

Diamond pad detector performance at high rate at PSI

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Section 1

Introduction



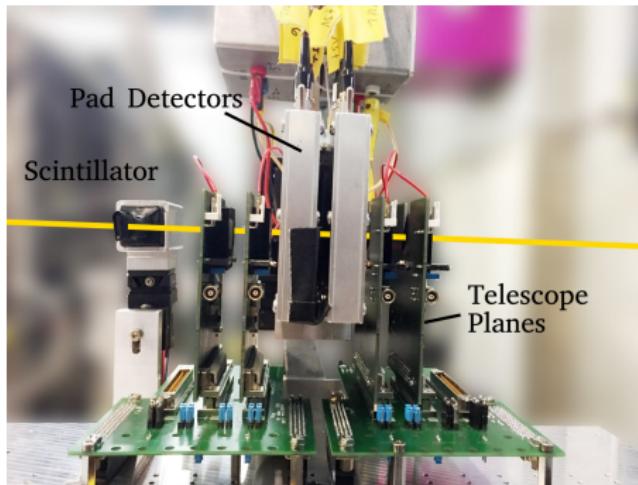
Goal:

- investigate if polycrystalline diamond pad detectors show a rate dependent pulse height

Measurements:

- tests of several diamonds pad detectors with a 260 Mev/c pion beam at PSI
- 3 beam tests in 2015: May, August, October
- thicknesses of the order of 500 μm
- size $\approx 5 \text{ mm} \times 5 \text{ mm}$
- irradiations: $5 \cdot 10^{13}$, $1 \cdot 10^{14}$ and $5 \cdot 10^{14}$ neutrons/ cm^2
- brands:
 - ▶ Element Six (single and poly-crystal)
 - ▶ II-IV Inc. (poly-crystal)
 - ▶ Ila Technologies (single and poly-crystal)
- flux range: from $1 \text{ kHz}/\text{cm}^2$ up to $10 \text{ MHz}/\text{cm}^2$ (at beam line pim1)

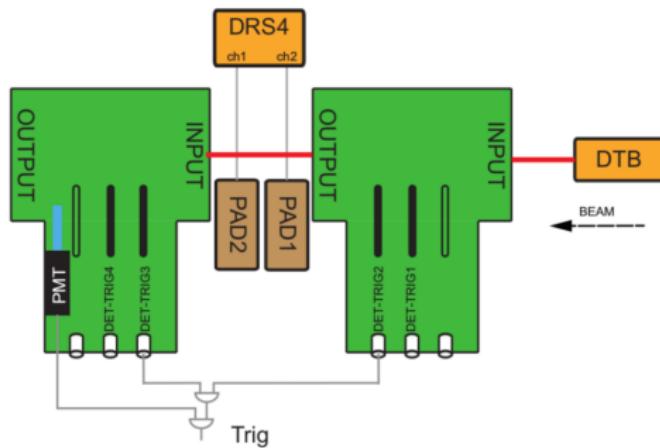
Setup



- 4 tracking planes with analogue CMS pixel chips
- 2 diamond pad detectors
- scintillator for precise trigger timing: sigma of 0.7 ns
- resolution: $\approx 80 \mu\text{m} \times 50 \mu\text{m}$

