

GEANT

Simulation of RCS

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Hall A Analysis Workshop

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Task

- GEANT simulation of HRS using magnetic field model of dipole and quadrupoles.
- $ep \rightarrow ep$ elastic scattering simulation.
- RCS simulation including HRS and calorimeter.

How GEANT works

- Initialization
 - fill the data structure with the particle and material properties
 - define the geometry of the different components of the setup
 - define tracking medium parameters
 - compute energy loss and cross-section tables and store them in the data structure

- Event processing

- process one event
- generate the kinematics of the event and store it in the data structure
- control the propagation of each particle in the the setup
- perform all the processing at the end of event and output the data

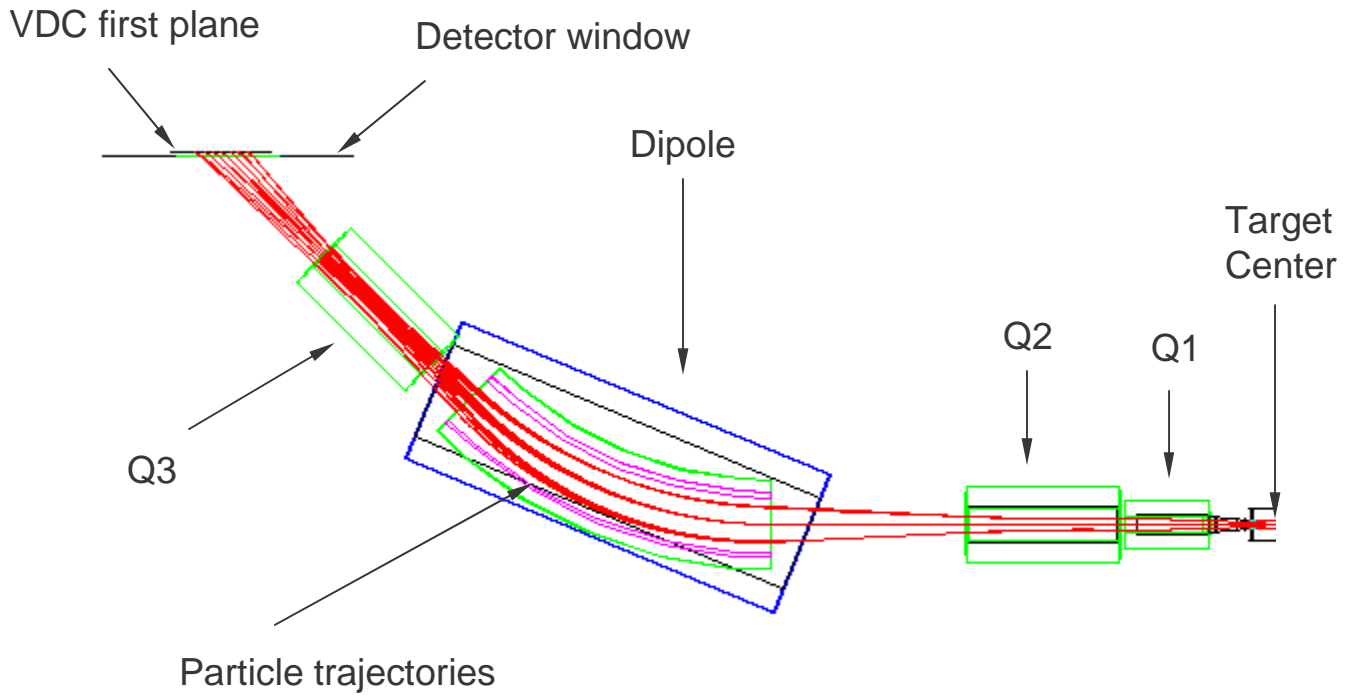
- Termination

- Output the necessary information
- Prepare for new event

Why GEANT

- Multiple scattering and ionization energy loss processes are included.
- No need to take account external radiative corrections (GEANT will take care of it).
- Easy to debug.
- GEANT's flexibility allows easy inclusion of RCS photon-arm (calorimeter and deflection magnet).

