SoLID Tracking Update

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SoLID Collaboration meeting

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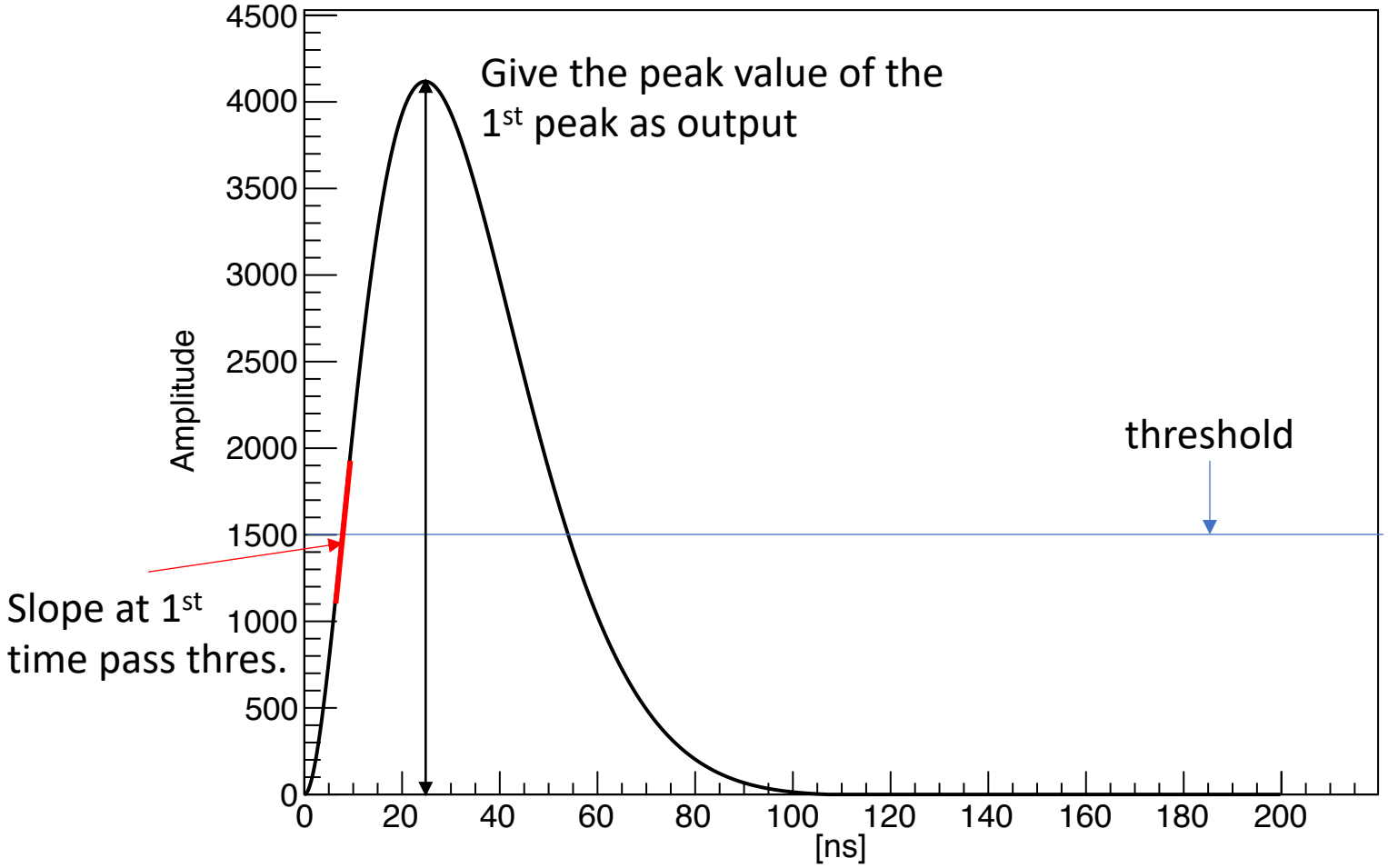
Outline

- Recent development on digitization
  - New development for VMM digitization
  - Other changes in GEM digitization
- Recent development on tracking
  - Tracking for longer endcap geometric setup
  - Various possible improvement for PVDIS tracking
- Summary

