Ion impact distributions on DS collimators in IP2

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(some changes and presented by John Jowett)

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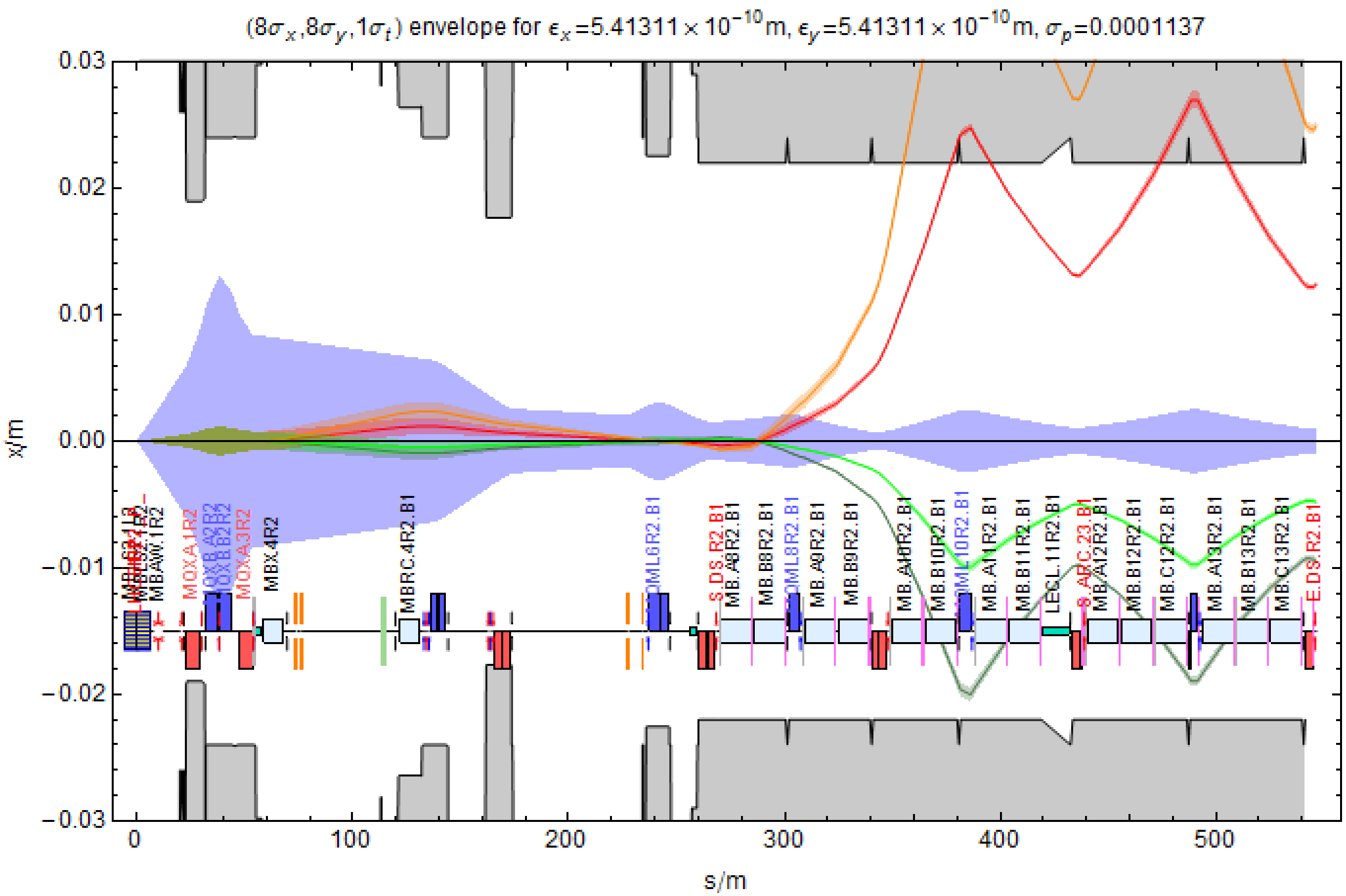
Motivation

Installation of collimators in the Dispersion Suppressor (DS) to both sides of ALICE (IP2) to intercept secondary beams from bound-free pair production (BFPP) and electromagnetic dissociation (EMD) .



