SNO+ Americium-Beryllium Source Calibration and Simulation
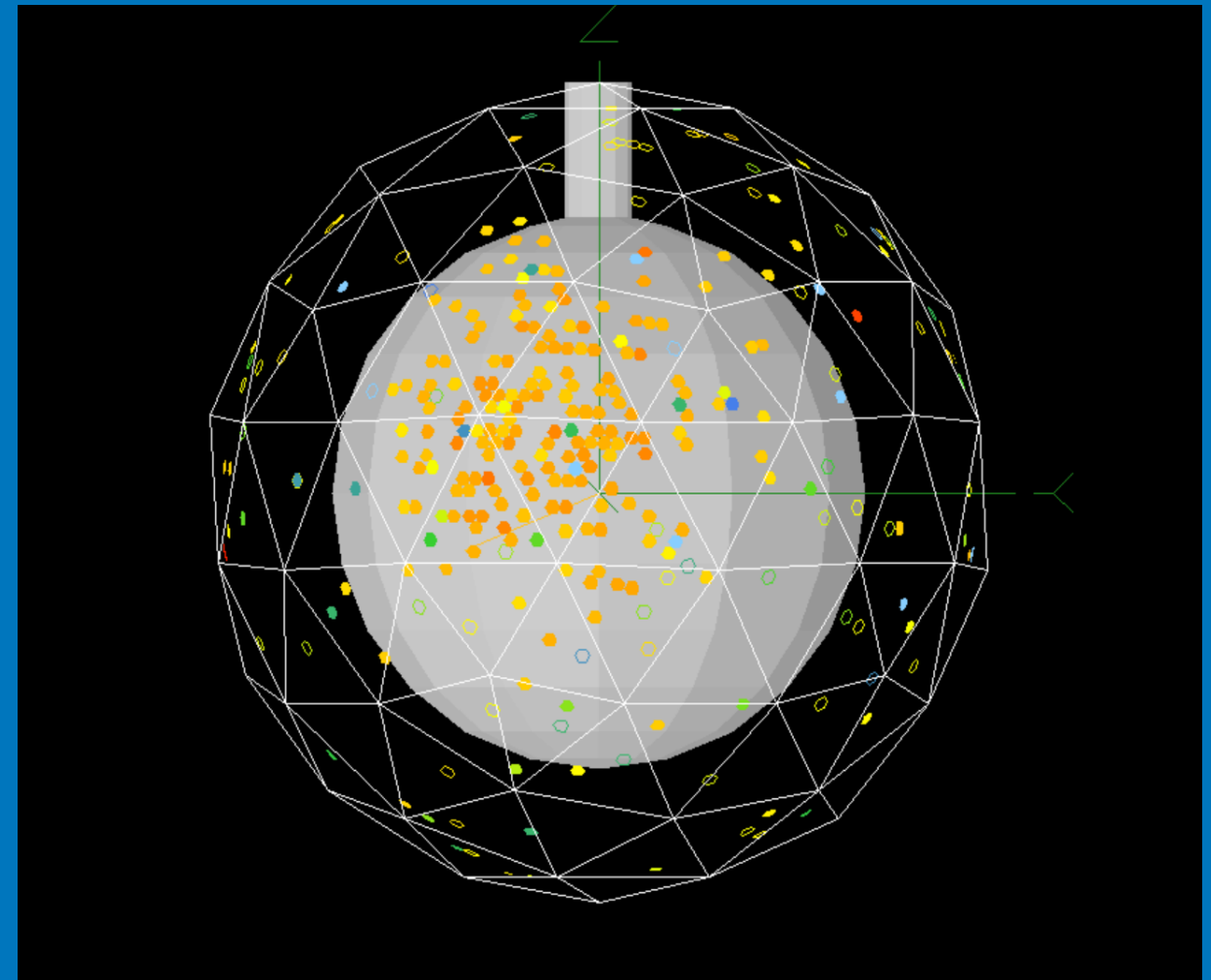
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Student Researcher

SNOLAB

SNO+ Detector – What is it?

- 12 meter diameter acrylic vessel
- ~9400 photo-multiplier tubes (PMTs)
- 780 tons of linear alkyl-benzene (LAB), a scintillator
- PMTs detect atomic interactions
- One interaction that gets detected by multiple PMTs is called an event.
- Number of PMTs fired per event is proportional to energy of event

Why Calibrate?

- We seek to better understand:
  - ➢ The optics of the detector
  - ➢ The energy response of the detector
- Looking at position dependence for calibration data
- We've deployed externally, but not internally yet
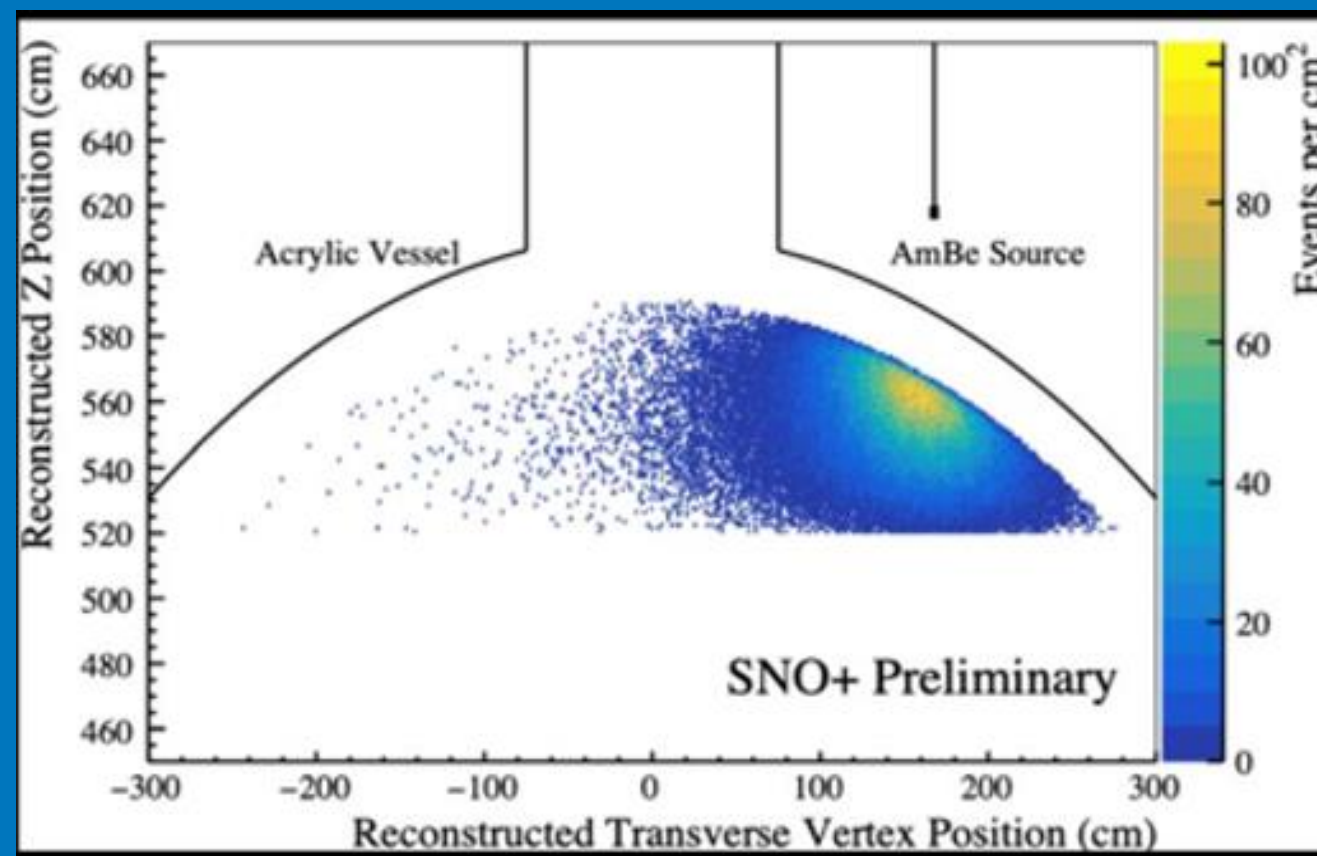
AmBe Source Calibration

