# Tagging coherent vector-meson production events at the EIC

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California EIC Consortium Meeting
UCLA
January 9, 2025

# Outline

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1. Motivation and Good-Walker paradigm
2. Details BeAGLE dataset
3. Incoherent event tagging efficiency study

    How well can we tag incoherent events at ePIC?

4. Comparisons between Pb and Au

# Good-Walker paradigm

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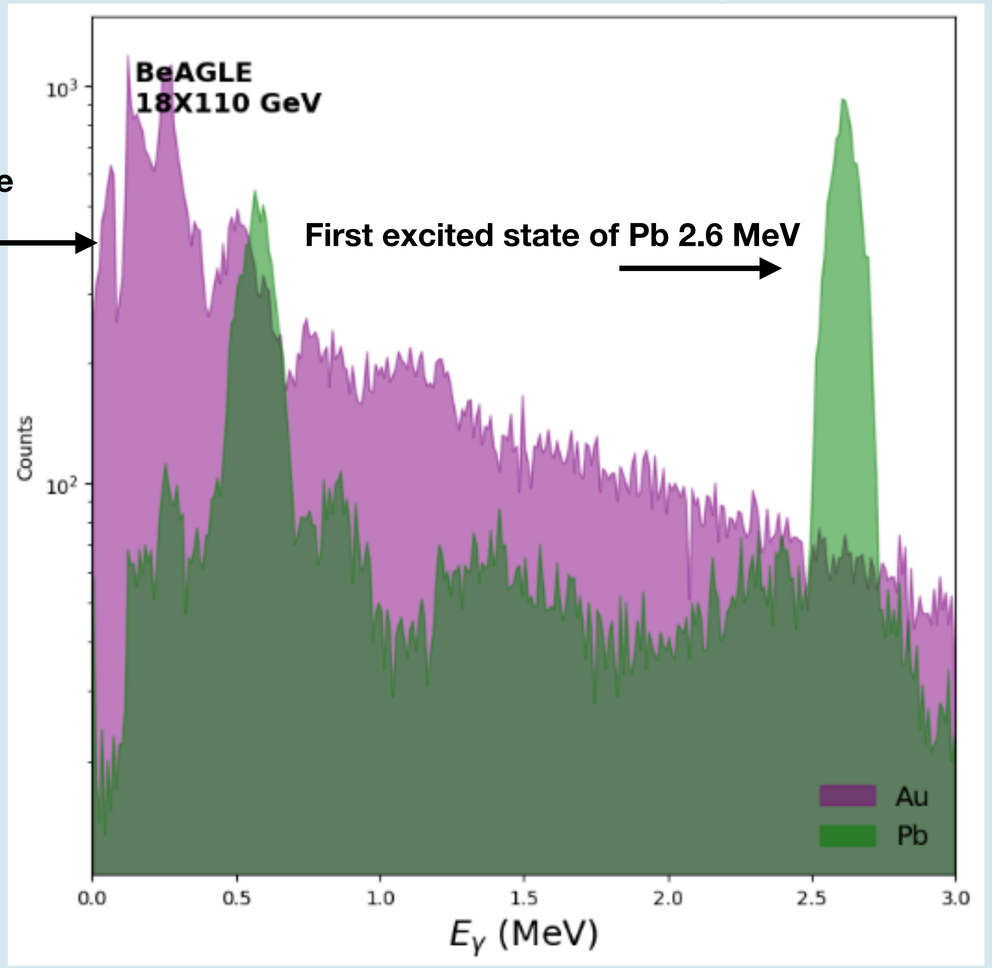
- Coherent exclusive vector meson production events are sensitive to the transverse gluon distribution within the nucleus
- Incoherent events are sensitive to event-by-event fluctuations
- Even nuclear excitations are incoherent, and the Good-Walker paradigm breaks down
- Measuring these photons coming from nuclear de-excitations can serve as a means of tagging incoherent events

# Event Generation

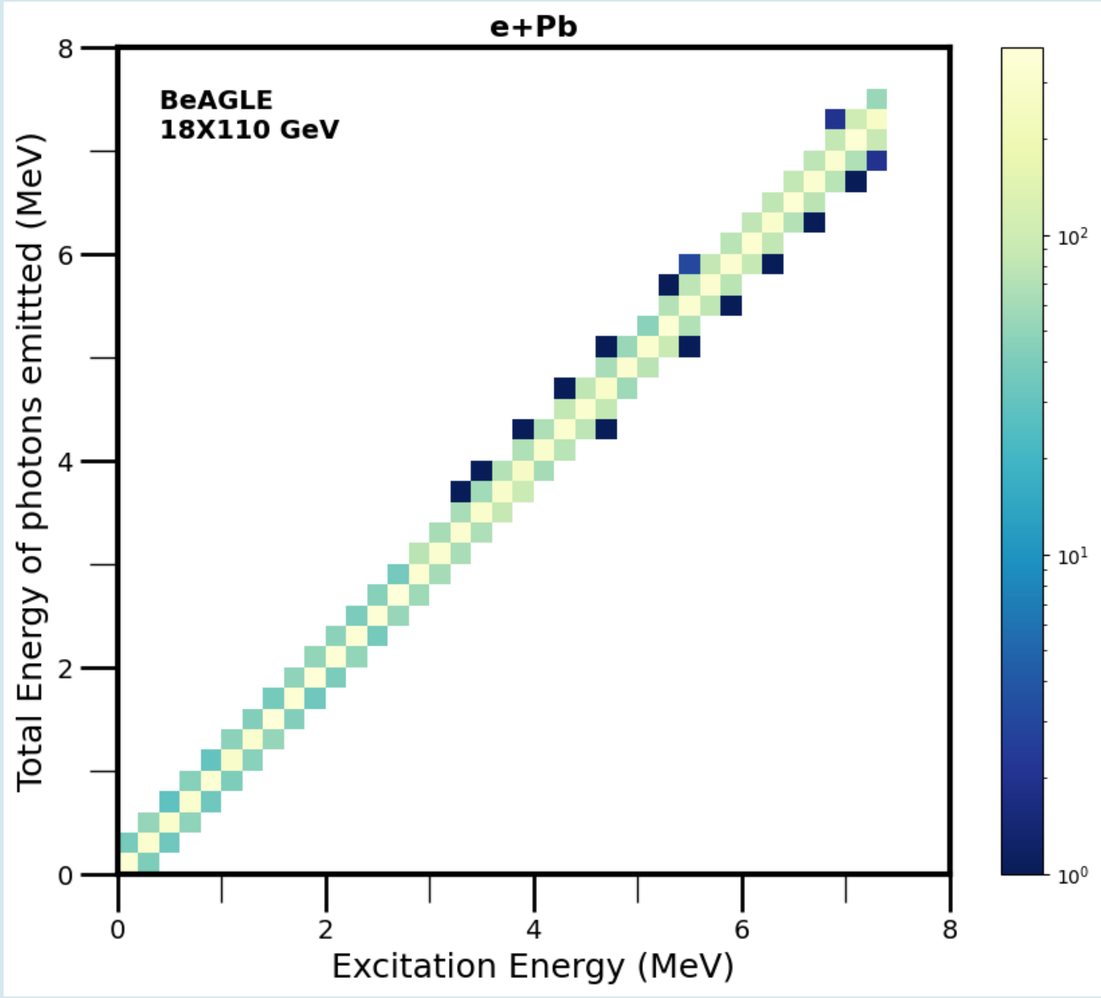
- Use BeAGLe to generate ~ 20 000 events with $J/\Psi$ production
  - e+Pb 18x110 GeV
  - e+Au 18x110 GeV
- Force the nucleus to remain intact (ARemn = 208, 197)
- Select only photons whose parent ID is a nucleus
- Is there a target species that is preferred for VM production?

