Update on IP-8 Simulation

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2024/01/22

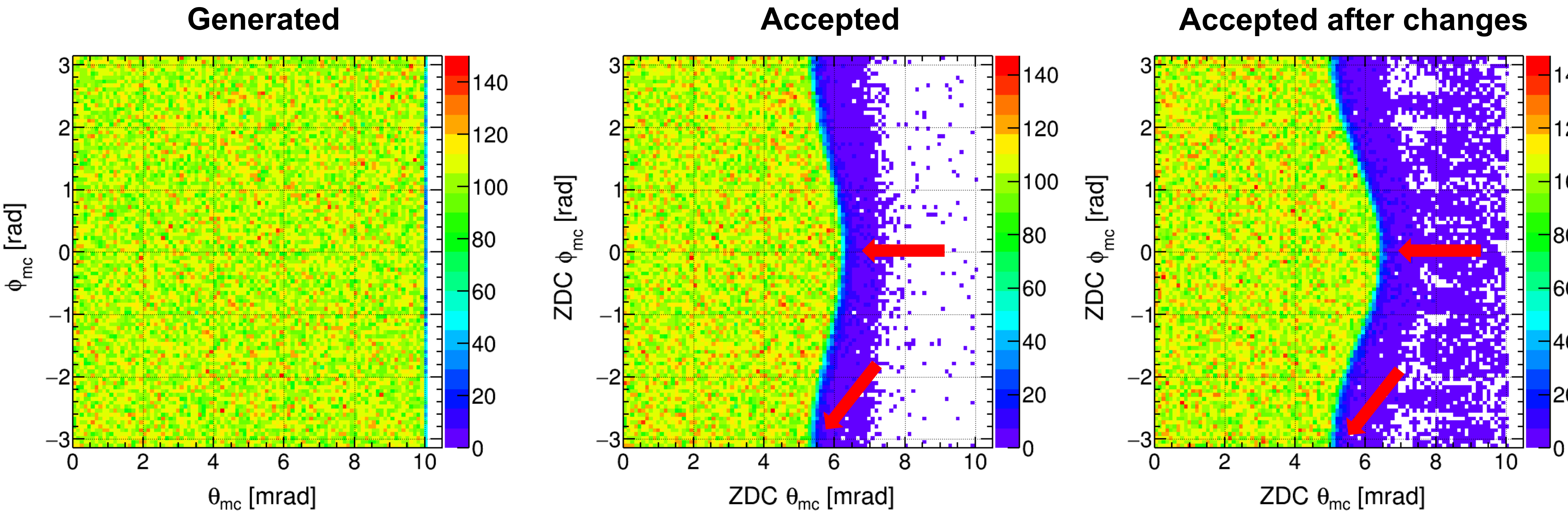
What's New

- Updated IP-8 hadron lattice
  - Dipole field (BXDS01A and BXDS01B)
  - IP-8 interaction point
  - Position of all hadron lattice in z
  - Kept same position of all far-forward detectors
  - Merged changes on D2EIC GitHub (thanks to Kong)
- Re-checked far-forward detector acceptance using single particle simulation
- Re-checked vetoing efficiency for incoherent events
- Further checked difference in vetoing efficiency between Wan's and my study
- (Work in progress) Started working on transfer matrix to reconstruction forward protons at roman pot at secondary focus

Far-Forward Detector Acceptance and Vetoing Efficiency

Zero Degree Calorimeter

Single Neutron
E = 275 GeV
$0 < \theta_{MC} < 10$ mrad

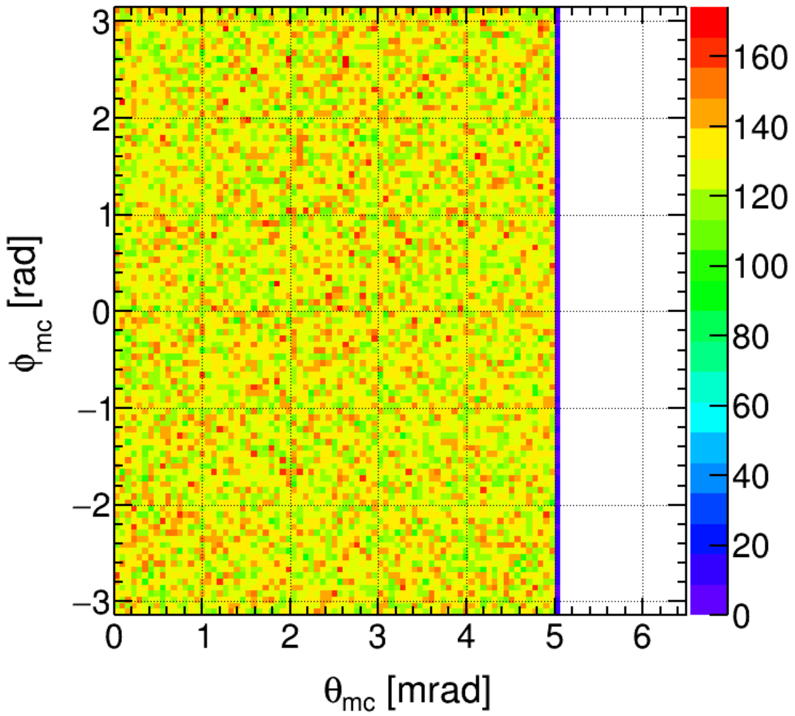


About **99.98 % (99.96 % after changes)** events were accepted **(θ_{MC} up to 5 mrad)**

