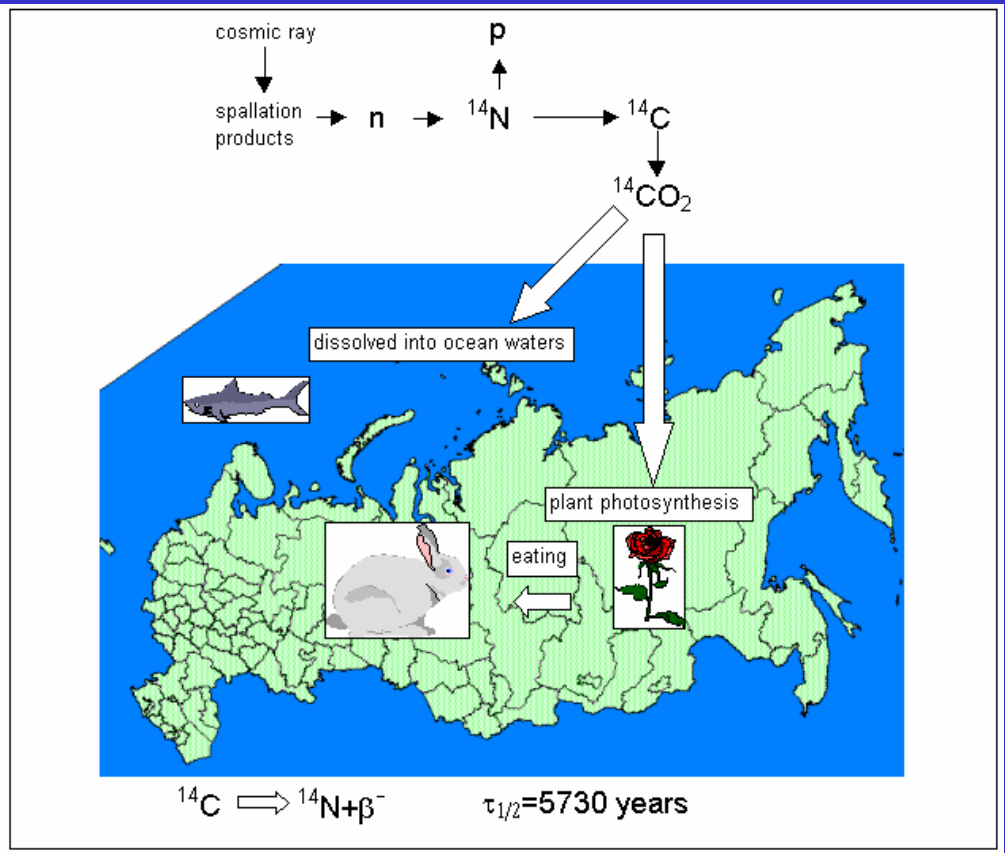
Radiocarbon measurements and background investigation at SD RAS Accelerator Mass Spectrometer

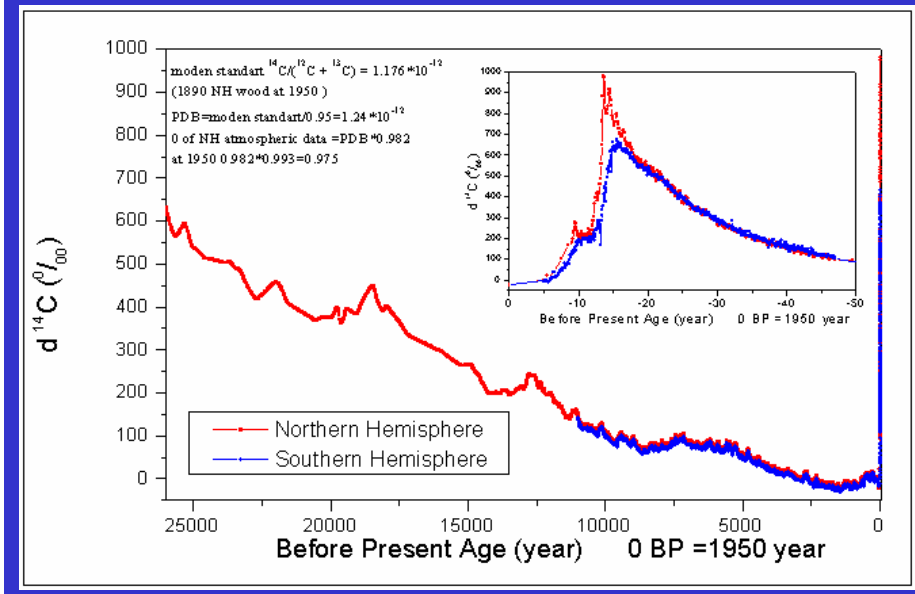
N.I. Alinovsky,
A.D. Goncharov,
V.F. Klyuev,
S.G. Konstantinov,
E.S. Konstantinov,
A.M. Kryuchkov,
V. V. Parkhomchuk,
M.V. Petrichenkov,
S.A. Rastigeev,
V.B. Reva,

BINP, Novosibirsk,
Russia.

Radiocarbon dating

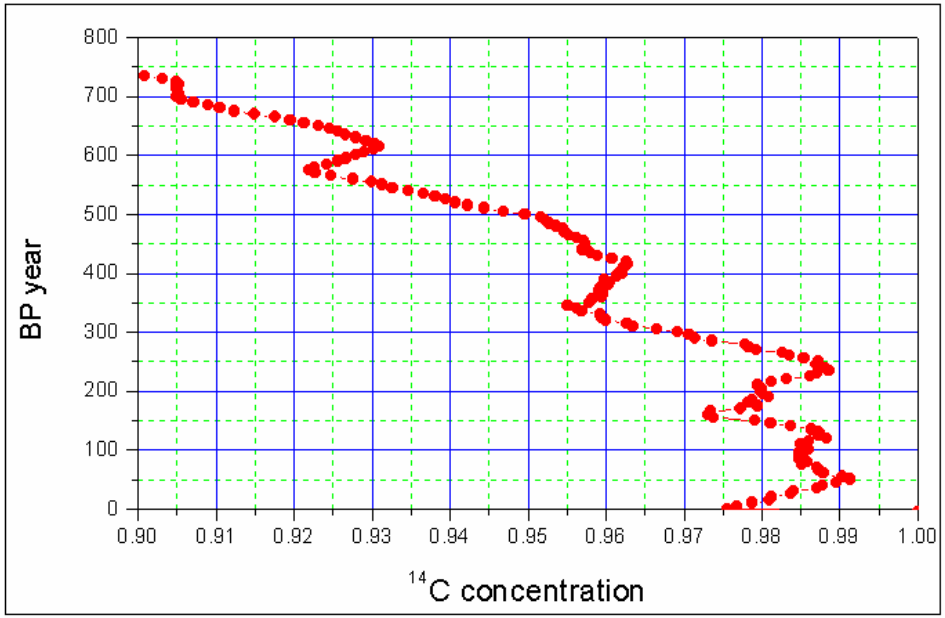


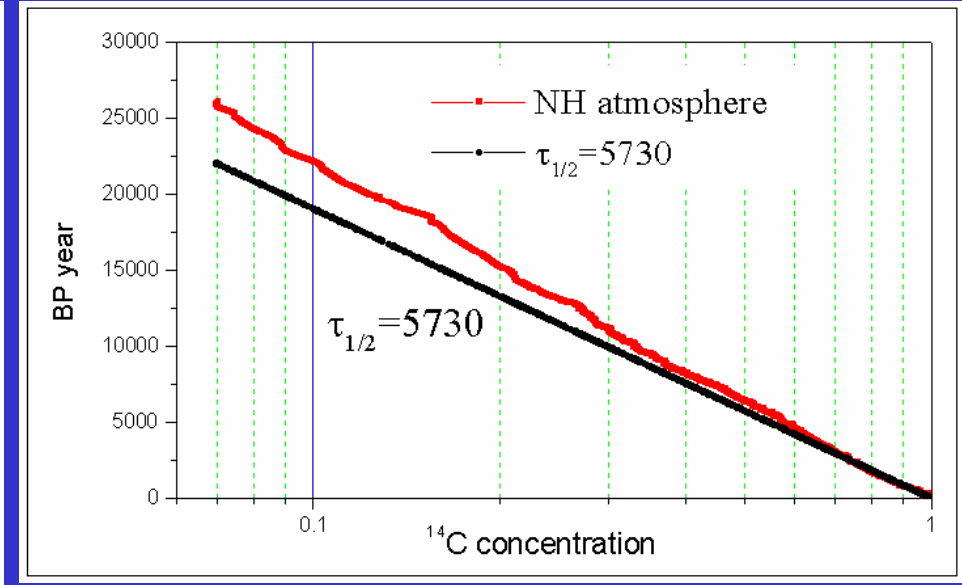
Radiocarbon calibration data

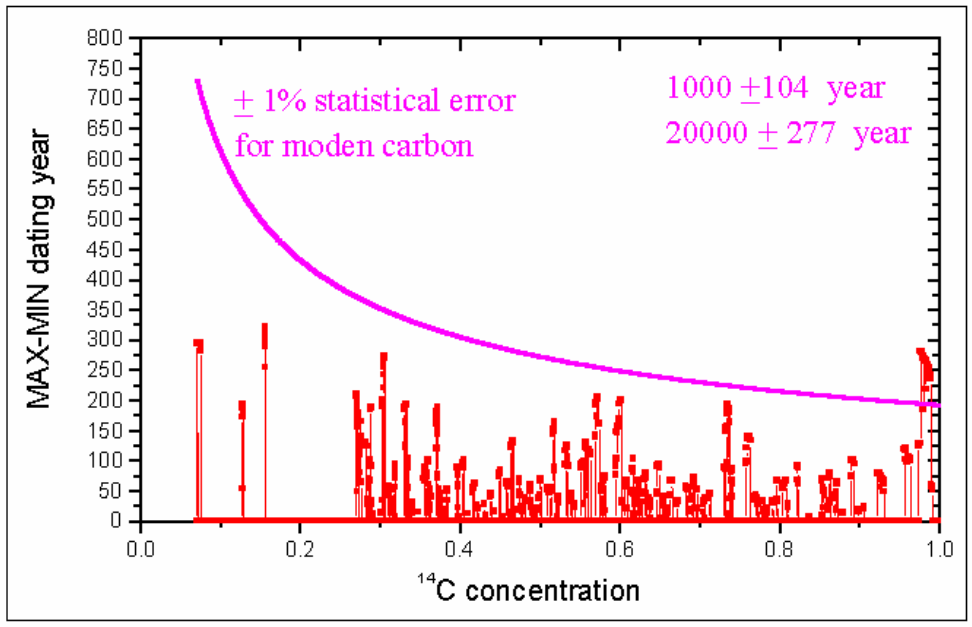


The ratio $^{13}C/^{12}C$ in atmosphere is about 1.1%.
The ratio $^{14}C/^{12}C$ in atmosphere is about $1.2*10^{-12}$,

Error estimation







The several sample ages are corresponded to the same ^{14}C concentration.

