# Tracking and Vertexing for the Heavy Photon Search Experiment

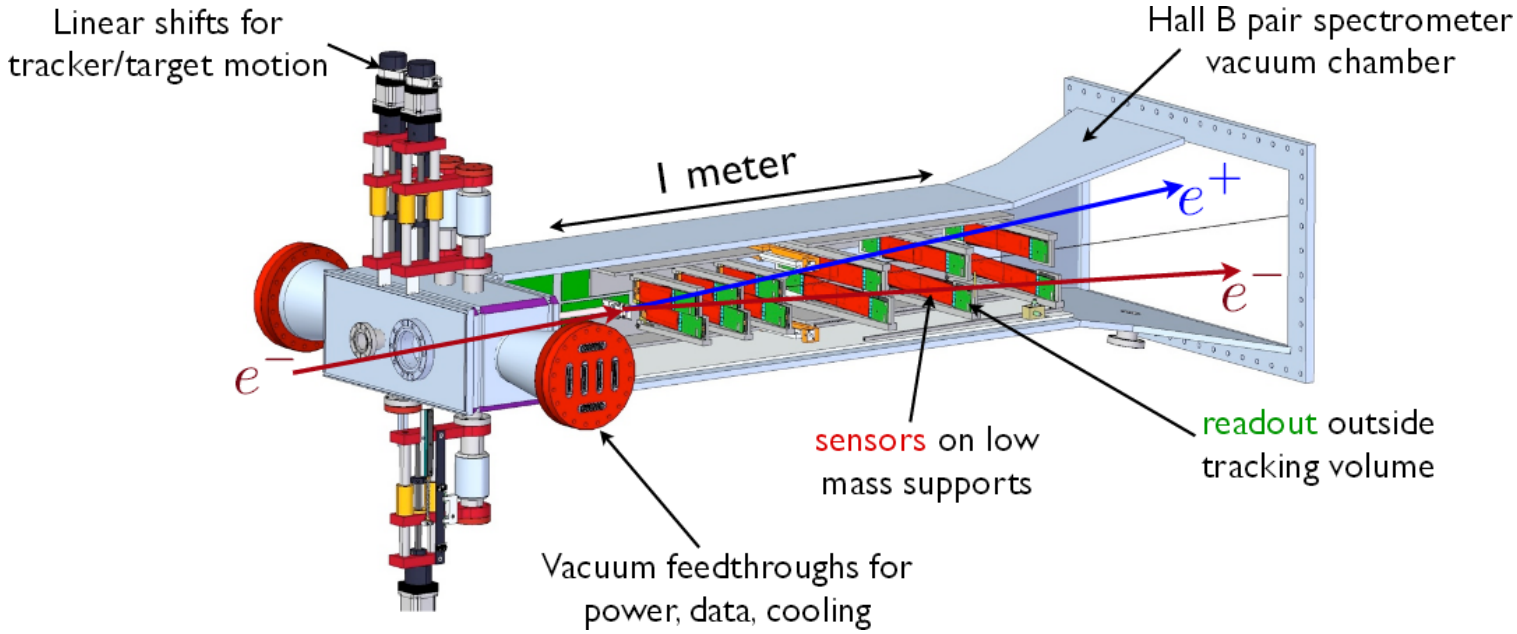
Sho Uemura

SLAC

on behalf of the HPS Collaboration


U.S. DEPARTMENT OF ENERGY
Office of Science

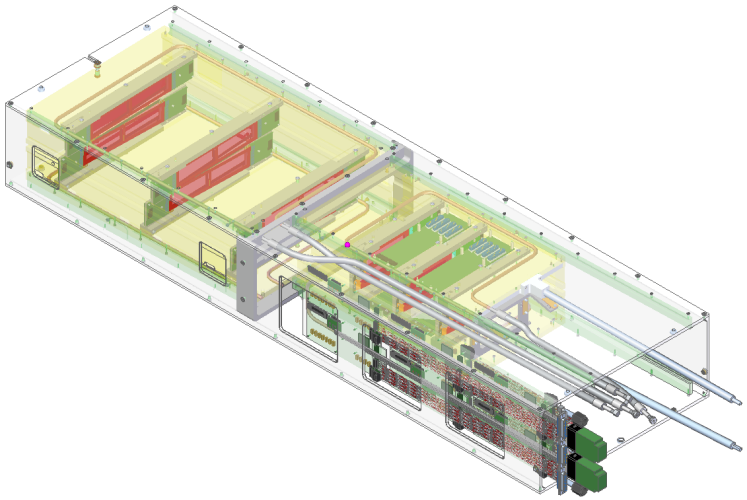
# The HPS SVT

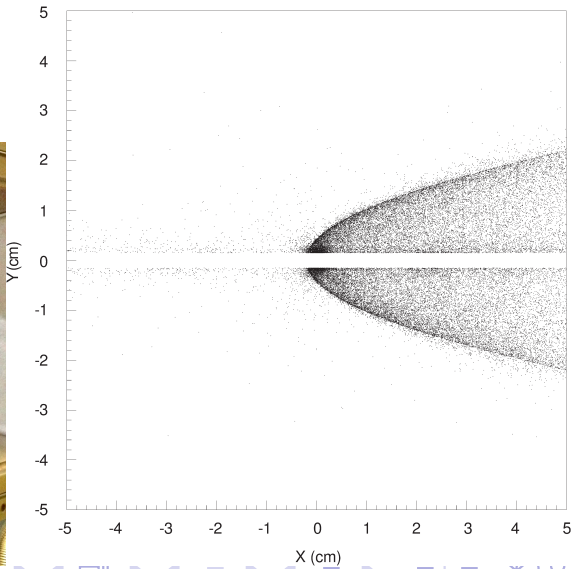



- The silicon vertex tracker (SVT) provides the basic HPS measurements: charge, momentum and vertex
- Dipole B-field (0.5 T at 2.2 GeV) from target to end of tracker
- Six layers: pairs of silicon microstrip sensors in small-angle stereo
  - Layers 1–3 (single-ended) are mounted on hinges and can move away from the beam