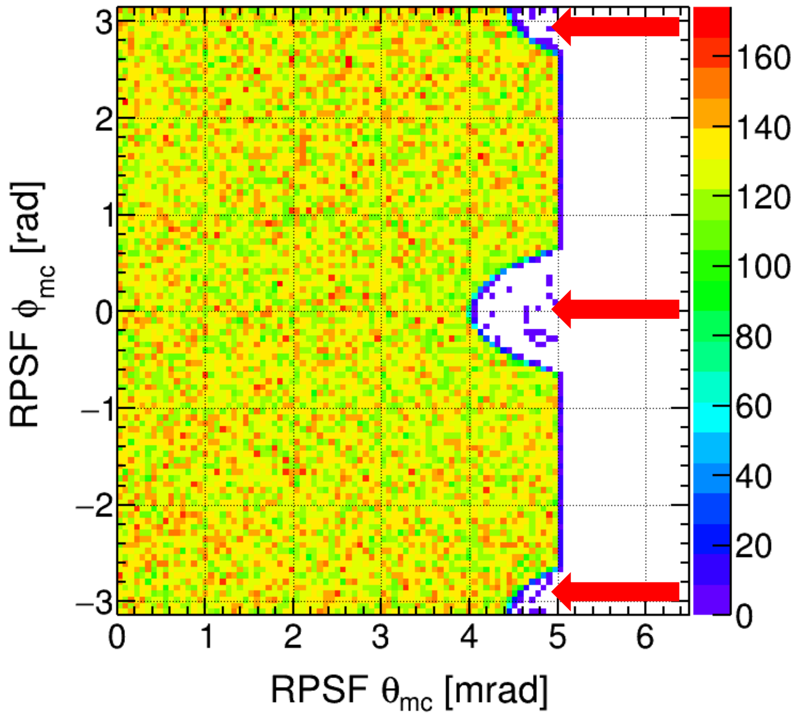
Roman Pots at Secondary Focus

Single Proton
E = 275 GeV
$0 < \theta_{MC} < 5$ mrad

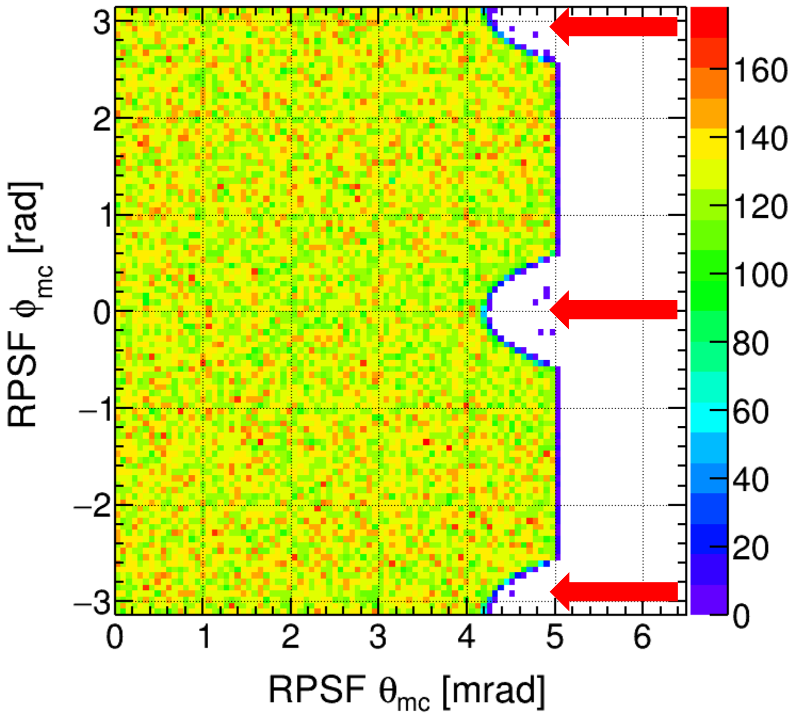
Generated



Accepted



Accepted after changes

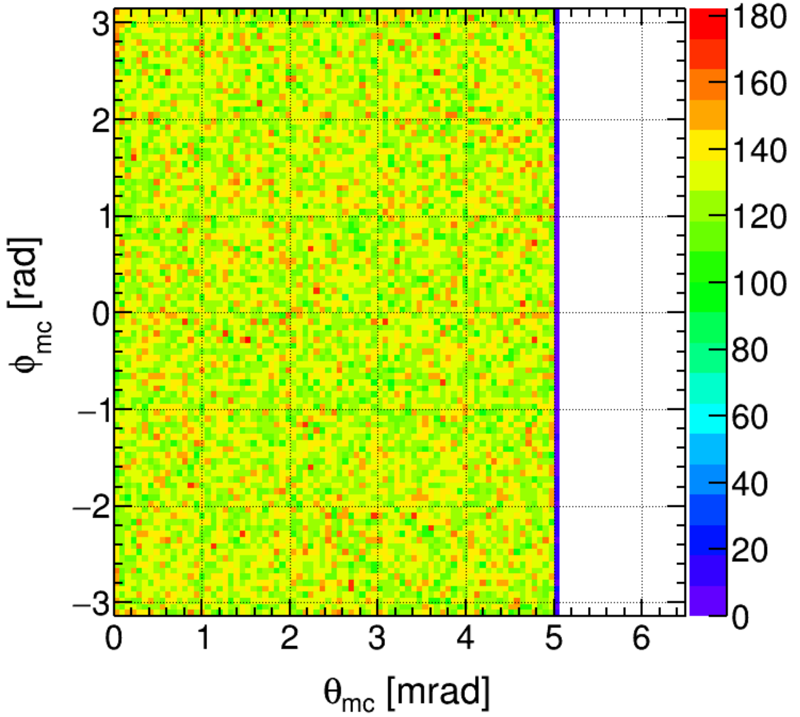


About **95.4 % (95.3 % after changes)** events were accepted

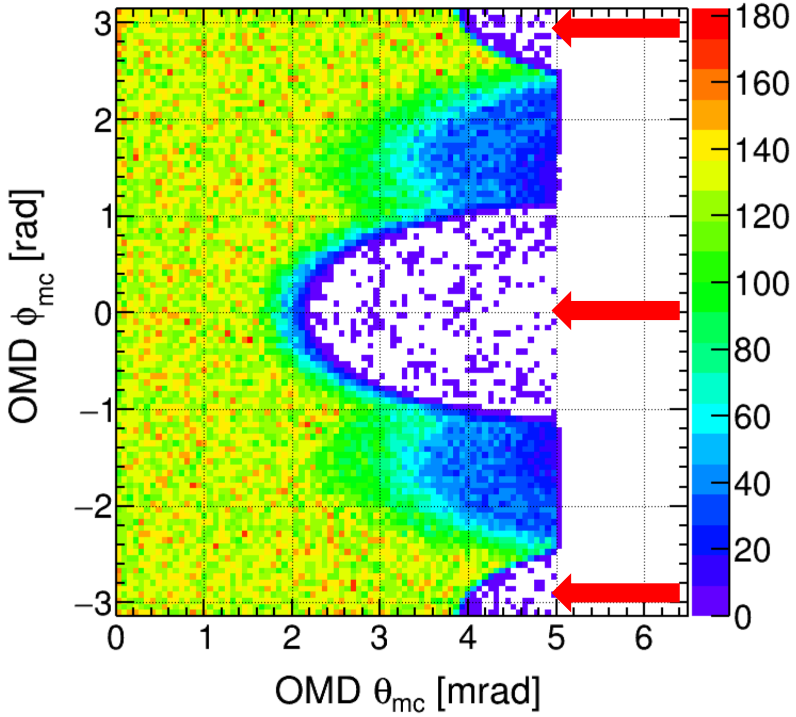
Off Momentum Detectors

Single Proton
123.75 GeV (45%) < E < 151.25 GeV (55%)
$0 < \theta_{MC} < 5$ mrad

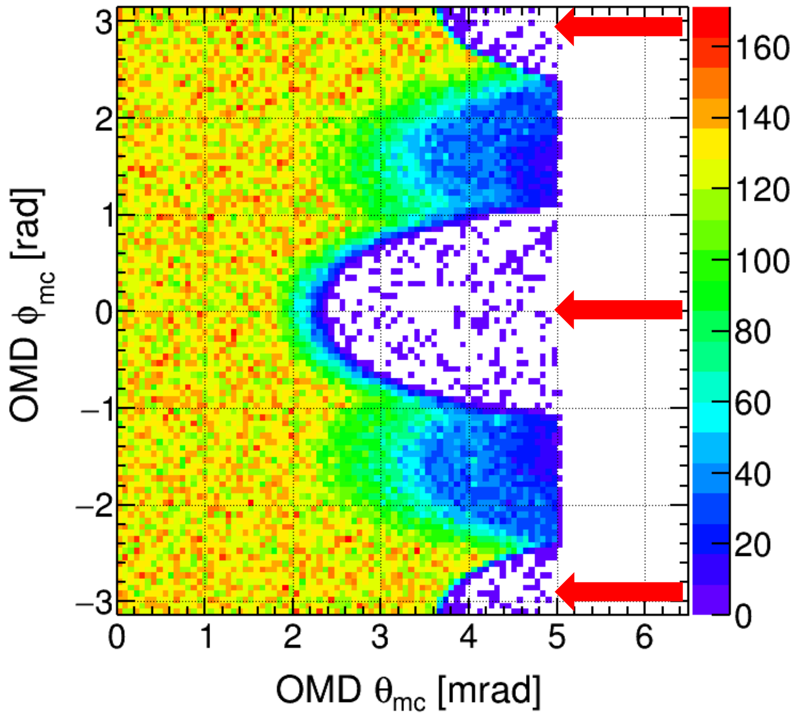
Generated



Accepted



Accepted after changes