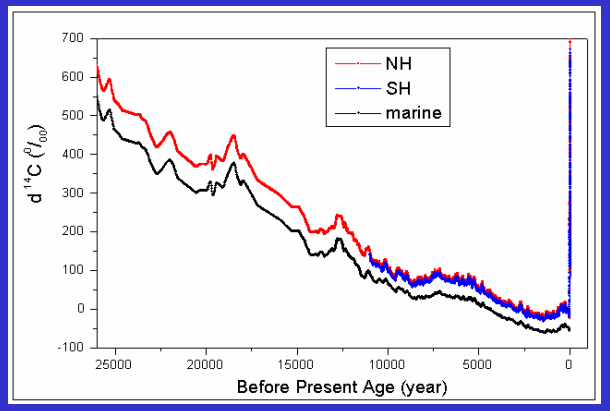
It is impossible to date finds with a true age less than 350 years.

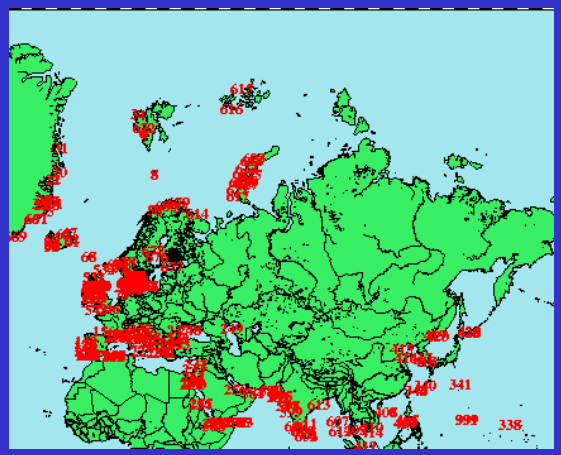
Sample fractionation

The shift in the $^{14}C/^{12}C$ ratio is about twice the shift in the $^{13}C/^{12}C$ ratio.
The ratio $^{13}C/^{12}C$ for PDB standard: 1.12372%

Material	Delta C-13 (per mille)
PDB dC13 standard	0
Atmospheric CO2	-9±2
Straw, flax	-14±3
Recent wood, charcoal	-25±3
Tree leaves, Wheat, straw etc.	-27±2

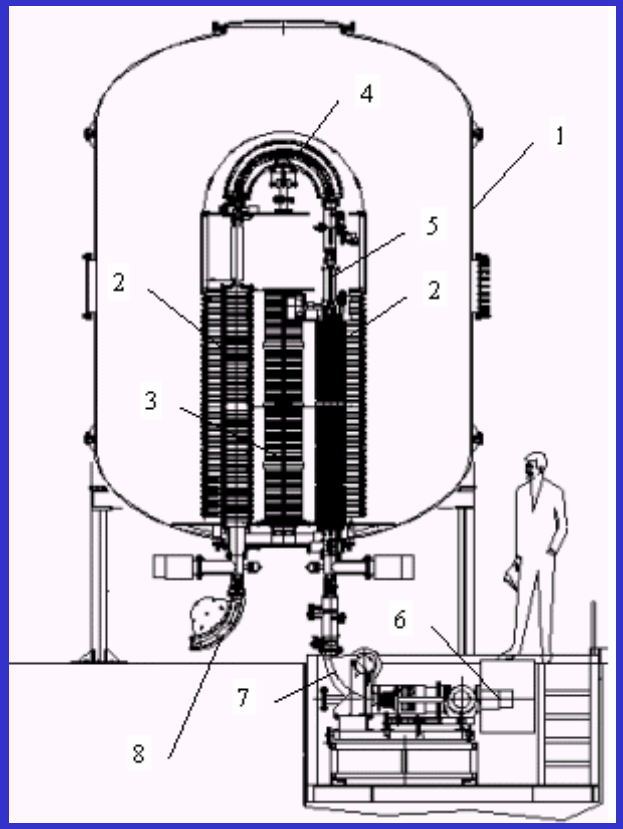
Marine reservoir correction



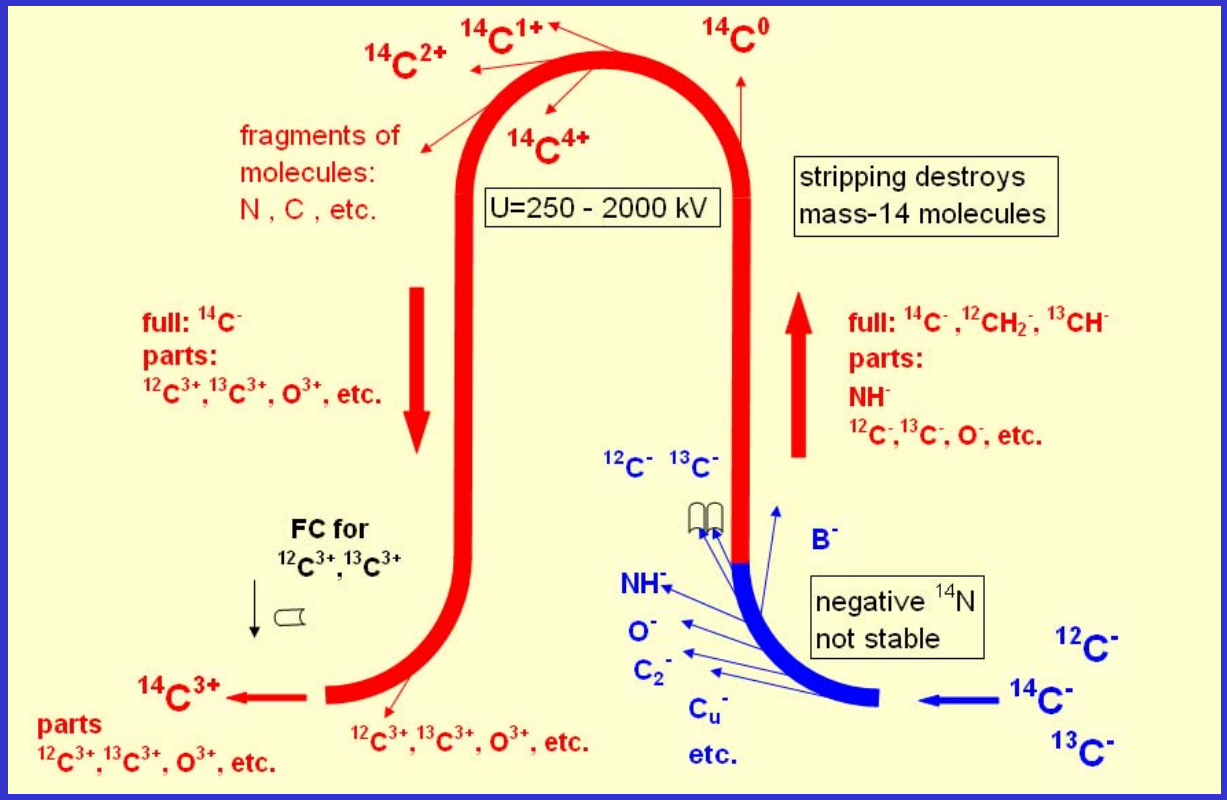


Radiocarbon ages of samples formed in the ocean are generally several hundred years older than the terrestrial samples,
It is need to know where the dated sample comes from, for correct sample dating.

AMS facility



1 - pressure tank,
2 - accelerator tube,
3 - cascade generator,
4 - middle energy electrostatic filter,
5 - magnesium vapors stripper,
6 - ion source,
7 - low-energy magnetic analyzer,
8- high-energy magnetic analyzer

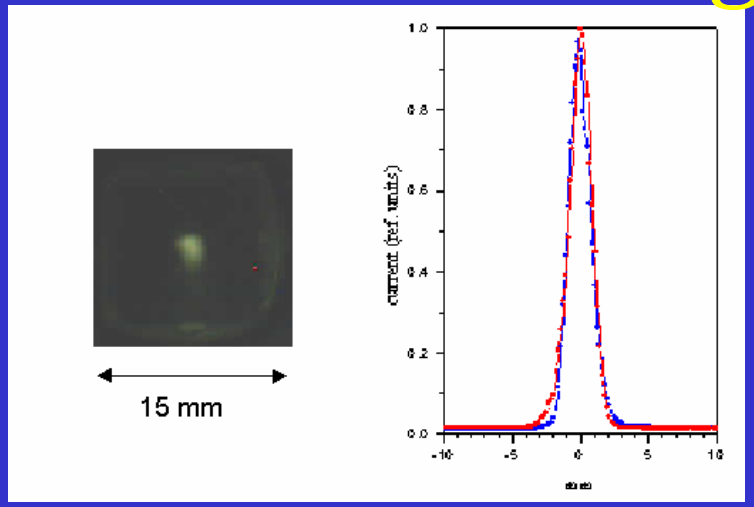


The most distinguishing features of our AMS machine is the use of the middle energy separator of ion beams and the magnesium vapors target as a stripper.

