The spin flipper doesn't cause the horns. What does?

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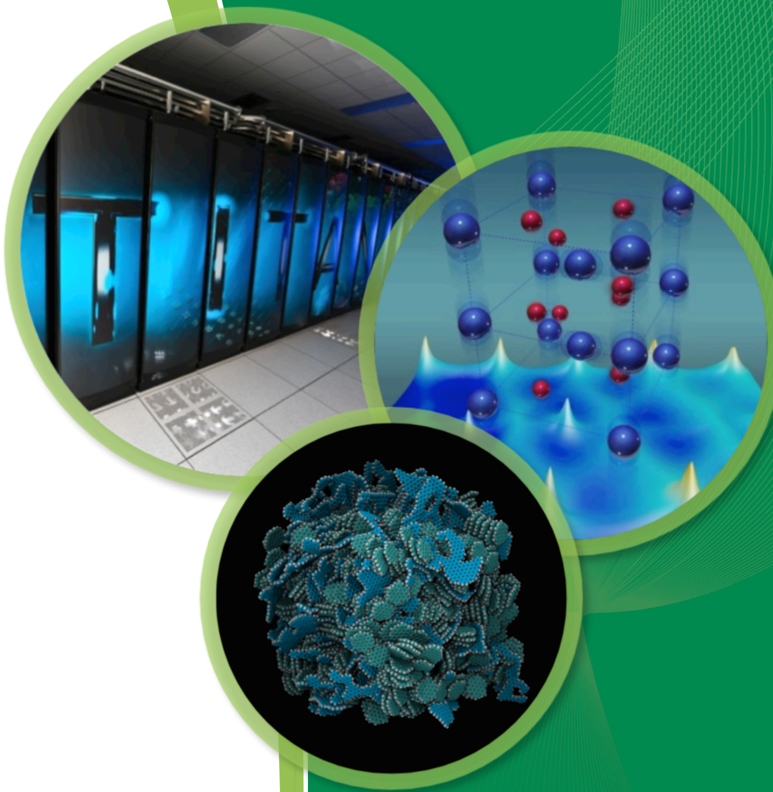
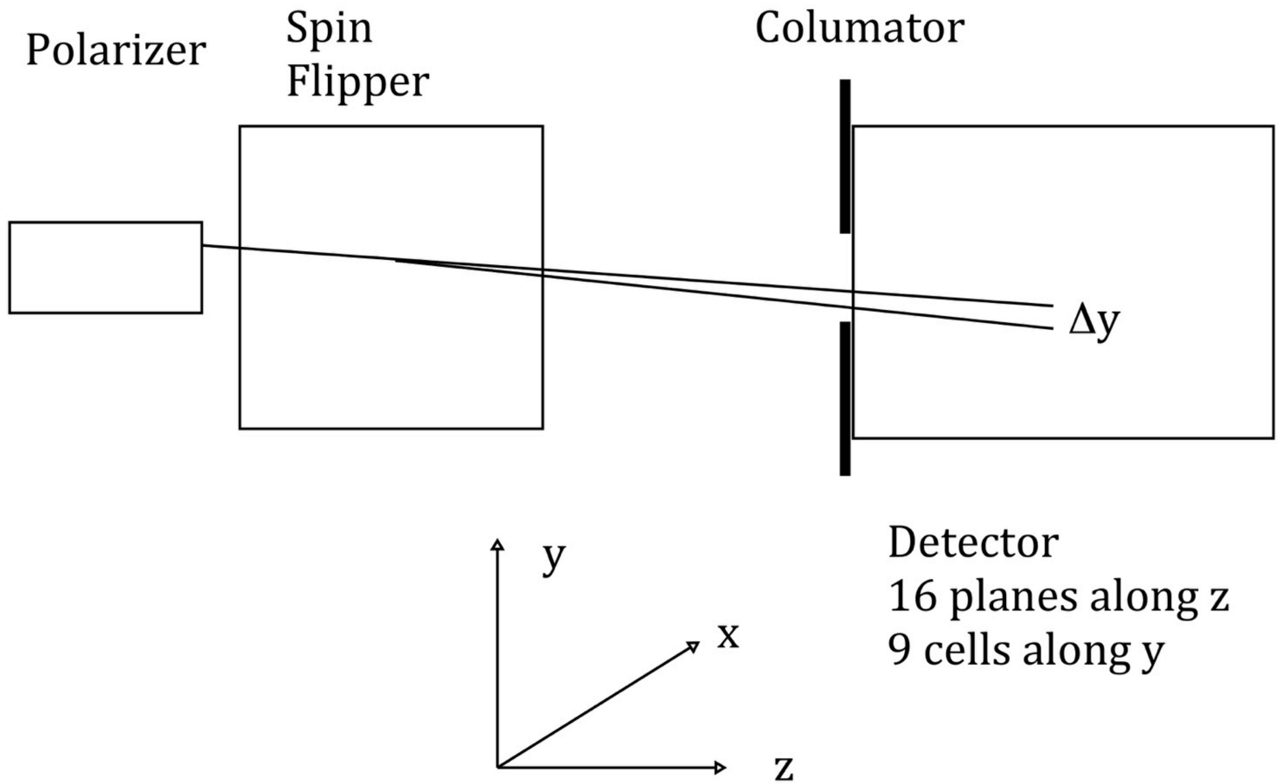
n-^{3}He meeting

