Exclusive, Diffraction, & Tagging Meeting

VM production in eA (preTDR material)

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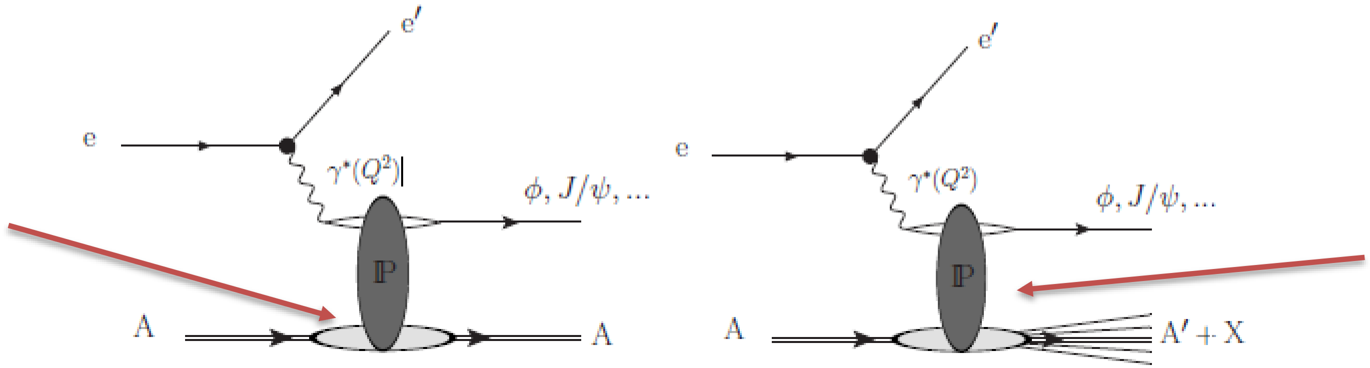
Motivation

- One of the three central questions highlighted in the NAS report on the EIC: gluon imaging and the onset of gluon saturation
  - ➢ Via exclusive and diffractive vector meson electroproduction
  - ➢ Electron exchanges a virtual photon which fluctuaties into $q\bar{q}$ dipole

Coherent =
with the entire nucleus
(nucleus intact)



Incoherent =
with individual nucleons
(nucleus breaks)

Figure 1: The coherent (left) and incoherent (right) exclusive vector meson production in eA collisions.

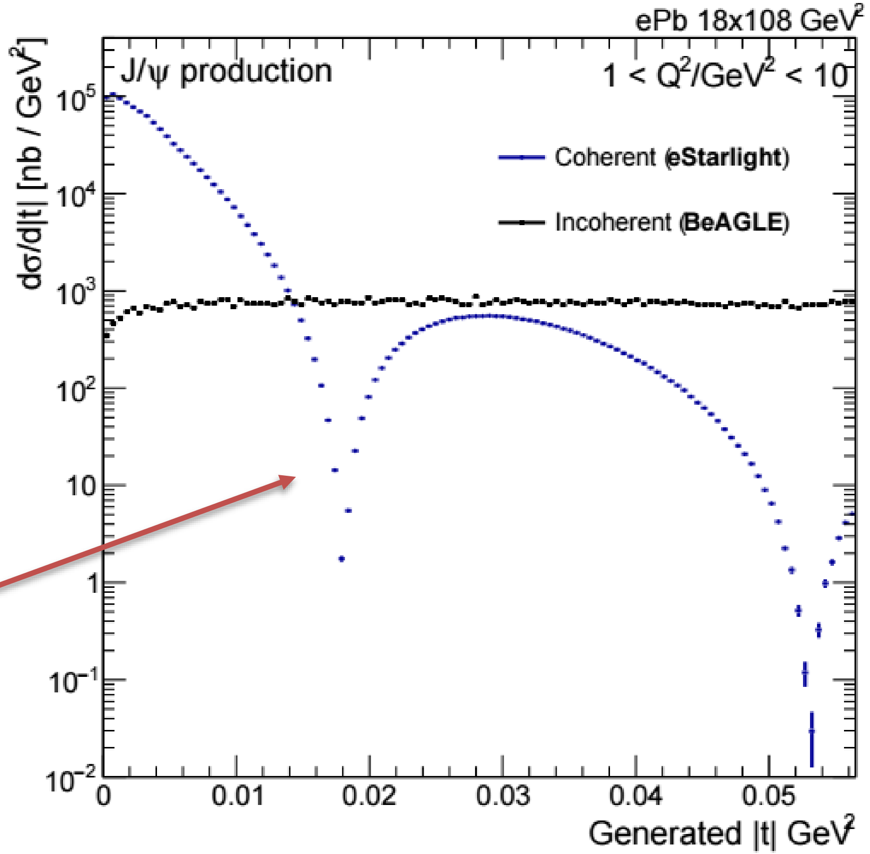
Motivation

- Coherent cross-section is higher than the incoherent (low t)
- Lighter mesons have higher cross-section, but too low mass enters non perturbative regime

	$\phi \to K^+K^-$	$J/\psi \to \mu\mu$
coherent	59.55 nb	4.95 nb
incoherent	2.35 nb	0.44 nb

