Study of structure of neutron rich nuclei around N~20 though electromagnetic excitation.

S. Chakraborty[1], A. Rahaman[1], T. Aumann[2], S. Beceiro[3], T. Le Bleis[4], K. Boretzky[2], D. Cotrina-Gil[3], C. Caesar[2], M. Chariter[5], W. N. Catford[6], U. Datta Pramanik[1]*, D. Gonzalez-Diaz[2], H. Emling[2], P. Diaz-Fernandez[3], Y. Dimitry[7], L. M. Fraile[8], , G. De Angelis[9], O. Ershova[2], H. Geissel[2], M. Heil[2], M. Heine[2], T. Heftrich[4], B. Jonson[10], A. Kelic[2], H. Johansson[10], R. Krucken[11], T. Kroll[4],C. Langer[2], Y. Leiffel[2], G. Munzenberg[2], A. Movsesyan[2], J. Marganiec[2],C. Nociforo[2], A. Najafi[12], V. Panin[2], R. Plag[2], H. A. Pol[3], S. Paschalis[13], R. Reifarth[2], D. Rossi[2], I. Ray[1], G. Rastrepina[2], H. Simon[2], C. Scheidenberger[2], S. Typel[2], J. Taylor[5], Y. Togano[14], E. Uberseder[2], V. Volkov[2], H. Weick[2], A.Wagner[7], F. Wamers[2], M. Weigand[2], J. Winfield[2], M. Zoric[2]

[1]Nuclear Physics Division, Saha Institute of Nuclear Physics, Kolkata -700064, INDIA
[2]Gesellschaft für Schwerionenforschung (GSI), D-64291 Darmstadt, Germany
[3] Univ. Santiago Compostela, E-15782 Santiago de Compostela, Spain
[4]Technical Unin. Dramstadt, Germany
[5] Department of Physics, University of Liverpool, UK
[6]University of Surrey, Guildford, UK
[7] Forschungszentrum Dresden-Rossendorf (FZD), Dresden, Germany
[8]Grupo de Física Nuclear, Facultad CC. Físicas, Universidad Complutense, E-28040 Madrid, Spain
[9] INFN,Laboratori Nationali di Legnaro, legnaro, Italy
[10] Fundamental Fysik, Chalmers Tekniska Högskola, S-412 96 Göteborg, Sweden
[11]Technical Unin. Munich, Germany
[12]Kernfysisch versneller instituut, Netherland
[13]Lawrence Berkeley National Laboratory, USA
[14]The Institute of Physical and Chemical Research (RIKEN), Japan
** email: ushasi.dattapramanik@saha.ac.in*

Introduction: Magic numbers in Nuclear Physics are familiar to us due to Mayer and Jensen and considered as the building block of nuclear structure since 1960. Pioneer works by Thibault et. al[1] and later Motobayashi et al[2] clearly pointed out the failure of "magic number" around N~20 mass region. The neutron rich isotope of magnesium containing magic number (N=20) of neutrons shows anomalous behavior with reference to the expected and ever seen properties of nuclei at magic numbers [2]. The break down would be clearly reflected in these nuclei (N~20) e.g. Ne, Na, Mg in their ground states, as the valence neutrons are at higher *pf* shell rather than at expected lower *sd* shell. Using Radioactive Ion Beam (RIB) we are now in a position to study the properties of those nuclei and probably to redefine the concept of "magic number" in future. In September, 2010 we have performed an experiment using existing RIB facility at GSI, Dramstadt to study the properties of nuclei through electromagnetic excitation of neutron rich nuclei around N~20. Our aim is to find out the quantum numbers of valence neutron of these nuclei for odd-even and even-even in their ground states and excited states above neutron threshold.

Experiment: ^{40}Ar beam (530 MeV/u), delivered by the synchrotron SIS at GSI, Dramstadt was fragmented using Be target (8gm/cm^2). Varieties of isotopes, produced by fragmentation were separated according to their magnetic rigidities using the Fragment Separator (FRS). Suitable degrader was used to take care of our interested nuclei of Ne, Na, Mg and Al with A/Z ratio 2.6-2.85. The secondary beam contained $^{27-28}$Ne, $^{30-31}$ Na,$^{31-33}$Mg, $^{34-35}$Al were transferred to cave C, where kinematically complete measurements were performed after the secondary reactions with Pb and C targets. In order to detect γ-rays, the target was surrounded by the 4π Crystal-Ball spectrometer consisting of

