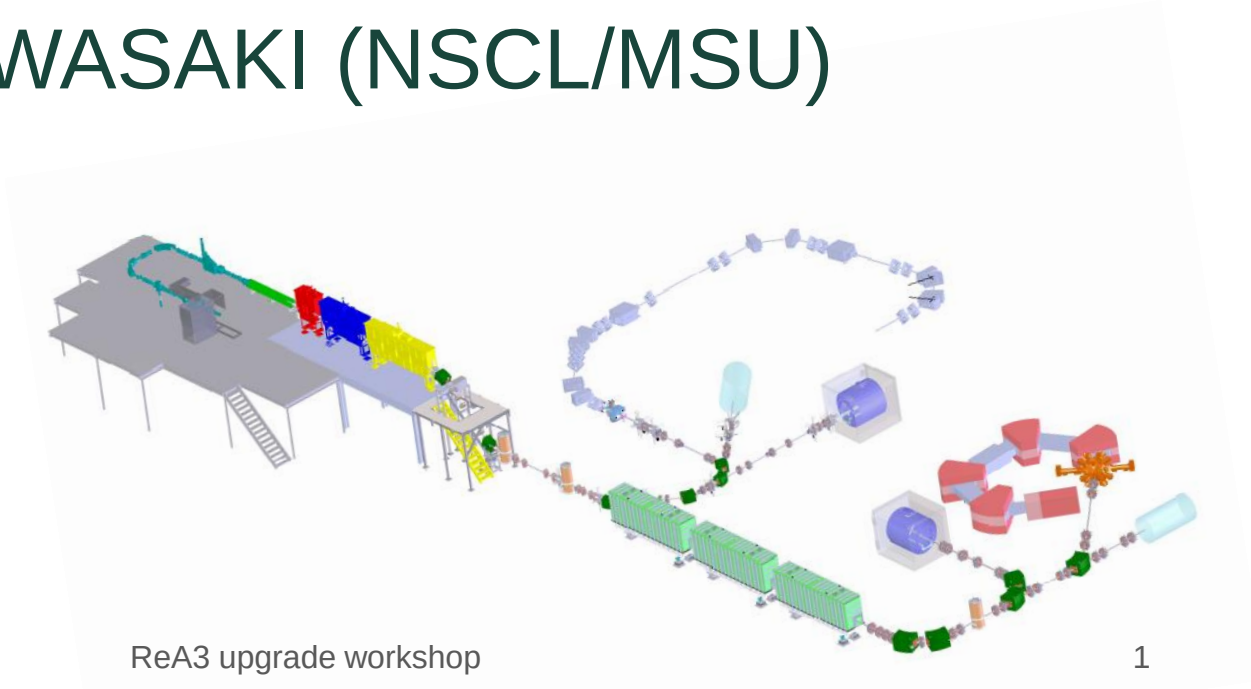
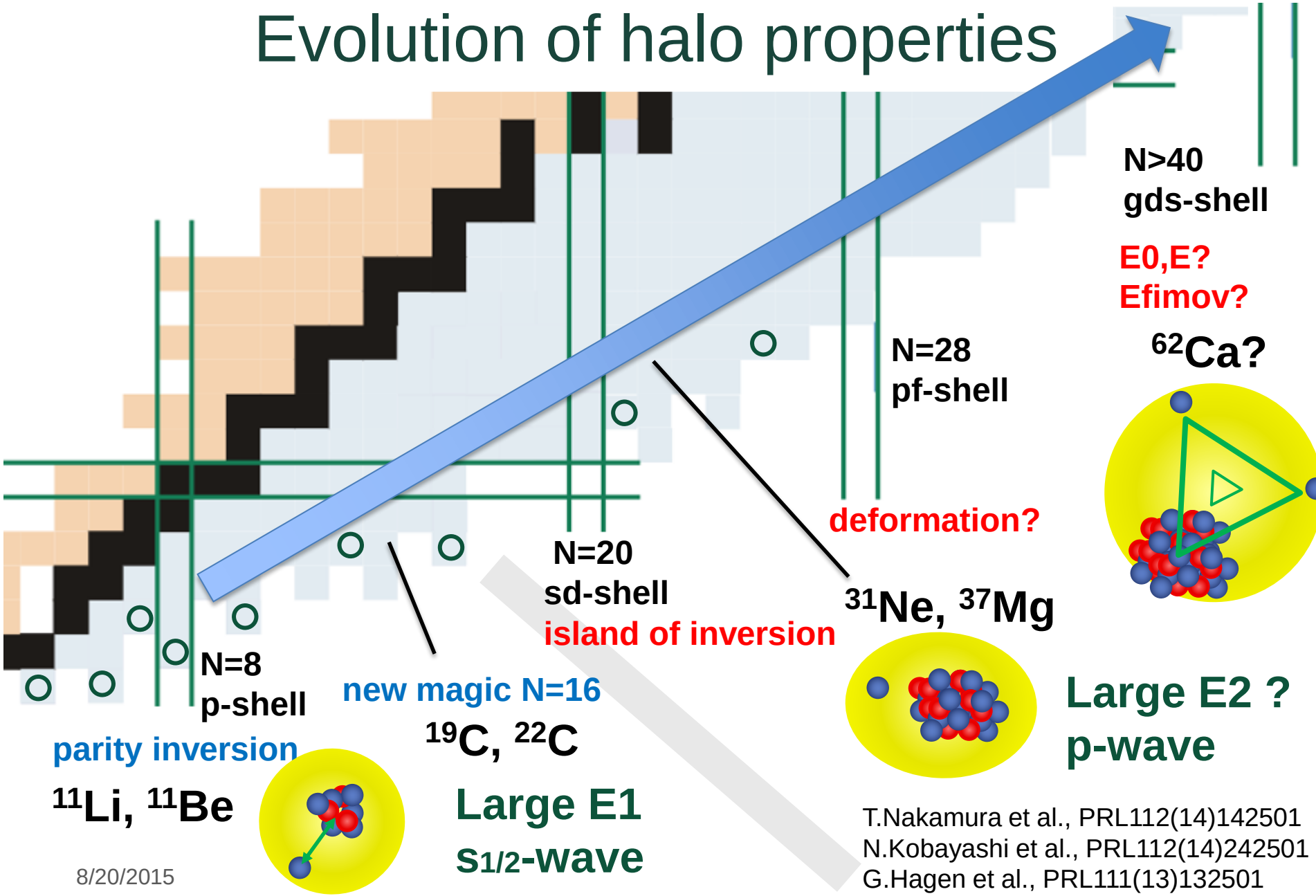
DSAM lifetime measurements at ReA

