Exploring the continuum, proton and neutron rich

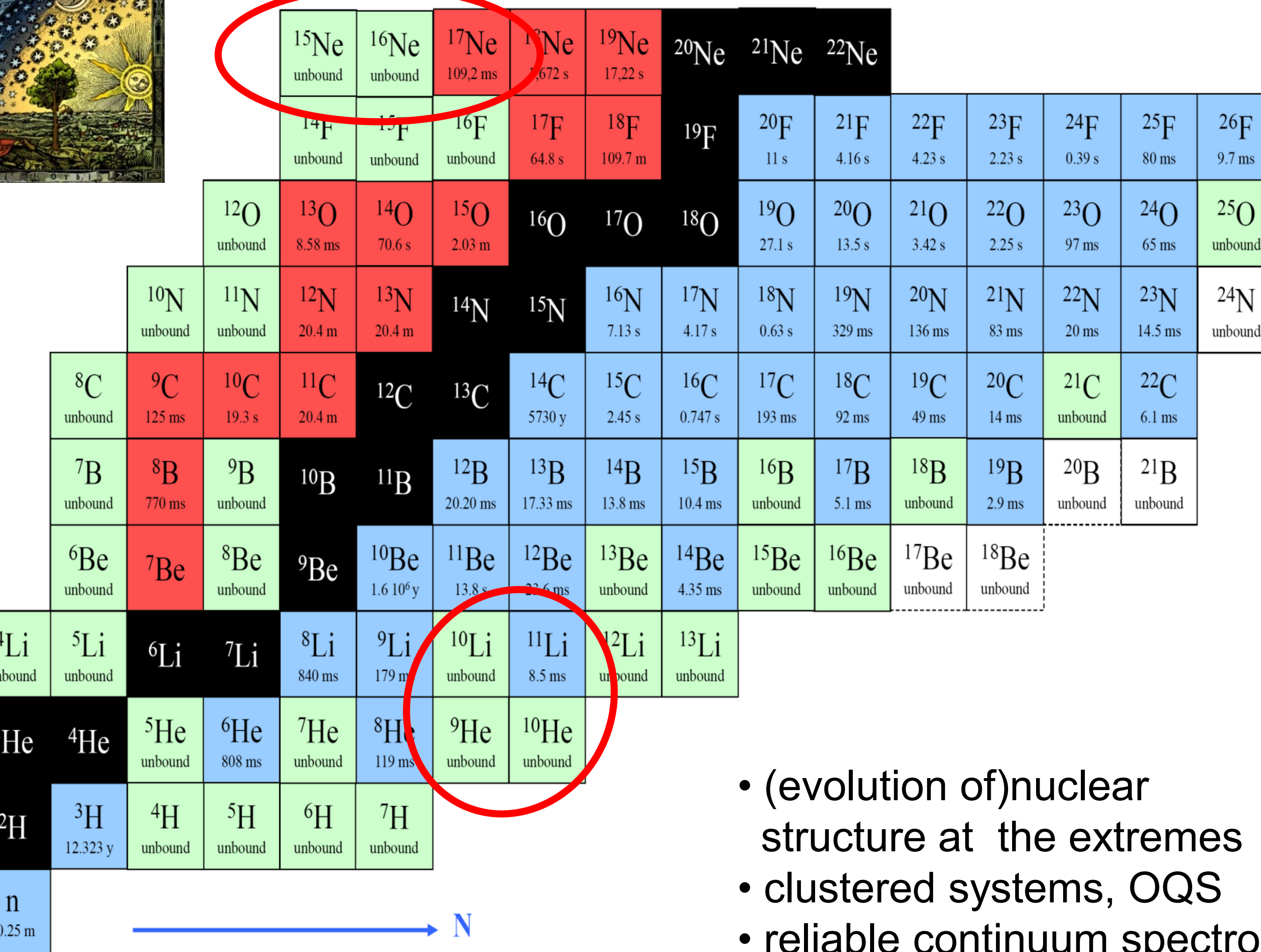
H. Simon GSI Darmstadt

Hirschegg 2015
Nuclear Structure and Reactions: Weak, Strange and Exotic
January 11th - 17th, 2015
Hirschegg, Austria

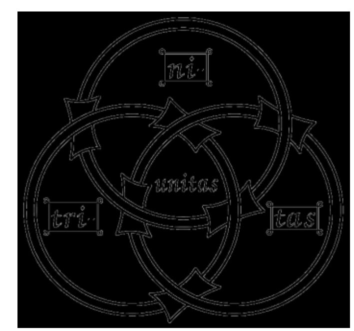
GSI FAIR EMMI

HELMHOLTZ GEMEINSCHAFT

At the boundaries: Three body systems



- (evolution of)nuclear structure at the extremes
- clustered systems, OQS
- reliable continuum spectroscopy



Menu

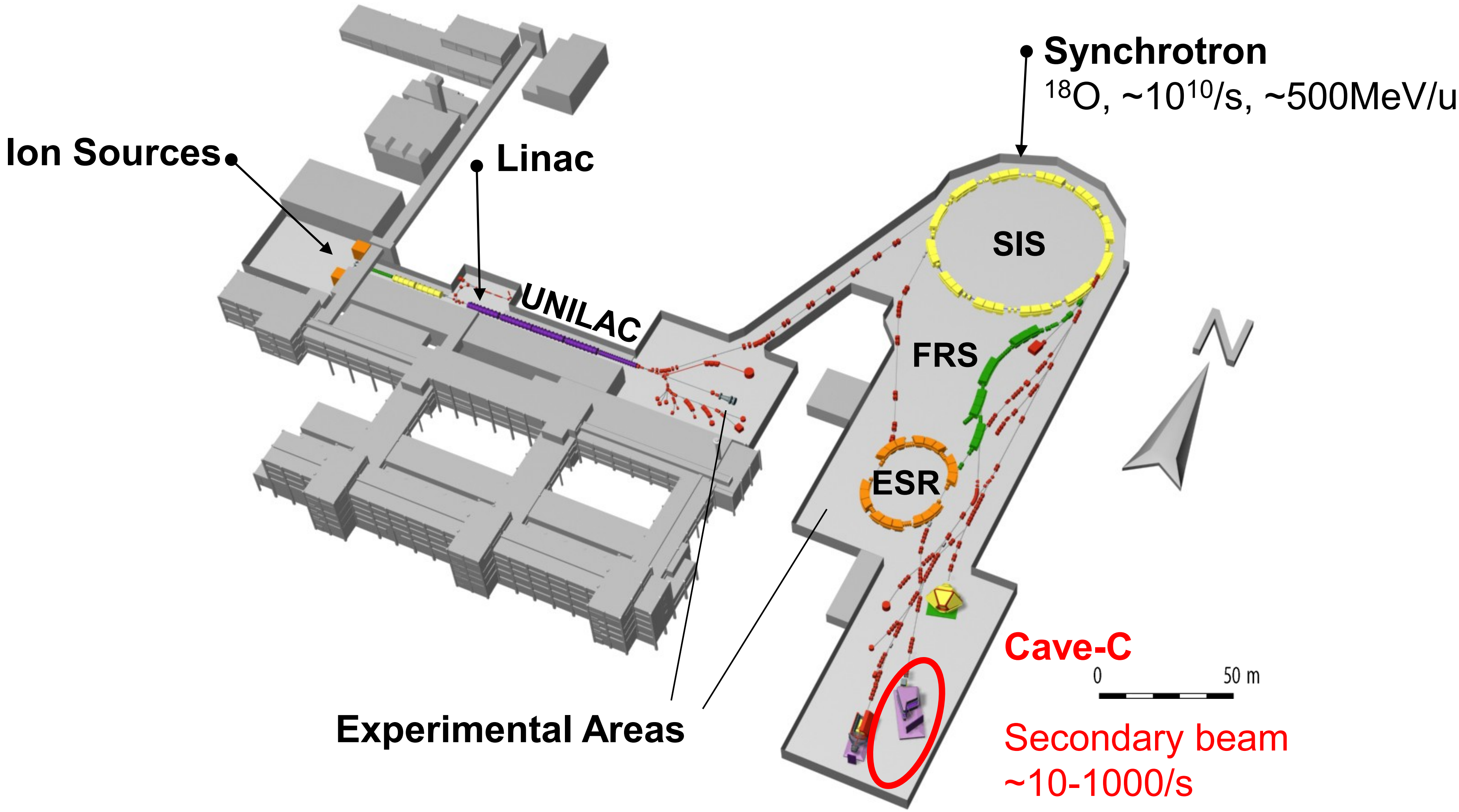
1. Breakup Experiments at high energy
   - and developments for FAIR

2. Extremely neutron rich systems: ^{9,10}He
   - remnants of ^{11}Li ?

3. Proton rich systems: $^{15-17}$Ne
   -across the proton dripline

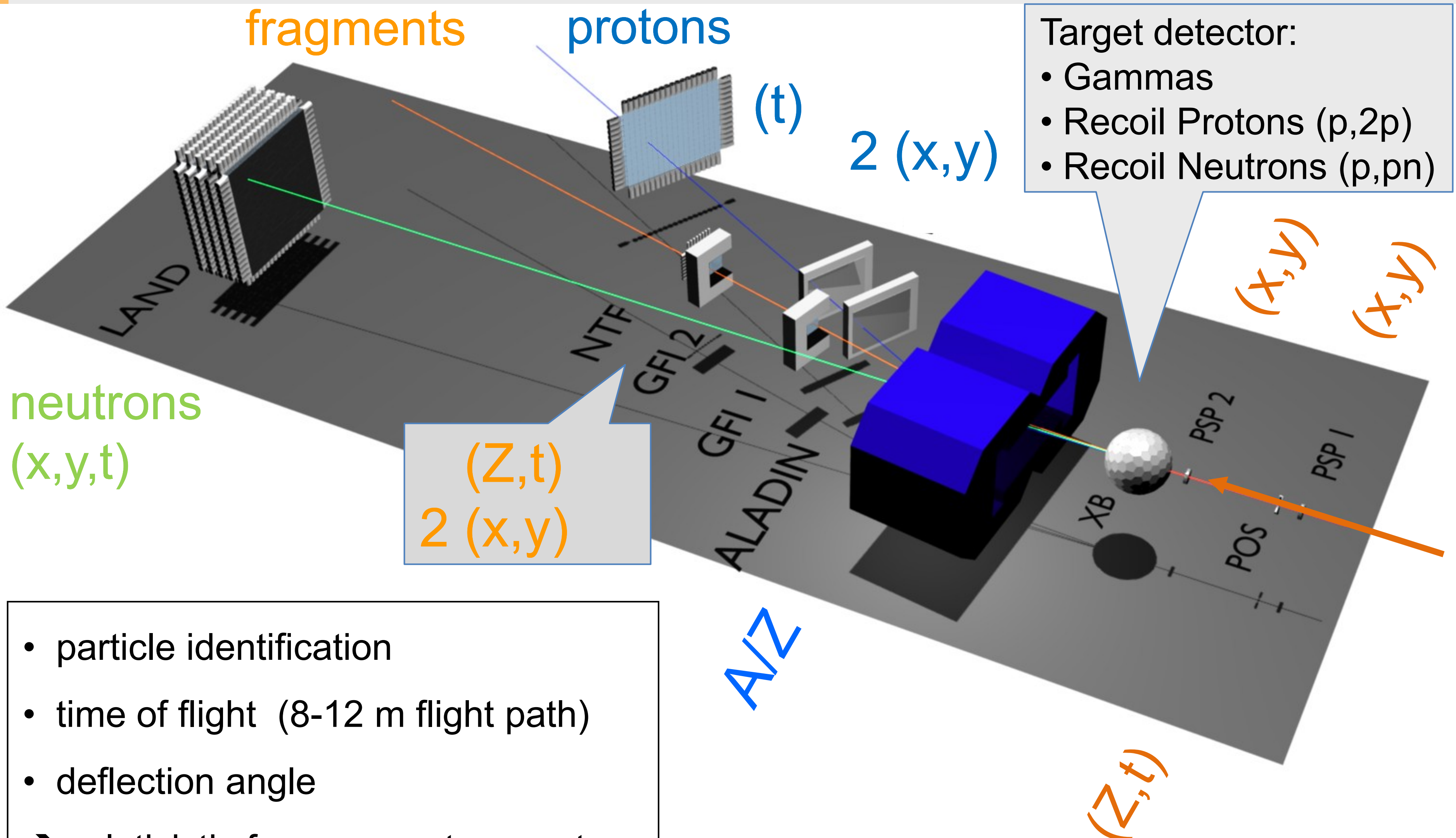
4. Summary

GSI accelerator facility …



Secondary beam
~10-1000/s
➔ 0.1 – 10/s after reaction

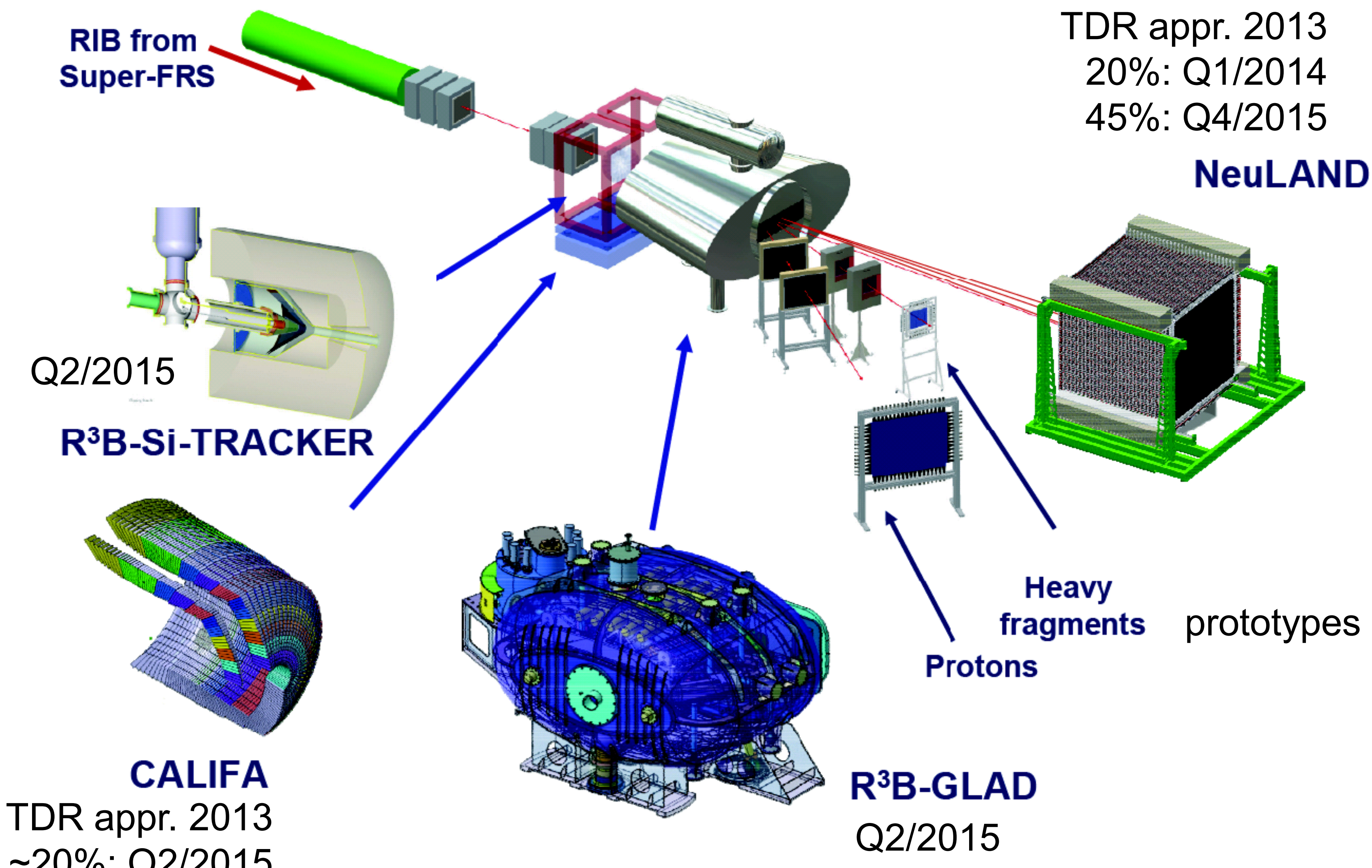
R³B/LAND Setup (kinematically complete)



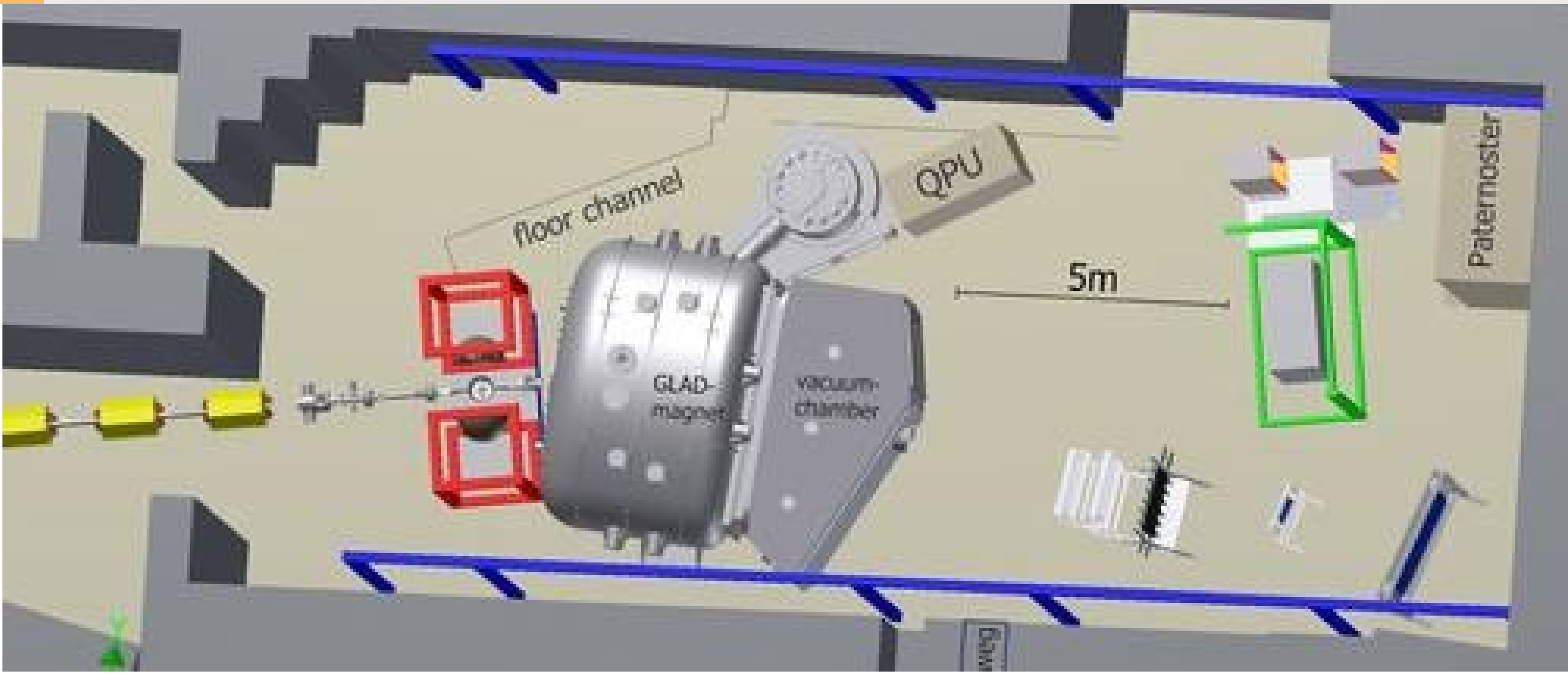
- particle identification
- time of flight (8-12 m flight path)
- deflection angle

