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Numerical study on the gain variation due to the gas-gap non-uniformity in large scale Micromegas production

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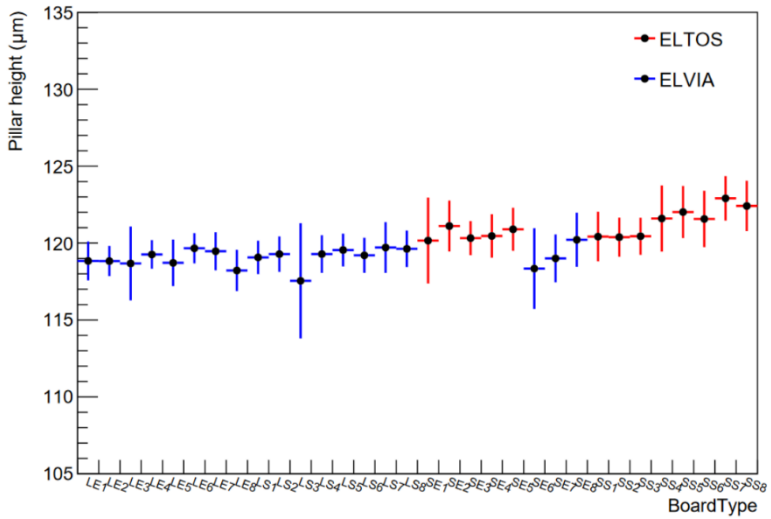
WHY GAS-GAP NON-UNIFORMITY?

- Production tolerances lead to a distribution of pillar heights and therefore gap size
- This distribution can have both systematic and statistical contributions
- The distribution has been measured, for example for ATLAS Micromegas (but this holds for all detectors):

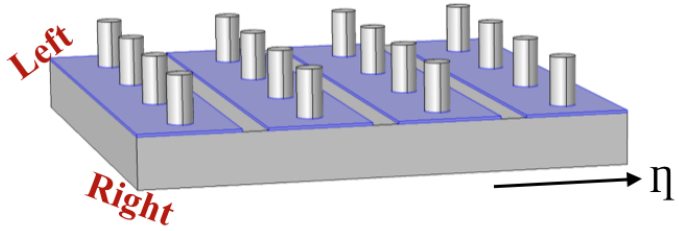


From: L.Longo – Production and test of Micromegas boards (ICHEP2020)

Different Types of non-uniformity

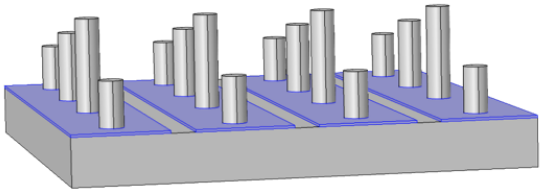
In Experiment

The case is ideal when the pillar height is uniform through out the strip and on all the strips

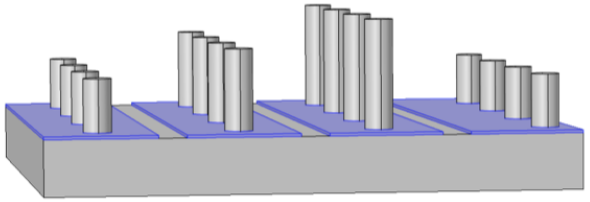


geometries are for illustration purpose only. dimensions and ratios are not respected.

Two possible scenarios of non-uniform pillar heights



- non-uniformity along a strip (left to right).
- The signal from each strip should be already convoluted depending upon the distribution of the non-uniformity.
- Strip by strip signal might not look too different.

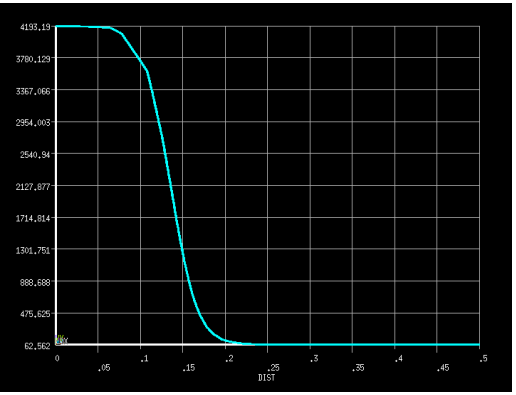


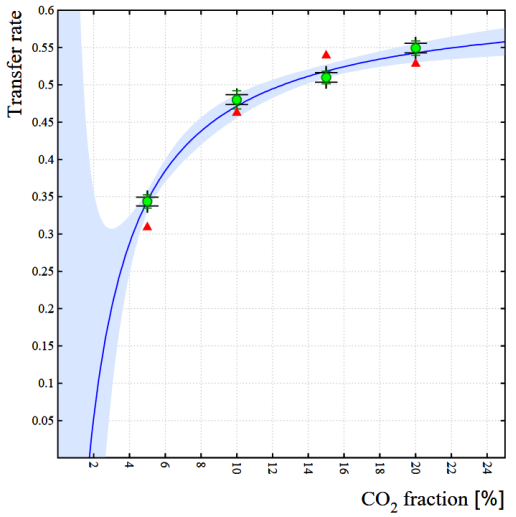
- non-uniformity in a PCB, changing from bottom to top (along η). But uniform along a strip.
- Strip by strip signal might look different.