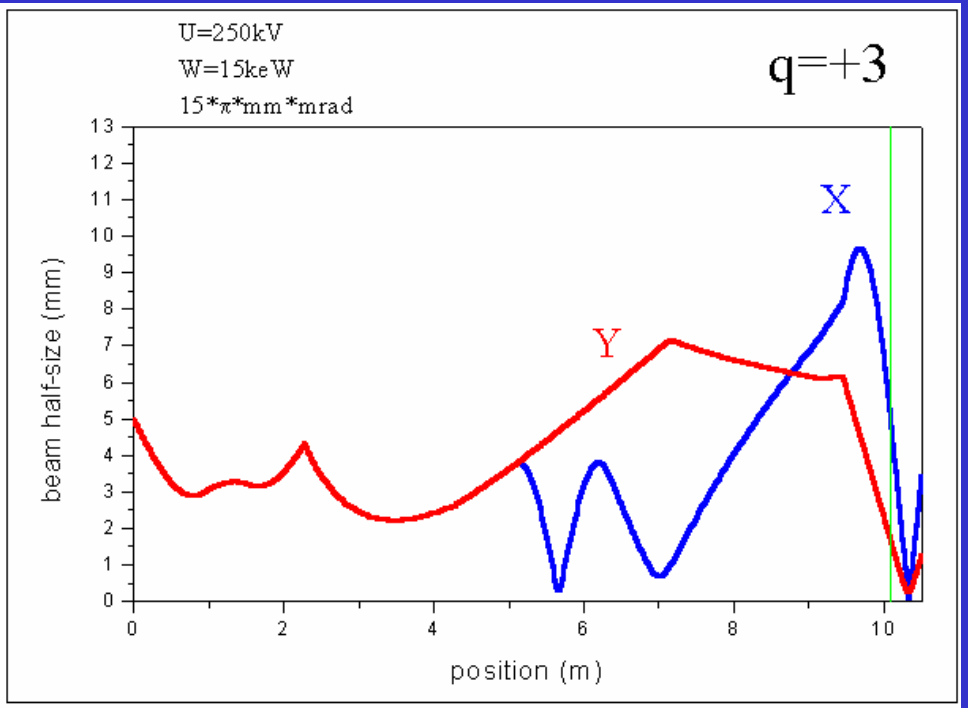
AMS optics for 250kV terminal voltage

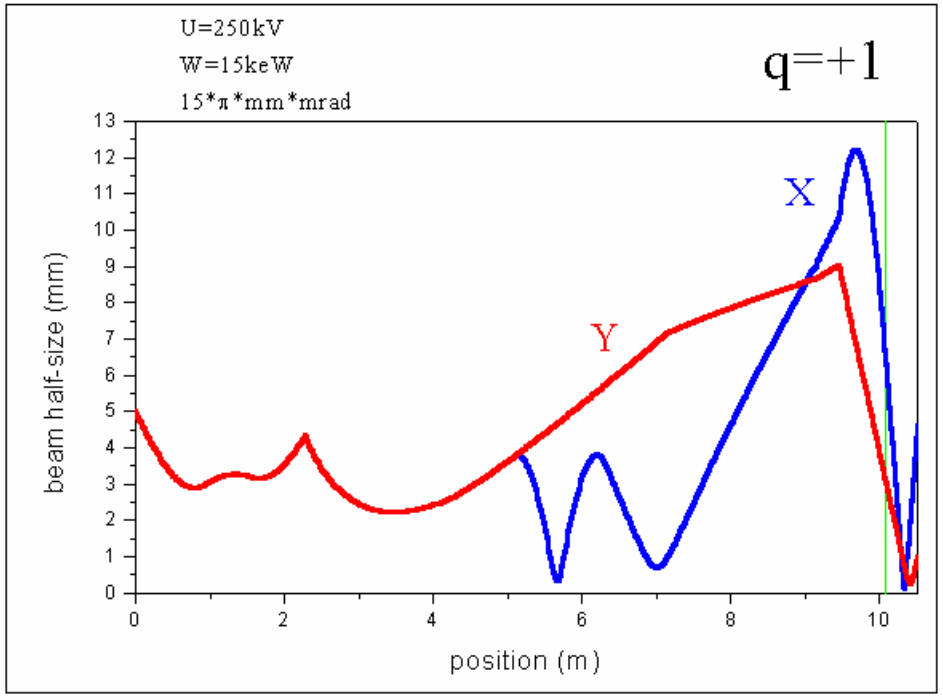
Calculation for:
W=15keV
emittance =15mm*mrad
1.84 mm*mrad*MeV$^{1/2}$

A typical emittance value for 100uA C^- beam is about: 5 mm*mrad*MeV$^{1/2}$
(taken from literature)

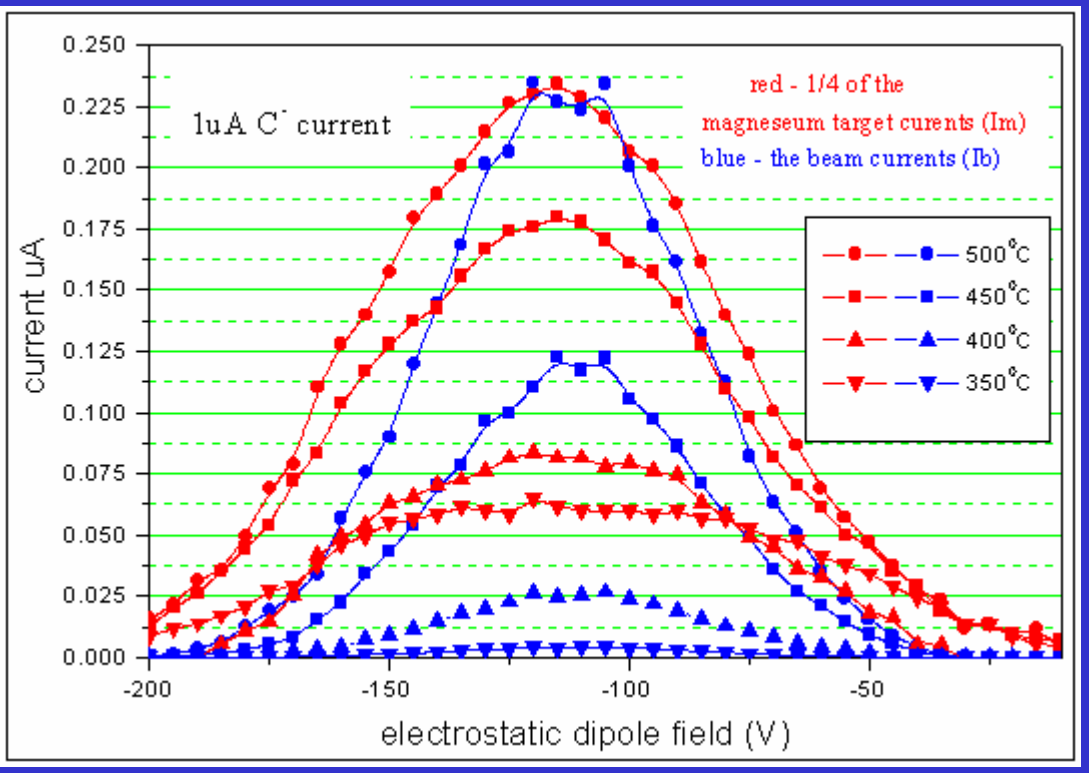


Beam at the exit of AMS





Beam transmission (250kV)



The $1uA\ C^{-1}$ ions are injected in the tandem accelerator

$I_m(350^0C) \cong 0.25uA$ – the lost beam at magnesium target

$I_m(500^0C)- I_m(350^0C)$ - the electrons stripped from the through-passing beam (1.5 electrons from 1 ions)

$(I_m(500^0C)- I_m(350^0C))/1.5 \cong 0.45$ uA
hrough-passing beam current

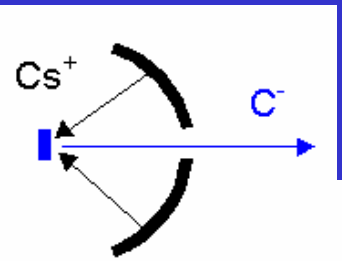
$I_b(500^0C) \cong 0.23$ uA

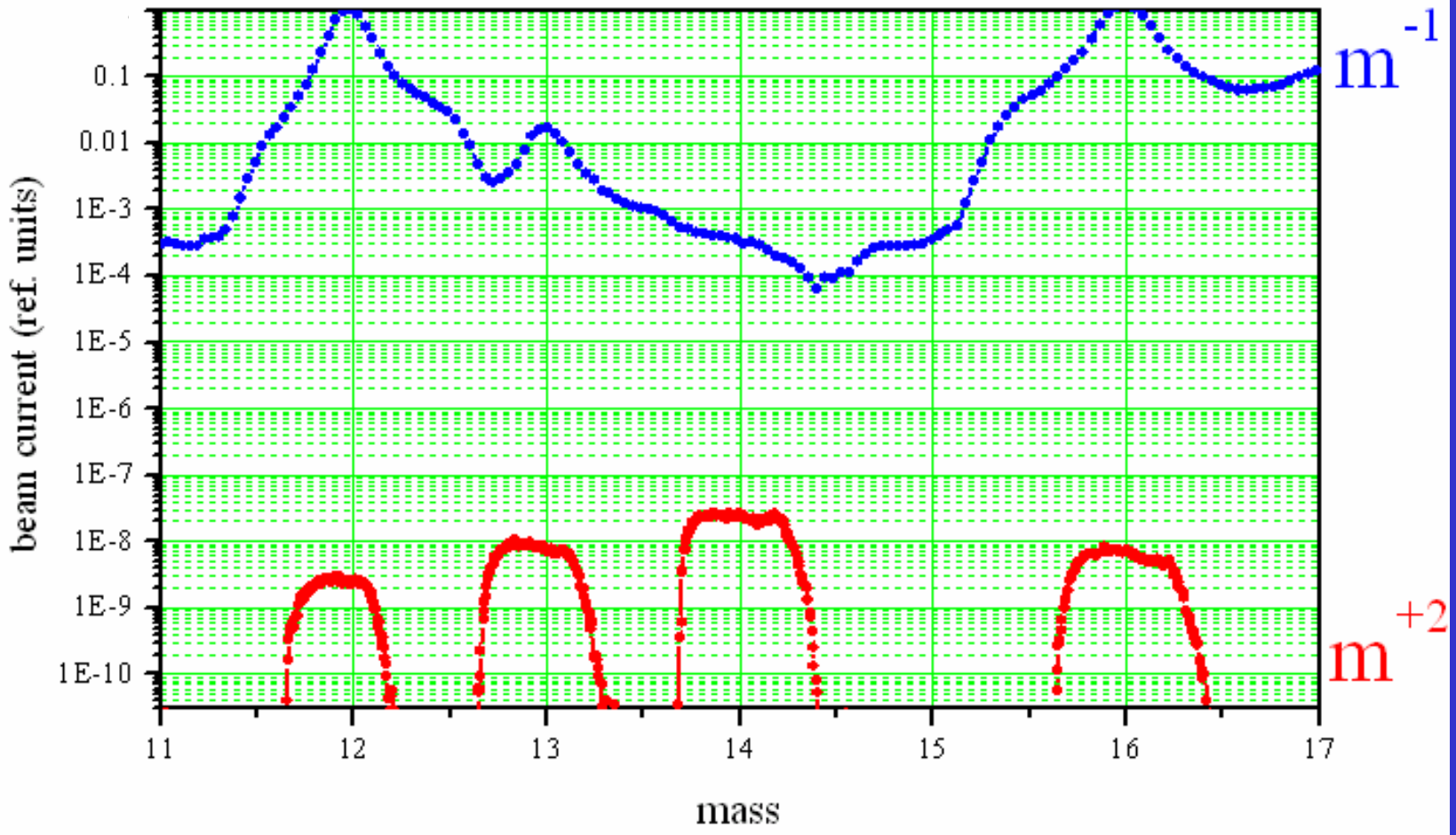
The C^{+1} beam transmission is about $0.5*0.5 = 25\%$,

the beam lost in the stripper channel (6 mm inner diameter)

