30 years of fast neutron beams at iThemba LABS: retrospective waypoints and future horizons

Andy Buffler

DEPARTMENT OF PHYSICS
UNIVERSITY OF CAPE TOWN

MeASURe
Metrological and Applied Sciences University Research Unit

…on behalf of the collaboration for the development of the Fast Neutron Metrology Facility at iThemba LABS.

NRF National Research Foundation | iThemba LABS Laboratory for Accelerator Based Sciences
nmisa National Metrology Institute of South Africa
DEPARTMENT OF PHYSICS UNIVERSITY OF CAPE TOWN
PTB Physikalisch Technische Bundesanstalt
IRSN Institut de Radioprotection et de Sûreté Nucléaire
NPL National Physical Laboratory

Workshop: Neutrons for the next decade and beyond
4-6 February 2019, iThemba LABS

n 2018: 30 years of the SSC

science & technology
Department: Science and Technology
REPUBLIC OF SOUTH AFRICA

NRF National Research Foundation
iThemba LABS
Laboratory for Accelerator Based Sciences

Celebrating 30 years of the Separated Sector Cyclotron

Raad van Beheer van die
Doenlikheidstudie vir 'n
Nasionale Versnellerfasiliteit
vir die
Republiek van Suid - Afrika

Board of Control of the
Feasibility Study for a
National Accelerator Facility
for the
Republic of South Africa

A B R I D G E D

REPORT ON THE REQUIREMENTS FOR AND THE CHOICE OF A NATIONAL ACCELERATOR FACILITY FOR THE REPUBLIC OF SOUTH AFRICA AND THE PLACING THEREOF

MARCH 1975

March 1975

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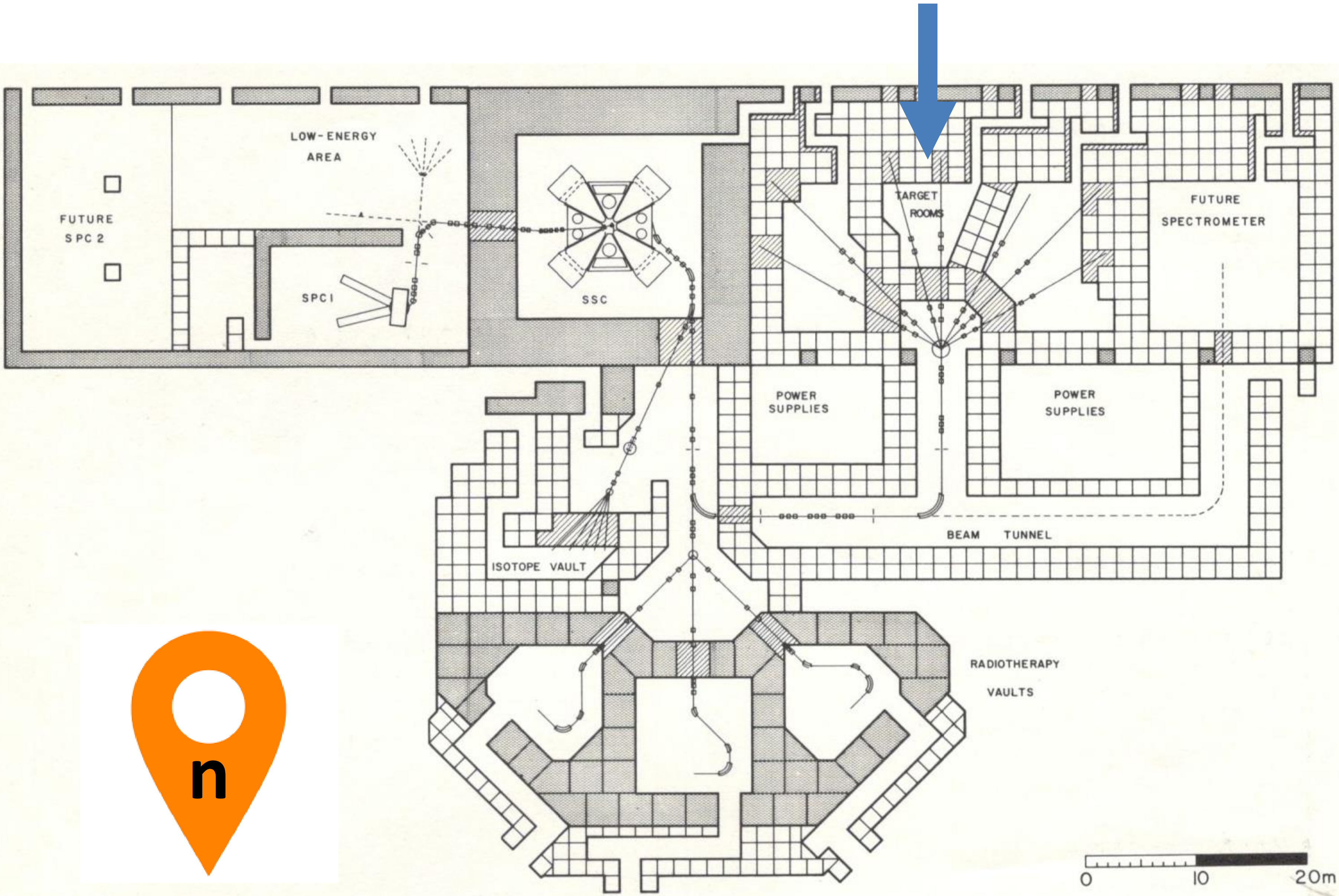
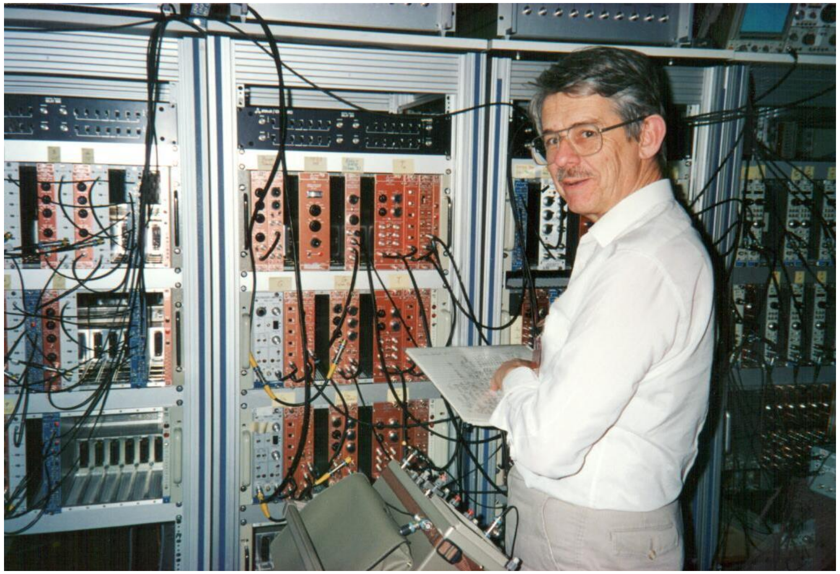
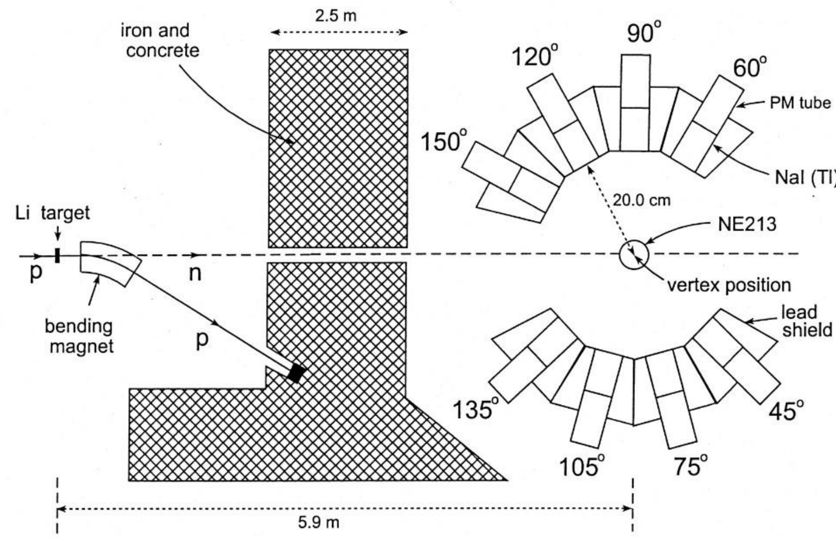


Fig 2 Plan of the shielded areas of the facility. Shaded areas represent fixed concrete while diagonal hatching represents hand stacked concrete blocks.

n

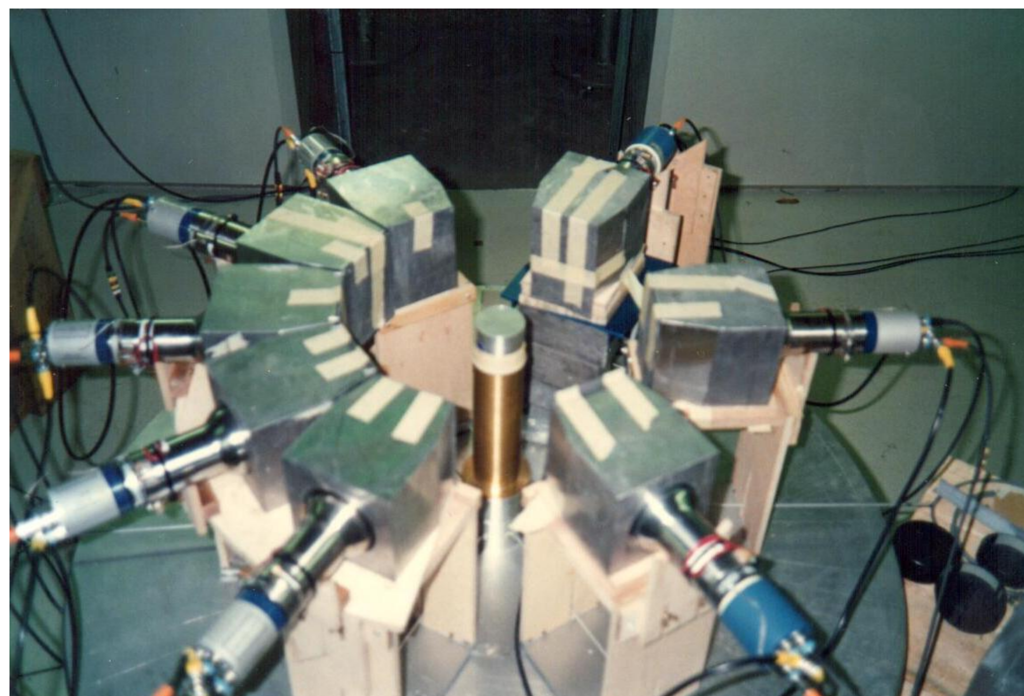
January 1980





Frank Brooks 1990

Differential cross section for n-p radiative capture at E_n = 66 MeV



ELSEVIER

Physics Letters B

Volume 314, Issue 2, 16 September 1993, Pages 173-178

open access

Differential cross section for n-p radiative capture at E_n = 63.4 MeV

M.S. Allie [a], F.D. Brooks [a], D.G. Aschman [a], A. Buffler [a], W.A. Cilliers [a], R.W. Fearick [a], C.G.L. Henderson [a], M.J. Oliver [a], M.R. Nchodu [a], S.M. Perez [a], D. Steyn [a], W.R. McMurray [b], B.R.S. Simpson [a], F.D. Smit [b], H.G. Miller [c], K. Bharuth-Ram [d], I.J. van Heerden [e]