  - Layers 4–6 (double-ended) are fixed at 15 mrad

# Requirements and constraints

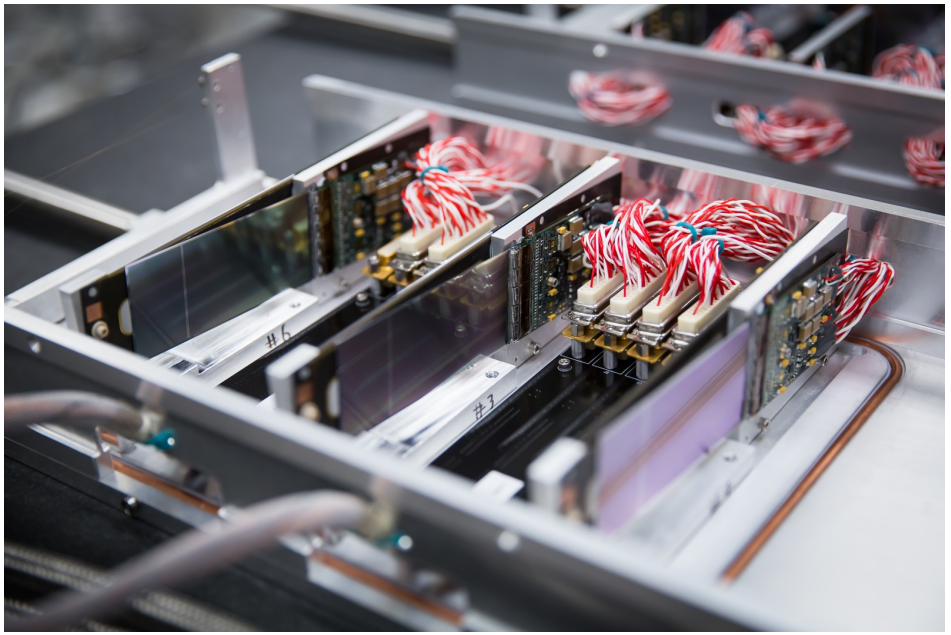
- Thin ($< 1\% X_0$ per layer): minimize multiple scattering
- Fast ($\sigma_t \approx 2$ ns): cut backgrounds (4 MHz/mm$^2$) with hit time measurement
- Cold: silicon at $-10^\circ$C to mitigate radiation damage
- Mobile: fine adjustment of distance from beam
- In vacuum: avoid beam-gas backgrounds
- Near target, near beam (10 cm downstream of target, 0.5 mm from beam): maximize vertex resolution and acceptance
- Compact: fits in existing magnet (16” W $\times$ 7” H)

