AWAKE-NA64 simulations

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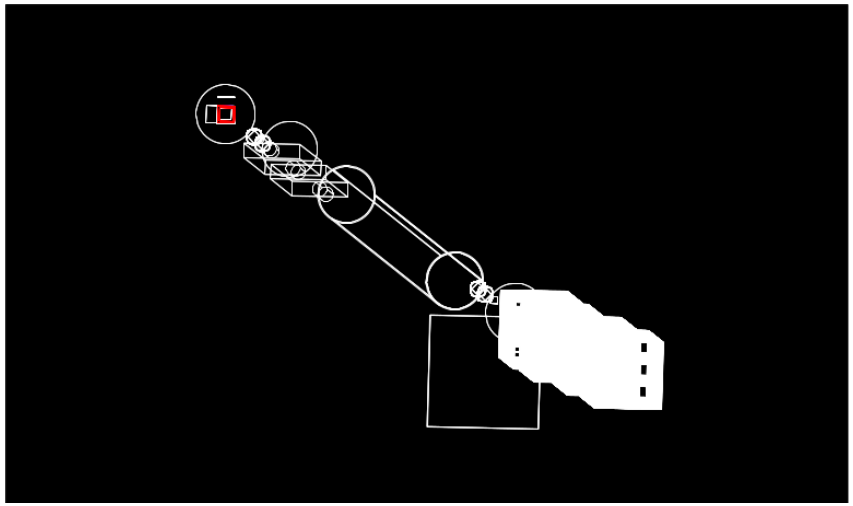
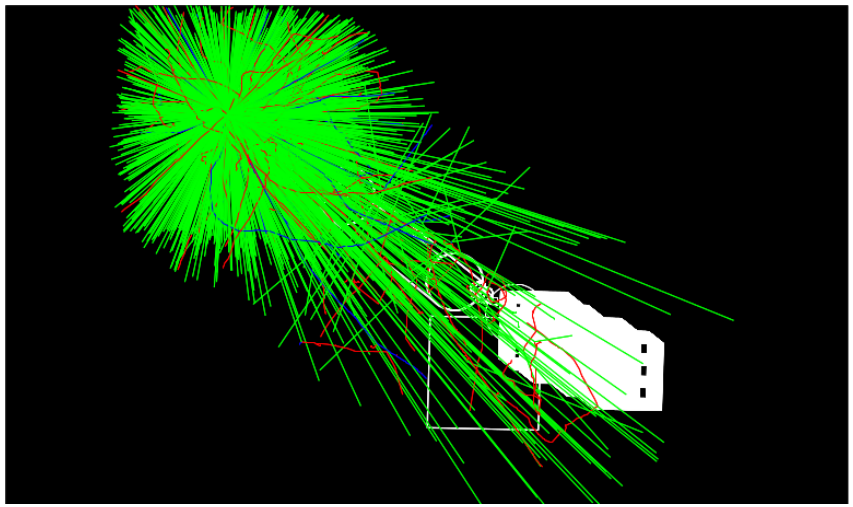
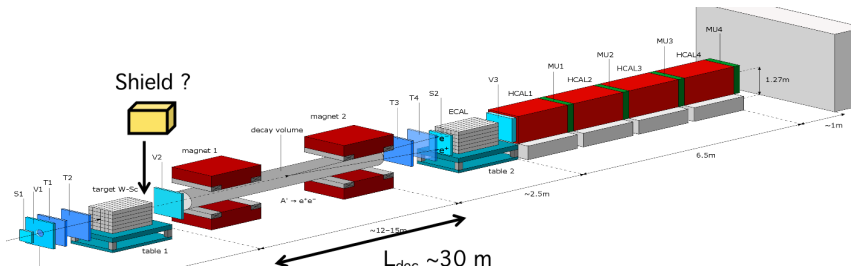
NA64-AWAKE geometry changes