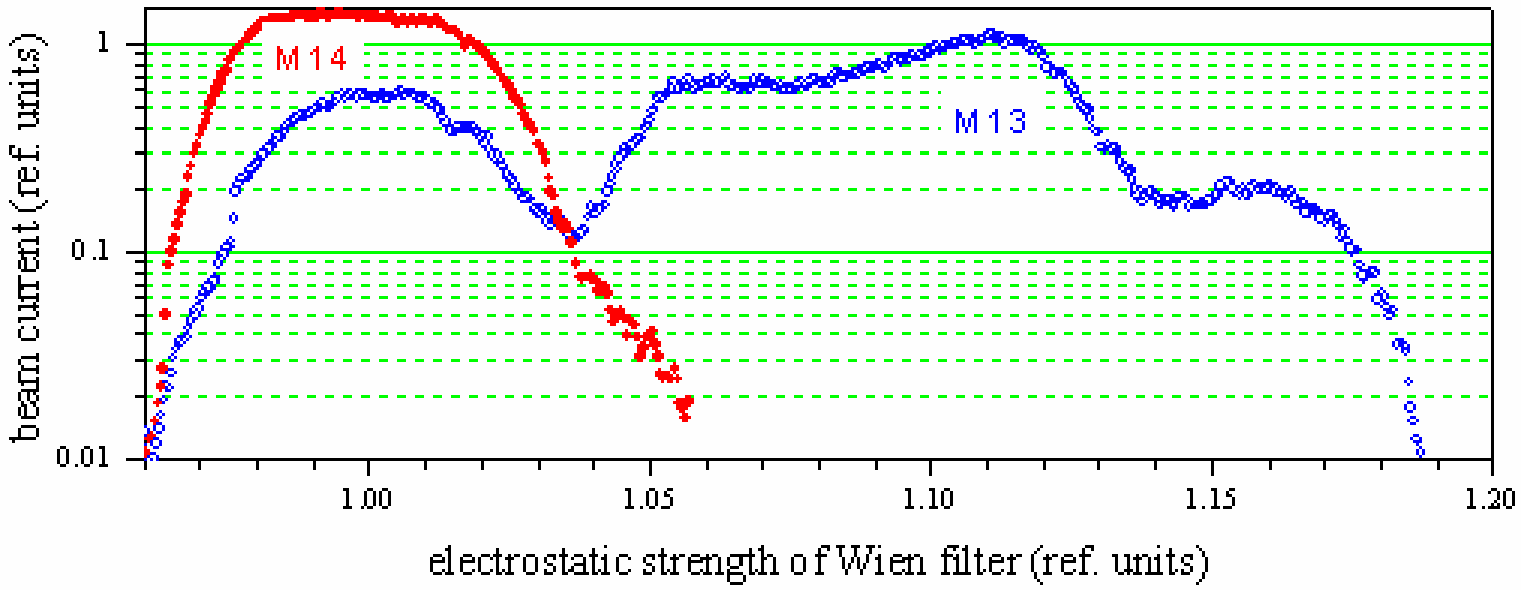
C^{+2} - 1.5% , C^{+3} - 0.05%

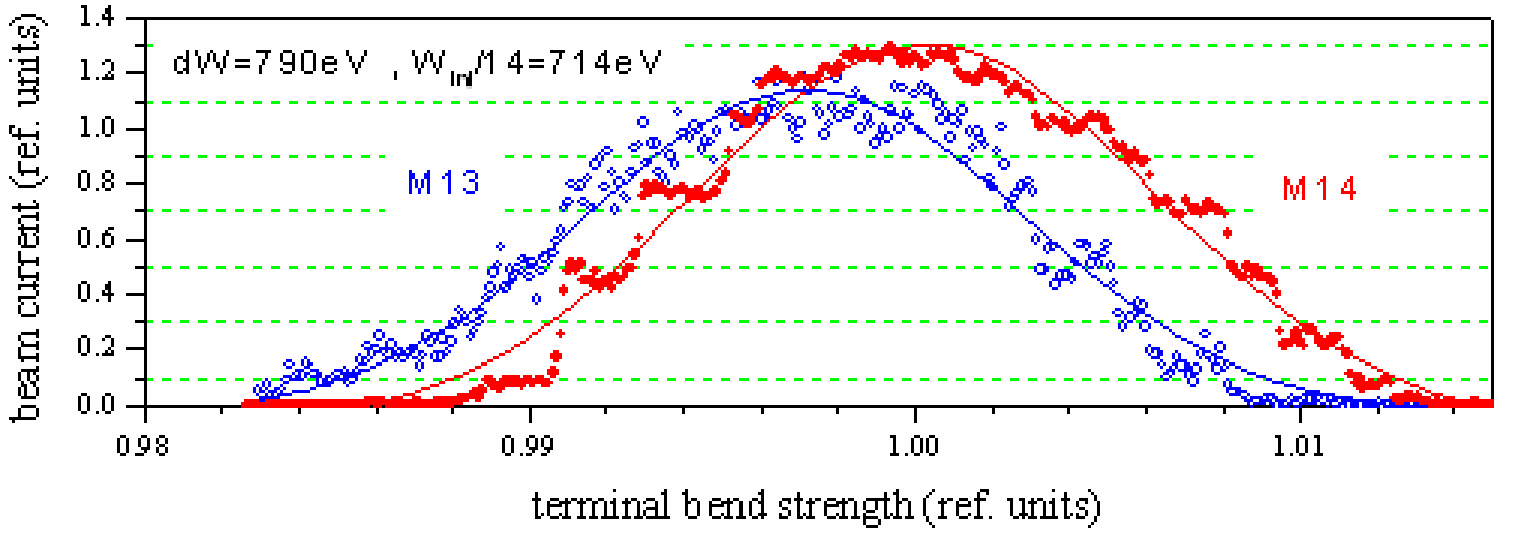
Mass spectrum of the graphite sample



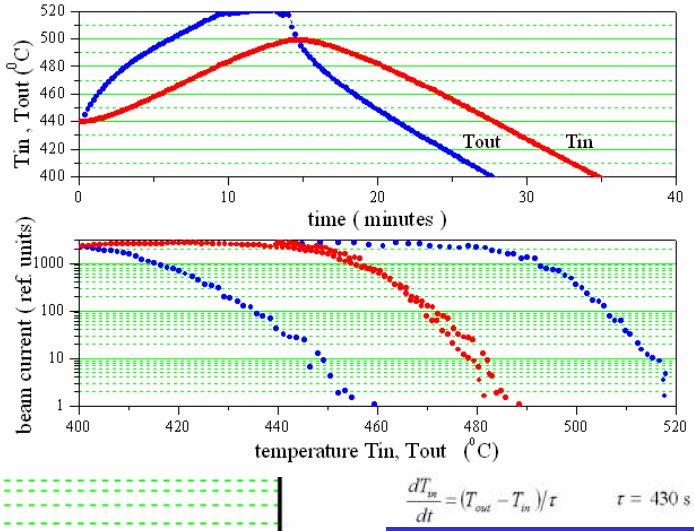


mass-13 background

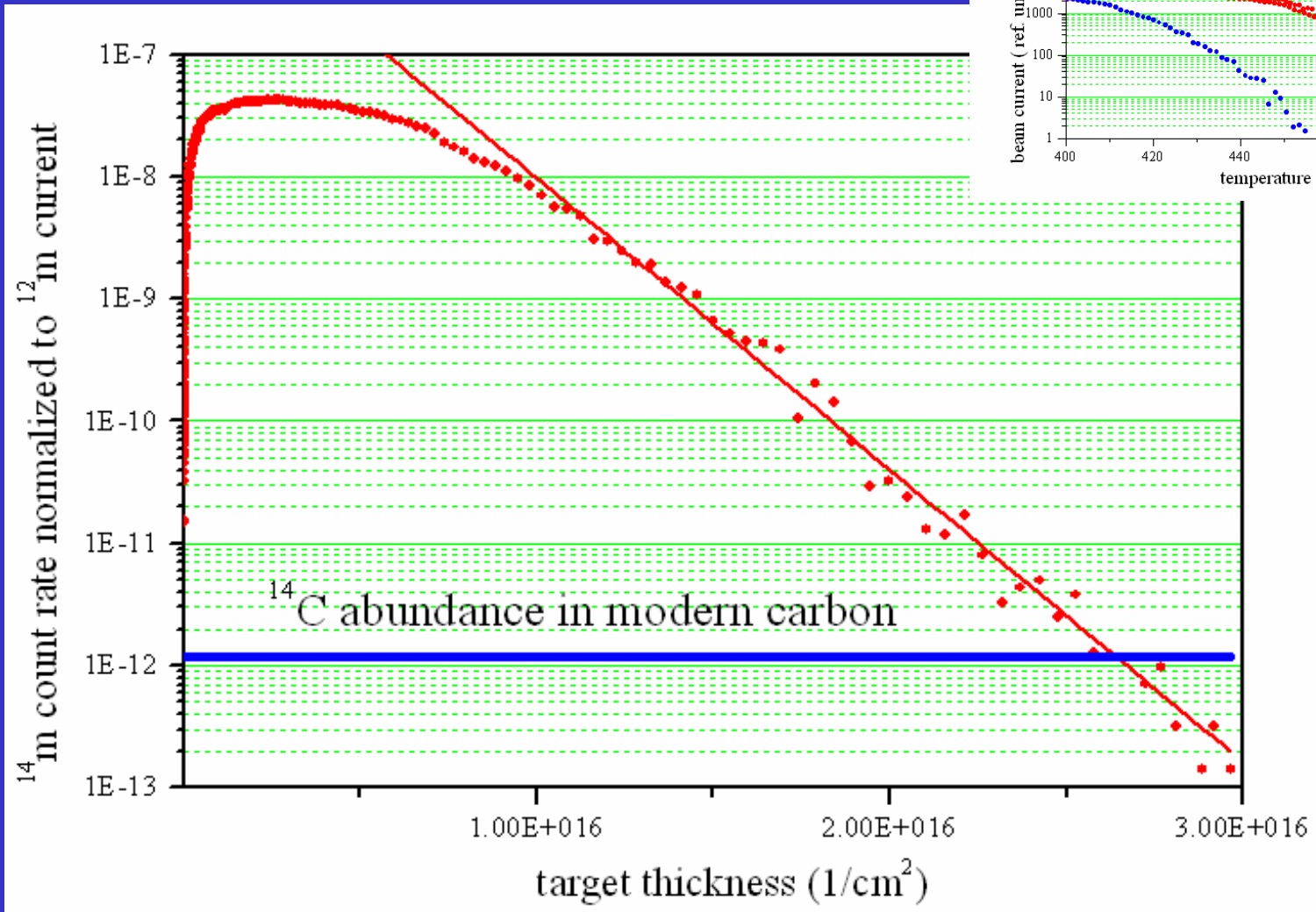




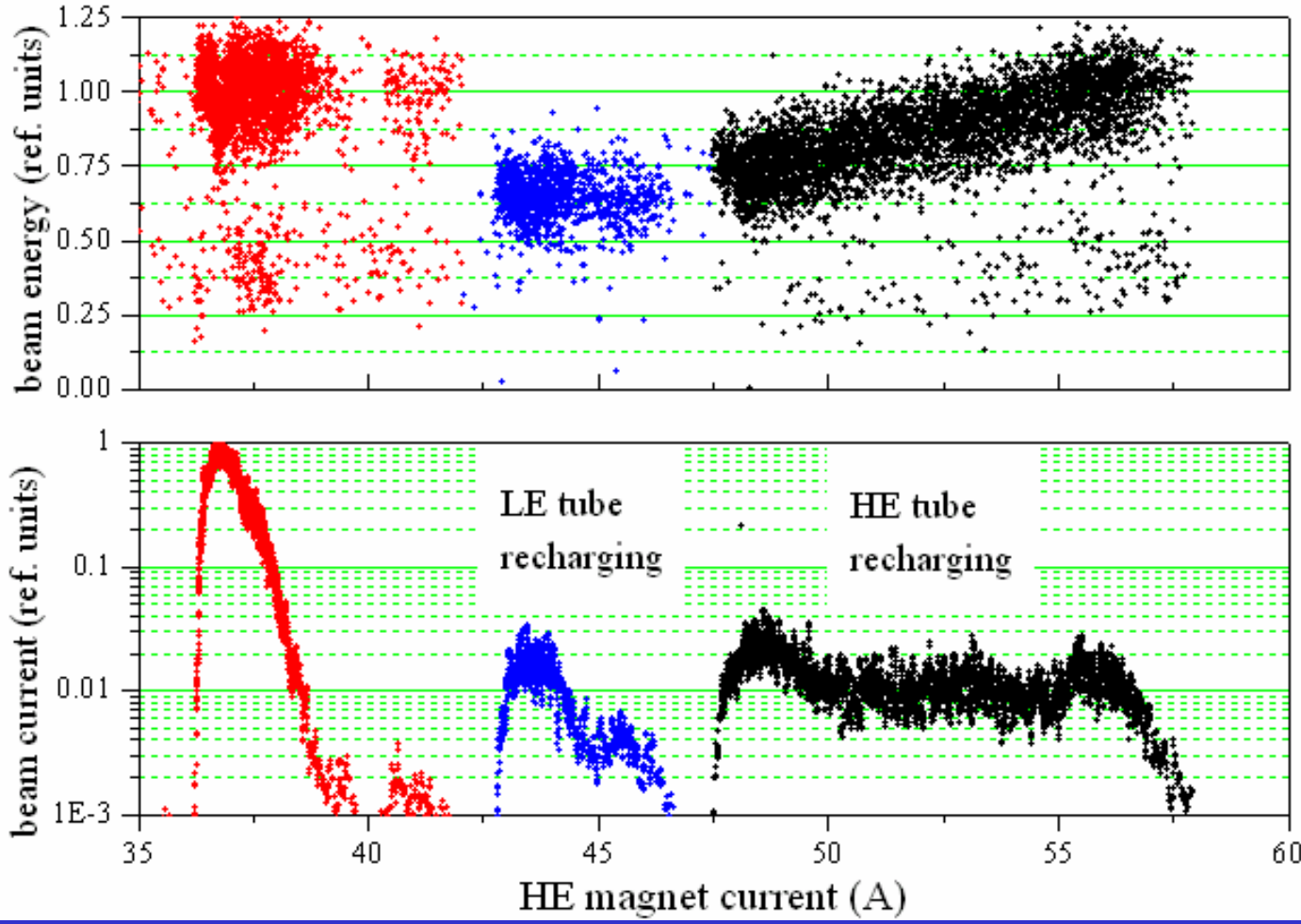
Molecules destruction



$$\frac{dT_{in}}{dt} = (T_{out} - T_{in})/\tau \qquad \tau = 430\ s$$



recharging in accelerator tubes



$(1+3)\cdot e\cdot V_t + W_{inj}$

1010 keV

$(2/3+2)\cdot e\cdot V_t + \frac{2}{3}W_{inj}$