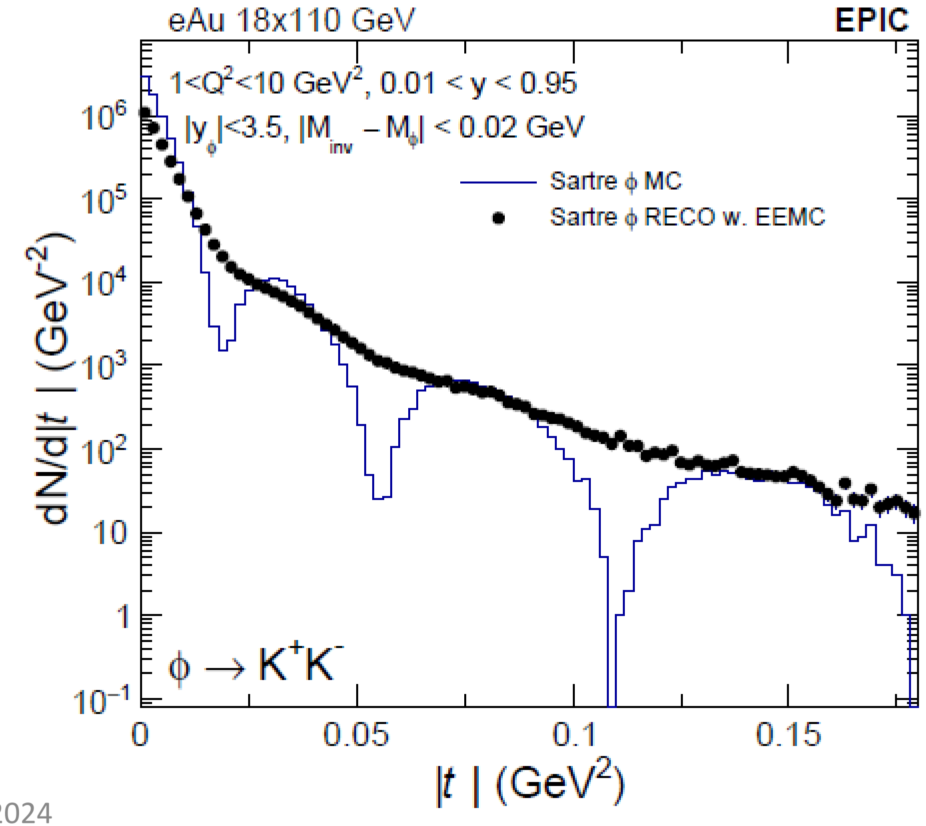
Table 1: Production cross-section time the branching ratio of vector mesons in coherent and incoherent interactions. Events were generated for $1 < Q^2/\text{GeV}^2 < 10$.

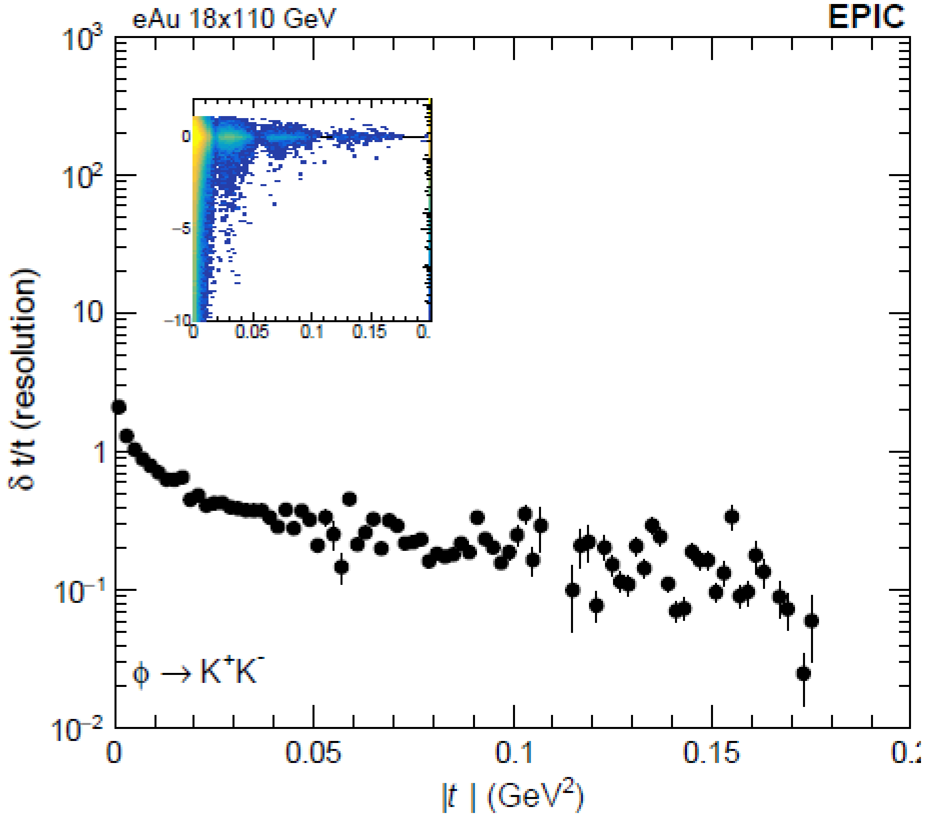
Diffractive dips → **Gluon distribution**
Main challenge it to measure these dips



Challenges

- Reconstruction of momentum transfer shows that the dips flushed away due to detector effects (plots obtained using July/August 2024 campaign)





