

Bkg for BSM

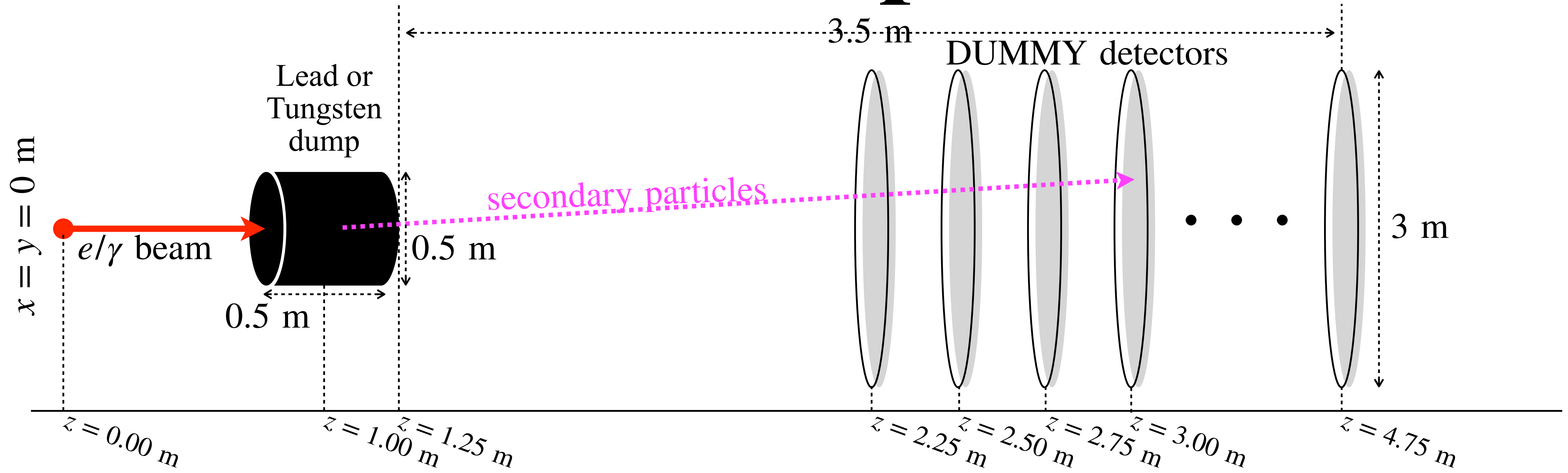
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OF SCIENCE



Feb 15 2021

Setup

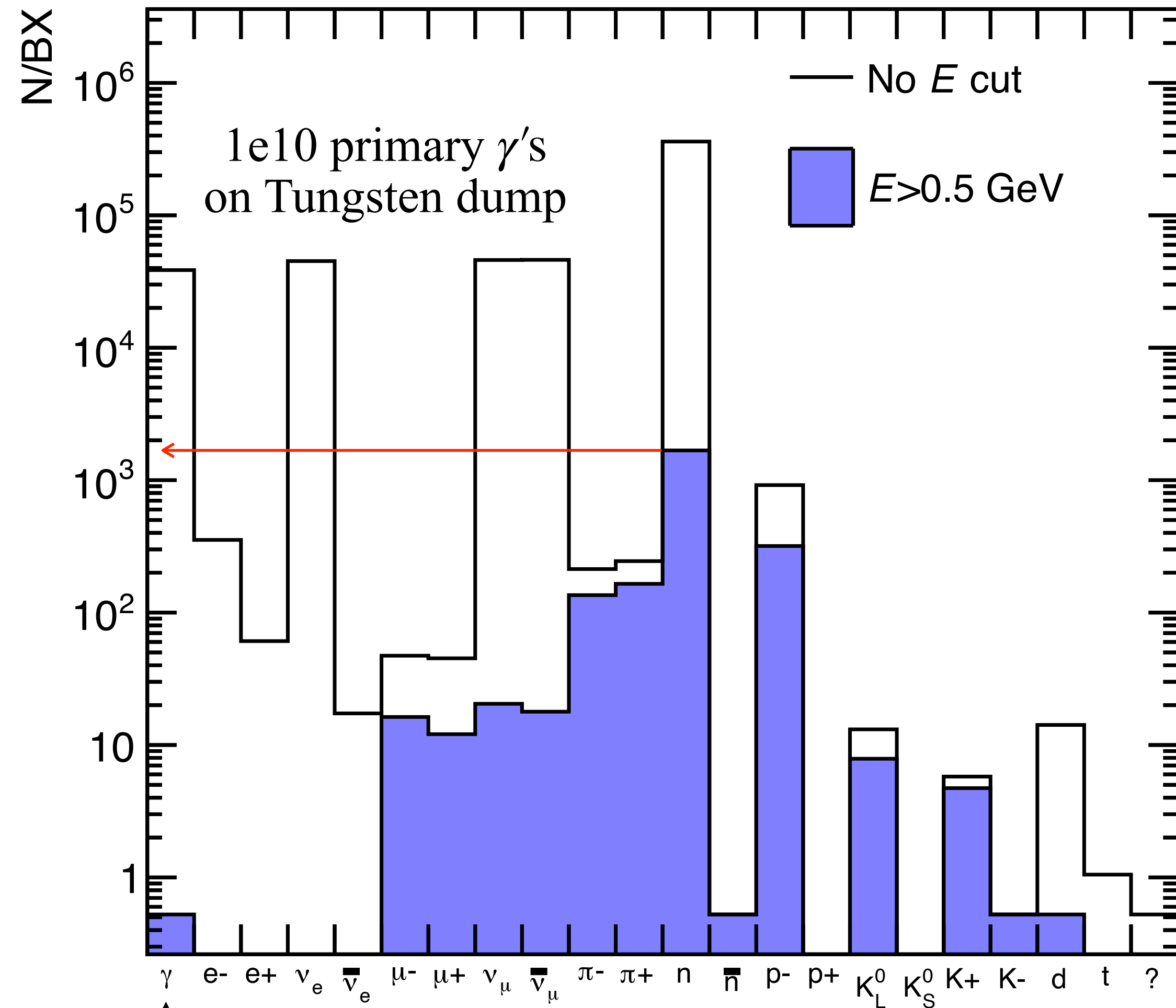


- World is in vacuum, dump is made of lead, several dummy disk-like detectors 0.25 m apart, 1 m after the dump end
- Shoot $1e10$ photons with energy distributed according to the Compton photons resulting from the e +laser interaction with $\tau=120$ fs, $w_0=10$ μm pulse (the new data from Tom)
- Distributions are normalised to one BX (recall that for the photon-beam discussed here: $N_\gamma \text{ per } e \simeq 3.5$)
- Particles are kept only if they traverse the dummy detector within $r(x, y) < 1$ m

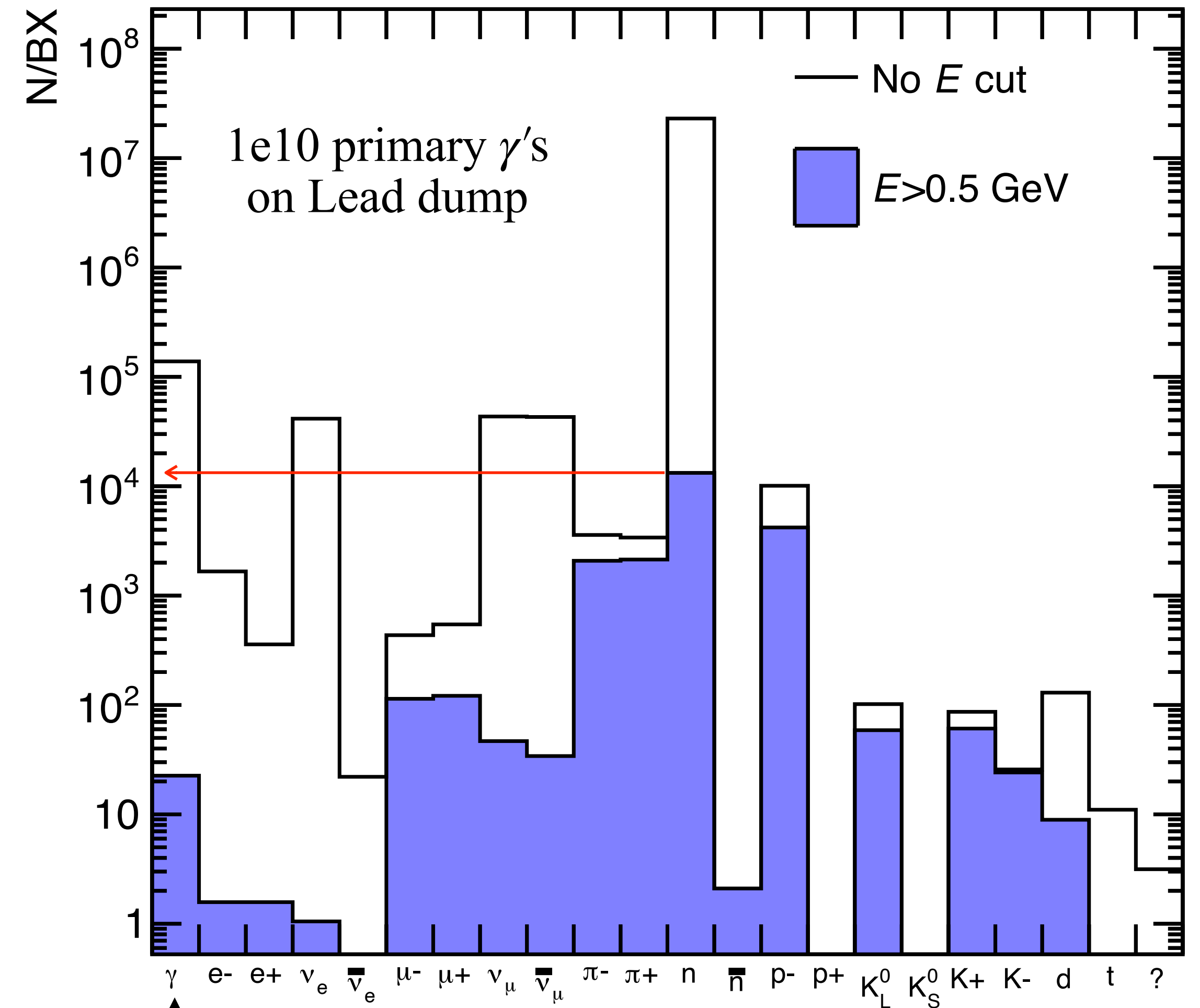
Bug fix

- If we define:
 - NBe: number of electrons in a bunch (the usual $1.5e9$)
 - NSe: number of primary electrons simulated
- Then the normalisation should be NB/NSe
- In the photon-beam case NSe has to be calculated from:
 - NSg: number of photons simulated ($1e10$ is what I shoot on the target)
 - Ngam_per_ele: number of Compton photons per primary electron (~ 3.5 in the 120 fs and 10 um pulse)
- Then, $NSe = NSg / Ngam_per_ele$ and to find the number of particles of some type x in the full stats per BX:
 - $Nx \text{ per BX} = Nx * NBe / NSe = Nx * NBe / (NSg / Ngam_per_ele)$
- My problem was that I have coded the scaling in two steps as `histogram->Scale(NSe/NSg)` and then `histogram->Scale(1/Ngam_per_ele)`. This 2-step procedure is a buggy remnant from the time I was doing this for the incident electron-beam case where there's no Ngam_per_ele factor...
- Bottom line: the resulting number of particles was divided by Ngam_per_ele instead of being multiplied by it.
 - Hence, the numbers were artificially a factor of $Ngam_per_ele^2 \approx 3.5^2$ smaller.
- Now: for the lead dump we have ~ 22.575 photons above 0.5 GeV per BX (instead of the wrong ~ 2 discussed earlier). We also have $\sim 1e4$ neutrons above 0.5 GeV (instead of the $\sim 1e3$ discussed earlier).

Overall rates

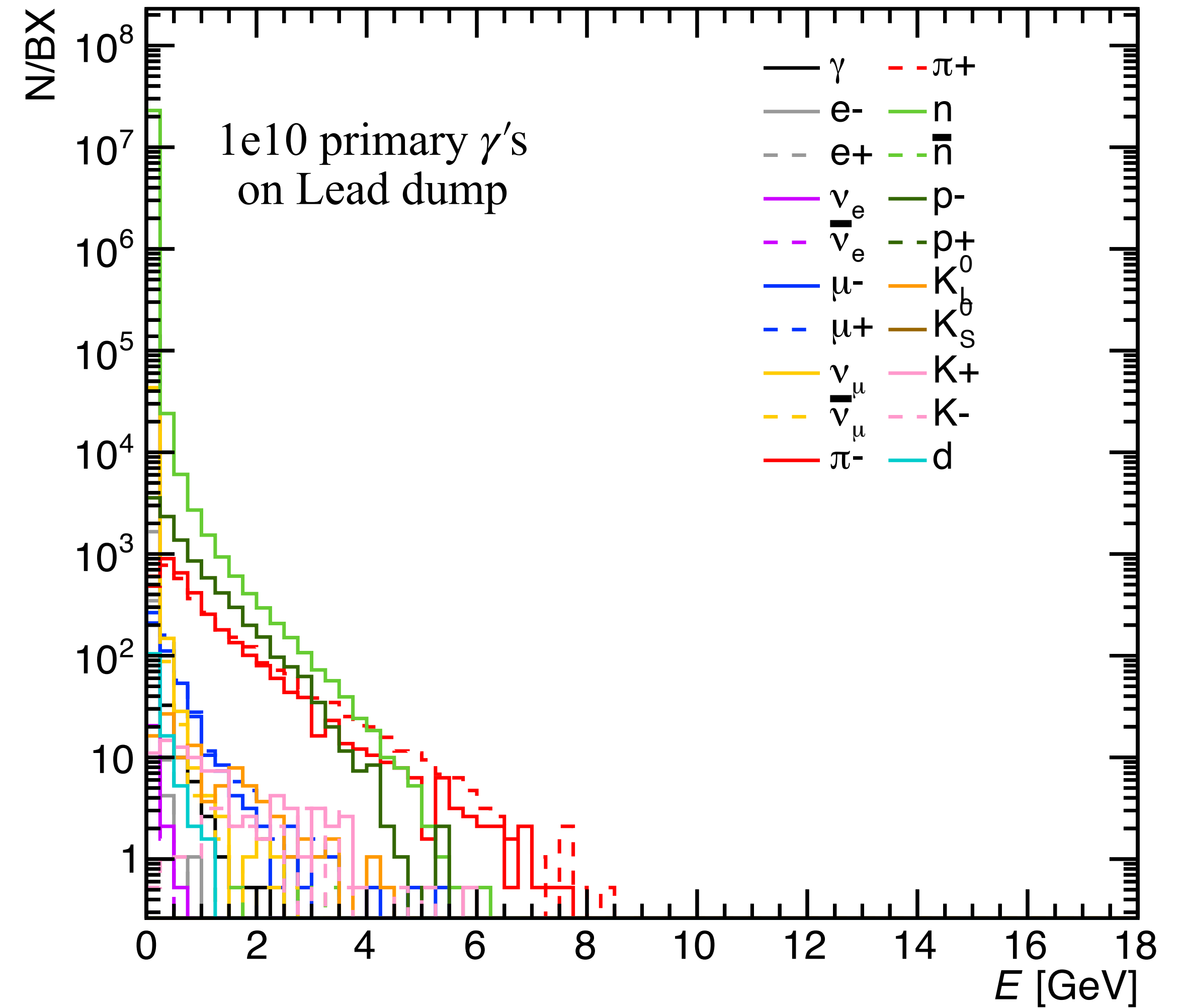
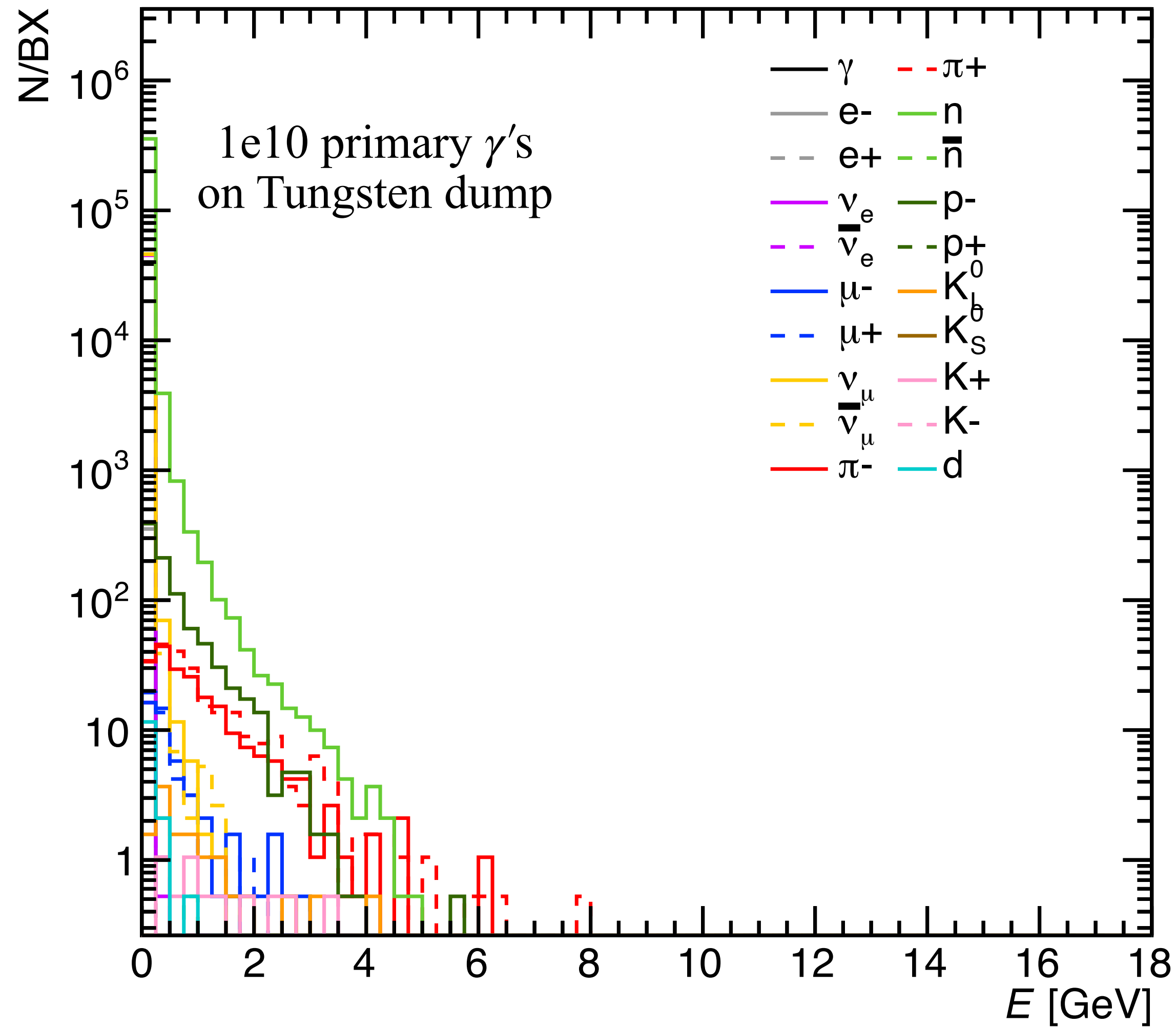


