eA study group

Update on VM production

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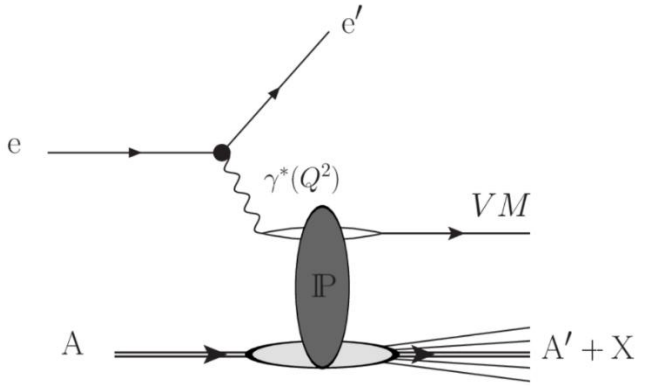
Introduction

Motivation

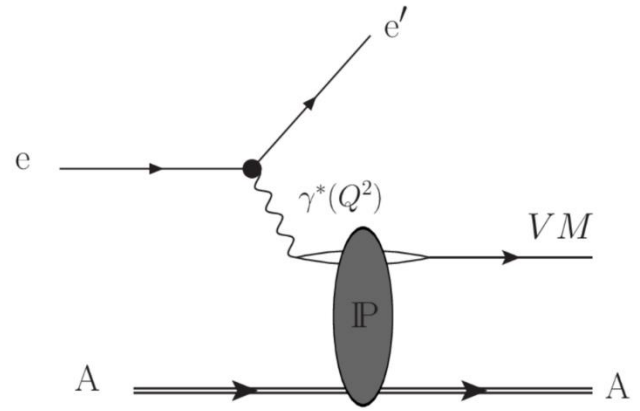
- Incoherent VM production is the main background process to the coherent one



Incoherent VM

Methodology

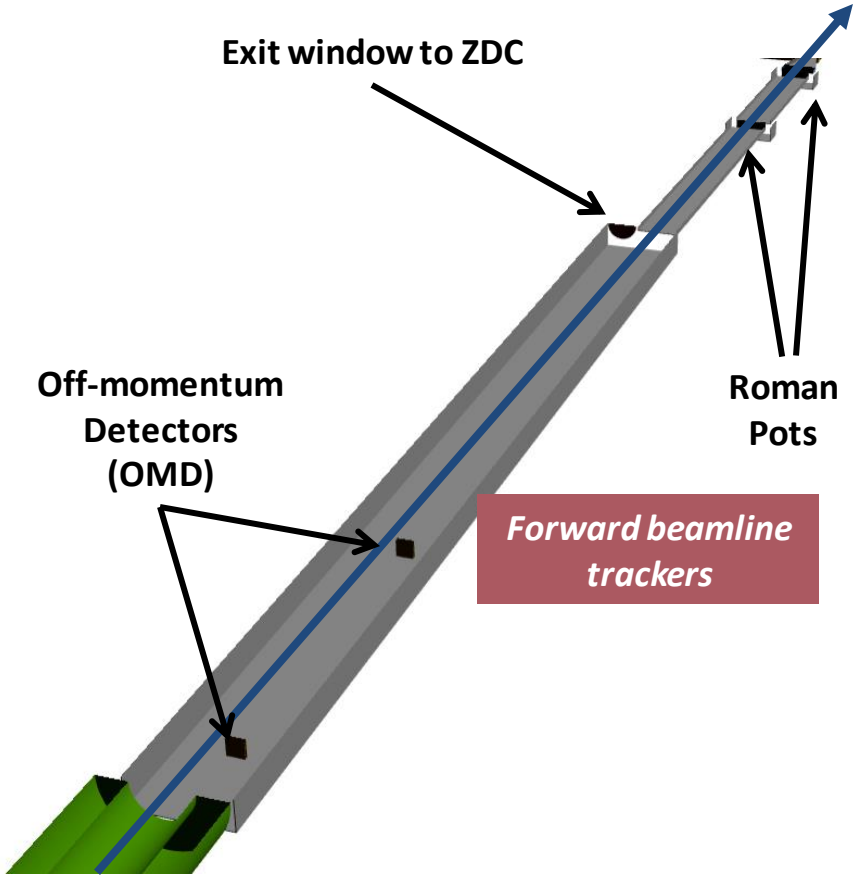
- Incoherent processes are detected via the ion decay products



