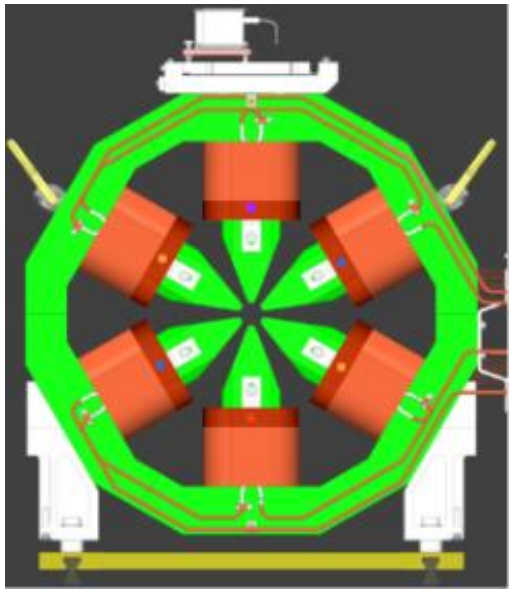
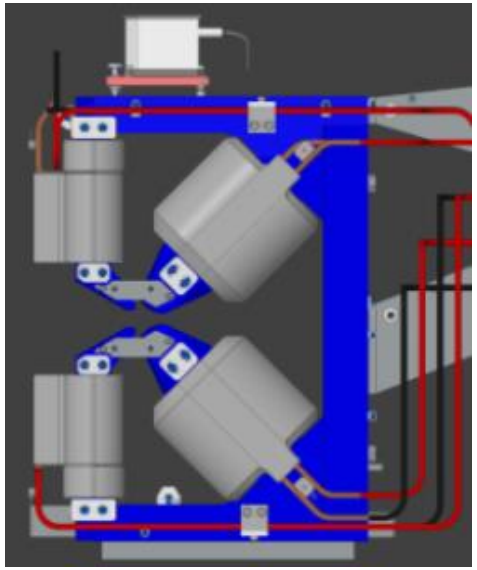
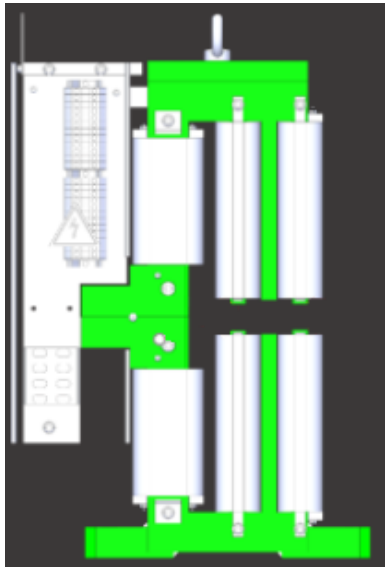
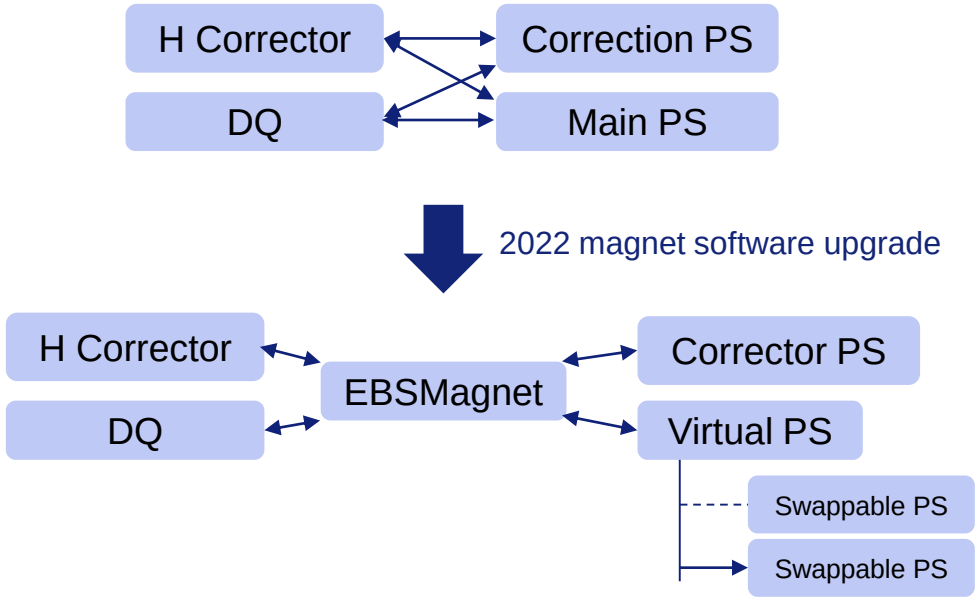
Magnet calibrations architecture at ESRF