(In target rest frame)



# Excitation energy

- We can then plot the excitation energy against the total energy of diffractive photons in the event
- Very well correlated
- Can conclude we are properly selecting photons coming from nuclear excitations



# Number of photons in each event

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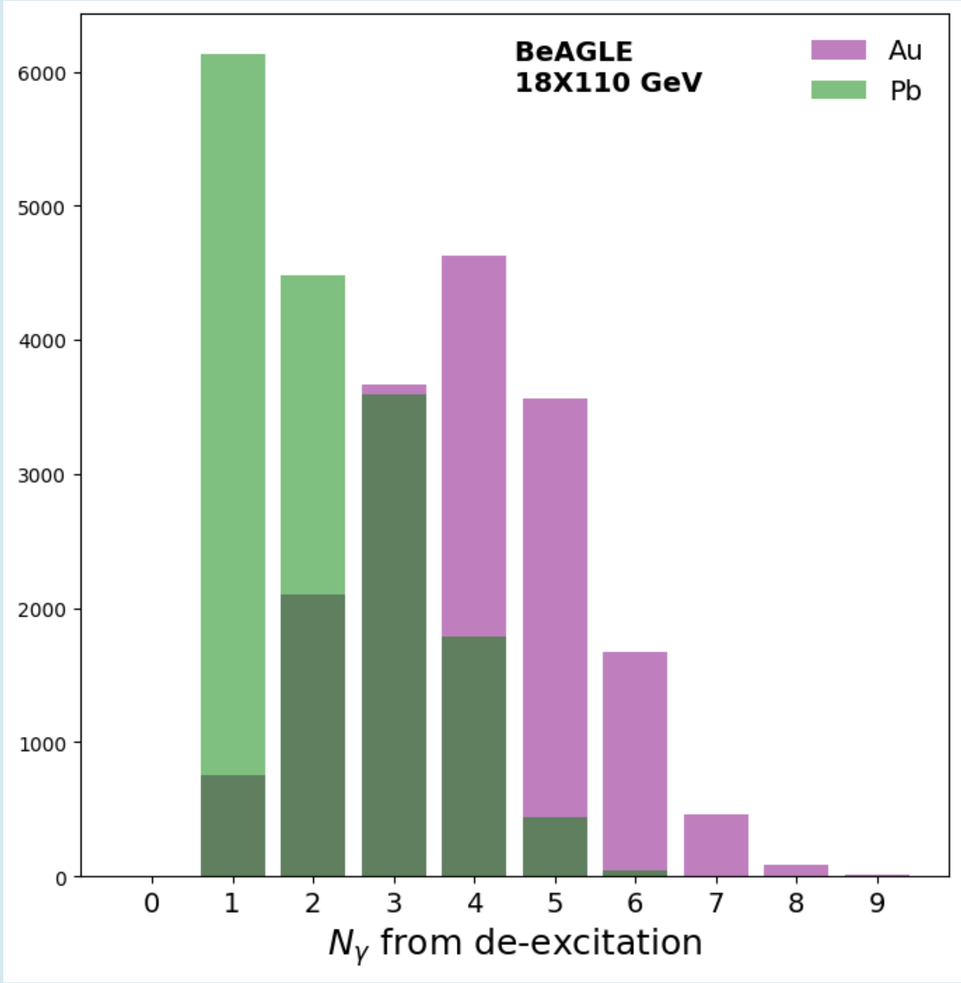
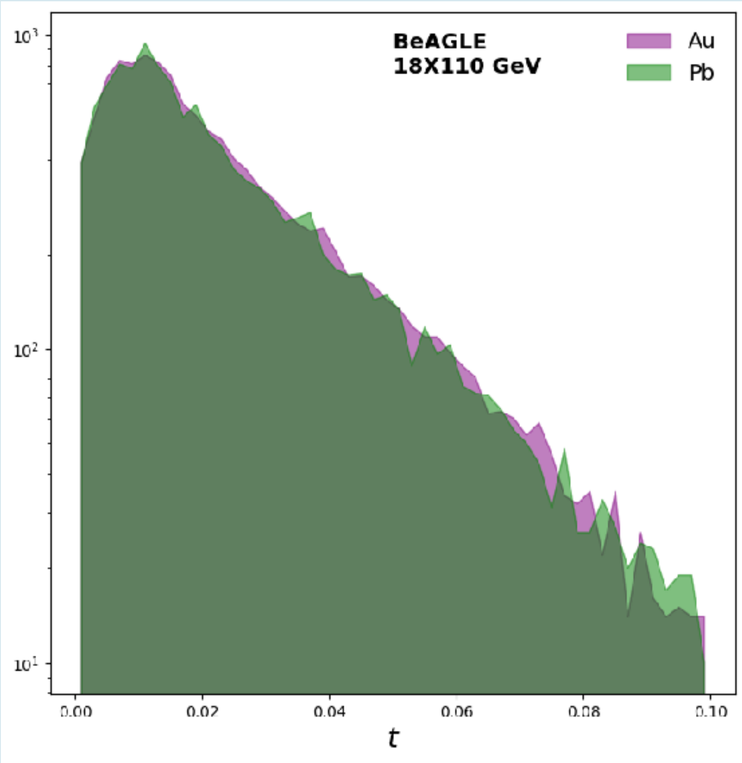
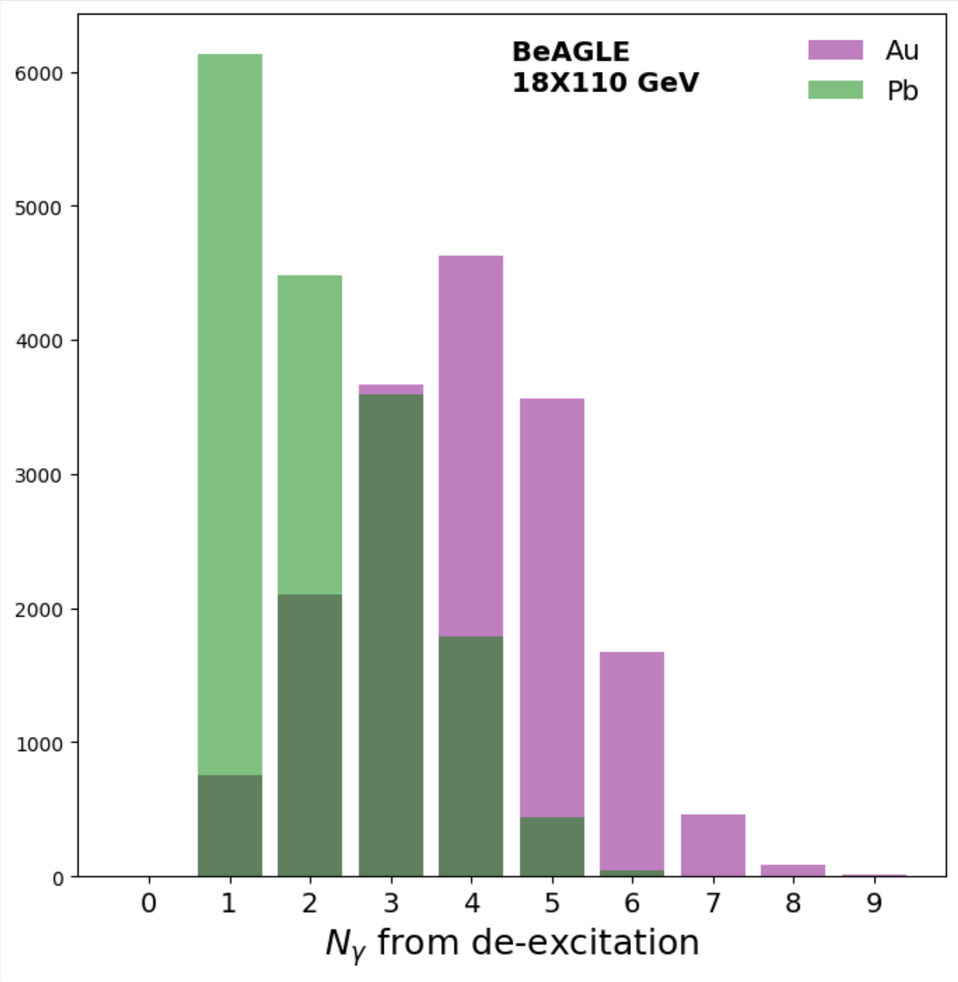
- We see Pb typically emits 1 photon, Au around 5 or 6



