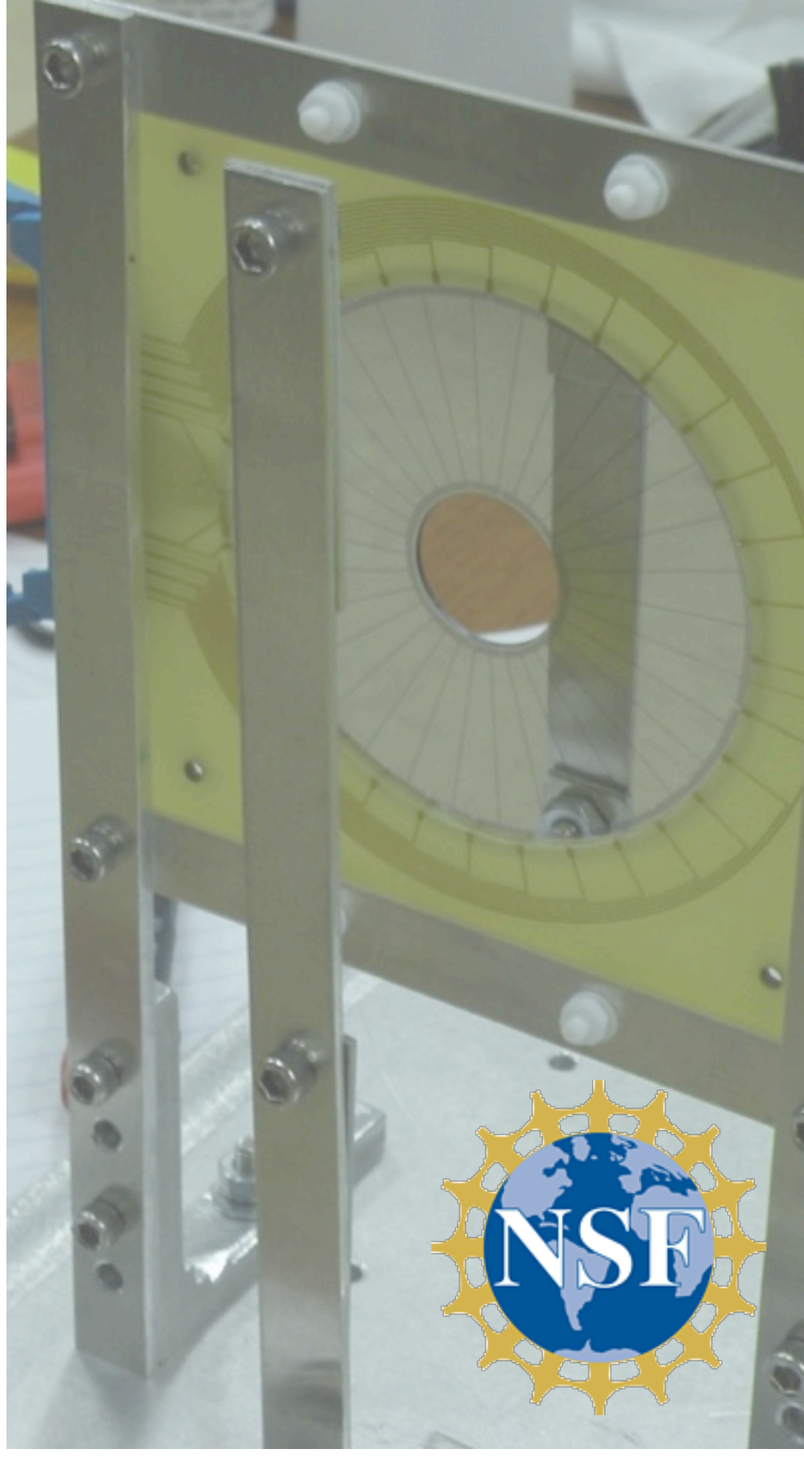
Triplet Polarimeter Status

May 12, 2015
GlueX Collaboration Meeting
Kei Moriya



Outline

- Introduction and Physics
- Setup
- Data Analysis
  - waveform analysis
  - Monte Carlo studies
- Looking Forward

Introduction

- Triplet polarimeter: measure linear polarization of photon beam
- Process: $\vec{\gamma} + e^- \rightarrow e^- + e^+ + e^-$
- Asymmetry of e^- around beamline gives measurement of polarization P :

$$\frac{d\sigma}{d\Omega} = \sigma_0 \cdot \frac{1}{2\pi}\left(1 + \lambda P \cos(2\phi)\right)$$

(σ_0 : unpolarized cross section, ϕ : azimuthal angle, λ : analyzing power)

- Allows independent measurement of photon polarization

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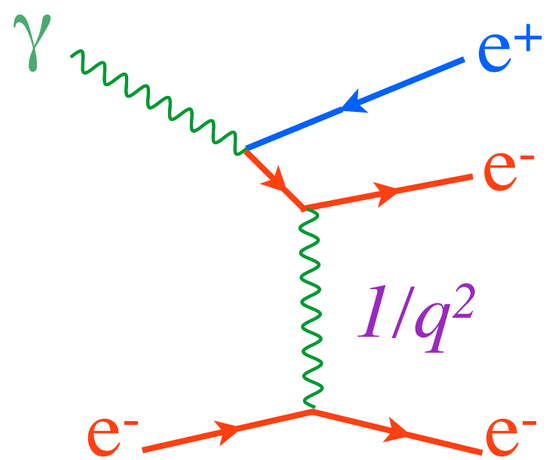
Feynman Diagrams

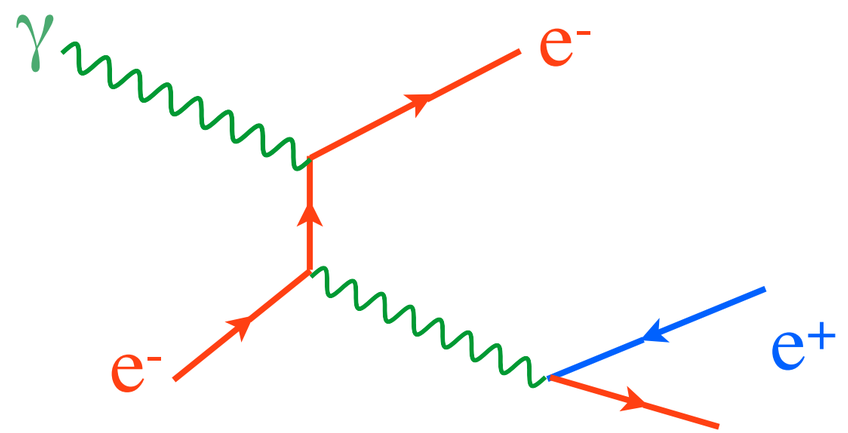
- 8 first-order Feynman diagrams (4 shown, exchange of e^- mom.)
- So-called Borsellino diagrams account for most of cross section
- Analyzing power λ depends on kinematics

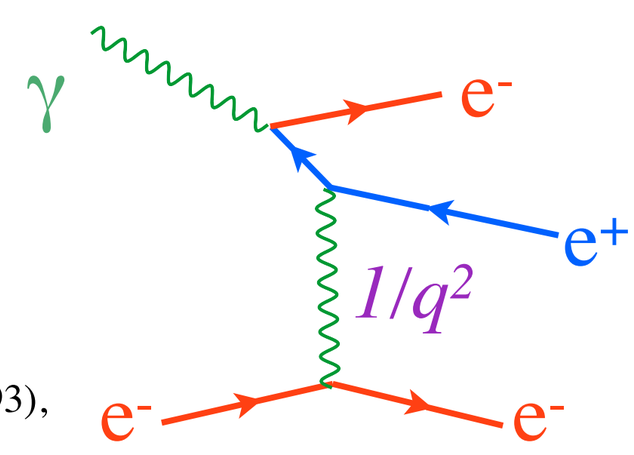
see for example, Endo, Kobayashi, NIMA328, 517 (1993), Asai, Skopik, NIMA432, 195 (1999),