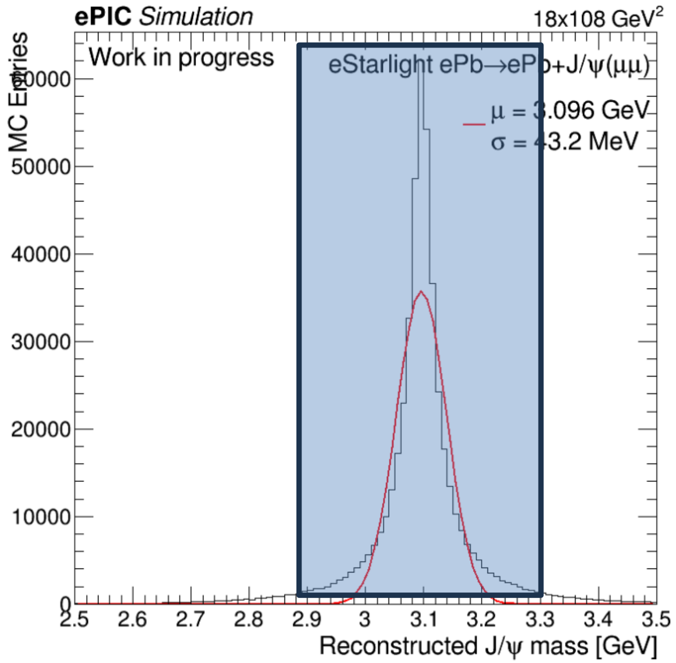
Analysis

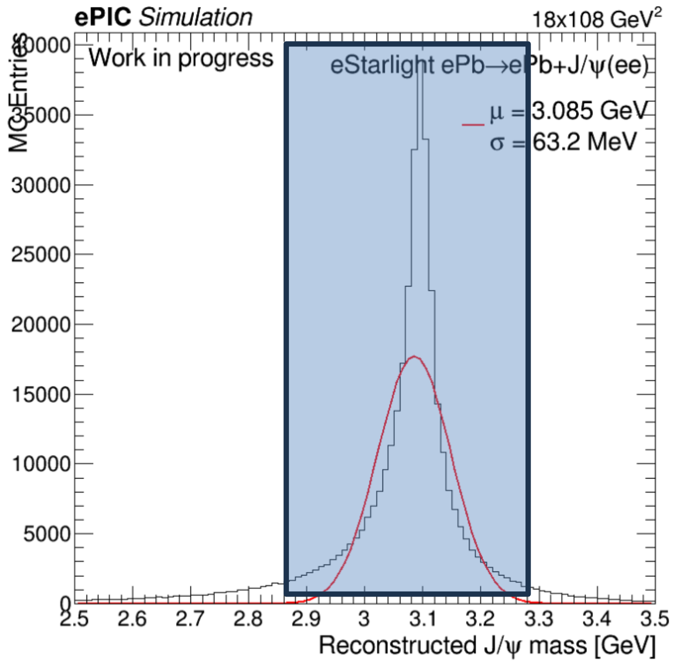
Coherent event Selection

Show J/psi selection (phi is ongoing)

- 3 track events (in Barrel)
- VM mass window of 0.4 GeV (no PID)
- Veto activity in forward region:

B0 tracks, B0 clusters, Tracks in OMD and ZDC Clusters





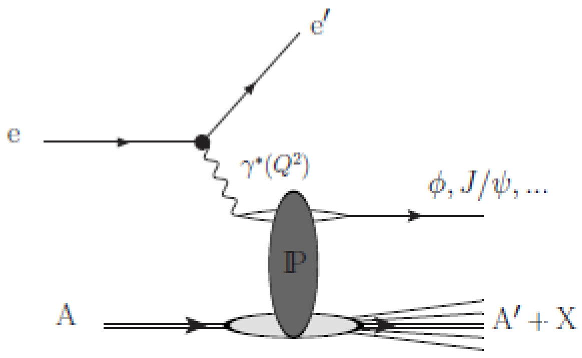
<u>Signal efficiency for different processes:</u>

Cut	$J/\psi \rightarrow ee$	$J/\psi \rightarrow \mu\mu$	$\phi \rightarrow KK$
3 tracks	0.973705	0.97383	ongoing
VM mass cut	0.838785	0.898815	ongoing
Veto FF Detectors	0.838745	0.898795	ongoing

Incoherent rejection

Background composition

Incoherent events characterized with ion breakup, and background rejection strategy rely on efficient tagging of forward particles



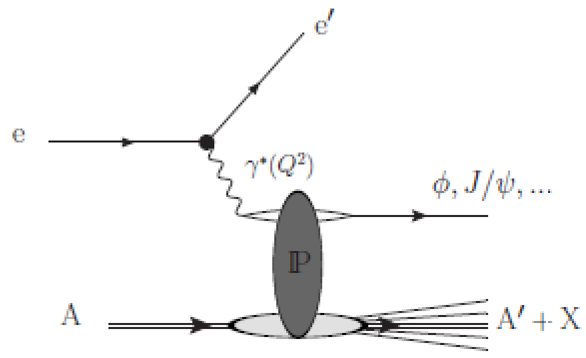
	Before selection (%)	After selection (%)
only photons	7.76754	95.7573
only protons	0	0
only neutrons	11.0551	0.0456204
photons and neutrons	53.3752	0.273723
protons and neutrons	1.34407	3.83212
protons and photons	2.30462	0
photons, neutrons and protons	24.1514	0.0456204

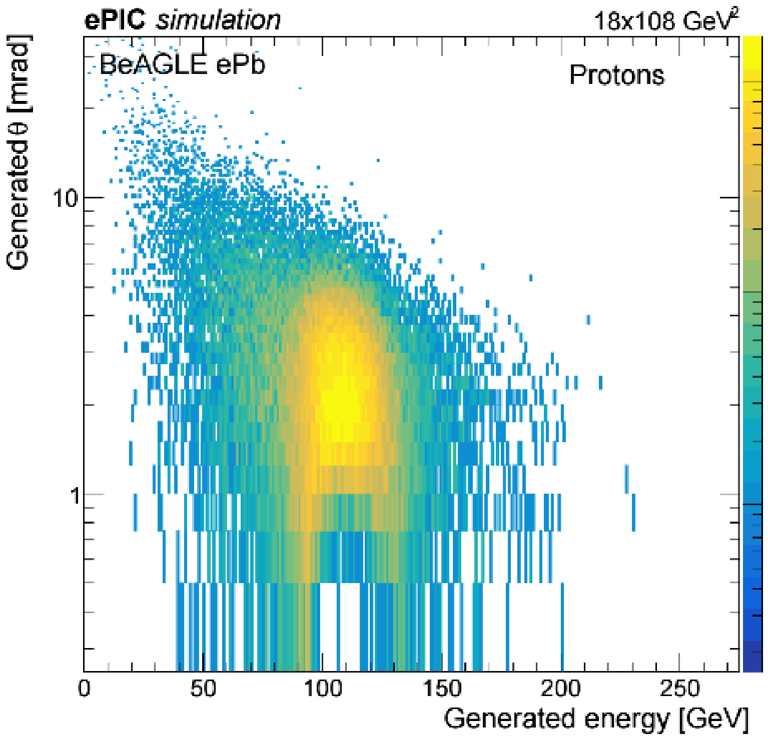
Table 2: Event composition in incoherent J/ψ production before and after full event selection

