NPOD background simulation studies update

Raquel Quishpe

March 13th , 2023

MC Simulation

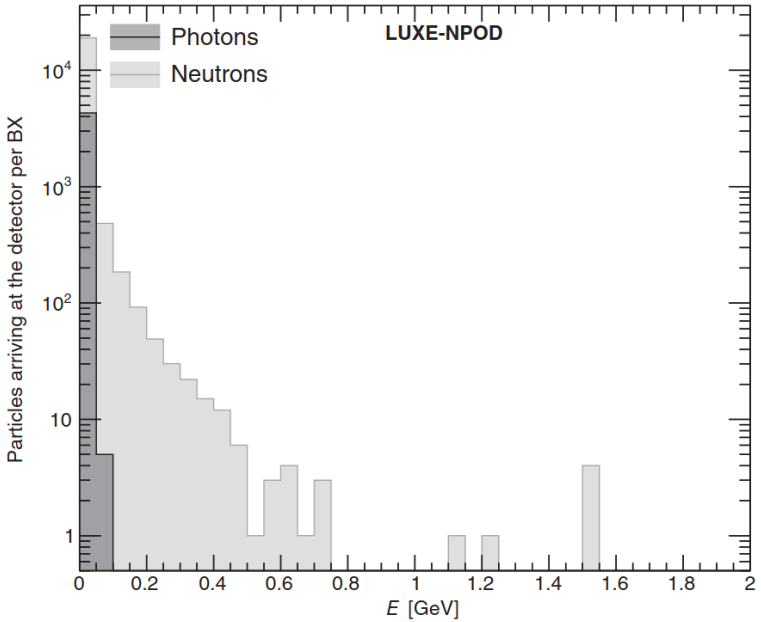
- Beam-laser simulation run with ptarmigan-v0.11
- Referenced input file from NAF-LUXE

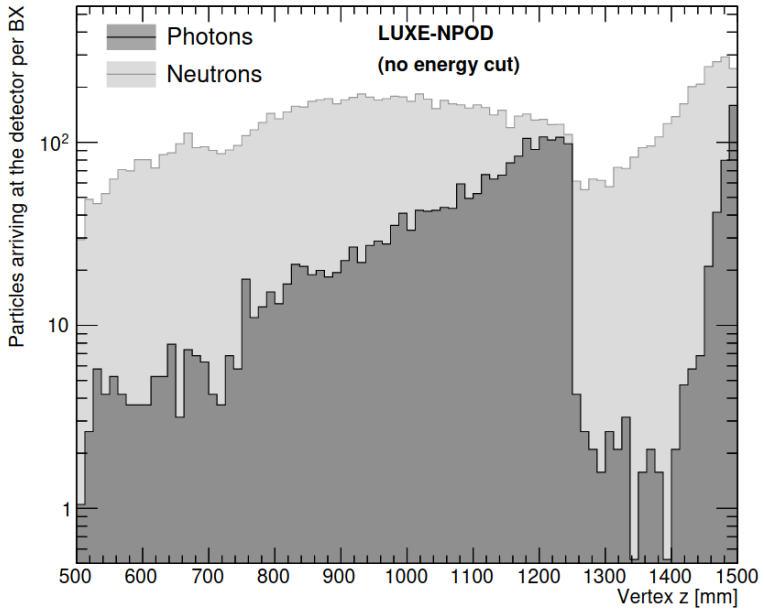
  `/nfs/dust/luxe/group/MCProduction/Signal/ptarmigan-v0.11/elaser/phase1/npod`
- 10 BXs simulated for phase-1
- Data available in ETP at `/ceph/rquishpe/luxe/npod/ptarmigan-v0.11/phase1`
- We stored 10 MC separate files for 1BX, hence there is a factor 10 that needs to be considered for the normalization in the g4 simulations analysis

NPOD G4 simulation

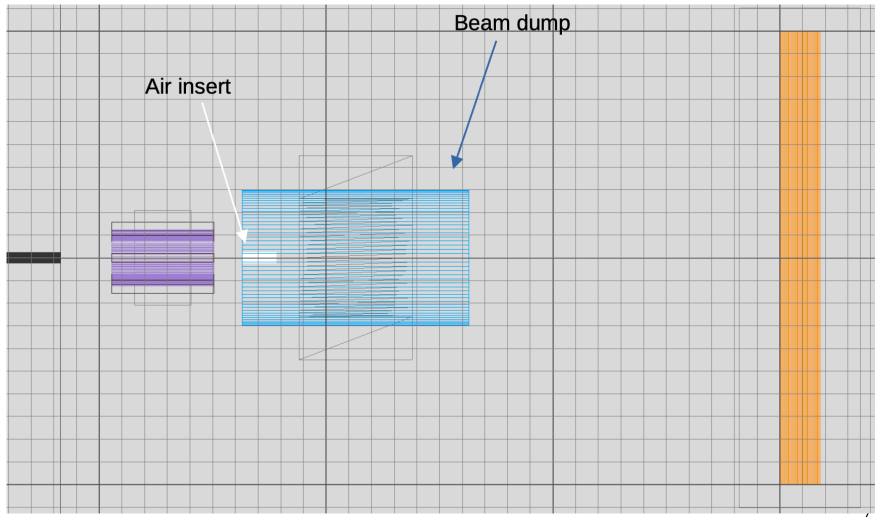
- The initial goal is to reproduce NPOD pheno paper results with the new G4 lxsim

- For the NPOD pheno paper 2BX of a 1m Tungsten dump was simulated
  - Dummy dump
  - Physics list: `QGSP_BERT`
  - Medium: vacuum
  - Distance from dump to BSM calo = 2.5m

