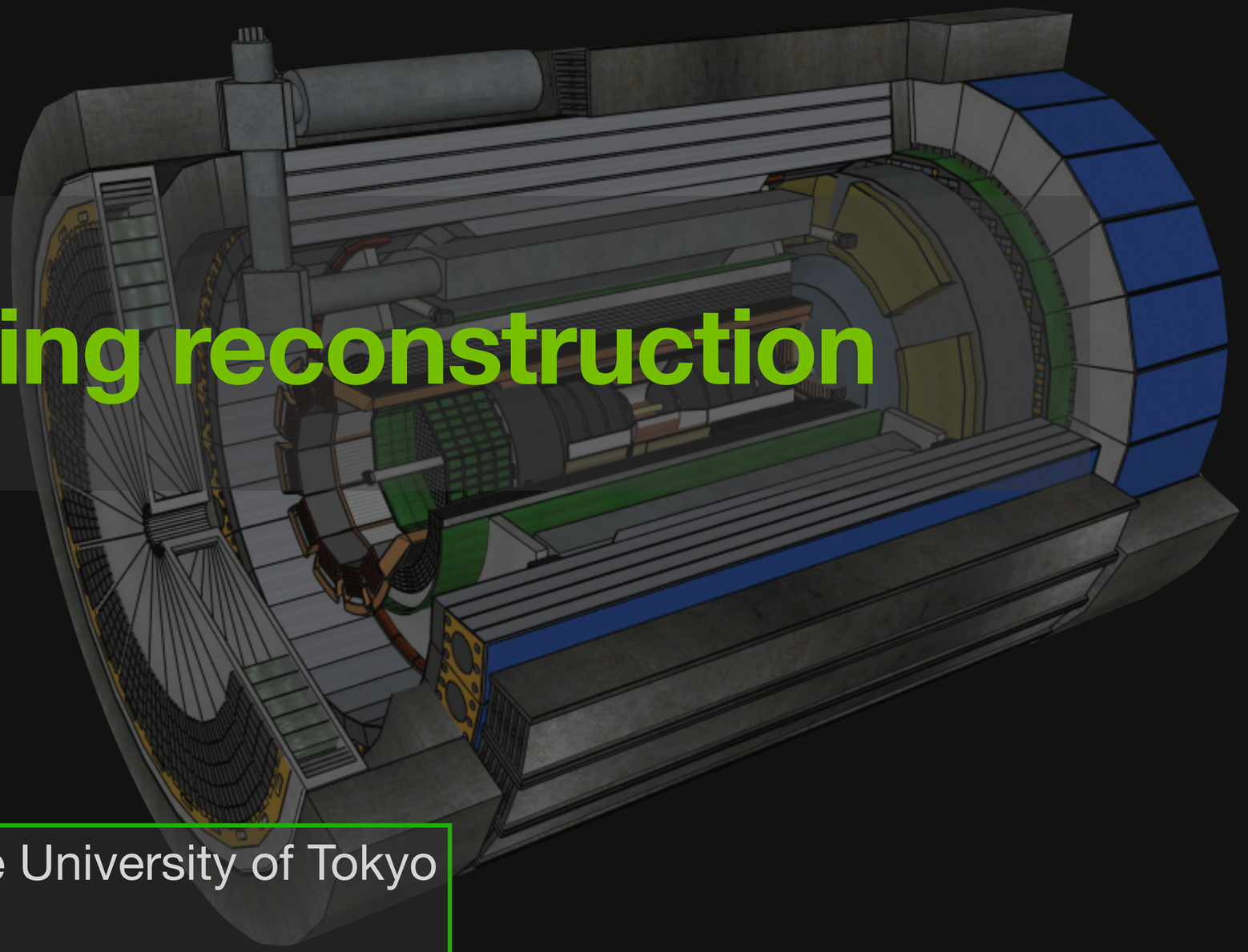
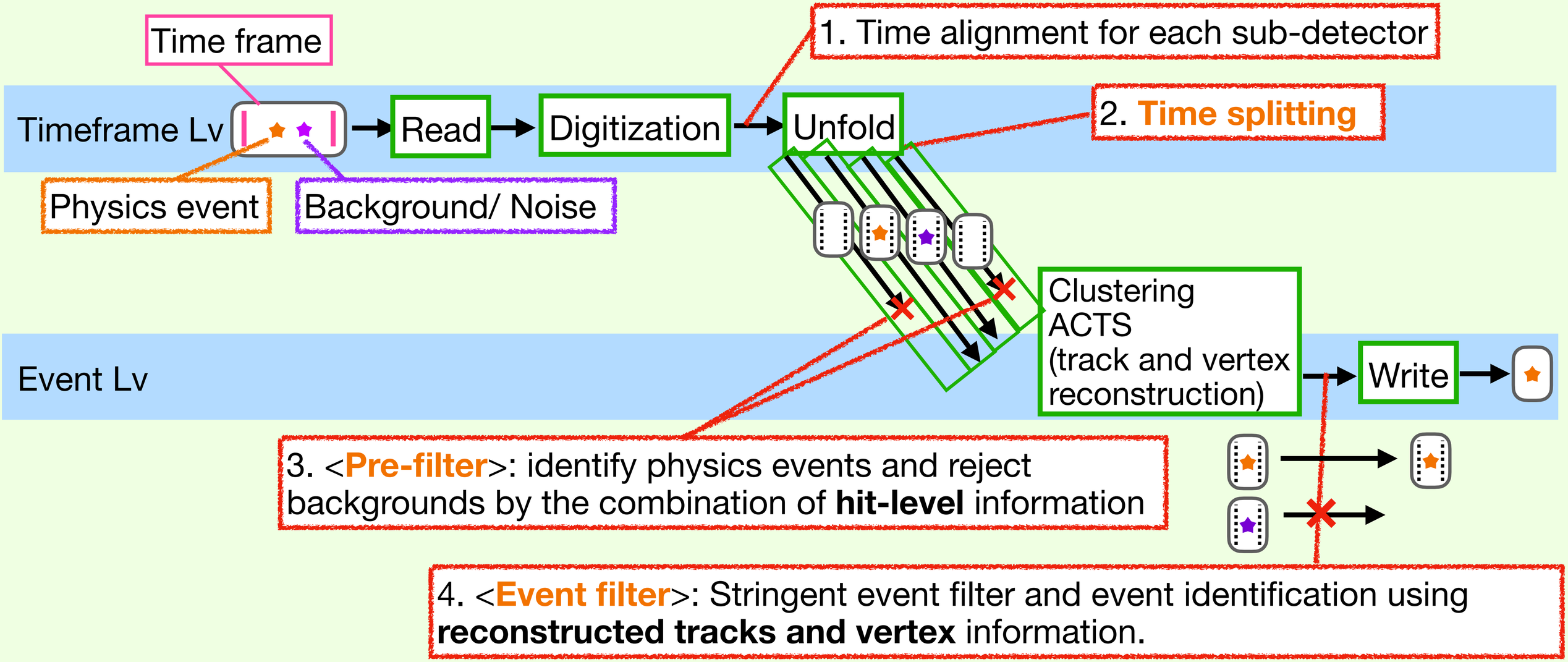
Streaming reconstruction



Quark Nuclear Science Institute, The University of Tokyo
Takuya Kumaoka

Online Event Filtering System



In 2025, I developed **1-3** baseline frameworks. (Of course, there's still plenty of room for improvement.)

