EXPERIMENTAL CHANNEL FOR PROTON BEAM WITH ENERGY 9 GEV

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Abstract

It was described one of possible version of experimental channel for proton beam with energy 9GeV for ITEP. It based on proton beam after quick extraction, on existing experimental hall and on existing quadrupoles.

INTRODUCTION

For investigation of inner design of different target it is possible to use proton beam which can pass through the target and specific channel for transport scattered beam between the target and equipment for measurement shape of the beam at the end of the channel. Now in ITEP there is such channel for proton beam with energy 0.8GeV. This report is devoted to one of possible version of new channel on extracted from ITEPs synchrotron proton beam with energy 9GeV. New channel will be able investigate more thick targets with more high resolution.

OPTICAL SOLUTION

It was suggested to use optical scheme of channel with minimal angular sizes of the beam at the target, and with focus of the beam by two symmetrical parts (like triplets of quadruples). The first triplet focus initial (without scattering into the target) beam in middle point. Scattered beam can be collimated in this point according angle of scattering. The second triplet focus initial beam in both planes on equipment for measurement its profile with magnification -1. So, scattered in any point of the target proton beam will be focus at the equipment with magnification -1. It was suggested to use 8 quadrupoles ML15 (L=0.9m, D=0.15m, B<0.7Tl), which are free now in ITEP. Optical properties of the channel were calculated by TRANSPORT in second order.

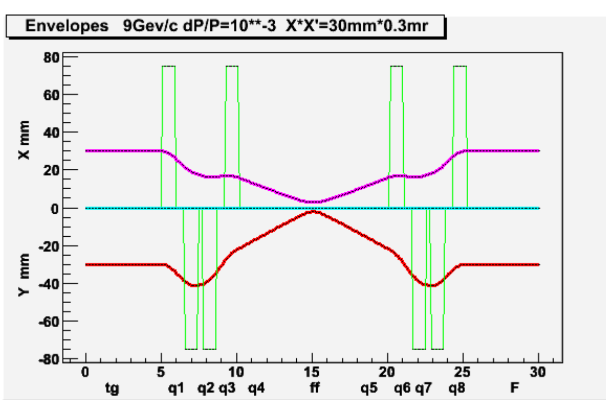


Figure 1. Scheme of proton beam envelopes into the cannel for beam without scattering in the target

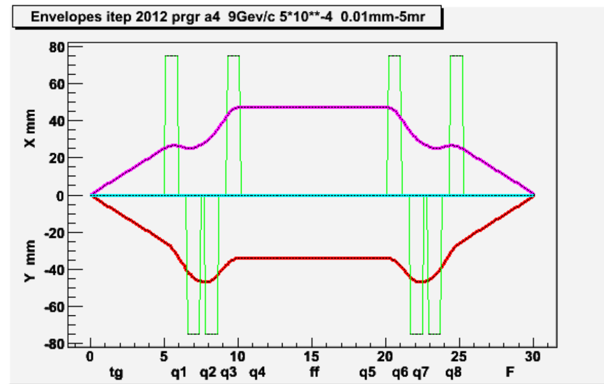


Figure 2. Scheme for beam envelopes for protons scattered in the target at angles 5mrad.

R11=R33=-1.0 magnifications are -1.0 in both planes. R116=R336=10^{-6}. Across sizes of the target have small influence on precision of measurements.

Chromatic aberration, which has strong influence on resolution, can be estimated in both planes as multiplication of those coefficients on angular sizes X' or Y' of scattered beam and on momentum spread dP/P of the scattered beam. According of calculations R126 = R346 = 30m. For dP/P=10-3 and X'=Y'≤5mrad limit of resolution according of chromatic aberration is like 0.15mm, for dP/P=10-4 and X'=Y'≤2mrad the same limit is like 0.006mm. Angular sizes of the beam in channel at measurement depend on initial angular sizes of the beam, on initial energy of protons, on properties of the target (length and material) and on collimation of the beam in middle point of the channel.

PRELIMINARY TRANSPORT OF EXTRACTED BEAM

Extracted proton beam at energy 9GeV has momentum spread in interval 10^{-3} < dP/P < 10^{-4}, its phase volumes are less 10mmmrad. If the target can change its properties quickly (10^{-6}sec) steel window with thickness like 10mm must be installed on the beam direction in 1m after 303 magnet of accelerator. Such window scattered protons on angles like 1mrad. At this condition sizes of beam for its transport to the target can be estimated 3mm*mrad < XX' < 16mm*mrad. Input proton beam at the target must be with diameter like 60mm and with minimal angular sizes. 4 existing quadrupoles 20K100 can be used for this aim.

