Available online at www.sciencedirect.com
ScienceDirect
Nuclear Instruments and Methods in Physics Research A 572 (2007) 601–606
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A
www.elsevier.com/locate/nima

Collimation of H^- beam transverse halo by triplets and foil scrapers ☆

J.Y. Tang*, G.H. Wei, C. Zhang

Institute of High Energy Physics, CAS, Yuquan Rd 19B, Beijing 100049, China

Received 17 October 2006; received in revised form 23 November 2006; accepted 13 December 2006
Available online 2 January 2007

Abstract

Transverse beam halo from a high current linac is an important source of beam losses in a ring as the next stage accelerator. A method is introduced that uses periodic triplet cells and foil scrapers to collimate the beam halo in the beam transport line from the linac to the ring and transports the collimated particles to a beam dump. It has good properties such as being low beam loss in the beam line and avoiding local collimators. Comparisons are made with doublet cells and FODO cells as well as with other collimation methods. In the paper, applying the method to the Chinese Spallation Neutron Source (CSNS) is also presented, together with the simulation results, using macro-particles and taking into account nuclear elastic scattering effect and foil stripping efficiency.

PACS: 29.27.Eg; 41.85.Ct

Keywords: Halo collimation; Triplet cells; Foil scraper; Mixed-beam transporting; Beam loss

1. Introduction

For high-power proton accelerators such as spallation neutron sources and proton drivers, the H^- beam is firstly accelerated in a linac and then injected into a rapid cycling synchrotron or an accumulator ring via stripping. The beam halo generated in linac will be an important source of beam losses in the ring if it is not treated properly. The collimation of the beam halo should be carried out in the injection beam line to the ring.

As H^- halo particles can be converted into protons by using stripping foils [1], it is thus relatively easier to remove them from the main beam. People usually use periodic FODO cells and collimators or beam dumps to remove the transverse beam halo and a symmetric achromat to remove the beam momentum tail [2–4]. This paper is focused on the collimation of transverse beam halo, but a different scheme based on periodic triplets will be introduced. The application of the method to the Chinese Spallation Neutron Source (CSNS) will be also presented.

2. Collimation and transport with periodic triplet cells

As mentioned above, it is an advantage to scrape the H^- halo particles by a stripping foil instead of collimating them directly by a massive collimator. The latter is usually used to collimate proton beam halo. With an H^- beam, the foil scraper method can avoid the reduction of the collimation efficiency due to nuclear scattering. There are two ways to deal with the converted protons: one is to absorb them locally by a collimator when they are sufficiently separate from the main beam; the other is to transport them to a beam dump. To have better collimation of beam halo, e.g. rectangular or hexagonal in emittance shape, two or three pairs of the foil scrapers in each transverse plane should be placed at a certain distant phase advance with a periodic focusing structure.

Here a new collimation method of using foil scrapers and the mixed transport of both H^- and proton beams based on periodic triplet cells is introduced. Doublet cells, instead of triplet cells, can give similar but less efficient results.

☆This was Work supported by the National Natural Science Foundation of China (10075065) and the CAS Knowledge Innovation Program—"Multi-disciplinary Platform—Spallation Neutron Source: Innovative Study on Some Key Technologies".

*Corresponding author. Tel.: +86 10 88235908.
E-mail address: tangjy@ihep.ac.cn (J.Y. Tang).

0168-9002/$ - see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.nima.2006.12.033

2.1. Triplet cells

Triplet cells are favored as they can give identical waists in both transverse planes. The advantage is that the beam line can transport the mixed H^- and proton beams without mismatch (see Figs. 1 and 2). The focusing of the H^- and proton beams looks like the exchange of the horizontal and vertical planes; thus, the use of designed optics for the H^- beam is also perfect for the proton beam.

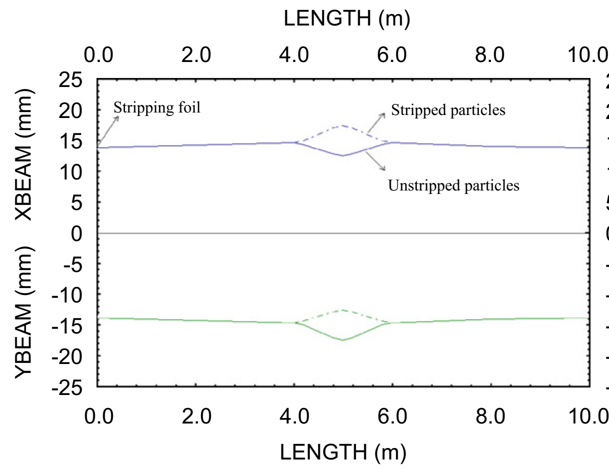

Fig. 1. Beam envelopes for mixed H^- and proton beams through a triplet cell.

