

Characterization of irradiated SiPM for the TOP detector at the Belle II experiment

Hamamatsu modules

Padova meeting
23/09/2024

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INFN Padova

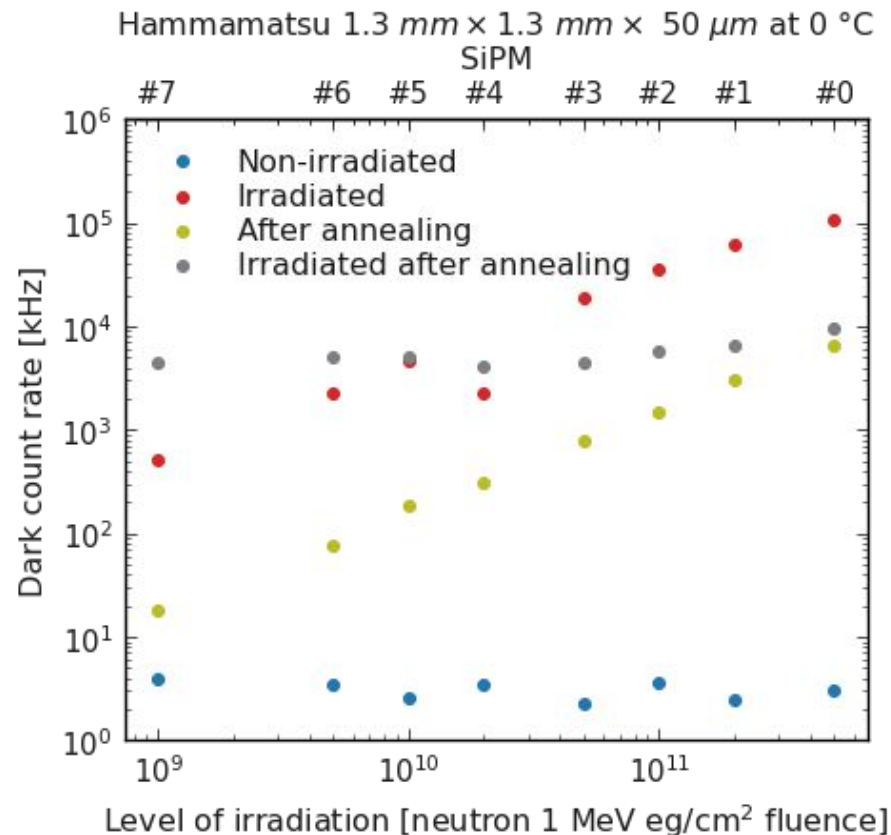
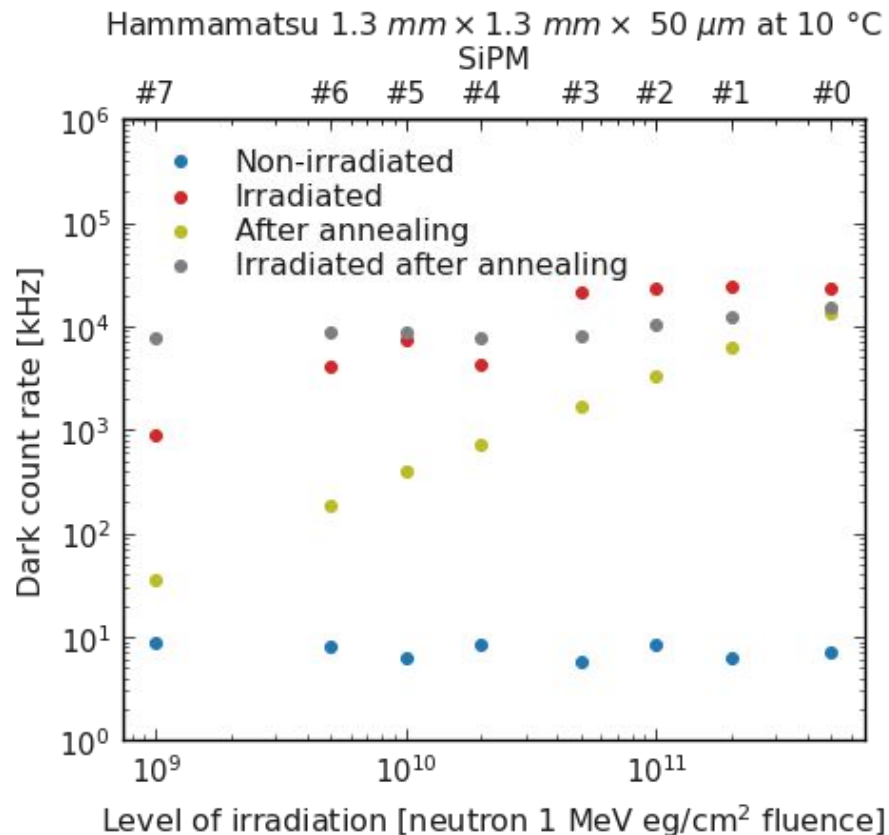
Tests with irradiated modules in Padova



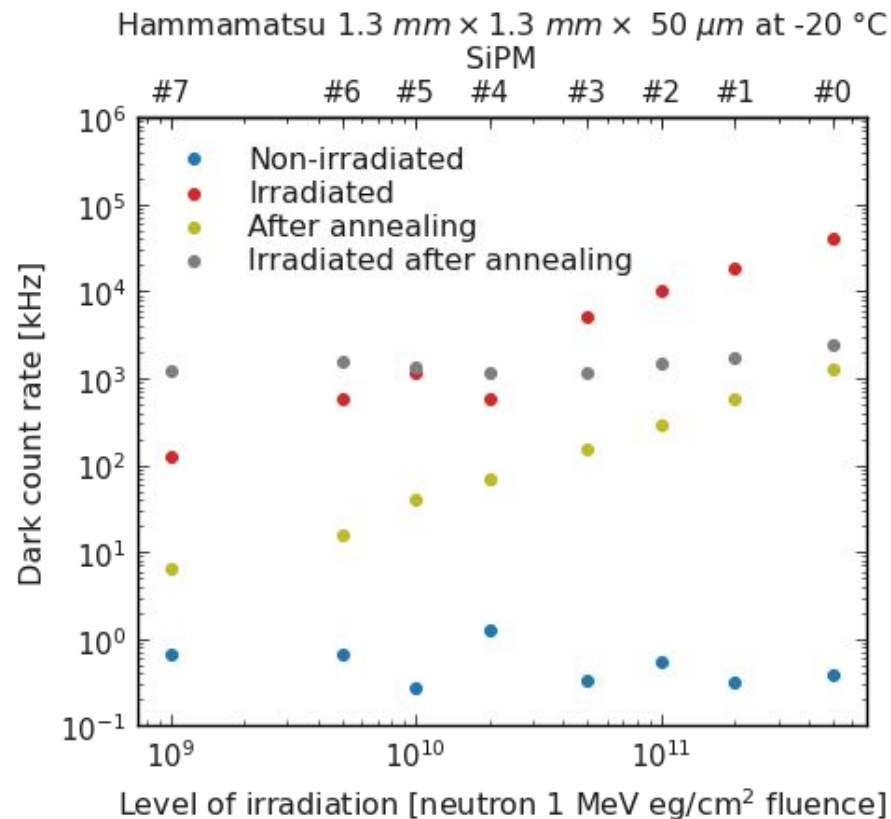
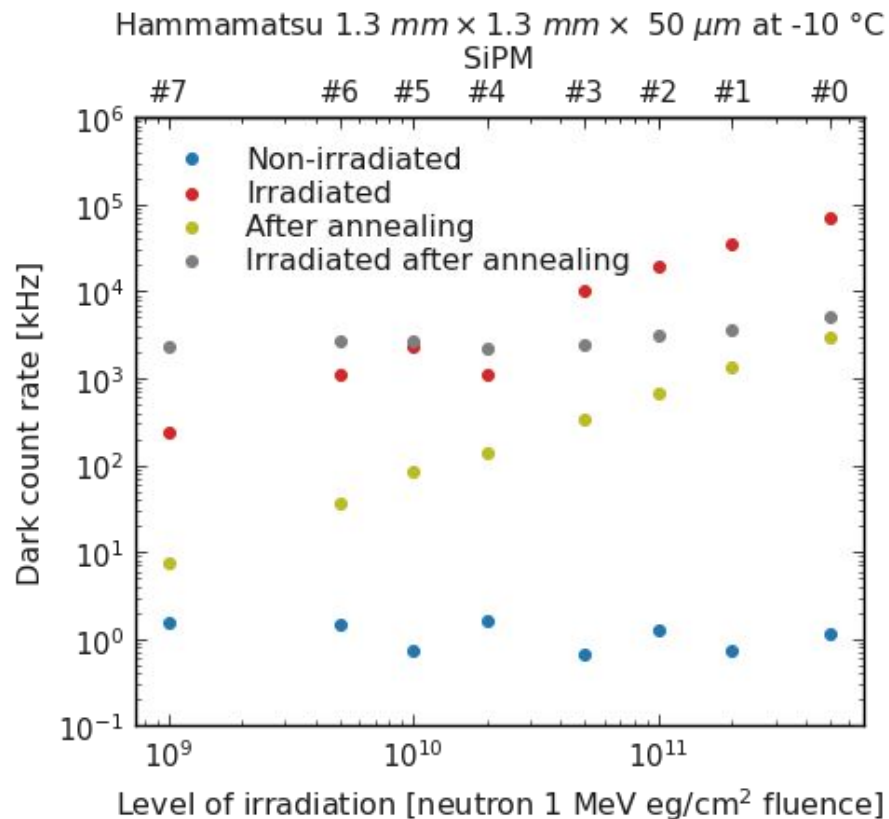
- In Belle II, MCP-PMTs with extended lifetime have been installed and they have limited lifetime depending on accumulated charge.
- We are trying to understand if they eventually can be replaced with SiPMs.
- We irradiated 24 SiPMs modules with different neutron fluxes and tested by laser.
- Sixteen of them are processed to study their response.
- Collected data are read from modules and analyzed.

Index	Producer	Dimension [mm×mm]	Pitch [μm]	Neutron 1 MeV eg/cm ² fluence
0	Hamamatsu	1.3 × 1.3	50	5.0·10 ¹¹
1	Hamamatsu	1.3 × 1.3	50	2.0·10 ¹¹
2	Hamamatsu	1.3 × 1.3	50	1.0·10 ¹¹
3	Hamamatsu	1.3 × 1.3	50	5.0·10 ¹⁰
4	Hamamatsu	1.3 × 1.3	50	2.0·10 ¹⁰
5	Hamamatsu	1.3 × 1.3	50	1.0·10 ¹⁰
6	Hamamatsu	1.3 × 1.3	50	5.0·10 ⁹
7	Hamamatsu	1.3 × 1.3	50	1.0·10 ⁹

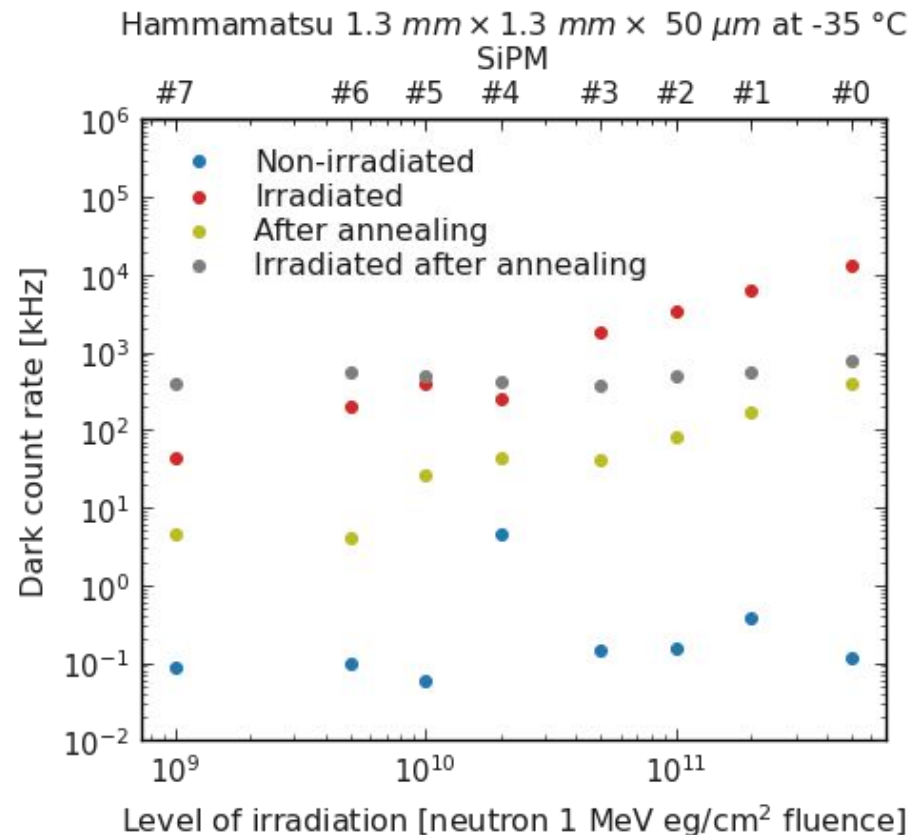
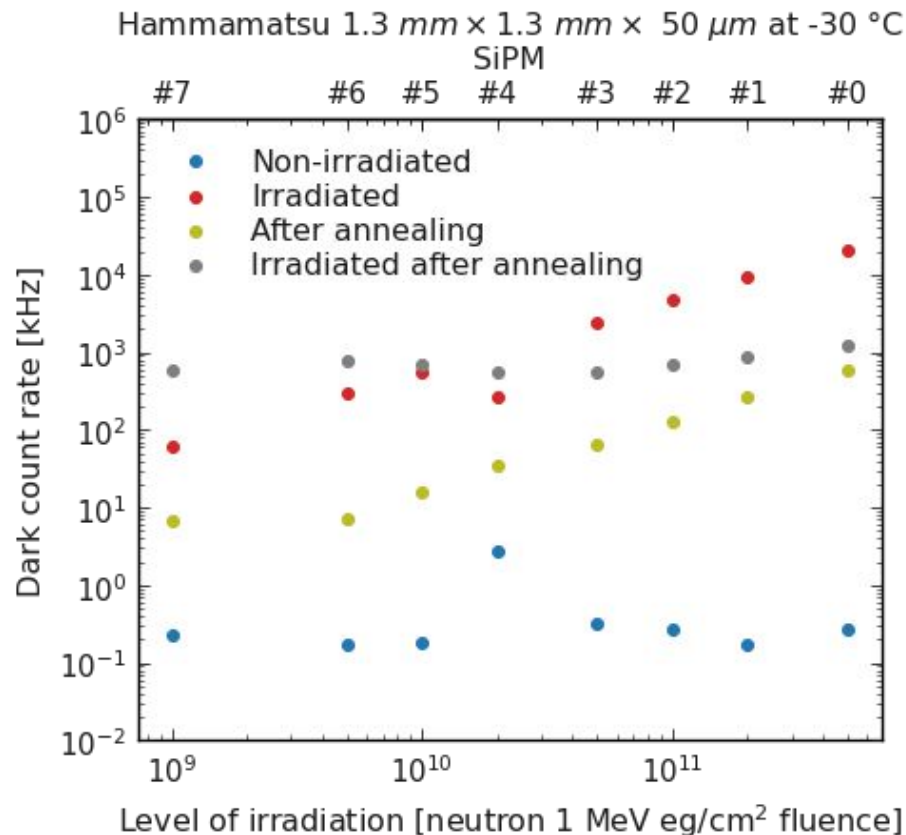
Dark count rate as function of level of irradiation



Dark count rate as function of level of irradiation



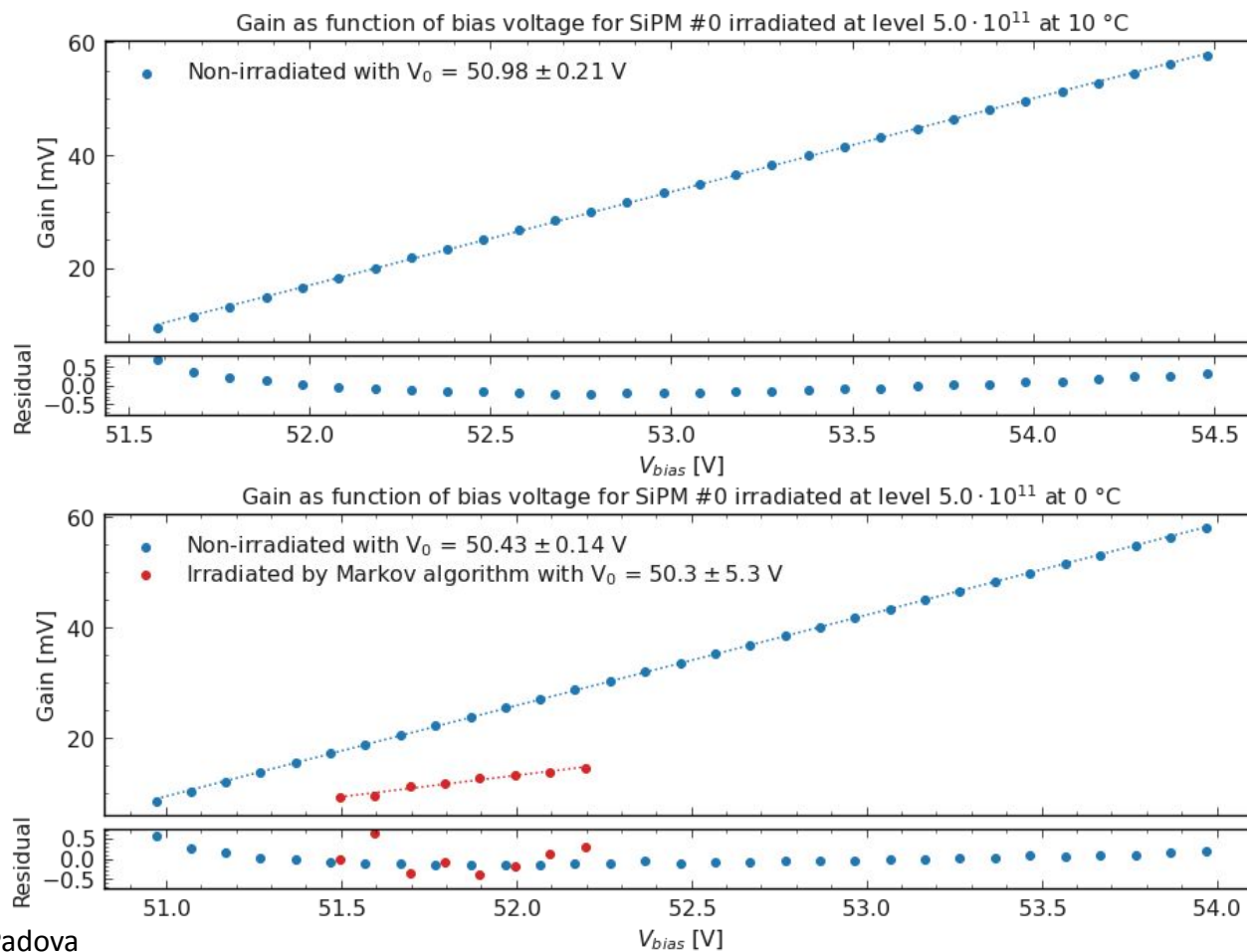
Dark count rate as function of level of irradiation



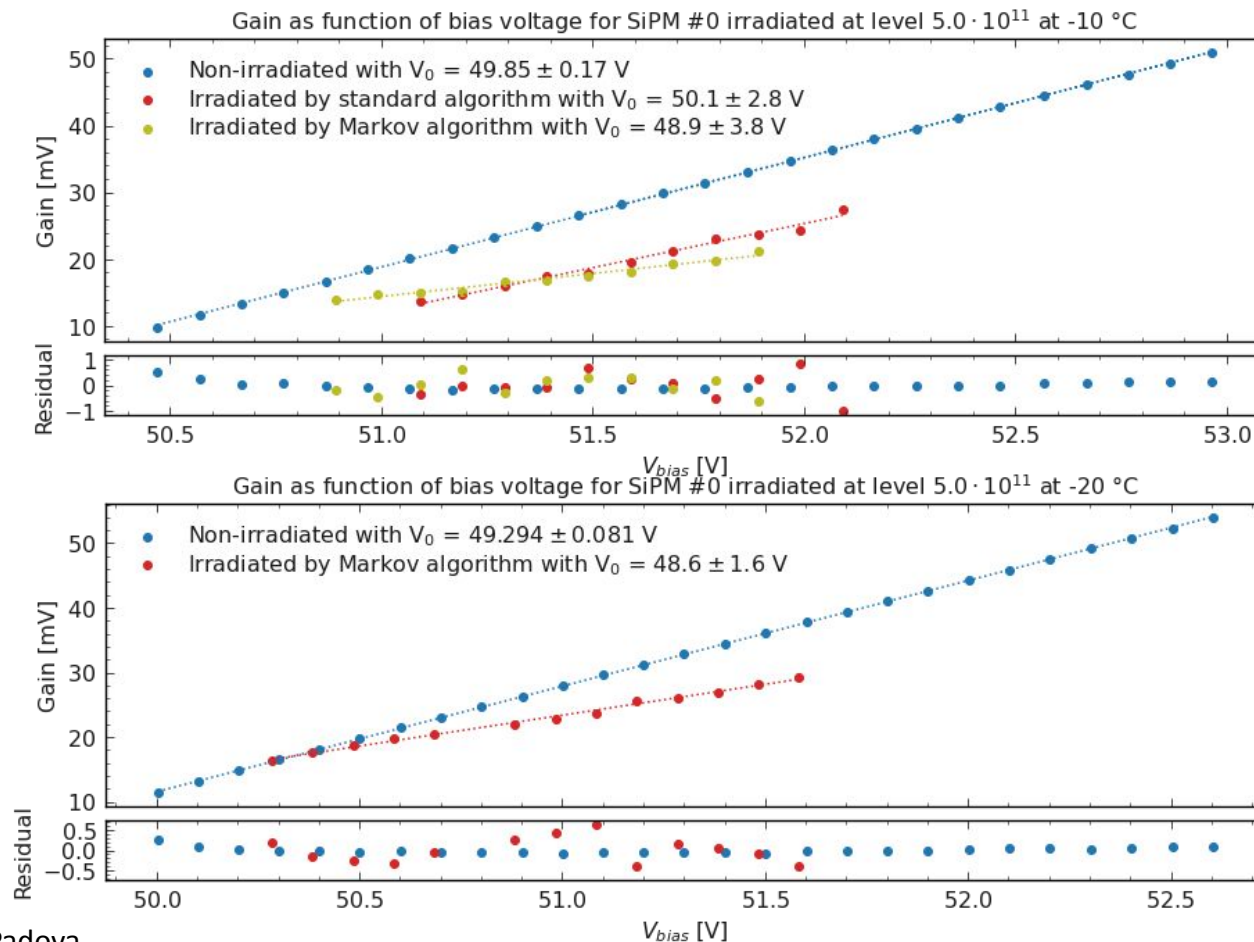
SIMP #0

Gain as function of bias voltage for SiPM #0

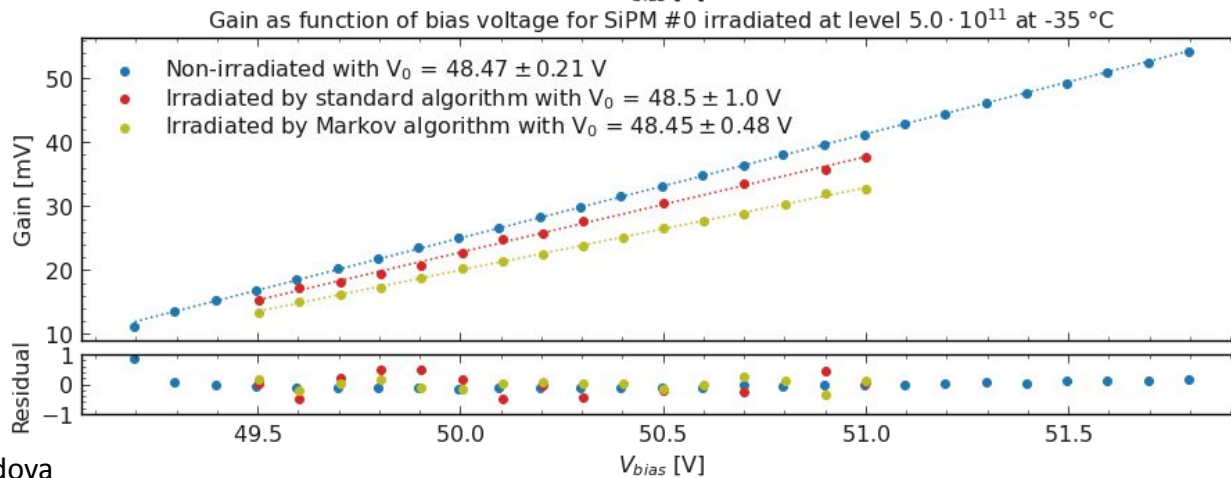
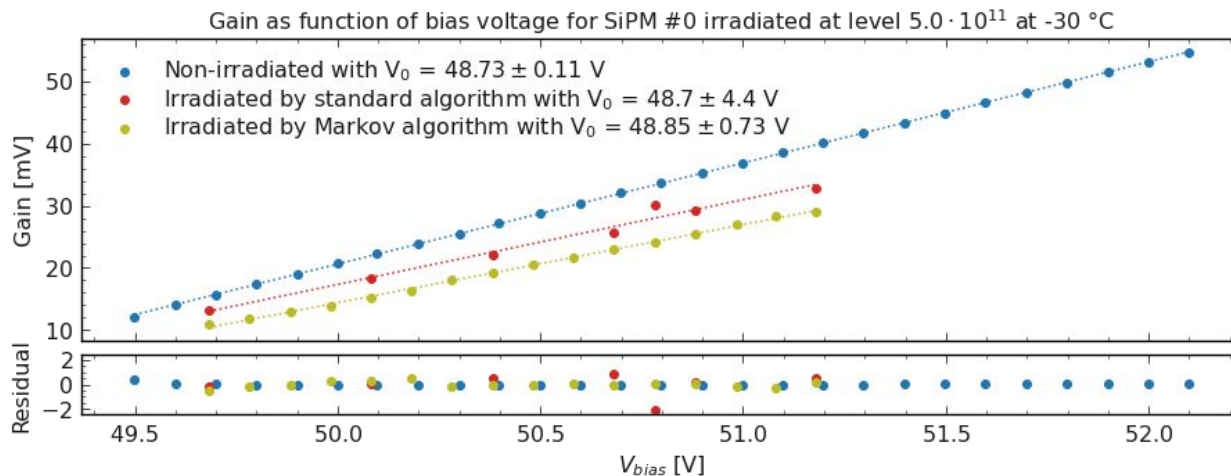
Gain as function of bias voltage



Gain as function of bias voltage

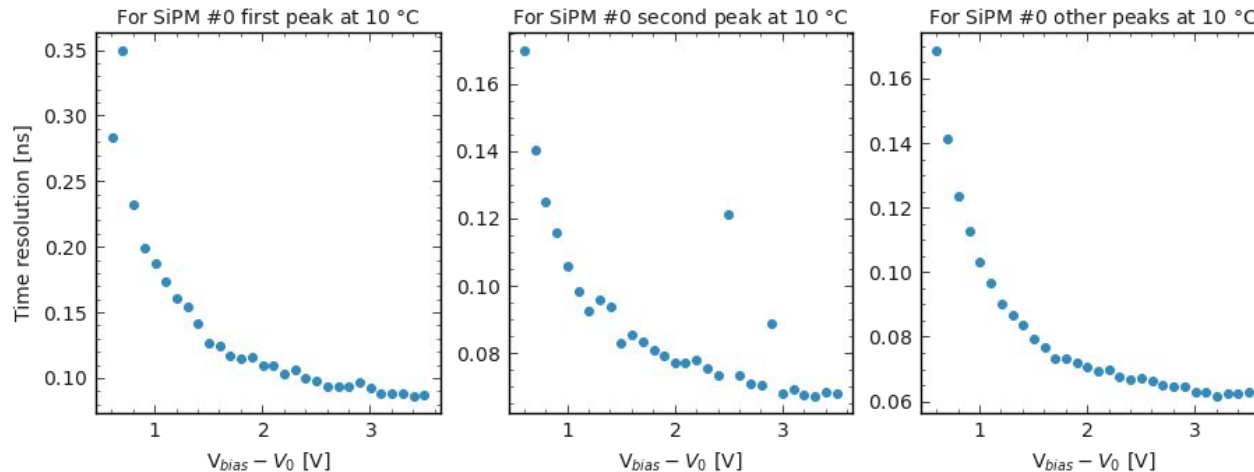


Gain as function of bias voltage

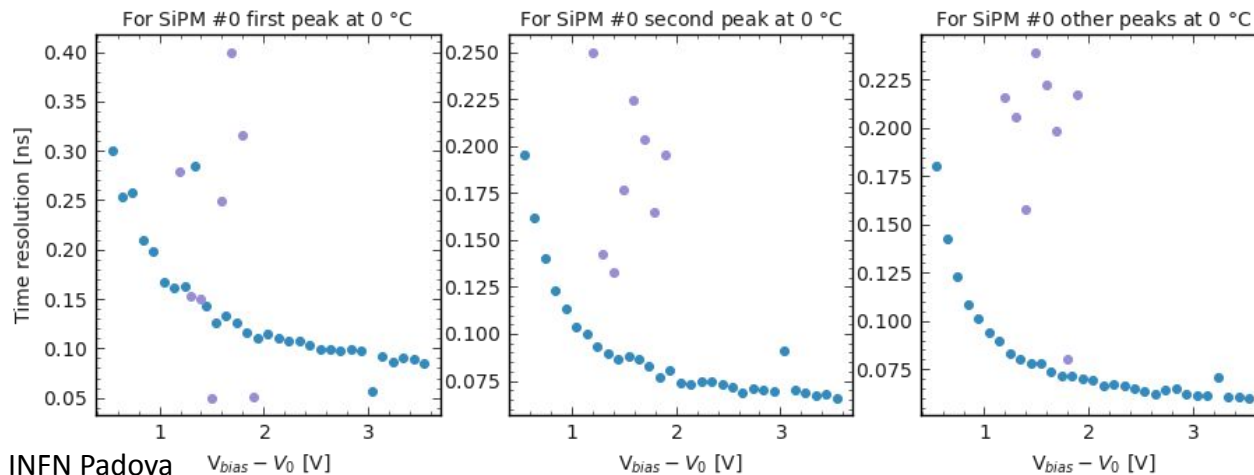


Time resolution for first, second and other photon peaks for SiPM #0

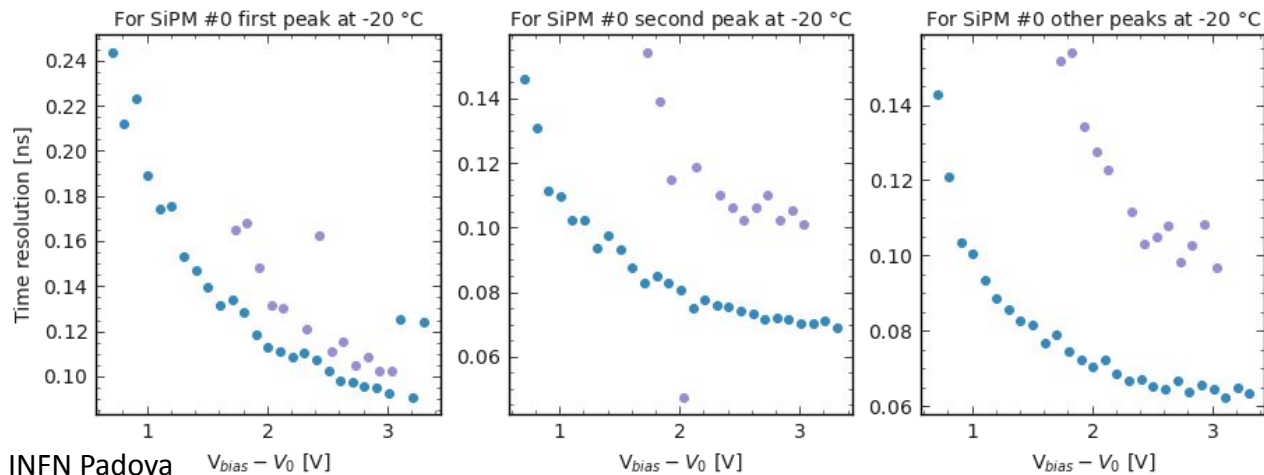
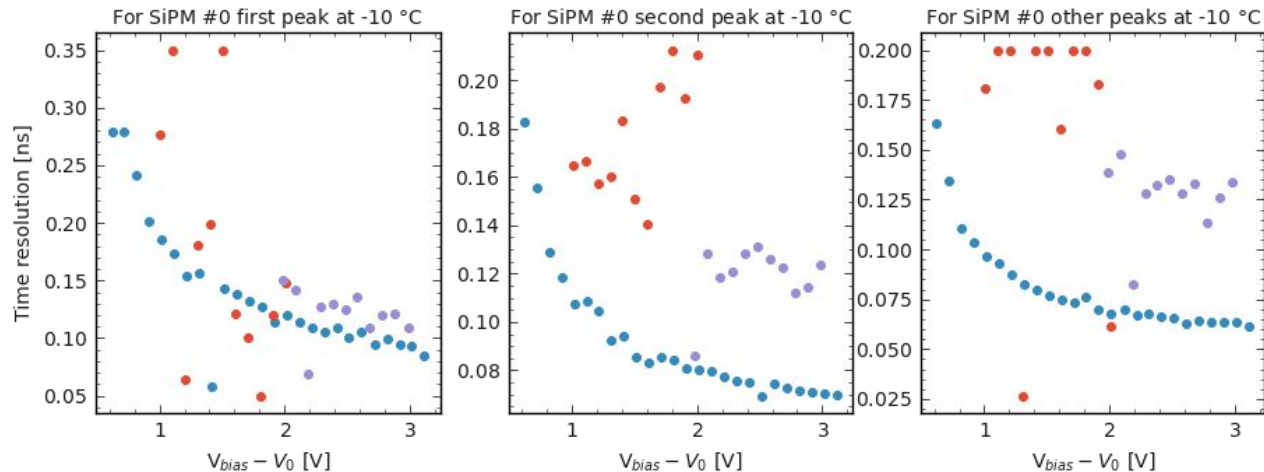
Time resolution



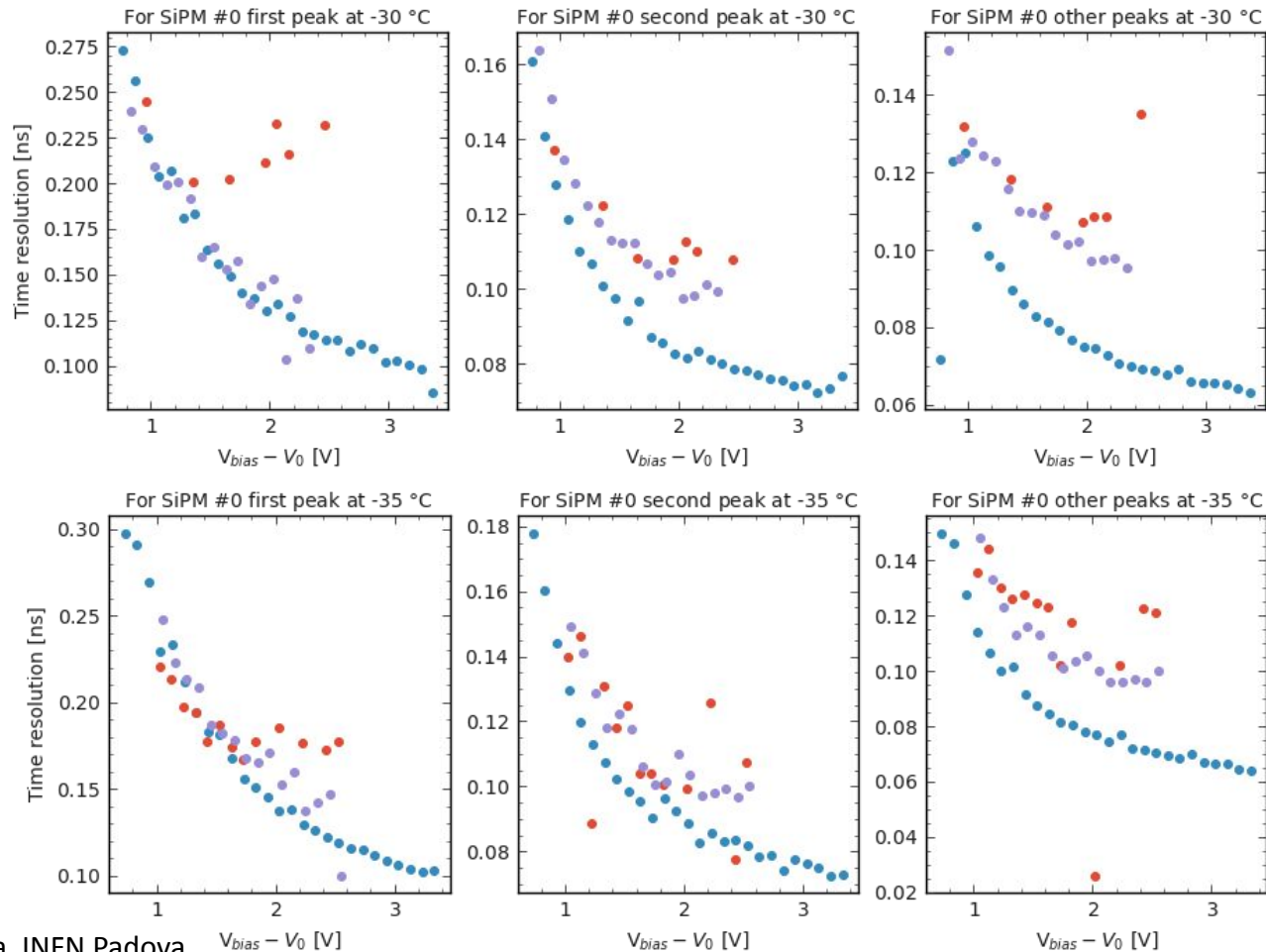
- Non-irradiated
- Irradiated by standard algorithm
- Irradiated by Markov algorithm



