Material construction, neutron transport, and neutron scattering data.

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Material construction

- There are three ways to construct materials in geant4
  - From it's isotopic composition
  - From it's elements
  - As an effective material (Aeff, Zeff)

Effective materials

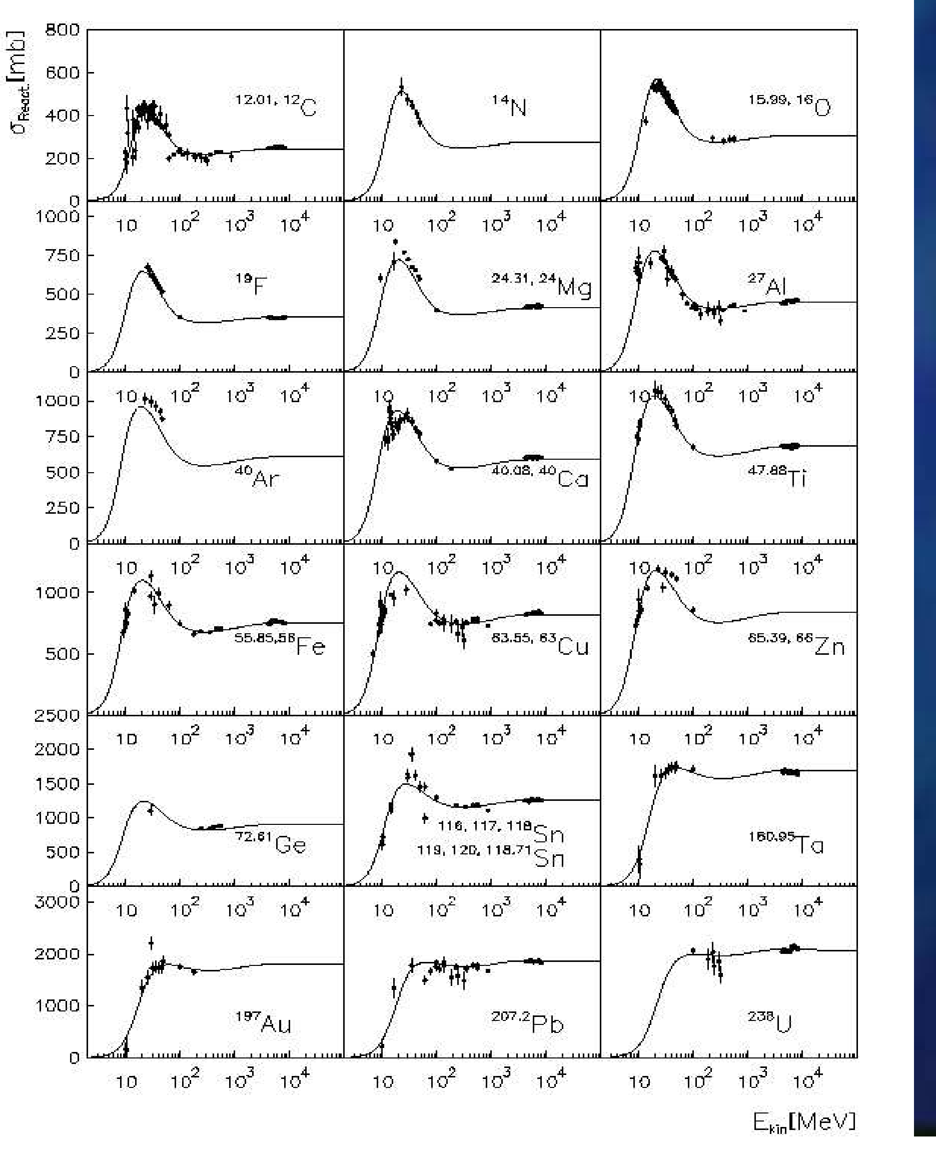
- Hadronics cross-section are not a function of material properties, but a function of nuclear properties.
- If we use effective numbers, the element composition cannot be automatically recovered.
- The cross-section will be 'highly approximate' at best.
- The final states will have wrong properties.
  - Simplest ex.: No recoil protons in a scintillator.

