# Evolution of the Electric Dipole Response in the Stable Sn Isotope Chain*

**Sergej Bassauer, Peter von Neumann-Cosel, Atsushi Tamii**
**and the E422 collaboration**
**Institut für Kernphysik, TU Darmstadt**

TECHNISCHE UNIVERSITÄT DARMSTADT

6th International Conference
on
Collective Motion in Nuclei
under
Extreme Conditions

*Supported by the DFG within SFB 1245

SFB 1245

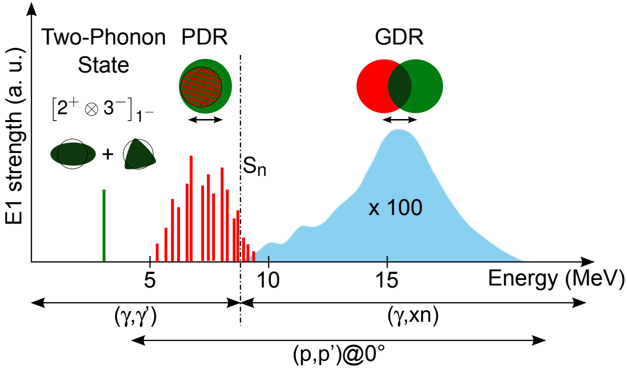
# Outline

TECHNISCHE UNIVERSITÄT DARMSTADT

- Motivation
- Experimental method
- Preliminary results
- The case of $^{120}$Sn
- Summary and outlook

# Electric Dipole Response in Nuclei

TECHNISCHE UNIVERSITÄT DARMSTADT




D. Martin, Master's thesis, TU Darmstadt (2013)

- Pygmy Dipole Resonance (PDR)
  - Oscillation of neutron skin against core
- Giant Dipole Resonance (GDR)
  - Oscillation of neutrons against protons

# Motivation: Electric Dipole Response
# What can be learned?

TECHNISCHE UNIVERSITÄT DARMSTADT

- Dipole polarisability
- Gamma strength function covering PDR and GDR
- Level densities in the GDR region

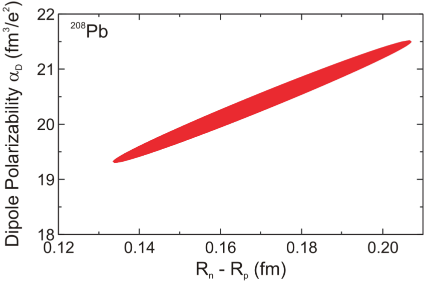
# Dipole Polarisability

TECHNISCHE UNIVERSITÄT DARMSTADT

- Static dipole polarisability

$$\alpha_D = \frac{\hbar c}{2\pi^2 e^2} \sum \frac{\sigma_{abs}(E_x)}{E_x^2} = \frac{8\pi}{9} \sum \frac{B(E1)(E_x)}{E_x} \left[\mathrm{fm}^3/\mathrm{e}^2\right]$$

- $\alpha_D$ is a measure of neutron skin
  - P.G. Reinhard, W. Nazarewicz, PRC **81** (2010) 051303



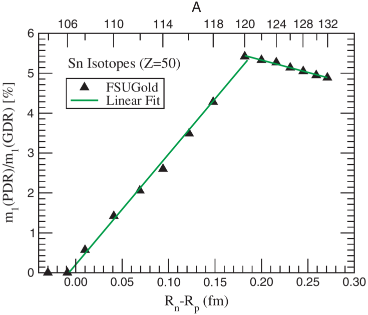
# Dipole Polarisability

TECHNISCHE
UNIVERSITÄT
DARMSTADT

- Static dipole polarisability

$$\alpha_D = \frac{\hbar c}{2\pi^2 e^2} \sum \frac{\sigma_{abs}(E_x)}{E_x^2} = \frac{8\pi}{9} \sum \frac{B(E1)(E_x)}{E_x} \left[\mathrm{fm}^3/\mathrm{e}^2\right]$$

- $\alpha_D$ is a measure of neutron skin
  - P.G. Reinhard, W. Nazarewicz, PRC **81** (2010) 051303
- PDR strength related to neutron skin
  - J. Piekarewicz, PRC **73** (2006) 044325