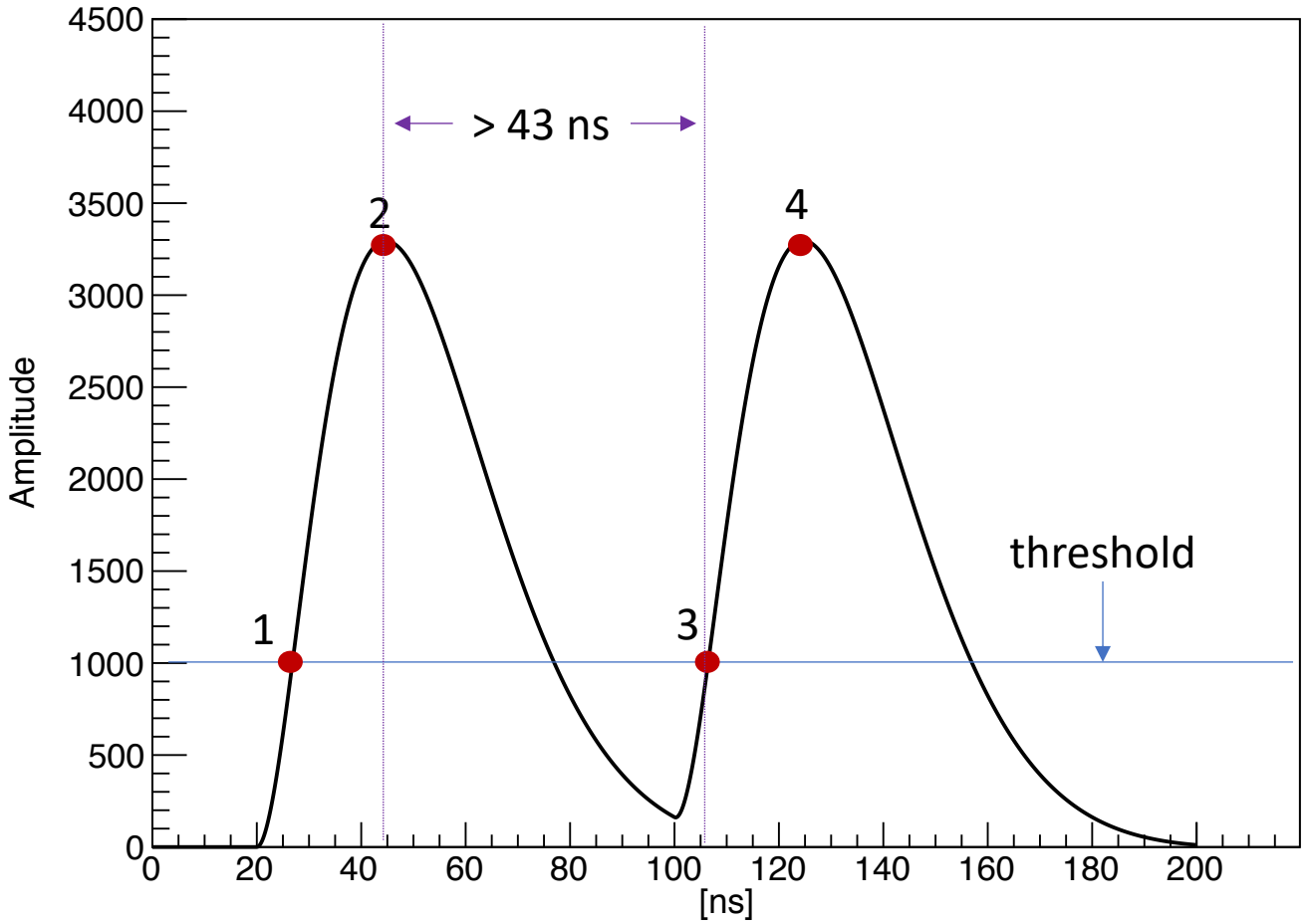
VMM3 digitization update

1. Define a threshold
2. Find the first time the signal across the threshold and determine slope at that point
   - Must be triggered on a positive slope
3. Find a first maximum above the threshold
4. Convert the maximum to 6-bit ADC output
5. Also record and output the time associated with the maximum using 160 MHz clock (~6ns step)