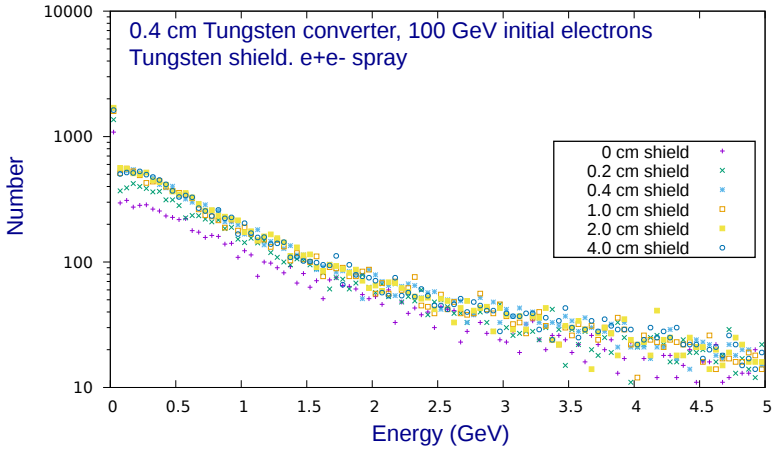




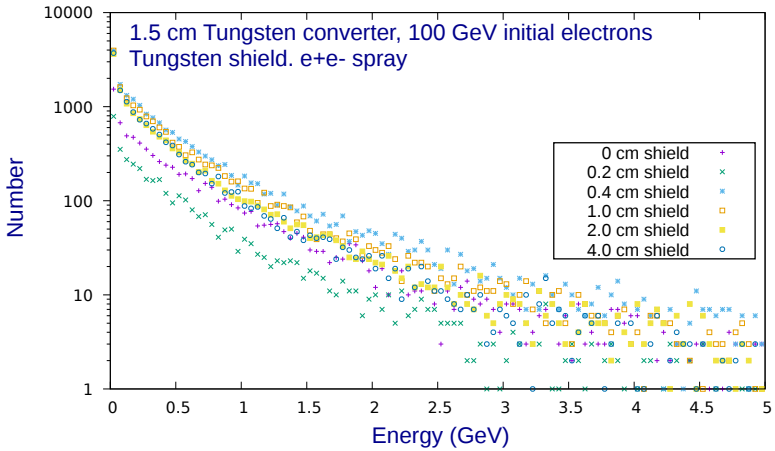
- NA64 designed for single electrons - AWAKE beam will be a bunch
- Use a converter to produce e+e- spray and a shield to partially inhibit the spray
- look for $A \rightarrow e^+e^-$ amid the background
- Adapted from NA64 geometry visible decay example by moving ECAL1 and ECAL2 forward of the drift tube
- Set ECAL1/2 to single layer, remove counter and vary converter thickness independently

