university of groningen

Online event building and filtering

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$\overline{\text{P}}$ANDA CM 21/1

Main goal

Complete event building and event filtering in the PandaRoot corresponding to the future DAQ system.

Presented in the previous collaboration meeting:

- Event mixing procedure
- Time-gap event building

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What was planned for this meeting :

- Investigate the event “scrambling”
- Implement time-ordered data flow for the EMC clusters and PndTracks
- Implement time-gap event building for the EMC clusters and PndTracks
- Implement event filtering and investigate its performance

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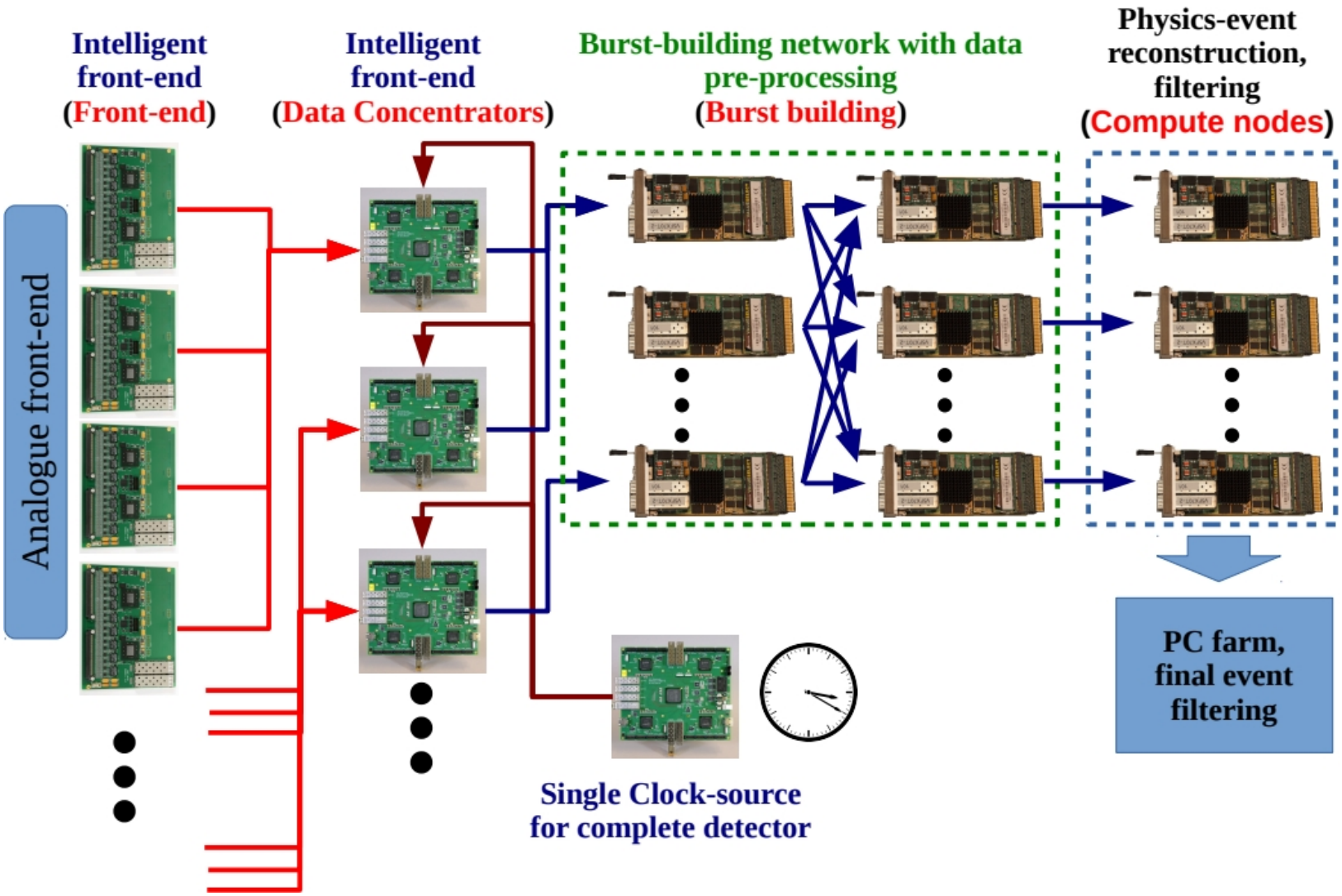
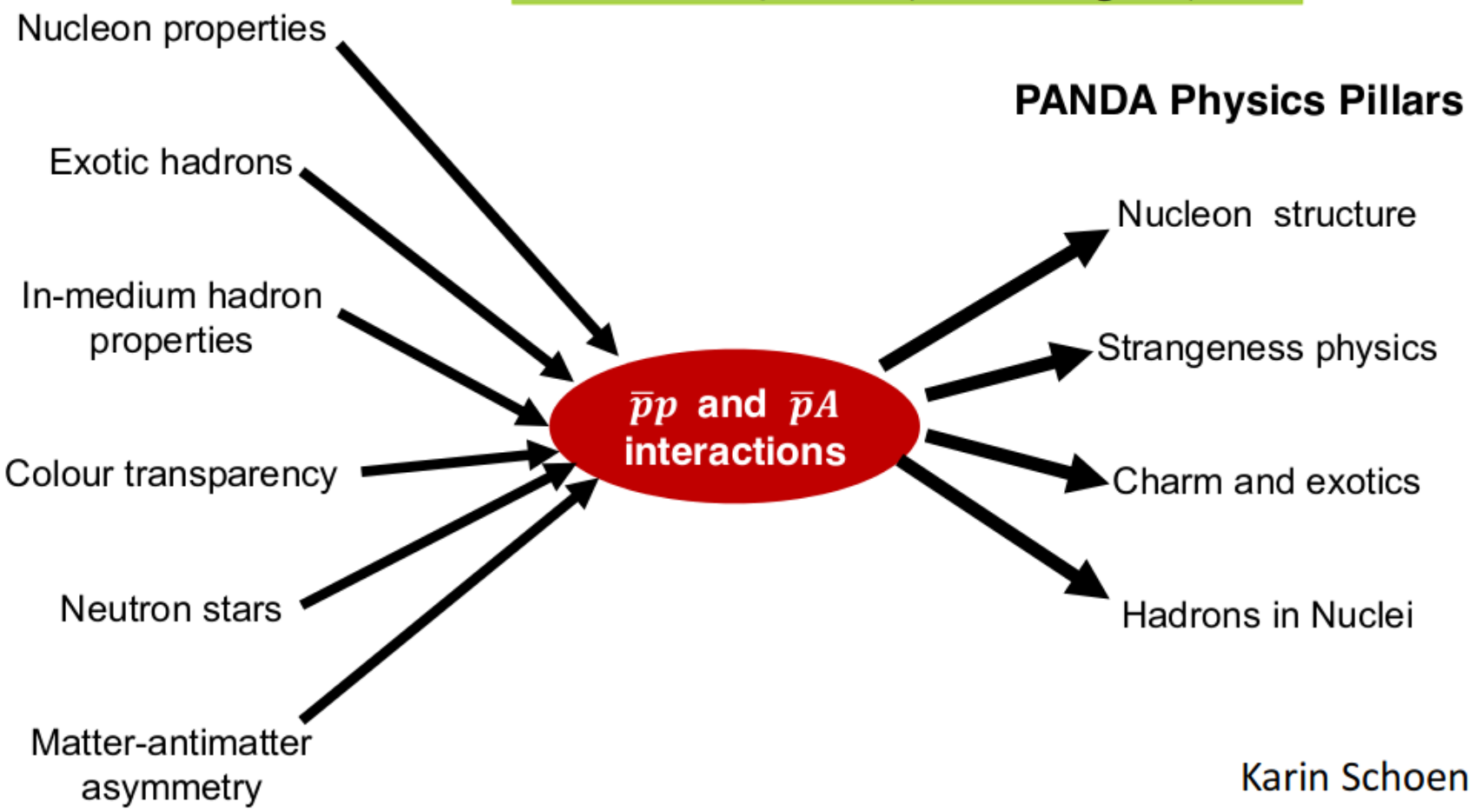
Triggerless DAQ system



PANDA Physics

Key questions

Impact by *precision* (statistics, resolution) and *uniqueness* (terra incognita)



Karin Schoenning

Benchmark channels for the DAQ

1) $\bar{p}p \rightarrow \Lambda^0(\rightarrow p\pi^-)\bar{\Lambda}^0(\rightarrow \bar{p}\pi^+)$ at E_{cm}= 2.304 GeV.

Study of hyperon spin observables for probing QCD in the confinement domain

2) $\bar{p}p \rightarrow J/\psi(\rightarrow e^+e^-)\pi^+\pi^-$ at E_{cm}= 3.872 GeV.

Study of charmonium exotic candidate X(3872)

3) $\bar{p}p \rightarrow e^+e^-$ at E_{cm}= 2.256 GeV.

Study of electric and magnetic form factors of the proton in the time-like region

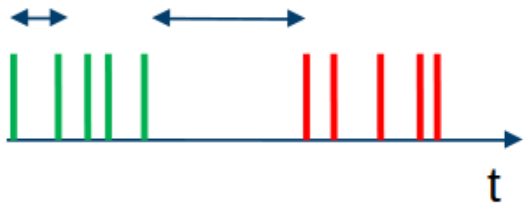
3) $\bar{p}p \rightarrow e^+e^-\pi^0(\rightarrow \gamma\gamma)$ at E_{cm}= 2.256 GeV.

In addition to previous one, this reaction allows to study time-like form factors of the proton below the threshold of the proton pair production of $(2M_p)^2$

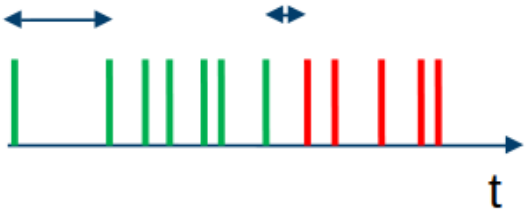
Main requirement : A reasonable efficiency after background suppression.

Time-gap event building in a nutshell

It is based on the time difference between adjacent hits

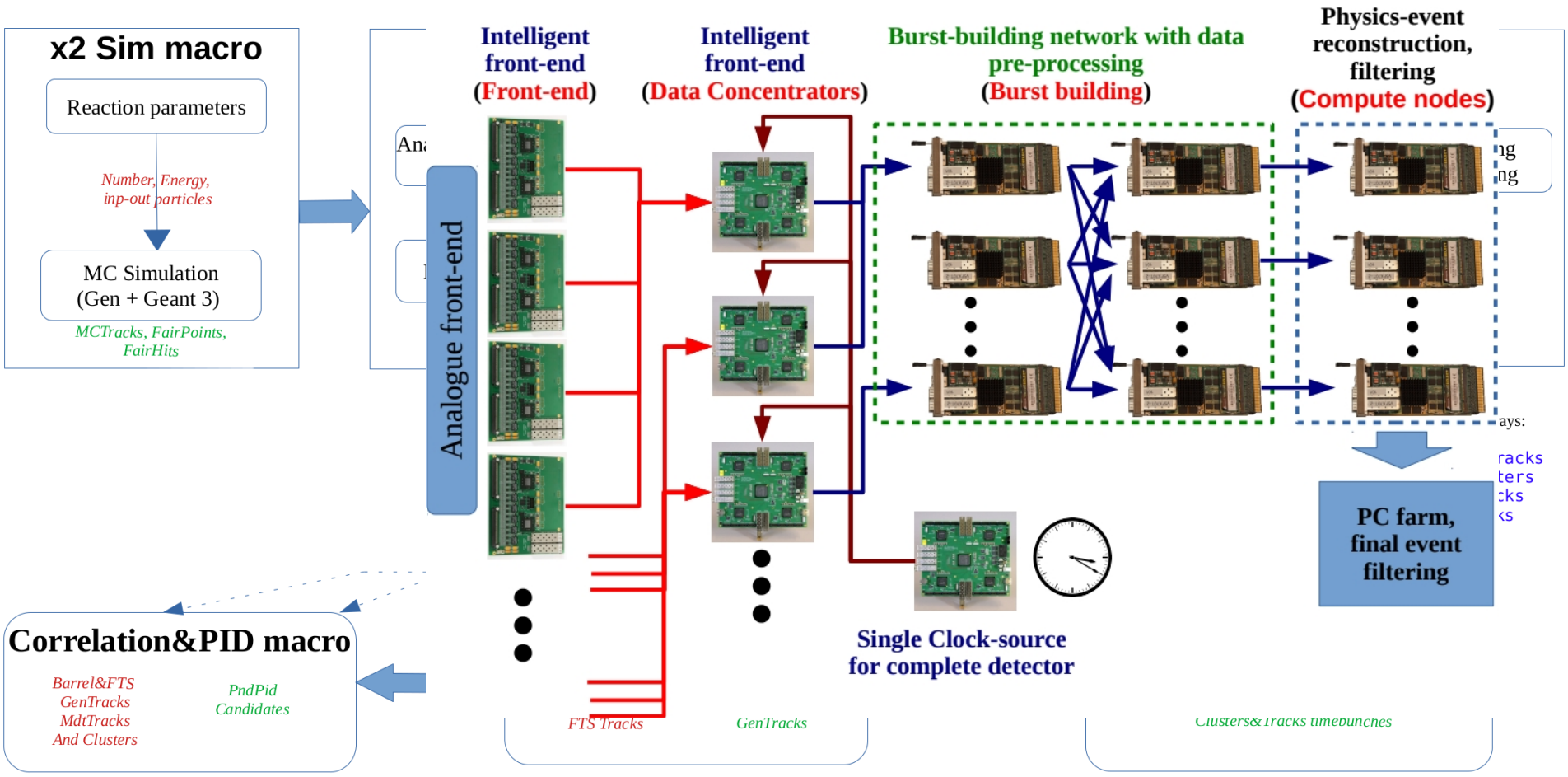


It performs well as long as a time difference between events is big

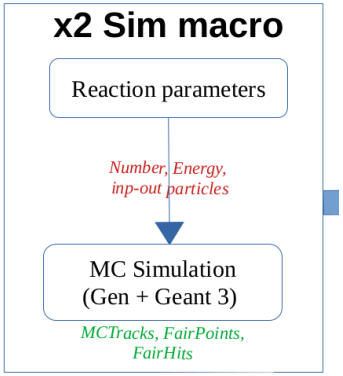


Picture is taken from Tobias Stockmanns' presentation.

Simulation workflow

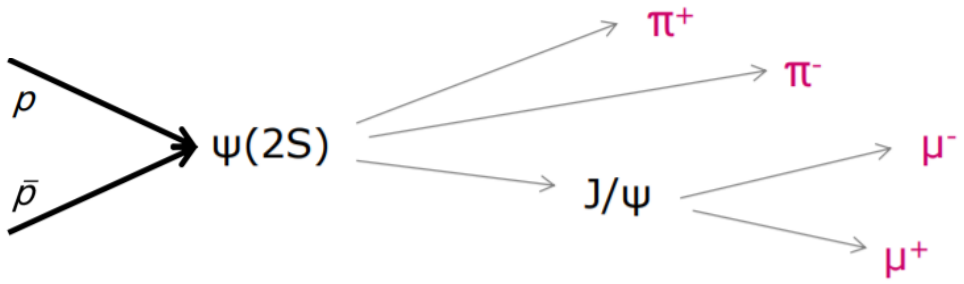


Monte-Carlo information

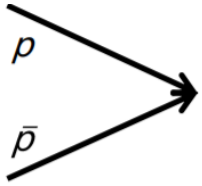


Generate two files with:

1. **SIGNAL** – 1000 events at 6.2315 GeV/c, EvtGen:

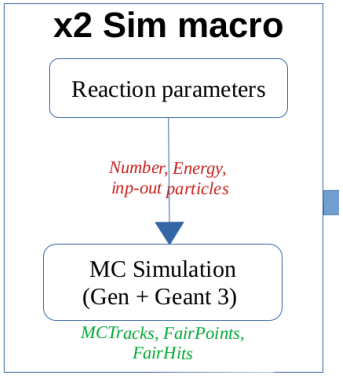


2. **BACKGROUND** – 2000 events at 6.2315 GeV/c, FTF generator:



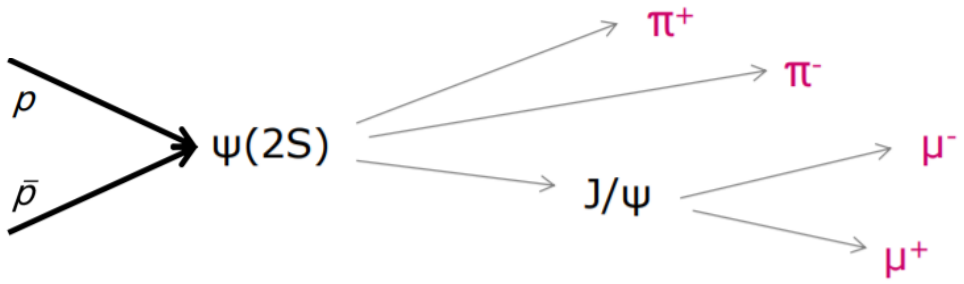
(all possible inelastic reactions, respecting cross-section)

Monte-Carlo information (VIRGO)

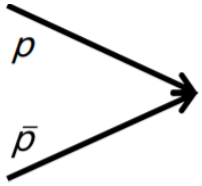


Generate two files with:

1. **SIGNAL** – 10^5 (100 per seed) events at 6.2315 GeV/c, EvtGen:

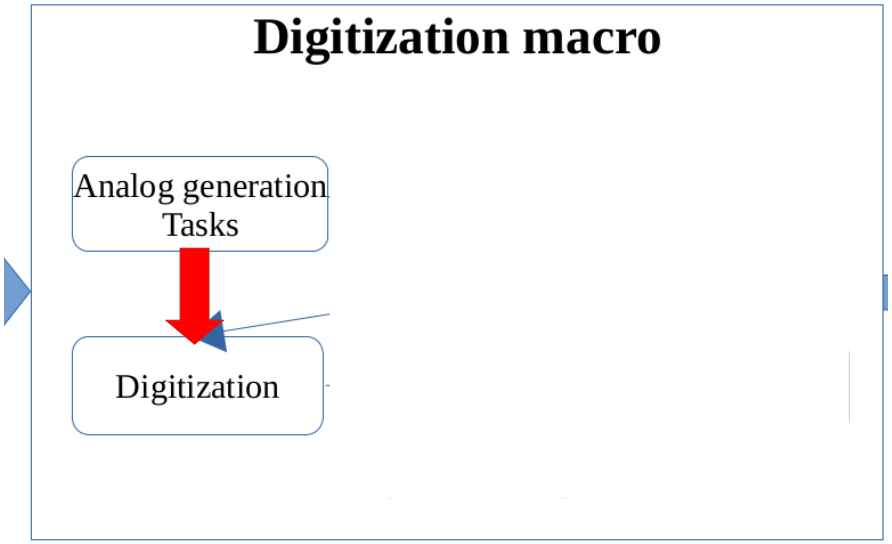


2. **BACKGROUND** – 10^6 (1000 per seed) events at 6.2315 GeV/c, FTF generator:



(all possible inelastic reactions, respecting cross-section)

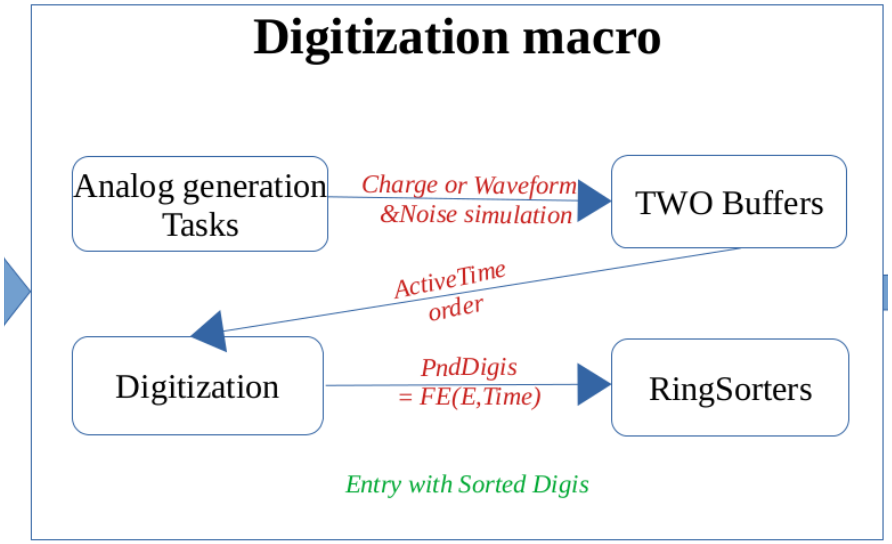
Digitization



Event-based

- generation of analogue signals
- digitization of analogue signals
- no overlap possibility
- no time sorting
- isolated events

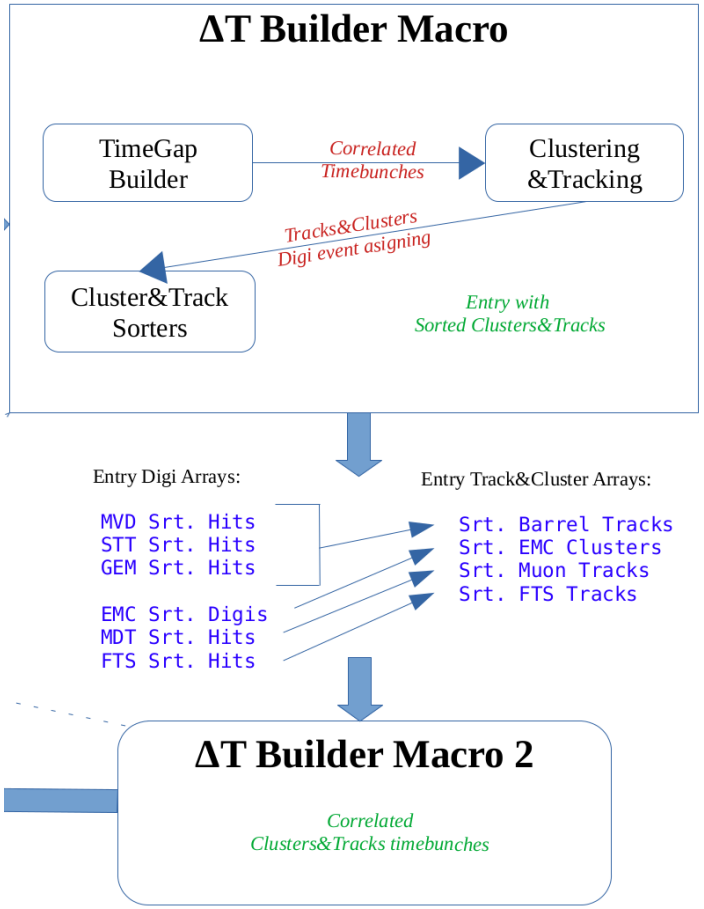
Digitization

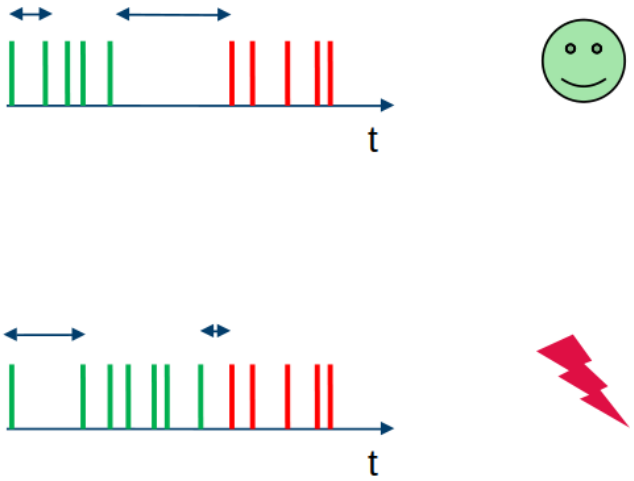


Time-based

- generation of analogue signals
- digitization of analogue signals
- overlap possibility (TWO Buffers)
- time sorting (Ring Sorters)
- time-ordered stream

