university of groningen

Time-based studies of the benchmark channels for the DAQ system

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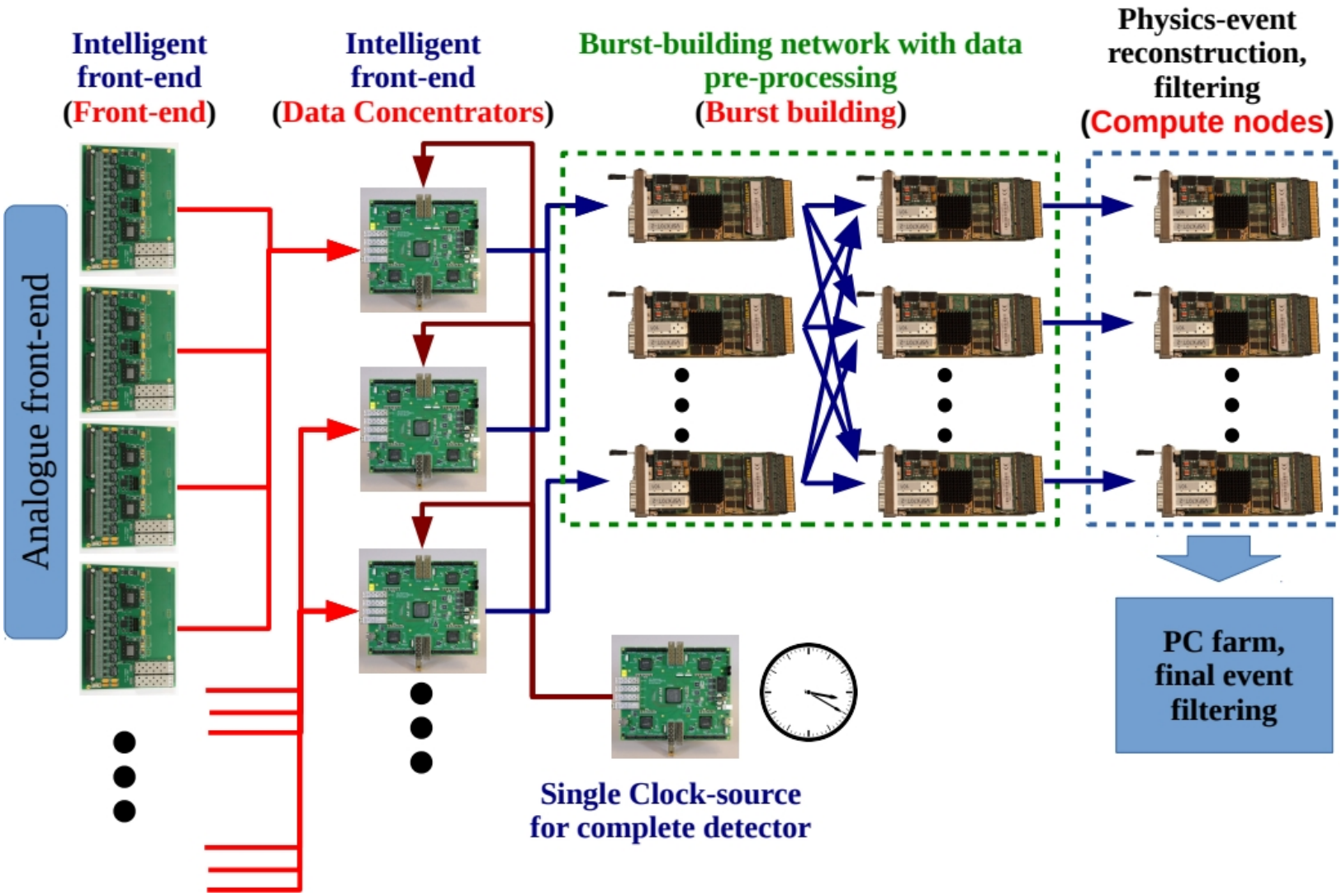
Oct 27, 2021, $\overline{\text{P}}$ANDA CM 21/3

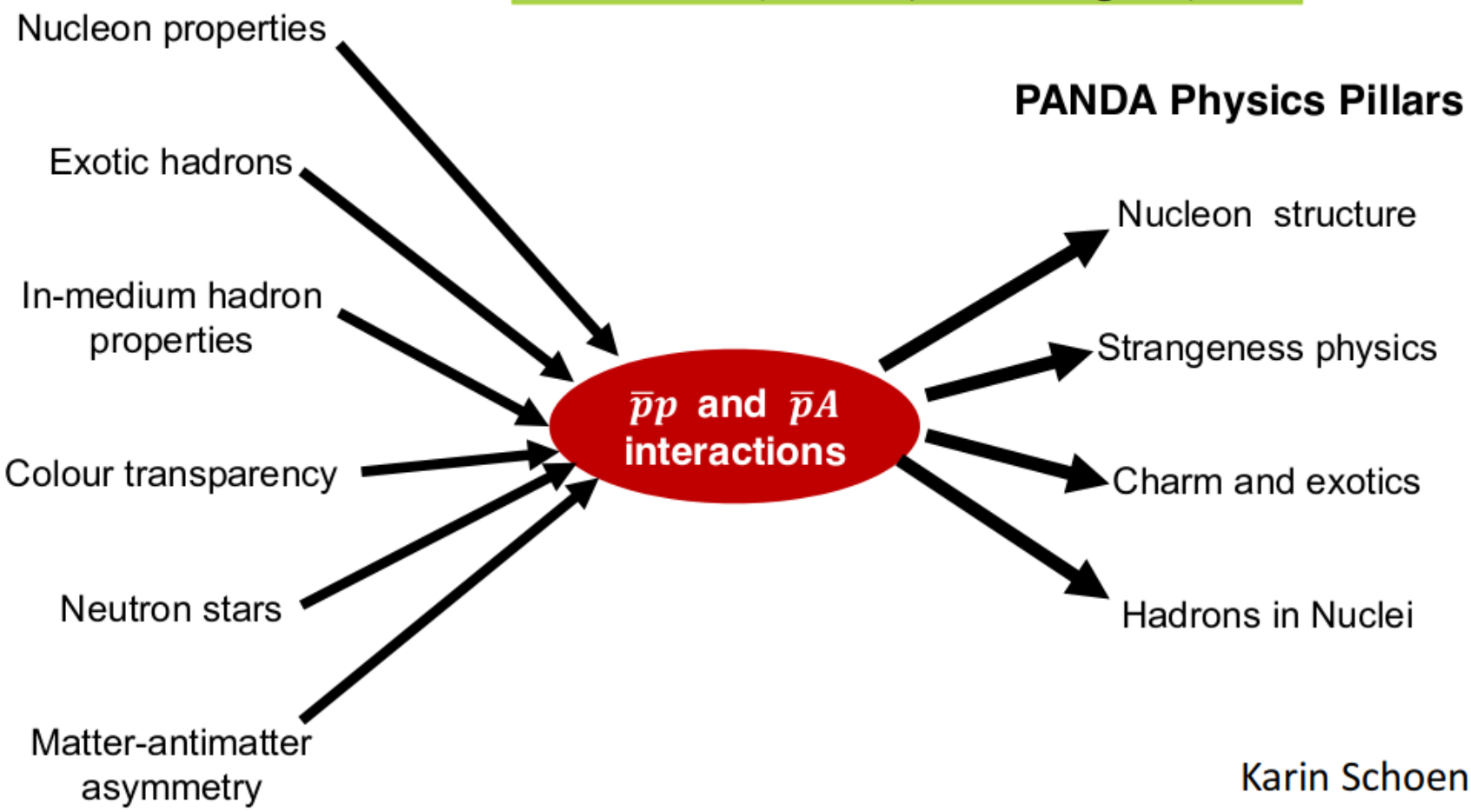
Triggerless DAQ system



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) $\bar{p}p \rightarrow J/\psi(\rightarrow \mu^+\mu^-)\pi^+\pi^-$ 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

4) $\bar{p}p \rightarrow e^+e^-\pi^0(\rightarrow \gamma\gamma)$ 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.

Benchmark channels for the DAQ

Previous studies

Framework: Geant3, FairRoot v.17.10b and FairSoft oct17p1;

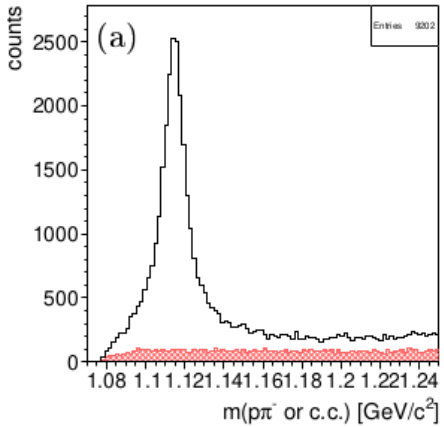
Data sample: 10^5 signal events (EvtGen); 10^6 background events (DPM)

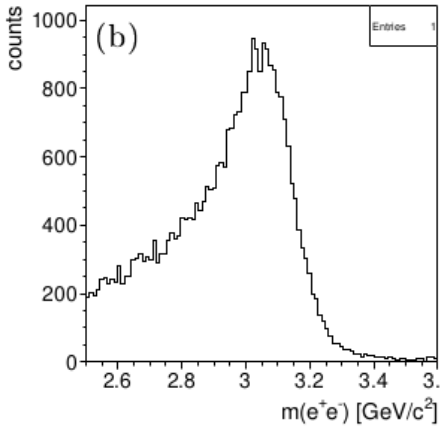
Fully event-based

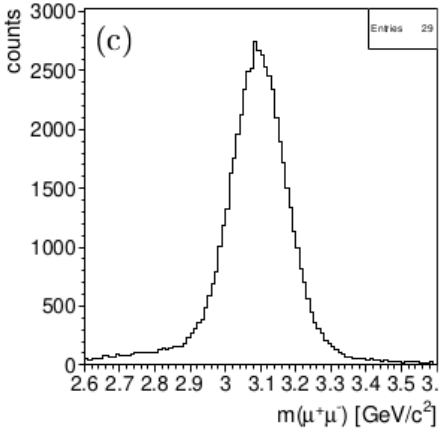
Smearing procedure is applied to tracks and clusters

Benchmark channels for the DAQ

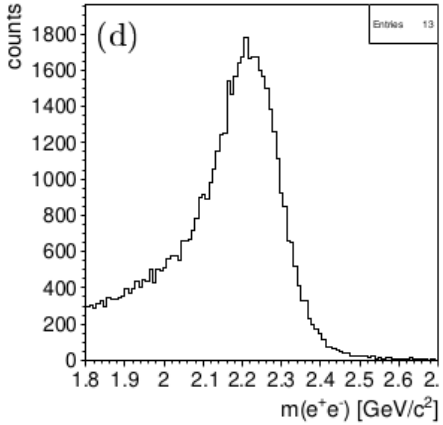
Previous studies

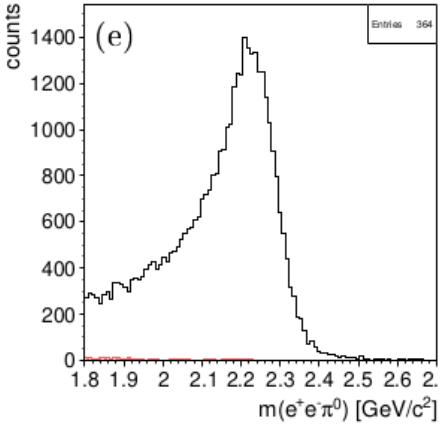






Channel	$\epsilon_S[\%]$	$\epsilon_B[\%]$	f_{sup} [×1000]
$\Lambda \to p\pi^-$	30.0	0.82	0.121
$J/\psi \to e^+e^-$	24.7	0.0001	$> 303^*$
$J/\psi \to \mu^+\mu^-$	56.3	0.0038	$> 22.2^*$
$\bar{p}p \to e^+e^-$	40.9	0.0009	$> 76.3^*$
$\bar{p}p \to e^+e^-\pi^0$	16.5	0.0156	6.41

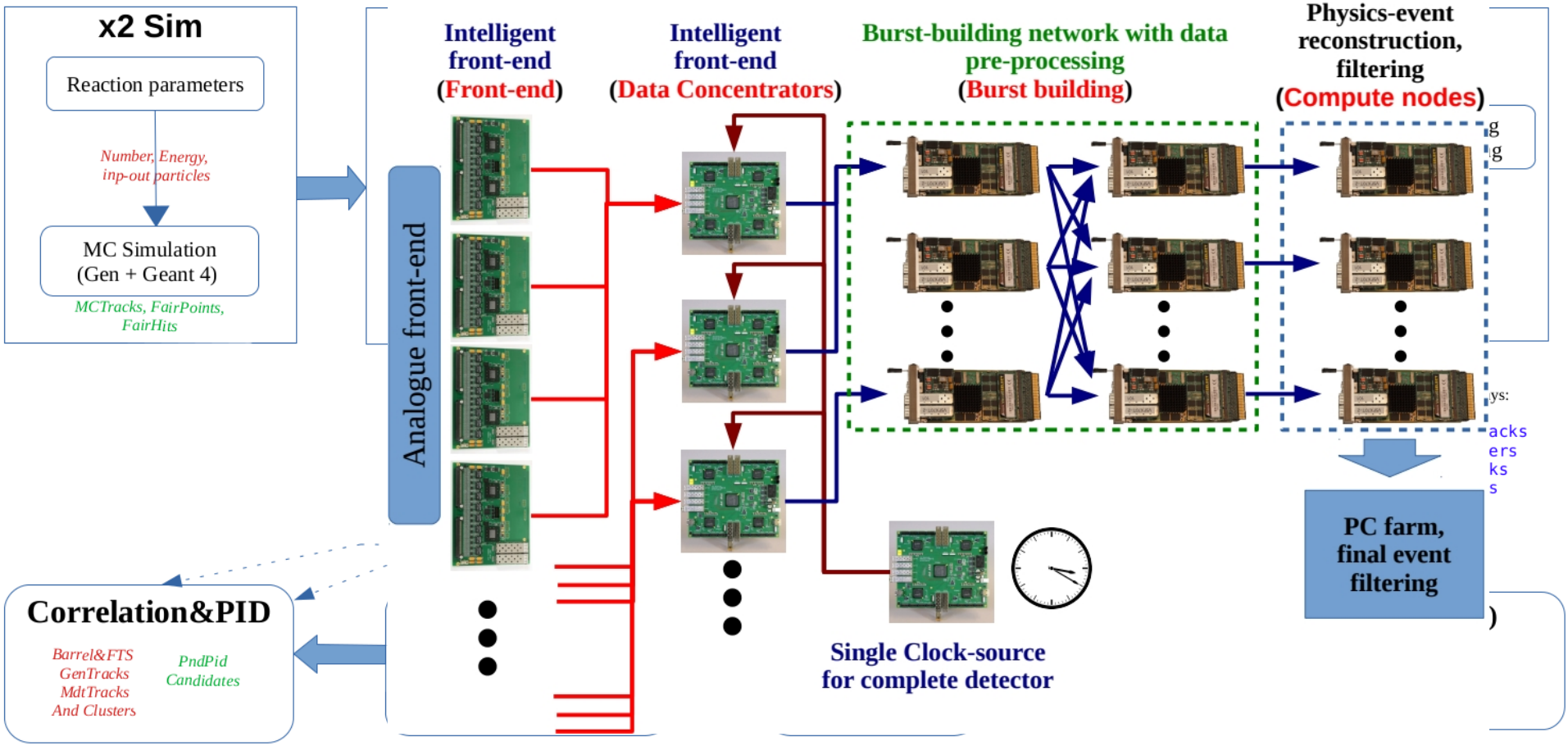




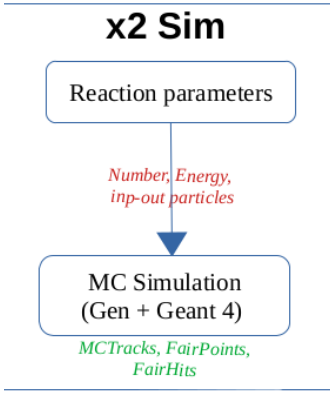
Motivation

Repeat these studies for each benchmark channel in the new framework, which will be more realistic and will correspond to the future DAQ system.

Simulation workflow



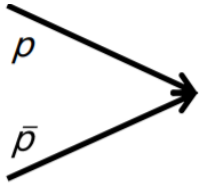
Monte Carlo information (local machine)



Two files were generated for each benchmark channel:

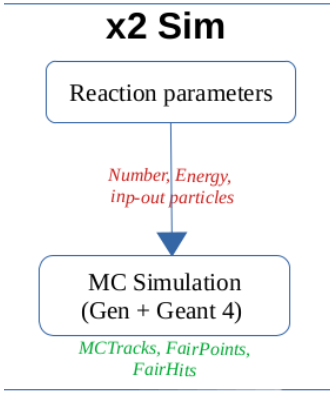
1. **SIGNAL** – 1000 events at the channel's P_{beam} momentum from EvtGen.

2. **BACKGROUND** – 2000 events at the channel's P_{beam} momentum from FTF generator:



(all possible inelastic reactions, respecting cross-section)

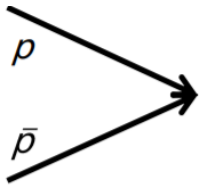
Monte Carlo information (VIRGO)



Two files were generated for each benchmark channel:

1. **SIGNAL** – 10^5 events at the channel's P_{beam} momentum from EvtGen.

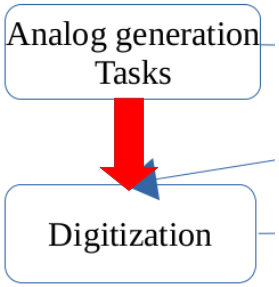
2. **BACKGROUND** – 10^6 events at the channel's P_{beam} momentum from FTF generator:



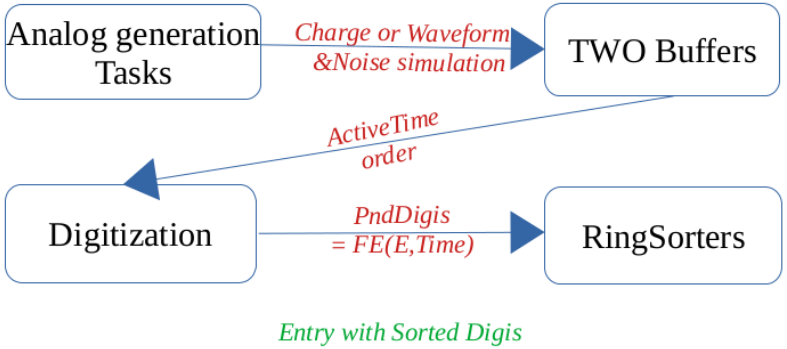
(all possible inelastic reactions, respecting cross-section)

Digitization

Digitization macro



Digitization macro



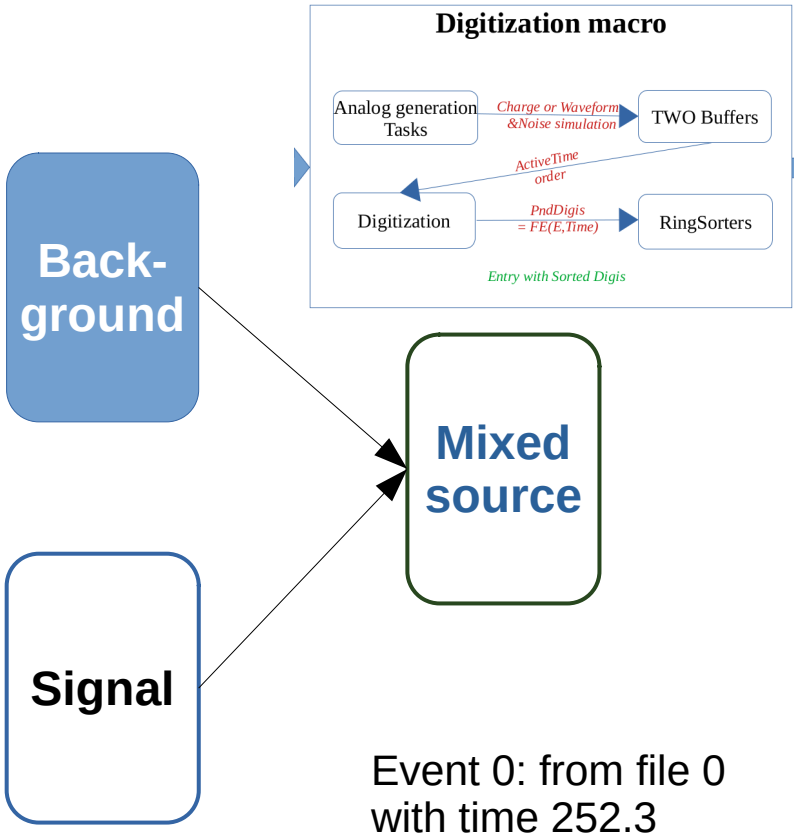
Event-based

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

Time-based

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

Time-based Simulation



Time-based

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

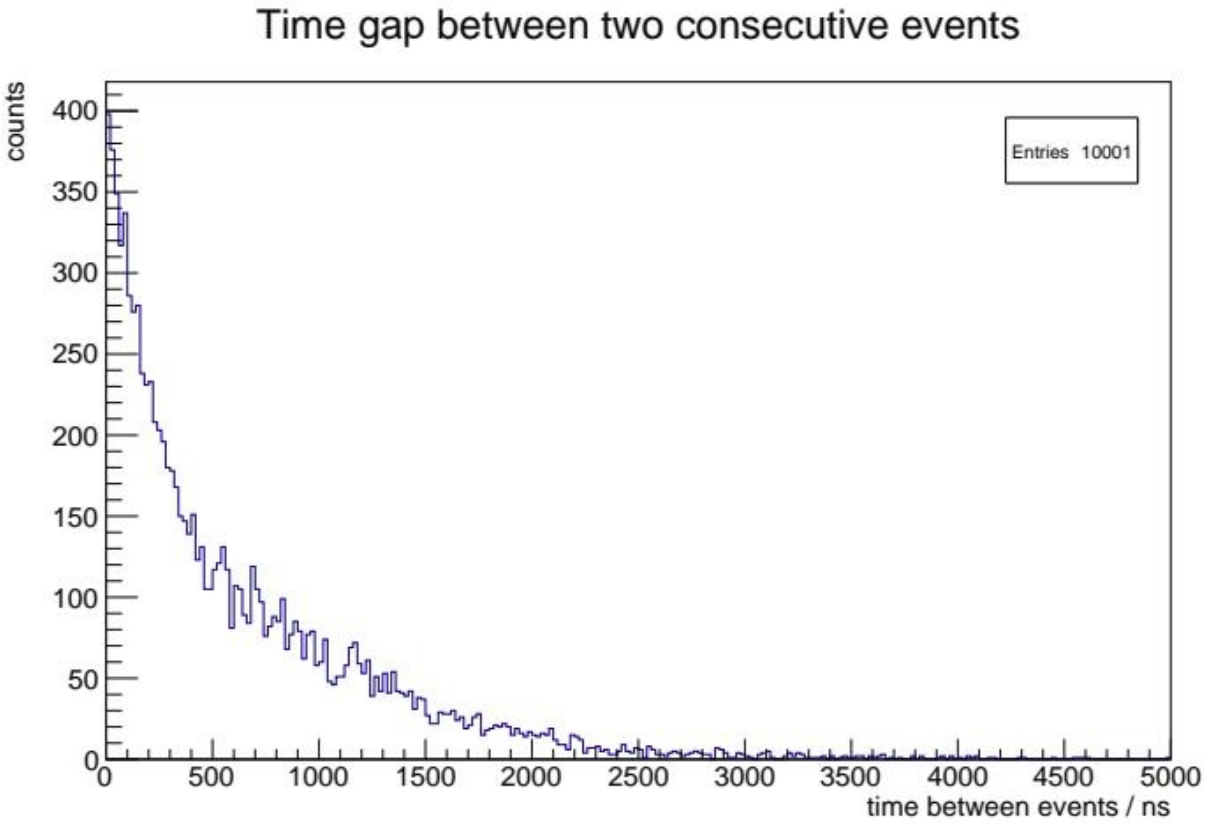
Event 0: from file 0
with time 252.3
Event 1: from file 1
with time 728.6
……
Event 50: from file 0
with time 7854.7

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

source->SetEventMeanTime(500);

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

Time-based Simulation

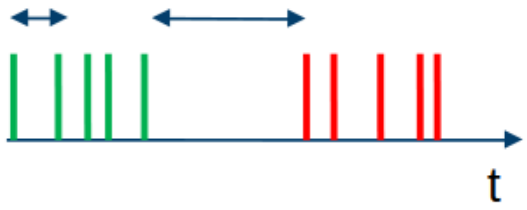


10000 anti-proton target interactions

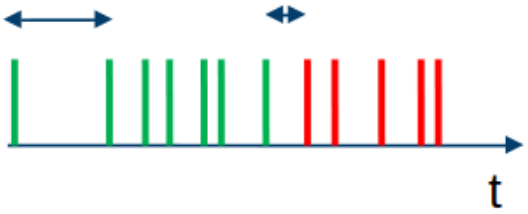
with a mean time duration of events 500 ns.

