# MANTRA BES III

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# Outline

# TOF MC Truth Issues

Tof:EMC matching, some issues were surfaced.

```
/////// TOF testing

cout<<red<<"*****************TOF Testing **********************"<<reset<<endl;
cout<<green<<"largest index = "<<largestindx<<"\t"<<"showesize="<<showersize<<reset<<endl;
double temptrkmom;
temptrkmom = 1.0; ///// particle gun monetum fed in MC, need to change for each p value of MC
      for(int t=0;t<showersize;t++)
       {/////tof shower loop
        if(t!=largestindx) continue;
       cout<<green<<"check n bar only : tof index  = "<<t<<"\t"<<"largeindx ="<<largestindx<<reset<<endl;
        int trkid =-1,tofid=-1;
        double tof =-1, ph=-1, path =-1, zrhit =-1, beta =-1, t0 =-1;
        double texp=-1;
    EvtRecTrackIterator itTrk=evtRecTrkCol->begin()+ishower[t];
    if(!(*itTrk)->isEmcShowerValid()) continue;
    if(!(*itTrk)->isTofTrackValid()) continue;
    cout<<"validating the TOF track"<<endl;
    SmartRefVector<RecTofTrack> tofTrkCol = (*itTrk)->tofTrack();
    SmartRefVector<RecTofTrack>::iterator iter_tof = tofTrkCol.begin();
          for(;iter_tof != tofTrkCol.end();iter_tof++)
              {////tof iteration
             TofHitStatus *status =  new TofHitStatus;
             status->setStatus((*iter_tof)->status());
            cout<<"ph before status check = "<<(*iter_tof)->ph()<<endl;
            cout<<"t0 before status check  = "<<(*iter_tof)->t0()<<endl;
            cout<<"status = "<<(*iter_tof)->status()<<endl;
  cout<<"Raw : "<<status->is_raw() <<",Cluster: "<<status->is_cluster() <<endl;
 if(status->is_raw()) continue; //// skip if noisy or unprocessed data
         //    if(!(status->is_cluster())) continue;//// only cluster hits are allowed
        //   cout<<"testing"<<endl;
            trkid = (*iter_tof)->trackID();
            tofid = (*iter_tof)->tofID();
            tof = (*iter_tof)->tof();
            ph = (*iter_tof)->ph();
            path = (*iter_tof)->path();
            zrhit = (*iter_tof)->zrhit();
            beta = (*iter_tof)->beta();
            t0 = (*iter_tof)->t0();
            double gammabeta = temptrkmom/0.93956;
            double beta2 = gammabeta/sqrt(1+gammabeta*gammabeta);
            texp = 10*path/beta2/velc;
            Ncut_tof_mostengyshower++;
           cout<<"inside tof iteration Ncut_tof_mostengyshower= "<<Ncut_tof_mostengyshower<<endl;
           cout<<"*ph* after status->is_raw()  = "<<(*iter_tof)->ph()<<endl;
           cout<<"*t0* after status->is_raw()  = "<<(*iter_tof)->t0()<<endl;
              }////tof iteration
      }////tof shower  loop
```

```
neutral trk shower size after barrel endcap and [1,9] cut = 1
shower number =0        eraw= 0.287141
*****************TOF Testing **********************
largest index = 0       showesize=1
check n bar only : tof index  = 0       largeindx =0
validating the TOF track
ph before status check = 9999
t0 before status check  = 0
status = 0
Raw : 0,Cluster: 0
inside tof iteration Ncut_tof_mostengyshower= 4763
*ph* after status->is_raw()  = 9999
*t0* after status->is_raw()  = 0
```

```
neutral trk shower size after barrel endcap and [1,9] cut = 4
shower number =0        eraw= 0.833762
shower number =1        eraw= 0.20184
shower number =2        eraw= 0.144952
shower number =3        eraw= 0.0895908
*****************TOF Testing **********************
largest index = 0       showesize=4
check n bar only : tof index  = 0       largeindx =0
validating the TOF track
ph before status check = 9999
t0 before status check  = 0
status = 0
Raw : 0,Cluster: 0
inside tof iteration Ncut_tof_mostengyshower= 4757
*ph* after status->is_raw()  = 9999
*t0* after status->is_raw()  = 0
Ncut_tof_mostengyshower   =  4757
```