- **Finally, a more practical situation is a mixture of both the above cases.**

(considering only perpendicular tracks to probe)

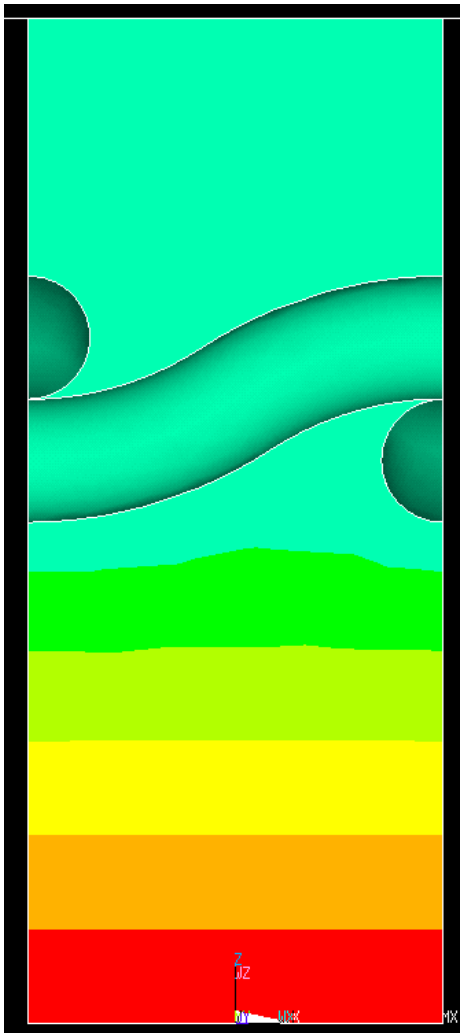
GARFIELD++ SIMULATION





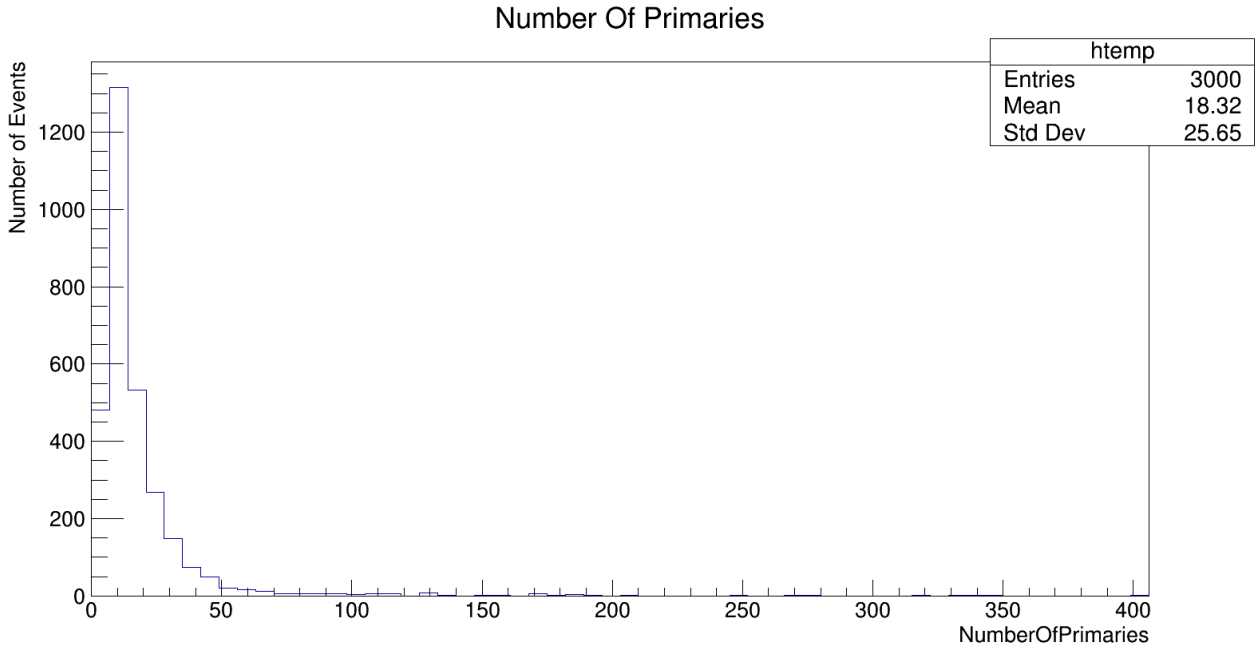
From: Ö. Sahin – Penning Transfer in Argon based Gas Mixtures

- ANSYS field map of a micromegas detector with a full mesh and a copper anode
- 93:7 Ar:CO_2 with full Penning simulation (0.42 transfer rate)
- V_C= -300V and V_A= 570V with grounded mesh, 118, 120, 122, 124, 126, 128 µm

