RADIOACTIVE ION BEAM LINE IN LANZHOU

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Abstract

In this presentation, we describe the radioactive ion beam line in Lanzhou (RIBLL), the main feature of RIBLL structure and main performances of RIBLL. Some preliminary experimental results are presented.

1. INTRODUCTION

So far, the most reaction induced by radioactive ion beam (RIB) was studied on the Projectile Fragmentation (PF) type RIB facility in the medium and high energy domain, such as LISE at GANIL, RIPS at RIKEN, FRS at GSI, A1200 at MSU and so on [1,2]. However, it is difficult to perform the higher accuracy experiment on PF type facility due to the poor RIB quality in momentum [3]. Thus some important information could not be observed in this kind experiment [4]. Therefore, it is the open subject to improve the experiment accuracy for new PF type facility. The Radioactive Ion Beam Line in Lanzhou (RIBLL) is the new PF type facility to overcome this problem partly in the energy up to 80 MeV/u.

2. DESIGN AND LAYOUT

RIBLL is deigned as the asymmetry double achromatic configuration of 2QD2Qfd(1)QD2Qfa(1)2Q D2Qfd(2)2QD2Qfa(2) (fig.1.) It consists of 16 quadruple, 4-dipole, 1 swinger and 35 meters beam transport line. In general, the primary target is put inside the target chamber of T0, and secondary target is set in the T1 or T2 depending on the experiment requirement. This kind of structure opens the opportunity to produce RIB in more pure, identify the RIB easily and flexibly use the 2nd part of RIBLL (T1 ~ T2) as high accuracy 0^0 spectrometer with the large acceptance of the geometry and the momentum. Two advantage methods used in other RIB facility were adopted in RIBLL, such as the strong focusing the primary beam on the primary target and the deflecting the incident beam to obtain partly polarization RIB.

Fig.2 shows the beam profile of 1st part of RIBLL (T0 ~ T1) which is calculated with the code TRANSPORT in the condition of Bρ= 4.15 Tm, $\Delta\theta=\Delta\varphi=50$mrad, $y_0=x_o=1$mm. The beam profiles in fig.2a and fig.2b represent the momentum dispersion of 0% and ±5% respectively, in which the solid line indicates the beam profile in 1st order calculation and dash line to 2nd order calculation. RIBLL's ion-optical system has been corrected for 2nd order aberrations by adopted the different shape in the entrance (~8.9m radium) and exit (~44 cm radium) of dipole. The main ion-optical parameters are listed in the table 1.

