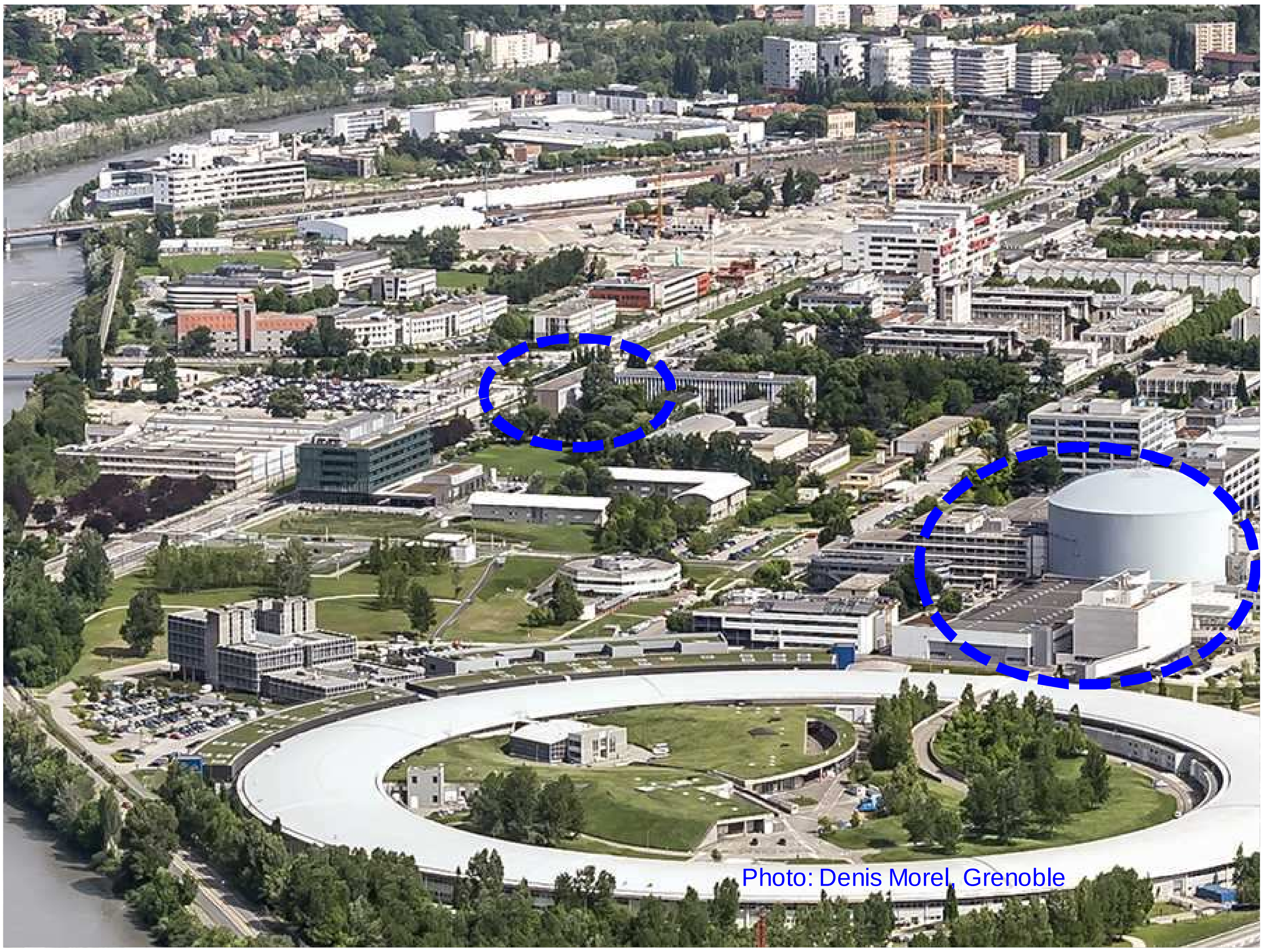
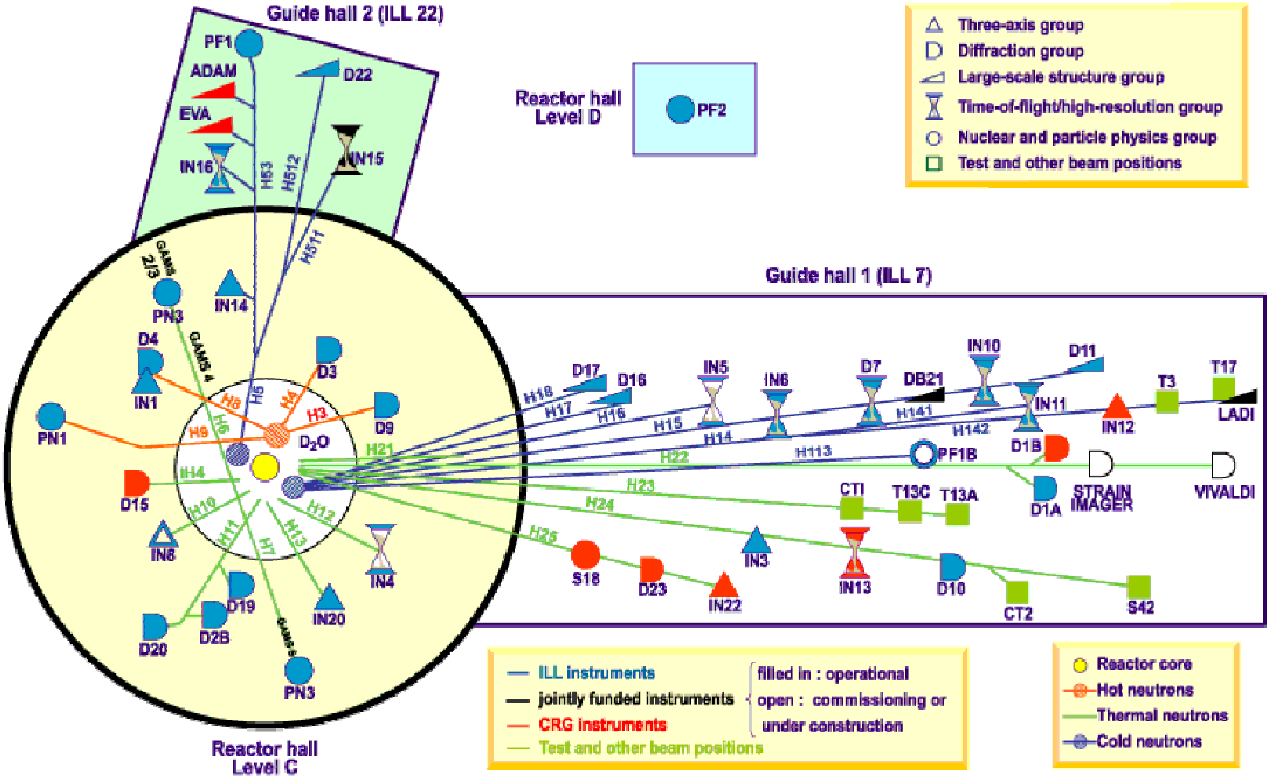
Opportunities for Test Experiments at ILL Grenoble

