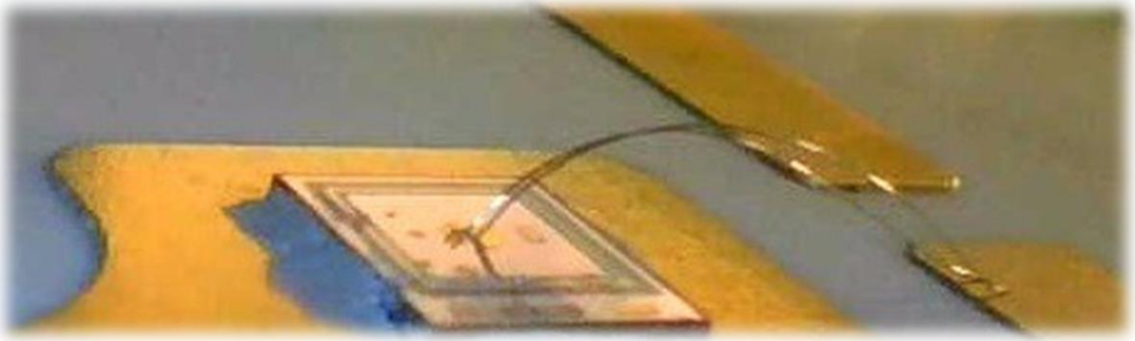
Radiation Tolerance of AIDA2020v2 LGADs manufactured at IMB-CNM

38th RD50 workshop

June 22nd 2021



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Outline

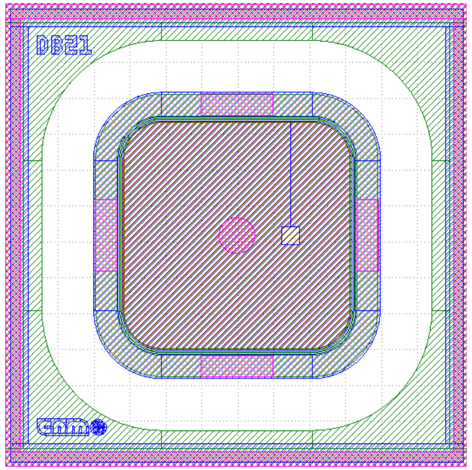
- Sample description
- Irradiation campaign: Fluence estimation.
- Charge collection vs fluence
- Short-time annealing.
- Timing vs fluence.
- Summary

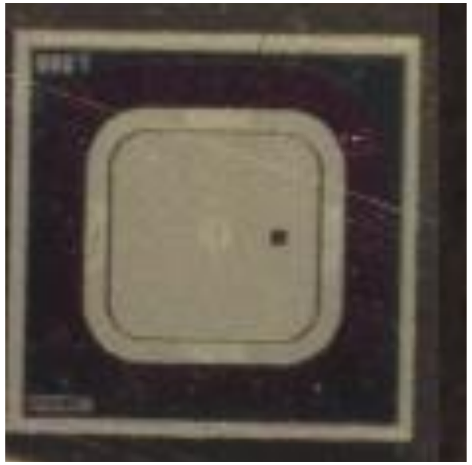
AIDA 2020v2 technology (run # 12916)

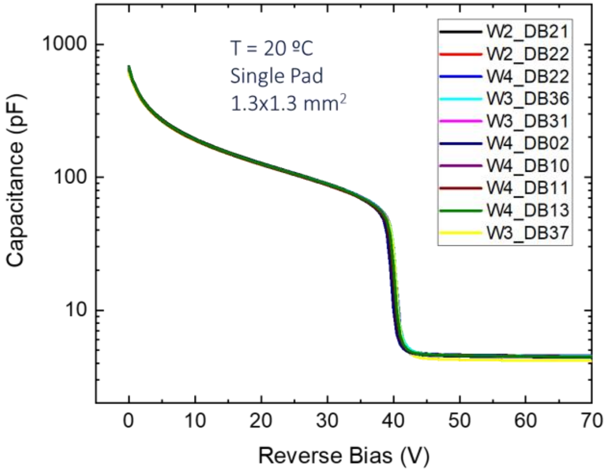
- **Four SiSi FZ wafers** with the same dose/energy parameters.
- Radiation tolerance study of total of 16 single-pads LGAD and 4 PIN diodes characterized.
- Single-pad layout accordingly to the designed pads of the ETL and HGTD sensors.

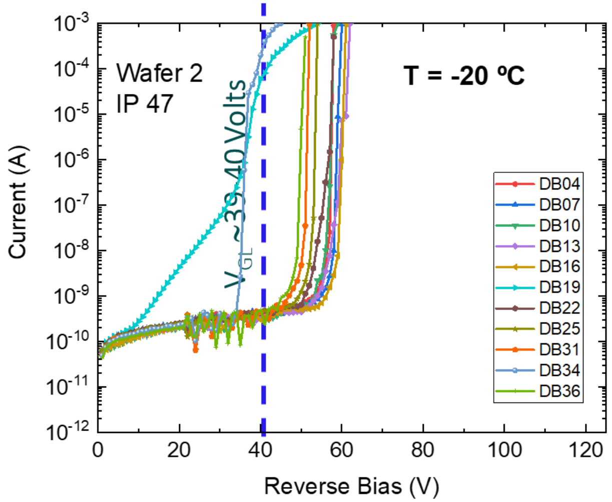
Wafer	Thickness (μm)	Dose (at/cm²)	Energy (keV)
1-4	50	Medium	Low