Main: **208-Pb-82+**

BFPP1: **208-Pb-81+**

BFPP2: **208-Pb-80+**

EMD1: **207-Pb-82+**

EMD2: **206-Pb-82+**

The rigidity of each beam changed by

$$\delta = \frac{1+\Delta m / m_{Pb}}{1+\Delta Q / Q} - 1$$

Interactive model: \\cern.ch\dfs\Users\j\jowett\Public\DSCollimatorBFPP.cdf

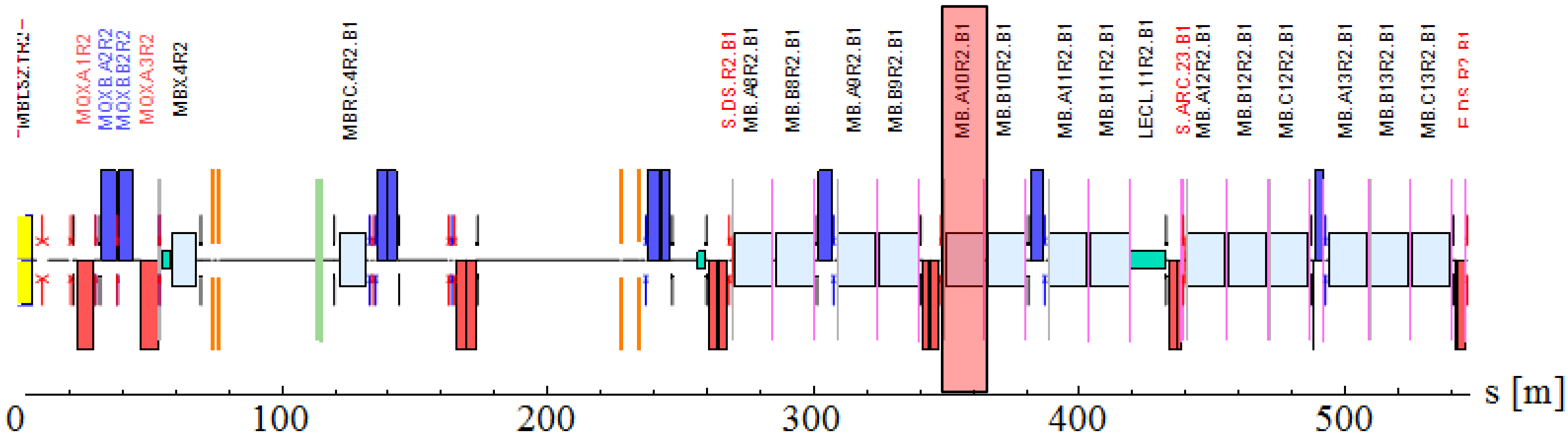
General Procedure

1. Modifying the layout to add DS collimator in IP2.
2. Generation of the luminosity source distribution at the IP.
3. Calculating the off-momentum transfer matrix from IP to start of collimator with MADX.
4. Tracking of source distribution to front jaw of collimator.
5. Conversion of MADX coordinates to desired coordinates for FLUKA.

