Roman Pots 220

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Roman Pots 220:

- part of ATLAS experiment at LHC
- Stations with silicon detectors inside the beampipe
- At 216 and 224 m from the IP
- Tag protons from elastic and diffractive events
- Each station measures x and y positions of a proton

PROTON AT IP

Decribed by:

- Vertex position: (x_0, y_0, z_0)
- Momentum: (p_x, p_y, p_z), or equivalently energy and slopes: (E, x'_0, y'_0), where

$$x'_0 = \frac{p_x}{p_z} \quad y'_0 = \frac{p_y}{p_z}.$$

PROTON AT $z = 216$ M

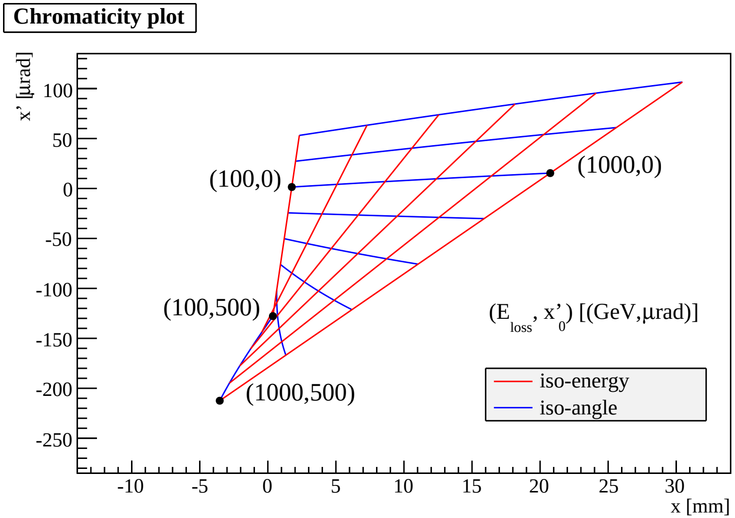
Described by:

- Position: (x, y)
- Slopes: (x', y')

$$x = x_{216} \qquad y = y_{216}$$

$$x' = \frac{x_{224} - x_{216}}{L}$$

$$y' = \frac{y_{224} - y_{216}}{L}$$


Chromaticity plot
x' [µrad]
100
50
0
-50
-100
-150
-200
-250
-10
-5
0
5
10
15
20
25
30
x [mm]
(100,0)
(1000,0)
(100,500)
(1000,500)
(E_loss, x'_0) [(GeV,µrad)]
iso-energy
iso-angle

$$\begin{aligned}
x &= A_x + x_0' B_x + x_0 C_x + x_0' z_0 D_x + z_0 E_x \\
y &= A_y + y_0' B_y + y_0 C_y + y_0' z_0 D_y + z_0 E_y \\
x' &= A_{sx} + x_0' B_{sx} + x_0 C_{sx} + x_0' z_0 D_{sx} + z_0 E_{sx} \\
y' &= A_{sy} + y_0' B_{sy} + y_0 C_{sy} + y_0' z_0 D_{sy} + z_0 E_{sy}
\end{aligned}$$

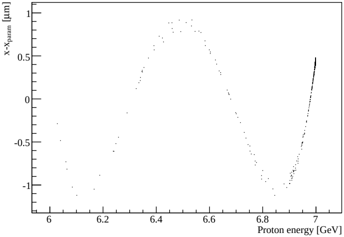
All coefficients are polynomials of E, f.e.

$$A_x = a_x^{(0)} + a_x^{(1)} E + a_x^{(2)} E^2 + a_x^{(3)} E^3$$

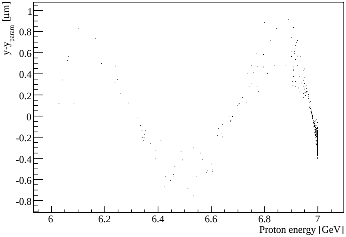
$$C_{sx} = c_{sx}^{(0)} + c_{sx}^{(1)} E + c_{sx}^{(2)} E^2 + c_{sx}^{(3)} E^3$$

Parametrisation calculated for Cartesian grid
in $x_0, y_0, z_0, x_0', y_0'$ and E.