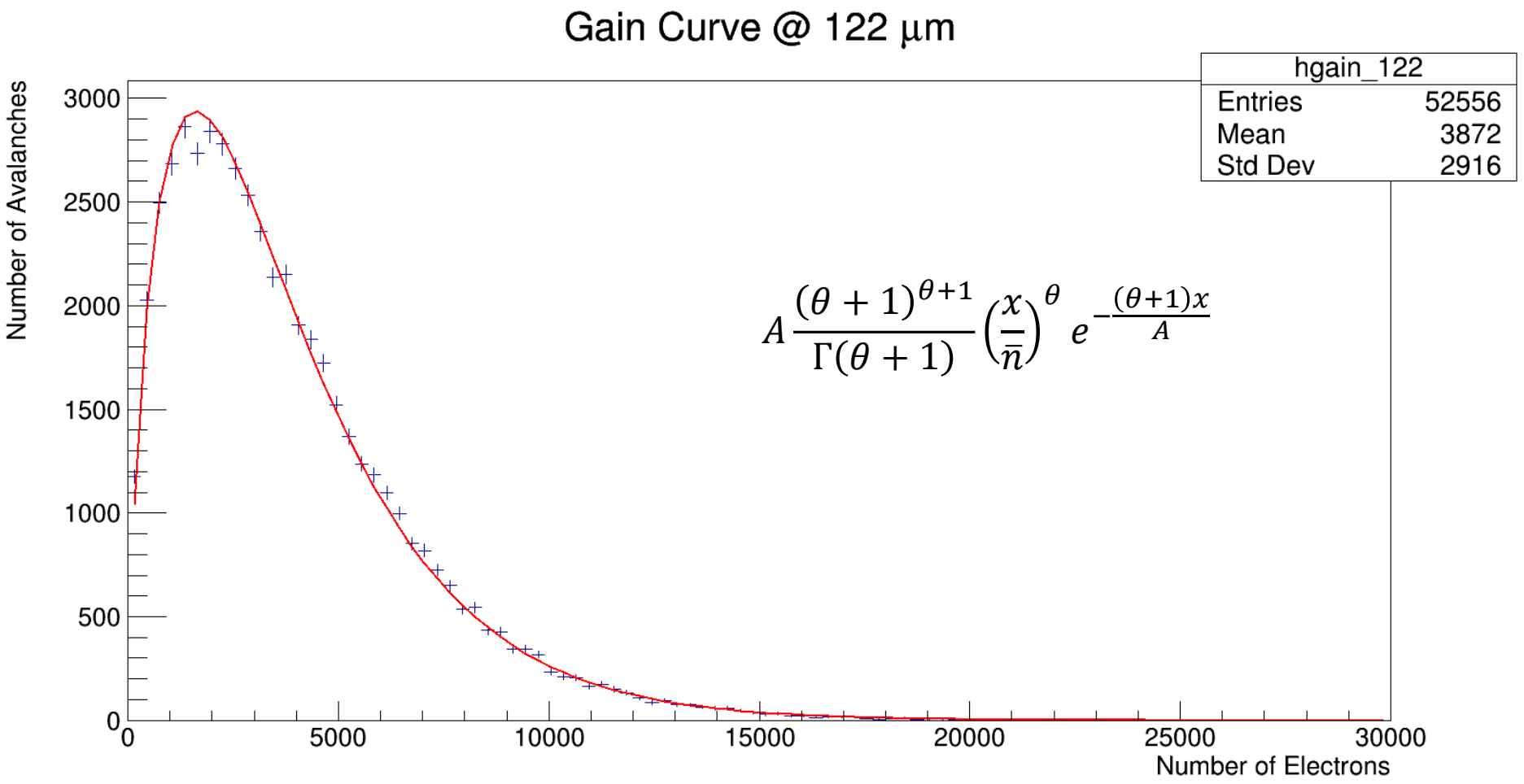


GARFIELD++ SIMULATION (CONT.)

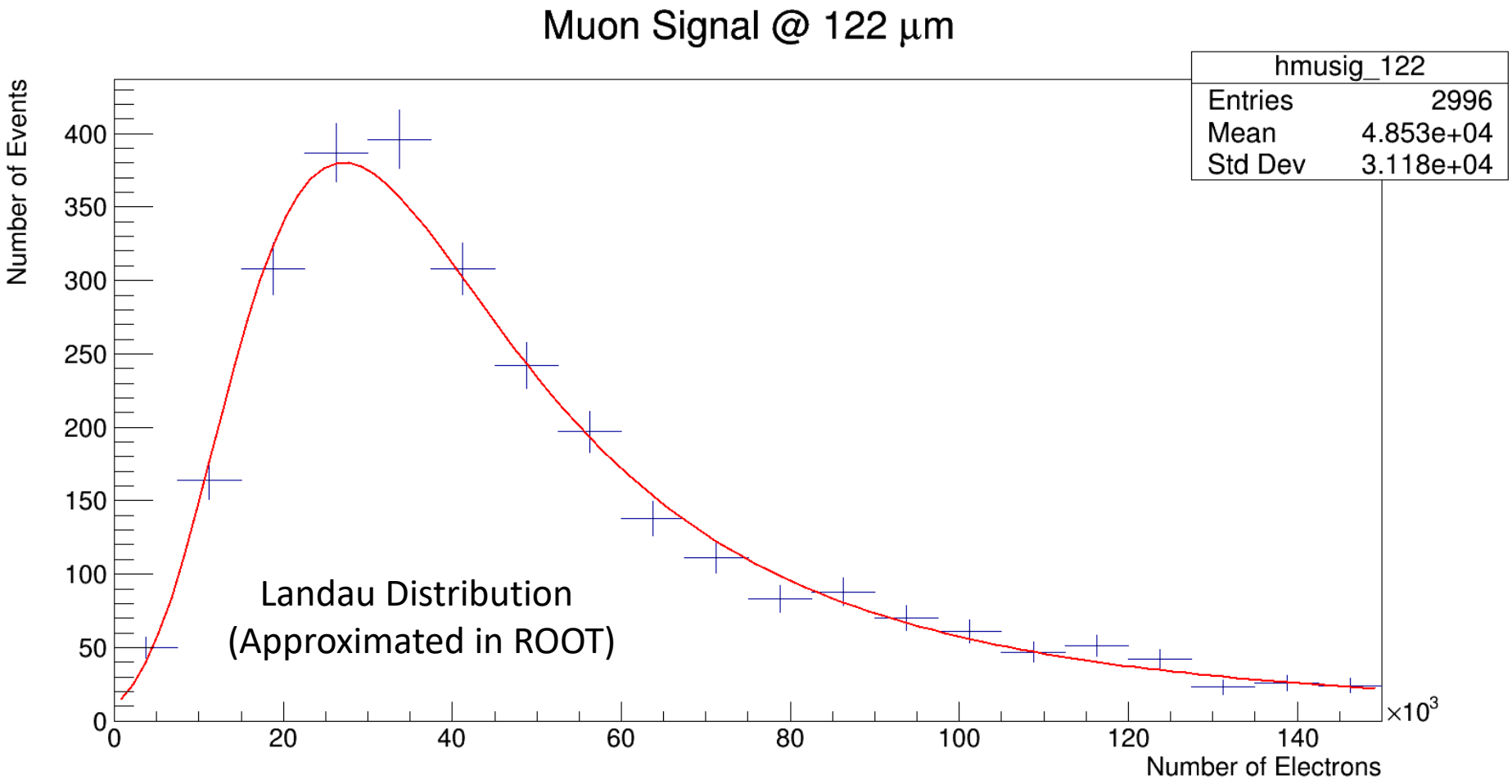
- For each event, one muon is injected into the detector
- This then ionises the argon in the gas in different clusters of electrons which are then tracked individually
- Both the amount of electrons on the anode and the induced signal (calculated using weighting fields) are obtained



