

GPU Based Track Finding for Muon g-2/EDM Experiment at J-PARC



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Introduction

Muon g-2/EDM experiment is dedicated to measuring the magnetic dipole moment and electric dipole moment of the muon to a very high precision[1].

$$\vec{\omega} = -\frac{q}{m_\mu} \left[a_\mu \vec{B} - \left(a_\mu - \frac{1}{\gamma^2 - 1} \right) \frac{\vec{\beta} \times \vec{B}}{c} + \frac{\eta}{2} (\vec{\beta} \times \vec{B} + \frac{\vec{E}}{c}) \right]$$

JPARC uses a very novel technique by using a 300 MeV/c reaccelerated thermal muon beam.

$$\vec{\omega} = -\frac{q}{m_\mu} \left[a_\mu \vec{B} + \frac{\eta}{2} (\vec{\beta} \times \vec{B}) \right]$$

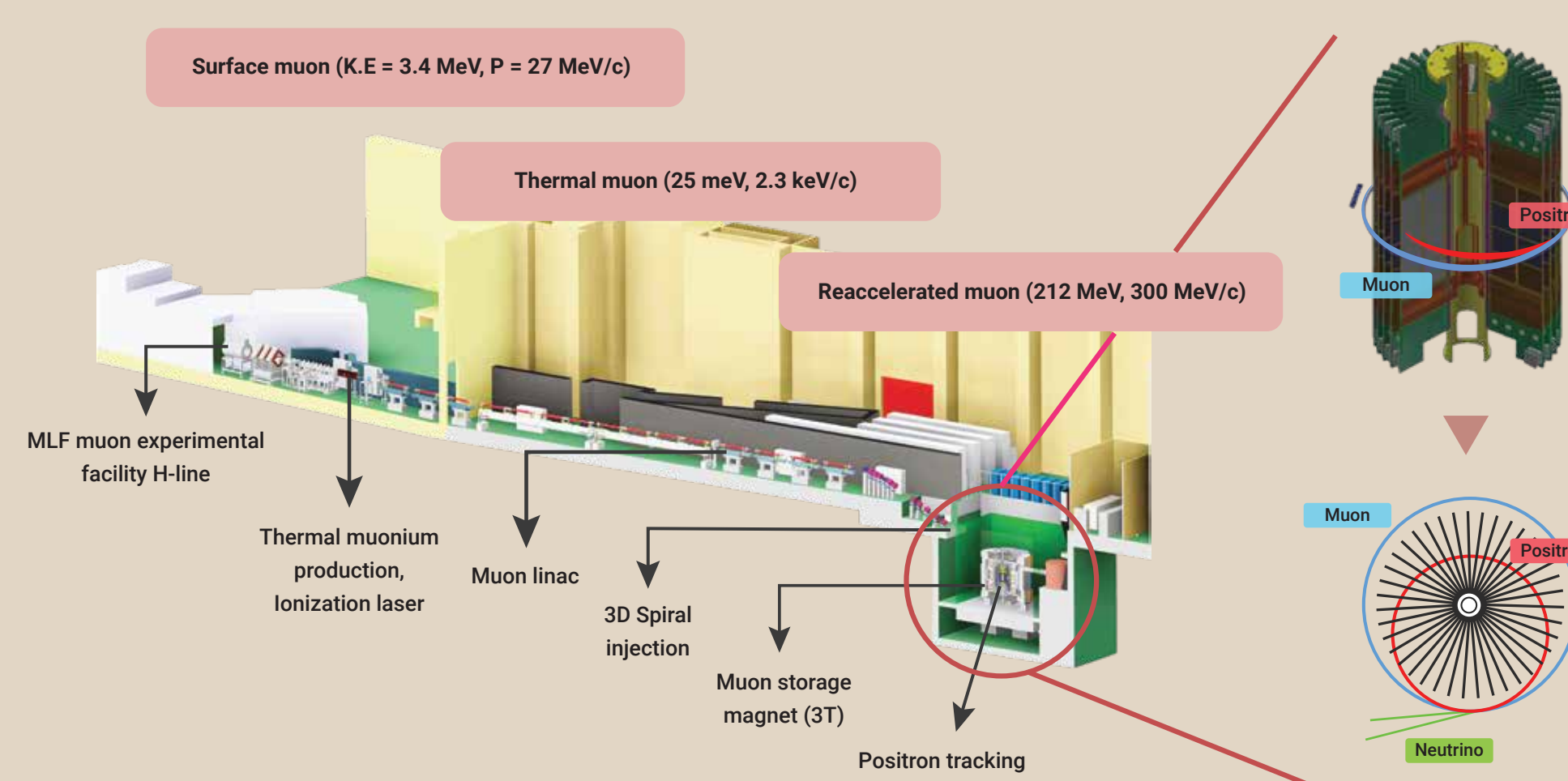
The standard model is broken

The standard model is correct



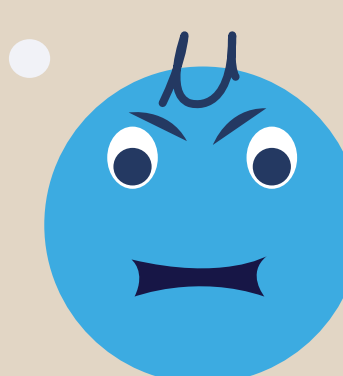
Experimental Setup

After the ionization of muonium atom, they are accelerated using LINAC till the p reaches 300 MeV/c



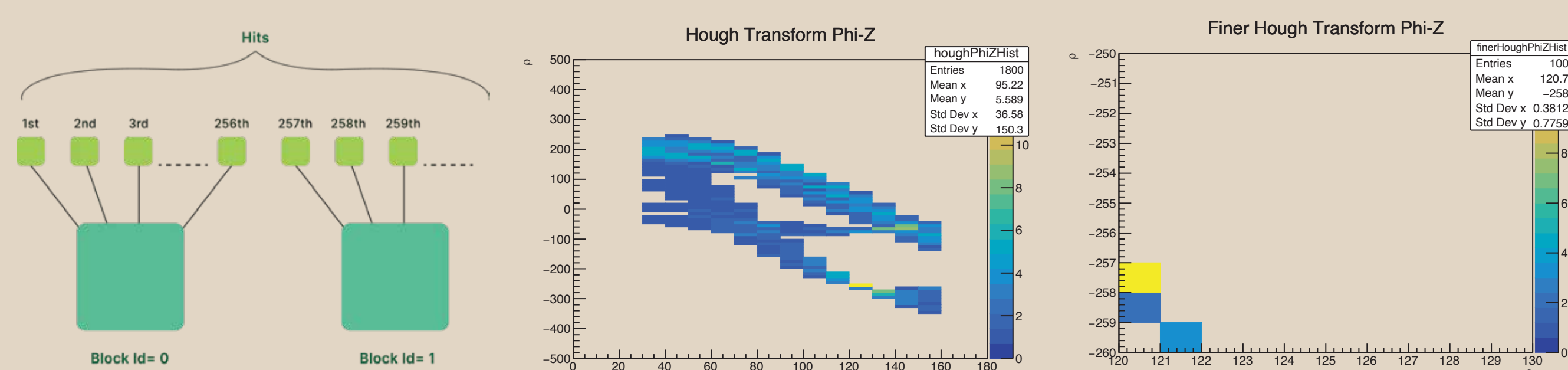
Its a long way to the storage ring if you wanna Rock "n" Roll

?????



Approach

Process 256 elements per block using shared memory. Each block handles hits in a 10 ns time window. Divide the Hough Histogram into coarse and fine bins to address shared memory constraints.