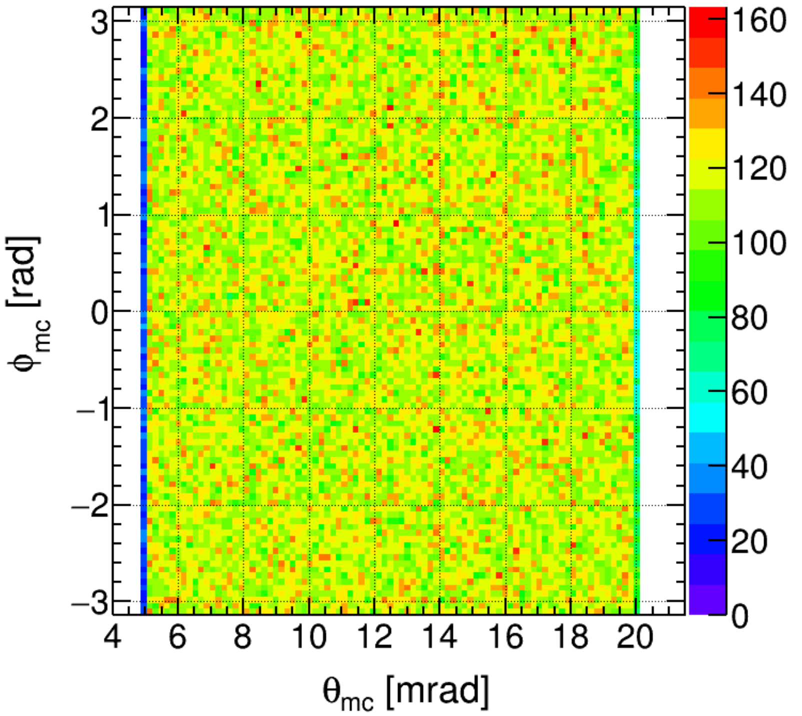


About **67.42 % (66.83 % after changes)** events were accepted

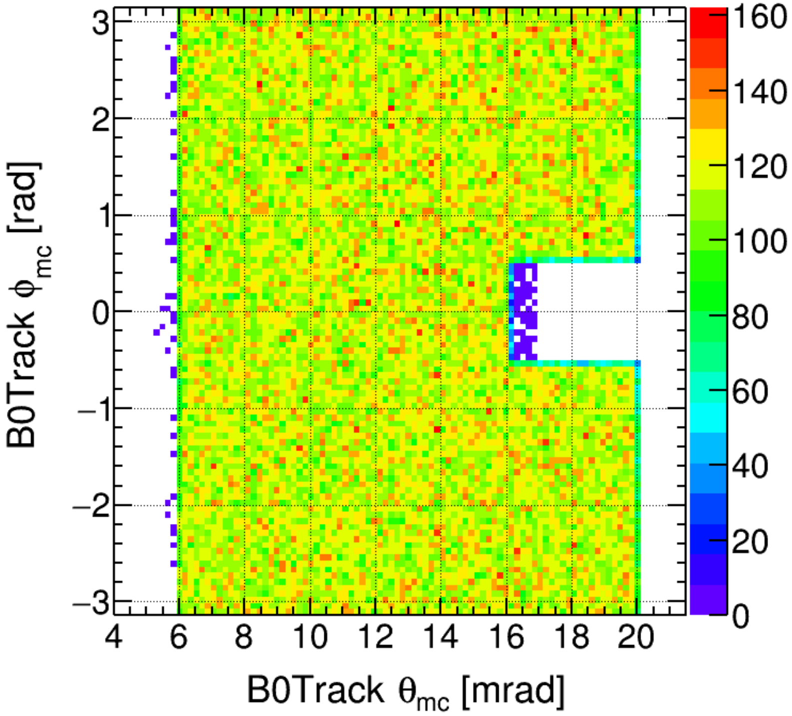
B0 Tracker

Single Proton
80 GeV < E < 120 GeV
$5 < \theta_{MC} < 20$ mrad

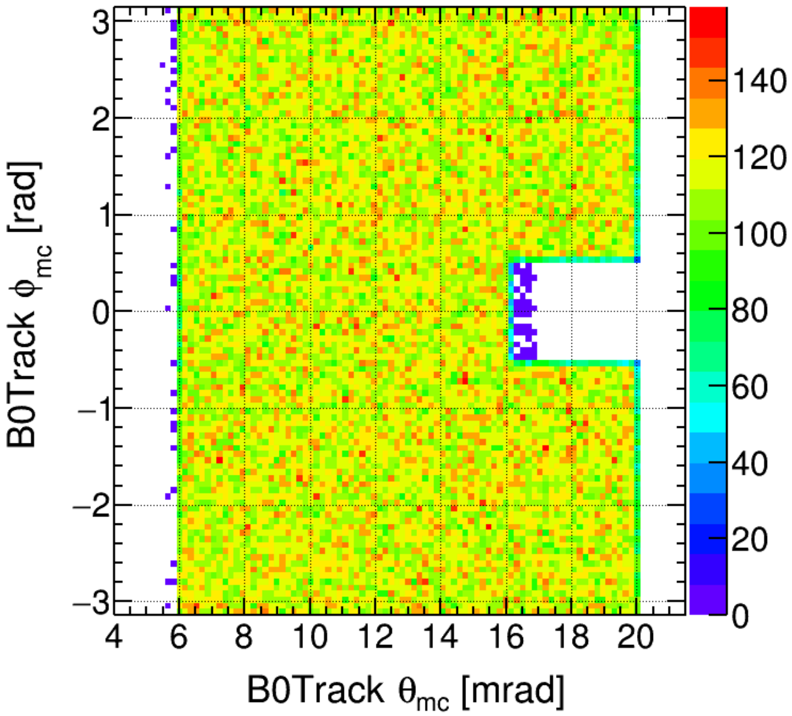
Generated



Accepted



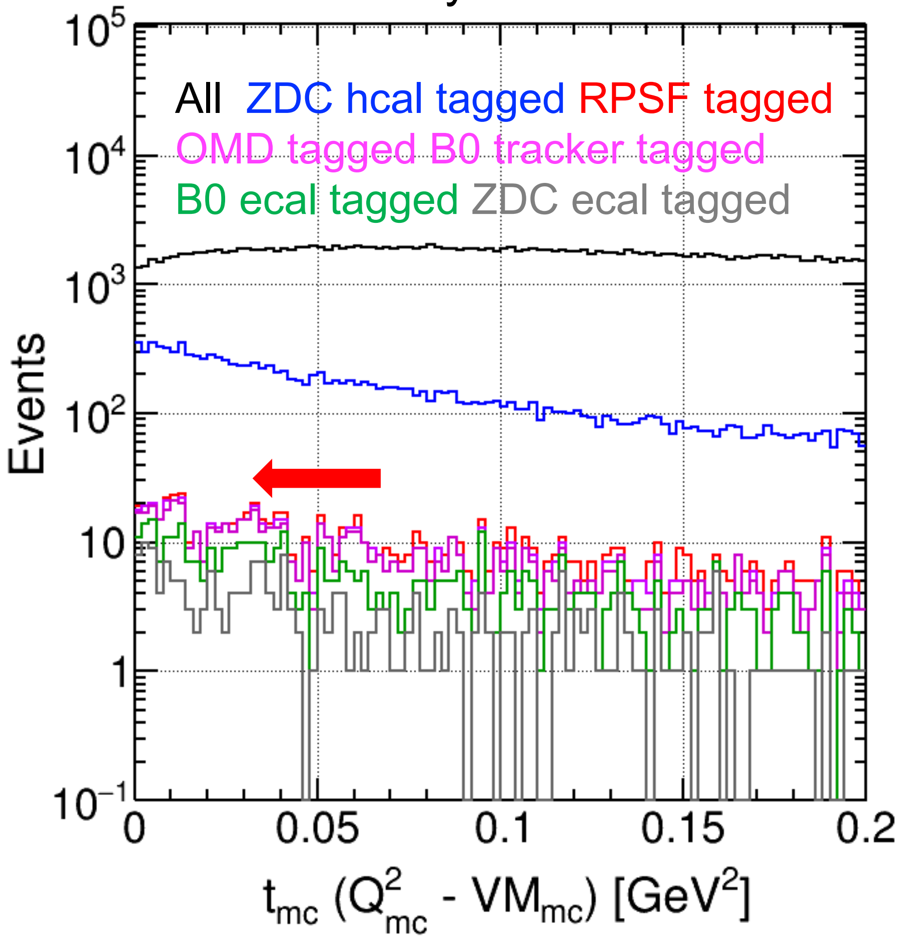
Accepted after changes

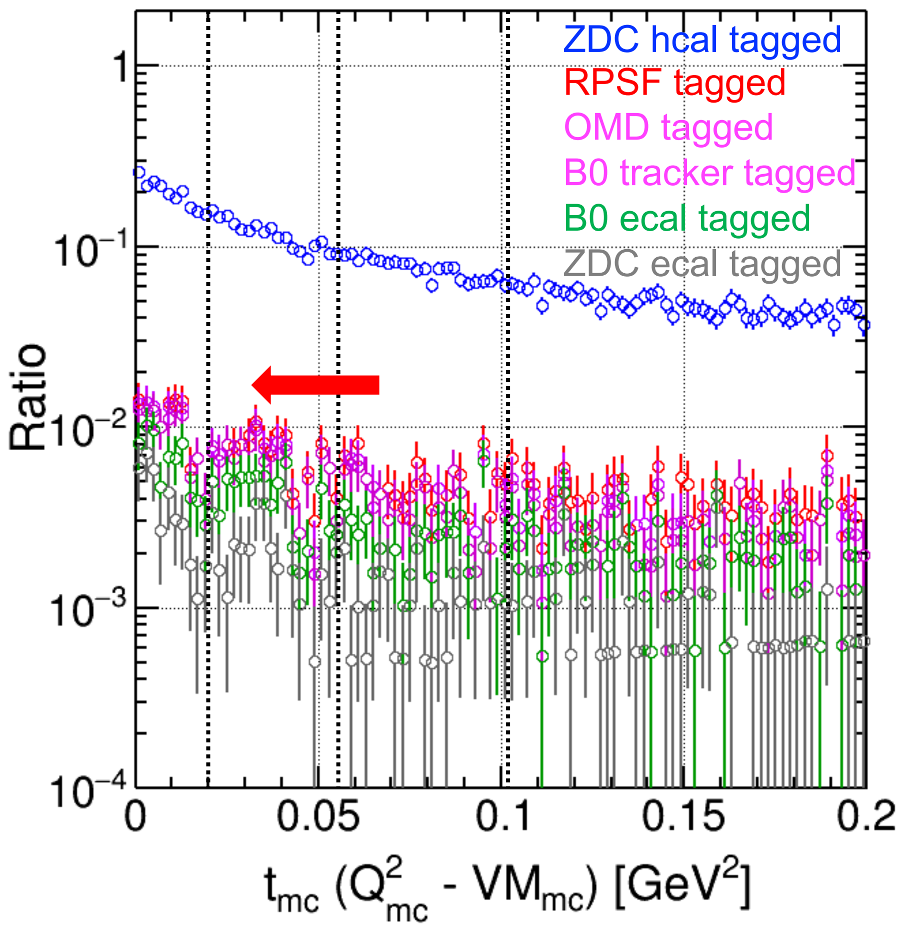


About **88.94 – 93.6 % (88.99 – 93.67 % after changes)** events were accepted requiring four layers or more than two layers

t Distribution (Before Changes)