ISBN 978-3-95450-125-0

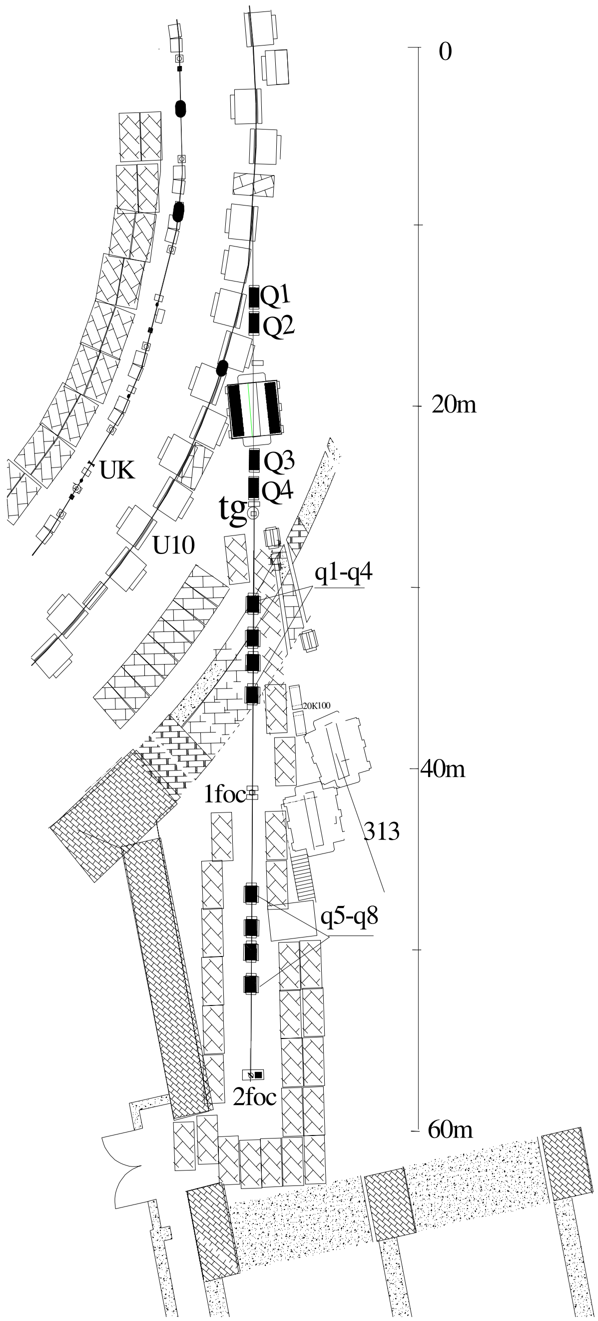


Figure.3. Layout of total channel and synchrotron ITEP.

LAYOUT OF THE CHANNEL

Initial direction of extracted proton beam is not fare from existing channel 311. New channel can be designed together with its quadrupoles, collimators, target, correctors, devices and concrete walls without destroy of existing channel 313 with its experimental equipments.

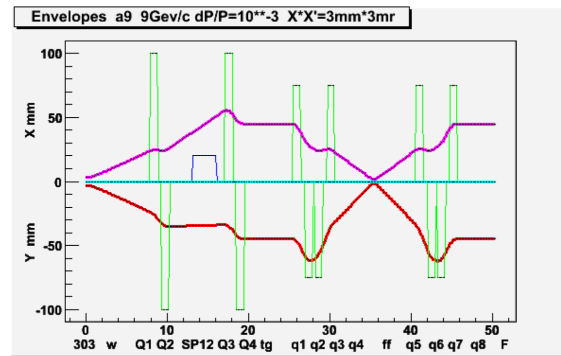


Figure.4. Scheme of proton beam envelopes into total channel for initial beam without of the target.