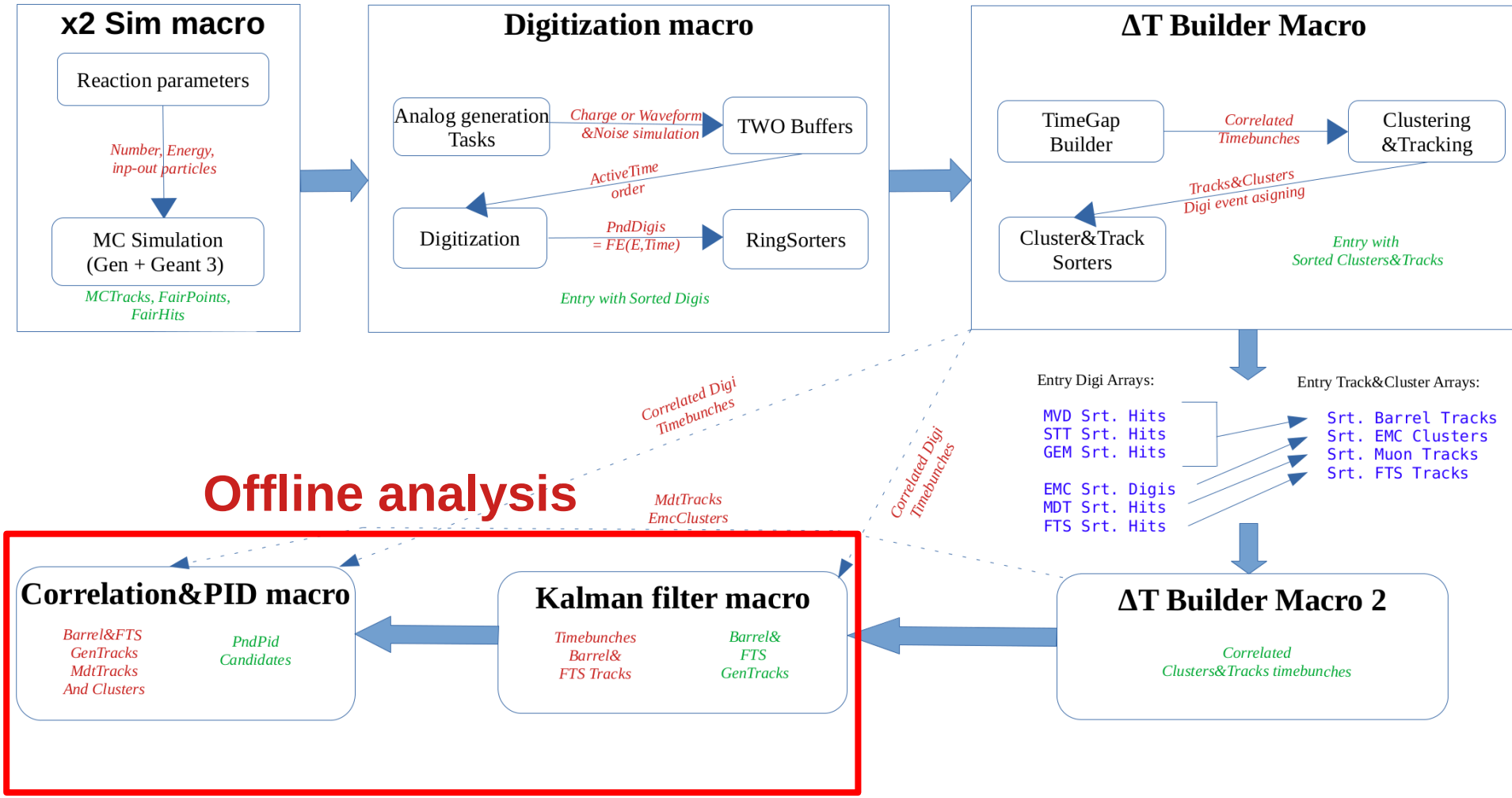
Timebunch creation





- **processing digi-bunches by the time-gap builder**
- **clustering&tracking, within created timebunches**
- **cluster&track sorting**
- **processing tracks&cluster bunches by the time-gap builder**

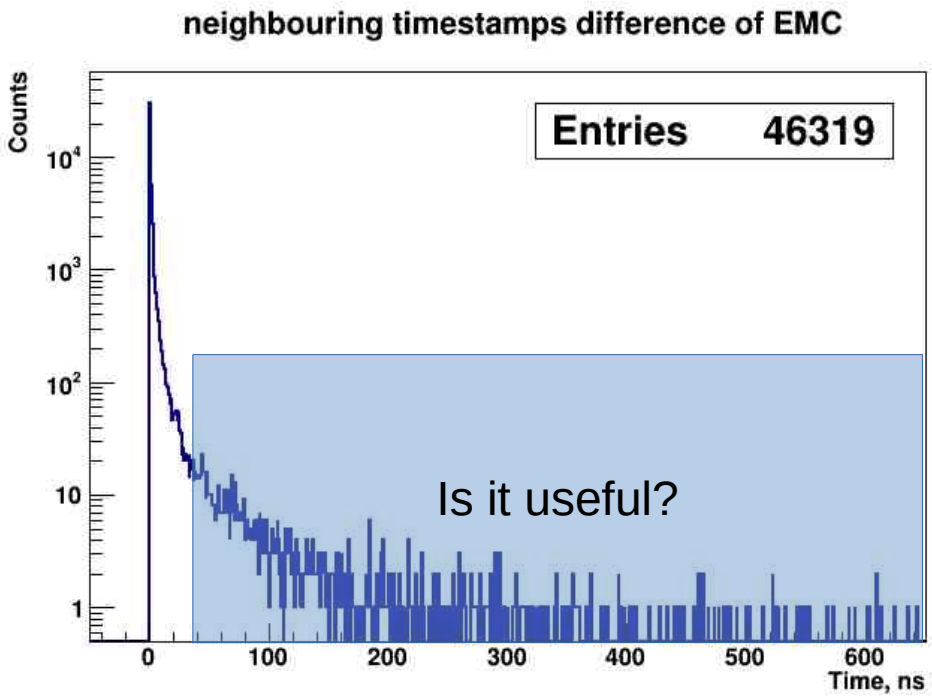
Simulation workflow

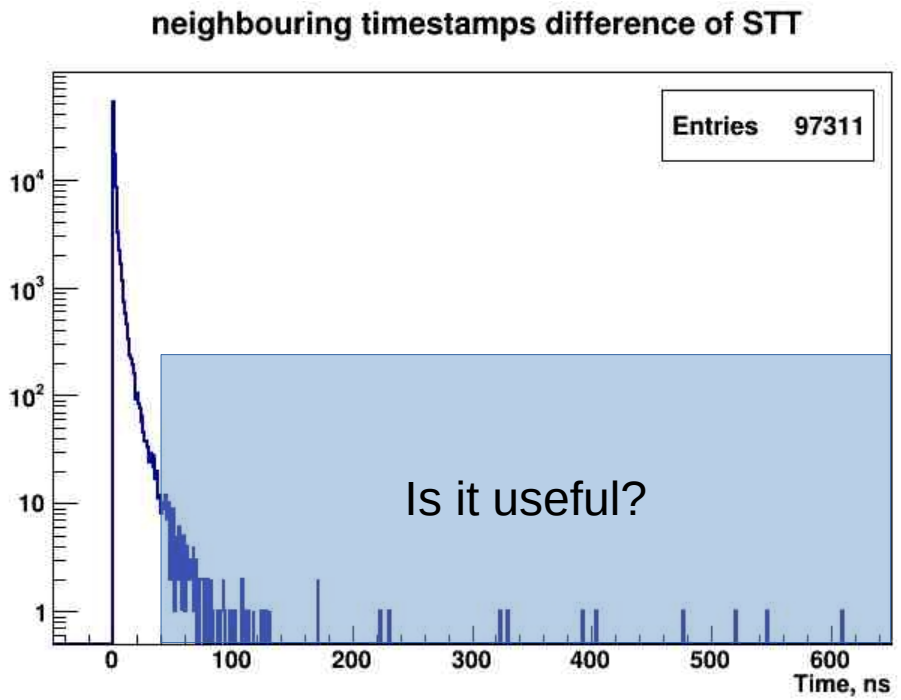


Possible imperfections of the time-gap method

Event-based study (Signal)

Time-difference distribution between adjacent-in-time hits if all events are used

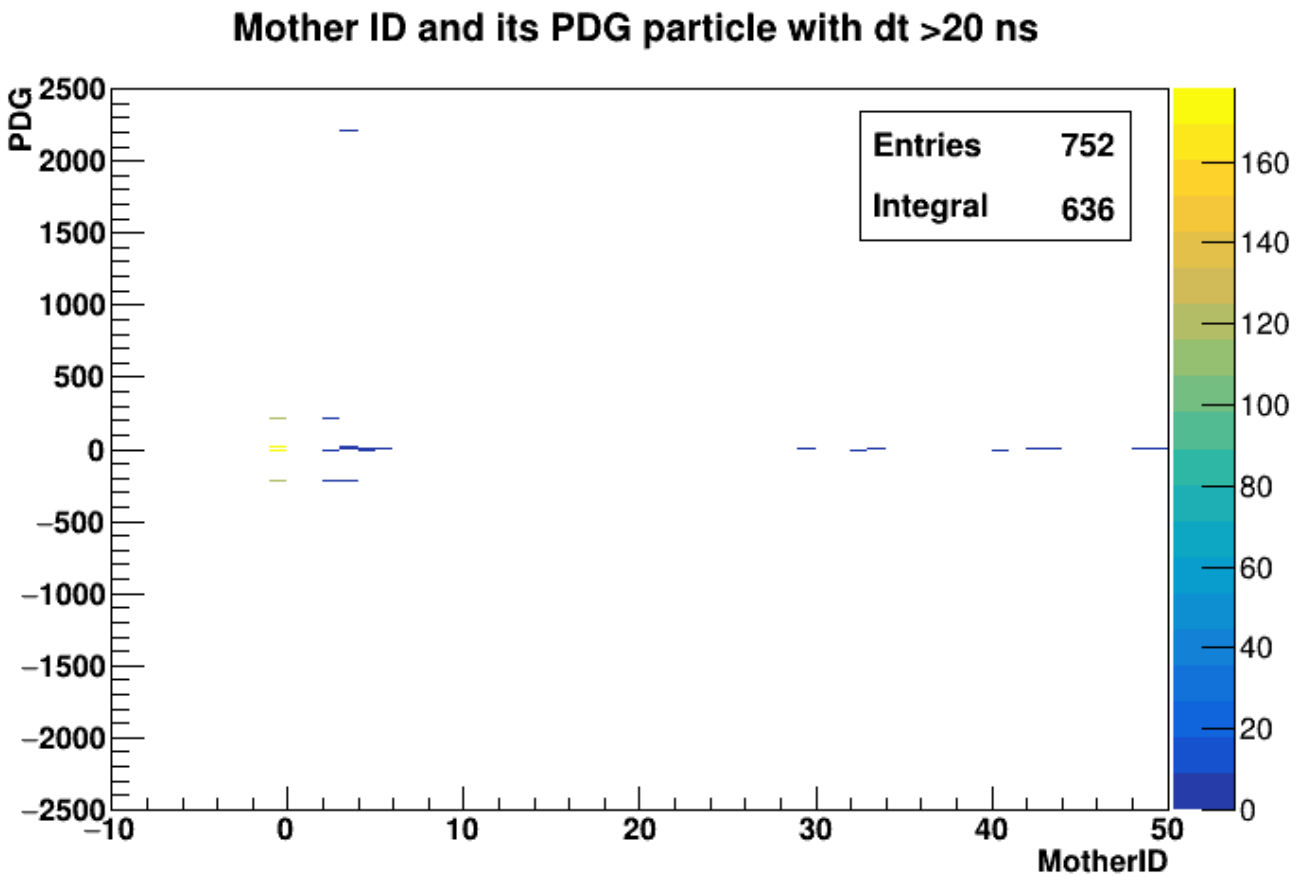




Event “smearing” effect

Possible imperfections of the time-gap method

Event-based study (Signal)



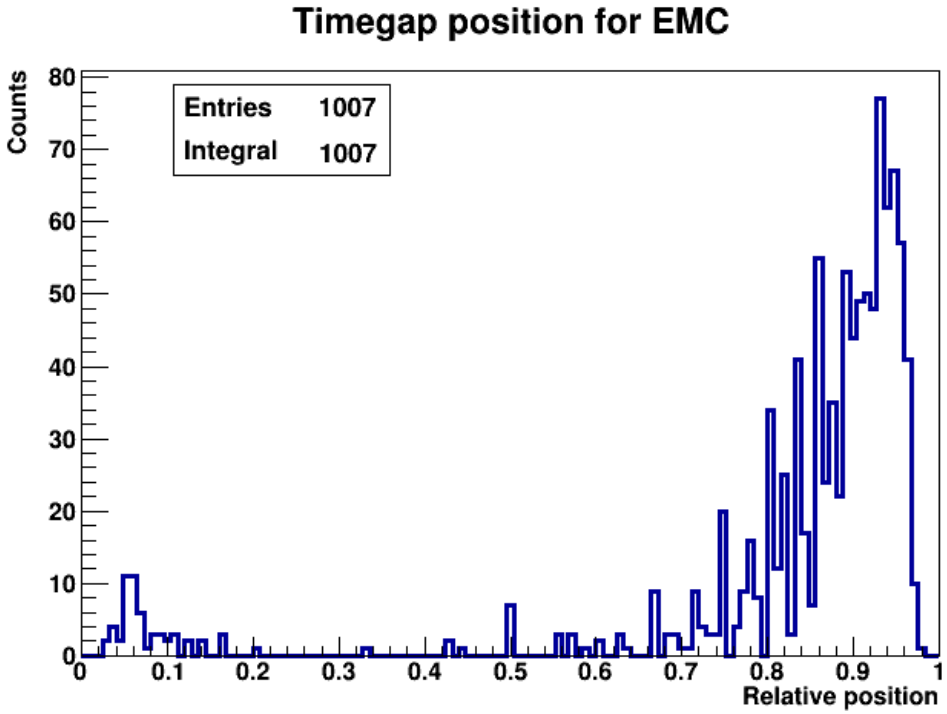
Potential danger of event "granulation"!

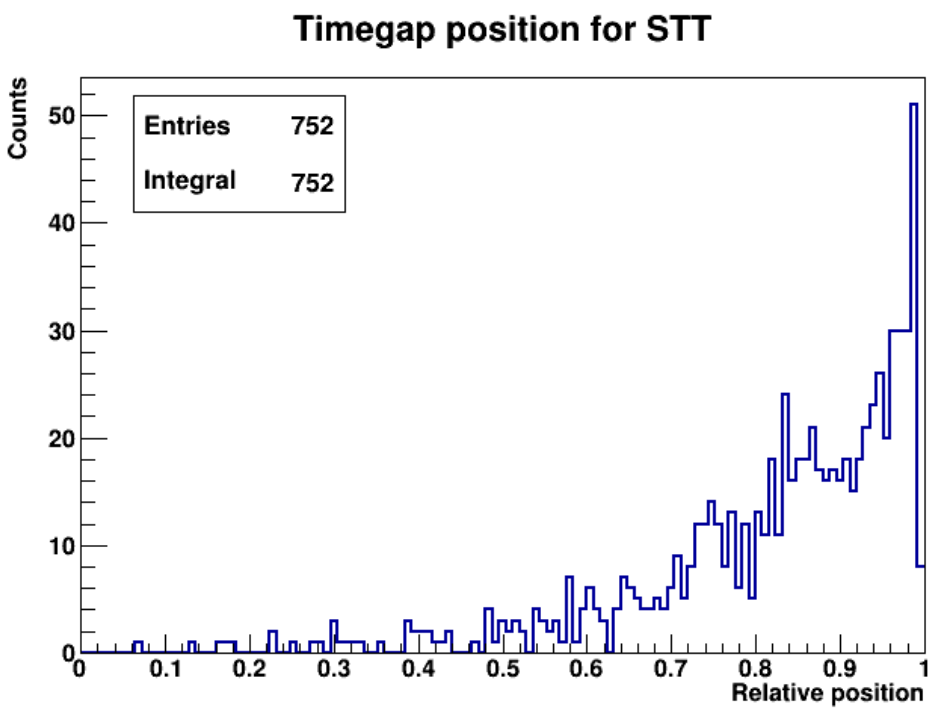
Possible imperfections of the time-gap method

Event-based study (Signal)

Length = #entries

Relative position = Index / Length

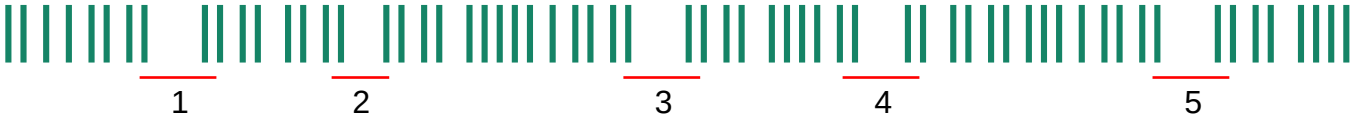


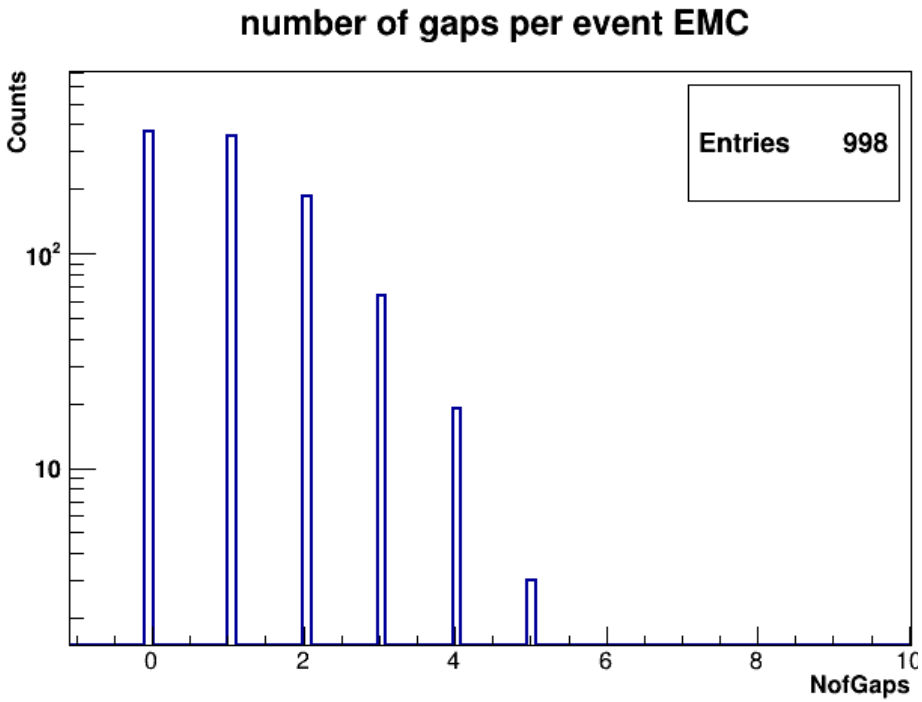


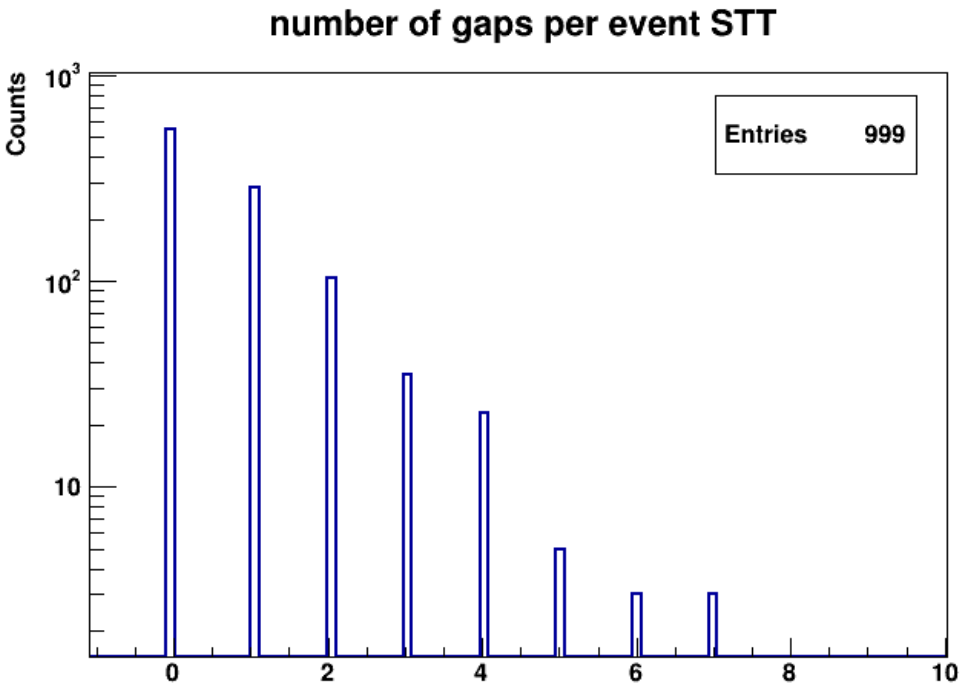
Event cutting with time-gap

Event-based study (Signal)

dt = 20 ns





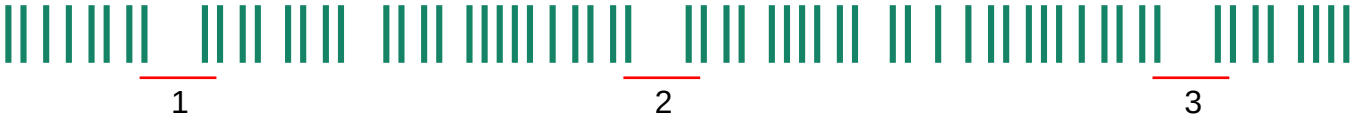


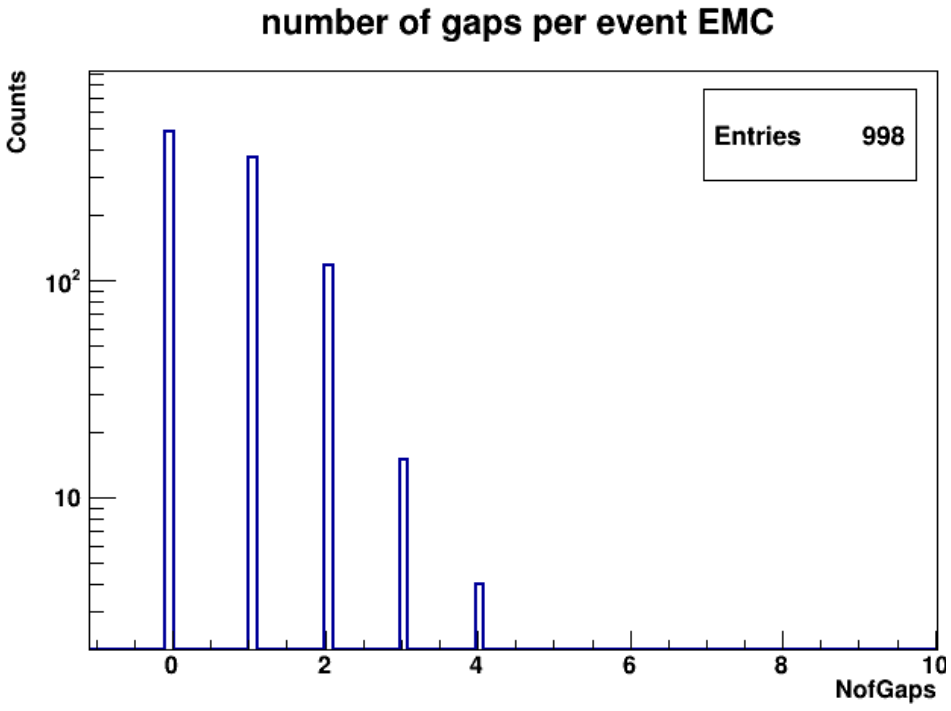
Considerable amount of events with a time-gap(-s)

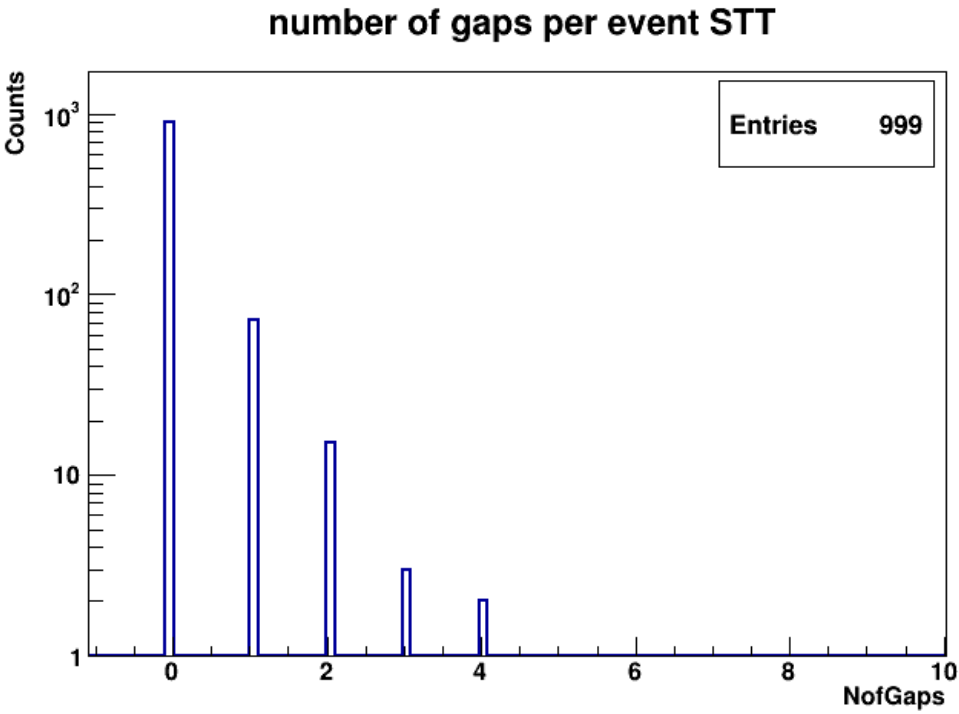
Event cutting with time-gap

Event-based study (Signal)

dt = 40 ns

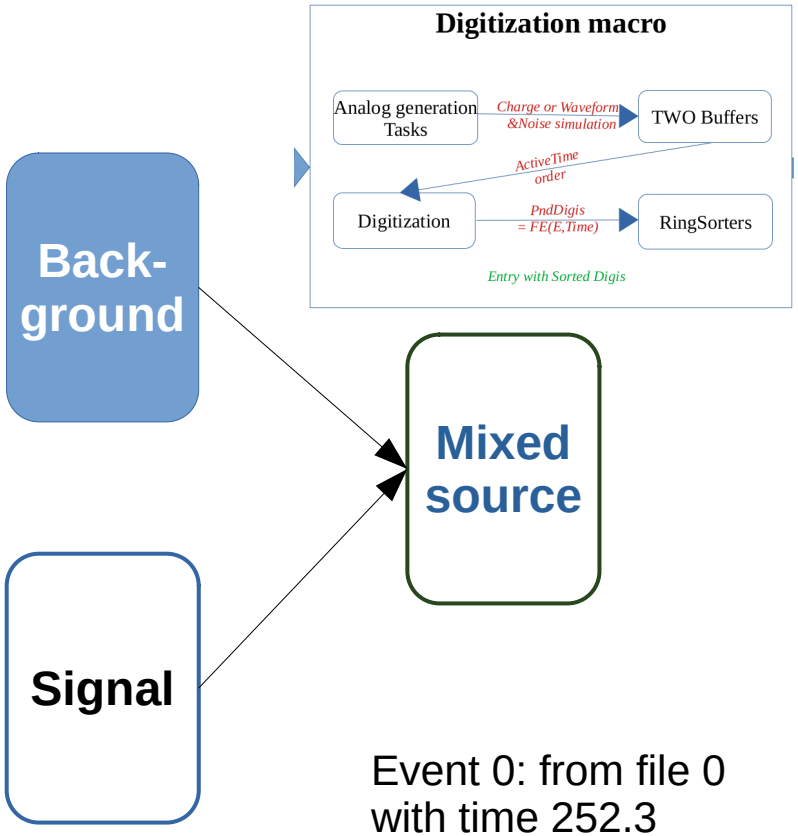






Trade between event mixing and event “granulation”

