



In-situ Gammaskpektrometrie



THEORIE

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EXPACS

Excel-based Program for calculating Atmospheric Cosmic-ray Spectrum

www.jaea.go.jp

in-situ

ICRU 53 (1994)
Lemerrier (2008)

absorbed dose rate
in air
nGy/h

$\times 0.7$

UNSCEAR

photon
fluence
rate

^{232}Th -series
 ^{238}U -series
 ^{40}K
Bq/kg in soil

$\times 0.6$

$\times 0.46$

$\times 0.041$

UNSCEAR

Effective
dose rate
nSv/h

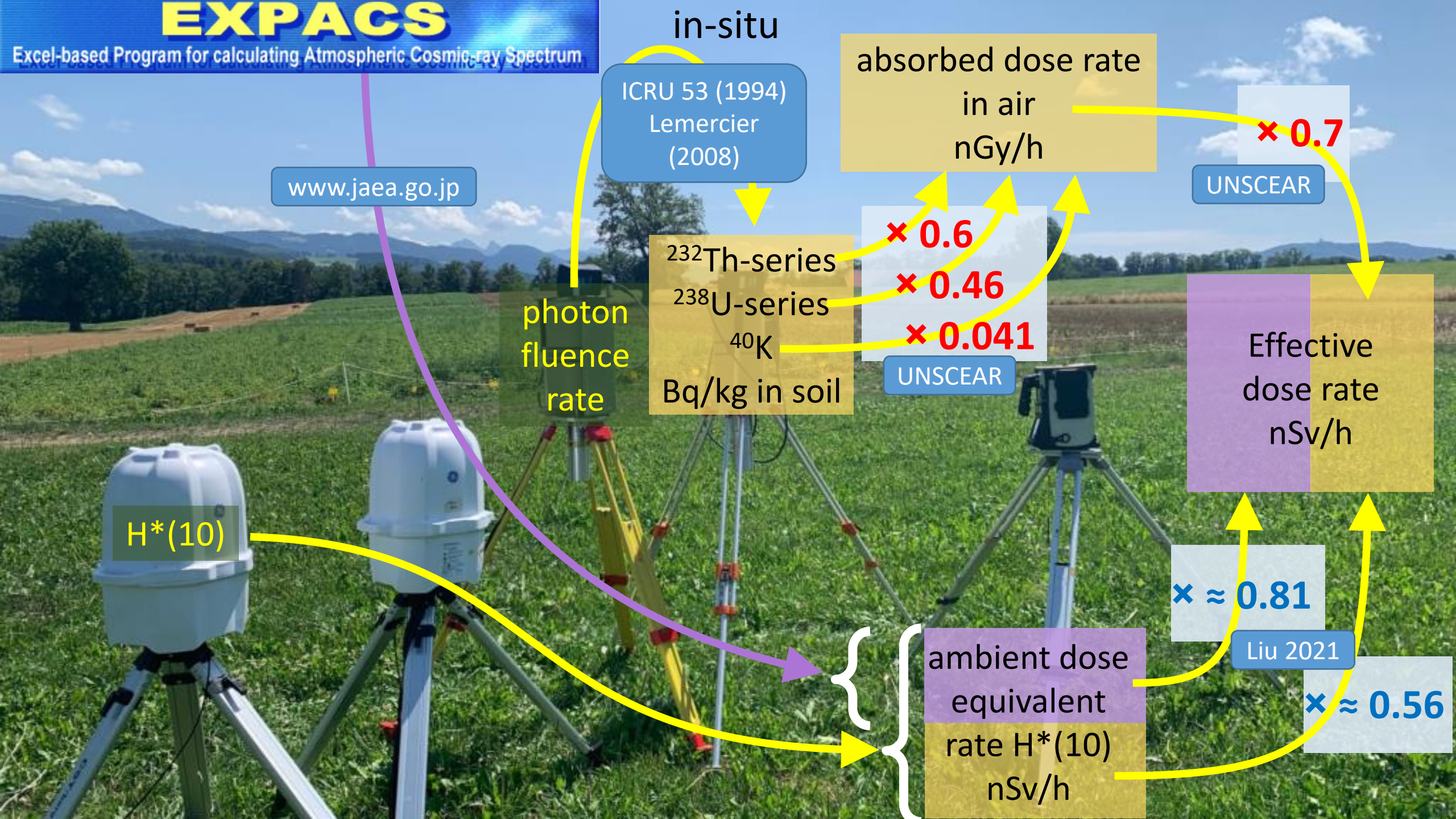
$\times \approx 0.81$

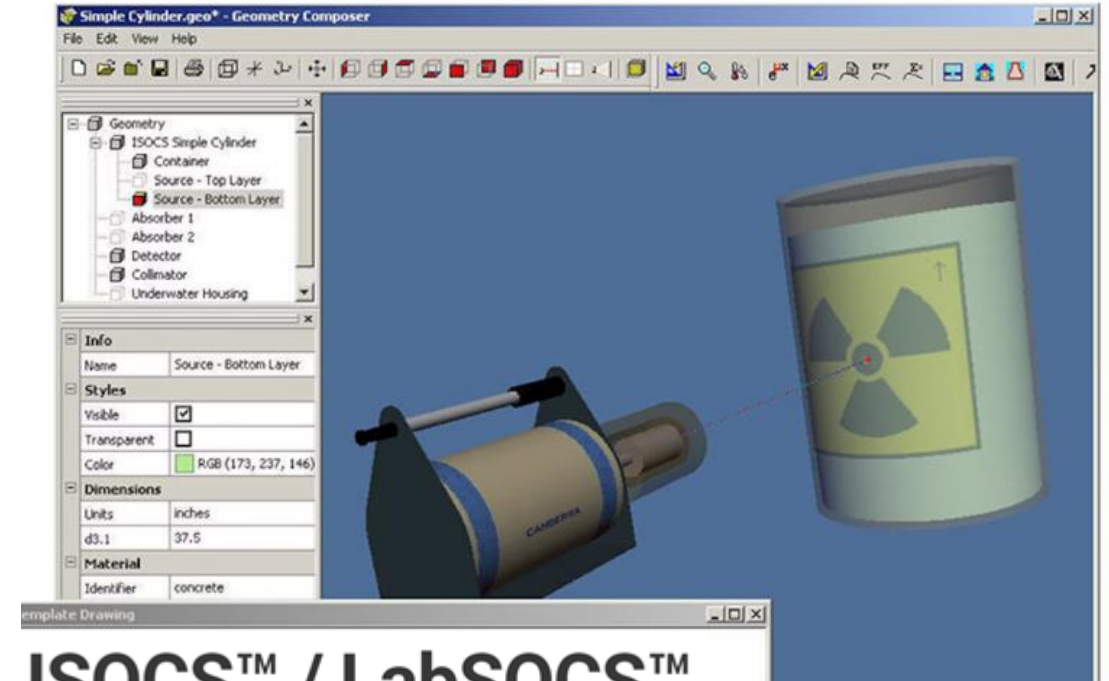
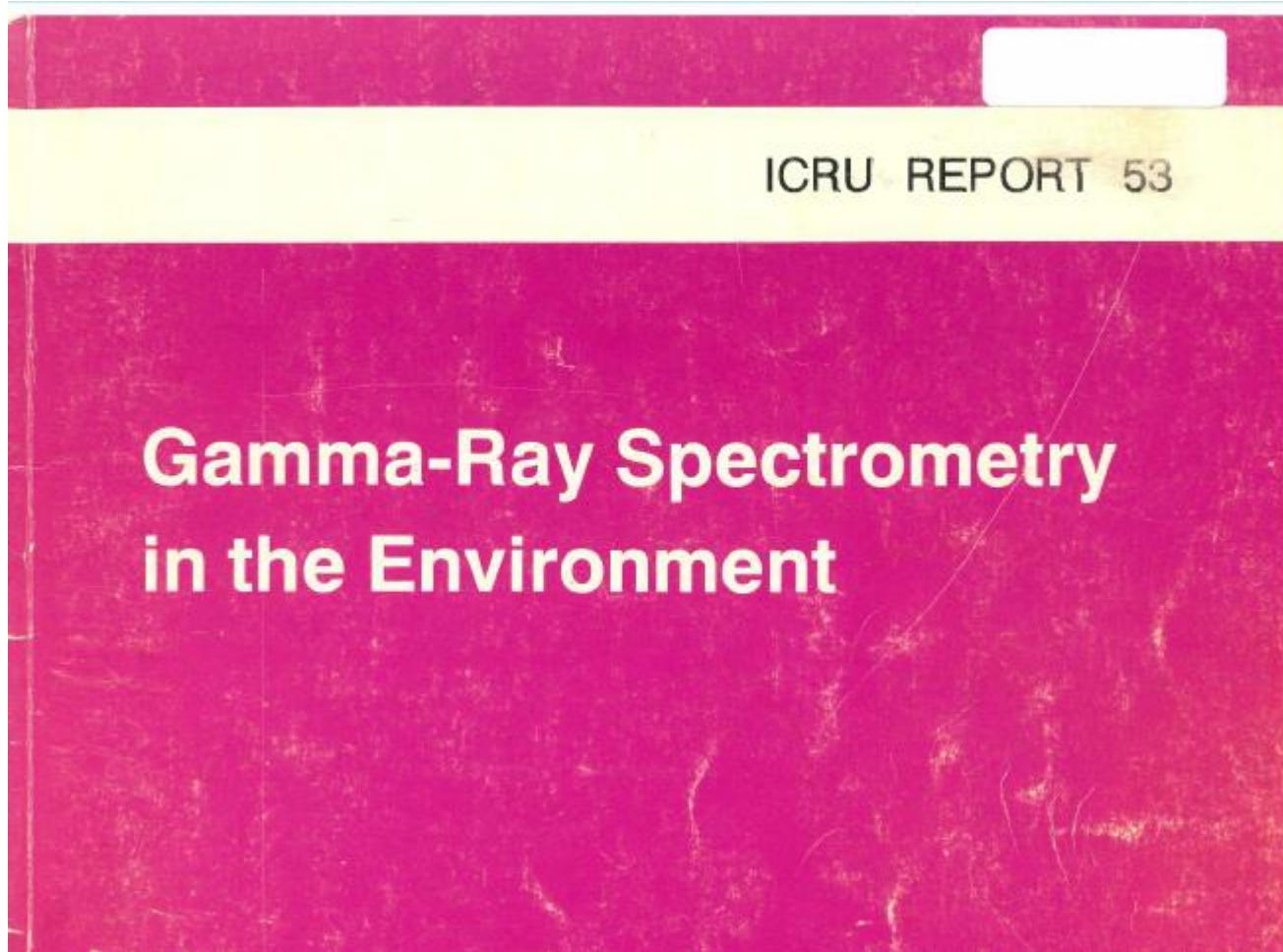
Liu 2021

