Plans for characterization of LGADs with 30 MeV protons

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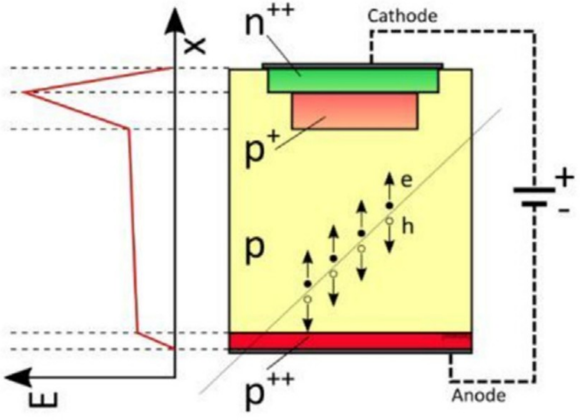
Motivation



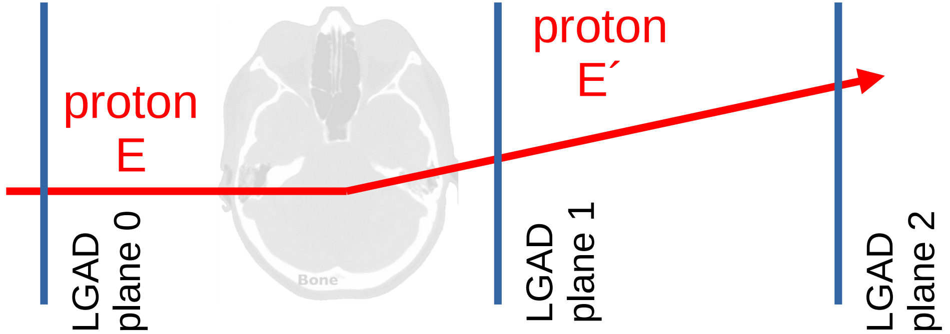
Low Gain Avalanche Detector

- Silicon detector with an additional highly doped p+ gain layer creating high electric field region for charge multiplication
- Intrinsic gain depends on: gain layer doping, bias voltage, temperature

Promising technology for **proton-CT**

LGADs offer fast signal collection
good spatial resolution
energy via time of flight

G.Kramberger LGAD sensors for application in proton CT, RAD2023



Why do we want to characterize LGADs with 30 MeV protons ?

- How does response depend on angle for highly ionizing particles?
- Can we see increased gain due to less screening for angled tracks?

U-120M cyclotron @ NPI CAS

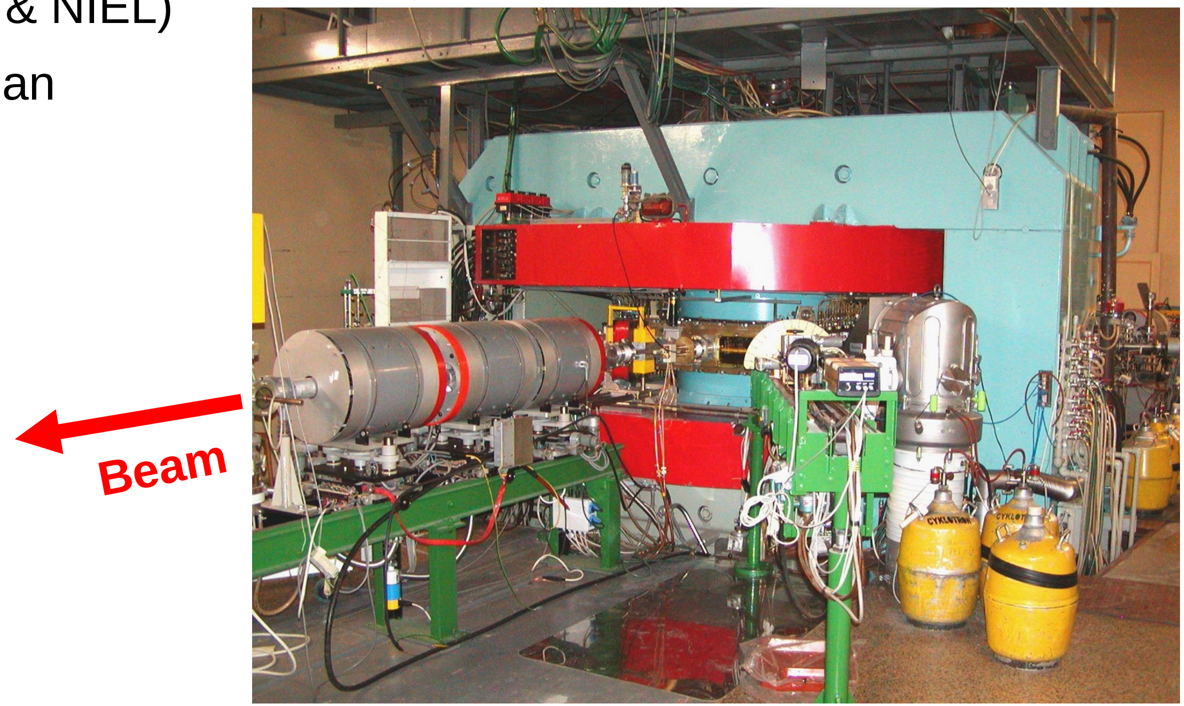
Protons ~ 30 MeV (TID & NIEL)

