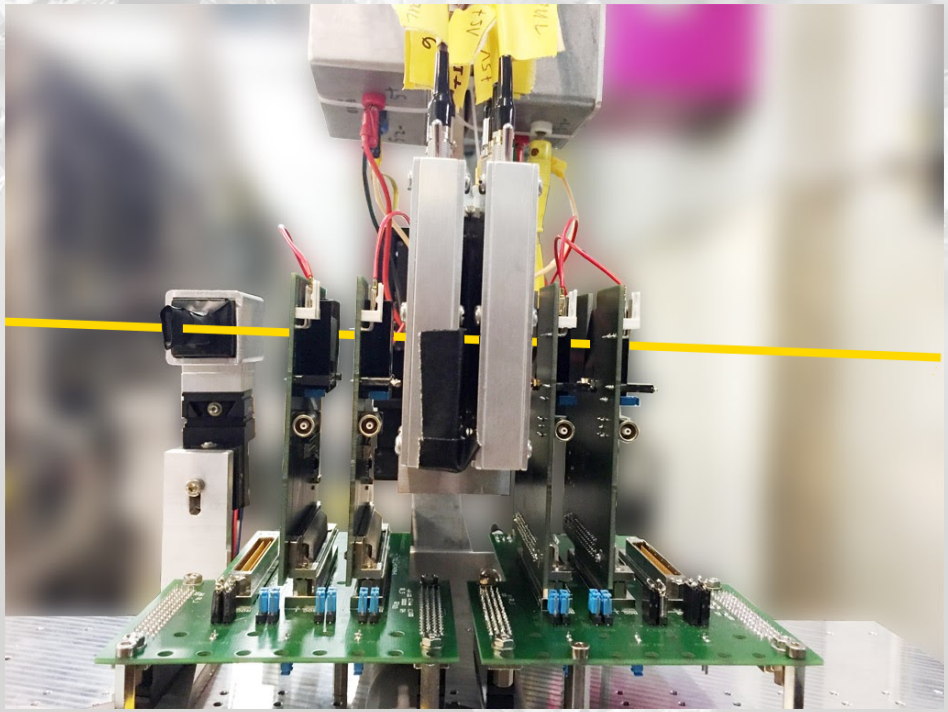

Results of High Rate Tests of Diamond Pad Detectors at PSI

Michael Reichmann

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Section 1

Introduction

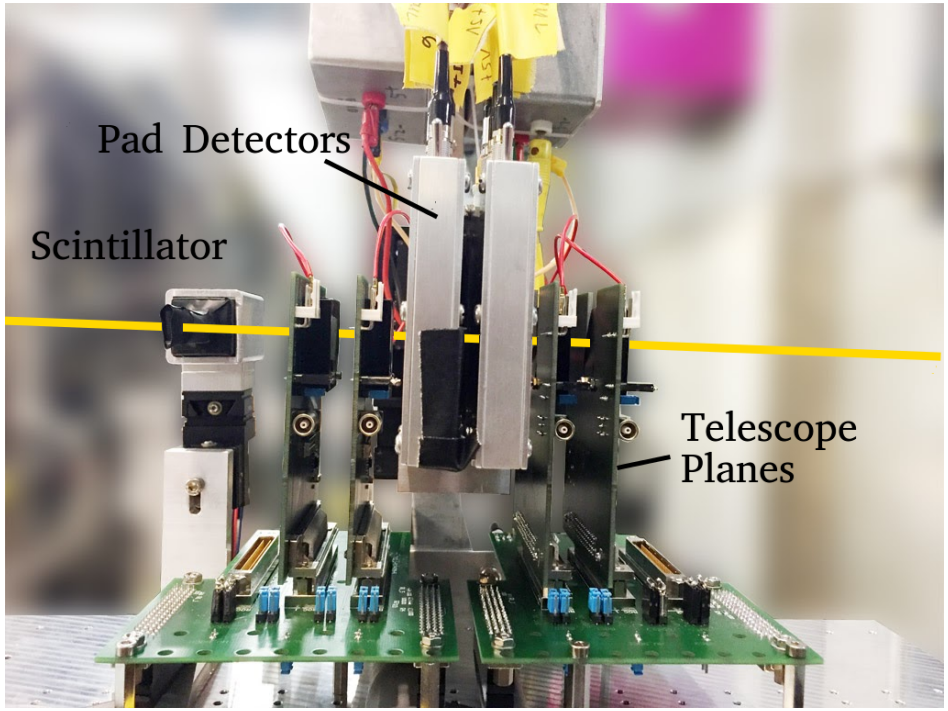
Goals of the beam test in August 2016:

- commissioning of the new setup ($\rightarrow$ Christians talk)
- confirming previous results $\rightarrow$ reproducibility
- investigating the high rate behaviour of higher irradiated diamonds
- testing a silicon diode as pad detector as reference

Measurements:

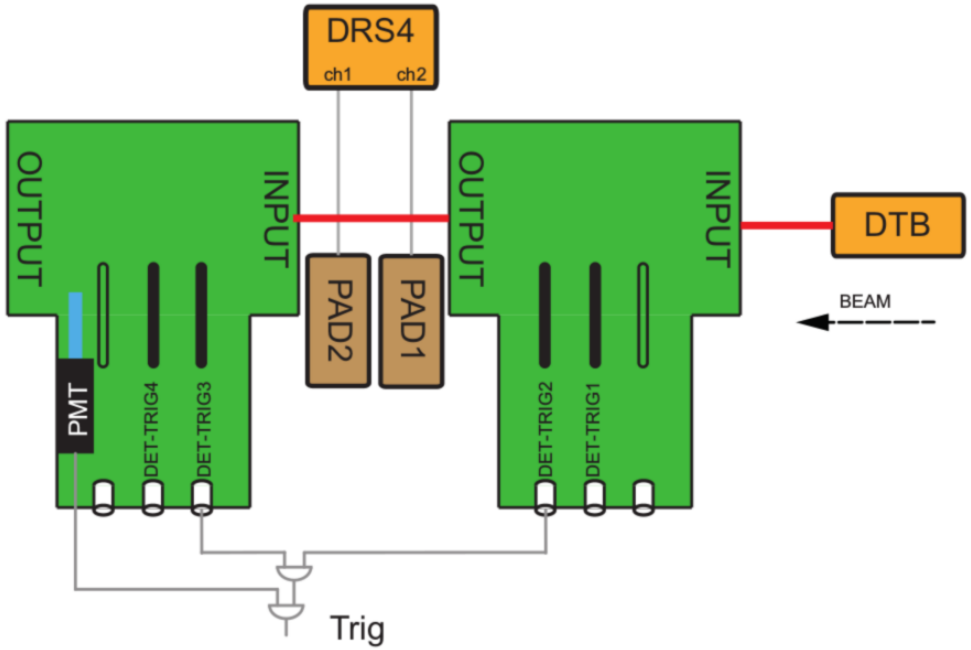
- tests of several diamond pad detectors and a silicon diode with a 260 Mev/c pion beam at Paul Scherrer Institute (PSI)
- sizes:
  - diamonds $\approx 5\,\text{mm} \times 5\,\text{mm}$
  - Si diode $1.71\,\text{mm} \times 1.23\,\text{mm}$
- irradiations: up to $1 \cdot 10^{15}$ neutrons/cm^2
- diamond brands:
  - Element Six (single and poly-crystal)
  - II-IV Inc. (poly-crystal
- flux range: from 1 kHz/cm^2 up to 3 MHz/cm^2 (at beam line pim1)

