IP-8 Veto Efficiency Update

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What's New

- Re-evaluate IP-8 Vetoing Efficiency with the latest BeAGLE events
  - v1.03.02 ePb 18×110 GeV^2

Approach – Incoherent Vetoing Efficiency

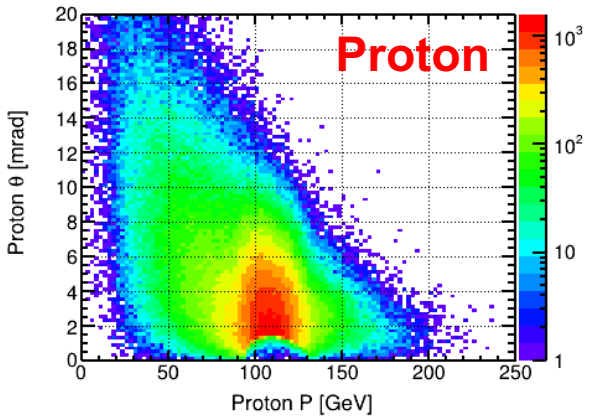
- Understand background to coherent J/ψ production
- Used **BeAGLE** ePb 18×110 GeV incoherent J/ψ events with $1 < Q^2 < 10$
- Passed through **afterburner IP-8 eAu** configuration
- Discarded events having **more than one electron in final state with η < -1**
- Calculated **10σ safe distance cut** based on **eAu β @ IP-8 RPSF** (updated on Dec/2023)
- **Tagged events for nuclear breakups <u>tagging purpose</u>**
  - ZDC Hcal: **any registered RAW hits**
  - RPSF: **one layer (closet to 2nd focus)** has registered RAW hits outside **10σ** safe distance
  - OMD: **two layers** (actual four layers as redundancy) have registered RAW hits
  - B0 Tracker: **at least two out of four layers** have registered RAW hits
  - B0 Ecal: **energy** of all hits greater than **100 MeV**
  - ZDC Ecal**: energy** of all hits greater than **100 MeV**

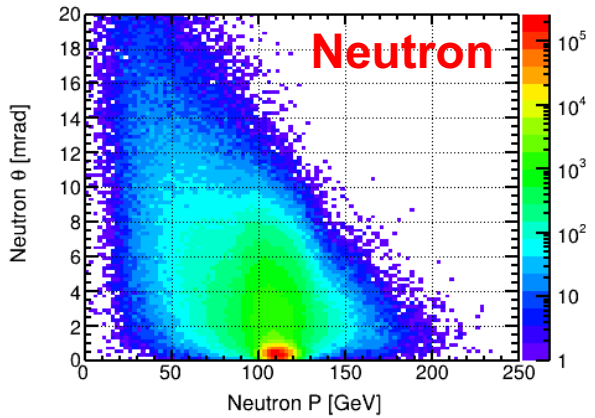
BeAGLE v1.03.02

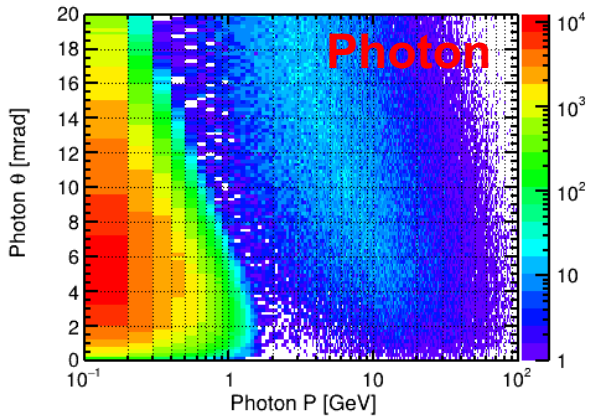
Nuclear Breakups Distribution

BeAGLE 18×110 GeV^2
Incoherent events
$ePb \rightarrow e' + J/\psi + X$

Generated Level	Nuclear Breakups at Final State	Number of Events
	Only Neutrons	7.86 %
	Only Protons	0.0001 %
	Only Photons	3.45 %
	Neutrons + Protons	3.18 %
	Neutrons + Photons	45.41 %
	Protons + Photons	1.85 %
	Neutrons + Protons + Photons	38.25 %