BeAGLE 18x110 GeV^2
Incoherent events
$ePb \rightarrow e' + J/\psi(\mu\mu) + X$





Found to be enough to suppress incoherent contribution at three minima
Vetoing efficiency is about 99.99%

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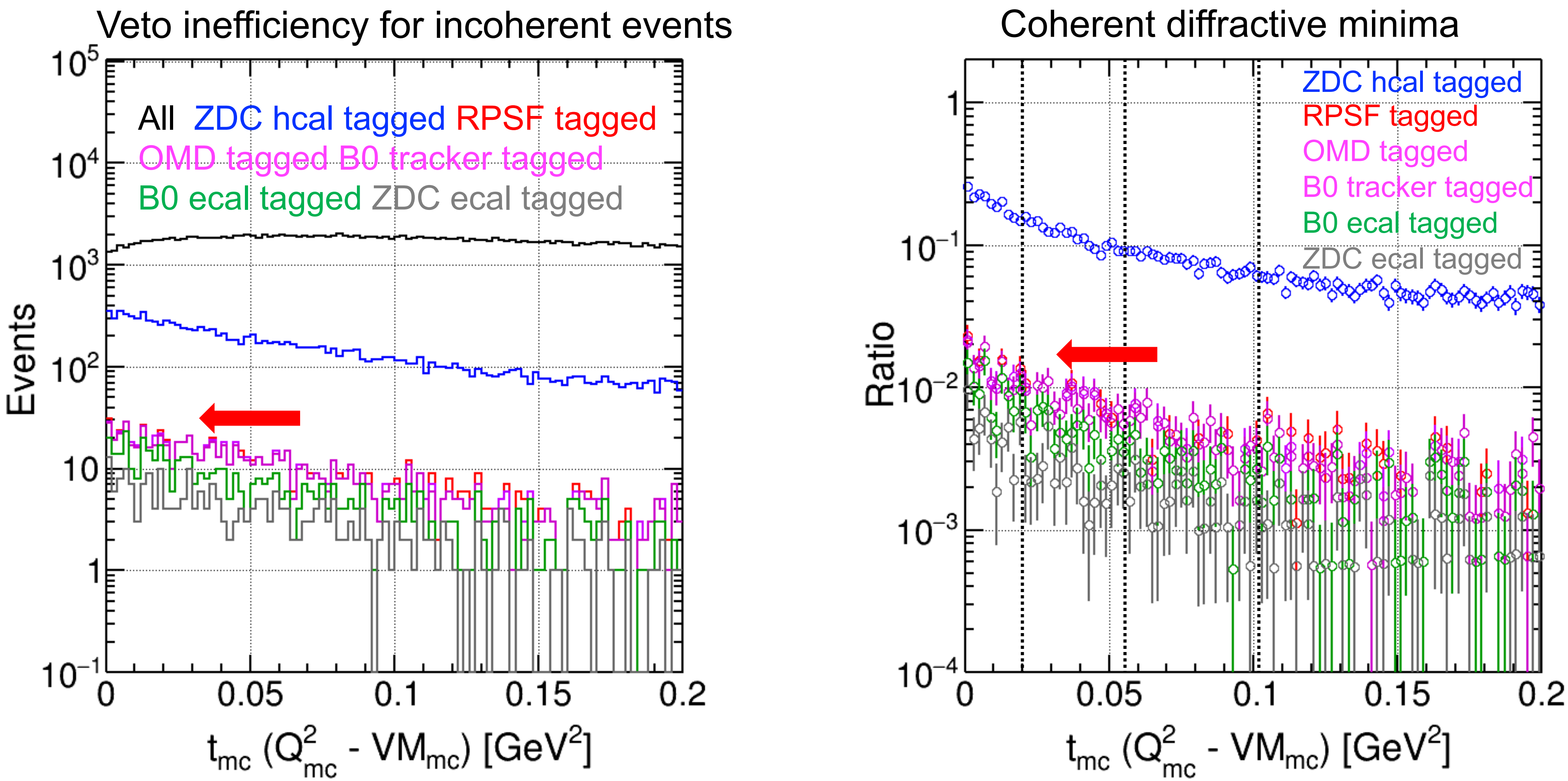

Found to be worse vetoing efficiency at very low t after changes

t Distribution (Before Changes)

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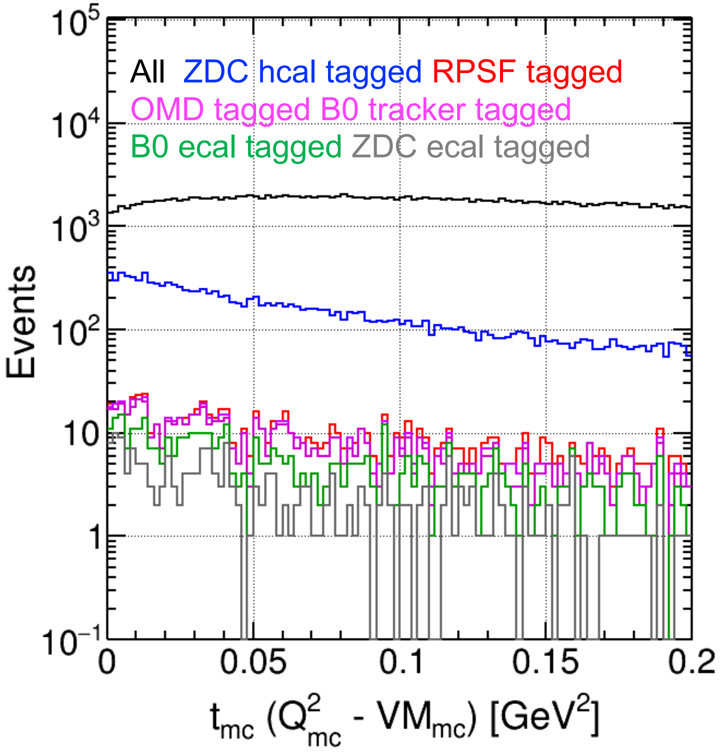
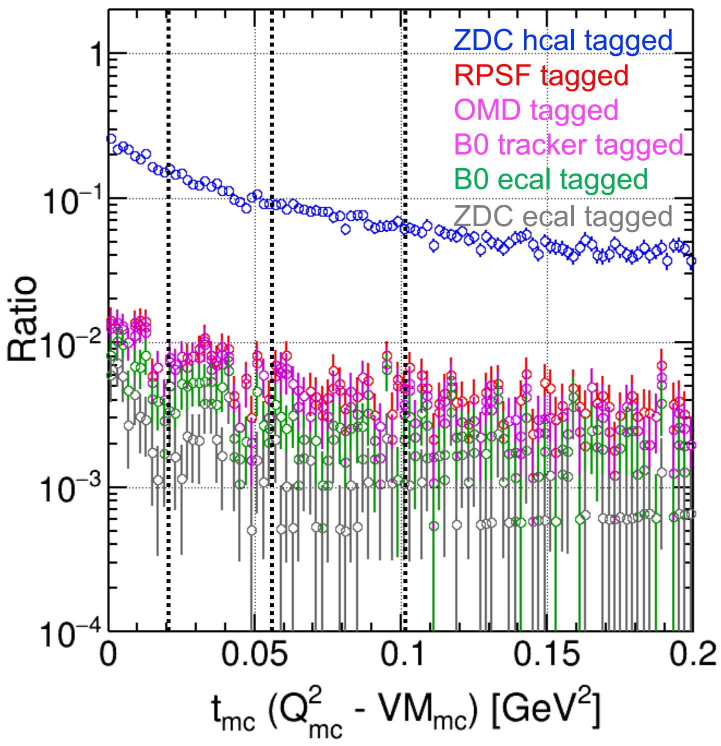
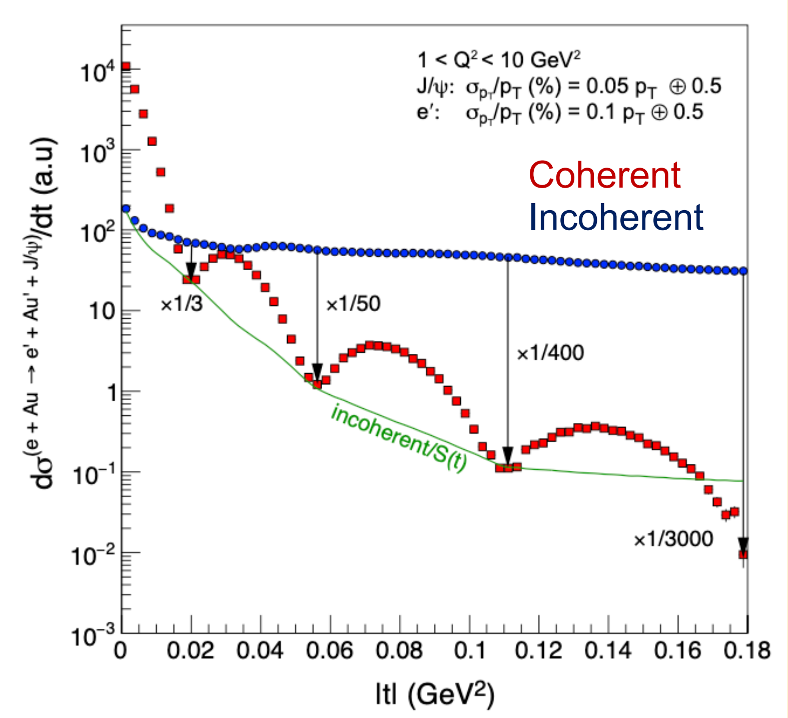
Veto inefficiency for incoherent events



