Perspectives on SFB RIKEN program

TECHNISCHE UNIVERSITÄT DARMSTADT

Thomas Aumann

July 4th 2018

SFB workshop Mainz

SFB 1245

Present SFB projects at RIKEN with R3 NeuLAND at RIBF

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- 4 double planes + electronics packed into boxes
- Shipping to RIKEN Nishina Center (Japan) starts on 12.01.2015
- Arrival in SAMURAI area on 27.01.2015

DFG SFB 1245

GSI

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NeuLAND + NEBULA setup

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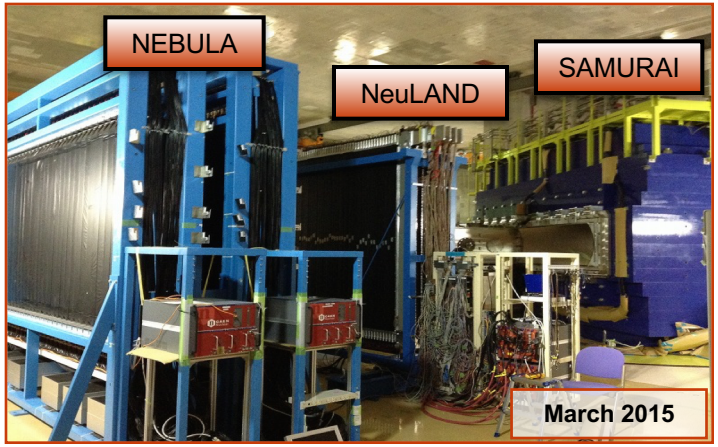
NEBULA

- Modular plastic scintillator-based neutron detector
- 4 modules containing each:
- 12 VETO paddles (32cm x 1cm x 190cm)
- 2 x 30 NEUT paddles (12cm x 12cm x 180cm)
- All paddles read out with 2 PMTs
- Only vertical paddles
- 1n efficiency: ~ 40% (2 modules; total 48 cm)

NeuLAND Demonstrator @ SAMURAI

- NeuLAND placed in front of NEBULA → better time resolution
- NEBULA VETO in front of NeuLAND



→ improved invariant-mass resolution

→ 4n detection possible for the first time

Summary NeuLAND at RIKEN

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- NeuLAND@SAMURAI allowed unique physics program
  - **4n detection possible for the first time**
  - **12** Experiments in **71 days** of beamtime
- 12 double-planes ready for FAIR phase-0 at GSI from 2018

Structure of n-rich nulcei

- "Soft" dipole excitation of ^{6,8}He
- Spectroscopy of *n*-rich Ca isotopes
- Dipole response of *n*-rich Ca isotopes
- Coulomb break-up of deformed halo nucleus ^{31}Ne
- Structure around the *N*=16 shell closure
- EoS: Heavy-ion collision in Sπrit TPC
- Calibration measurement for 1*n* detection efficiency

Multi-neutron decays beyond the dripline

- Search for a resonant tetraneutron system
  - ^{8}He(p,pα)^{4}n
  - ^{8}He(p,2p)^{7}H
- Spectroscopy of ^{27,28}O
- Lifetime of ^{26}O(g.s.)

Side products

- ^{6}He(p,pα)^{2}n
- Unbound F isotopes

NeuLAND shipped back to GSI
What next ? RIBF still the most powerful RI beam facility

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- Packing of NeuLAND + electronics August/September 2017
- Flight to Frankfurt mid-September
- Arrival at GSI on 21.09.2017

Accepted proposal: Dipole response of the drip-line nuclei ^{24}O and ^{29}F

(Proposal for NP1512-SAMURAI37)

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Thomas Aumann

&

Takashi Nakamura

December 7th 2017

18th Nuclear Physics PAC Meeting

RIBF RIKEN

Proposal

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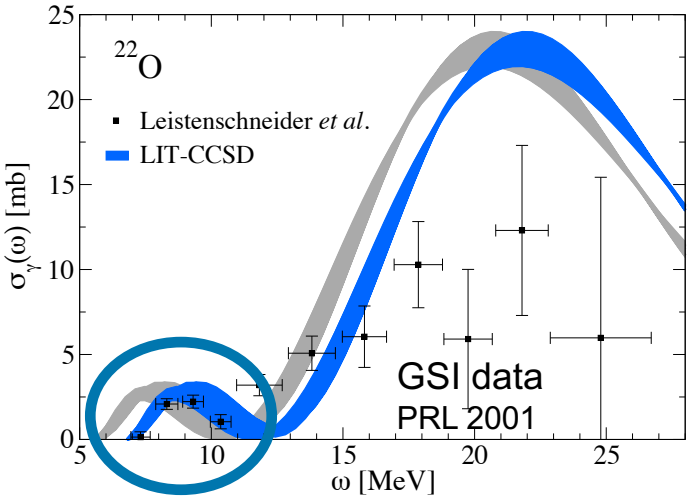
- **Electromagnetic excitation and neutron decay of the drip line nuclei ^{24}O and ^{29}F**
- **Aim: Extraction of low-energy B(E1) strength**
  direct (model-independent) comparison to ab initio theory
- **^{24}O**: New ab-initio calculations of B(E1) available for ^{22,24}O
  - Coupled cluster + Lorentz integral transform (S. Bacca et al.)
  - No-core shell model (Christina Stumpf et al., AG R. Roth)

