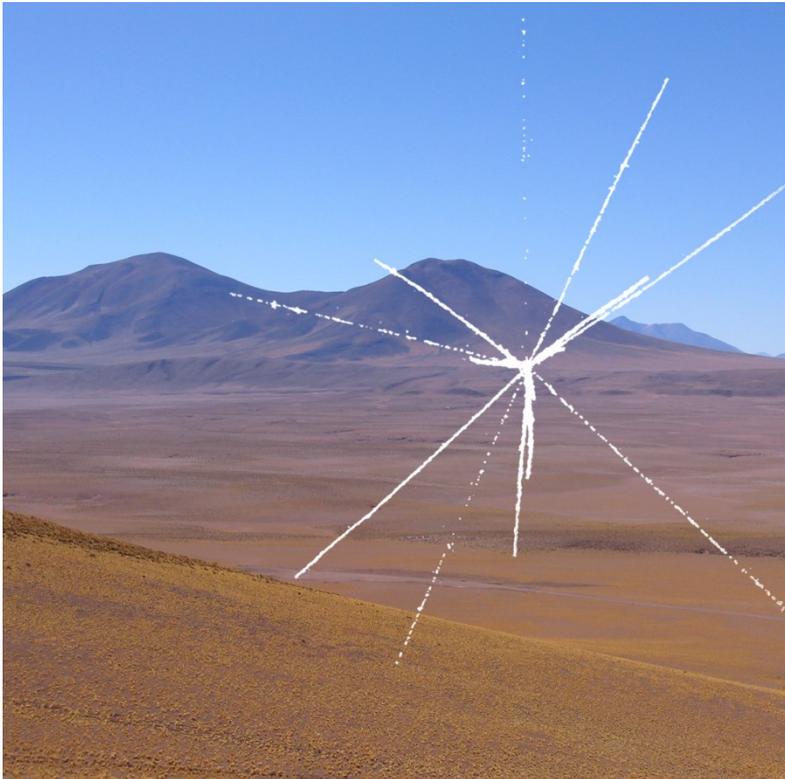
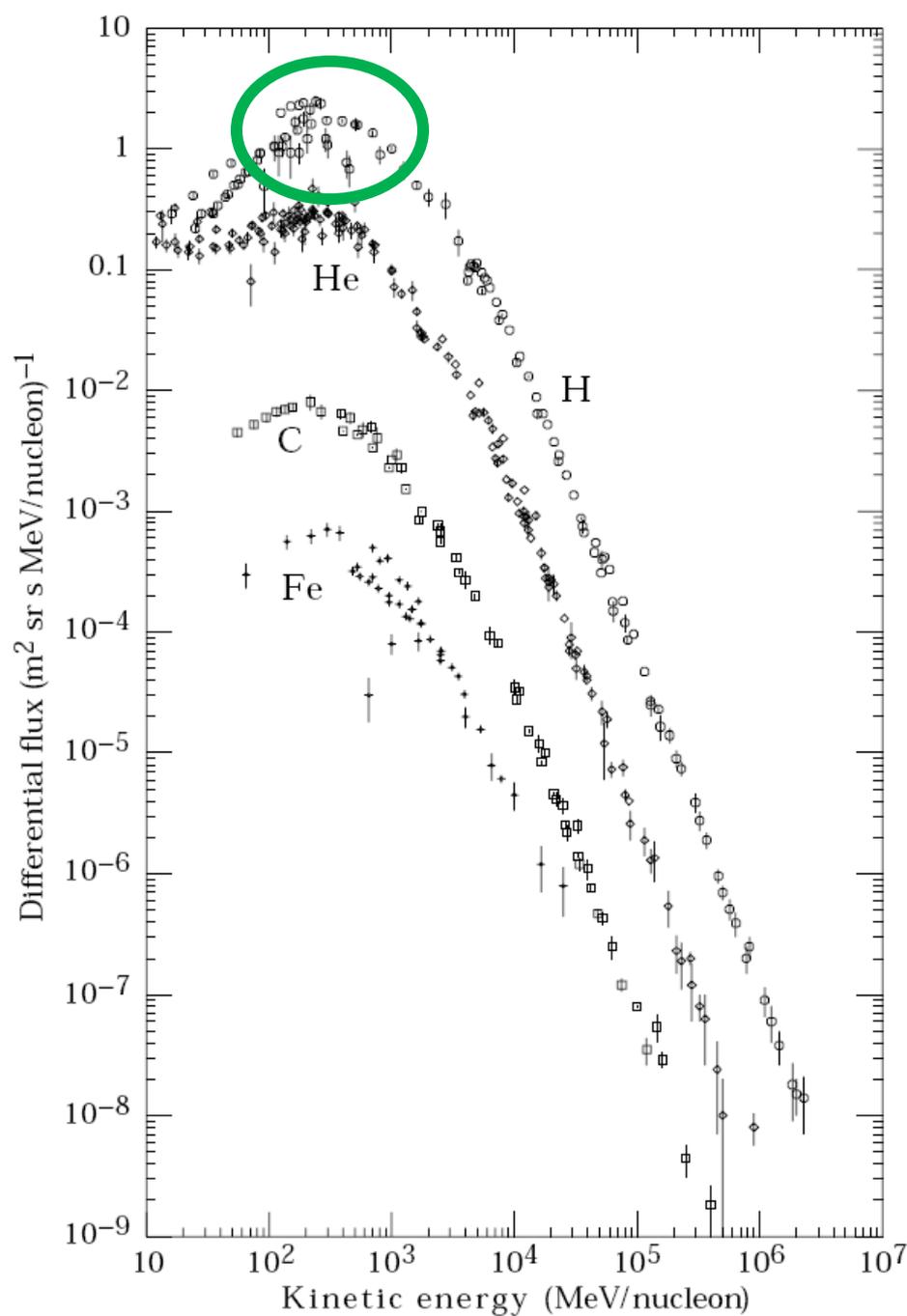