Outlook map

5. Test online chain (E0 - E1 orchestraton::connect detector/rucio) (**- Sep?)**

1. Test for **various** physics events (**low Q^2**) (**- May)**

Time frame

Timeframe Lv

Read → Digitization → Unfold

Physics event

Background/ Noise

3. Apply **multi-threads** (or GPU) (**- Jun**)

6. Apply detector response (???)

Event Lv

Clustering
ACTS
(track and vertex reconstruction)

Write

2. Up date the pre-filter using **all sub-detectors** (**- May)**

4. Implement "**Event filter**": Stringent event filter and event identification using **reconstructed tracks and vertex** information. (**- July)**

7. Add calibration stream line (**???)**

Current Status / Progress

1. Make some simulation files with new backgrounds.

2. Fix the estimation way of the time splitting event reconstruction efficiency.

3.Preparing the event filter algorithm with ML
→ Learned the basic NN and establish a plan how to use it. (mid Jan - Mid - Feb)

4. Local beam test
→ Another report

1. Create some simulations

1. Beam energy 10x100, Q^2 = 1 GeV^2, DIS, with backgrounds.

2. Beam energy 10x100, photo production J/ψ, physics only.

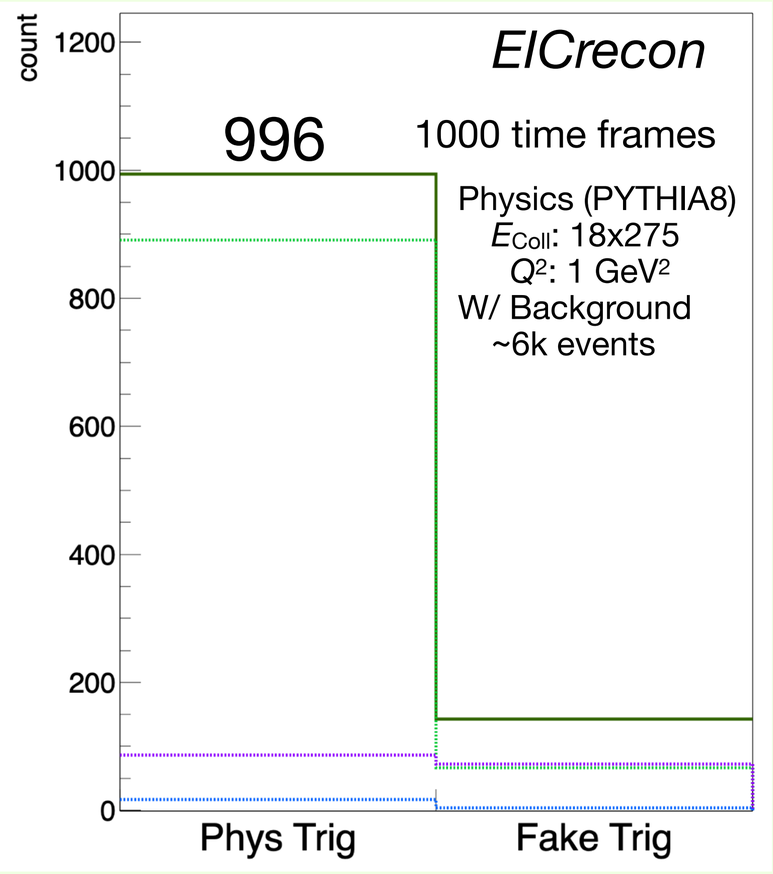
3. Each background only: Synchrotron radiation, e Bremsstrahlung, Coulomb losses, Touschek, hadron beam gas

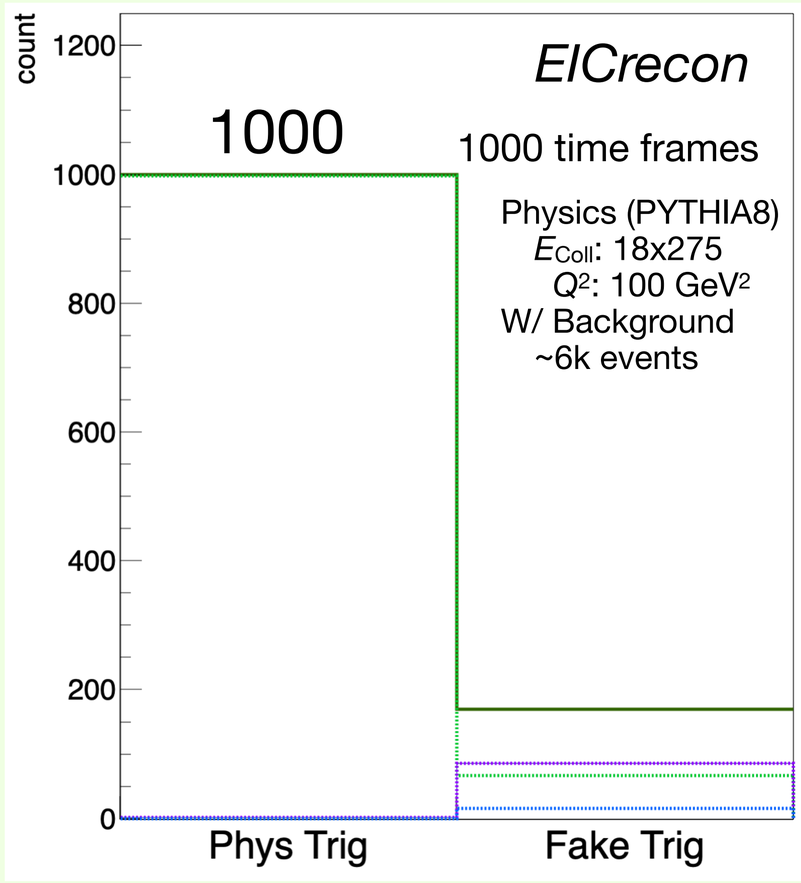
rates in kHz	5x41 GeV	5x100 GeV	10x100 GeV	10x275 GeV	18x275 GeV	Vacuum
Total ep	12.5 kHz	129 kHz	184 kHz	500 kHz	83 kHz	
hadron beam gas	12.2kHz	22.0kHz	31.9kHz	32.6kHz	22.5kHz	10000Ahr
	131.1kHz	236.4kHz	342.8kHz	350.3kHz	241.8kHz	100Ahr
electron beam gas (Bremsstrahlung scatterings)	2181.97 kHz	2826.38 kHz	3177.25 kHz	3177.25 kHz	316.94 kHz	10000Ahr
electron beam gas (Coulomb losses - w/ collimators)		116.57 kHz		29.56 kHz	0.86 kHz	10000Ahr
electron intrabeam (Touschek losses - w/ collimators)		1112.3 kHz		233.5 kHz	0.55 kHz	
DIS eA	kHz	kHz	kHz	/	/	
hadron beam (Au) gas	7.36kHz	10.3kHz	10.3kHz	/	/	10000Ahr
	79.1kHz	110.7kHz	110.7kHz	/	/	100Ahr
electron SR		36608 MHz		36608 MHz	3324 MHz	

