Chap. 20 – Background & Shielding

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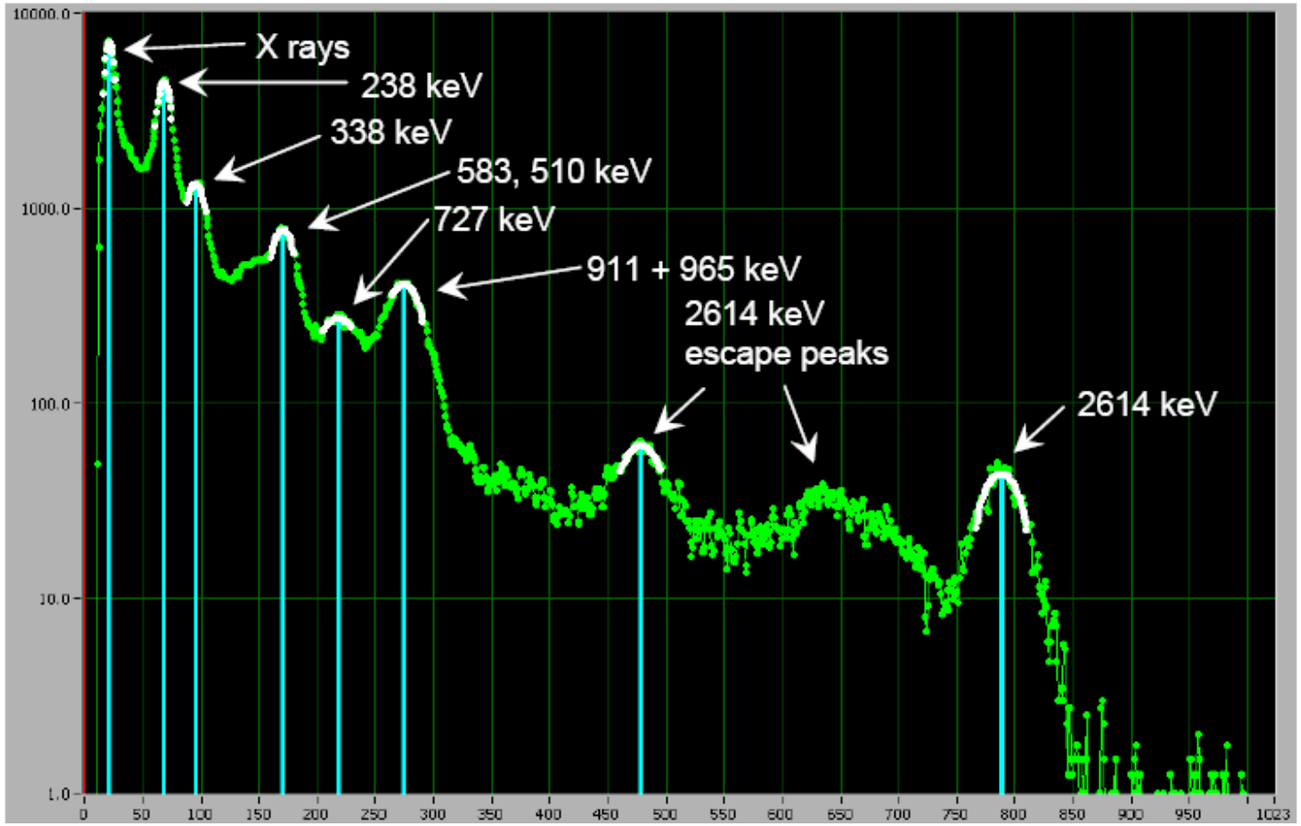
Nuclide	T ½	Source
^{235}U	$7x10^{8}$ yr	0.72% of all natural uranium
^{238}U	$4x10^{9}$ yr	99.2745% of all natural uranium; 0.5 to 4.7 ppm total uranium in the common rock types
^{232}Th	1.41×10^{10} y	1.6 to 20 ppm in the common rock types with a crustal average of 10.7 ppm
^{226}Ra	1.60×10^{3} yr	0.42 pCi/g (16 Bq/kg) in limestone and 1.3 pCi/g (48 Bq/kg) in igneous rock
^{222}Rn	3.82 days	Noble Gas; annual average air concentrations range in the US from 0.016 pCi/L (0.6 Bq/m^3) to 0.75 pCi/L (28Bq/m^3)
^{40}K	1.28×10^{9} yr	soil - 1-30 pCi/g (0.037-1.1 Bq/g)
^{14}C	5730 yr	Cosmic-ray interactions, $^{14}N(n,p)^{14}C$, 6 pCi/g (0.22 Bq/g) in organic material
^{3}H	12.3 yr	Cosmic-ray interactions with N and O, spallation from cosmic-rays, $^{6}Li(n, alpha)^{3}H$, 0.032 pCi/kg (1.2×10^{-3} Bq/kg)

http://www.physics.isu.edu/radinf/natural.htm

70 kg person

Nuclide	Activity
U : 90 μg	1.1 Bq
Th : 30 μg	0.11 Bq
Ra : 31 pg	1.1 Bq
^{40}K : 17 mg	4.4 kBq
^{14}C : 22 ng	3.7kBq
^{3}H : 60 fg	37 Bq