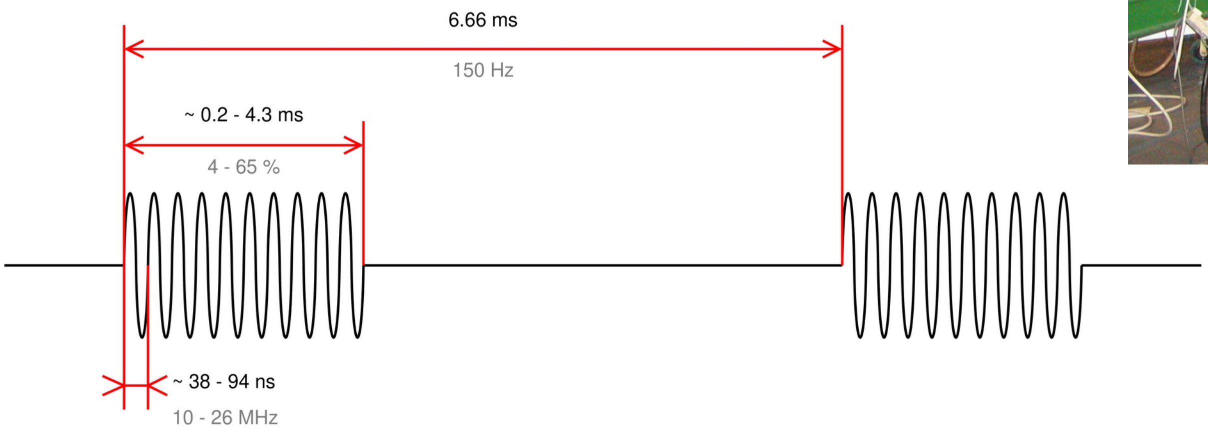
Beam profile 2D symmetric Gaussian

$\sigma_x = \sigma_y = 11$ mm

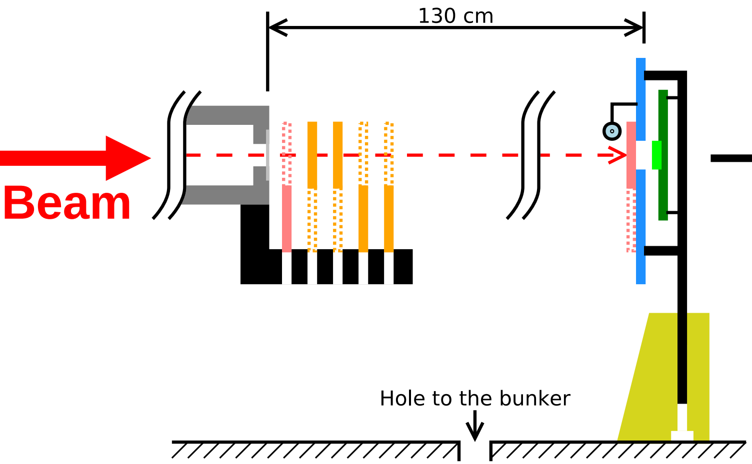
Time structure of the beam

- frequency 25 MHz
- shaped with 150 Hz macropulse
- typical duty cycle 5 - 10%

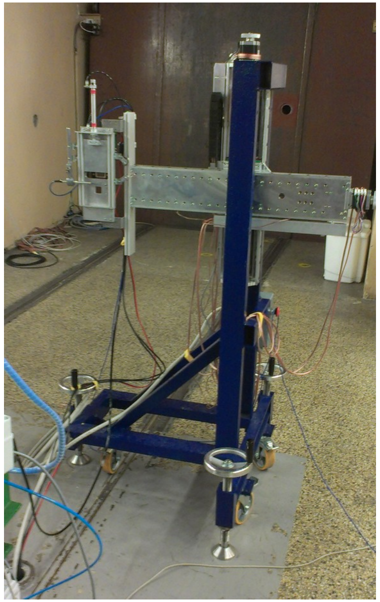




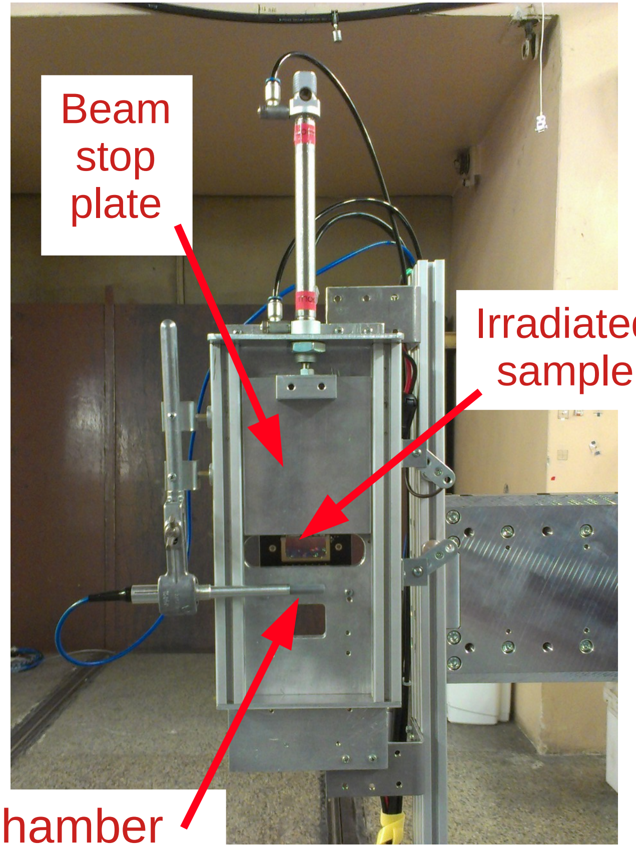
Setup used for MAPS irradiation



- Energy degrader plates (0.5 - 4 mm Al)
- Beam stop plates (8 mm Al)
- Shielding (8 mm Al)
- Ionization chamber
- Irradiated s ip)
- Shielded part of target (circuit board)
- X-Y posi MCL)
- Beam pipe and its exit window
- Proton beam