$\times \approx 0.56$

$H^*(10)$

ambient dose
equivalent
rate $H^*(10)$
nSv/h





ISOCS™ / LabSOCS™ Calibration Methodology

International Commission on Radiation Units and Measurements



In-situ Gammaskpektrometrie

count rate per unit activity
at energy E

detector dependent
model dependent



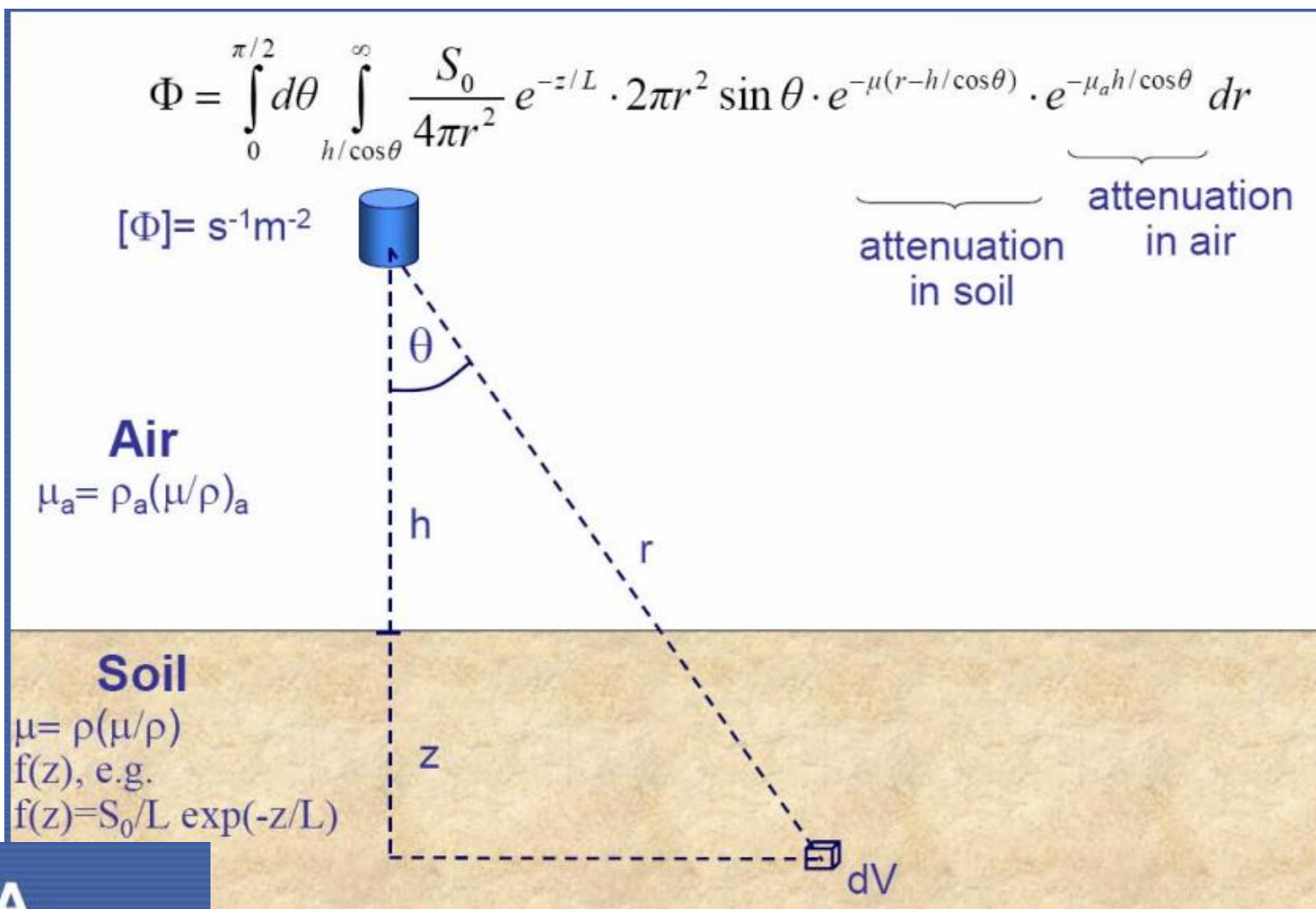
$$\frac{\dot{N}}{A_x} = \frac{\dot{N}}{\dot{N}_0} \cdot \frac{\dot{N}_0}{\varphi} \cdot \frac{\varphi}{A_x},$$

(3.1)

ICRU 53 report



In-situ model





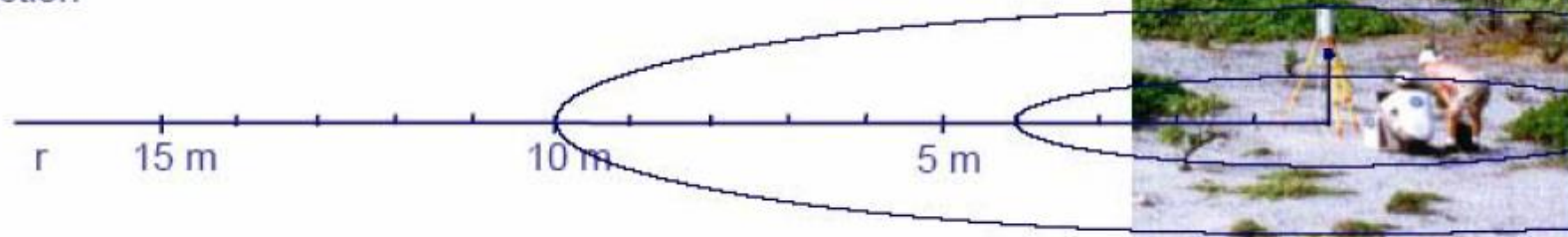
field of view

Example

photon energy 662 keV (^{137}Cs)
 detector at height $h=1\text{m}$
 soil density $\rho=1.6\text{ g cm}^{-3}$
 relaxation length $L=3.0\text{ cm}$

r	Fraction of total flux $\Phi(r)/\Phi$	Surface area πr^2
4 m	65%	$\sim 50\text{ m}^2$
10 m	85%	$\sim 310\text{ m}^2$
>10 m	15%#	$\sim 710\text{ m}^2$ (at $r=15\text{m}$)