^{232}Th spectrum .. The ^{208}Pb line



^{232}Th spectrum in a small $CdWO_4$ survey device

Background & Shielding: Singles

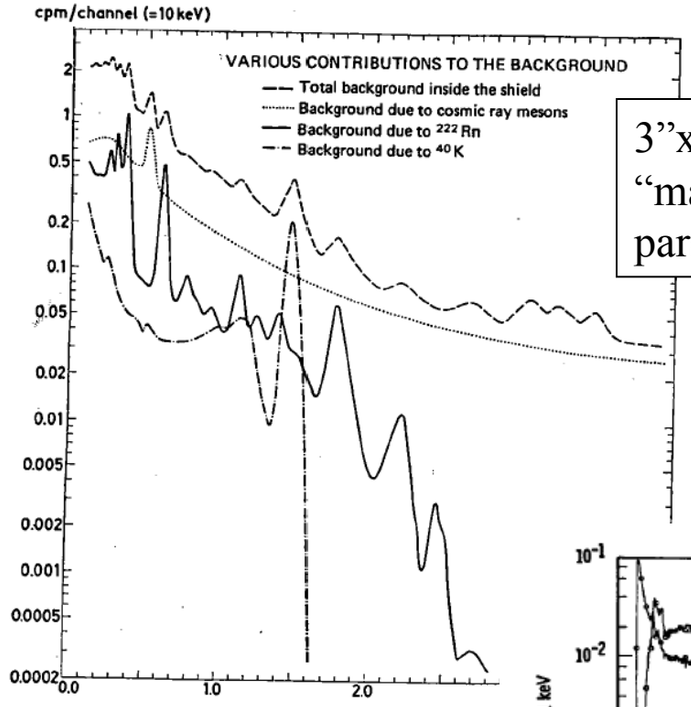
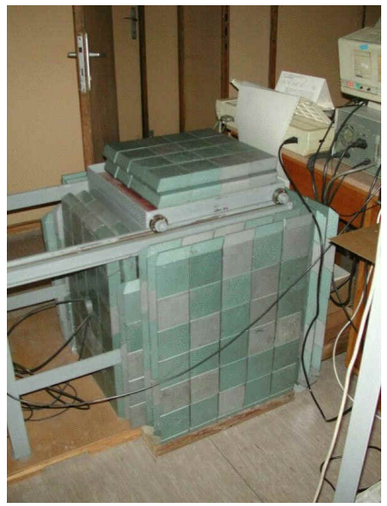


Fig. 20.2 Knoll, 3rd Ed.