Ulli Köster

16 October 2015

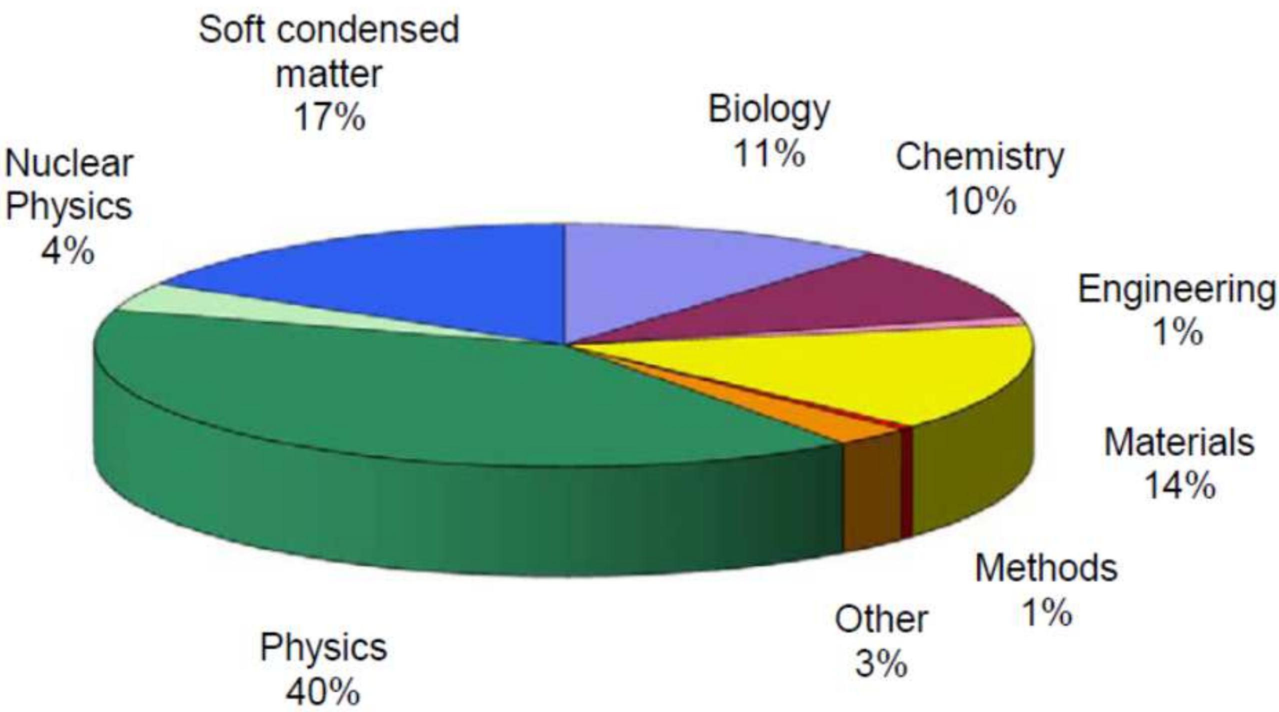


ILL instruments

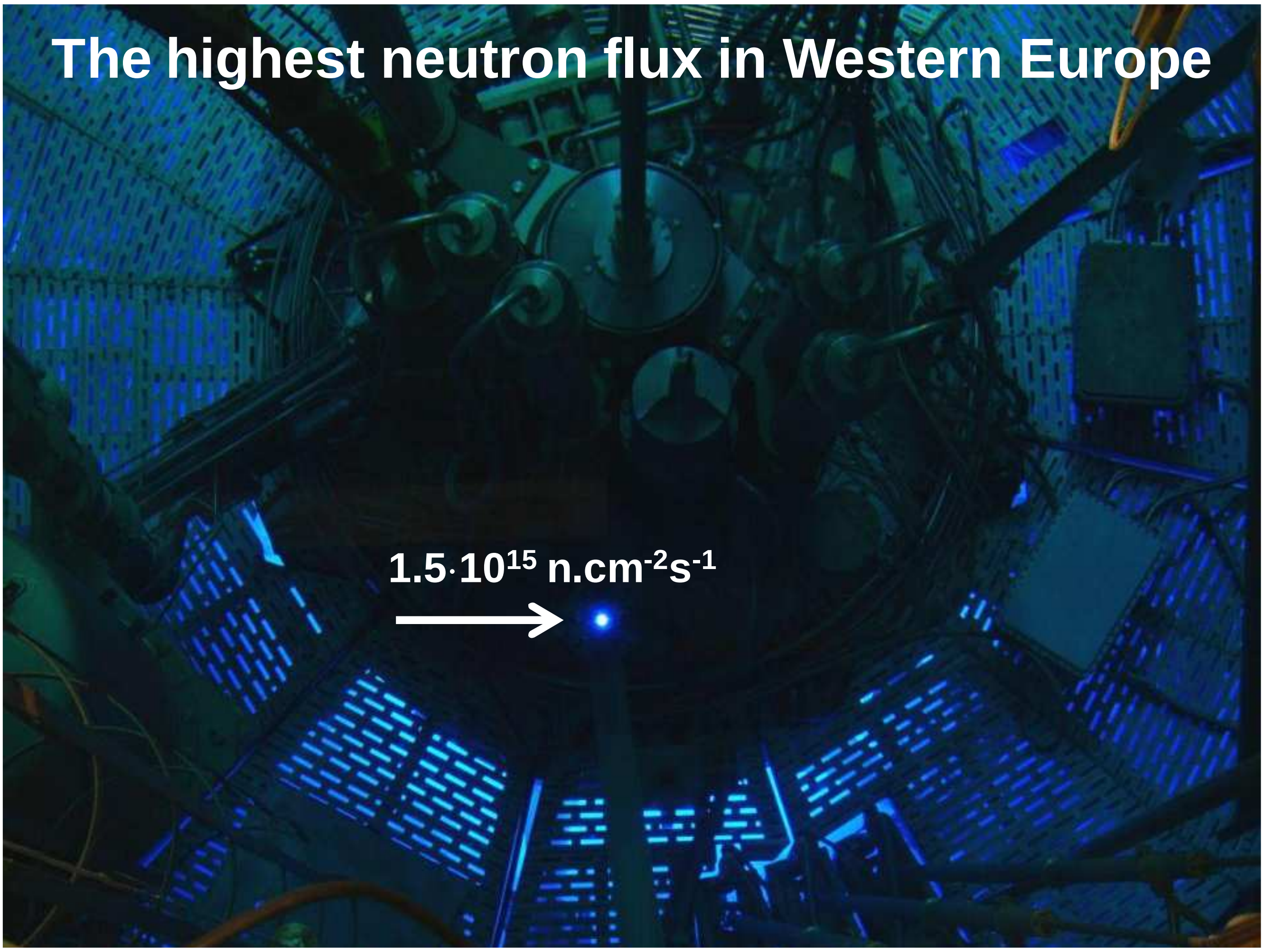


40 instruments running simultaneously for 200 days per year

Research area of the submitted proposals

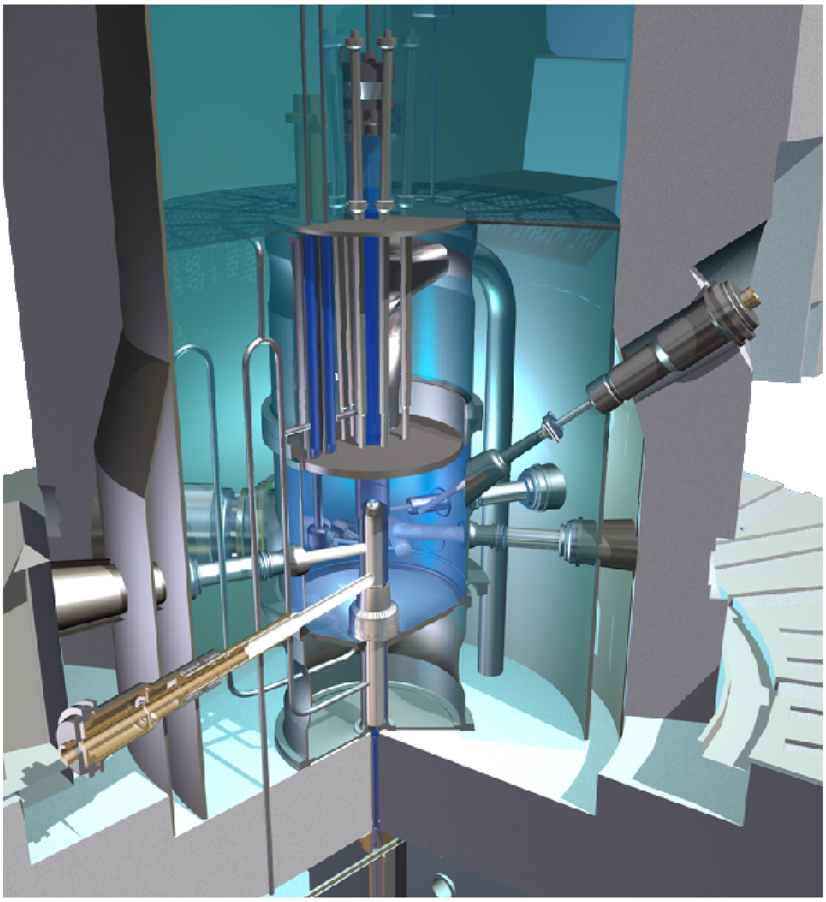


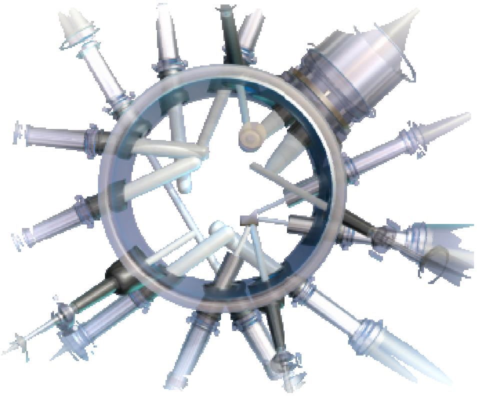
The highest neutron flux in Western Europe



