# APEX Fast Trigger and PID Capability

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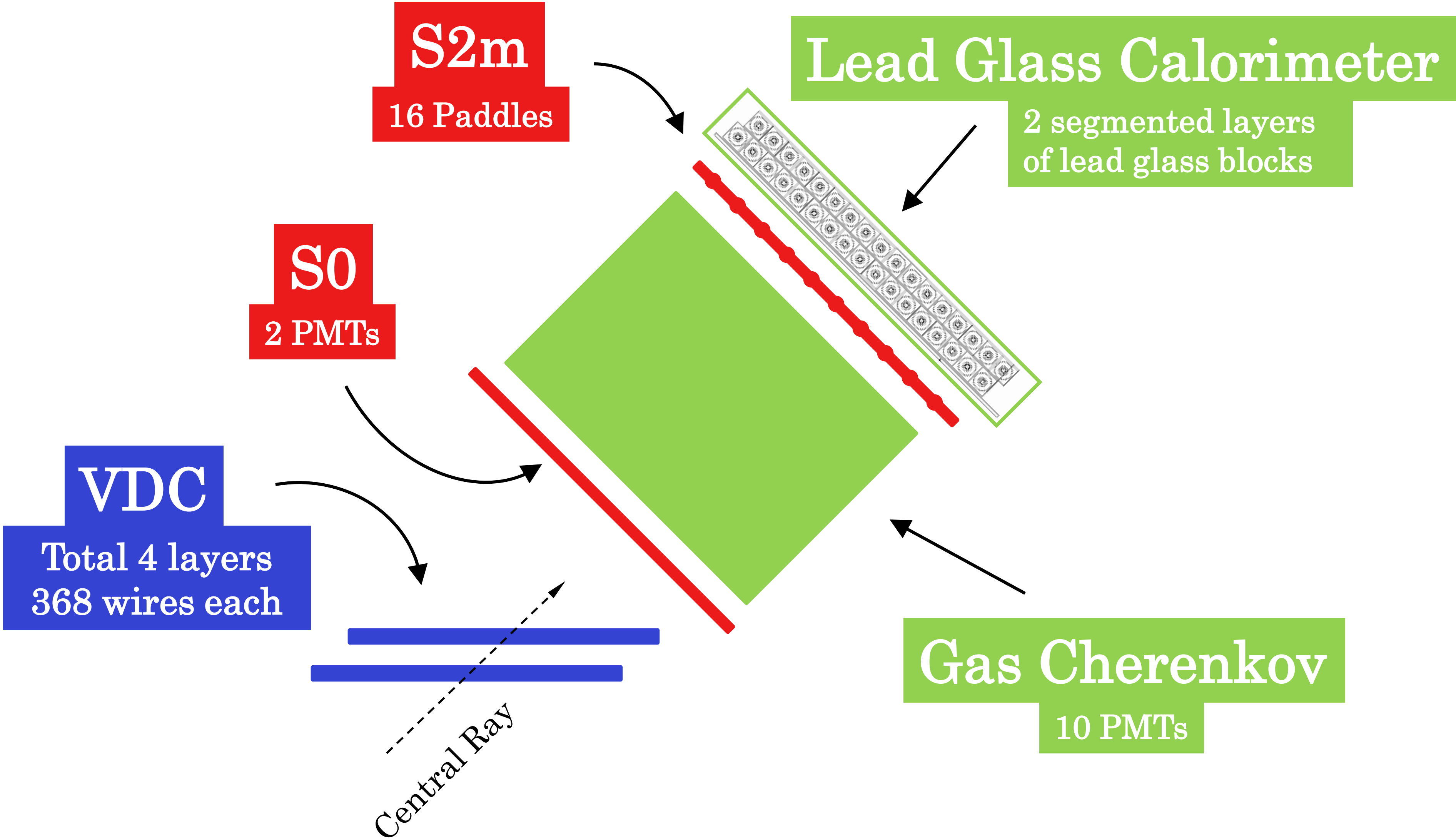
# APEX Fast Trigger and PID Capability

- Components of HRS trigger/PID
- Scheme and performance of trigger
- Calibration and performance of PID
- Projected PID in other kinematics
- DAQ rates and dead time