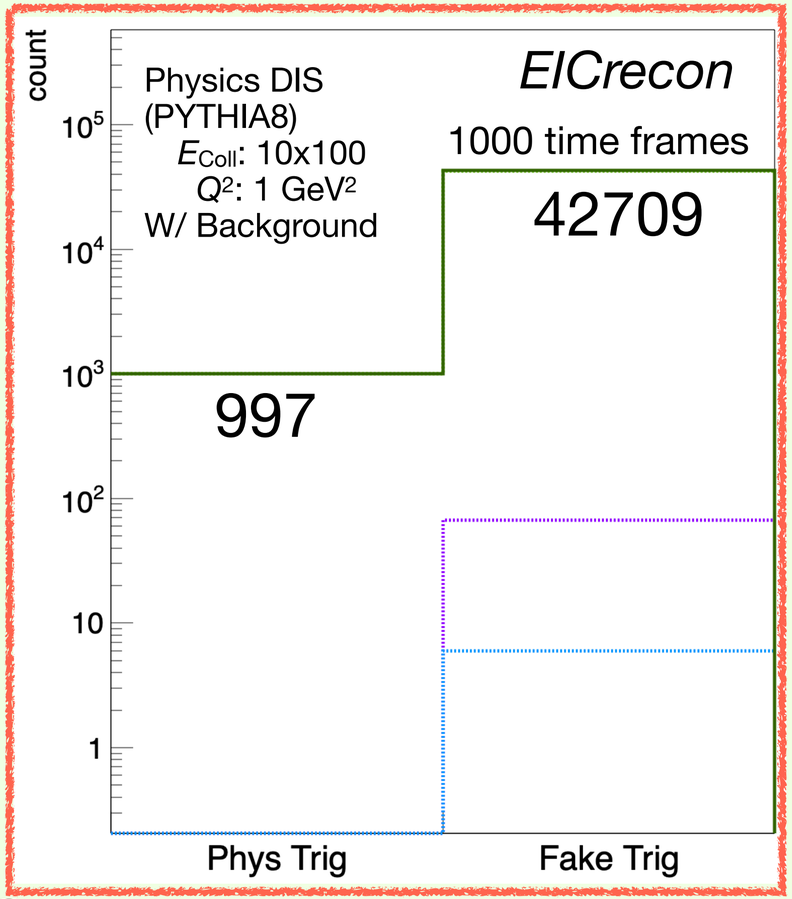
https://docs.google.com/presentation/d/1NY-BKU110ver17LpcPRbLXfiebLeBkN55kHVR7dCisA/edit?slide=id.g3b985a67abe_0_32#slide=id.g3b985a67abe_0_32

Pre-filter Efficiency

- There were problem to count the triggered physics event.
→ Fixed them, but there are still some concerns.

