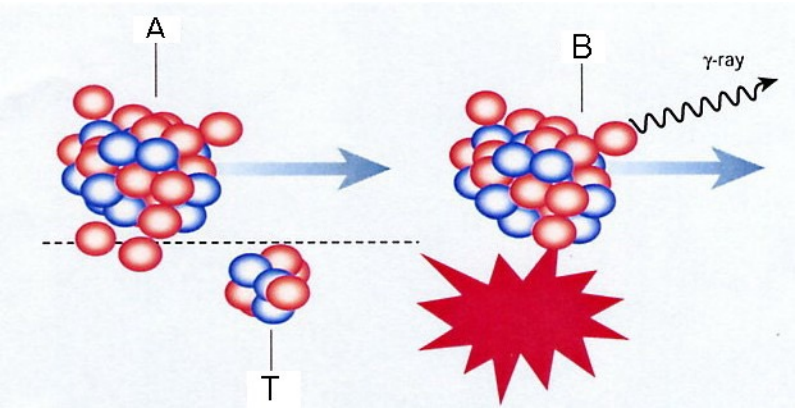
DREB2024: Keynote Experiment ... Or the wild things that happened in experimentation with direct reactions over the past 2 years

Alexandra Gade
Professor of Physics
FRIB and Department of Physics and Astronomy
Michigan State University

Outline

What is the purpose of a Keynote?

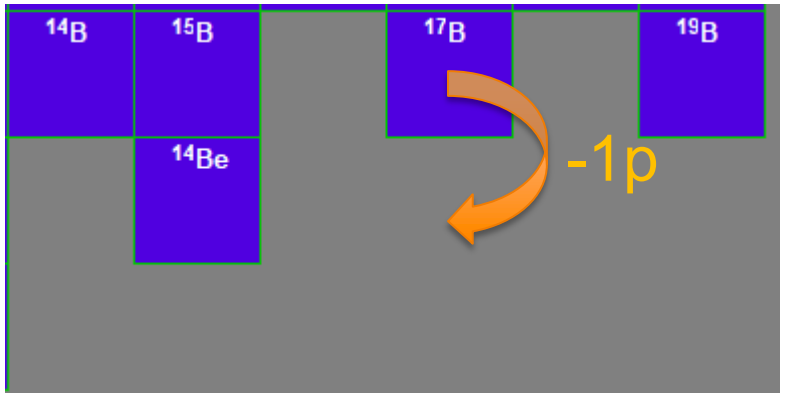
Google, one of the top hits:
A keynote, put simply, is a talk or speech given at the start of any event. It sets the tone of the event and establishes the theme.

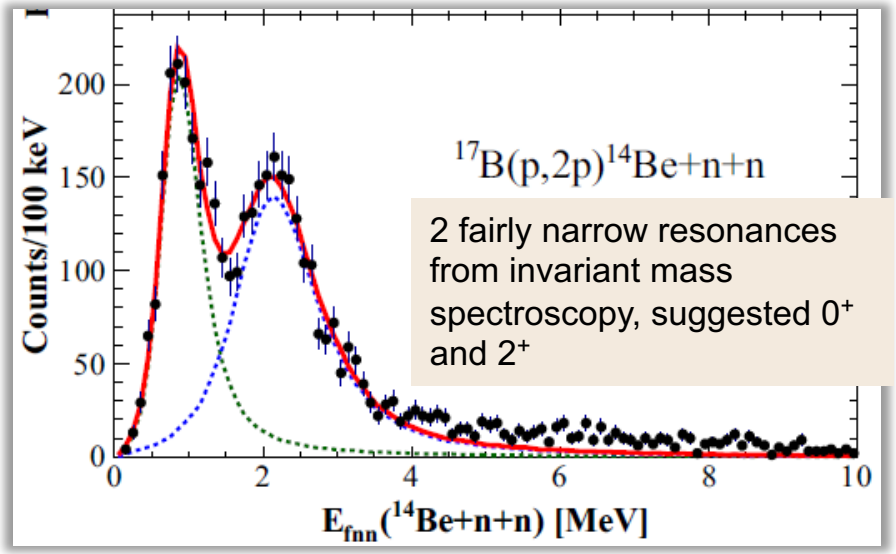


- Direct reactions to lead beyond the neutron dripline
- Direct reactions interrogate the nuclear physics near the proton dripline
- Direct reactions populate resonances of special interest
- Direct reactions for spectroscopy of neutron-rich nuclei
- Direct reactions to explore fission barriers
- Direct reactions at the luminosity frontier
- Direct reactions in astrophysics
- Not so direct – a tale of tails
- Direct reactions contribute to … what? Dark matter searches? Huh?

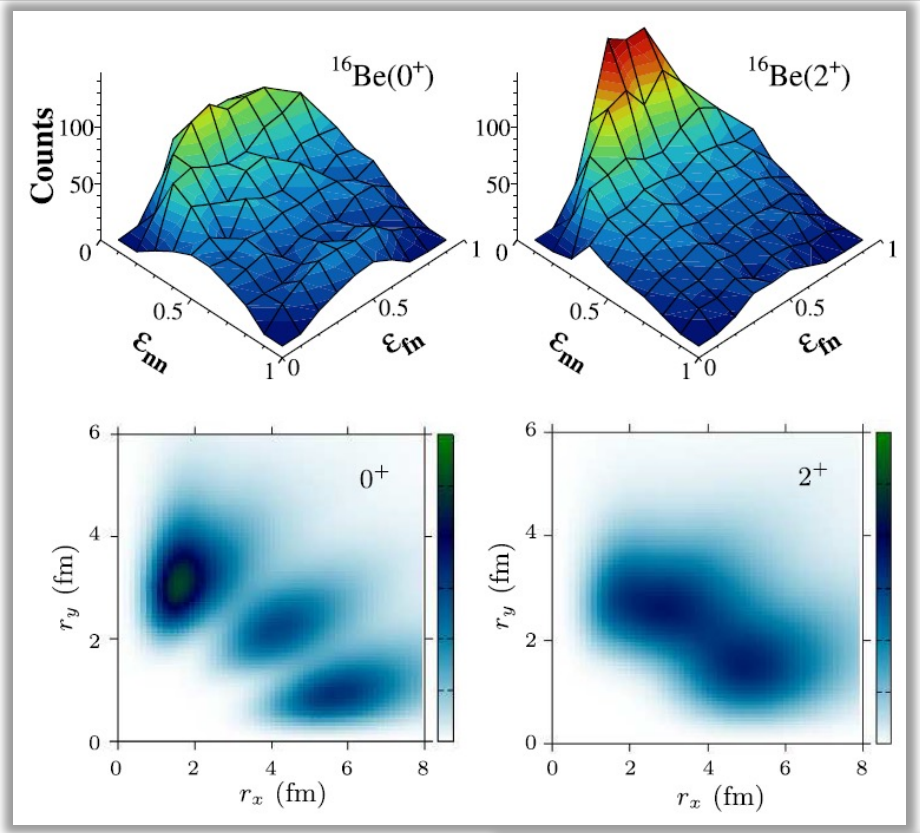
Mass, Spectroscopy, and Two-Neutron Decay of ^{16}Be

- Direct reaction, (p,2p), to lead beyond the neutron dripline





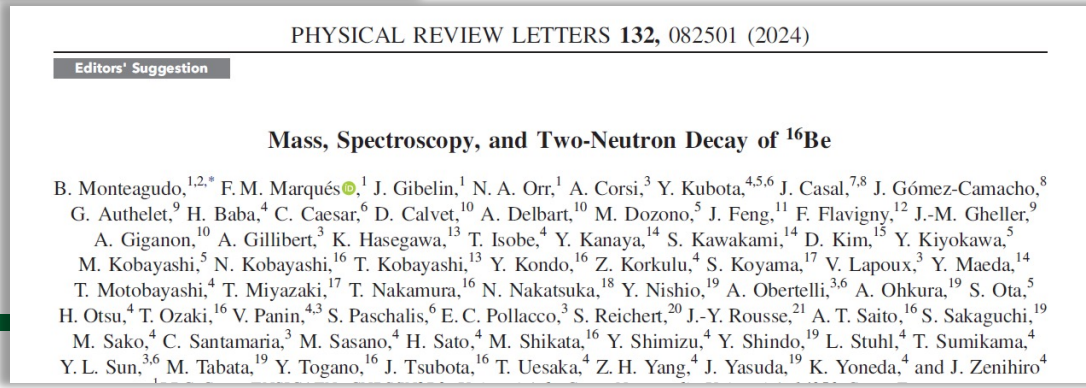
2 fairly narrow resonances from invariant mass spectroscopy, suggested 0^+ and 2^+



Experiment: Correlation measurements are important and reveal, in concert with theory, possible di-neutron configurations and details of spatial extent

Theory: Realistic 3-body modeling incorporating the asymptotic properties after the time evolution of the initial resonance wave function important

^{17}B beam at 277 MeV/u from RIBF/RIKEN on MINOS target, using SAMURAI and NEBULA



PHYSICAL REVIEW LETTERS **132,** 082501 (2024)

Editors' Suggestion

Mass, Spectroscopy, and Two-Neutron Decay of ^{16}Be

B. Monteagudo,[1,2,*] F. M. Marqués,[1] J. Gibelin,[1] N. A. Orr,[1] A. Corsi,[3] Y. Kubota,[4,5,6] J. Casal,[7,8] J. Gómez-Camacho,[8] G. Authelet,[9] H. Baba,[4] C. Caesar,[6] D. Calvet,[10] A. Delbart,[10] M. Dozono,[5] J. Feng,[11] F. Flavigny,[12] J.-M. Gheller,[9] A. Giganon,[10] A. Gillibert,[3] K. Hasegawa,[13] T. Isobe,[4] Y. Kanaya,[14] S. Kawakami,[14] D. Kim,[15] Y. Kiyokawa,[5] M. Kobayashi,[5] N. Kobayashi,[16] T. Kobayashi,[13] Y. Kondo,[16] Z. Korkulu,[4] S. Koyama,[17] V. Lapoux,[3] Y. Maeda,[14] T. Motobayashi,[4] T. Miyazaki,[17] T. Nakamura,[16] N. Nakatsuka,[18] Y. Nishio,[19] A. Obertelli,[3,6] A. Ohkura,[19] S. Ota,[5] H. Otsu,[4] T. Ozaki,[16] V. Panin,[4,3] S. Paschalis,[6] E. C. Pollacco,[3] S. Reichert,[20] J.-Y. Rousse,[21] A. T. Saito,[16] S. Sakaguchi,[19] M. Sako,[4] C. Santamaria,[3] M. Sasano,[4] H. Sato,[4] M. Shikata,[16] Y. Shimizu,[4] Y. Shindo,[19] L. Stuhl,[4] T. Sumikama,[4] Y. L. Sun,[3,6] M. Tabata,[19] Y. Togano,[16] J. Tsubota,[16] T. Uesaka,[4] Z. H. Yang,[4] J. Yasuda,[19] K. Yoneda,[4] and J. Zenihiro[4]

