BB

GANIL

The new LISE 2000 Facility at GANIL

presented by Rémy ANNE ,

GANIL, BP 5027, 14076 Caen Cedex 5 France ,

for the LISE 2000 collaboration ,

at the " EXON – 2001" International Symposium on Exotic Nuclei,
Baikal lake, Irkutsk, 24-28 July 2001

GANIL P 02 01

The new LISE 2000 facility at GANIL.

presented by Remy ANNE

for the LISE 2000 collaboration.

1. Introduction.

The project LISE 2000 was discussed in the GANIL Scientific Council session of 3-4 December 1998 (ref. 1). It is a project financed and constructed by a collaboration of laboratories:

GANIL Caen
CEN – Bordeaux Gradignan
CHARISSA collaboration (UK)
IPN Orsay
LPC Caen

The LISE facility has been running since 1984. All along the last years, different upgradings were achieved, essentially aiming at providing supplementary selection means, in order to purify the secondary beams of exotic nuclei. They were:

A variable angle of the incident primary beam on the target in order to reject the beam charge states.

A velocity filter.

The increase of the magnetic rigidity of the first analysing section, allowing theoretically to work with thick degraders.

Finally a variable vertical angle dipole mounted on a rotating platform, transforming the LISE spectrometer in a mass spectrometer (A/Q) by matching the dispersion of the Wien filter with the one of the vertical dipole (ref. 2).

Nevertheless, as far as the energy is concerned, the maximum available magnetic rigidity remains to day limited at 3.2 T.m.

The upgrade of LISE, called LISE 2000, (see fig.1), consists in the addition of a new magnetic analysis channel, partly existing, on the (same) production target of LISE, but having:

a magnetic rigidity increased, up to 4.3 T m instead of 3.2,
a geometrical acceptance increased by a factor 3.

2. The physics motivations.

Among the motivations for such an upgrade are: the study of light neutron rich nuclei at the limit of stability up to Z = 9, the halo nuclei, like 8 He, 11 Li, 9 C, the nuclei having a clusters structure like 12 Be, 16 C, the study of the nuclei properties in the Al – Cl region around the shell closure N = 28, and finally the study of isomeric states in the neutron rich nuclei, around

N = 40 and 50. For this last topic, some nuclei having a very short time of life, the gain in collection can be very much increased, due to the shorter LISE 2000 line length,(ref. 3, 4, 5)

For all these studies, the higher magnetic rigidity will mainly allow the production with a better statistics of neutron rich nuclei, taking also benefit of the maximum available energy of GANIL beams, which is not now the case.

3. Some elements of optics.

The optics of the LISE 2000 line and its properties are similar to the one of LISE, concerning the double achromatism, the use of an achromatic degrader and so on (see ref.2). The main constraint for the implantation of this new line was naturally the existing LISE facility, which must not be too much disturbed by this new construction. The second one was the necessity to have enough place around the focus point in the D4 room, preserving the mounting of large detectors like for example DEMON which needs a time of flight length as long as possible i.e. at least 6 meters.

These two constraints determined the dipole angle of the new compensating section: 22.5 °, instead of 45 ° for LISE.

The beam envelope is shown on fig. 2 for the following transverse phase space:

$(x_i, \theta_i) = (+/- 1.5$ mm, $+/- 37$ mr)

$(y_i, \varphi_i) = (+/- 1.5$ mm, $+/- 20$ mr)

$dp / p = 0.0$

The first order transport matrix A between the target and the dispersive focal plane is the following:

$(x_f \; \theta_f \; y_f \; \Phi_f, \; l_f \; dp/p) = A \; (x_i, \theta_i \; y_i \; \Phi_i \; l_i \; dp/p_i)$.

(Transport units: cm, mr, m and %).

-2.79	0.0	0.0	0.0	0.0	-1.95054
14.06841	-0.35776	0.0	0.0	0.0	-4.21949
0.0	0.0	-3.06977	0.0	0.0	0.0
0.0	0.0	-8.98394	-0.32564	0.0	0.0
-3.92354	0.06978	0.0	0.0	1.0	-0.20355
0.0	0.0	0.0	0.0	0.0	1.0

Between the target point and the focal point, that is, at the detection location, the matrix M is:

2.02421	0.0	0.0	0.0	0.0	0.0
-32.65237	0.49359	0.0	0.0	0.0	0.0
0.0	0.0	1.44552	0.0	0.0	0.0
0.0	0.0	49.64932	0.76490	0.0	0.0
0.0	0.0	0.0	0.0	1.0	-0.23481
0.0	0.0	0.0	0.0	0.0	1.0

And between the degrader position and the focal point:

-0.72456	0.0	0.0	0.0	0.0	-1.41365
4.73783	-1.37962	0.0	0.0	0.0	3.42032
0.0	0.0	-0.49584	-0.0	0.0	0.0
0.0	0.0	-9.31724	-2.35695	0.0	0.0
-0.42194	0.19506	0.0	0.0	1.0	-0.03123
0.0	0.0	0.0	0.0	0.0	1.0

4. Simulations

Some simulations using the LISE code (ref. 6) are presented (ref. 7). They include production comparisons between LSE 2000 and the existing GANIL devices, like LISE3 (ref.2) and SISSI (ref. 8). The simulations which are compared, are done in all cases, for the optimum set-up of each device. Thus, is taken into account: the geometrical and momentum acceptances of each one, but also the optimum target thickness and the magnetic rigidity limitations.