Time resolution

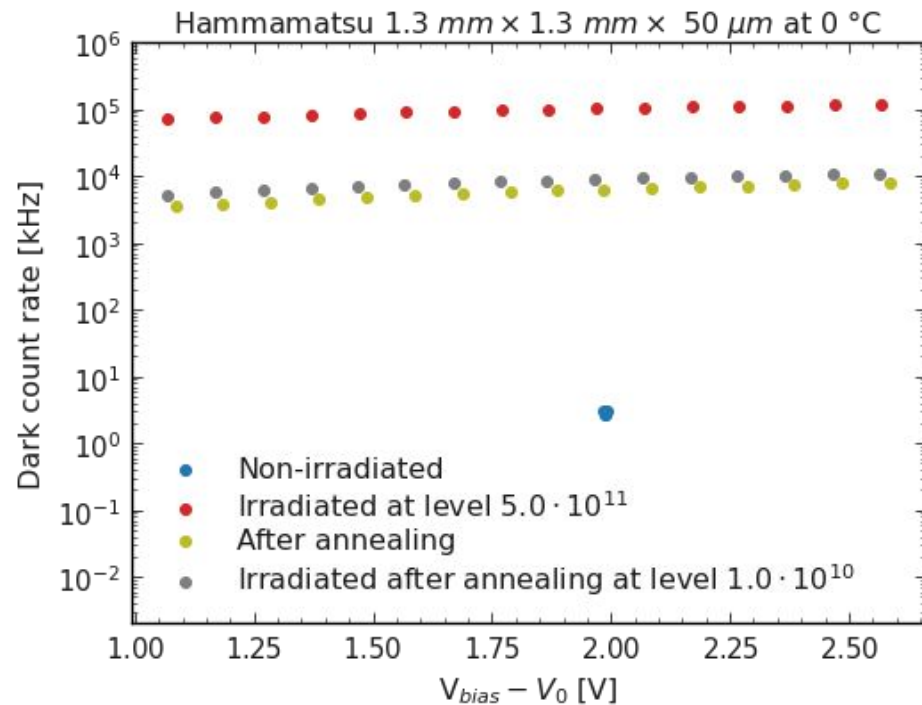
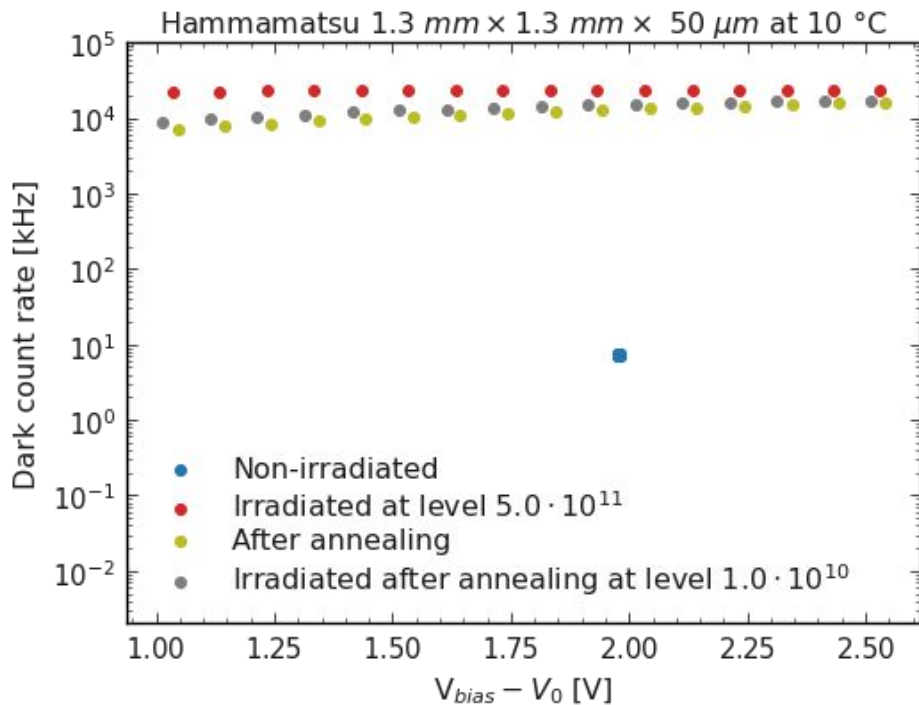


Time resolution

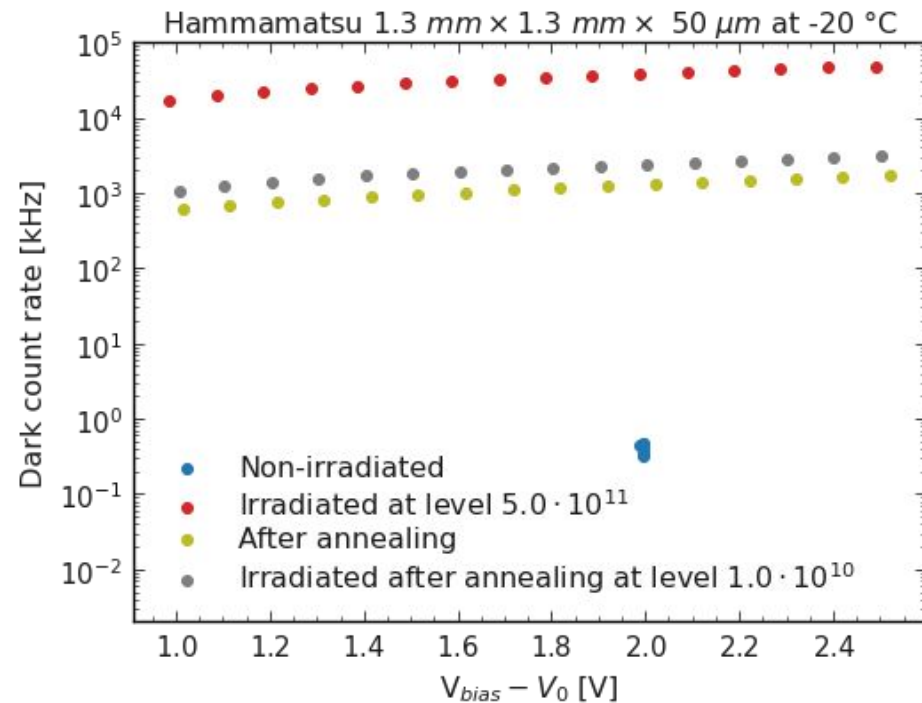
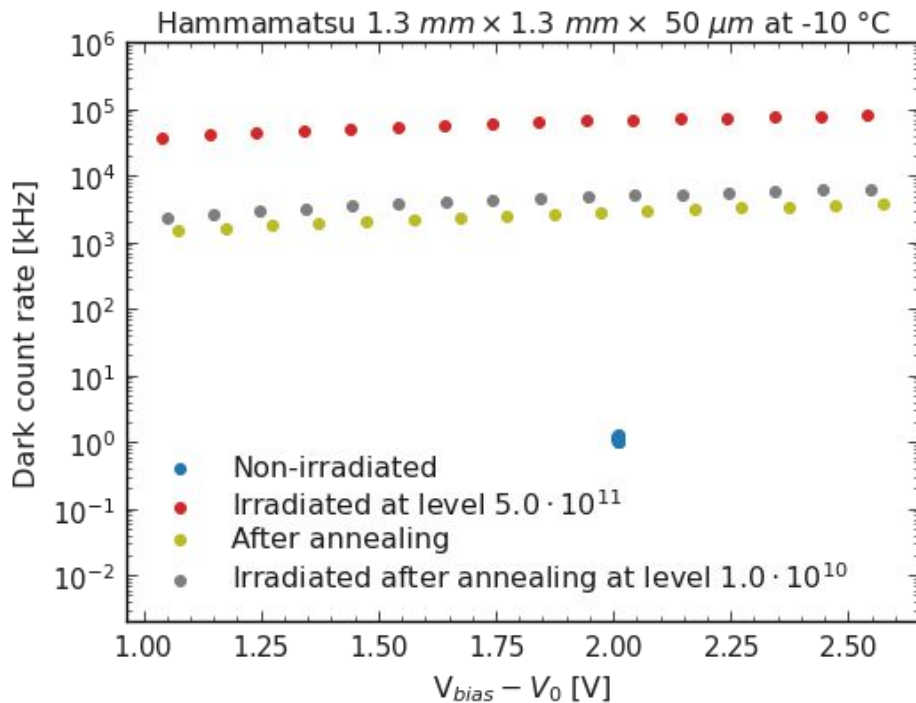


Dark count rate for SiPM #0

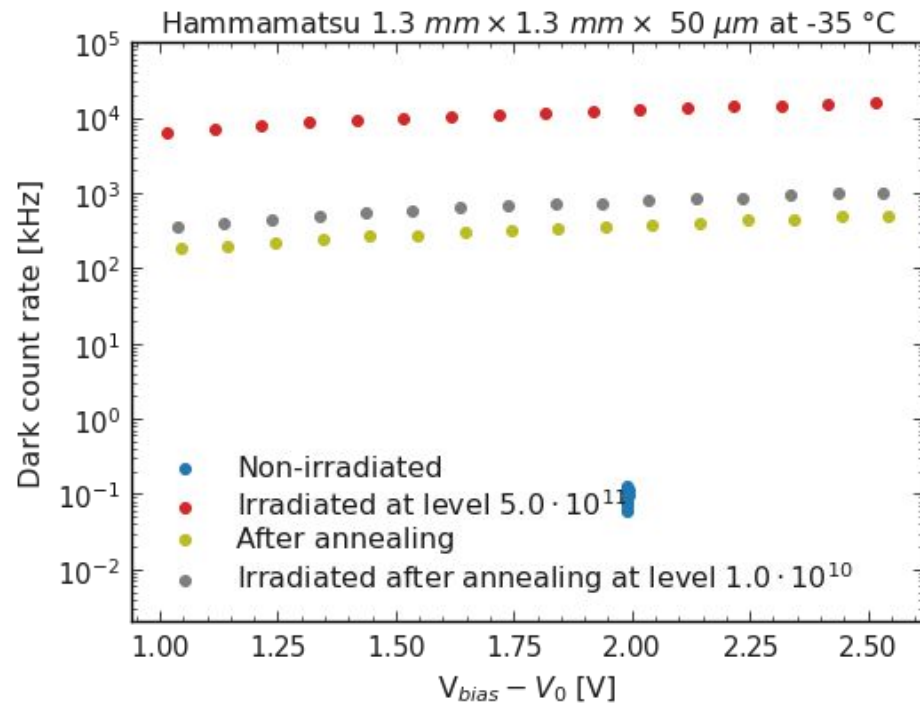
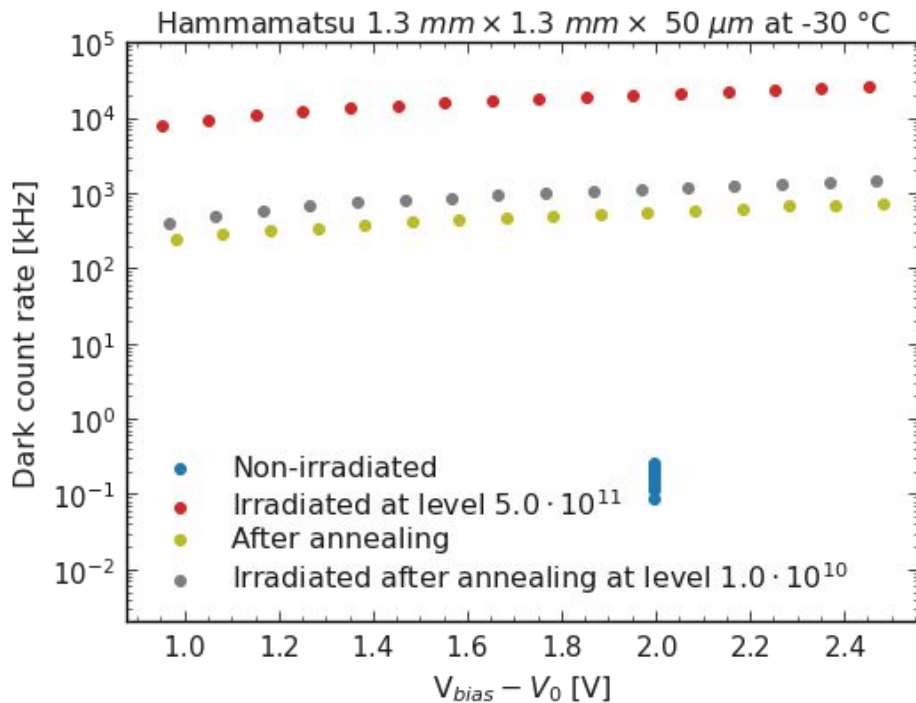
Dark count rate



Dark count rate



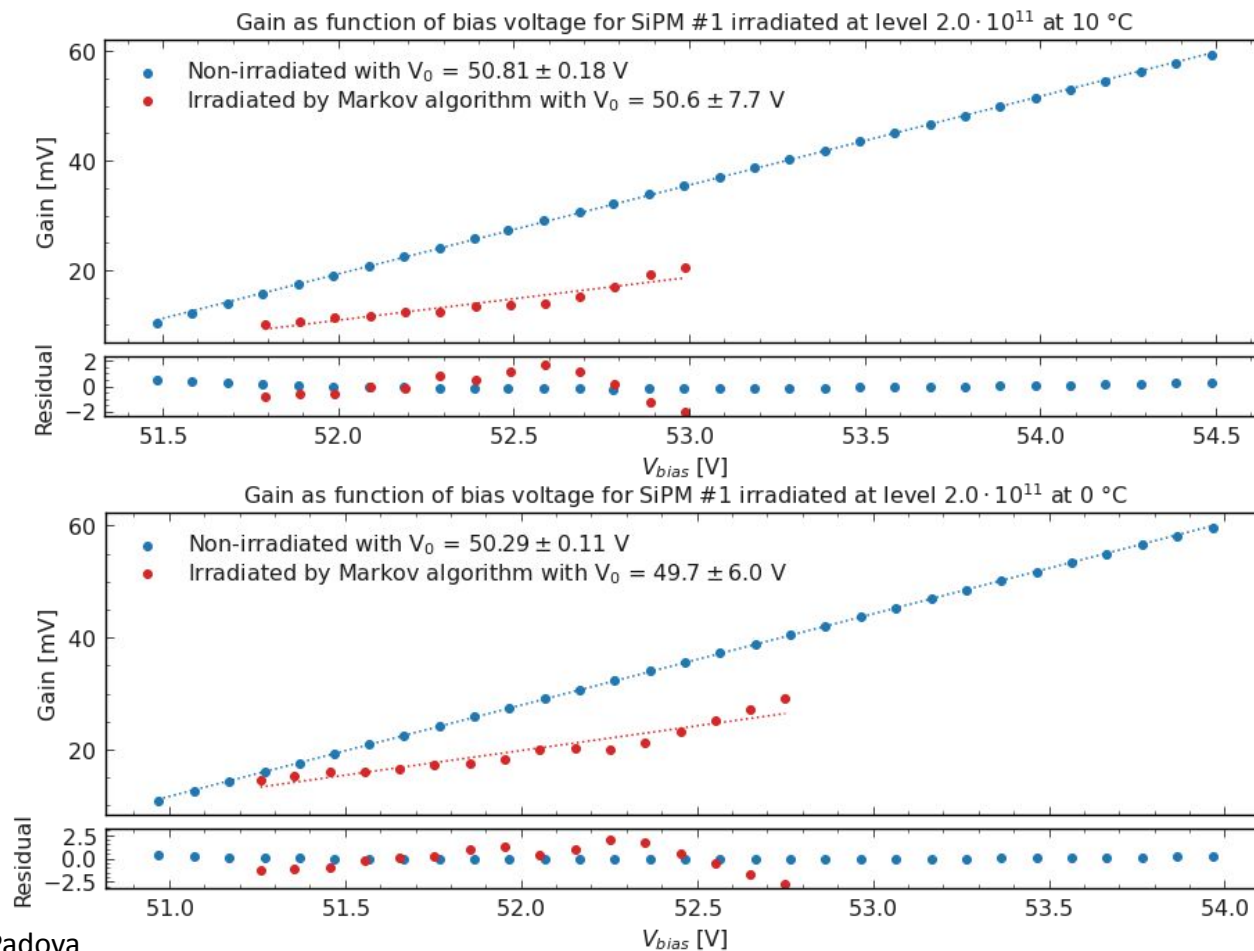
Dark count rate



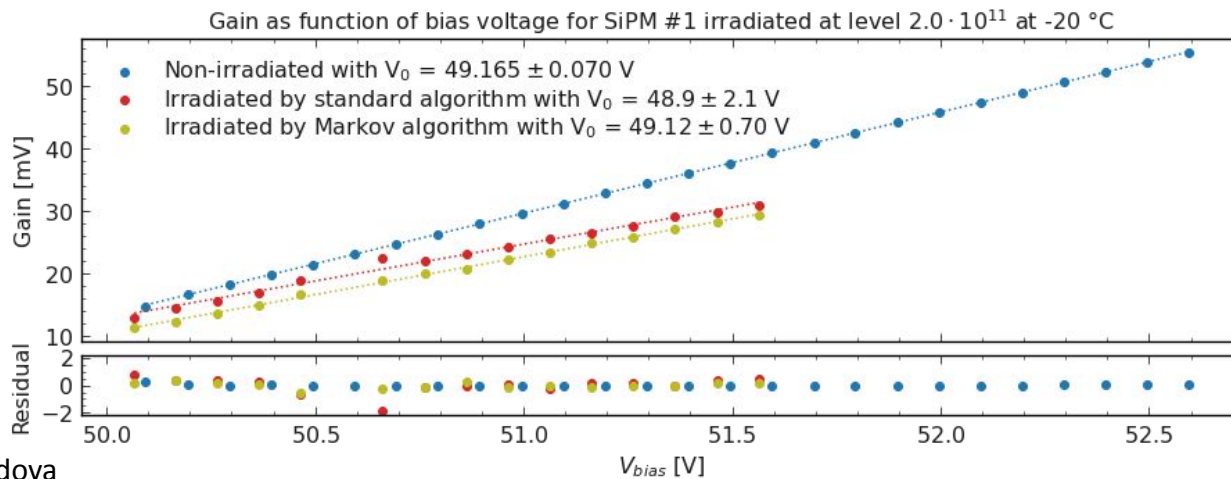
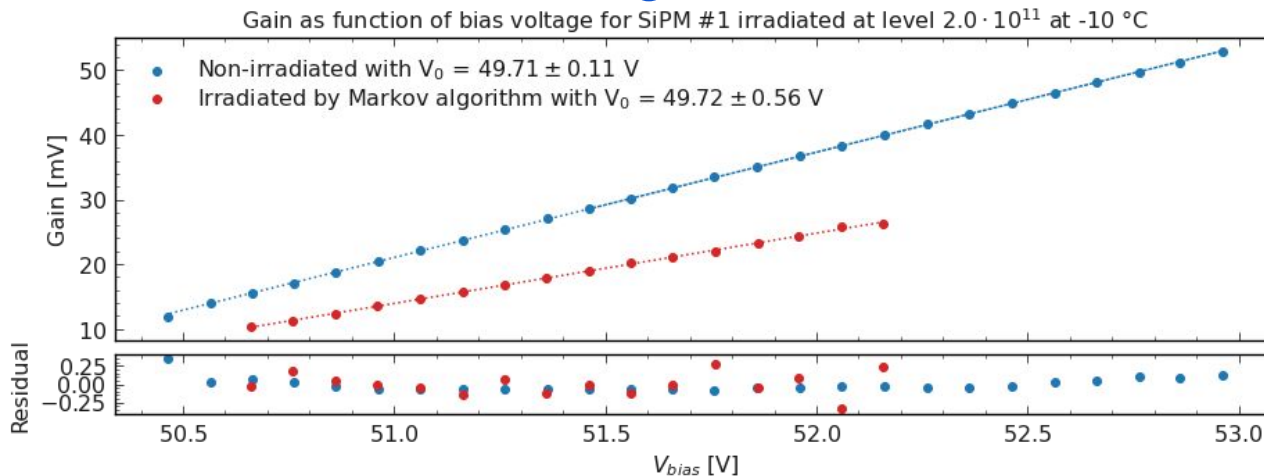
SiMP #1

Gain as function of bias voltage for SiPM #1

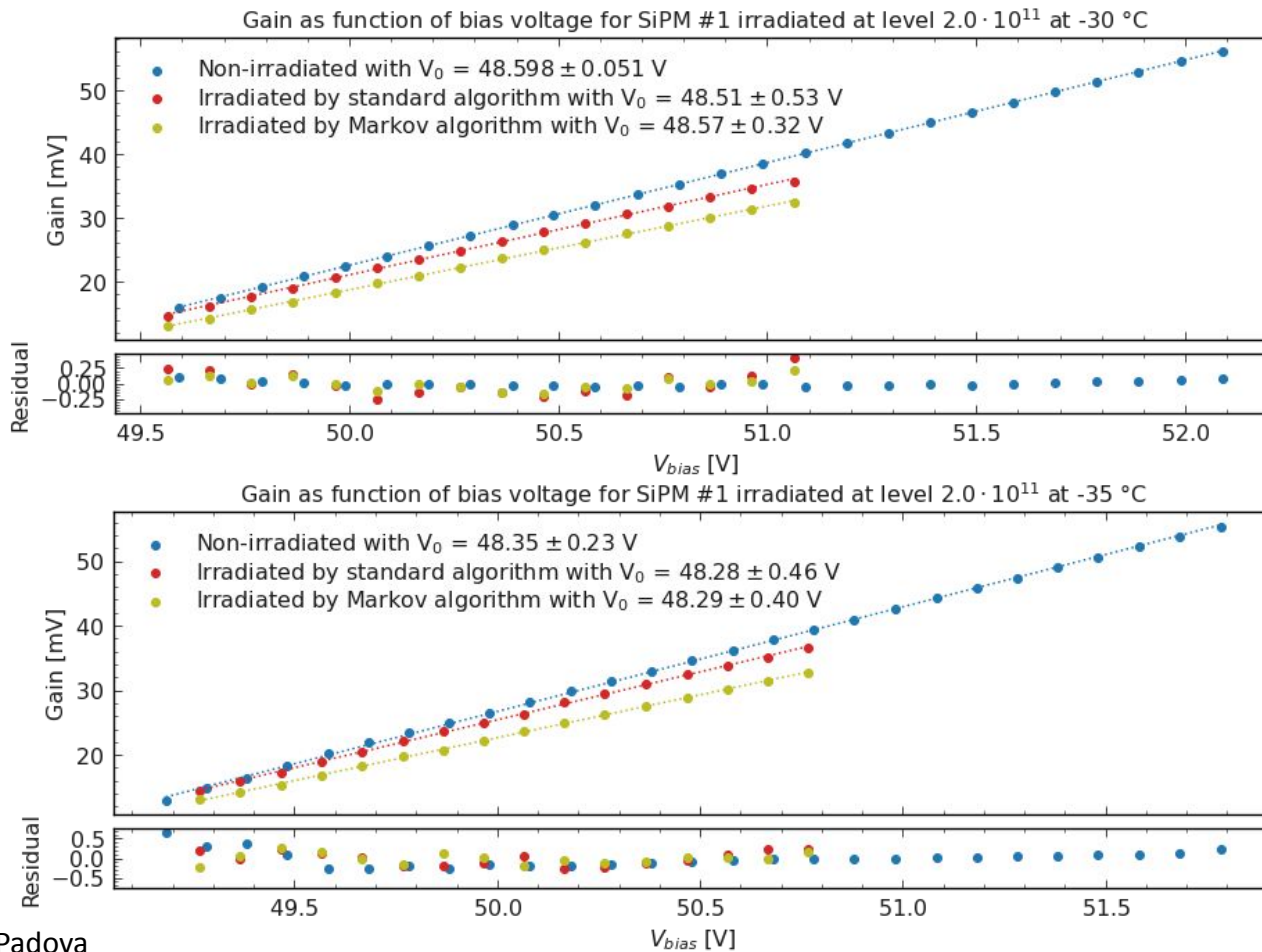
Gain as function of bias voltage



Gain as function of bias voltage

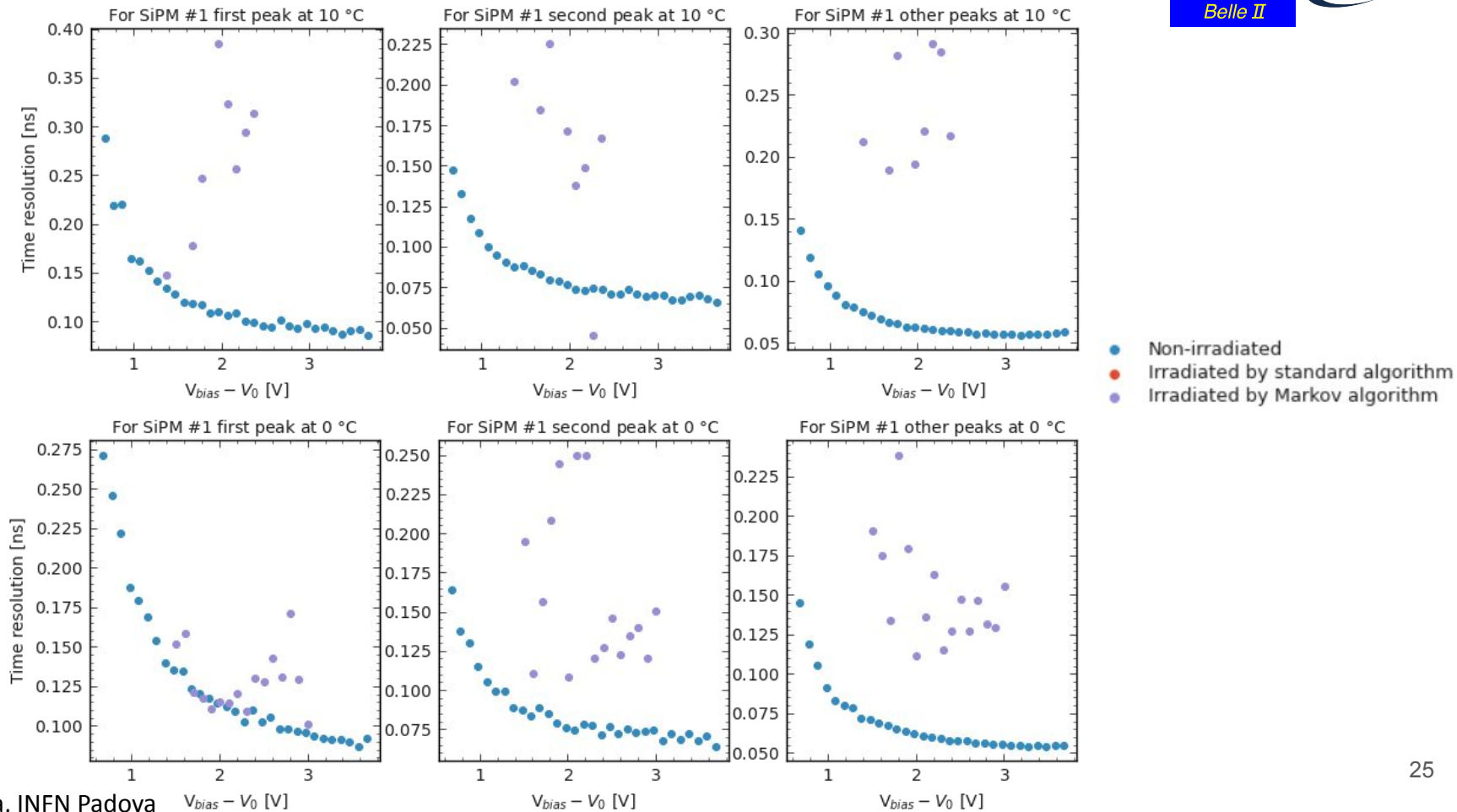


Gain as function of bias voltage

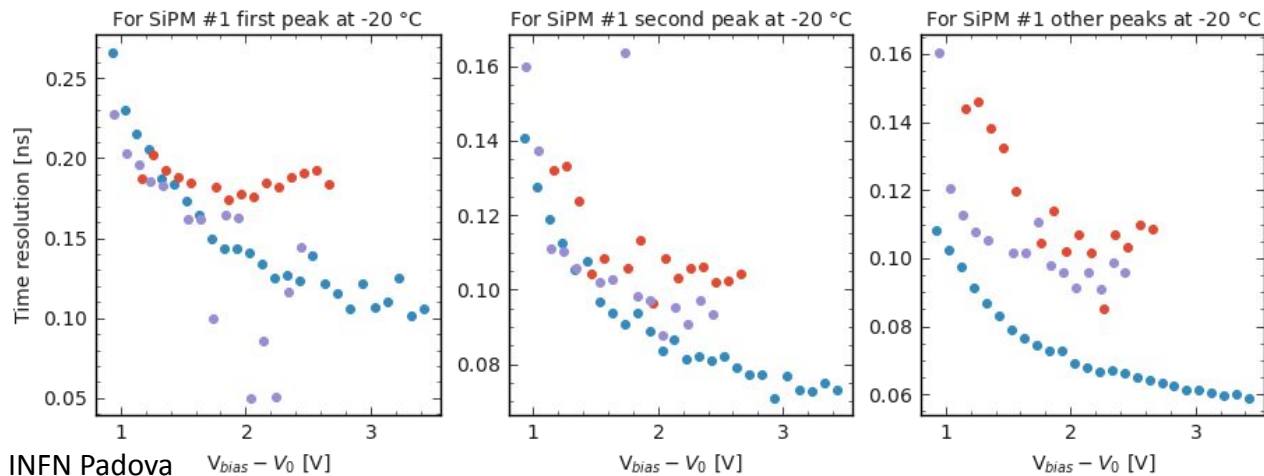
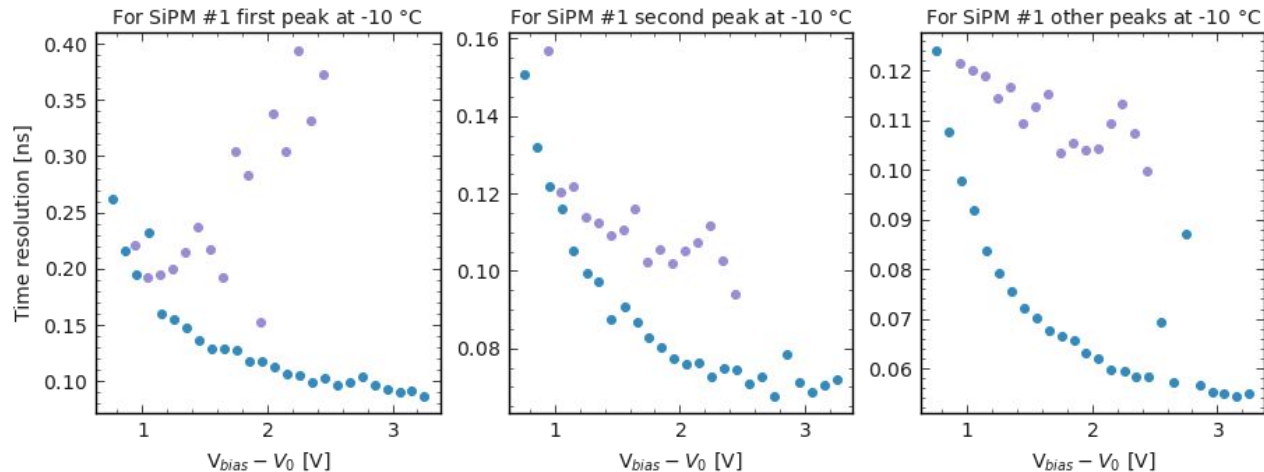


Time resolution for first, second and other photon peaks for SiPM #1

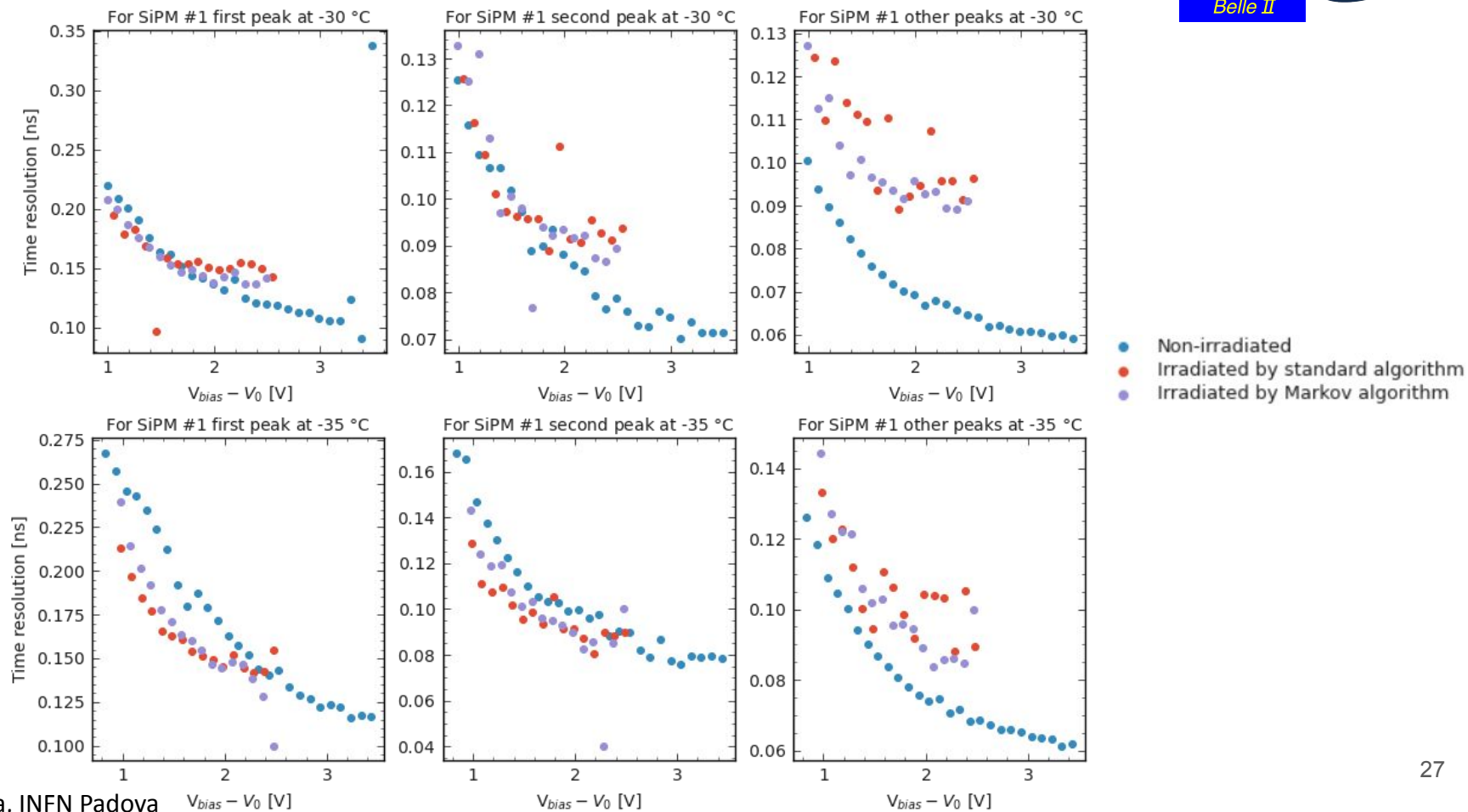
Time resolution



Time resolution

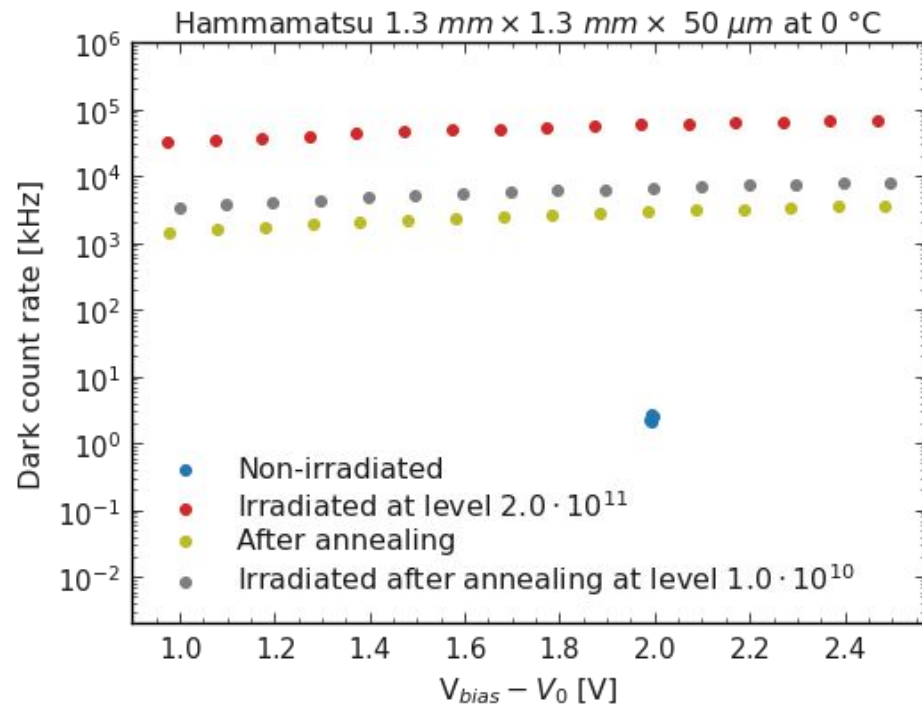
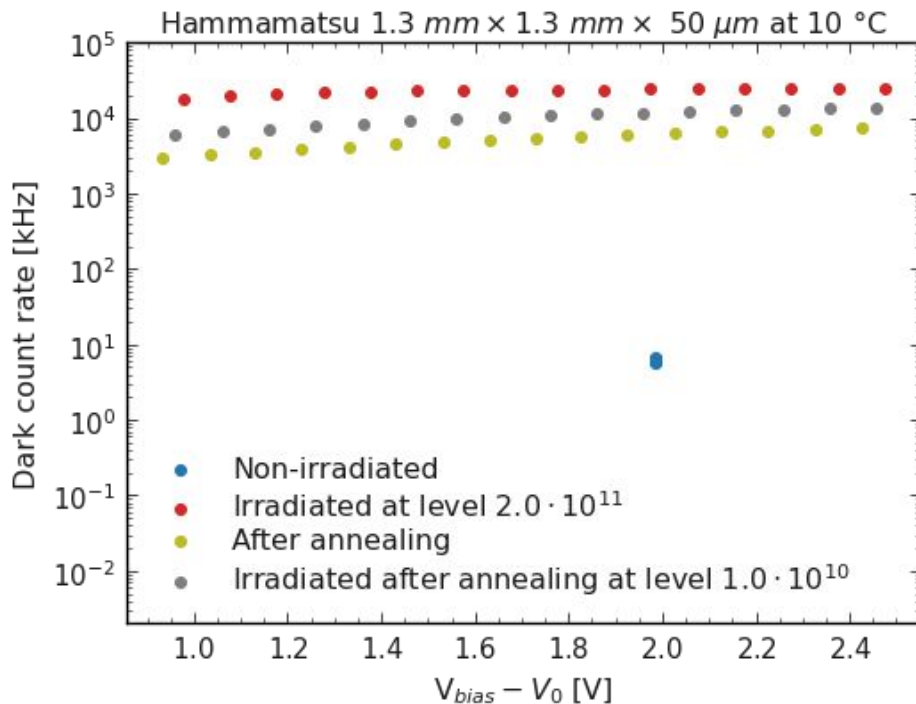


