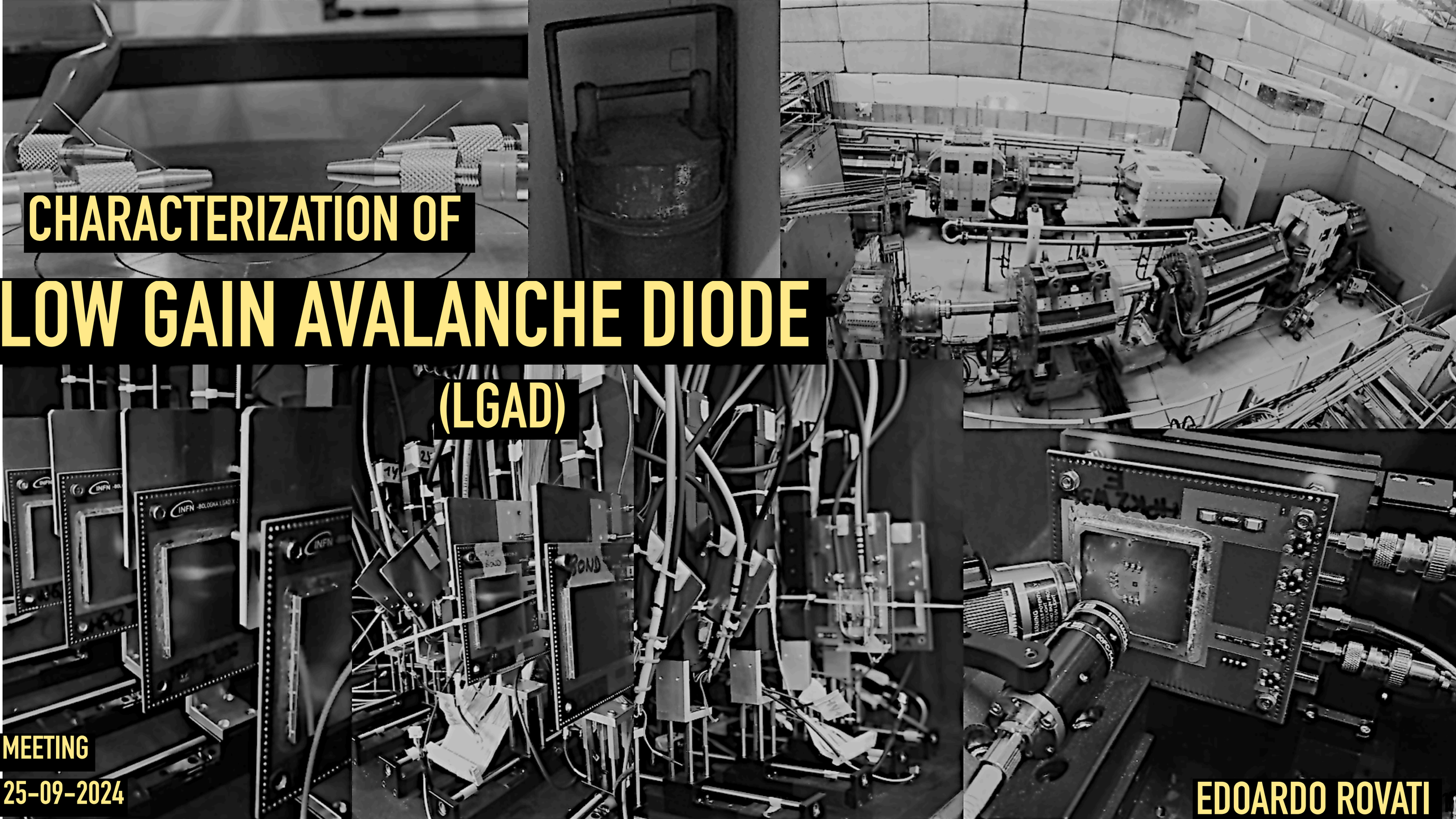


CHARACTERIZATION OF LOW GAIN AVALANCHE DIODE (LGAD)

MEETING

25-09-2024

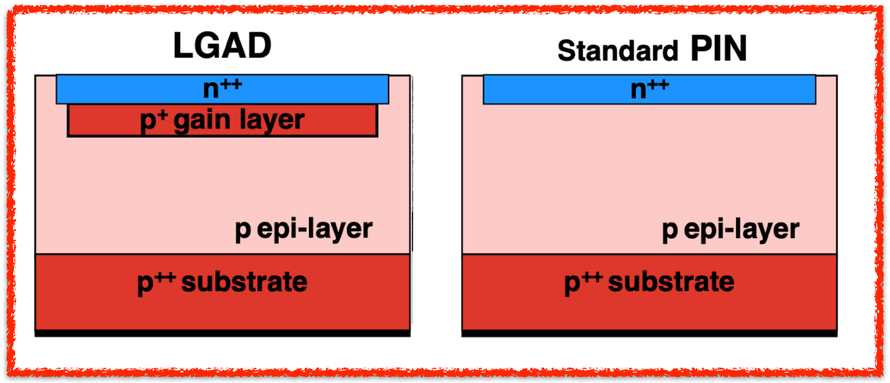
EDOARDO ROVATI

INTRODUCTION TO DEVICE CONSIDERED

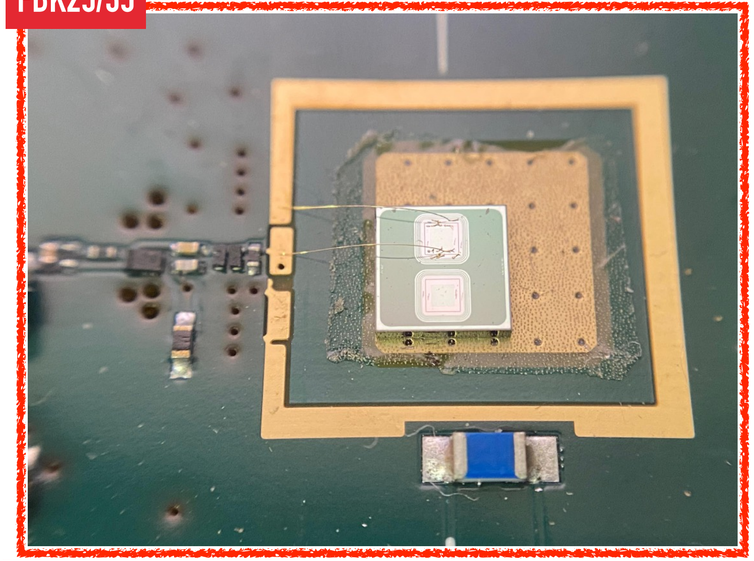
Study and characterization of LGAD:

- Single LGAD concept (sLGAD)
- Double LGAD concept (dLGAD)