In the continuum, and (p,pN) to explore correlations

Thursday

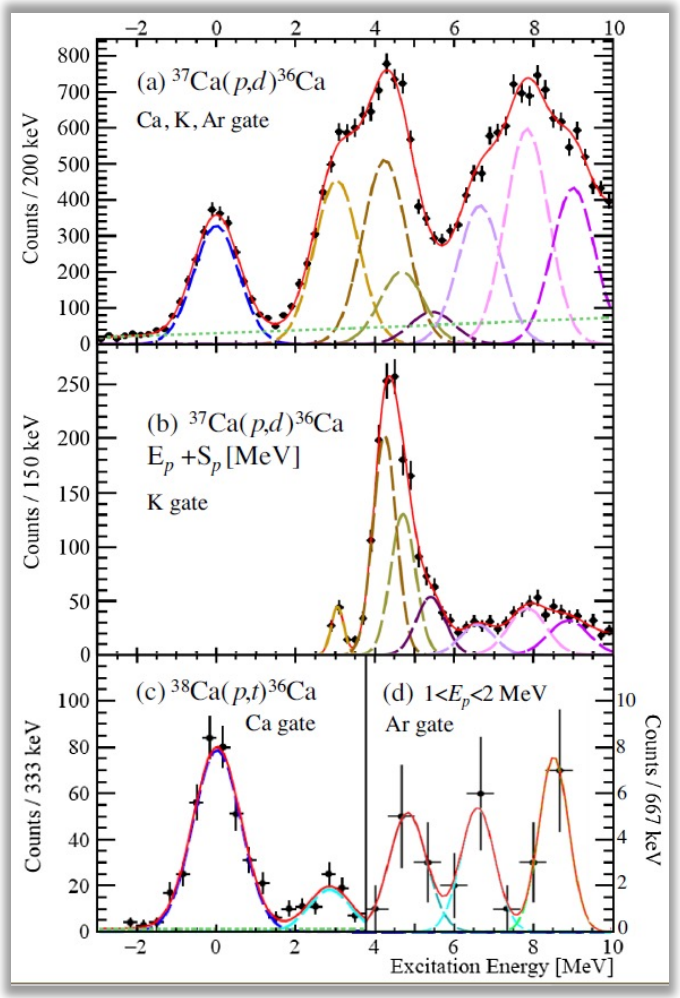
Precise determination of the n-17B scattering length	*emeline oliveira*
Kurhaus Wiesbaden	10:40 - 11:00
Search for near-threshold multi-neutron resonances in (p,2p) reactions with neutron-rich nuclei at R3B	*Nikhil Mozumdar*
Kurhaus Wiesbaden	11:40 - 12:00
Structure of extremely neutron-rich 9,10He	*Dr Yelei Sun*
Kurhaus Wiesbaden	14:20 - 14:40

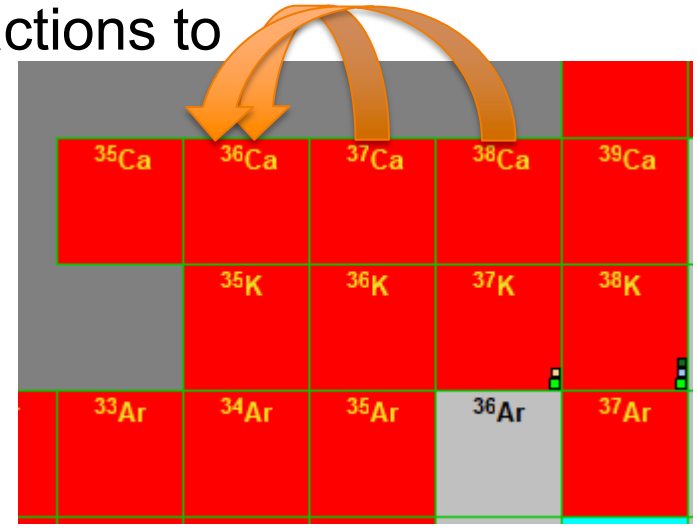
Friday

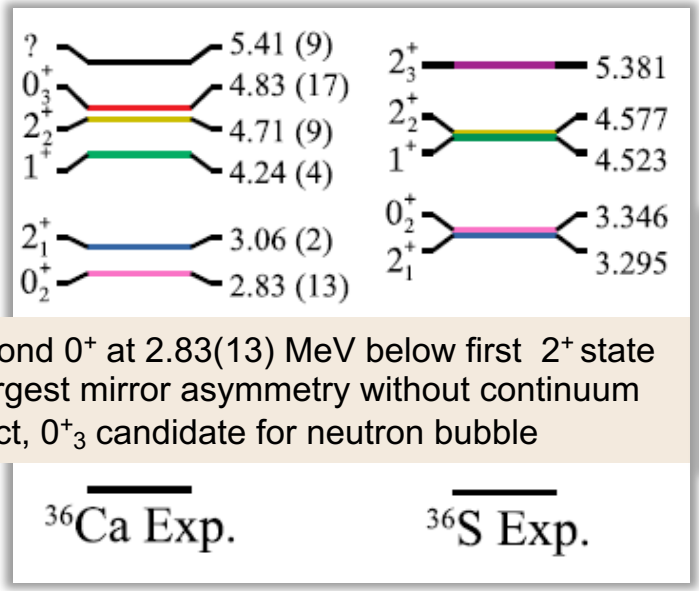
Deuteron quasi-free scattering reactions: a tool to probe nucleon-nucleon short-range correlations in atomic nuclei	
Stefanos Paschalis	
Study of two nucleons correlation via (p,dN) in 6He	*Satoru TERASHIMA*
Kurhaus Wiesbaden	09:40 - 10:00
Study of np correlations via two-nucleon removal reactions	*Dr Hongna Liu*
Kurhaus Wiesbaden	09:20 - 09:40
Short-range correlations in asymmetric nuclei investigated at R³B	*Andrea Lagni*
Kurhaus Wiesbaden	11:00 - 11:20

Structure of ^{36}Ca under the Coulomb Magnifying Glass

- (p,d) and (p,t) transfer reactions to get to ^{36}Ca

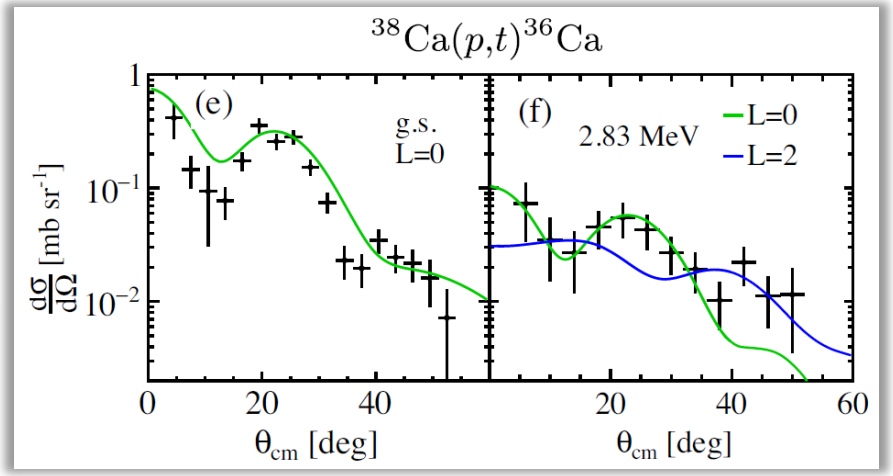






Second 0^+ at 2.83(13) MeV below first 2^+ state – largest mirror asymmetry without continuum effect, 0^+_3 candidate for neutron bubble

^{37,38}Ca beam 50 MeV/u from LISE/GANIL on CRYPTA target, using MUST2 for d and t detection



PHYSICAL REVIEW LETTERS **129,** 122501 (2022)

Structure of ^{36}Ca under the Coulomb Magnifying Glass

L. Lalanne,[1,2,*] O. Sorlin,[2,†] A. Poves,[3] M. Assié,[1] F. Hammache,[1] S. Koyama,[4,2] D. Suzuki,[5] F. Flavigny,[6] V. Girard-Alcindor,[2] A. Lemasson,[2] A. Matta,[6] T. Roger,[2] D. Beaumel,[1] Y. Blumenfeld,[1] B. A. Brown,[7] F. De Oliveira Santos,[2] F. Delaunay,[6] N. de Séréville,[1] S. Franchoo,[1] J. Gibelin,[6] J. Guillot,[1] O. Kamalou,[2] N. Kitamura,[8] V. Lapoux,[9] B. Mauss,[5,2] P. Morfouace,[2,10] M. Niikura,[4] J. Pancin,[2] T. Y. Saito,[4] C. Stodel,[2] and J-C. Thomas[2]

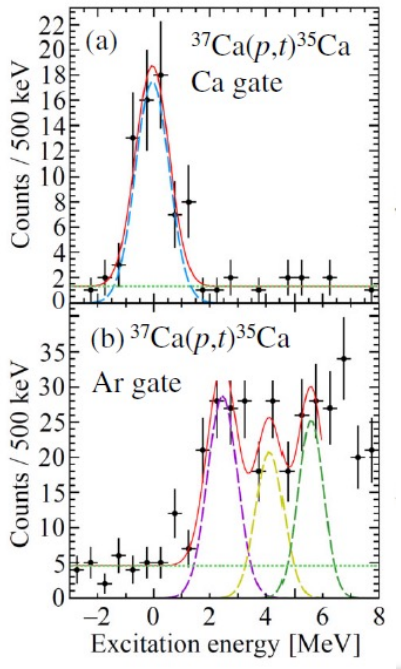
More on states with depleted *s* strength … or bubbles

Wednesday

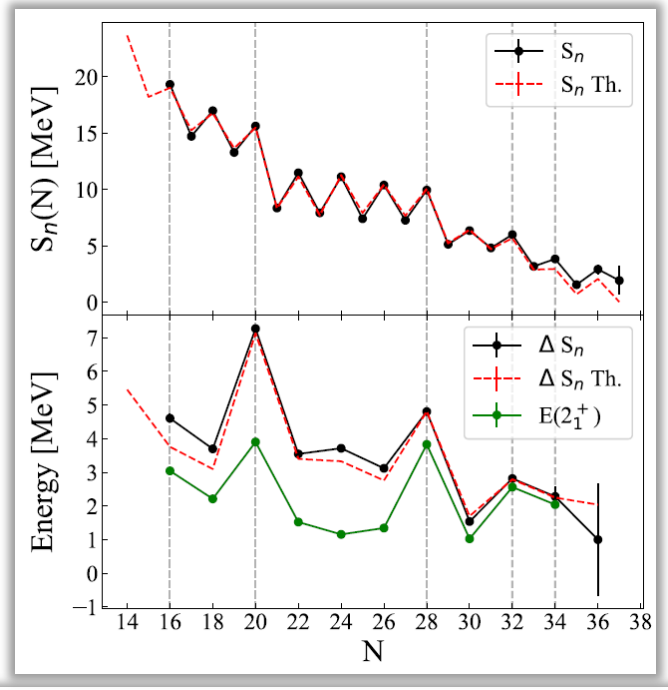
46Ar: a bubble nucleus?	*Daniele Brugnara*
Kurhaus Wiesbaden	17:20 - 17:40