Time resolution

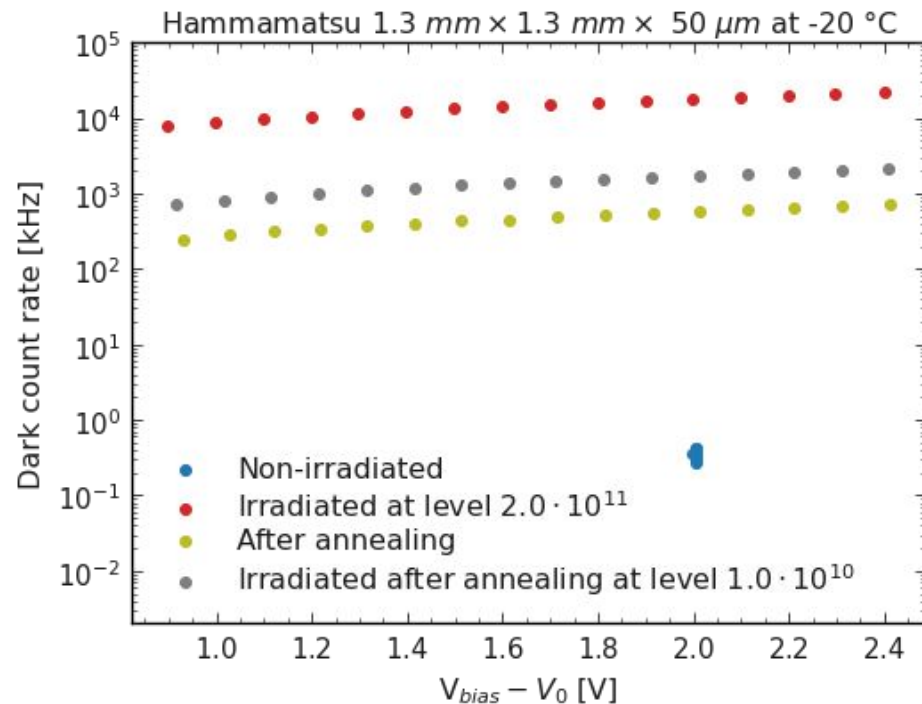
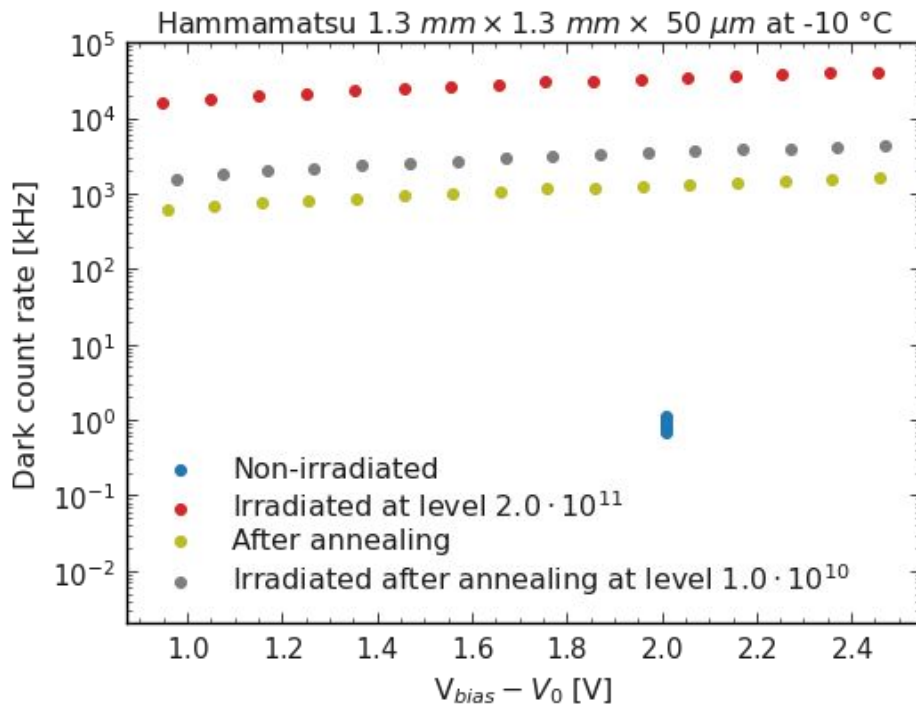


Dark count rate for SiPM #1

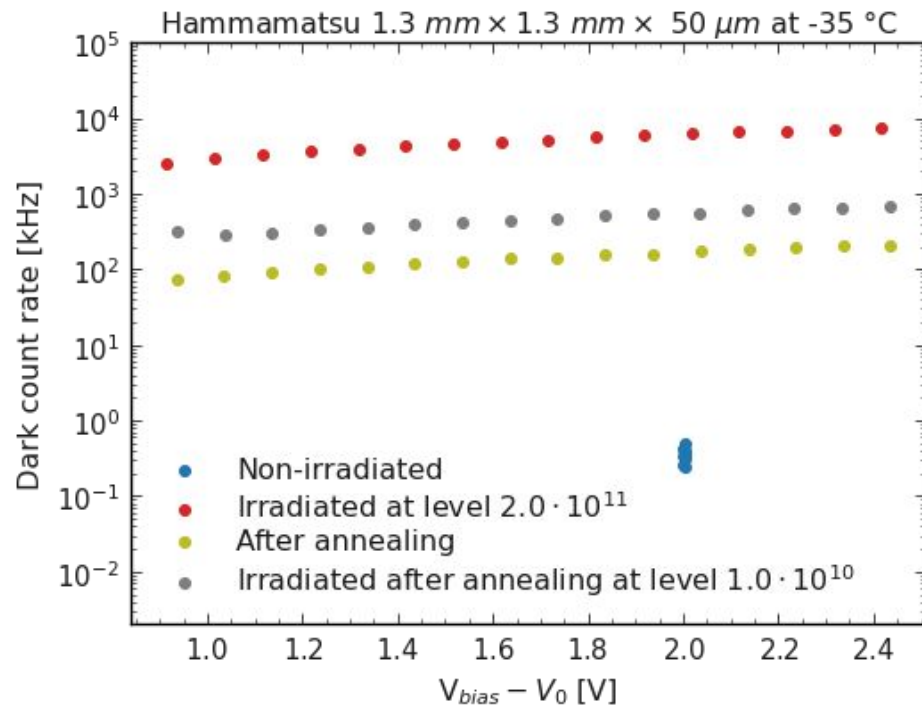
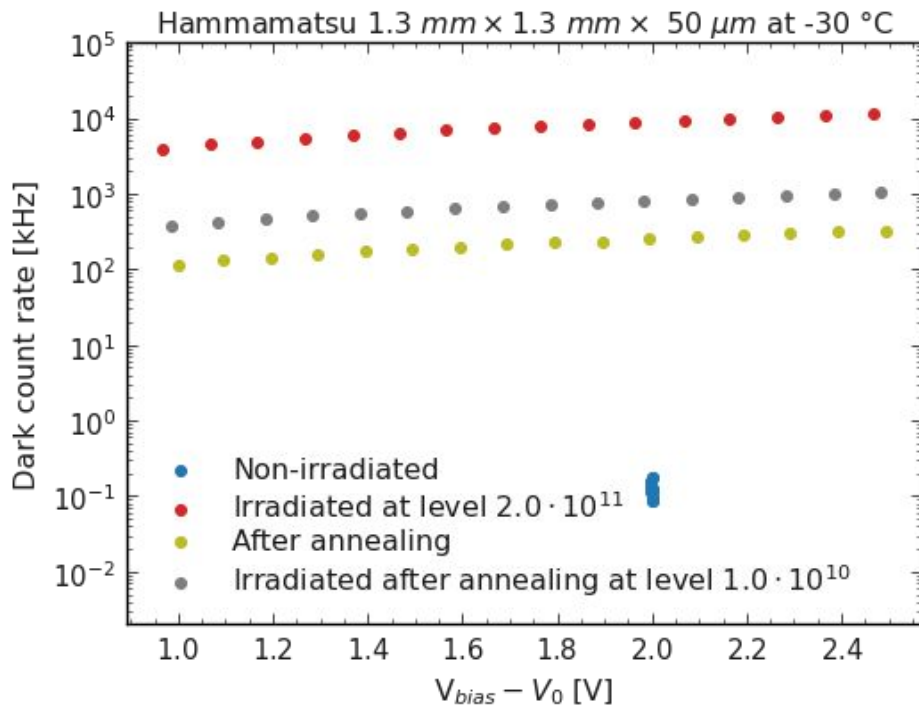
Dark count rate



Dark count rate



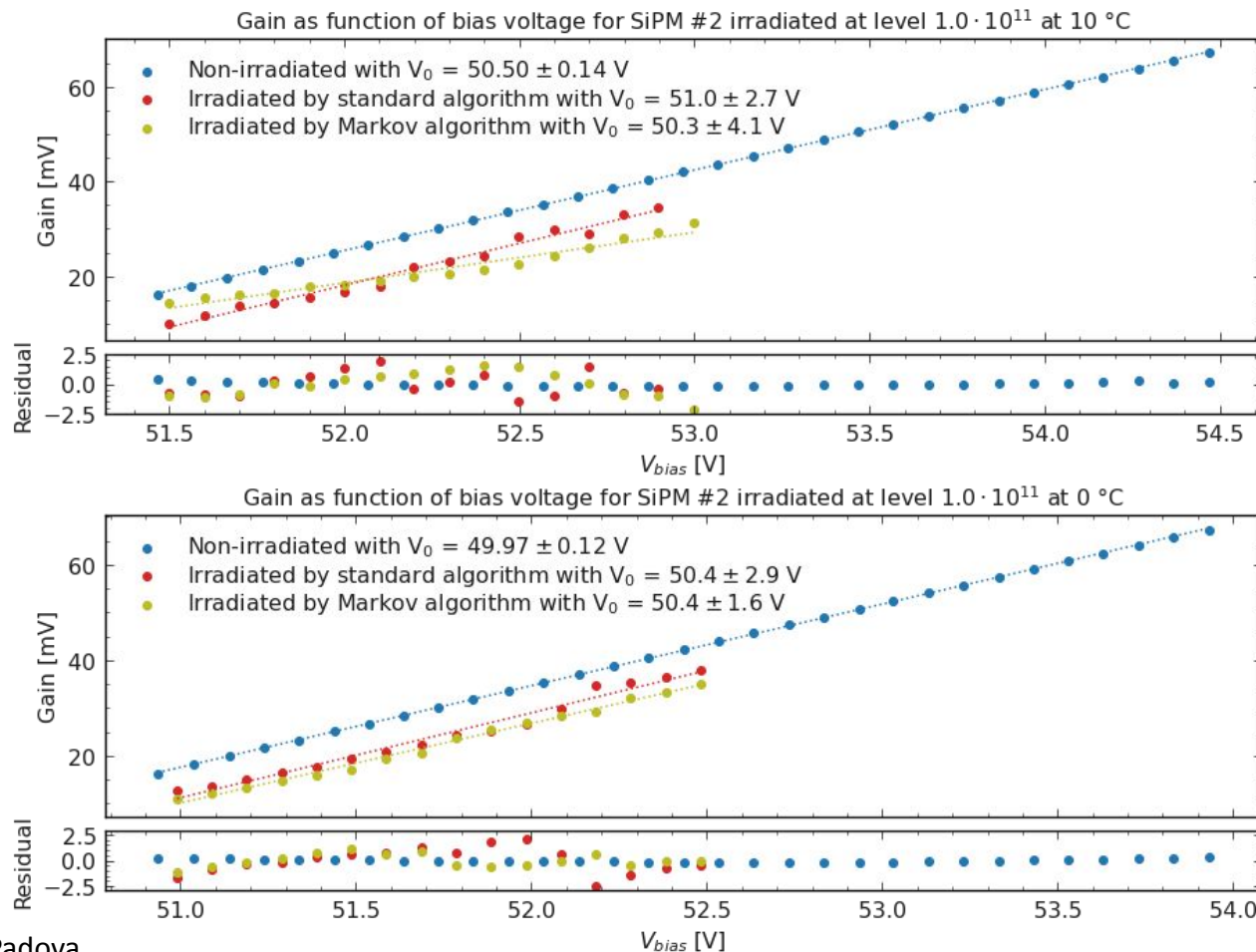
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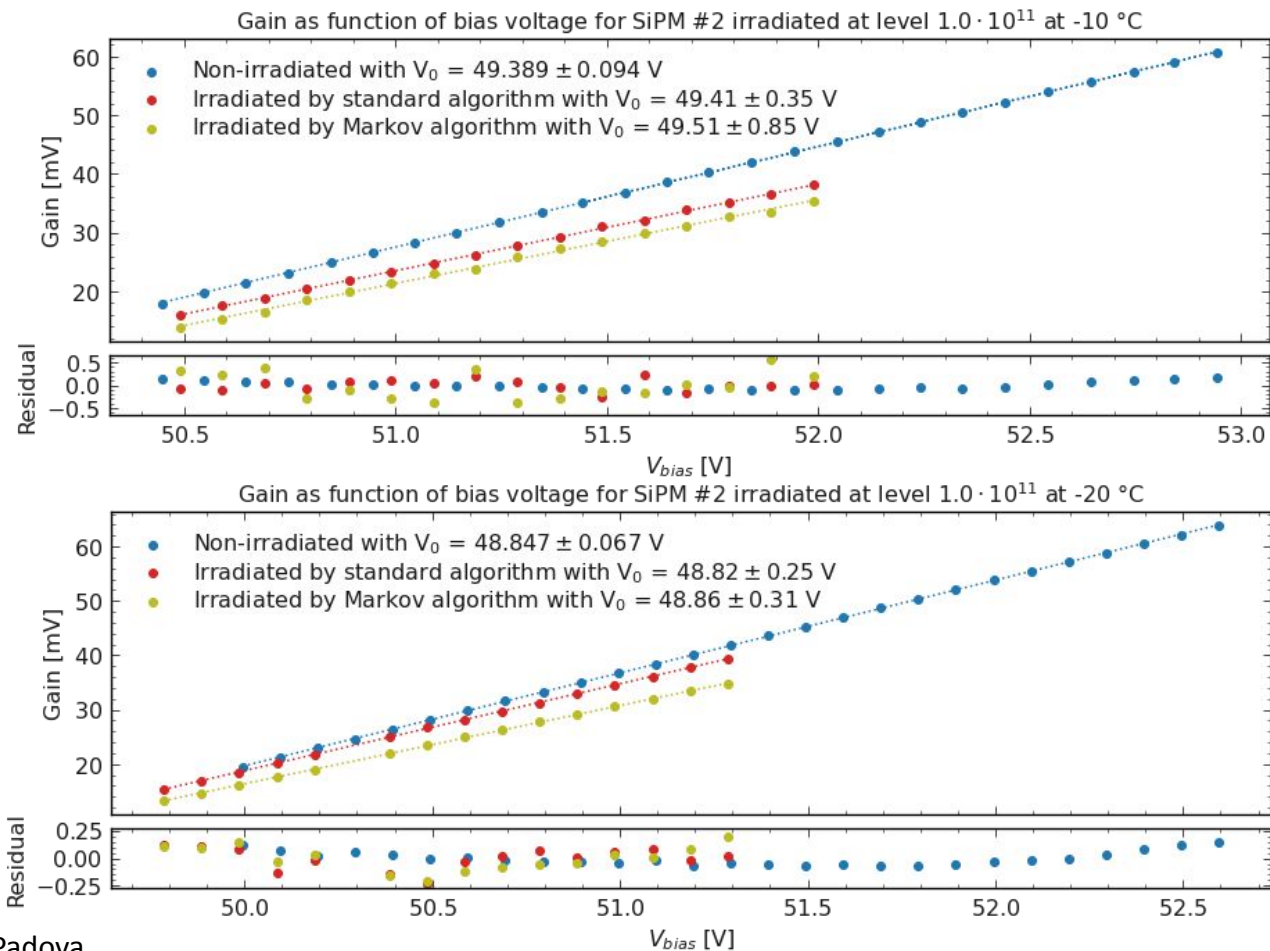
SIMP #2

Gain as function of bias voltage for SiPM #2

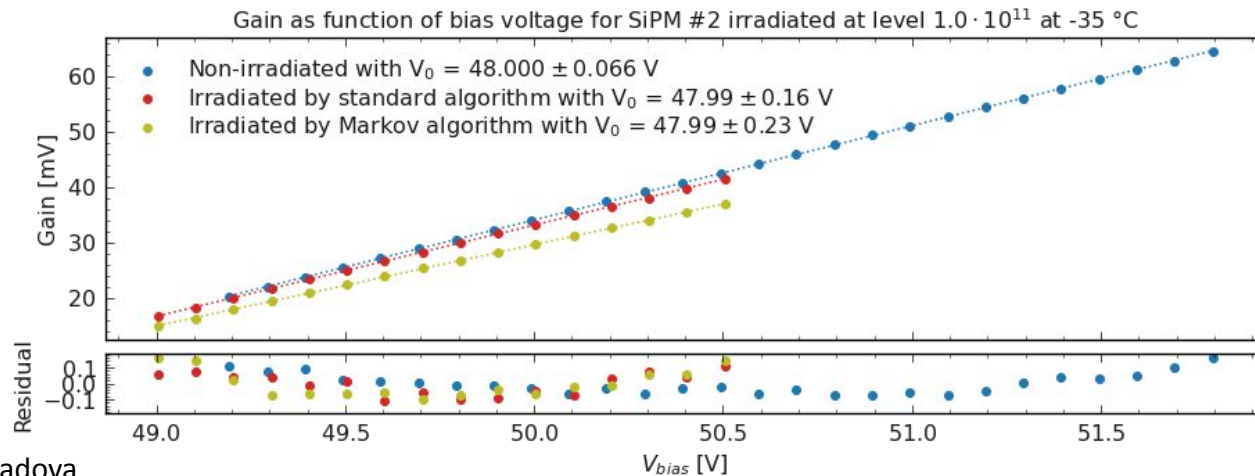
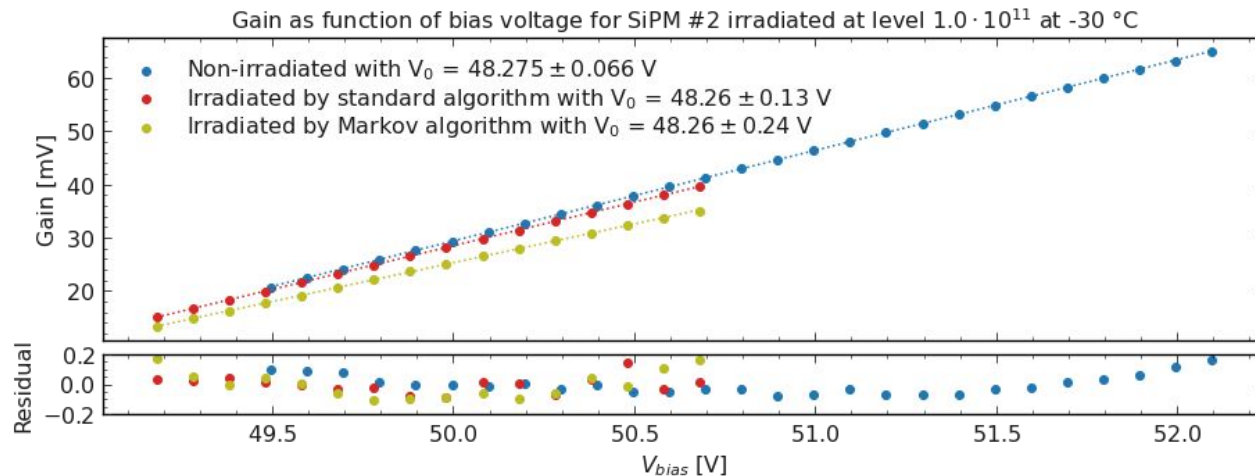
Gain as function of bias voltage



Gain as function of bias voltage

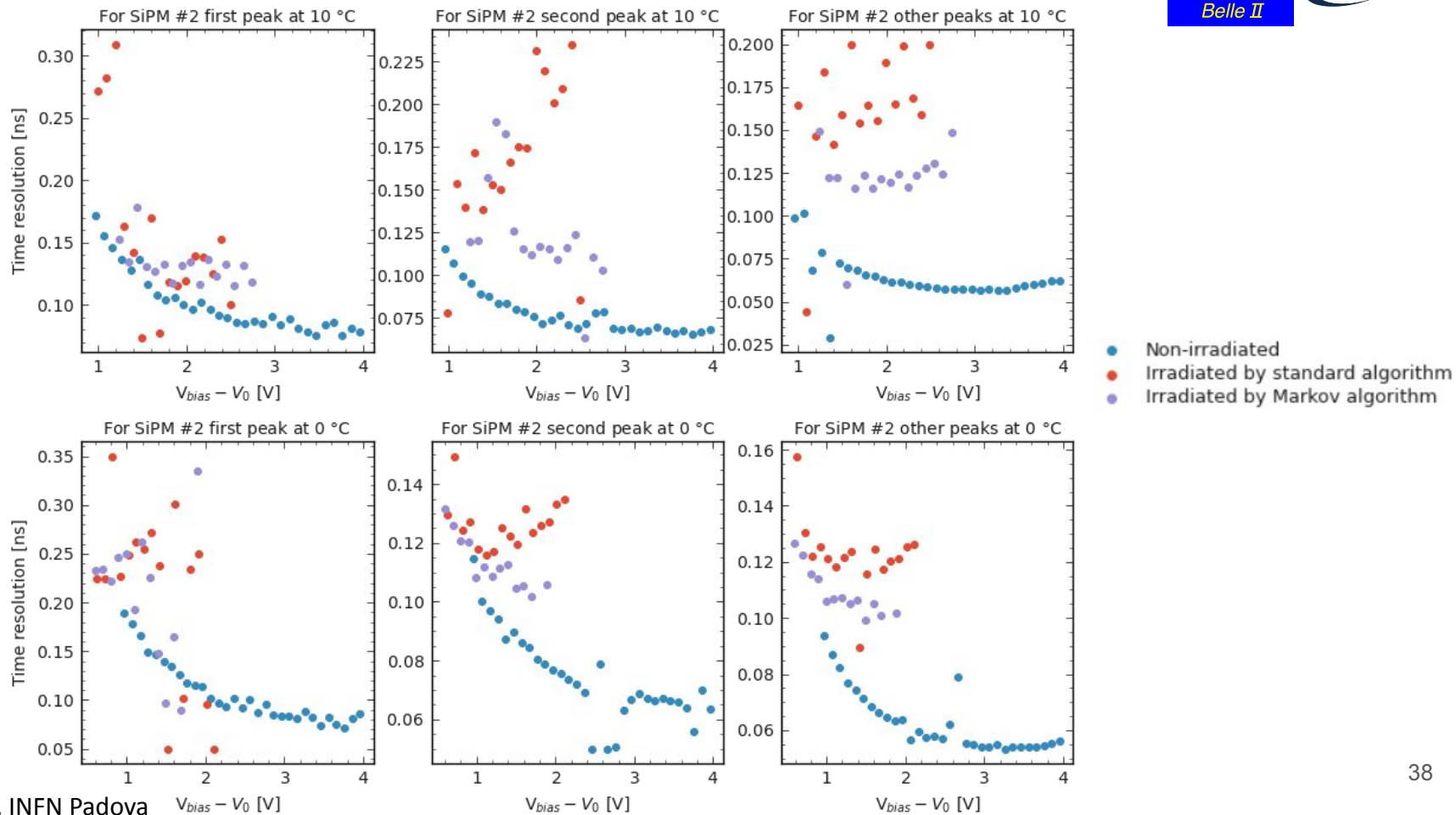


Gain as function of bias voltage

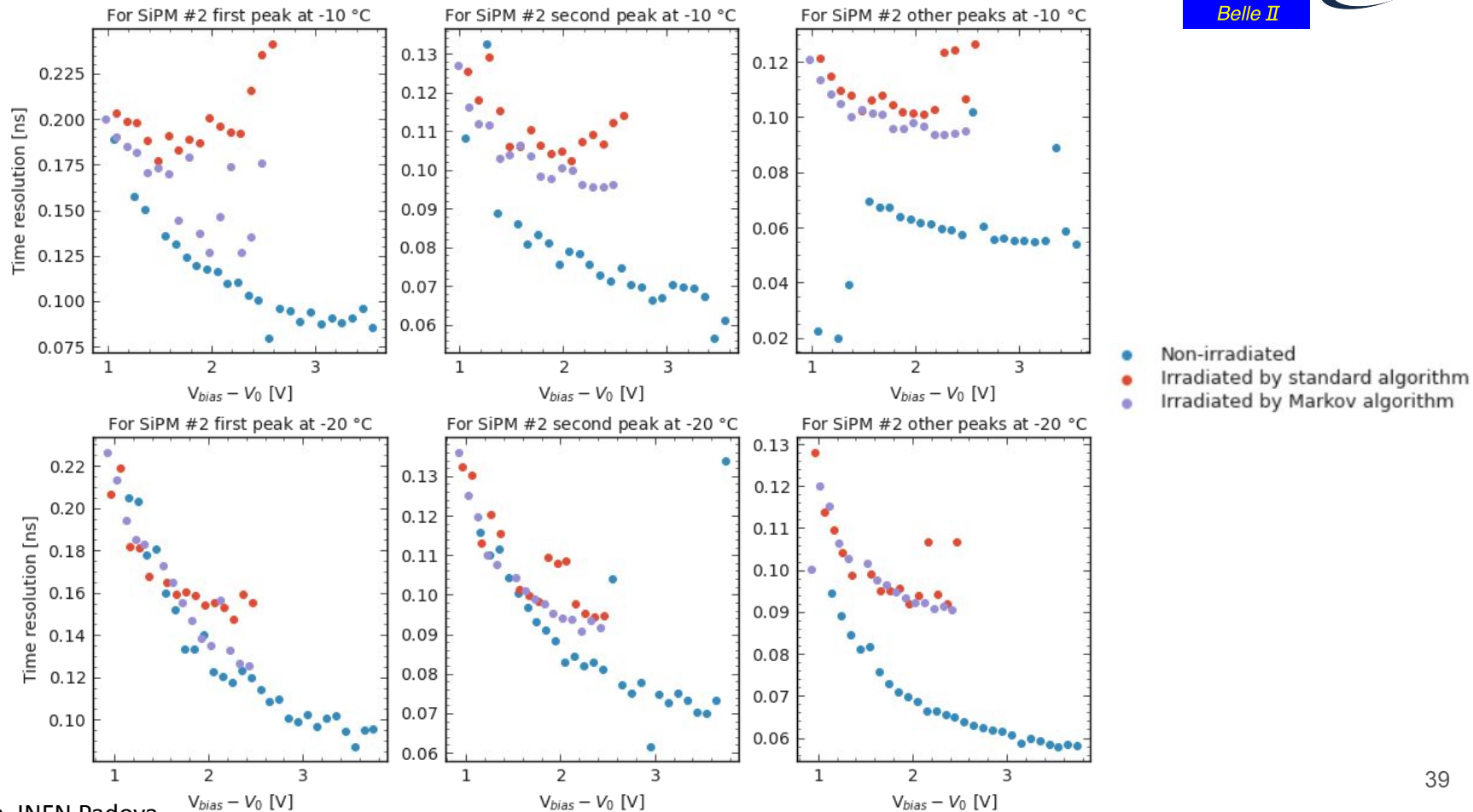


Time resolution for first, second and other photon peaks for SiPM #2

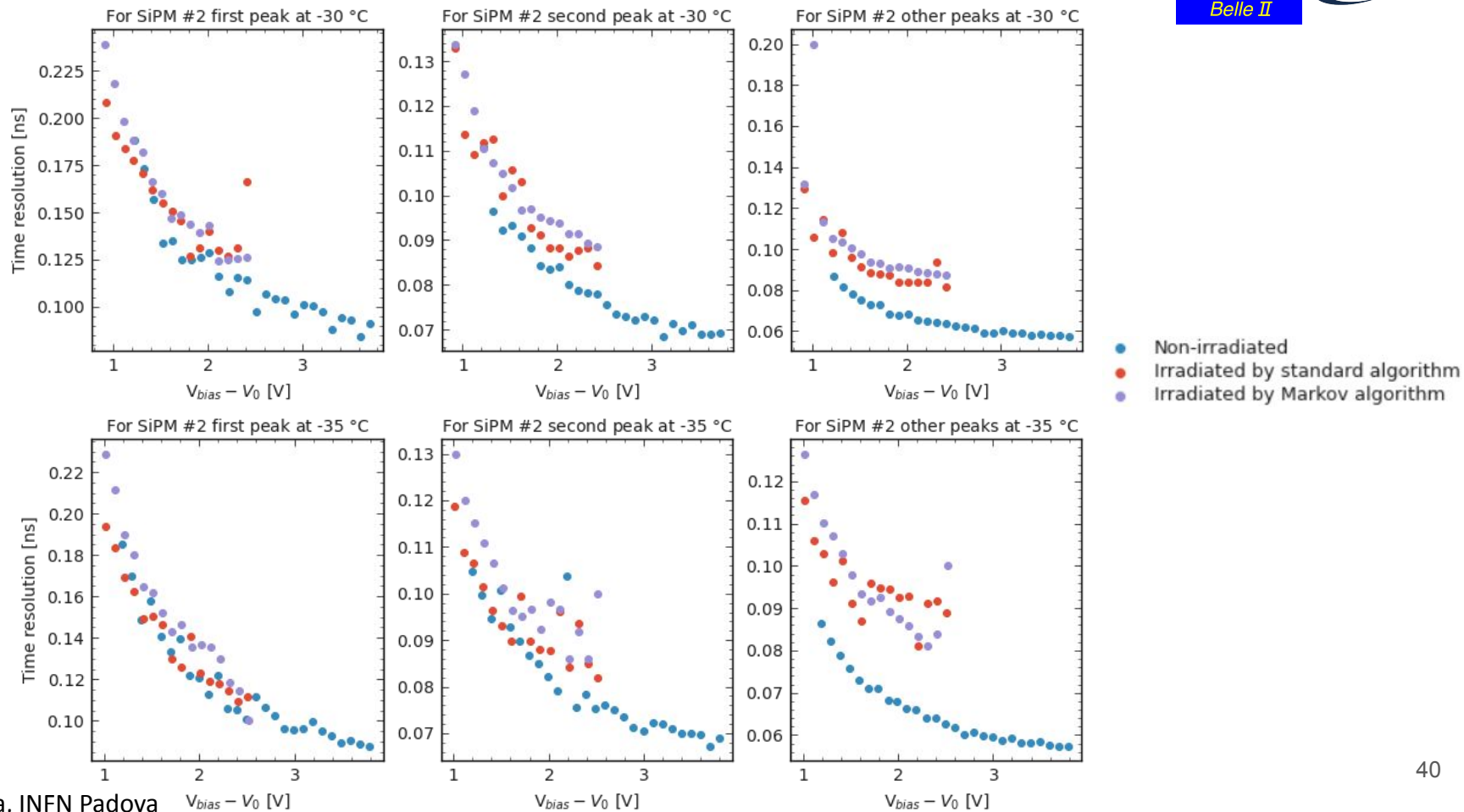
Time resolution



Time resolution

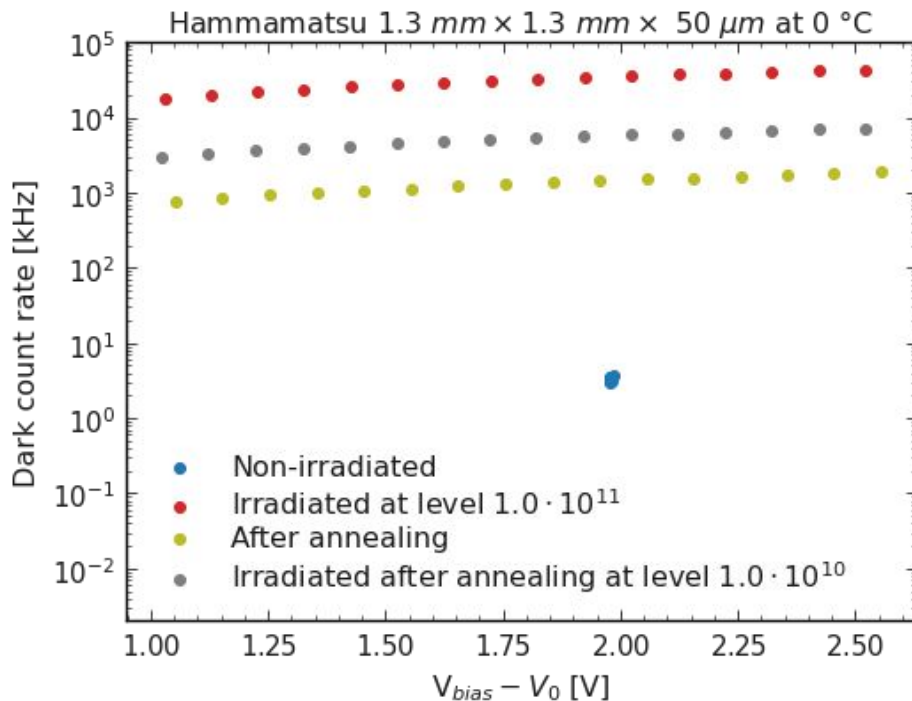
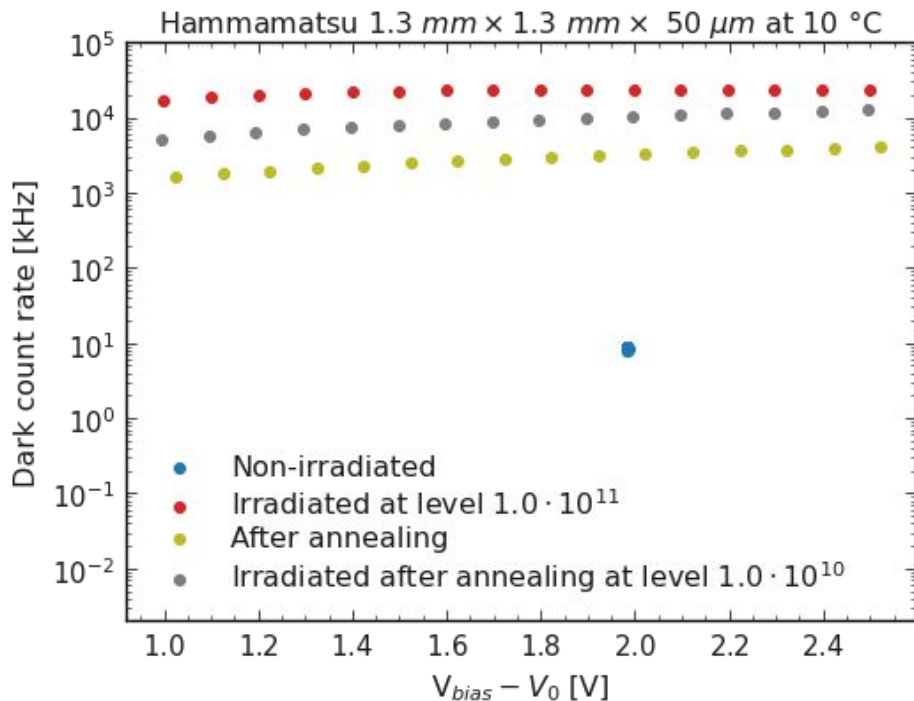