Coherent VM

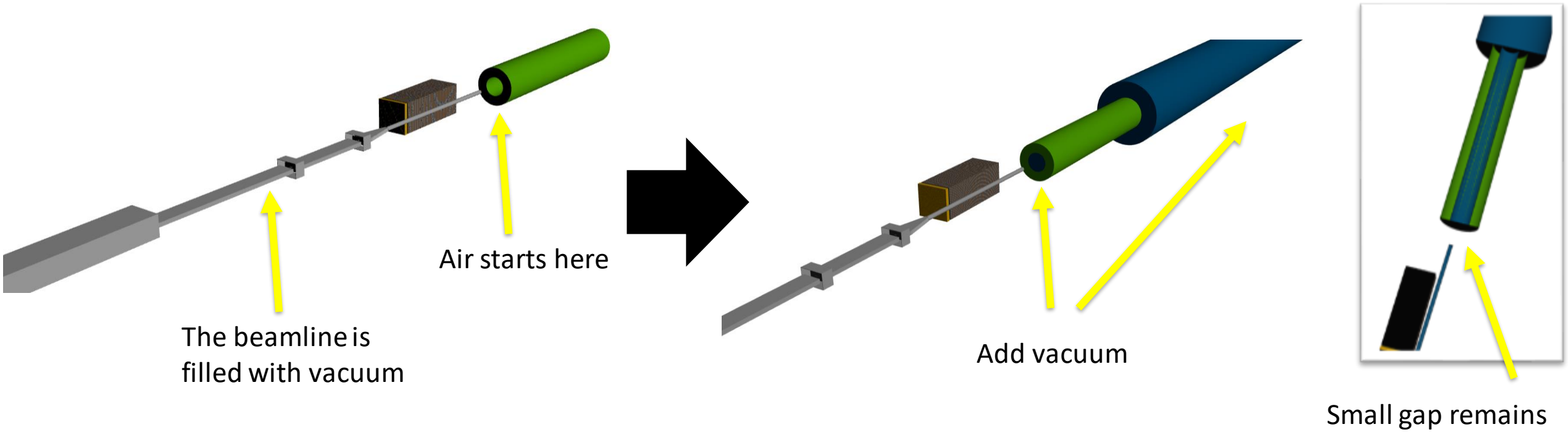
Simulation updates

- New FF design (merged by Alex since Apr 4 PR-665), adding vacuum inside the hadron beampipe



Simulation updates

- Extending the vacuum for z>40 (RP-720)