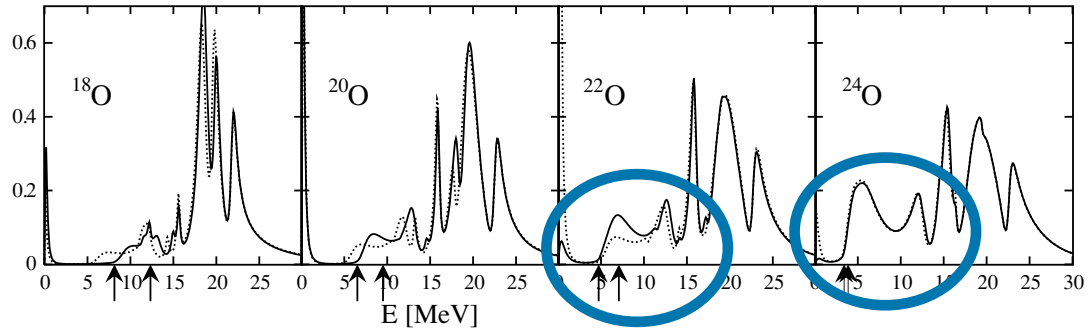
  heaviest (only) doubly magic drip-line nucleus in reach, strong Pygmy expected

  data from GSI stop at ^{22}O

Theory predictions



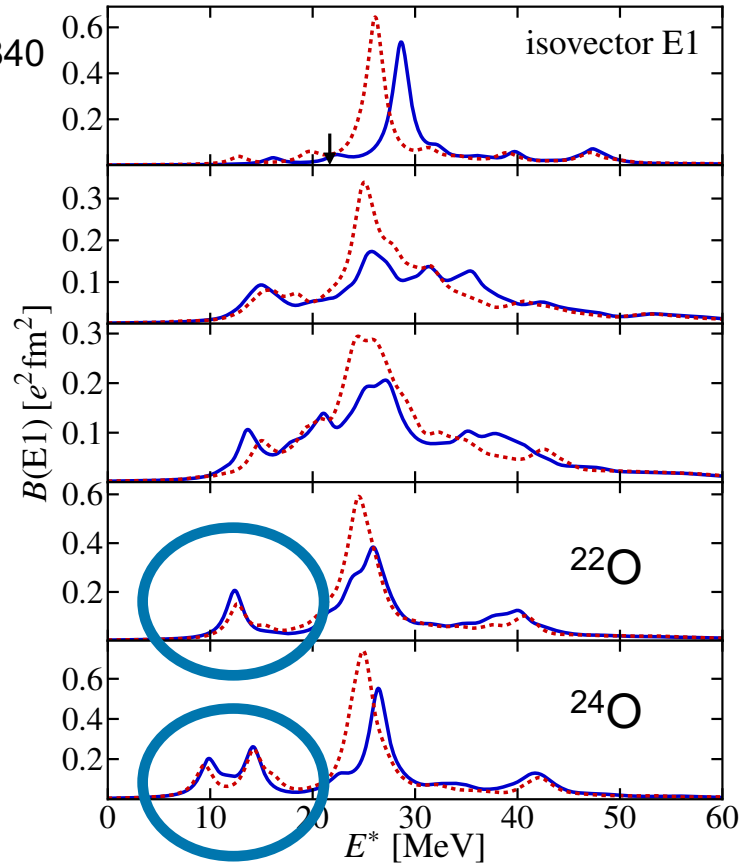
S. Bacca et al.
coupled-cluster + Lorentz integral transform



