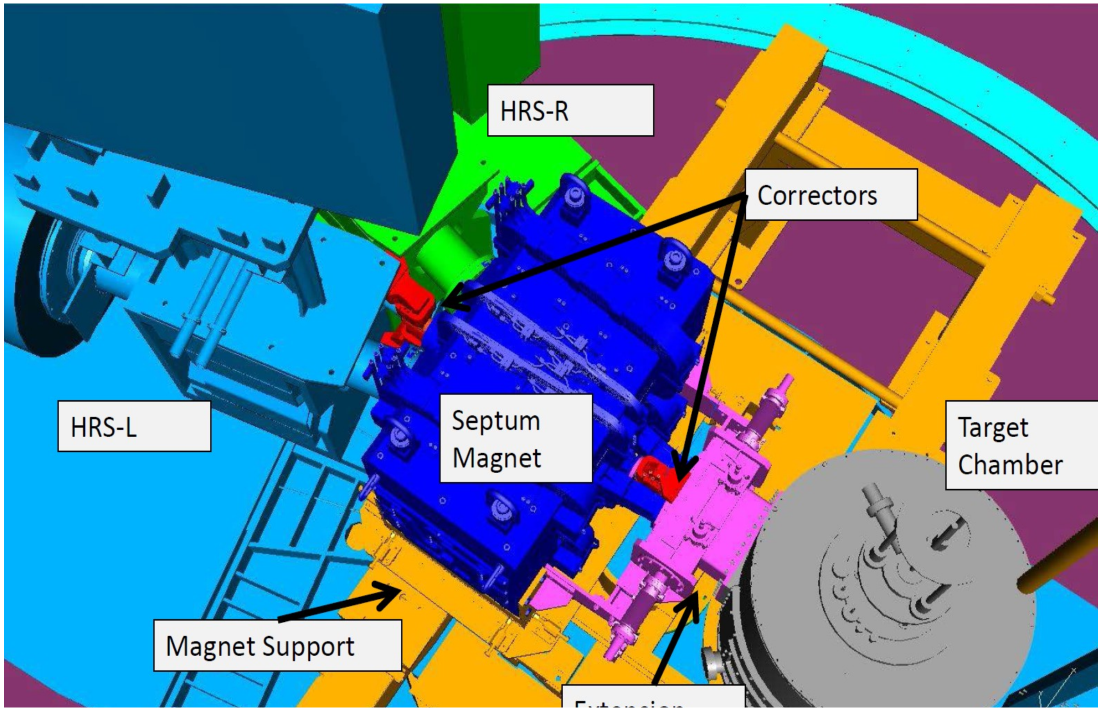