Signal simulation

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
```

Execution time:

No ions in the record: 2.01 s/Event
Standard: 183.20 s/Event
PR720 (add more vacuum): 16.23 s/Event

$$\begin{aligned} \sigma(Q^2 < 0.001) &= 73.907\ nb \\ \sigma(0.001 < Q^2 < 0.03) &= 25.496\ nb \\ \sigma(0.03 < Q^2 < 20) &= 28.170\ nb \end{aligned}$$

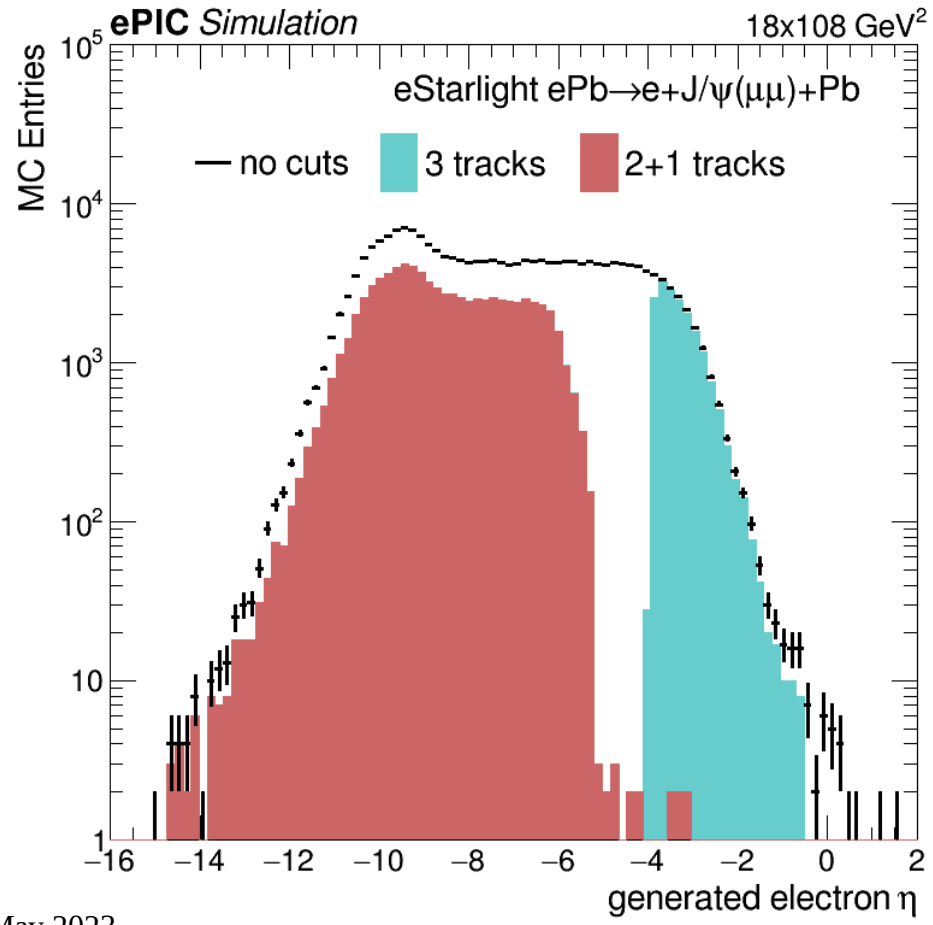
Simulate three samples: $\log(Q^2) < -3;\ 0.001 < Q^2 < 0.03;\ 0.03 < Q^2 < 20$

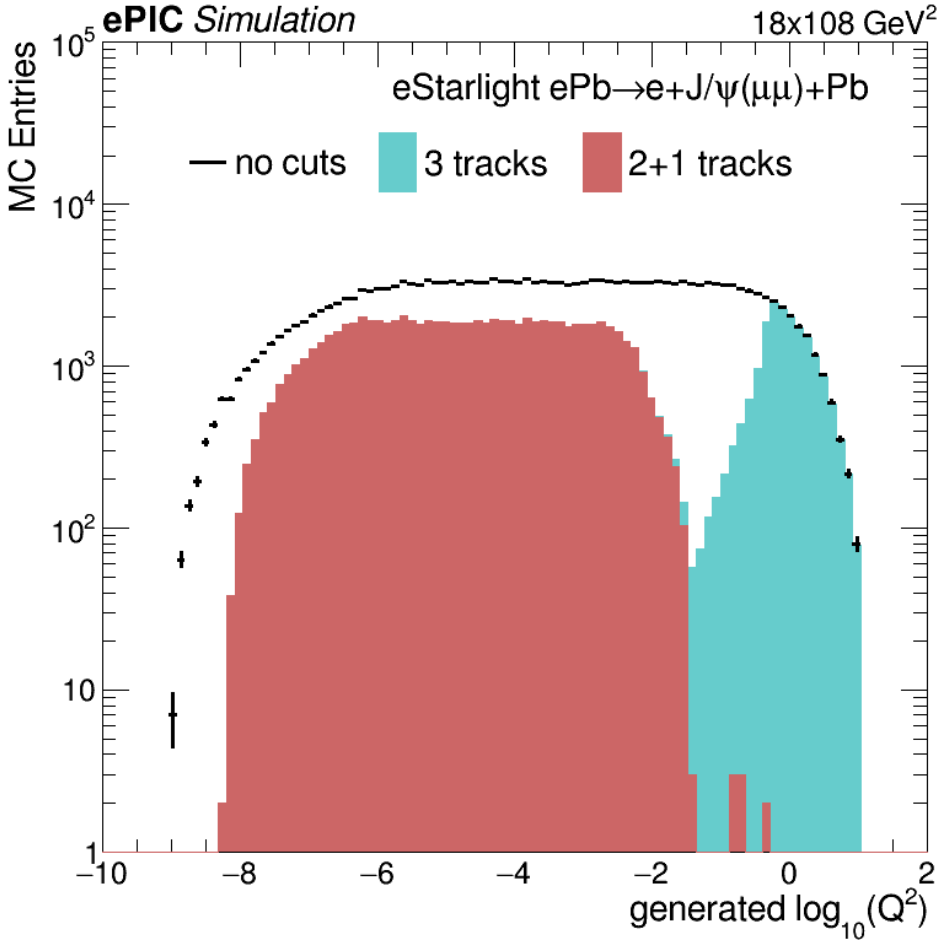
Q2 region is discussed in the next slides

Q2 and electron scattering

- The phase-space is divided into two regions **Acceptance of low-Q taggers** and