Show more

https://doi.org/10.1016/0370-2693(93)90445-N

Abstract

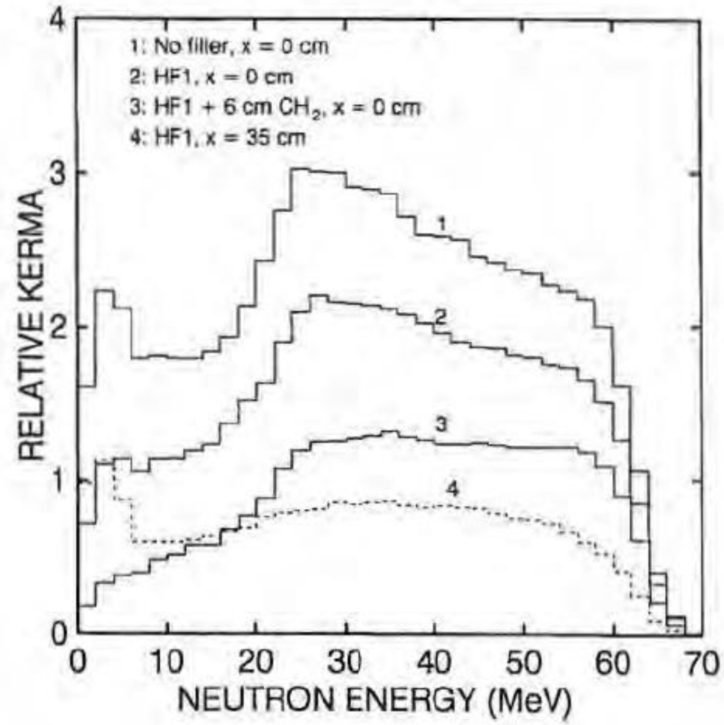
The angular distribution of photons from n-p radiative capture of 63.4 MeV neutrons has been measured. Data taken at eight n-γ laboratory angles (45°–150°) were transformed to deuteron photodisintegration cross sections at the equivalent laboratory energy, E_γ = 33.9 MeV, and analysed in combination with independent measurements of the 0° and 180° cross sections. Legendre polynomial coefficients obtained from the analysis are consistent with values reported from global fits and deviate marginally from predictions based on the Bonn and Paris potentials.

Neutron fluence and kerma spectra of a p(66)/Be(40) clinical source

D. T. L. Jones, J. E. Symons, and T. J. Fulcher
Division of Medical Radiation, National Accelerator Centre, P.O. Box 72, Faure, 7131 South Africa

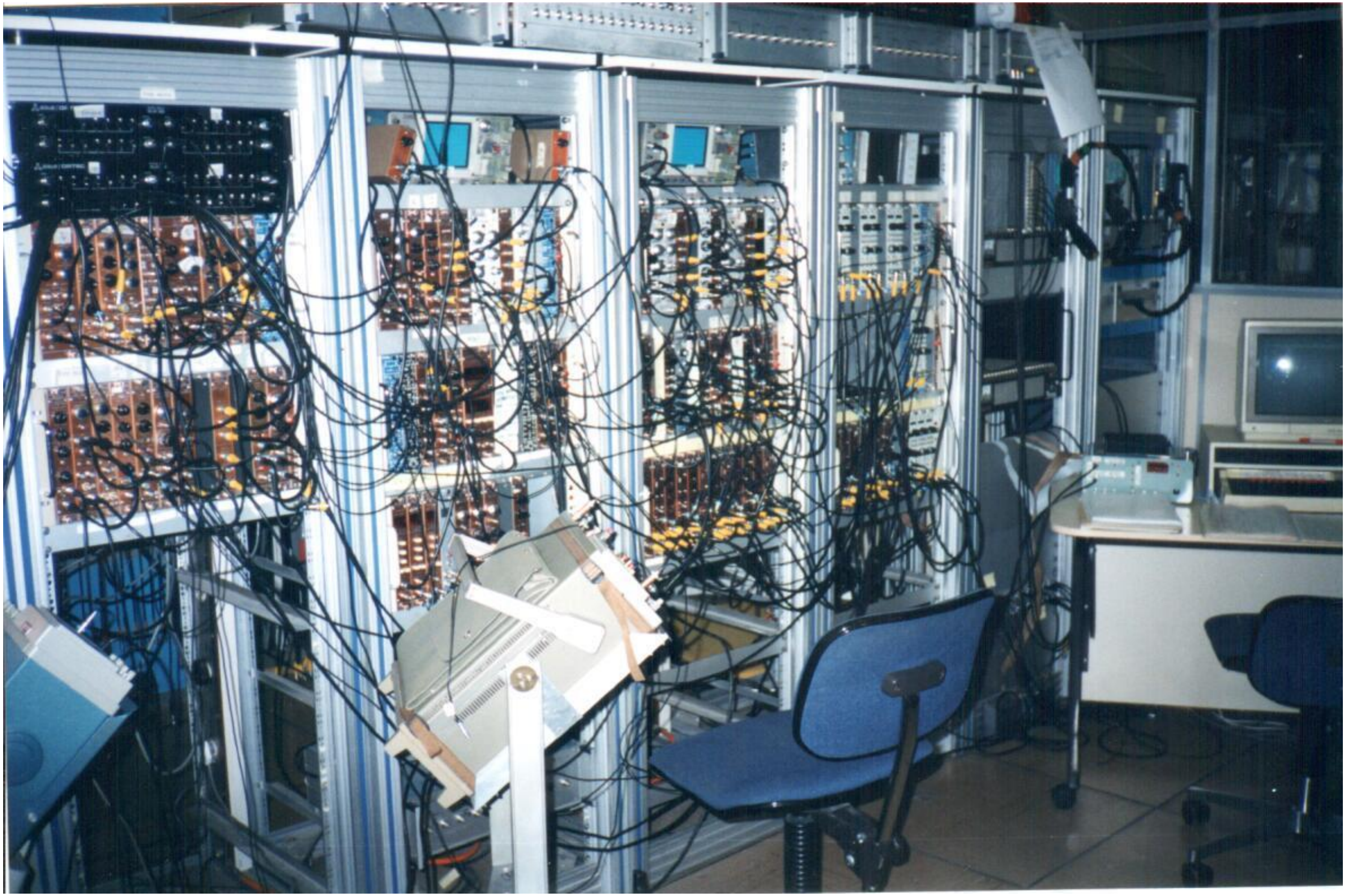
F. D. Brooks, M. R. Nchodu, M. S. Allie, A. Buffler and M. J. Oliver
Department of Physics, University of Cape Town, Rondebosch, 7700 South Africa

(Received 11 November 1991; accepted for publication 24 January 1992)