- Never use effective A, Z with hadronic physics.
  (There are situations, where we may not be able to avoid it, so geant4 must not protect against it.)

Materials from elementary composition

- This is good enough for most applications.

Example: Proton induced reactions



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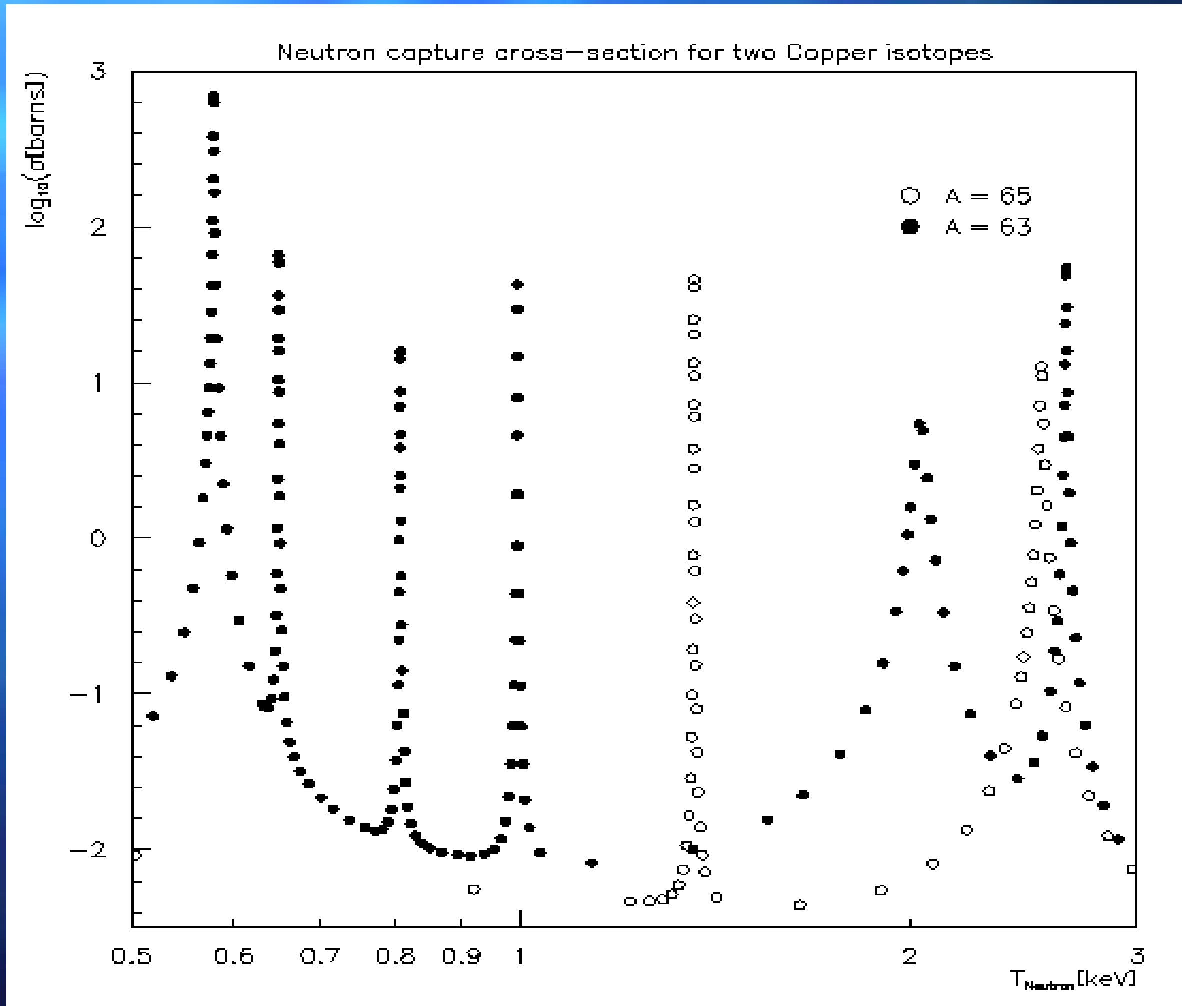
Isotope wise composition

- When detailed simulation of low energy neutrons is important, as in radiation studies, element info is not sufficient (E<20MeV) to get the cross-section and final states right.
  - For different isotopes, the neutron nuclear resonances will be at entirely different positions
  - For different isotopes, the final state channels open can differ drastically.