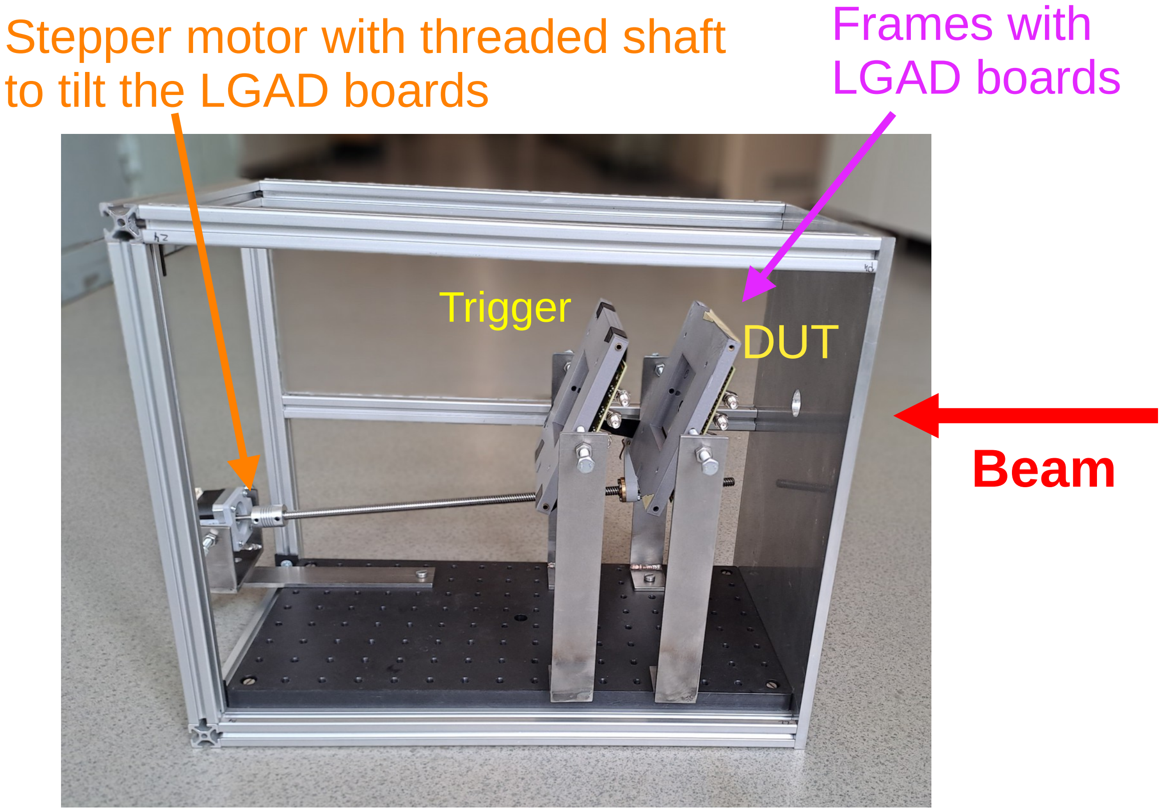
Movable XY stage



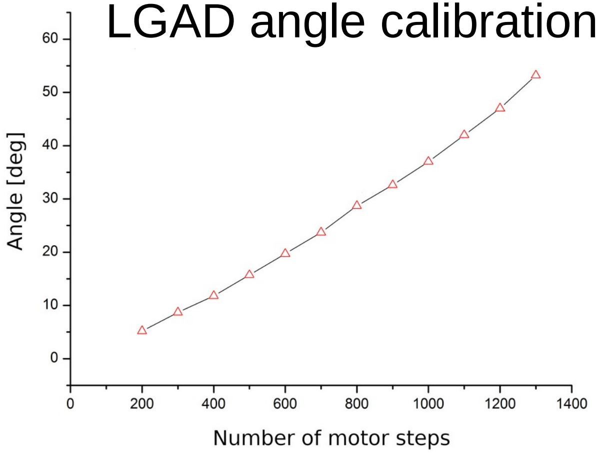
Ionization chamber

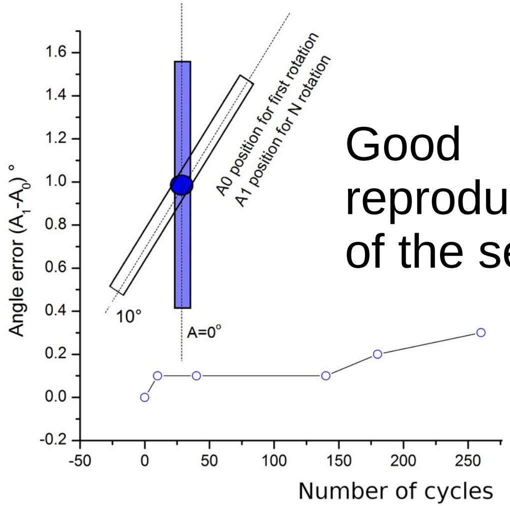
linear response up to 10^9 protons cm^{-2} s^{-1}