Single-pad diodes



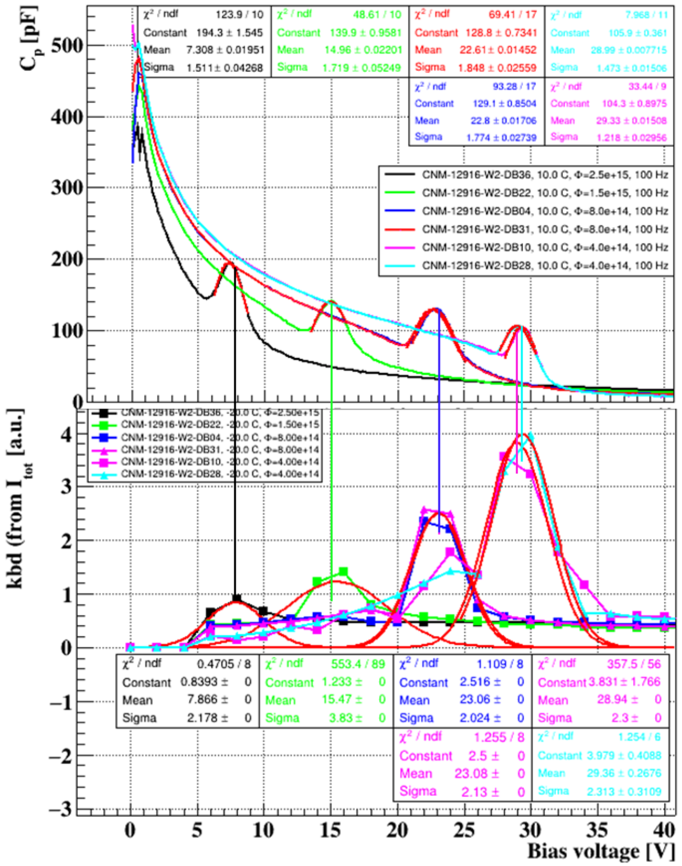






Irradiation campaign – Fluence dispersion

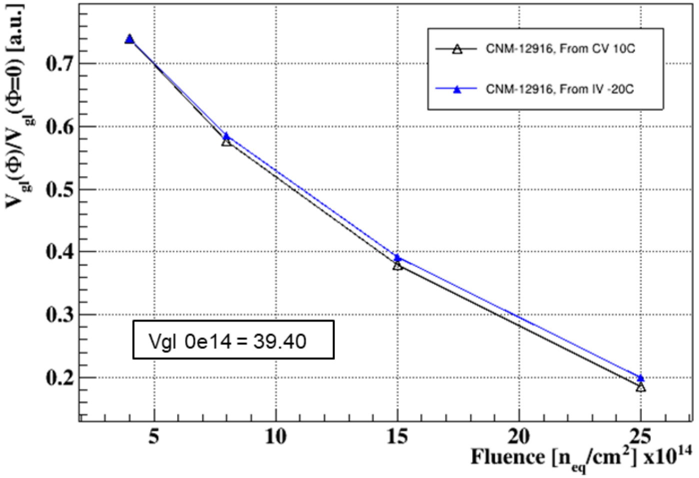
- Neutron irradiated, four target fluences: 4e14, 8e14, 15e14 & 25e14 n_{eq}/cm^2
- Two irradiation batches @ Ljubljana: CERN (Summer 2020, **Annealed** 80 min at 60°) and IFCA (Fall 2020 **non-annealed**).

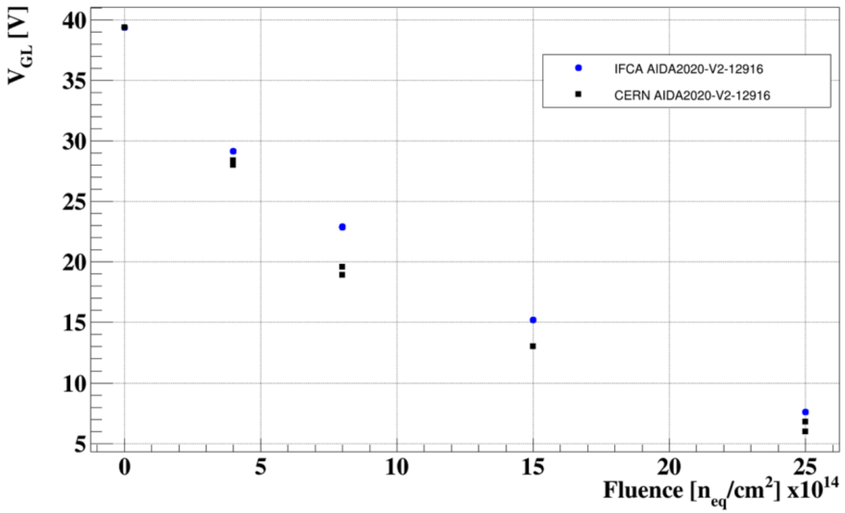


For kbd definition see M. Fernández RD50 37th

V_{GL} from CV			
4E14 n_{eq}/cm^2	8E14 n_{eq}/cm^2	15E14 n_{eq}/cm^2	25E14 n_{eq}/cm^2
29.16 V	22.70 V	14.96 V	7.3 V