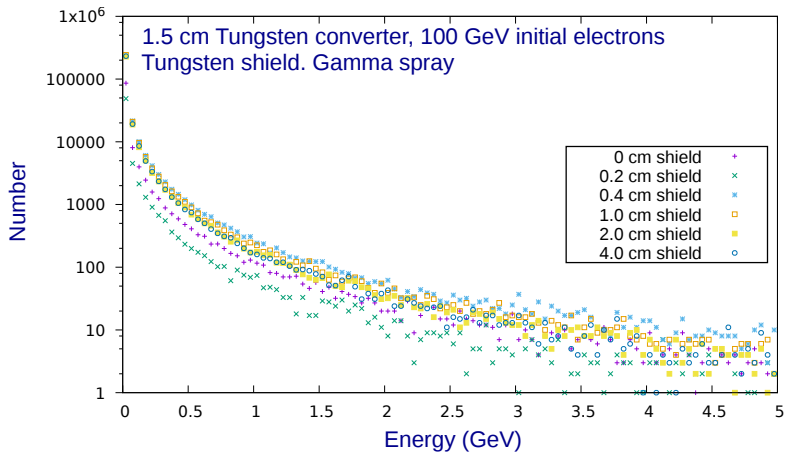


e+e- spray and shield

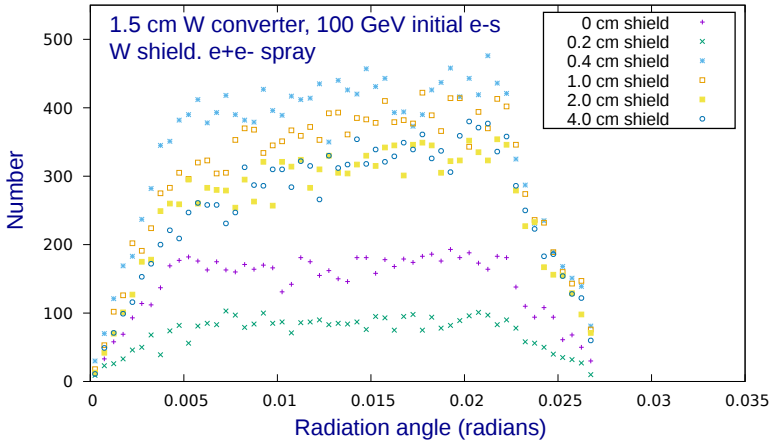


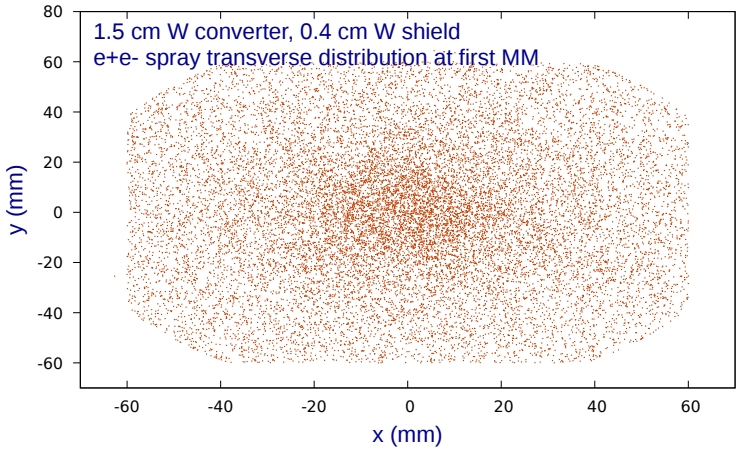
- Tungsten converter and shield ($x_0 = 0.345$ cm). Independently varying thicknesses. Record spray at first MM. 1000 initial seeds
- Spray rates vary relatively most at the low end of the spectrum
- Rates can go up or down since the shield can produce additional spray



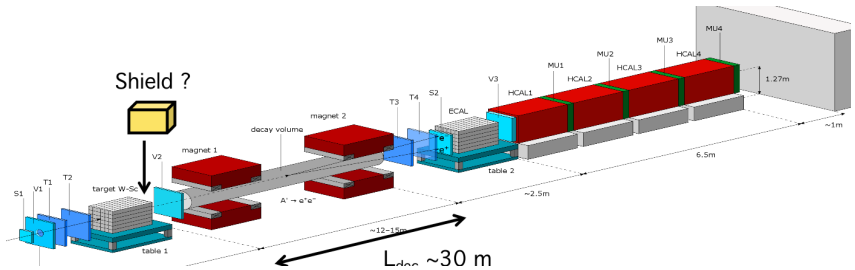


Angular distribution of spray

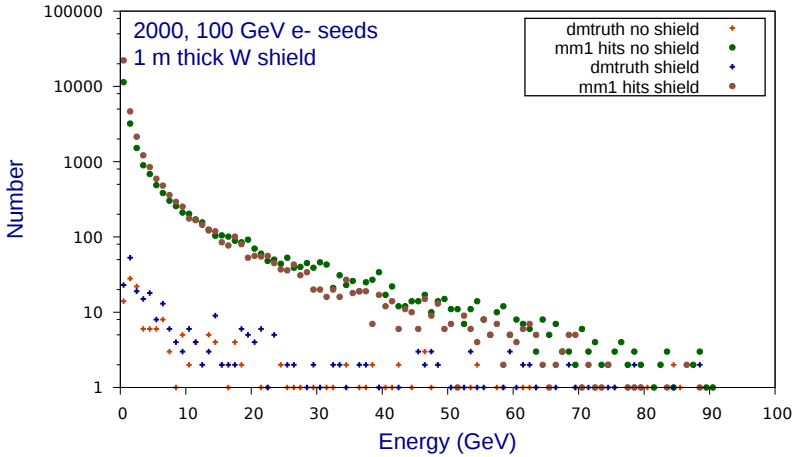


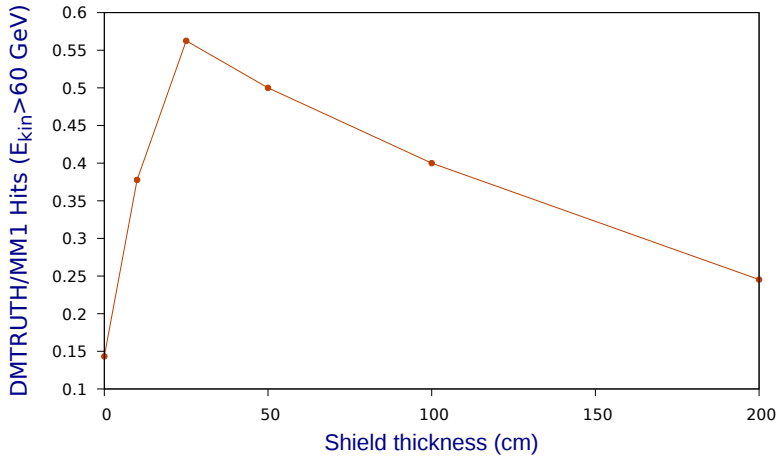


- Front face of converter at z=-19.4 metres. Recorded at first MM at z=-16.932 m
- hit density largest at centre (no surprise)
- Artificial cut off of radial distribution by extent of square MM detector