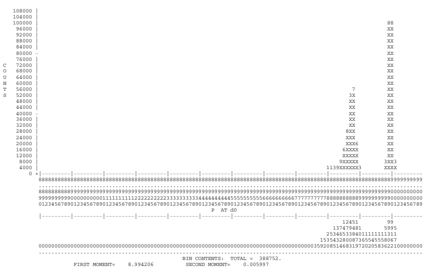
ESTIMATION OF REAL RESOLUTION

Resolution of the channel depends on properties of the initial beam and the target strongly. In addition to chromatic aberration it is necessary take in account scattering protons into the target and length of the target, quality of a surface between of different part of the target and bends of this surface to beam direction, on possibilities of equipment for measurement shape of the beam, on quality of magnetic fields in all quadrupoles, on un stability of currents in all quadrupoles and mistakes at choosing optimal currants in all quadrupoles.

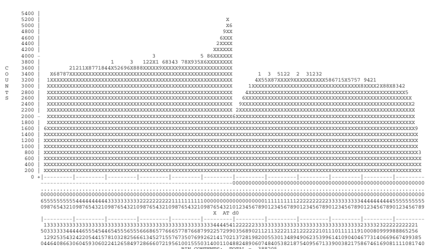
MK REVMOC [1] program was used for estimation resolution for different ideal targets (materials C, Fe, W and with length 2mm, 10mm, 30mm, 100mm. For each condition were calculated distribution protons by its momentum and its linear distribution in final point with steps 0.01mm. A few examples of calculations are shown on Figure 5 for Fe targets with different length and with rigid boundary between Fe and vacuum. Shape of decreasing intensity in point of boundary show ideal resolution of suggested channel.

ISBN 978-3-95450-125-0

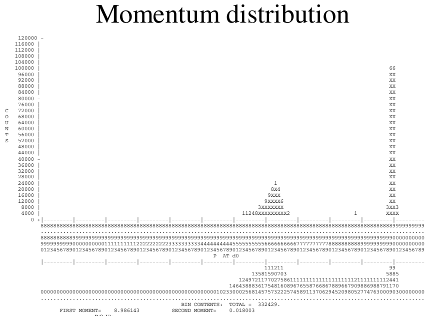
L=10mm X'=0.5mrad
Momentum distribution



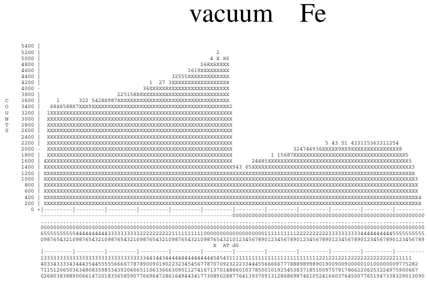
Linear distribution
step 0.01mm
resolution 0.01mm
vacuum Fe



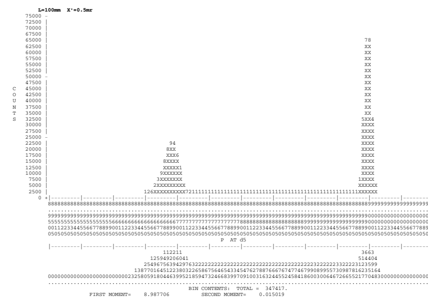
L=30mm X'=0.5mrad
Momentum distribution



Linear distribution
step 0.01mm
resolution 0.02mm
vacuum Fe



L=100mm X'=0.5mrad
Momentum distribution



Linear distribution
step 0.01mm
resolution 0.06mm
vacuum Fe

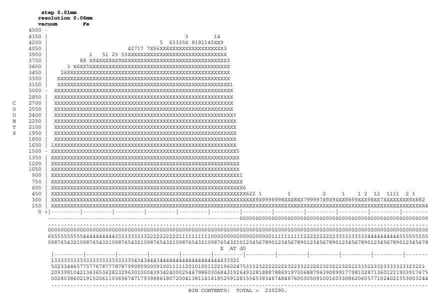


Figure 5. Calculated momentum distributions and linear distributions of the beam in point of measurement for Fe-vacuum targets with different length (10mm, 30mm, 100 mm).

CONCLUSIONS

Resolution of the channel better 0.01mm can be useful only for targets with length less 30mm.

Suggested on base of free in ITEP quadrupoles channel can be suitable for investigation targets without or with quick changes of the targets properties.

REFERENSIS

[1] C.J.Kost, P.Reeve. A MonteCarlo Beam Transport Program REVMOC TRI-DN-82-28, TRIUMF, Canada

ISBN 978-3-95450-125-0