V_{GL} from IV			
4E14 n_{eq}/cm^2	8E14 n_{eq}/cm^2	15E14 n_{eq}/cm^2	25E14 n_{eq}/cm^2
29.12 V	23.07 V	15.47 V	7.86 V

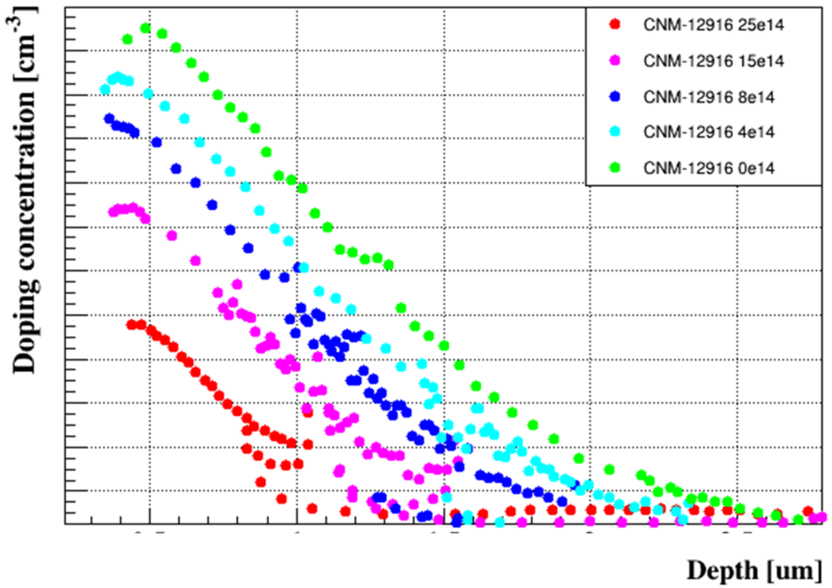


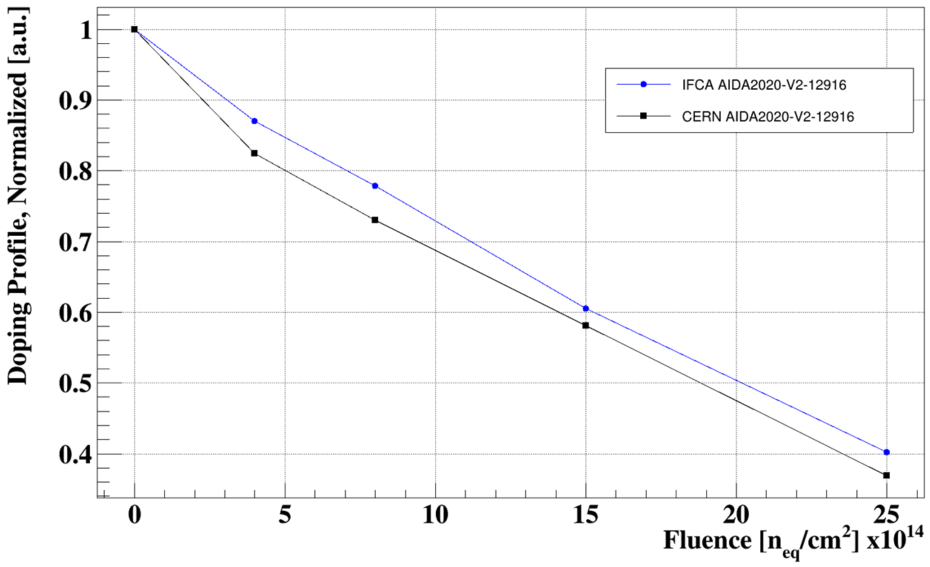


CERN samples possibly irradiated at higher fluences than IFCA samples (Vgl@CERN > Vgl@IFCA)

Irradiation campaign – Fluence dispersion (2)