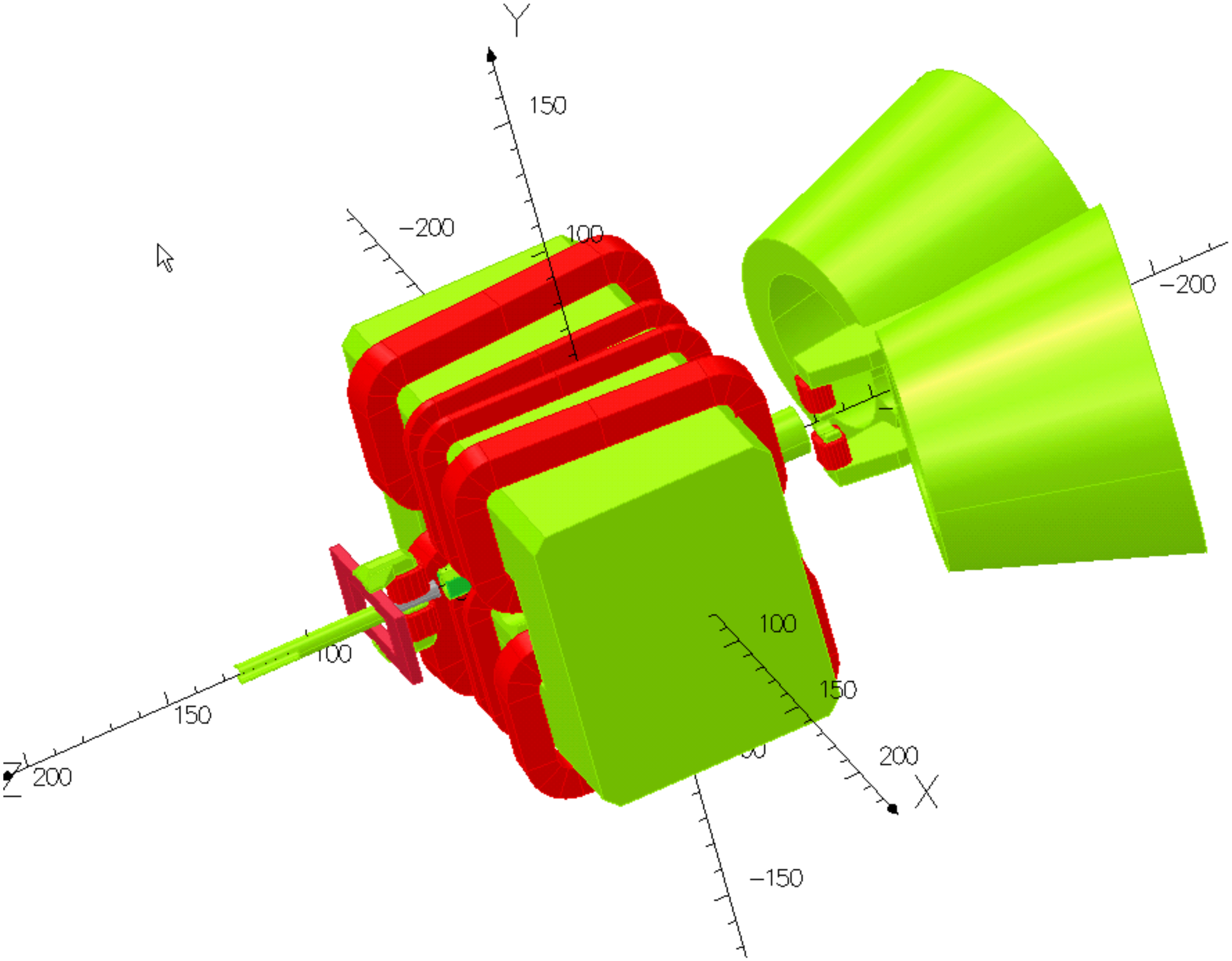
APEX equipment