Time-gap event building in a nutshell

It is based on the time difference between adjacent hits

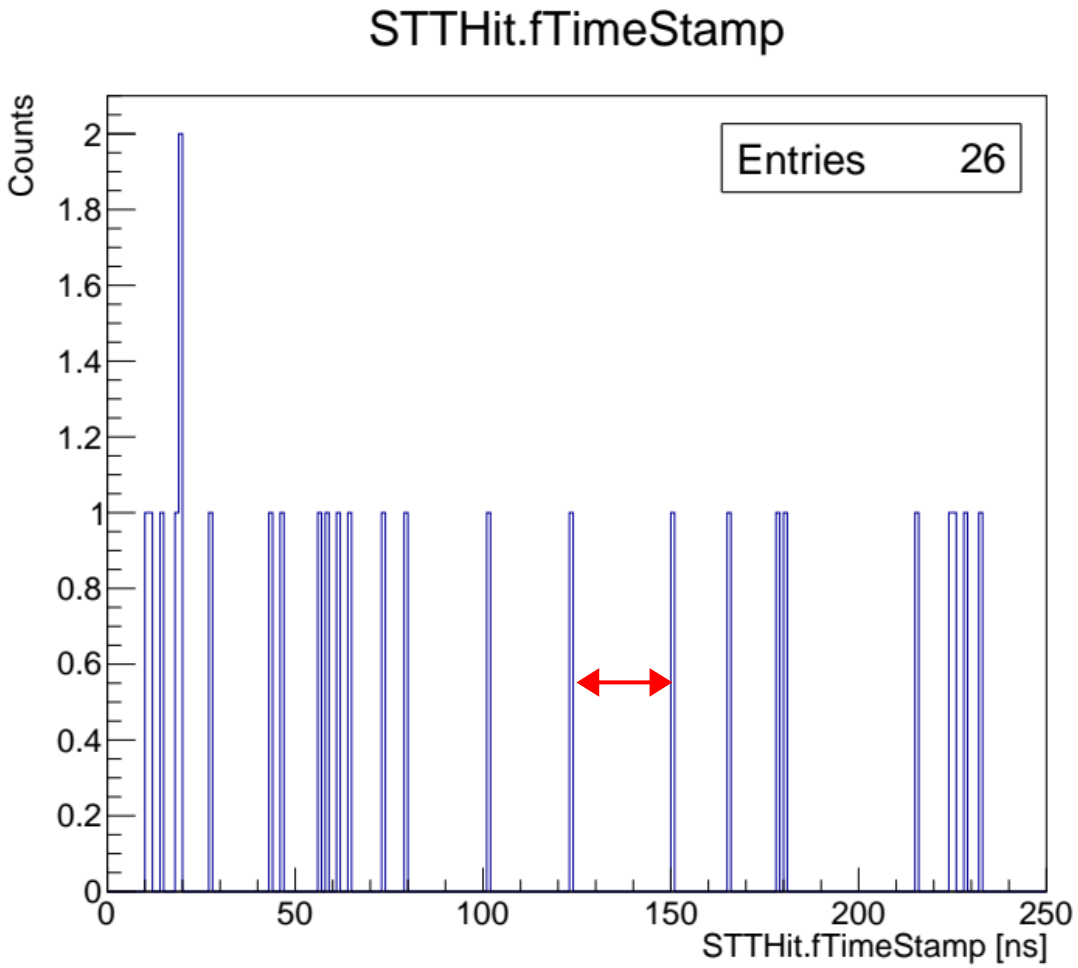


It performs well as long as a time difference between events is big

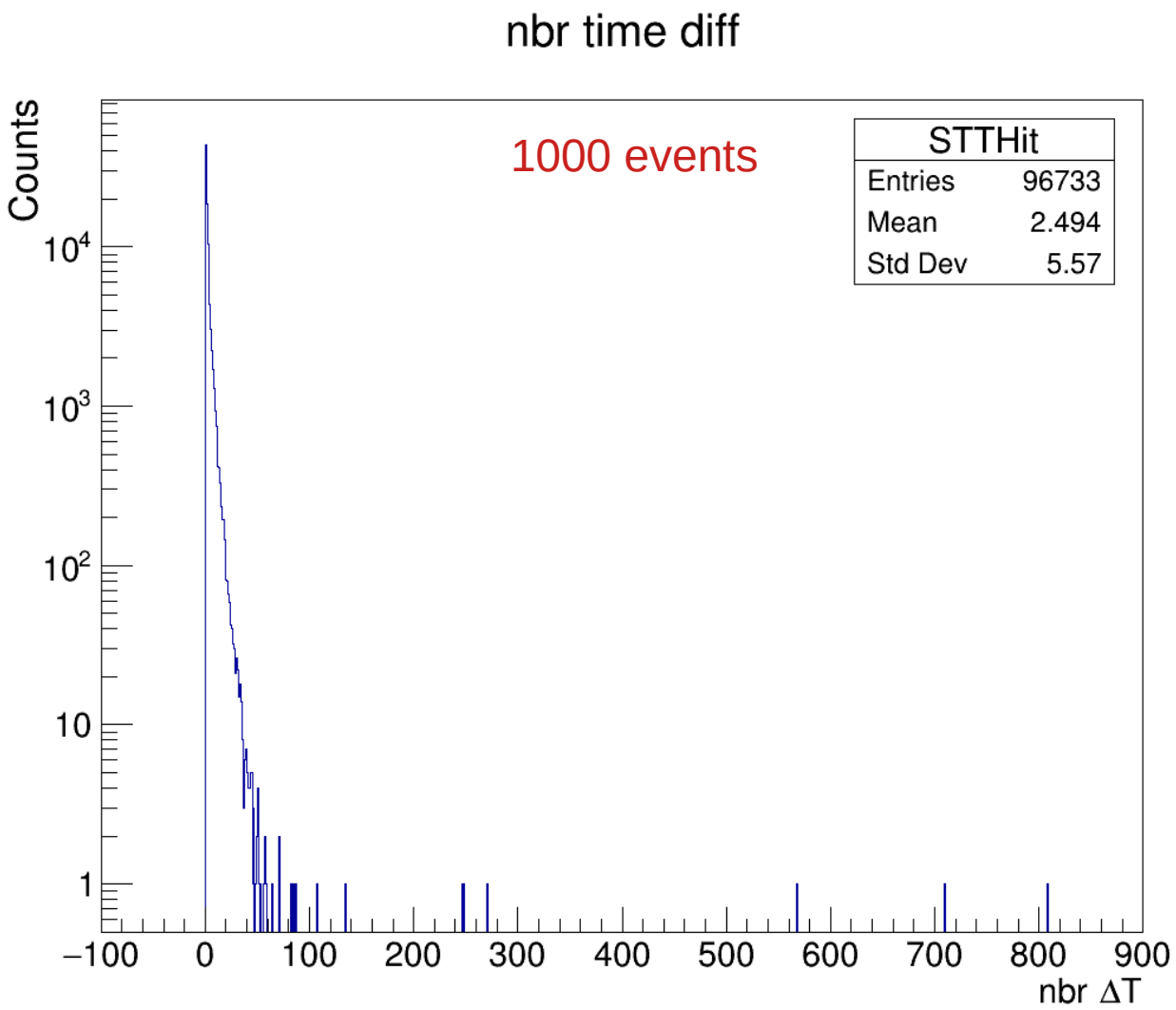


Picture is taken from Tobias Stockmanns' presentation.