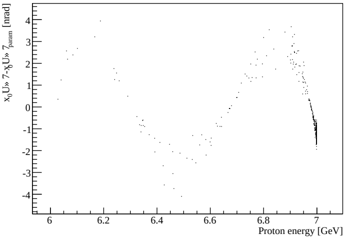
x parameterisation error for beam 1 at 216 m



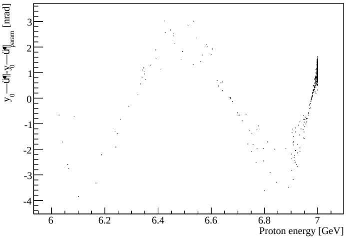
y parameterisation error for beam 1 at 216 m



x_0U» 7 parameterisation error for beam 1 at 216 m



y_0—ü¶ parameterisation error for beam 1 at 216 m



x and x' at 216 can be measured by the detectors, and are given by parameterisations.

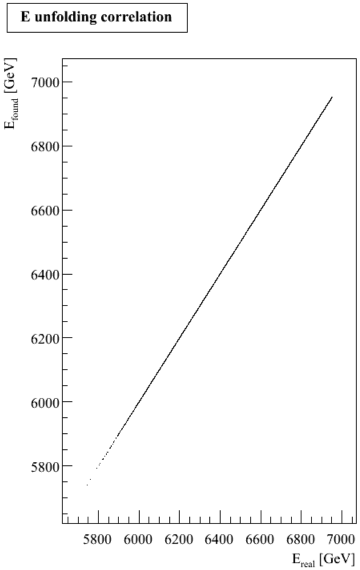
$$\begin{aligned} x_{DET} &= A_x + x'_0 B_x + x_0 C_x + x'_0 z_0 D_x + z_0 E_x &\rightarrow (x'_0)_x \\ x'_{DET} &= A_{sx} + x'_0 B_{sx} + x_0 C_{sx} + x'_0 z_0 D_{sx} + z_0 E_{sx} &\rightarrow (x'_0)_{sx} \end{aligned}$$

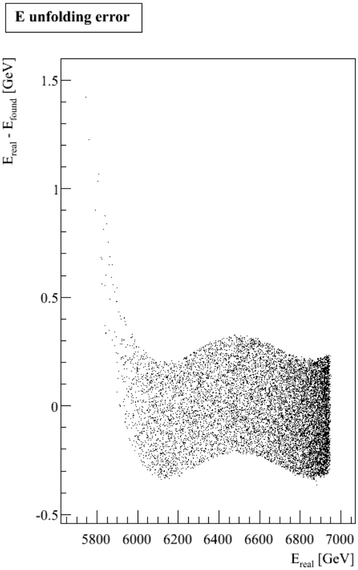
Calculate x'_0 from both equations and construct $f(E)$.

