SUPA Physics Scotland

SUPA IAC Meeting – 30th May 2019

Nuclear and Plasma Physics

Theme Leader: Professor Dave Ireland

Theme: Edinburgh, Glasgow, Strathclyde, and UWS

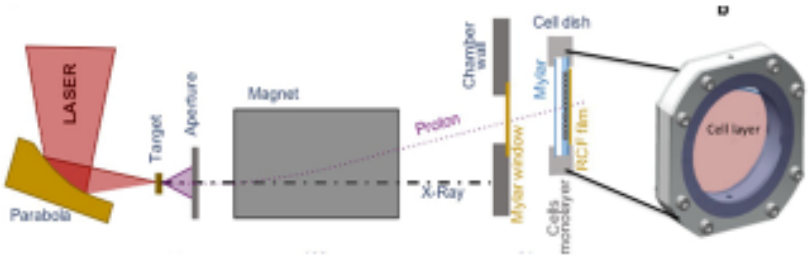
Existing Scope of Theme

- **Plasma Physics**: high field physics, fusion related physics, laboratory astrophysics,
- **Laser-plasma based accelerators and radiation sources**: compact coherent X-ray, gamma-ray, THz & microwave sources, radiotherapy, imaging
- **Nuclear physics**: hadron structure, hadron spectroscopy, mesons, nucleons and nuclei, nuclear astrophysics, exotic nuclei
- **SCAPA: enabling facility** for cross-disciplinary research
- **Industry engagement**: radiotherapy, radiation damage and imaging for security, defence, health and the environment.
- **Spin-out companies**: Anacail, Lynkeos

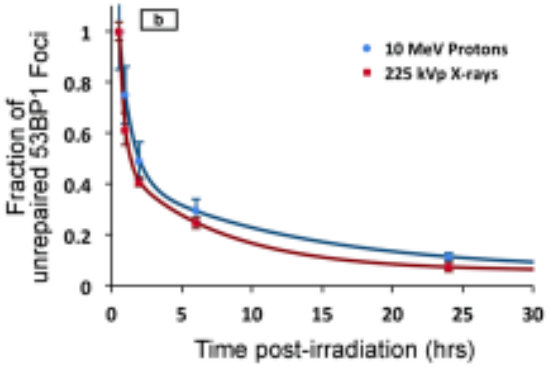
Laser-Accelerated Protons

DNA repair dynamics following irradiation with laser-driven protons at ultra-high dose rates

- Laser-accelerated protons used to investigate the radiobiological effects of cell irradiation at ultra-high dose rates
- human skin fibroblasts-AG01522B cells irradiated at does rates of 10^9 Gy/s, orders of magnitude higher than conventional ion accelerators
- Results show strong similarity in DNA repair with cyclotron accelerated protons and X-ray pulses, independent of the rate of dose delivery



Credit: clf.ac.uk



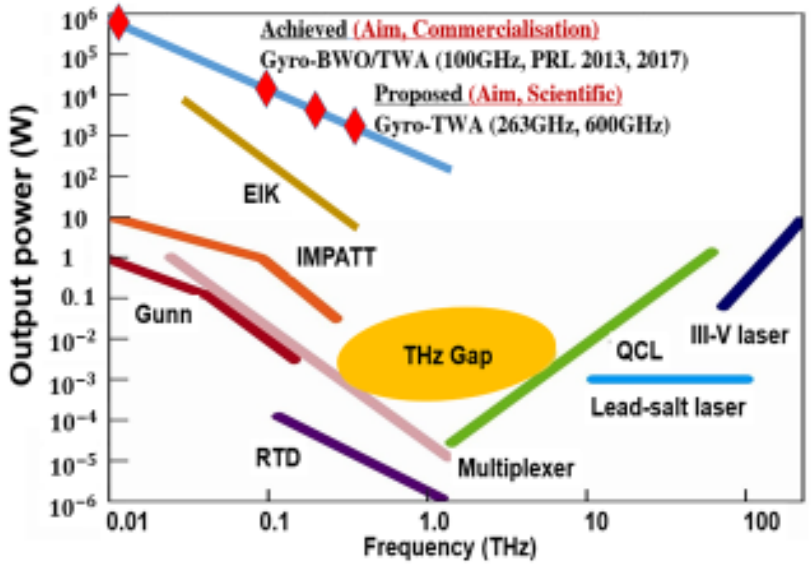
F. Hanton *et al*, Sci. Rep., 9, 4471 (2019)
A-SAIL collaboration experiment

For further information: paul.mckenna@strath.ac.uk

Microwave Amplification

High Power Microwave Wave Sources

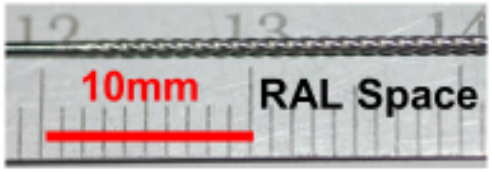
Liang Zhang; Craig Donaldson; Craig Robertson; Philip MacInnes; Amy MacLachlan; Colin Whyte; Alan Young; Wenlong He; Alan Phelps; Kevin Ronald; Adrian Cross



