Effect of the Neutron Absorber on Electron Beam Dump and Iron Shield

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Introduction:

- Handling neutrons coming from electron beam dump can be challenging.
    - Neutrons will not create hits on tracker material, but the radiation doze will be a problem.
- Need to see how we can reduce the neutrons coming from electron beam dump.
- A thin absorber on electron beam dump added.
    - made of borated polyethylene concrete.
- Iron shielding added after calorimeter.
- Want to understand the effect of them on the background particles.

e+laser background setup:

- FullSim (total 2BX) $\rightarrow$ plots normalized to 1 BX.
- FullSim with Iron Shielding and additional neutron absorber (total 0.42 BX) $\rightarrow$ plots normalized to 1 BX.
- FastSim (total 7.45BX) $\rightarrow$ plots normalized to 1 BX.
- Looked at the background particles:
  - Electrons
  - Photons
  - Positrons
  - Neutrons
- Plots from the tracks intersecting the tracker plane (not necessarily making a hit in the tracker).

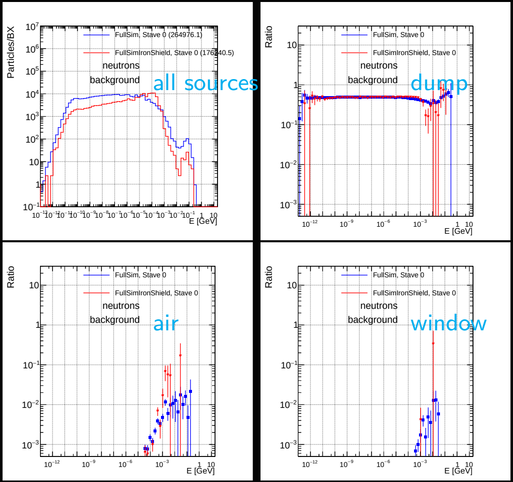
Selections of background particles

- Selected particles originated from the dump, air and vacuum exit window
  - Background from dump with vertex requirement: (6800 mm $<$ vtxz $<$ 8300 mm) and (-1700 mm $<$ vtxx $<$ 500 mm)
  - Background from window with vertex requirement: (3850 mm $<$ vtxz $<$ 3900 mm) and (-600 mm $<$ vtxx $<$ 600mm)
  - Background from air if: If vertex falls within a cylinder of radius 5cm, the axis of the cylinder being a straight line connecting window and dump.
    - The straight line is drawn from these two points
    - Window: z1=3925, x1=39, y1=0
    - Dump: z2=7000, x2=102, y2=0

- First layer, first stave plot (positron side)

Background neutrons: FullSim

- Background neutrons in first layer, first stave of tracker.



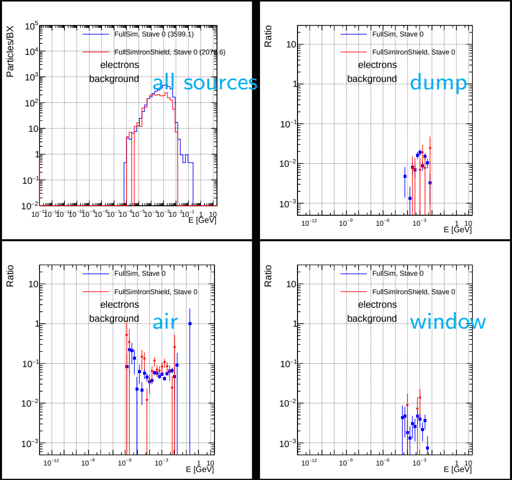
figures

Top left: energy distribution from all sources. Top right: ratio of energy, particles from dump over particles from all sources. Bottom left: ratio of energy, particles from air over particles from all sources. Bottom right: ratio of energy, particles from exit window over particles from all sources.

- 33% less neutron with neutron absorber.
- Less number of high energetic neutron.

Background electrons: FullSim

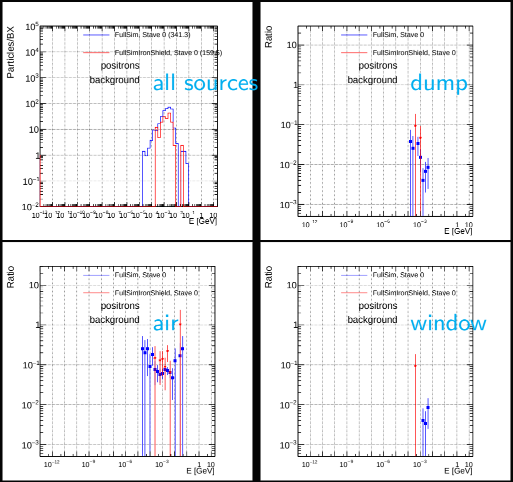
- Background electrons in first layer, first stave of tracker.