Acceptance in central detector



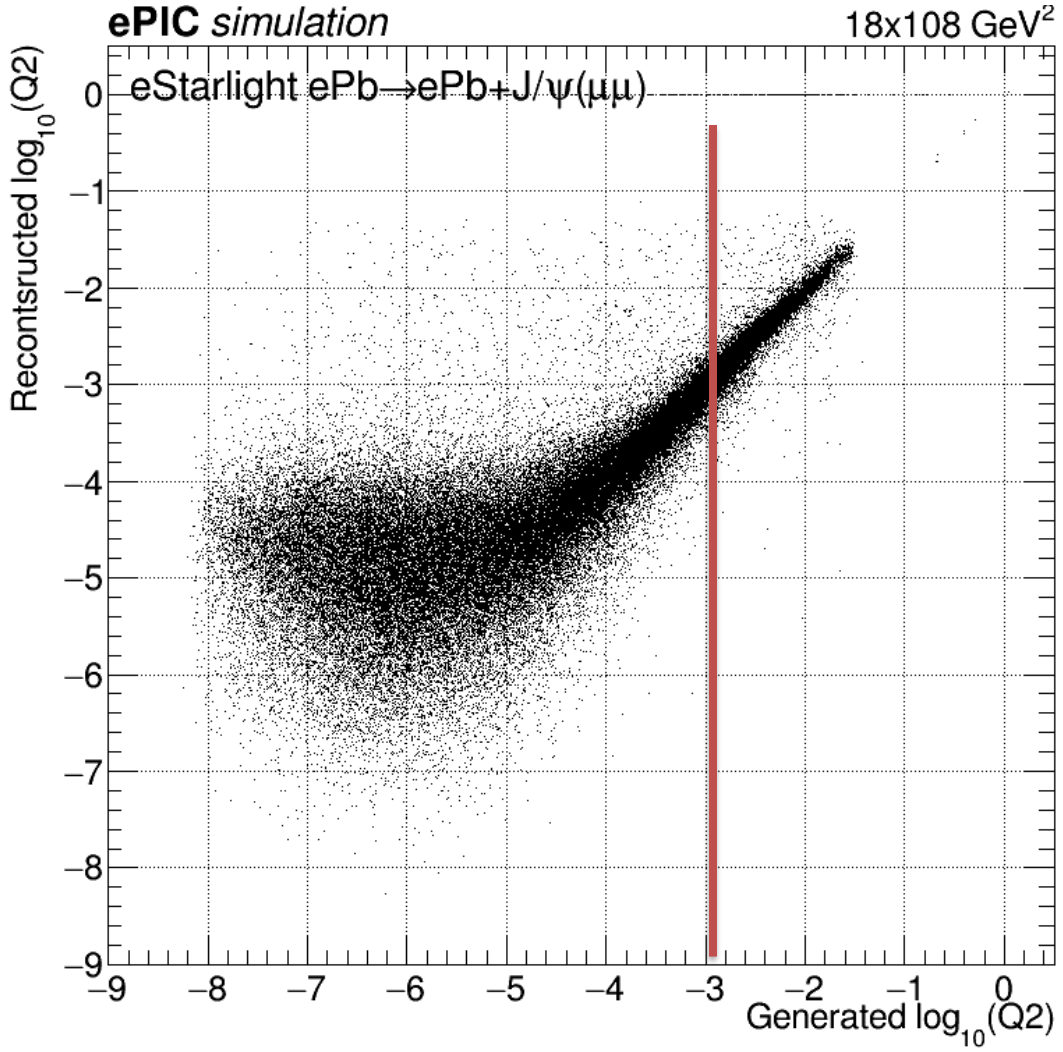


Q2 and electron scattering

- The low Q2 tagger phasespace is further divided into two regions:

$$0.001 < Q2 < 0.03$$

$$low(Q2) < -3$$



Low-Q2 tagger performance:

- Electrons with log(Q2) < -3 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
- Since last week (commit)

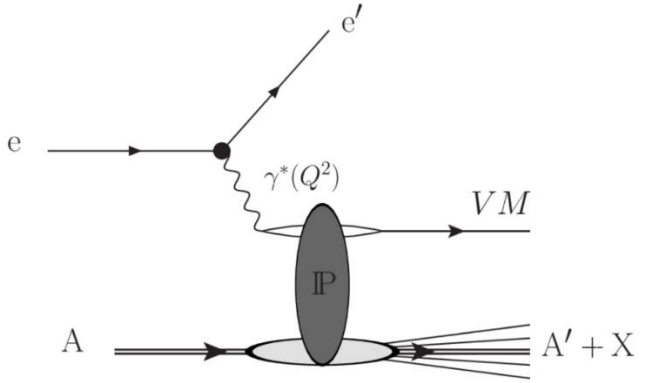
LowQ2TrackParameters → TaggerTrackerTrackParameters

LowQ2Trajectories → TaggerTrackerTrajectories

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     0.03      20.0      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
```