remaining fraction



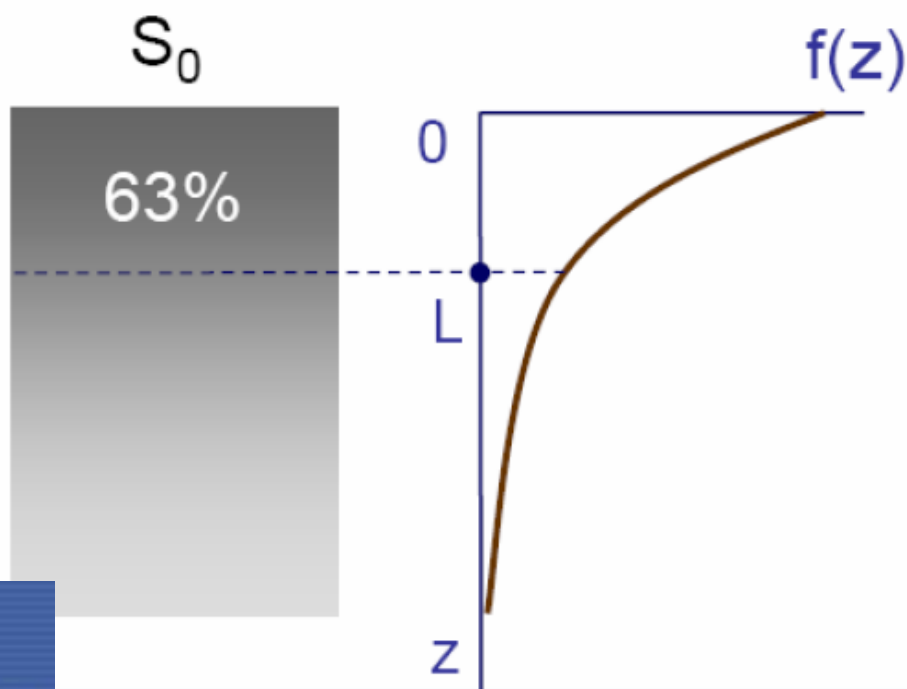


exponential distribution

$$f(z) = \frac{S_0}{L} e^{-z/L}$$

S_0 – activity in a soil column, total inventory (Bq m⁻²)

L – relaxation length, e.g. (cm)



Interpretation of S_0 :

$$\int_0^{\infty} f(z) dz = S_0$$

Interpretation of L :

$$\int_0^L f(z) dz \approx 0.63 S_0$$



In-situ Gammaskpektrometrie

count rate per unit activity
detector efficiency for parallel photon beam at energy E
detector dependent

count rate per unit activity
at energy E

detector dependent
model dependent

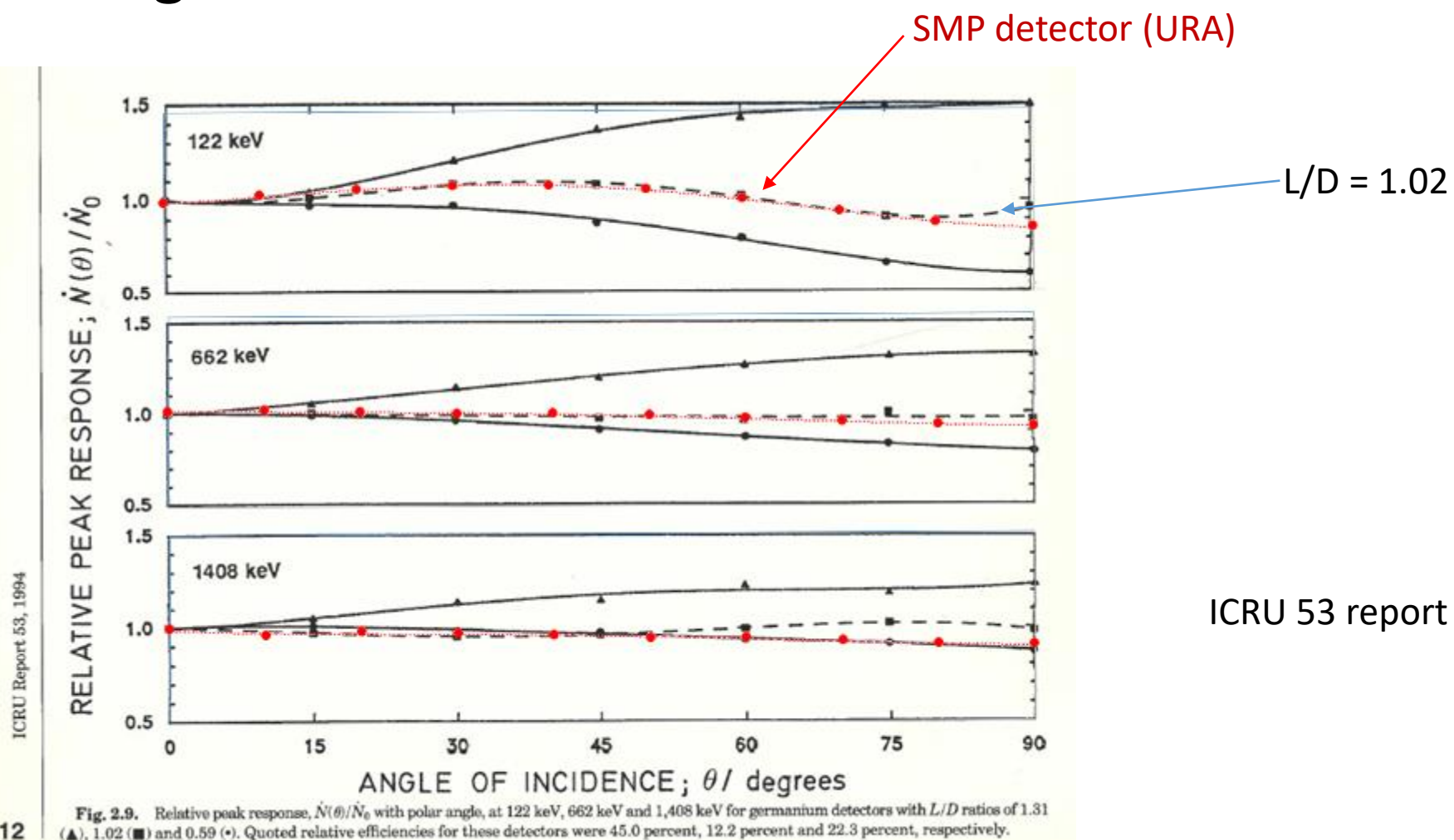
$$\frac{\dot{N}}{A_x} = \frac{\dot{N}}{\dot{N}_0} \cdot \frac{\dot{N}_0}{\varphi} \cdot \frac{\varphi}{A_x}, \quad (3.1) \quad \text{ICRU 53 report}$$