42% less electron with neutron absorber and iron shield.

Background positrons: FullSim

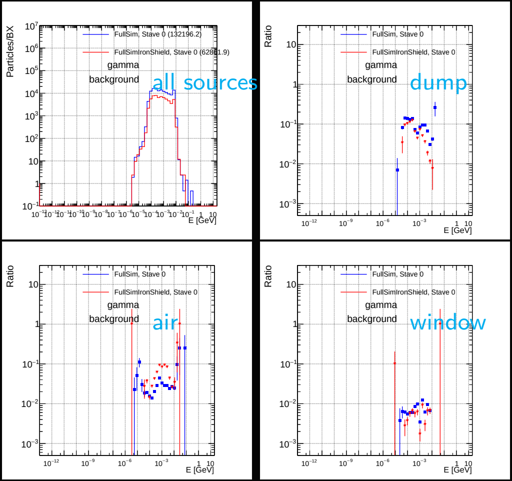
- Background positrons in first layer, first stave of tracker.



53% less positron with neutron absorber and iron shield.

Background gamma: FullSim

- Background gamma in first layer, first stave of tracker.

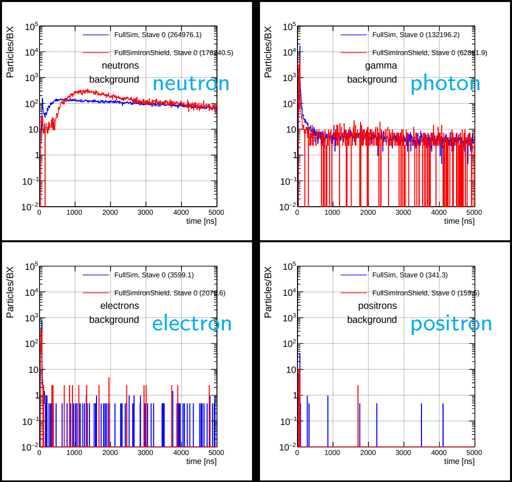


- 52% less photon with neutron absorber and iron shield.
- The energy spectrum shapes are similar here.

- Timing distribution, Stave 0

Background timing distribution: FullSim, Stave0

- Background particles timing distribution in first layer, first stave of tracker.



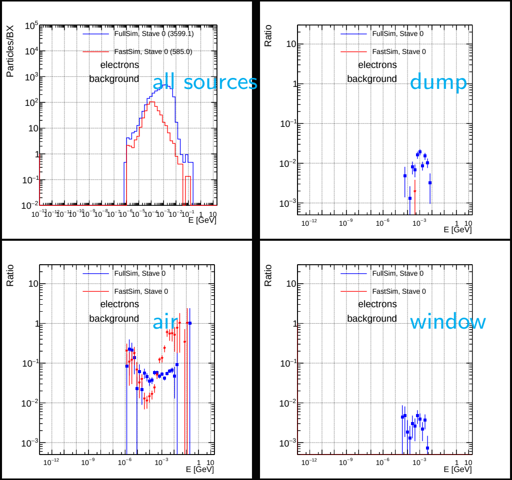
Summary:

- In the tracker first layer first stave, neutron absorber and iron shielding reduces
  - $\sim 33\%$ of neutron particles from the dump.
  - $\sim 42\%$ of electrons.
  - $\sim 53\%$ of positrons.
  - $\sim 52\%$ of photons.
- Neutron timing distribution is flat.
- If we cut at 1000 ns (1 μs- detector readout time), we can get rid of many neutrons($\gtrsim 75\%$).
- Similar conclusion can be drawn from the tracker last stave last layer plots (in backup).
- 2D distribution showing the source of the background particles are also in the backup.
- To do: Identifiy the physics processes that generate electrons and photons: see the contribution of the hadronic activities.

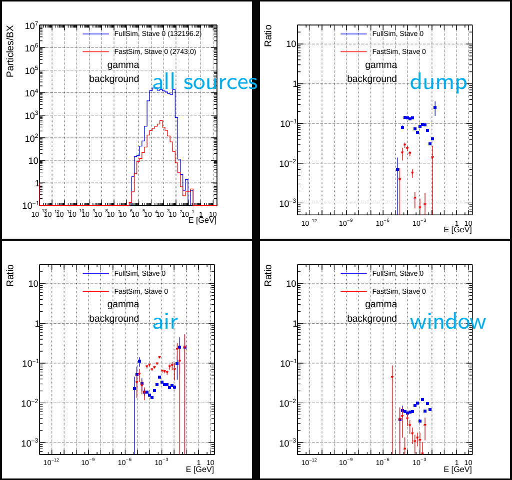
- Back up

- FullSim and FastSim comparison

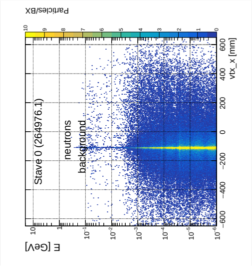
FastSim and FullSim comparison: electron