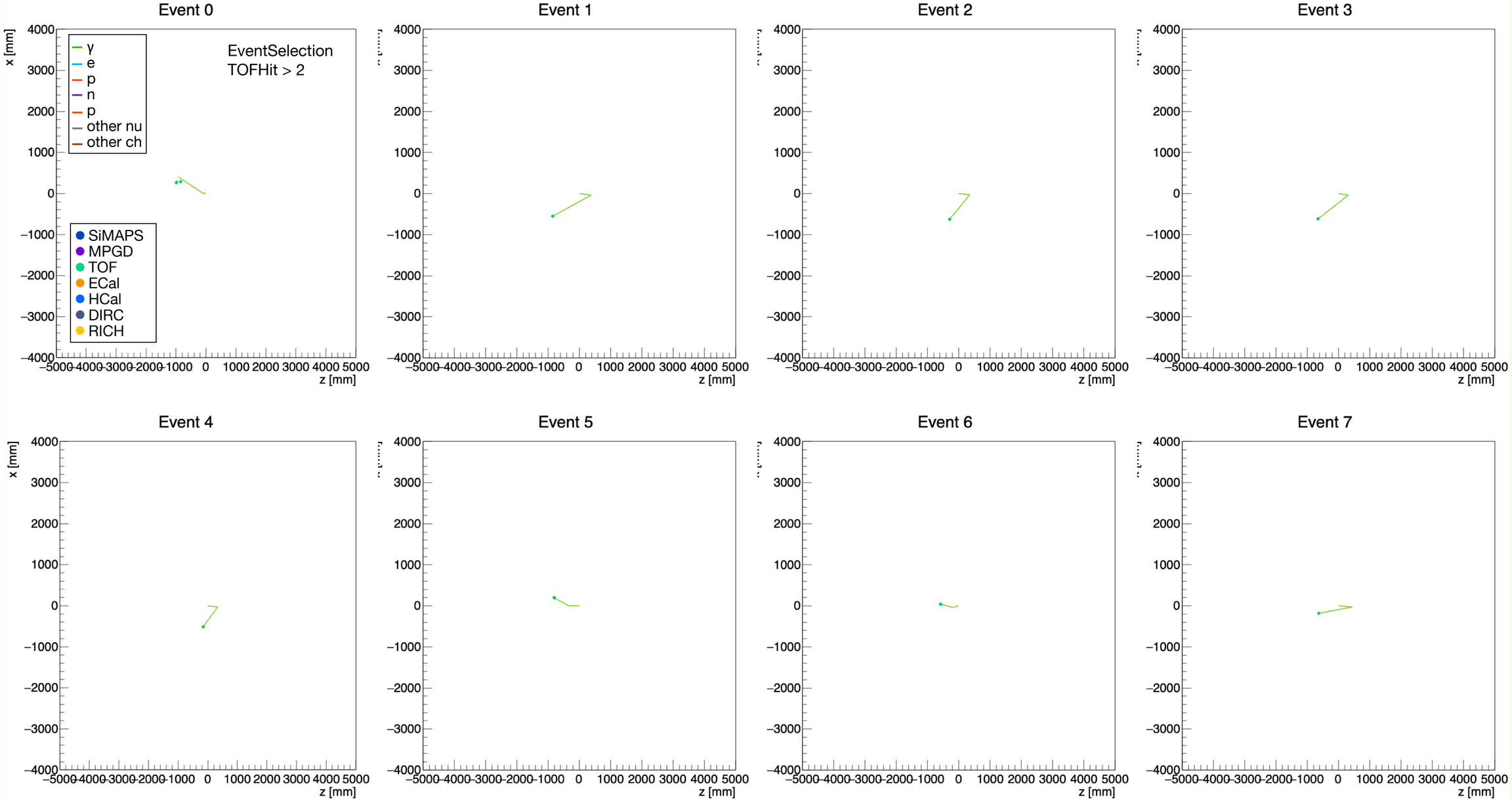




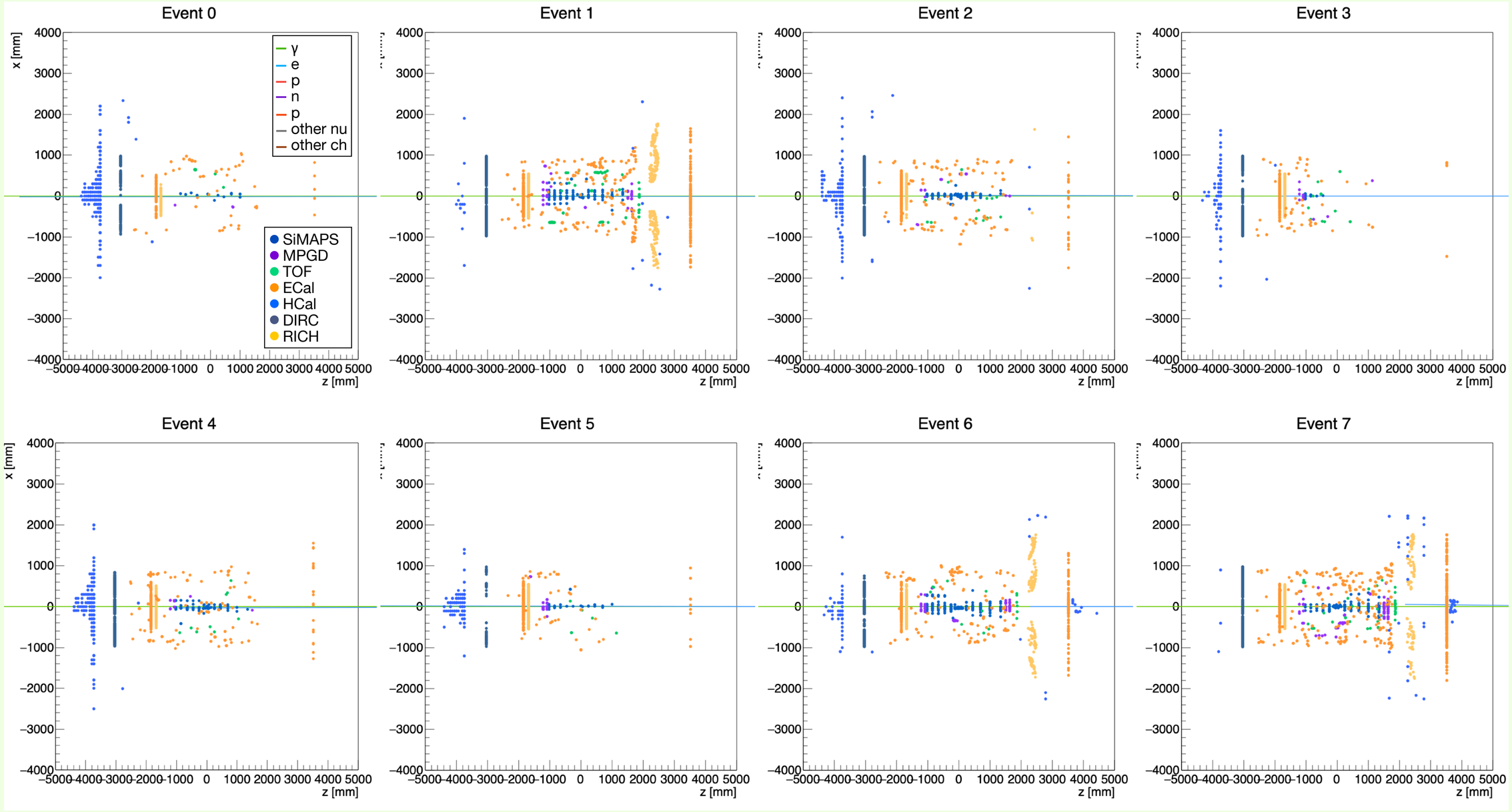


- Found the pre-filter can triggered most low Q2 (> 1 GeV^2) DIS events.
- In the new bkg simulation, large number of fake triggers were created.
→ I am checking the details now.