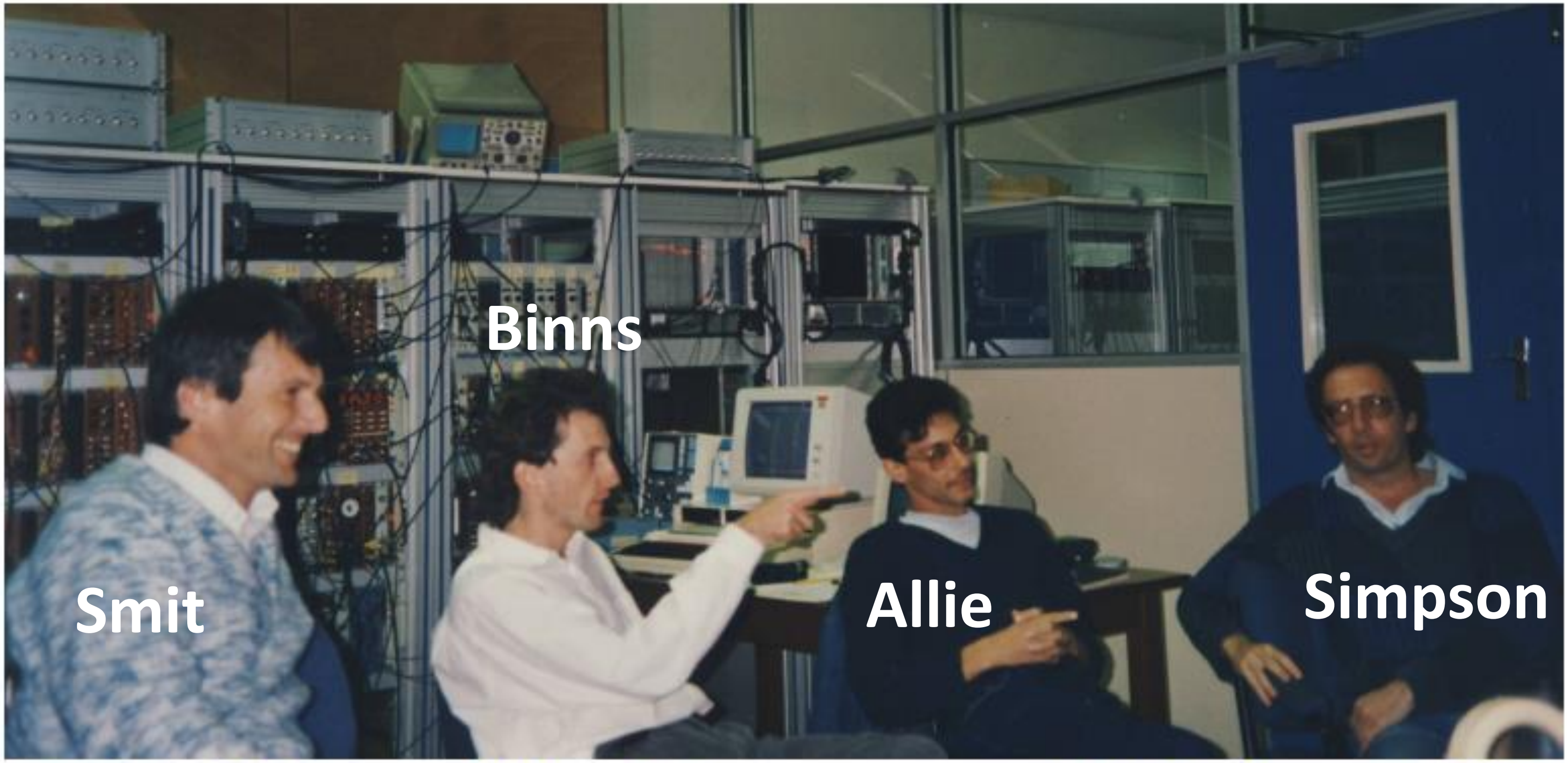


Medical Physics, **19**(5) (1992) 1285

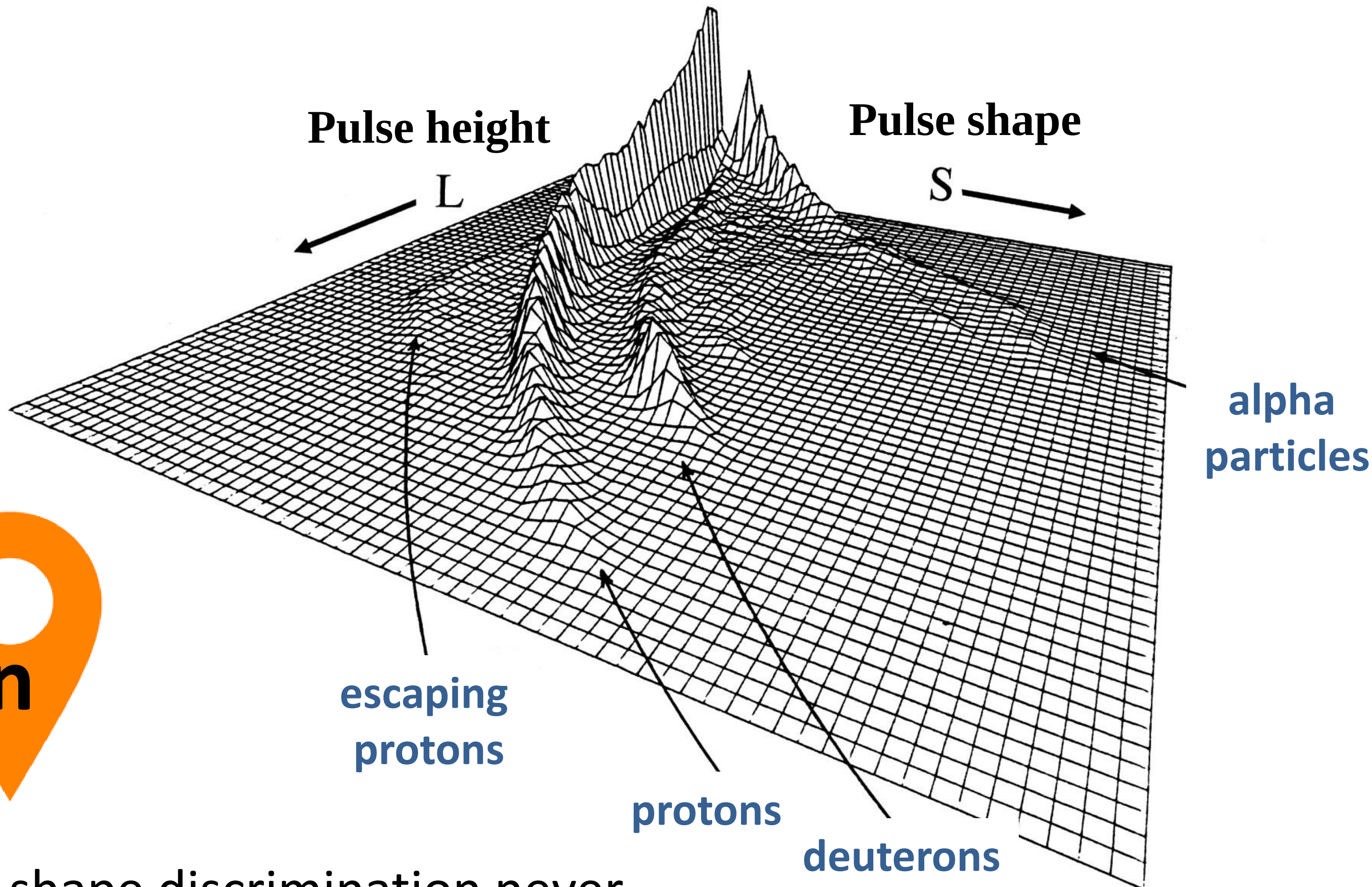
1990



1990



66 MeV protons on ^{nat}Li (5mm)
Measurements in a 2” NE213 detector at 6 m



Pulse shape discrimination never seen before at these energies

1990

University of Cape Town
Department of Physics

The Response of Organic Scintillators to Neutrons of Energy 14-63 MeV

Andy Buffler

A thesis submitted to the
University of Cape Town
for the degree of
Master of Science

December 1990

n

1994

Dr. H. Klein in:

Physikalisch-Technische Bundesanstalt

Braunschweig und Berlin

PTB

Physikalisch-Technische Bundesanstalt   Postfach 33 45   38023 Braunschweig

Prof. Dr. F.D. Brooks
Dept. of Physics
University of Cape Town
Rondebosch

Cape 7700
South Africa

Ihr Zeichen, Ihre Nachricht vom	Unser Zeichen, unsere Nachricht vom	Telefon	Datum
	7.2/kl	7200	21.7.94

Dear Dr. Brooks,

It was a great pleasure to meet with you at the conference on Crete Island. As usual there was not time enough to discuss the problems of organic scintillation detectors in all details. Please find attached copies of our publications on the properties and applications of NE213 scintillation detectors. We are very much interested in your opinion on the findings. Criticism and suggestions for improvements and further investigations are also welcome.

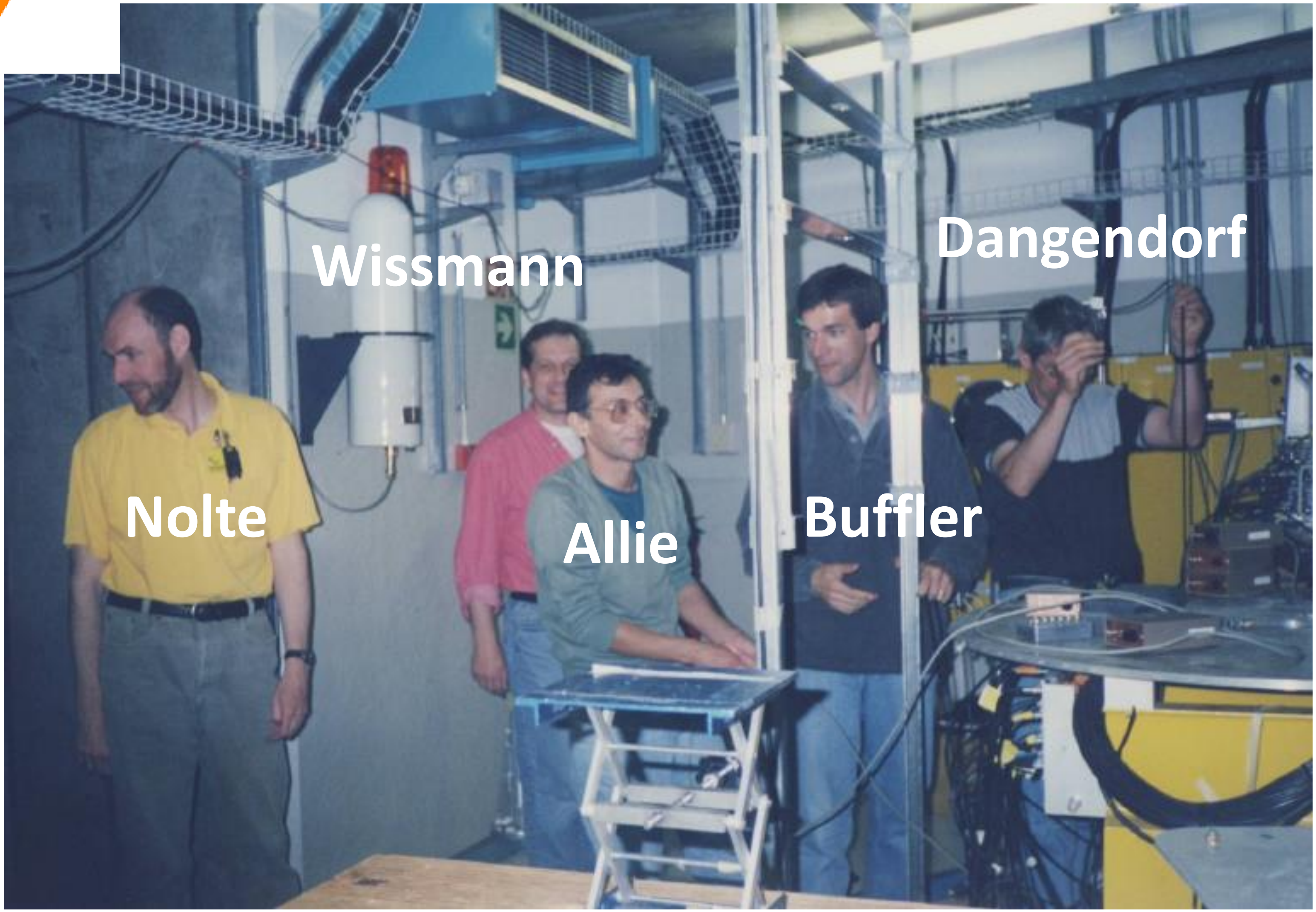
For your information I attach the 1993 annual report of the neutron physics division of PTB and the bibliographies of the papers published by the neutron metrology group (before 1989 neutron dosimetry group). Feel free to ask for copies by listing the numbers only, e.g. by Email.

Looking forward to your comments.

Yours sincerely, Horst Klein

PS: My contribution to the proceedings is still in preparation. You will receive a copy as soon as available.

2000 (?)