# Why Tin Isotope Chain?

TECHNISCHE UNIVERSITÄT DARMSTADT

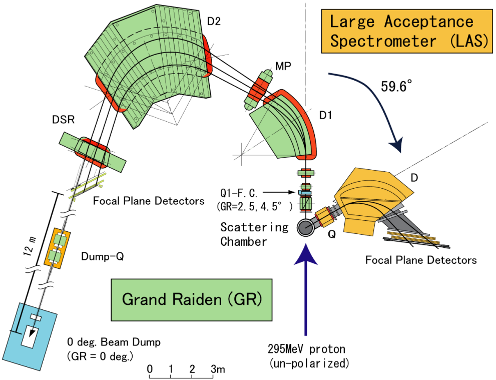
| $^{112}$Sn | $^{113}$Sn | $^{114}$Sn | $^{115}$Sn | $^{116}$Sn | $^{117}$Sn | $^{118}$Sn | $^{119}$Sn | $^{120}$Sn | $^{121}$Sn | $^{122}$Sn | $^{123}$Sn | $^{124}$Sn | ... | $^{132}$Sn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STABLE | 115.09 D | STABLE | STABLE | STABLE | STABLE | STABLE | STABLE | STABLE | 27.03 H | STABLE | 129.2 D | STABLE | | 39.7 S |
| 0.97% | | 0.66% | 0.34% | 14.54% | 7.68% | 24.22% | 8.59% | 32.58% | | 4.63% | | 5.79% | | |
| | ε: 100.00% | | | | | | | | β-: 100.00% | | β-: 100.00% | | | β-: 100.00% |

- Wide mass range with little change of the underlying structure
- Experiment: Data available in stable and unstable isotopes
  - NRF: $^{112}$Sn, $^{116}$Sn, $^{120}$Sn, $^{124}$Sn
  - Coulomb dissociation: $^{124-132}$Sn
  - Alpha scattering: $^{124}$Sn, $^{128}$Sn, $^{132}$Sn
  - Proton scattering: $^{120}$Sn, $^{112}$**Sn**, $^{114}$**Sn**, $^{116}$**Sn**, $^{118}$**Sn**, $^{122}$**Sn**, $^{124}$**Sn**
- Theory: Many calculations for PDR available
  - N. Tsoneva *et al.*, NPA **731** (2004); PRC **77** (2008)
  - N. Paar *et al.*, PLB **606** (2005)
  - J. Piekarewicz, PRC **73** (2006)
  - S. Kamerdizhiev, S.F. Kovaloo, PAN **65** (2006)
  - J. Terasaki, J. Engel, PRC **74** (2006)
  - E. Litvinova *et al.*, PLB **647** (2007); PRC **78** (2008)

# Experiment at RCNP: E422 campaign

TECHNISCHE UNIVERSITÄT DARMSTADT

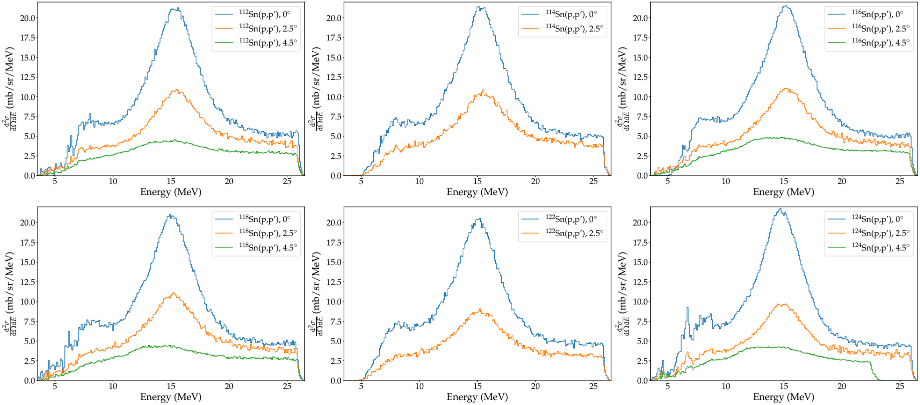
- Reaction: (p,p')
- Beam energy: 295 MeV
- Resolution: $\sim$ 30 keV
- Measured angles: 0°, 2.5°, 4.5°
- Main targets: $^{112}$**Sn**, $^{114}$Sn, $^{116}$**Sn**, $^{118}$Sn, $^{122}$Sn, $^{124}$**Sn**
- $^{120}$Sn
  A. Krumbholz *et al.*, Phys. Lett. **B** 744 (2015)
  T. Hashimoto *et al.*, Phys. Rev. **C** 92 (2015)



