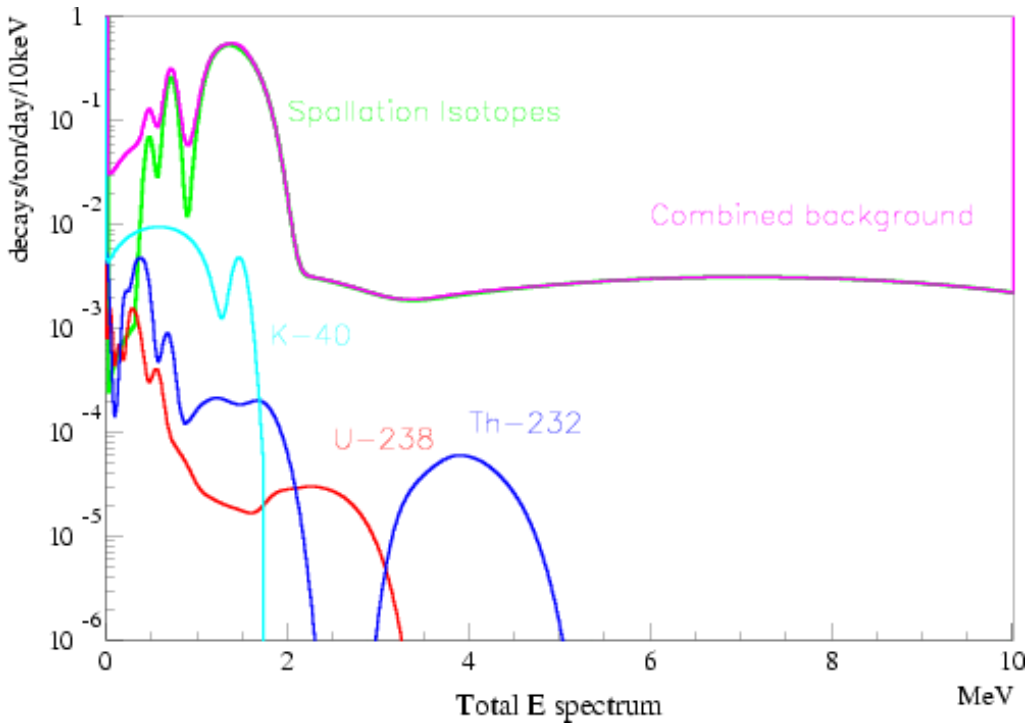
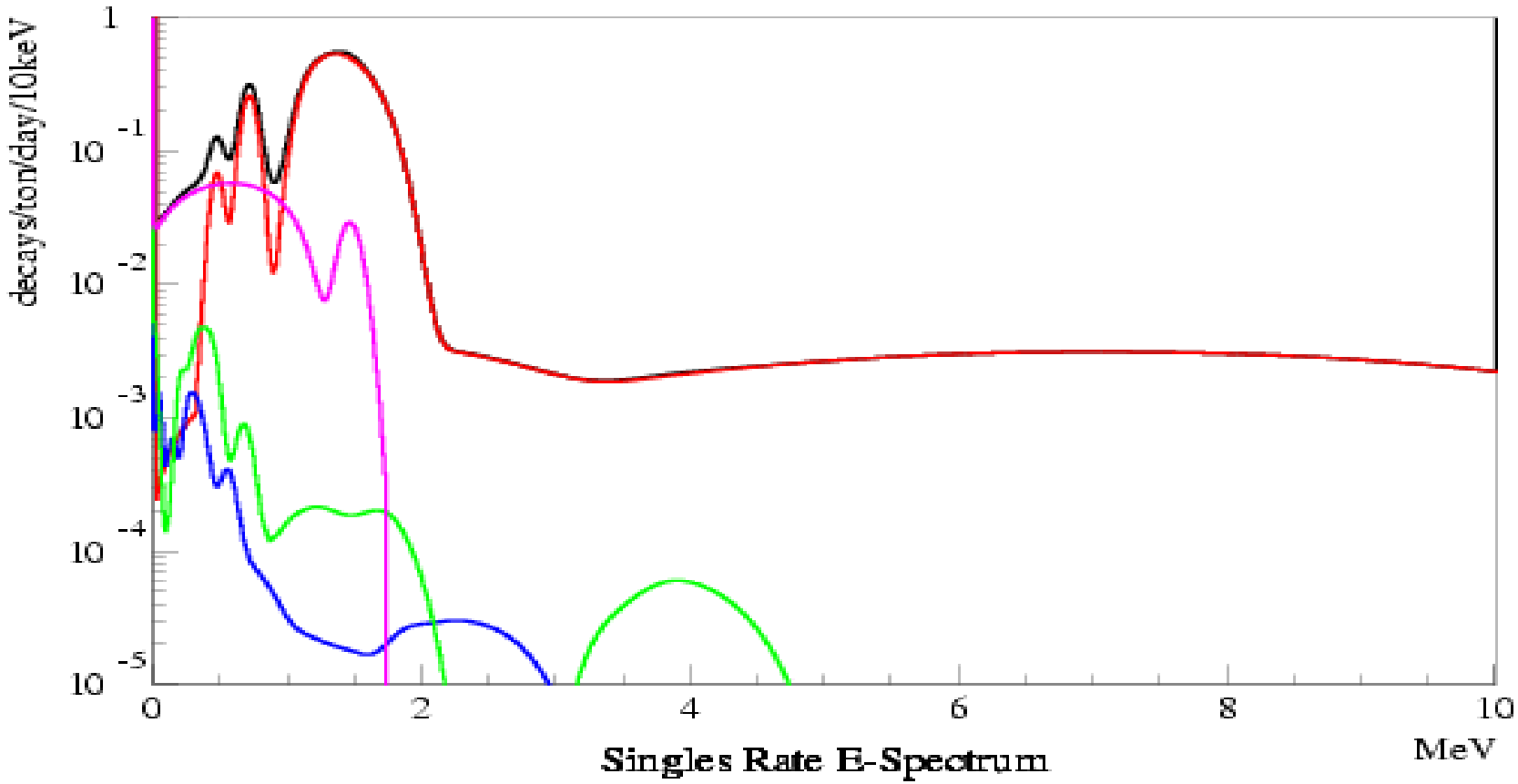
Backgrounds from Radioactive Decay