➔ relativistic four momentum vectors

Ongoing:
Stagewise implementation of R³B for FAIR



Next step
GLAD magnet @ R³B/CaveC



Installation of a superconducting replacement for ALADiN in 2015
➔ Test bench for R³B at FAIR

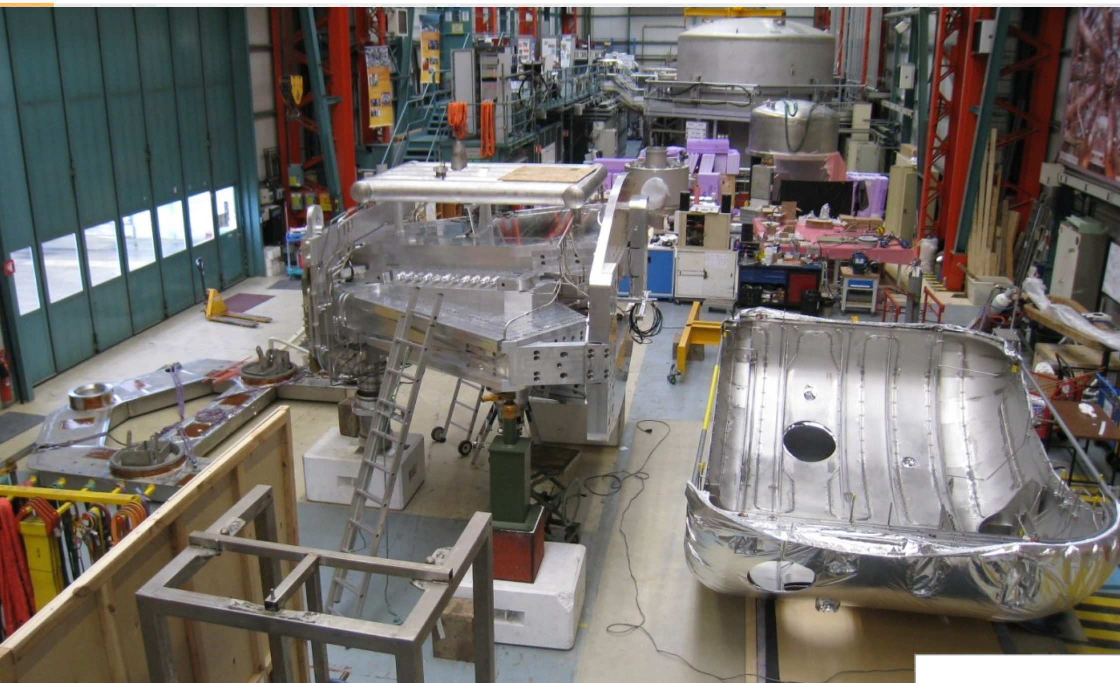
Already available:

(1) Cryogenics

(2) Power supply and Quench Protection

(3) Experiment Vacuum Chamber

GLAD magnet system …

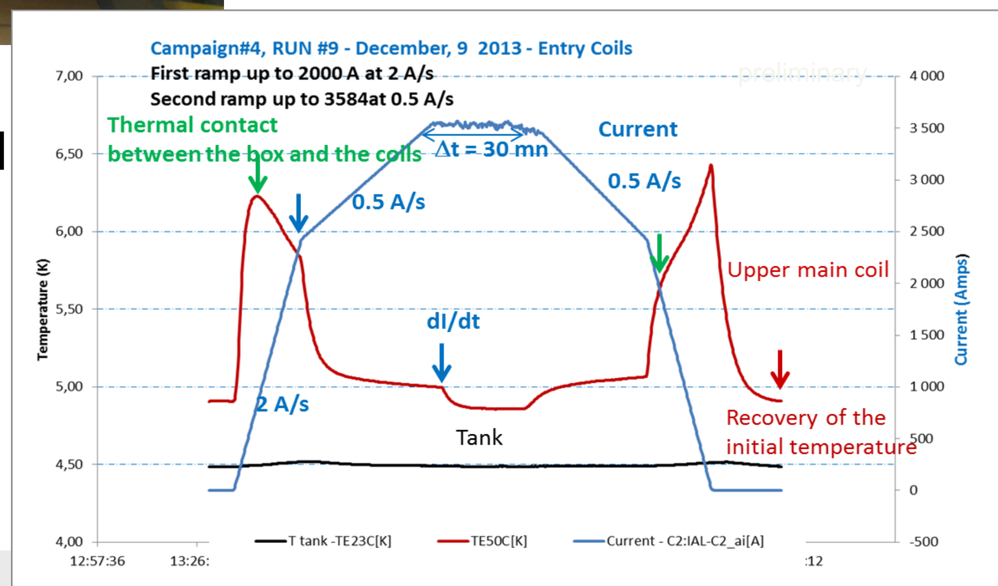


@CEA Saclay

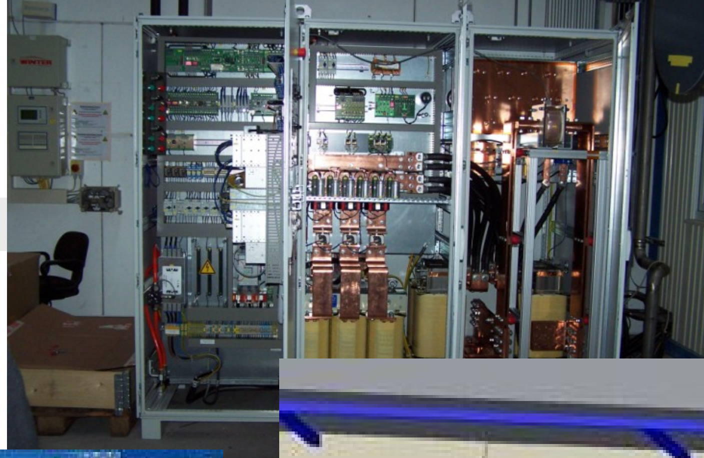
- Magnet cold mass ready and tested, December 2013.
- Integration into cryostat finishes this month.
- Delivery to GSI expected in April 2015.

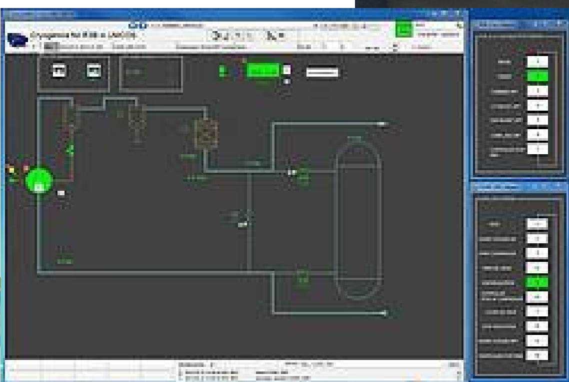
@GSI

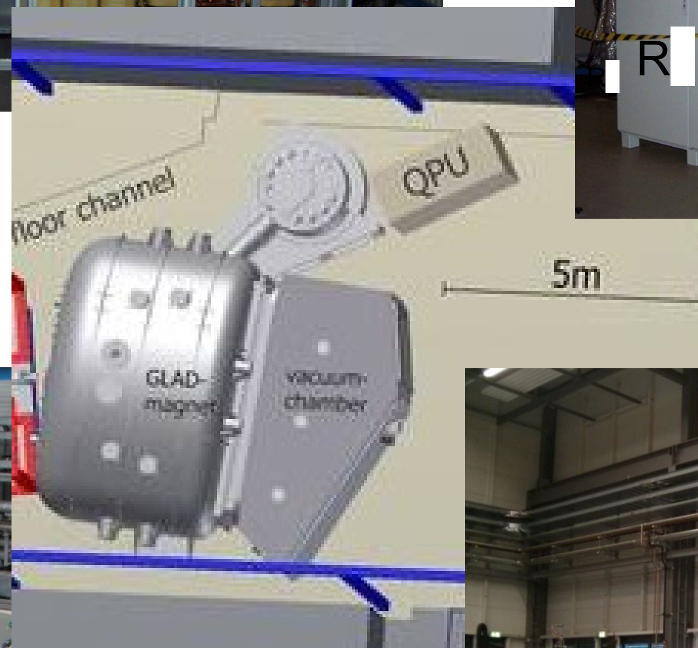
- Cryoplant from Desy → Refurbished operational Dec 2014
- New Power Supply and Quench Protection → Installed Dec 2014
- Experiment Chamber for GLAD delivered and tested Nov 2014

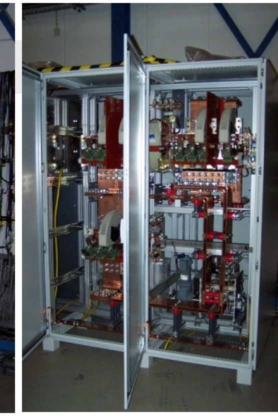


2013/14









… and Infrastructure @ GSI

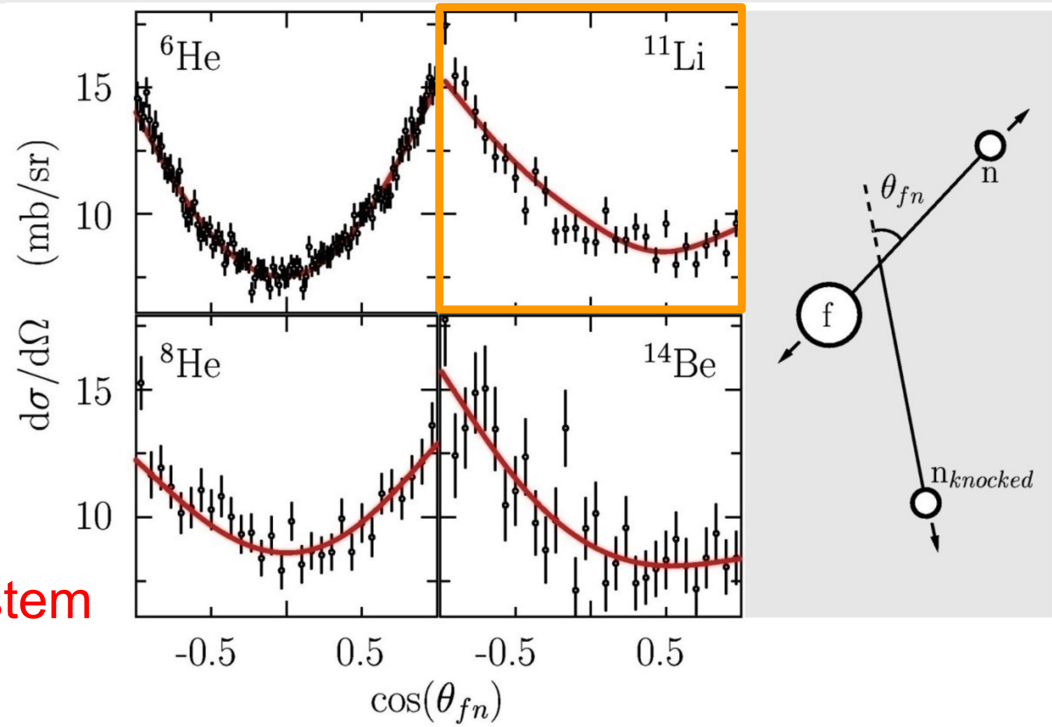
Intermediate system tells g.s. properties (n or p knockout reaction)

Observables:

Momentum knocked out neutron

missing momentum

CMS: $\mathbf{p}_m = -\mathbf{p}_{n2} = \mathbf{p}_{n1} + \mathbf{p}_f$



Spectroscopy of intermediate system

relative energy

CMS: $\mathbf{p}_{fn} = \mu/m_n\, \mathbf{p}_n - \mu/m_f\, \mathbf{p}_f$

Angular correlations (momenta)

$E_{fn} = p_{fn}^2 / 2\mu$

$$\cos(\theta)_{fn} = \frac{\mathbf{p}_m\, \mathbf{p}_{fn}}{p_m\, p_{fn}}$$

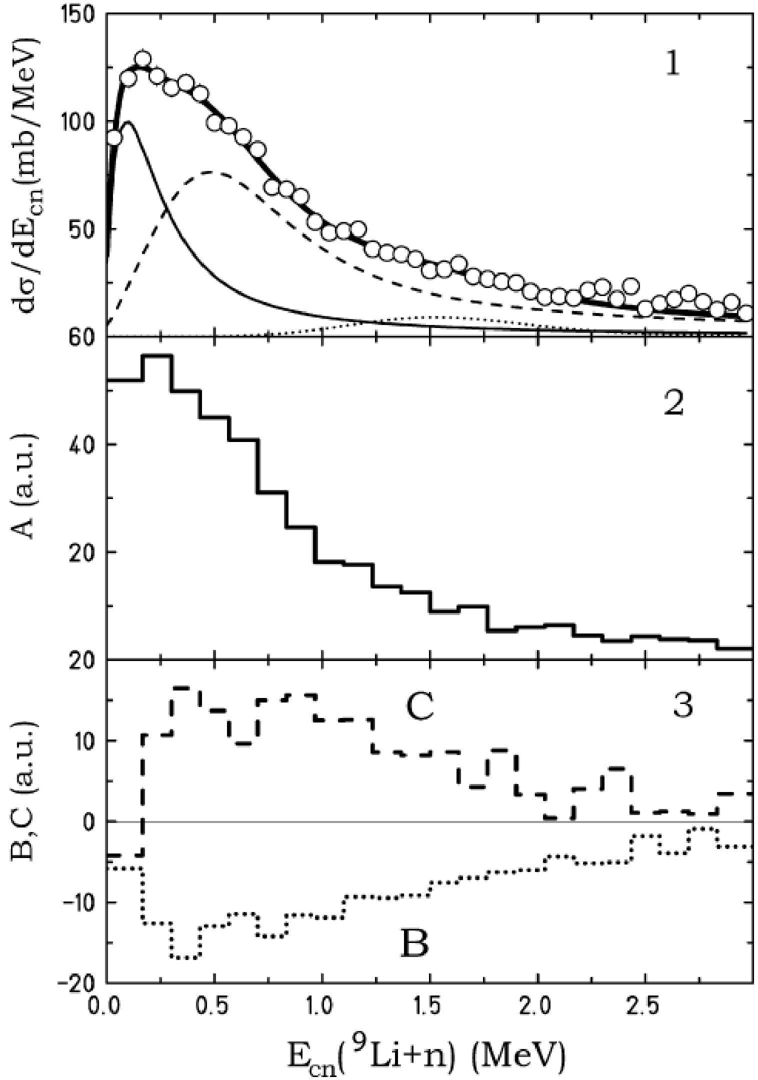
Linking seed nucleus with intermediate system - angular correlations vs. relative energy

Polynomial fit

A + B cos(θ) + C cos²(θ)

for angular correlations

Plot parameters vs. ^{10}Li relative energy spectrum



➔s @ threshold
➔p @ ~ 0.5 MeV

H.S. et al., NPA791 (2007) 267

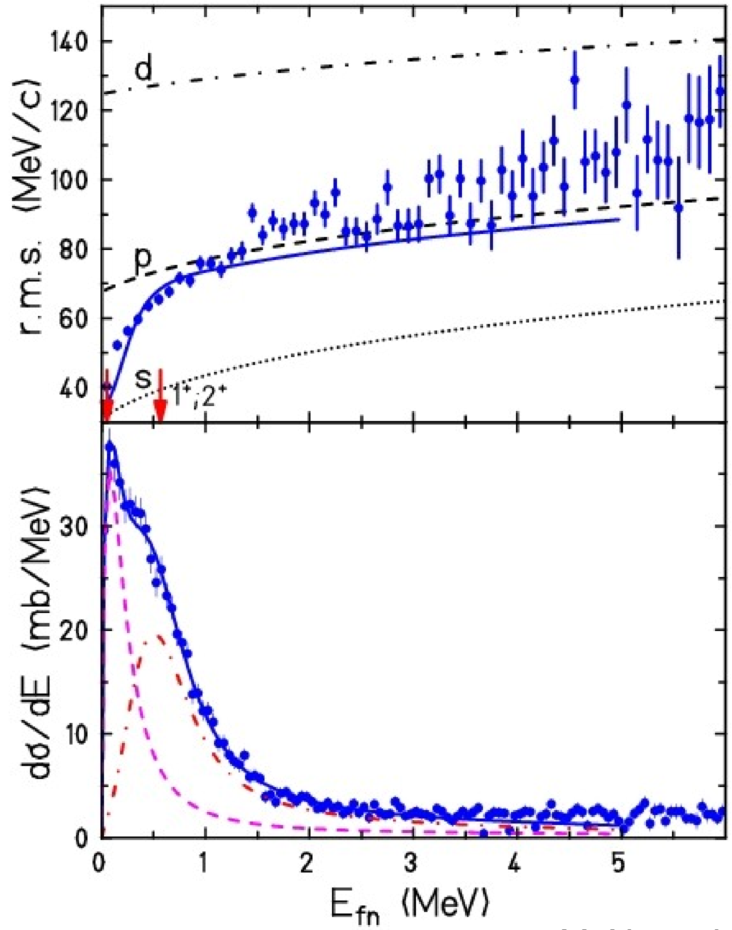
Sensitive observable:
Momentum profile & spectroscopy

^{10}Li ^{11}Li

Transverse momentum
Distribution of ^{10}Li
(missing momentum)

Decomposition and position of
s and p confirmed!