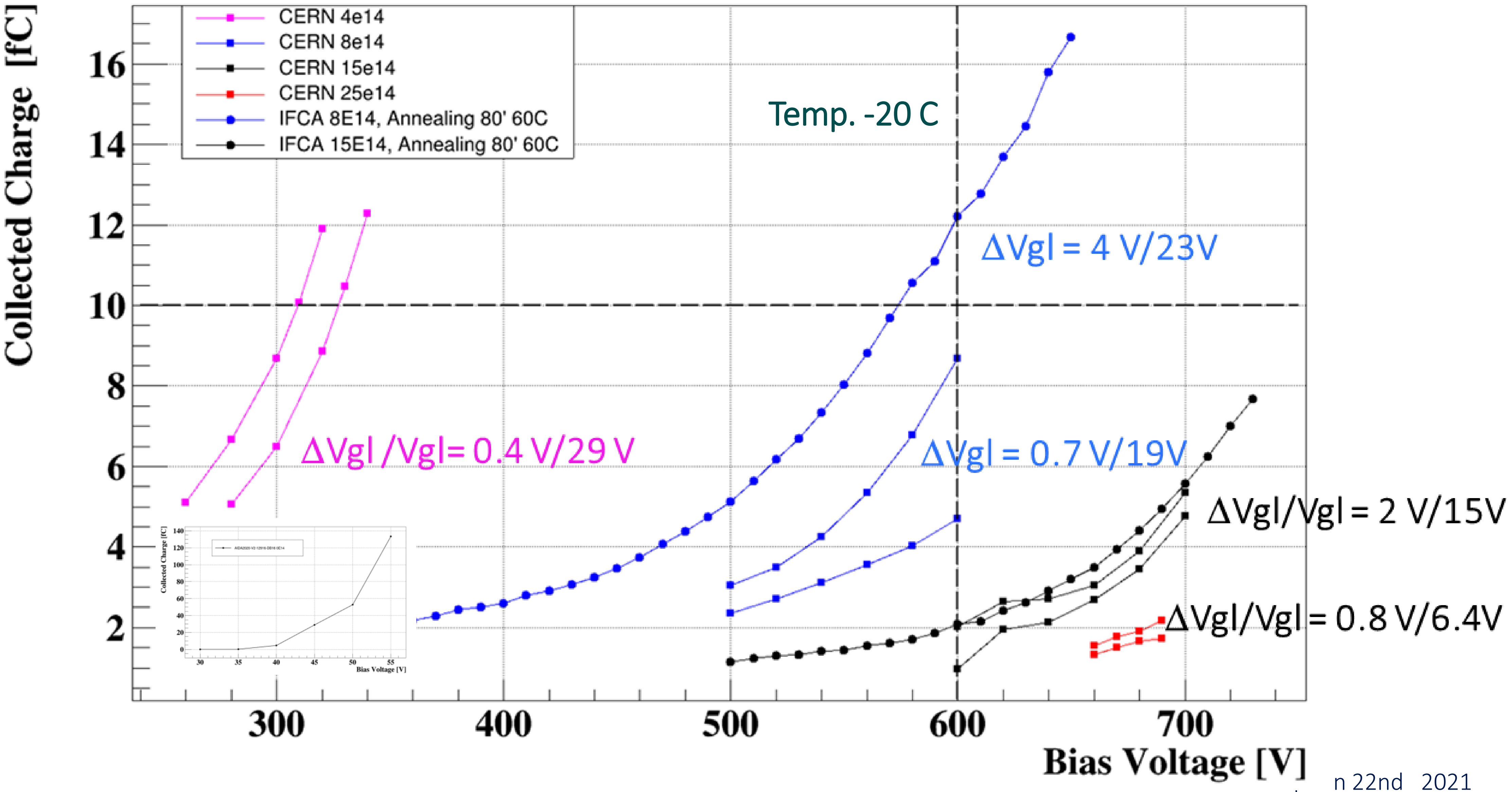
- Neutron irradiated, four target fluences: 4e14, 8e14, 15e14 & 25e14 n_{eq}/cm^2
- Two irradiation batches: CERN (**Annealed** 80 min at 60°) and IFCA (**non-annealed**).





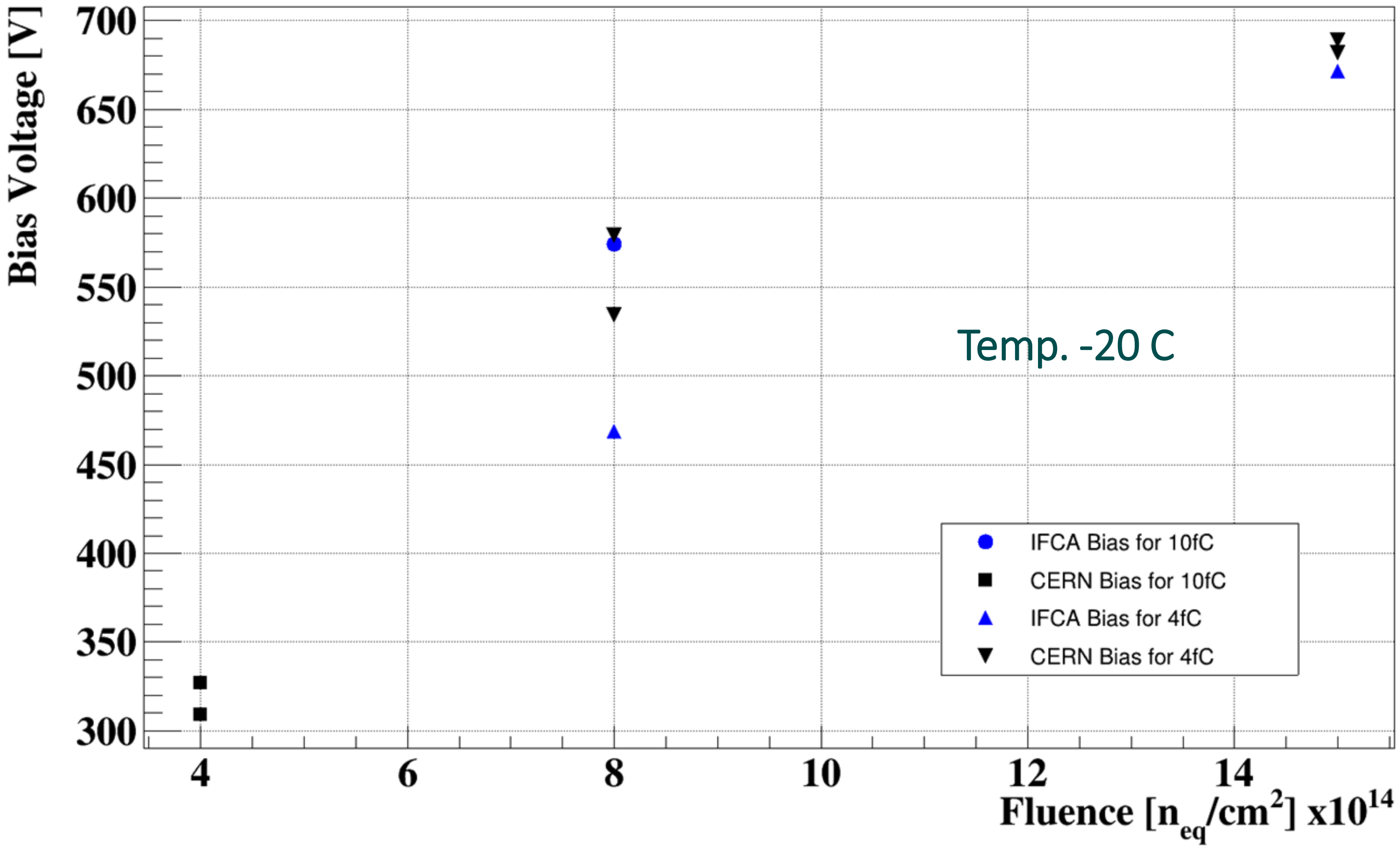
- The doping profiles confirm that the CERN samples were subjected to higher fluences (the effect of annealing will be shown later in the talk).

