Beam dynamics after the sieve

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09/06/10

Introduction

- The sieve is a plate with holes. Aim:
  - Decrease the beam current (by a factor of 5).
  - Keep the emittance of the H- beam.
- 1731 holes of 1.5 mm diameter.
- Linac2
  - At 50 MeV.
  - 12 mm thick plate made of 1.8 g/cm^3 graphite.
- Linac4:
  - At 160 MeV
  - materials of the sieve : graphite or copper.

Introduction

- Placed 6 m after BHZ.40.

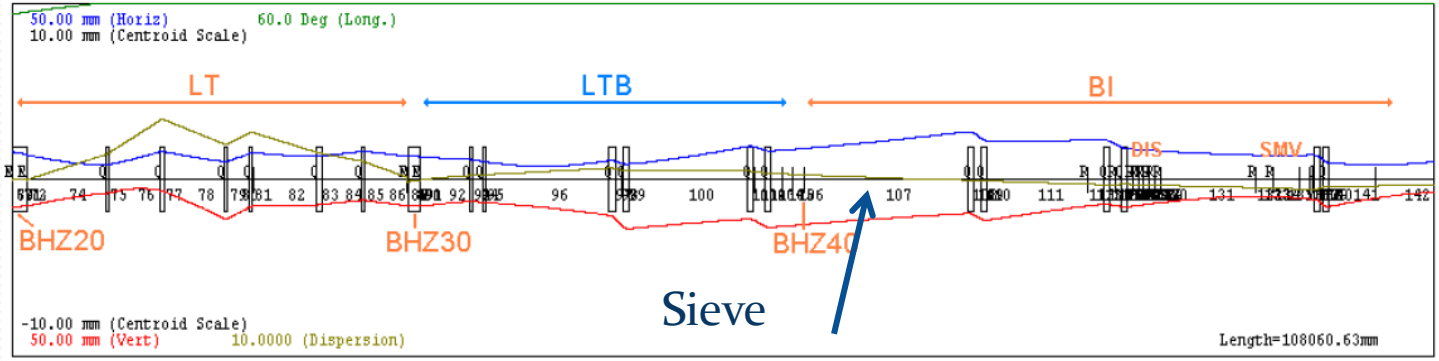


Figure 1. Sketch of the Linac2/Linac4 transfer line, common part.

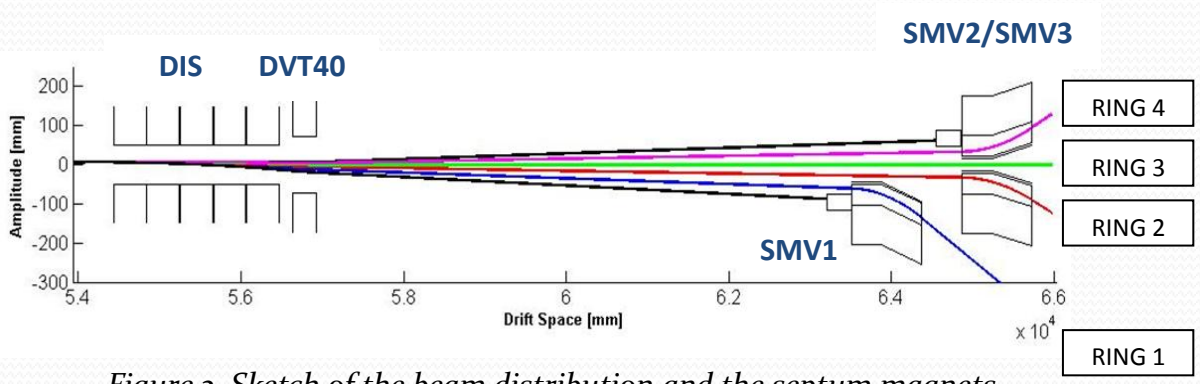


Figure 2. Sketch of the beam distribution and the septum magnets.