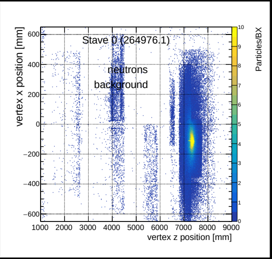


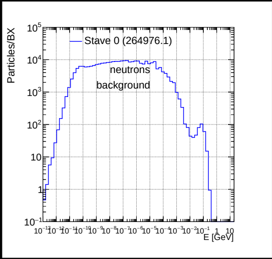
FastSim and FullSim comparison: photons

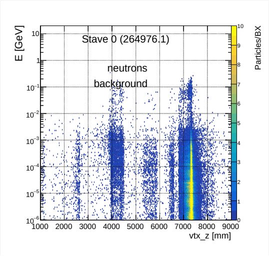


- 2D plots, Stave 0


Stave 0 (264976.1)
neutrons
background
E [GeV]
vtx_x [mm]
Particles/BX

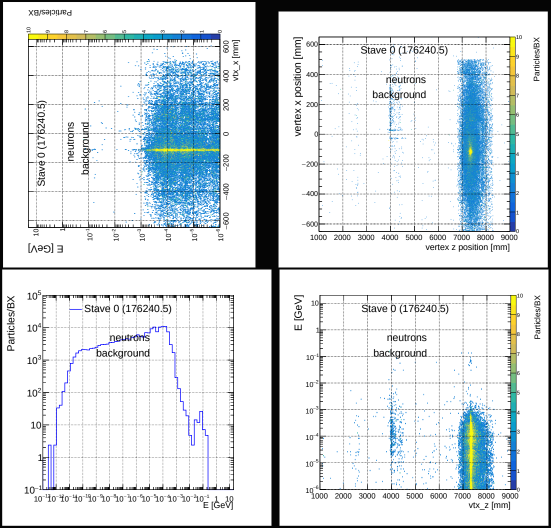

Stave 0 (264976.1)
neutrons
background
vertex x position [mm]
vertex z position [mm]
Particles/BX


Stave 0 (264976.1)
neutrons
background
Particles/BX
E [GeV]


Stave 0 (264976.1)
neutrons
background
E [GeV]
vtx_z [mm]
Particles/BX

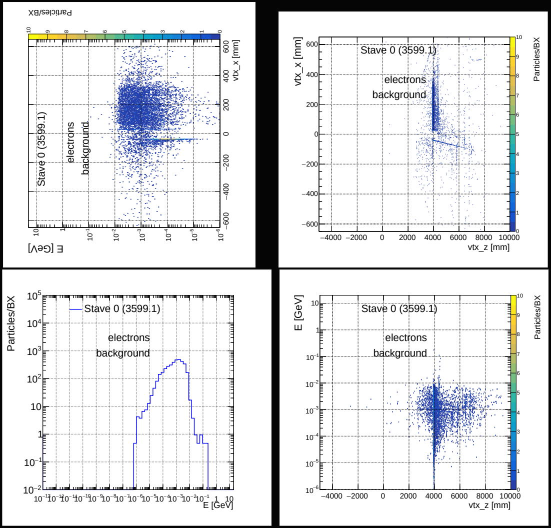
- 2D plot

FullSim with Iron Shielding: Neutron. Tracker first stave first layer (Stave0)



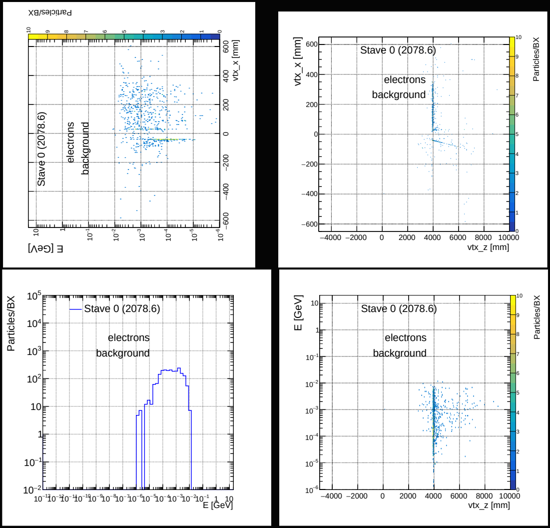
- 2D plot

FullSim: Electron. Tracker first stave first layer (Stave0)



