HEBT Momentum Scraper, H^+ Ray Trace Simulation*

1.Introduction:

In the 1MW National Spallation Neutron Source(SNS), the High-Energy Beam Transfer line (HEBT) connects the linac to the accumulator ring. A major requirement of the SNS complex is to have low uncontrolled beam losses (<= 1nA/m), to allow hands on maintenance. The HEBT is equipped with three sets of beam halo scrapers, one for momentum collimation and two for transverse collimation. The momentum scraper is located at a maximum dispersion point (between DD3 dipole and Q14 quad of the HEBT line), is a foil that strips the H^- beam that has momentum spread ($\delta p/p \exists 0.2\%$) into H^+, and the H^+ ions are then directed out of the accelerator to a beam dump by the next bending magnet DD4. In order to reduce the radiation in the beam dump station region, we performed H^+ particle tracking in order to determine the outer boundaries and the angle of the Y-type vacuum chamber that will contain the H^+ beam. The H^+ tracking was performed by using the RAYTRACE[1] code and OPERA-2D[2].

2.The layout of the new lattice of HEBT line:

In the latest version of HEBT lattice(Since April, 2000), the quadrupole and dipole corrector has been swap(Fig.1), in order to get more space to install the BPM. The H^+ Ray-trace tracking with quadrupole at old location was done on March, 2000, now we need to do ray-trace tracking again at the different potential operating beam energy of HEBT line(1.0Gev, 1.3Gev and 840Mev).

3.The simulation results of the HEBT momentum scraper H^+ exit obits:

We built the 2D-model to do ray-trace tracking so as to save the computation time and using the RAYTRACE(MIT code) and OPERA-2D(VectorField code). The accuracy is good enough for H^+ exit obits calculation. Fig.2 just show the HEBT dipole 2D model.

Fig.3-4 give the ray trace tracking result and compare with quadrupole at old location @1.0Gev.

Fig.5-6 give the tracking results @1.3Gev and compare with @1.0Gev(quadrupole at new location)

Fig.7-8 give the tracking results @840Mev and compare with @1.0Gev(quadrupole at new location)

4.Conclusion:

From Fig.4, we know the ray-trace Δ[(newp101+066%)-(newp099-066%)](quadrupole at new location) less than Δ[(oldp101+066%)-(oldp099-066%)](quadrupole at old location), that means the focusing effect is stronger for H^+ when the quadrupole moved downstream about 0.5m.

From Fig.5 and Fig.8, we know the maximum of Δ[dp_0%, dp+066%, dp-066%](1.3Gev-1.0Gev) is about $\pm$0.02cm; Δ[dp_0%, dp+066%, dp-066%](840Mev-1.0Gev) is about $\pm$0.06cm.

As analysis above shows, the angle of the Y-type extraction vacuum chamber is bwteen 10.155° →10.169°→10.173° when the beam energy change from 840Mev to 1.3Gev. So the original design of the HEBT momentum scraper chamber is satisfy the requirement of the outer boundaries and the angle of H^+ exit ray traces. That design doesn't need any modification. The Y-type extraction chamber is shown in Fig.9.

References:

[1] S.B. Kowwalski, and H. Enge "The Ion-Optical Program Raytrace" NIM 407 **A258** (1987)

[2] VectorFields Inc.

Fig.1:

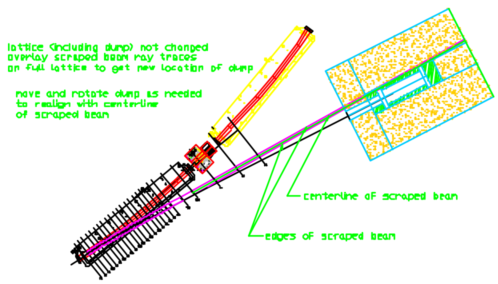
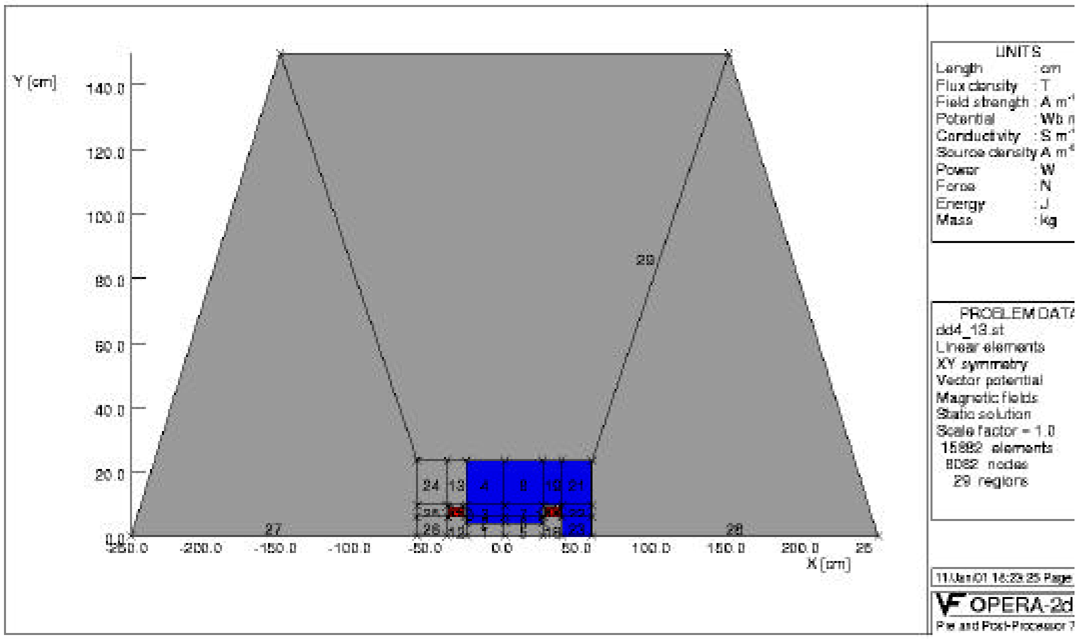
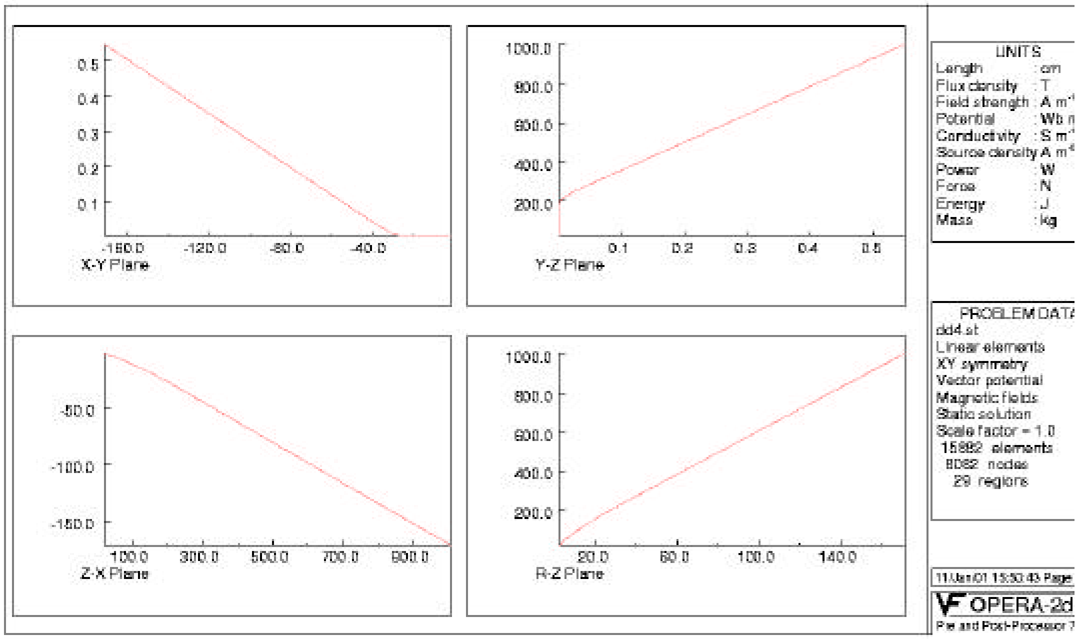

lattice (including dump) not changed
overlay scraped beam ray traces
on full lattice to get new location of dump
move and rotate dump as needed
to realign with centerline
of scraped beam
centerline of scraped beam
edges of scraped beam