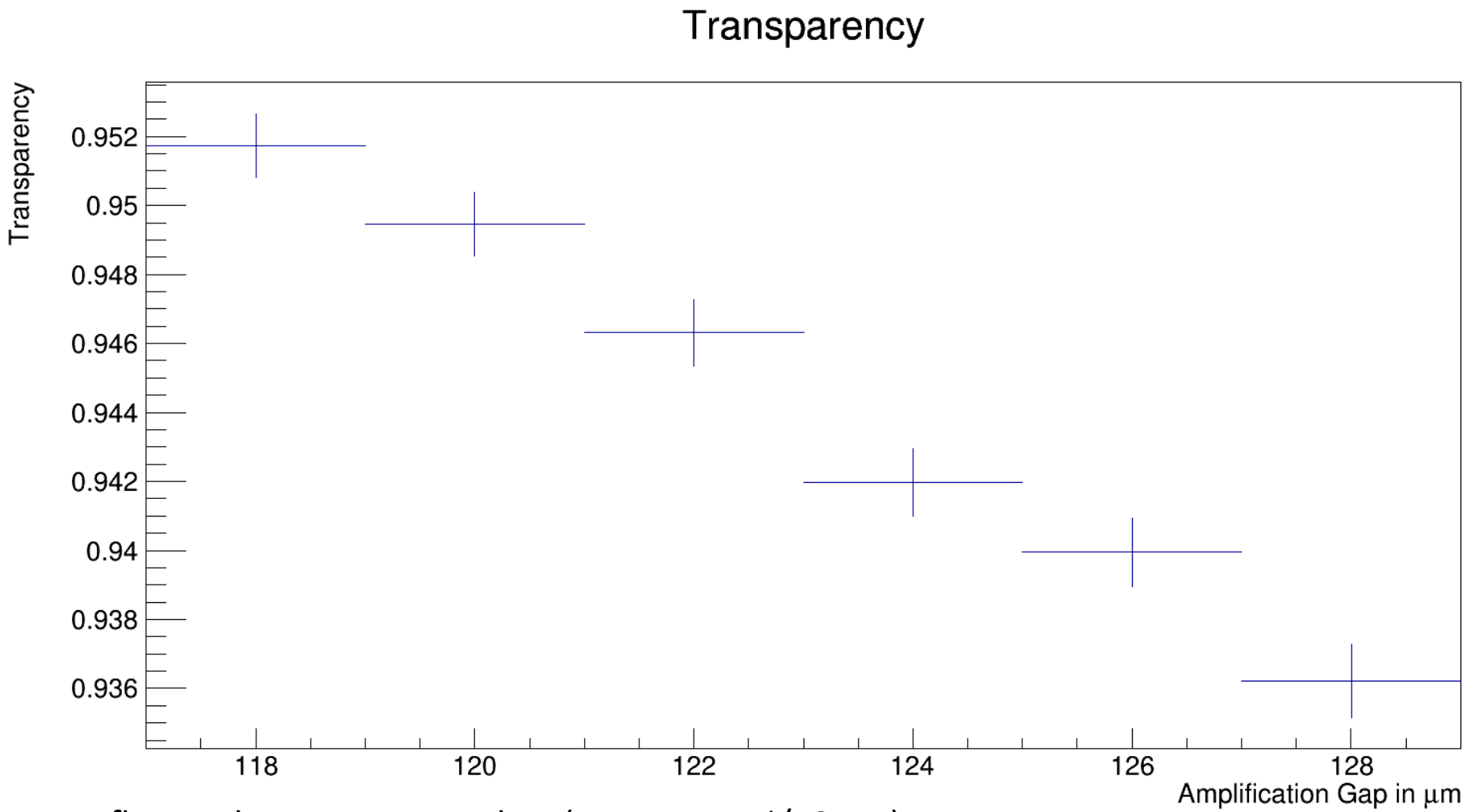
GAIN CURVE (I.E. GAIN PER ELECTRON)