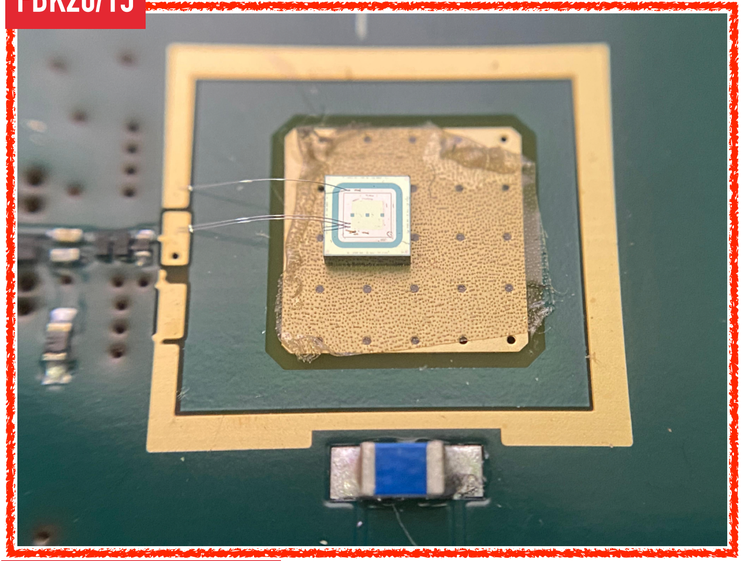
Thickness: 50-35-25-20-15 μm



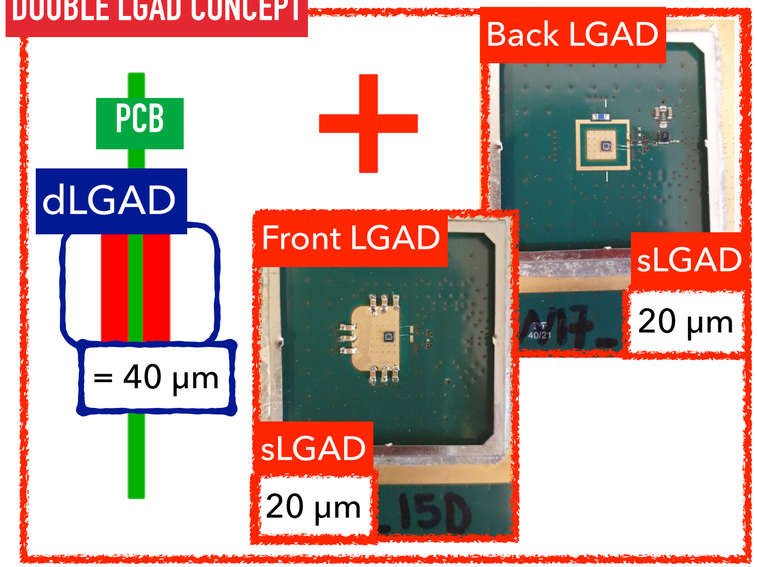
FBK25/35



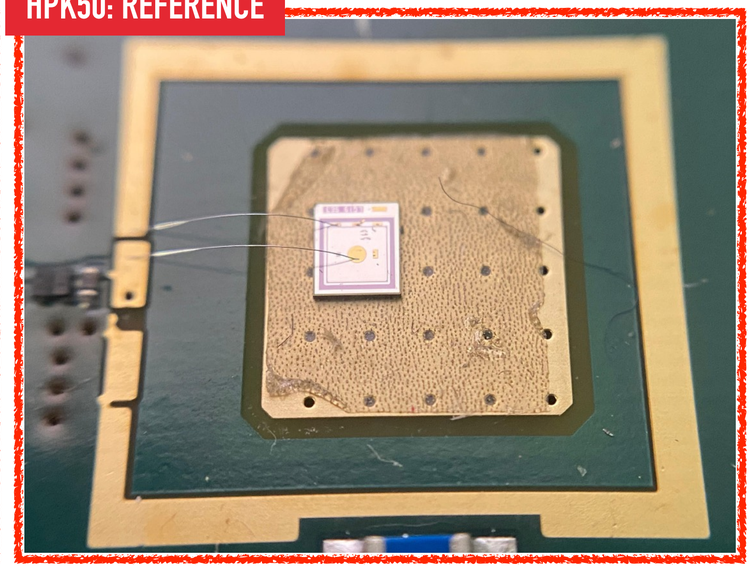
FBK20/15



DOUBLE LGAD CONCEPT

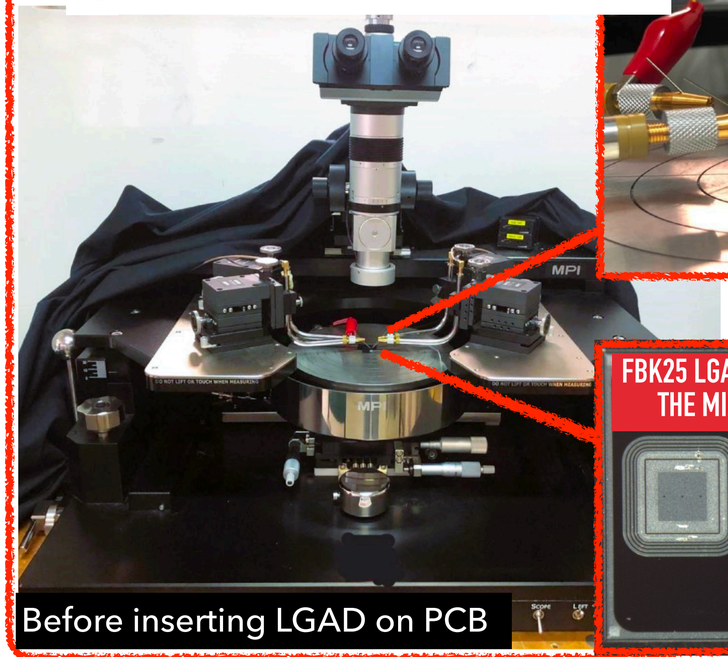


HPK50: REFERENCE

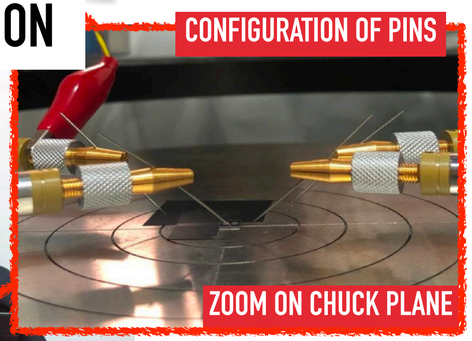


MY THESIS ACTIVITIES

1] SENSOR CHARACTERIZATION



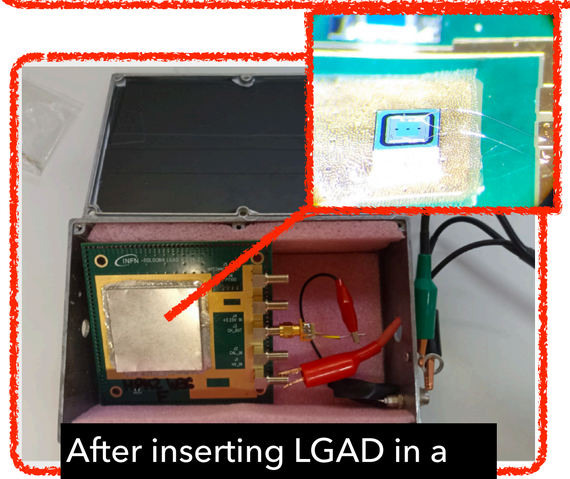
Before inserting LGAD on PCB



CONFIGURATION OF PINS

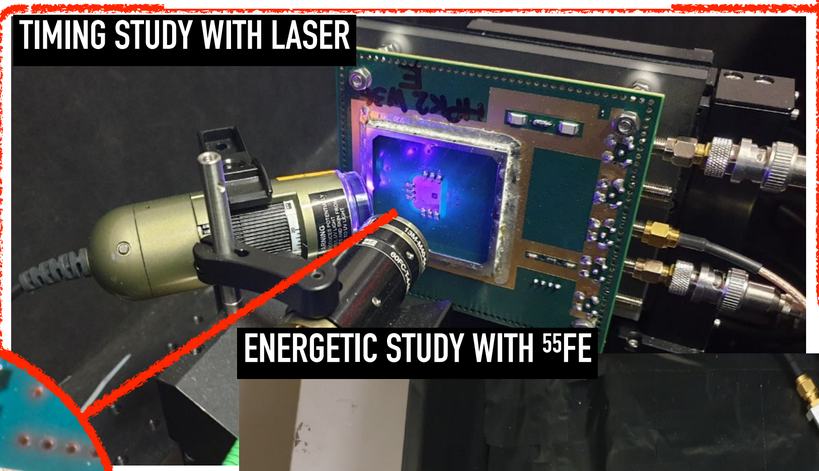
ZOOM ON CHUCK PLANE

FBK25 LGAD-PIN UNDER THE MICROSCOPE

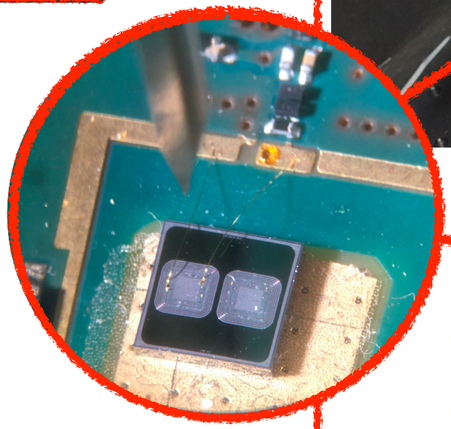


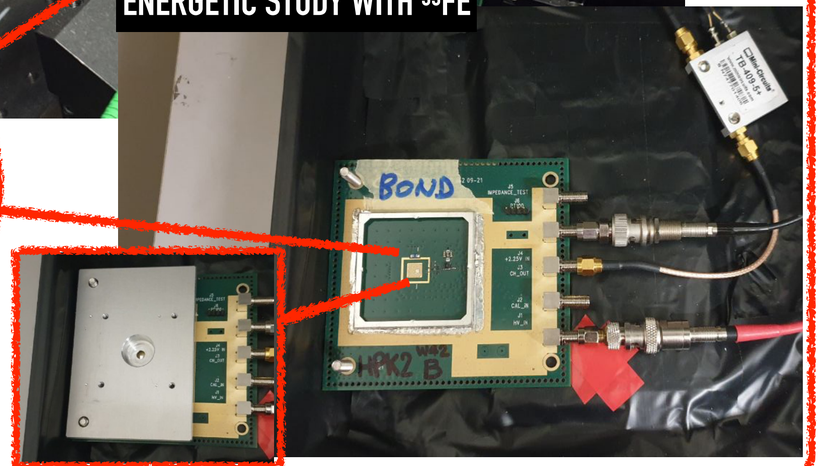
After inserting LGAD in a PCB and bonded