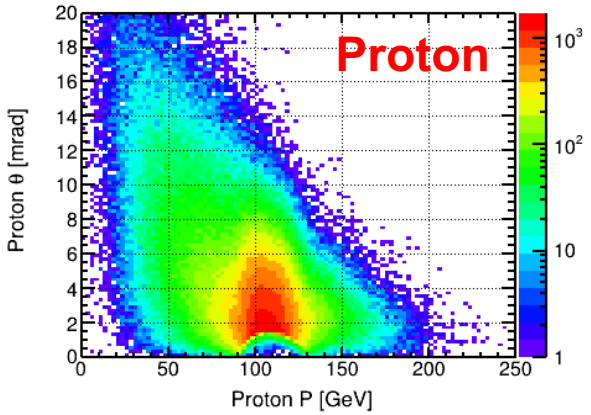
Brookhaven National Laboratory

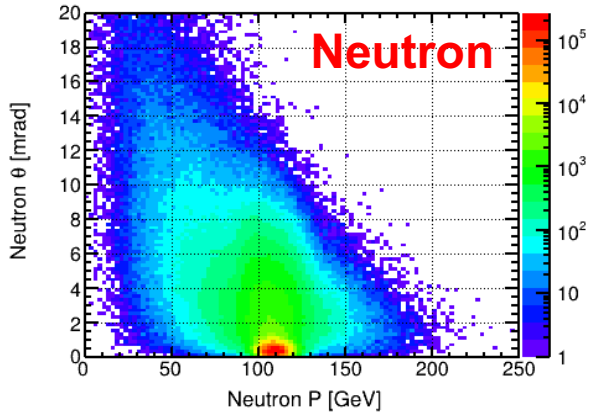
BeAGLE v1.01.04

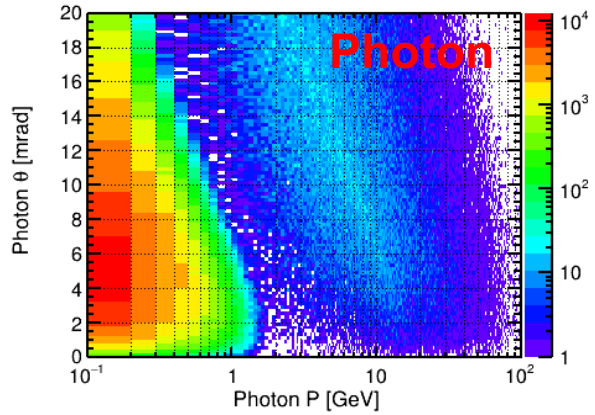
BeAGLE 18×110 GeV^2
Incoherent events
$ePb \rightarrow e' + J/\psi + X$

Nuclear Breakups Distribution

Generated Level	Nuclear Breakups at Final State	Number of Events
	Only Neutrons	7.55 %
	Only Protons	0.0004 %
	Only Photons	3.24 %
	Neutrons + Protons	3.28 %
	Neutrons + Photons	43.98 %
	Protons + Photons	2.24 %
	Neutrons + Protons + Photons	39.72 %