Coherent diffractive minima



Reference from EIC YR p.352



At position of third diffractive minimum, rejection factor for incoherent event better than 400:1 must be achievable

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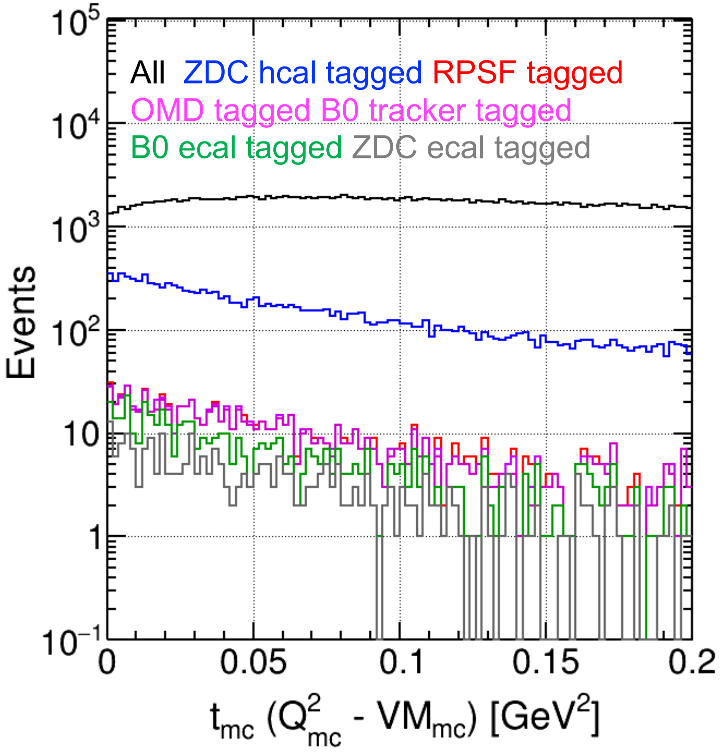
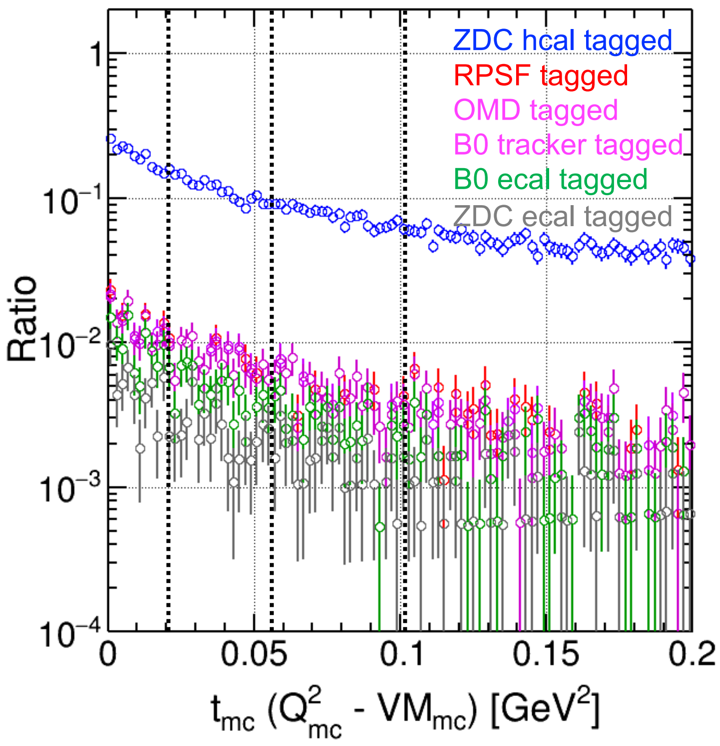


Coherent diffractive minima



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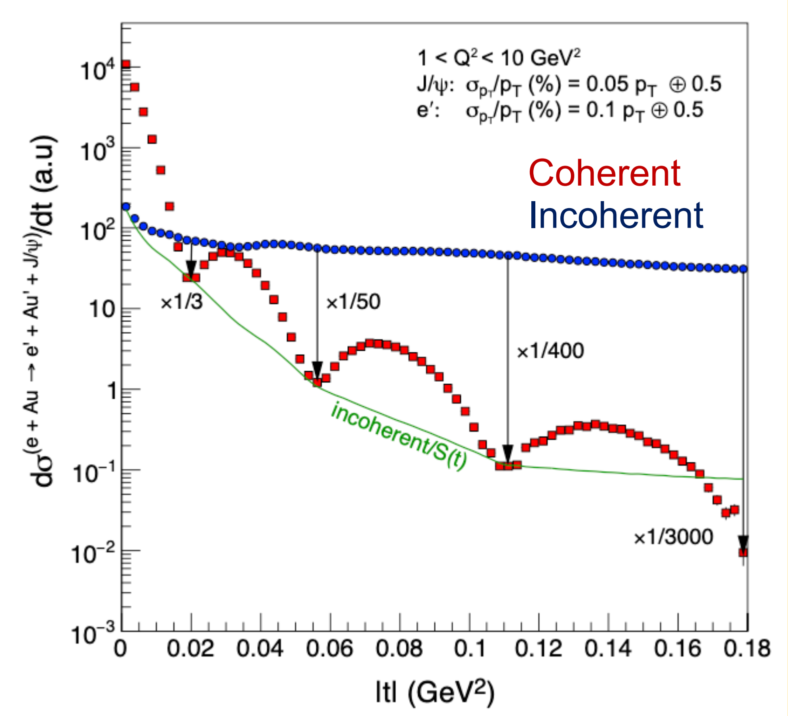

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Found to be worse vetoing efficiency at very low t after changes, but still be enough to suppress incoherent contribution at three minima

Remaining Events

BeAGLE 18x110 GeV^2
Incoherent events
$ePb \rightarrow e' + J/\psi(\mu\mu) + X$

Veto Selections	Surviving Events	
	Before Changes	After Changes
All events	801,464	797,464
Events with one scattered electron identified and $\lvert\eta_{J/\psi}\rvert < 4$	711,795 (100.0 %)	708,248 (100.0 %)
ZDC HCAL tagged	41,751 (**5.86559 %**)	41,666 (**5.88297 %**)
+ RPSF tagged	2,785 **(0.391264 %)**	2,315 **(0.326863 %)**
+ OMD tagged	2,484 (0.348977 %)	2,202 (0.310908 %)
+ B0 tracker tagged	1,994 (0.280137 %)	1,961 (0.27688 %)
+ B0 ecal tagged	1,257 (0.176596 %)	1,205 (0.170138 %)
+ ZDC ECAL tagged	589 (**0.0827485 %**)	637 (**0.0899402 %**)

With 10σ safe distance cut based on ***eAu β @ IP-8 RPSF***

Found to be worse vetoing efficiency at very low t after changes, but still be enough to suppress incoherent contribution at three minima