Hiro IWASAKI (NSCL/MSU)

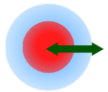
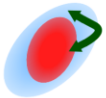


Evolution of halo properties



T.Nakamura et al., PRL112(14)142501
N.Kobayashi et al., PRL112(14)242501
G.Hagen et al., PRL111(13)132501

Transition rates (level lifetimes) and halo properties

Type of halo	Configuration of valence neutron	B(E1) established	B(M1) - to be established -	B(E2) - to be established -
Spherical 	Pure $s_{1/2}$ + core (0^+)	◎	×	△
Deformed 	Mixed (sd) or (pf) + core	◎	○ 1)	○

◎ Enhanced
○ Favored
× Hindered
△ Depends on core deformation

Large B(E1) – evidence for halo / skin

^{11}Be ($1/2^+ \rightarrow 1/2^-$) : 0.1 e^2fm^2, 0.36 W.u.

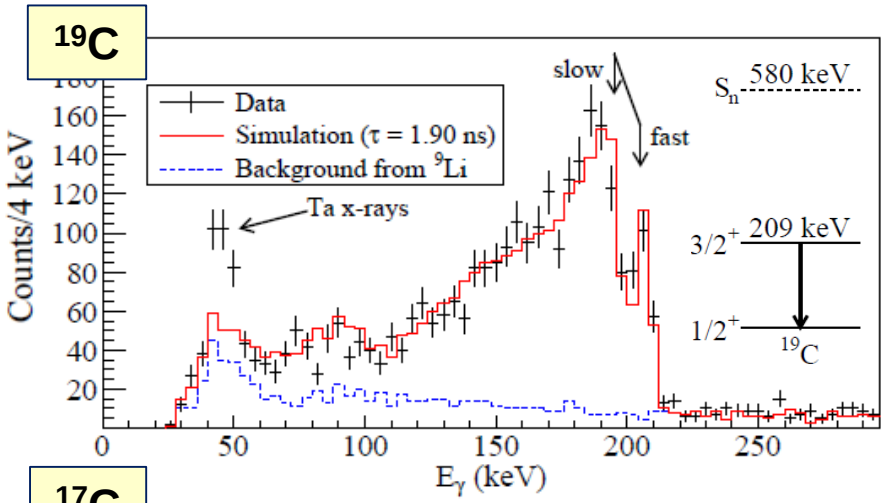
^{68}Ni PDR : 1.2e^2fm^2, 1W.u. (5% of EWSR)