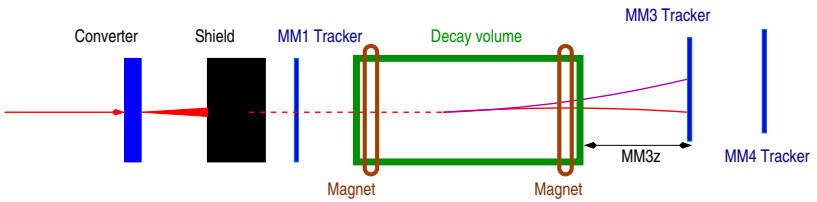


Spray and Dark matter photon spectra

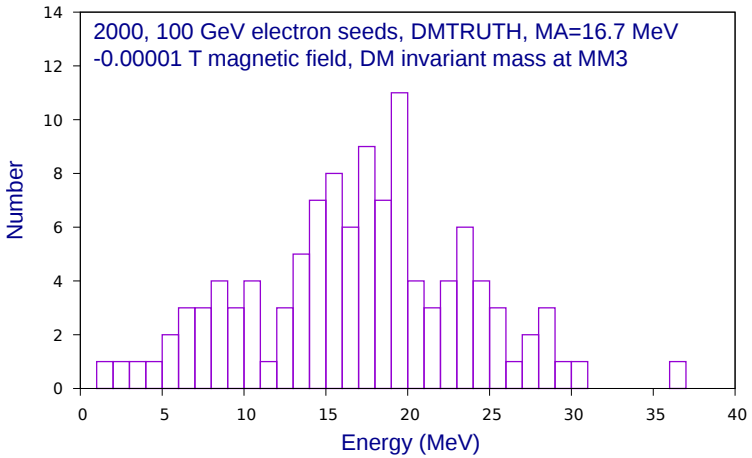


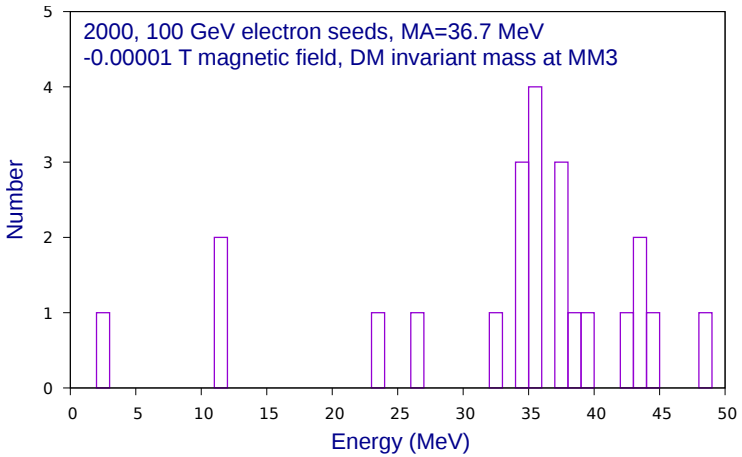


- Compare spectra of e+e- hits on first tracker MM1, to kinetic energy of DM photons
- Signal swamped by background at low energy, better ratio at high energy
- Count DMTRUTH vs background above 60 GeV $\rightarrow$ optimise shield thickness