The rising star for radionuclide therapy

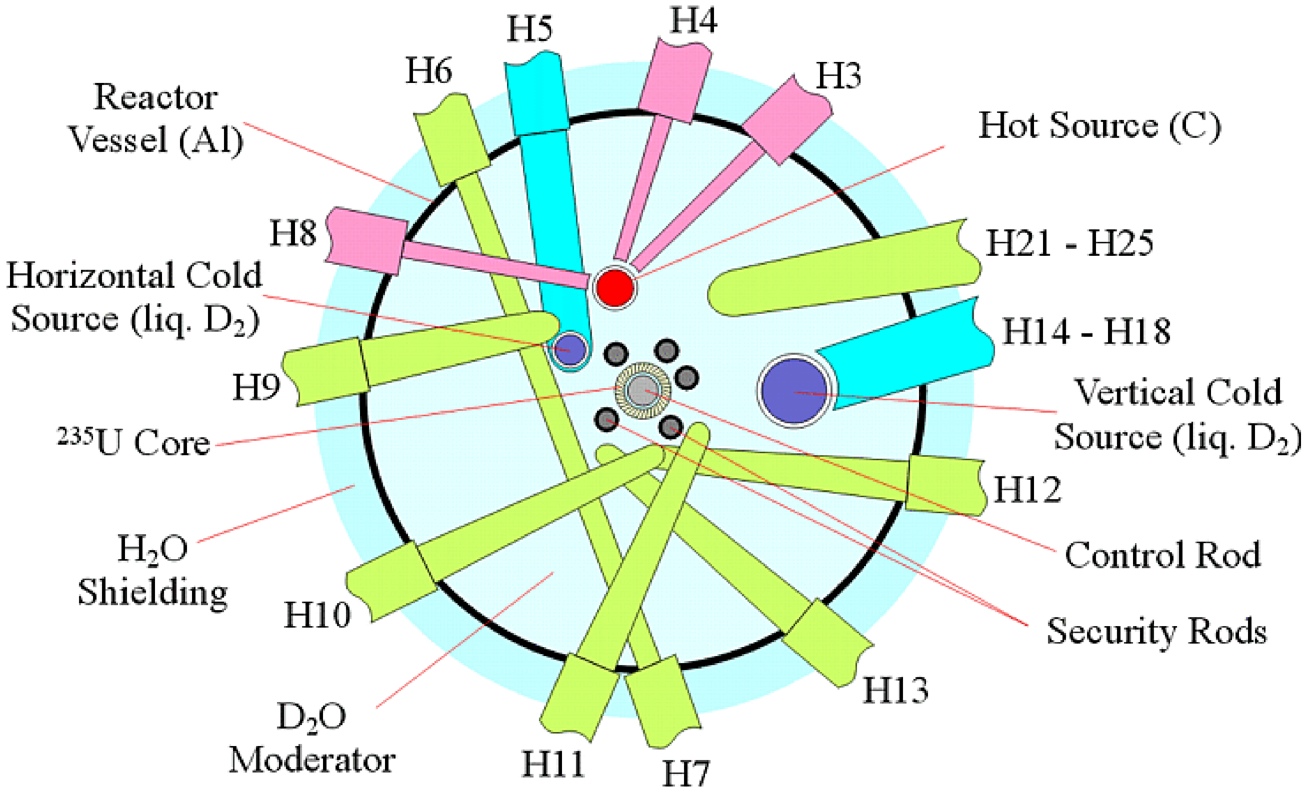
The ILL Reactor





$5 \cdot 10^{18}$ neut./s generated at 57 MW

Thermal, cold and hot neutrons



Neutrograph: intense thermal neutron beam

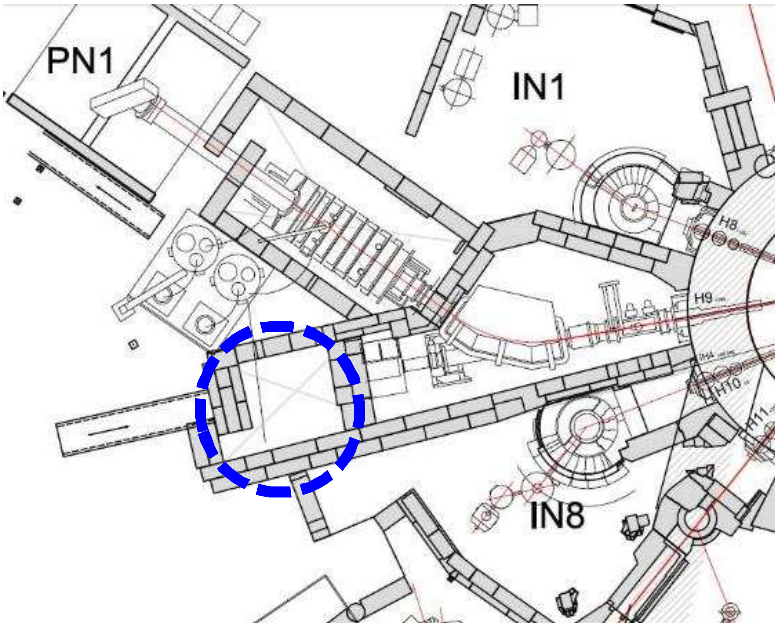
Flux $3 \cdot 10^9$ n.cm^{-2}s^{-1}

Beam 20 x 16 cm^2

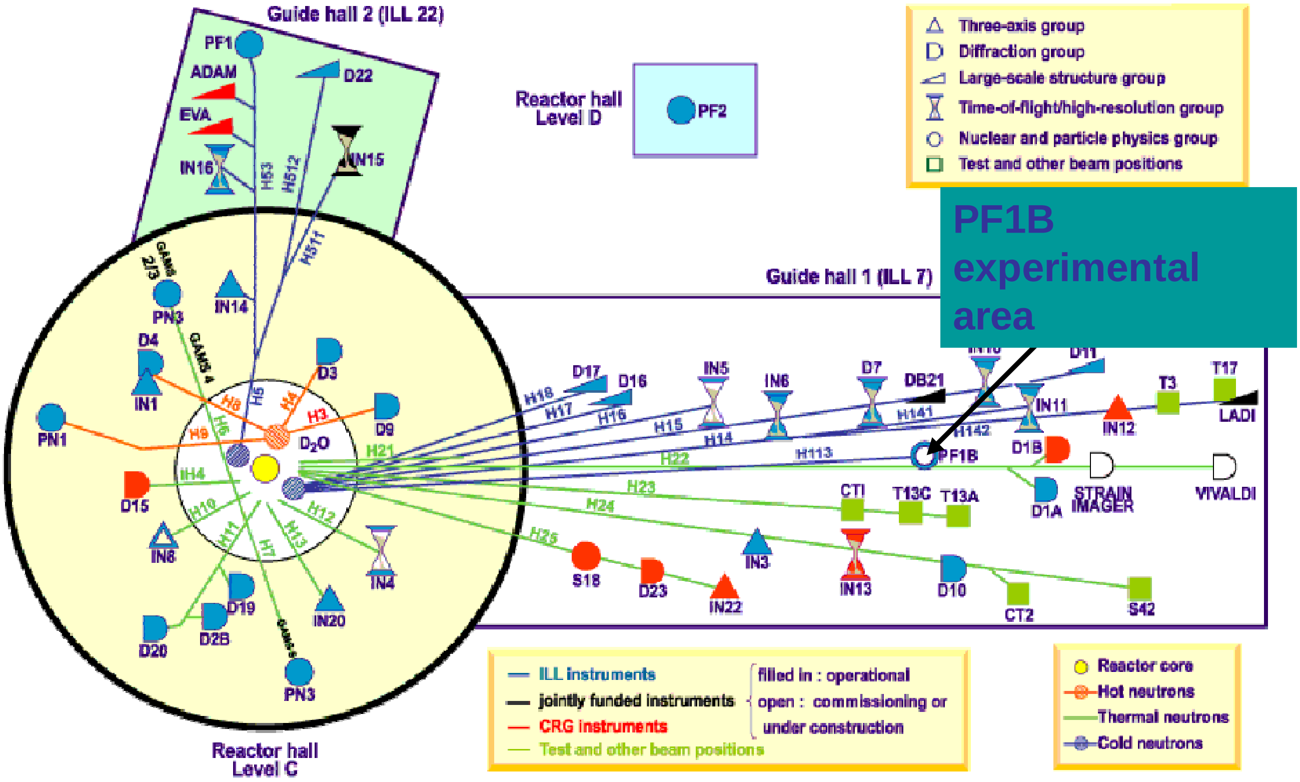
L/D~140, i.e. θ ~ 7 mrad