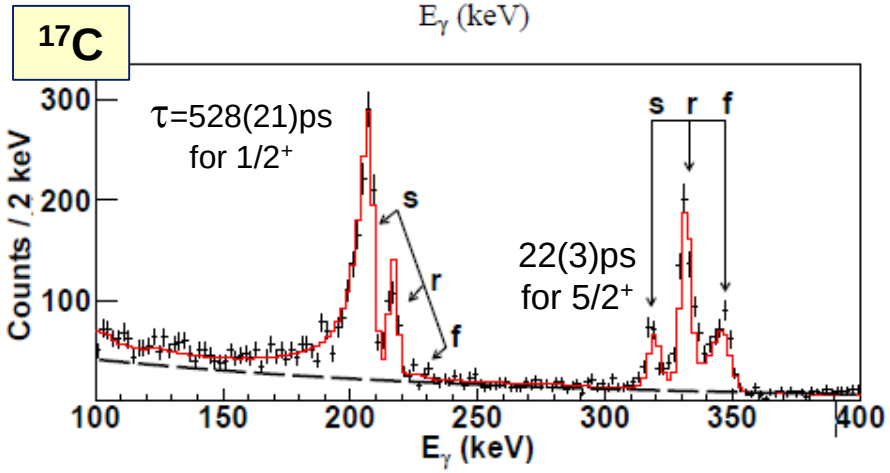
O.Wieland et al., PRL102(09)092502

1) cf. Soft Scissors Mode: P. Van Isacker, Heavy Ion Physics 6 (1997) 45

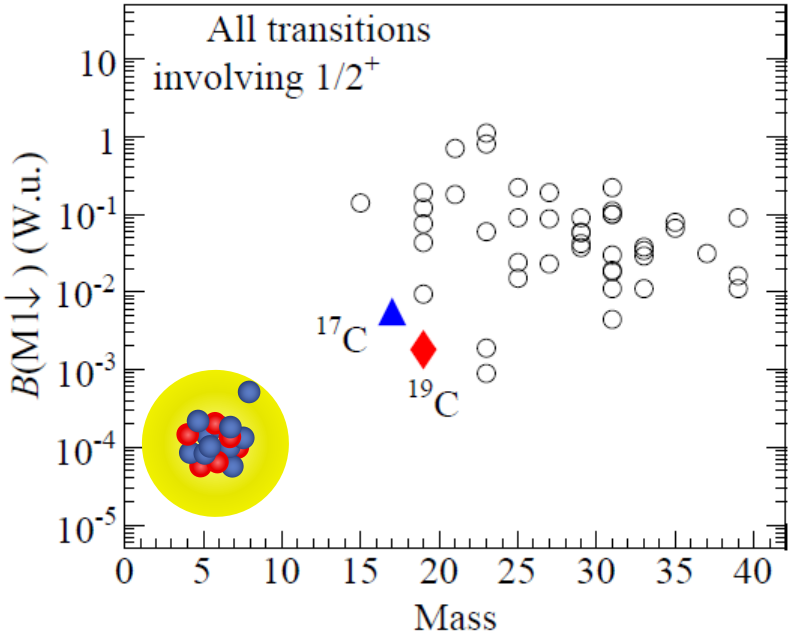
From GRETINA 1st Campaign with fast RI beams