Setup



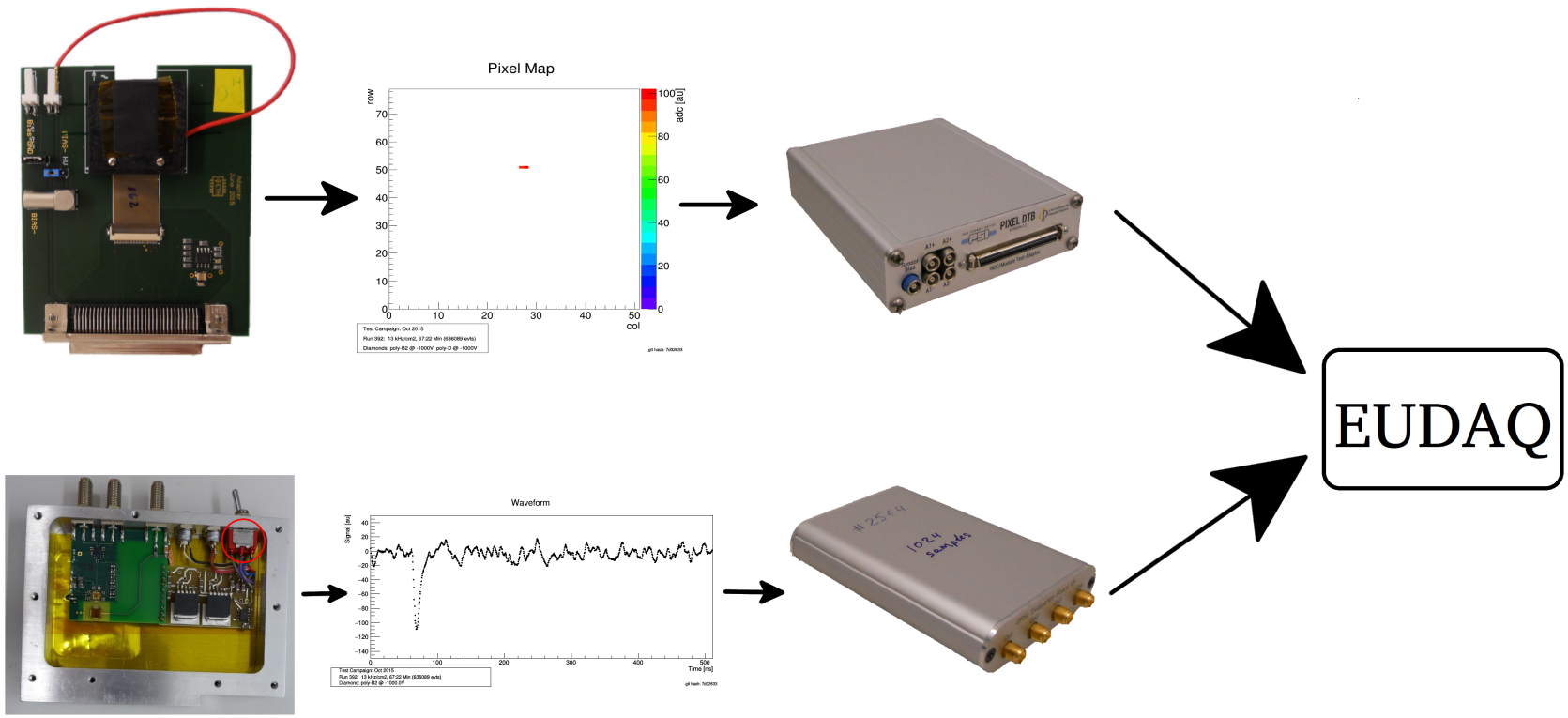
- 4 tracking planes with analogue CMS pixel chips
- 2 diamond pad detectors
- scintillator for precise trigger timing: sigma of 1.3(1) ns

Schematic Setup



- using PSI DRS4 Evaluation Board as digitizer for the pad waveforms
- using Digital Test Board (DTB) and pXar software for the telescope readout
- global trigger as coincidence of fastOR self trigger and scintillator signal
- EUDAQ as DAQ framework