Masayuki Matsuo et al., PRC 71 (2005) HFB + CQRPA

C. Stumpf, T. Wolfgruber, R. Roth, arXiv:1709.06840

No-core shell model



IS and IV dipole in ^{22,24}O: I. Hamamoto, H. Sagawa, private communication

Proposal

TECHNISCHE UNIVERSITÄT DARMSTADT

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- **Aim: Extraction of low-energy B(E1) strength**
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- **^{24}O**: New ab-initio calculations of B(E1) available for ^{22,24}O
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  - No-core shell model (R. Roth et al.)

  heaviest (only) doubly magic drip-line nucleus in reach, strong Pygmy expected

  data from GSI stop at ^{22}O
- **^{29}F**: Heaviest Borromean close-to-dripline nucleus

  N=20 (closed shell?) nucleus (^{28}O + p)

  p-state intruder ? (P. Doornenbal, H. Scheit et al, PRC 2017) → enhanced low-lying dipole

  (large-scale SM: Utsuno, Otsuka et al.: narrowed gap (pf), gain of correlation energy → ^{29}F bound, island of inversion)

  in addition information from 1n knockout reaction + nuclear excitation

  ➔ Experiment will clarify the valence-neutron shell structure

Coulomb breakup of drip-line / halo nuclei

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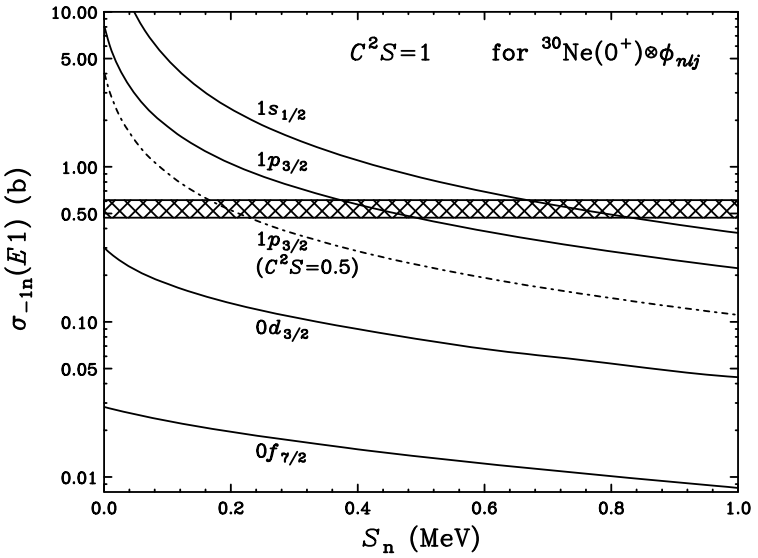
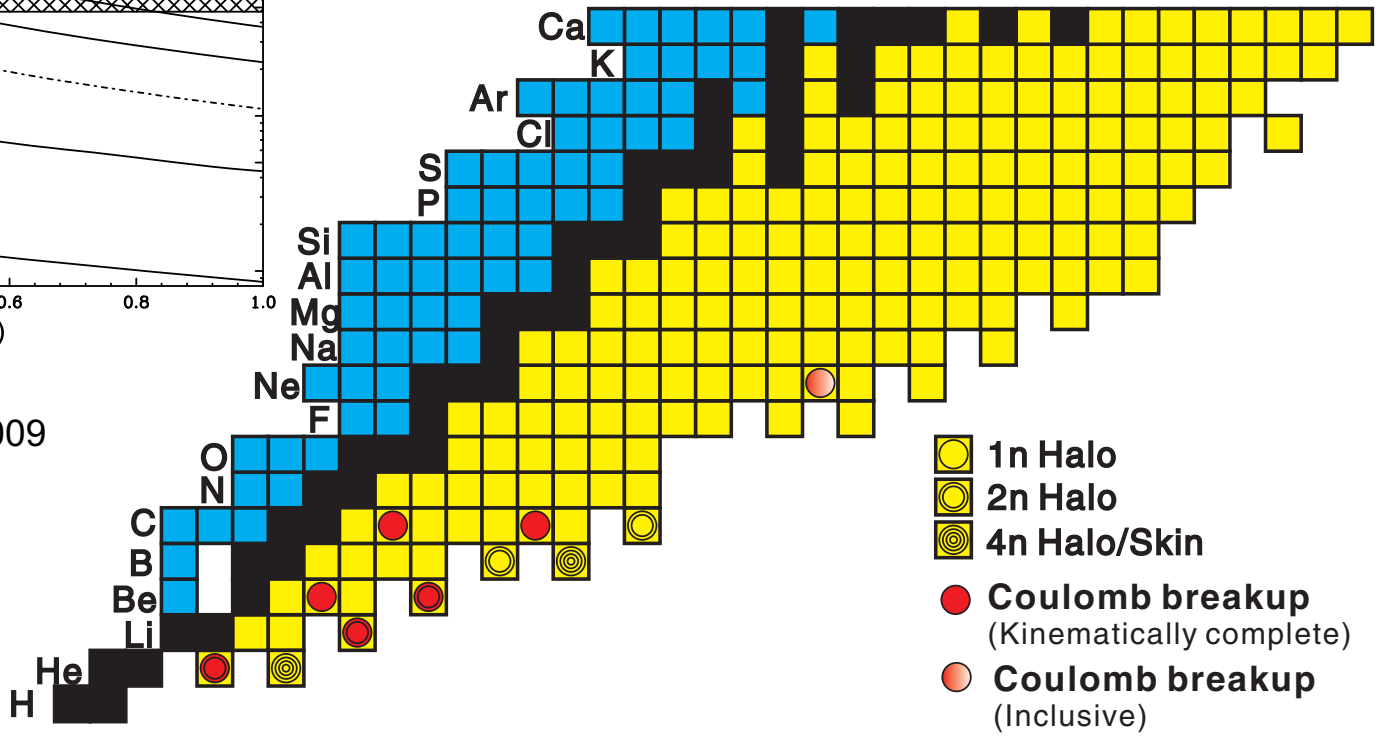