66 MeV protons on ^{nat}Li (5mm)
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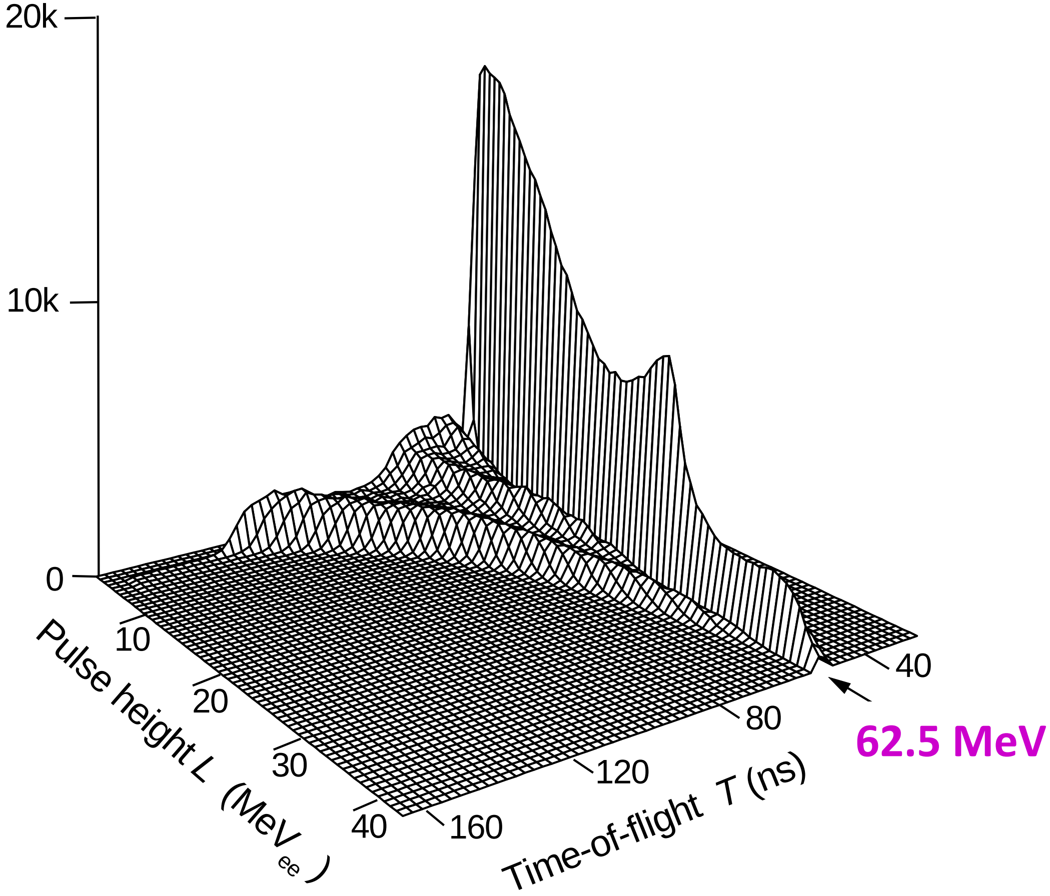
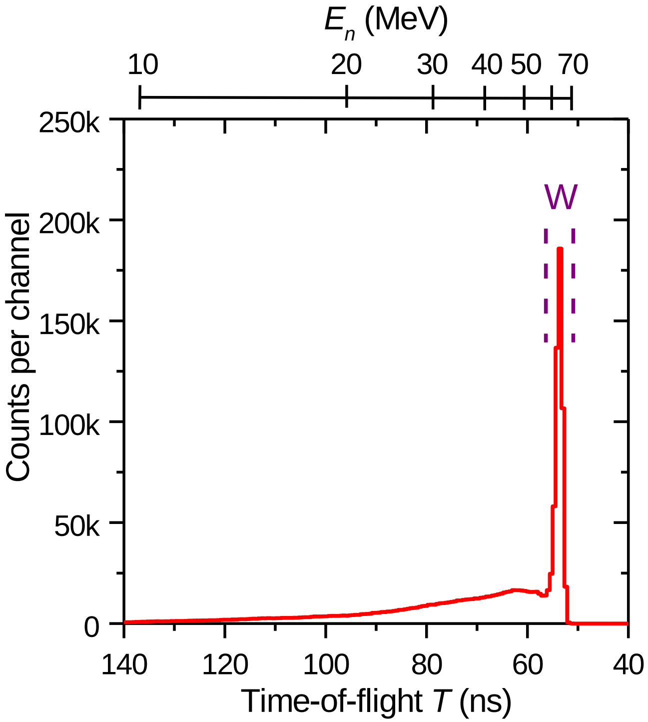
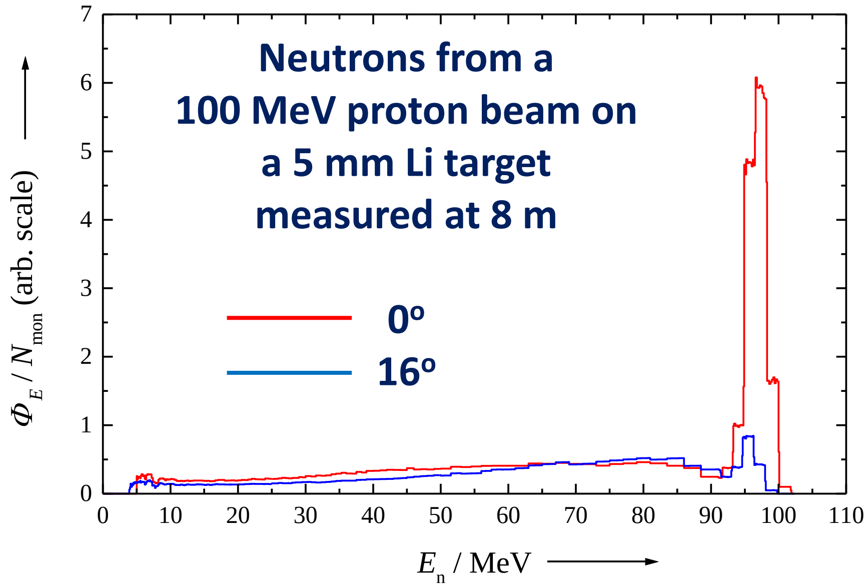
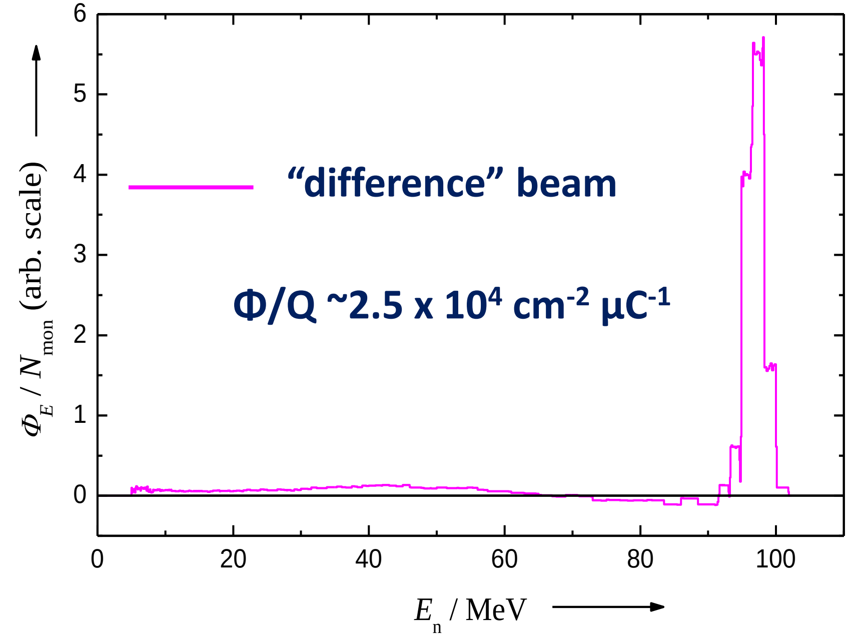




Quasimonoenergetic neutron beams at iThemba LABS





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Nuclear Instruments and Methods in Physics Research B 240 (2005) 617–624
NIM B
Beam Interactions with Materials & Atoms
www.elsevier.com/locate/nimb

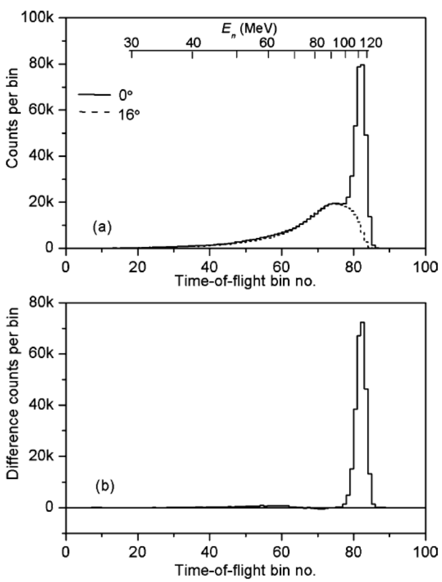
2005

Cross-section measurements for neutron-induced reactions in copper at neutron energies of 70.7 and 110.8 MeV

J.M. Sisterson [a,*], F.D. Brooks [b], A. Buffler [b], M.S. Allie [b], D.T.L. Jones [c], M.B. Chadwick [d]

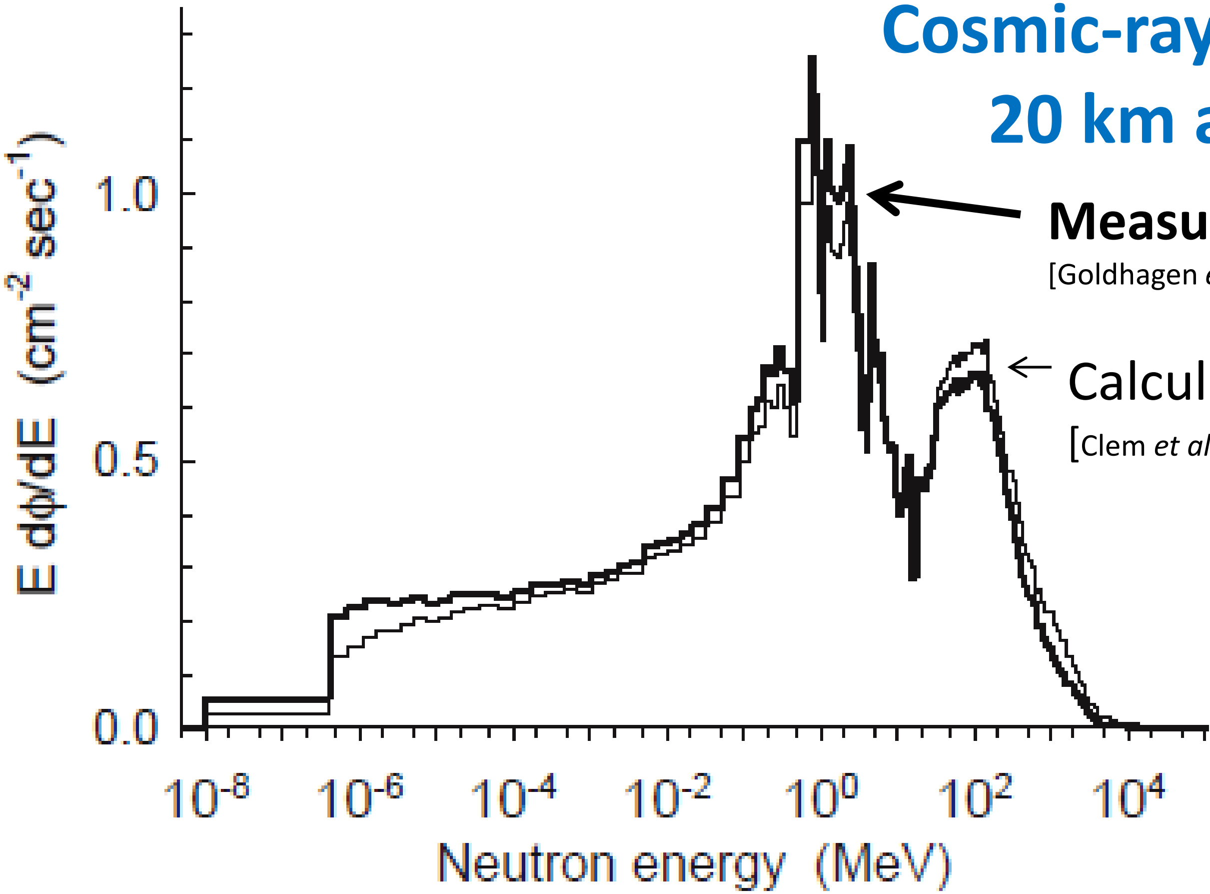
[a] *Northeast Proton Therapy Center, Massachusetts General Hospital, 30 Fruit Street, Boston, MA 02114, USA and the Harvard Medical School*
[b] *Department of Physics, University of Cape Town, Rondebosch, South Africa*
[c] *iThemba LABS, Box 722, Somerset West 7129, South Africa*
[d] *Advanced Simulation and Computing, Los Alamos National Laboratory, Los Alamos, NM 87544, USA*

