CERN Secondary Beam Lines Software Migration Project

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Abstract

The Experimental Areas group of the CERN Engineering department operates a number of beam lines for fixed target experiments, irradiation facilities and test beams. The software currently used for the layout of the beam lines, beam optics, particle tracking and muon halo calculation has been developed in Fortran in the 1970's and 1980's and requires renovation in order to ensure long-term continuity. The on-going Software Migration Project transfers the beam line description to a set of newer commonly used software codes, such as MADX, FLUKA, G4Beamline, BDSIM etc. This contribution summarizes the goals and the scope of the project. It discusses the implementation of the beam lines in the new codes, their integration with the CERN layout database and the interfaces to the software codes used by other CERN groups. The latter includes the CERN secondary beam line control system CESAR, which is used for the control of the beam via setting of the magnets, collimators, filters etcetera, as well as readout of the beam instrumentation. The proposed interface is designed to allow a comparison between the measured beam parameters and the ones calculated with beam optics software.

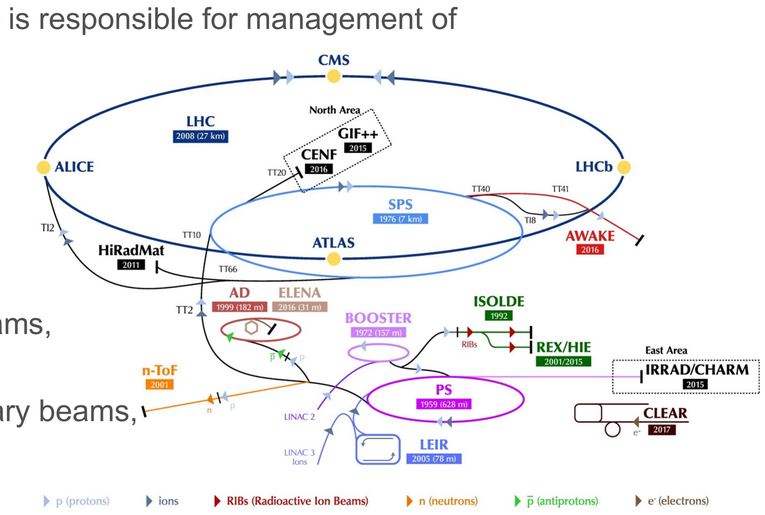
Tasks of Experimental Areas group

The Experimental Areas group is responsible for management of

- Fixed target experiments,
- Test beams,
- Associated facilities,
- Beam line elements,
- Infrastructure.

This includes

- Operation of secondary beams,
- Design of new beam lines,
- Physics studies for secondary beams,
- Technical support,
- Engineering support.

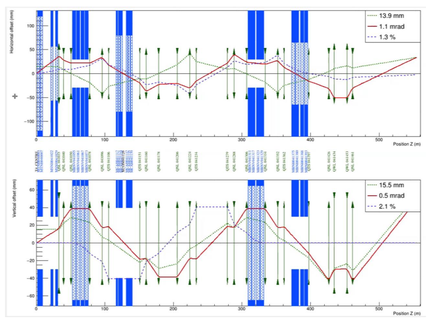


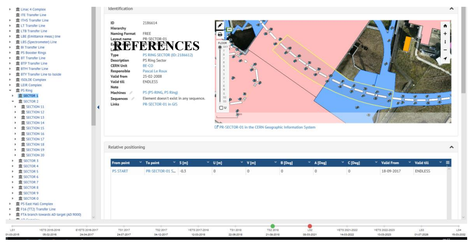
=> Broad requirements on the software which is used to describe the beam lines, simulate the beams, control the beam line elements and read out beam instrumentation data.

Software Migration Project

Set of currently utilized software includes:

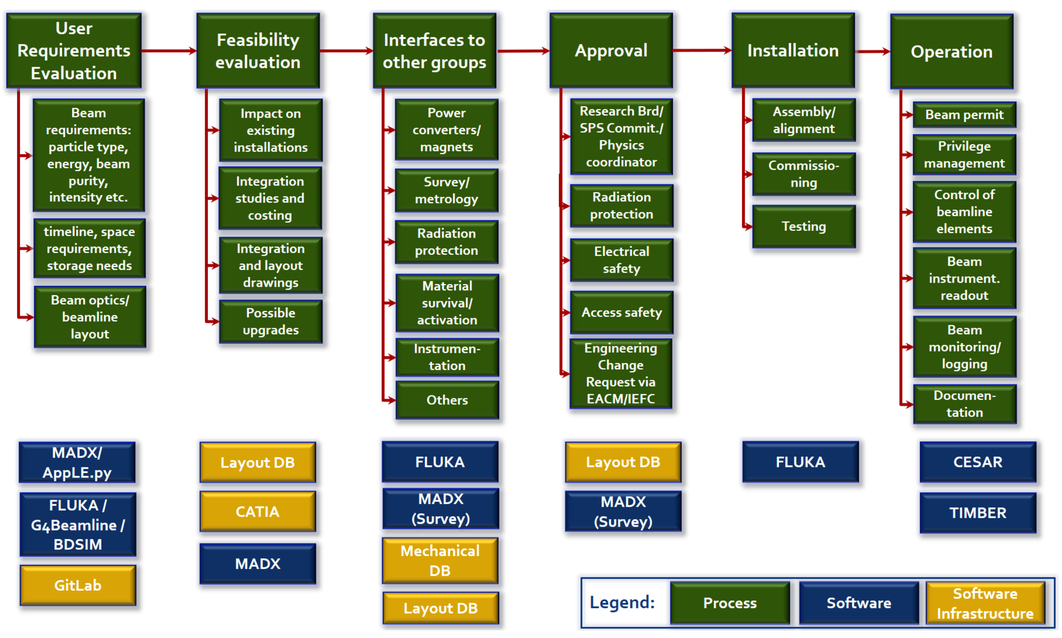
- BEATCH to generate coordinates of beam line elements
- TRANSPORT is a matrix based tool for beam optics calculations
- TURTLE is a particle-tracking tool
- HALO is a Monte-Carlo simulation software for muon tracking
- Other auxiliary tools, such as Beamplt, Beamopt and BLI.