Hannah Newfield-Plunkett, Aug. 11, 2004

Sources of Background



- Decay of spallation isotopes: Li-9, C-11, Be-7, C-10, Li-8, He-6, B-8, C-9, He-8, B-12, N-12 (based on production at 450 mwe)
- Decay of K-40 (based on concentration of 2.7E-16 g/g from KamLAND)
- Decay chain of U-238 (based on concentration of 3.5E-18 g/g from KamLAND)
- Decay chain of Th-232 (based on concentration of 5.2E-17 g/g from KamLAND)

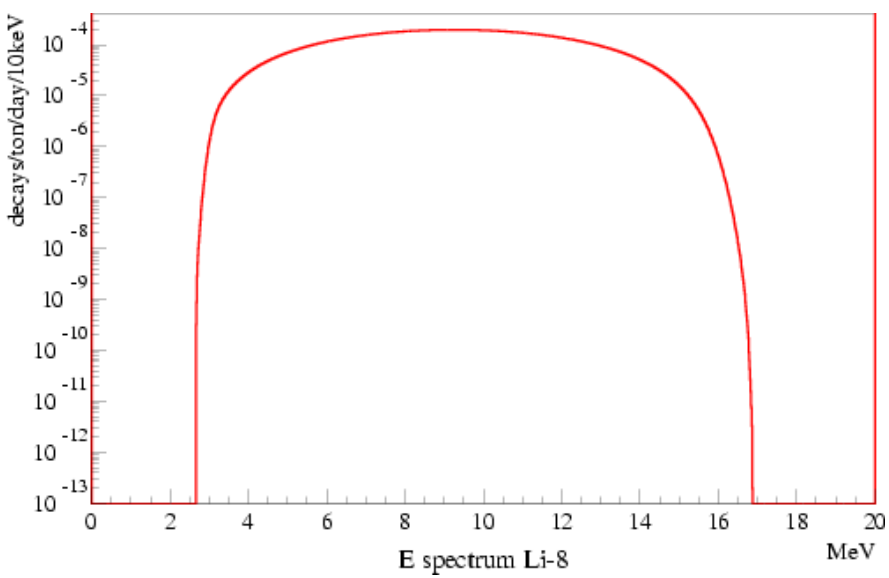
Beta Decay Spectra

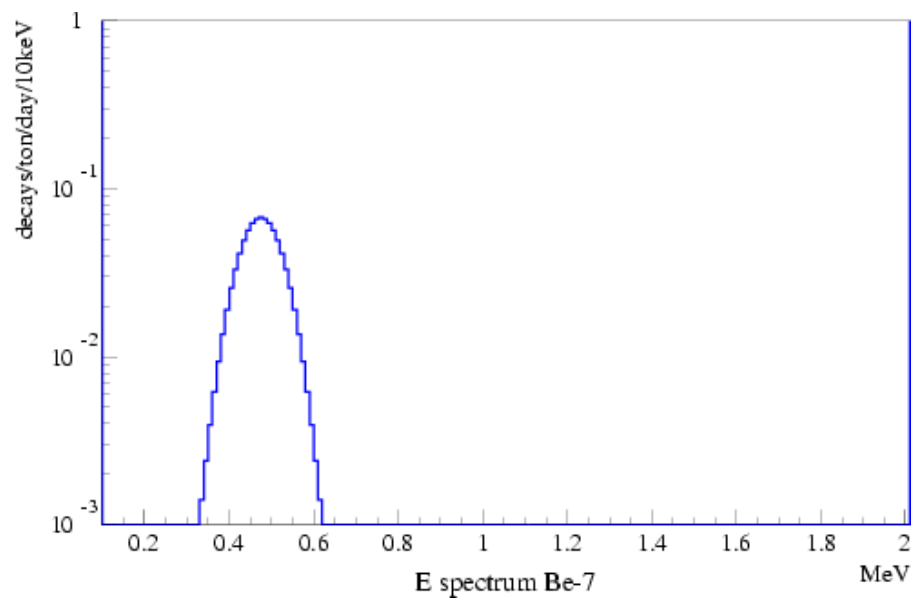
- Beta spectra from Fermi's theory of beta decay:

$$N(T_e) = C\sqrt{T_e^{\,2} + 2T_e m_e}\,(Q - T_e)^2 (T_e + m_e)$$

Some modifications:

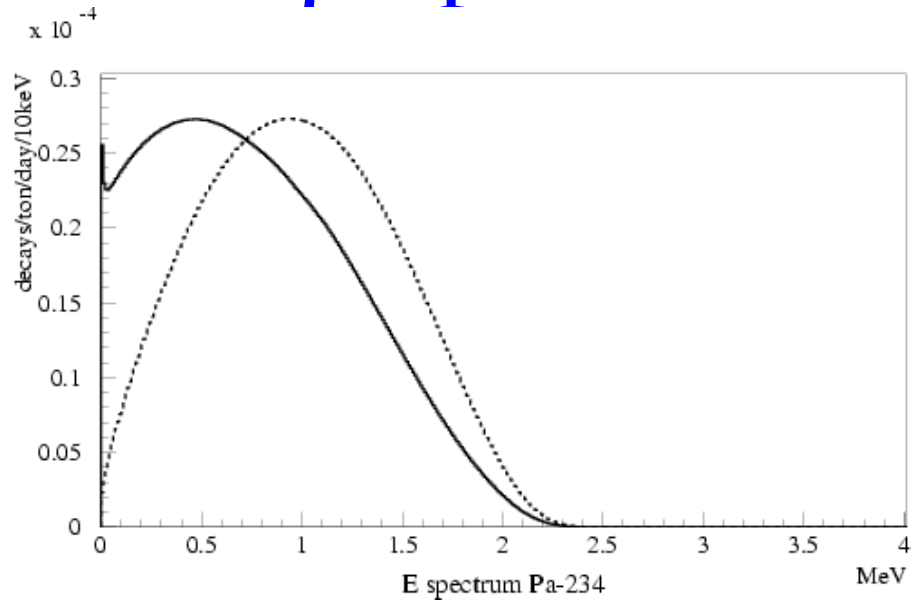
- Not all decays occur from ground state to ground state, some occur to an excited state, followed by a gamma decay (Li-8)
- Some "beta" decays are actually electron capture: only gamma energy from excited state is visible (Be-7)