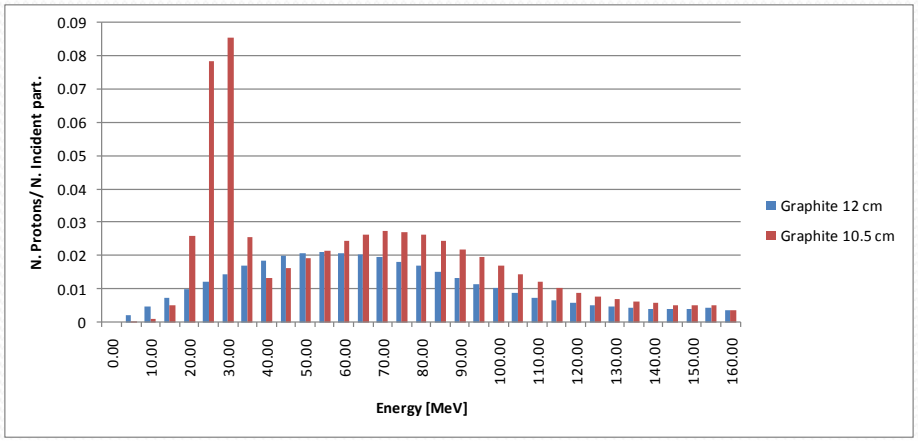
LINAC-4: 160 MeV

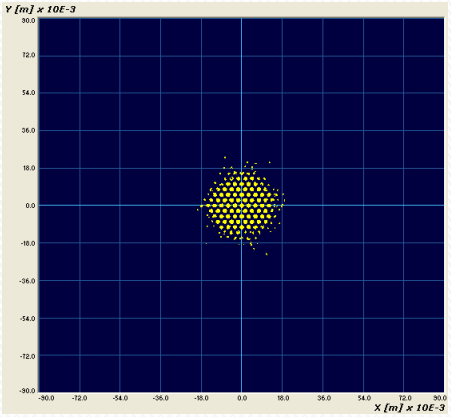
- After the sieve: H-, protons and neutrons.
- Beam distributions after the sieve have been calculated with Fluka [4][5].
- Beam dynamics : simulated with code Path Manager.

Material - Thickness	H- after the sieve per primary	Protons after the sieve per primary	Neutron after the sieve per primary	Total number particles after the sieve per primary
Graphite - 10.5 cm	0.22	0.60	0.009	0.82
Graphite - 12 cm	0.22	0.35	0.009	0.58
Copper - 2.7 cm	0.22	0.57	0.014	0.80
Copper - 3 cm	0.22	0.29	0.014	0.52