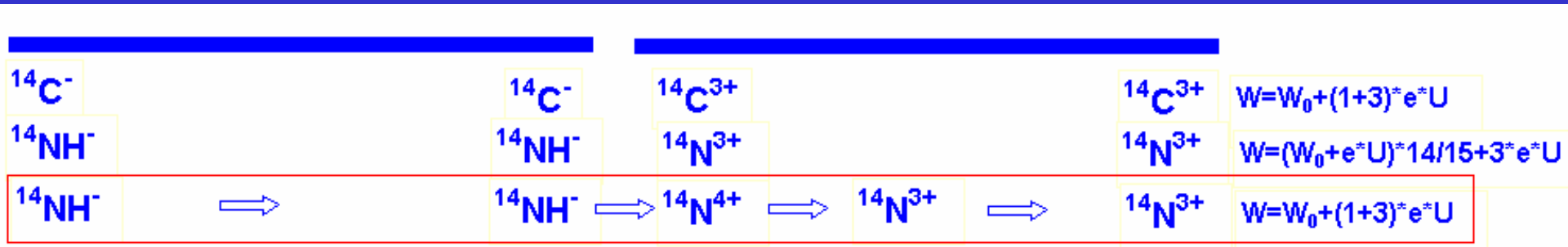
673 keV

$(1+2)\cdot e\cdot V_t + W_{inj}$

760 keV

^{14}N background (M/dM=84000)

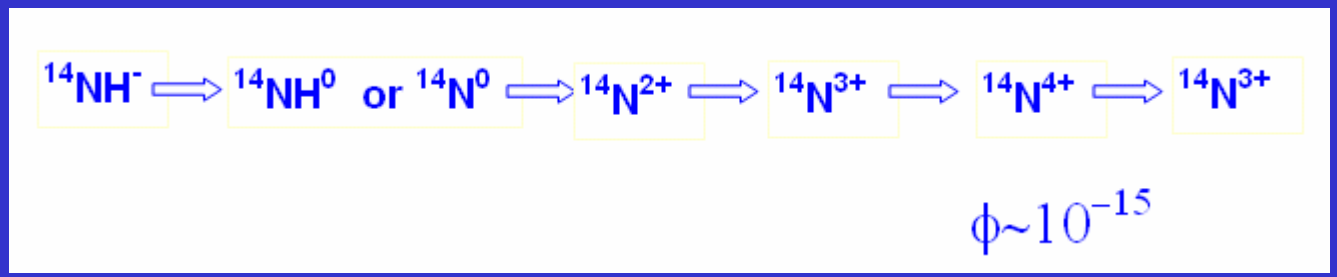
Without tandem terminal filter:



$\sigma_{43} \cong 10^{-16} cm^2$ P=10^{-6}Torr l=1cm $\Longrightarrow$ $\phi \cong 3*10^{-6}$

With tandem terminal filter:

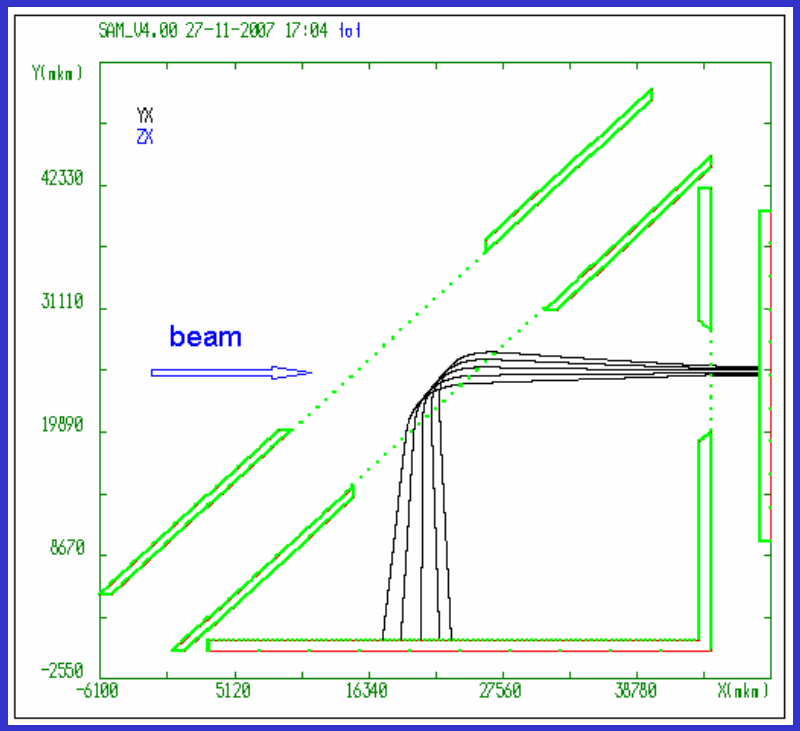
The ^{14}N and ^{14}C ions energy have the same values at the exit of accelerator only after five steps recharging process.