Charge collected vs Vbias



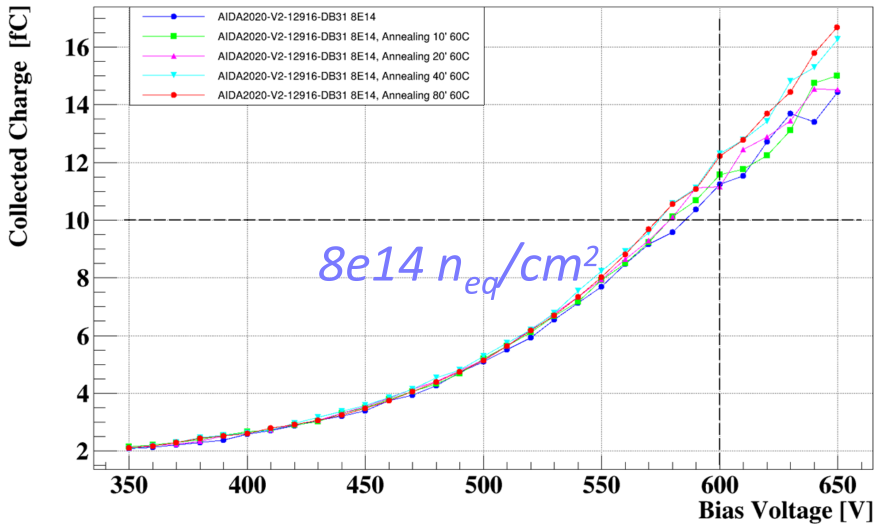
Collected charge: Operational voltage

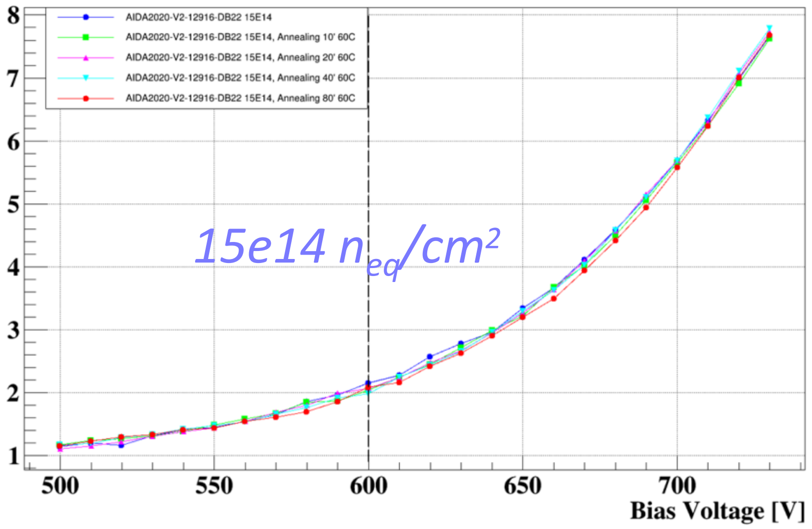
– What is the bias voltage needed for achieving 10fC/5fC?

