eA study group

Update on VM production

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Introduction

Goal

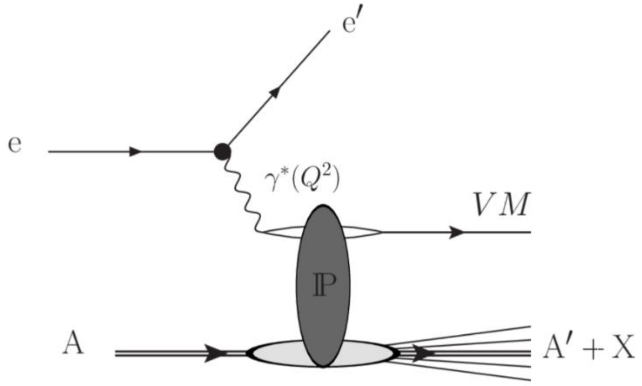
- Study of the VM production in eA collisions

Tasks

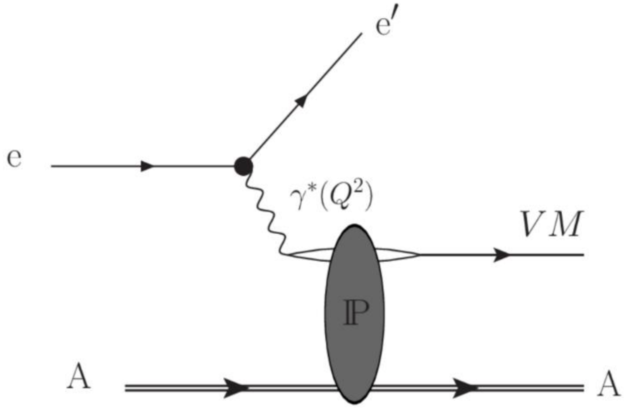
- Discriminating coherent from incoherent processes (done)
- Reconstruction of event kinematics (work in progress)

Simulation

- DDSIM and EICRECON using the master branches (June 2024 includes vacuum in forward region and low-Q2 reco)



Incoherent VM



Coherent VM

Introduction

DDSIM settings

source /gpfs02/eic/mpitt/Analysis/CoherentVM/epic/install/bin/thisepic.sh

ddsim -I $infile --compactFile $DETECTOR_PATH/epic_craterlake_18x275.xml --outputFile edm4hep.root

(NOTE that $DETECTOR_PATH/$DETECTOR_CONFIG.xml pointing to 5x41 beam setup)

EICRECON settings

eicrecon -Pjana:nevents=-1 -PLOWQ2:LowQ2Trajectories:electron_beamE=18

-Pdd4hep:xml_files $DETECTOR_PATH/epic_craterlake_18x275.xml

-

Ppodio:output_include_collections=MCParticles,TaggerTrackerTrackParameters,TaggerTrackerTrajectories,ReconstructedCharged

Particles,B0ECalClusters,ForwardOffMRecParticles,ForwardRomanPotRecParticles,ForwardOffMTrackerHits,ForwardRomanPotHit

s,EcalFarForwardZDCClusters,HcalFarForwardZDCClusters,B0ECalHits

Signal simulation

Execution time:

No ions in the record: 0.9 s/Event

eStarlight: https://github.com/michael-pitt/estarlight/tree/FixIonPDG

W_MAX = -1 #Max value of w from HERA
W_MIN = -1 #Min value of w from HERA
W_N_BINS = 50 #Bins i w
W_GP_MAX = -1 #Max value of W_gp
W_GP_MIN = -1 #Min value of W_gp
EGA_N_BINS = 400
CUT_PT = 0 #Cut in pT? 0 = (no, 1 = yes)
CUT_ETA = 0 # Cut in Eta on VM decay products
PROD_MODE = 12 #narrow / wide switch (12 = coherent vector meson (narrow), 13 = coherent vector meson (wide))
N_EVENTS = 1000
PROD_PID = 443011 # 443011 - Jpsi->ee , 443013 - Jpsi->mumu,
PYTHIA_FULL_EVENTRECORD = 1 # Write full pythia information to output (vertex, parents, daughter etc).
QUANTUM_GLAUBER = 1 # Do a quantum Glauber calculation instead of a classical one
SELECT_IMPULSE_VM = 0 # Impulse VM parameter