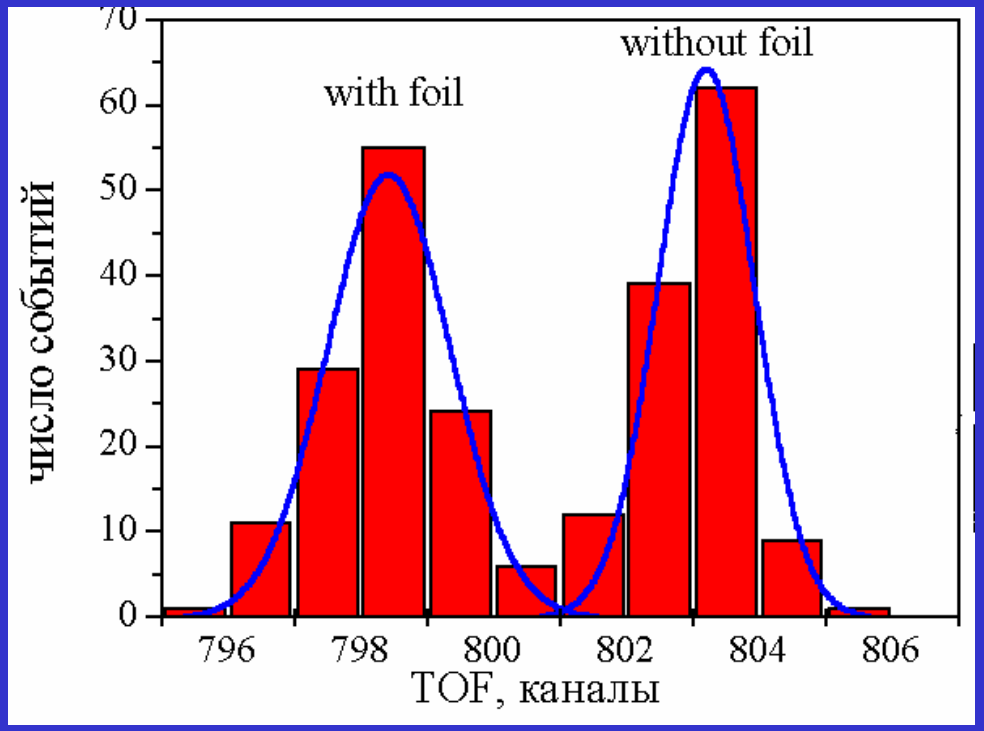


Moreover, the magnesium vapors stripper had no the observable influence on vacuum condition

TOF detector

Used collodion foil:

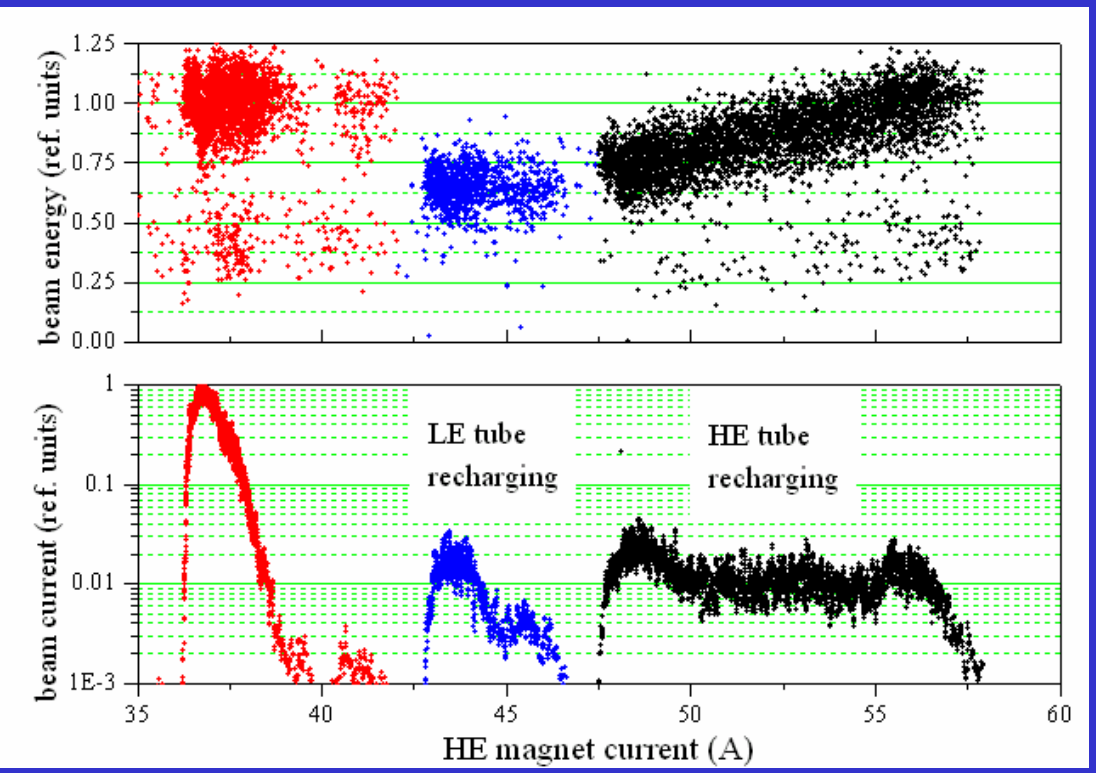




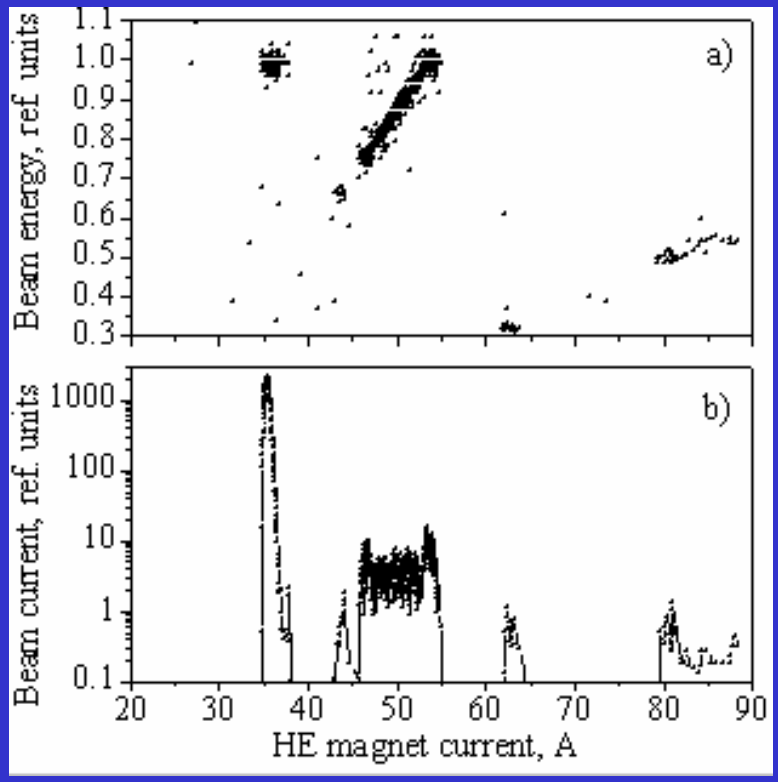
^{11}B E=1MeV dE=60keV

foil thickness: - 0.13ug/cm^2

recharging in accelerator tubes

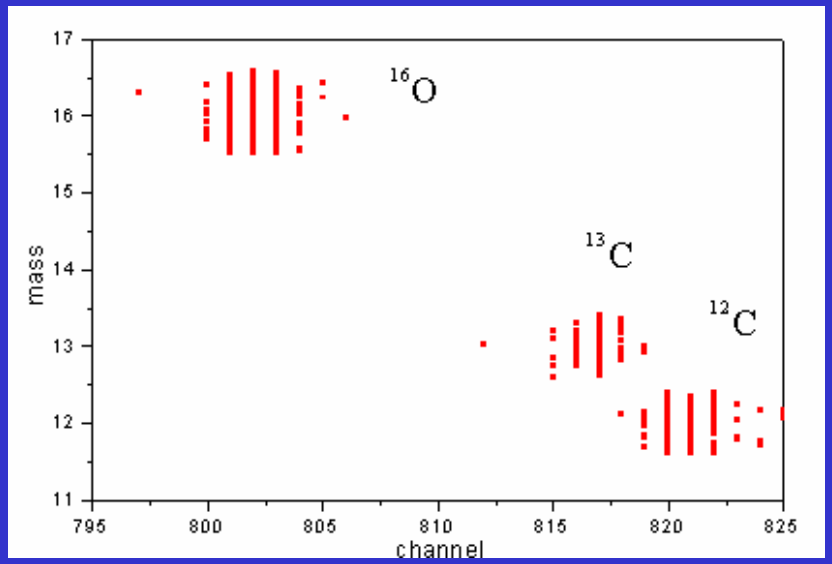


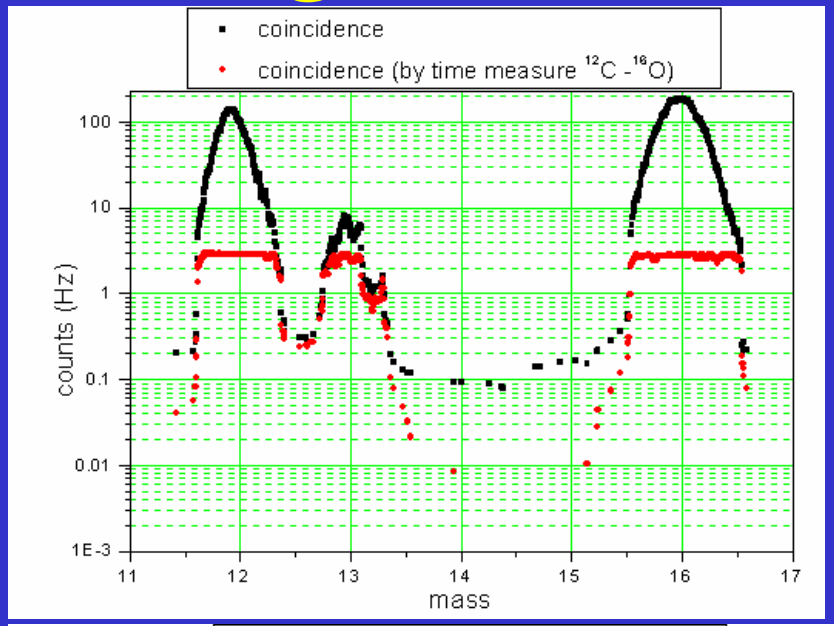
Measured by SSB detector

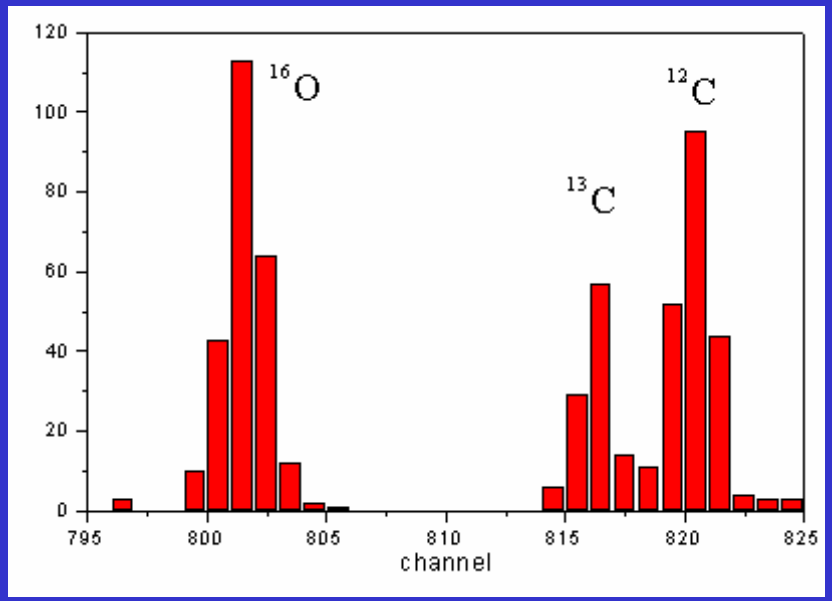


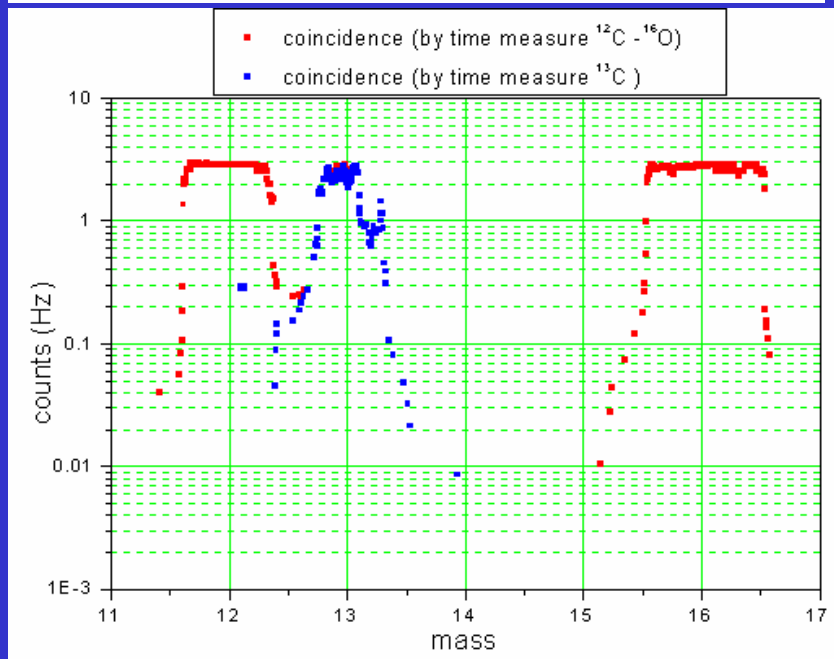
Measured by TOF detector

TOF detection of the HE magnet scan

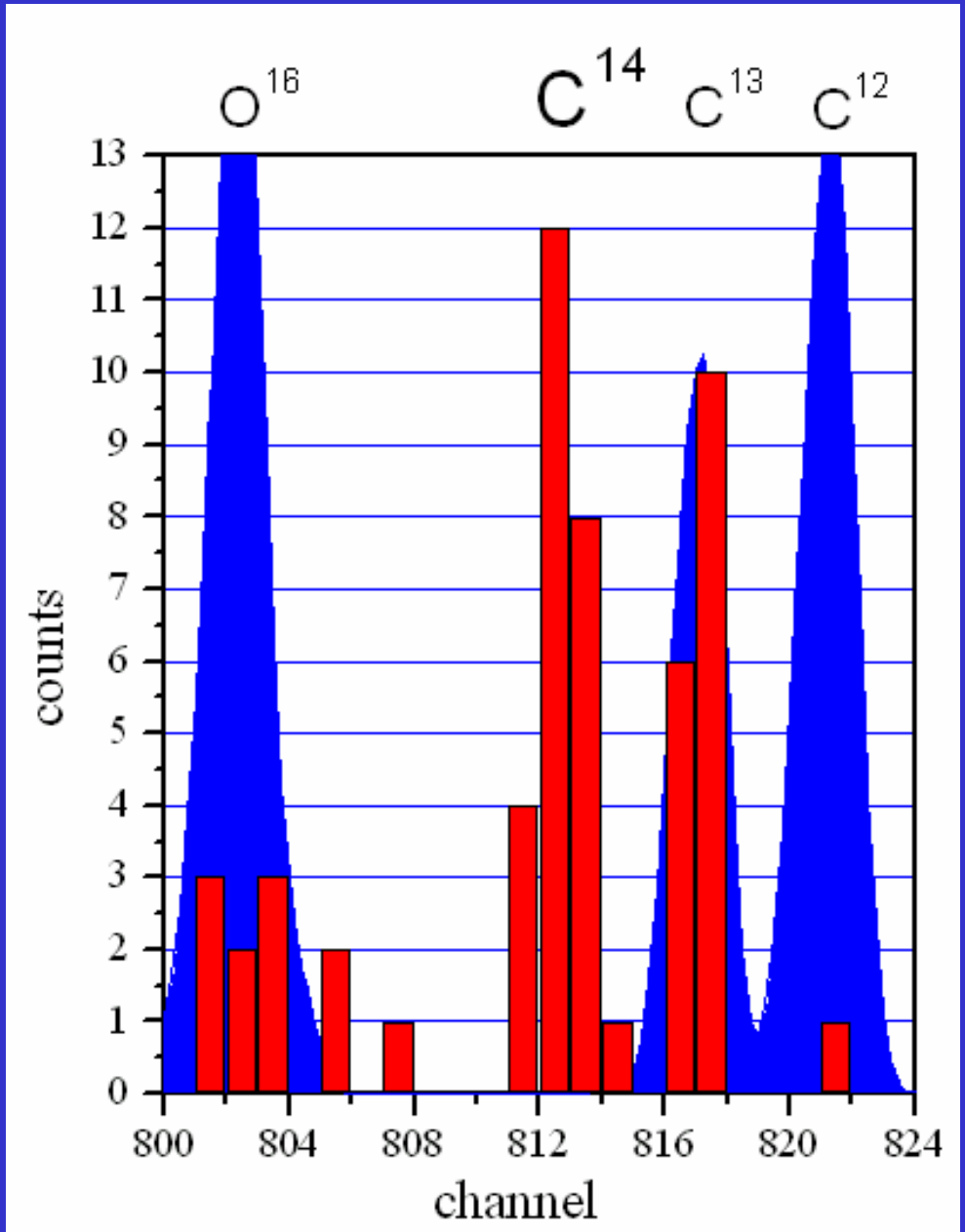




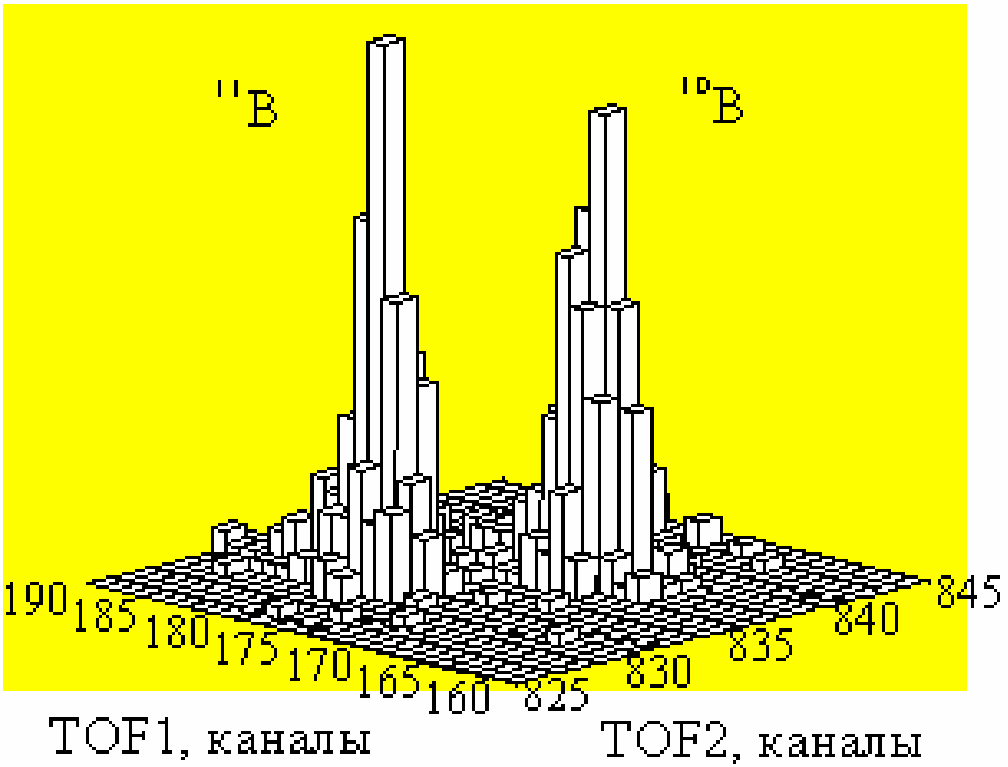




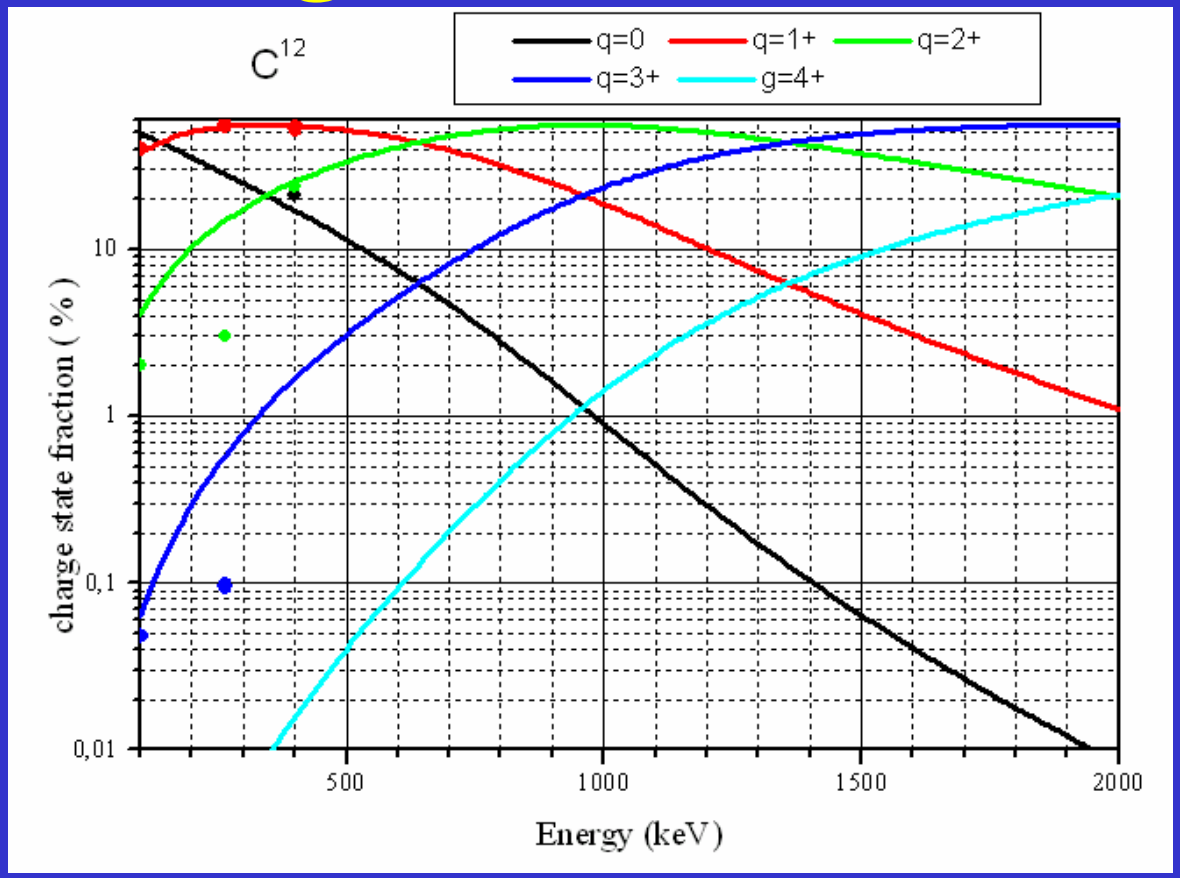
First $^{14}C^{3+}$ ions was detected

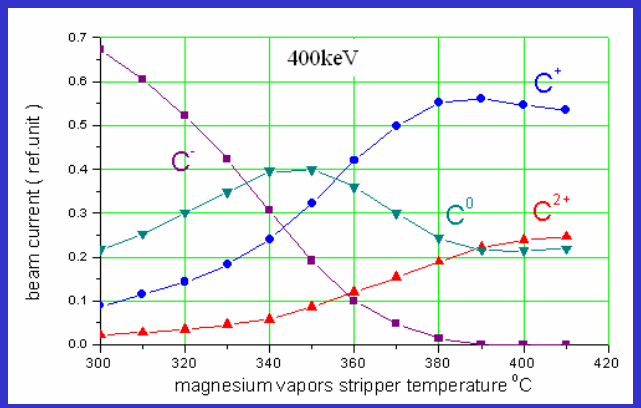


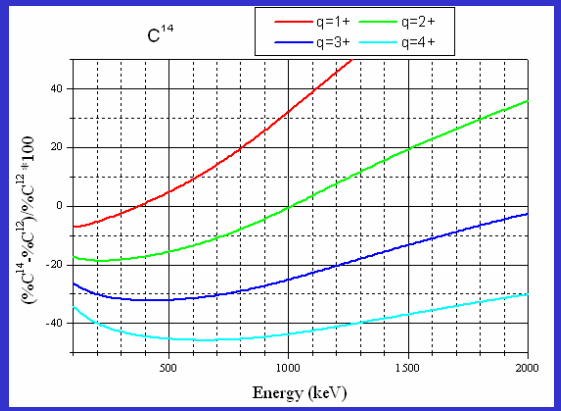
2D TOF distribution for the boron ions.