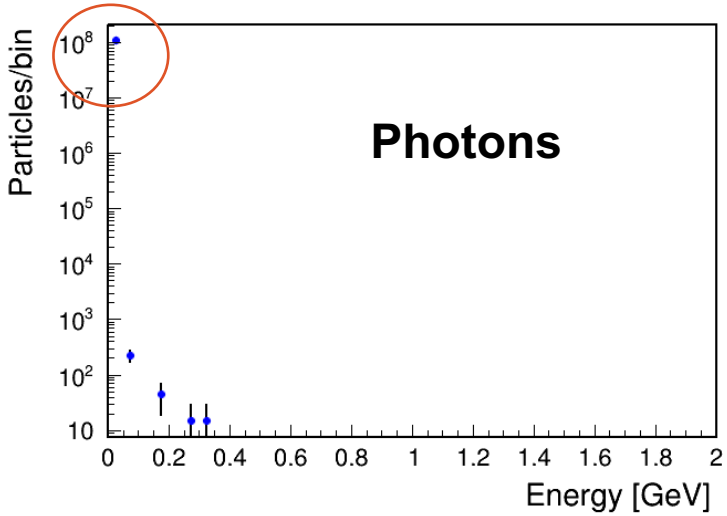


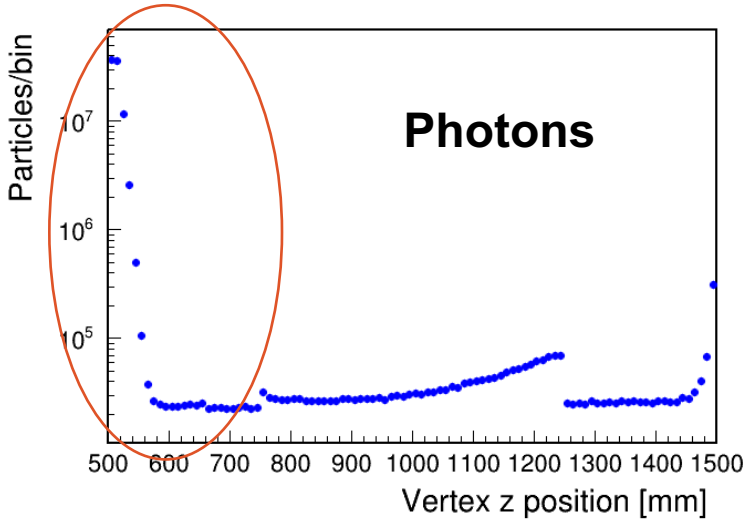


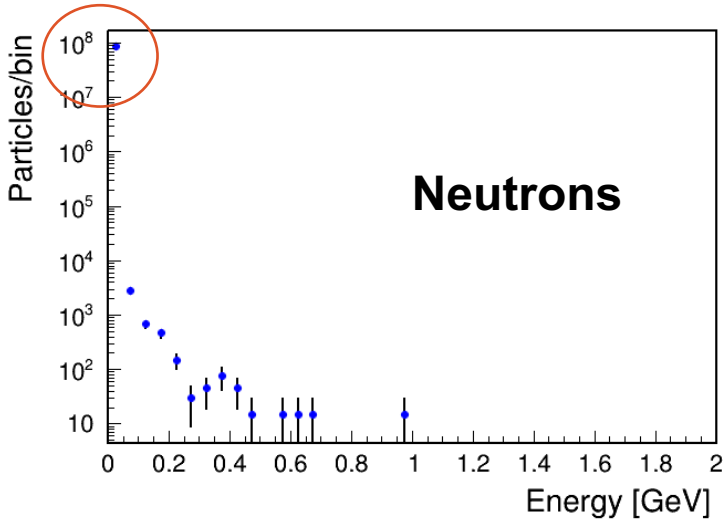
NPOD background studies – air insert

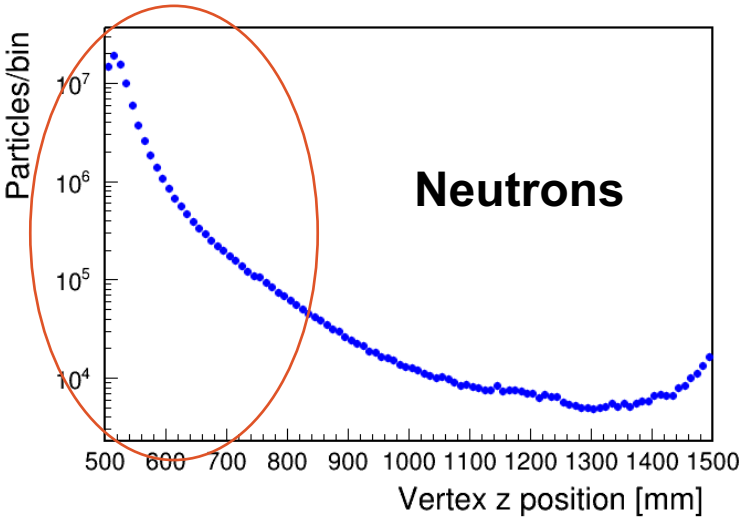


- Cylindrical air insert on front side: L=15cm, D=48.26mm
- Air insert is needed to efficiently absorb the back scattered particles to reduce background
- Air insert not in NPOD pheno paper
- Dump: Tungsten, L=1m, R=30cm
- Simulated 1BX
  - Physics list: `QGSP_BERT_HP`
  - Medium: air
- `detid==9000`
- `sqrt(x*x+y*y)<1000.0`
- `abs(z-17130.0)<0.1` (front side of the detector)