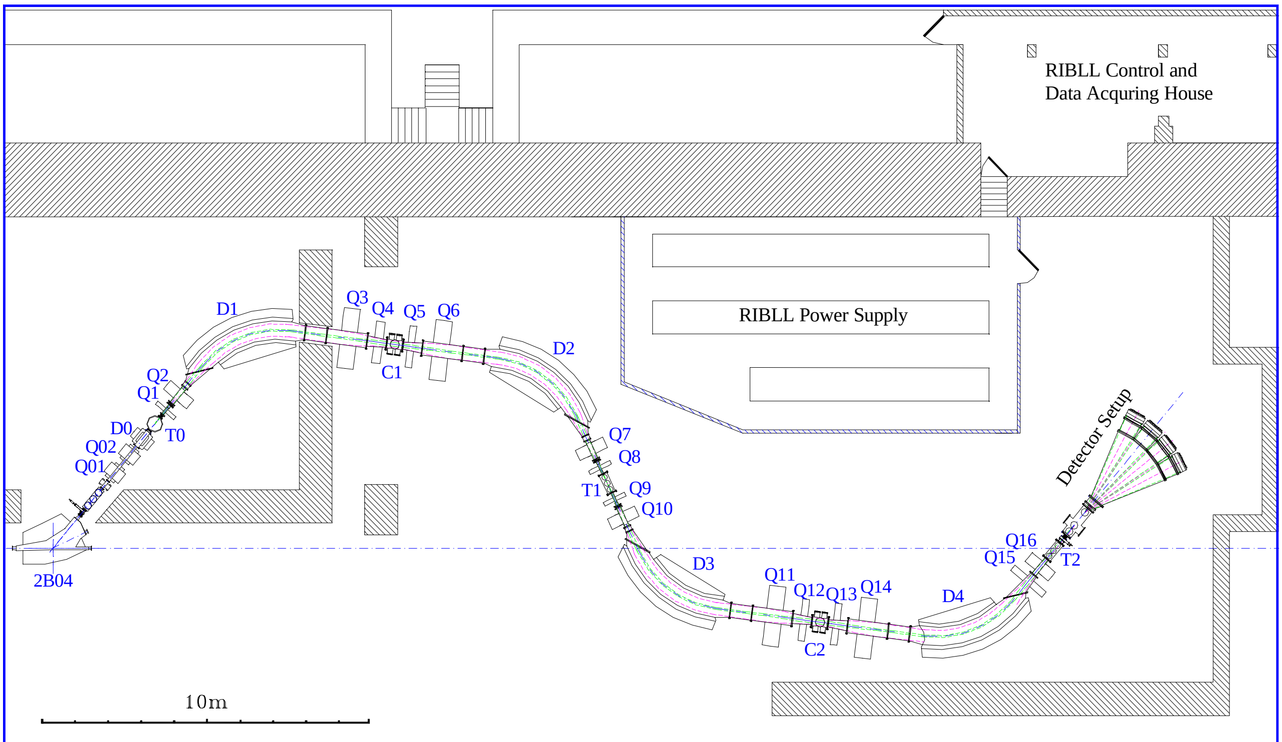

Fig. 1 RIBLL layout

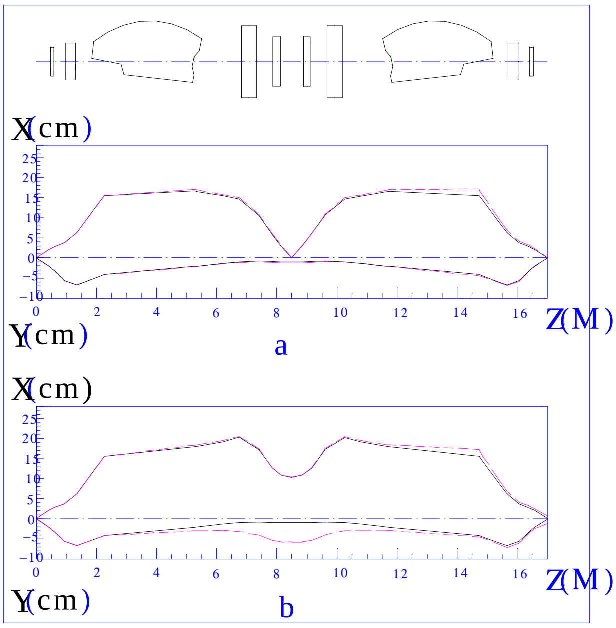

Fig.2 the profile of RIBLL

Table 1. Main ion-optical parameters

Matrix element	At C1	At T1
(x|x)	0.592	1.000
(x|x')[cm/mrad]	0.000	0.000
(x|δp)[cm/%]	-2.070	0.000
(x'|x)[mrad/cm]	0.149	0.000
(x'|x')	1.689	1.000
(x'|δp)[mrad/%]	0.000	0.000
(y|y)	9.516	1.000
(y|y')[cm/mrad]	0.024	0.000
(y'|y)[mrad/cm]	0.069	0.000
(y'|y')	0.105	1.000

The main performances of RIBLL are indicated in table 2. Considerably large solid angle acceptance and momentum acceptance are designed. The 17 meters length of TOF in the 2^{nd} part of RIBLL will benefit the particle identify and the higher mass resolution.

Table 2. RIBLL main performances

ΔΩ[msr]	>7
ΔP/P[%]	10%
Bρ [Tm]	4.2
ΔBρ/Bρ	6×10^{-4}
A/ΔA	>300
Swinger Angle	$0^o\sim5^o$

3. RIBLL CONSTRUCTION & EXPERIMENT

3.1 RIBLL Construction

RIBLL was construction from Nov. 1995 to June 1997 within 20 months. The accuracy of dipole is about 5×10^{-4} and 5×10^{-3} for quadruple gradient. The alignment of the magnet device on RIBLL is typical of ±0.1mm in the horizontal, vertical direction and ±0.5mm in the beam transport direction.

3.2 Experimental Setup

The tuning experiments were performed by the reaction of 60MeV/u ^{18}O + Be and 80MeV/u ^{20}Ne + Be beginning in July 1997. 2-3mm thick target was mount in the target chamber of T0 to produce radioactive ion beam (RIB). 1 mm thick wedge shape degrator was set in C1 to select RIB by the method of Bρ-ΔE-Bρ[5]. In order to identify RIB, the transparent type (~50μm plastic scintillator foil) timing detector t1 and t2 were put into T1 and T2 to obtained TOF (ΔTOF_{FWHM} < 200ps), a si slice detector to measure ΔE (δΔE/ΔE ~ 3×10^{-3}) and a position sensitive CsI detector used as E_r detector (($\delta E_r/E_r$ ~ 1.5%) and beam spot detector in T2. Hence, the RIB can be identify event by event as follow:

$$A/Q \propto B\rho*(1.0+\delta\rho)*TOF$$

$$Q \propto E*TOF/B\rho_0(1+\delta\rho)$$

$$Z \propto \sqrt{\Delta E}/TOF$$

3.3 Experimental Results

About 50 RIB species were extracted in two reaction successfully. Fig.3 shows the overview of RIB in the