Setup for LGAD irradiation



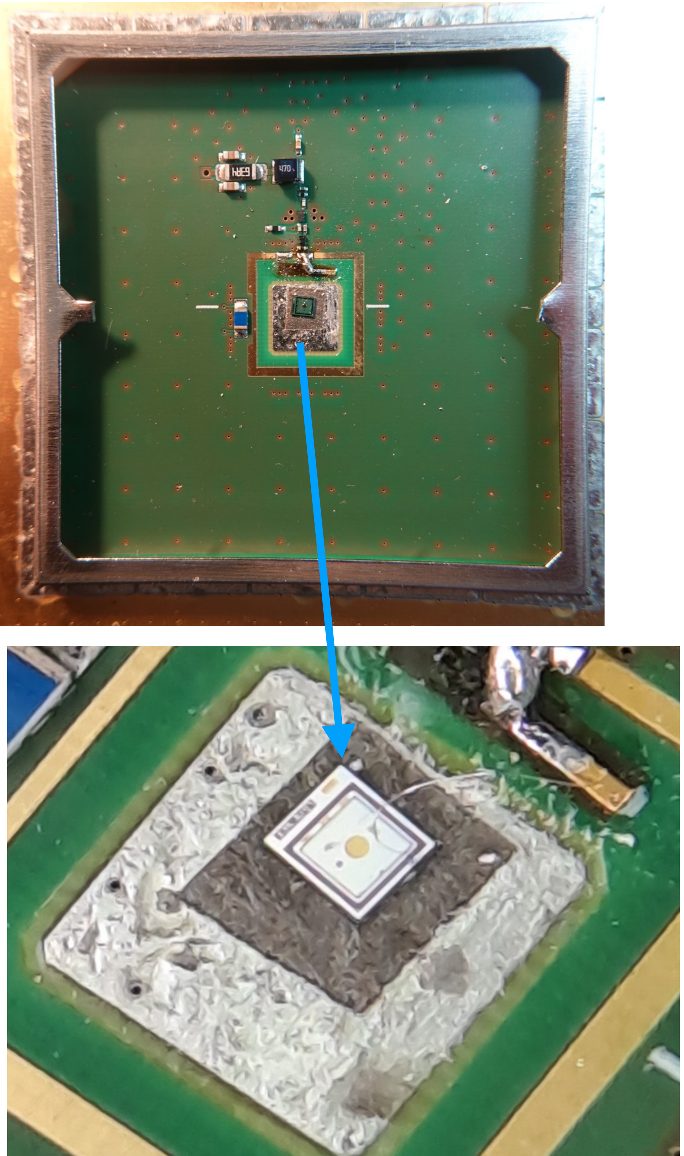
LGAD angle calibration





Good reproducibility of the set angle

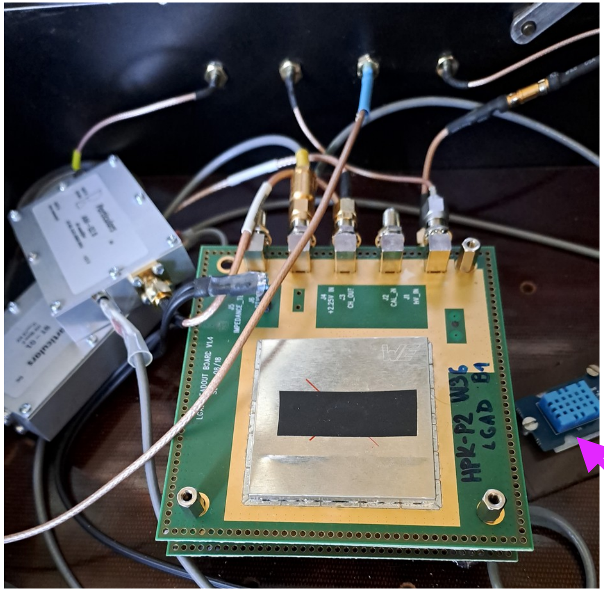
- Alignment of both LGADs with laser
- Enclosing the setup with metal sheets



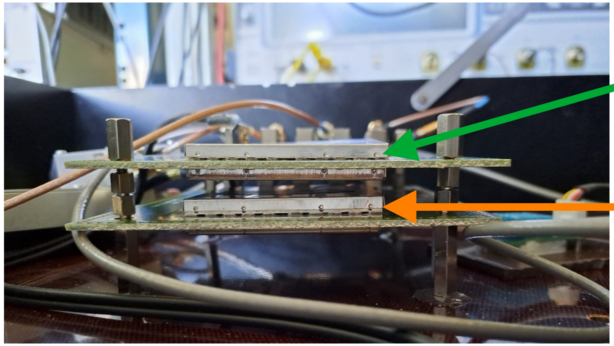
LGADs

Thickness	200 μm
Active layer	50 μm
Gain layer depletion voltage	~51.5 V
Gain layer depth	~2.4 μm
Full depletion voltage	~60 V
Break down voltage of devices	~200 V
Size of the pads	1.3×1.3 mm^2