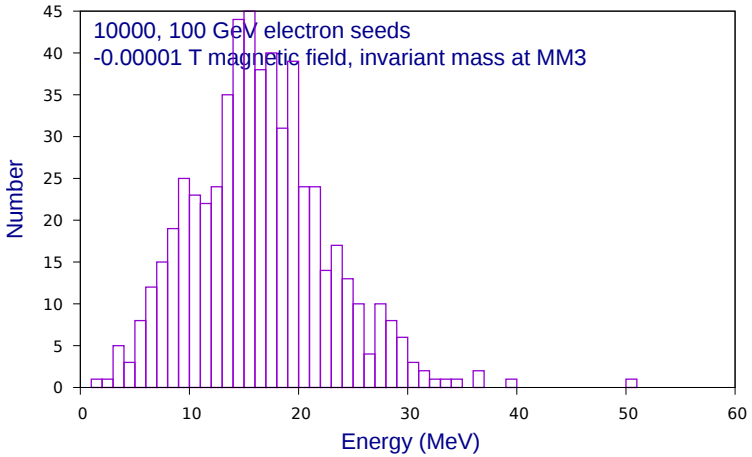
Dark matter truth at MM3 tracker

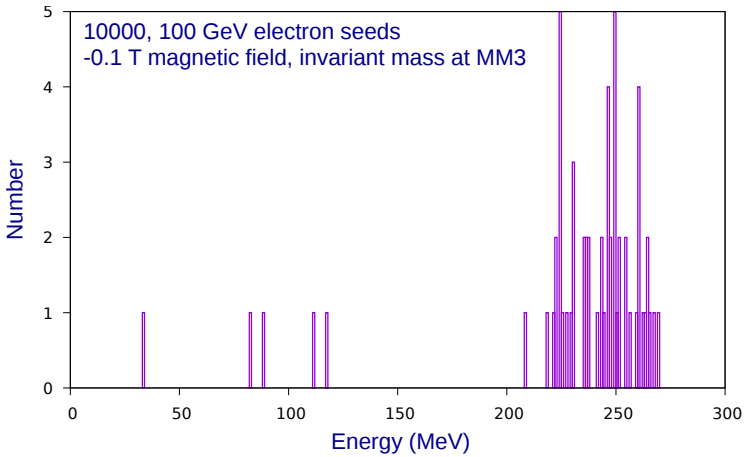




- Nominal Dark photon parameters: MA=16.7 MeV, $\sigma = 0.00003$ (default), $\varepsilon = 0.000316$ (benchmark)
- Record DM decay track IDs, compare to track IDs for MM3 hits
- Correct invariant mass peaks, nominal 16.7 MeV and cross-check to other MA values
- Broadening of invariant mass spectrum due to, track misidentification? ionisation?

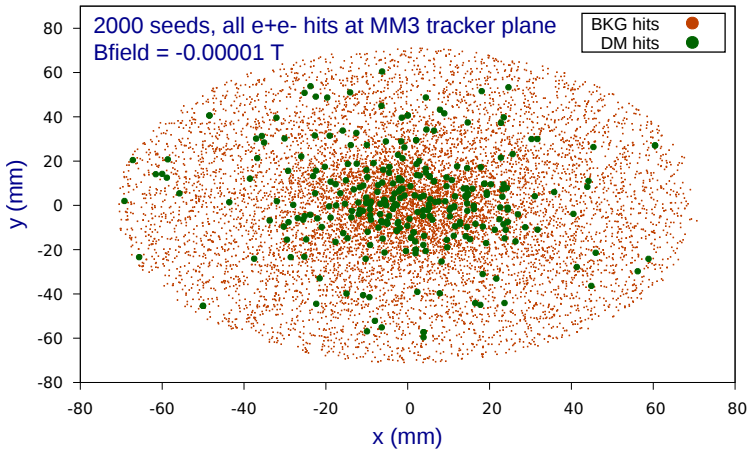
Effect of magnetic field on DM invariant mass