- Region of interest for 0νββ is ~2.5 MeV
- Americium and Beryllium create a neutron and a gamma, which create 2.2 MeV and 4.4 MeV peaks in scintillator
- These energy ranges bracket the 2.5 MeV 0νββ energy range
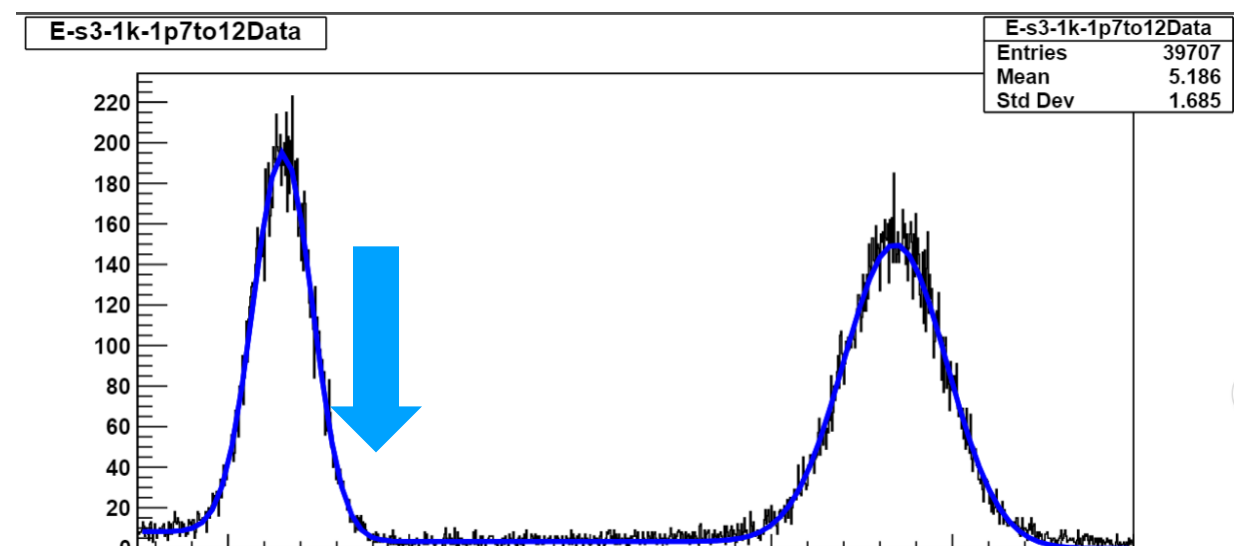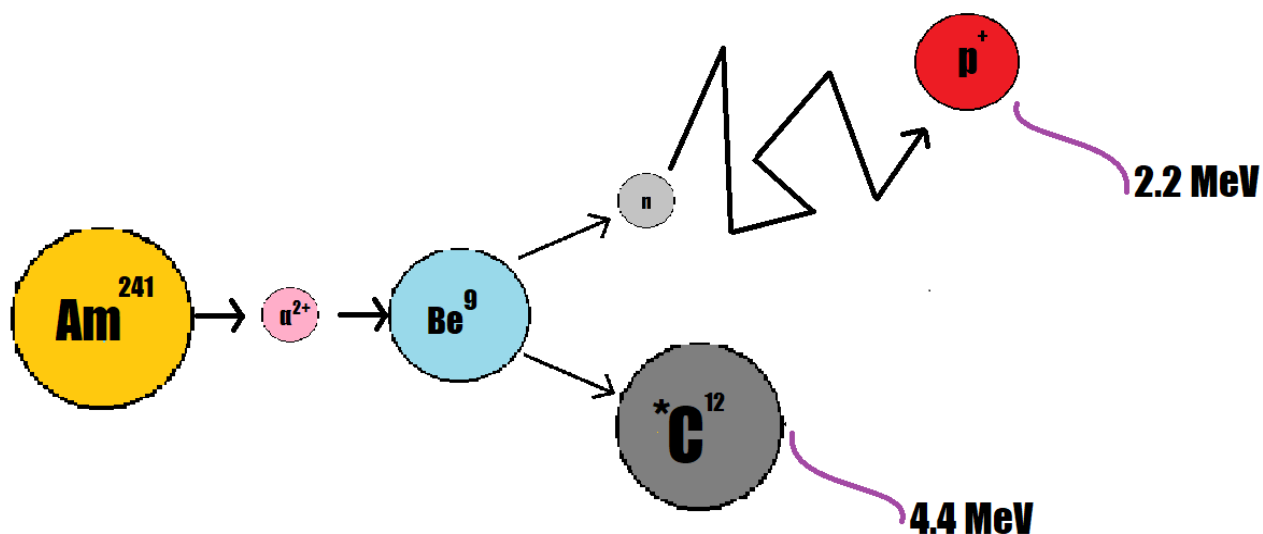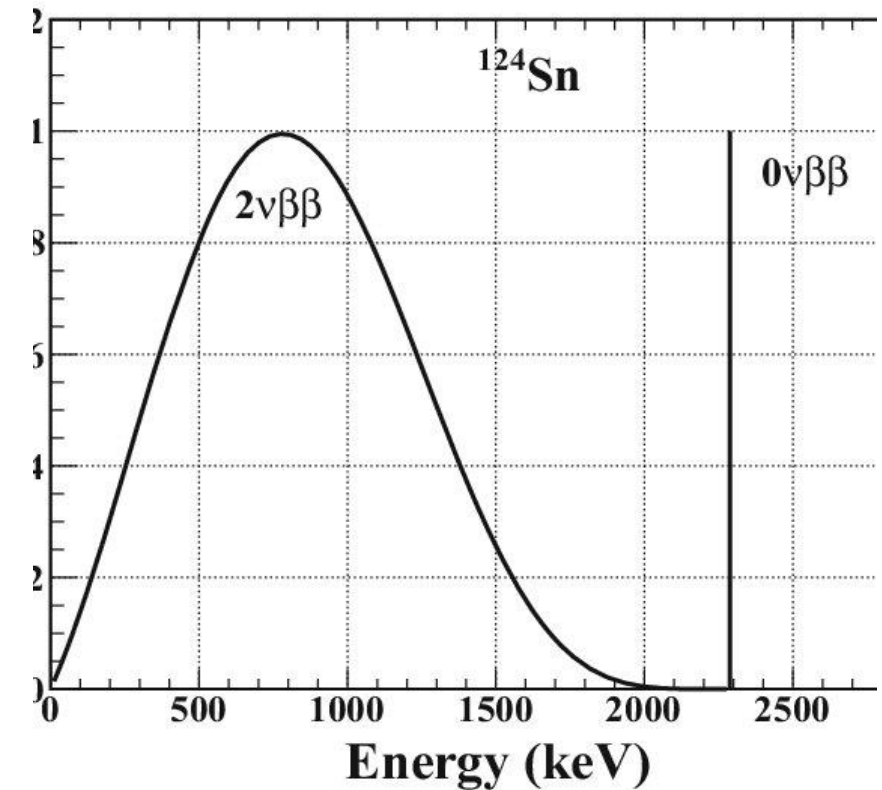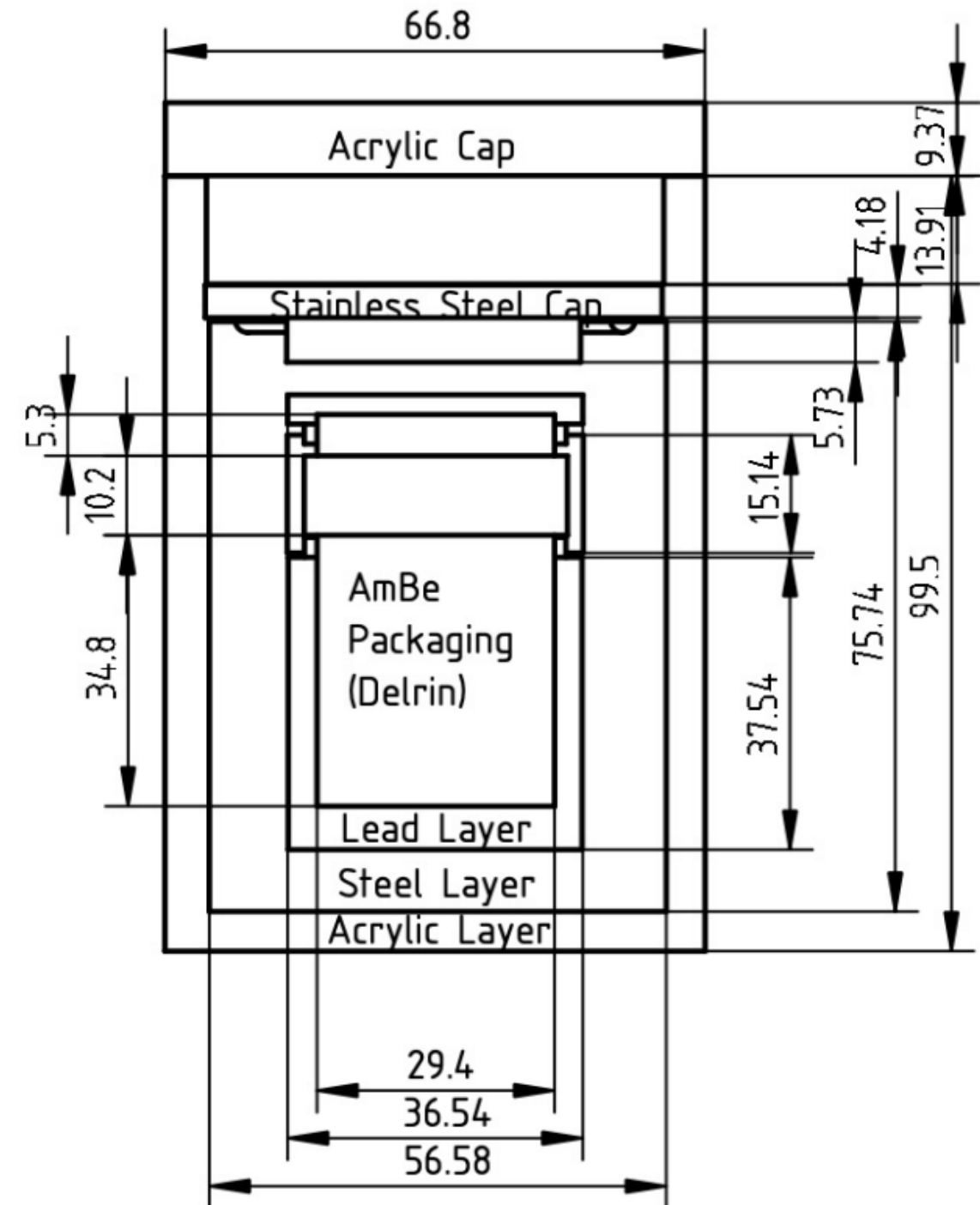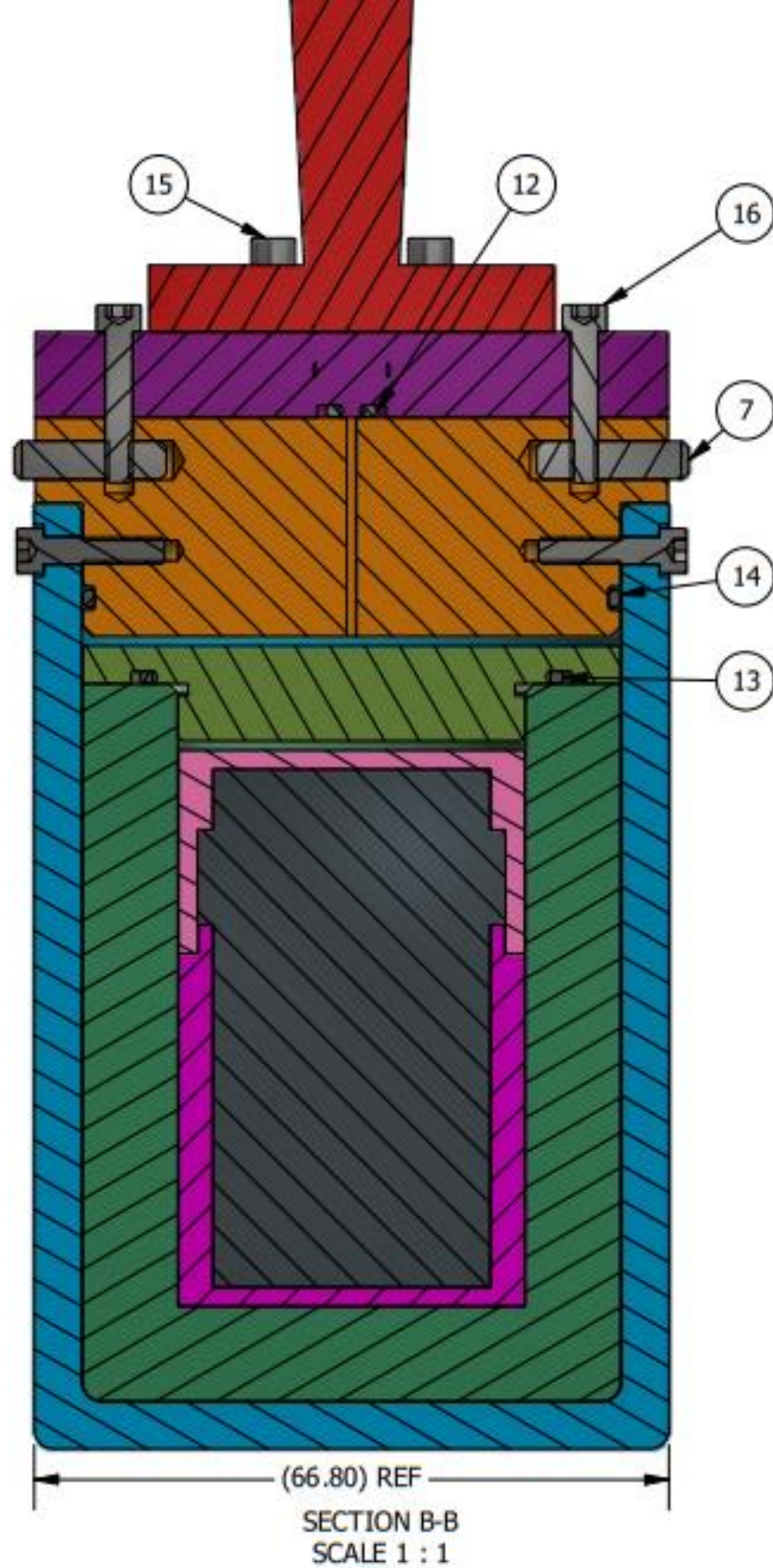
A model of the assembles source encapsulation as built with the AmBe source package.