Proton-rich Nuclei Continued – Mind the Gaps

- (p,t) transfer reactions to get to ^{35}Ca – ^{37}Ca from LISE/GANIL on CRYPTA target, MUST2

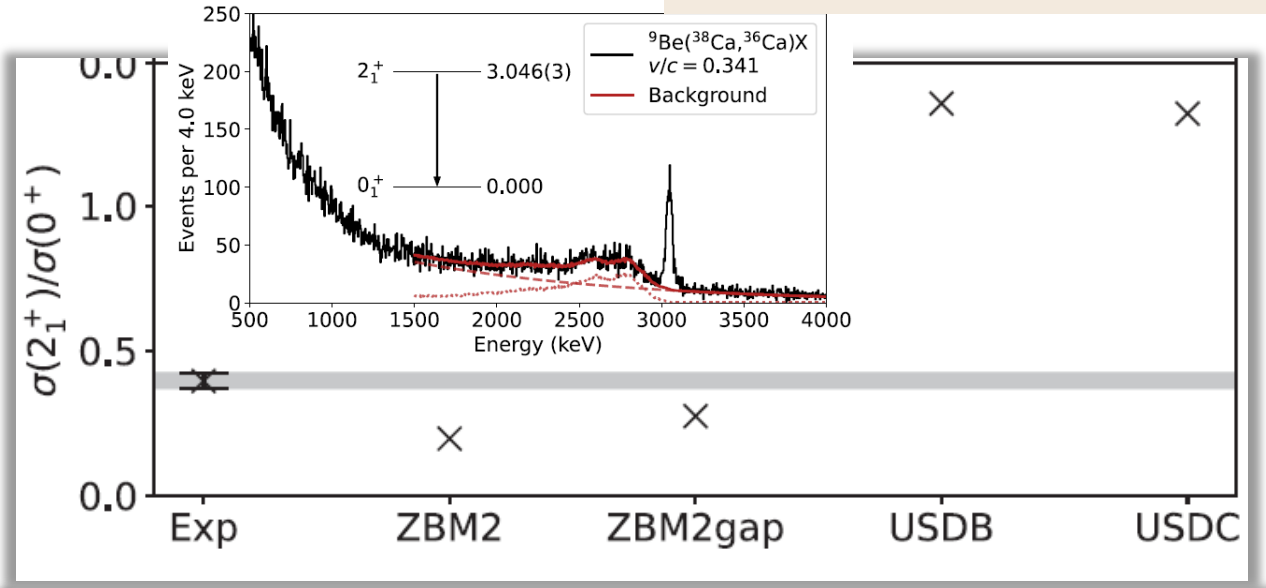


^{36}Ca doubly-magic nucleus with N=16 gap



^{38}Ca two-neutron knockout to ^{36}Ca at 61 MeV/u at NSCL with GRETINA@S800

Only the ZBM2 effective shell-model interaction, that has proton cross-shell excitation reproduced the cross section ratio



PHYSICAL REVIEW LETTERS **131,** 092501 (2023)

$N = 16$ Magicity Revealed at the Proton Drip Line through the Study of ^{35}Ca

L. Lalanne,[1,2,*] O. Sorlin,[2,†] A. Poves,[3] M. Assié,[1] F. Hammache,[1] S. Koyama,[4,2] D. Suzuki,[5] F. Flavigny,[6] V. Girard-Alcindor,[2] A. Lemasson,[2] A. Matta,[6] T. Roger,[2] D. Beaumel,[1] Y Blumenfeld,[1] B. A. Brown,[7] F. De Oliveira Santos,[2] F. Delaunay,[6] N. de Séréville,[1] S. Franchoo,[1] J. Gibelin,[6] J. Guillot,[1] O. Kamalou,[2] N. Kitamura,[8] V. Lapoux,[9] B. Mauss,[5,2] P. Morfouace,[2] J. Pancin,[2] T. Y. Saito,[4] C. Stodel,[2] and J-C. Thomas[2]

PHYSICAL REVIEW C **108,** L061301 (2023)

Letter

Probing proton cross-shell excitations through the two-neutron removal from ^{38}Ca

T. Beck,[1,*] A. Gade,[1,2] B. A. Brown,[1,2] J. A. Tostevin,[3] D. Weisshaar,[1] D. Bazin,[1,2] K. W. Brown,[1,4] R. J. Charity,[5] P. J. Farris,[1,2] S. A. Gillespie,[1] A. M. Hill,[1,2] J. Li,[1] B. Longfellow,[1,2,†] W. Reviol,[6] and D. Rhodes[1,2,‡]

Probing proton cross-shell excitations through two-neutron removal from ^{38}Ca — Tobias Beck

Kurhaus Wiesbaden — 10:40 - 11:00

Wednesday

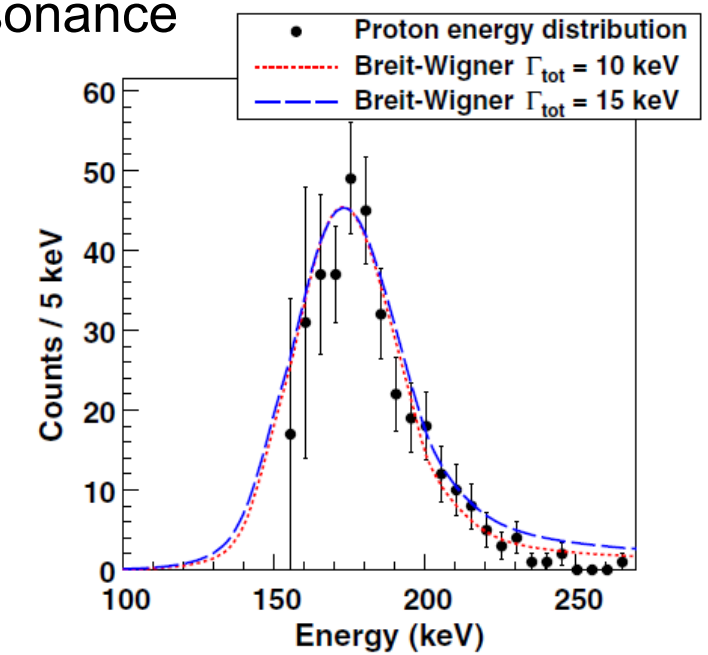
Direct reactions in Ca – Mind the Gaps

Wednesday

Probing proton cross-shell excitations through two-neutron removal from ^{38}Ca	*Tobias Beck*
Kurhaus Wiesbaden	10:40 - 11:00
Single-particle states in fp-shell nuclei through 50Ca(d, p)51Ca transfer reaction.	*Carlos Ferrera González*
Kurhaus Wiesbaden	11:00 - 11:20

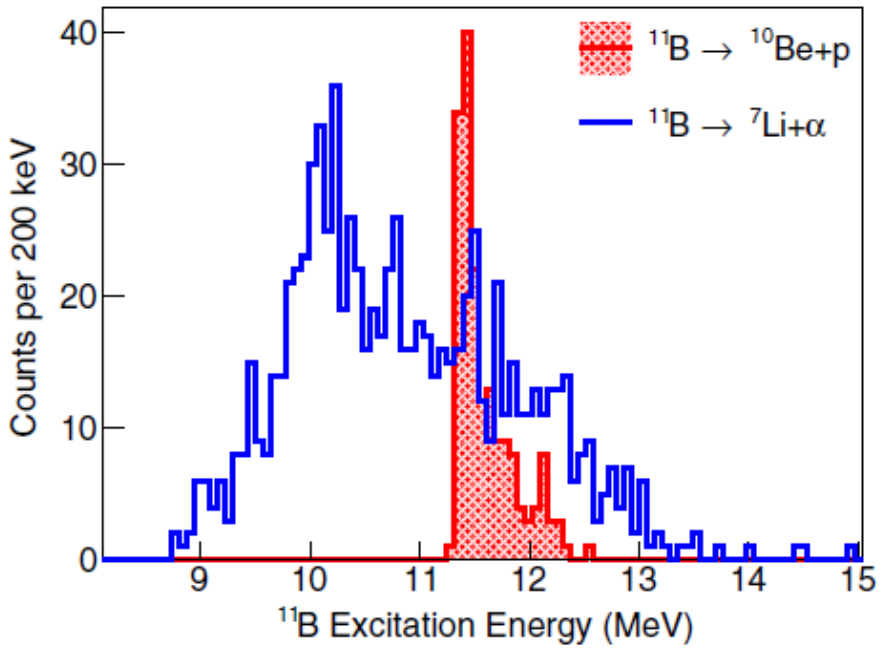
Populating an exotic near-threshold resonance in (d,n)

Prologue: β-delayed proton emission from neutron halo ^{11}Be observed to proceed through a resonance



Many ways to characterize the resonance, proton resonant scattering (MSU) and a transfer reaction that populates a low-l state near threshold

- FSU used ^{10}Be(d,n)^{11}B → ^{10}B+p to propose (1/2$^+$) resonance at E_r=211(40) keV



Experiment: ^{10}Be beam at 39 MeV from FSU's RESOLUT facility via ^{9}Be(d,p)^{10}Be. CD_2 target to induce (d,n), IC for recoil detection, and p and ^{7}Li+α from ^{11}B breakup in Si telescope

Status: Theory has not yet been able to reproduce the very strong β-delayed proton emission branch

PHYSICAL REVIEW LETTERS 129, 012502

Observation of a Near-Threshold Proton Resonance in ^{11}B

E. Lopez-Saavedra,[1,*] S. Almaraz-Calderon,[1,†] B. W. Asher,[1] L. T. Baby,[1] N. Gerken,[1] K. Hanselman,[1] K. W. Kemper,[1] A. N. Kuchera,[2] A. B. Morelock,[1] J. F. Perello,[1]