3/7/16



The apparatus



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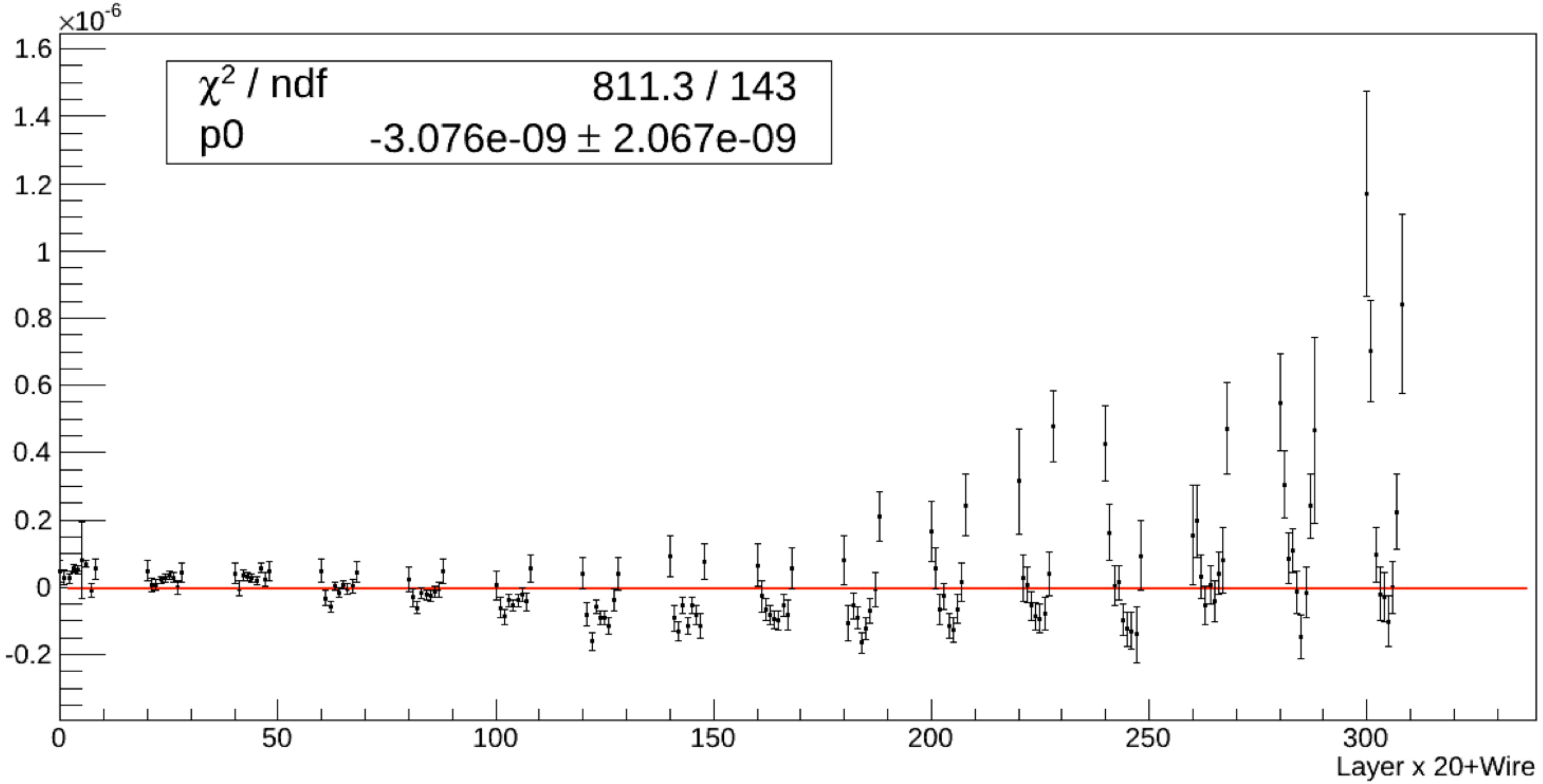
The horns were first found as a symmetric pattern in *ΔLog[Yield]* when the spin is flipped. The pattern was largest for the highest and lowest cells and the size increased with z.



