HRPPD B-field Campaign – Partial Results

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HRPPD B-field Measurements at BNL Meeting
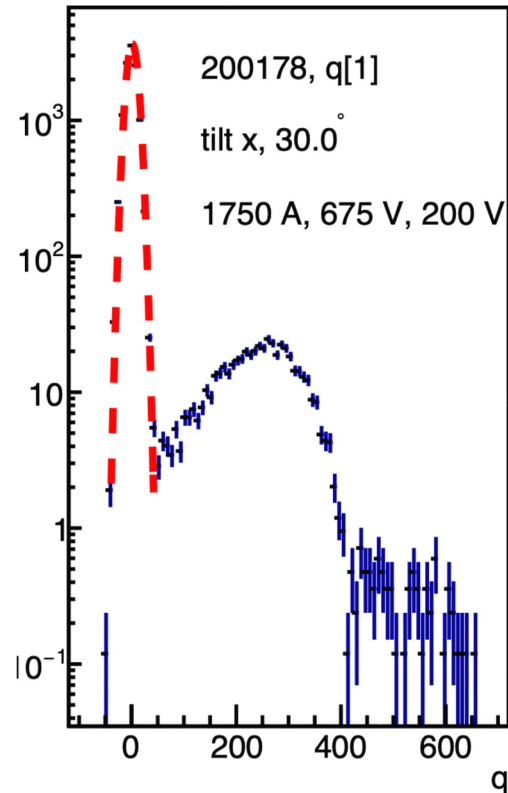
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Overview

o Looked into a subset of available data. (thanks to Ping and Alexander)

o Generated some figures to support interpretation of HRPPD performance

    o Charge spectra for different magnet currents and inclination angles

    o Mean charge as a function of magnet currents

        o With different inclination angle
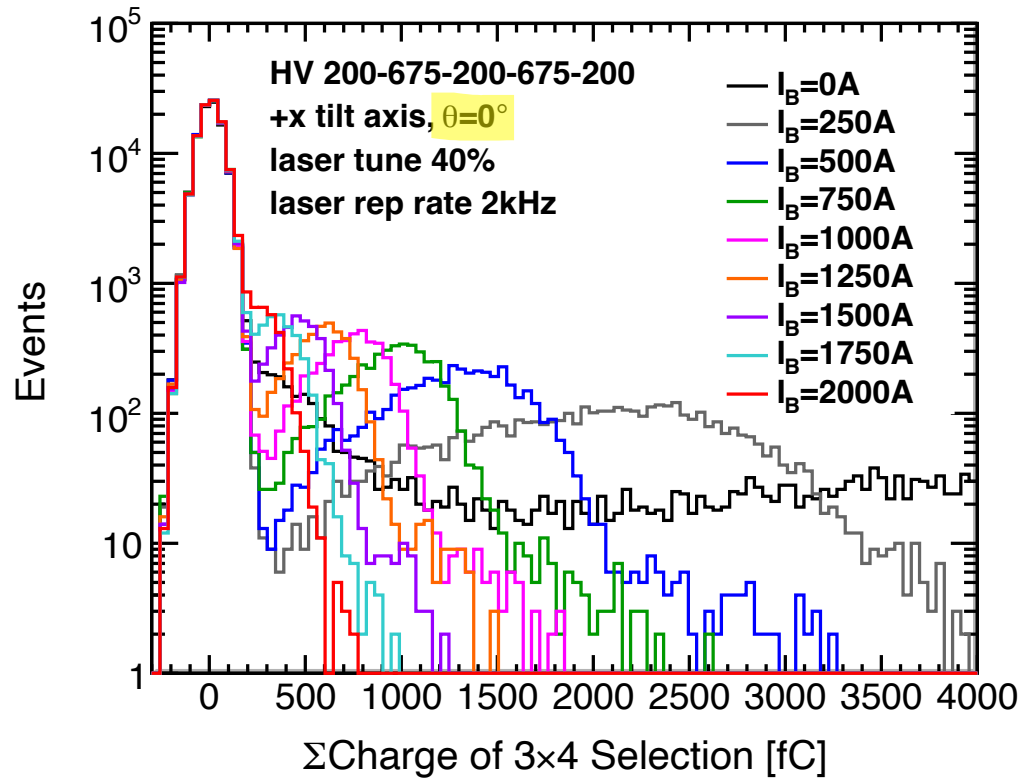
        o With different bias voltage

o To-do list

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Charge Calculation

Thanks to Ping

Update Mean Charge Extraction

200178, q[1]

tilt x, 30.0°

1750 A, 675 V, 200 V

- Fit the pedestal
- Chop off the pedestal with a 4-sigma cut
- Mean charge=Histo->GetMean()

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Charge Spectra VS Magnet Current

HV 200-675-200-675-200
+x tilt axis, θ=0°
laser tune 40%
laser rep rate 2kHz

— I_B=0A
— I_B=250A
— I_B=500A
— I_B=750A
— I_B=1000A
— I_B=1250A
— I_B=1500A
— I_B=1750A
— I_B=2000A
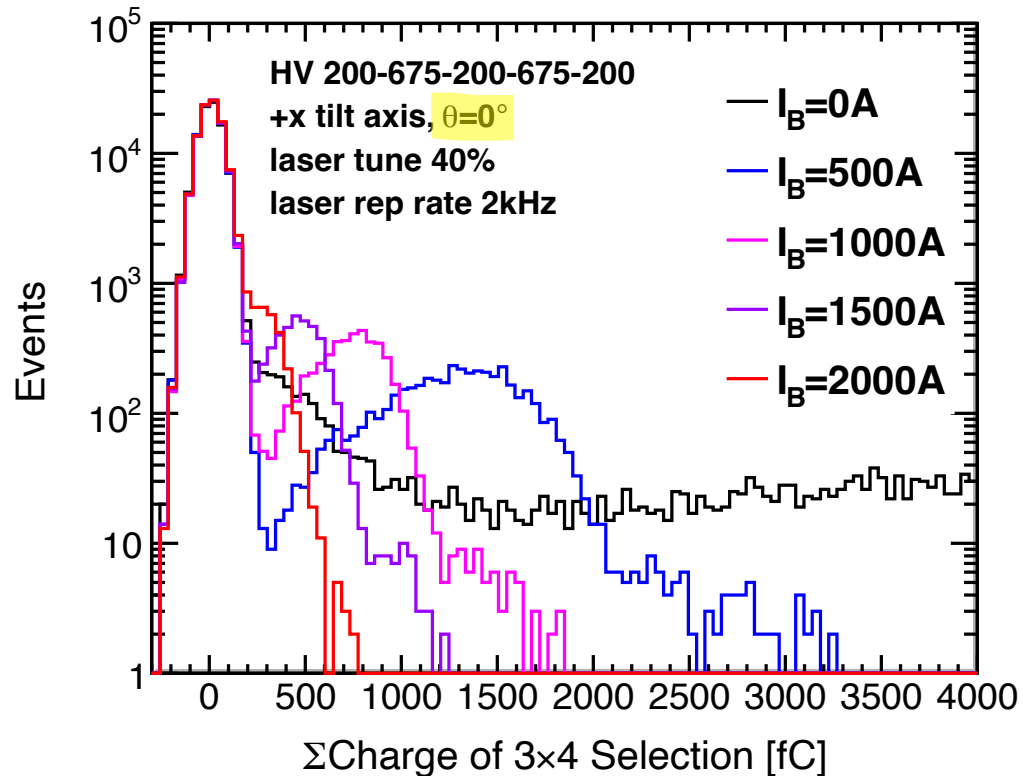
Events

ΣCharge of 3×4 Selection [fC]

- ○ Measured **charge spectra** with different **magnet current**
- ○ **Charge calculation**:
  - ○ 3×4 channel selection
  - ○ Channels: 10-13, 16-19, 22-25

Data used: 200197, 200198, 200199, 200200, 200201, 200202, 200203, 200204, and 200205

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Charge Spectra VS Magnet Current

HV 200-675-200-675-200
+x tilt axis, θ=0°
laser tune 40%
laser rep rate 2kHz

- I_B=0A
- I_B=500A
- I_B=1000A
- I_B=1500A
- I_B=2000A
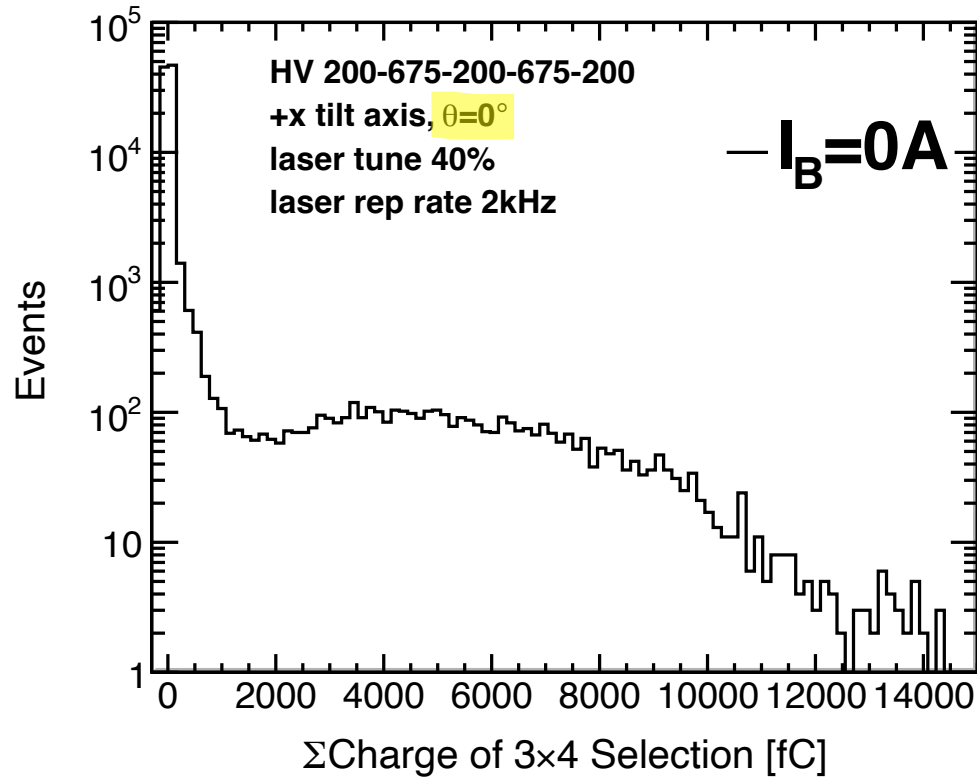
Events

ΣCharge of 3×4 Selection [fC]