Recoil-distance method for ^{17,19}C with TRIPLEX plunger





One of the most hindered M1 strengths found for one neutron halo nucleus ^{19}C

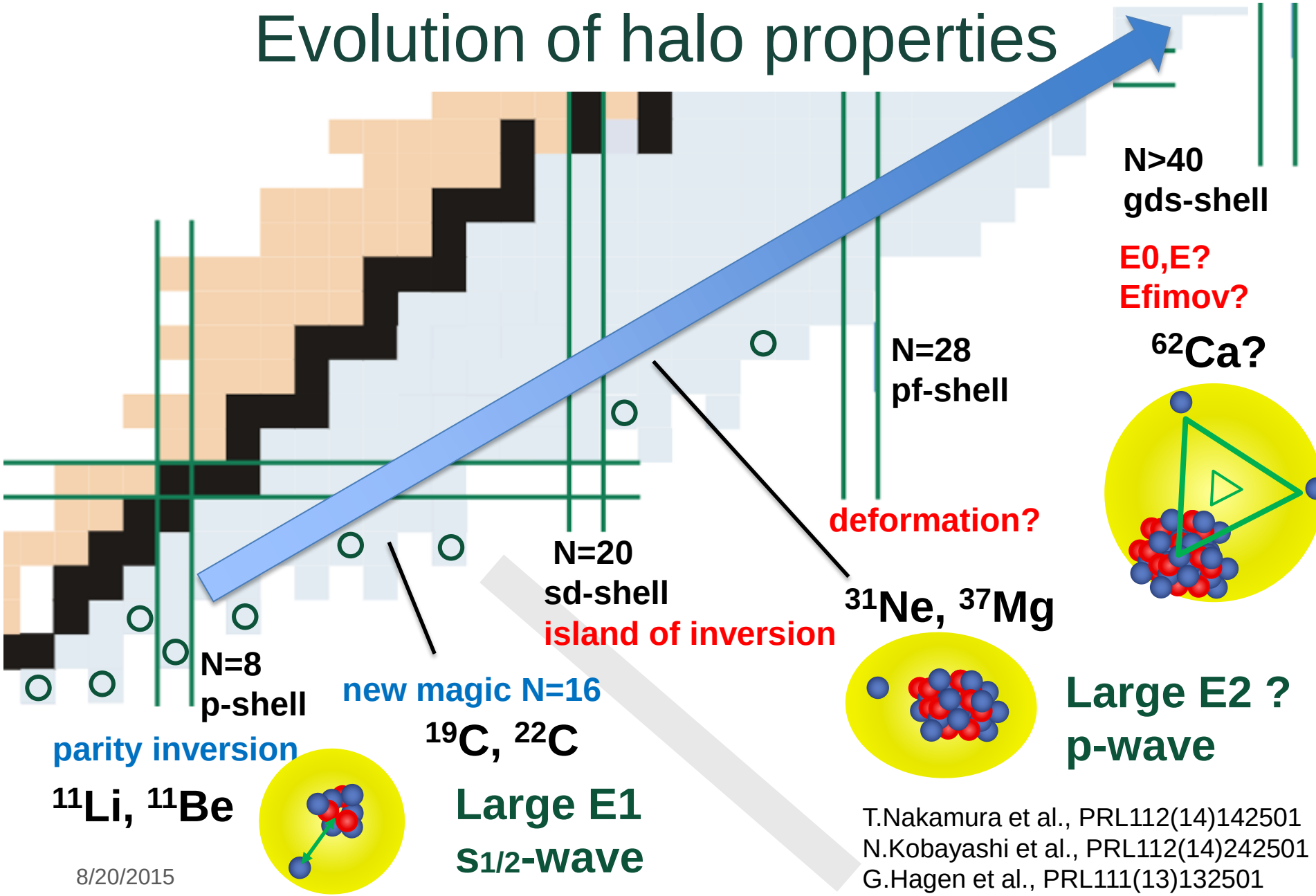


A comparison with shell model calculations suggests the s-wave prevalence in both the ground ($1/2^+$) and excited ($3/2^+$) states in ^{19}C, characteristic of halo structure, causes a diminished magnetic response.

^{17}C : D.Smalley, H.Iwasaki, P.Navratil, R.Roth et al., effects of 3NF, continuum in NCSM(C), *submitted*

^{19}C : K.Whitmore, D.Smalley, H.Iwasaki et al., Phys.Rev.C91(2015)041303(R)

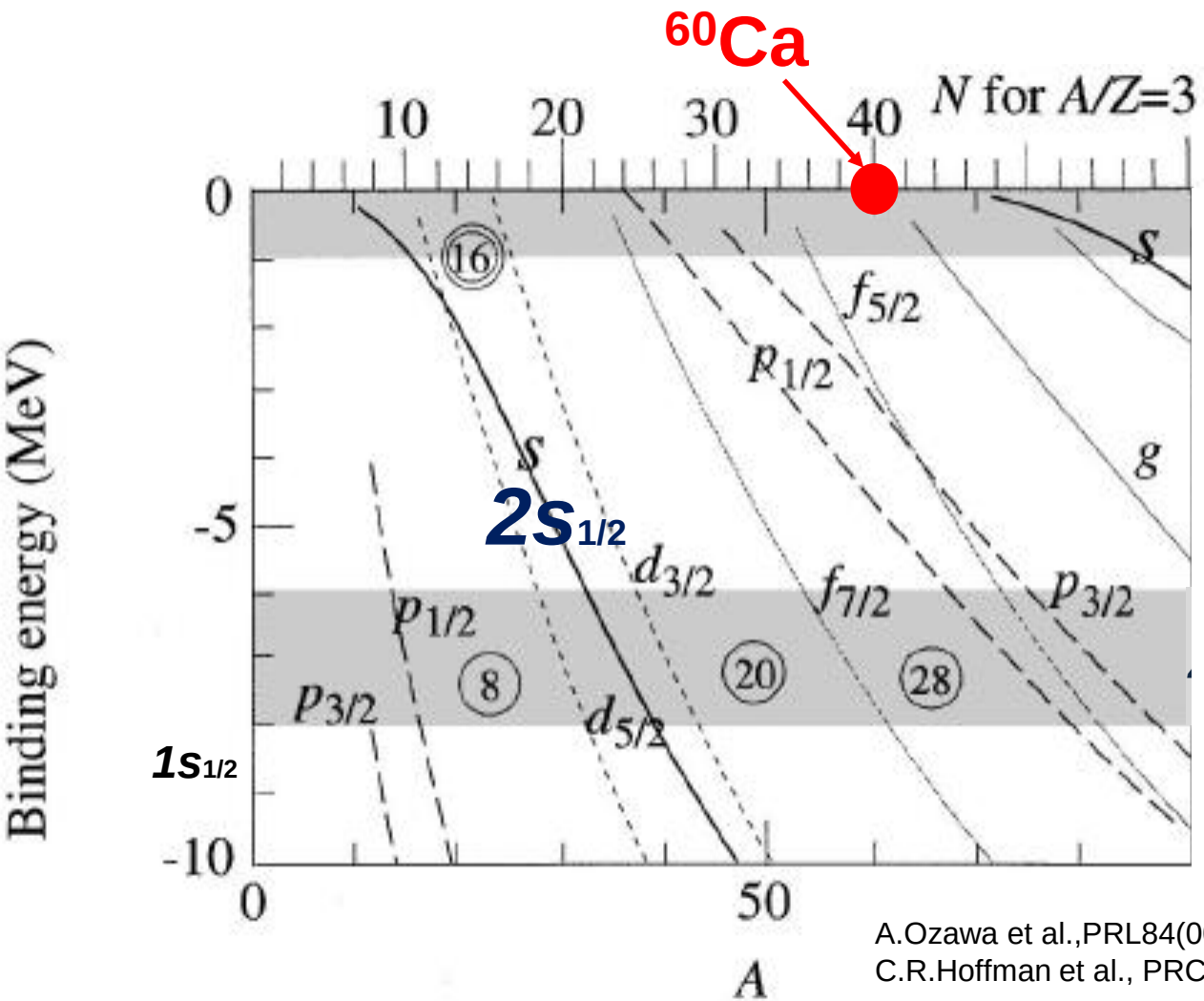
Evolution of halo properties



T.Nakamura et al., PRL112(14)142501
N.Kobayashi et al., PRL112(14)242501
G.Hagen et al., PRL111(13)132501

Evolution from stable Sn to exotic Ca

Lowering of the *3S1/2* state near the dripline?