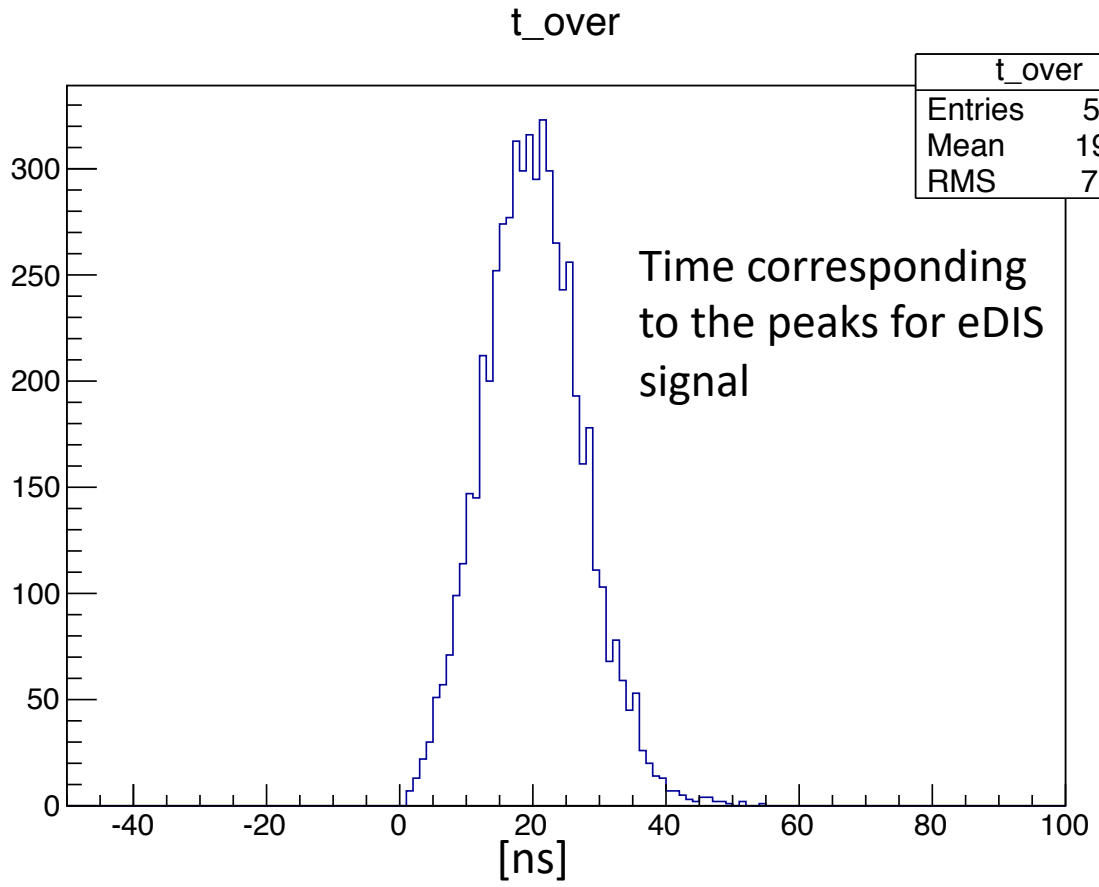
VMM3 digitization update

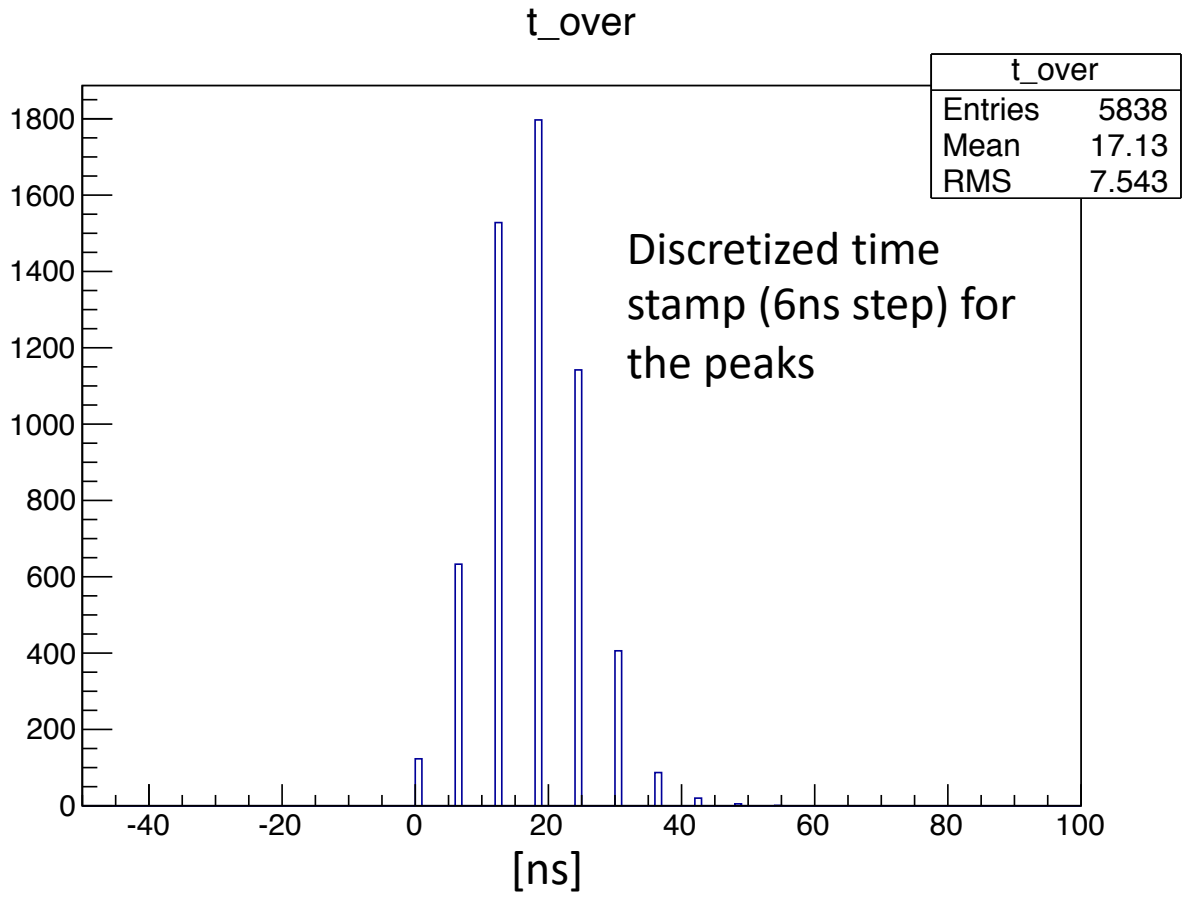
- Two signals comes consecutively in time. Two points capable of triggering the chip (point 1 and 3) and two maxima (point 2 and 4).
- We require that there must be at lest 43ns between point 2 and 3, otherwise the chip will not be able to record the second maximum
- Currently in the digitization, I will check if there is a maximum that is above the threshold and less than 43ns before the trigger point of current signal.
  - If there is, not saving the maximum of current signal



VMM3 digitization update

- In high background environment, it is very important that we utilize the time information of the signal
- One way is to use the time stamp associated with the peak, and cut at for example t < 40ns



