30 T ON TARGET NEUTRINO FACTORY/MUON COLLIDER FRONT-END

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The main objective of the study is to investigate the effects of a higher magnetic field on the target. The *Neuffer* front end consists of

- Target and capture section
- Bunching and rf phase rotation sections
- cooling lattice

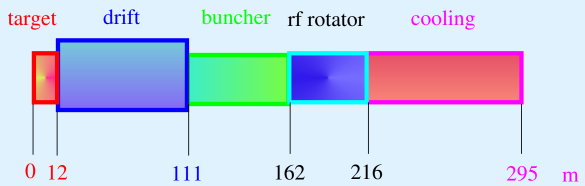

Figure 1: Layout of the Front-End.

Different Components of the Front-End

- Capture Section: Hg jet target; 2-3 ns 8 GeV proton *(24 GeV)*. Solenoidal channel: Length ≈ 12 m, 30 *(20)* $\geq B_z \geq$ 2.6 *(1.75)* T
- Decay Drift: Length ≈ 100 m, $B_z \approx 2.6$ (1.75) T
- Adiabatic Bunching: 27 cavities with 13 different ⇓ frequencies and changing ⇑ gradients. Length ≈ 50 m, $B_z = 1.75\ T$
  - $333 \leq f \leq 234$ MHz $5 \leq Grad. \leq$ 10 MV/m
- Phase Rotator: 72 cavities with 15 different ⇓ frequencies; constant gradient. Length ≈ 50 m, $B_z = 1.75\ T$
  - $232 \leq f \leq 201$ MHz $Grad = 12.5$ MV/m
- Cooling: Solenoidal FOFO lattice; Length ≈ 50 m, $B_z = \pm 2.8$ T; $Grad. = 15.25$ MV/m, $f =$ 201.25 MHz

Bunching and Phase Rotation Region

In the scheme the correlated beam is first adiabatically bunched using a series of rf cavities with decreasing frequencies and increasing gradients. The beam is then phase rotated with a second string of rf cavities with decreasing frequencies and constant gradient. The final rms energy spread in the new design is 10.5%.

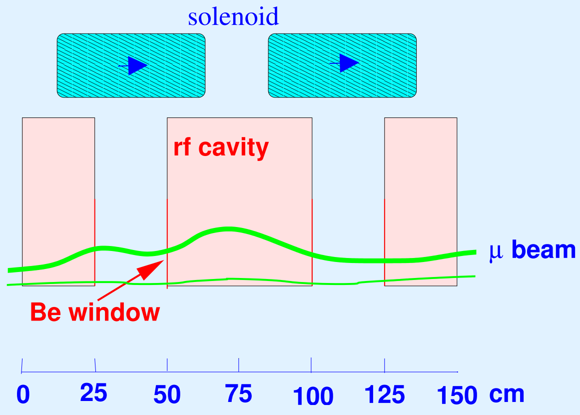

Figure 2: Schematic of 2 cells of the buncher or rotator section.

Cooling Section

A novel aspect of this design comes from using the windows on the rf cavity as the cooling absorbers. This is possible because the near constant β function does not significantly increase the emittance heating at the window location. The window consists of a 1 cm thickness of LiH with a 75μm layer of Be on the rf cavity field side and, 25μm layer of Be on the opposite side. (The Be will, in turn, have a thin coating of TiN to prevent multipactoring). The alternating 2.8 T solenoidal field is produced with one solenoid per half cell, located between the rf cavities.

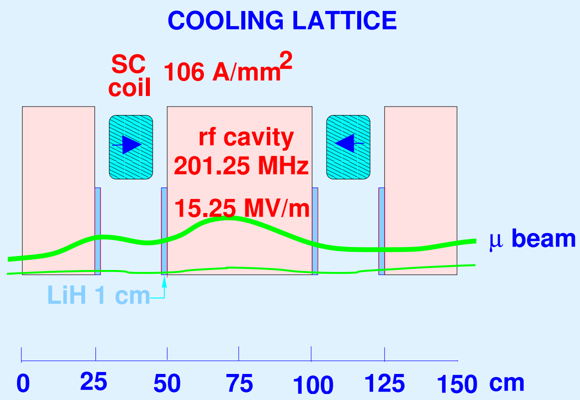

Figure 3: Schematic of one cell of the cooling section. Beta function is constant ≈ 80 cm. Windows are absorbers.

Simulation Performance: 20 T Solenoid on Target

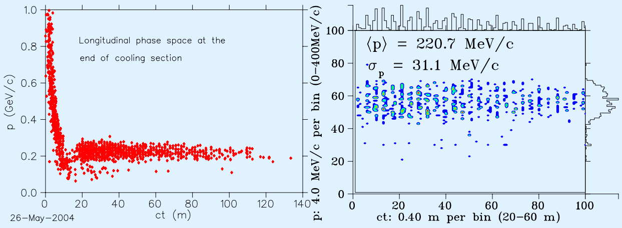

Figure 4: Longitudinal phase space at the end of the channel.

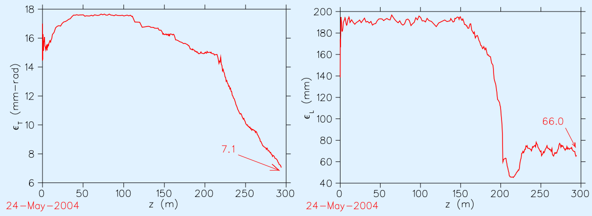

Figure 5: Normalized transverse emittance (left) and longitudinal emittance (right) along the front-end for a momentum cut $0.1 \leq p \leq 0.3$ GeV/c.

Number of μ/p in $A_\perp$ and A_L : Final values are 0.176 with 24 GeV and 0.08 with 8 GeV protons on target.

