

p-irradiated 3D FBK sensors

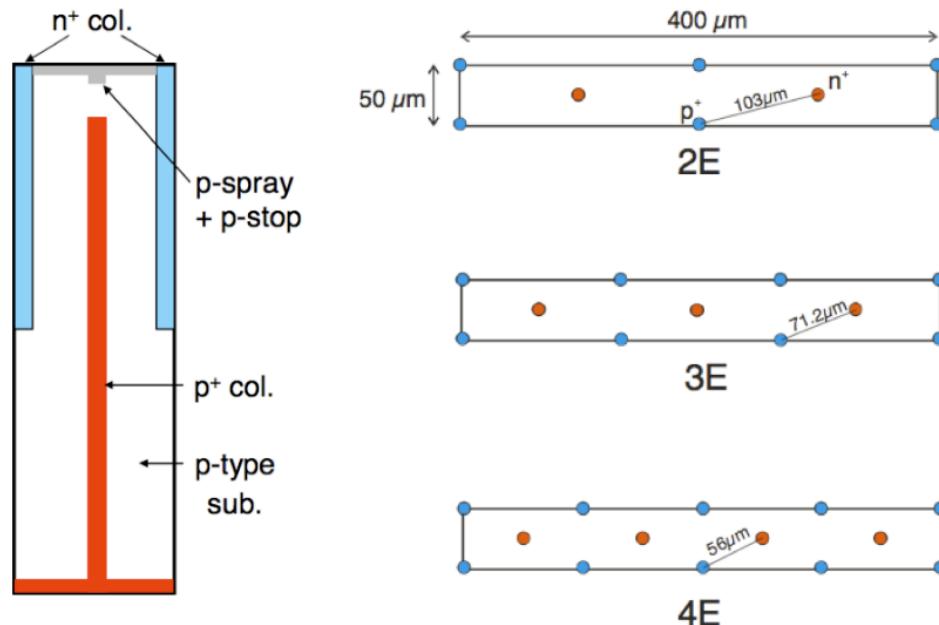
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CERN

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Devices under test

- 3D FBK-irst Double side Double Type Column
 - p-type substrate
 - Bump bonded at Selex (Indium based technology)
 - Flip-chipped on FE-I3
- Devices irradiate with 25MeV p-beam in Karlsruhe (by Univ. Bonn)
 - Fluence: $5.4 \text{ E}14 \text{ p/cm}^2 = 1 \text{ E}15 \text{ n}_{\text{eq}}/\text{cm}^2$
- DUT: **3E-type**