Liang Zhang & Craig Donaldson were awarded the best poster prize at the 20th International Vacuum Electronics Conference (IVEC) 2019, held in Busan, South Korea 1/05/2019 for:-

World-leading wideband high power source.
Largest power–bandwidth product $P \cdot \Delta f$.
Phys. Rev. Lett., 2013

World-leading wideband high power amplifier
Largest gain–bandwidth product $G \cdot \Delta f$
Phys. Rev. Lett., 2017



Applications	Centre frequency (GHz)	-3dB IFB (GHz)	Output power (kW)
Communications & Space Object Identification	94 (PRL, 2017)	10	5
Magnetic resonance spectroscopy for bio-chemistry	263 (… 2019)	50	1
	585 (… 2020)	60	0.5

ESA TWT for Satellite Comms: Strathclyde \ RAL Space \ TMD Ltd

- Travelling Wave Tube Amplifier
  - 71GHz to 76GHz, 100W

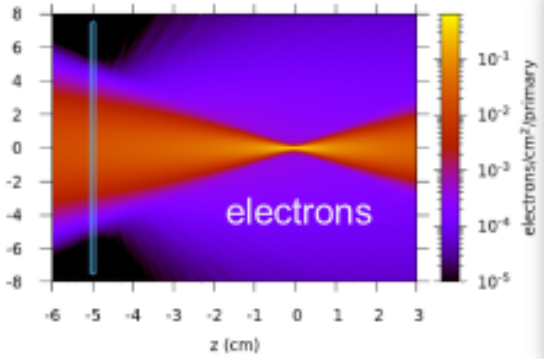
Robertson C.W., et al, Gilmour C. et al Huggard P.G. et al , Ronald K., IVEC2019

Laser-Plasma Interaction

Laser-plasma acceleration: focussed beams for radiotherapy, attosecond electron bunches, fs synchrotron radiation

University of Strathclyde

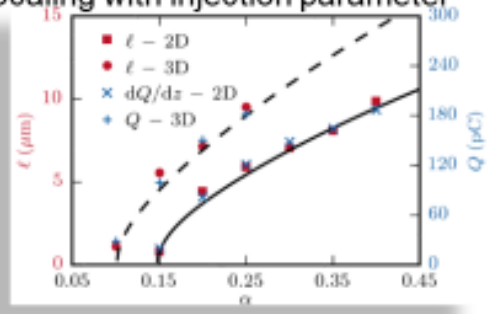
200 MeV beams focused with 15° convergence angle