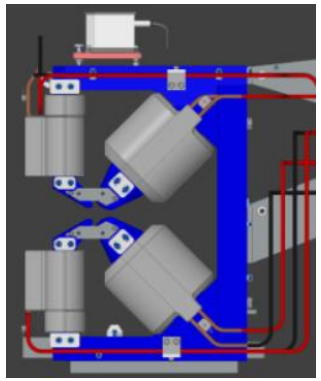




Second Accelerator Middle Layer Workshop, 12-14 February 2025
Jean-Luc Pons

EBS MAGNETS SOFTWARE UPDATE (2022)

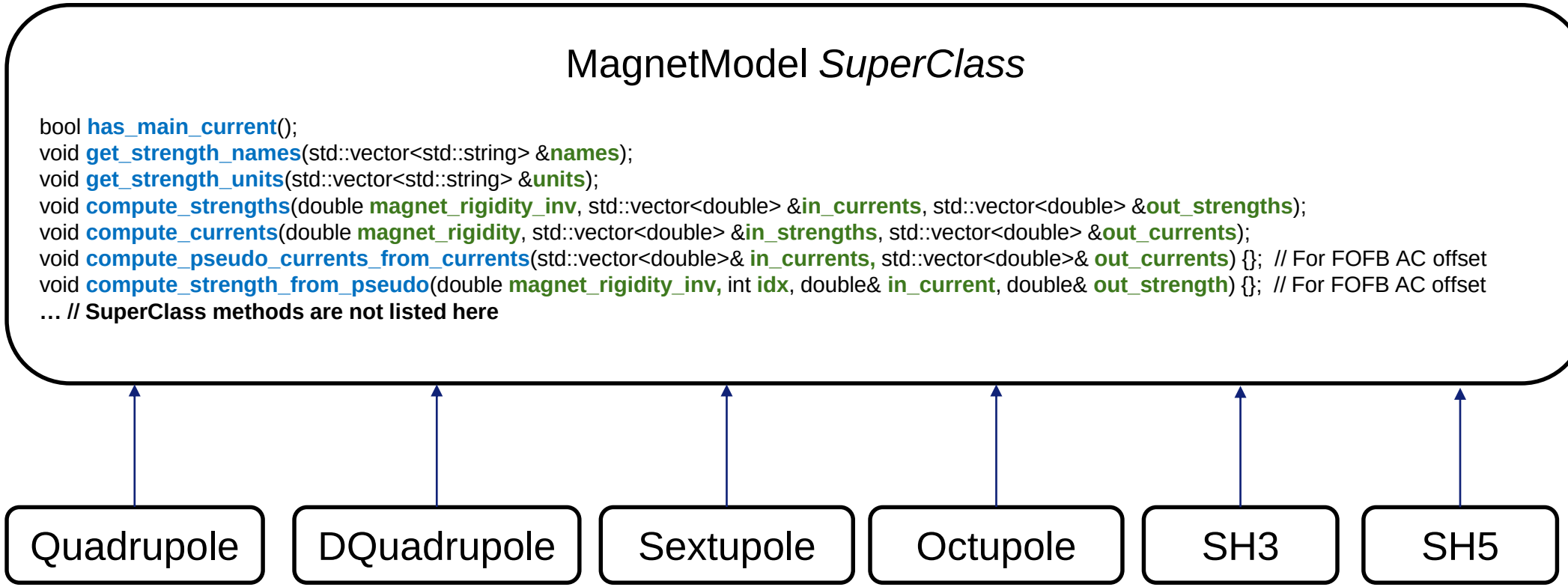
- **Improve maintainability/reactivity**
  - Centralize magnet calibration data and source code in a single library
  - Fix conflicts when applying strengths on combined function magnets
  - No #ifdef SIMULATOR directive in the code
  - Minimize hardware access, allow to set H/V at once
- **Power supply virtualization layer**
  - Integrate HotSwap system
  - Handle low level connection between magnet and PS
  - Use a unique device name to access a magnet
  - Allow standalone power supply (QF1E QF1A for injection)
  - Allow HotSwap spare usage for mini-beta optics evaluation (using additional quads)
- **Digital shadow / Simulator**
  - Simulate magnet cycling and electrical power overhead
  - Implement digital twin application
- EBS: 1056 swappable PS / 1156 corrector PS