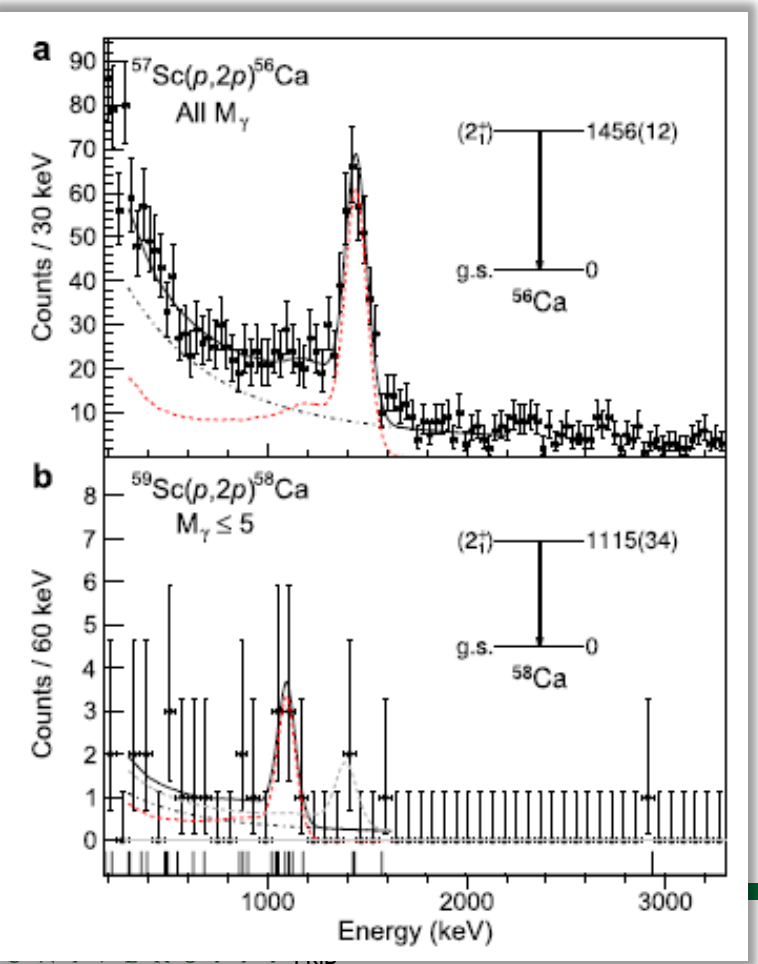
The curious case of ^{11}B continues

Thursday

Revealing the nature of near-threshold narrow resonances in 11B with the HELIOS spectrometer.	*Dr Ben Kay*
Kurhaus Wiesbaden	15:20 - 15:40

Pioneering level structures of ^{56,58}Ca from (p,2p)

(p,2p) reactions from Sc projectiles to the most neutron-rich Ca isotopes with spectroscopy yet – possible due to high-luminosity facilitated by MINOS at SAMURAI



Cross sections used to extract $f_{7/2}$ strength

	Experiment				DWIA	VS-IMSRG			GXPF1Bs			A3DA-t		
	E_{exp}	σ_{exp}	J^π	nl_j	σ_{sp}	E_x	C^2S_{th}	σ_{th}	E_x	C^2S_{th}	σ_{th}	E_x	C^2S_{th}	σ_{th}
^{56}Ca	0	0.80(6)	$0^+_{g.s.}$	$0f_{7/2}$	1.80	0	0.61	1.10	0	0.69	1.24	0	0.62	1.11
	1456(12)	0.43(4)	2^+_1	$0f_{7/2}$	1.74	1002	0.29	0.50	1416	0.25	0.44	1519	0.27	0.47
			4^+_1	$0f_{7/2}$	1.73	1307	0.05	0.09	1776	0.02	0.04	2339	0.01	0.02
	Inclusive	1.23(5)						1.69			1.72			1.60
^{58}Ca	0	0.66(24)	$0^+_{g.s.}$	$0f_{7/2}$	1.58	0	0.80	1.26	0	0.83	1.31	0	0.46	0.73
	1115(34)	0.47(19)	2^+_1	$0f_{7/2}$	1.54	1075	0.16	0.25	1382	0.15	0.23	1040	0.42	0.65
			4^+_1	$0f_{7/2}$	1.52	1423	0.001	0.002	1772	0.001	0.002	2084	0.05	0.08
	Inclusive	1.14(15)						1.51			1.54			1.46

If the ^{58}Ca level structure gets confirmed, interesting drop in 2^+ energy towards *N=40*

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

Level structures of ^{56,58}Ca cast doubt on a doubly magic ^{60}Ca

S. Chen [a,b,c,*], F. Browne [b], P. Doornenbal [b], J. Lee [a], A. Obertelli [d,e,b], Y. Tsunoda [f], T. Otsuka [b,g,h], Y. Chazono [i], G. Hagen [n,j], J.D. Holt [k,l], G.R. Jansen [m,n], K. Ogata [i,o], N. Shimizu [f], Y. Utsuno [h,f], K. Yoshida [h], N.L. Achouri [p], H. Baba [b], D. Calvet [e], F. Château [e], N. Chiga [b], A. Corsi [e], M.L. Cortés [b], A. Delbart [e], J.-M. Gheller [e], A. Giganon [e], A. Gillibert [e], C. Hilaire [e], T. Isobe [b], T. Kobayashi [q], Y. Kubota [b,f], V. Lapoux [e], H.N. Liu [e,d,r], T. Motobayashi [b], I. Murray [s,b], H. Otsu [b], V. Panin [b], N. Paul [e,t], W. Rodriguez [b,u,v], H. Sakurai [b,g], M. Sasano [b], D. Steppenbeck [b], L. Stuhl [f,w,x], Y.L. Sun [e,d], Y. Togano [y], T. Uesaka [b], K. Wimmer [g,b], K. Yoneda [b], O. Aktas [r], T. Aumann [d,z], L.X. Chung [aa], F. Flavigny [s], S. Franchoo [s], I. Gasparic [ab,d,b], R.-B. Gerst [ac], J. Gibelin [p], K.I. Hahn [ad,x], D. Kim [ad,b,x], T. Koiwai [g], Y. Kondo [ae], P. Koseoglou [d,z], C. Lehr [d], B.D. Linh [aa,af], T. Lokotko [a], M. MacCormick [s], K. Moschner [ac], T. Nakamura [ae], S.Y. Park [ad,x], D. Rossi [d], E. Sahin [ag], P.-A. Söderström [d], D. Sohler [w], S. Takeuchi [ae], H. Törnqvist [d,z], V. Vaquero [ah], V. Wagner [d], S. Wang [ai], V. Werner [d], X. Xu [a], H. Yamada [ae], D. Yan [ai], Z. Yang [b], M. Yasuda [ae], L. Zanetti [d]

More (p,pN) to probe Ca

Wednesday

Quasi-free scattering reactions along the calcium isotopic chain — *Ryo Taniuchi*

Kurhaus Wiesbaden — 09:00 - 09:20

Probing the size of single-particle orbitals in neutron-rich calcium isotopes from quasi-free scattering missing moment...
Madalina Enciu

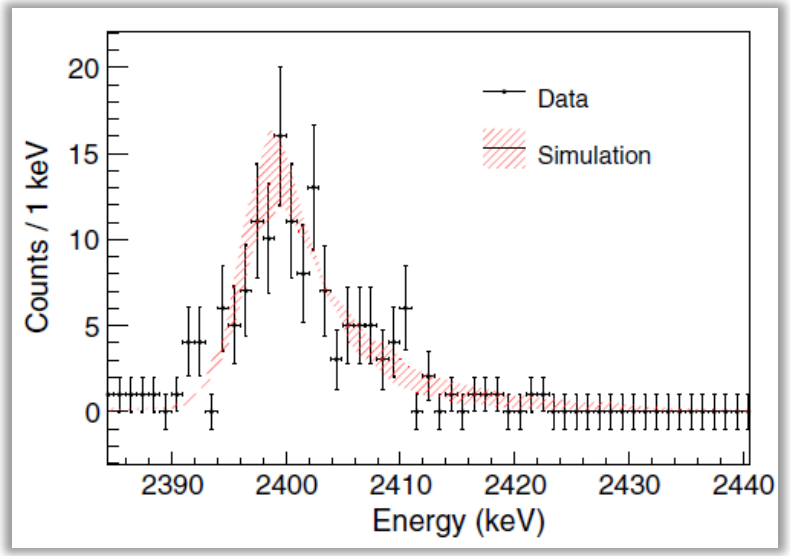
Thursday

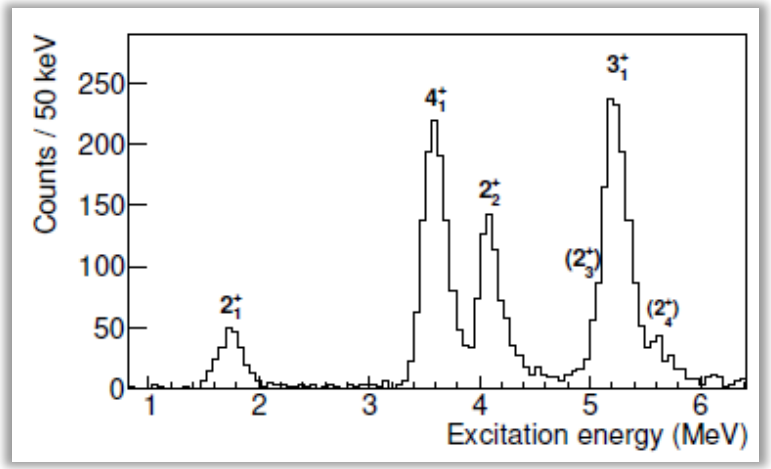
One and two proton removal from neutron-rich nuclei: a comparative sensitivity study in the mass region of 52Ca
Christina Xanthopoulou

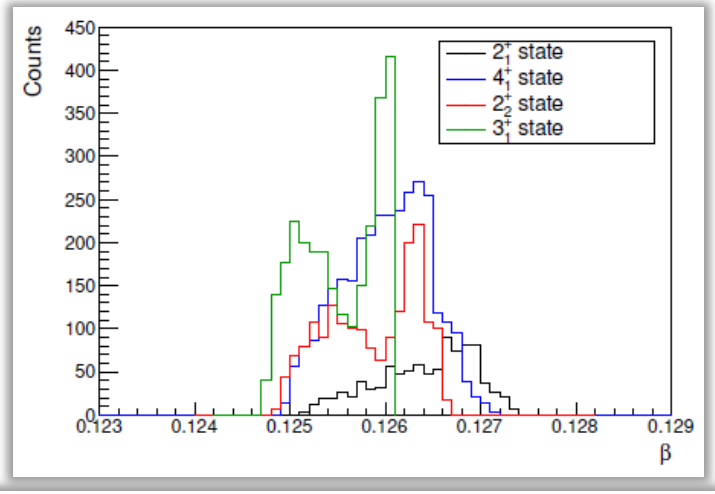
High-Precision Spectroscopy of ^{20}O Benchmarking Ab Initio Calculations in Light Nuclei

^{19}O(d,p)^{20}O reaction at 8 MeV/u at GANIL with MUSGAST and VAMOS++ on thin CD_2 target with Au backing for DSAM to measure transition strength to be confronted with ab-initio theory

Direct reaction used to precisely constrain kinematics (and excitation energy) of recoil for DSAM measurement.







