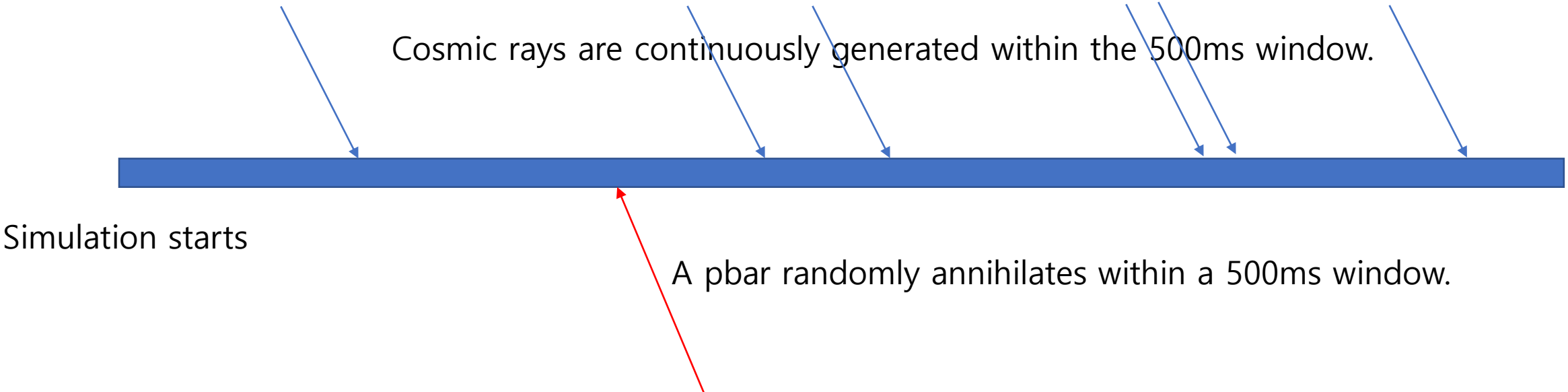
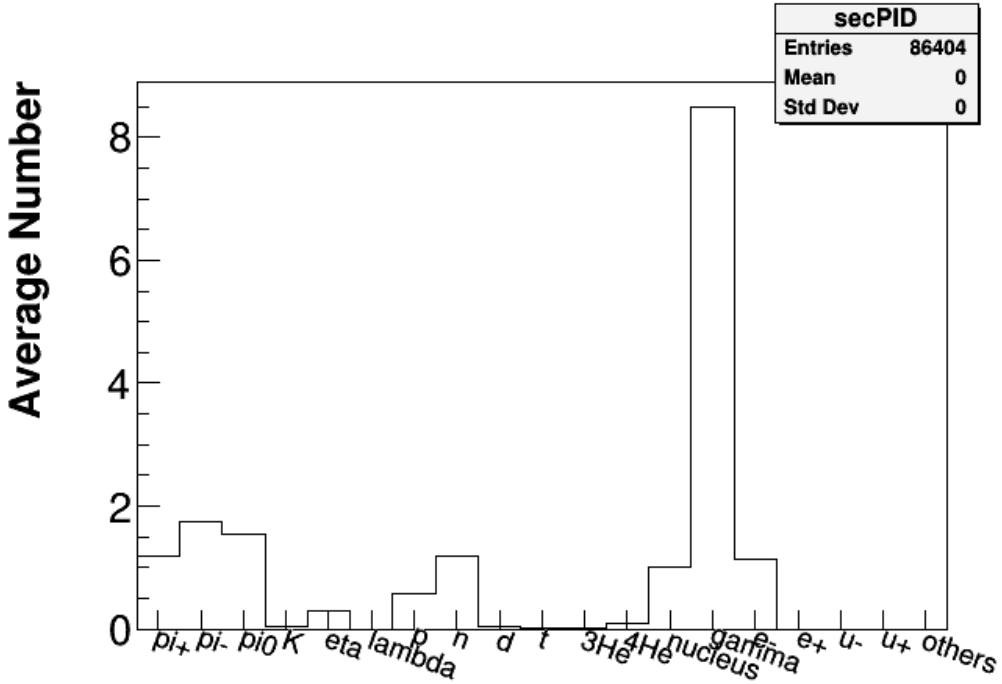
Neutron Tracking Problem