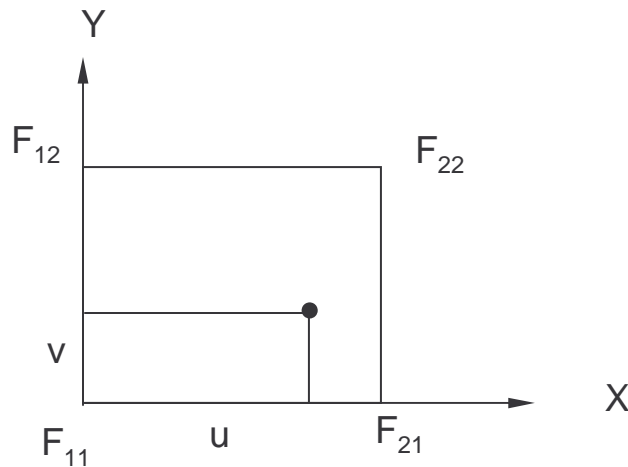
HRS geometry



GEANT graphical output for HRS central momentum $P_0=2.88 \text{ GeV}/c$.
Rays have origin at target point (0,0) and have momentum
 $(P-P_0)/P_0=-3\%$ to 3% with a 1% step and vertical angles (0,-50,50) mr.

Field map implementation in GEANT

- Map generated for $P_0=837.27 \text{ MeV}/c$
- Step size of map is 1 cm in space
- Find the grid numbers which surround the given point in GEANT geometry
- Linear interpolation of field at given point and using field values in surrounding points