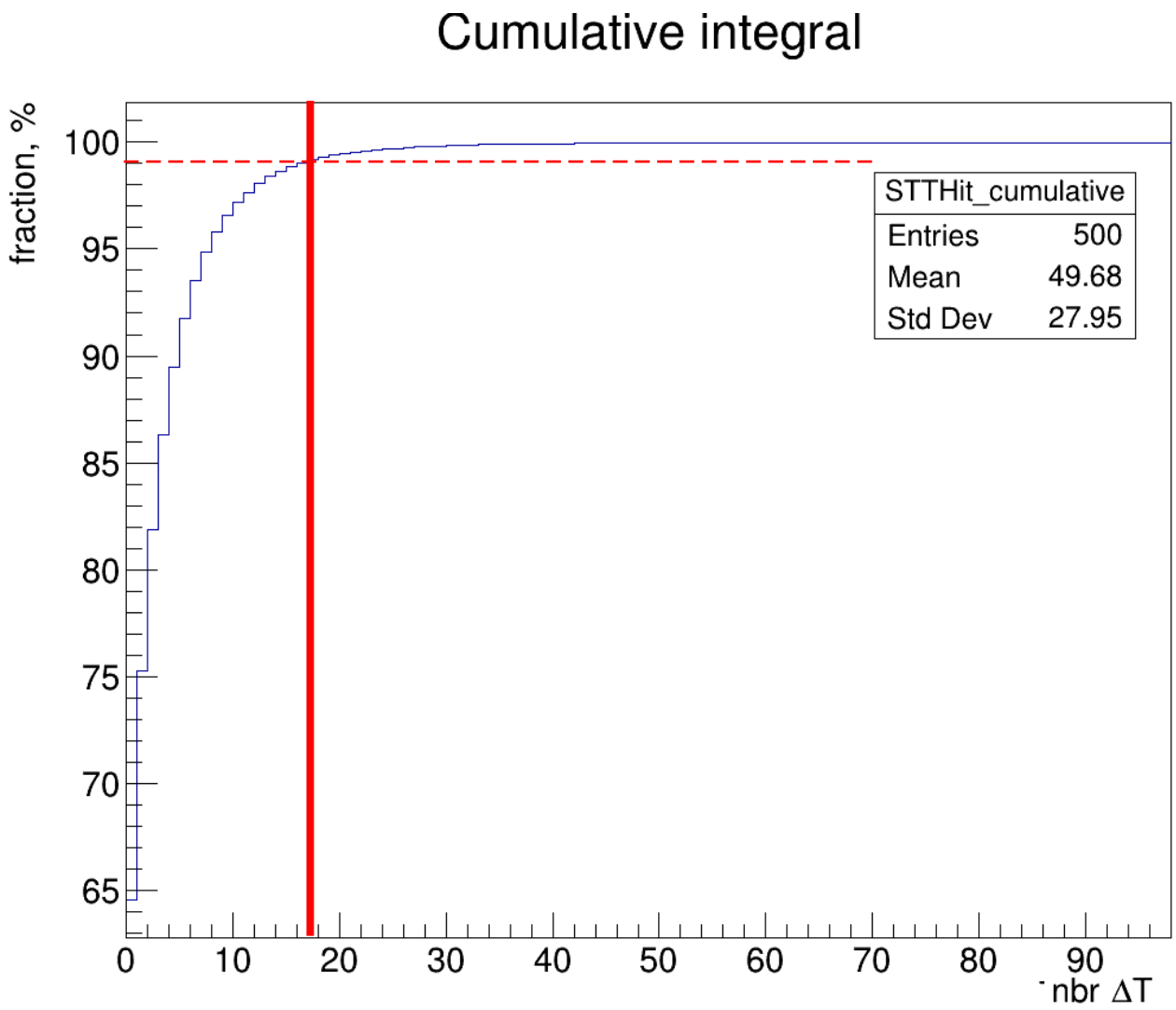
Event-based studies



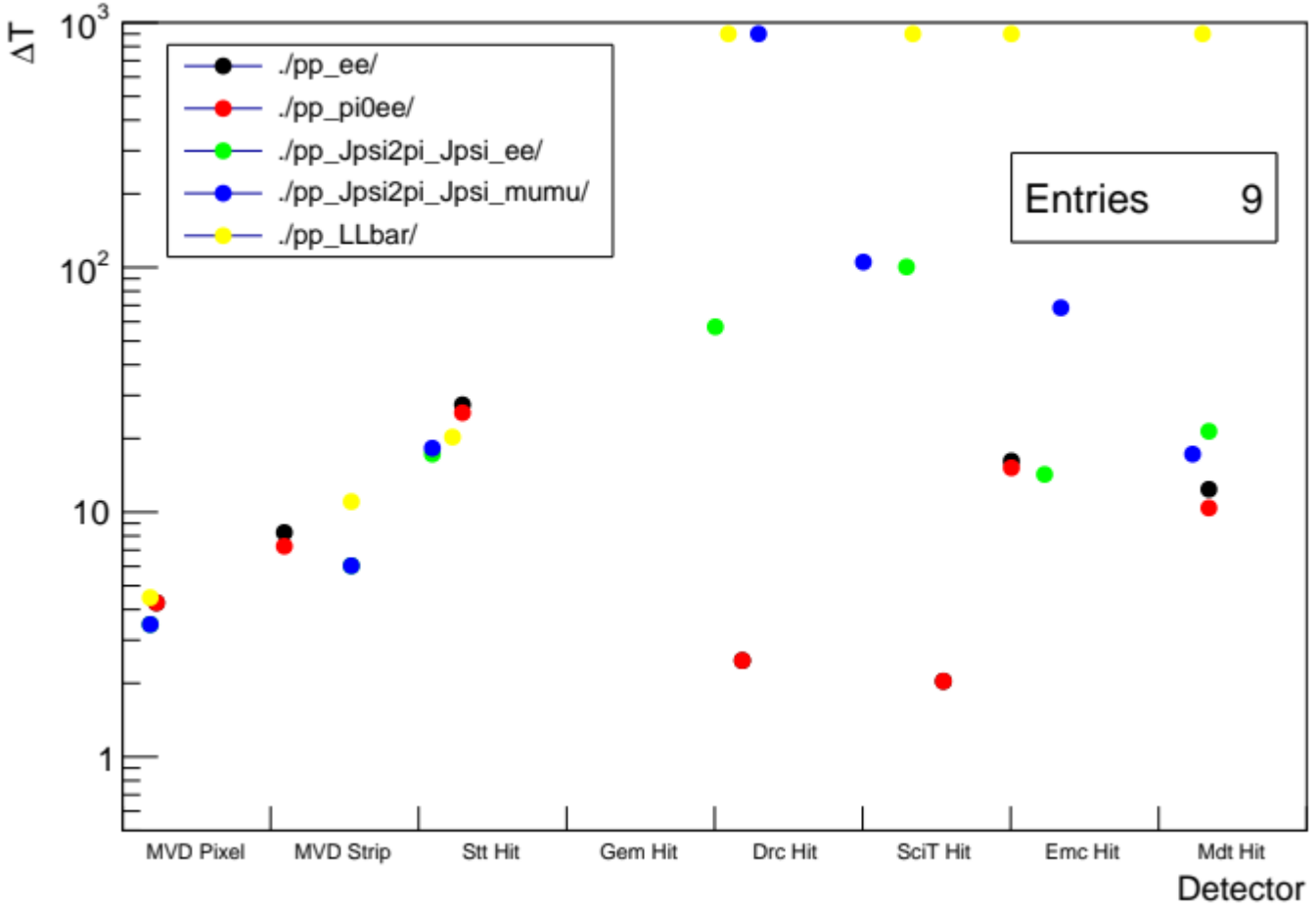
Event-based studies



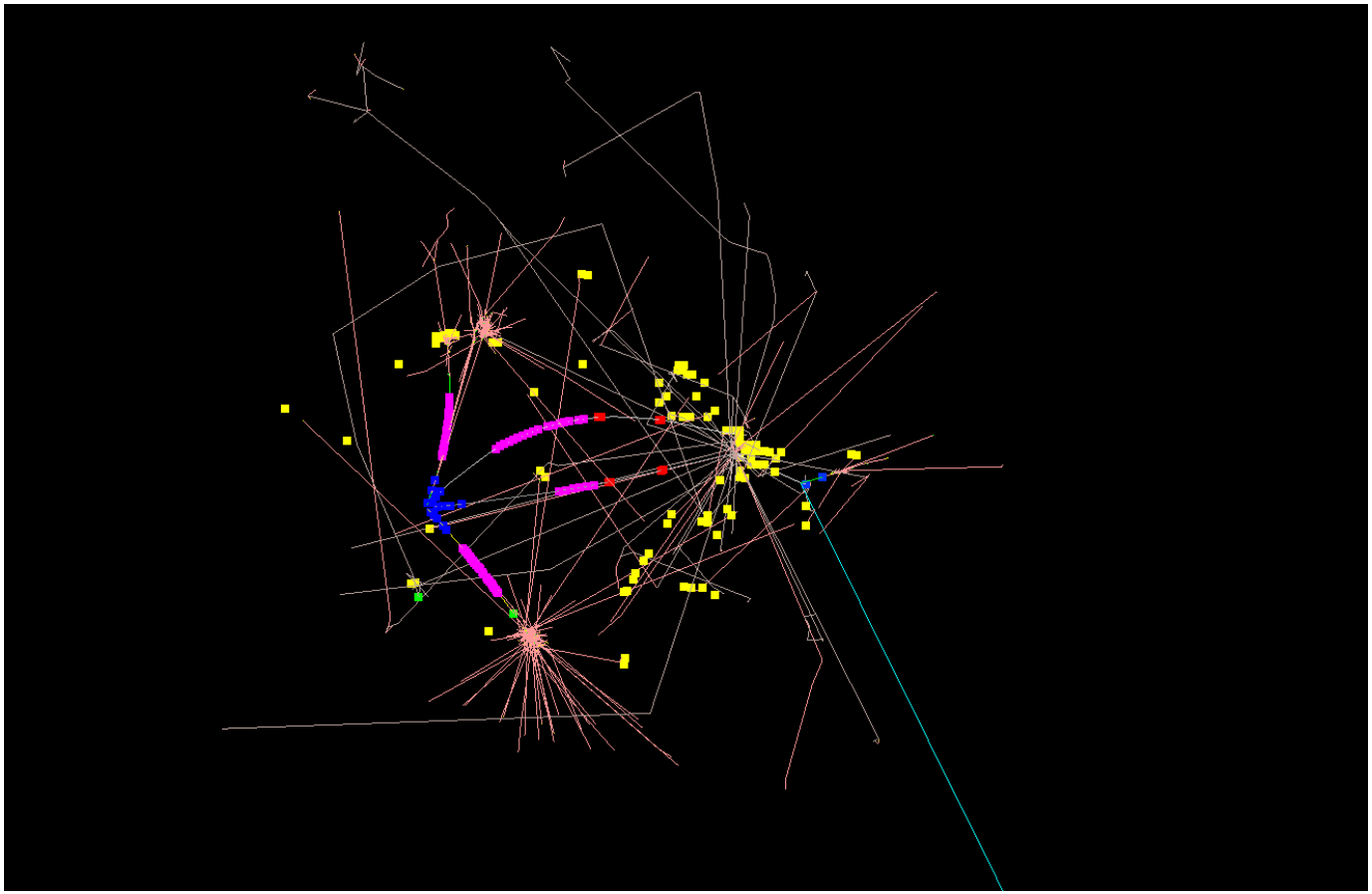
Event-based studies



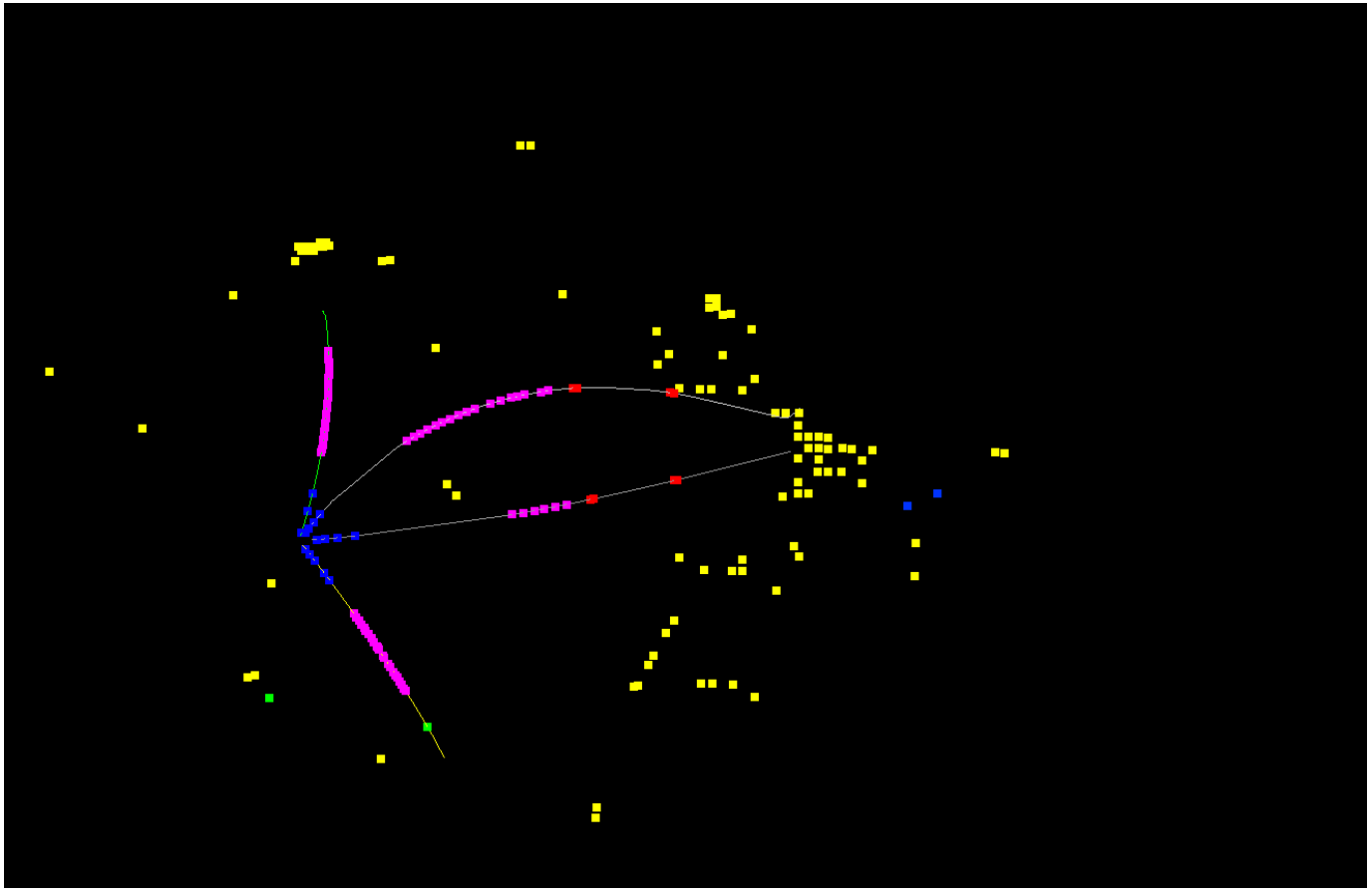
Event-based studies



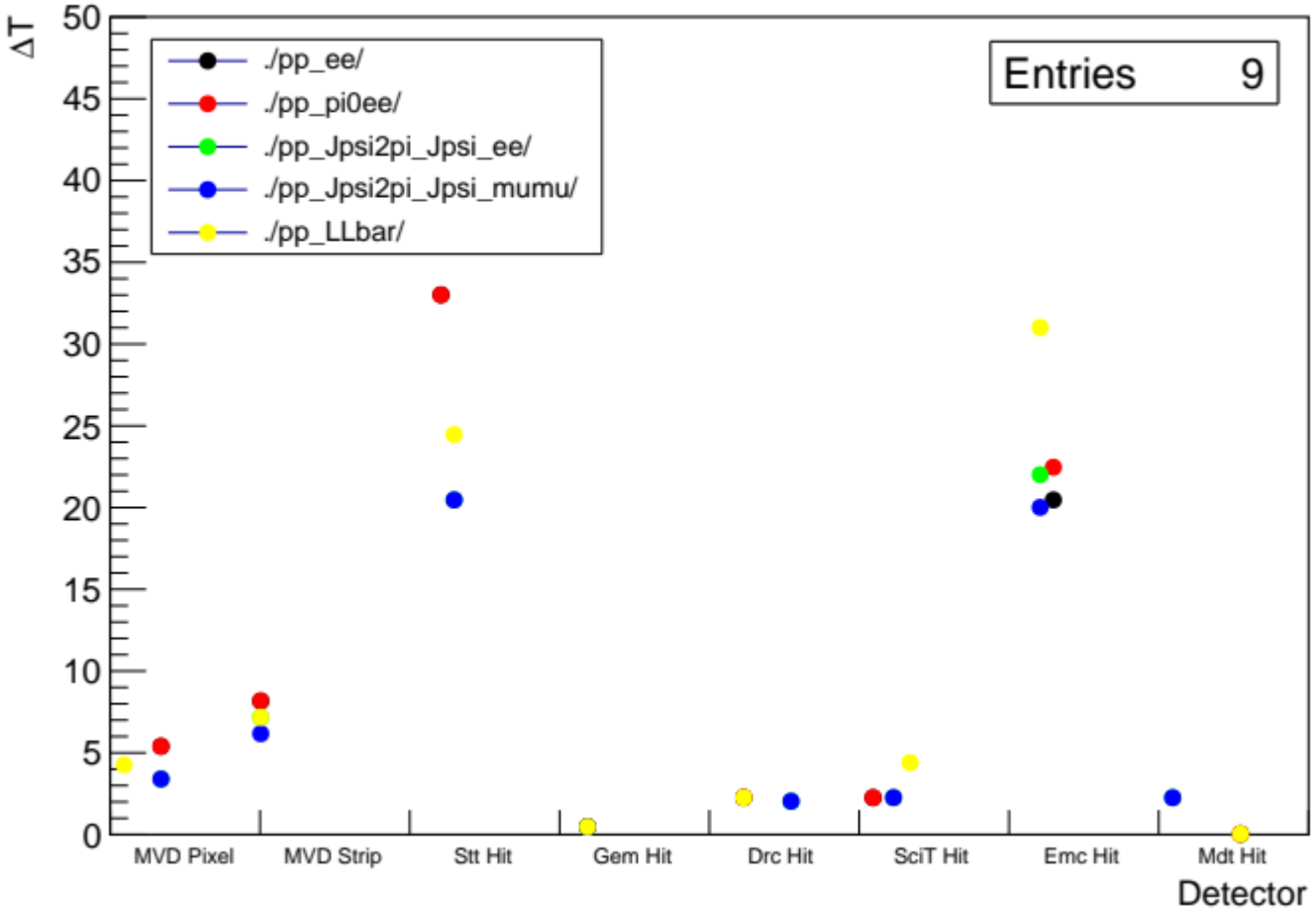
Event-based studies



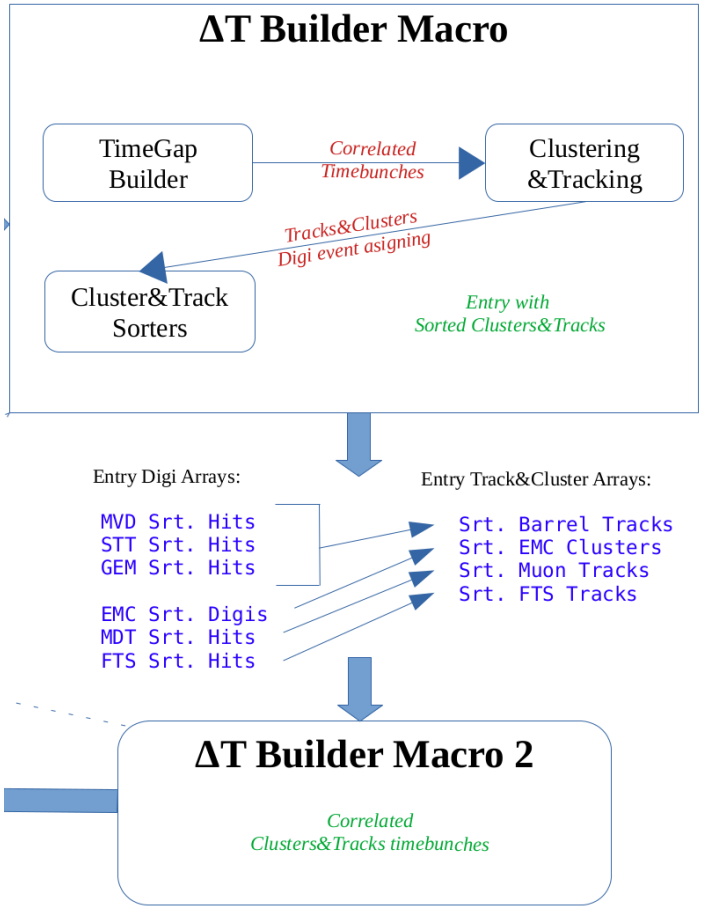
Event-based studies

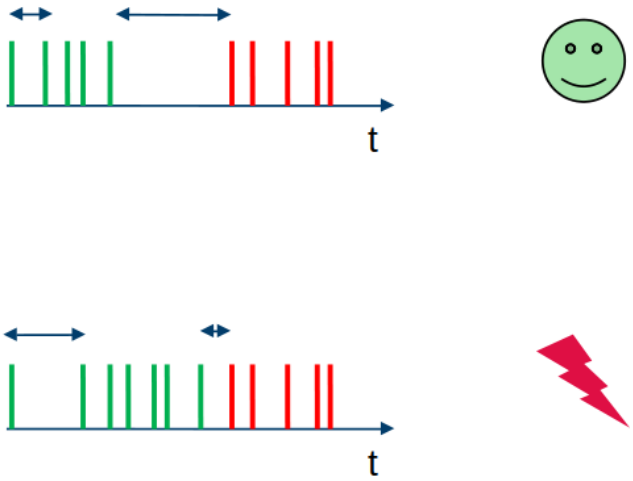


Event-based studies



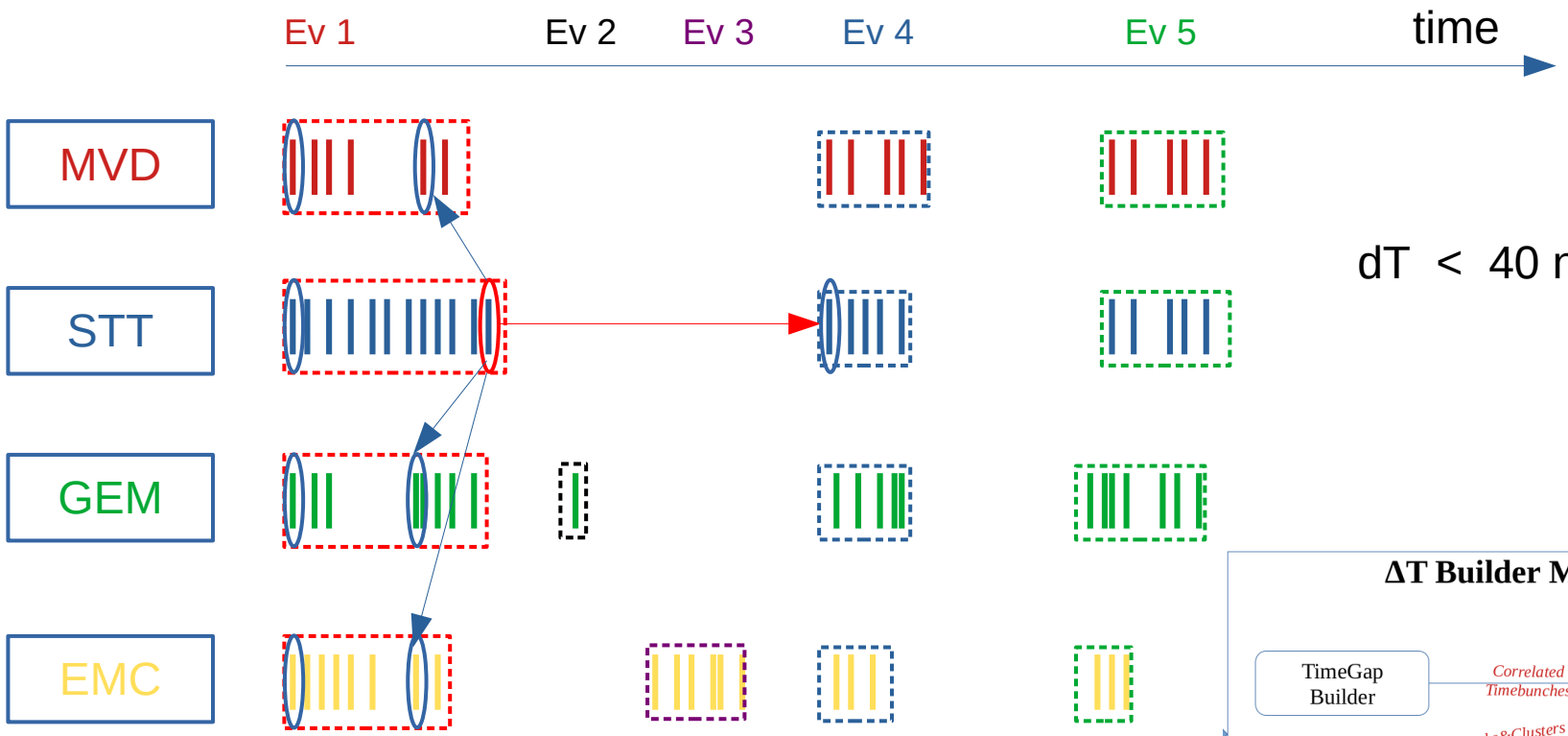
Timebunch creation



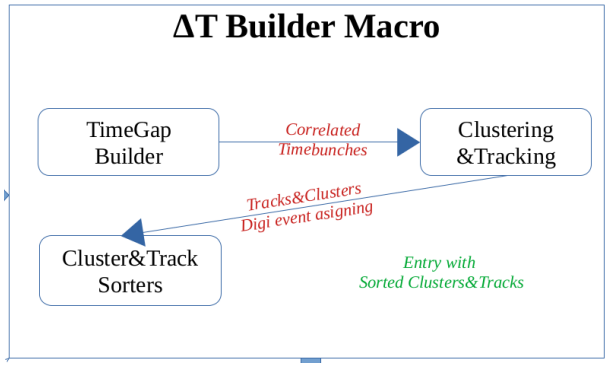


- **processing digi-bunches by the time-gap builder**
- **clustering&tracking, within created timebunches**
- **cluster&track sorting**
- **processing tracks&cluster bunches by the time-gap builder**

Time-gap event builder algorithm

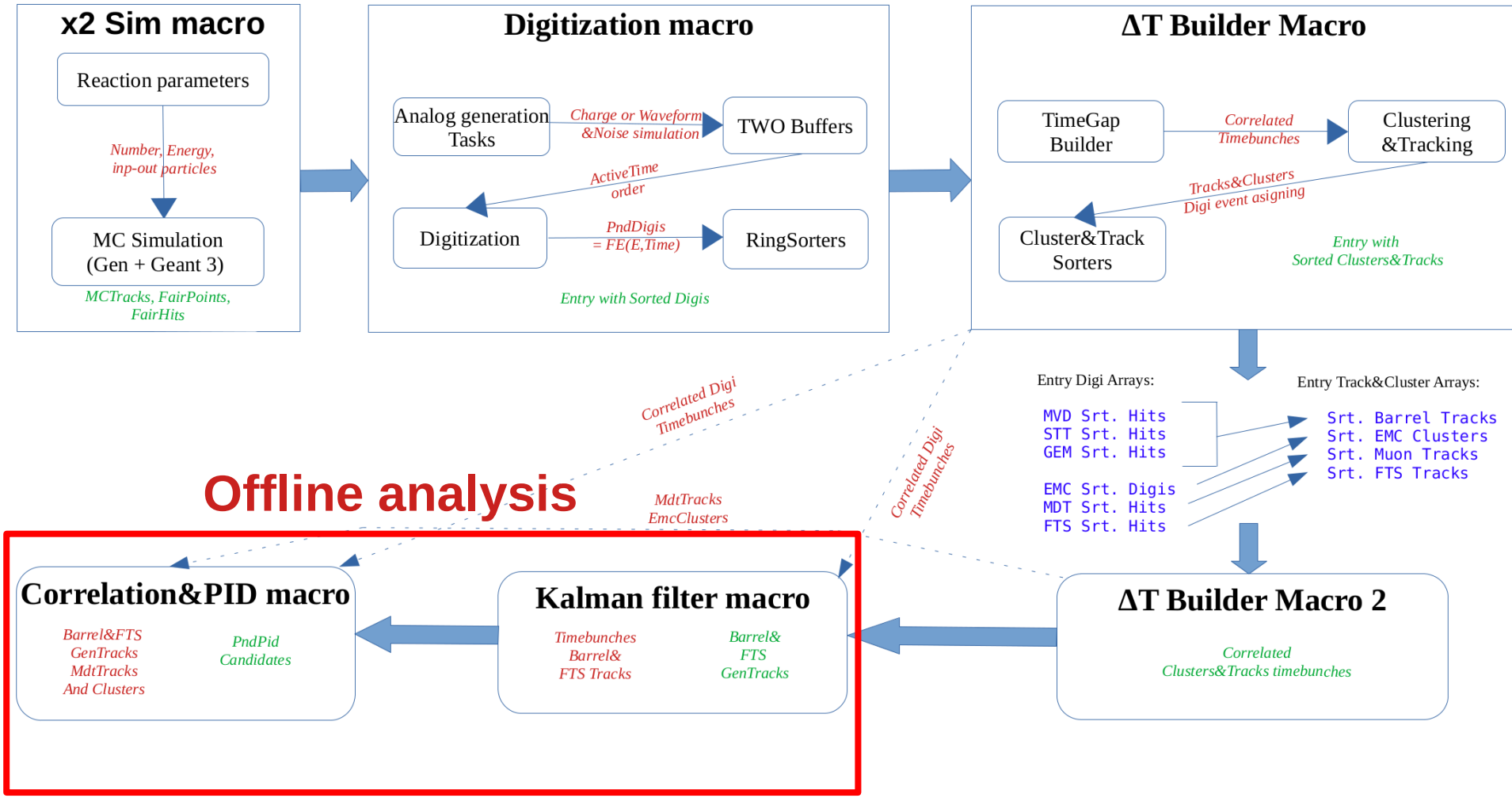


dT < 40 ns

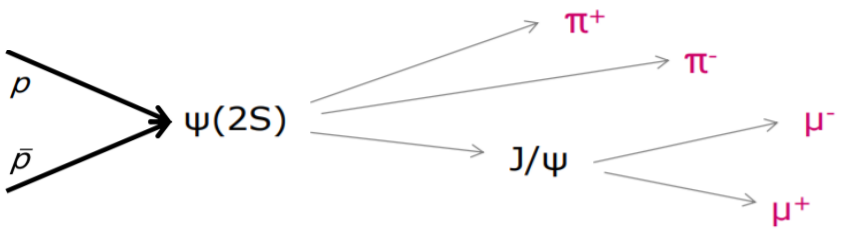


GetData(Detector,TimeGap, Δt ns)

Simulation workflow



Offline analysis

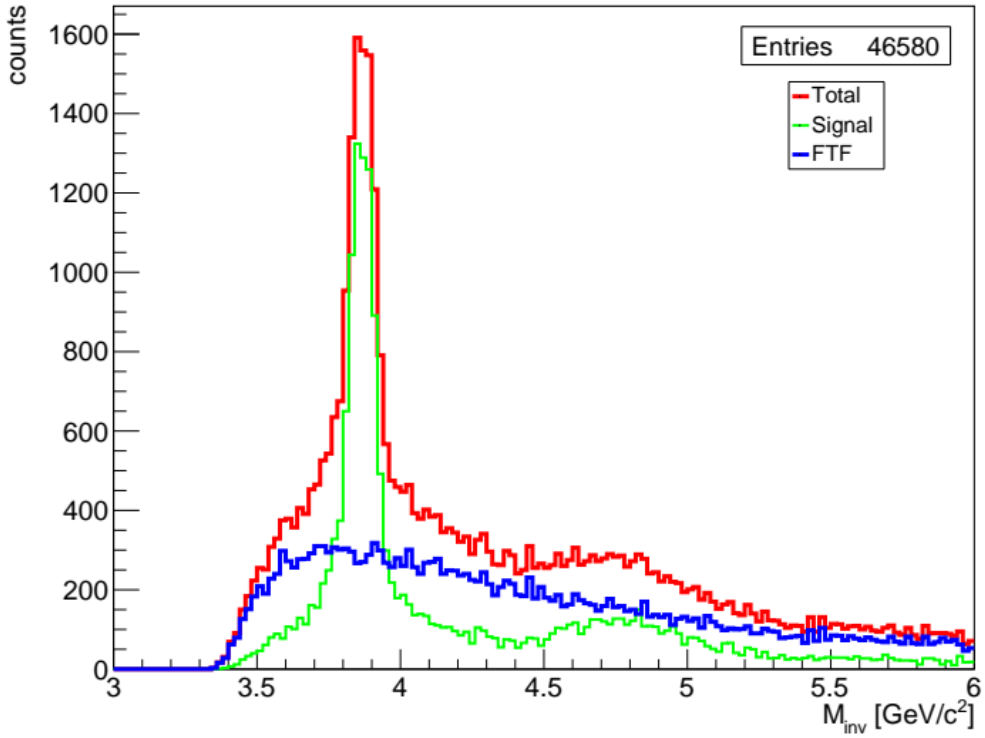


0.1 GeV mass cut for
the J/psi candidates is applied

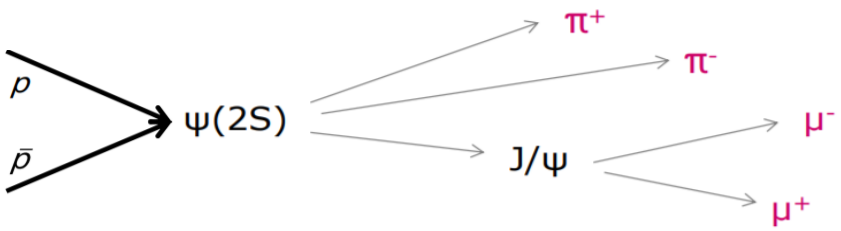
$Ev_{sig} : Ev_{b} = 1 : 9$
Total number = 1000000

Event-based (Sum)

pbp invariant mass



Offline analysis



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$Ev_{sig} : Ev_{b} = 1 : 9$
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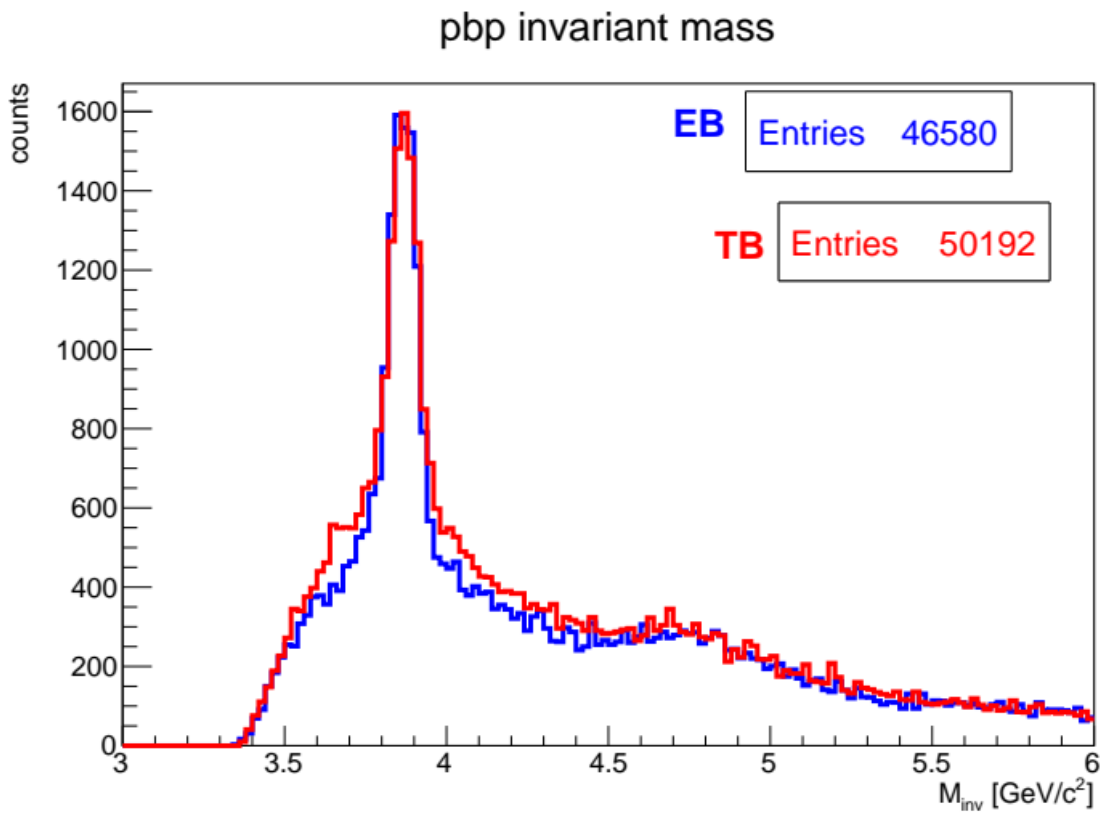
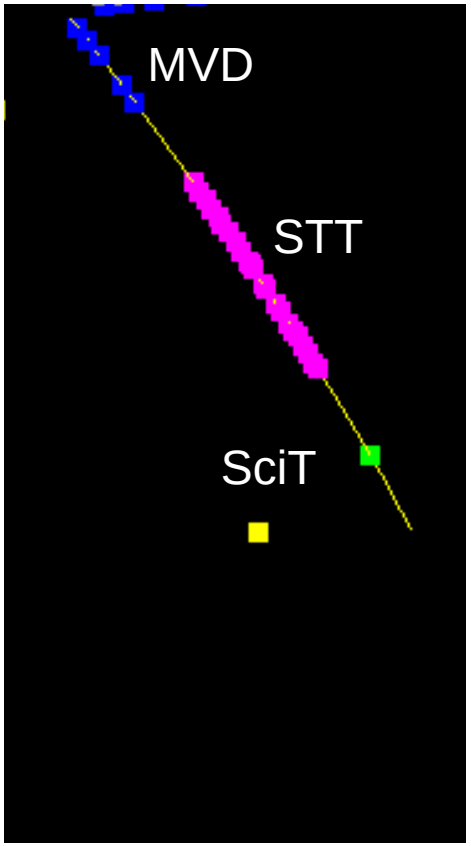
Time-based (Time-Gap)