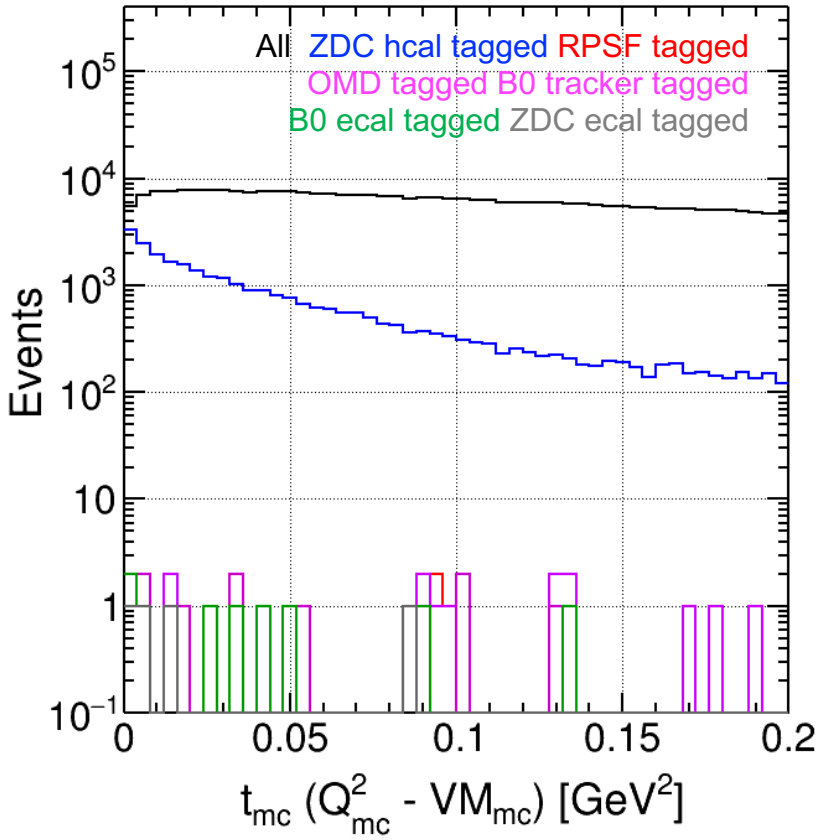


BeAGLE v1.03.02

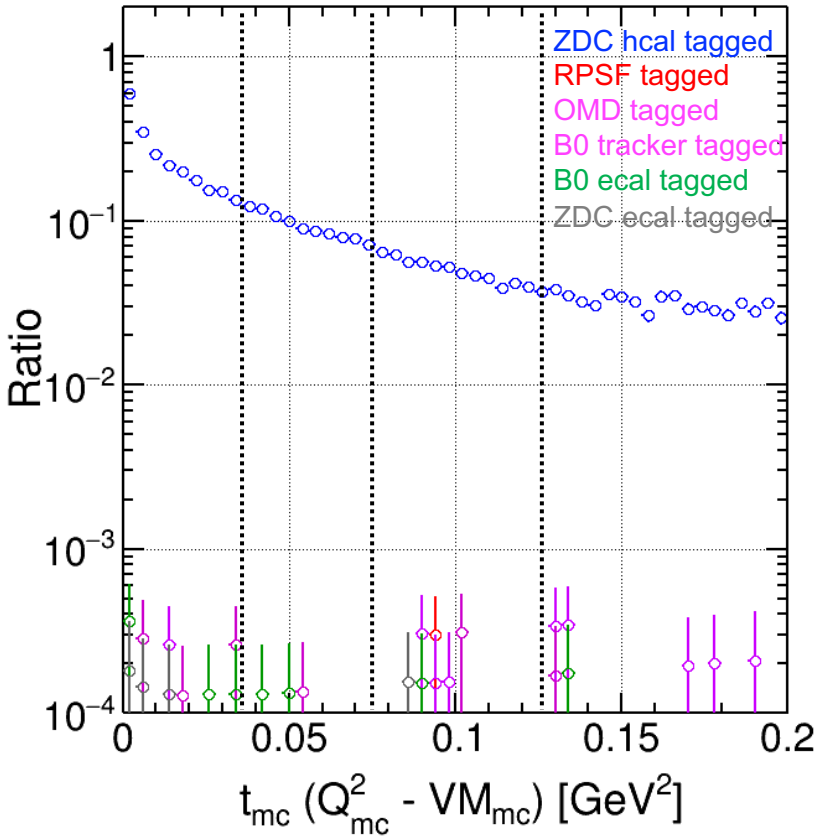
t Distribution

BeAGLE 18×110 GeV^2
Incoherent events
$ePb \rightarrow e' + J/\psi + X$

Veto inefficiency for incoherent events



Coherent diffractive minima



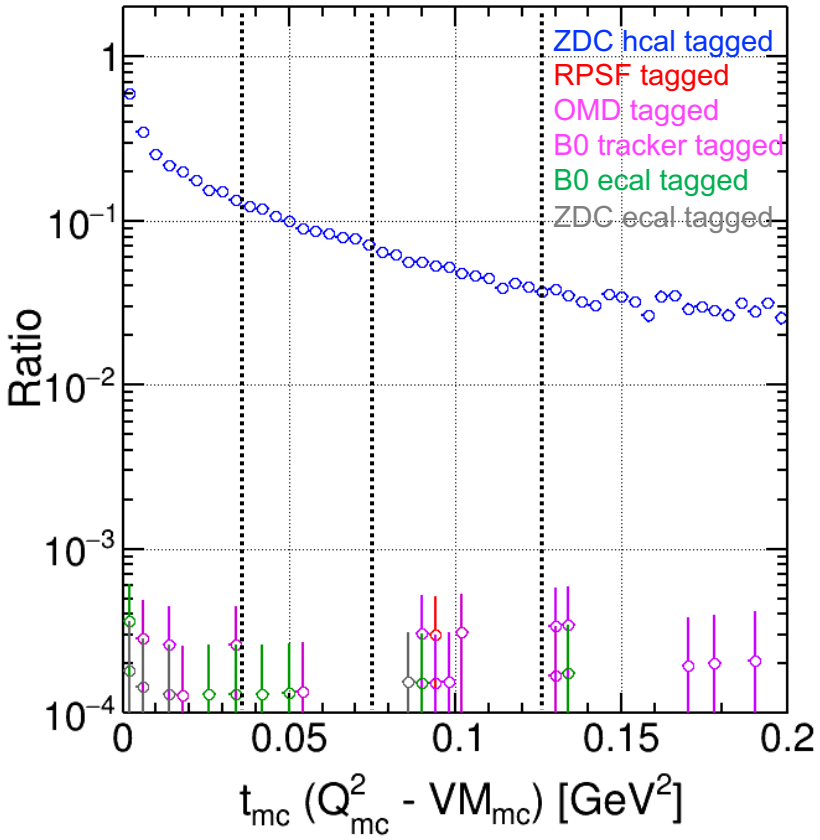
Found to be enough to suppress incoherent contribution at three minima
Vetoing efficiency is about 99.99% at all three minima