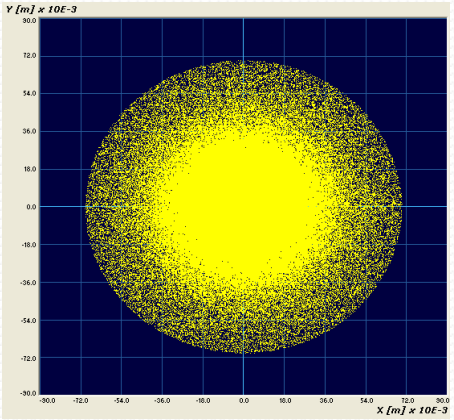
160 MeV : Beam distributions

Graphite

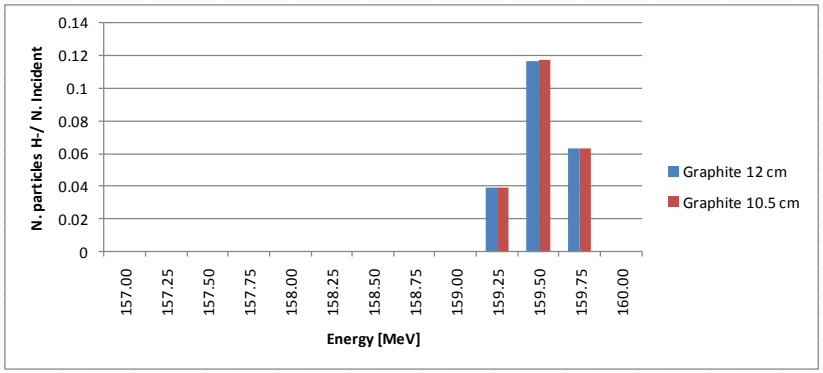


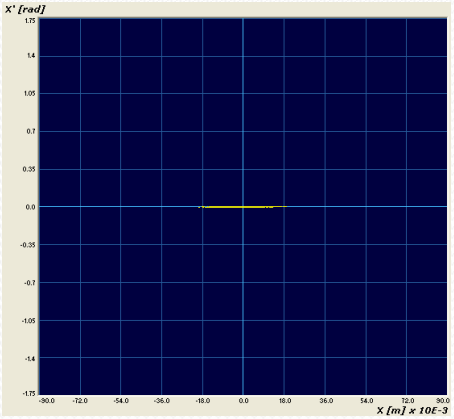


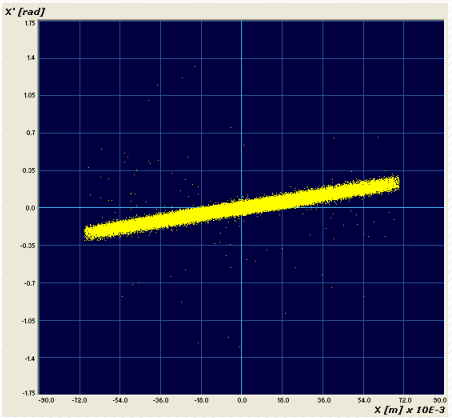
H⁻ Beam



H⁻ and proton Beam

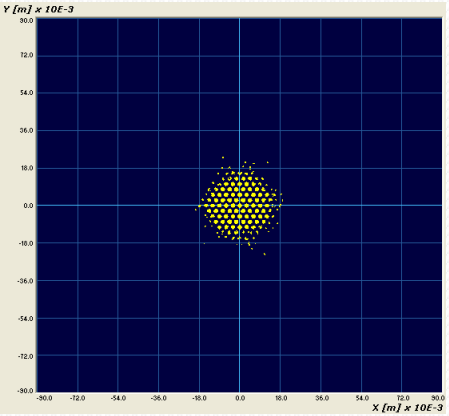




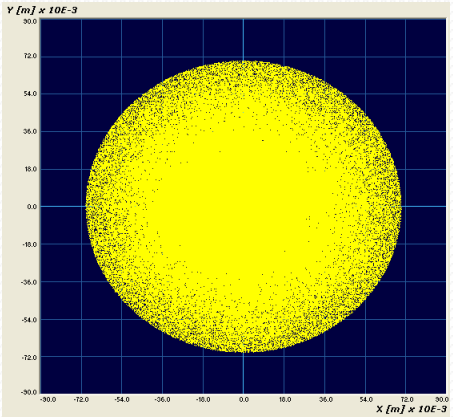


160 MeV : Beam distributions

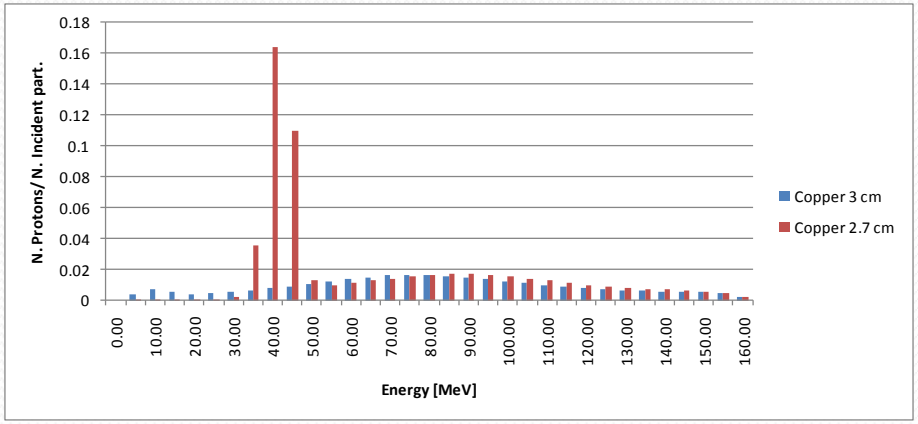
Copper

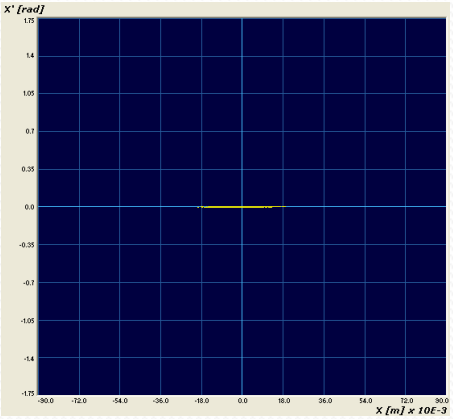