} FBK-irst
INFN Trento
INFN Genova



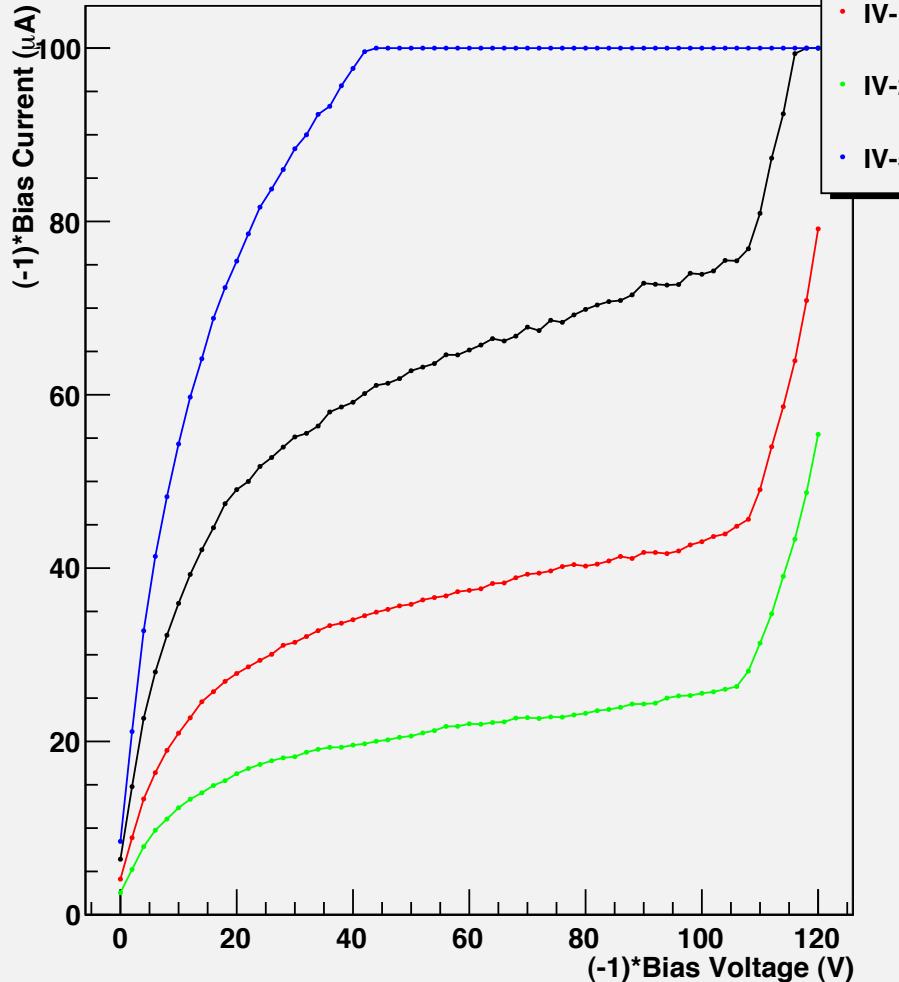
Parameter	Unit	Value
Substrate thickness	um	200
Junction column thickness	um	100 -110
Ohmic column thickness	um	180 -190
Column overlap	um	90 - 100
Substrate doping concentration	cm ⁻³	1×10^{12}
Lateral depletion voltage	V	3
Full depletion voltage	V	12
Capacitance vs backplane	fF/column	35
Leakage current @ Full depletion	pA/column	< 1
Breakdown voltage	V	> 70

Leakage current vs bias voltage

IV-10C + IV-15C + IV-20C + IV-5C.
Module "3E-p-irrad-(1E15neq)"

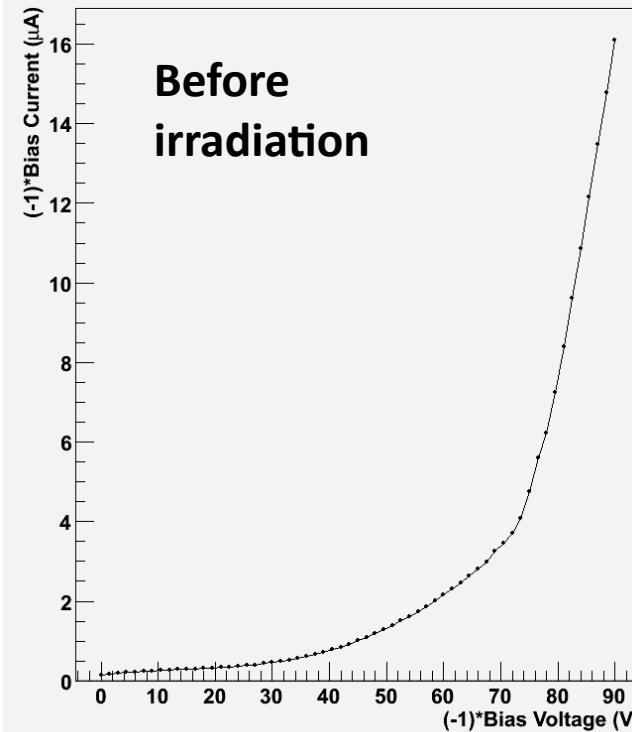
Fluence: 1 E15 n_{eq}

After irradiation



iv.
Module "3EM7"