Envisaged Software infrastructure:

- GitLab for software development
- Layout database

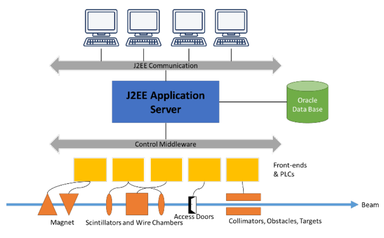


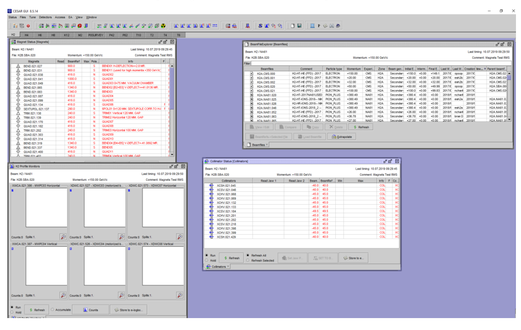
Set of beam simulation software envisaged for the future:

- MADX for
  - Generation of coordinates for survey
  - Beam optics calculations
  - Particle-tracking
- Graphical output tool APPle.py
  - Developed within Experimental Areas group
  - uses the MADX Twiss output
  - Produces a figure with relevant optics parameters
  - Includes information on
    - Magnet apertures
    - Collimators
    - Beam line element names
    - Transmission
- For beam-matter interaction
  - FLUKA
  - G4Beamline
  - BDSIM

Integration with CESAR Software

CESAR is an existing client-server control system for the beam lines of the PS and SPS experimental areas, used by the beam physicists, operators and the user teams of the experimental areas.





The beam can be tuned by controlling the magnets, collimators, instrumentation and other equipment. There is the possibility to view the beam profile and intensity with help of beam instrumentation devices, such as wire chambers, scintillating counters and ionisation chambers. The aforementioned elements are of several different types, and hence have different FESA classes for the data acquisition and control. However, as an example, in CESAR a regrouping the different profile types in a single window has been implemented.

It is planned to develop applications to:

- Create a beam file directly from a MADX Twiss output
  - Read the Twiss file
  - Find the corresponding magnets and currents inside CESAR database (to be synchronized weekly with the central CERN layout database)
  - Check if all the elements from the MADX output file are present in the CESAR database
- Display of its MADX graphical output within the CESAR GUI window.

In the longer term an application for creating the MADX input files using the CESAR database can be developed.

- Live beam optics display
- Database containing a table with most of the magnet types used for beam line
- Possibility to add magnets and other beam elements
- New magnet types can be created
- Can be used for automated beam tuning

Software References (selection):

MADX: H. Grote, F. Schmidt, L. Deniau and G. Roy, "The MAD-X Program (Methodical Accelerator Design) Version 5.02.08, User's Reference Manual," EUROPEAN LABORATORY FOR PARTICLE PHYSICS, Geneva, Switzerland, March 3, 2016

FLUKA: T. Böhlen, F. Cerutti, M. Chin, A. Fasso, A. Ferrari, P. Ortega, A. Mairani, P. Sala, G. Smirnov and V. Vlachoudis, "The FLUKA Code: Developments and Challenges for High Energy and Medical Applications," Nuclear Data Sheets , vol. 120, pp. 211-214, 2014, A. Ferrari, P. Sala, A. Fasso and J. Ranft, "FLUKA: a multi-particle transport code," CERN-2005-10 (2005), INFN/TC_05/11, SLAC-R-773.

G4Beamline: T. Roberts, "G4beamline User's Guide, 3.06," Muons, Inc., http://g4beamline.muonsinc.com/, 2018

BDSIM: L. Nevay and et.al., "BDSIM - Accelerator Beamline Simulation Tool," Royal Holloway, University of London, [Online]. Available: http://www.pp.rhul.ac.uk/bdsim/manual/.

CESAR: V. Baggiolini, P. Bailly, B. Chauchaix, F. Follin, J. Fullerton, P. Malacarne, L. Mateos-Miret and L. Pereira, "The CESAR Project using J2EE for Accelerator Controls," CERN-AB-2004-001-CO, vol. https://cds.cern.ch/record/704809, p. 4 p, 2004, "CESAR - Controls for the SPS experimental areas," European Organization for Nuclear Research (CERN), 28 10 2016. [Online]. Available: https://be-dep-co.web.cern.ch/content/cesar.