With Reduced Samples

o Measured **charge spectra** with different **magnet current**

o **Charge calculation**:
  o 3×4 channel selection
  o Channels: 10-13, 16-19, 22-25

o **Observation**:
  o Clear peak shift with increasing magnetic field
  o Higher magnetic field → **narrower spectra**
  o Peak shifts toward **lower charge values**

o **Conclusion**:
  o **Gain reduction** with increasing magnetic field

Data used: 200197, 200198, 200199, 200200, 200201, 200202, 200203, 200204, and 200205

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Charge Spectra VS Magnet Current

HV 200-675-200-675-200
+x tilt axis, θ=0°
laser tune 40%
laser rep rate 2kHz

— I_B=0A

Events

ΣCharge of 3×4 Selection [fC]

o Measured **charge spectra** with **magnet current 0A**

o **Charge calculation**:
  o 3×4 channel selection
  o Channels: 10-13, 16-19, 22-25

o **Observation**:
  o Charge distribution extends up to 14,000 fC

Data used: 200197, 200198, 200199, 200200, 200201, 200202, 200203, 200204, and 200205

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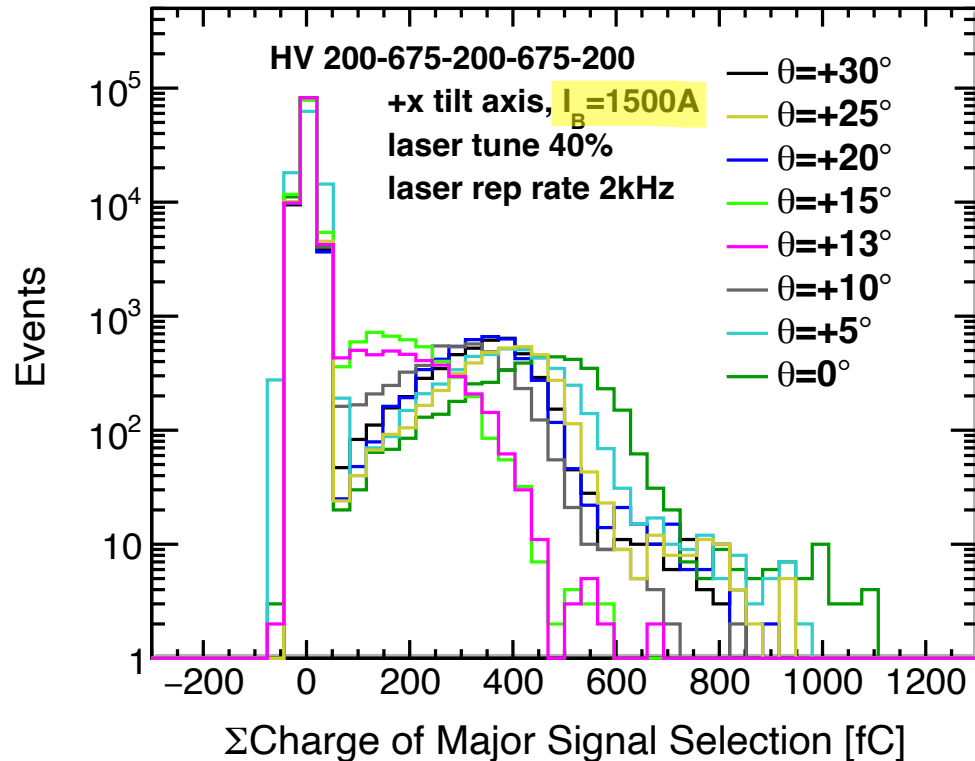# Charge Spectra VS Inclination Angle
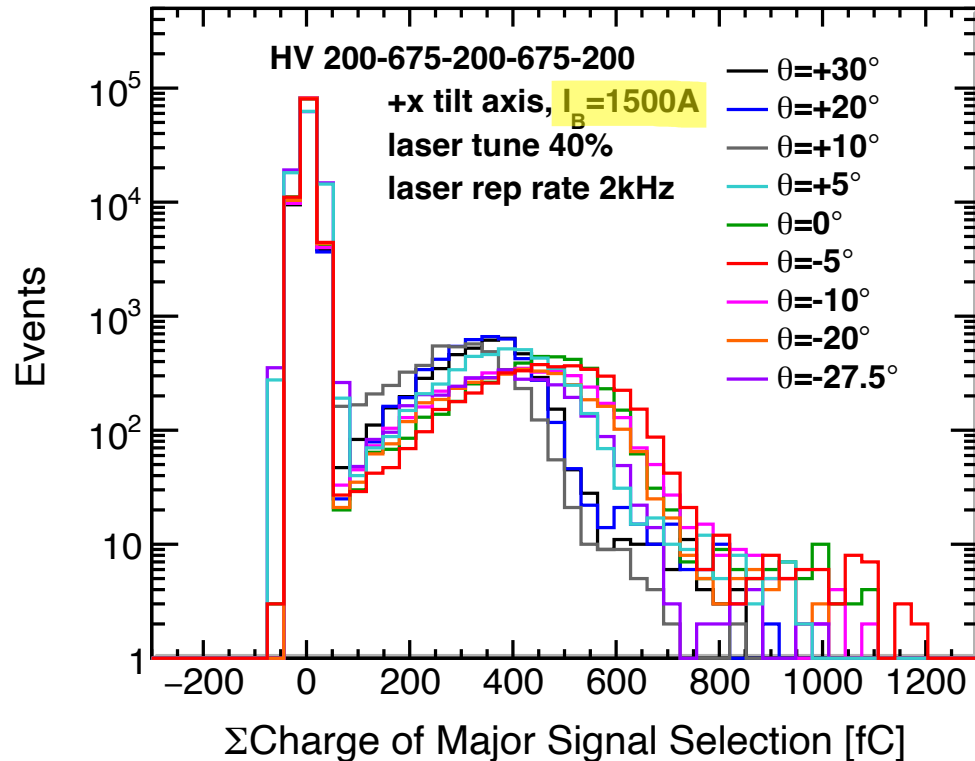
- Measured **charge spectra** with different **inclination angle** at $\vec{B} \sim$ **1.4 T**

- **Charge calculation**:
  - Major signal channel selection by accumulated signals

- **Observation**:
  - At fixed magnetic field, charge shows **weak angular dependence**
  - Two distinct trends observed for **positive and negative angles**

- **Conclusion**:
  - Overall **angular dependence is weak**

Data used: 200171, 200185, 200194, 200203, 200217, 200227, 200236, 200245, and 200254

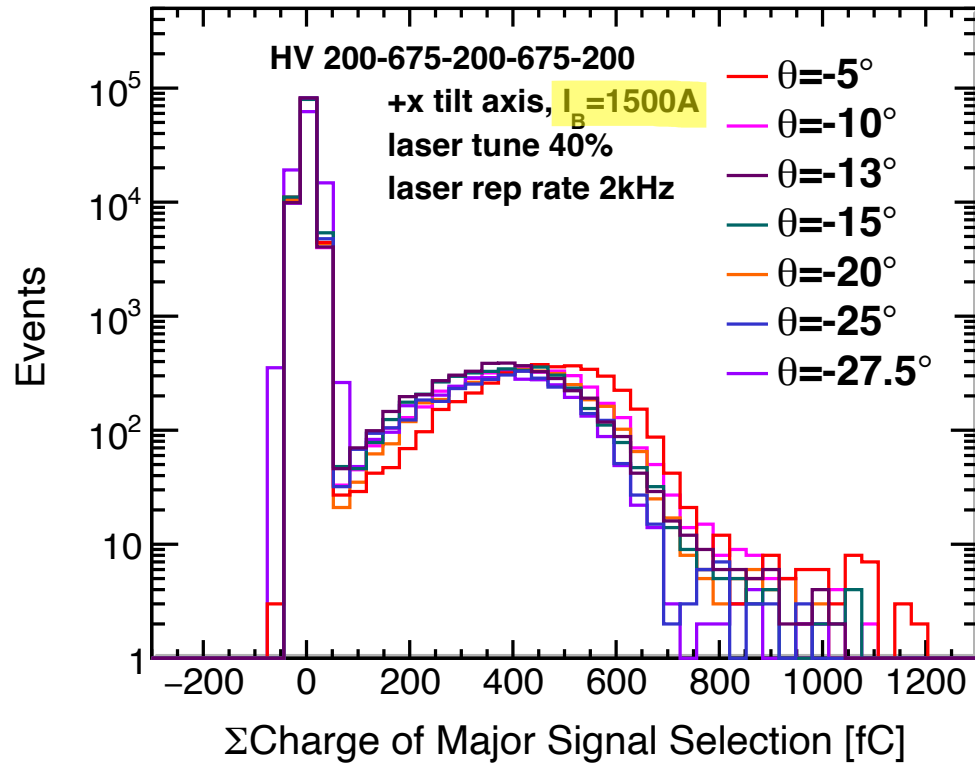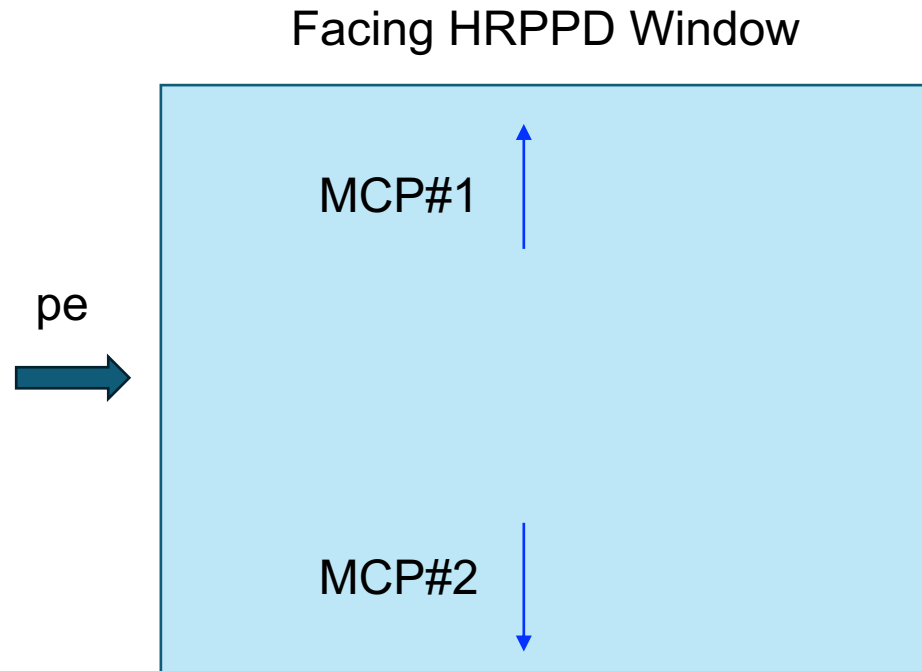# Charge Spectra VS Inclination Angle
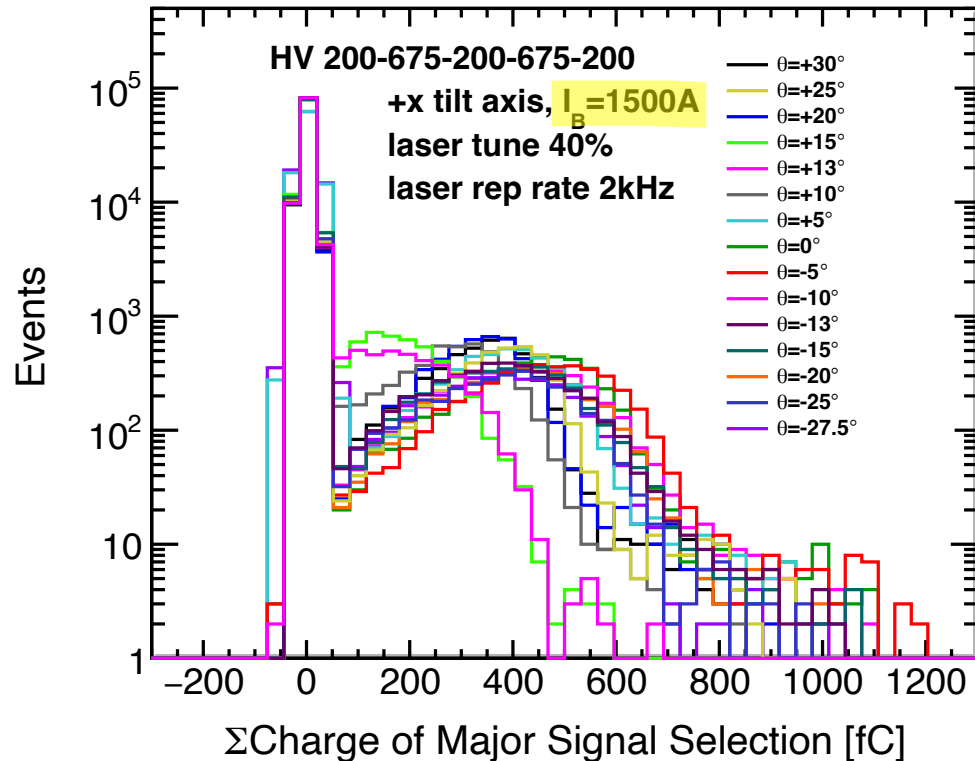
- Measured **charge spectra** with different **inclination angle** at $\vec{B} \sim$ **1.4 T**
- **Charge calculation**:
  - Major signal channel selection by accumulated signals
- **Data note**:
  - Some runs lack **laser repetition rate information**
  - Affects angles: $\theta = \pm15°, \pm25°, \pm13°$
- **Observation**:
  - **13°** and **15°** exhibit trends different from other angles
- **Conclusion**:
  - Overall **angular dependence is weak**