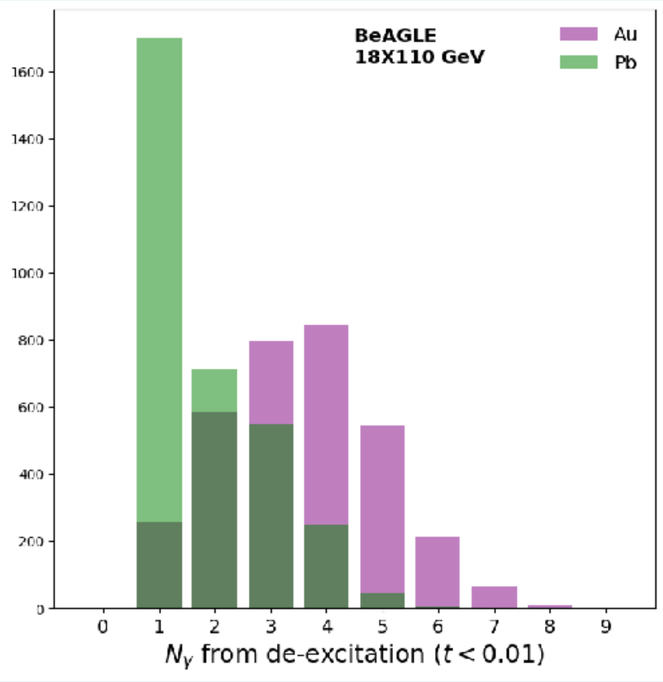
# Number of photons in each event

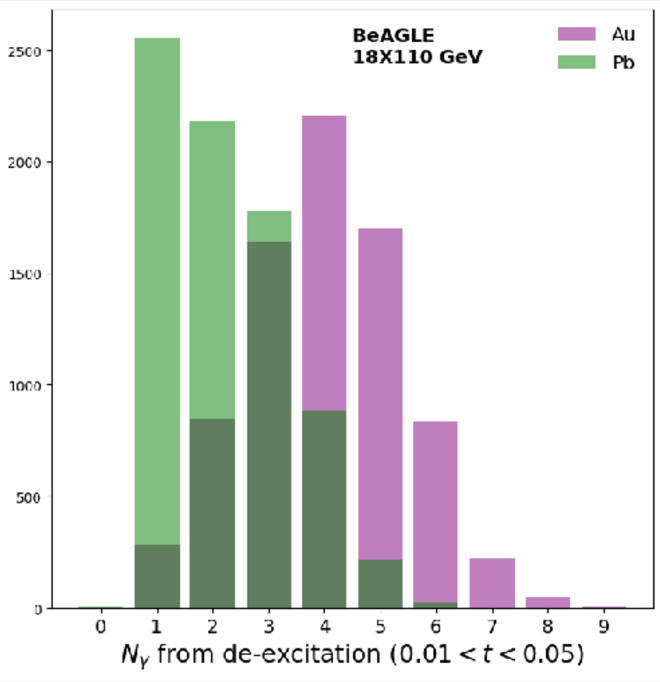
- We see Pb typically emits 1 photon, Au around 5 or 6
- How does this plot behave as a function of *t*?

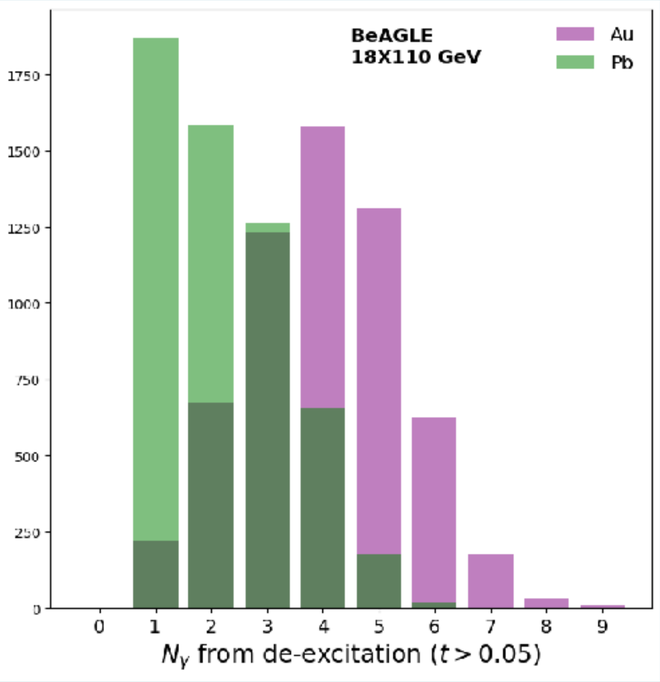


# Number of photons in each event




- As $t$ increases, the collision becomes more violent and we produce more photons