DAQ

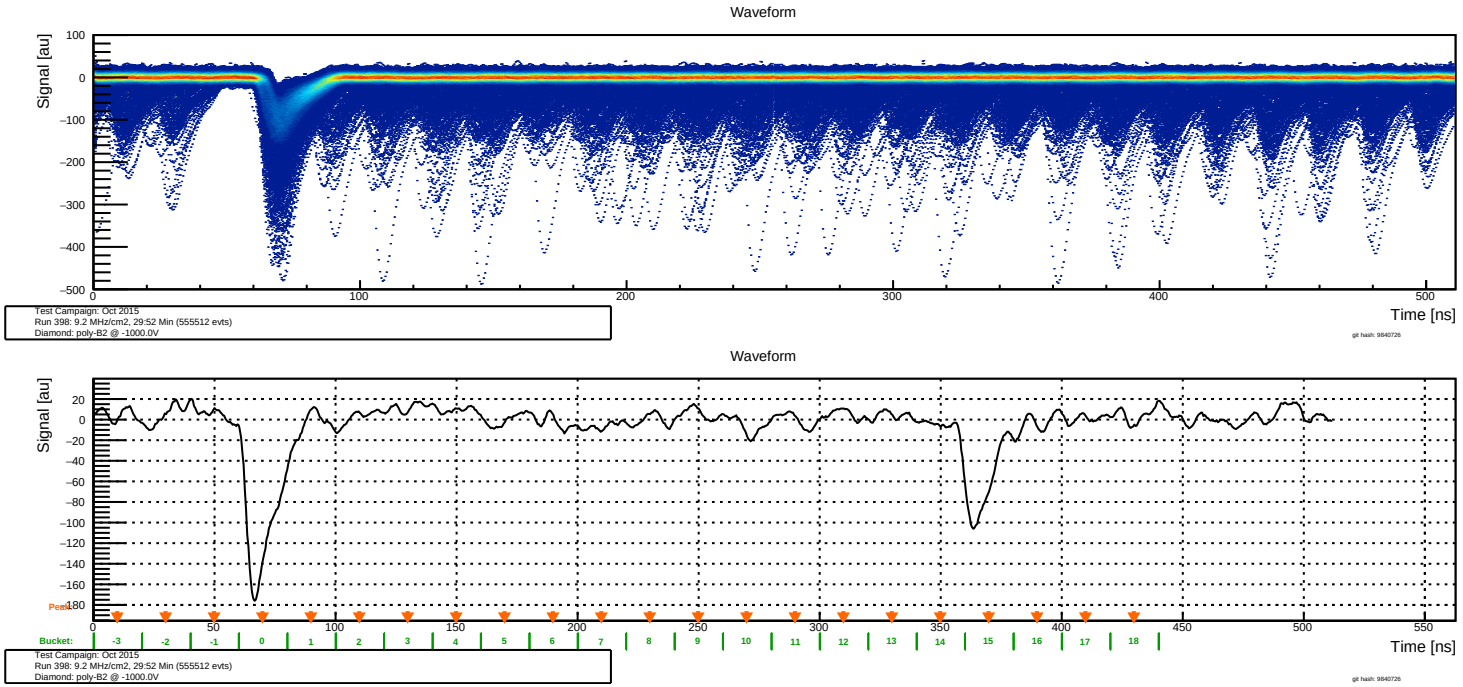


- EUDAQ saves event based data stream as binary file
- → conversion into ROOT-TTrees

Section 2

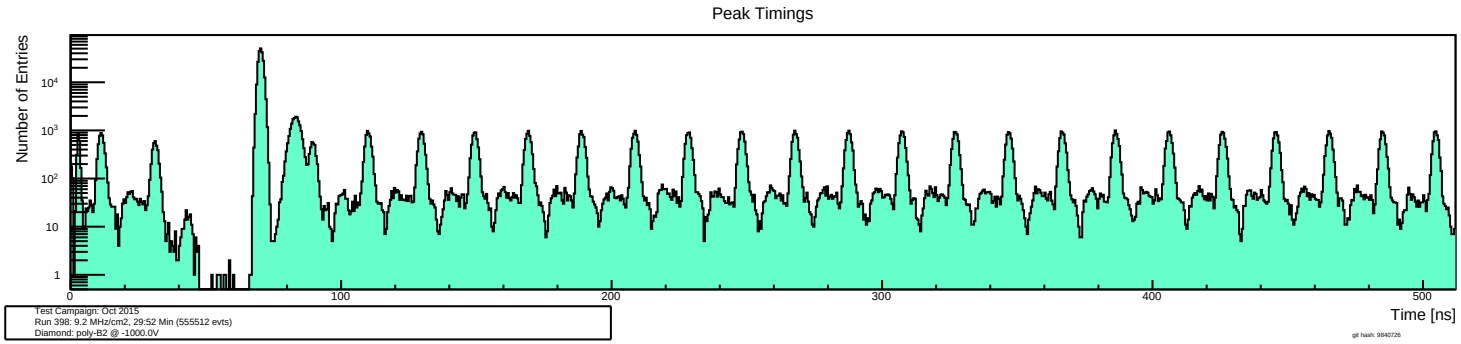
Analysis

Waveforms



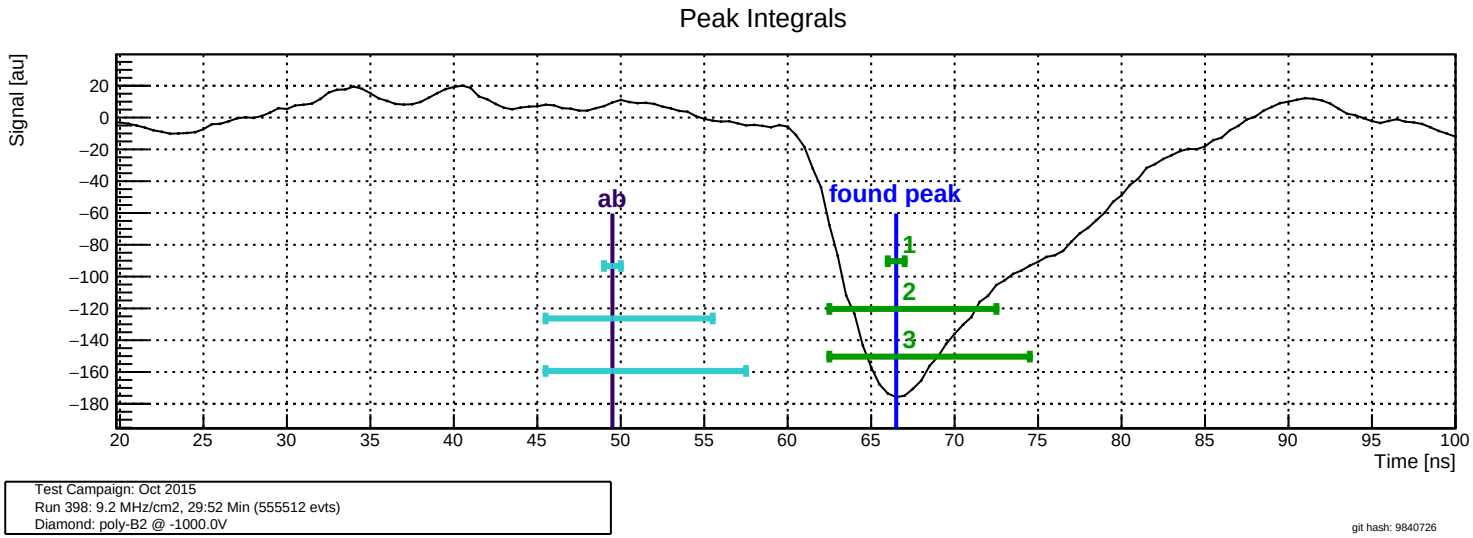
- most frequented peak: triggered signal
- other peaks signal from other bunches
- no signals in pre-signal bucket due to fastOR deadtime