1.6 m x 2.6 m usable area in casemate

1 m heavy concrete shielding

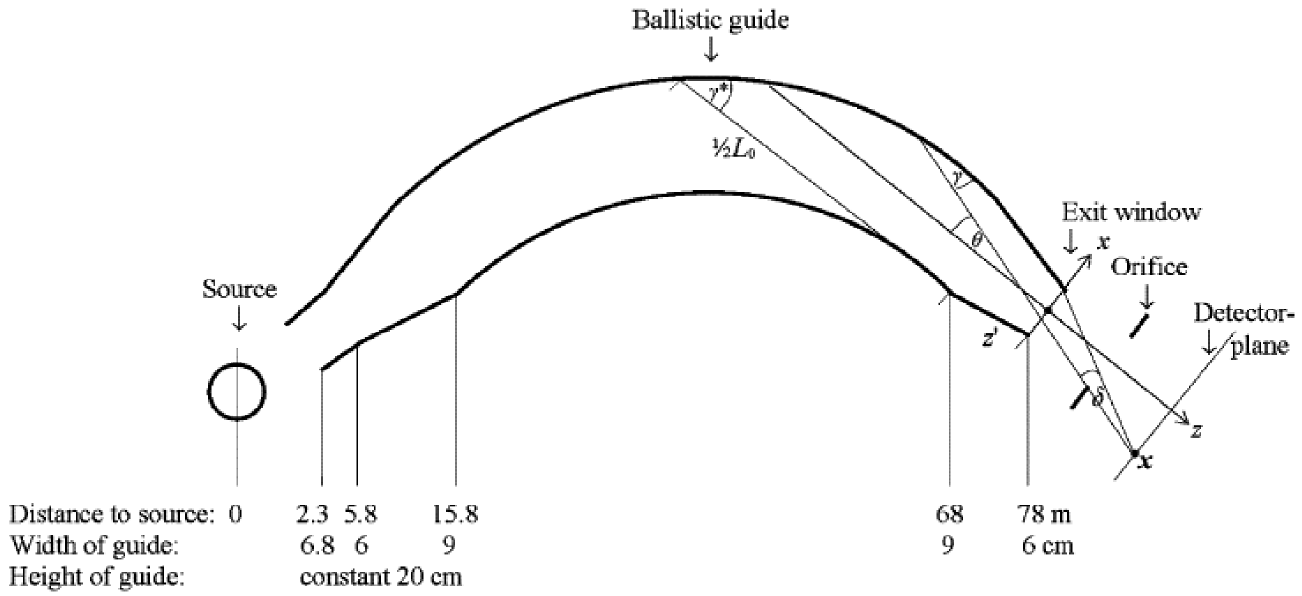


ILL instruments



40 instruments running simultaneously for 200 days per year

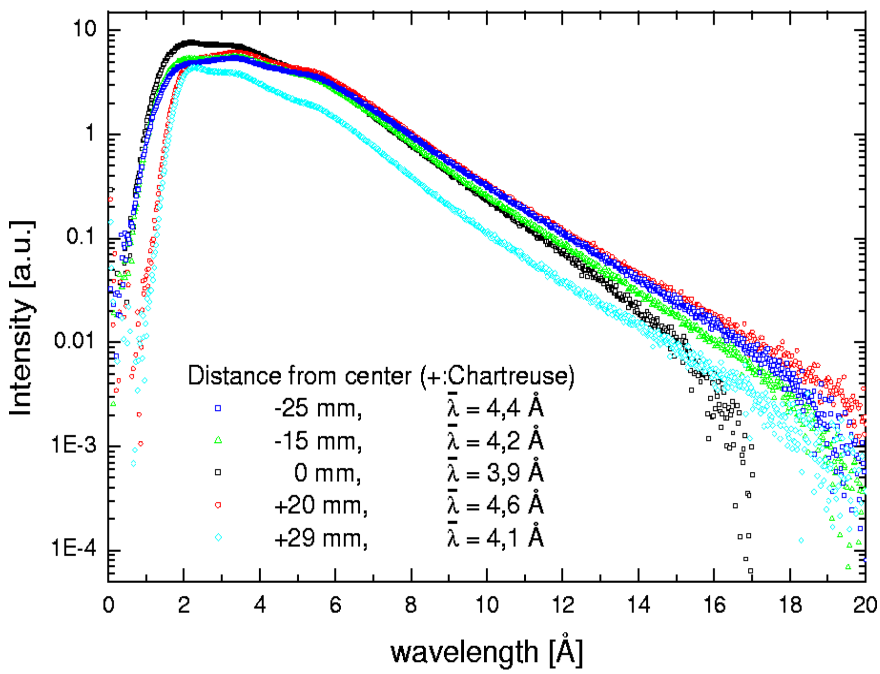
Guided neutron beams are “clean”



Fast neutrons and gamma rays are not transported.

H. Abele et al. Nucl. Instr. Meth. A562 (2006) 407.

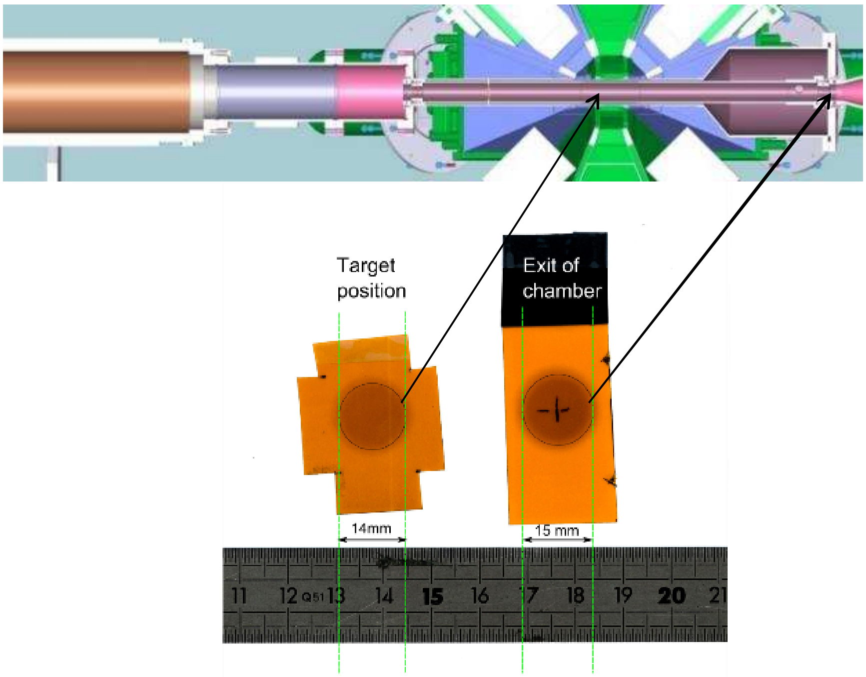