160 NaI detectors. The secondary beam was identified uniquely by means of energy-loss in PSP and time difference between two scintillators (POS and S8) placed before the secondary target. The trajectories of the particles were measured with position-sensitive silicon diodes placed before and after the secondary target. After the secondary reaction the fragments, fragment-decaying particle like proton(s), neutron(s), alpha(s) etc. are forward focused due to Lorentz boost and pass trough A Large Dipole Magnet (ALADIN). Neutron's trajectory remains unchanged inside the ALADIN and detected by Large Area Neutron Detector (LAND). The fragments are deflected inside ALADIN depending upon their A/Z ratios and tracked via GFI and TFW kept at an angle 15 degree with respect to LAND. Since protons are much lighter they are deflected much inside ALADIN and tracked via Drift Chamber (DC)

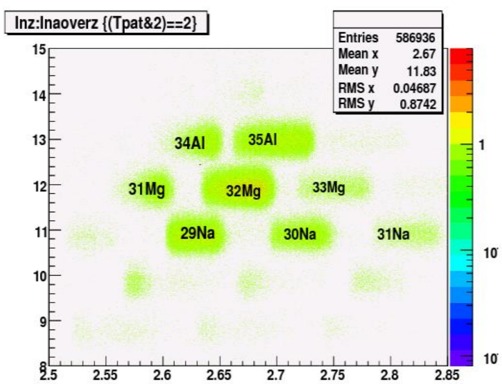

Fig. 1 Incoming beam A/Z vs Z

and DTF kept at an angle 30 degree.

Calibration: In this experiment we are using several detectors to measure the kinematics of fragments, ejectiles and gamma decaying from fragments. Proper calibration is required to extract information after performing the experiment.

<u>Incoming identification</u>: The nuclei with different charges when pass through PSP they loss energy which serve as the fingerprint of the nuclei. Using ATIMA calculation based on Bethe-Bloch formula we can estimate the amount of energy loss in the active dimension of PSP and from there we can plot Z vs. Channel in PSP spectra. Using the slope and intercept of the straight-line and time of flight measurement we can identify the incoming particles. Fig. 1 shows such a plot.

Outgoing fragments identification:

<u>TFW</u>: We use TFW to measure time, position and energy loss of the fragments after the secondary reaction. TFW consists of 14 horizontal and 18 vertical paddles which are made of scintillator. During sweep run all the vertical paddles are illuminated. After performing the pedestal subtraction, gain matching of individual paddles was performed and fig. 2 shows such a gain matched plot.

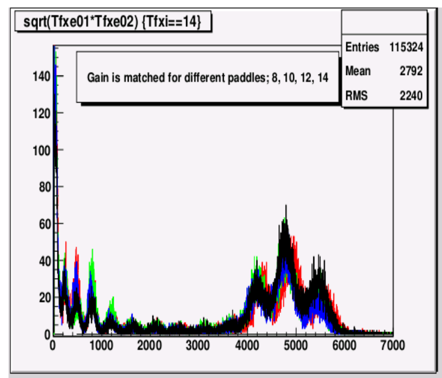

Fig.2. Square root of Fragment energy loss

Discussion: Low lying dipole strength has been measured for neutron-rich carbon, oxygen, neon isotopes. Experimentally, low-lying dipole strengths were observed in the light halo nuclei ^{6}He[3], ^{11}Li[4], ^{11}Be[5], ^{15,17}C[6],^{19}C[7], but recently also more tightly bound isotope $^{17-22}$O[8]. We are looking for low lying dipole strength of Na, Mg, Al in this mass region. Our aim is to study the ground states and excited states of neutron rich Al, Mg, Na, Ne nuclei above neutron threshold by the method of coulomb breakup [5, 6, 7, 8].

References:

[1] C. Thibault et al., PRC 12, 644 (1975).
[2] Motobayashi T, et al. PLB, 346, 9(1995).
[3] T. Aumann, et al. , PRC 59 1252(1999) .
[4] D. Sackett, et al. , PRC 48, 118 (1993).
[5] T. Nakamura, et al. , PLB 331, 296 (1994).
[6] U. Datta Pramanik, et al. , PLB 551, 63 (2003).
[7] T. Nakamura, et al. , PRL 83 1122(1999).
[8] A. Leistenschneider, et al. , PRL 86, 5442 (2001) .