BeAGLE Update

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- Photons from $^{208}$A (mostly $^{208}$Pb)
- Results from e+U
Digging even deeper into Pb

With help from Charles!

• BeAGLE handling of $A^* \rightarrow A + \gamma$ is fairly generic
• In the real world, different nuclei behave differently
  • Pb decays usually include a $\gamma$ with $E \geq 2.6$ MeV
  • Au decays include smaller energies & more quasi-stable states
Photon energy in Target Rest Frame

$e^+Pb \ 10 \times 40 \ \text{J/} \psi \rightarrow ee/\mu \mu \ \text{with } N_{\text{nevap}} = 0$

All values of $A_{\text{remn}}$

$A_{\text{remn}} = 208$
$A_{\text{remn}}$ dependence

$E_{\gamma}^{\text{TRF}} \times 10^{-3}$

$E' = \sqrt{p_{\text{targ}}^2 - p_{\text{final}}^2} \times (p_{\text{final}} \cdot p_{\text{targ}} \cdot A_{\text{remn}} \cdot K_S \cdot \text{true}\times0.991-\text{true}\times0.991)$

$E'_{\text{true}}$: the true energy of the target proton.

$K_S$: the kinematic factor for a secondary hadron.

$\text{true}\times0.991$: a correction factor for the true energy of the target.

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Question 2: Are these events $^{208}\text{Pb}$?
To be checked.
Digging even deeper into Pb

- BeAGLE handling of $A^* \rightarrow A + \gamma$ is fairly generic **No it's not!**
- In the real world, different nuclei behave differently
  - Pb decays usually include a $\gamma$ with $E \geq 2.6$ MeV **2.4 MeV?**
  - Au decays include smaller energies & more quasi-stable states

TAKEN FROM 14-JULY-2017 JLAB SEMINAR
3D Glauber in BeAGLE

\[ \rho = \sqrt{X^2 + Y^2} \]

R(θ) from root (old parameters)

\[ \hat{U} \] randomized event-by-event

Except for debug mode where it always points along x, y, or z as selected.
3D Glauber in BeAGLE

1D:
\[ \rho(r) = \rho_0 \frac{1 + w(r/R)^2}{1 + \exp\left(\frac{r-R}{a}\right)}, \]

3D:
\[ \rho(x, y, z) = \rho_0 \frac{1}{1 + \exp\left(\frac{r-R(1+\beta_2 Y_{20}+\beta_4 Y_{40})}{a}\right)}, \]

\[ Y_{20} = \sqrt{5/16\pi} \ (3\cos^2\theta - 1) \]

\[ Y_{40} = 3/[16\sqrt{\pi}] \ (35\cos^4\theta - 30\cos^2\theta + 3) \]
Relating 1d to 3d. Part 1.

\[ \rho(x, y, z) = \rho_0 \frac{1}{1 + \exp \left( \frac{r-R(1+\beta_2 Y_{20}+\beta_4 Y_{40})}{a} \right)} \]

\[ \rho(r) = \rho_0 \frac{1 + w(r/R)^2}{1 + \exp \left( \frac{r-R}{a} \right)} \]

\( r_{1\text{Def}} = \frac{r_{3D}}{1+\beta_2 Y_{20}+\beta_4 Y_{40}} \) is wrong!

It would lead to larger skin depth in the long direction.

Correct:

\( r_{1\text{Def}} = r_{3D} - R(1+\beta_2 Y_{20}+\beta_4 Y_{40}) \)

So:

\( r_{1\text{Def}} = r_{3D} - R(\beta_2 Y_{20}+\beta_4 Y_{40}) \)

Skin depth \( a \) is independent of \( \theta \)
Relating 1d to 3d. Part 2.

\[ \rho(x, y, z) = \rho_0 \frac{1}{1 + \exp \left( \frac{r - R(1 + \beta_2 Y_{20} + \beta_4 Y_{40})}{a} \right) } , \]

\[ \rho(r) = \rho_0 \frac{1 + w(r/R)^2}{1 + \exp \left( \frac{r - R}{a} \right) } , \]

The average value of \( R(1 + \beta_2 Y_{20} + \beta_4 Y_{40}) \) is \( R \): basic feature of \( Y_{J0}(\cos \theta) \)

But the VOLUME (and therefore density or \( \rho_0 \)) is not the same.

I got this wrong and assumed it was the same at first:
Effectively \( V_0 = 4\pi R^3/3 \) with small corrections for the skin depth – done numerically in PyQM.

The actual volume is \( V \sim 4\pi R^3/3 \left[ 1 + 3/4\pi(\beta_2^2 + \beta_4^2) + O(\beta^3) \right] \sim 1.02 \, V_0 \)

So my density should be about 2\% lower and my results are 2\% too high right now. Probably in the noise of our understanding...
"d" ePb vs. eU

Tagged ePb (samples scaled to same area)

- Blue: Periph. 47%
- Red: Central 0.8%

Tagged eU (samples scaled to same area)

- Blue: Peripheral 26.3%, $<d> = 3.25 \pm 0.02$ fm / 1.02
- Red: Central 0.9%, $<d> = 9.42 \pm 0.11$ fm / 1.02

10x40 $x>0.02$, $0.01<y<0.95$
"d" from Pb and U

Some increase from $R_U > R_{pb}$

Modest increase due to shape selection.

Pb Plot from G. Wei 01/25/2018

Yield for $x > 0.02$
"d" cut effectiveness in e+U

minbias eU

0.9%

4.86 fm

9.24 fm

0.9%
What about Thickness?

Central 1.0% eU / Central 1.1% ePb = 1.10
T(b) cut effectiveness in e+U

Min. bias eU, $<T(b)> = 8.48 \pm 0.02$ fm

1.0%
Conclusions

- BeAGLE (FLUKA) does seem to know about the $^{208}$Pb* structure!
  - Puzzle: 2.4 vs. 2.6 MeV?
- 3D U works now, including d, T(b) calculation.
  - Still need to install the density correction (2% for U)
- Uranium improvement is significant, but modest
  - Will charged particles help?