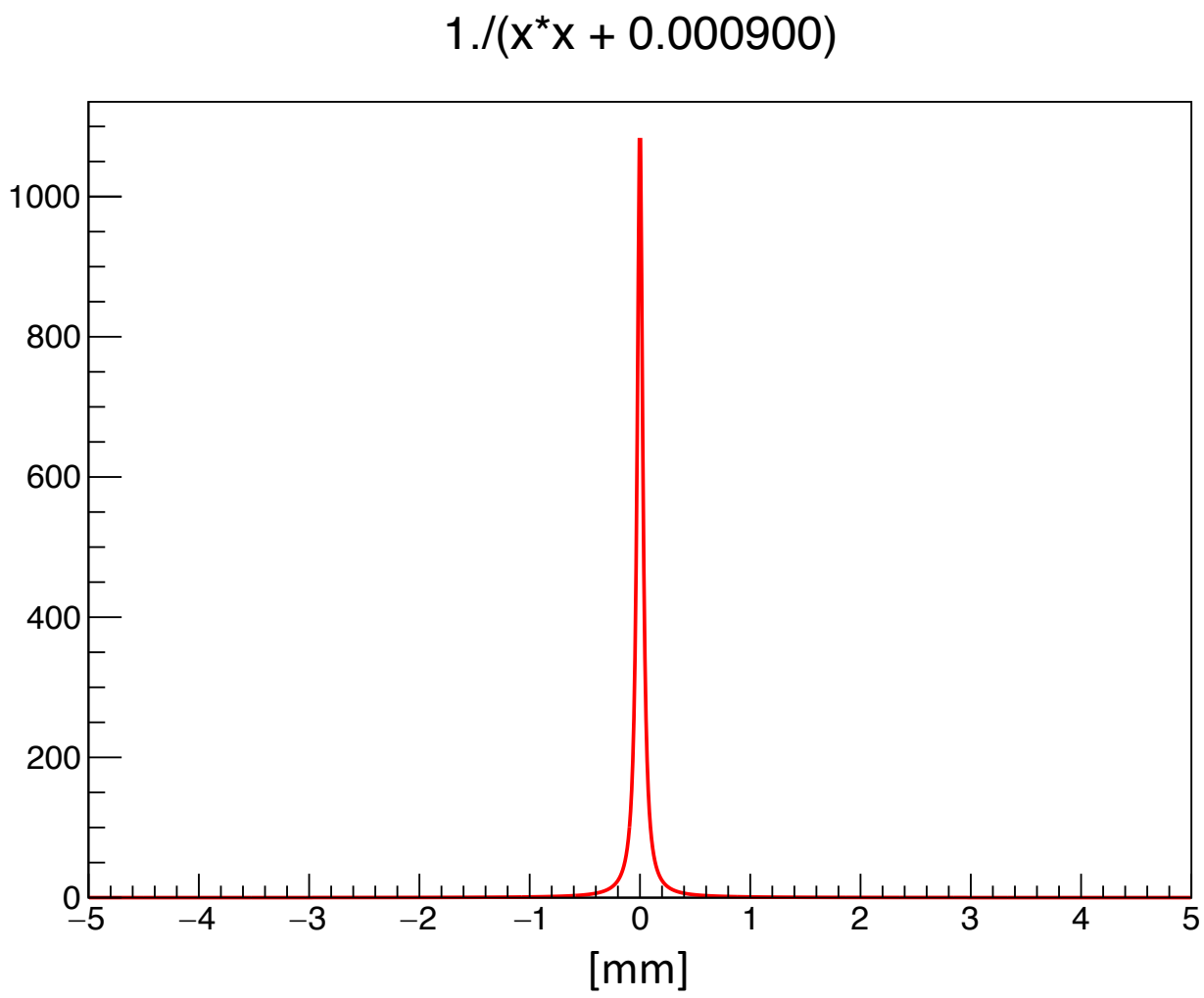


Tracking result comparison (for PVDIS at 100% bg)

- Using 40ns cut on the time stamp
- Without including the deadtime effect, the signal track efficiency and accuracy:
  - 91.3%(0.1%)/ 95.9%(0.1%)
- With the deadtime effect, the signal track efficiency and accuracy:
  - 86.8%(0.2%) / 94.2%(0.1%)

Avalanche profile

- For each ion pair, the avalanche profile takes the form $C/(x^2 + y^2 + \gamma^2)$
- γ is typically around 0.03 mm for the SoLID version of the digitization
- The gap between two holes on a GEM foil is about 0.14mm, so can the width be much smaller than the distance between two gaps?
- Seems like in the SBS GEM digitization, the γ is exactly the squared root of what we are using in the SoLID digitization, so ~0.17 mm instead
- With larger γ, the cluster size will increase and that means higher occupancy



PVDIS

With old γ

	40ns	60ns	80ns
Plane 1	5.3%	7.1%	8.8%
Plane 2	2.7%	3.7%	4.6%
Plane 3	2.4%	3.2%	4.0%
Plane 4	0.9%	1.2%	1.6%
Plane 5	1.0%	1.3%	1.6%

Zero-track rate	Single-track rate	Multi-track rate	Single-track acc.
13.0%	86.8%	0.2%	94.2%

With new γ

	40ns	60ns	80ns
Plane 1	7.5%	9.9%	12.0%
Plane 2	4.3%	5.7%	7.0%
Plane 3	3.7%	4.9%	6.1%
Plane 4	1.6%	2.1%	2.6%
Plane 5	1.6%	2.1%	2.6%

Zero-track rate	Single-track rate	Multi-track rate	Single-track acc.
18.9%	80.7%	0.4%	91.9%

No strip segmentation in both cases
40ns cut on the time stamp in both cases

SIDIS – He3

With old γ

	40ns	60ns	80ns
Plane 1	0.8%	1.2%	1.5%
Plane 2	2.8%	3.9%	4.9%
Plane 3	1.3%	1.7%	2.2%
Plane 4	0.8%	1.1%	1.4%
Plane 5	0.8%	1.1%	1.3%
Plane 6	0.6%	0.8%	1.0%

	Zero-track rate	Single-track rate	Multi-track rate	Single-track acc.
electron	2.7%	97.1%	0.0%	98.7%
pion	9.0%	90.9%	0.0%	97.9%

With new γ

	40ns	60ns	80ns
Plane 1	1.3%	1.8%	2.2%
Plane 2	4.0%	5.5%	6.9%
Plane 3	1.9%	2.6%	3.3%
Plane 4	1.2%	1.6%	2.1%
Plane 5	1.2%	1.6%	2.1%
Plane 6	0.9%	1.2%	1.5%

	Zero-track rate	Single-track rate	Multi-track rate	Single-track acc.
electron	6.6%	93.3%	0.0%	98.2%
pion	11.6%	88.2%	0.0%	97.0%