Time-based Simulation



Time-based

- generation of analogue signals
- digitization of analogue signals
- overlap possibility (TWO Buffers)
- time sorting (Ring Sorters)
- time-ordered stream

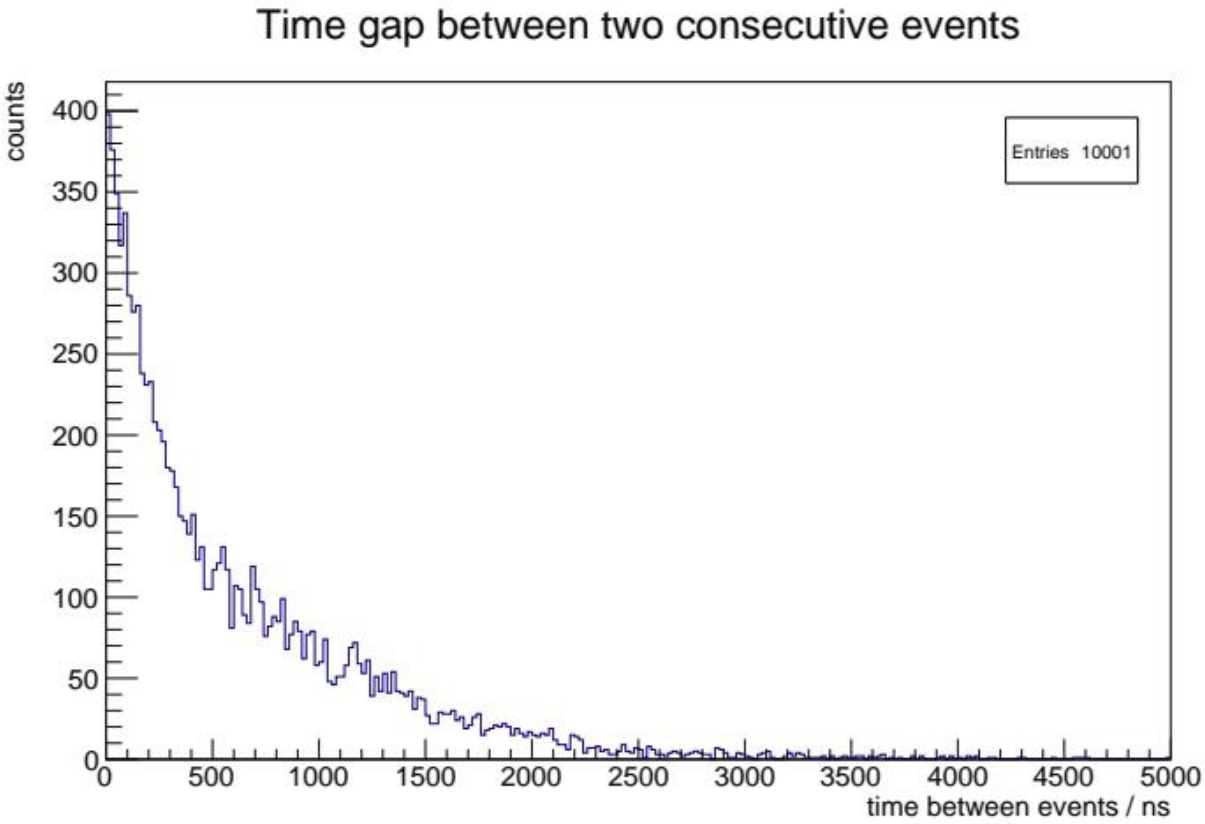
Event 0: from file 0
with time 252.3
Event 1: from file 1
with time 728.6
……
Event 50: from file 0
with time 7854.7

```
source->BGWindowWidthNo(2,1);

source->SetEventMeanTime(500);

source->SetBeamTime(1600, 400);
```

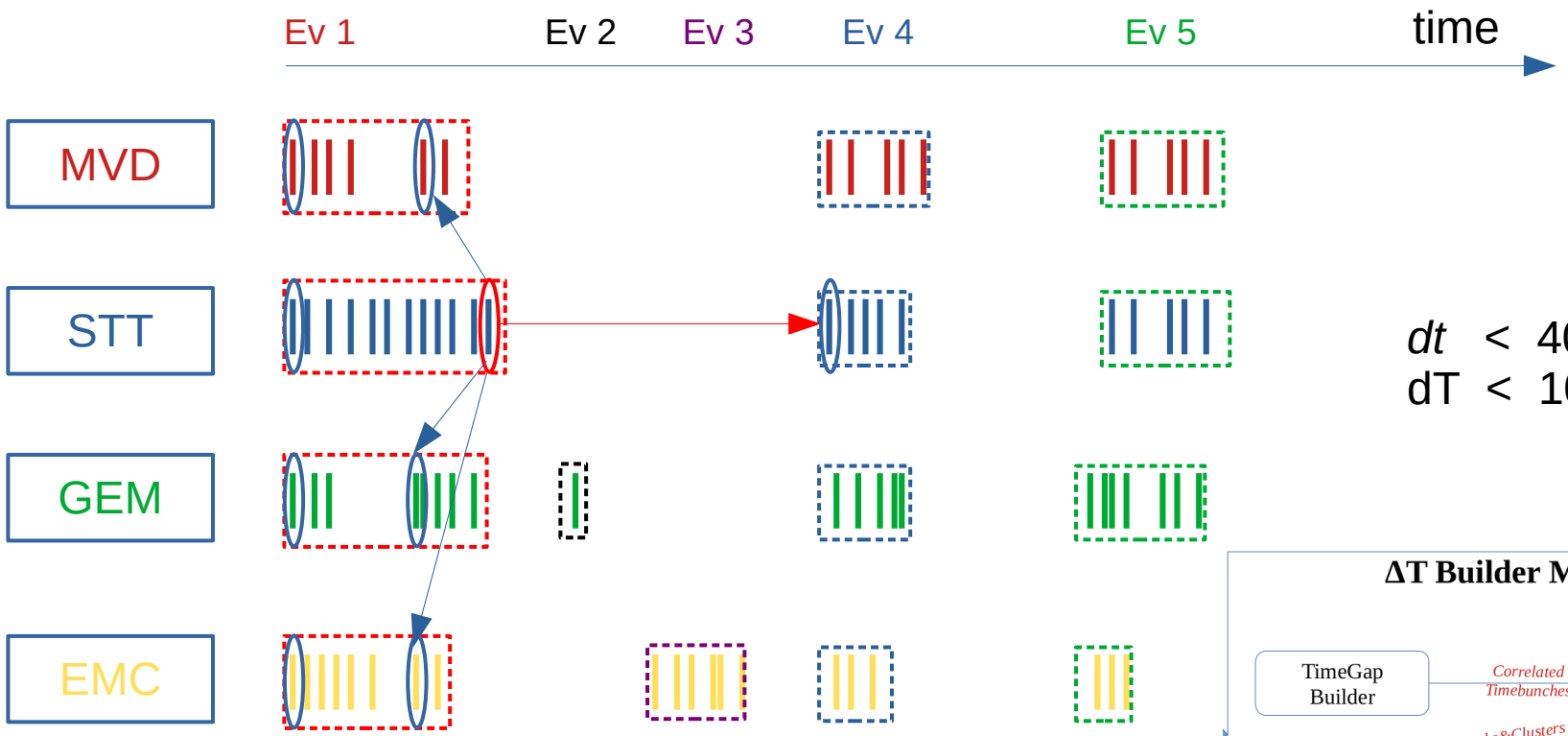
Time-based Simulation



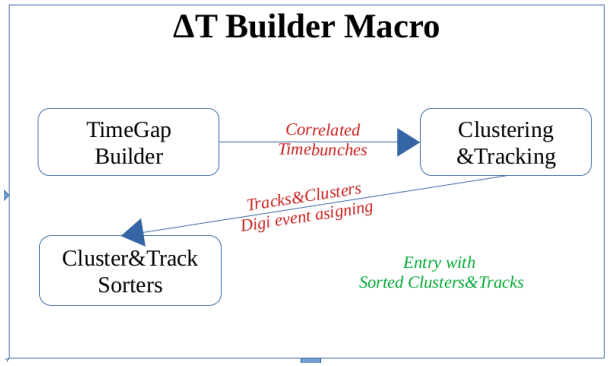
10000 anti-proton target interactions

with a mean time duration of events 500 ns.

Time-gap event builder algorithm



dt < 40 ns
dT < 100 ns



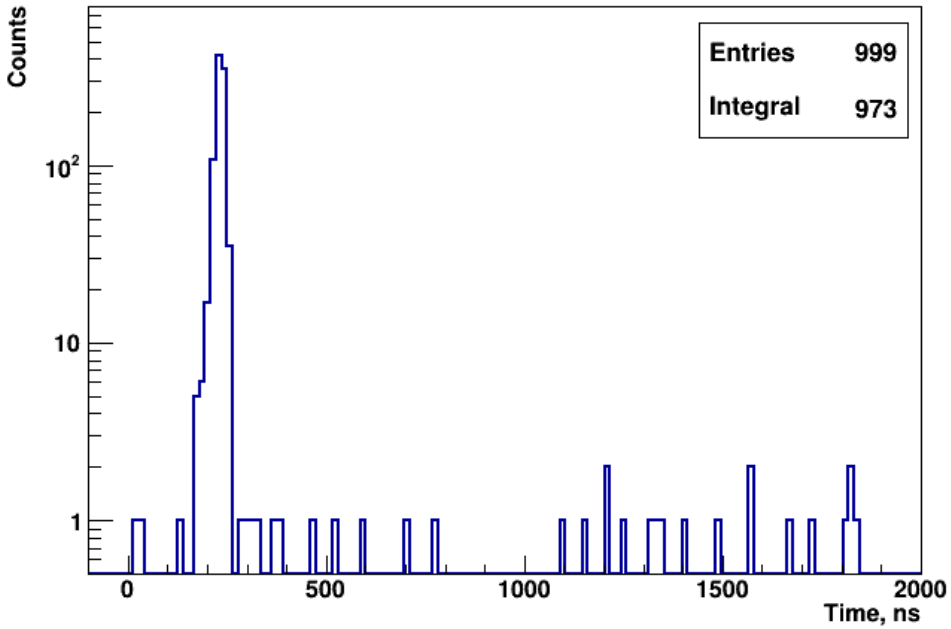
GetData(Detector,TimeGap, 40 ns)

Time duration of event

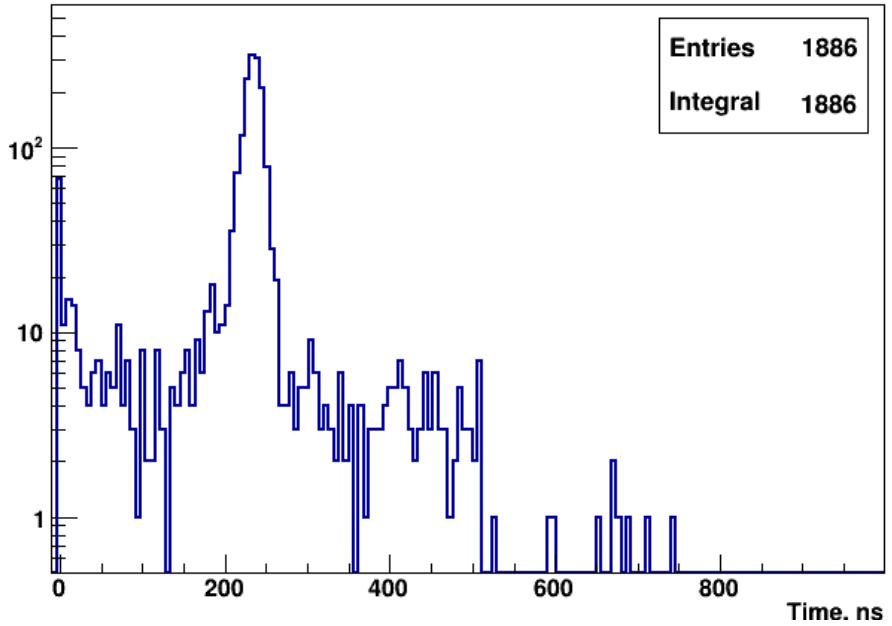
Signal (STT)

$$Time = T_{end} - T_0$$

Event-based



Time-based 40ns



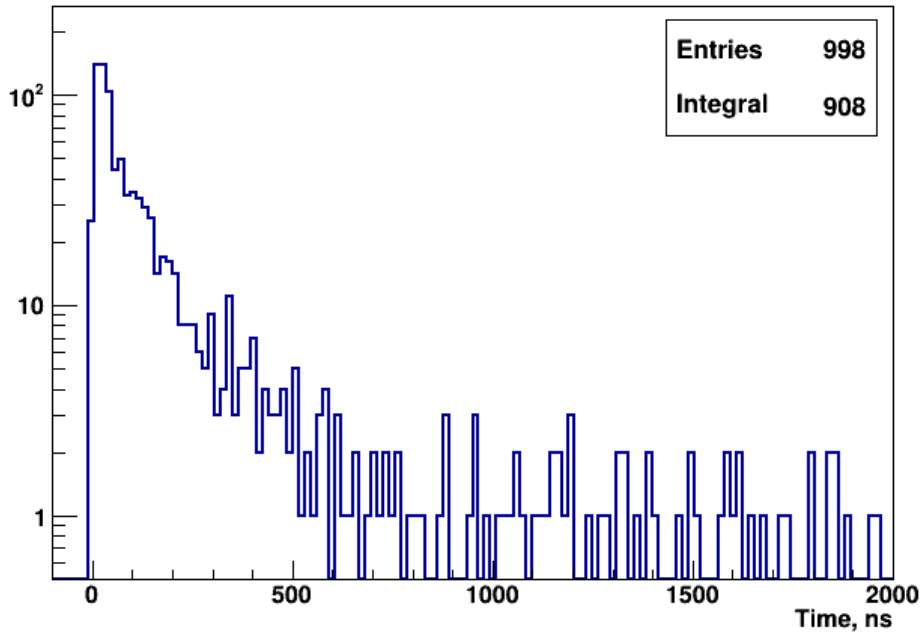
Higher number of events due to the event “granulation” effect

Time duration of event

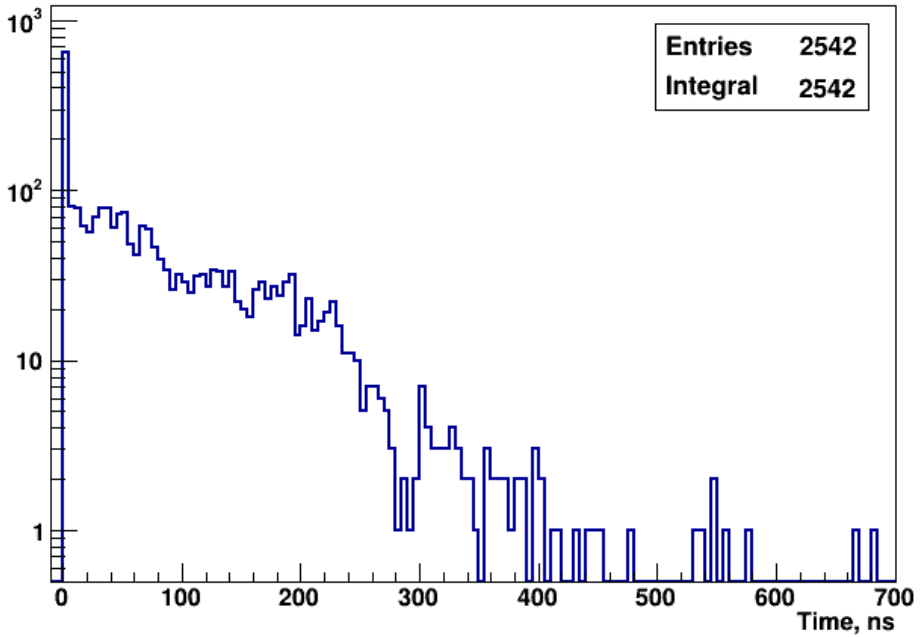
Signal (EMC)

$$Time = T_{end} - T_0$$

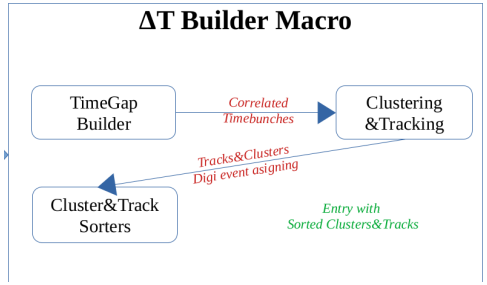
Event-based



Time-based 40ns



Same picture for EMC clusters

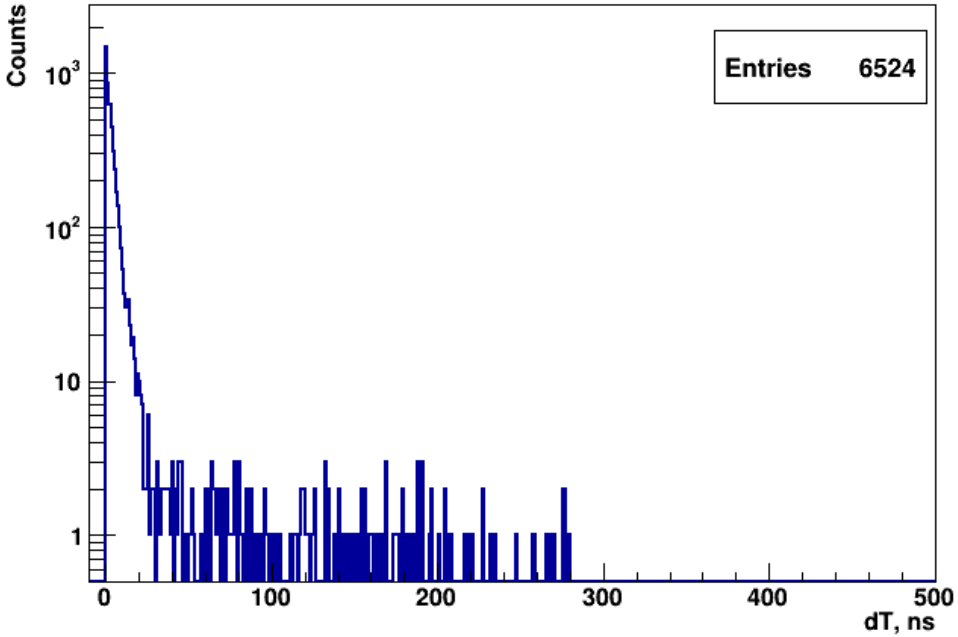


Time difference for tracks and clusters

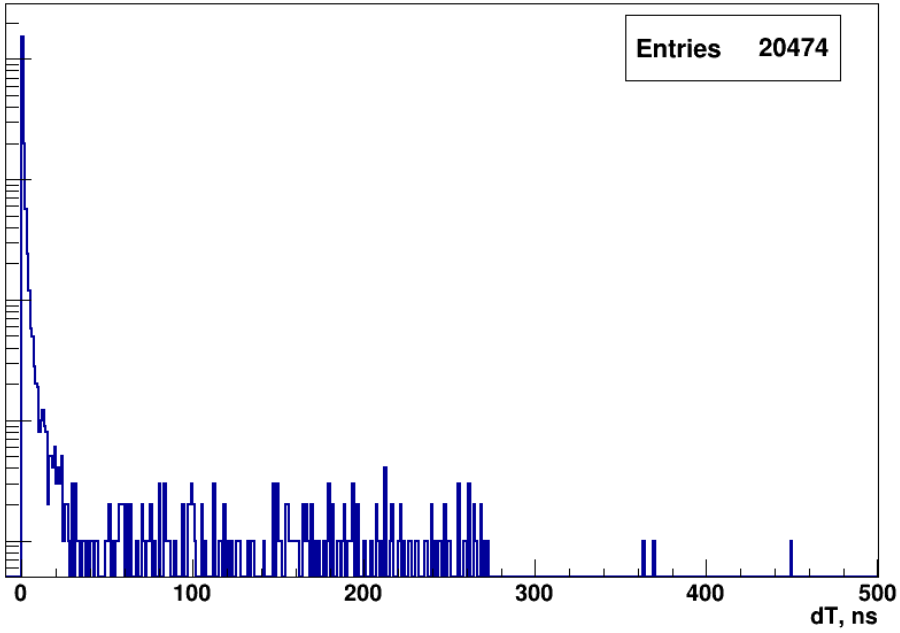
After time-gap EB (dt = 40 ns)

Time-difference distribution between adjacent-in-time tracks&clusters

BarrelTrack



EmcCluster

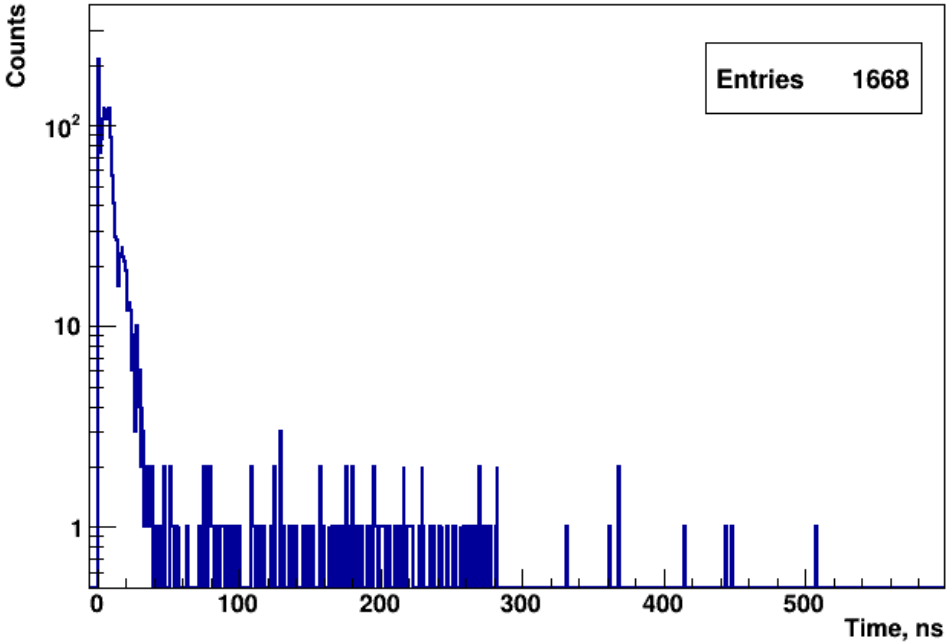


Time duration of track&cluster events

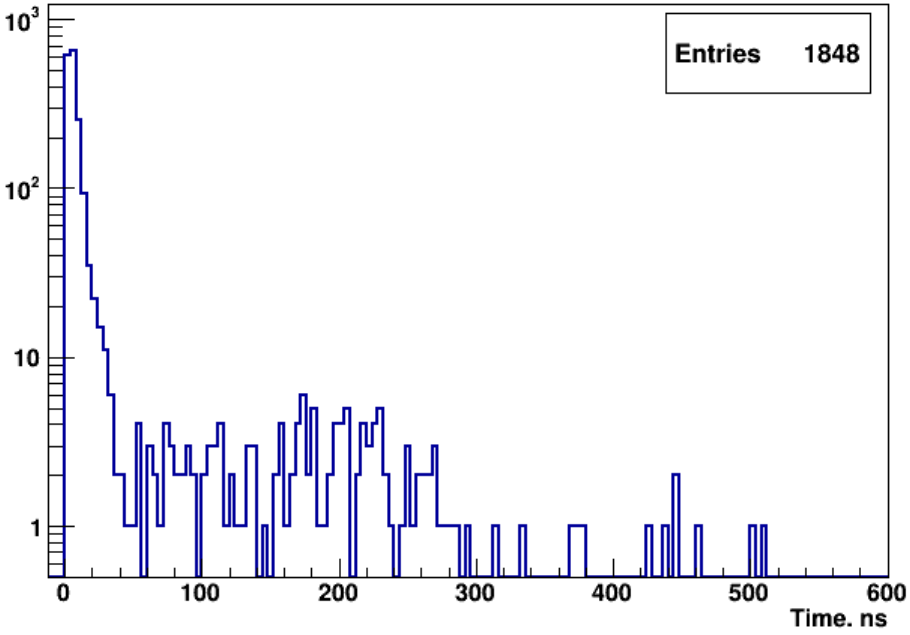
After time-gap EB (dt = 40 ns)