IV curve



Before
irradiation

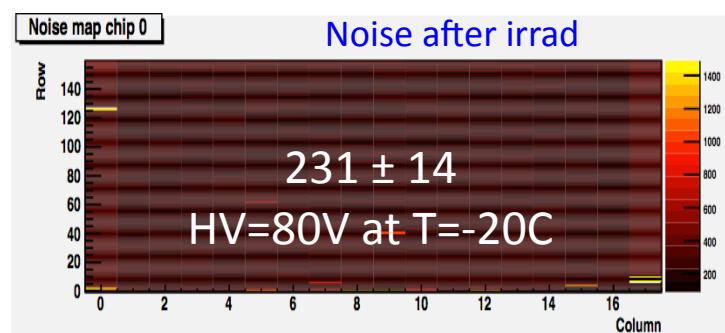
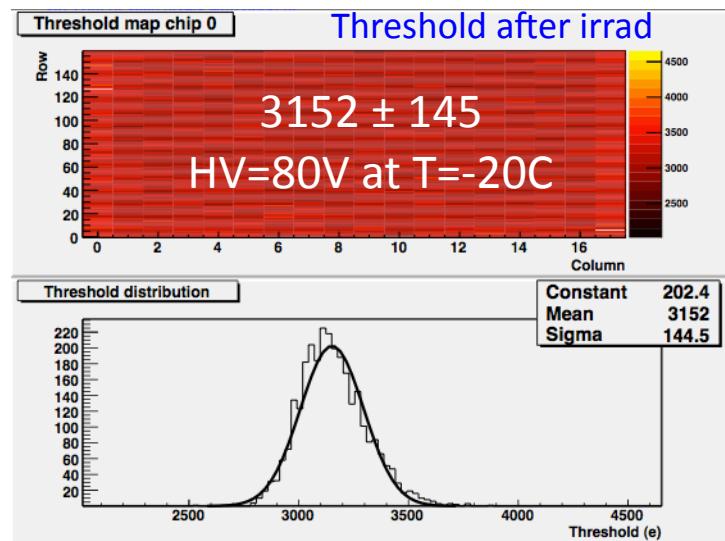
Irradiated device in agreement with
the theory: low temperature, low current

Damage rate α (scaled at room temperature):
4.3 E-17 A/cm

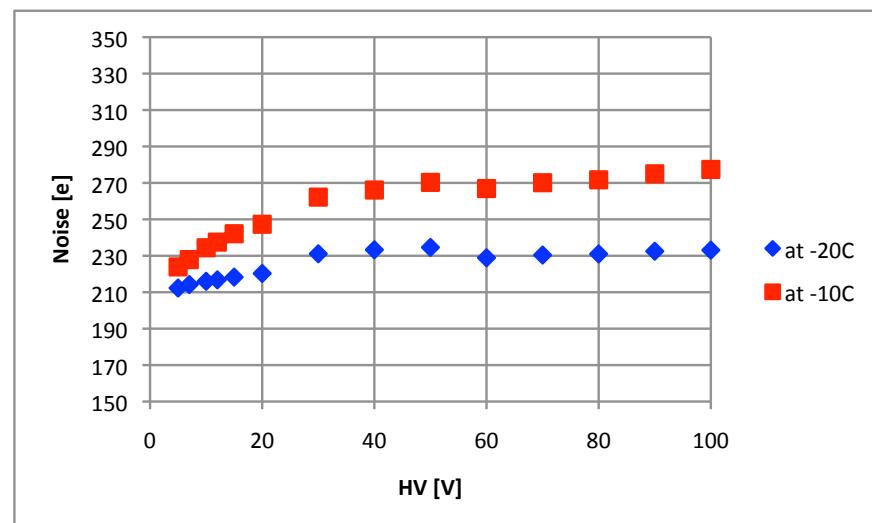
In agreement with published exp results !