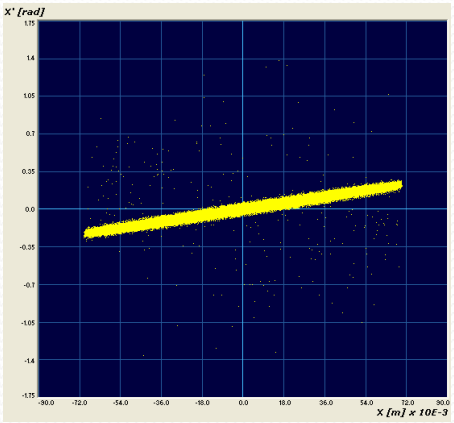
H⁻ Beam

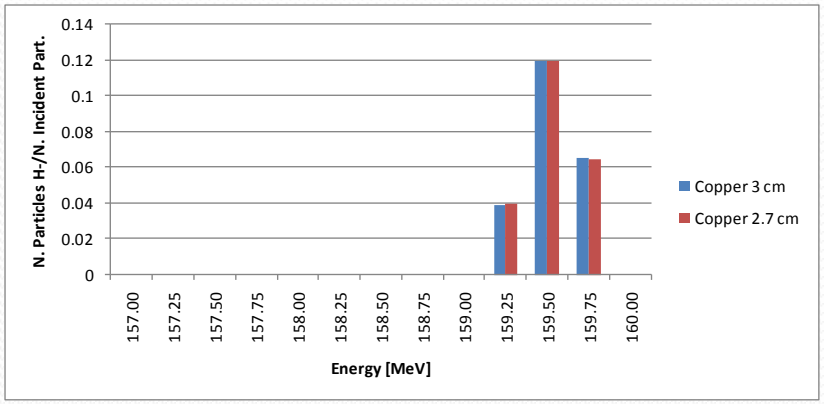


H⁻ and proton Beam









160 MeV Graphite

Tracking the protons :

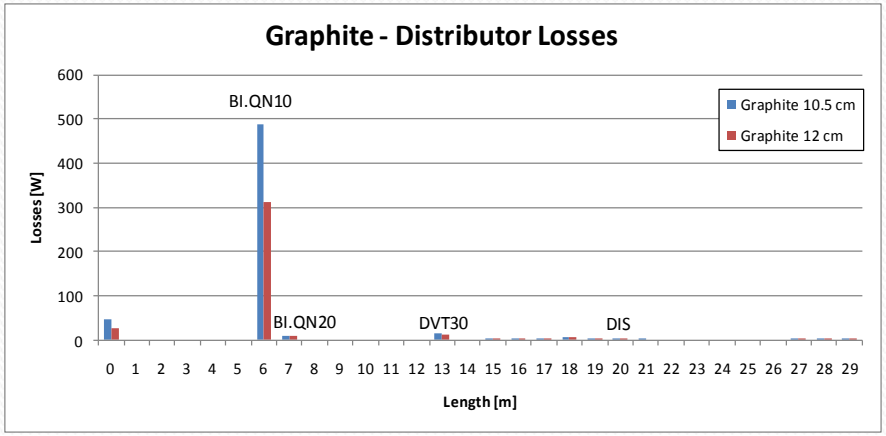


Figure 3.- Proton Losses. Graphite.

Destination H-	Graphite 10.5 cm ‰ Protons Output Ring 3	Graphite 12 cm ‰ Protons Output Ring 3
To Ring 1	0.16	0.30
To Ring 2	0.84	1.42
To Ring 3	0.89	1.65
To Ring 4	0.55	0.95