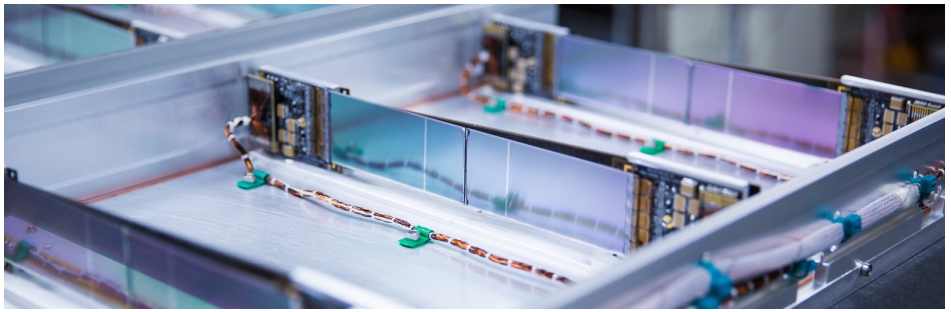


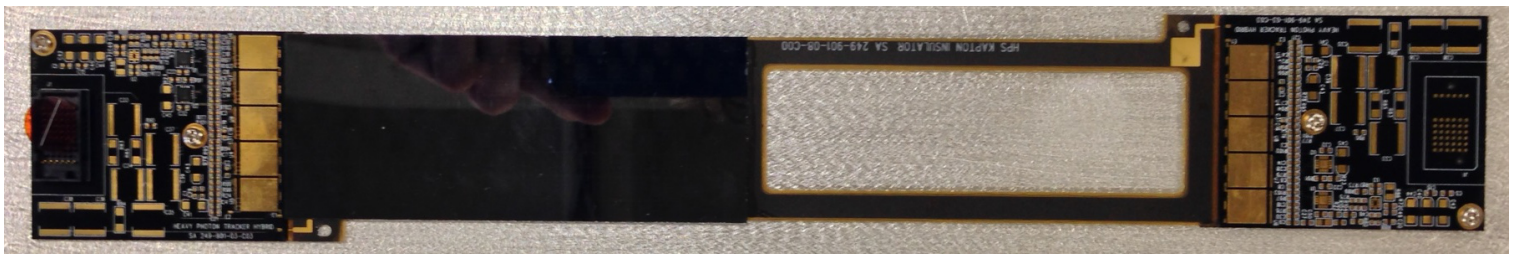


# Mechanical design

- Sensors from D0 run IIb
- Support structure is thinner than the silicon; total average thickness 0.7$X_0$ per module
- Spring pivot pulls the silicon flat, module structure cools silicon from both ends
- “U-channels” support and cool modules in sets of 3
- Aligned to 100 $\mu$m, surveyed to 50 $\mu$m