Received 1 April 2005; received in revised form 24 May 2005
Available online 9 August 2005



(Determination of neutron cross sections of radioisotope production on Au, Ge, C, Te and Cd as major background reactions in ultrasensitive double beta decay experiments)

Cosmic-ray neutron spectrum: 20 km at 54° N, 117° W

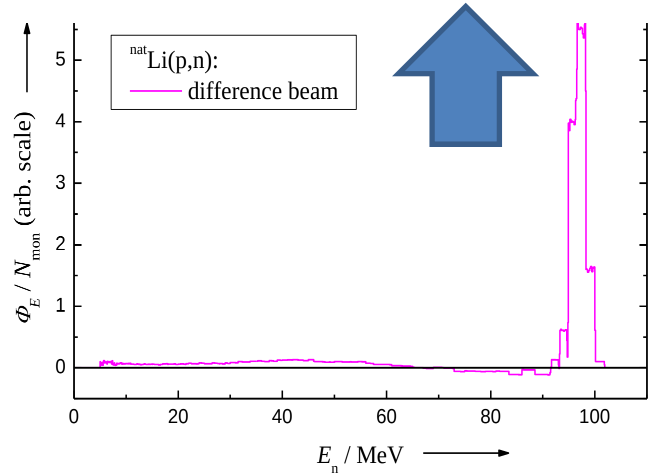


Measured

[Goldhagen *et al.* Rad. Prot. Dos. (2004) vol.110 p.387]

Calculated

[Clem *et al.* Rad. Prot. Dos. (2004) vol.110 p.423]



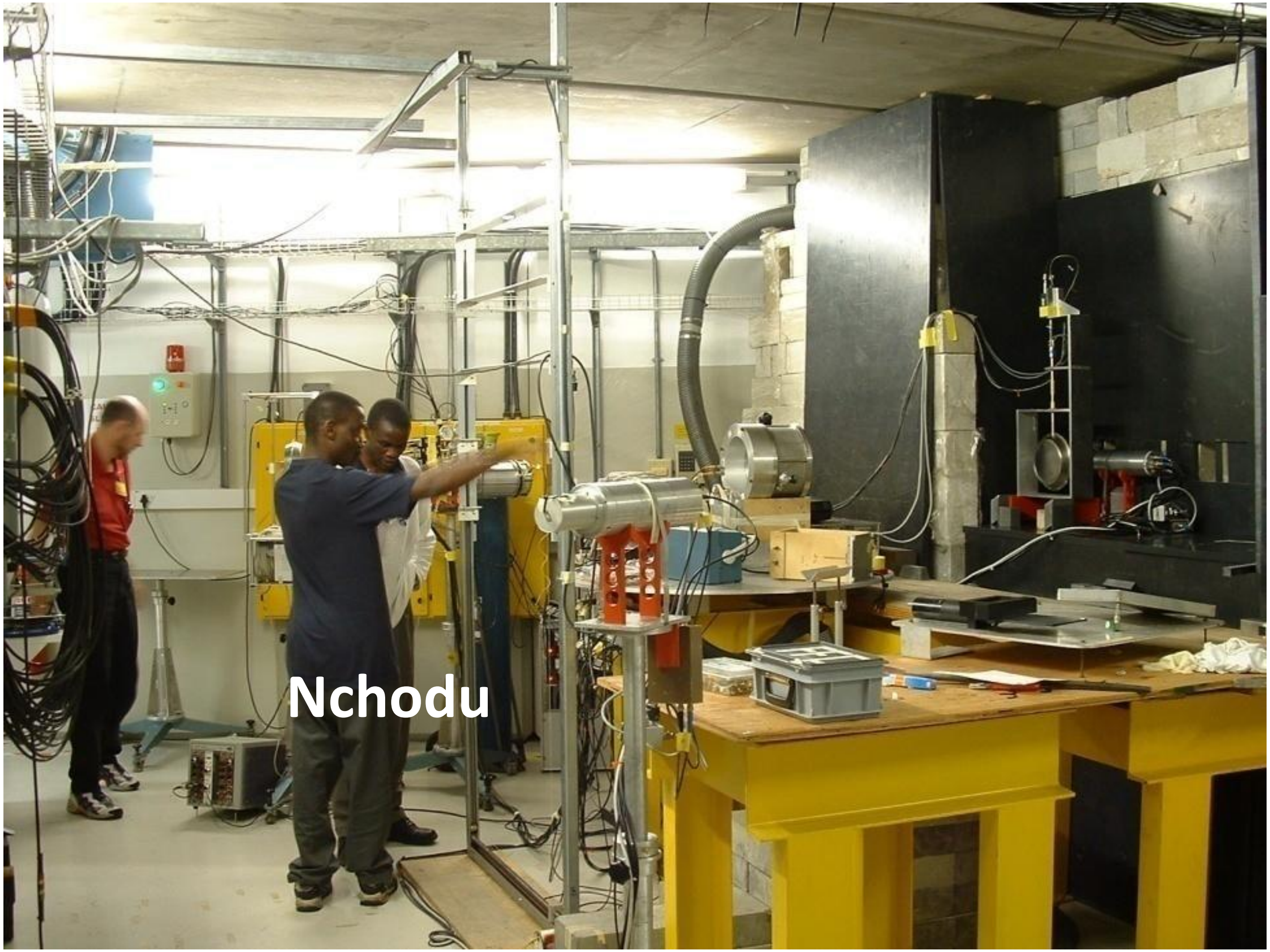
DOSMAX

Dosimetry of Aircraft Crew Exposure to Radiation During Solar Maximum

[DG RESEARCH, Nuclear Fission and Radiation Protection, Contract N° FIGM-CT-2000-00068]

DOSMAX@iThemba LABS:
UCT-PTB-Collaboration

2005 (?)



European Radiation Dosimetry Group e. V.

EURADOS-2014-XX

Braunschweig, February 2014

Irradiations at the High-Energy Neutron Facility at iThemba LABS

A.Buffler[1], G. Reitz[2], S. Röttger[3], F. D. Smit[4], F. Wissmann

(Eds.)

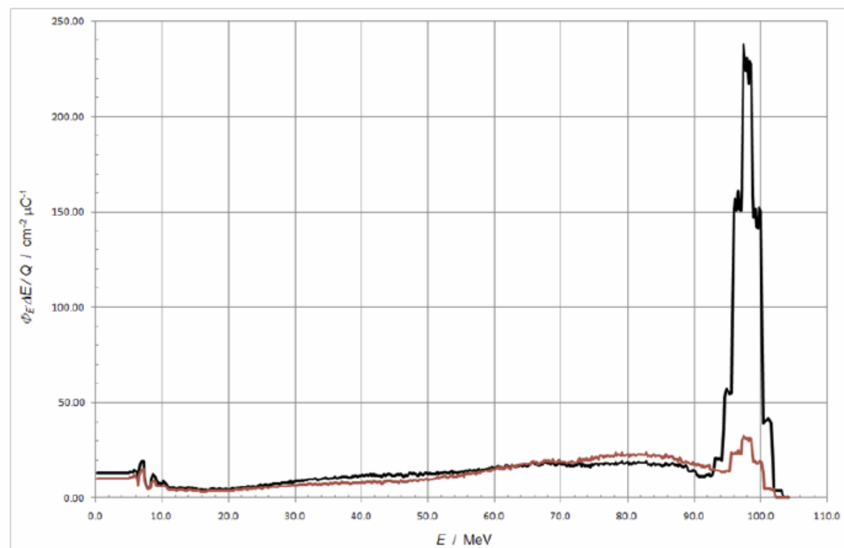
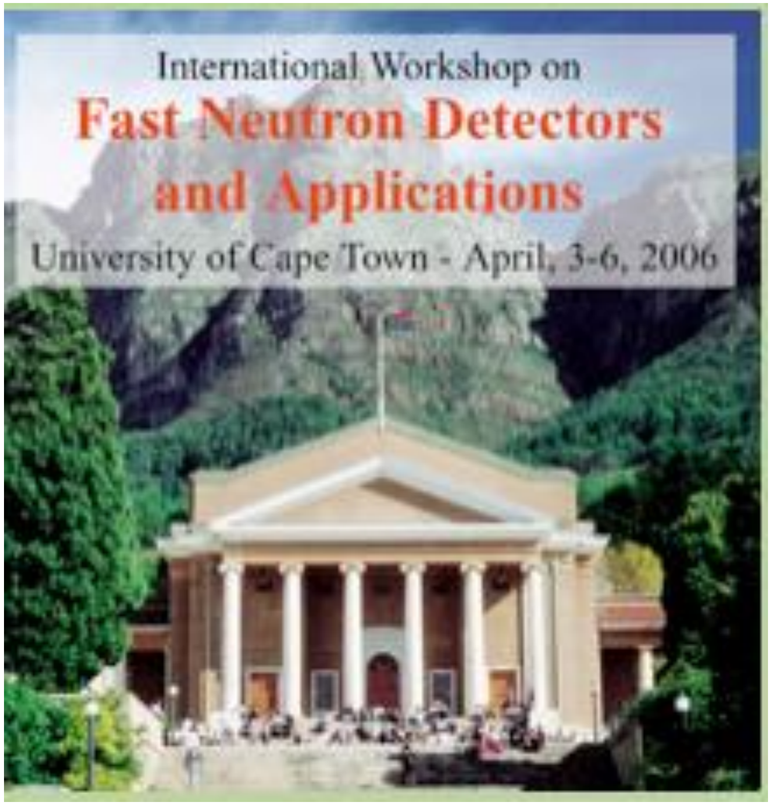