Peak Positions



- determine beam structure: $\approx 19.7\,\text{ns}$ distance between the peaks
  - exactly the time distance between the bunches of the PSI beam
- approximate particle flux by the number of peaks
  - good agreement to trigger measurements

Pulse Height Calculation

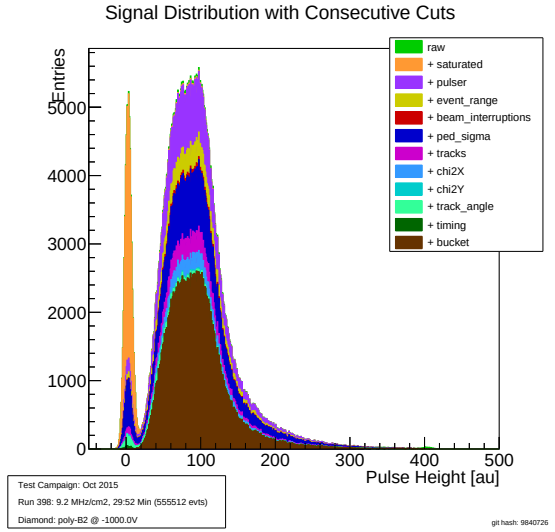


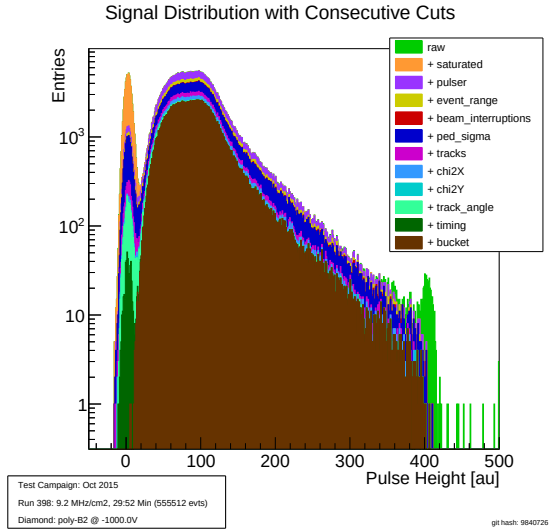
- finding the peak in the signal region
- signal integral
  - waveform in a fixed time window around the peak
- pedestal (base line) integral
  - integration of the bucket before the peak with the same size
- window optimised to highest SNR (Integral / Pedestal Sigma)
- integral subtracted by pedestal value

Event Cuts

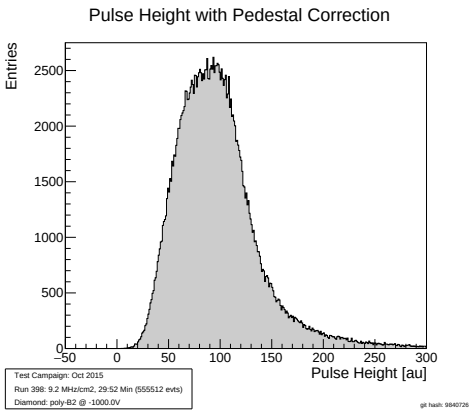
Exclude events:

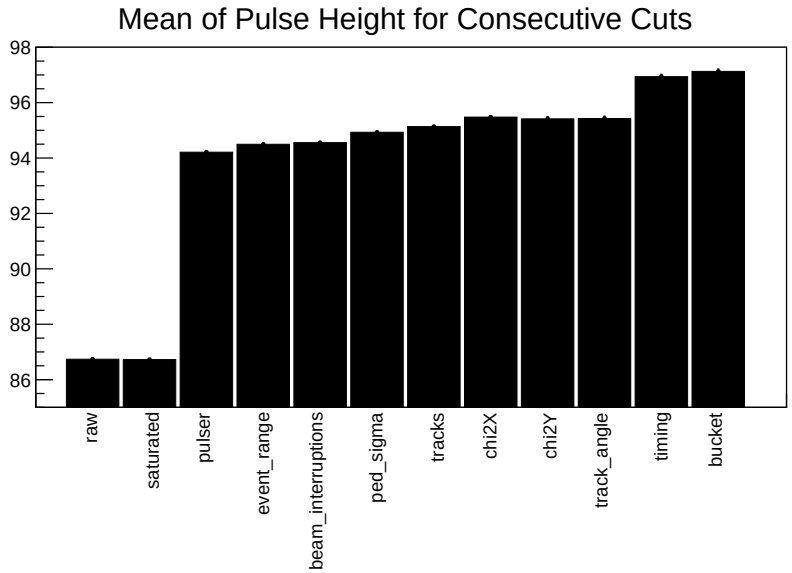
- saturated: with saturated waveforms
- pulser: reference events
- event_range: first five minutes
- beam_interrupts: beam is down
- ped_sigma: uncommon pedestal events (outside 3 sigma)
- tracks: with incomplete tracks
- chi2: bad track fits
  - 90% quantile in x and y
- track_angle: too large track angles
  - abs(2 deg)
- timing: not within 4 sigma of peak timing
- bucket: signal in wrong bucket