$$Time = T_{end} - T_0$$

BarrelTrack

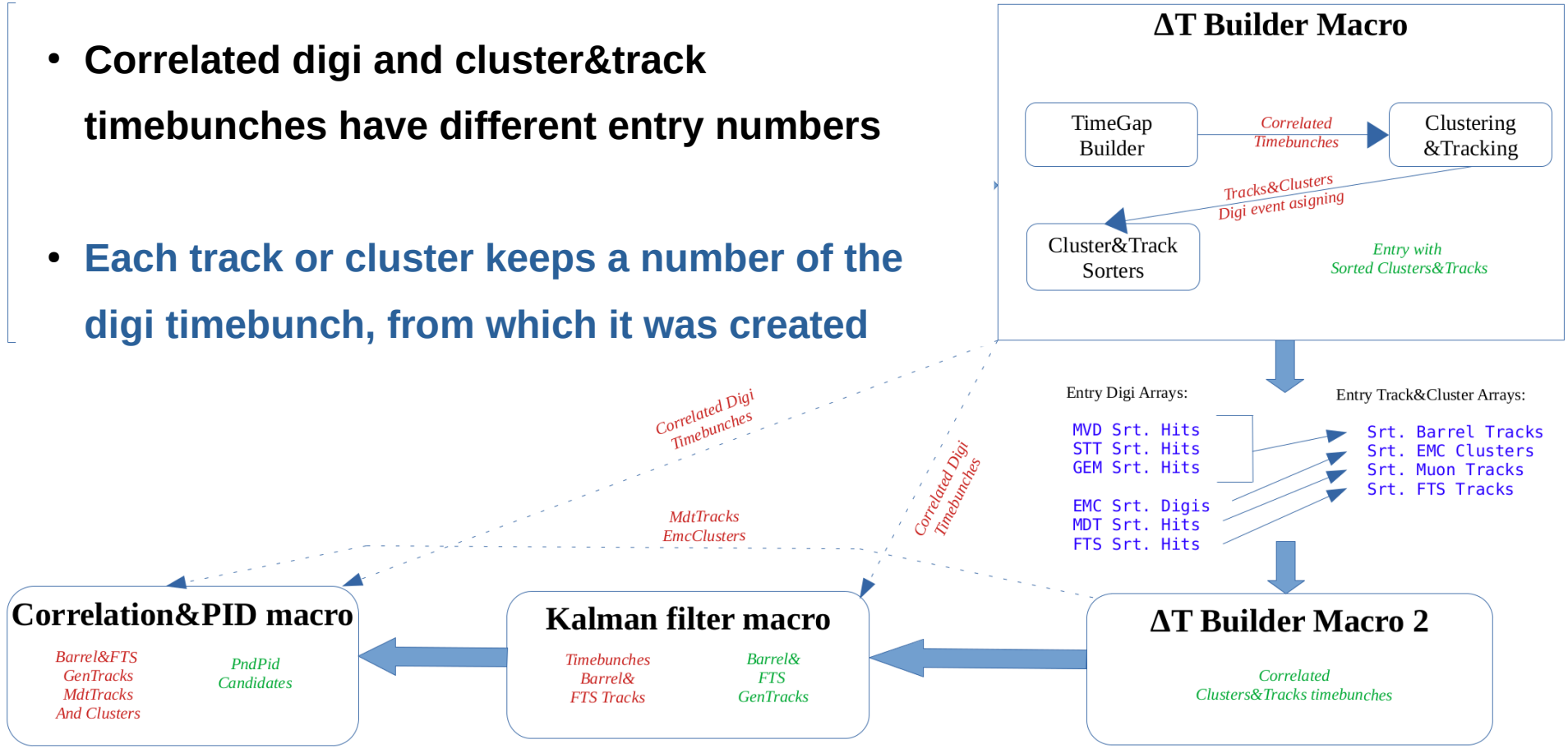


EmcCluster

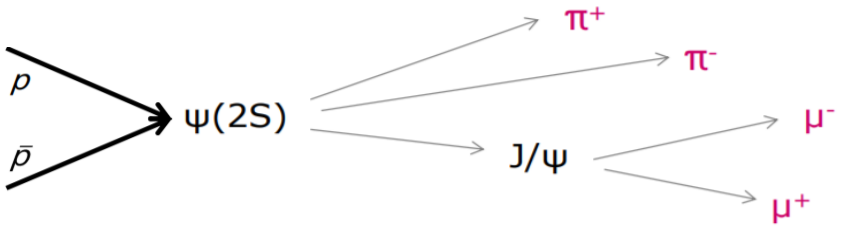


Time-gap EB for clusters&tracks

- **Correlated digi and cluster&track timebunches have different entry numbers**
- **Each track or cluster keeps a number of the digi timebunch, from which it was created**



Offline analysis

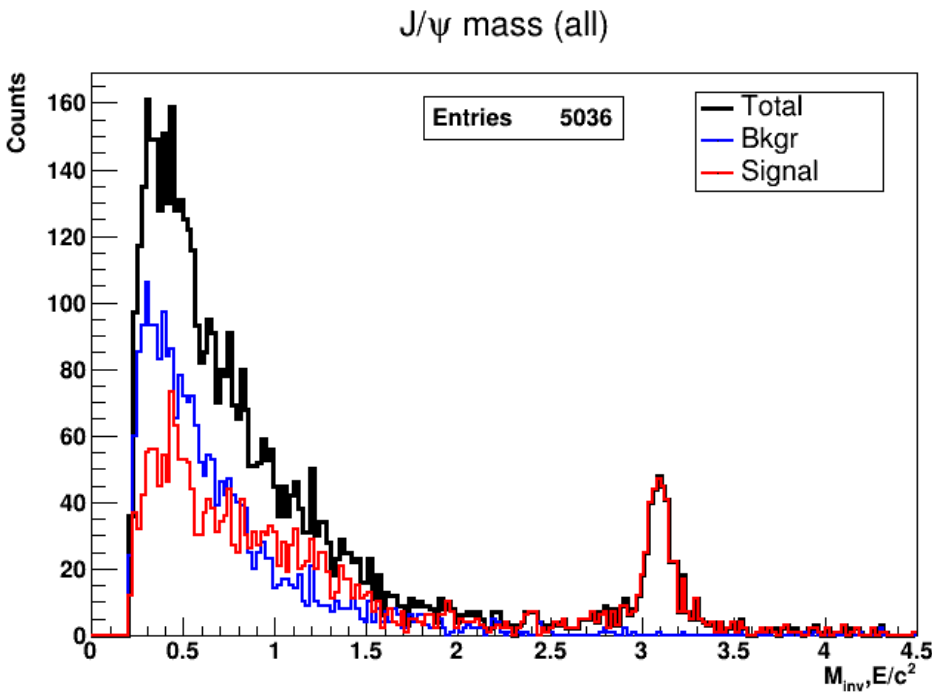


J/psi mass(all) : Invariant mass distribution for the J/psi candidates. Only charge condition is applied.

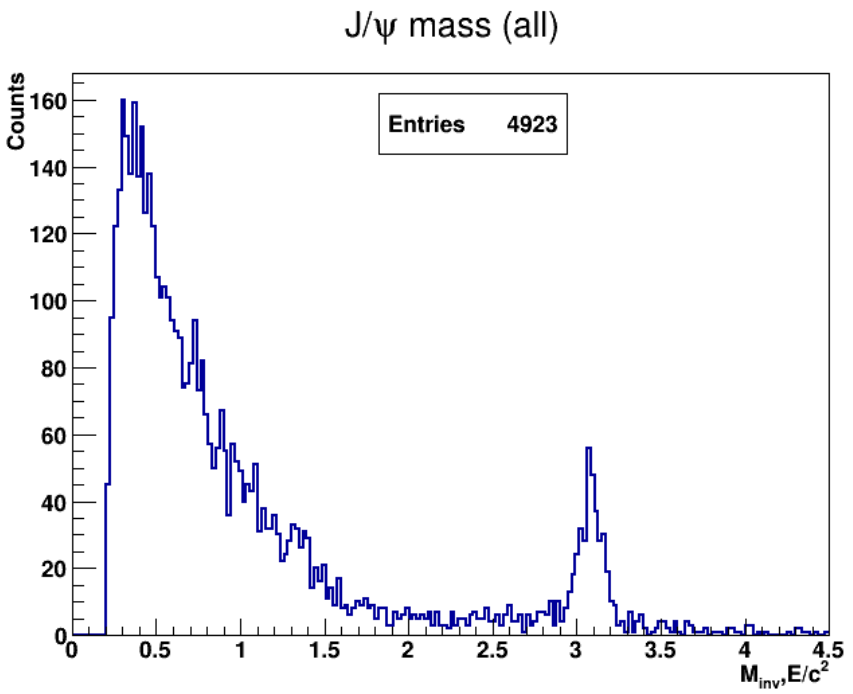
$Ev_{sig}/Ev_b = 1$

Total number = 2000

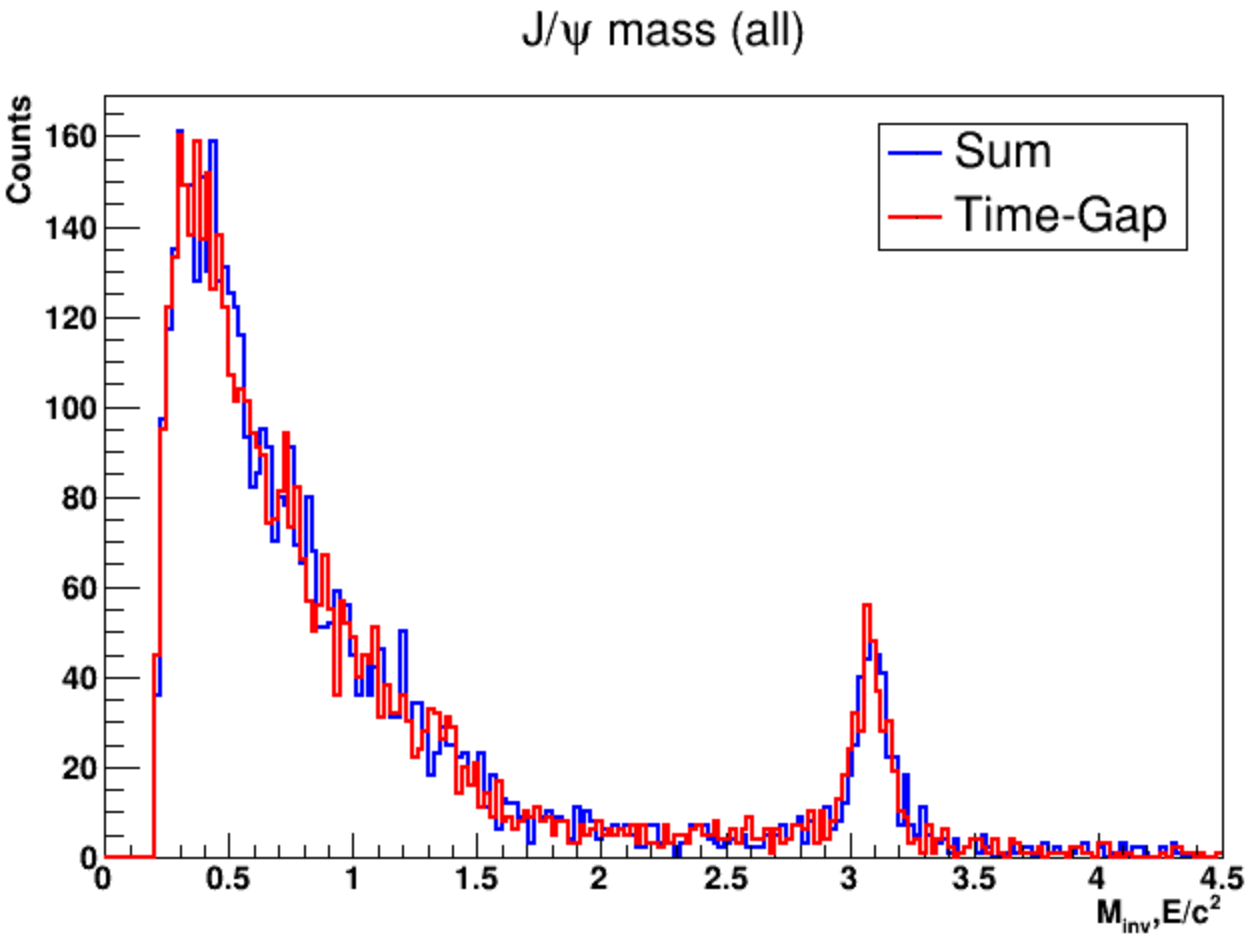
Event-based (Sum)



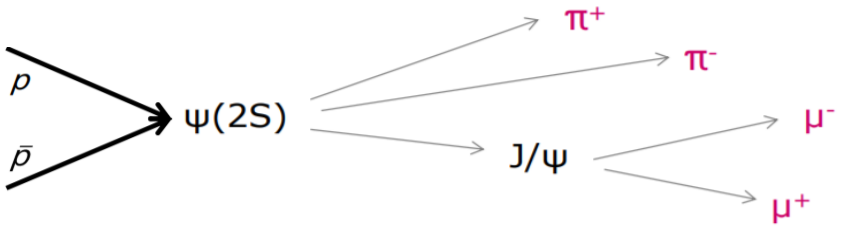
Time-based (Time-Gap)



Offline analysis



Offline analysis (VIRGO)

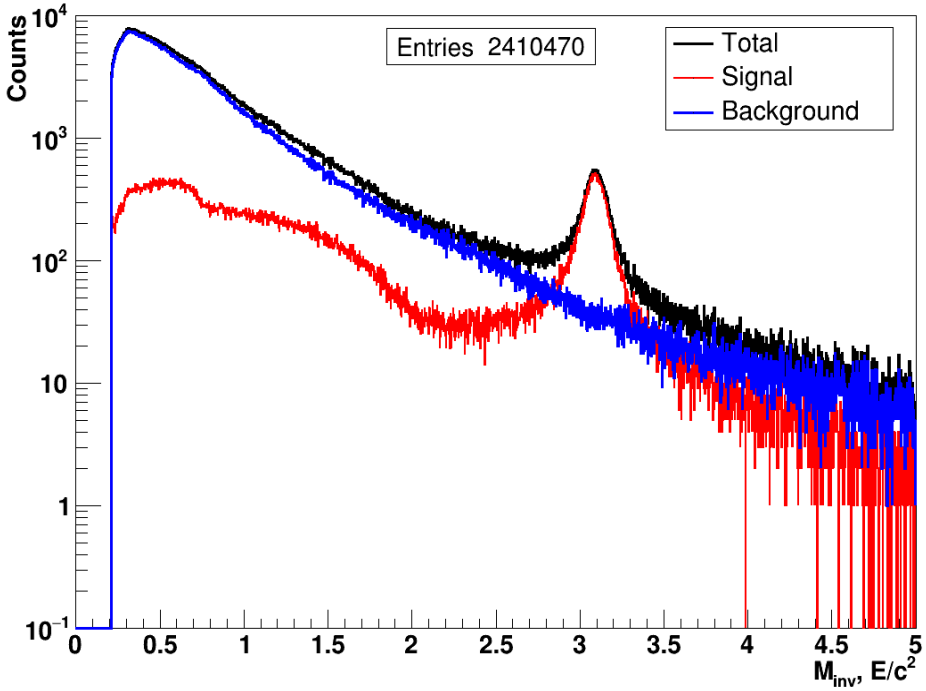


J/psi mass(all) : Invariant mass distribution for the J/psi candidates. Only charge condition is applied.

Ev_{sig}/Ev_{b} = 1/9
Total number = 1000000

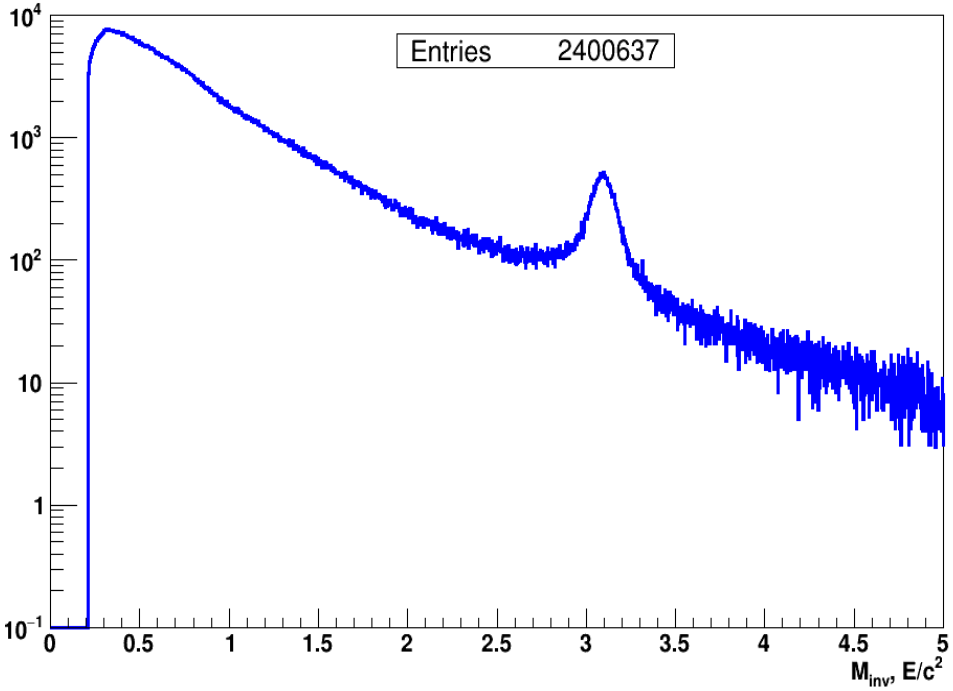
Event-based (Sum)

J/ψ mass (all)

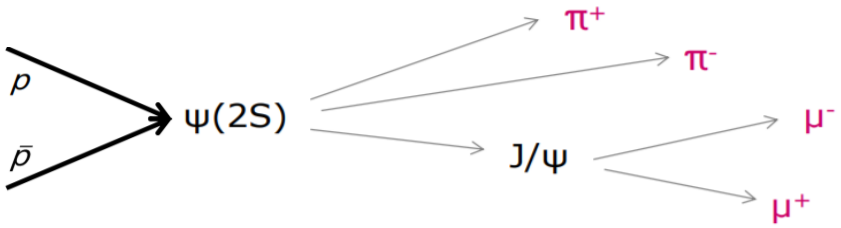


Time-based (Time-Gap)

J/ψ mass (all)



Offline analysis (VIRGO)



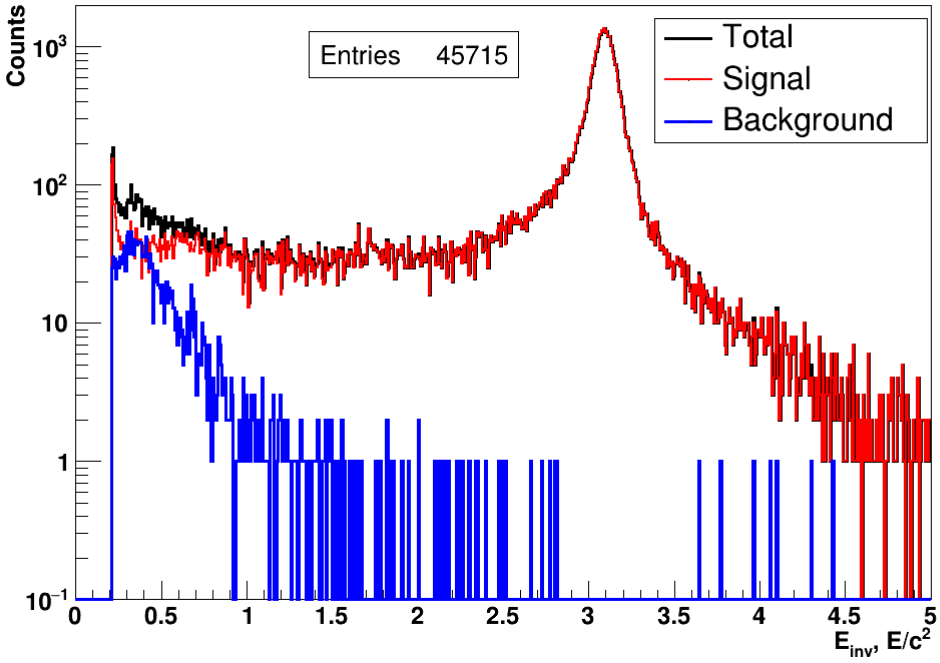
J/psi mass(tight pid) : Invariant mass distribution for the J/psi candidates when Pnd Candidate is muon with probability higher then 50%

Ev_{sig}/Ev_{b}= 1/9

Total number = 1000000

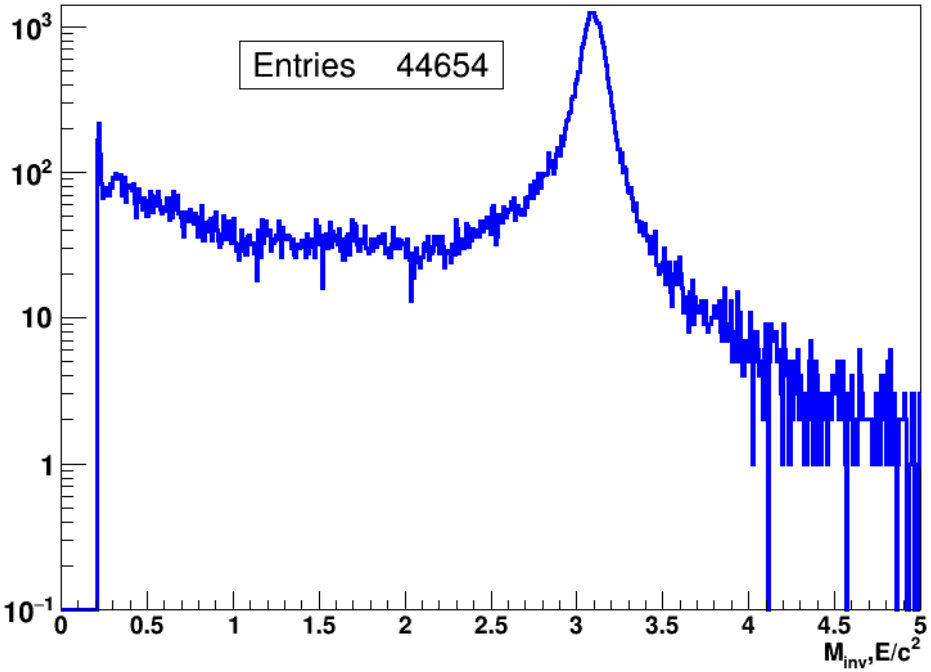
Event-based (Sum)

J/ψ mass (tight pid)

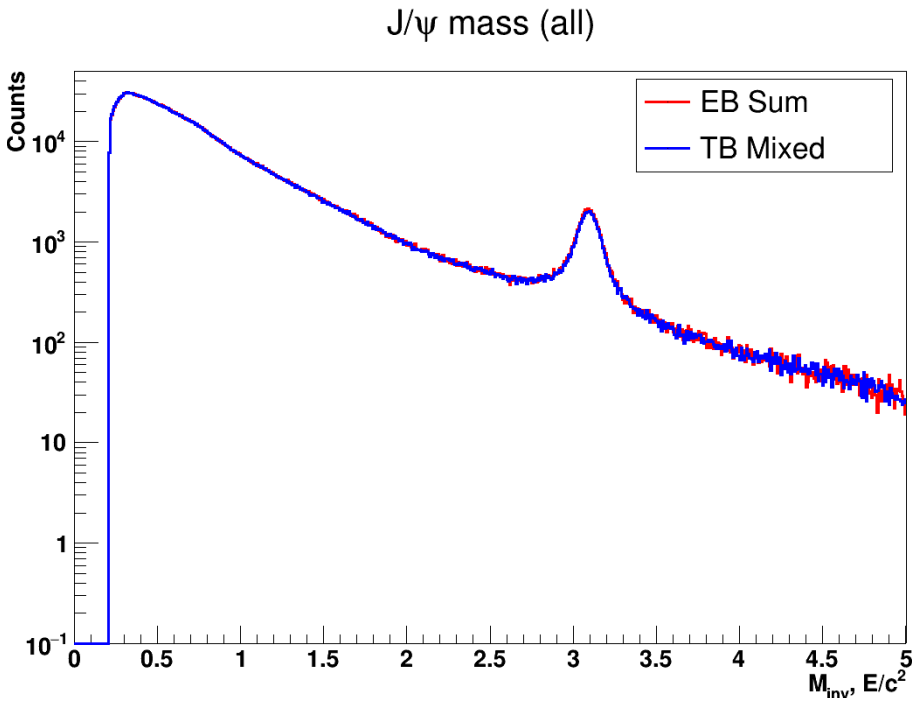


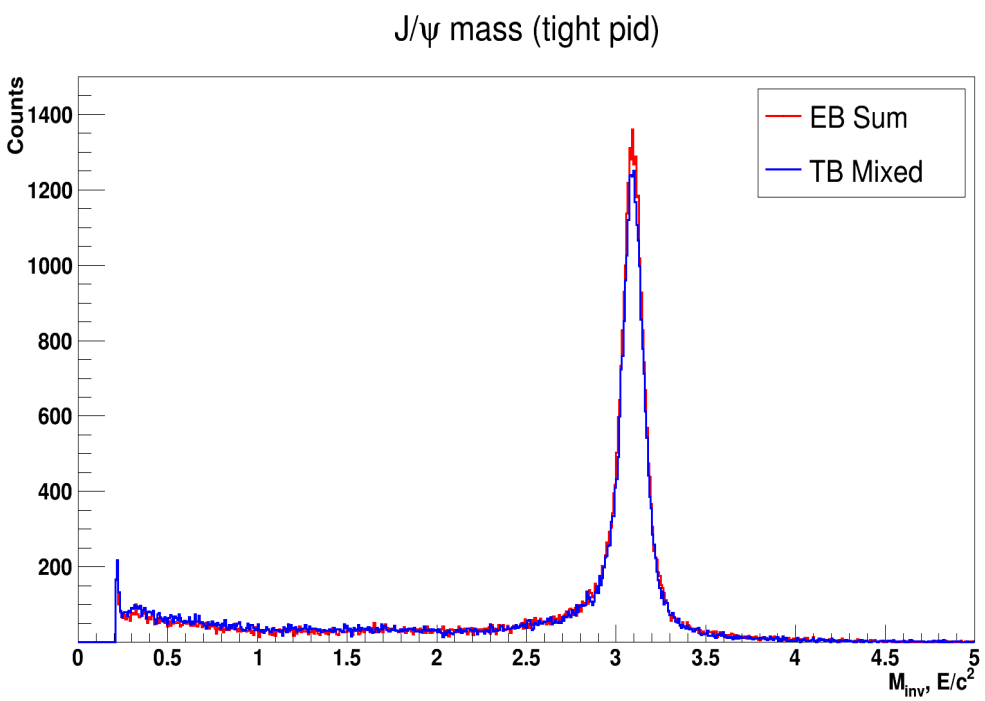
Time-based (Time-Gap)