$$F = F_{11}(1-u)(1-v) + F_{21}u(1-v) + F_{22}uv + F_{12}(1-u)v$$

For 3 dimensional case formula will be

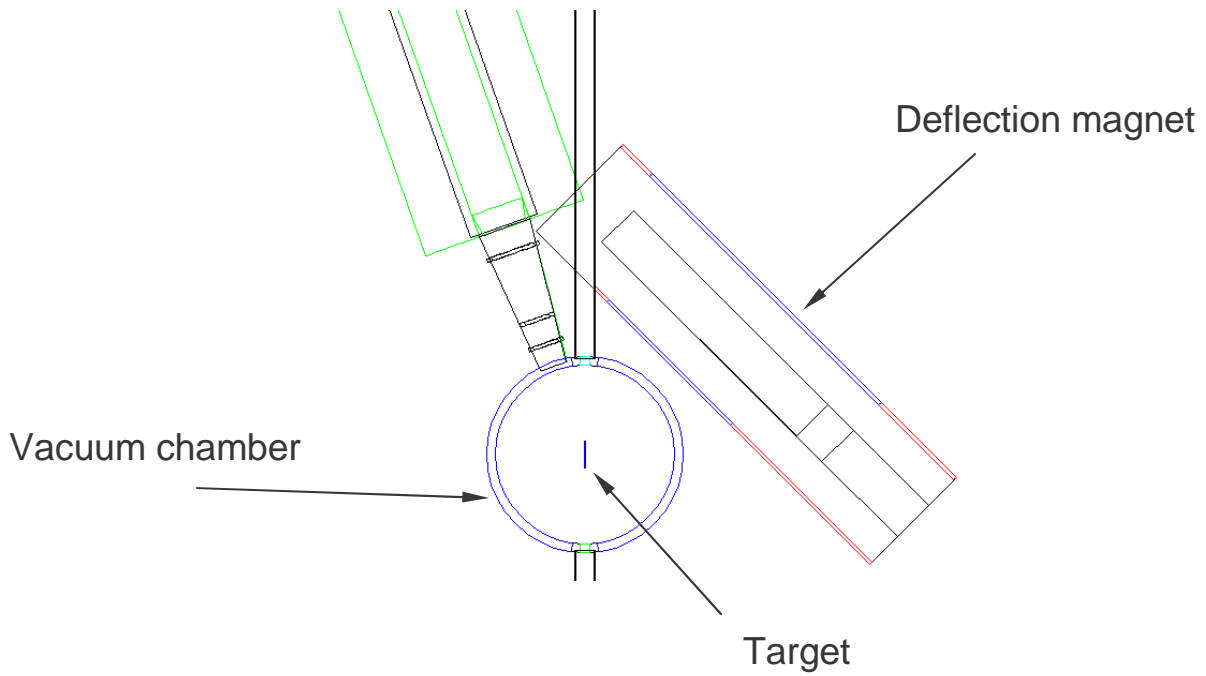
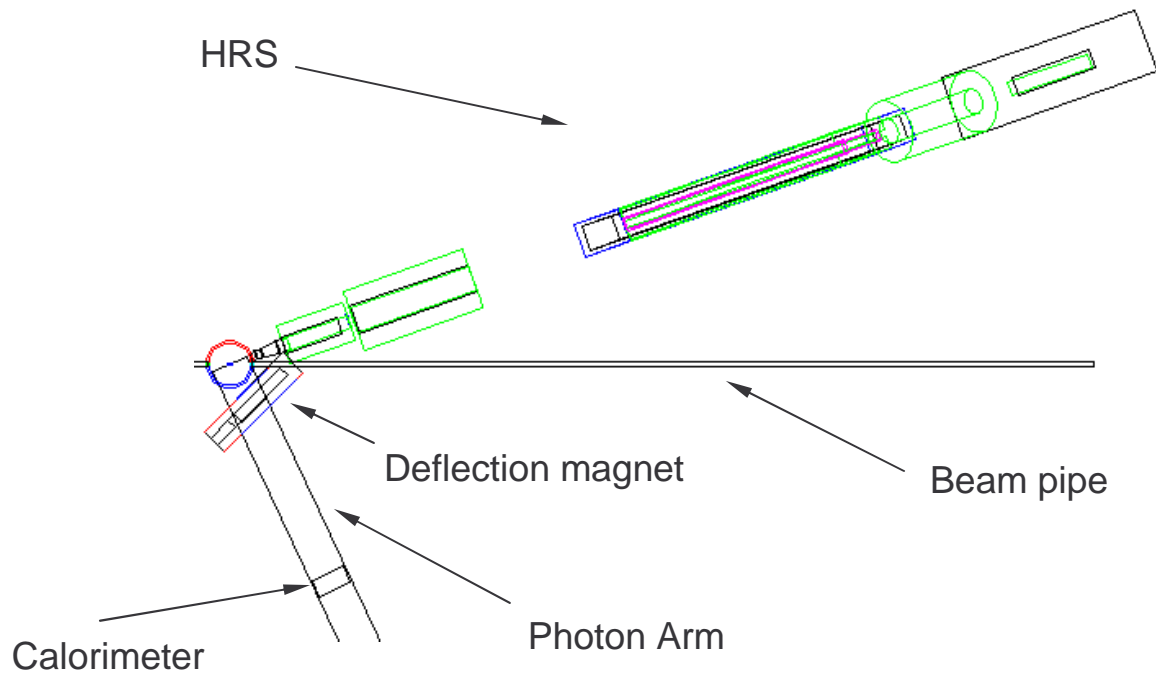
$$F = F_{111}(1-u)(1-v)(1-t) + F_{211}u(1-v)(1-t) + F_{221}uv(1-t) + F_{121}(1-u)v(1-t) + F_{112}(1-u)(1-v)t + F_{212}u(1-v)t + F_{222}uvt + F_{122}(1-u)vt$$

This procedure is done for all three components of magnetic field

For different central momentum settings field value is scaled by P/P_0

Photon-arm

- The key parts of photon arm are deflection magnet and high resolution calorimeter.



First order matrix elements

First order matrix elements can be found by shifting the target variables and finding the corresponding focal plane variables.

X_tg	TH_tg	Y_tg	PH_tg	Delta
-2.0E-3	0.0	0.0	0.0	0.0
+2.0E-3	0.0	0.0	0.0	0.0
0.0	-2.0E-3	0.0	0.0	0.0
0.0	+2.0E-3	0.0	0.0	0.0
0.0	0.0	-2.0E-3	0.0	0.0
0.0	0.0	+2.0E-3	0.0	0.0
0.0	0.0	0.0	-2.0E-3	0.0
0.0	0.0	0.0	+2.0E-3	0.0
0.0	0.0	0.0	0.0	-1.0E-3
0.0	0.0	0.0	0.0	+1.0E-3