Threshold and noise measurements

- FE tuned with 60 ToT at 20ke and Th=3.2ke
 - After irradiation ($1 \text{ E}15 \text{ n}_{\text{eq}}/\text{cm}^2$)
 - Configuration used during June 2010 test beam

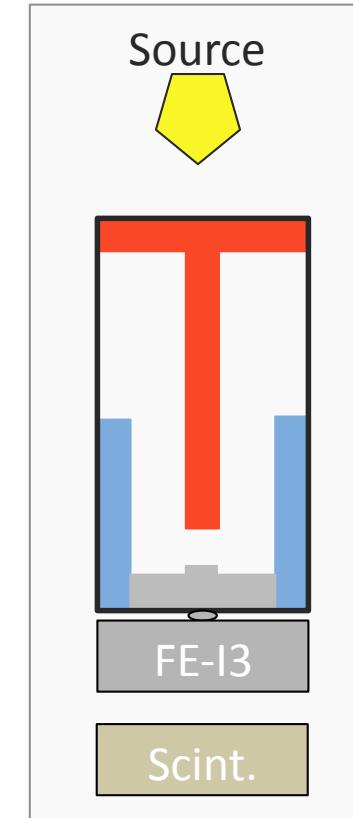


	Threshold [e]	Noise [e]
Before irrad	3292 ± 57	214 ± 8
After irrad	3152 ± 145	231 ± 14

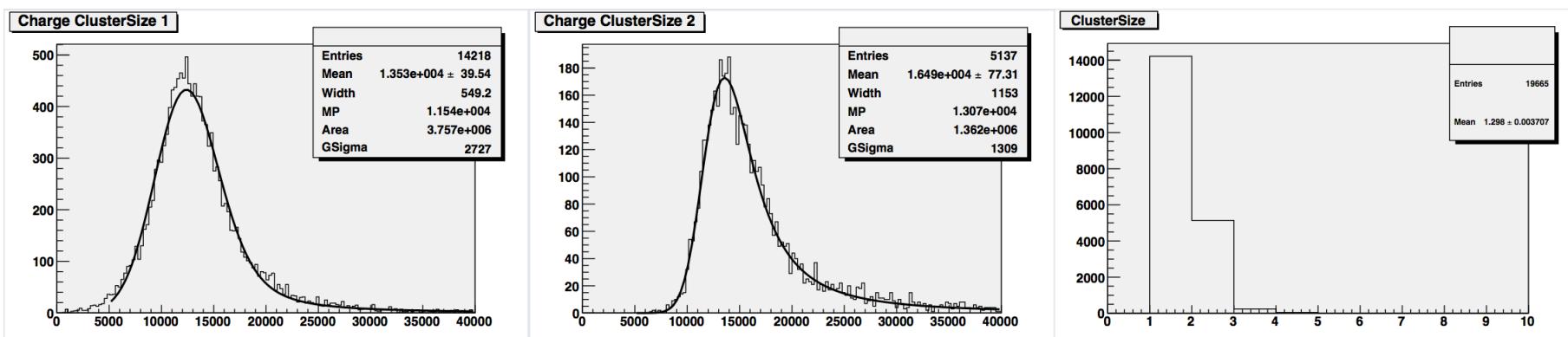
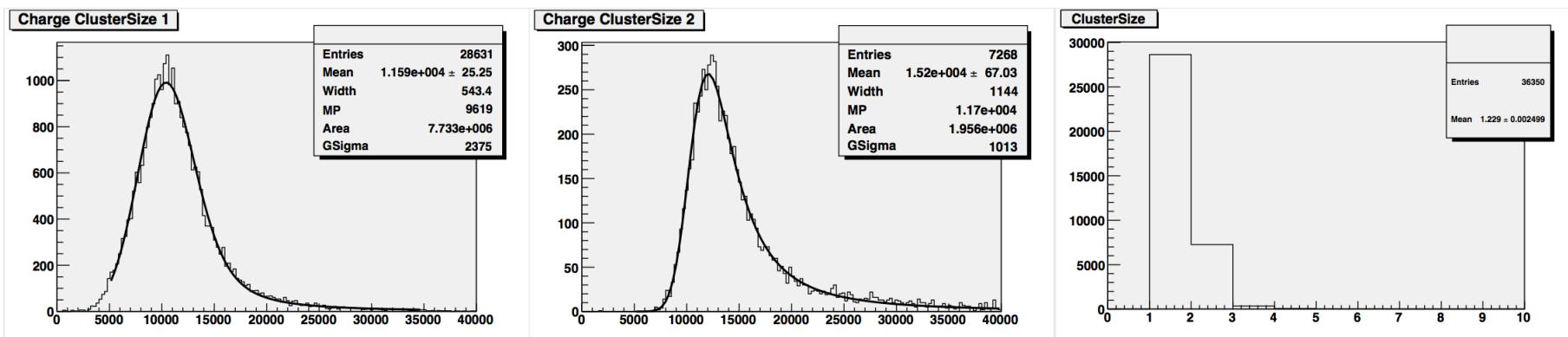
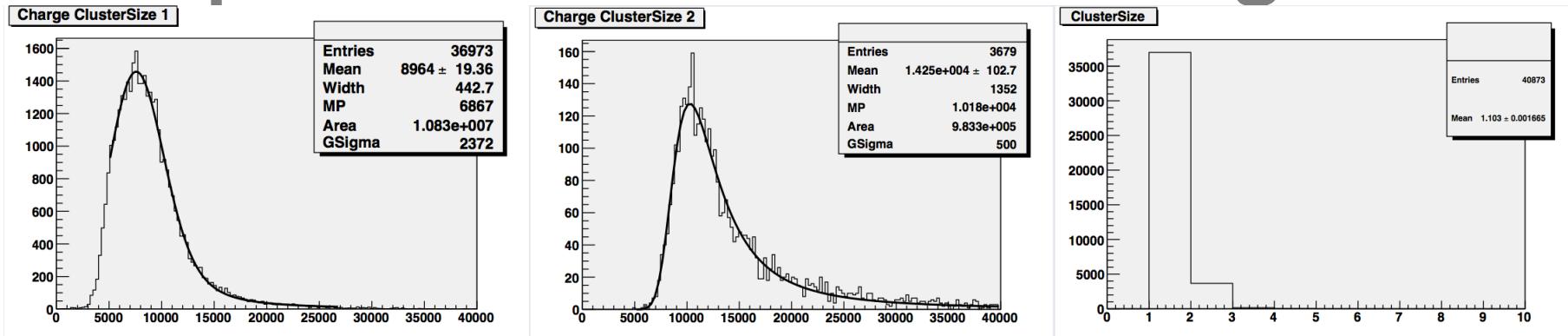