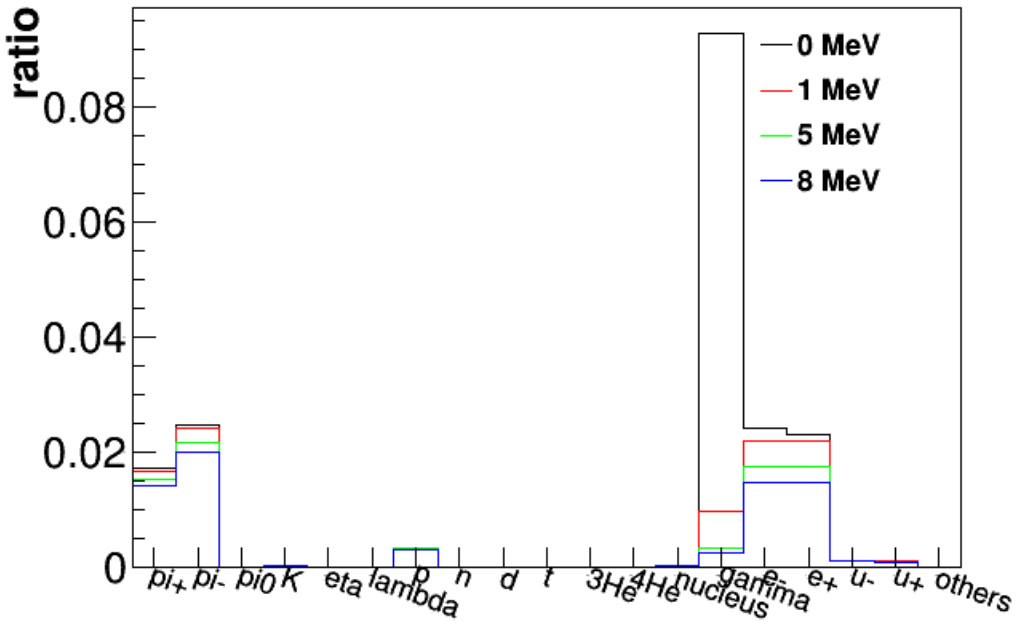
- Pbar + cosmic ray simulation does not track neutrons.
- But neutron creation has no problem.



Neutron Tracking Problem

- Left (secondaries from pbar) Right (scintillator hit particles)





Neutron Tracking Problem

- Neutron tracking is stopped after 10us elapsed from a simulation start. (physicslist basic setting)

```
*********************************************************************************************
* G4Track Information:   Particle = neutron,   Track ID = 5891,   Parent ID = 5880
*********************************************************************************************

Step#    X(mm)    Y(mm)    Z(mm) KinE(MeV)  dE(MeV) StepLeng TrackLeng  NextVolume ProcName
    0     8.62   -0.392      309      4.89        0        0         0  ChamberTop initStep
    1     8.62   -0.392      309      4.89        0        0         0  ChamberTop nKiller

*********************************************************************************************
* G4Track Information:   Particle = neutron,   Track ID = 5890,   Parent ID = 5880
*********************************************************************************************

Step#    X(mm)    Y(mm)    Z(mm) KinE(MeV)  dE(MeV) StepLeng TrackLeng  NextVolume ProcName
    0     8.62   -0.392      309      8.16        0        0         0  ChamberTop initStep
    1     8.62   -0.392      309      8.16        0        0         0  ChamberTop nKiller
```