Figure 3.2.2: Spectral fluence (Φ_E $\Phi_{E/Q}$) normalized to beam charge at a distance of 8 m from the Li target for neutron emission angles of 0° (black) and 16° (red) and a proton energy of Ep = 99.35 MeV. The fluence ratio between 0° and 16° is ($\Phi_{0°}/\Phi_{16°}$) = 1.640

FNDA @ UCT April 2006



PROCEEDINGS OF SCIENCE

Scintillation detectors for fast neutrons

Horst Klein *

Physikalisch-Technische Bundesanstalt (PTB)
Bundesallee 100, 38116 Braunschweig, Germany
E-mail: `horst.klein@ptb.de`

Frank D. Brooks

Department of Physics
University of Cape Town
Rondebosch 7700, South Africa
E-mail: `fbrooks@science.uct.ac.za`

The properties and various applications of scintillation detectors for neutrons of energy > 1 keV are reviewed. Characteristics of the organic scintillator neutron detectors are discussed in some detail and the energy resolution achieved in neutron spectrometric applications is reviewed. Present trends and future needs in neutron detection are summarised and discussed.

International Workshop on Fast Neutron Detectors
University of Cape Town, South Africa
April 3 – 6, 2006

PoS(FNDA2006)097

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11th Symposium on Neutron and Ion Dosimetry (NEUDOS11)
iThemba LABS, 12-16 October 2009

NEUTRON AND ION DOSIMETRY SYMPOSIUM
11th
NEUDOS-11
12-16 October 2009
Cape Town
South Africa
iThemba LABS

Radiation Measurements

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PROCEEDINGS OF THE 11TH SYMPOSIUM ON NEUTRON AND ION DOSIMETRY

< Previous vol/issue   Next vol/issue >

iThemba Laboratory for Accelerator-Based Sciences

12-16 October 2009 • Cape Town, South Africa

Edited by D.T.L. Jones, F.D. Smit

Volume 45, Issue 10, Pages 1073-1604 (December 2010)

Radiation Measurements 45 (2010) 1342–1345

ELSEVIER

Contents lists available at ScienceDirect

Radiation Measurements

journal homepage: www.elsevier.com/locate/radmeas

Characterisation of the high-energy neutron beam at iThemba LABS

M. Mosconi [a,*], E. Musonza [b], A. Buffler [b], R. Nolte [a], S. Röttger [a], F.D. Smit [c]

[a] Physikalisch-Technische Bundesanstalt, Bundesallee 100, D-38116 Braunschweig, Germany
[b] University of Cape Town, Private Bag, Rondebosch 7701, South Africa
[c] iThemba Laboratory for Accelerator Based Sciences, PO-Box 722, Somerset West 7129, South Africa

n

2010

4. Conclusions

Dosemeter calibrations, irradiation of samples and cross section measurements can be performed at the iTL neutron facility with reliable monitoring and a neutron beam characterisation traceable to PTB standards. The beam profile is usually flat and it is presently monitored using passive detectors. Direct measurements of the low-energy contribution can be carried out at the 16° position and by empty target runs. A thermal neutron background not larger than few per cent of the ambient dose is present for neutron energies above 100 MeV. An additional study of its reduction by means of a suitably designed neutron shielding is currently under development.

2010

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LABORATORY FOR ACCELERATOR BASED SCIENCES

iThemba LABS

P O Box 722
Somerset West
7129
South Africa

Tel : +27 21 843 1000
Fax : +27 21 843 3525
Email : director@tlabs.ac.za
Internet : http://www.tlabs.ac.za

14 May 2010

Professor Buffler
Department of Physics
University of Cape Town

Dear Prof. Buffler

RESEARCH PROPOSAL TO iThemba LABS:
PR178a Characterization of particle detectors and dosemeters used in high-energy mixed radiation fields

The PAC noted that iThemba LABS has important advantages as a mono-energetic neutron facility which should be nurtured:

- it is close to being ISO approved
- it has a pulsed beam capability
- it has a dual angle capability for the subtraction of background
- it has a long flight path for ToF measurements
- it has low background
- it has good infrastructure with well characterized detectors
- it has a good local team

recommended that future experiments go beyond basic metrology by developing new innovations and techniques. It advised that it be the responsibility of the local spokespersons to ensure that any use of iThemba facilities for the calibration of third party detectors have a proper acknowledgement of iThemba LABS.

Please submit a written progress report, of approximately one A4 page in length, on this project to the PAC on the occasion of each of the bi-annual meetings of the PAC, beginning with the meeting immediately following your first beam-time and continuing until the project is completed. It is requested that the status of the project should also be reflected in the form of relevant figures. The project is considered completed with the appearance of scientific journal article(s).

Journal of Instrumentation

2nd International Workshop on Fast Neutron Detectors and Applications (FNDA2011)

The 2nd International Workshop on Fast Neutron Detectors and Applications (FNDA 2011) was held at Kibbutz Ein Gedi, near the Dead Sea in Israel on 6-11 November 2011. It featured more than 70 presentations dealing with recent developments in the construction of detectors and sources for neutrons at energies ranging from keV to GeV, and their application in various fields of science and technology. The presentations may be viewed on the conference website.

FNDA2011 follows the first FNDA workshop, which was held in 2006 at the University of Cape Town, South Africa. The proceedings of this workshop are available here.

Andy Buffler, Guest Editor
on behalf of the other members of organising committee
(Volker Dangendorf, David Vartsky and Amos Breskin)

FNDA 3 ??

European Radiation Dosimetry Group e. V.

EURADOS

EURADOS Report 2012-xx

Braunschweig, December 2012

High-energy quasi-monoenergetic neutron fields: existing facilities and future needs

Pomp S.[1], Bartlett D.T.[2], Mayer S.[3], Reitz G.[4], Röttger S.[5], Silari, M.[6], Smit F.D.[7], Vincke H.[6], and Yasuda H.[8]

“ … a new reference QMN facility is required providing energies at least to 200 MeV …”

13 October 2013

FIRST ADDENDUM TO AGREEMENT

Between:

THE NATIONAL RESEARCH FOUNDATION

And

NATIONAL METROLOGY INSTITUTE OF SOUTH AFRICA

Cooperate in the Development of the iThemba LABS Neutron D-Line

	Initial	Witnesses:	Witnesses:
iThemba	FA	[signature]	[signature]
NMISA	[signature]	[signature]	

NMISA through this addendum enables the formulation of a project with UCT Physics, PTB and the IRSN to develop and utilise the iThemba LABS quasi-monoenergetic neutron (QMN) laboratory of the iThemba LABS for neutron dosimetry metrology activities.

iThemba LABS commit to upgrade the neutron beam line to make it compatible with metrology requirements, and once the beam line is completed, to make it available to research, including metrology applications/services.

... a few other events ...

... agreement that the fast neutron facility should be redeveloped for meet both “general physics” and “metrology” needs.

2018 Final green light from iThemba LABS for the redevelopment.

Jan/Feb 2019 First measurements and this workshop ....

First measurements: February 2019

… and to the future …

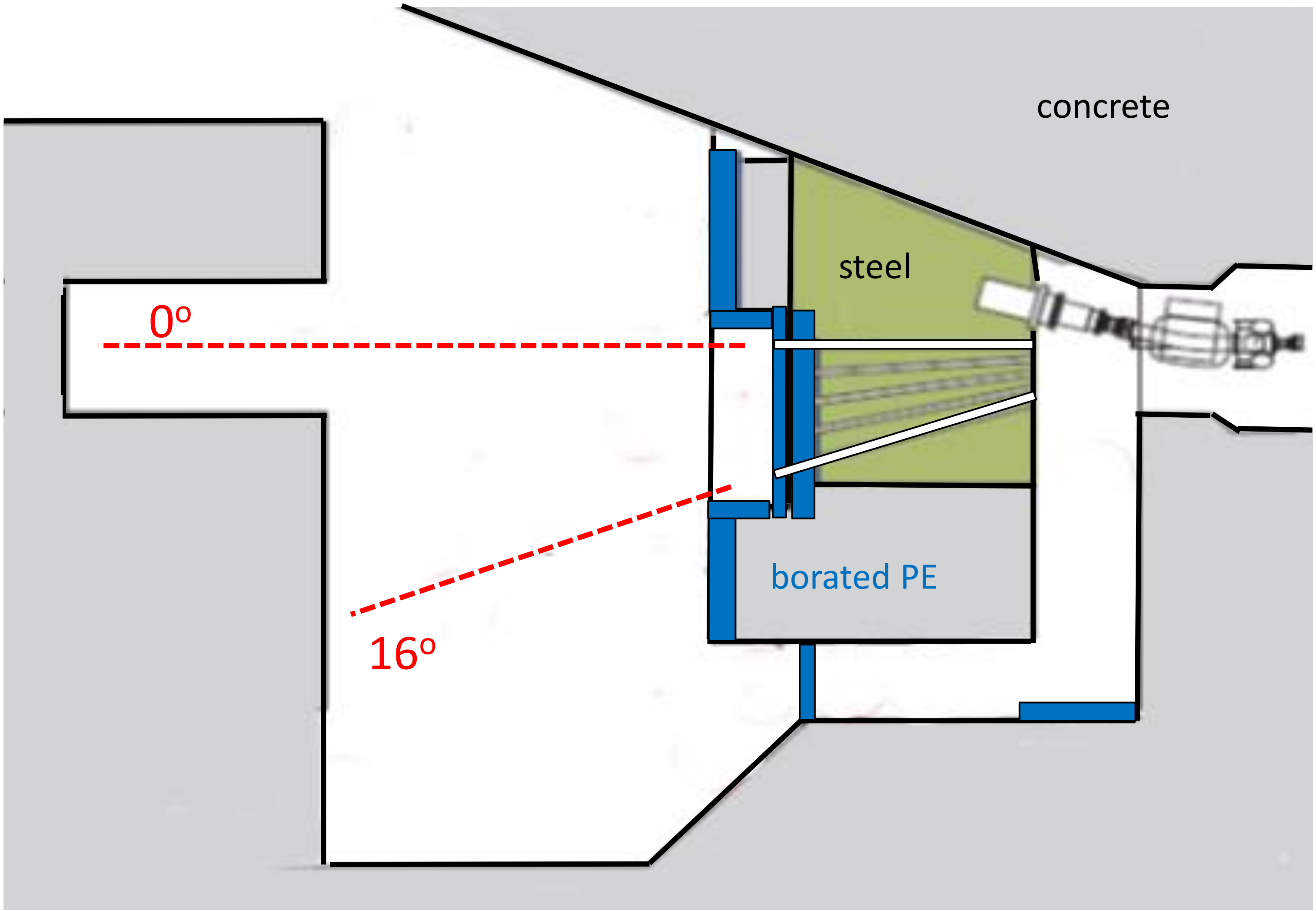
Development of the Fast Neutron Metrology Facility at iThemba LABS

- Measurements and modelling
- Changes to physical infrastructure
- Improvements to instrumentation
- Metrology protocols
- Key comparison studies
- ISO certification … how? … time line?