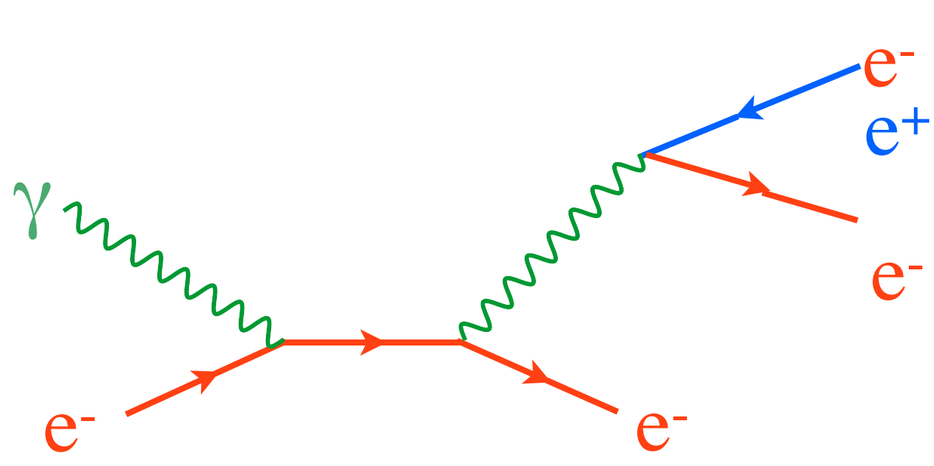
Borsellino



γ-e







For Borsellino diagrams, photon propagator suppresses energy transfer to e^-

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Signal, Background

- Reaction occurs on converter foils
- Pair production:
  - Triplet reaction cross section $\propto Z$
  - pair production cross section $\propto Z^2$

    $\Rightarrow$ low-Z material preferred, use Be (Z = 4)
- Knock out electrons
- Energy deposit difference allows discrimination of low- and high-energy e^-

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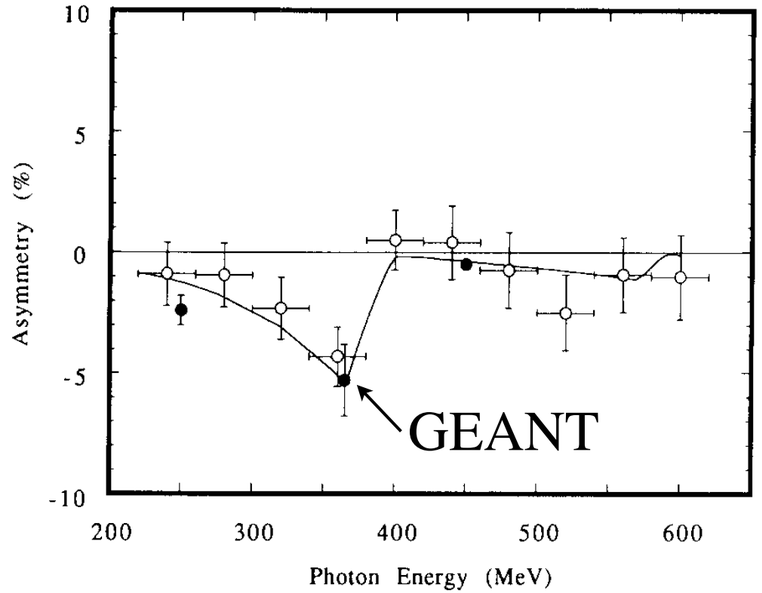
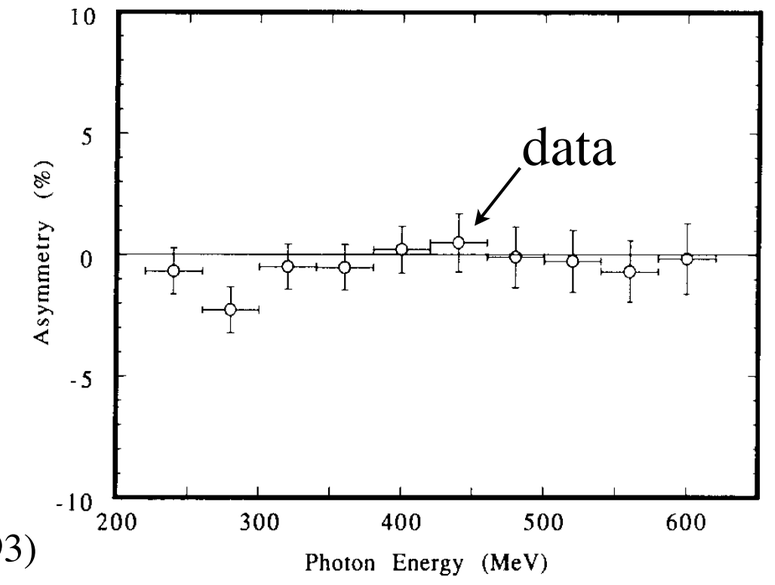
Experimental Status

- Attempted by CLAS, Mainz groups
- If successful, would be the first measurement at GlueX energies
- Would be independent check of the coherent bremsstrahlung spectrum analysis
- Best results show asymmetries for 1.2 GeV beam

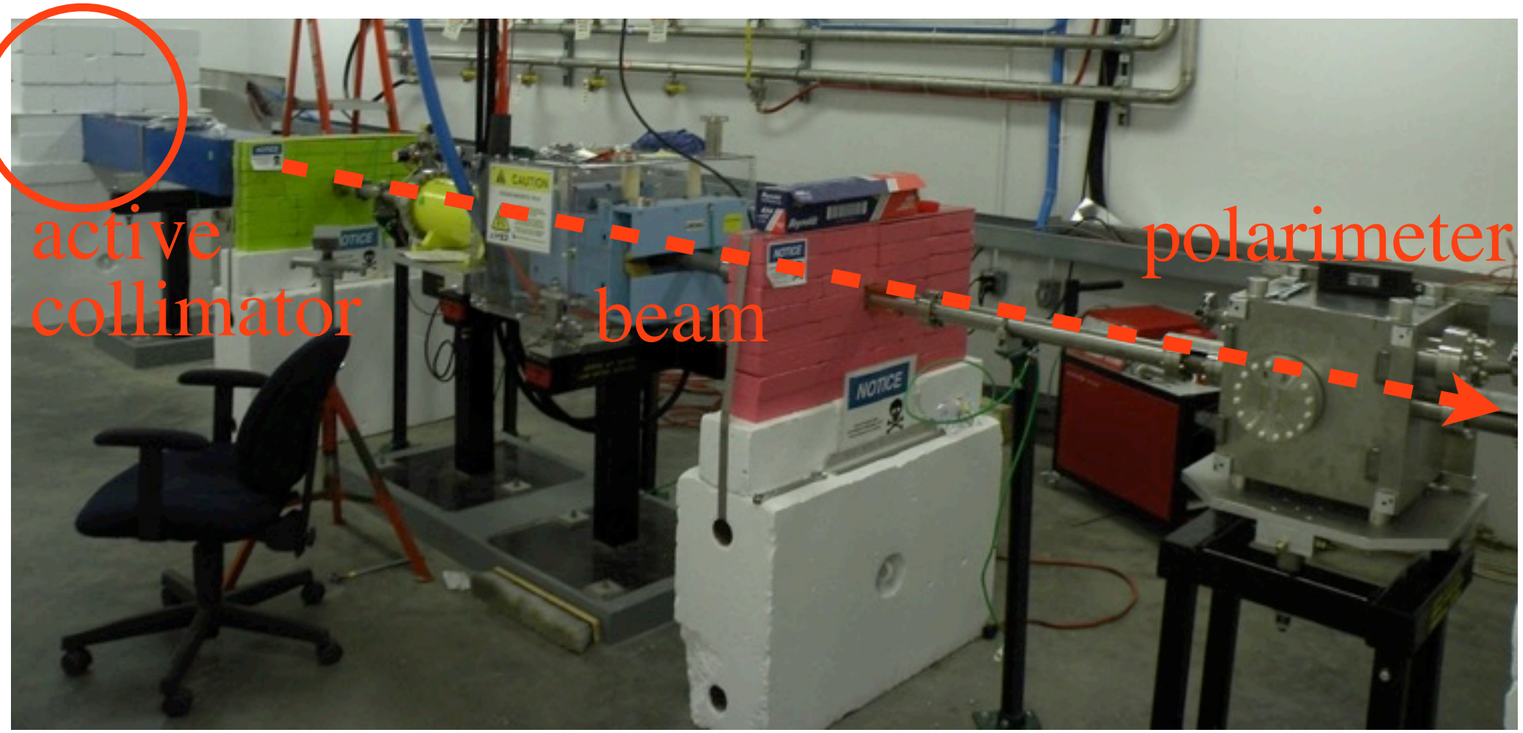




Iwata et al., NIMA336, 146 (1993)

