# Light fusion-evaporation reactions with Gretina + FMA

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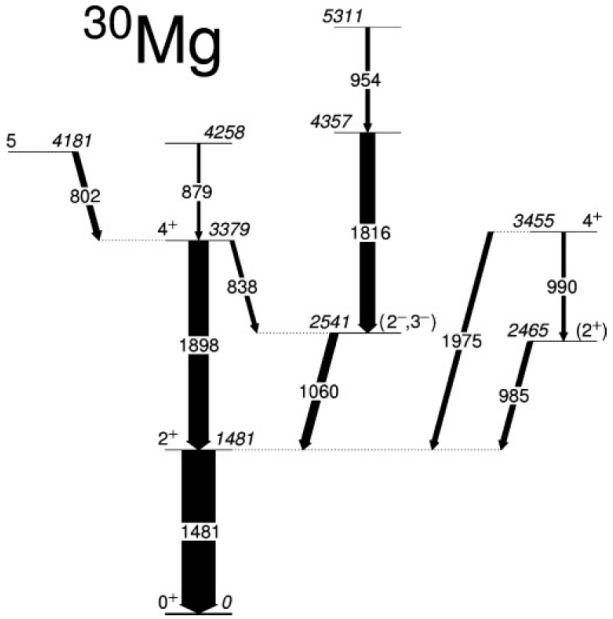
# Physics motivation

- Understand correlations driving intruder configurations around N ~ 20
  - $^{30}$Mg: A. N. Deacon *et al.*, PRC **82**, 034305 (2010)
  - $^{34}$Si: S. Paschalis *et al.*, J. Phys. Conf Ser. **312**, 092050 (2011)
- Exotic excitation modes in neutron-rich nuclei
  - $^{16}$C: M. Wiedeking *et al.*, PRL **100**, 152501 (2008)
- Detailed tests of the p-sd shell model interactions and competition between pairing and quadrupole strengths
  - $^{18}$N: M. Wiedeking *et al.*, PRC **77**, 054305 (2008)
- Onset of deformation in neutron-rich fp-shell nuclei and stringent tests of fp-g shell model interactions
  - $^{59}$Cr: S. J. Freeman *et al.*, PRC **69**, 064301 (2004)
  - $^{60}$Cr: S. Zhu *et al.*, PRC **74**, 064315 (2006)

# Physics motivation

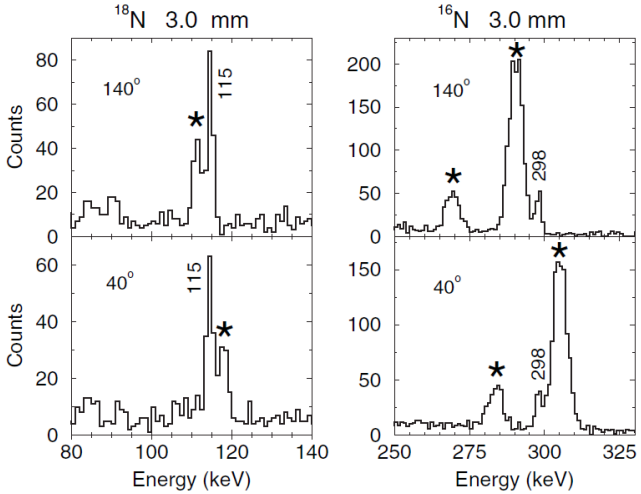
- Successful in surrounding nuclei through recoil- or particle-γ fusion evaporation measurements
  - 2p: $^{30}$Mg, $^{16}$C, $^{34}$Si, $^{18}$N, $^{59,60}$Cr, etc...