Electrons on the Anode

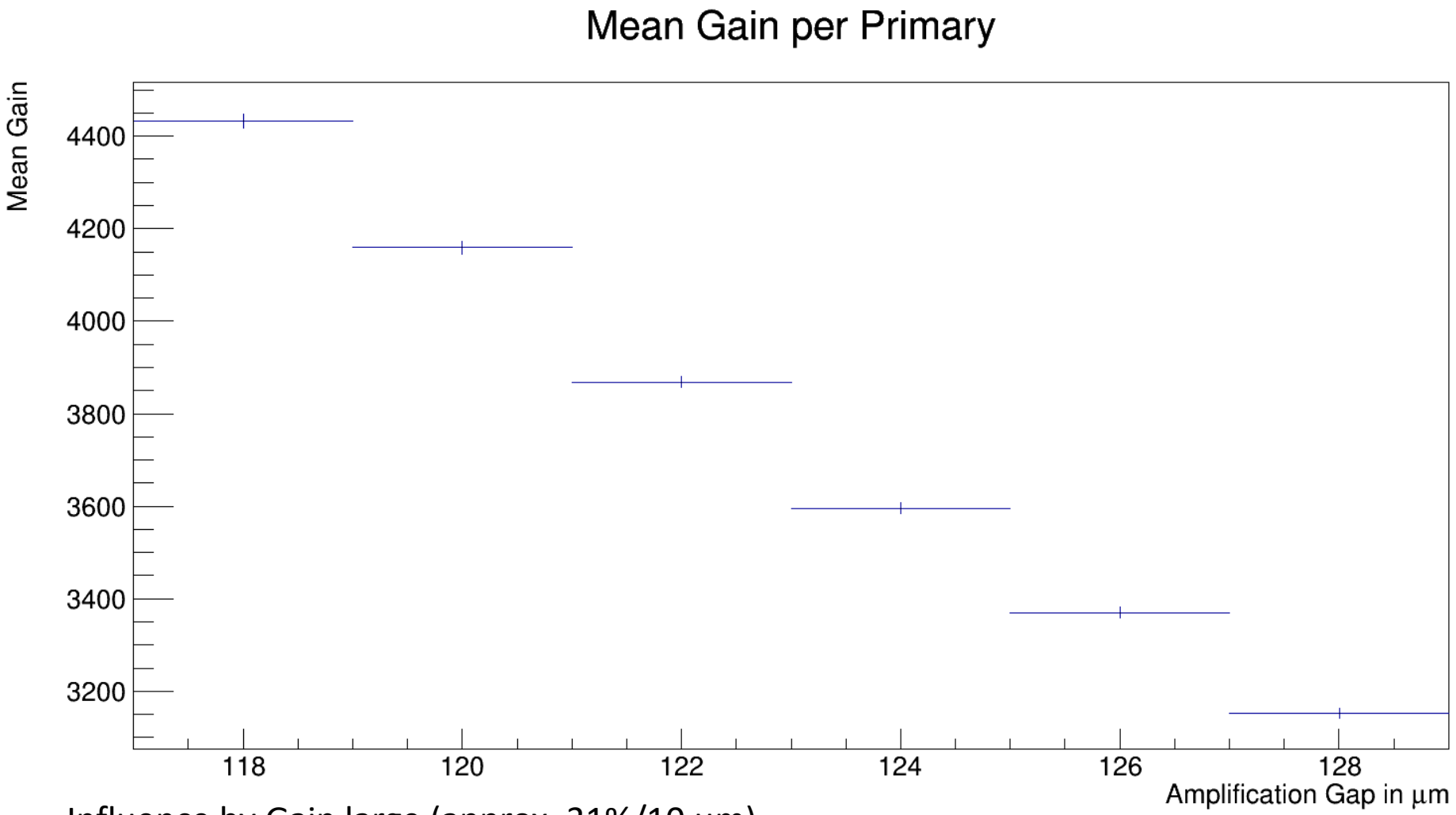


Transparency vs Gap Size



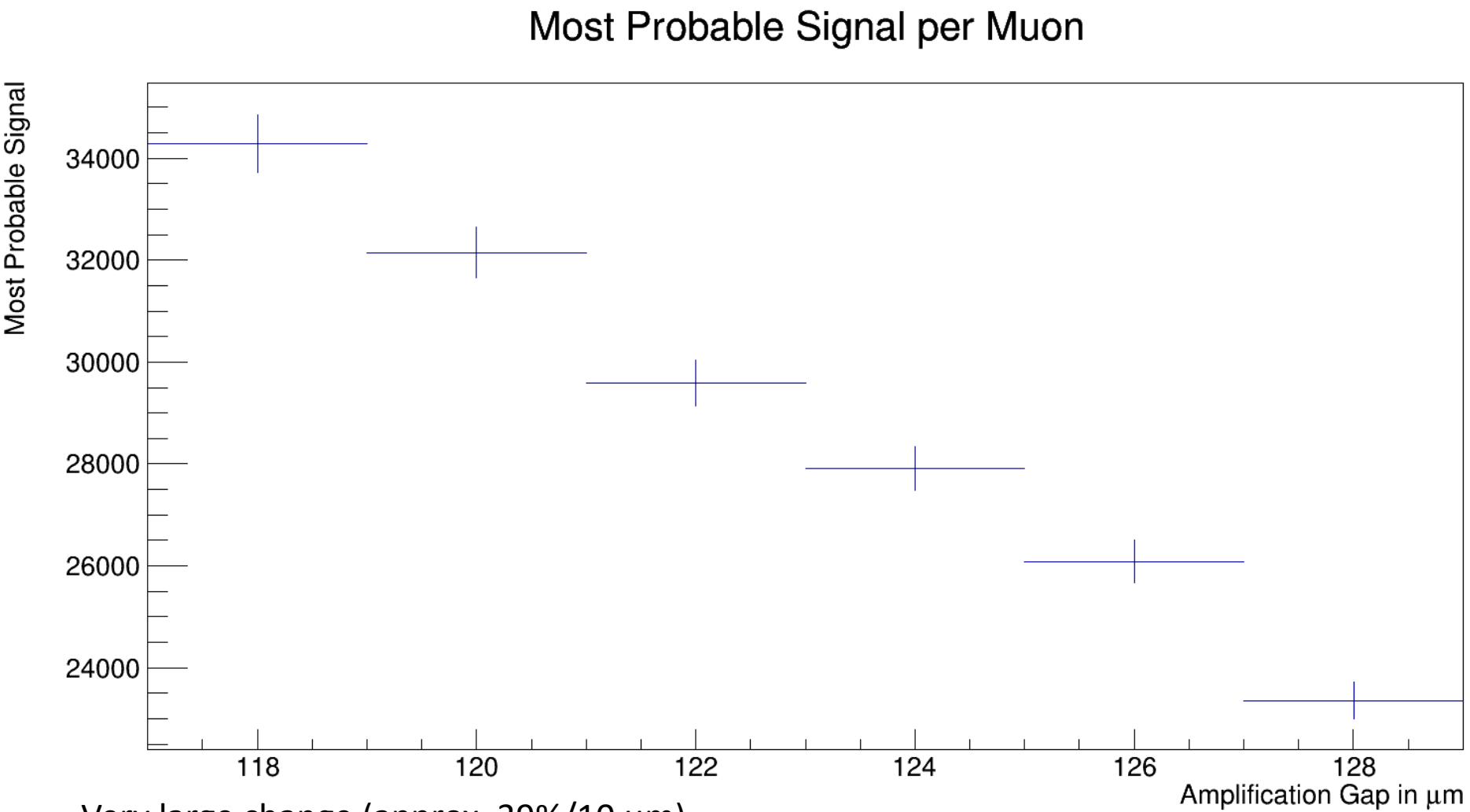
Influence by Transparency low (approx. 1,7%/10 µm)