# TOF MC Truth Issues (cont)

We looked into $e^-$ and proton gun 500 events @ 1GeV/c ph and tof ID

.

```
********testing eminus only *****
evtRecTrkCol->size() : 1
evtRecEvent->totalCharged() = 1
i=  0   # total charged =1  neutral = 0   total = 1
iGood.size() = 1
 nchtrk = 1
nGood_eminus= 1 netCharge_eminus=-1
*******  nGoodCh= 1     ChTrks=1
******************TOF Testing **********************
nGood = 1       tofTrkCol.size() =7
before status check = 65650;t0  = 0;Raw : 0,Cluster : 0ph  = 288.072
before status check = 1048658;t0  = 0;Raw : 0,Cluster : 0ph  = 483.737
before status check = 1118292;t0  = 0;Raw : 0,Cluster : 0ph  = 571.234
before status check = 65714;t0  = 0;Raw : 0,Cluster : 0ph  = 483.416
before status check = 1048722;t0  = 0;Raw : 0,Cluster : 0ph  = 941.123
before status check = 1118356;t0  = 0;Raw : 0,Cluster : 0ph  = 1054.12
before status check = 2236632;t0  = 0;Raw : 0,Cluster : 1ph  = 825.398
after is_cluster check = 2236632;t0  = 0;Raw : 0,Cluster : 1
ph after status cluster check = 825.398
******* Electron particle gun : execute()
```

```
********testing proton  only *****
evtRecTrkCol->size() : 1
evtRecEvent->totalCharged() = 1
i=  0   # total charged =1  neutral = 0   total = 1
iGood.size() = 1
 nchtrk = 1
nGood_proton= 1 netCharge_proton=1
*******  nGoodCh= 1     ChTrks=1
******************TOF Testing **********************
nGood = 1       tofTrkCol.size() =7
before status check = 65650;    t0  = 0;Raw : 0,Cluster : 0   ph  = 3636.56
before status check = 1048658;    t0  = 0;Raw : 0,Cluster : 0   ph  = 2185.02
before status check = 1118292;    t0  = 0;Raw : 0,Cluster : 0   ph  = 4585.84
before status check = 65714;    t0  = 0;Raw : 0,Cluster : 0   ph  = 1791.5
before status check = 1048722;    t0  = 0;Raw : 0,Cluster : 0   ph  = 1081.73
before status check = 1118356;    t0  = 0;Raw : 0,Cluster : 0   ph  = 2373.71
before status check = 2236632;    t0  = 0;Raw : 0,Cluster : 1   ph  = 3424.36
after is_cluster check = 2236632;t0  = 0;Raw : 0,Cluster : 1
ph after status cluster check = 3424.36
charged =1  neutral = 0   total = 1
execute()
*** proton- particle gun:  Execute () ****
```

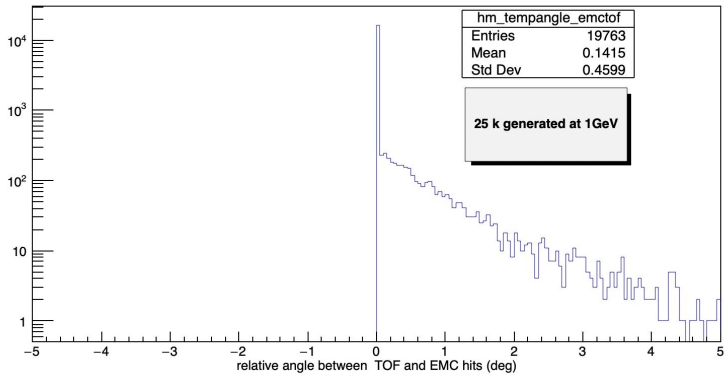
```
********testing proton  only *****
evtRecTrkCol->size() : 5
evtRecEvent->totalCharged() = 1
i=  0   # total charged =1  neutral = 4   total = 5
iGood.size() = 1
 nchtrk = 1
nGood_proton= 1 netCharge_proton=1
*******  nGoodCh= 1     ChTrks=1
******************TOF Testing **********************
nGood = 1       tofTrkCol.size() =3
before status check = 65650;    t0  = 0;Raw : 0,Cluster : 0   ph  = 1269.36
before status check = 1048658;    t0  = 0;Raw : 0,Cluster : 0   ph  = 908.195
before status check = 1118300;    t0  = 0;Raw : 0,Cluster : 1   ph  = 1950.7
after is_cluster check = 1118300;t0  = 0;Raw : 0,Cluster : 1
ph after status cluster check = 1950.7
```

I am working on what is the root cause for this issue in $\bar{n}$ gun.