1. Modified layout of DS around IR2

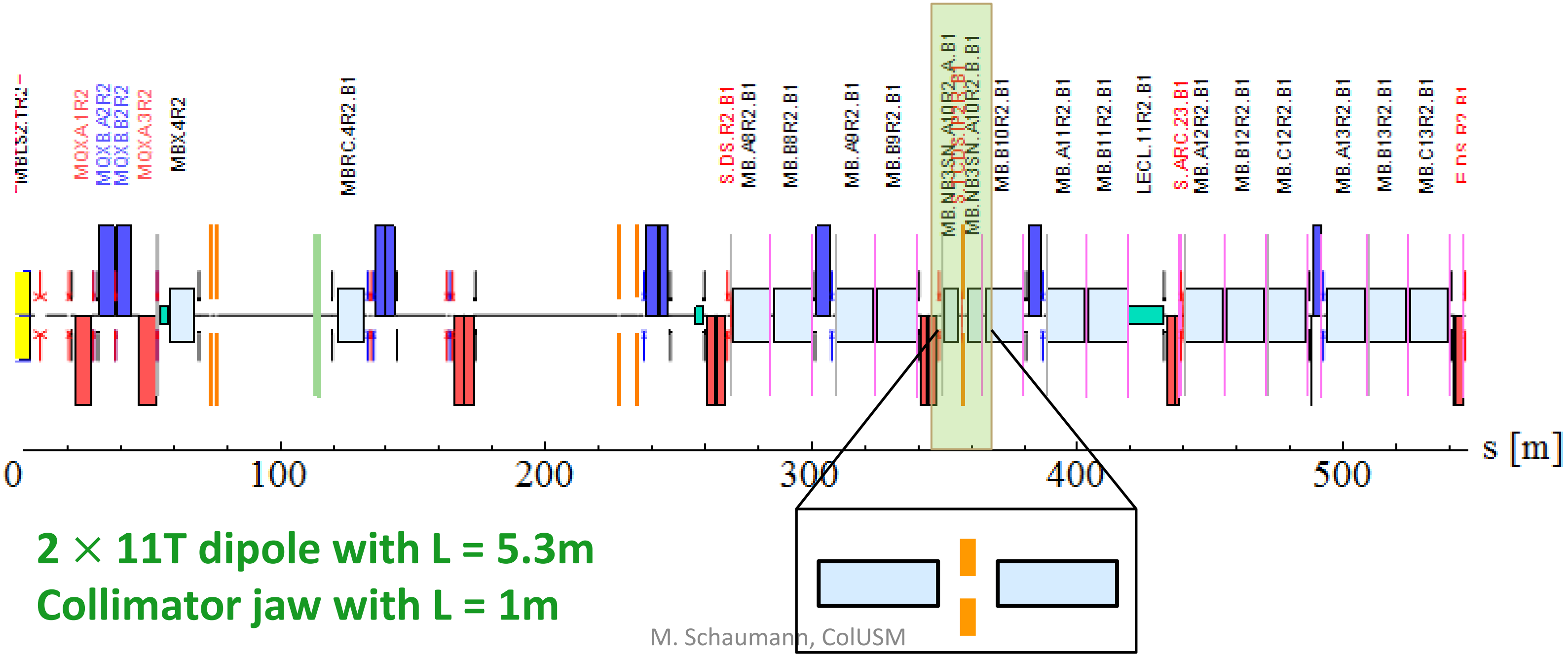
Magnet to be replaced **MB.A10R2**

Nominal Beam Line



IP2

Modified Sequence



2 × 11T dipole with L = 5.3m

Collimator jaw with L = 1m

2. Generating distribution @ IP

R. Bruce et al., *Beam losses from ultraperipheral nuclear collisions between 208Pb82+ ions in the Large Hadron Collider and their alleviation*, Phys. Rev. ST Accel. Beams 12, 071002 (2009)

Generate x_0, x'_0 & y_0, y'_0

Assume Gaussian Distribution of the main beam:

$$f_\beta(x_0, x'_0) = \frac{N_b \beta_0}{2\pi\sigma_0^2} \exp\left(-\frac{x_0^2 + (\alpha_0 x_0 + \beta_0 x'_0)^2}{2\sigma_0^2}\right)$$

Distribution of collision point at the IP:

$$\lambda(x_0, x'_0) = \frac{\beta_0}{\sqrt{2}\pi\sigma_0^2} e^{-\frac{2x_0^2 + (\alpha_0 x_0 + \beta_0 x'_0)^2}{2\sigma_0^2}}$$

→ Gaussian distribution with smaller standard deviation $\sigma_{\lambda,0}$.

→ The standard deviation of the angular distribution $\sigma_{p,0}$ is similar to the main beam.

$$\sigma_{\lambda,0} = \left(\int x_0^2\, \lambda(x_0, x'_0)\, dx'_0\, dx_0\right)^{1/2} = \frac{\sigma_0}{\sqrt{2}} \qquad \sigma_{p,0} = \sqrt{\frac{\epsilon}{\beta_0}\frac{2+\alpha_0^2}{2}}$$