# How well can we tag incoherent events?

# How many of photons do we see in ZDC?

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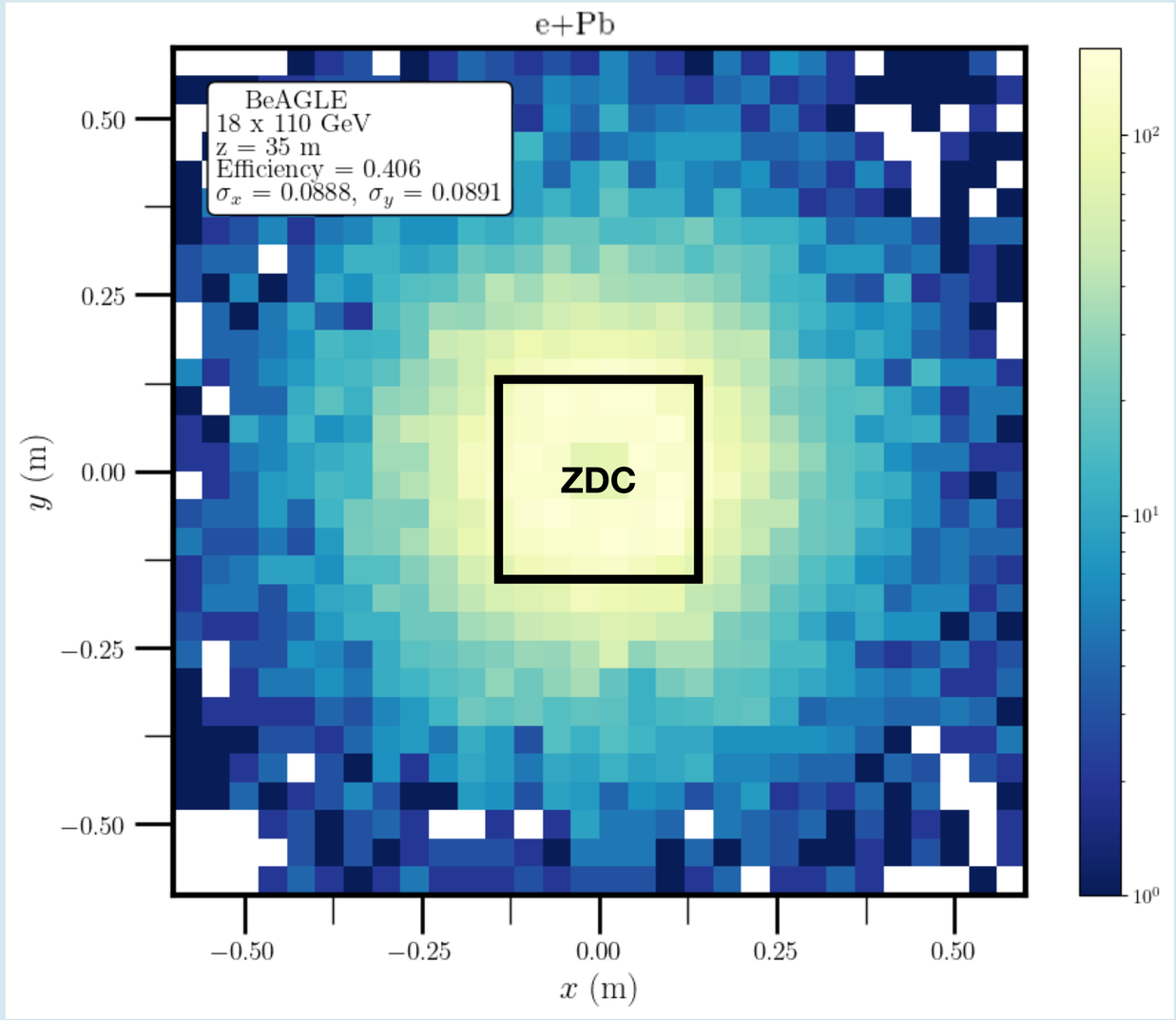
- Select on the plane $Z$ = 35 m
- Select photon with highest $\eta$ in each event
- Plot the $X$-$Y$ distribution of the photons
- Effective area of ZDC: 17x17 cm
- Can tag around 40% of events as incoherent in fiducial region of ZDC