Challenges

Current Software

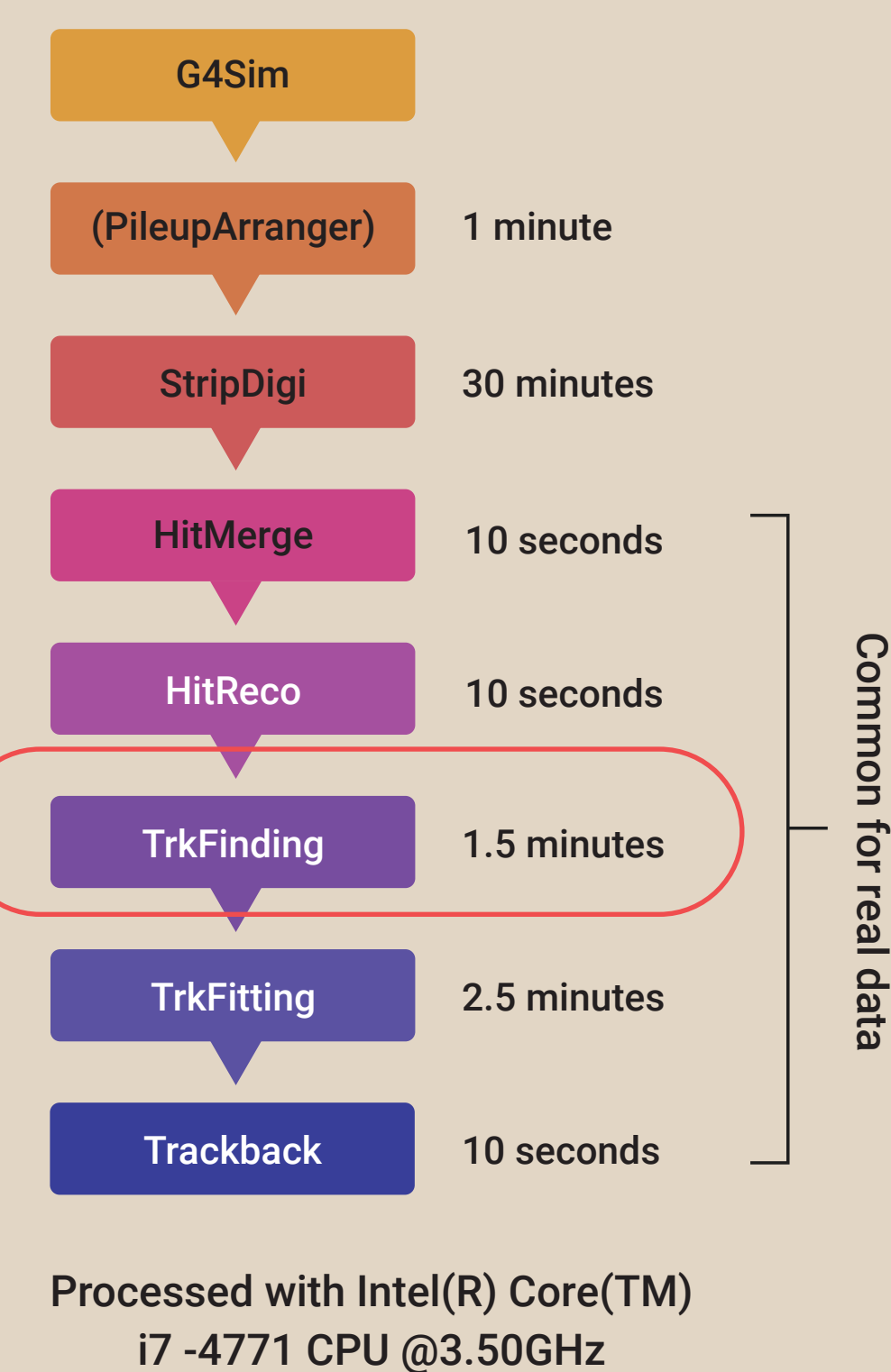
100 muons/sec/CPU
10⁵ muons/sec (for 1000 CPUs)

Required Speed

~10¹³ muon decays Beam intensity ~10⁶ muons/sec
Speed required - O(10⁶ muons/sec)



Whattttt ???
Faster than me ??