Line drawing of the assembled source showing dimensions measured from the constructed source.

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AmBe Source Encapsulation

Deployment Plan - Changing source Position

- Move the AmBe source to different positions in the detector and take data
- Vertical scan and horizontal scans taken in 0.5m increments
- Diagonal scans taken in 1.0m increments
- 27 minutes at each position will capture 100,000 neutrons
- Total deployment time: 47 hours
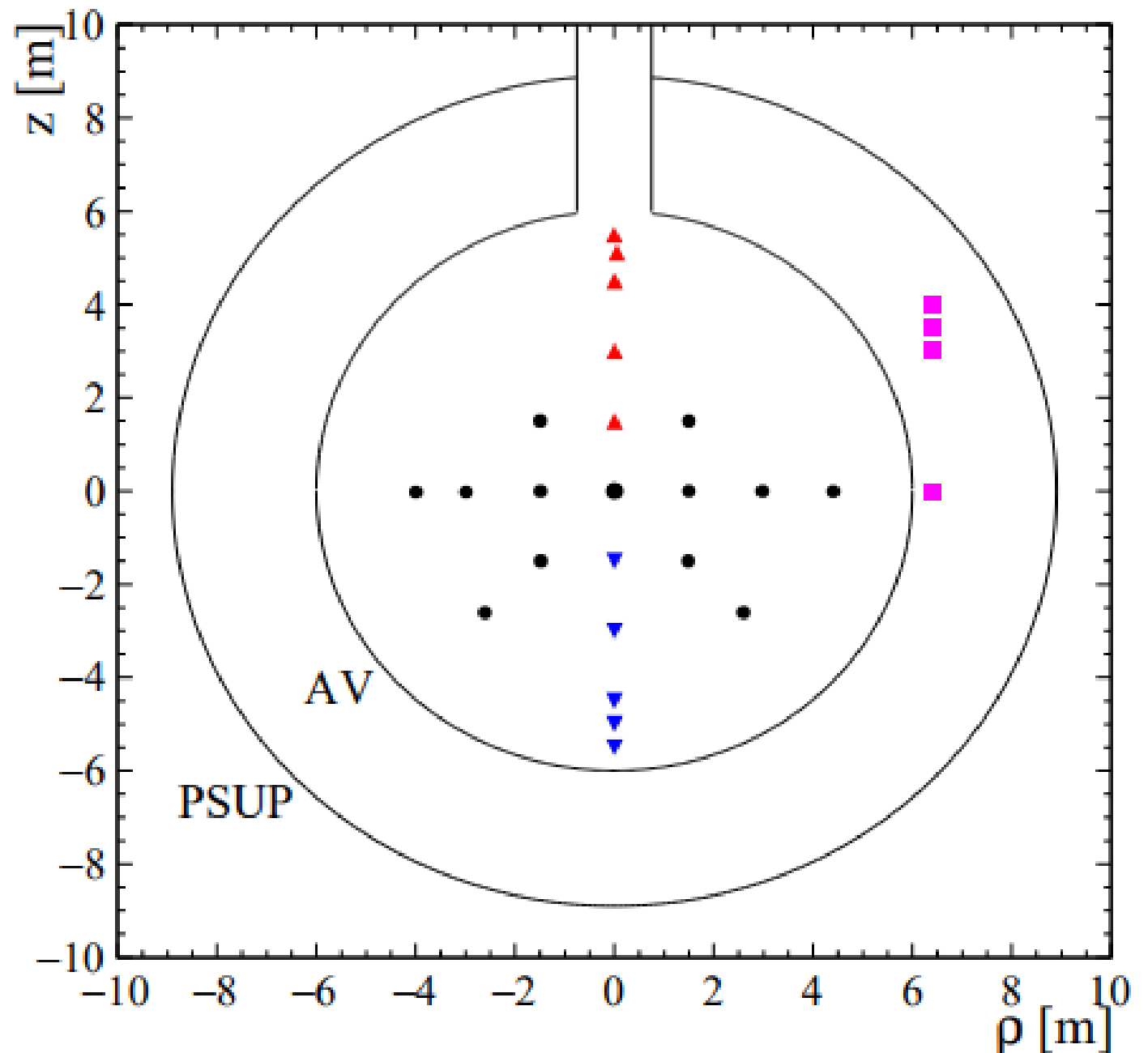
```perl
my $path="/noahf/scratch/AmBeScint";
my $localMac="/noahf/Project/AmBeScint/";
my $localDat="/noahf/Project/AmBeScint/";
use strict;
use warnings;

# my $run="252280";
# my $name="AmBesource_exwater_354406_r0000${run}_
my $folder="/";
my $mac2="AmBesource_ScintNoSteel.mac";

`mkdir -p /home/${path}$folder`;
my @runs=(354354);
# my @runs=("354363", "354364", "354365", "354366"
6","354377", "354378");
foreach(@runs){
    my $run=$_;
    my $name="AmBesource_ScintEncap_r0000${run}_p0
    print "$_ $run $name\n";
    for (my $xpos=-4500;$xpos<5500;$xpos+=1000){