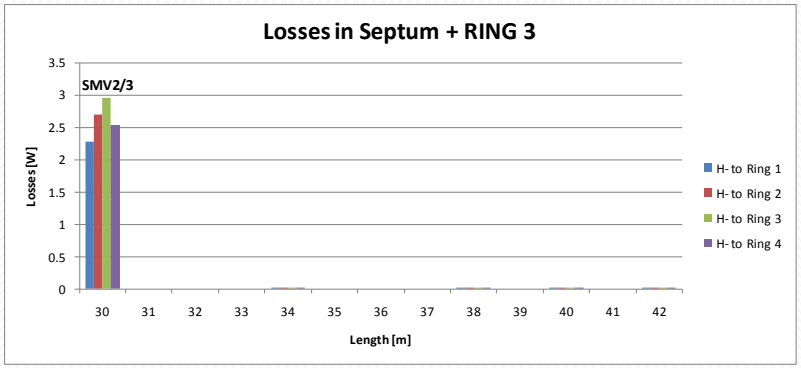


Figure 4.- Proton Losses in the septum. Graphite 10.5 cm.

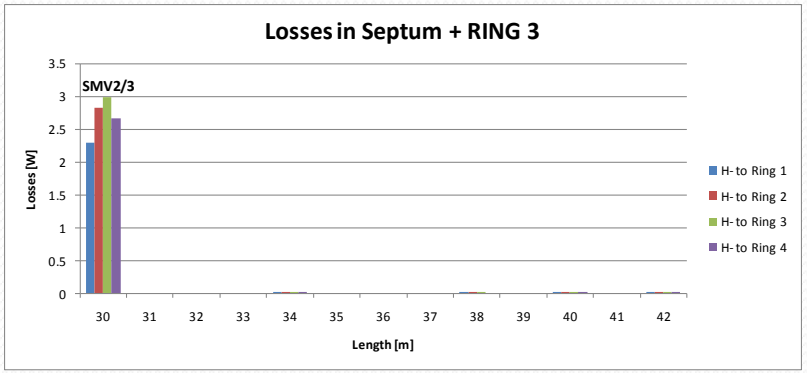
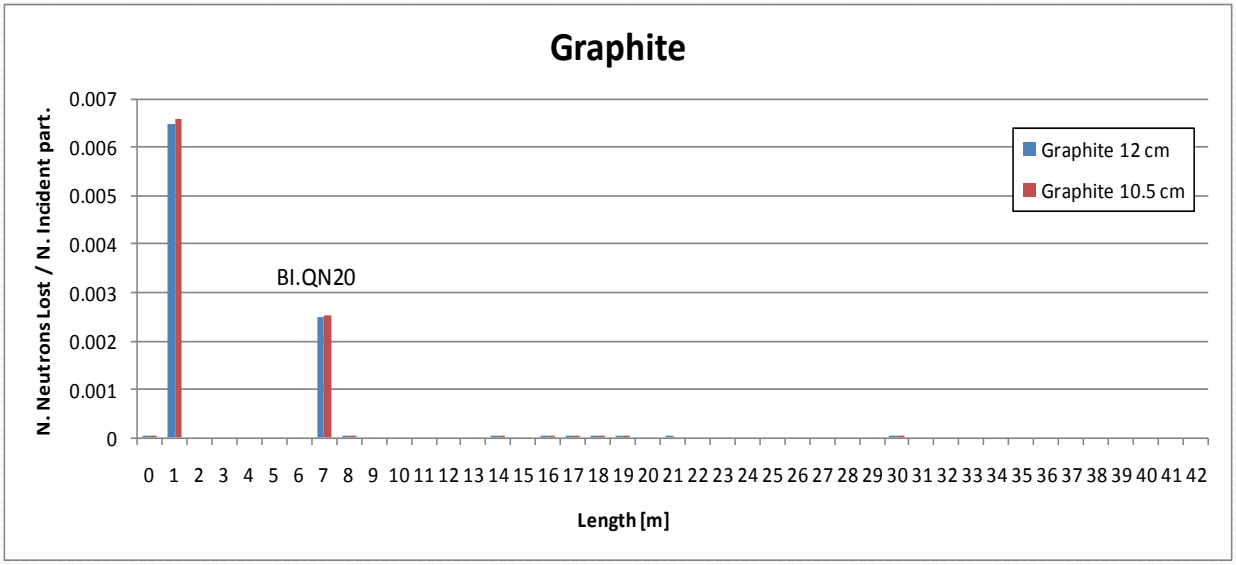


Figure 5.- Proton Losses in the septum. Graphite 12 cm.