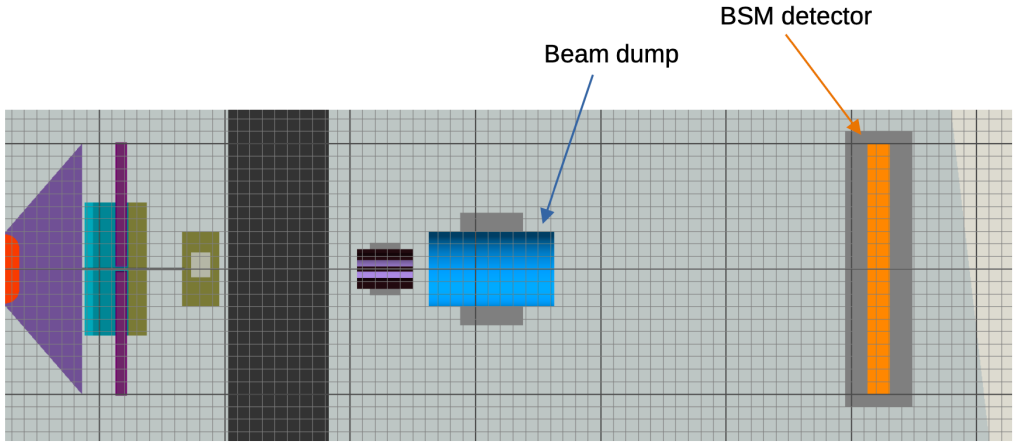




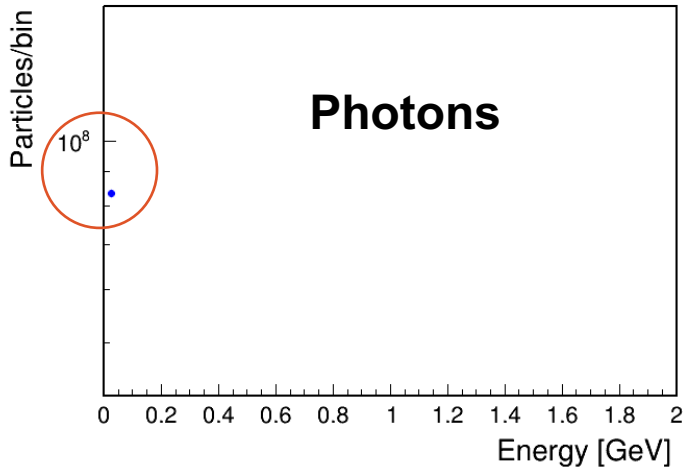


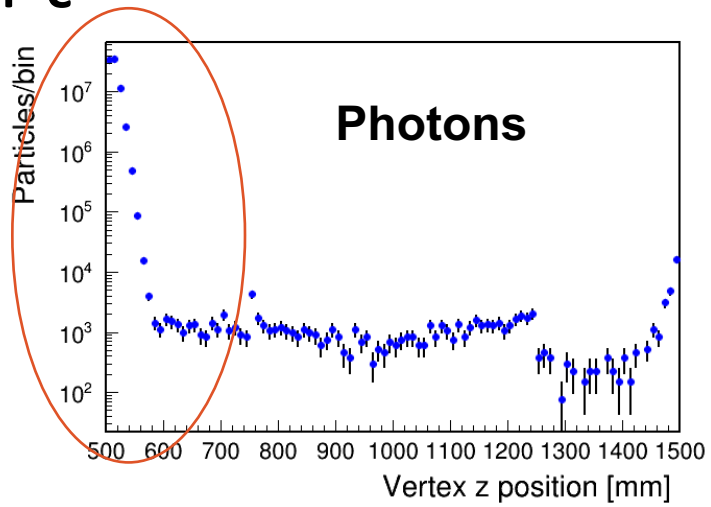
Unexpected strong presence of low-E particles at the beginning of the dump. Disagrees with the pheno paper studies

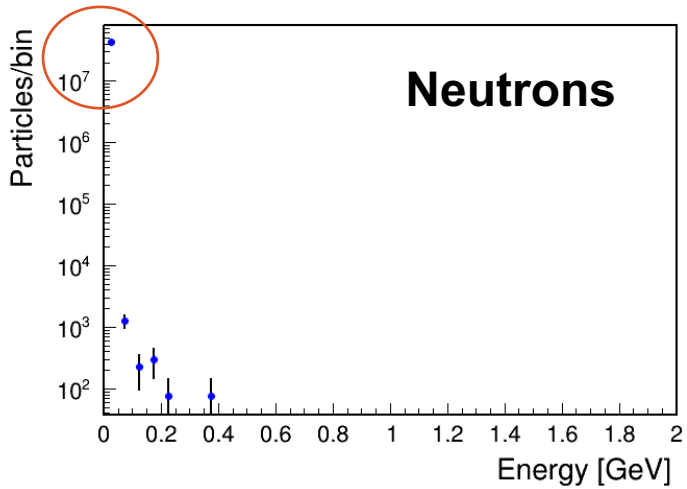
NPOD background studies – no air insert

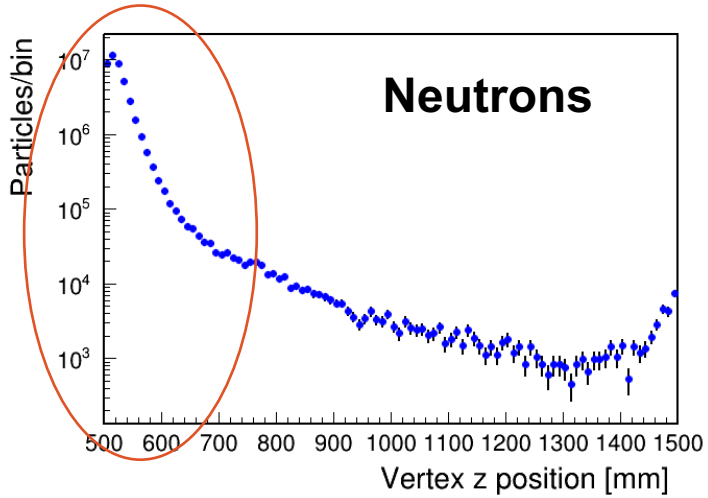


- Dump: Tungsten, L=1m, R=30cm
- Simulated 20%BX
  - Physics list: `QGSP_BERT`
  - Medium: Galactic
- Other configurations and materials here
- `detid==9000`
- `sqrt(x*x+y*y)<1000.0`
- `abs(z-17130.0)<0.1`
- `vtxz>13630.0 && vtxz< 14630.0`
- `sqrt(vtxx*vtxx+vtxy*vtxy)<1000.0`







