Protons and Electrons in the IDS Front-end

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(Dated: September 9, 2010)

Abstract

Recently C. Rogers[1] has studied the number of protons and electrons and their energy content downstream the IDS baseline front-end. In this note we report our study, prompted by Rogers' and suggest possible strategies to diminish their potential impact on the transmission of the front-end.

INTRODUCTION

The present IDS baseline front-end is shown schematically in Fig. 1

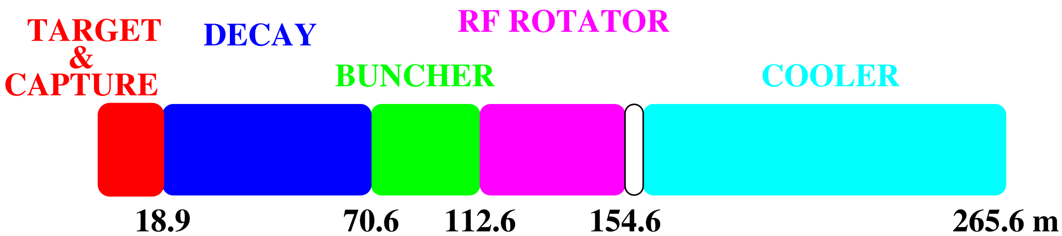

FIG. 1. [color] Schematics of the IDS front-end

The MARS-15[2] output at the end of the target is used as input to ICOOL. A significant number of primary and secondary protons as well as secondary electrons are capture and focused in the channel, in addition of the muon beam which is our only concern. These protons and electrons at best are a nuisance and at worst could have a significant deleterious effect on the efficiency of the front-end. Beam loading of the rf cavities and energy deposition in the superconducting magnets are obvious serious concerns between many, that we need to address.

The magnitude of the problem is depicted in the following figures. In Fig. 2 we show the number of protons (left) and electrons (right) along the front-end.

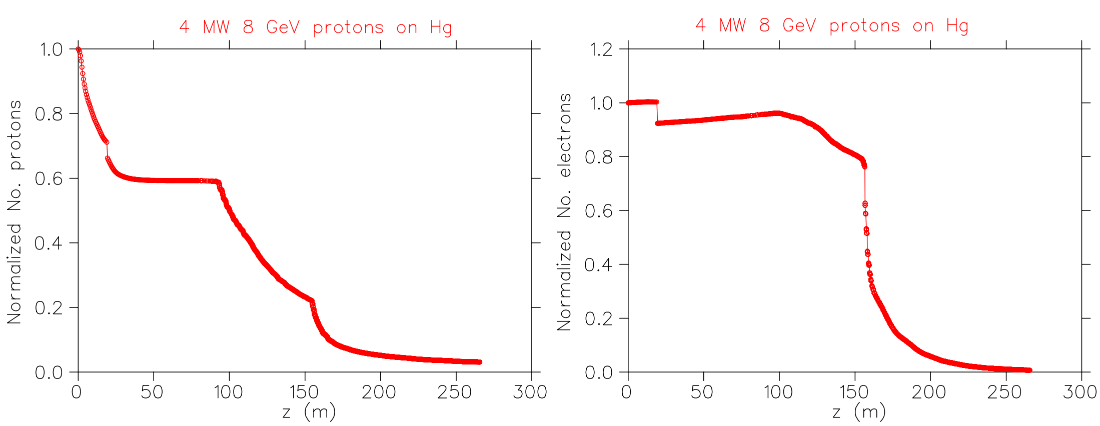

FIG. 2. [color] (left) Normalized number of protons; (right) number of electrons as a function of z the distance along the beamline. These numbers correspond to a MARS15 run with 8 GeV on a Hg target.

In Figs. 3, 4 we plot the energy in the proton beam and the energy deposited per unit length as a function of z. These plots assume a 4 MW, 8 GeV proton beam on a Hg target with a geometry depicted in Fig. 5.

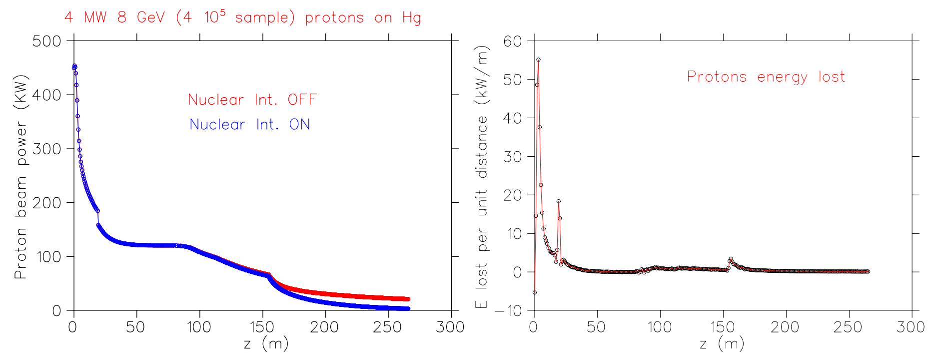

FIG. 3. [color](left) Energy in the proton beam as a function of z the distance along the beamline; (right) energy deposited per unit of length by the proton beam as a function of z.