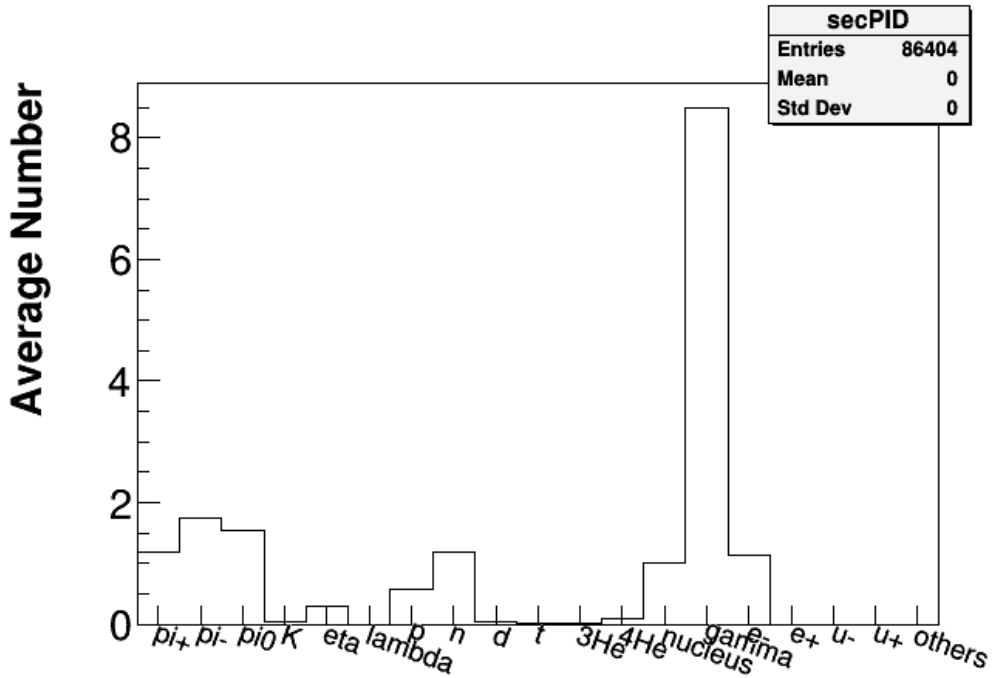
```
WARNING in G4StoppingPhysics::ConstructProcess:                    not able to deal with nucl
WARNING in G4StoppingPhysics::ConstructProcess:                    not able to deal with nucl
### G4HadronicAbsorptionBertini added for xi-
WARNING in G4StoppingPhysics::ConstructProcess:                    not able to deal with nucl
### Adding tracking cuts for neutron  TimeCut(ns)= 10000  KinEnergyCut(MeV)= 0
 Revised FTFTP_BERT_TRV - new threshold between BERT and FTFP  is over the interval 2 to 4 GeV
  -- quasiElastic was asked to be 0 and it is reset to 0
### kgbarPhysicsList::ConstructProcess is done
```