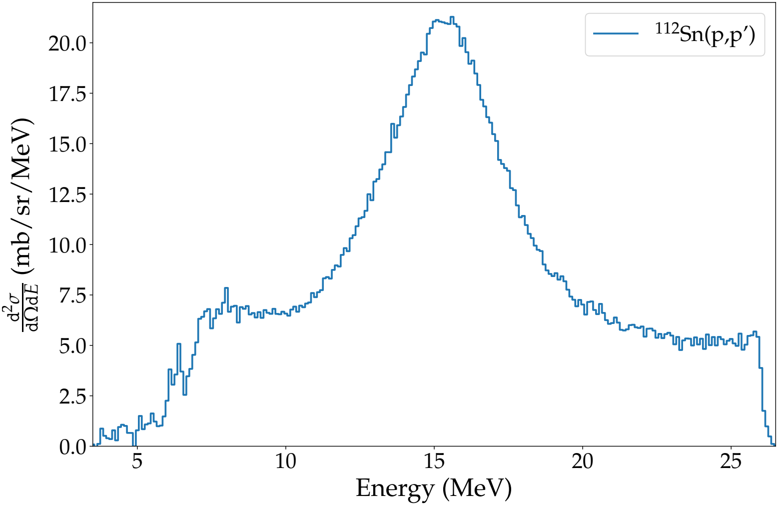

A. Tamii, Seminar, TU Darmstadt (2005)

# Preliminary Results

TECHNISCHE UNIVERSITÄT DARMSTADT

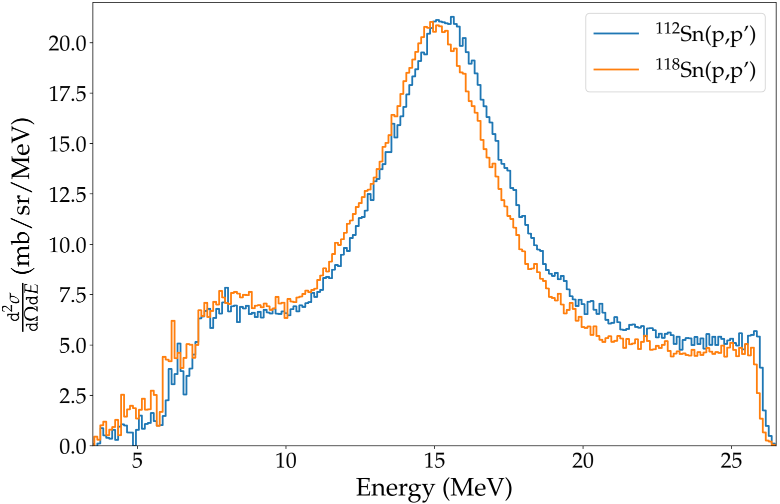


# Preliminary Results



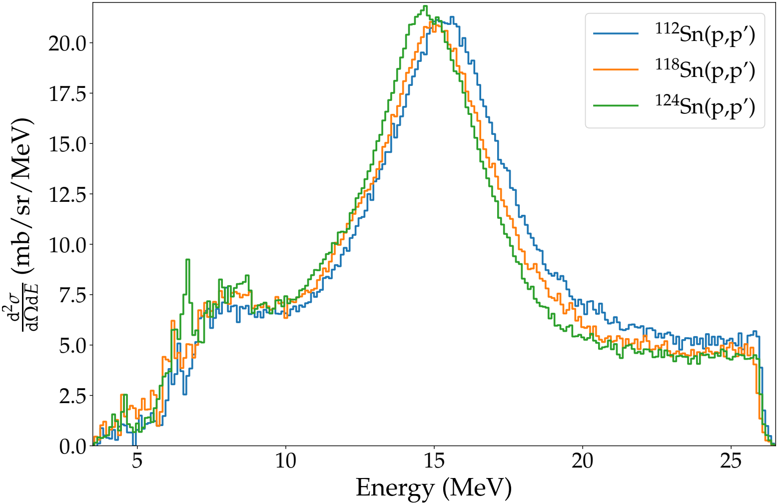
# Preliminary Results



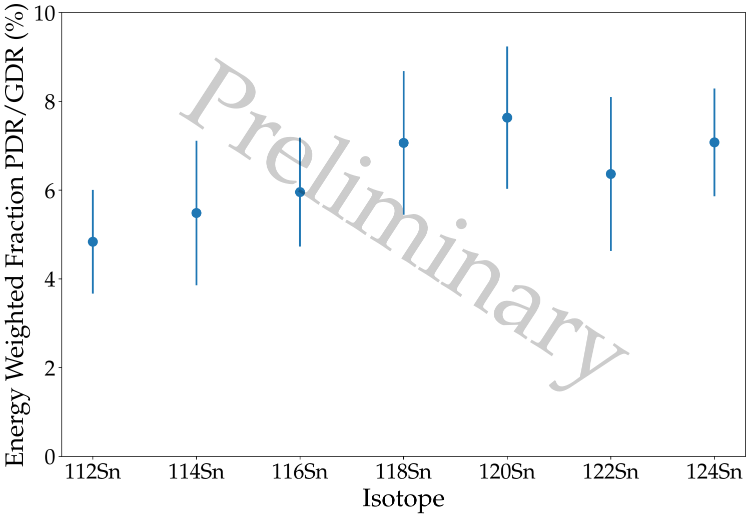


# Preliminary Results

TECHNISCHE
UNIVERSITÄT
DARMSTADT

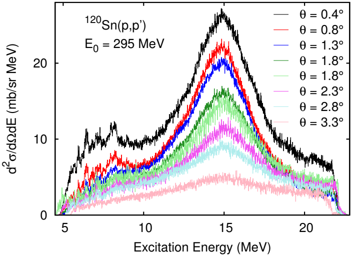


# Preliminary Results

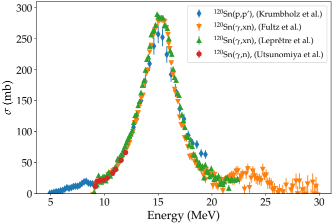


# The Case of $^{120}$Sn(p,p')

- $^{120}$Sn(p,p') experiment conducted at RCNP, Japan
- DDCS converted to photoabsorption cross section using Virtual Photon Method
- E1 gamma strength function determined from photoabsorption cross section




A. Krumbholz *et al.*, Phys. Lett. **B** 744 (2015) 7

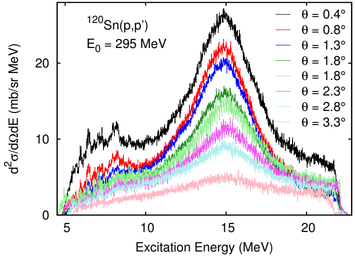


# The Case of $^{120}$Sn(p,p')

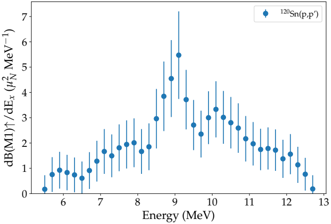
TECHNISCHE UNIVERSITÄT DARMSTADT

- $^{120}$Sn(p,p') experiment conducted at RCNP, Japan
- DDCS converted to photoabsorption cross section using Virtual Photon Method
- E1 gamma strength function determined from photoabsorption cross section
- M1 gamma strength function determined from M1 strength which was obtained using the unit cross section technique