Cosmic ray-produced radionuclides in Earth Sciences



Prof. Dr. Tibor Dunai
Inst. f. Geologie und Mineralogie,
Universität zu Köln

ASPERA workshop, Paris, 1.12.2010

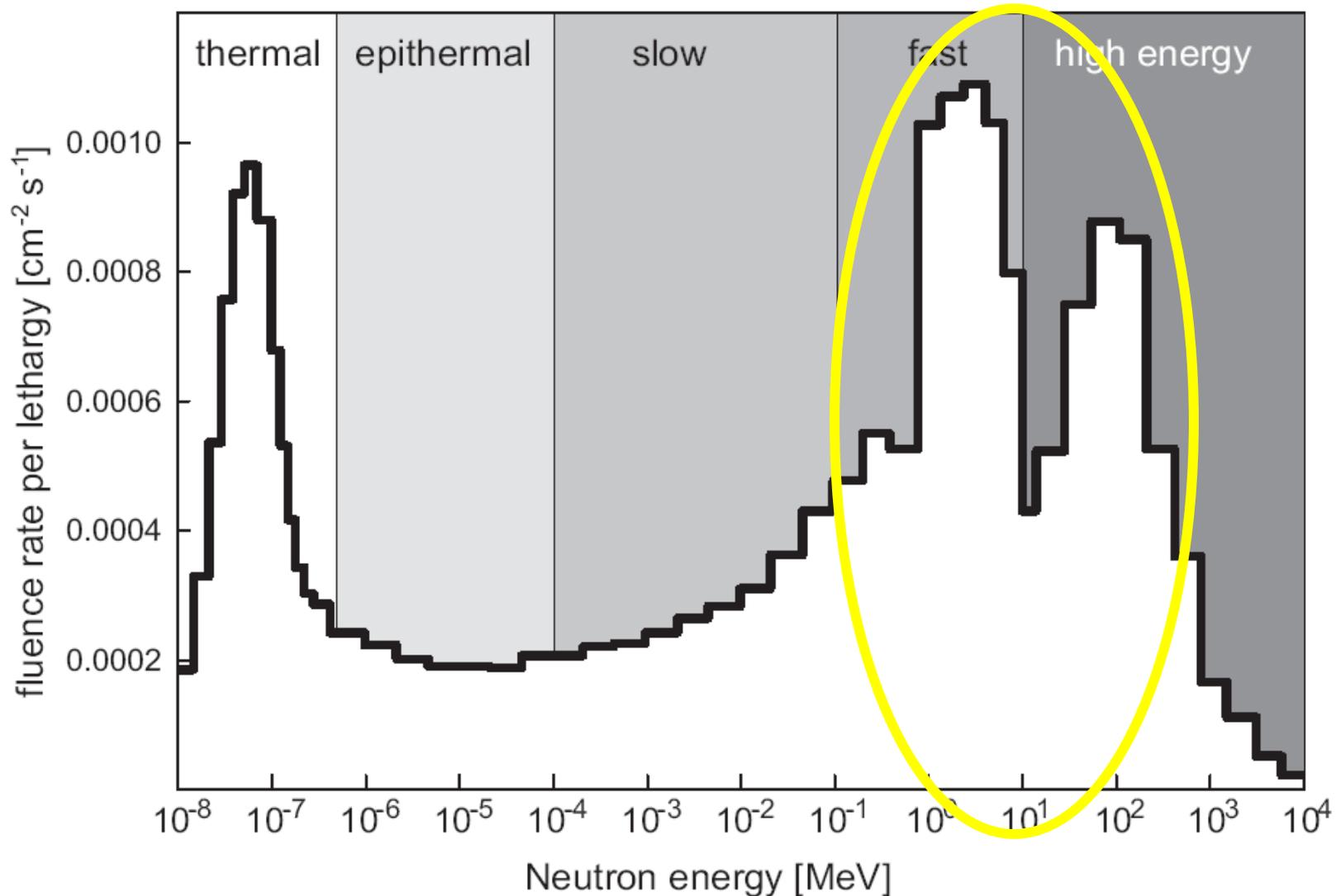


Primary Nature:
High-energy charged
particles

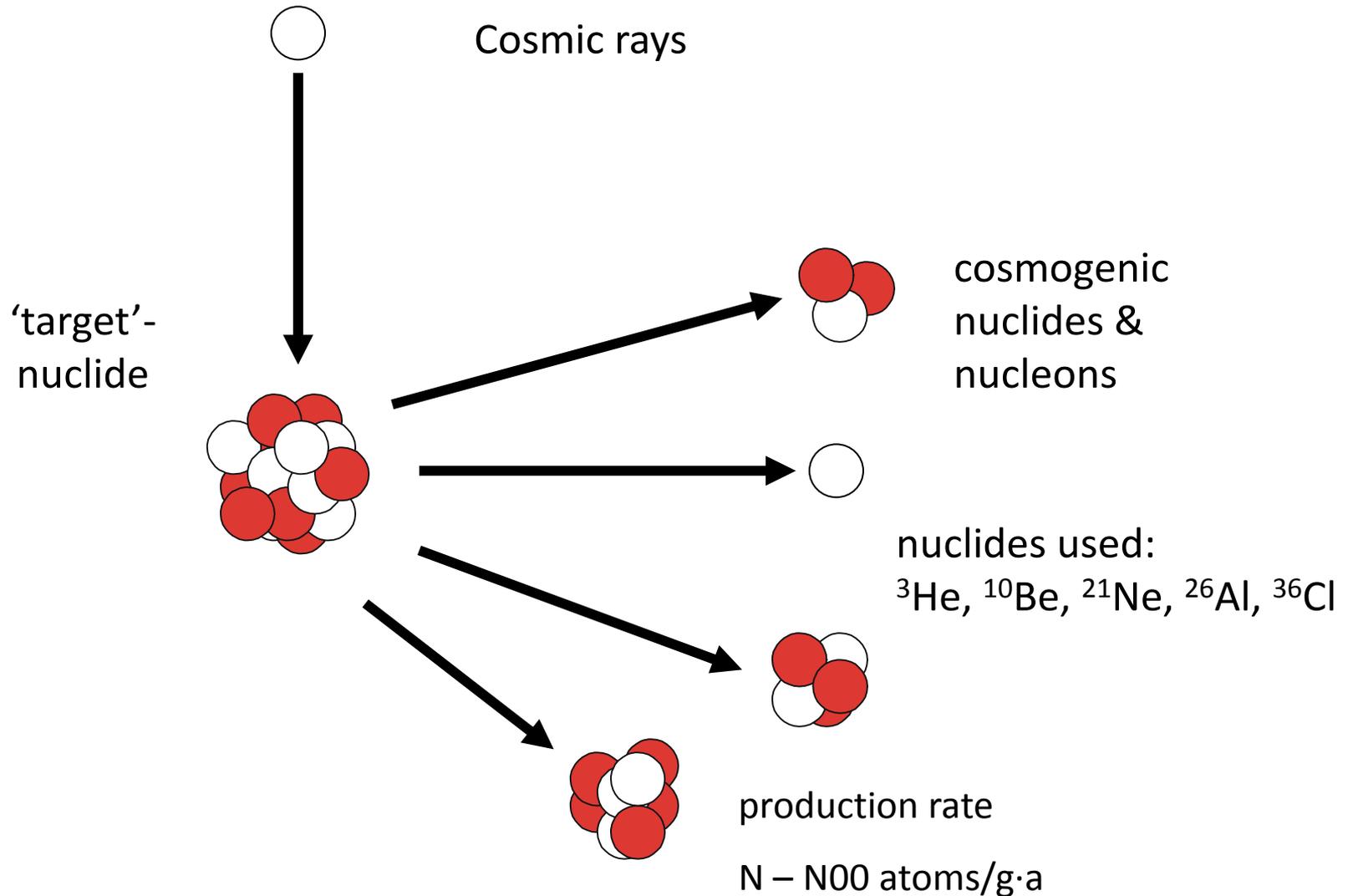