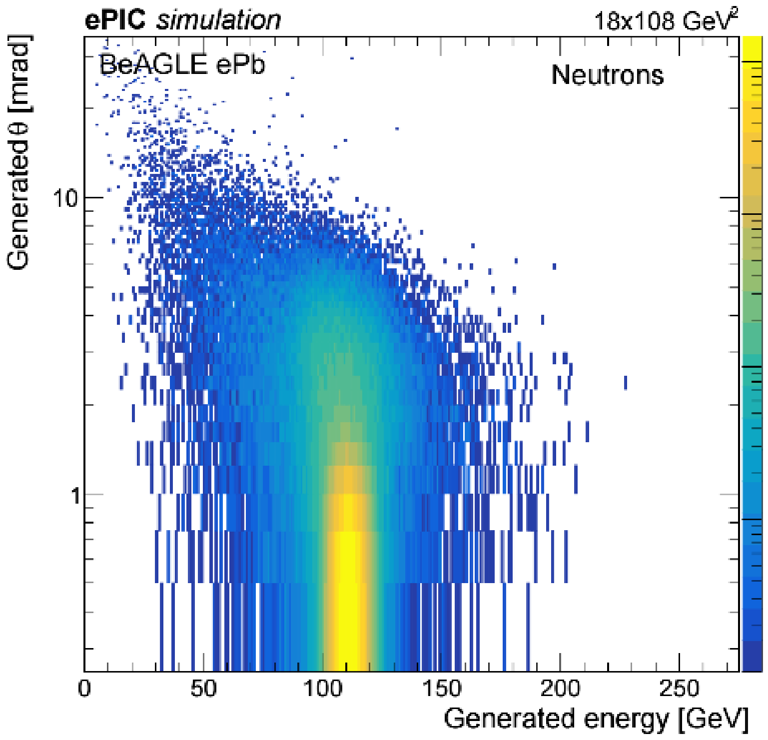
Incoherent rejection

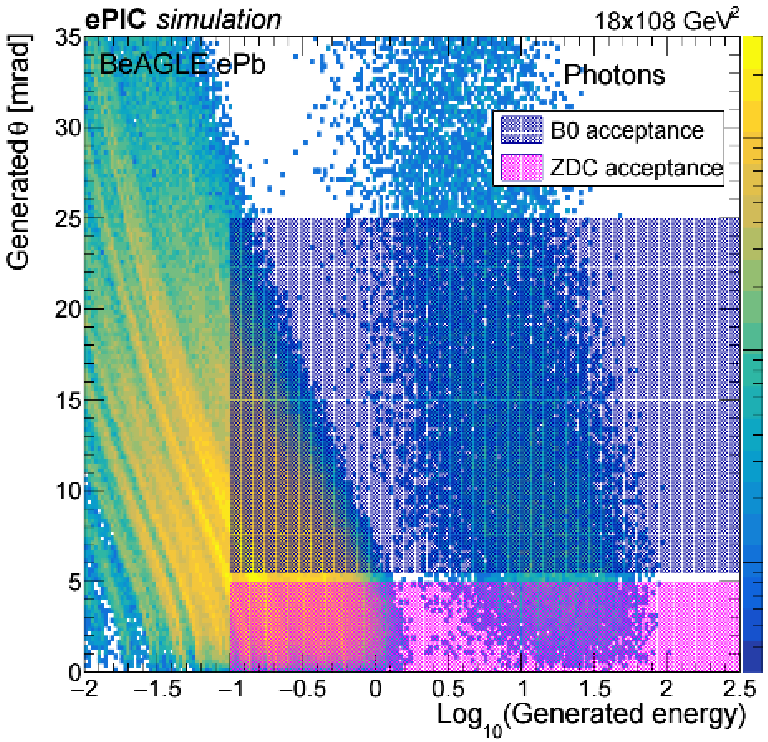
Background composition

Incoherent events characterized with ion breakup, and background rejection strategy rely on efficient tagging of forward particles