one photon
times $1.5e9/(1e10/3.5) = 0.525$

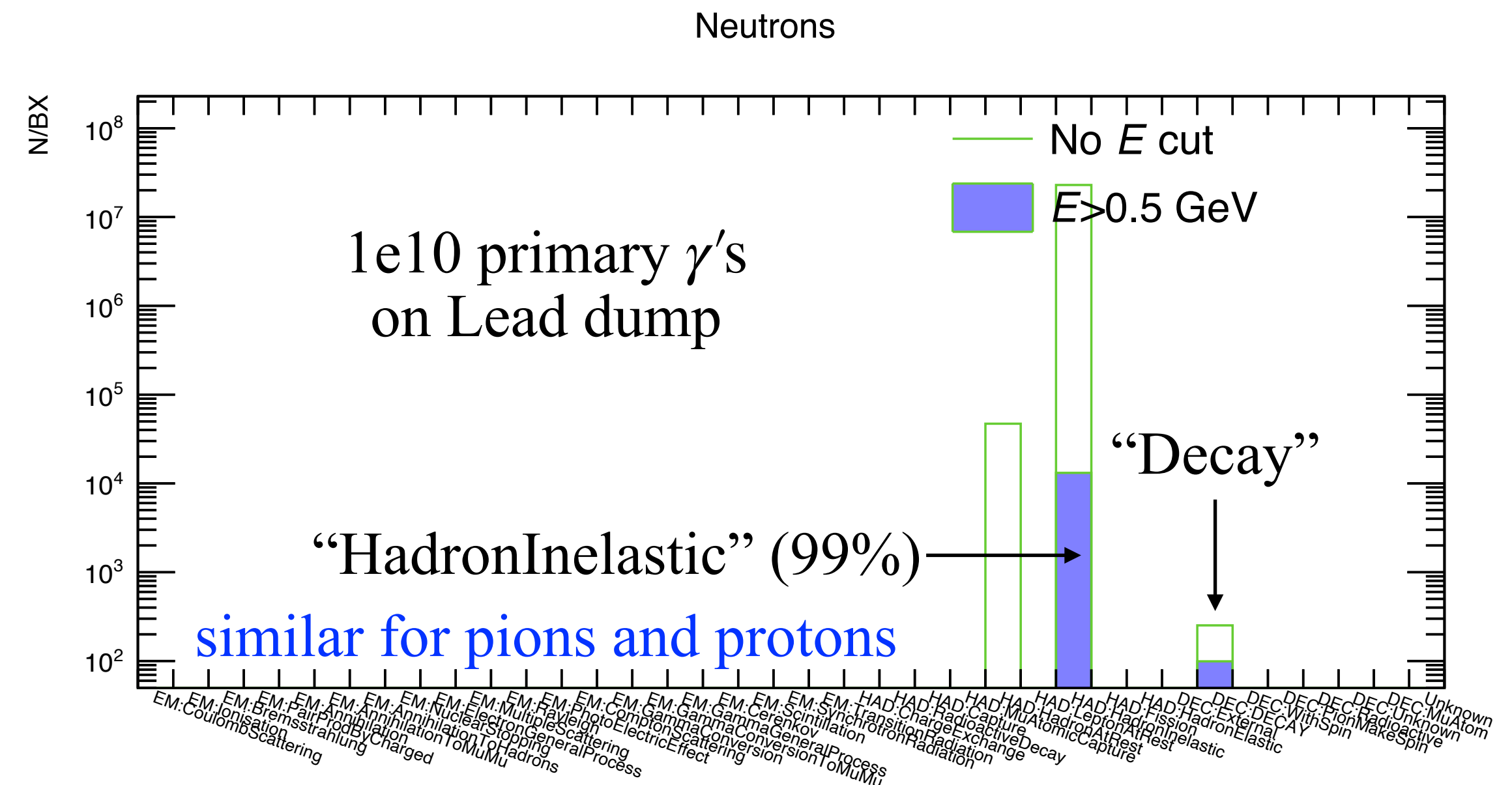
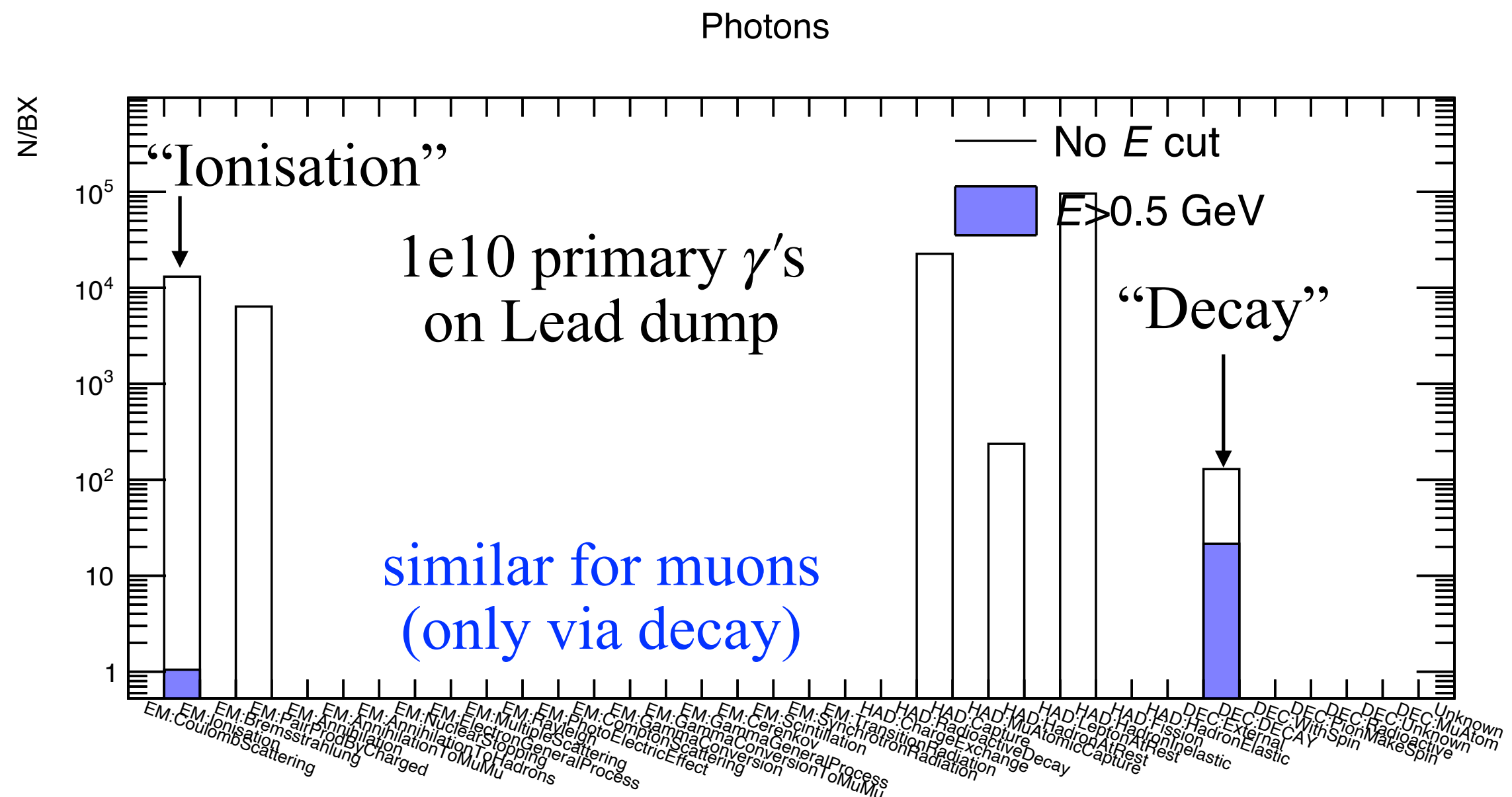
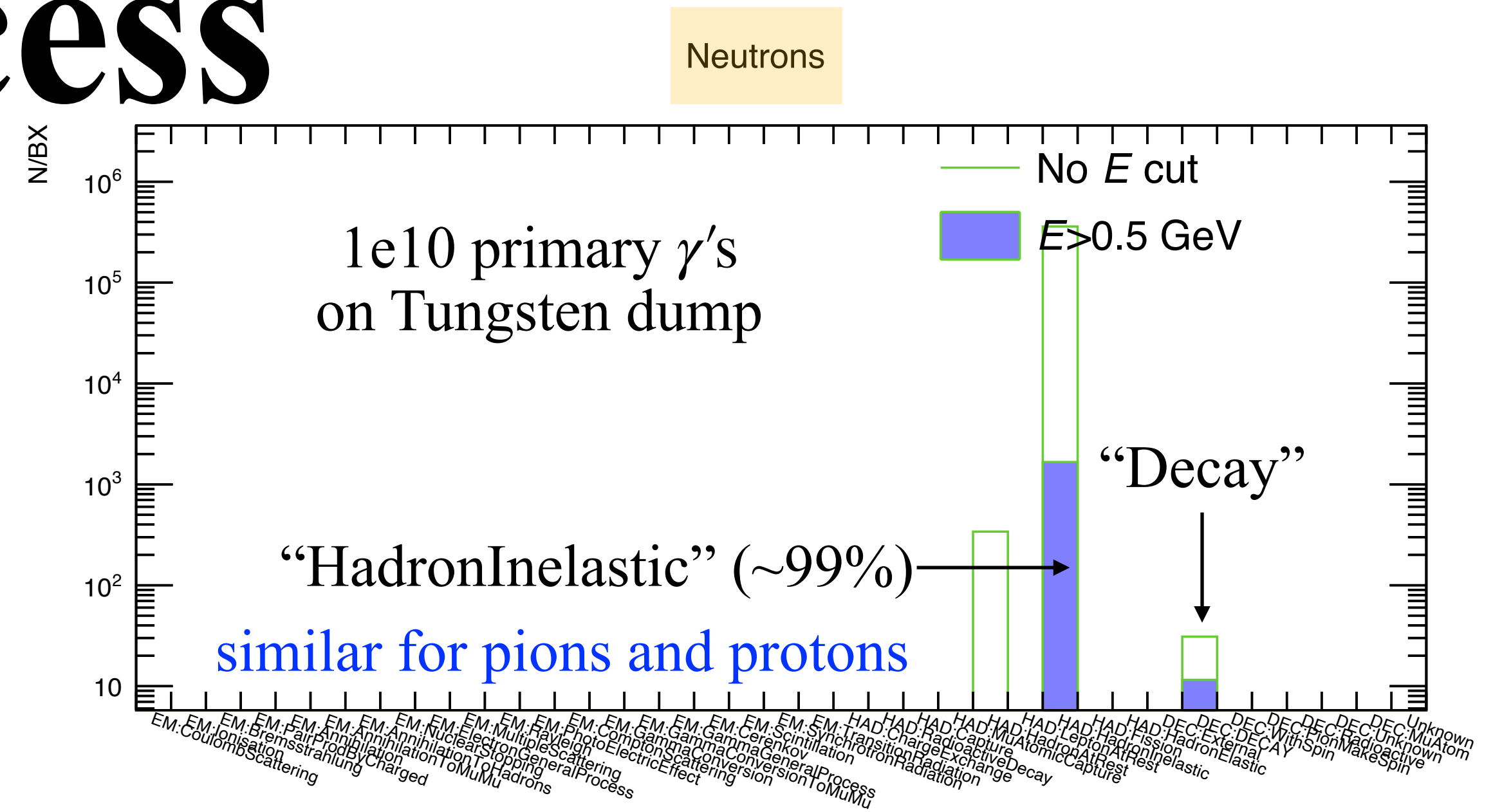
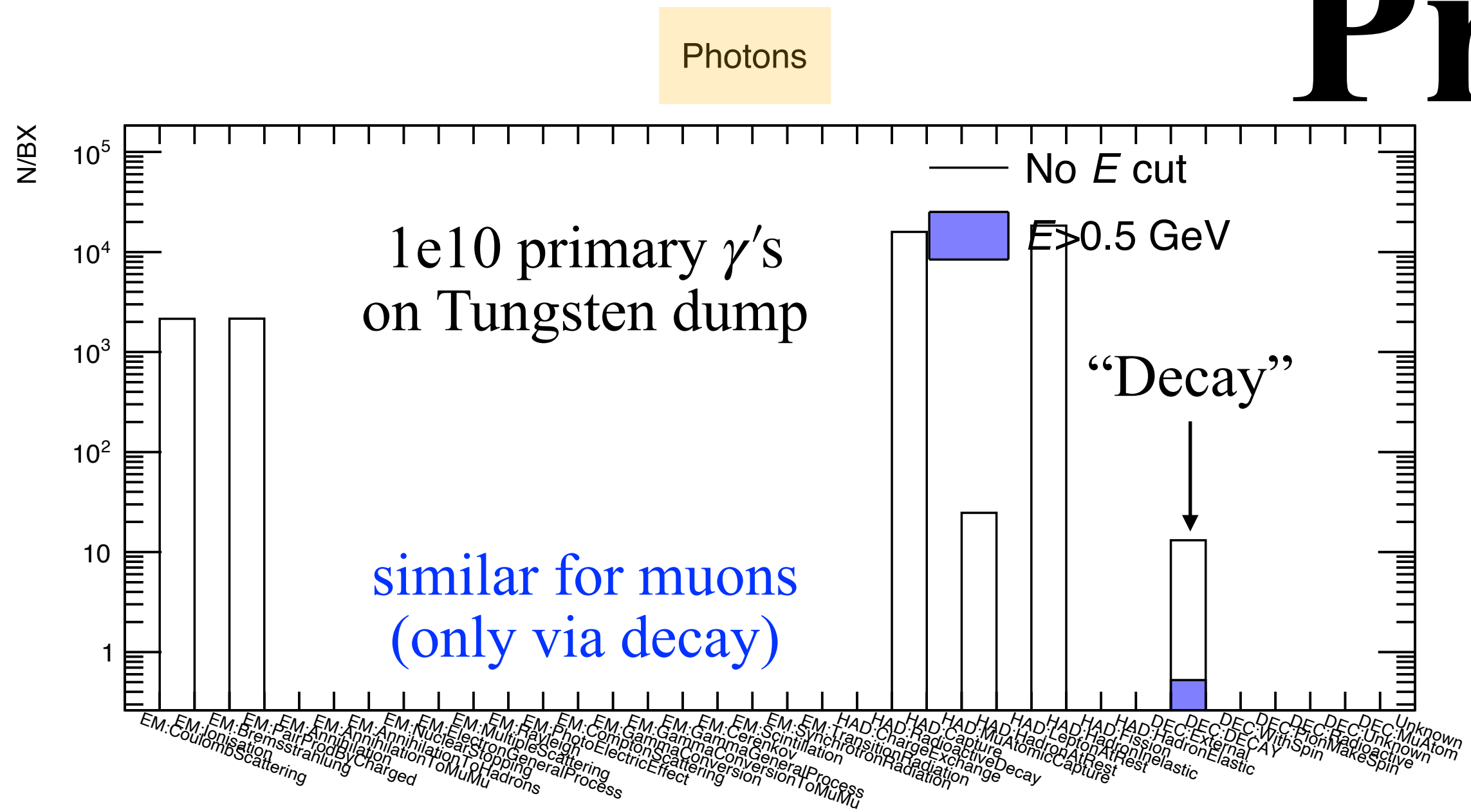


43 photons
times $1.5e9/(1e10/3.5) = 22.575$

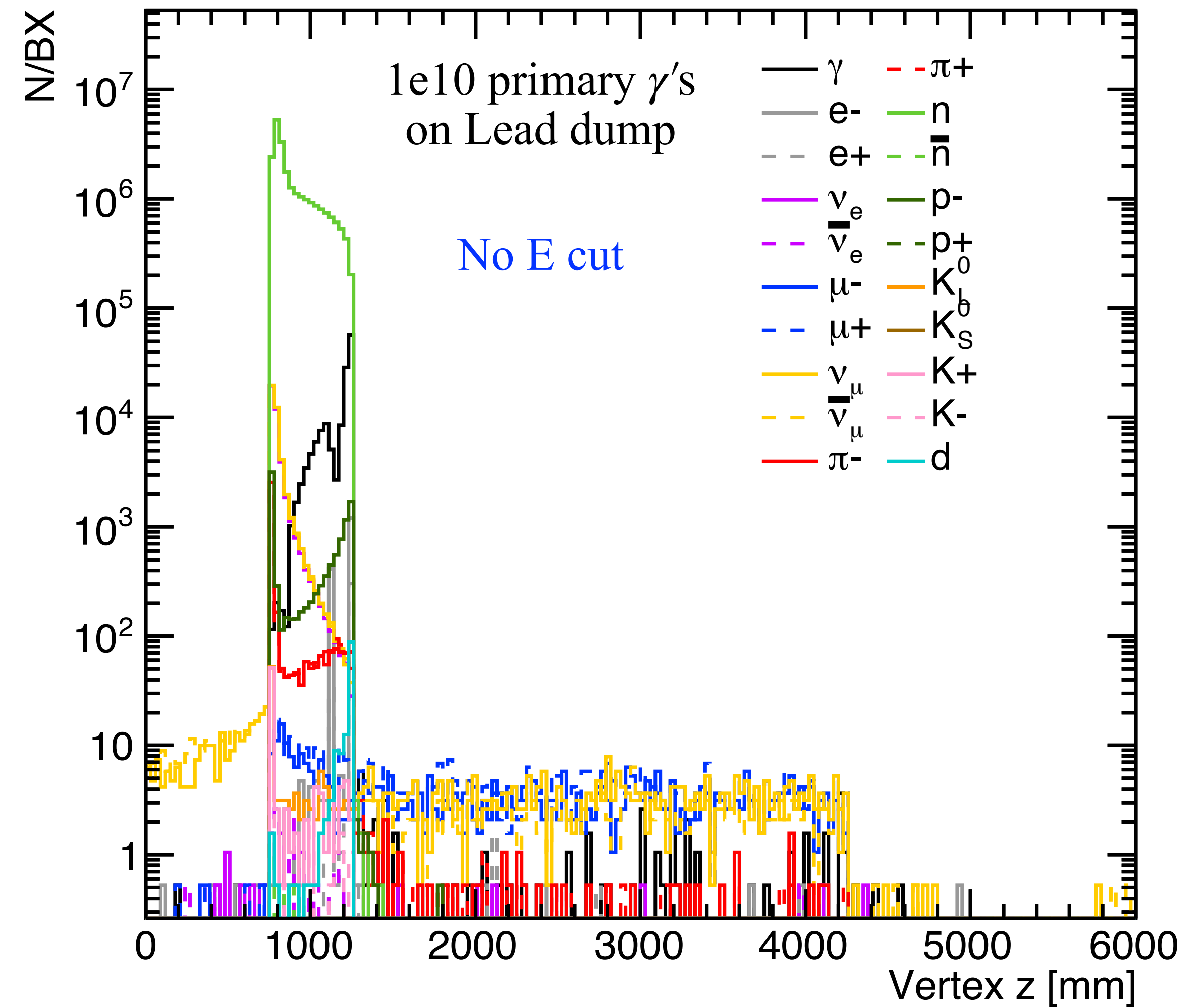
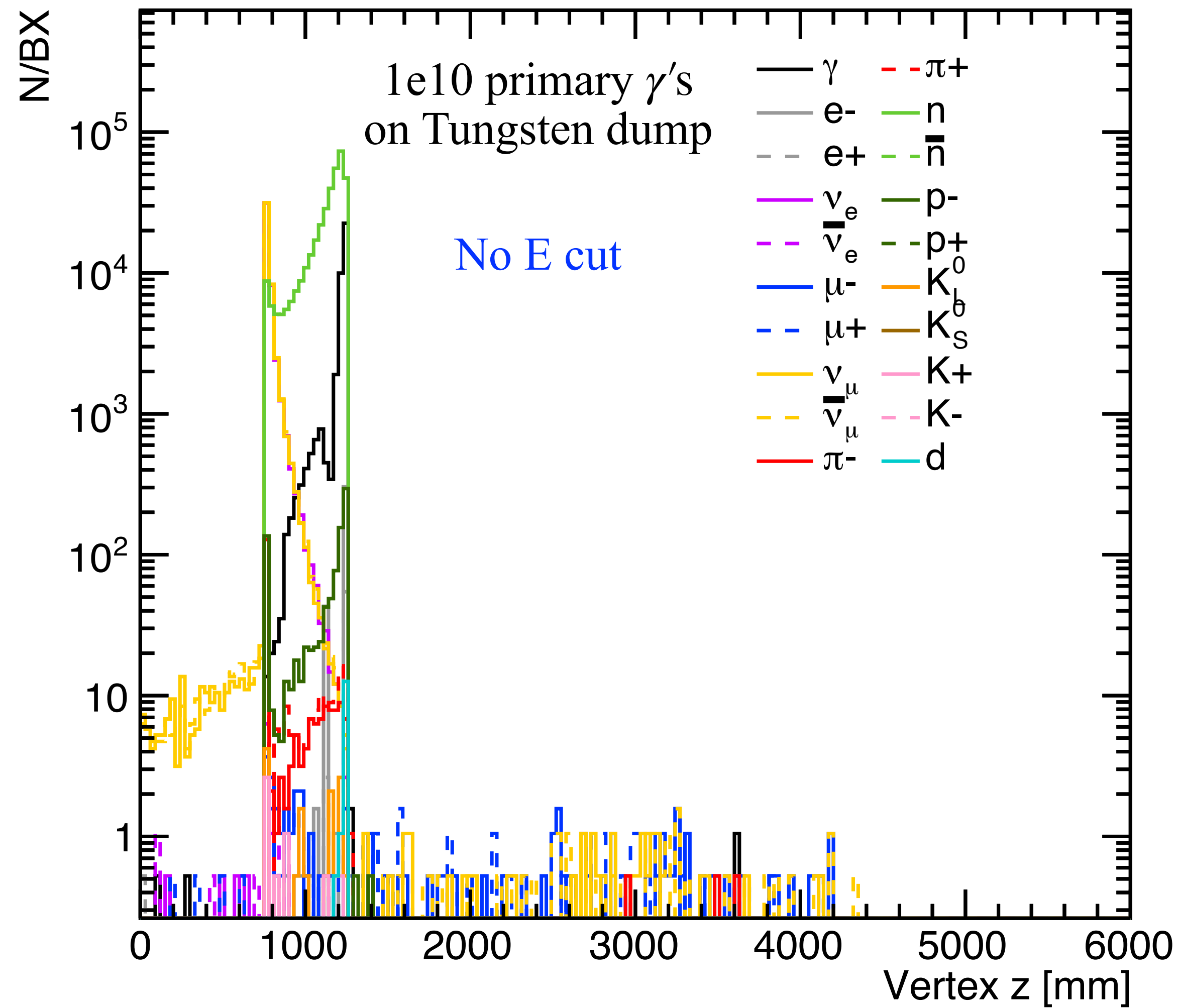
Energies



Process

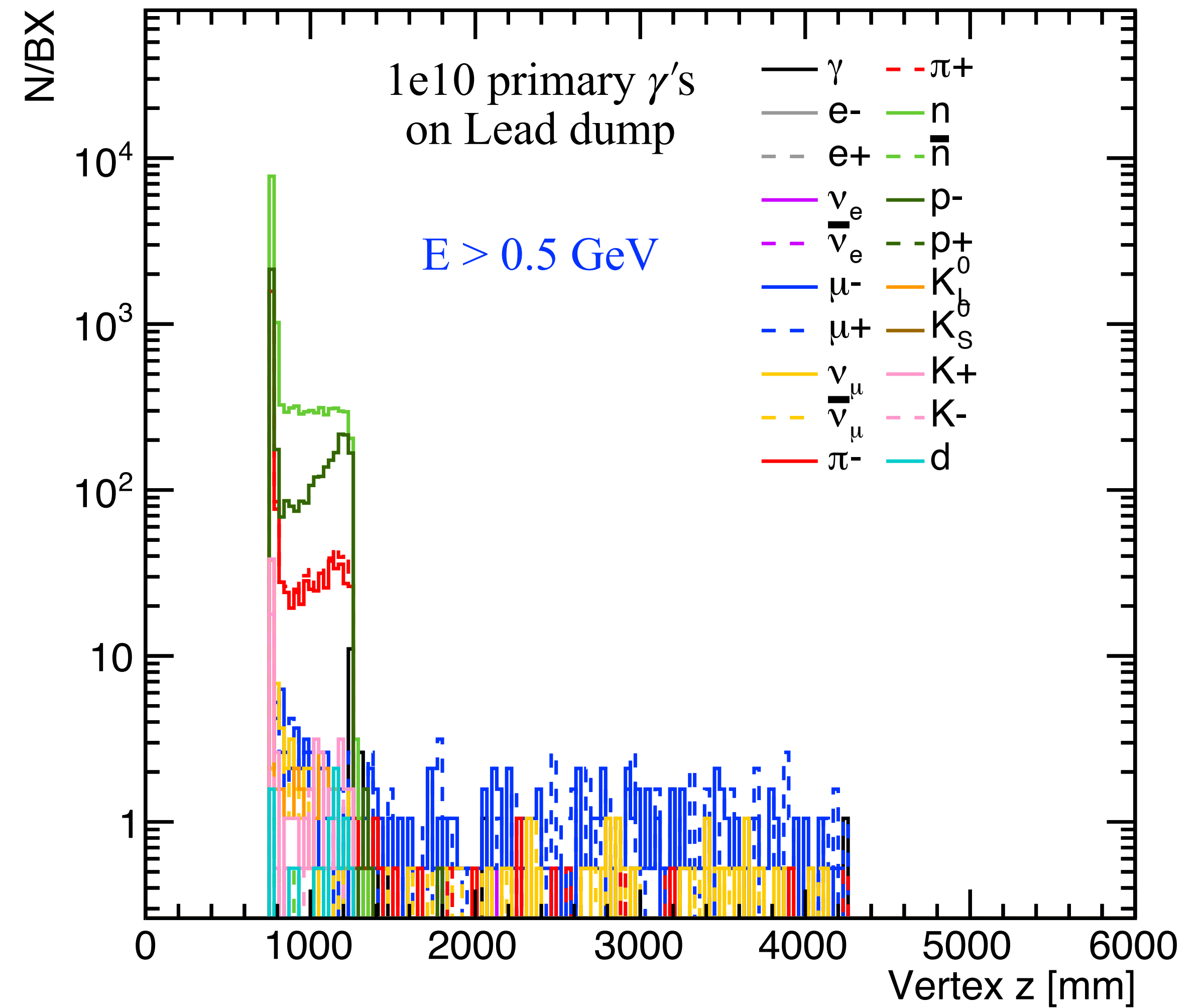
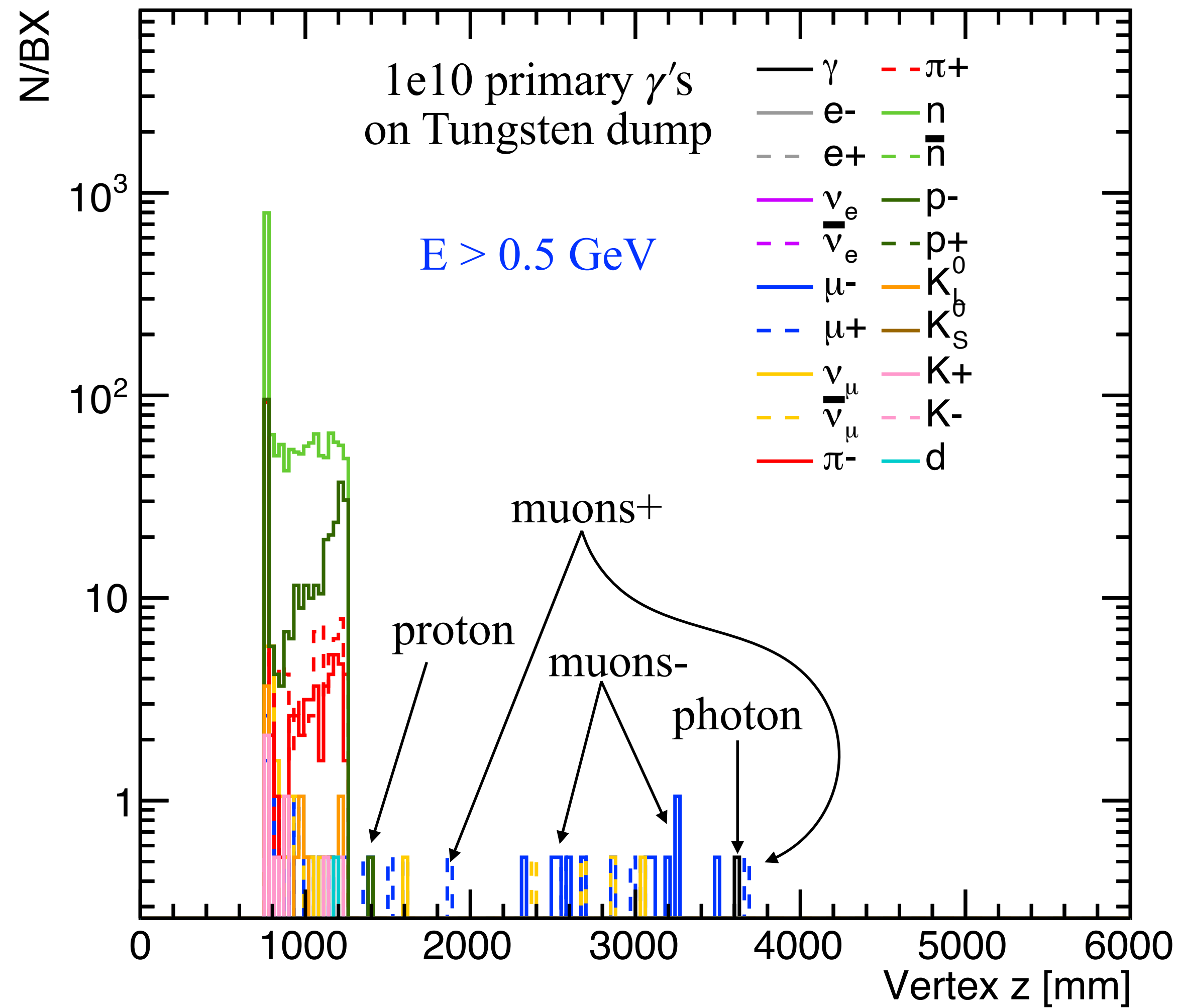


