NEUTRON CALIBRATION AND MC PRODUCTION FOR THE DEAP-3600 DETECTOR

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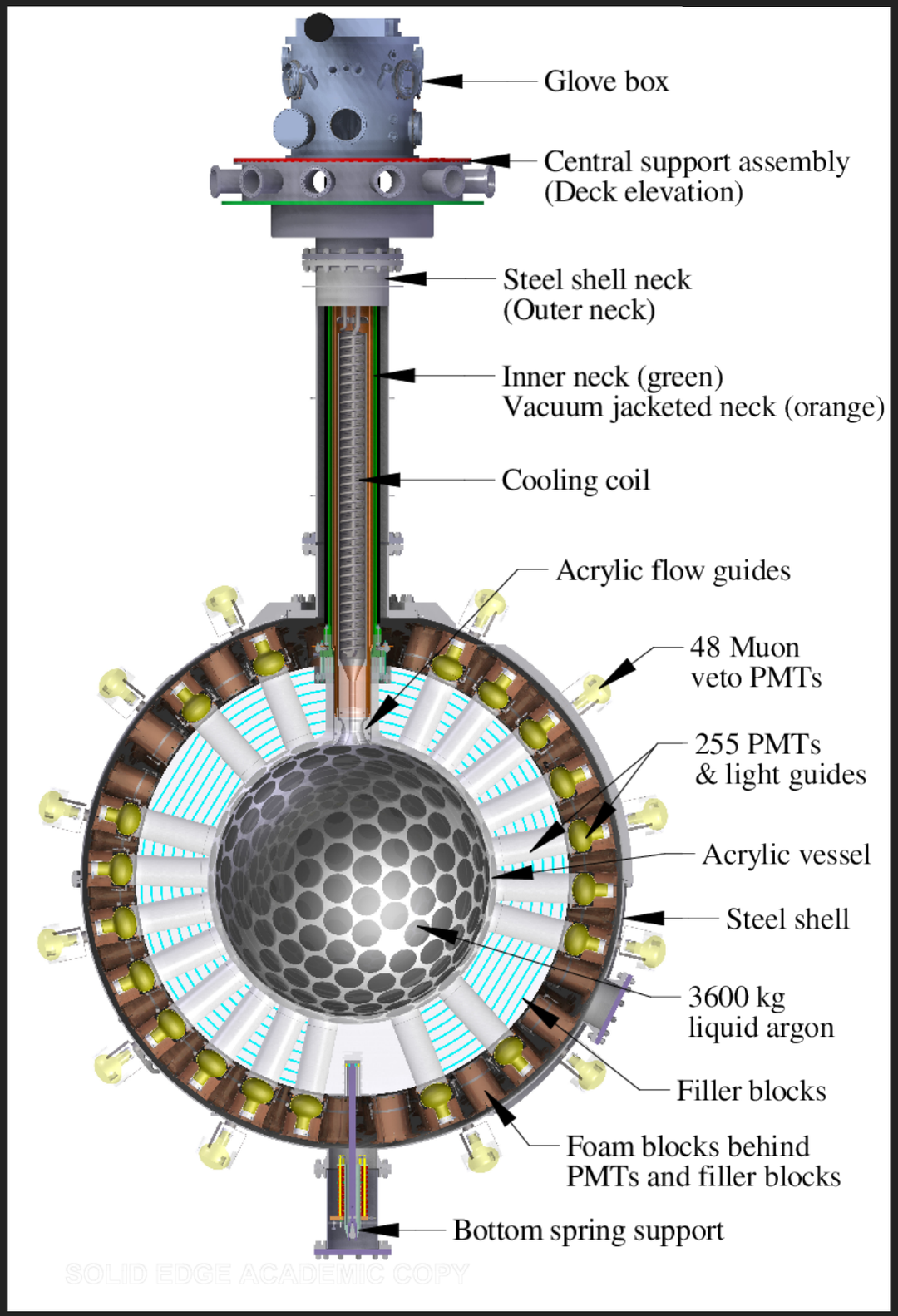
DETECTOR

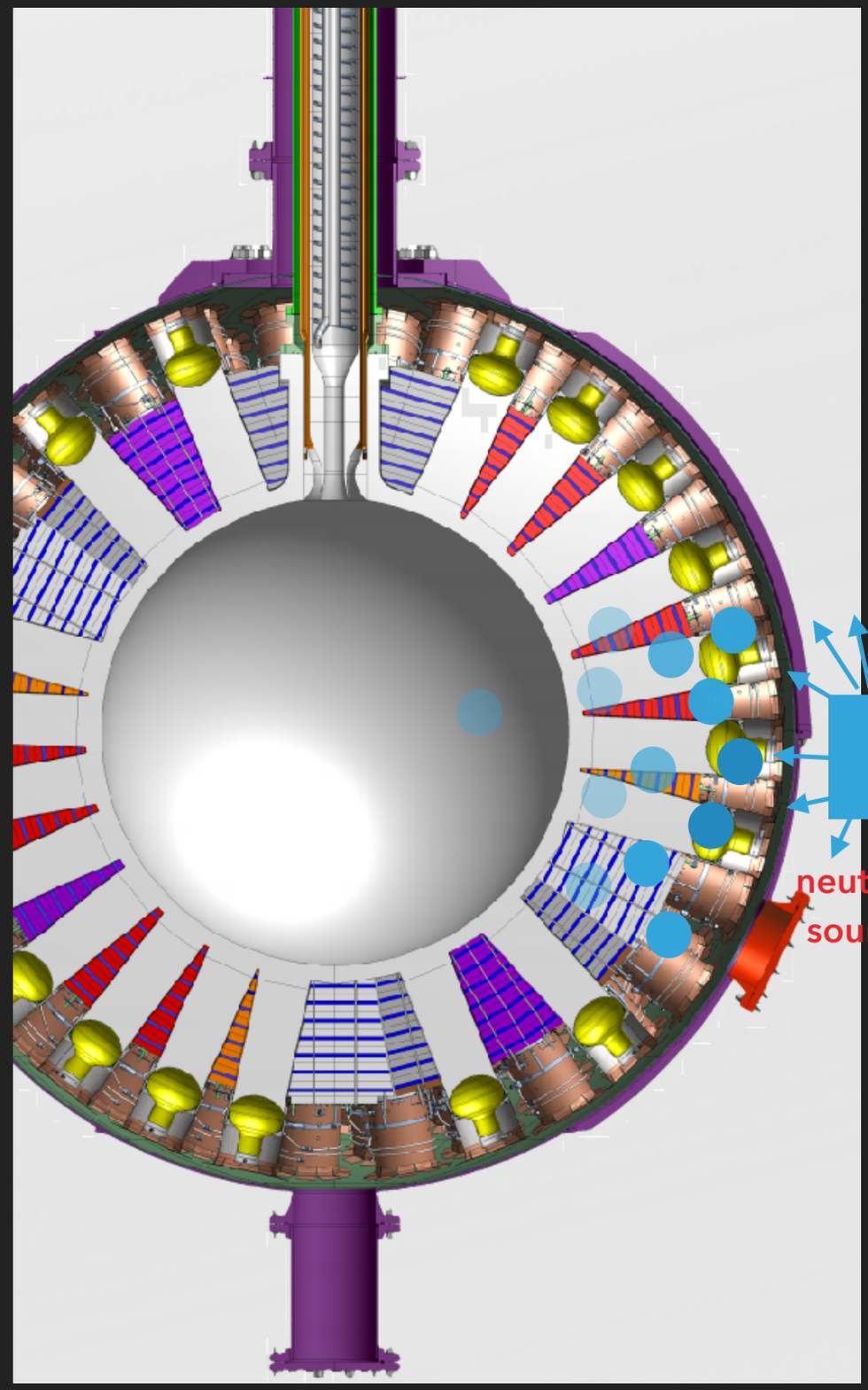
DEAP-3600 is a single phase liquid argon detector located 2 km underground at SNOLAB in Sudbury, Ontario, Canada.