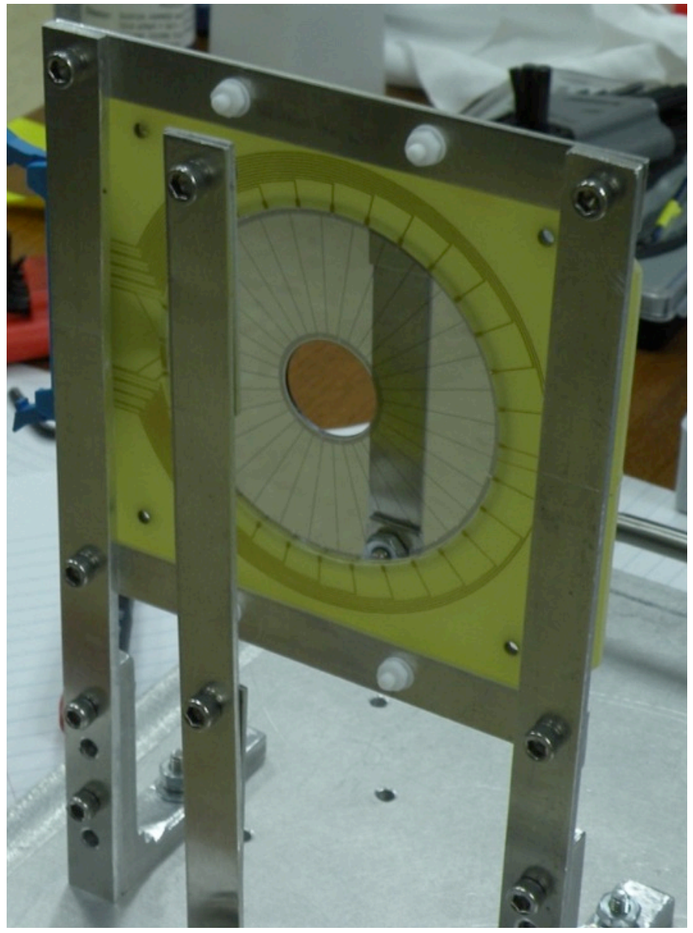
Polarimeter Setup in GlueX

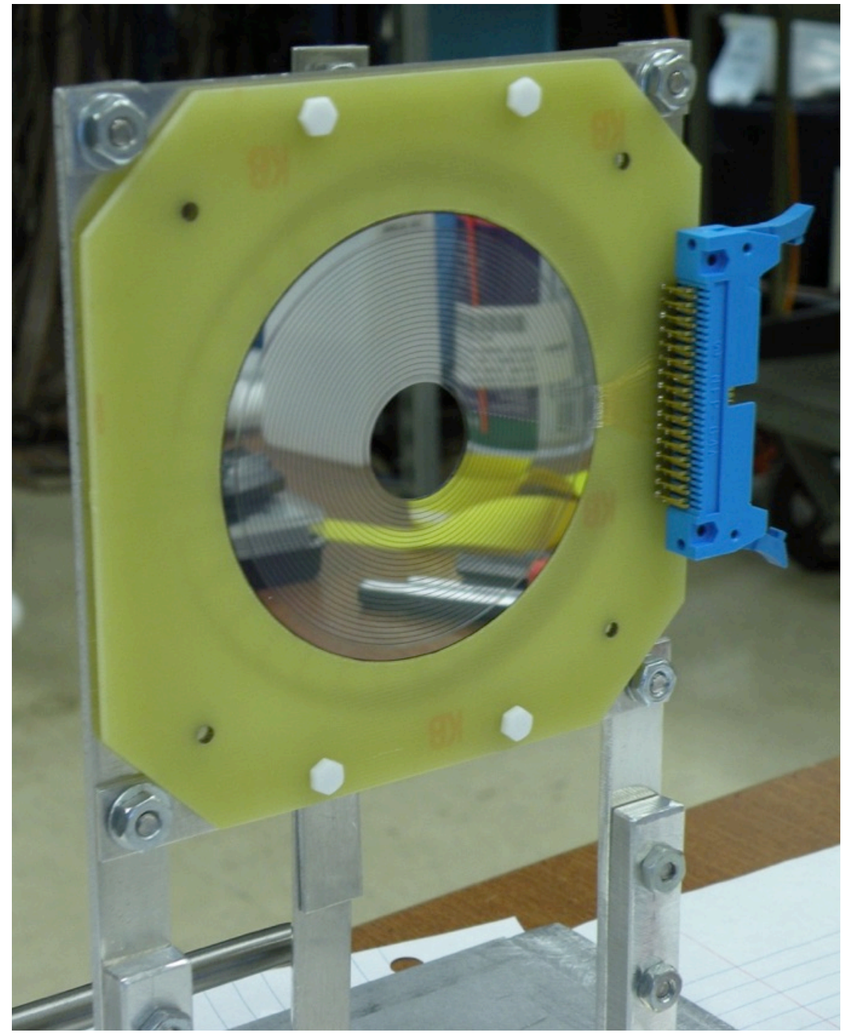
- Kinematics of triplet production is such that there will be a very low energy e^- (~ MeV), and a high energy $e^+ e^-$ pair
- Detect low-energy e^- in silicon detector, high-energy pair in pair spectrometer
- Located upstream of PS, in collimator cave



Silicon Detector

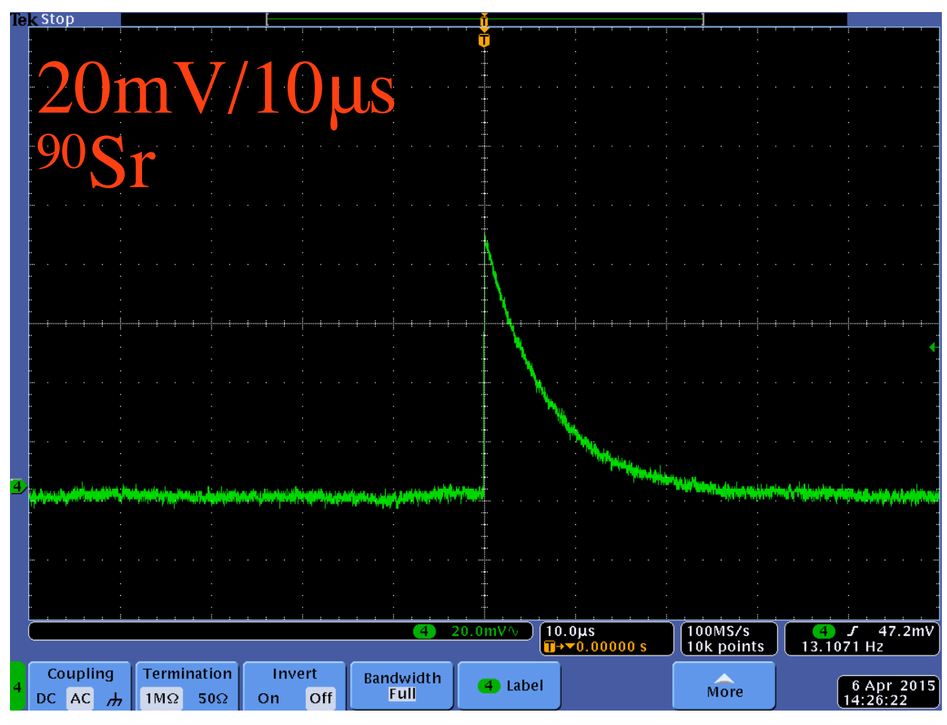
- Double-sided silicon detector
- 32 sectors on one side, 24 rings on the other
- Read out with fADC250s
- For this run period we had readout for sectors only