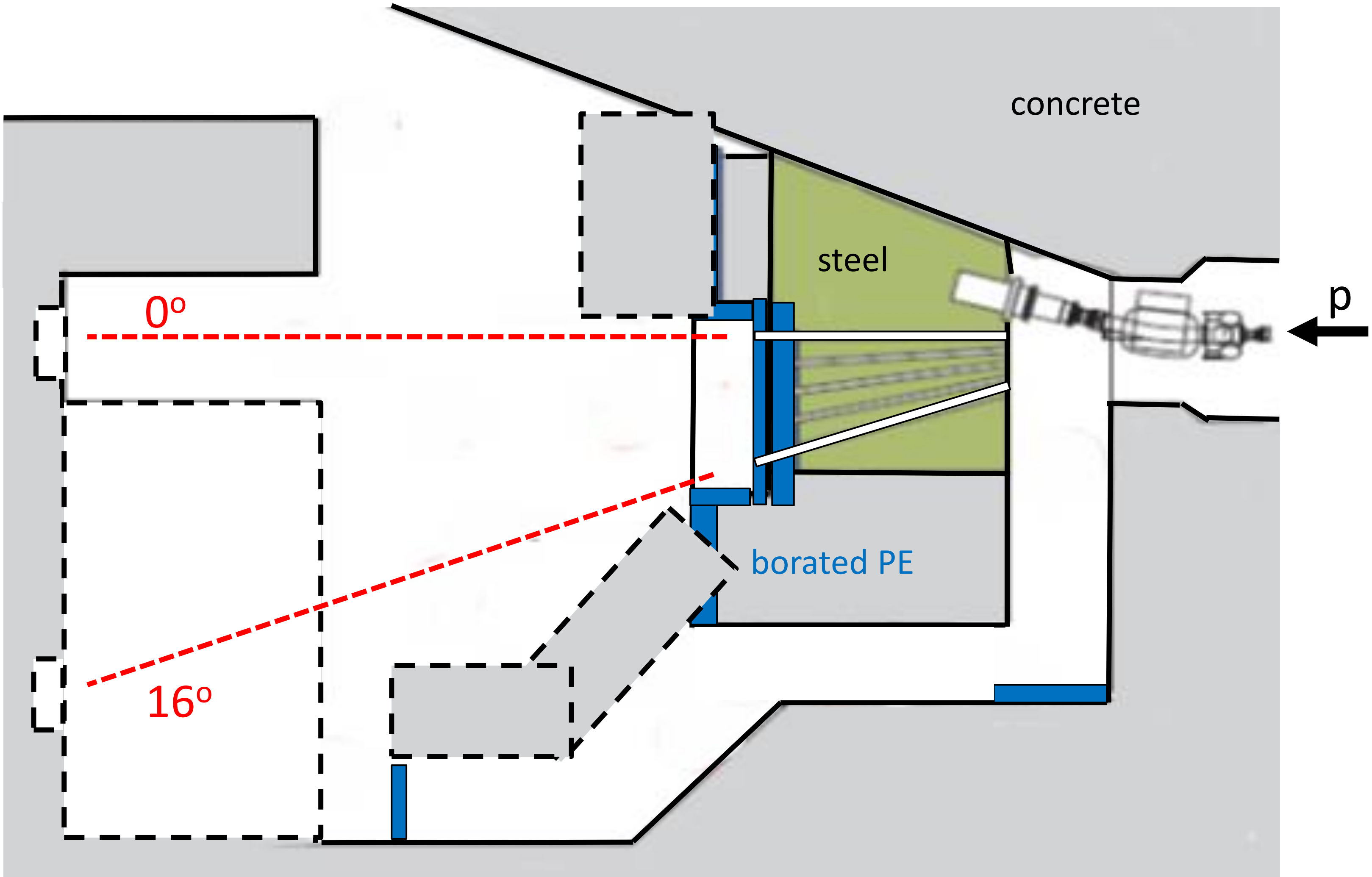
Peane Maleka
iThemba LABS neutron beam facility status and plans

Quentin Ducasse
Monte Carlo simulations of the present vault

Neutron vault: present layout



Neutron vault: physical plan improvements



Instrumentation: proposed improvements

Primary metrology references: σ_{np} scattering and $\sigma_{U\text{-}238}$ fission

Neutron energy range: 30 – 200 MeV

- New proton recoil telescope to cover the full energy range
- New or upgraded U-238 fission chamber
- Proton beam position monitor
- Flexible infrastructure in vault for instrumentation
- Neutron beam spot scanning device for larger devices
- [Data acquisition system $\rightarrow$ digital]

Fast neutron users “phase space”

Production of (man-made) fields

Source development Reference fields Shielding

Development of instrumentation

TLDs TEPCs Bonner sphere EPDs Si-based Scintillators

Use of instrumentation (seasurement in different contexts)

Reactor/accelerator Medical Earth/Atmos/Space Reference fields Other

Numerical modelling (simulation / calculation)

Dosimetric calculations Nanodosimetry Detectors Reference fields Other

Effects

Biological / radiobiology Rad damage to electronics Other

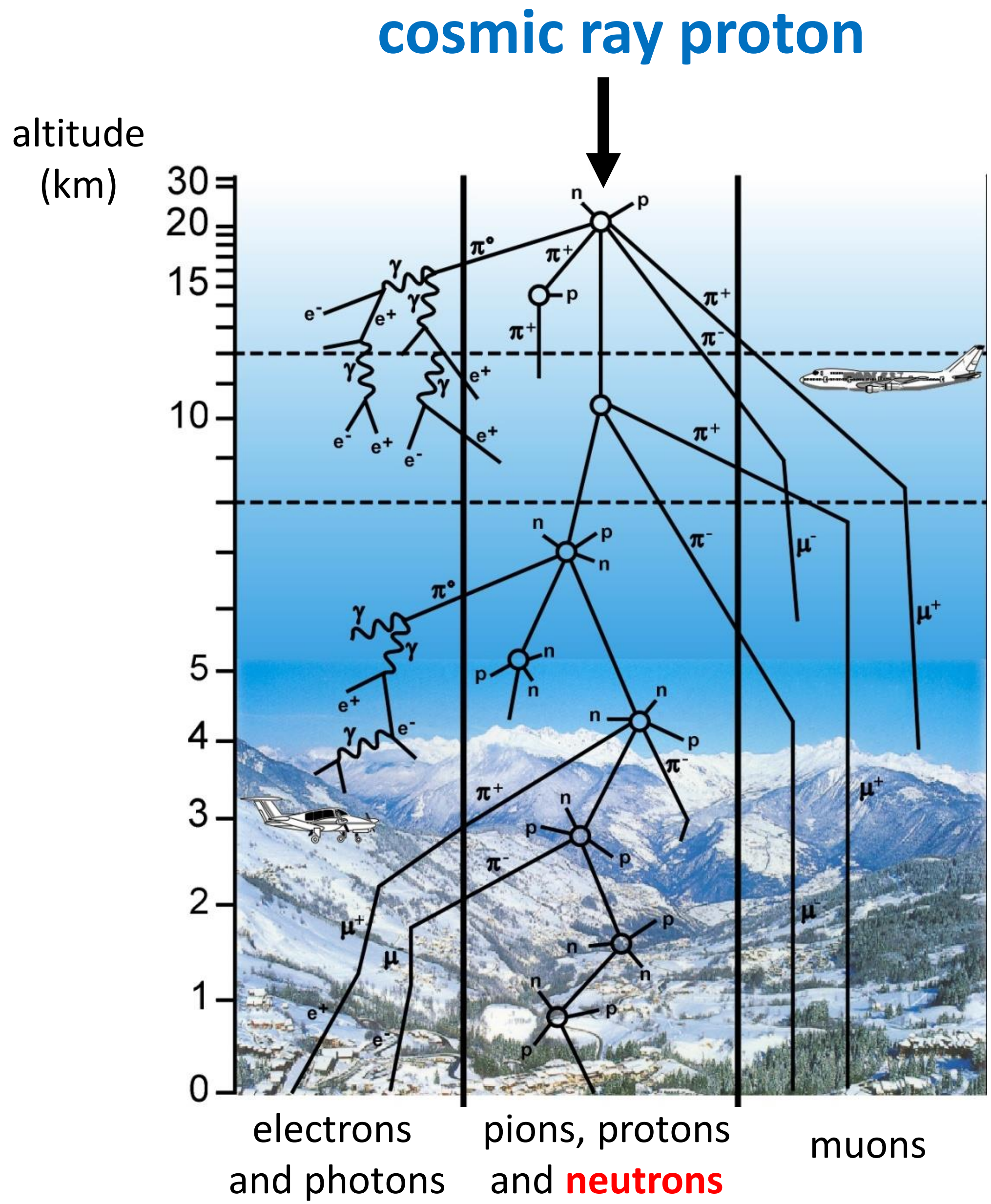
Physics

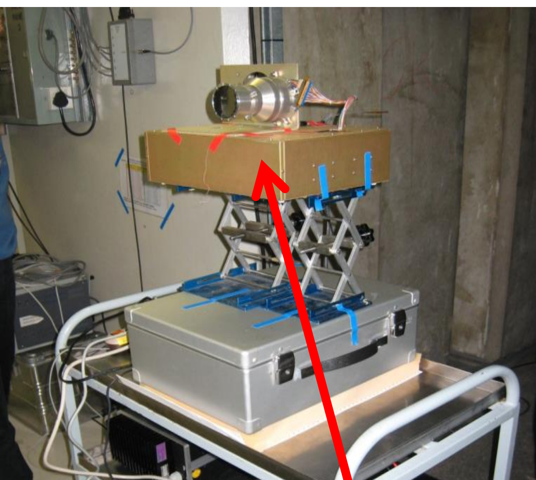
Cross sections Models Strong interaction: (n,p); (n,d); … Neutrino physics