- Spherical Acrylic Vessel (AV) surrounded by 255 8-inch Hamamatsu R5912 HQE photomultipliers.
- AV filled with 3600 kg liquid argon (fiducial volume 1000kg) and coated with tetraphenyl butadiene (TPB) wavelength shifter.
- Detector enclosed in a stainless steel shell and dispersed in a 8 metre diameter cylindrical water tank.



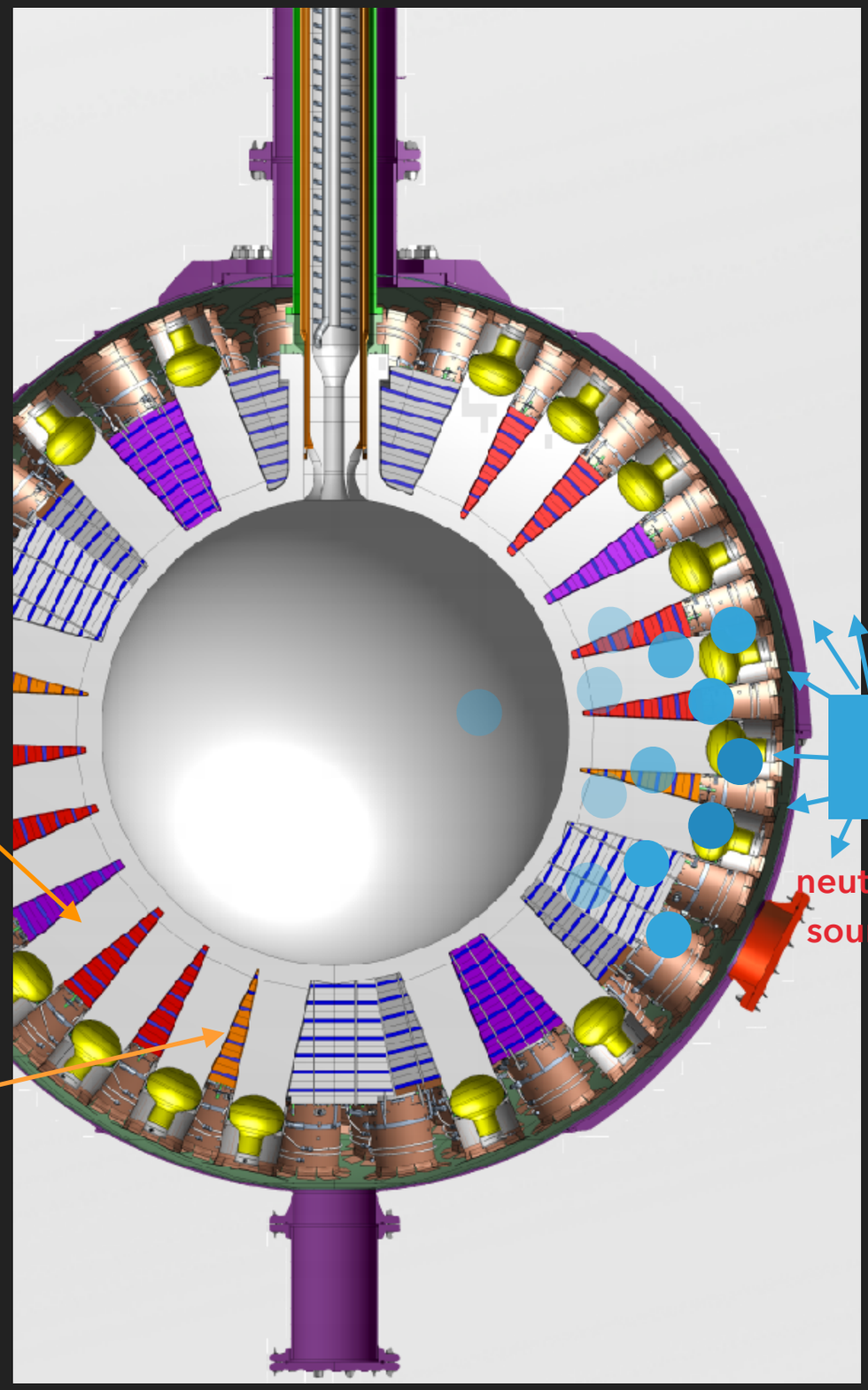
NEUTRON SHIELDING

- A neutron entering the LAr volume can mimic a WIMP-like signal.
- Thus, the detector is designed to shield against neutrons.
  - Very “hot” source is required for calibration.
  - MC production quite challenging.