J. Birkhan *et al.*, PRC 93 (2016) 041302

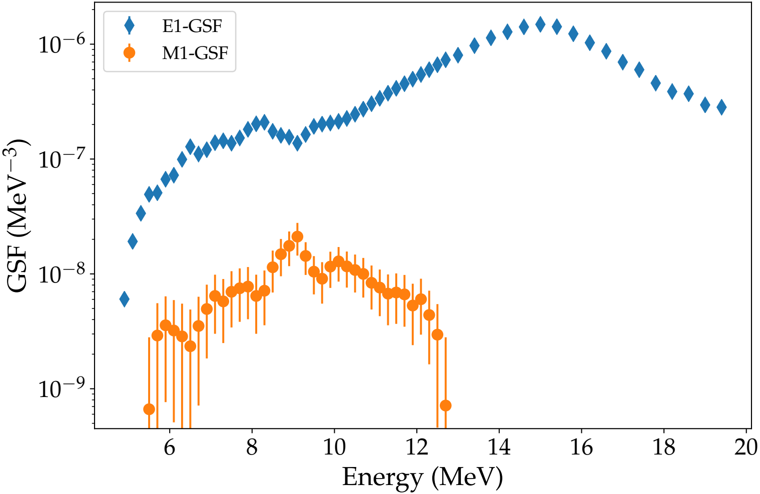



A. Krumbholz *et al.*, Phys. Lett. **B** 744 (2015) 7



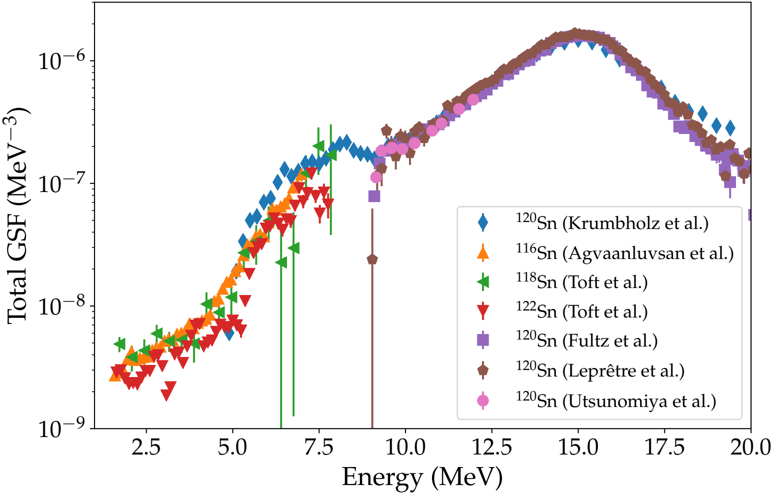
# E1 and M1 Gamma Strength Functions

TECHNISCHE UNIVERSITÄT DARMSTADT



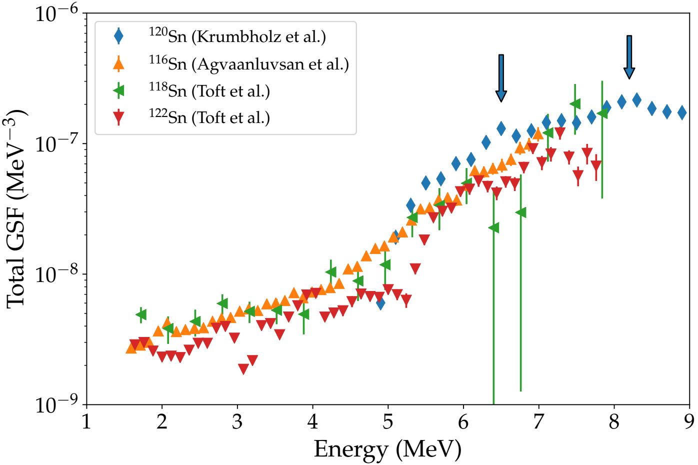
# Total Gamma Strength Function

TECHNISCHE UNIVERSITÄT DARMSTADT



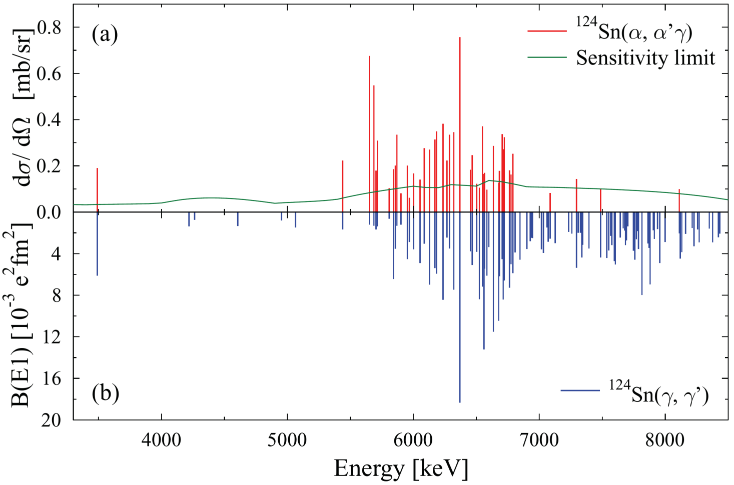
# Total Gamma Strength Function

TECHNISCHE UNIVERSITÄT DARMSTADT

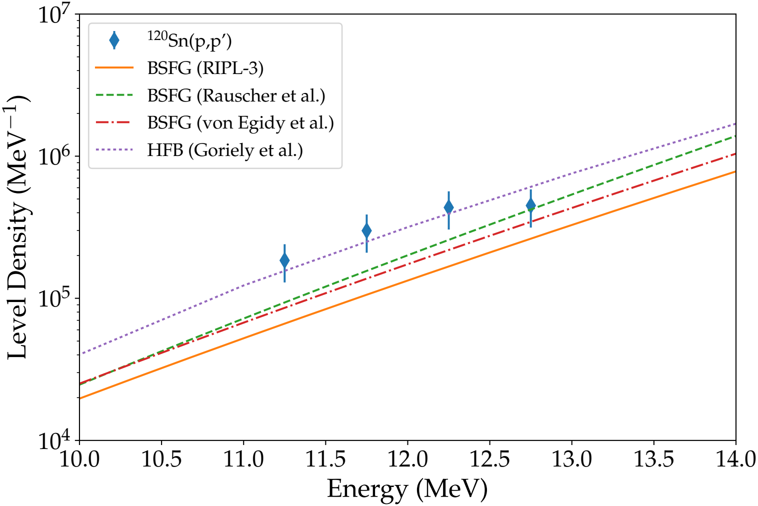