2] STUDIES WITH PHOTONS



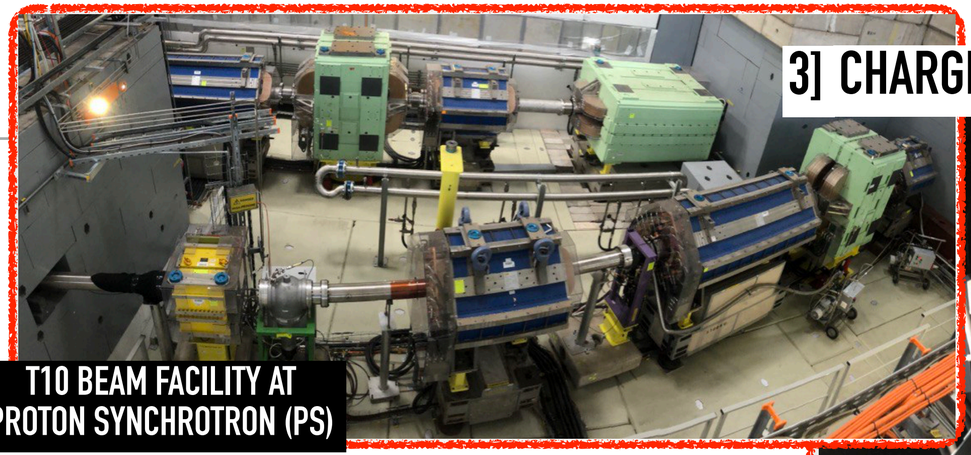
TIMING STUDY WITH LASER



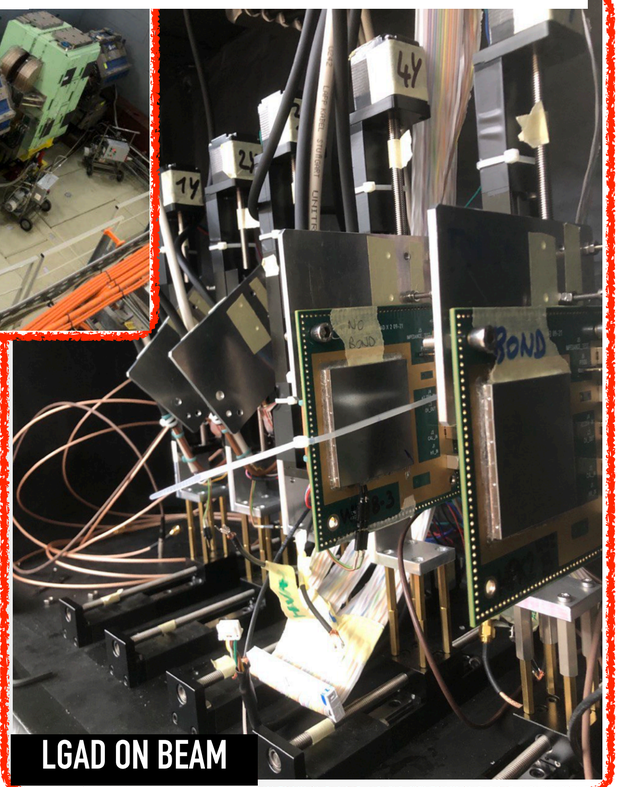


ENERGETIC STUDY WITH ^{55}FE

3] CHARGED PARTICLES STUDIES



T10 BEAM FACILITY AT PROTON SYNCHROTRON (PS)



LGAD ON BEAM

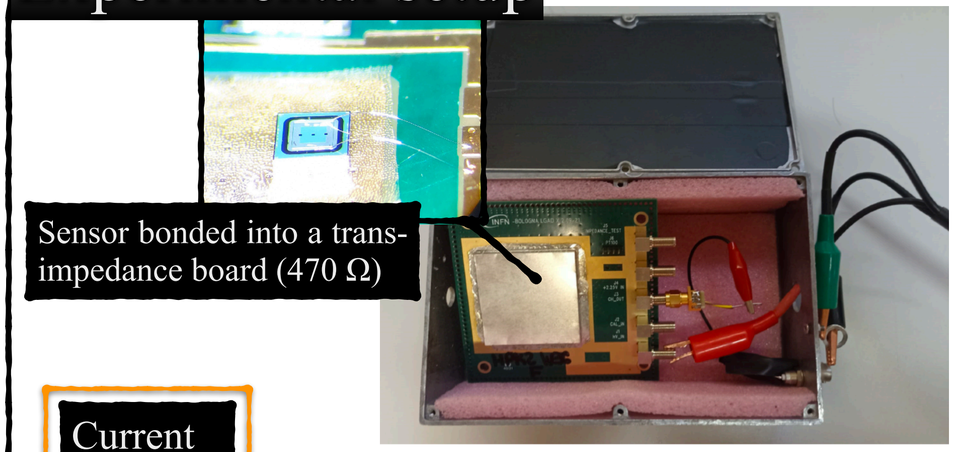
CHARACTERIZATION

- Extraction of Breakdown value (BD)
- Identification of Working Range (WR)

Typical BD values per thickness

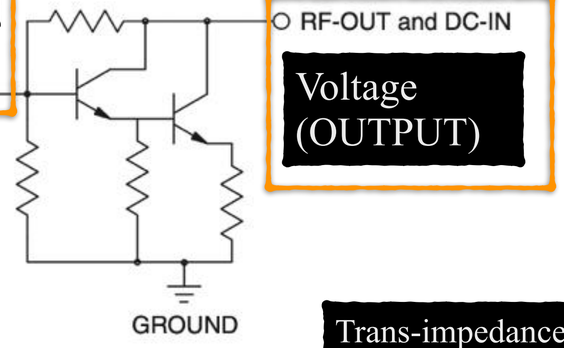
- 50 µm ≈ 240 V
- 35 µm ≈ 260 V
- 25 µm ≈ 120 V
- 15 µm ≈ 140 V
- 20 µm ≈ 150 V

Experimental setup



Sensor bonded into a trans-impedance board (470 Ω)

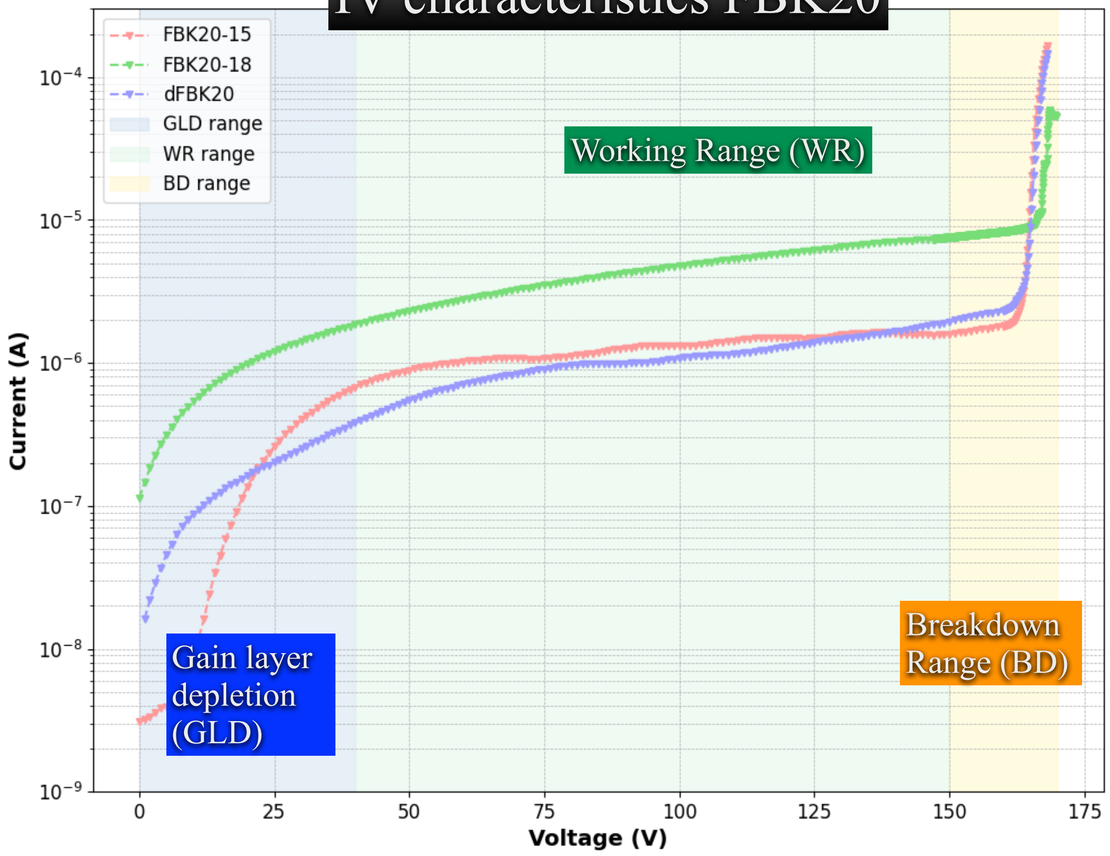
Current (INPUT)



Voltage (OUTPUT)