Execution time:

Standard: 313.52 s/Event
PR720 (add more vacuum): 31.29 s/Event

Majority of the execution time spent on detector response

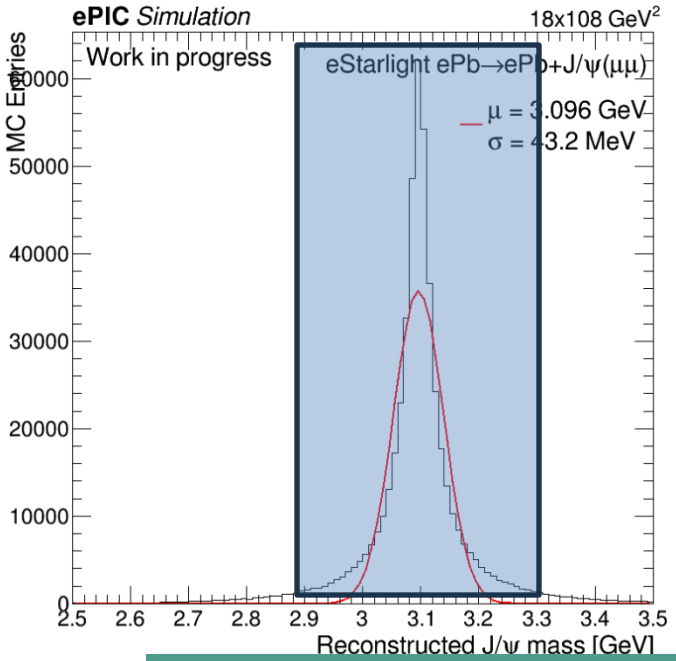
Using t-Filter for t<0.2
Filter efficiency ε~40%