# High Resolution Spectrometer Detector Layout

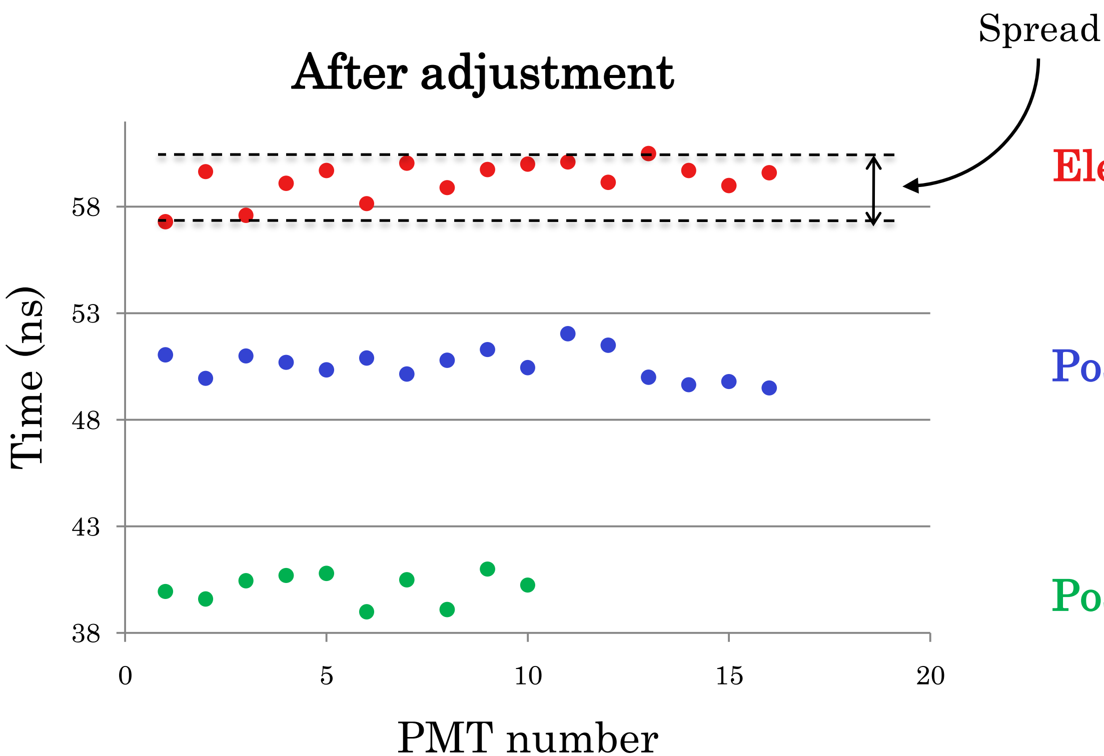


# Trigger Logic

- 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

# Timing Alignment in Hardware

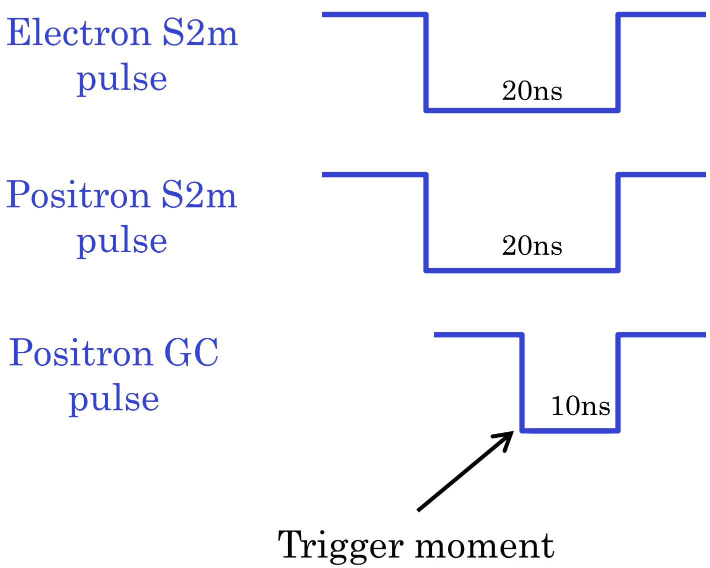
- Run at high rates, small timing gate is important
- Must align timing of the trigger detectors
  - S0 counter as a reference
  - Inserted 1–5 ns delay cables