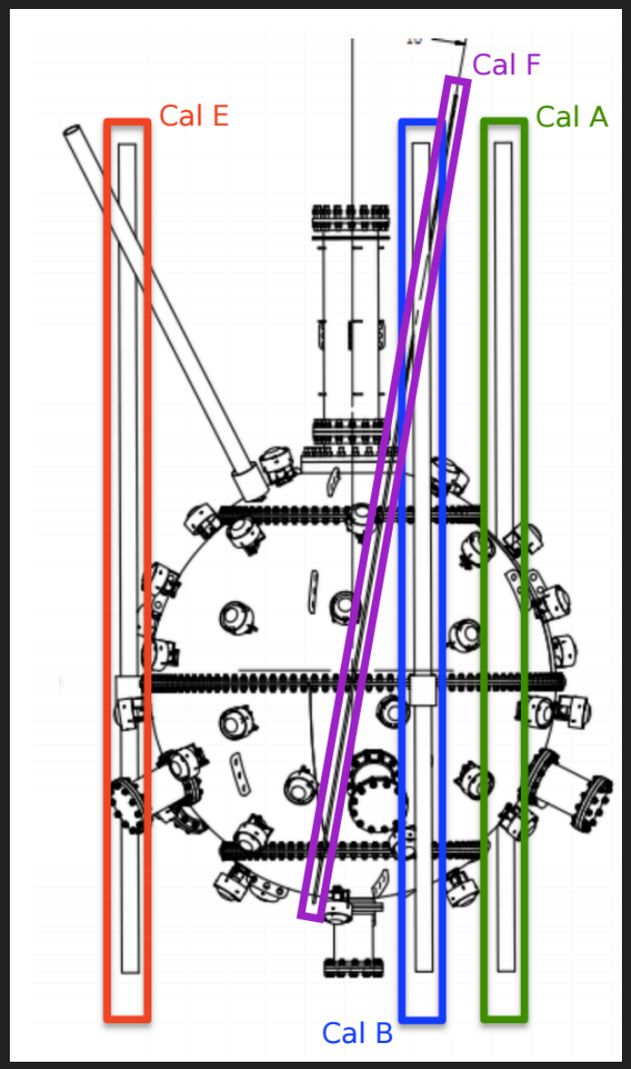


NEUTRON SHIELDING

- Light guides: Spartech Polycast UVA acrylic. High hydrogen content (50 cm lenght).
- Filler blocks: alternating layers of high density polyethylene and styrofoam.



EXTERNAL NEUTRON SOURCE

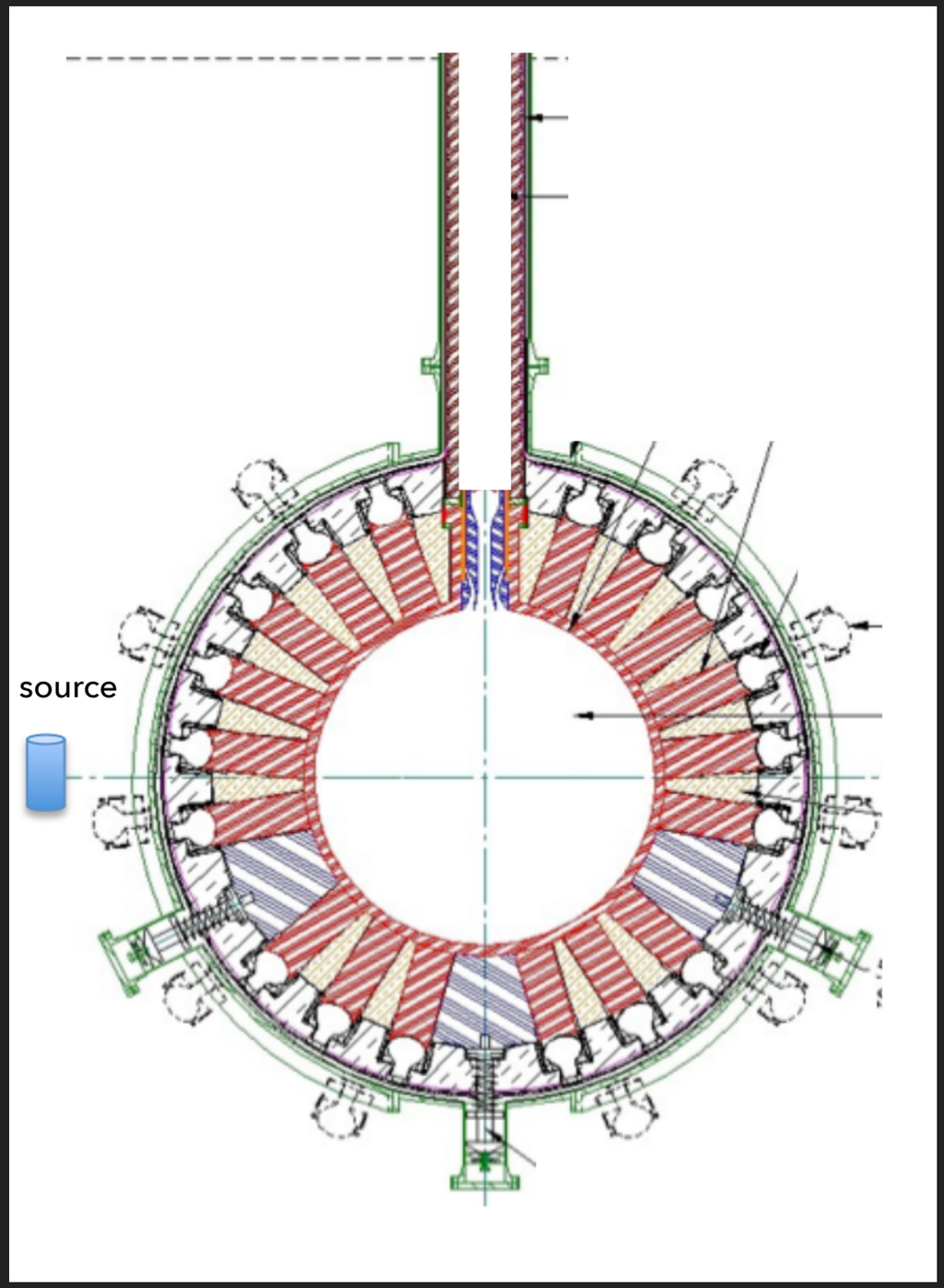


- 74 MBq Americium Beryllium (AmBe) neutron source (~5000 neutrons/s).
- Deployed in 3 external vertical tubes through an automated deployment rack.
- Distance from deployment point to centre of detector is 1.9 m.
- ~ 19 events/hour would make it in ROI in calibration runs.
- Very high absorption rate (~32B neutrons/hour should make it into the LAr volume without any shielding).
- Long calibration runs (~100 hrs) to populate the detector with significant statistics.

AmBe MC GENERATION CHALLENGE

- Need to simulate billion of neutrons to get a statistically significant MC set for calibration purposes is quite challenging:
  - Many CPU hours.
  - Many TBs of disk required.