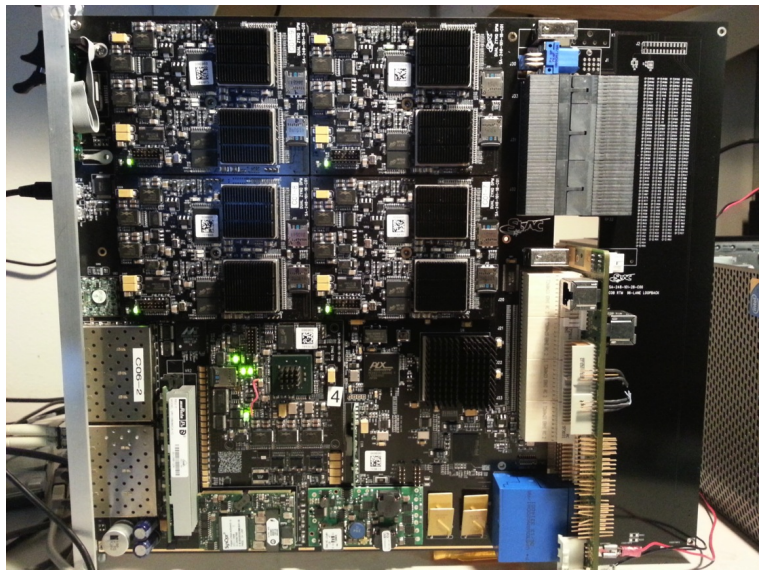






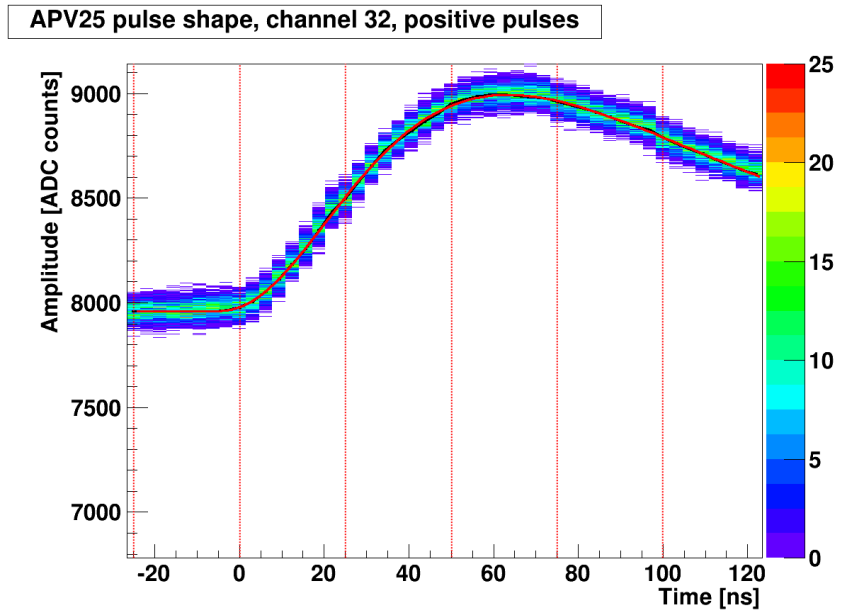
# Data acquisition

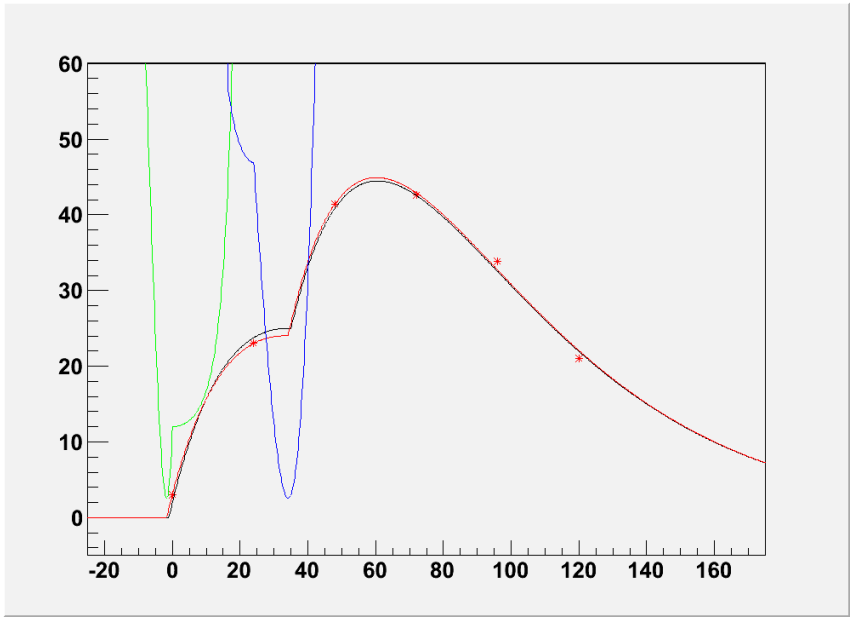
- APV25-based hybrid readout board: triggered 40 MHz analog readout
- Frontend boards: control and trigger, low voltage distribution, ADC
- Flange boards: vacuum penetration and copper-to-fiber transceivers
- RCE DAQ: data reduction, event building
- Trigger rate up to 50 kHz, data rate to tape up to 100 MB/s

# Hit time reconstruction

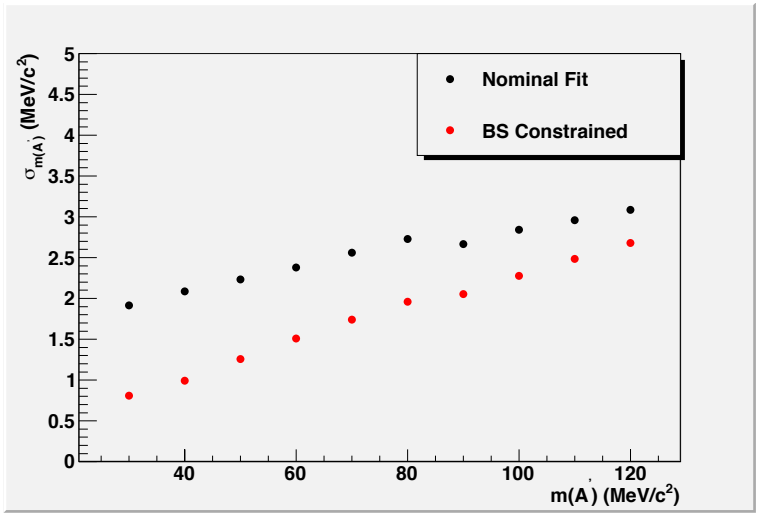
- Beam backgrounds will make ∼100 junk hits per event
- Hottest strips will see hit rates over 1 MHz; lots of pileup
- Read out six samples at 24 ns intervals, fit preamp pulse shape including pileup
- Use hit times in track finder to reject junk hits
- Test run time resolution was 2.6 ns; expect 2 ns with preamp tuning, improved fitter