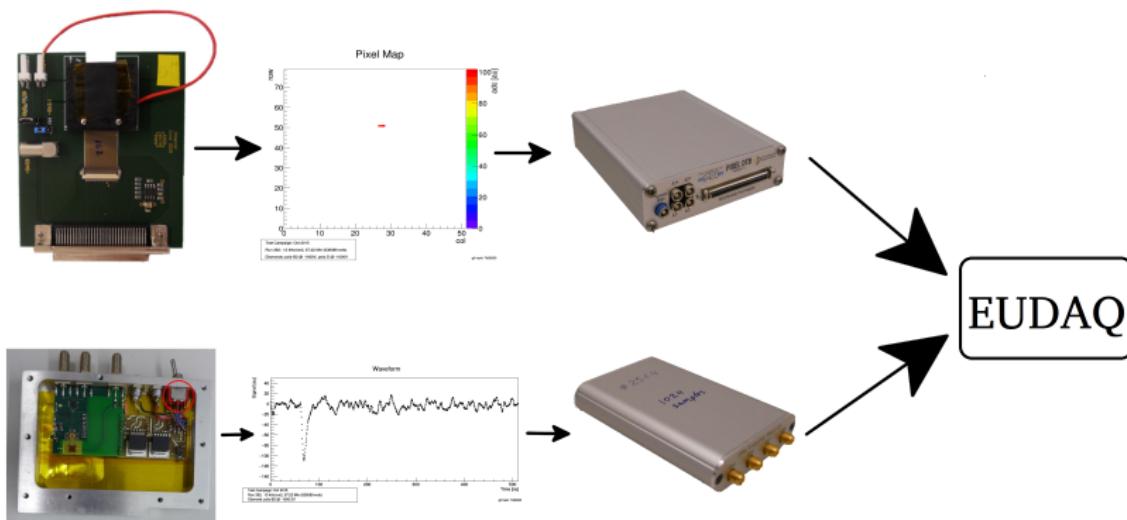


Schematic Setup



- using PSI DRS4 Evaluation Board as digitizer for the pad waveforms
- using DTB and pXar for the telescope readout
- trigger on 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