Trans-impedance circuit

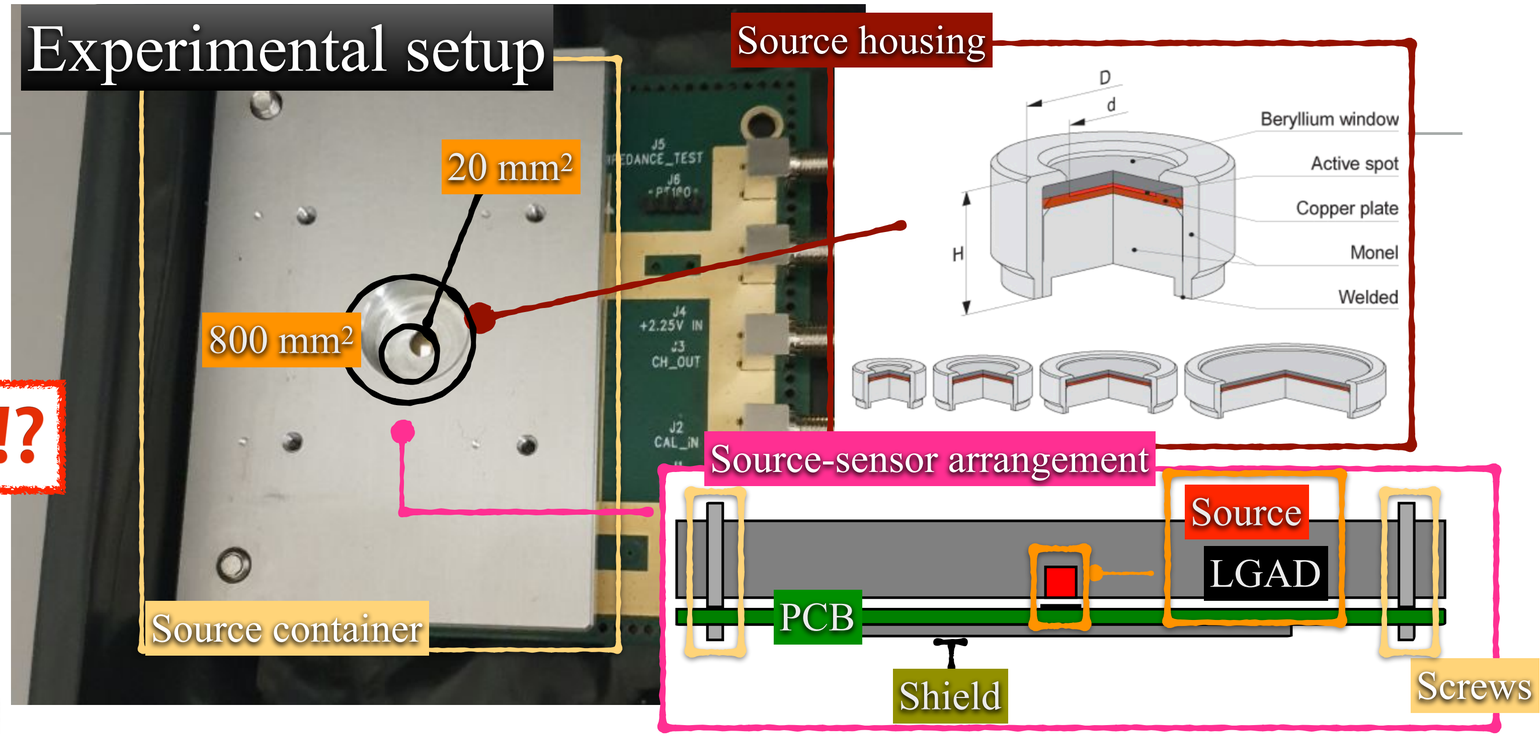
IV characteristics FBK20



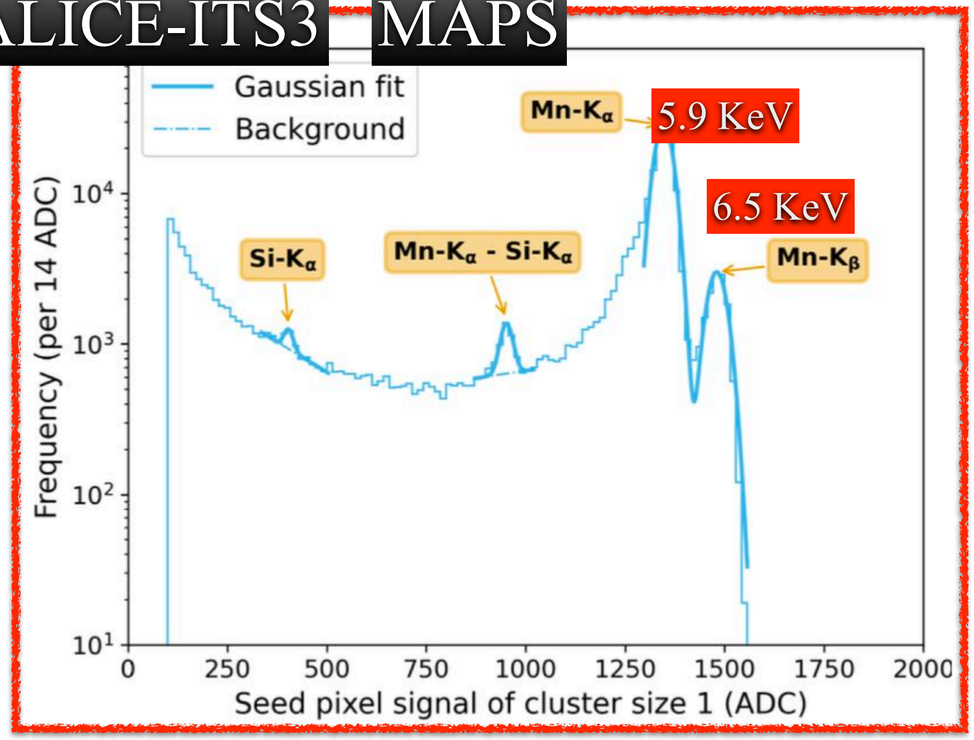
STUDY WITH ^{55}FE

- Extract peak resolution
- Determine charge deposited
- Determine N_{eh}
- Extract S/N

→ sLGADs
→ dLGADs !?