Event type definition for PndCandidates (MC Truth)



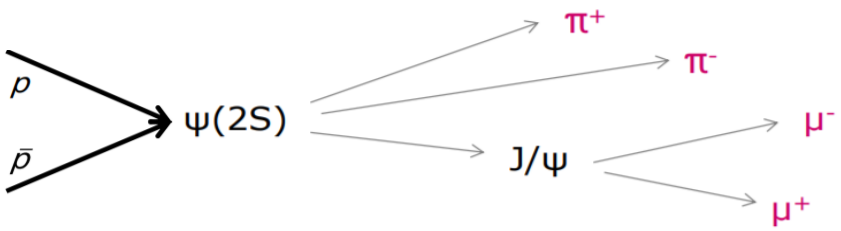
PndDetHit → FairLinks → FileId

FileId = 1, file with signal events

FileId = 0, file with background events

$$EvType = \frac{\sum_{N_{det}} T_{det}}{N_{det}} \qquad T_{det} = \frac{\sum_{N_{hits}} FileId_{hit}}{N_{hits}}$$

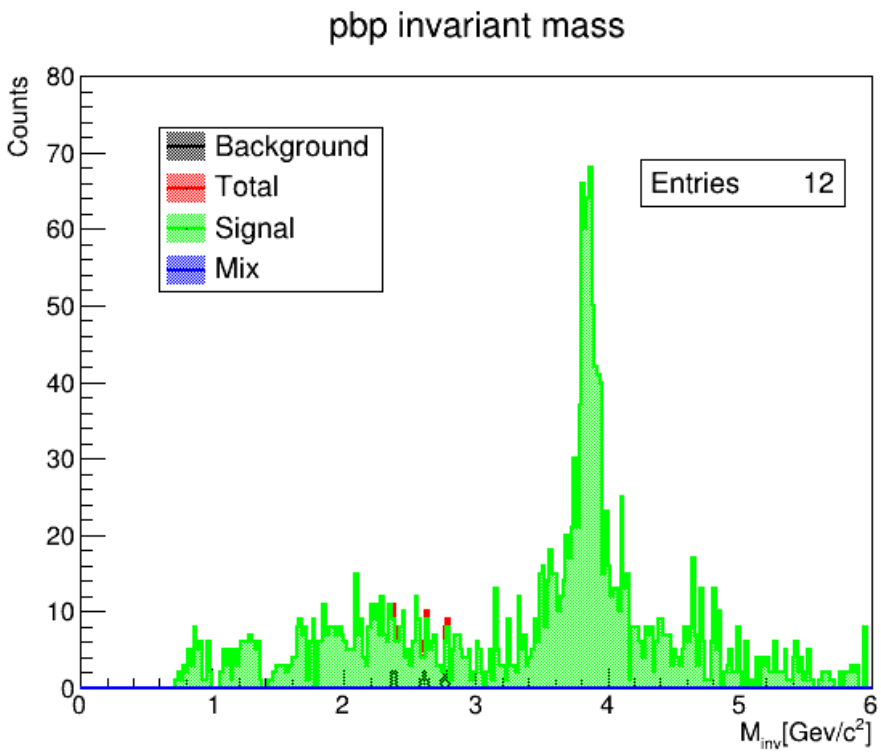
Framework performance



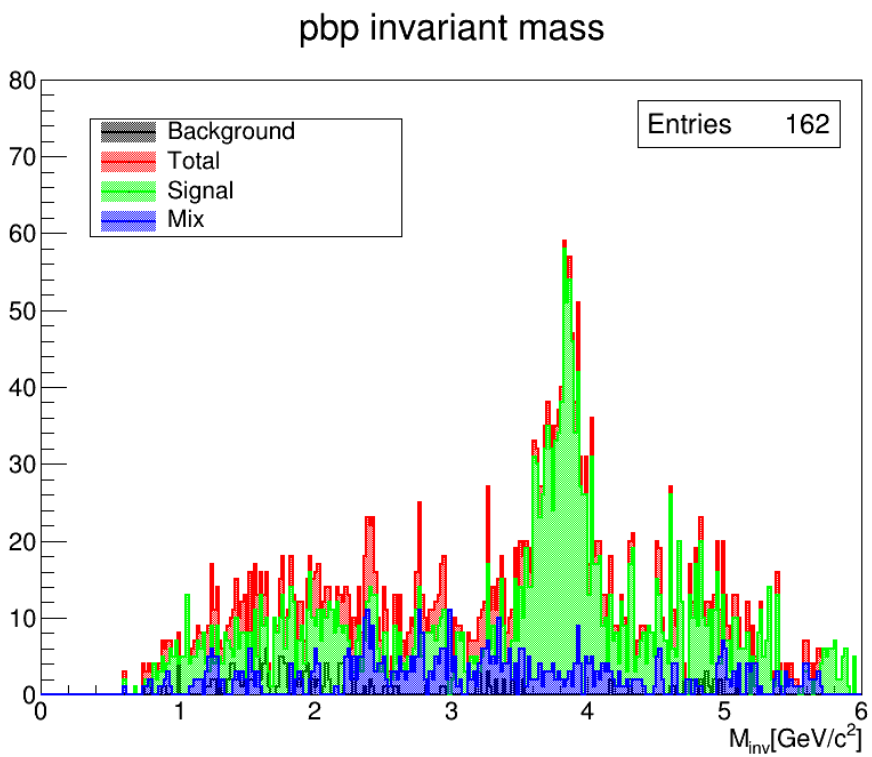
$Ev_{sig} : Ev_b = 1 : 1$
Total number = 2000

Online filtering is used

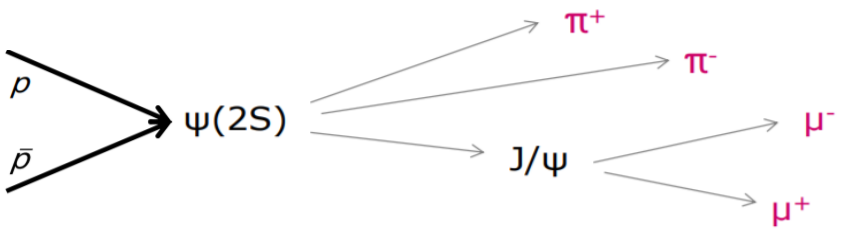
2kHz



2MHz



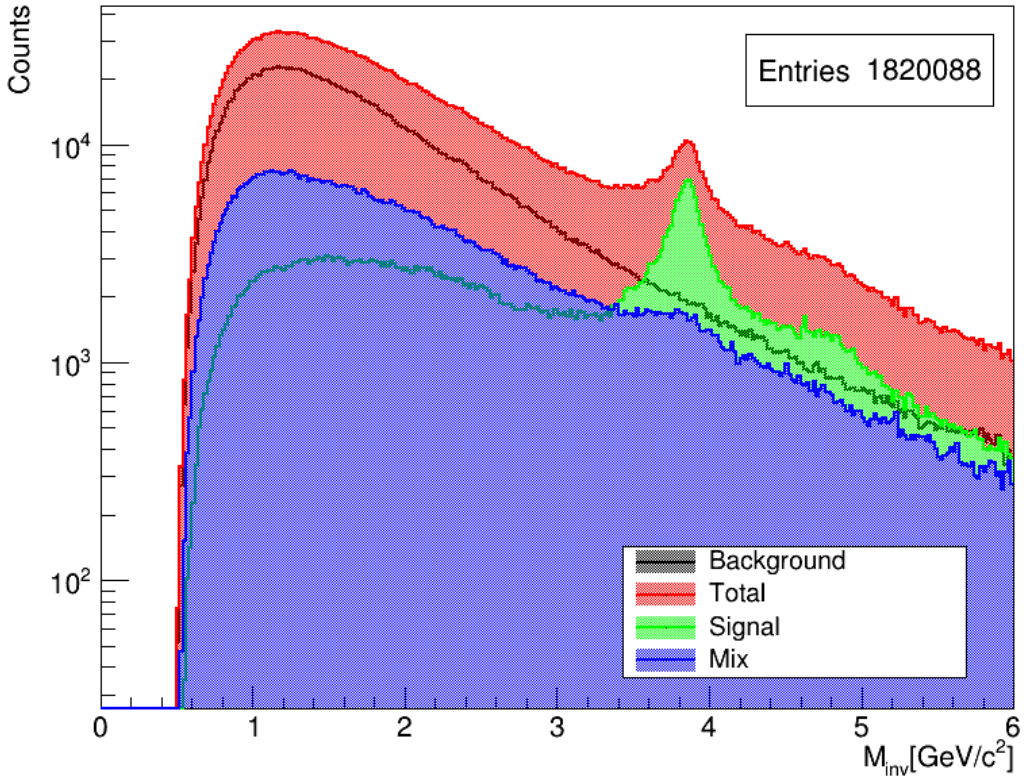
Offline analysis



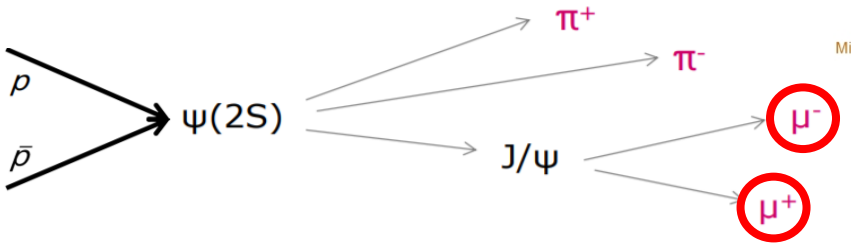
$Ev_{sig} : Ev_b = 1 : 1$
Total number = 200000

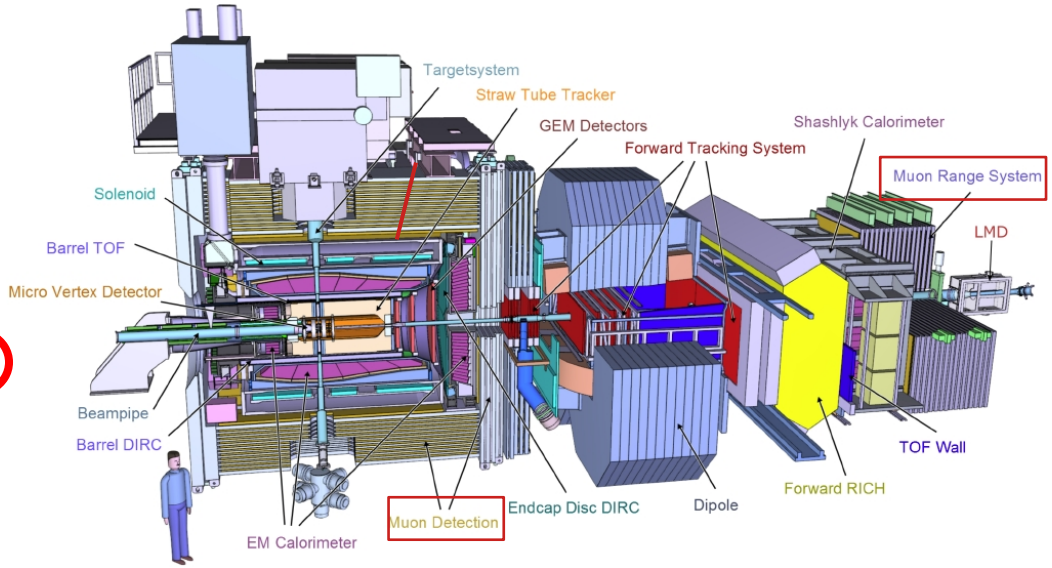
Time-based (Time-Gap)

pbp invariant mass



Event Filtering





Kalman filter macro

Timebunches Barrel& FTS Tracks — *Barrel& FTS GenTracks*

Event filter

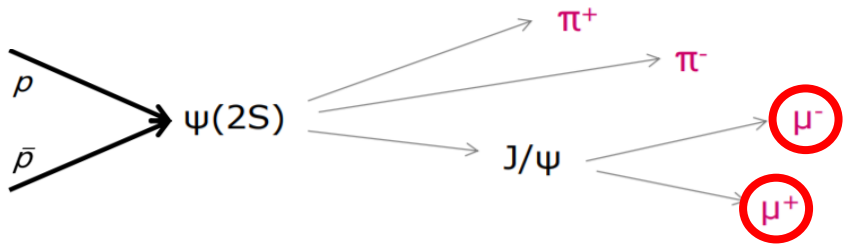
Timebunches — *Passed Timebunches*

ΔT Builder Macro 2

Correlated Clusters&Tracks timebunches

Two Mdt tracks with iron distance > 40 cm

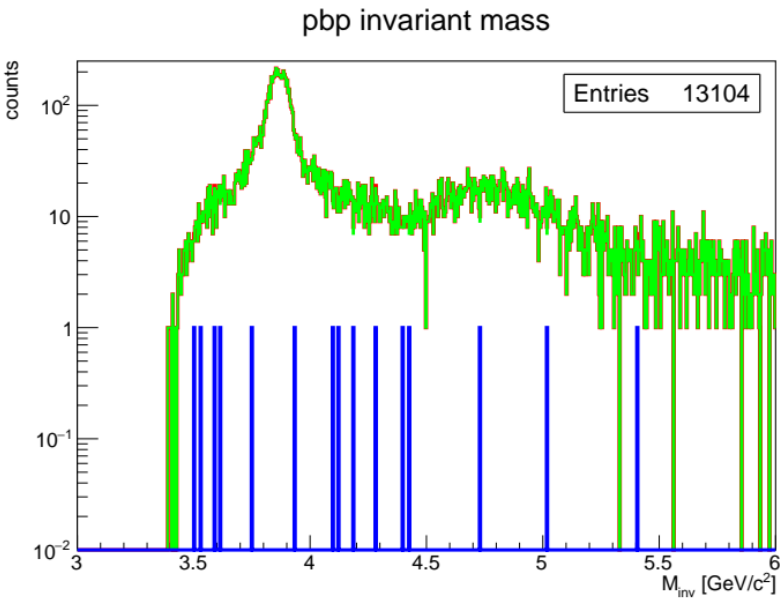
Offline analysis (Filter)



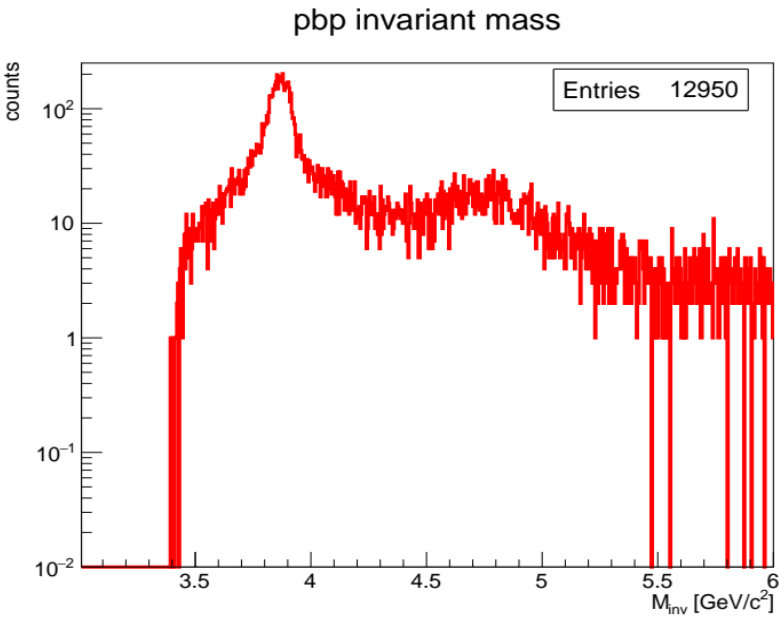
0.1 GeV mass cut for
the J/psi candidates is applied

$Ev_{sig} : Ev_{b} = 1 : 9$
Total number = 1000000

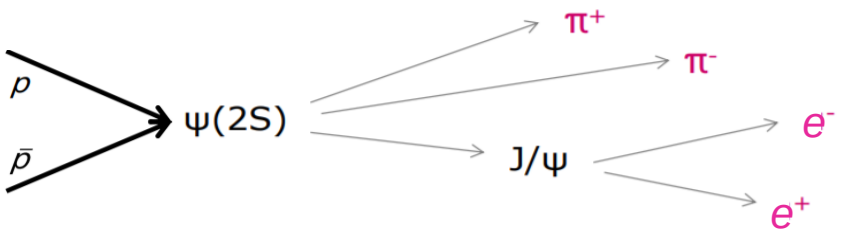
Event-based (Sum)



Time-based (Time-Gap)



Offline analysis



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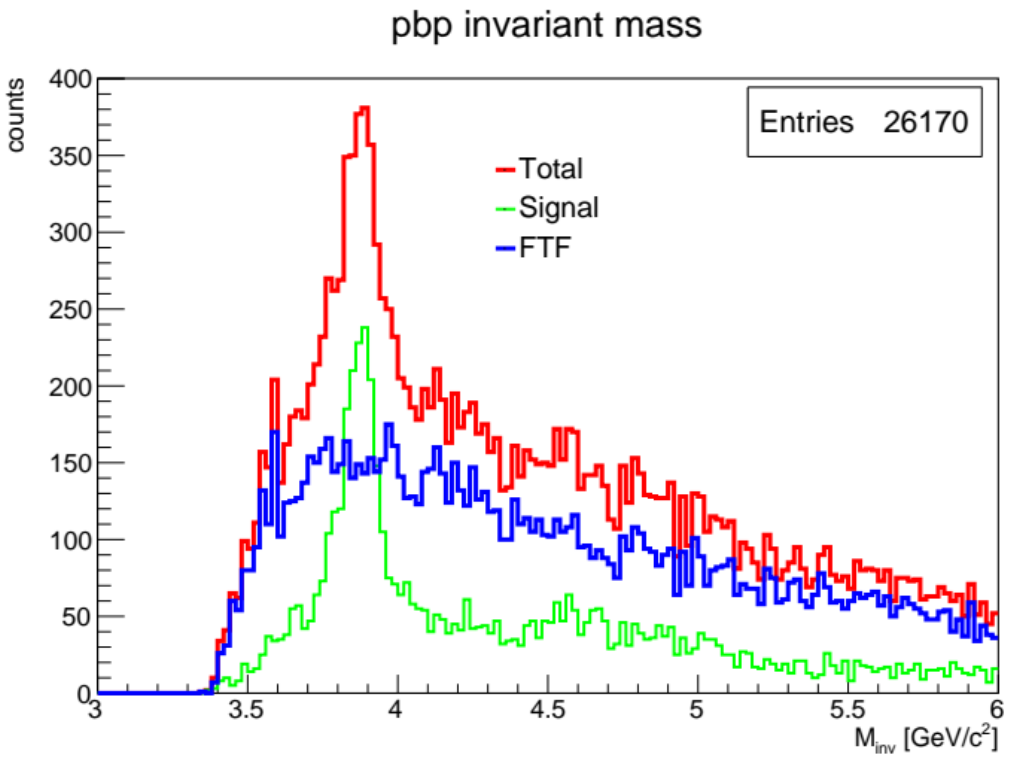
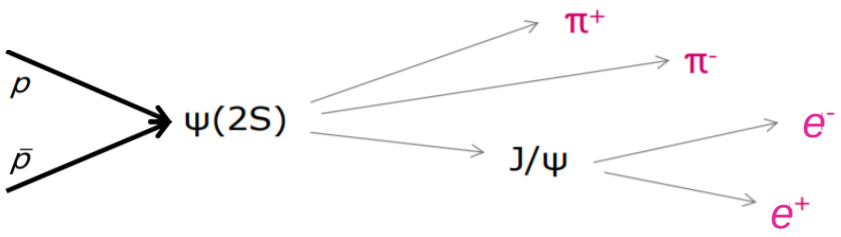


Offline analysis



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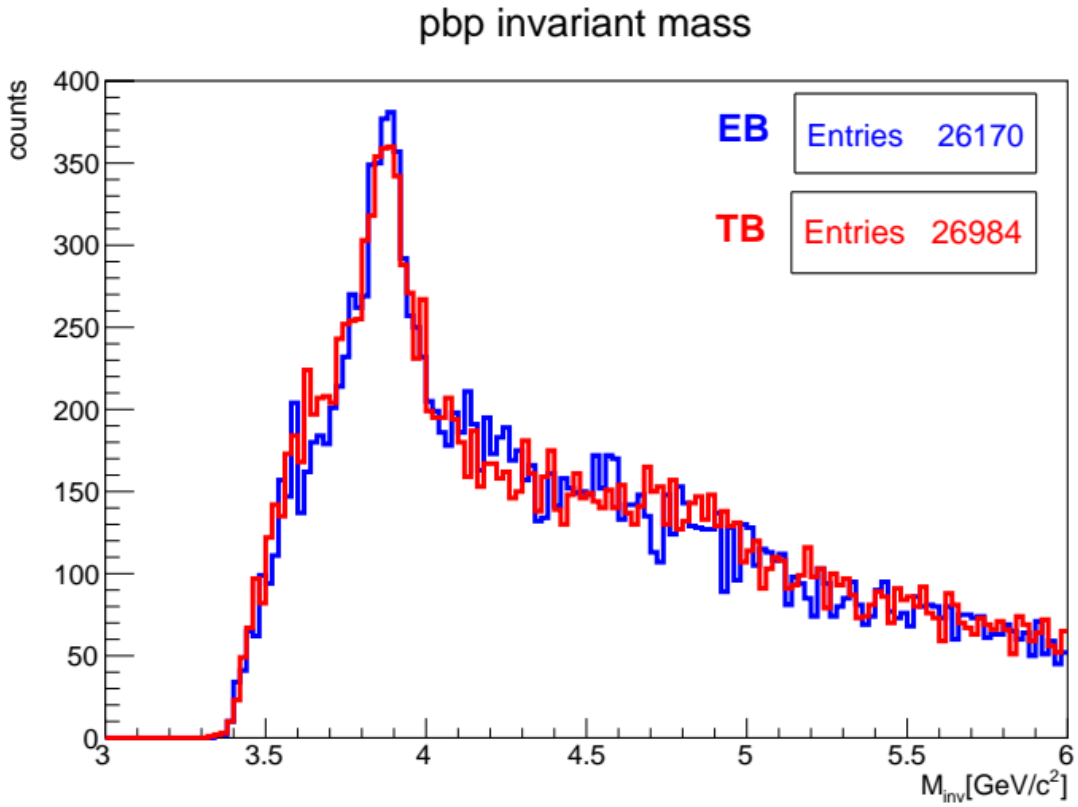
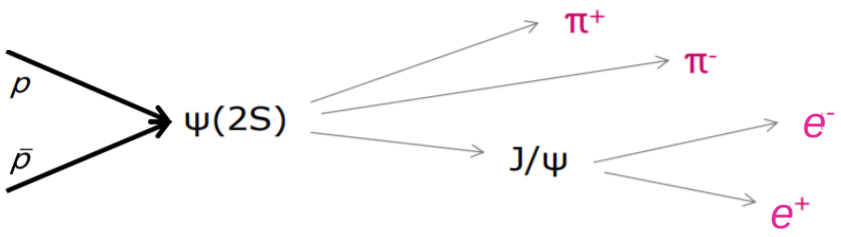
Total number = 1000000