Data used: 200171, 200185, 200194, 200203, 200217, 200227, 200236, 200245, 200254, *200267*, *200280*, *200289*, *200298*, *200307*, and *200316*

Charge Spectra VS Inclination Angle

HV 200-675-200-675-200
+x tilt axis, I_B=1500A
laser tune 40%
laser rep rate 2kHz

— θ=+30°
— θ=+25°
— θ=+20°
— θ=+15°
— θ=+13°
— θ=+10°
— θ=+5°
— θ=0°
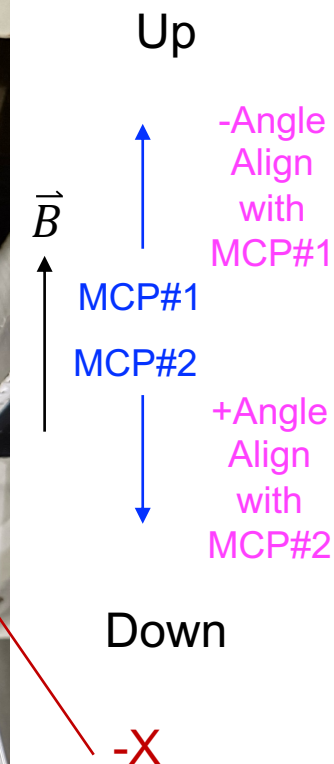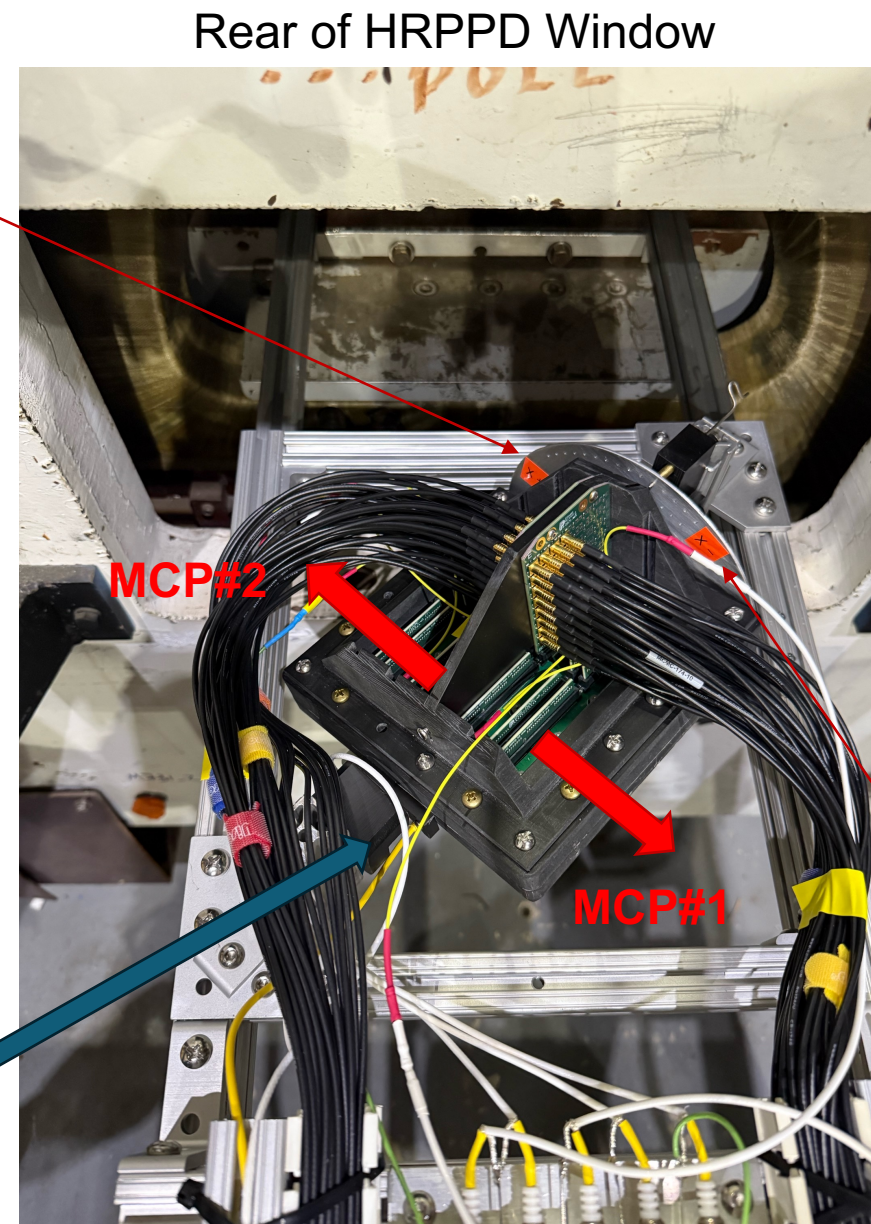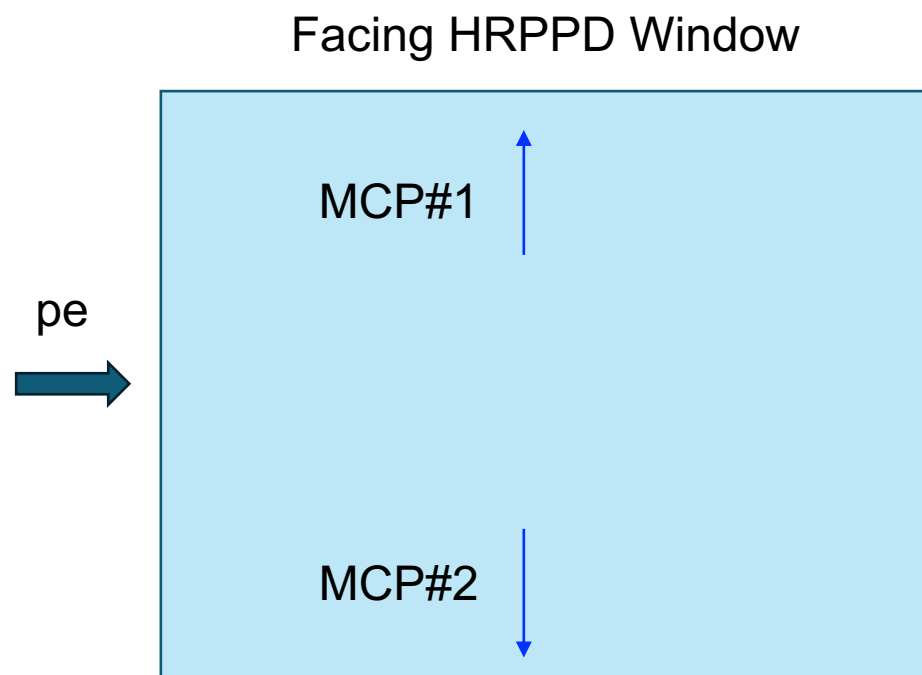
Events

ΣCharge of Major Signal Selection [fC]

- o Measured **charge spectra** with different **inclination angle** at $\vec{B}$ ~ **1.4 T**

- o **Charge calculation**:
  - o Major signal channel selection by accumulated signals

- o **Data note**:
  - o Some runs lack **laser repetition rate information**
  - o Affects angles: $\theta = \pm15°, \pm25°, \pm13°$

- o **Observation**:
  - o **13°** and **15°** exhibit trends different from other angles