To obtain a hexagonal shape for the collimated beam emittance, three pairs of foil scrapers in each transverse plane are planned at the waists, separated by 60° in phase advance. The six pairs of foil scrapers, together with two periodic triplet cells (see Fig. 3), can perform perfect halo collimation in both horizontal and vertical planes (see Fig. 4). The proton distributions (in red) in x–x' and y–y' are superimposed in two parts: a hollow one coincident to the H^- hexagonal shape due to the stripping in the same plane, and an original distribution before collimation due to the stripping in the other plane.

As the stripped particles (protons) will be naturally separated from the H^- beam at a downstream switch magnet and transported to a well-shielded beam dump with almost no beam loss in the path, the whole beam line is very clean and good for hands-on maintenance.

Although the focusing structure is perfect for both the H^- beam and proton beam, there are nuclear elastic

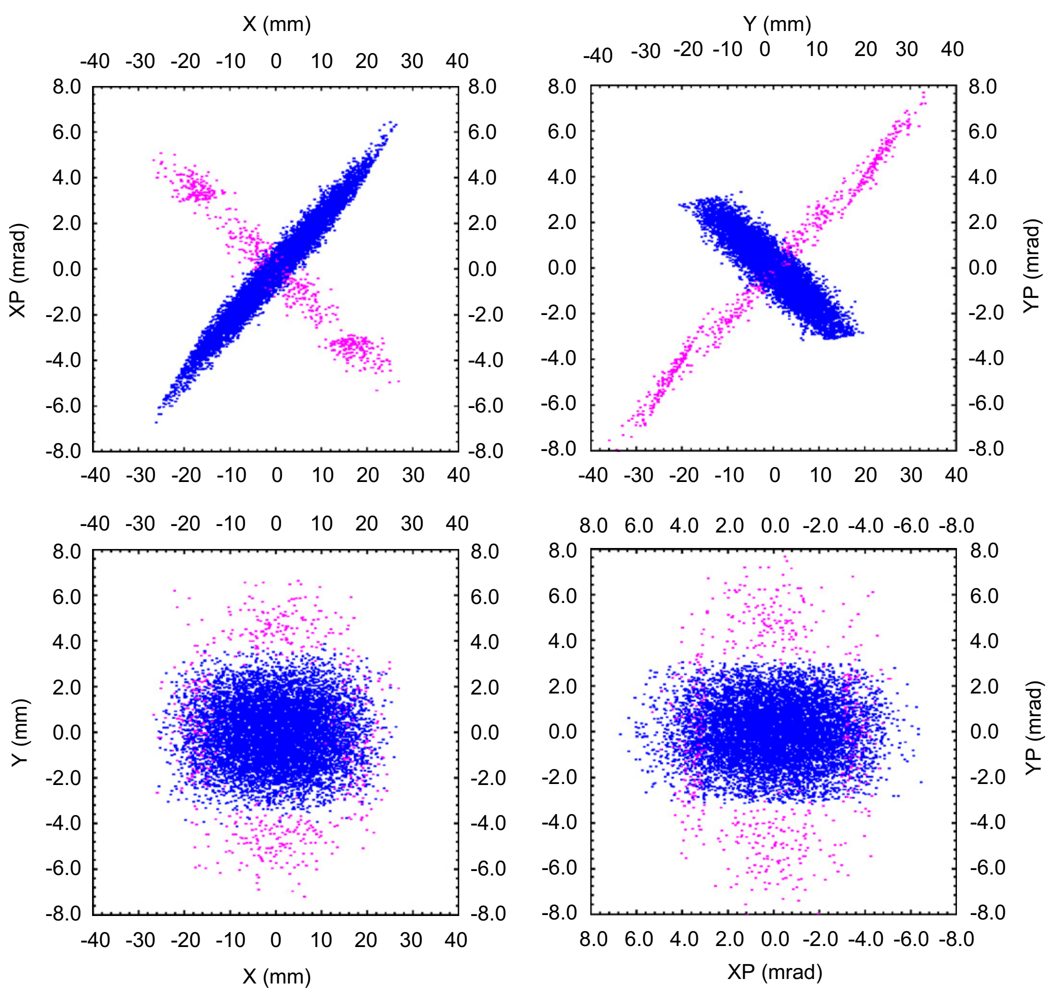

Fig. 2. Distribution of mixed H^- and proton beams in phase space at a quadrupole (blue: H^-; red: proton).