- We split the MC generation into 2 stages:
  - ✦ STAGE 1:
    - Simulate a large number of neutrons from AmBe spectrum (~4B) using a simplified geometry.
    - Neutrons absorption rate unchanged.
    - Volumes removed from GEANT4 geometry to reduce interaction steps:



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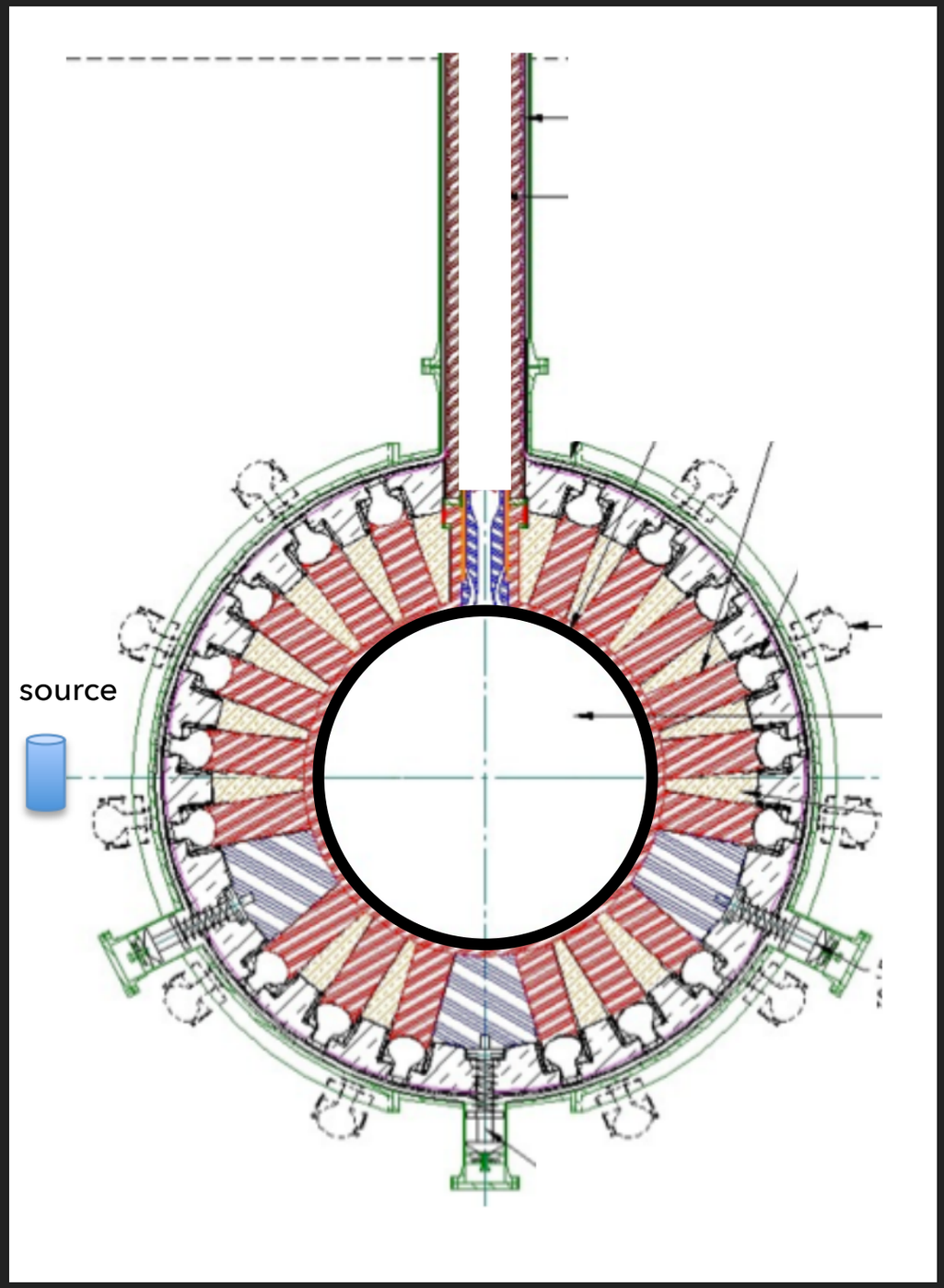

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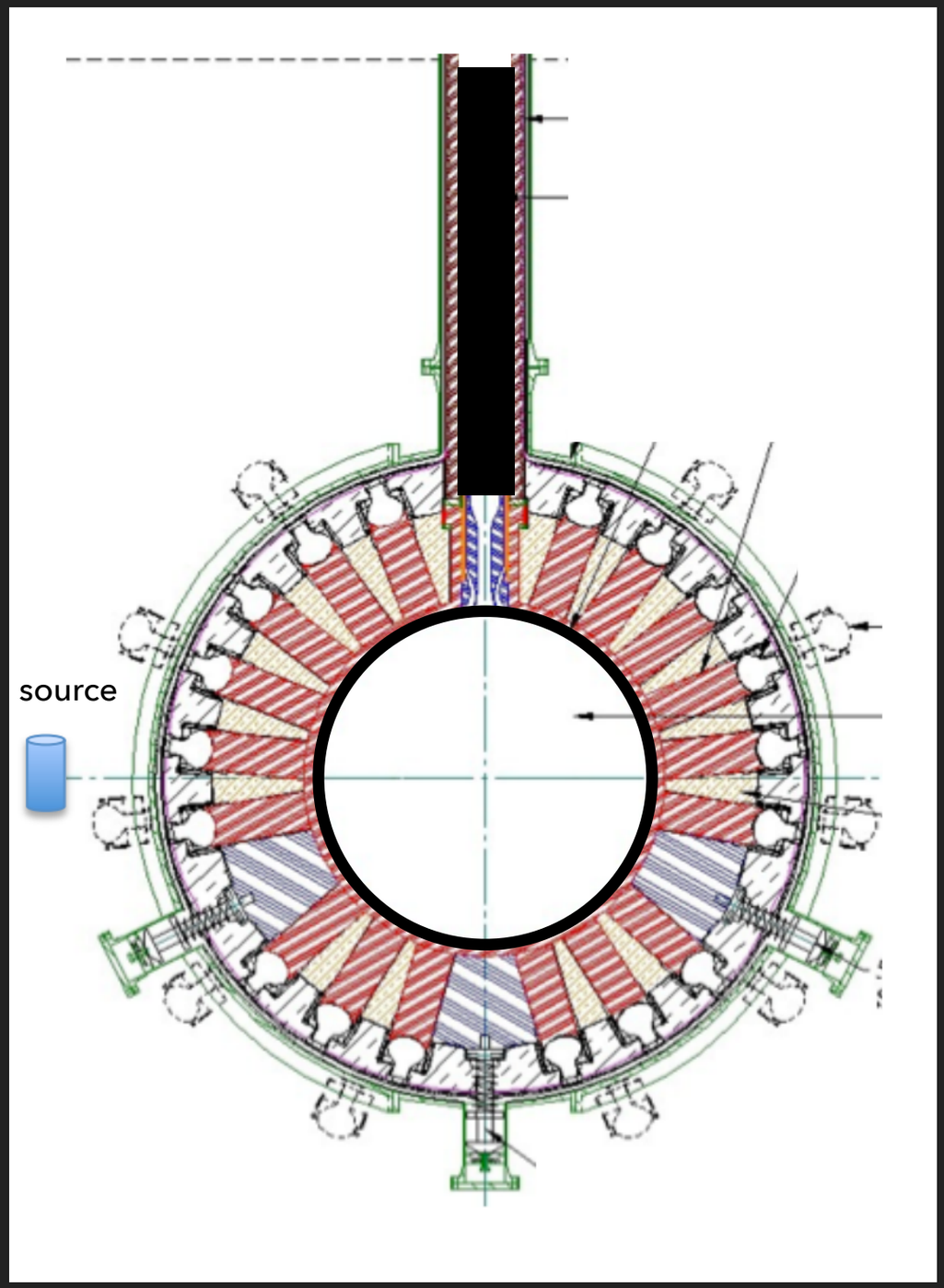