For geoscientists: high energy protons

Secondary nature: Neutrons

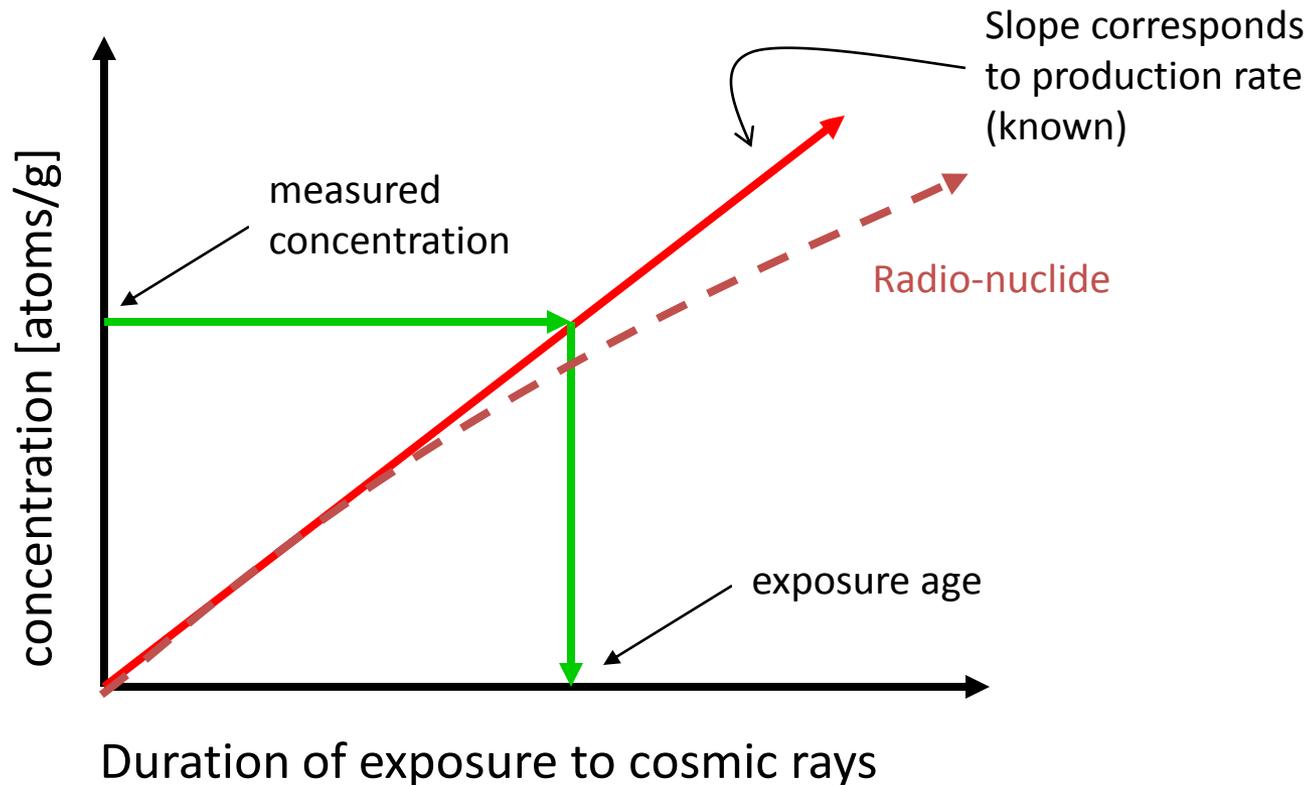
For Geoscientist of primary importance...



Production of cosmogenic nuclides

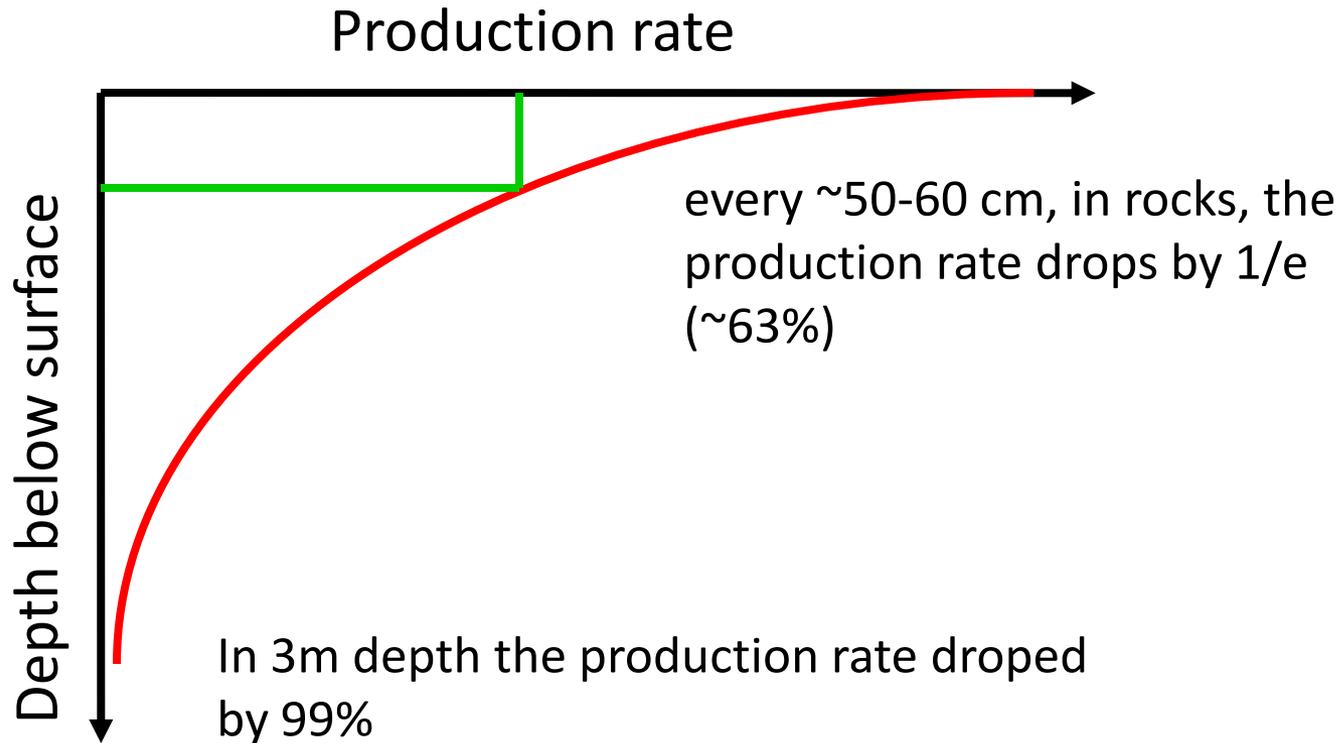


The concentration of cosmogenic nuclides in a sample is a function of the duration of exposure