        my $pospath = "${path}${folder}AmBe_${xpos
        `mkdir -p /home/${pospath}`;
        my $mac3="AmBesource_xpos${xpos}.mac";
        open(my $mc, ">/home/${pospath}/$mac3");
        print $mc "/rat/physics_list/OmitMuonicPro
        print $mc "/rat/physics_list/OmitHadronicP
        print $mc "/rat/db/set DETECTOR geo_file \
        print $mc "/rat/db/set GEO[inner_av] mater
        print $mc "/rat/db/load /AmBeScint/geo/Pb2
        print $mc "/rat/db/set GEO[AmBeShielding]
#/rat/db/load nSPECTRUM_NEW.ratdb
        print $mc "/rat/db/set NOISE_MC noise_flag
        print $mc "/rat/db/set MC event_cutoff_tim
        print $mc "/run/initialize\n";
        print $mc "/rat/tracking/store full\n";
        print $mc "/rat/tracking/omit e-\n";
        print $mc "/rat/tracking/omit opticalphoto
        print $mc "/rat/proc frontend\n";
        print $mc "/rat/proc trigger\n";
        print $mc "/rat/proc eventbuilder\n";
        print $mc "/rat/proc calibratePMT\n";
```
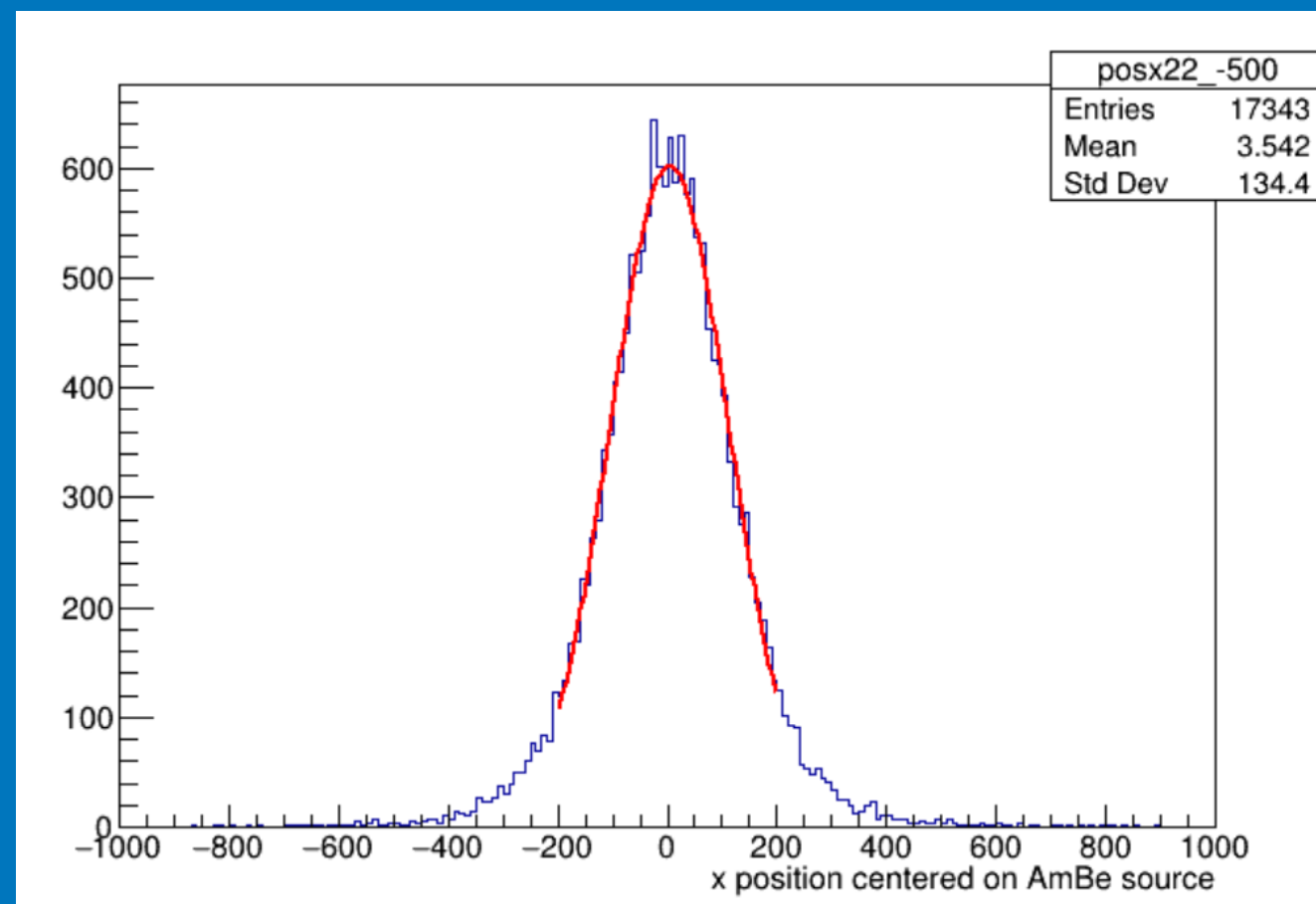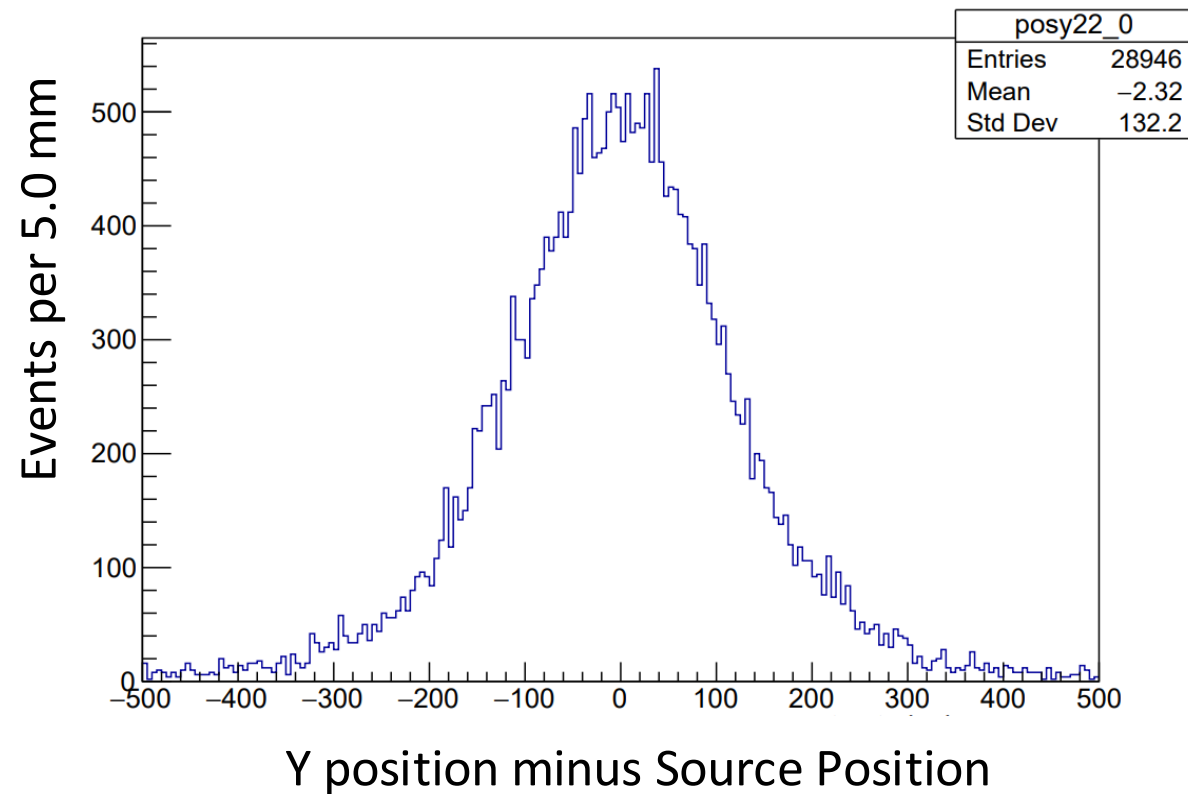
Simulation Data