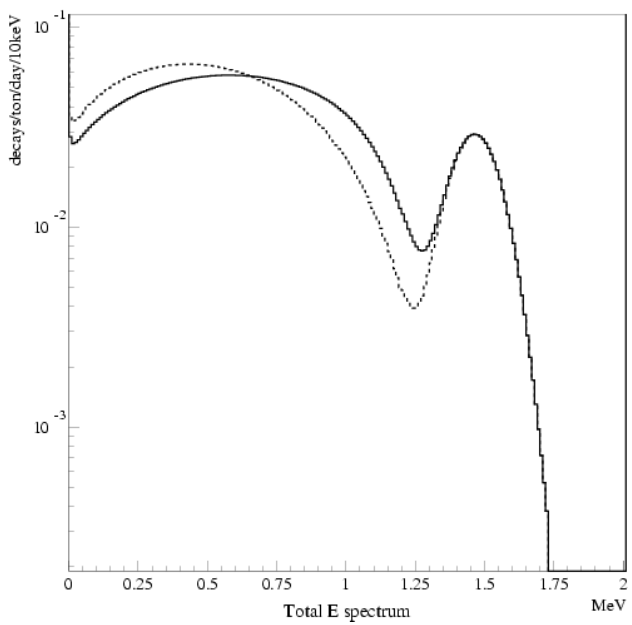


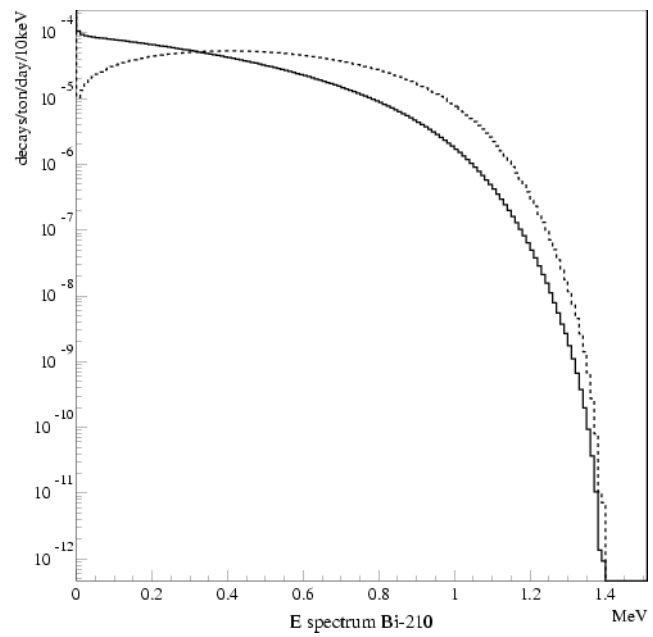


Corrections to β-spectra

- Fermi correction: accounts for finite radius of nucleus and Coulomb attraction between β and parent nucleus
- Corrections accounting for forbiddenness of decay (not yet completed)
- Forbiddenness correction for K-40
- Correction of Bi-210 to observed shape

