Intense Proton Beam Transport for FRANZ

L.P. Chau, C. Wiesner, M. Droba, O. Meusel and U. Ratzinger

IAPhysik der Johann Wolfgang Goethe-Universität D-60325 Frankfurt am Main

It is planned to develop an intense neutron generator “FRANZ” at Frankfurtwithin the next 4 years to deliver a quite intense neutron spectrum from the ^{7}Li(p,n) ^{7}Be reaction [1]. The proton driver linac consists of a high voltage terminal already under construction to provide primary proton beam energies of up to 150 keV. A volume type ion source will deliver a DC beam current of 100-250 mA at a proton fraction of 90%. A low energy beam transport using four solenoids will inject the proton beam into an RFQ while a chopper in between will create a pulse lengths around 100 ns at a repetition rate of up to 250 kHz. A drift tube cavity with variable beam end energies in a range from 1.9 to 2.1 MeV will be installed downstream of the RFQ. Finally a bunch compressor of the Mobley type forms a proton pulse length of 1 ns at the Li target.

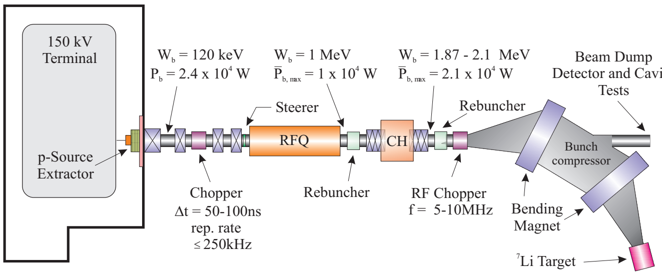

Fig. 1: Schematic layout of the **Fra**nkfurter **N**eutron Source at the Stern-Gerlach-**Z**entrum, “FRANZ”.

Space charge effects become quite severe at the high beam intensity needed for the neutron generator. Therefore numerical simulation of beam transport have been started. In the first section the dc beam will be matched into the magnetic chopper by two solenoids. A static space charge compensation of 85% is assumed. Downstream of the chopper the beam pulse length is of 100ns with a repetition rate of about 250kHz. The beam transport was calculated under full space charge here with respect to the rise time of the compensation process in a range of about 50μs [2].

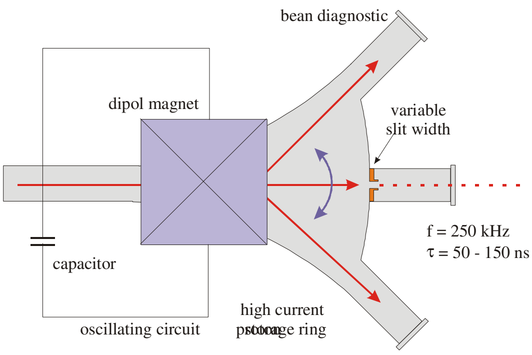

Fig. 2: Schematic of the magnetic chopper array.

In order to get high intensity 1ns pulses at the target a bunch compressor of the Mobley type [3] is proposed, whereby periodic deflection by a rf-chopper at one focus of a magnetic bending system guides the bunch train from the LINAC on different paths to the other focus, where the n-production target is located in the time focus.

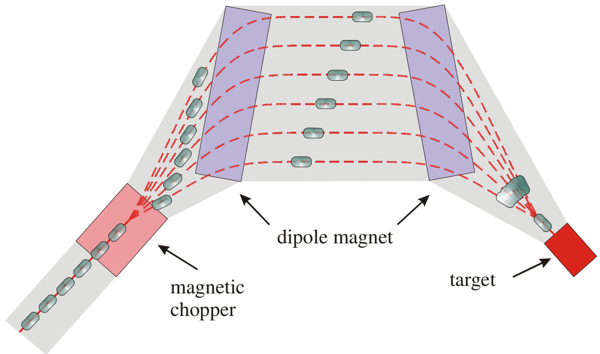

Fig. 3: Bunch compressor composed of an rf chopper and two dipole magnets with spatially varying magnetic fields.

The peak current of the compressed bunch leads into extremely high space charge forces in the merging region in the near of the target. To prevent a divergence of the compressed bunch a neutralization of the beam space charge by an electron cloud could be envisaged.

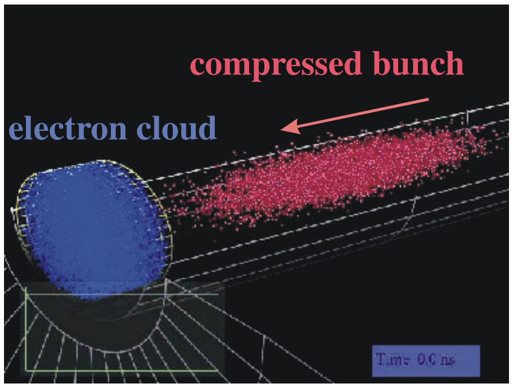

Fig. 4: Scheme of a pure electron column for neutralization of the compressed bunch.

Gabor lenses use a confined pure electron column to the focus ion beams. Under the assumption of a low electron temperature inside the lens it is possible that some of the electrons will be captured in the potential of the proton bunch. Very first calculations show a space charge compensation of about 30%.

References

[1] M. Heil et al., “A 4πBaF_2 detector for (n, γ) cross section measurement at a spallation source”, Nucl. Inst. Meth. A 459, 229-246 (2001)

[2] K. Reidelbach, A. Jakob, J. Pozimski, P. Gross, R. Doelling and H. Klein First numerical calculations and measurements of dynamic space charge compensation GSI Ann. Rep. HEDIM 1996 GSI-97-08, p. 46

[3] R.C. Mobley, Proposed Method for Producing Short Intense Monoenergetic Ion Pulses, Phys. Rev.88(2), 360-361 (1951)