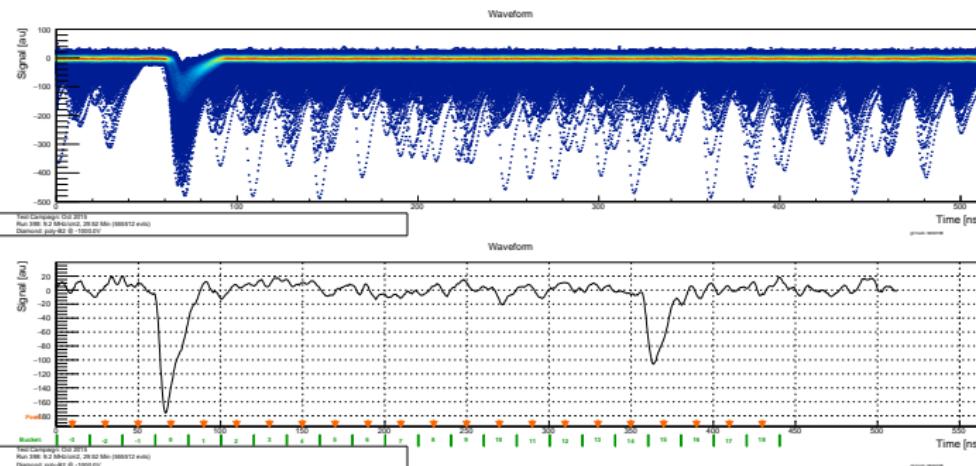


Section 2

Analysis

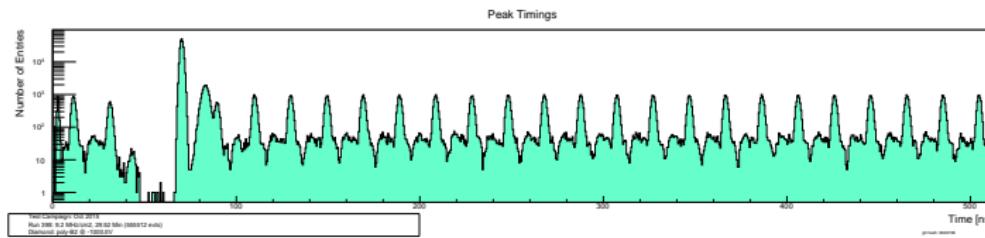
Waveforms

Waveforms



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

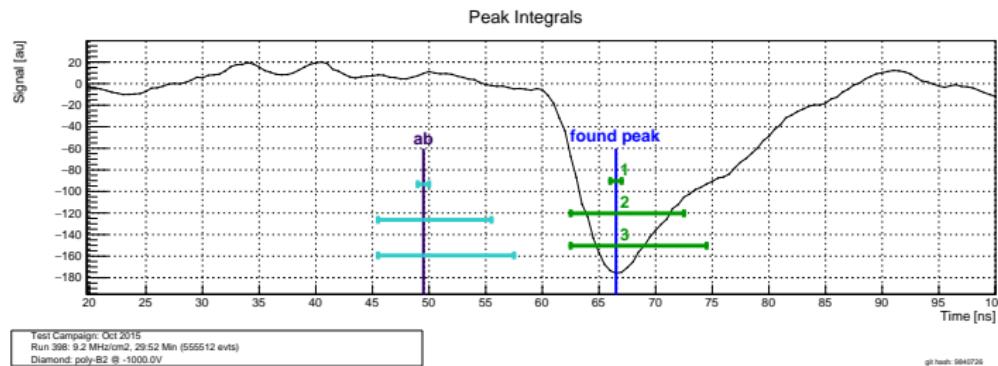
Peak Positions



- determine beam structure: ≈ 19.7 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

Waveforms

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

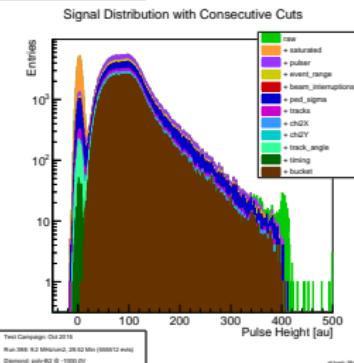
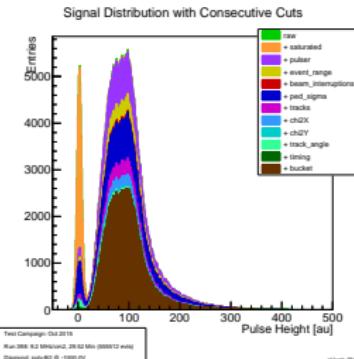


Event Cuts

Event Cuts

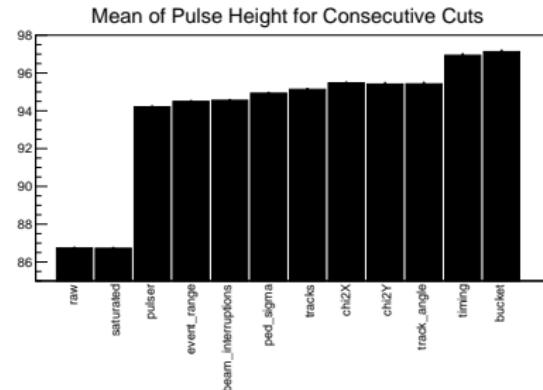
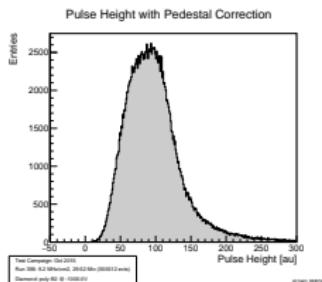
Exclude events:

- 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
 - ▶ $\text{abs}(2 \text{ deg})$
- timing: not within 4 sigma of peak timing
- bucket: signal in wrong bucket