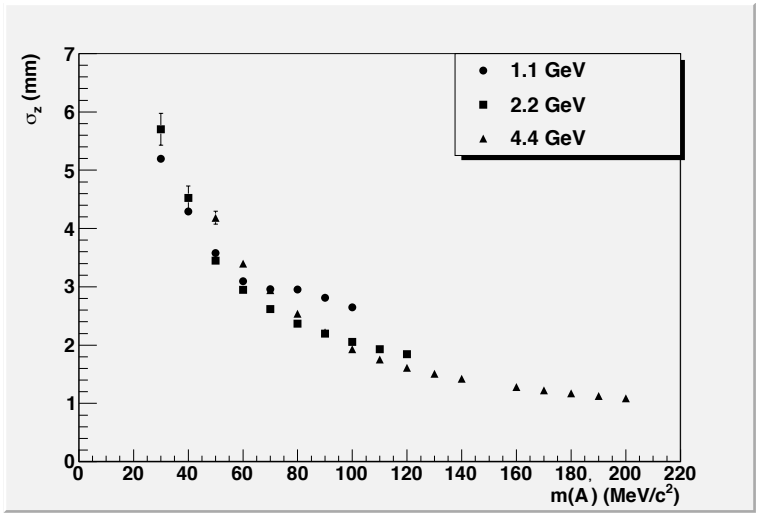


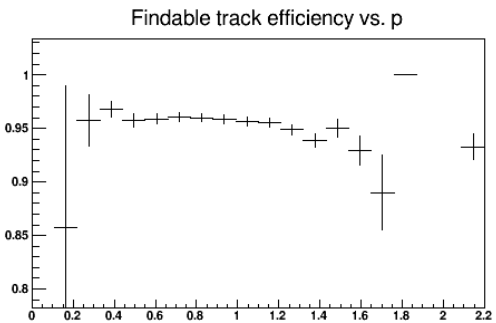



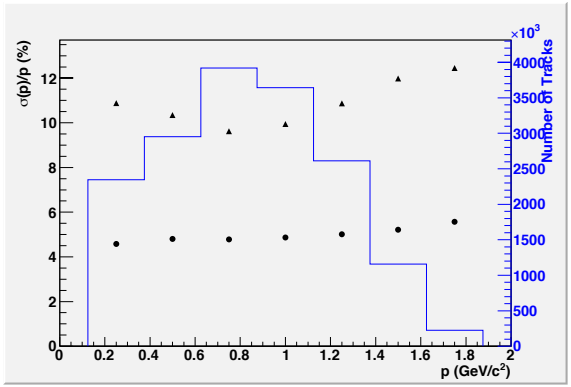
# Performance and resolutions

- Hit resolutions: $\sigma_x < 125\mu$m, $\sigma_y < 10\mu$m
- Single-hit efficiency better than 99%, track efficiency better than 95%
- Momentum resolution $\approx 5\%$ (improves with GBL refit)
- All resolutions (momentum, mass, vertex) dominated by multiple scattering