J/ψ mass (tight pid)



Offline analysis (VIRGO)

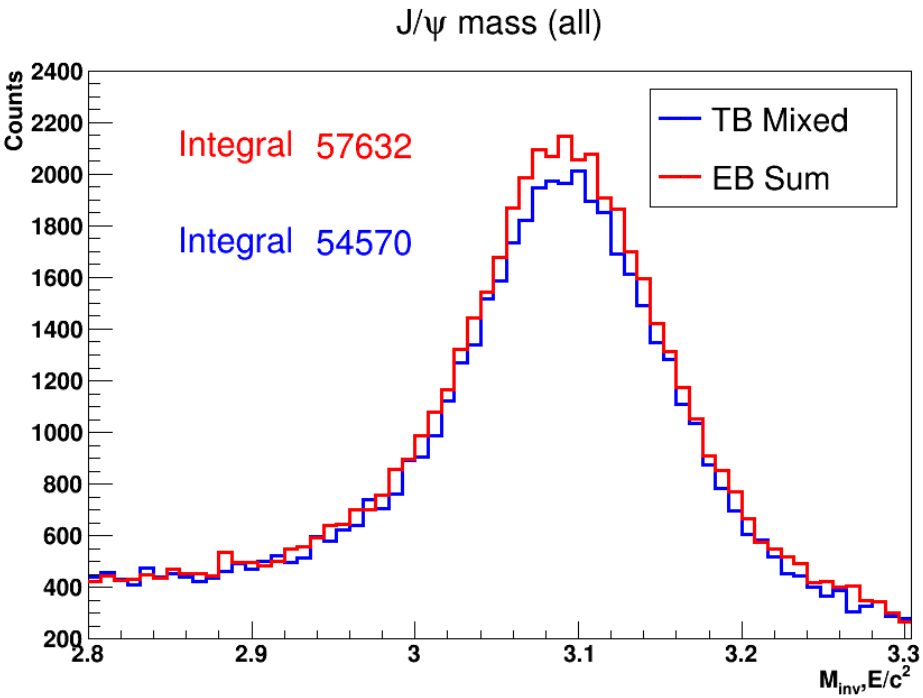


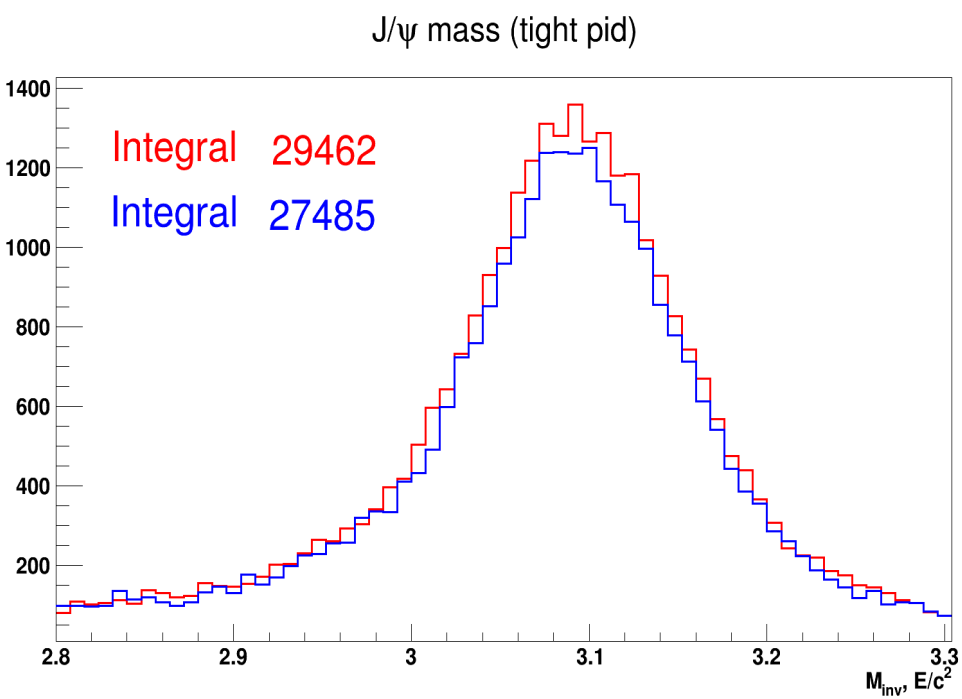


Discrepancy between EB and TB simulation. How big is it?

Offline analysis (VIRGO)

Comparison by integration in the J/psi region

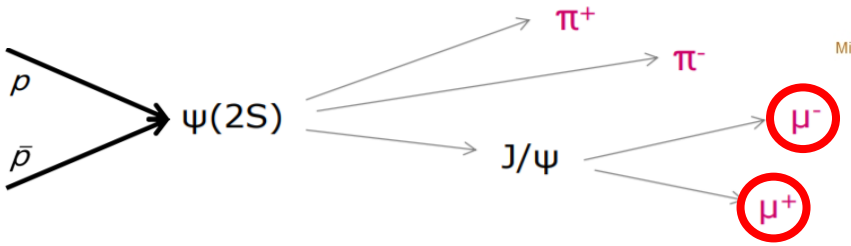


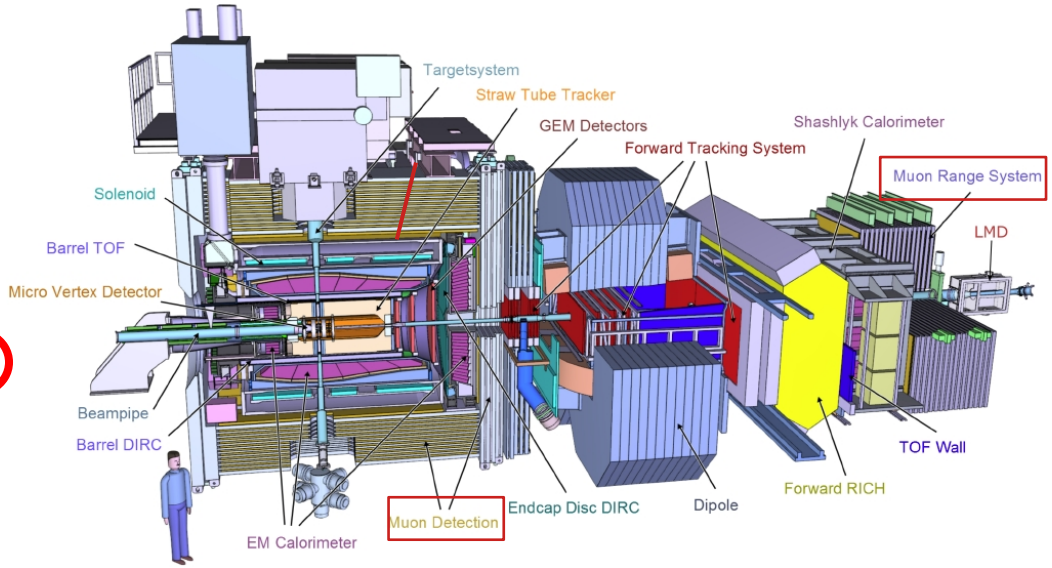


This difference is caused by granulation effect and event mixing

Event Filtering

Two Mdt tracks with iron distance > 40 cm





Kalman filter macro

Timebunches Barrel& FTS Tracks

Barrel& FTS GenTracks

Event filter

Timebunches

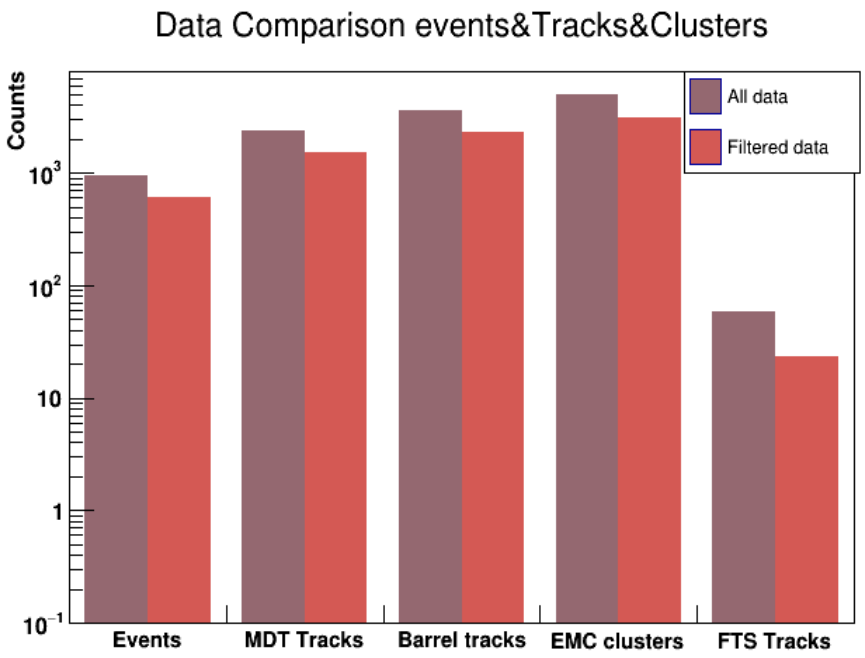
Passed Timebunches

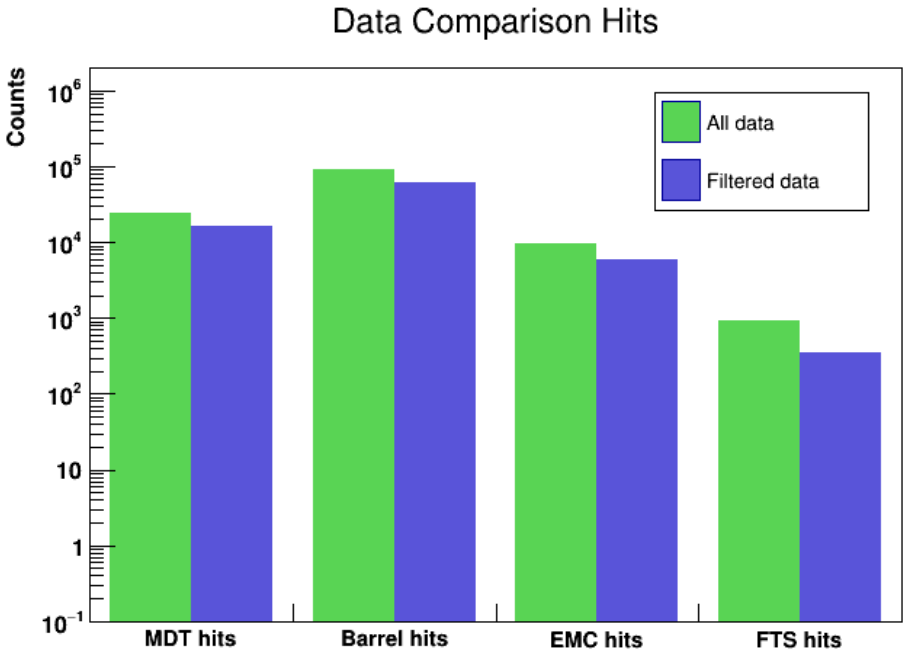
ΔT Builder Macro 2

Correlated Clusters&Tracks timebunches

Event Filtering

Event-based (Signal)

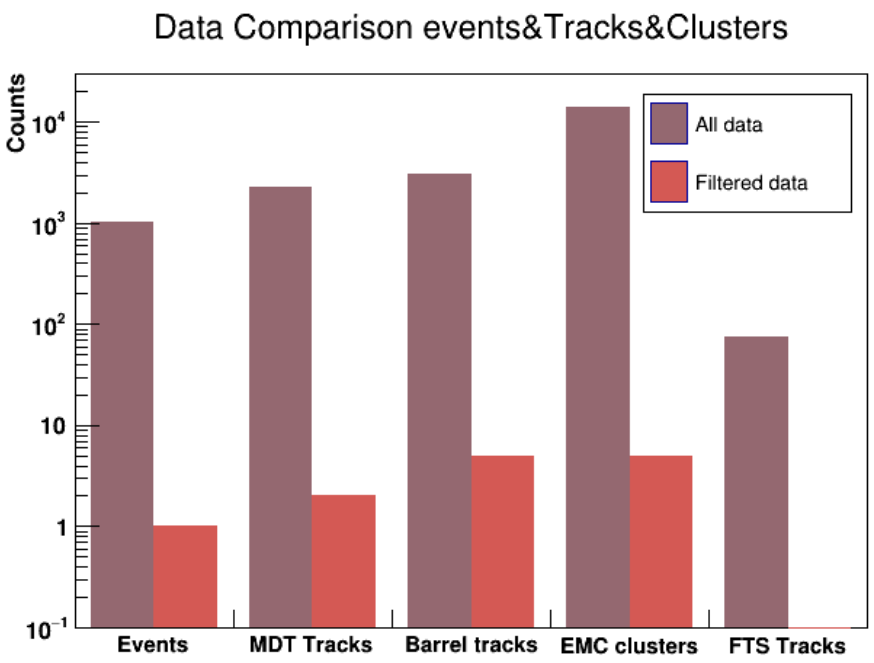


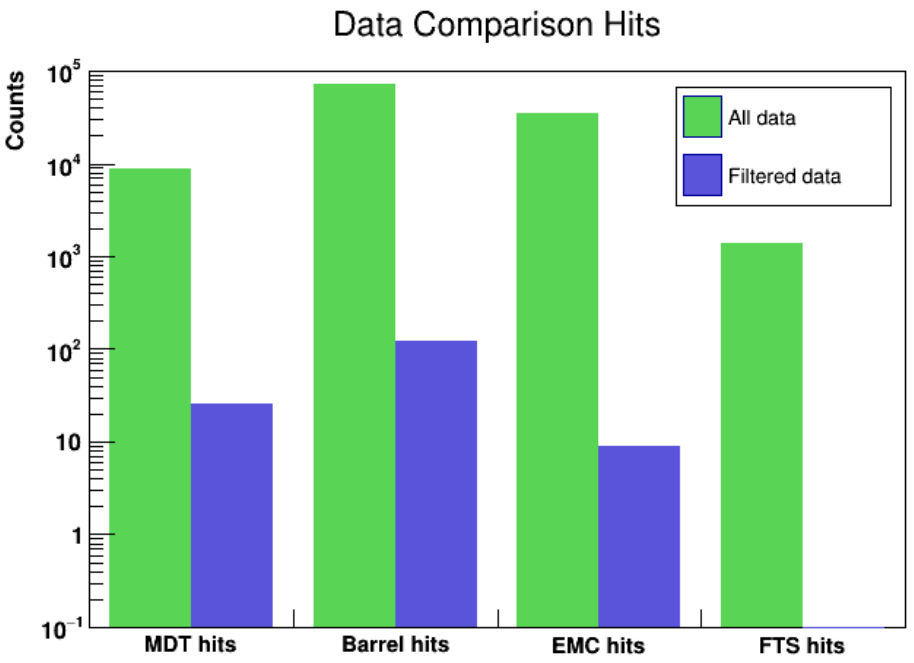


Most events pass through the filter
(except the miss-reconstructed ones)

Event Filtering

Event-based (Background)



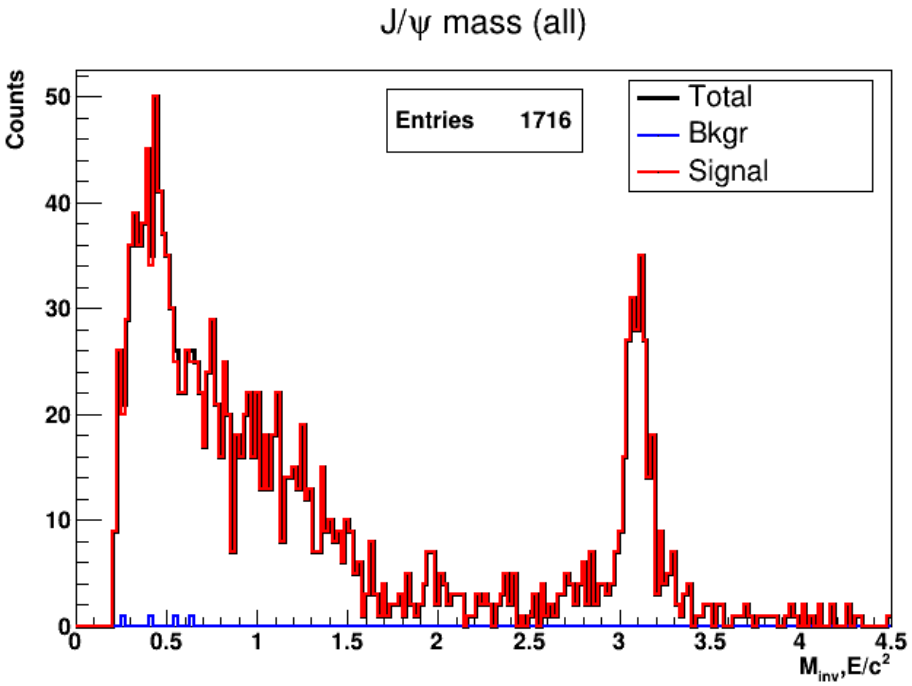


Suppression ≈ 1000

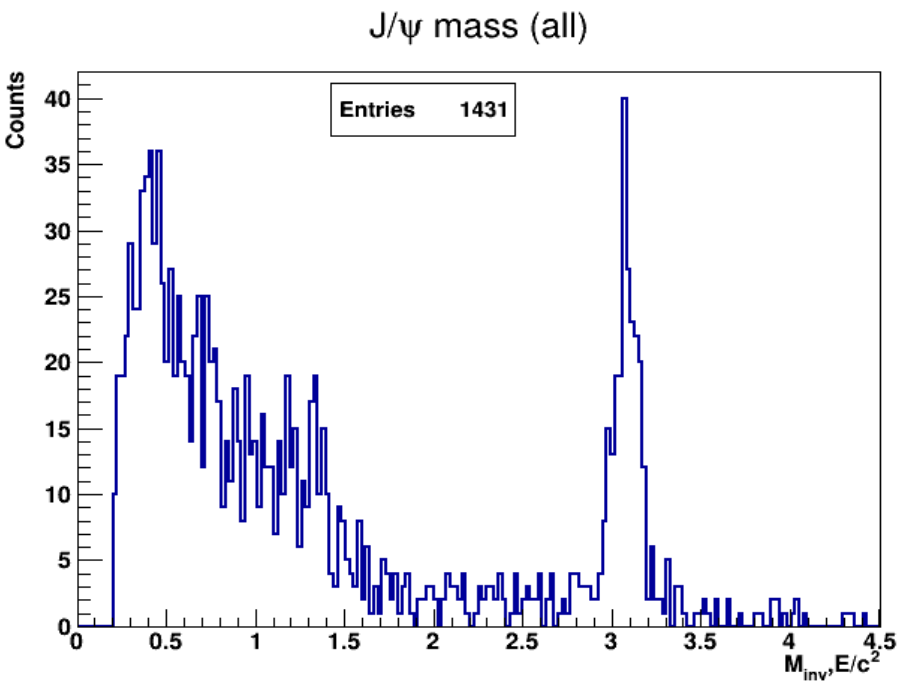
Event Filtering

Offline analysis with online filtering

Event-based (Sum)



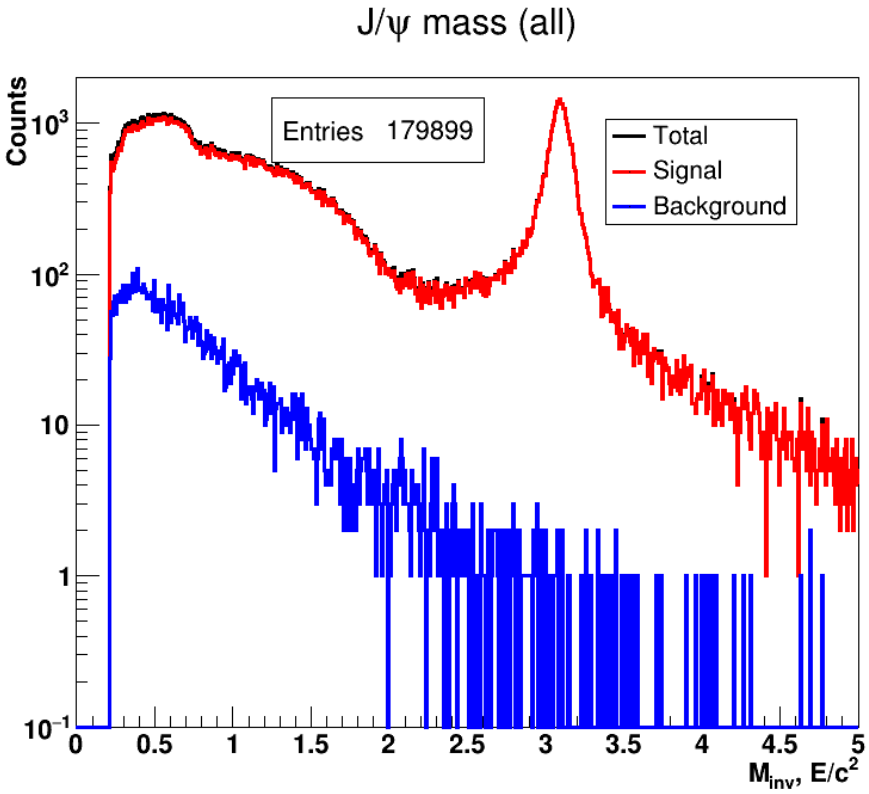
Time-based (Time-Gap)



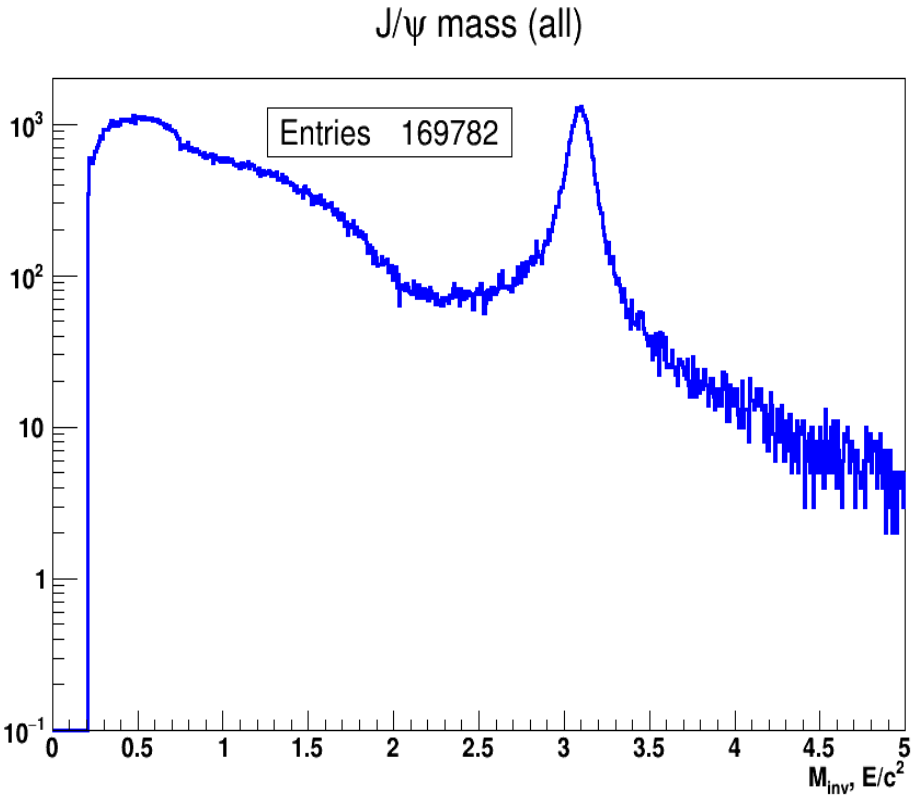
Event Filtering (VIRGO)

Offline analysis with online filtering

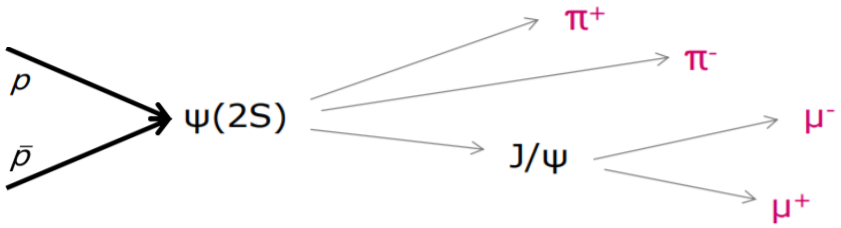
Event-based (Sum)



Time-based (Time-Gap)



Offline analysis (VIRGO)

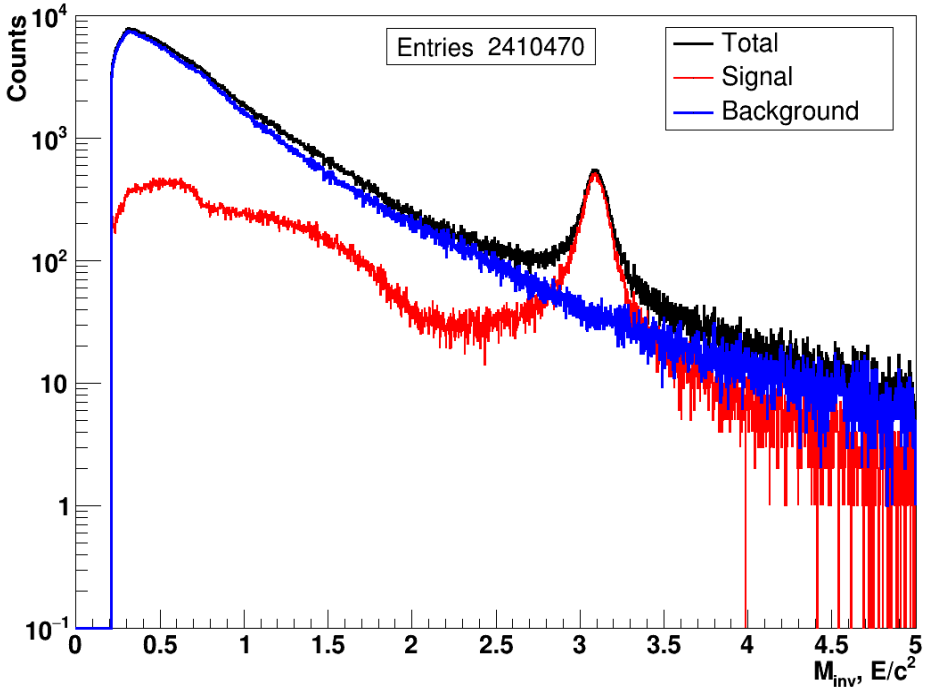


J/psi mass(all) : Invariant mass distribution for the J/psi candidates. Only charge condition is applied.