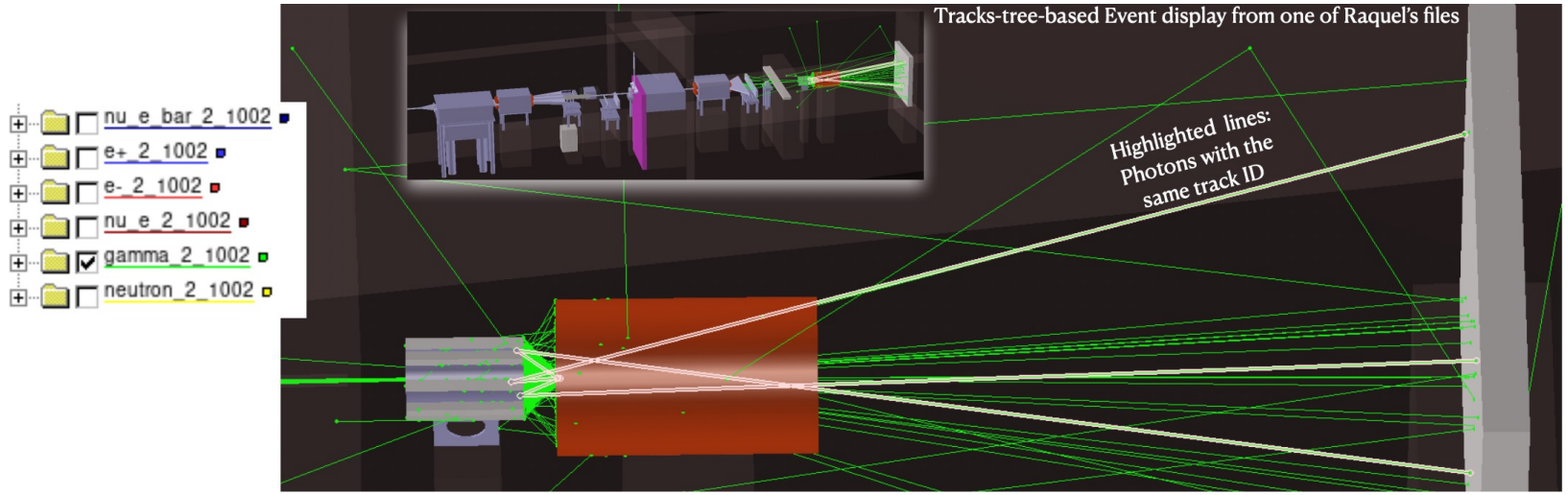


Strong presence of low-E persists

Possible origin of low-E particles: Second backscattering

Noam's slides

- photons produced very close to the beginning of the dump, backscattered to the negative z direction
- then re-scattered from other materials, e.g. the backscattering calo (wasn't in the pheno paper) to the positive z direction
- intermediate steps are not recorded in the Tracks tree so it appears as if the photons travel in the dump to the detector, which is not the case

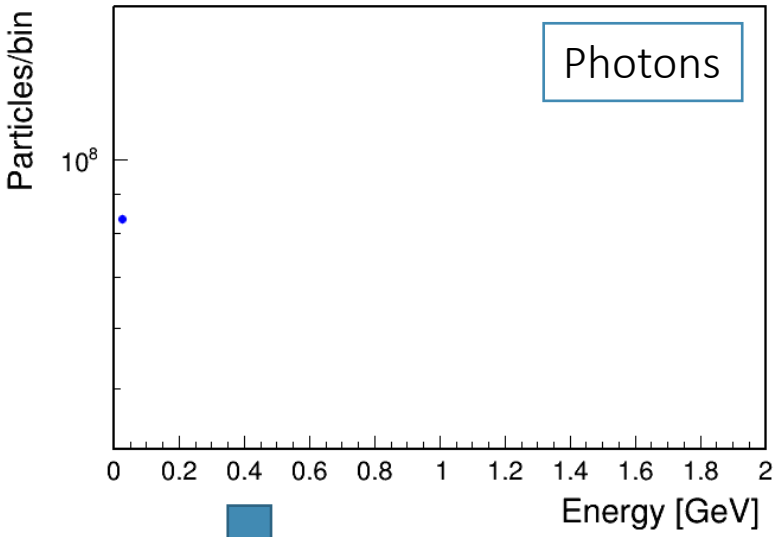


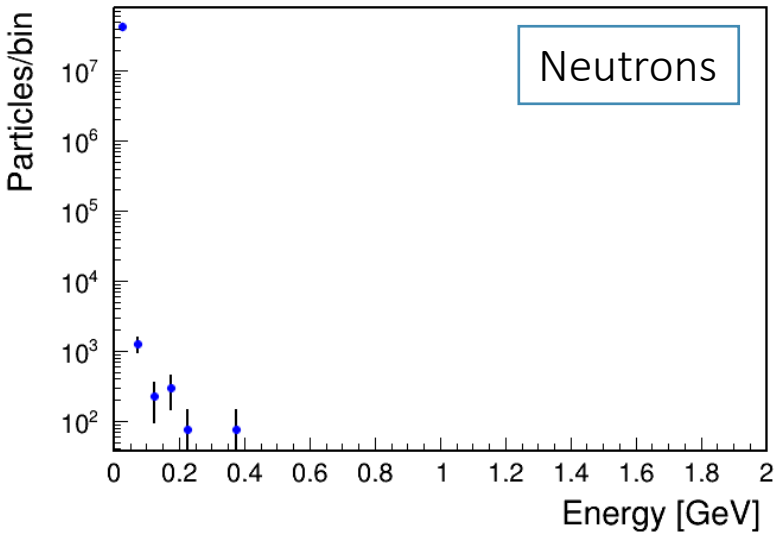
Suggested crosschecks to validate pheno paper:

- Apply a cut to the z-vertex aiming particles produced in the dump, e.g. `vtxz>(dump_front_end+10cm)`
- Look at the number of secondaries of all photons produced in the dump as a rough proxy to the number of interactions and require that these photons have zero or at most 1 secondaries
  - A flag `status` has been added to Tracks tree, e.g.:
    - `status==0` particles that escaped the dump through the front plane
    - `status==6` particles that escaped from the side