Incoherent rejection

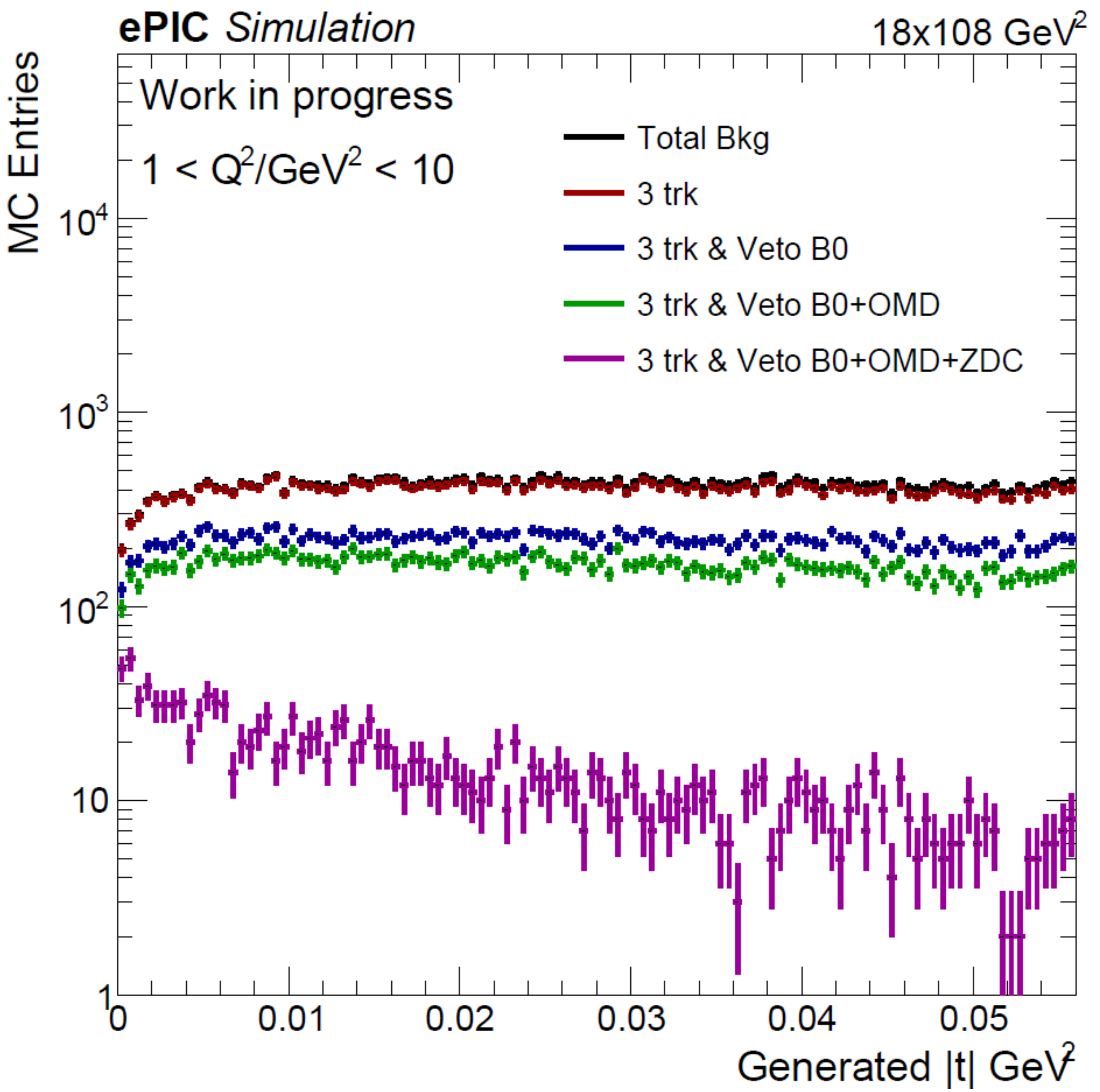
Coherent event Selection

Background rejection strategy – veto using signals from Far-forward detectors

Background efficiency based on ePIC FFD simulation

Cut	J/ψ (%)	ϕ(%)
3 tracks	0.914885	ongoing
VM mass cut	0.827045	ongoing
Veto B0	0.429656	ongoing
Veto OMD/RP	0.29286	Ongoing
Veto ZDC	0.013776	ongoing

TABLE IV. Cutflow for background processes for diffractive J/ψ production



Summary and discussion

Coherent VM production - status

- Simulation of FF region:
  - Simulation performed with recent ePIC geometry + small updates with B0 (PR788)
  - Production looks good for both coherent and incoherent events
- Coherent VM selection and background veto – all plots ready for pre-TDR
- Check simulation with Au instead of Pb (to compare with Sar*t*re)
- Add signal/background samples for central production (Oct. campaign)

Going beyond pre-TDR (for BGU group)

<u>Coherent VM</u>:

- Include low-Q taggers (double statistics) + t reconstruction

<u>Quasi-coherent VM</u>:

- Following the completion of the GEN level study (documentation in preparation), we plan to test this channel with the ePIC simulation

Backup

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 = 4000
PROD_PID = 443011 # 443011 - Jpsi->ee , 443013 - Jpsi->mumu, 333 – phi->KK
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
MIN_GAMMA_Q2 = 1.0
MAX_GAMMA_Q2 = 10.0
SELECT_IMPULSE_VM = 0   # Impulse VM parameter

Execution time:

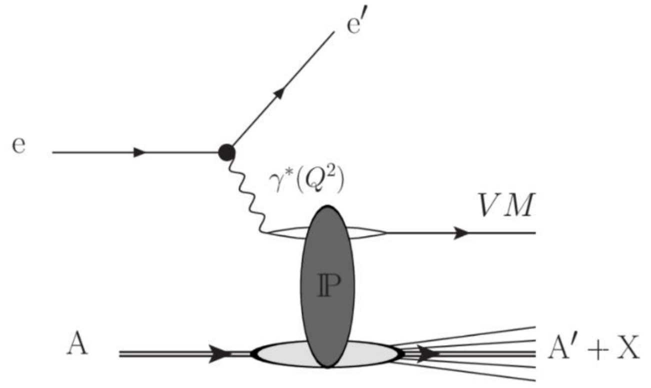
No ions in the record: 2.01 s/Event
Standard: 16.23 s/Event