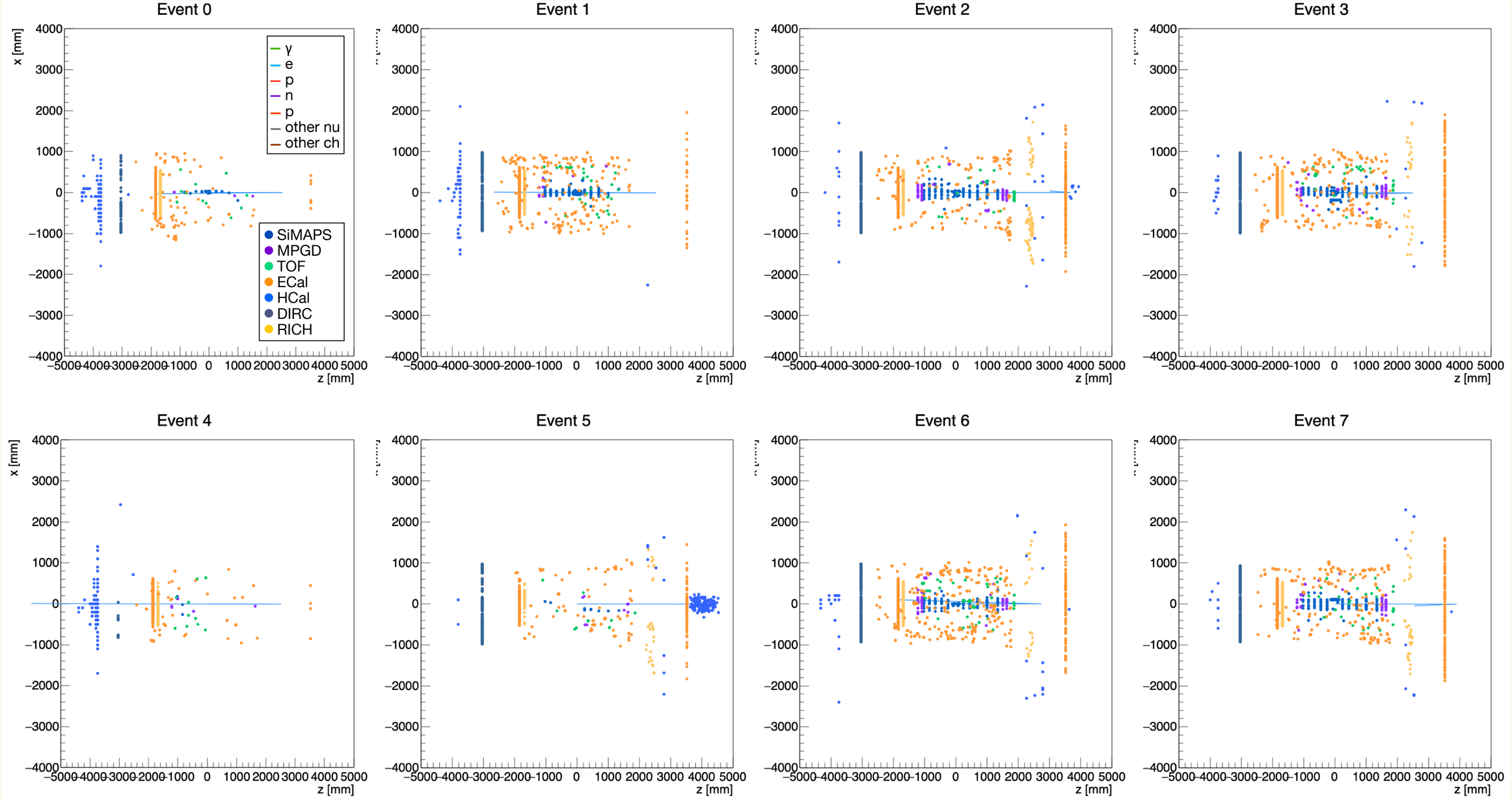
Synchrotron radiation



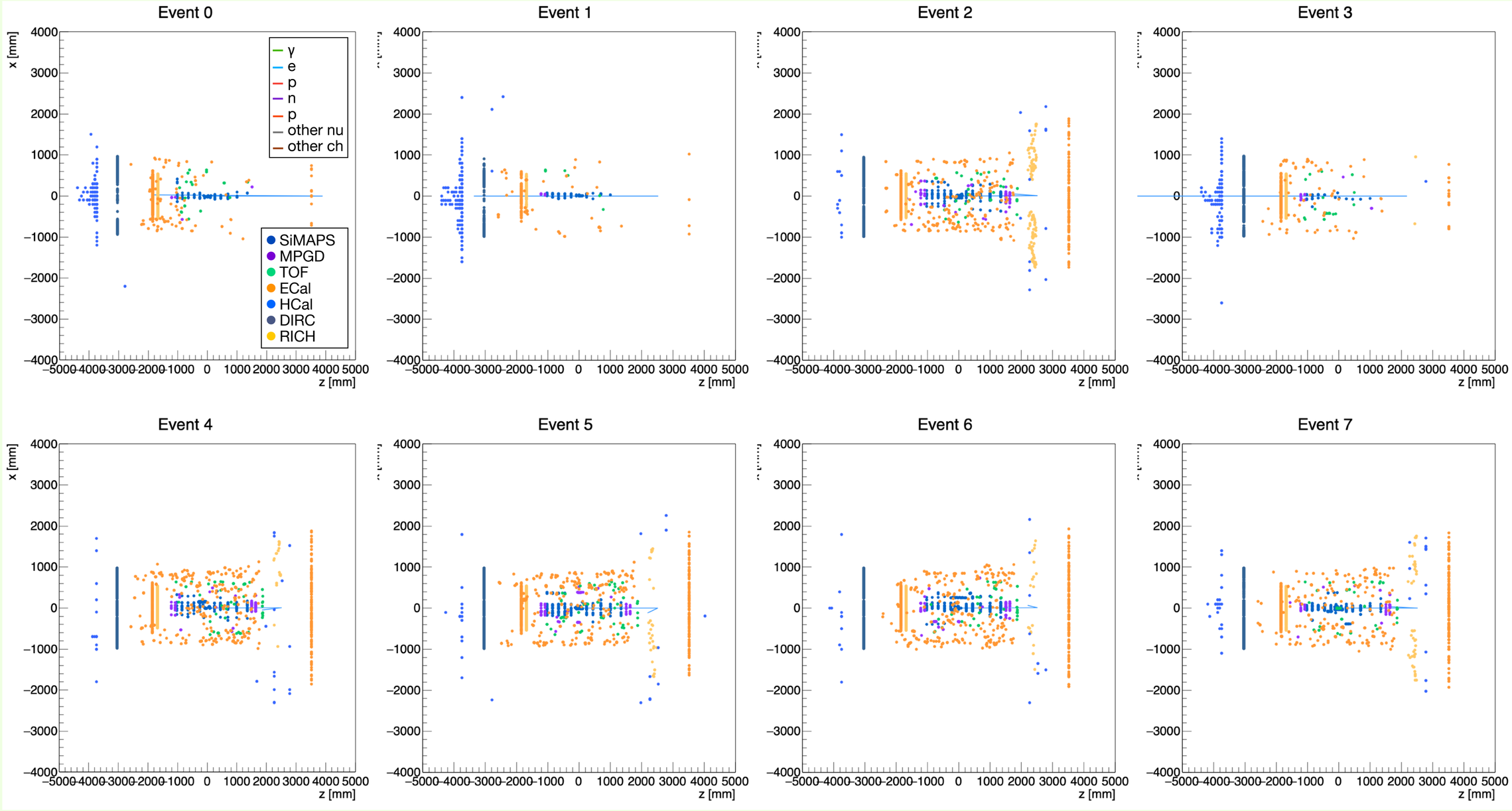
e Bremsstrahlung



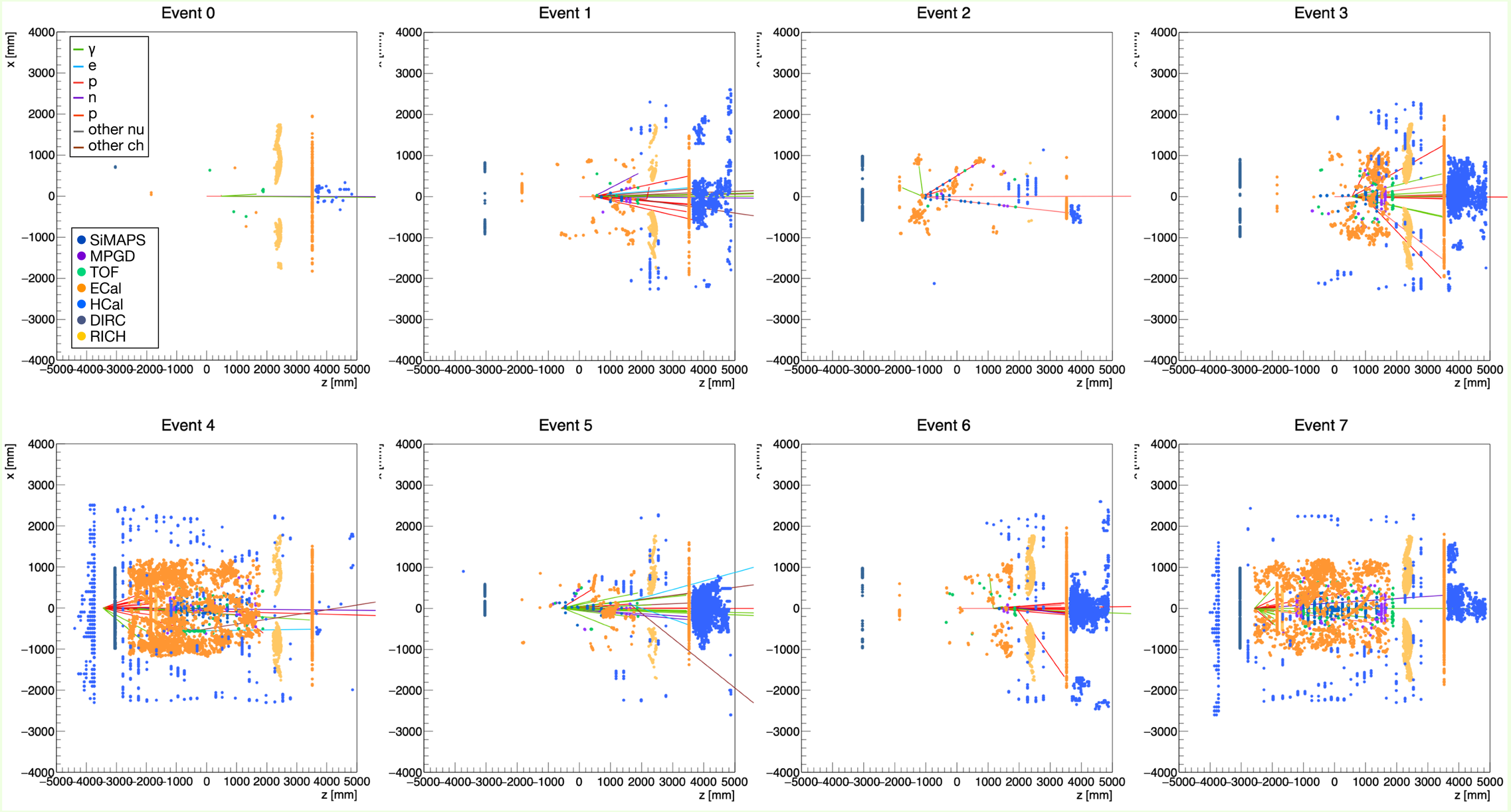
Coulomb losses



Touschek

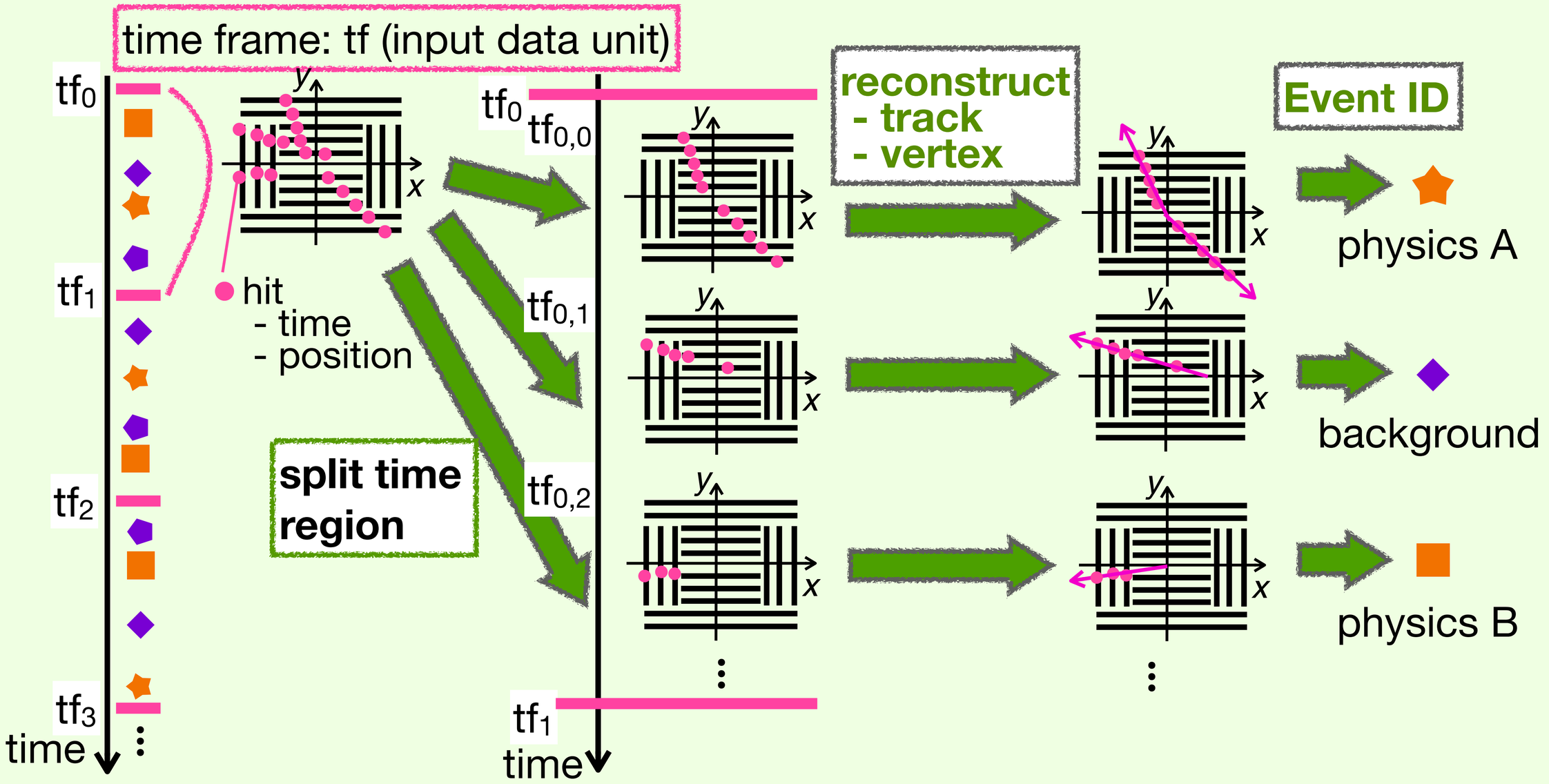

Event 0
Event 1
Event 2
Event 3
Event 4
Event 5