BeAGLE v1.03.02

t Distribution

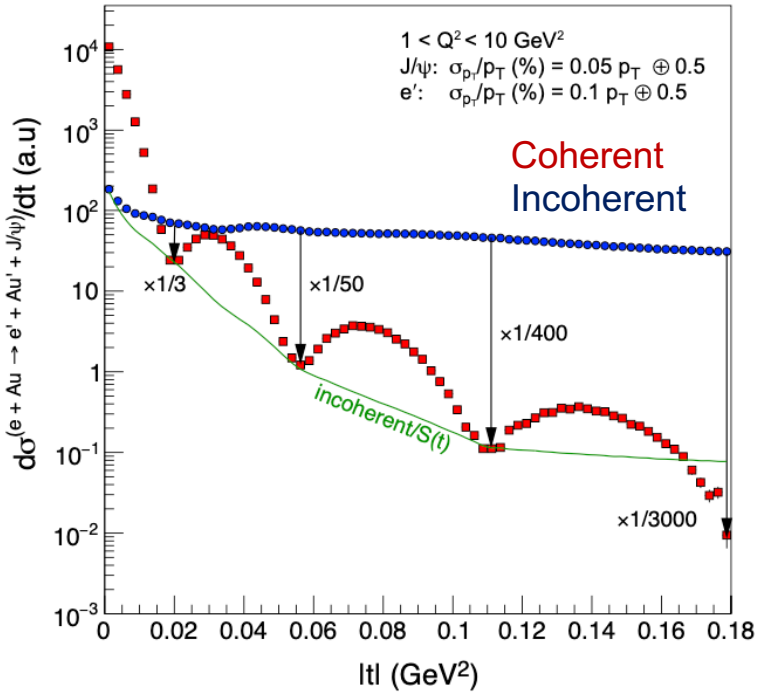
BeAGLE 18×110 GeV^2
Incoherent events
$ePb \rightarrow e' + J/\psi + X$

Coherent diffractive minima



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

BeAGLE v1.01.04

t Distribution

BeAGLE 18×110 GeV^2
Incoherent events
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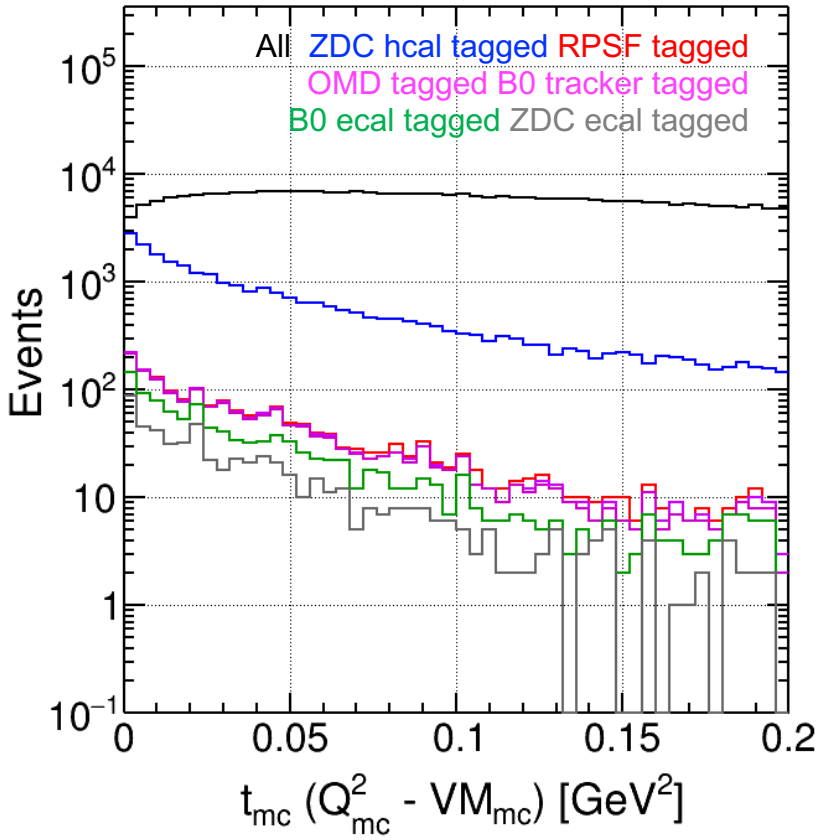
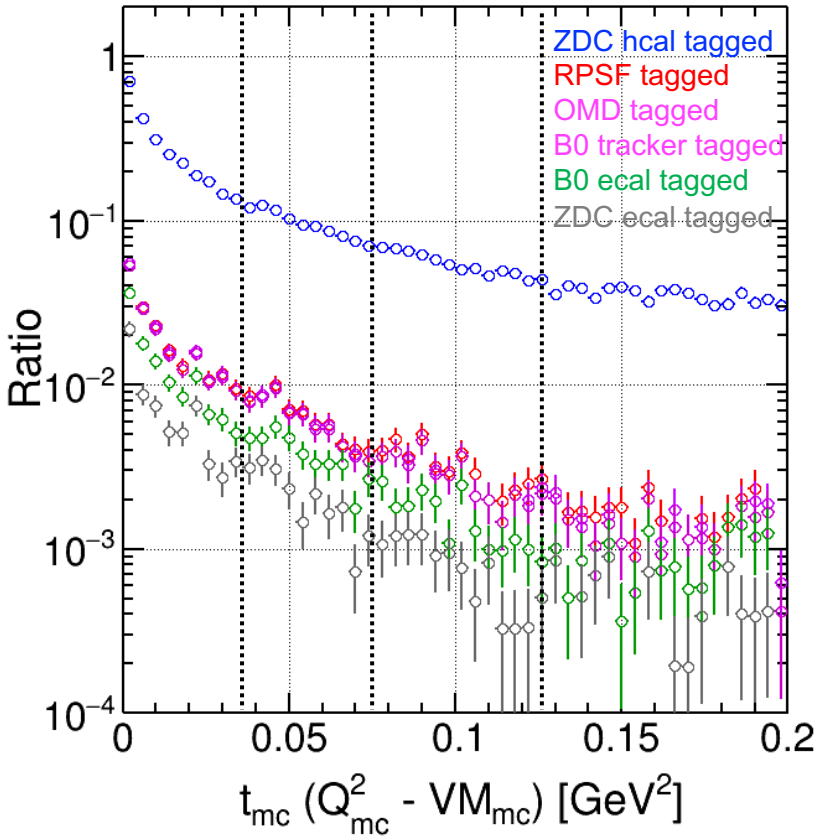
Veto inefficiency for incoherent events