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       10.0    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
```



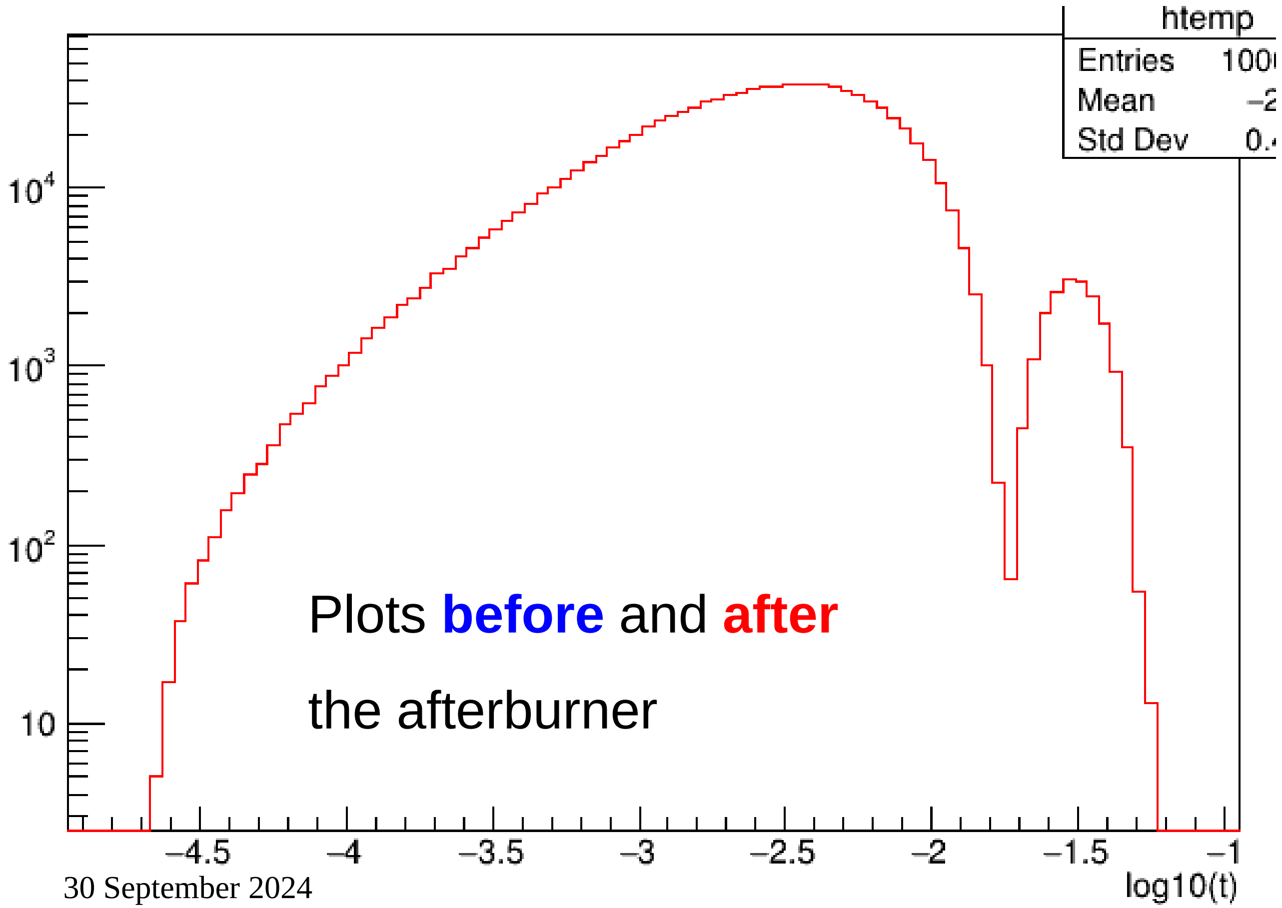
Execution time:

Standard: 35 s/Event

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

Afterburner configuration

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



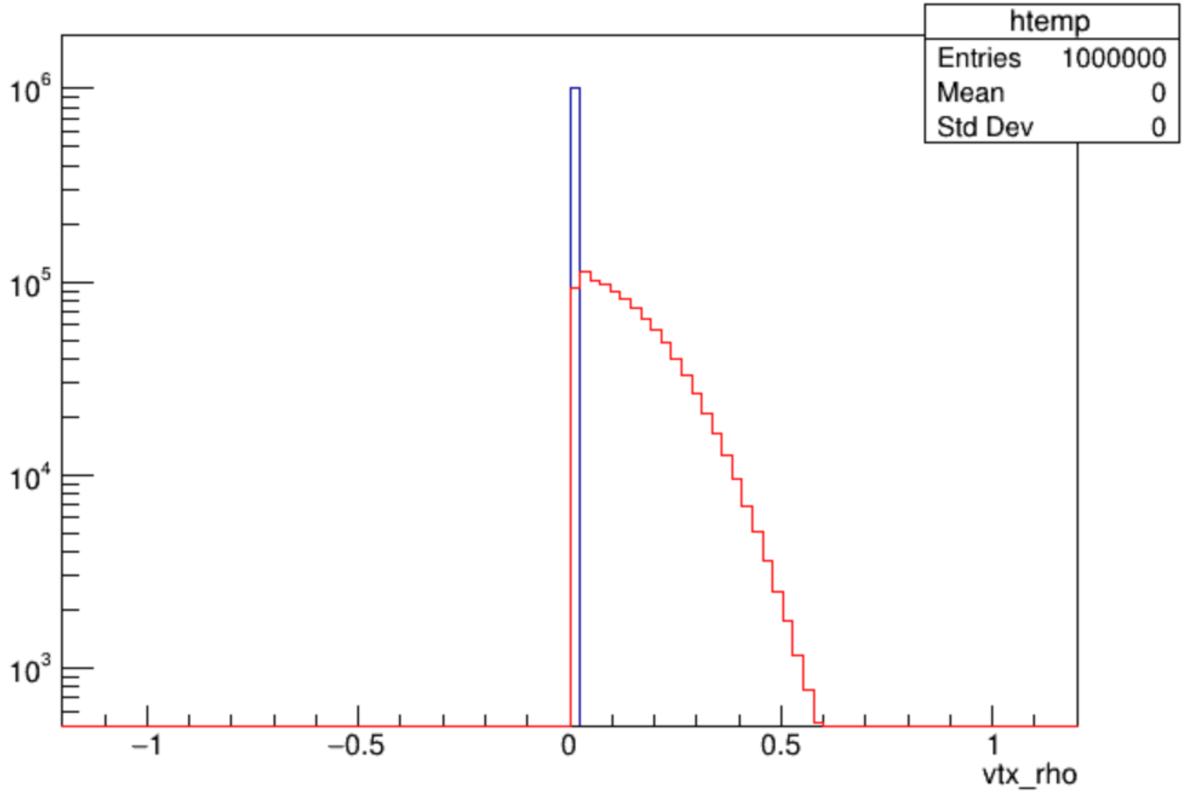
Plots **before** and **after** the afterburner

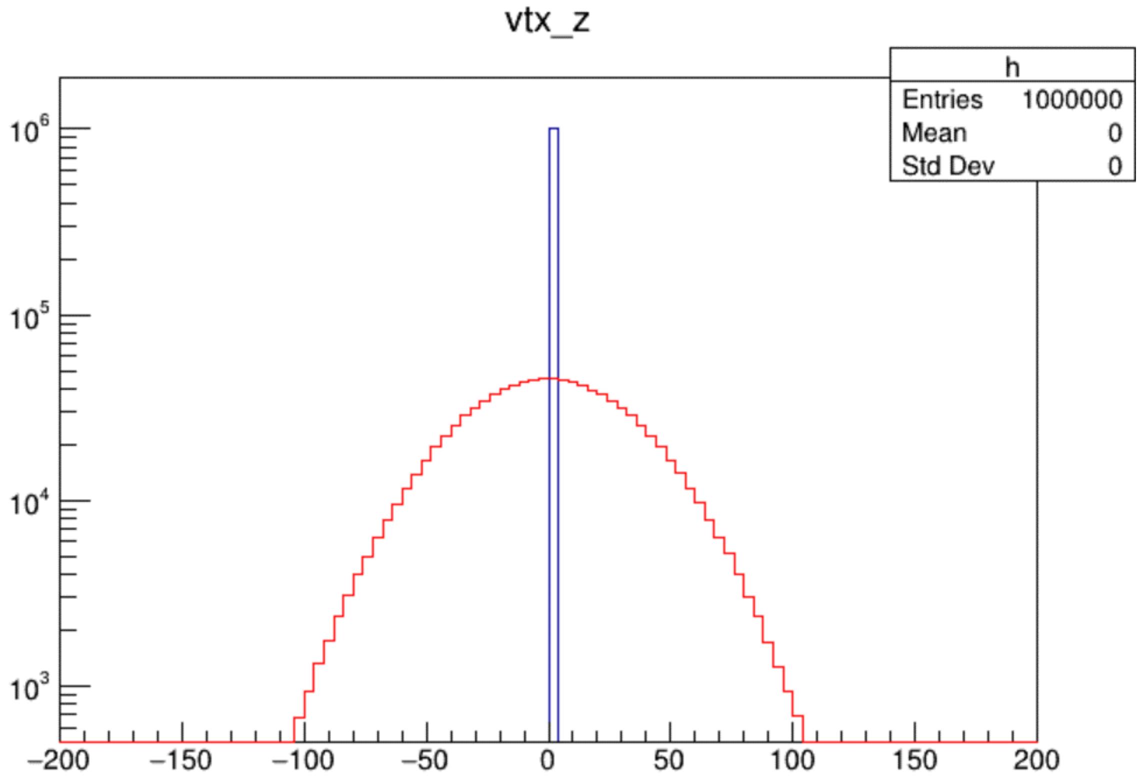