angular correction at energy E
detector dependent
model dependent

fluence rate per unit activity at energy E
model dependent



angular correction



ICRU Report 53, 1994

12

ICRU 53 report



angular correction

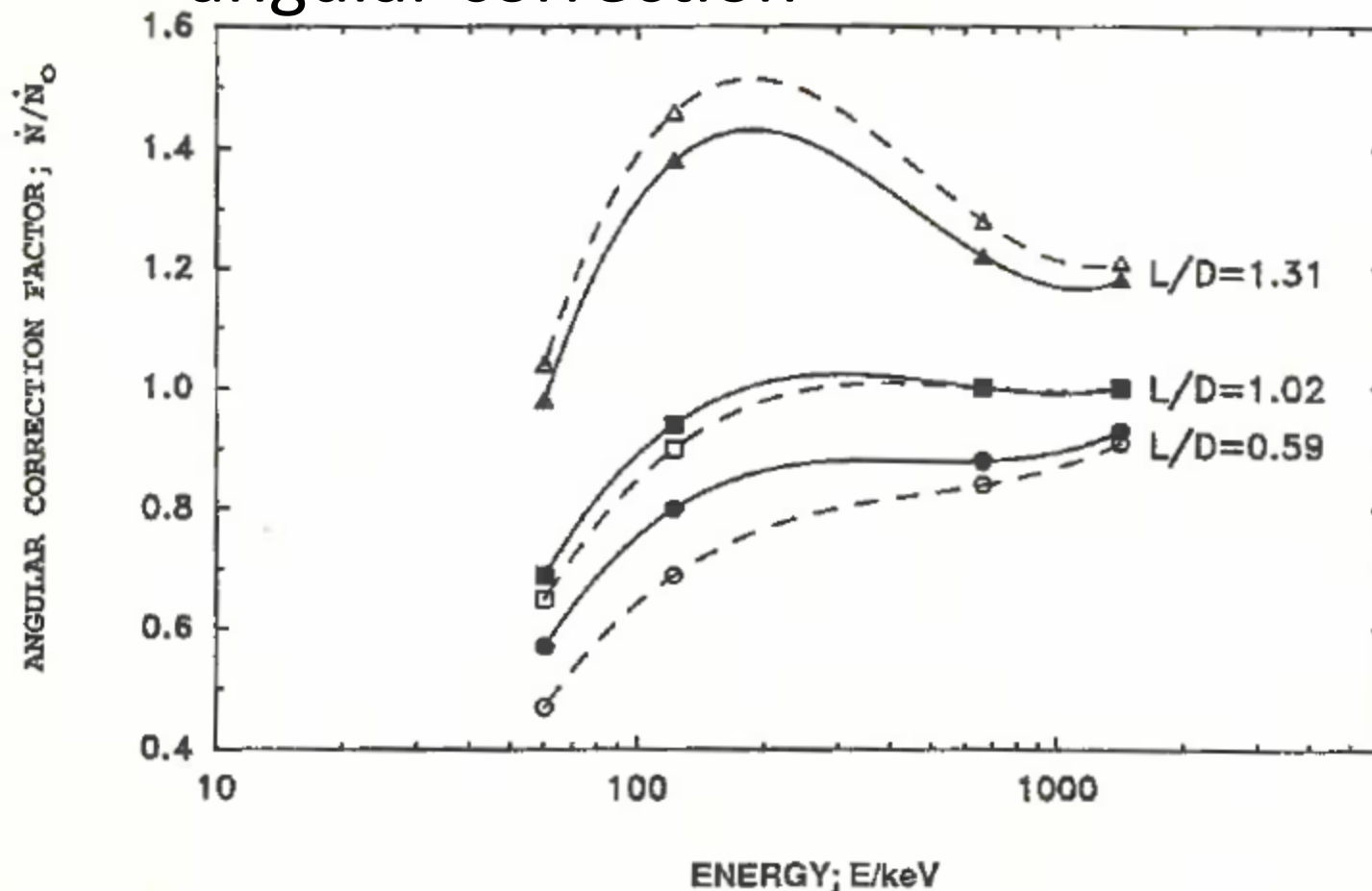


Fig. 3.4. Angular correction factor for germanium detectors of three different shapes (from Figure 2.9) for a source distribution that is uniform with depth (—) and a surface plane (----).