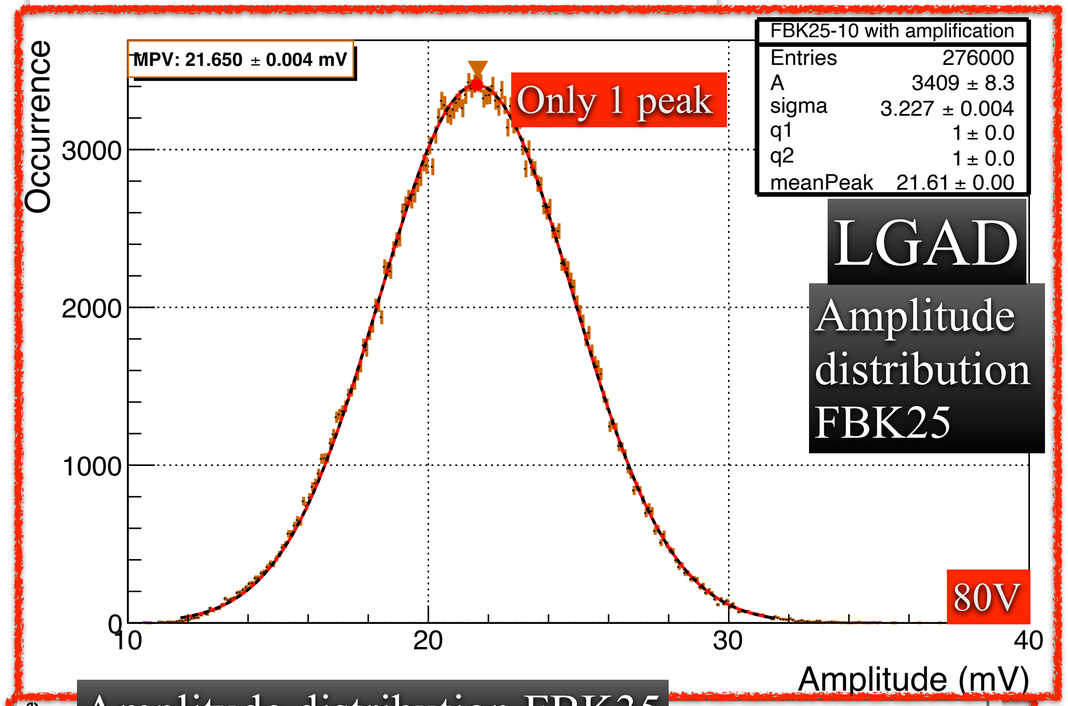


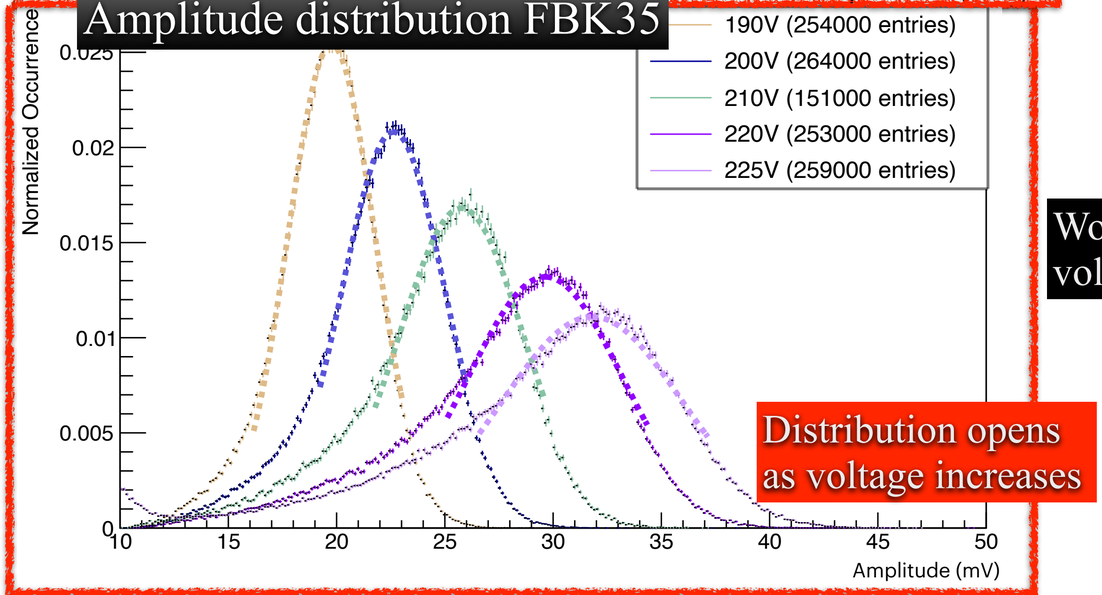
ALICE-ITS3 MAPS

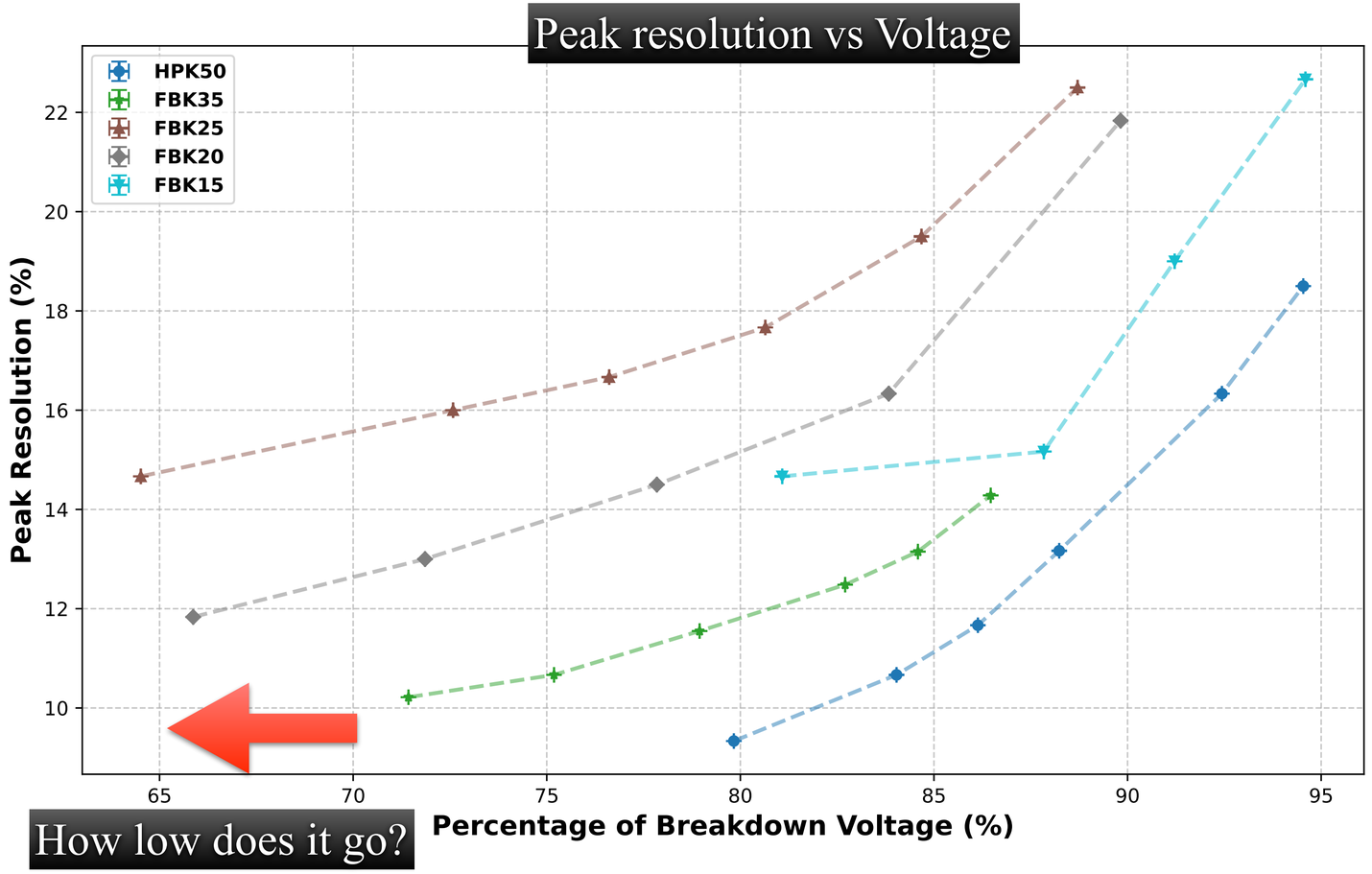


$^{55}Fe + e^- \rightarrow {}^{55}Mn + \nu$	Energy (keV)	Emissions per 100 disint.
Auger electrons	0.47 - 0.67	140.2 (8)
	4.95 - 6.53	60.1 (5)
X-rays	0.56 - 0.72	0.524 (21)
	5.888	8.45 (14)
	5.899	16.57 (27)
	6.490	3.40 (7)
	6.535	
γ	125.959	$1.3\ (1) \times 10^{-7}$

STUDY WITH ^{55}FE [1]