3"x3" NaI(Tl) inside a "massive" lead/borated-parafin shield



85 cm^3 Ge in a laboratory shield

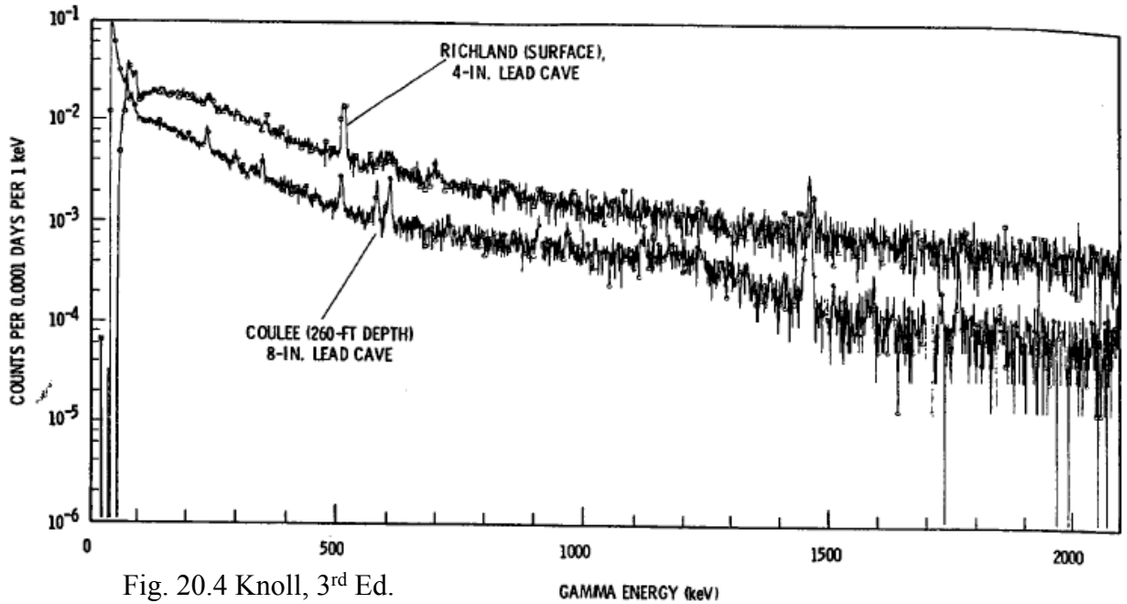
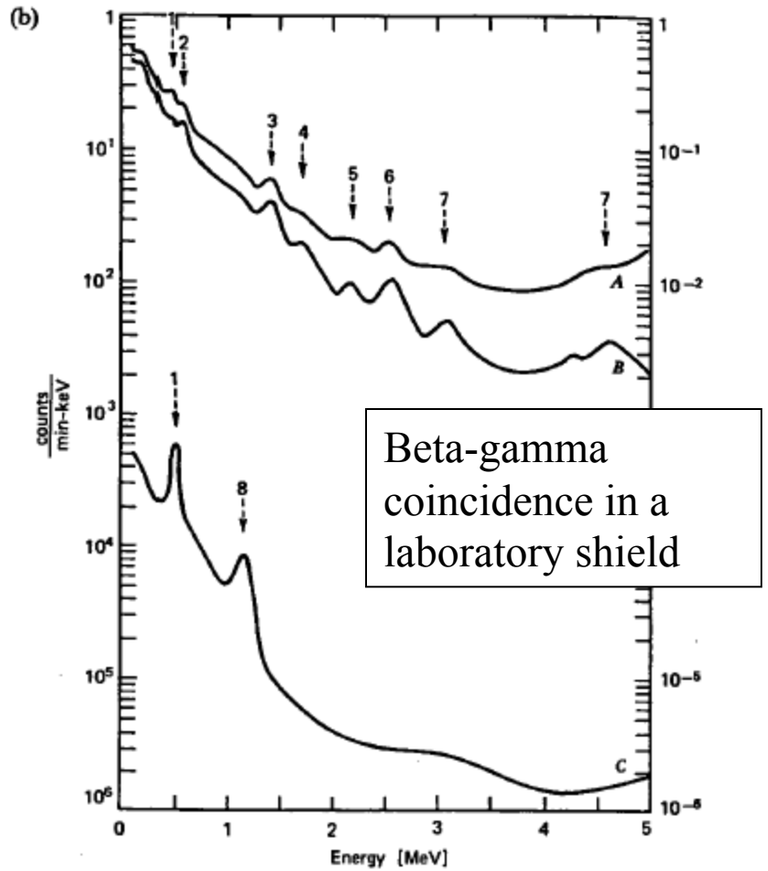


Fig. 20.4 Knoll, 3rd Ed.