$^{14}$C($^{18}$O,2p) @ 37 MeV



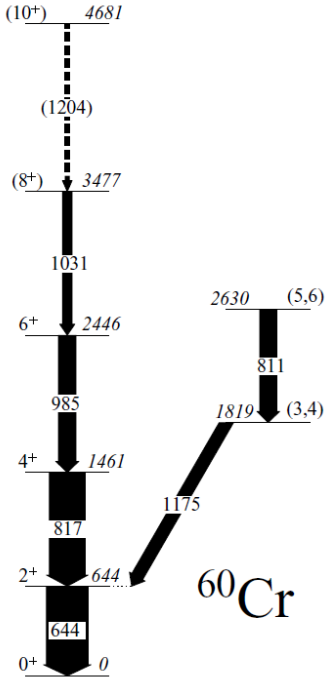

A. N. Deacon et al., PRC 82, 034305 (2010)

$^{9}$Be($^{11}$B,2p) @ 50 MeV




M. Wiedeking et al., PRC 77, 054305 (2008)

$^{14}$C($^{48}$Ca,2p) @ 130 MeV

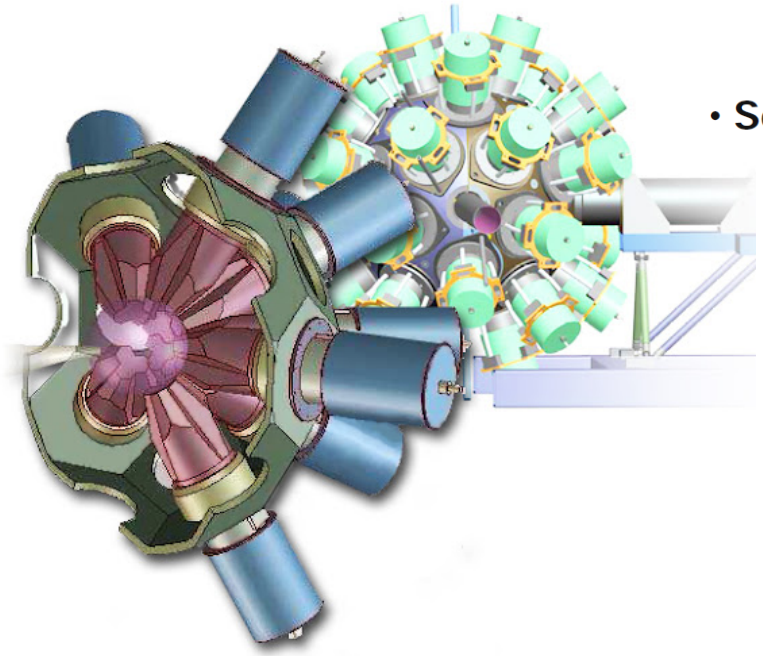


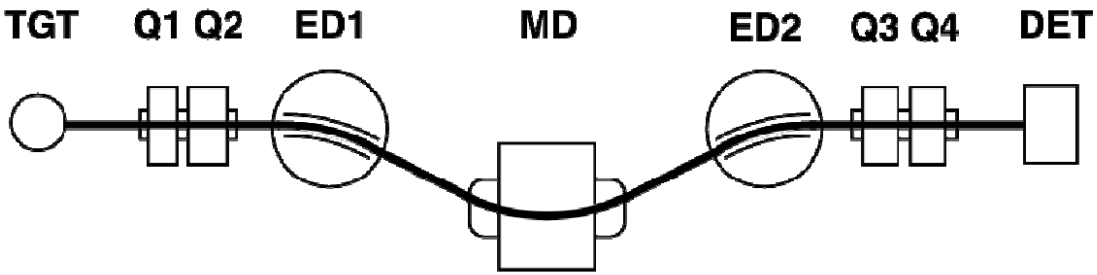

S. Zhu et al., PRC 74, 064315 (2006)

# Characteristics Fusion evaporation reactions in light nuclei

- Exotic nuclei reside in weak channels
  - 1p, 2p, 2p2n, etc...
  - ~100 ub out of ~1 b
  - Tag particles (microball, Si detector) or recoils (FMA)
- Low multiplicity events
  - Sn or Sp nearby
- High energy gamma-rays
  - First excited states in even-even nuclei typically ~1.5 - 2 MeV
  - Gamma rays with > 3 -4 MeV
- Low beam energies (< 10 MeV/u)
  - Doppler correction can become important for high energy peaks
  - Also help in overall sensitivity

# Advantages of Gretina + FMA for fusion evaporation reaction with light nuclei






• Solid Angle acceptance 8 msr

- Location of Gretina relative to entrance of the FMA
  - Acceptance for recoils increased
    - 2 msr (90 cm) → 8 msr (30 cm)
  - Enhancement Factor is reaction dependent
  - Clean trigger for γ-ray events
- Gamma-ray rates will not overwhelm gretina due to low-multiplicity events
  - Beam intensity likely limited by FMA focal plane (reaction dependent)