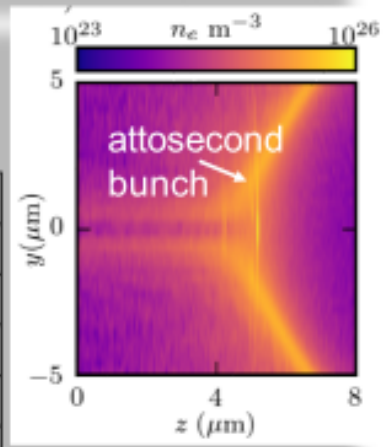


Focused beam radiotherapy

Kokurewicz et al. SPIE 2019

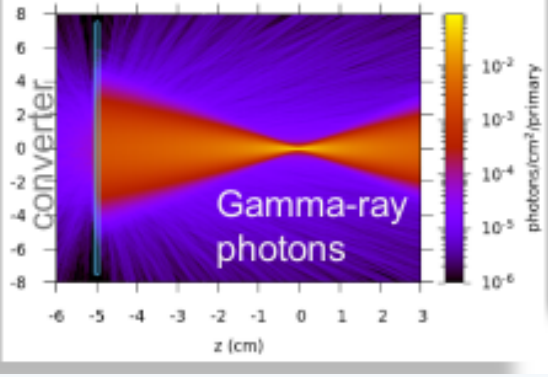
Scaling with injection parameter

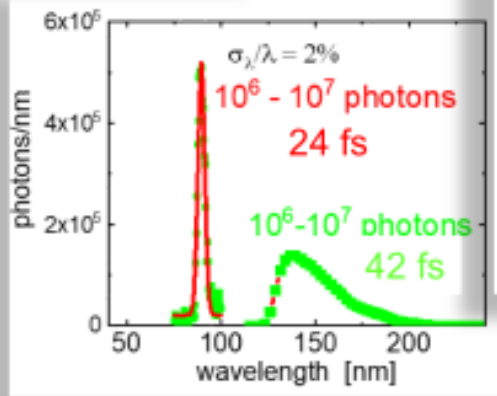




Tooley et al., PRL 2017

Focussed beams to ≈80 μm FWHM for 1 GeV beam



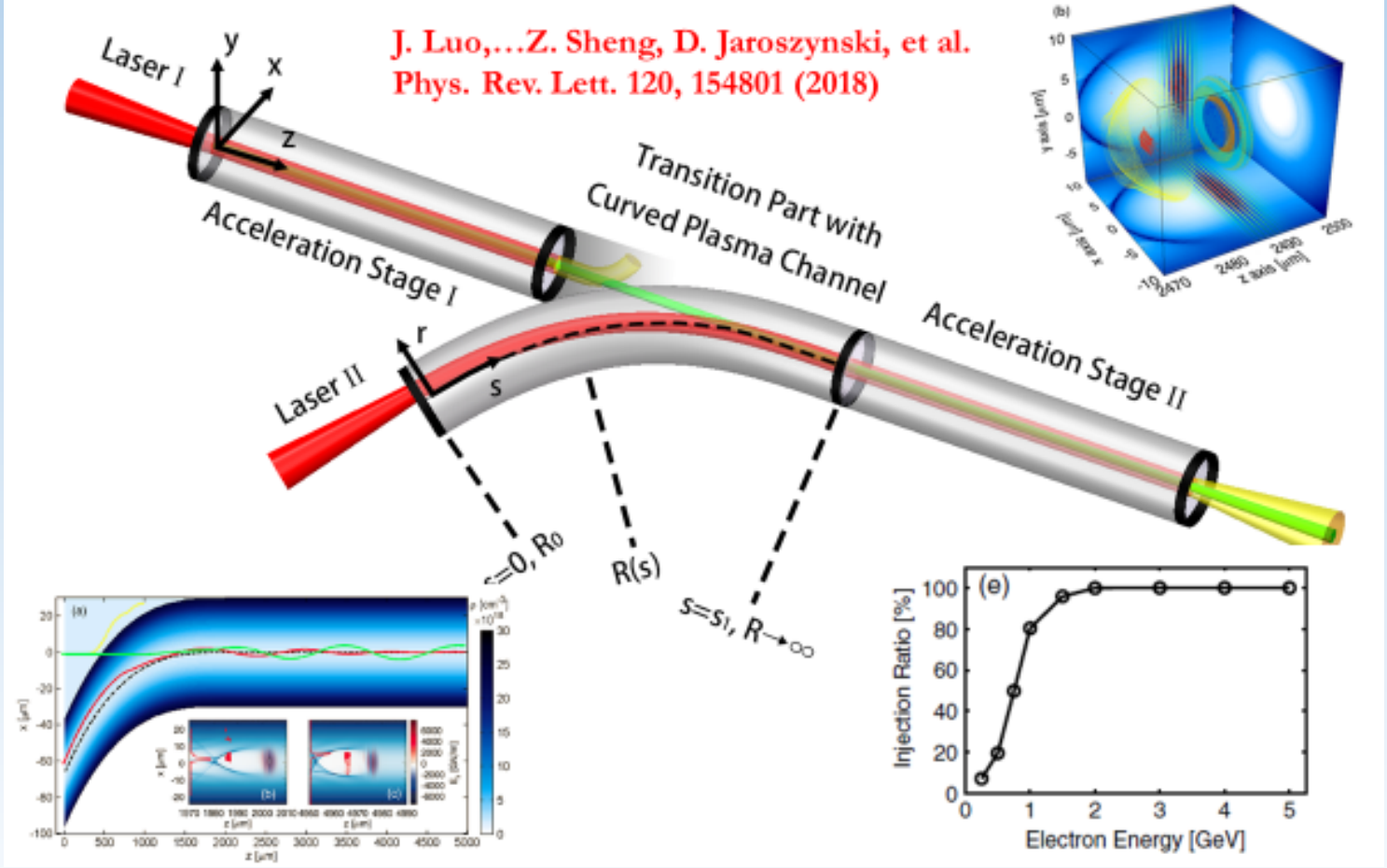


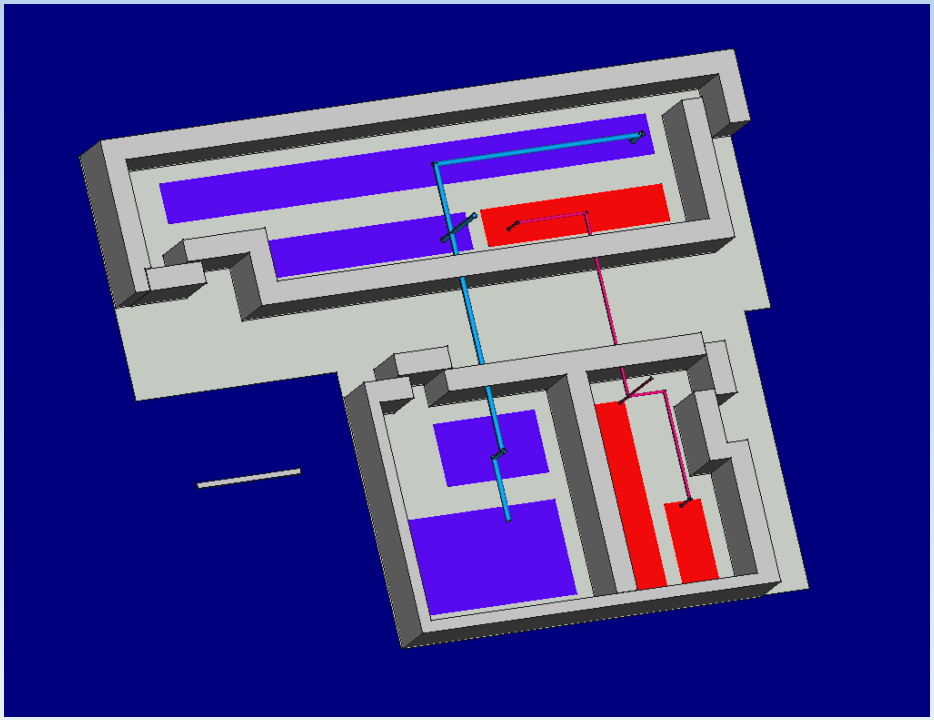
Anania et al. APL 2014, Jaroszynski et al. SPIE 2019

dino@phys.strath.ac.uk SUPA 2019

Laser-Plasma Interaction

New scheme of staging acceleration for TeV electron acceleration





Beamline A2 for LWFA

Full operation imminent – May 2019.

Optimising focal spot on target and plasma channel production (full-power – attenuated in A2).