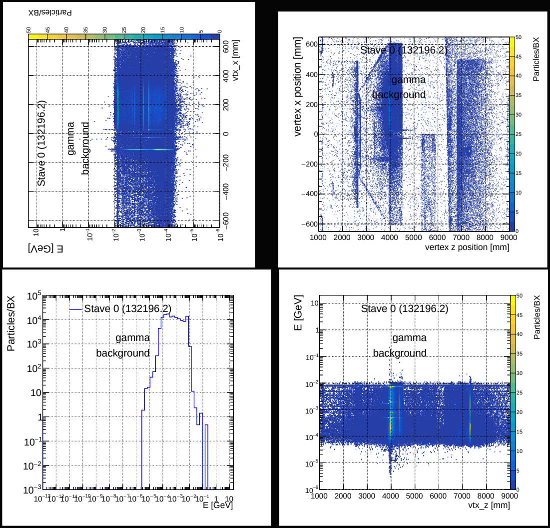
- 2D plot

FullSim with Iron Shielding: Electron. Tracker first stave first layer (Stave0)



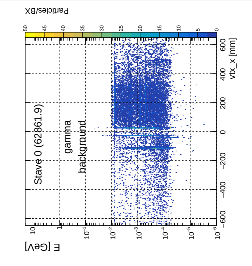
- 2D plot

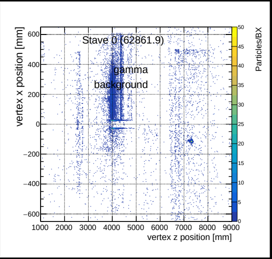
FullSim: Photon. Tracker first stave first layer (Stave0)

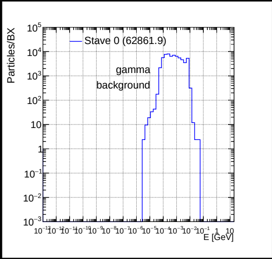


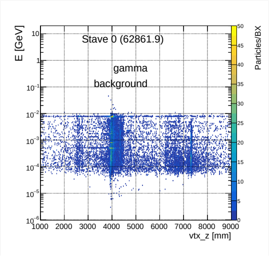
- 2D plot

FullSim with Iron Shielding: Photon. Tracker first stave first layer (Stave0)



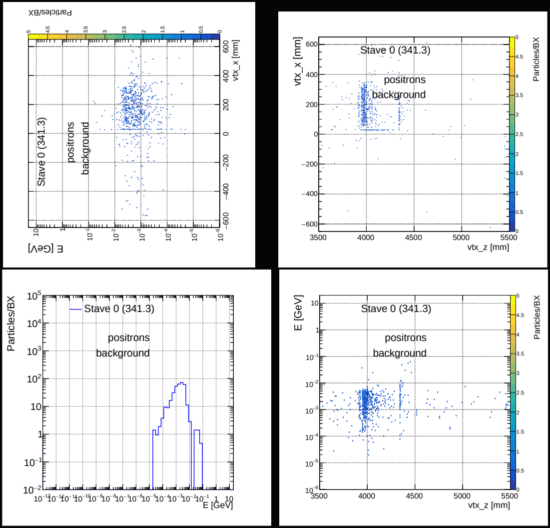






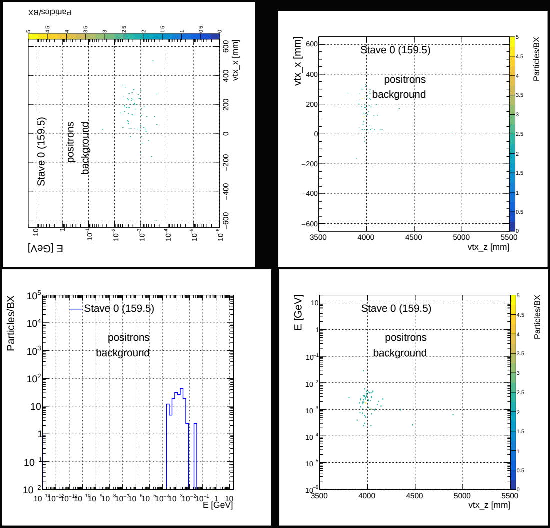
- 2D plot

FullSim: Positron. Tracker first stave first layer (Stave0)



- 2D plot

FullSim with Iron Shielding: Positron. Tracker first stave first layer (Stave0)

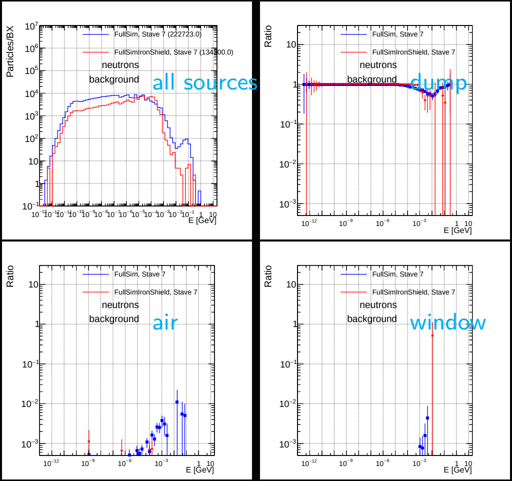


- 2D plot

- Last layer, last stave plots (positron side)