As an example, the case of the production of fluorine nuclei produced by fragmentation of a 36 S beam is presented. Fig. 3 shows the optimum BR for the production of N = 10 to 22 isotopes, using SISSI, LISE3, or LISE 2000.

On fig. 4, can be seen for the same fluorine isotopes, the production rates of SISSI and LISE 2000 normalized to the one of LISE3. Beyond N = 17, the gain is clearly significant.

Fig. 5 shows the production in LISE 2000 and SISSI normalized to the one of LISE3, of the different nuclear species (Z = 2 to 9) at the drip line, i.e., 8 He, 11 Li, 14 Be, 19 B, 22 C, 23 N, 24 0, 31 F, using the fragmentation of the same 36 S projectile beam. The expected gain can be 5 to 10.

On fig 6a are shown, identified by the ' energy loss / time of flight' technique, the different species produced by fragmentation of a 36 S beam. Among these nuclei, is plotted on fig 6b as an example, the rate of 8 He and O 24 nuclei, both for LISE3 and LISE 2000. The nuclei are doubly selected, by an achromatic degrader of optimal thickness and by the Wien filter, for LISE3 ,while for LISE 2000 they are only selected by an achromatic degrader.

Concerning the plot 6 b, the 'total rate' is the counting rate of all the produced nuclei (plot 6a), the 'maximum rate' is the maximum counting rate for a nucleus (eventually surrounded by many contaminants), and the 'rate' is the counting rate of this nucleus for a given set-up (i.e. configuration of the Wien filter, and / or, of the degrader).

This plot represents the 'purity of the beam' (of 8 He or 24 O), versus its transmission through the spectrometer:

For the 24 O beam, we see that with LISE 2000, we can have the maximum counting rate (100 %) with a purity of 0.1 %, but still around 85 % with a purity increased by a factor 1000, i.e. without loosing too much nuclei (15 %).

If LISE3 is used, the counting rate is limited to about 40 %, but with a much higher purity.

Concerning the 8 He beam, the counting rate can be much higher using LISE 2000 instead of LISE 3, with a purity about 90 %! (instead of 100 %).

Finally, fig. 7 shows the result which could be obtained for the production of a 31 F beam, using the fragmentation of a 36 S primary beam on a Be target and a selection by a Be achromatic degrader: few contaminants, (note that 28 O is probably not produced) and a transmission around 80 %.

5. Conclusion.

In the field of the production and study of light neutron rich nuclei and short life isomers, LISE 2000 should represent a cheap but significant upgrade of the LISE spectrometer. It should be started in next November.

** At the date of 15 12 01, LISE 2000 has been successfully tested, and a first experiment dedicated to isomers produced by fragmentation of a Krypton beam, in the region of 78 Ni is going on (see photo 1).

References:

1. Scientific Council of GANIL 3-4 December 1998
2. R.Anne,D. Bazin, A.C.Mueller, J.C.Jacmart and M.Langevin., N.I.M. A257 (1987) 215 .
   R.Anne and A.C.Mueller, N.I.M. B70 (1992) 276.
   www.ganil.fr/lise
3. M. Lewitowicz, F. de Oliveira and R. Anne .– Project LISE 2000 - Internal report 28/05/99
4. F. de Oliveira, M. Lewitowicz, . GANIL Info. n° 146 – LISE 2000 -.
5. C. Tribouillard. GANIL Info n° 147 – le Projet LISE 2000 –
6. D. Bazin, M. Lewitowicz, O. Sorlin, O. Tarasov. Code LISE. Web site: http://www.ganil.fr/lise/prog.html
7. F. de Oliveira. Private communication. 07 / 01.
8. C. Grunberg and al., - SISSI – GANIL RI-260 / 89.

Figures captions.

1. General layout of LISE 2000 / LISE3.
2. horizontal and vertical beam envelopes.
3. Available magnetic rigidity for producing Z = 9 isotopes.
4. Production comparison of the Z = 9 isotopes.
5. Production comparison at the drip line.

6a. Ensemble of nuclei produced by fragmentation of a 36 S beam at 77.5 MeV / u.