I investigated whether or not the forces acting on the neutron could produce horns. There are many cases to consider: static B-fields, their gradients, and the spin flipper RF fields.
12 adjustable parameters need to be studied.

First method:
Work out each case analytically (following Rabi) and estimate Δy for spin flipper on and off.
I worked out a few cases, but there are too many equations to solve without making mistakes.

Second method:
I laboriously coded up the equations of motion and integrated them numerically. I could then easily investigate different cases.

9 equations of motion

$$\frac{dx_k}{dt} = v_k$$

$$m\frac{dv_1}{dt} = \mu\left(\sum_{k=1}^{3} u_k \frac{dB_k}{dx_1}\right)$$

$$m\frac{dv_2}{dt} = \mu\left(\sum_{k=1}^{3} u_k \frac{dB_k}{dx_2}\right) - mg$$

$$m\frac{dv_3}{dt} = \mu\left(\sum_{k=1}^{3} u_k \frac{dB_k}{dx_3}\right)$$

$$\frac{du_k}{dt} = -\gamma\left(\vec{u}\times\vec{B}\right)_k$$

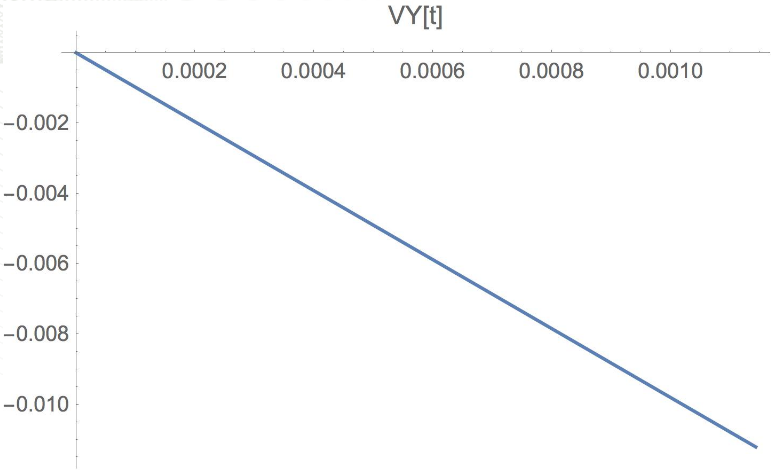
9 initial conditions

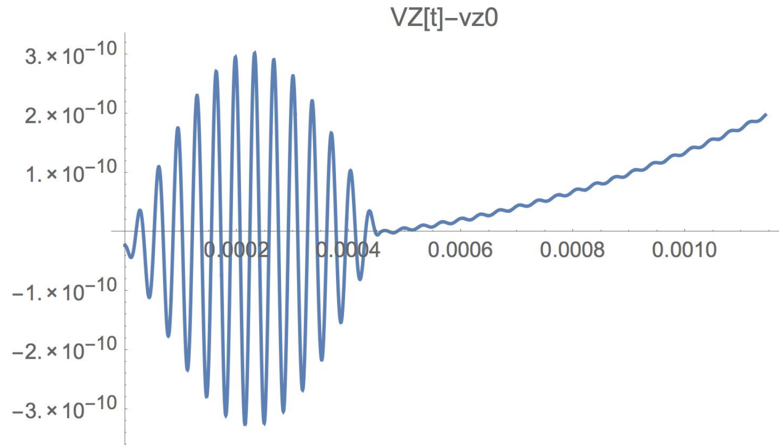
$$\vec{x}, \vec{v}, \vec{u}$$

12 adjustable parameters

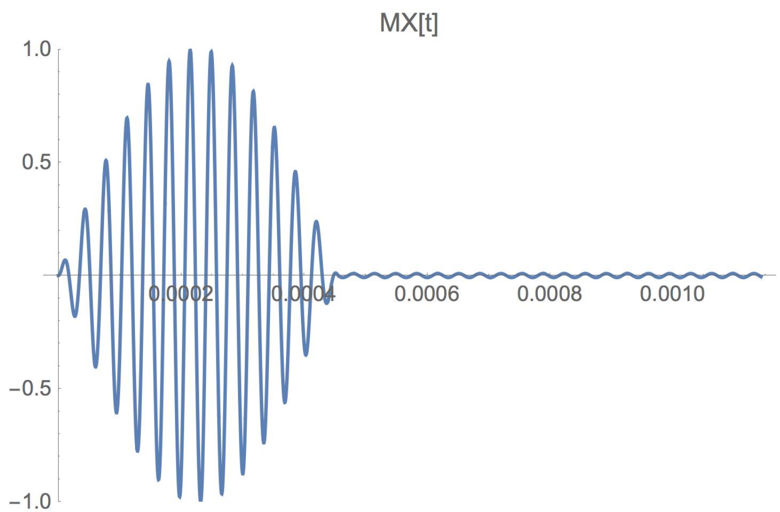
$$\vec{B}_0, \frac{dB_k}{dx_j}, \vec{B}_{rf},$$

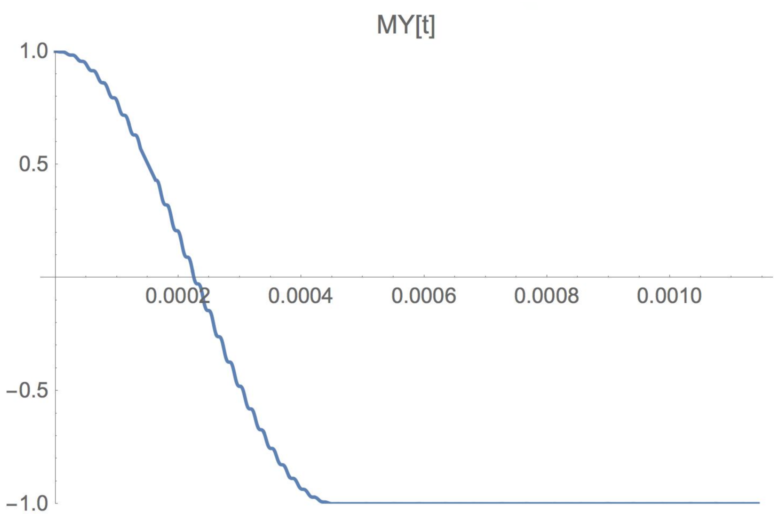
y and z velocities





x and y magnetic moment components





Results:

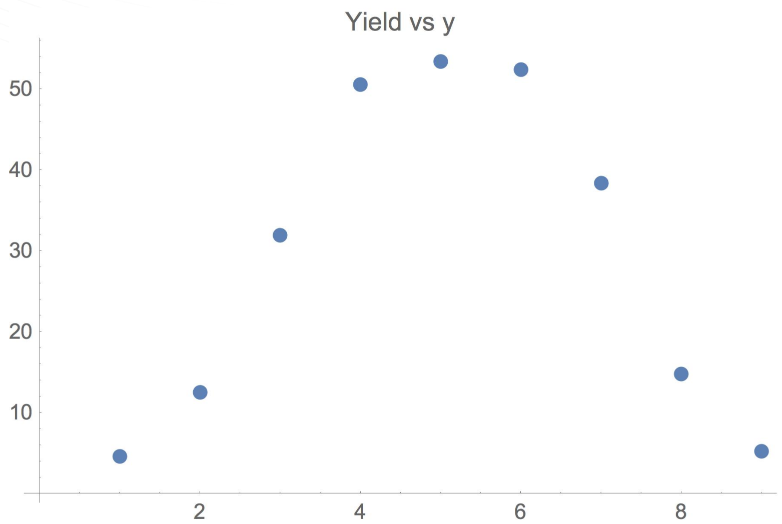
Condition	False PV(10^{-8})	Horn(10^{-8})
nominal	7.2 10^{-6}	
dBx/dx—>10^{-5} T/m	7.2 10^{-6}	
dBx/dy—>10^{-5} T/m	6.8 10^{-6}	
dBx/dz—>10^{-5} T/m	6.5 10^{-5}	-8.6 10^{-5}
dBy/dy—>10^{-5} T/m	.31	
dBy/dz—>10^{-5} T/m	6.9 10^{-6}	-3.4 10^{-6}
x_0—>.05 m	8.2 10^{-6}	-8.7 10^{-6}
Bx_0—>.0001 T	7.2 10^{-6}	
Bz_0—>.0001 T	8.0 10^{-6}	
RF polar—>.1 rad	7.6 10^{-6}	
RF azimuthal—>.1 rad	7.5 10^{-6}	
RF phase—>$\pi/2$ rad	7.2 10^{-6}	

