eA study group

# Incoherent VM production

*02 April 2024*

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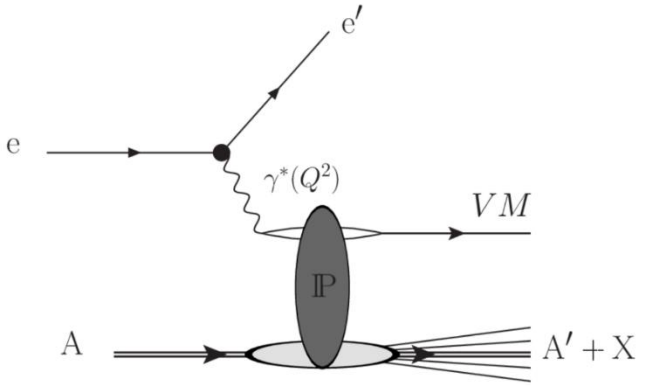
# Introduction

## Motivation

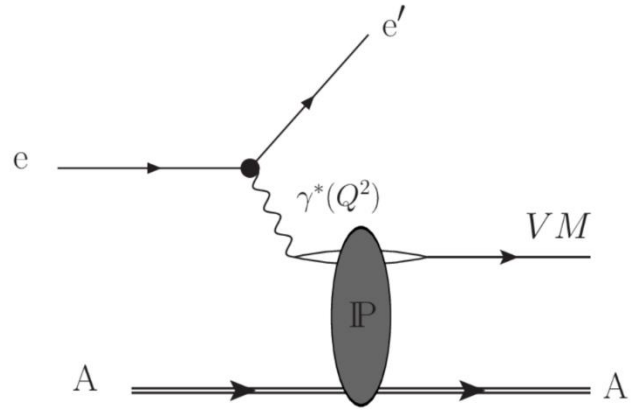
- Incoherent VM production is the main background process to the coherent one




***Incoherent VM***

## Methodology

- Incoherent processes are detected via the ion decay products




***Coherent VM***

# Incoherent production

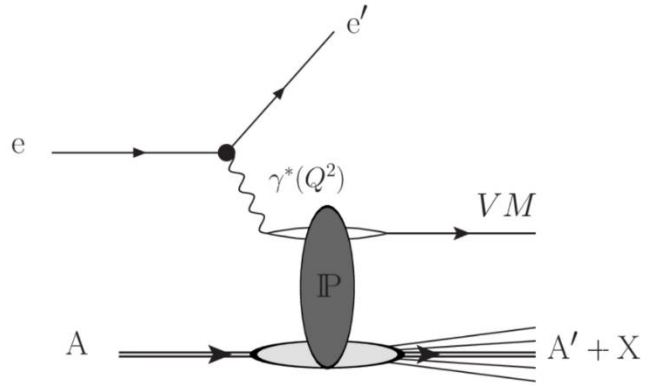
## Background simulation

BeAGLE V1.03.02 (https://eic.github.io/software/beagle.html)

```
PROJPAR                                          ELECTRON
TARPAR        208.0     82.0
TAUFOR         10.0      25.0      1.0
FERMI          2         0.62      1         0
-------------------------------------------------------------------
*             yMin      yMax    Q2Min     Q2Max   theta_Min theta_Max
L-TAG         0.01      0.95      1.0     100.0       0.0      6.29
-------------------------------------------------------------------
* model selection (0=all, 1=rho,2=omega,3=phi,4=J/psi)
PYVECTORS       4
USERSET        15         9.0
MODEL                                            PYTHIA
* if PYTHIA model specify pythia input cards
PY-INPUT                                         S3VJL003
```

**Simulate two samples:** $-4 < \log(Q^2) < 0$ **and** $0 < log(Q^2) < 2$

***Q2 region is discussed in the next slides***




Execution time:
(produced in February)
Standard: 210 s/Event
Vacuum: 70 s/Event

Using t-Filter for t<0.07
Filter efficiency ε~40%

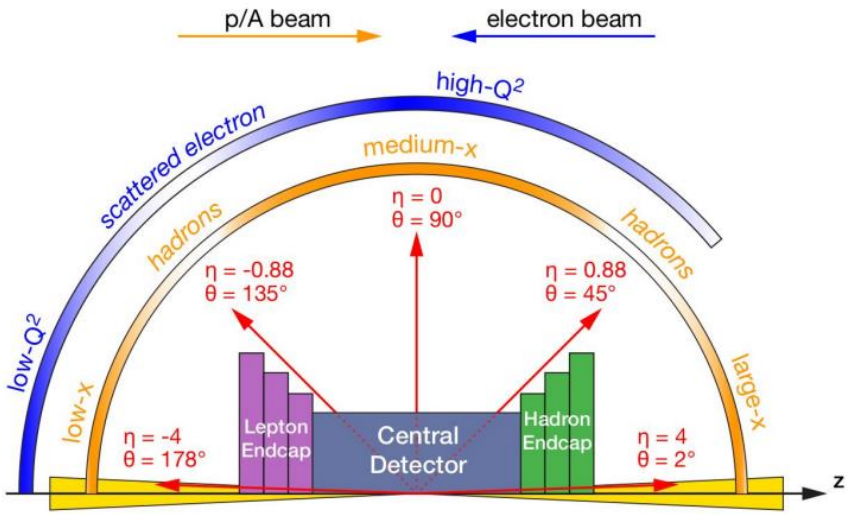
Planning to add vacuum at Z>40m since ion remnants propagate in air between Z=40 and Z=100m