Mean Gain ($\bar{n}$) vs Gap Size



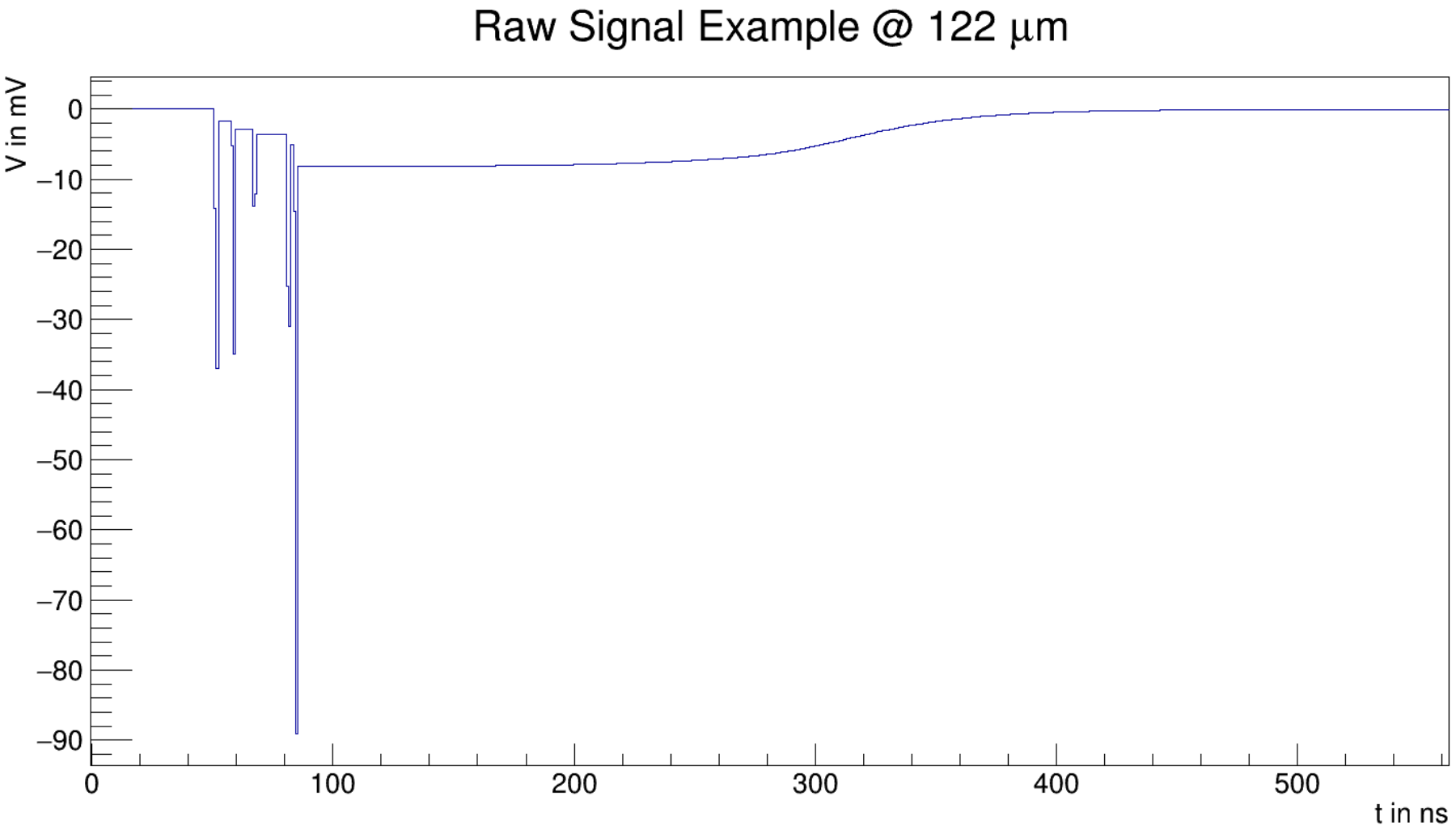
Influence by Gain large (approx. 31%/10 µm)