Ev_{sig}/Ev_{b}= 1/9
Total number = 1000000

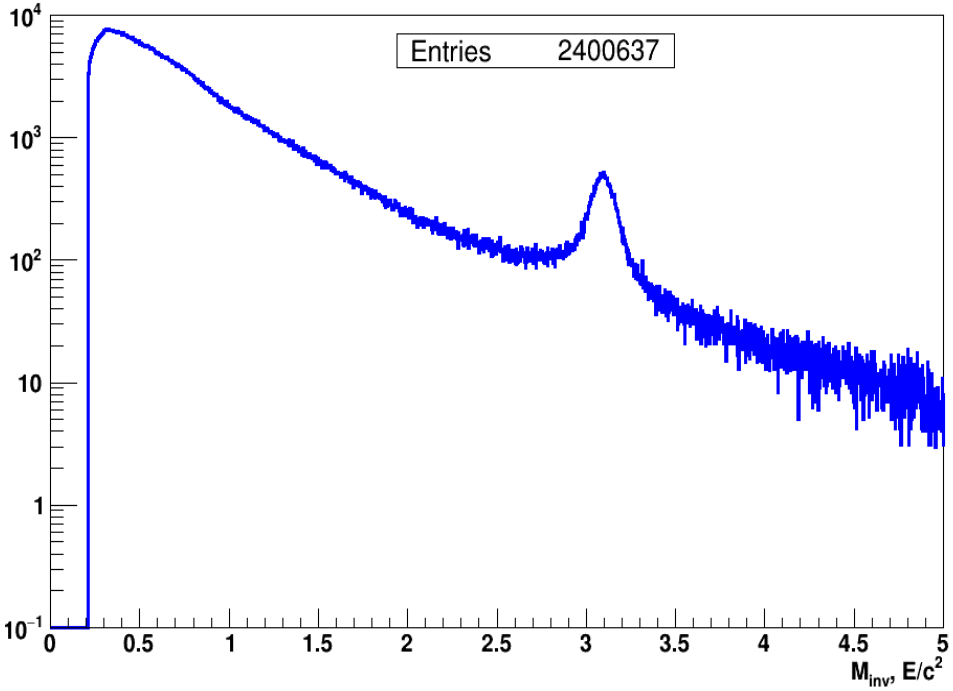
Event-based (Sum)

J/ψ mass (all)



Time-based (Time-Gap)

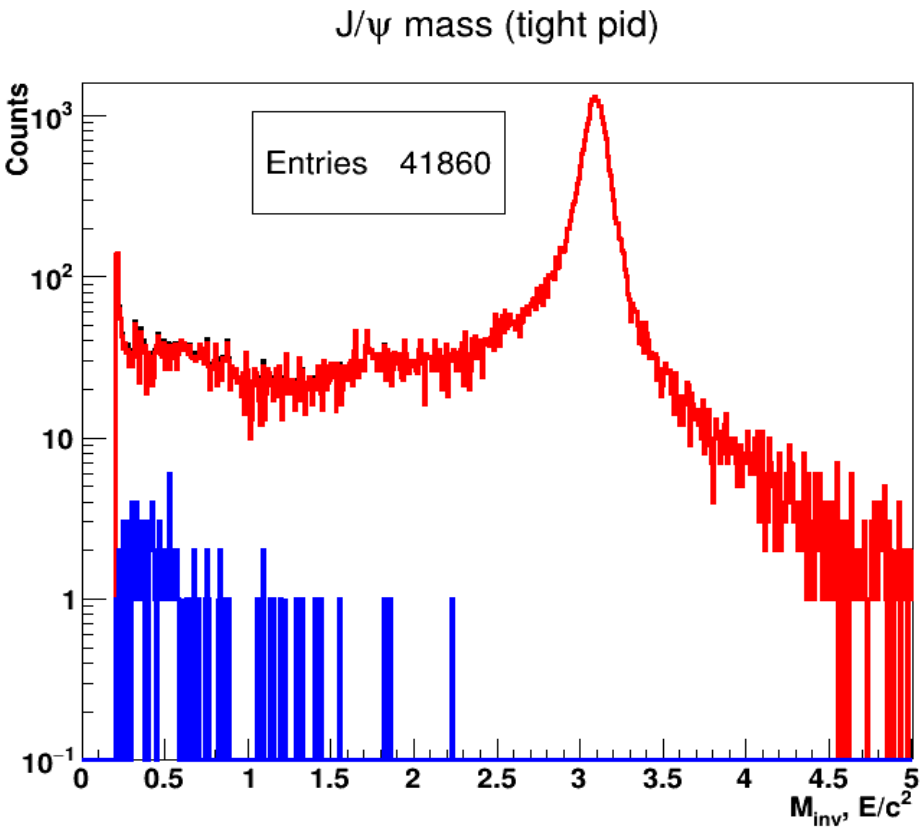
J/ψ mass (all)



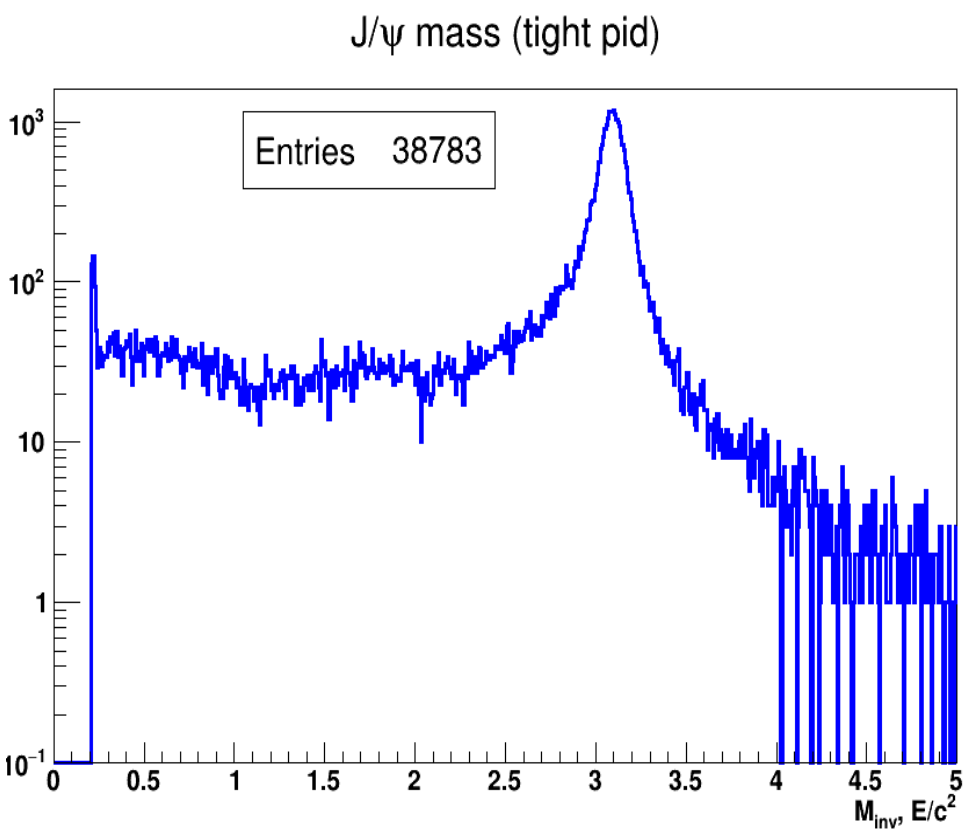
Event Filtering (VIRGO)

Offline analysis with online filtering

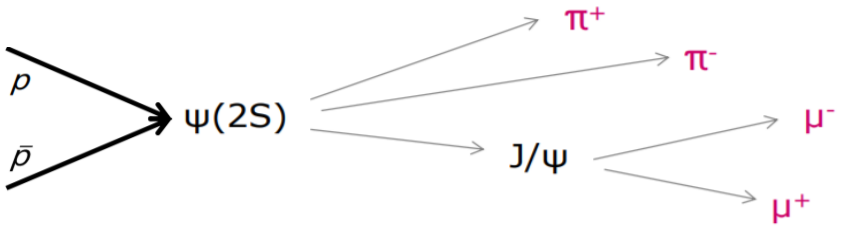
Event-based (Sum)



Time-based (Time-Gap)



Offline analysis (VIRGO)



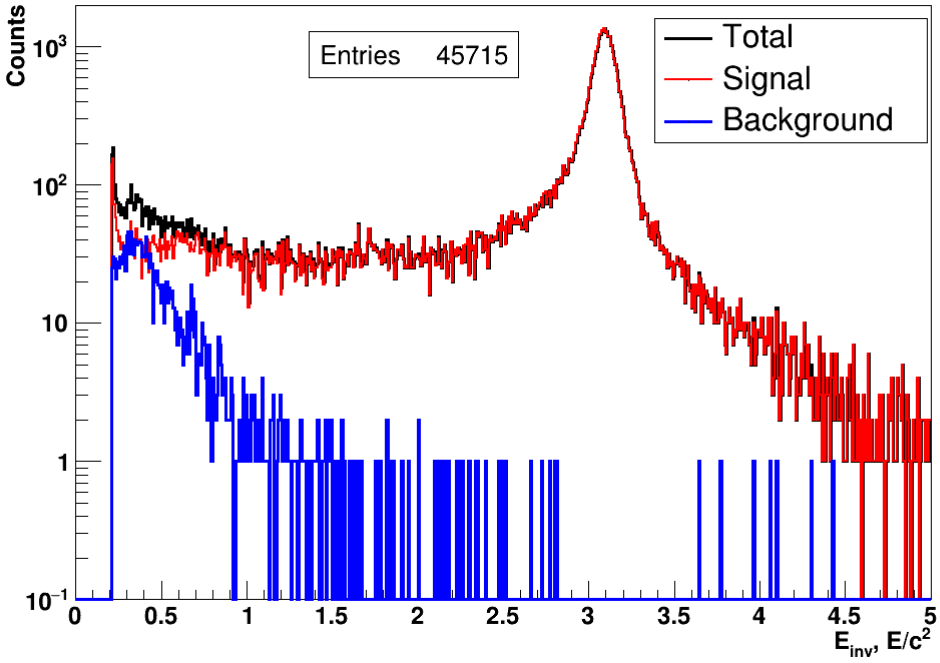
J/psi mass(tight pid) : Invariant mass distribution for the J/psi candidates when Pnd Candidate is muon with probability higher then 50%

Ev_{sig}/Ev_{b}= 1/9

Total number = 1000000

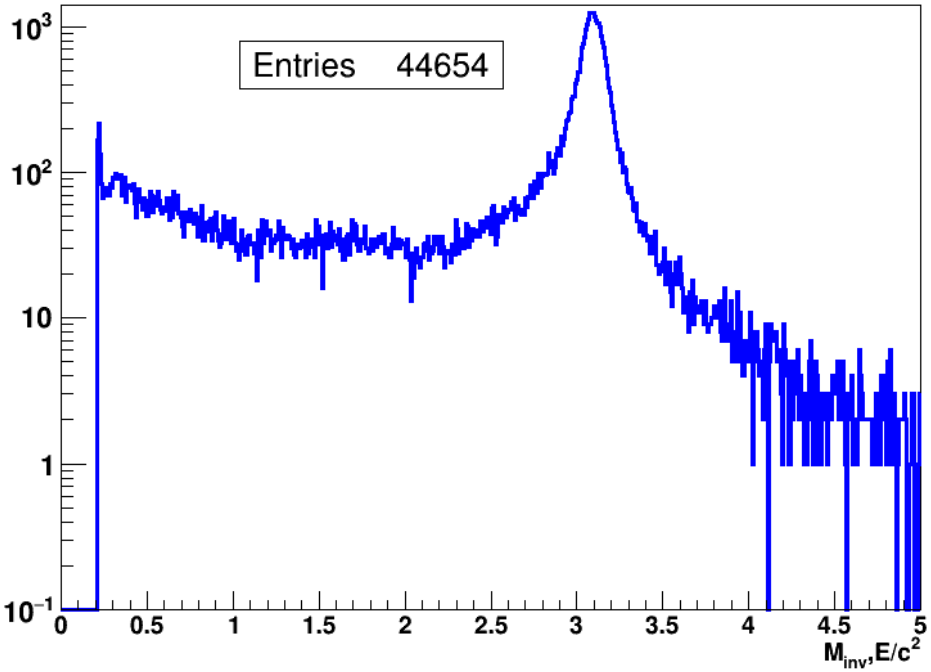
Event-based (Sum)

J/ψ mass (tight pid)



Time-based (Time-Gap)

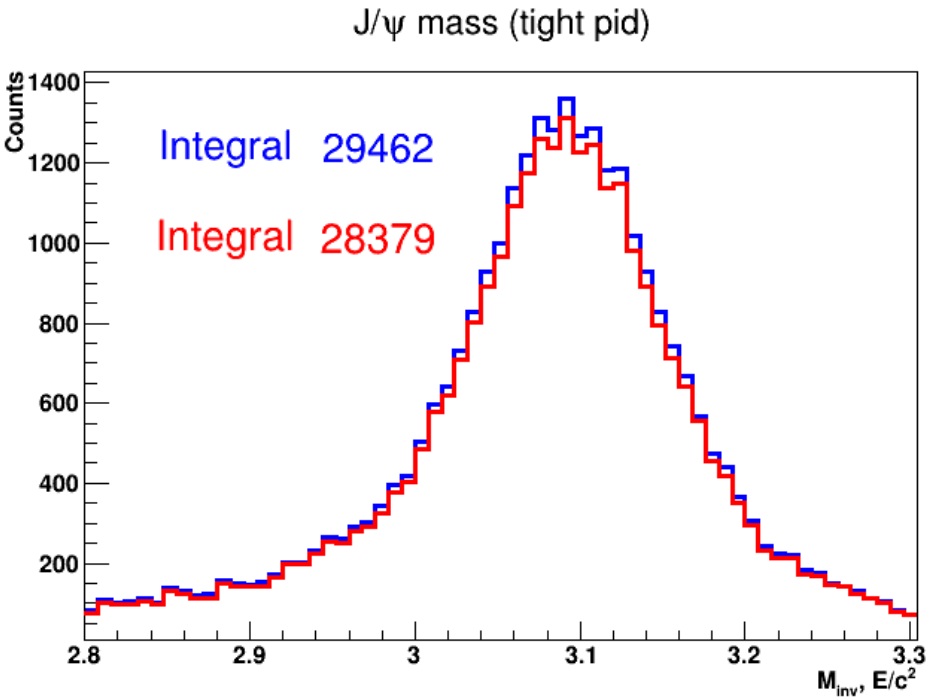
J/ψ mass (tight pid)



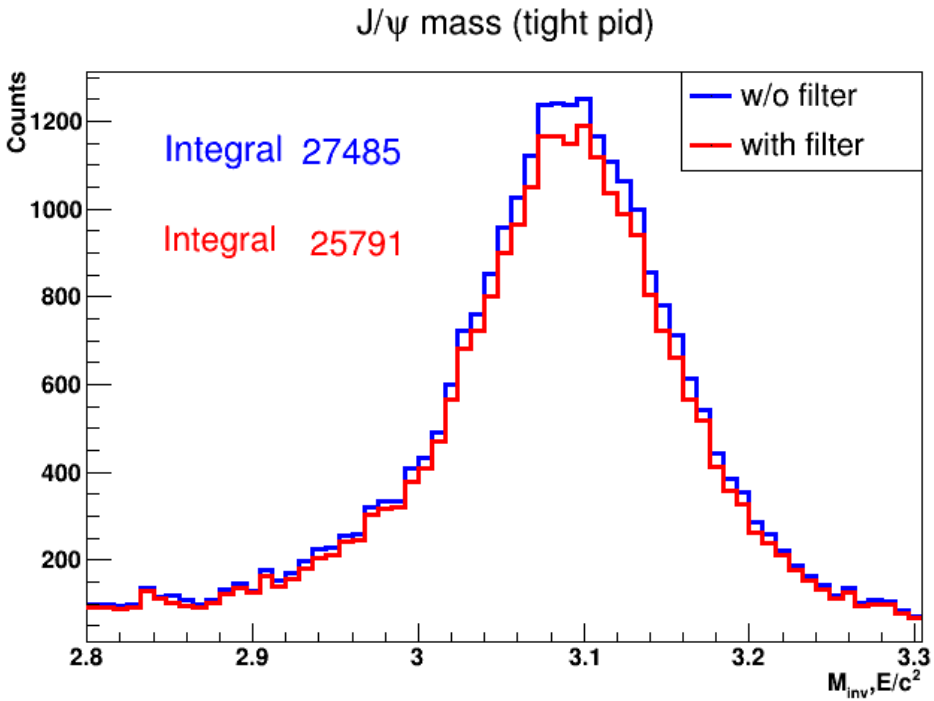
Event Filtering (VIRGO)

Comparison
With and w/o online filtering

Event-based (Sum)



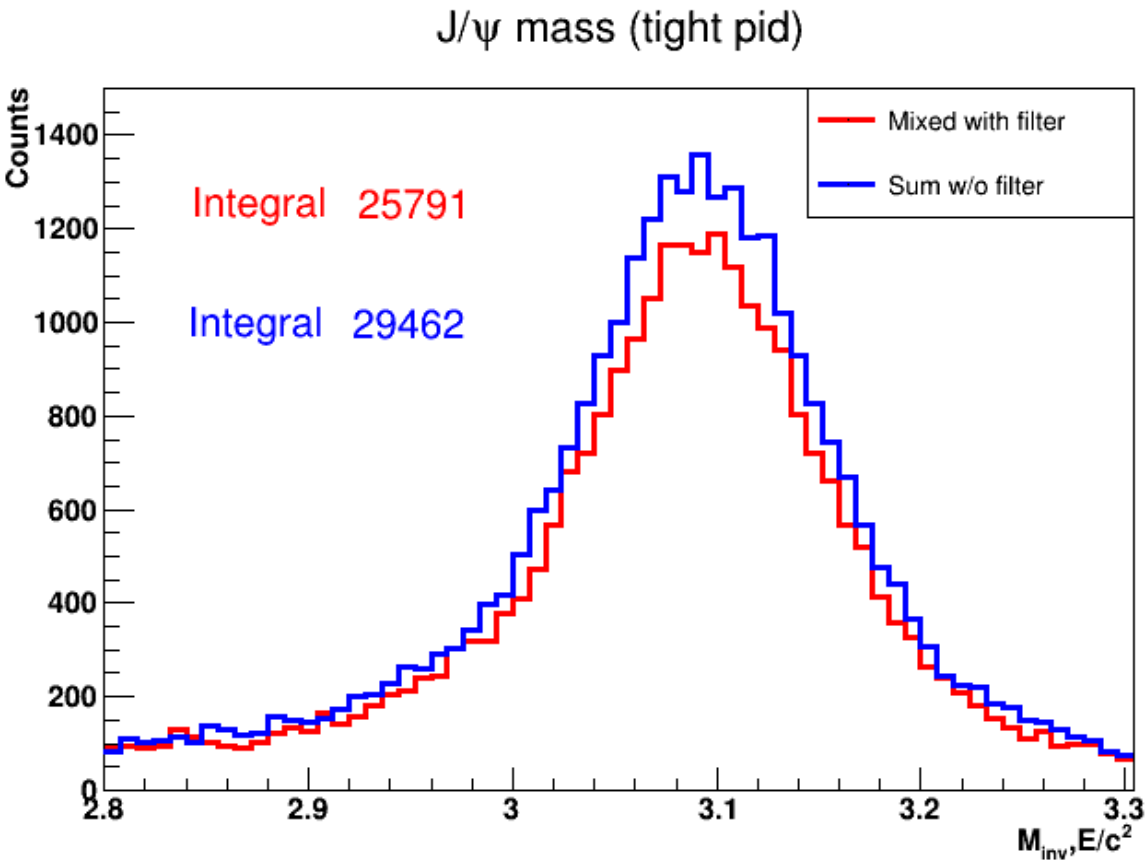
Time-based (Time-Gap)



Slight suppression if PID is required

Event Filtering (VIRGO)

Comparison of EB and TB with filter



Further optimisation is still needed!

Summary

- **Framework for event building and event filtering was developed in the PandaRoot**
- **Performance of the framework was studied by comparing with event-based simulation**
- **Further optimisation of framework parameters is required for better performance**
- **Rest of the benchmark channels still has to be studied using this framework**

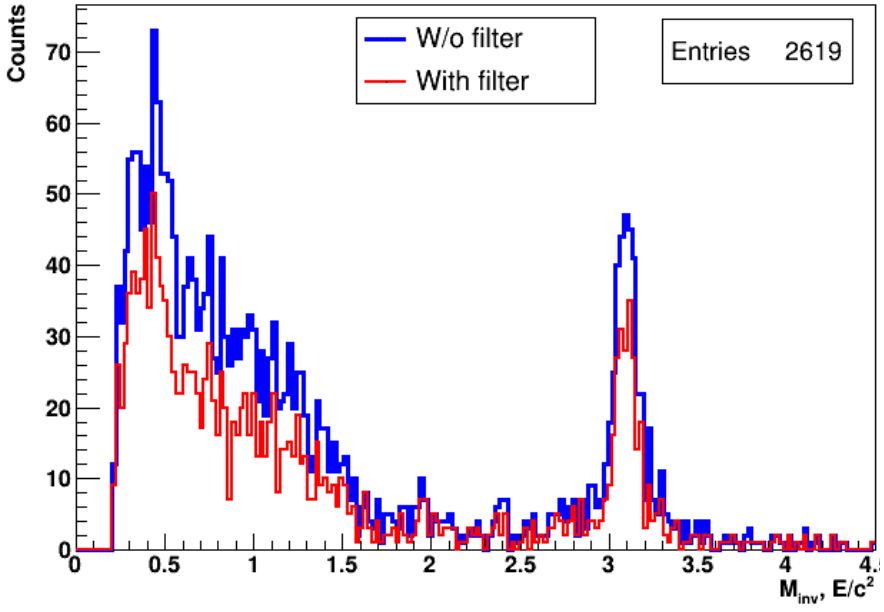

THANK YOU FOR YOUR ATTENTION
AND STAY HEALTHY!