AmBe Source Simulation

- The simulation predicts how the detector will respond to deployed source
- Using GEANT4 and RAT in scintillator
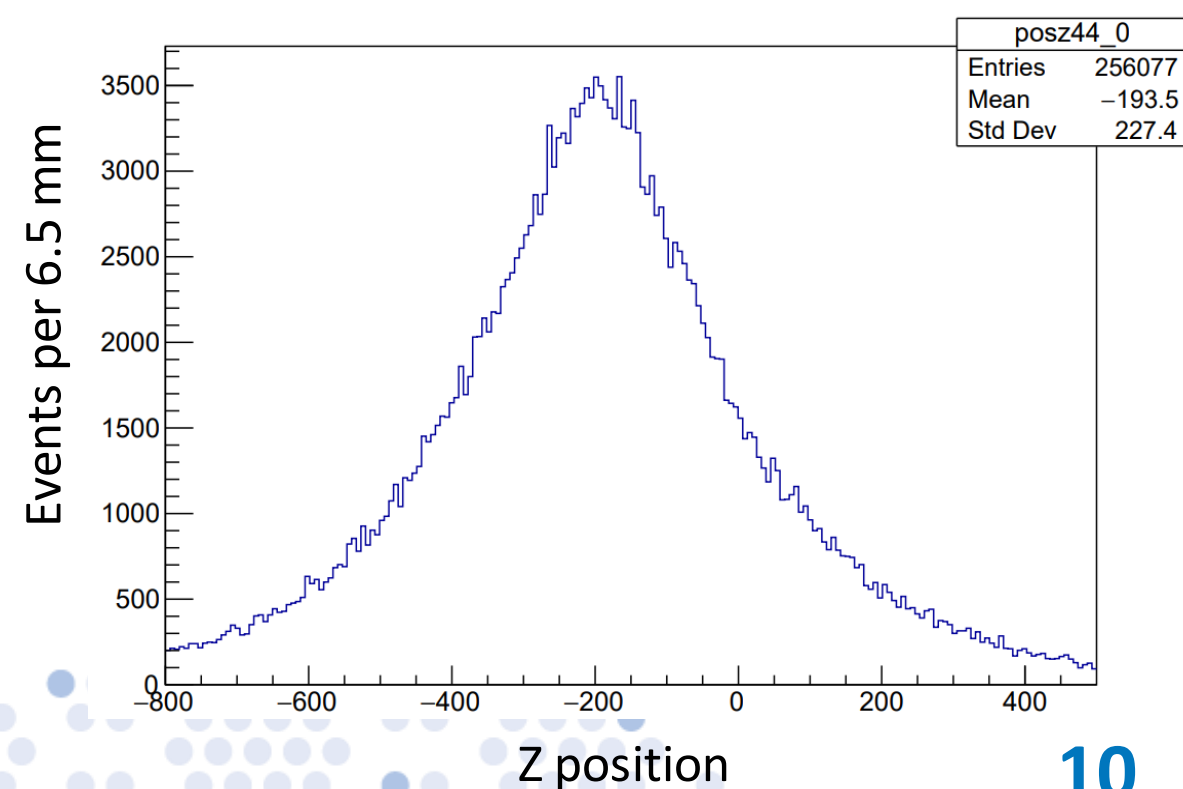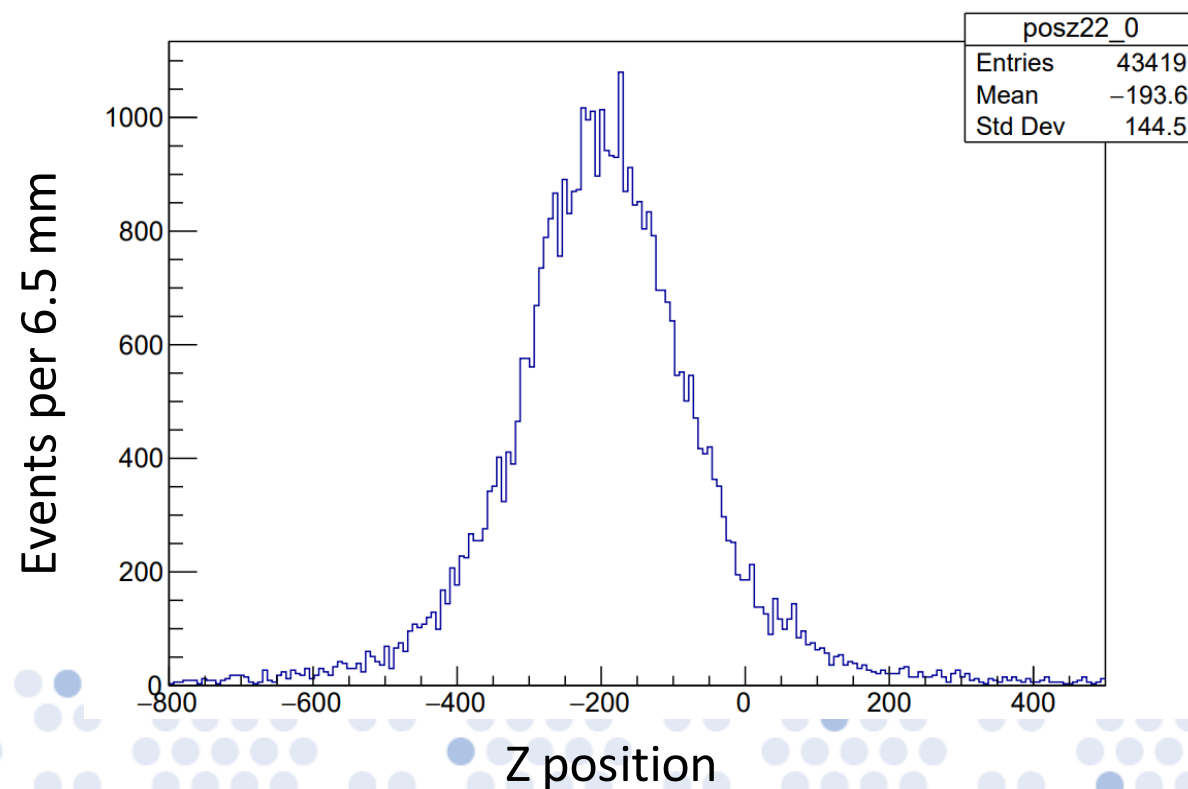