Source test measurements

- TurboDAQ and climate chamber
 - FE: Th=3.2ke- with 60 ToT at 20ke-
 - Sr90 β -source test (external triggered)
 - 241Am γ -source test (self triggered)
 - Temperature: -20C

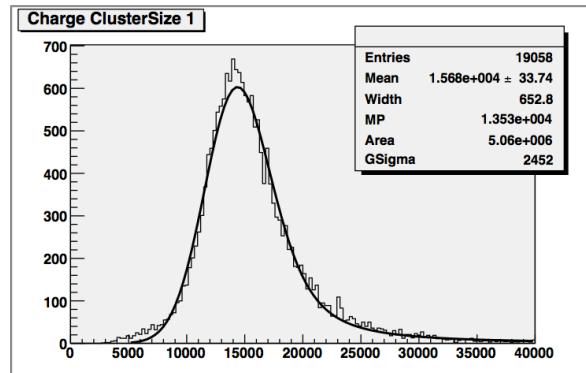


Sr90 β -source scan at -20C: Langau fit



Sr90 β -source scan

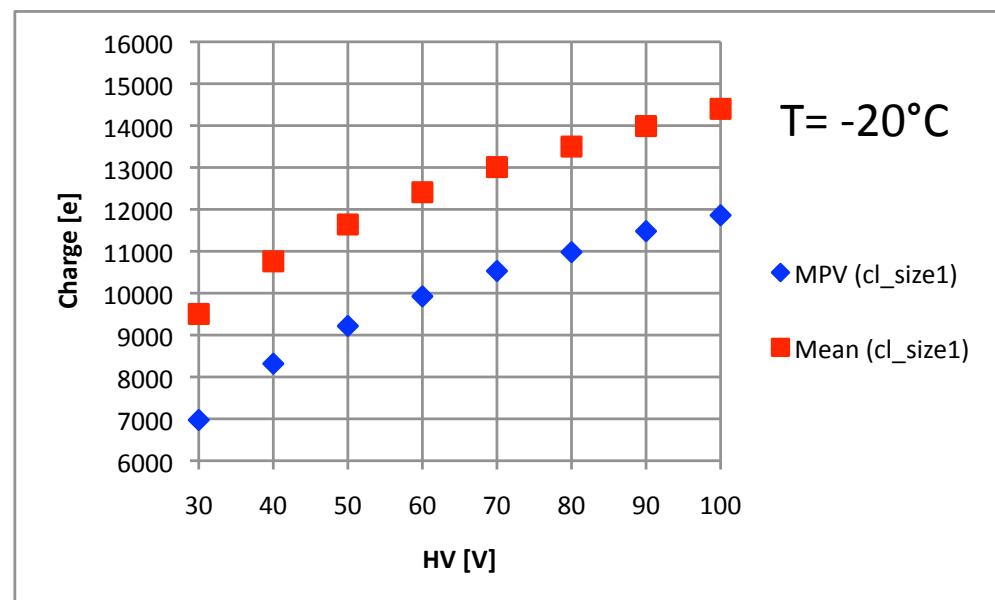
- Before irradiation ($T=22^\circ\text{C}$ and $\text{HV}=35\text{V}$)



Cl_size 1: MPV = 13.53 ke-

Expected value if we compare it with what has been obtained from Planar pixel sensor (250um thick):
16.02 ke- (Cl_size 1)

- Measurements at different bias after irradiation ($1 \text{ E}15 \text{n}_{\text{eq}}$)



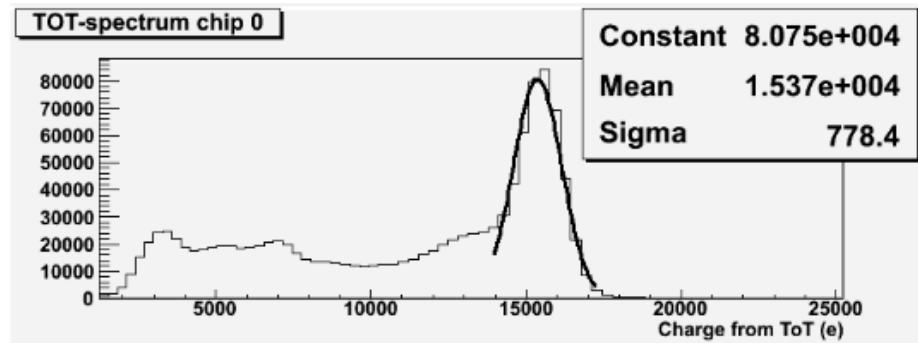
15% of lost charge at 100V
(irrad: MPV of 11.54ke-)

30% of lost charge at 60V
(irrad: MPV of 9.62ke-)

51% of lost charge at 30V
(irrad: MPV of 8.96ke-)