Event Filtering

Results of the offline analysis with online filtering (Signal)

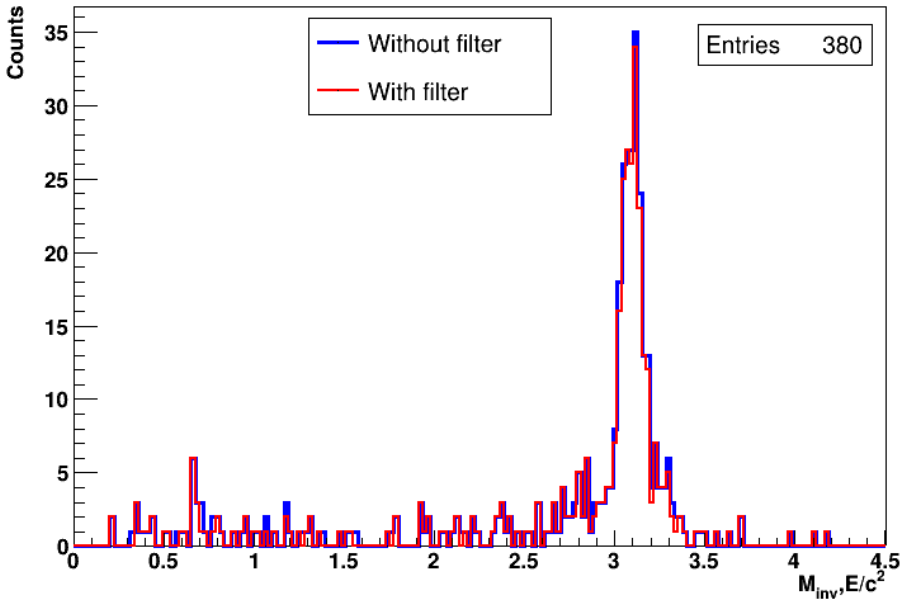
No PID

J/ψ mass (all)



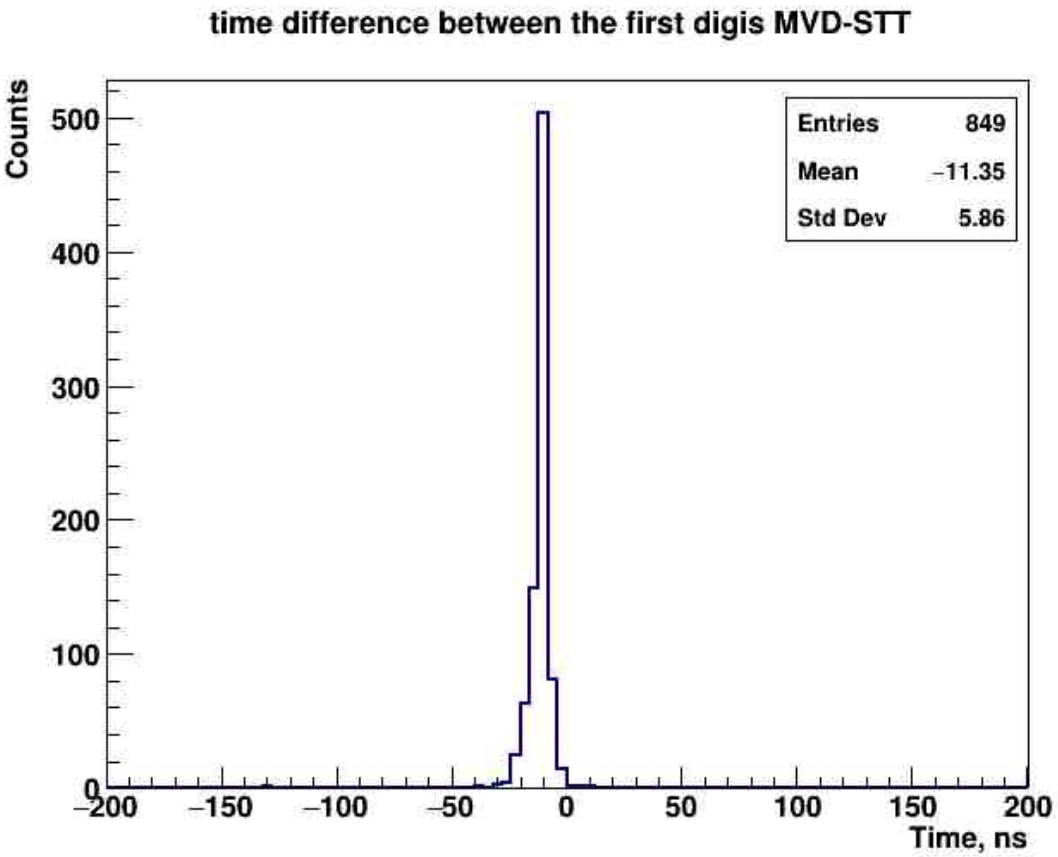
With PID

J/ψ mass (tight pid)

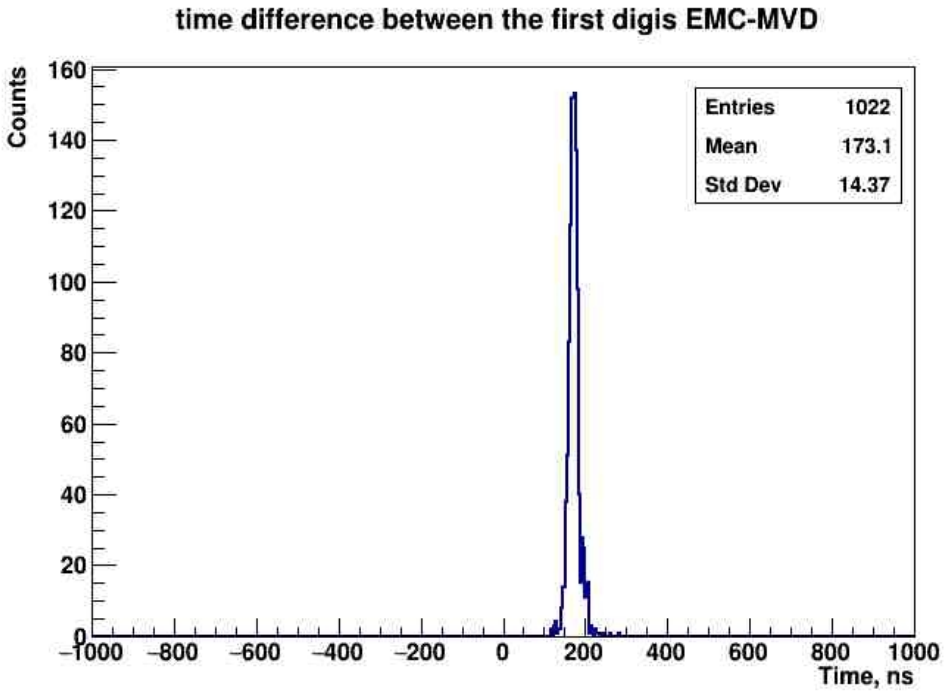


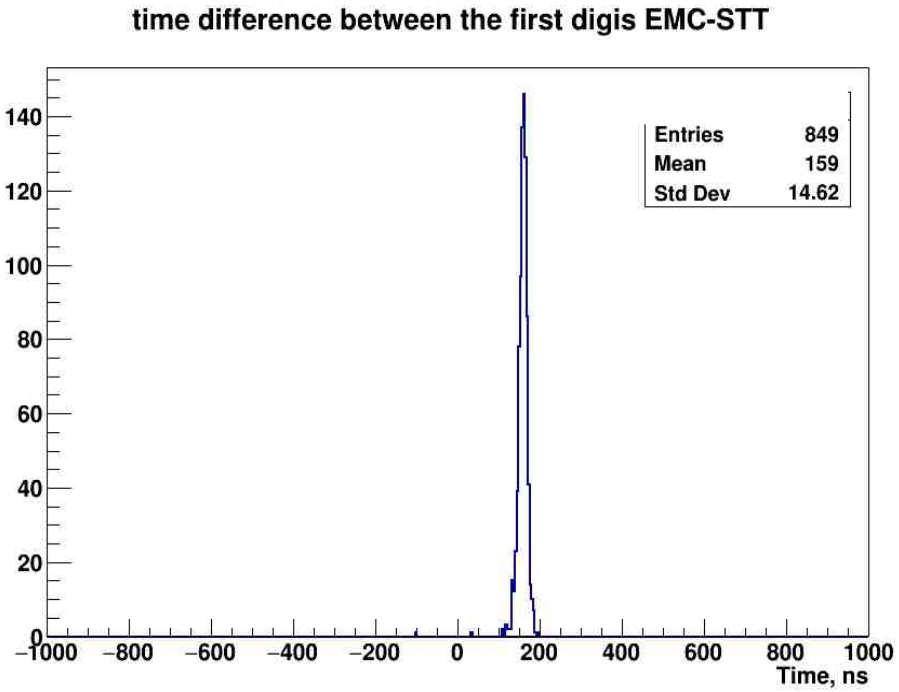
Slight suppression if PID is required

Time detector difference



Time detector difference

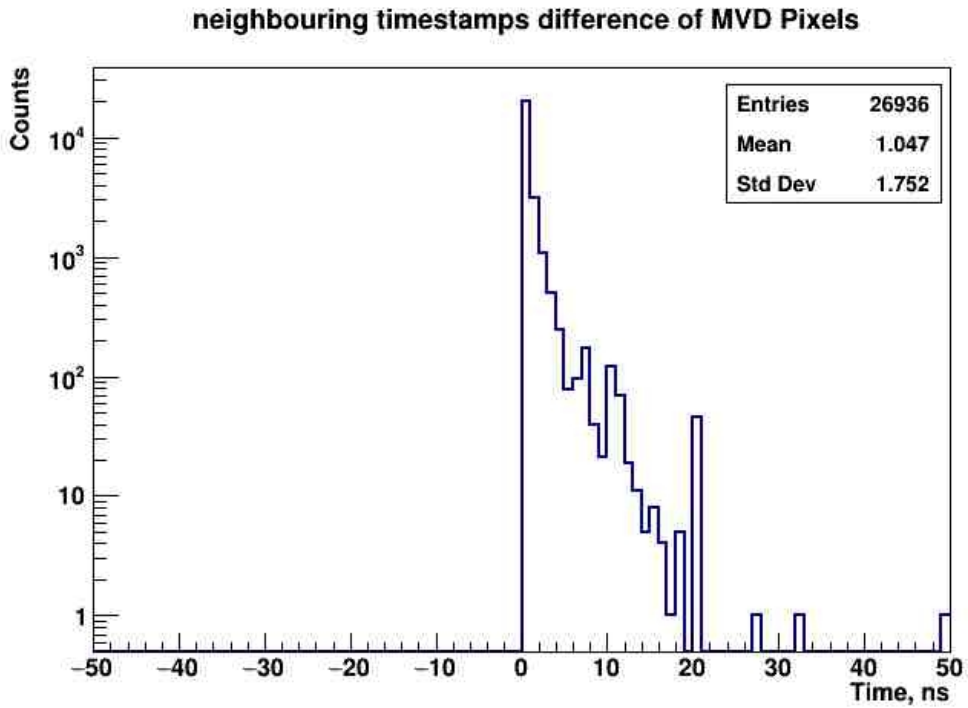


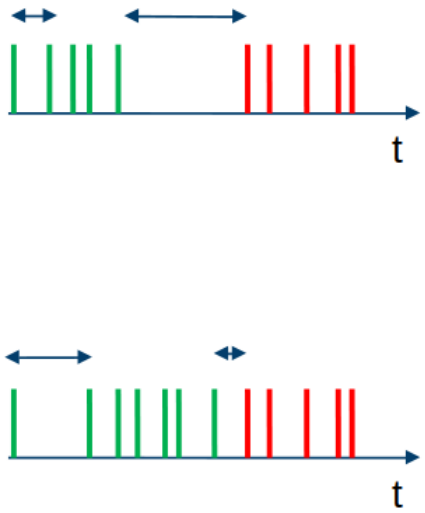


All detectors have to be calibrated before EB

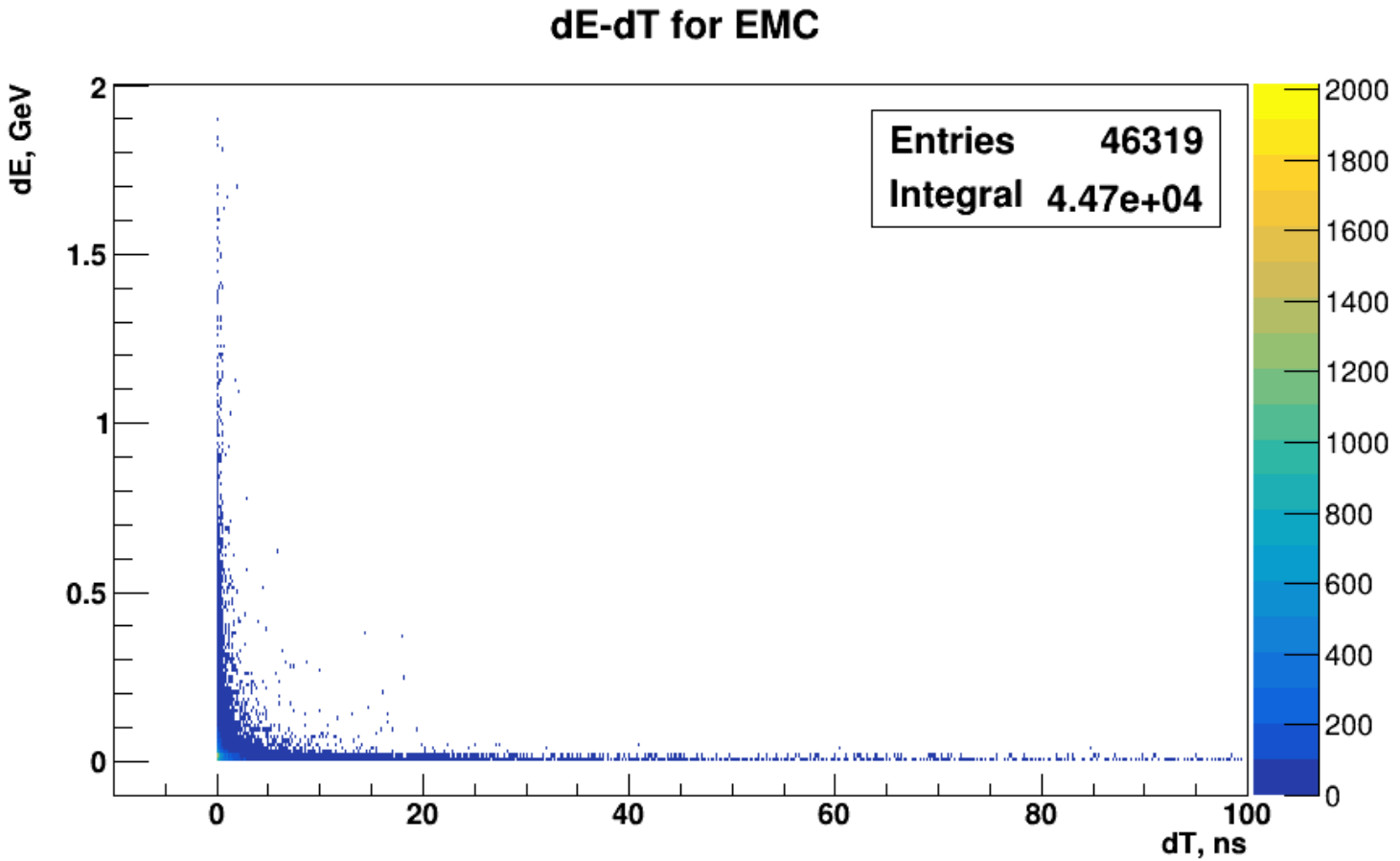
Time difference between “neighbours”

ftf_sim.root – 2000 events at 6.2315 GeV beam

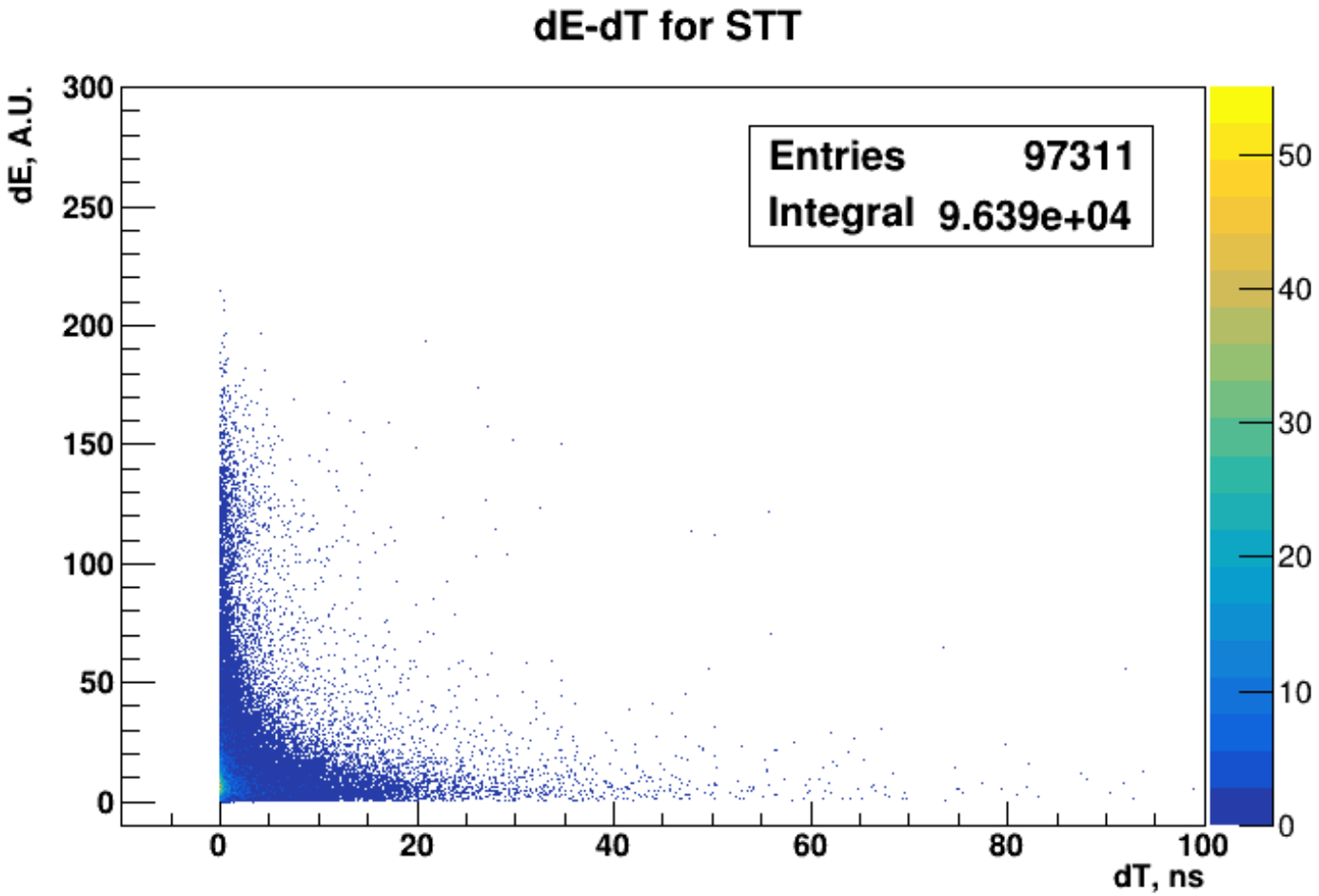




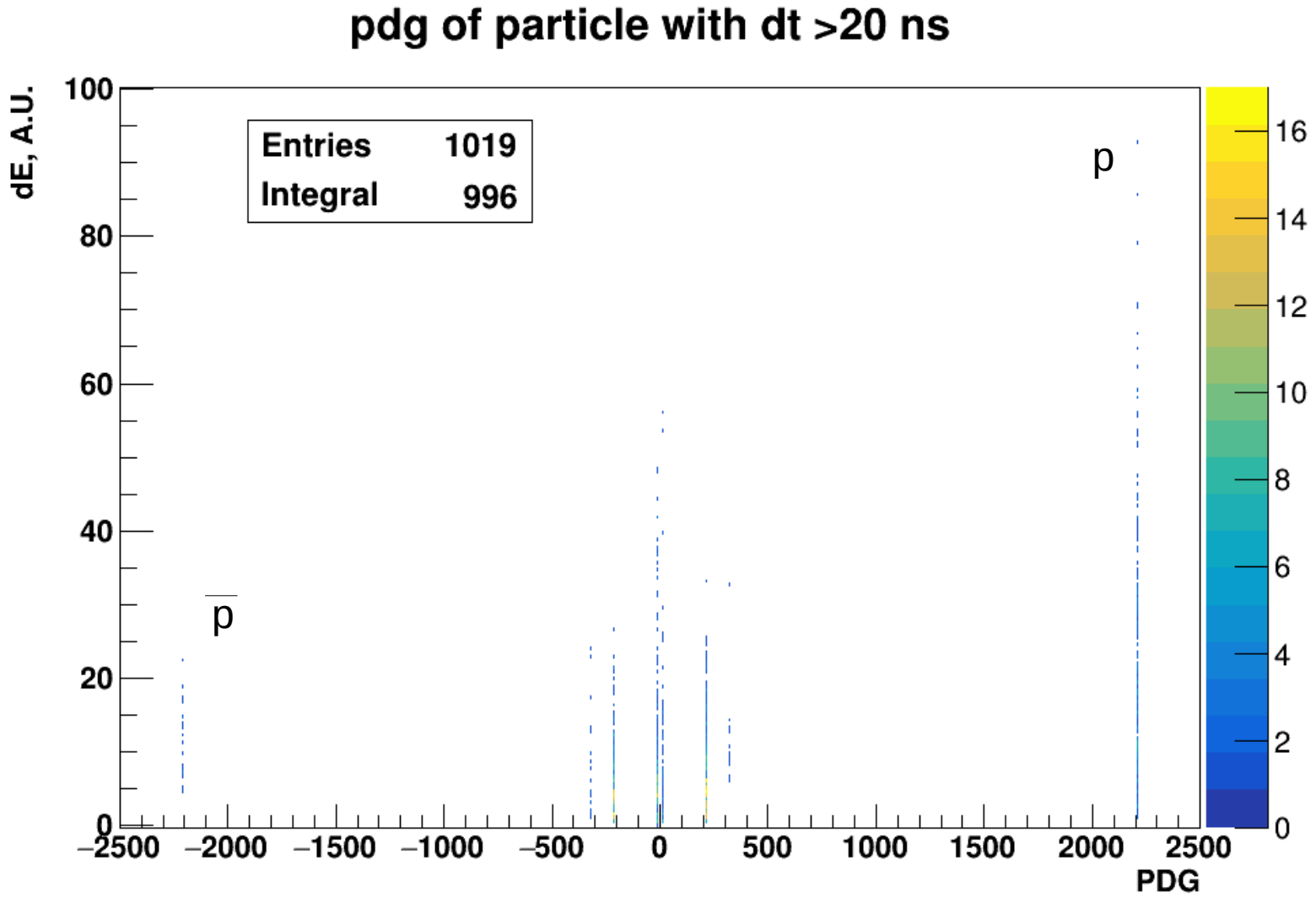
Time difference between “neighbours”



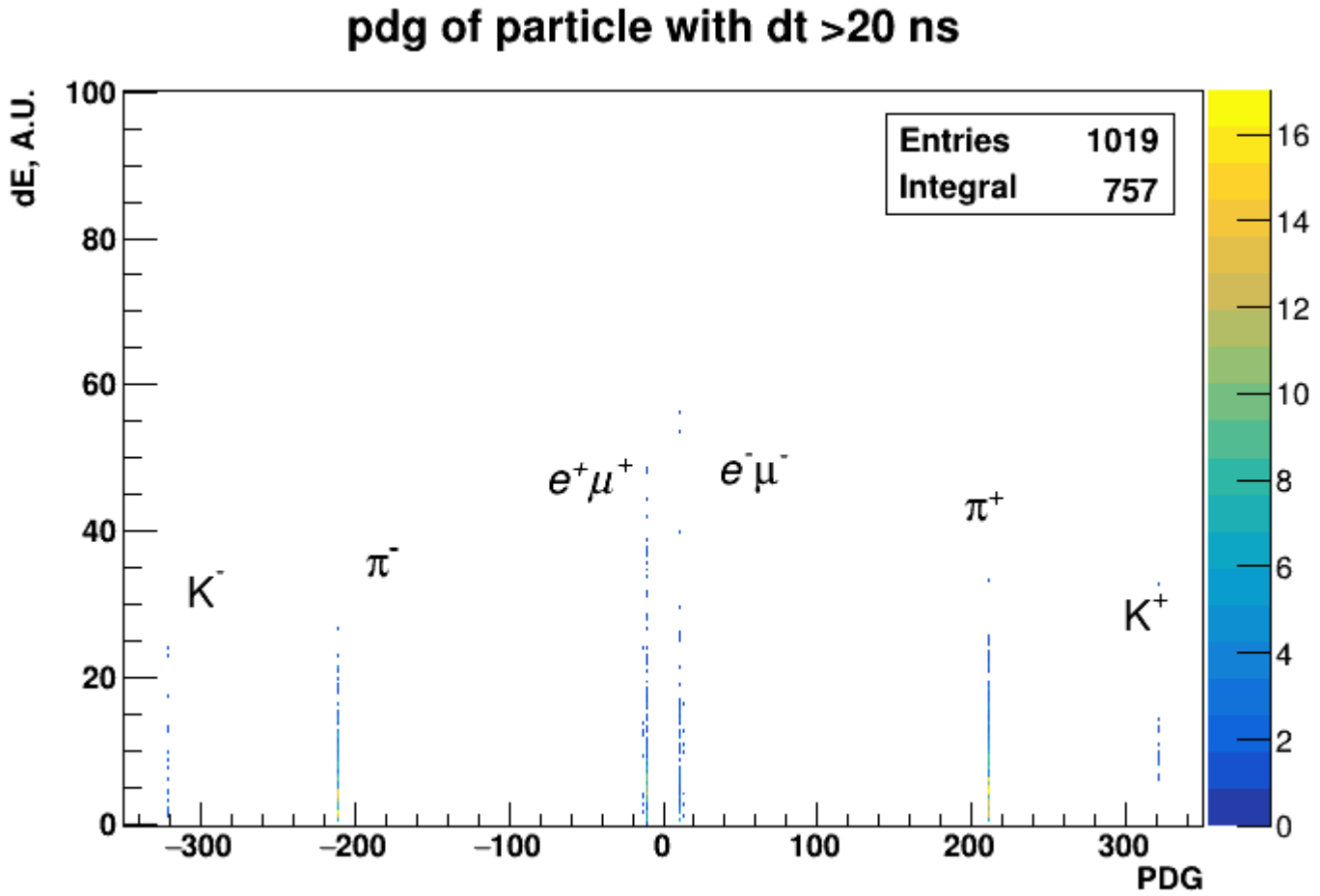
Time difference between “neighbours”



Time difference between “neighbours”



Time difference between “neighbours”