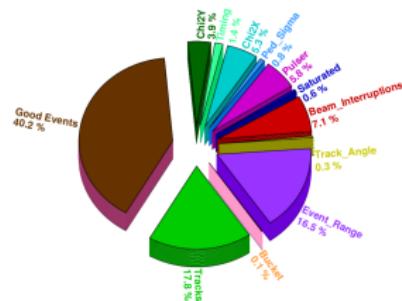


Event Cuts

Pulse Height Distribution



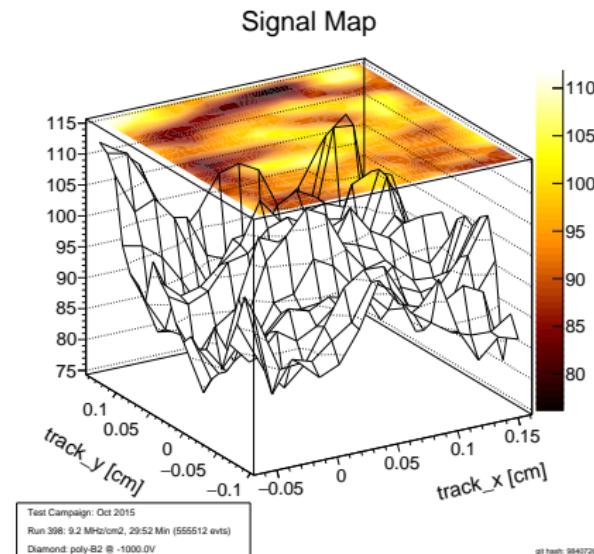
- pedestal is completely gone after application of the cuts
- wide Landau due to polycrystalline diamonds
- mean of the pulse height increases significantly due to cuts (pedestal goes away)





Signal Map

Signal Map



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

Section 3

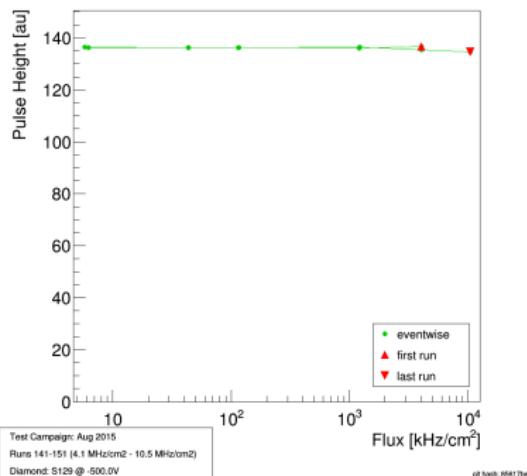
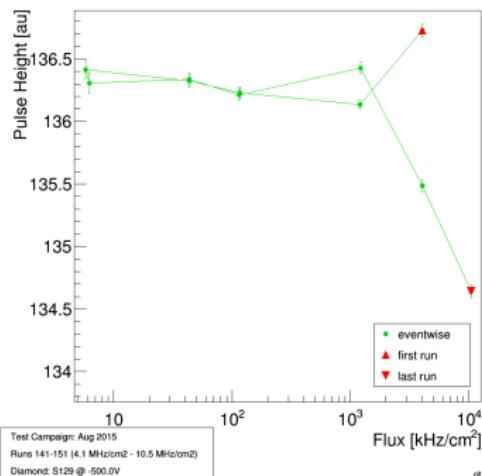
Results

S129 (Element Six - single crystal)

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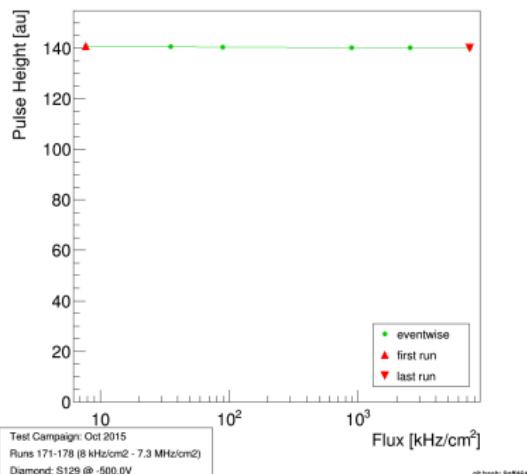
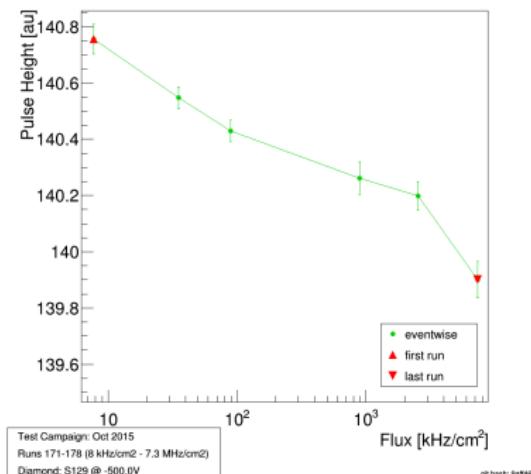
+500 V August - unirradiated