Cold neutron beam H113 to PF1b



H. Abele et al. Nucl. Instr. Meth. A562 (2006) 407.

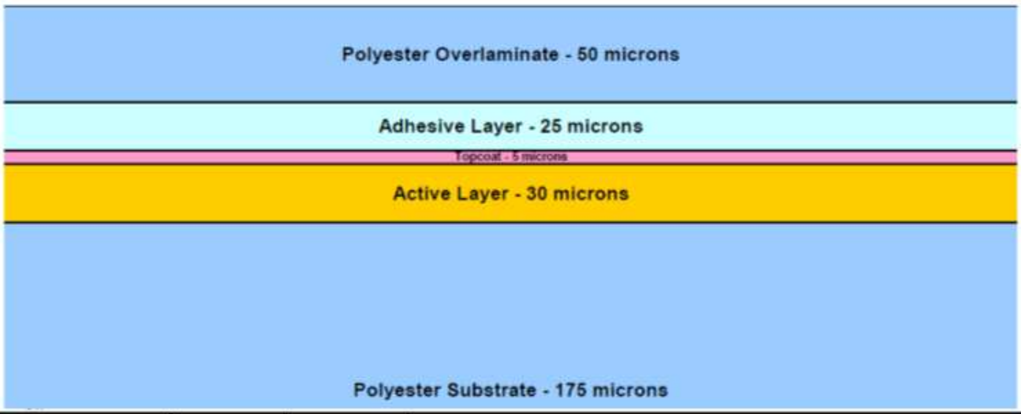
- Ballistic supermirror neutron guide H113:
  76 m length
- **$2 \cdot 10^{10}$ n.cm^{-2}s^{-1} on 20x6 cm^2**
- **0.7 mrad divergence**
- **Gamma ray flux from the reactor: negligible**
- Ratio slow neutrons to fast neutrons is ~10^6
- **Average neutron energy:**
  <E> ≈ 5 meV