TimeGapEventBuilderTask updated v 1.1

-I- PndGapEventBuilderTask:Exec 3

Branch MVDSortedPixelDigis has first digi time = 3095.07 length 51 and last digi time = 3120
Branch MVDSortedStripDigis has first digi time = 3094.53 length 22 and last digi time = 3115.03
……..
……..
Branch SciTSortedHit has first digi time = 1305.56 length 1 and last digi time = 1305.56
……..
Branch FTSSortedHit has first digi time = 3391.84 length 31 and last digi time = 3524.54
 Min timestamp of the first digi: = 1305.56

Branches: SciTSortedHit is part of event with first digi = 1305.56 and last digi = 1305.56

 Max timestamp of the last digi: = 1305.56

MVDSortedPixelDigis 3095.07 51
 output array before 0 time 3095.07
 output array after 0
 OK

MVDSortedStripDigis 3094.53 22
 output array before 0 time 3094.53
 output array after 0
 OK

TimeGapEventBuilderTask updated v 1.1

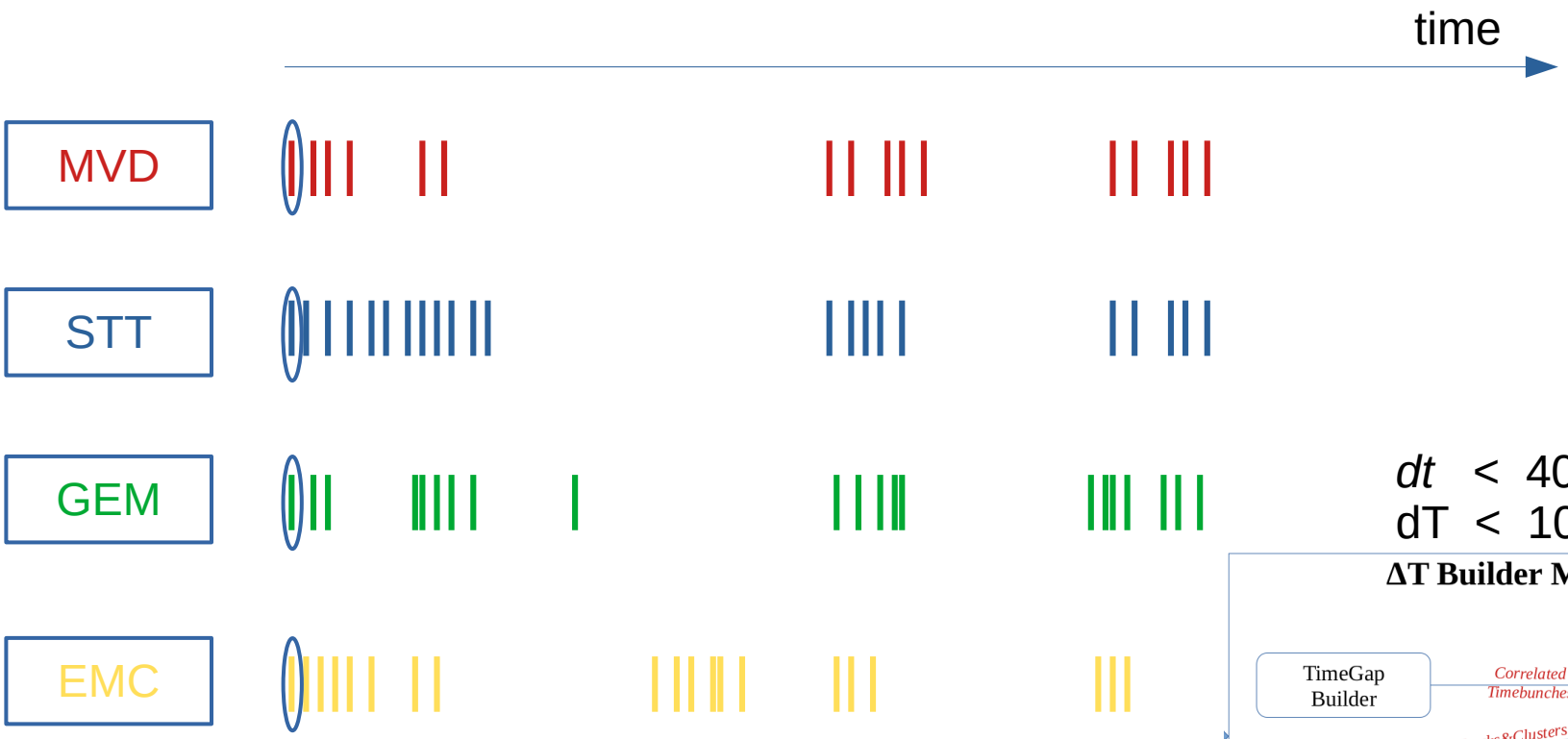
-I- PndGapEventBuilderTask:Exec 4

Branch MVDSortedPixelDigis has first digi time = 3095.07 length 51 and last digi time = 3120
Branch MVDSortedStripDigis has first digi time = 3094.53 length 22 and last digi time = 3115.03
Branch STTSortedHits has first digi time = 3107.21 length 123 and last digi time = 3340.78
Branch GEMSortedDigi has first digi time = 3103.33 length 8 and last digi time = 3103.33
Branch SciTSortedHit has first digi time = 3106.54 length 3 and last digi time = 3106.89
Branch EmcDigiSorted has first digi time = 3092.8 length 10 and last digi time = 3118.89
Branch MdtSortedHit has first digi time = 3112.57 length 23 and last digi time = 3116.15
Branch FTSSortedHit has first digi time = 3391.84 length 31 and last digi time = 3524.54
Min timestamp of the first digi: = 3092.8

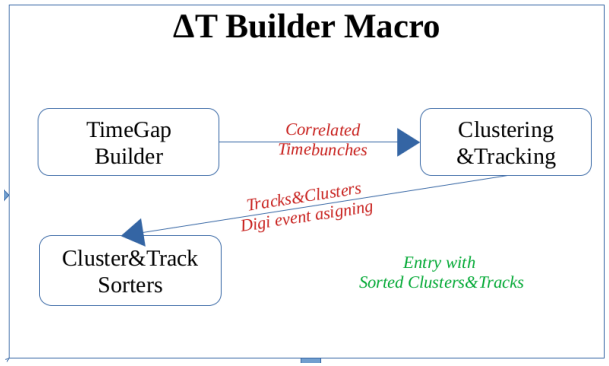
Branches: MVDSortedPixelDigis is part of event with first digi = 3095.07 and last digi = 3120
Branches: MVDSortedStripDigis is part of event with first digi = 3094.53 and last digi = 3115.03
Branches: STTSortedHits is part of event with first digi = 3107.21 and last digi = 3340.78
Branches: GEMSortedDigi is part of event with first digi = 3103.33 and last digi = 3103.33
Branches: SciTSortedHit is part of event with first digi = 3106.54 and last digi = 3106.89
Branches: EmcDigiSorted is part of event with first digi = 3092.8 and last digi = 3118.89
Branches: MdtSortedHit is part of event with first digi = 3112.57 and last digi = 3116.15

MVDSortedPixelDigis 3380 11
output array before 51 time 3380
output array after 51
MVDSortedStripDigis 3382.88 11
output array before 22 time 3382.88
output array after 22

Time-Gap Algorithm updated v 1.0

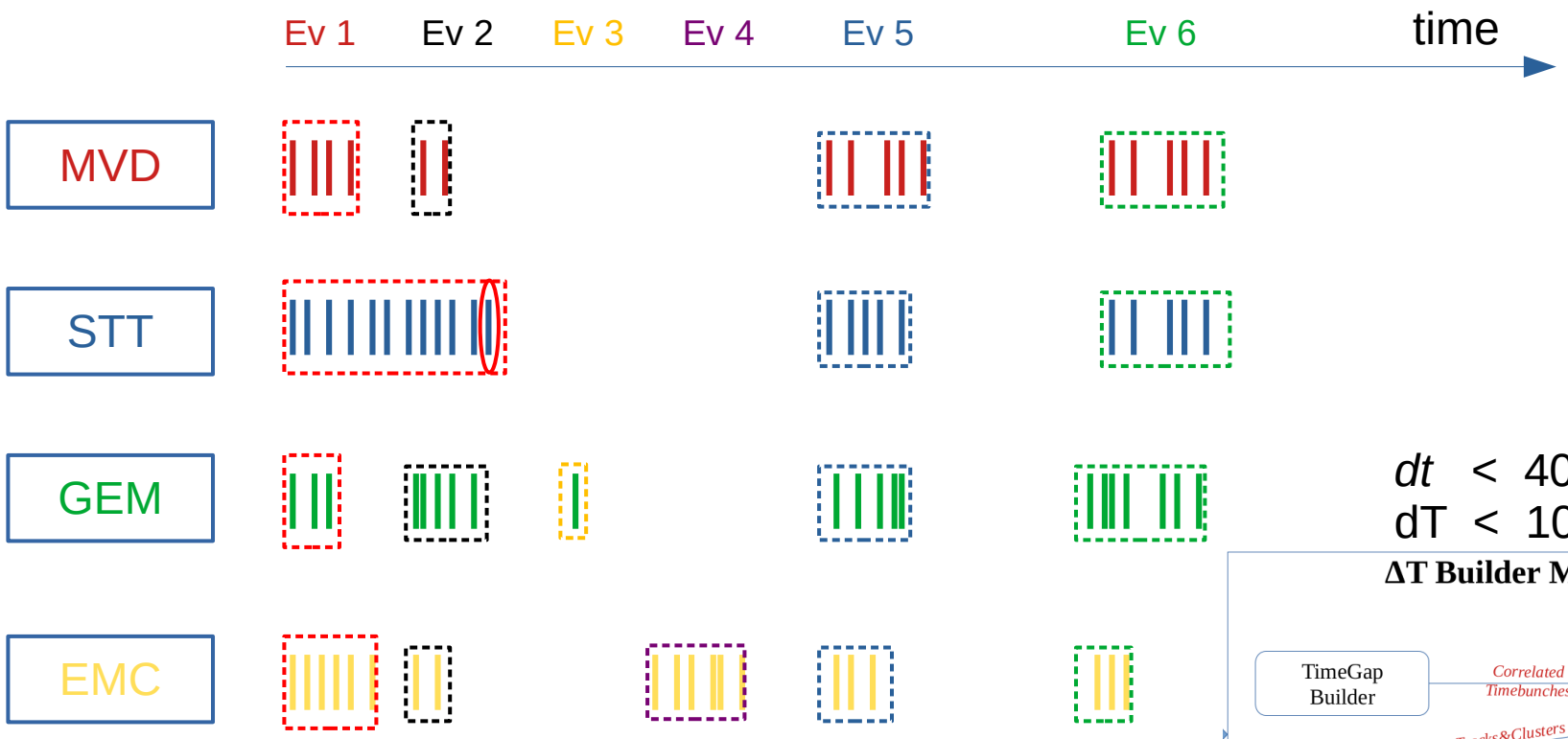


dt < 40 ns
dT < 100 ns

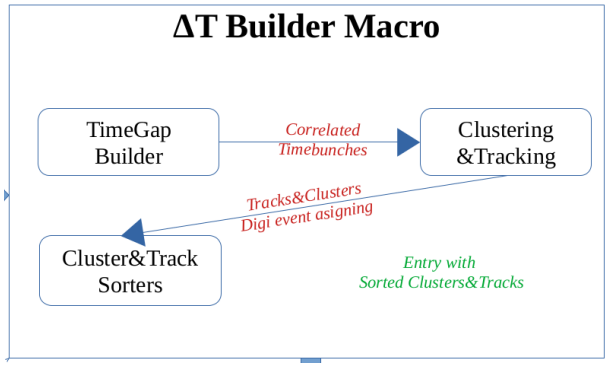


GetData(Detector,TimeGap, 40 ns)

TimeGap Algorithm updated v 1.1

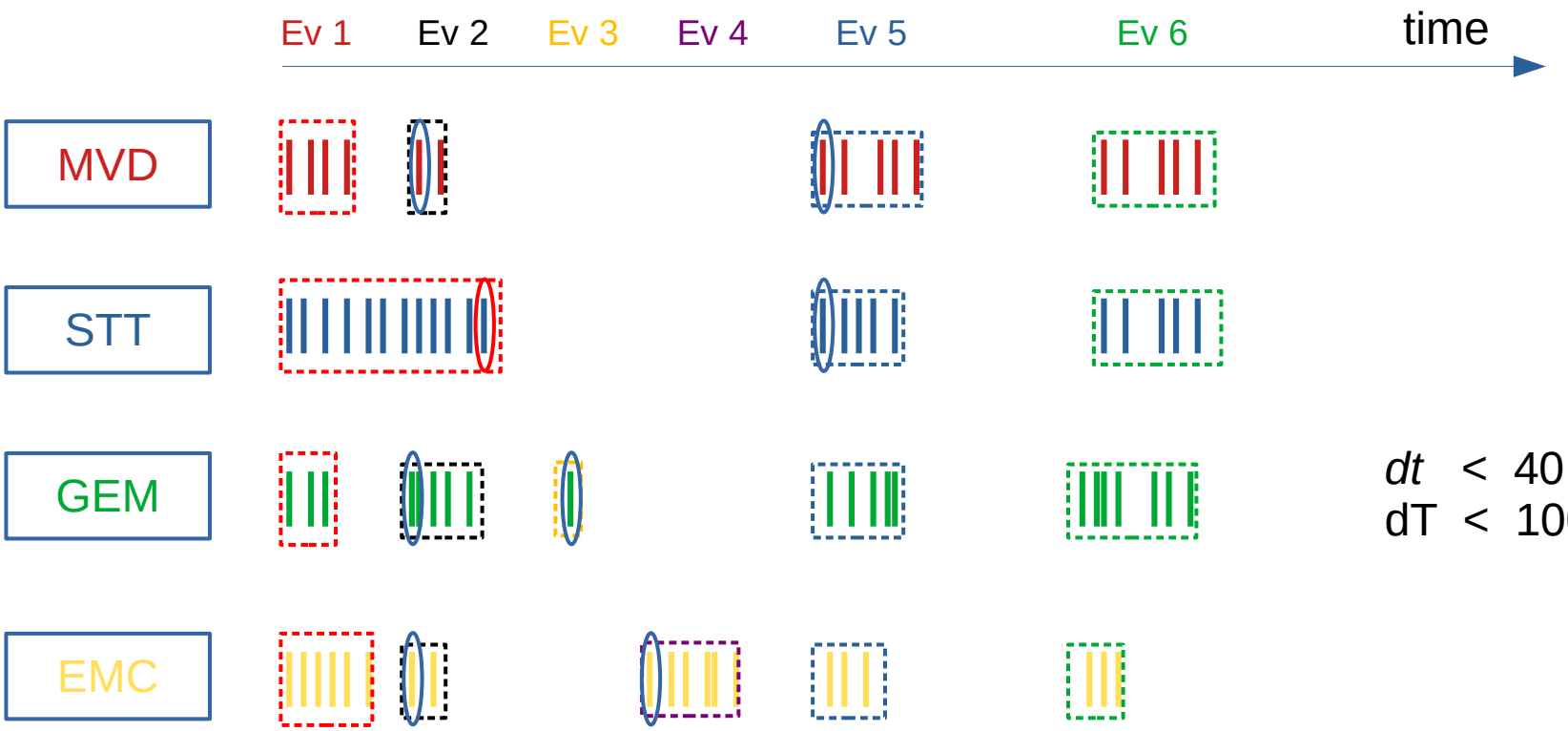


dt < 40 ns
dT < 100 ns



GetData(Detector,TimeGap, 40 ns)

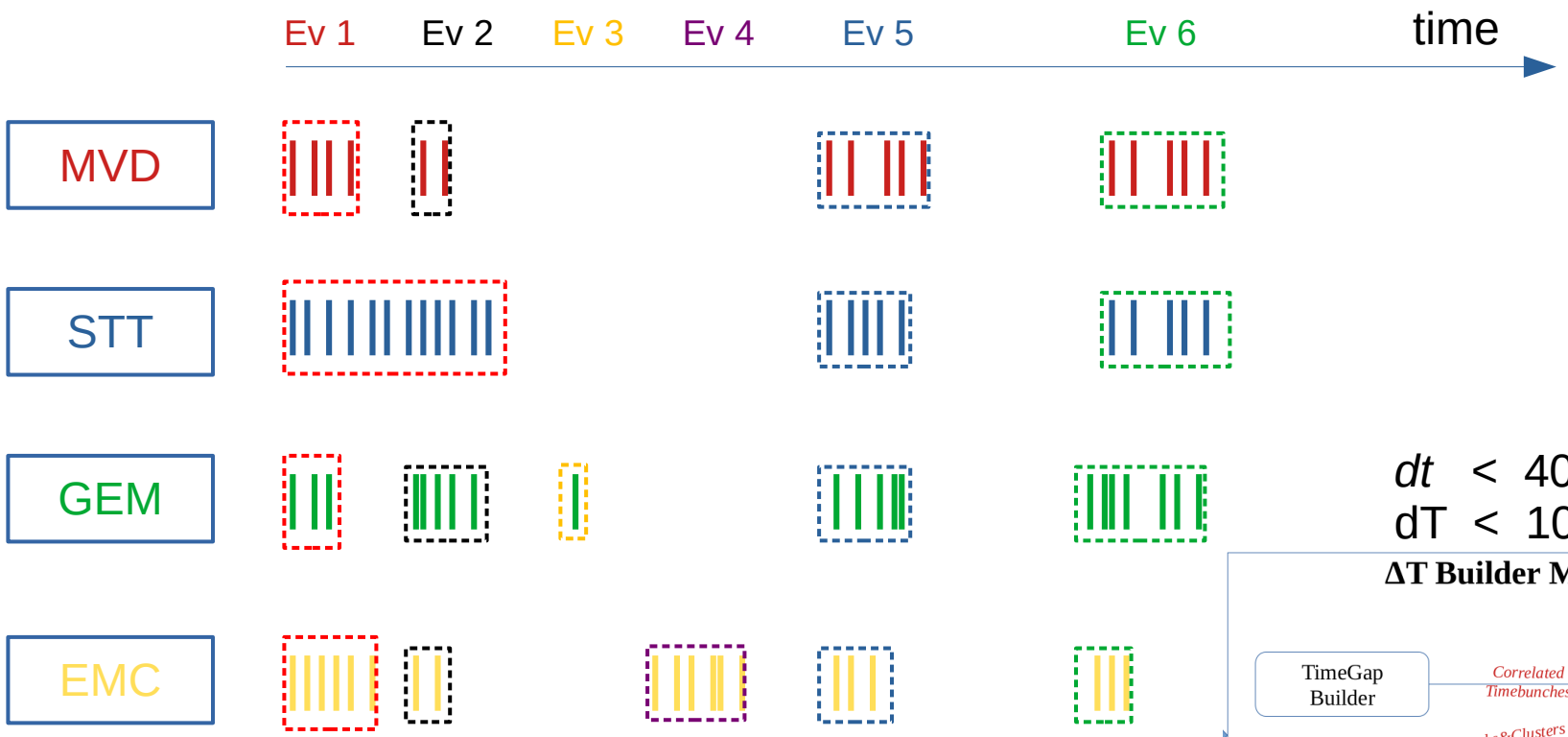
TimeGapEventBuilderTask updated v 1.1



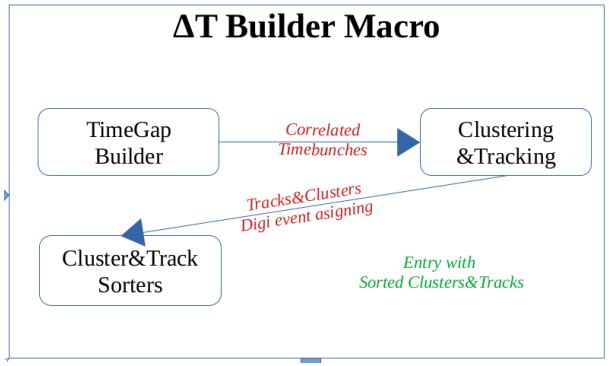
dt < 40 ns
dT < 100 ns

GetData(Detector,TimeGap, 40 ns)

TimeGapEventBuilderTask updated v 1.0



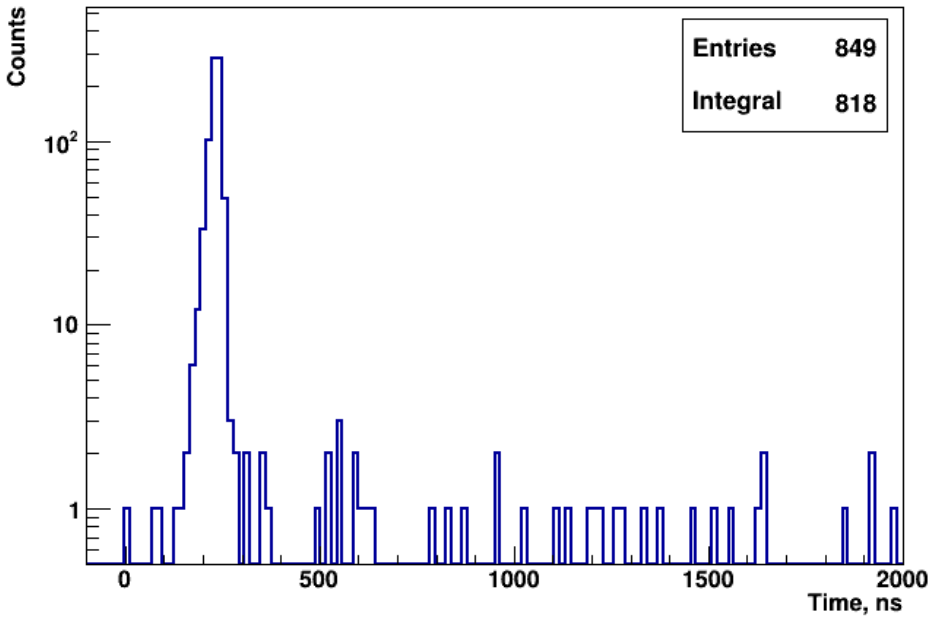
dt < 40 ns
dT < 100 ns



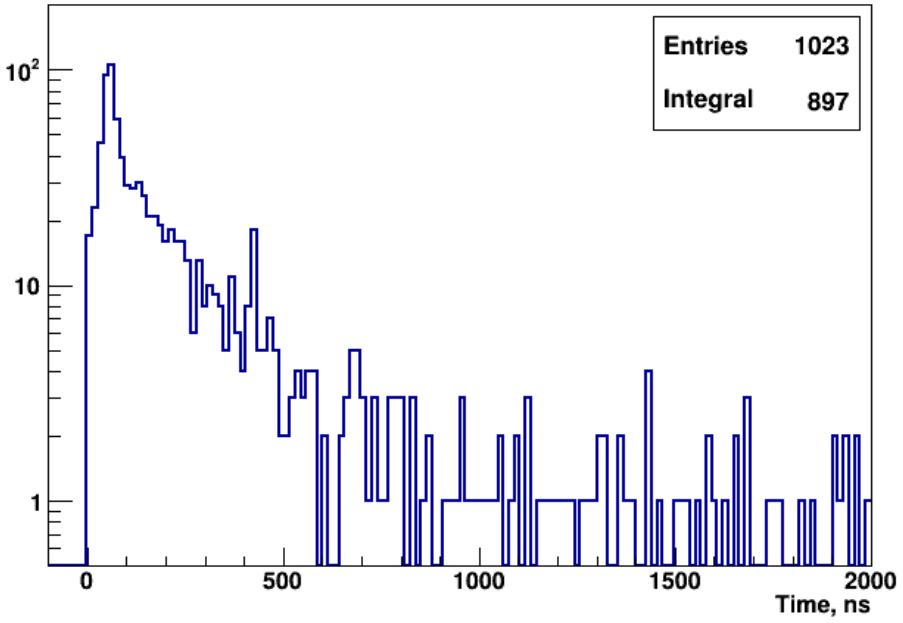
GetData(Detector,TimeGap, 40 ns)

Time duration of event
Background (STT)

STT

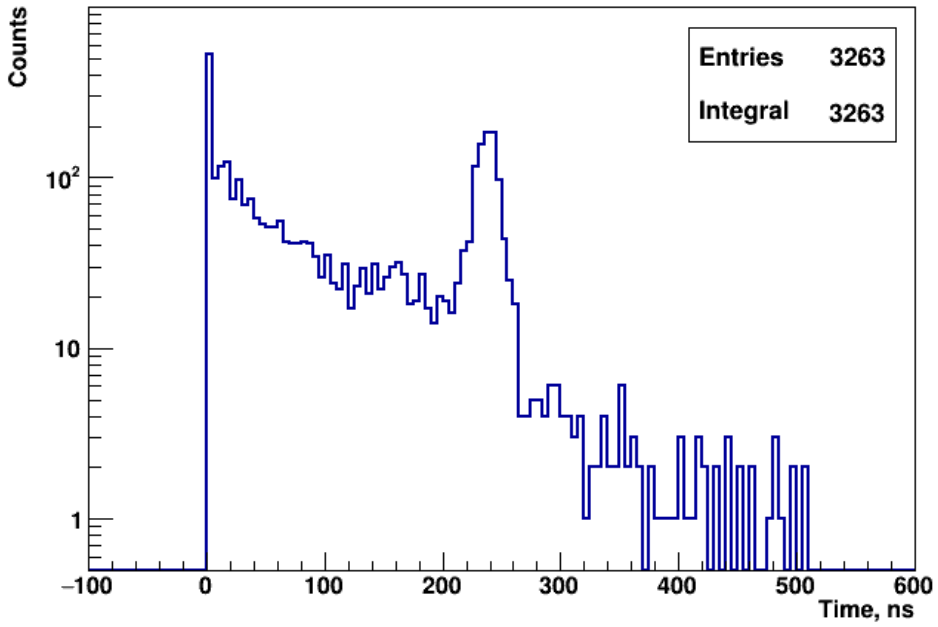


EMC



Time duration of event
After time-gap EB (dt=20 ns)

STT



EMC