2. Generating distribution @ IP

MAD canonical momentum is: $p_t = \frac{E - E_0}{p_0 c}$

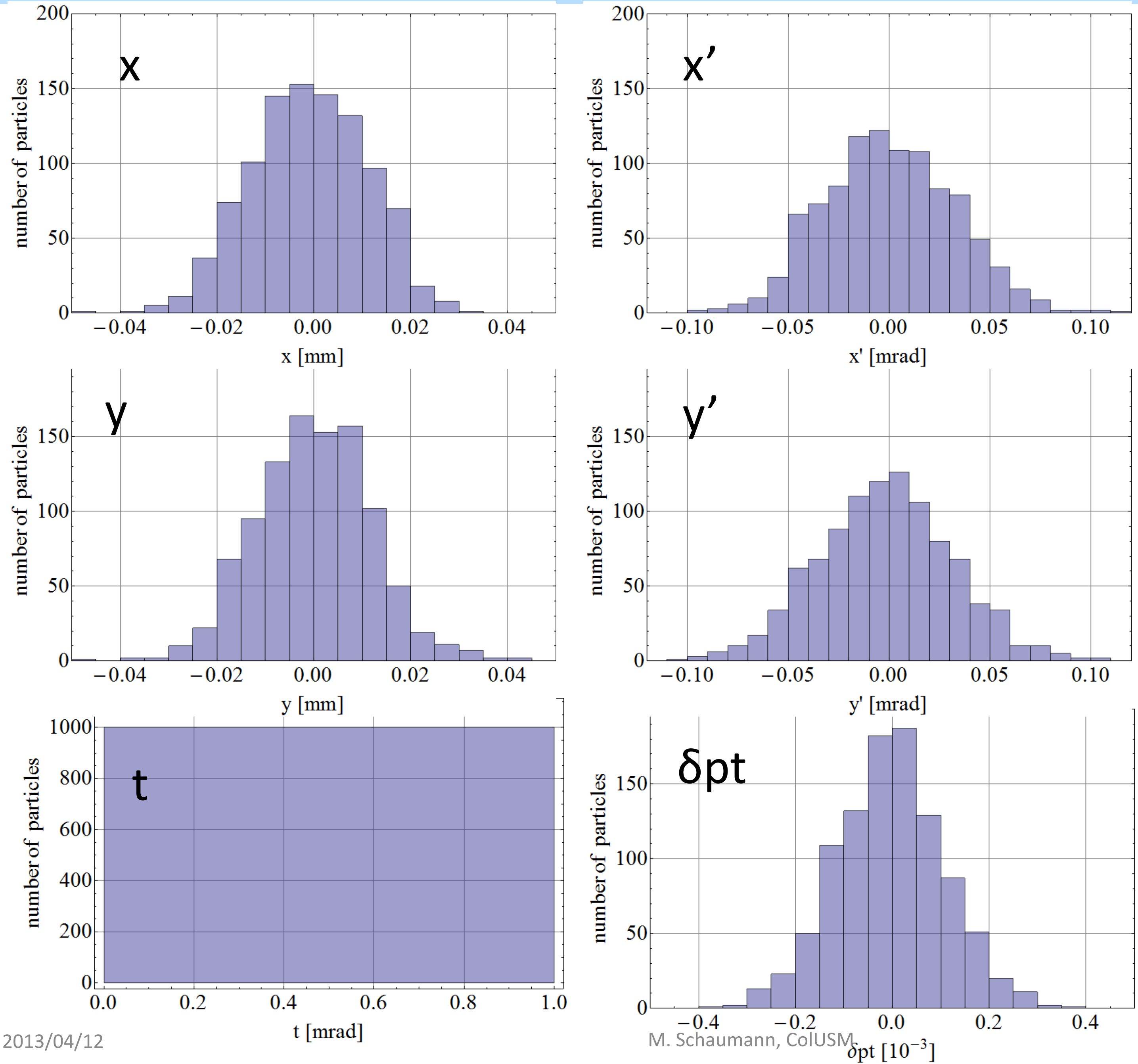
Generate t_0, p_{t0}

where $p_0 = (6.5Z \text{ TeV})(1+\delta)$

- The longitudinal positions of the particles are not important for this analysis, since the impact point (front plane of the collimator) is fixed for this first attempt:
  → set them all to ***t = 0*** at the IP.

- Assume that the $\boldsymbol{p_t}$ values are Gaussian distributed around $\langle p_t \rangle = 0$ at the IP,
  → take the change in rigidity into account when generating the transfer matrix for a beam with a given $\delta \neq 0$.

2. Generating distribution @ IP



Example coordinates of 1000 particles at the IP

3. Transfer Matrix

Do TWISS with initial conditions at the IP and RMATRIX flag on:

→ δp= δp_{BFPP}, $\beta_{x,y}$, $\alpha_{x,y}$, x, y, px/(1+δ), py/(1+δ)

with $\beta_{x,y}$, $\alpha_{x,y}$, x, y, px, py of the main beam orbit at IP2.

This generates TWISS table with transfer matrix elements after each element in the sequence.

MADX 6D Transfer Matrix:

→ form IP2 @ *s* = 0m

→ to new front plane of collimator @ *s* = 356.27m

4. Tracking

$$\boldsymbol{x}_{coll} = \boldsymbol{x}_{co,coll} + M\,\boldsymbol{x}_{IP2}$$

where ***x*** = *(x, px, y, py, t, pt)*
and *M* = *(6 × 6)* matrix

Since the δp was considered in the TWISS calculation, but the pt variable given by MADX is only the variation around the δp of the main beam, therefore δp has to be added to all pt coordinates to get the correct energy.

4. Tracking

Coordinates of the orbit for a beam with δp = δpBFPP:

Mean tracked Coordinates :
(0.0115, 0.00046 ,-0.000023, 2.04×10^{-7},0.0014 ,0.01234}

5. Conversion to FLUKA coordinates

- Positions and angles on collimator
- Energy in GeV

Things to be done…

1. Discuss how to proceed with FLUKA runs:
   Initial model of simple jaw

2. Calculations for B2 on left side of IP2.

3. Intercept other secondary beams from IP (EMD1, BFPP2, EMD2, …) as function of collimator gap (reduce losses in IR3 and elsewhere).

4. Other positions of the collimator?

5. Other optics cases