Coherent diffractive minima



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

BeAGLE v1.03.02

Remaining Events

BeAGLE 18×110 GeV^2
Incoherent events
$ePb \rightarrow e' + J/\psi + X$

Veto Selections	Surviving Events
All events	998,161
Events with one scattered electron identified and $\lvert\eta_{J/\psi}\rvert < 4$ and 1 < Q^2 < 10	732,707 (100.0 %)
ZDC HCAL tagged	41,880 (5.71579 %)
+ RPSF tagged	94 (0.0128291 %)
+ OMD tagged	93 (0.0126927 %)
+ B0 tracker tagged	51 (0.00696049 %)
+ B0 ecal tagged	27 (0.00368497 %)
+ ZDC ECAL tagged	15 (**0.0020472 %**)

With 10σ safe distance cut based on ***eAu β @ IP-8 RPSF***
15 of 998,161 events were NOT vetoed

BeAGLE v1.01.04

Remaining Events

BeAGLE 18×110 GeV^2
Incoherent events
$ePb \rightarrow e' + J/\psi + X$

Veto Selections	Surviving Events
All events	801,464
Events with one scattered electron identified and $\lvert\eta_{J/\psi}\rvert < 4$ and $1 < Q^2 < 10$	712,813 (100.0 %)
ZDC HCAL tagged	41,935 (5.88303 %)
+ RPSF tagged	2,325 (0.326173 %)
+ OMD tagged	2,212 (0.31032 %)
+ B0 tracker tagged	1,971 (0.27651 %)
+ B0 ecal tagged	1,213 (0.170171 %)
+ ZDC ECAL tagged	644 (**0.0903463 %**)

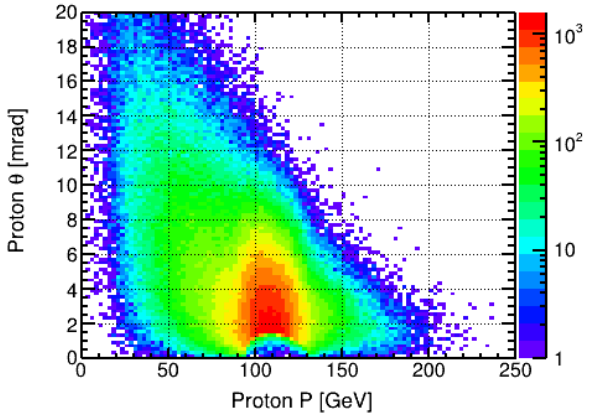
With 10σ safe distance cut based on ***eAu β @ IP-8 RPSF***
644 of 801,464 events were NOT vetoed