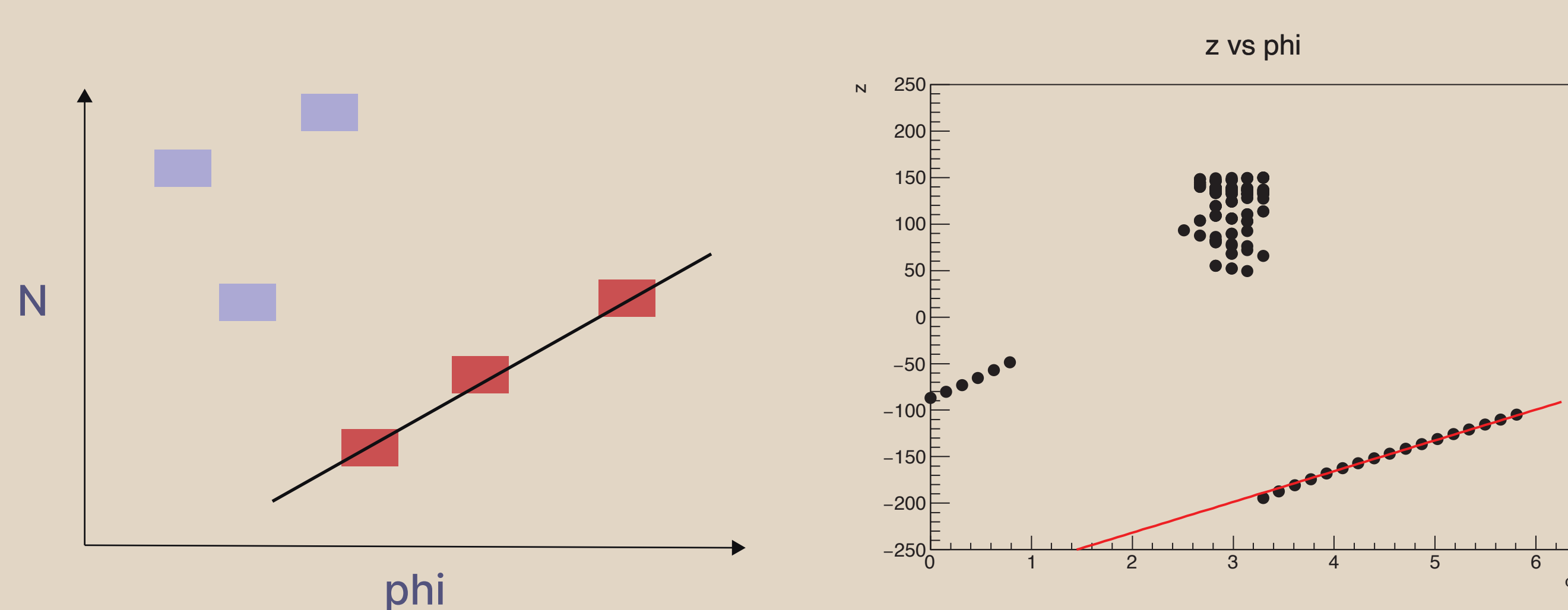


A 10-Fold Improvement in Speed is Required

Result

	Functions	Time
GPU Activities	Main Kernel	136.61 ms
	Memcpy HtD	5.45 ms
API Calls	Kernel Launch	288.90 ms
	Device Sync	144.08 ms
	Cuda Malloc	49.90 ms
	Memcpy	6.32 ms

GPU activity shows much acceleration in Hough Transformation



Summary and Outlook

- We have performed HT in GPU.
- We have seen good acceleration in the track finding process.
- Further refinement and clustering are needed to obtain a clean and complete track.

References

[1] M Abe et al. "A new approach for measuring the muon anomalous magnetic moment and electric dipole moment". In: Progress of Theoretical and Experimental Physics 2019.5 (May 2019), p. 053C02.
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