Time-based (Time-Gap)

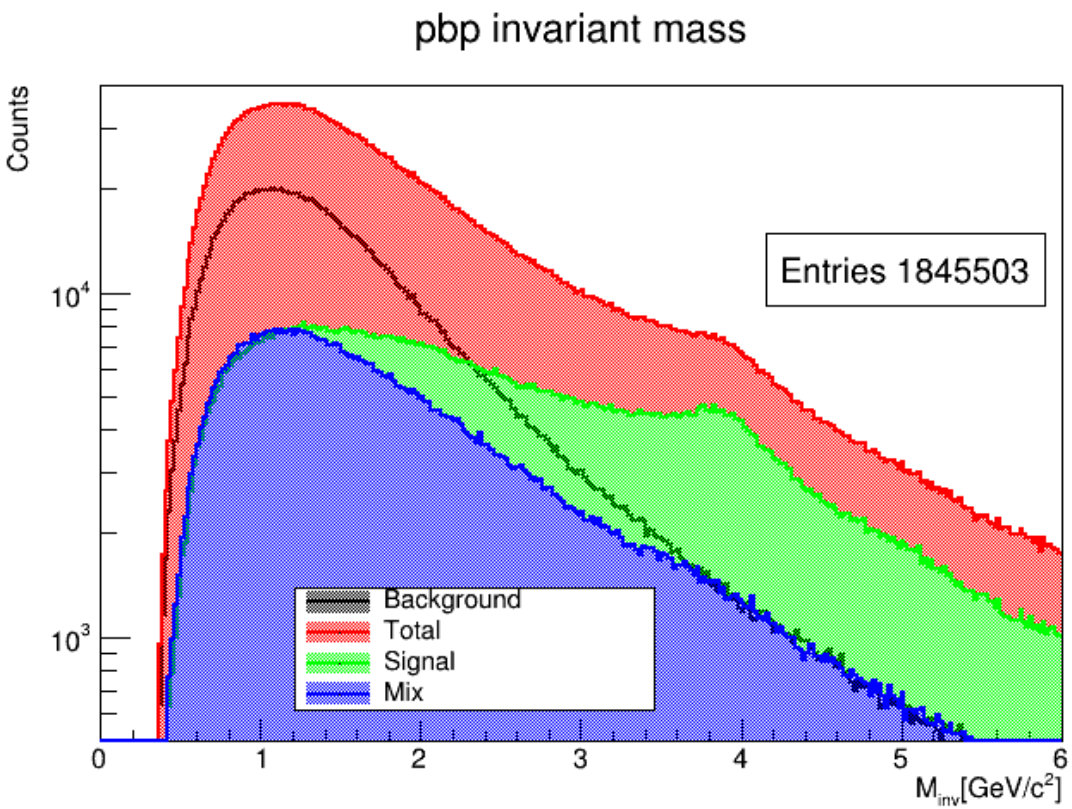


Offline analysis

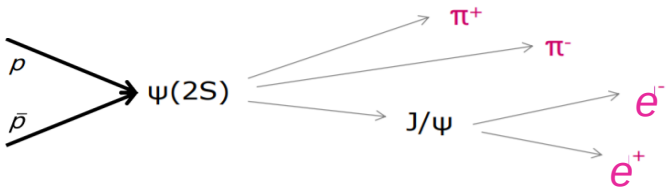


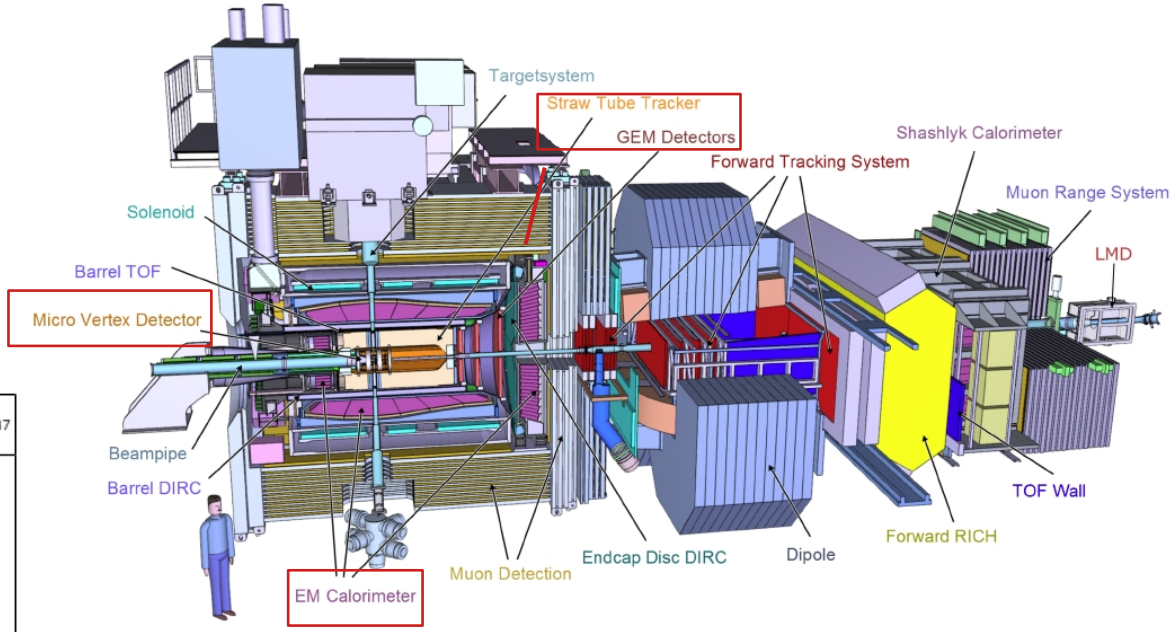
$Ev_{sig} : Ev_b = 1 : 1$
Total number = 200000

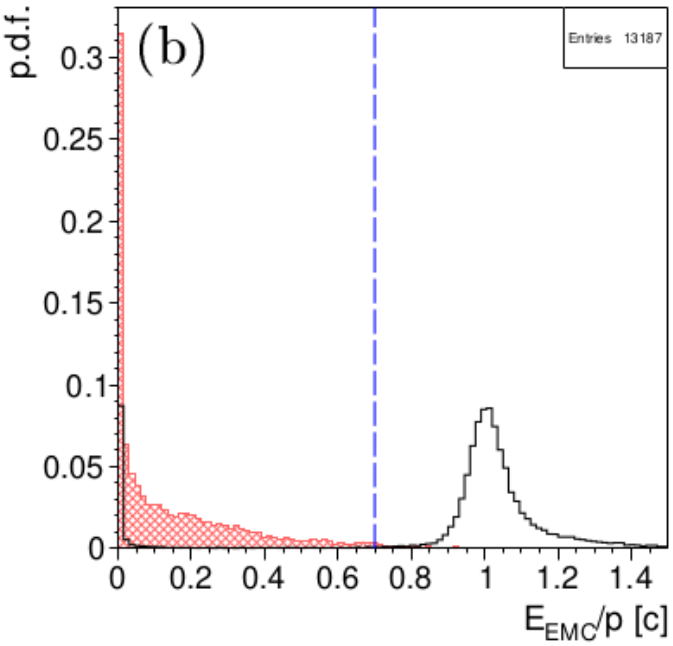
Time-based (Time-Gap)



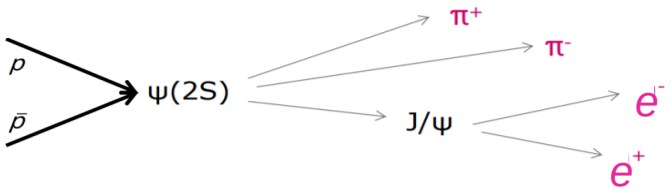
Event Filtering

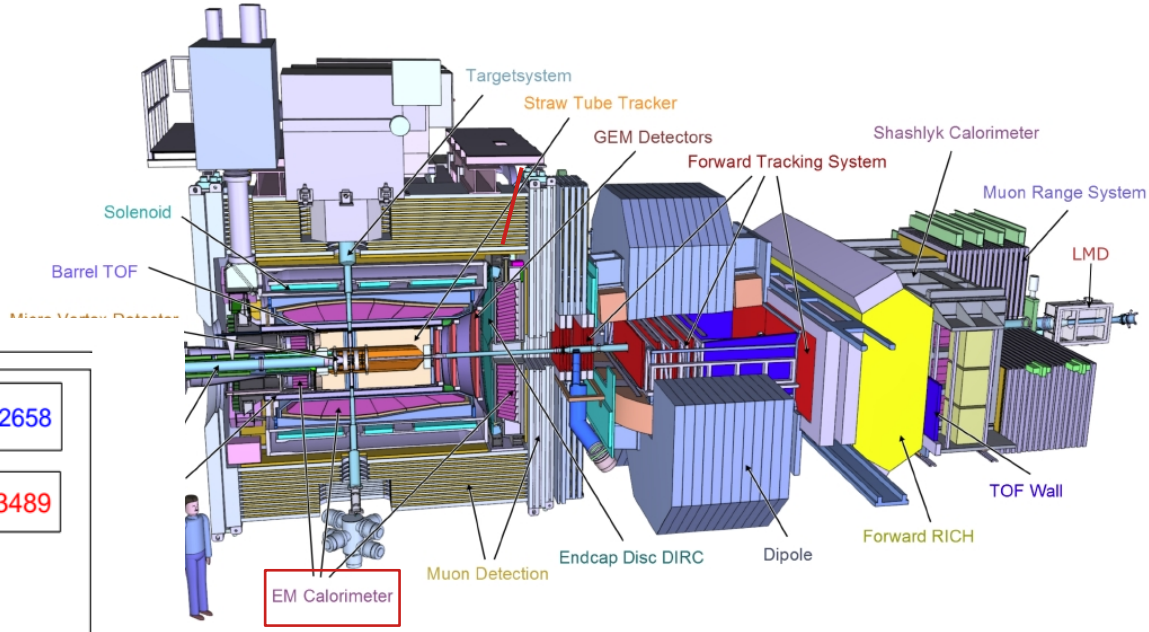


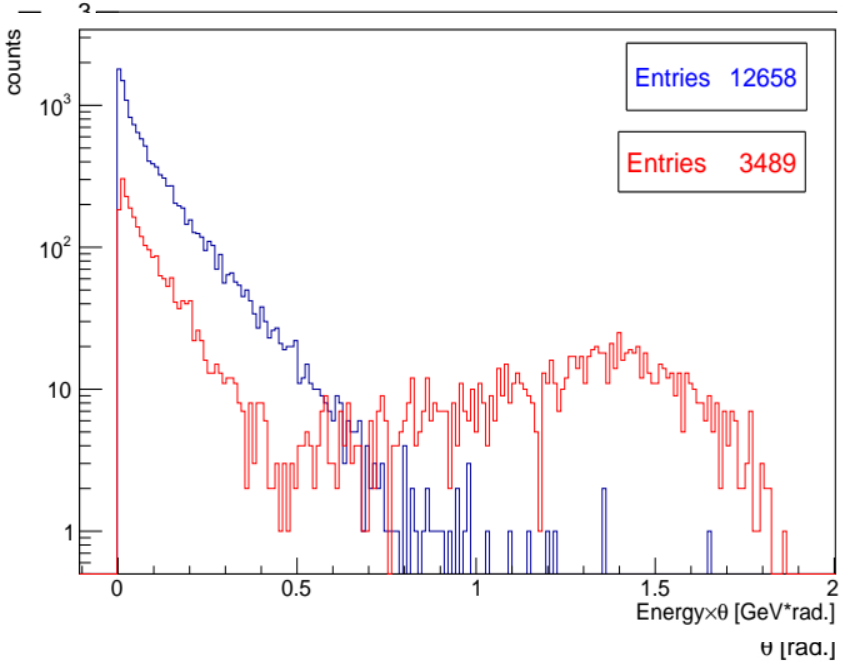




Event Filtering



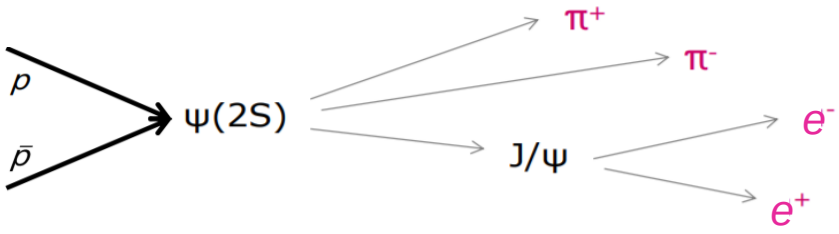




TVector3(x, y, z) → Theta angle

Polar angle correlation with energy of cluster

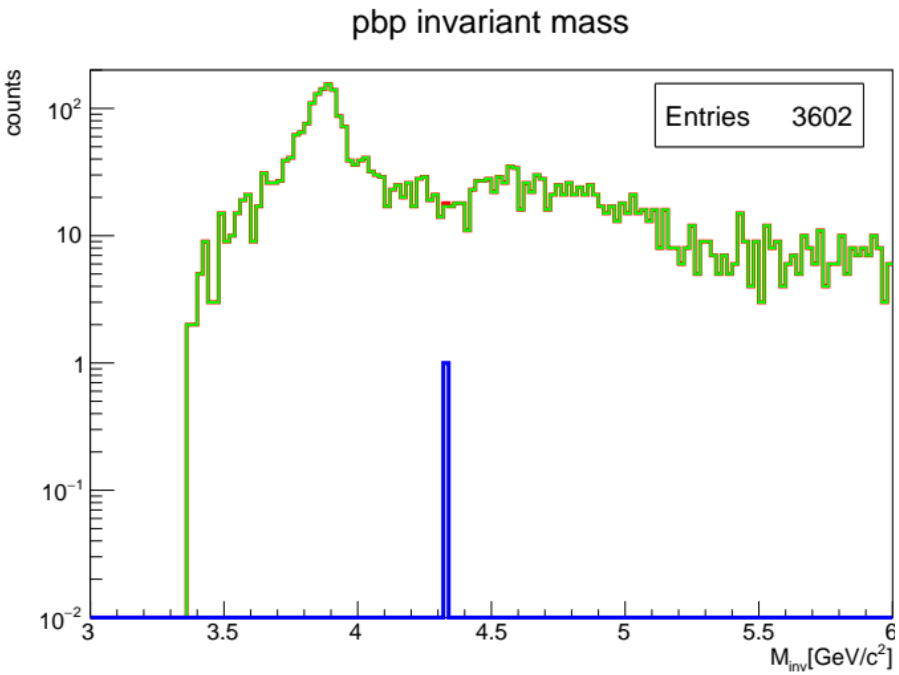
Offline analysis (Filter)



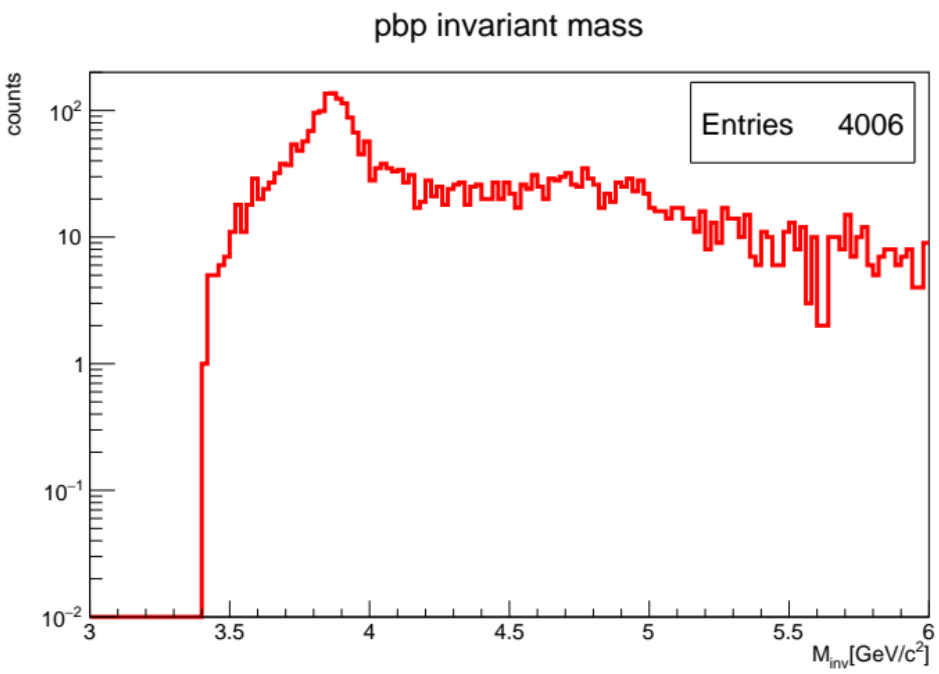
0.1 GeV mass cut for
the J/psi candidates is applied

$Ev_{sig} : Ev_{b} = 1 : 9$
Total number = 1000000

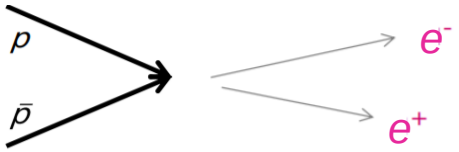
Event-based (Sum)



Time-based (Time-Gap)

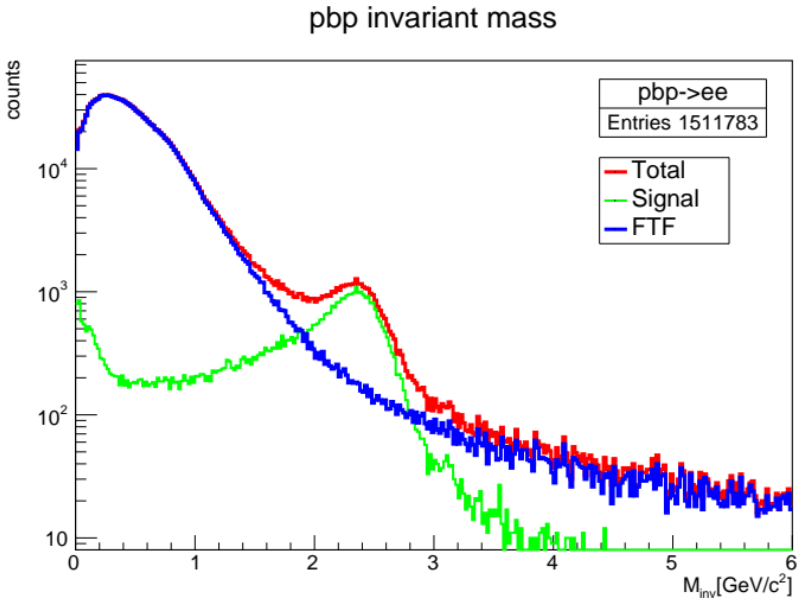


Offline analysis

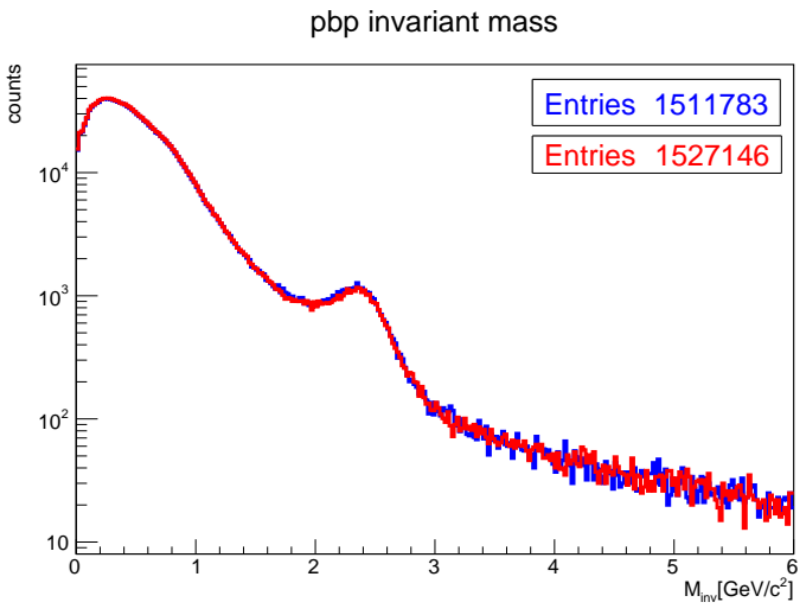


$Ev_{sig} : Ev_b = 1 : 9$
Total number = 1000000

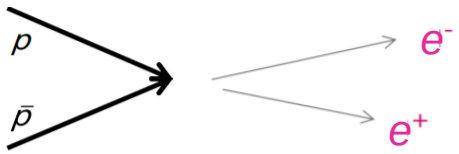
Event-based (Sum)



Time-based (Time-Gap)