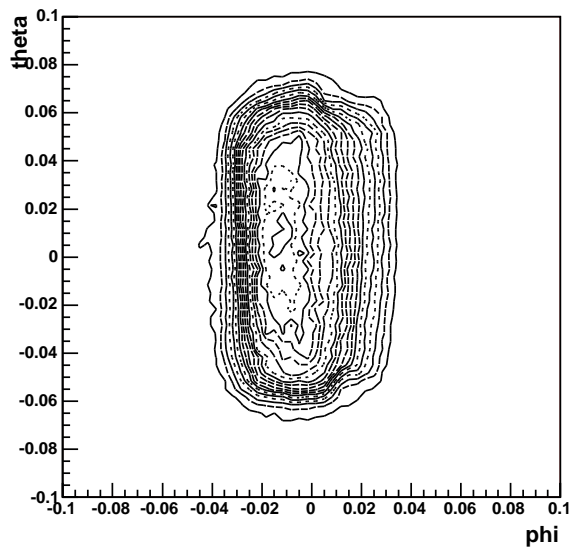
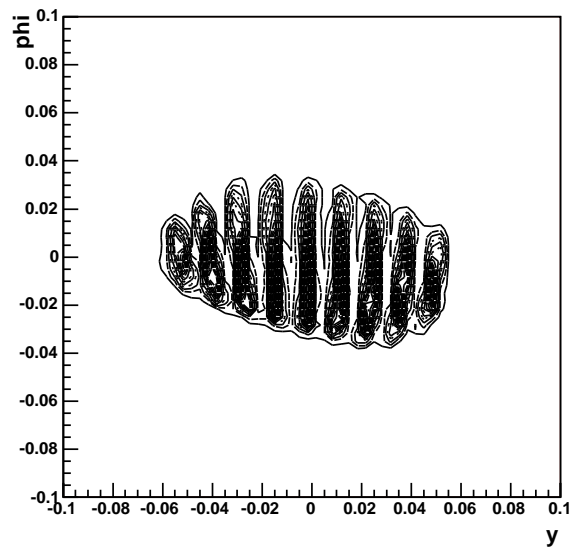
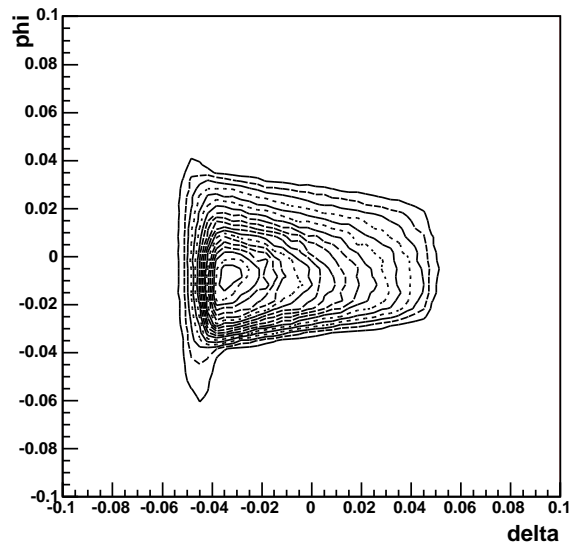
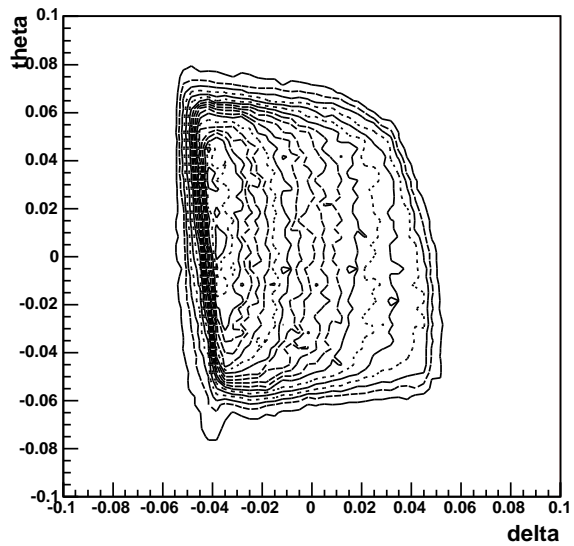
First order matrix elements from SNAKE