First experiments this week

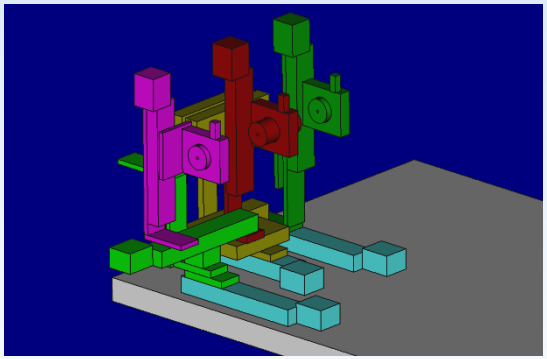
Beamline B1 for solid targets

Optics installation in progress.

Wavefront sensor installed after plasma mirror.

Focal spot obtained (full-power – attenuated).

Expected operation – Jan. 2020.



Beamline A3 for LWFA

Magnet design completed for FEL development Phase A.

Stages designed for PMQ tuning range 0.5-1.0 GeV.

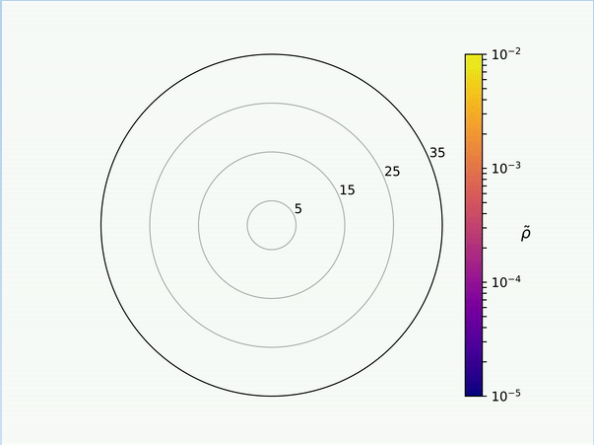
Procurement awaits Cockcroft Institute contractual agreement.

Expected operation July 2021.

Plasma Physics

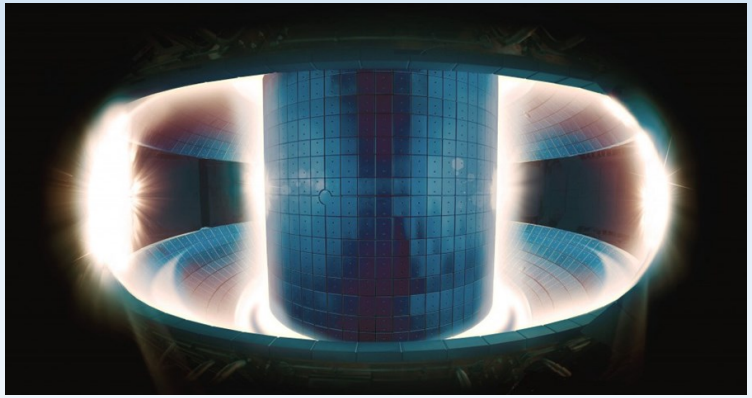
Modelling of cryogenic pellet ablation in a hot plasma and the subsequent gas-plasma interaction