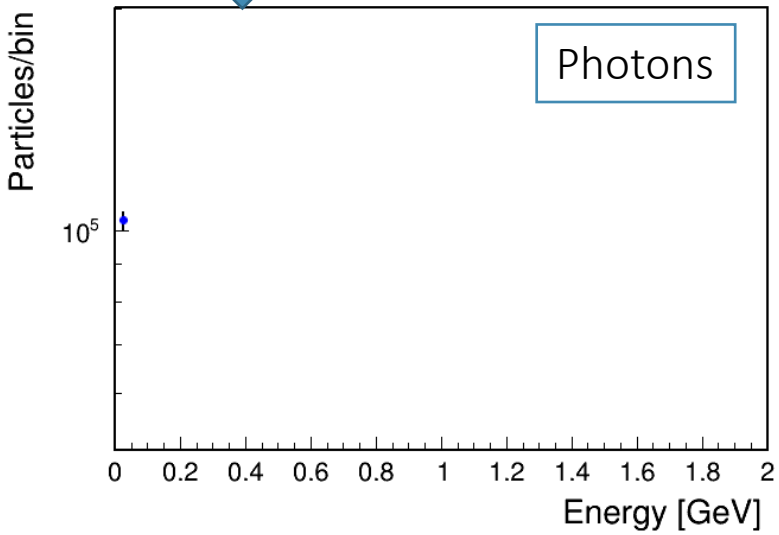
NPOD background studies – no air insert

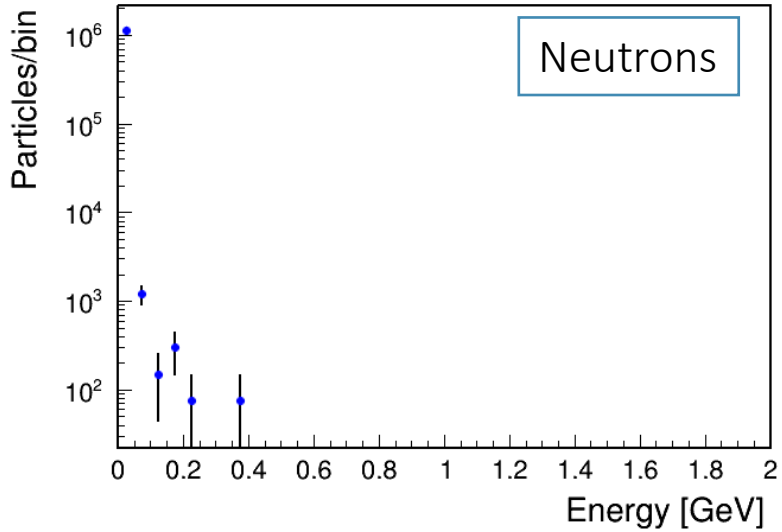
- Dump: Tungsten, L=1m, R=30cm
- Simulated 20%BX
  - Physics list: `QGSP_BERT`
  - Medium: Galactic
- `detid==9000`
- `sqrt(x*x+y*y)<1000.0`
- `abs(z-17130.0)<0.1`
- `vtxz>13630.0 && vtxz< 14630.0`
- `sqrt(vtxx*vtxx+vtxy*vtxy)<1000.0`





After applying suggested cut at vtxz>(dump_front_end+10cm)



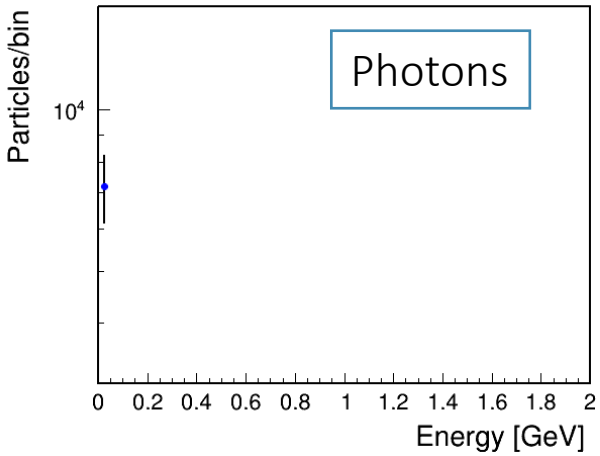


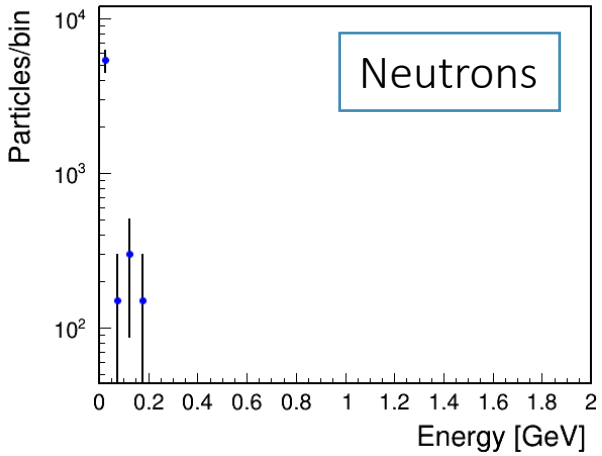
- Cut reduces particles to ~0.1% Photons and ~3% Neutrons
- Less low-E particles, but discrepancy persists

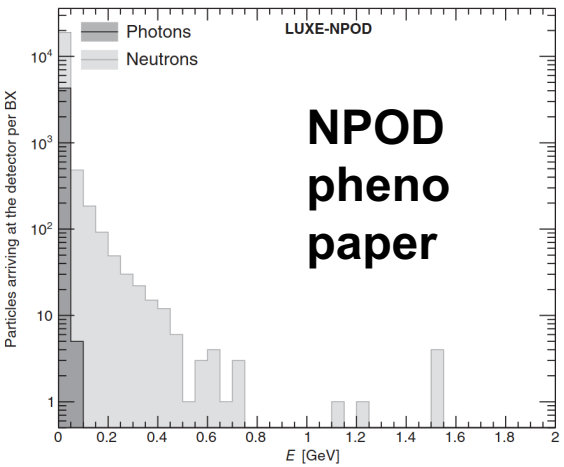
Simulation with flag “status”

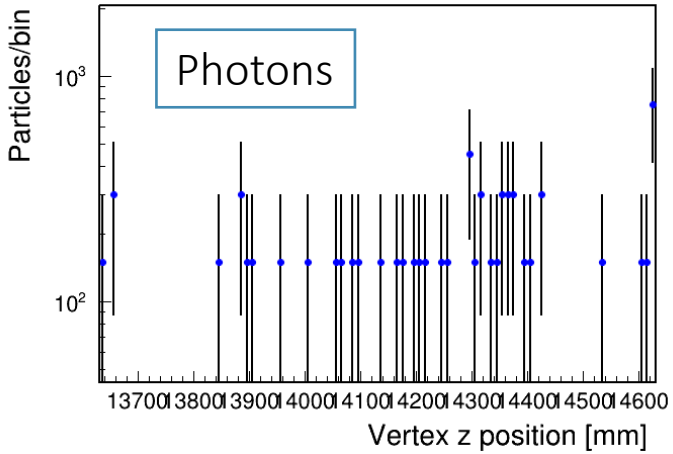
- Dump: Tungsten, L=1m, R=30cm
- Simulated 10%BX
  - Physics list: `QGSP_BERT`
  - Medium: Galactic
- `detid==9000`
- `sqrt(x*x+y*y)<1000.0`
- `abs(z-17130.0)<0.1`
- `vtxz>13630.0 && vtxz< 14630.0`
- `sqrt(vtxx*vtxx+vtxy*vtxy)<2000.0`
- **`status==0`**