# How many photons do we see in B0?

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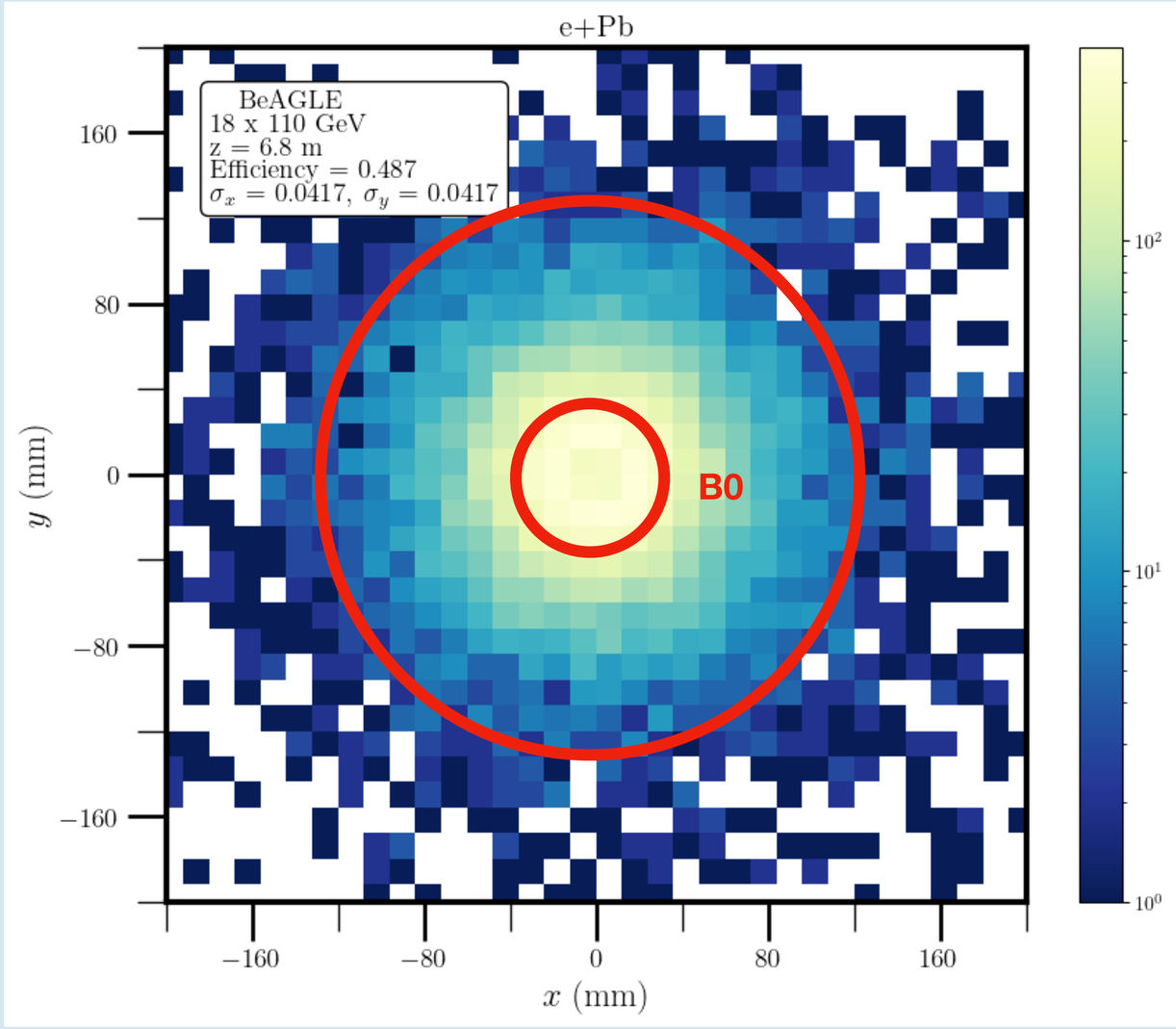
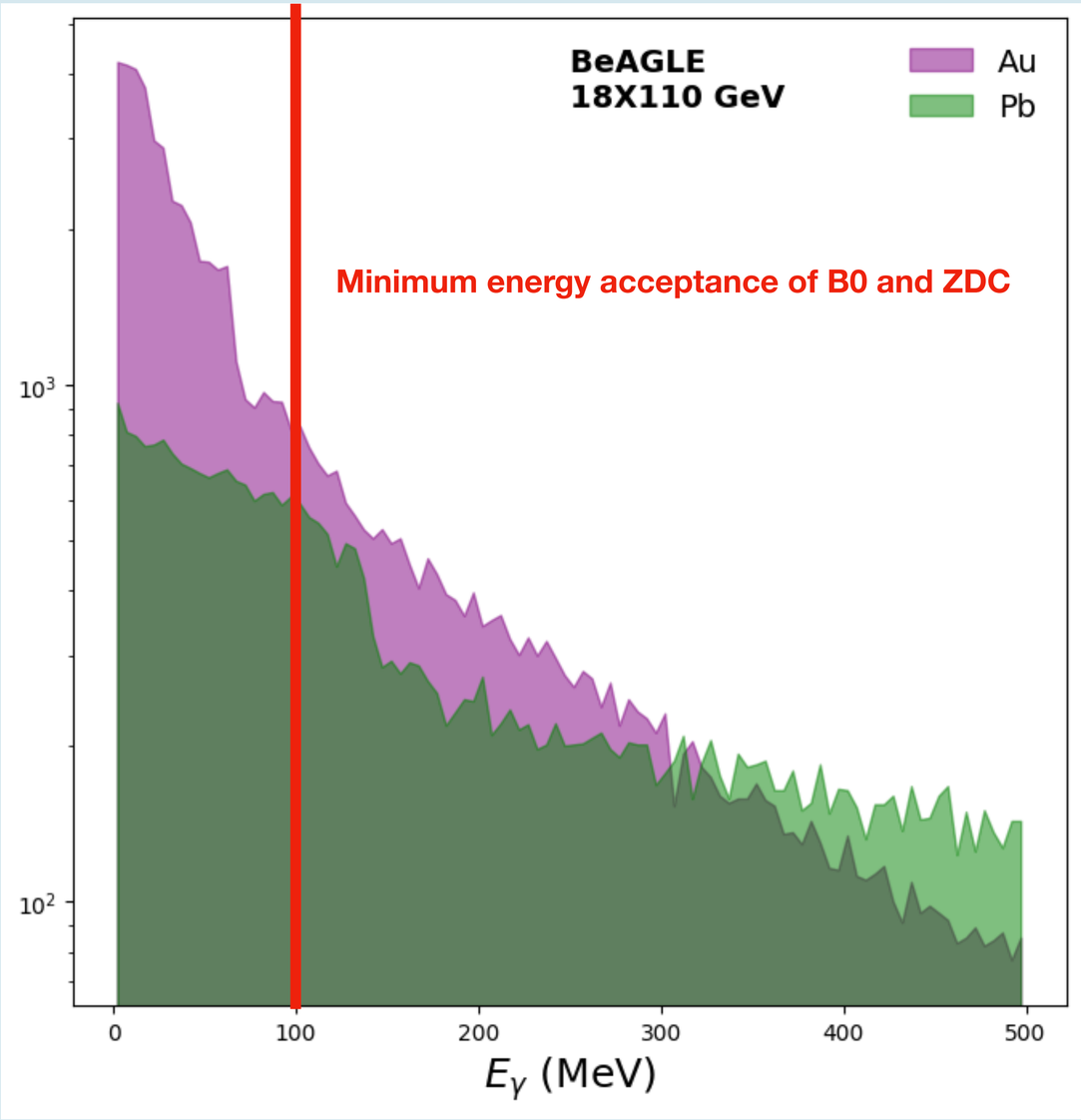
- We catch around half of the photons in the B0 at the z = 6.8 m plane
- Inner radius:  40 mm
- Outer Radius 150 mm
- Have not accounted for irregular geometry
- We see around a 50% incoherent event tagging efficiency in the B0



# Accounting for minimum energy threshold

- The ZDC and B0 will be able to see photons with energies (roughly) greater than 100 MeV
- Select photon with the highest $\eta$ whose energy in the lab frame is greater than 100 MeV



# What about with gold?

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- Gold has some excited states that are very long lived
- 77 KeV → 1.91 ns
- 409 KeV → 7.73 s
- The nucleus will travel far down the beampipe before it emits these photons
- If we want to make a similar plot, we should first cut them out