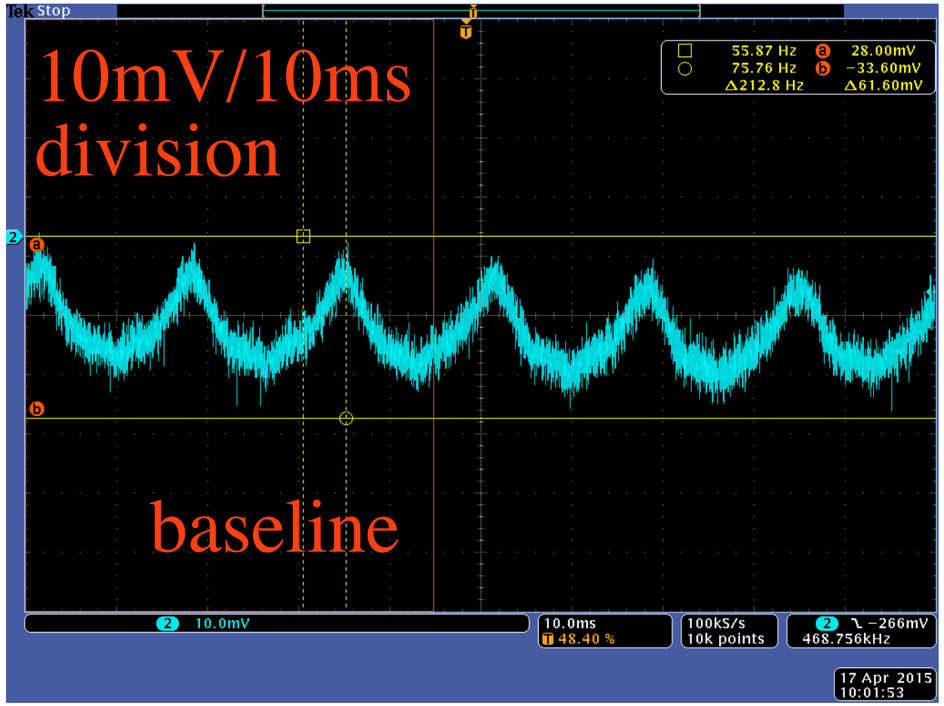


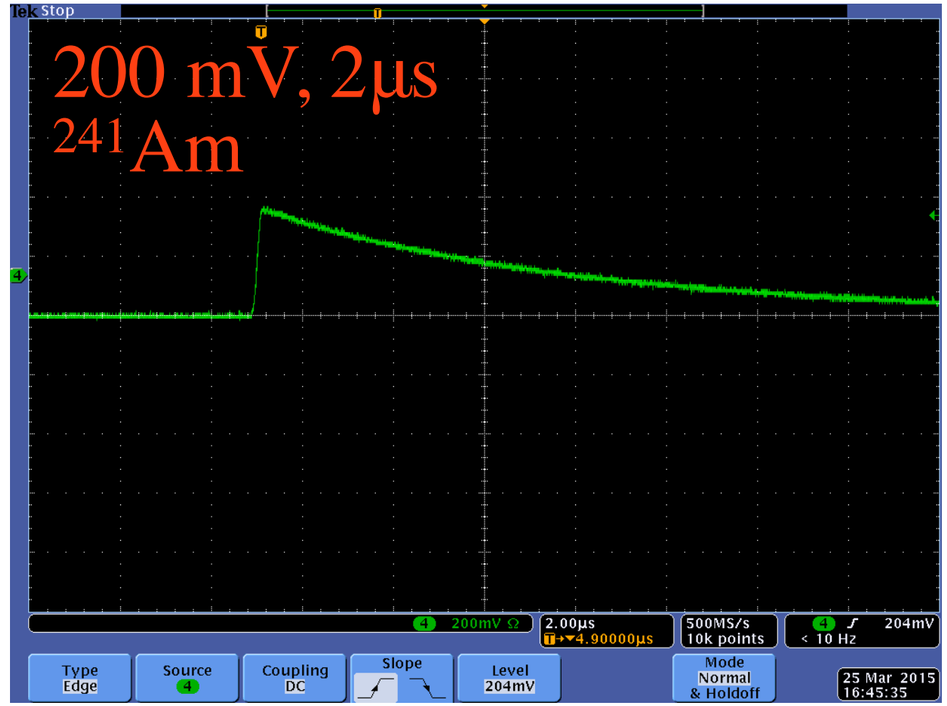


Source Data, Noise

- Radioactive sources used: ^{90}Sr (β), ^{241}Am (α)
- Very long decay time (6 μs) from preamp
- Baseline modulation at 60 Hz, higher frequency







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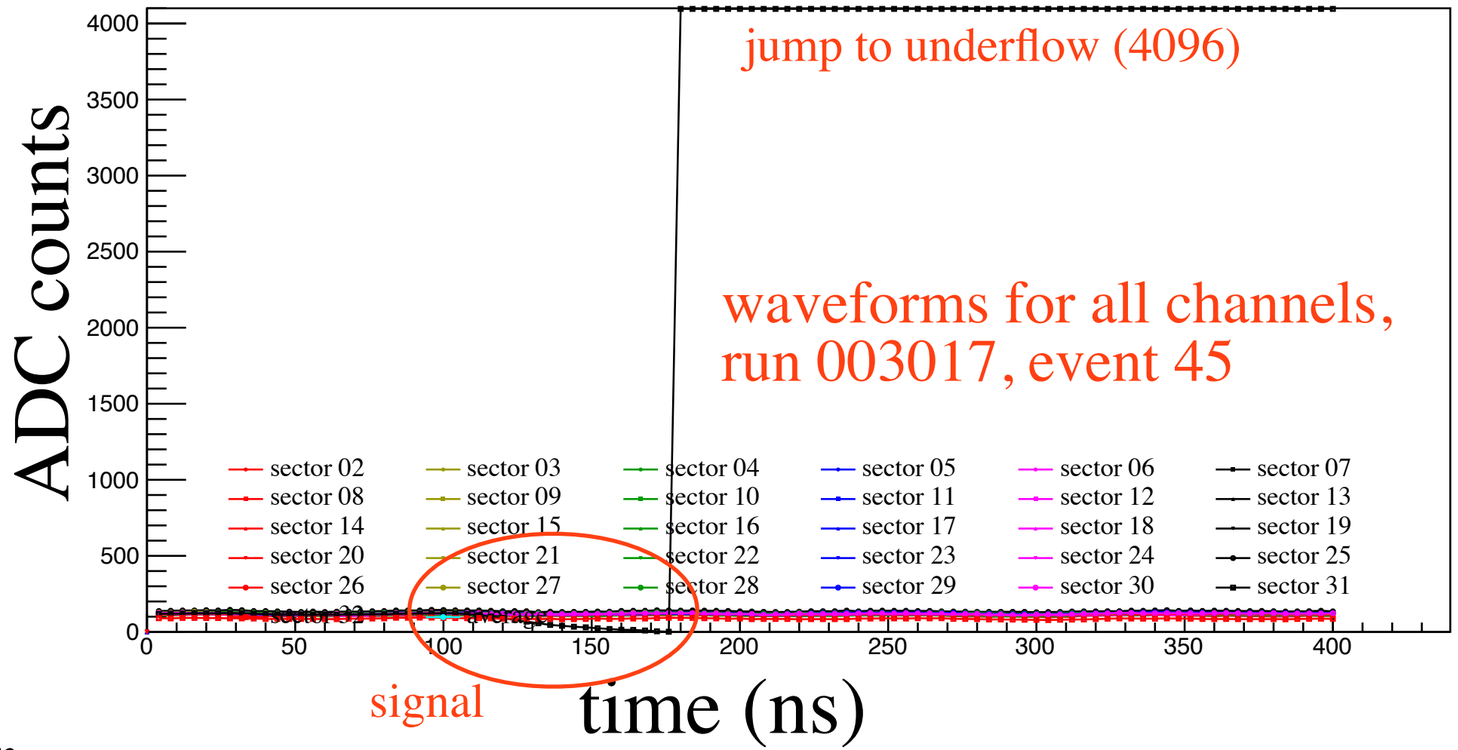
Data Taking

