

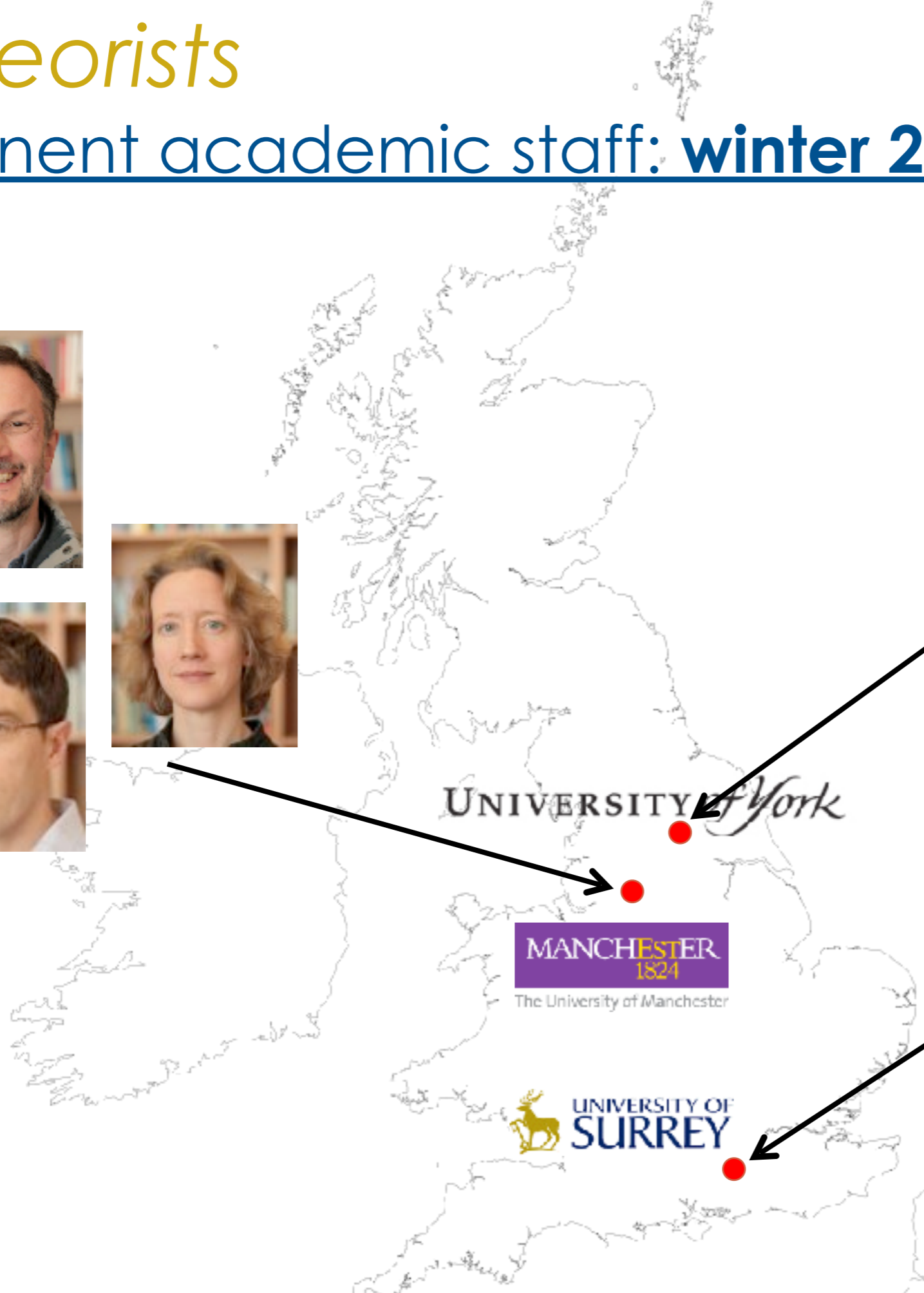
UK Nuclear Theory

Warwick 2020 Meeting

Arnau Rios Huguet
Senior Lecturer
Department of Physics

UK theorists

Permanent academic staff: winter 2016



+1.5 PDRAs

UK theorists

Permanent academic staff: winter 2019



+1 PDRA



+1 PDRA



+3 PDRA

Nuclear Theory Vision

Nuclear Theory Vision @ UK Oct 2015 - Dec 2019 (£140k)

→ 2 international **TALENT summer schools**

▶ Density Functional Theory (York, July 17-August 6 2016)

▶ **Lecturers:** J Dobaczewski, A Pastore (York), A Idini (Surrey) & N Schunck (LLNL)

▶ **Materials:** http://fribtheoryalliance.org/TALENT/courses/course_04.php

▶ Bayesian methods & machine learning (York, 10-28 June 2019)

▶ **Lecturers:** C Forssen (Goteborg), D Furnstahl (OSU) and D Phillips

▶ **Materials:** http://fribtheoryalliance.org/TALENT/courses/course_04.php

→ 10 **UK Nuclear Theory Meetings**

▶ 2 x year with a **transformative** effect on community

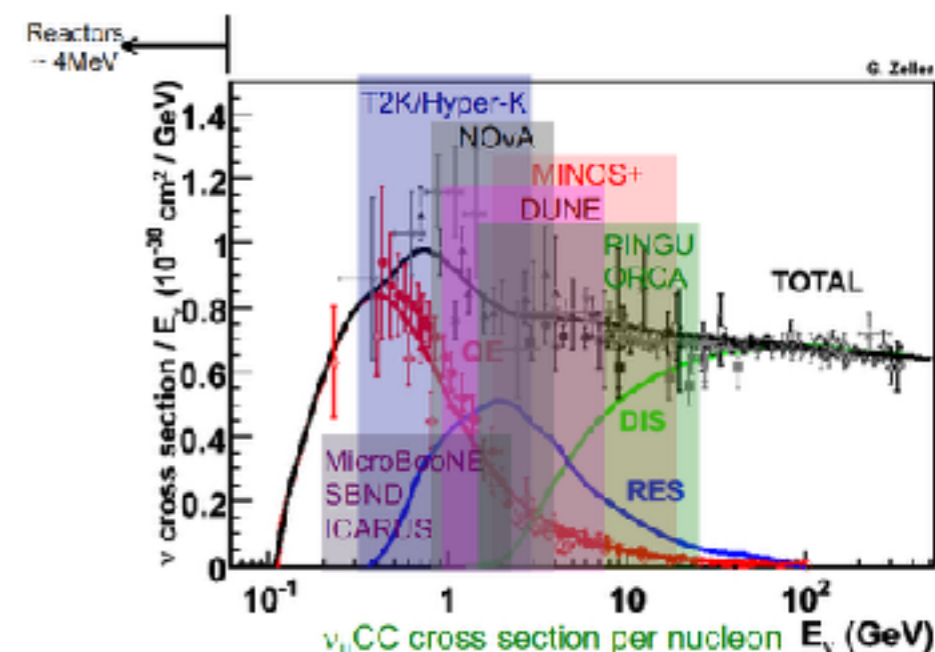
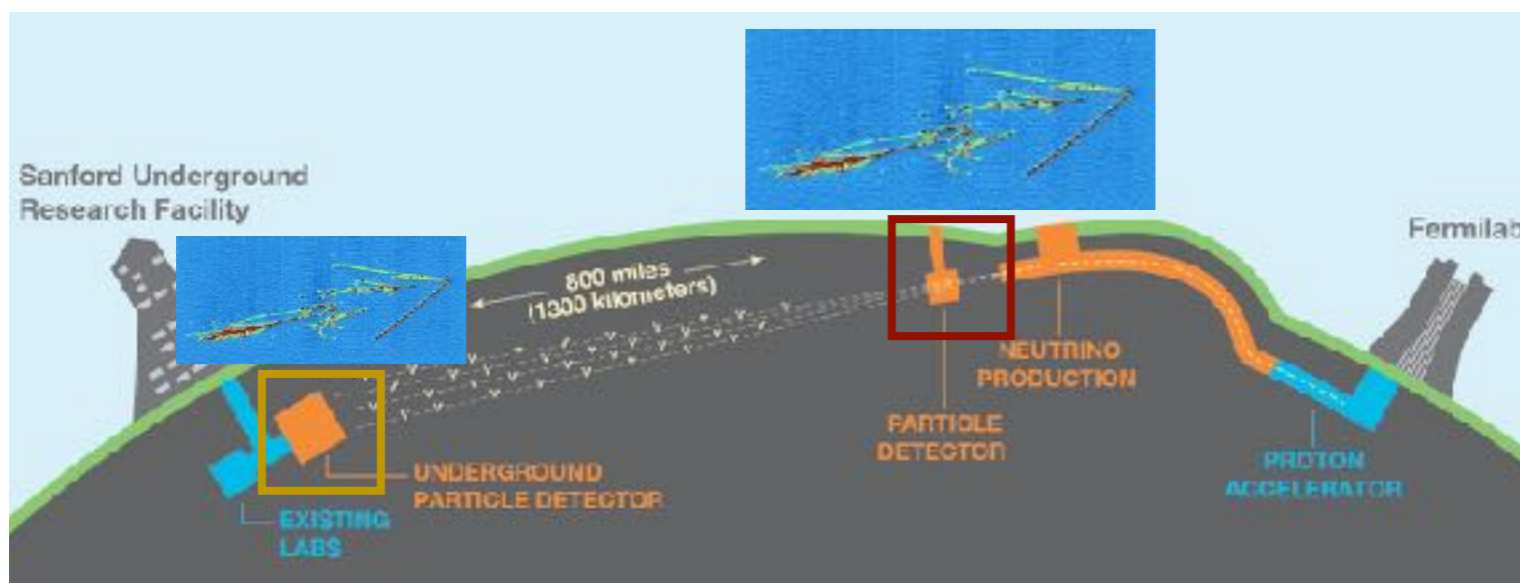
→ **Visitor program (25)**