n

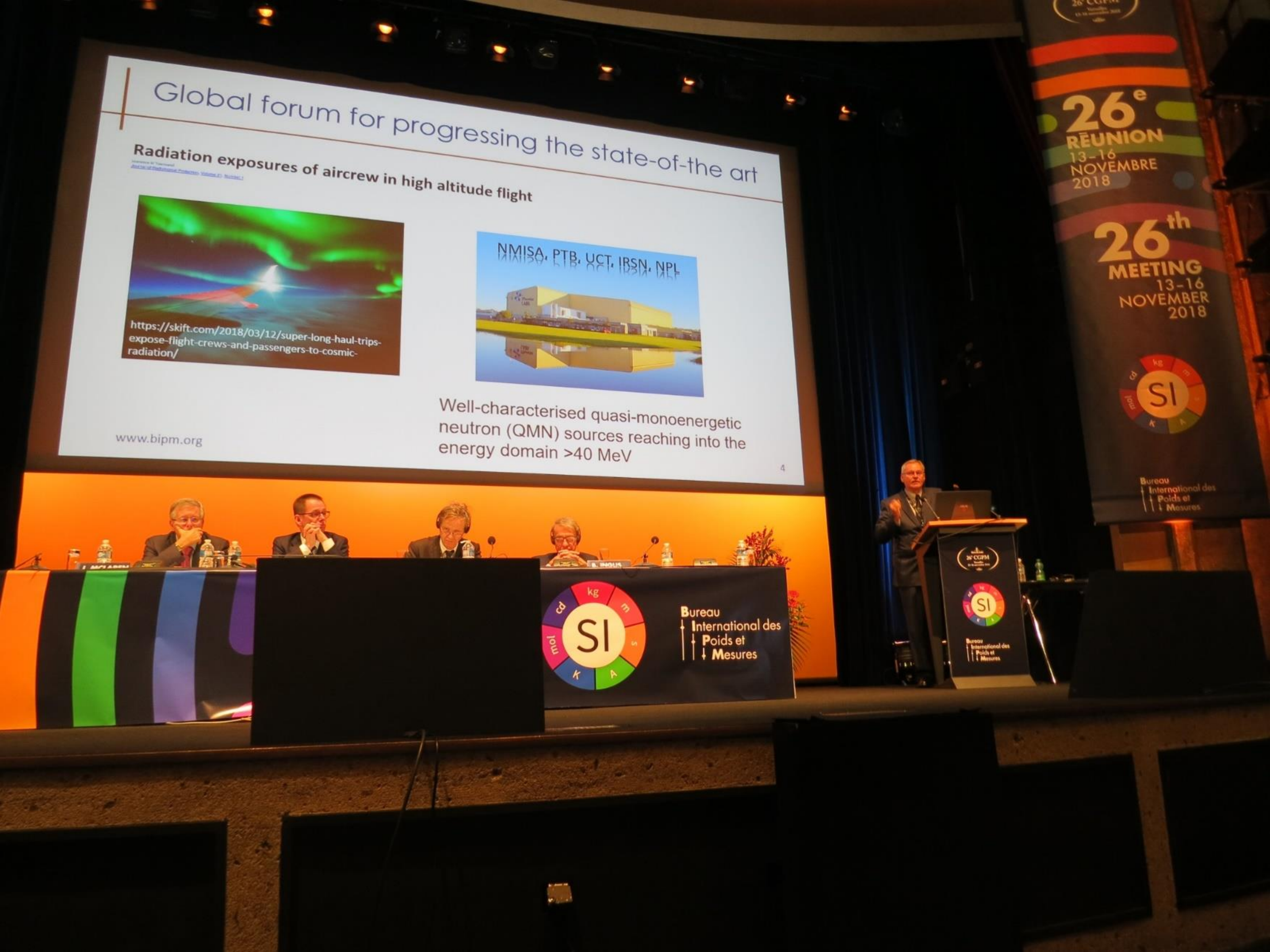
Instrumentation characterization for dosimetry

[Accelerator centres, air, space, …]





RAD radiation detector on board the Curiosity rover calibrated using neutron beams at iThemba LABS

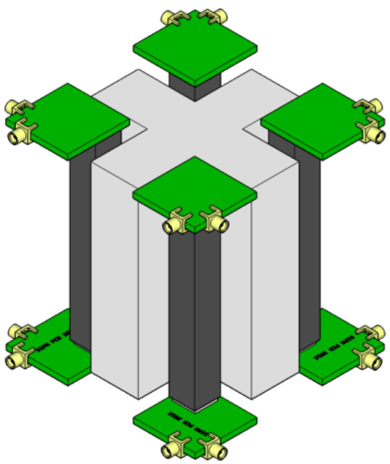

Global forum for progressing the state-of-the art
Radiation exposures of aircrew in high altitude flight
https://skift.com/2018/03/12/super-long-haul-trips-expose-flight-crews-and-passengers-to-cosmic-radiation/
NMISA, PTB, UCT, IRSN, NPL
Well-characterised quasi-monoenergetic neutron (QMN) sources reaching into the energy domain >40 MeV
www.bipm.org
4
26e RÉUNION 13–16 NOVEMBRE 2018
26th MEETING 13–16 NOVEMBER 2018
SI
kg m s A K mol cd
Bureau International des Poids et Mesures
Bureau International des Poids et Mesures
Bureau International des Poids et Mesures

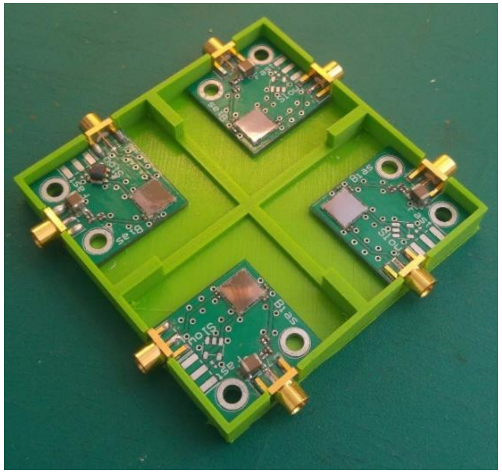
New neutron detectors

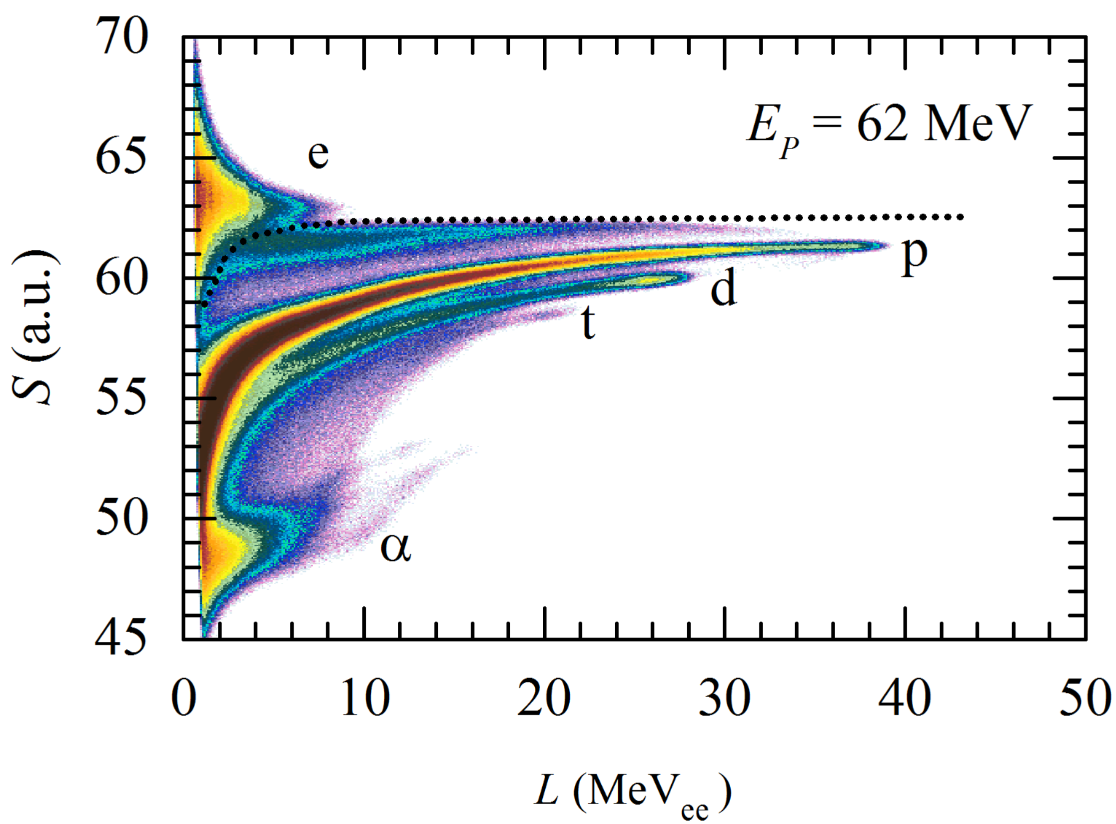
A new compact neutron spectrometer

8 x MicroFC-60035 SiPM (SensL)

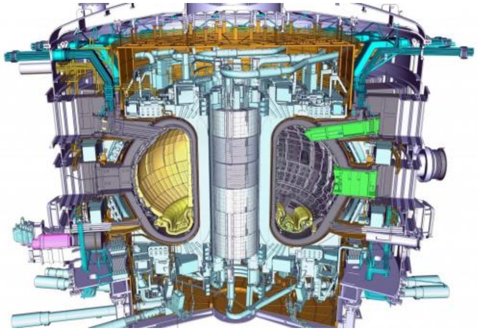
4 x 6 x 6 x 50 mm^3 EJ299-33 "PSD" scintillator







n Cross section measurements



(ITER will be built)

Xavier Ledoux
Neutron induced reactions studies in the 1-200 MeV energy range

Ralf Nolte
Nuclear data measurements at white and quasi-monoenergetic sources of high-energy neutrons

Marcin Bielewicz
The new collaboration of the JINR and the iThemba LABS for cross-section (n,xn) reaction measurements

Vision for fast neutron facility

A designated fast neutron facility at iThemba LABS covering the range 30 to 200 MeV which is recognised and supported by both the international neutron physics and radiation metrology communities.

Strategy (2018-2020) includes

- Strong relationships in core team (iThemba / PTB / IRSN / UCT / IRSN)
- Dedicated staff on project who are sited at iThemba LABS
- Strong commitment to development task schedule (2018-2020)

- Drive to attract postgraduate students to the project
- Drive to attract interest from international neutron community