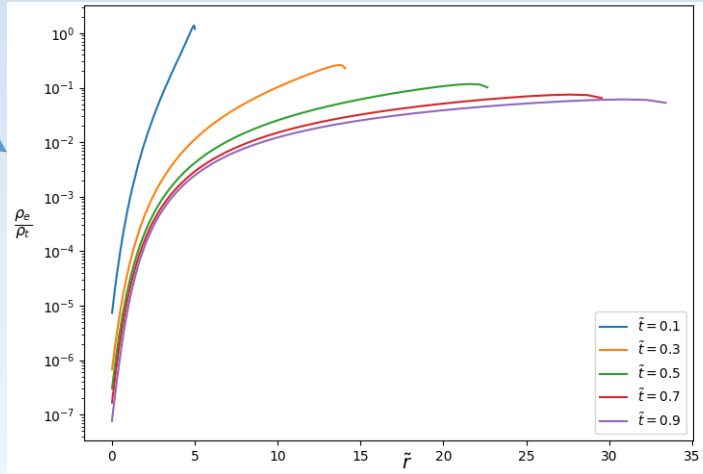
- F K Martin[1], A D Wilson[1], D A Diver[1], M Valovič[2]
- [1] University of Glasgow, Kelvin Building [2] Culham Centre for Fusion Energy, Culham Science Centre



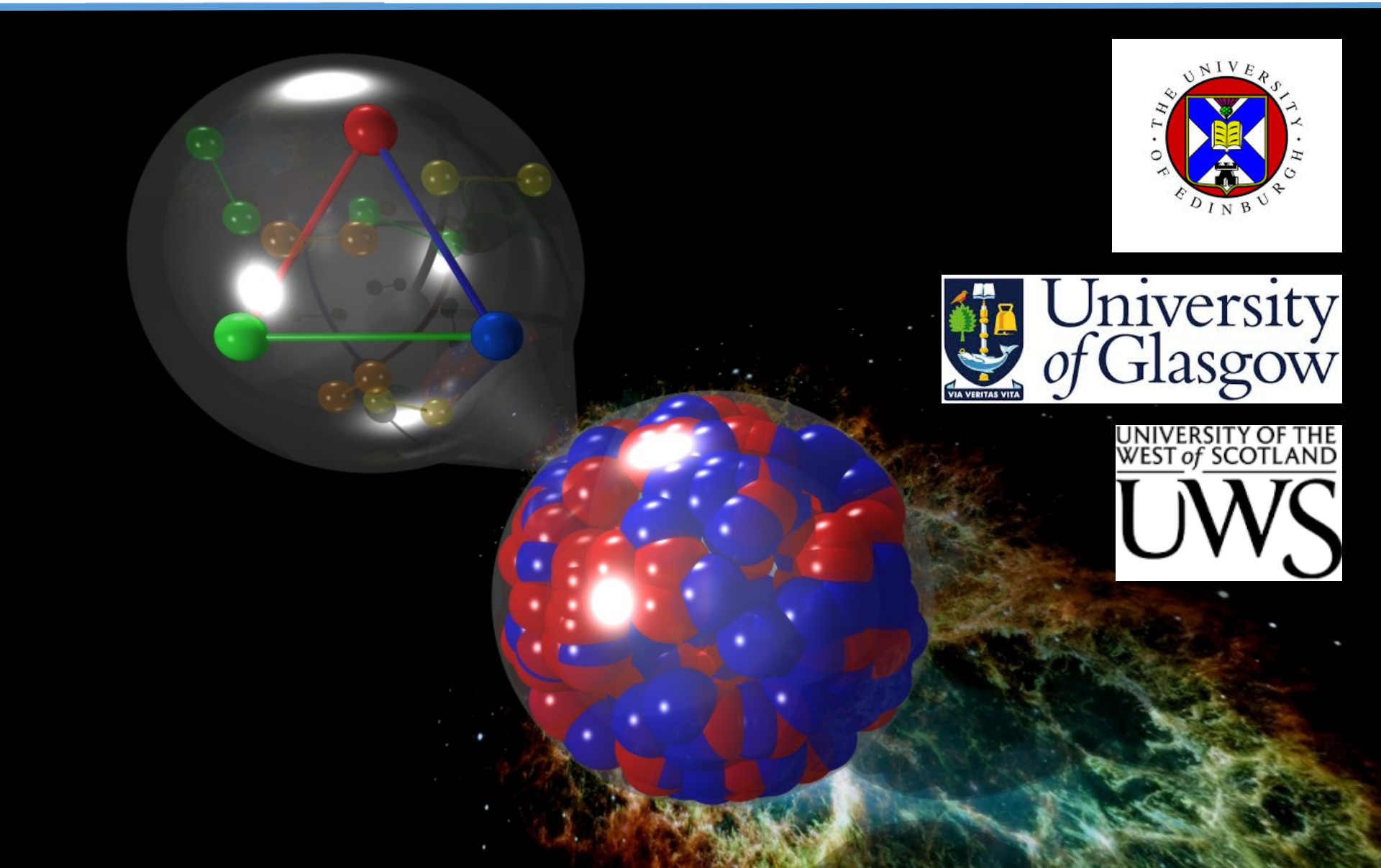
Pellet ablation after injection into tokamak – density profile evolution