# Advantages of Gretina + FMA for fusion evaporation reaction with light nuclei

- Efficiency for high energy γ-rays through tracking
  - With tracking implimented high energy efficiency of Gretina equals Gammasphere @ ~3 MeV
  - Small reduction in absolute efficiency at 1.3 MeV (~7% to ~9%) is compensated for by FMA recoil acceptance gain
  - Still hurt by lower γ–γ efficiency relative to (digital) gammasphere, but not as drastic for high energy γ rays.
- Doppler reconstruction
  - Gain in sensitivity, especially for high-energy γ-rays (~few keV)
  - Know recoil angle from FMA combined with gamma-ray position
    - Important particularly for light nuclei
- Lifetime measurements possible
- Polarization

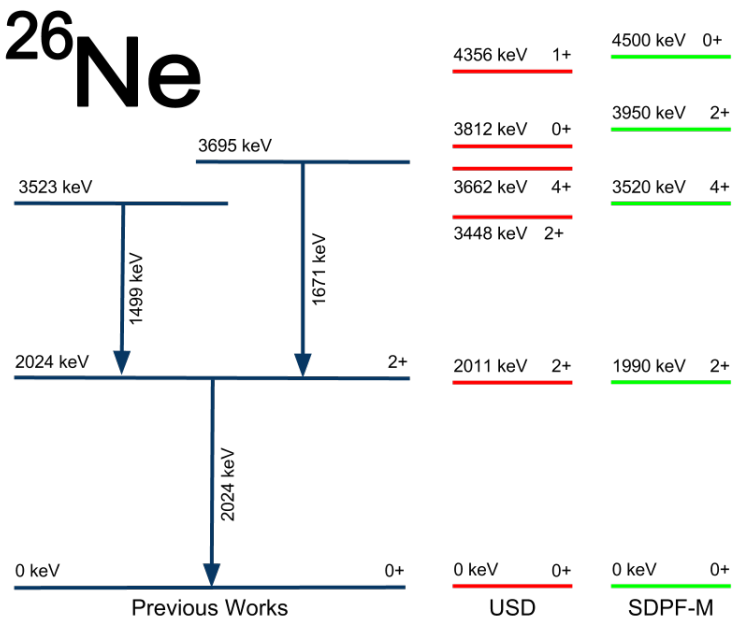
Thank You

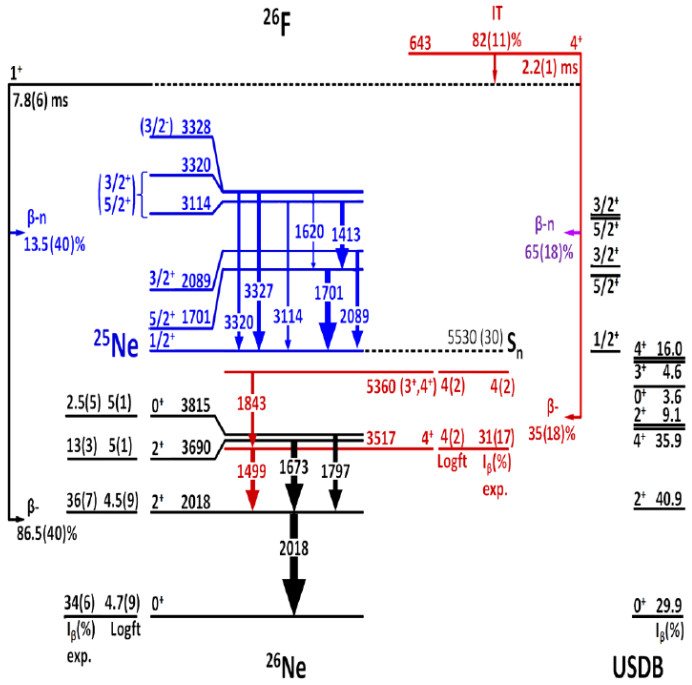
# Cons / Break-evens of Gretina + FMA vs. DGS + FMA

- Angular correlations
  - No need for continuous angle determination in angular correlations
- Multiplicity
  - Detection of high-fold events, if present, may be hindered
- Throughput
  - If beam current is NOT limited by FMA focal plane, DGS can handle larger throughput, hence, possibly a lower trigger multiplicity

# New physics

- New targets, new opportunities
  - States in $^{26}$Ne via -2p from $^{14}$C + $^{14}$C, or $^{18}$O + $^{10}$Be




A. Lepailleur et al., PRL 110, 082502 (2013)