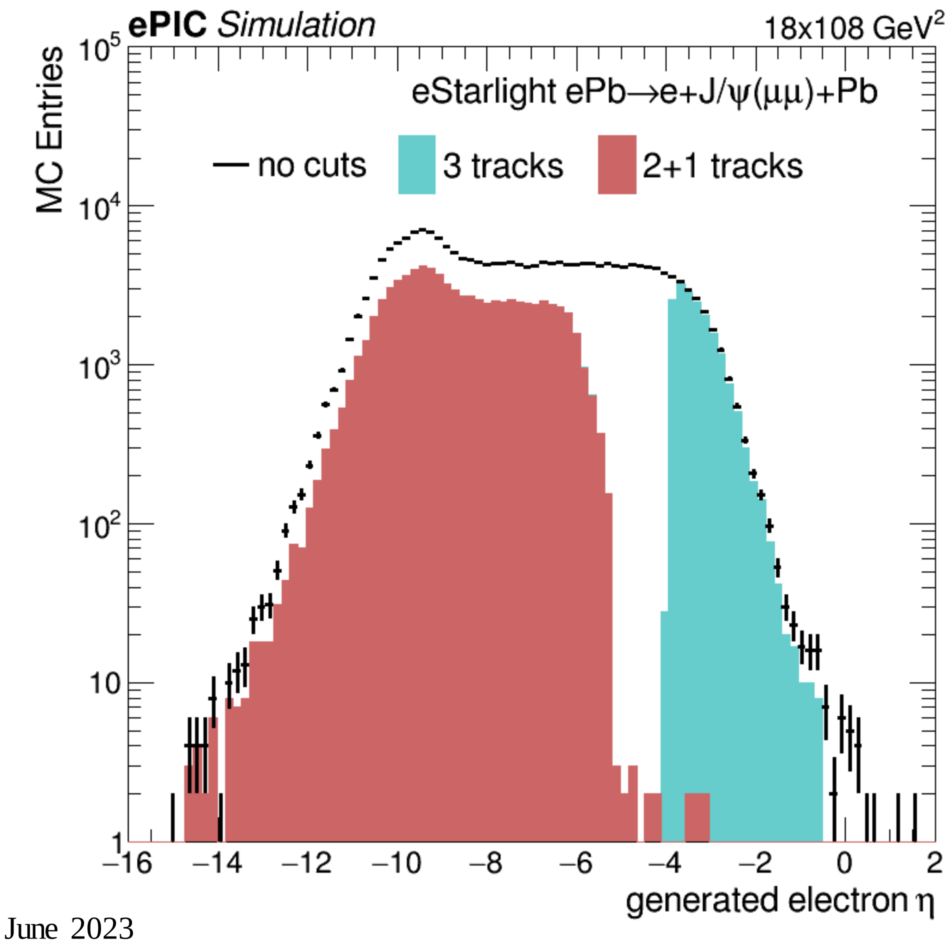
Q^2 Range		Cross – section
$0.0001 < Q^2 < 0.3$	=	$120\ nb$
$1 < Q^2 < 10$	=	$10\ nb$

