PIP Linac, Laser Notch and TRACEWIN

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Laser Notch Review / FNAL

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Actual TRACEWIN “start-to-end” model of the PIP linac (from the Ion Source to the Booster). MEBT quotes checked carefully with DJ.

In the actual “s2e” model of the TRACEWIN model, 60 mA / 100k distribution is generated at the ion source and 41949 particles reach the booster. 25.169 mA at booster from TW. Close to what is measured on the linac (“low to mid 40% transmission”)

Fernanda requested a new set of simulation to be performed to check the sensitivity of the linac to a new MEBT configuration (to accommodate for the laser notch)

First MEBT doublet pushed 12.5 mm closer to the MEBT buncher.

With the new MEBT configuration, 40209 particles reach the booster without any rematching. 24.125 mA at booster. Additional loss of about 4.15 % from actual configuration.

After a “light” rematching (lowering the MEBT quads by few percent) 41497 reach booster. 24.9 mA at booster. Additional loss of about 1% from actual configuration.
July-2014 TRACEWIN model of the PIP linac
Asymmetric

\[
\begin{align*}
\alpha_x &= 0.57848 \\
\beta_x &= 5.2643 \times 10^{-2} \text{ mm/mrad} \\
\alpha_y &= -0.4043 \\
\beta_y &= 5.6954 \times 10^{-2} \text{ mm/mrad}
\end{align*}
\]

133.425 cm

\[
\begin{align*}
X_{Final} &= 0 \\
X_{Sol 1} &= 27.393 \text{ cm} \\
X_{Sol 2} &= 84.293 \text{ cm} \\
X_{RFQ_Up} &= 5 \text{ cm}
\end{align*}
\]

\[
\begin{align*}
\alpha_x &= 8.6 \\
\beta_x &= 0.5 \text{ mm/mrad} \\
\alpha_y &= 8.4 \\
\beta_y &= 0.5 \text{ mm/mrad}
\end{align*}
\]

IF 50 mm DRIFT TUBE AT 60 mA

\[
\begin{align*}
\alpha_x &= 4.7 \\
\beta_x &= 0.3 \text{ mm/mrad} \\
\alpha_y &= 4.7 \\
\beta_y &= 0.3 \text{ mm/mrad}
\end{align*}
\]

IF 50 mm DRIFT TUBE AT 0 mA

(100% NEUTRALIZED)
PIP MEBT DISTANCES (TRACEWIN Model)

ACTUAL (7/31/2014) MEBT AS IMPLEMENTED IN TRACEWIN

Distance from outside flange to the upstream face of Quad 01 of D120.
At the Booster Region (TRACEWIN Model)

- Where does the TW model end?: 6.145 meters downstream Q17 (see below)

We stop about 6.145 meters after Q17 (close to stripping foil)
RMS Size X and Y along the PIP Linac (From TRACEWIN, July 2014 lattice)

100k / 60 mA at Ion Source. 41949 at Booster.
Large Losses in DTL#01

~58% losses along the linac
Beam distribution at booster. Baseline configuration. 41949/100k

Ele: 596 [202.547 m]  NGOOD: 41949 / 100000

X(mm) - X'(mrad)

Y(mm) - Y'(mrad)

Z(mm) - dp/p(%)  Zmax = 240.881 mm  dp/pmax = 0.904 %

X(mm) - Y(mm)  Xmax = 84.028 mm  Ymax = 94.829 mm
MEBT modification for laser notch installation
Laser Notch Implementation on the PIP MEBT
(First doublet pushed downstream by 12.5 mm)
Losses along the PIP Linac (From TRACEWIN, July 2014 lattice)

100k / 60 mA at Ion Source. 40209 at Booster.

~60% losses along the linac
Losses along the PIP Linac (From TRACEWIN, New MEBT Configuration, No Rematching)
100k / 60 mA at Ion Source. 40209 at Booster.
Losses along the PIP Linac (From TRACEWIN, New MEBT Configuration, After Rematching) First MEBT doublet lowered by ~4%. Second MEBT Doublet by about 2%. 100k / 60 mA at Ion Source. 41453 at Booster.
Beam Sizes at the laser notch
Installation (3 locations)
1/ 60 mm + 1/2"

2/ 60 mm + 1.5"

3/ 60 mm + 1"

Start/Middle/End
X-X'
Emit [rms] = 0.4068 Pi.mm.mrad [ Norm. ]
Emit [93.10%] = 2.0340 Pi.mm.mrad [ Norm. ]
Beta = 0.1598 mm/Pi.mrad
Alpha = -1.1651

