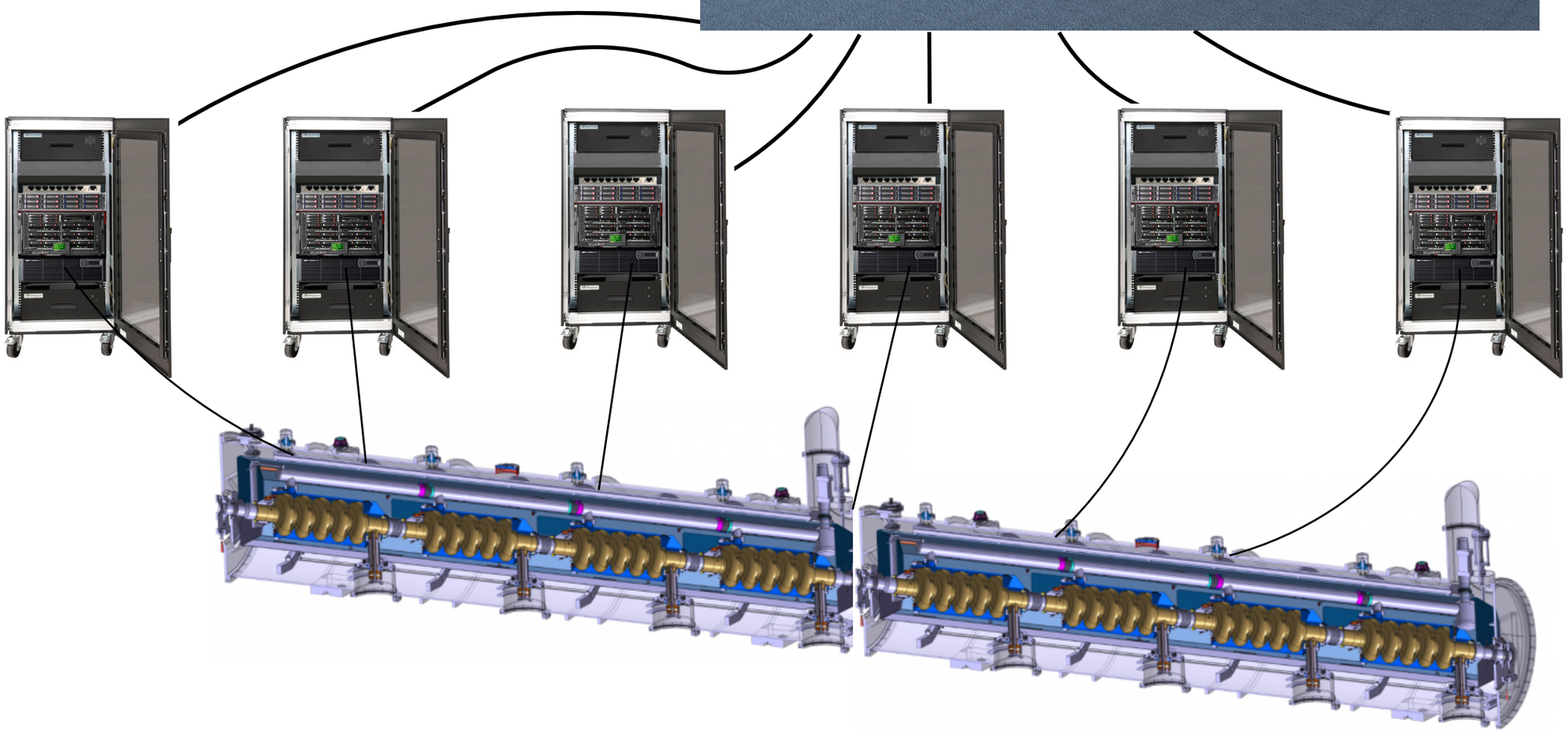
Thursday 6th of April 2017

EUROPEAN SPALLATION SOURCE

EPICS 7 applications and services

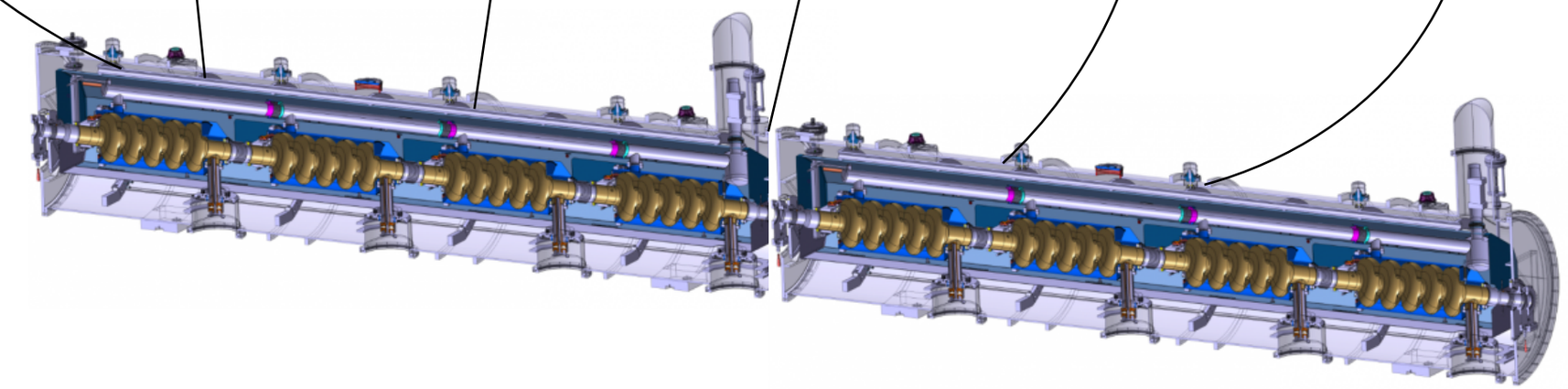
Emanuele Laface

The context



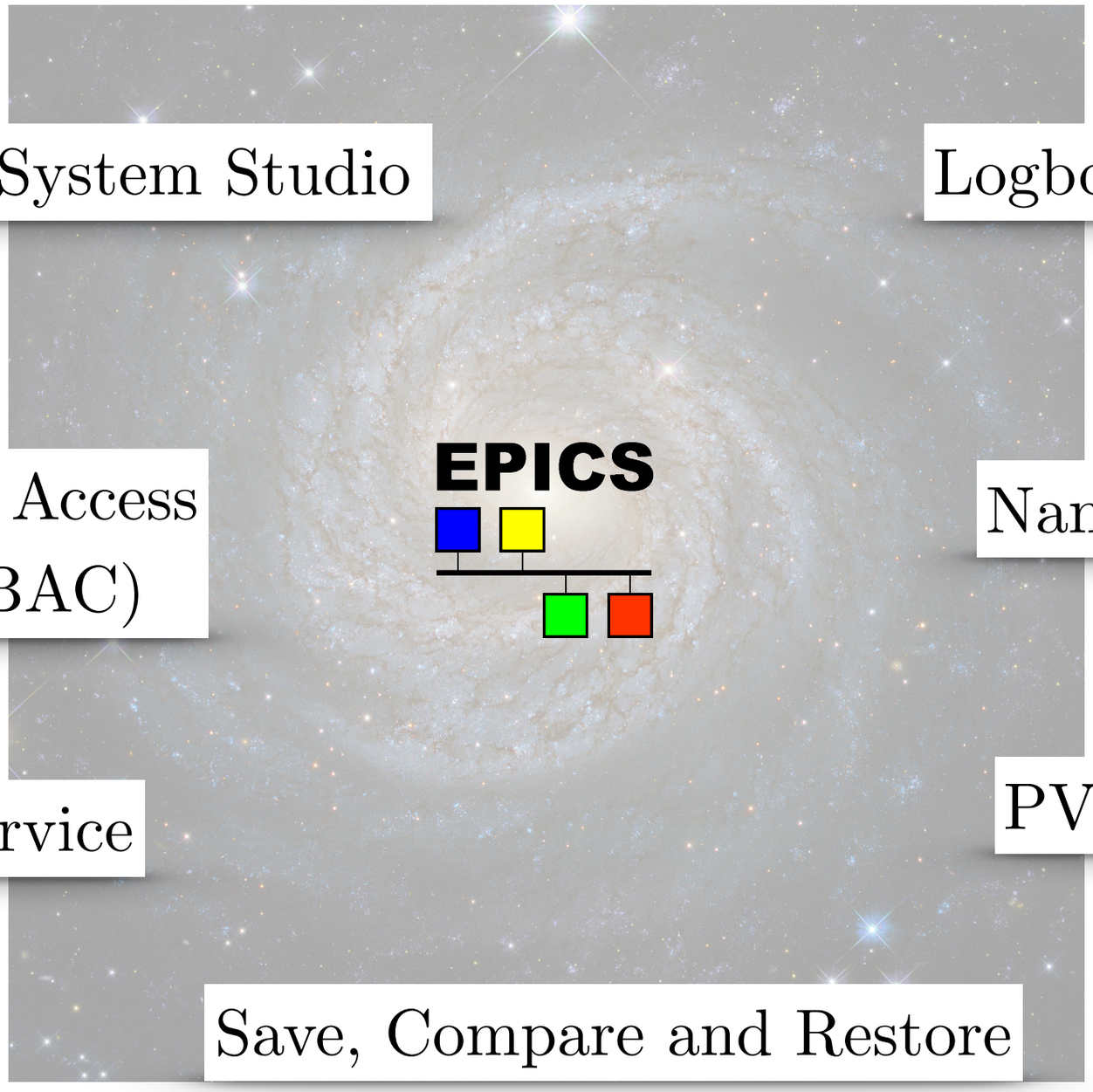
The context

EPICS EPICS EPICS EPICS EPICS EPICS EPICS



The context

There is a galaxy of applications and services that will work with EPICS



Control System Studio

Logbook

Role Based Access Control (RBAC)

Naming Server

Alarm Service

PV Logger

Save, Compare and Restore

The context

In this presentation I will be focused on the applications required for the Beam Commissioning. The so called High-Level Applications.

The plan