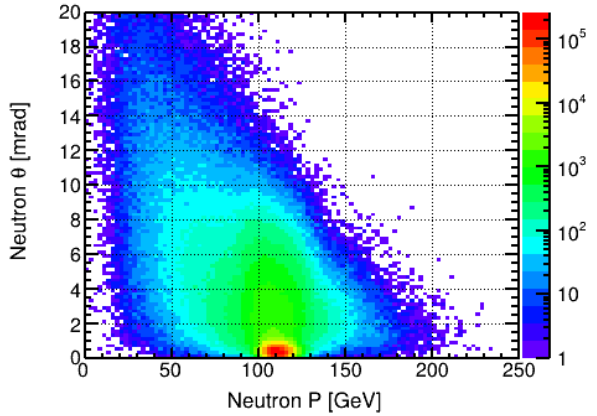
BeAGLE v1.03.02

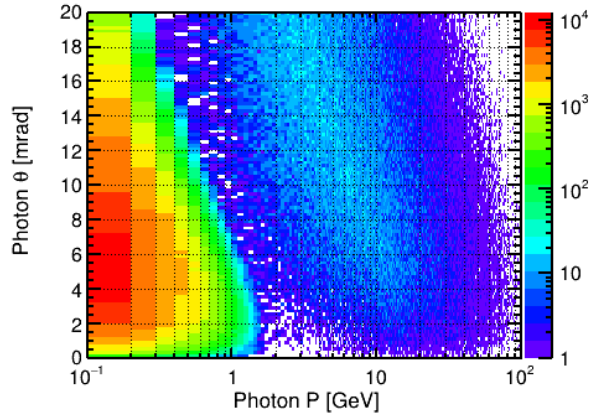
Remaining Events

BeAGLE 18×110 GeV^2
Incoherent events
$ePb \rightarrow e' + J/\psi + X$

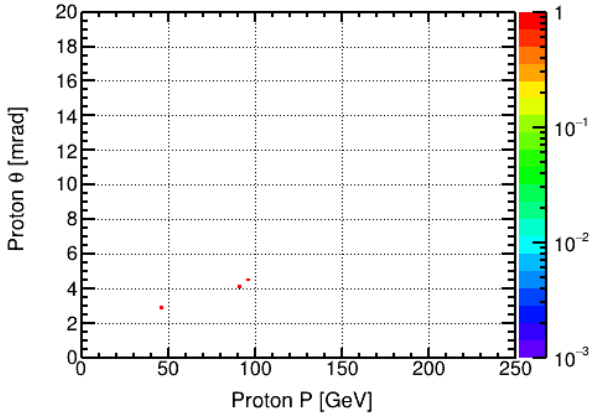
Generated level

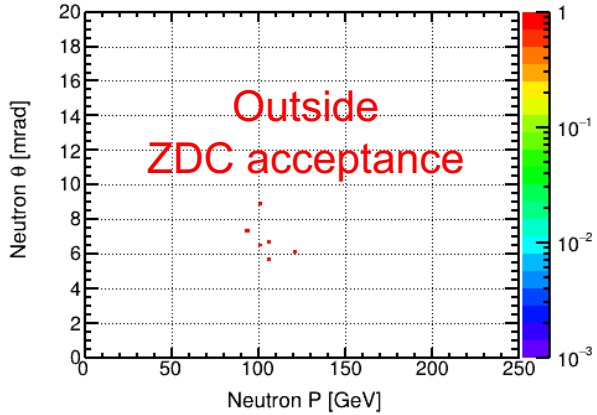


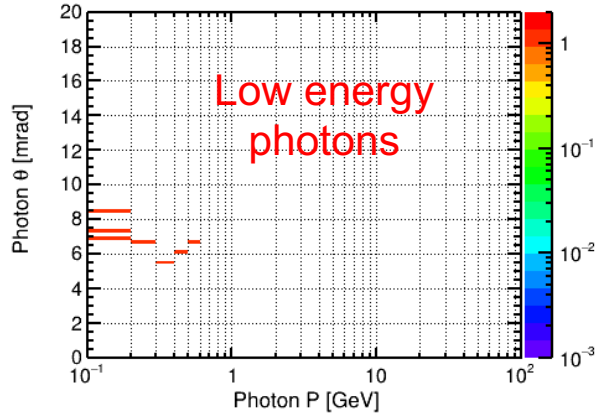




Remained level







BeAGLE v1.01.04

Remaining Events

BeAGLE 18×110 GeV^2
Incoherent events
$ePb \rightarrow e' + J/\psi + X$