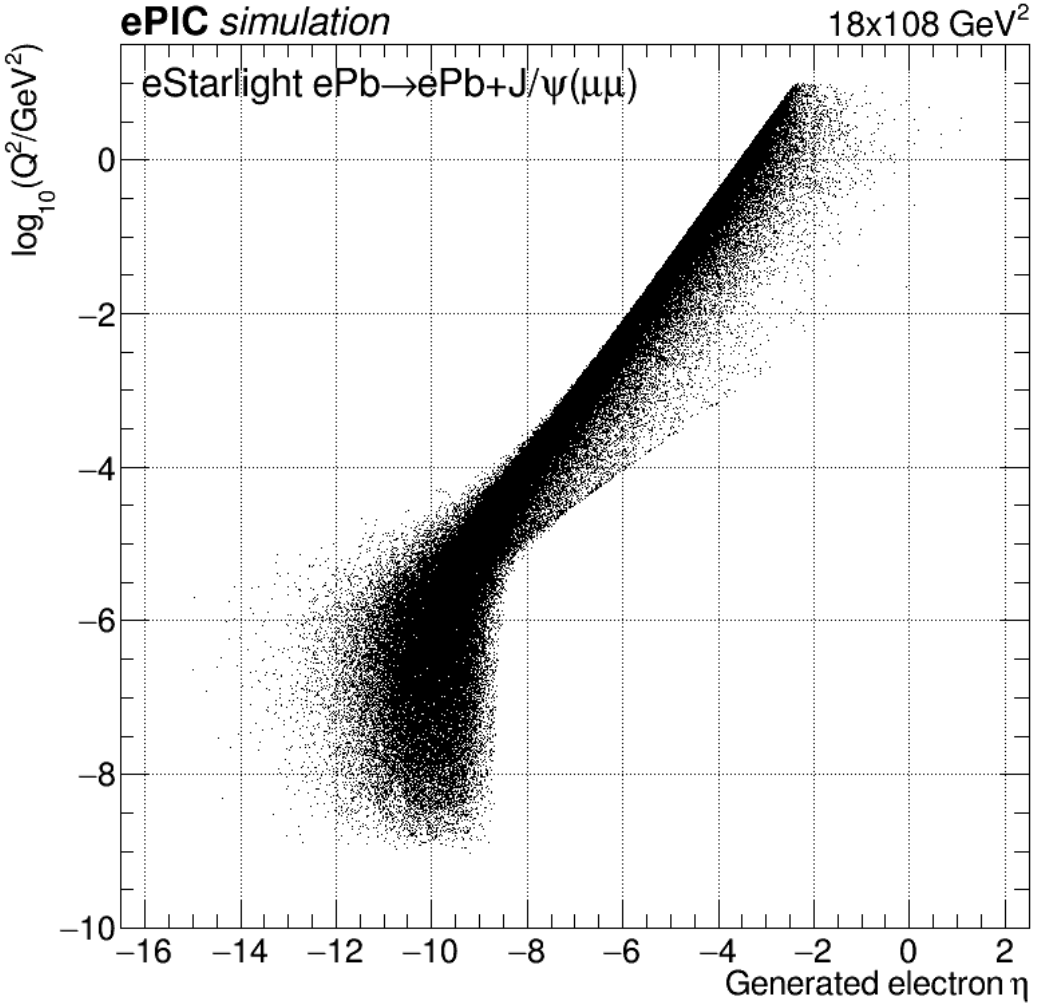
# Q2 and electron scattering

- Outgoing electron scattering angle determines the photon virtuality ($Q^2$)

Simulation of coherent, inclusive in $Q^2$

Production in Sep 2023



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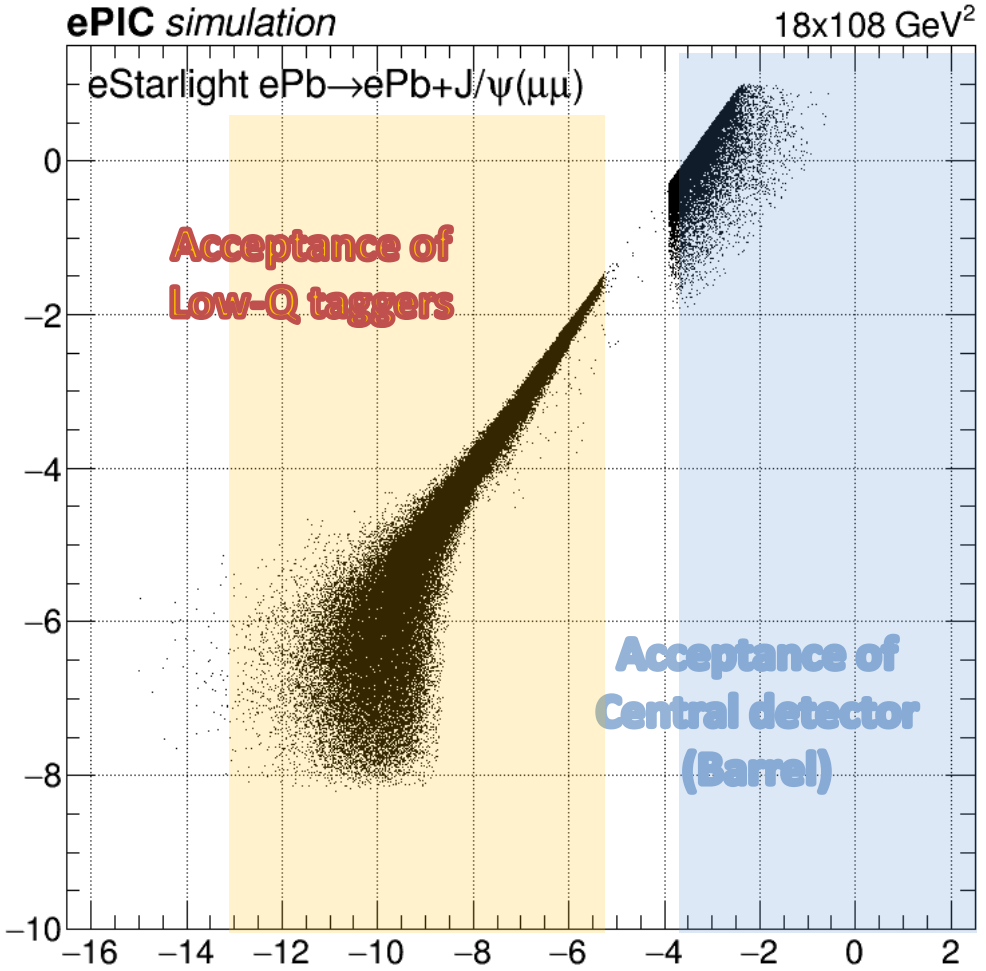

