Ion Animations in a Triple GEM Detector

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RD51 Collaboration Mini-week, 15-19 February 2021

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Outlook

1. We studied ion backflow in triple GEMs, and created animations of the process, similar to the electron avalanche *movie* presented at last year's mini-week.

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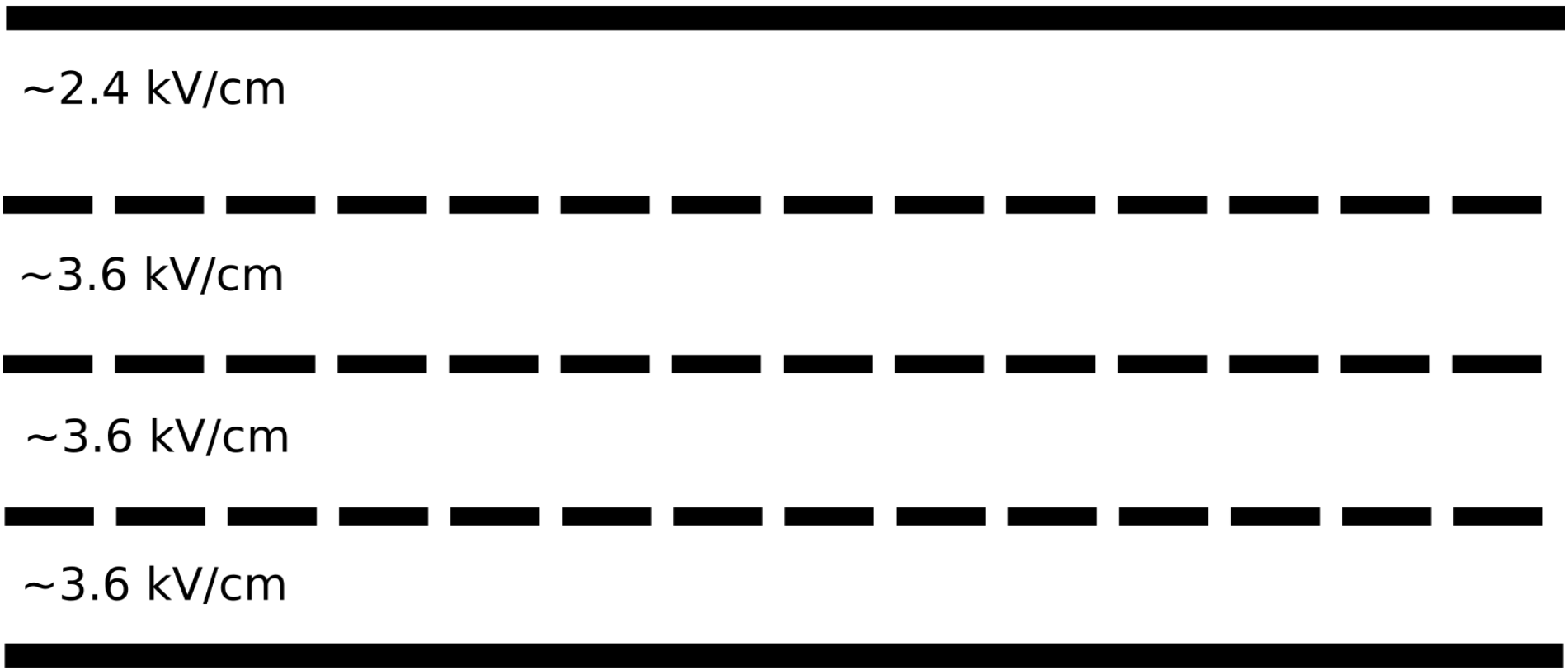
Methodology - I

Triple GEM Schematic:



3-2-2-2 gap configuration

`image not to scale

Methodology - II

1. We used Ar-CO_2 mixture in the ratios of 80-20 and $70 - 30$.
2. More than 300 events simulated to get ion statistics.
3. Single event used to create a "movie" of the ion backflow process from the mid and bottom GEM layers.

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Recap from earlier

1. Ion drift time between layers: typically μs order. Ion deposition within a layer: typically within a few *ns* of the avalanche process.