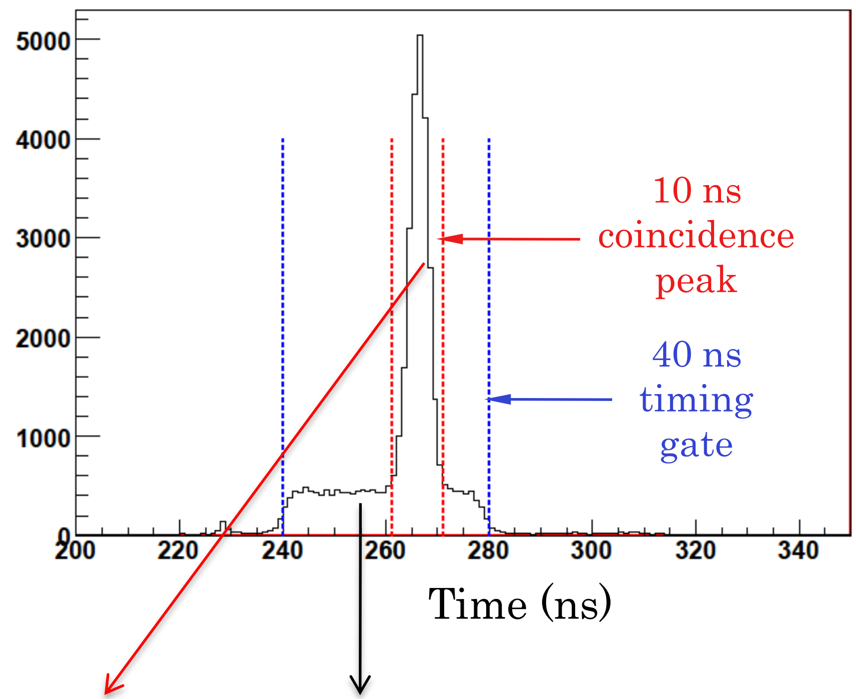

| | σ | Spread |
|---|---|---|
| Electron S2m | 0.9 ns | 3.2 ns |
| Positron S2m | 0.7 ns | 2.6 ns |
| Positron GC | 0.7 ns | 2 ns |