Event 6
Event 7
x [mm]
z [mm]
γ
e
p
n
p
other nu
other ch
SiMAPS
MPGD
TOF
ECal
HCal
DIRC
RICH

Proton beam gas



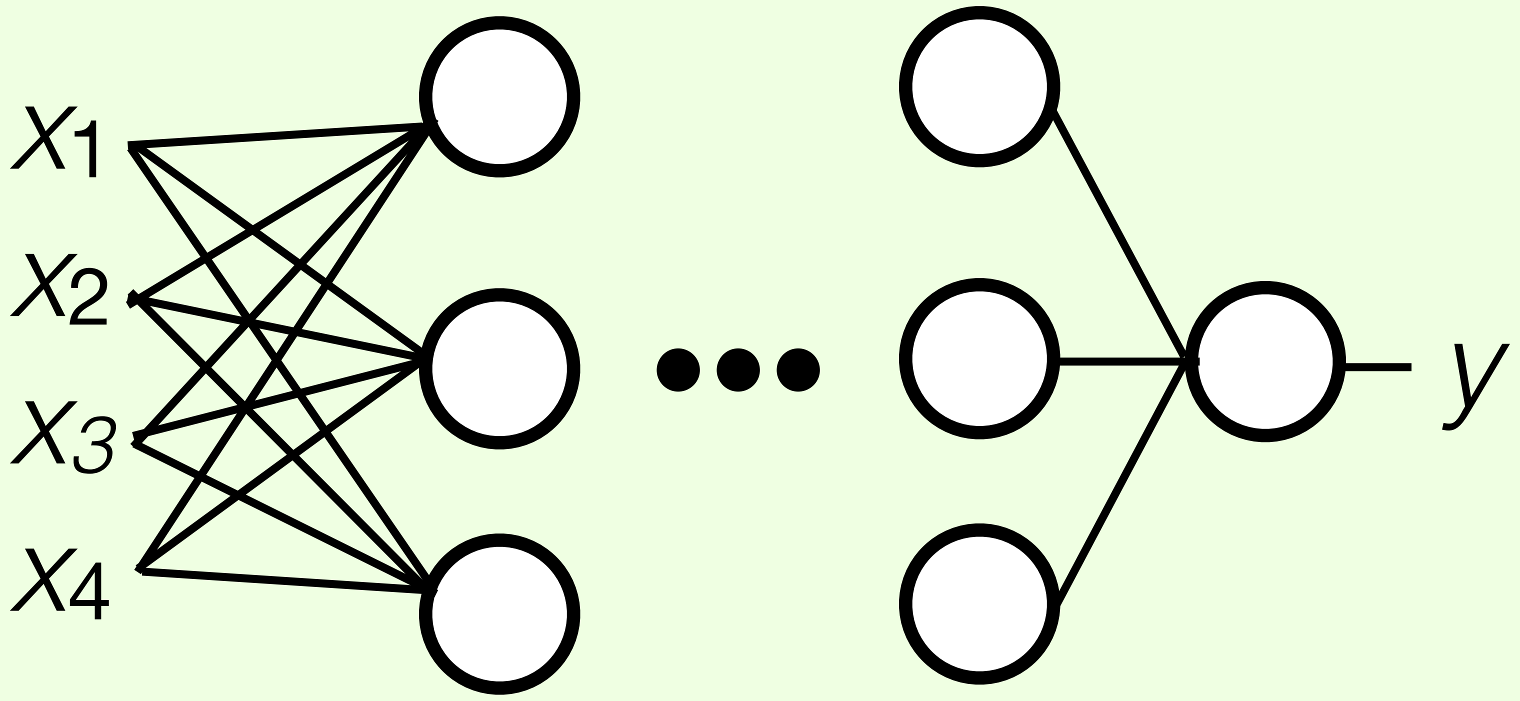
Use ML/AI to identify physics and background

Extract physics events from a time frame and identify their physics process.