2. Ion backflow from GEM-III: $\sim 0.6\%$ blocked by GEM-II and $\sim 21\%$ blocked by GEM-I.

3. Ion backflow from GEM-II: $\sim 54\%$ blocked by GEM-I. (numbers from June '20)

Ion Backflow - I

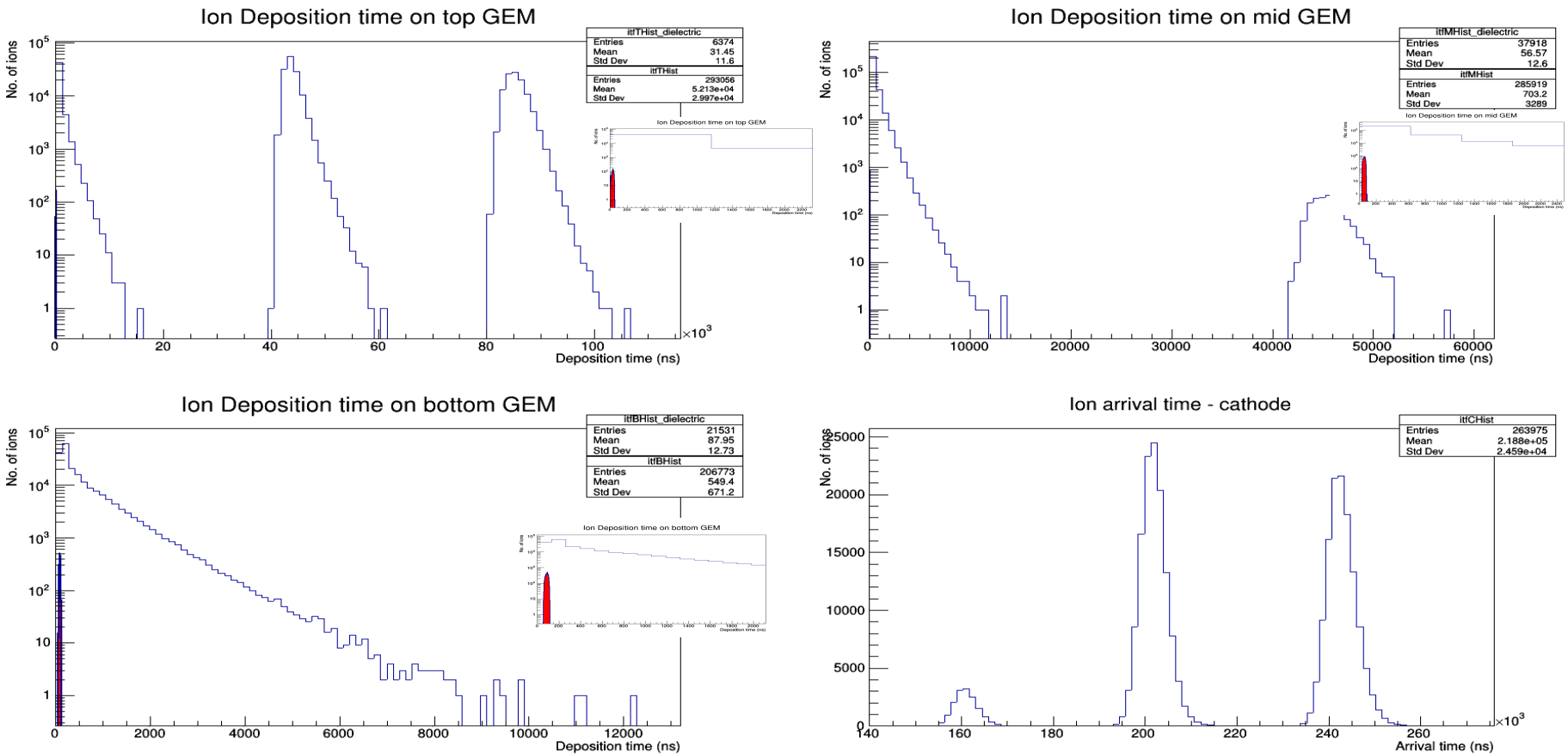


Figure: 70-30 gas mixture

Visualizing the backflow -

1. Using a similar algorithm to what was used to create the electron avalanche movies, we plot the ion transport in time slices.
2. Unlike electrons, the ion movement takes place on much larger timescales ($\sim \mu s$ order), and we cannot use the same ns timeslices.
3. The *AvalancheMC()* class was used to integrate the ion equations of motion, with constant distance stepping.
4. For plotting, we chose to use time slices of $1ns$ initially, which was increased progressively to $2ns$, $10ns$, $50ns$ and $100ns$.
5. Downside: A positional uncertainty, (in the animation only) will be introduced. Upper limit of this uncertainty was estimated to be $\sim 1.4um$, at $t \geq 1000ns$.