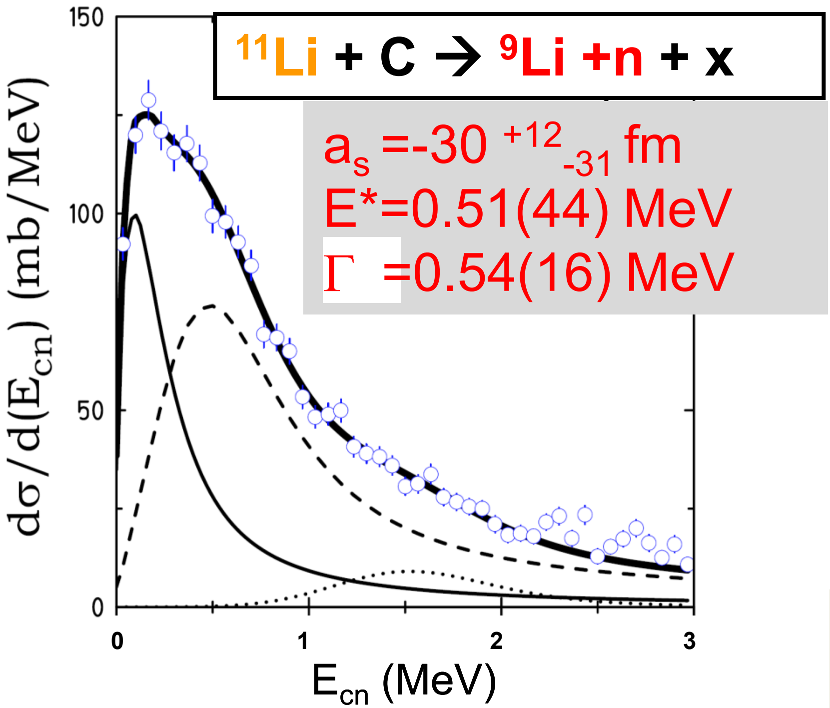
similar result with energy
dependent angular correlations

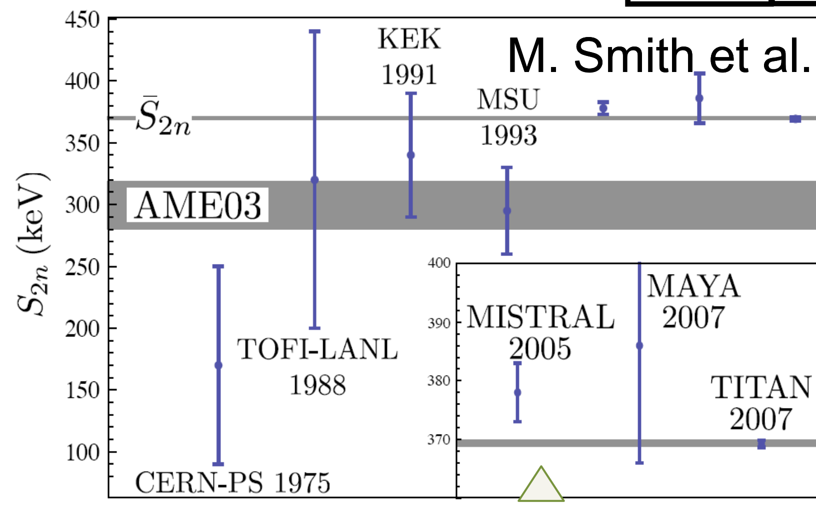


Y. Aksyutina et al.,
PLB718 (2013) 1309

The structure of ^{11}Li via ^{10}Li

^{10}Li | ^{11}Li





PRL **101**, 202501 (2008)   Nucl.Phys.**A826**, 1 (2009)

H.S. et al.
Phys. Rev. Lett. **83** (1999) 496
Nucl. Phys. **A 791** (2007) 267

Confirmed eg @ GANIL (N.Orr, H.Al Falou)
^{11}Be, ^{14,15}B → ^{9}Li+n

Correlation data, B(E1), matter radii, cross sections

binding energy 369.15(65) keV

charge radius 2.467(37) fm

R. Sanchez et al., PRL**96** (2006) 033002

quadrupole moment 33.3 (5) mb

R. Neugart et al., PRL**101**(2008)132502

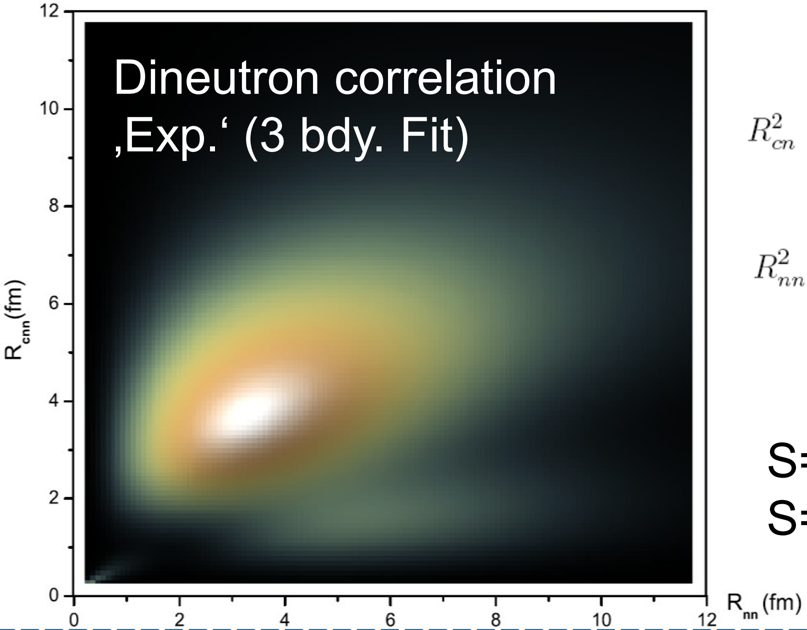
Phenomenological wave function

(s1/2)²: 37%
(p1/2)²: 47%
(p3/2)²: 9%

N.B. Shulgina, B. Jonson, M.V.Zhukov
Nucl. Phys. **A825**(2009)175

2n pairs in ^{11}Li via opening angle (in average!) ?

- there are two humps !

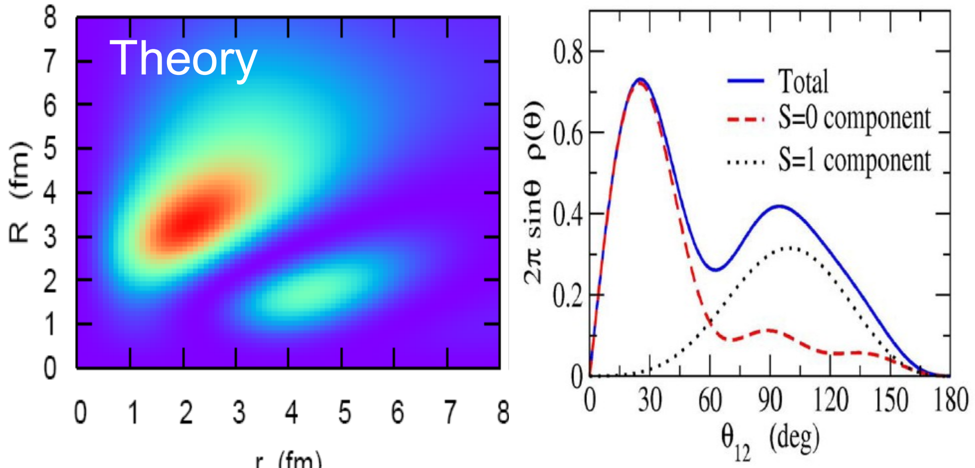


$$R^2_{cn} = \frac{5}{2673}(297w^2_{s_{1/2},s_{1/2}}\rho^2_{s_{1/2}\,s_{1/2}} + 298w^2_{p_{1/2},p_{1/2}}\rho^2_{p_{1/2}\,p_{1/2}} + 299w^2_{p_{3/2},p_{3/2}}\rho^2_{p_{3/2}\,p_{3/2}} - 3\sqrt{33}w_{s_{1/2},s_{1/2}}w_{p_{1/2},p_{1/2}}\rho^2_{s_{1/2}\,p_{1/2}} - 3\sqrt{66}w_{s_{1/2},s_{1/2}}w_{p_{3/2},p_{3/2}}\rho^2_{s_{1/2}\,p_{3/2}})$$

$$R^2_{nn} = \frac{1}{297}(297w^2_{s_{1/2},s_{1/2}}\rho^2_{s_{1/2}\,s_{1/2}} + 298w^2_{p_{1/2},p_{1/2}}\rho^2_{p_{1/2}\,p_{1/2}} + 299w^2_{p_{3/2},p_{3/2}}\rho^2_{p_{3/2}\,p_{3/2}} + 30\sqrt{33}w_{s_{1/2},s_{1/2}}w_{p_{1/2},p_{1/2}}\rho^2_{s_{1/2}\,p_{1/2}} + 30\sqrt{66}w_{s_{1/2},s_{1/2}}w_{p_{3/2},p_{3/2}}\rho^2_{s_{1/2}\,p_{3/2}}) \quad (21)$$

S=0 (81%)
S=1 (19%)

$<\Theta_{12}>$ = 62



K. Hagino et al., PRL 99, 022506 (2007)

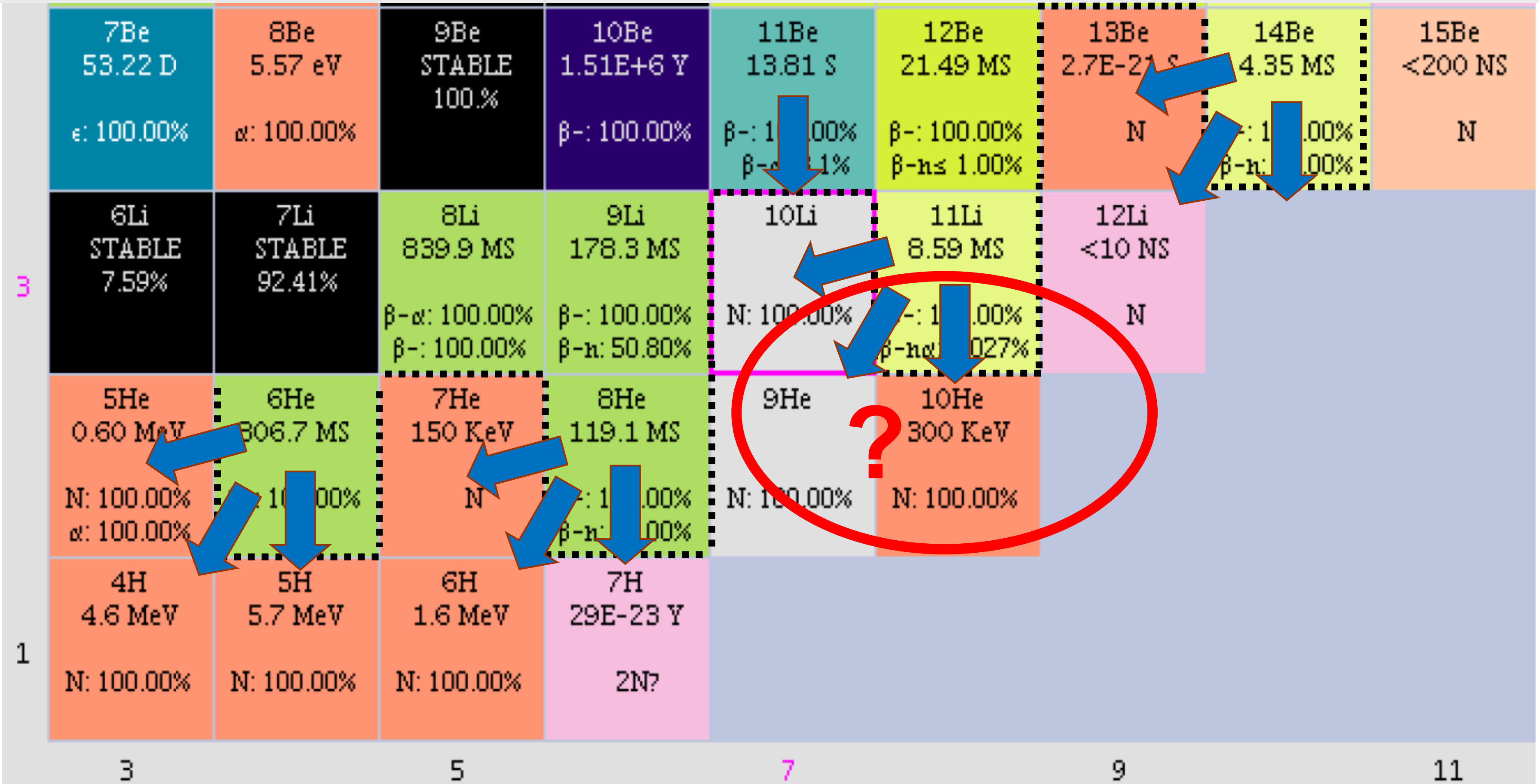
$<\Theta_{12}>$ = 66

$<\Theta_{12}>$ = 48 (+14/-18)

B(E1) = 1.42(18) e²fm² (< 3MeV)
cluster sum-rule, matter radius
T. Nakamura et al.

Exotic structure across the dripline

P.G. Hansen, Nature 328 (1987) 476



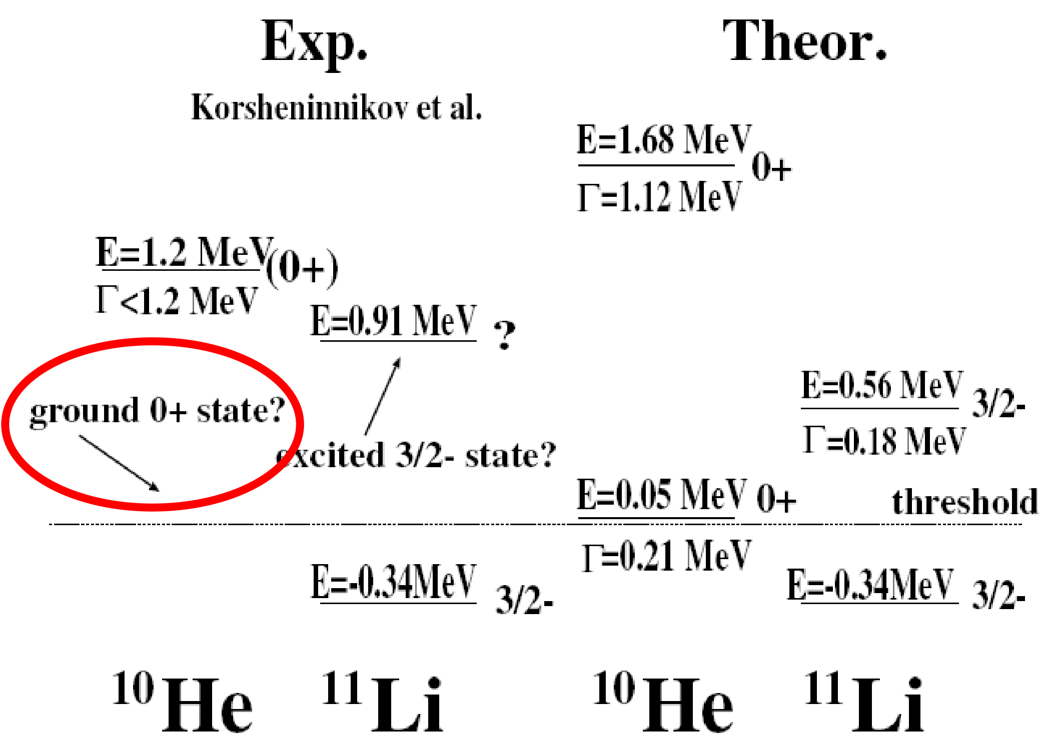
Clean & unbiased production

2n halo nuclei as seeds, here ^{11}Li with known structure

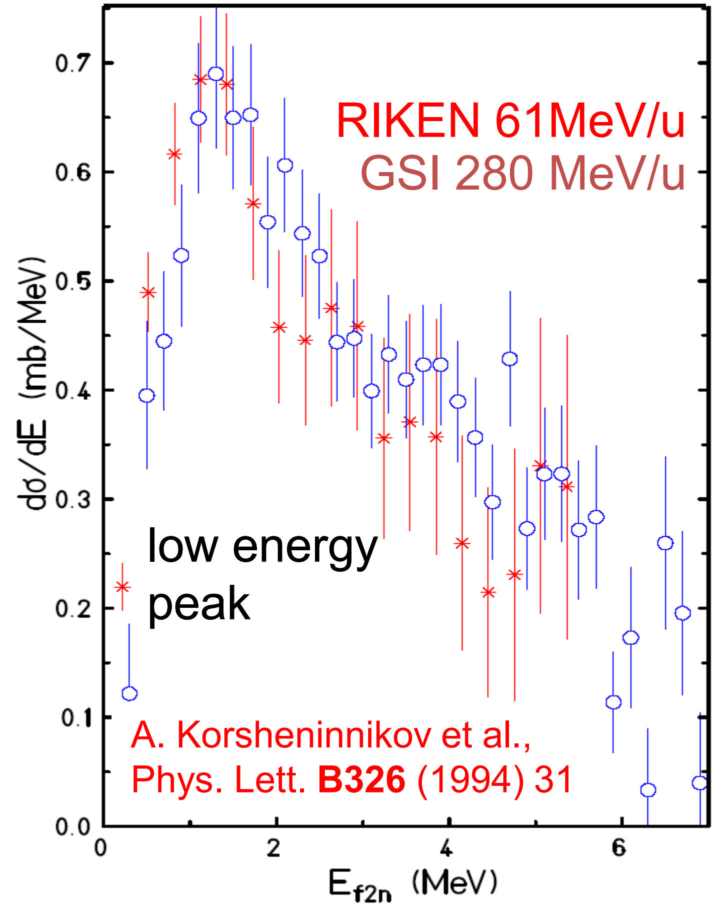
Possible similarity of ^{10}He and ^{11}Li g.s.