New septum:

- allows registration of small-angle e^+e^- pairs in HRS;
- provides operation for full momentum range of the experiment (up to 2.2 GeV);
- has a good magnetic shielding of the beam line.

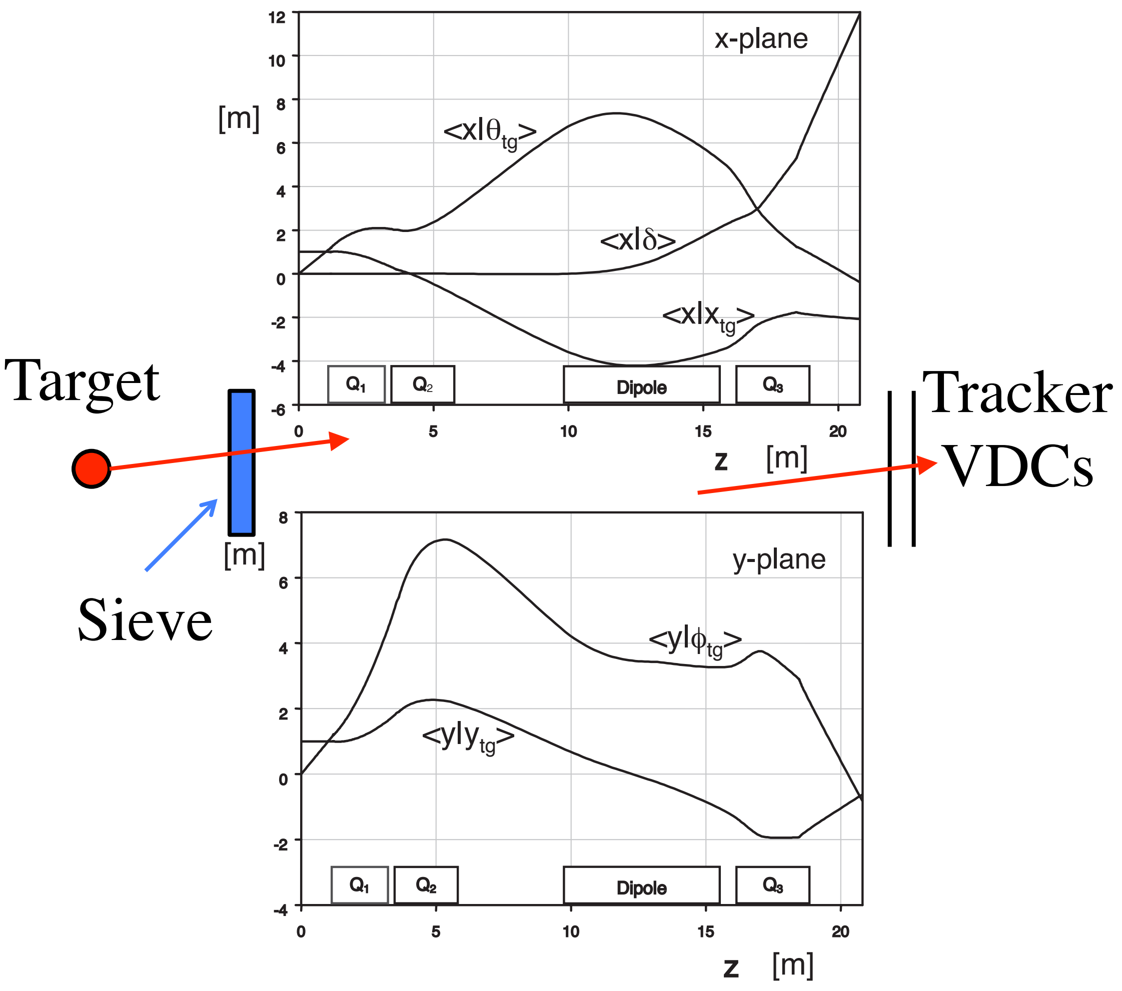


Septa magnet view and correctors

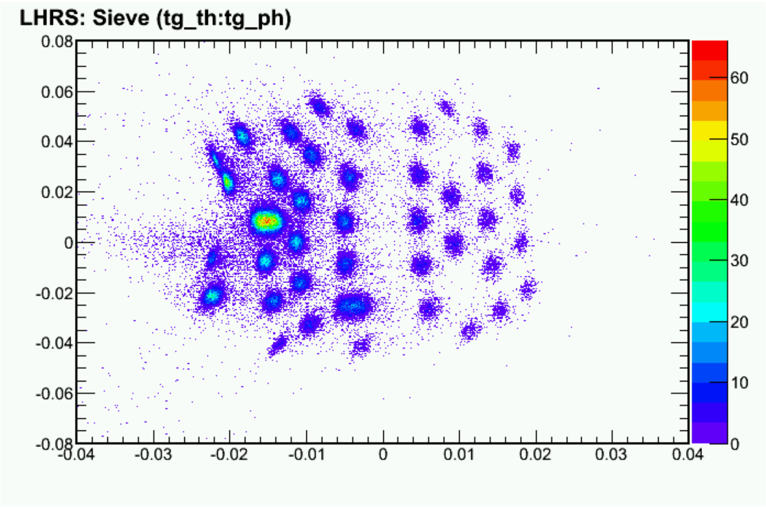


Specialized APEX detector: SciFi detector

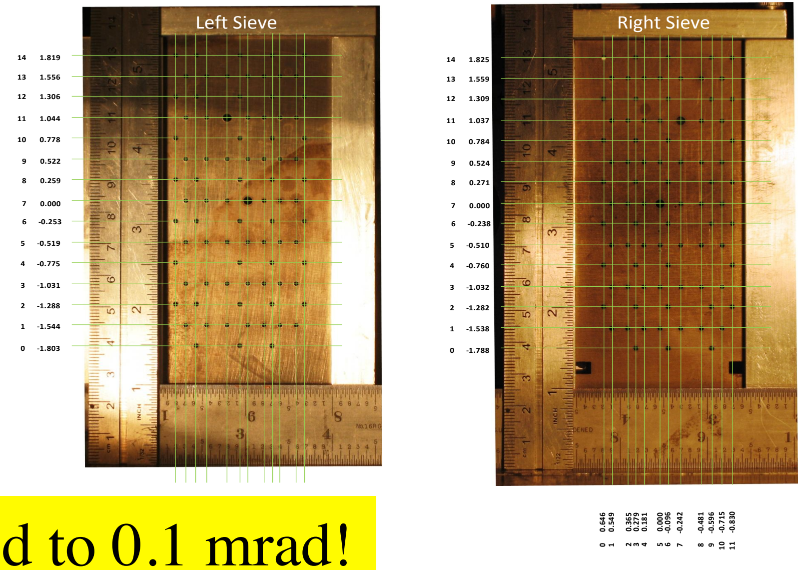
Spectrometer optics



Traditional sieve pattern



Sieve Hole Position Measurement (inches)



