



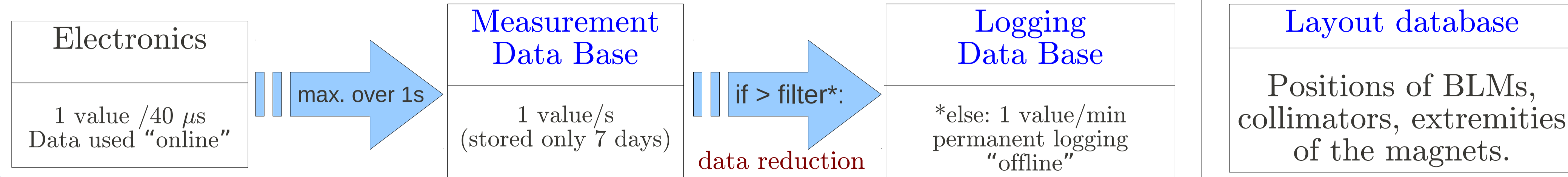
The unprecedented quantity of data (100 Gb/day) produced by the measurements from the beam instrumentation devices in CERN's Large Hadron Collider (LHC) requires new developments for access, process, combination and analysis. The Beam Loss Monitoring (BLM) system protects the LHC by initiating the extraction of the beam from the machine when the detected losses are above the predefined beam abort thresholds. It is possible to detect and study unexpected losses, requiring intensive offline analysis. This poster describes the ensemble of tools, called **toolbox**, developed to: access the loss data produced (50 000 values/s); access relevant system layout information; access, combine and display the analysed machine data.

Introduction

- The layout of the machine around the loss is as important as the loss itself
- 4000 detectors × 12 time integration intervals
= 50 000 values in 1 second → need automation
- Creation of a **toolbox** to access, combine and analyse the data, and display the result.