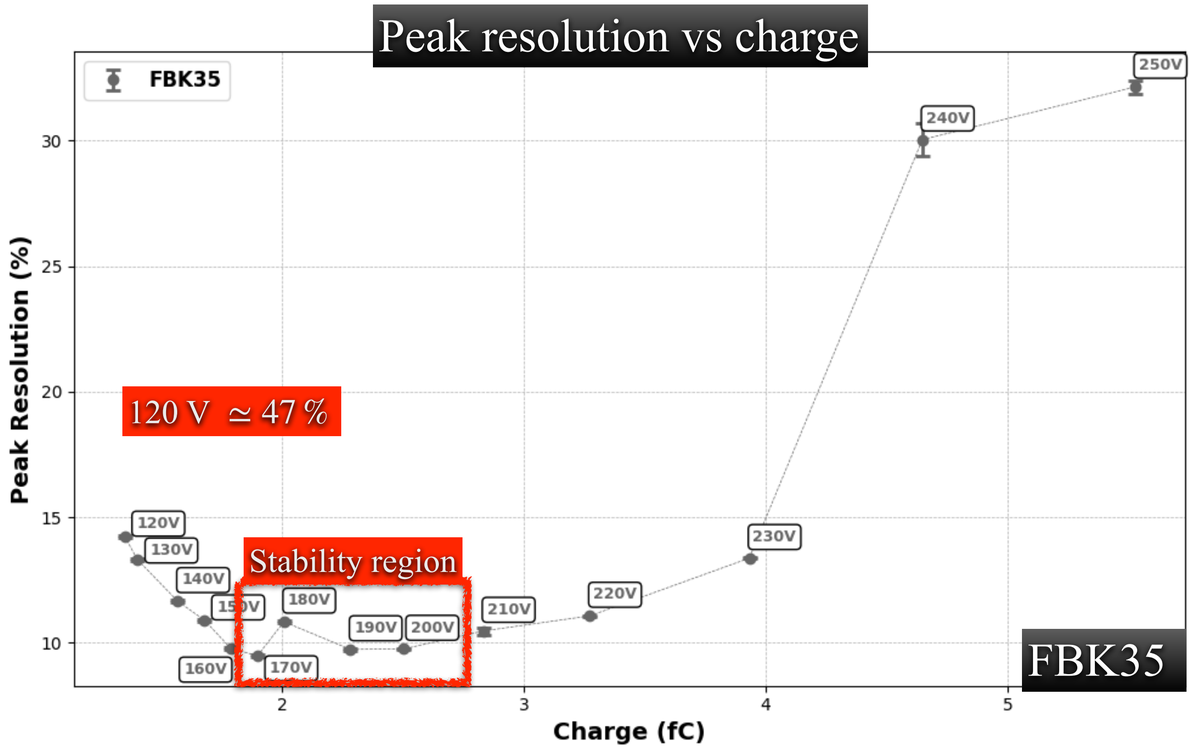


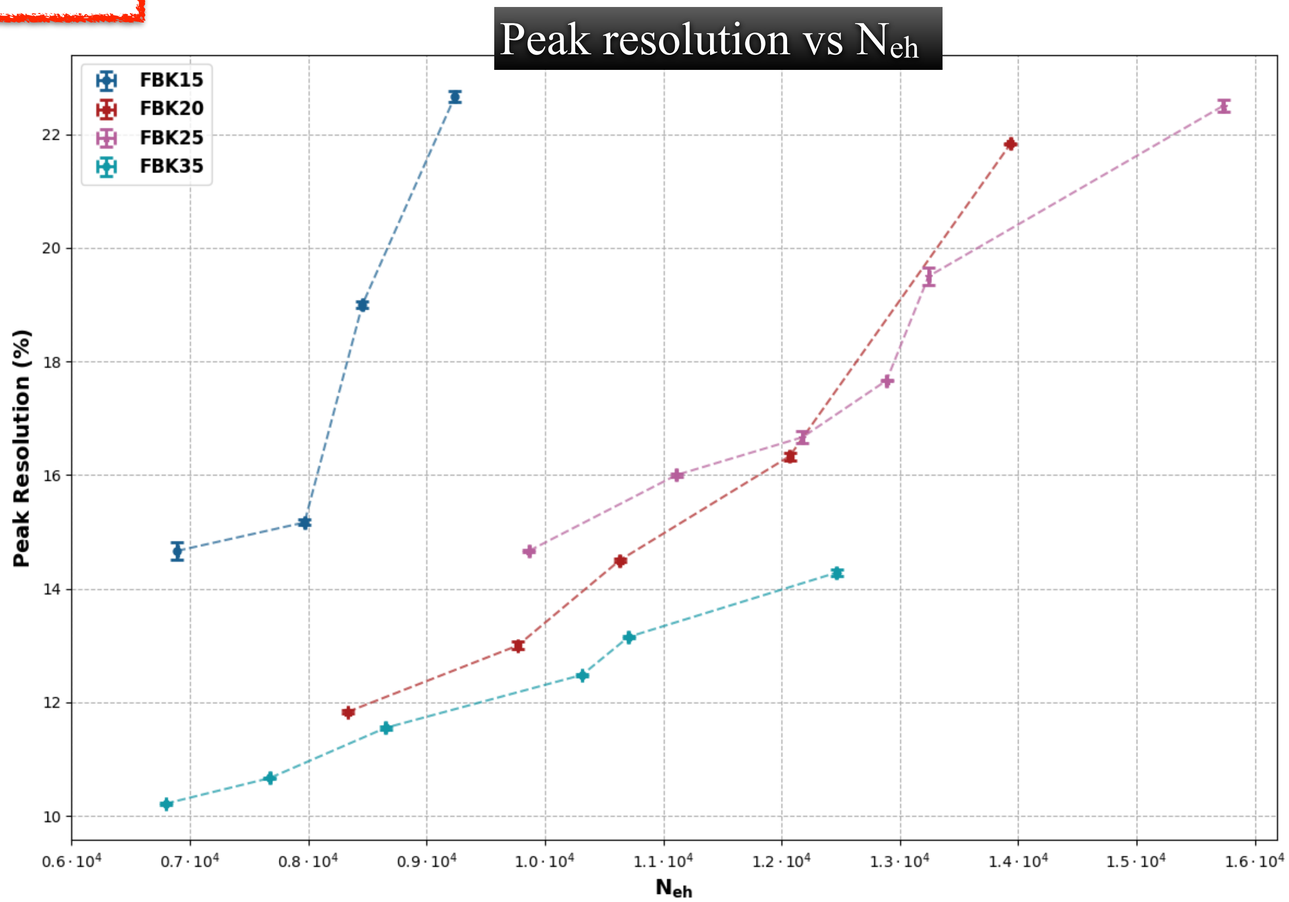
Worsening as voltage increases

Voltage	Mean (mV)	Sigma (mV)
190	(19.76 ± 0.03)	(2.00 ± 0.06)
200	(22.62 ± 0.02)	(2.35 ± 0.04)
210	(25.76 ± 0.02)	(2.85 ± 0.05)
220	(29.64 ± 0.03)	(3.52 ± 0.08)
225	(31.88 ± 0.04)	(4.11 ± 0.02)

STUDY WITH ^{55}FE [2]

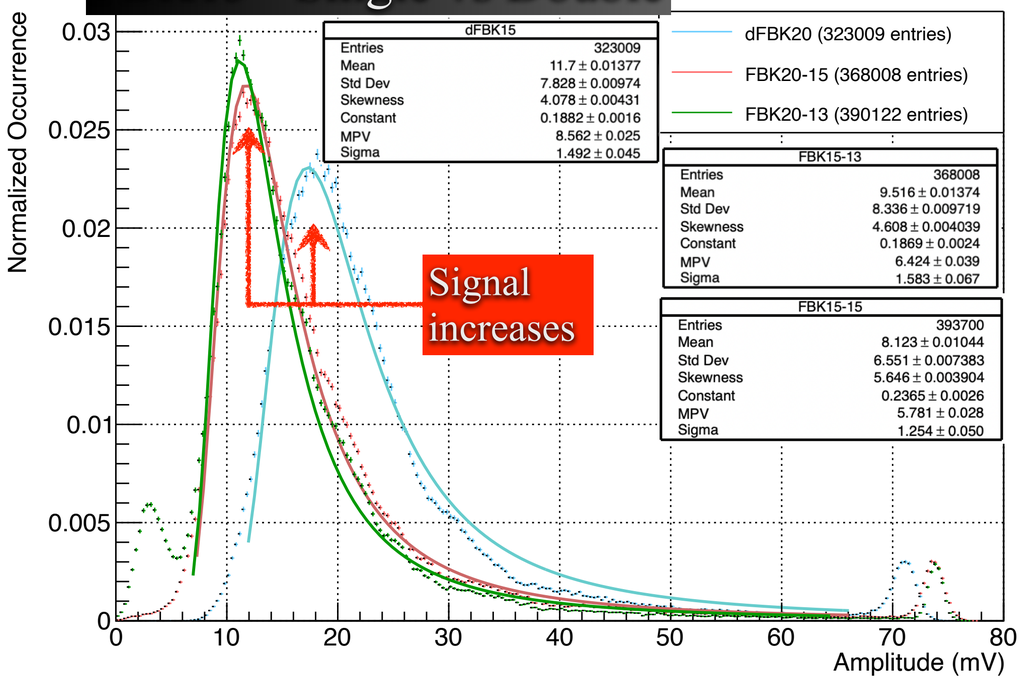
- Difficult explore low voltage regime for thinner sensor
- Unreliable results FBK20-FBK15
- Difficulty in comparing with HPK50 reference