# Coincidence Timing

## Trigger Timing Diagram



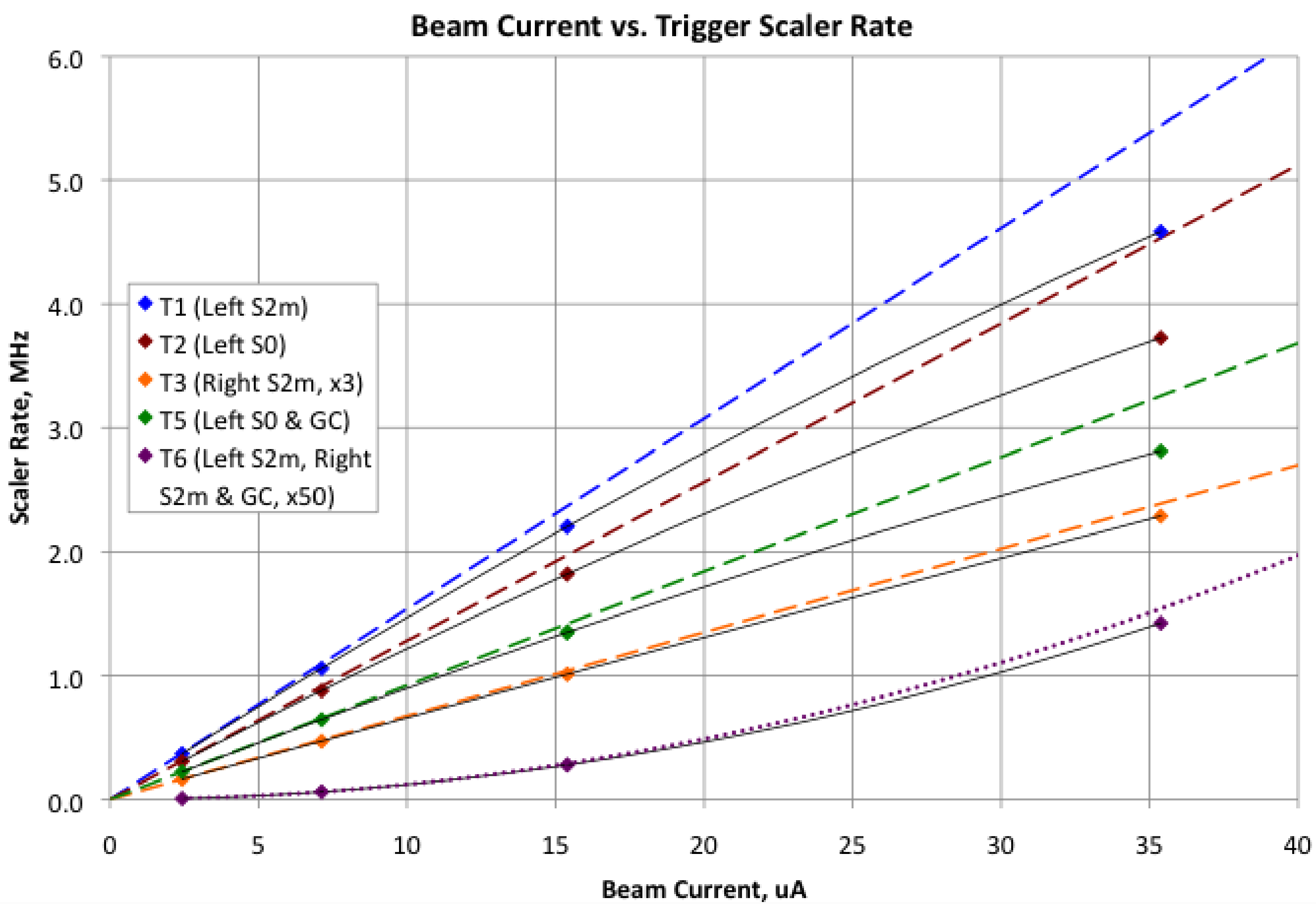

## Time difference between Electron S2m and trigger




Under test run conditions: signal / background is ~ 5/1

For proposed experiment: signal / background expected to be ~ 1/4 which improves in off-line to ~ 12/1

# Triggers Performance




Observed dead time in the detector system is ~35 ns per single arm trigger

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

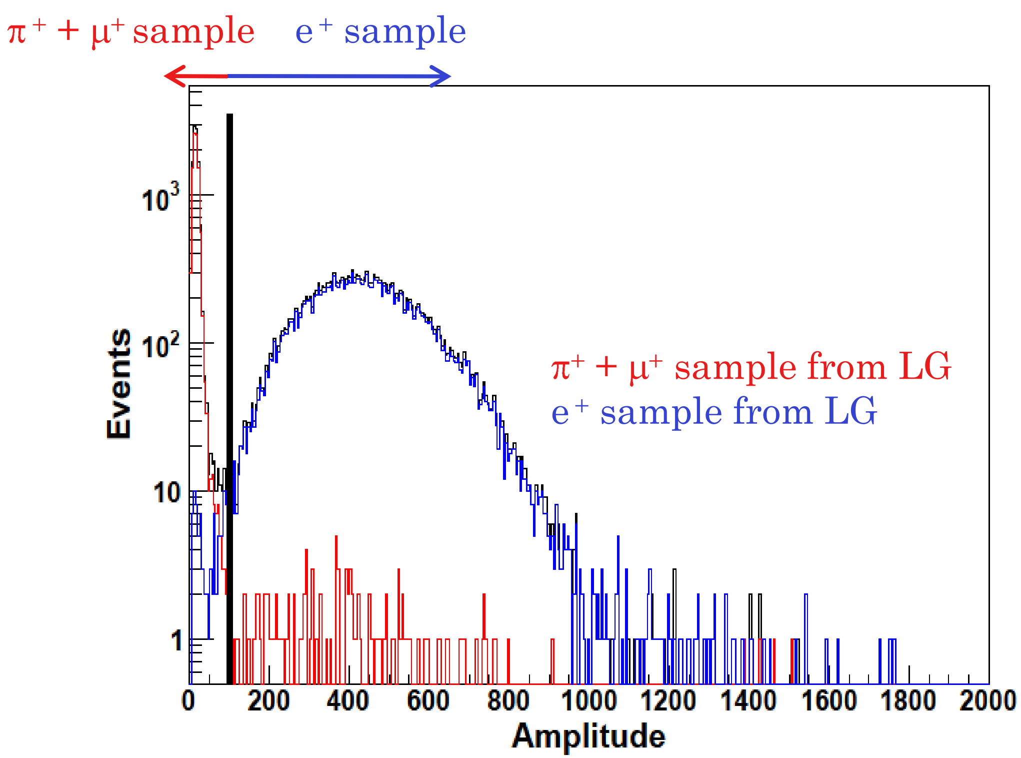
# Particle Identification Requirements and Reality