▶ Hatsuda, Hagen, Brown, Hjorth-Jensen, Macchiavelli, Colò

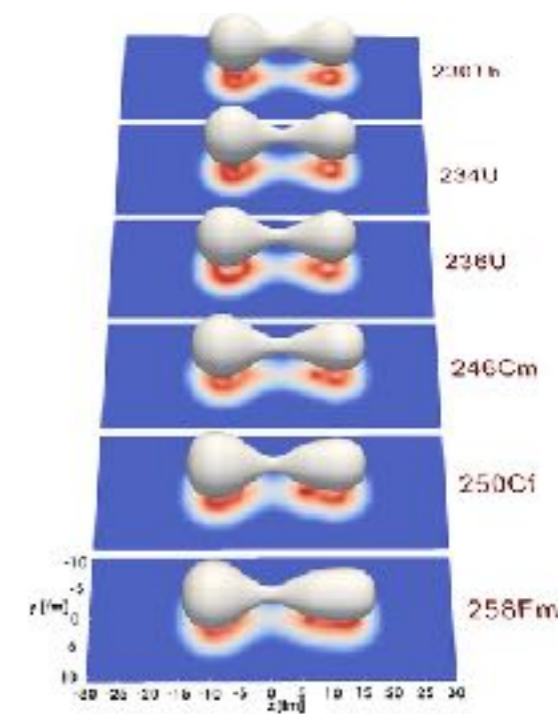
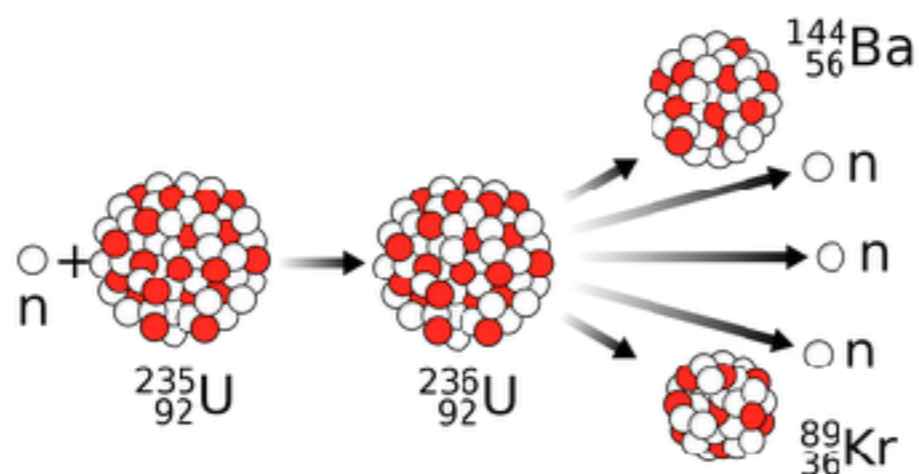
[http://personal.ph.surrey.ac.uk/%7Ecb0023/uktheory/Nuclear Theory Vision %40 UK/](http://personal.ph.surrey.ac.uk/%7Ecb0023/uktheory/Nuclear%20Theory%20Vision%20UK/)

Nuclear theory: projects

- **Specific, deliverable** projects that sit beyond the remit of Consolidated Grants where we have **expertise**:
 - **Neutrino-nucleus cross-sections framework (Surrey)**



- **Spontaneous & induced fission hub (York)**



PDRAs



Pierre Arthuis
(2018-20)



Mehdi Drissi
(2018-21)

Academics



Carlo Barbieri



Arnau Rios



Chris McIlroy



James Keeble

AB INITIO NUCLEAR THEORY WORKSHOP

FROM BREAKTHROUGHS TO APPLICATIONS
UNIVERSITY OF SURREY 24-26 JULY 2019



Neutron Physics in Neutrino Astronomy

IoP APP-NS Joint Workshop
King's College London, 8 November 2019

PDRAs



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(2018-20)