Table 1: Table of Results.

$< p_z >$ Mean Momentum (MeV/c)	220
rms Energy Spread (MeV)	31
$\epsilon_\perp^N$ (mm-rad)	7.1
$\epsilon_\perp^{equil.}$ (mm-rad)	5.5
ϵ_L^N (mm)	66
$A_\perp$ (mm-rad)	30
A_L (mm)	150
No. μ/p in $A_\perp$ and A_L	0.08

Simulation Performance: 30 T Solenoid on Target

We use a MARS generated πs file for an optimized target system with 8 GeV proton on Hg. The magnetic field on Target, Capture, Drift is *naively* scaled by a factor of $\frac{3}{2}$ and the radius of the pipeline is decrease to 25 cm same size as the Be windows in Buncher and Rotator sections.

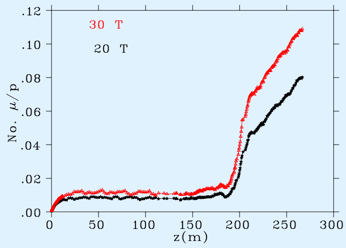

Figure 6: Comparison between 20 and 30 T examples: (left) transverse emittance vs z; (right) number of muons per incident proton on target vs z. Final values: for 20 T is 0.08; for 30 T is 0.11.

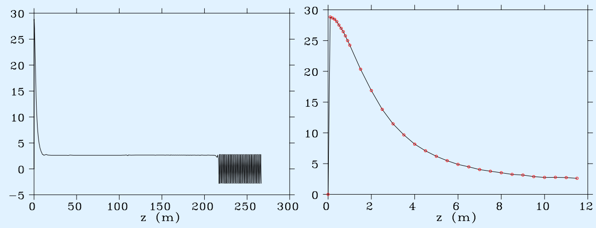

Figure 7: (Left) Magnetic field (T) on the total length of the front end; (Right) magnetic field (T) on the capture region.

In this examples the constant magnetic field on both bunching and rotator sections was $2.6\ T(1.75 \times \frac{3}{2})$. **If we reduce the field to the standard $1.75\ T$ and disregard the lack of matching at the different magnetic field inter-phases**, then

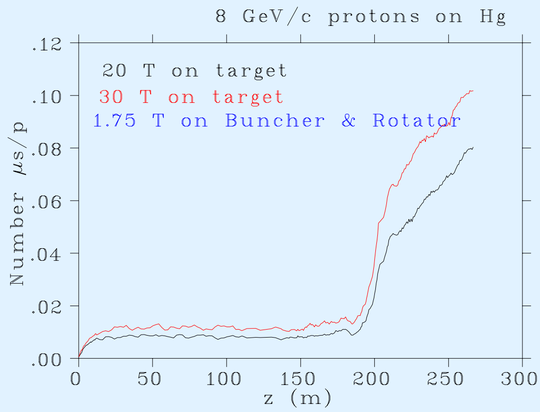

Figure 8: Comparison between 20 and 30 T examples: number of μs per incident proton on target vs z. Final values: for 20 T 0.08; for 30 T 0.10.

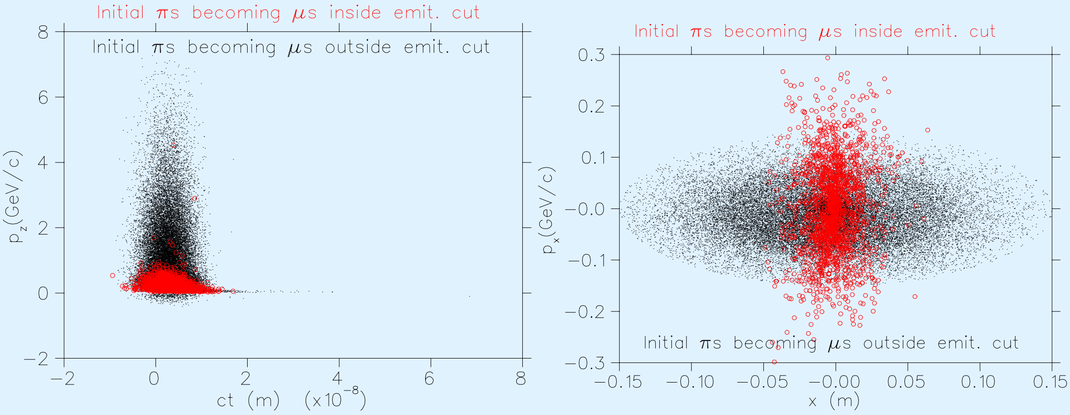

Figure 9: Longitudinal phase space (left); transverse phase space (right) of initial πs.

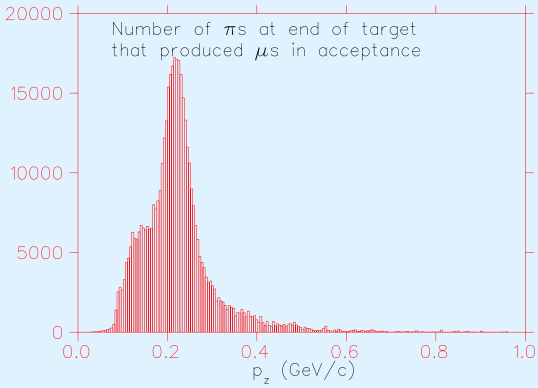

Figure 10: Number of πs on 2.5 MeV/c momentum intervals.

Suggested Conclusions

- New 8 GeV MARS 15 increases the efficiency of the front-end by $\approx 30\%$
- For a larger magnetic field on target $(20\,T \Longrightarrow 30\,T)$, the efficiency increases by $\approx 30\%$.