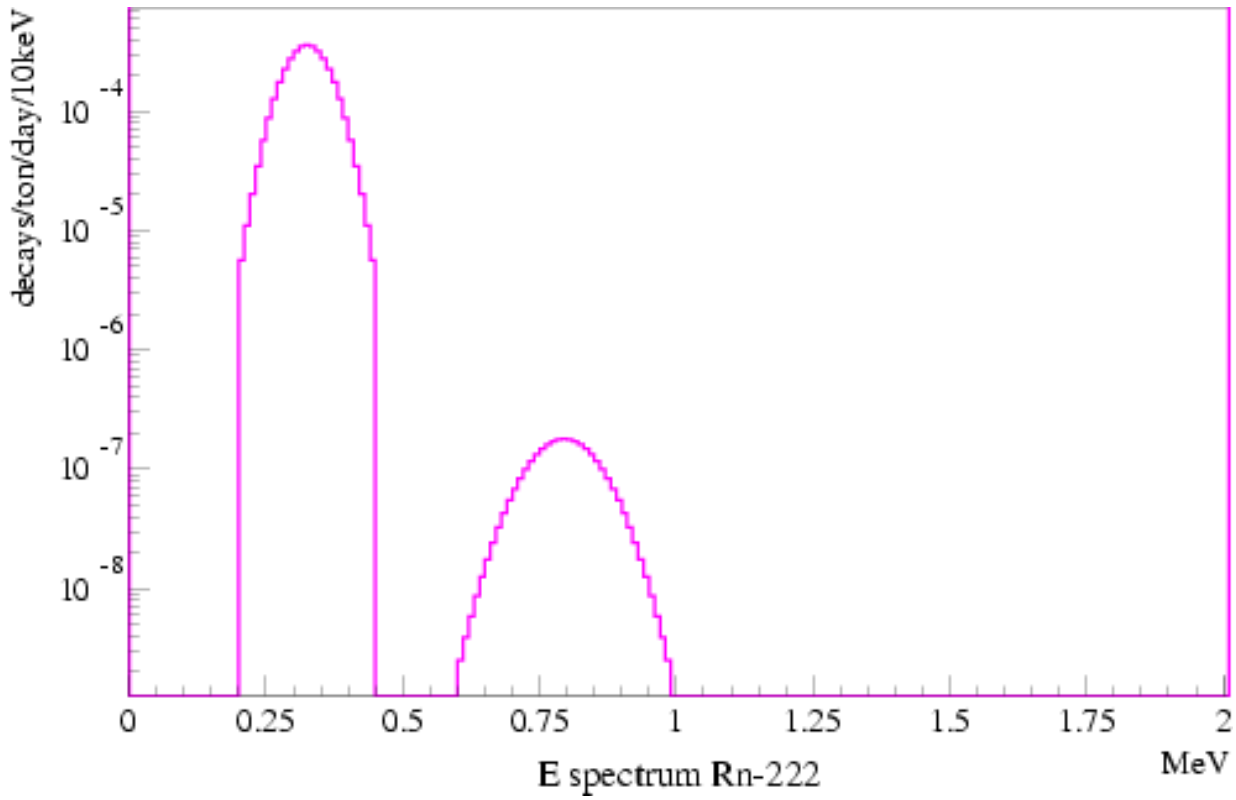




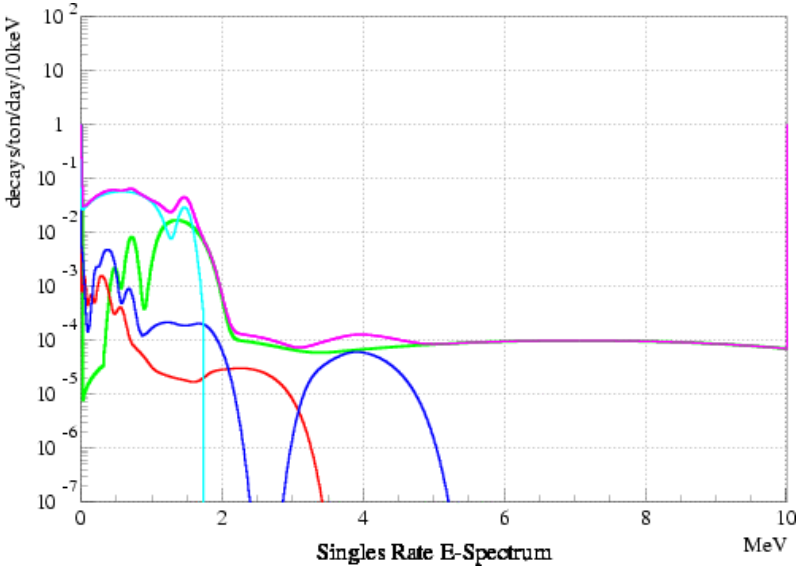


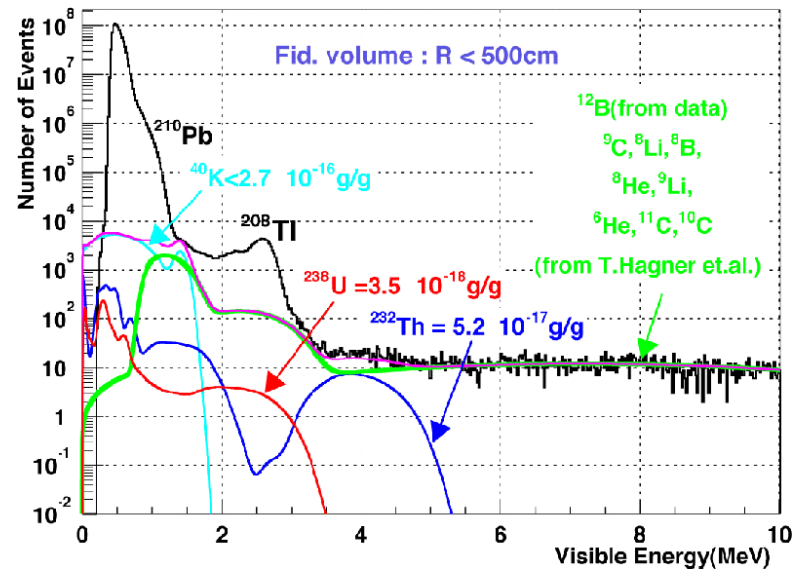
Alpha Decay Spectra

- Simpler than beta decay!
- Quenching is modeled according to Birks' law

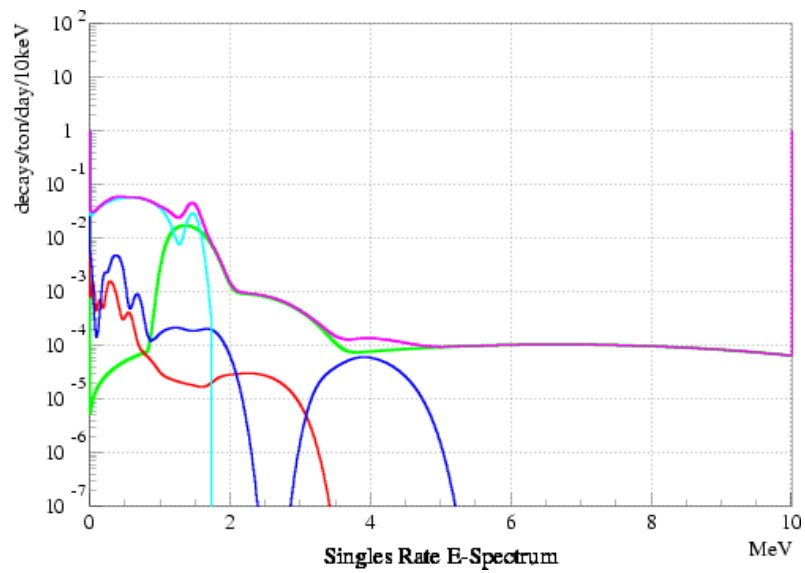


Similarities to KamLAND



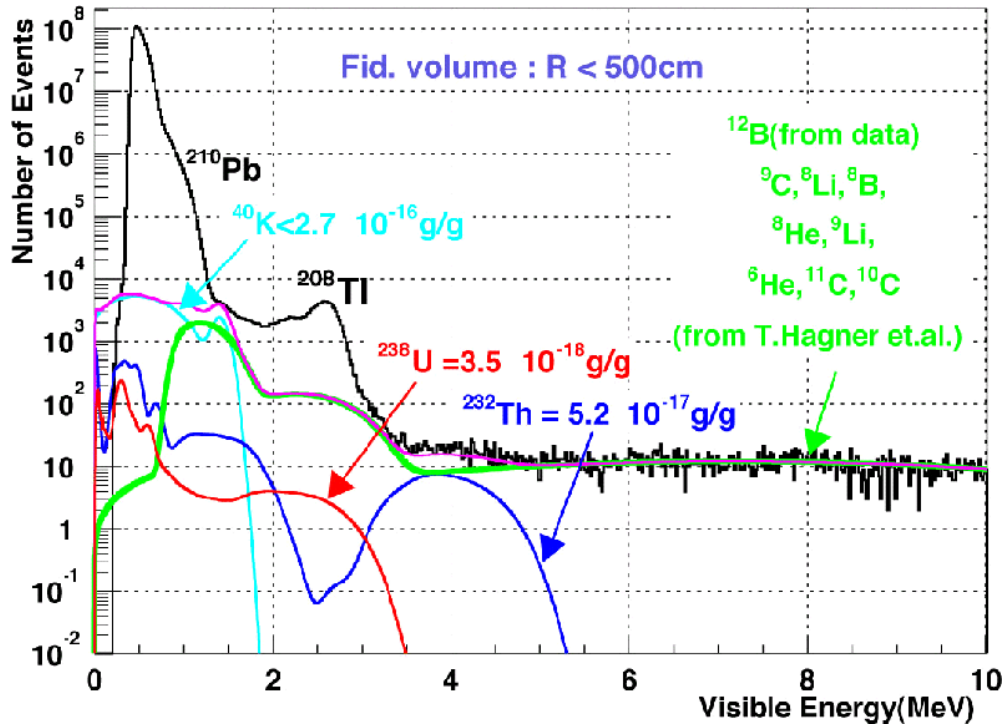


- Many similarities in U-238, Th-232, and K-40 spectra
- Differences in shape of spallation spectrum
- Differences can be reconciled by using simplified model of β-decay
- Difference in thorium spectrum not yet accounted for



Further work to be done

- Corrections to forbidden decays using tabulated correction factors
- Possible study of edge effects
- Study of the causes of the difference between KamLAND's predictions and data



Further plots of modeled backgrounds can be found at
http://home.fnal.gov/~hannahnp/decay/decay.html

Conclusions

- If U-238, K-40, and Th-232 concentrations are as small as KamLAND's, the singles rate is dominated by spallation for energies over 1 MeV at 450 mwe.
- Properly accounting for beta decays (at KamLAND or Braidwood) makes the singles rate spectrum effectively flat for energies above 2 MeV