```
Remove["Global`*"]
```

What is the Momentum of a Proton and 2 Electrons at the end of our 400 MeV Linac

$m_{p0} = 938.272 \frac{MeV}{C^2}$ (* $\frac{MeV}{C^2}$ for Proton*);

$m_{e0} = .511 \frac{MeV}{C^2}$ (* $\frac{MeV}{C^2}$ for electron*);

$m_0 = 1 * m_{p0} + 2 * m_{e0}$ (* $\frac{MeV}{C^2}$ total*)

$\frac{939.294\,MeV}{C^2}$

$E_{tot} = \gamma\, m_0\, C^2$ (*total energy*)

$E_0 = m_0\, C^2$

$KE = E_{tot} - E_0 = (\gamma - 1)\, m_0\, C^2 = \gamma\, m_0\, C^2 - m_0\, C^2$

$Cp = \sqrt{E_{tot}^2 - E_0^2}$ (*Momentum times Speed of Light*)

(*or*)

$Cp = m_0\, C^2 \sqrt{\gamma^2 - 1}$

KE = 400 MeV;

u = Solve[KE == $(\gamma - 1)\, m_0\, C^2$, γ]

{{$\gamma \to 1.42585$}}

$E_{tot} = \gamma\, m_0\, C^2$ /. u

$E_0 = m_0\, C^2$

{1339.29 MeV}

939.294 MeV

$Cp = \sqrt{E_{tot}^2 - E_0^2}$

$\left\{954.691 \sqrt{MeV^2}\right\}$

$p = 954.691 \frac{MeV}{C}$

(*Just To Check Our Work*)

$Cp = m_0\, C^2 \sqrt{\gamma^2 - 1}$ /. u

{954.691 MeV}

Using this, the Survey from Mad8 and the Magnet Characteristics from TD find the power supply current

From Eric Prebys Grad Physics Accelerator School slides "Basic E&M and Relativity" USPAS, Austin, TX 2012

"If the path length through a transverse magnetic field is short compared to the bend radius of the particle, the we can think of the particle receiving a transverse "

Kick ".....and it will be bent through the small angle " $\Delta\theta = \frac{Bl}{B\rho}$

Bl is integrated field for the length of a magnetic and given in TD magnet specs
Bρ is magnetic rigidity

956.691 MeV = .956691 GeV

```
p = .956691(* GeV/c *);
```

$B\rho = \frac{10}{2.9979}\, p$ (*with P in $\frac{GeV}{c}$ and Bρ in tesla meters*)

(*$\Delta\theta = \frac{Bl}{B\rho}$ or*)

3.1912

For E : UVT02

```
Δθ = .018024 - .016172
Bl = Δθ * Bρ
```

0.001852

0.00591011

For E : UVT04

```
Δθ = .019065 - .017213
Bl = Δθ * Bρ
```

0.001852

0.00591011

For E : UVB05 remember this one uses both coils

$\Delta\theta_1 = \frac{B_1\, l_1}{B\rho}$

$\Delta\theta_2 = \frac{B_2\, l_2}{B\rho}$

$\Delta\theta = \Delta\theta_1 + \Delta\theta_2 = \frac{B_1\, l_1}{B\rho} + \frac{B_2\, l_2}{B\rho} = \frac{B_1\, l_1 + B_2\, l_2}{B\rho}$

```
Δθ = .028170 - .029869
B1 l1 + B2 l2 = Δθ * Bρ
```

```
-0.001699
```

Set::write : Tag Plus in $B_1 l_1 + B_2 l_2$ is Protected. ≫

```
-0.00542186
```

For E : UVB12

```
Δθ = -.000133 - .029295
Bl = Δθ * Bρ
```

```
-0.029428
```

```
-0.0939107
```

For the BCorr outer Coil

```
TableBLTableOuter =
  {-0.00021, -0.000100, .000320, .000740, .001170, .001590, .002010, .002430, .002860,
   .002430, .002010, .001590, .001170, .000750, .00032, -0.00010, -0.00021};
TableIouter = {-0.225, -0.026, 0.778, 1.583, 2.389, 3.194, 3.999, 4.805,
   5.61, 4.807, 4.001, 3.196, 2.391, 1.587, 0.781, -0.024, -0.225};
```