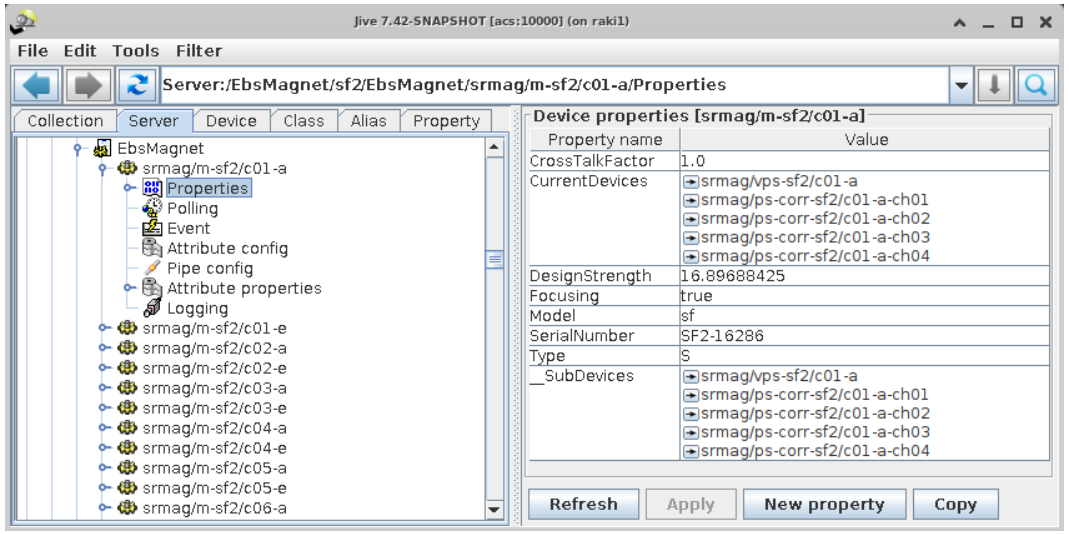


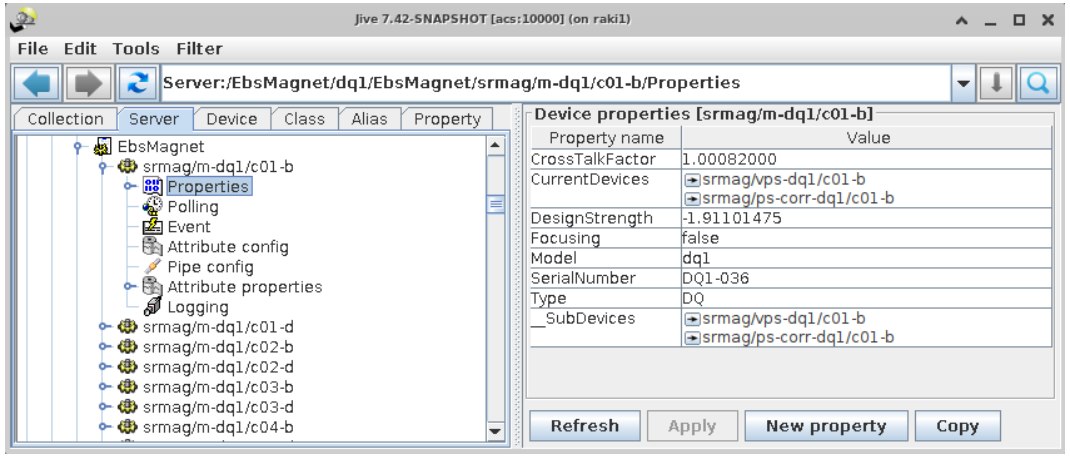
EBS MAGNETS CALIBRATION LIBRARY

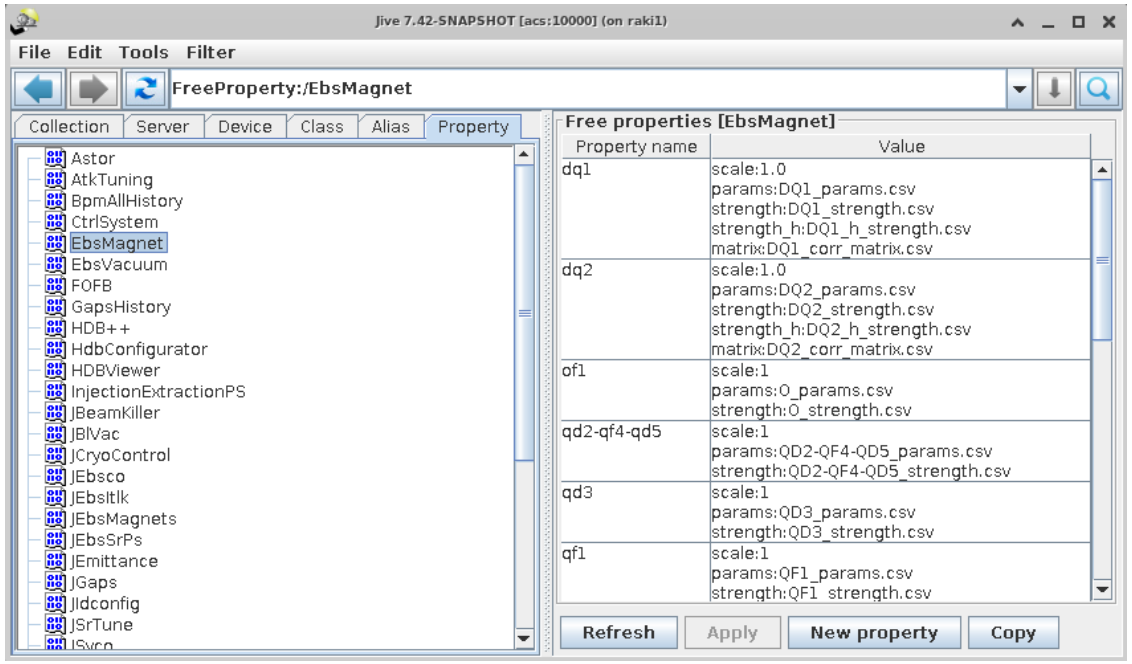
- https://gitlab.esrf.fr/accelerators/Magnets/MagnetModel
- Avoid code duplication
- Prevent calculation conflicts
- Database is used for configuration
- Based on Eigen C++ linear algebra library