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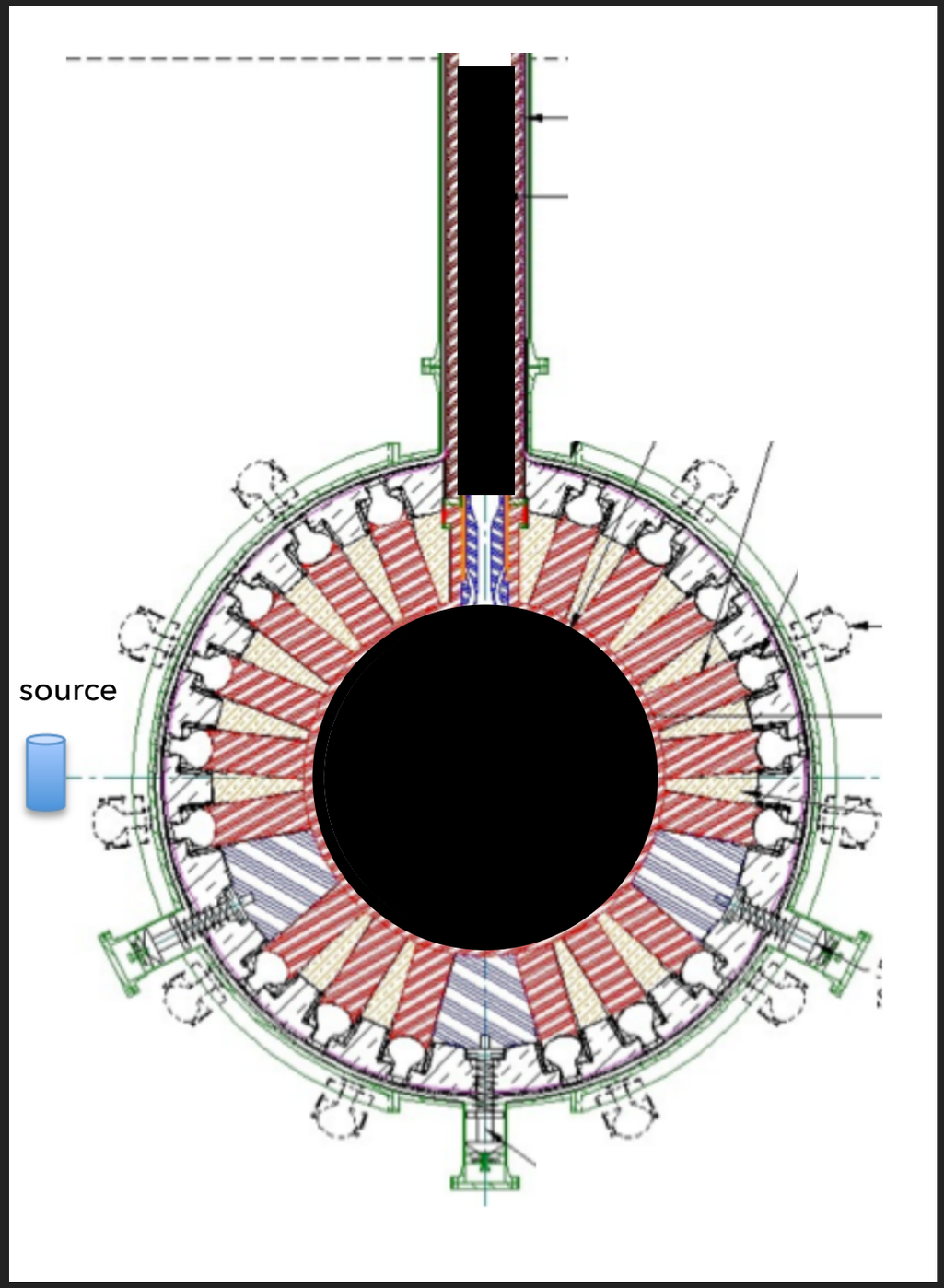