Measured and simulated Doppler line shapes for 2^+_2 to 0^+_1 transition provide τ=70(10) fs

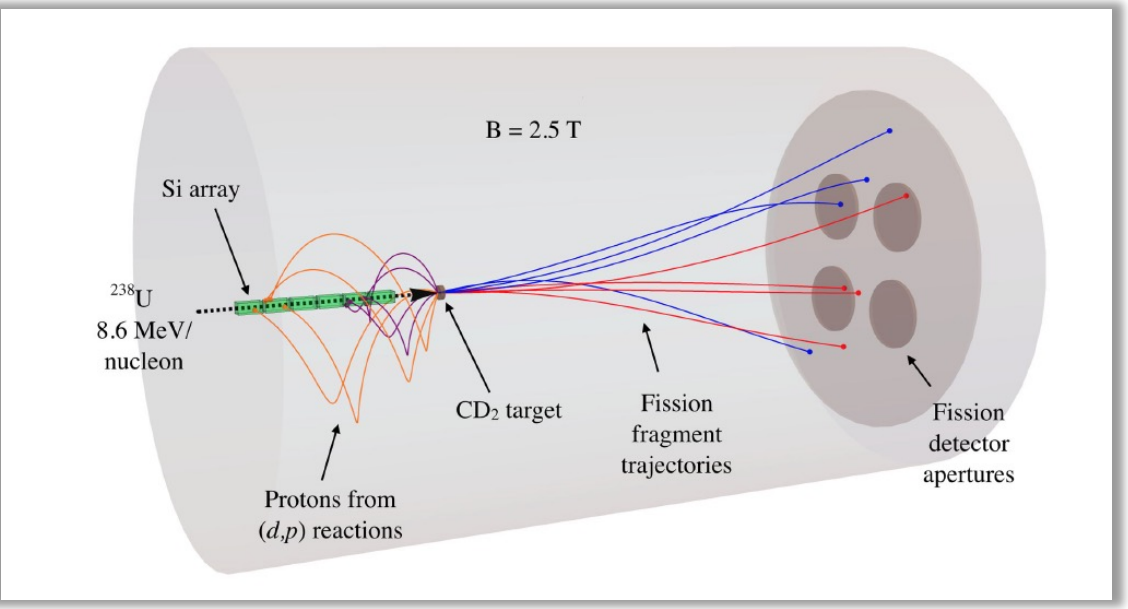
PHYSICAL REVIEW LETTERS **131,** 262501 (2023)

High-Precision Spectroscopy of ^{20}O Benchmarking *Ab Initio* Calculations in Light Nuclei

I. Zanon,[1,2,*] E. Clément,[3] A. Goasduff,[1] J. Menéndez,[4] T. Miyagi,[5,6,7] M. Assié,[8] M. Ciemała,[9] F. Flavigny,[10] A. Lemasson,[3] A. Matta,[10] D. Ramos,[3] M. Rejmund,[3] L. Achouri,[10] D. Ackermann,[3] D. Barrientos,[11] D. Beaumel,[8] G. Benzoni,[12] A. J. Boston,[13] H. C. Boston,[13] S. Bottoni,[14,12] A. Bracco,[12,14] D. Brugnara,[1,15] G. de France,[3] N. de Sereville,[8] F. Delaunay,[10] P. Desesquelles,[8] F. Didierjean,[16] C. Domingo-Prato,[17] J. Dudouet,[18] J. Eberth,[19] D. Fernández,[20] C. Fougères,[3] A. Gadea,[17] F. Galtarossa,[8] V. Girard-Alcindor,[3] V. Gonzales,[21] A. Gottardo,[1] F. Hammache,[8] L. J. Harkness-Brennan,[13] H. Hess,[19] D. S. Judson,[13] A. Jungclaus,[22] A. Kaşkaş,[23] Y. H. Kim,[24] A. Kuşoğlu,[25] M. Labiche,[26] S. Leblond,[3] C. Lenain,[10] S. M. Lenzi,[27] S. Leoni,[12] H. Li,[3] J. Ljungvall,[8] J. Lois-Fuentes,[20] A. Lopez-Martens,[8] A. Maj,[28] R. Menegazzo,[27] D. Mengoni,[15,27] C. Michelagnoli,[3,24] B. Million,[12] D. R. Napoli,[1] J. Nyberg,[29] G. Pasqualato,[15,27] Zs. Podolyak,[30] A. Pullia,[12] B. Quintana,[31] F. Recchia,[15,27] D. Regueira-Castro,[20] P. Reiter,[19] K. Rezynkina,[32] J. S. Rojo,[33] M. D. Salsac,[34] E. Sanchis,[21] M. Şenyiğit,[23] M. Siciliano,[34,35] D. Sohler,[36] O. Stezowski,[18] Ch. Theisen,[34] A. Utepov,[3,10] J. J. Valiente-Dobón,[1] D. Verney,[8] and M. Zielinska[34]

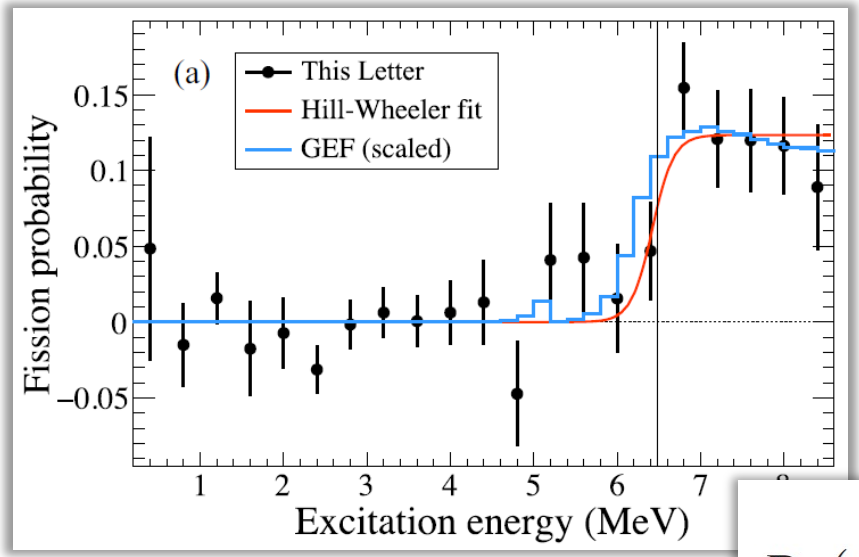
Direct Determination of Fission-Barrier Heights Using Light-Ion Transfer in Inverse Kinematics

^{238}U(d,pf) used to determine fission barrier height of ^{239}U reaction – benchmarked against n-induced fission → new method proven



Example particle trajectories in HELIOS@ANL for reactions populating the ground state in ^{239}U (orange) and states close to the fission barrier (purple) Example fission fragment trajectories for fragments with A=138 (red) and A=100 (blue), for a range of emission angles.

Direct reaction used to precisely constrain kinematics (and excitation energy) of recoil for DSAM measurement.



Experimental fission probability compared with a GEF simulation

$$P_f(E_x) = \frac{N_{d,pf}(E_x)}{N_{d,p}(E_x) \cdot \epsilon_f}$$

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Direct Determination of Fission-Barrier Heights Using Light-Ion Transfer in Inverse Kinematics

S. A. Bennett,[1] K. Garrett,[1] D. K. Sharp,[1,*] S. J. Freeman,[1,2] A. G. Smith,[1] T. J. Wright,[1] B. P. Kay,[3] T. L. Tang,[3,†] I. A. Tolstukhin,[3] Y. Ayyad,[4] J. Chen,[3] P. J. Davies,[5] A. Dolan,[6] L. P. Gaffney,[6] A. Heinz,[7] C. R. Hoffman,[3] C. Müller-Gatermann,[3] R. D. Page,[6] and G. L. Wilson[8,3]

Measurements with solenoid spectrometers

Monday

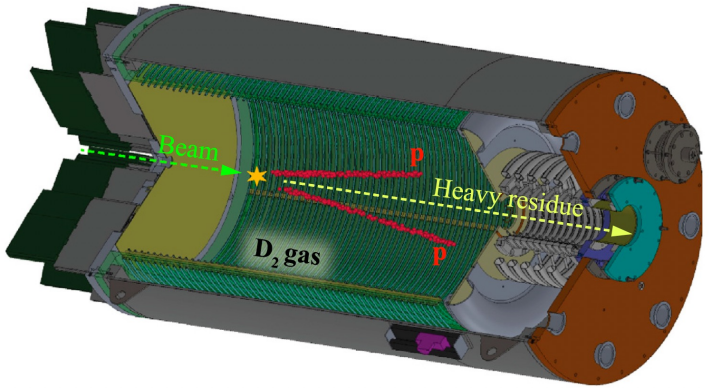
Overview of recent direct-reaction measurements in inverse kinematics at the ISOLDE Solenoidal Spectrometer, CERN
Dr Patrick MacGregor

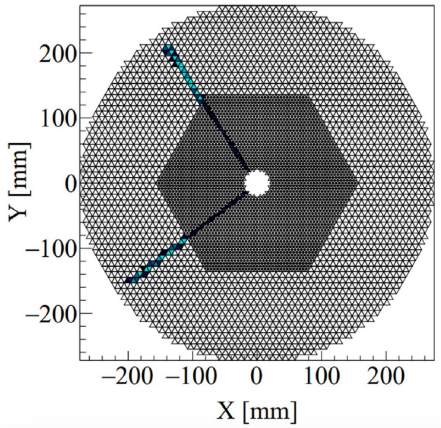
Tuesday

Investigating near the N=20 island of inversion with the 32Si(t,p)34Si reaction using SOLARIS *Nate Watwood*
Kurhaus Wiesbaden 11:00 - 11:20

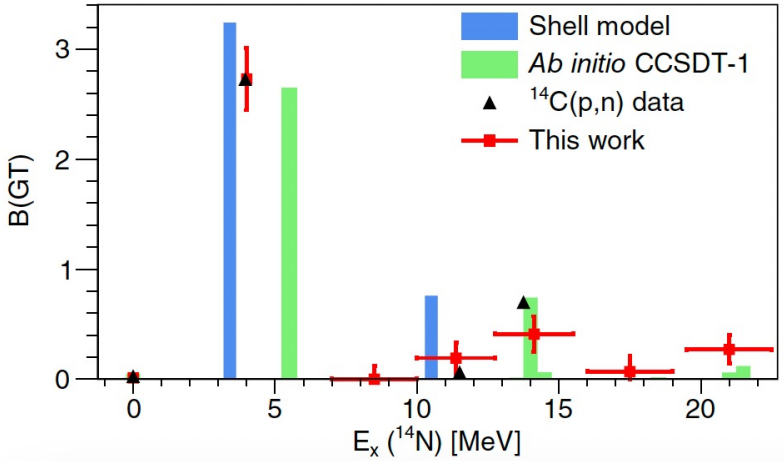
β^+ Gamow-Teller Strengths from Unstable ^{14}O via the (d,^{2}He) Reaction in Inverse Kinematics

Charge-exchange on exotic beams in the β^+ direction has limited probes - imagine (n,p) on unstable nuclei! At energies at or above 100 MeV/u, CEX is mediated by pion exchange and characterized by $\Delta S=1$, $\Delta T=1$, and $\Delta L=0$, at q=0, the energy of the two protons is very small → AT-TPC@S800