Excited Nuclear States for Au-197 (

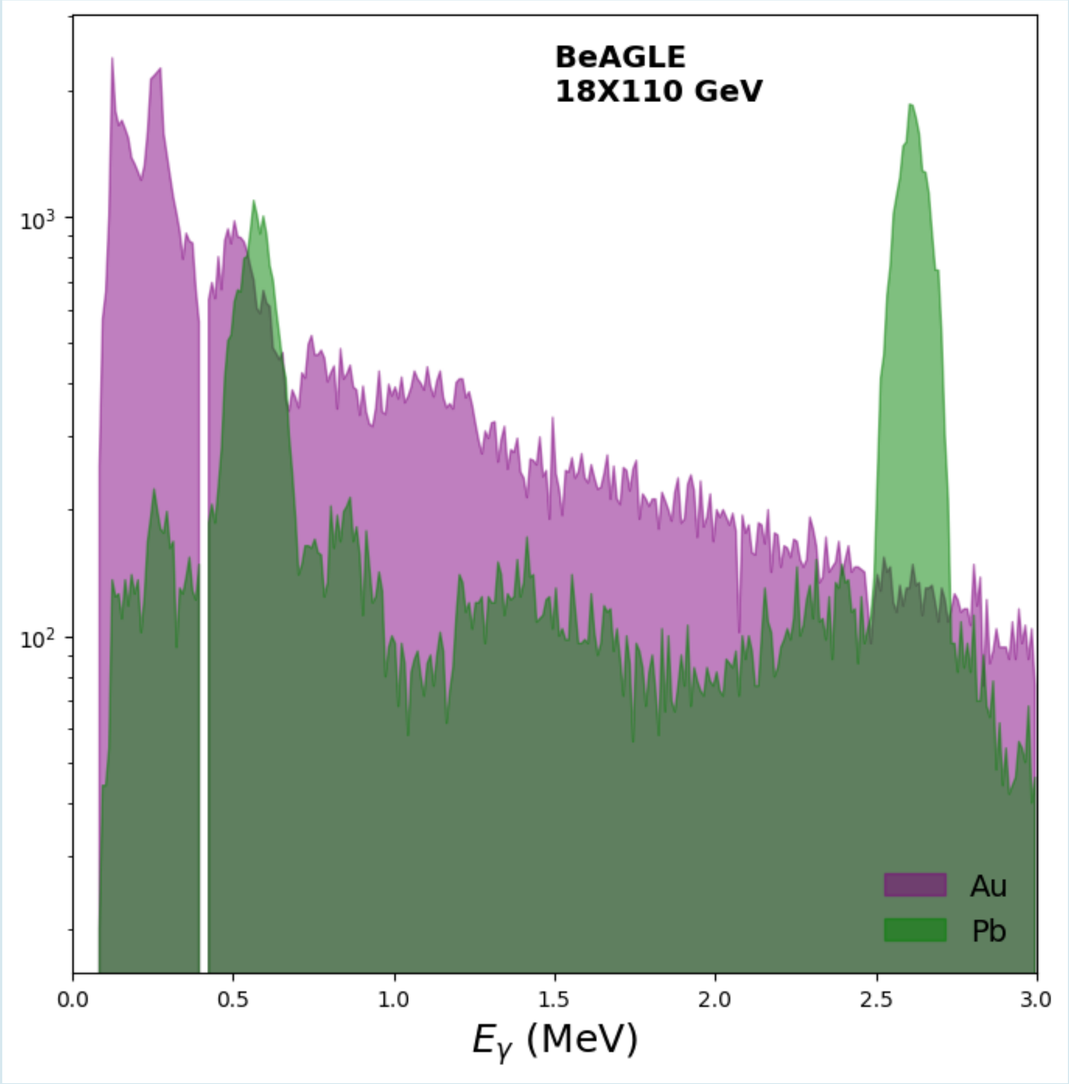
Energy levels

| $E^*$ [keV] | $2J^\pi$ | $\mu$ | $Q$ | $T_{1/2}$ or $\Gamma_{cm}$ |
|---|---|---|---|---|
| 0.0[a] | $3^+$ | +1.145746(9) | +0.547(16) | Stable |
| 77.351(2) | $1^+$ | +0.420(3) | | 1.91(1) ns |
| 268.788(10) | $3^+$ | | | 15.4(13) ps |
| 279.00(5)[A] | $5^+$ | +0.53(5) | | 18.6(15) ps |
| 409.15(8)[B] | $11^-$ | ⟨+⟩5.98(9) | +1.68(5) | 7.73(6) s |
| 502.52(13) | $5^+$ | +3.0(5) | +3.0(5) | 1.77(+19-12) ps |
| 547.5(2)[a] | $7^+$ | +0.53(7) | | 4.61(+19-13) ps |
| 583.86(17)[C] | ⟨$7^-$⟩ | | | |
| 736.84(15) | $7^+$ | +1.7(5) | +1.7(5) | 1.09(+13-9) ps |
| 767.09(23)[B] | ⟨$15^-$⟩ | | | |
| 855.6(2)[A] | $9^+$ | +1.5(5) | +1.5(6) | 2.67(+25-15) ps |
| 882(5) | | | | |
| 888.11(20) | $1^+$ | | | |
| 935.96(14) | ⟨$5^+$⟩ | | | |
| 947.86(20)[C] | ⟨$9^-$⟩ | | | |
| 1003.56(21)* | ⟨$13^-$⟩ | | | |
| 1045.05(16) | ⟨$7^+$⟩ | | | |
| 1059.67(21)* | ⟨$9^+$⟩ | | | |
| 1118.80(19)* | | | | |
| 1150.54(16) | $3^+$,$5^+$ | | | |
| 1217.28(22) | ⟨$3^+$⟩ | | | |
| 1220(10) | | | | |
| 1231.7(3)[a] | $11^+$ | +2.0(10) | | 0.91(1) ps |
| 1242.02(22) | ⟨$1^+$⟩ | | | |

# What about with gold?

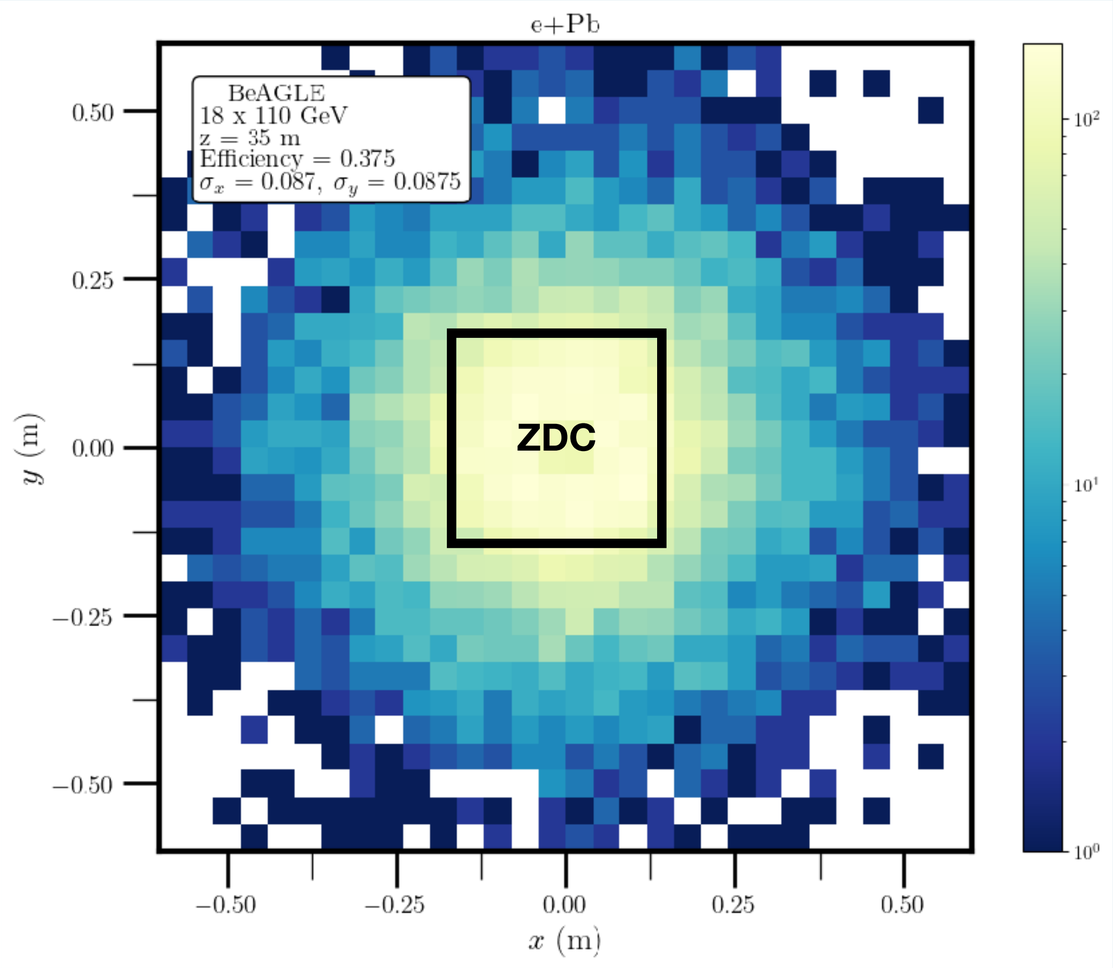
- Gold has some excited states that are very long lived
- 77 KeV → 1.91 ns
- 409 KeV → 7.73 s
- The nucleus will travel far down the beampipe before it emits these photons
- If we want to make a similar plot, we should first cut them out
- For 409 KeV peak, have not accounted for decays to higher energy levels