^{11}Li
^{10}He

Shigeyoshi Aoyama, PRL**89** (2002) 052501

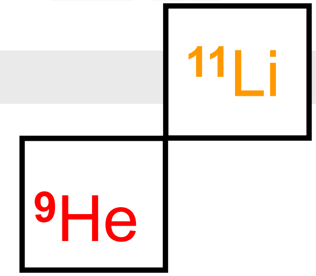


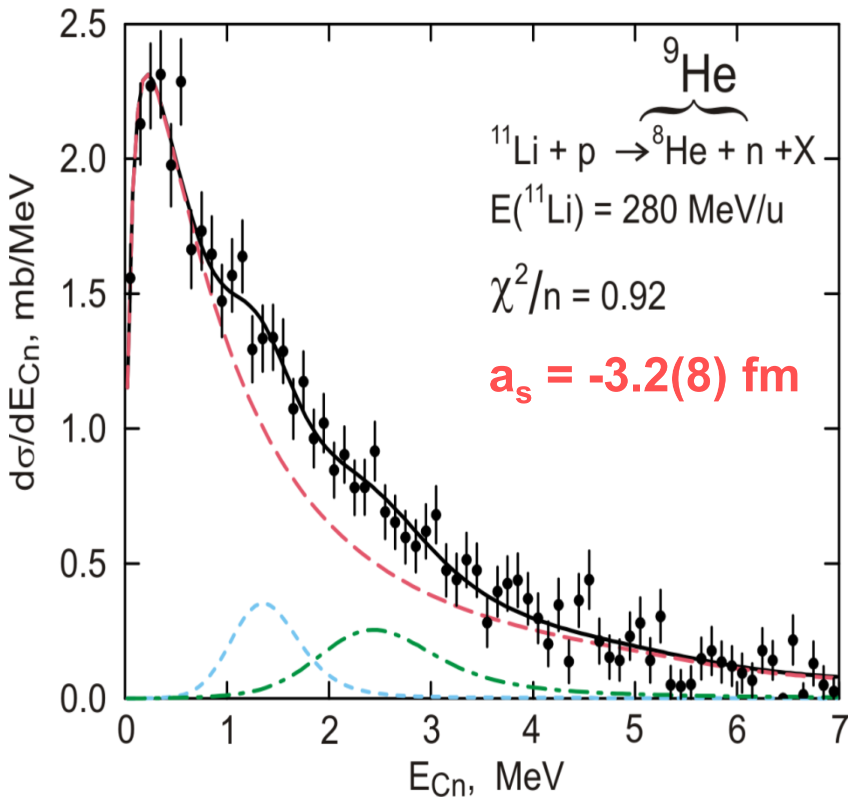
^{11}Li + p/CD_2,C → ^{8}He + n + n



Confirmed ^{14}B @NSCL: PRL 109, 232501 (2012)
➔ No problem for small relative neutron energies.

Constraining the ^{10}He groundstate via ^{9}He …



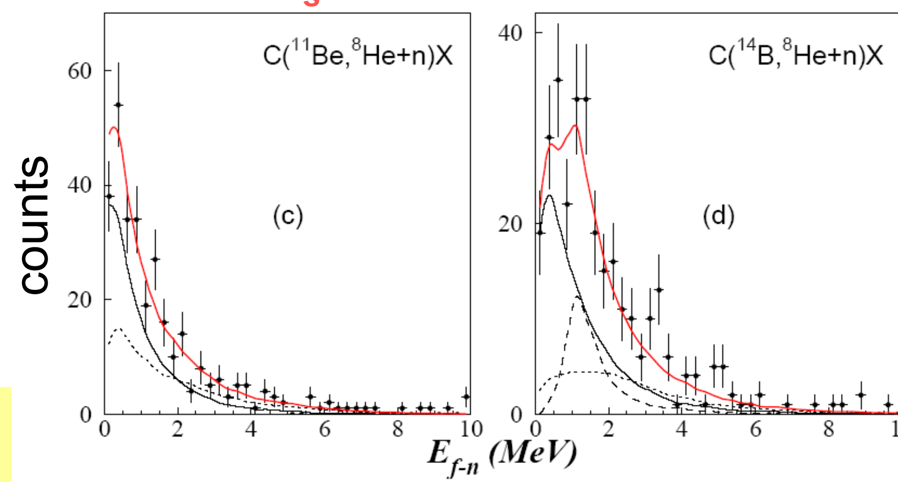


E_r=1.33(8) MeV, Γ=0.1 MeV
E_r=2.4 MeV, Γ=0.7 MeV
Prog.Part. Nucl.Phys. 42(1999)17

H.T. Johansson et al., Nucl. Phys. **A842** (2010) 15

L. Grigorenko, M. Zhukov,
PR**C77** (2008) 034611
^{9}He: a_s < -5fm ↔ ^{10}He g.s. at threshold

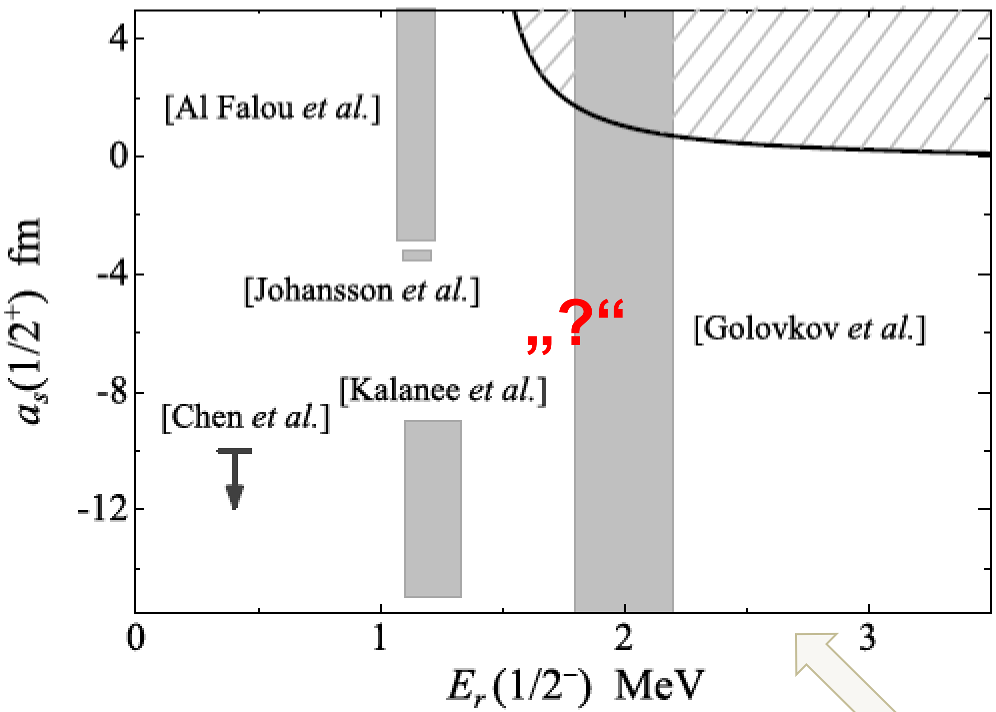
GANIL a_s = - 3 .. 0 fm



A. Falouh et al., Niigata Conf. 2010
T. al Kalanee et al.PRC **88** (2013) 034301
a_s ~10-12 fm ^{8}He(d,p) @15.4 MeV/u

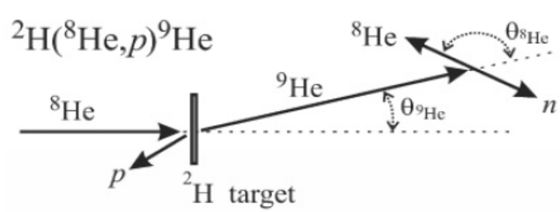
Anomalous population of ^{10}He states in reactions with ^{11}Li

P.G. Sharov,[1,2] I.A. Egorova,[3,2] and L.V. Grigorenko[1,4,5]

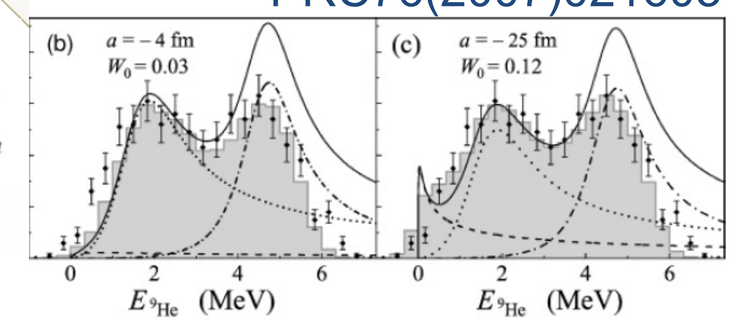


Prediction for ^{9}He states Using a calculation for the ^{10}He ground state

Missing Mass ^{9}He
PRC76(2007)021605



25MeV/u



Description of the three body continuum

- Reduction (CMS, E*, rot. inv)

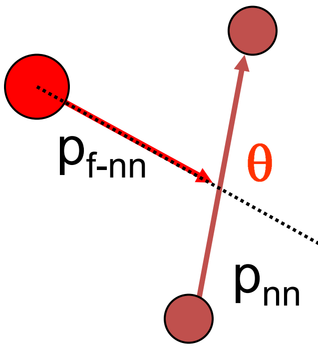
  9 variables $\rightarrow$ 2 variables **(ε, θ)**

ε is the fractional energy for a subsystem (e.g. $\varepsilon = E_{nn}/E_{nnf}$)

θ is the angle between the relative momenta (e.g. p_{nn}, $p_{f\text{-}nn}$)

- Three body correlation function (expansion in hyperspherical harm.):

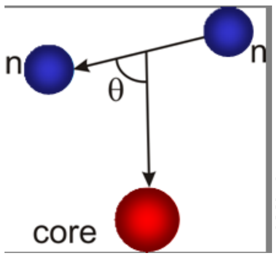
$$W(\varepsilon,\theta) \propto \frac{d^2\sigma}{d\varepsilon d\theta} \propto \sum_{\alpha,\alpha'} C^{\dagger}_{\alpha'} C_{\alpha} \mathcal{Y}^{\dagger}_{\alpha'}(\varepsilon,\theta) \mathcal{Y}_{\alpha}(\varepsilon,\theta)$$

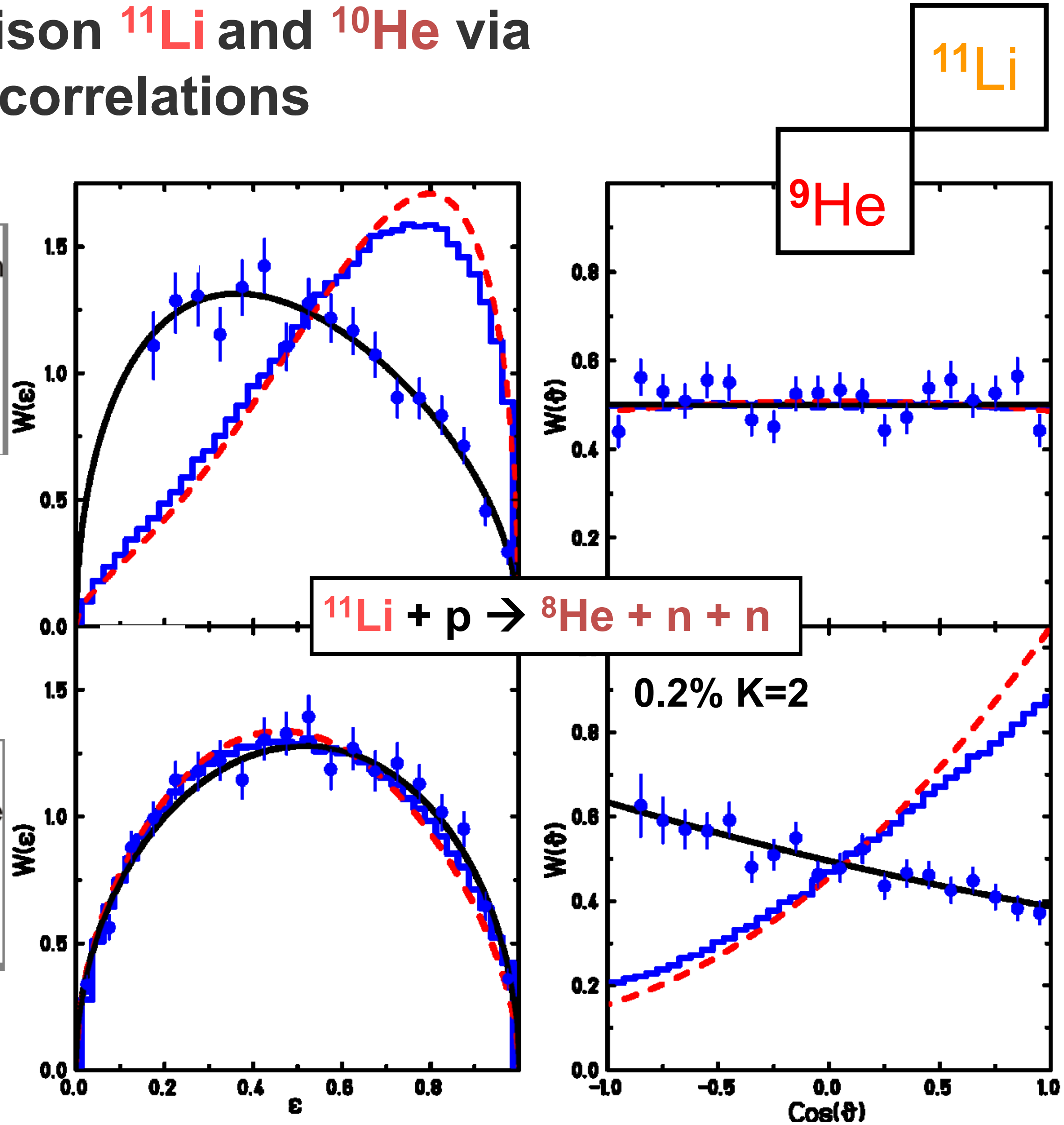


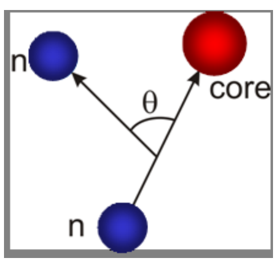
- Complex coefficients C depend on quantum numbers $\alpha = \{K, L, S, l_x, l_y\}$

L.V. Chulkov, H.S., I.Thompson, et al., NPA759 (2005) 23
M.Meister, L.V. Chulkov, H.S., et al., PRL91 (2003) 16504

Comparison ^{11}Li and ^{10}He via angular correlations







Excitation energy range 1-3 MeV (low energy region 0^+)

above 2+

- no resemblance to ^{11}Li seed angular correlations

➔ ^{10}He is structurally different

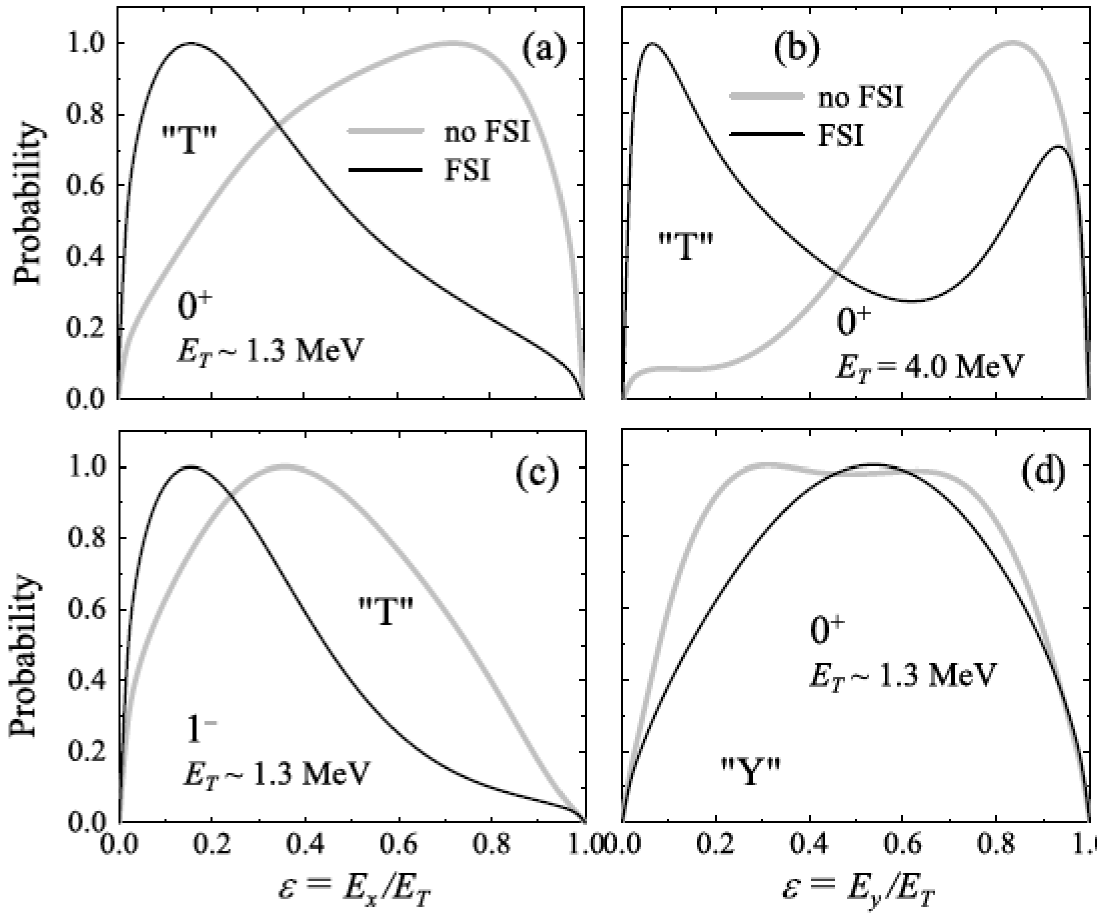
H.T. Johansson, Y. Aksyutina, Nucl. Phys. **A847** (2010) 66