6b. Purity of a beam versus its transmission.

6. Selection of a 31 F beam.

Photo 1 : The detection point of LISE 2000 in the D4 room at GANIL.

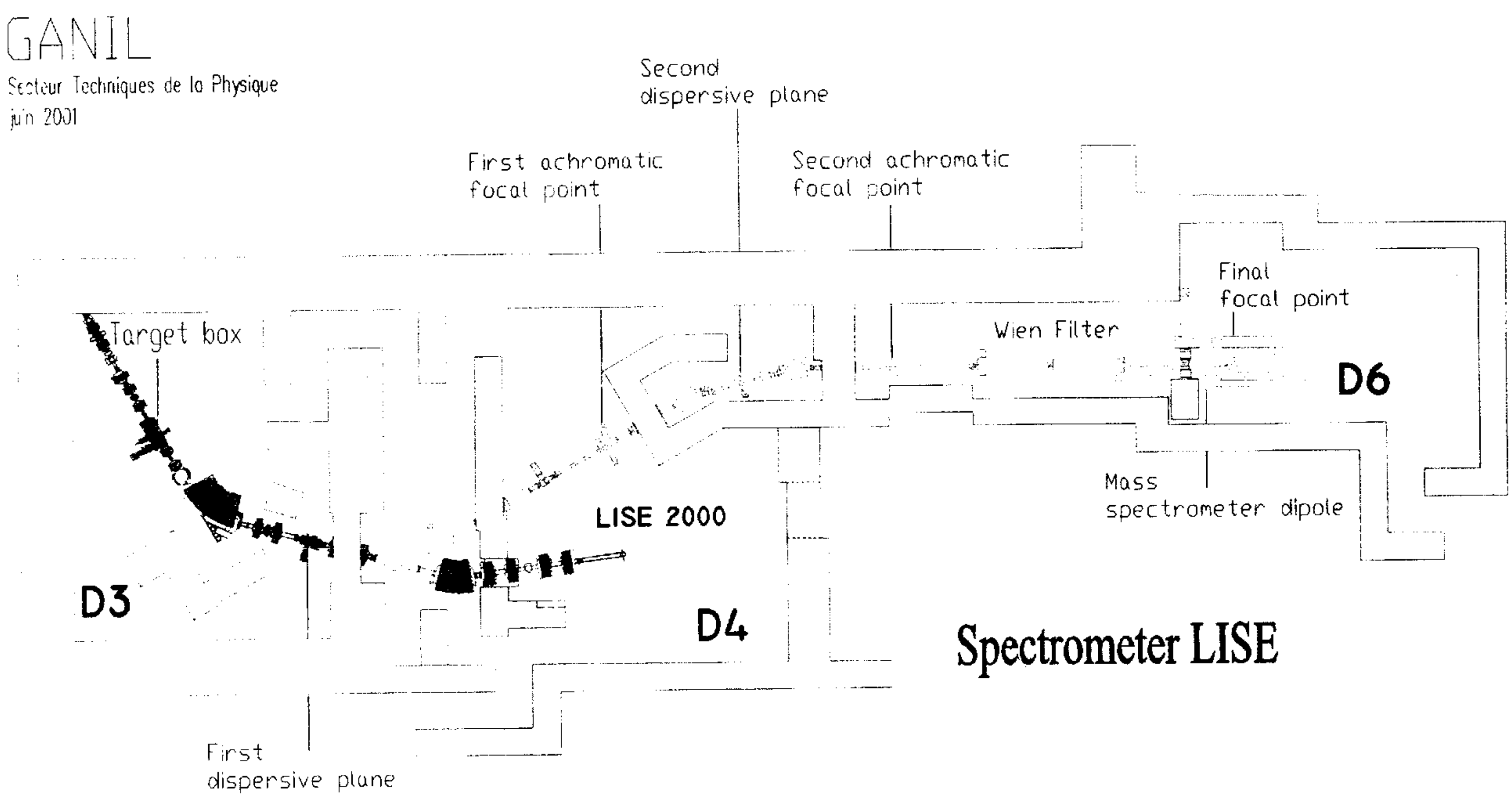

GANIL
Secteur Techniques de la Physique
juin 2001
Second
dispersive plane
First achromatic
focal point
Second achromatic
focal point
Final
focal point
Wien Filter
Target box
D6
Mass
spectrometer dipole
LISE 2000
D3
D4
Spectrometer LISE
First
dispersive plane