Production vertex

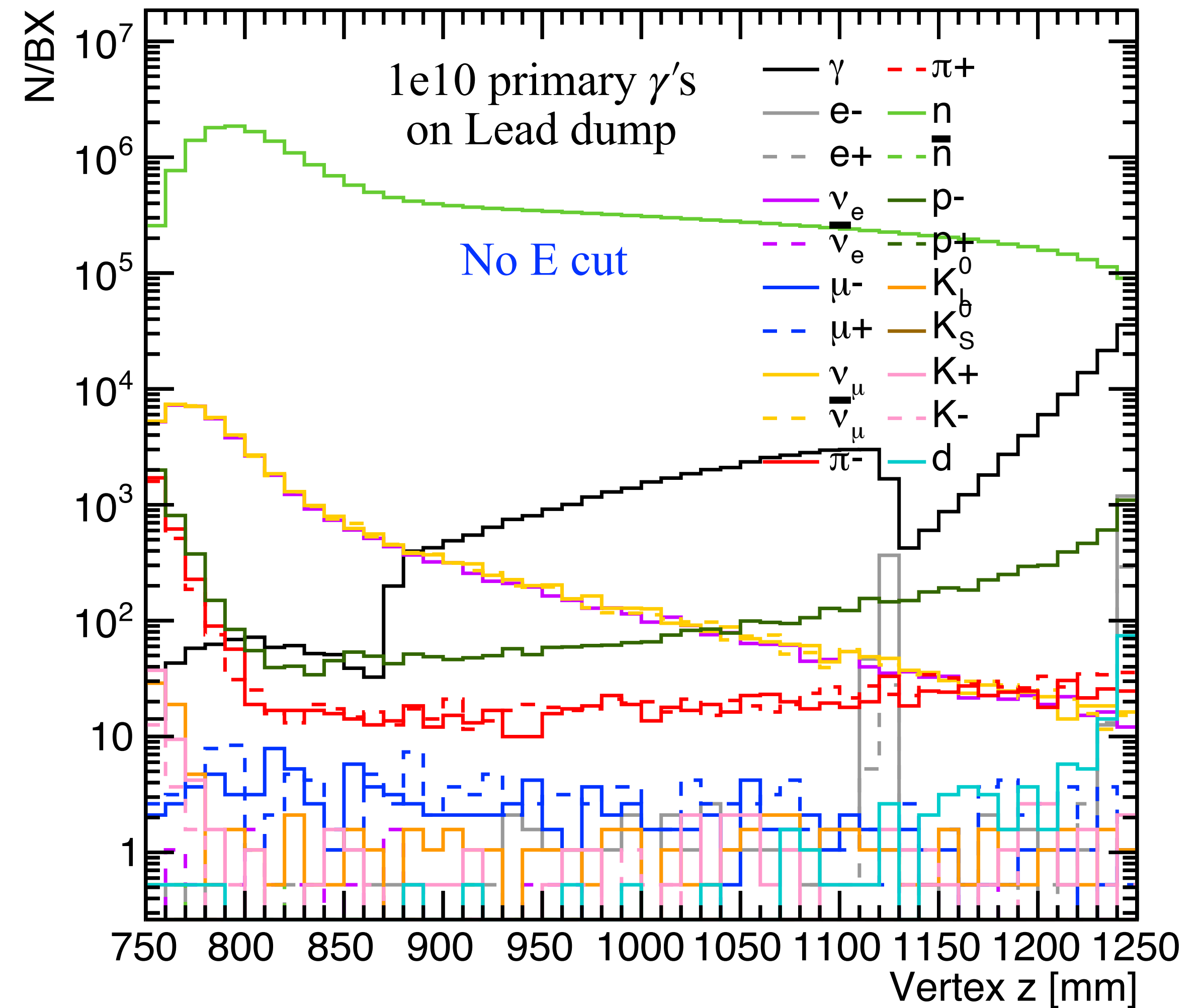
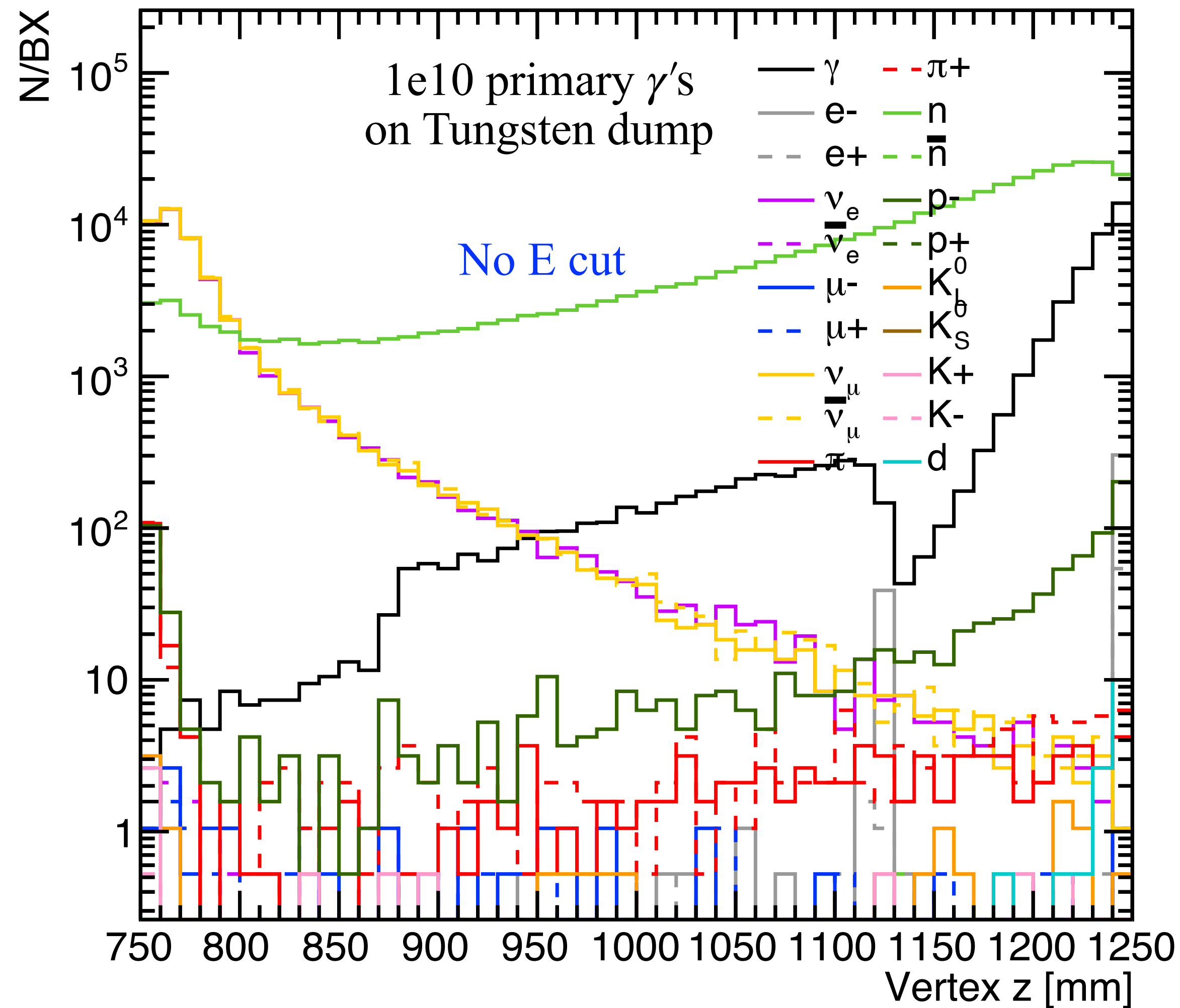


Production vertex

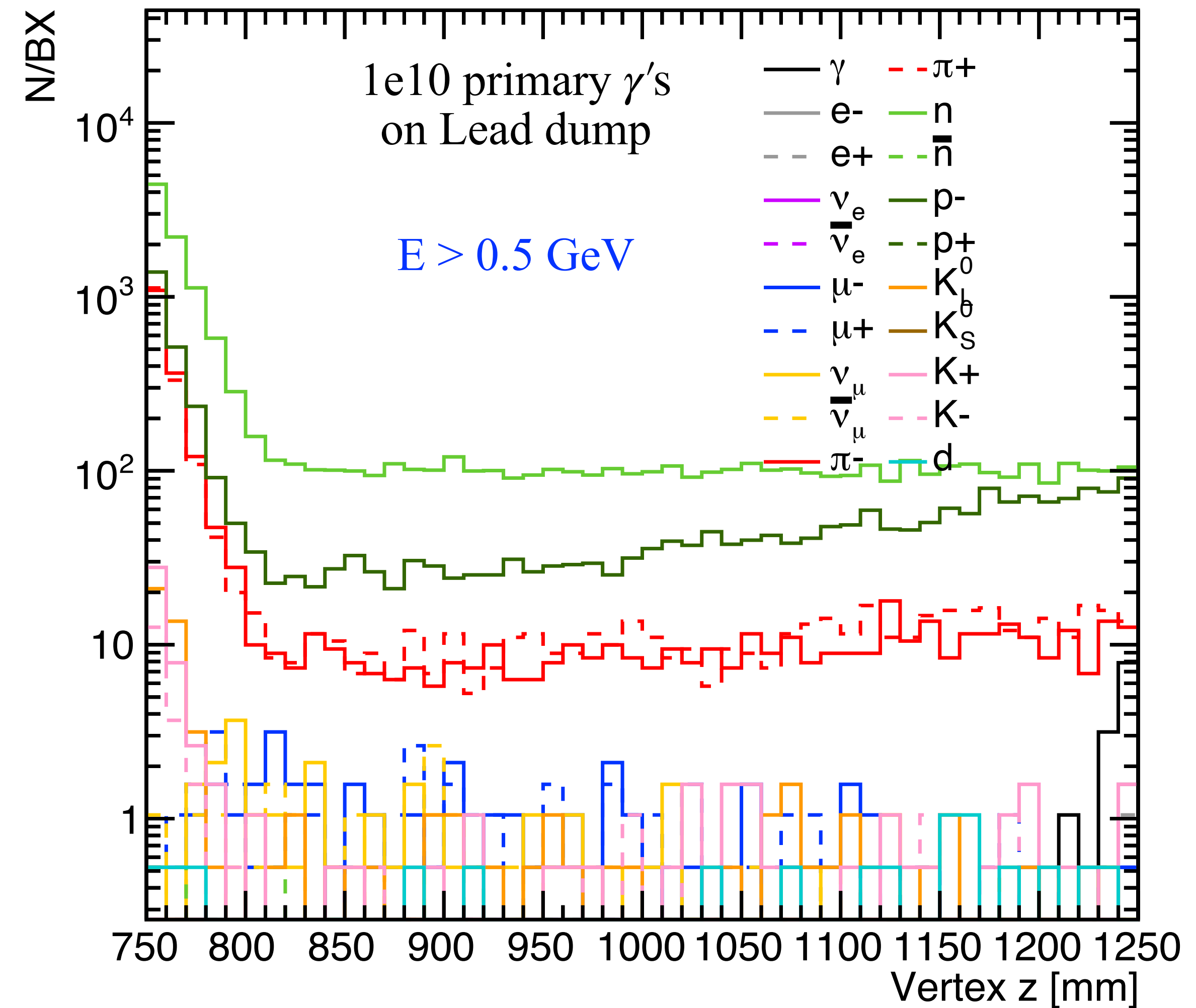
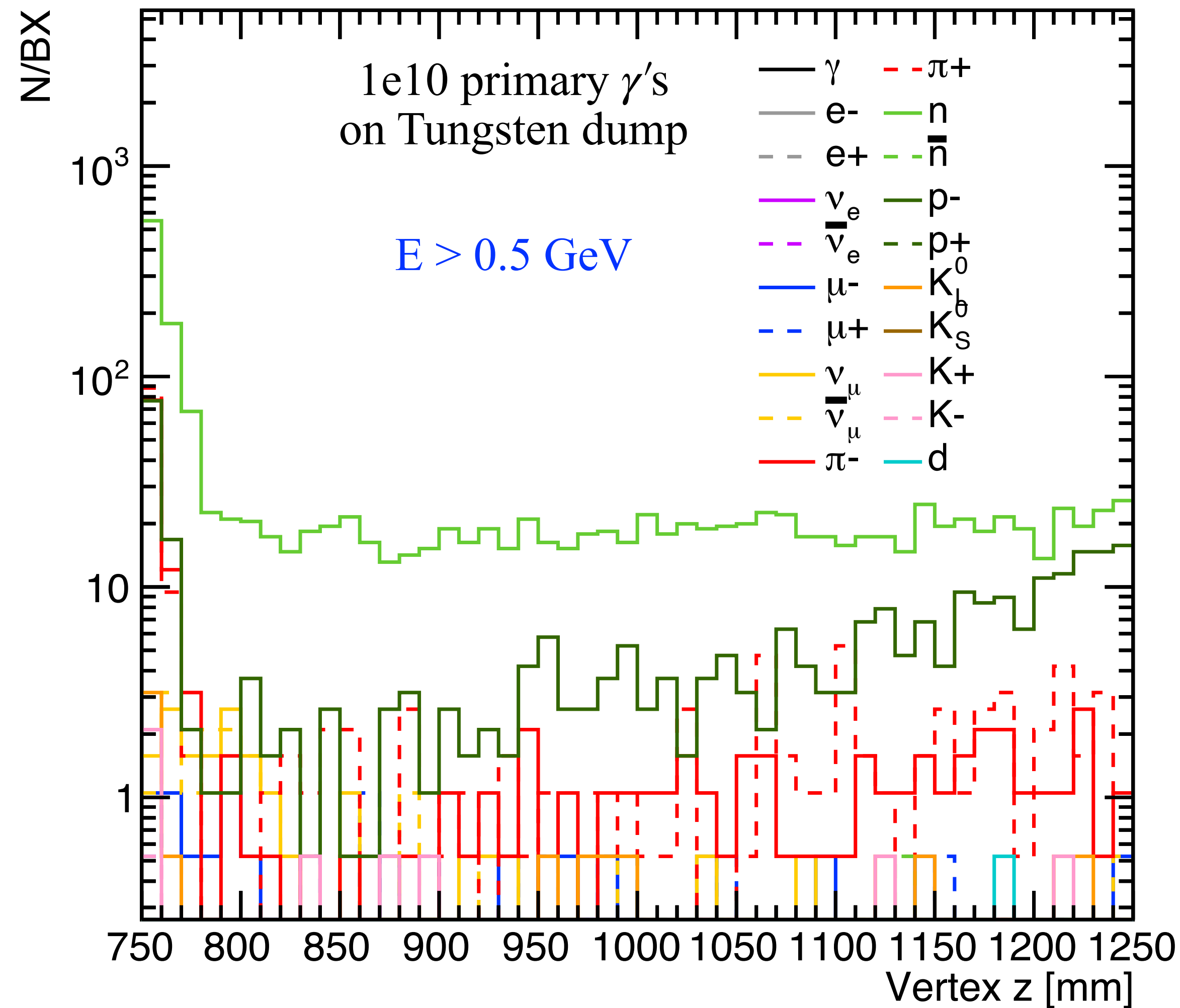
for $E > 0.5$ GeV