Y-Y'
Emit [rms] = 0.3687 Pi.mm.mrad [ Norm. ]
Emit [92.61%] = 1.8435 Pi.mm.mrad [ Norm. ]
Beta = 0.2385 mm/Pi.mrad
Alpha = -2.6274

Phase-Energy
Emit [rms] = 0.5067 Pi.deg.MeV [ Norm. ]
Emit [97.05%] = 2.5334 Pi.deg.MeV [ Norm. ]
Beta = 1272.5465 deg/Pi.MeV
Alpha = 2.1188

X-Y
Emit [rms] = 1.9142 mm² [ Norm. ]
Emit [93.17%] = 9.5711 mm² [ Norm. ]
Beta = 0.8598
Alpha = 0.0021

Mo = 939.29402679 MeV
Gamma = 1.000779794

Sigma_X [rms] = 1.2829 mm
Sigma_X' [rms] = 12.3256 mrad
Sigma_Y [rms] = 1.4921 mm
Sigma_Y' [rms] = 17.5867 mrad
Sigma_PHASE [rms] = 25.3926 deg
Sigma_ENERGY [rms] = 0.0468 MeV

Sigma_X [rms] = 1.2829 mm
Sigma_Y [rms] = 1.4921 mm

Sigma_X [rms] = 12.3256 mrad
2/ 60 mm + 25.4 mm from RFQ (1 inch)

X-X'
Emitt [rms] = 0.4040 Pi.mm.mrad [ Norm. ]
Emitt [93.02%] = 2.0198 Pi.mm.mrad [ Norm. ]
Beta = 0.1941 mm/Pi.mrad
Alpha = -1.4401

Y-Y'
Emitt [rms] = 0.3679 Pi.mm.mrad [ Norm. ]
Emitt [92.50%] = 1.8396 Pi.mm.mrad [ Norm. ]
Beta = 0.3125 mm/Pi.mrad
Alpha = -3.1596

Phase-Energy
Emitt [rms] = 0.4842 Pi.deg.MeV [ Norm. ]
Emitt [96.46%] = 2.4212 Pi.deg.MeV [ Norm. ]
Beta = 1723.6946 deg/Pi.MeV
Alpha = 2.6180

X-Y
Emitt [rms] = 2.4039 mm² [ Norm. ]
Emitt [93.50%] = 12.0194 mm² [ Norm. ]
Beta = 0.8258
Alpha = 0.0013
Beta = 0.039469278 Gamma = 1.000779823
Mo = 939.29402679 MeV

Sigma_X [rms] = 1.4089 mm
Sigma_X' [rms] = 12.7266 mrad
Sigma_Y [rms] = 1.7062 mm
Sigma_Y' [rms] = 18.0924 mrad
Sigma_Phase [rms] = 28.8908 deg
Sigma_Energy [rms] = 0.0470 MeV
Sigma_X [rms] = 1.4089 mm
Sigma_Y [rms] = 1.7062 mm

4D (X-X'-Y-Y')
E [rms] = 0.1485924931 (Pi.mm.mrad)² [ Norm. ]
3/60 mm + 38.1 mm from RFQ (1.5 inches)

**X-X'**
- Emit \([\text{rms}] = 0.4015 \text{ Pi.mm.mrad [Norm.]}\)
- Emit \([92.93\%] = 2.0077 \text{ Pi.mm.mrad [Norm.]}\)
- Beta = 0.2356 mm/Pi.mrad
- Alpha = -1.7239

**Y-Y'**
- Emit \([\text{rms}] = 0.3679 \text{ Pi.mm.mrad [Norm.]}\)
- Emit \([92.41\%] = 1.8393 \text{ Pi.mm.mrad [Norm.]}\)
- Beta = 0.3997 mm/Pi.mrad
- Alpha = -3.7066

**Phase-Energy**
- Emit \([\text{rms}] = 0.4635 \text{ Pi.deg.MeV [Norm.]}\)
- Emit \([95.75\%] = 2.3175 \text{ Pi.deg.MeV [Norm.]}\)
- Beta = 2279.7234 deg/Pi.MeV
- Alpha = 3.1538

**X-Y**
- Emit \([\text{rms}] = 2.9856 \text{ mm}^2 [\text{Norm.}]\)
- Emit \([93.78\%] = 14.9282 \text{ mm}^2 [\text{Norm.}]\)
- Beta = 0.8020
- Alpha = 0.0006
- Beta = 0.039469944 Gamma = 1.000779850
- Mo = 939.29402679 MeV

**4D (X-X'-Y-Y')**
- E \([\text{rms}] = 0.1476744903 (\text{Pi.mm.mrad})^2 [\text{Norm.}]\)

**Gamma**
- \(\Gamma = 1.000779850\)
- Mo = 939.29402679 MeV