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Academics



Carlo Barbieri



Arnau Rios



Industry



James Keeble

AB INITIO NUCLEAR THEORY WORKSHOP

FROM BREAKTHROUGHS TO APPLICATIONS
UNIVERSITY OF SURREY 24-26 JULY 2019

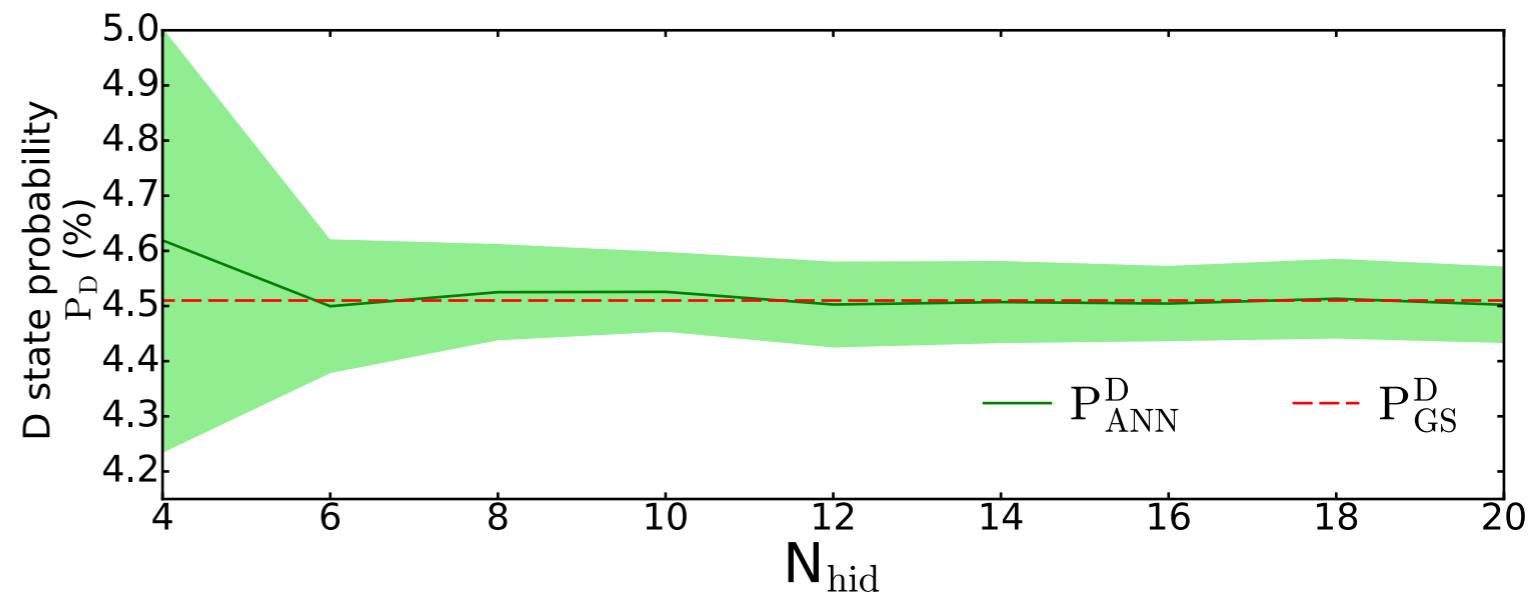
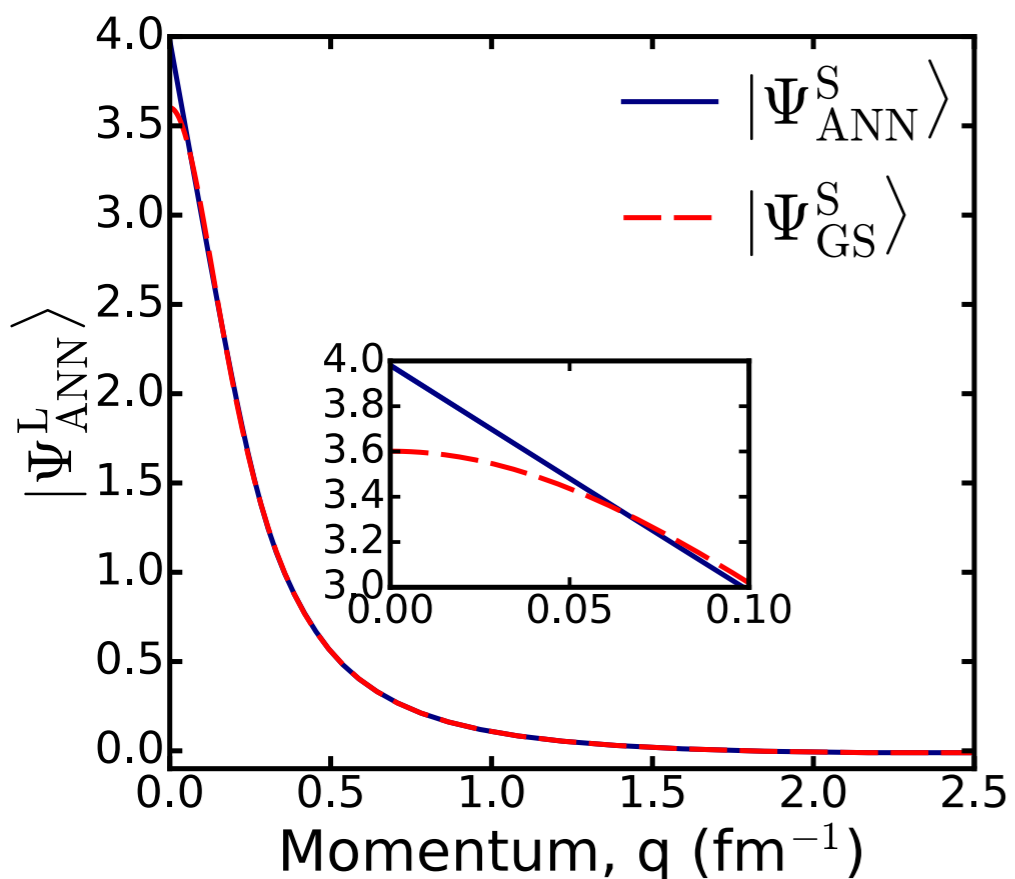
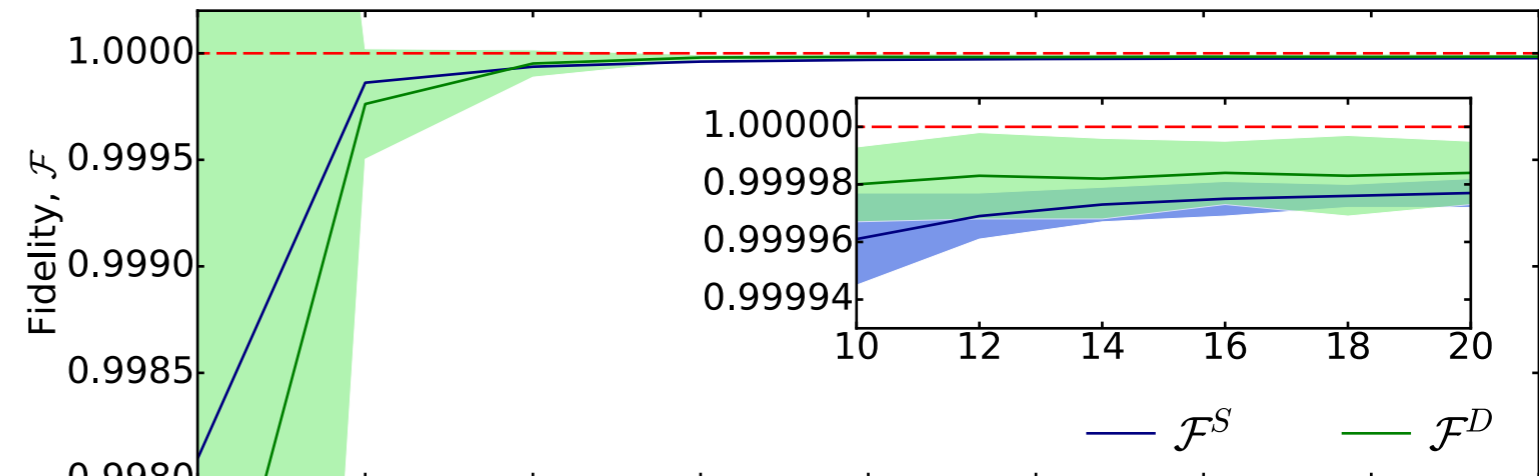
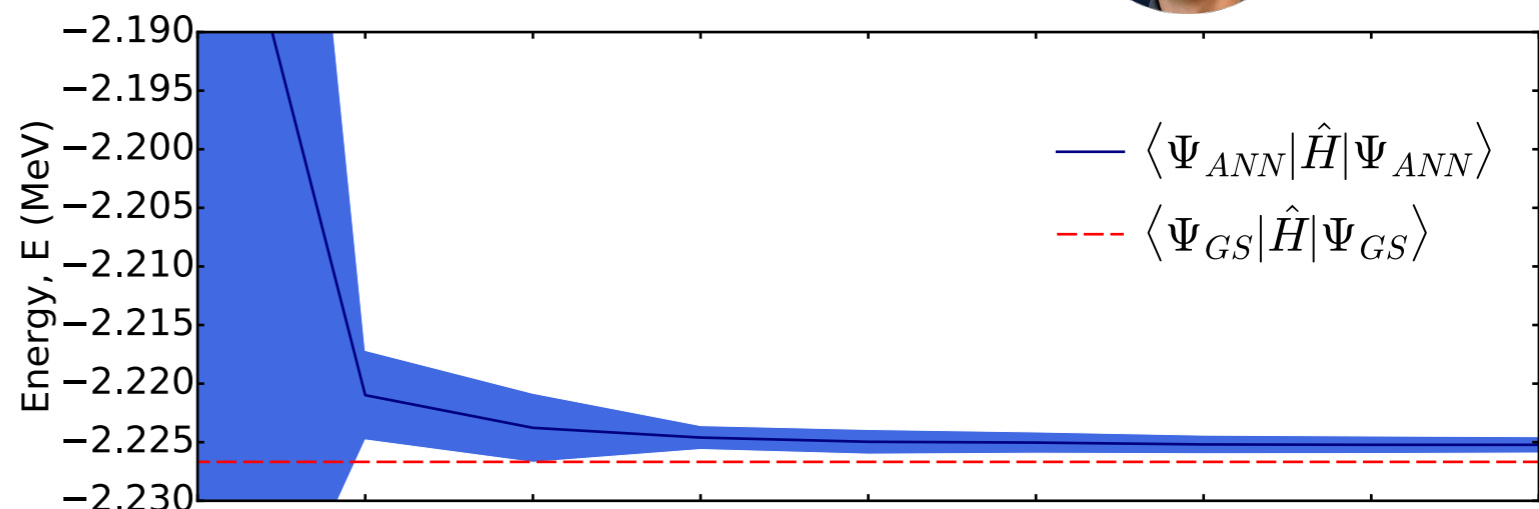
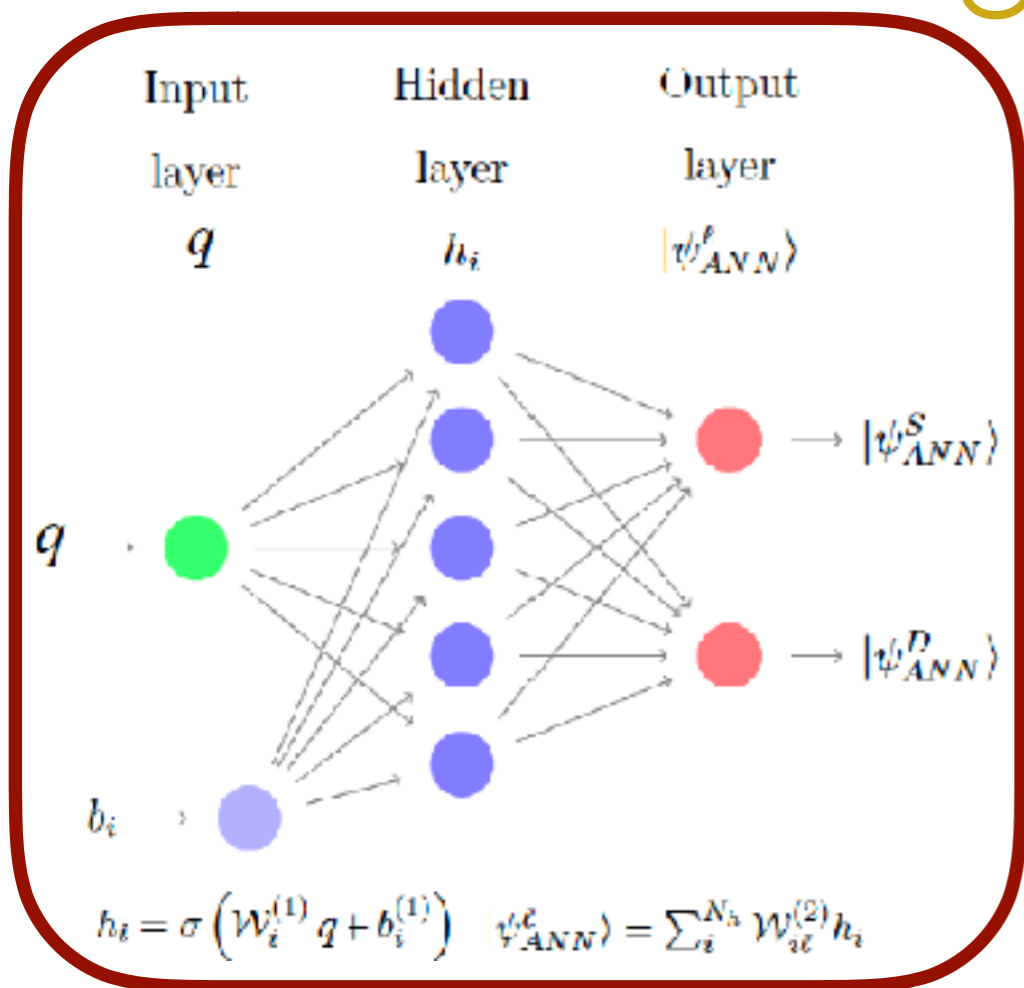
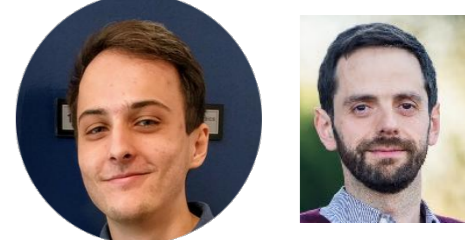