Coincidence of 2 LGADs in lab

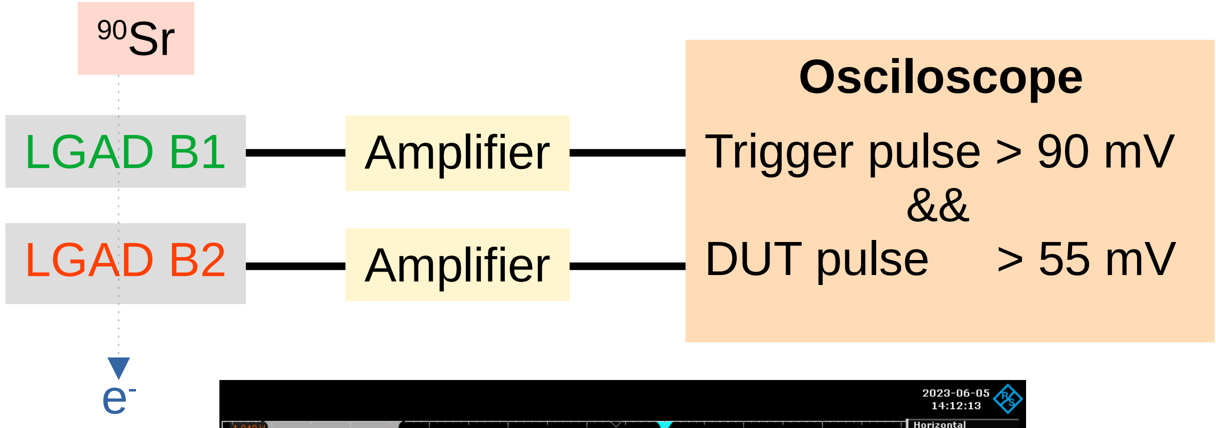


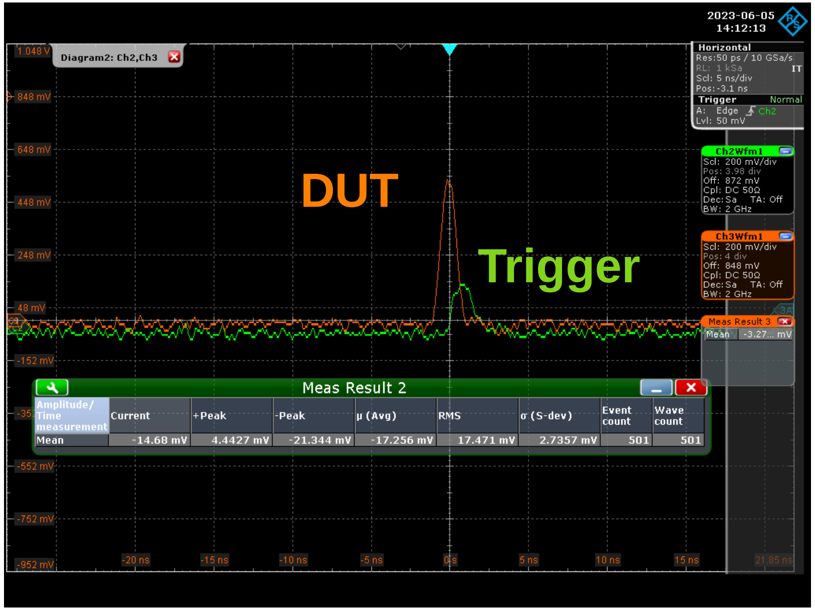
Temp. & Humidity monitor



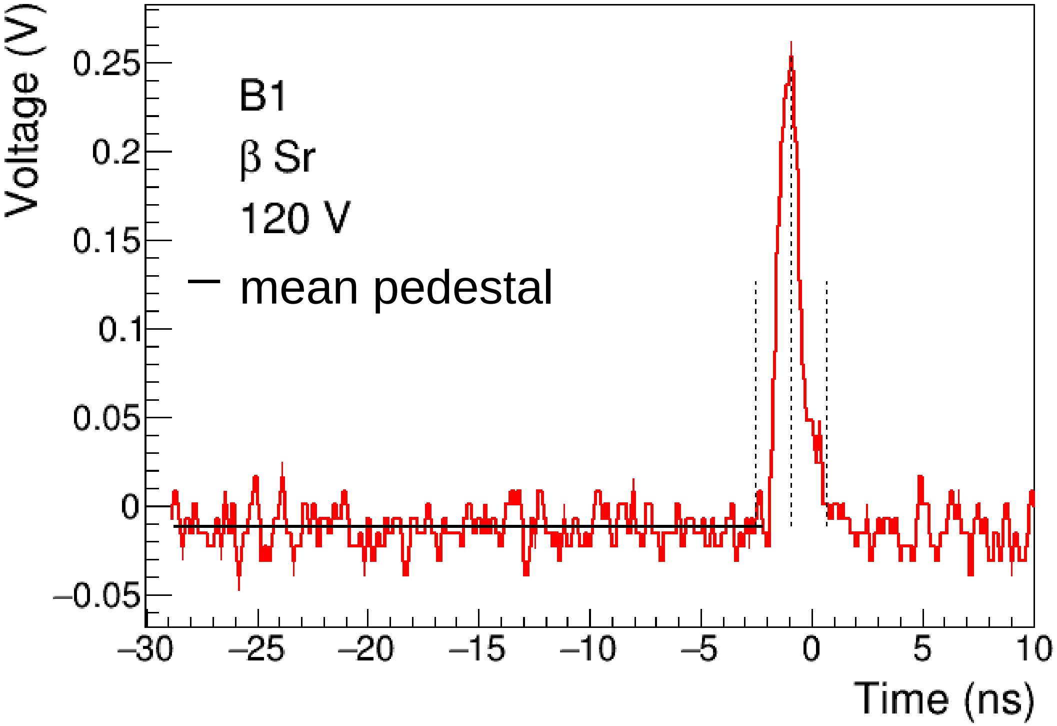
LGAD B1
Trigger

LGAD B2
DUT





Waveform analysis

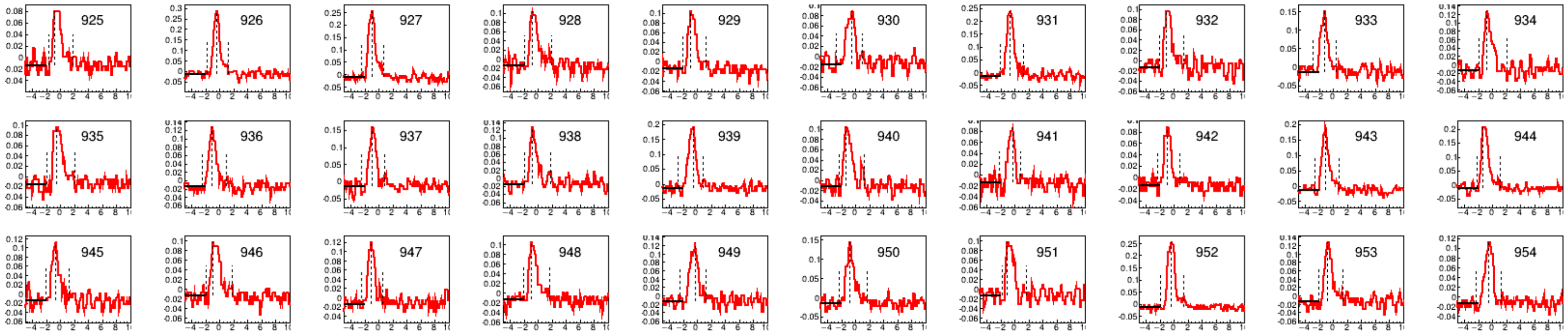


- Fit pedestal level
- Evaluate pedestal noise RMS
- Find signal maximum
- Peak amplitude > 5× noise RMS
- Integrate signal in the peak region

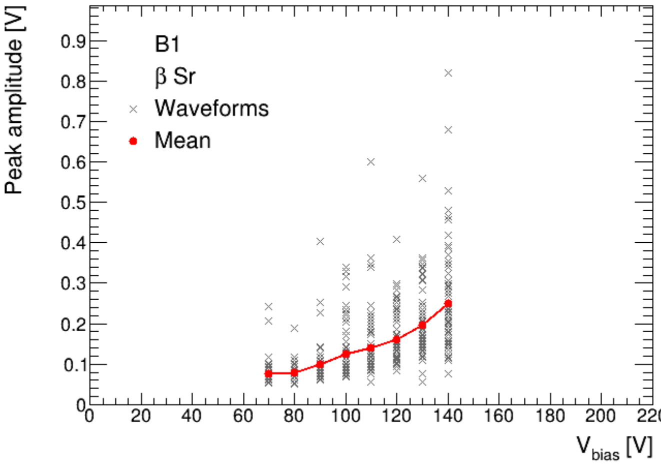
  (between the shorter dashed lines)