# TOF MC Truth Issues (cont)

We worked on bck splash PDGs for TOF truth, there is no function for getting PDG in TOF truth TofMcHit, but it is available in EmcMcHit

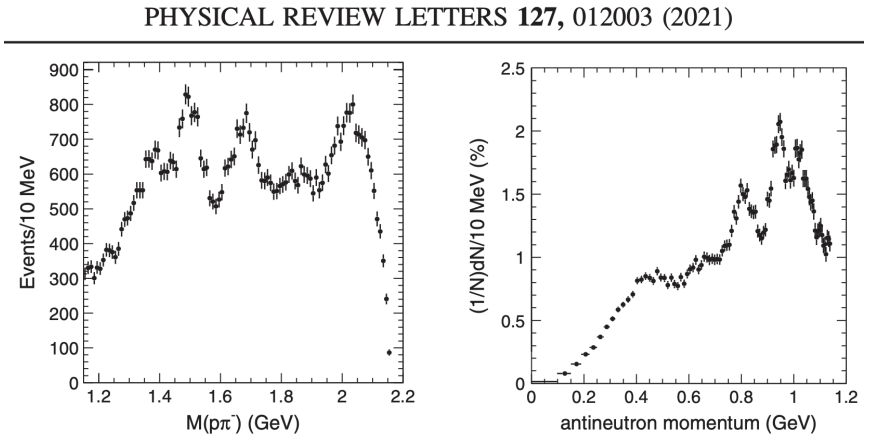
```
        Event::TofMcHitCol::iterator it_tof;
        Event::EmcMcHitCol::iterator it_emc;
cout<<"total emcHit size  "<<emchitsize<<"\t"<<"total tofHit size "<<tofhitsize<<endl;

         for(it_tof = tofHits->begin(); it_tof!= tofHits->end();it_tof++)
          { ////it_tof
           TVector3 tofPos((*it_tof)->getPositionX(),(*it_tof)->getPositionY(),(*it_tof)->getPositionZ());
           cout<<green<<"tof hit position at (" <<tofPos.X()<<","<<tofPos.Y()<<","<<tofPos.Z()<<")"<<reset<<endl;

            for(it_emc = emcHits->begin(); it_emc != emcHits->end(); it_emc++)
            {   ////it_emc

           TVector3 emcPos((*it_emc)->getPositionX(),(*it_emc)->getPositionY(),(*it_emc)->getPositionZ());
           cout<<green<<"emc hit position at (" <<emcPos.X()<<","<<emcPos.Y()<<","<<emcPos.Z()<<")"<<reset<<endl;

            double tempangle =  tofPos.Angle(emcPos) * (180.0 / pivalue);
            if(tempangle<=0.0025){ continue;}
          cout<<green<<  "angle between tof and emc ="<<tempangle<<reset<<endl;
          hm_tempangle_emctof->Fill(tempangle);


            }/////it_emc


        }   ////it_tof
```

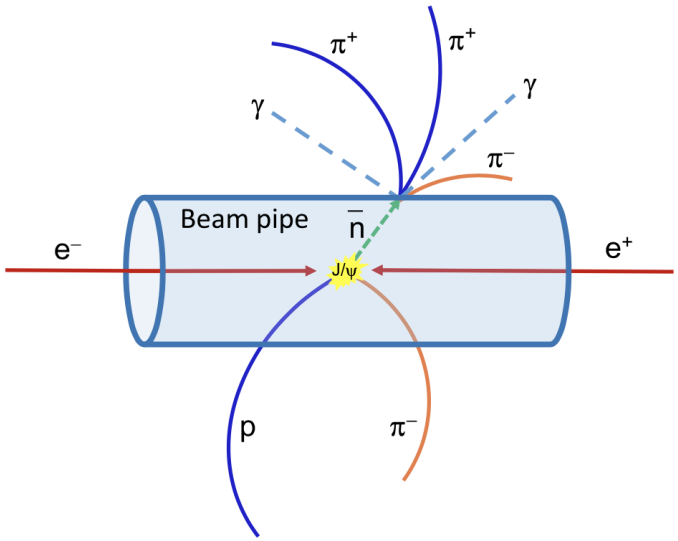



We calculated the relative angle between tof hits and emc hits in truth.