This is the ideal case: no erosion

The production rate of cosmogenic nuclides decreases exponentially with depth





rock-falls



glacial and fluvial deposits



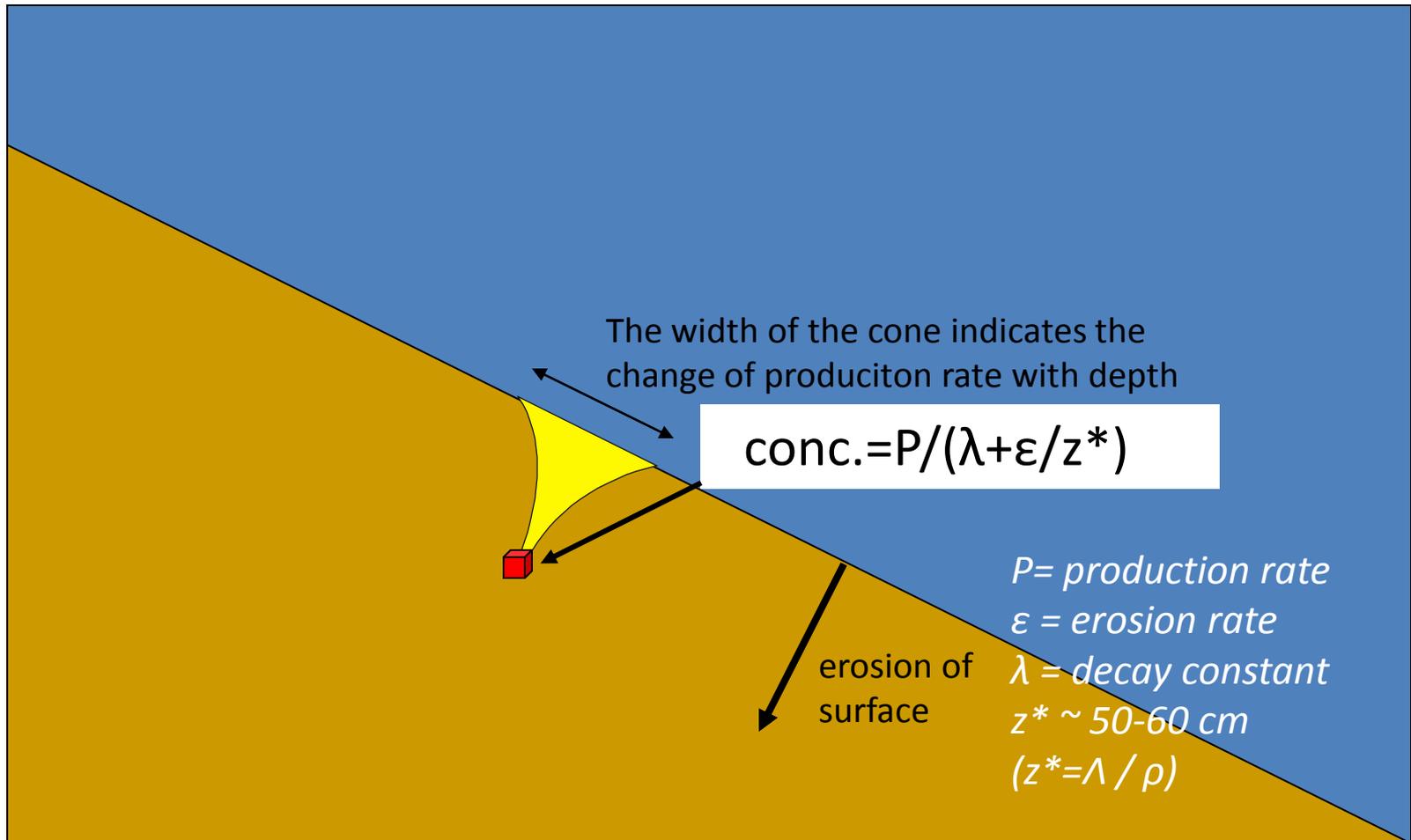
fault scarps

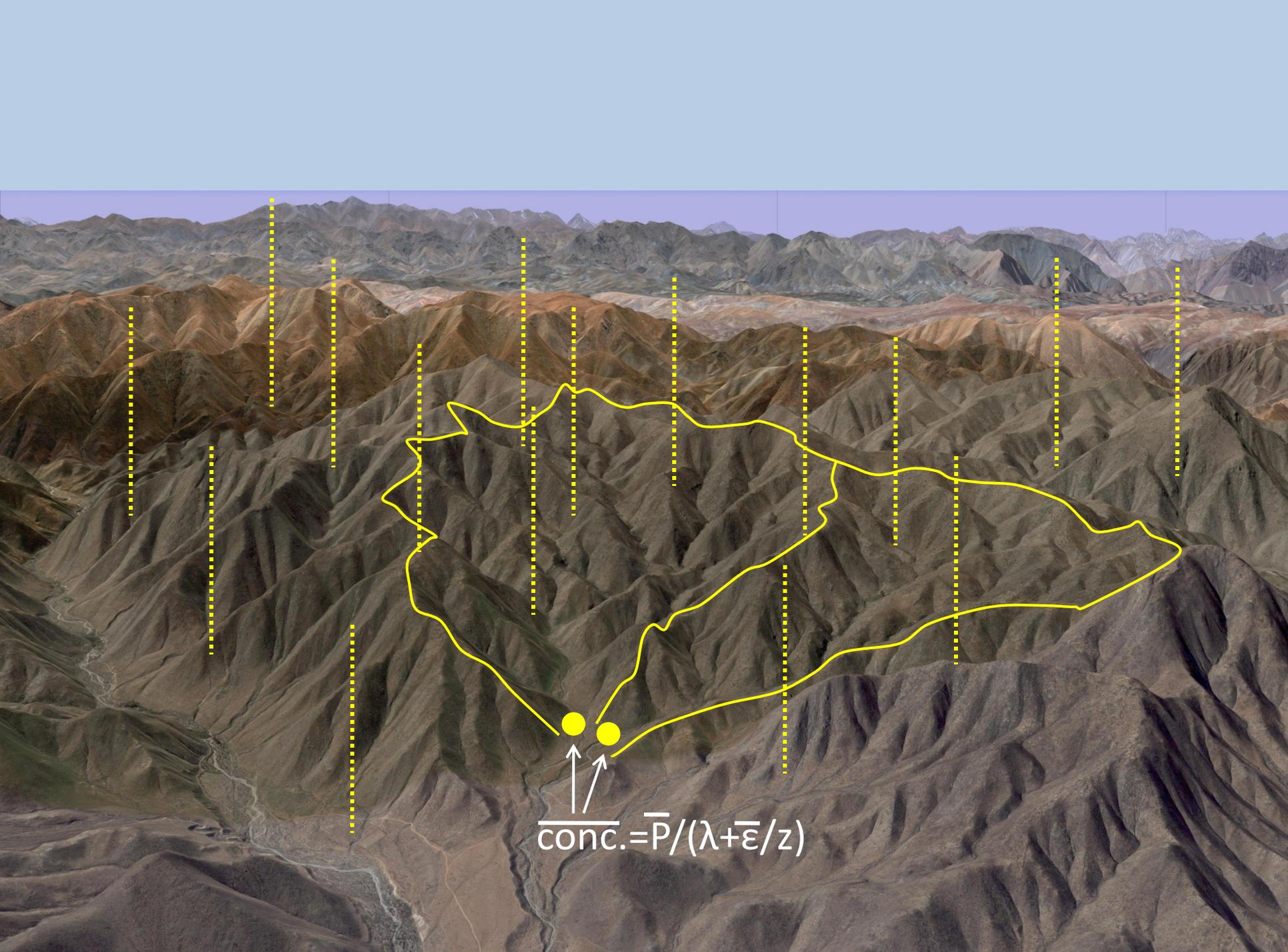


volcanic deposits

... in principle any surface that is created by a geological process (and more)

The concentration of cosmogenic nuclides is a function of the erosion rate





$$\overline{\text{conc.}} = \overline{P} / (\lambda + \overline{\epsilon} / z)$$

LETTERS

SCIENCE VOL 311 10 MARCH 2006

The Last Deglaciation of the Southeastern Sector of the Scand

nature

REPORTS

LETTERS
29 APRIL 2005 VOL 30

Early Local Last Glacial Maximum in the Tropics

Jacqueline A. Smith,^{1*} Geoffrey O. Seltzer,¹ Donald T. Rodbell,³

The local last glacial maximum in the tropics was more extensive than previously thought, based on 10Be dating) from moraines in Peru and Bolivia. The ice extent in the last glacial cycle ~34,000 years ago was retreating by ~21,000 years before the present. Ice on ice volumes were asynchronous with the present. Estimates of snowline depression reflect about half the temperature change indicated by previous widely cited figures, which helps resolve the discrepancy between estimates of terrestrial and marine temperature depression during the last glacial cycle.