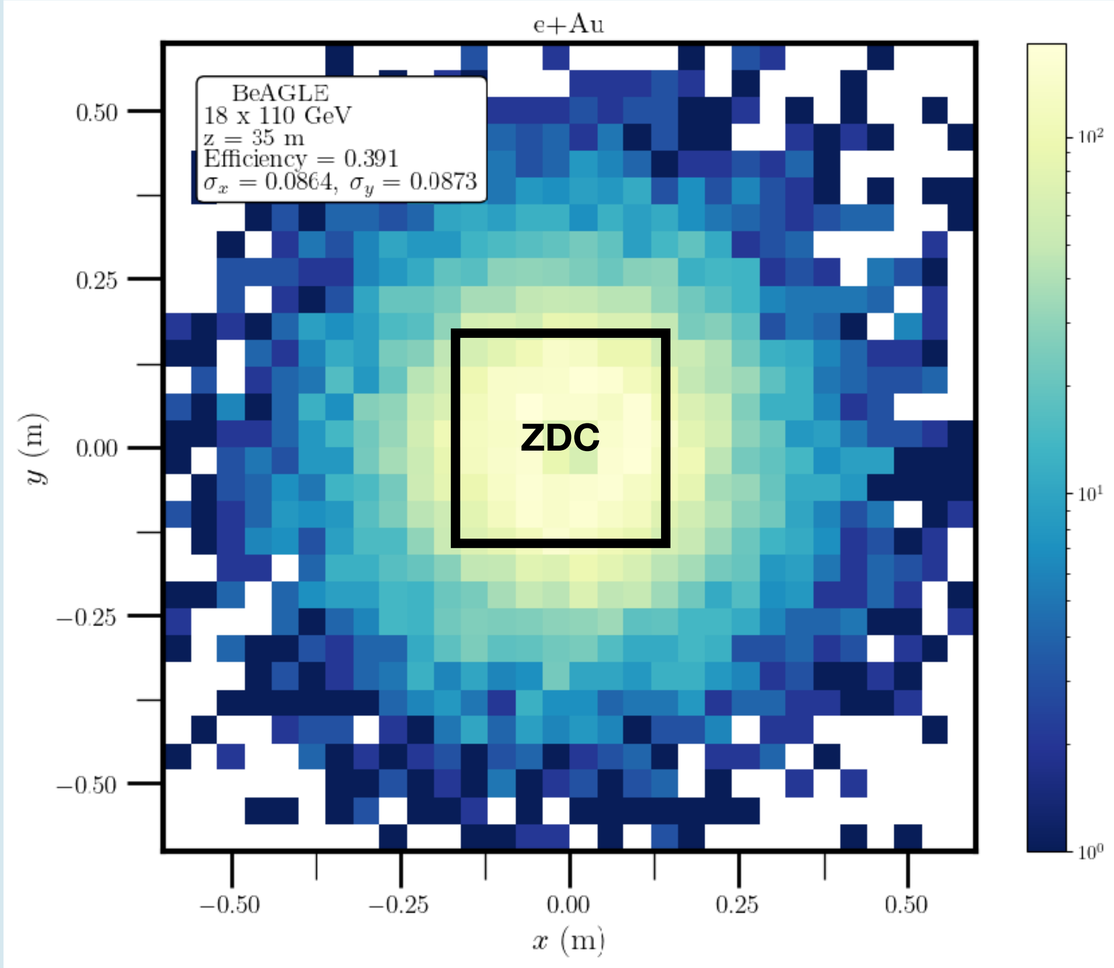
(In target rest frame)



# How many of photons do we see in ZDC?

$$\text{Efficiency} = \frac{\#\text{ of events with photon in ZDC acceptance}}{\#\text{ of total events}}$$