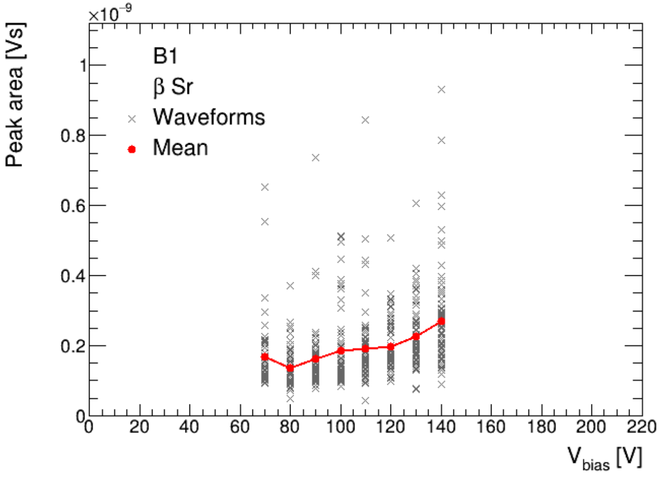
Statistical analysis

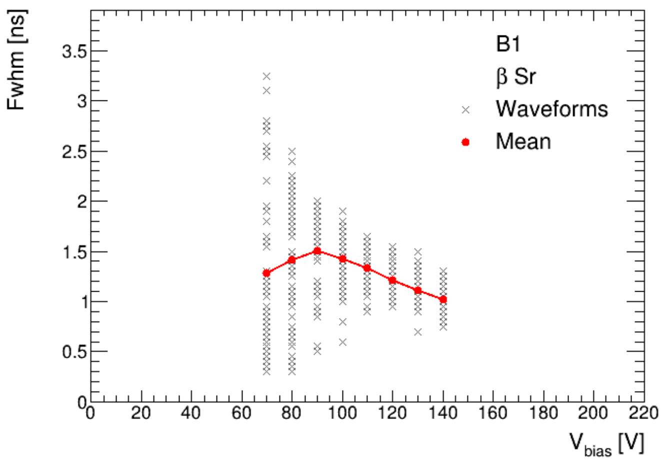
For given V_{bb} record ~80 waveforms



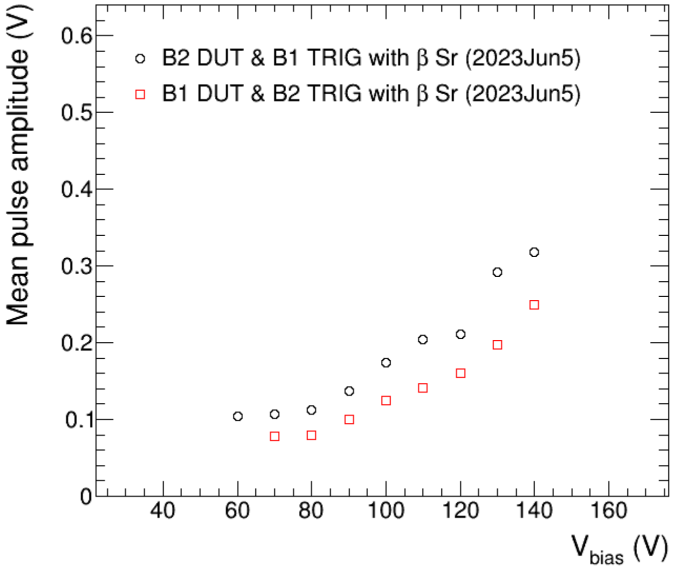
Look at statistical spread

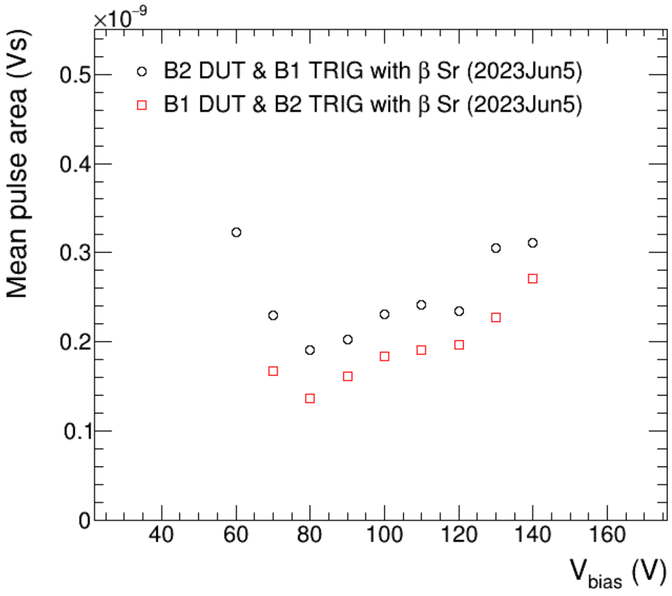


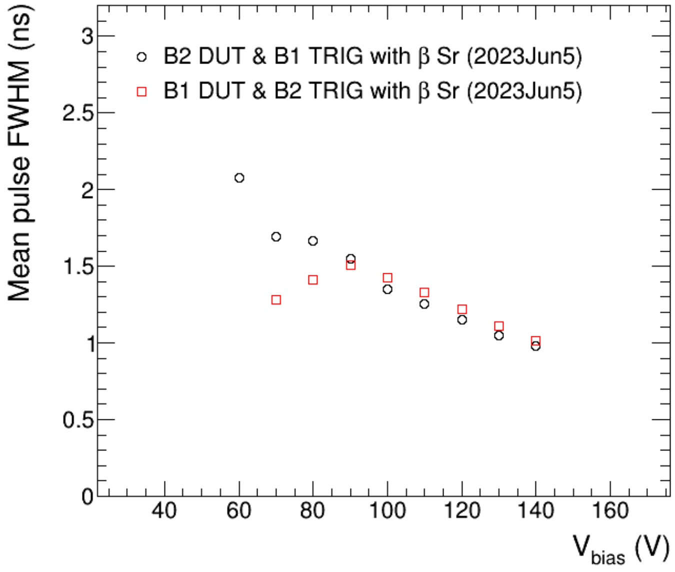




Mean peak amplitude, area, FWHM for ^{90}Sr β source with 2 LGADs in coincidence

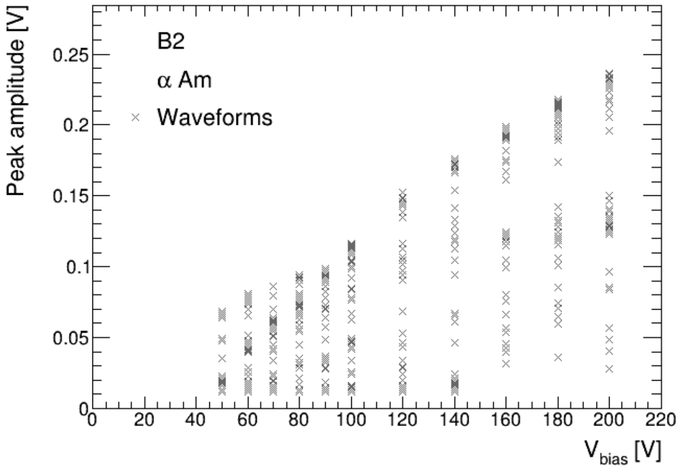


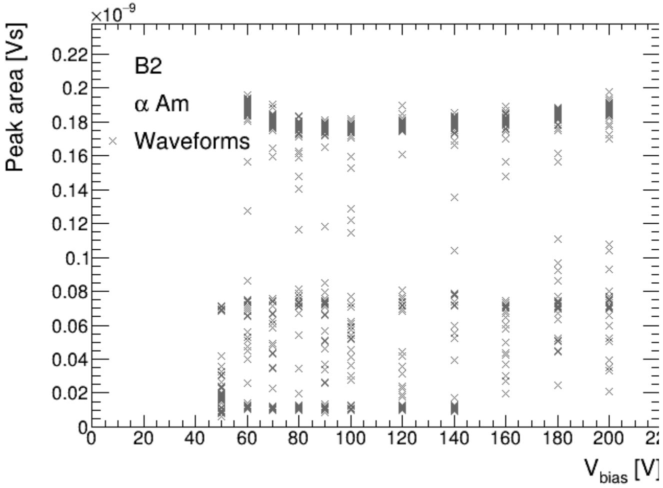