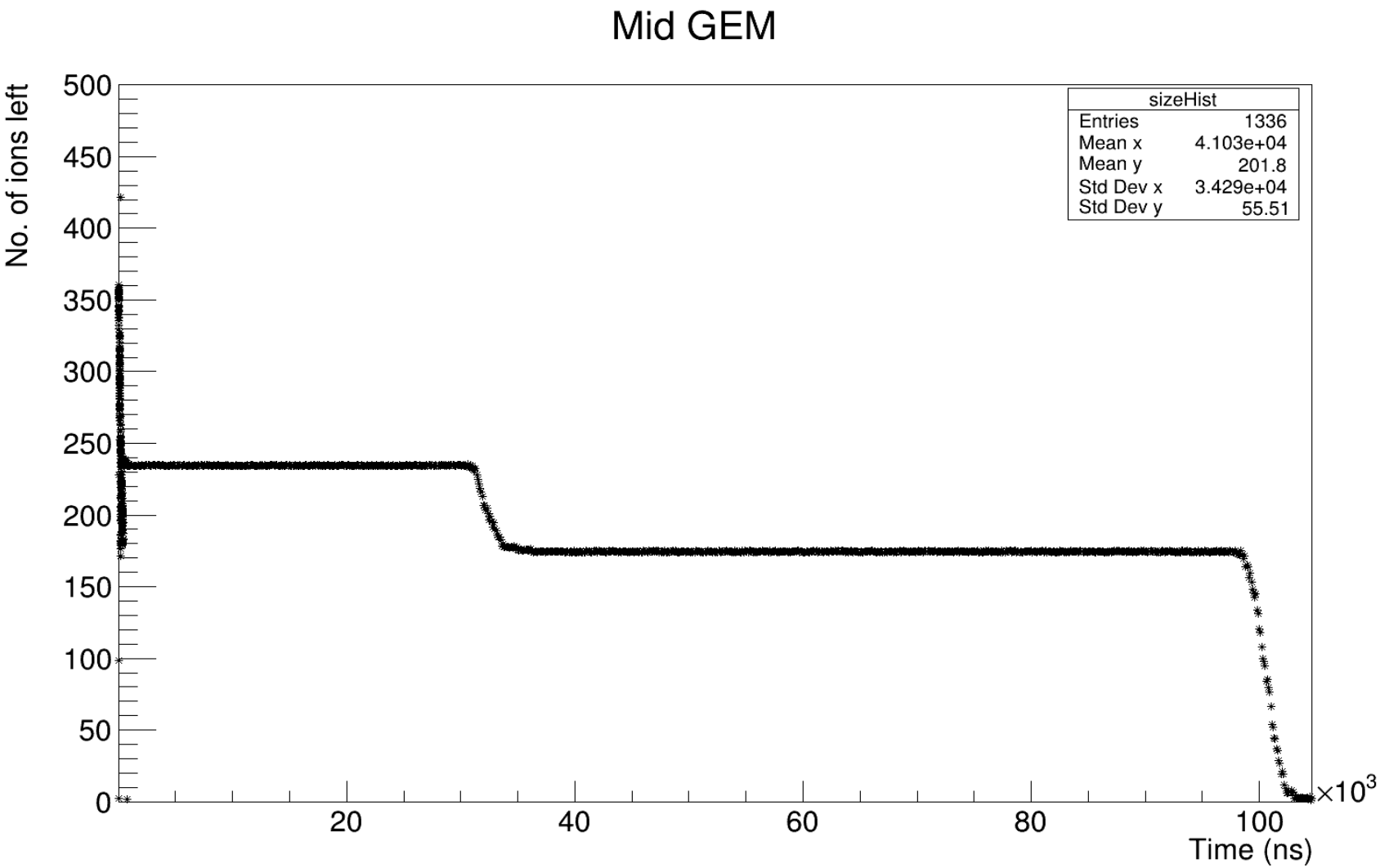
Ion Movie - Backflow from GEM-II

Click to play animation 1 (GEM-II backflow).