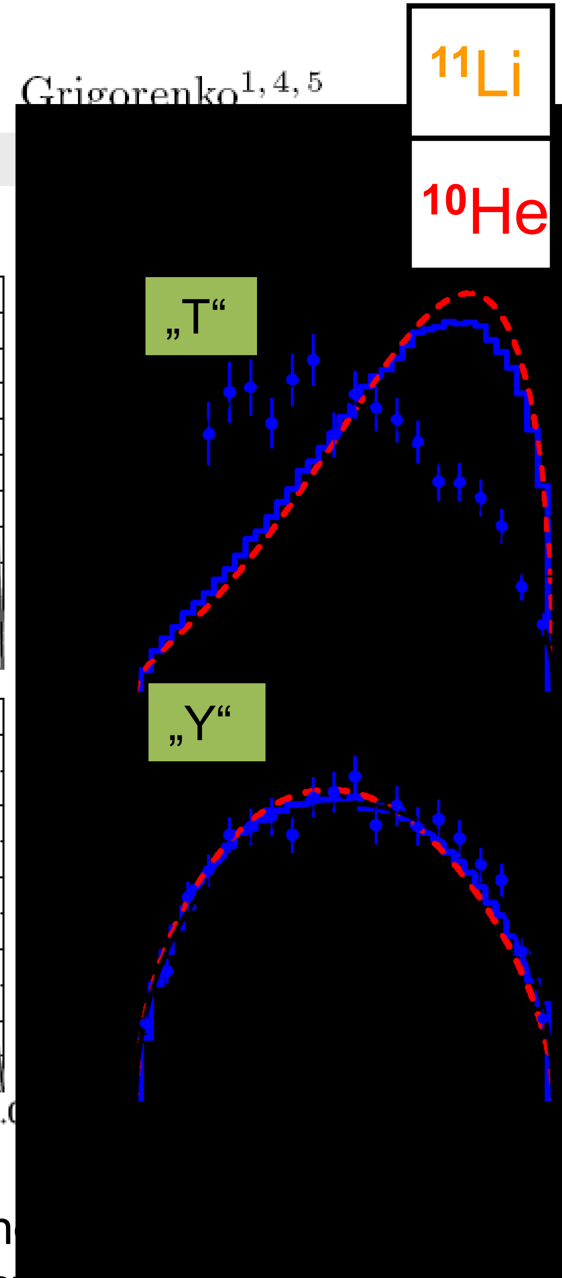
^{11}Li wave function ➔ Correlation ➔ Experimental Filter

Anomalous population of ^{10}He states in reactions with ^{11}Li

P.G. Sharov,[1,2] I.A. Egorova,[3,2] and L.V. Grigorenko[1,4,5]

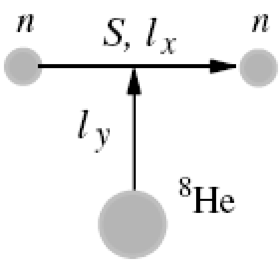
transfer



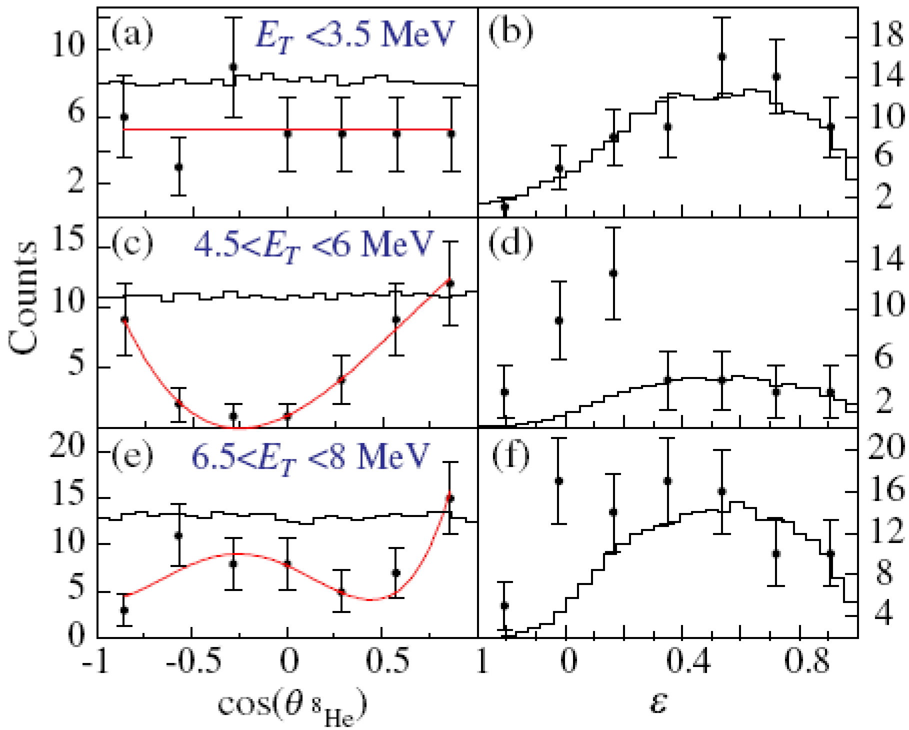


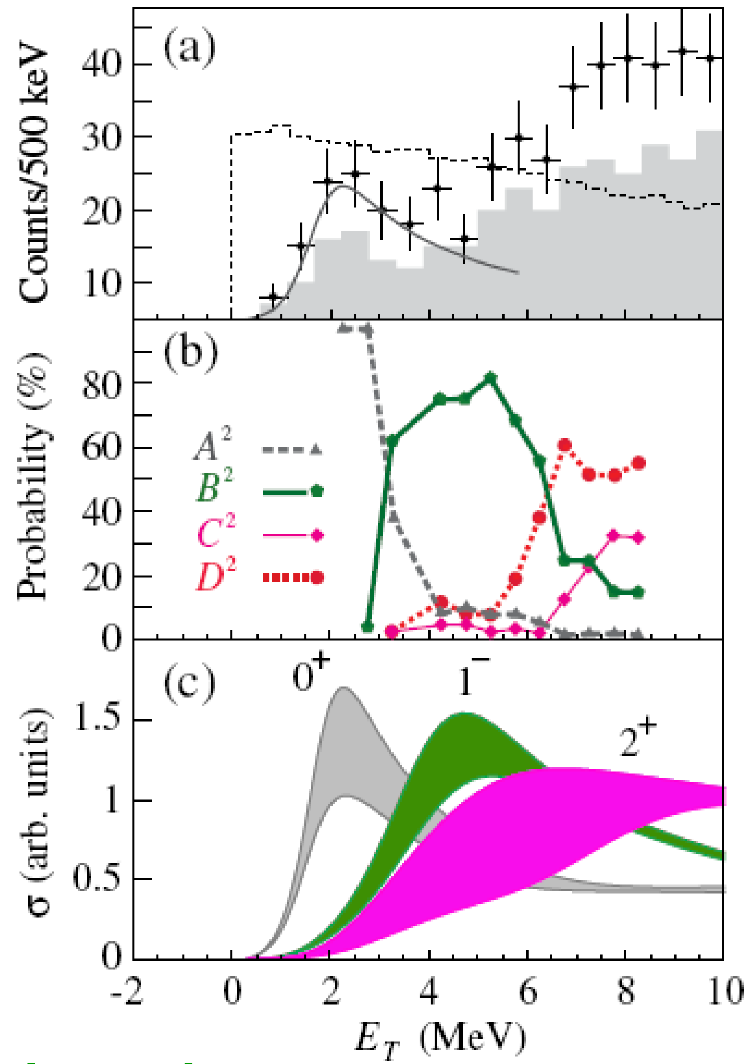
1. ^{10}He FSI modifies stron[redacted]
2. Deviations from our data …

Excitation spectrum ^{10}He* JINR/ACCULINA



S.I. Sidorchuk et al.
PRL 108(2012)202502
^{3}H(^{8}He,p)^{10}He @21.5AMeV



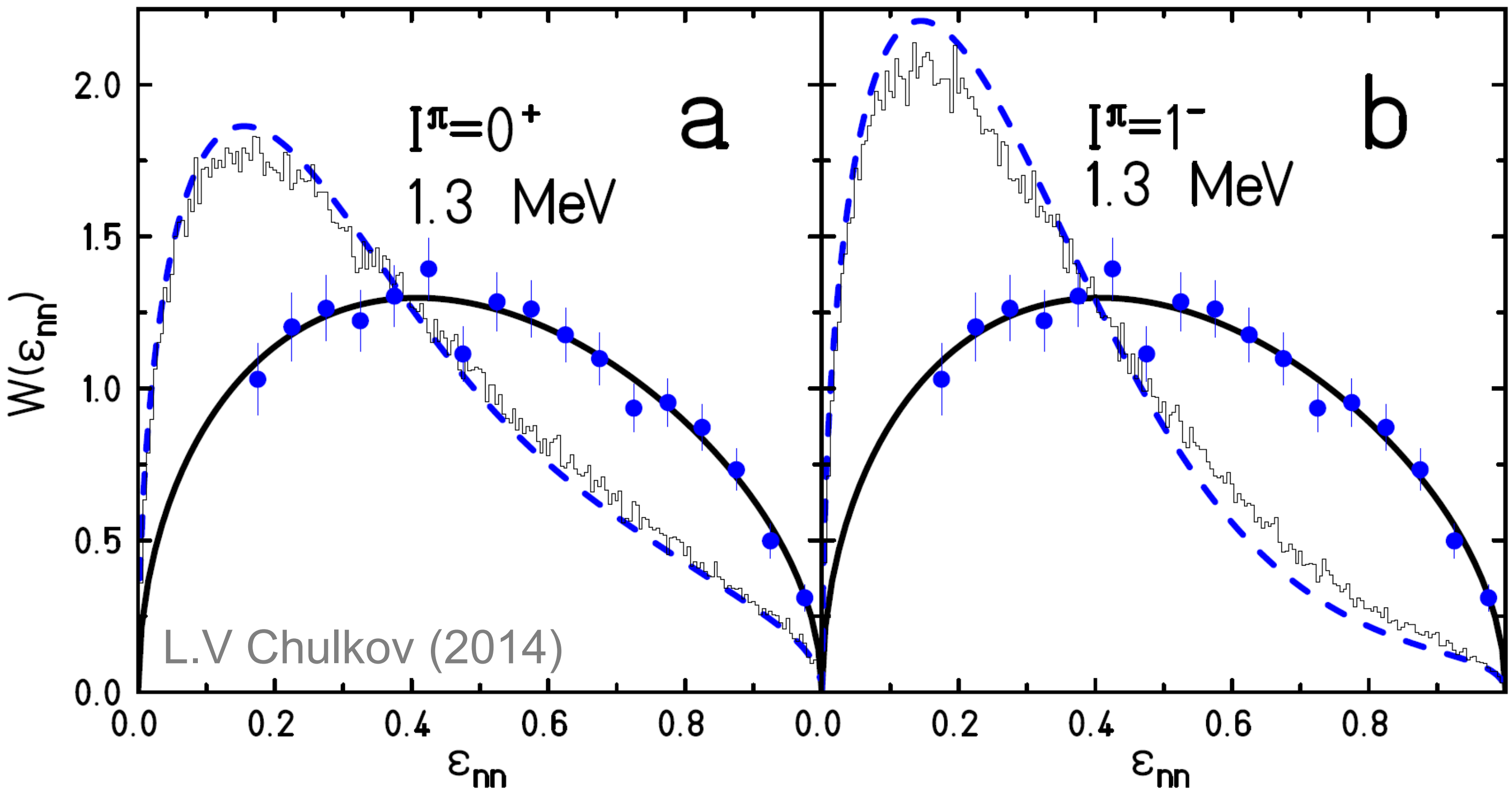


Indication for soft dipole mode

Theory <meets> Experiment ^{10}He groundstate

^{11}Li

^{10}He



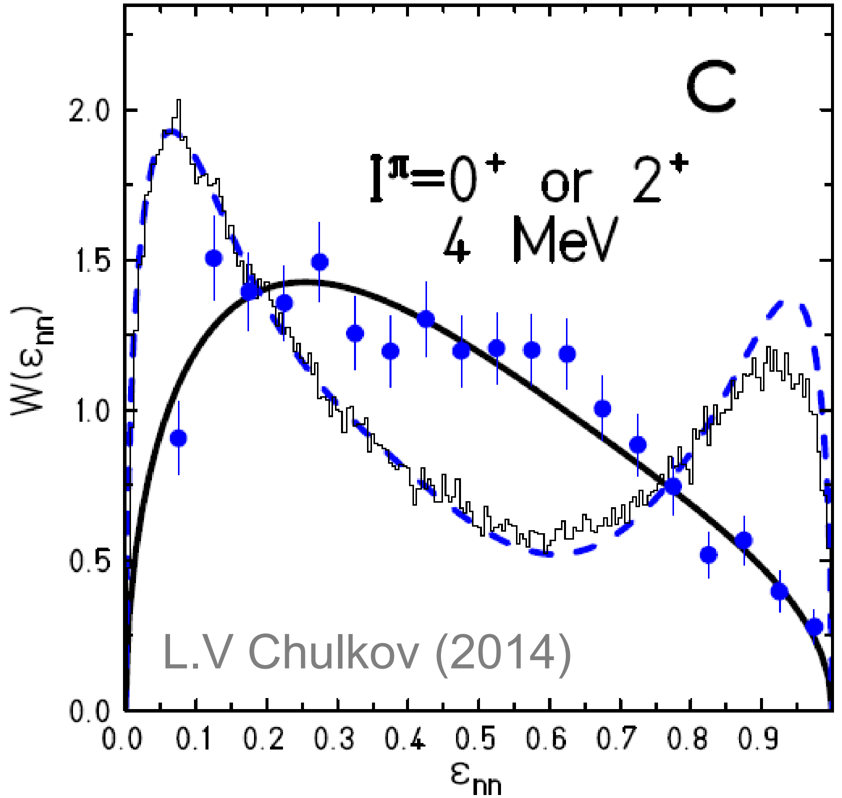
… cannot be explained by experimental effects

➔ No conclusive evidence for a low lying 1$^-$ state.
accordance to H.T.Fortune PRC88 (2013))034328

Theory <meets> Experiment ^{10}He* excited

^{11}Li

^{10}He



… as well not at higher energies

➔ Direct discussion ongoing !

Lessons learned:

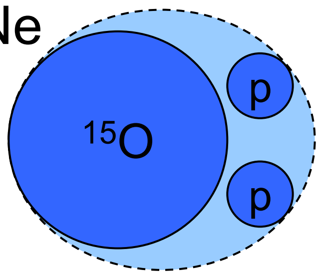
1. Initial state and final state can be separated by measuring the correlations in the system.
2. The energy spectra are strongly influenced by the initial state and the reaction mechanism.
3. Data sets are otherwise often consistent.
4. Interplay with theory – including structure and reaction theory is needed!

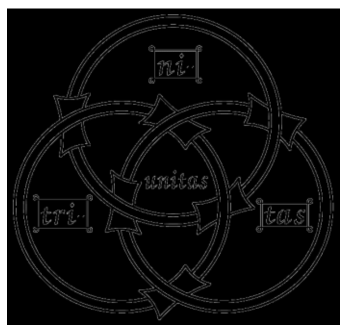
^{17}Ne a potential 2p halo

"^{17}Ne is a proton-dripline nucleus,
with strong indications of having a 2p – halo"

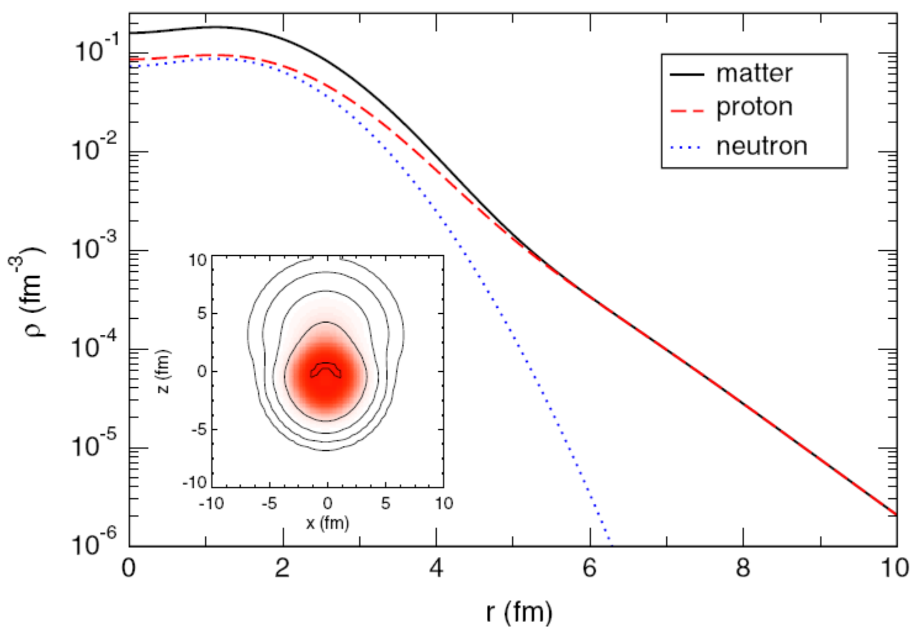
*Zhukov & Thompson, PR**C** 52 (1995) 3505*

^{17}Ne





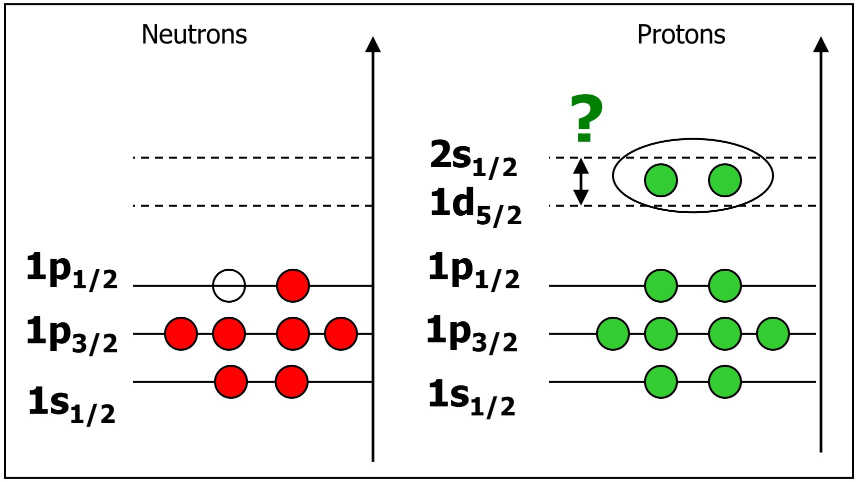
*W. Geithner, T.Neff et al, PRL **101** 252502 (2008)*

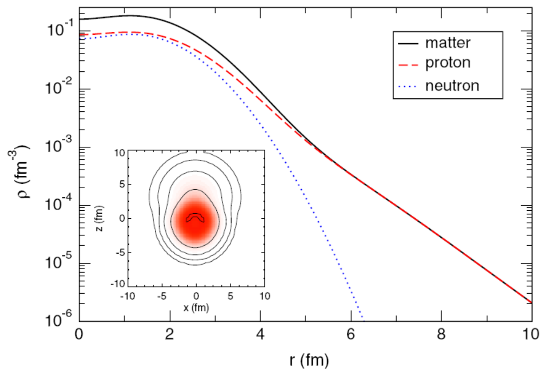


- S_{2p} = 943 keV, S_p = 1479 keV
- $T_{1/2}$ = 109.2 ms (β^+ to ^{17}F)
- Groundstate J^π=1/2$^-$; no bound exc. states

Looking for halo signatures

Large fraction of the valence protons in the classically forbidden region ?