Using the Tantalum target: 2.2 GeV running

- Observed ratio of the rates $e^-/(\pi^- + \mu^-) \sim 50/1$
- Observed ratio of the rates $e^+/(\pi^+ + \mu^+) \sim 1/1.5$
- PID should provide e/meson ratio in online sample of 10/1
- Positron arm needs a factor of 15 rejection of meson background
- Gas Cherenkov and lead glass calorimeters used for this purpose

# Gas Cherenkov in Positron Arm (low rate)

2 μA on Pb Target
Positron arm rate – 57 kHz

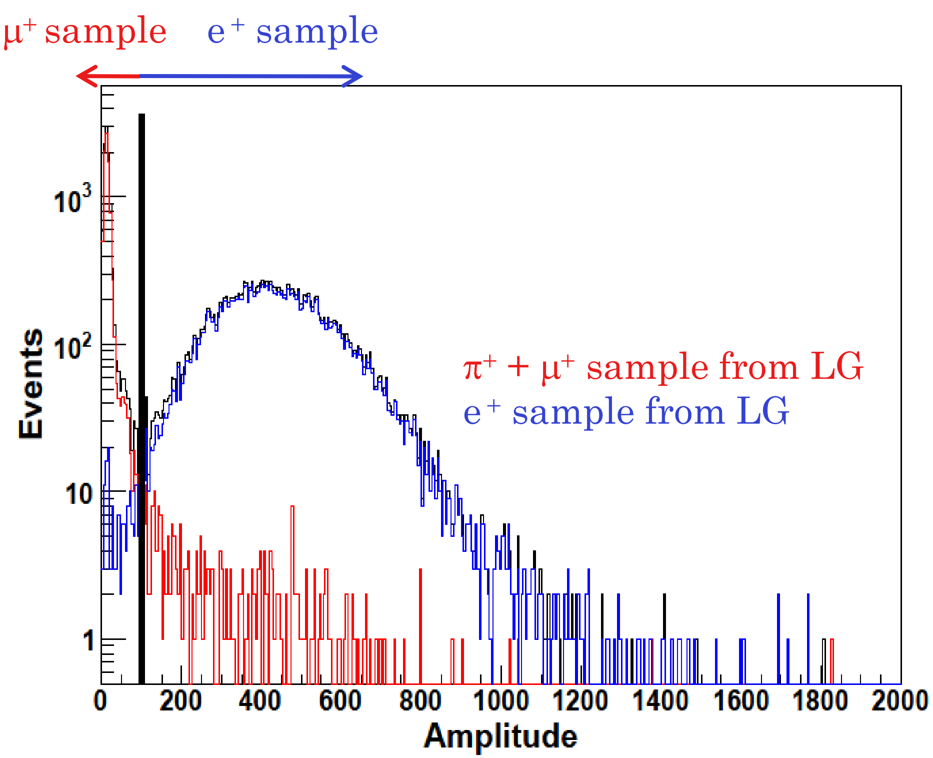



| | |
|---|---|
| Electron detection eff. | 0.995 |
| Pion rejection eff. | 0.987 |

**Meson background rejected by a factor of 75**

# Gas Cherenkov in Positron Arm (high rate)

30 μA on Pb Target
Positron arm rate – 765 kHz
(close to maximum expected rate)