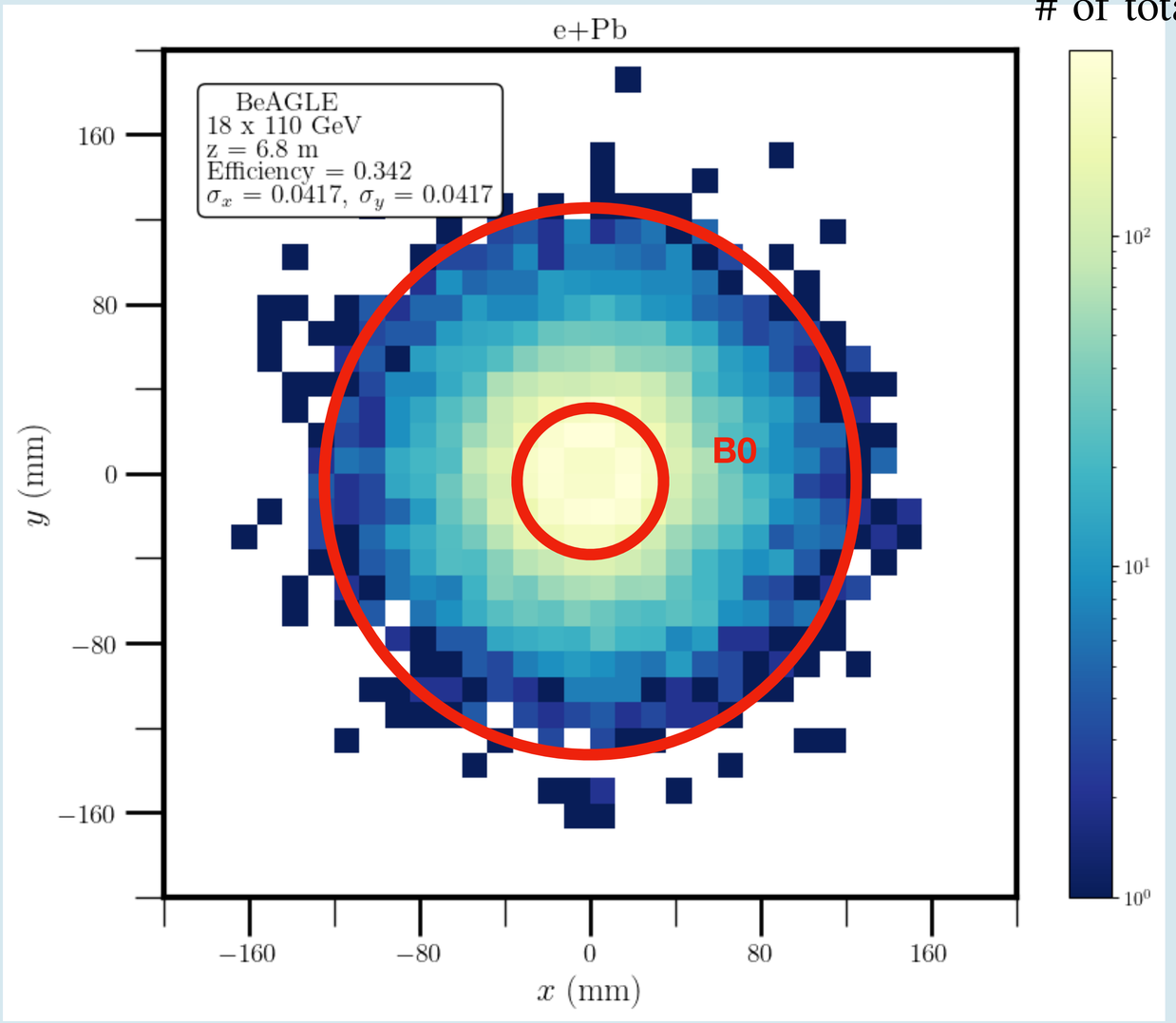


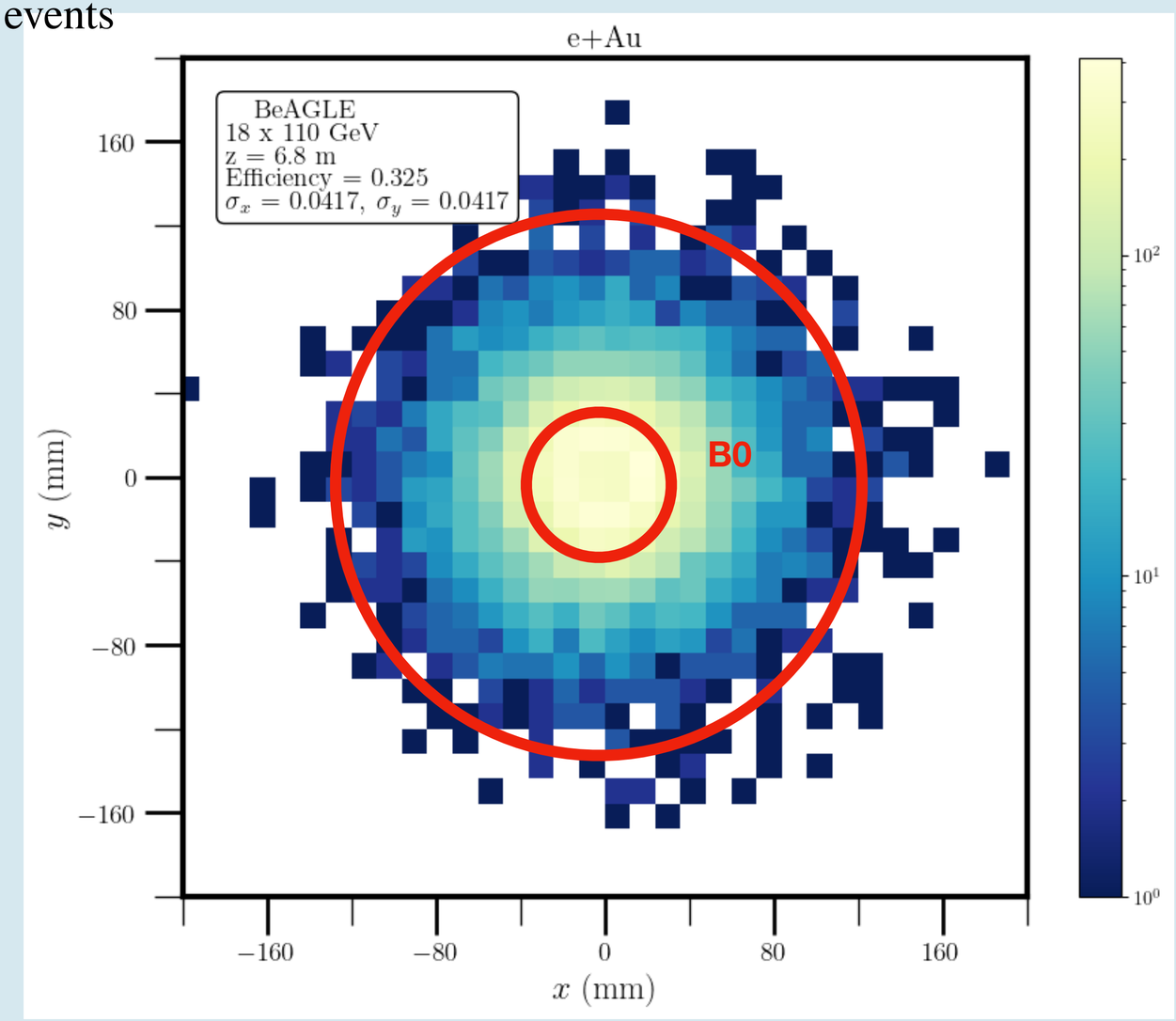




***WITH minimum energy requirement $E_\gamma > 100$ MeV

# How many photons do we see in B0?

$$\text{Efficiency} = \frac{\text{\# of events with photon in B0 acceptance}}{\text{\# of total events}}$$




*****WITH minimum energy requirement $E_\gamma > 100$ MeV**

# Conclusion

- It is critical to tag incoherent events when studying vector meson production
- We can tag incoherent events with the ZDC with a ~38% efficiency
- We can tag incoherent events with the B0 with a ~34% efficiency
- Au spectrum has some longer lived states that wont decay within ePIC acceptance
- Regardless, the tagging efficiencies are roughly the same between the two species