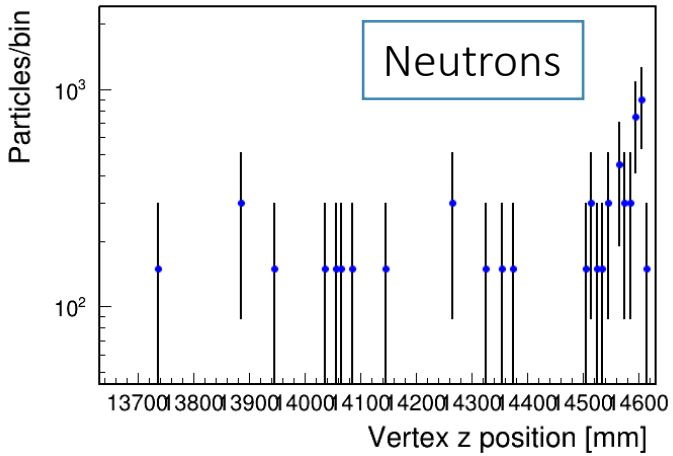
Distributions agree more in the order with the pheno paper

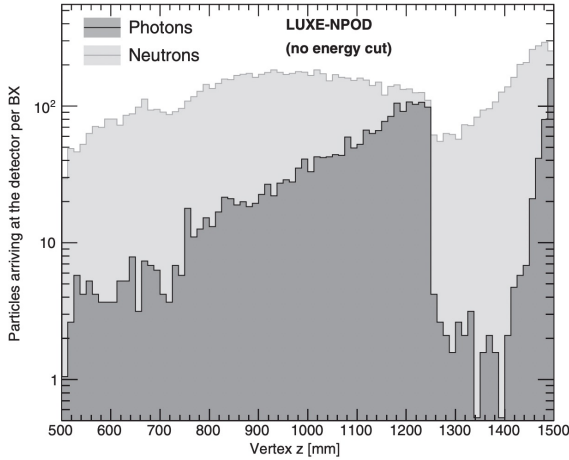




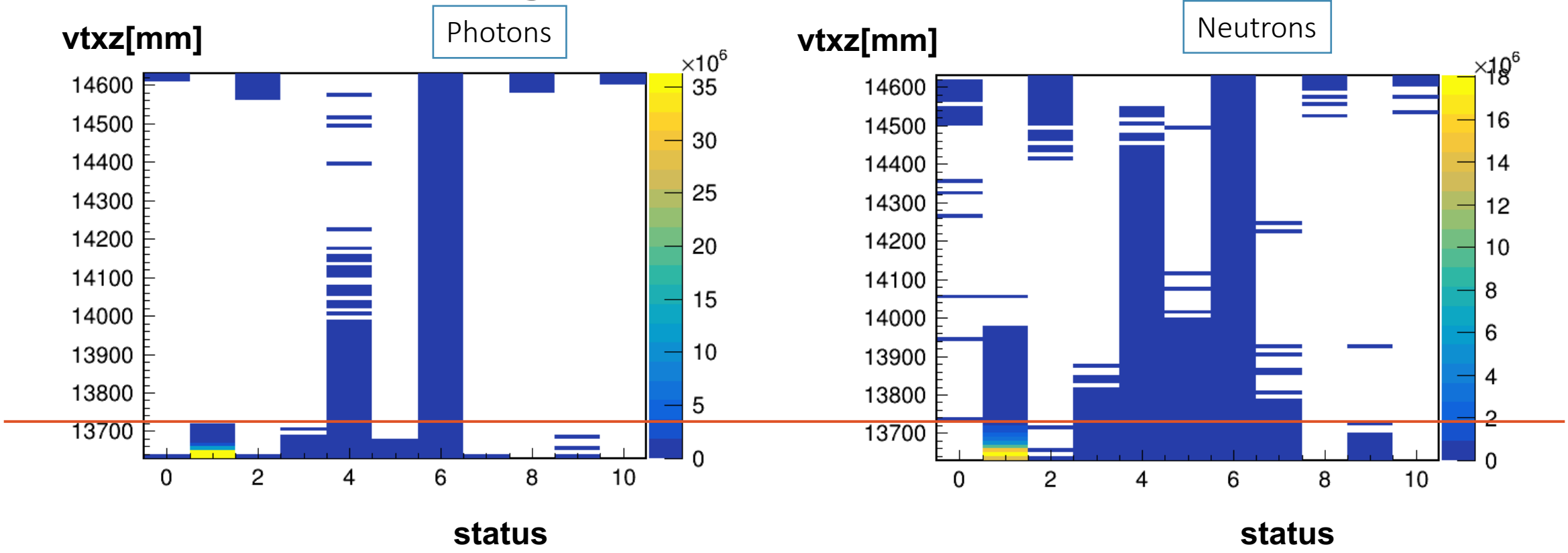








Simulation with flag status



- A cut in vtxz>(dump_front_end + 10cm) is not enough for neutrons
- Most of the particles remaining correspond to particles that scaped from the side (status==6)

Comments

- Excluding “second backscattered” particles (status==0) remove a significant amount of low-E particles, and results are compatible with the ones from the NPOD pheno paper

- It was suggested to implement a cut of 10cm from the dump front-end. The cut reduces low-E particles, but it is not enough

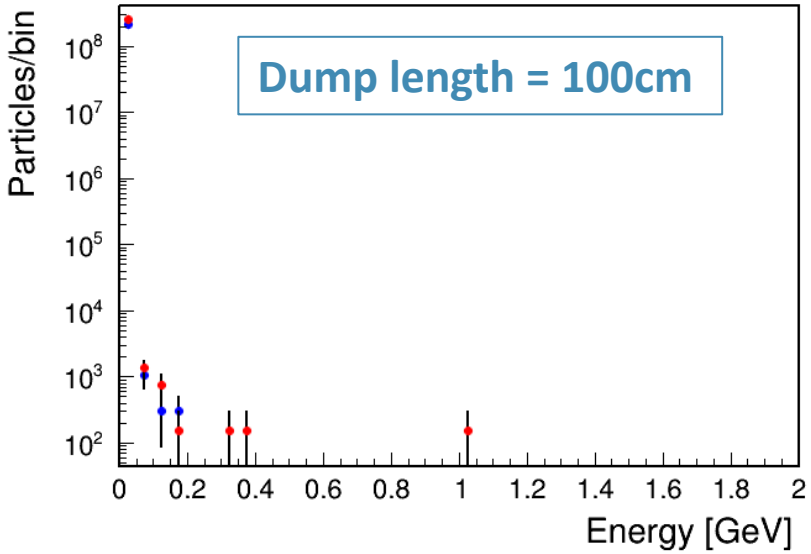
- Further analysis show that most of the particles remaining after cuts correspond to particles that escaped from the side
  - How do we constraint this? *ToDo*: Dump enclosed in concrete wall