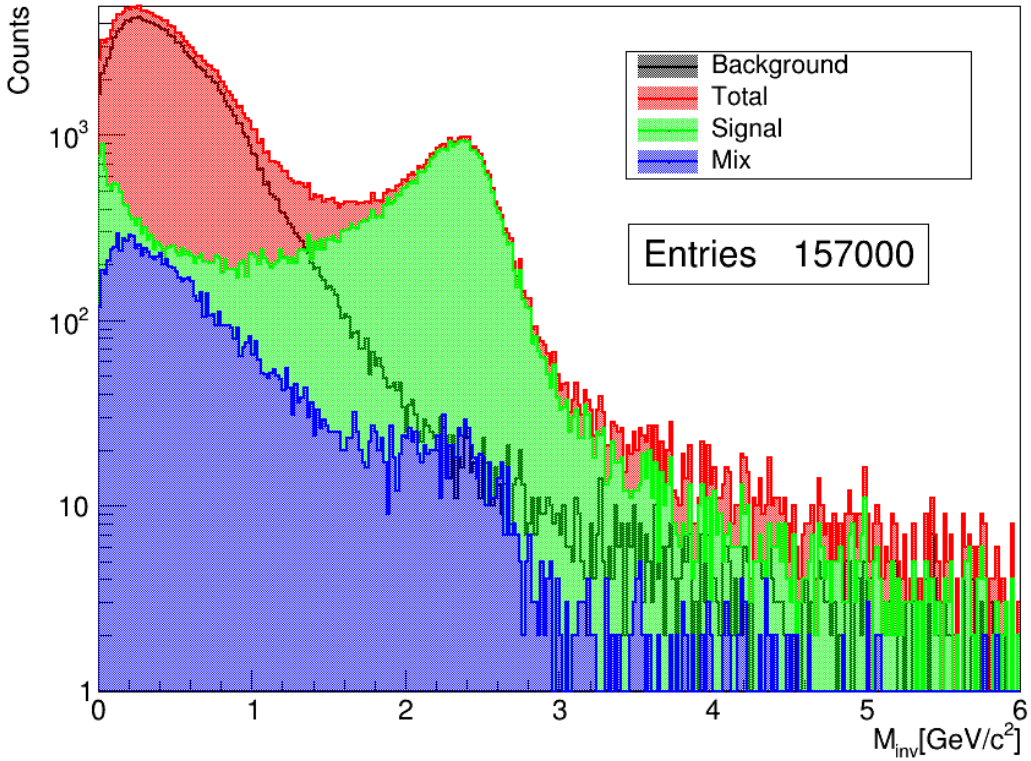
Offline analysis



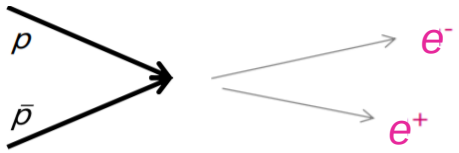
$Ev_{sig} : Ev_b = 1 : 1$
Total number = 200000

Time-based (Time-Gap)

pbp invariant mass

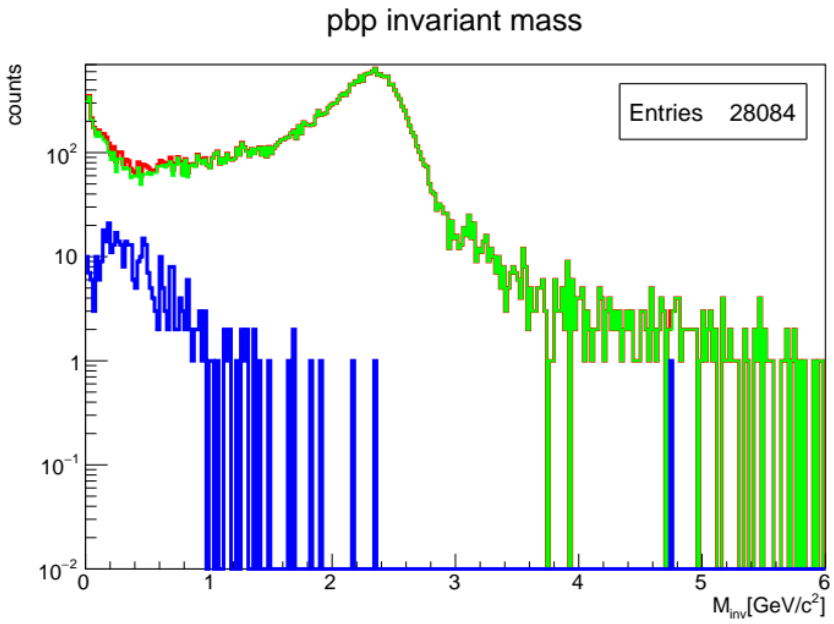


Offline analysis (Filter)

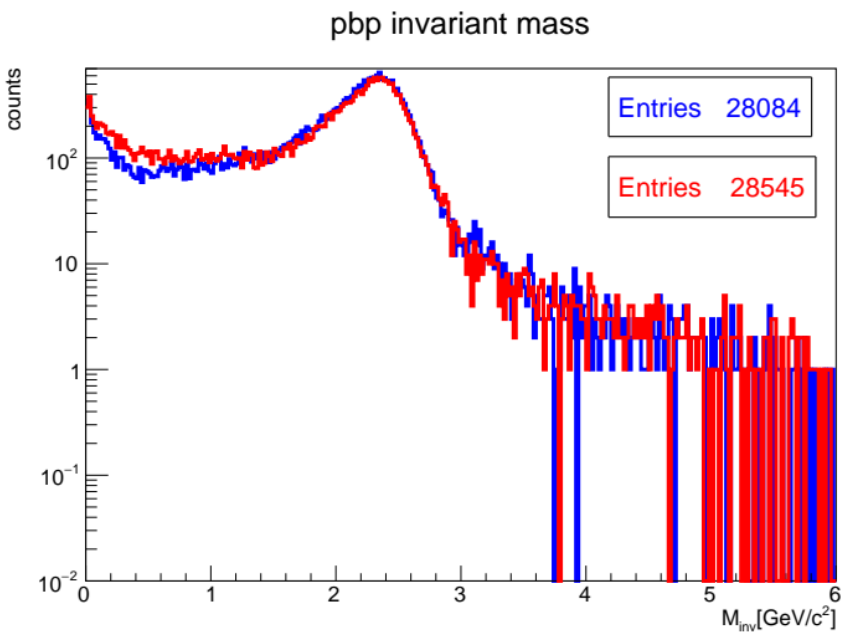


$Ev_{sig} : Ev_b = 1 : 9$
Total number = 1000000

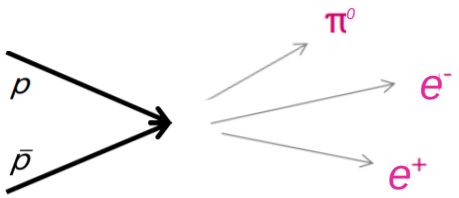
Event-based (Sum)



Time-based (Time-Gap)

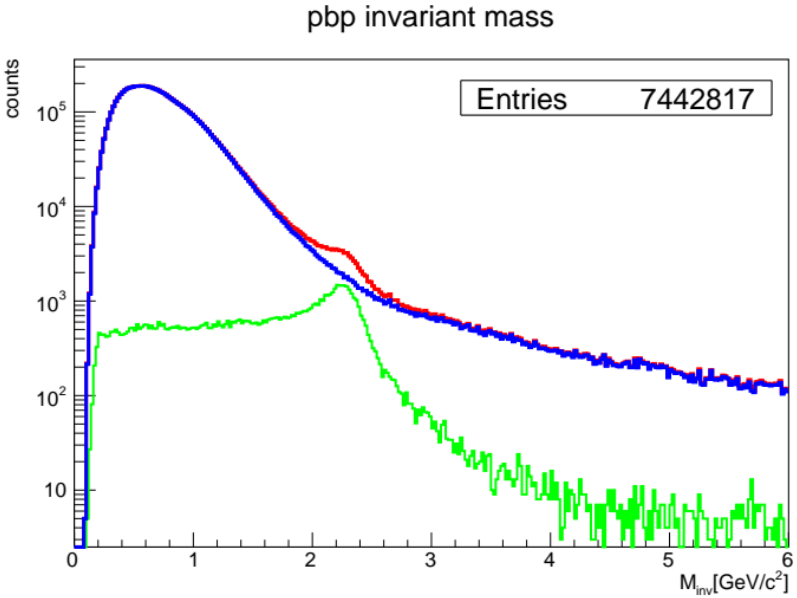


Offline analysis

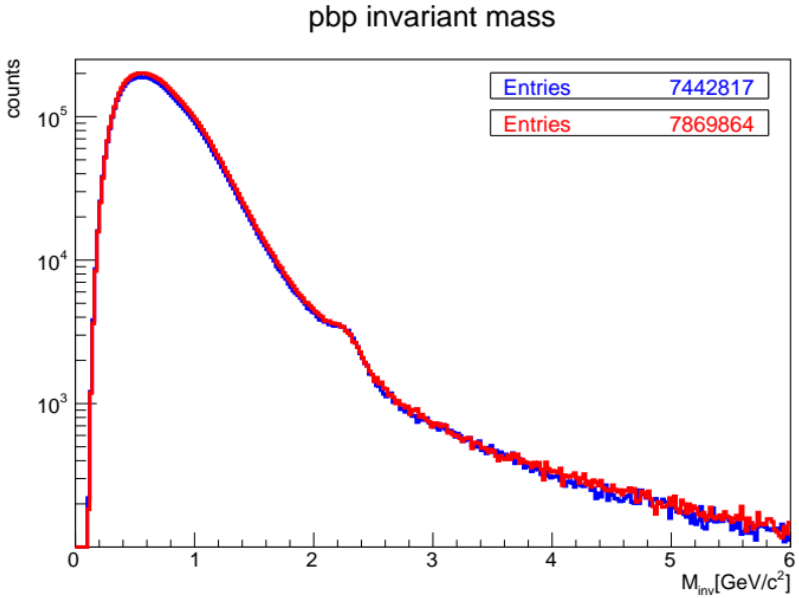


$Ev_{sig} : Ev_{b} = 1 : 9$
Total number = 1000000

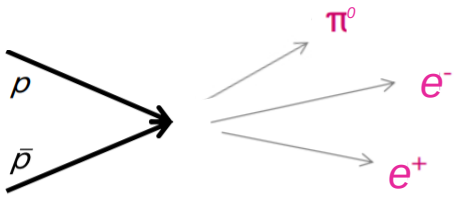
Event-based (Sum)



Time-based (Time-Gap)

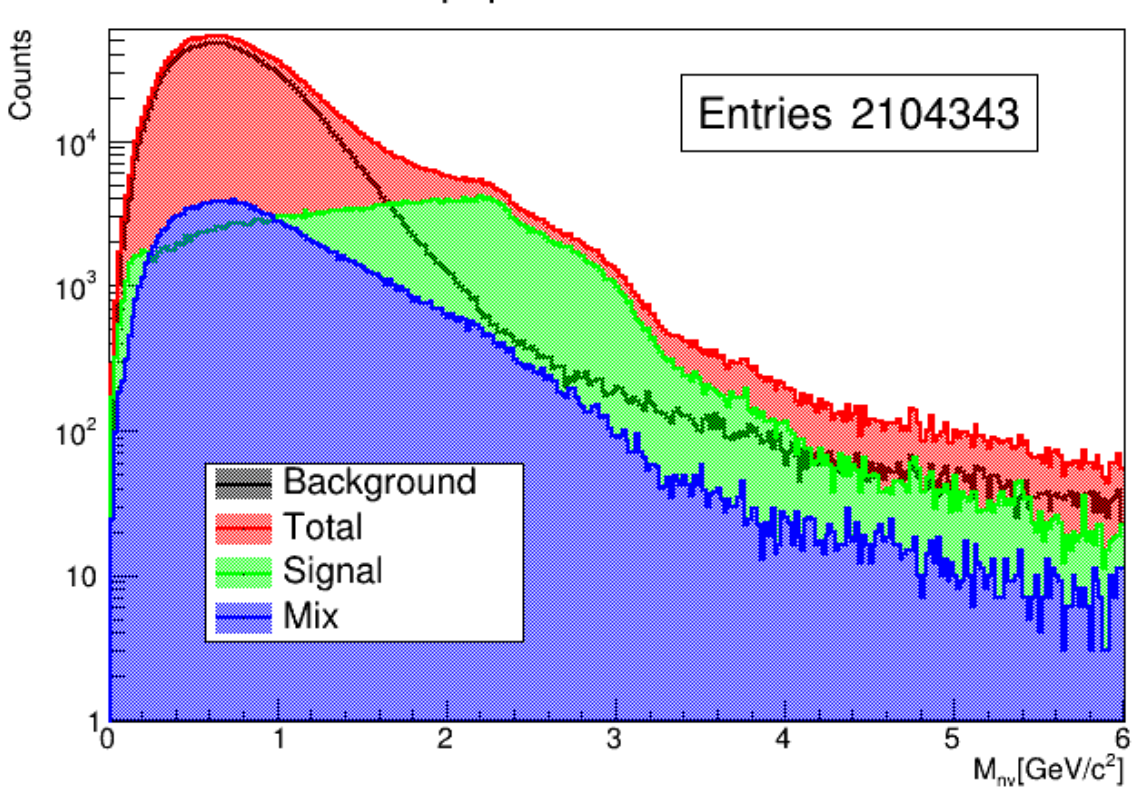


Offline analysis

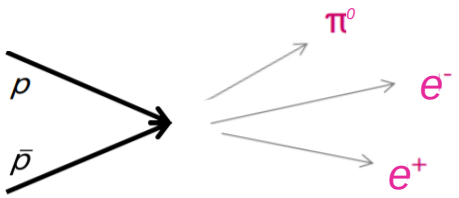


$Ev_{sig} : Ev_b = 1 : 1$
Total number = 200000

Time-based (Time-Gap)

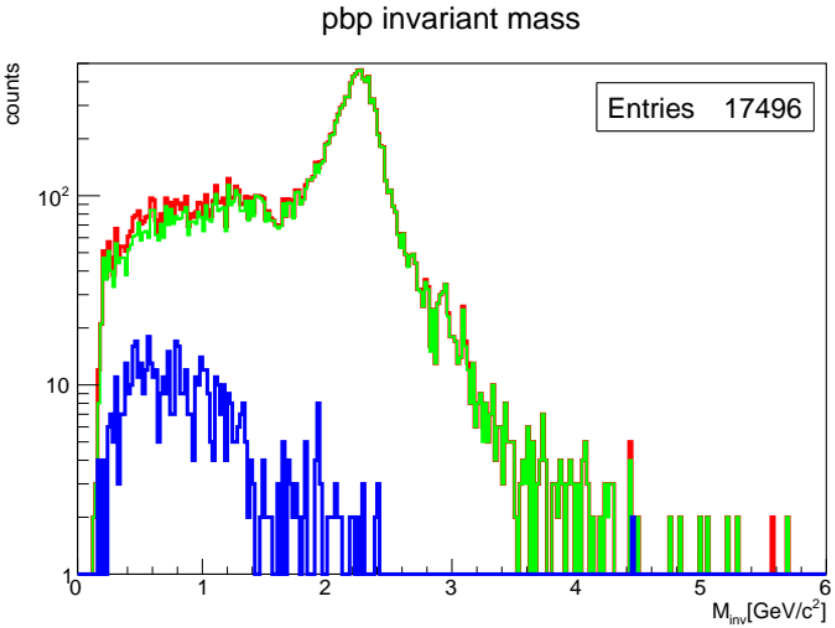


Offline analysis (Filter)

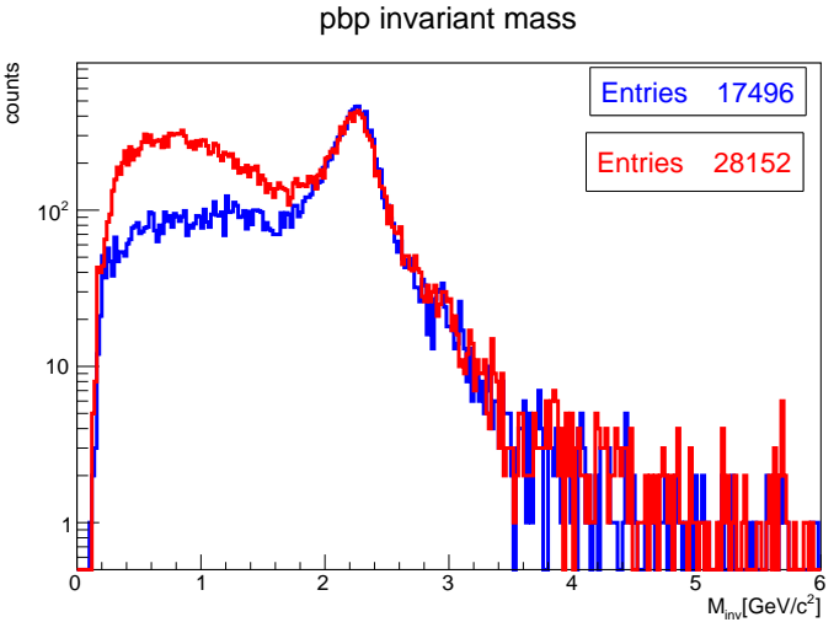


$Ev_{sig} : Ev_b = 1 : 9$
Total number = 1000000

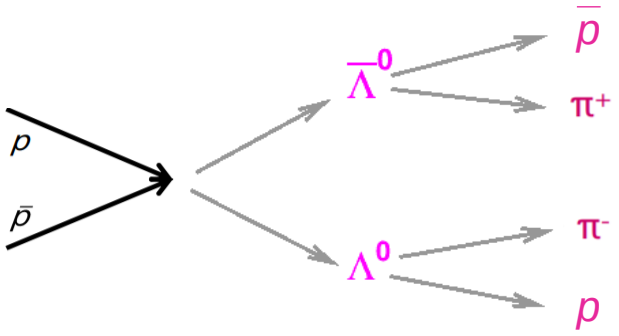
Event-based (Sum)



Time-based (Time-Gap)



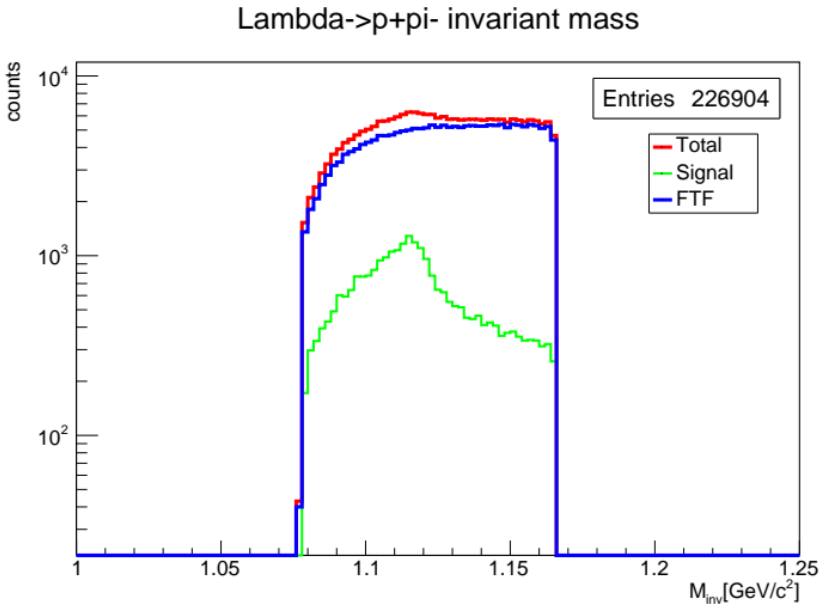
Offline analysis

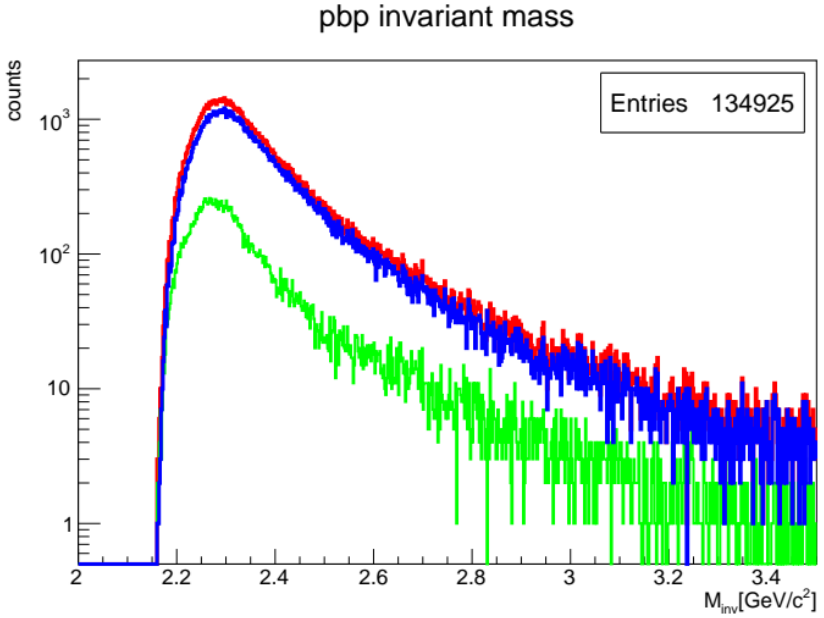


0.1 GeV mass cut for
the Lambda candidates is applied

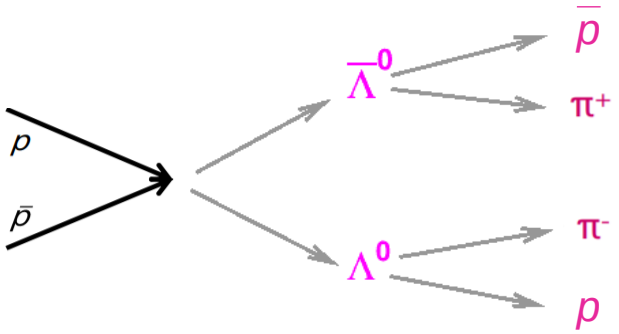
$Ev_{sig} : Ev_b = 1 : 9$
Total number = 1000000

Event-based (Sum)





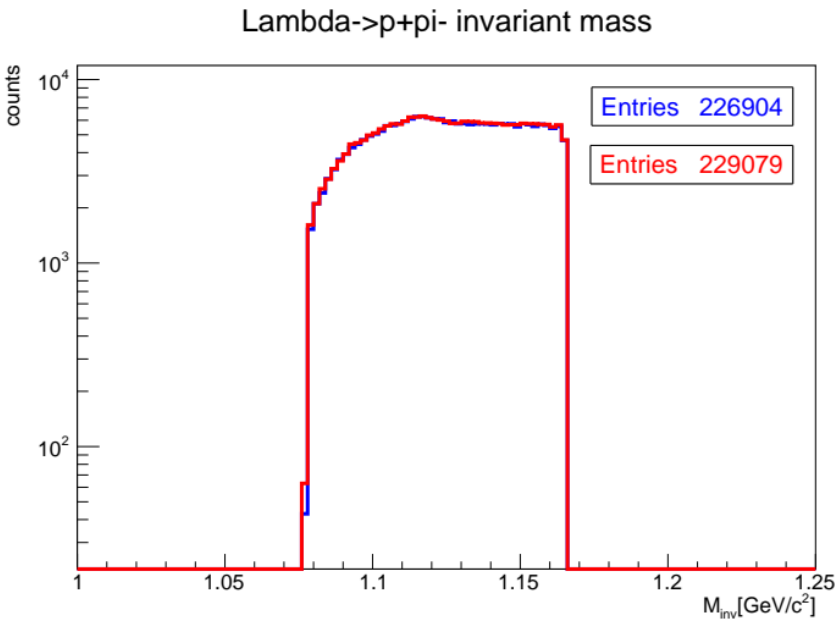
Offline analysis

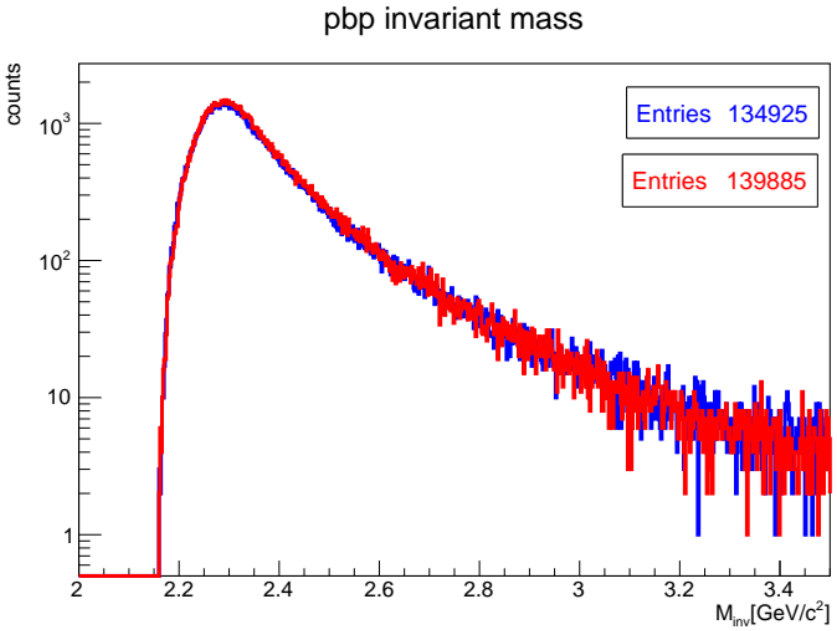


0.1 GeV mass cut for
the Lambda candidates is applied

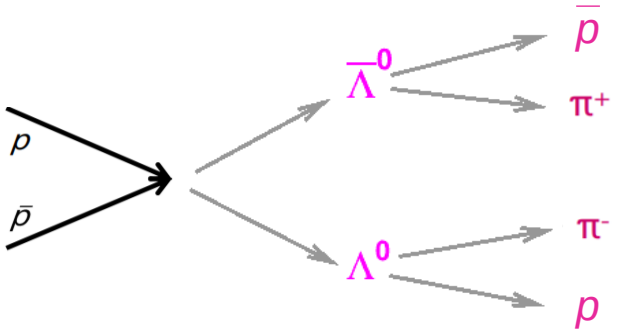
$Ev_{sig} : Ev_b = 1 : 9$
Total number = 1000000