- Design, construction, testing at ASU has been ongoing since early 2014
- Started shipping, setting up in EEL 126 at end of February
- Everything set up just in time for beam
- Sasha added us into the PS trigger at end of April

fADC, Trigger Setup

- fADC flips polarity of signal
- Our signals go negative in fADC
- Originally had baseline at 100 ADC counts, now set to 3500



- Sasha working with Hai on fix

Trigger

- Included in PS trigger
- Read out raw waveforms for all channels for each trigger
- For physics + PS trigger, read out for all events: DAQ dead time contribution

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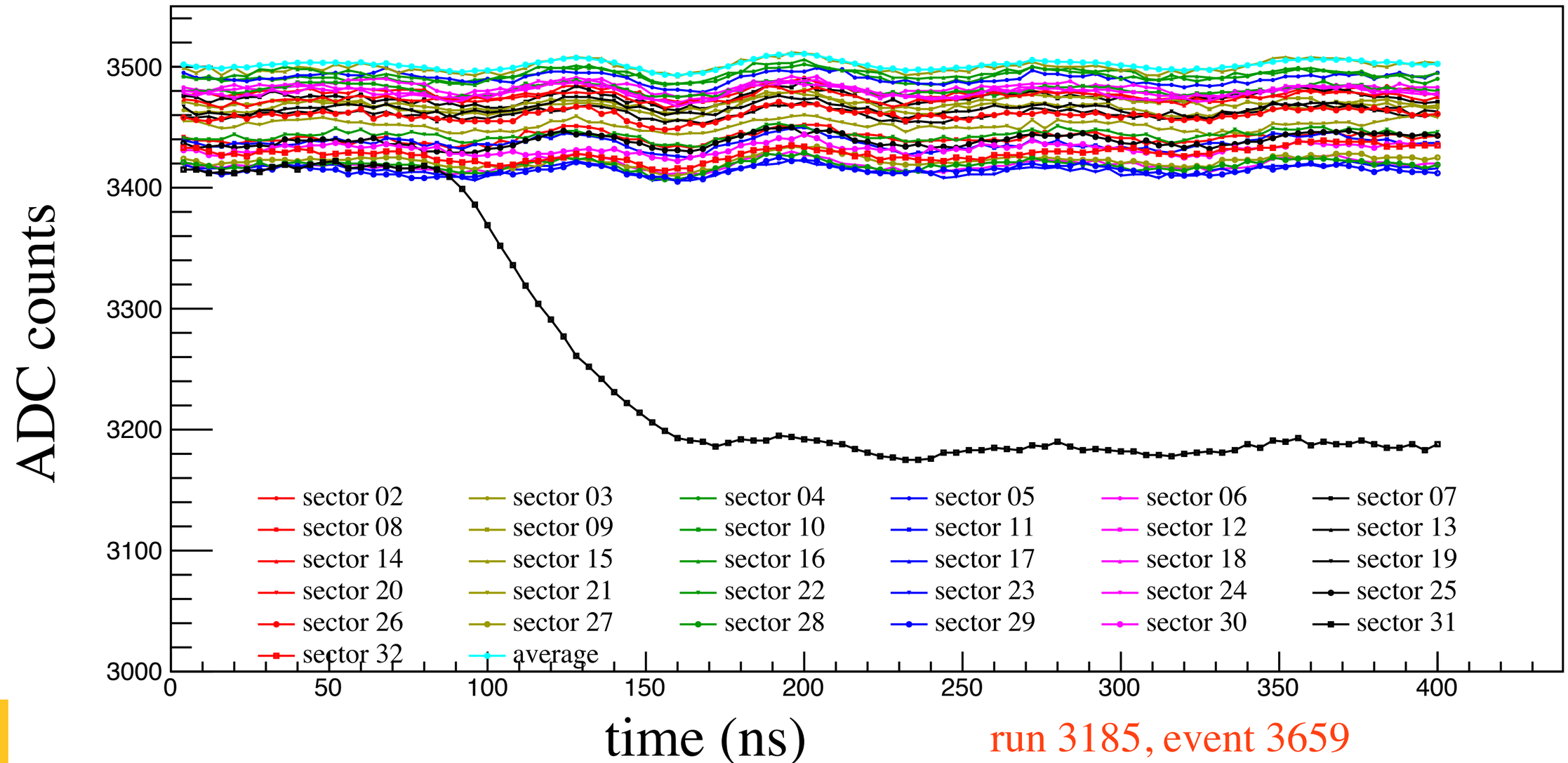
Raw Waveforms