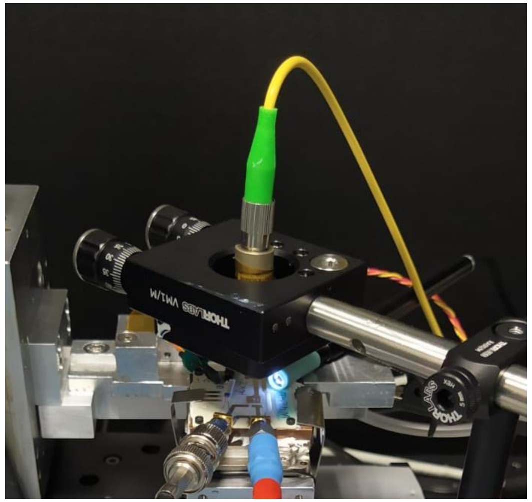


Charge collected: Short-term annealing

- Motivation:
  - Is the observed scattering in charge collection due to lack of annealing?
- Short-term annealing of IFCA samples at 60°C: 10’, 20’, 40’ and 80’.
- TCT IR laser setup



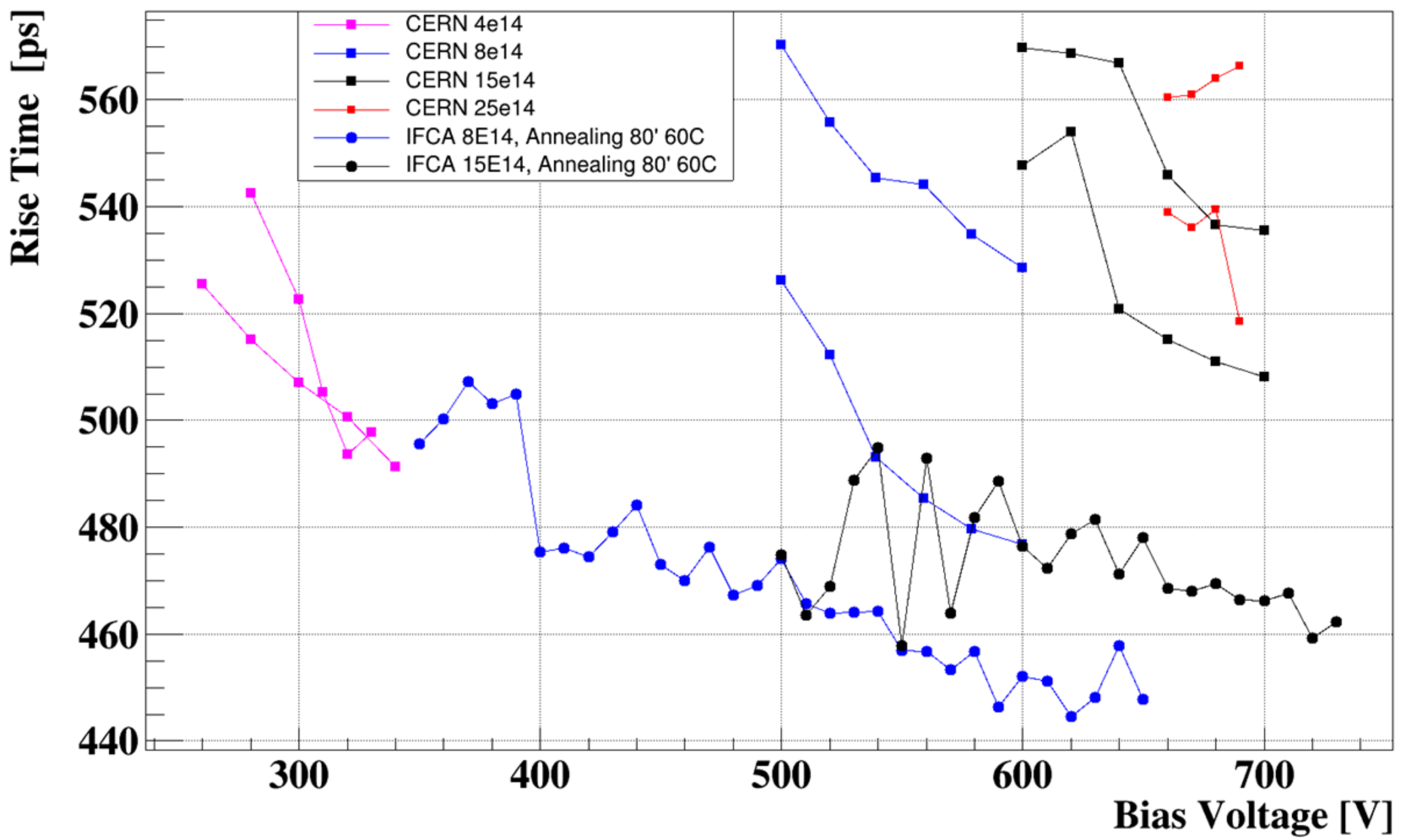




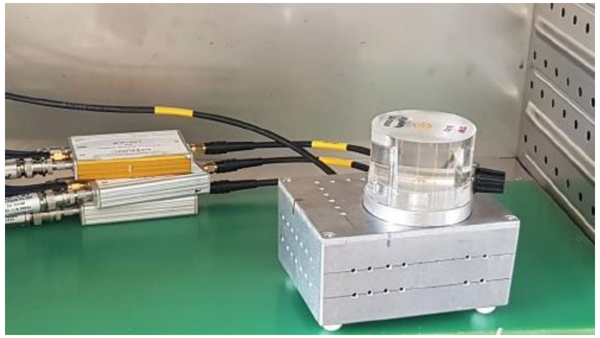
No significant effect observed

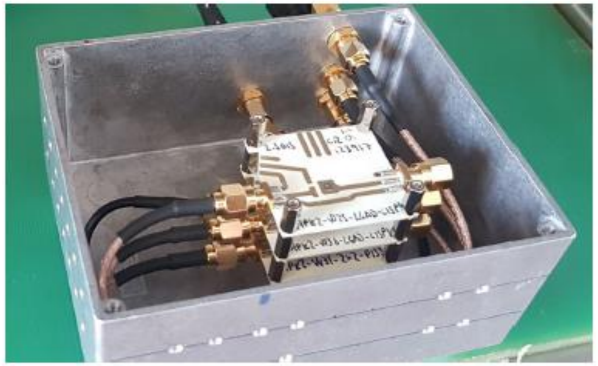
Timing vs fluence: Risetime

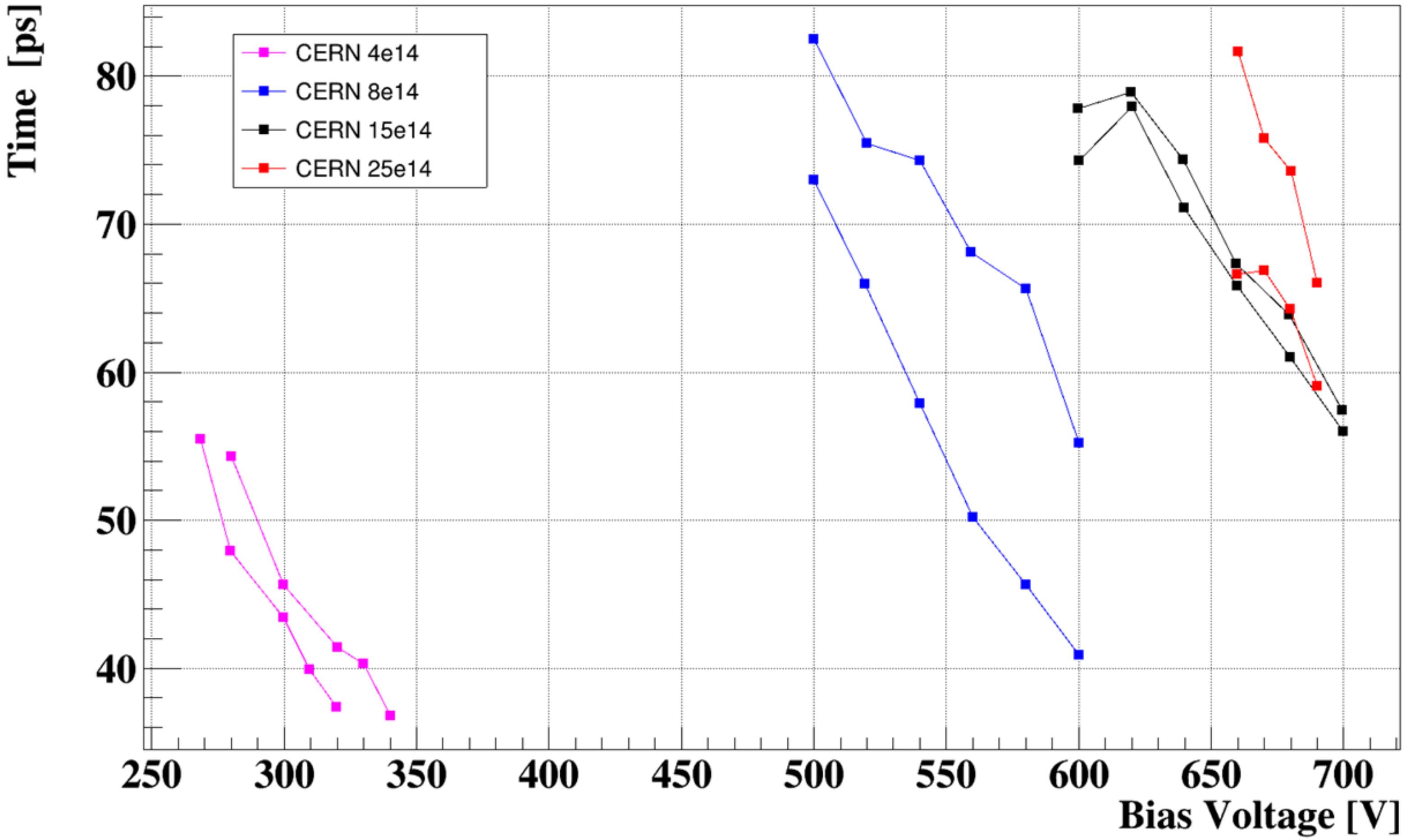
– All risetimes are well within the required range for fast timing



