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ORIC CENTRAL REGION CALCULATIONS*

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Abstract

The central region for the K=100 Oak Ridge Isochronous Cyclotron, ORIC, will be modified to provide better orbit centering, focusing of orbits in the axial direction, and phase selection, in order to improve extraction efficiency, and reduce radioactive activation of cyclotron components. The central region is specifically designed for the acceleration of intense light ion beams such as 60 MeV protons and 15 - 100 MeV alphas. These beams will be used in the production of radioactive atoms in the Radioactive Ion Beam Project at Oak Ridge National Laboratory.

I. RIB PRODUCTION REQUIREMENTS ON ORIC

The Holifield Radioactive Ion Beam Facility, HRIBF, will use the K= 100, Oak Ridge Isochronous Cyclotron, ORIC, as a driver to provide beams of light ions (protons, deuterons, helium, and lithium) ranging from 10 – 65 MeV on target[1]. These will produce proton-rich radioactive atoms for acceleration in the HRIBF 25 MV Tandem. The Target Ion Source on the RIB Platform, presently has a carbon window 170 mg/cm^2 thick. Using the energy loss in this window as a guide, ORIC will need to operate at K$\geq$15 for protons, K$\geq$35 for deuterons and 2-plus helium, and K$\geq$60 with 3-plus lithium. These beams need intensity so as to provide experimenters with sufficient radioactive ions to study nuclear structure and astrophysis. Direct and induced radioactivity produced by these beams, require further constraints on ORIC. The administrative limits for operation as a low hazard facility will be 50μA of 65 MeV protons, and 200μA of 100 MeV alphas. Good extraction efficiency (90+%) is needed to minimize the induced radioactivity produced in ORIC.

II. AN OVERVIEW OF ORIC HISTORY

ORIC was constructed and began operation over three decades ago[2]. It was initially used to accelerate both light ions. The acceleration of heavy ions in ORIC first took place in 1968[3]. Extraction was achieved by inducing radial oscillations near the center of the cyclotron, and using the precession at 29 in., while ν_r was still $\simeq$ 1.05, to increase the radial separation between turns near the deflector septum[4]. In the early 80's, ORIC was converted to be used as a booster for the 25 MV tandem accelerator. A new magnetic field mapping was performed for this conversion in the range of 12–20 kG. This enabled the writing of a set of cyclotron injection/orbit/extraction codes which accurately predicted machine settings for operating the cyclotron in coupled mode for K$\geq$ 60[6]. A new extraction method soon followed. The injected tandem beam had a small emittance, a 6° RF Phase width, and was injected with very good centering. A first harmonic bump was then used at outer radii to produce radial separation closer to the $\nu_r = 1$ resonance, ($\nu_r \simeq 1.017$). These qualities improved the extraction efficiency from a typical 30% to a typical 70%[5] Calculated turn separation at extraction is .1 in.

III. THE PRESENT ORIC CENTRAL REGION

The ORIC central region has been restored to a configuration similar to central regions used before the coupled operations. A PIG ion source is inserted on a radial arm from the North side of the machine. The source, which was modified to use a smaller chimney, can be positioned in both directions in the median plane. The puller, which is a little hook extending out from the dee, can be positioned in one dimension only, along the edge of the 180° dee. It's position in the other direction can be changed by removing the dee and replacing the puller. A radial clipper has been added. It is a small plate with a slot cut axially, that has been mounted on the dee, and runs parallel to the puller. In addition, the source head has been modified so that two plates can be mounted on them to form an axial slit which will restrict the beam axially within the first few turns[7].

Axial focusing in the central region is provided by two separate mechanisms. The first is geometric. The source chimney is set back from the leading edge of the source head. The electric field, which was calculated with RELAX3D[8], penetrates in to the source. Calculations, made with Z3CYCLONE[9], show that this provides axial focusing over most of the gap between the source and the puller when the electric field is accelerating the ions. This axial focusing in the first gap is extremely strong. It over focuses, causing the beam to expand axially. This

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