Background & Shielding: Coincidence



Beta-gamma coincidence in a laboratory shield

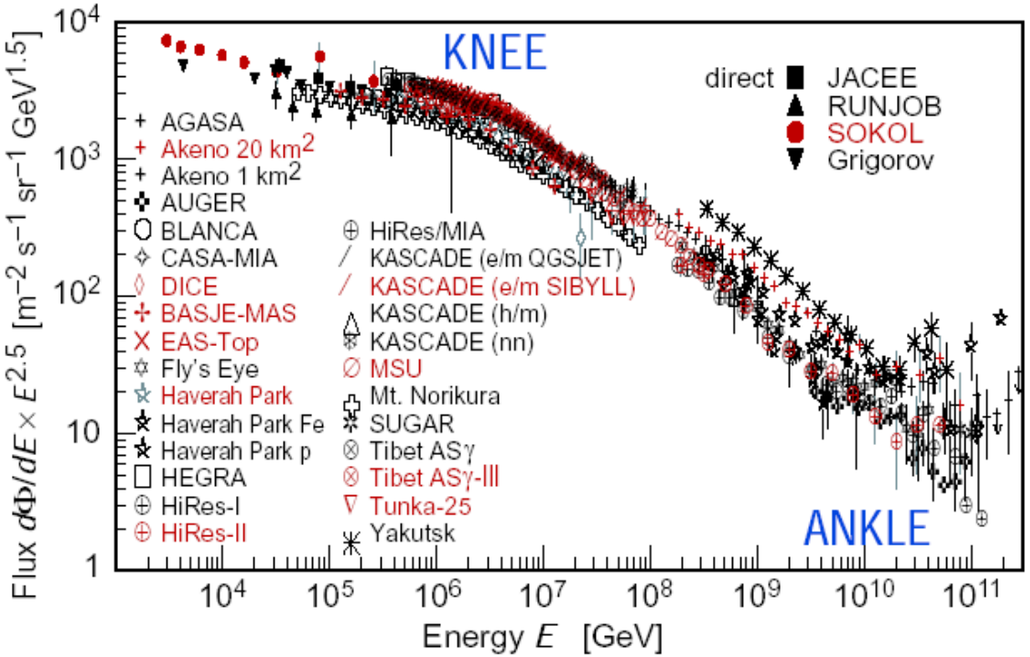
Fig. 20.10 Knoll, 3rd Ed.

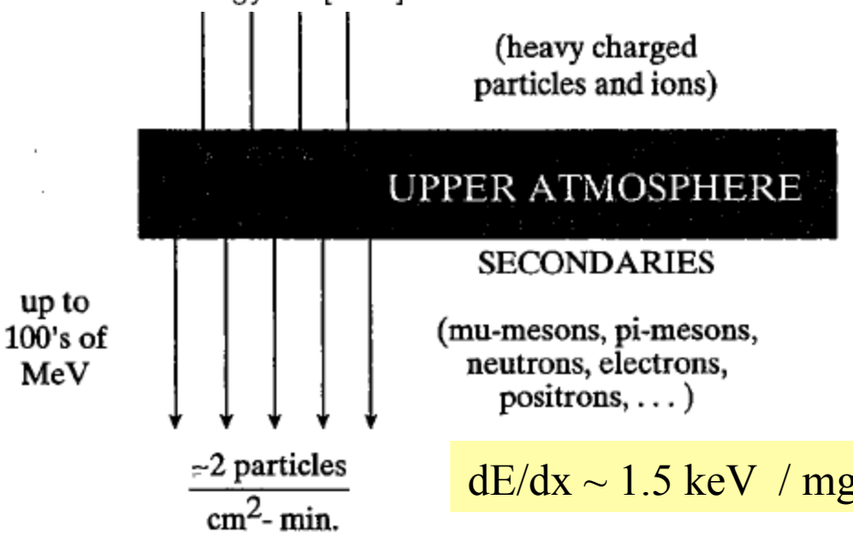
Use the time dimension to make a cut on the data.

$\Delta t \sim 10^{-6}$ s is called 'slow' coincidence

$\Delta t \sim 10^{-8}$ s is typical 'fast' coincidence for modern experiments .. except for Ge detectors.