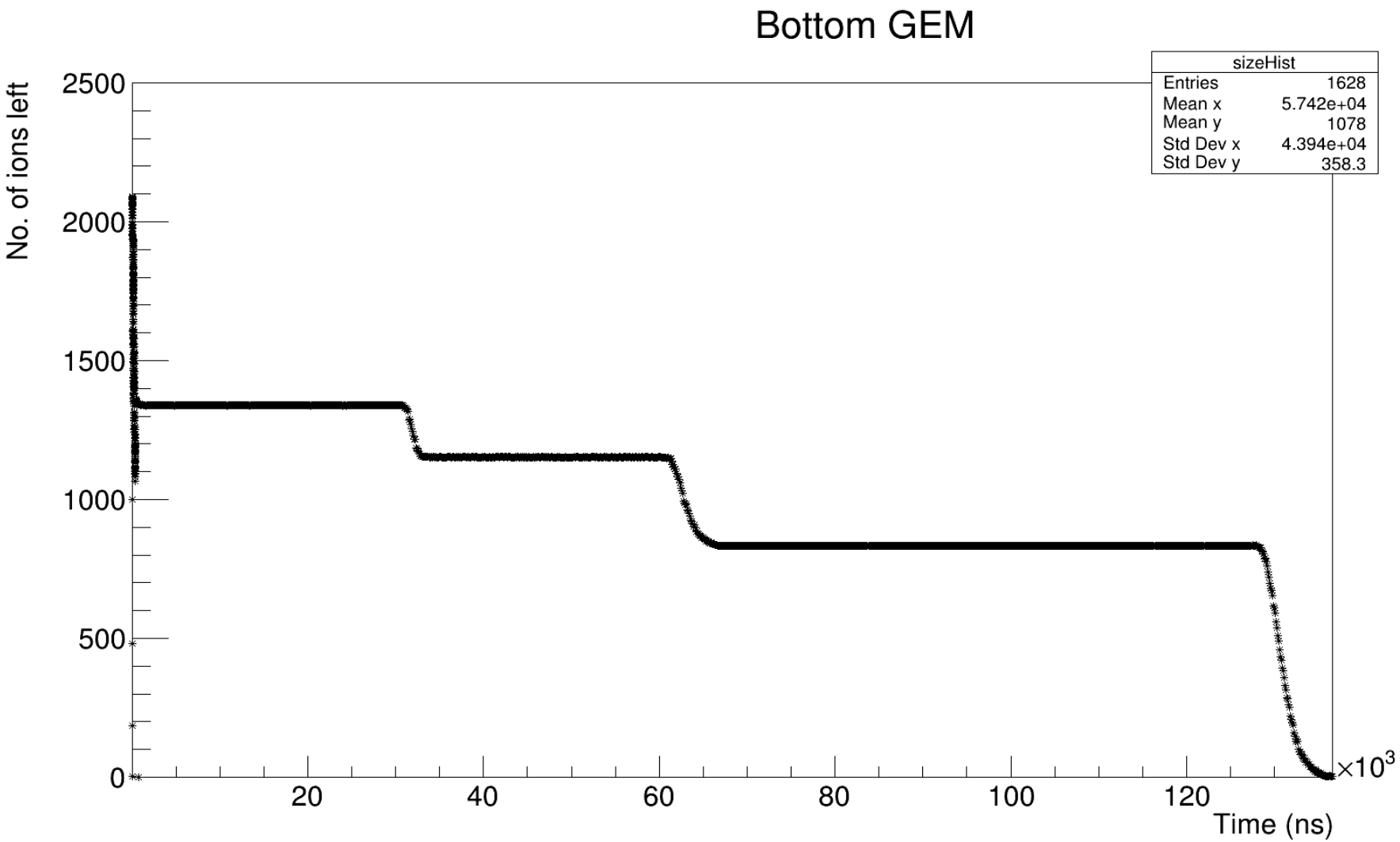
Click to play animation 2 (GEM-III backflow).

Slight Correction: Units on the X and Y axes should be μm.

Counting the ions in the simulation - I



Counting the ions in the simulation - II



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Some Issues That Remain, and Further Plans

1. We had to use dynamic time stepping in the animation, for it to complete within a reasonable time. This had the downside of introducing an uncertainty as mentioned earlier.

2. Garfield++ uses Ar^+ in Ar mobility data, which is not accurate in general for the gas mixtures. (except for 80-20 Ar-CO_2, which is what we used for the animation). Formation of ion clusters is also not taken in account.

3. The model for ion diffusion is not very accurate. Studying and improving on this is among our future plans.

THANK YOU!