Neutron Physics in Neutrino Astronomy

IoP APP-NS Joint Workshop

King's College London, 8 November 2019

Machine learning the deuteron



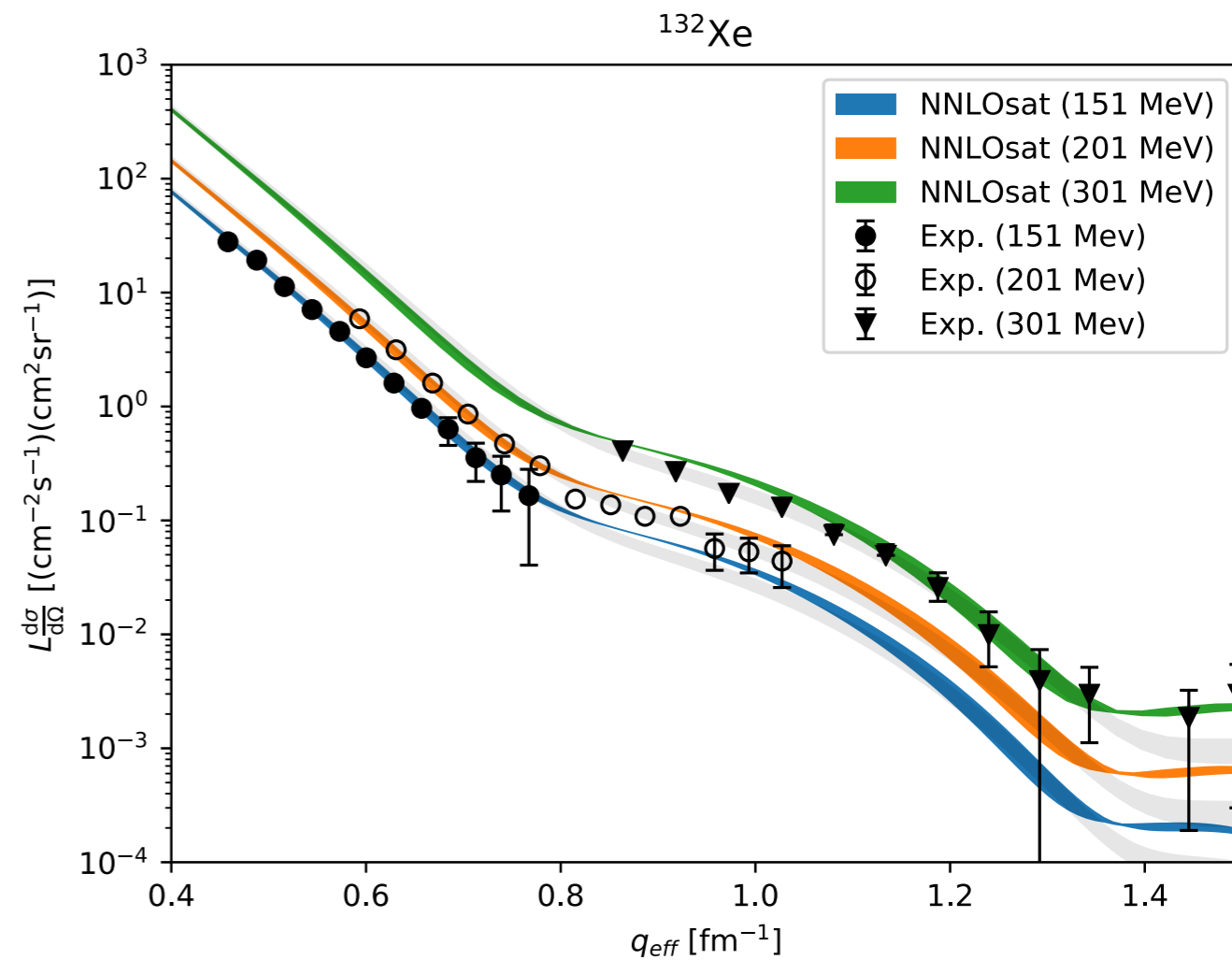
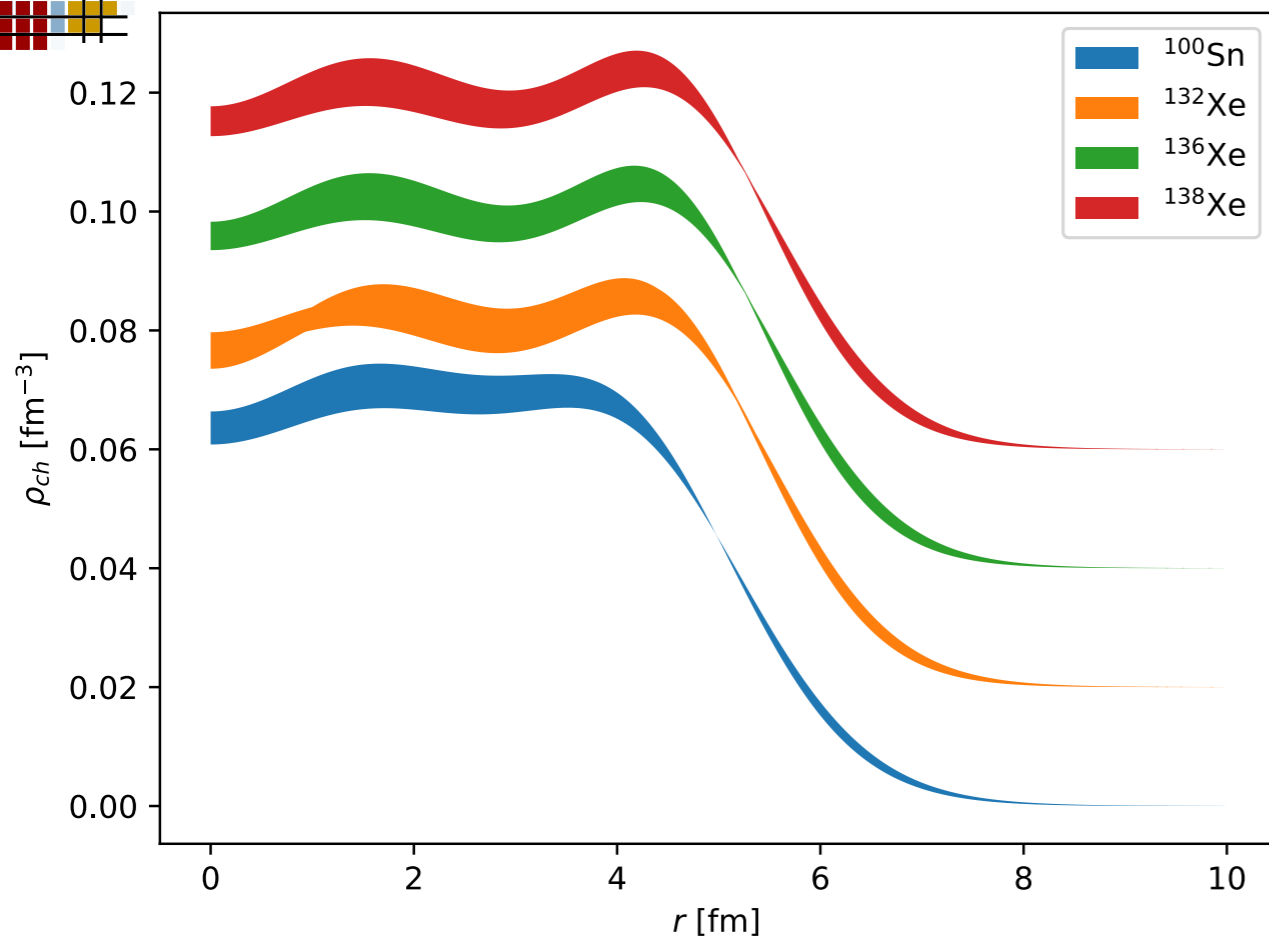
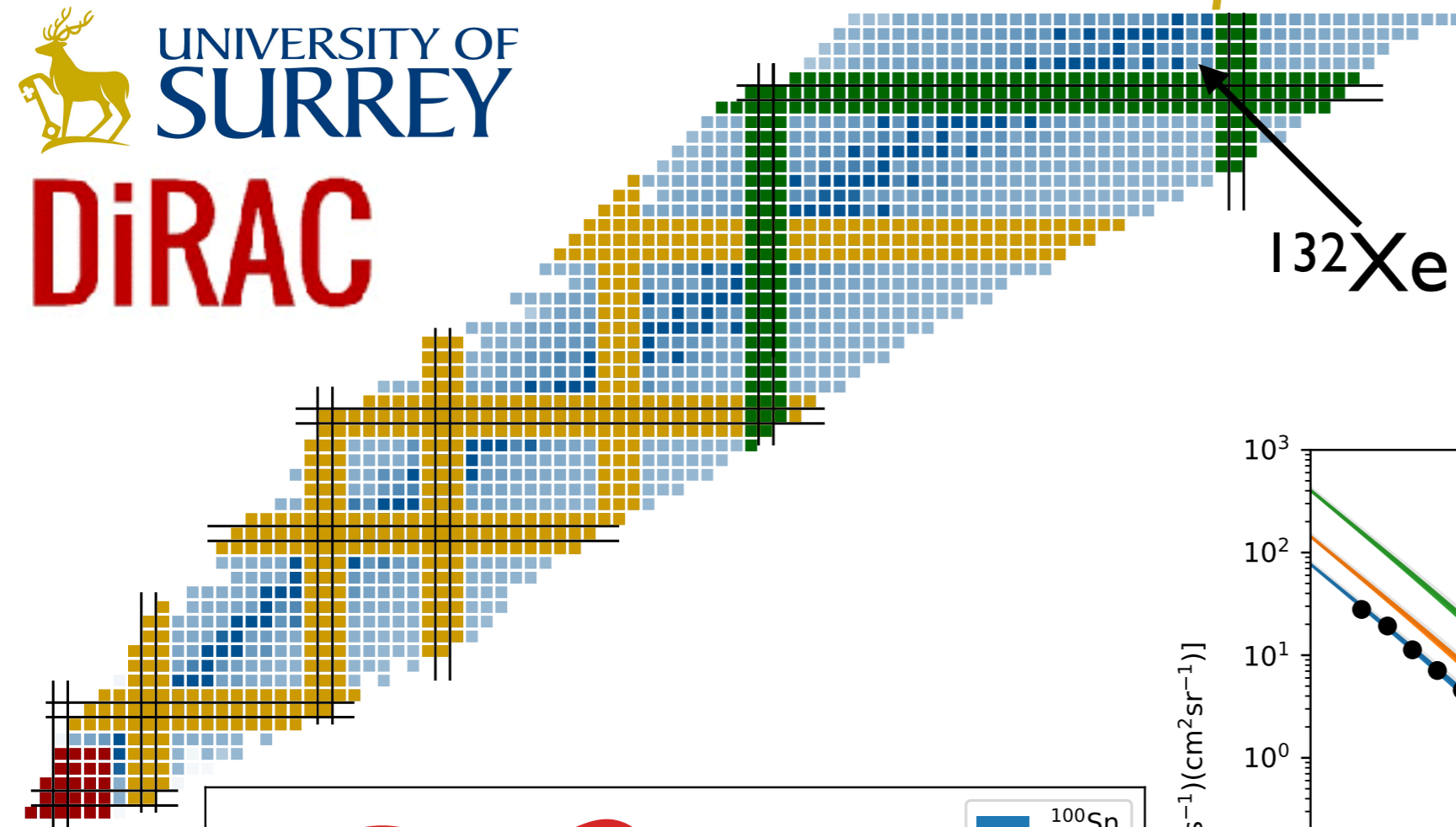
Heaviest *ab initio* isotopes