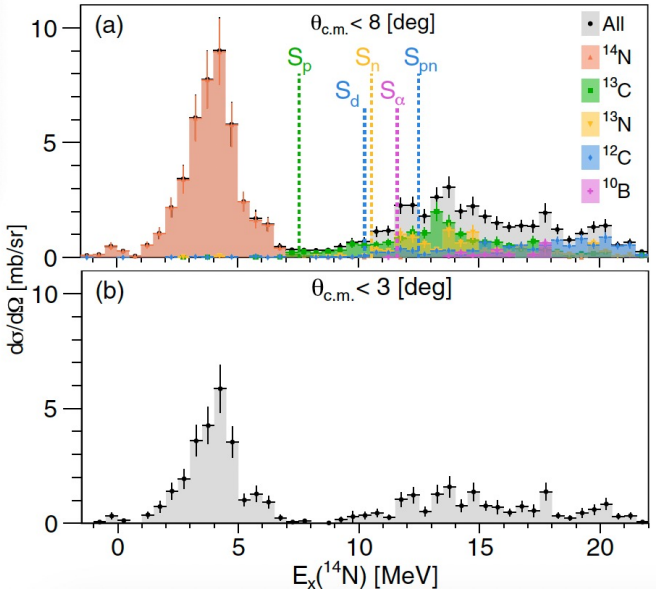




^{14}O(d,^{2}He)^{14}N at 105 MeV/u from A1900 at NSCL/MSU as proof of principle



Proof of principle succeeded and another (d,^{2}He) measurement just finished at FRIB



Cross section for ^{14}O(d,^{2}He)^{14}N (top) and gated on zero degree (to enhance GT strength)

PHYSICAL REVIEW LETTERS **130,** 232301 (2023)

β^+ Gamow-Teller Strengths from Unstable ^{14}O via the $(d, ^2\mathrm{He})$ Reaction in Inverse Kinematics

S. Giraud,[1,2,3,*] J. C. Zamora,[1] R. G. T. Zegers,[1,2,3,†] D. Bazin,[1,3] Y. Ayyad,[4,1] S. Bacca,[5,6] S. Beceiro-Novo,[3,7] B. A. Brown,[1,2,3] A. Carls,[1,2,3] J. Chen,[1,8] M. Cortesi,[1] M. DeNudt,[1,2,3] G. Hagen,[9,10] C. Hultquist,[1,2,3] C. Maher,[1,2,3] W. Mittig,[1,3] F. Ndayisabye,[1,2,3] S. Noji,[1] S. J. Novario,[9,10] J. Pereira,[1,2] Z. Rahman,[1,2,3] J. Schmitt,[1,2,3] M. Serikow,[1,2,3] L. J. Sun,[1,2] J. Surbrook,[1,2,3] N. Watwood,[1,2,3] and T. Wheeler[1,2,3]

The rise of the time projection chambers

Monday

Transfer reactions with ACTAR TPC	*Beatriz Fernandez-Dominguez*
Kurhaus Wiesbaden	14:50 - 15:10

Tuesday

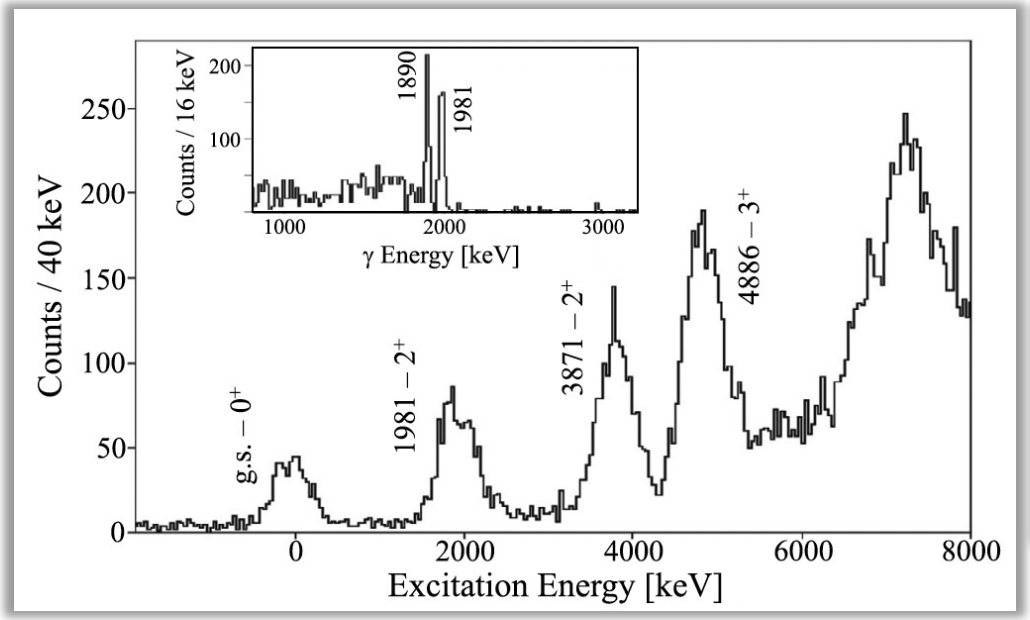
Spectroscopy of rare isotopes with the Active Target Time Projection Chamber	*Daniel Bazin et al.*
Kurhaus Wiesbaden	16:20 - 16:40

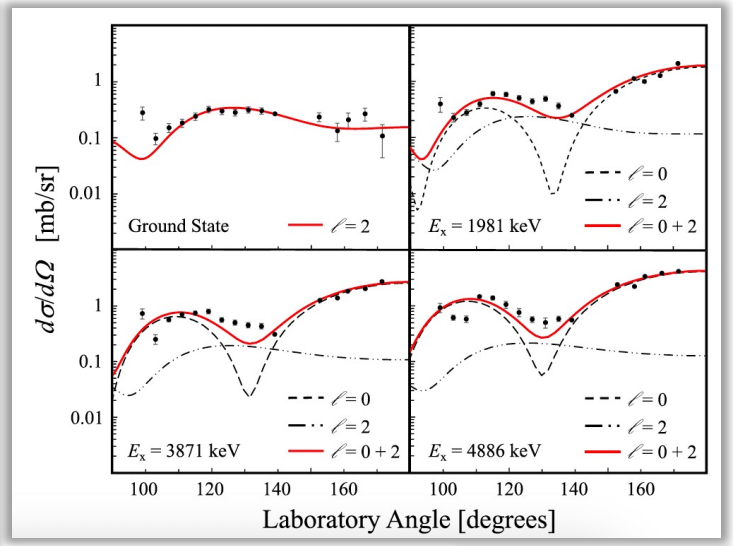
Thursday

Observation of a near-threshold isoscalar dipole resonance in 10Be using the AT-TPC coupled with SOLARIS	*Jie Chen*
Kurhaus Wiesbaden	11:00 - 11:20
Measurement of unbound states in 17C using the Active Target Time Projection Chamber	*Gordon McCann*
Kurhaus Wiesbaden	12:00 - 12:20

Single neutron transfer on ^{23}Ne and its relevance for the pathway of nucleosynthesis in astrophysical X-ray bursts

Resonance strengths in the astrophysical ^{23}Al(p,γ)^{24}Si determined from ^{23}Ne(d,p)^{24}Ne. ^{24}Ne is T=2 mirror of ^{24}Si (SF to 20%, resonance strength uncertainty reduced by factor 4)





Found that the ^{23}Al(p,γ)^{24}Si reaction is effective in bypassing the ^{22}Mg waiting point in the rp process

8 MeV/u ^{23}Ne beam on CD_2 target from ISAC-II at TRIUMF, using SHARC Si array with TIGRESS γ-ray detection

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Single neutron transfer on ^{23}Ne and its relevance for the pathway of nucleosynthesis in astrophysical X-ray bursts

G. Lotay [a,*], J. Henderson [a,b], W.N. Catford [a], F.A. Ali [c,d], J. Berean [b], N. Bernier [b,e,1], S.S. Bhattacharjee [b,2], M. Bowry [b,3], R. Caballero-Folch [b], B. Davids [b,f], T.E. Drake [g], A.B. Garnsworthy [b], F. Ghazi Moradi [c], S.A. Gillespie [b,4], B. Greaves [c], G. Hackman [b], S. Hallam [a], D. Hymers [c], E. Kasanda [c], D. Levy [b], B.K. Luna [h], A. Mathews [b], Z. Meisel [i], M. Moukaddam [a,5], D. Muecher [b,c], B. Olaizola [b,6], N.A. Orr [j], H.P. Patel [b], M.M. Rajabali [h], Y. Saito [b,e], J. Smallcombe [b,7], M. Spencer [a,b], C.E. Svensson [c], K. Whitmore [f], M. Williams [b,k]

Direct reactions in pursuit of understanding nucleosynthesis

Tuesday

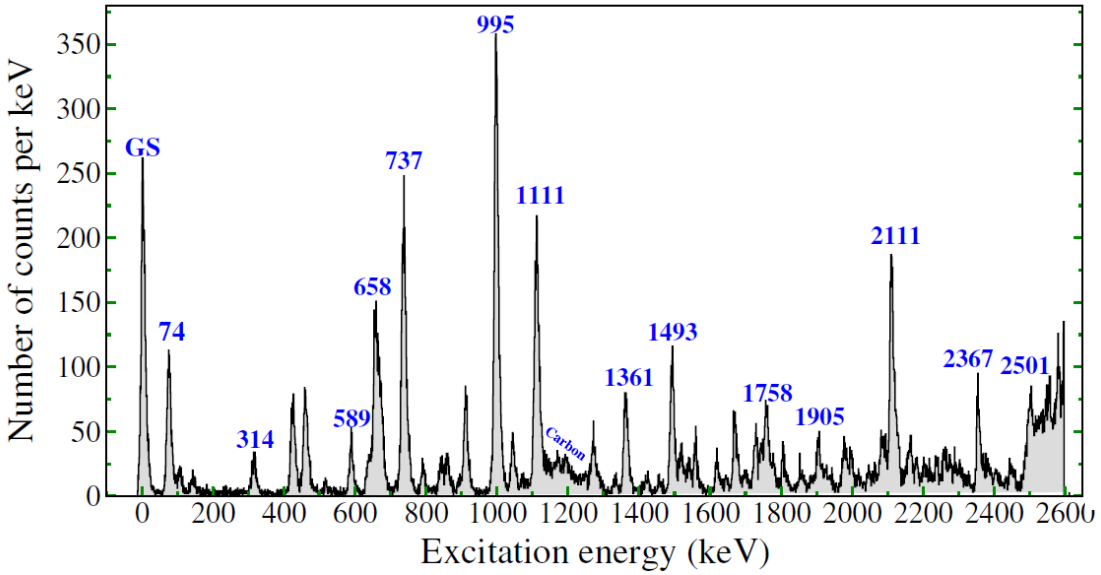
A study of the (d,pg) reaction on radioisotope 85gKr to constrain a key s-process branching point *Sara Carollo*