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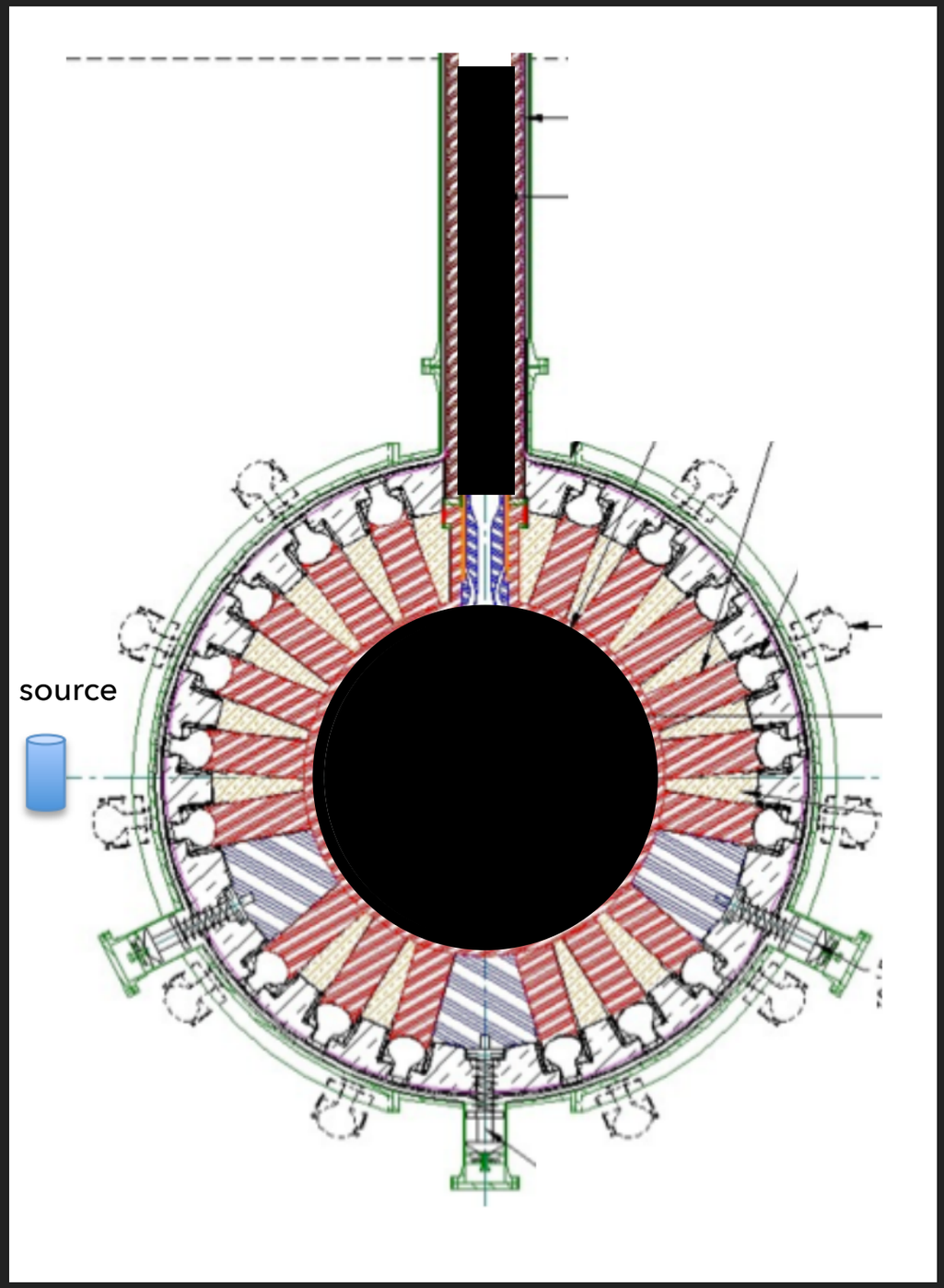
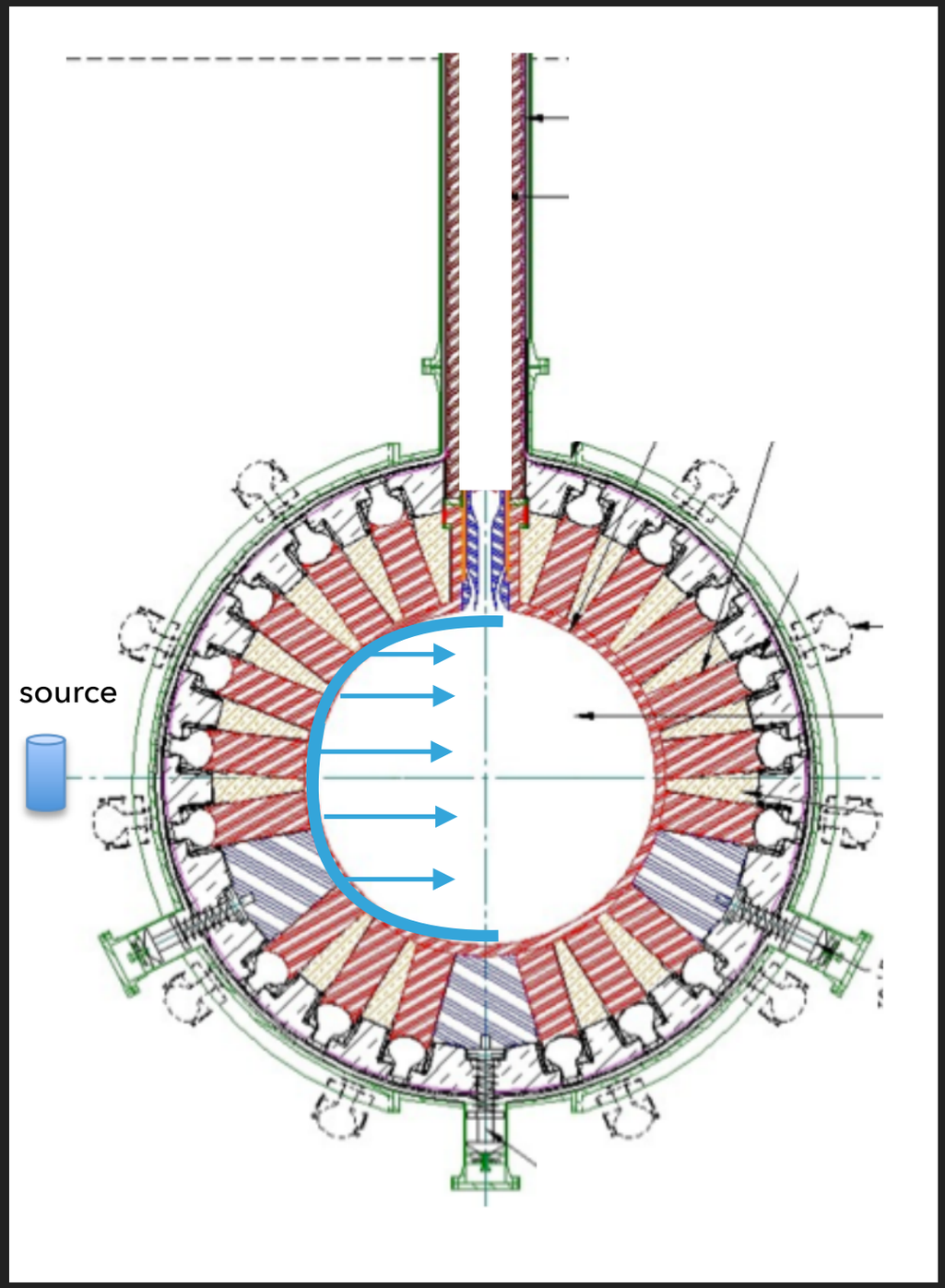
    - Neutrons absorption rate unchanged.
    - Volumes removed from GEANT4 geometry to reduce interaction steps:
      - TPB; Neck geometry; LAr.
    - No electronic/DAQ response in simulation at this stage.