Production vertex in the dump

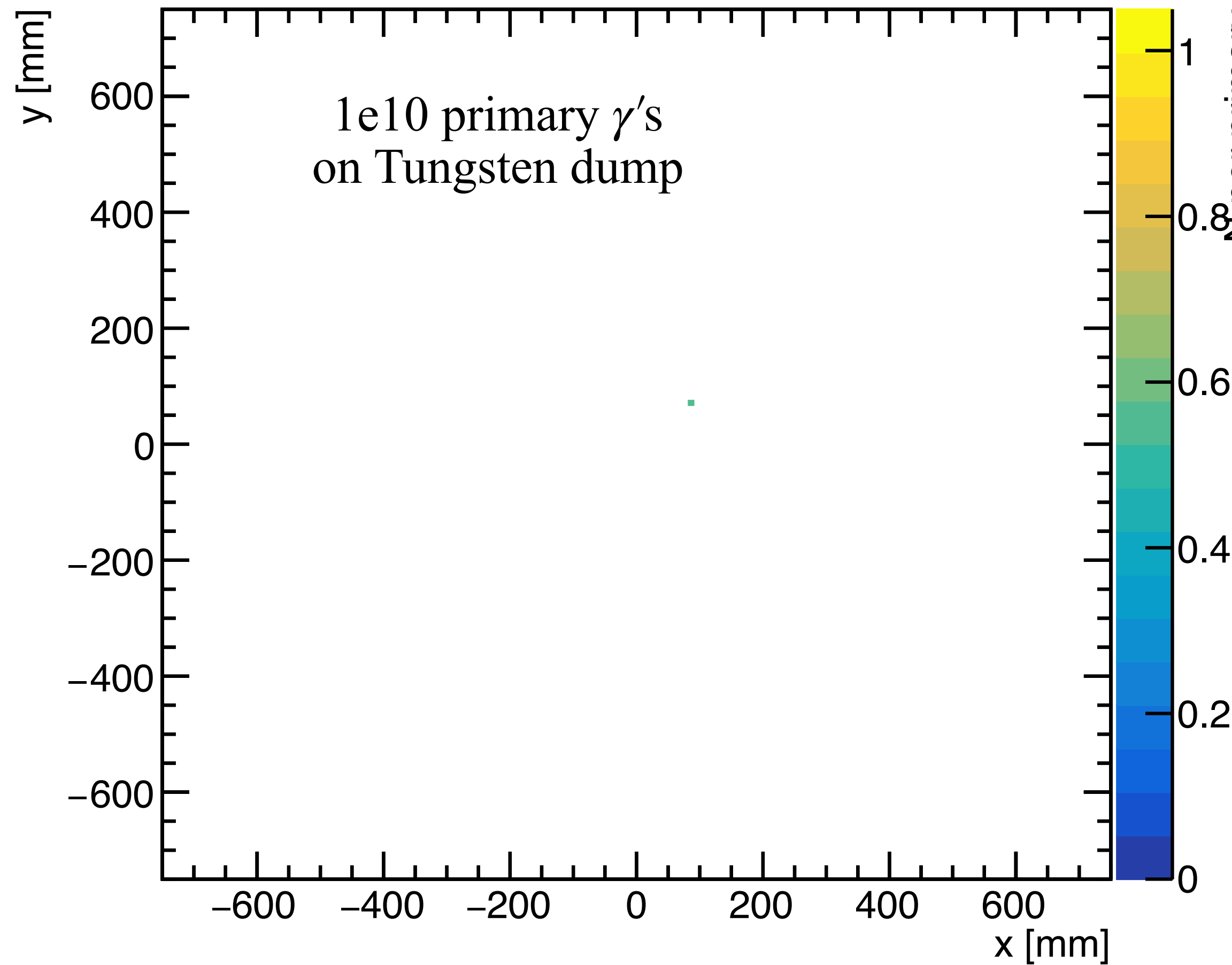


Production vertex in the dump

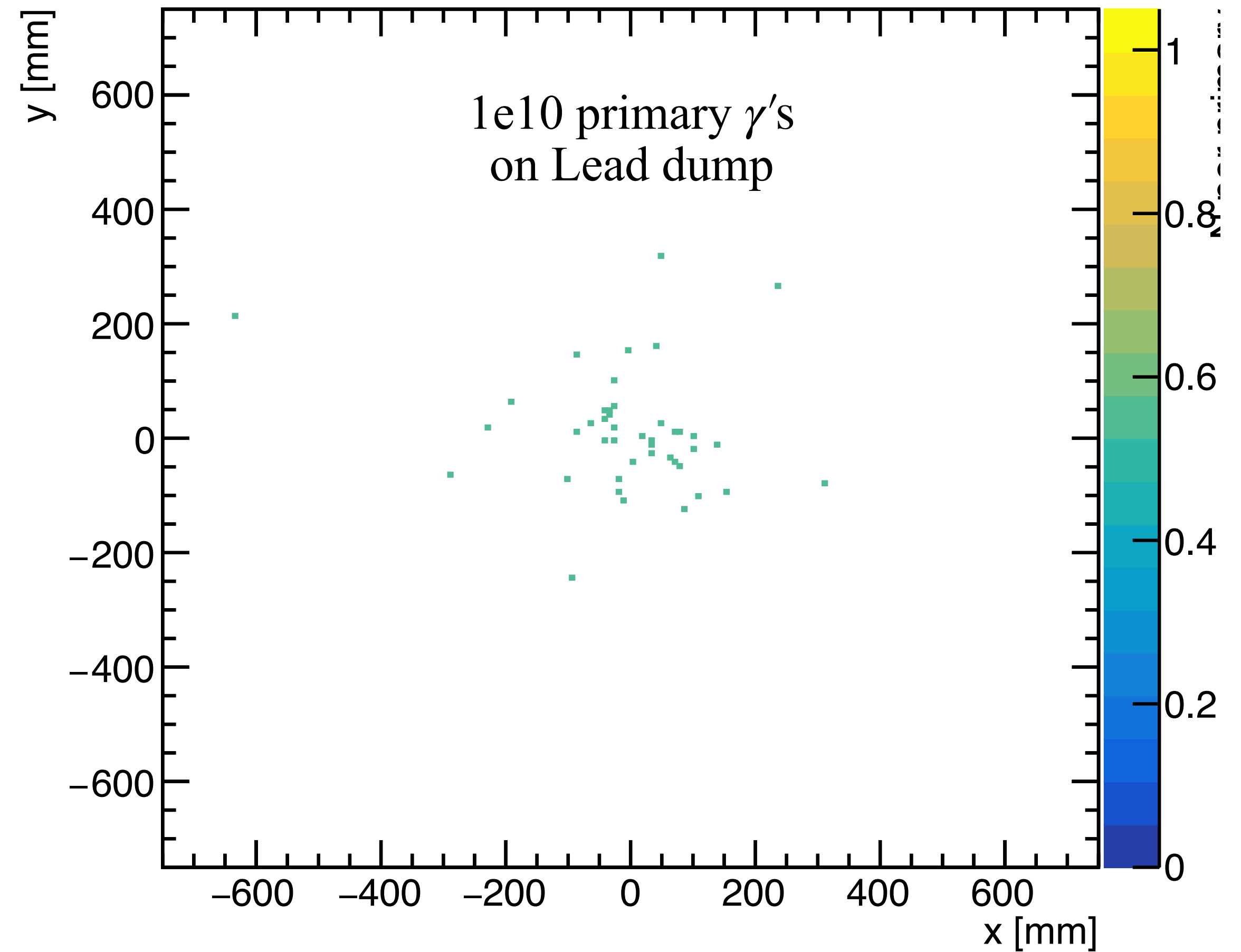


Dump exit profiles: photons

photons dump exit y vs x for $E > 0.5$ GeV

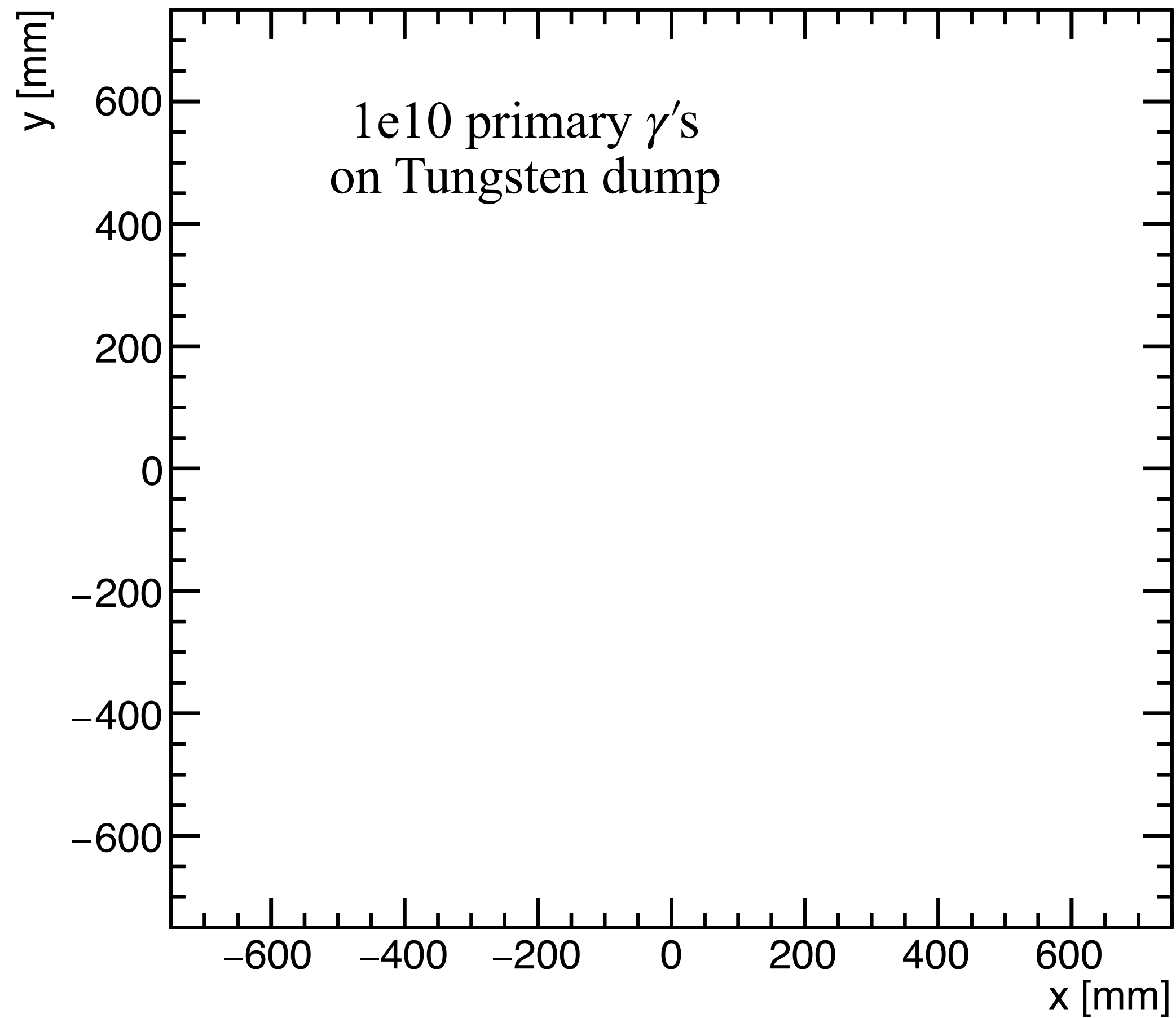


photons dump exit y vs x for $E > 0.5$ GeV

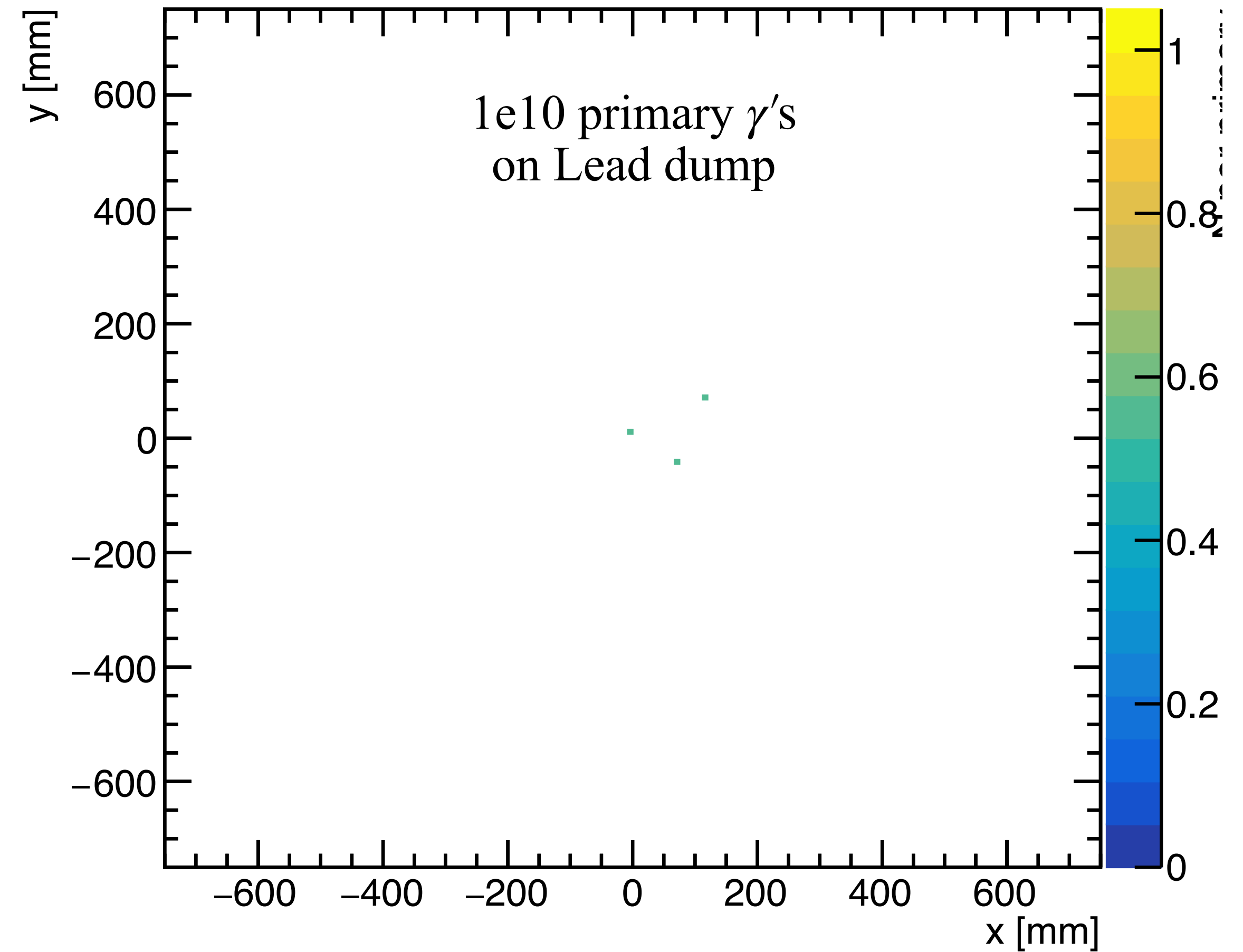


Dump exit profiles: electrons

electrons dump exit y vs x for $E > 0.5$ GeV

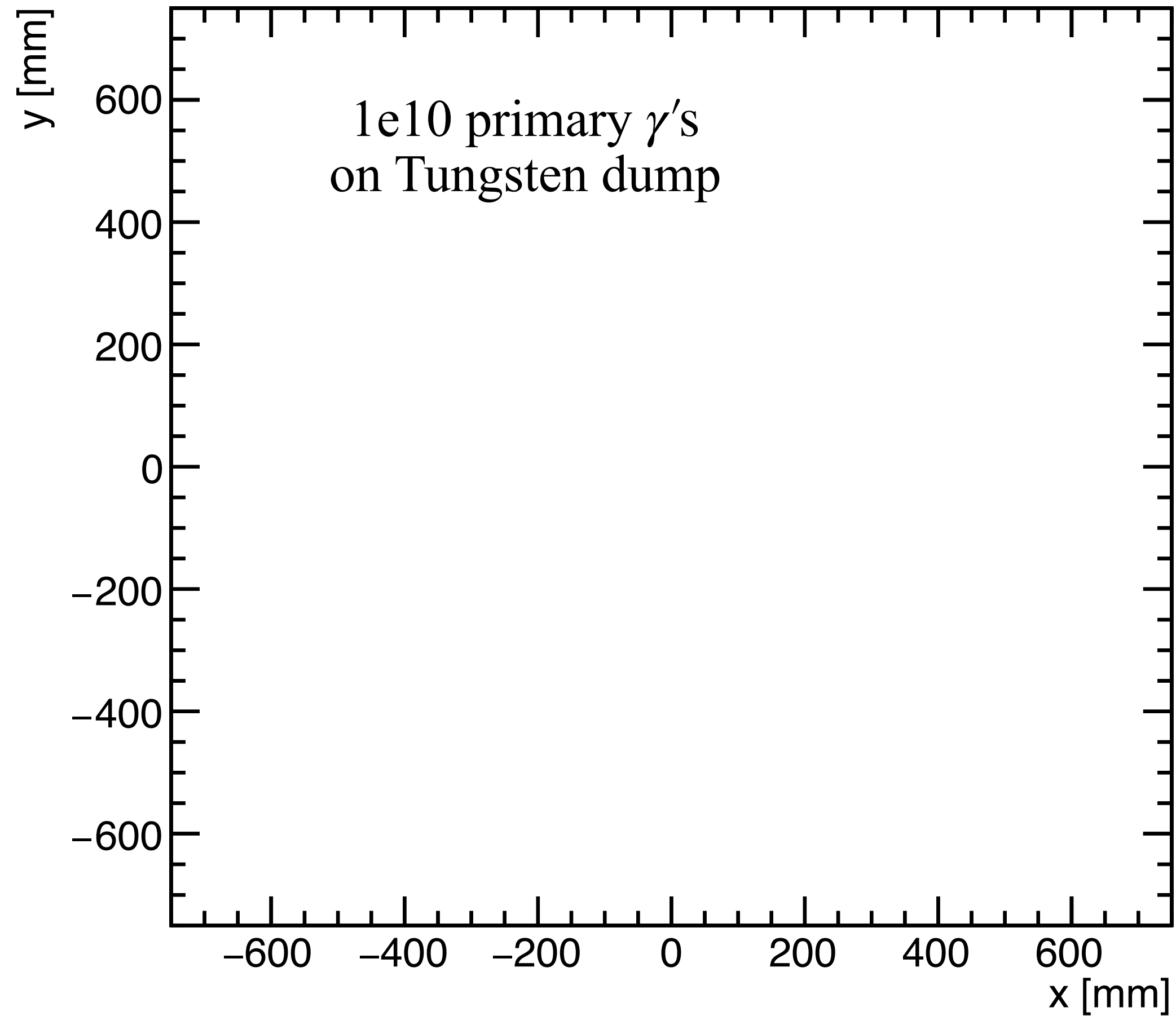


electrons dump exit y vs x for $E > 0.5$ GeV

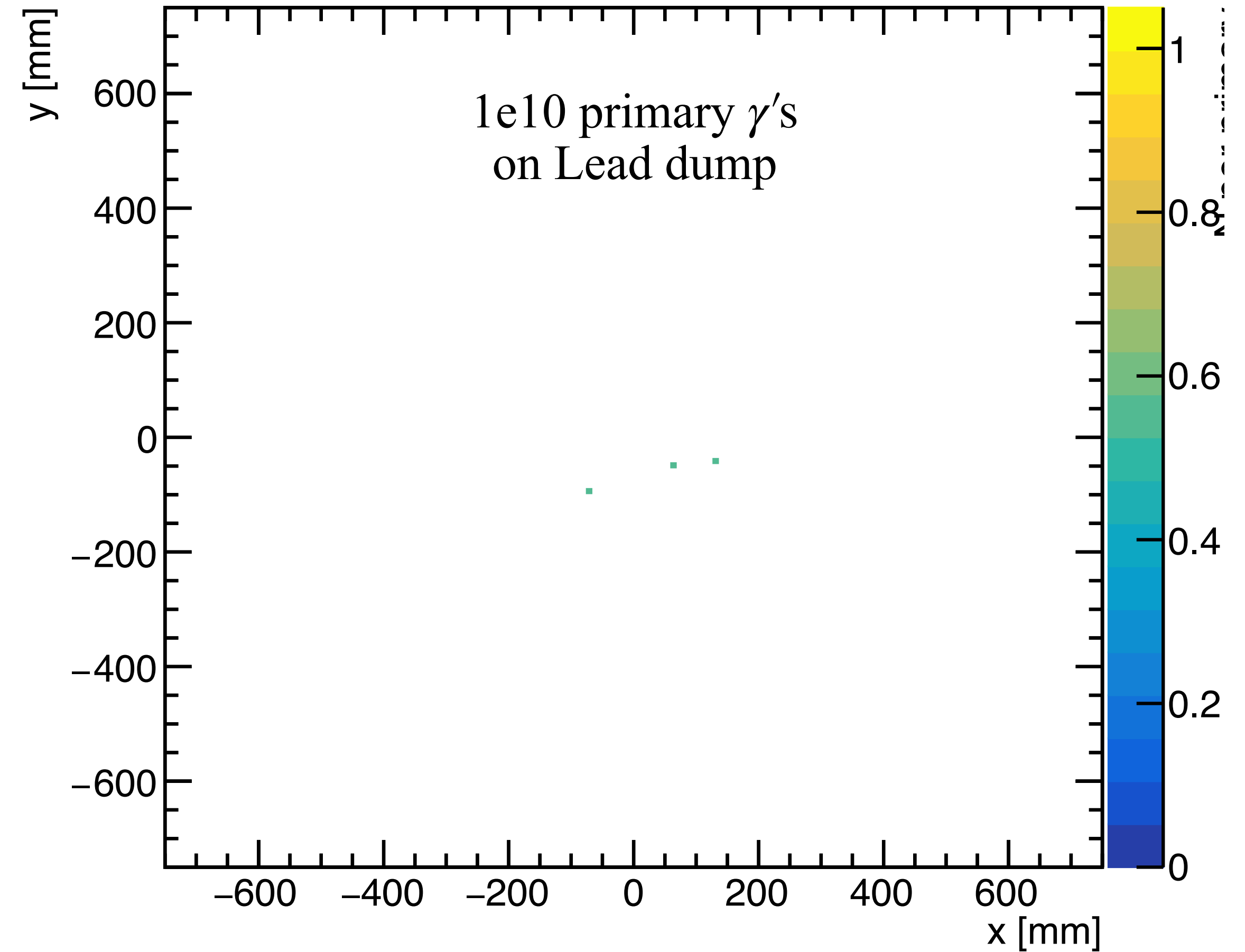


Dump exit profiles: positrons

positrons dump exit y vs x for $E > 0.5$ GeV

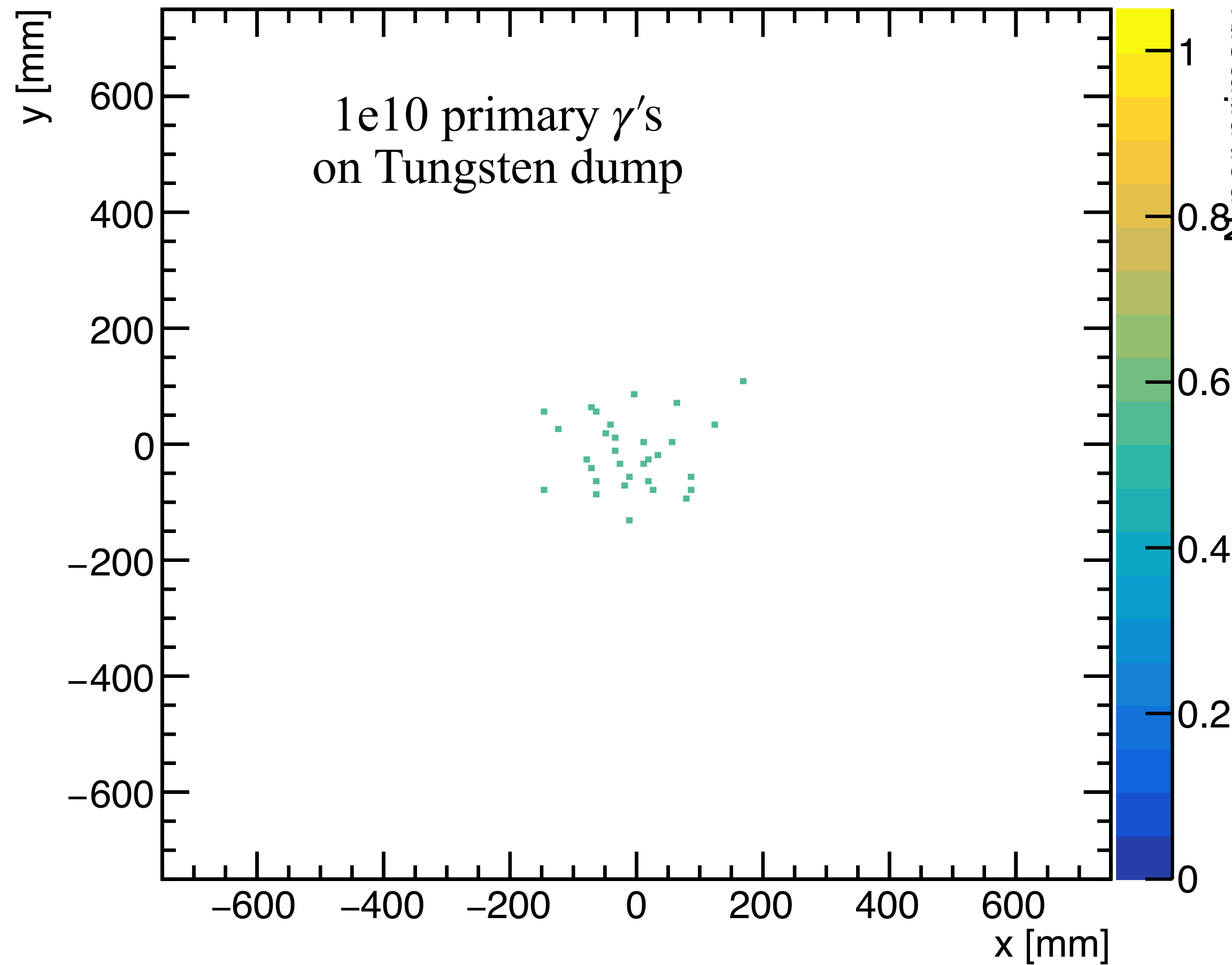


positrons dump exit y vs x for $E > 0.5$ GeV

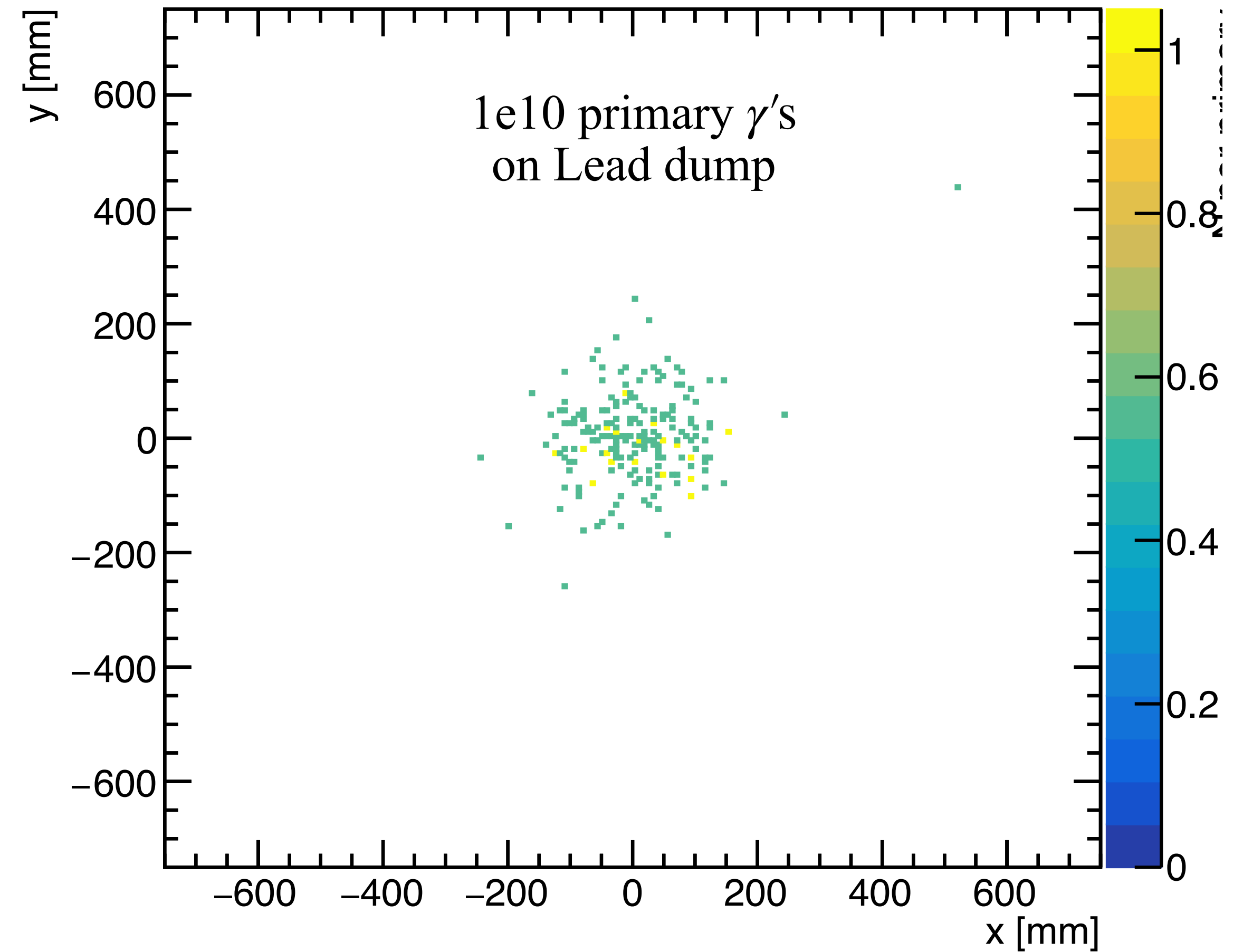


Dump exit profiles: muons-

muons- dump exit y vs x for $E > 0.5$ GeV

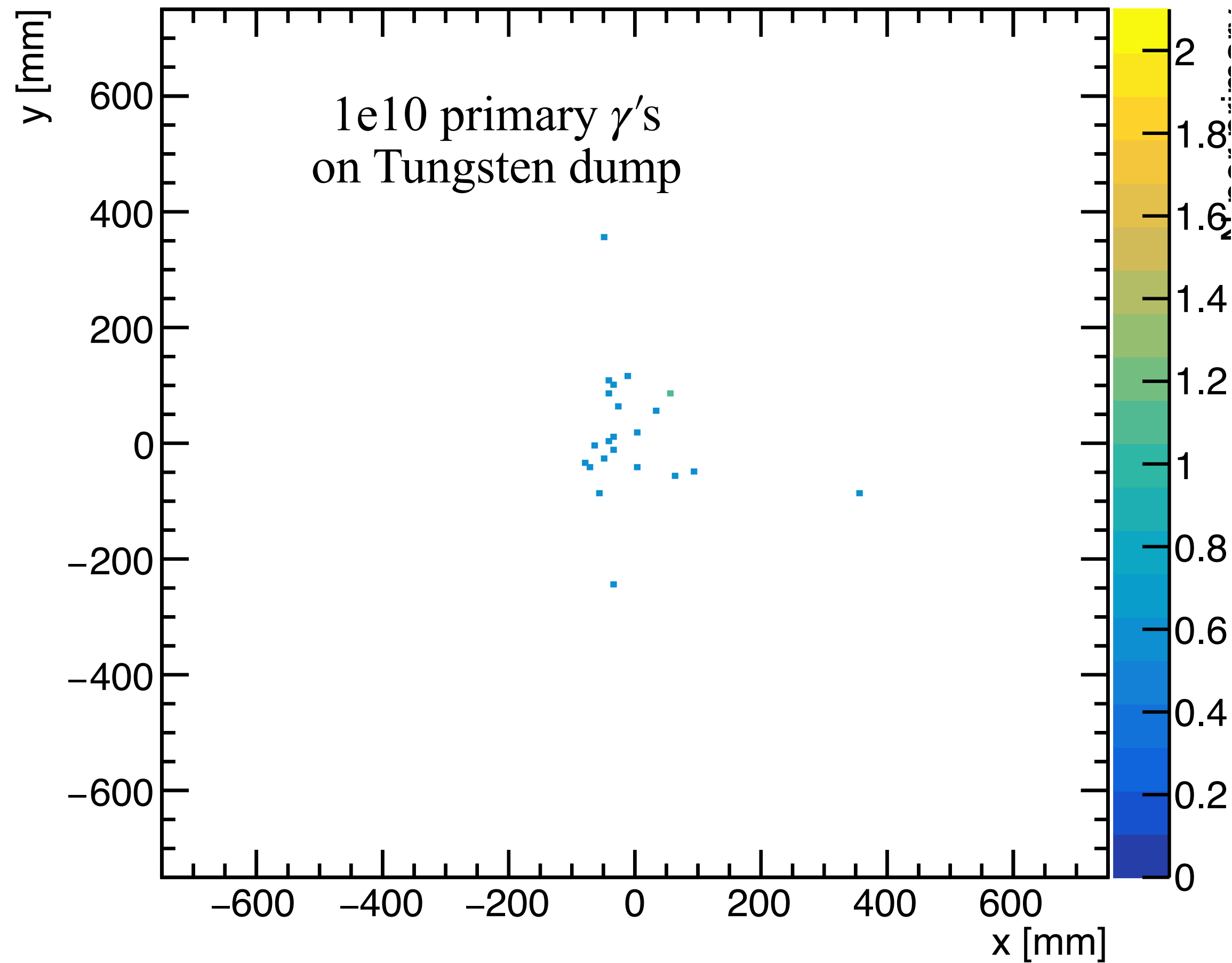


muons- dump exit y vs x for $E > 0.5$ GeV

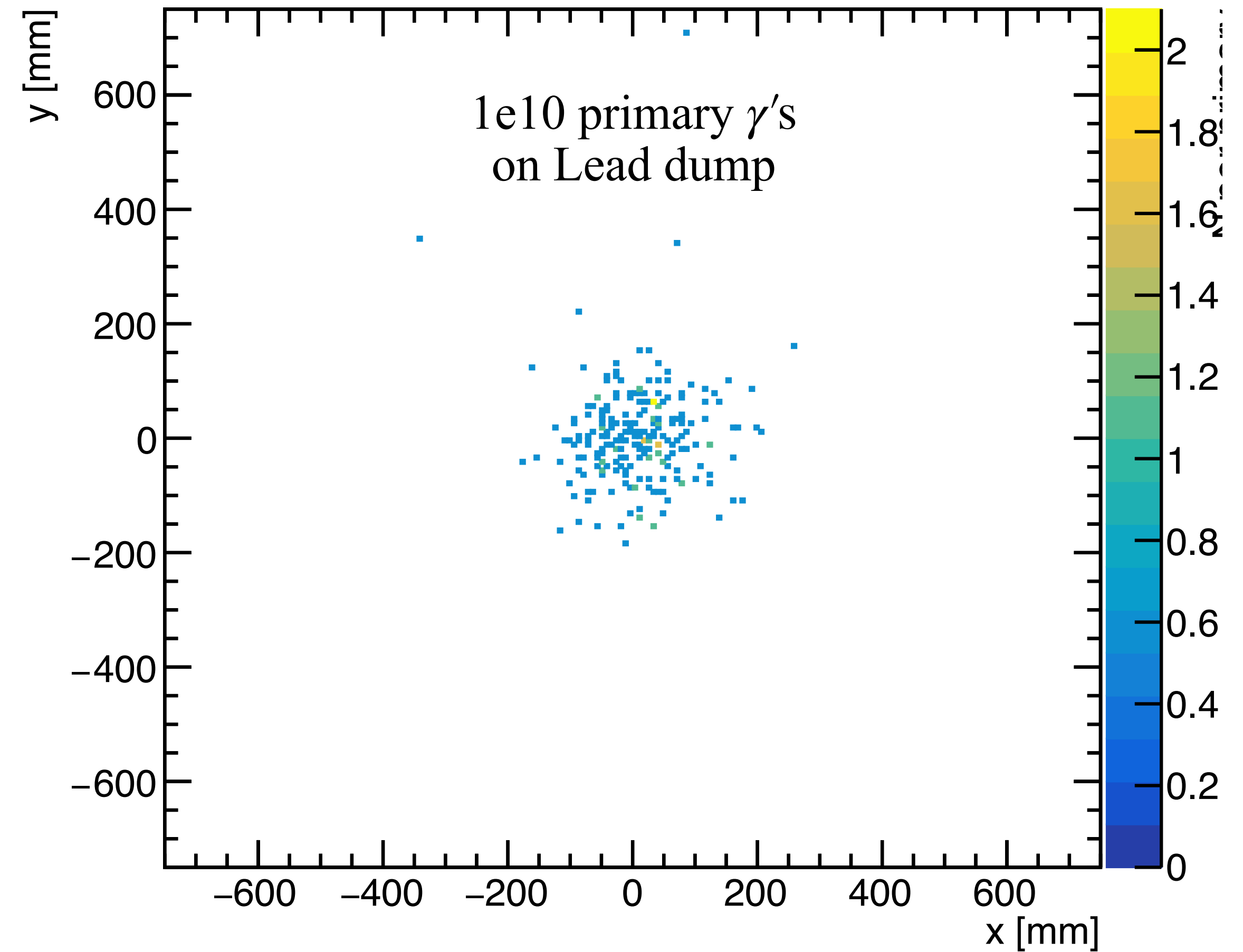