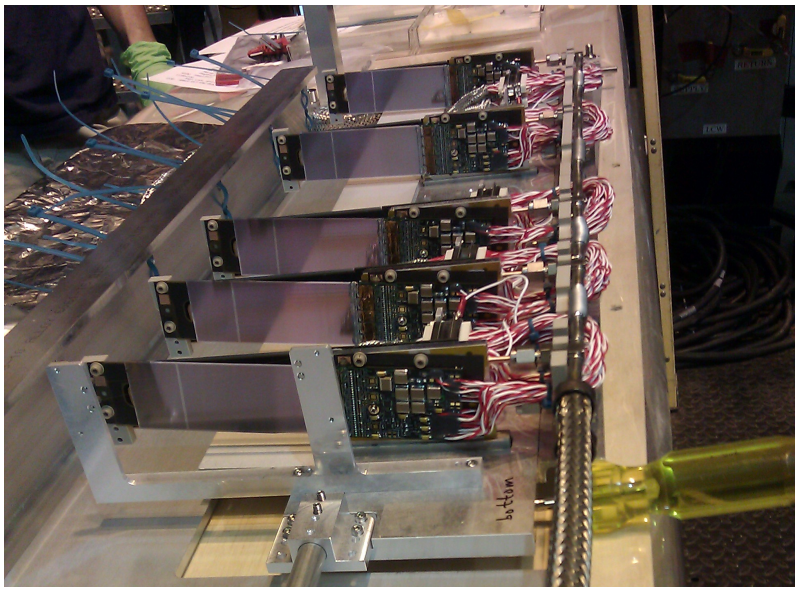



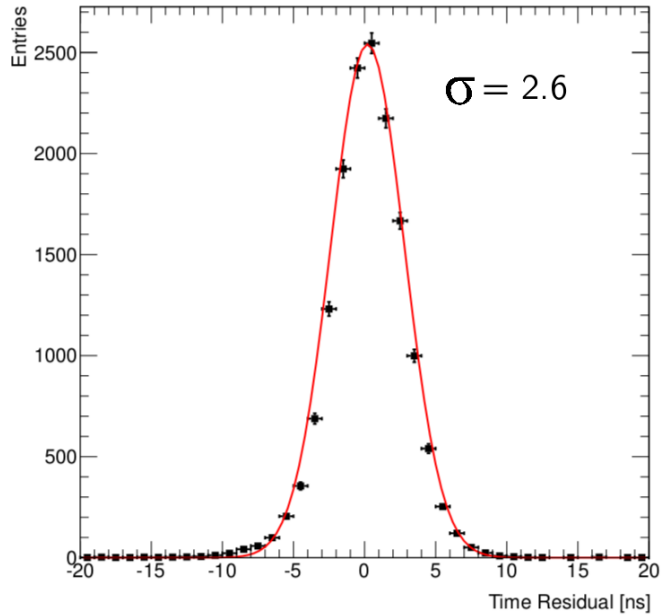



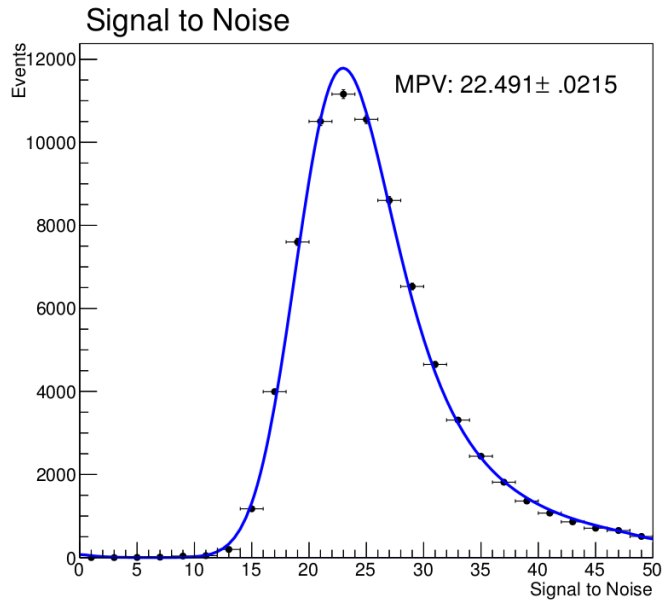



# Test run

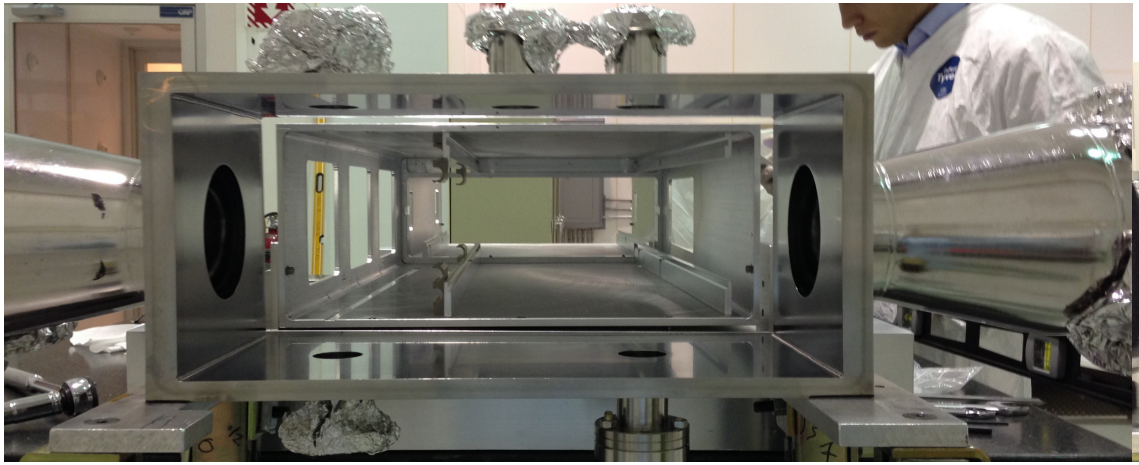
- 2012 test run with first-attempt design on a very tight schedule
- Developed all the basic elements of our design, and found areas for improvement
- Proved detector performance (timing, S/N, efficiencies)