- Plot waveforms for all channels



run 3185, event 3659

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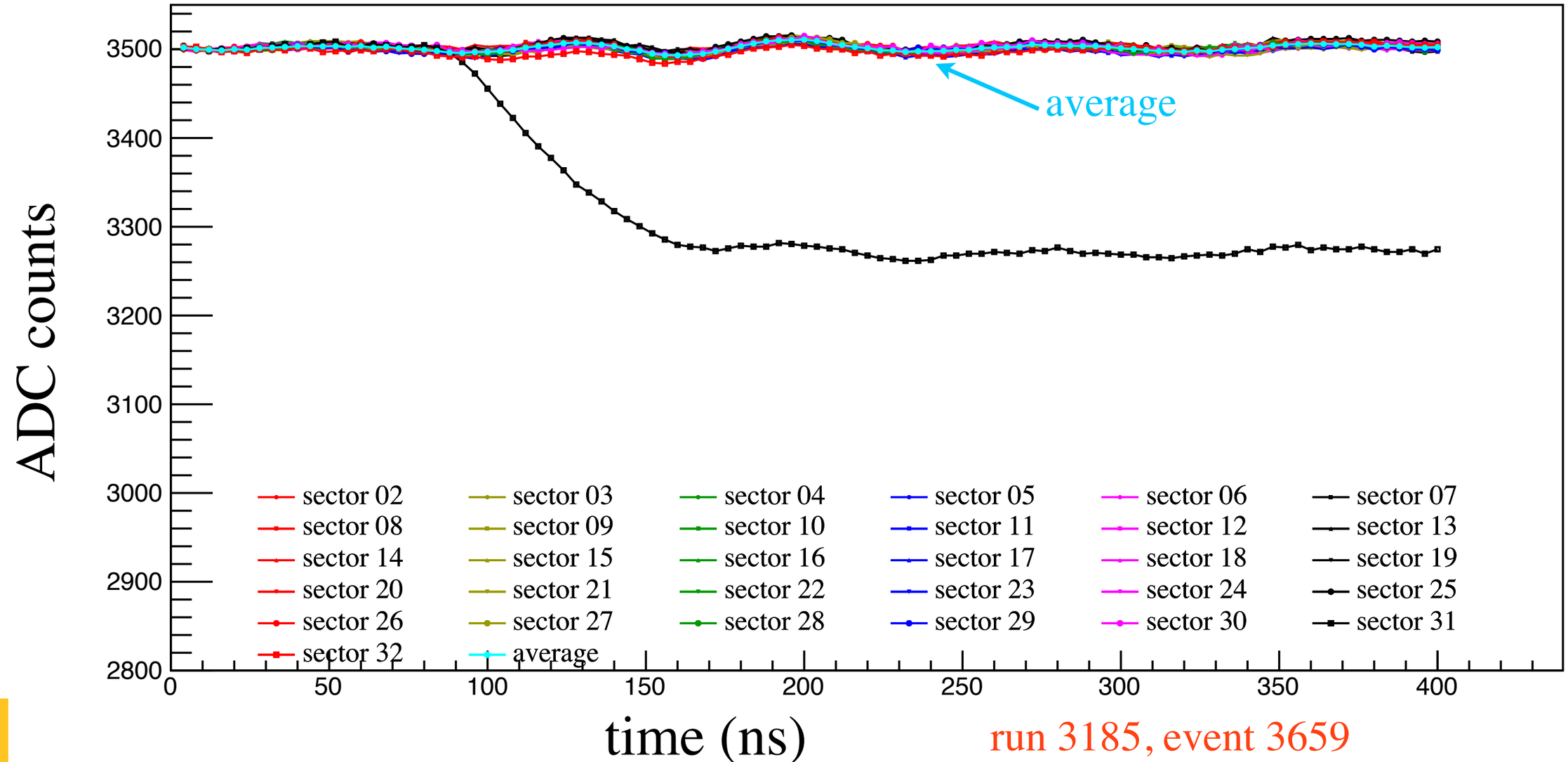
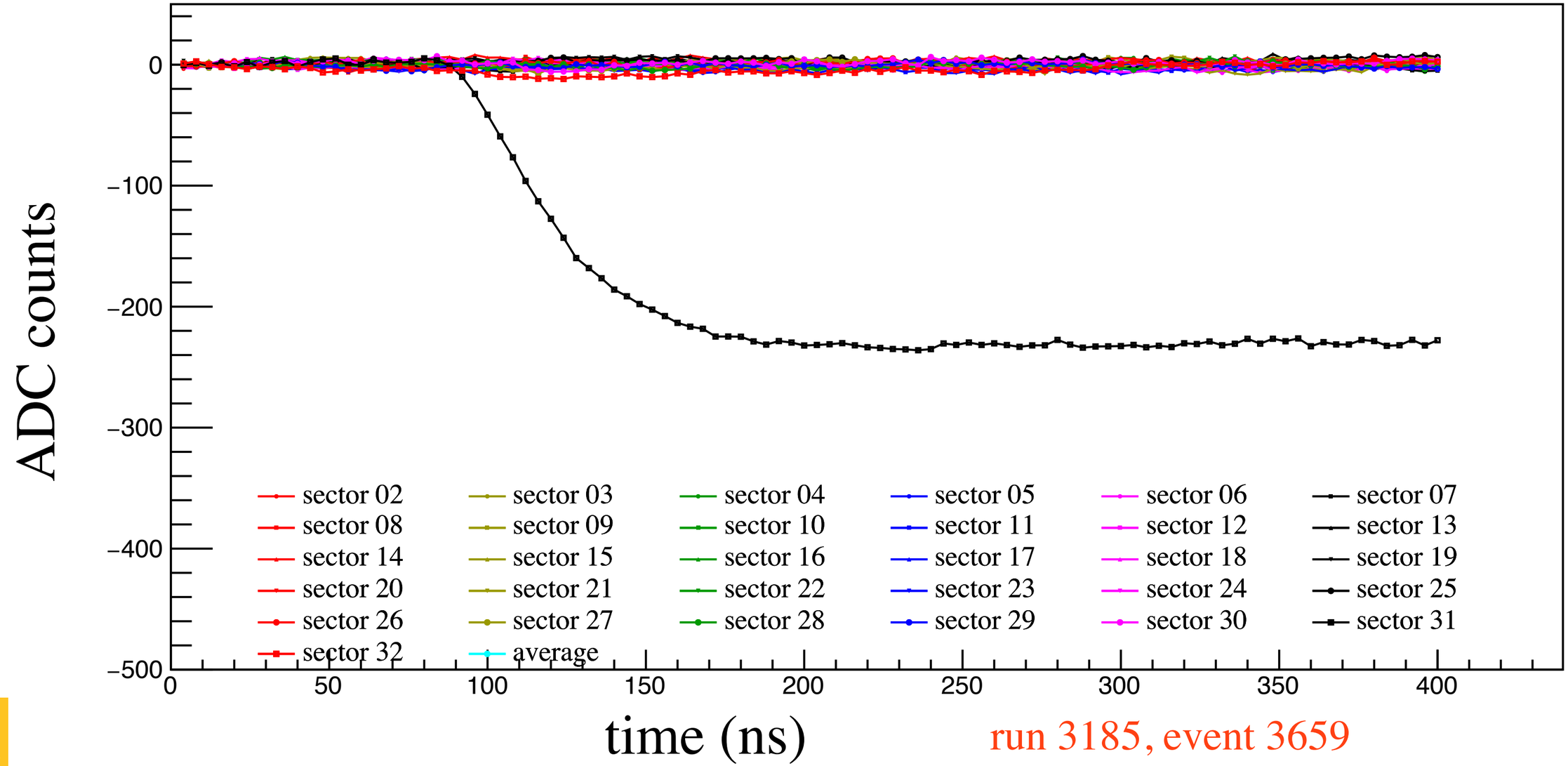
Average Waveform

- Adjust pedestals to 3500, take average waveform from channels without hits



Normalized Waveforms

- Plot waveforms for all channels



run 3185, event 3659

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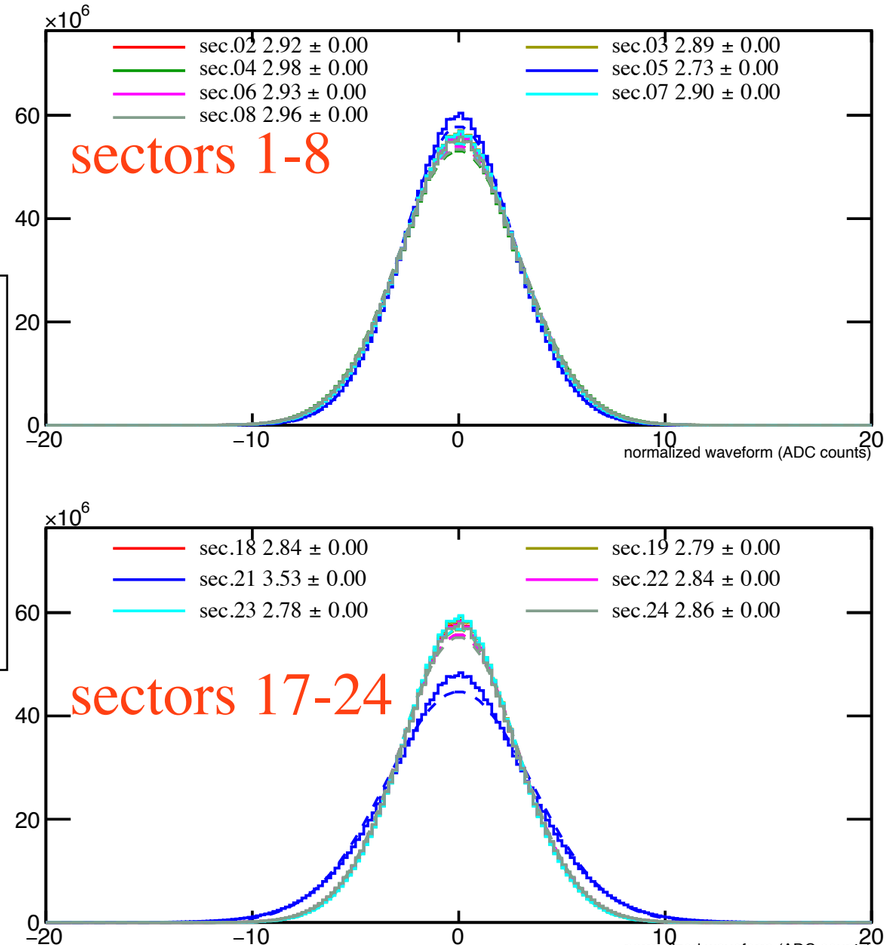
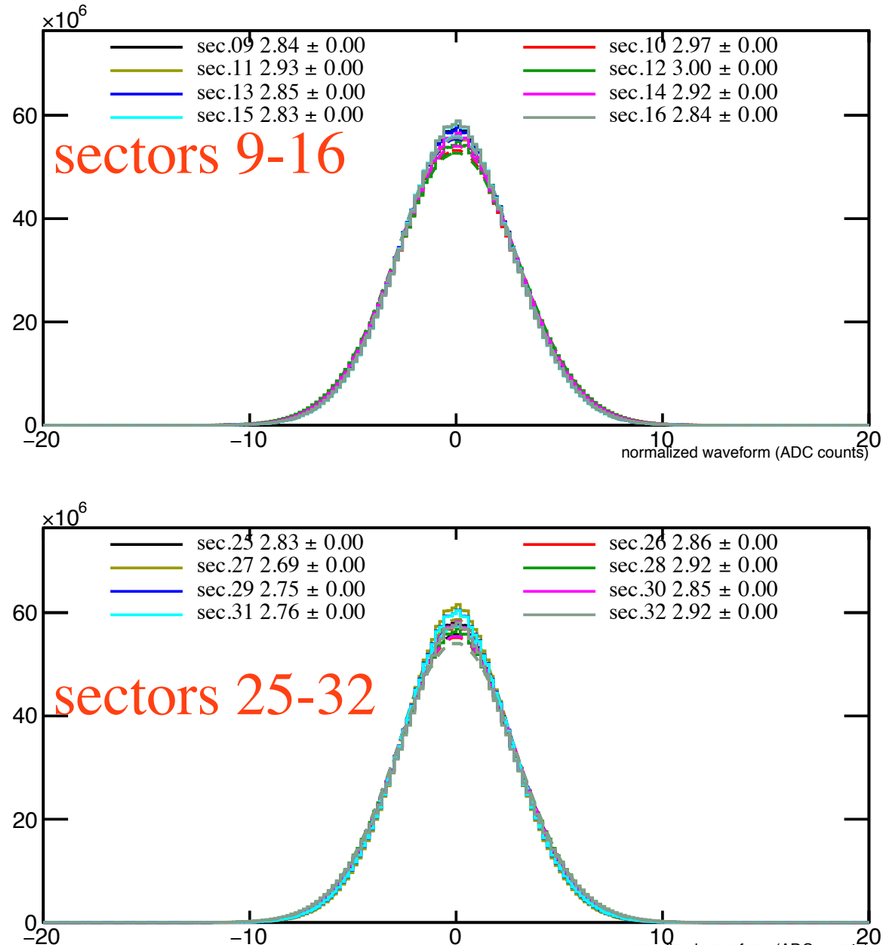
Normalized Waveforms Distributions