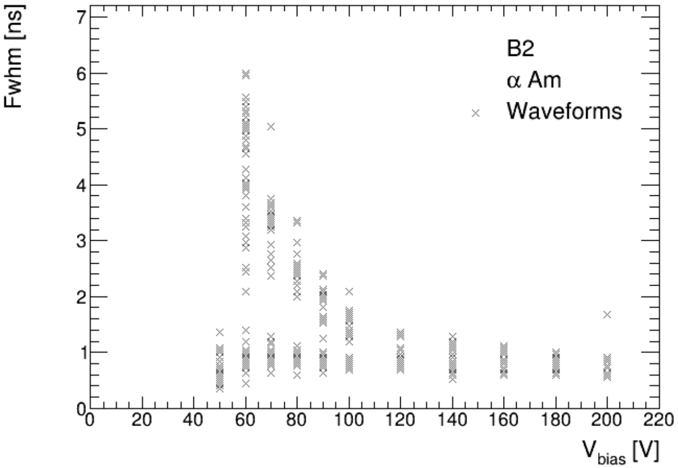


T ~24 °C

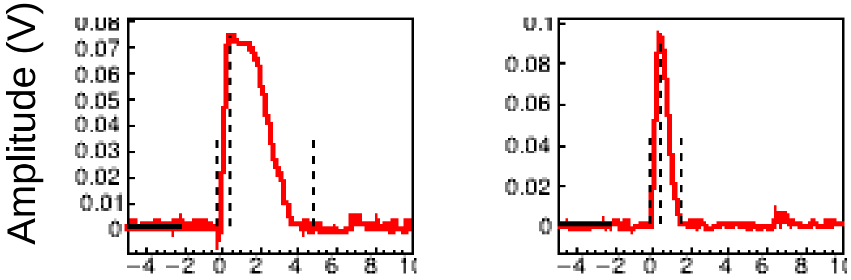
Mean peak amplitude, area, FWHM for ^{241}Am source & w/o amplifier & autotrigger







Waveforms for V_{bb} = 80 V



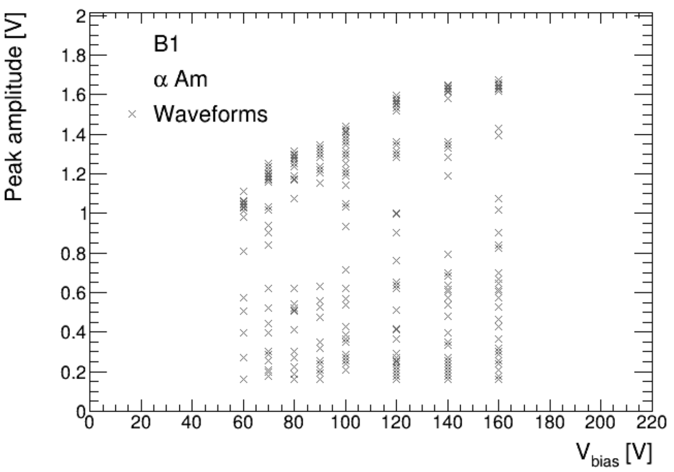
- Mixed field of α and γ (60 keV)
- With amplifier pulse amplitude exceeds ~0.6 V when amplifier starts to saturate

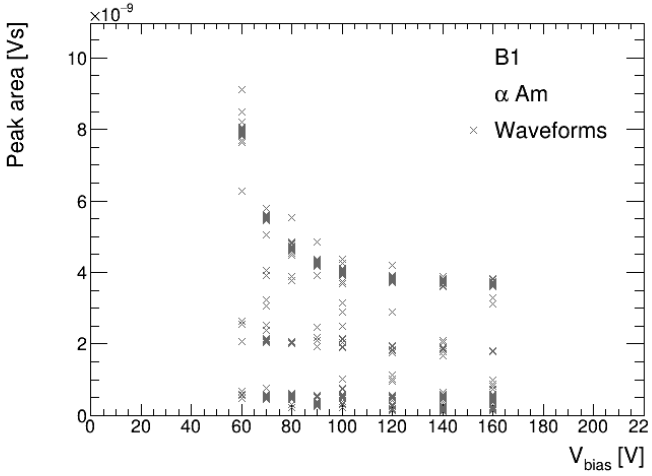
Outlook

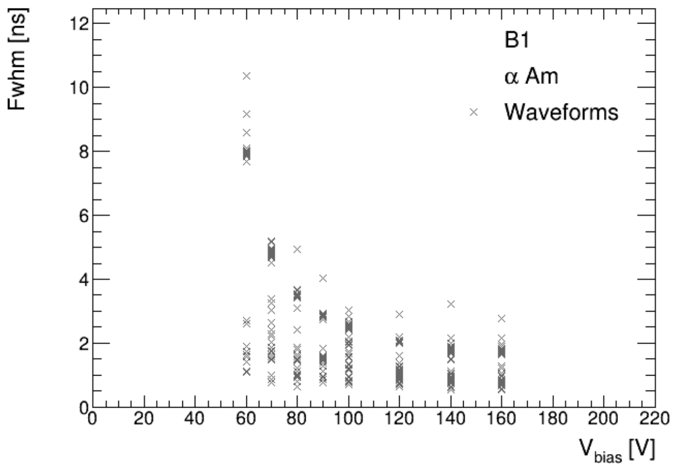
- Make reference measurements with PIN diods
- Finilize setup for the test at cyclotron
- Investigate whether cyclotron RF matters
- The experiment is expected during September

Backup

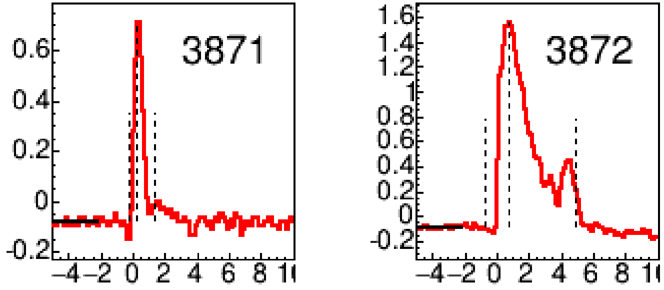
Mean peak amplitude, area, FWHM for ^{241}Am source & with amplifier & autotrigger







Waveforms for V_{bb} = 140



- Mixed field of α and γ (60 keV)
- Pulse Amplitude exceeds amplifier ~0.6 V when amplifier starts to saturate