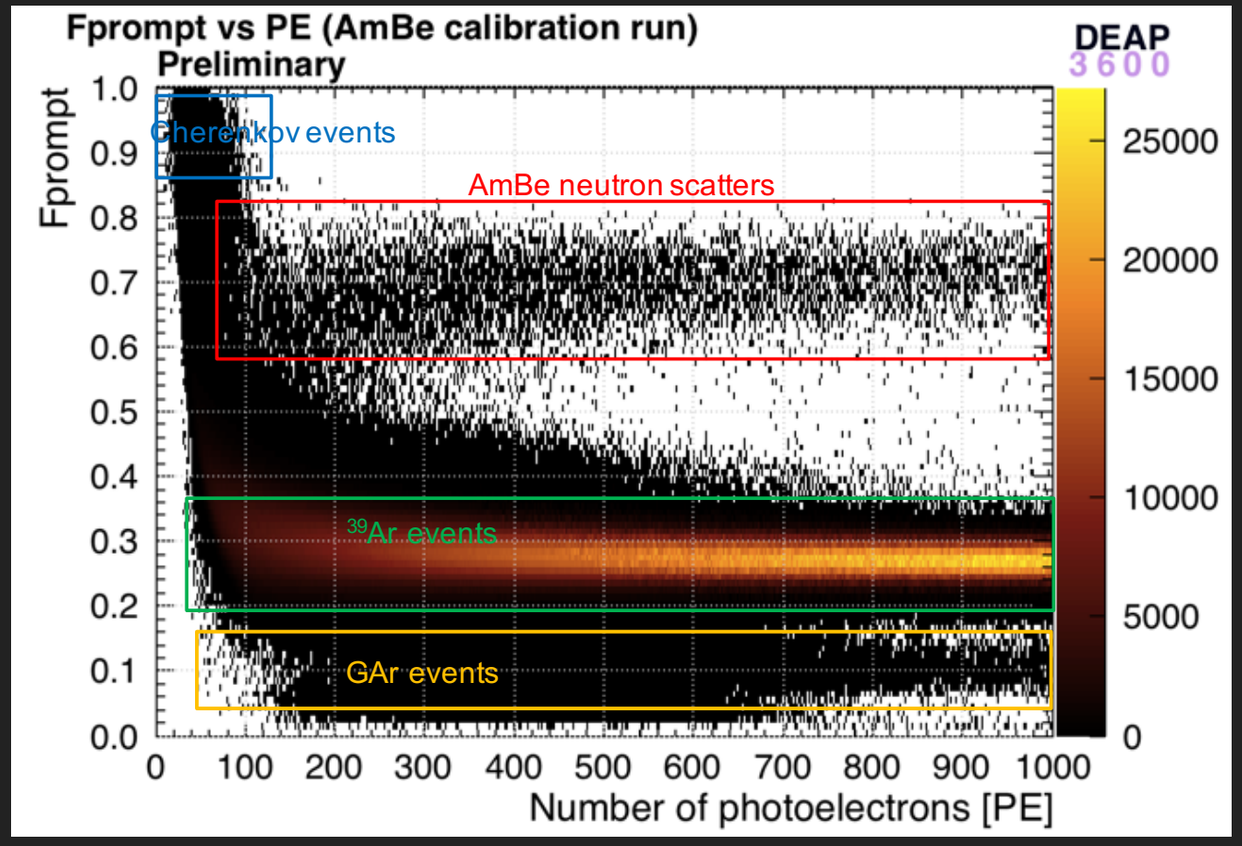


- We split the MC generation into 2 stages:
  - ✦ STAGE 2:
    - Record neutron position/ momentum when entering the AV volume from stage 1.
    - Re-simulate “surviving” neutrons and associated inelastic gammas with the full DEAP-3600 and DAQ response near the edge of the acrylic vessel.

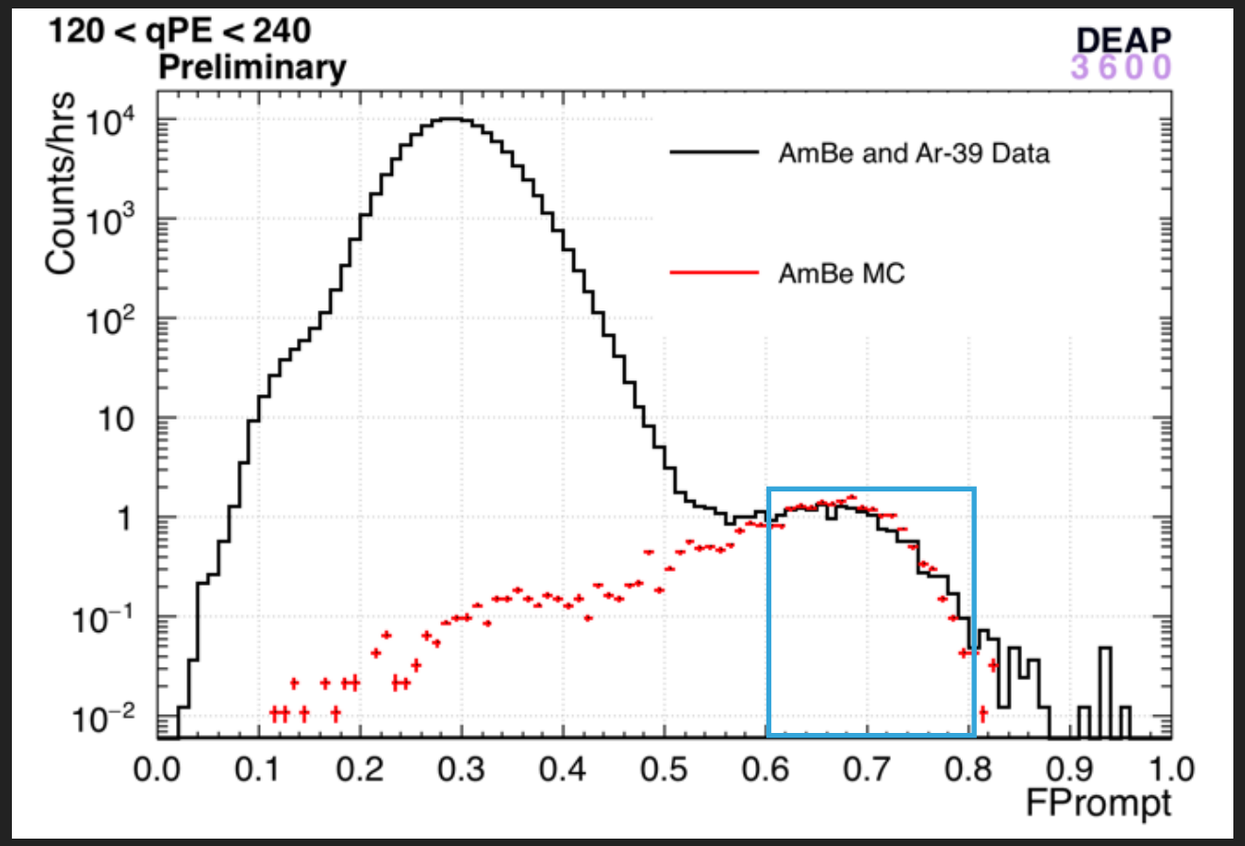


- Four different event types can be identified in the bottom left plot (AmBe calibration run): Gaseous ^{39}Ar events, Liquid ^{39}Ar events, Cherenkov events from high energy gammas and nuclear recoil events.
- Our AmBe MC only simulates neutron scatters, and a comparison with AmBe data shows good agreement in the region of interest (bottom right plot).