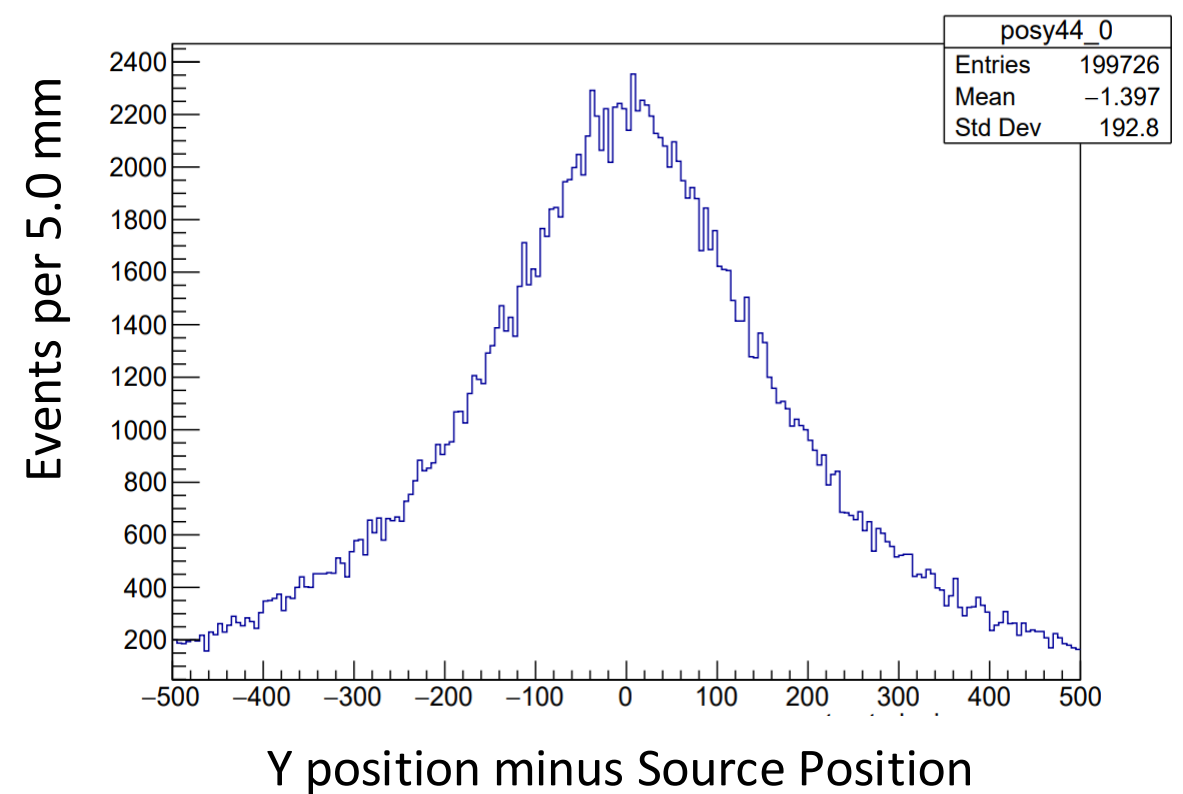- Included size and components of source and encapsultion
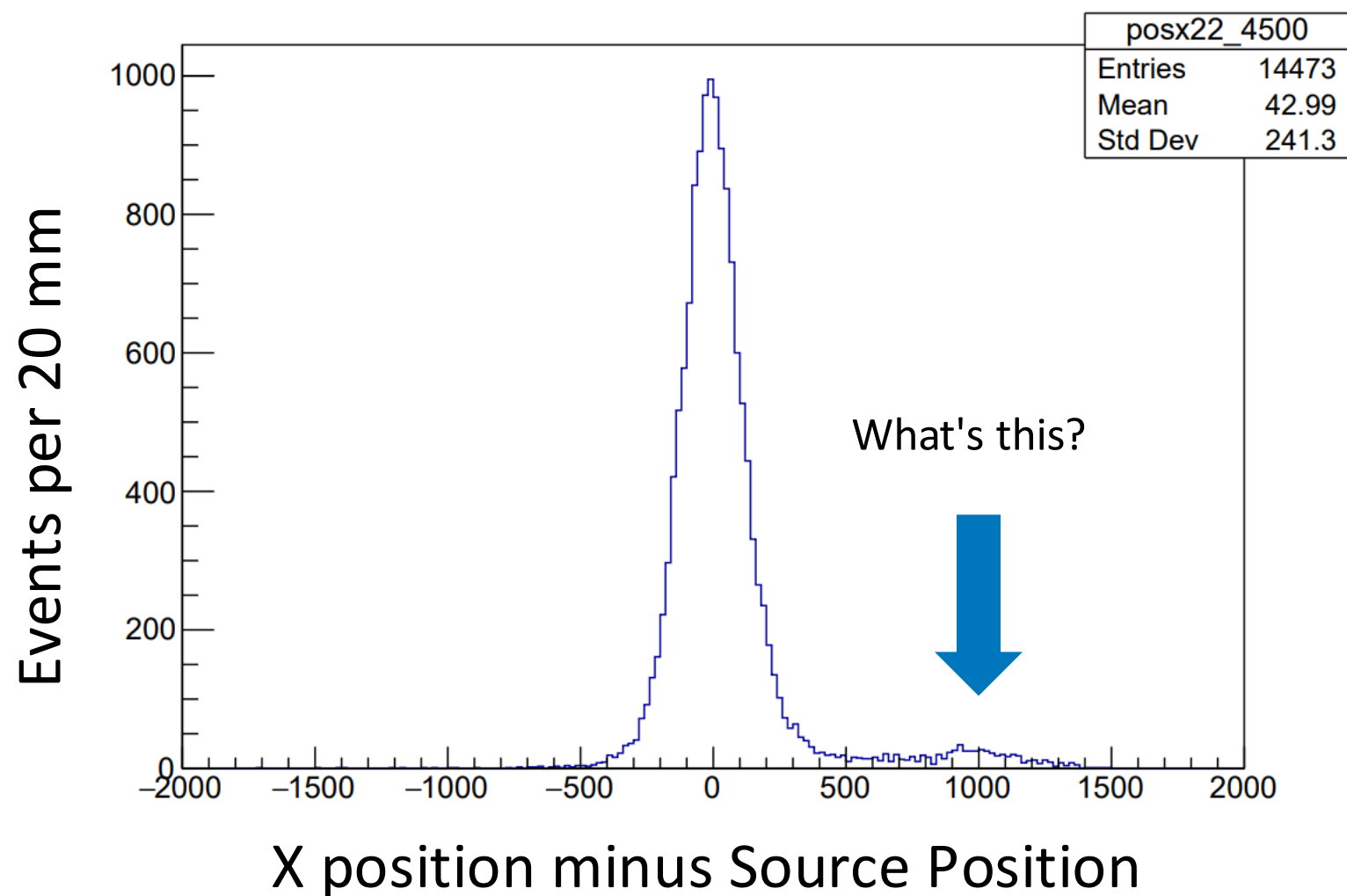
Number of Events vs Position
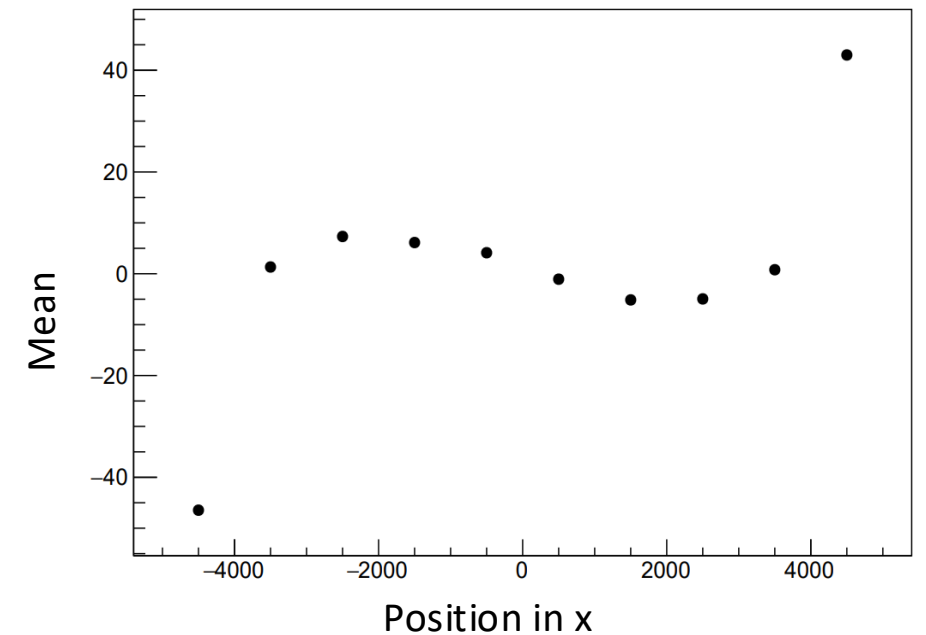
Number of Events vs Position