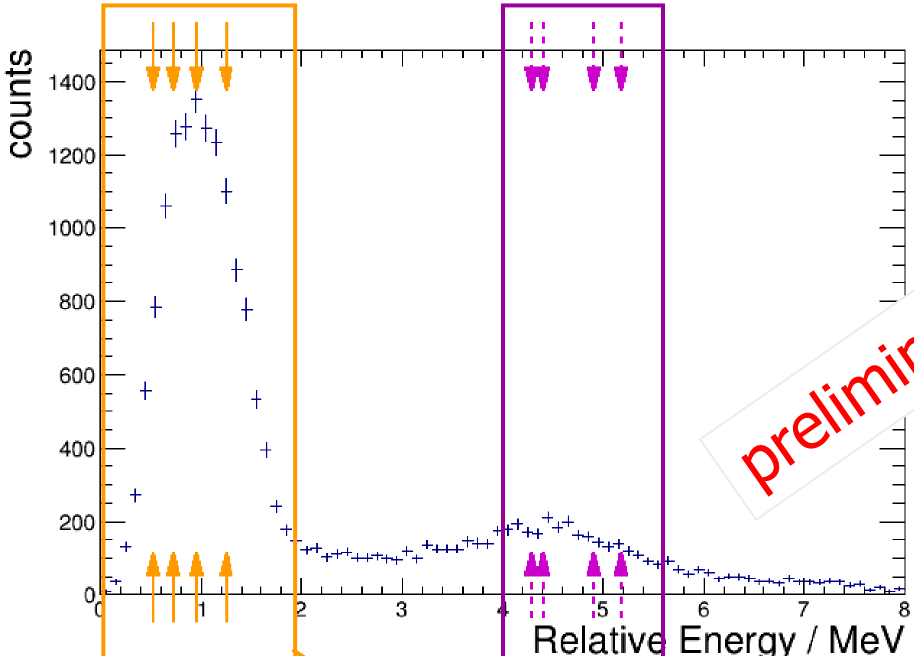
*W. Geithner, T.Neff et al, PRL **101** 252502 (2008)*

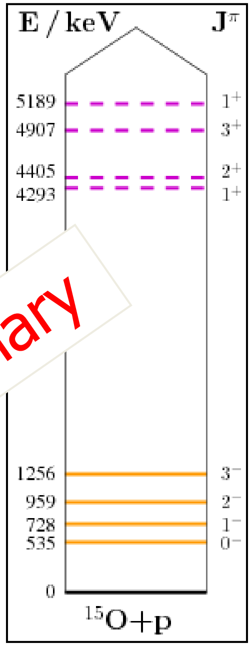
Coulomb wall in addition
to angular momentum barrier (s,d)…
➔ search for strong s^2 configuration

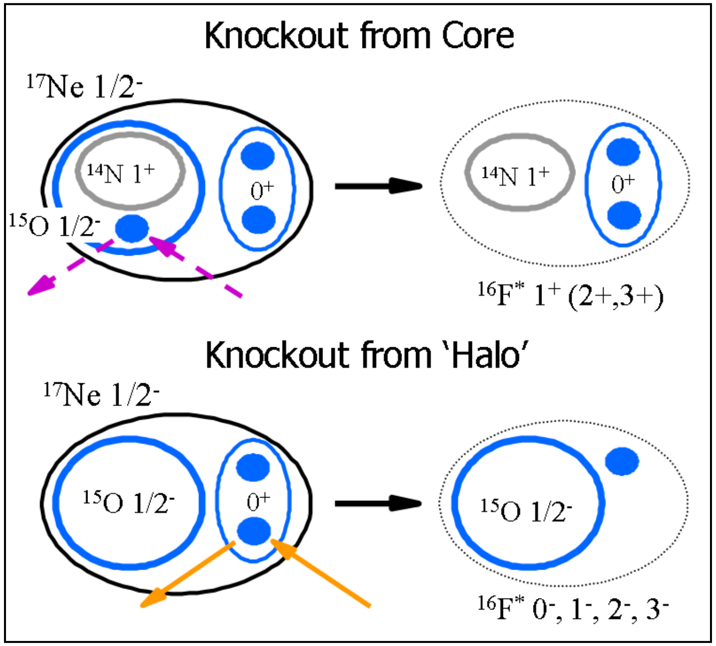
- *Grigorenko et al., PRC 71 (2005) 051604(R).*
  - 3-body cluster model: s^2 content 48%.
- *Geithner&Neff et al., PRL 101 (2008) 252502.*
  - Charge radius measurement + FMD: 42% s^2.
- *Tanaka et al., PRC 82 (2010) 044309.*
  - Reaction cross-sections: Long tail in ^{17}Ne matter density, dominant s^2 configuration.
- *Oishi et al., PRC 82 (2010) 024315.*
  - 3-body model: s^2 content 15%.

One-proton knockout from ^{17}Ne – ^{16}F relative energy Spectrum

F. Wamers







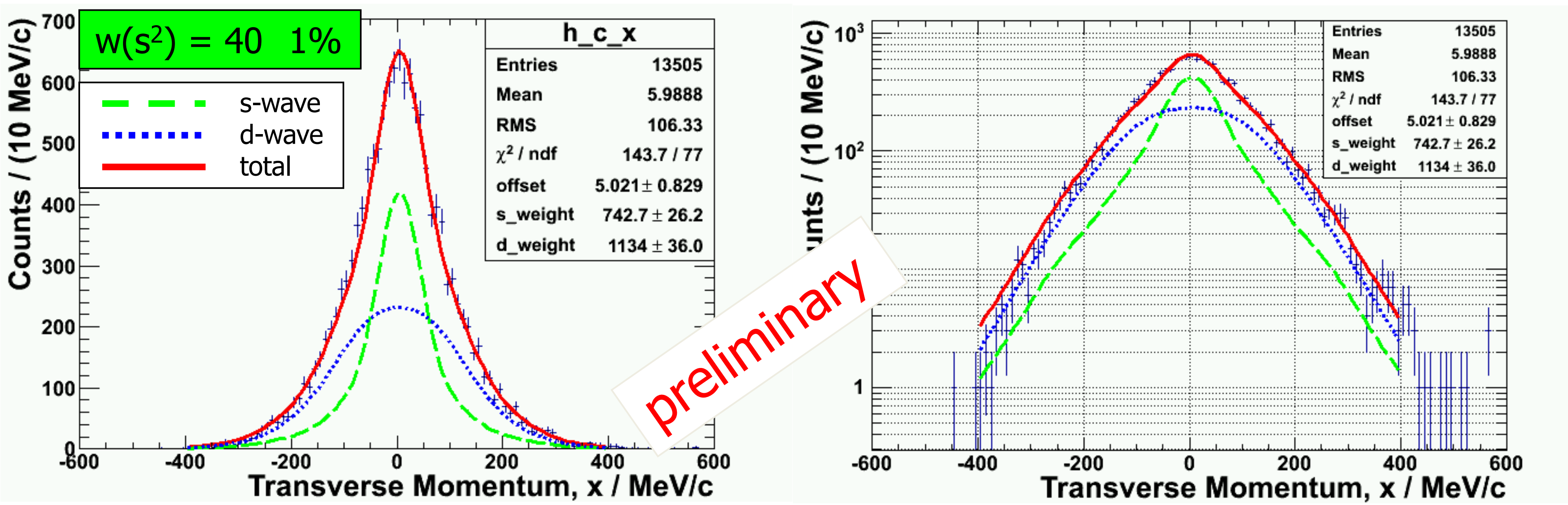
Grigorenko, PRC 71 (2005) 051604(R).

Exclusive selection of knockout from valence protons

$$\vec{p}_{proton} = - \; (^{16}F)$$

Halo-Proton Knockout from ^{17}Ne: ^{16}F (=^{15}O+p) Transverse Momentum Distribution

F. Wamers

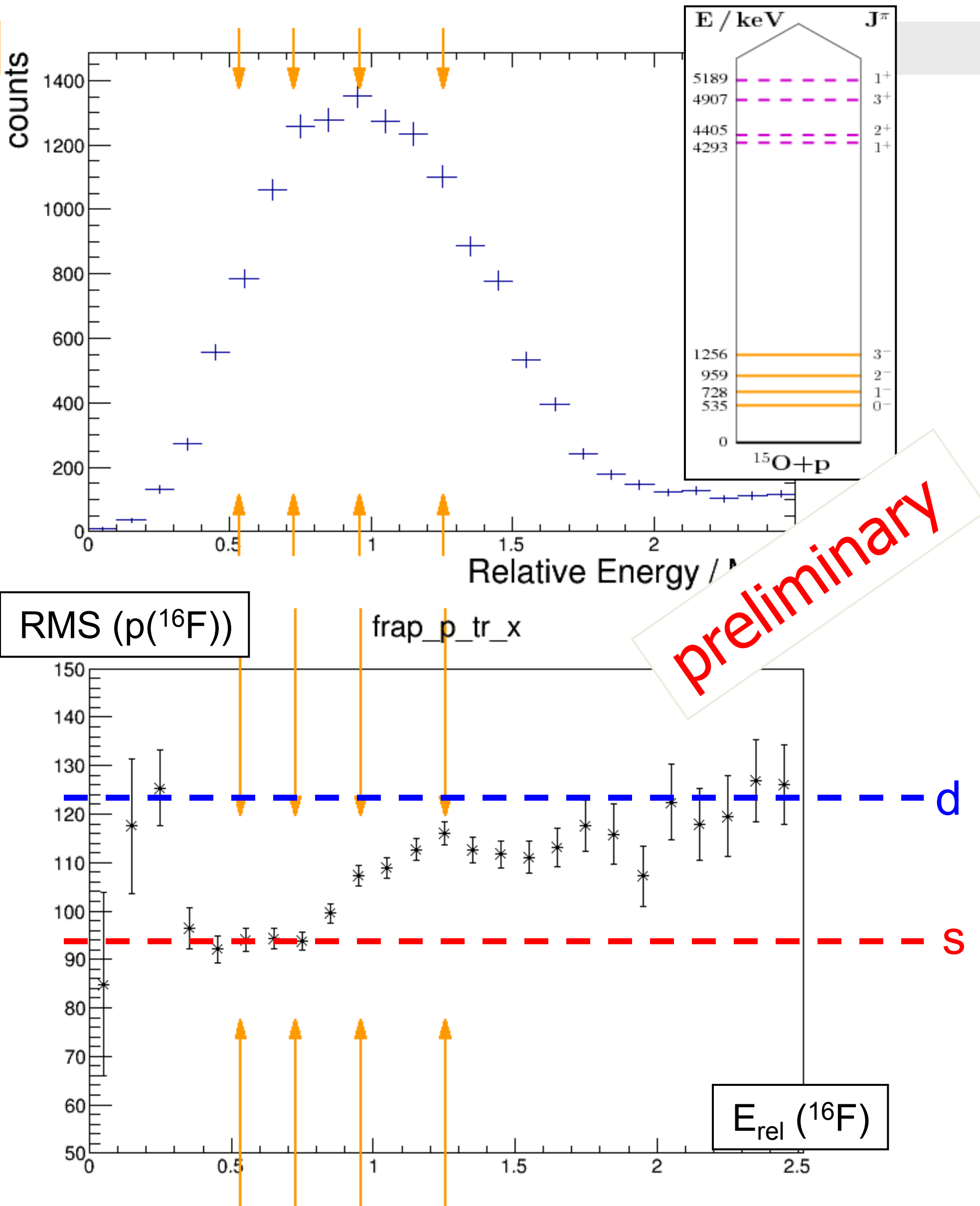


Glauber-type calculation (MOMDIS): 1s/0d single-particle p-removal from ^{16}F+p
Bertulani et al., CPC 175 (2006) 372

- s-wave c ont ents ~40% in the ^{17}Ne halo (p$_x$: 39.6 1.1 %, p$_y$: 40.4 1.1 %)
- Moderate halo character of ^{17}Ne confirmed
- Good agreement with Grigorenko et al., and with Geithner/Neff et al.

Momentum Profile (^{16}F)

F. Wamers



Eikonal Theory (MOMDIS)

RMS (s): 92.3 MeV/c
RMS (d): 123.1 MeV/c

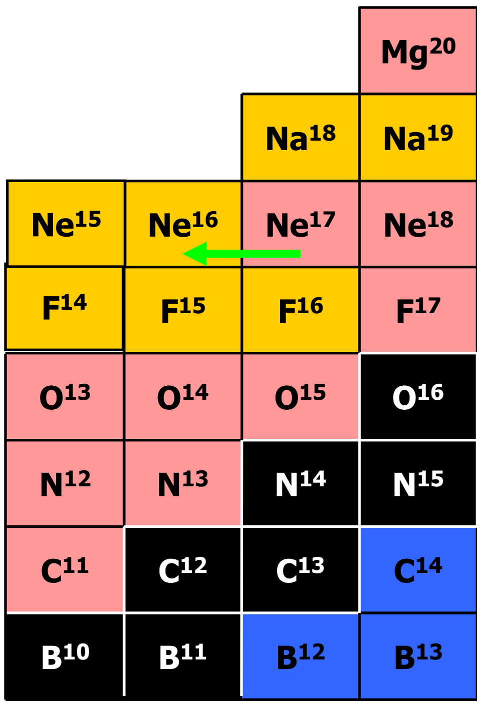
^{16}F momentum profile around1 MeV: consistent with calculation for knocked out valence p's.

- Step-like increase, s- to d-protons (^{16}F negative-parity states)

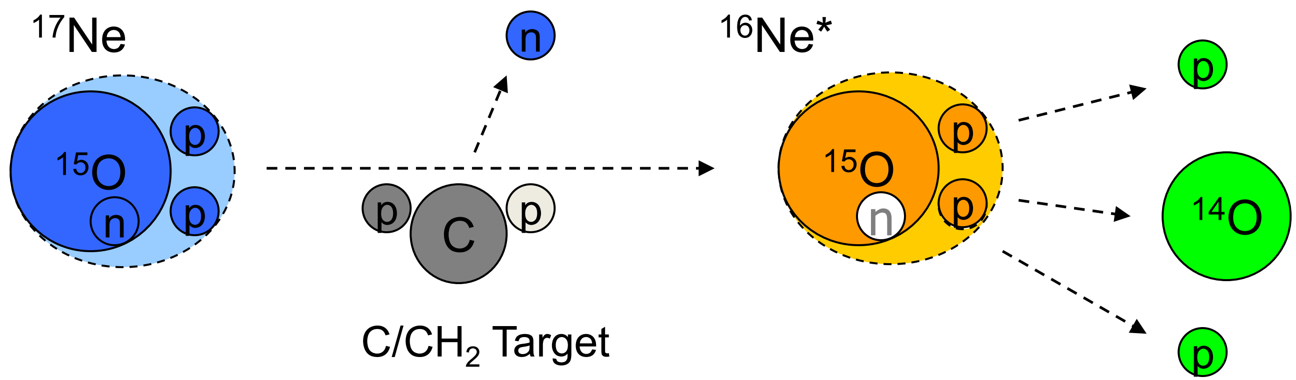
(C. Bertulani, MOMDIS)

Neutron Knockout from ^{17}Ne: Unbound ^{16}Ne

F. Wamers

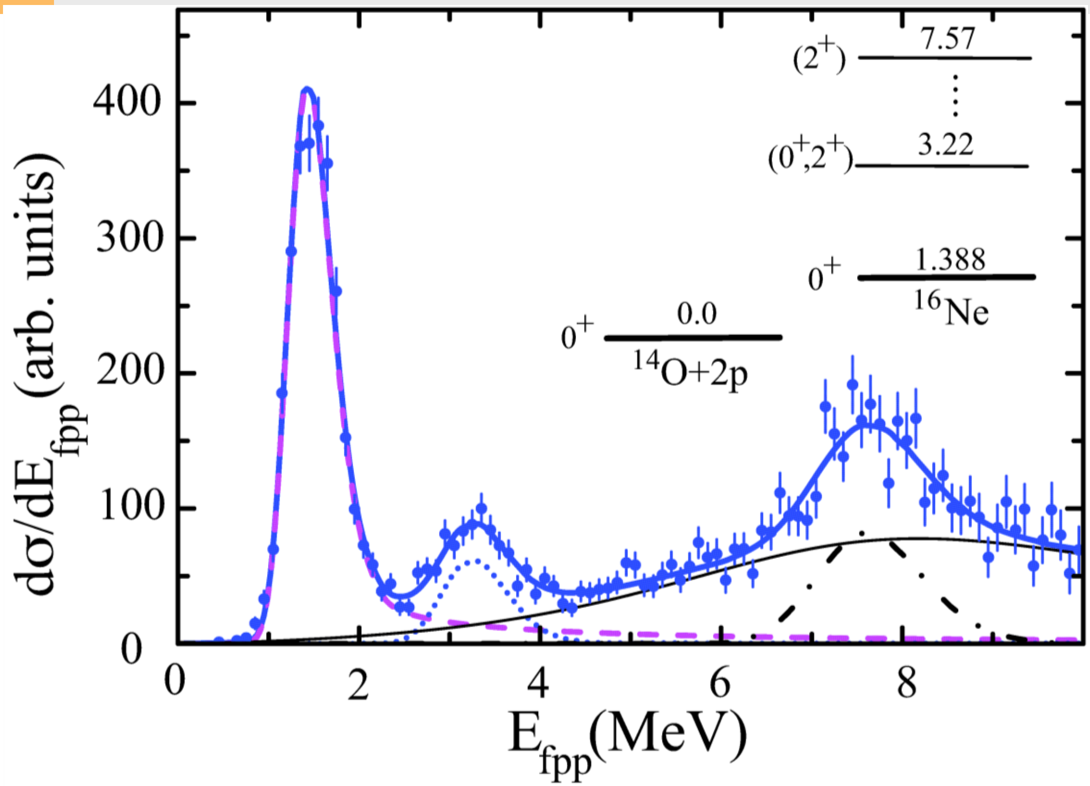


One-neutron Knockout



^{16}Ne relative energy spectrum

F. Wamers et al., PRL 112, 132502 (2014)



$I^\pi = 0^+$		$I^\pi = (0^+,2^+)$		$I^\pi = (2^+)$		
E_r	Γ	E_r	Γ	E_r	Γ	Ref.
1.388(15)	0.082(15)	3.22(5)	≤ 0.05	7.57(6)	≤ 0.1	[⋆]
1.33(8)	0.2(1)	3.02(11)	–	–	–	[11]
1.466(45)	–	–	–	–	–	[12]
1.399(24)	0.11(4)	–	–	–	–	[13]
–	–	3.5(2)	–	–	–	[14]
1.35(8)	–	–	–	7.6(2)	0.8($^{+4}_{-8}$)	[15]

[11] G.J. KeKelis et al., Phys. Rev. C 17, 1929 (1978).
[12] G.R. Burleson et al., Phys. Rev. C 22, 1180 (1980).
[13] C.J. Woodward, R.E. Tribble and D.M. Tanner, Phys. Rev. C 27, 27 (1983).
[14] K. Föhl et al., Phys. Rev. Lett. 79, 3849 (1997).
[15] I. Mukha et al., Phys. Rev. C 79, 061301(R) (2009)

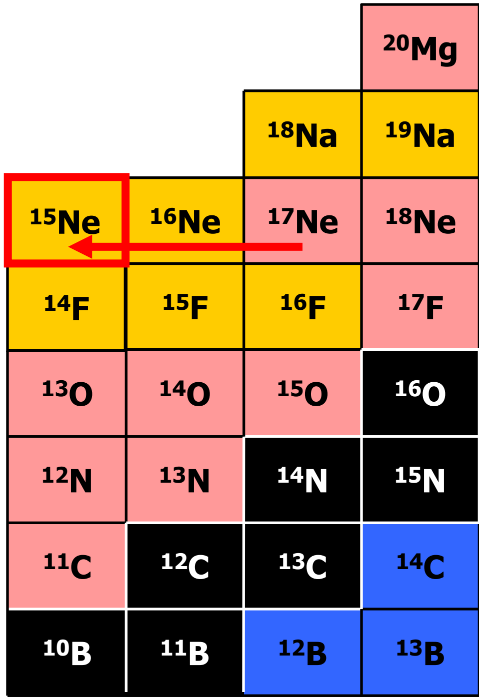
Confirmation of previous results.
Narrow width for
1st and 2nd excited state.