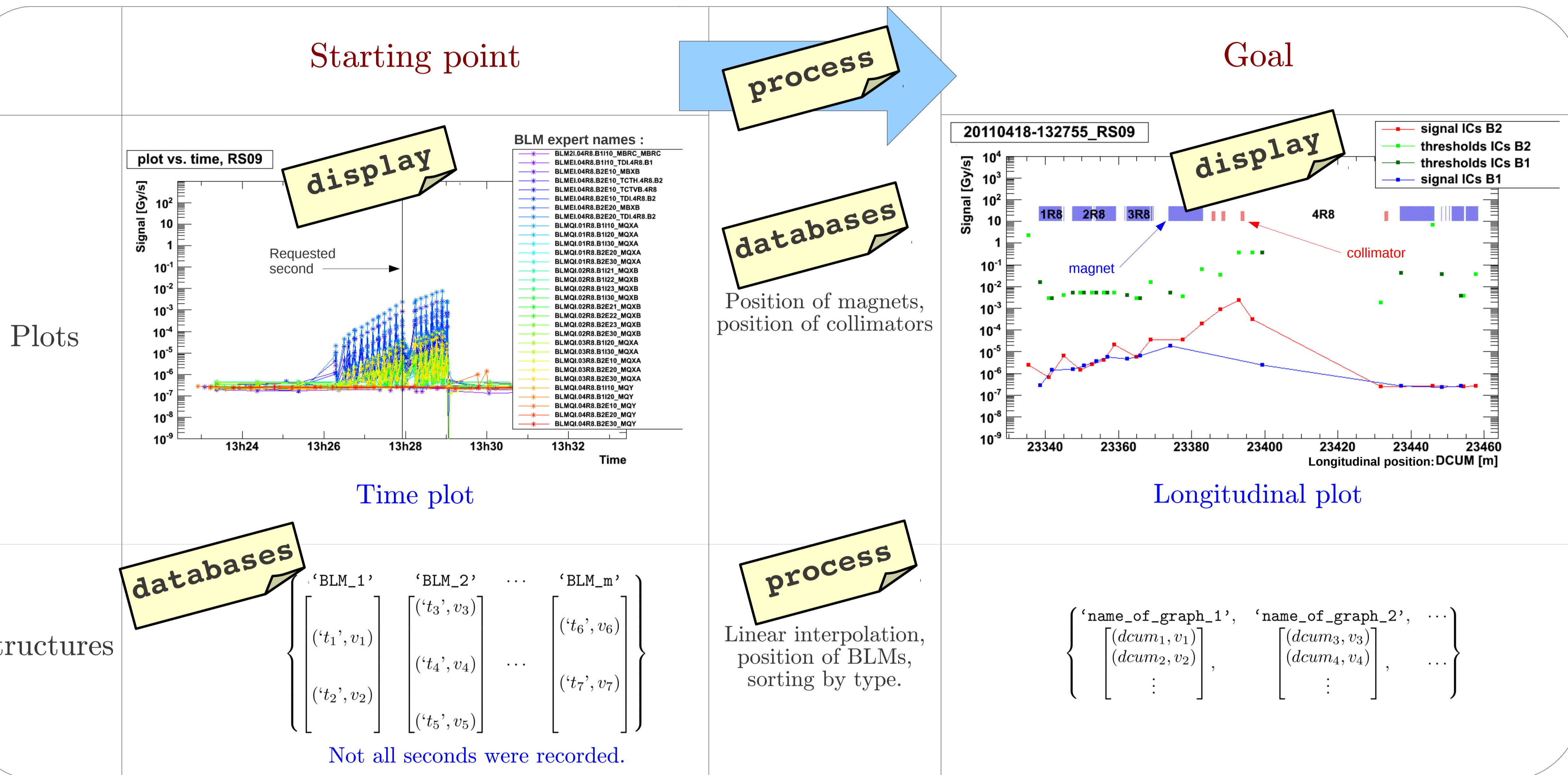
Databases

Values of losses per monitor per time integration interval:



Beam Loss Analysis Toolbox

Function	Module
Access data	databases
Combine & process data	process
Plot data (Root objects)	display
Do it automatically	analysis