EBS MAGNETS CALIBRATION CONFIGURATION





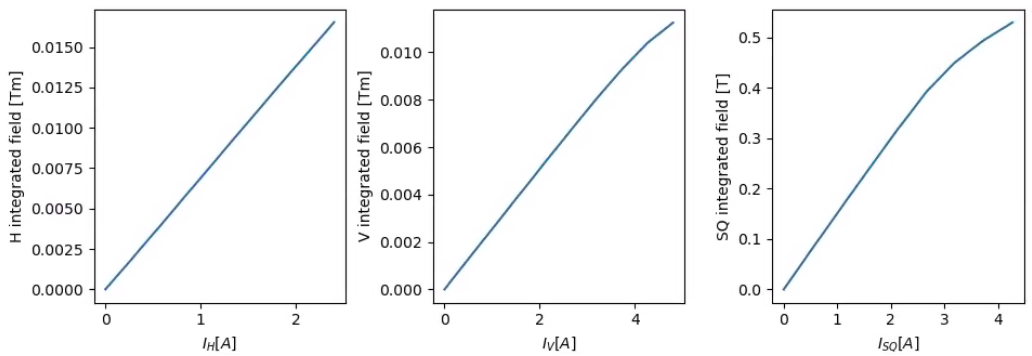


Magnet configuration

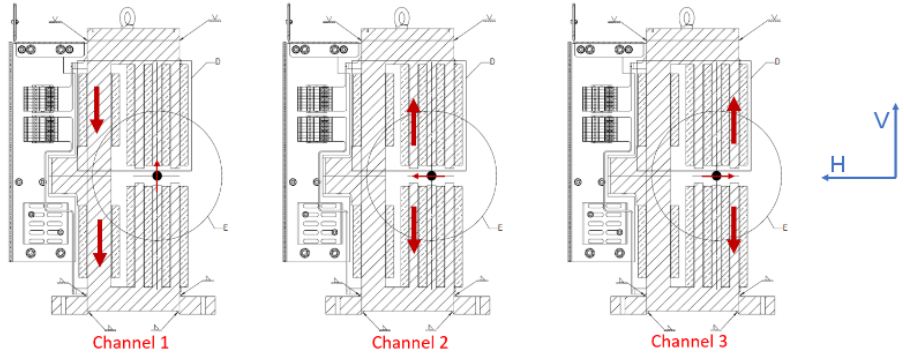
- All specific settings are in the database and on file system
- Only one Tango class (EbsMagnet) handle all magnet types.

EBS MAGNETS CALIBRATION EXAMPLE (SH MAGNET)

- Compute coil currents from strength setpoints and reverse transform
- Calibration data (calibration curves and matrix) issue from magnetic measurements

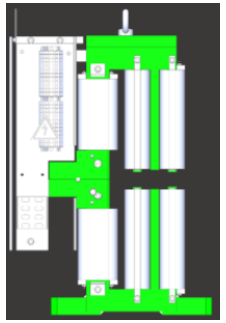


Excitation curves H,V and skew quad



$$\mathbf{M} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & -1.061 \\ 0 & 0.962 & 1 \end{pmatrix}$$

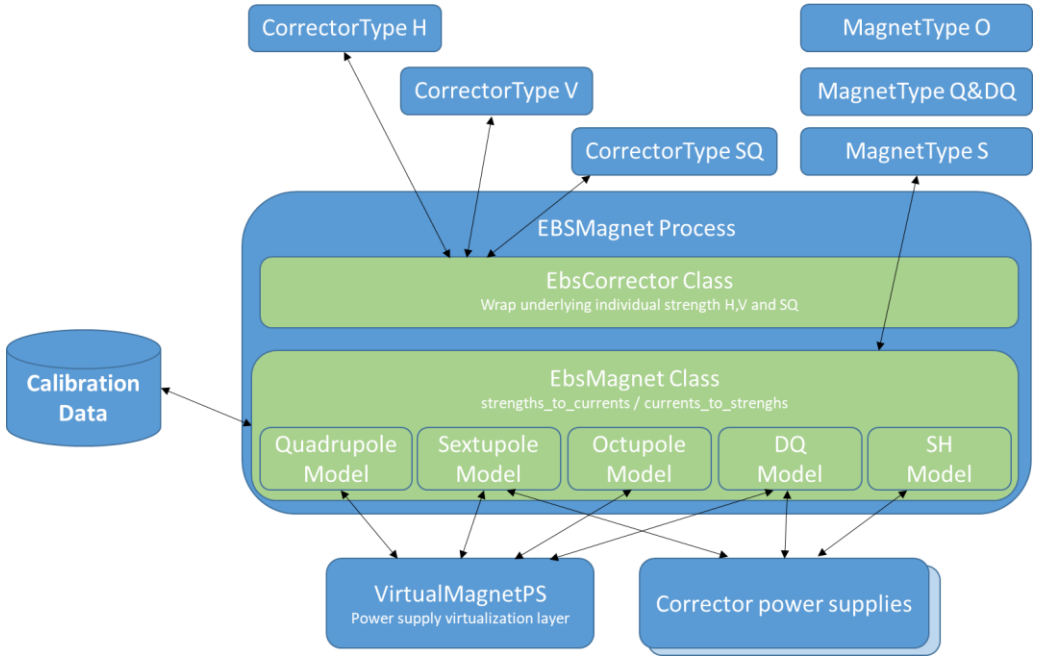
$$\begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix} = M^{+} \begin{pmatrix} I_H \\ I_V \\ I_{SQ} \end{pmatrix} \quad \begin{pmatrix} I_H \\ I_V \\ I_{SQ} \end{pmatrix} = M \begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix}$$