400µs puse, 40 mA, 1Hz repetition rate.
Total Losses Graphite 10.5 cm = 580 W
Total Losses Graphite 12 cm = 380 W

160 MeV Graphite

- Tracking the neutrons up to the end of the TL:
- Neutrons generated after the sieve are lost in the first meter or in the second quad.
- The losses are independent of the thickness.



160 MeV Copper

Tracking the protons :

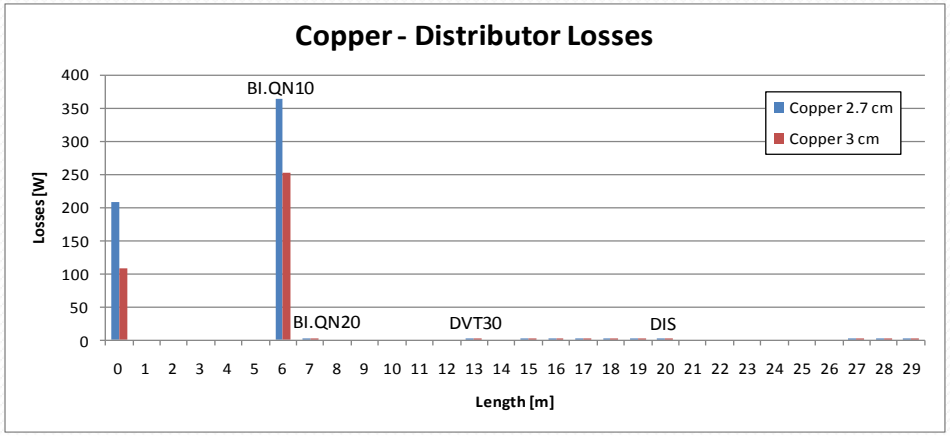


Figure 6.- Proton Losses. Copper.

Destination H-	Copper 2.7 cm ‰ Protons Output TL to Ring 3	Copper 3 cm ‰ Protons Output TL to Ring 3
To Ring 1	0.02	0.01
To Ring 2	0.09	0.19
To Ring 3	0.19	0.32
To Ring 4	0.04	0.07

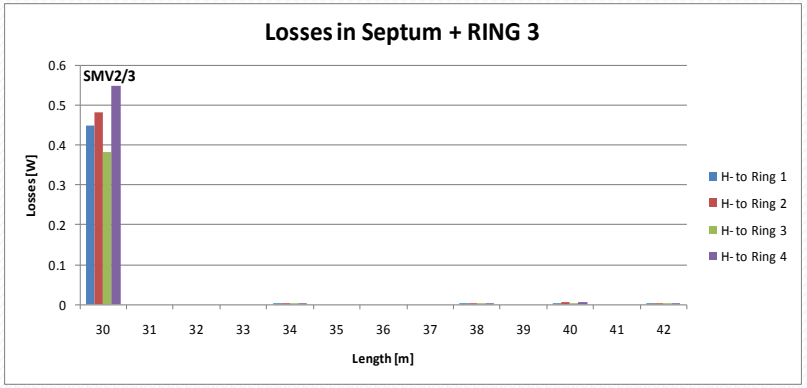


Figure 7.- Proton Losses in the septum. Copper 2.7 cm.