Mean Signal (Number of Electrons) vs Gap Size

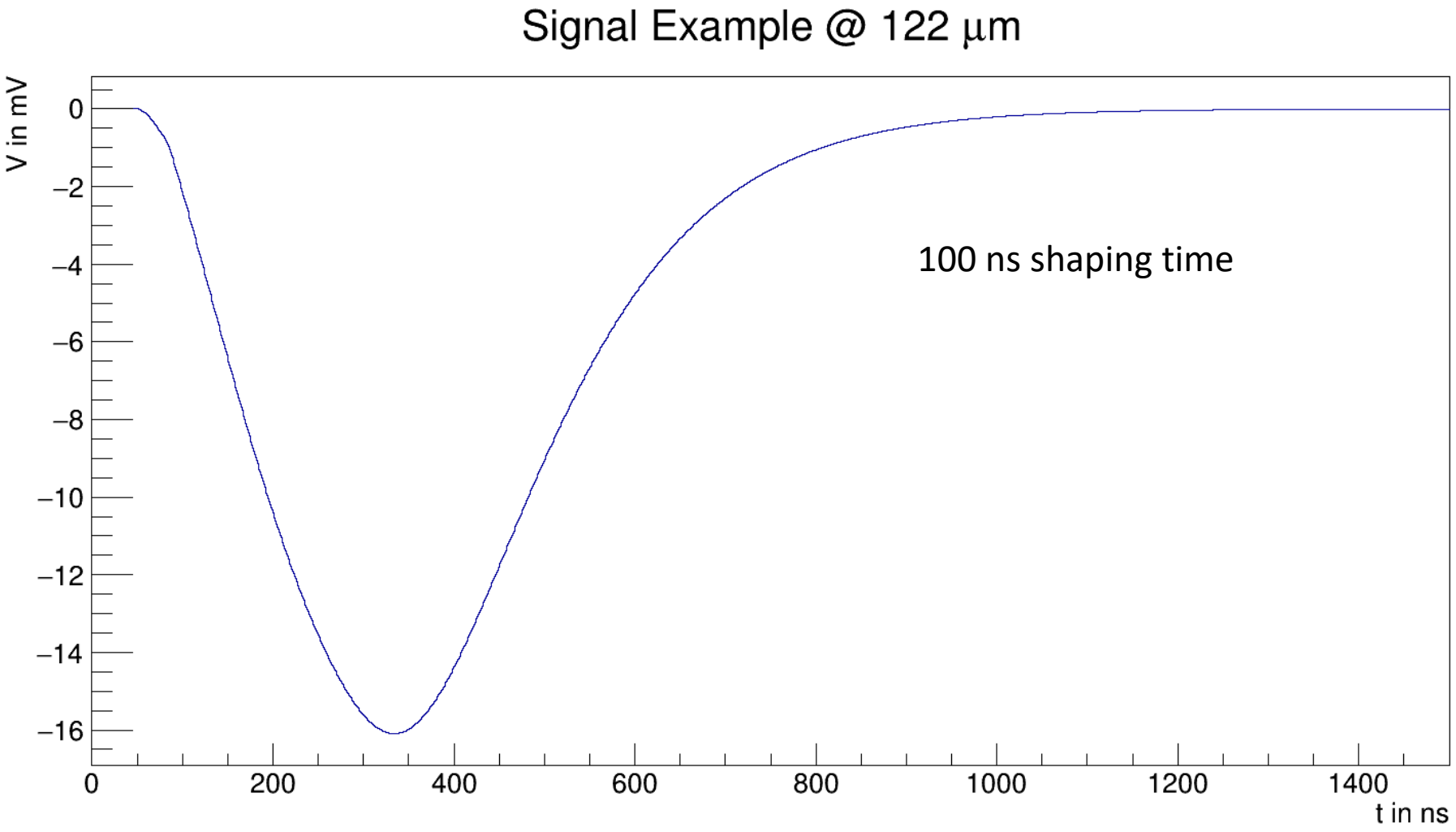


Very large change (approx. 39%/10 µm)

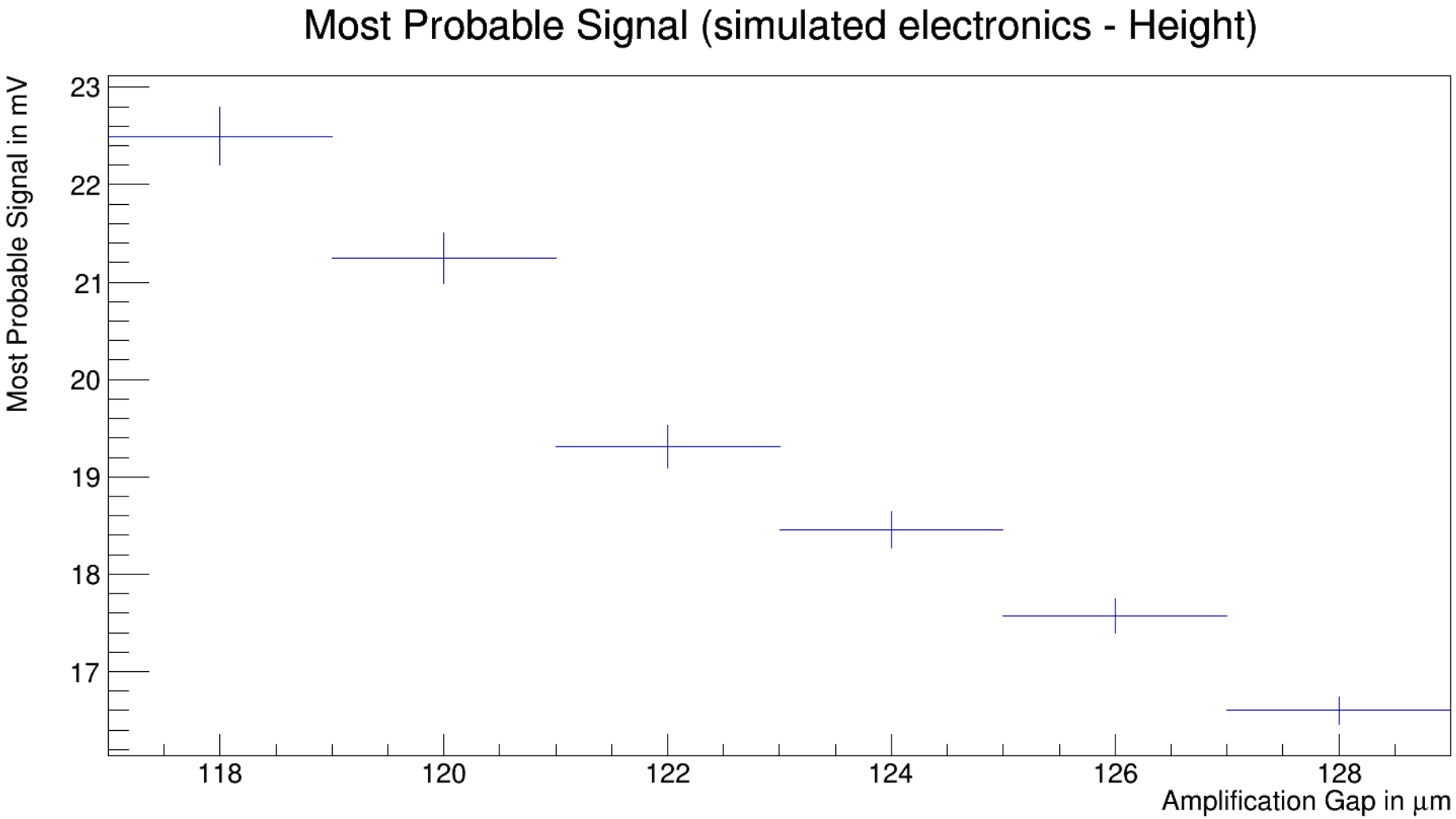
Example of a Signal before electronics For one Muon Event