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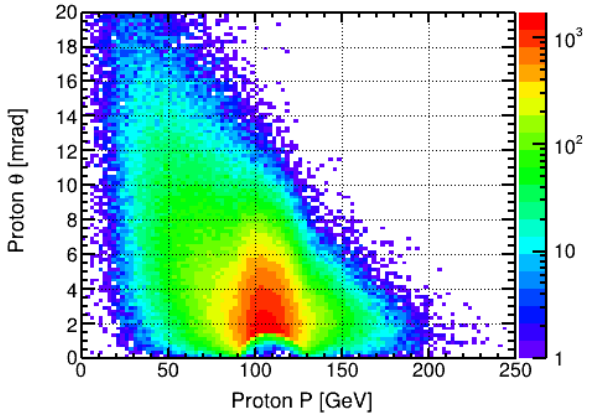
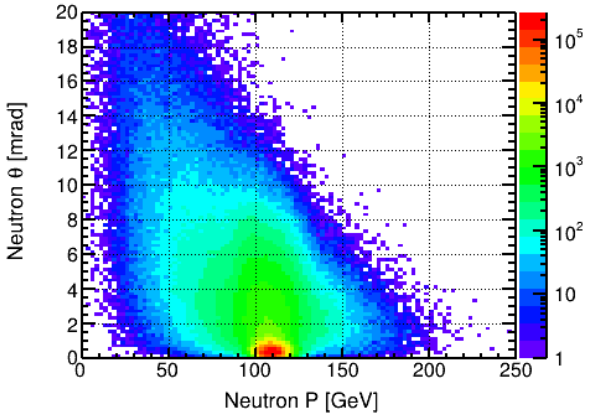
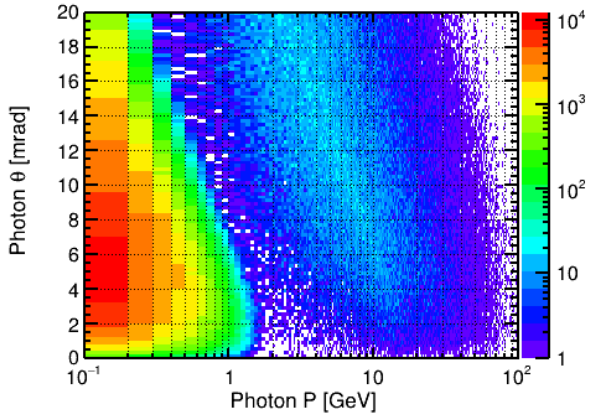
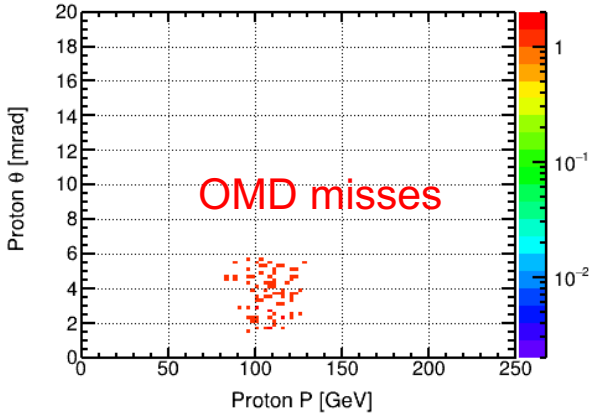
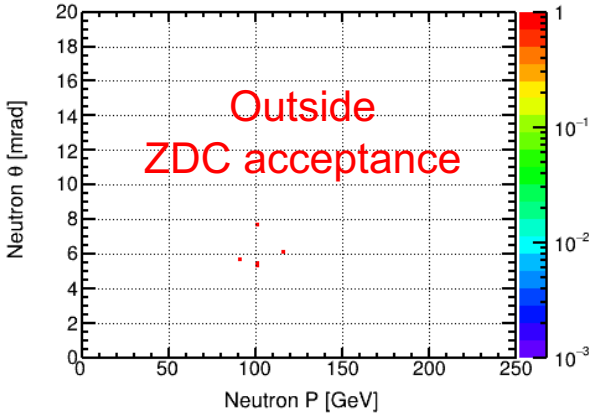


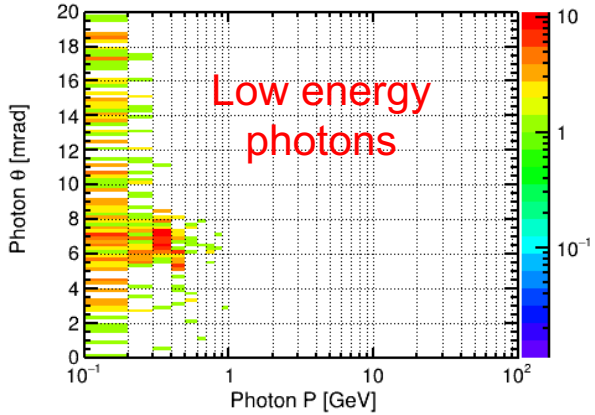




Remained level







Summary and Next Steps

- Re-evaluated IP-8 vetoing efficiency using BeAGLE v1.03.02 ePb 18×110 GeV^2 events
  - Found to be enough to suppress incoherent contribution at three minima