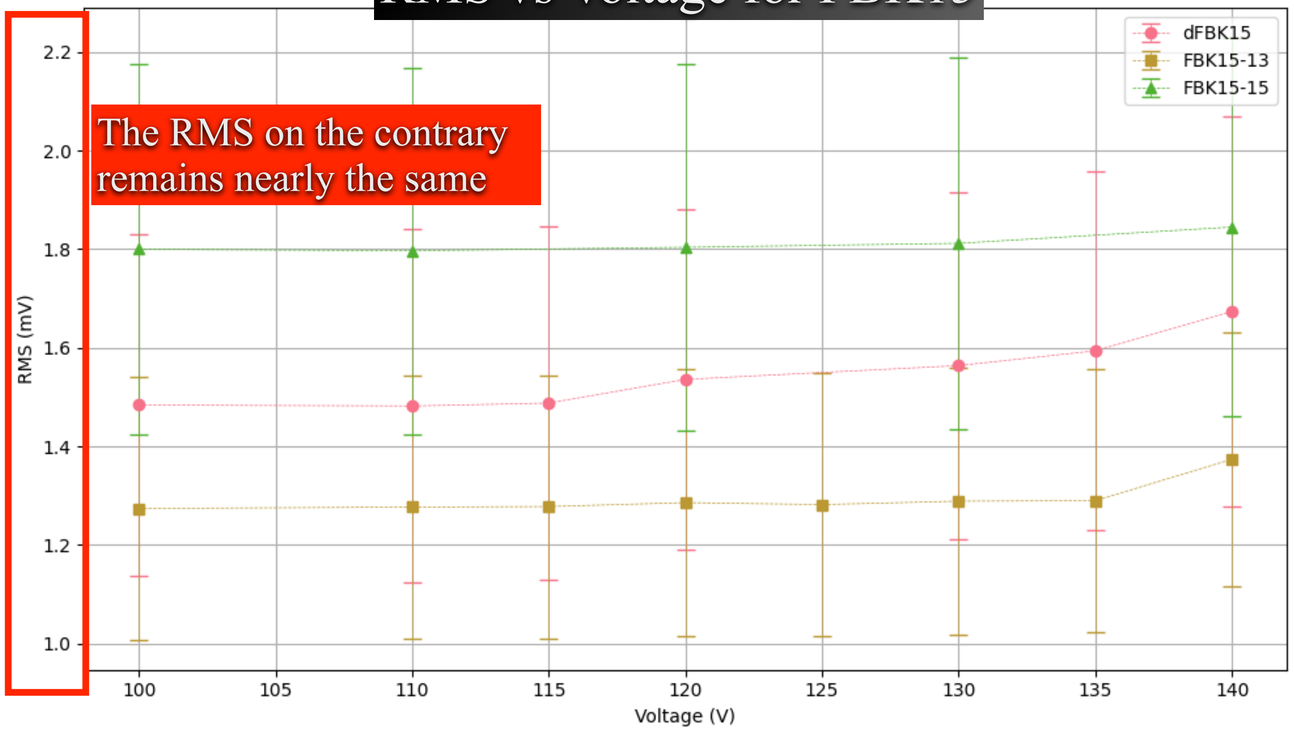


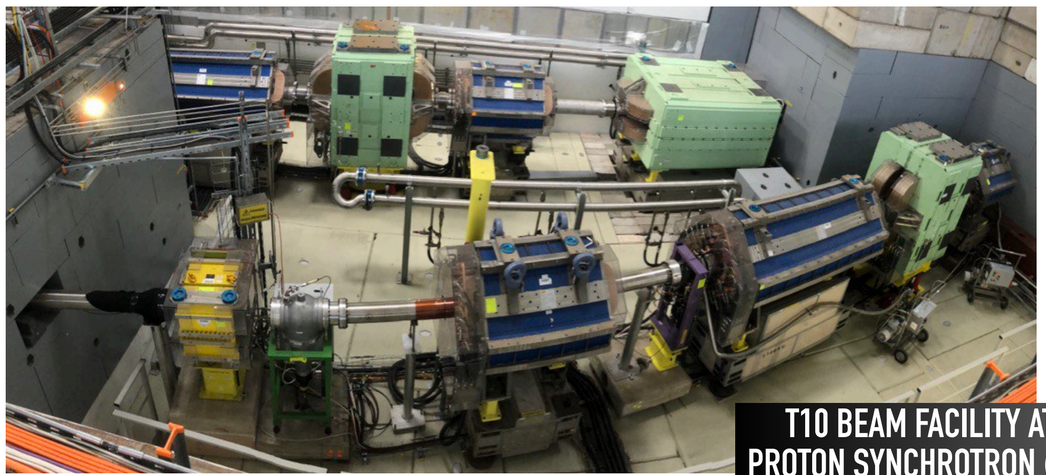
BEAM FACILITY AT PS T10

FBK15 - Single vs Double

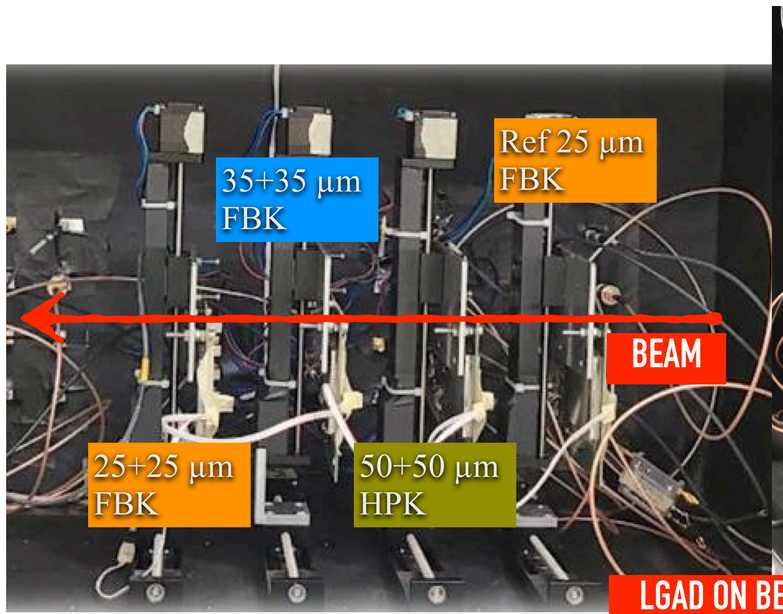


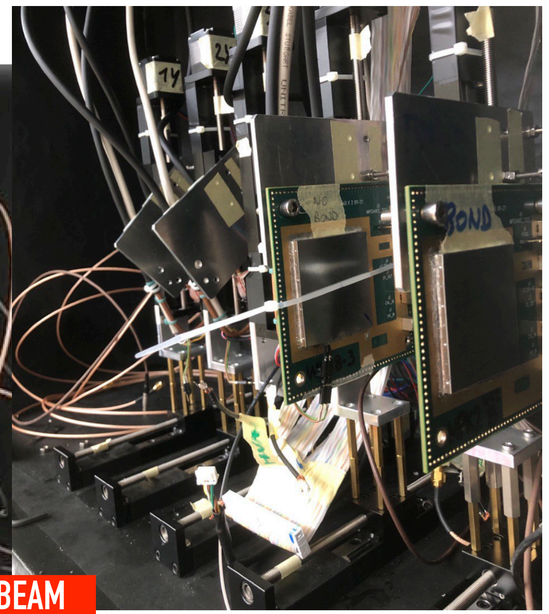
RMS vs Voltage for FBK15





T10 BEAM FACILITY AT PROTON SYNCHROTRON (PS)





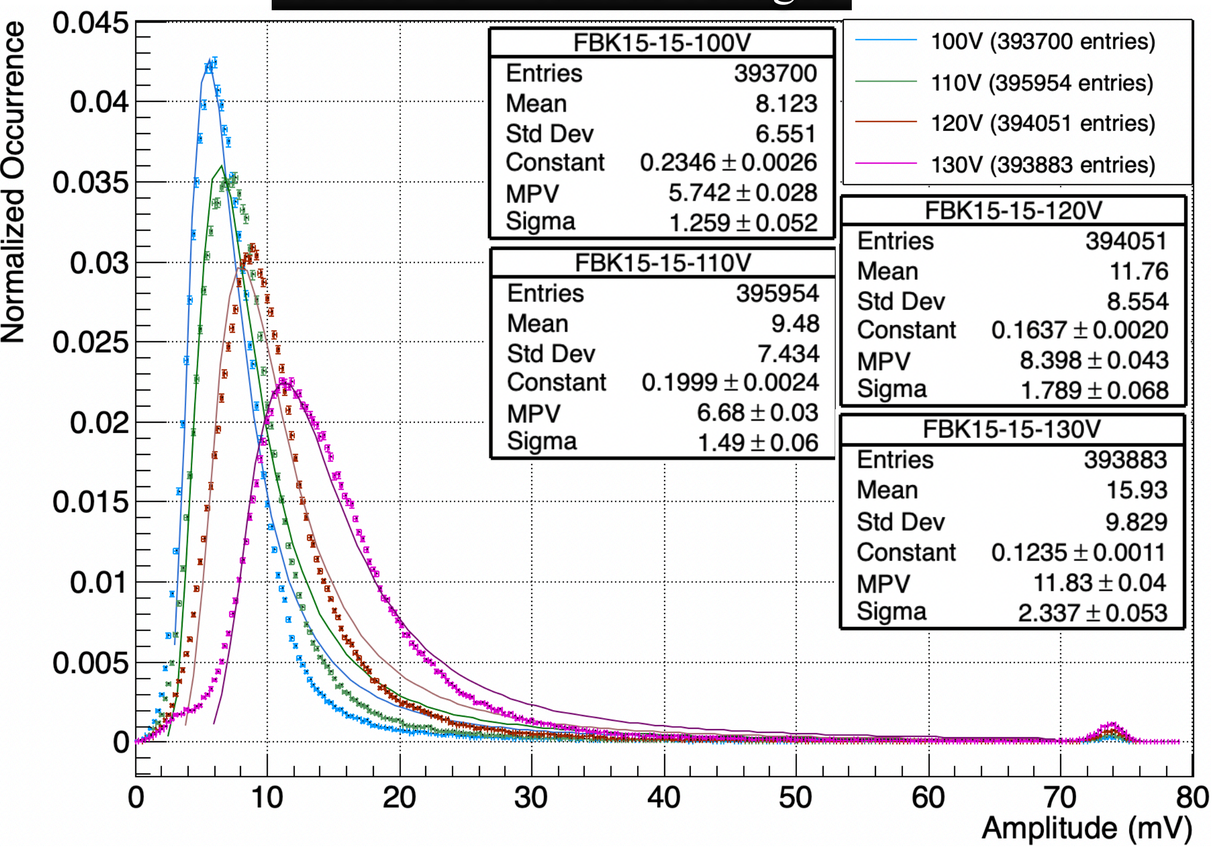
LGAD ON BEAM

BEAM FACILITY AT PS T10 [1]