- Distribution of all wave samples for all events
- Gaussian widths are < 3 ADC counts after normalization

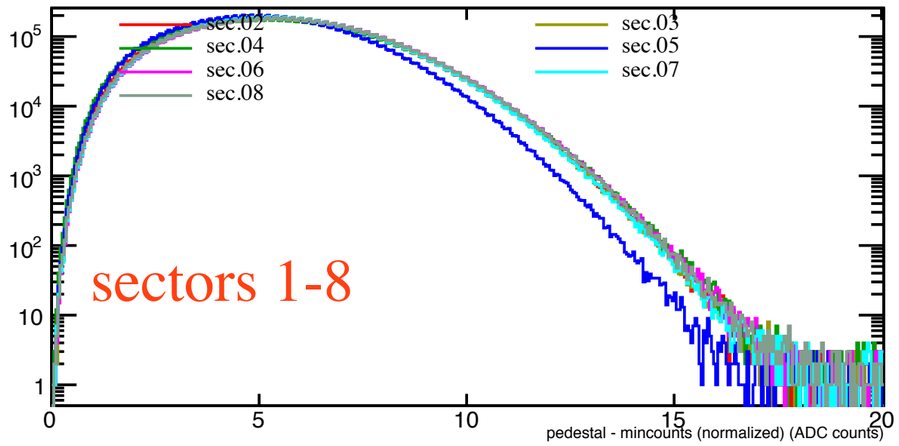
Run 3185: waveforms read out for all events regardless of trigger type. Number of triplet signal events is < 1% of total

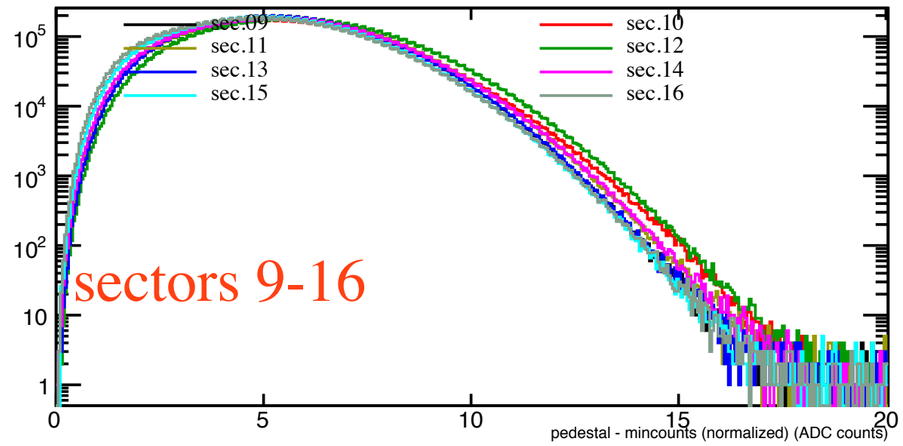


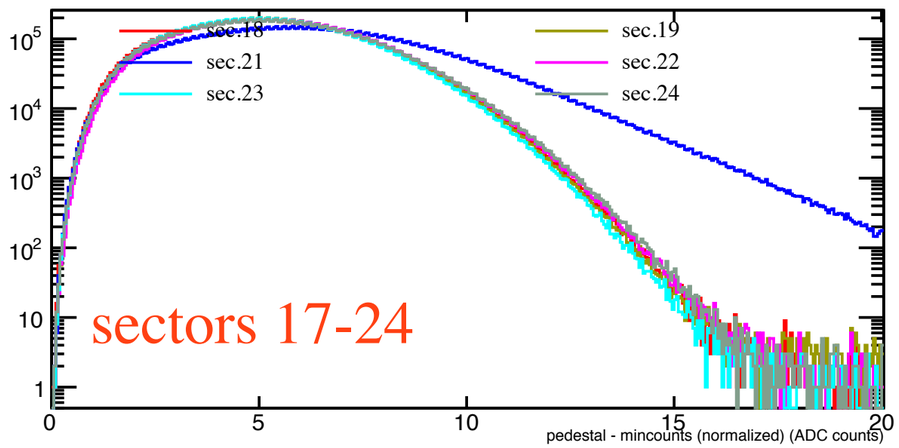


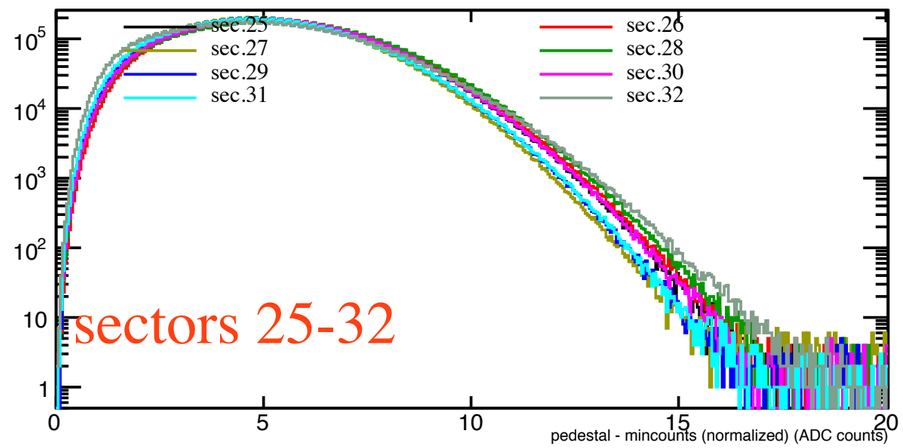
Signal Counts

- Distribution of pedestal - minimum sample
- Very tight distribution of < 15 ADC counts with very long tails (cosmics?)