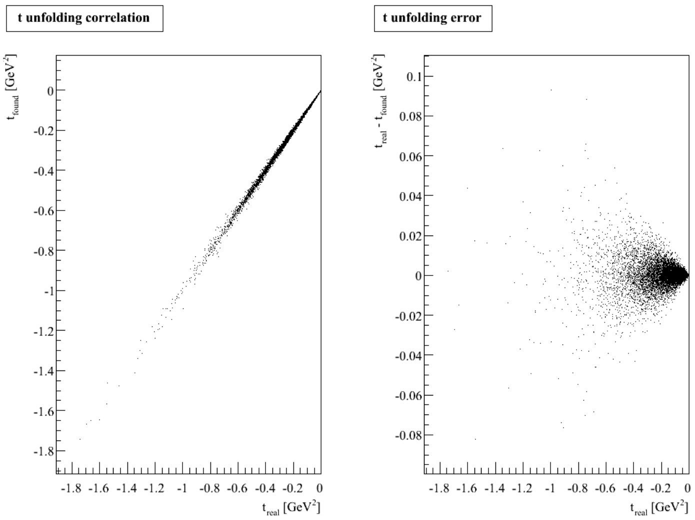
$$f(E) = (x'_0)_x - (x'_0)_{sx}$$

$f(E) = 0$ for E $=$ real energy

Energy unfolding - equation method





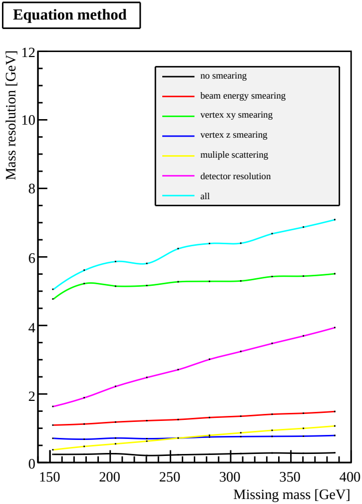

t unfolding correlation
t_found [GeV²]
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
-1.8
-1.8 -1.6 -1.4 -1.2 -1 -0.8 -0.6 -0.4 -0.2 0
t_real [GeV²]
t unfolding error
t_real - t_found [GeV²]
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-1.8 -1.6 -1.4 -1.2 -1 -0.8 -0.6 -0.4 -0.2 0
t_real [GeV²]

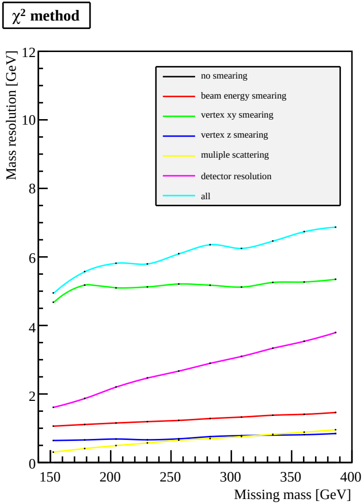
$$\chi^2 = \chi^2(E, x'_0, y'_0, x_0, y_0, z_0)$$

$$\chi^2 = \frac{(x_{216}^{DET} - x_{216}^{PAR})^2}{\sigma_x^2} + \frac{(y_{216}^{DET} - y_{216}^{PAR})^2}{\sigma_y^2} + \frac{(x_{224}^{DET} - x_{224}^{PAR})^2}{\sigma_x^2} + \frac{(y_{224}^{DET} - y_{224}^{PAR})^2}{\sigma_y^2}$$

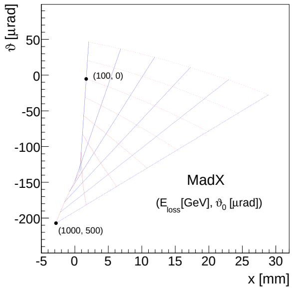
- Put $x_0 = 0$, $y_0 = 0$, $z_0 =$ real value (or 0)
- $\frac{\partial \chi^2}{\partial x'_0} = 0 \quad \rightarrow \quad x'_0 = x'_0(E)$
- $\frac{\partial \chi^2}{\partial y'_0} = 0 \quad \rightarrow \quad y'_0 = y'_0(E)$
- $\chi^2 = \chi^2(E)$
- Find minimum of $\chi^2(E)$

- Beam energy smearing (0.77 GeV)
- Beam angle smearing at IP ($30\ \mu$rad)
- Vertex smearing ($11.7\ \mu$m in x_0 and y_0, 5.6 cm in z_0)
- Multiple scattering at first station ($0.6\ \mu$rad)
- Detector resolution ($10\ \mu$m ix x, $40\ \mu$m in y)


Equation method
Mass resolution [GeV]
Missing mass [GeV]
0
2
4
6
8
10
12
150
200
250
300
350
400
no smearing
beam energy smearing
vertex xy smearing
vertex z smearing
muliple scattering
detector resolution
all


χ^2 method
Mass resolution [GeV]
Missing mass [GeV]
0
2
4
6
8
10
12
150
200
250
300
350
400
no smearing
beam energy smearing
vertex xy smearing
vertex z smearing
muliple scattering
detector resolution
all

MadX transport



FPTrack transport