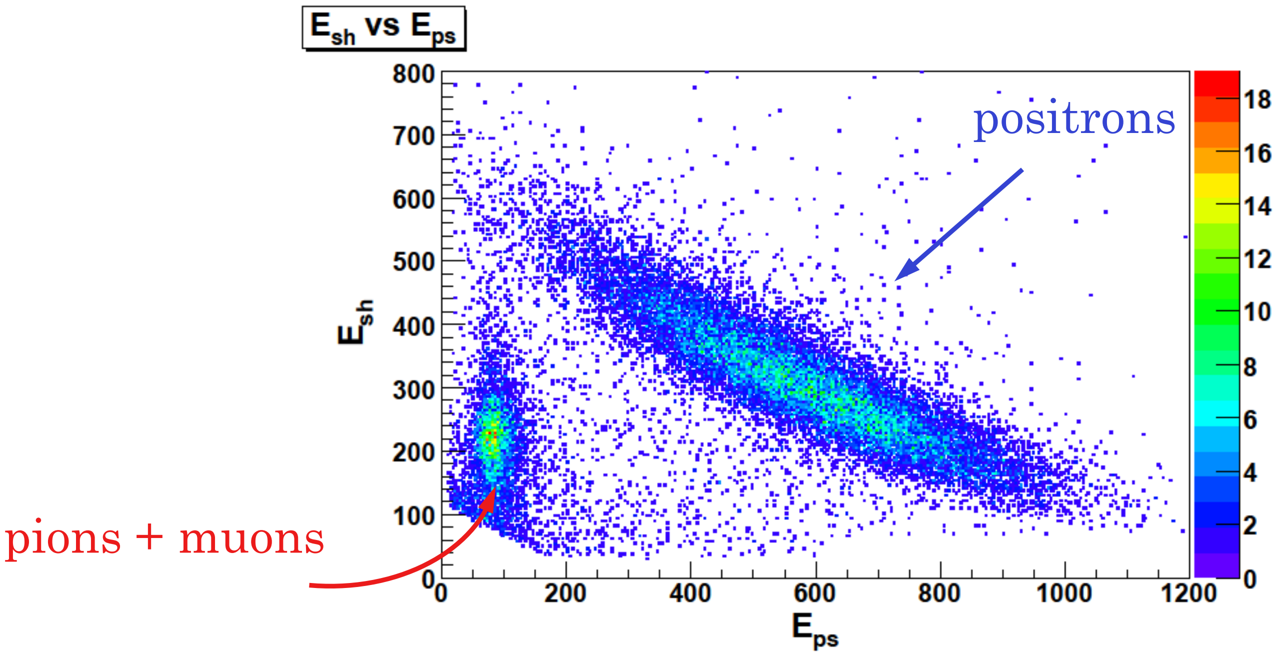

| | |
|---|---|
| Electron detection eff. | 0.992 |
| Pion rejection eff. | 0.970 |

**Meson background rejected by a factor of 30**

**This analysis didn't use timing and coordinate information**

# Lead Glass Particle ID in Positron Arm (high rate)

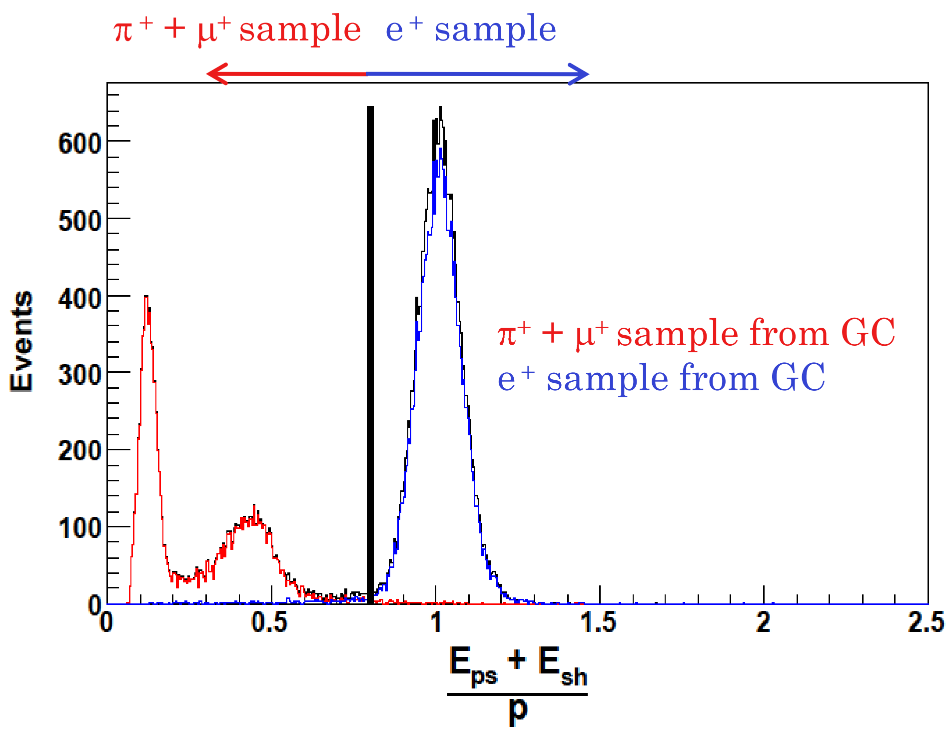
30 μA on Pb Target
Positron arm rate – 765 kHz