- Noticeable second event peak at edge of detector
- Scintillator and acrylic have similar index of refraction
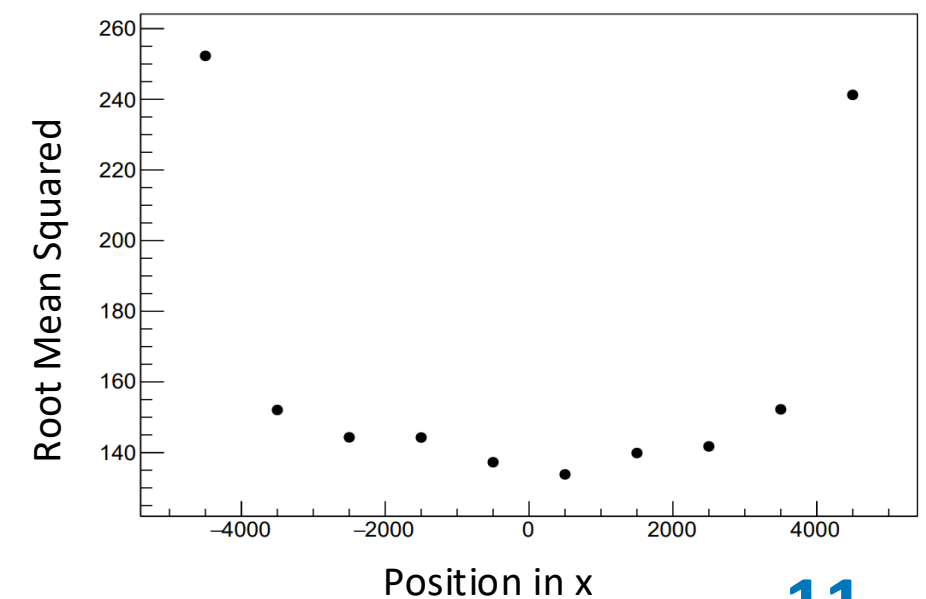- Total internal reflection of light passing through vessel

Mean of Data in x

2.2 MeV Peak

posx22_4500	
Entries	14473
Mean	42.99
Std Dev	241.3

What's this?

Events per 20 mm

X position minus Source Position

RMS of Data in x

Conclusion

- Simulation was successfully generated
- Confirms that run plan will be effective
- Optical effects will be a factor in data reconstruction for deployment
- Simulation data will be compared to deployment data once it is performed

Thank you! Any questions?