Ł You may be tempted to construct your materials from Isotopes in this case

Copper as an example



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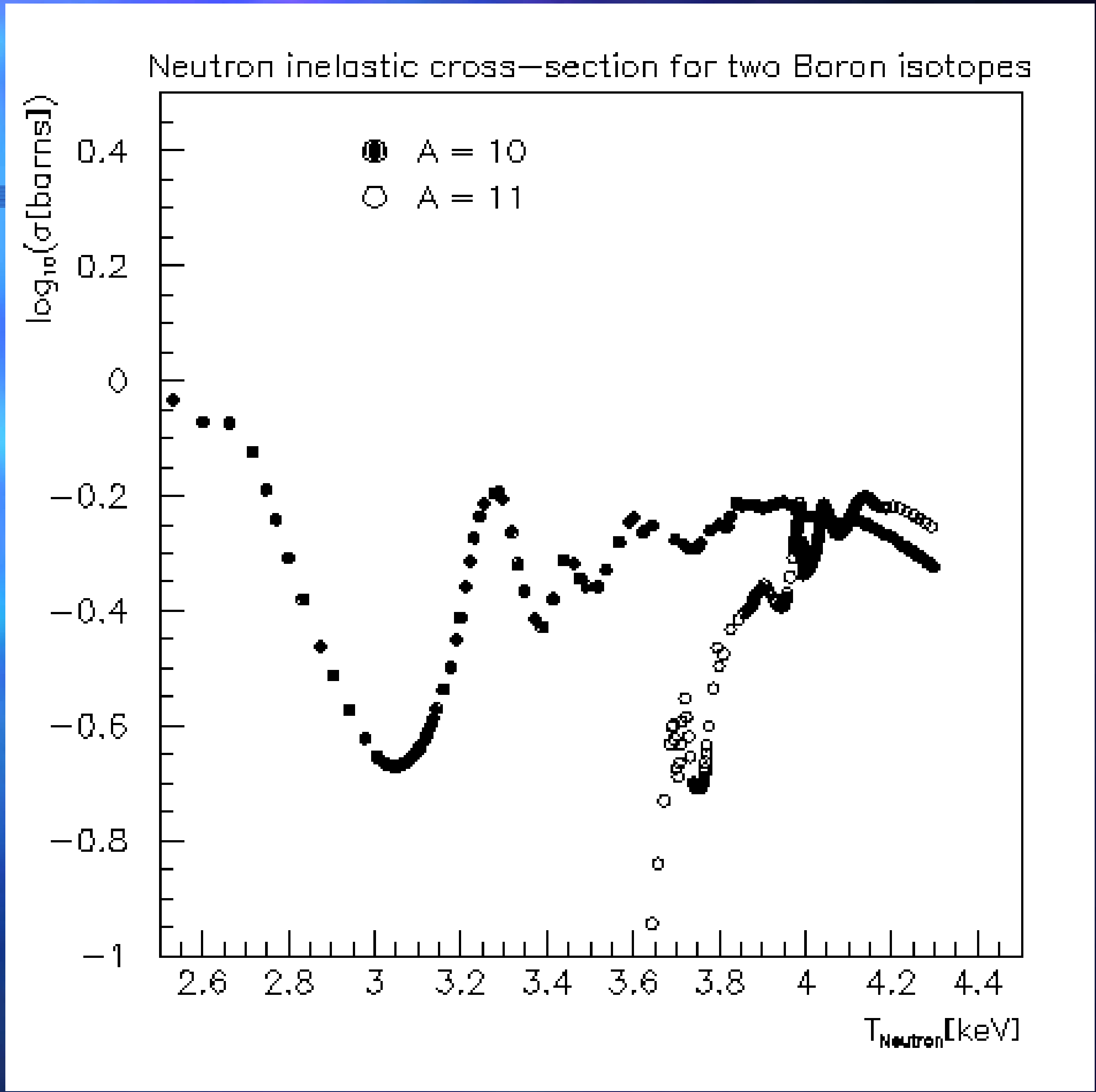
Isotope wise composition

