OAK RIDGE National Laboratory

Plotting Flux Spectra from KENO

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Best Practices for SCALE Modeling & Simulation
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Outline

- Flux edits in KENO
- Group structures
- Lethargy and “per unit lethargy”
- Plotting mechanics
- Summary

Flux edits in KENO

- Flux is not tallied or edited by default in KENO
  - Originally a k_{eff} calculator, so such edits were not necessary
- Tallies and edits activated with FLX=yes in the PARAMETER block
- Flux is tallied by *region* and by *unit* in KENO
  - Added regions, e.g., nested cylinders, will refine flux edits
  - Reported flux is averaged over all instances of a unit in the model
  - This applies most frequently to arrays, but applies equally to units used as holes in multiple places

Group structures

- MG calculations always tally flux in the group structure used for transport, i.e., 56, 200, or 252
- CE calculations use the 252-group MG structure by default
- Others can be specified in ENERGY or PARAMETER blocks
  - Only applies to CE calculations
  - Provide NGP=*n* in PARAMTER block for SCALE library structures
  - In ENERGY block, provide upper boundary of each group plus bottom of last group
    - Energies are in eV
    - SCALE energy range: 20e6 eV (20 MeV) to 1e-5 eV (10 μeV)
    - Total of N+1 entries for N groups

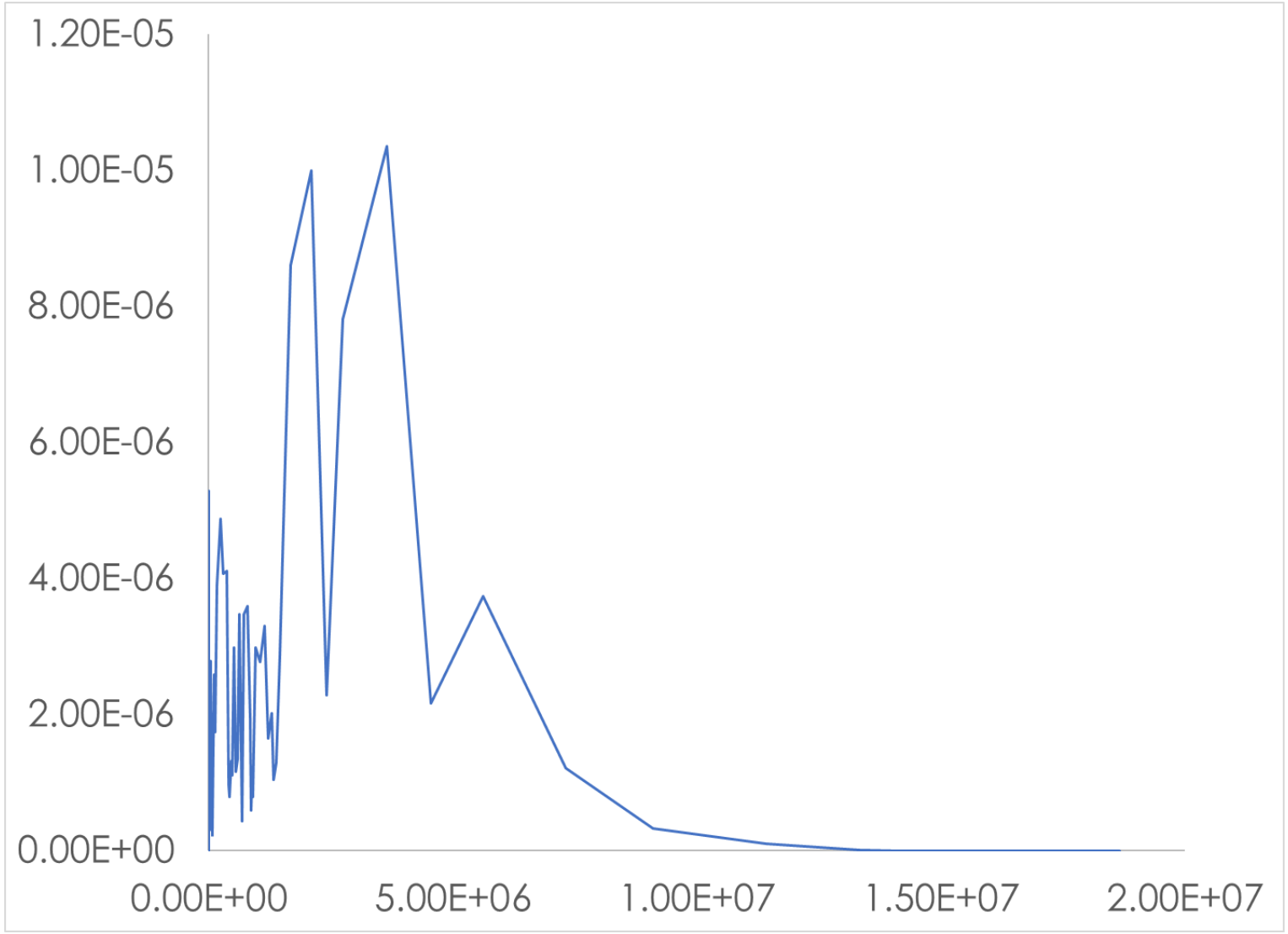
Lethargy and "per unit lethargy"