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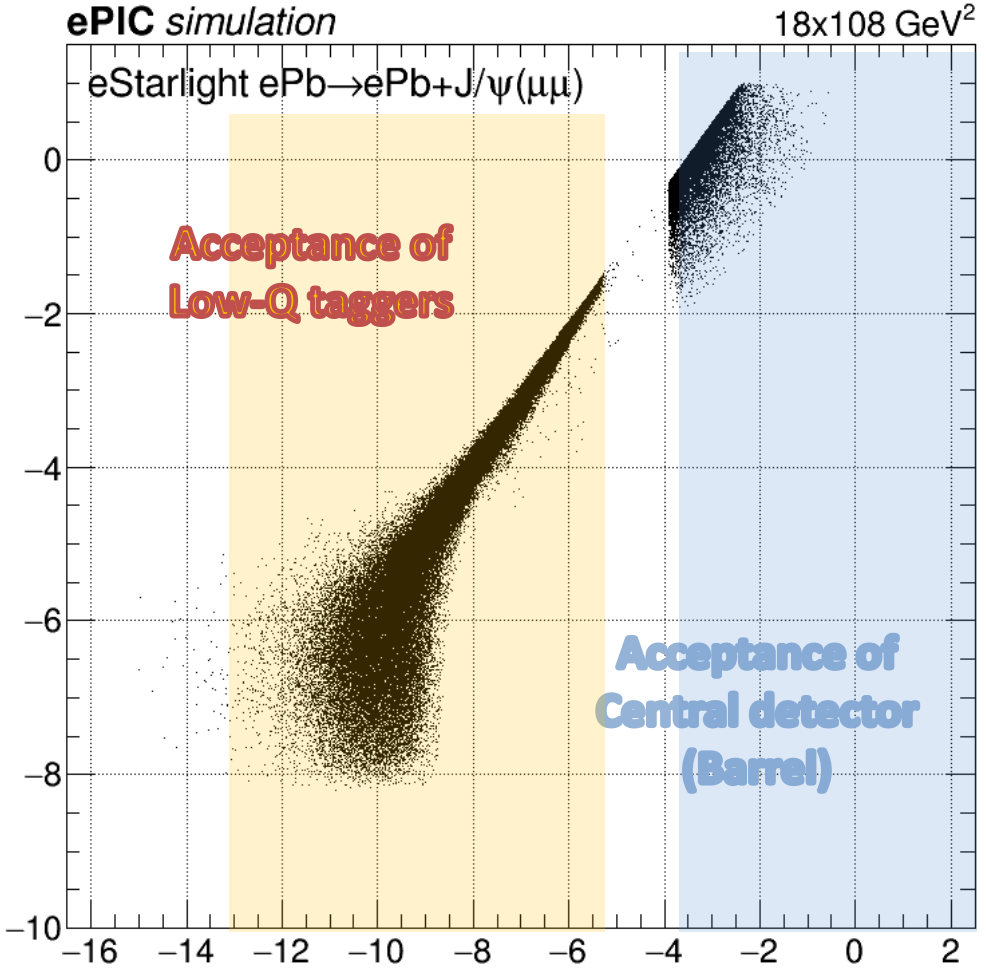
<u>Low-Q2 tagger performance</u>:

- Electrons with Q2 < $3.5 \times 10^{-3}$ cannot be distinguished
- At the design lumi, hundreds of brem. electrons produced every bunch crossing



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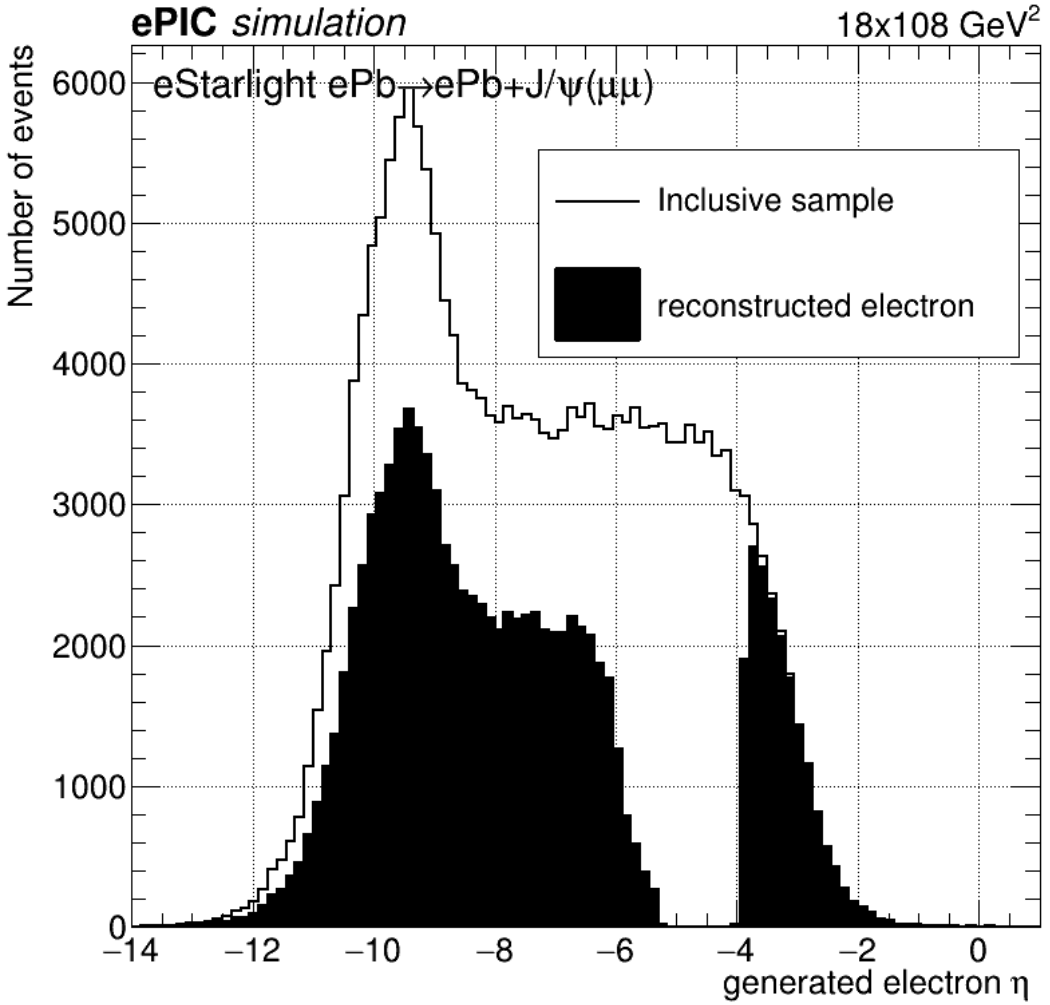