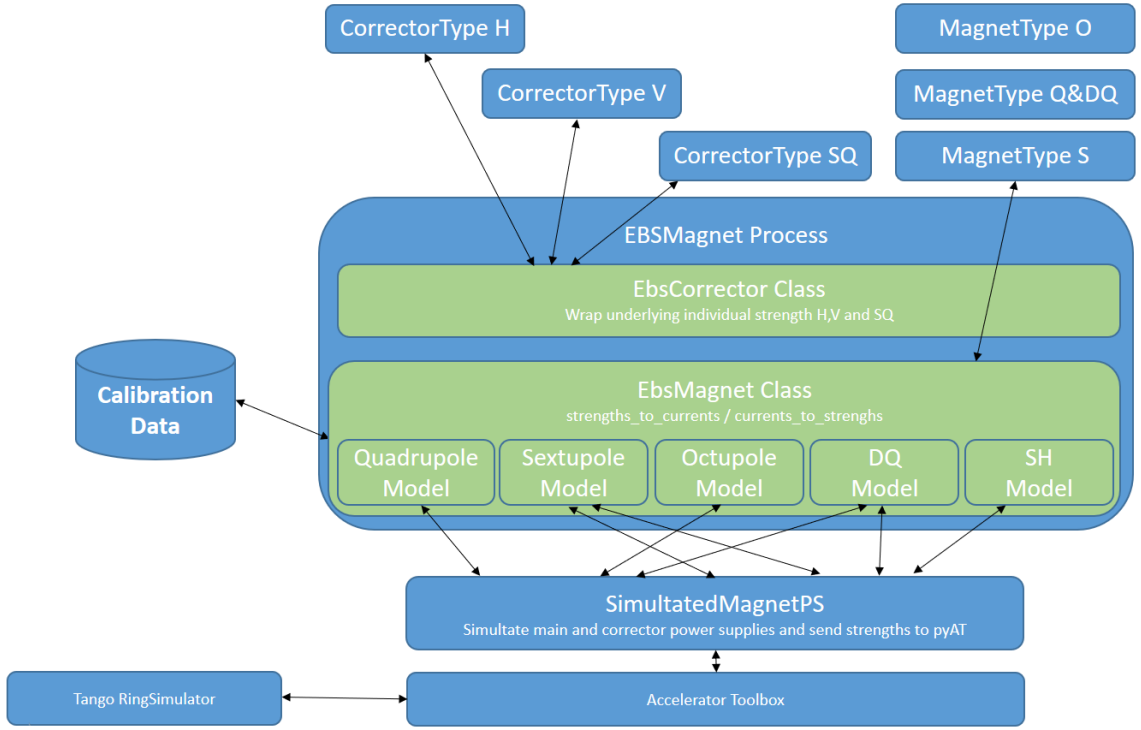
I_H, I_V and I_{SQ} are named “pseudo current”. Each one can be mapped to a single multipole strength.

To get strengths, integrated fields are then normalized by the magnet rigidity Bρ [Tm].

EBS MAGNET GLOBAL ARCHITECTURE



Live Machine



Simulated Machine

- EbsMagnet class prevents from conflicts when applying/loading strengths on combined function magnets.
- No #ifdef SIMULATOR directive in the code.
- Allow to change directly PS current and simulate cycling on simulators (useful for software development).
- Simulate electrical power overhead.