K.W. Brown et al,
Phys.Rev.Lett. 113, 232501 (2014)
gs. Er=1.476(20) Γ<60keV
„width puzzle“

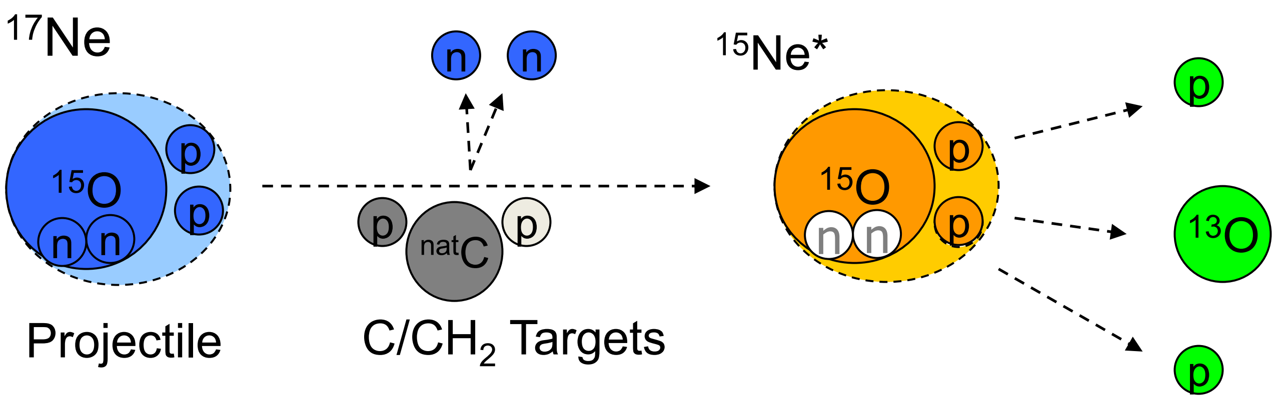
→ Talk by Ivan Mukha

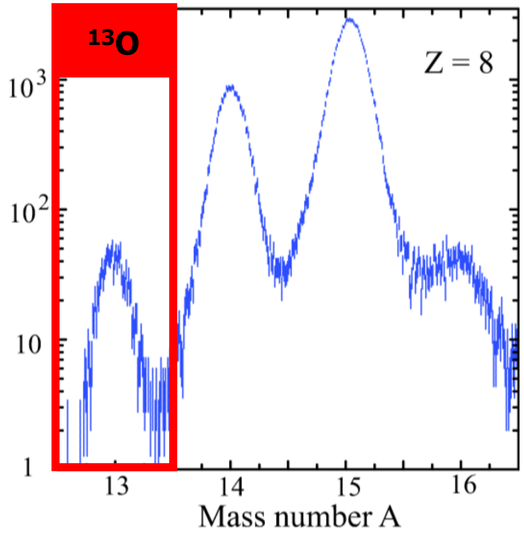
Crossing the Proton Dripline to ^{15}Ne

F. Wamers



Two-neutron Knockout





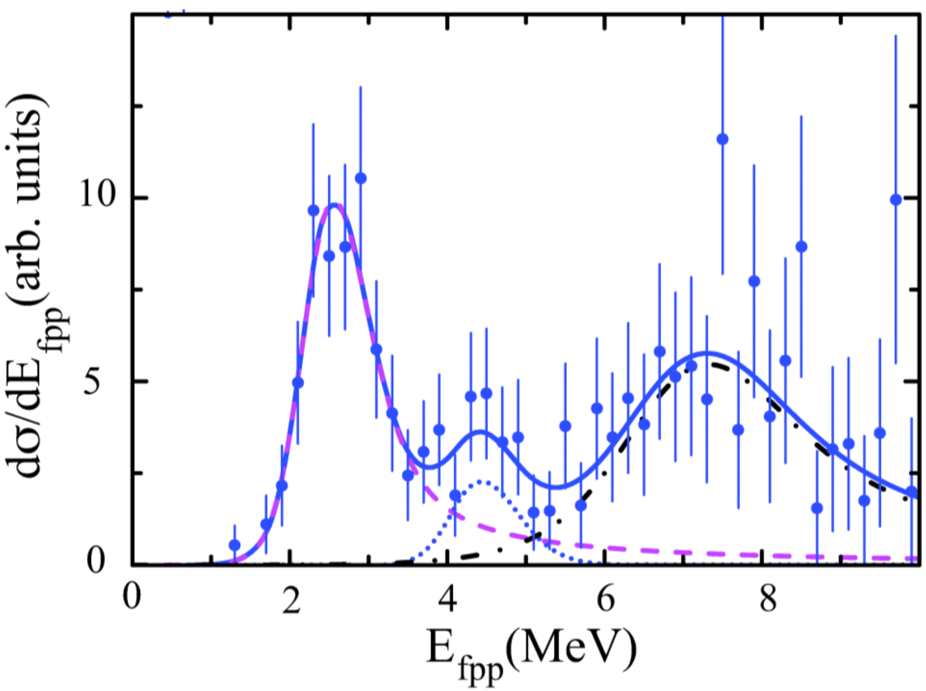
^{13}O + 2 proton FSI

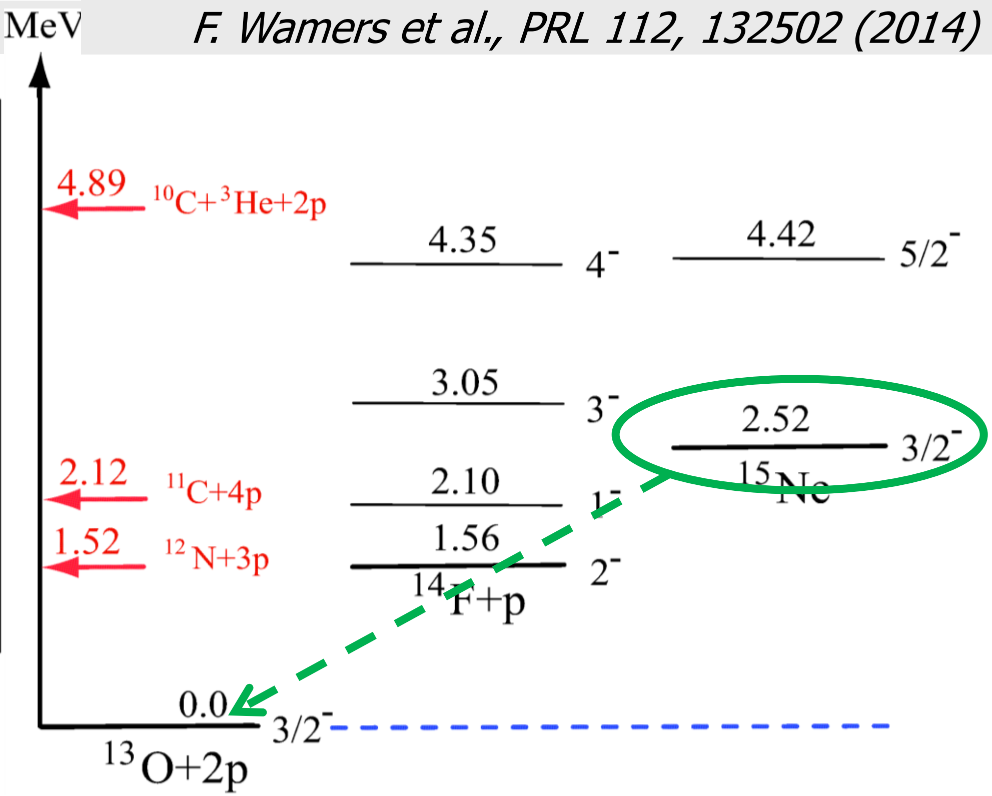
→ ^{15}Ne 3-body relative-energy spectrum

→ 3-body angular correlations

First Observation and spectroscopy of ^{15}Ne

F. Wamers et al., PRL 112, 132502 (2014)





- Groundstate
  Er = 2.522(66), Γ = 0.59(23) MeV
- 1st exc. State
  Er = 4.42(4), Γ ≤ 0.1 MeV
- (2nd) exc. States
  Er around 7-9, Γ around 2.5 MeV

- ^{15}Ne ground state unbound
  S_{2p} = 2.522(66) MeV
- Corresponds to mass excess
  ME(^{15}Ne) = 40.215(69) MeV
- Good agreement with *model prediction*:
  S_{2p} = 2.68(24) MeV

H.T. Fortune, Phys. Lett. B 718, 1342 (2013)

^{15}Ne Mass: prediction via mirror nuclei systematics

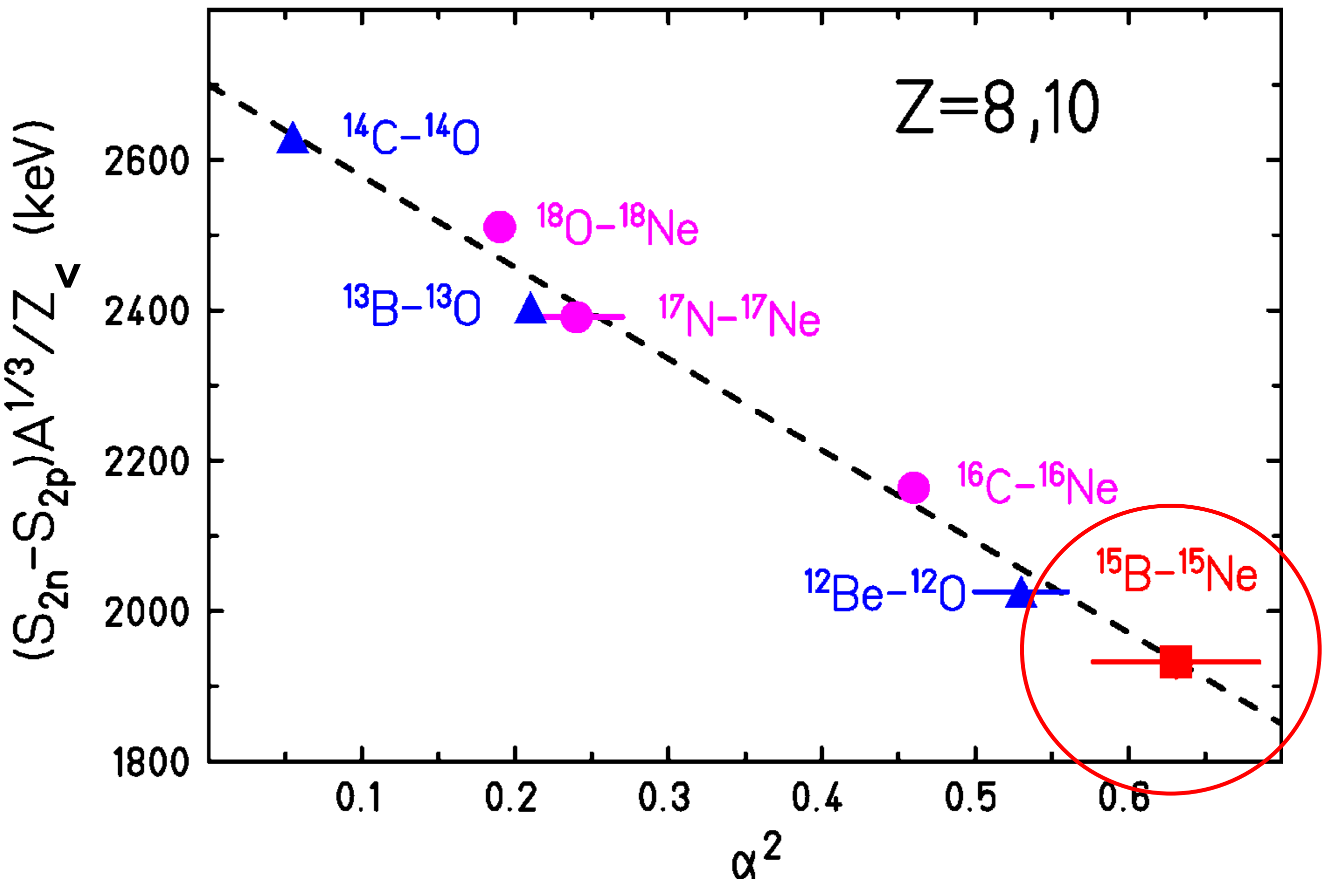
F. Wamers et al., PRL 112, 132502 (2014)

„Improved Garvey-Kelson Mass relations" (sytematics) — *J. Tian et al, Phys. Rev. **C 87**, 014313 (2013)*

→ ME(^{15}Ne) = 41.555(23) MeV, vs. ME(^{15}Ne)$_{exp}$ = 40.215(69) MeV

Model: N,Z=8,10 (sd)^2 shell nuclei: |g.s.> ~ $\alpha(1s_{1/2})^2 + \beta(0d_{5/2})^2$ | P(s²)=66(10)%, ^{16}C-^{15}**B**-^{14}Be

→ ME(^{15}Ne) = 40.37(24) MeV, vs ME(^{15}Ne)$_{exp}$ = 40.215(69) MeV

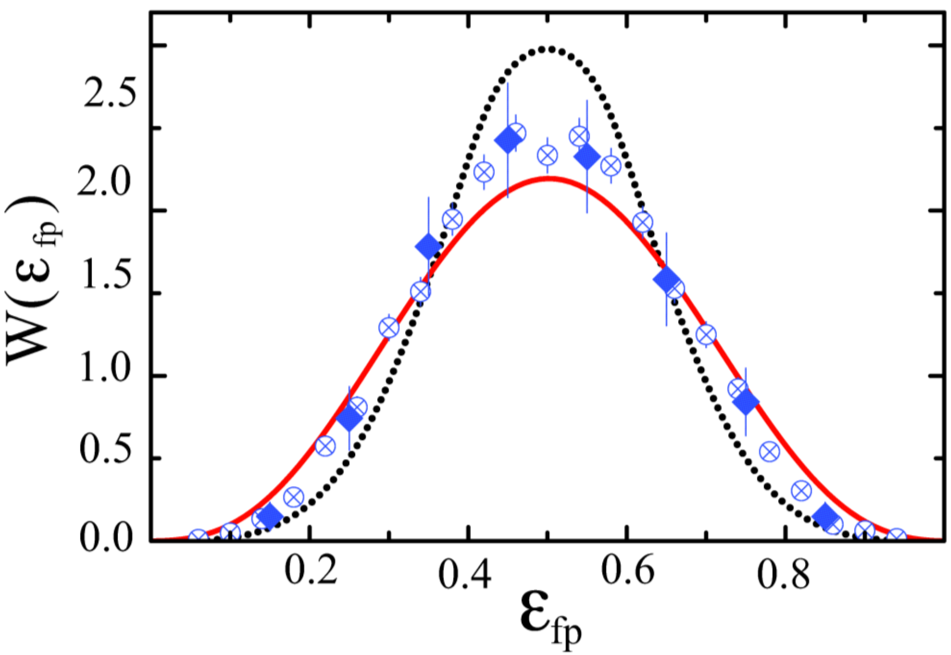


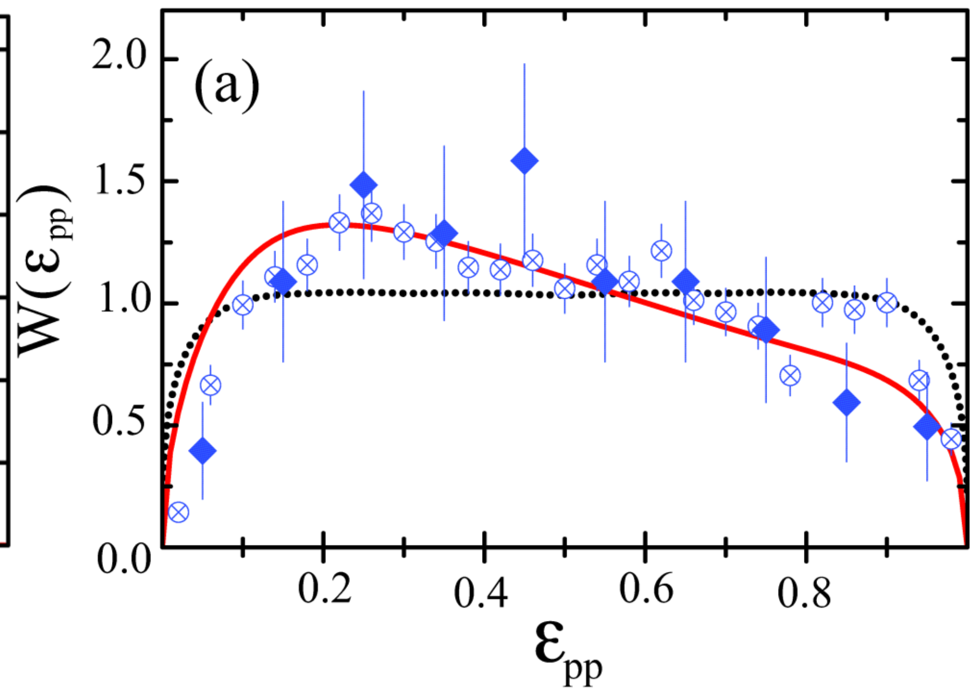
*H.T. Fortune, Phys. Lett. **B718**, 1342 (2013)*

→ 63(5) % of $(1s_{1/2})^2$ in ^{15}Ne ground state

Characterization of the decays

F. Wamers et al., PRL 112, 132502 (2014)





⊗ ^{16}Ne exp data

♦ ^{15}Ne exp data

Calculation of ^{16}Ne isotropic 3-body decay

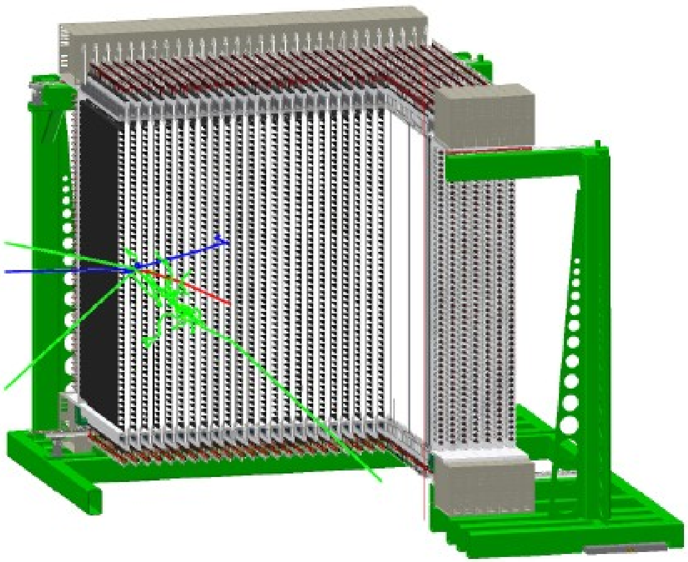
Calculation of ^{15}Ne sequential decay via the ^{14}F ground state

L.V. Grigorenko, I.G. Mukha, I.J. Thompson, and M.V. Zhukov, Phys. Rev. Lett. 88, 042502 (2002).