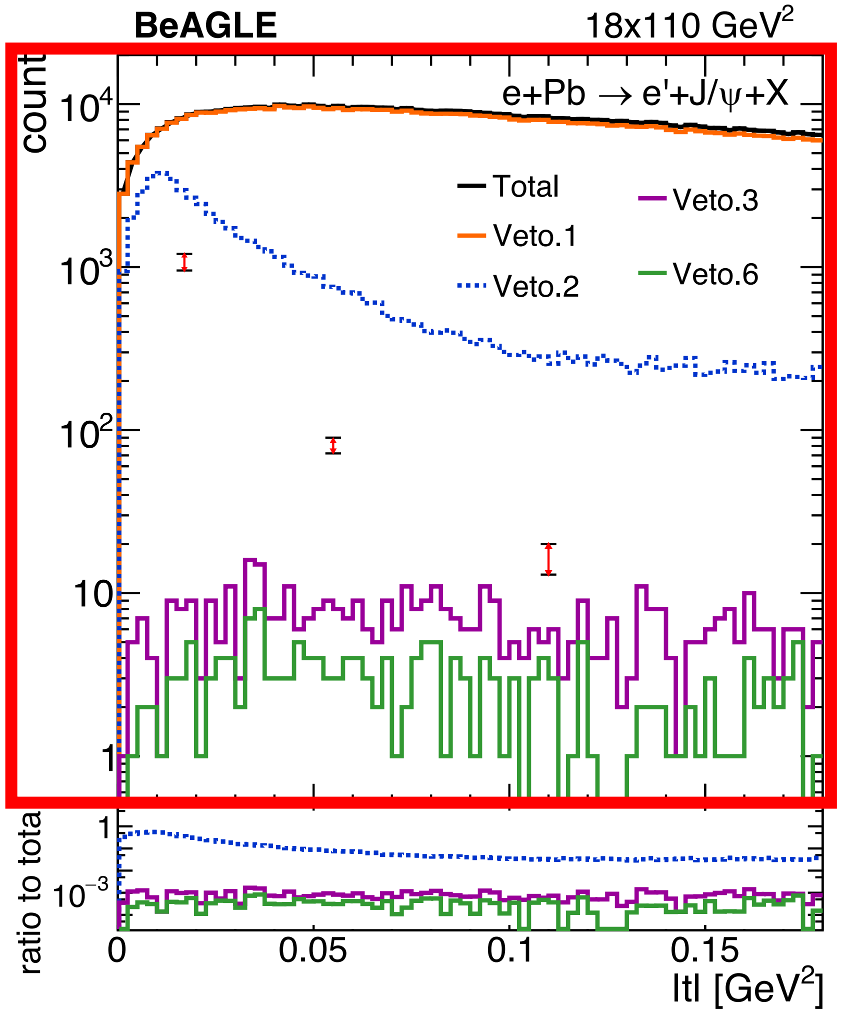
Will proceed to implement beampipe between OMD-ZDC-RPSF to study "beampipe impact" more realistic (next step)

Vetoing Efficiency Comparison to Wan's
: shown different vetoing power and to understand difference between two studies

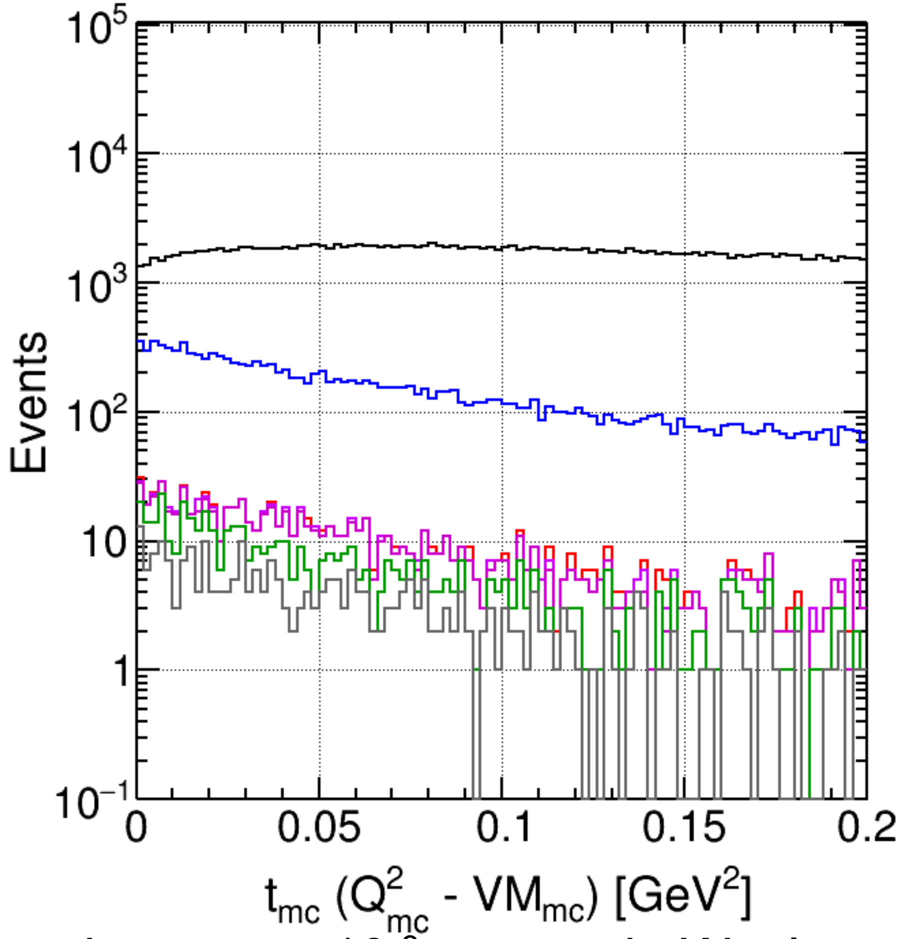
Reminder: t Distribution

BeAGLE 18x110 GeV^2
Incoherent events
$ePb \rightarrow e' + J/\psi + X$

IP-8 EicRoot (Wan Chang)



IP-8 DD4hep (Jihee Kim)



Flat vetoing power 10^{-3} at any t in Wan's result, but in DD4hep simulation it quite different trend at low t

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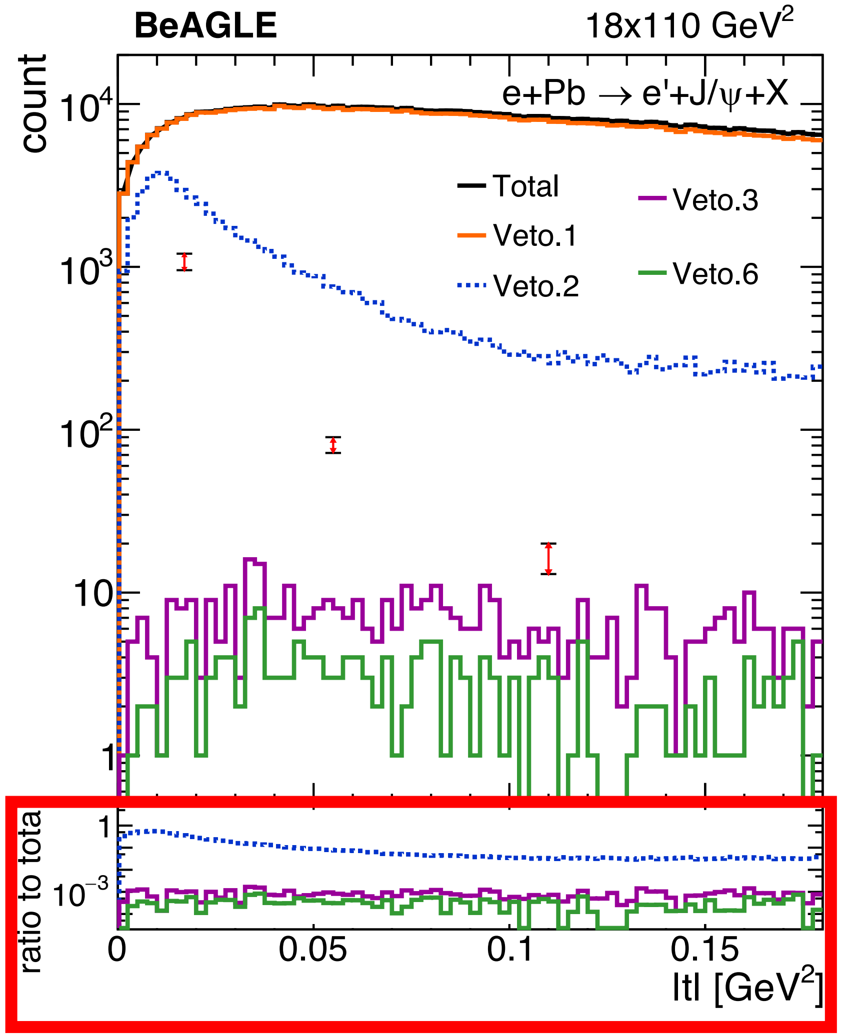