Time resolution

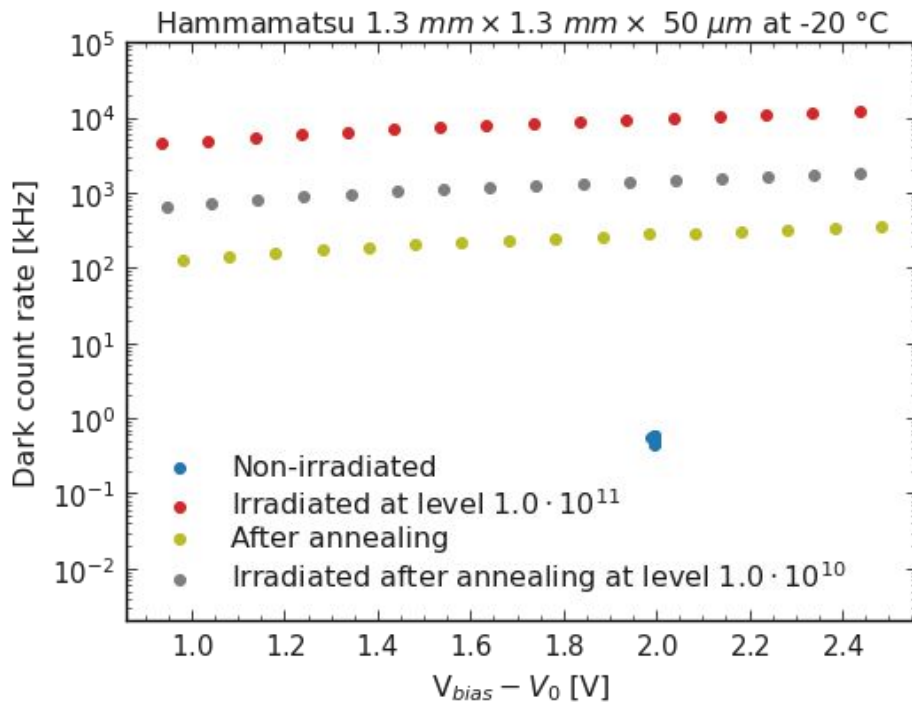
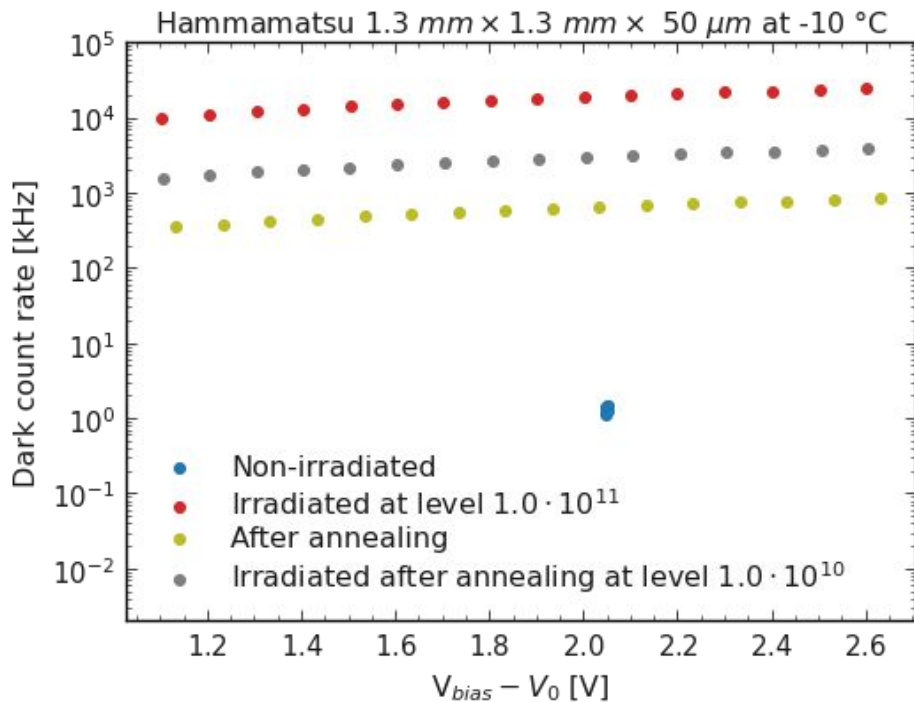


Dark count rate for SiPM #2

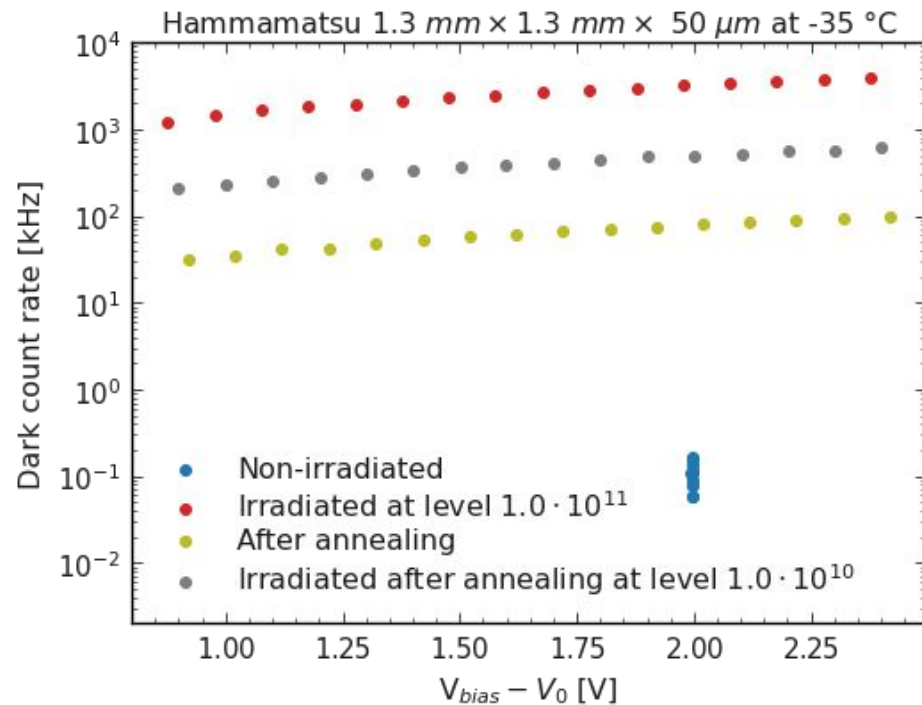
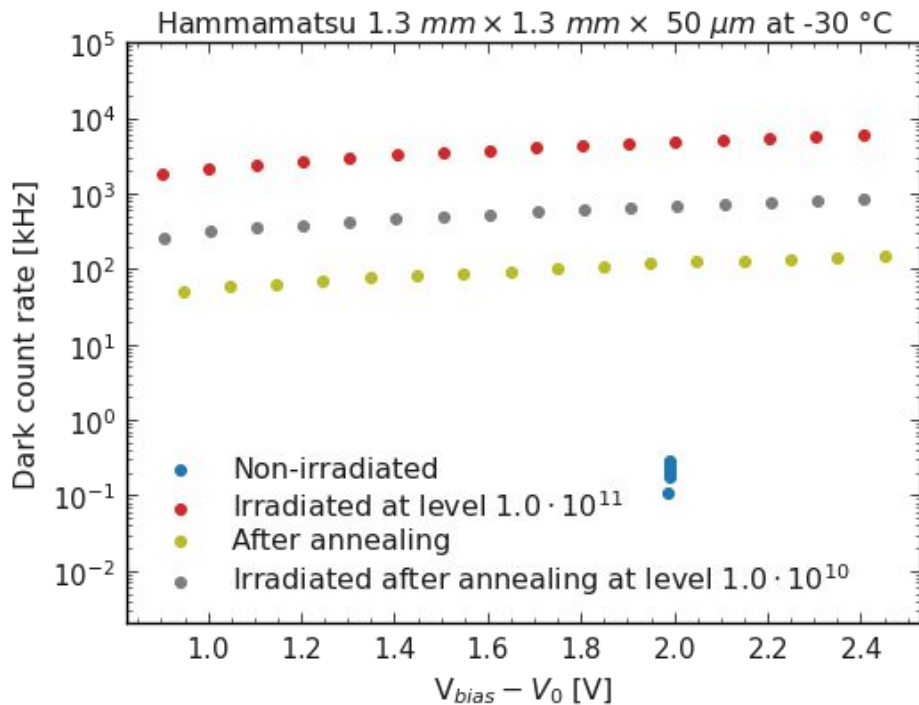
Dark count rate



Dark count rate



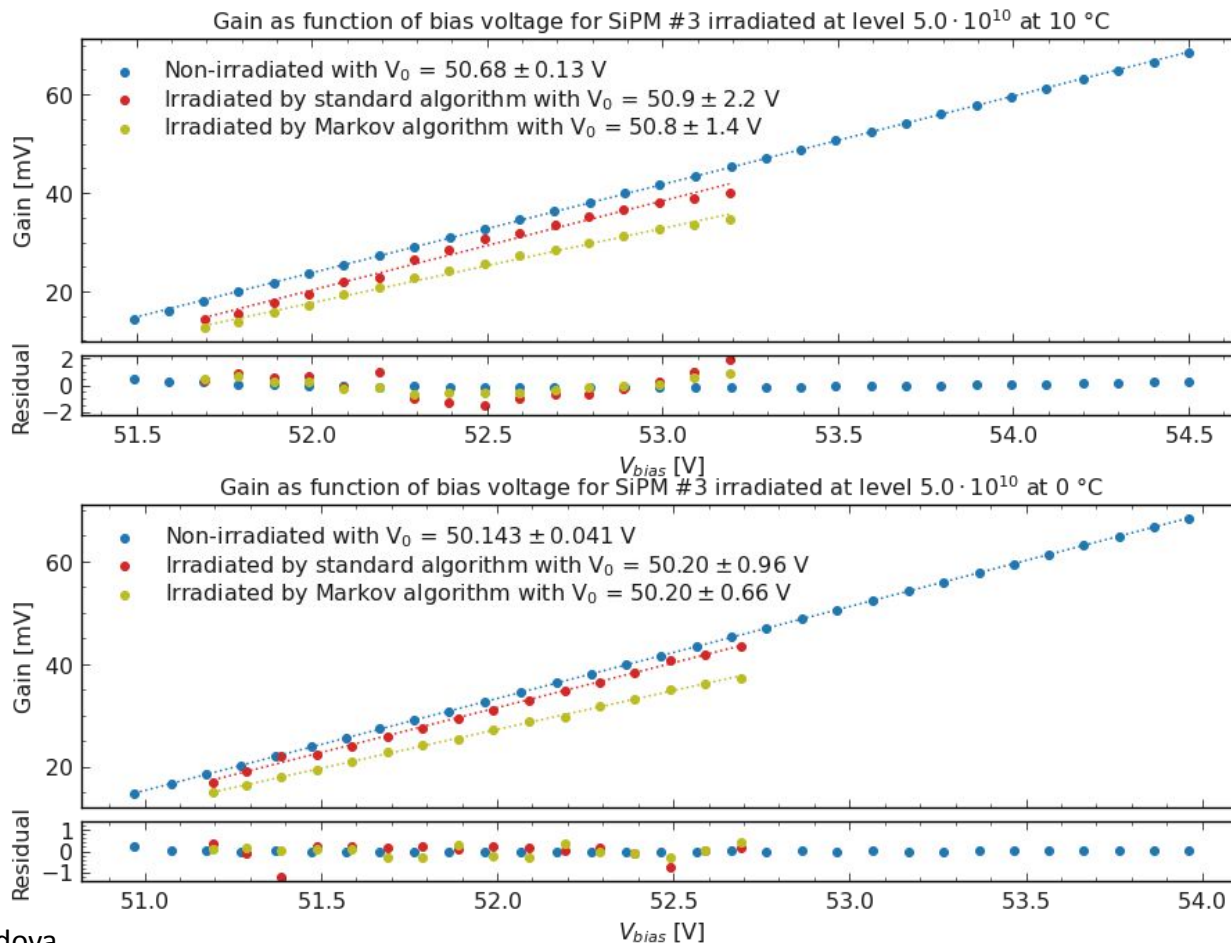
Dark count rate



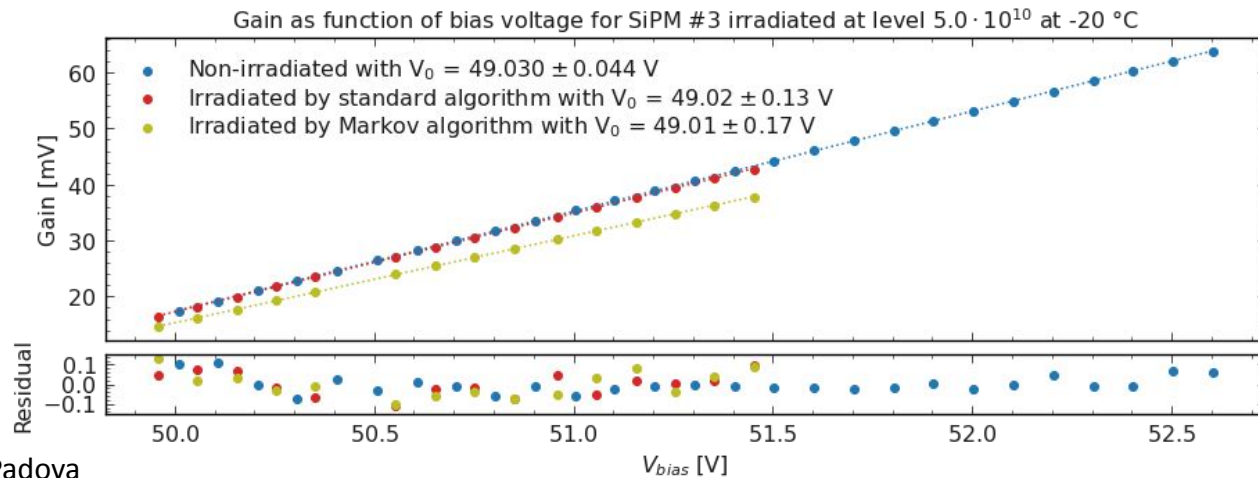
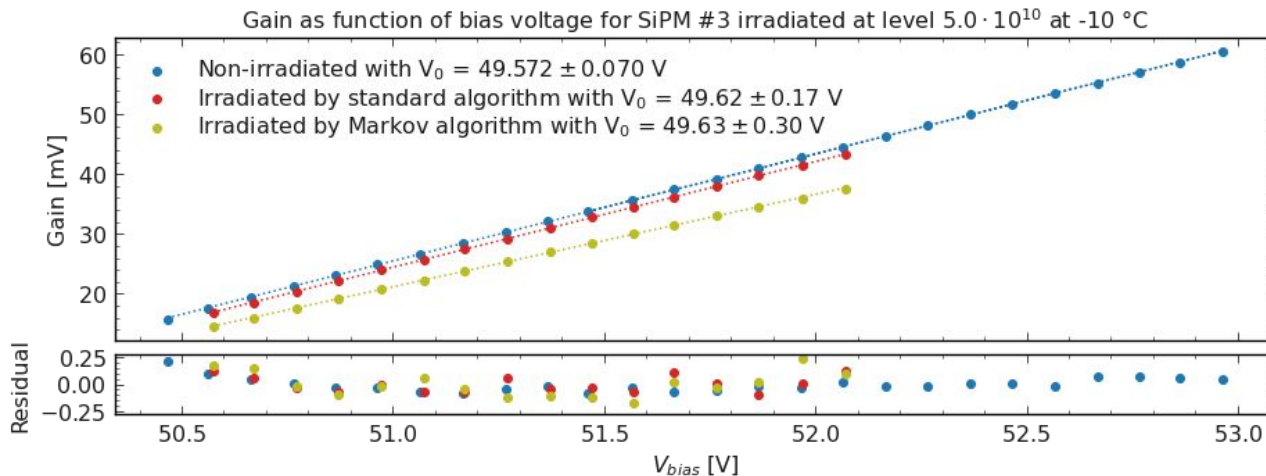
SIMP #3

Gain as function of bias voltage for SiPM #3

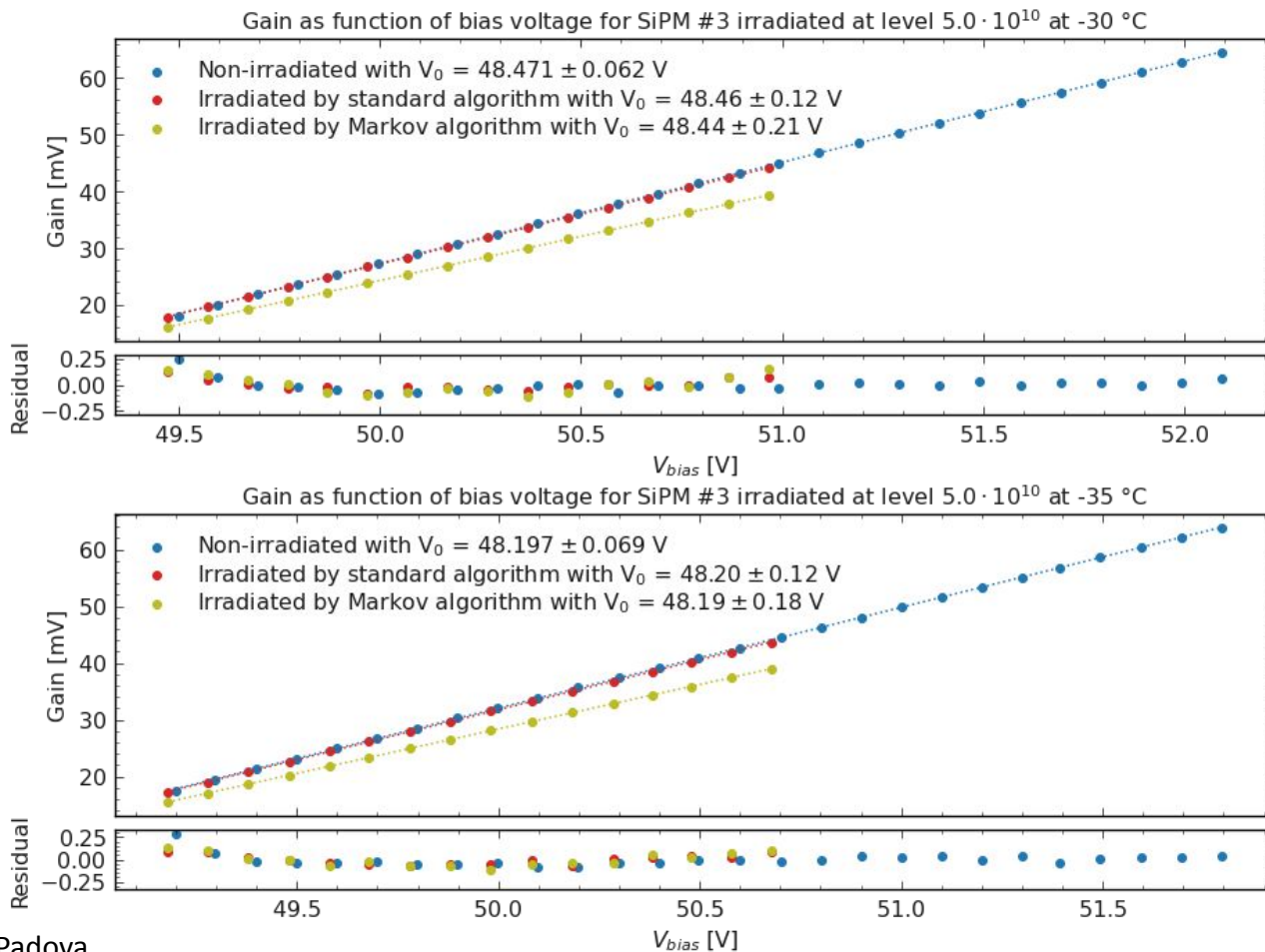
Gain as function of bias voltage



Gain as function of bias voltage

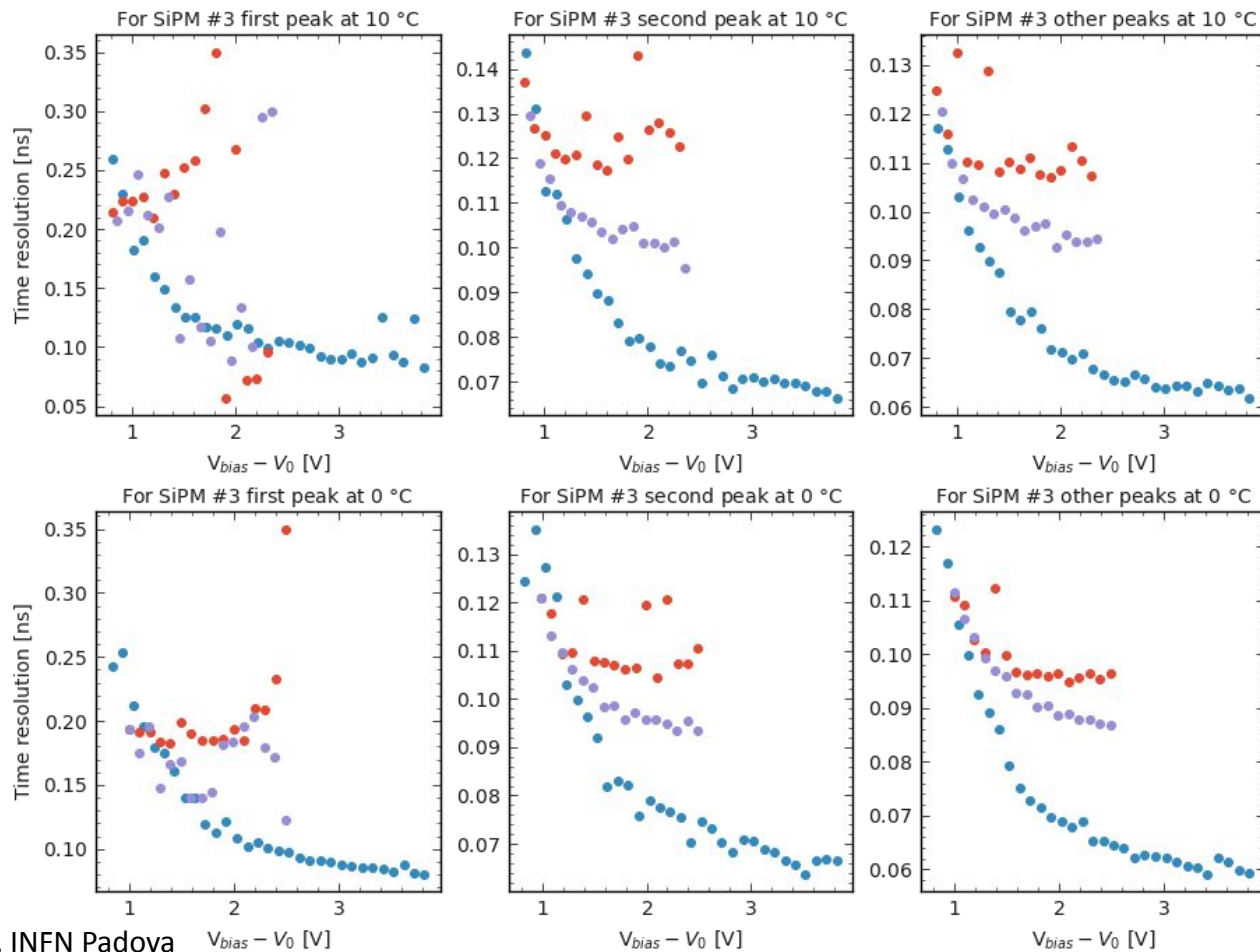


Gain as function of bias voltage

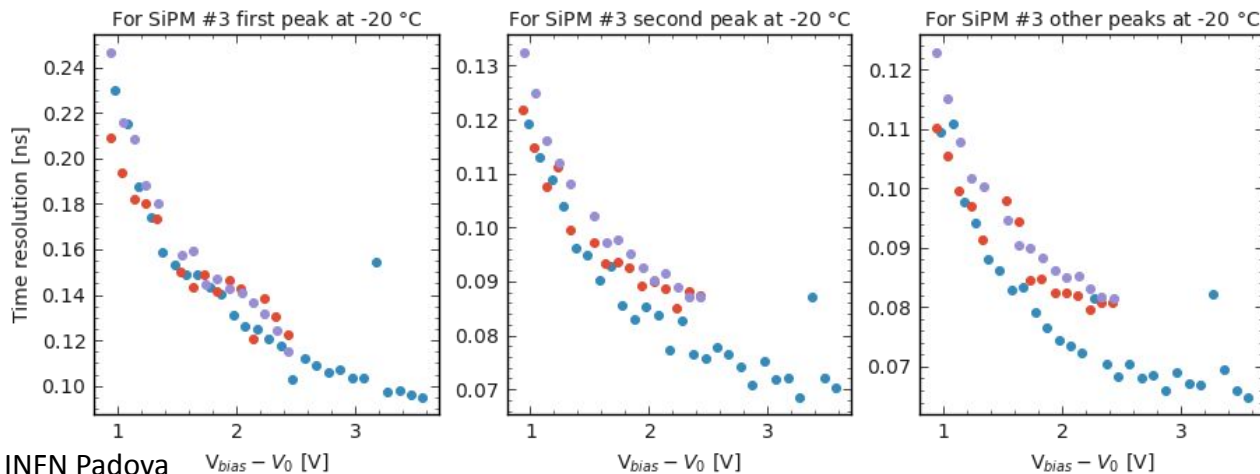
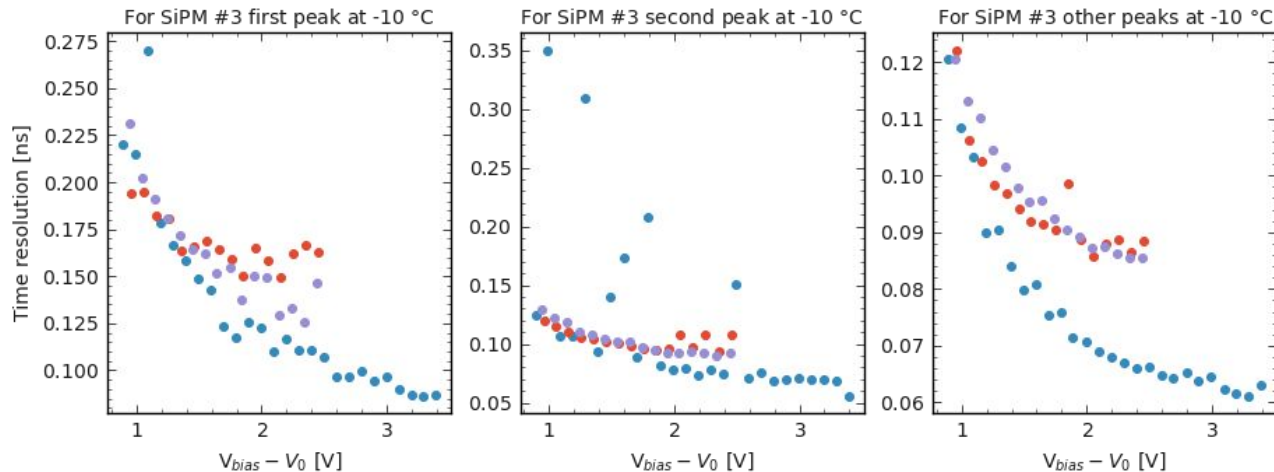


Time resolution for first, second and other photon peaks for SiPM #3

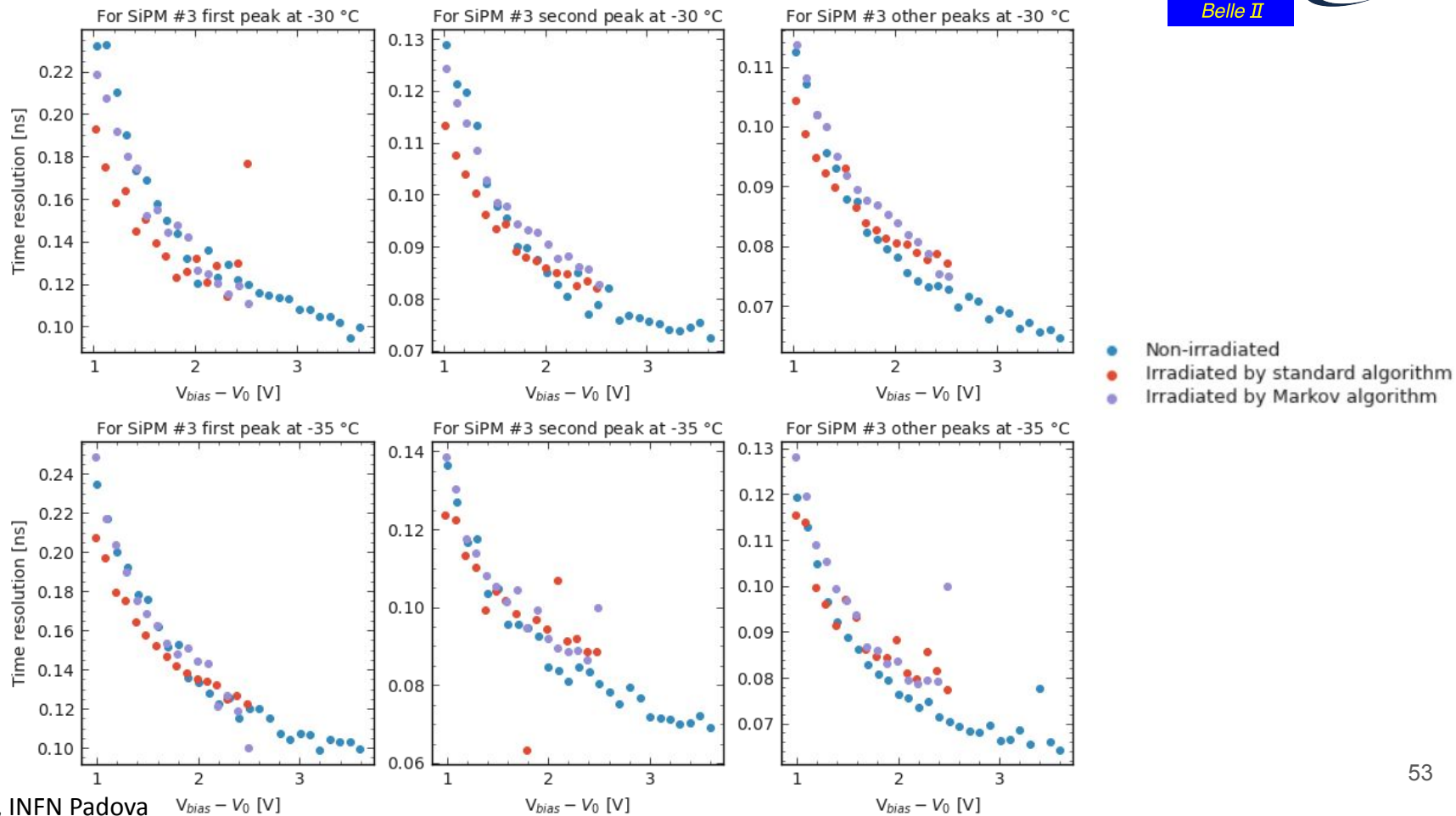
Time resolution



Time resolution

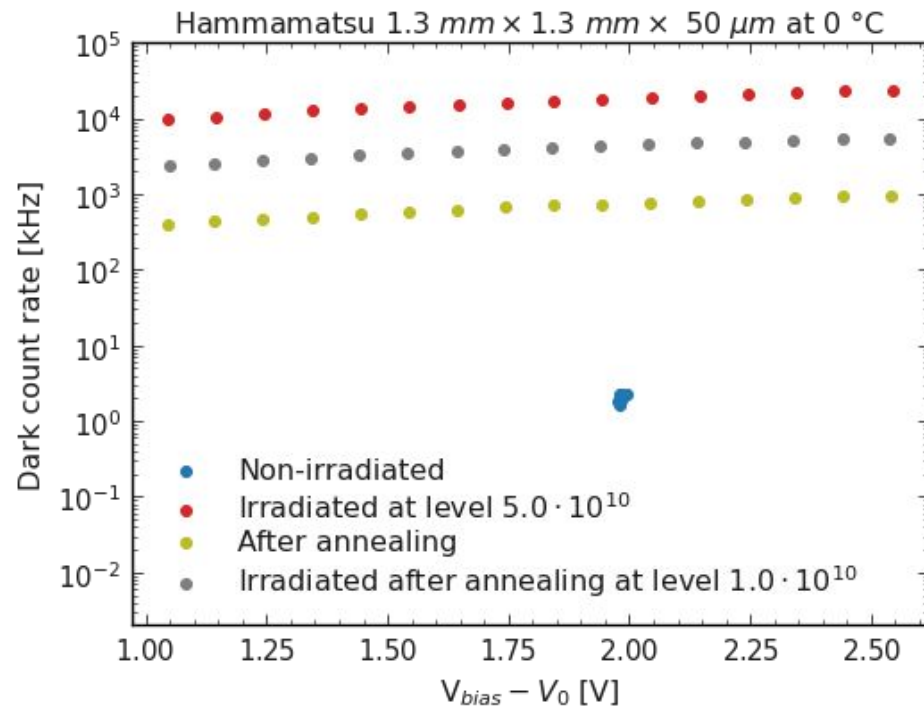
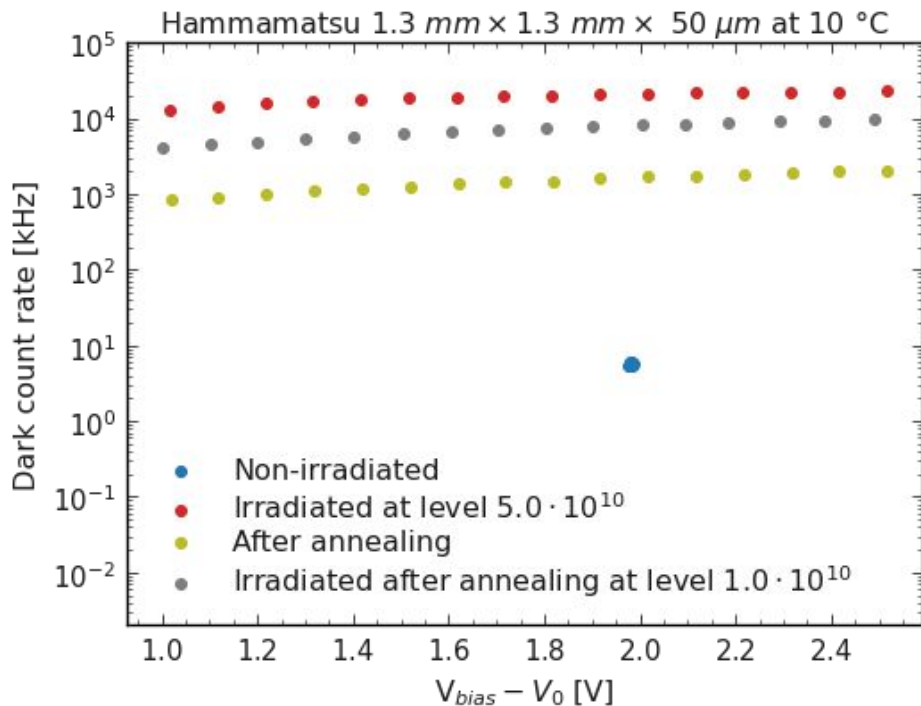