- Brink-Axel hypothesis violated?

# Comparison with Isoscalar Probe

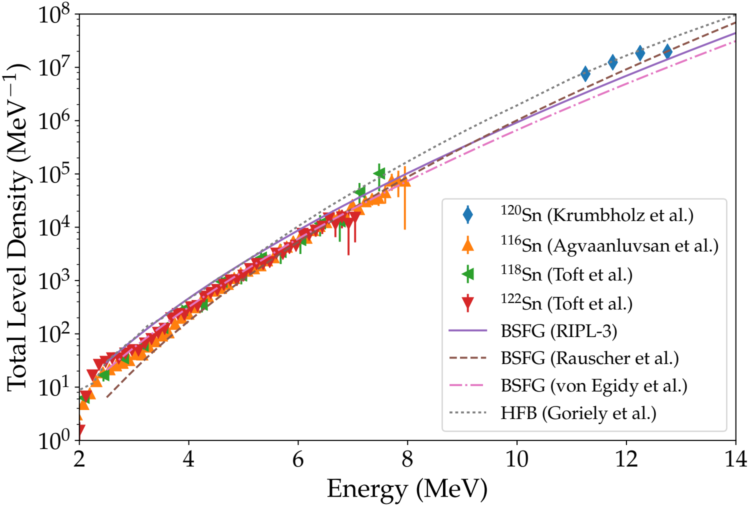


# Level Densities of $1^-$ States



# Comparison of the Total Level Density

TECHNISCHE UNIVERSITÄT DARMSTADT



# Summary and Outlook

TECHNISCHE UNIVERSITÄT DARMSTADT

## Summary

- Preliminary results
  - Comparison of tin isotopes
- The case of $^{120}$Sn
  - Gamma strength function
  - Level densities

## Outlook

- Multipole Decomposition Analysis ongoing
- Extract electric dipole polarisability
- Determine GSF and NLD