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# Q2 and electron scattering

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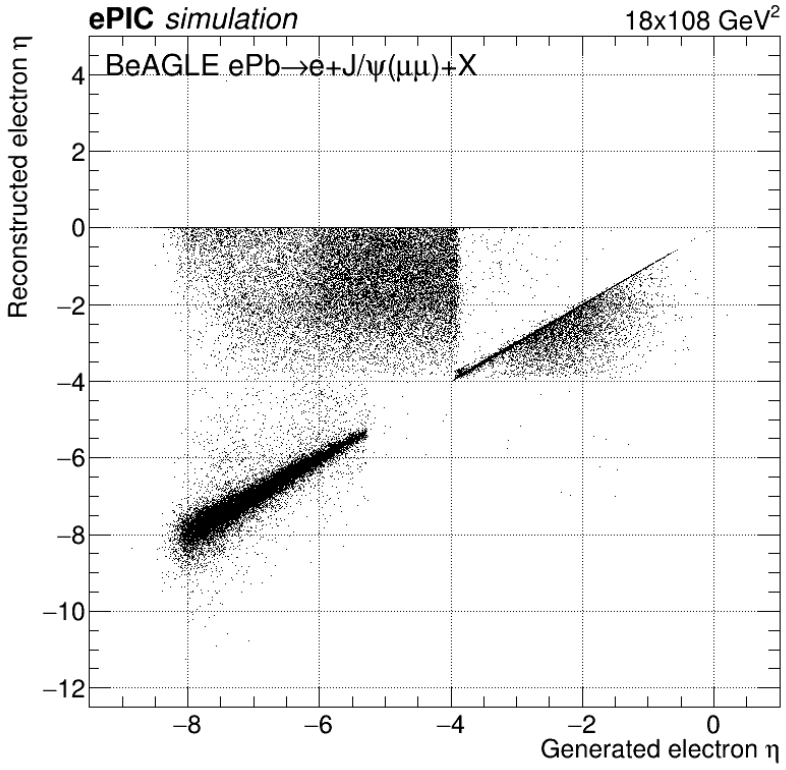