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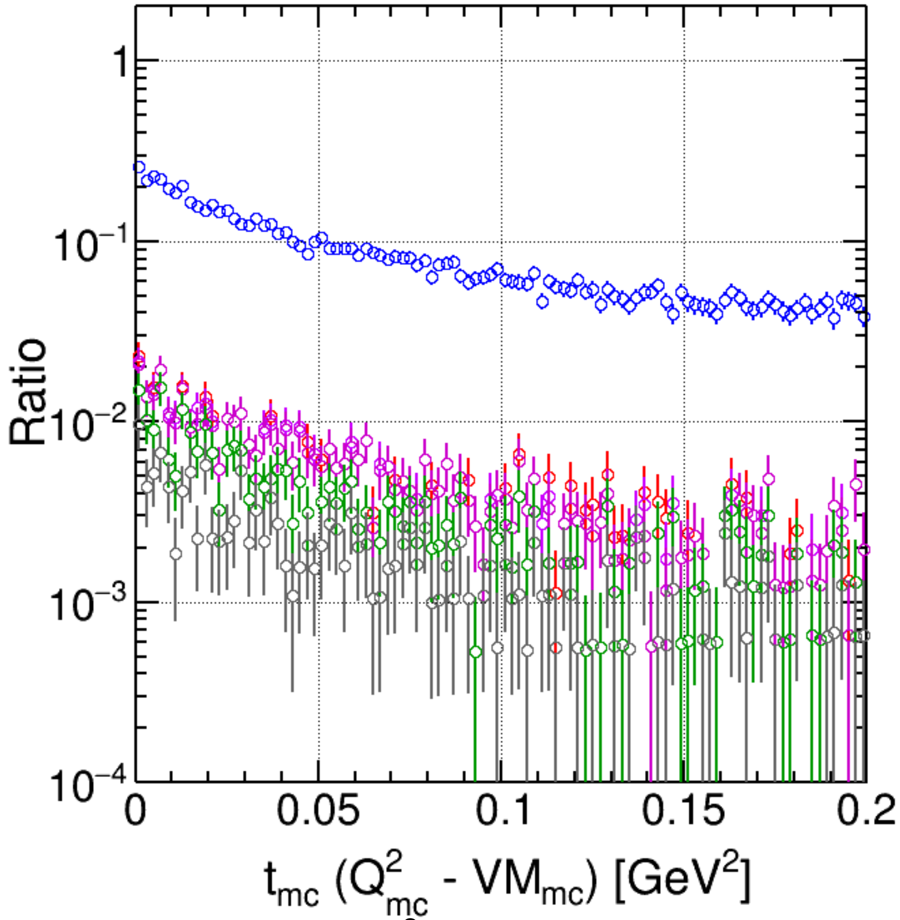

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Comparison with Wan's IP-8 Study

- Located BeAGLE input ROOT files used in Wan's IP-8 study (thanks to Alex)
- Converted into HepMC file and passed through afterburner (thanks to Kolja)
  - Applied proper crossing angle and beam effects as same as my study
  - While converting to HepMC, I got some warnings saying

    "Warning: I am a hadron or lepton with status 2, but I have too many parents. Discarding the older one"
- Ran Wan's input in DD4hep simulation for apple-to-apple comparison
- Use same script to calculate vetoing efficiency
  - When t calculation, used decaying J/Psi directly and same scattered electron procedure
- Compare two results

- FYI, I couldn't run entire her input data, but almost tried to have similar total number of events for vetoing efficiency calculation

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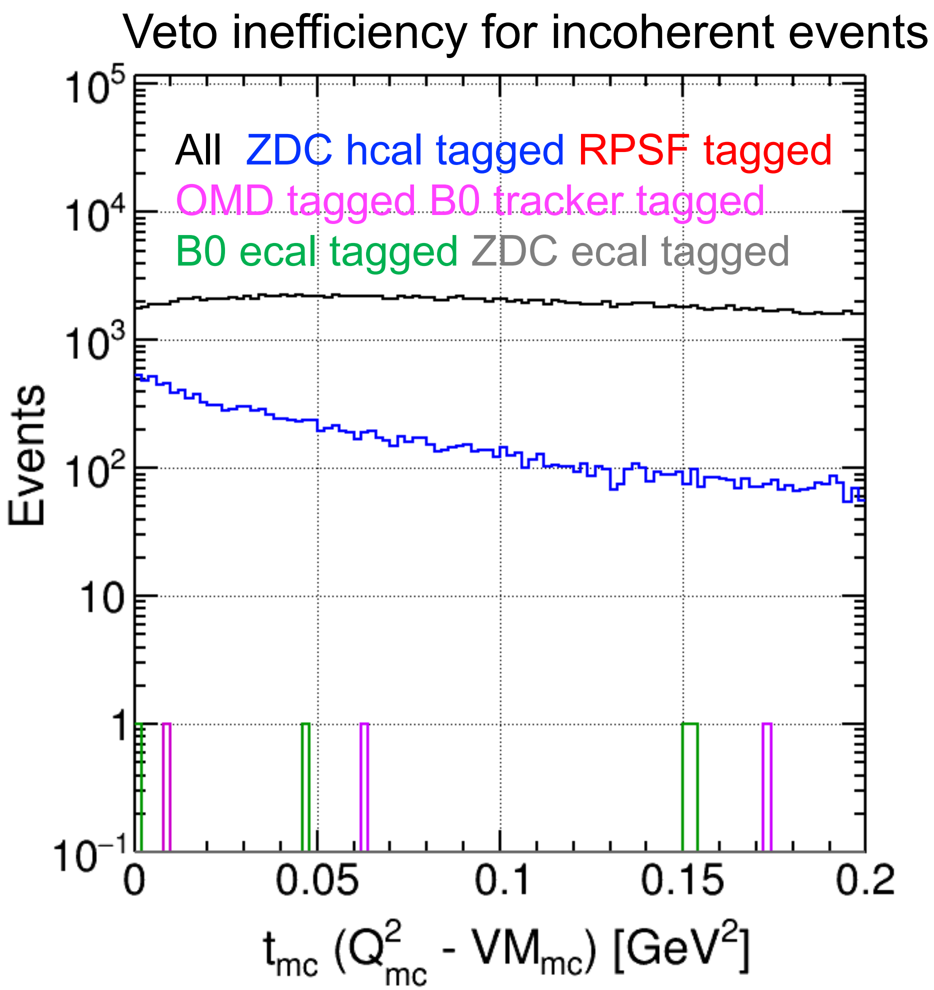
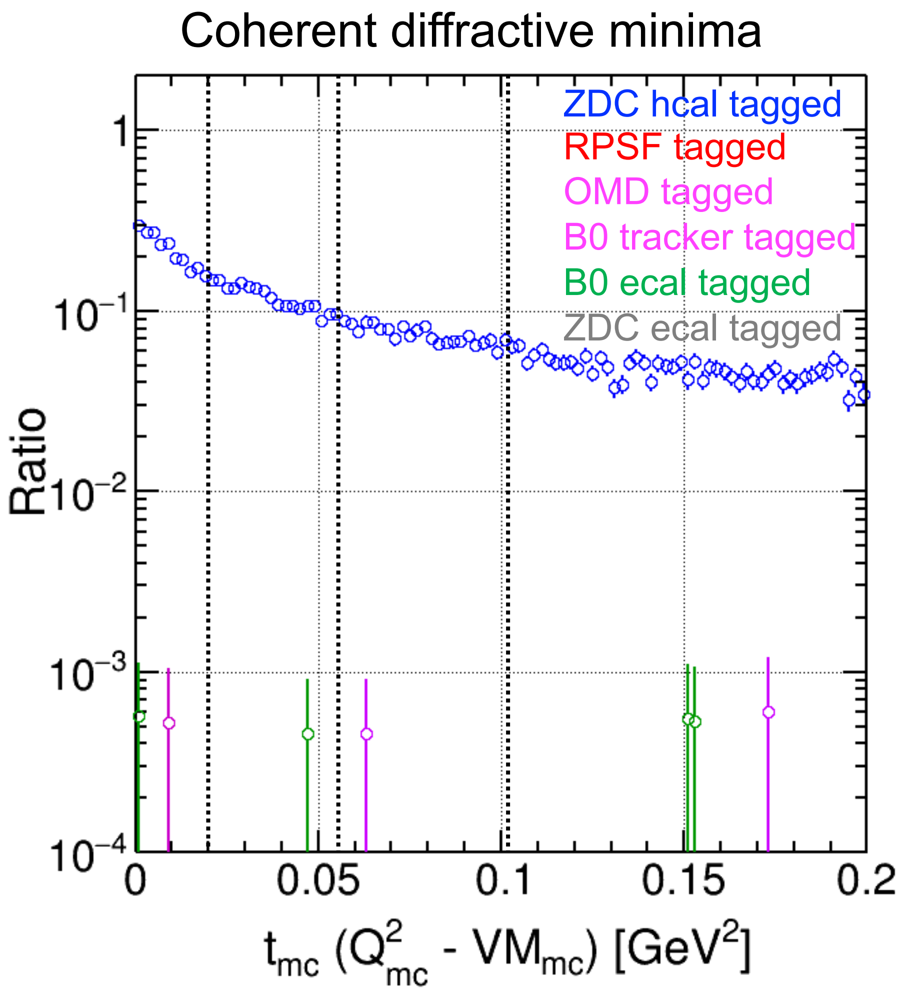
Incoherent events
$ePb \rightarrow e' + J/\psi(\mu\mu) + X$