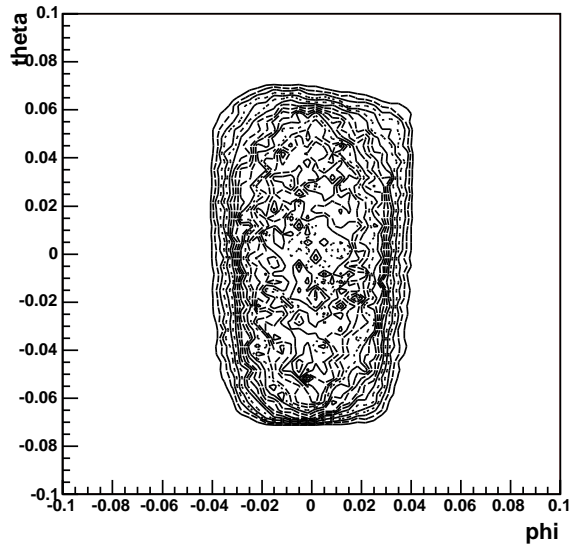
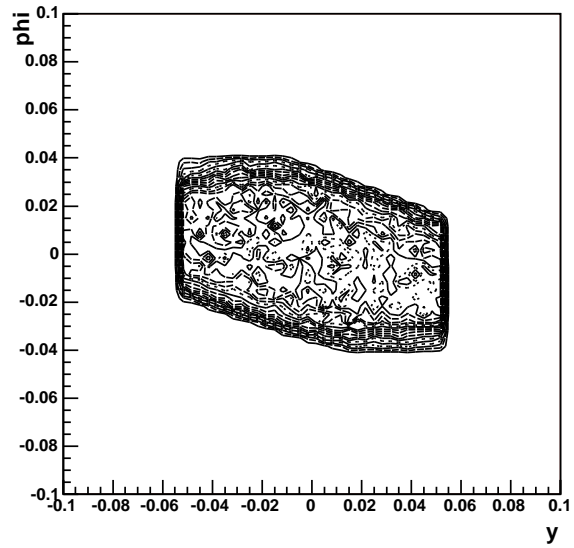
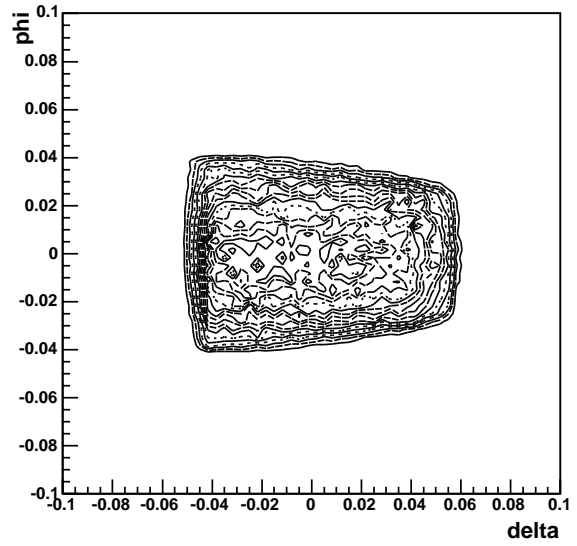
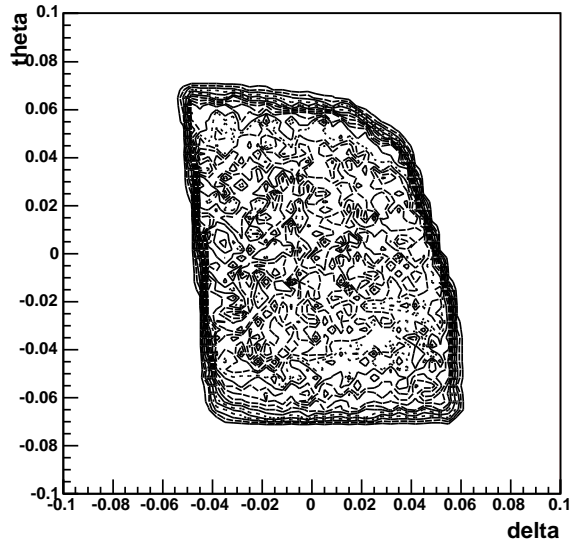
$$\begin{bmatrix} X_{fp} \\ \theta_{fp} \\ Y_{fp} \\ \phi_{fp} \\ \delta_{fp} \end{bmatrix} = \begin{bmatrix} -2.332 & -0.138 & 0.000 & 0.000 & 11.688 \\ -0.106 & -0.442 & 0.000 & 0.000 & 1.901 \\ 0.000 & 0.000 & -0.686 & -0.751 & 0.000 \\ 0.000 & 0.000 & 0.166 & -1.277 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 1.000 \end{bmatrix} \begin{bmatrix} X_{tg} \\ \theta_{tg} \\ Y_{tg} \\ \phi_{tg} \\ \delta_{tg} \end{bmatrix}$$