^{15}Ne decay shows a genuine 3-body character, despite intermediate states in ^{14}F.

Summary

- Nuclear systems at the extremes cleanly produced and analyzed
- Largest neutron/proton asymmetries
- Rôle of seed nuclei discussed, correlations analyzed
- Frontier line: Oxygen isotopes (^{26}O)



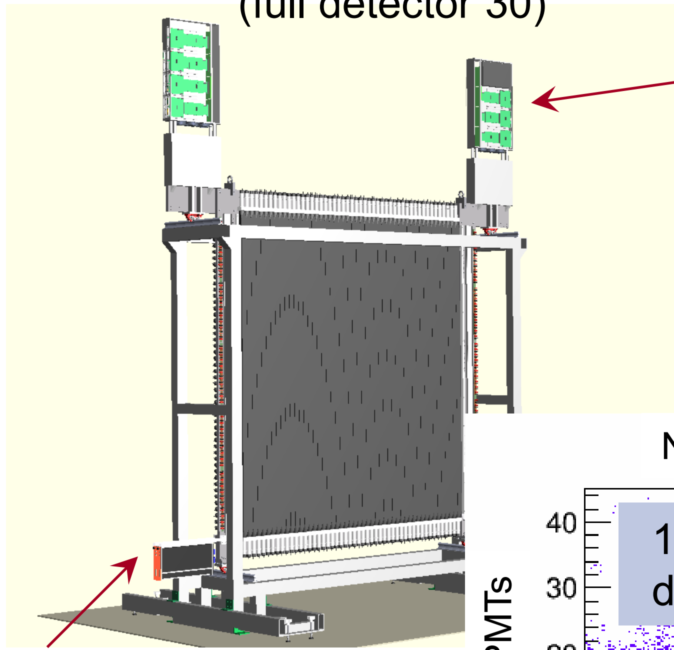
- New Detectors ➔ better sensitivity
- New facilities ➔ higher intensity

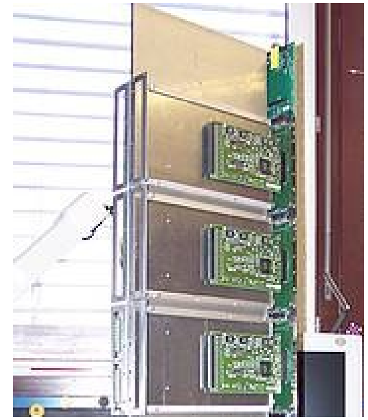
➔ f + n + n + n + n (e.g. ^{7}H) in reach

Next Step: Novel neutron detector for R³B - NeuLAND demonstrator performance

6 Double planes in test (August and October 2014)

(full detector 30)





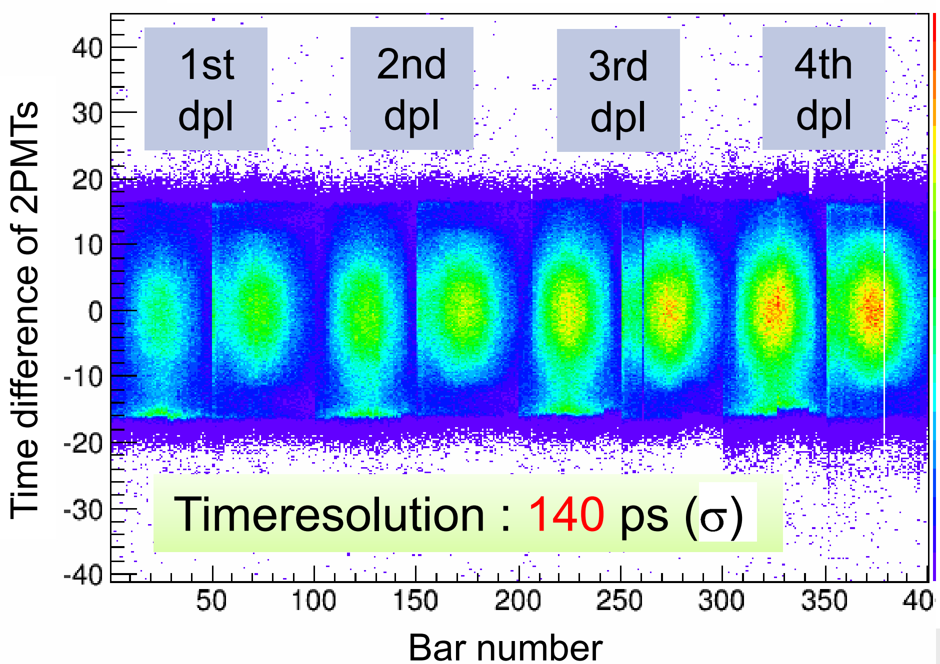
FPGA TDC based

Readout Electronics

HV system

PNPI: Site Acceptance Test week before X-Mas 2014

Neutron hit patterns in 4 double planes



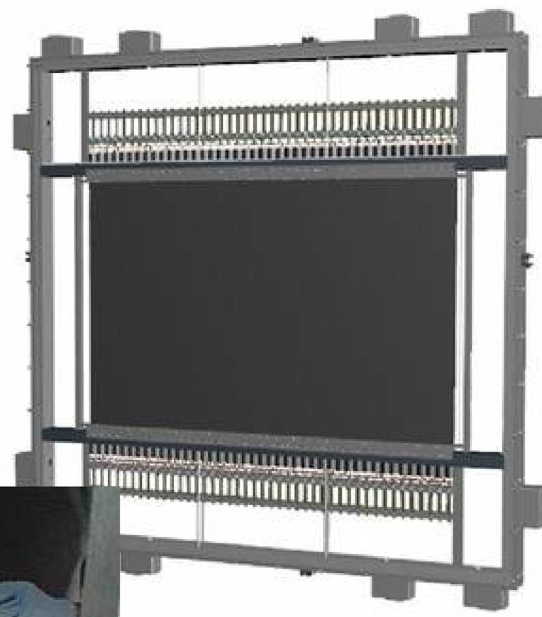
Improve multi neutron detection efficiency down to low energy

Next step:
R³B Time-of-flight detector prototyping

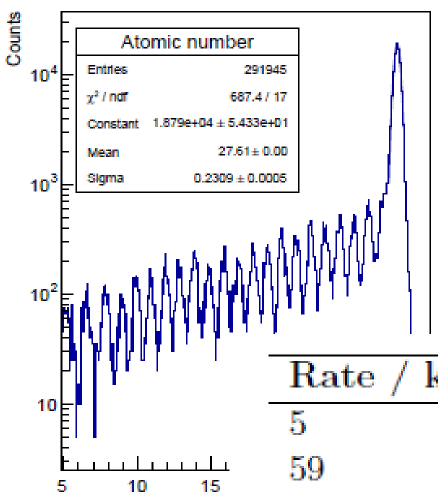
Performance goals:

- Time resolution σ_t/t = 2E-4
  (⇔ σ_t =20 ps for 20 m flight path at 1 *A*GeV)
- Energy resolution σ_E /E = 1%
- High-counting rate capabilities (~1 MHz)
- Large dynamic range (up to Pb-U).
- FPGA based TDC readout (ΔE via ToT Techniques)

Detector layout



375kHz



Excellent time and energy resolution at high rates

Rate / kHz	σ_t / ps	σ_t^{det} / ps
5	41	14
59	41	14
375	45	16
1000	64	23

Prototype studies @ Cave-C 08/2014 10/2014

Next Step: The new FAIR facility

Intensity increase 3-4 orders of magnitude !

The Halo Collaboration

Y. Aksyutina, T. Aumann, H. Álvarez-Pol, T. LeBleis, E. Benjamim, J. Benlliure, K. Boretzky, M.J.G. Borge, C. Caesar, M.Caamaño, E. Casarejos, L.V. Chulkov, D. Cortina-Gil, K. Epinger, Th. W. Elze, H. Emling, C. Forssén, H. Geissel, R. Gernhäuser, M. Hellström, J. Holeczek, K.L. Jones, H. Johansson, B. Jonson, J.V. Kratz, R. Krücken, R. Kulessa, C.Langer, M. Lantz, Y. Leifels, A. Lindahl, K. Mahata, M. Meister, P. Maierbeck, K. Markenroth, G. Münzenberg, T. Nilsson, C. Nociforo, G. Nyman, R. Palit, M. Pantea, S. Paschalis, D.Pérez, M. Pfützner, V. Pribora, A. Prochazka, R. Reifarth, A. Richter, K. Riisager, C. Rodríguez, C. Scheidenberger, G. Schrieder, H. Simon, J. Stroth, K. Sümmerer, O. Tengblad, H. Weick, and M.V. Zhukov.

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Universytet Jagiellonski, Kraków, Poland;
University Santiago de Compostela, Spain;
Technische Universität, Darmstadt, Germany; Technische Universität, München, Germany;
CERN, Genève, Switzerland; Aarhus Universitet, Aarhus, Denmark

The R3B Collaboration

Aksouh, Farouk; Al-Khalili, Jim; Algora, Alejandro; Alkhasov, Georgij; Altstadt, Sebastian; Alvarez, Hector; Atar, Leyla; Audouin, Laurent; Aumann, Thomas; Pellereau, Eric; Martin, Julie-Fiona; Gorbinet, Thomas; Seddon, Dave; Kogimtzis, Mos; Avdeichikov, Vladimir; Barton, Charles; Bayram, Murat; Belier, Gilbert; Bemmerer, Daniel; Michael Bendel; Benlliure, Jose; Bertulani, Carlos; Bhattacharya, Sudeb; Bhattacharya, Chandana; Le Bleis, Tudi; Boilley, David; Boretzky, Konstanze; Borge, Maria Jose; Botvina, Alexander; Boudard, Alain; Boutoux, Guillaume; Boehmer, Michael; Caesar, Christoph; Calvino, Francisco; Casarejos, Enrique; Catford, Wilton; Cederkall, Joakim; Cederwall, Bo; Chapman, Robert; Alexandre Charpy; Chartier, Marielle; Chatillon, Audrey; Chen, Ruofu; Christophe, Mayri; Chulkov, Leonid; Coleman-Smith, Patrick; Cortina, Dolores; Crespo, Raquel; Csatlos, Margit; Cullen, David; Czech, Bronislaw; Danilin, Boris; Davinson, Tom; Paloma Diaz; Dillmann, Iris; Fernandez Dominguez, Beatriz; Ducret, Jean-Eric; Duran, Ignacio; Egelhof, Peter; Elekes, Zoltan; Emling, Hans; Enders, Joachim; Eremin, Vladimir; Ershov, Sergey N.; Ershova, Olga; Eronen, Simo; Estrade, Alfredo; Faestermann, Thomas; Fedorov, Dmitri; Feldmeier, Hans; Le Fevre, Arnaud; Fomichev, Andrey; Forssen, Christian; Freeman, Sean; Freer, Martin; Friese, Juergen; Fynbo, Hans; Gacsi, Zoltan; Garrido, Eduardo; Gasparic, Igor; Gastineau, Bernard; Geissel, Hans; Gelletly, William; Genolini, B.; Gerl, Juergen; Gernhaeuser, Roman; Golovkov, Mikhail; Golubev, Pavel; Grant, Alan; Grigorenko, Leonid; Grosse, Eckart; Gulyas, Janos; Goebel, Kathrin; Gorska, Magdalena; Haas, Oliver Sebastian; Haiduc, Maria; Hasegan, Dumitru; Heftrich, Tanja; Heil, Michael; Heine, Marcel; Heinz, Andreas; Ana Henriques; Hoffmann, Jan; Holl, Matthias; Hunyadi, Matyas; Ignatov, Alexander; Ignatyuk, Anatoly V.; Ilie, Cherciu Madalin; Isaak, Johann; Isaksson, Lennart; Jakobsson, Bo; Jensen, Aksel; Johansen, Jacob; Johansson, Hakan; Johnson, Ron; Jonson, Bjoern; Junghans, Arnd; Jurado, Beatriz; Jaehrling, Simon; Kailas, S.; Kalantar, Nasser; Kalliopuska, Juha; Kanungo, Rituparna; Kelic-Heil, Aleksandra; Kezzar, Khalid; Khanzadeev, Alexei; Kissel, Robert; Kisselev, Oleg; Klimkiewicz, Adam; Kmiecik, Maria; Koerper, Daniel; Kojouharov, Ivan; Korsheninnikov, Alexei; Korten, Wolfram; Krasznahorkay, Attila; Kratz, Jens Volker; Kresan, Dima; Anatoli Krivchitch; Kroell, Thorsten; Krupko, Sergey; Kruecken, Reiner; Kulessa, Reinhard; Kurz, Nikolaus; Kuzmin, Eugenii; Labiche, Marc; Langanke, Karl-Heinz; Langer, Christoph; Lapoux, Valerie; Larsson, Kristian; Laurent, Benoit; Lazarus, Ian; Le, Xuan Chung; Leifels, Yvonne; Lemmon, Roy; Lenske, Horst; Lepine-Szily, Alinka; Leray, Sylvie; Letts, Simon; Li, Songlin; Liang, Xiaoying; Lindberg, Simon; Lindsay, Scott; Litvinov, Yuri; Lukasik, Jerzy; Loeher, Bastian; Mahata, Kripamay; Maj, Adam; Marganiec, Justyna; Meister, Mikael; Mittig, Wolfgang; Movsesyan, Alina; Mutterer, Manfred; Muentz, Christian; Nacher, Enrique; Najafi, Ali; Nakamura, Takashi; Neff, Thomas; Nilsson, Thomas; Nociforo, Chiara; Nolan, Paul; Nolen, Jerry; Nyman, Goran; Obertelli, Alexandre; Obradors, Diego; Ogloblin, Aleksey; Oi, Makito; Palit, Rudrajyoti; Panin, Valerii; Paradela, Carlos; Paschalis, Stefanos; Pawlowski, Piotr; Petri, Marina; Pietralla, Norbert; Pietras, Ben; Pietri, Stephane; Plag, Ralf; Podolyak, Zsolt; Pollacco, Emanuel; Potlog, Mihai; Datta Pramanik, Ushasi; Prasad, Rajeshwari; Fraile Prieto, Luis Mario; Pucknell, Vic; Galaviz -Redondo, Daniel; Regan, Patrick; Reifarth, Rene; Reinhardt, Tobias; Reiter, Peter; Rejmund, Fanny; Ricciardi, Maria Valentina; Richter, Achim; Rigollet, Catherine; Riisager, Karsten; Rodin, Alexander; Rossi, Dominic; Roussel-Chomaz, Patricia; Gonzalez Rozas, Yago; Rubio, Berta; Roeder, Marko; Saito, Takehiko; Salsac, Marie-Delphine; Rodriguez Sanchez, Jose Luis; Santosh, Chakraborty; Savajols, Herve; Savran, Deniz; Scheit, Heiko; Schindler, Fabia; Schmidt, Karl-Heinz; Schmitt, Christelle; Schnorrenberger, Linda; Schrieder, Gerhard; Schrock, Philipp; Sharma, Manoj Kumar; Sherrill, Bradley; Shrivastava, Aradhana; Shulgina, Natalia; Sidorchuk, Sergey; Silva, Joel; Simenel, Cedric; Simon, Haik; Simpson, John; Singh, Pushpendra Pal; Sonnabend, Kerstin; Spohr, Klaus; Stanoiu, Mihai; Stevenson, Paul; Strachan, Jon; Streicher, Brano; Stroth, Joachim; Syndikus, Ina; Suemmerer, Klaus; Taieb, Julien; Tain, Jose L.; Tanihata, Isao; Tashenov, Stanislav; Tassan-Got, Laurent; Tengblad, Olof; Teubig, Pamela; Thies, Ronja; Togano, Yasuhiro; Tostevin, Jeffrey A.; Trautmann, Wolfgang; Tuboltsev, Yuri; Turrion, Manuela; Typel, Stefan; Udias-Moinelo, Jose; Vaagen, Jan; Velho, Paulo; Verbitskaya, Elena; Veselsky, Martin; Wagner, Andreas; Walus, Wladyslaw; Wamers, Felix; Weick, Helmut; Wimmer, Christine; Winfield, John; Winkler, Martin; Woods, Phil; Xu, Hushan; Yakorev, Dmitry; Zegers, Remco; Zhang, Yu-Hu; Zhukov, Mikhail; Zieblinski, Miroslaw; Zilges, Andreas;