- In the neutron_hp models (detailed neutron transport below 20MeV), we recover the natural isotopic composition automatically, in case materials and mixtures are specified in terms of their constituting elements.
- In case of enriched isotopes (like B10, or Li6), we need to use the G4Isotope directly when specifying the material.
  - Normally you do not need to use the G4Isotope in the detector construction

Enriched isotopes?

Ex.: Neutrons in Boron



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Neutrons in Lithium

- Neutron inelastic cross-section at 150eV:
  - Li-7: 0.00 millibarns
  - Li-6: 12.2 barns !
- Open inelastic channels:
  - Li-7: none
  - Li-6: nLiŁ tα

  (which makes Li-6 a well known shielding isotope)

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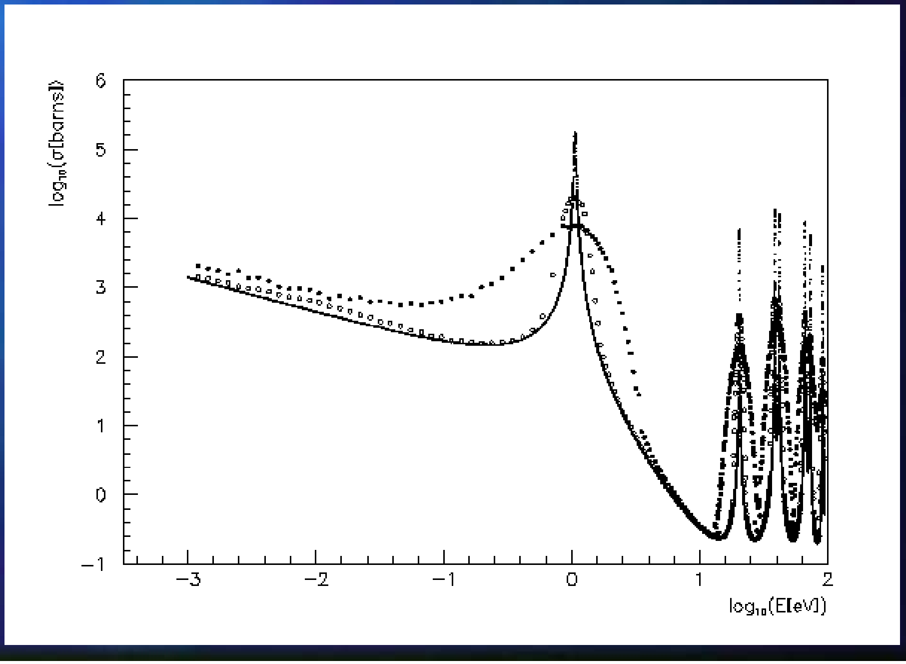
A brief note on the two main effects of non-zero temperatures

- The sharp neutron nuclear resonances undergo Doppler broadening
- The cross-sections at low energies will start to rise as 1/v.



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The state of G4NDL3.7:

- G4NDL was largely assembled in 1997, with few additions at later dates.
- A set of elements/isotopes are used in CMS or LHCb, but no data are present in G4NDL:
  - Zinc, Bromine, Silver, Antimony, O_18.
- Elements CMS or LHCb are using, but only 'average' element cross-sections tables are available
  - Carbon, Sulfur, Chlorine, Calcium, Titanium, Indium, Tin, Tungsten.
- Add missing elements/isotopes?
- Re-evaluate 'old' data based on current knowledge?
- Use isotope-wise evaluations, rather than average element data?