Left Sieve

14	1.819
13	1.556
12	1.306
11	1.044
10	0.778
9	0.522
8	0.259
7	0.000
6	-0.253
5	-0.519
4	-0.775
3	-1.031
2	-1.288
1	-1.544
0	-1.803

Right Sieve

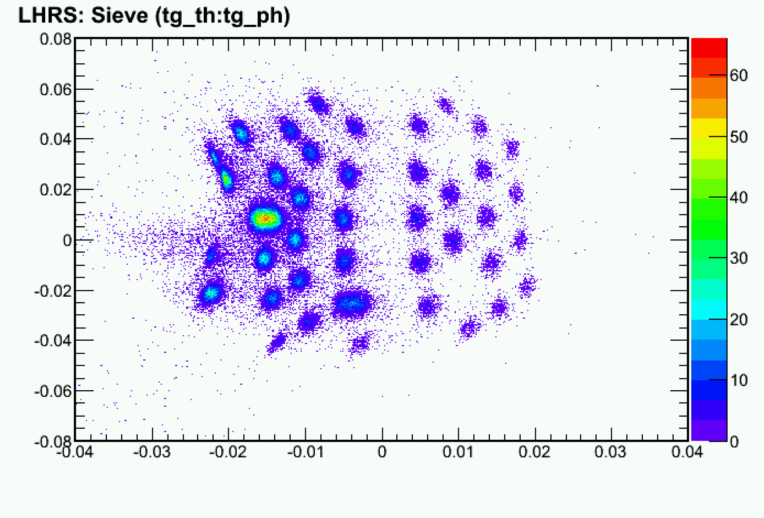
14	1.825
13	1.559
12	1.309
11	1.037
10	0.784
9	0.524
8	0.271
7	0.000
6	-0.238
5	-0.510
4	-0.760
3	-1.032
2	-1.282
1	-1.538
0	-1.788

0	0.646
1	0.549
2	0.365
3	0.279
4	0.181
5	0.000
6	-0.096
7	-0.242
8	-0.481
9	-0.596
10	-0.715
11	-0.830

Calibrated optics is good to 0.1 mrad!