Fig. 1

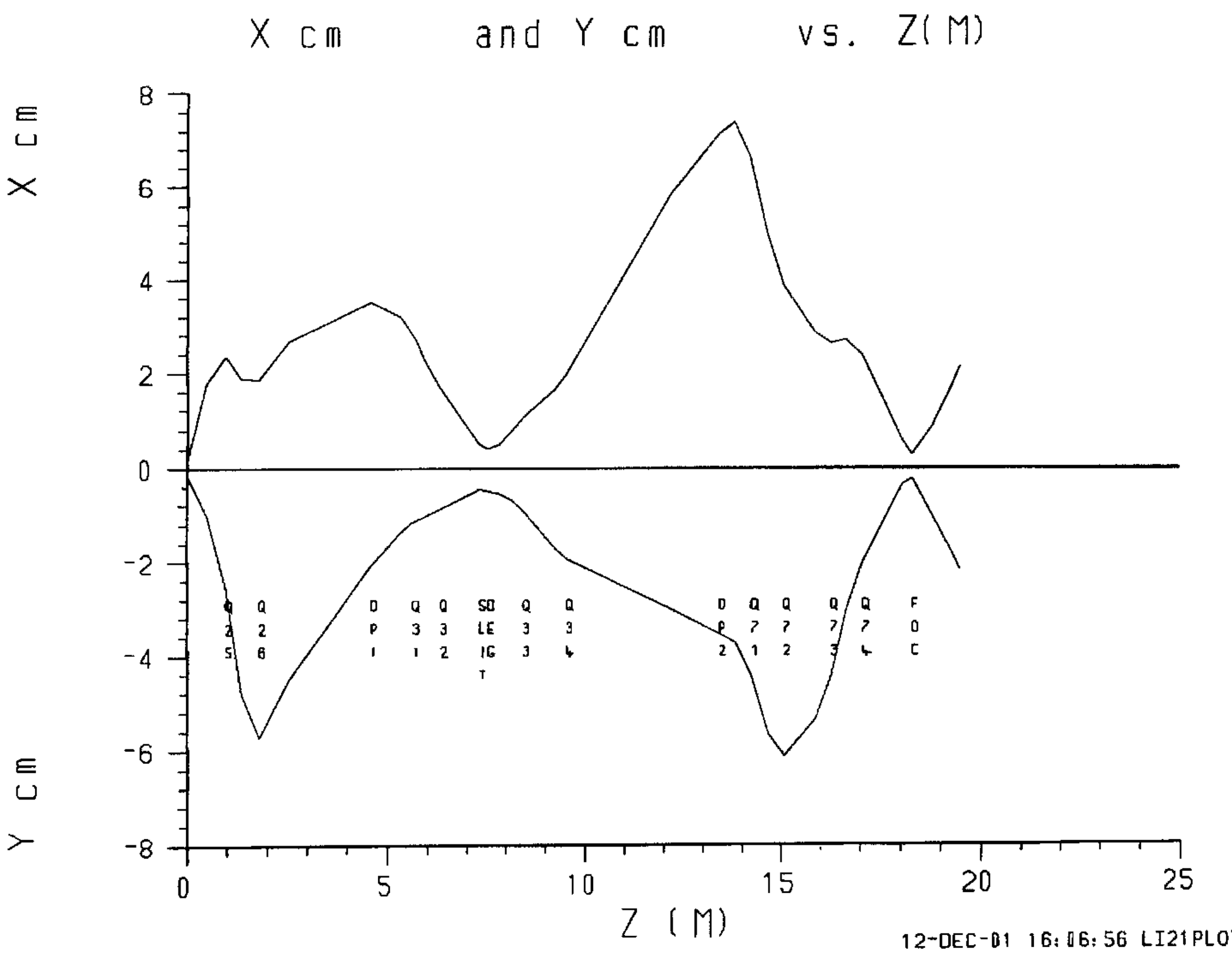


Fig. 2

Magnetic Rigidity

^{36}S beam

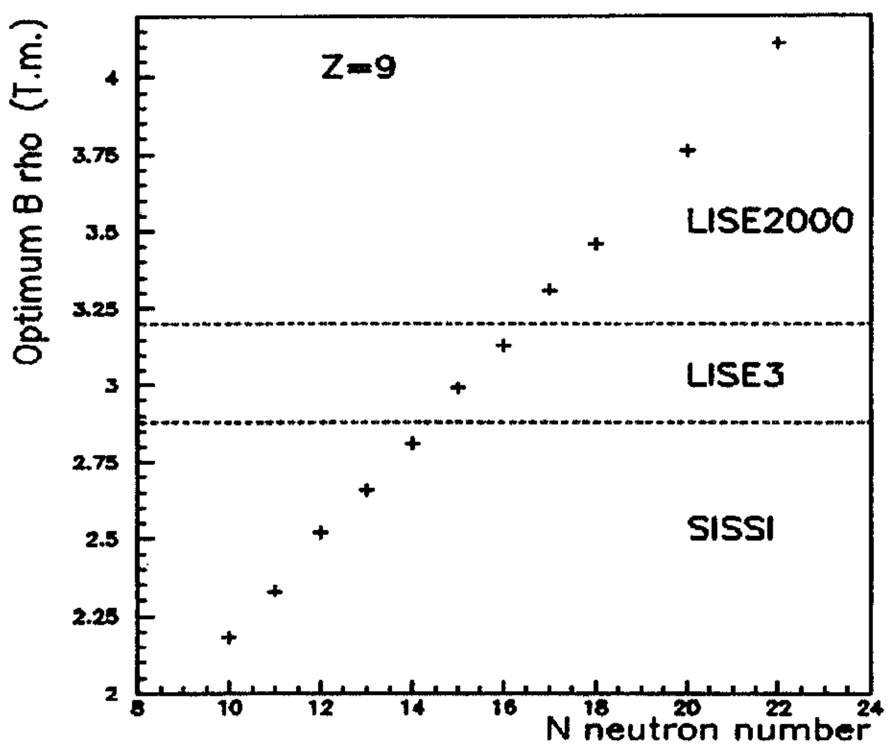


Fig.3

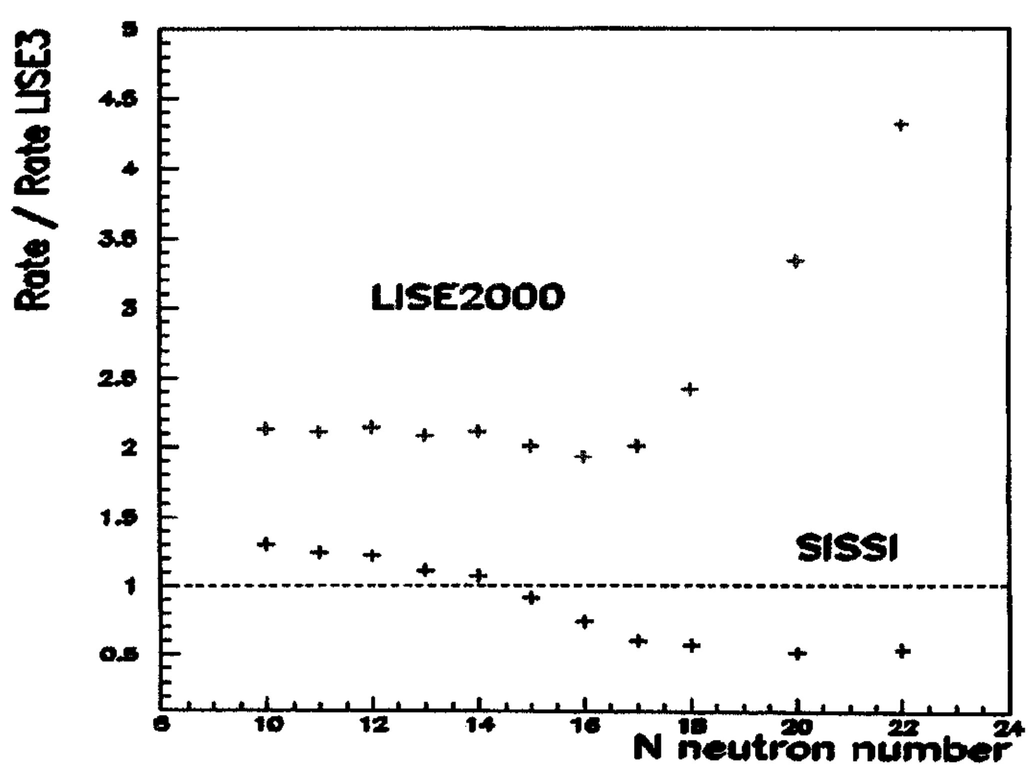


Fig.4