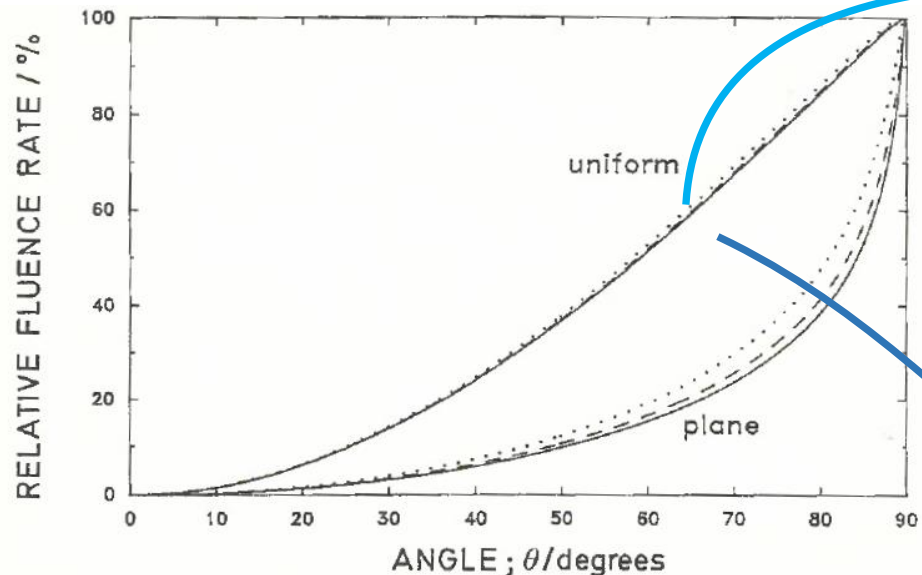
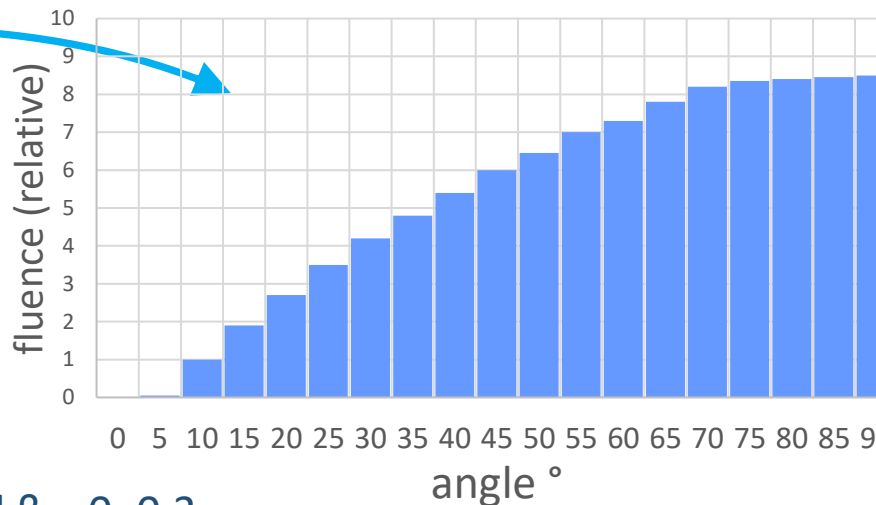


Fig. 3.3. Fraction of primary fluence rate at a height of 1 m above ground and at angles less than θ , for a source of photons at 122 keV (····), 662 keV (----) and 1,408 keV (—) for uniform and plane source distributions.

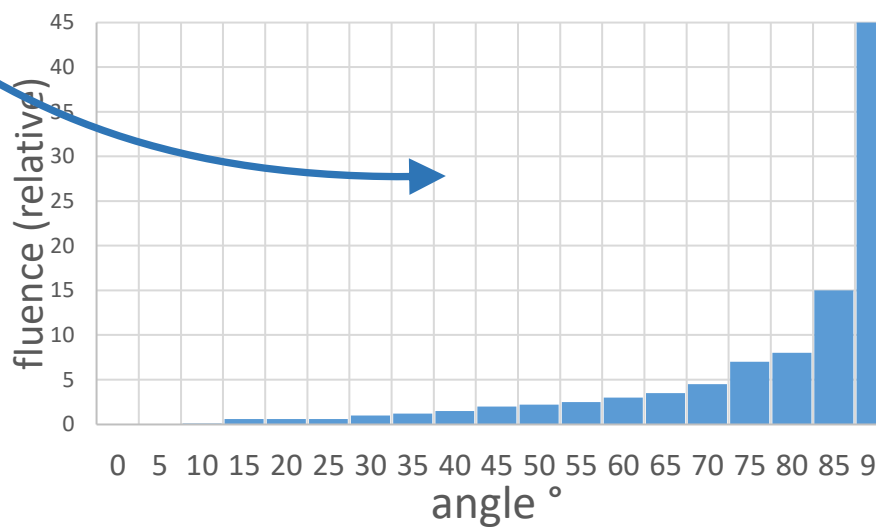
ICRU 53 report

Model $\beta = \infty$



Φ

Model $\beta = 0; 0.3; \dots$



Bq/kg or Bq/m²
for the chosen model

conversion to
other models ?