Dump exit profiles: muons+

muons+ dump exit y vs x for $E > 0.5$ GeV

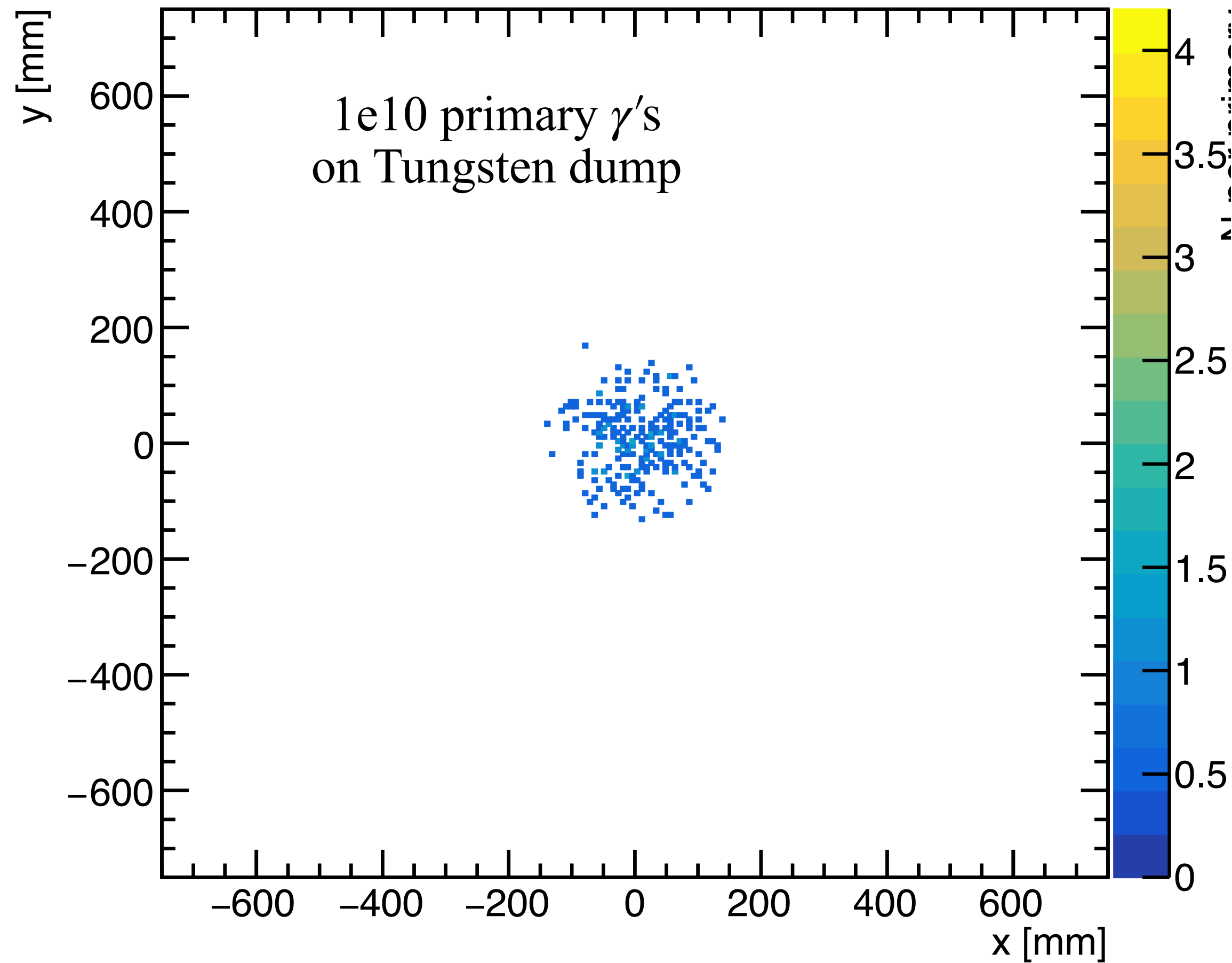


muons+ dump exit y vs x for $E > 0.5$ GeV

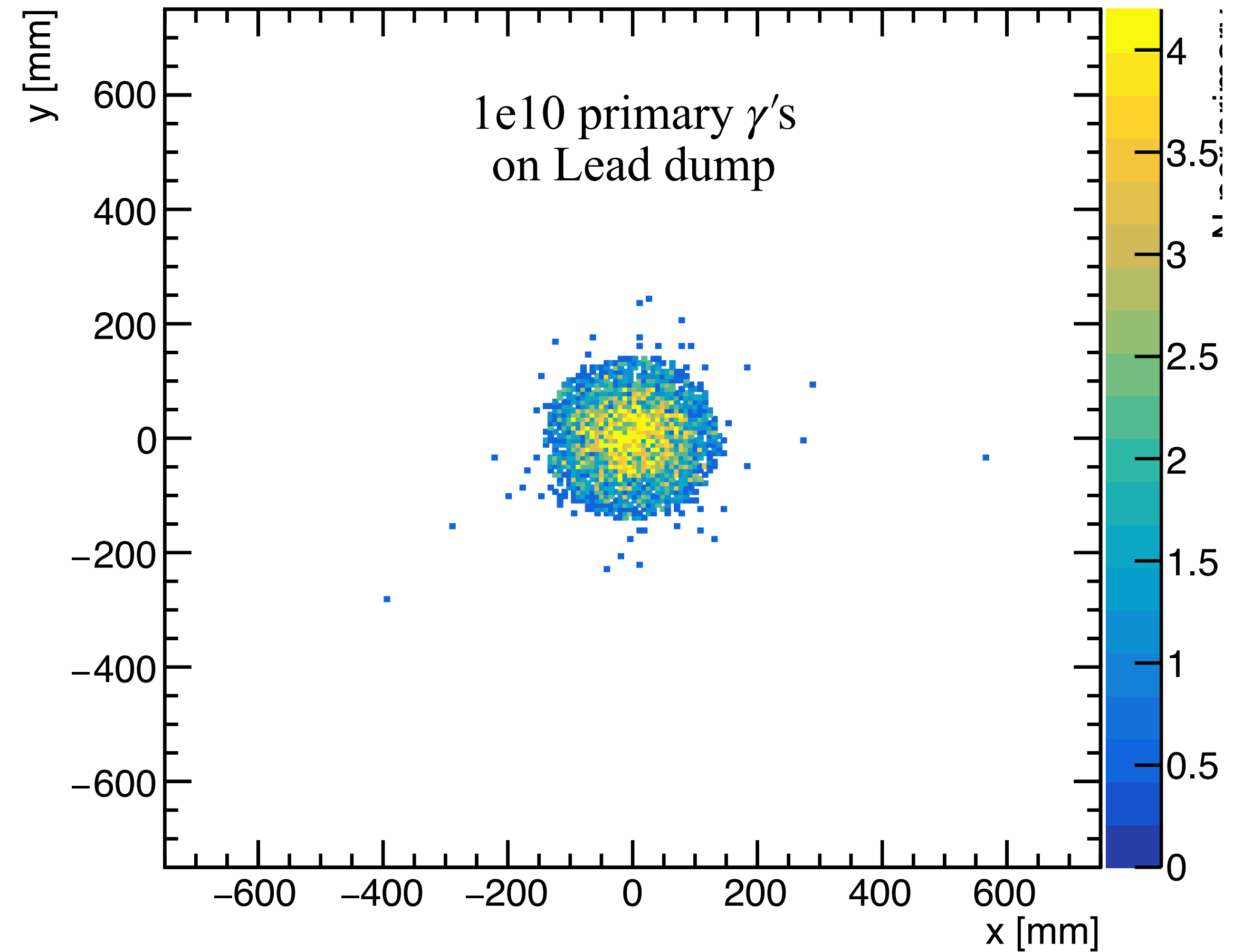


Dump exit profiles: pions-

pions- dump exit y vs x for $E > 0.5$ GeV

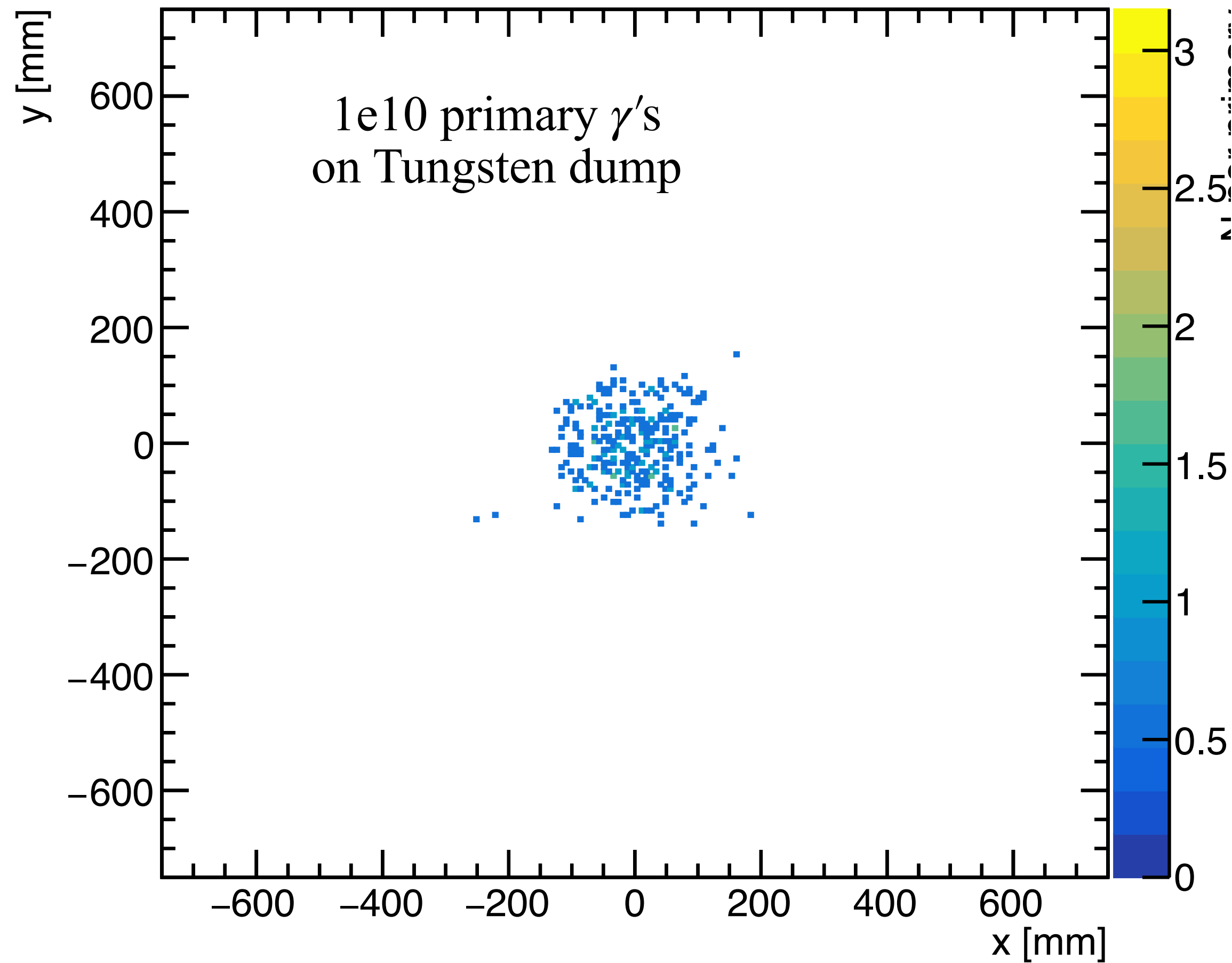


pions- dump exit y vs x for $E > 0.5$ GeV

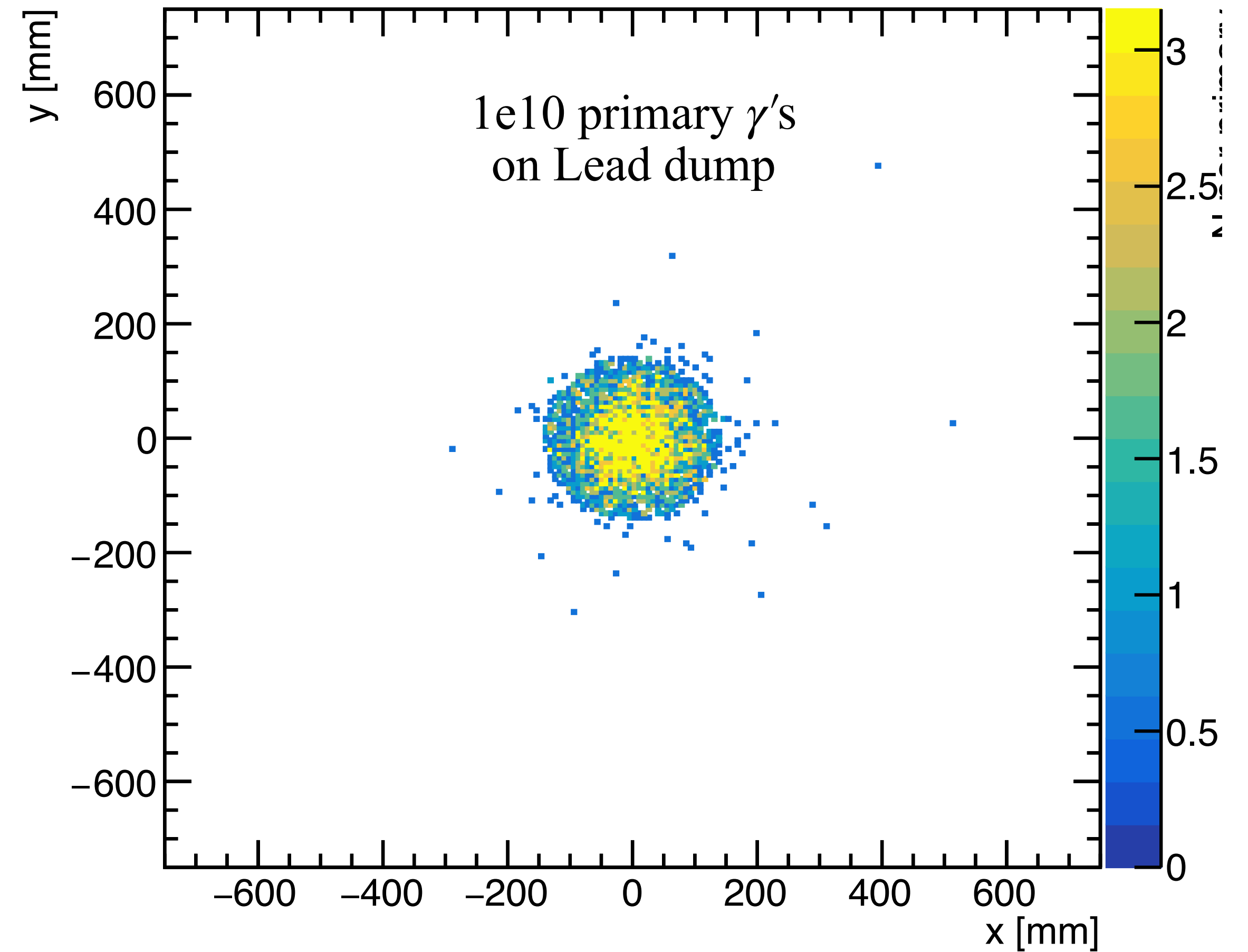


Dump exit profiles: pions+

pions+ dump exit y vs x for $E > 0.5$ GeV

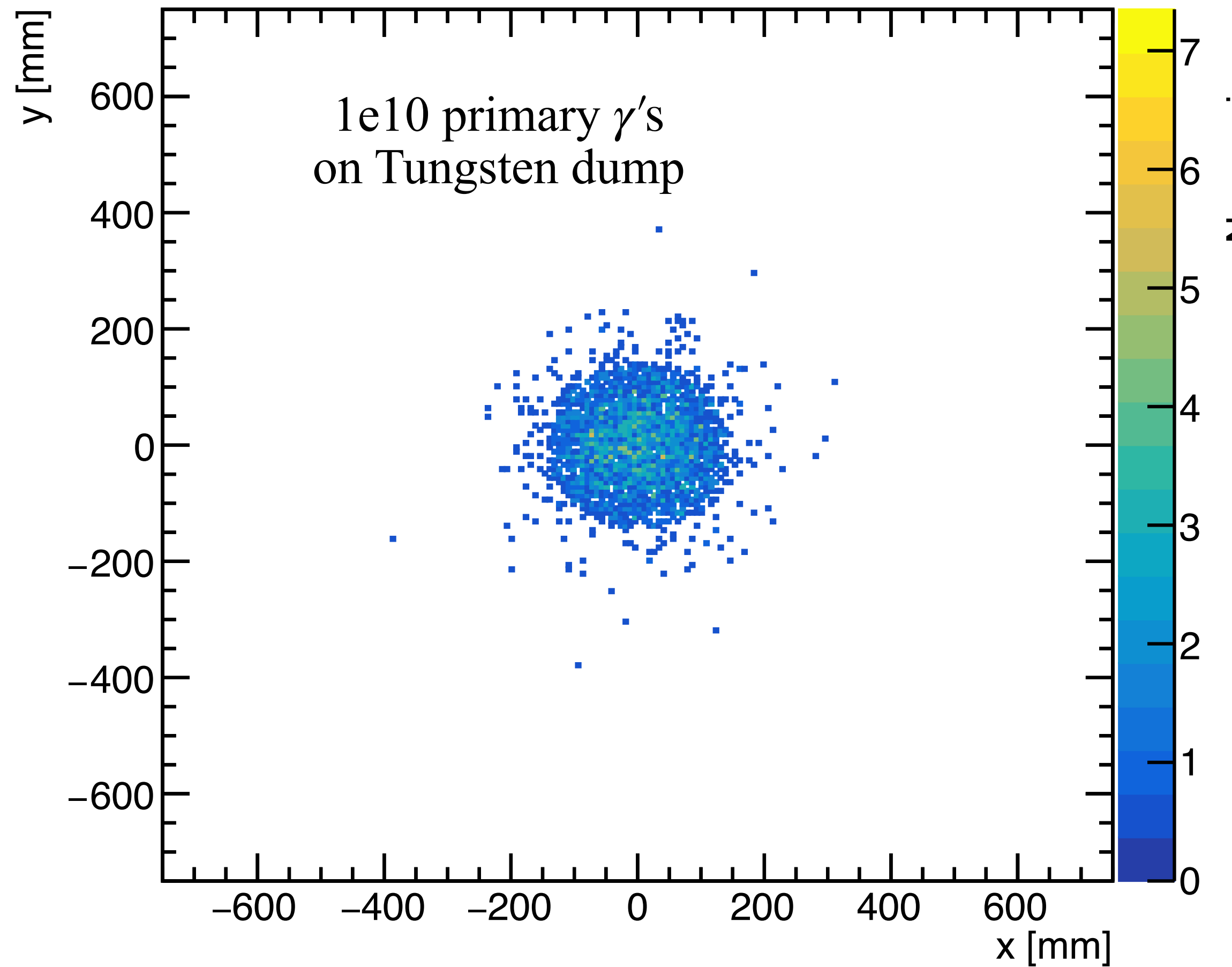


pions+ dump exit y vs x for $E > 0.5$ GeV

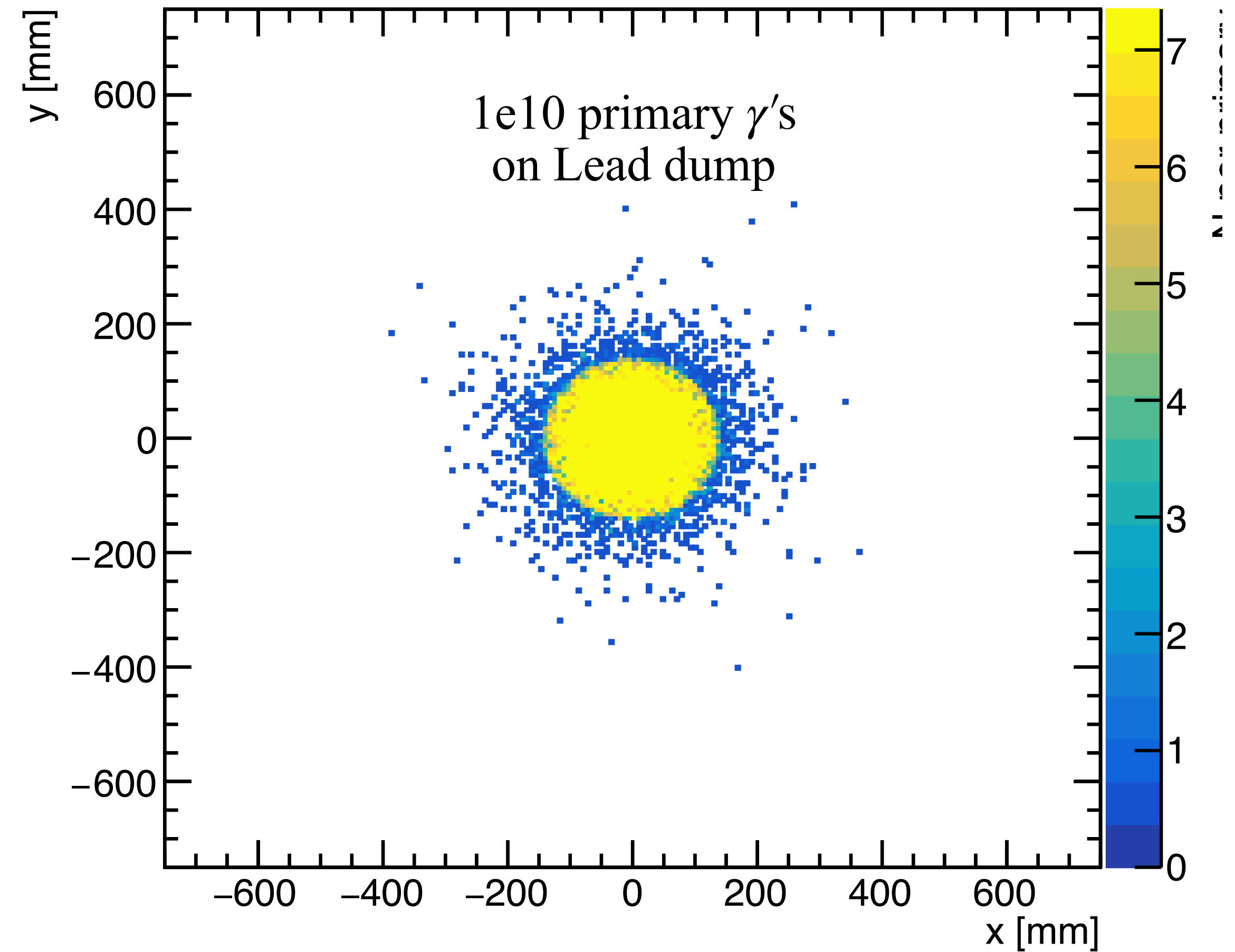


Dump exit profiles: neutrons

neutrons dump exit y vs x for $E > 0.5$ GeV

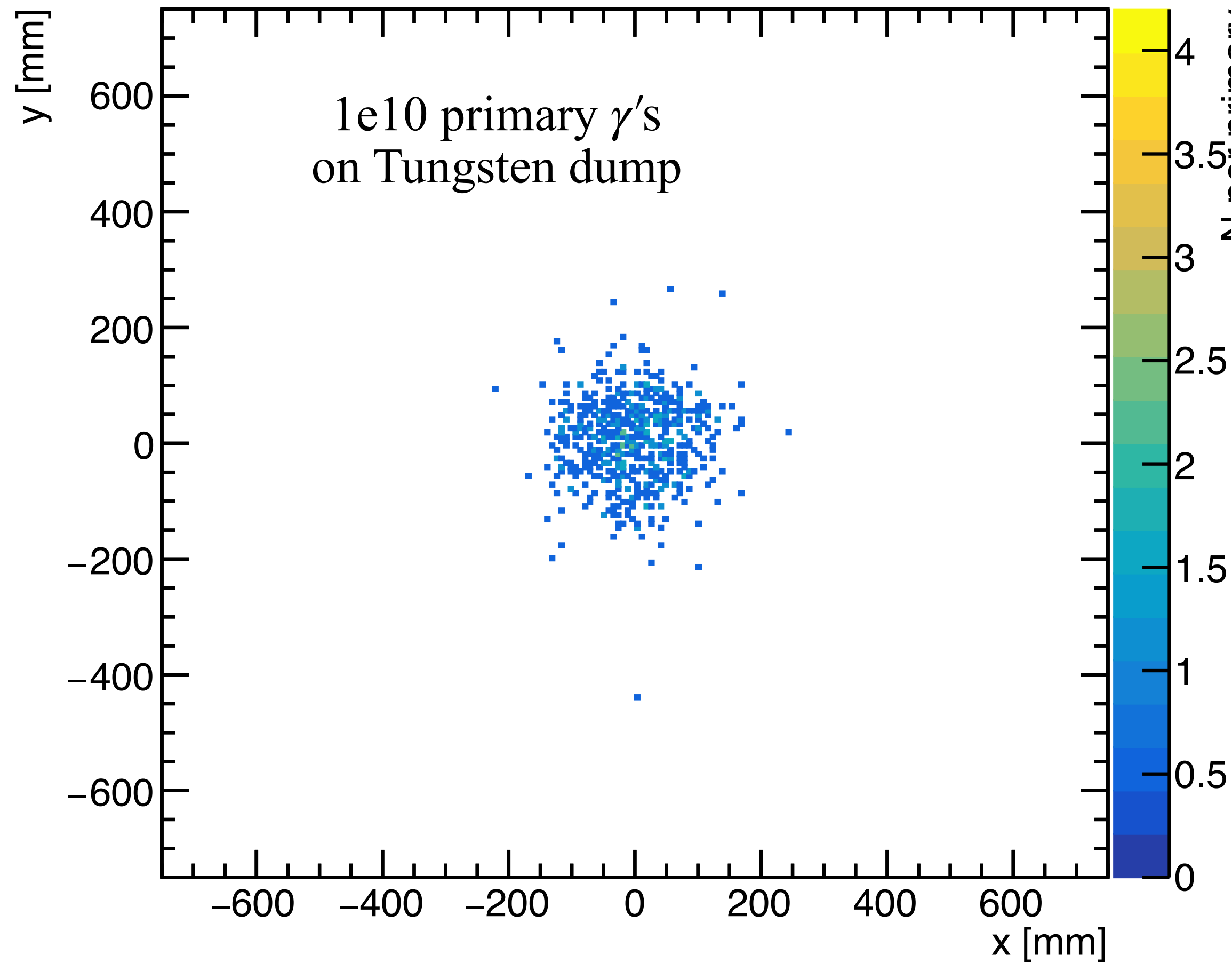


neutrons dump exit y vs x for $E > 0.5$ GeV

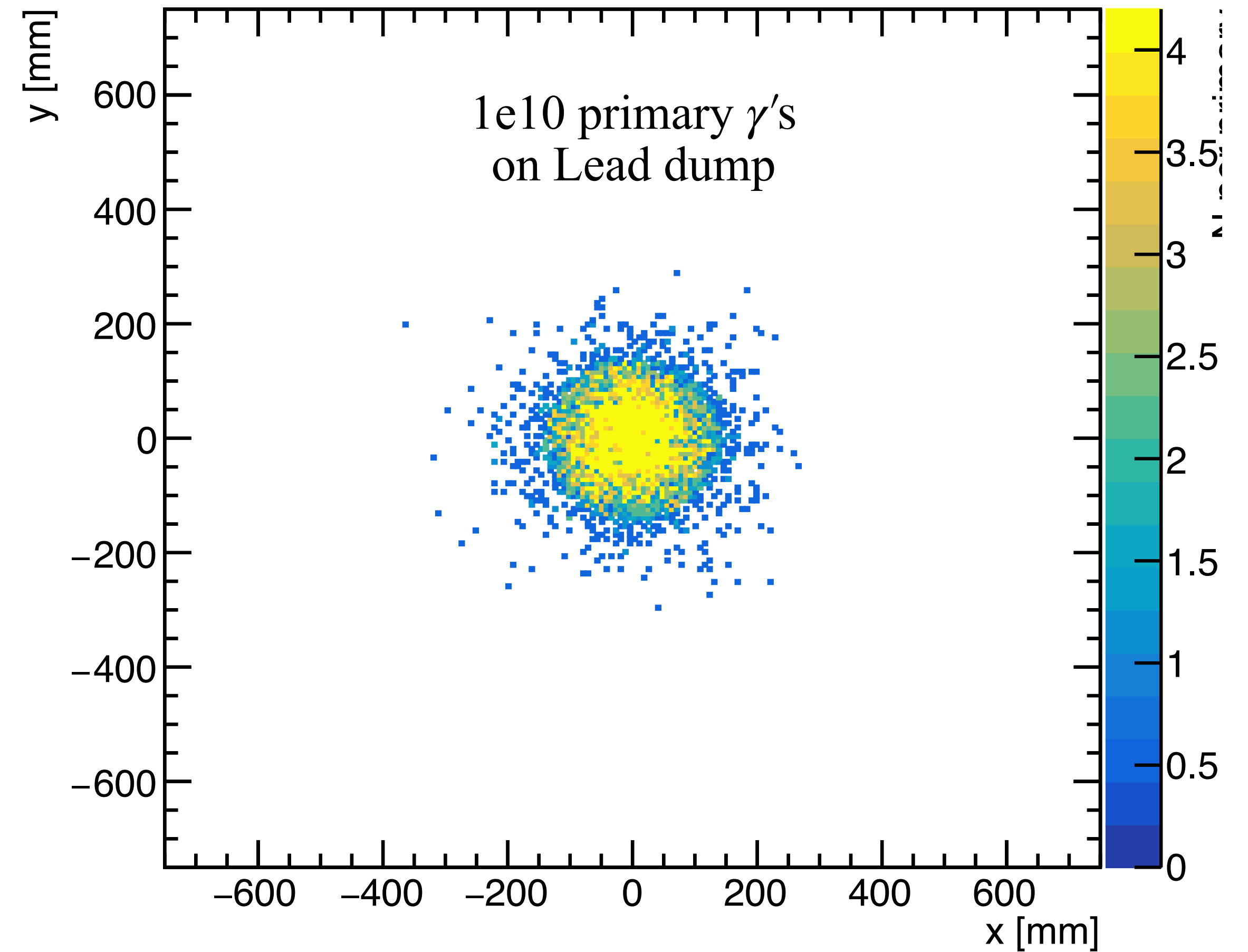


Dump exit profiles: protons-

protons- dump exit y vs x for $E > 0.5$ GeV

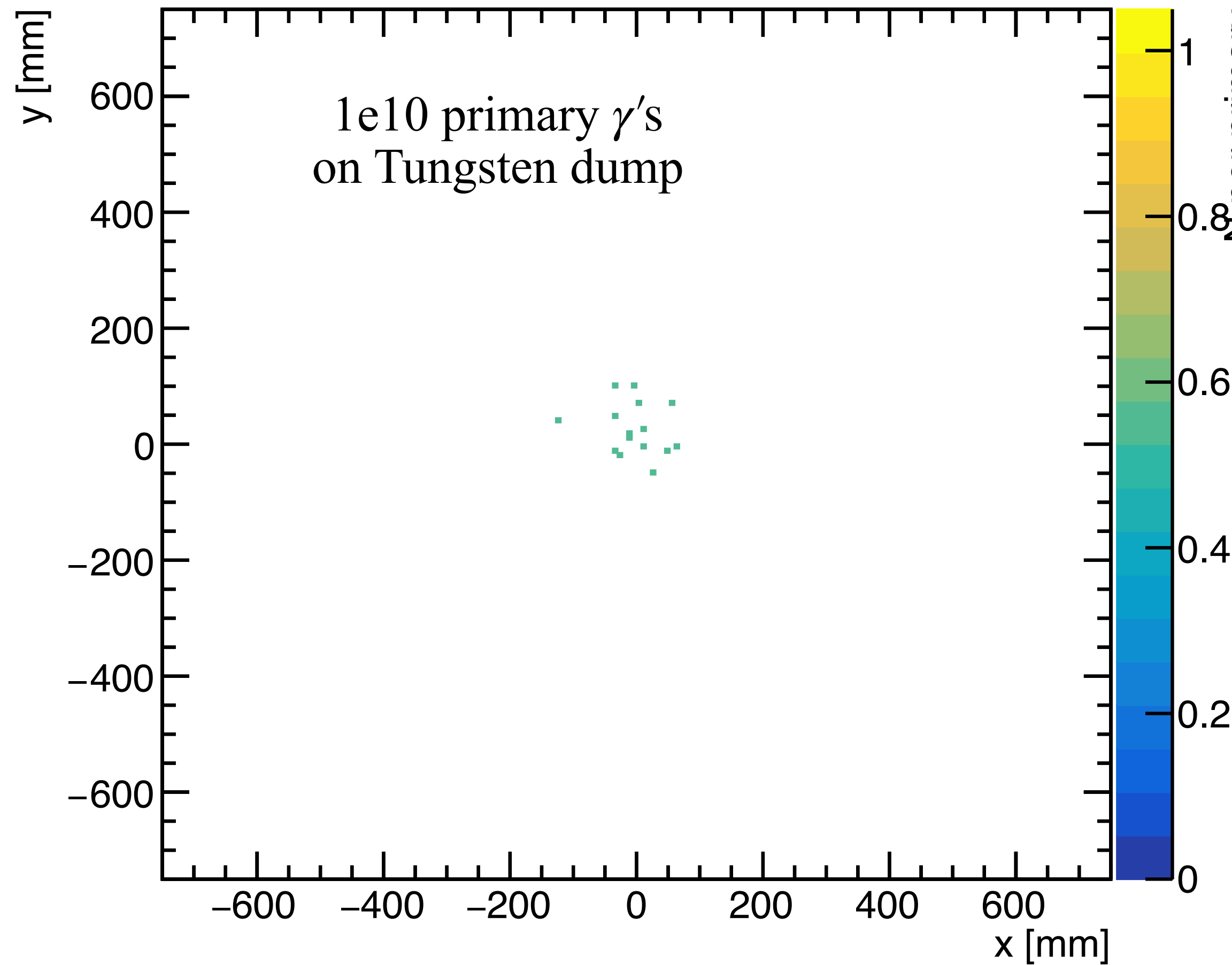


protons- dump exit y vs x for $E > 0.5$ GeV