DiRAC



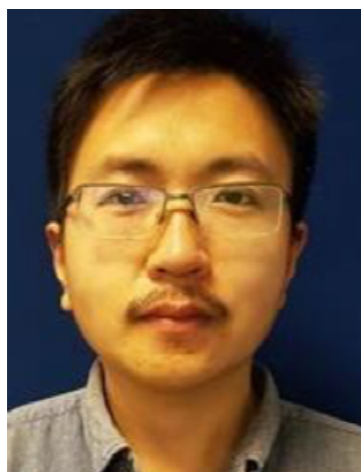
- *Ab initio* 2000s
- *Ab initio* 2015
- *Ab initio* 2025



Data from SCRIT experiment

Surrey updates 2019-2020

PDRAs



Kai Wen
(2017-19)

New
PDRA
(2020-21)

Academics



Paul Stevenson



Natasha Timofeyuk



That TV guy



Alexis Diaz-Torres



Cory Green



Michael Dinmore



Rafael v d Bossche



Terry Vockerodt

Emeriti



Tostevin



Johnson

Surrey updates 2019-2020

PDRAs



Tsukuba

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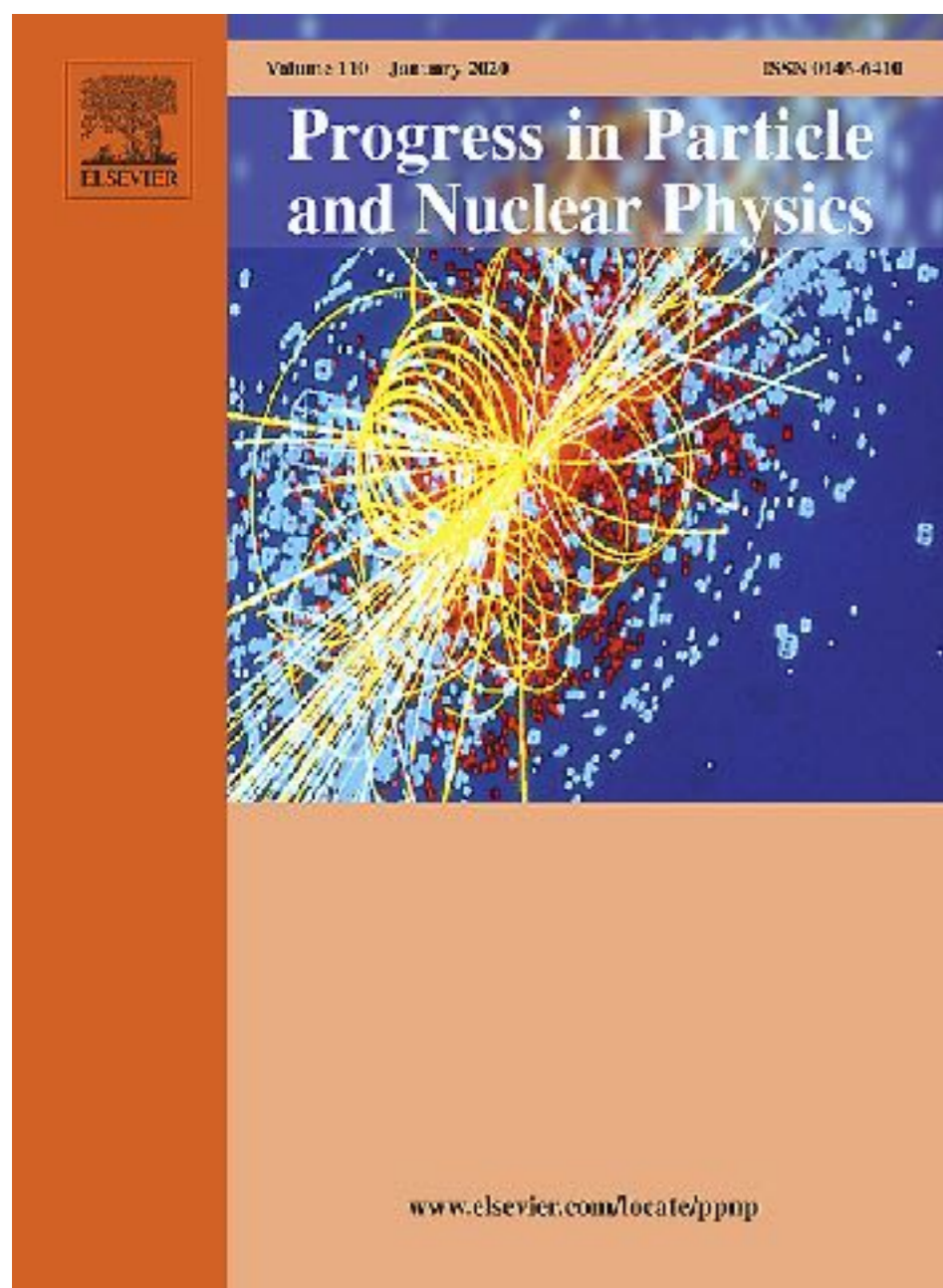