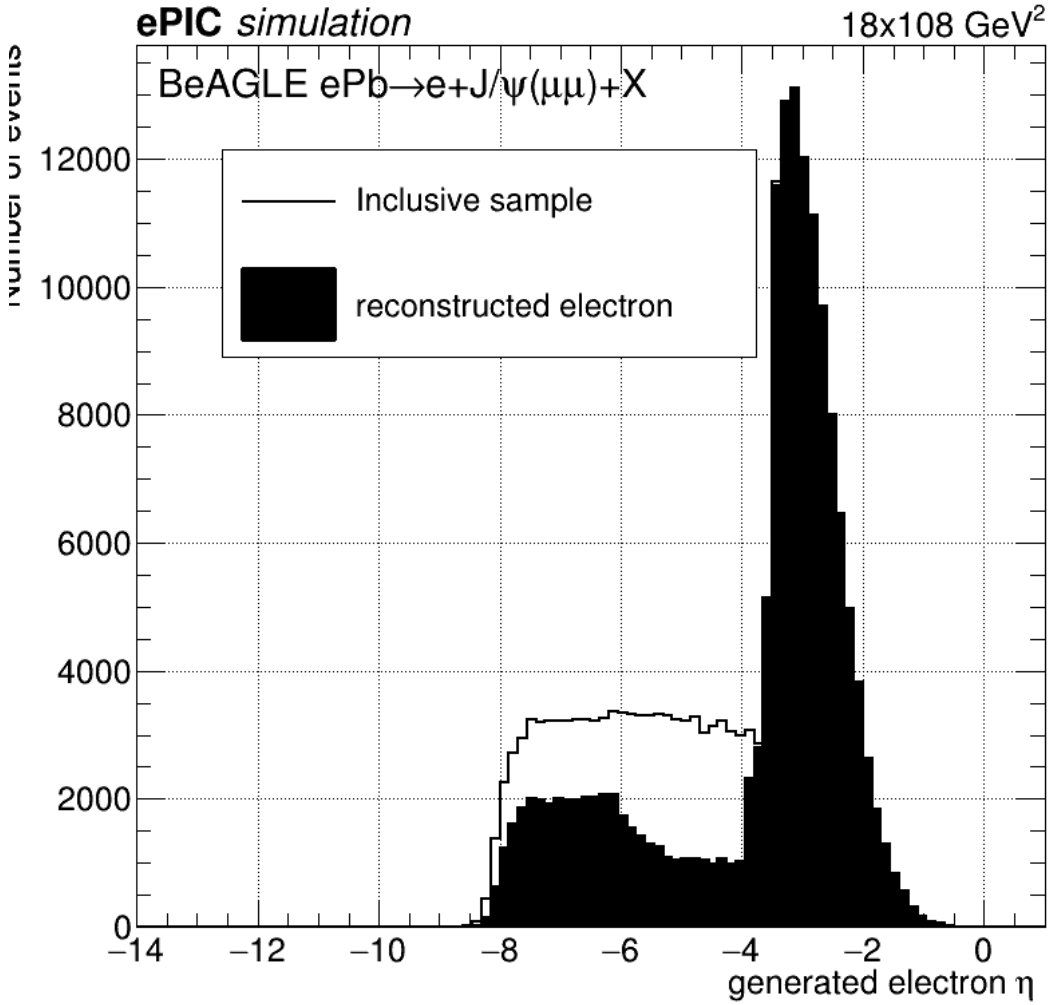

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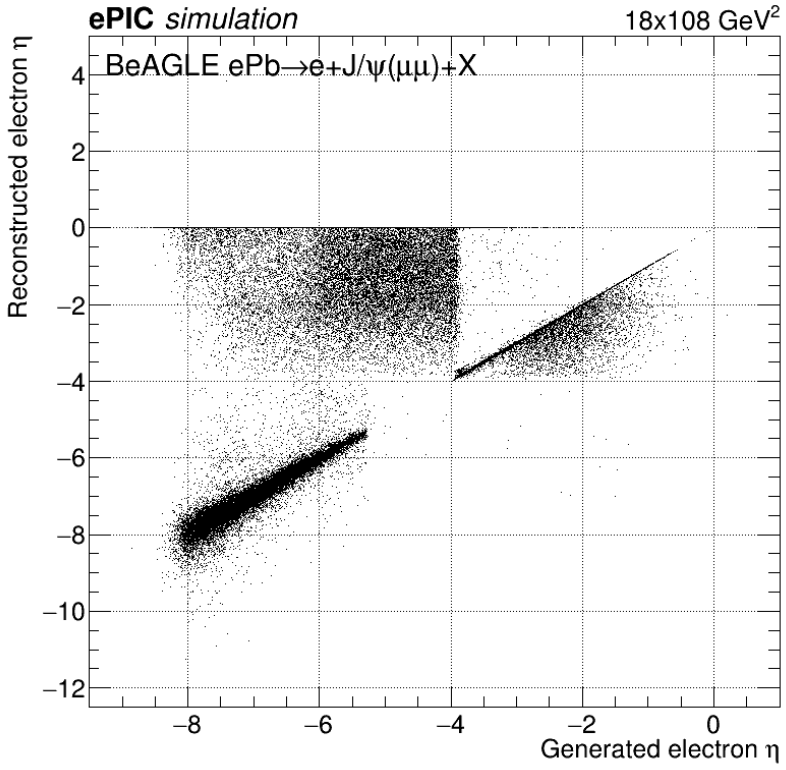
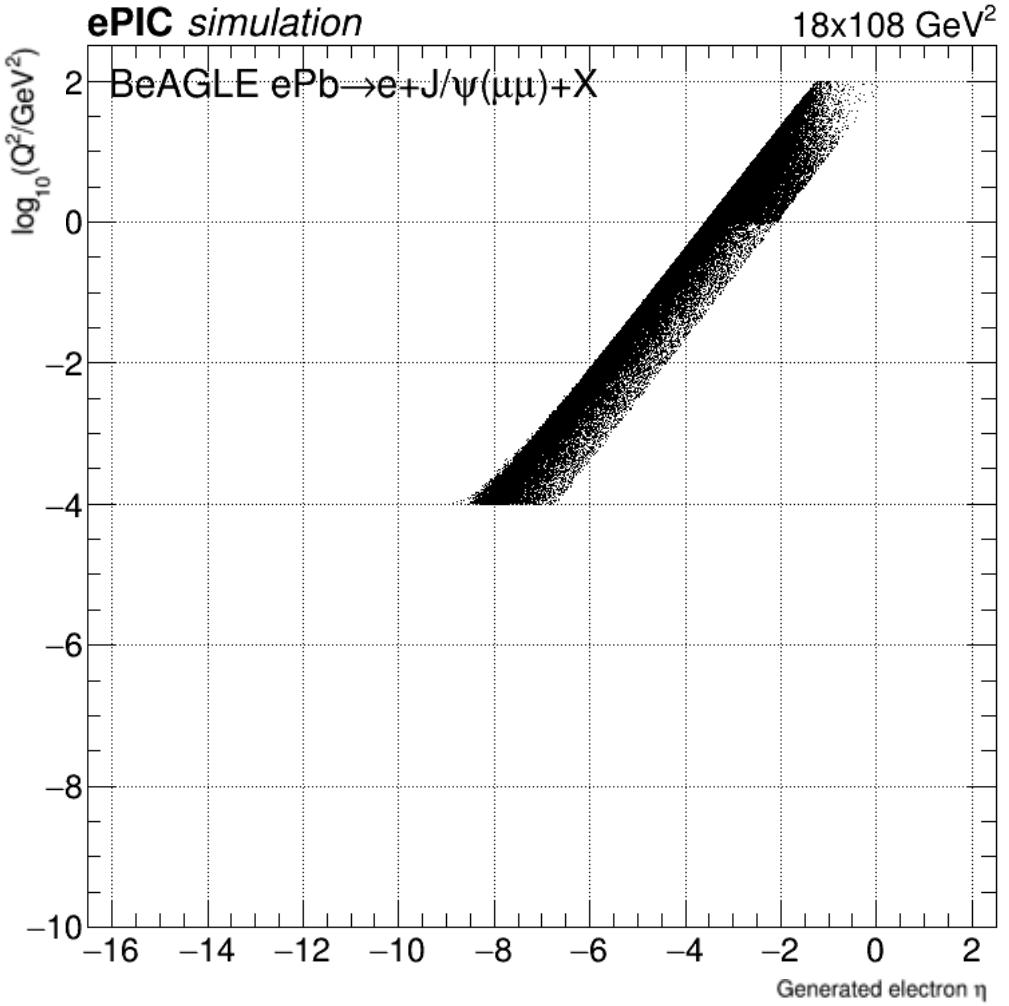