Time-based (Time-Gap)





Offline analysis

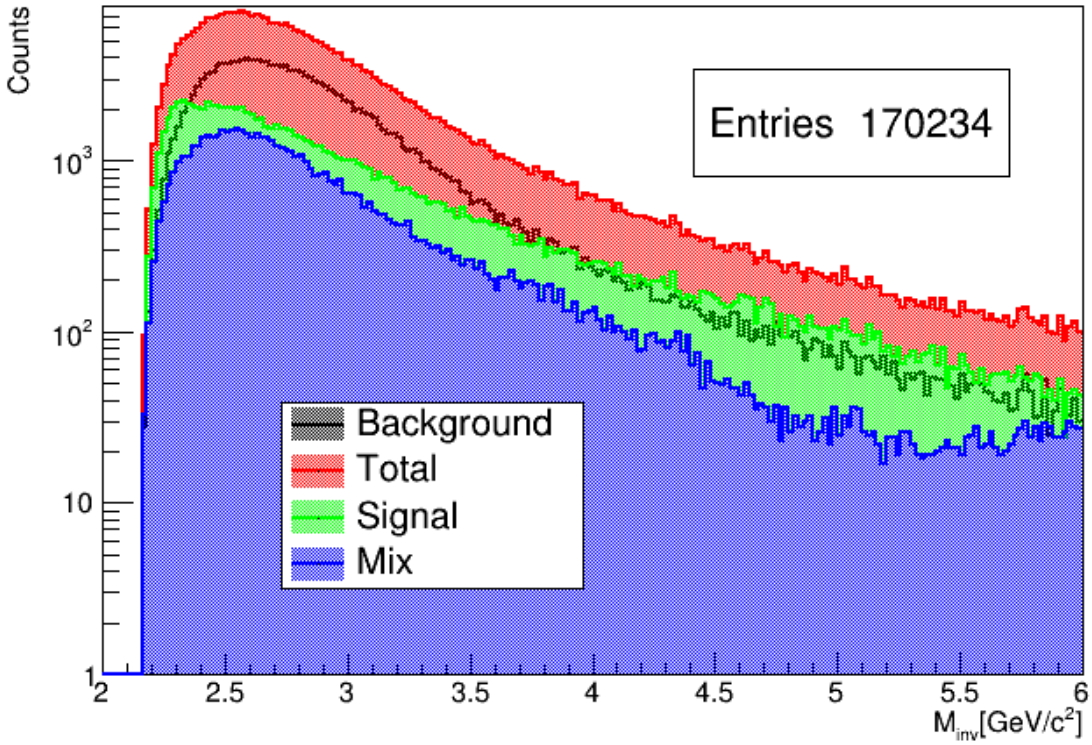


$Ev_{sig} : Ev_b = 1 : 1$

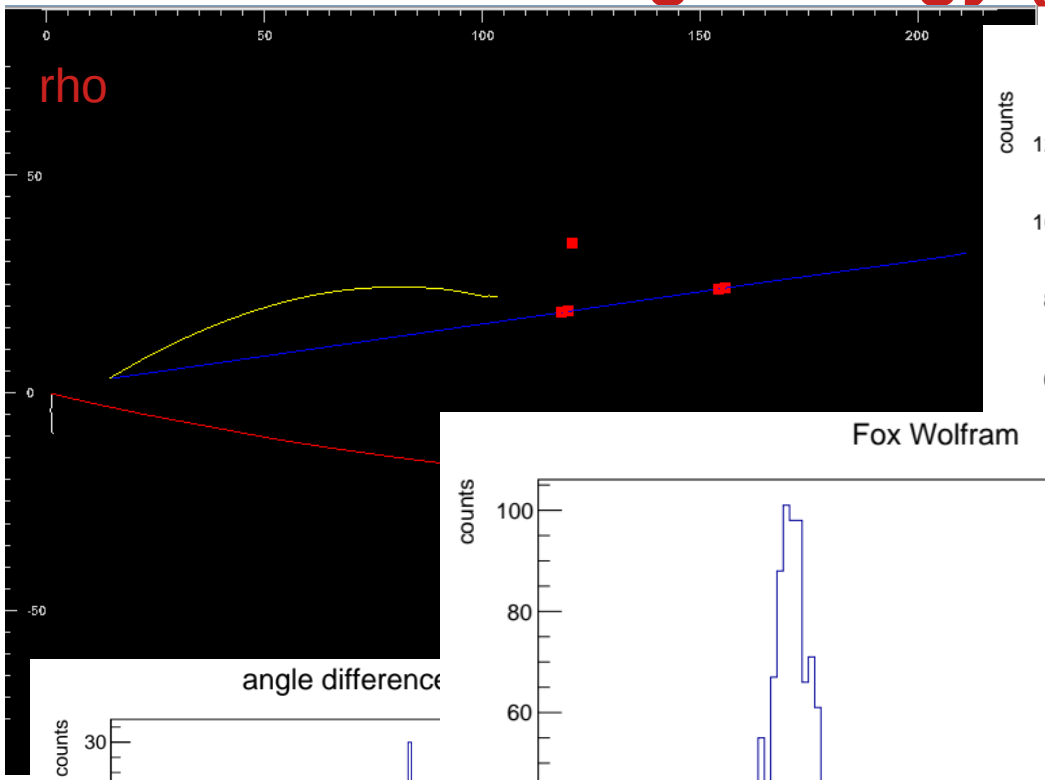
Total number = 200000

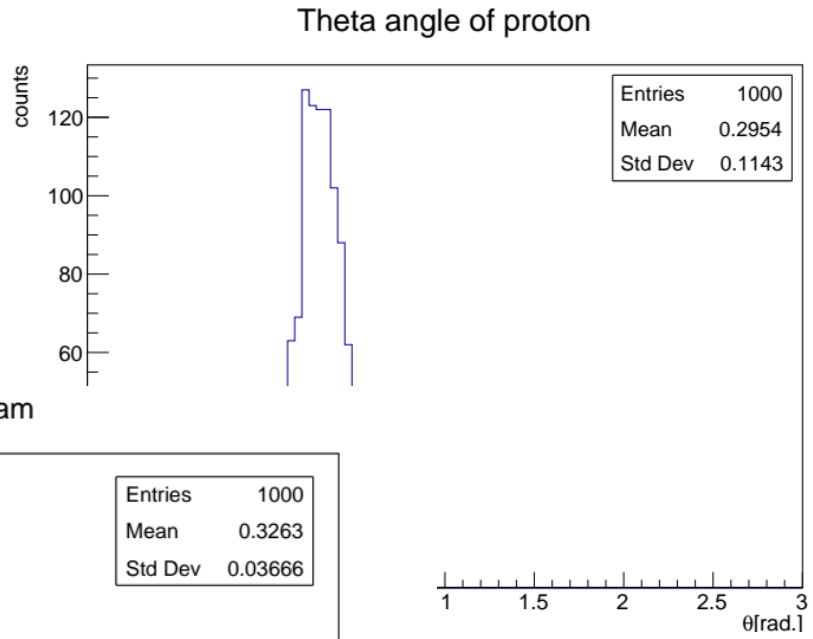
Time-based (Time-Gap)

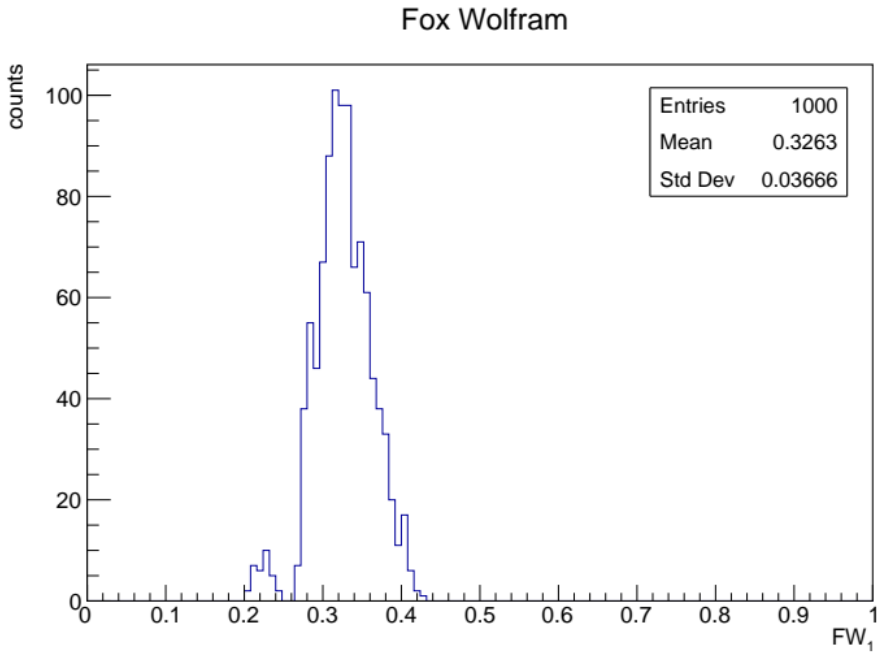
pbp invariant mass

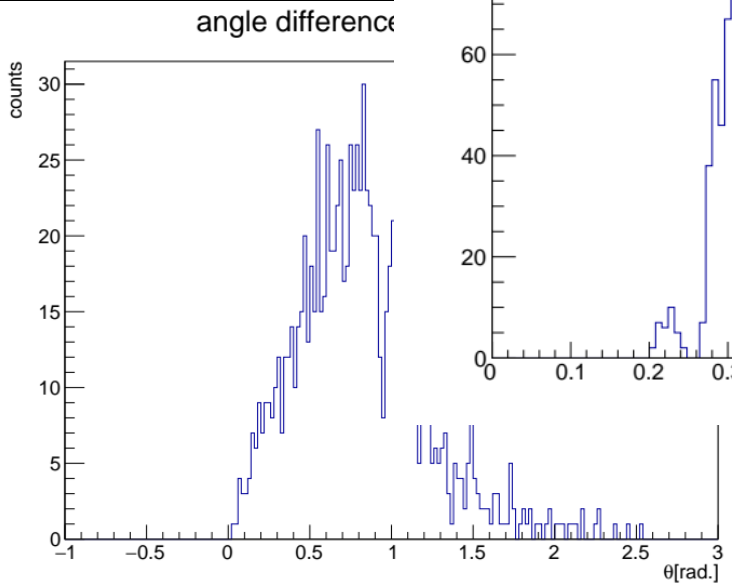


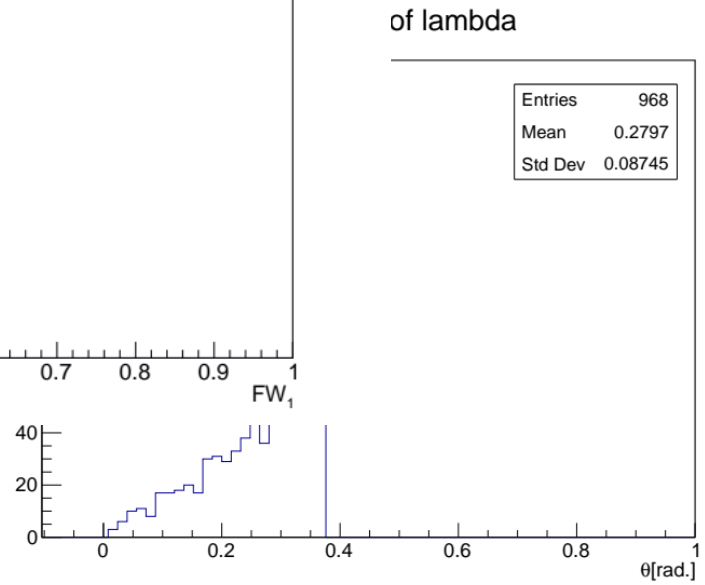
Filtering strategy (Monte Carlo)



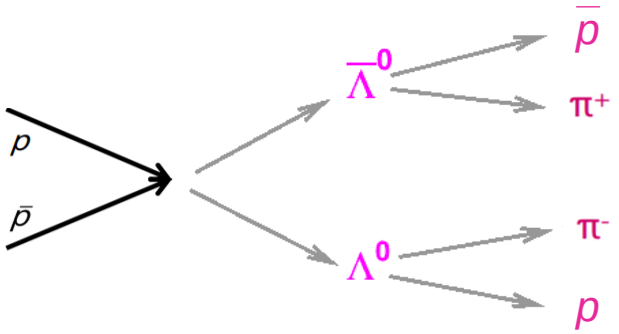


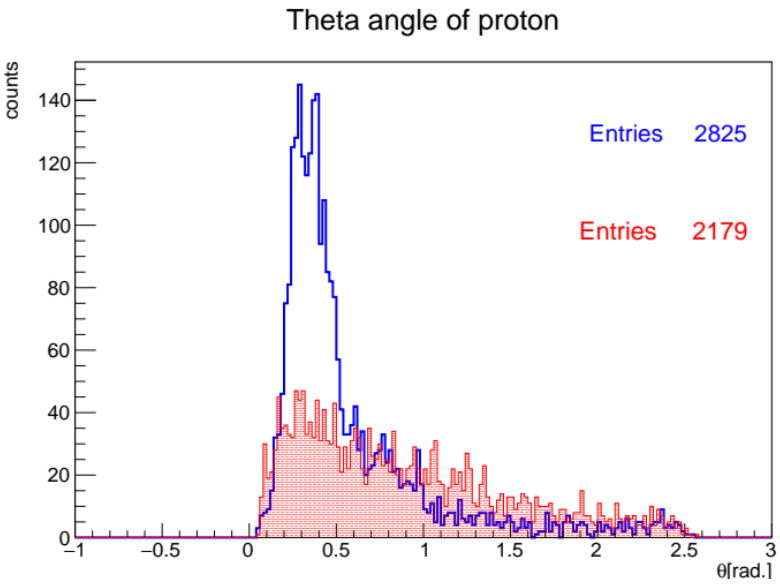


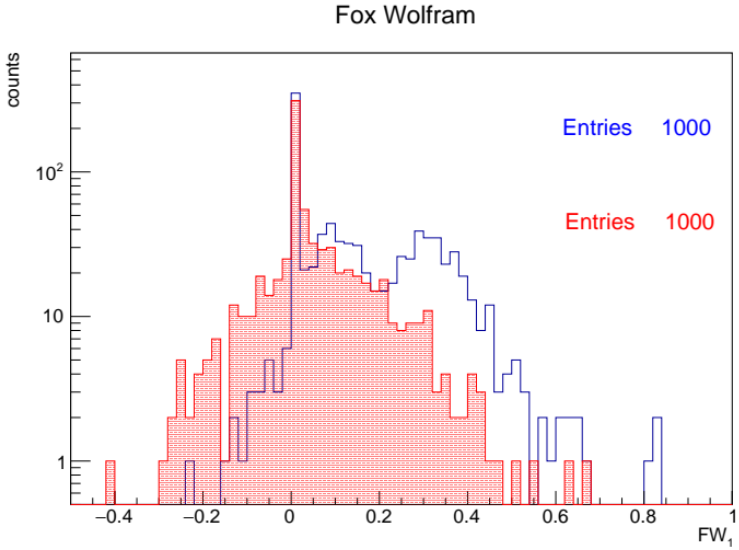


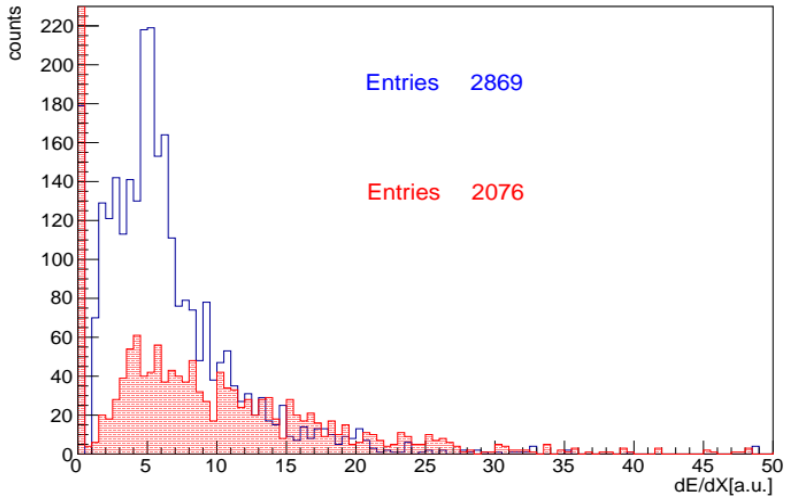


Filtering strategy (Reconstr.)

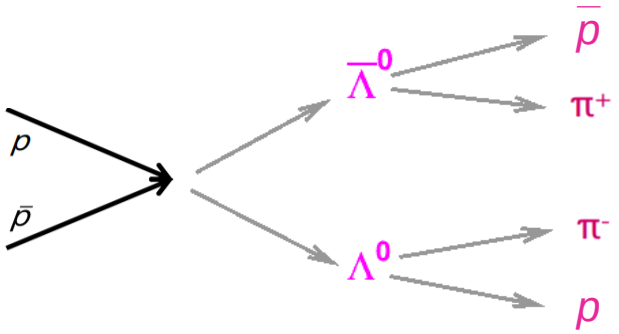






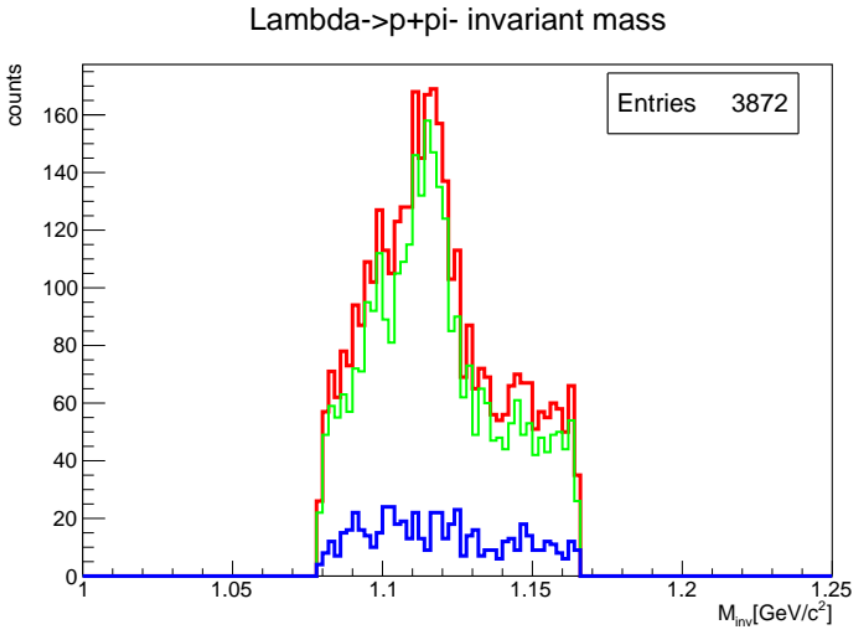


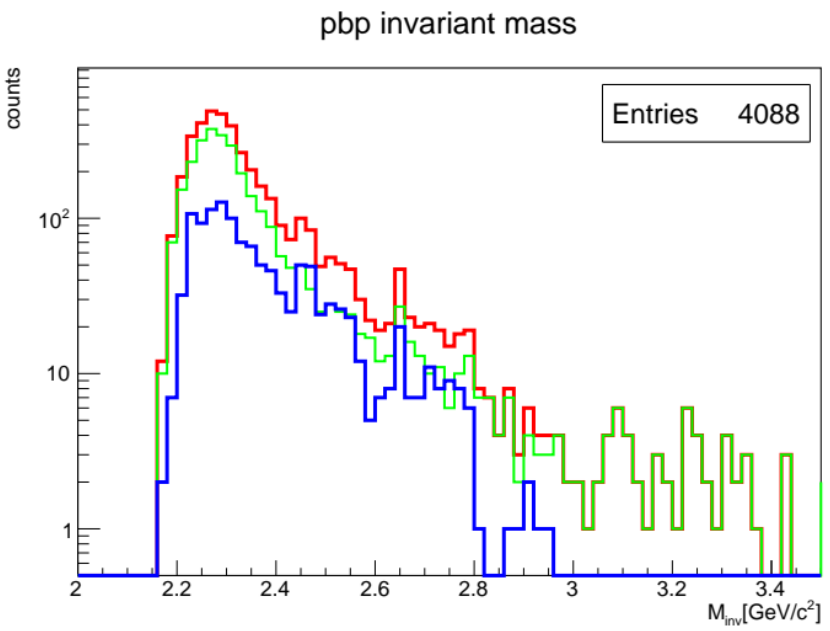
Offline analysis(Filter)



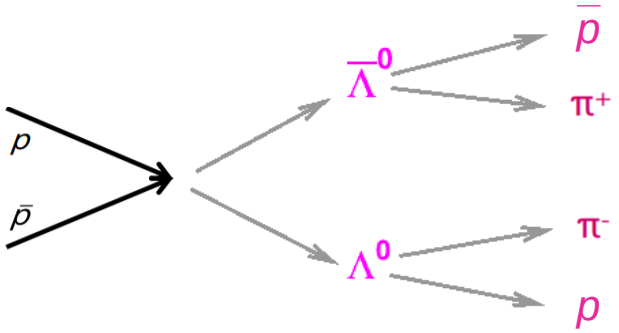
$Ev_{sig} : Ev_b = 1 : 9$
Total number = 1000000

Event-based (Sum)