- Lethargy is a measure of neutron slowing, calculated as the logarithm of a reference energy E_0 to the current energy E

$$u = \ln\left(\frac{E_0}{E}\right)$$

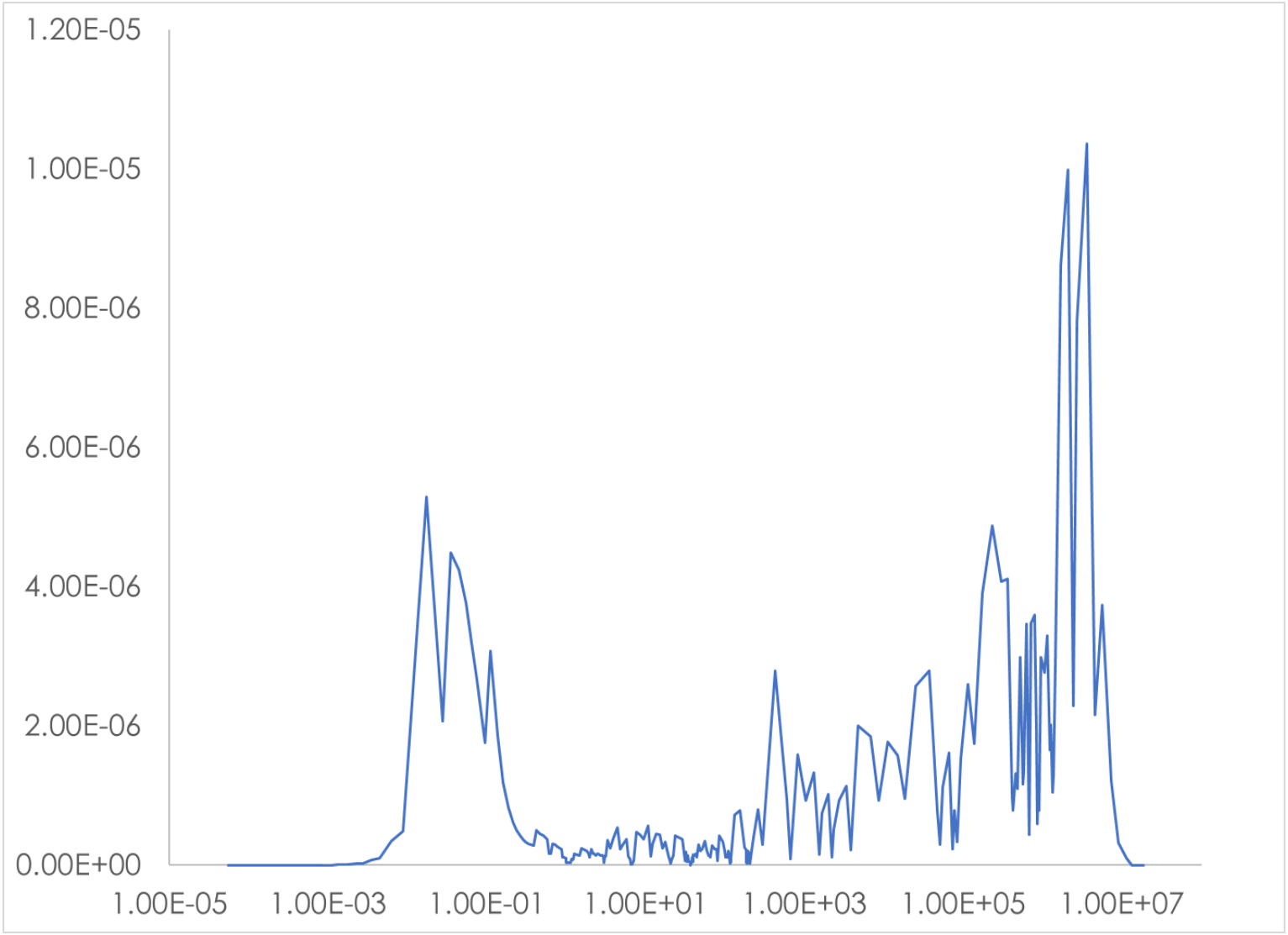
  - Lethargy increases as energy decreases
  - E_0 is a reference high energy (I use 20 MeV: the top of the library)
    - Ultimately irrelevant for calculation of Δu