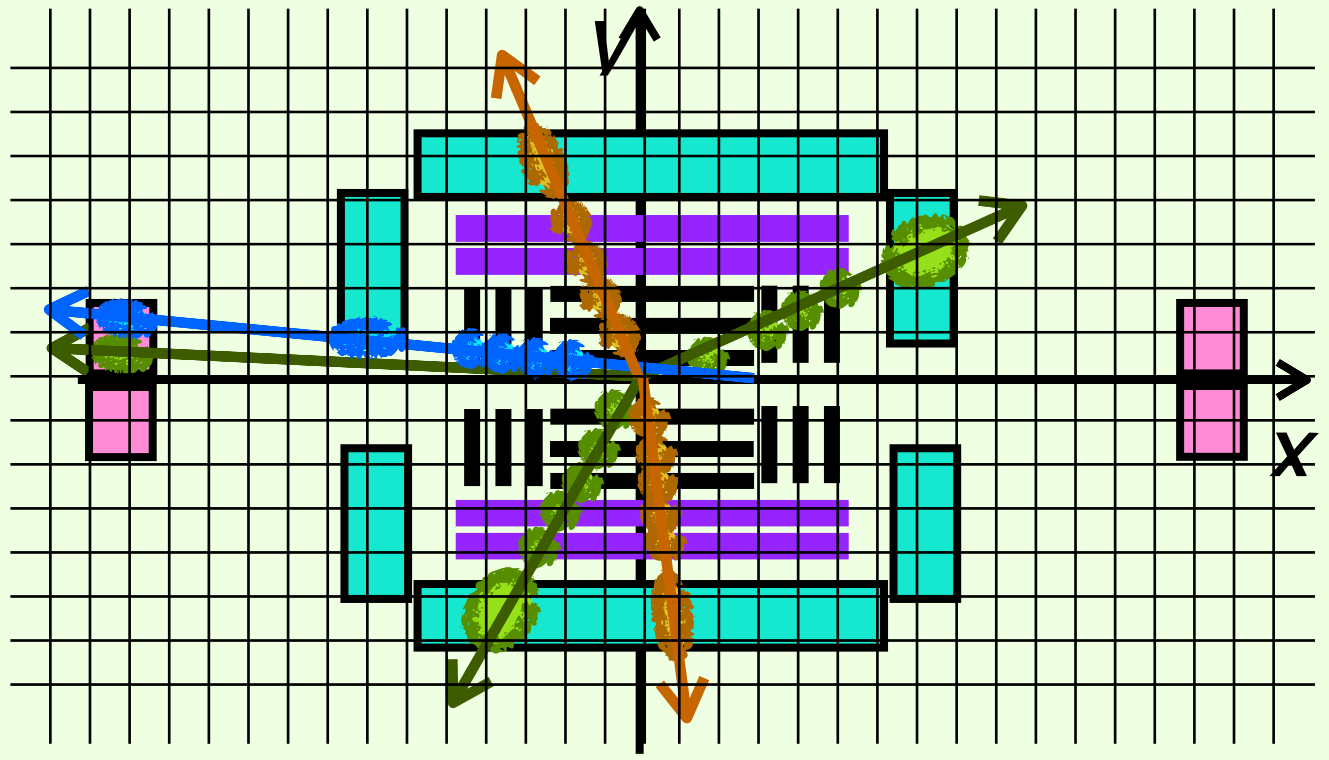


How to apply ML

The input shapes need to be consistent. (large dimension/very sparse)



Case1: hit like picture



Grid the geometrical region

Pros: Simple

Cons: Not effective

Case2: Minimum input

$$x_1 = \begin{pmatrix} t_{\text{det1, hit1}}, x_{\text{det1, hit1}} \\ t_{\text{det1, hit2}}, x_{\text{det1, hit2}} \\ t_{\text{det1, hit3}}, x_{\text{det1, hit3}} \\ t_{\text{det1, hit4}}, x_{\text{det1, hit4}} \\ 0 \\ 0 \\ t_{\text{det2, hit1}}, x_{\text{det2, hit1}} \\ t_{\text{det2, hit2}}, x_{\text{det2, hit2}} \\ t_{\text{det2, hit3}}, x_{\text{det2, hit3}} \\ 0 \\ 0 \\ 0 \\ \vdots \end{pmatrix}$$

$maxHits_{\text{det1}}$

$maxHits_{\text{det2}}$

Optimized? hit level

Pros: Simple + a little effective

Cons: Not sure the # of max hits

Case3: Use Tracks and Vertex

$$x_1 = \begin{pmatrix} t_{\text{vertex1}}, x_{\text{vertex1}}, y_{\text{vertex1}}, z_{\text{vertex1}} \\ t_{\text{track1}}, p_{\text{Ttrack1}}, \theta_{\text{track1}}, charge_{\text{track1}} \\ t_{\text{track2}}, p_{\text{Ttrack2}}, \theta_{\text{track2}}, charge_{\text{track2}} \\ t_{\text{track3}}, p_{\text{Ttrack3}}, \theta_{\text{track3}}, charge_{\text{track3}} \\ t_{\text{track4}}, p_{\text{Ttrack4}}, \theta_{\text{track4}}, charge_{\text{track4}} \\ 0 \\ 0 \end{pmatrix}$$

$maxtracks$

Pros: Small dimension

Cons: Reduced information

Outlook1: physics simulations

Physics simulation [git]: All ready is prepared.

BACKGROUNDS	Update background configurations (#5)
DDIS	Add DDIS configuration for rapgap3.310-1.0 ep noRad 10x...
DIS	Add BeAGLE1.03.02-2.0 DIS eAu configurations for 10x10...
EXCLUSIVE	Add lAger3.6.1-1.0 DVMP JPsi MuMu configurations for 10
SIDIS	Add DIJET dataset configuration for pythia6.428-dijet-v1..
SINGLE	Collect timing data for single neutrons
SR	nevents needs gzip

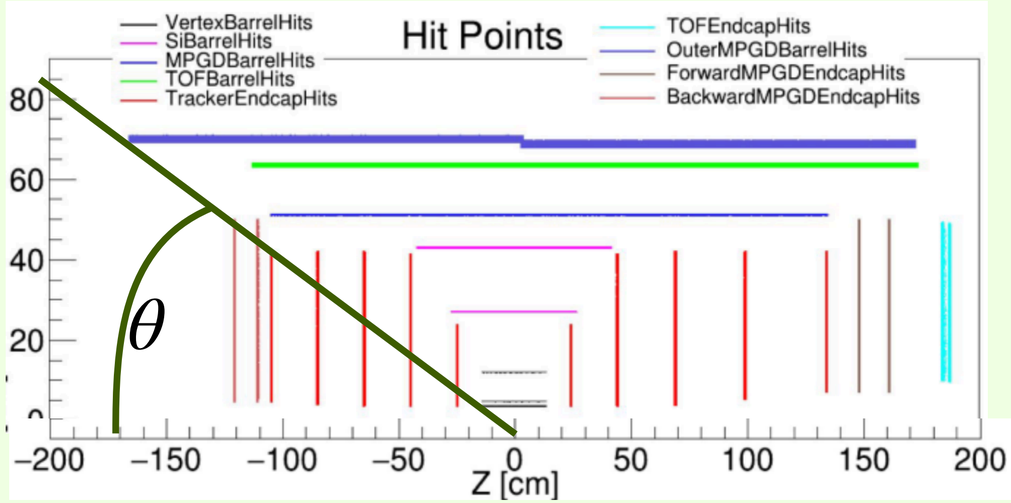
EXCLUSIVE physics

DDVCS	1.1.6-1.0 EpIC DDVCS and 1.3.0-1.0 eSTARlight Photoproduction JPSI...
DEMP	Add DEMPgen-1.2.4
DIFFRACTIVE_JPSI	1.1.6-1.0 EpIC DDVCS and 1.3.0-1.0 eSTARlight Photoproduction JPSI...
DIFFRACTIVE_PHI	New diffractive phi and diffractive rho samples (#16)
DIFFRACTIVE_RHO	New diffractive phi and diffractive rho samples (#16)
DVCS	Adding DVCS 10x130 version 1.1
DVMP	Add lAger3.6.1-1.0 DVMP JPsi MuMu configurations for 10x130, 10x2...
OMEGA	More and smaller chunks for EXCLUSIVE
PHOTOPRODUCTION_JPSI	1.1.6-1.0 EpIC DDVCS and 1.3.0-1.0 eSTARlight Photoproduction JPSI...
RHO	More and smaller chunks for EXCLUSIVE
SPECTROSCOPY	Split spectroscopy files

Most physics simulations are prepared.
→ Various DIS physics simulations have been prepared (W/ background, some beam energy)
→ **Need simulations of EXCLUSIVE/SIDIS for eicrecon.**

Outlook2: use all detector

The current trigger algorithm uses **only tracking detectors**, but it misses low-Q^2 events because the emitted particles do not produce hits.