Measurement of collimation performance



A. Blanc et al. EPJ Web of Conferences 62 (2013) 01001.

Gafchromic radiochromic films



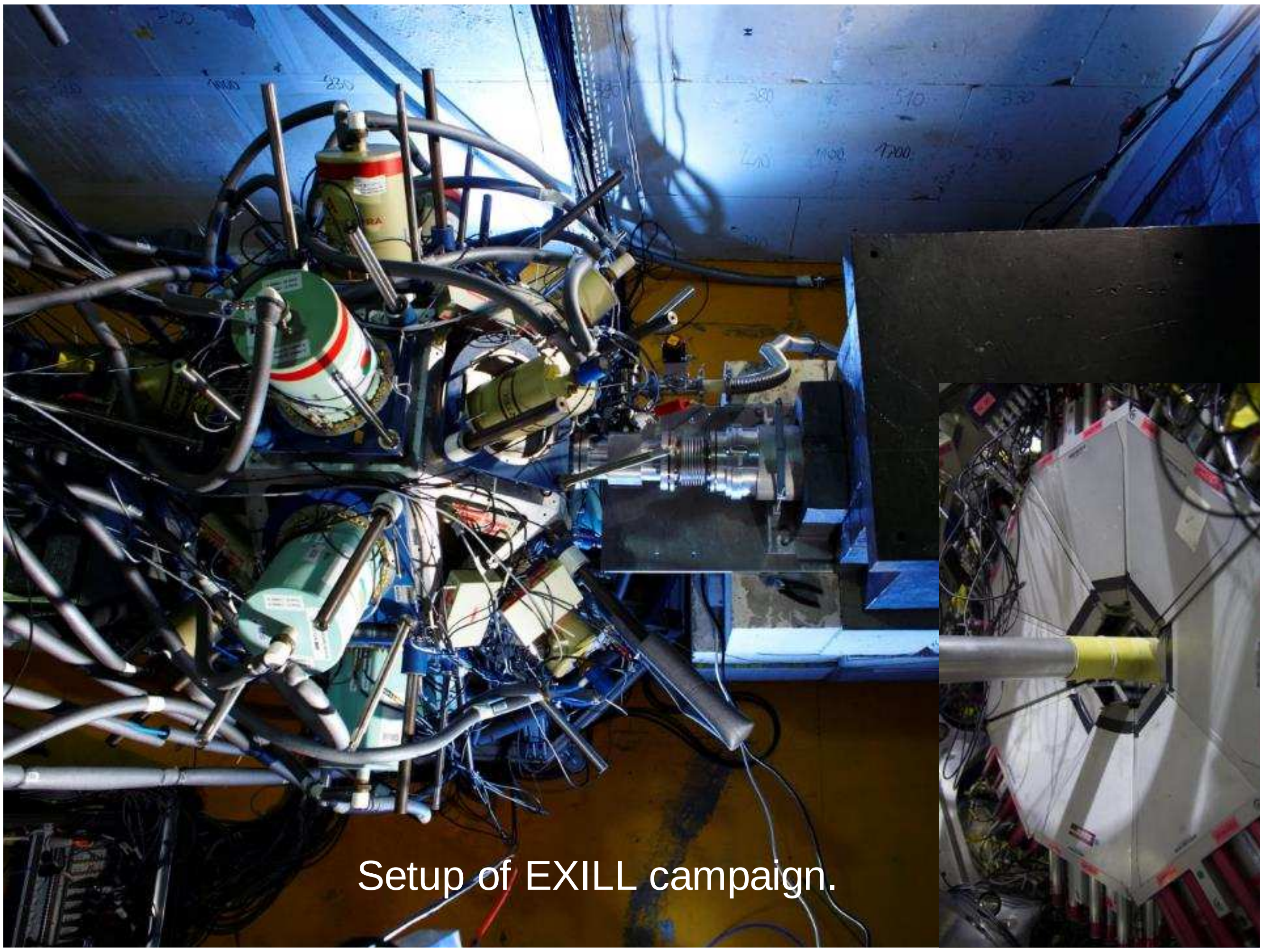
Layer	Thickness*** microns	Approximate density g/cm2	COMPOSITION (ATOM%)									
			H	Li	C	N	O	Na	S	Cl	K	Br
Polyester film base*	50	1.35	36.4%	0.0%	45.5%	0.0%	18.2%	0.0%	0.0%	0.0%	0.0%	0.0%
Adhesive*	25	1.2	57.1%	0.0%	33.3%	0.0%	9.5%	0.0%	0.0%	0.0%	0.0%	0.0%
Surface layer (assumes 7.5% moisture)**	5	1.2	56.9%	0.9%	25.7%	0.0%	15.6%	0.0%	0.0%	0.9%	0.0%	0.0%
Active layer (assumes 7.5% moisture)**	30	1.2	58.3%	0.8%	29.6%	0.1%	10.7%	0.0%	0.0%	0.3%	0.1%	0.1%
Polyester film base*	175	1.35	36.4%	0.0%	45.5%	0.0%	18.2%	0.0%	0.0%	0.0%	0.0%	0.0%
Overall Composition			40.85%	0.10%	42.37%	0.01%	16.59%	0.00%	0.00%	0.04%	0.01%	0.01%

http://www.ashland.com/Ashland/Static/Documents/ASI/Advanced%20Materials/lewis-radiochromic-film.pdf

Active layer: lithium pentacosa-10,12-diynoate

Slow neutrons capture 50% in Li, 25% in N
⇒ Recoils dominate local polymerization and colouring

Excellent beam collimation



Setup of EXILL campaign.

How dangerous are slow neutrons?

ELSEVIER

ICRP Publication 116

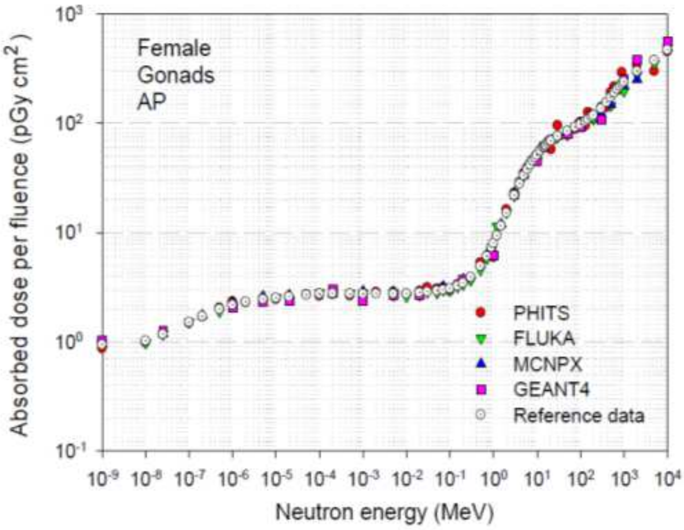
ICRP
Annals of the ICRP

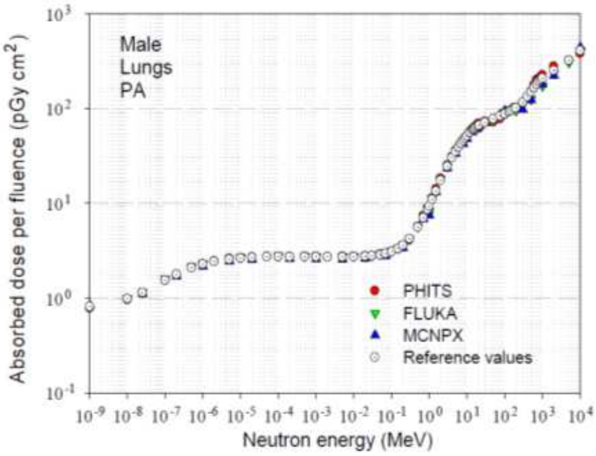
Conversion Coefficients for Radiological Protection Quantities for External Radiation Exposures