AmBe & ^{39}Ar Data

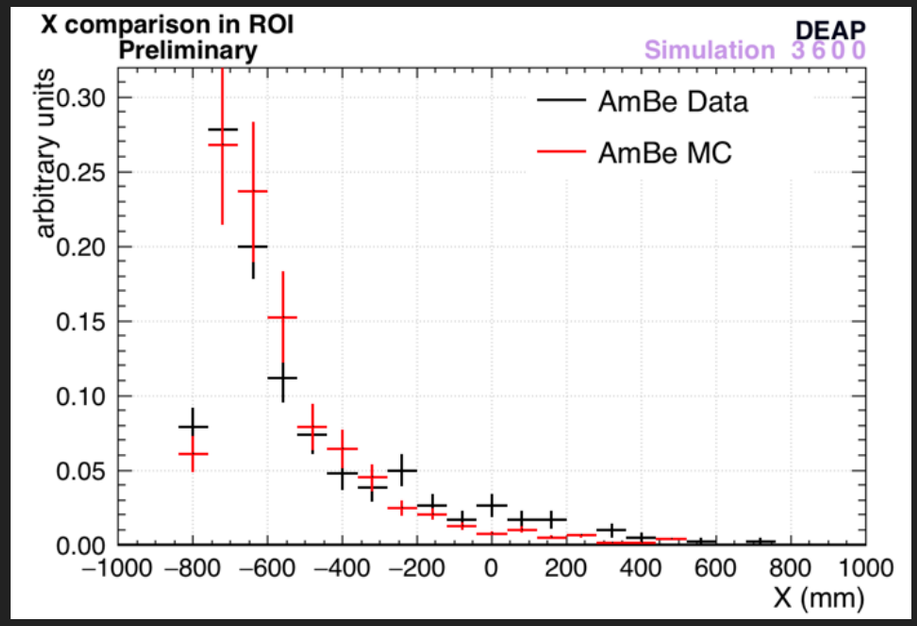


AmBe MC & data comparison



(*) Fprompt is defined as the fraction of light in an early time window (~150 ns) over the total light collected in the event.

- Good agreement also in position reconstruction between AmBe data and MC.



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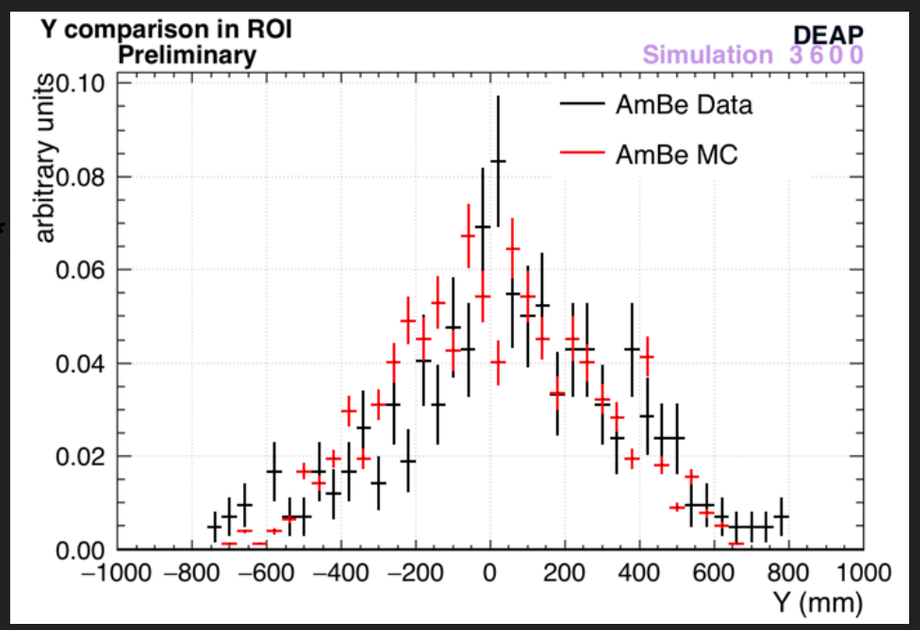

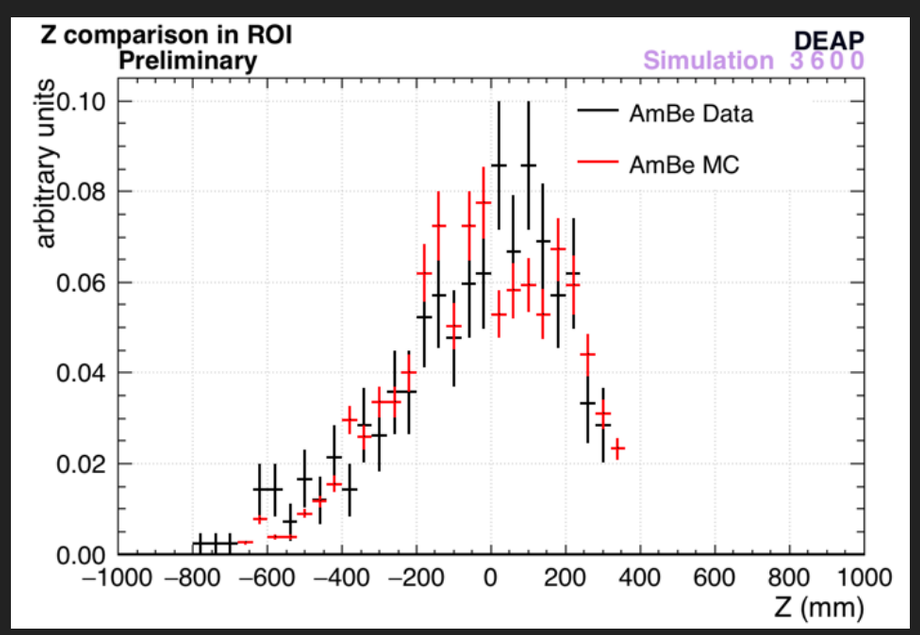

CONCLUSIONS AND OUTLOOK

- The 2 stages MC generation method has allowed us to build up large statistic AmBe MC set equivalent to 4 days of source deployment without requiring an enormous computing power.
- The plan is to further increase this MC set.
- Preliminary results indicate good agreement with data in the ROI.

BACKUP

SINGLE AND MULTIPLE SCATTERS IN AMBE MC