- amplifier issues during the last two runs

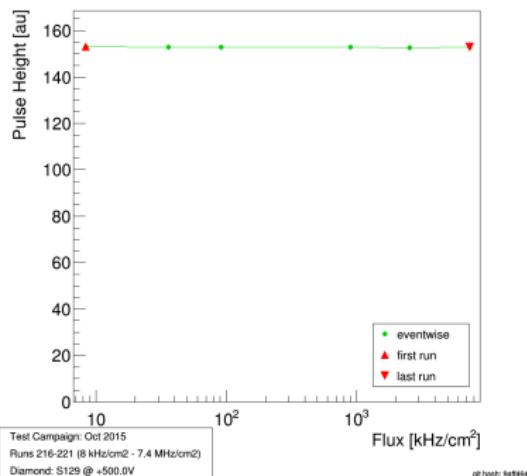
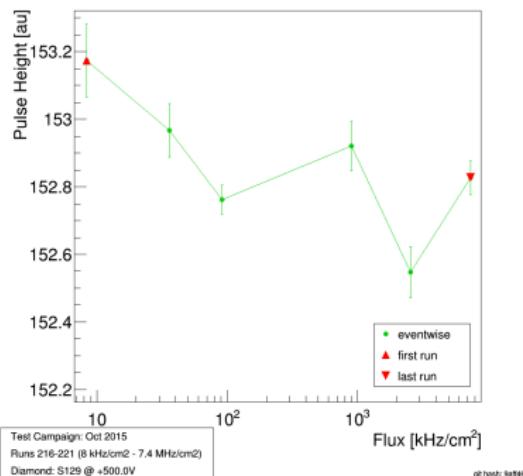
S129 (Element Six - single crystal)

-500 V October - unirradiated



S129 (Element Six - single crystal)

+500 V October - unirradiated

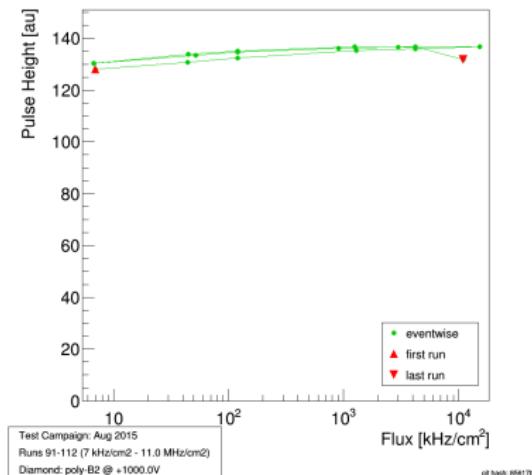
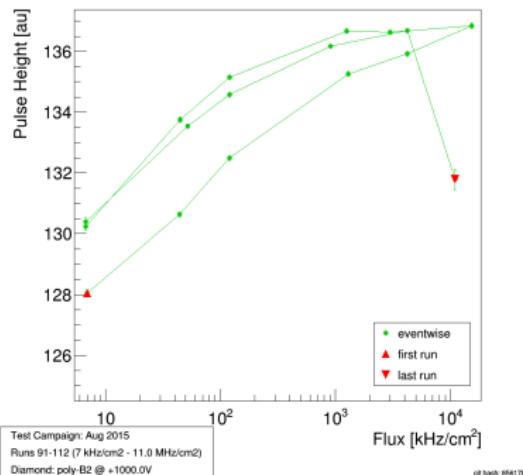