ICRP PUBLICATION 116

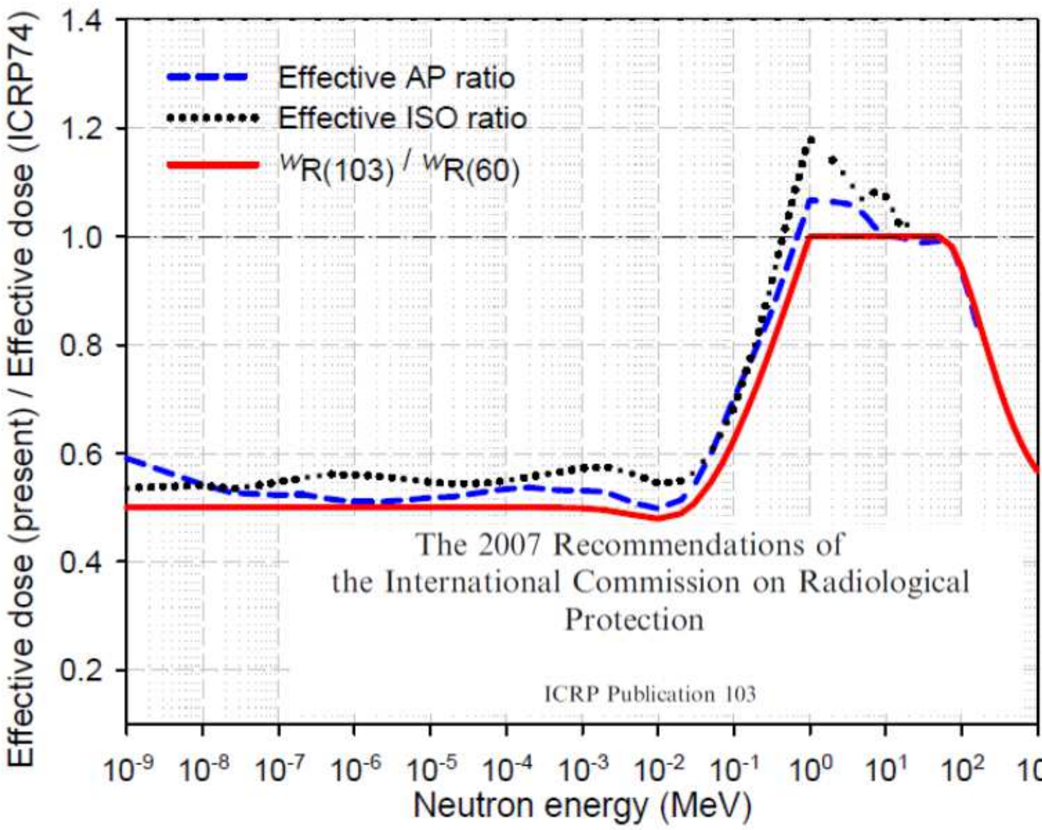
Approved by ICRP in October 2010 and

adopted by ICRU in November 2010

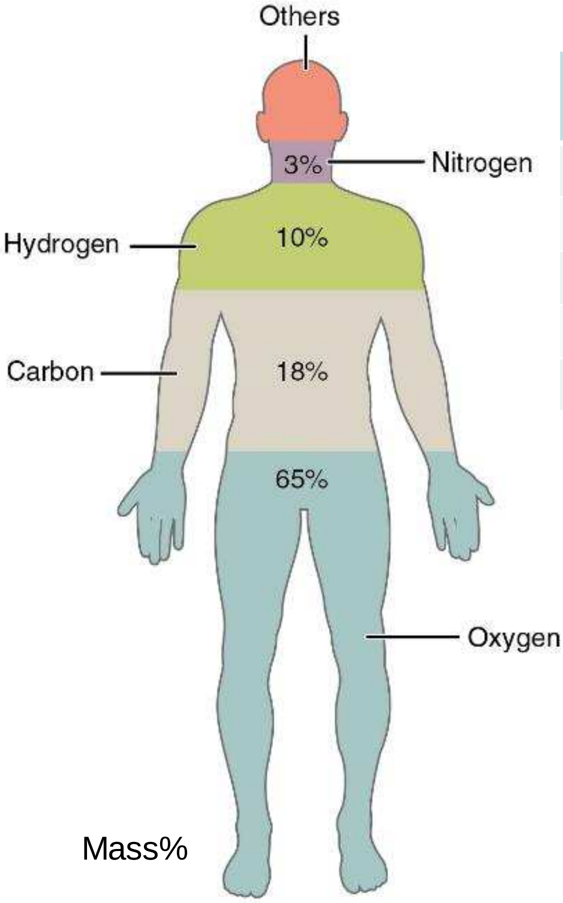




Slow neutrons got less dangerous

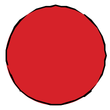


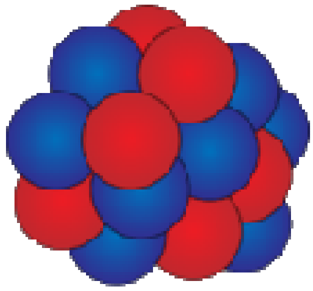
A human as neutron target



Ele-ment	Atom %	Captures	Gamma dose	Recoil dose
H	62	86%	82%	2%
C	12	0.2%	0.4%	0%
N	1.1	9%	1.7%	98%
O	24	0.0%	0.1%	0%
Cl	0.02	3.4%	12%	0%

$^{14}N(n,p)$

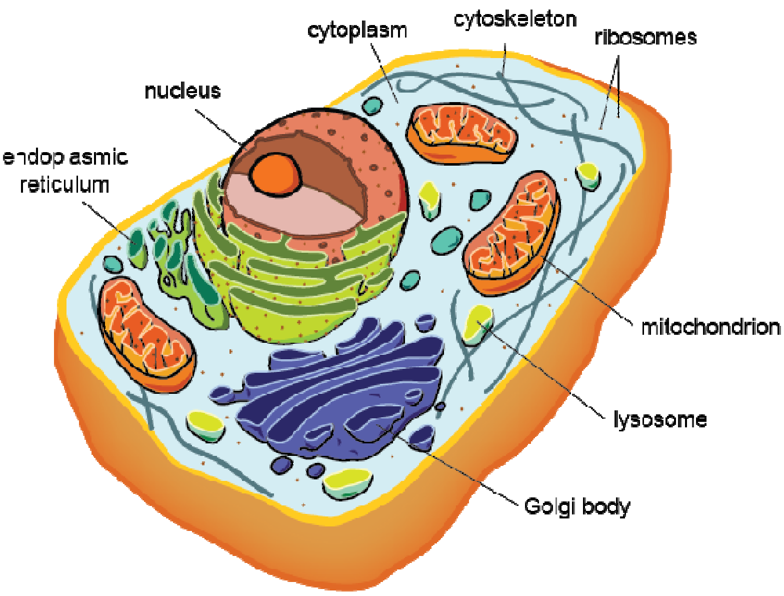




p
12 μm
12 keV/μm

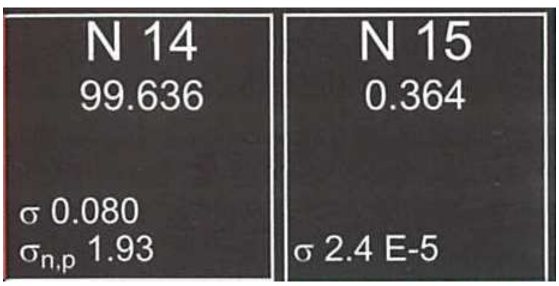
^{14}C
0.25 μm
170 keV/μm

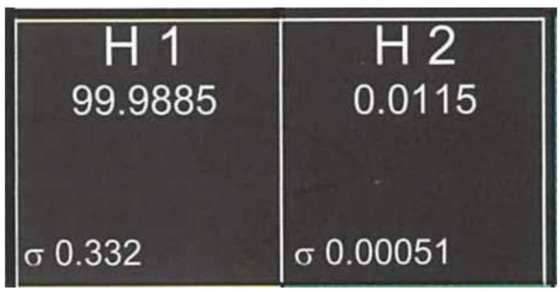
Microscopic nitrogen distribution?