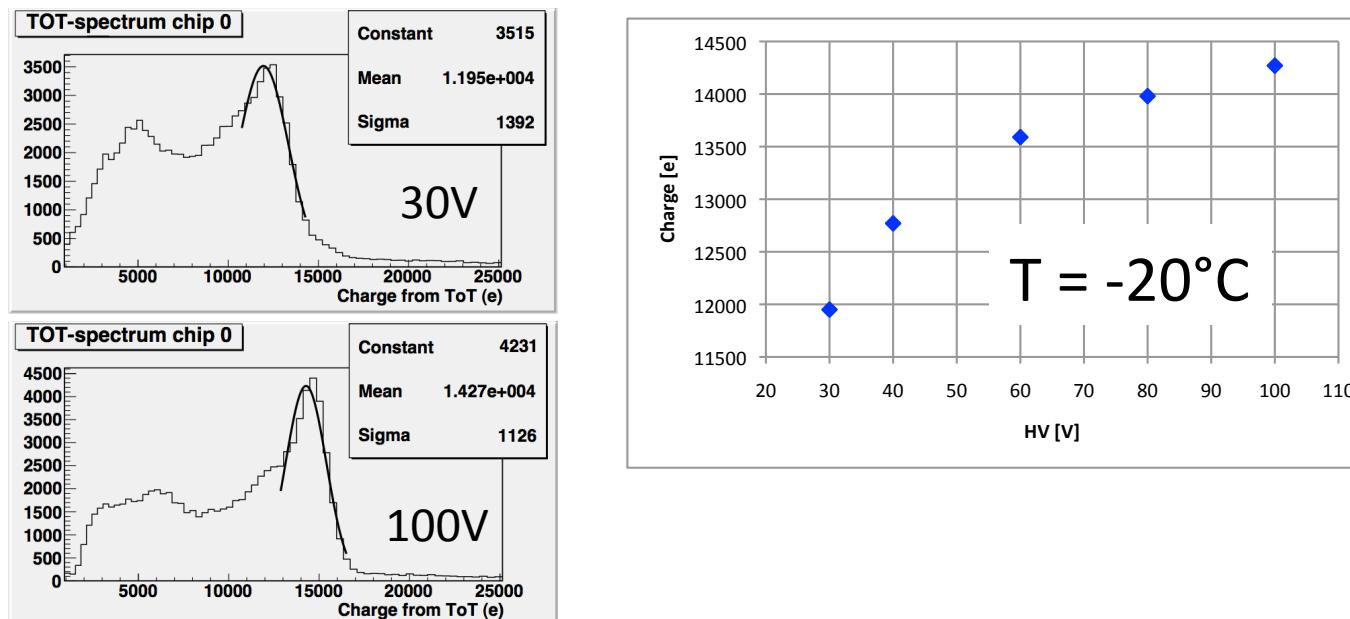
241Am γ -source scan

- Before irradiation ($T=22^\circ\text{C}$ and $\text{HV}=35\text{V}$)



Shows the source spectrum as a sum over all pixels without any clustering.

- Measurements at different bias after irradiation ($1 \text{ E}15 \text{n}_{\text{eq}}$)



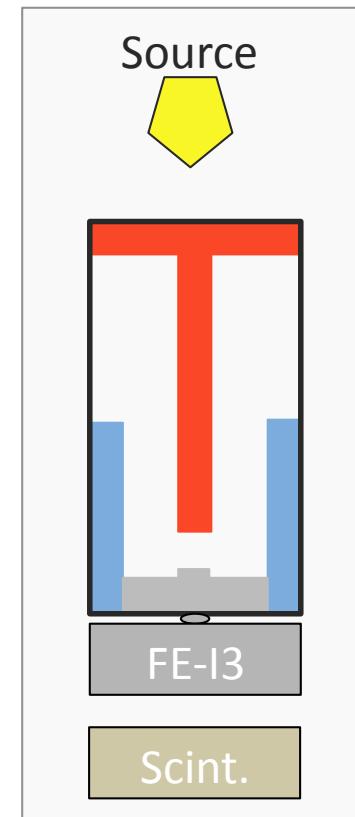
Open question about lost charge ...

- From Sr90 β -source test (cluster size 1)

	30V	40V	60V	80V	100V
Lost charge	49%	40%	30%	21%	15%

- From 241Am γ -source test (any clustering)

	30V	40V	60V	80V	100V
Lost charge	22%	17%	12%	9%	7%



A huge different of lost charge has been observed between Sr90 and 241Am sources test measurements.

Considering the exp setup (see fig) and that 241Am gives 60KeV photons which convert anywhere in the bulk to 60keV electrons (which have a CSDA[§] range of about 35um), WHY did we observe less lost charge with 241Am than with Sr90 ?