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

# Lead Glass Particle ID in Positron Arm (low rate)

2 μA on Pb Target
Positron arm rate – 57 kHz



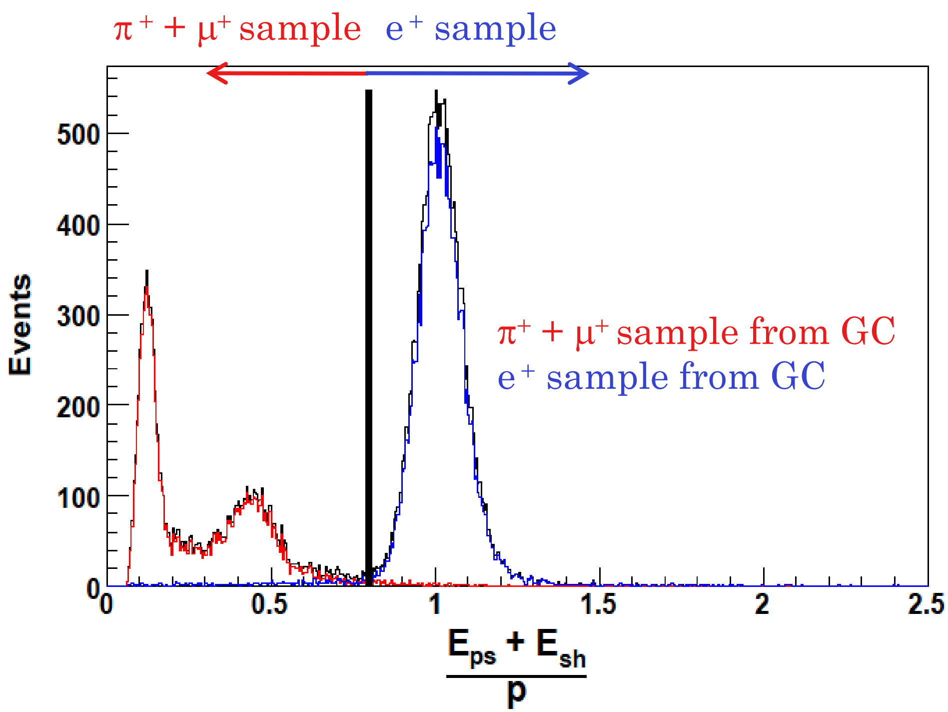

| | |
|---|---|
| Electron detection eff. | 0.983 |
| Pion rejection eff. | 0.990 |

**Meson background rejected by a factor of 100**

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

# Lead Glass Particle ID in Positron Arm (high rate)

30 μA on Pb Target
Positron arm rate – 765 kHz




| | |
|---|---|
| Electron detection eff. | 0.977 |
| Pion rejection eff. | 0.985 |

**Meson background rejected by a factor of 60**

**This analysis didn't use coordinate information**

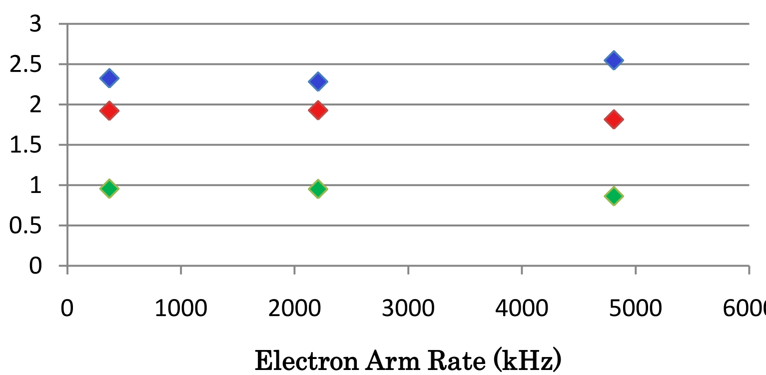
- $E_{PS}$ – Energy deposition in 1st layer
- $E_{SH}$ – Energy deposition in 2nd layer
- p – Particle momentum