Tracking detector

- Silicon MAPS: ~2 μs [ref, p11]
- MPGD: ~10 ns [ref, p11]
- TOF: ~30 ps[ref, p11]

PID

- hpDIRC: ~50 ps [ref, sec2]
- dRICH: ~20 ps [ref, p2]
- pfRICH / HRPPD / LAPPD: ~50 ps [ref, sec2]

Calorimeter

- Barrel Imaging Calorimeter: ~ 3.25 ns [ref]
- Backward/Forward EMCal, Barrel/Forward/Backward HCal: ?? s
- Zero Degree Calorimeter: ~30ps [ref]

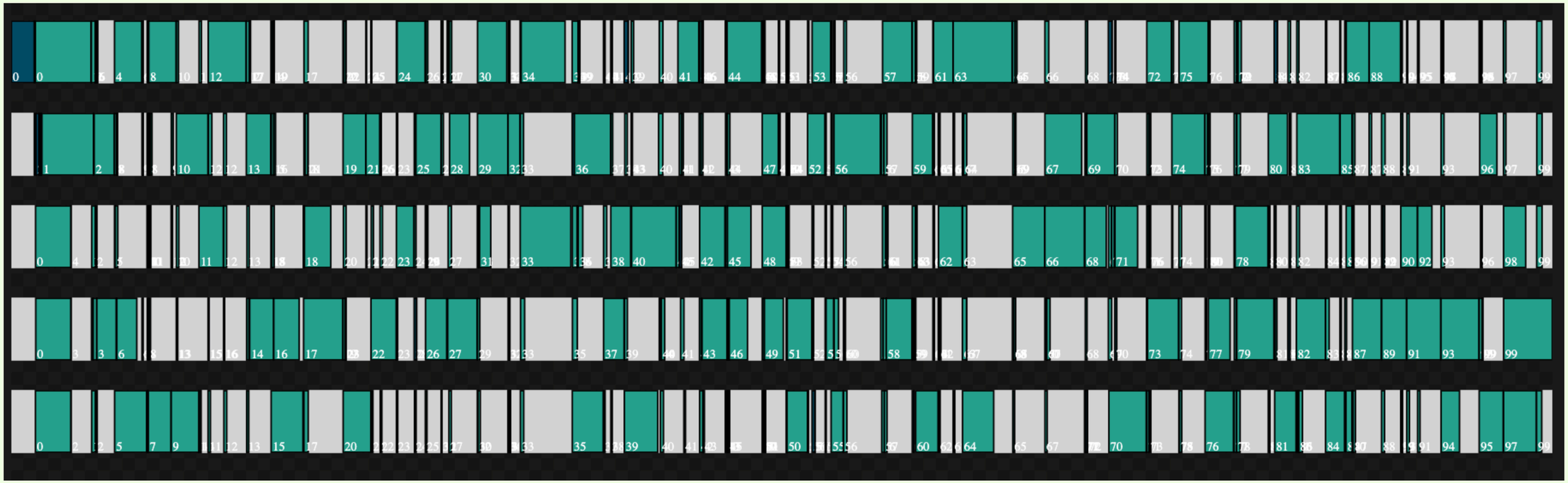
Far-forward

- Roman Pots / Off-Momentum Detectors / B0: 30 ps [ref]

Outlook3: nthread test

nthread=1: 456.223 s / 100 time frame

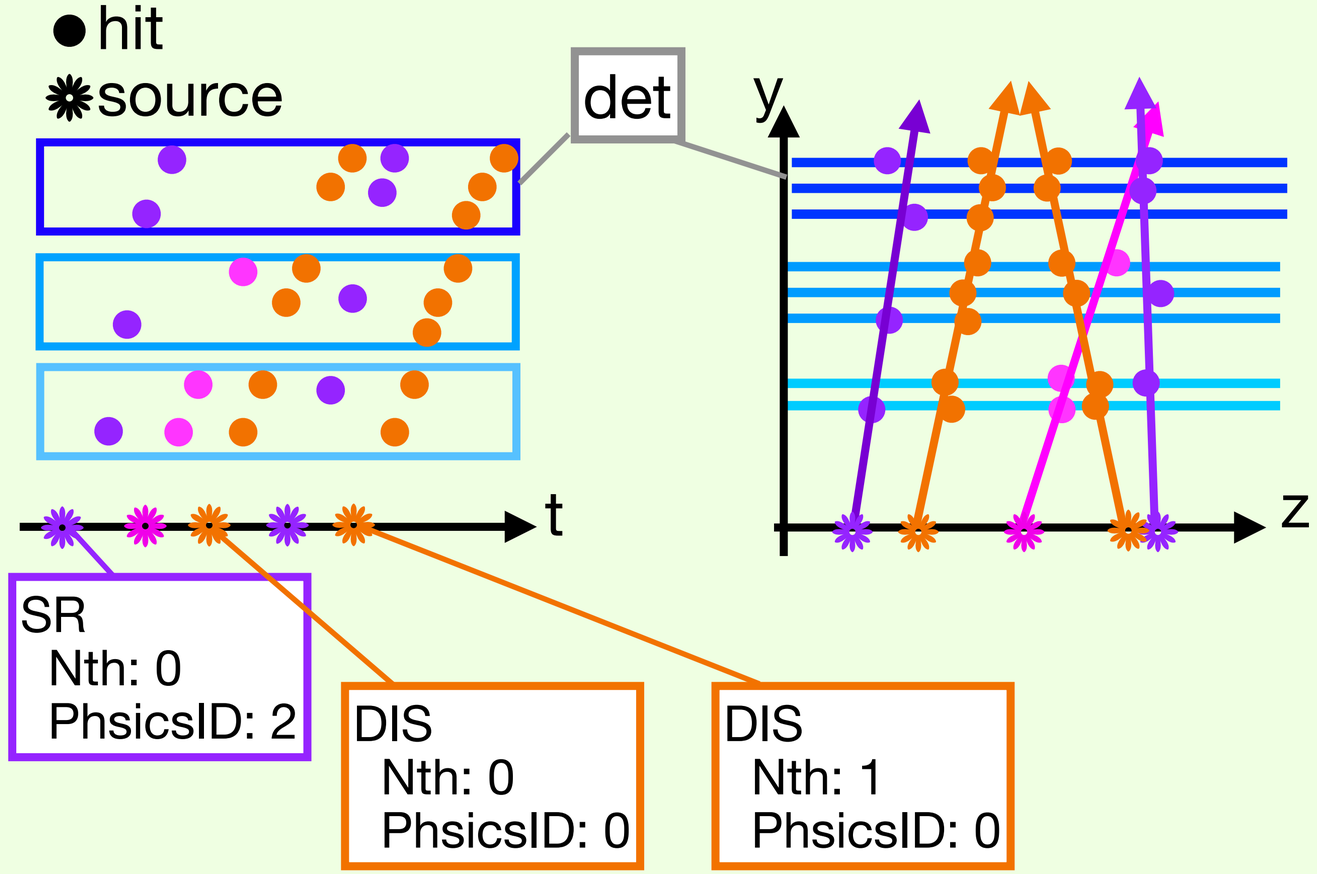
nthread=5: 541.52 s / 100 time frame



Despite increasing the number of threads correctly, the processing time increased.
→ Need to understand the Nathan's evaluator and the reason.

New Source Data Type Proposal

Currently we are missing some event source information (source time, numbering, Q^2…).
We have MC particles information and it has generation status to distinguish physics and background. However, this status cannot distinguish different sources of same type source.
→The proposing data type enable to distinguish sources and give valuable information.
And it is helpful for both MC and reconstruction (a little duplicate reco vertex).



✸ EventInfo ← NEW
- Nth
- CollisionTiming
- CollisionEnergy
- CollisionPosition
- CollisionAngle
- Q2
- PhysicsID → background

[DIS, EXCLUSIVE, SR, etc…]
0 1 2 …

● DetRecHits
- ⋮
- EventAssociation ← NEW