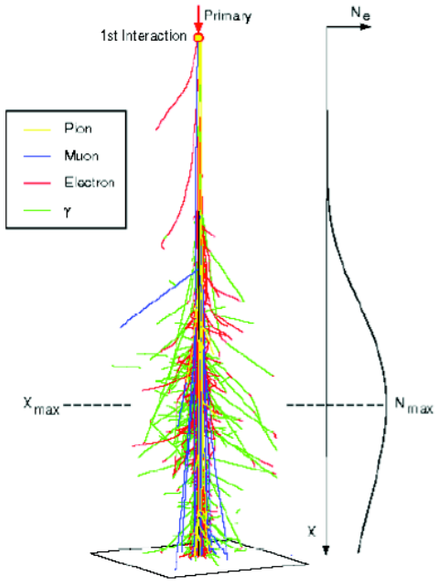
Background: Cosmic Rays





Scaled distribution at the top of the atmosphere

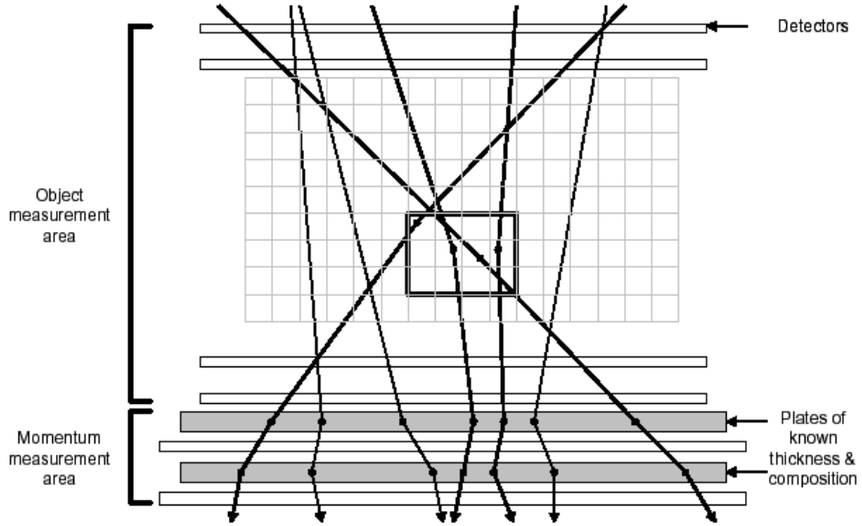
~$\cos^2 \Theta$ angular distribution



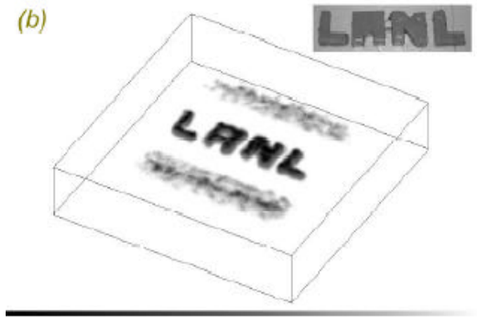
R. Chartrand, et al. LANL

dE/dx ~ 1.5 keV / mg/cm^2

Background: Cosmic Ray Radiography



K.N. Borodzin, et al. Nature 422 (2003) 277



1" Pb-stock, 10^5 muons

Q: How long did it take?

See also early work: Search for Hidden Chambers in the Pyramids, L. Alvarez, et al. **Science** 167 (1970) 832.

Chap. 20 – Background & Shielding Question

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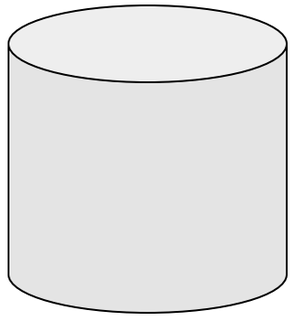
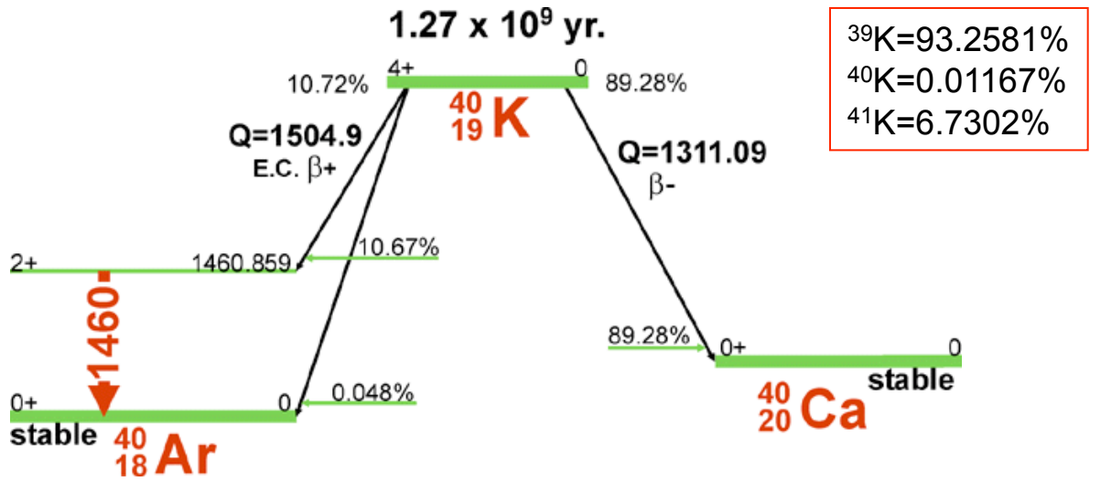
Problem 20.1 – One potential source of background counts from sodium iodide scintillators is ^{40}K from trace level potassion impurity in the crystal [both K and Na are Group 1 alkali metals].

a) Find the maximum potassium concentration (in ppm) if the corresponding background rate from a 7.62 x 7.62 cm cylindrical crystal is not exceed 1 cps.

b) What is the approximate counting rate from cosmic rays in this crystal?





^{39}K=93.2581%
^{40}K=0.01167%
^{41}K=6.7302%