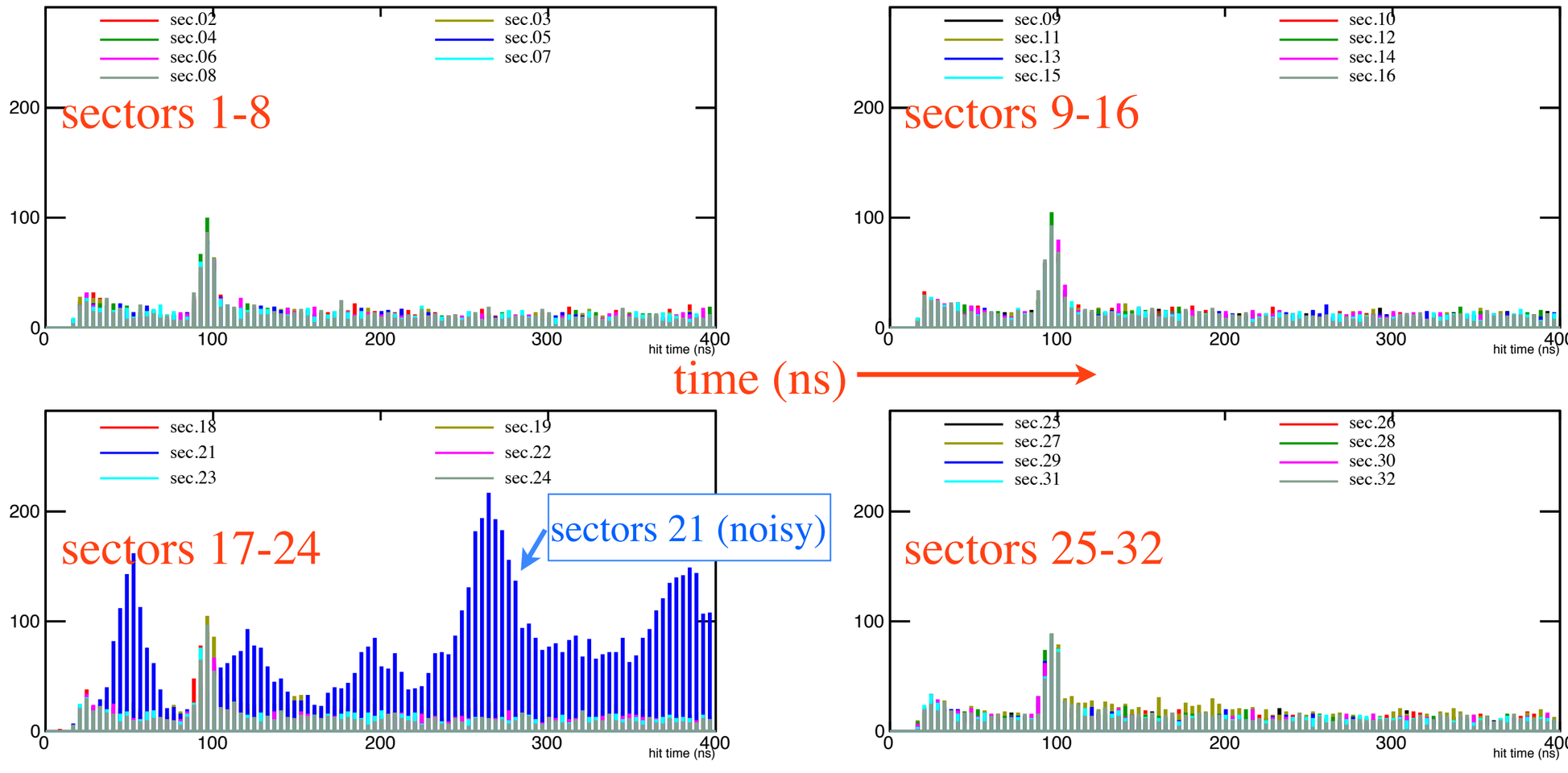






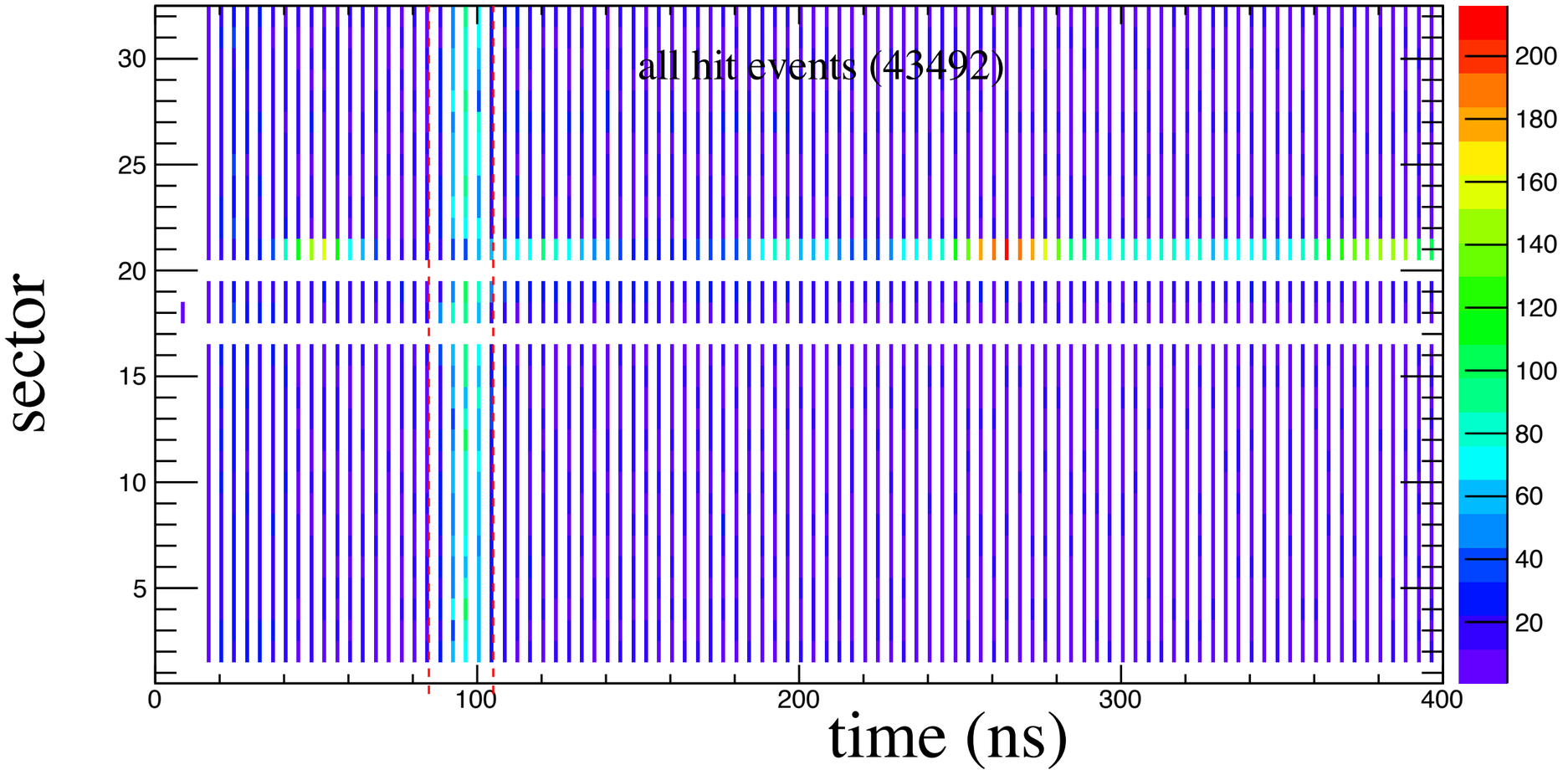
Timing

- Hit time defined as time of first sample to have deviation from pedestal of > 20
- Clear peak shows in many channels



Sector Distribution

- Sector # vs hit time
- Projection gives asymmetry, currently working on systematics, backgrounds



Further Systematics

- No selection of signal amplitude
- No consideration of channel multiplicities (treating sectors as counters)
- Dependence on converter thickness (75 μm for run 3185)
- Dependence on beam position, current (shift of position creates asymmetry)
- Background events (accidentals, noise, knock out electrons)
- Correlation with PS energy
- Mike working on GEANT4 simulation of detector, backgrounds
- Probably a few more unknown unknowns

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Looking Forward

- Successfully installed polarimeter into hall during spring 2015 run
- Analyzing data
- Hardware upgrades (ring readout, HV upgrade) expected over down time
- Noise reduction
- Sasha has set up fADC self-triggering, can take source data
- Integration into JANA framework
- Goal is to pull out asymmetry, photon polarization for various energies

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Acknowledgements

Work on the polarimeter would not have been successful without the help of many folks: Lubomir, Sasha, Hovanes, Beni, Elton, David L., Mark D., Tom, Tim, Mark Stevens, Josh Foyles, Keith, Fernando, Chris Stanislav, Nick Sandoval, Adam Hartberger (sources)