Background neutrons: FullSim

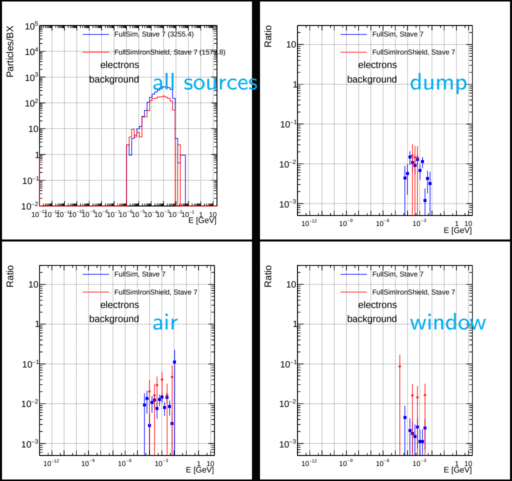
- Background neutrons in last layer, last stave of tracker.



- 40% less neutron with neutron absorber and iron shield.
- Less number of high energetic neutrons.

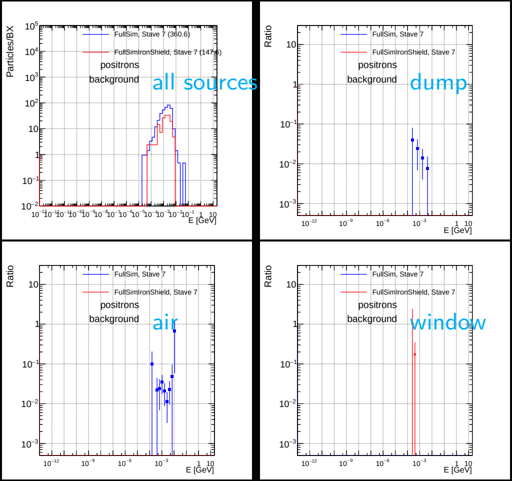
Background electrons: FullSim

- Background electrons in last layer, last stave of tracker.



- 52% less electron with neutron absorber and iron shield.
- Less number of high energetic electrons.

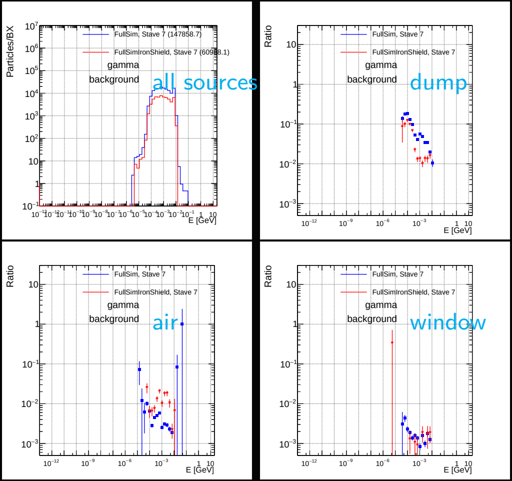
- Background positrons in last layer, last stave of tracker.



- 60% less positron with neutron absorber and iron shield.
- Less number of high energetic positrons.

Background gamma: FullSim

- Background gamma in last layer, last stave of tracker.

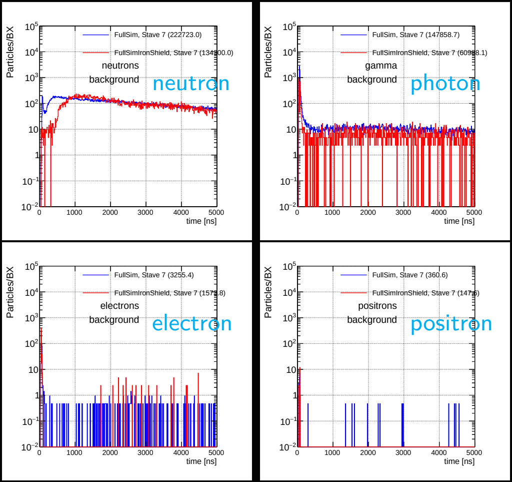


- 59% less photon with neutron absorber and iron shield.
- The energy spectrum shapes are similar here.