First order matrix elements from GEANT

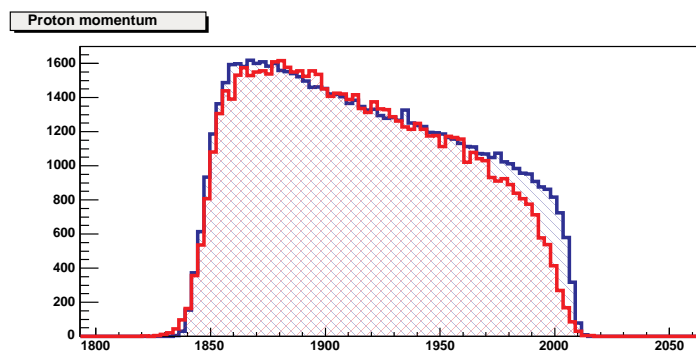
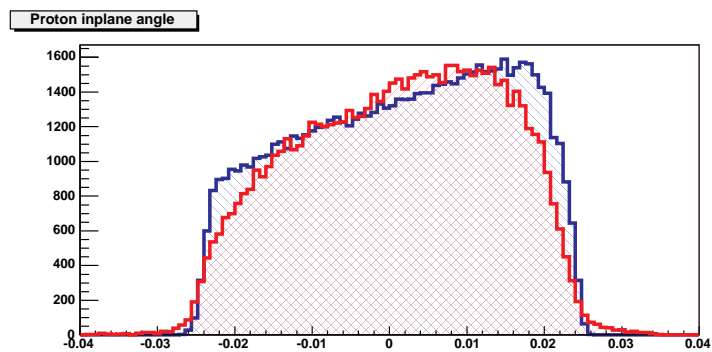
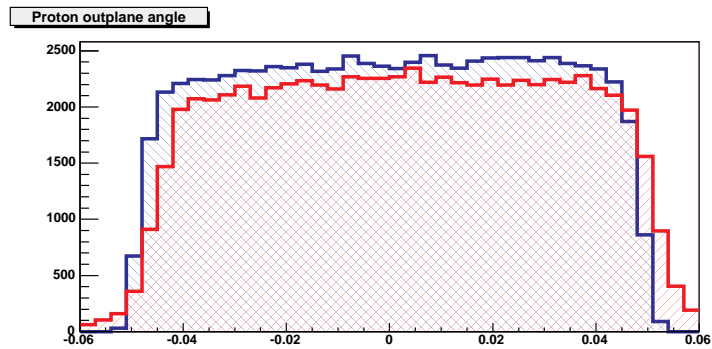
$$\begin{bmatrix} X_{fp} \\ \theta_{fp} \\ Y_{fp} \\ \phi_{fp} \\ \delta_{fp} \end{bmatrix} = \begin{bmatrix} -2.152 & -0.550 & 0.000 & 0.000 & 11.900 \\ -0.150 & -0.424 & 0.000 & 0.000 & 1.970 \\ 0.000 & 0.000 & -0.170 & ????? & 0.000 \\ 0.000 & 0.000 & 0.216 & -1.680 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 1.000 \end{bmatrix} \begin{bmatrix} X_{tg} \\ \theta_{tg} \\ Y_{tg} \\ \phi_{tg} \\ \delta_{tg} \end{bmatrix}$$

Single arm simulation





Elastic ep simulation



Simulation (blue), experiment (red)

Internal radiative corrections were not applied.

Absolute yield

Outlook

- Understanding discrepancies between first order matrix elements obtained from GEANT and SNAKE.
- For more detailed comparison with experimental technique, simulate HRS optics optimization procedure and include within focal plane to target transformation.
- Complete simulation of ep elastic scattering including internal radiative corrections.
- Implementation of RCS deflection magnet map.
- RCS simulation including π^0 and epy backgrounds.