N>40
gds-shell

A.Ozawa et al.,PRL84(00)5493,
C.R.Hoffman et al., PRC89(14)061305(R)

Level Schemes in N=69 isotones

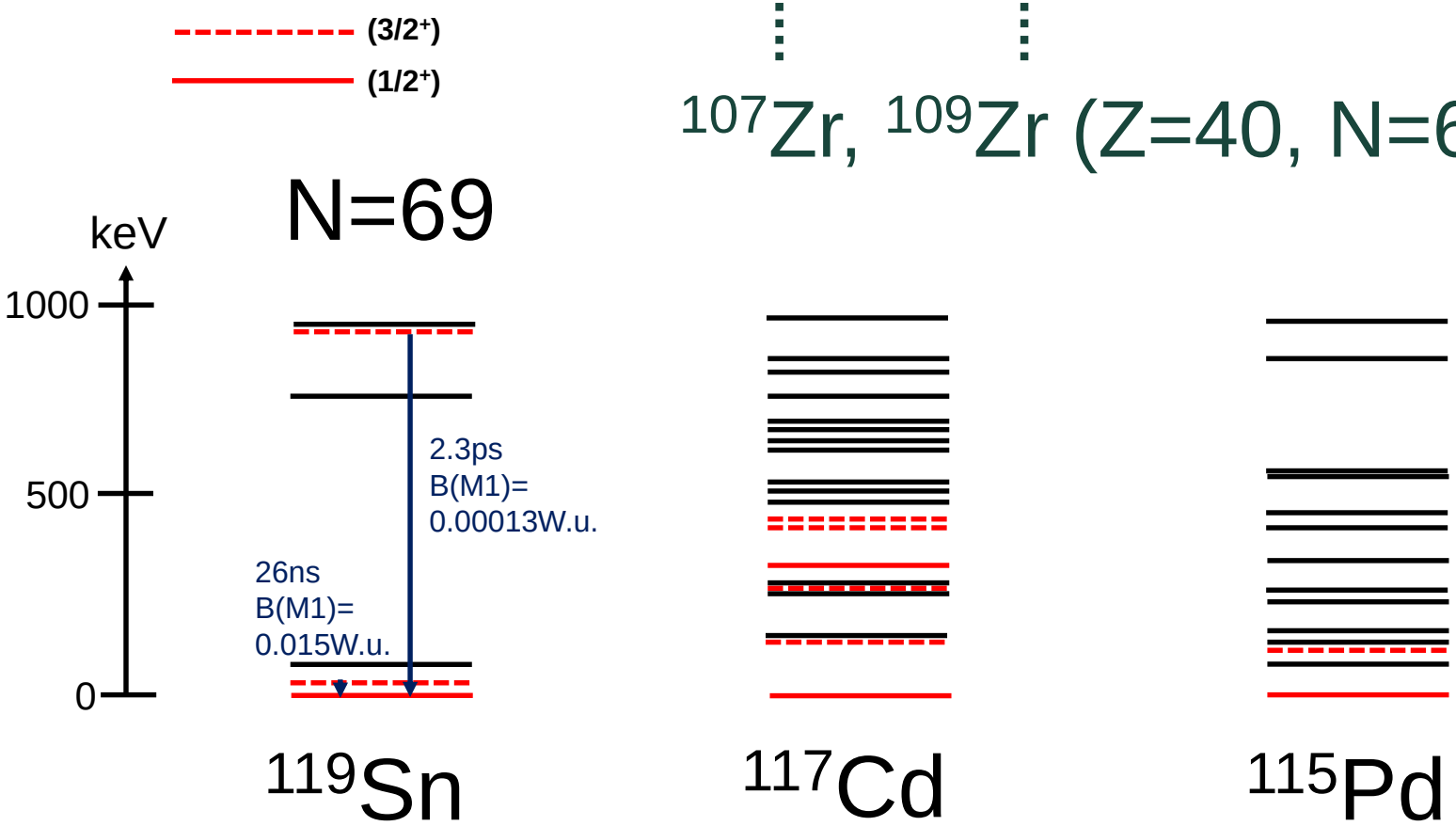
MICHIGAN STATE UNIVERSITY

^{17}C, ^{19}C (Z=6,N=11,13) → ^{117}Sn, ^{119}Sn (Z=50, N=67,69)

^{115}Cd, ^{117}Cd (Z=48, N=67,69)

⋮ ⋮

^{107}Zr, ^{109}Zr (Z=40, N=67,69)