Reporting in the Envira xml format

<https://www.envira.ch/labordb/labordb-schema.pdf>

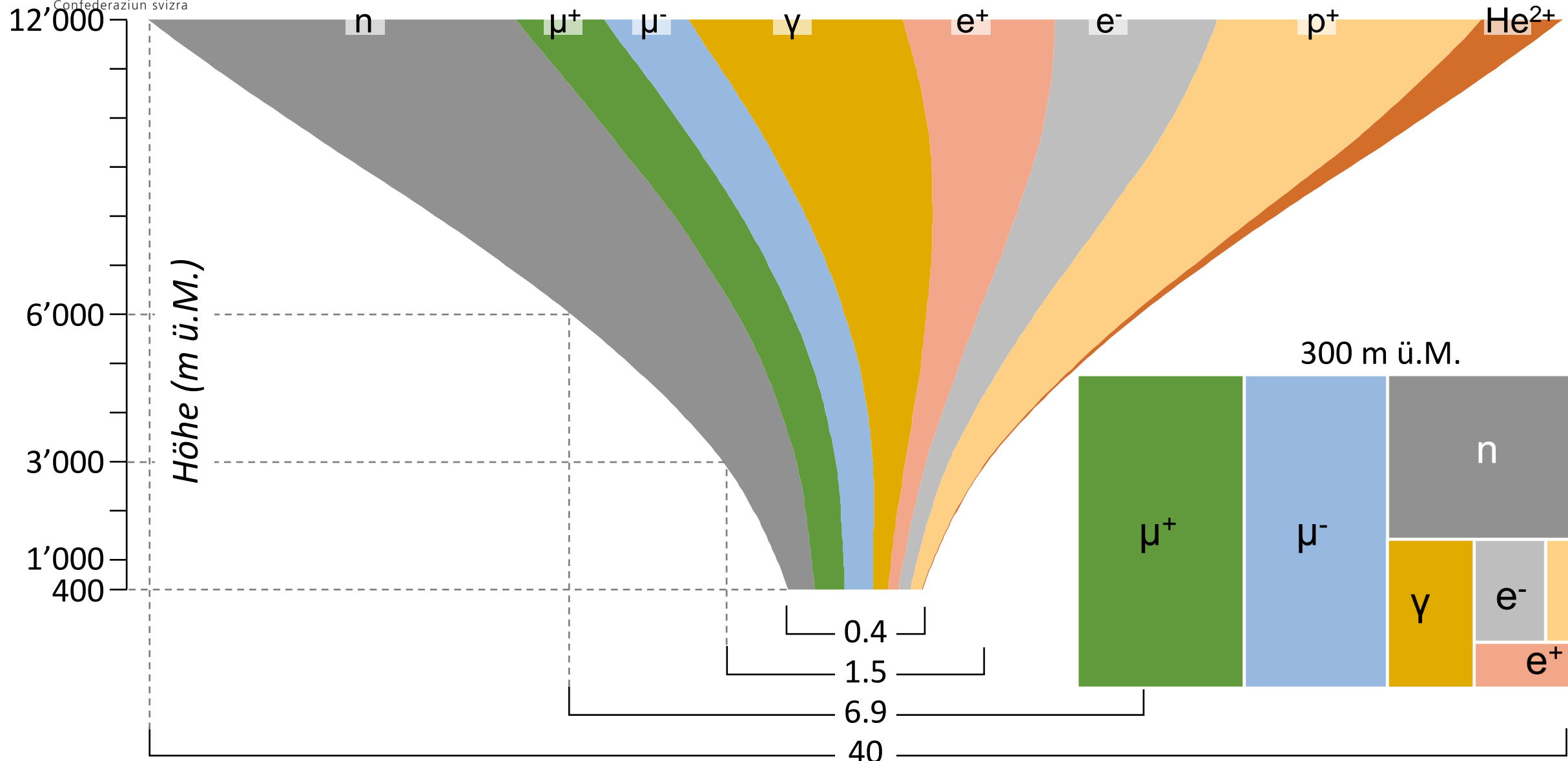
Element	Attribut		xsd Type	Restrictions	Beschreibung
samples					Root-Element des XML-Dokuments mit <ul style="list-style-type: none"> Informationen zum XML-Dokument selbst eine beliebige Anzahl von Proben
	date	?	dateTime		Datum/Zeit des XML-Dokuments
	from		string (10)	* Liste der Labors BAG	Herkunft des XML-Dokuments
	test	?	boolean	default="false"	Handelt es sich um Testdaten ?
sample		+			Einzelne Probe mit <ul style="list-style-type: none"> eindeutiger Identifikation durch <laboratory> und <nummer>
					URA-Sr z KL-BAG Kantonale Labors
	in-situ		boolean	false true	Labormessungen in Situ Messung
	other-samples	?			Liste von Proben, die mit der aktuellen Probe zusammenhängen