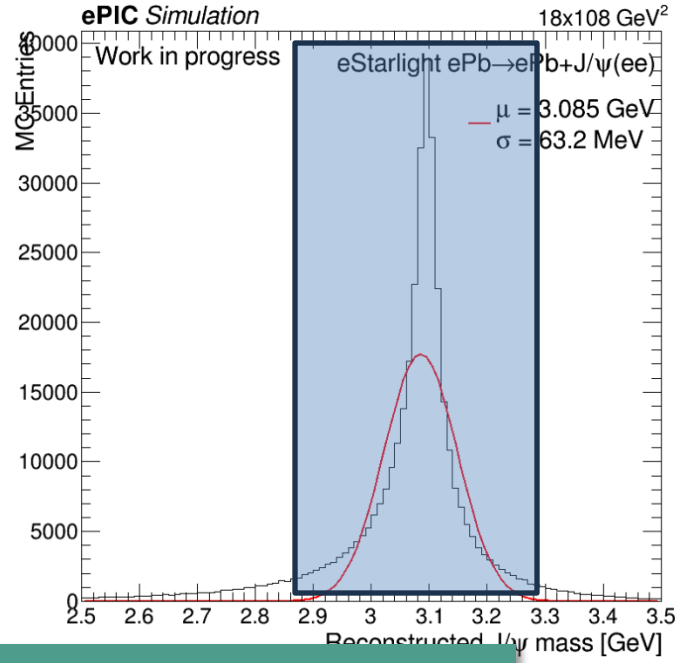
Coherent event Selection

- 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





Adding low-Q2 category double statistics

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

	electrons			Muons		
Cut	$Q^2<0.001$	$0.001<Q^2<0.03$	$0.03<Q^2<20$	$Q^2<0.001$	$0.001<Q^2<0.03$	$0.03<Q^2<20$
3 tracks	0.565585	0.338035	0.37418	0.566175	0.337	0.376885
VM mass cut	0.495305	0.29898	0.31144	0.52959	0.317285	0.339365
Veto FFD	0.495305	0.29897	0.31144	0.52959	0.31727	0.33935

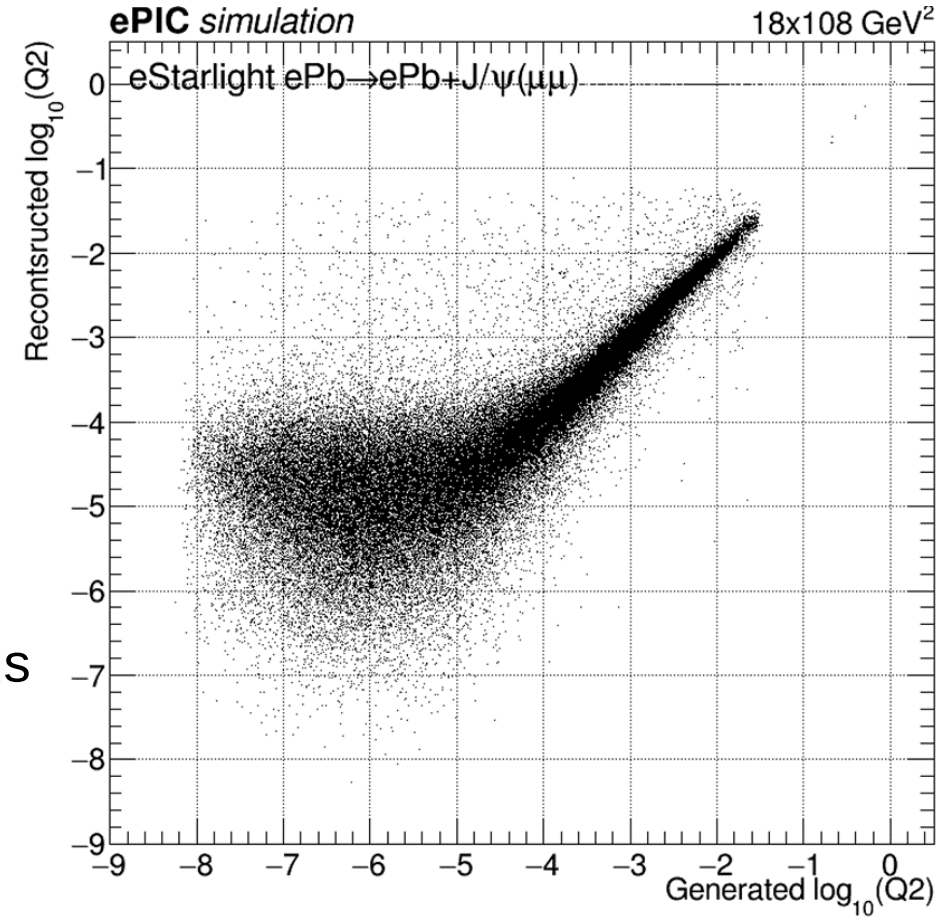
Event categorization

- Depends on the electron reconstructed eta (Barrel) or Q2 (Taggers)
  - Central detector: 60 nb x 0.3 ~ 20 nb
  - Low-Q2 taggers: 50 nb x 0.3 ~ 15 nb

Adding low-Q2 category double statistics

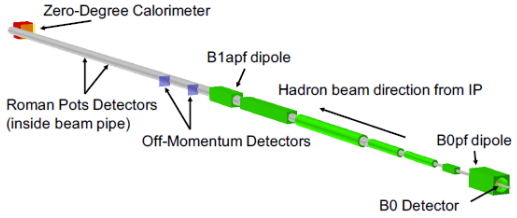
- Tagging Very-Q2 region: need to estimate backgrounds