Ice central

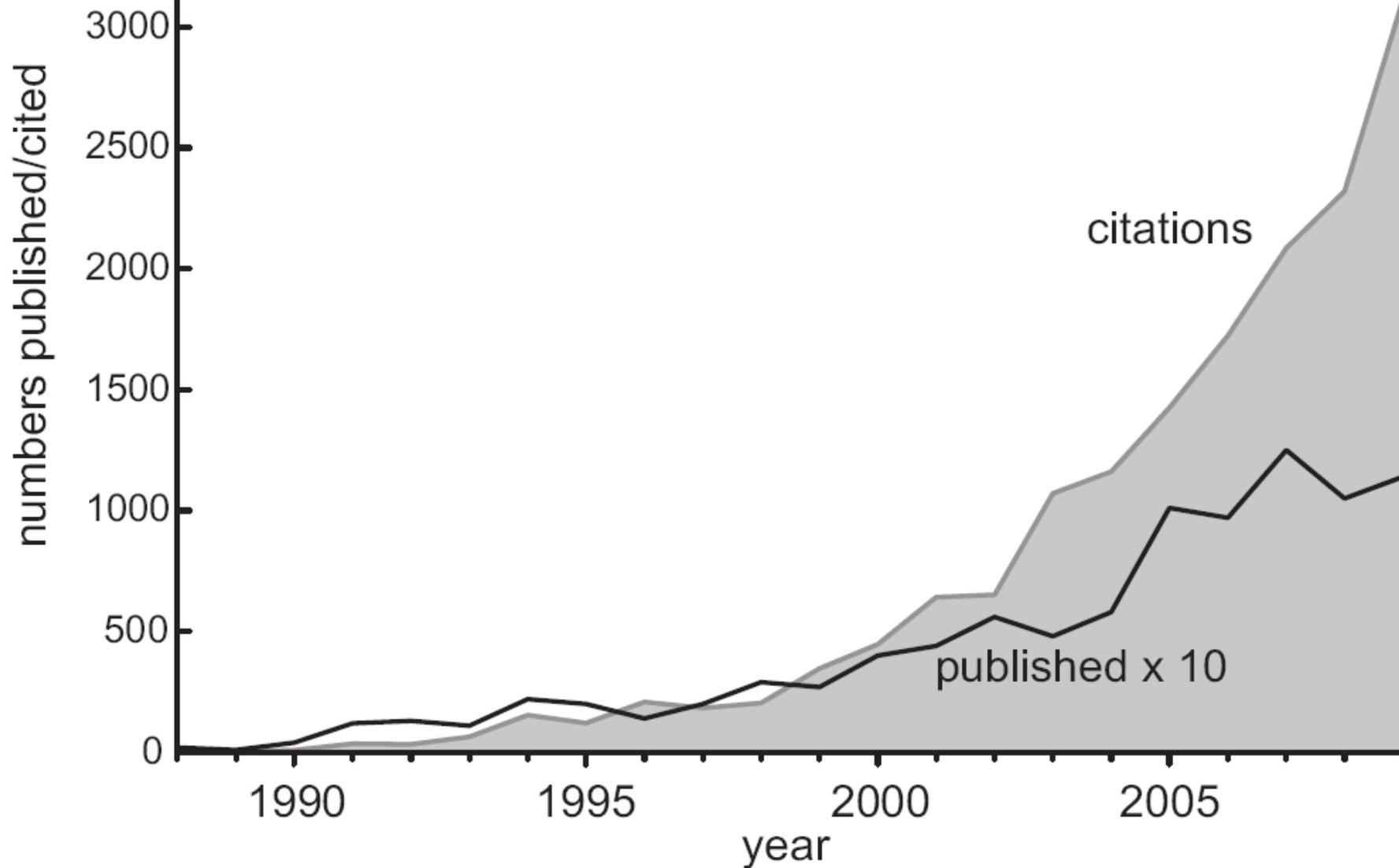
Patagonian Glacier Response During the Late Glacial–Holocene Transition

18 JULY 2008 VOL 321 SCIENCE

Robert P. Ackert Jr.,^{1*} Richard A. Becker,² Brad S. Singer,² Mark D. Kurz,³ Marc W. Caffee,⁴ David M. Mickelson²

Whether cooling occurred in the Southern Hemisphere during the Younger Dryas (YD) is key to understanding mechanisms of millennial climate change. Although Southern Hemisphere records do not reveal a distinct climate reversal during the late glacial period, many mountain glaciers readvanced. We show that the Puerto Bandera moraine (50°S), which records a readvance of the Southern Patagonian Icefield (SPI), formed at, or shortly after, the end of the YD. The exposure age (10.8 ± 0.5 thousand years ago) is contemporaneous with the highest shoreline of Lago Cardiel (49°S), which records peak precipitation east of the Andes since 13 thousand years ago. Absent similar moraines west of the Andes, these data indicate an SPI response to increased amounts of easterly-sourced precipitation—reflecting changes in the Southern Westerly circulation—rather than regional cooling.

Papers on Earth science applications of cosmogenic nuclides



Emerging Research Infrastructure in Europe



CologneAMS (June 2010)



ASTER, CEREGE, Univ. Marseille (2008)

Smiles all around? Or are there problems...

Smiles:

- Combined calibration efforts of CRONUS-EU (FP6 MC-RTN) and CRONUS-Earth (NSF) reduced systematic uncertainties to $< 5\%$ for **many** localities world-wide.
- analytical methodology is improved and research infrastructure built (e.g. four dedicated AMS-facilities in Europe since 2005).
- training of young scientists (e.g. 10 postdocs in CRONUS-EU, all found further employment in research institutions).

Problems:

- CRONUS calibration studies revealed inadequacies of models for high-mountain altitude, the site of unique climate records (e.g. tropical glaciers).
- This problem arises mainly from our patchy knowledge of neutron energy spectra for the deep atmosphere (i.e. the part that is relevant for geosciences).