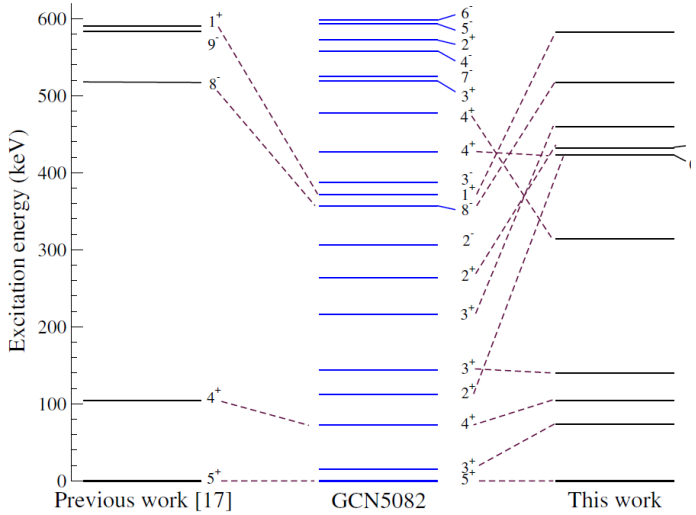
Kurhaus Wiesbaden 14:20 - 14:40

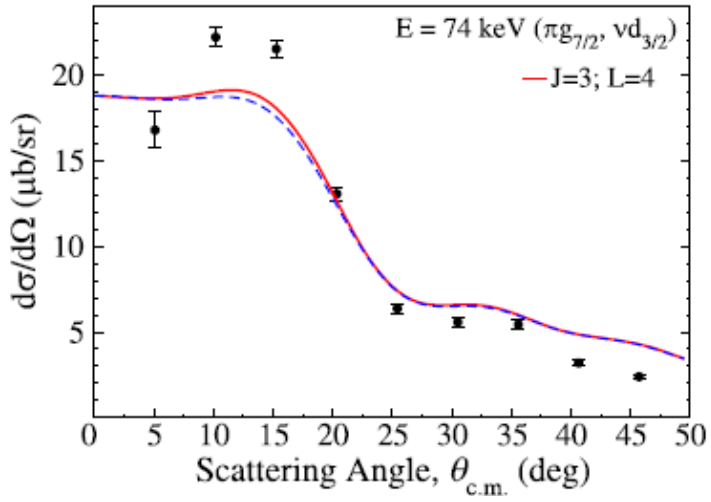
Using (d,p) Transfer Reactions at OEDO-SHARAQ to Measure Astrophysical Reactions Important in r- and vp- processes
Thomas Chillery

^{138}Ba(d,α) Study of States in ^{136}Cs: Implications for New Physics Searches with Xenon Detectors

^{136}Xe neutrino-less double beta decay detectors present an opportunity to detect solar neutrinos or fermionic dark matter via charged-current capture to 1^+ states in ^{136}Cs. Now, if the decay path of 1^+ proceeds through ns isomer, one can use a delayed trigger on the isomeric decay for background-free tagging of such events.







3^+_1 state in the path of the 1^+_1 decay found that was later established to have τ=157(4) ns lifetime, a nice candidate tag

PHYSICAL REVIEW LETTERS **131,** 052501 (2023)

^{138}Ba(d,α) Study of States in ^{136}Cs: Implications for New Physics Searches with Xenon Detectors

B. M. Rebeiro,[1,2] S. Triambak,[1,*] P. E. Garrett,[3,1] G. C. Ball,[4] B. A. Brown,[5] J. Menéndez,[6] B. Romeo,[7] P. Adsley,[8] B. G. Lenardo,[9] R. Lindsay,[1] V. Bildstein,[3] C. Burbadge,[3,†] R. Coleman,[3] A. Diaz Varela,[3] R. Dubey,[1,10] T. Faestermann,[11] R. Hertenberger,[12] M. Kamil,[1] K. G. Leach,[13] C. Natzke,[13] J. C. Nzobadila Ondze,[1] A. Radich,[3] E. Rand,[3] and H.-F. Wirth[12]

Pair transfer and topics off the beaten track

Tuesday

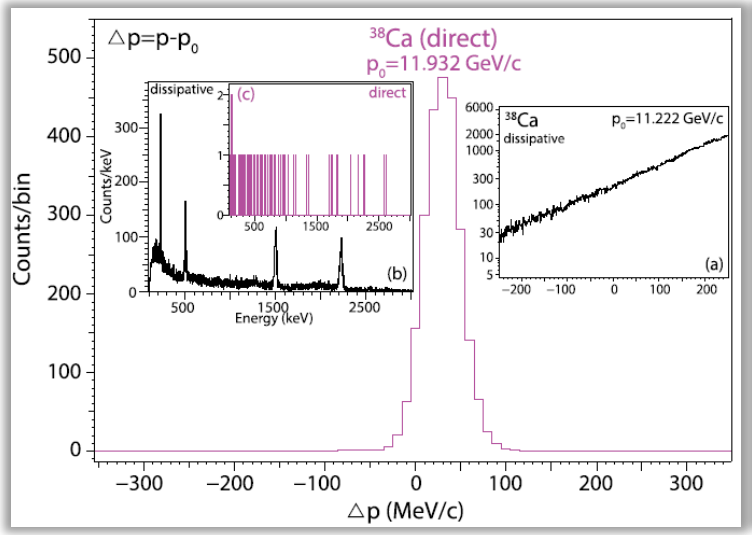
Super-radiance and two-neutron transfer reactions *	*Augusto Maccchiavelli*
Kurhaus Wiesbaden	16:00 - 16:20

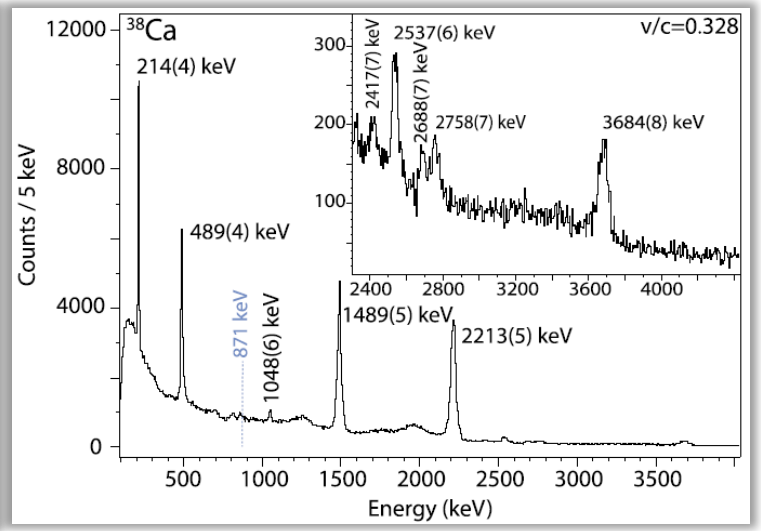
Friday

Proton-neutron pairing in the fp-shell via the ^{48}Cr(p,^{3}He)^{46}V transfer reaction	*Hugo Jacob*
Kurhaus Wiesbaden	10:40 - 11:00

The Messy Side of “Direct” – A Tale of Tails I

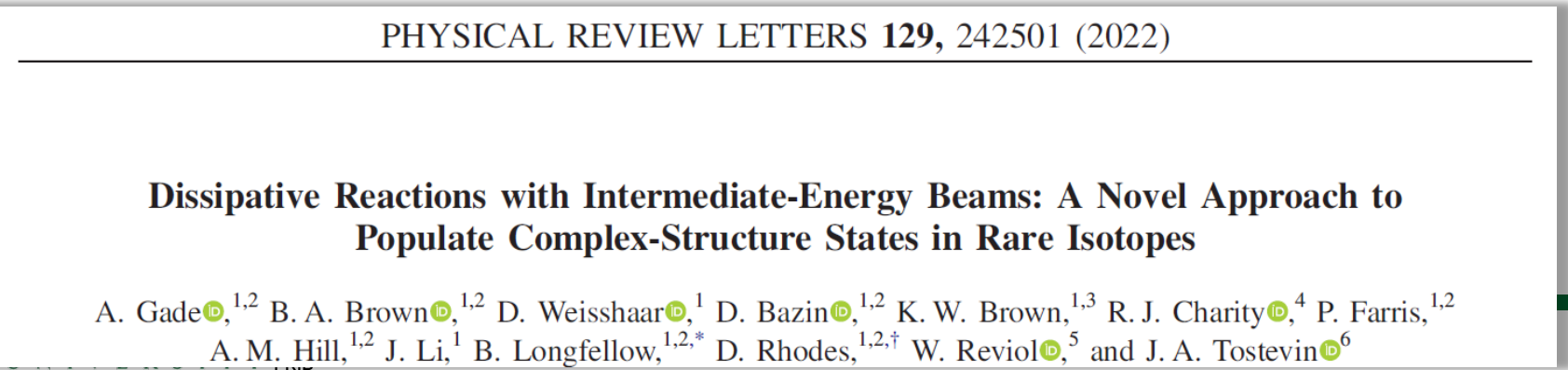
^{9}Be(^{38}Ca,^{38,39}Ca+γ)X with GRETINA@S800 at 61 MeV/u but looking at ^{38,39}Ca that lost >600 MeV/c in momentum





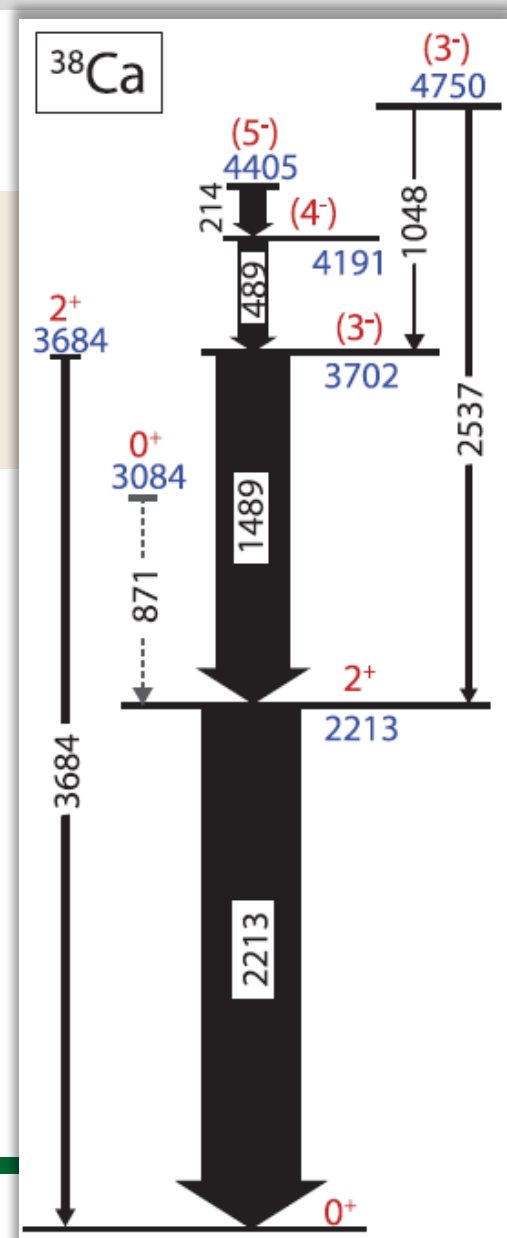
Strongly populated states are particle hole excitations from *sd* to *fp* shell