- o **Conclusion**:
  - o Overall **angular dependence is weak**

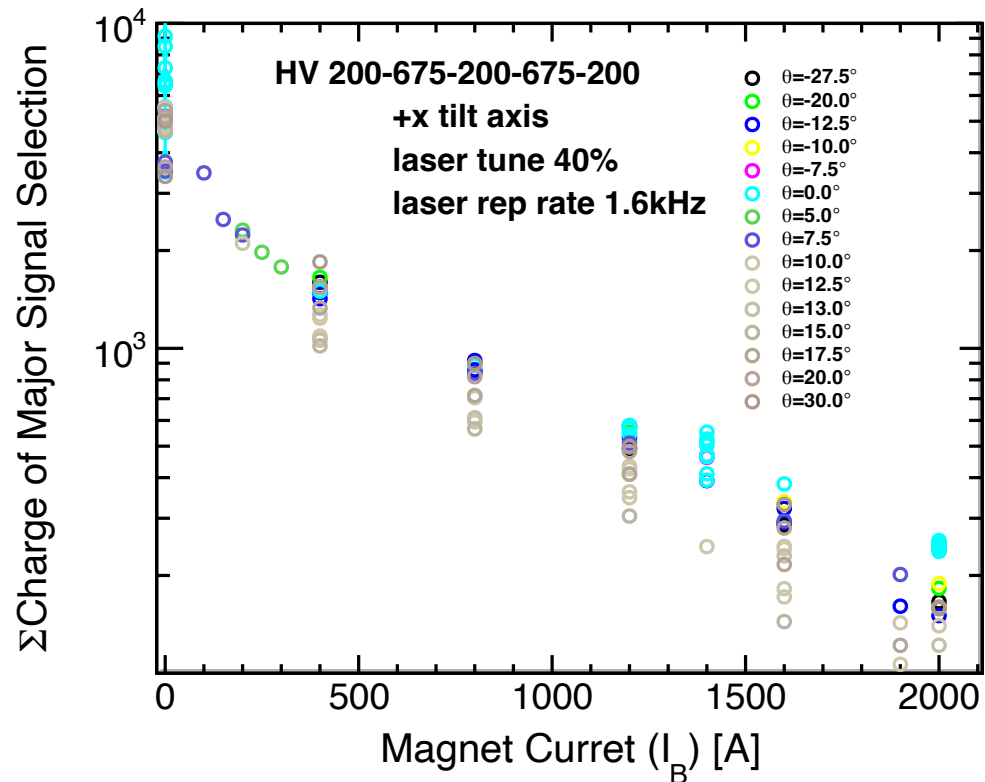Data used: 200217, 200227, 200236, 200254, *200289*, *200298*, and *200307*

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Charge Spectra VS Inclination Angle

- Measured **charge spectra** with different **inclination angle** at $\vec{B} \sim$ **1.4 T**
- **Charge calculation**:
  - Major signal channel selection by accumulated signals
- **Data note**:
  - Some runs lack **laser repetition rate information**
  - Affects angles: $\theta = \pm15°, \pm25°, \pm13°$
- **Observation**:
  - Overall **consistent trend** across angles
- **Conclusion**:
  - Overall **angular dependence is weak**

Data used: 200217, 200227, 200236, 200254, *200289*, *200298*, and *200307*

Sign Alignment

Facing HRPPD Window
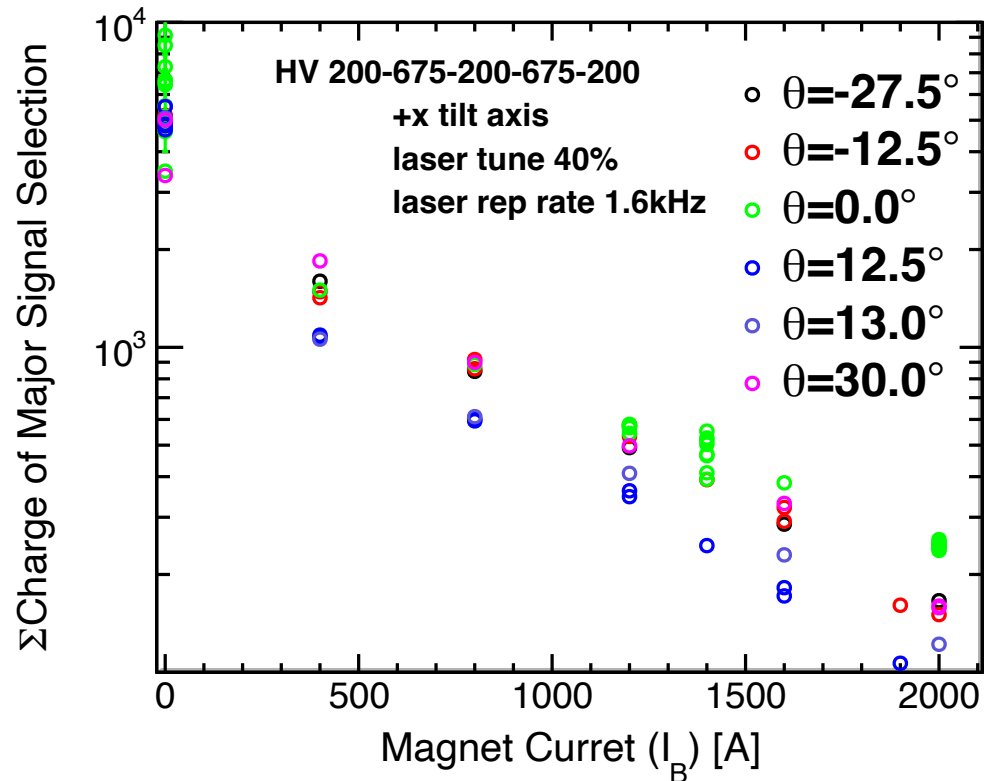
MCP#1

pe

MCP#2

Sign Alignment

Facing HRPPD Window

MCP#1

pe →

MCP#2

Rear of HRPPD Window

+X

MCP#2

MCP#1

pe

Up

$\vec{B}$

-Angle Align with MCP#1

MCP#1

MCP#2

+Angle Align with MCP#2

Down

-X

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Charge VS Magnet Current

HV 200-675-200-675-200
+x tilt axis
laser tune 40%
laser rep rate 1.6kHz

θ=-27.5°
θ=-20.0°
θ=-12.5°
θ=-10.0°
θ=-7.5°
θ=0.0°
θ=5.0°
θ=7.5°
θ=10.0°
θ=12.5°
θ=13.0°
θ=15.0°
θ=17.5°
θ=20.0°
θ=30.0°

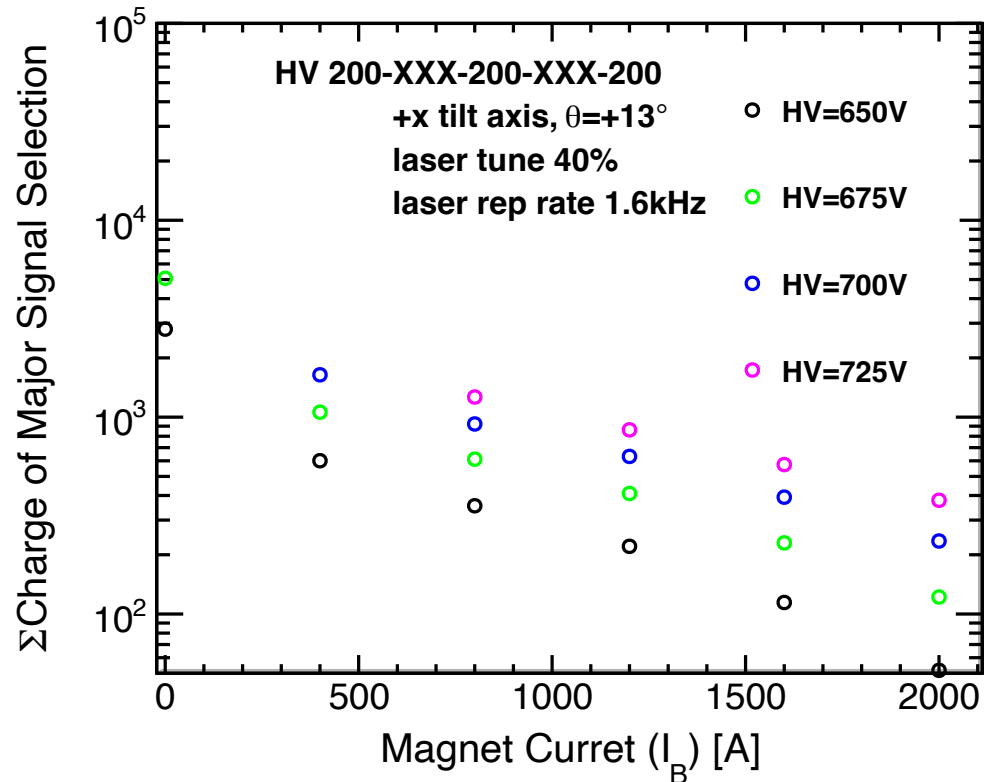ΣCharge of Major Signal Selection
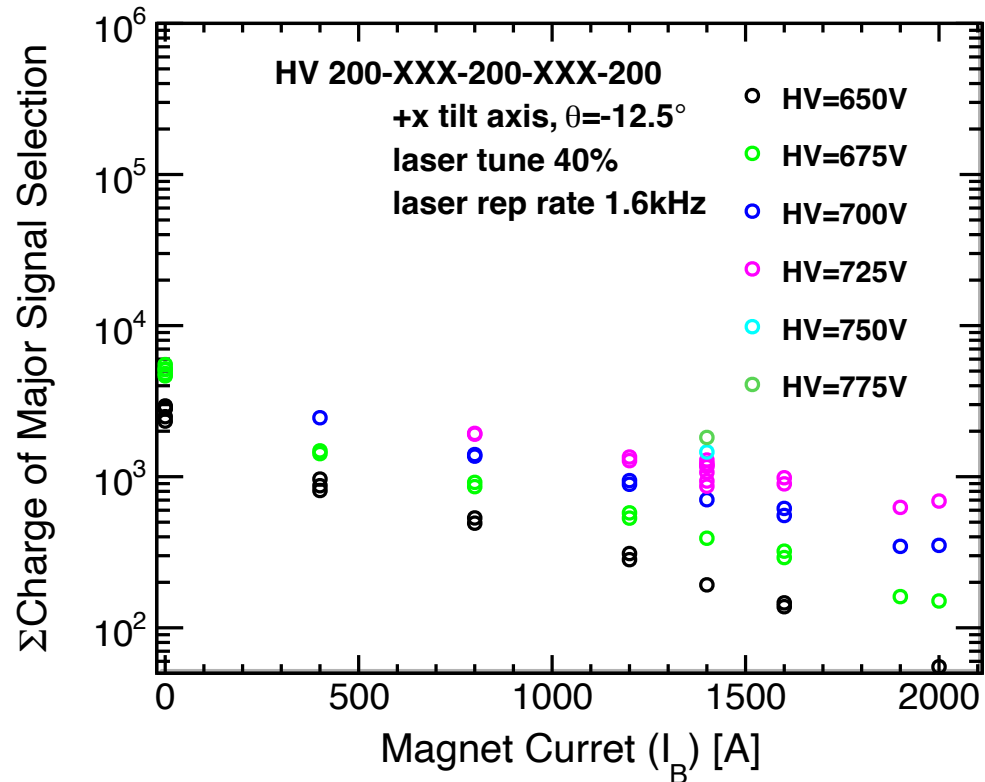
Magnet Curret (I_B) [A]

o Measured **mean charge** with different **inclination angle**

o **Charge calculation**:
  o Major signal channel selection by accumulated signals

o **Observation**:
  o Overall **follows exponential slope** across angles
  o Two distinct trends observed for **positive and negative angles**

o **Conclusion**:
  o Overall **angular dependence is weak**

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Charge VS Magnet Current

HV 200-675-200-675-200
+x tilt axis
laser tune 40%
laser rep rate 1.6kHz

θ=-27.5°
θ=-12.5°
θ=0.0°
θ=12.5°
θ=13.0°
θ=30.0°

ΣCharge of Major Signal Selection

Magnet Curret (I_B) [A]