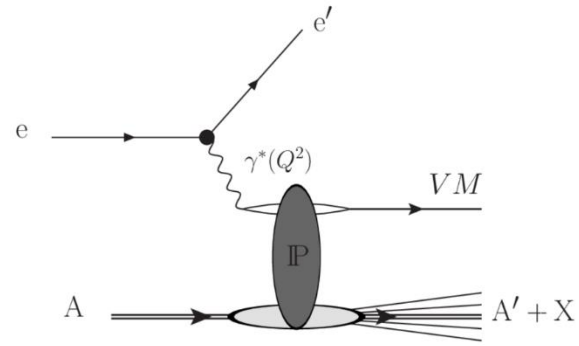
Cut	$Q^2<0.001$	$0.001<Q^2<0.03$	$0.03<Q^2<20$
2 tracks	0.975	0.9666	0.60978
reco Q2<0.001	0.56631	0.0943	---



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/ψ 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	0.001 < Q^2< 0.03	0.03 <Q^2< 20
3 tracks	0.319094	0.449577
VM mass cut	0.290249	0.400734
Veto B0	0.133347	0.19588
Veto RP/OMD	0.133347	0.19588
Veto ZDC	0.00618824	0.00551

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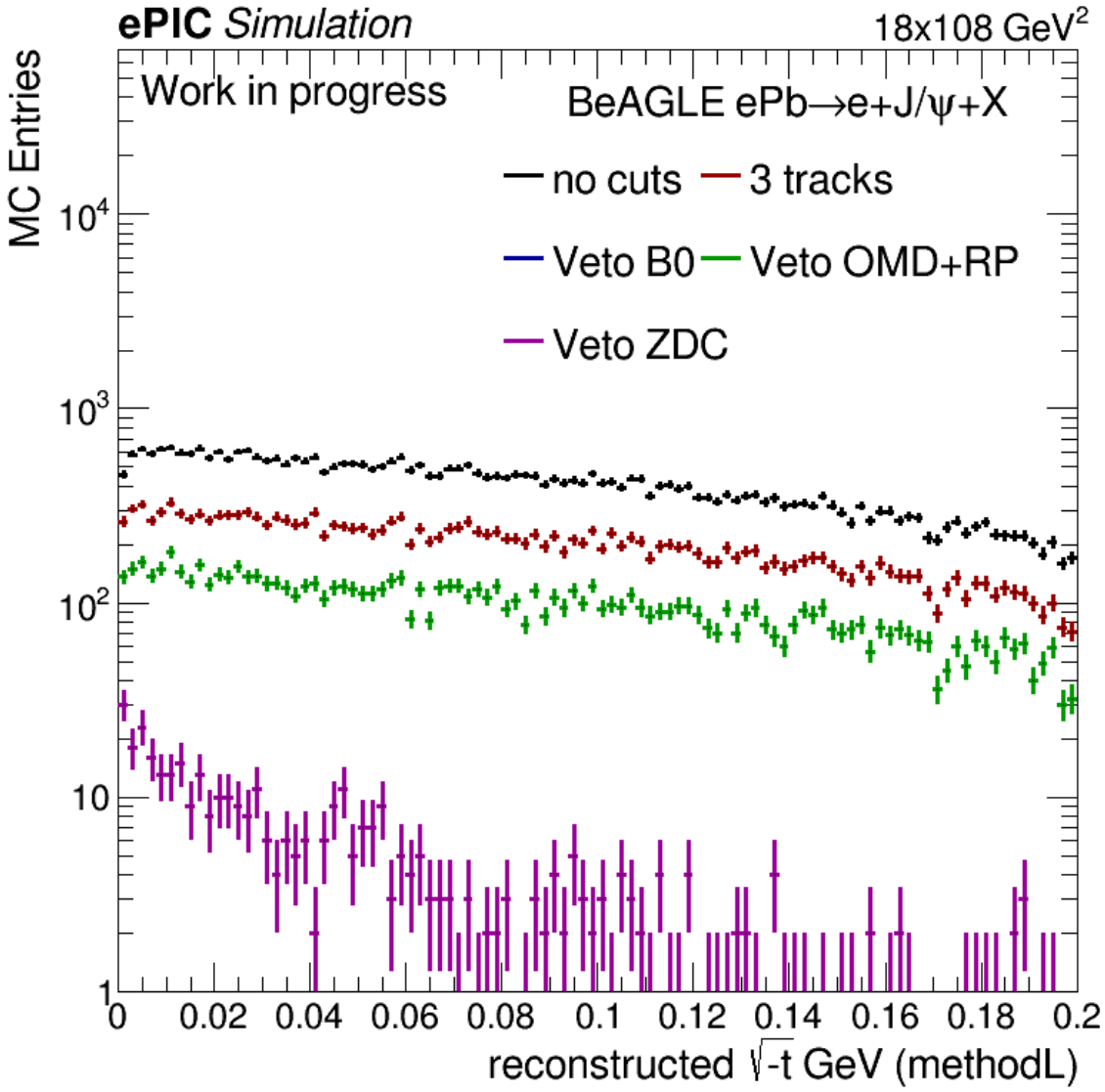


Coherent event Selection

- 3 track events (with 2 tracks in |η|<4) → define three signal regions
  - Very low Q2 (Q2 < 0.001)
  - 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 in very low Q2