Time resolution

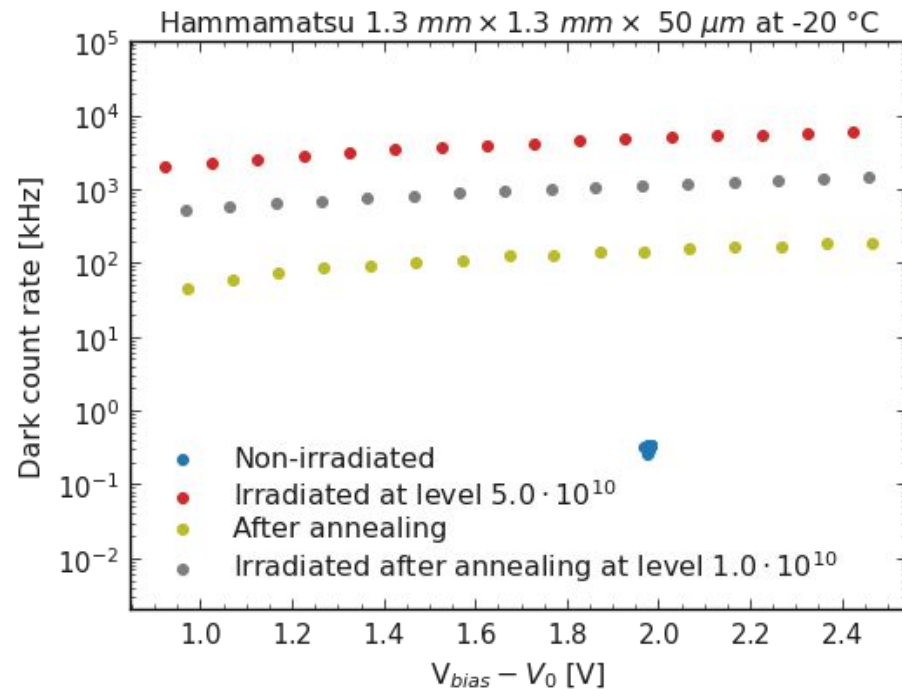
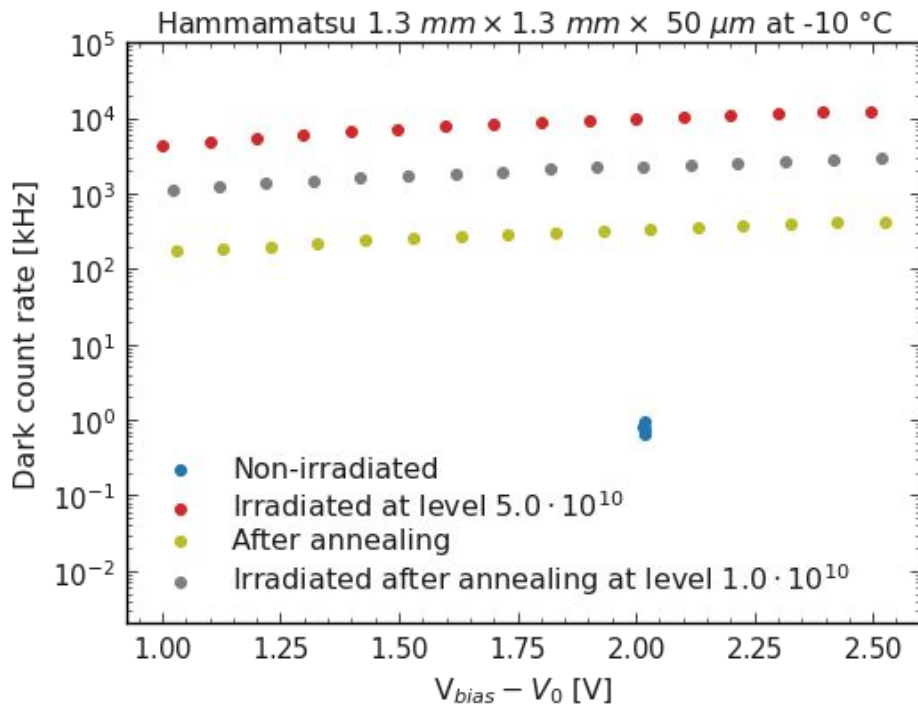


Dark count rate for SiPM #3

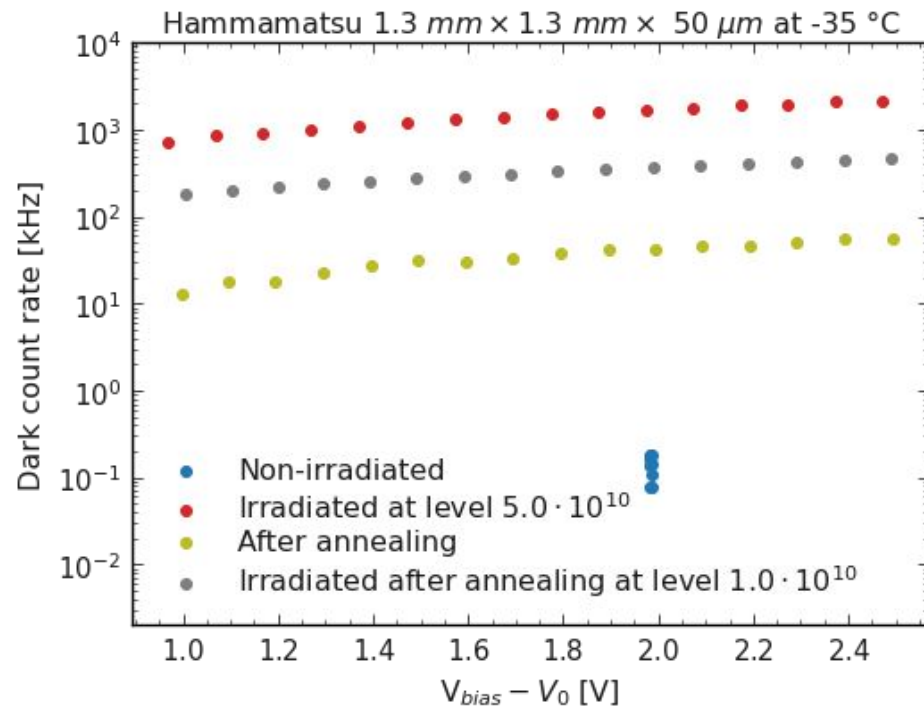
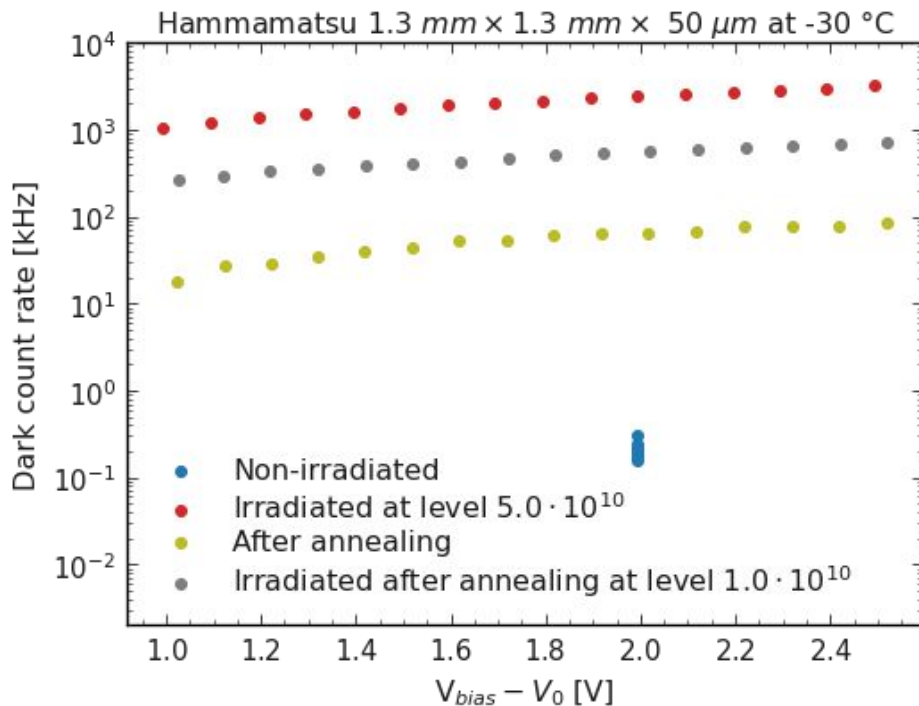
Dark count rate



Dark count rate



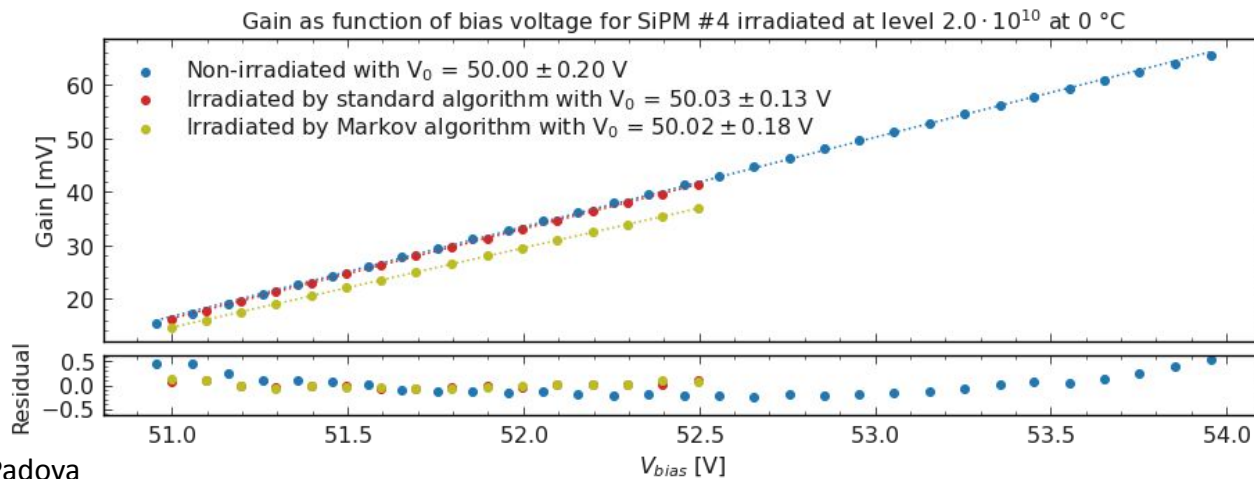
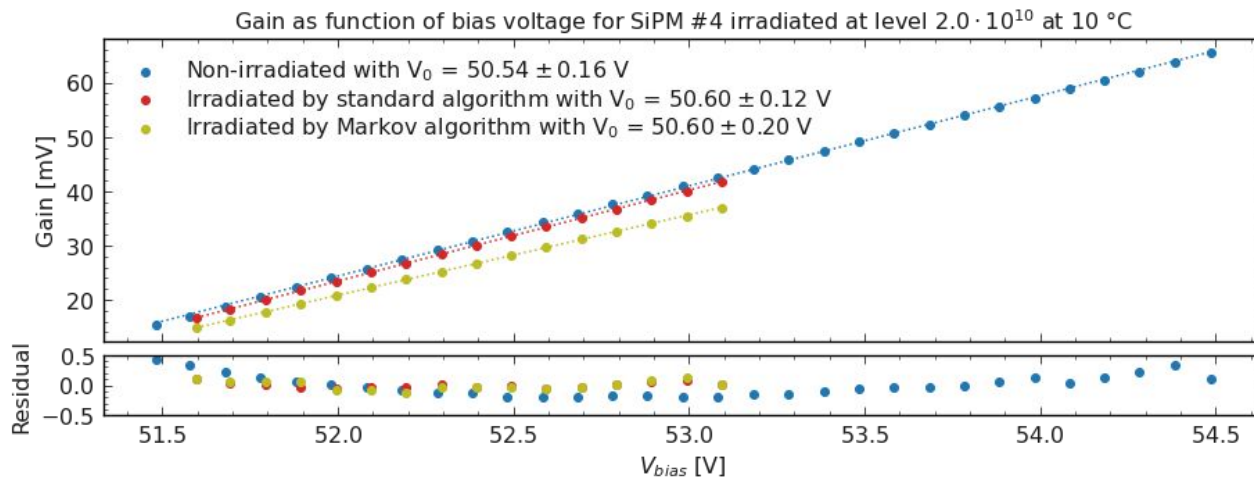
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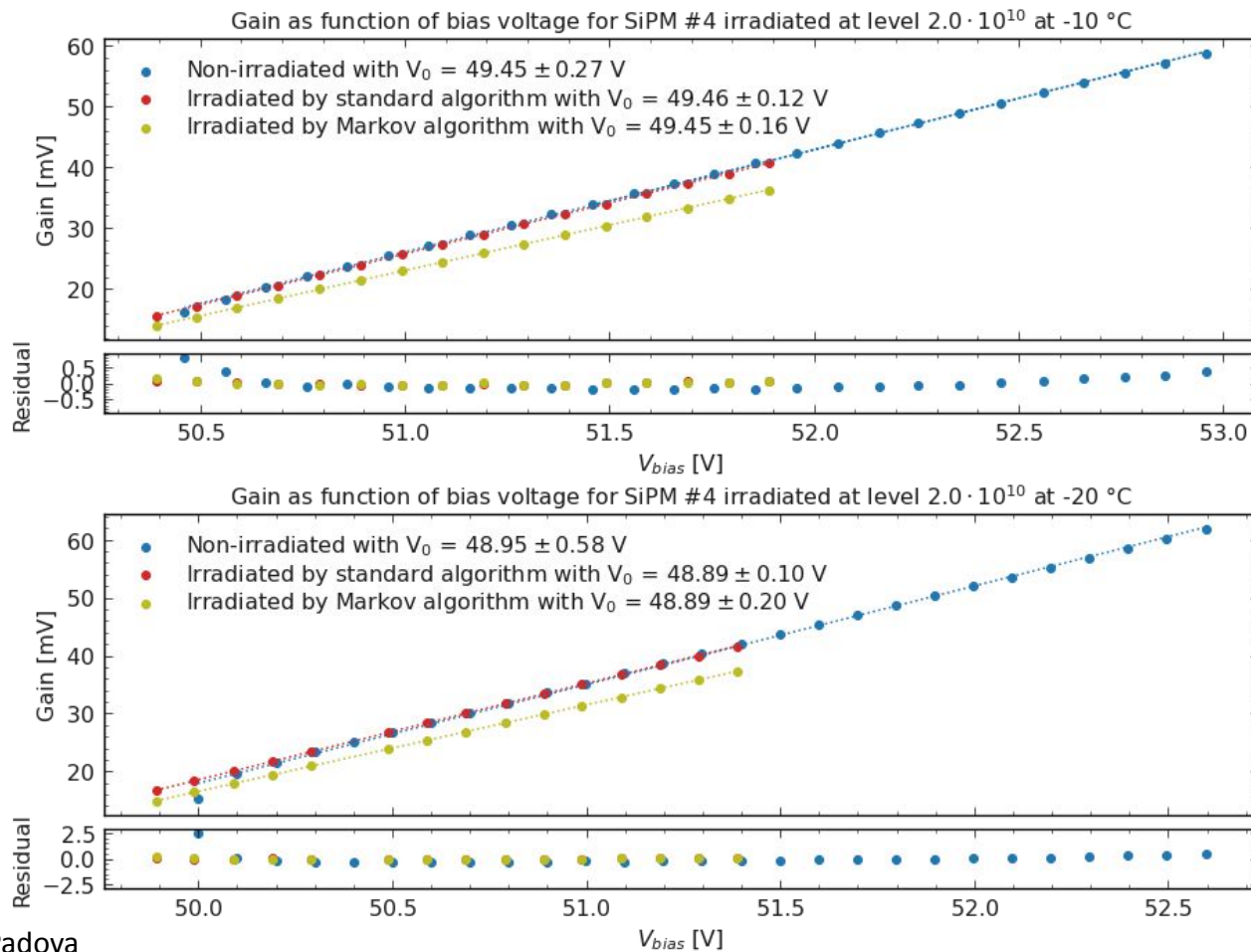
SIMP #4

Gain as function of bias voltage for SiPM #4

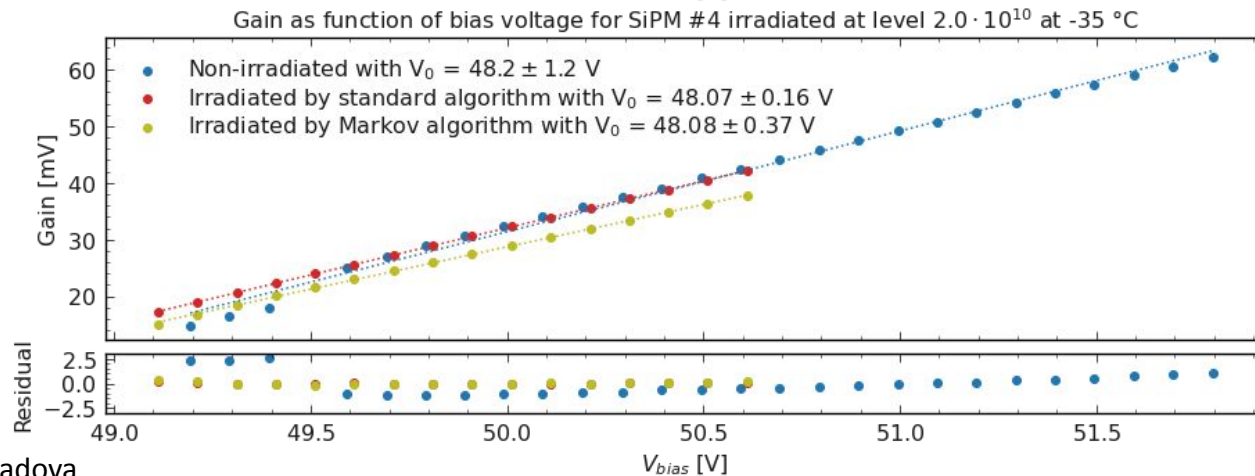
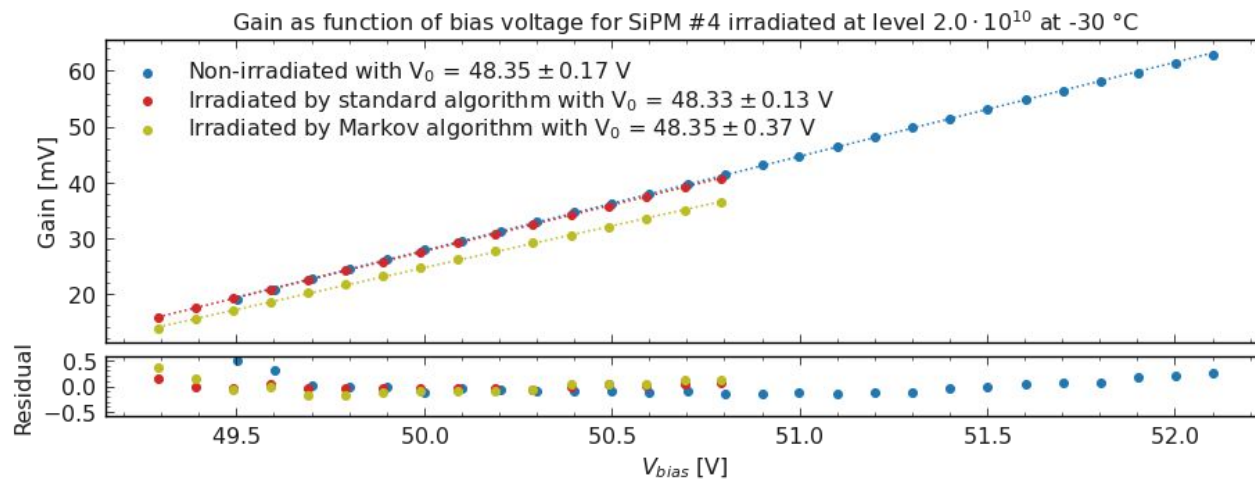
Gain as function of bias voltage



Gain as function of bias voltage

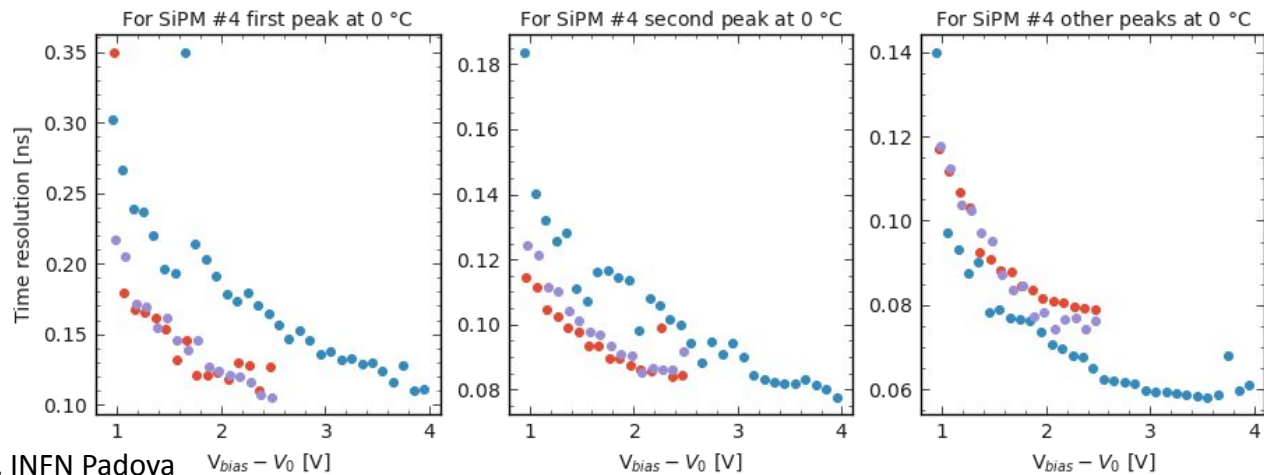
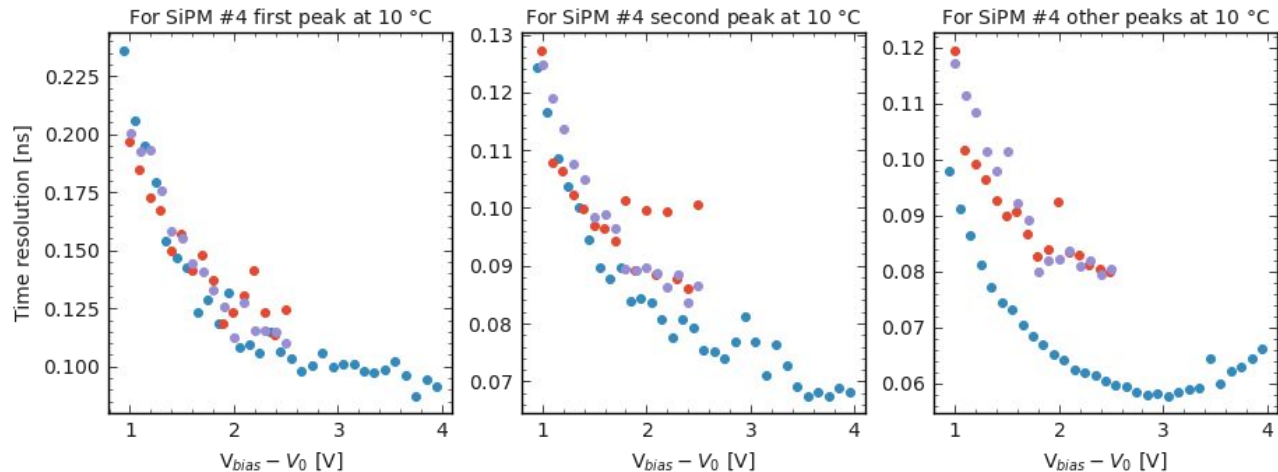


Gain as function of bias voltage

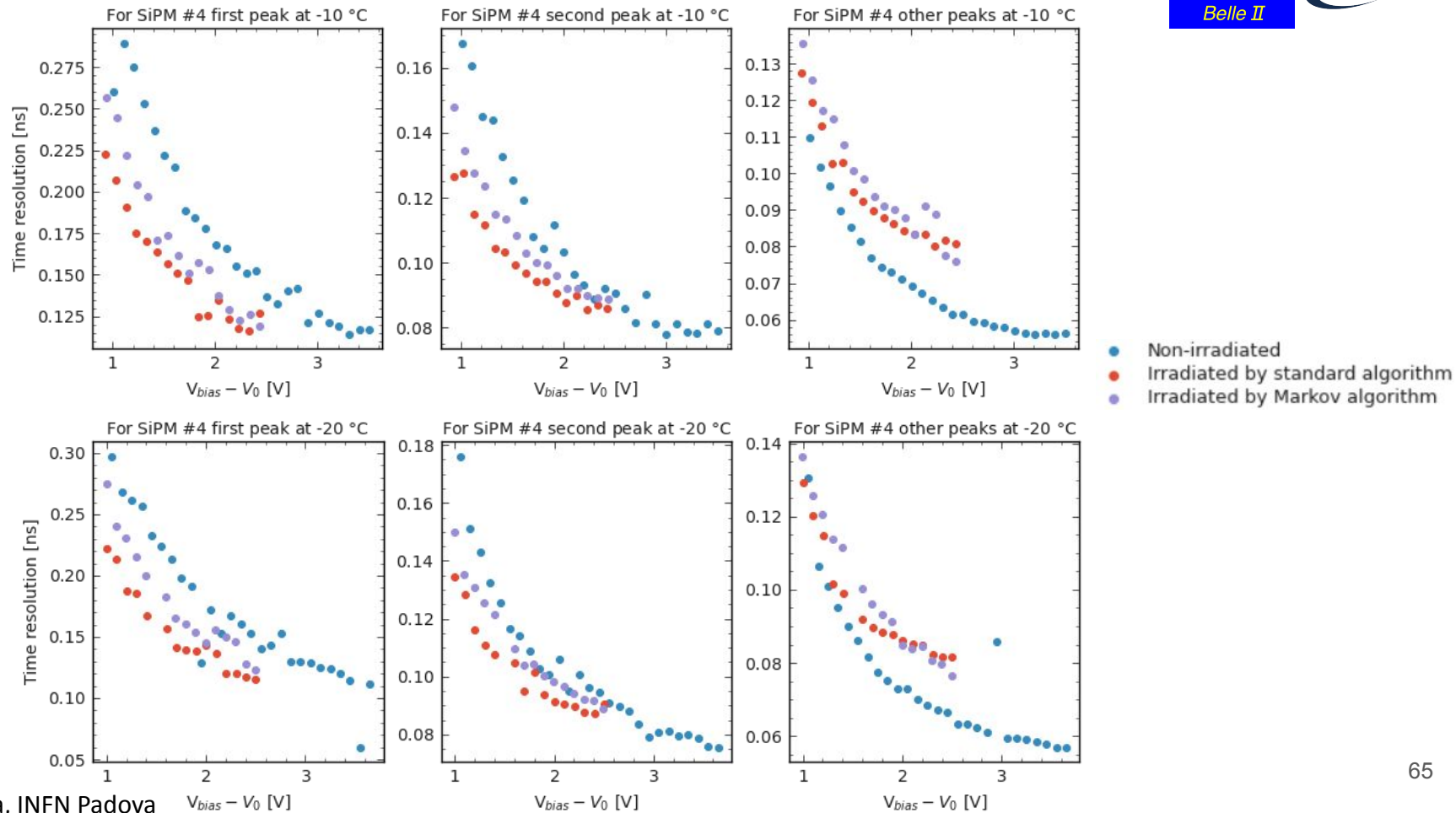


Time resolution for first, second and other photon peaks for SiPM #4

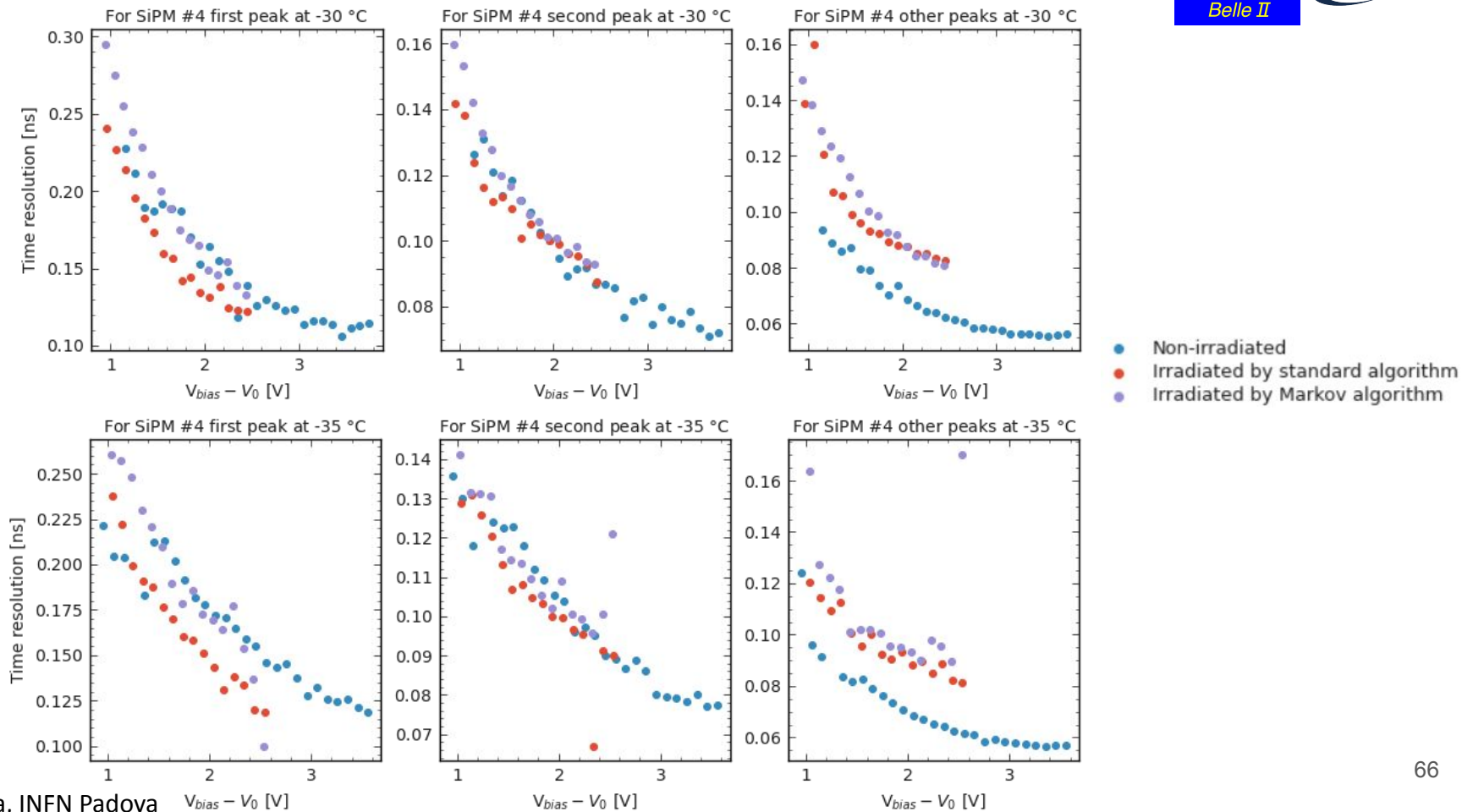
Time resolution



Time resolution

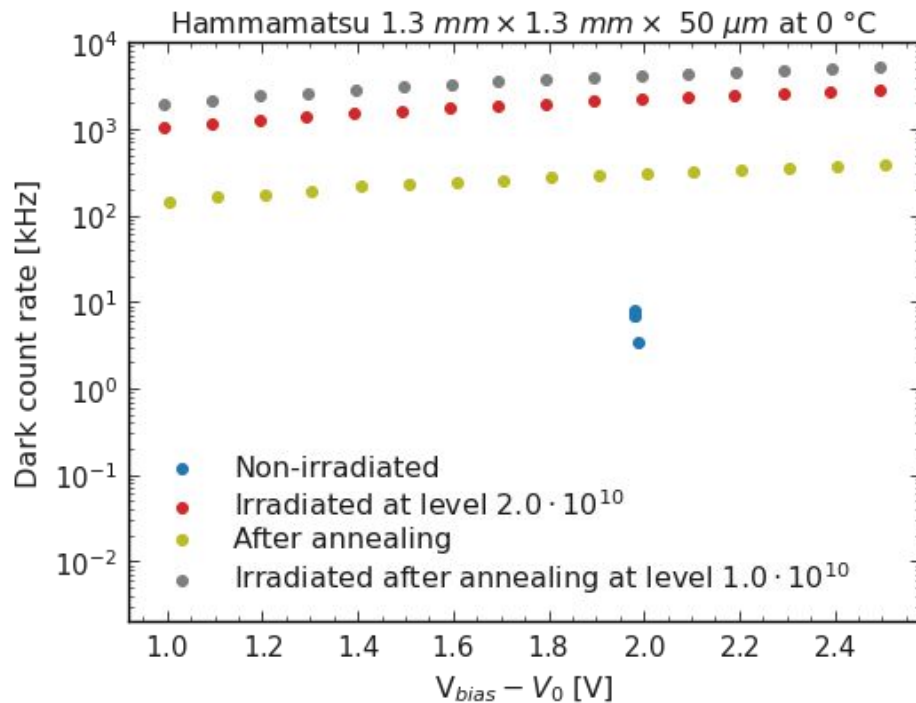
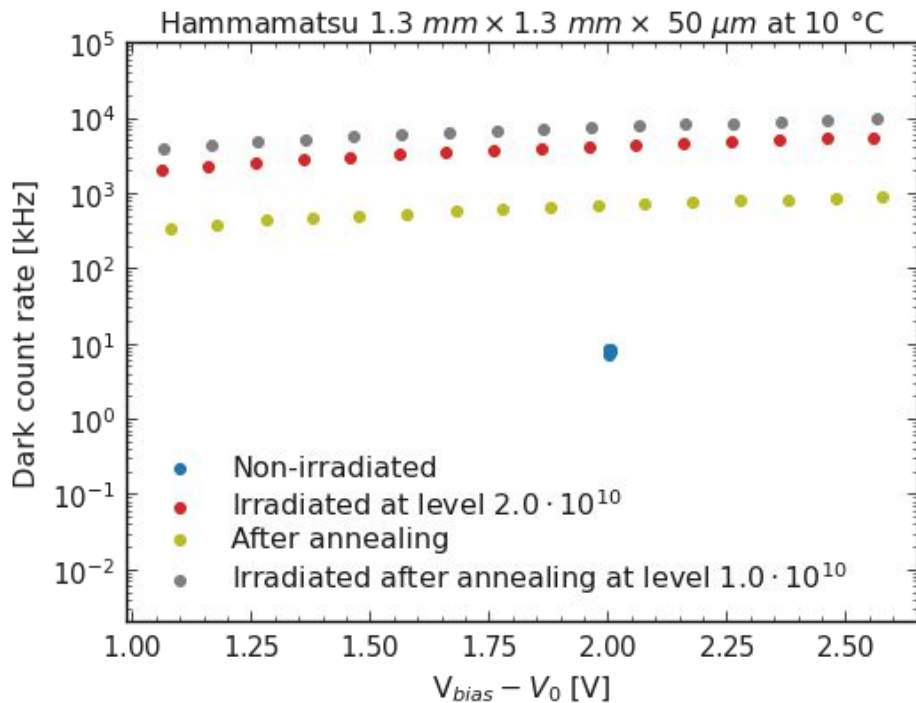


Time resolution

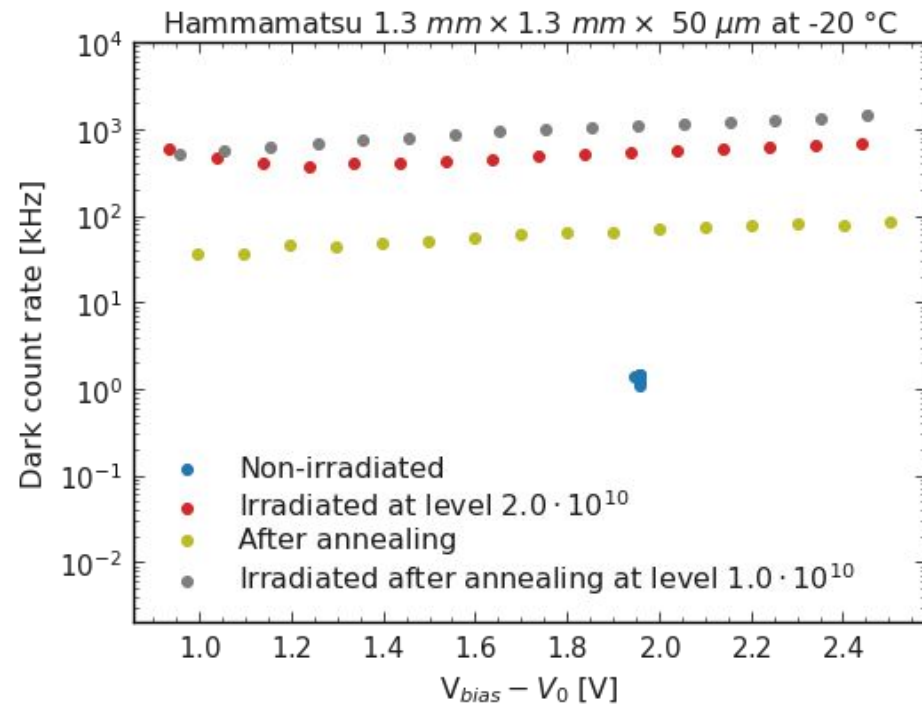
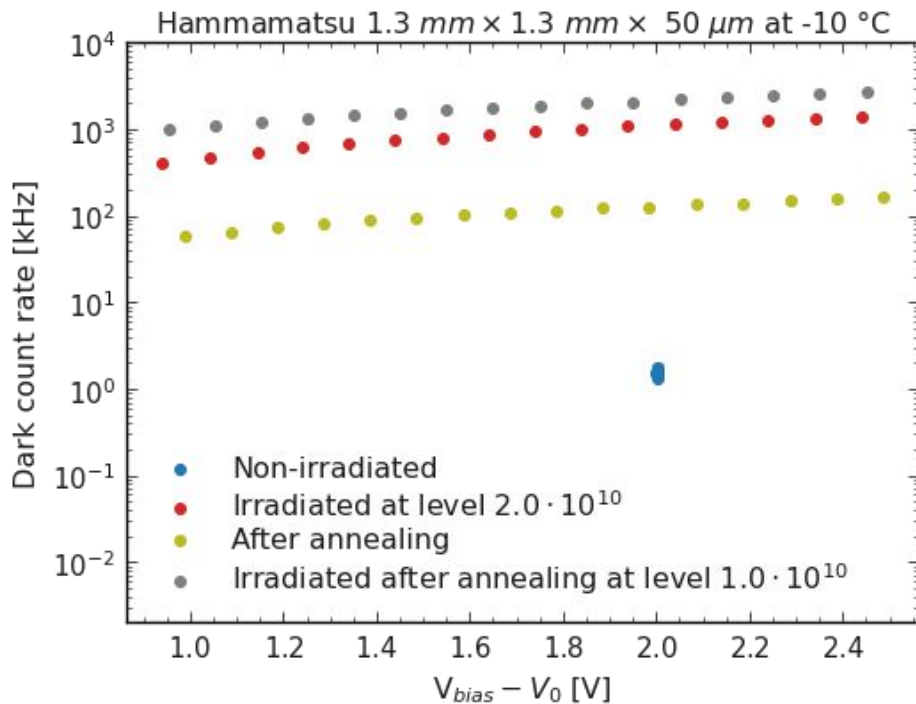