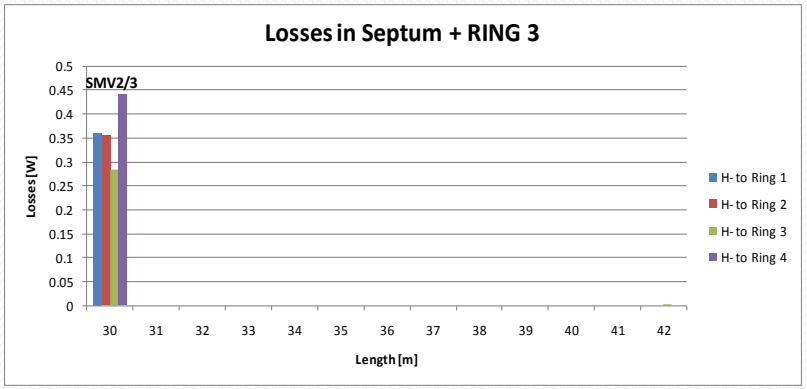
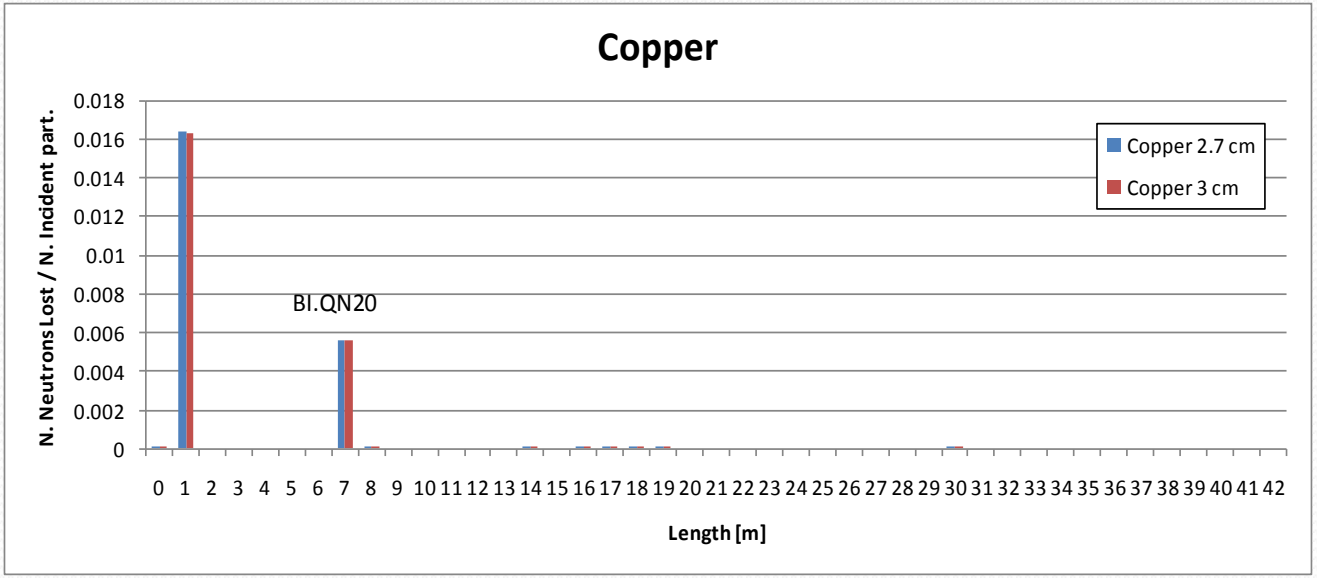


Figure 8.- Proton Losses in the septum. Copper 3cm.

400µs puse, 40 mA, 1Hz repetition rate.
Total Losses Copper 2.7 cm = 576W
Total Losses Copper 3 cm = 364 W

160 MeV Copper

- Neutrons generated after the sieve are all lost along the line.



Summary of results

Material - Width	Transmission ‰ Protons Output Ring 3 (Worst Case)	Transmission ‰ Neutrons Output Ring 3	% Protons Lost
Graphite - 10.5 cm	0.89	0	99.91
Graphite - 12 cm	1.65	0	99.84
Copper - 2.7 cm	0.19	0	99.98
Copper - 3 cm	0.32	0	99.97

Conclusions

- Only ~20% of H^- are stopped by the sieve for the thinner thicknesses. The rest come out as a protons at degraded energy.
- Most of the losses are located at the first two quads (QN10 and QN20). The level of losses is not acceptable.
- Neutrons:
  - Distribution of neutrons independent of the material thickness.
  - No neutrons transmitted to the PSB.
- Protons:
  - More protons generated for thinner material thickness → Bragg peak outside the material.
  - Protons arriving to septum magnets are lost → There will be protons only at the end of ring 3.
  - Protons inside the acceptance are alive at the end of the TL (injection to Booster Ring 3).
- New approaches changing the sieve location are being studied in order to solve the issues concerning the sieve at 160 MeV. See [7]

References

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- [2] A. Perrin and J.F Amand, Travel v4.07, users manual,CERN (2003).
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- [7] M. Garcia Tudela, A. Christov, A. Lombardi, “Reduction of the beam intensity by means of a sieve for Linac4”