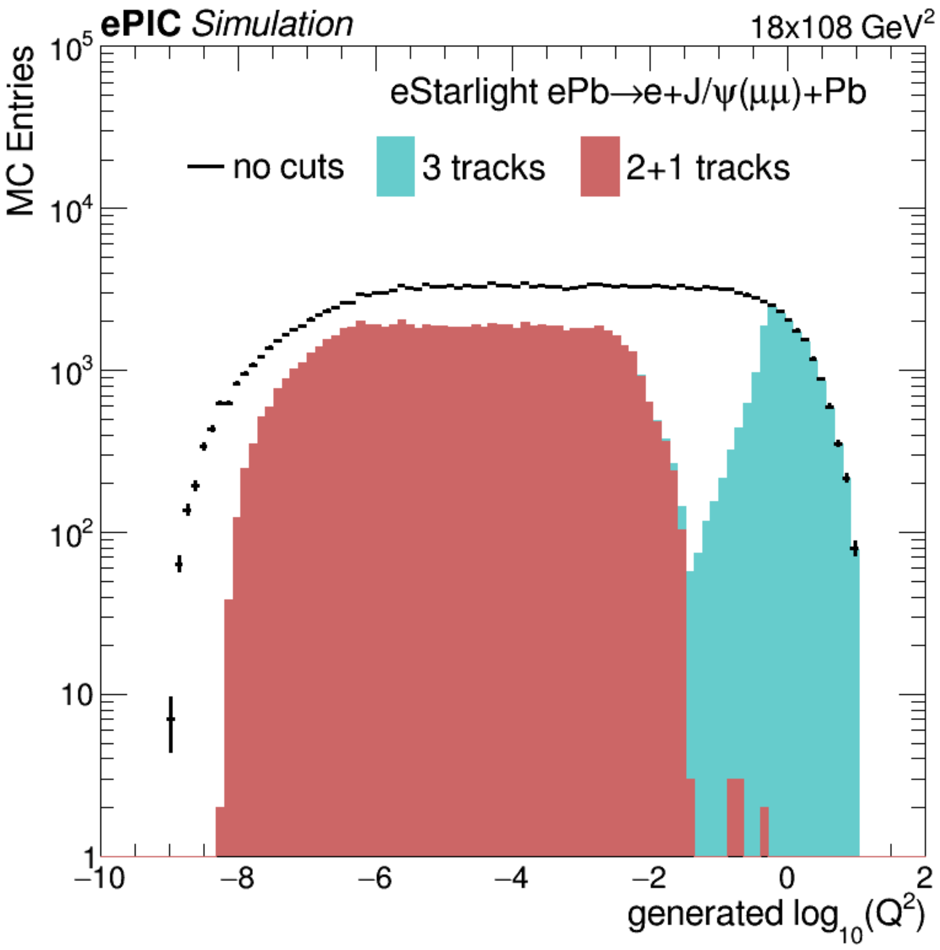
Simulate two samples: low/high Q $(\mathbf{0.0001 < Q^2 < 0.03; 1 < Q^2 < 10})$

Q2 region is discussed in the next slides

Q2 and electron scattering

- The phase-space is divided into two regions Acceptance of low-Q taggers and Acceptance in central detector (old plots)





Q2 and electron scattering

- The low Q2 tagger phasespace is further defined to be within:

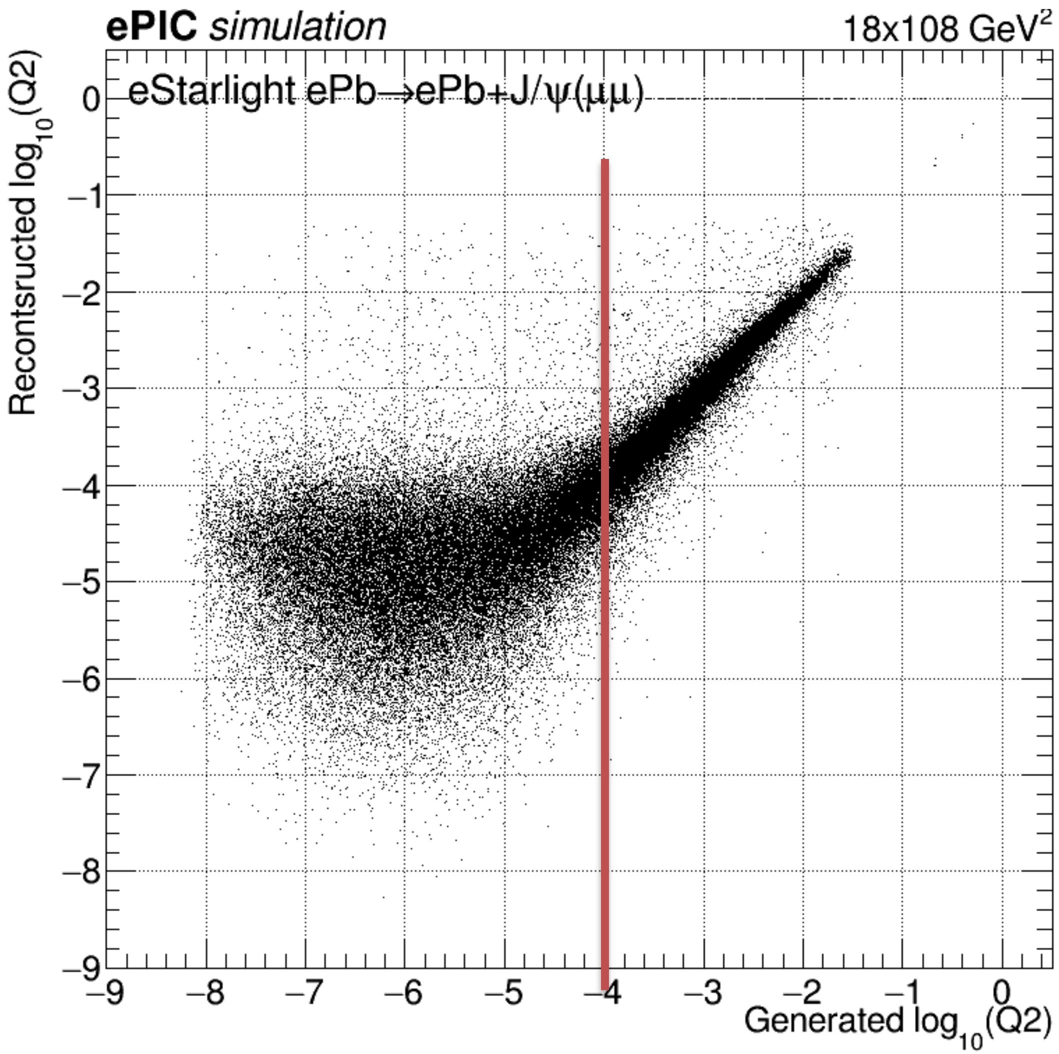
  0.0001 < Q2 < 0.03

<u>Low-Q2 tagger performance</u>:

- Electrons with log(Q2) < -3.5 cannot be distinguished
- At the design lumi, hundreds of brem. electrons produced every bunch crossing
- More bout Low-Q2 taggers is in [Simon's](#) talk
- In master branch the relevant branches are:

TaggerTrackerTrackParameters

TaggerTrackerTrajectories



t reconstruction

- Copied from https://github.com/KongTu/EICreconOutputReader/blob/benchmark-july-2023/src/diffractive_vm_simple_analysis.cxx#L3

```
MASS_PB208 = 195.16058
mp = 0.93827  # proton mass in GeV
a_beam_scattered_corr = ROOT.TLorentzVector(0,0,0,0)
aInVec = ROOT.TLorentzVector(0,0,108.63884*208,np.sqrt(108.63884*208*108.63884*208+MASS_PB208*MASS_PB208))
def getMethodL(eIn, eOut, vmOut):
  method_L = 0;

  a_beam_scattered = aInVec-(vmOut+eOut-eIn)
  p_Aplus = a_beam_scattered.E()+a_beam_scattered.Pz();
  p_TAsquared = a_beam_scattered.Perp2();
  p_Aminus = (MASS_PB208*MASS_PB208 + p_TAsquared) / p_Aplus;
  a_beam_scattered_corr.SetPxPyPzE(a_beam_scattered.Px(),a_beam_scattered.Py(),(p_Aplus-p_Aminus)/2., (p_Aplus+p_Aminus)/2. );
  method_L = -(a_beam_scattered_corr-aInVec).Mag2();

  return method_L;
```