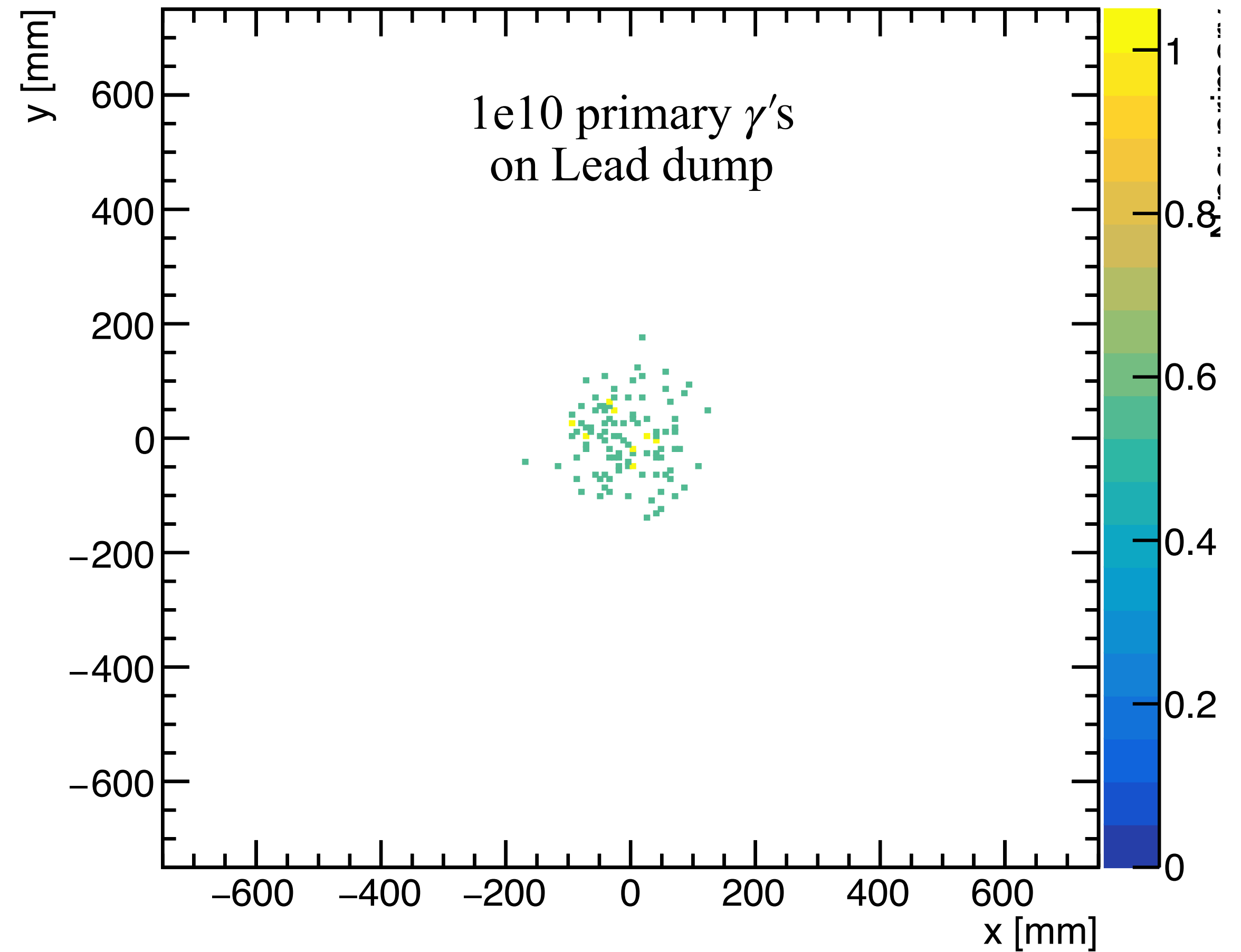


Dump exit profiles: K_L

kaon0L dump exit y vs x for $E > 0.5$ GeV

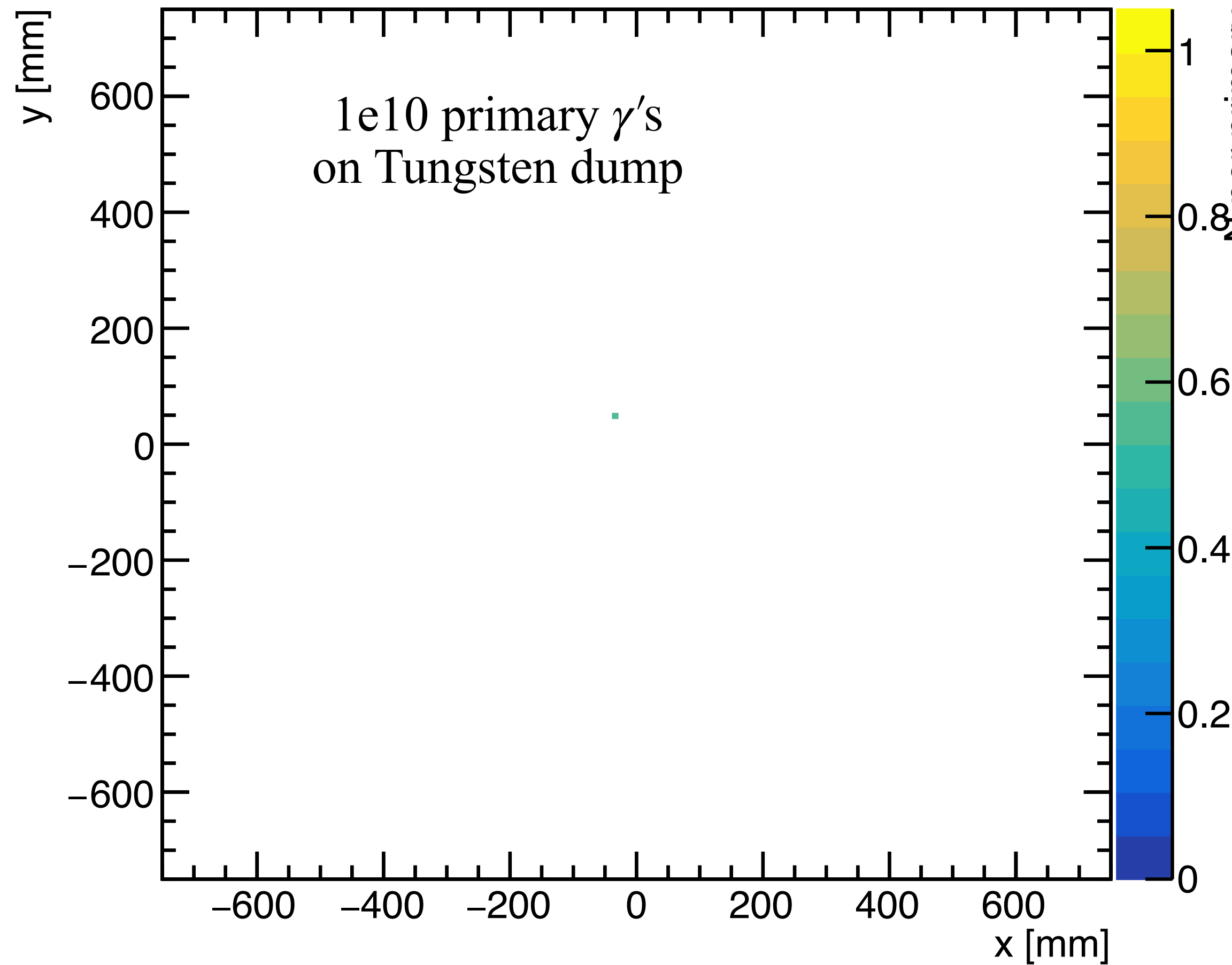


kaon0L dump exit y vs x for $E > 0.5$ GeV

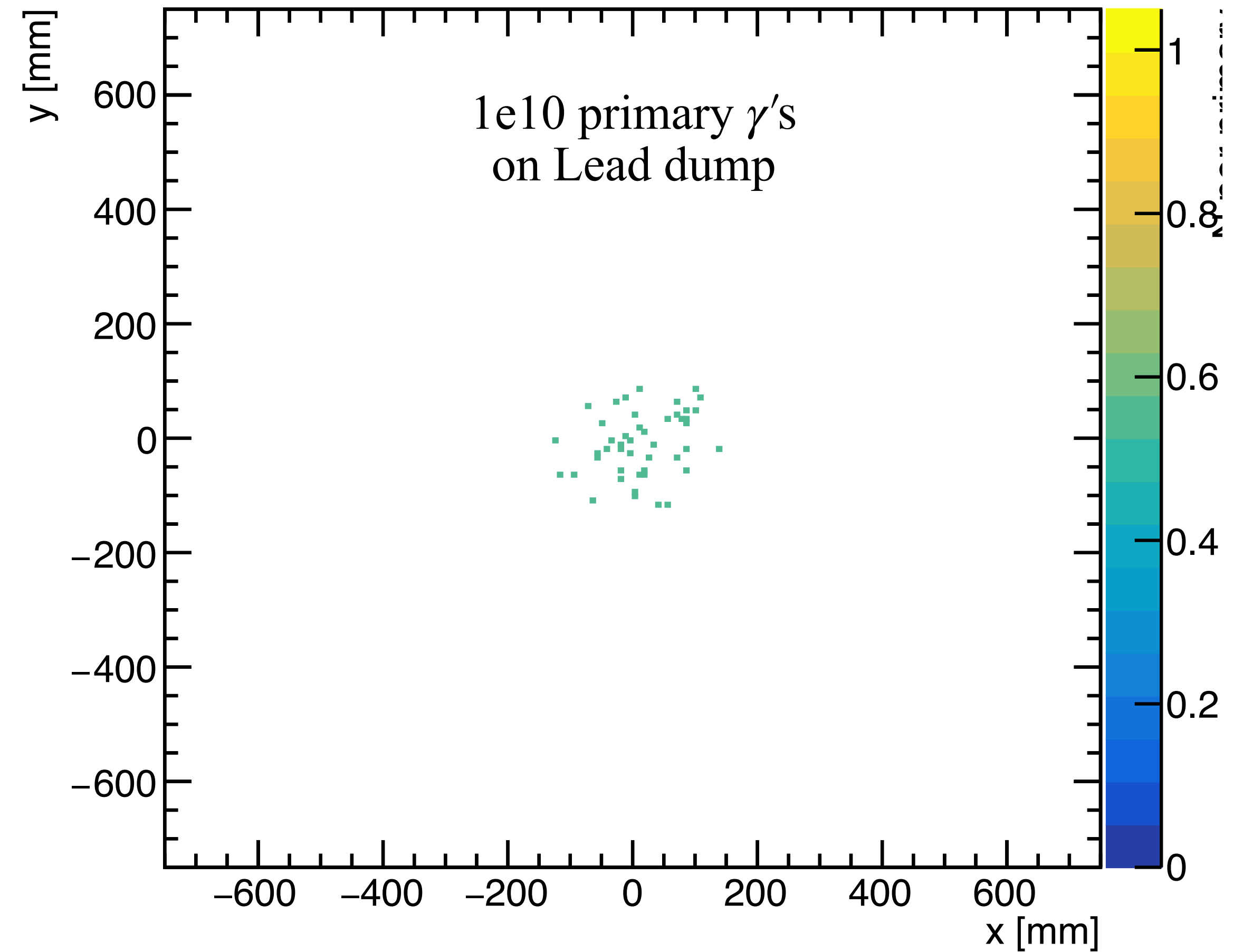


Dump exit profiles: kaons-

kaon- dump exit y vs x for $E > 0.5$ GeV

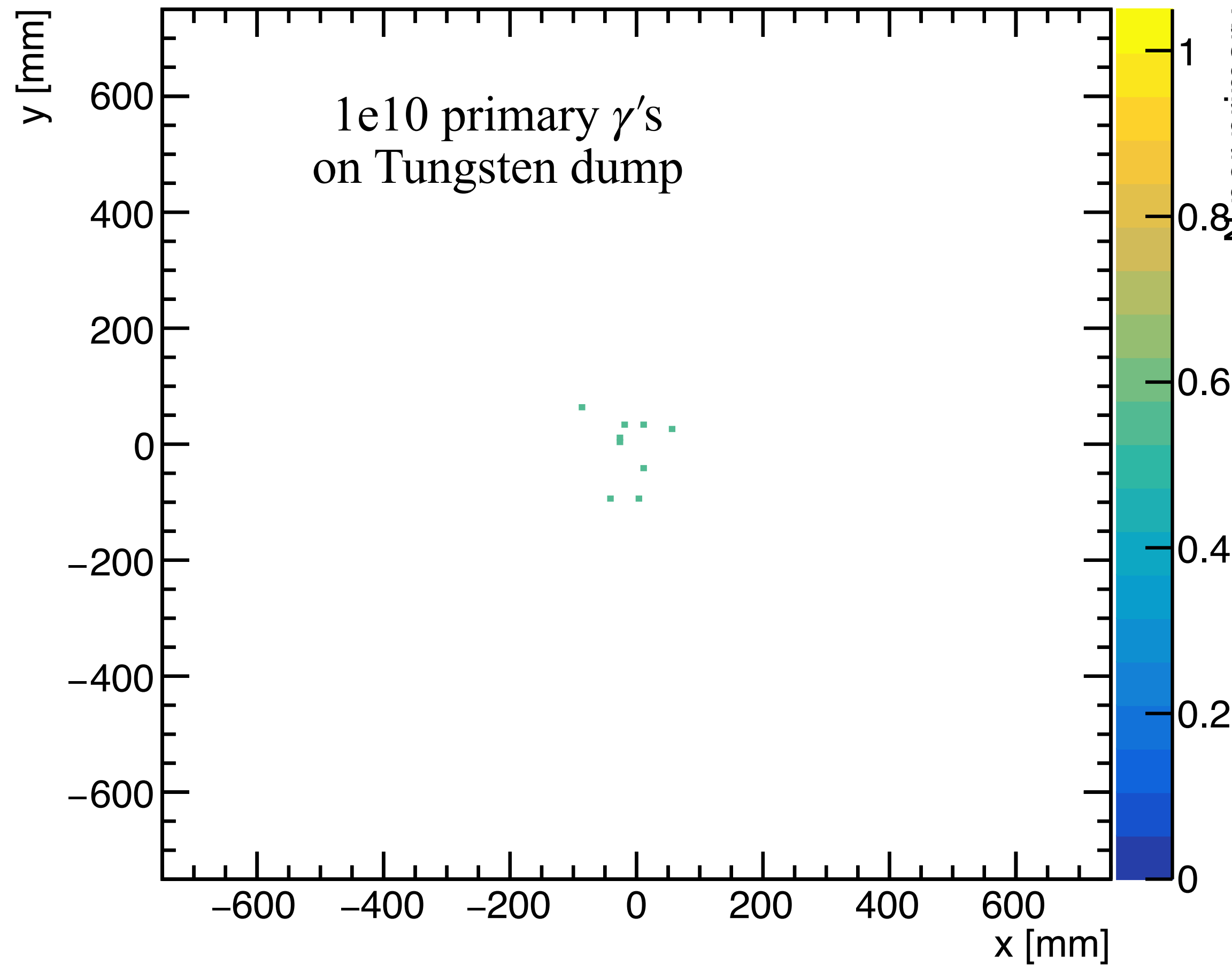


kaon- dump exit y vs x for $E > 0.5$ GeV

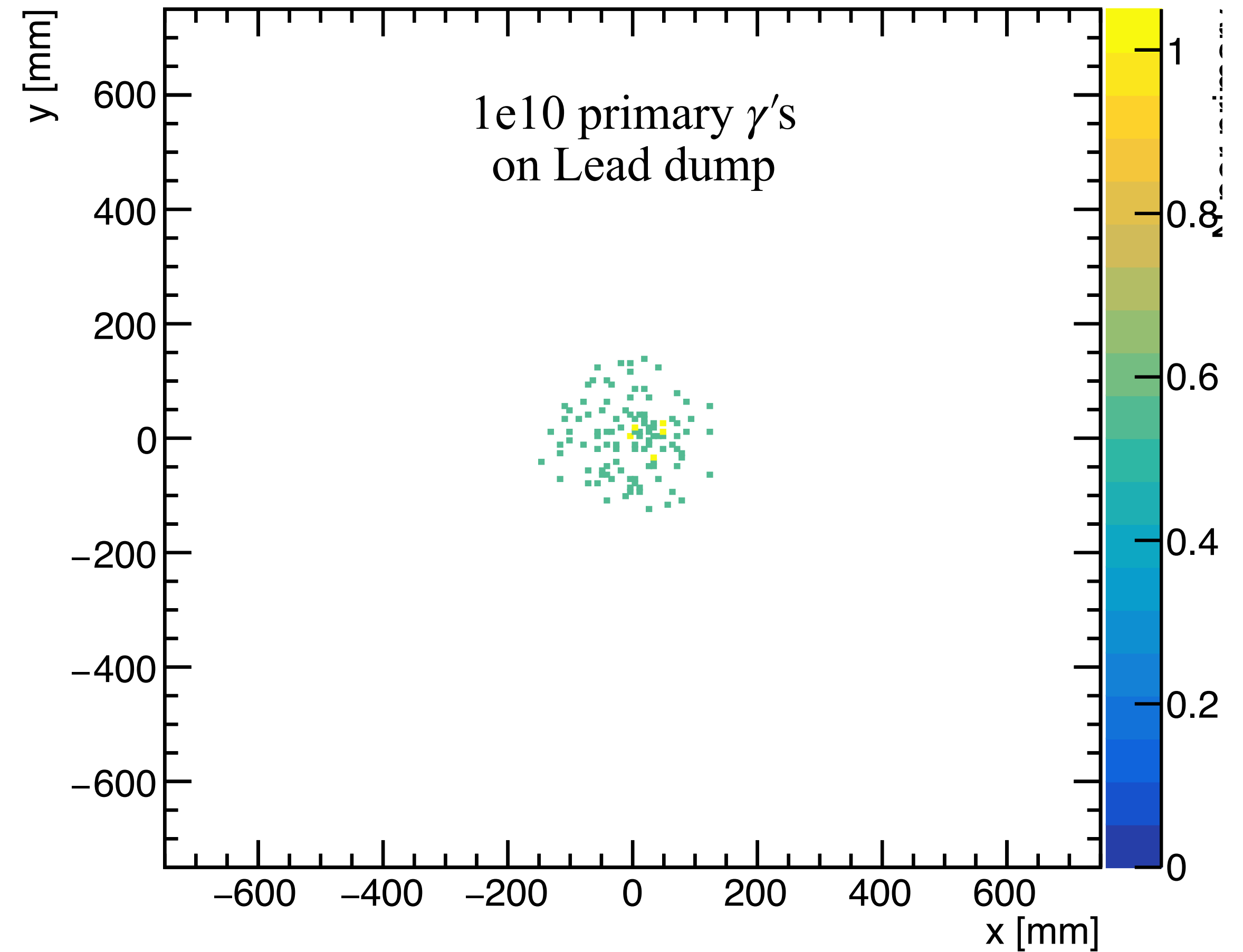


Dump exit profiles: kaons+

kaon+ dump exit y vs x for $E > 0.5$ GeV

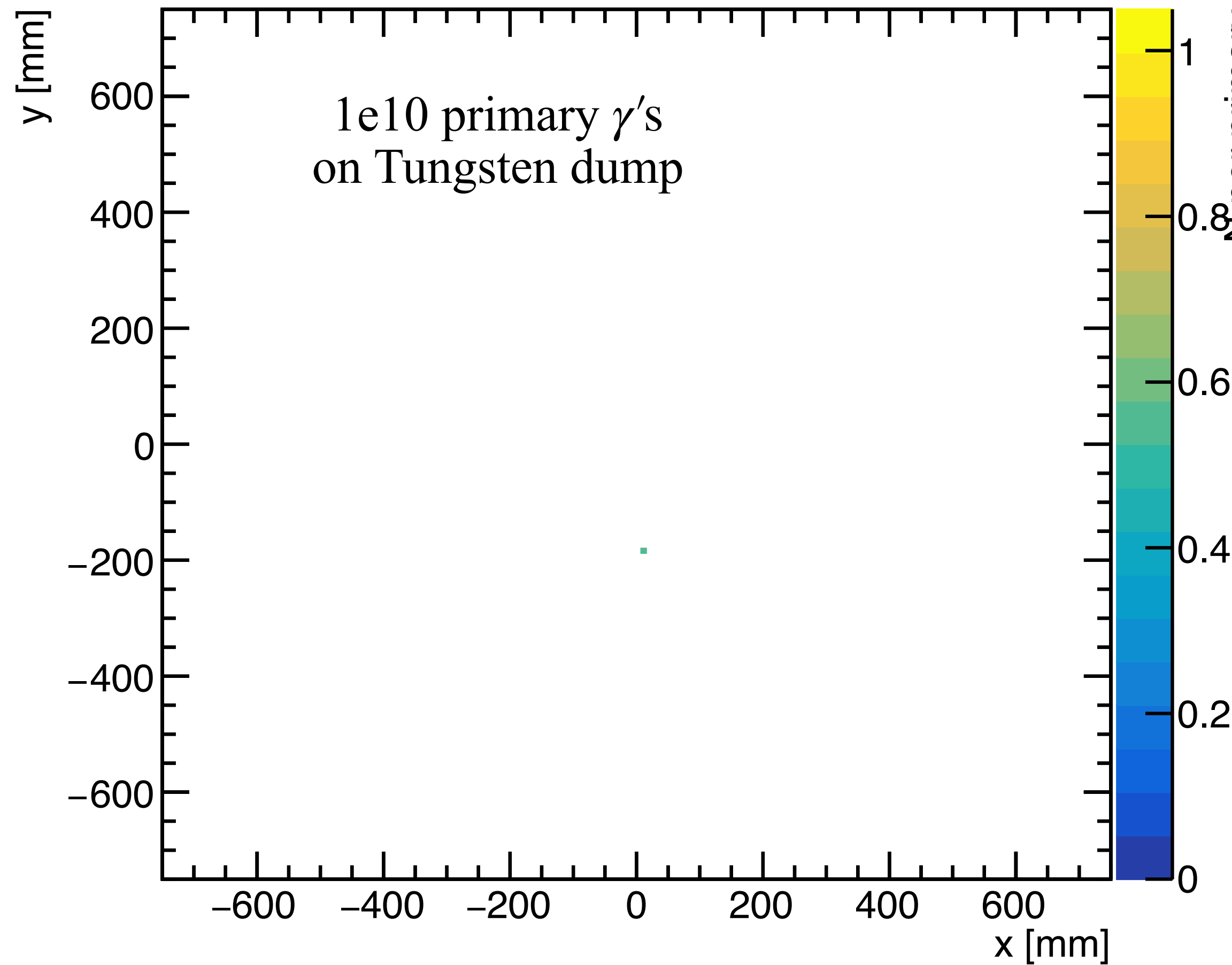


kaon+ dump exit y vs x for $E > 0.5$ GeV

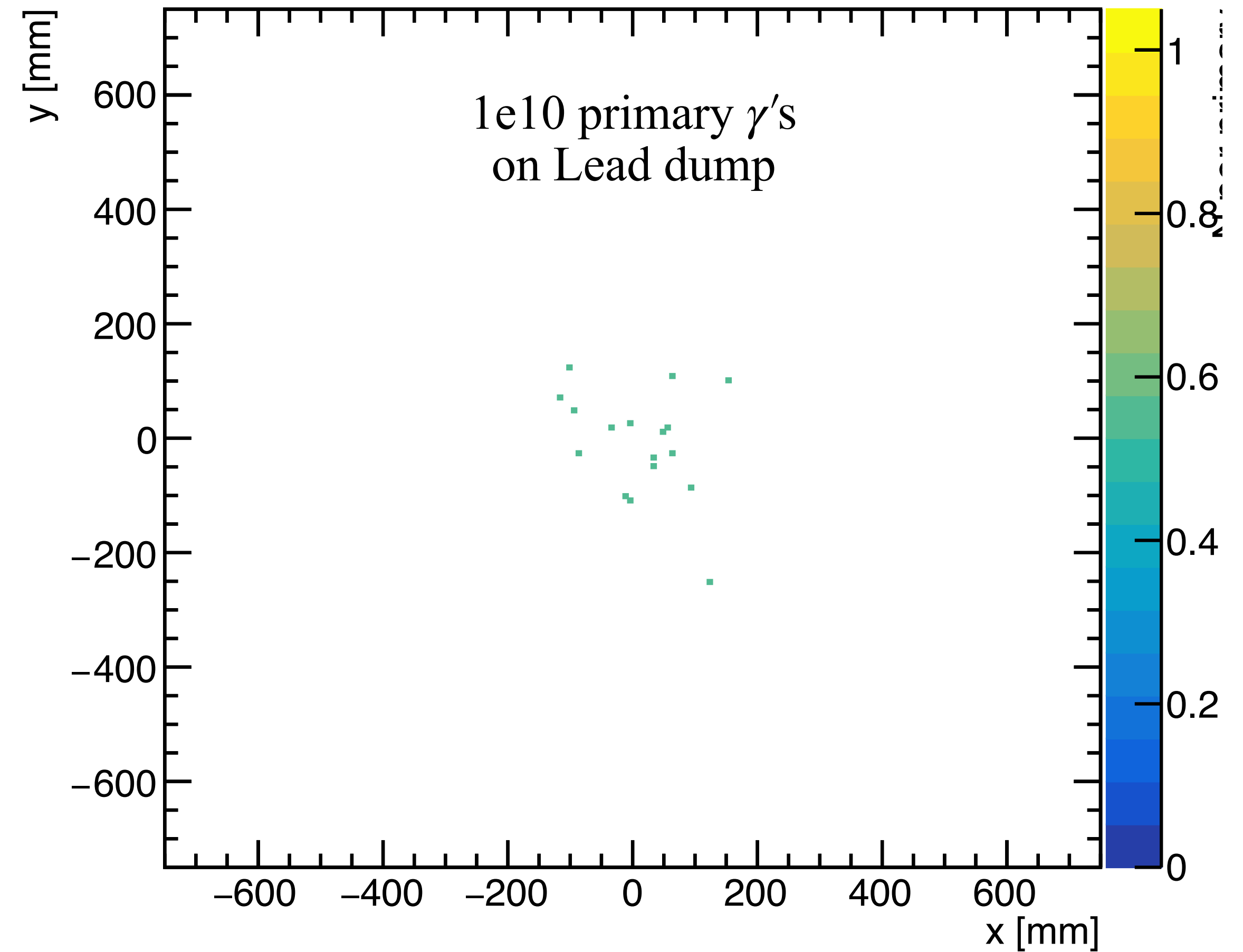


Dump exit profiles: neutrons

deuteron dump exit y vs x for $E > 0.5$ GeV



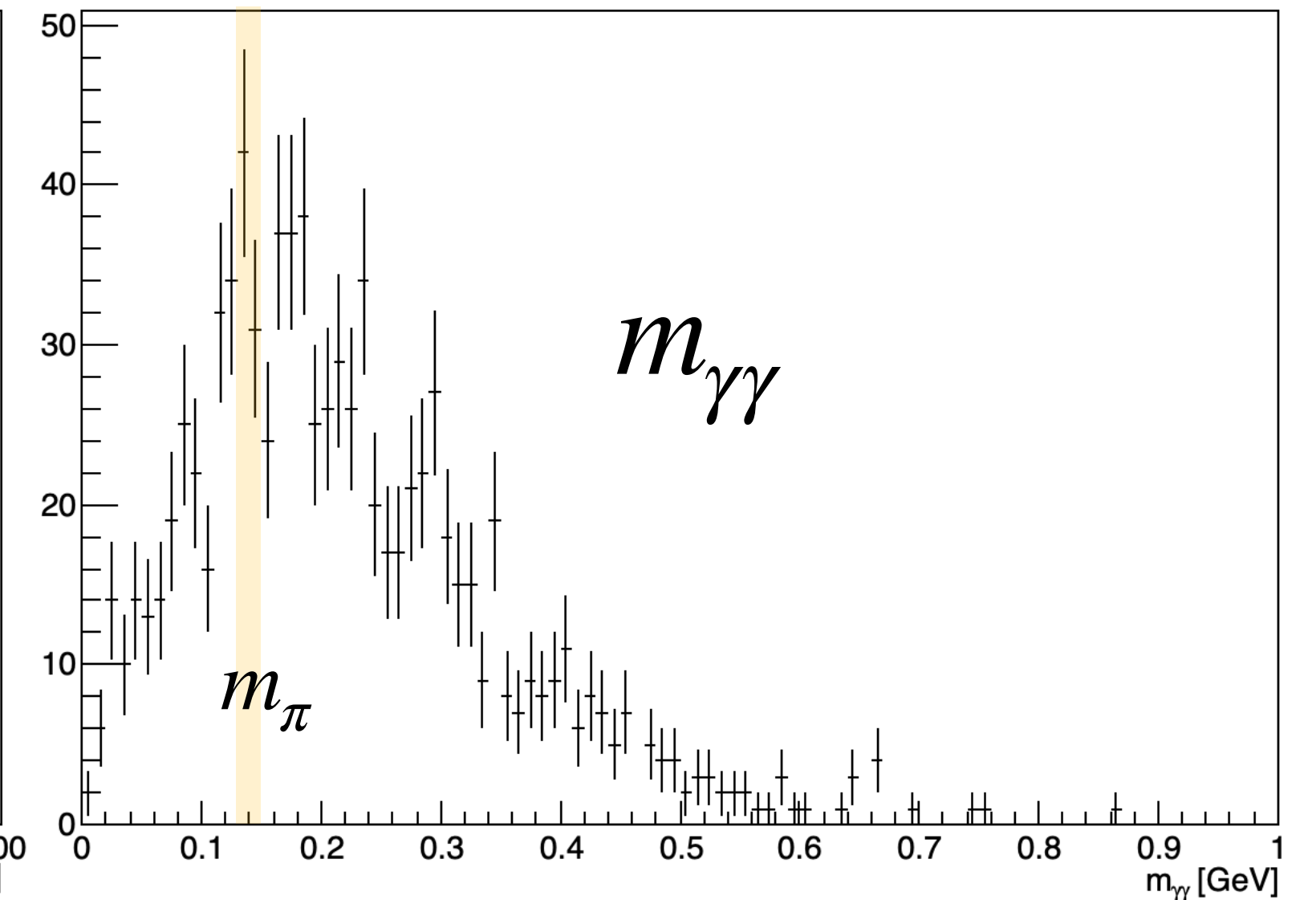
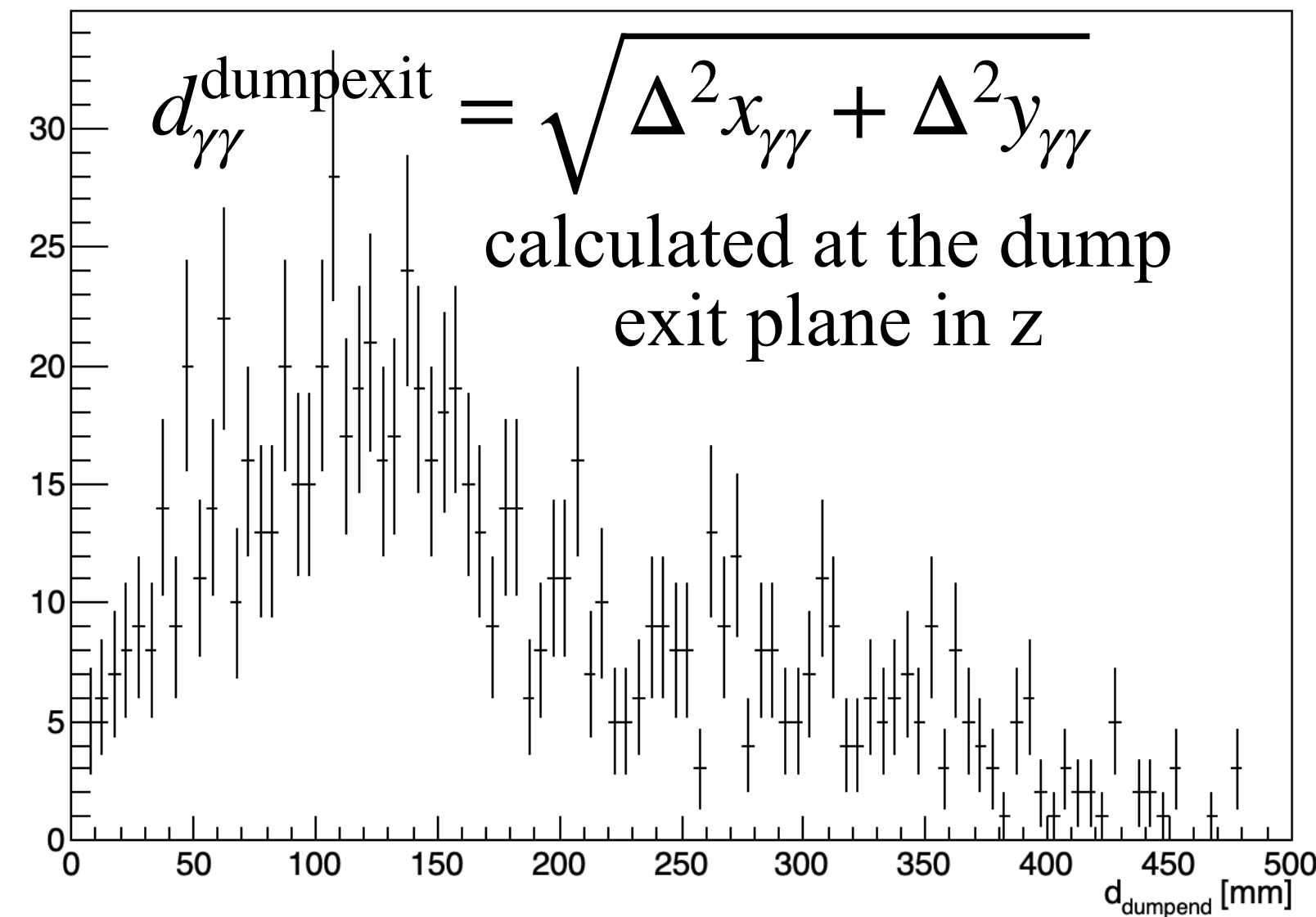
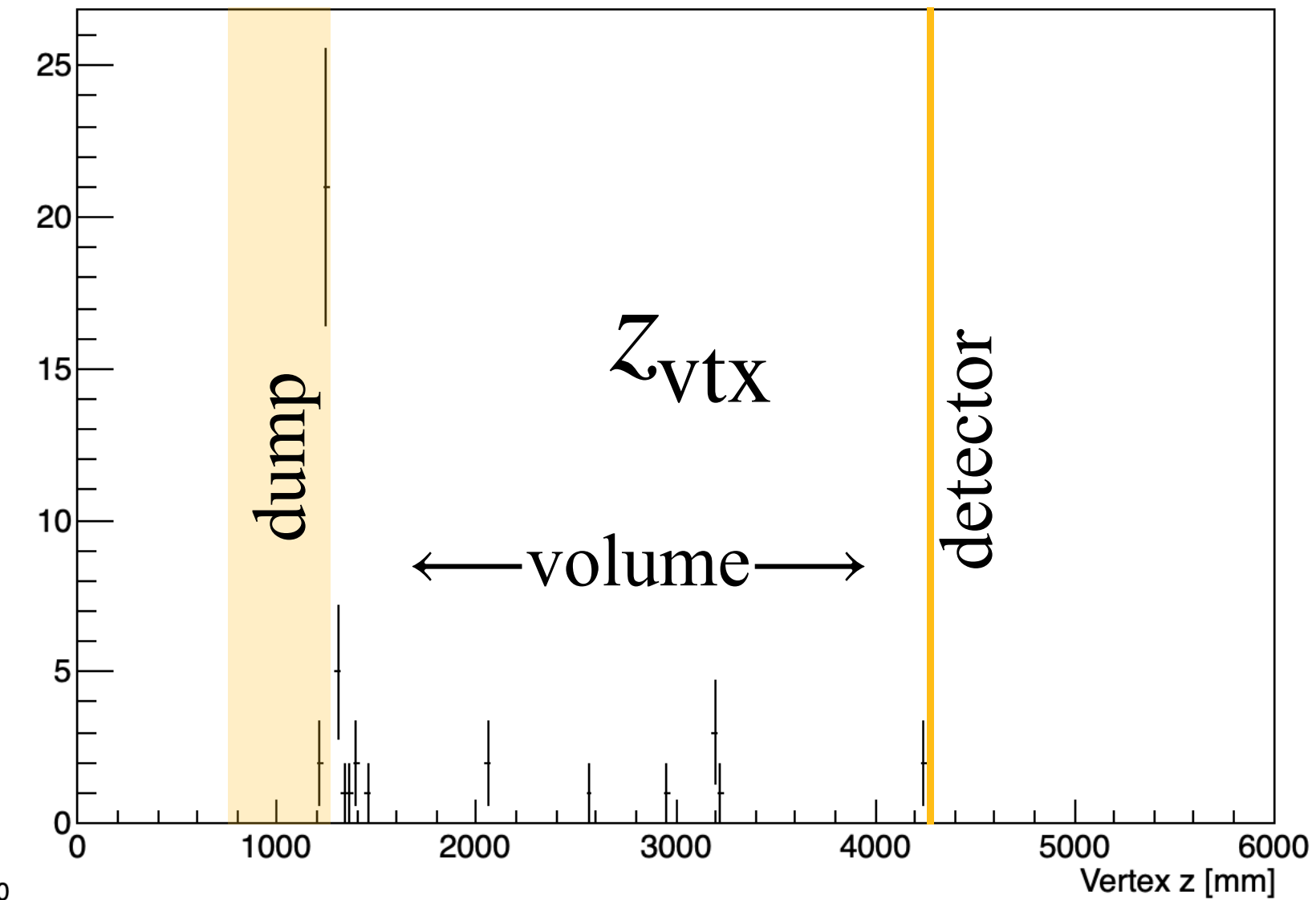
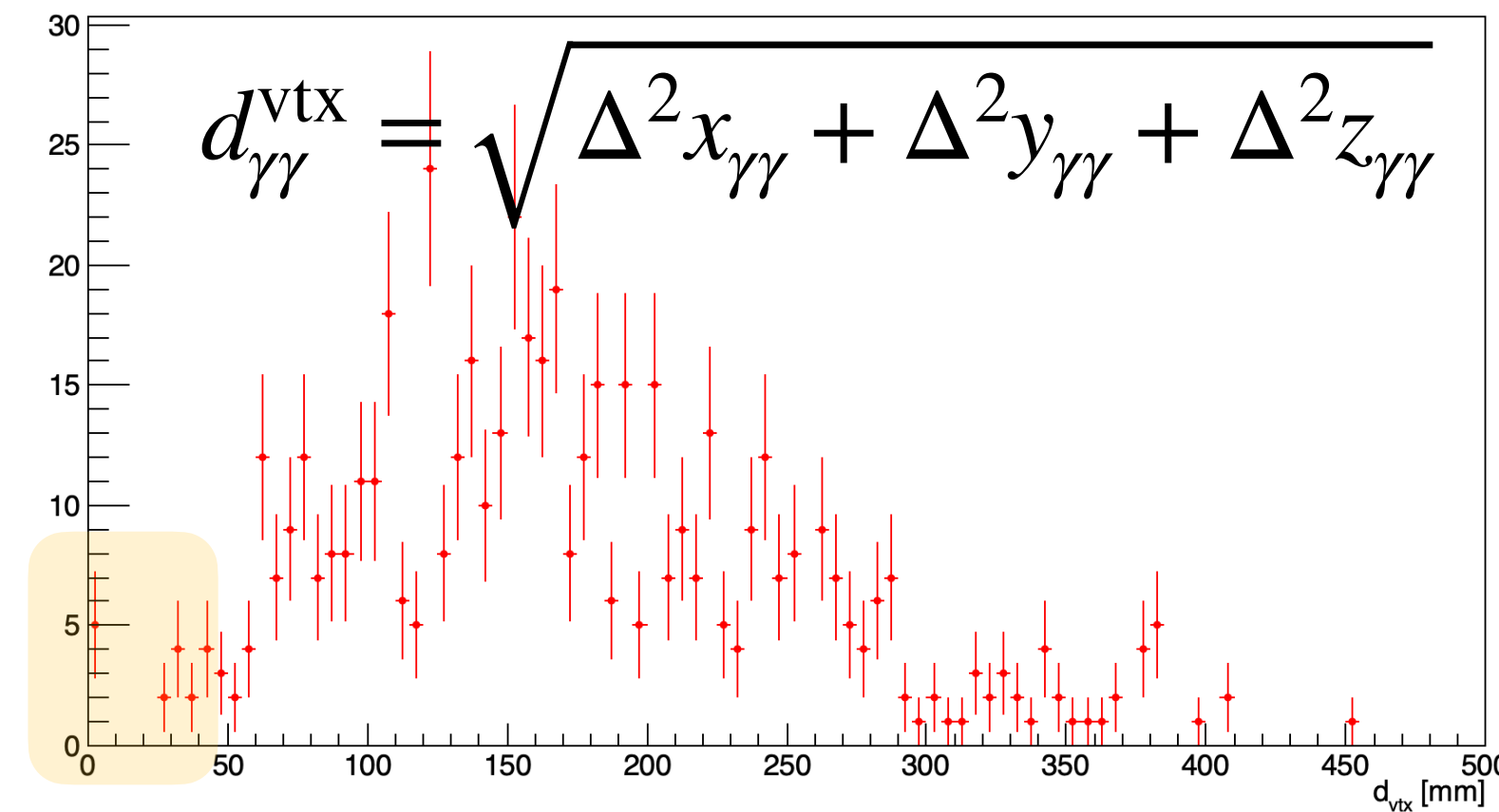
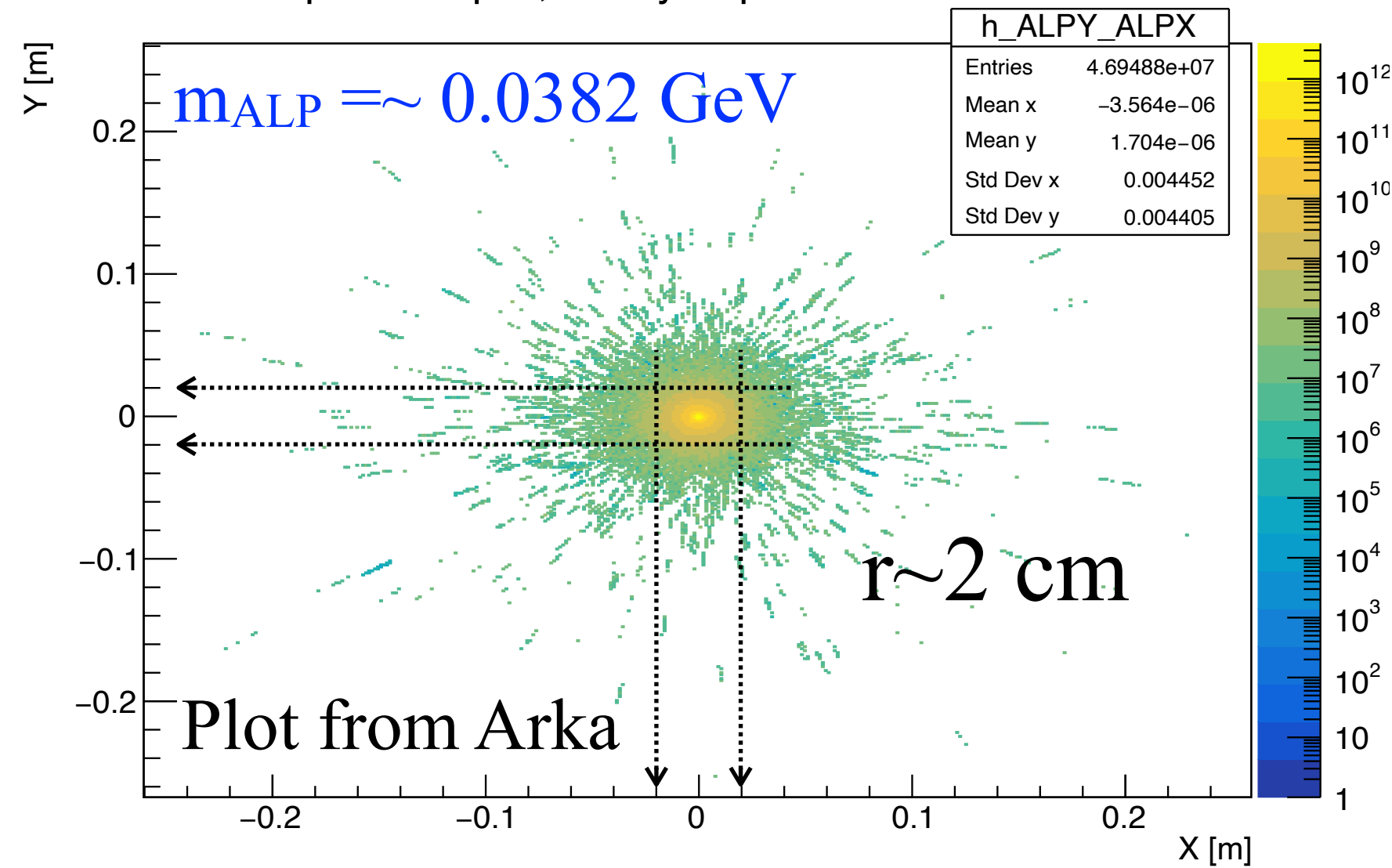