No strip segmentation in both cases
40ns cut on the time stamp in both cases

JPsi

With old γ

	40ns	60ns	80ns
Plane 1	2.1%	3.0%	3.8%
Plane 2	4.3%	5.9%	7.4%
Plane 3	2.6%	3.6%	4.6%
Plane 4	2.0%	2.8%	3.6%
Plane 5	1.9%	2.6%	3.4%
Plane 6	1.5%	2.1%	2.7%

Zero-track rate	Single-track rate	Multi-track rate	Single-track acc.
9.4%	90.5%	0.1%	96.7%

With new γ

	40ns	60ns	80ns
Plane 1	3.1%	4.2%	5.4%
Plane 2	5.9%	8.0%	10.0%
Plane 3	3.7%	5.1%	6.4%
Plane 4	2.9%	4.0%	5.1%
Plane 5	2.8%	3.9%	5.0%
Plane 6	2.2%	3.1%	4.0%

Zero-track rate	Single-track rate	Multi-track rate	Single-track acc.
16.4%	83.5%	0.1%	94.2%

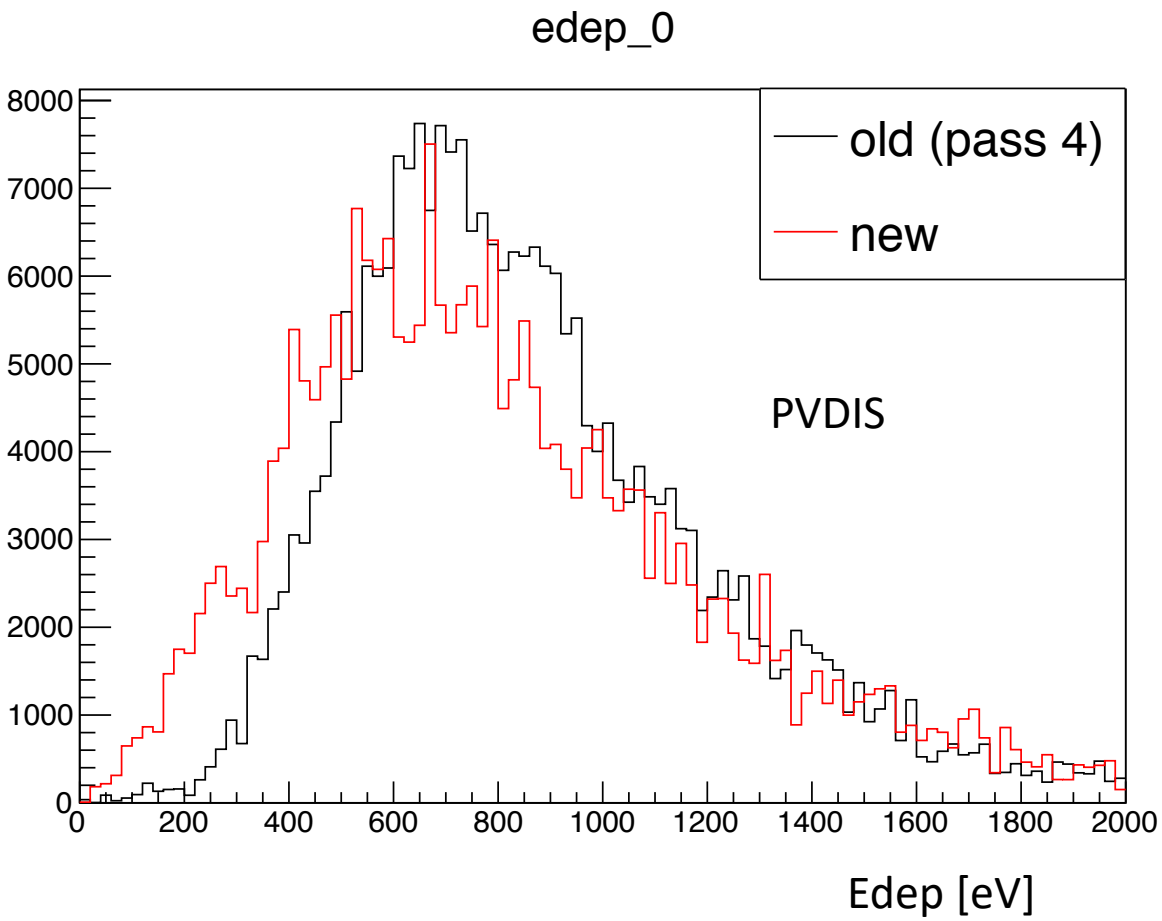
No strip segmentation in both cases
40ns cut on the time stamp in both cases