Production   Nuclei at drip line

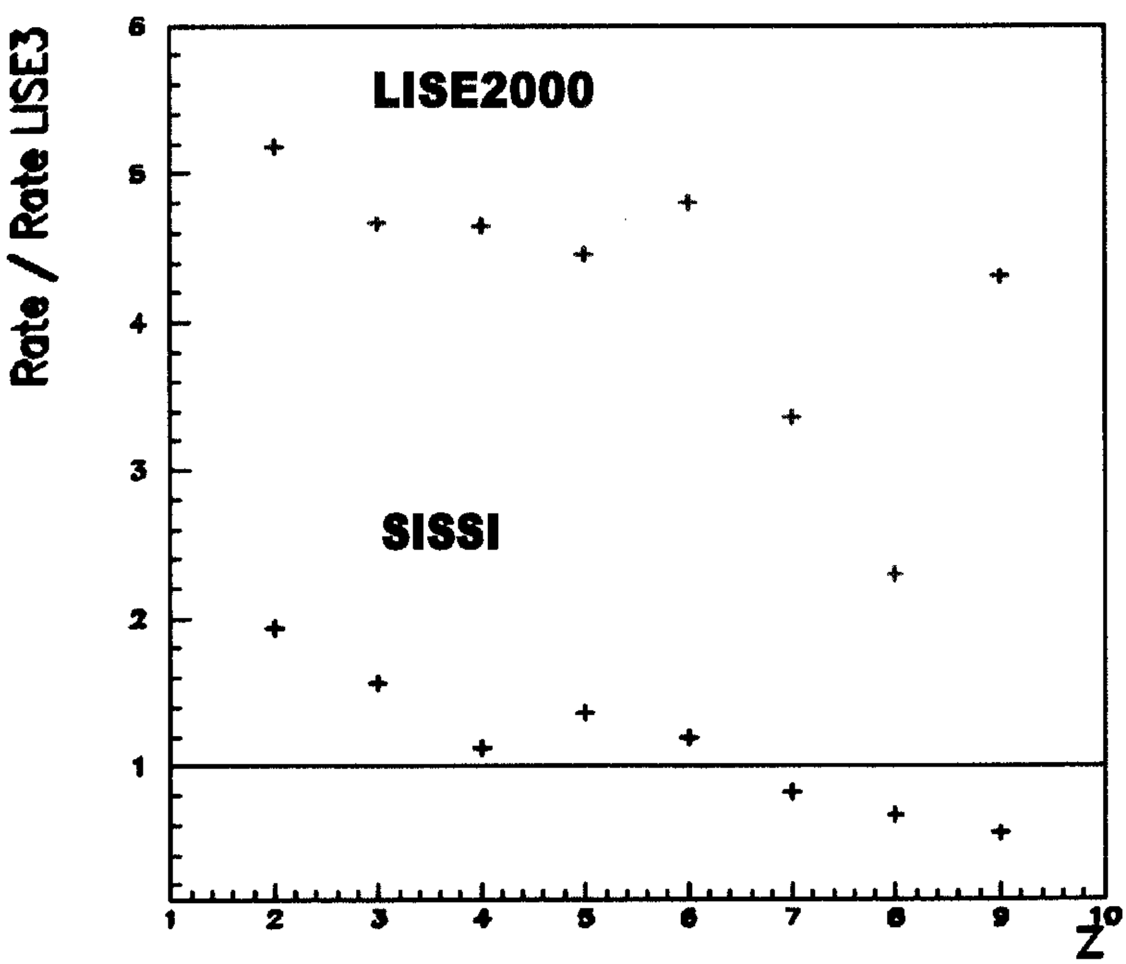


Fig.5

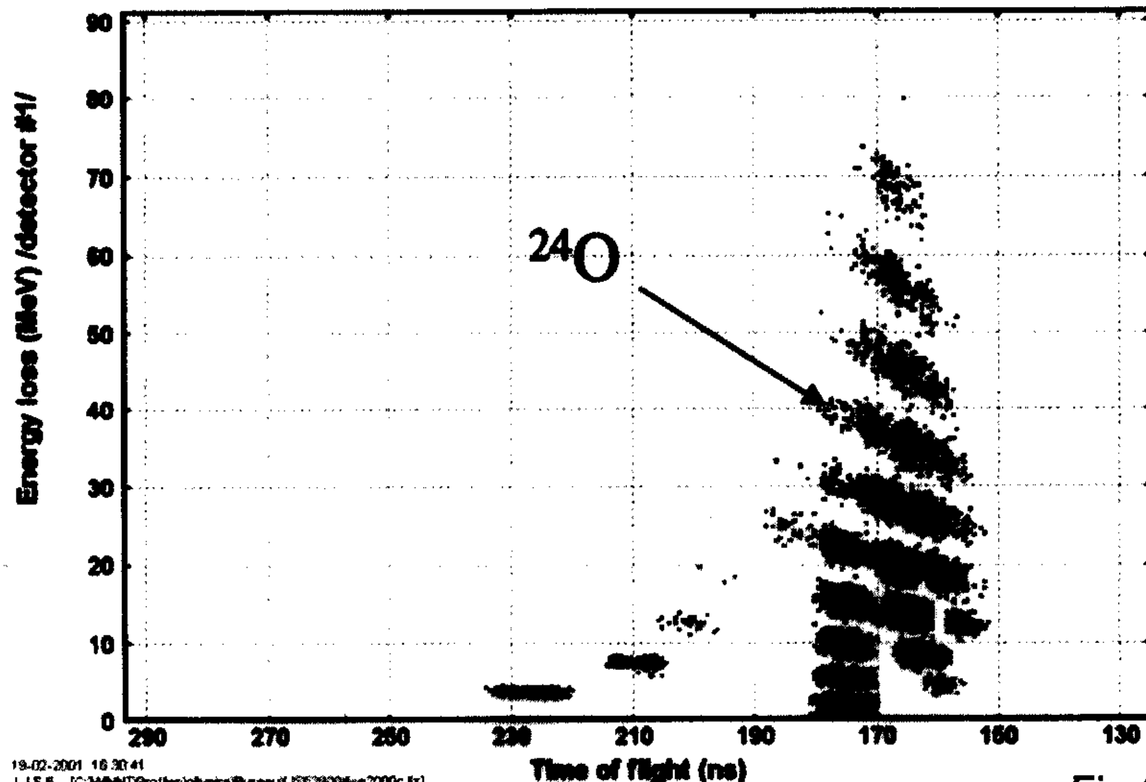

Energy loss (MeV) /detector #1/
Time of flight (ns)
^{24}O
19-02-2001 16:30:41