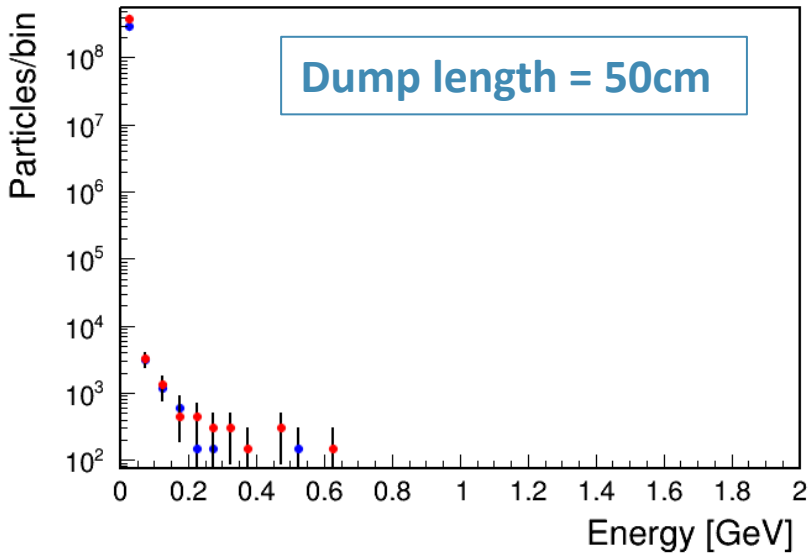
Backup

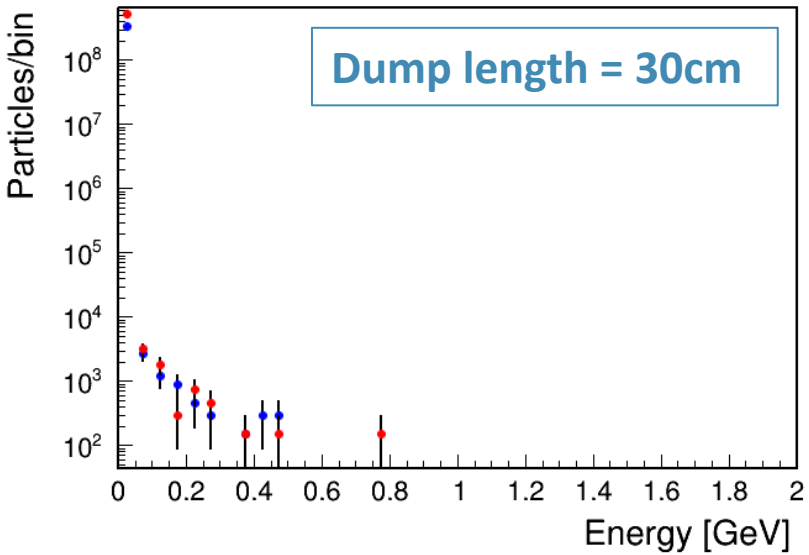
Comparison of different dump materials and length

Photons energy spectra

- Distance from dump to detector = **100cm**
- Dump radius = **10cm**
- Dump material **W**, **Pb**
- 10% BX