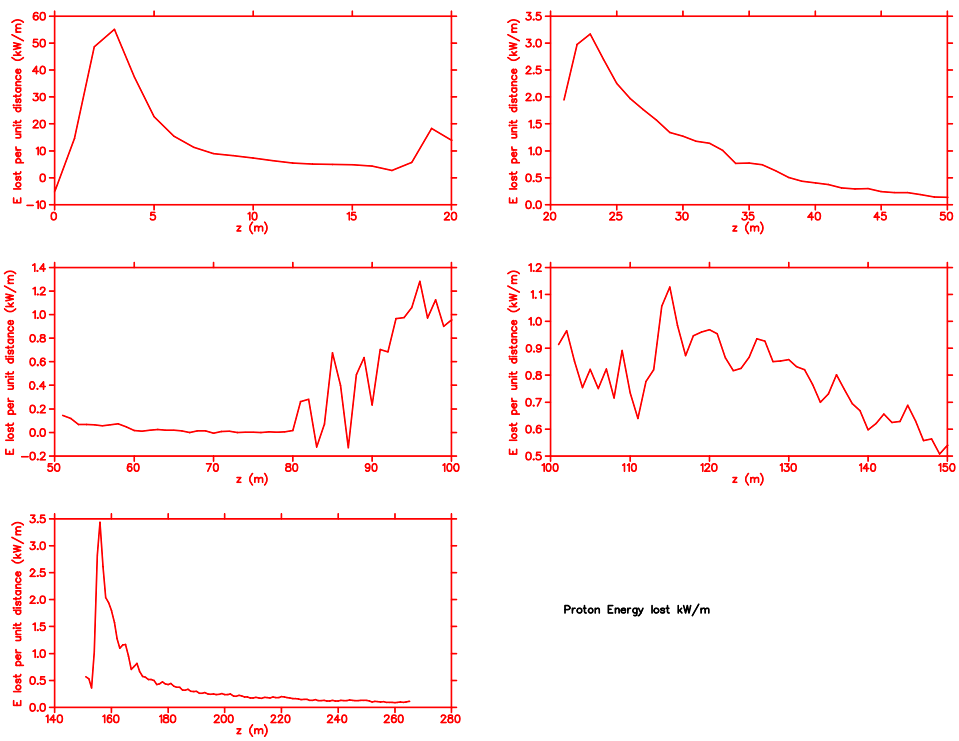

FIG. 4. [color] Energy deposited per unit of length by the proton beam as a function of the distance z for each section of the IDS front-end isolated for better display (notice the ordinate scale).

Likewise, in Fig. 6 we plot the energy in the electron beam as a function of z;

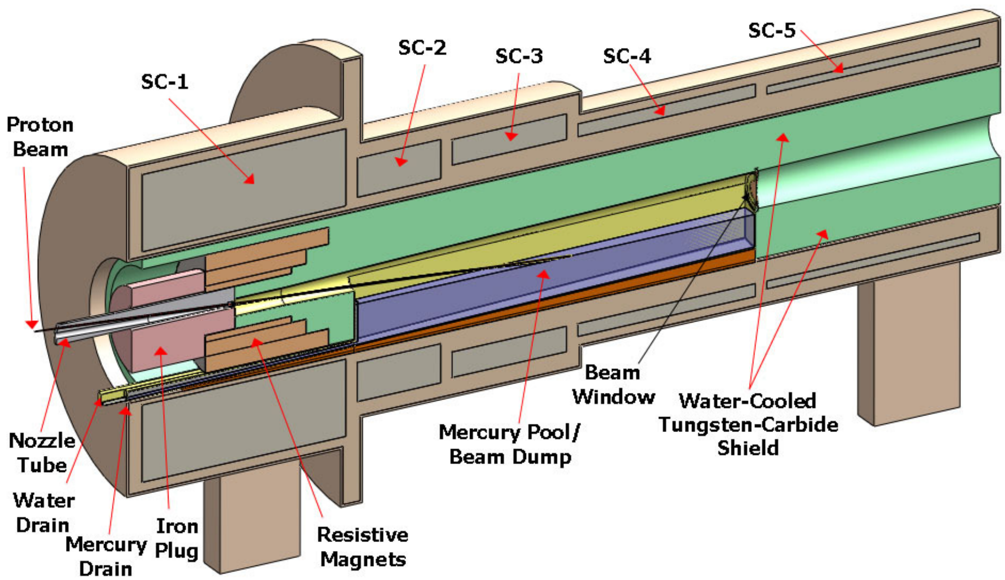

FIG. 5. [color] Schematics of the target geometry.