Dark count rate for SiPM #4

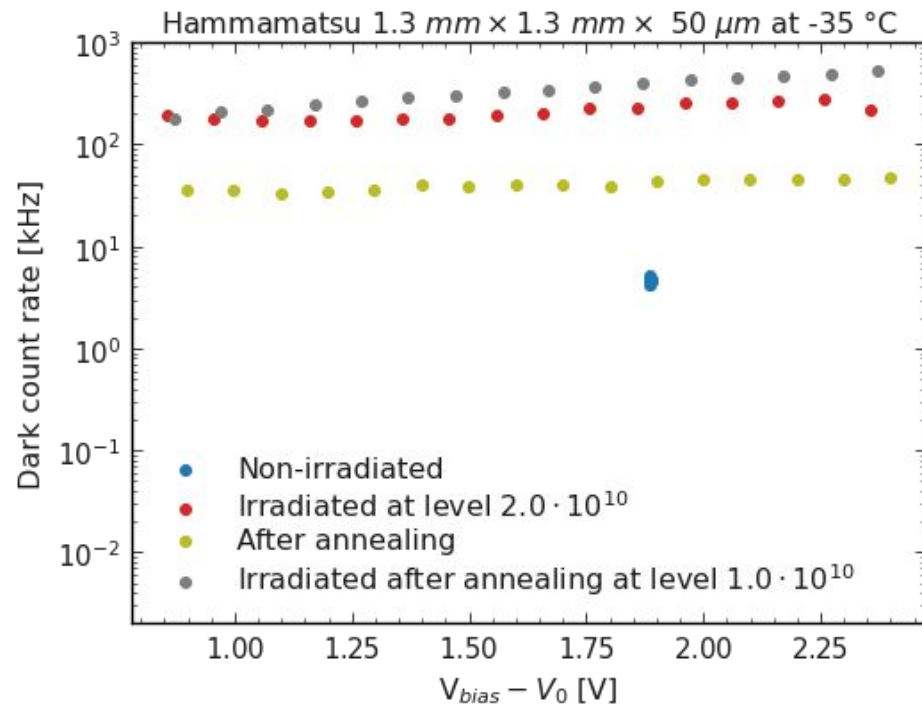
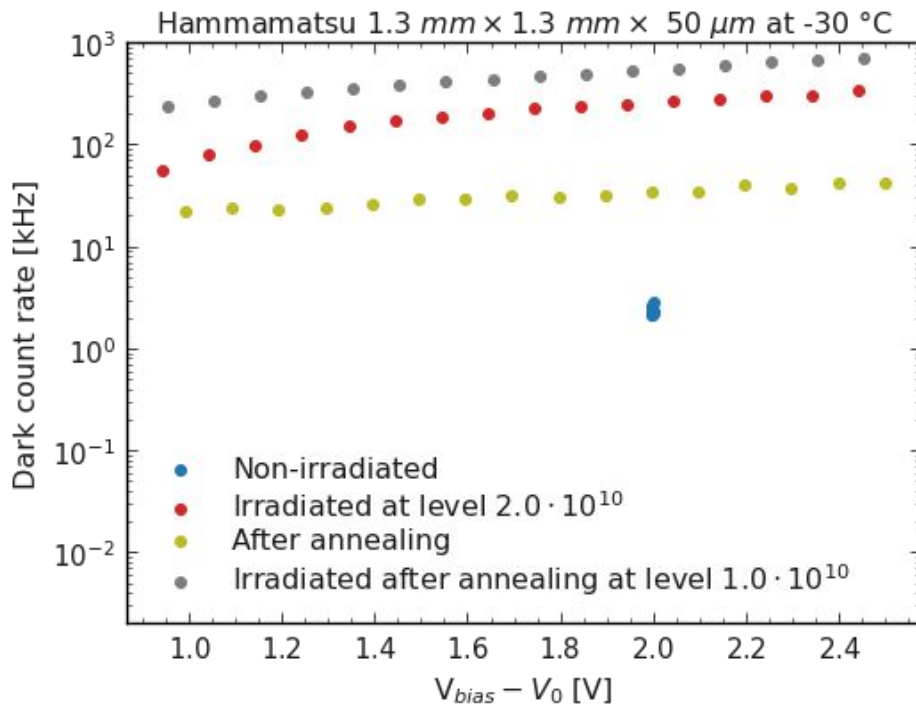
Dark count rate



Dark count rate



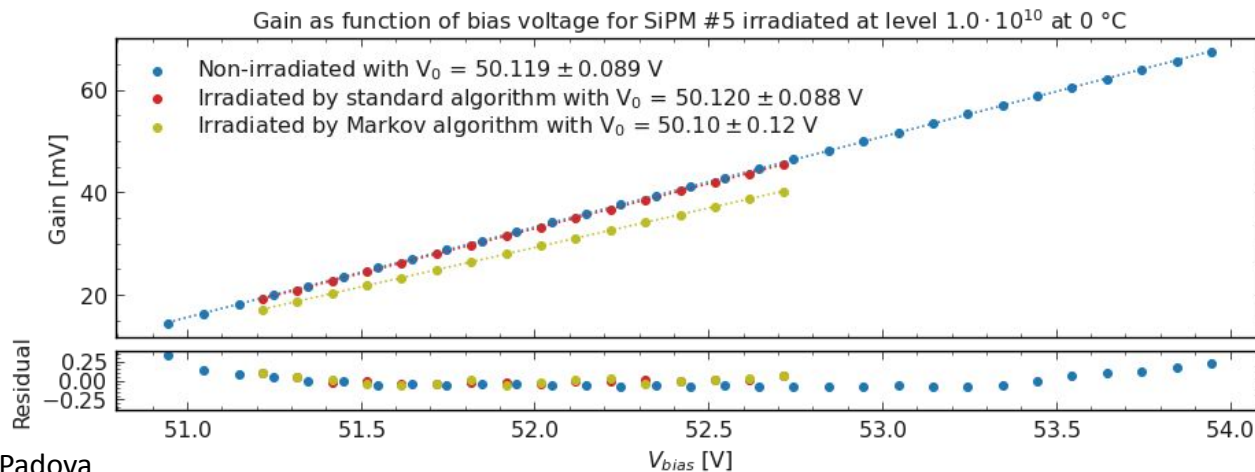
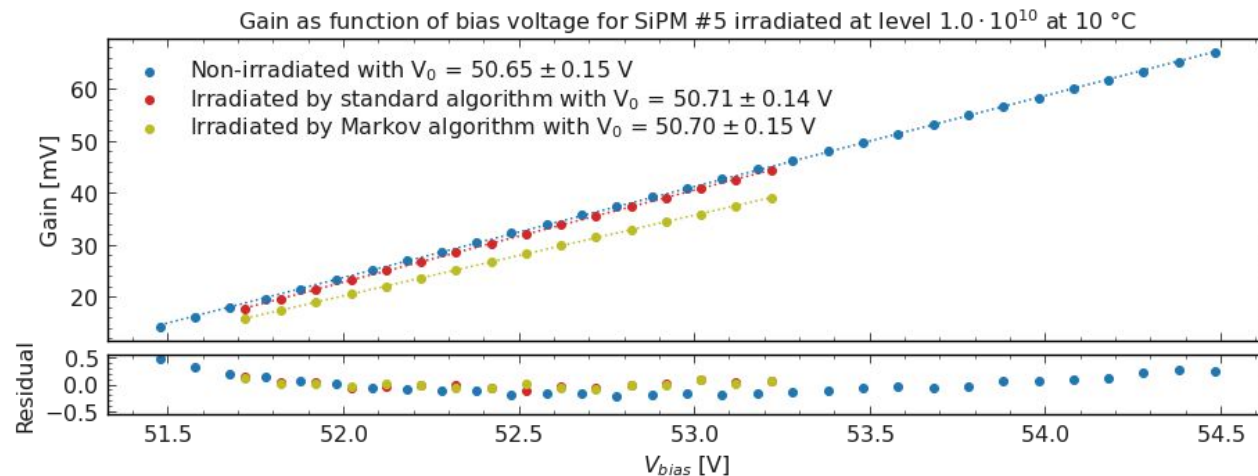
Dark count rate



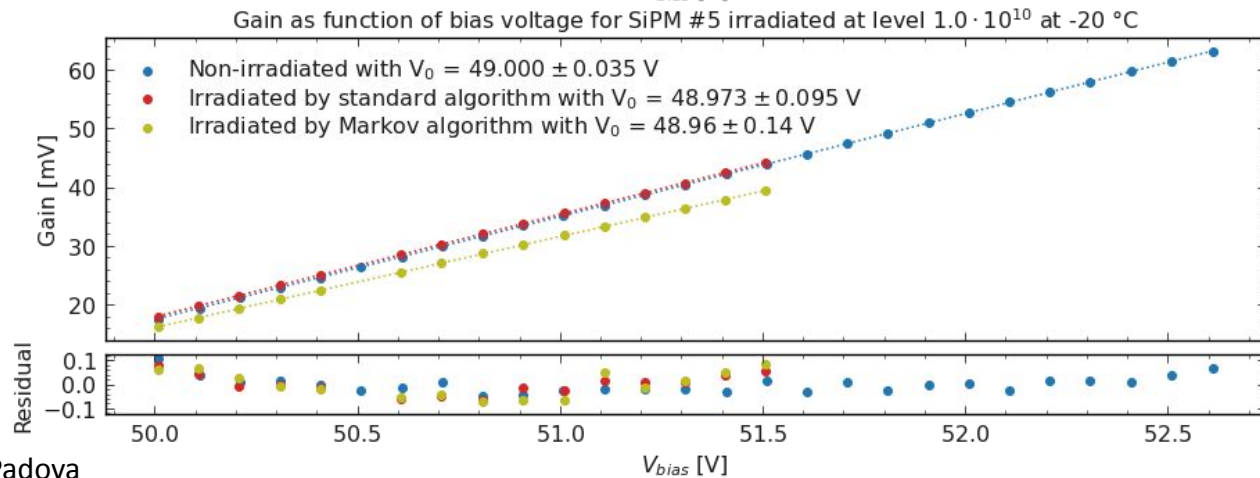
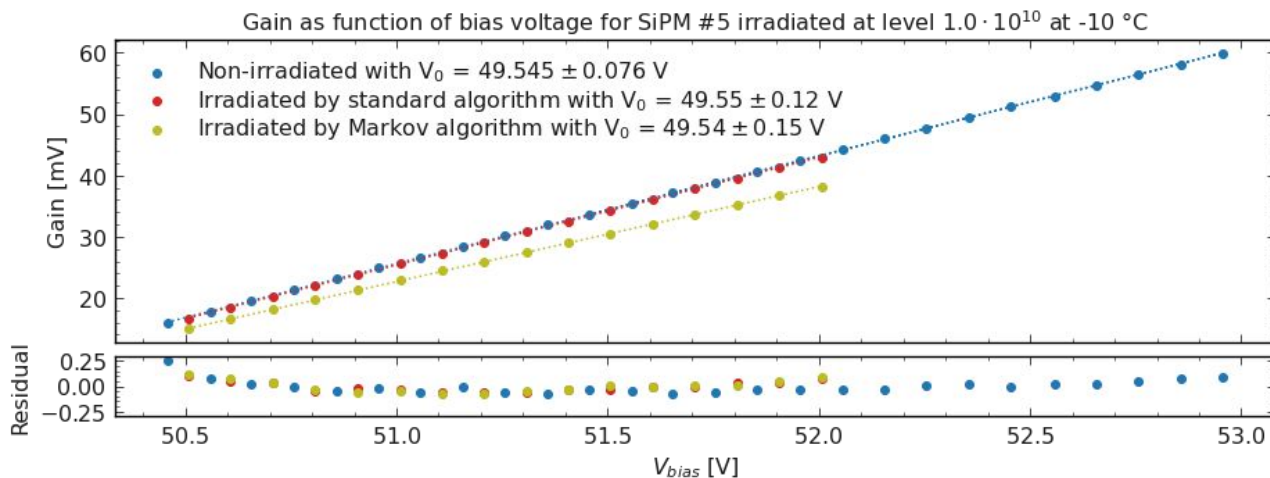
SIMP #5

Gain as function of bias voltage for SiPM #5

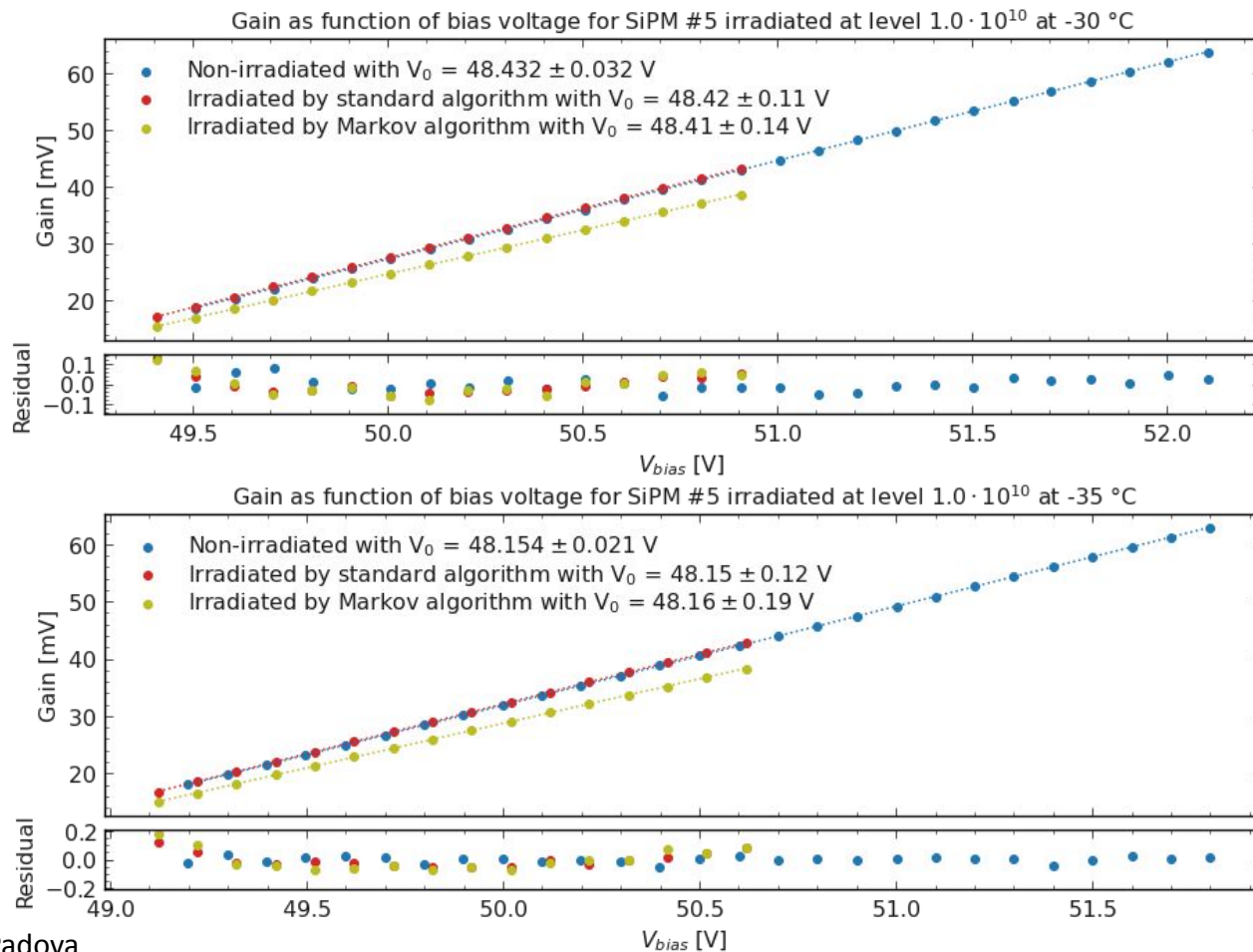
Gain as function of bias voltage



Gain as function of bias voltage

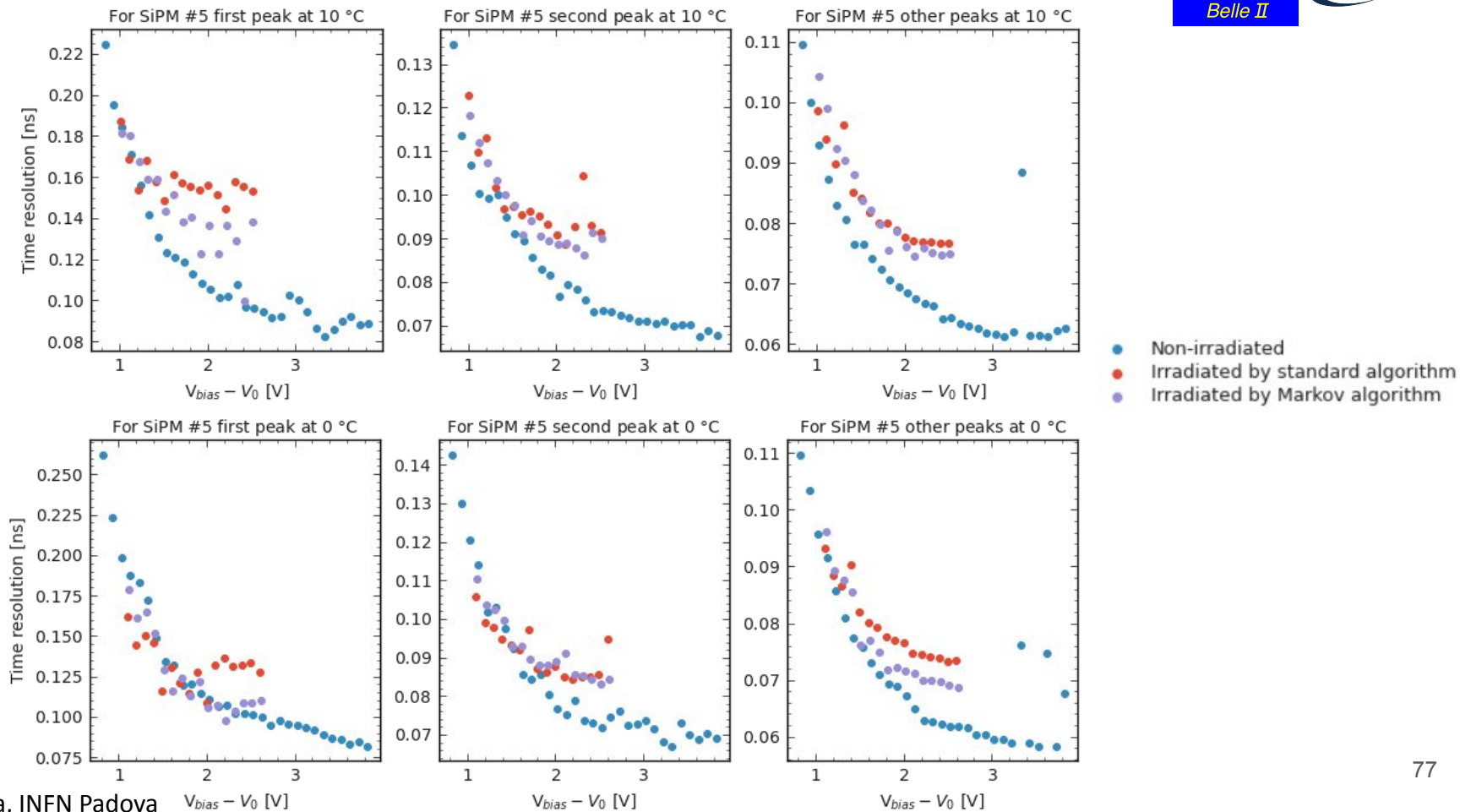


Gain as function of bias voltage

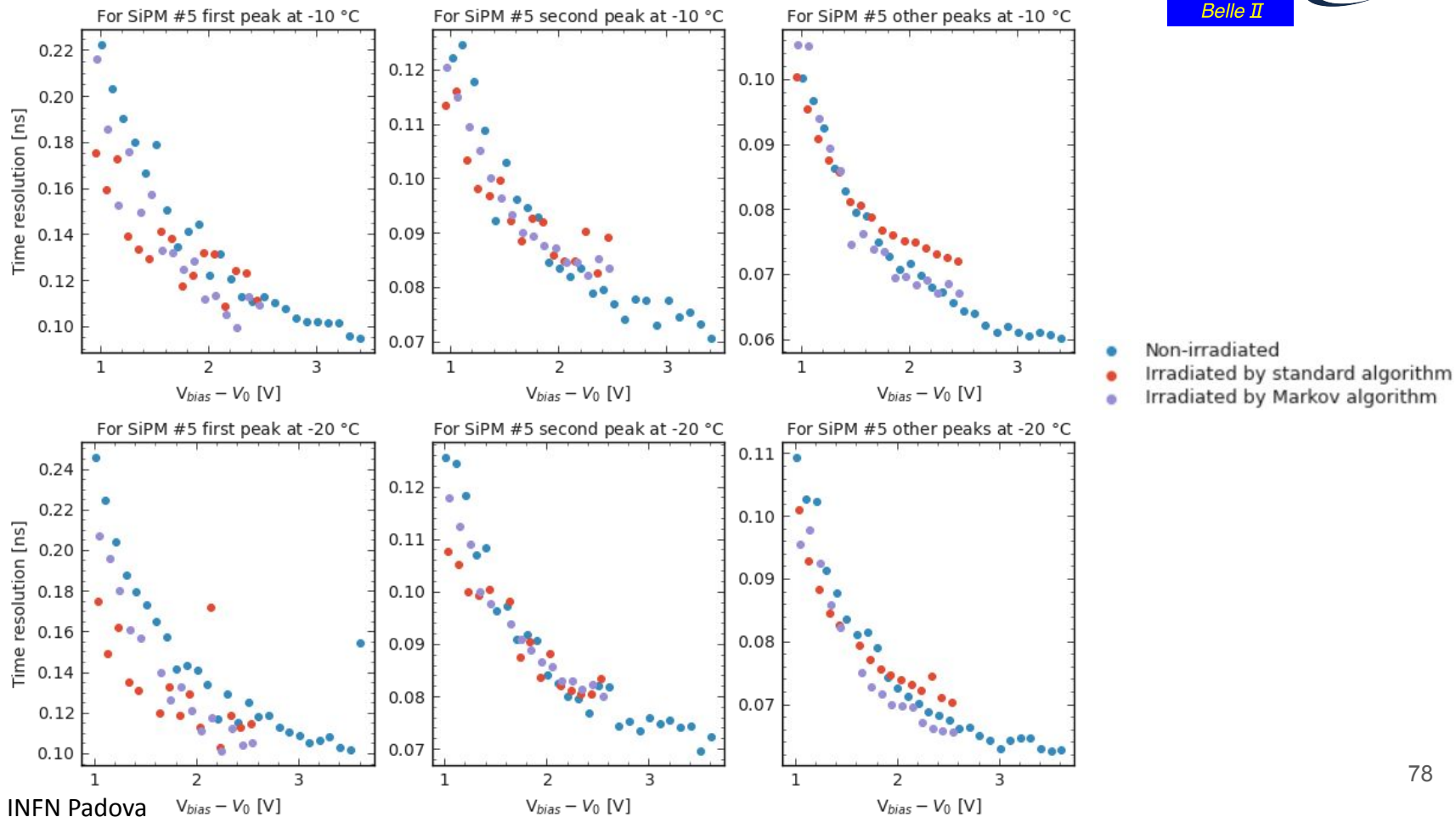


Time resolution for first, second and other photon peaks for SiPM #5

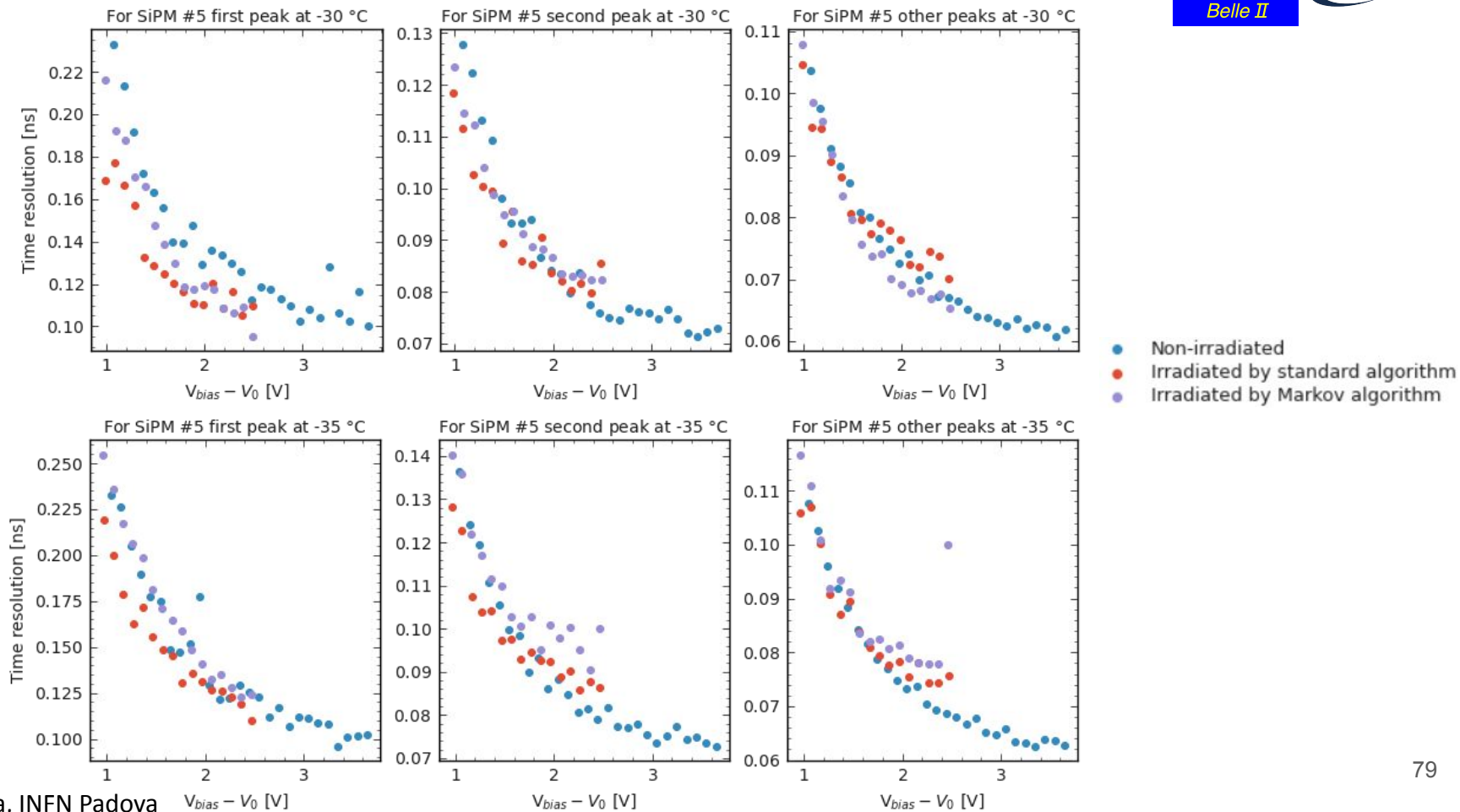
Time resolution



Time resolution

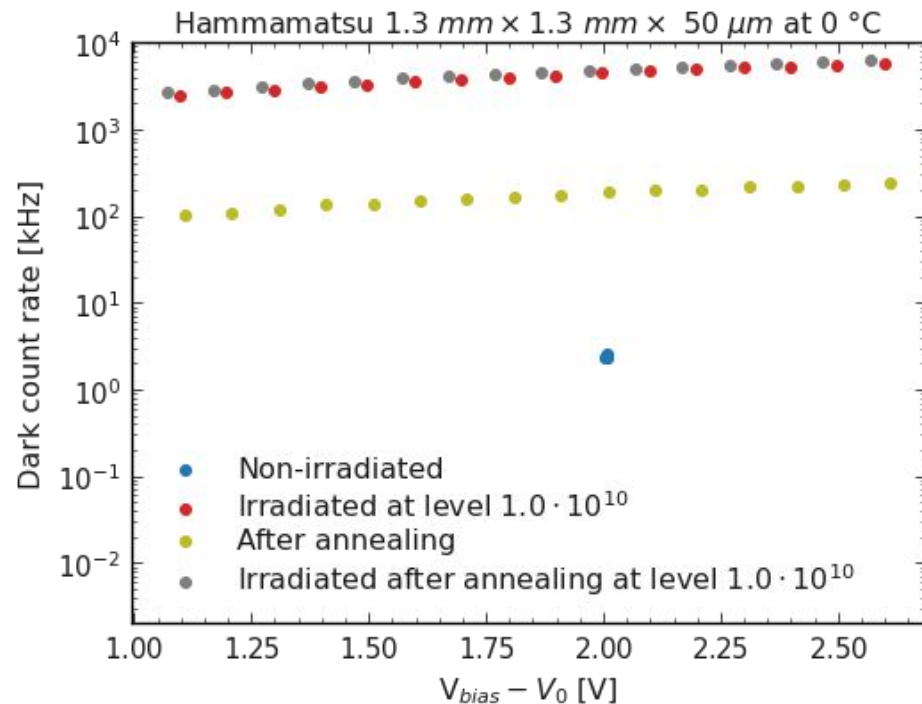
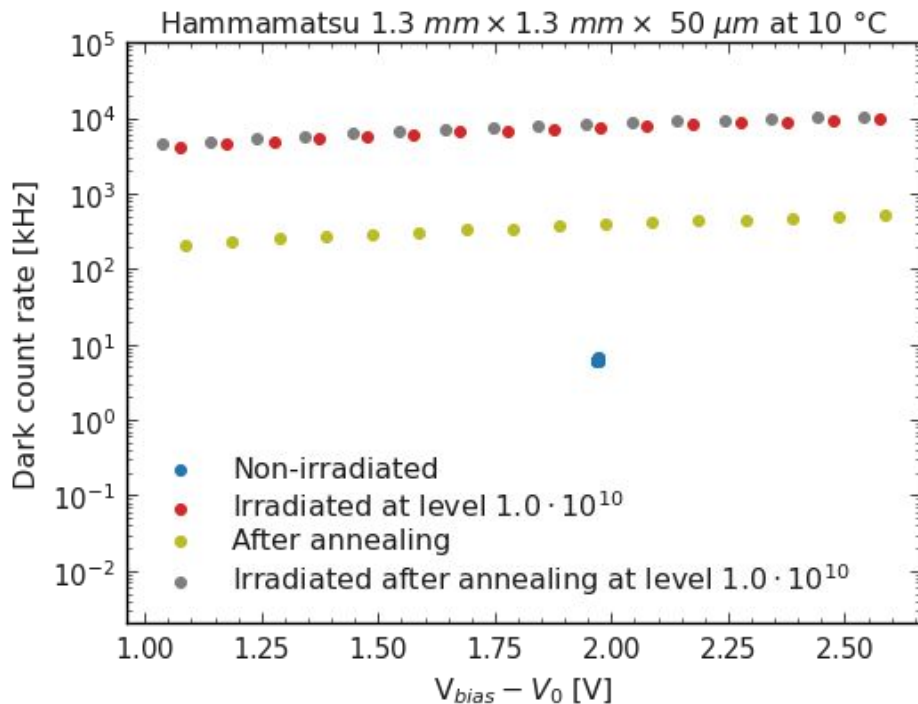


Time resolution

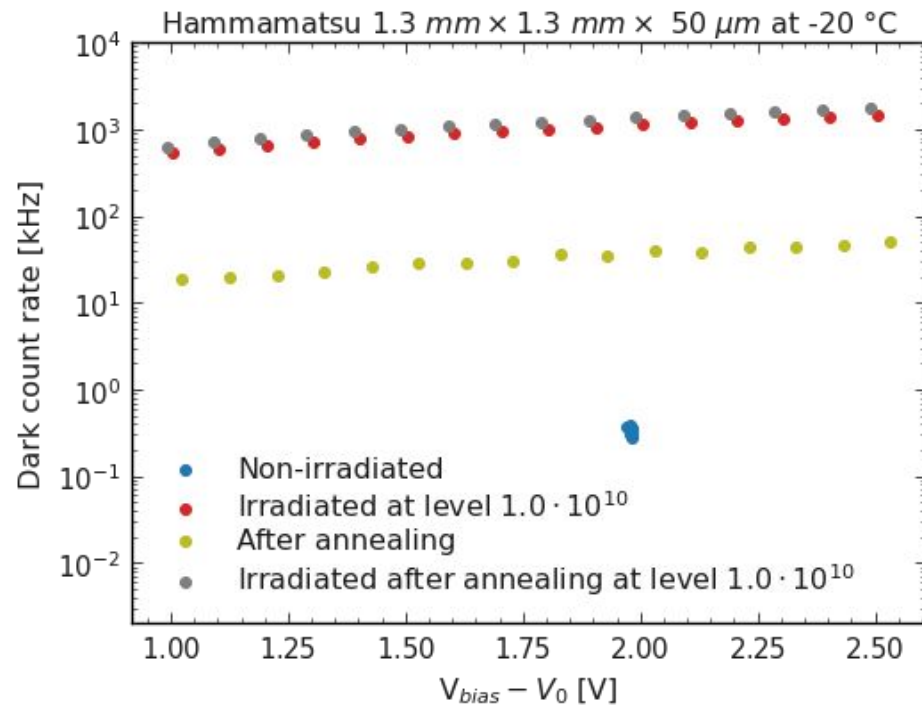
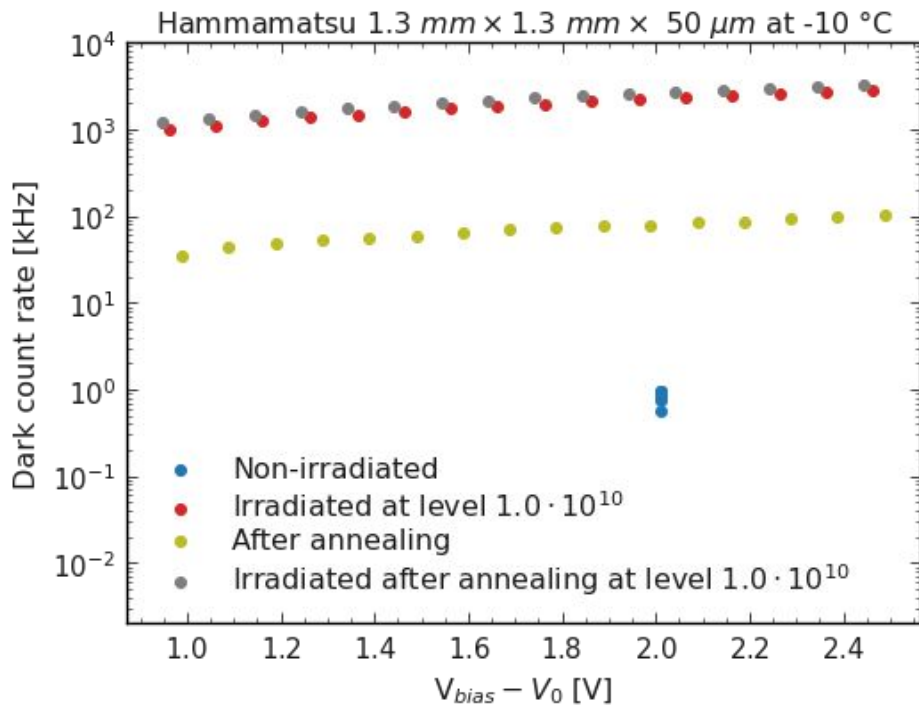