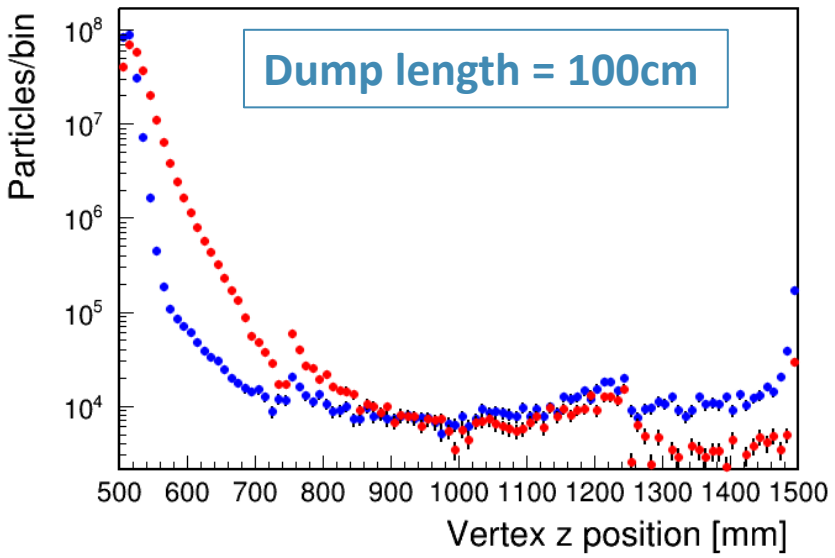


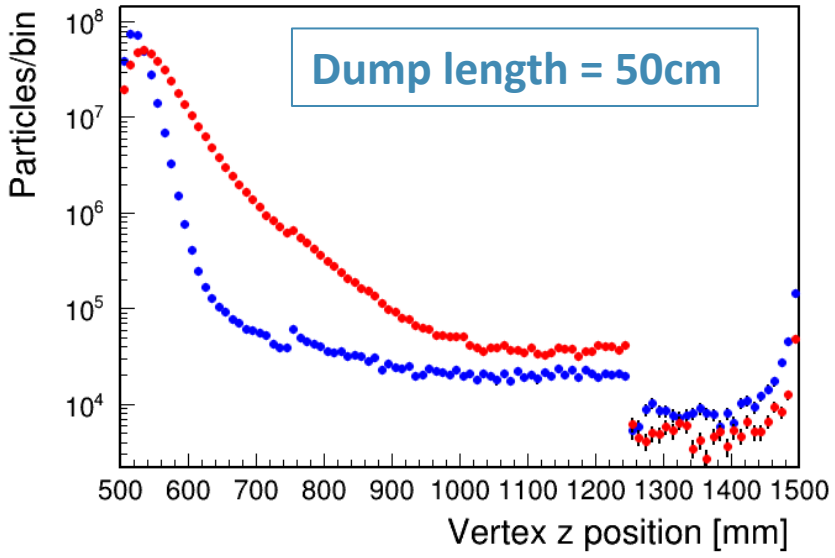


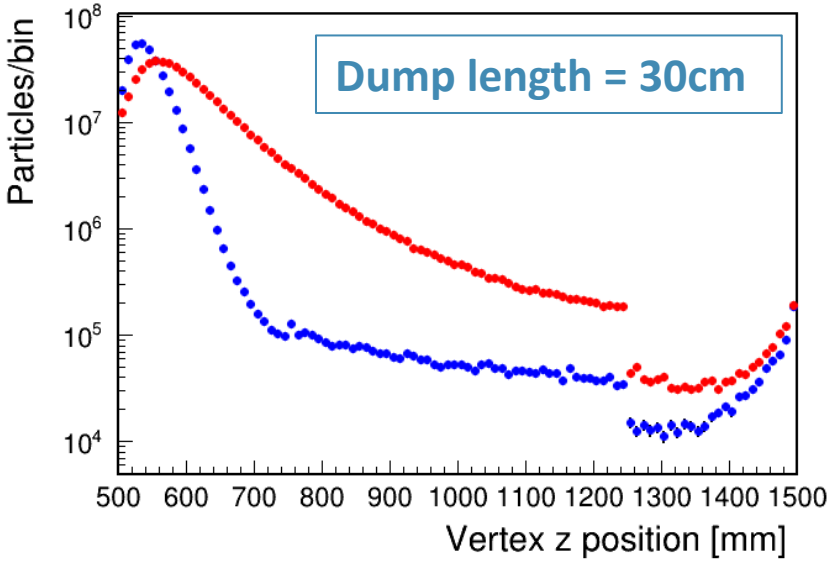


Photons z-vertez distribution

- Distance from dump to detector = 100cm
- Dump radius = 10cm
- Dump material **W**, **Pb**
- 10% BX

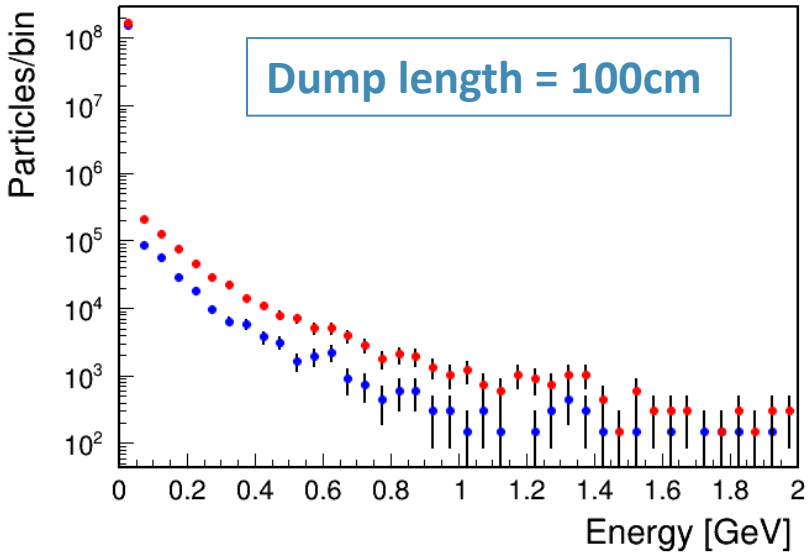


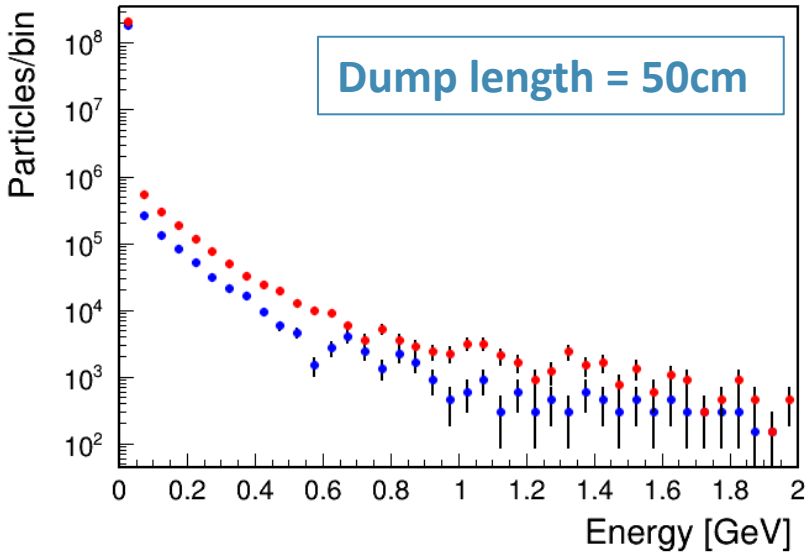


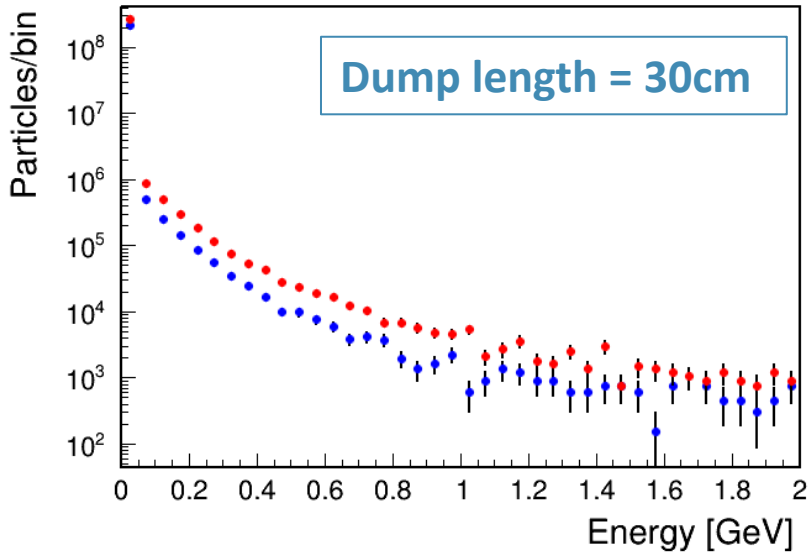


Neutrons energy spectra

- Distance from dump to detector = 100cm
- Dump radius = 10cm
- Dump material **W**, **Pb**
- 10% BX







Neutrons z-vertex distribution

- Distance from dump to detector = 100cm
- Dump radius = 10cm
- Dump material **W**, **Pb**
- 10% BX