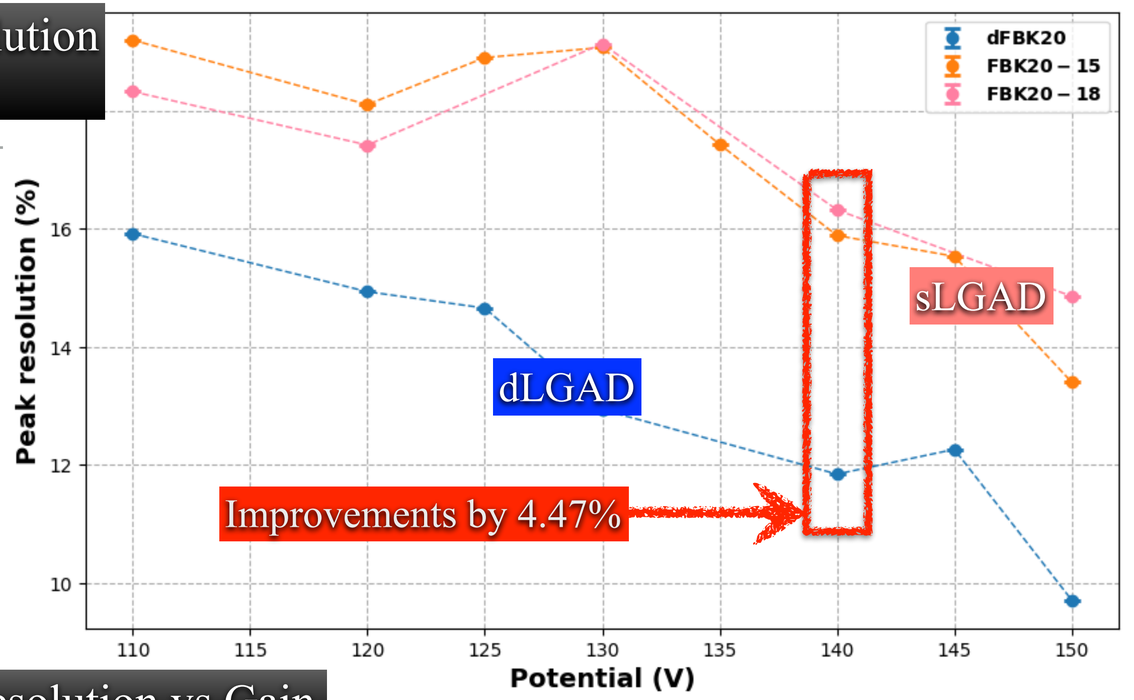
FBK20-15

- Timing resolution studies (Yet to be completed)
- Peak resolution studies

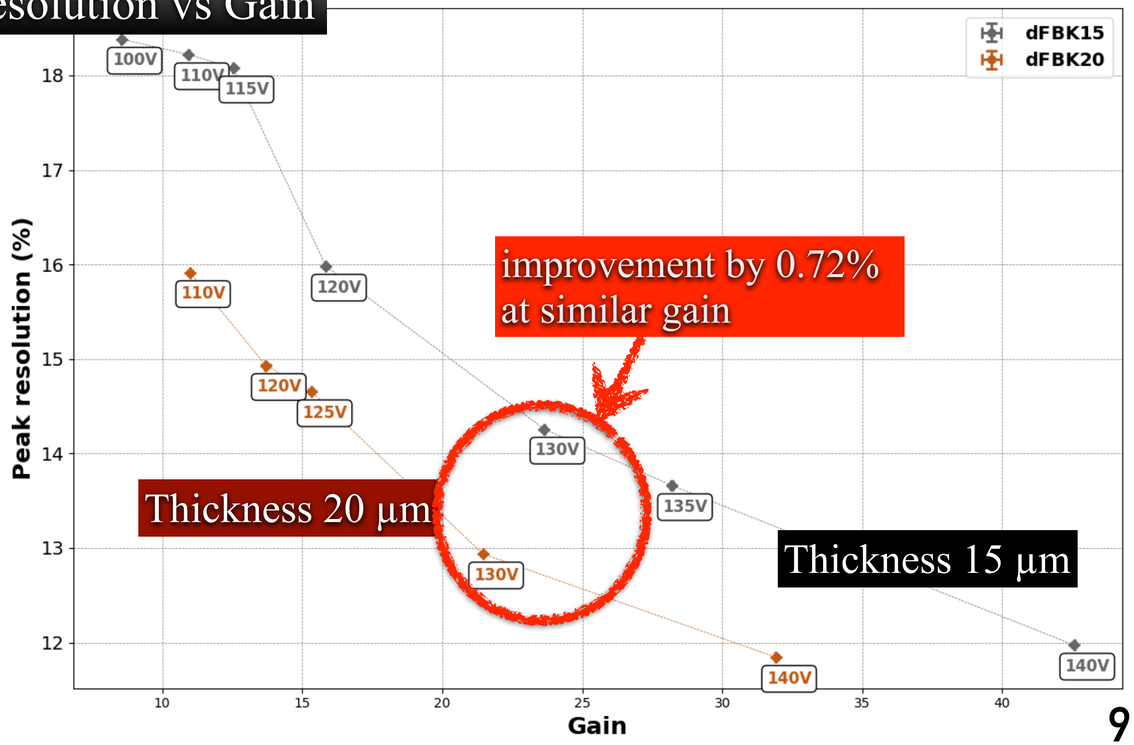
FBK15-15 - various voltages



Peak resolution FBK20



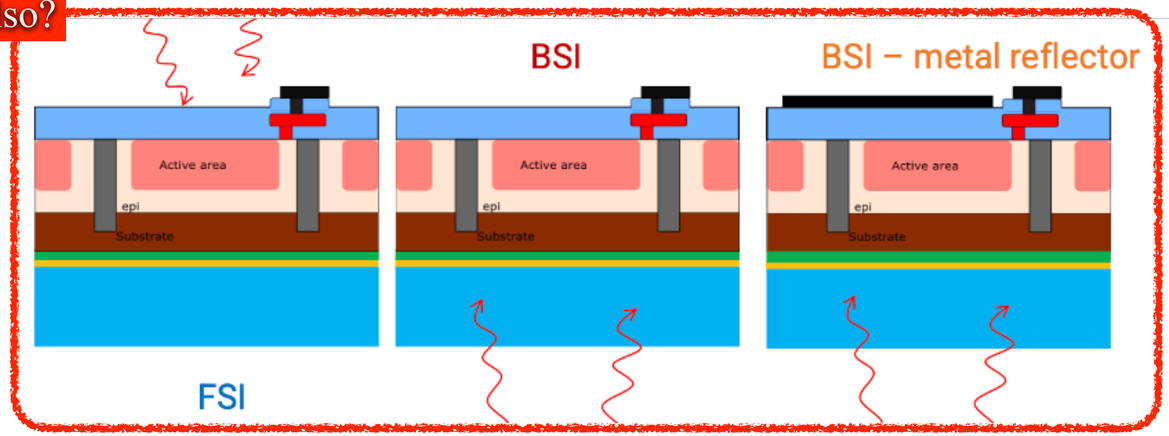
Peak resolution vs Gain



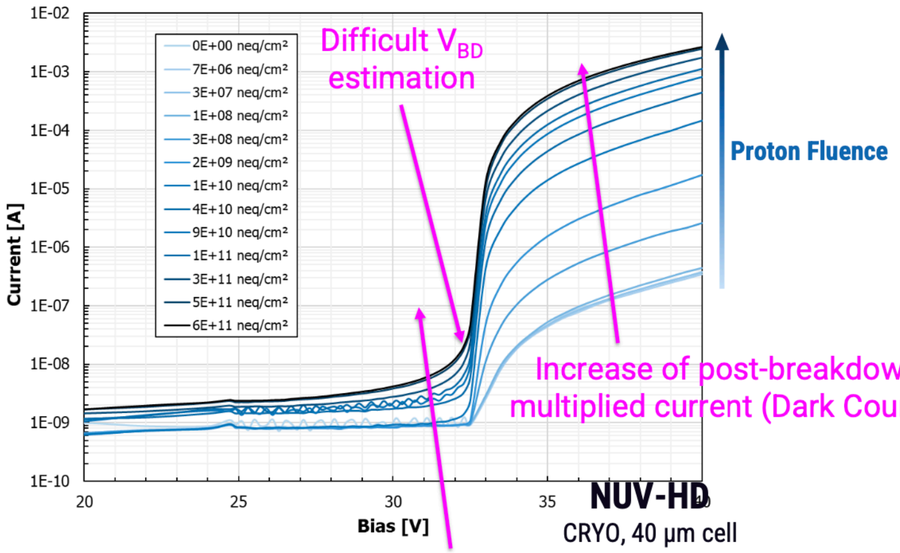
THEME OF MY PHD

- Working on Silicon PhotonMultipliers (SiPM) and radiation damage
- R&D for a radiation tolerant device for imaging application !

Could working for timing also?



Effects of irradiation on reverse IVs



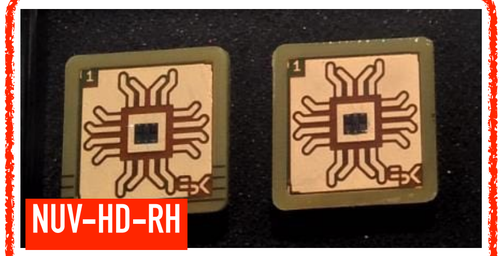
Difficult V_{BD} estimation

Increase of post-breakdown, multiplied current (Dark Counts)

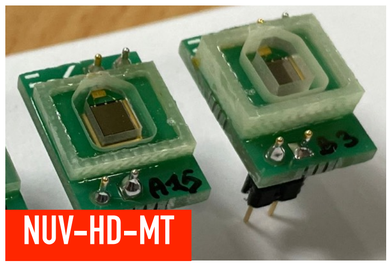
Increase of pre-breakdown, non-multiplied (~surface) current

SIPM

2022



2023



2024

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THANK YOU FOR YOUR ATTENTION
EDOARDO ROVATI