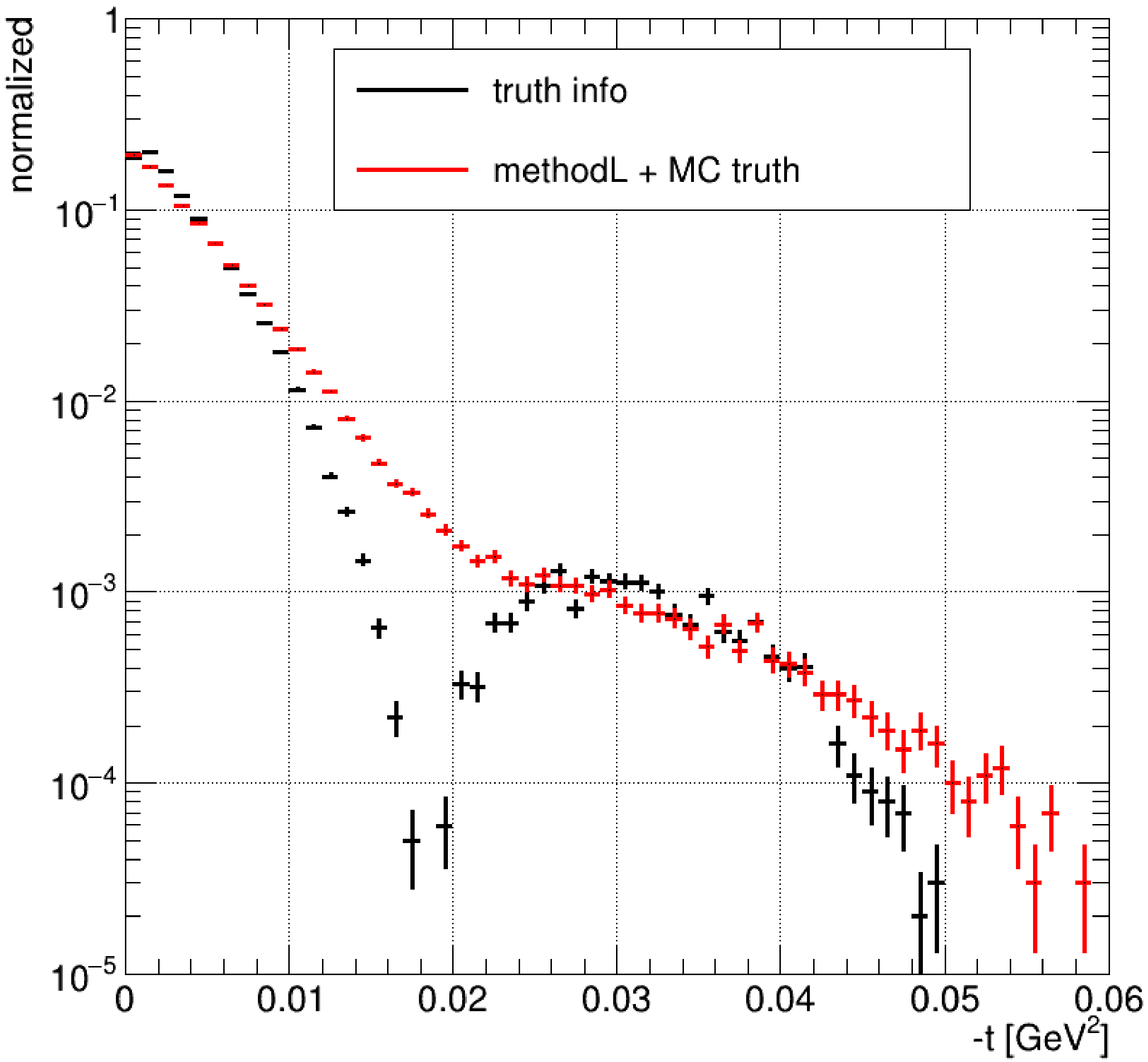
- We calculate t from MCParticles branch (truth info), making Lorentz Vectors (lv) from J/psi, outgoing/incoming electrons

gen_t = -(lv_VM + lv_outE - lv_inE).M2()

rec_method_truth = getMethodL(lv_inE, lv_outE, lv_VM)