Johnson



24th European Conference on Few-Body Problems in Physics

1-6 September 2019
University of Surrey



Theory of deuteron stripping and pick-up reactions for nuclear structure studies

N.K. Timofeyuk  , R.C. Johnson

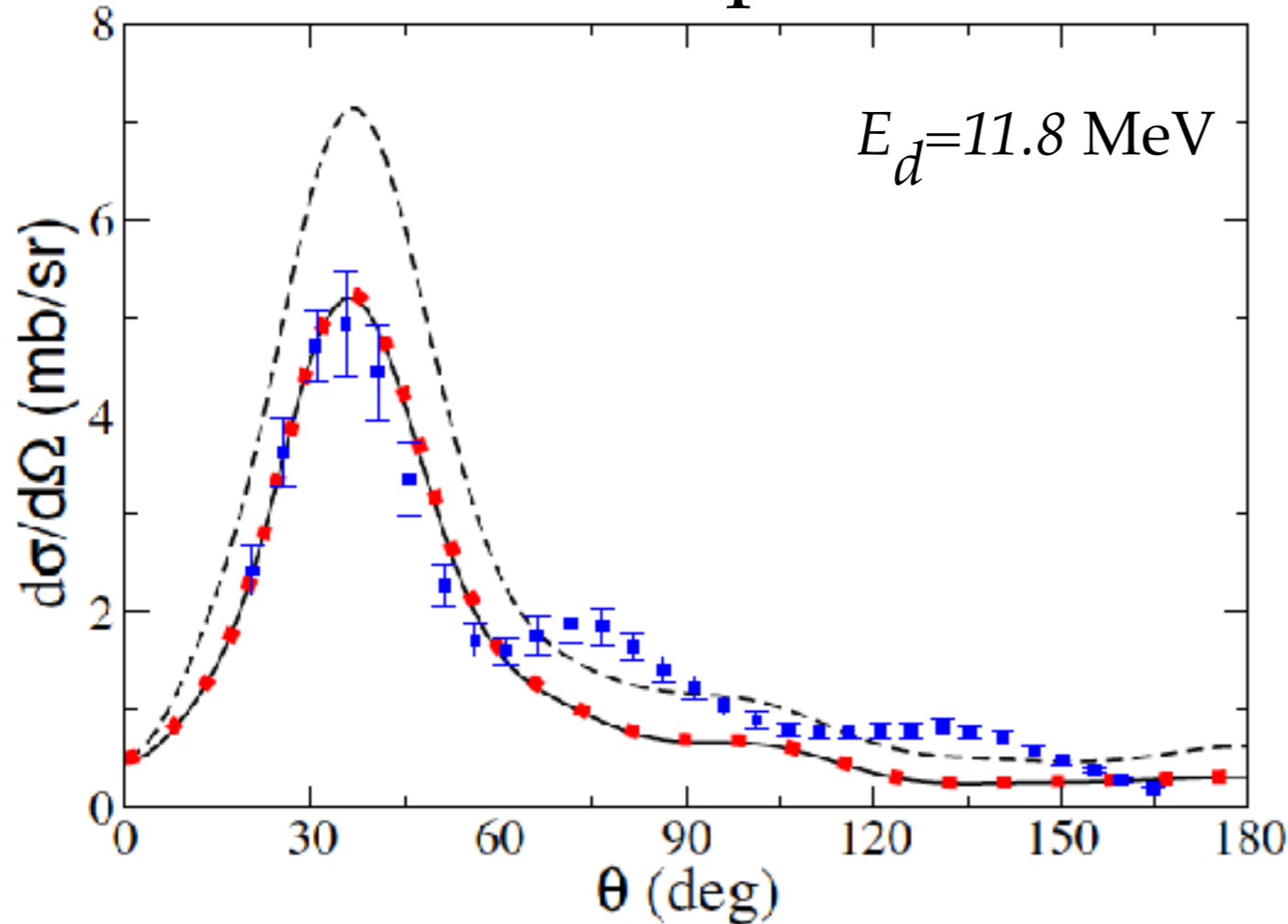
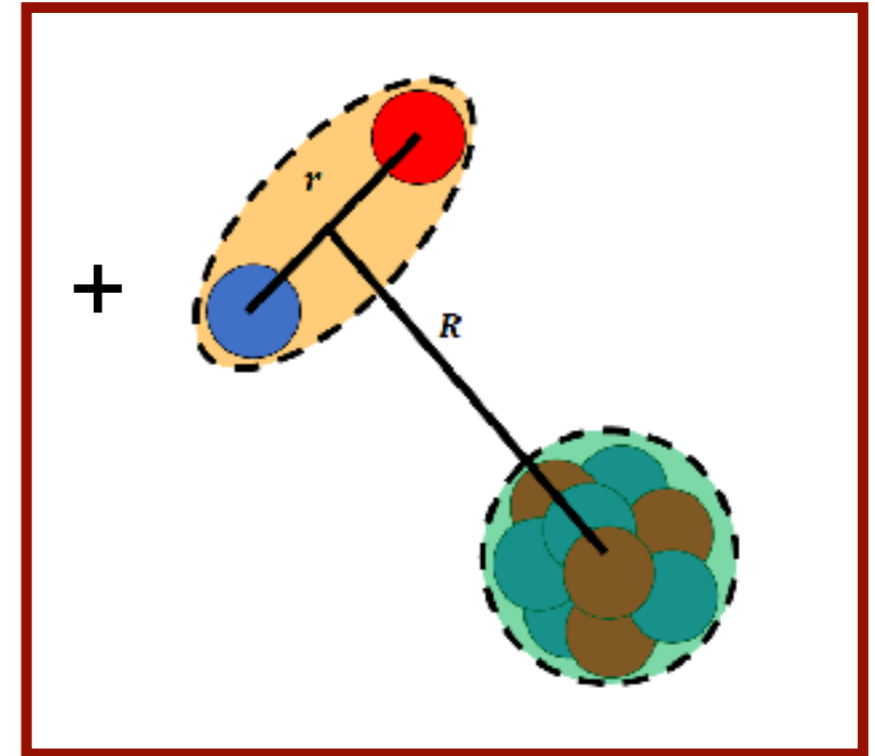
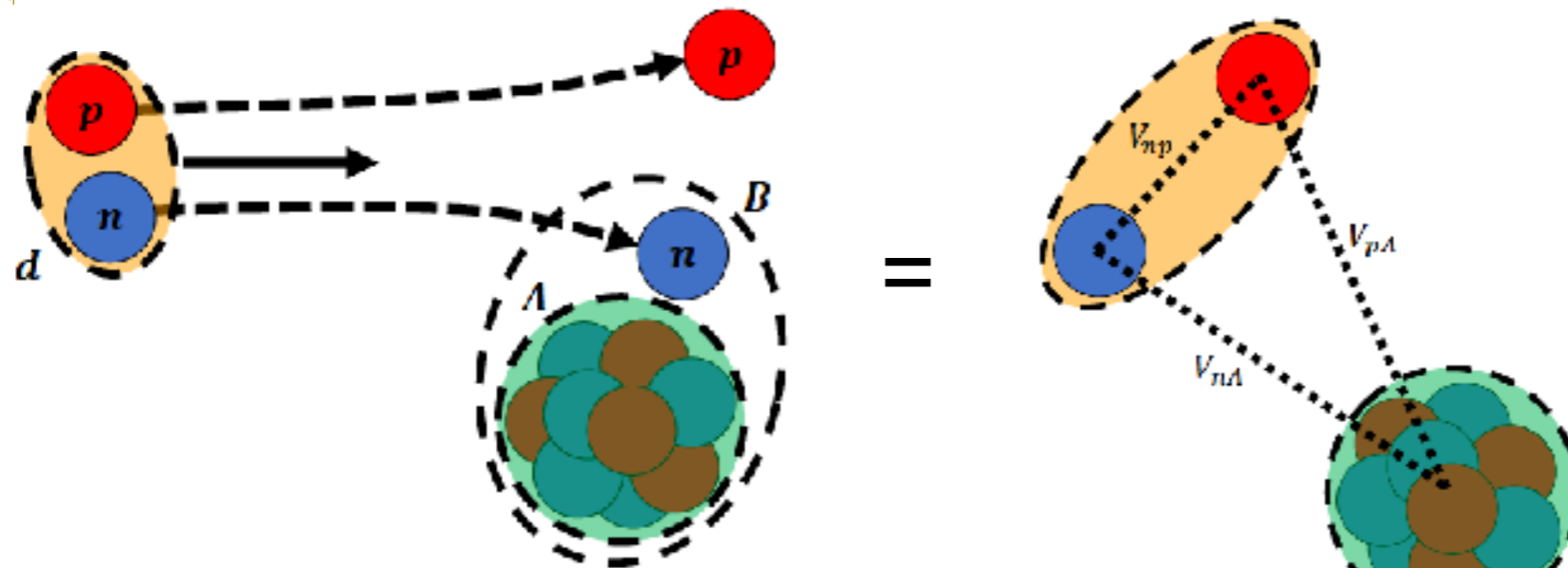


Low-energy heavy-ion reactions and the Skyrme effective interaction

P.D. Stevenson  , M.C. Barton



Induced 3-body terms in (d,p)



Effects of an induced three-body force in the incident channel of (d,p) reactions

M. J. Dinmore, N. K. Timofeyuk, J. S. Al-Khalili, and R. C. Johnson
Phys. Rev. C **99**, 064612 – Published 18 June 2019



York updates 2019-2020

PDRAs



Pierre Becker
(2017-19)



Jérémy Bonnard
(2019-21)

Academics



Jacek Dobaczewski



Alessandro Pastore



Antonio Romero



Matthew Shelley



David Muir



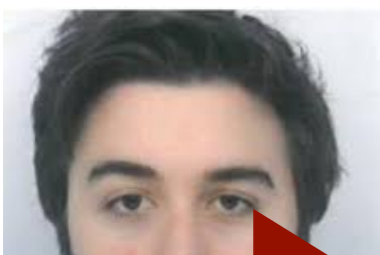
Paolo Sassarini

Workshop on 'Future of Theory in Fission'

Monday 14 October 2019, 9.00am

York updates 2019-2020

PDRAs



Pierre Becker
(2017-19)



Jérémy Bonnard
(2019-21)

Academics



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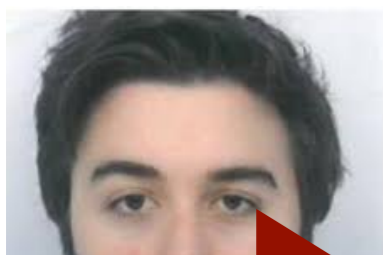
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Alessandro Pastore



N Carolina



Matthew Shelley



David Muir



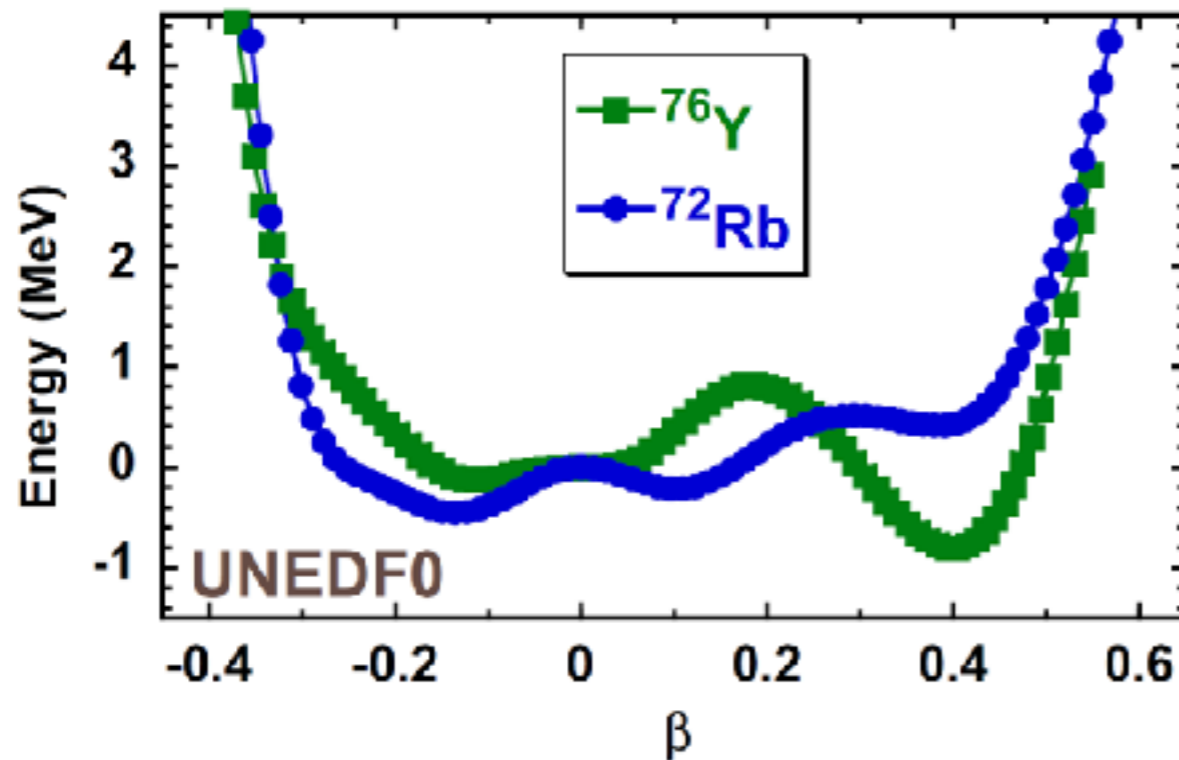
Paolo Sassarini

Workshop on 'Future of Theory in Fission'