With Reduced Samples

o Measured **mean charge** with different **inclination angle**

o **Charge calculation**:
   o Major signal channel selection by accumulated signals

o **Observation**:
   o Overall **follows exponential slope** across angles
   o Two distinct trends observed for **positive and negative angles**

o **Conclusion**:
   o Overall **angular dependence is weak**

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Charge VS Magnet Current

- Measured **mean charge** with different **bias voltage**
- **Charge calculation**:
  - Major signal channel selection by accumulated signals
- **Data note**:
  - Inclination angle at 0°
- **Observation**:
  - Mean charge reduces as higher magnet current
  - Mean charge increases as higher bias voltage
- **Conclusion**:
 - Gain partially recovered by **increasing bias voltage**

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Charge VS Magnet Current

- Measured **mean charge** with different **bias voltage**
- **Charge calculation**:
  - Major signal channel selection by accumulated signals
- **Data note**:
  - Inclination angle at +13°
- **Observation**:
  - Mean charge reduces as higher magnet current
  - Mean charge increases as higher bias voltage
- **Conclusion**:
  - Gain partially recovered by **increasing bias voltage**

Charge VS Magnet Current

o Measured **mean charge** with different **bias voltage**

o **Charge calculation**:
  - o Major signal channel selection by accumulated signals

o **Data note**:
  - o Inclination angle at $-12.5°$

o **Observation**:
  - o Mean charge reduces as higher magnet current
  - o Mean charge increases as higher bias voltage

o **Conclusion**:
  - o Gain partially recovered by **increasing bias voltage**

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Accumulated Waveforms at I_B = 400 A

+x title axis, $\theta = -12.5°$, laser tune 40 %, laser rep rate 1.6 kHz
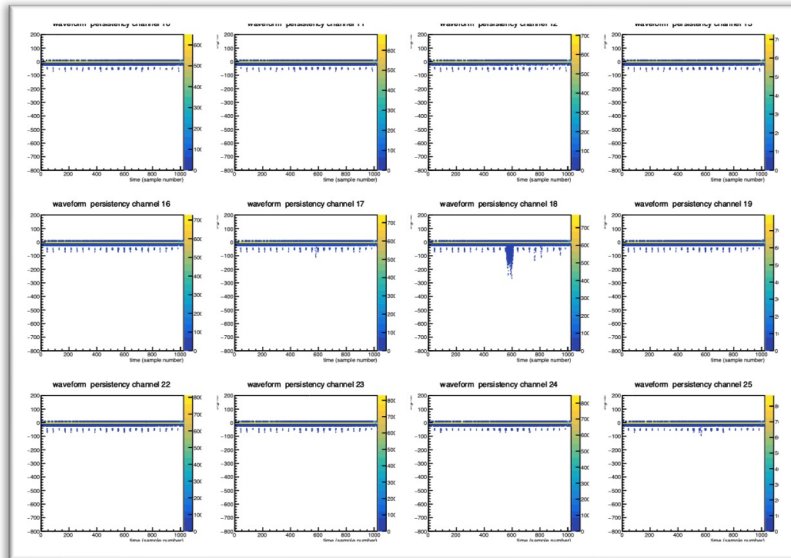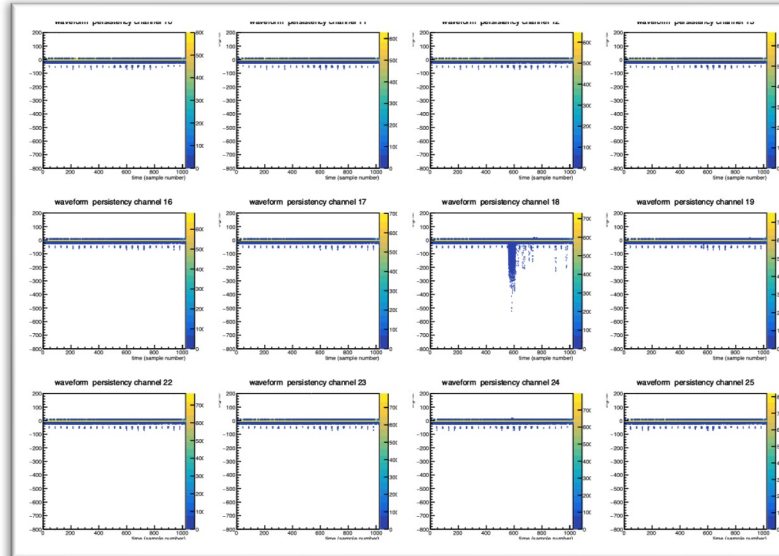
HV 200-**650**-200-**650**-200   HV 200-**675**-200-**675**-200   HV 200-**700**-200-**700**-200
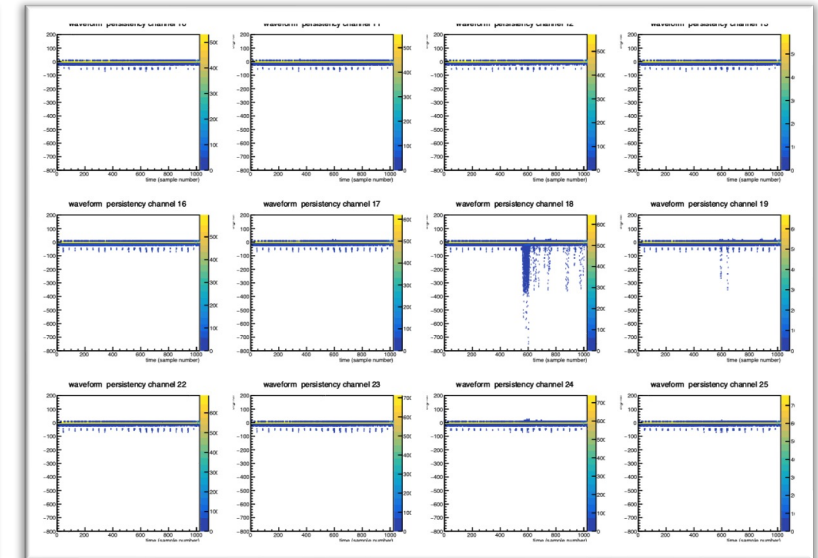
Primary signal channel is 18 and an increase in MCP bias voltage leads to more pronounced afterpulses and higher signal amplitude
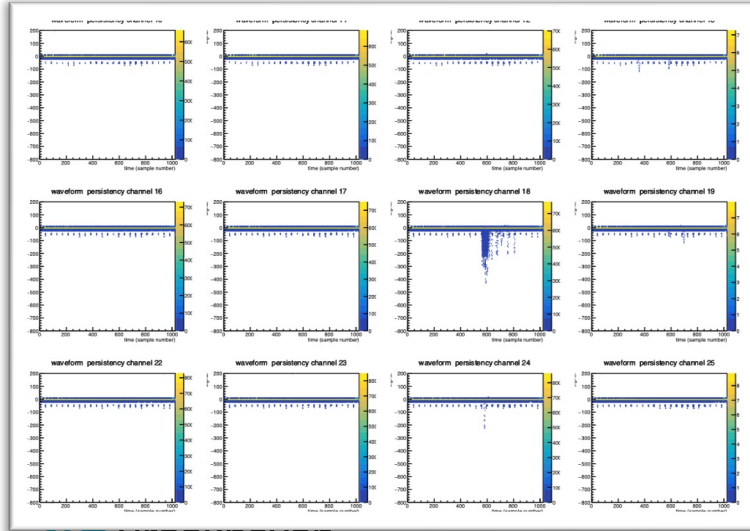
Data used: 200938, 200939, and 200940

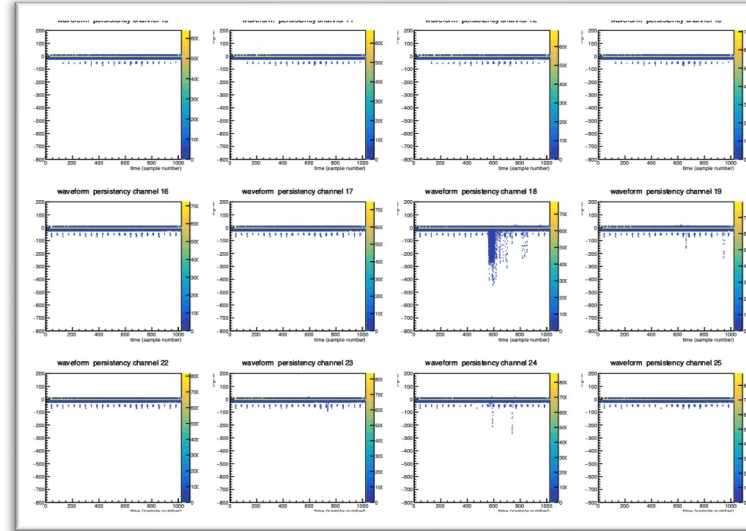# Accumulated Waveforms at $I_B = 800$ A

HV 200-**650**-200-**650**-200
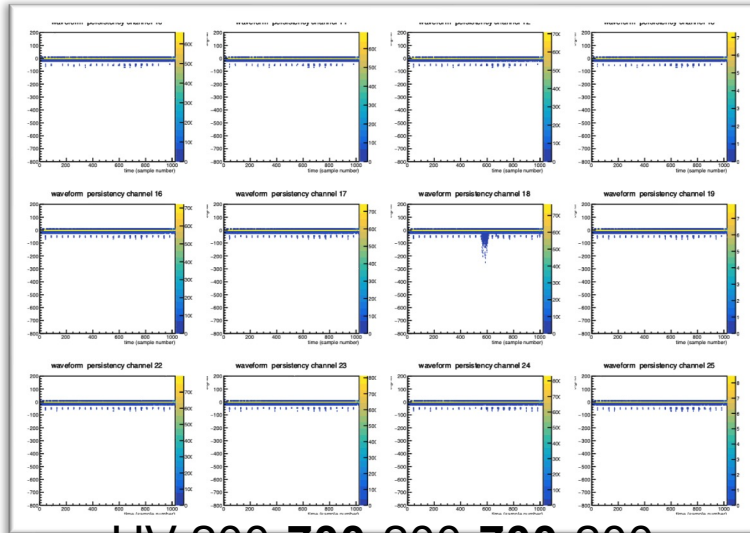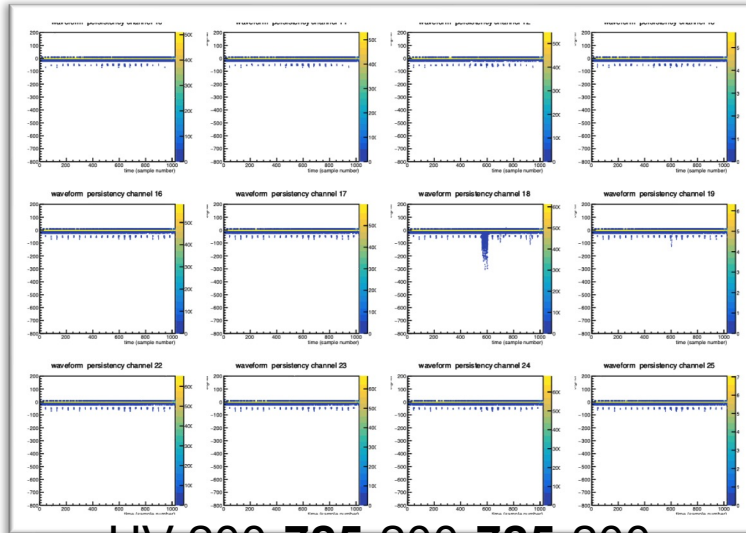
HV 200-**675**-200-**675**-200

HV 200-**700**-200-**700**-200

HV 200-**725**-200-**725**-200

+x title axis, $\theta = -12.5°$,
laser tune 40 %,
laser rep rate 1.6 kHz

Primary signal channel is 18 and an increase in MCP bias voltage leads to more pronounced afterpulses and higher signal amplitude
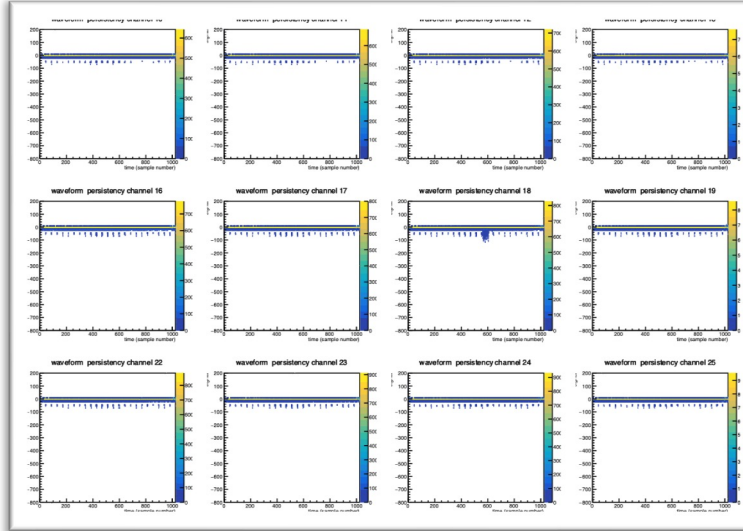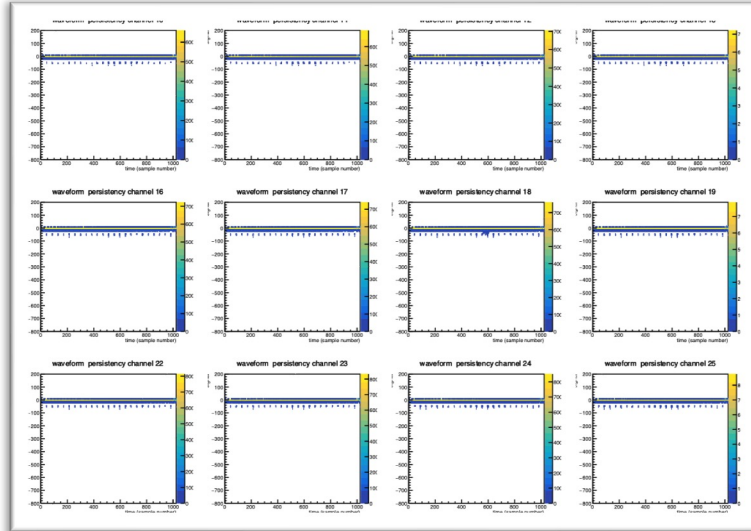
Data used: 200941, 200942, 200943, and 200944

Accumulated Waveforms at I_B = 1600 A
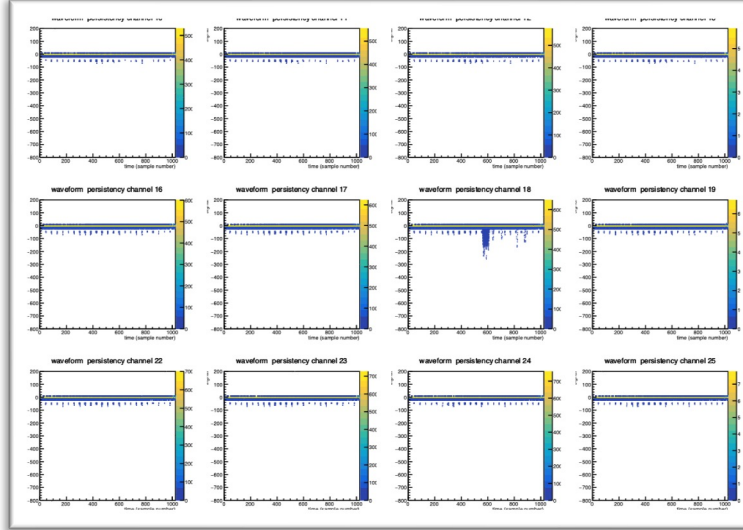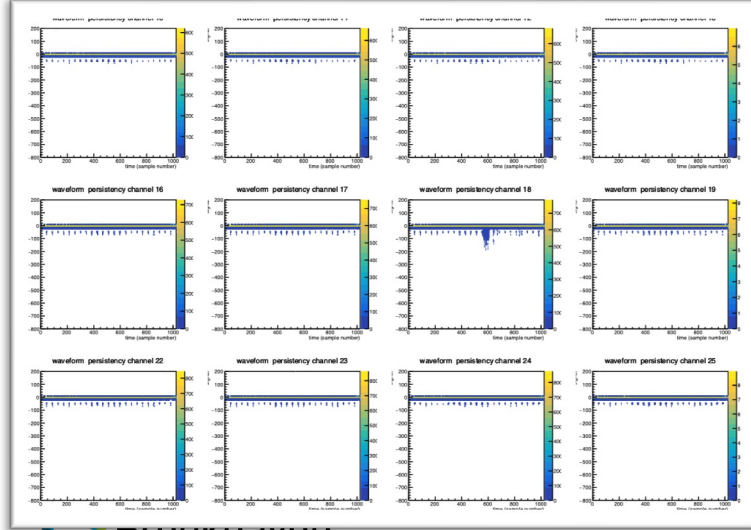
HV 200-**650**-200-**650**-200

HV 200-**675**-200-**675**-200

HV 200-**700**-200-**700**-200

HV 200-**725**-200-**725**-200

+x title axis, $\theta = -12.5°$,
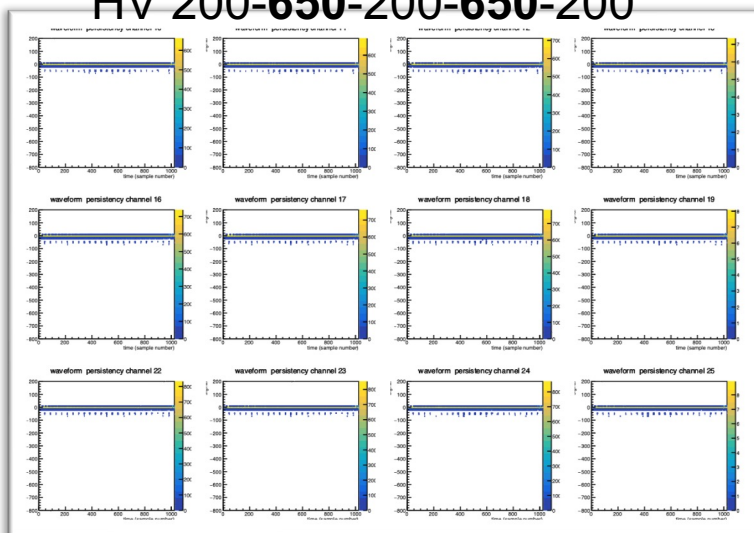laser tune 40 %,
laser rep rate 1.6 kHz

Primary signal channel is 18 and an increase in MCP bias voltage leads to more pronounced afterpulses and higher signal amplitude

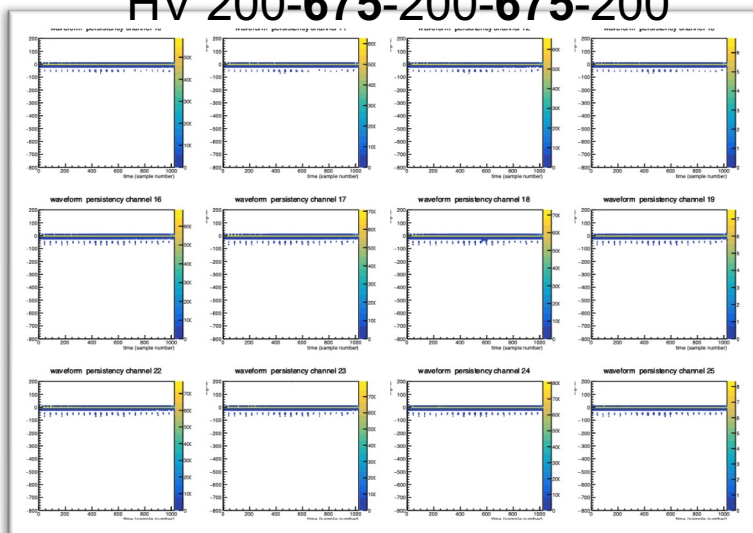Higher magnetic field strength results in fewer afterpulses

Data used: 200952, 200953, 200954, and 200955

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Accumulated Waveforms at I_B = 1900 A
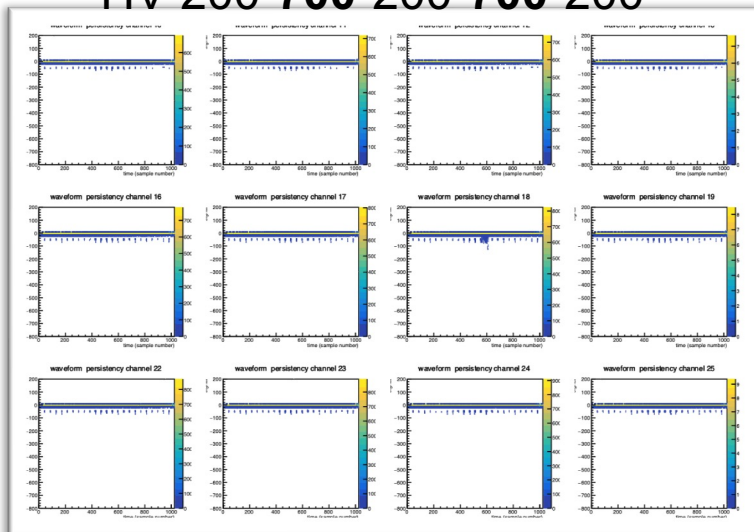
HV 200-**650**-200-**650**-200

HV 200-**675**-200-**675**-200

HV 200-**700**-200-**700**-200

HV 200-**725**-200-**725**-200

+x title axis, $\theta = -12.5°$,
laser tune 40 %,
laser rep rate 1.6 kHz
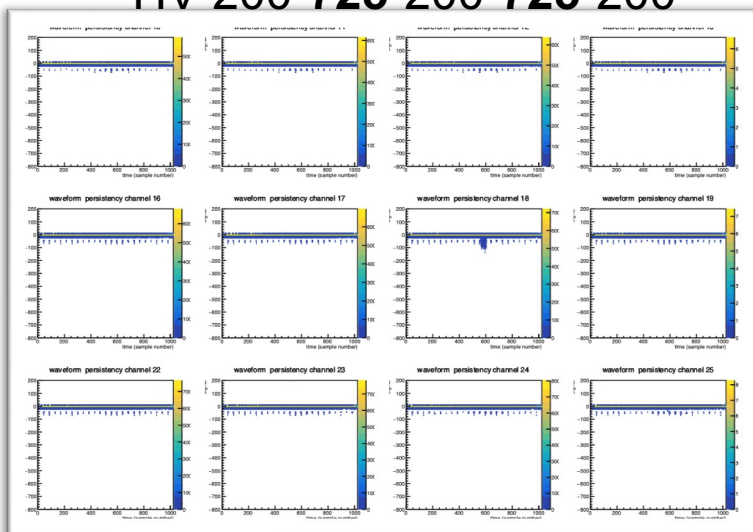
Primary signal channel is 18 and an increase in MCP bias voltage leads to more pronounced afterpulses and higher signal amplitude

Higher magnetic field strength results in fewer afterpulses

Data used: 201451, 201452, 201453, and 201454

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Accumulated Waveforms at I_B = 2000 A

HV 200-**650**-200-**650**-200

HV 200-**675**-200-**675**-200

HV 200-**700**-200-**700**-200

HV 200-**725**-200-**725**-200

+x title axis, $\theta = -12.5°$,
laser tune 40 %,
laser rep rate 1.6 kHz
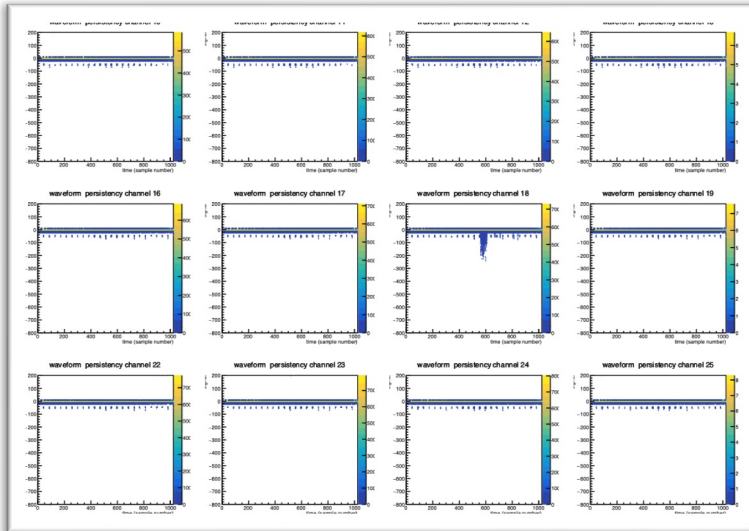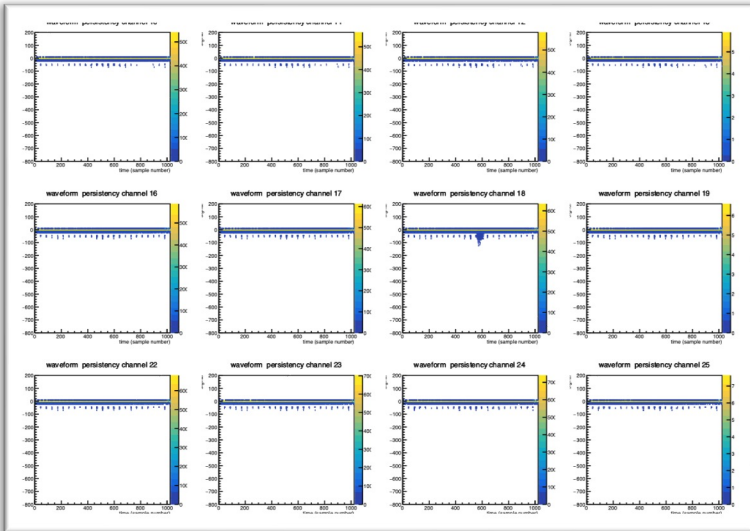
Primary signal channel is 18 and an increase in MCP bias voltage leads to more pronounced afterpulses and higher signal amplitude
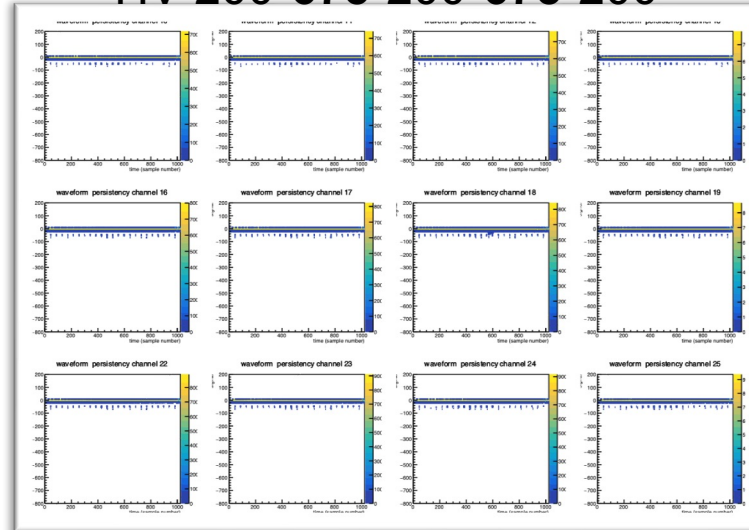
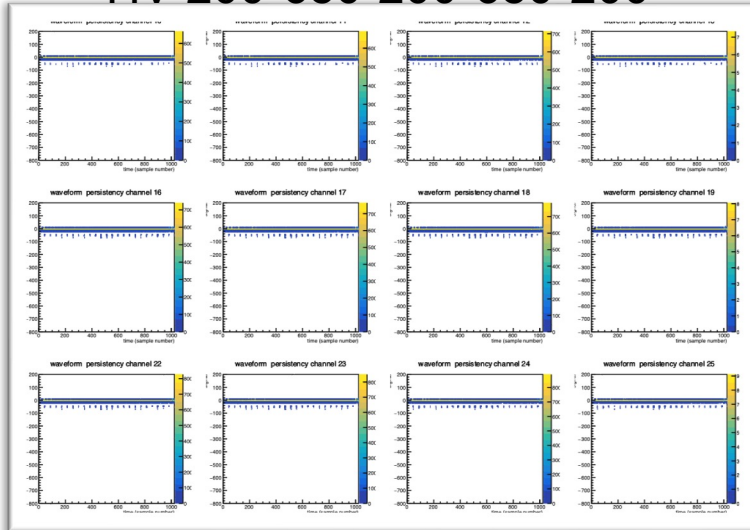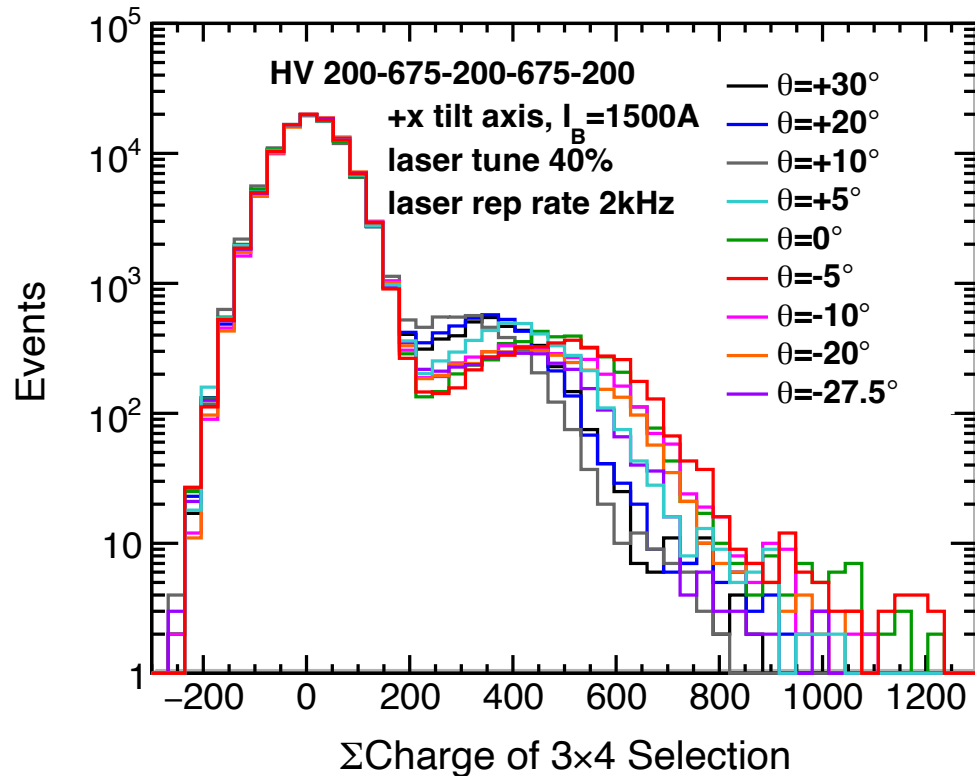Higher magnetic field strength results in fewer afterpulses

Data used: 200956, 200957, 200958, and 200959

To-Do List

o Convert mean charge to gain

  o 160 fC ~ Gain of 10^6

o Verify sign alignment with MCP #1 and #2

  o Cross-check with MCP#1 (top) and MCP#2 (bottom) using recorded photos

o Apply an exponential fit to mean charge (gain) versus magnet current

o Identify runs with significant dark current

  o Compare behavior across different bias voltages

o Review current mean charge extraction method

  o Based on combined 1-photon and 2-photon contributions (first-order approximation acceptable)

  o Develop a weighted mean charge method: Aim to isolate and extract 1-photon mode

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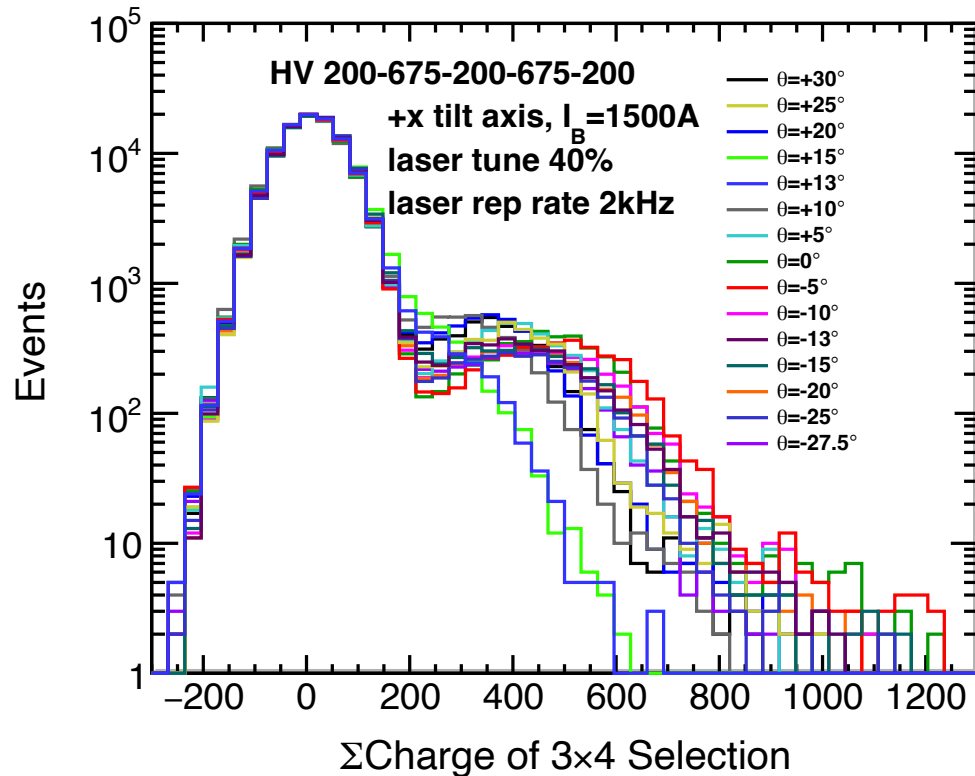National Laboratory

Backup Slides

Charge Spectra VS Inclination Angle

o Measured **charge spectra** with different **inclination angle**

o **Charge calculation**:
  - o 3×4 channel selection
  - o Channels: 10-13, 16-19, 22-25

o **Observation**:
  - o At fixed magnetic field, charge shows **weak angular dependence**
  - o Two distinct trends observed for **positive and negative angles**

o **Conclusion**:
  - o Overall **angular dependence is weak**

Data used: 200171, 200185, 200194, 200203, 200217, 200227, 200236, 200245, and 200254

Charge Spectra VS Inclination Angle

HV 200-675-200-675-200
+x tilt axis, I_B=1500A
laser tune 40%
laser rep rate 2kHz

θ=+30°
θ=+25°
θ=+20°
θ=+15°
θ=+13°
θ=+10°
θ=+5°
θ=0°
θ=-5°
θ=-10°
θ=-13°
θ=-15°
θ=-20°
θ=-25°
θ=-27.5°

Events

ΣCharge of 3×4 Selection

o Measured **charge spectra** with different **inclination angle**

o **Charge calculation**:
  - o 3×4 channel selection
  - o Channels: 10-13, 16-19, 22-25

o **Data note**:
  - o Some runs lack **laser repetition rate information**
  - o Affects angles: $\theta = \pm15°, \pm25°, \pm13°$

o **Observation**:
  - o 13° and 15° exhibit trends different from other angles

o **Conclusion**:
  - o Overall **angular dependence is weak**

Data used: 200171, 200185, 200194, 200203, 200217, 200227, 200236, 200245, 200254, *200267*, *200280*, *200289*, *200298*, *200307*, and *200316*

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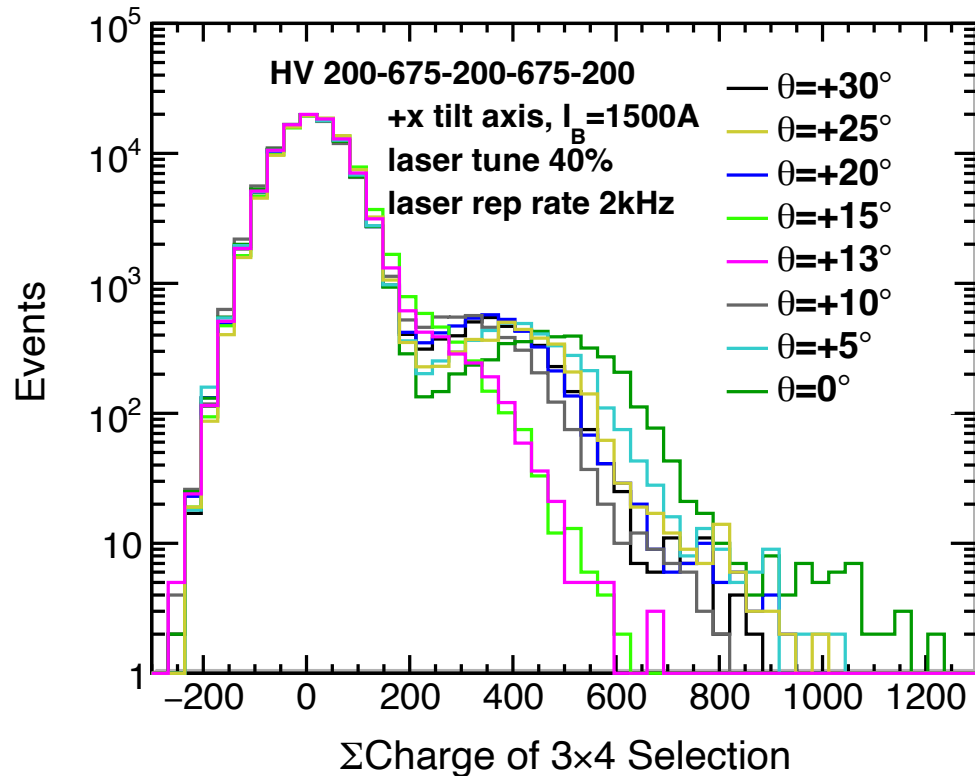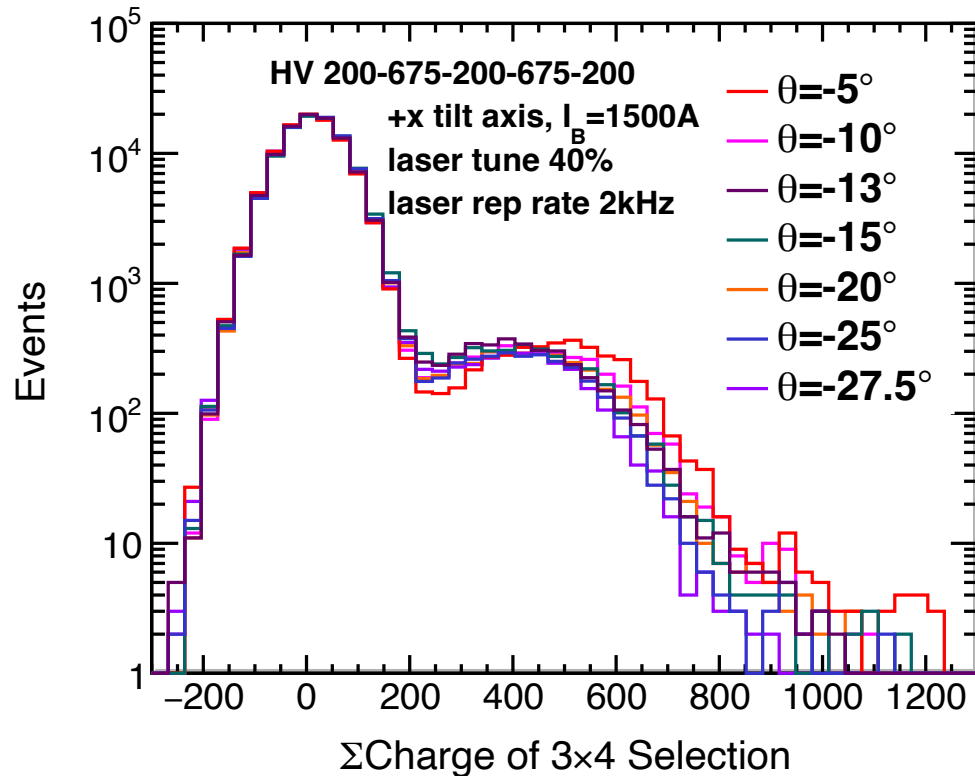Brookhaven
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Charge Spectra VS Inclination Angle

o Measured **charge spectra** with different **inclination angle**

o **Charge calculation**:
   o 3×4 channel selection
   o Channels: 10-13, 16-19, 22-25

o **Data note**:
   o Some runs lack **laser repetition rate information**
   o Affects angles: $\theta = \pm 15°, \pm 25°, \pm 13°$

o **Observation**:
   o 13° and 15° exhibit trends different from other angles

o **Conclusion**:
   o Overall **angular dependence is weak**

Data used: 200171, 200185, 200194, 200203, 200245, *200267*, *200280*, and *200316*

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Charge Spectra VS Inclination Angle

- Measured **charge spectra** with different **inclination angle**

- **Charge calculation**:
  - 3×4 channel selection
  - Channels: 10-13, 16-19, 22-25

- **Data note**:
  - Some runs lack **laser repetition rate information**
  - Affects angles: $\theta = \pm 15°, \pm 25°, \pm 13°$

- **Observation**:
  - Overall **consistent trend** across angles

- **Conclusion**:
  - Overall **angular dependence is weak**

Data used: 200217, 200227, 200236, 200254, *200289*, *200298*, and *200307*