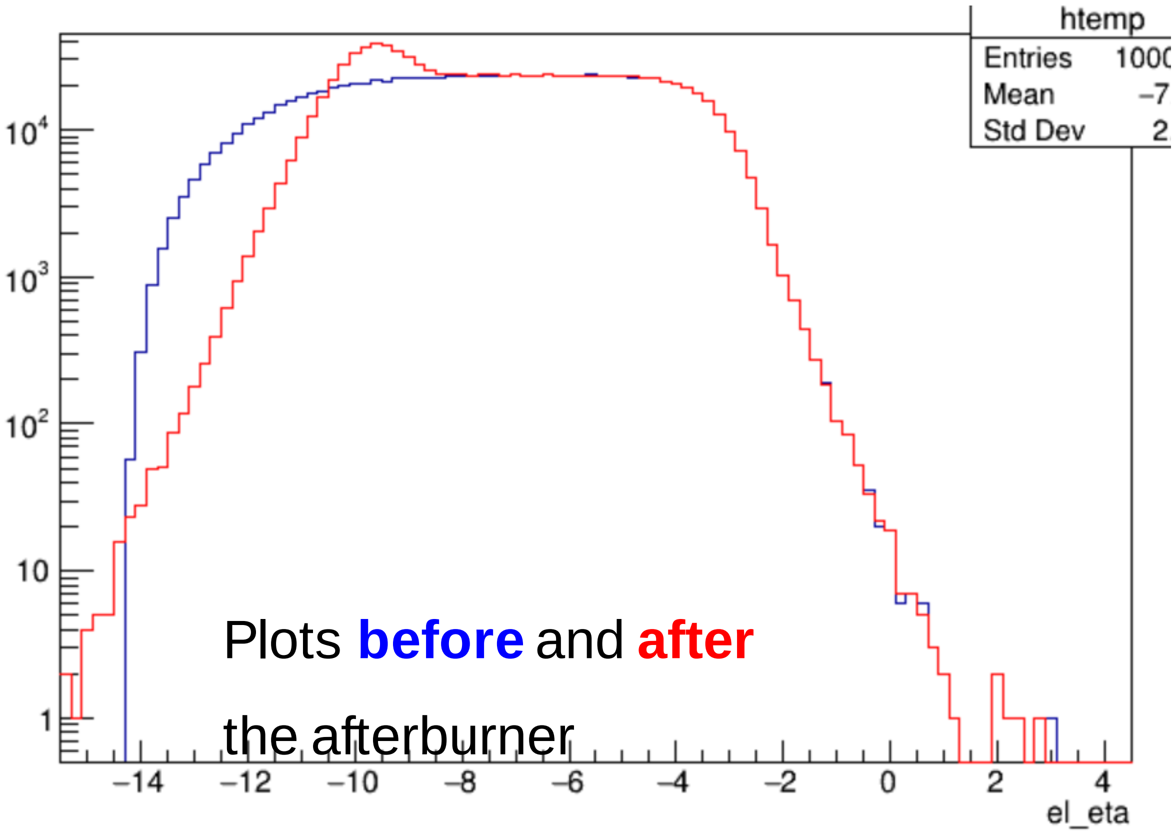
t reconstruction

- Using the truth info the peaks are smeared



Afterburner configuration

Using eic-shell and abconv –p 2 (https://github.com/eic/afterburner)



Plots **before** and **after** the afterburner

A ab_afterburner_is_used 1
A ab_crossing_angle 0.025
A ab_hadron_beta_crab_hor 500000
A ab_hadron_beta_star_hor 910
A ab_hadron_beta_star_ver 40
A ab_hadron_divergence_hor 0.000218
A ab_hadron_divergence_ver 0.000379
A ab_hadron_rms_bunch_length 70
A ab_hadron_rms_emittance_hor 4.32e-05
A ab_hadron_rms_emittance_ver 5.8e-06
A ab_lepton_beta_crab_hor 150000
A ab_lepton_beta_star_hor 1960
A ab_lepton_beta_star_ver 410
A ab_lepton_divergence_hor 0.000101
A ab_lepton_divergence_ver 3.7e-05
A ab_lepton_rms_bunch_length 9
A ab_lepton_rms_emittance_hor 2e-05
A ab_lepton_rms_emittance_ver 6e-07
A ab_use_beam_bunch_sim 1

Summary and discussion

Analysis workflow:

- 3 track events (with 2 tracks in $|\eta|<4$) → define two signal regions
  - High Q2 – high acceptance of outgoing electron, baseline
  - Low Q2 (Q2 < 0.03) – demonstration of low-Q2 taggers
- VM mass window of 0.4 GeV (no particle ID, assume massless tracks)
- Veto activity in the forward region (reco/hits):

B0 tracks, B0 clusters, OMD tracks, RP tracks, Ecal and Hcal ZDC Clusters

Work in progress:

1. t reconstruction, work in progress, We think of checking the AB parameters to see which cases affect the method, any ideas are welcomed.
2. Benchmark incoherent processes (we need to check the updated RP/OMD reco, and decide wheather benchmark using hits or reco tracks)
3. Need to estimate background rates in very low Q2

Backup