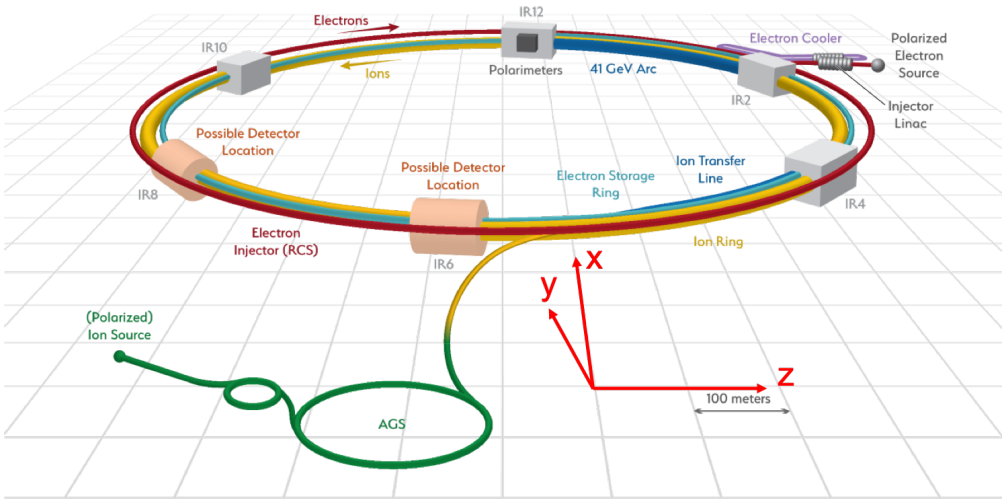
Input for various IR-Simulations

Note: any questions and concerns should be directed to E.C.Aschenauer elke@bnl.gov and Holger Witte hwitte@bnl.gov

This document describes the format for the input files provided to allow for simulations of the acceptance for different physics observables, synchrotron radiation, beam gas background and design of the vacuum system.

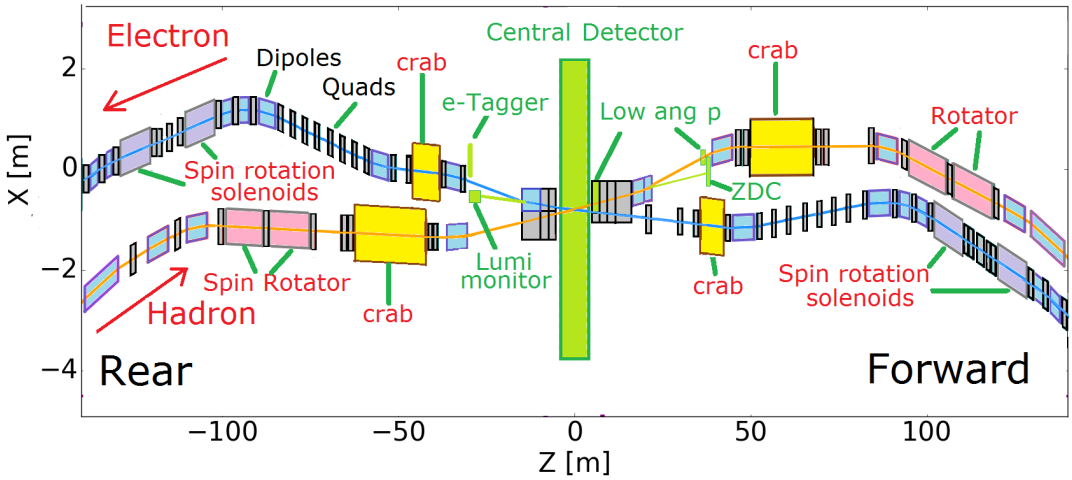
Coordinate systems:

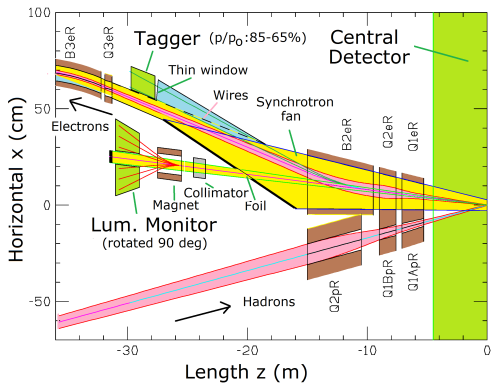
For EIC the hadron beam is going counter clockwise and the lepton beam clockwise as is shown below. The hadron beam defines the positive z -axis and x points to the ring inside as would be correct for a right handed coordinate system.