T. Nakamura et al., PRL 2009

T. Aumann, T. Nakamura, Phys. Scr. 2013



Experiment

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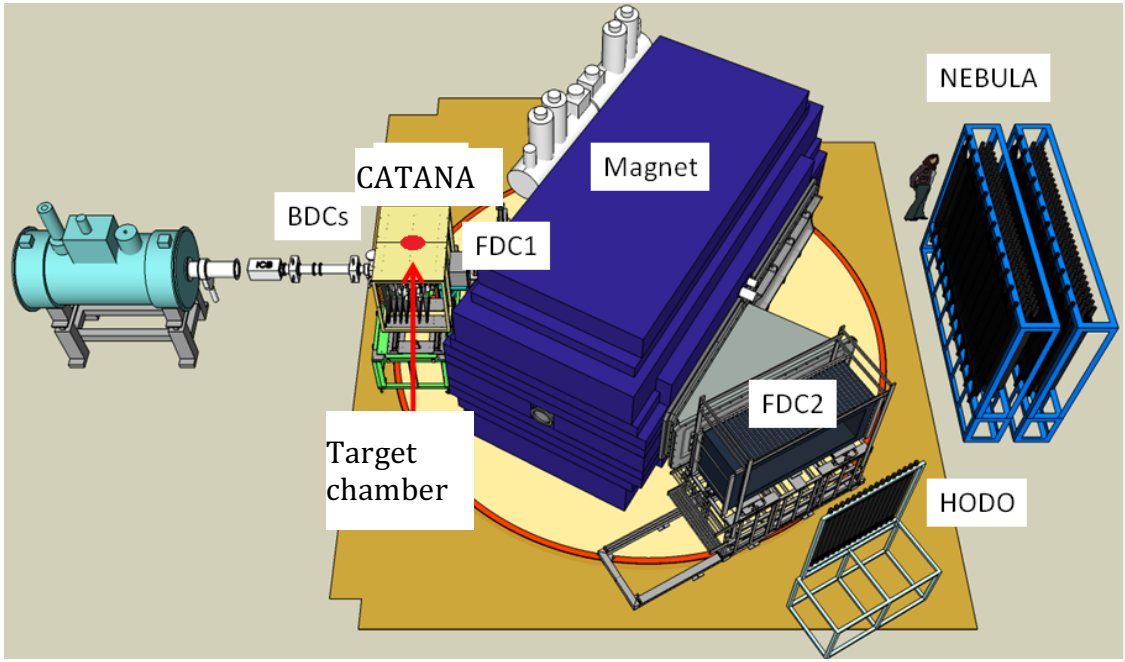
Standard neutron configuration of SAMURAI



Electromagnetic excitation
+ 1n,2n decay
➡ **B(E1)**
+
Nuclear excitation
➡ **Excited states**
+
Knockout reaction
$^{29}F \rightarrow ^{28}F \rightarrow ^{27}F+n$
Angular correlation ($\mathbf{p}_{28F}$ vs. $\mathbf{p}_n$) sensitive to quantum numbers
➡ **Structure of ^{29}F**

Invariant-mass method

$$E^* = \left(\sqrt{\sum_i m_i^2 + \sum_{i \neq j} m_i m_j \gamma_i \gamma_j (1 - \beta_i \beta_j \cos\theta_{ij})} - m_{proj} \right) c^2 + E_\gamma$$