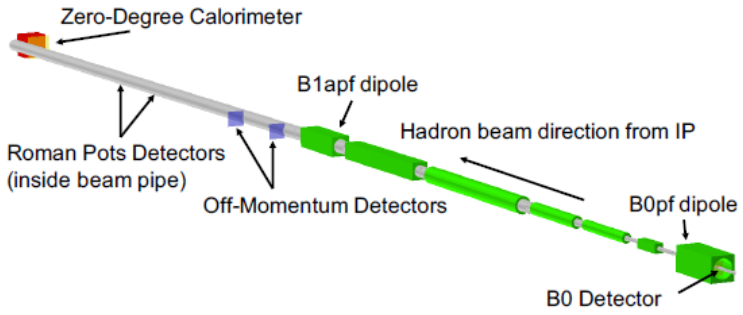
Summary and discussion

- Simulation:
  - Development of detector geometry is frozen, unless an unecpected developments we will proceed with the current setup
  - Blind response of OMD+RP is investigated (maybe a bug in my code), should be resolved by the next week
- The lowQ2 taggers are not in the EICRecon https://github.com/eic/EICrecon/pull/675
- Proposal to make three Q2 regions: Q2 in 0, 0.001, 0.03, 20): 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

Incoherent rejection

- Compare to old results



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

Cut	$0.001 < Q^2 < 0.03$	$0.03 < Q^2 < 20$
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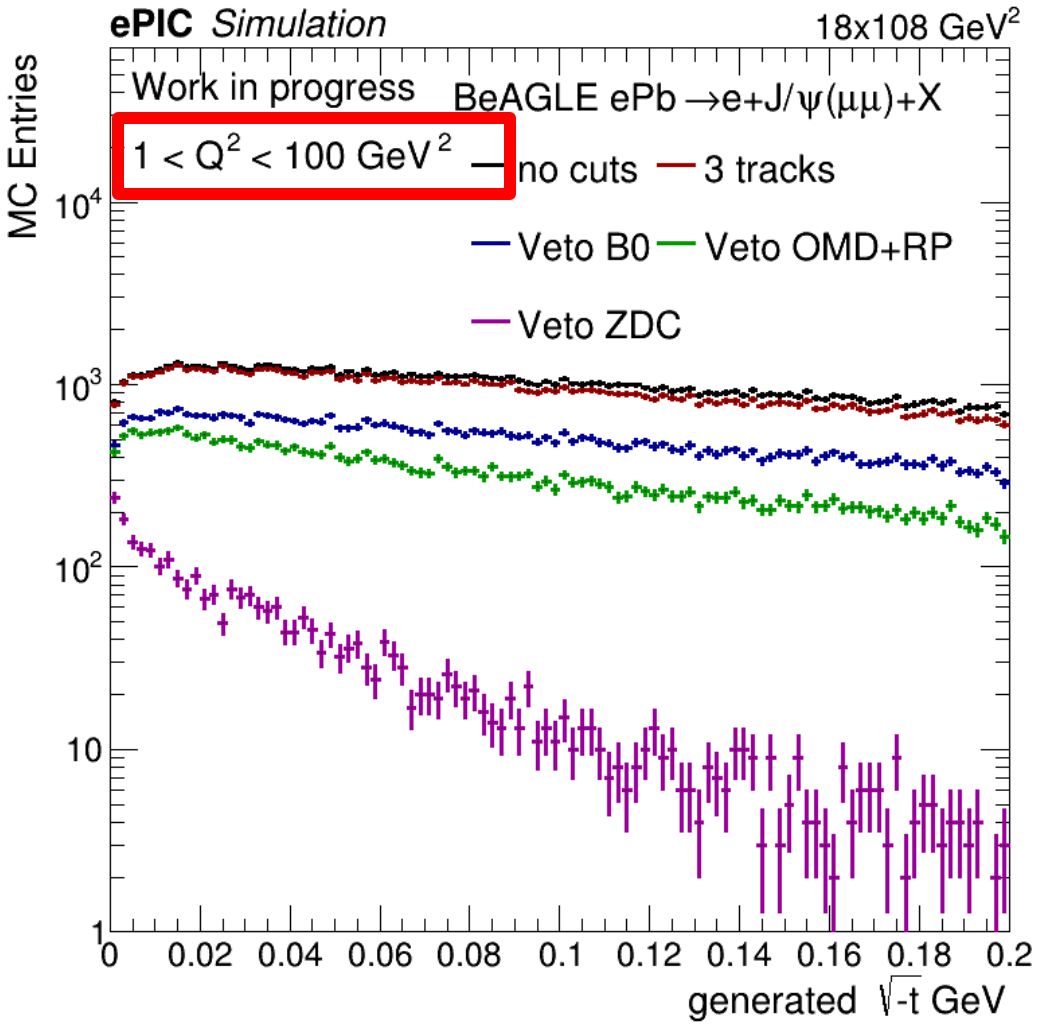
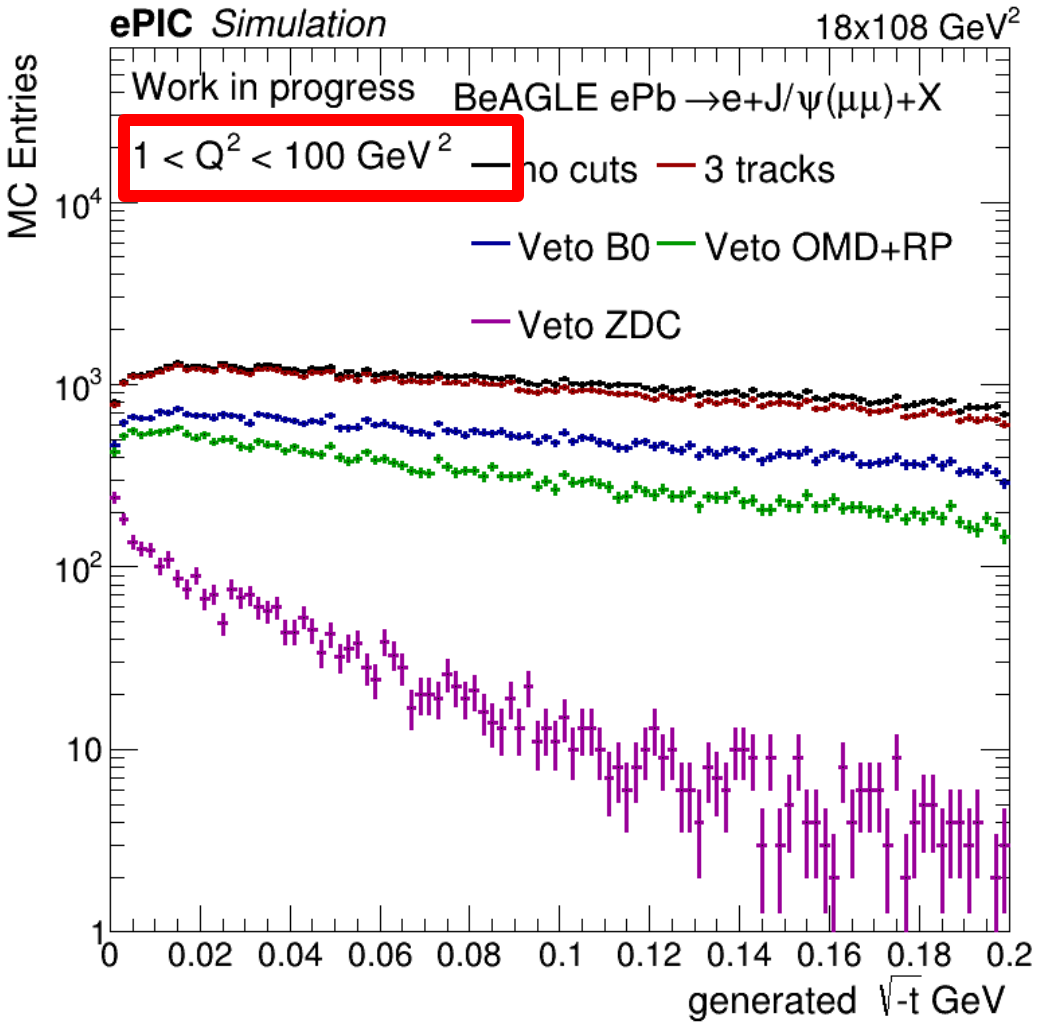
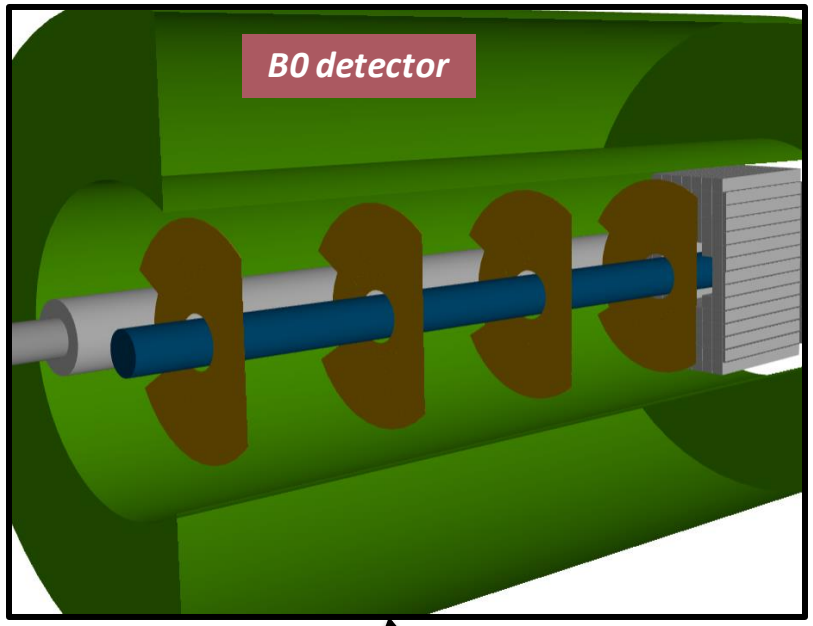
New geomergy

Background rejection





The Far-Forward detectors



Detector	Acceptance
Zero-Degree Calorimeter (ZDC)	θ < 5.5 mrad (η > 6)
Roman Pots (2 stations)	0.0* < θ < 5.0 mrad (η > 6)
Off-Momentum Detectors (2 stations)	0.0 < θ < 5.0 mrad (η > 6)
B0 Detector	5.5 < θ < 20 mrad (4.6 < η < 5.9)