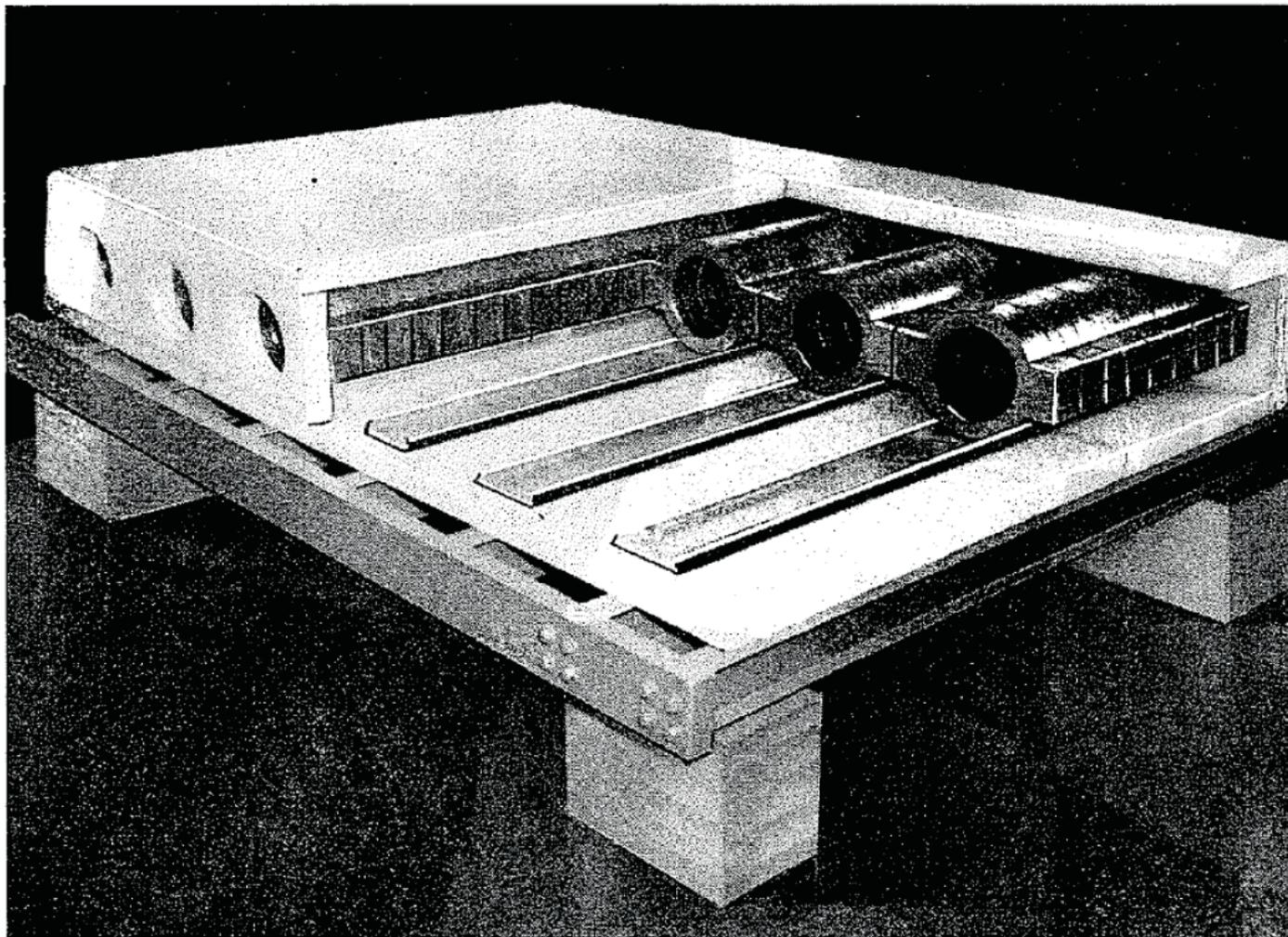


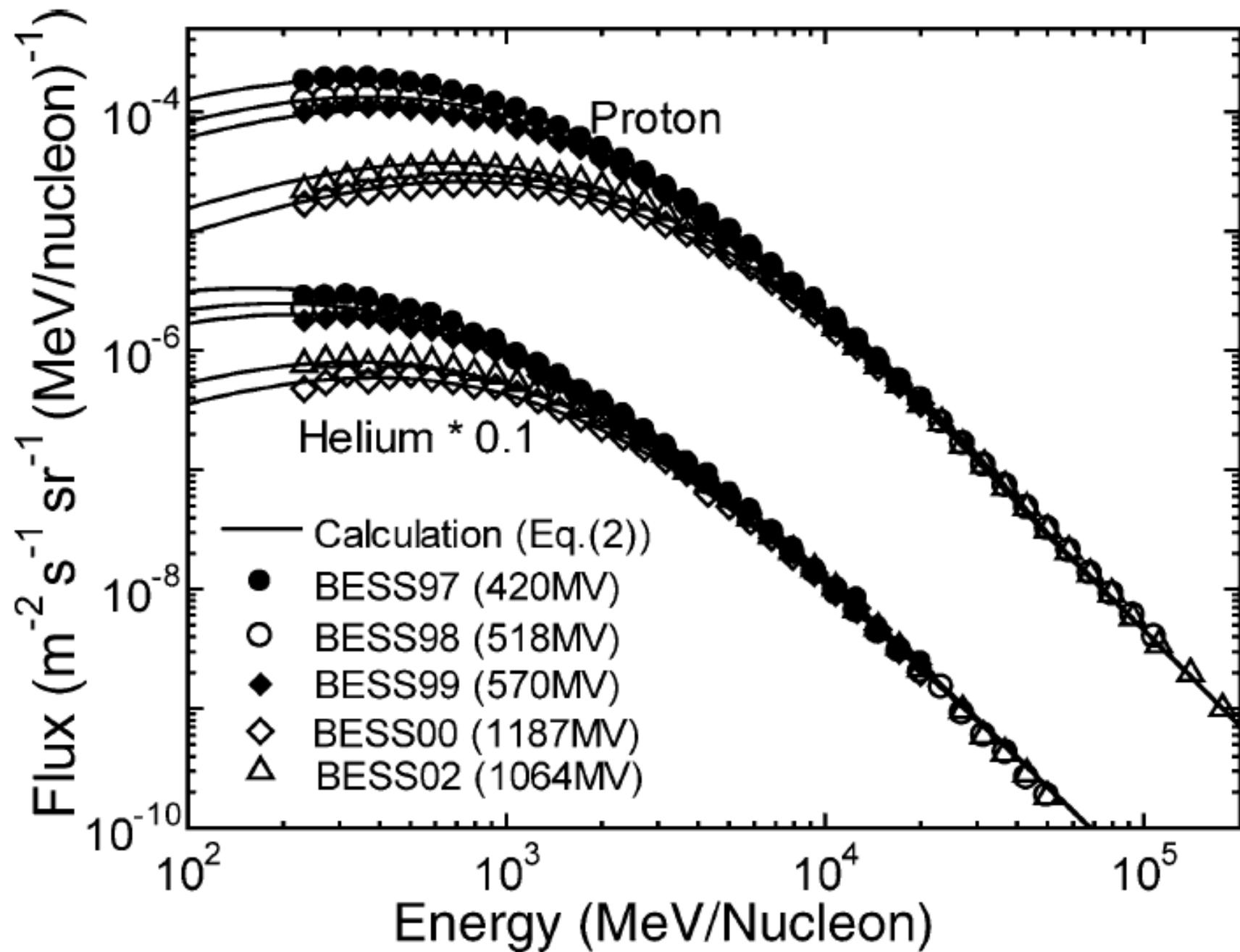
FIG. 2. A 6-counter unit of an NM-64 neutron monitor during construction.

All currently used scaling factors rely on data from station and survey monitors that have a marginal capacity to resolve the neutrons' energy

BESS

Balloon-borne Experiment with Superconducting Spectrometer
(ISAS/JAXA & NASA; 2004-2007)







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Cosmic rays 'harm pilots' sight'

Airline pilots may be at increased risk of eye damage because of their exposure to cosmic radiation, warn experts.