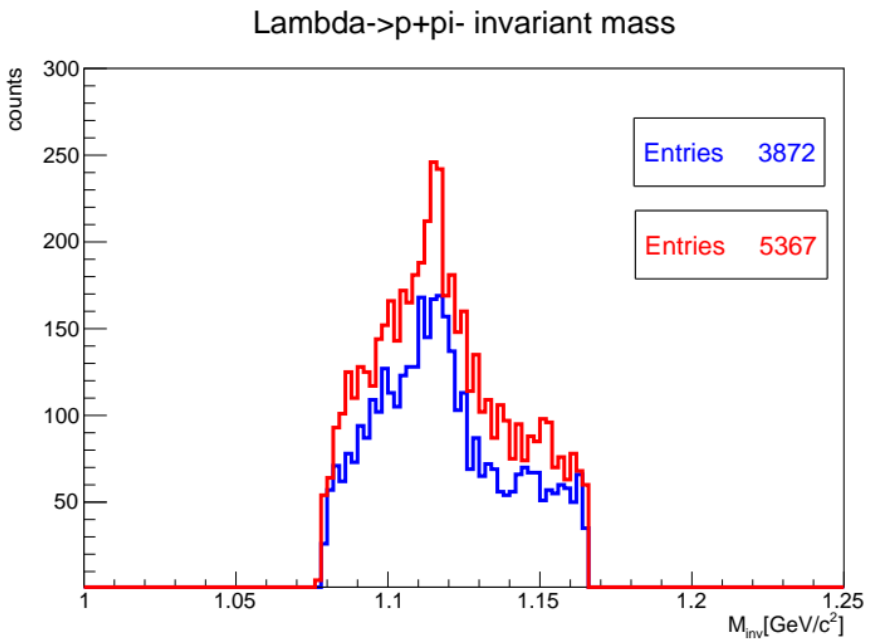
Offline analysis(Filter)

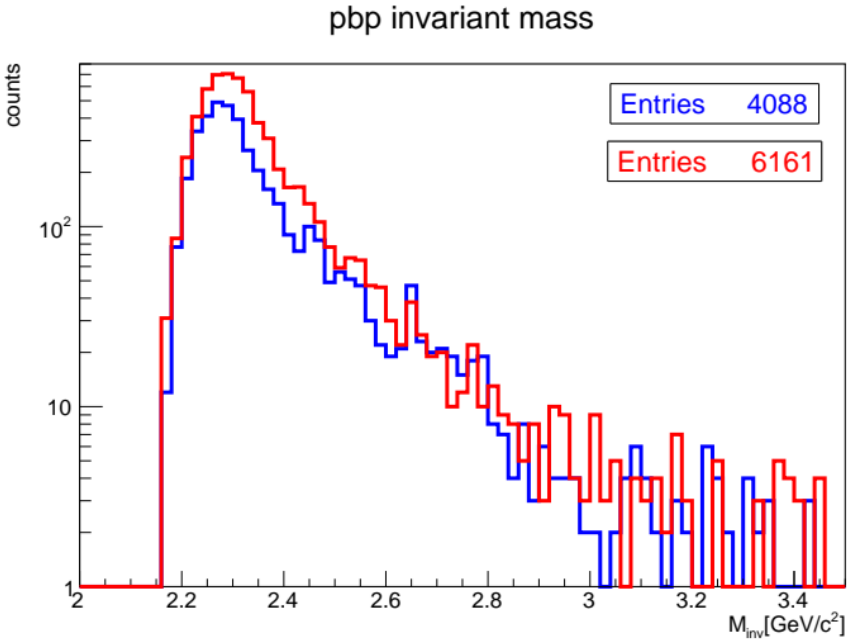


$Ev_{sig} : Ev_b = 1 : 9$

Total number = 1000000

Time-based (Time-Gap)





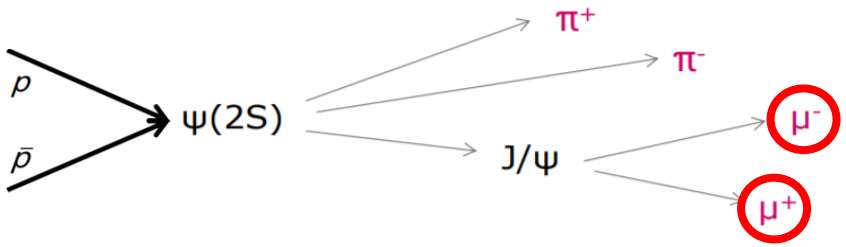
Summary

- **Framework for event building and event filtering was developed in the PandaRoot**
- **Performance of the framework was studied by comparing with event-based simulation**
- **All the benchmark channels can be detected using the proposed framework**
- **There are discrepancies present due to the mixing and clipping effects**


THANK YOU FOR YOUR ATTENTION
AND STAY HEALTHY!

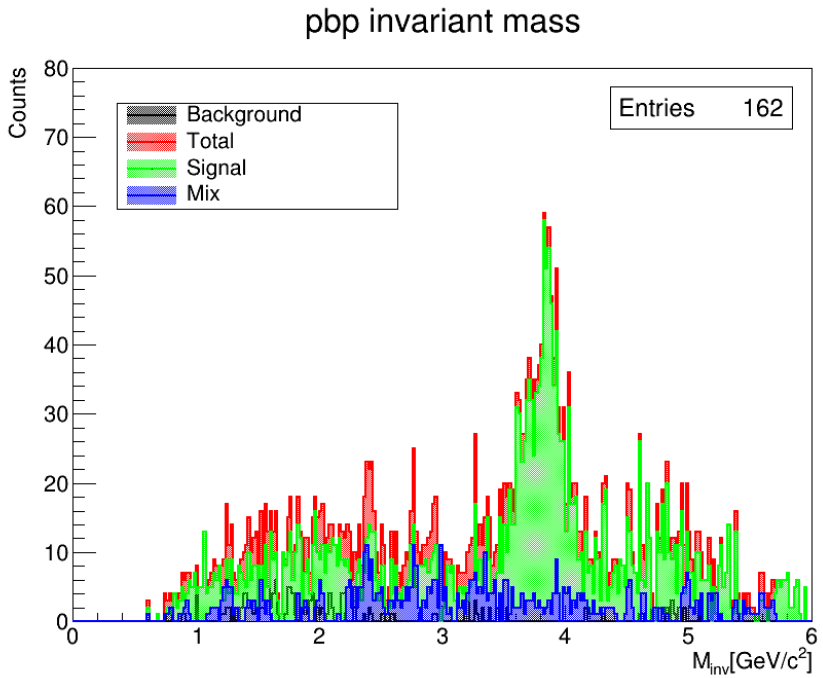
Backup Slides

Offline analysis (Filter)

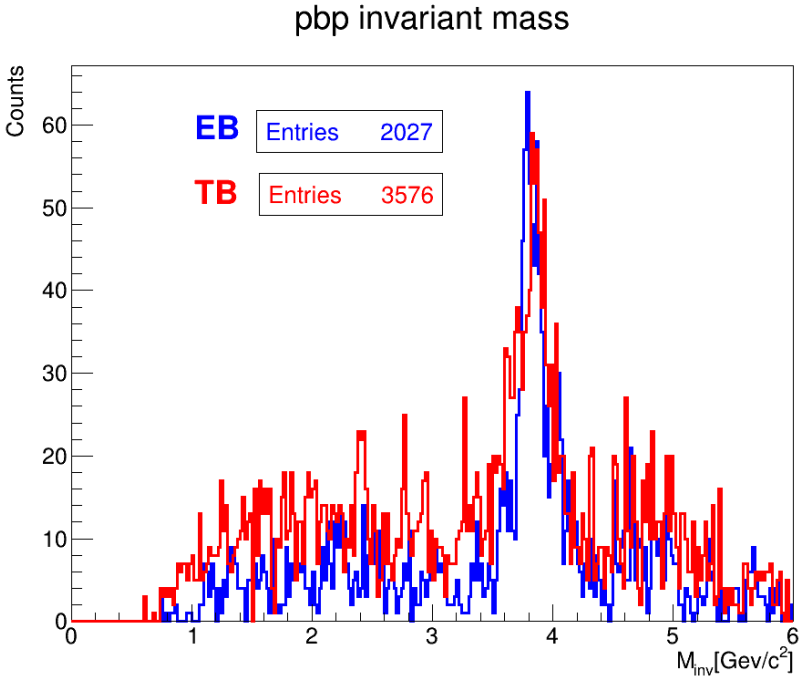


$Ev_{sig} : Ev_b = 1 : 1$
Total number of events = 2000

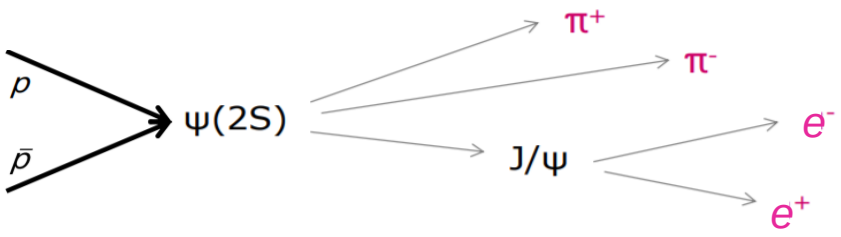
Time-based (Time-Gap)



Comparison

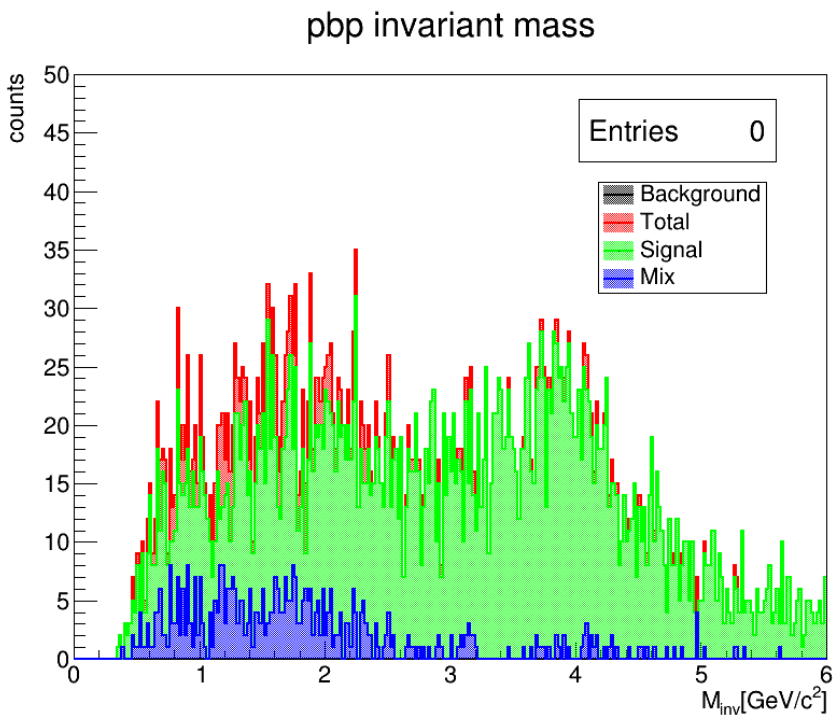


Offline analysis (Filter)

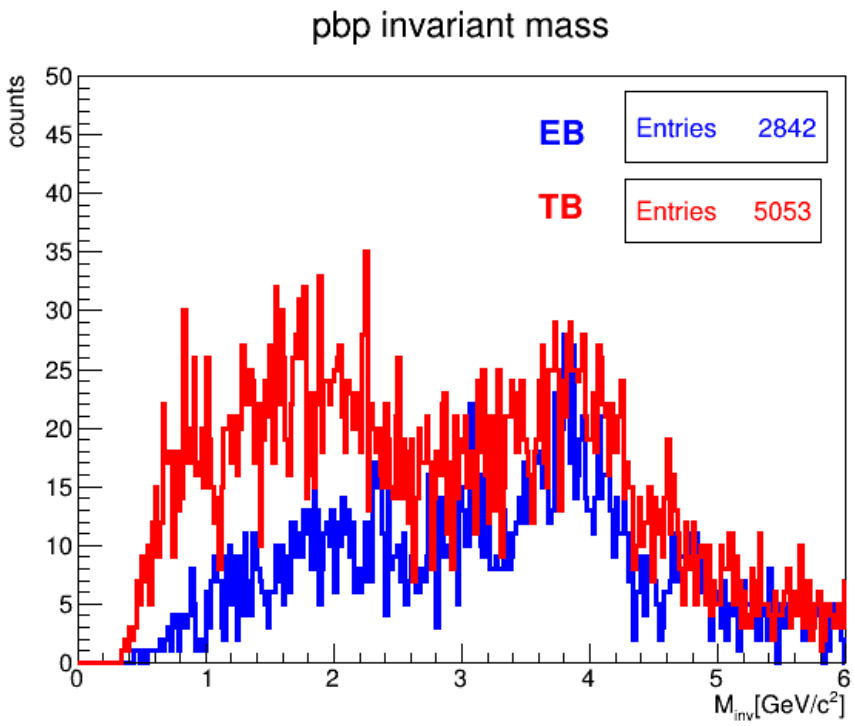


$Ev_{sig} : Ev_b = 1 : 1$
Total number of events = 2000

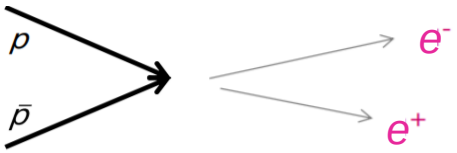
Time-based (Time-Gap)



Comparison

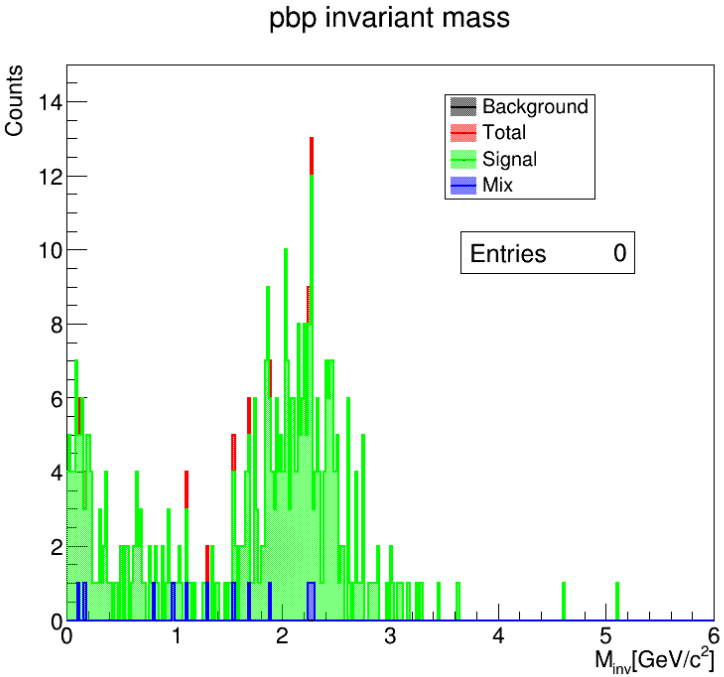


Offline analysis (Filter)

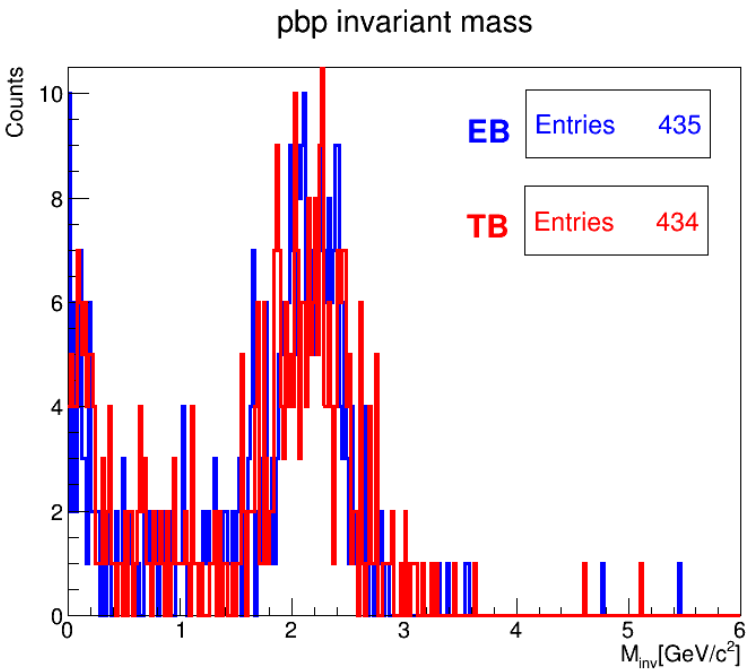


$Ev_{sig} : Ev_b = 1 : 1$
Total number of events = 2000

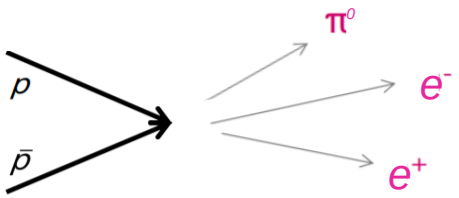
Time-based (Time-Gap)



Comparison

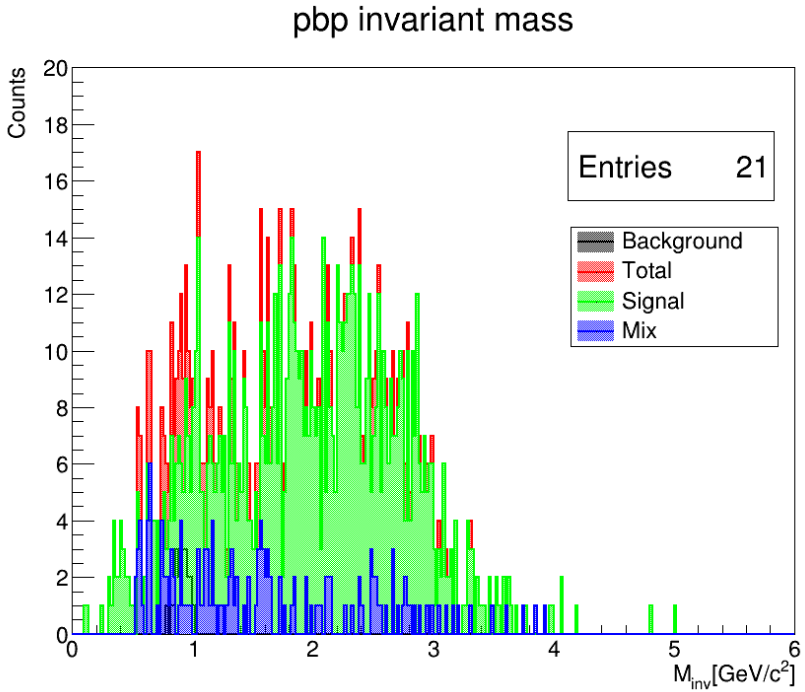


Offline analysis (Filter)

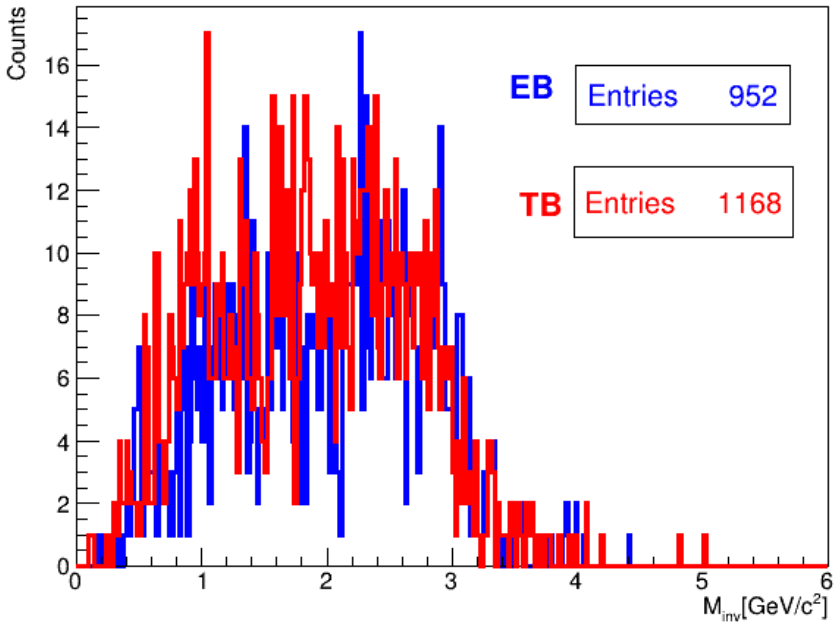


$Ev_{sig} : Ev_b = 1 : 1$
Total number of events = 2000

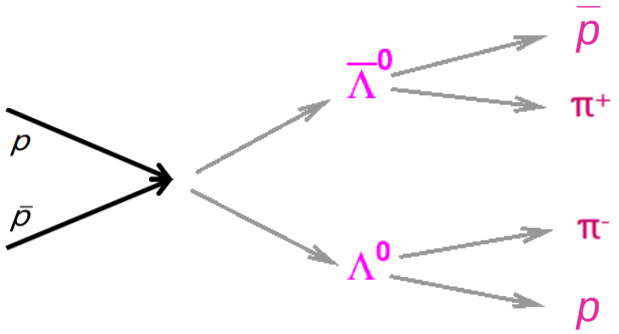
Time-based (Time-Gap)



Comparison



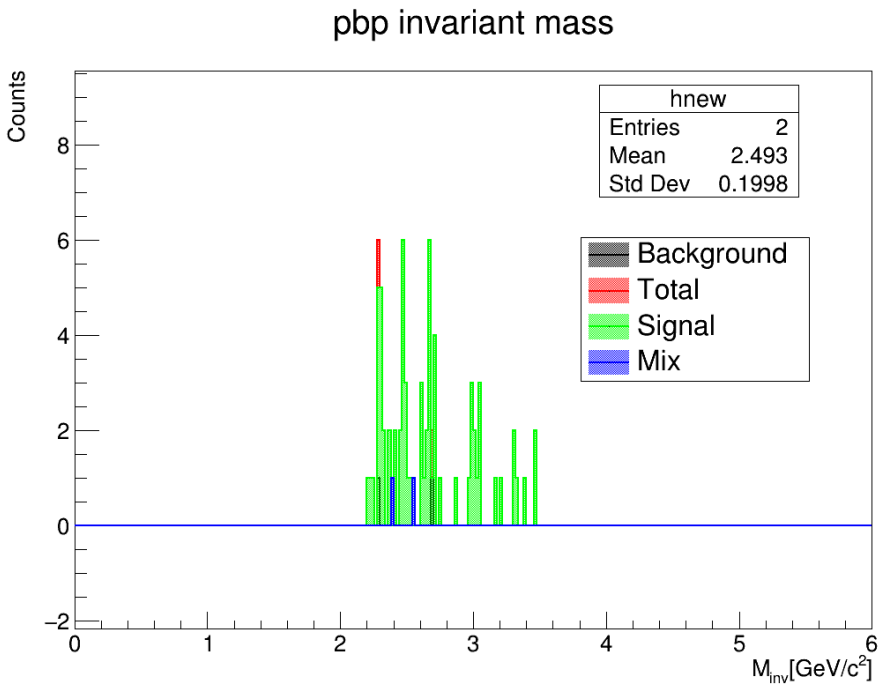
Offline analysis(Filter)



$Ev_{sig} : Ev_b = 1 : 1$

Total number of events = 2000

Time-based (Time-Gap)



Comparison