- Timing distribution, Stave 7

Background timing distribution: FullSim, Stave7

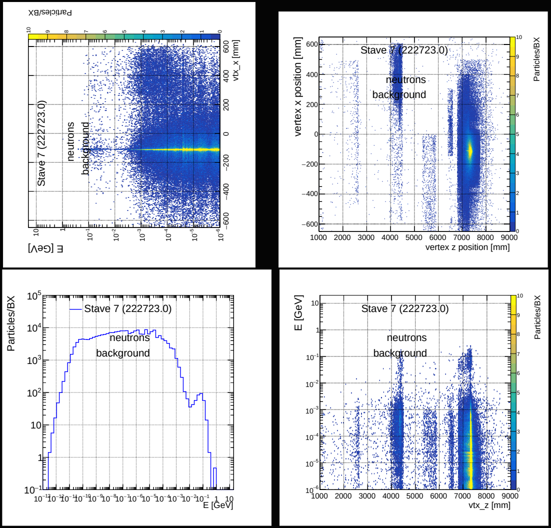
- Background particles timing distribution in last layer, last stave of tracker.



Summary: tracker last layer last stave

- In the tracker first layer first stave, neutron absorber and iron shielding reduces
  - $\sim$ 40% of neutron particles from the dump.
  - $\sim$ 52% of electrons.
  - $\sim$ 60% of positrons.
  - $\sim$ 59% of photons.
- Neutron timing distribution is flat.
- If we cut at 1000 ns (1 μs- detector readout time), we can get rid of many neutrons ($\gtrsim$ 75%).

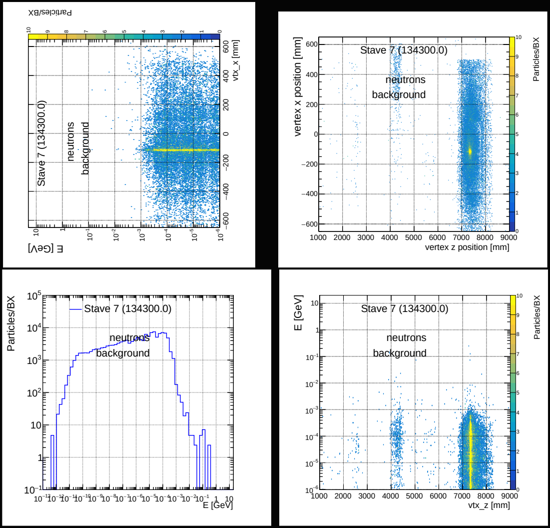
- 2D plots, Stave 7



Stave 7 (222723.0)
neutrons
background
Particles/BX
E [GeV]
vtx_x [mm]
vertex x position [mm]
vertex z position [mm]
vtx_z [mm]

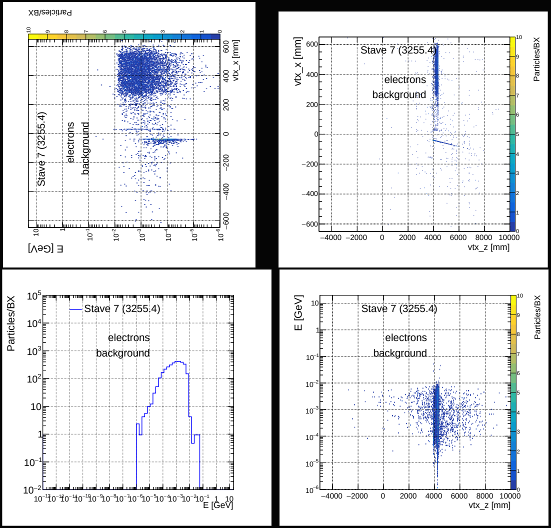
- 2D plot

FullSim with Iron Shielding: Neutron. Tracker last stave last layer (Stave7)