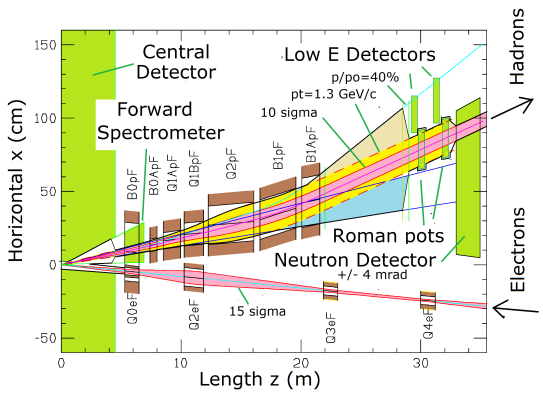


Current IR Layout:

The picture below represents a cartoon layout of the IR to visualize things. Unfortunately it is flipped 180° compared to the upper picture so the ring inside is on the bottom and ring outside on the top.







The relevant files are provided from BMAD, which have the full layout of the hadron and electron machine integrated.
Both for the hadron and electron beam two files are provided one with has all the element positions which is labeled ***survey*** in the name and the 2nd file labeled ***optics*** which has the optics information about beta-functions and so on.
The coordinate system is the one used for RHIC, which is different to the one in the IR figures above.

General agreements / understanding for the files:

- The hadron beam has an angle of 17 mrad
- The electron beam has an angle of 8 mrad
  → this results in the total crossing angle of 25 mrad
- The files have the longitudinal, x and y position of the different elements, i.e. magnets. In general values are specified for the end of each element; the beginning is the end of the prior element.
- There is one file for the rear and forward side around IP6
- The first Quad is always vertically focusing
- The IP is shifted compared to RHIC by 81 cm (shift = $\sqrt{dx^2 + dz^2}$ because the RHIC ring is rotated in space)

The inner apertures of the magnets can be found in Tables 3.2, 3.9 and 3.10 in section 3.2 "Interaction Region Development" in the following document https://wiki.bnl.gov/eic/upload/EIC.Design.Study.pdf. The individual rotations of some of the magnets are included in the BMAD files.

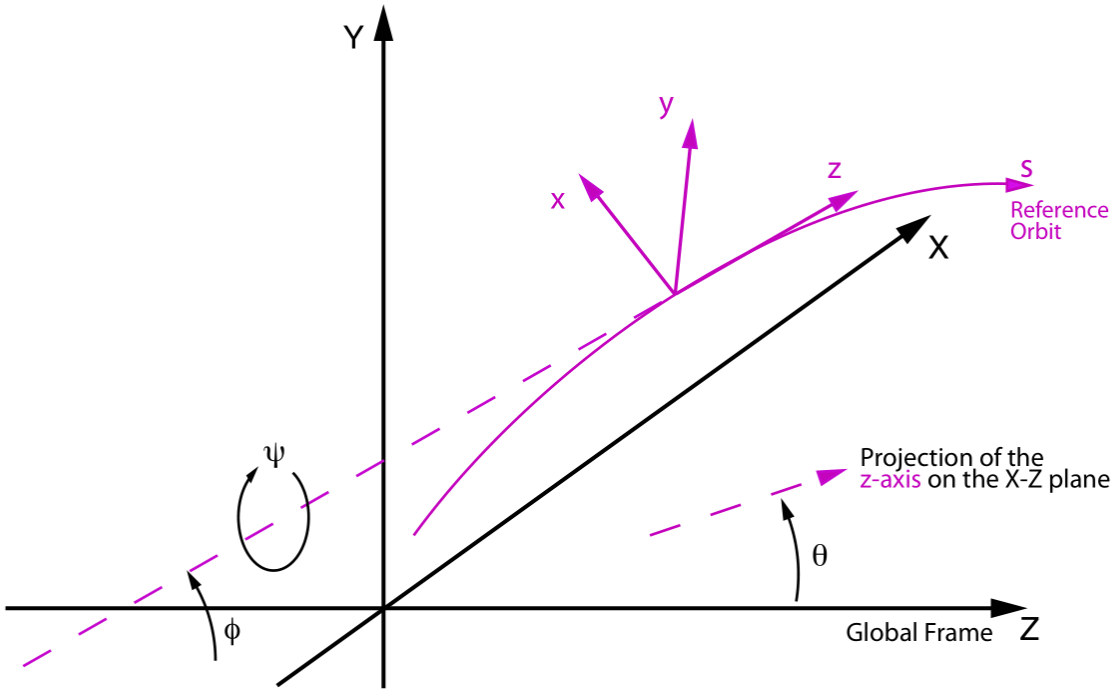
Format for the *survey* file:

- Name: name of the element
- Key: type of the element
- S: longitudinal position around the ring for the reference orbit
- L: length of the element
- x-pitch: rotation in x-z plane of element
- x-offset: shift in x
- the following variables really give the absolute position of the elements in the RHIC coordinate system and should be used in the simulation. For further information on the RHIC coordinate system see technical note RHIC/AP/12 in same folder as this document.
- floor actual x (m): x-position of the element in the global "floor" coordinate system including offsets and rotations.
- floor actual y (m): y-position of the element in the global "floor" coordinate system including offsets and rotations.
- floor actual z (m): z-position of the element in the global "floor" coordinate system including offsets and rotations.

- floor actual theta (rad): Azimuth angle: Angle in the (X,Z) plane between the Z–axis and the projection of the z–axis onto the (X,Z) plane. A positive angle of $\theta = \pi/2$ corresponds to the projected z–axis pointing in the positive X direction.
- floor actual phi: Pitch (elevation) angle: Angle between the z–axis and the (X,Z) plane. A positive angle of $\varphi = \pi/2$ corresponds to the z–axis pointing in the positive Y direction. Not used.
- floor actual psi: Roll angle: Angle of the x–axis with respect to the line formed by the intersection of the (X,Z) plane with the (x,y) plane. A positive ψ forms a right–handed screw with the z–axis. Not used.

the starting coordinates for IP6 are (in m)
beginning[x_position] = 31694.295102
beginning[z_position] = 30209.627602
beginning[theta_position] = 3.106687849

The BMAD coordinate system definitions are illustrated in the following figure



Format for the *optics* file:

Note: The optics files are only valid for one beam energy which is specified in the name of the file

- Name: name of the element
- Key: type of the element
- S: longitudinal position around the ring
- L: length of the element
- BETA-a,BETA-b = beta functions in horizontal (a=x) and vertical (b=y) plane
  ALPHA-a, ALPHA-b = slope of the beta functions
  PHI-a = phase advance from IP6 i.e. fraction of betatron oscillations in units of 2pi
  ETA-a = dispersion function in the horizontal plane
- ETAp = slope of the dispersion function
  ANGLE = bending angle of a dipole
- K1 = quadrupole strength (K1*L=integrated quadrupole strength)

The fields of the magnets can be calculated following the prescriptions
Dipole field in T: B_{rho}*ANGLE/L
Quadrupole gradient in T/m: B_{rho}*K1

The B_{rho} is beam energy dependent:

	5 GeV	**10 GeV**	**18 GeV**
Electron B_{rho} (T-m)	16.6782	33.3564	60.0415
	41 GeV	**100 GeV**	**275 GeV**
Hadron B_{rho} (T-m)	136.7255	333.5494	917.2959

Location of files:
https://brookhavenlab.sharepoint.com/:f:/s/eRHIC/bnl&slac/EhyBseTUBq9CvfM58YAZpyI-BRzbV3mL2SemtHy3wkhMb7Q
General EIC parameter table: section 3.2 table 3.3. to 3.6 in EIC Design Study Document: