Summary Status of APEX

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on behalf of the APEX collaboration

Outline

- ★ Overview of PAC 35 concerns
- ★ Summary of how APEX has addressed these concerns in the 2010 test run
- ★ Readiness overview
- ★ Future plans

PAC 35 Concerns

1) Run with the zig-zag mesh Tungsten target, prove that it allows requested vertex resolution

2) Prove that it is possible to reach the uncertainty of 0.1 mrad in determining the central scattering angle between the two spectrometers

3) Prove that the vertical drift chambers (VDC's) can operate at a rate higher than 20 kHz/wire (that, according to TAC report, is the highest Hall A has operated until now)

4) Prove that a 20 ns (S0-S0) and 40 ns (S0-S0-C) gate can be achieved

5) Prove that it is possible to use the gas Cherenkov counters in the trigger to help clean pions. In fact the TAC report claims that this is not possible with total rates/PMT at the level of a few hundred Hz/MHz. Also prove that the offline rejection of 10,000:1 can be achieved.

6) Prove that a 20 ns (S0-S0) and 40 ns (S0-S0-C) gate can be achieved

7) If possible, set up septum at higher fields to prove that also at energies higher than 2 GeV it is possible to reach the uniformity of field requested from the experiment

8) Detailed description of different contributions to the background and their importance (how assumptions and/or approximations can influence the predictions) and comparison with measurement.

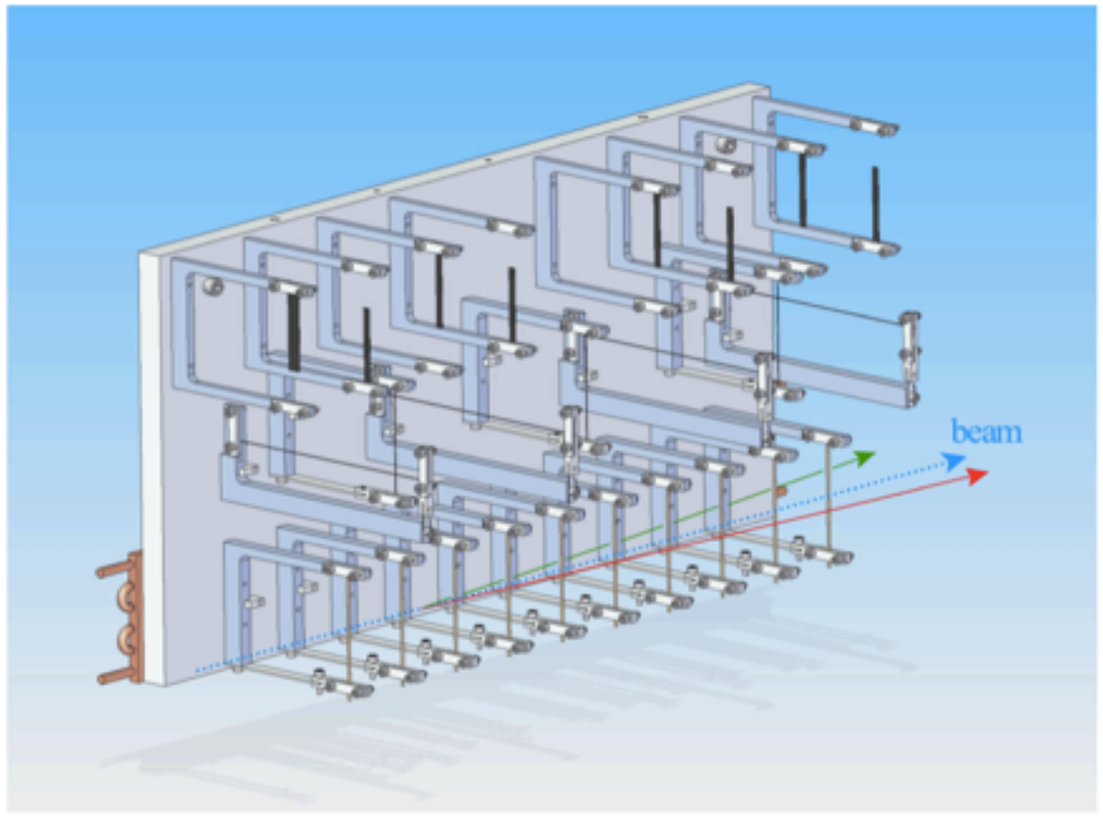
PAC 35 Concerns - Target System

See P.S. talk on target

1) Long target and vertex resolution

Claim: factor of 10 rejection of accidentals from vertex resolution along target

– **Note** revised target design after proposal; built but not installed for test run.



New target design:

Dedicated optics, alignment, empty, and production target sections

- Z vertex resolution of 1 cm expected → use to get x10 rejection of accidentals
- Modify the ribbon layout for use in all configurations
- Attachments to “waterfall” lifter built and ready, alignment and installation procedure plans will be refined.

PAC 35 Concerns - Angular Measurements

See J. Huang's talk on optics

2) Uncertainty < 0.1 mrad in central scattering angle between spectrometers

Central scattering angle uncertainty <u>not important for mass resolution</u>

- appears as a high order correction
- 5% accuracy (~8 mrad) is good enough for 1% mass resolution

Small uncertainty on opening angle <u>needed to combine different samples</u>

- need accuracy better than mass resolution
- 0.3% opening angle accuracy (~0.5 mrad) allows samples each with 1% mass resolution to be compared and combined

Survey target chamber - sieve slit hole separation to within ~0.5 mm for sufficient accuracy

PAC 35 Concerns - High Rate VDC Operation

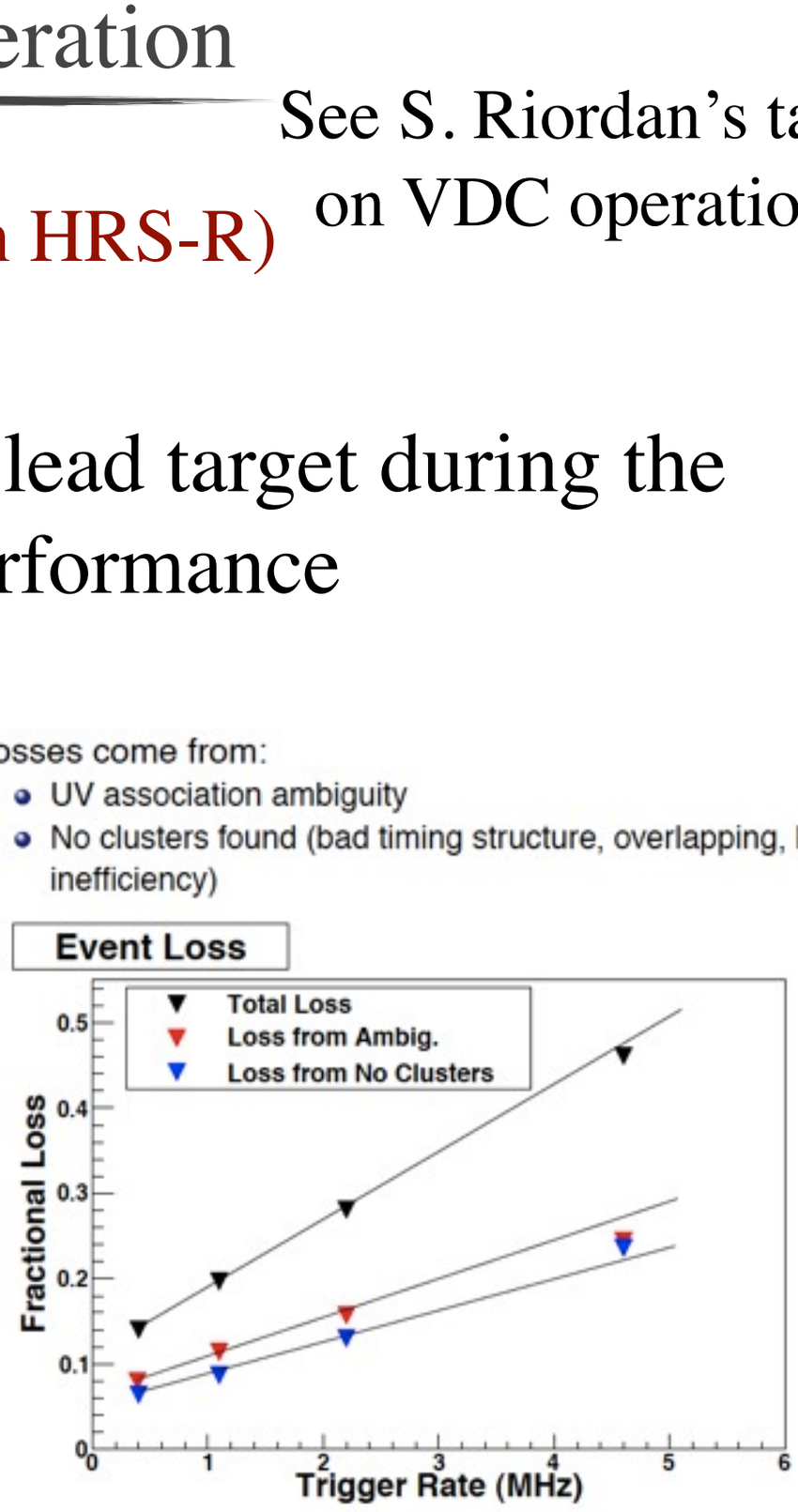
See S. Riordan's talk on VDC operation

3) VDC operation at required rates
up to 6 MHz in HRS-Left (up to 2.2 MHz on HRS-R)

High rate data acquired on the 10% PREX lead target during the test run → thorough testing of the VDC performance

- **No hardware problems**
- Test run data used to develop improved reconstruction software
- 60% efficiency for 4.5 MHz achieved
- Directions identified for further improvements up to 75% or higher

- Losses come from:
  - UV association ambiguity
  - No clusters found (bad timing structure, overlapping, hit inefficiency)



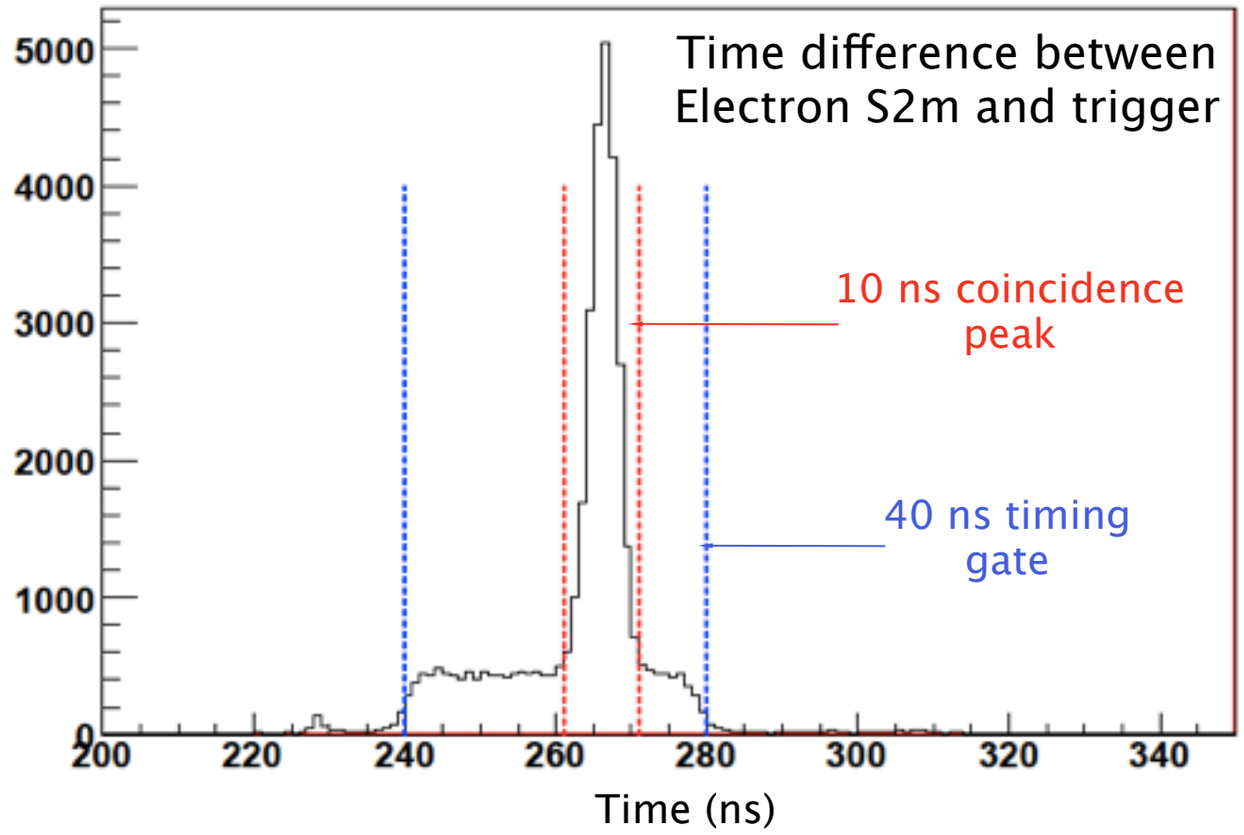
PAC 35 Concerns - High Rate Trigger

See E. Jensen's talk on trigger and PID

4) Achieve 20 ns (S0-S0) and 40 ns (S0-S0-C) gates

40 ns gate used in test run, 20 ns usable

- Electron Arm Trigger (T1)
  - Electron S2m
- Positron Arm Trigger (T3)
  - Positron S2m
- Coincidence Trigger (T4)
  - Electron S2m + Positron S2m
- "Golden" Coincidence Trigger (T6)
  - Electron S2m + Positron S2m + Positron Gas Cherenkov



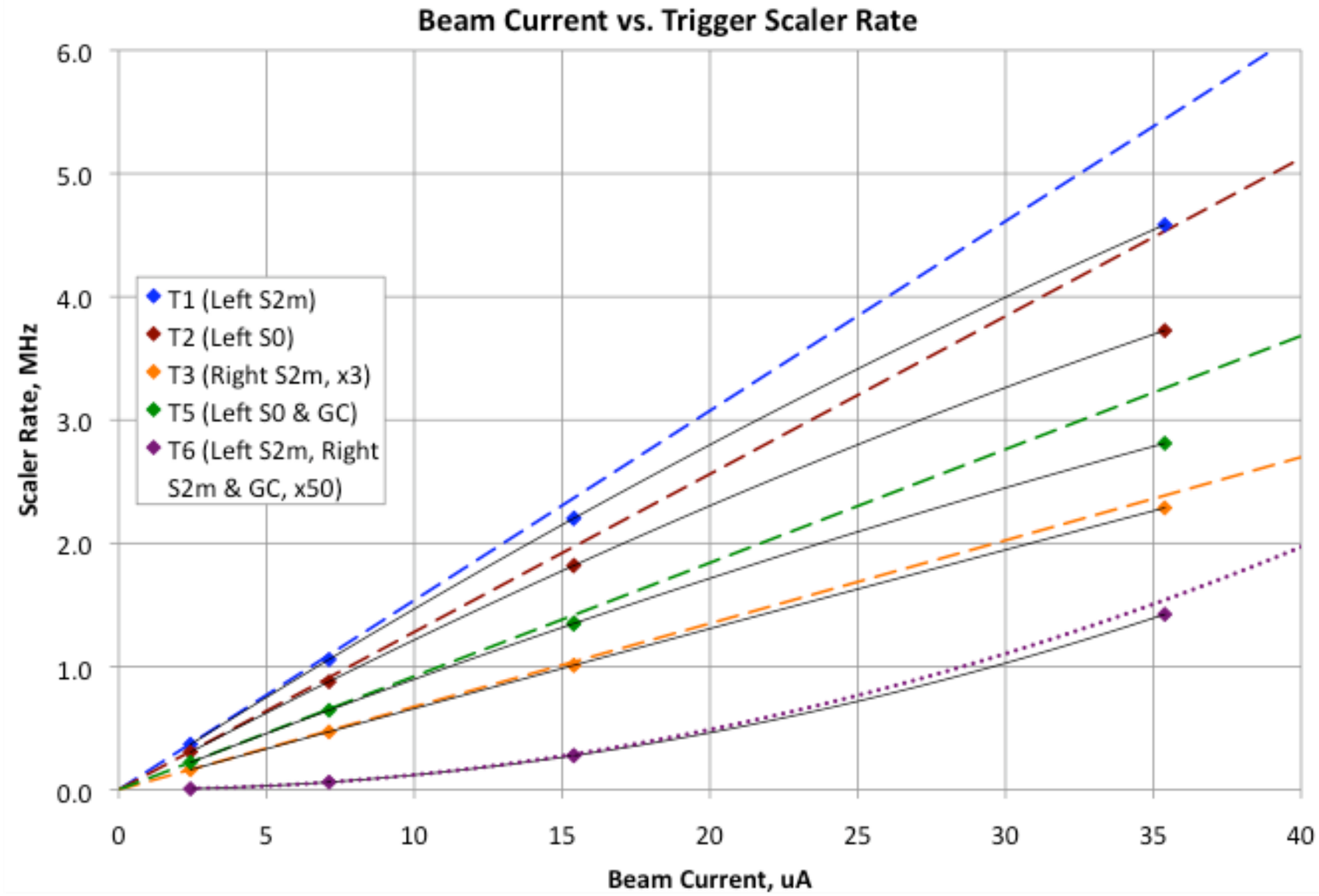
10 ns online coincidence timing peak!

PAC 35 Concerns - High Rate Trigger

See E. Jensen's talk on trigger and PID

4) Achieve 20 ns (S0-S0) and 40 ns (S0-S0-C) gates

40 ns gate used in test run, 20 ns achievable



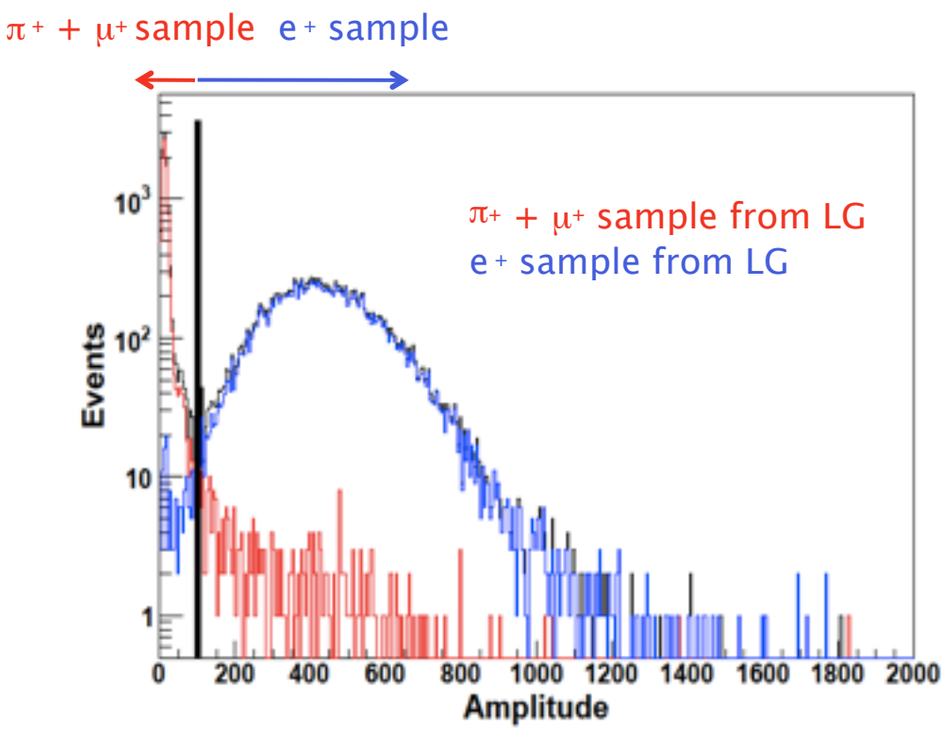
Overall T6 ("golden" coincidence) dead time less than 8% up to left arm detector rates of 5 MHz

PAC 35 Concerns - High Rate Particle Identification

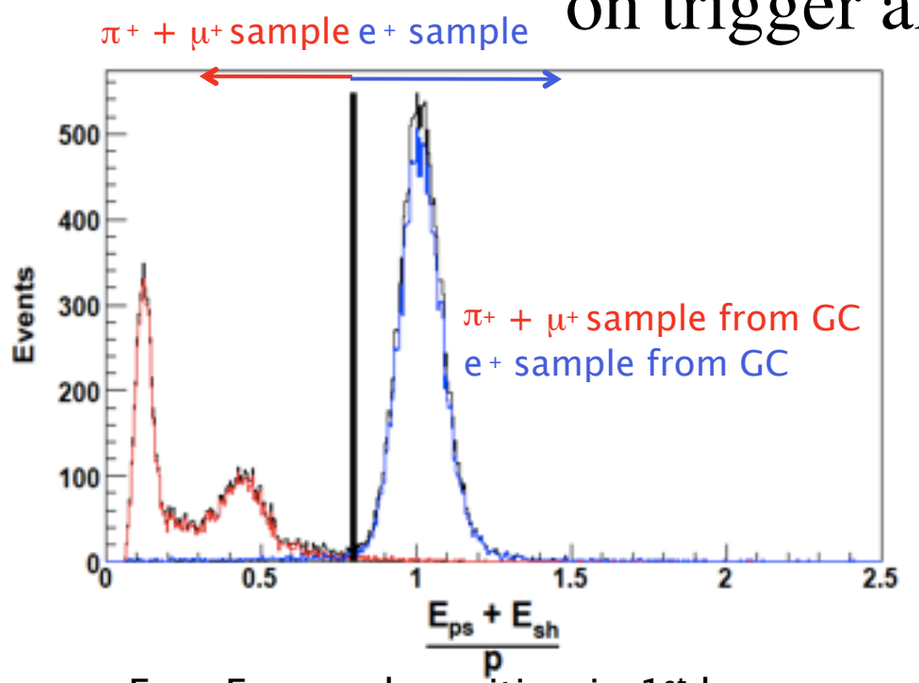
5) Online and Offline Pion Rejection

See E. Jensen's talk on trigger and PID

30 μA on Pb Target, positron arm rate – 765 kHz
680 kHz pions & muons + 85 kHz positrons



Electron detection eff.	0.992
Pion rejection eff.	0.970



- E_{PS} – Energy deposition in 1st layer
- E_{SH} – Energy deposition in 2nd layer
- p – Particle momentum

Electron detection eff.	0.977
Pion rejection eff.	0.985

Online meson background rejected by a factor of 30;
rejection of 50 possible with tighter threshold

Offline meson background rejected by a factor of 60

Proposal **estimates**: 1/100 online (GC), 10^{-4} offline (GC & LG)

- **Require** 1/25 online (3-pass 1/90), no further offline rejection
- Demonstrated 1/50 (GC) x 1/60 (LG) in test run

⇒ **pion rejection more than sufficient for 1-, 2-, and 4- pass running**

⇒ might require lower current by 50% for 3-pass (but probably not!)

PAC 35 Concerns - Good Septum Performance

6) Septum field uniformity at high energies

In the test run, we could not check high energy operation with the PREX septum setup

- Good performance of septum with the 2-pass configuration in test run
- Expectation (from J. LeRose) is that non-uniformity can be accounted for by optics matrix
- Performance at energies up to 4 GeV based on simulation → sufficiently good

See P. Brindza's talk on septum magnets

PAC 35 Concerns

7) Background contributions and comparison with observation

Comparison with earlier experimental data E04-012 performed in APEX proposal → 20% agreement

Comparison of test-run rates to theory is ongoing (complicated by modifications to beamline, spectrometer acceptance and target uncertainties)

- e^- rates in data compared to theory estimate (scaled from proposal)
  - Pb target: agreement within 50%
  - Ta target: observed rate very low, suspect thin or damaged target

- Good agreement in (e^+e^- coincidence)/(e^+ singles) ratio off Ta
  - 80:1 observed, preliminary theory expectation = 97:1

- $\pi^\pm$ rates lower than expectation by factor of 6-10
  - Not surprising (Wiser code extrapolates from higher energies)
  - Implies weaker Particle ID requirements

...complete analysis to be finished, but electron, positron, and coincidence rates consistent with expectations. Pion rates much lower than expected.

Lessons from APEX Test Run

What did we test or prepare?

- overall installation and check-out of the experiment
- performance of the trigger, timing, and efficiency
- prepared a revised target system
- performance of PID (pion rejection) at high rates
- VDC tracking at high rate
- optics calibration
- the resonance search (analysis of test run data underway)

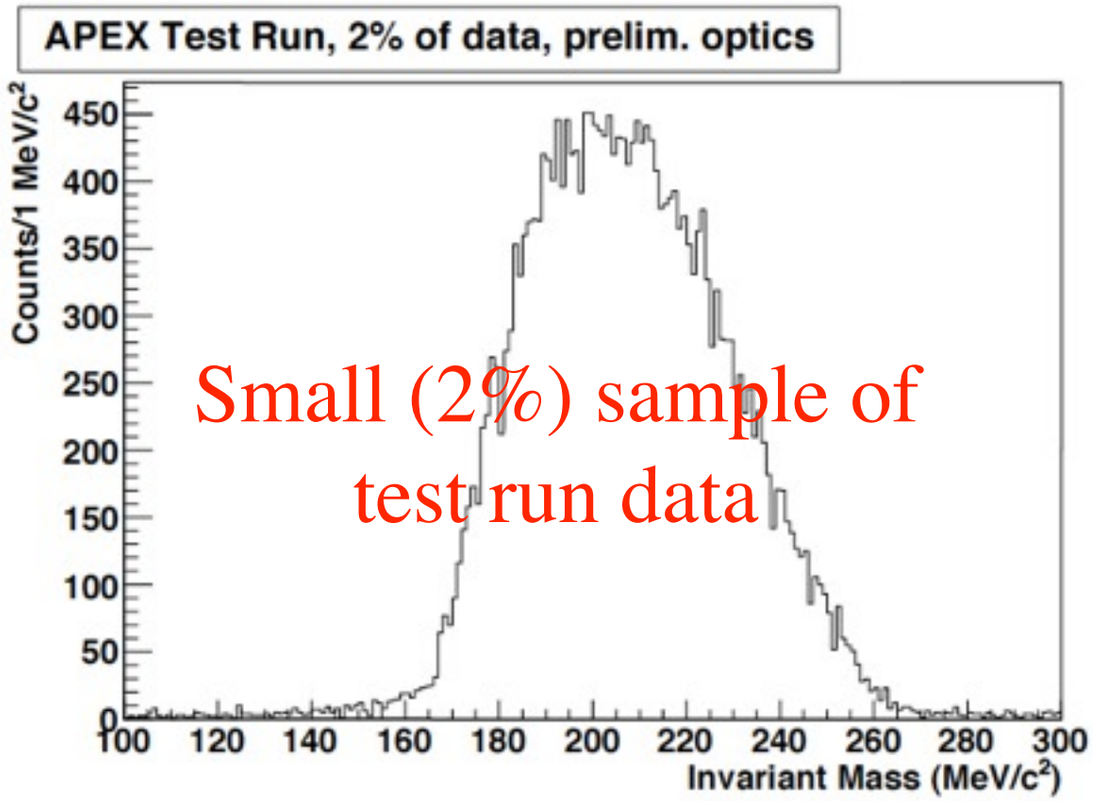
Important lessons:

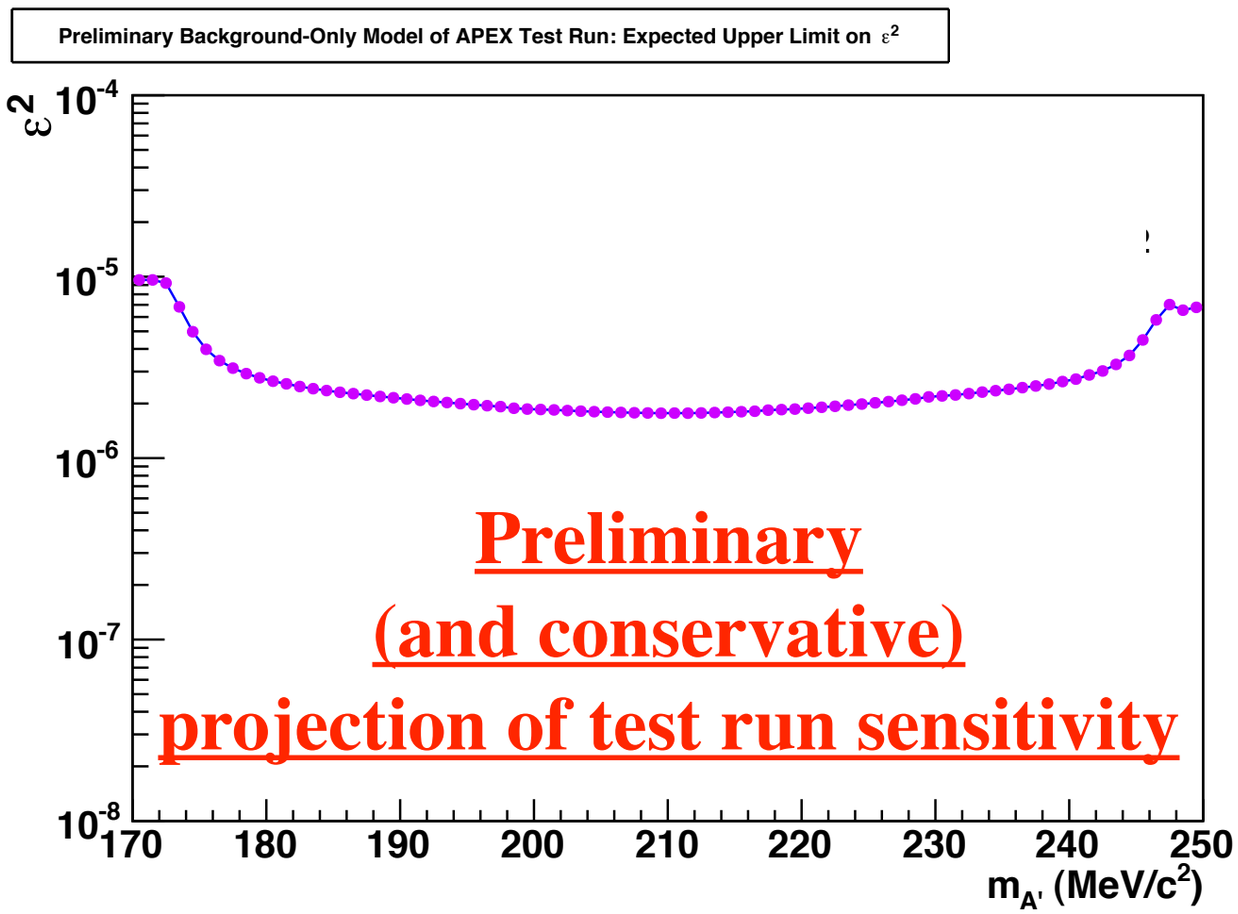
- online trigger timing very good (10 ns coincidence peak width)
- electron & positron rates consistent with expected (analysis ongoing). Pion rates low by a factor of several.
- pion rejection sufficient for all settings
- VDC tracking efficiency around 60-75% for highest rate.
- optics angular resolution in agreement with expected

Lessons from APEX Test Run

See J. Beacham's talk on A' search

Analysis procedure developed on test run data





- Test run → 1.4 M coincidence events
- Mass range (test run): ~170 MeV to ~250 MeV
- All analysis procedures being developed and refined
- **Test run sensitivity is expected to surpass all past experiments!**
- Investigating muon pairs to extend sensitivity and mass coverage

APEX is ready (almost) to perform the full experiment!

PAC 35 concerns largely addressed

A few tasks to finish before starting a full run:

- Target components and performance studies need to be finished for 1-, 3-, and 4-pass running (do not anticipate serious problems)
- Additional software development
- Final optimization of running conditions based on test run analysis
- Once scheduled, prepare beam line equipment

Once scheduled, need ~1-2 months to prepare.

Future Plans: Run Plan

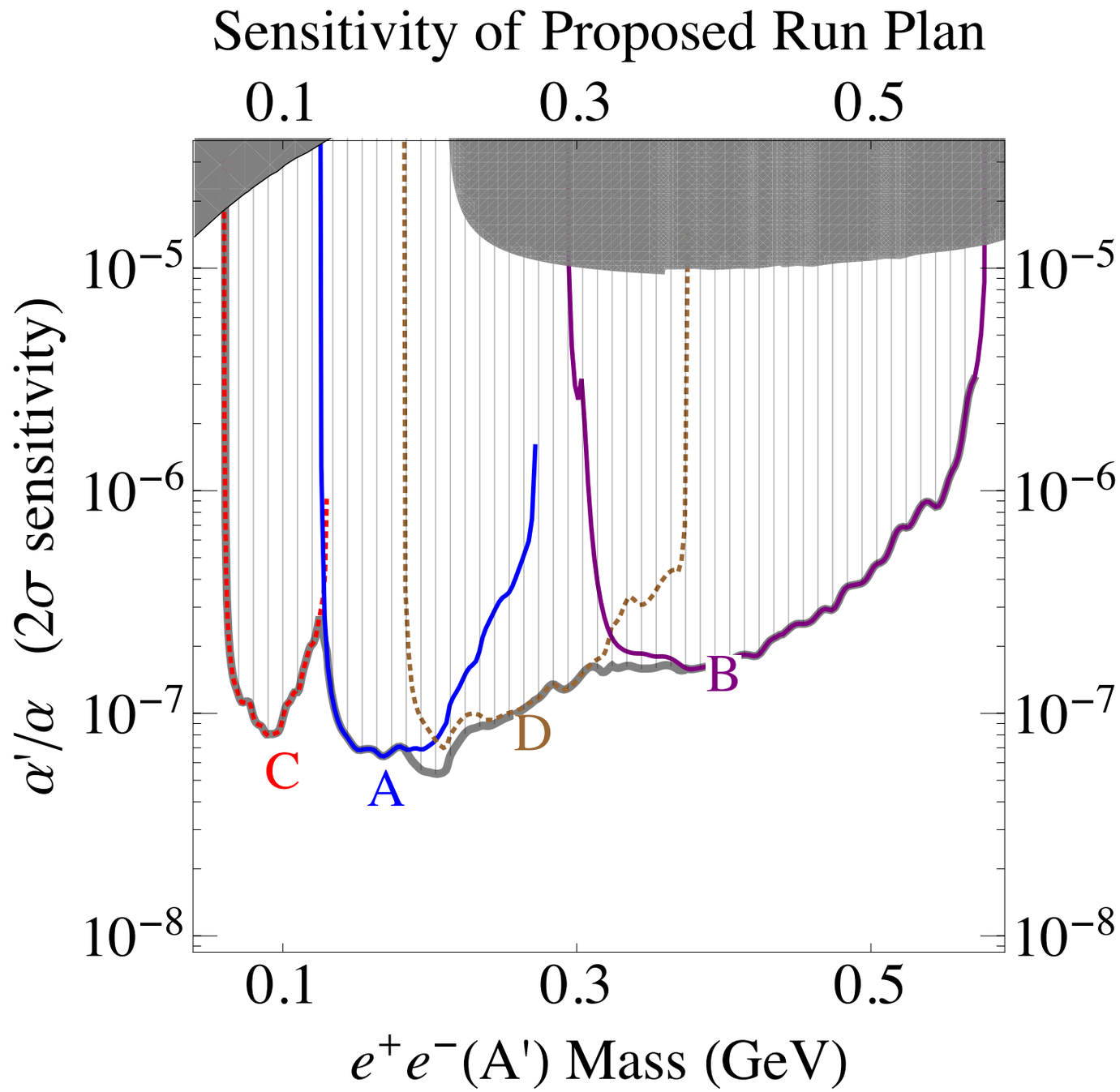
Settings	**A**	**B**	**C**	**D**
Beam energy (GeV)	2.302	4.482	1.1	3.3
Beam current (μA)	75	75	75	75
Nominal central angle	5.0°	5.5°	5.0°	5.0°
Time Requested (hrs)				
Energy change	–	4	4	4
Angle change	–	16	–	–
Magnet setup	4	4	4	4
Optics calibration	4	4	4	4
10% $\mathcal{L}$	2	2	2	2
Normal $\mathcal{L}$	144	288	144	144
Total	154	318	158	158

4 energy settings
2 angle settings [could be reduced to one]

anticipate ~2 extra days for each setting to swap target cartridges, check alignment, and add time to optics calibration (+8 total)

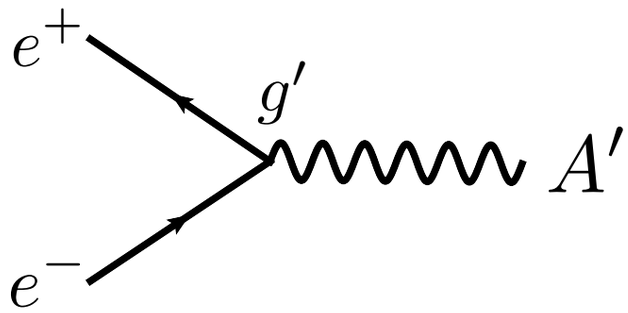
41 days total (34 days beam)

Future Plans: Anticipated Sensitivity



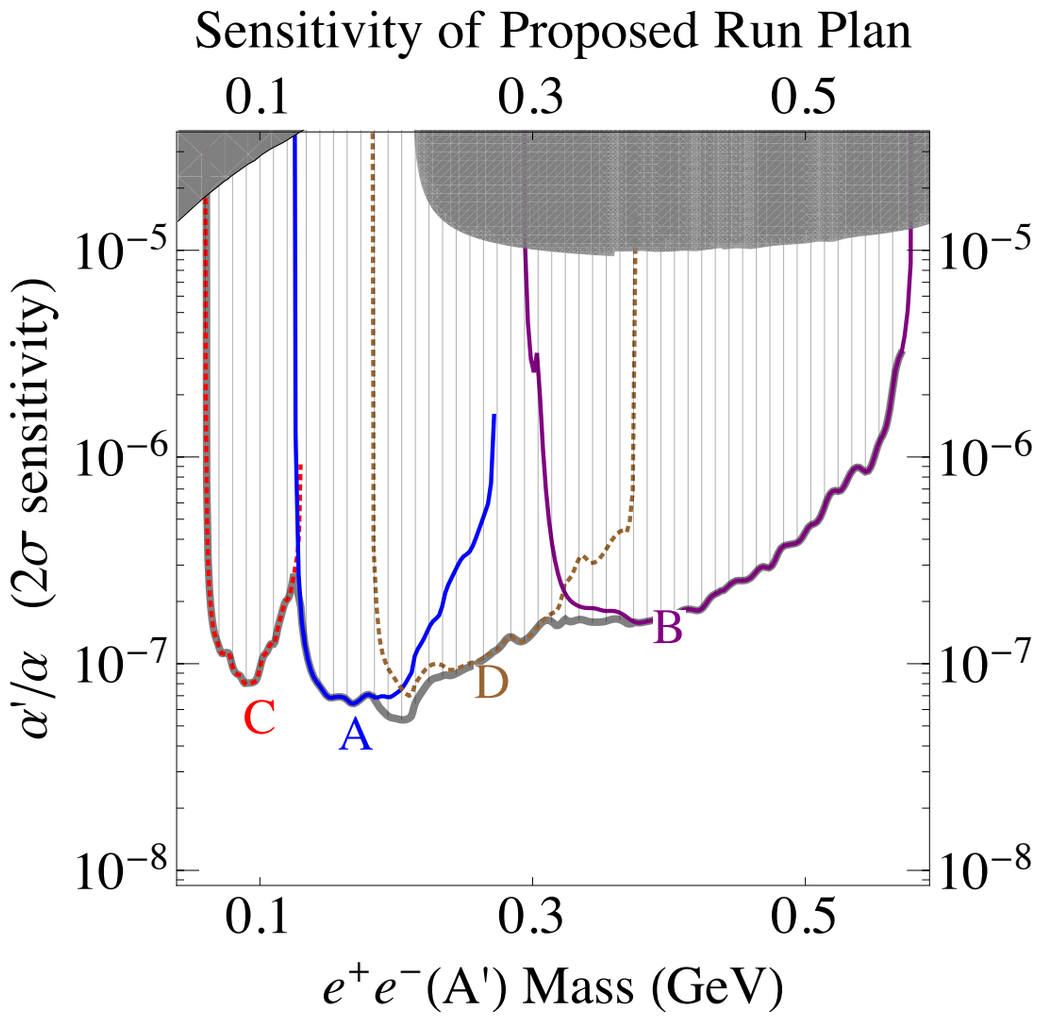
We don't expect significant differences w.r.t the January 2010 proposal

Conclusions



- **JLab Hall A is ideal:** ready equipment, high resolution, momentum selectivity, unprecedented statistics.

- In 30 beam-days, achieve 10,000 x statistics, 100 x cross-section sensitivity of previous searches. **Excellent discovery potential!**



- Test run analysis will approach 10^{-6} level of sensitivity → new territory already being explored

- Ongoing analysis of successful test run → key lessons for optimizing physics performance during a full run

- **APEX is ready: We hope that the full experiment will be scheduled after this workshop**

Thank You!