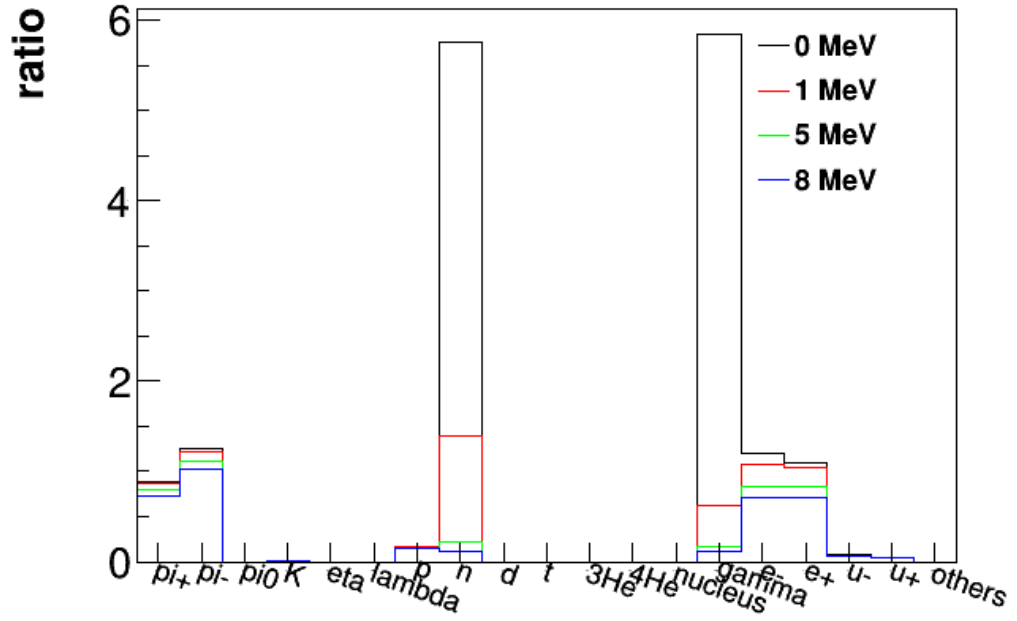
Neutron Tracking Problem

- If only FTFP_BERT_TRV is imported, Geant4 macro /physics_engine/neutron/timeLimit can change the neutron tracking time.
- In kgbar simulation, FTFP_BERT_TRV+radioactive library are imported.
- I cannot find such macro or way to import the macro.
- So change basic setting in Geant4 and recompile it.

Neutron Tracking Problem

```
WARNING in G4StoppingPhysics::ConstructProcess:                    not able to
### G4HadronicAbsorptionBertini added for xi-
WARNING in G4StoppingPhysics::ConstructProcess:                    not able to
### Adding tracking cuts for neutron  TimeCut(ns)= 5.1e+08  KinEnergyCut(MeV)= 0
 Revised FTFTP_BERT_TRV - new threshold between BERT and FTFP  is over the interv
  -- quasiElastic was asked to be 0 and it is reset to 0
### kgbarPhysicsList::ConstructProcess is done
world cuts are set
```





After the treatment

- Threshold = 0.3 MeV
- With pile-up treatment
- The 1st algorithm is effective when the threshold is low.

		1 S.E (B.R)	2 S.E (B.R)	3 S.E (B.R)
Before	Upward	0.383 (0.030)	0.353 (0.032)	0.342 (0.020)
	Downward	0.334 (0.037)	0.330 (0.036)	0.323 (0.022)
After	Upward	0.489 (0.021)	0.330 (0.039)	0.324 (0.024)
	Downward	0.433 (0.026)	0.337 (0.037)	0.333 (0.023)

After the treatment

- Threshold = 5 MeV
- Selection efficiency increase after the treatment.
- Background rates decrease after the treatment.

		1 S.E (B.R)	2 S.E (B.R)	3 S.E (B.R)
Before	Upward	0.2817 (0.0073)	0.2672 (0.0062)	0.2427 (0.0056)
	Downward	0.2609 (0.0078)	0.2589 (0.0063)	0.2455 (0.0051)
After	Upward	0.2969 (0.0070)	0.2739 (0.0061)	0.2531 (0.0054)
	Downward	0.2768 (0.0072)	0.2688 (0.0060)	0.2575 (0.0049)