Fig.6a

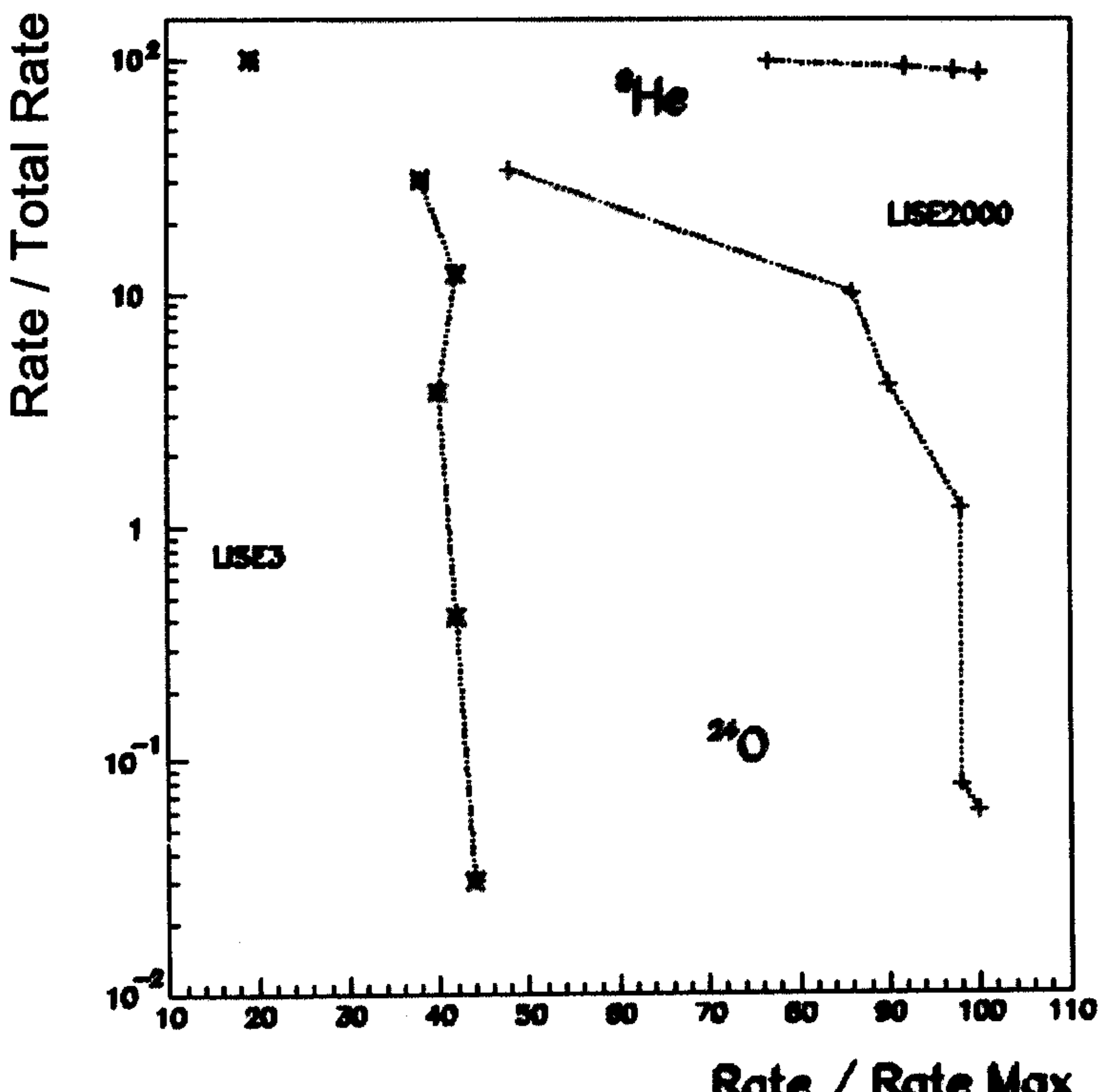
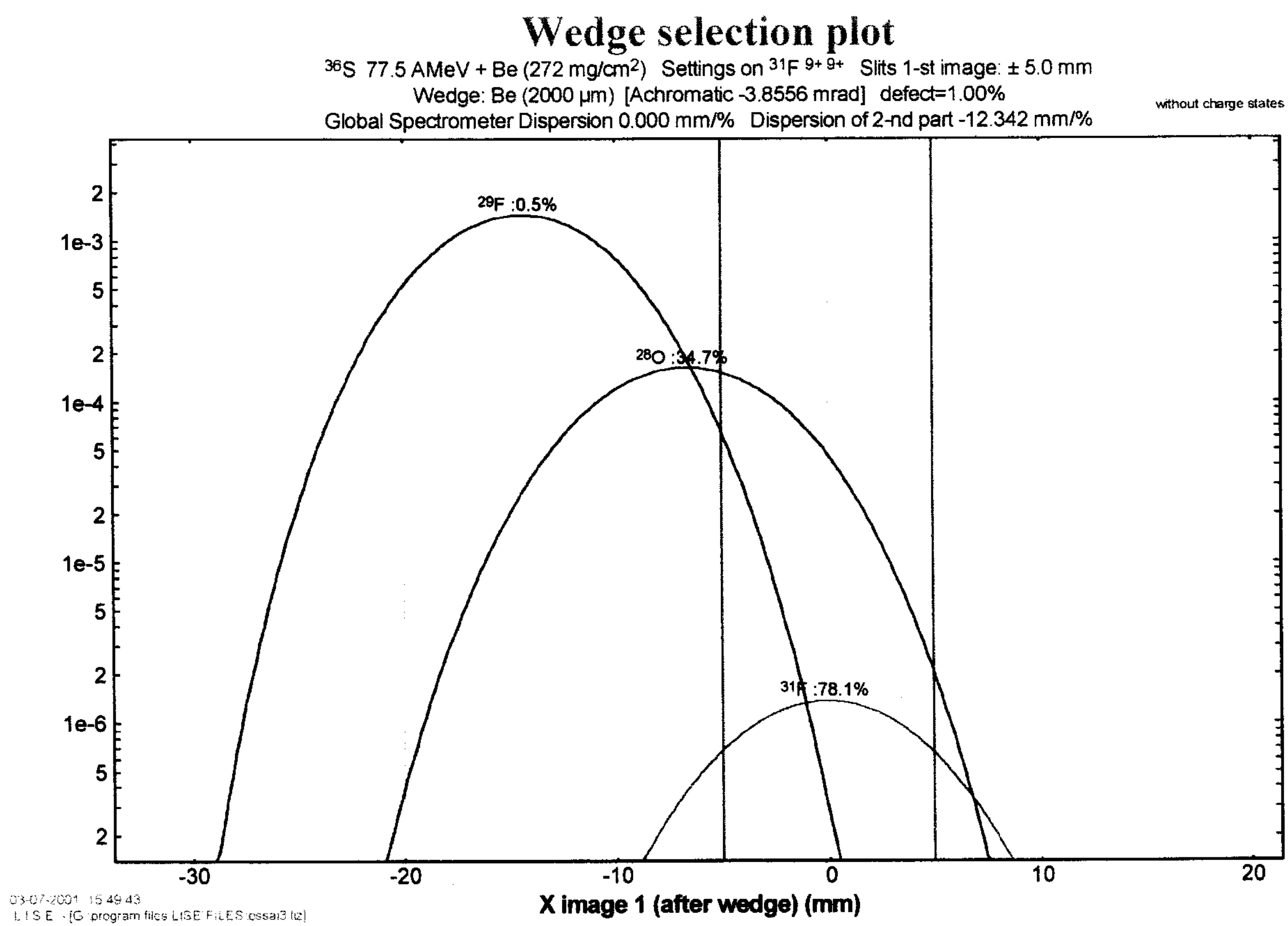

Rate / Total Rate
Rate / Rate Max
^{6}He
LISE2000
LISE3
^{24}O

Fig.6b



Wedge selection plot
^{36}S 77.5 AMeV + Be (272 mg/cm^2) Settings on ^{31}F 9+ 9+ Slits 1-st image: ± 5.0 mm
Wedge: Be (2000 μm) [Achromatic -3.8556 mrad] defect=1.00%
Global Spectrometer Dispersion 0.000 mm/% Dispersion of 2-nd part -12.342 mm/%
without charge states
^{29}F :0.5%
^{28}O :34.7%
^{31}F :78.1%
1e-3
1e-4
1e-5
1e-6
-30
-20
-10
0
10
20
X image 1 (after wedge) (mm)
03-07-2001 15:49:43

Fig.7