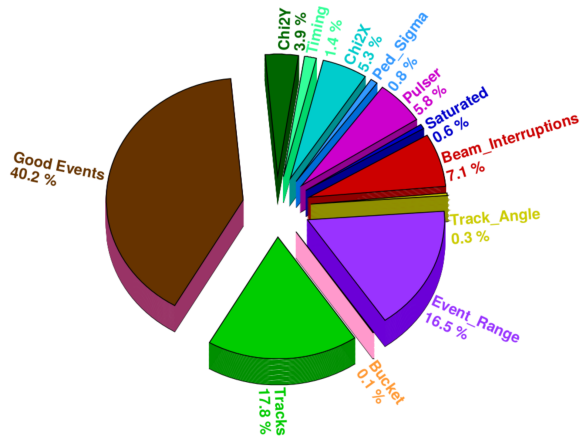


Pulse Height Distribution

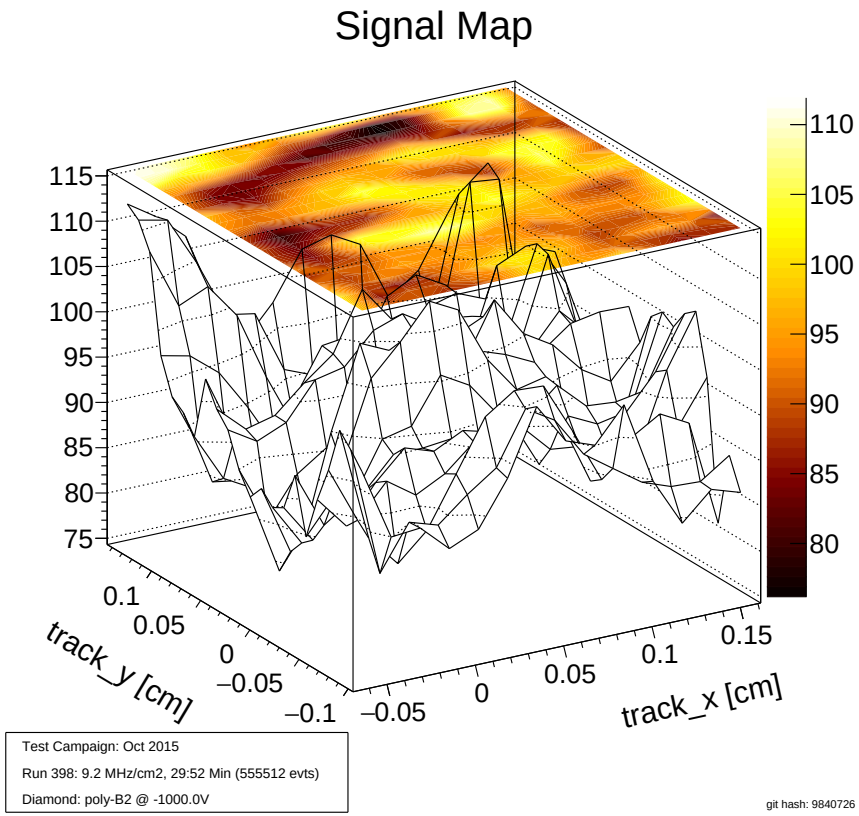




- pedestal is completely gone after application of the cuts
- wide Landau due to polycrystalline diamonds
- mean of the pulse height increases significantly due to cuts (pedestal goes away)



Signal Map

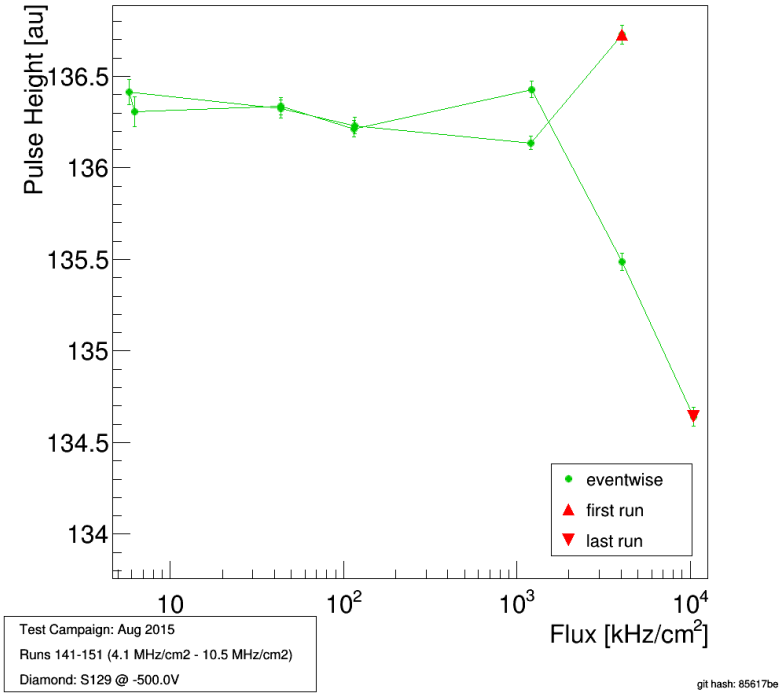


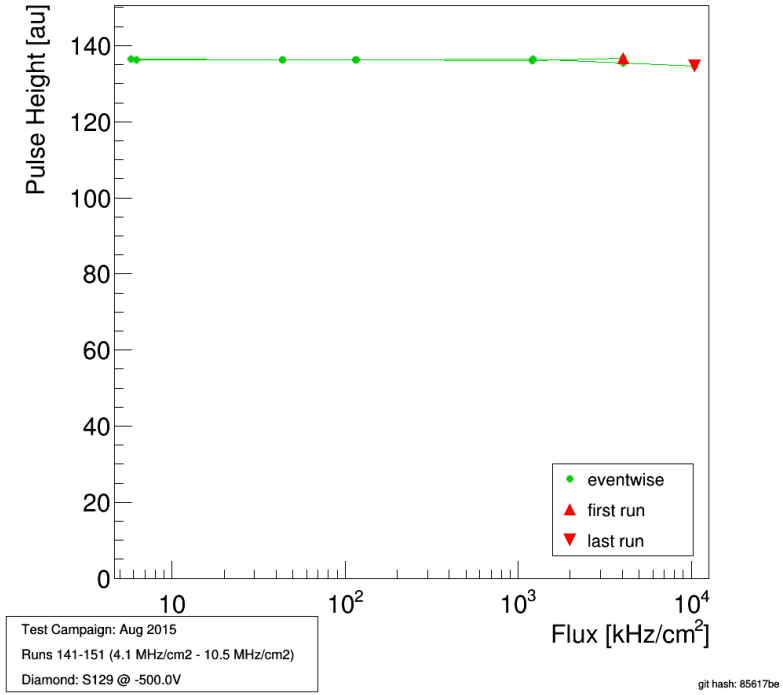
- different regions inside the diamond yield different average pulse heights
- does not change with rate or time