# $J/\psi \to p\bar{n}\pi^-$, PRL **127**, 012003 (2021)

- New source of $\bar{n}$ from $J/\psi$ in $e^+e^-$ .
- By tagging the particles recoiling against an $\bar{n}$ in $J/\psi$ decays, the momentum and direction of these $\bar{n}$ can be determined. $8 \times 10^6 \bar{n}$ can be tagged in the $1 \times 10^{10} J/\psi$ sample
- The momentum of the $\bar{n}$ at BESIII is known with an uncertainty of about $6 - 7 MeV/c$
- The beam pipe and the inner tube of the MDC can be targets of beryllium and carbon.
- we expect 1%– 2% of the tagged $\bar{n}$ to interact with beryllium and another 1% –2% with carbon fiber targets.



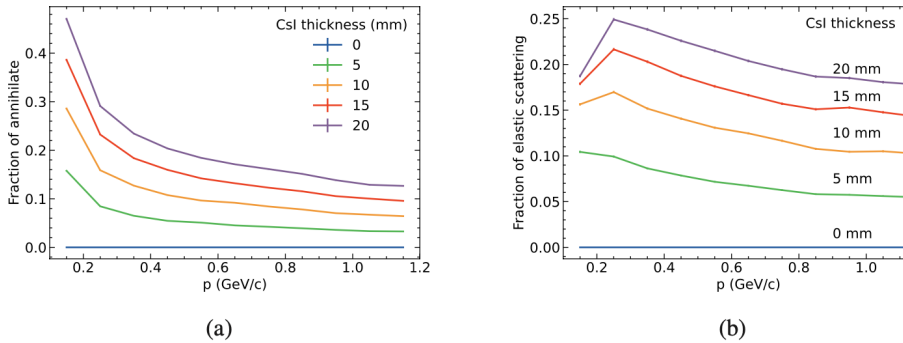



# An approach to study interactions of $\bar{n}$ with CsI at a $J/\psi$ factory. arXiv:2310.01746v1 [hep-ex] 3 Oct 2023

- From MC we obtain clean $\bar{n}$ from $p\pi^-$ tracks with well defined $p$ & $\theta$
- The agreement between data and MC simulation for interaction between $\bar{n}$ and CsI simulated with GEANT4 is poor. Data driven method is used when reliable estimation of the efficiency is needed.
- the $(p_{\bar{n}})max$ from $J/\psi \rightarrow p\bar{n}\pi^-$ can reach 1174 MeV/c.
- we expect 1%– 2% of the tagged $\bar{n}$ to interact with beryllium and another 1% –2% with carbon fiber targets.
- Single proton, $\pi^-$, and $\bar{n}$ samples, as well $J/\psi \rightarrow p\bar{n}\pi^-$ are generated at diff CsI thickness, $p$ and direction of the particles.

# An approach to study interactions of $\bar{n}$ with CsI at a $J/\psi$ factory (cont)

- Study of single $\bar{n}$ sample:
- simulating a single $\bar{n}$ and adding CsI thickness in the detector.
- $p$ is $[0, 1.2] GeV/c$ and Cos$\theta$ is $[0, 0.93]$.
- Out of $10 \times 6$ events of $\bar{n}$ a fractions of $\bar{n}$ annihilated and $\bar{n}$ nuclei elastic scattered.
- The simulation shows 3.7% of annihilation and 1.0% of elastic scattering, of $\bar{n}$ and beam pipe interactions happened.




5: Probability of interactions (a) annihilation (b) elastic scattering between anti-neutron

- Contacted the authors regarding $\bar{n}$ simulation studies, still waiting for their reply :

# An approach to study interactions of $\bar{n}$ with CsI at a $J/\psi$ factory (cont)

- thicker CsI tube can produce and helps to select more antineutron-CsI interactions.
- the $\sigma_p, \sigma\theta$ and $\sigma_\phi$ of the $\bar{n}$ will decrease and make the measurement of the interactions less precise.
- For the accuracy of the $\bar{n}$ tagging, the thickness of CsI should not more than 15 mm.
- the efficiency and resolution of tag $\bar{n}$ vary significantly in different momentum ranges.
- antineutrons with high momentum (above 0.8 GeV/c), thicker CsI needs to be added to ensure the quantity of tagged antineutrons.
- thicker CsI will results in more interactions recorded, the events may suffer from multiple interactions thus make the study more complicated.