# Analysis

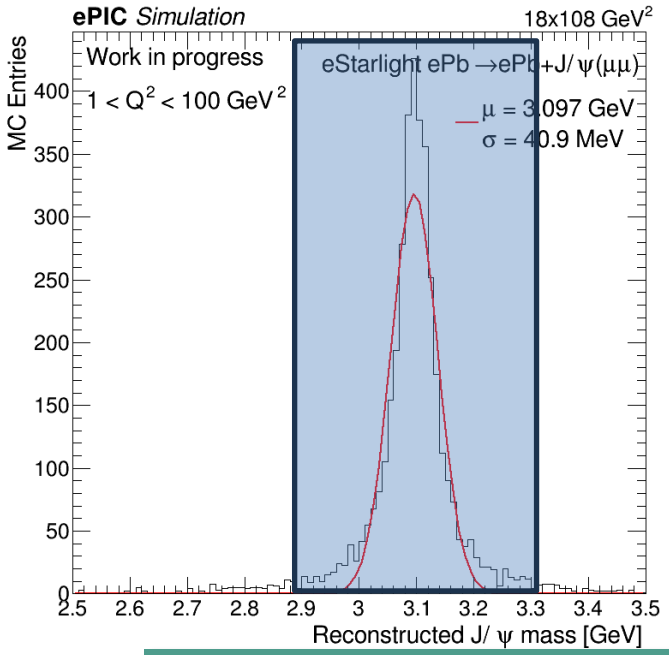
## Coherent event Selection

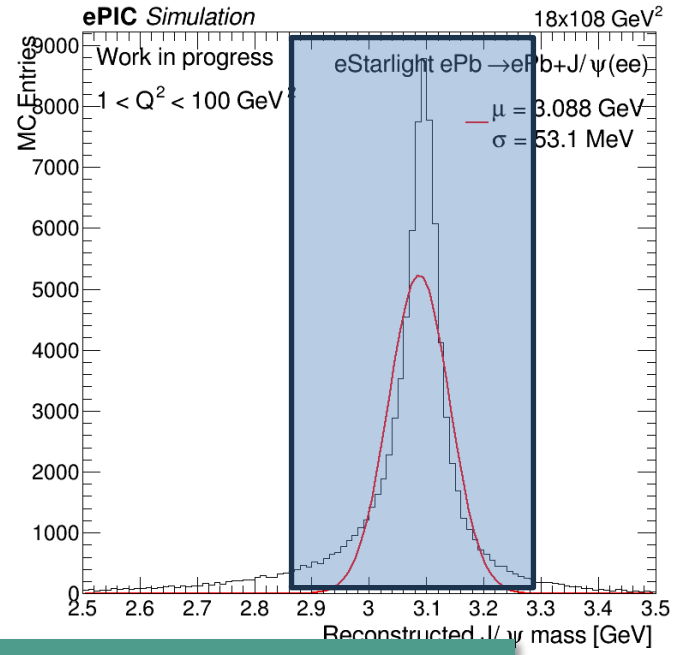
- 3 track events (with 2 tracks in |η|<4)
- VM mass window of 0.4 GeV
- Veto activity in forward region (reco/hits):

B0 tracks, B0 clusters, OMD tracks, RP tracks,

Ecal and Hcal ZDC Clusters

<u>Signal efficiency for different $Q^2$ regions:</u>




Adding low-Q2 category double statistics

| | electrons | | Muons | |
|---|---|---|---|---|
| Cut | 1 GeV <Q < 10 GeV | 0.01 GeV <Q < 1 GeV | 1 GeV <Q < 10 GeV | 0.01 GeV <Q < 1 GeV |
| 3 tracks | 0.975394 | 0.366818 | 0.9755 | 0.371375 |
| VM mass cut | 0.858704 | 0.100727 | 0.9235 | 0.107313 |
| Veto FFD | 0.858693 | 0.100727 | 0.9235 | 0.107313 |

# Analysis

## Event categorization

- Depends on the electron reconstructed eta
  - Central detector: 4.9 nb x 0.9 ~ 4.4 nb
  - Low-Q2 taggers: 66 nb x 0.1 ~ 6.6 nb

## Event Kinematics

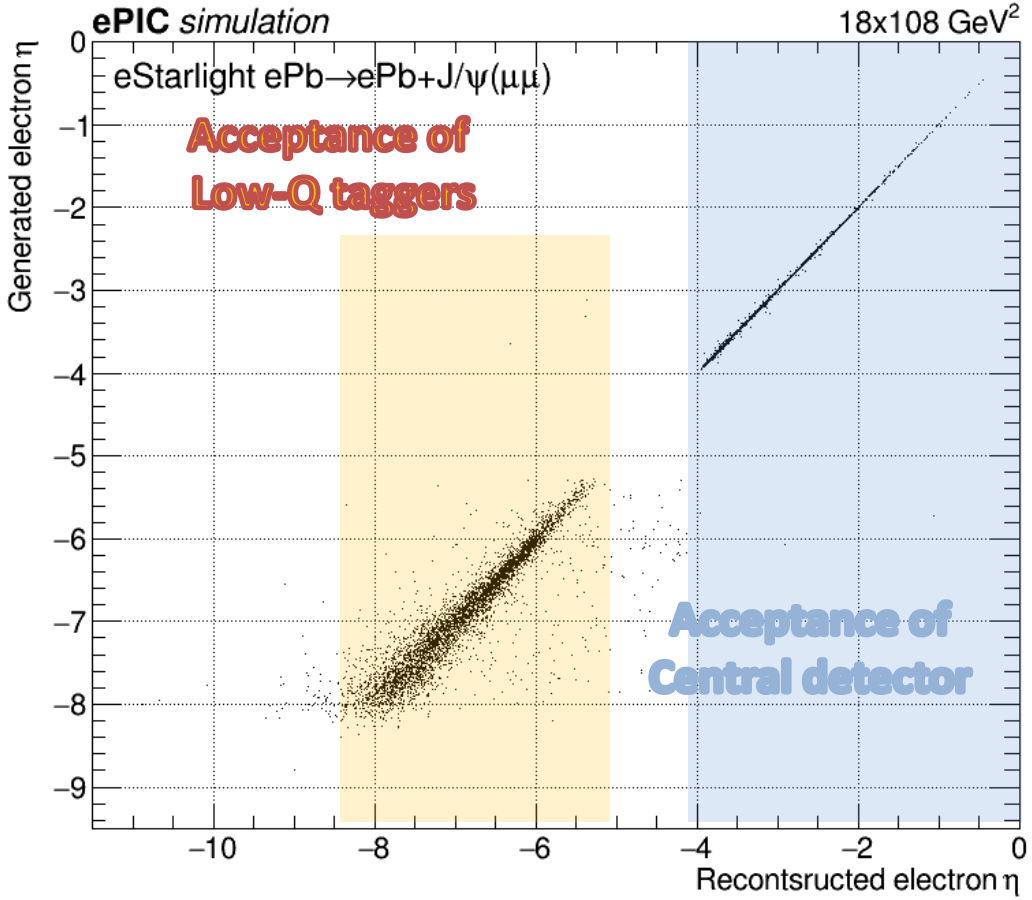
Reconstruction of parameters of interest:

$e$ – incoming electron (**fixed**)

$e$’ – outgoing electron (**measured**)

$VM$ – vector meson (**measured**)

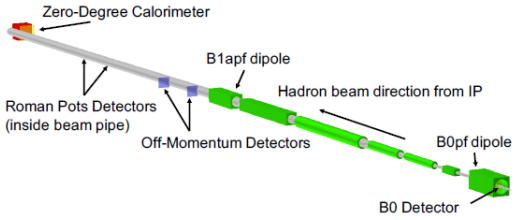
- Momentum transfer –t =($VM$ −($e$−$e'$ )).M2()

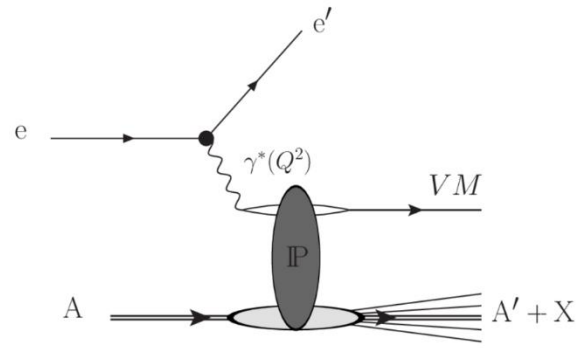



Adding low-Q2 category double statistics

# Incoherent rejection

- The main background for coherent VM production is the incoherent VM production
- Testing the veto strategy (based on reconstructed objects)