Fig.2:



Y [cm]
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-250.0
-200.0
-150.0
-100.0
-50.0
0.0
50.0
100.0
150.0
200.0
X [cm]
29
27
28
24
13
4
9
10
21
26
23
UNITS
Length : cm
Flux density : T
Power : W
Force : N
Energy : J
Mass : kg
PROBLEM DATA
dd4_13.st
Linear elements
XY symmetry
Vector potential
Magnetic fields
Static solution
Scale factor = 1.0
15892 elements
8082 nodes
29 regions
OPERA-2d

Fig.3:



0.5
0.4
0.3
0.2
0.1
-160.0
-120.0
-80.0
-40.0
X-Y Plane
1000.0
800.0
600.0
400.0
200.0
0.1
0.2
0.3
0.4
0.5
Y-Z Plane
-50.0
-100.0
-150.0
100.0
300.0
500.0
700.0
900.0
Z-X Plane
1000.0
800.0
600.0
400.0
200.0
20.0
60.0
100.0
140.0
R-Z Plane
UNITS
Length : cm
Flux density : T
Potential : Wb
Power : W
Force : N
Energy : J
Mass : kg
PROBLEM DATA
dd4.st
Linear elements
XY symmetry
Vector potential
Magnetic fields
Static solution
Scale factor = 1.0
15892 elements
8082 nodes
29 regions
OPERA-2d

Fig.4:

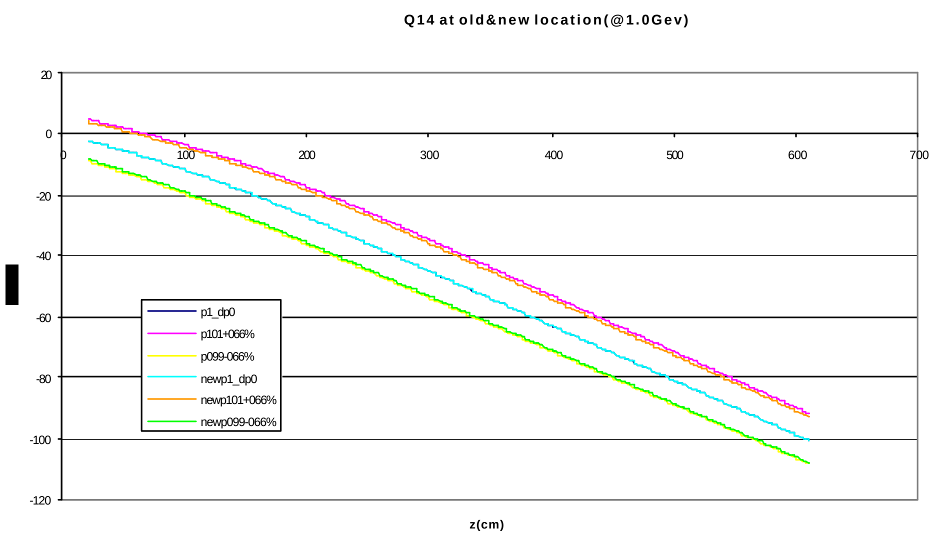

Q14 at old&new location(@1.0Gev)
20
0
-20
-40
-60
-80
-100
-120
0
100
200
300
400
500
600
700
p1_dp0
p101+066%
p099-066%
newp1_dp0
newp101+066%
newp099-066%
z(cm)

Fig.5:

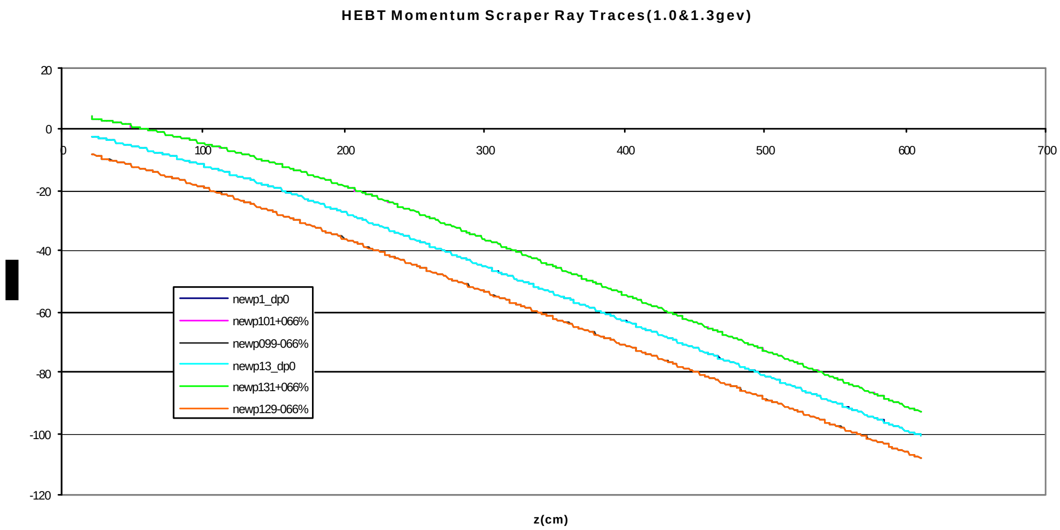

HEBT Momentum Scraper Ray Traces(1.0&1.3gev)
20
0
-20
-40
-60
-80
-100
-120
0
100
200
300
400
500
600
700
[redacted]
newp1_dp0
newp101+066%
newp099-066%
newp13_dp0
newp131+066%
newp129-066%
z(cm)

Fig.6:

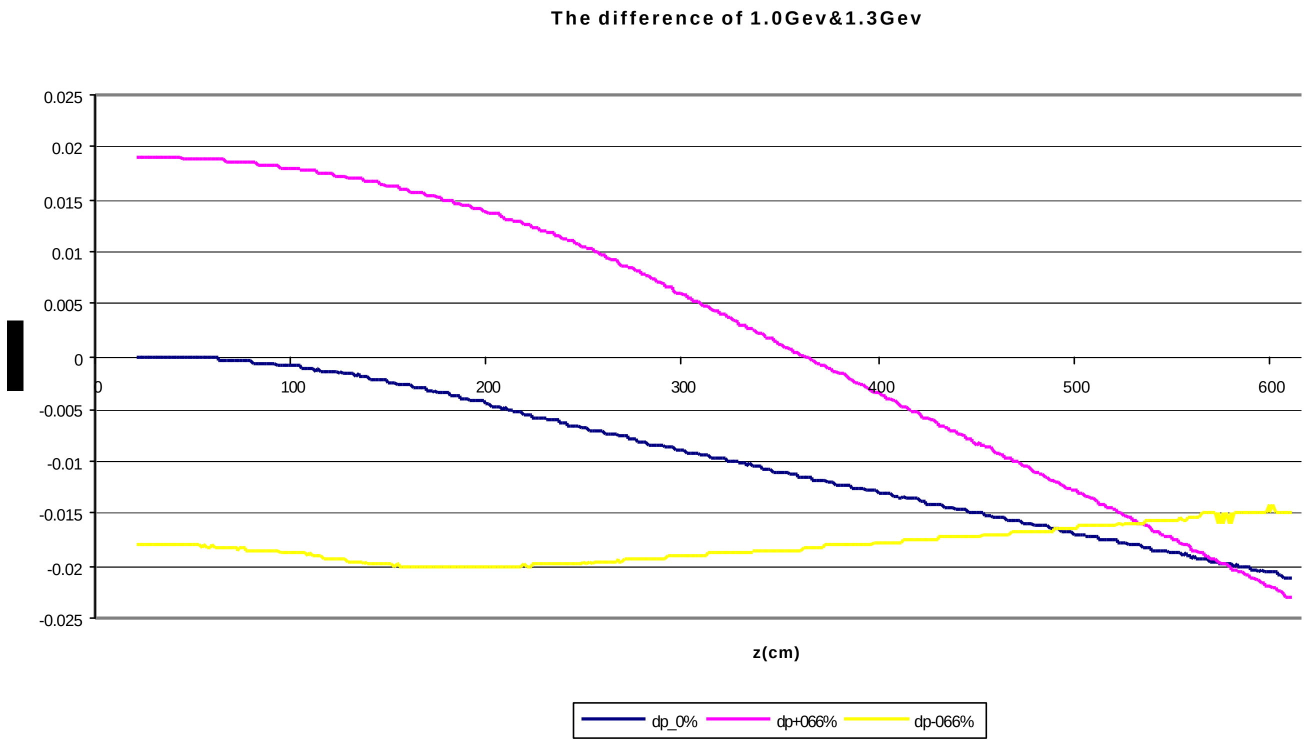

The difference of 1.0Gev&1.3Gev
0.025
0.02
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
-0.025
0
100
200
300
400
500
600
z(cm)
dp_0%
dp+066%
dp-066%

Fig.7:

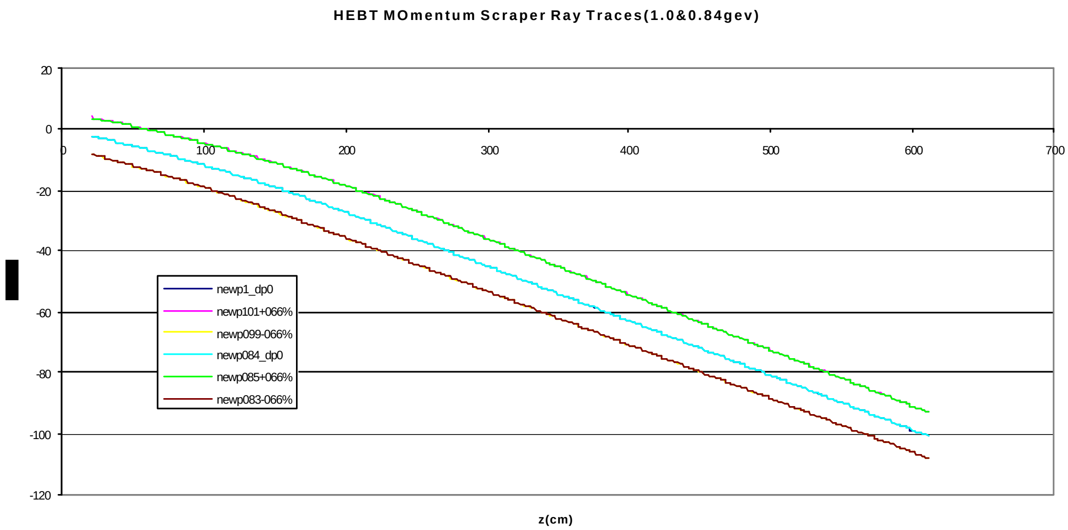

HEBT MOmentum Scraper Ray Traces(1.0&0.84gev)
20
0
-20
-40
-60
-80
-100
-120
0
100
200
300
400
500
600
700
newp1_dp0
newp101+066%
newp099-066%
newp084_dp0
newp085+066%
newp083-066%
z(cm)

Fig.8:

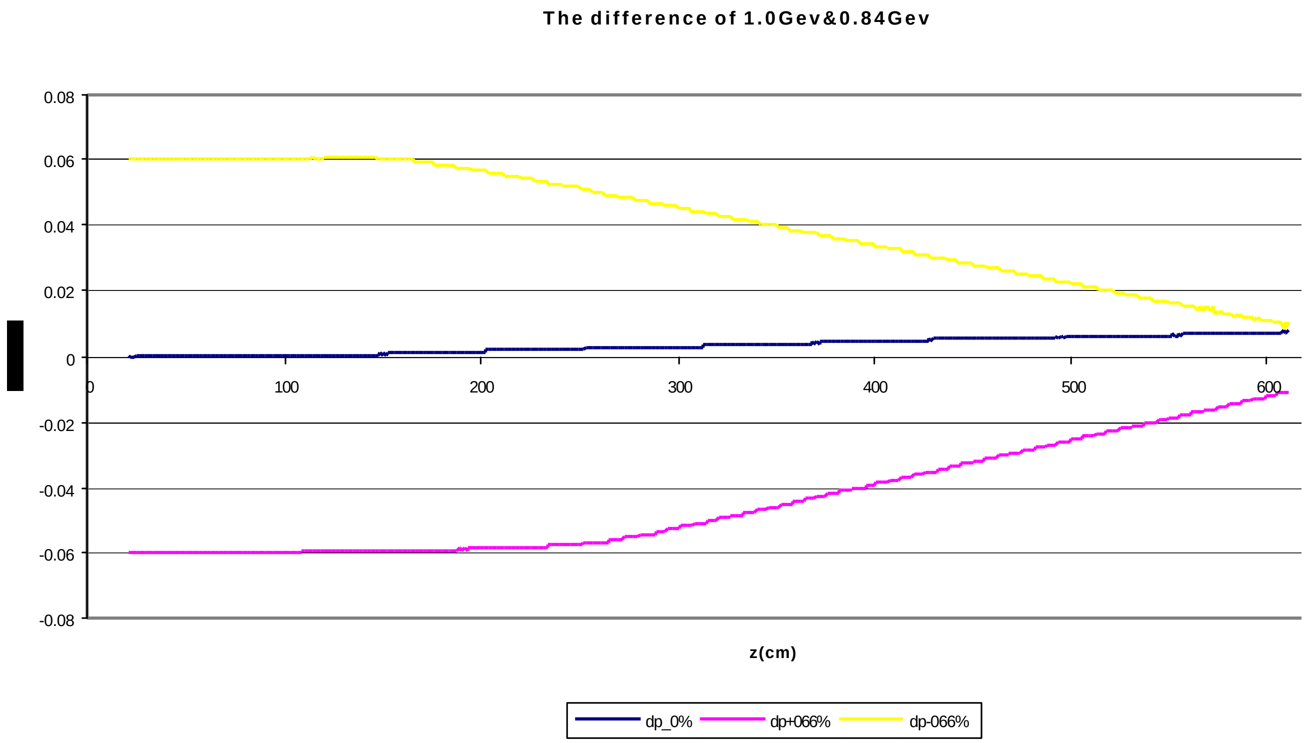
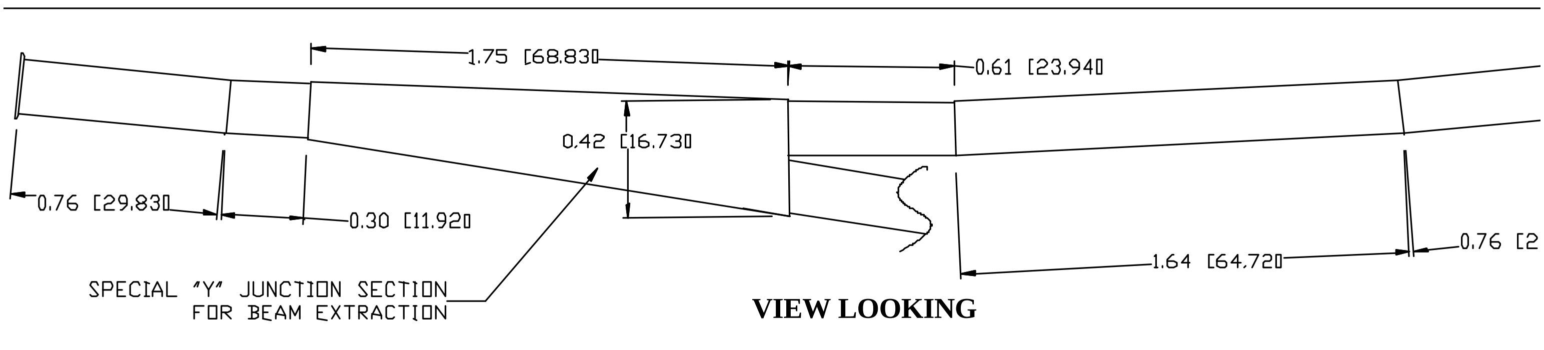

The difference of 1.0Gev&0.84Gev
[redacted]
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
0
100
200
300
400
500
600
z(cm)
dp_0%
dp+066%
dp-066%

Fig.9:


1.75 [68.83]
0.61 [23.94]
0.42 [16.73]
0.76 [29.83]
0.30 [11.92]
1.64 [64.72]
0.76 [2
SPECIAL "Y" JUNCTION SECTION
FOR BEAM EXTRACTION
VIEW LOOKING