Modified 1st algorithm

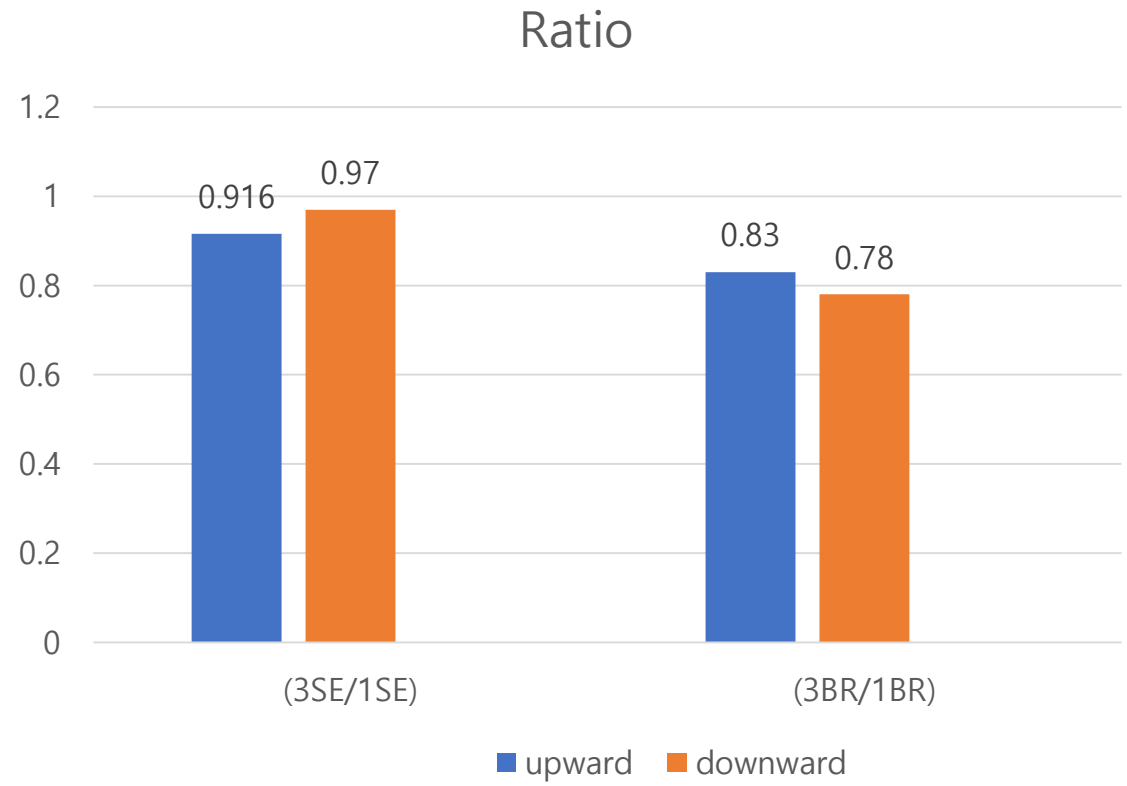
- The Earliest bottom-top hit within a trigger dt > 2 ns rejects.
- Not top-bottom 2 hits coincidence, but 3hits coincidence containing top-bottom combination

- Very effective and efficient for low threshold = 0.3MeV

	0.3 MeV S.E (B.R)	5 MeV
upward	0.4857 (0.0131)	0.2762 (0.0065)
downward	0.4304 (0.0167)	0.2656 (0.0063)

3rd and modified 1st algorithms

5MeV threshold	3rd S.E (B.R)	Modified 1st
upward	0.2531 (0.0054)	0.2762 (0.0065)
downward	0.2575 (0.0049)	0.2656 (0.0063)



- Difference of efficiency and background rate between two algorithms for different thresholds will be tested.

Back up

- The word “event” means the annihilation of one antiproton event.
- If a hit occurs, a trigger is started.
- Selection efficiency =

  (# of event whose # of selected trigger is one)/(# of total event)
- Background rate = False trigger rate =

  (# of false trigger)/ (# of event whose # of selected trigger is one)

Back up

- 1) First, we select the triggers having Top-Bottom combination with two or more hits, which have at least one hit at Top and Bottom, each. Then, by checking the time difference between the earliest top hit and earliest bottom hit, we reject the trigger with a condition of $\Delta t = T_{bot} - T_{top} > 2$ ns according to the distributions of cosmic-rays.

- 2) This algorithm is almost same as 1) but checking that the time differences of all possible combinations of a top hit and a bottom hit are less than 2 ns. If one of them, at least, is more than 2 ns, that trigger is rejected.

- 3) This algorithm is almost same as 2) but select the trigger with more than two hits at first.