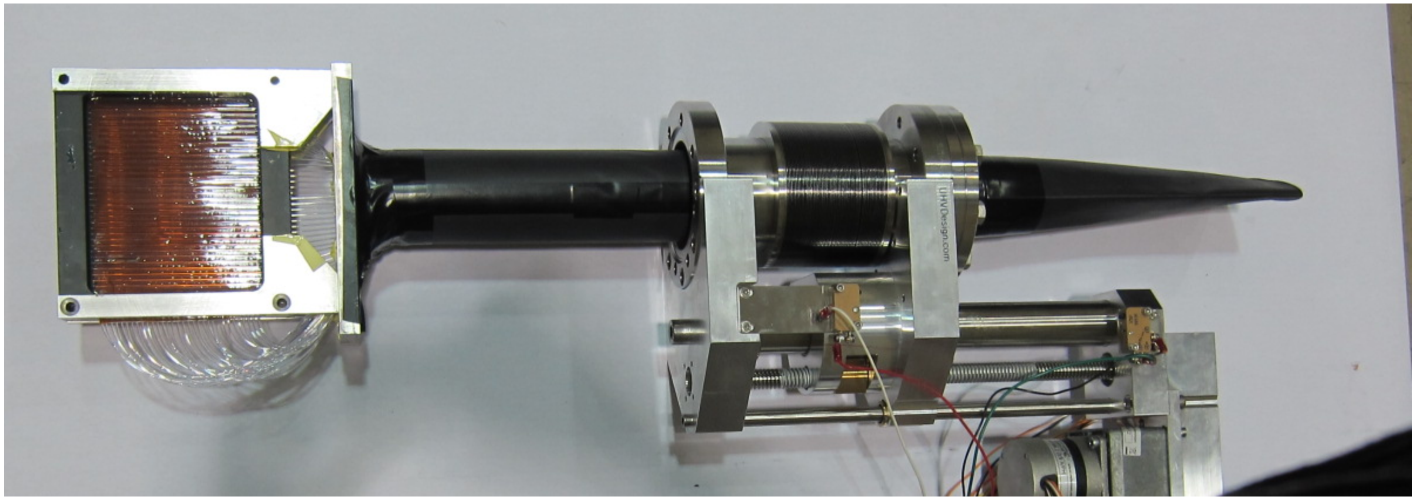
Specialized APEX detector: SciFi detector

Traditional sieve pattern



Positively charged particle optics needs a better method: the SciFi

Active “sieve slit”: a Sci Fiber detector with 1 mm fibers with 1/4” pitch connected via a bundle of 1.5 mm clear fibers to a 64-channel PMT.



SciFI will be used during the optics calibration run with 1 μA beam intensity.
Readout via 1877S TDC; 1-3 MHz rate per fiber; off-line time window of < 5 ns

APEX: Status of equipment

- ✓ HRS electronics (including fADC) upgrade was performed
- ✓ Septa magnet is ready
- ✓ Power supply for 2 kA, 650kW (SBS) is ready
- ✓ Scintillator Fiber hodoscopes will be moved to Hall A in Aug.-Sept.
- ✓ Vacuum chambers are ready
- ✓ Corrector magnets: all parts ordered
- ➢ Support structure designed, ordered
- ✓ Target is tested for thermo cycles

Several tests of these components are under way

Hall A Projected Experiment Schedule as of 1/2018

	Spring	**Fall**	**Spring**	**Fall**	**Spring**	**Summer !!!!**	**Fall**
CY 2017	Ar(e,e'p)	^{3}H/^{3}He group*					
CY 2018			^{3}H/^{3}He group	^{3}H/^{3}He group			
CY 2019					*APEX*	*PREX2*	*CREX*

New and exciting news!
This is the plan…
…BUT…there are caveats….

SBS 2020
MOLLER?, SoLID? →

Experiments in red represent PAC "high impact" experiments

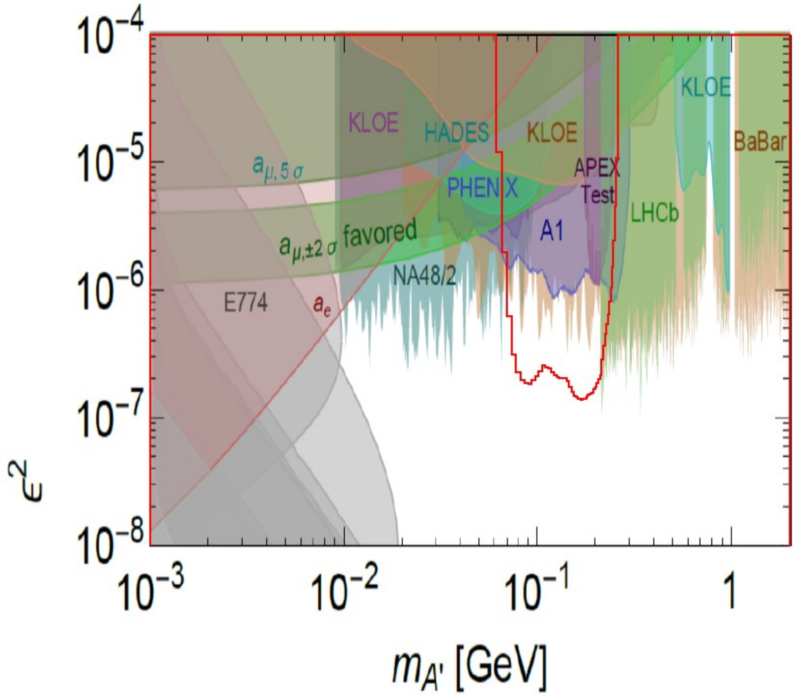
Hall A Experiment Schedule as of 5/11/2018