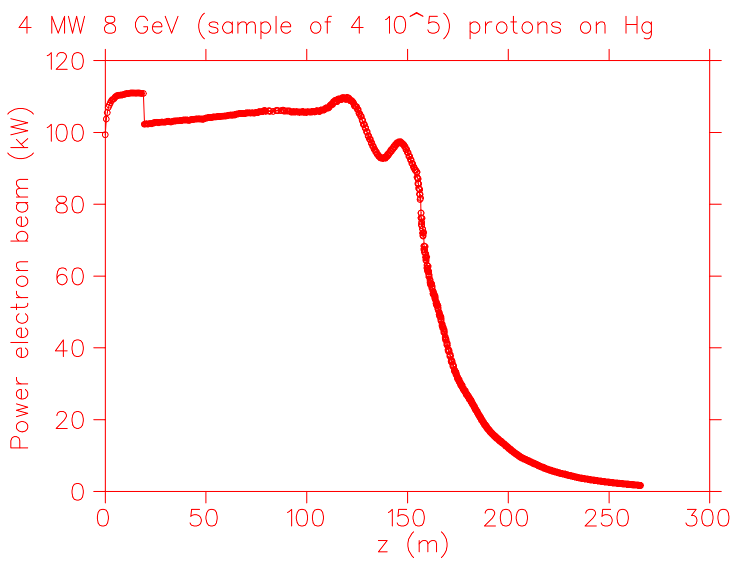

FIG. 6. [color] Energy in the electron beam as a function of z the distance.

ALTERNATIVE MITIGATION

A few proposals has been put forward to reduce the flux of protons and electrons to manageable levels along the front-end and, in particular in the cooling section. A bent solenoid has a long tradition and it was proposed in the second muon collider feasibility study [3]. We set a bent solenoid immediately after the target section con parameters shown in Table I. Right at the end of the bent solenoid we compare the energy spectrum of protons in Fig. 7.

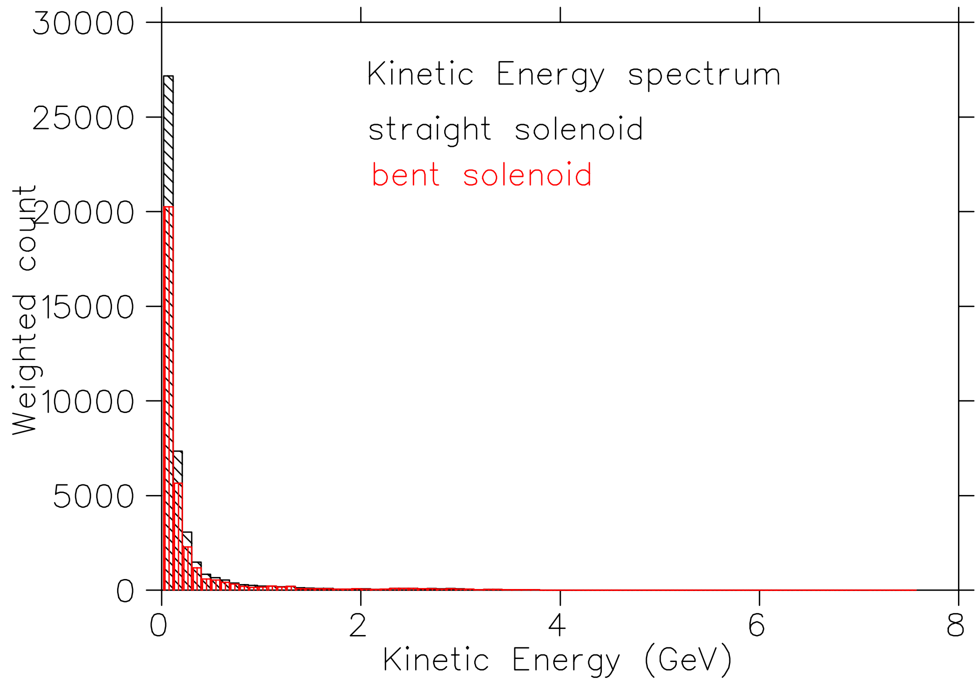

FIG. 7. [color] Energy spectrum of protons with and without bent solenoid; each bin corresponds to 100 MeV.

The impact of the bent solenoid in the performance and reduction of number of undesirable protons and electrons is shown in Fig. 8.

As we can see the number of protons in the cooling section is decreased by about 88%; the number of muons in the acceptance at the end of the cooling section has decreased by about 18% and finally the number of electrons in the cooling section has decreased by about 27%.

TABLE I. Parameters of a bent solenoid. We are not using any matching at either ends.

