

# Proposal for Beam Time and Research Program at IFJ PAN LINAC

## 1. General Information

**Project Title:** Measurements of stretched resonances decays in light atomic nuclei

**Principal Investigator (PI):** Natalia Cieplicka-Oryńczak

**Co-Investigators / Research Team:** Bogdan Fornal, et al.

## 2. Particle and Energy Selection

*Please check the required particle and the target energy section:*

### Primary Particle:

Proton (p+)

Deuteron (2H+ / d)

Alpha (4He2+)

Lithium-7 (7Li3+)

Other (e.g., 16O8+): \_\_\_\_\_

### Acceleration Stage (Energy):

**Section 1:** 2.5 MeV/u

**Section 2:** 12.5 MeV/u

**Section 3:** 250 MeV/u (Future expansion / High energy)

**Custom Energy:** approx. 100-150 MeV/u (Variable range within section limits)

## 3. Abstract of Planned Research

*(Provide a brief description of the experiment, its scientific goals, and the expected outcome – max 300 words)*

This research program focuses on the experimental study of decays of high-lying nuclear states known as "stretched resonances". These single-particle excitations involve a particle and a hole occupying the highest angular-momentum orbitals in their respective shells, coupling to the maximum spin. Due to their relatively simple structure, they offer a unique benchmark for theoretical models capable of describing the unbound states.

We propose to investigate the decays of M4 stretched resonances arising from  $1p_{3/2} \rightarrow 1d_{5/2}$  transitions, populated via inelastic proton scattering at beam energies of  $\sim 100\text{--}150$  MeV. These studies will employ coincidence measurements of: scattered protons (to determine the excitation energy of the target nucleus), light charged particles from the resonances decays, and gamma rays from daughter nuclei. Specific cases include  $^{11}\text{B}$ ,  $^{15}\text{N}$ ,  $^{17}\text{O}$ ,  $^{18}\text{O}$  nuclei with M4 states located in the 11–22 MeV energy range.

The experimental setup will rely significantly on equipment already available at the Cyclotron Centre Bronowice, namely: a large vacuum chamber, the KRATTA system for scattered protons measurements, the PARIS array for gamma-ray spectroscopy, and a mini-array of DSSD detectors for light charged particle detection. Recent experiments at CCB, involving  $^{13}\text{C}$  and  $^{16}\text{O}$  cases, have

demonstrated the feasibility of this approach. However, certain improvements would be beneficial to achieve more accurate results for more complex cases with overlapping states. These experiments would greatly benefit from utilizing a pencil-like beam with stable energy, a substantially reduced halo, well-defined interaction point on the target and a finely controlled timing.

Additional upgrades to the setup include: HPGe detectors for discrete gamma-ray spectroscopy, a mass spectrometer to improve excitation energy resolution, and neutron detectors to measure neutron decay branches. These developments would also enable the studies of M6 ( $1d_{5/2} \rightarrow 1f_{7/2}$ ) resonances decays in nuclei such as  $^{28}\text{Si}$ ,  $^{24}\text{Mg}$ ,  $^{26}\text{Mg}$ , and  $^{32}\text{S}$ , where high resolution of gamma and excitation energy is crucial.

#### 4. Technical Beam Requirements

*Please specify the desired beam parameters to ensure the feasibility of the experiment:*

**Intensity / Current:**

Required current on target: 0.1 nA – 20 nA

High intensity requirements (if applicable): \_\_\_\_\_ mA

**Time Structure:**

Pulse repetition rate:  100 ns |  200 ns |  400 ns |  Other: \_\_\_\_\_

Bunch width (Sigma/FWHM): ~1 ns FWHM

Requirement for zero dark current (no background between pulses)

**Beam Spot Geometry:**

Desired spot size on target: 0.5 mm

Requirement for no beam halo

**Energy Resolution:**

$\Delta E$  requirement: < 100 keV or better

#### 5. Application Category

**Fundamental Nuclear Physics**

**Medical Applications**

**Electronics Irradiation**

**Material Science / Biophysics**

#### 6. Additional Infrastructure Needs

- HPGe detectors
- Neutron detectors
- Large experimental hall needed for placing the equipment, in particular a mass spectrometer.