Section 3

Results

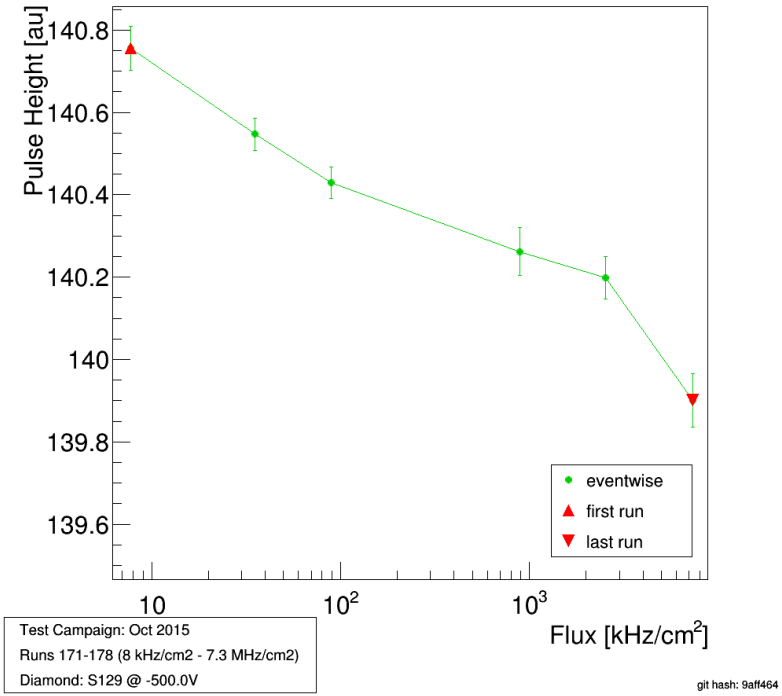
+500 V August - unirradiated

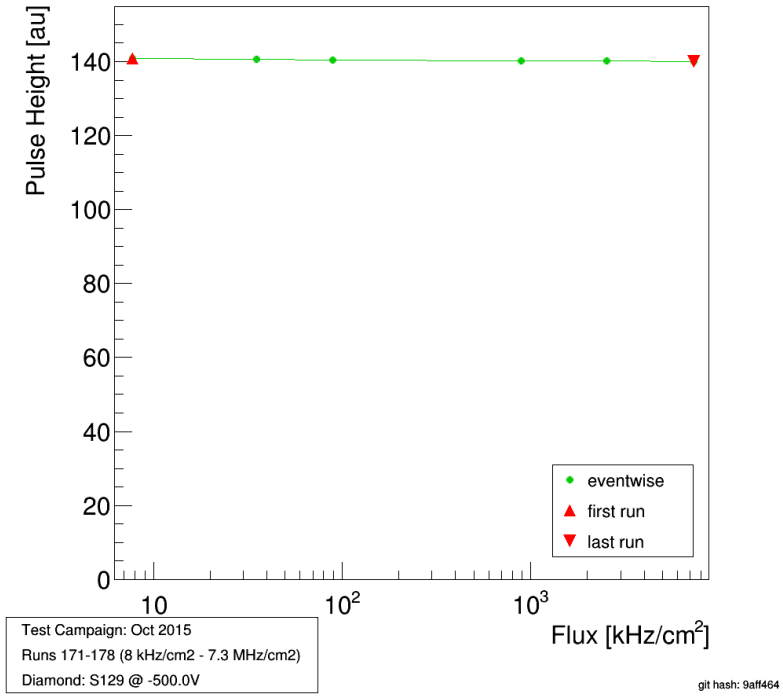




- amplifier issues during the last two runs

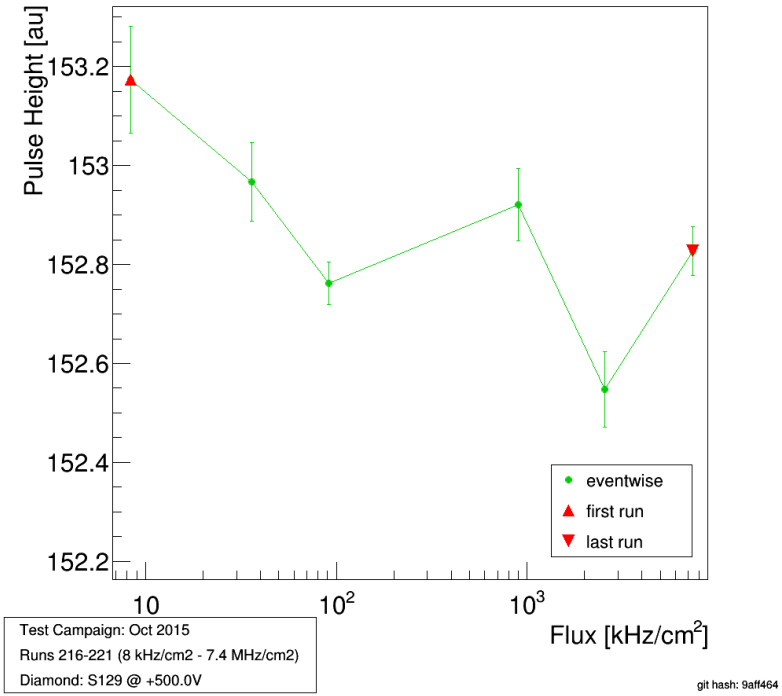
−500 V October - unirradiated

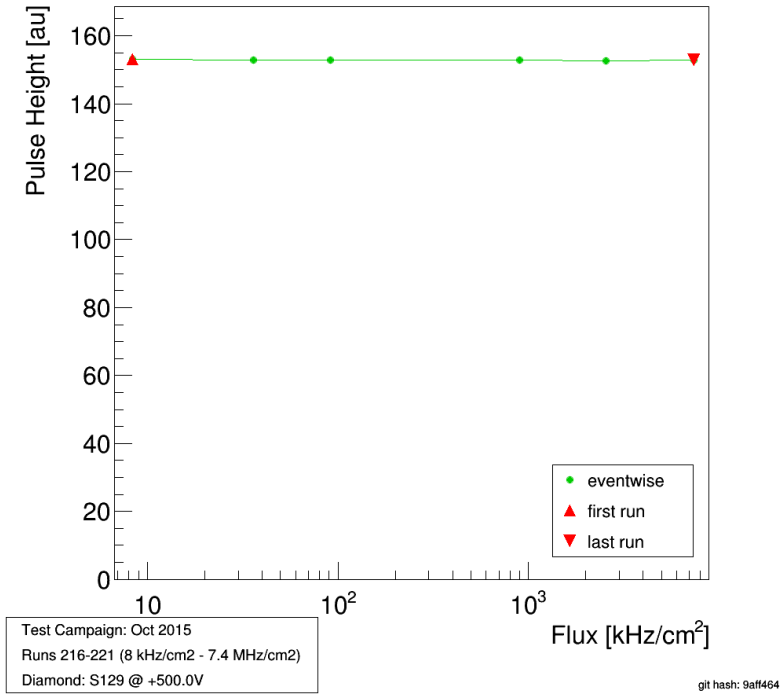




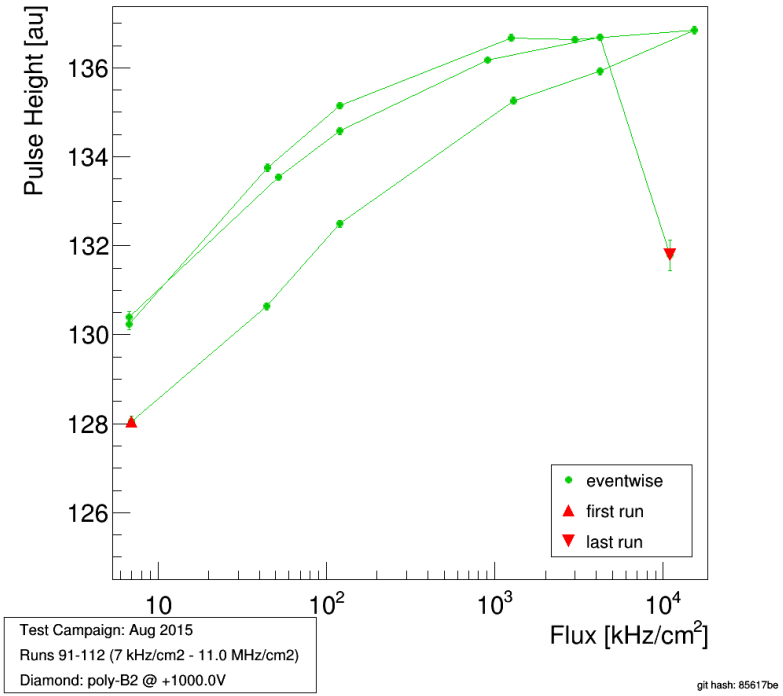
S129 (Element Six - single crystal)