Very rich γ-ray spectrum observed in the tail of inelastically scattered ^{38}Ca, 600 MeV/c off-center. States are of complex structure and would require rearrangement of several nucleons in one interaction


PHYSICAL REVIEW LETTERS **129,** 242501 (2022)

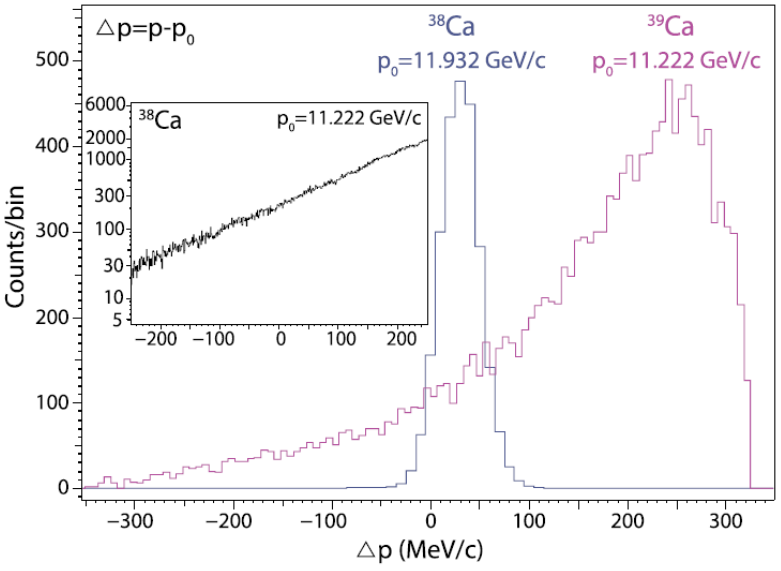
Dissipative Reactions with Intermediate-Energy Beams: A Novel Approach to Populate Complex-Structure States in Rare Isotopes

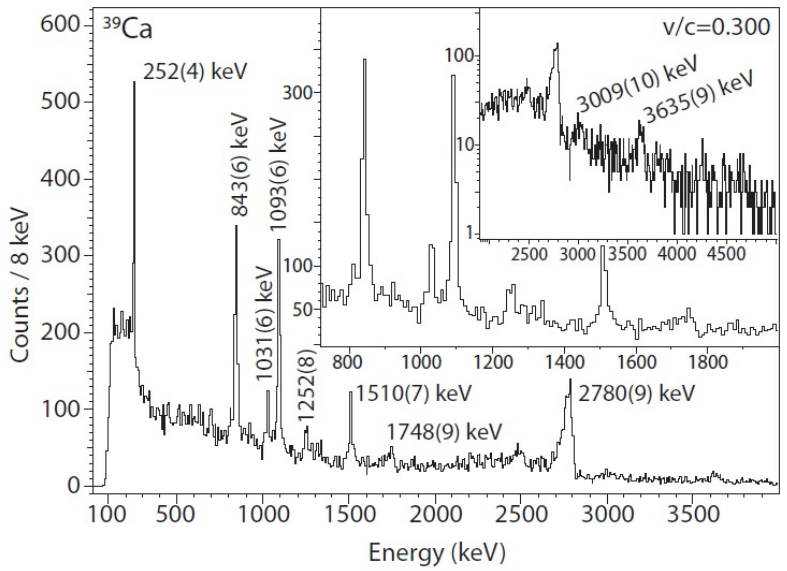
A. Gade,[1,2] B. A. Brown,[1,2] D. Weisshaar,[1] D. Bazin,[1,2] K. W. Brown,[1,3] R. J. Charity,[4] P. Farris,[1,2] A. M. Hill,[1,2] J. Li,[1] B. Longfellow,[1,2,*] D. Rhodes,[1,2,†] W. Reviol,[5] and J. A. Tostevin[6]

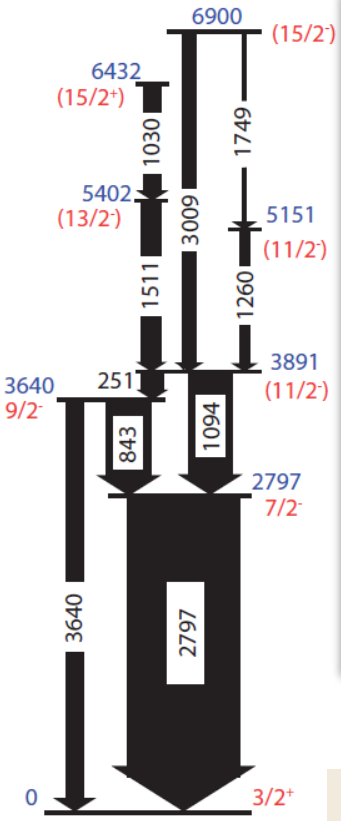


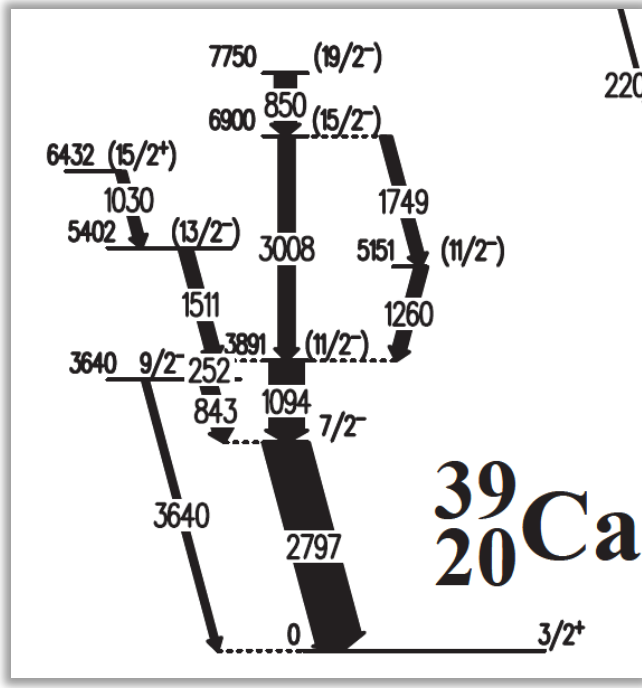
The Messy Side of "Direct" – A Tale of Tails II

^{9}Be(^{38}Ca,^{39}Ca+γ)X with GRETINA@S800 at 61 MeV/u but looking at ^{39}Ca that lost >700 MeV/c in momentum









Very rich γ-ray spectrum observed in the tail of one-neutron pickup from ^{38}Ca to ^{39}Ca, 700 MeV/c off-center from peak

PHYSICAL REVIEW C **106**, 064303 (2022)

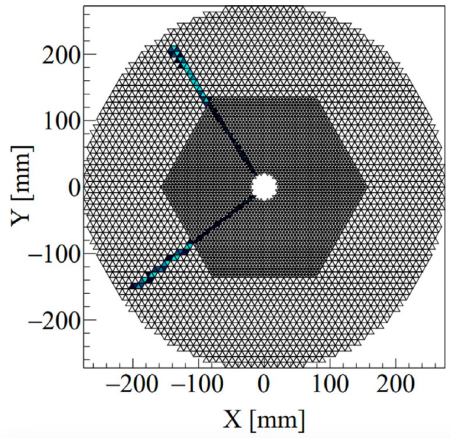
Exploiting dissipative reactions to perform in-beam γ-ray spectroscopy of the neutron-deficient isotopes ^{38,39}Ca

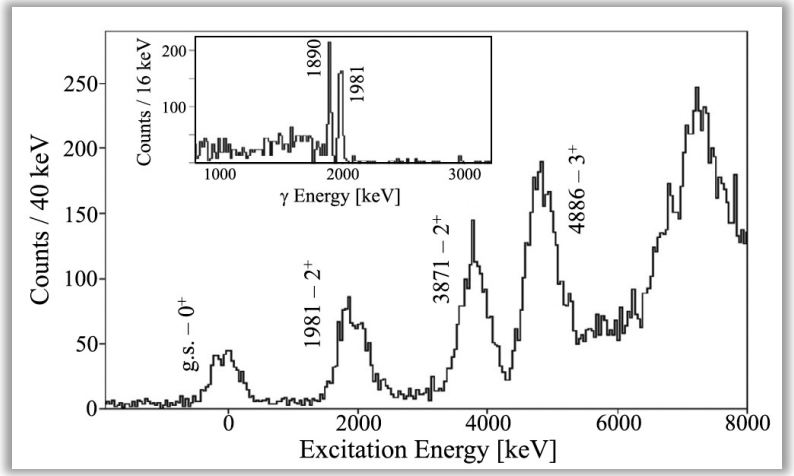
A. Gade,[1,2] D. Weisshaar,[1] B. A. Brown,[1,2] D. Bazin,[1,2] K. W. Brown,[1,3] R. J. Charity,[4] P. Farris,[1,2] A. M. Hill,[1,2] J. Li,[1] B. Longfellow,[1,2,*] D. Rhodes,[1,2,†] W. Reviol,[5] and J. A. Tostevin[6]

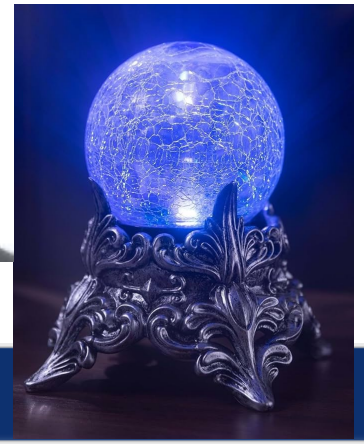
Strongly populated high-spin states with complex particle-hole character (e.g. 3p-4h for 15/2^{-})

Summary and Outlook

- Direct reactions have been used for many great things from low to high energies since the last DREB and you will see a large cross section during this meeting
- Depending on the application, approaches such as γ-tagging or track reconstruction in time projection chambers provided beautiful results
- Direct reactions are useful for an amazing number of topics from nuclear structure physics to nuclear astrophysics and even have impact on fission and schemes for neutrino and dark matter detection







Wednesday

Towards next-generation in-beam gamma-ray spectroscopy at the RIBF with HYPATIA — Pieter Doornenbal
Kurhaus Wiesbaden — 11:20 - 11:40

Perspective talk — Olivier Sorlin
Kurhaus Wiesbaden — 11:20 - 11:50

Thank you!

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