Timing vs fluence: time resolution







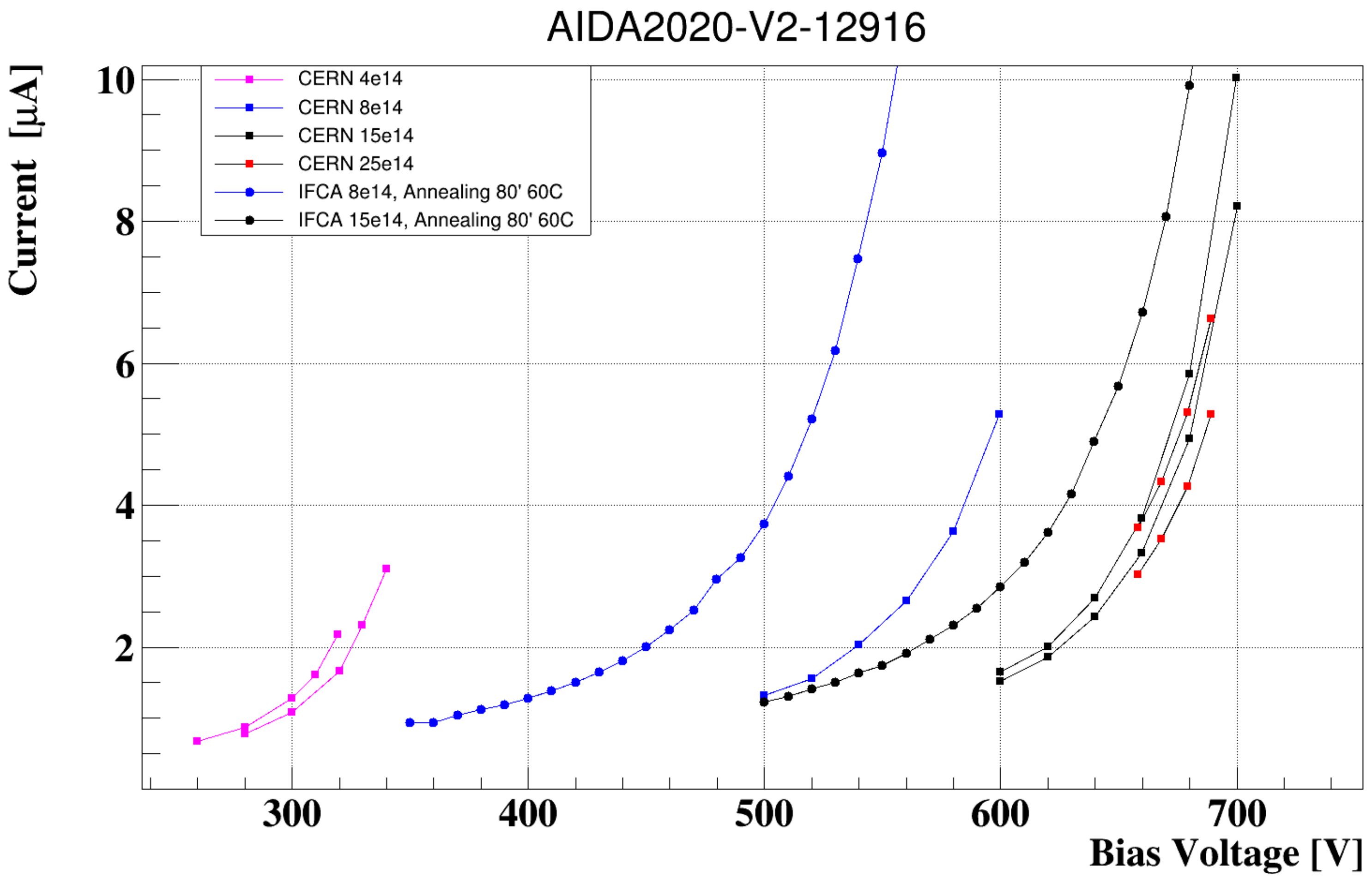
Timing estimation using a beta source
See E. Currás talk in this workshop
for details

Concluding remarks

- Full radiation tolerance study of the AIDA2020v2 LGAD production (the latest available production from IMB-CNM in FZ substrates)
- Radiation tolerance criteria (Q>10fC, Vbias<12V/μm) achieved up to approximately 10^{15}n/cm^2 fluence for neutrons
- However, a few *well-known* caveats apply(*):
  - The radiation tolerance to protons has not been studied yet (acceptor removal depends on irradiation type)
  - Incertitude on the actual fluence introduces dispersion on results. For neutron-irradiated samples in the summer/fall 2020 irradiation campaigns a fluence cross-check based on Vgl and/or doping profiles advisable.
  - Timing performance are done using very fast, power hungry, bulky amplifiers; high bandwidth and high sampling rate digital scopes with algorithms using the full waveform information, bottom line: **expect an optimistic timing resolution estimate.**
- In addition, Non-irradiated AIDA2020v2 LGAD at -20 C has Vop close to Vgl.

* And are mostly valid for recent HPK-P2 and FKB productions

Current



AIDA2020-V2-12916
CERN 4e14
CERN 8e14
CERN 15e14
CERN 25e14
IFCA 8e14, Annealing 80' 60C
IFCA 15e14, Annealing 80' 60C
Current [μA]
10
8
6
4
2
300
400
500
600
700
Bias Voltage [V]