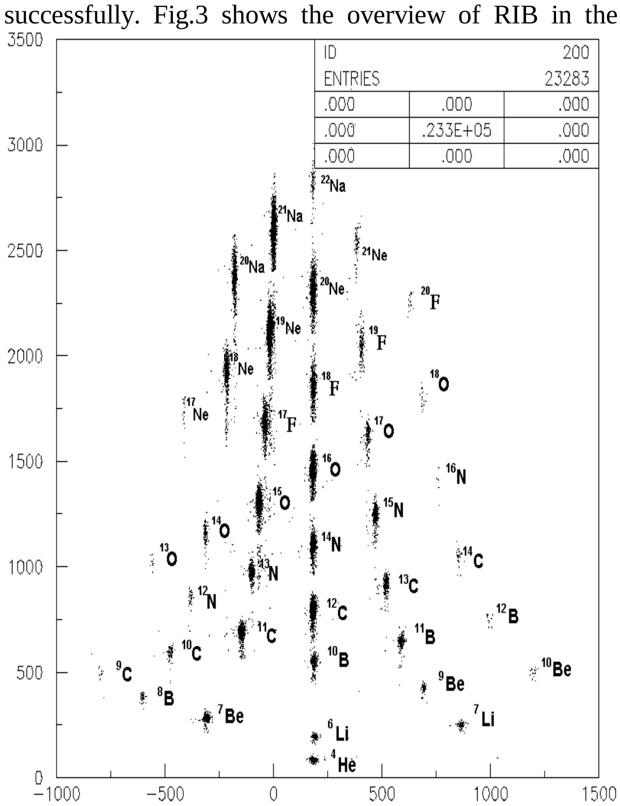

Fig.3 RIB distribution in the reaction of 80MeV/u ^{20}Ne + Be

reaction of 80Mev/u ^{20}Ne + Be which is good agreement with the prediction. Obviously, the every particle is identified clearly. The mass resolution >300 is obtained by projecting ^{16}O on TOF axis as fig.4, where the zero channel is about -3900. The RIB spot on T1 is about 1.2 cm in X and 1.0 cm in Y, and that on T2 is about 3.0 cm in X and 2.0 cm in Y which agree with the calculation by the code TRANSPORT.

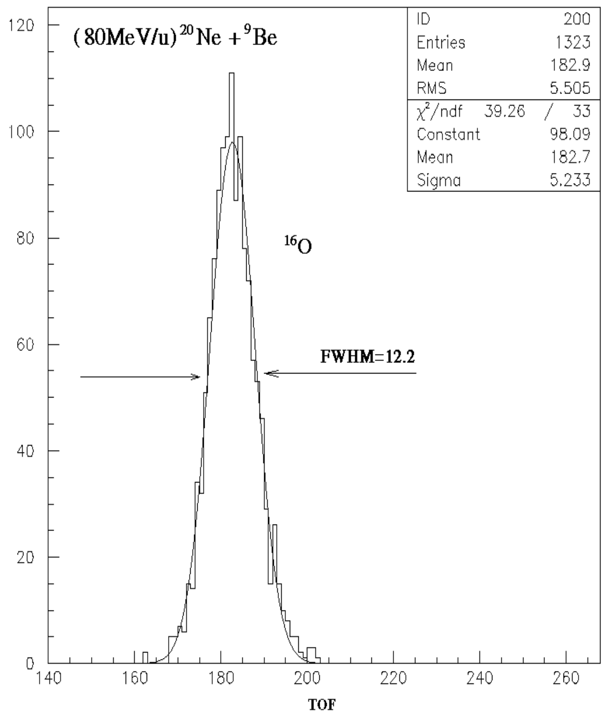

Fig.4 ^{16}O spectrum in 80MeV/u ^{20}Ne + Be reaction

There are two kind operating modes on RIBLL. In 1st mode, RIB is produced in T_0 and separated in flight by maximum 3 stage of Bρ-ΔE-Bρ from D1 to D4. Therefore, high purity RIB can be obtained this operating mode. In 2nd mode, RIB is produced in T_0 and separated in flight by only one stage of the Bρ-ΔE-Bρ from D1 to D2. The high accuracy experiment could be performed in which RIB bombarding the target on the T_1, then, measuring its products by the spectrometer ability of the 2nd part of RIBLL.

4. CONCLUSION

In the summary of the presentation, RIBLL is high performance PF type RIB facility since some advantage methods are combined in it and its asymmetry double achromatic structure can be flexibly to use the 2nd part as high accuracy 0^0 spectrometer with the large acceptance of the geometry and the momentum. The delicate construction and detail tuning experiment make the good agreement between the experiment. And, RIB products rate is matching the prediction.

5. ACKNOWLEDGMENTS

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