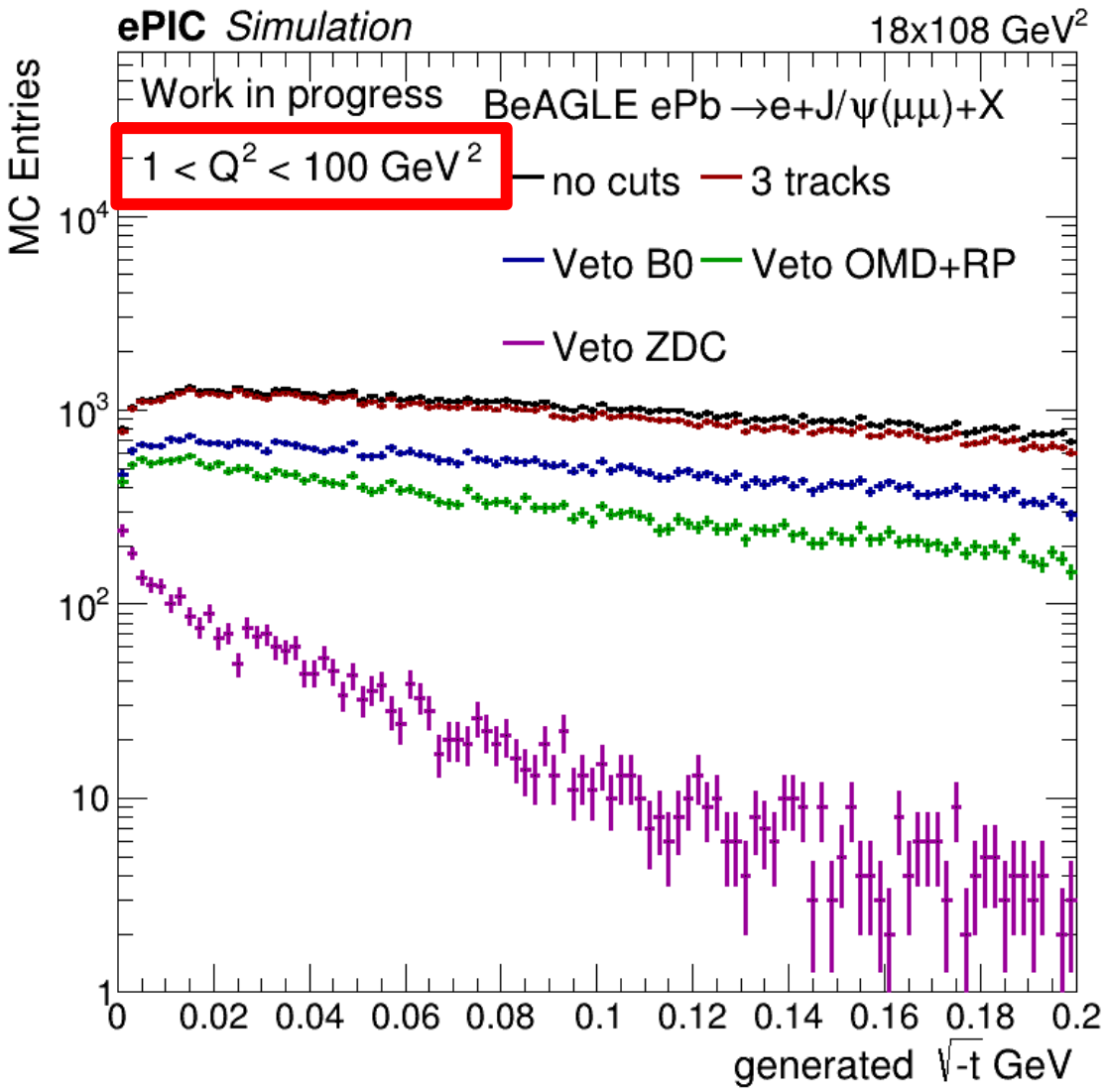



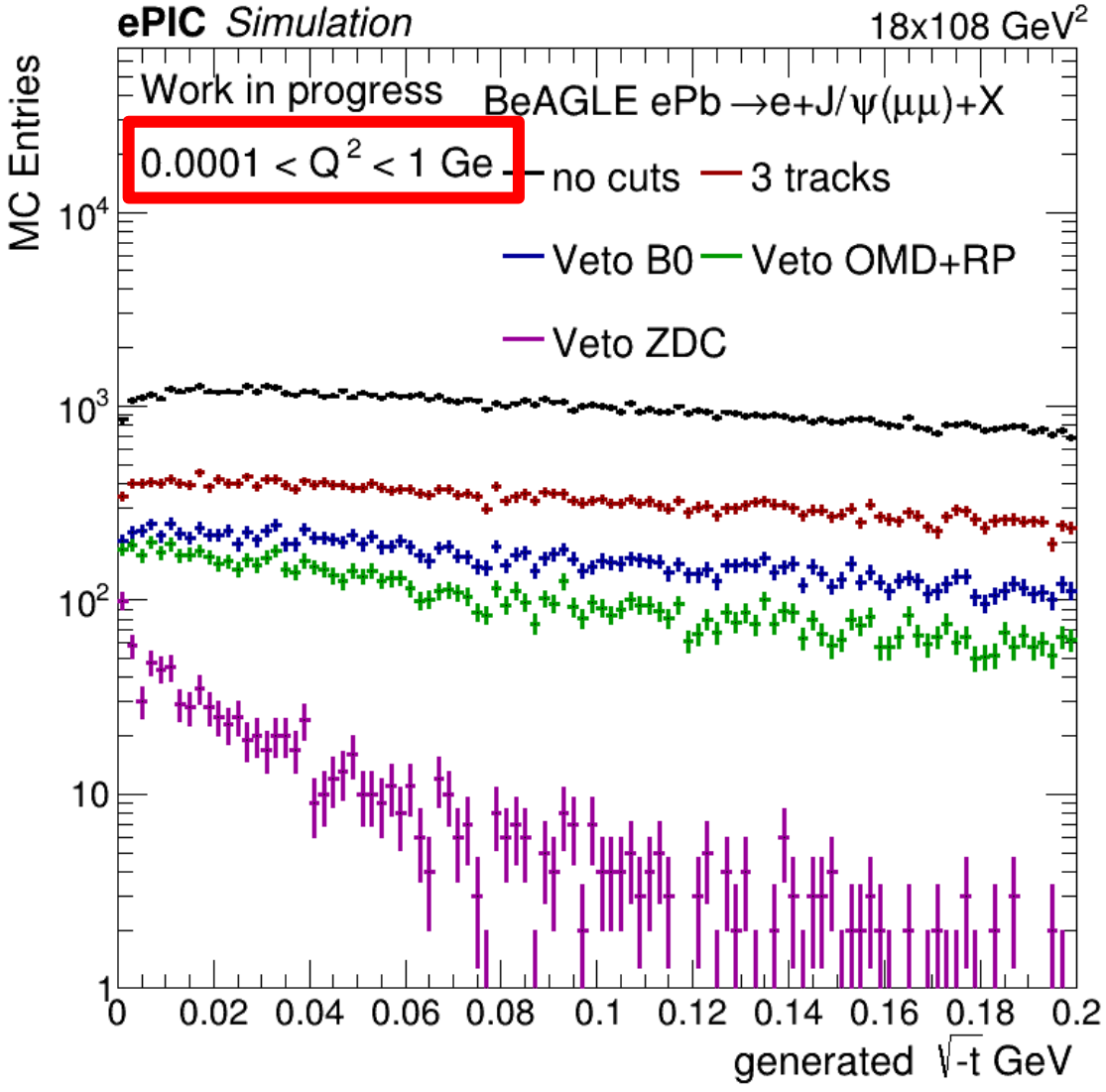

- Veto.1: no activity other than $e^-$ and $J/\psi$ in the main detector ( $|\eta| < 4.0$ and $p_T > 100$ MeV/$c$) ;
- Veto.2: Veto.1 and no neutron in ZDC;
- Veto.3: Veto.2 and no proton in RP;
- Veto.4: Veto.3 and no proton in OMDs;
- Veto.5: Veto.4 and no proton in B0;
- Veto.6: Veto.5 and no photon in B0;
- Veto.7: Veto.6 and no photon with $E > 50$ MeV in ZDC.

Background efficiency based on ePIC FFD simulation

| Cut | 1 GeV <Q < 10 GeV | 0.01 GeV <Q < 1 GeV |
|---|---|---|
| 3 tracks | 0.920164 | 0.334928 |
| VM mass cut | 0.854001 | 0.126962 |
| Veto B0 | 0.465476 | 0.0568307 |
| Veto RP/OMD | 0.293481 | 0.0353035 |
| Veto ZDC | 0.0270966 | 0.00324511 |

# Background rejection



# Coherent event Selection

- 3 track events (with 2 tracks in |η|<4) → define three signal regions
  - Very low Q2 (Q2 < 3.5e-3)
  - Intermediate Q2 (electron in low-Q2 tagger above background level
  - High Q2 – high acceptance of outgoing electron
- VM mass window of 0.4 GeV
- Veto activity in forward region (reco/hits):

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

- Need to estimate background rates
  - ➢ Electron beam gas https://statics.teams.cdn.office.net/evergreen-assets/safelinks/1/atp-safelinks.html
  - ➢ eA MinBias events (Pythia?)

# Summary and discussion

- Simulation of incoherent events:
  - Time-consuming due to the presence of air – planning to add vacuum after Z>40 m.
  - Currently, all neutrals going to ZDC, radiate particles into the RP – waiting for https://github.com/eic/epic/pull/665 to be merged to repeat the veto study
- Benchmarking scripts: need to be developed, I was hoping to add the lowQ2 taggers, yet the https://github.com/eic/EICrecon/pull/675 is not merged
- Proposal to make three Q2 regions: Q2 in 0, 3.5-e3, 0.1, 100): very-low, intermediate, high Q2 regions
- Semi-coherent events (not discussed today) – Eden is working on it (estimation of beam backgrounds https://github.com/eic/ProtonBeamGas, evolved into a separate study)
- TODO: t reconstruction (unfolding)

# Backup