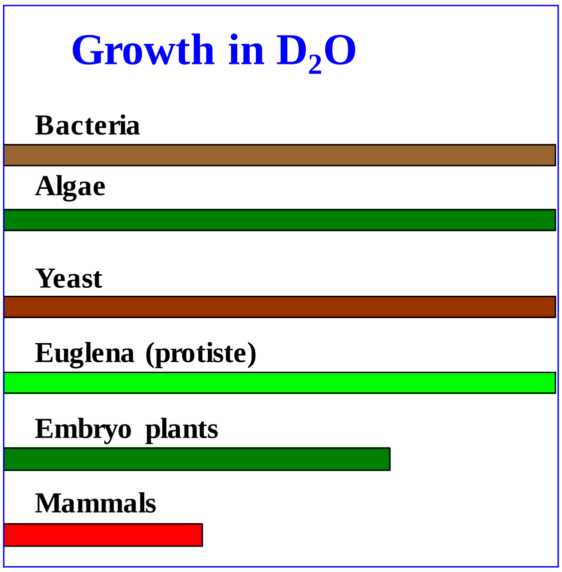
Nucleobases

Ele-ment	Atom %	Captures	Recoil dose
H	36	15%	0%
C	32	0%	0%
N	35	85%	100%
O	7	0%	0%





ILL's Deuteration Laboratory



ATOM % D
Adapted from Katz and Crespi (1970)

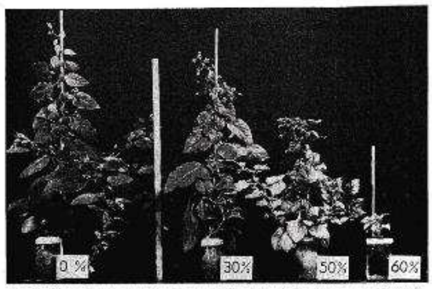
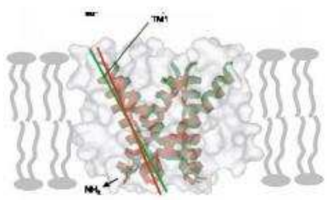
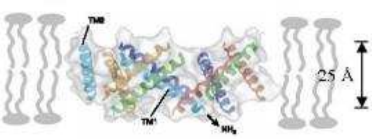


Fig. 3. Plants of *Atropa belladonna* grown hydroponically in nutrient solutions containing increasing concentrations of D_2O. [Upham *et al.* (29)]

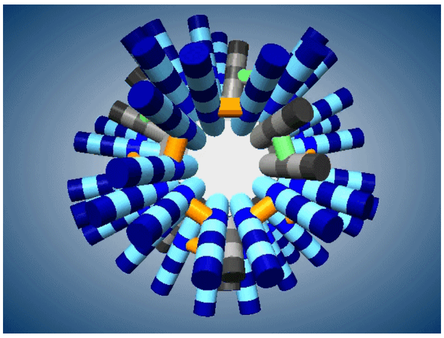
T. Forsyth,
M. Haertlein, ILL.

The Deuteration Laboratory Previous highlights

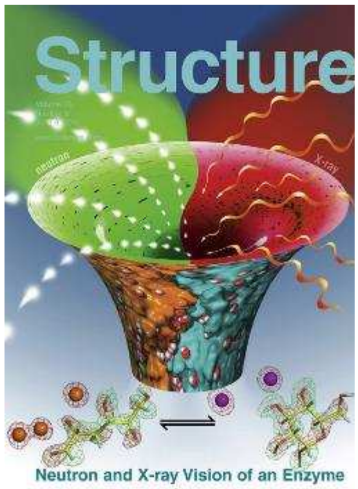




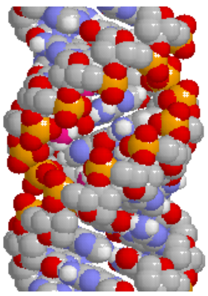
Mechanosensitive channel - NMR and neutron reflectometry (Karlshrue/Oxford). *Biophys J.*



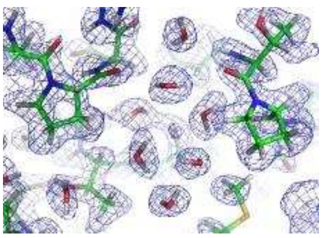
Pyruvate Dehydrogenase Complex (Glasgow), *J. Mol. Biol.*



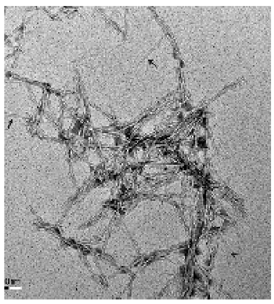
Xylose Isomerase (LANCSE, ILL, Keele, ISIS, Chase) *Structure*



DNA Crowding (Leiden), *Phys Rev.*



Type III Anti freeze protein (IGBMC) *J. Mol. Rec.*



Amyloid (Lund) *(in prep)*

T. Forsyth, ILL.

Experiment Opportunities at ILL

- ILL provides intense beams of slow neutrons from neV to eV
- Very clean, minimum fast neutron and gamma contamination
- Small divergence for good collimation
- On-site labs for deuteration and ^{15}N doping (P2)
- On-site biology labs for (slightly) radioactive samples
- On-site synchrotron & X-ray sources for comparative studies

- Test of imaging devices with $^{10}B(n,\alpha\gamma)$ or $^{157}Gd(n,\gamma)$
- Not clinical, not pre-clinical, but fundamental radiobiology studies in vitro
- Compare internalizing vs. non-internalizing Gd vectors
- Measure RBE_B, RBE_{Gd}, RBE_H, RBE_N for different cell lines
- Needs experienced radiobiology group!

ICTR-PHE 2016

INTERNATIONAL CONFERENCE
ON TRANSLATIONAL RESEARCH IN RADIATION ONCOLOGY

PHYSICS FOR HEALTH IN EUROPE

February 15 – 19, 2016
CICG, Geneva, Switzerland

IMPORTANT DATES

Abstract submission and early registration deadline: Oct 30, 2015

Late registration deadline: Jan 18, 2016

http://cern.ch/ictr-phe16

UNITING PHYSICS, BIOLOGY AND MEDICINE FOR BETTER HEALTHCARE

Outlook

Next ILL proposal deadline: 9 February 2016

ICTR-PHE 2016 Conference: 15 – 19 February 2016