The Icelandic researchers found commercial pilots were three times more likely than normal to develop cataracts - clouding of the lens of the eye.

Cosmic rays - very energetic particles and radiation which bombard the Earth from outer space - have already been linked to cataracts among astronauts.

The research appears in the journal Archives of Ophthalmology.

Cataracts

The authors looked at 445 men aged 50 and over - 71 of whom had a type of cataract called nuclear cataract and 374 with other or no lens problems. Among the men, 79 were commercial pilots and 366 had never been pilots.

When the researchers compared the rates of cataracts with occupation, they found pilots were far more likely than the other men to have this eyesight problem.



Frequent flying may push pilots' exposure over safe limits

SEE ALSO:

- Hundreds ring cataracts helpline 08 Oct 04 | Devon
- Patients get 'private' eye ops 07 Jun 04 | Cumbria
- Asthma drug 'raises cataract risk' 18 Sep 03 | Health

RELATED INTERNET LINKS:

- Archives of Ophthalmology
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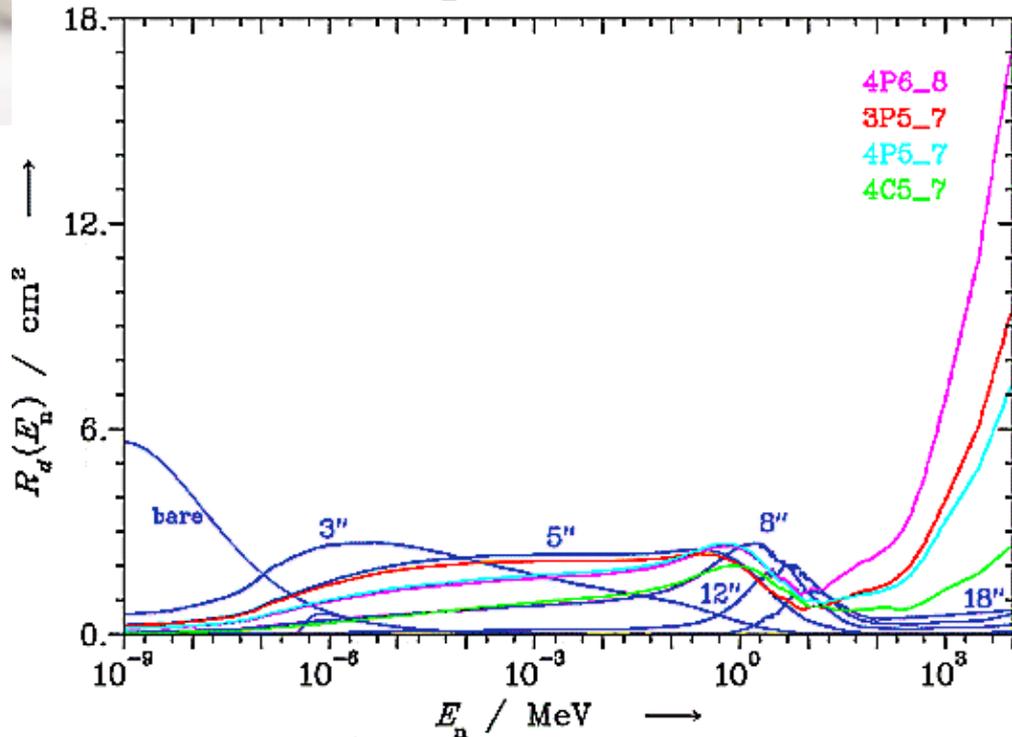
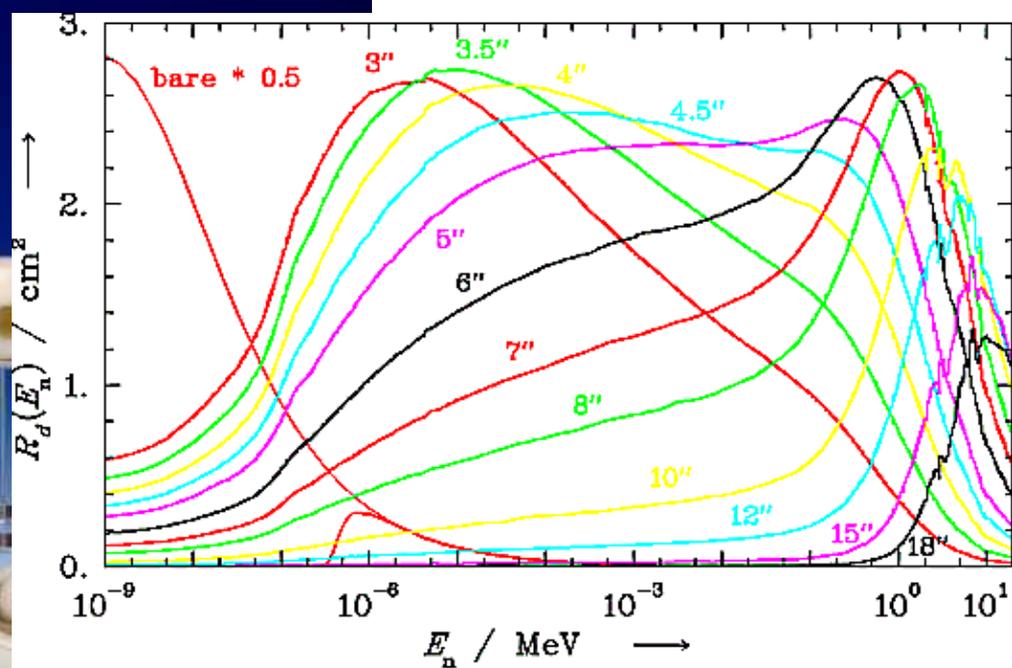
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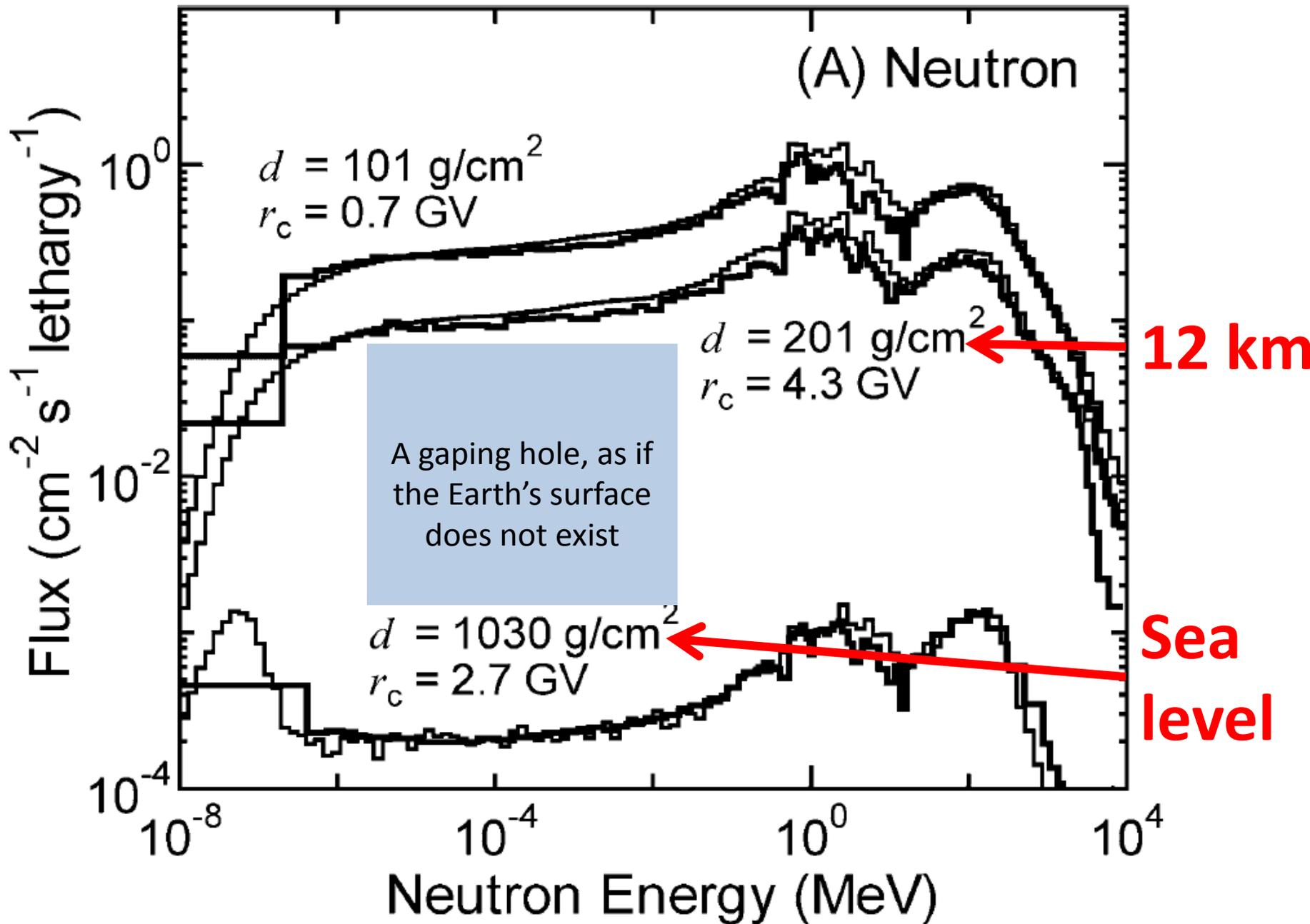