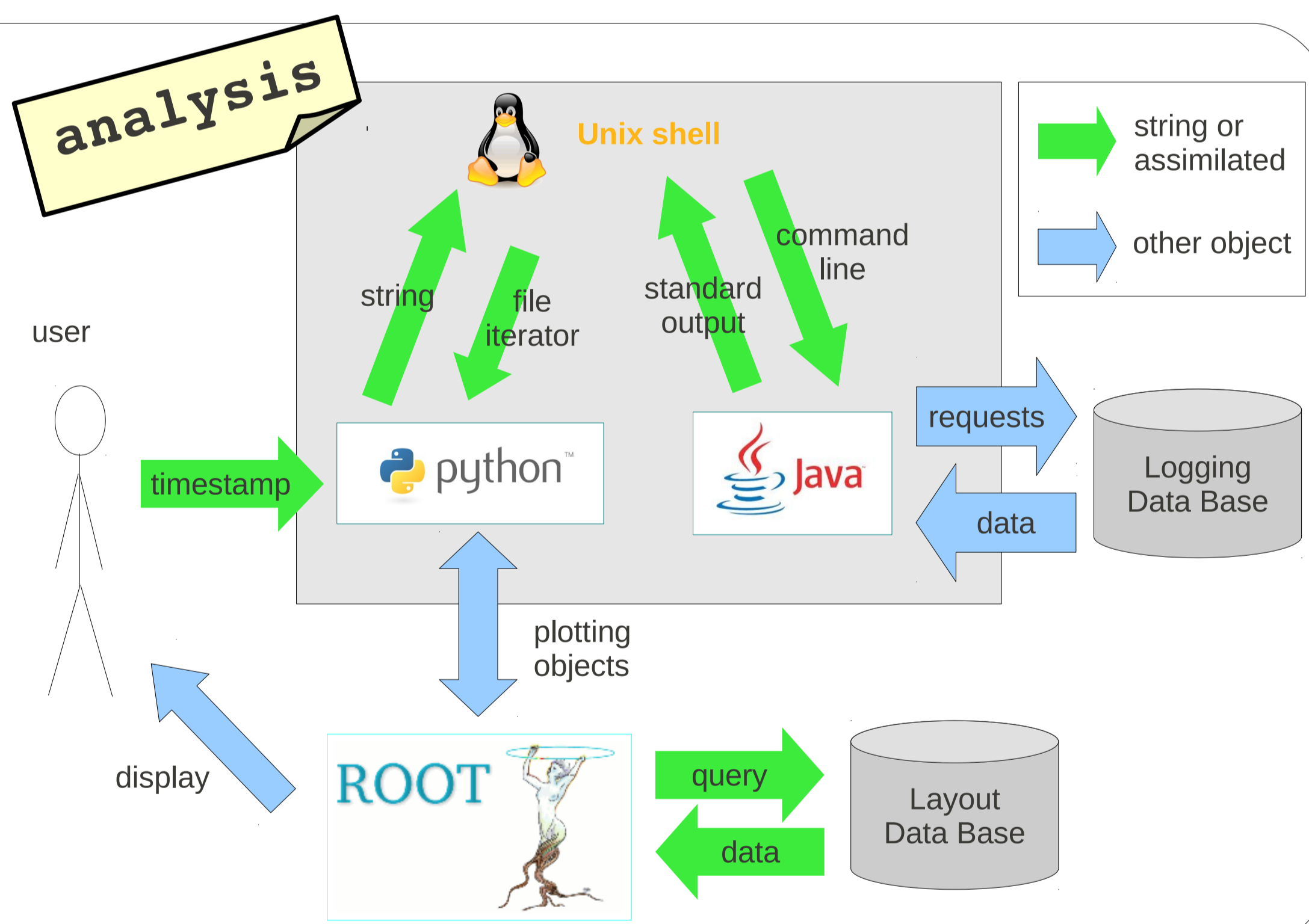


Python Structures

- { }: dictionary. "key" (variable name) mapped to "value" (list)
- []: list. "mutable iterable" (dynamic): elements can be appended.
- (): tuple. "immutable iterable": constant after creation.

Data Access Techniques

- All done using Python
- Layout database:
 - ROOT objects [1]
 - SQL queries
 - strings (easy manipulation)
 - direct access: need user name, password, client and application names
- Measurement & Logging databases:
 - Java API called from command line: provided by the Database Management [3]
 - Python function `os.popen`: results are written in the standard output, in a "file iterator"



Data Combining

- Algorithm progresses through the list of tuples
- The requested second might not have been recorded due to data filtering) ⇒ linear interpolation:

$$v_{req} = v_1 + \frac{v_2 - v_1}{t_2 - t_1} \cdot (t_{req} - t_1)$$

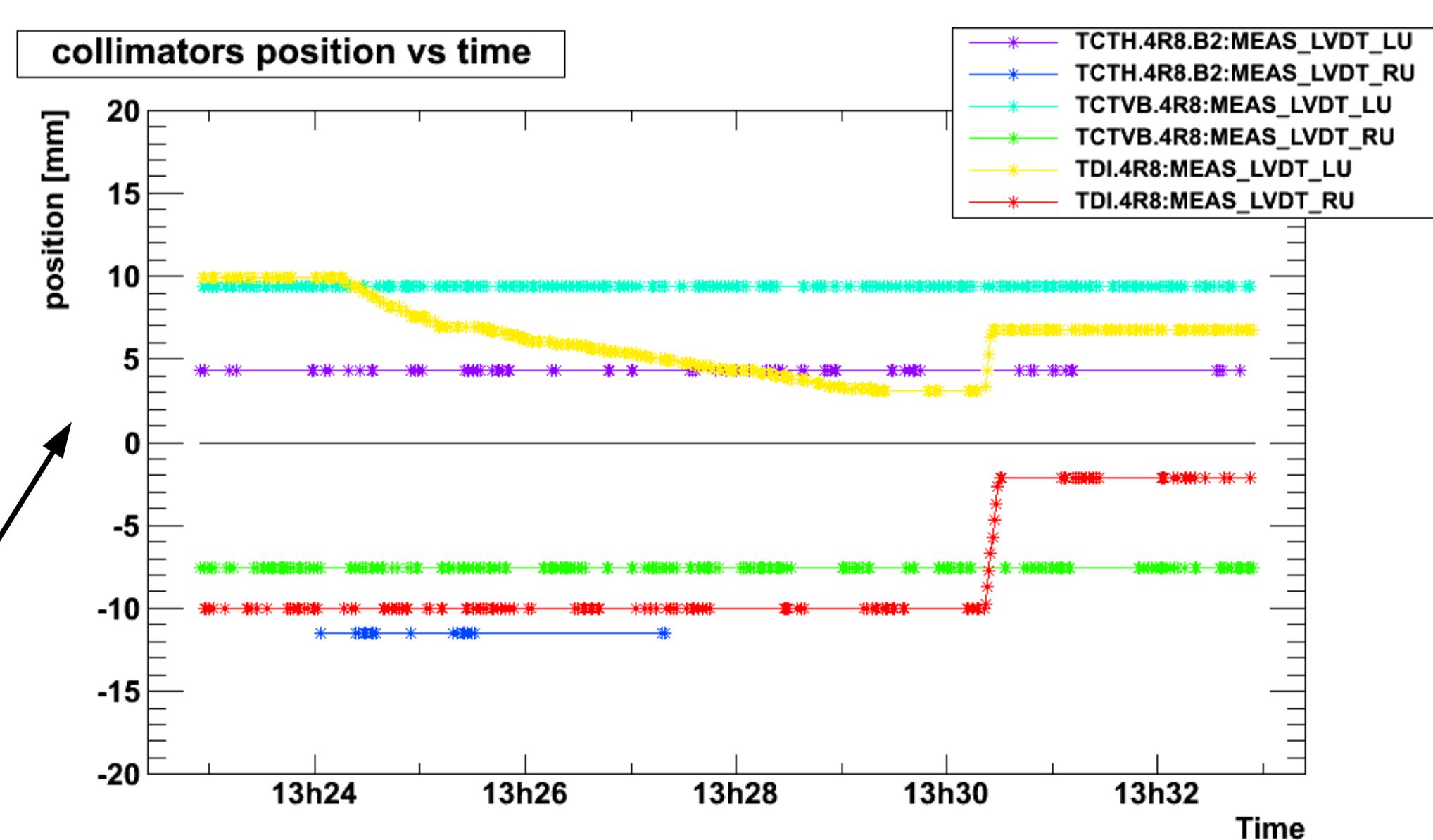
v_{req} is the value at the requested time t_{req} , t_1 and t_2 the registered times before and after t_{req} , v_1 and v_2 the corresponding values.
- BLMs are sorted depending on their types (B1 or B2, ...)
- Losses are associated with the longitudinal position of the corresponding BLM.

Basic Behaviour

- Methods called automatically when calling the toolbox:
- find the corresponding BLMs, collimators and magnets with information from the Layout DB;
 - get the losses and thresholds for the relevant BLMs from the measurement or Logging DB;
 - display the losses versus time (see figure);
 - combine all data to display the loss in the LHC at the requested time (see figure).

Additional Methods

- Additional method available on user call:
- save the data set;
 - print all the names of the LHC elements in longitudinal order;
 - search for a string in the BLM names;
 - plot a vertical line at a given longitudinal position;
 - plot the ratio signal/threshold for each BLM;
 - order BLMs by criticality (closeness to threshold);
 - plot the beam intensity at the time;
 - plot the position of the jaws of the displayed collimators;
 - plot the signals of the Beam Position Monitors;
 - plot the optics in the LHC.



Conclusion

- Direct database access
- No middle step (data file, parsing...)
- Final result obtained with one command line
- Now used as a standard database access in the CERN Beam Loss section
- Future improvements: parallel downloading, adaptation to BLM-specific database (no data reduction)
- Flexible: default arguments for advanced behaviour
- Objects common to different module
- User-friendly

References

- ROOT class index, <http://root.cern.ch/root/html528/ClassIndex.html>
- LHC logging project, C. Roderick, CERN BE-CO-DM <http://lhc-logging.web.cern.ch/lhc-logging/software/default.htm>
- Logging Data Extraction Client, Command Line API, <https://espace.cern.ch/be-dep/CO/DM/CALS/other/CommandLineManual.pdf>