Hall A completed two experiments using the tritium target during the fall 2017 and winter/spring 2018 period: E12-010-103 ("MARATHON"), a measurement of the neutron to proton structure function ratio which will enable knowledge of the elusive down to up quark ratio; and E12-14-011 which leverages the asymmetric A=3 nuclei ^{3}H and ^{3}He to verify predictions suggesting that high momentum distributions in nuclei are dominated by short distance correlated pairs of different type nucleons. A third experiment using the tritium target was started, and will continue into the Fall 2018 run. This experiment, E12-11-112, will also use the asymmetric A=3 nuclei, in this case to perform a precision test of the isospin dependence of the two nucleon short range correlations, and extend such measurements into a regime where three nucleon short range correlations may be observed. On a best effort basis, Hall A will then begin installation to run the APEX experiment in spring 2019. Installation and running of PREX-II and CREX follow in summer and Fall 2019.

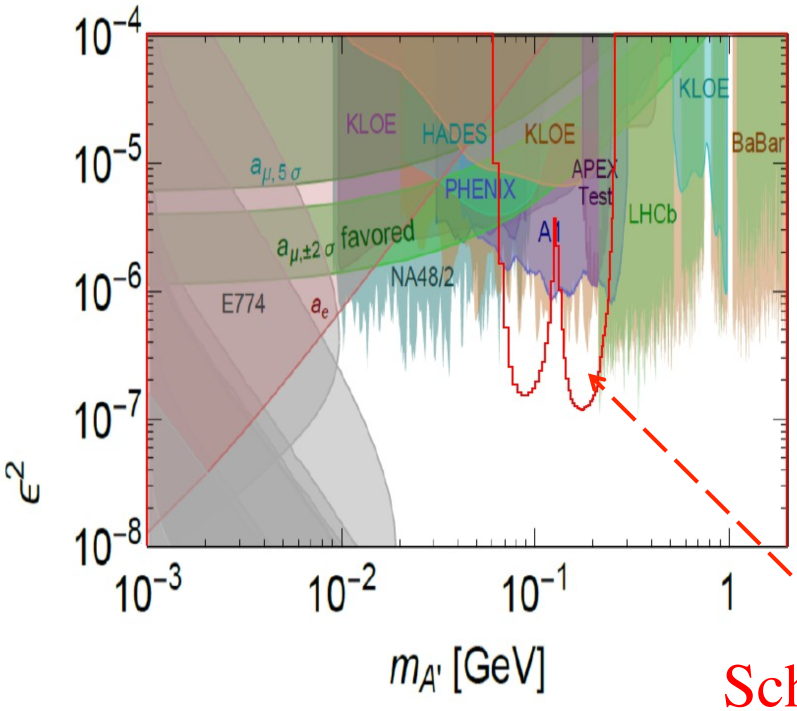
Installation: from December 2018 until January 29, 2019

Beam on target from January 30 until March 10, 2019
(with one beam energy of 2.1 GeV)

Updated plan (all energies)



10 days at 1.1 GeV beam
10 days at 1.65 GeV beam
10 days at 2.2 GeV beam



Scheduled

15 days at 1.1 GeV beam
15 days at 2.2 GeV beam

APEX collaboration

- Welcome to students
- Welcome to postdocs
- Welcome to data taking crews
- Thanks to Hall A designers
- Thanks to Hall A technical experts
- Thanks to CEBAF MCC beam crews
- Thanks to the APEX Executive Committee
- Thanks to JLab and Hall A management