Reporting in the Envira xml format

<https://www.envira.ch/labordb/labordb-schema.pdf>

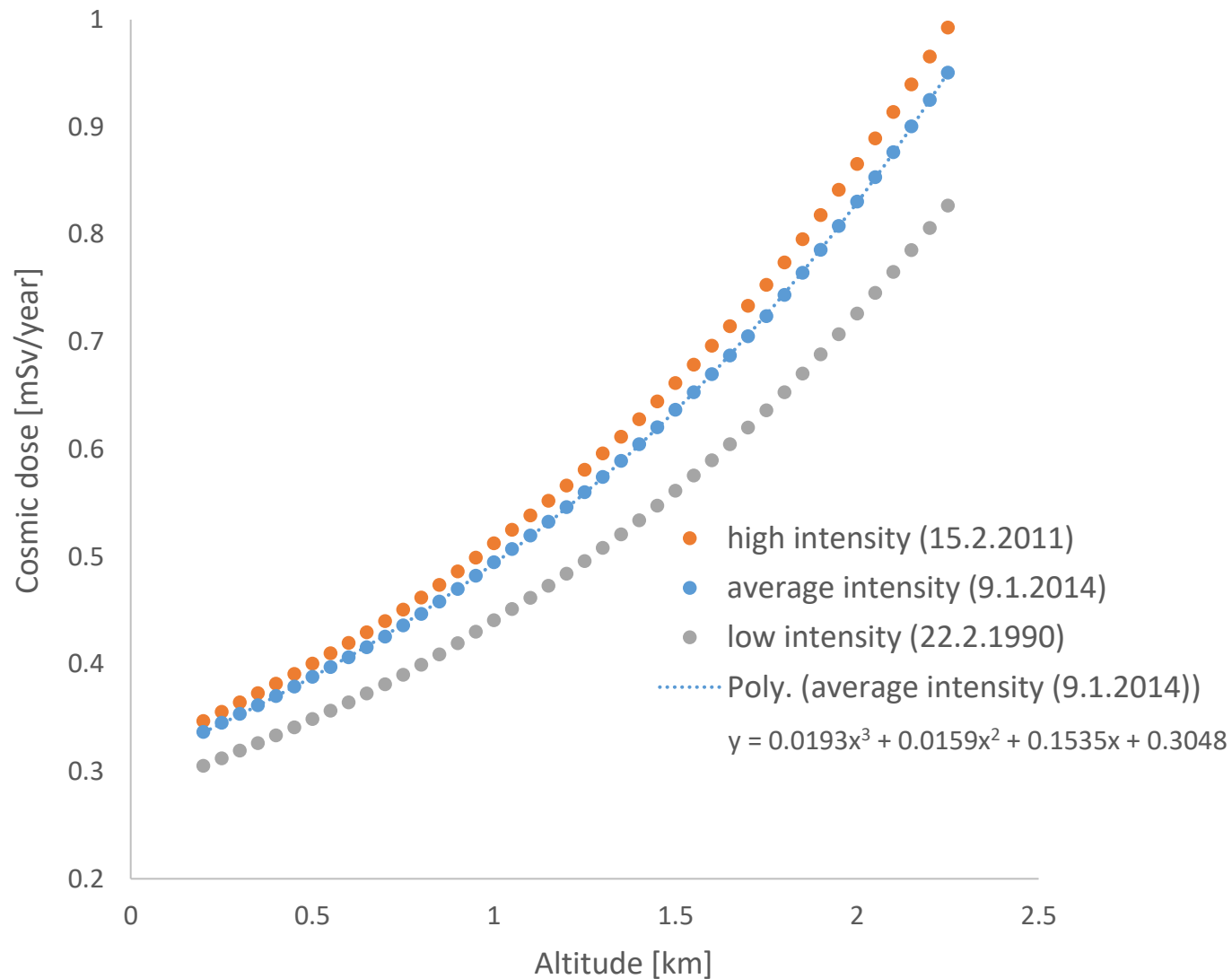
Element	Attribut		xsd Type	Restrictions	Beschreibung
sample-type		?	string (10)	single mix collection	Probentyp: Einzelprobe Mischprobe Sammelprobe
bag-code			string (8)	[0-9]{2}[1-9A-Z]{1,6}	Warencode • erste 3 Ziffern obligatorisch • muss gültig sein (nach Liste der Warencodes gemäss "version") Beim aktuellen Warencode entsprechen die ersten beiden Ziffern dem Kapitel im Schweizerischen Lebensmittelbuch.
	version		string (8)		Version des BAG-Warencodes aktuell = "2003" vorher = "1999"
description		?	string (4000)		genauere Beschreibung der Probe
Station		?			Station eines Messnetzes



Effektive Dosis (mSv/Jahr) bei 100% Aufenthalt im Freien (Quadratwurzelskala)

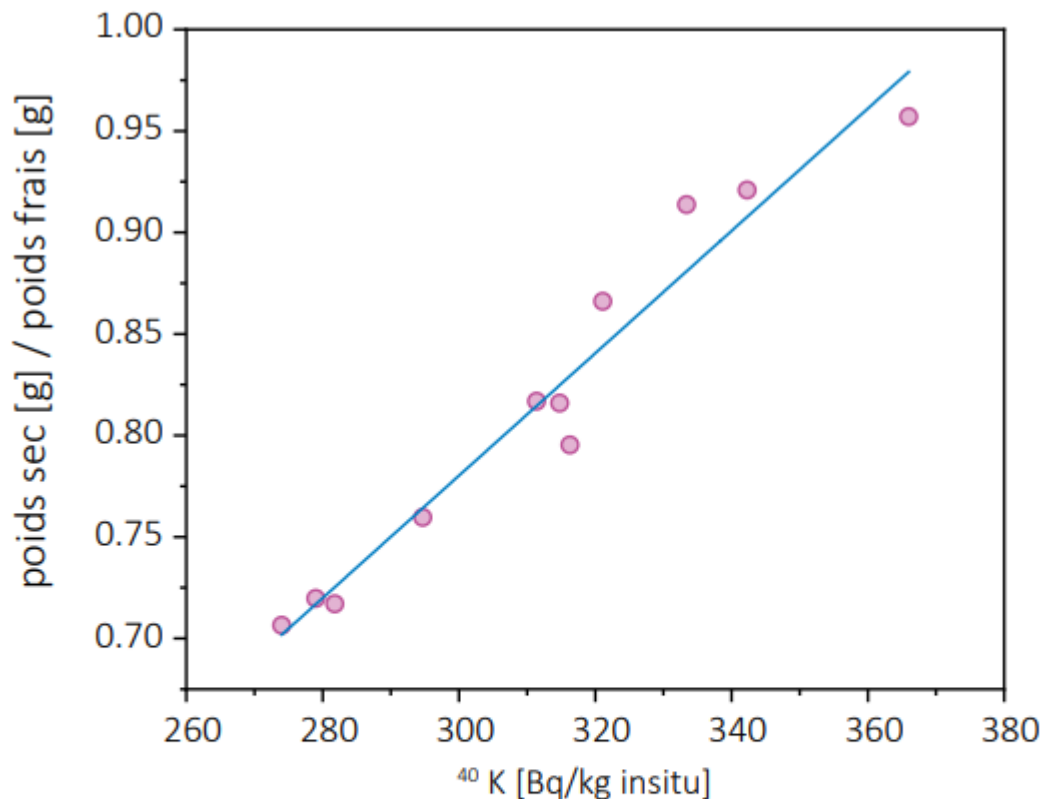


Cosmic dose vs. altitude, Switzerland (Expacs 4.10)





soil humidity



variation: 270 – 370 Bq/kg

difference of ca. 30%

dry soil: no correction

wet soil: +35%

Figure 2:

Mise en corrélation de la concentration du ^{40}K de 2012 à 2022 avec le rapport poids sec sur poids frais des prélèvements de sol. Mesures et prélèvements effectués à la station Beznau Meteo.