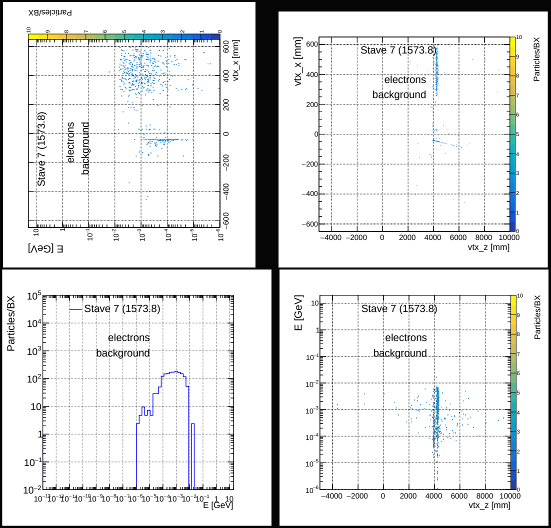


- 2D plot

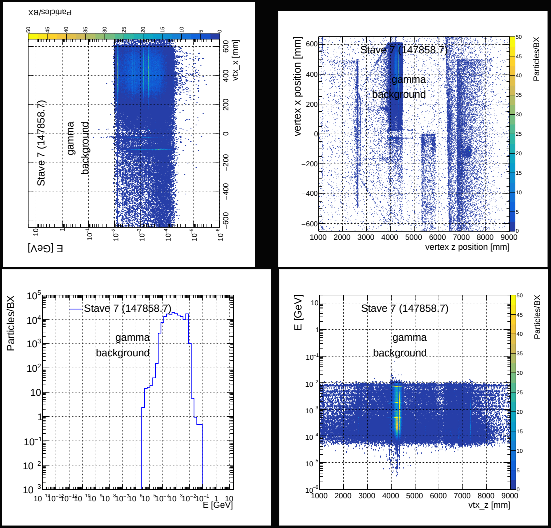
FullSim: Electron. Tracker last stave last layer (Stave7)



- 2D plot

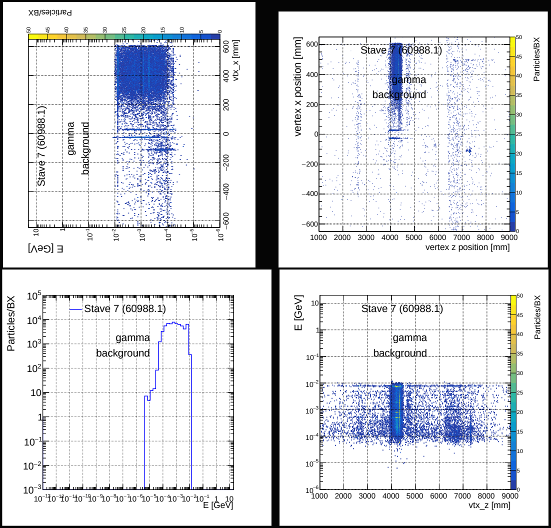

Stave 7 (1573.8)
electrons
background
Particles/BX
vtx_x [mm]
vtx_z [mm]
E [GeV]

- 2D plot


Stave 7 (147858.7)
gamma
background
vertex x position [mm]
vertex z position [mm]
Particles/BX
E [GeV]
vtx_x [mm]
vtx_z [mm]

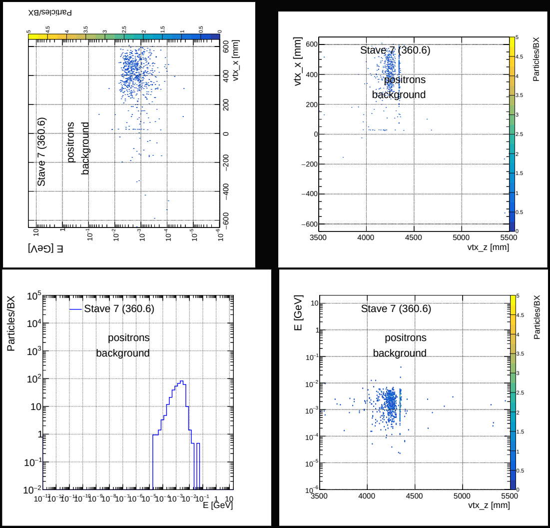
- 2D plot

FullSim with Iron Shielding: Photon. Tracker last stave last layer (Stave7)

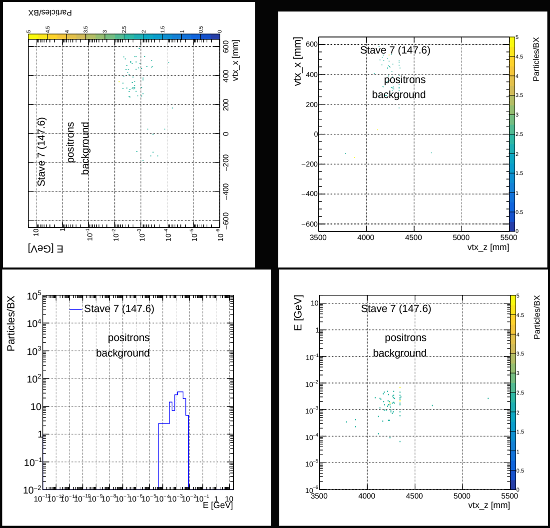


- 2D plot

FullSim: Positron. Tracker last stave last layer (Stave7)



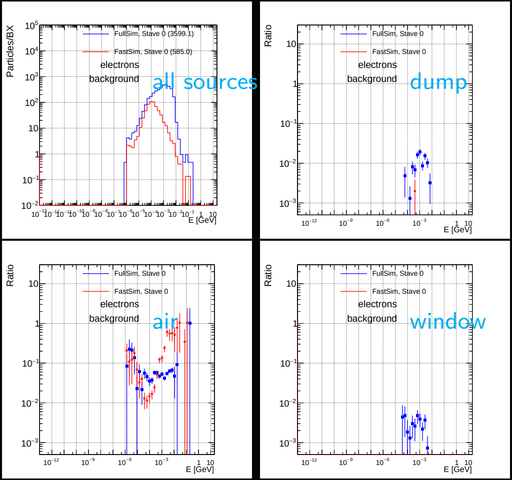
- 2D plot


Stave 7 (147.6)
positrons
background
vtx_x [mm]
E [GeV]
Particles/BX
vtx_z [mm]
Stave 7 (147.6)
positrons
background
Particles/BX
E [GeV]
Stave 7 (147.6)
positrons
background
vtx_z [mm]
E [GeV]
Particles/BX