Showing stopping power of ablation cloud for 10keV electrons





Nuclear Physics



Nuclear Astrophysics

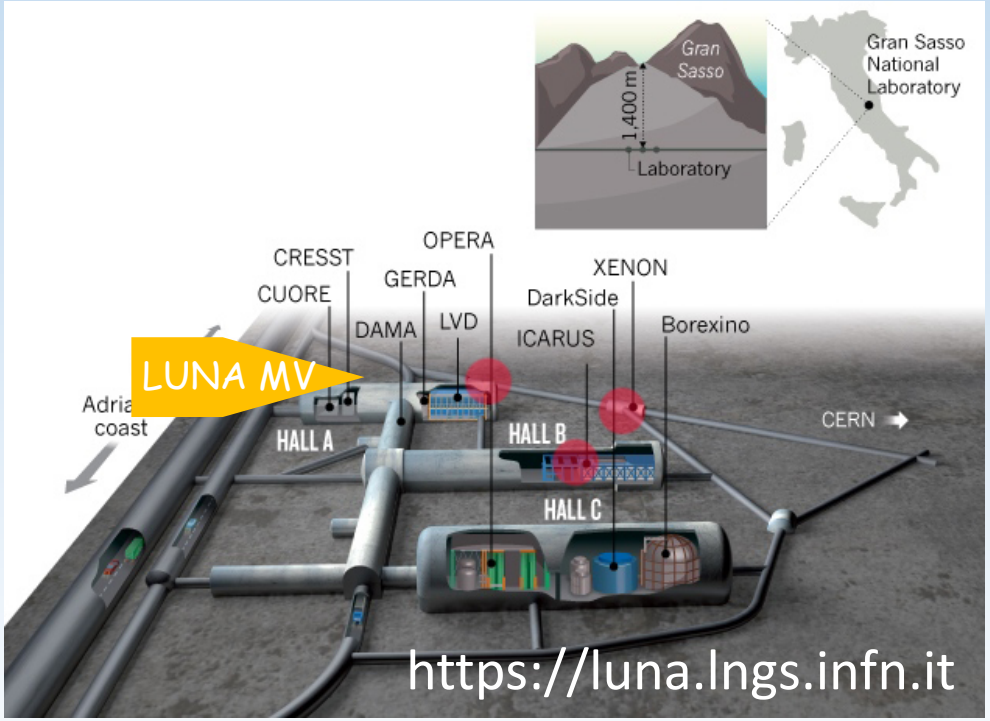
THE LUNA Collaboration

LUNA 50 kV (1992-2001) – Solar Phase

LUNA 400 kV (2000-2018) – CNO, Mg-Al and Ne-Na cycles, BBN

LUNA-MV (from 2020) – Helium burning, Carbon burning

- $^{12}C(^{12}C,p)^{23}Na$ and $^{12}C(^{12}C,\alpha)^{20}Ne$
- $^{13}C(\alpha,n)^{16}O$
- $^{22}Ne(\alpha,n)^{25}Mg$
- $^{12}C(\alpha,\gamma)^{16}O$



Nuclear Astrophysics

Computational Nuclear Astrophysics

Massive nuclear network calculations simultaneously varying all reaction rates for a given astrophysical environment. Have identified key nuclear reaction rates and their level of importance.

- Deeper engagement with modellers and observers
- Has also motivated 3 new studies at CERN nTOF, all led by the Edinburgh Group.

MNRAS 478, 4081–4121 (2018)
Advance Access publication 2018 May 5

Uncertainties in s-process nucleosynthesis in low-mass stars determined from Monte Carlo variations

G. Cescutti,[1★†] R. Hirschi,[2,3†] N. Nishimura,[4†] J. W. den Hartogh,[2,5†] T. Rauscher,[6,7†] A. St. J. Murphy[8†] and S. Cristallo[9,10]

MNRAS 476, 3133–3139 (2018)
Advance Access publication 2017 December 7

Uncertainties in the production of *p* nuclides in thermonuclear supernovae determined by Monte Carlo variations

N. Nishimura(西村信哉),[1,2★†] T. Rauscher,[3,4†] R. Hirschi,[2,5†] A. St. J. Murphy,[5†] G. Cescutti[4,7†] and C. Travaglio[8†]