PVDIS digitization with longer endcap

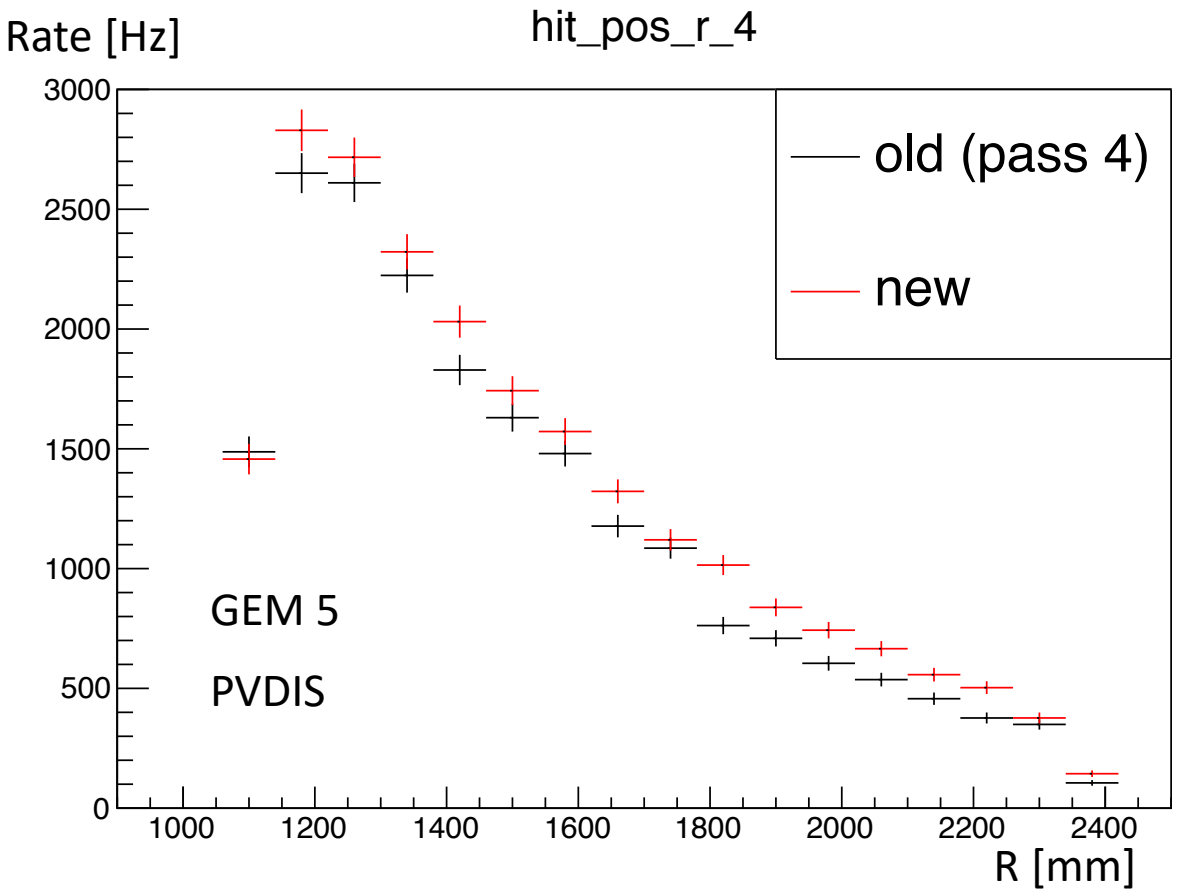
- To make the digitization works for the longer endcap version of the simulation
  - ➢ Change in geometry: downstream GEMs and EC are shifted downstream by 10cm, GEM sizes are different compared to the shorter endcap simulation
  - ➢ Update field map in the reconstruction with the latest 3D field map
- Tracking reconstruction works for the longer endcap setup
- Noticeable inconsistency in tracking results observed between longer endcap and previous shorter endcap version
  - Efficiency 77.3% +/- 0.2% v.s. 80.7% +/- 0.2% (previous)
  - Most likely due to different version of GEMC and Geant4 (edep in GEM, background rate…)
  - Still under investigation