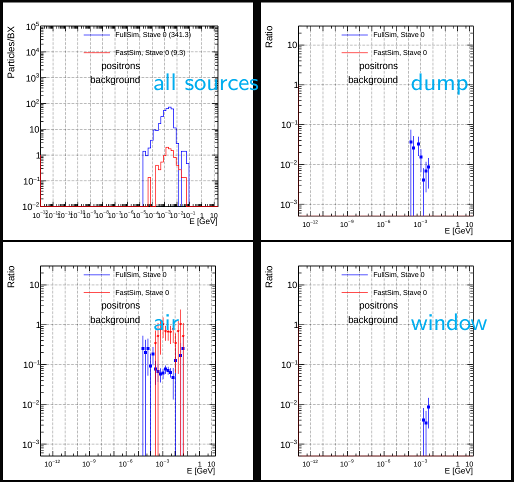
- 2D plot

- FullSim and FastSim comparison

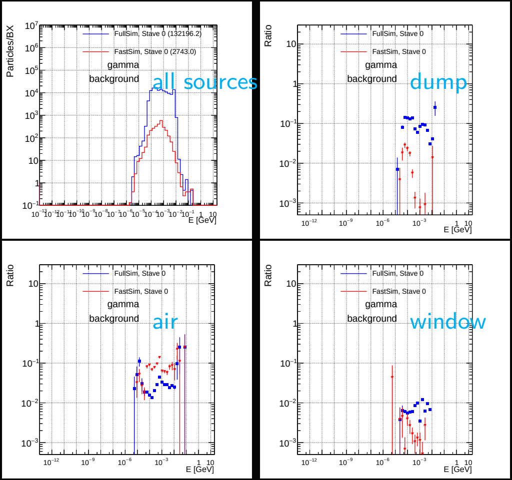
FastSim and FullSim comparison: electron

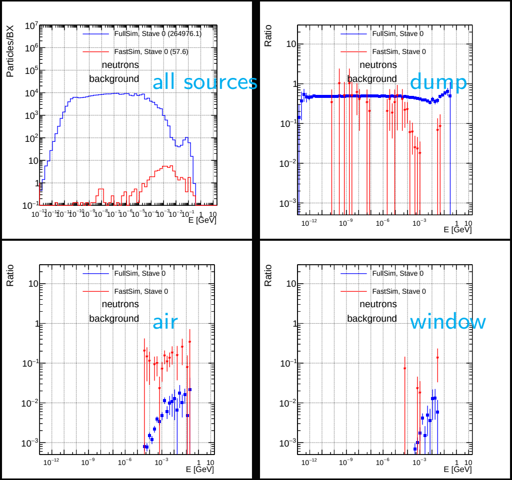


FastSim and FullSim comparison: positron

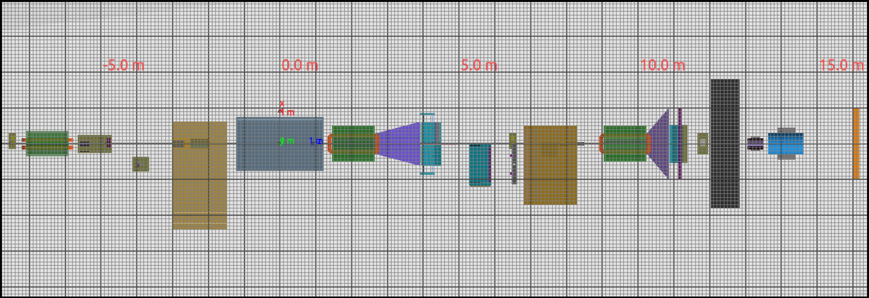


FastSim and FullSim comparison: photons




Particles/BX
FullSim, Stave 0 (264976.1)
FastSim, Stave 0 (57.6)
neutrons
background
all sources
E [GeV]
Ratio
FullSim, Stave 0
FastSim, Stave 0
neutrons
background
dump
E [GeV]
Ratio
FullSim, Stave 0
FastSim, Stave 0
neutrons
background
air
E [GeV]
Ratio
FullSim, Stave 0
FastSim, Stave 0
neutrons
background
window
E [GeV]

The LUXE design



Near the tracker detector