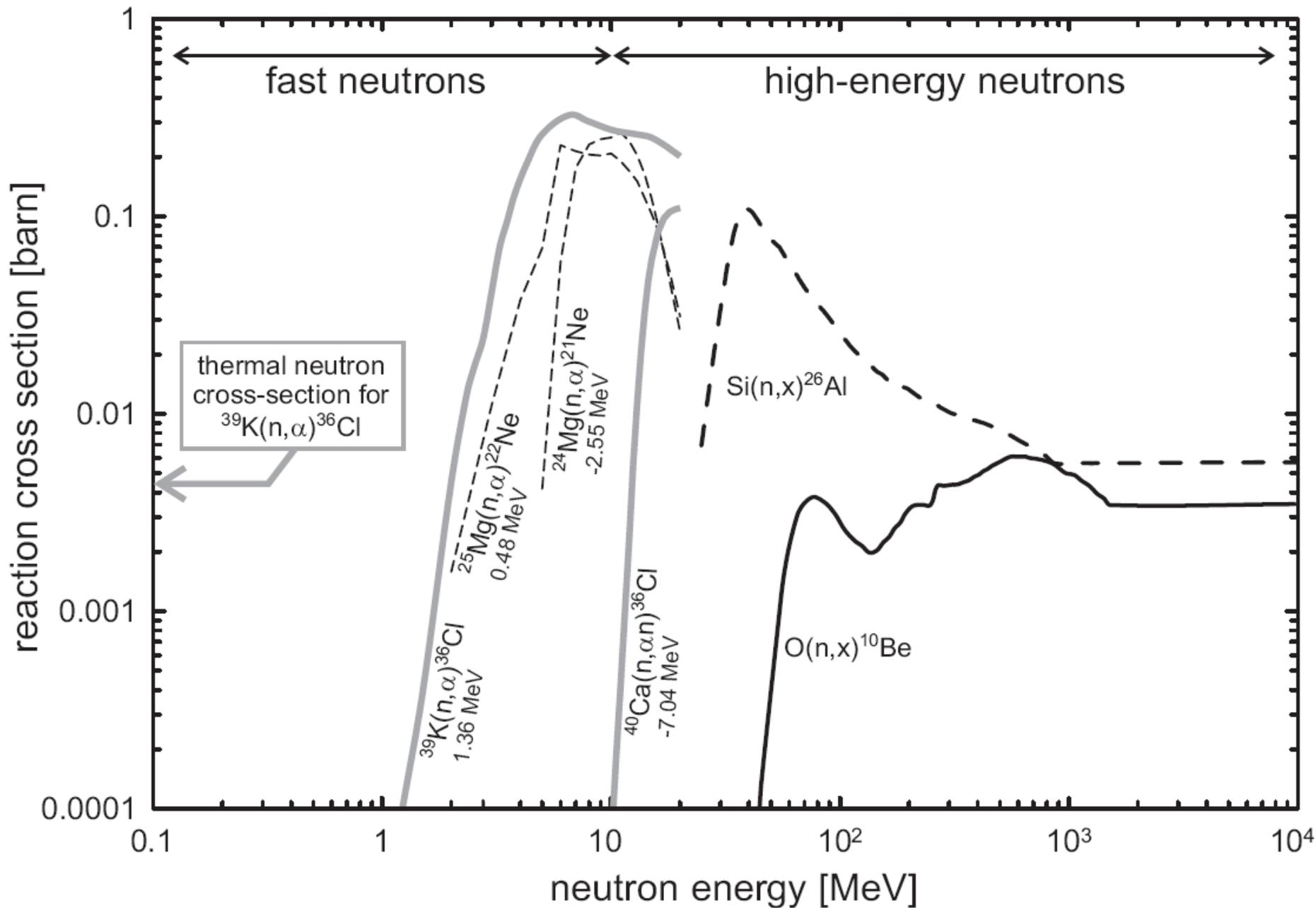
News feeds



Bonner Spheres allow the detailed description of the secondary neutron energy spectrum

- available since the 1960's
- environmental surveys since 2002





Required next steps

- Latitude and altitude surveys with energy-dispersive neutron monitors at altitudes relevant for Earth-surface processes.
- Conduct surveys at solar minimum and maximum.
- This would allow the full description of the neutron flux relevant for cosmogenic nuclide production.
- Merging this information with new reaction cross-section data.
- Result: accurate exposure ages would be routinely possible at **all** latitudes and altitudes.

Why do I state this here?

- The (astro-)physics community helped to generate the present methodological framework for cosmogenic nuclide production for geoscientists as a by-product (which served geosciences remarkably well).
- The quality upgrade sought, would require a tailor-made product; this to achieve the accuracy needed for pertinent research questions (e.g. paleo-climatology).
- The astrophysics community has the infrastructure, as well as the expertise, to help to realize this enterprise in collaboration with dedicated 'cosmogenic' geoscientists.
- What is needed is - hard to come by - interdisciplinary funding.