Monday 14 October 2019, 9.00am

Half-lives of ^{73}Sr and ^{76}Y and the consequences for the proton dripline

L. Sinclair,^{1,2} R. Wadsworth^{1,*}, J. Dobaczewski,^{1,3,4} A. Pastore,¹ G. Lorusso,^{2,5,6} H. Suzuki,² D. S. Ahn,² H. Baba,² F. Browne,^{2,7} P. J. Davies,^{1,†} P. Doornenbal,² A. Estrade,^{8,‡} Y. Fang,^{9,§} N. Fukuda,² J. Henderson,^{1,||} T. Isobe,² D. G. Jenkins,¹ S. Kubono,² Z. Li,¹⁰ D. Lubos,^{2,11} S. Nishimura,² I. Nishizuka,^{12,¶} Z. Patel,^{2,6} S. Rice,^{2,6} H. Sakurai,² Y. Shimizu,² P. Schury,^{2,#} H. Takeda,² P.-A. Söderström,^{2,**} T. Sumikama,¹³ H. Watanabe,¹⁴ V. Werner,¹⁵ J. Wu,^{2,10} and Z. Y. Xu¹⁶



In Fig. 8, we show the calculated deformation energies in ^{72}Rb and ^{76}Y . The obtained values are fairly flat: i.e., between $\beta = -0.3$ & 0.5 all deformation energies are between -1 and $+1$ MeV. Nevertheless, we clearly see a shift of the minimum from oblate in ^{72}Rb and to prolate in ^{76}Y . This assignment of ground-state deformations conforms with the previously suggested oblate and prolate shapes of the neighbouring isobars, ^{72}Kr and ^{76}Sr .

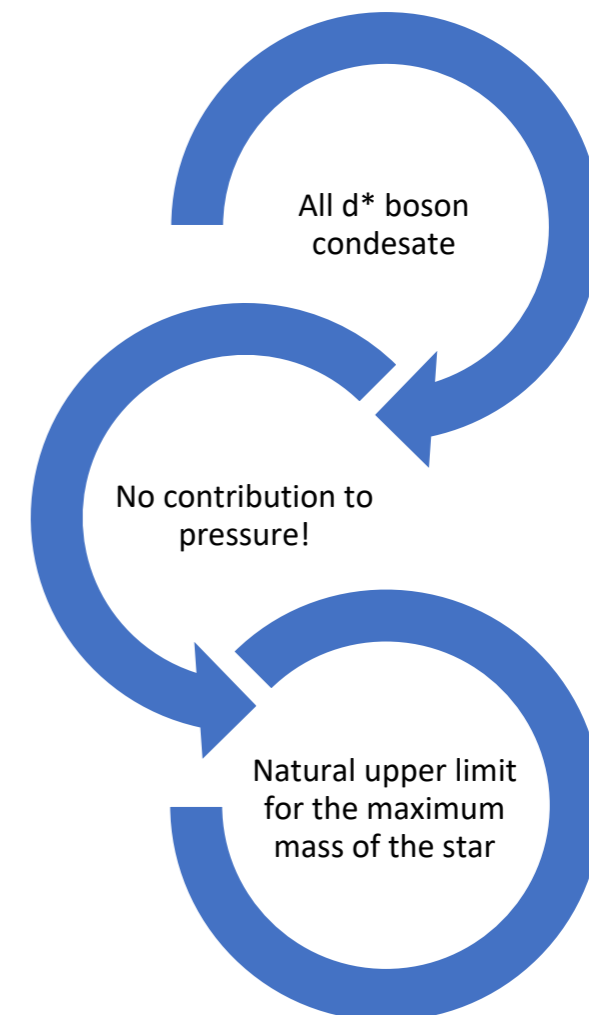
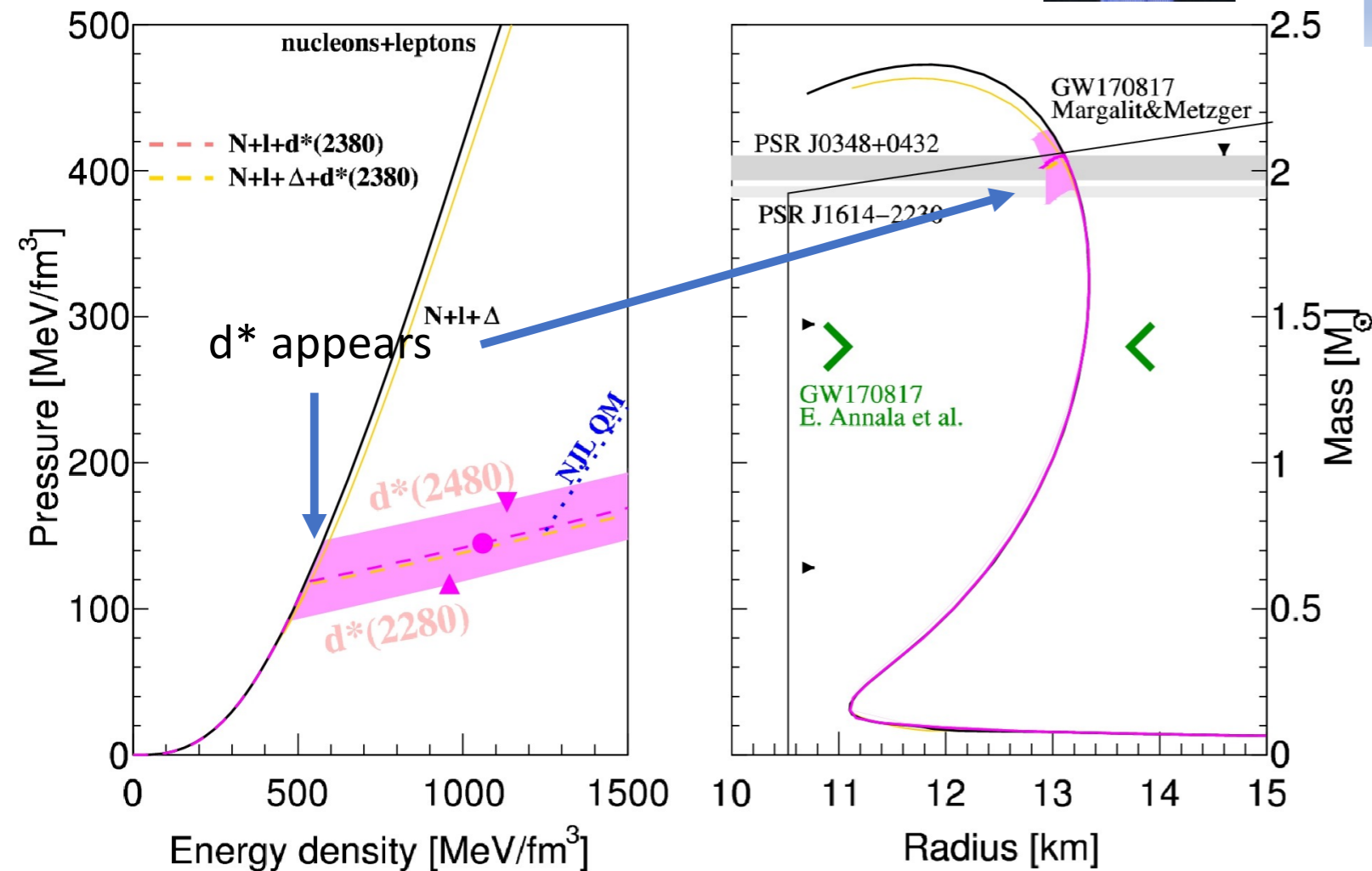
FIG. 8. Deformation energies as a function of the quadrupole deformation β calculated for ^{72}Rb and ^{76}Y using the Skyrme functional UNEDF0 [30].



d^* in astrophysics



Goal the collaboration:
To study the role of d^* boson ($J^\pi=3^+$) in the core of a neutron star (no strangeness!)



d^* enters in the nucleonic sector of the EOS as Δ resonance. No reason to neglect it!