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Poly-B2 (II-IV B2 - poly crystal)

+1000 V August - unirradiated

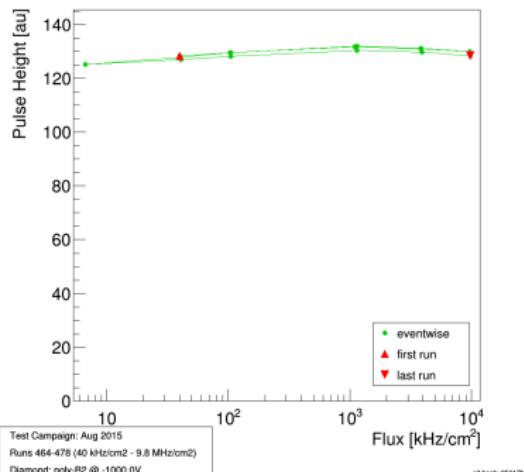
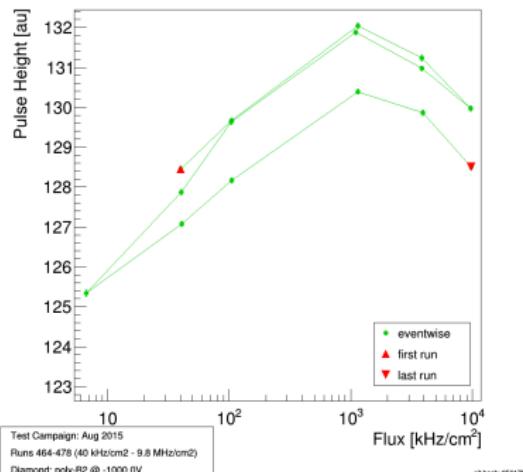


Poly-B2 (II-IV B2 - poly crystal)

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–1000 V August - unirradiated

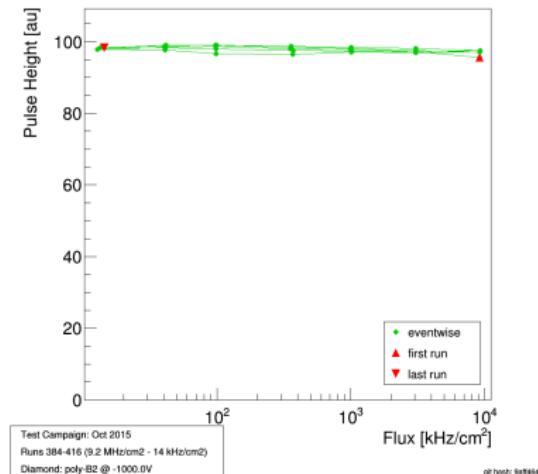
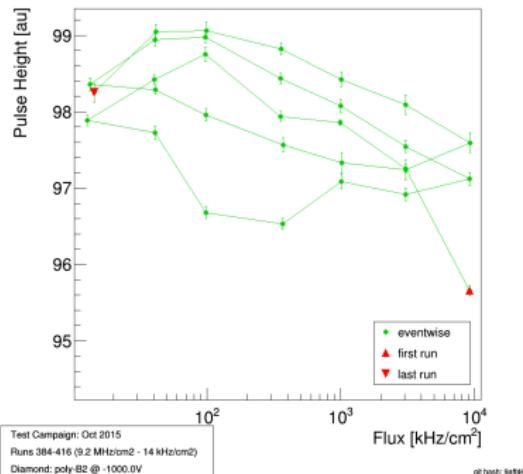


Poly-B2 (II-IV B2 - poly crystal)

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–1000 V October - irradiated



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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 $1\text{ kHz}/\text{cm}^2$ and $10\text{ MHz}/\text{cm}^2$
- 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

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Section 5

Outlook

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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