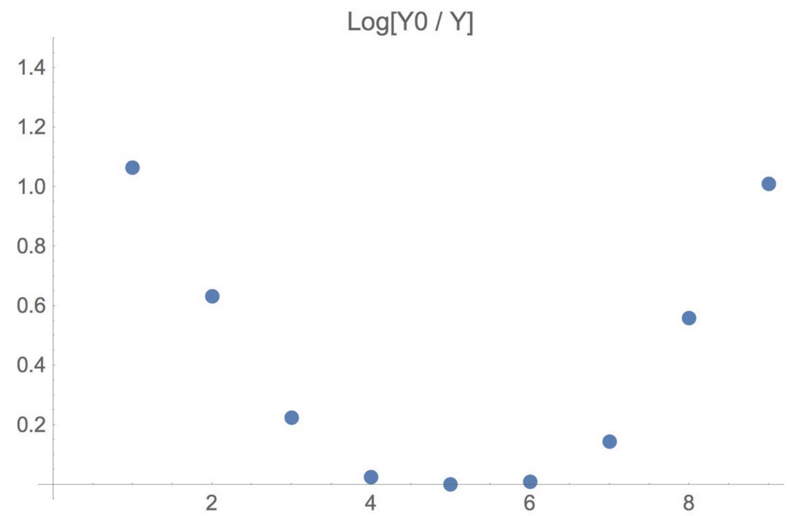
Conclusion: The spin-dependent forces are too weak to produce the observed horns, but do produce a false PV signal of ~ 3 10^{-9}

So what makes the horns?

- Turning the spin flipper on and off doesn't make the horns. Therefore, sorting data on spin up or down won't yield information on the horns.
- Chris Crawford has conjectured that the horns are created by a combination of:
  - Wrap-around neutrons that have a larger transverse phase space than direct neutrons
  - Intensity fluctuations that don't cancel out in the horn algorithm $(Y_{up}-Y_{down})/(Y_{up}+Y_{down})$

Yield vs. y in z plane #2
The pattern of Yield vs. y is created by the collimator and can produce "horns" when combined with a background





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Hints concerning the origin of the “horns”

- The horns are not caused by the spin flipper state.
- The size of the horns increases with z, the detector plane #
- The horns have the same shape as 1/Yield[z]

I find the idea that the horns are caused by background attractive

- If background is caused by a long range radiation, then it explains why the horns increase with z. There is a larger background/signal as z increases
- The averaging time would be determined by the lifetime of the parent species.

Ideas concerning the origin of the “horns”

- If the “horns” don’t depend on spin flipper state, then we won’t be able top understand them by sorting on SF state.
- Dropped pulses
- Intensity fluctuations
- Wrap-around neutrons
- Background in the detector
- The horns may be caused by statistical fluctuations. If so, then what is fluctuating
  - Background (radiation history). Remember the 200 sec Al beta decay background in NPDGamma.
  - Dropped pulse history
  - Beam intensity (pulse to pulse or long term?)

A suggestion:

- Improve our “horn” diagnostics
- Fit data for each each plane and each pulse to
  - A + B G(y) + C H(y)
  - A is the y independent part ~ intensity
  - B is PV signal: β = B/A independent of intensity.
  - C is reduced horn signal: γ = C/A is independent of intensity.
- Correlate β and γ with candidate causes of horns
- Is γ random?
- If so, what is the time scale of fluctuations in γ?

Comments concerning averaging

- Assume that we find that Ave(γ) has some time correlation time, τ. If τ = 0 (completely random) then we have large RMS γ.
  - 4 10^4 runs with 2.5 10^4 t_0's each. 10^9 t_0's.
  - If τ = 0, and γ fluctuates randomly, then the RMS size of for a single t_0 must be 10^{-7} $(10^9)^{1/2}$ ~ 3 10^{-3} that would be visible in a few t_0's.
- We need to characterize the statistical properties of γ.
  - We expect γ to be independent of pulse intensity
  - Does it depend on radiation history?
  - What is the correlation time?
  - Does it depend on dropped pulse history?