MNRAS 463, 4153–4166 (2016)
Advance Access publication 2016 September 8

Uncertainties in the production of *p* nuclei in massive stars obtained from Monte Carlo variations

T. Rauscher,[1,2,3★] N. Nishimura,[3,4] R. Hirschi,[3,4,5] G. Cescutti,[2,3] A. St. J. Murphy[3,6] and A. Heger[7]

MNRAS 469, 1752–1767 (2017)
Advance Access publication 2017 March 22

Uncertainties in *s*-process nucleosynthesis in massive stars determined by Monte Carlo variations

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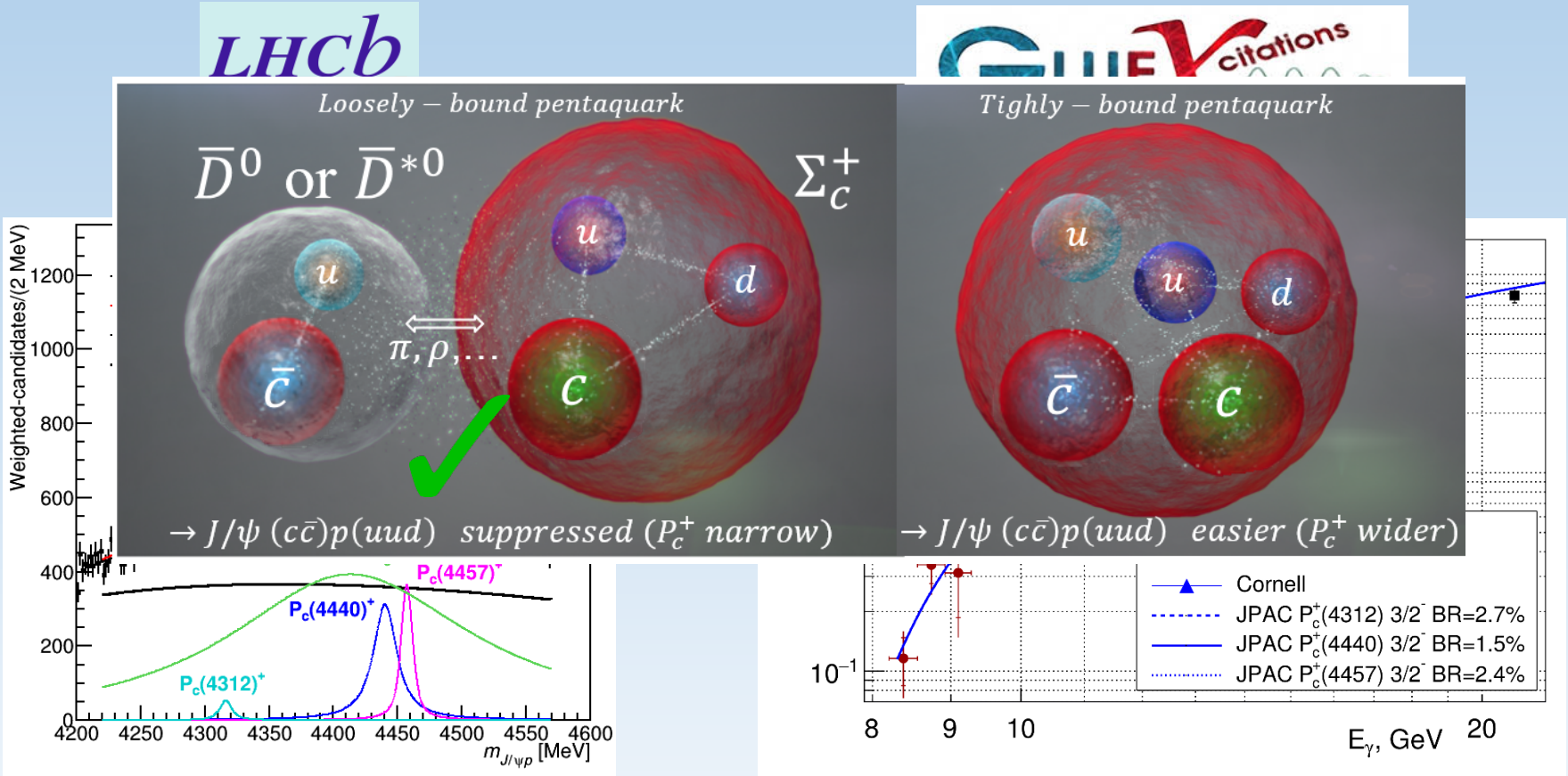
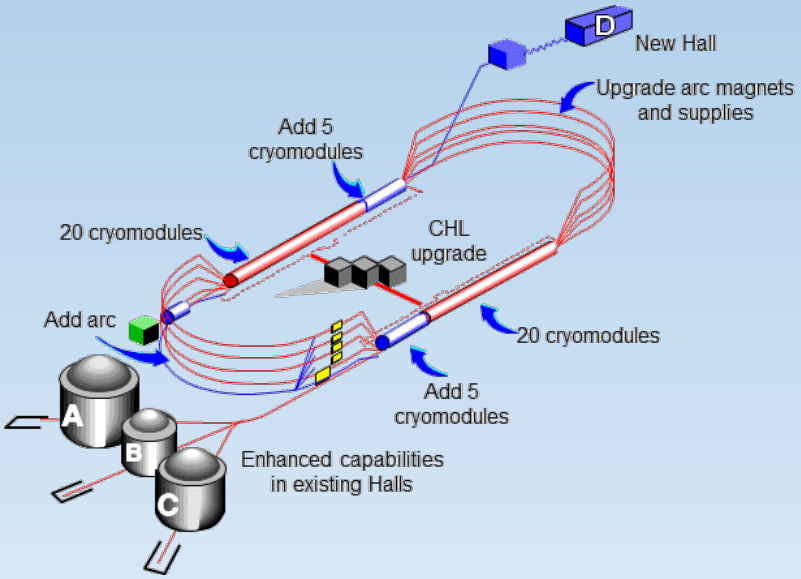
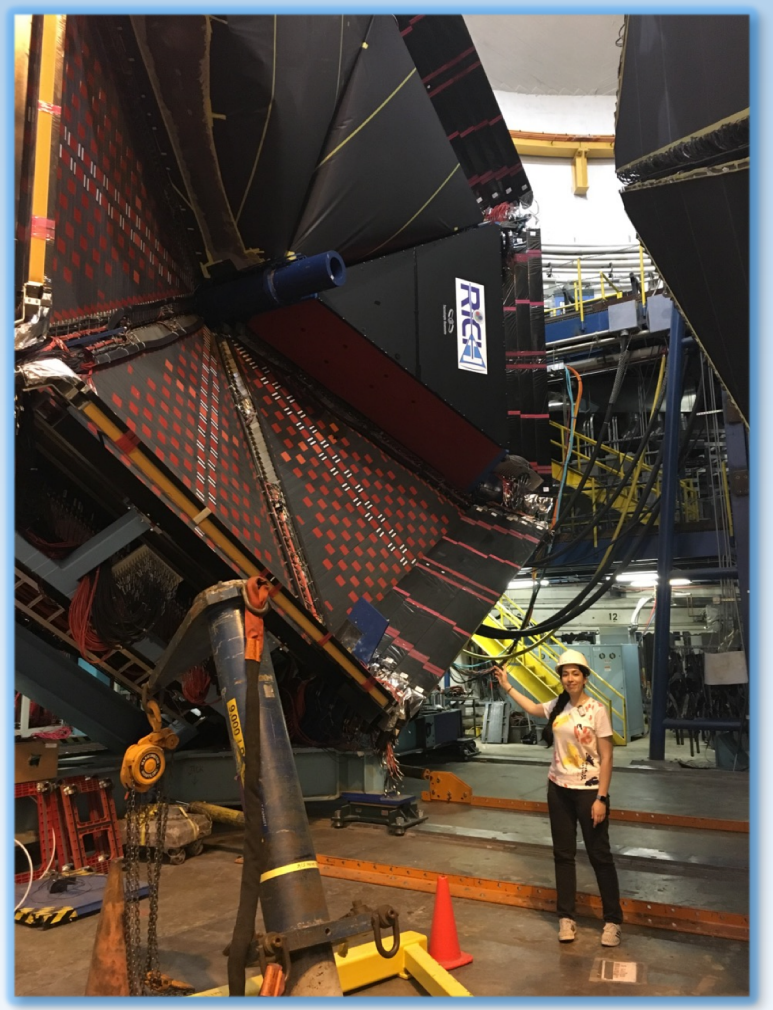
Pentaquark Searches



New Personnel





Dr Rachel Montgomery (Glasgow):
STFC Ernest Rutherford Fellowship
Hall A programme at JLab

University of Glasgow

New Personnel

New Lecturer at Edinburgh:
Dr (Moritz) Pascal Reiter

Previously with the TITAN group at TRIUMF

Starts 1 September 2019.

Spin-out Companies

Anacail

Food preservation

Berry Gardens

LYNKEOS TECHNOLOGY LTD

Business Start-up Award 2018
IOP Institute of Physics

Inspection of Nuclear Waste

IOP Institute of Physics

International Nuclear Physics Conference 2019

INPC 2019 Glasgow, UK

29 July – 2 August 2019, Scottish Event Campus, Glasgow, UK

Public Lecture

Tuesday 30 July 2019

Nuclear Physics and the Making of the Modern Periodic Table

by Professor Jim Al-Khalili

… sponsored by SUPA!