Difference in GEMC simulation

Energy deposition for eDIS track in the GEM primary ionization layer

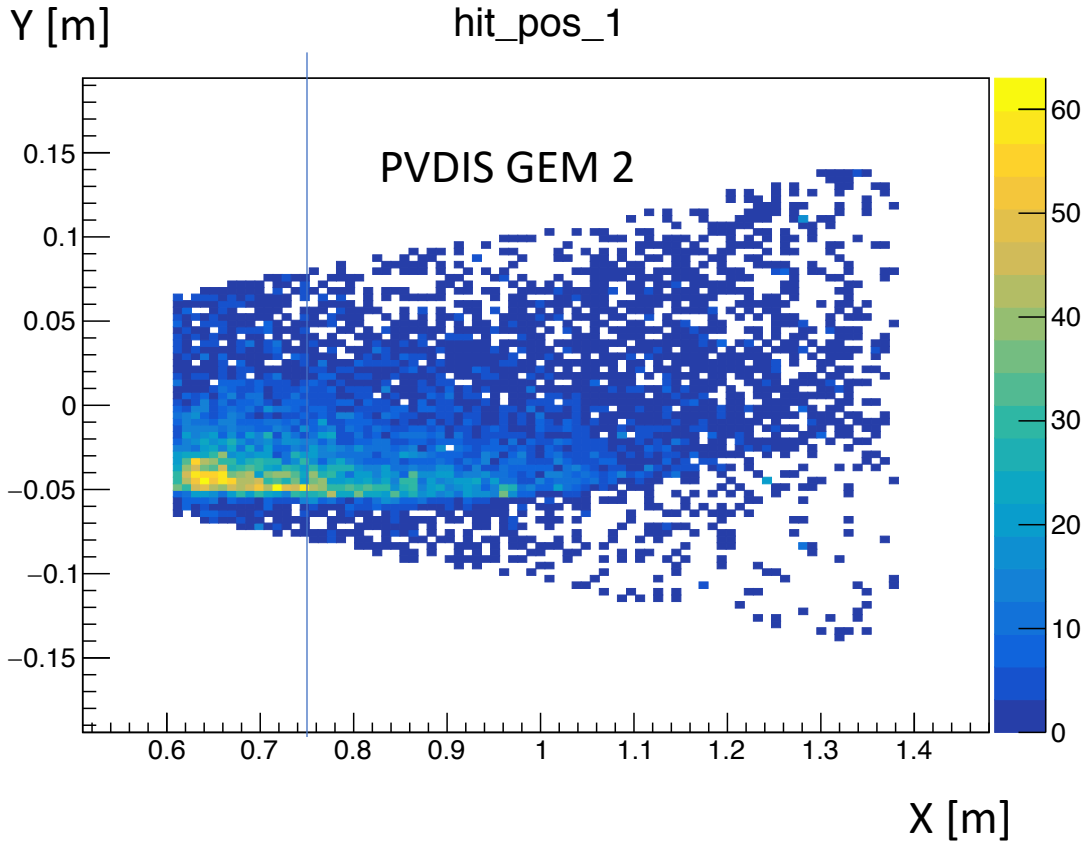


Background rate as a function of R



Possible Improvement for PVDIS tracking

- Solution 1: shifting the first GEM upstream to where the original GEM 2 and GEM 3 are
  - ➢ Minor improvement (4% to 5%) on single track accuracy, no significant improvement on the efficiency
- Solution 2: segmenting the strips for the upstream GEMs
  - ➢ Significant improvement (5% to 10%) for both tracking efficiency and single track accuracy, based on APV25 studies
  - ➢ Similar improvement for VMM chip as well
  - ➢ Position of segmenting not optimized yet, most likely can gain more improvement



Possible Improvement for PVDIS tracking

- Solution 3: allowing 3 hits tracks (currently requires 4 out of 5)
  - ➢Significant improvement on the efficiency
  - ➢Minor reduction on accuracy (3 hits tracks are not going to be as accurate)
  - ➢Need to evaluate the overall uncertainty in order to judge whether it is worth doing

- Shifted GEM 1 applied for all cases
- Accuracy for 3 hits tracks is about 68%

	No seg.	No seg. Include 3/5	Seg.	Seg. Include 3/5
Efficiency [%]	77.3 +/- 0.2	85.2 +/- 0.2	84.5 +/- 0.2	89.6 +/- 0.2
Accuracy [%]	95.5 +/- 0.1	93.0 +/- 0.1	97.0 +/- 0.1	95.3 +/- 0.1

Summary

- Developing VMM digitization including dead-time effect
- Further development for VMM digitization is needed. Input from VMM test is highly desired

- Fixing a potential bug in the GEM avalanche model. Cluster sizes increase and obvious decrease in tracking performance was observed

- Optimization for PVDIS tracking is on-going
  - Optimizing the geometry
  - How to segment the strips
  - Whether to include 3 hits tracks in order to improve efficiency