# Current Dependence of Particle Yield

Charge Normalized Particle Yield Corrected to Dead time: $\frac{kHz}{\mu A}$

| **Beam current** | **Electron trigger rate** | **Positron trigger rate** |
|---|---|---|
| 2 μA on **Pb** | 210.5 | 32.4 |
| 11 μA on **Pb** | 251.8 | 39.0 |
| 28 μA on **Pb** | 203.3 | 34.1 |
| 72 μA on **Ta** | 2.50 | 0.46 |
| 143 μA on **Ta** | 2.31 | 0.44 |

**Particle Ratios on Pb**

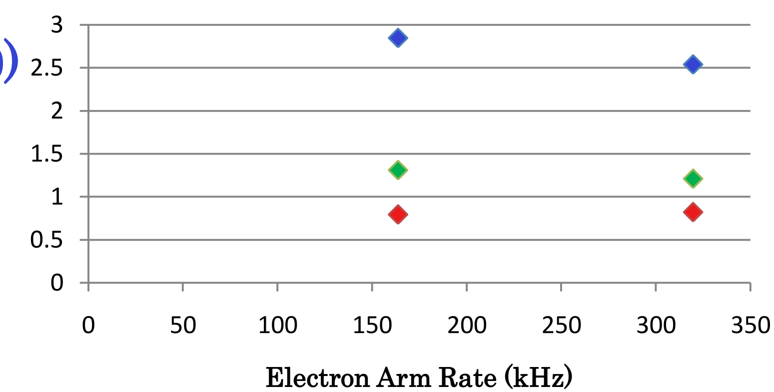



$e^-/\pi^-$ (x 1/20)

$e^+/\pi^+$

$\mu^+/\pi^+$

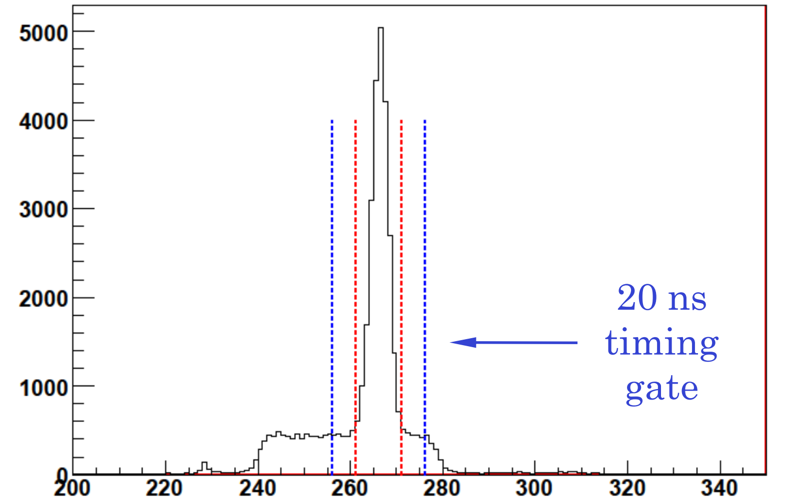
**Particle Ratios on Ta**



# DAQ rates and dead time
# 2.2 GeV full luminosity

- A 20 ns coincidence gate would acquire a rate of 3.1 kHz
- DAQ dead time is 10% for 4 kHz

Time difference between Electron S2m and trigger




Time (ns)

# Concluding Remarks

- 10 ns ONLINE coincidence timing peak for $e^+e^-$ signal events
- Particle ID from the shower detector allows to reduce pion content in positron sample below 5%
- Gas Cherenkov allows further reduction of pion background by at least a factor of 10
- Rates and particle ID are stable up to high intensities

Test run results obtained to maximum rates projected for APEX data taking