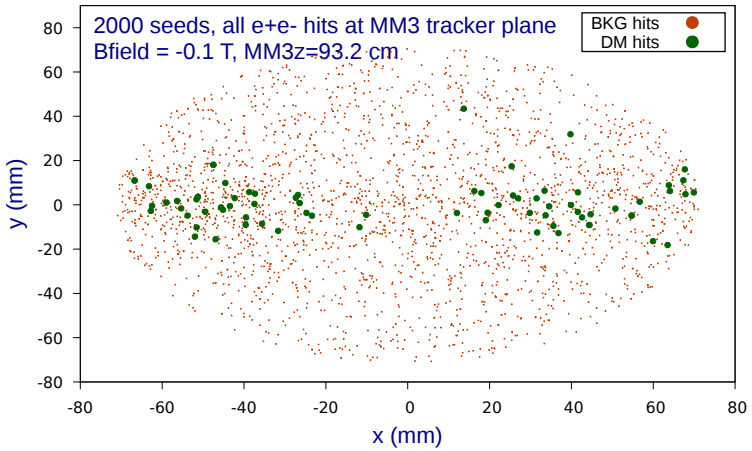


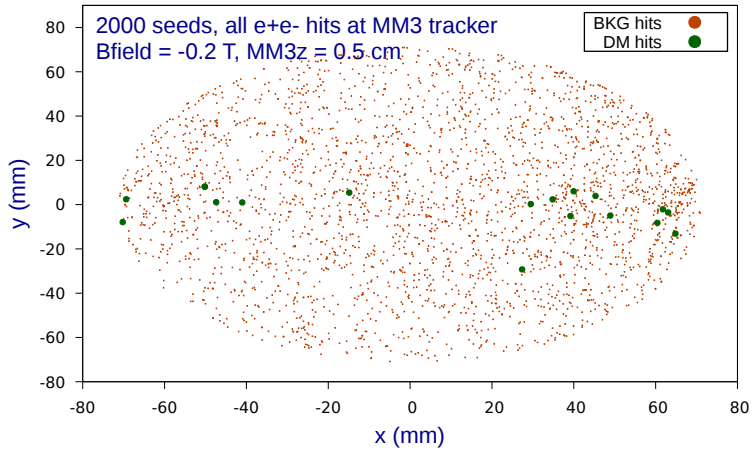
- For no background field, nice invariant mass peak at nominal MA=16.7 MeV
- A field of even -0.1 T results in invariant mass peak ”disappearing”
- DM decay, hitting something else?
- Track IDs get reassigned?

DM signal vs background at MM3 tracker plane

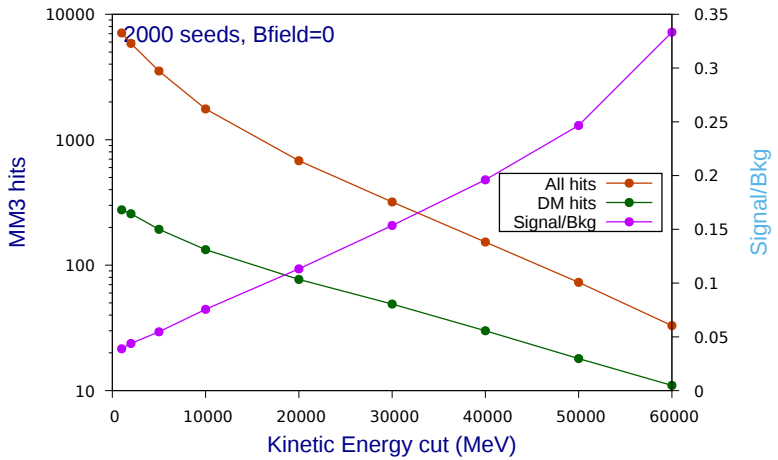


- Compare DM decay hits at MM3 plane to all e+e- hits
- Both signal and background disperse with modest magnetic field
- Move the MM3 tracker up to end of decay volume. -0.2 T field about limit to see some signal



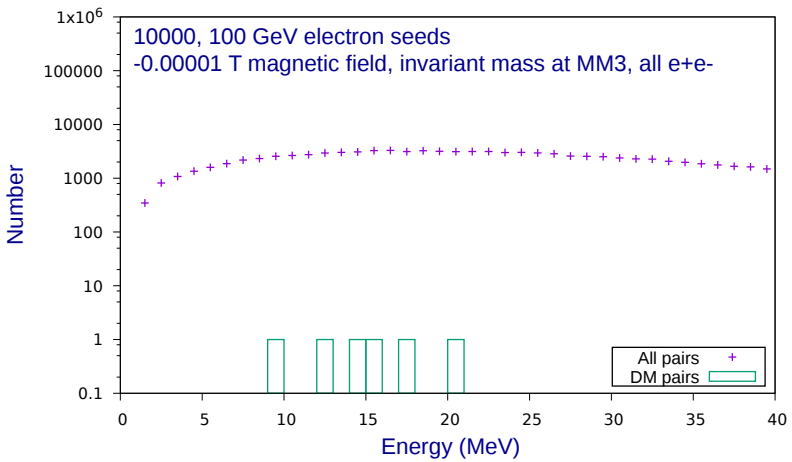


Kinetic energy and invariant mass cuts



- Imagine a world where I can cut on the kinetic energy at MM3...
- The higher the cut, the lower the occupancy and the better the signal/backgroud ratio
- 2000 seeds is still a long way from an electron bunch though - heavy computing needed
- 10000 seeds takes about 30 minutes... so 5x10^9 takes...

Full run with cuts



- 10^4 seeds, Kinetic energy cut at 40 GeV (otherwise no DM signal)
- 6 DM pairs, amongst 110,876 possible pairs
- Need to remove more of the background, but...