Length $\approx 30\ m$	start at z=18 m
Aperture radius	$R_A = 0.30\ m.$
Magnetic field on axis	$B_s \approx 1.8\ T$
Radius of curvature	$R_s = 10^4\ m,\ (h = 10^{-4})$
Vertical dipole field	$B_D = 1\ T.$

A second alternative is to intercept the composed beam of muons, protons, electrons and to lesser extend of pions with Be plugs. This study has yet to be done.

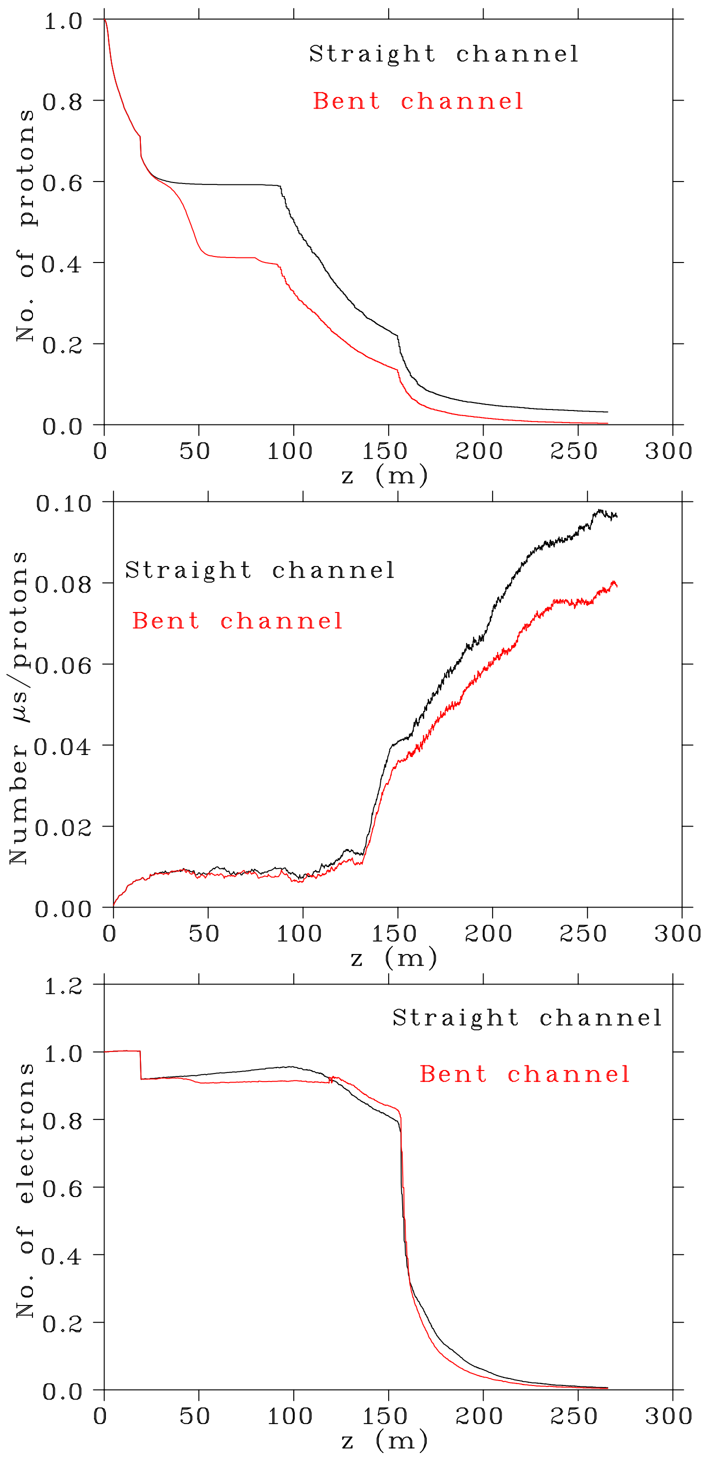

FIG. 8. [color] A comparison of the number of protons in the front-end with and without bent solenoid.

CONCLUSIONS

It seems that a bent solenoid upstream the beamline could be effective to reduce the number of protons in the cooling section albeit at the cost of diminishing the muon yield within the accelerator acceptance. More studies are needed to optimize the bent solenoid parameters and ascertain its technical feasibility.

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[1] C. Rogers,
`http://www.astec.ac.uk/groups/beams/users/rogers/Front_End/2010-06-22/rogers_transmission_l`

[2] N. Mokhov, *Proceedings of the 2001 Particle Accelerator Conference* (2001), p. 745; see also `http://www-ap.fnal.gov/MARS/`.

[3] $\mu^+\mu^-$ *Collider: A Feasibility Study*, sec. 4.3.2, BNL-52503; FermiLab-Conf.-96/092; LBNL-38946 (1996).