Computer Code “TRIO-DRAW” for an Ion Trajectory Calculation and Display Including TOF Information
Features of “TRIO-DRAW”

- "TRIO" and "BEIS" are combined to be a single program
- Flight time calculation can be executed up to the second order approximation using transfer matrix method.
- Ion trajectory calculation and display
- Image shape calculation
- Estimation of mass resolution
Path Length Deviation

Flight time of an arbitrary particle

\[ T = \int_{s_0}^{s} \frac{ds}{v} = \int_{z_0}^{z} \frac{1}{v} \frac{ds}{dz} \, dz \]

- \( v \): velocity of arbitrary particle
- \( ds / dz \): unity on the optics axis

Flight time of the reference particle

\[ T_0 = \int_{z_0}^{z} \frac{dz}{v_0} \]

- \( v_0 \): velocity of reference particle

Time deviation

\[ t = T - T_0 = \int_{z_0}^{z} \left( \frac{1}{v} \frac{ds}{dz} - \frac{1}{v_0} \right) \, dz \]

\[ = t_0 + (t \mid x) x_0 + (t \mid \alpha) \alpha_0 + (t \mid \gamma) \gamma + (t \mid \delta) \delta + \ldots \]

Path length deviation

\[ l = v_0 \, t \]

\[ l = l_0 + (l \mid x) x_0 + (l \mid \alpha) \alpha_0 + (l \mid \gamma) \gamma + (l \mid \delta) \delta + \ldots \]
First order transfer matrix

\[
\begin{pmatrix}
  x_2 \\
  \alpha_2 \\
  \gamma \\
  \delta \\
  y_2 \\
  \beta_2 \\
  l_2
\end{pmatrix} =
\begin{pmatrix}
  (x | x) & (x | \alpha) & (x | \gamma) & (x | \delta) & 0 & 0 & 0 \\
  (\alpha | x) & (\alpha | \alpha) & (\alpha | \gamma) & (\alpha | \delta) & 0 & 0 & 0 \\
  0 & 0 & 0 & 1 & 0 & 0 & 0 \\
  0 & 0 & 0 & 0 & (y | y) & (y | \beta) & 0 \\
  0 & 0 & 0 & 0 & (\beta | y) & (\beta | \beta) & 0 \\
  (l | x) & (l | \alpha) & (l | \gamma) & (l | \delta) & 0 & 0 & 1
\end{pmatrix}
\begin{pmatrix}
  x_1 \\
  \alpha_1 \\
  \gamma \\
  \delta \\
  y_1 \\
  \beta_1 \\
  l_1
\end{pmatrix}
\]

Total transfer matrix

\[
\begin{pmatrix}
  x_f \\
  \alpha_f \\
  \gamma \\
  \delta \\
  y_f \\
  \beta_f \\
  l_f
\end{pmatrix} = (C) (B) (A)
\begin{pmatrix}
  x_i \\
  \alpha_i \\
  \gamma \\
  \delta \\
  y_i \\
  \beta_i \\
  l_i
\end{pmatrix}
\]
Calculation Method of Ion Trajectory and Path Length Deviation in TRIO-DRAW

- Define the parameter of the optical system
- Calculate the transfer matrix of each element
- Calculate the total transfer matrix by making the matrix product
- Calculate the final position vector by making the matrix product
- Draw the flame of electrode and optical axis
- Divide each element into 20-30 pieces
- Calculate the position of ion trajectory at these divided profile plane
- Connect these points
Drawing Method of TOF Information

- Calculate the path length deviation at the profile plane
- Select appropriate color that based on the path length deviation from prepared color table
- Draw line following the traject drawing method with selected color

![Diagram of TOF information drawing method]
Drawing Method of Image Shape

- Calculate the total transfer matrix of the system
- Decide on the maximum initial conditions
- Select 10000 ions having the random initial conditions
- Calculate the position and the path length deviation at the detector plane for the respective condition
- Count the numbers of ions that reach within a certain mesh as a functions of position or path length
- Estimate the peak width and simulate the theoretical mass resolution
Calculation Method of “isochronous plane”

- Calculate the total transfer matrix of the system
- Decide on the maximum initial conditions
- Select 5000 ions having the random initial conditions
- Calculate the position deviation, angle deviation, the path length deviation at the detector plane for the respective condition
- Calculate the positions of all ions when reference particle arrived at detector surface in 3D space
- Display these positions using graphing software
Acknowledgement

- Prof. Toru Sakurai (JAIST)
  Offer the calculation code “unify4”