Dark count rate for SiPM #5

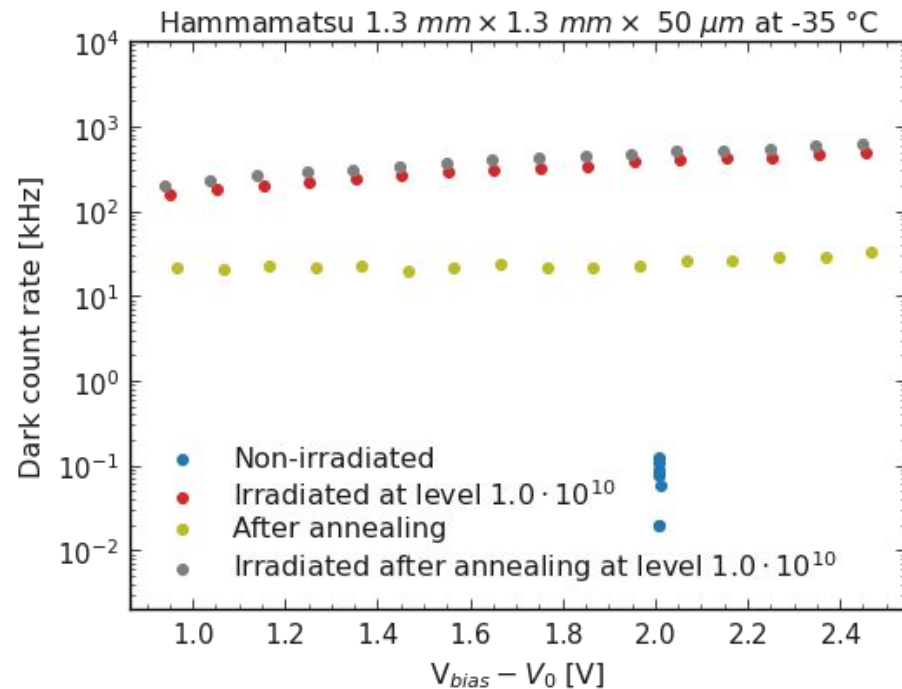
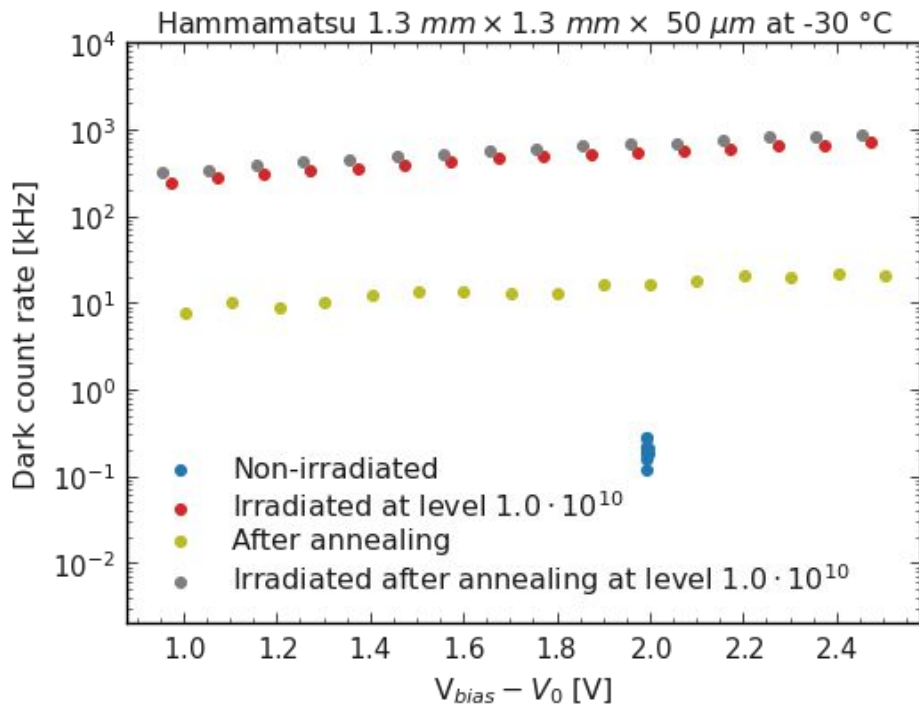
Dark count rate



Dark count rate



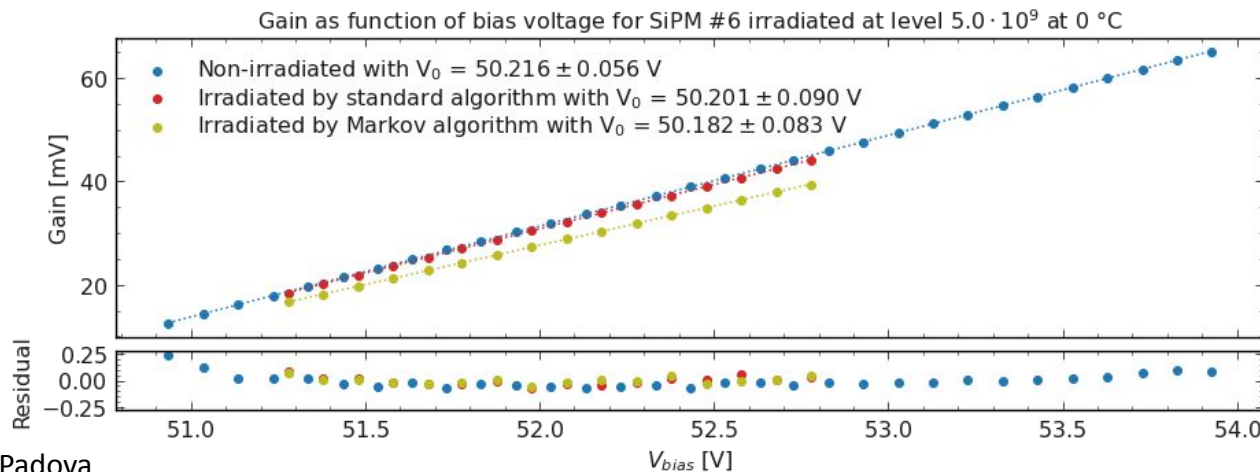
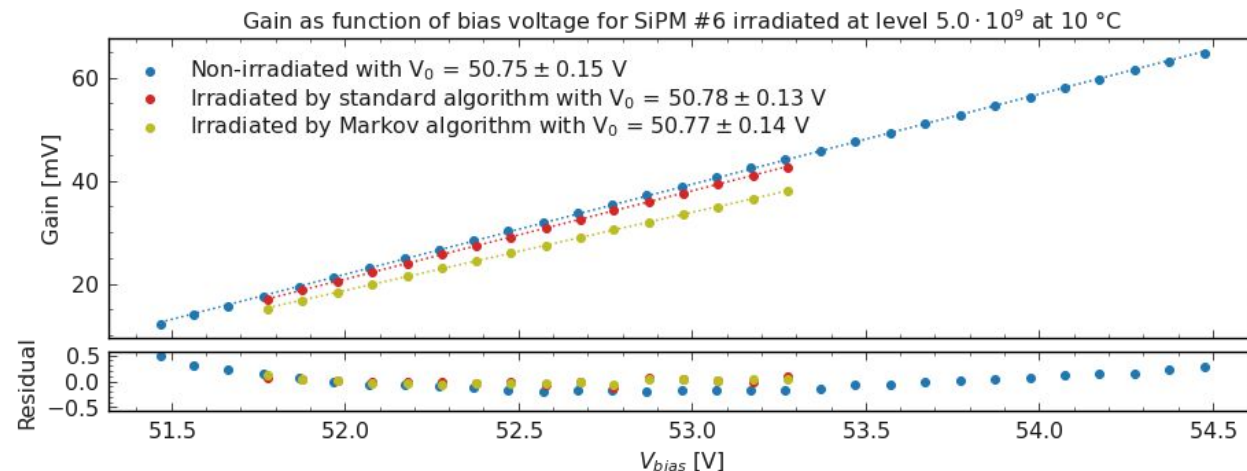
Dark count rate



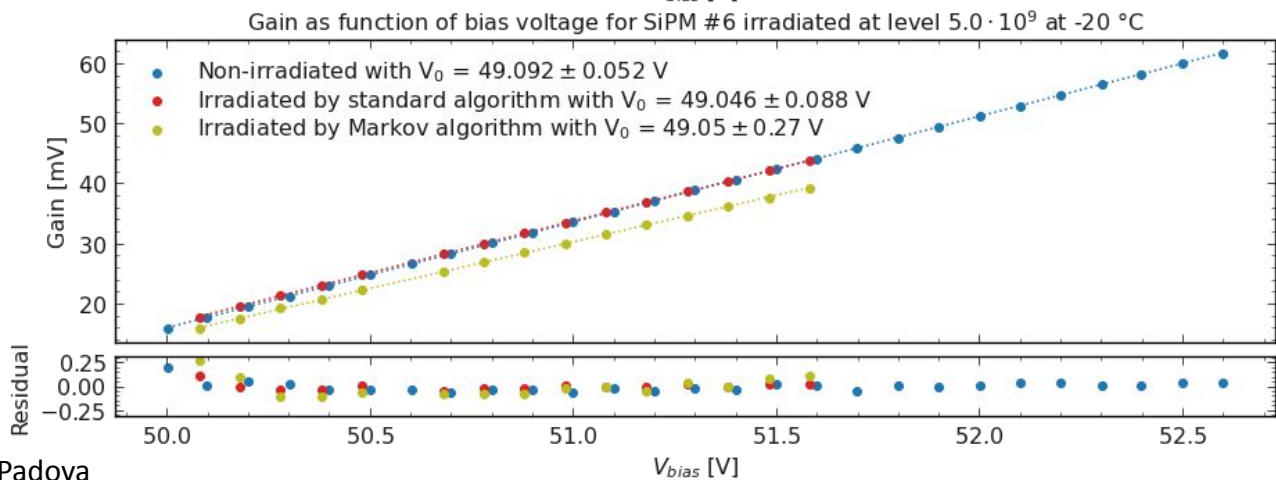
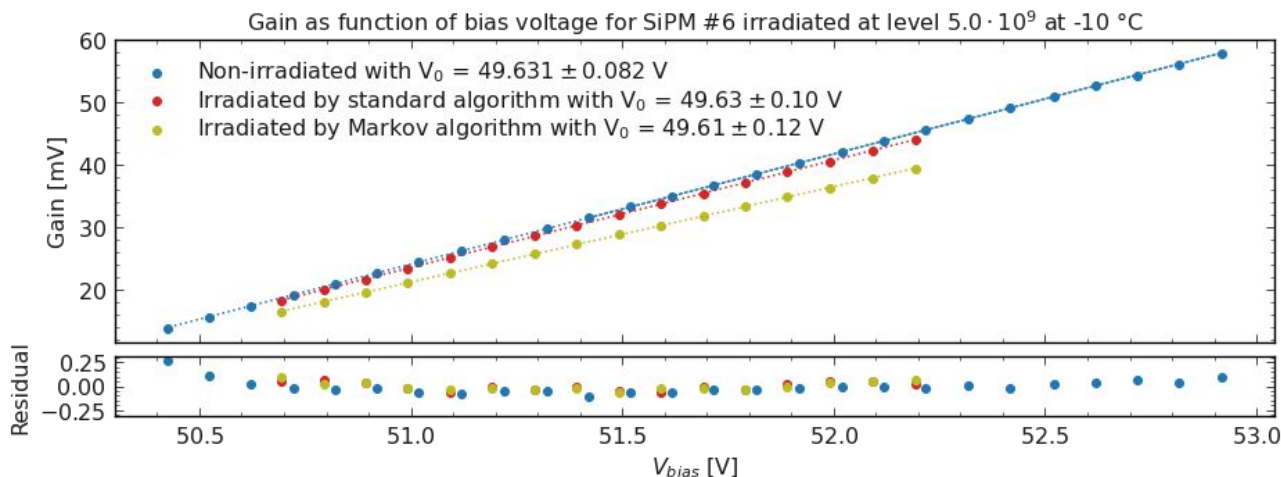
SIMP #6

Gain as function of bias voltage for SiPM #6

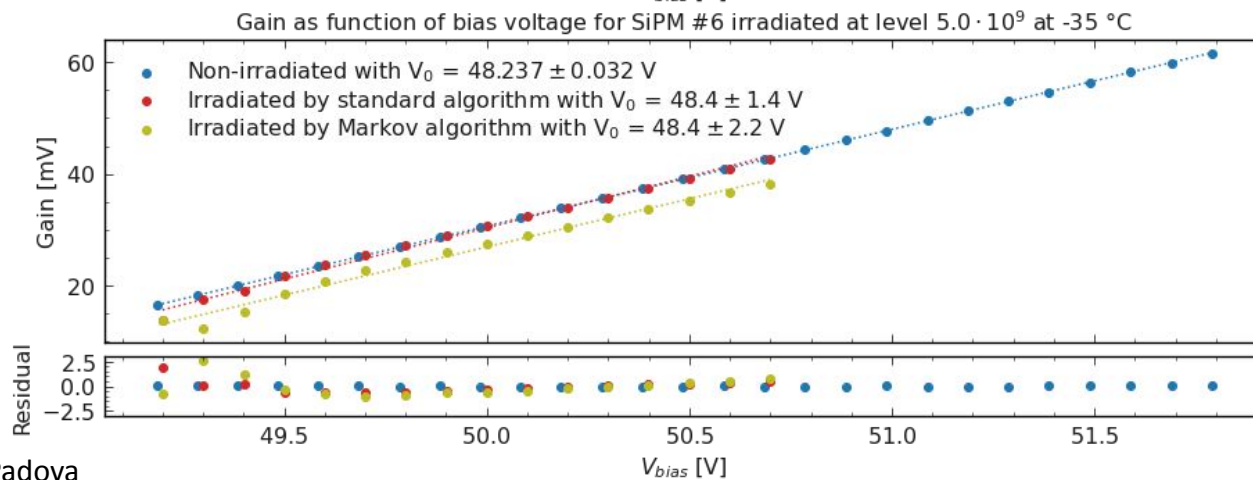
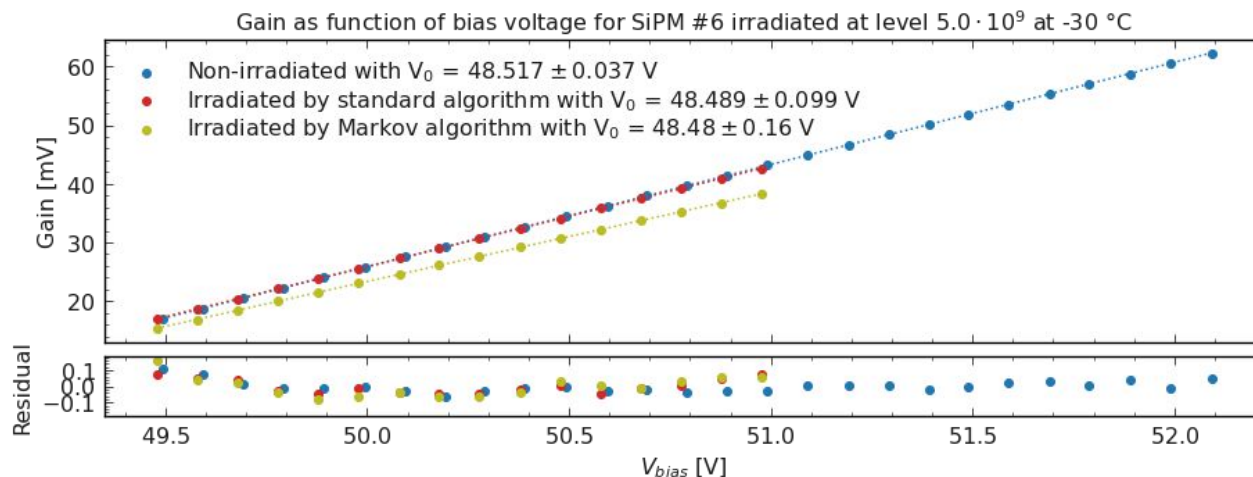
Gain as function of bias voltage



Gain as function of bias voltage

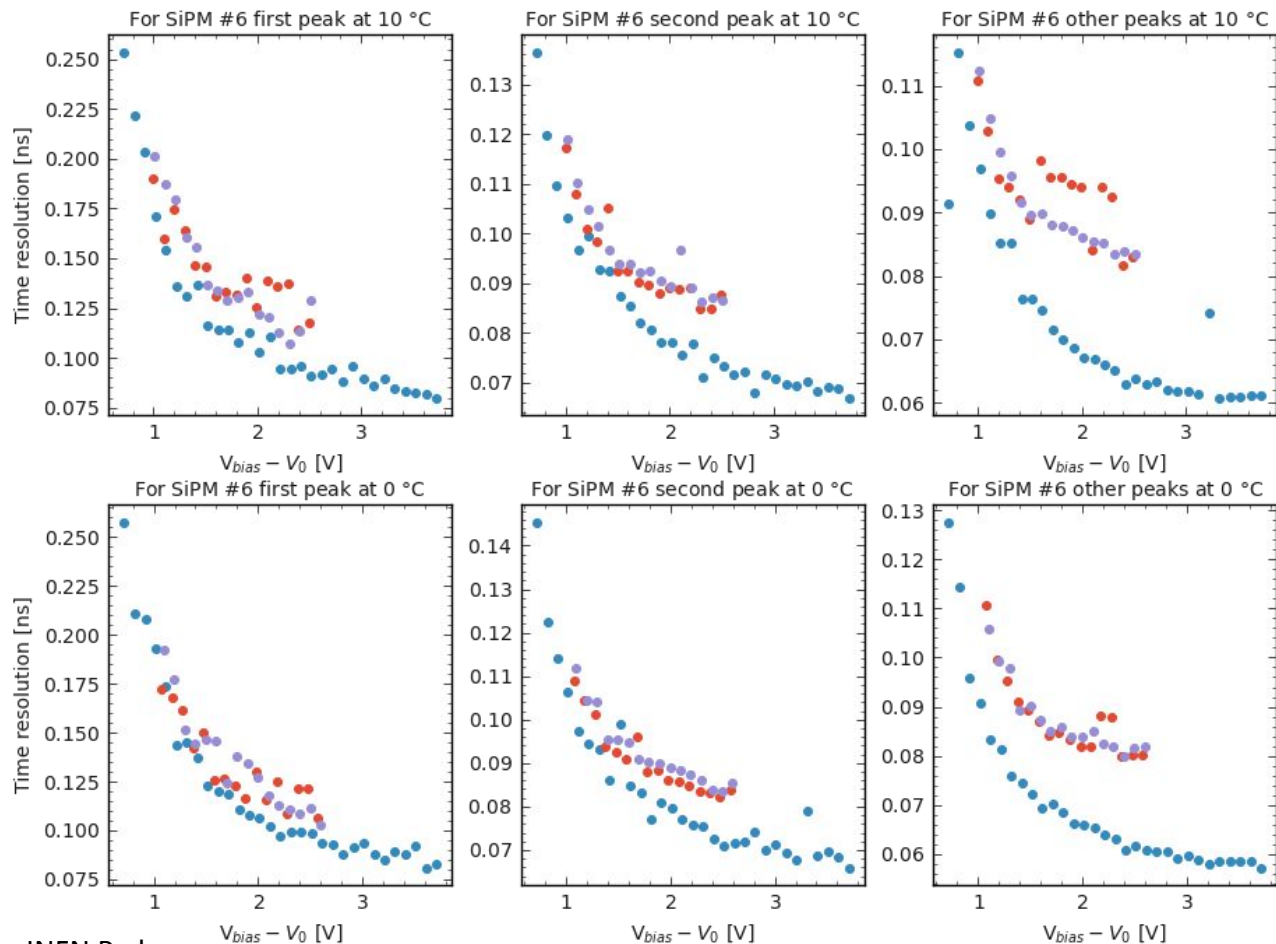


Gain as function of bias voltage

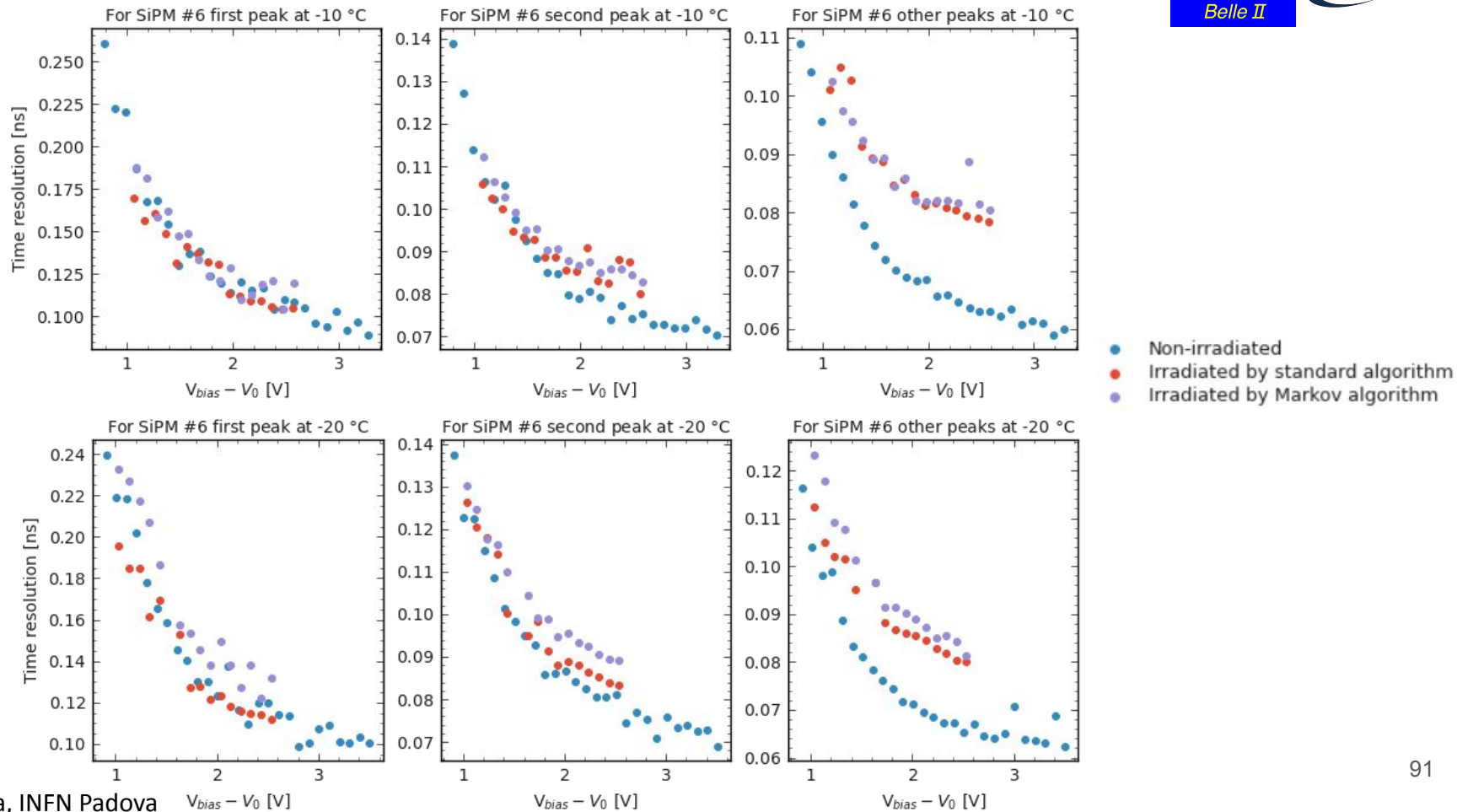


Time resolution for first, second and other photon peaks for SiPM #6

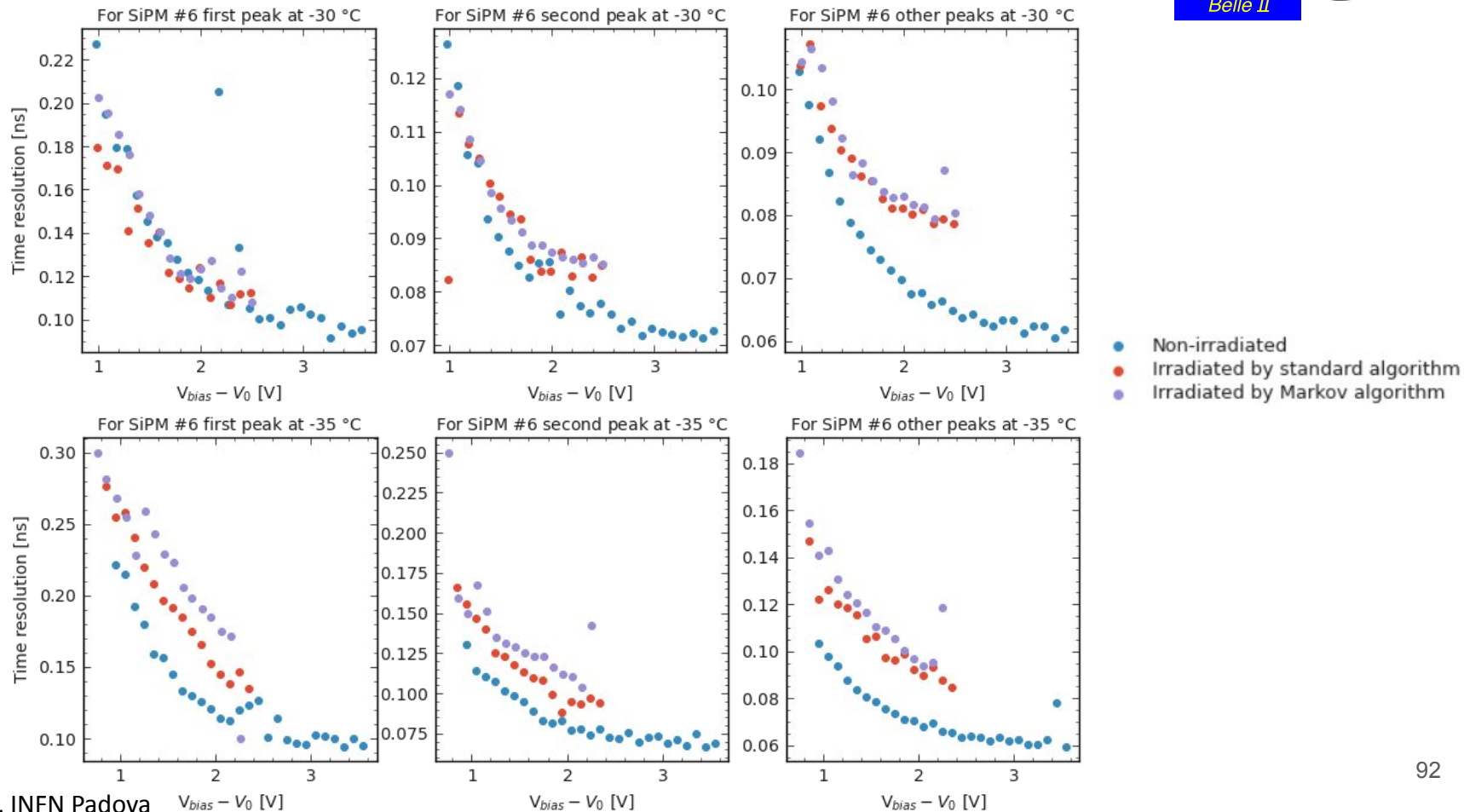
Time resolution



Time resolution

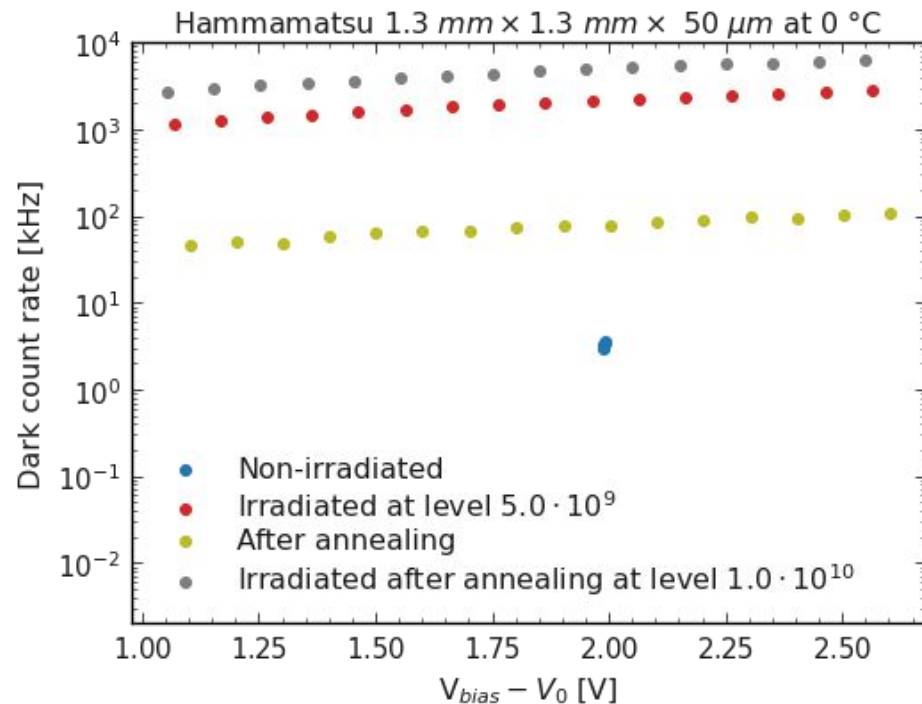
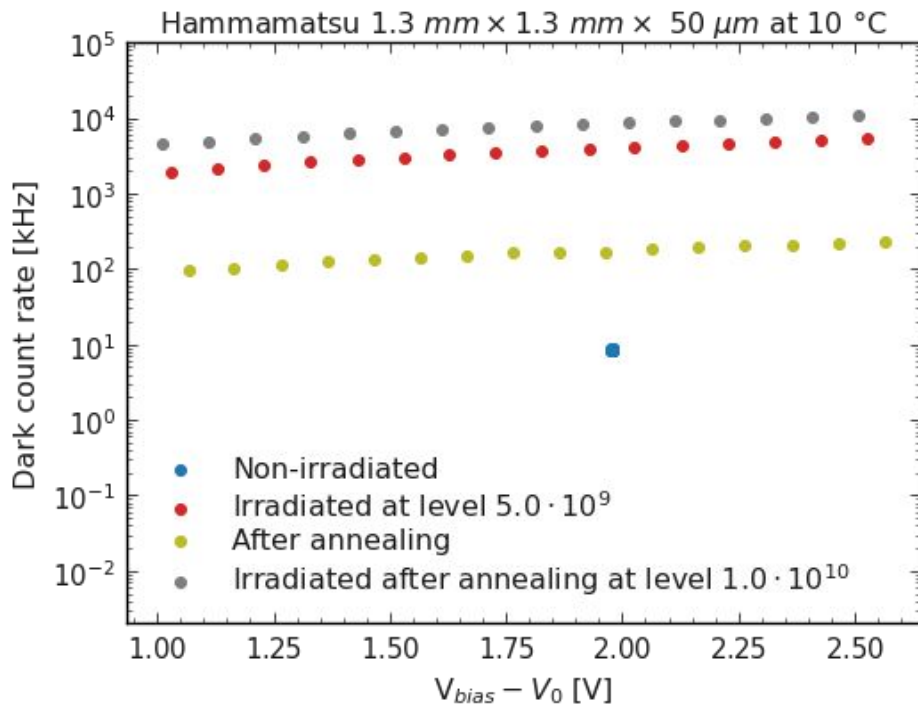


Time resolution

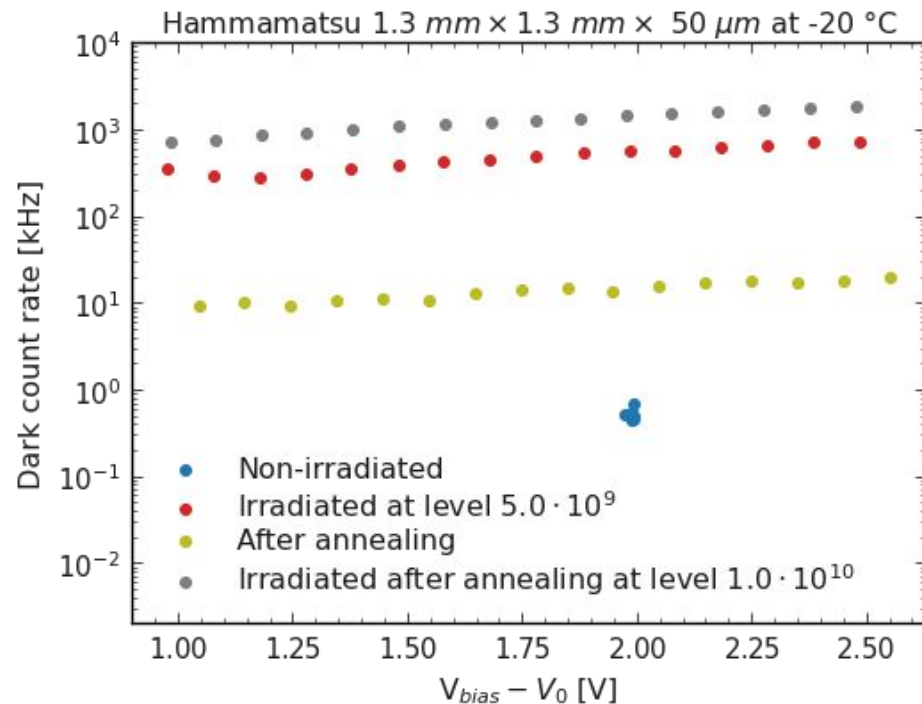
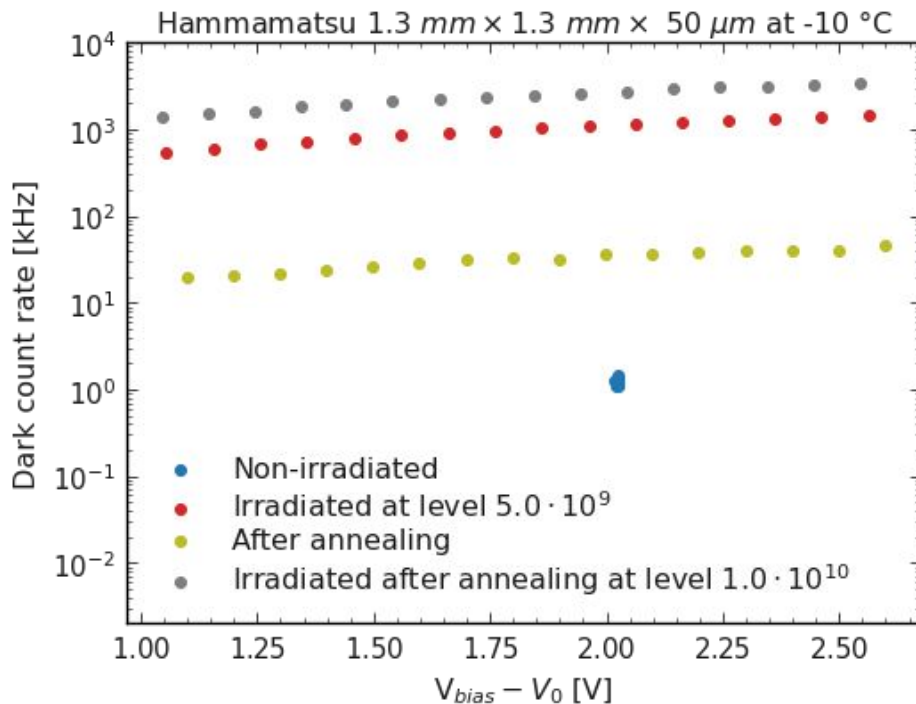


Dark count rate for SiPM #6

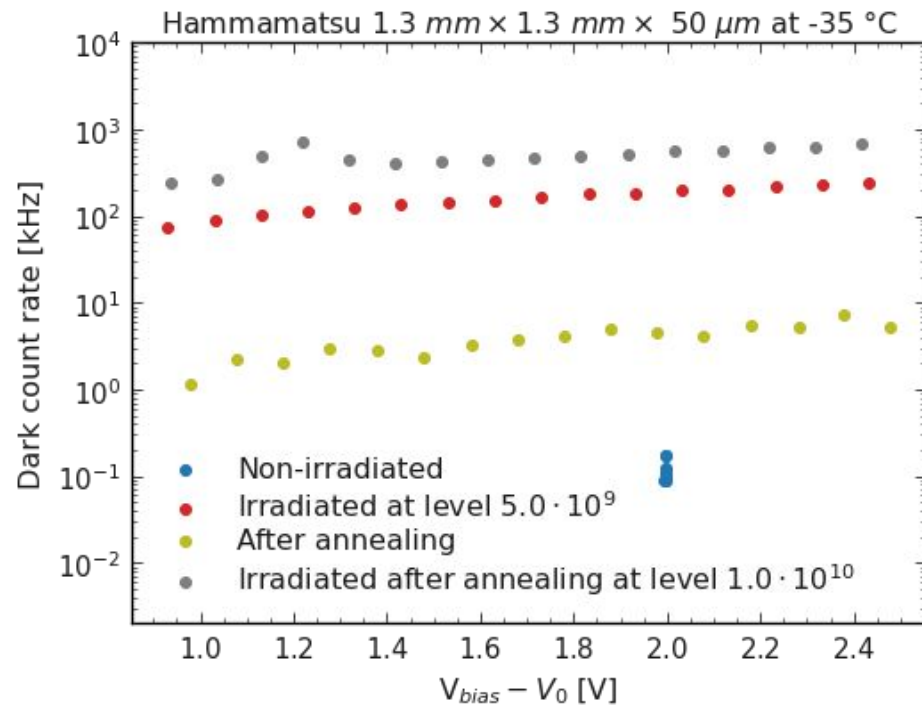
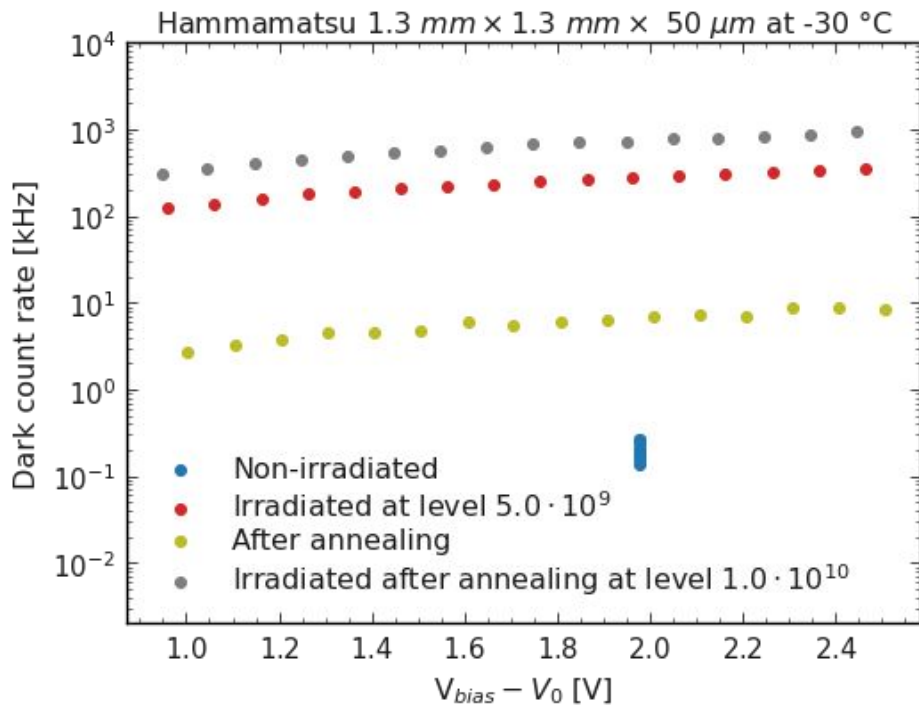
Dark count rate