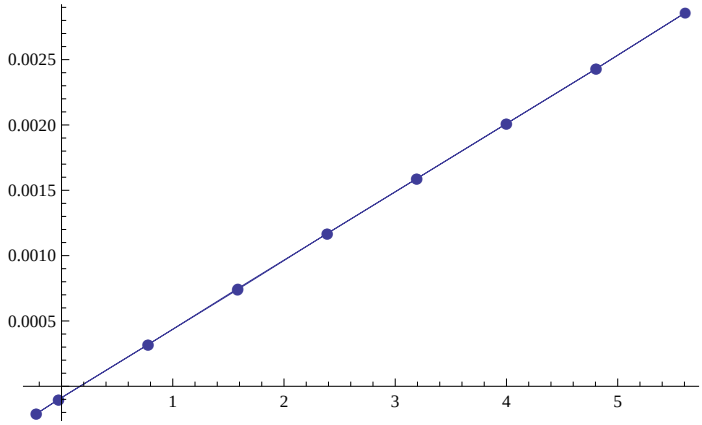
```
{-0.00021, -0.0001, 0.00032, 0.00074, 0.00117, 0.00159, 0.00201, 0.00243, 0.00286,
 0.00243, 0.00201, 0.00159, 0.00117, 0.00075, 0.00032, -0.0001, -0.00021}
```

```
{-0.225, -0.026, 0.778, 1.583, 2.389, 3.194, 3.999, 4.805,
 5.61, 4.807, 4.001, 3.196, 2.391, 1.587, 0.781, -0.024, -0.225}
```

```
outer = Table[{ TableIouter[[i]], TableBLTableOuter[[i]]}, {i, 17}]
```

```
{{-0.225, -0.00021}, {-0.026, -0.0001}, {0.778, 0.00032}, {1.583, 0.00074},
 {2.389, 0.00117}, {3.194, 0.00159}, {3.999, 0.00201}, {4.805, 0.00243}, {5.61, 0.00286},
 {4.807, 0.00243}, {4.001, 0.00201}, {3.196, 0.00159}, {2.391, 0.00117},
 {1.587, 0.00075}, {0.781, 0.00032}, {-0.024, -0.0001}, {-0.225, -0.00021}}
```

```
ListPlot[outer, Joined → True, PlotMarkers → Automatic]
```




```
outerFit = Fit[outer, {1, x}, x]
```

-0.000088392 + 0.000524913 x

```
out[x_] := -0.00008839202711788548` + 0.0005249129867430686` x
```

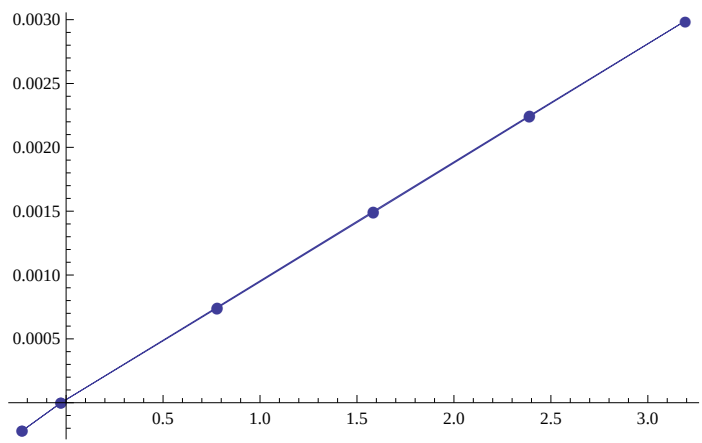
```
Here X is BL
```

For the BCorr inner coil

```
TableBLTableInner = {-0.000220, 0, .00074, 0.001490,
   .002240, .002990, .002250, .001500, .000750, .00000, -0.00022};
TableIinner = {-0.227, -0.0260 , .778, 1.585, 2.389, 3.193,
   2.391, 1.5850, .78, -0.026, -0.226};
inner = Table[{TableIinner[[i]], TableBLTableInner[[i]]}, {i, 11}]
```

```
{{-0.227, -0.00022}, {-0.026, 0}, {0.778, 0.00074},
 {1.585, 0.00149}, {2.389, 0.00224}, {3.193, 0.00299}, {2.391, 0.00225},
 {1.585, 0.0015}, {0.78, 0.00075}, {-0.026, 0.}, {-0.226, -0.00022}}
```

```
ListPlot[inner, Joined → True, PlotMarkers → Automatic]
```



```
innerFit = Fit[inner, {1, x}, x]
```

0.0000102875 + 0.000935293 x

```
in[x_] := -0.00001028751440508434 1` + 0.0009352933208875102` x
```

```
out[x]
```

-0.000088392 + 0.000524913 x

```
in[x]
```

-0.0000102875 + 0.000935293 x

Now Back to UVB05 which uses both coilsvide

$B_1 l_1 + B_2 l_2 = \Delta\theta * B\rho = -0.005421855328730108`$

```
Solve[out[x] + in[x] == -0.005421855328730108`, x]
```

{{x → -3.6455}}

For UVT02 uses inner coil

$\Delta\theta = .018024 - .016172$
$Bl = \Delta\theta * B\rho$

0.001852

0.00591011

```
Solve[in[x] == 0.005910109516661661`, x]
```

{{x → 6.32999}}

For UVT04 which uses the Inner

$\Delta\theta = .019065 - .017213$
$Bl = \Delta\theta * B\rho$

0.001852

0.00591011

```
Solve[in[x] == 0.005910109516661661`, x]
```

{{x → 6.32999}}

UVB12 is a completely different kind of magnet