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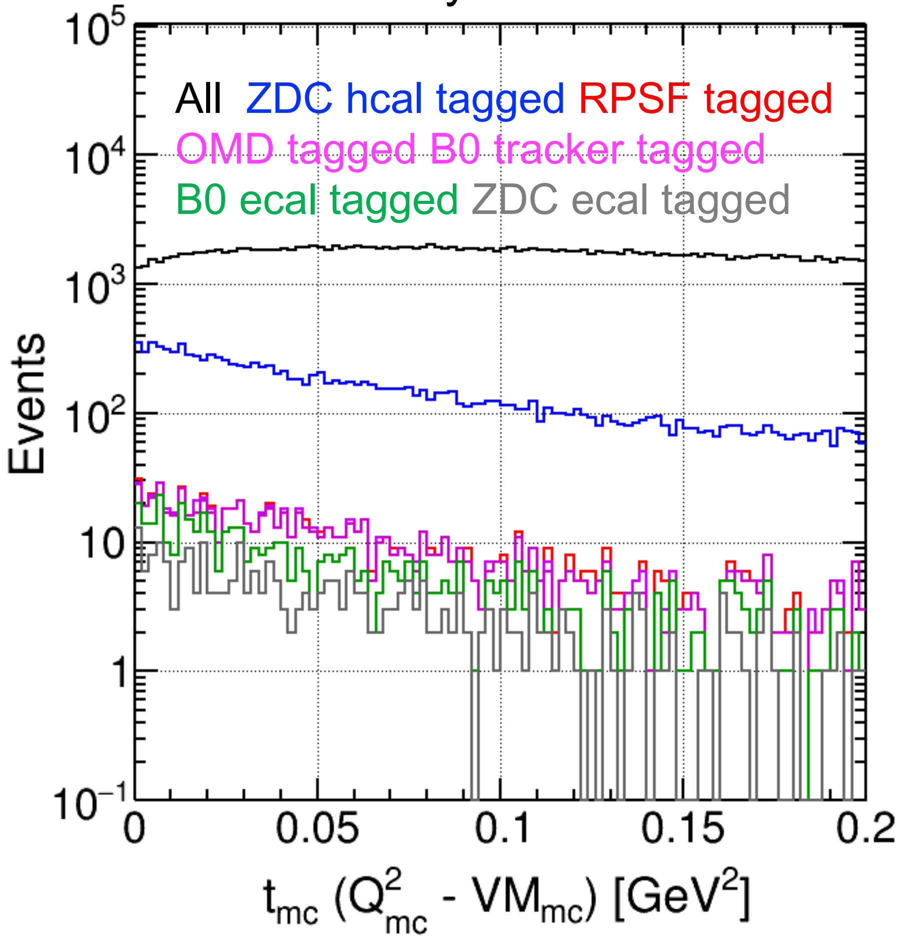
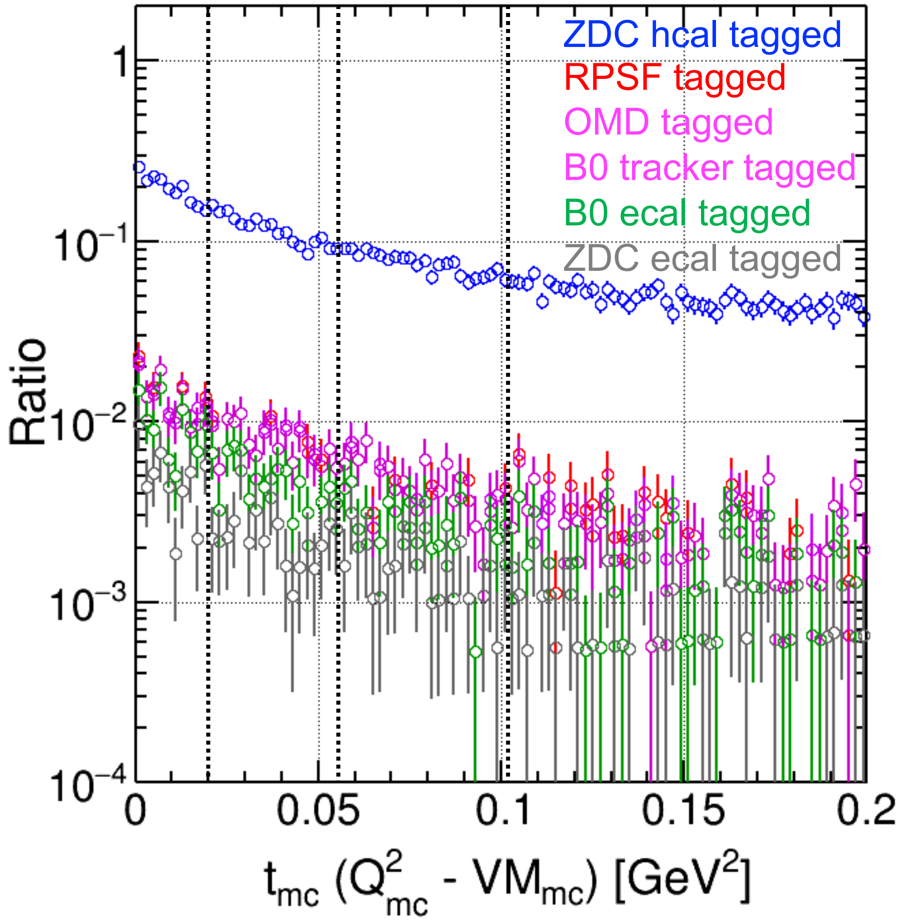
Veto inefficiency for incoherent events



Coherent diffractive minima



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+ OMD tagged	27 (0.00380677 %)	2,202 (0.310908 %)
+ B0 tracker tagged	17 (0.00239685 %)	1,961 (0.27688 %)
+ B0 ecal tagged	9 (0. 00126892%)	1,205 (0.170138 %)
+ ZDC ECAL tagged	1 (**0.000140991 %**)	637 (**0.0899402 %**)

With 10σ safe distance cut based on ***eAu β @ IP-8 RPSF***
Found to be Wan's input (i.e. final state nuclear fragments) very different so that it affects final vetoing efficiency

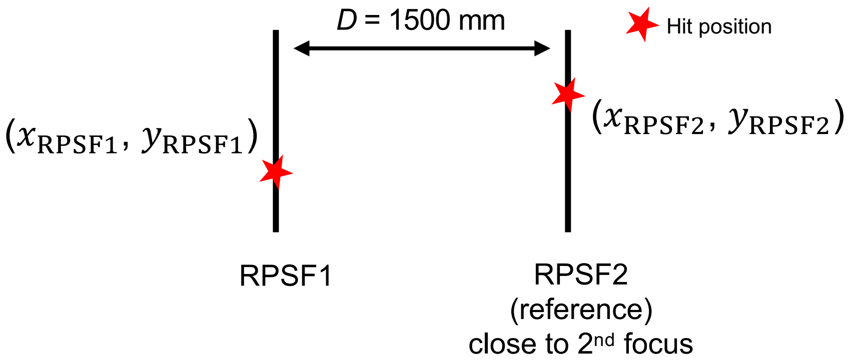
Transfer Matrices at Roman Pot 2nd Focus
(Work in progress)
: to scattered proton reconstruction

Brookhaven National Laboratory

Transfer Matrix at Roman Pot 2nd Focus

- Momentum reconstruction requires transfer matrices to describe particle motion through the magnets
- Ran three trajectories to define transfer matrix at roman pot at secondary focus
  - Central protons with $\boldsymbol{\theta_{x,\,\mathrm{IP}} = 0}$ **mrad** and $\frac{\Delta p}{p}_{\mathrm{IP}} = \mathbf{0}$ to obtain offsets between two planes
  - Protons with $\boldsymbol{\theta_{x,\,\mathrm{IP}} = 1}$ **mrad** and $\frac{\Delta p}{p}_{\mathrm{IP}} = \mathbf{0}$
  - Protons with $\boldsymbol{\theta_{x,\,\mathrm{IP}} = 0}$ **mrad** and $\frac{\Delta p}{p}_{\mathrm{IP}} = \mathbf{1\%}$

*units in mm and mrad



Focusing on purely x-dependent part of matrix assuming x and y are independent for now

$$\begin{pmatrix} \mathbf{4.7} & \mathbf{0.13} \\ \mathbf{0.001} & \mathbf{-0.6305} \end{pmatrix} \begin{pmatrix} \frac{\Delta p}{p} \\ \theta_x \end{pmatrix}_{\mathrm{IP}} = \begin{pmatrix} x \\ \theta_x \end{pmatrix}_{\mathrm{DET}}$$

Work in progress: y-dependent part of matrix

very simple approach to start with

Next Steps

- Implement beampipe between OMD-ZDC-RPSF to study beampipe impact
- Continue evaluating transfer matrices for RPSF to describe particle motion through magnets toward detector for very forward final-state proton reconstruction
  - Move onto t reconstruction, $t = |p - p'|^2$. Maybe start with DVCS ep events
  - See if it works and then move on more refined approach
- How to upload updated IP-8 hadron lattice information on EIC Detector 2 wiki page? *Renee asked at last detector II meeting*