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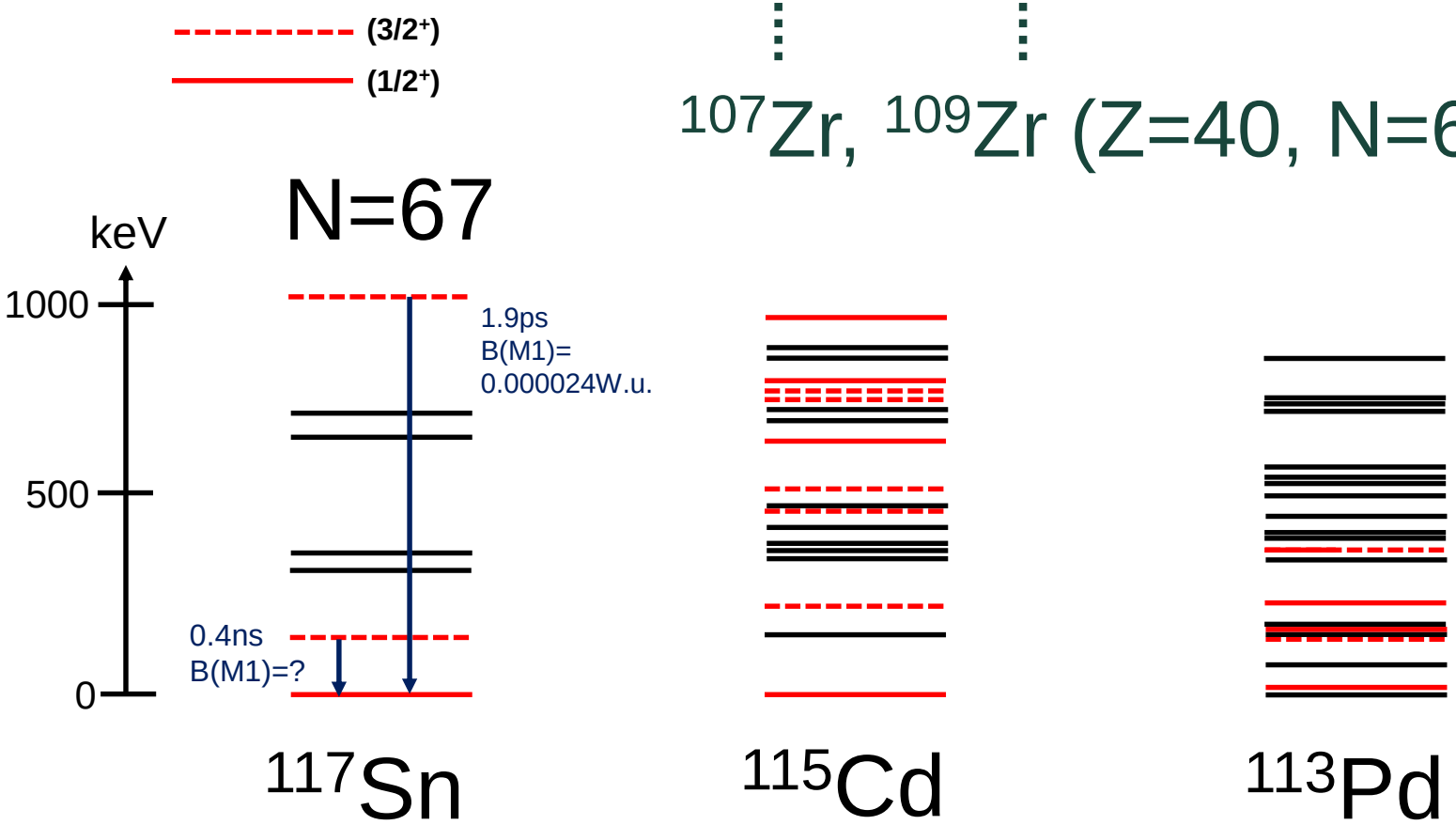
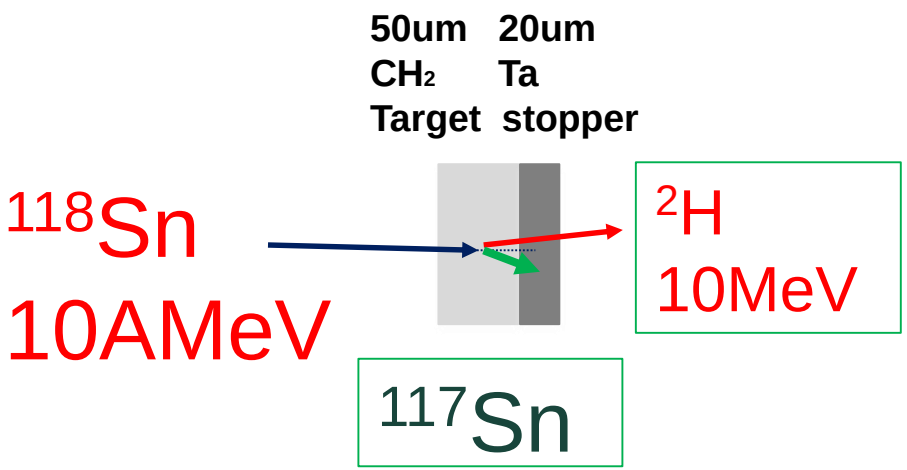
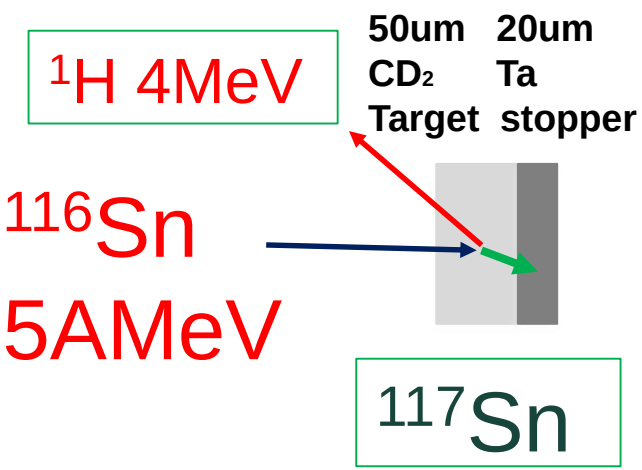


Direct reactions (p,d),(d,p)… with ReA beams + DSAM

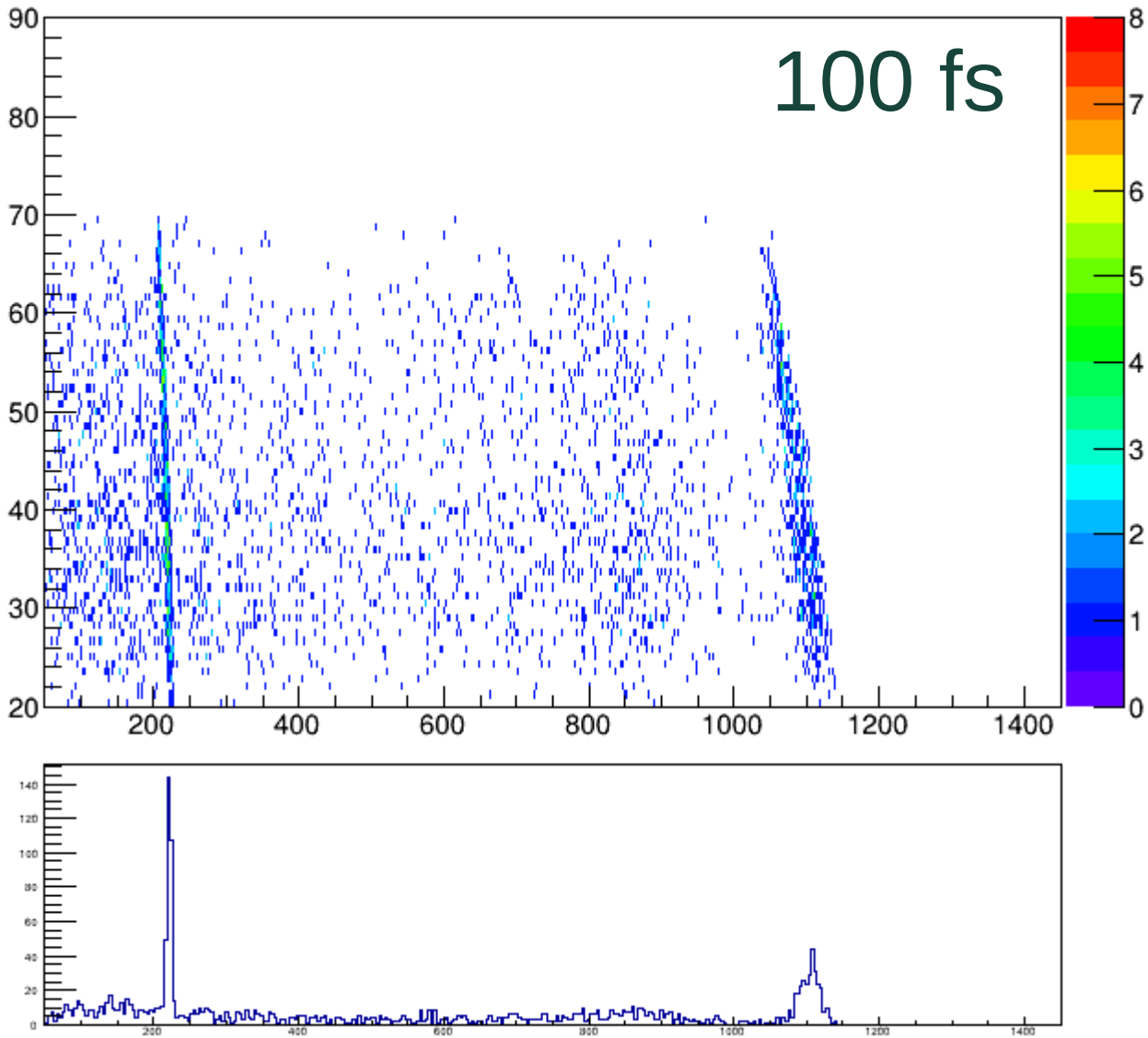
- Measure recoils (energy, angle) − tag reactions, Q value
  (p,d) Q = -8MeV (ReA9-A12) : (d,p) Q>0MeV (ReA6)
- Momentum matching − selective to specific states (*l*)





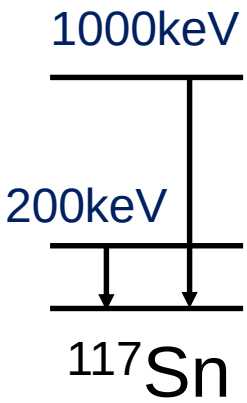
DSAM with GRETINA at ReA in inverse kinematics

– to measure sub-*ps* lifetimes of exotic nuclei



^{118}Sn(p,d)
at 10AMeV

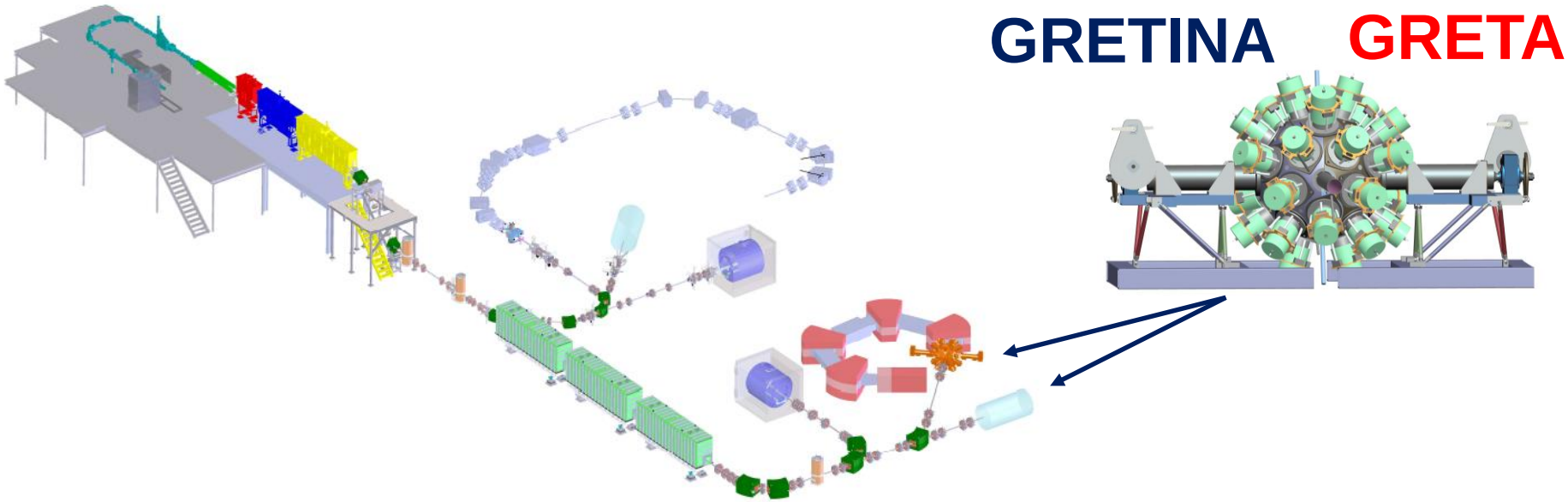
50um CH_2 Target **20um Ta stopper**



Opportunities … for ReA6/ReA9/ReA12 ...

300 counts in one experiment

- 10^5 beam × 1 mb (or 10^4 beam × 10mb)



Physics opportunities :

l-forbidden M1 measurement (pseudospin partners)

E2 transitions (for higher-lying states, symmetries)

Collective M1, E3 transitions

Summary

· Spectroscopy and lifetime measurements at ReA6/ReA9/Re12 (above Coulomb barrier) are discussed.

· The behavior of the 3s orbital is discussed as a key observable to investigate the shell evolution from stable Sn to exotic Ca.

· As a possible probe, sub-ps lifetime measurements based on DSAM technique with ReA beams are proposed to study the l-forbidden M1 transitions.
Similar experimental approaches can be used in various spectroscopic studies on low-lying structure of exotic nuclei.

Thank you, and…

Whitepaper for ReA3 upgrade

This workshop will be the kickoff for a whitepaper outlining the science opportunities at the ReA facility.

All speakers and those who are interested are invited to send a 1-page document describing their science interests.

Schedule:	August 20	ReA3 upgrade workshop
	August 31	organizer(s) will contact with you
	September 30	deadline for the 1-page draft
	November 30	first draft for whitepaper
	January, 2016	final version

Presentation slides and any updates for whitepaper preparation, ReA project, etc will be posted at

https://people.nscl.msu.edu/~iwasaki/rea6.html

Outline of the whitepaper (tentative)

· Introduction and Executive Summary

· Physics Opportunities at ReA ← discussed today in workshop
- Structure of exotic nuclei
  shell and shape evolution, collective phenomena, high-spin states, nuclear clustering, weakly-bound system
- Reaction dynamics at and above Coulomb barrier
  fusion, direct reactions, multi-fragmentation, isospin equilibration (EOS)
- Heavy and super-heavy element studies
  multi-nucleon transfer reactions, chemical studies of neutron-rich SHEs
- Nuclear astrophysics
  transfer reactions, ANC,
- other applications
  particle emission of compound nuclei, photon strength function, …

· ReA6/ReA9/ReA12 facility
- conceptual design
- possible ideas for major equipment
- cost estimates and time lines for the ReA and associated infrastructure

Thank you