Flux vs energy on a linear scale



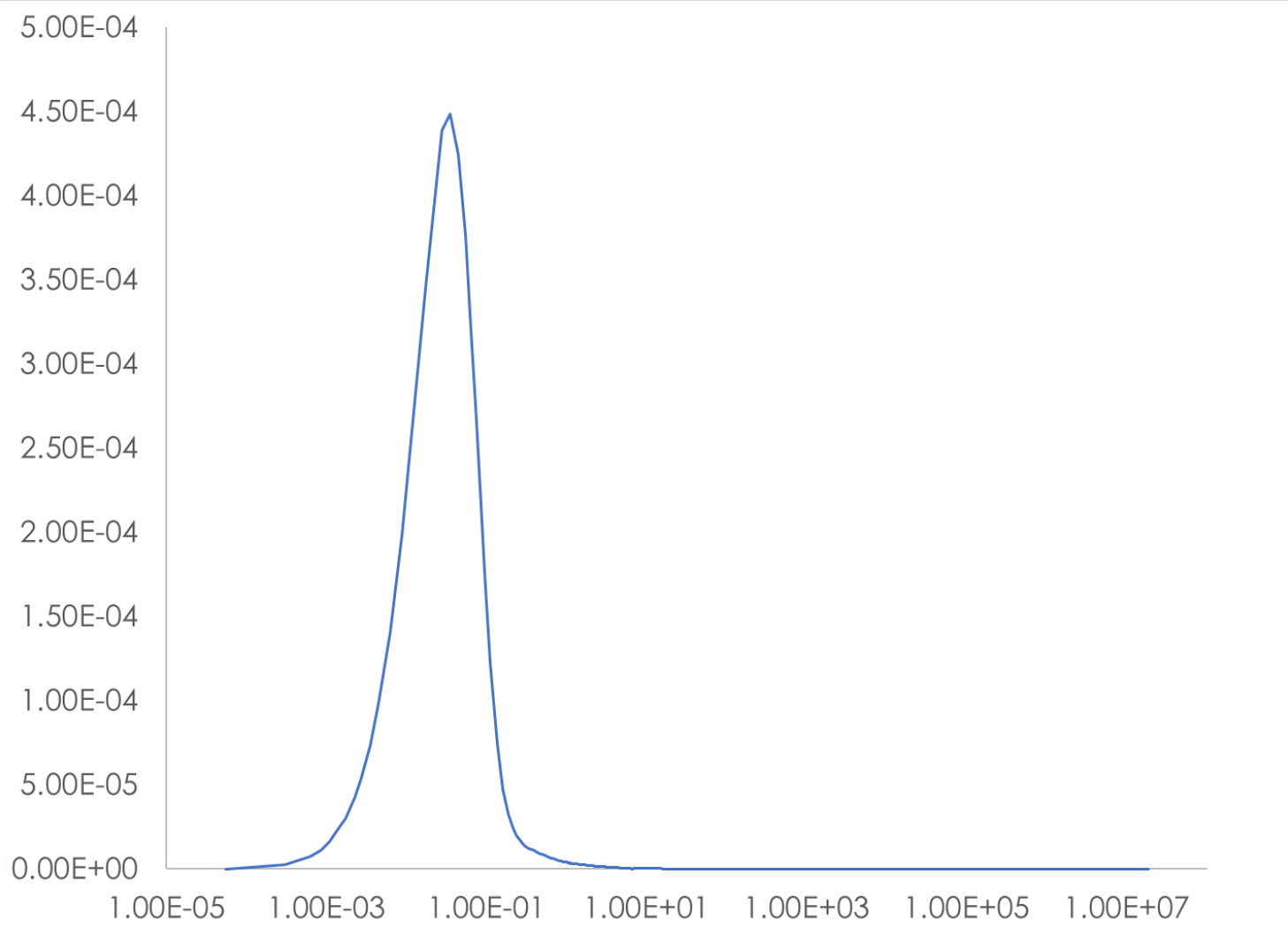
- This isn't helpful – too many decades covered
- Let's try a log scale – standard approach to solve this problem