Example of a Signal with Electronics for one Muon Event

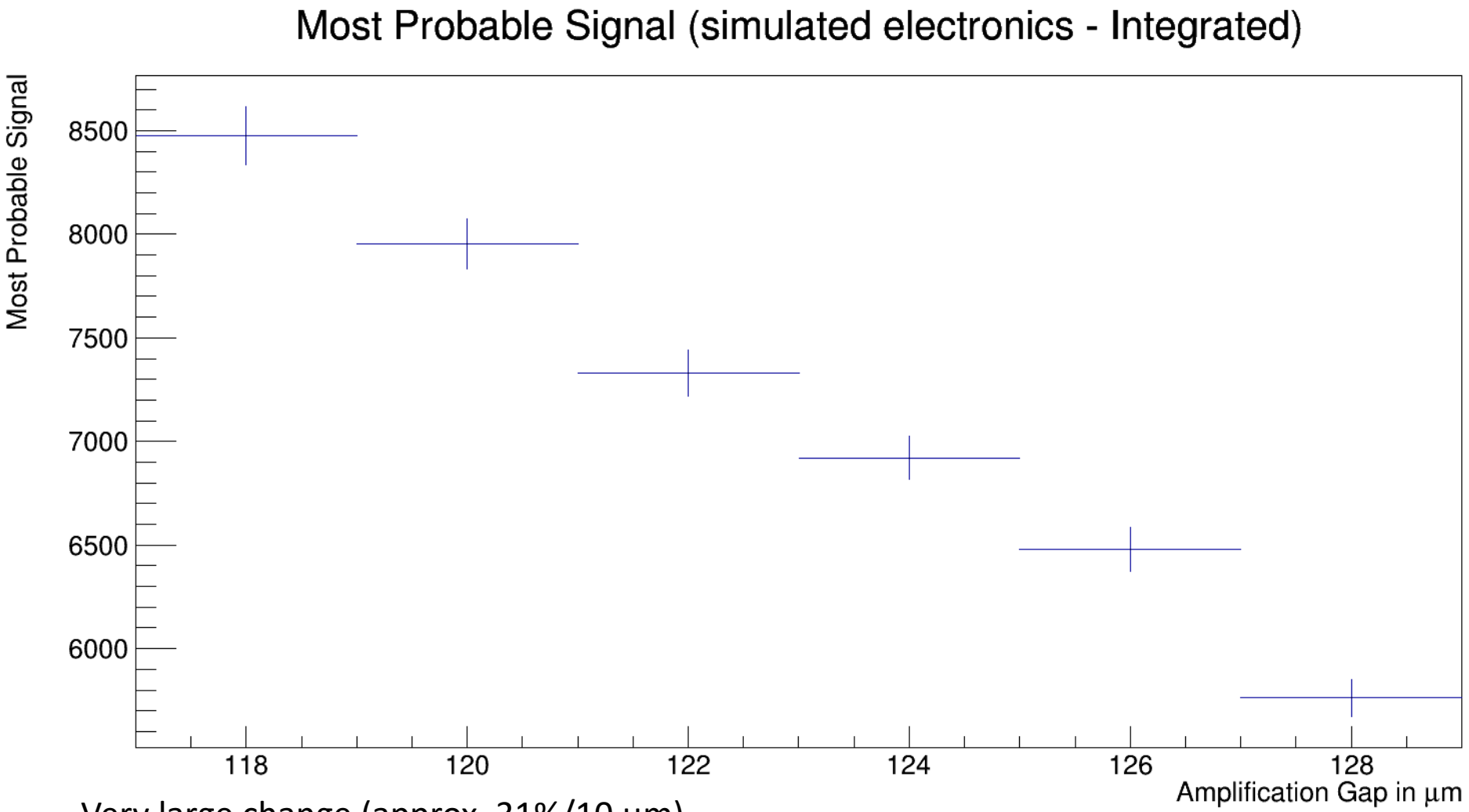


Signal with simulated Electronics vs Gap Size (Height)



Very large change (approx. 31%/10 µm)

Signal with simulated Electronics vs Gap Size (Integrated)



Very large change (approx. 31%/10 µm)

Conclusion

- Small Variations in gap size can make large differences in gain ($\approx 31\%$/ 10 µm) and in signal ($\approx 31\%$/ 10 µm)
- These effects have been studied in simulations
- Goal to look at electronics simulation and gain more information, like timing
- Also, different gasses might be studied in the future (like 93:5:2 Ar:CO_2:Isobutane)

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