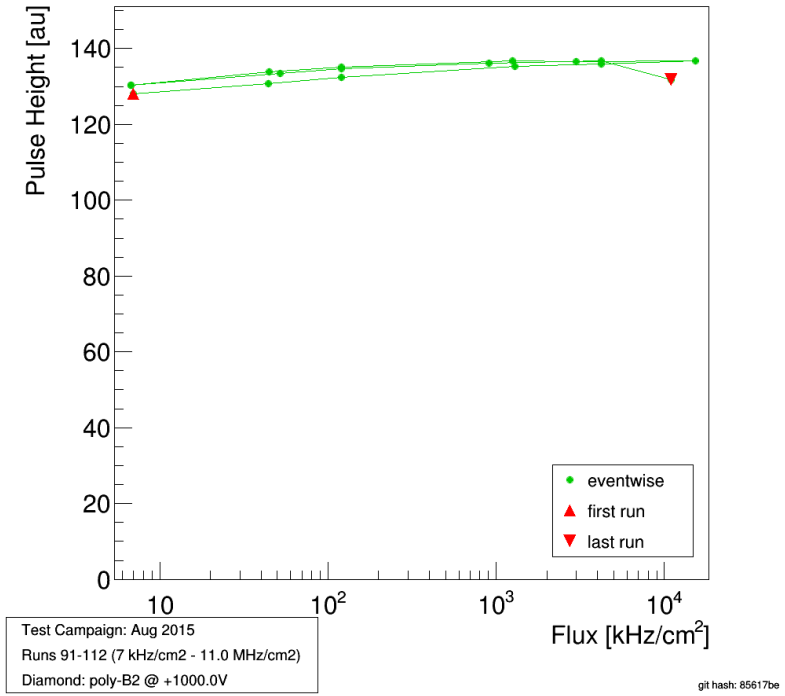
+500 V October - unirradiated



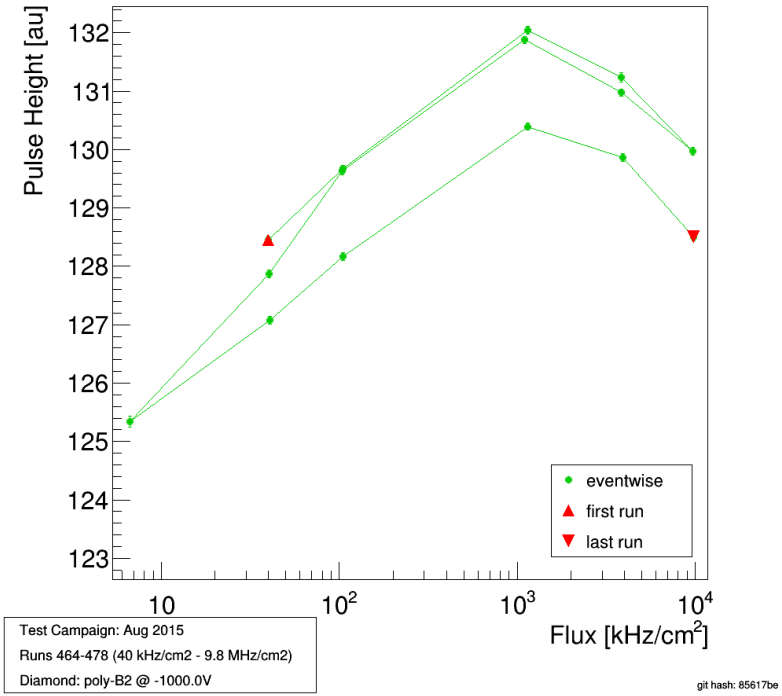


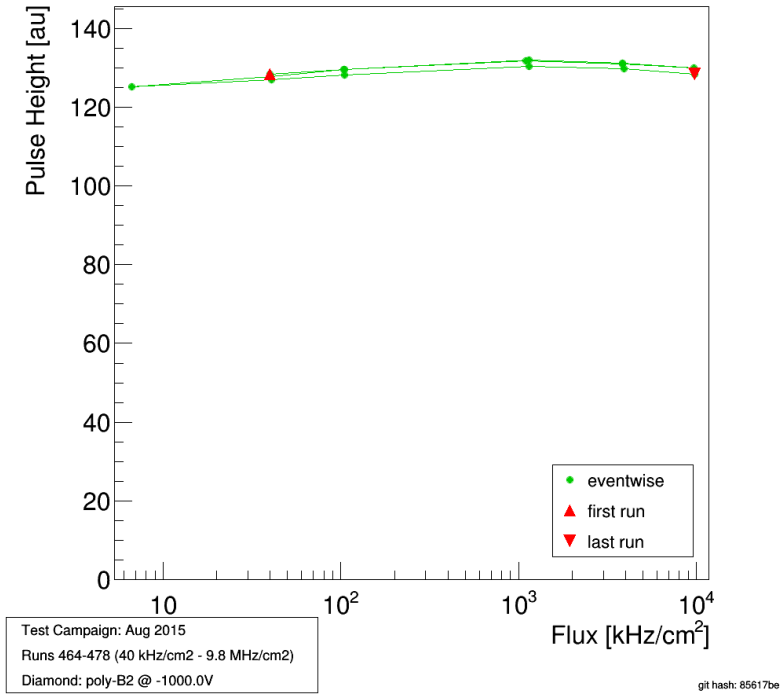
+1000 V August - unirradiated





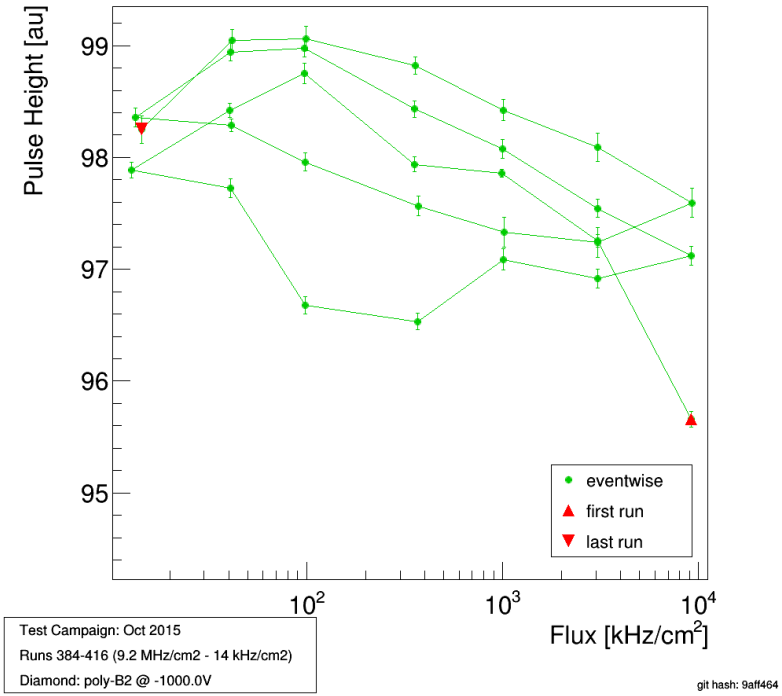
−1000 V August - unirradiated

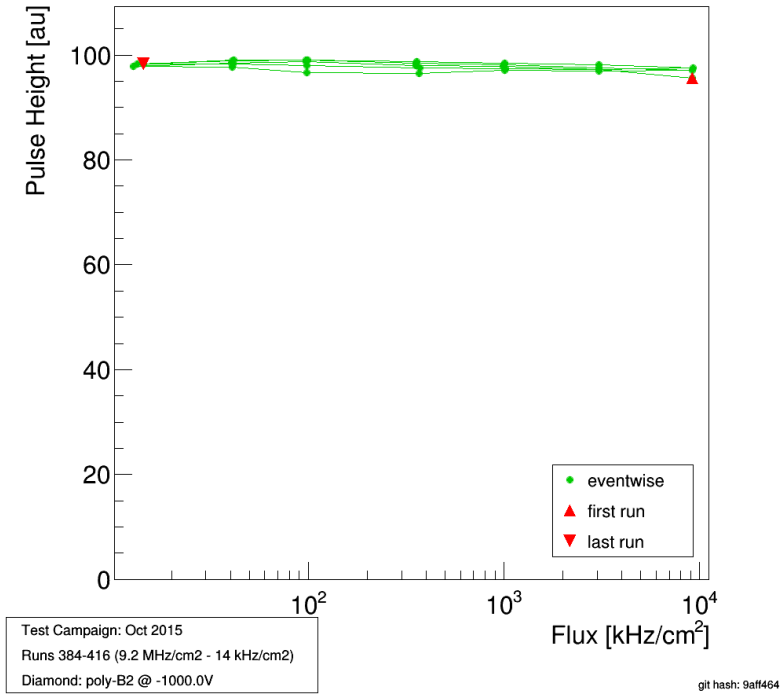




Poly-B2 (II-IV B2 - poly crystal)

−1000 V October - irradiated





Section 4

Conclusion

Conclusion

- very good timing resolution with scintillator allows for precise integration and separation of the signal
- tested several diamond pad detectors with fluxes between 1 kHz/cm^2 and 10 MHz/cm^2
- unirradiated single crystal shows almost no rate dependence
- most of the polies behave similarly
- some of the diamond pad detectors have only a very slight $(1 - 3\%)$ rate dependence after irradiation

Section 5

Outlook

Outlook

Event Synchroniser:

- fix unsynchronous runs (event misalignment)
- using pulser reference runs to check alignment
- writing program to detect and realign the runs

Finish Analysis:

- vary and confirm cuts
- create all final plots
- make a final presentation