Dark count rate



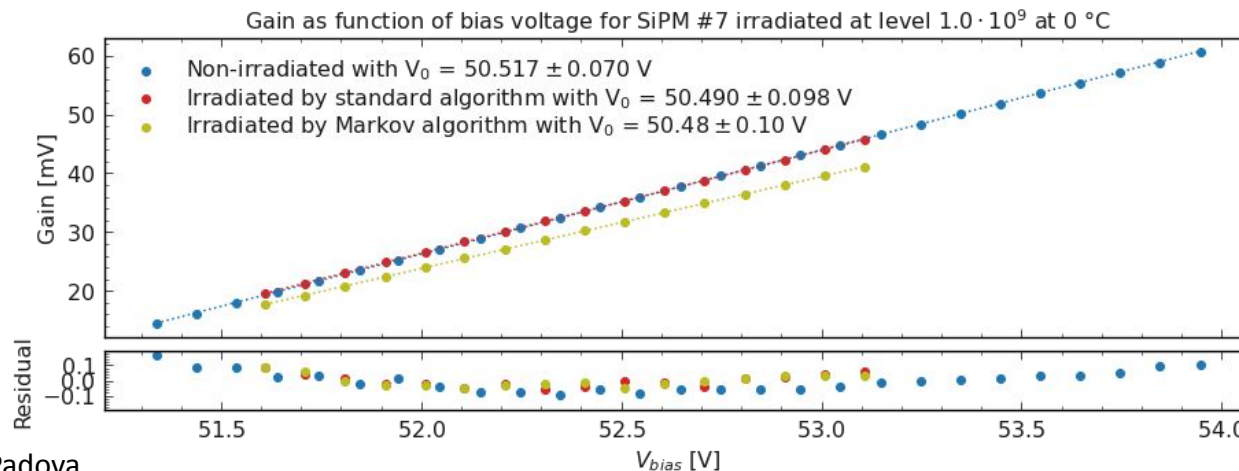
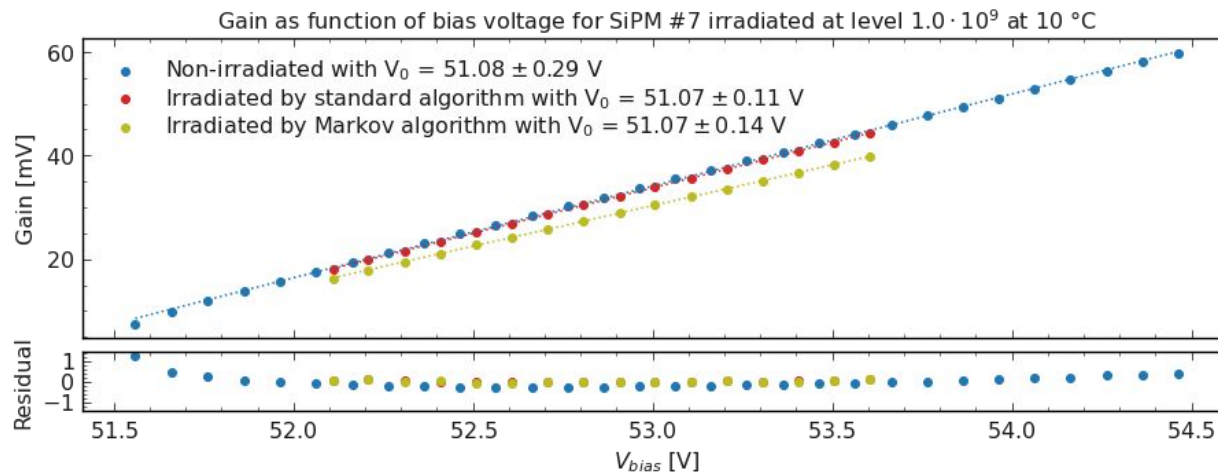
Dark count rate



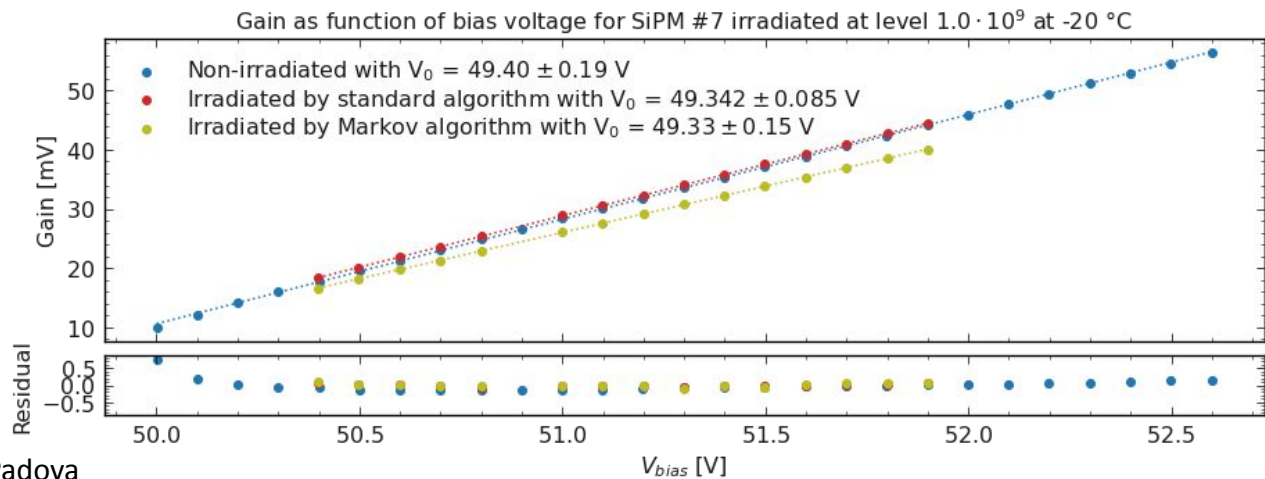
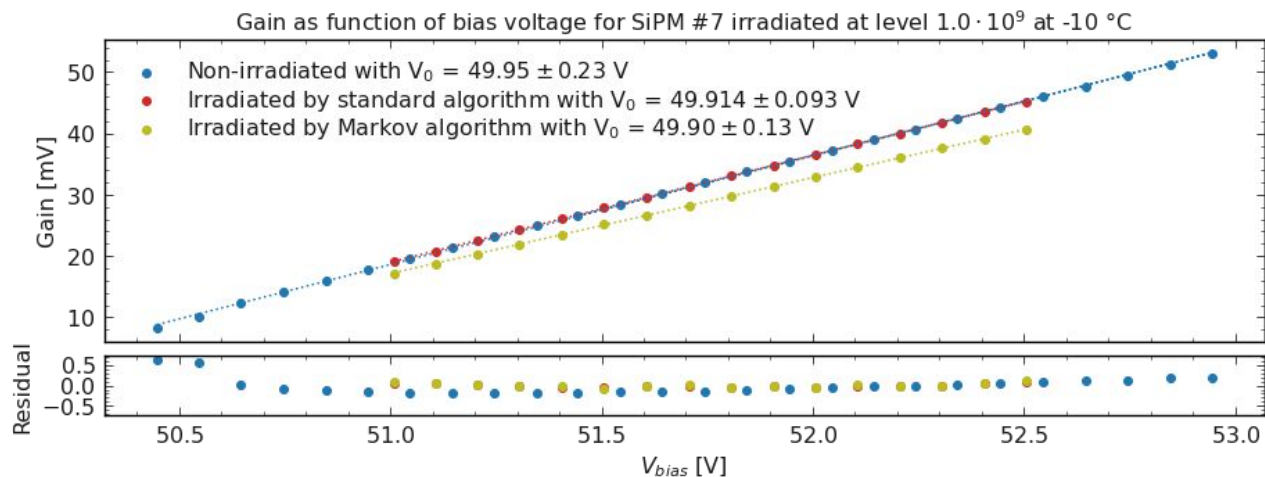
SIMP #7

Gain as function of bias voltage for SiPM #7

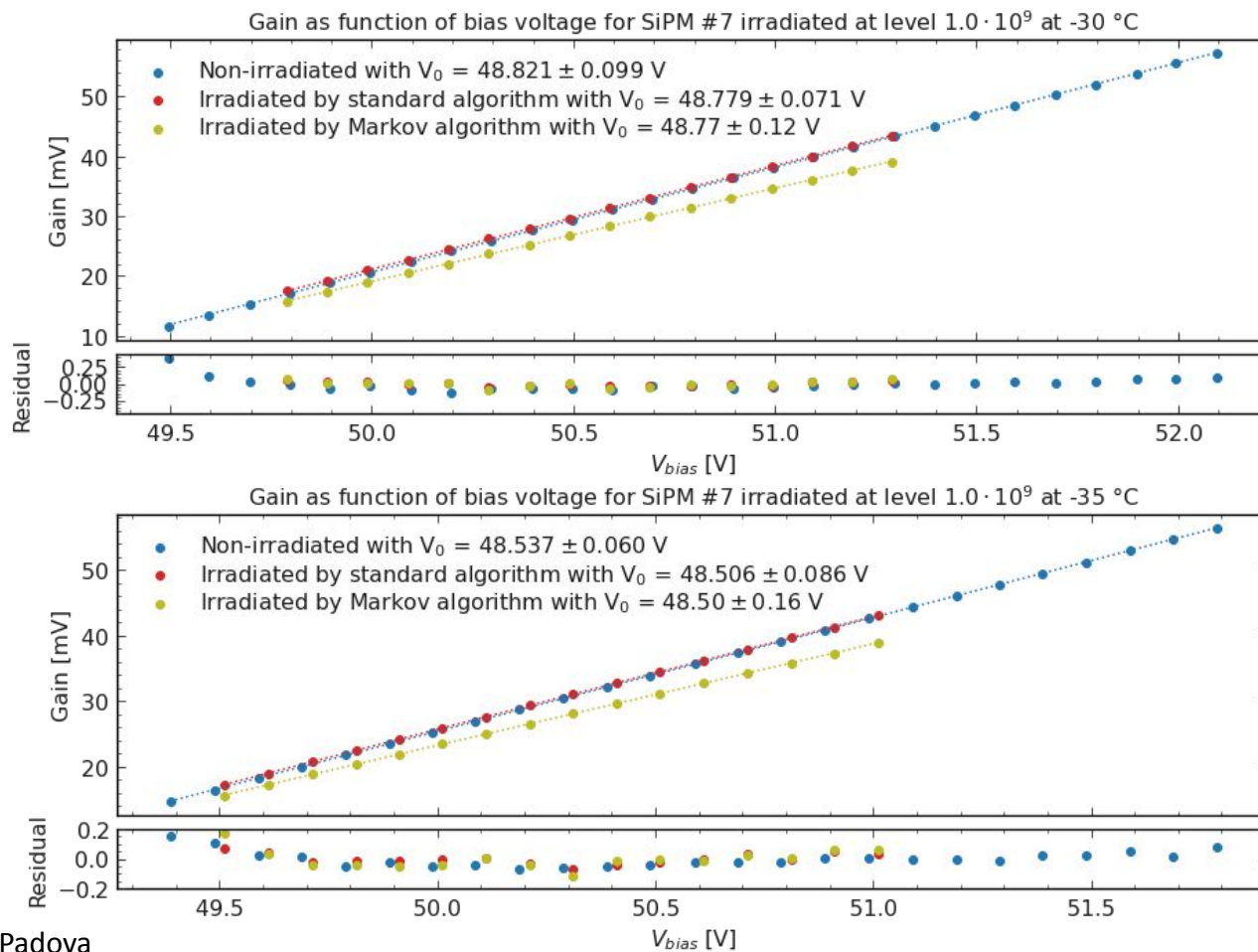
Gain as function of bias voltage



Gain as function of bias voltage

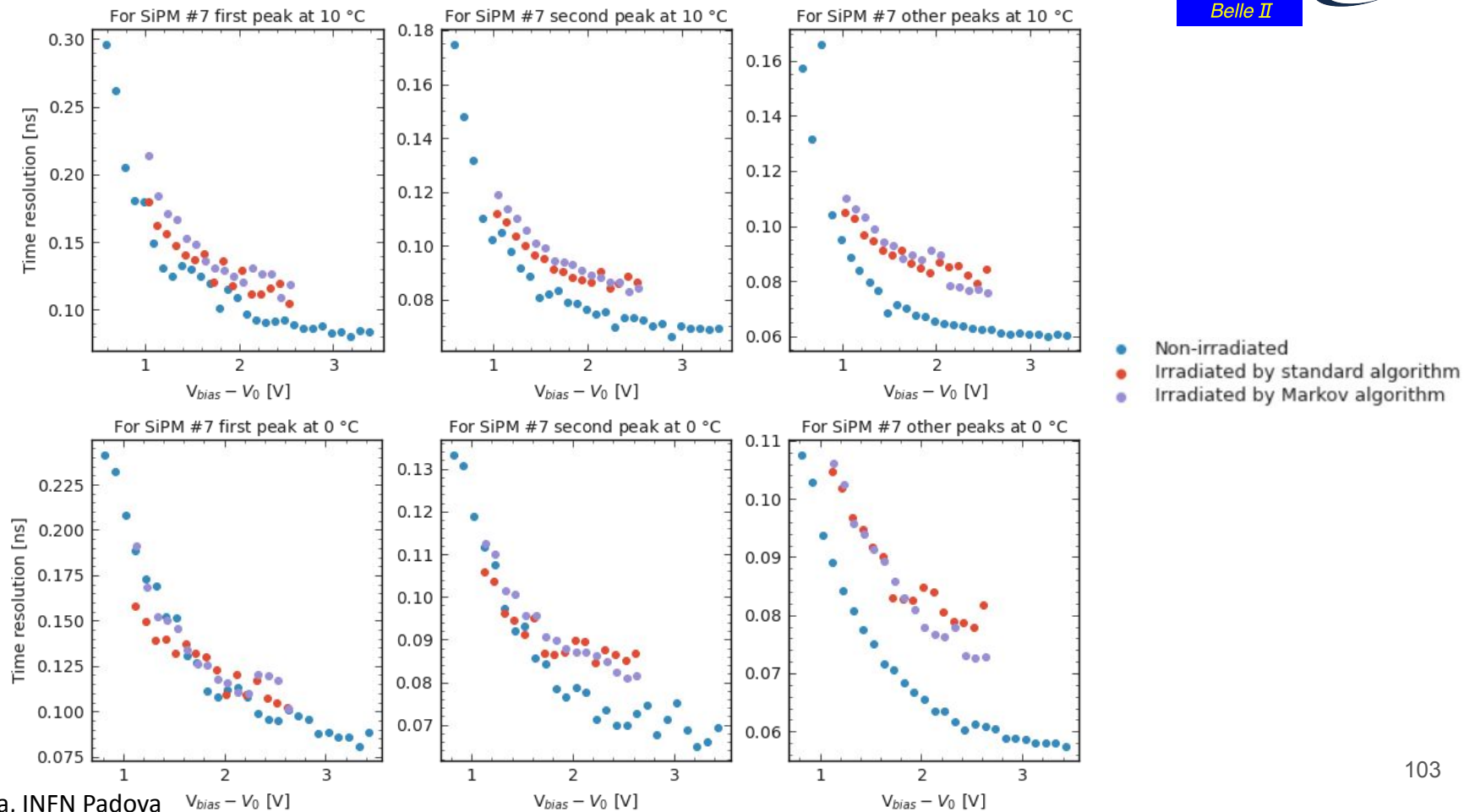


Gain as function of bias voltage

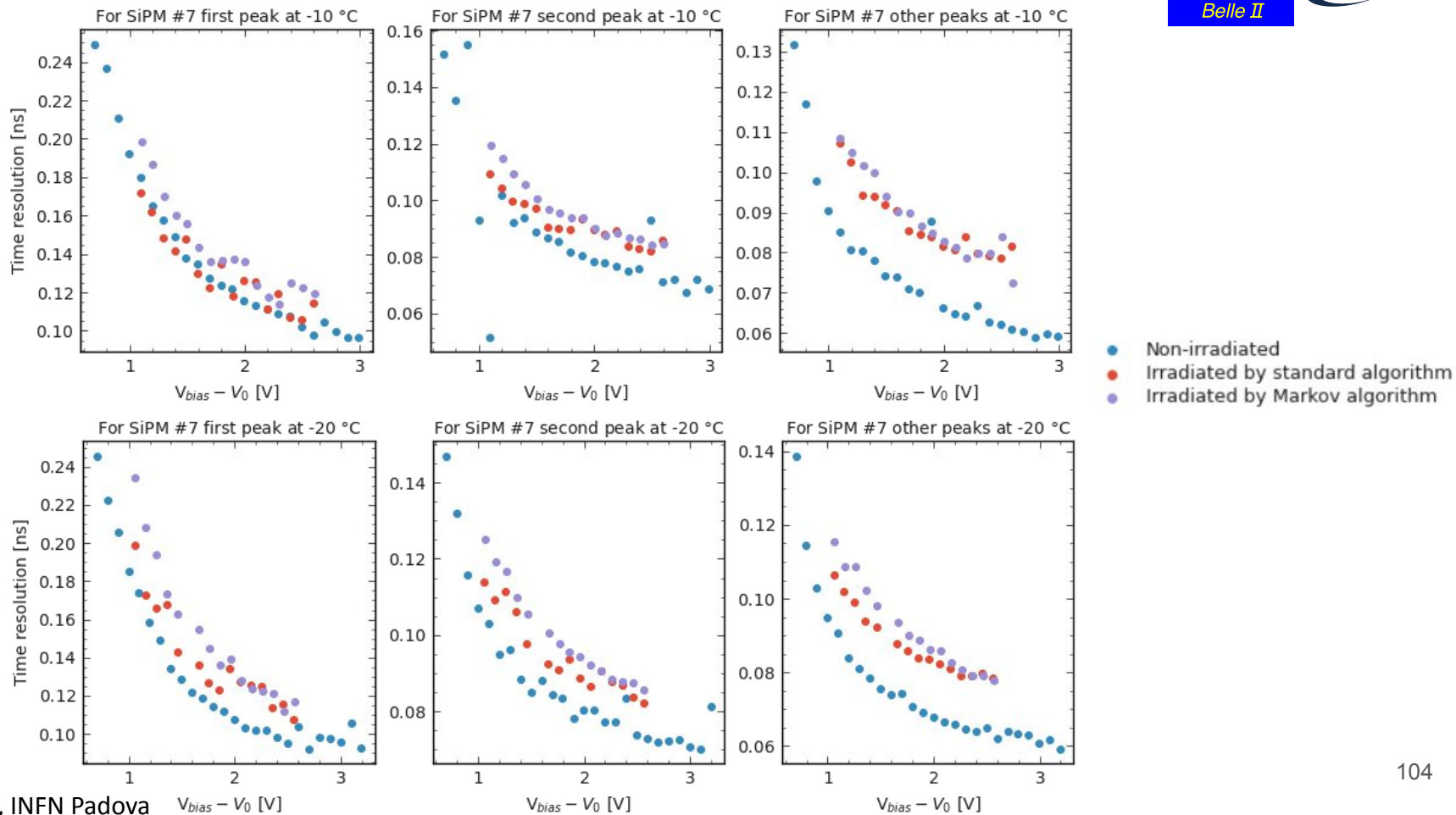


Time resolution for first, second and other photon peaks for SiPM #7

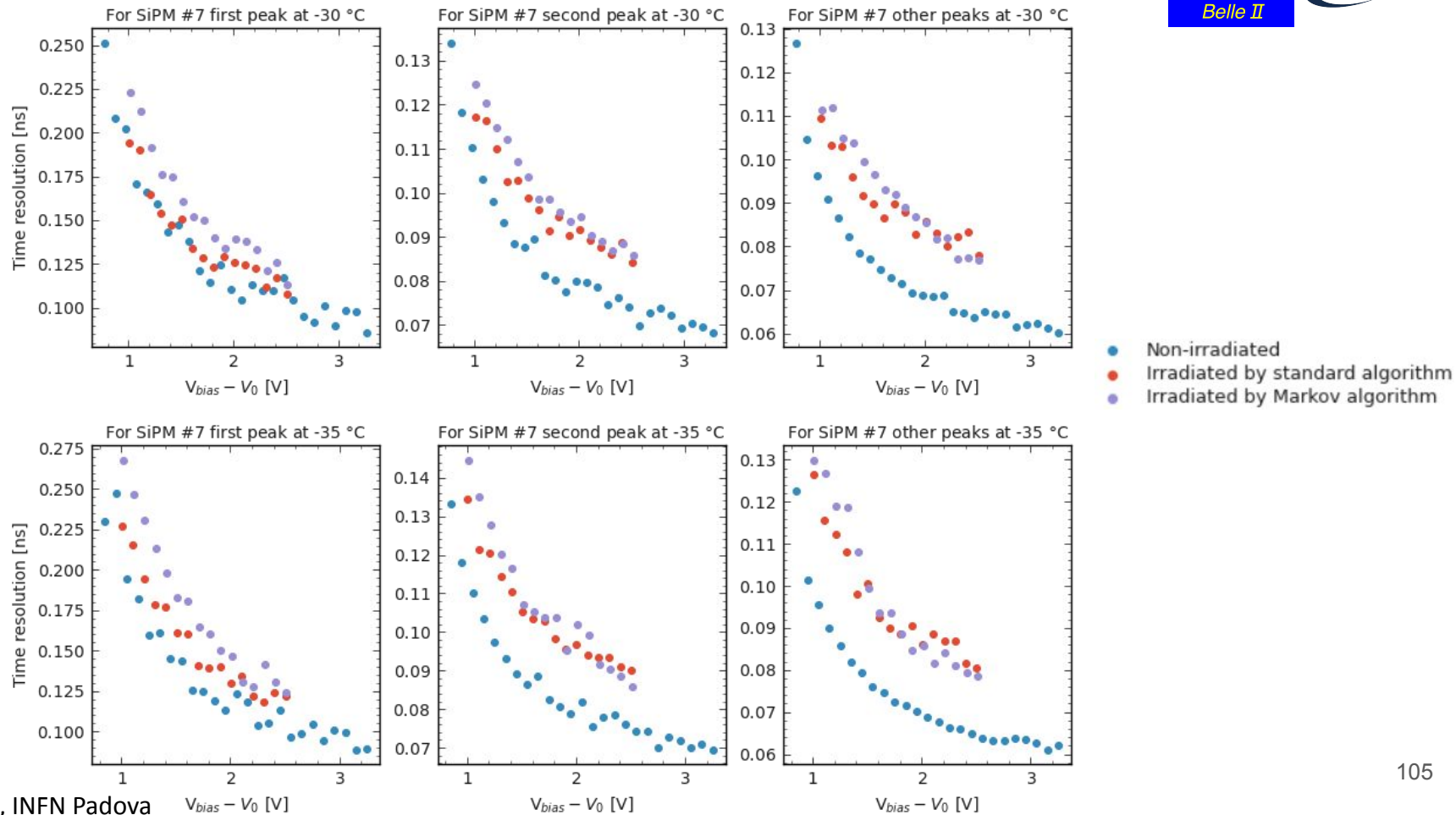
Time resolution



Time resolution

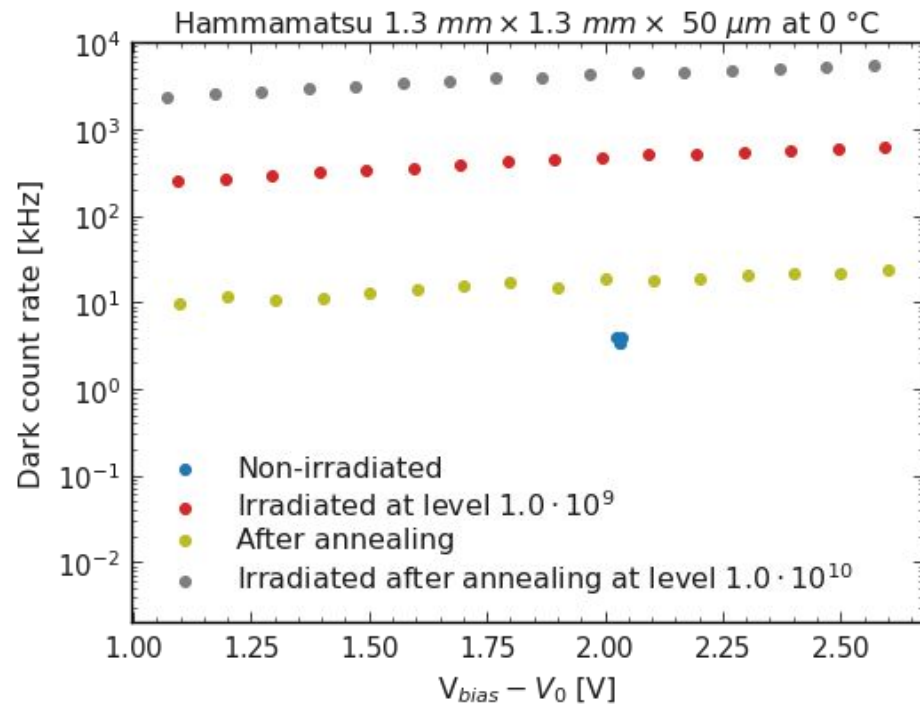
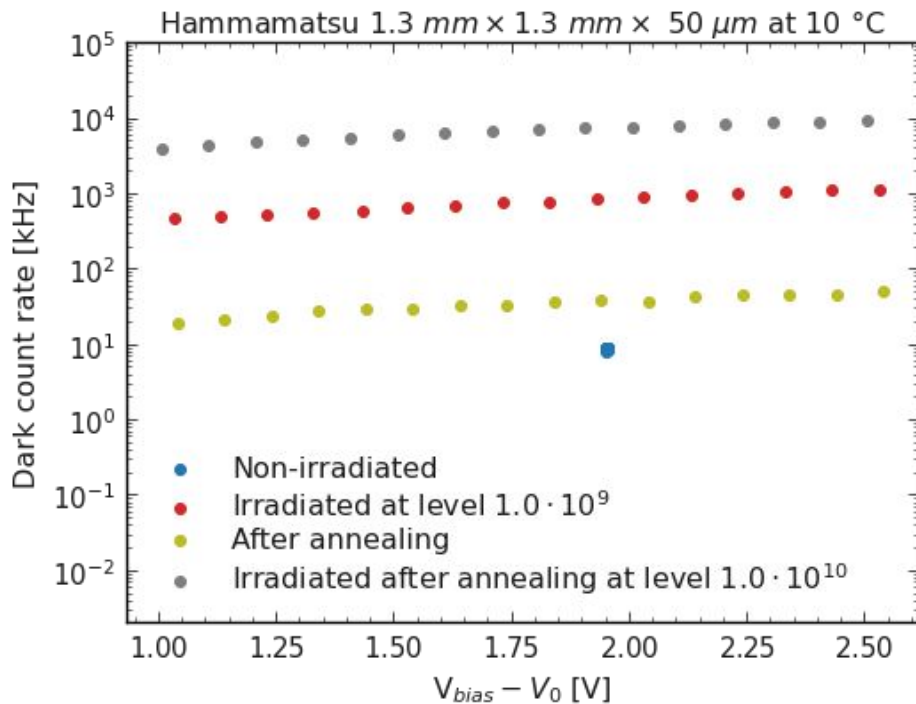


Time resolution

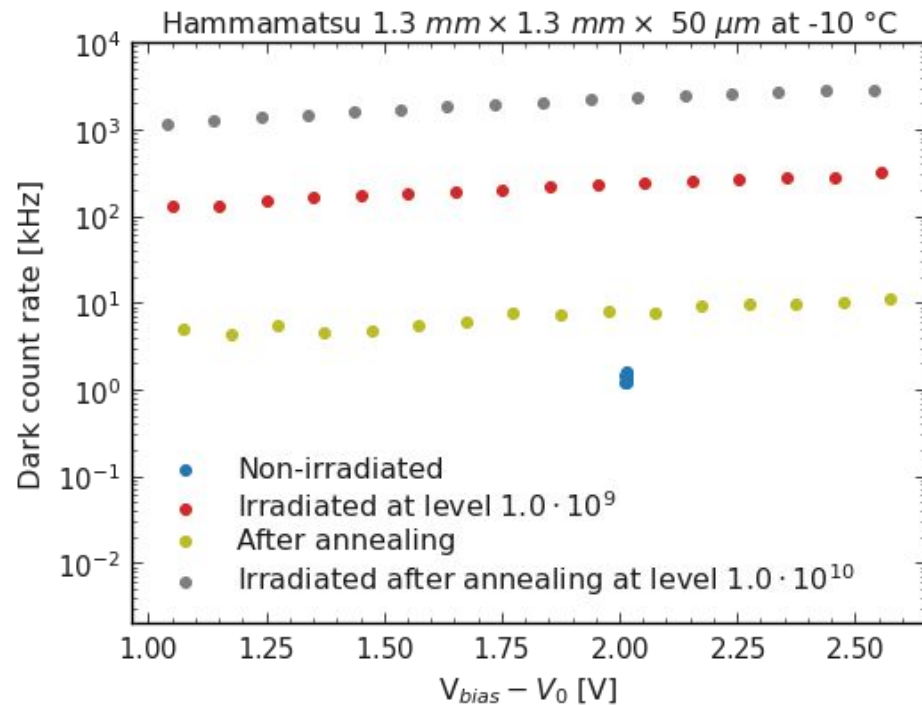
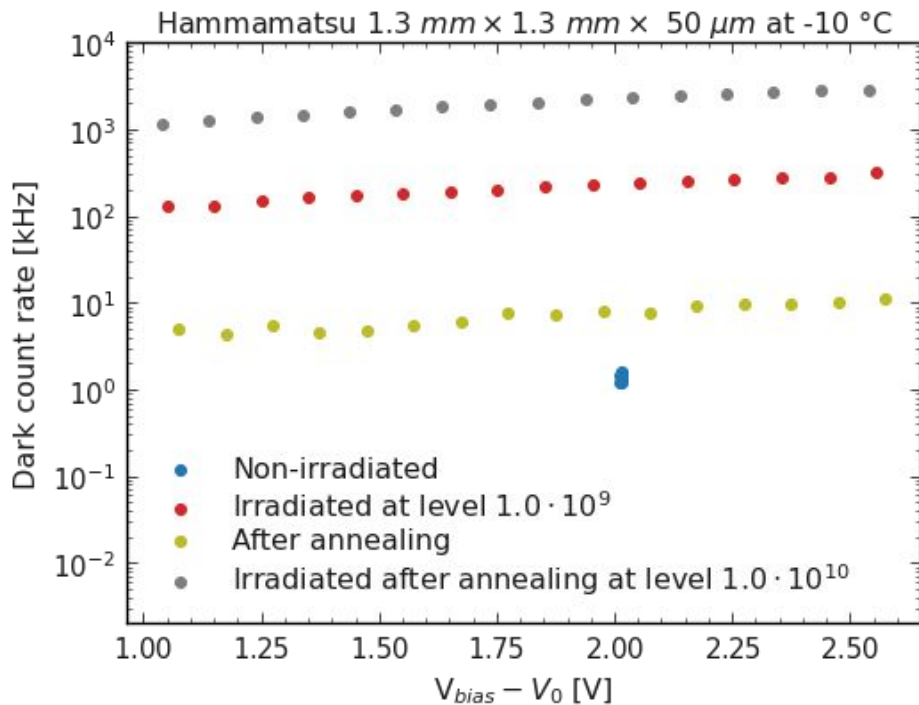


Dark count rate for SiPM #7

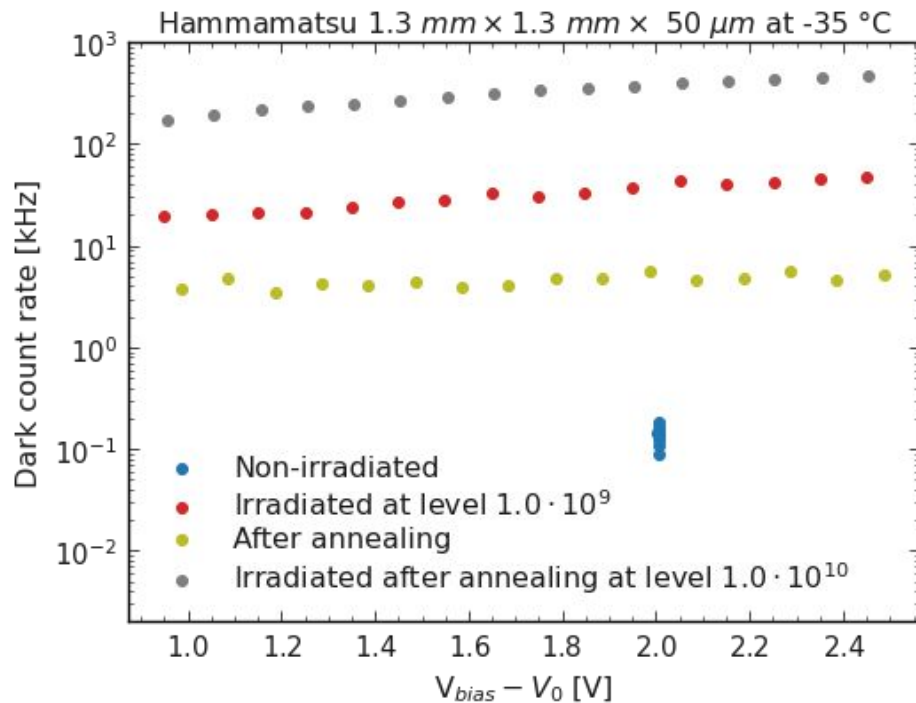
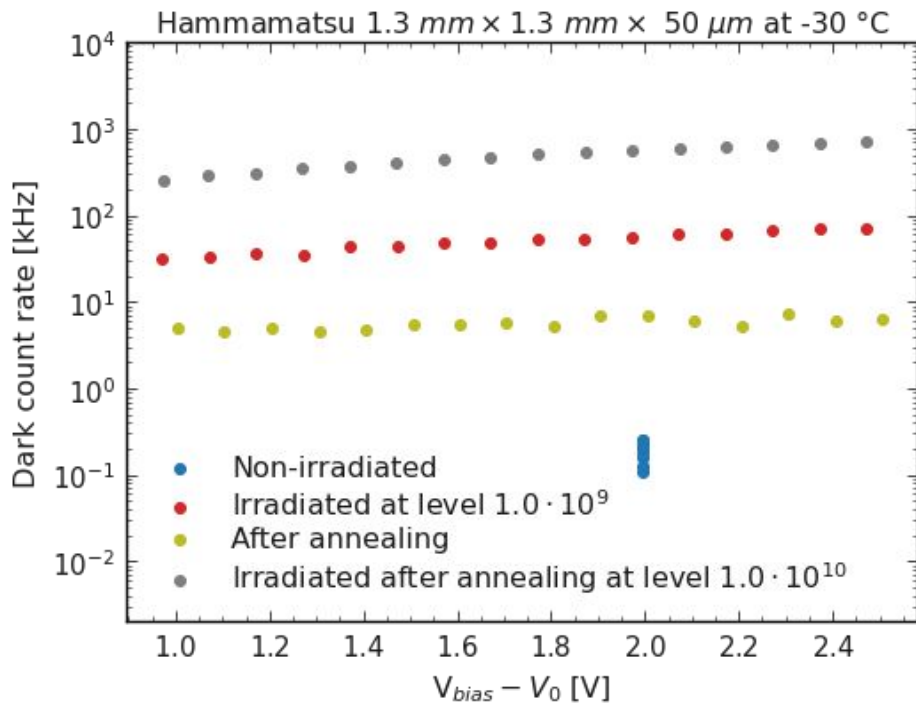
Dark count rate



Dark count rate



Dark count rate



Backup