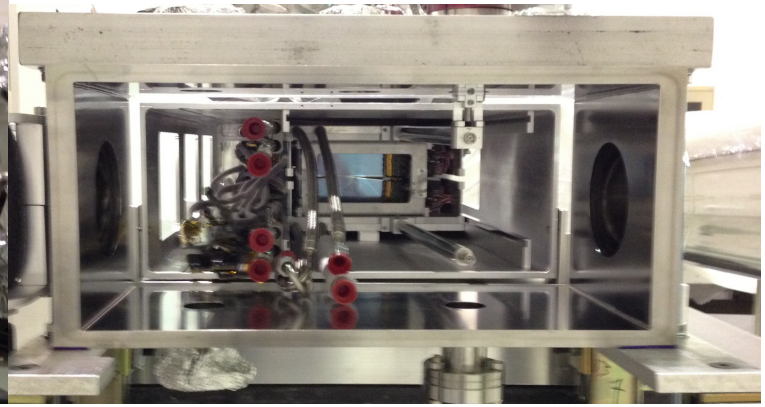


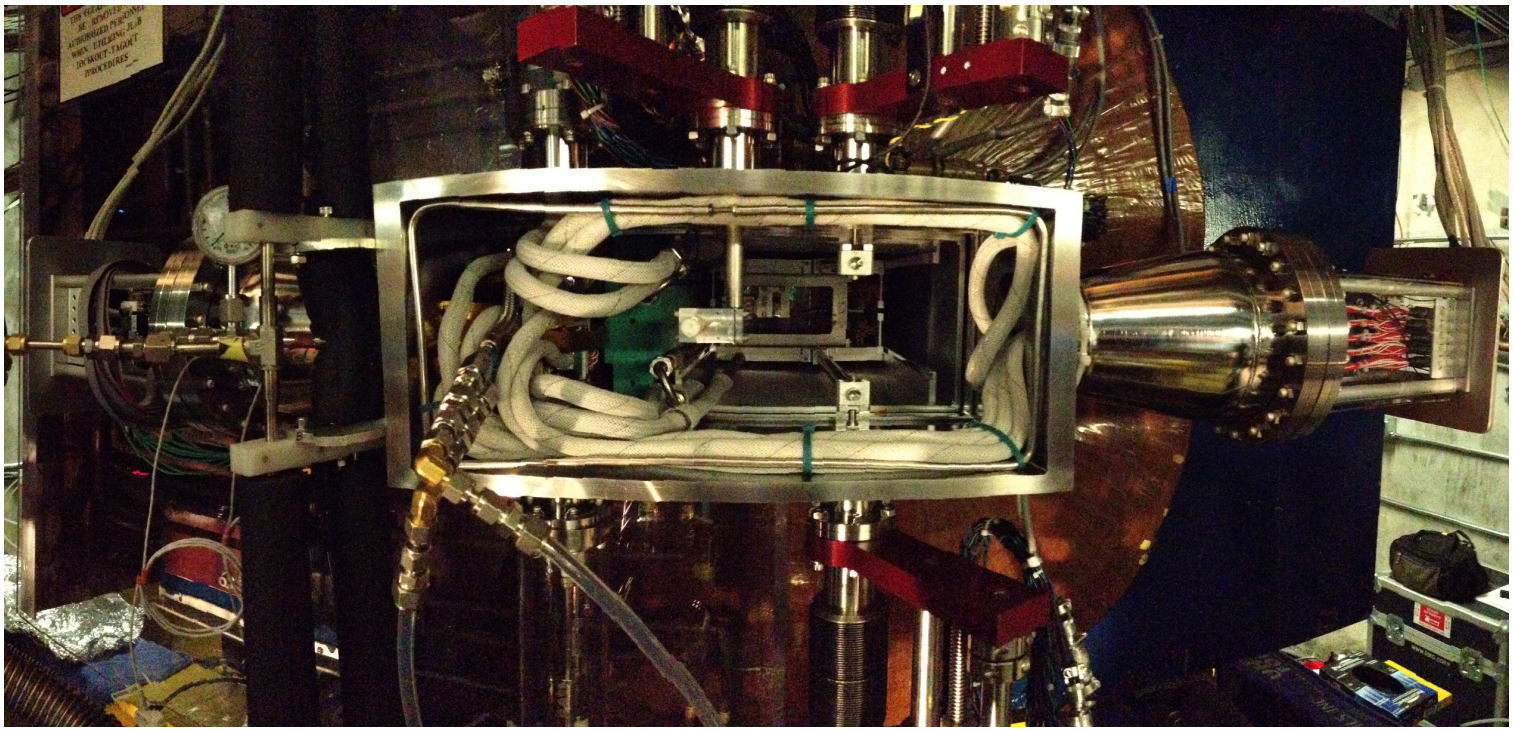


# Installed February 23

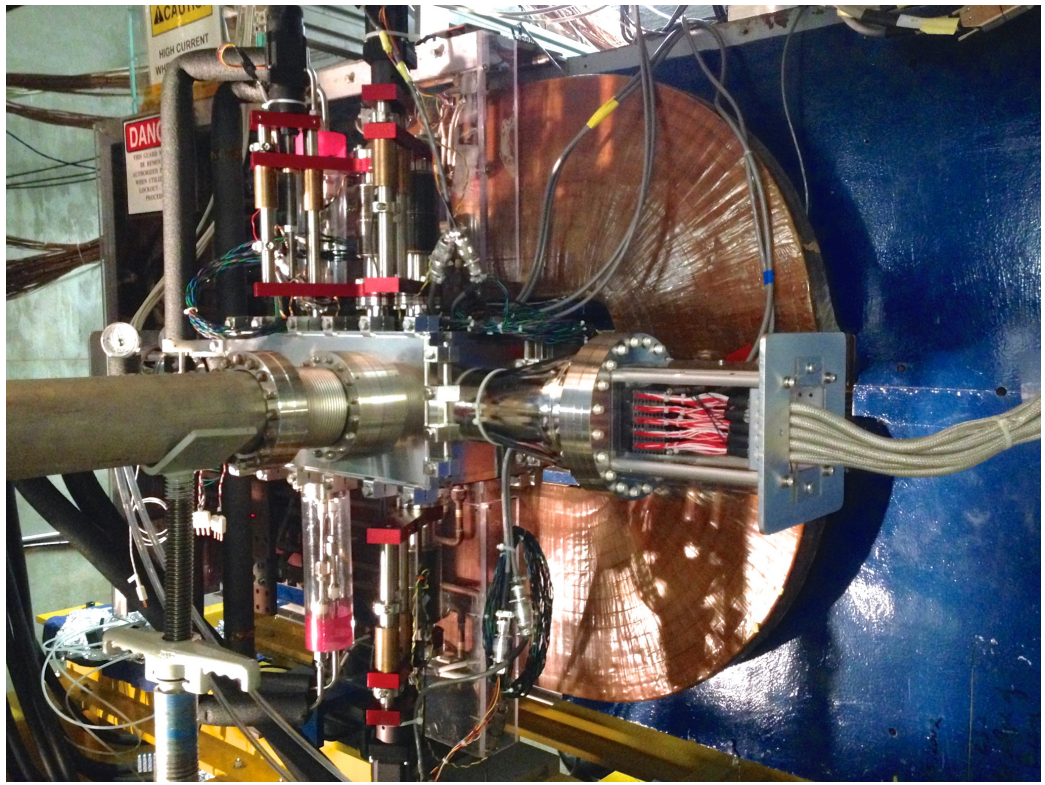






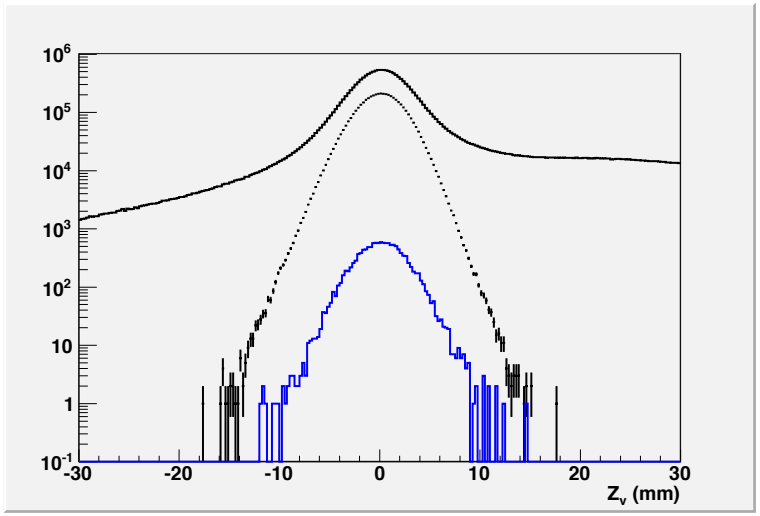
# Ready for beam!

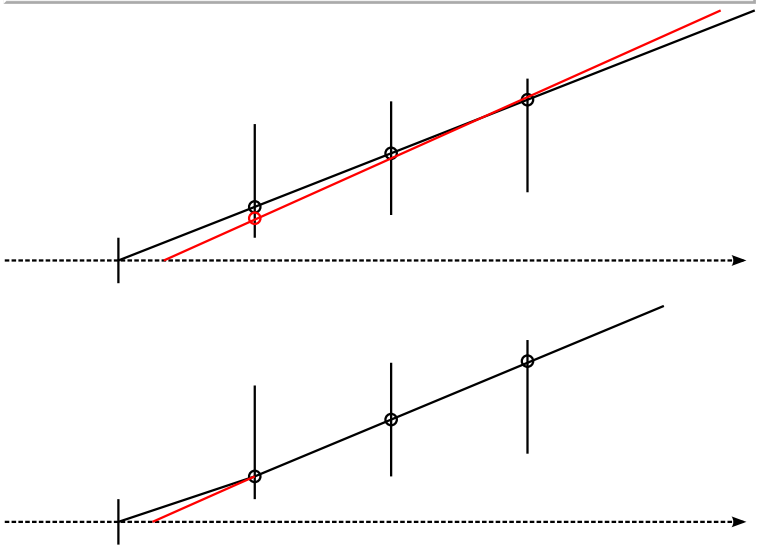
- Pre-beam checks all OK:
  - 4/23004 bad channels
  - DAQ tested at full trigger and data rates
  - Pedestal, gain, pulse shape calibrations tested
  - Power, cooling and motion OK
- Beam is expected any day now



# Backup: vertex resolution

- Vertexing search achieves $10^{-7}$ rejection of the trident background
- Misassociated layer 1 hits are the main source of vertex tails



# Backup: reach

- Vertex cut (10–30 mm) set for $< 0.5$ events/mass bin