Flux vs energy on a log scale



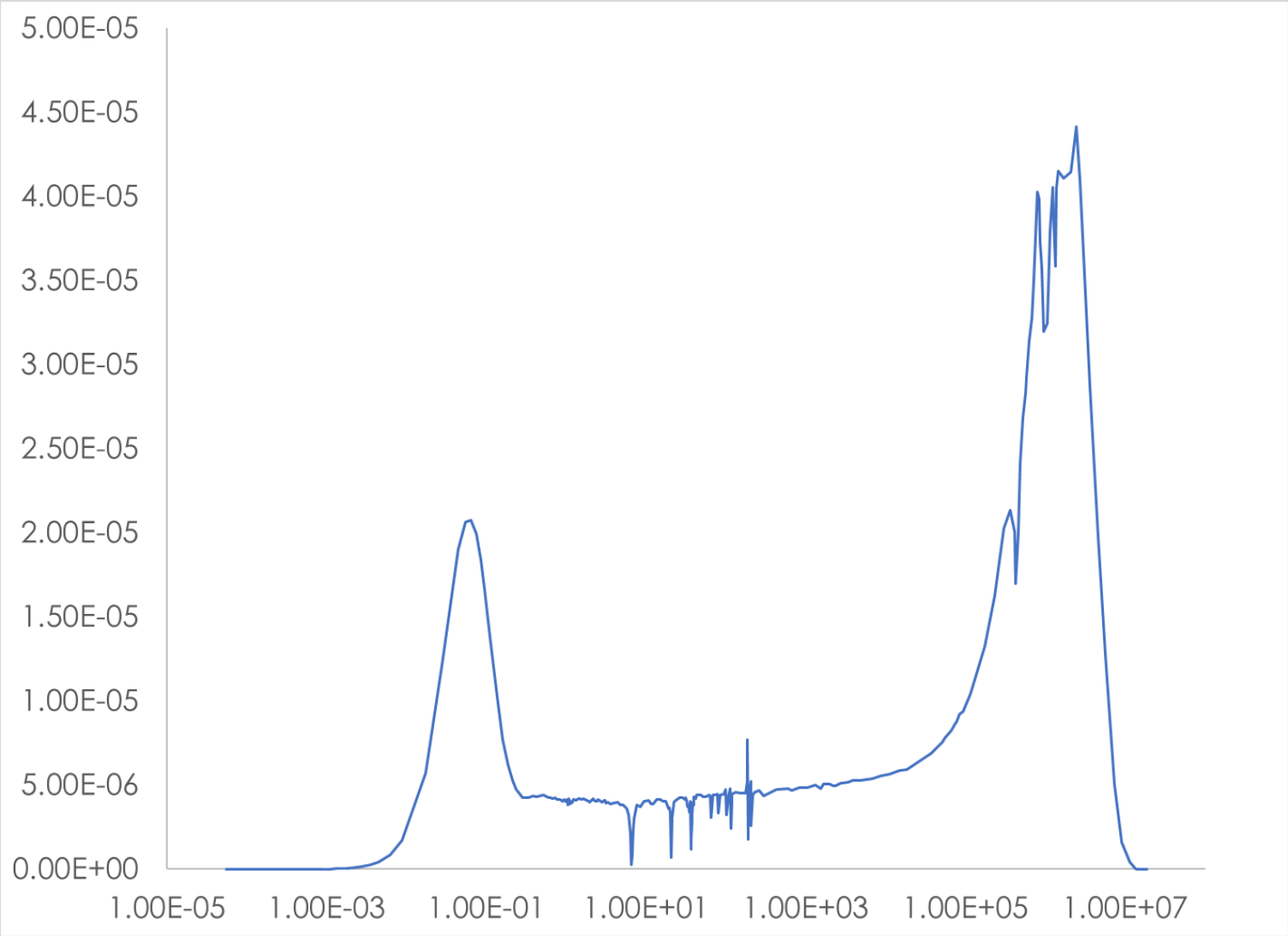
- That's better
- But…
  - Spikes and troughs
  - Groups aren't same width
- Maybe if we normalize by group widths

Flux normalized by group width vs energy (log scale)



- This clearly isn't right
- Dividing by group energy width isn't right
- Maybe if we normalize by lethargy width?

Flux normalized by lethargy width vs energy (log scale)



- That looks right
- Hence normalizing per unit lethargy is correct
  - Plotting on a log scale requires a log unit

Plotting mechanics

- Obtain relevant flux edits from output file
- Generate list of energy group boundaries
  - Table 10.1.9 of SCALE 6.2 manual for 252-group library
  - In CE calculations the group structure is printed in the KENO output just after the problem parameter echo
- Calculate group lethargy widths
  - $\Delta u = \ln\left(\frac{E_{high}}{E_{low}}\right)$
- Divide flux by lethargy width of energy group
- Plot with energy axis on a log scale

Summary

- Flux edits in KENO can be activated with FLX=yes
- Edits are collected by *region* and by *unit*
  - Beware of the average over multiple uses of the same unit
- Flux spectrum must be normalized per unit lethargy to generate a true area plot
  - Same technique can be used with fission density edits
- Manipulation of output information is straightforward to generate meaningful spectrum plots