Vidana, Bashkanov, Watts & Pastore, *Physics Letters* **B 781**, 112-116 (2018)
 Bashkanov, Watts & Pastore, *Physical Review* **C 100**, 012201 (2019)
 Mantziris, Pastore, Vidana, Watts & Bashkanov, A. M. Romero, *A&A* (to be submitted)



Manchester updates 2019-2020

PDRAs



Johannes Kircher
(2018-20)

Academics



Mike Birse



Judith McGovern



Niels Walet



Felipe Isaule



Alex Moore



Tom Parry

Manchester updates 2019-2020

PDRAs



Johannes Kircher
(2018-20)

Academics



Mike Birse



Judith McGovern



Niels Walet



Barcelona



Alex Moore



Tom Parry

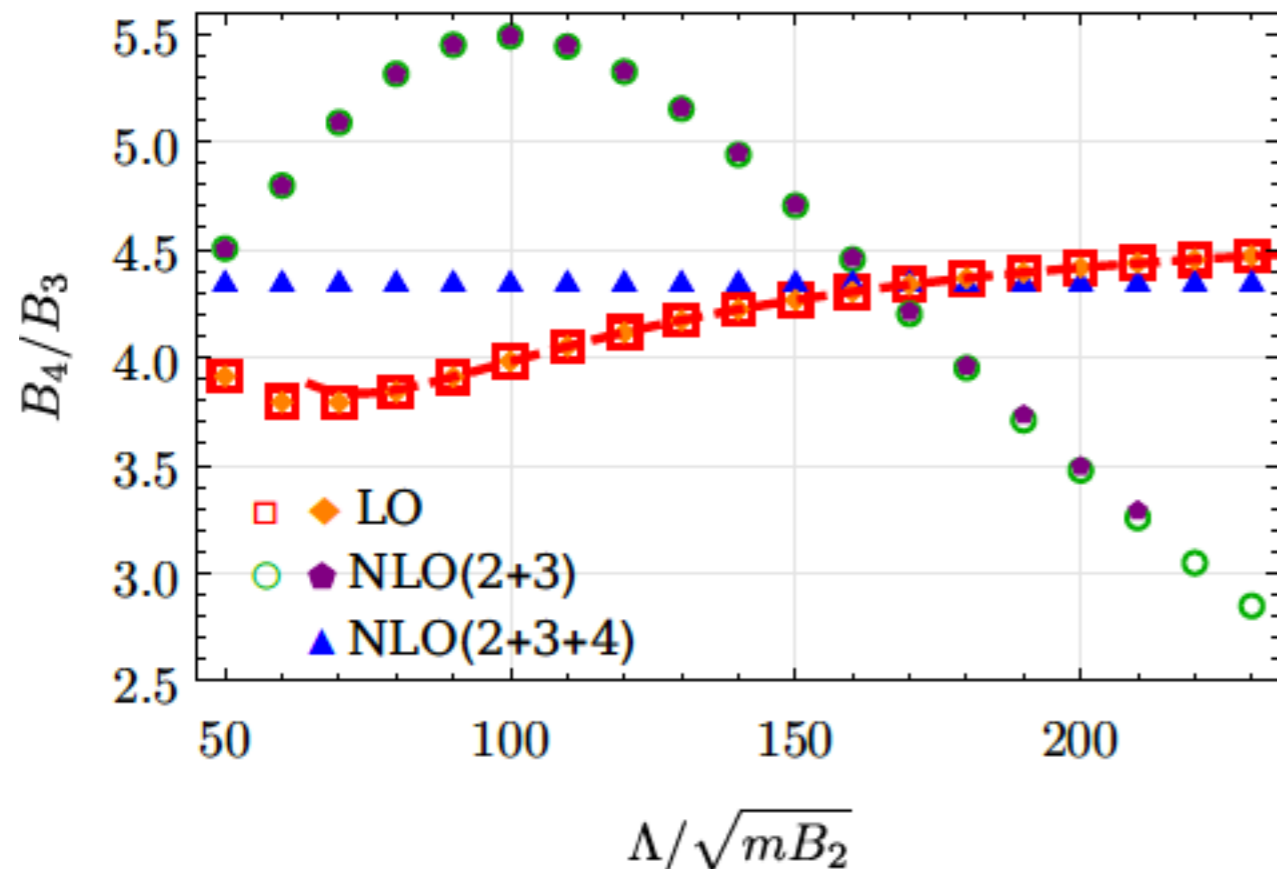
Universality in few-body systems



Editors' Suggestion

Four-Body Scale in Universal Few-Boson Systems

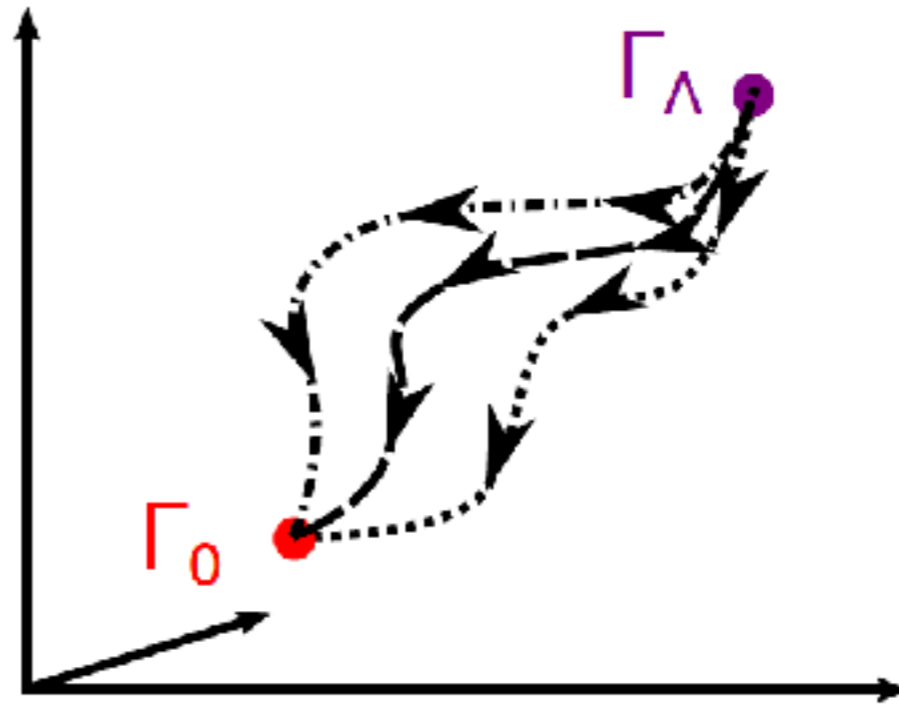
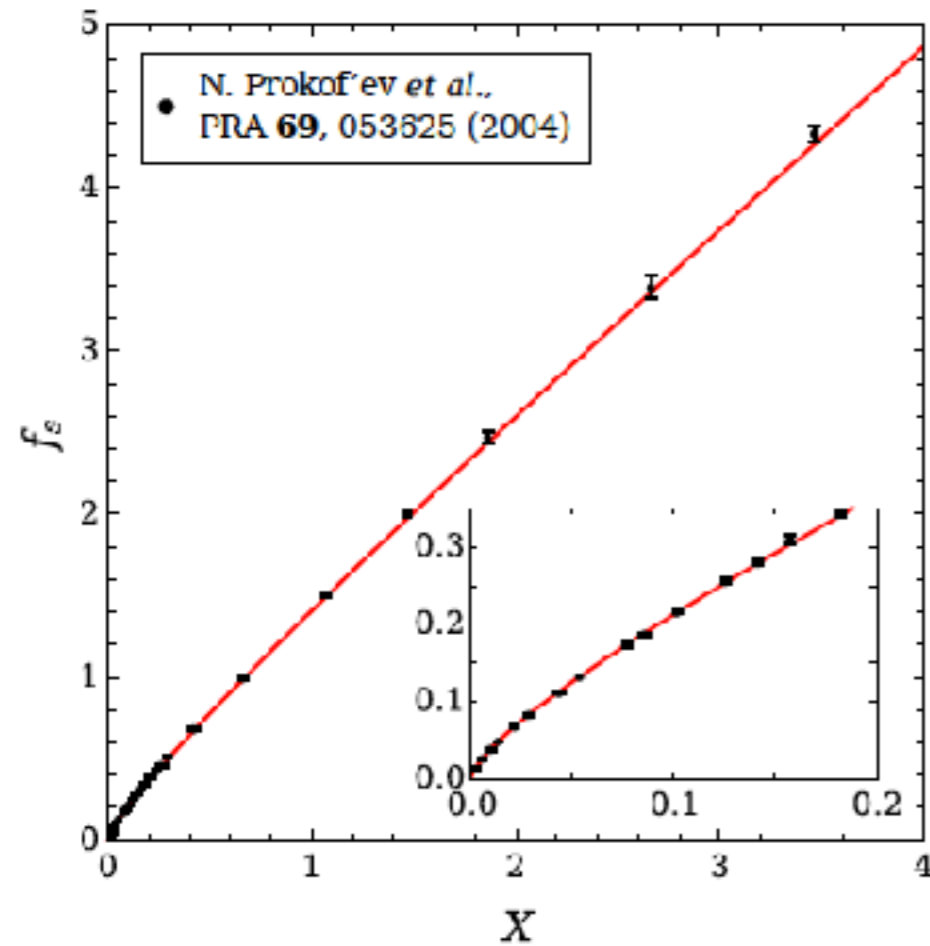
B. Bazak, J. Kirscher, S. König, M. Pavón Valderrama, N. Barnea, and U. van Kolck
Phys. Rev. Lett. **122**, 143001 – Published 10 April 2019



Conjecture
New scales appear at $N^{A-3}LO$

It is known that no four-body force is needed at leading order. In the case of bosonic systems, at NLO order, a four-body force is found to be needed to renormalise the binding energies of 4-, 5- and 6-particle systems

Functional renormalisation group



$$f_s = \frac{\rho_s}{m^3 T^2 u_{2,\Lambda}}, \quad X = \frac{\mu - \mu_c}{m^3 T^2 u_{2,\Lambda}^2}$$

$$\partial_K \Gamma = \frac{1}{2} \text{ (circle with square) }$$

The functional renormalisation group has been used to study the thermodynamics of Bose gases in 1D, 2D & 3D. Felipe developed an approach that correctly handles the Goldstone modes in the physical limit. This is needed for extensions of the method to fermionic superfluids in nuclear contexts.

Takehome messages

- **Delivering strong scientific output across UK**
 - **Subject areas:** structure, reactions, hadron & astrophysics
 - **PDRA support key** to maintain world-leading programme
- **Project Funding** sought (how to deliver it?)

	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25
Nuclear Theory								
Neutrino-nucleus Fission								
		ongoing		future		exploitation		horizon
				PRD		exploitation at other facilities inc GSI		

Figure 9: Project timescales

- **Nuclear Theory Vision** is over
- **Growth?**