deuteron dump exit y vs x for $E > 0.5$ GeV



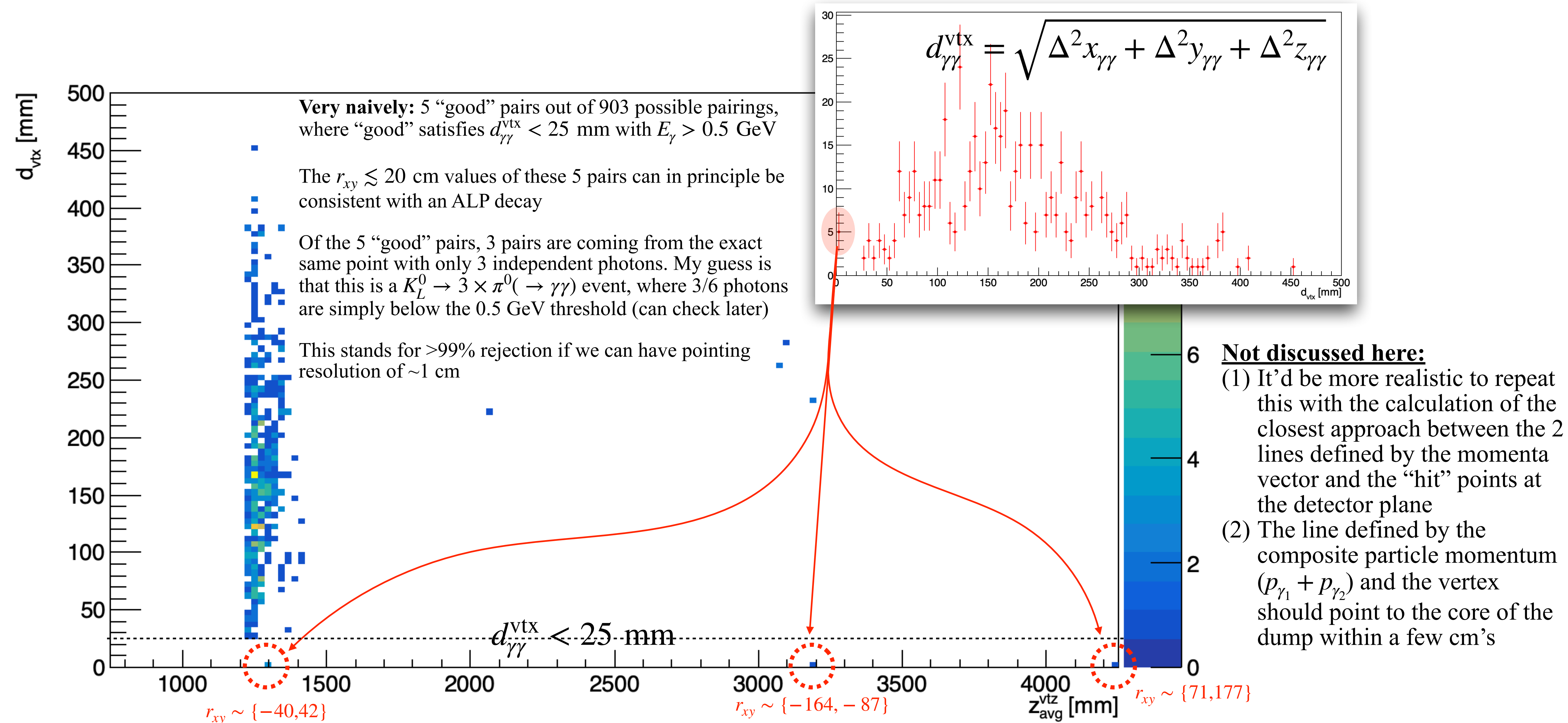
Photon pairings (Lead dump, $E > 0.5$ GeV)

- 43 photons out of $1e10$ primary photons simulated (equivalent to ~ 1.9 BXs)
- Note:** not splitting the sample into $1+0.9$ BXs but treat it simply as one BX
- plots are shown without any normalisation
- Extrapolating the trajectory defined by the vertex and the position in the detector to the dump exit plane shows that
 - in all cases there's more than ~ 1 cm difference between the 2 photons
 - for the signal there is zero difference

alp Y vs alp X, decayed photon $E > 0.0$ GeV



Photon pairings (Lead dump, $E > 0.5$ GeV)



Summary

- Tungsten is better (but need to redo the signal generation? maybe not)
- Neutrons and photons are the main concern but we should not forget the charged particles (p, π, μ, K, e)
 - B-field(s), muon chambers behind the calo,... ?
- Need much more stat with considerably faster setup
 - can we optimise the step sizes?
 - $\text{GammaBeamDumpProductionCut} = 1^* \text{ cm}$;
 - $\text{GammaBeamDumpProductionCut_ele} = 0.1^* \text{ mm}$;
 - $\text{GammaBeamDumpProductionCut_pos} = 0.1^* \text{ mm}$;
 - $\text{GammaBeamDumpProductionCut_gam} = 1^* \text{ cm}$;
 - need to optimise the dump geometry a bit (longer? composite?...)
 - how much do we care about precise neutrons simulation (need some fake-rate numbers - Sasha may ~have it already)
 - need to save some decay chain histories
- Based on the Lead dump stat (43 photons in ~ 1.9 BXs):
 - a naive vertexing cut assuming $\sim O(1)$ cm resolution to position the vertex provides $\sim 99\%$ bkg rejection
 - global mass constraints do not buy us anything
 - can veto a small range around the pion mass: need good energy resolution
 - this veto should be taken in the signal acceptance calculation
 - more rejection will come from the pointing of the composite particle to the dump entry (at its centre)