A ab_afterburner_is_used 1
A ab_crossing_angle 0.025
A ab_hadron_beta_crab_hor 500000
A ab_hadron_beta_star_hor 910
A ab_hadron_beta_star_ver 40
A ab_hadron_divergence_hor 0.000218
A ab_hadron_divergence_ver 0.000379
A ab_hadron_rms_bunch_length 70
A ab_hadron_rms_emittance_hor 4.32e-05
A ab_hadron_rms_emittance_ver 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

Afterburner configuration

Compare vtx distribution stored in hepmc files used in the simulation **before** and **after** the afterburner

Vertex coordinates (x,y,z,t?) obtained from “E” line in the hepmc files (in mm)

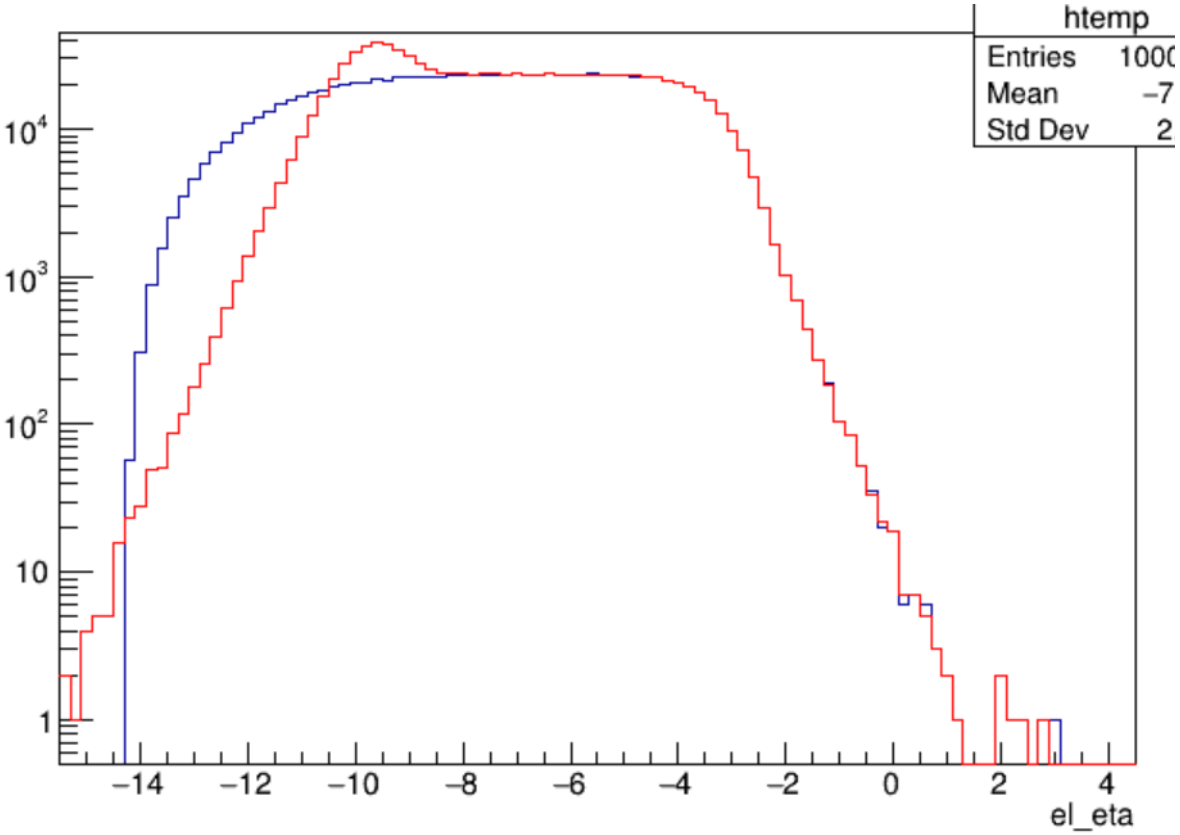


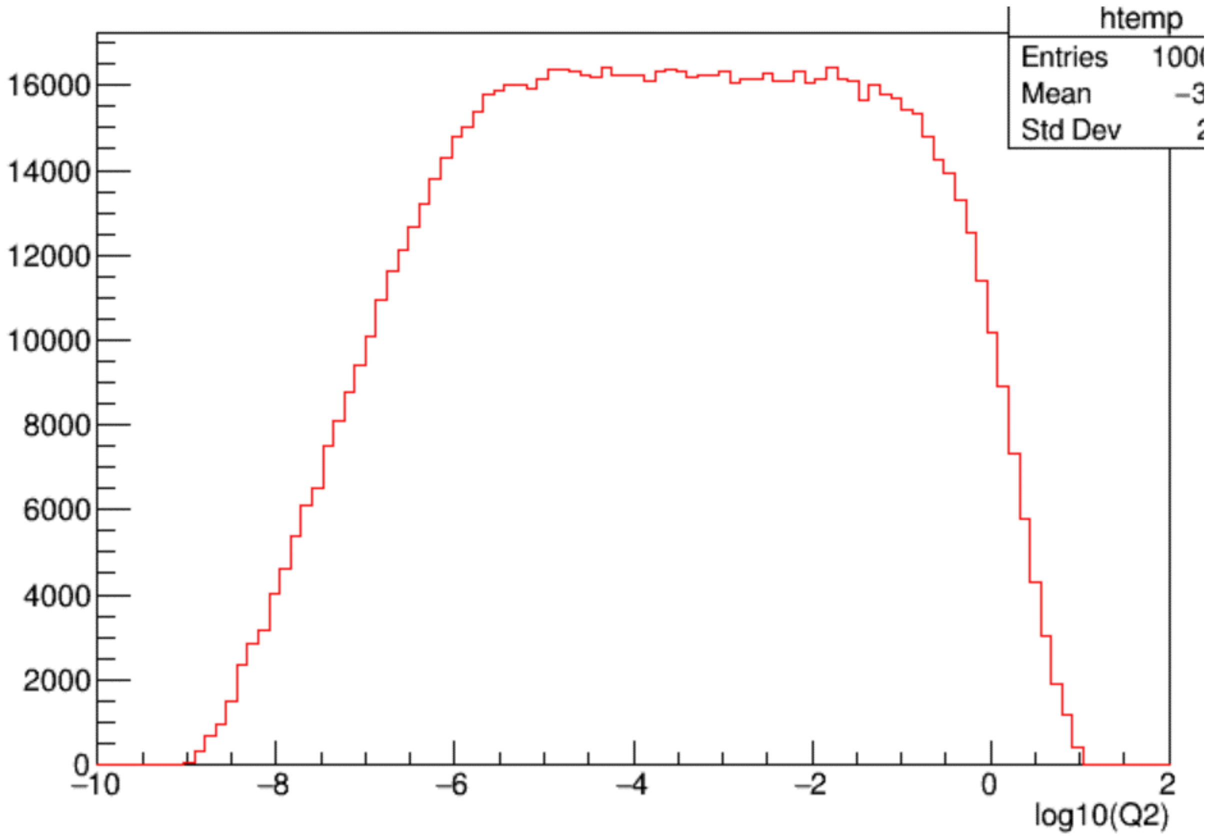


Coherent and incoherent production

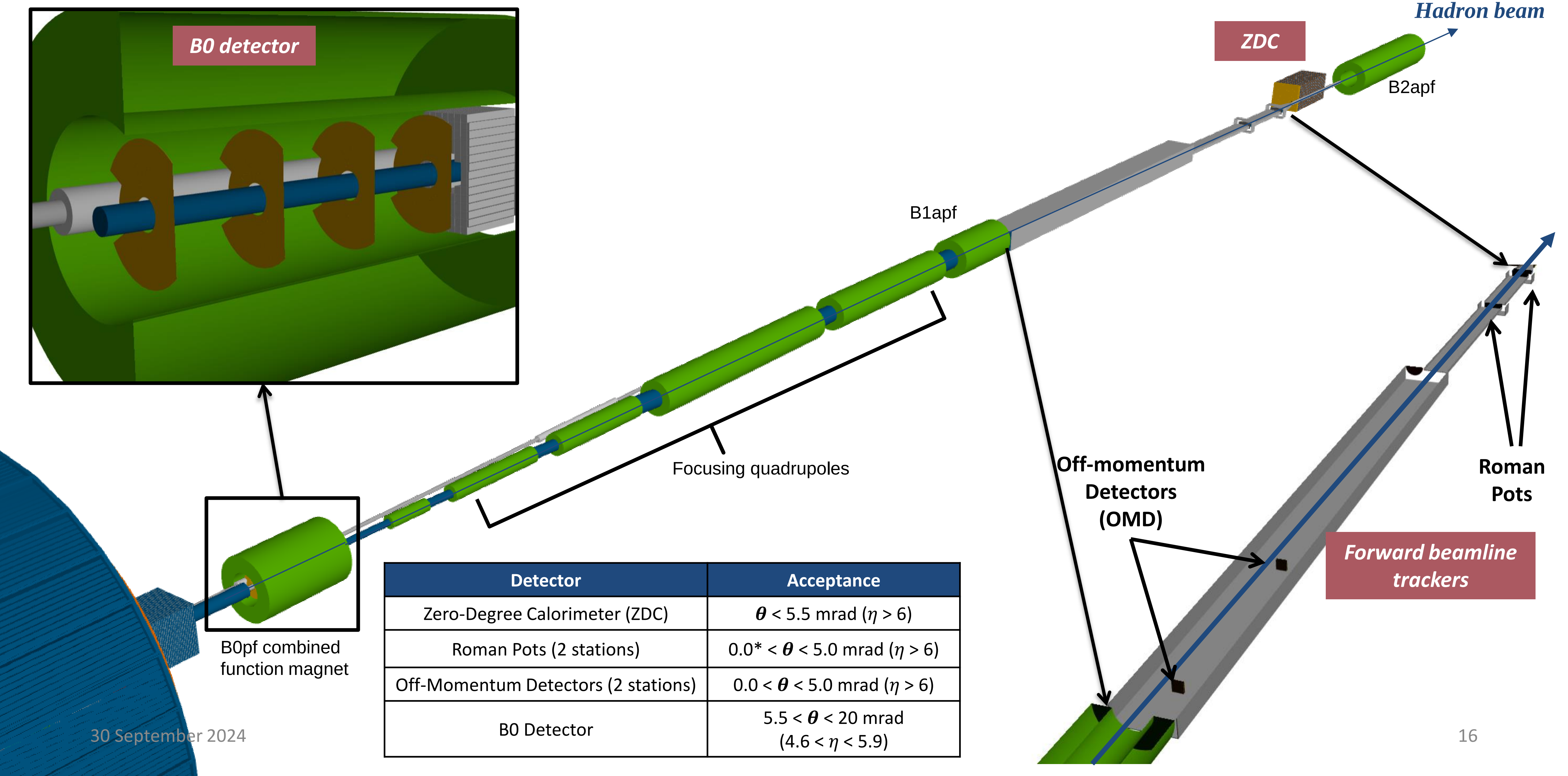
Afterburner configuration

Compare outgoing electron distribution **before** and **after** the afterburner





The Far-Forward detectors



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