- Will compare it to geometry with beampipe implementation which gives more realistic performance and vetoing power
- Writing up this progress as moving forward
- Would like to look at tagging/vetoing efficiency using far-forward detectors using various nucleus A, especially with an inclusion of secondary focus

Backup Slides

Capture from Wan's Presentation

Vetoing Incoherent Events with IP-8

Wan Chang

2023/09/20

Incoherent diffractive events

Event samples with BeAGLE:

$e + Pb \rightarrow e' + J/\psi + X(p, n, \gamma)$ 18x110 GeV $\tau_0 = 10$ fm

The incoherent J/psi is produced togather with on or more ions, as shown in table:

Produced particle	rate
Only neutron(s)	7.66%
Only proton(s)	0%
Only photon(s)	3.25%
Neutron(s) and proton(s)	3.19%
Neutron(s) and photon(s)	44.24%
Proton(s) and photon(s)	2.27%
Neutron(s), proton(s) and photon(s)	39.39%

- Vetoing forward neutrons, protons and photons.
- Only one particle is needed to be detected for a successful veto.

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Capture from Wan's Presentation

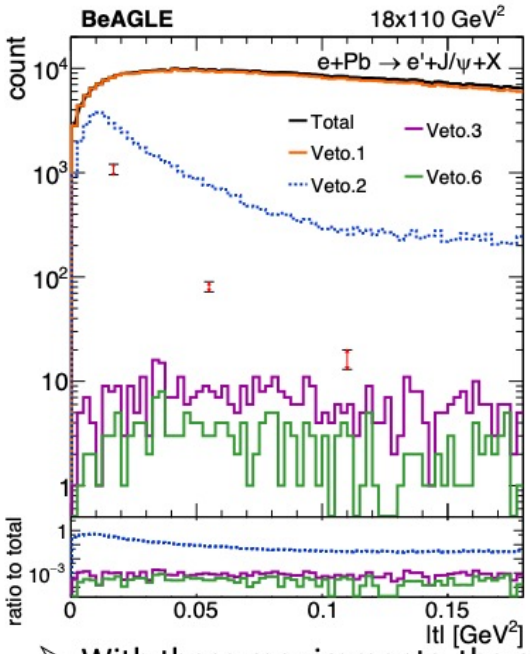
Vetoing Incoherent Events with IP-8

Wan Chang

2023/09/20

Vetoing Incoherent Events

The impact of the different detectors(B0, Roman Pots @ SF, Off-momentum detector, ZDC) in IP-8 is studied by adding one requirement / cut after the other:



Veto.1:
- no activities ($|\eta| < 4.0 \& p_T > 100\,\mathrm{MeV/c}$) other than e^- and J/ψ in the main detector (generator level)

Veto.2:
- veto.1 and no neutron in ZDC;

Veto.3:
- veto.2 and no charged particles in Roman Pots @ SF;

Veto.4:
- veto.3 and no proton in OMD;

Veto.5:
- Veto.4 and no charge particles in B0;

Veto.6:
- Veto5 and no photon *E>50*MeV in ZDC

- With these requirements, the rejection power is found to **enough** to reach the three coherent minima positions from Sartre.

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Capture from Wan's Presentation

Vetoing Incoherent Events with IP-8

Wan Chang

2023/09/20

Vetoing Incoherent Events

Survived event count		
	Count	Ratio to total
Total	1322778	100%
Veto.1	1149549	86.9%
Veto.2	84169	6.36%
Veto.3	1786	0.14%
Veto.4	1786	0.14%
Veto.5	1438	0.11%
Veto.6	685	0.05%

Veto.1:
- no activities ($|\eta| < 4.0 \& p_T > 100\,\mathrm{MeV/c}$) other than e^- and J/ψ in the main detector (generator level)

Veto.2:
- veto.1 and no neutron in ZDC;

Veto.3:
- veto.2 and no charged particles in rpsf;

Veto.4:
- veto.3 and no proton in OMD;

Veto.5:
- Veto.4 and no charged particles in B0;

Veto.6:
- Veto5 and no photon *E>50*MeV in ZDC

Difference between Wan's and Jihee's

- BeAGLE sample
  - Wan: v1.01.01
  - Jihee: v1.03.02 (old one v1.01.04)
  - Big changes (excitation energy related to breakups process) made in BeAGLE generator (v1.03.01 Aug/2023)
- 10σ cut at Roman Pot Secondary Focus

	σ_x	σ_y
Wan	0.328283	0.085217
Jihee (updated Dec/2023)	0.146677	0.140271