Charge state fractions.

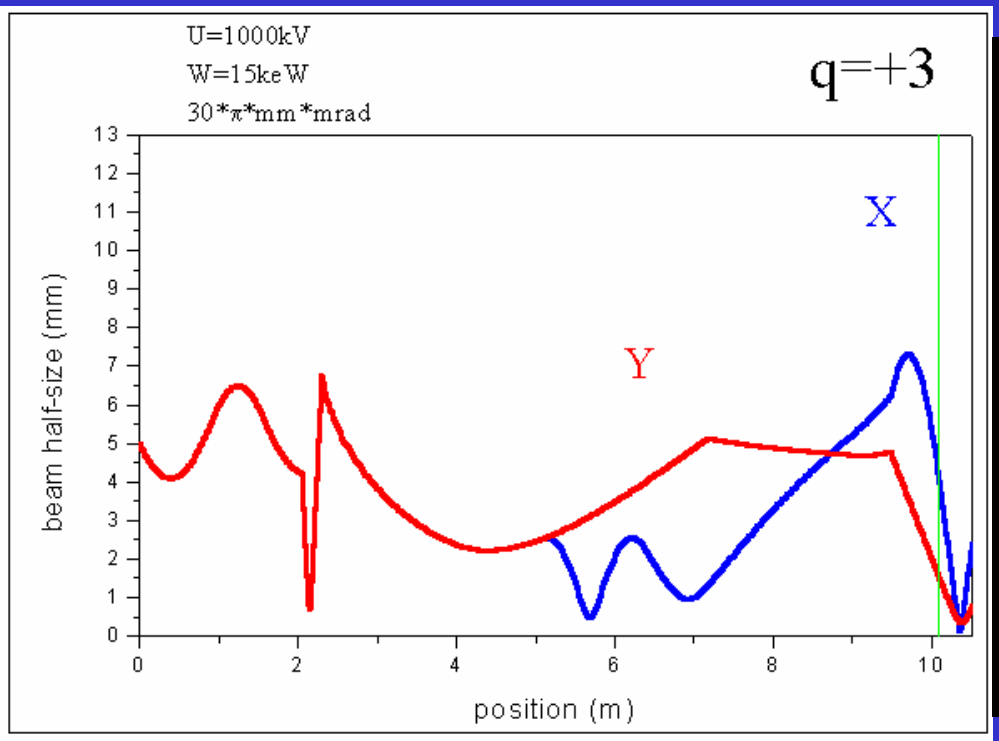


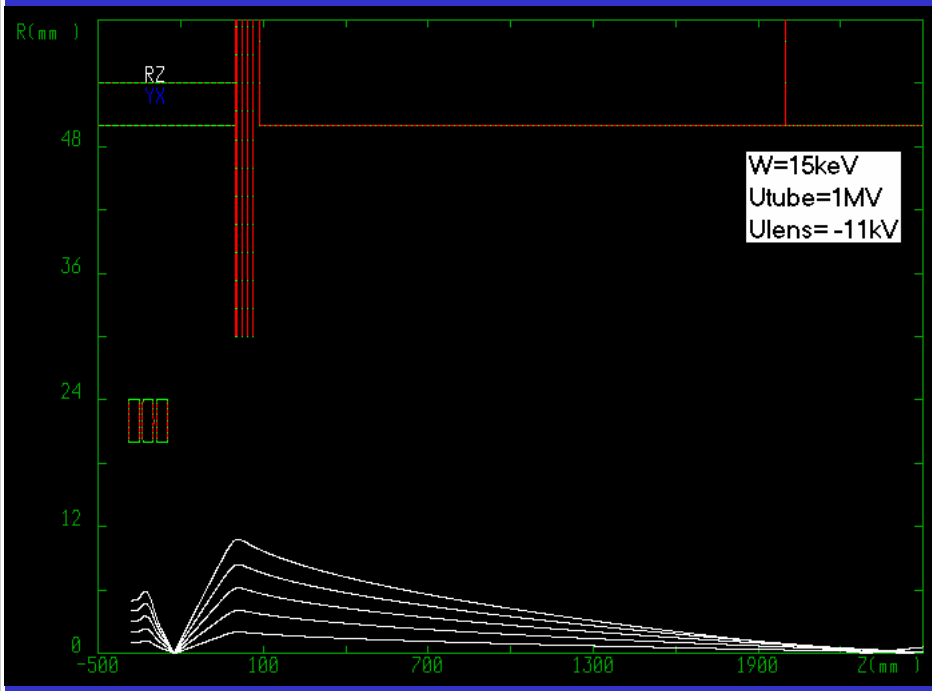




AMS optics

Calculation for:
W=15keV
emittance =30mm*mrad
3.7 mm*mrad*MeV$^{1/2}$





SUMMARY

The main parts of AMS facility have been installed and tested at BINP. The ion background was enough removed from radiocarbon beam. The first experiments for radiocarbon detection was carry out for low

beam energy at 250 kV tandem accelerator voltage.

The assembling of the AMS complex in specialized building for AMS (Dating Center) has begun this year.

We plan to use ~ 2MV tandem voltage for optimum 3+ charge state transmission in this Center equipped with radiation shielding.
(3+ transmission: 0.05% (250keV) ---> 25-50% (2MeV))