2018-02-05 ~ 2018-03-11	Beam commissioning up to LEBT
2018-09-17 ~ 2018-10-14	Beam commissioning up to MEBT
2019-01-28 ~ 2019-03-03	Beam commissioning up to DTL4
2019-06-10 ~ 2019-06-23	Beam commissioning up to tuning dump
2020-04-xx	Target ready (no beam yet??)
2021-03-xx	First neutron instrument ready (first beam to target??)
2023-08-xx	User program starts
2025-xx-xx	5 MW beam power??

Courtesy of R. Miyamoto

Expected by Beam Physics team

Simple scan and check

General
- Polarity
- Beam based alignment

LEBT
- Iris vs current
- Chopper timing/voltage
- Gas pressure vs space charge compensation

RFQ
- Power vs energy/transmission
- LEBT solenoids/steerers vs transmission

MEBT
- Chopper timing/voltage
- Collimator positions

A2T (including dogleg)
- Achromatic condition
- Phase advance between the raster system and shield wall

Physics based tuning

Standard
- Trajectory correction
- Phase scan
- Matching with 3(+)profiles
- Quad/buncher scan
- Matching with an emittance measurements

Other linear model based
- Quad transfer function measurement
- Transfer matrix measurement
- Beam based alignment

Special??
- Matching with an emittance measurement

Courtesy of R. Miyamoto

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Scanning
Model
Scanning and measurements
Measurements

Courtesy of R. Miyamoto

OpenXAL

Based on EPICS

Works at SNS

Is in Java (as CSS)

Linear solvers (SVD)

Virtual accelerator

Collaboration

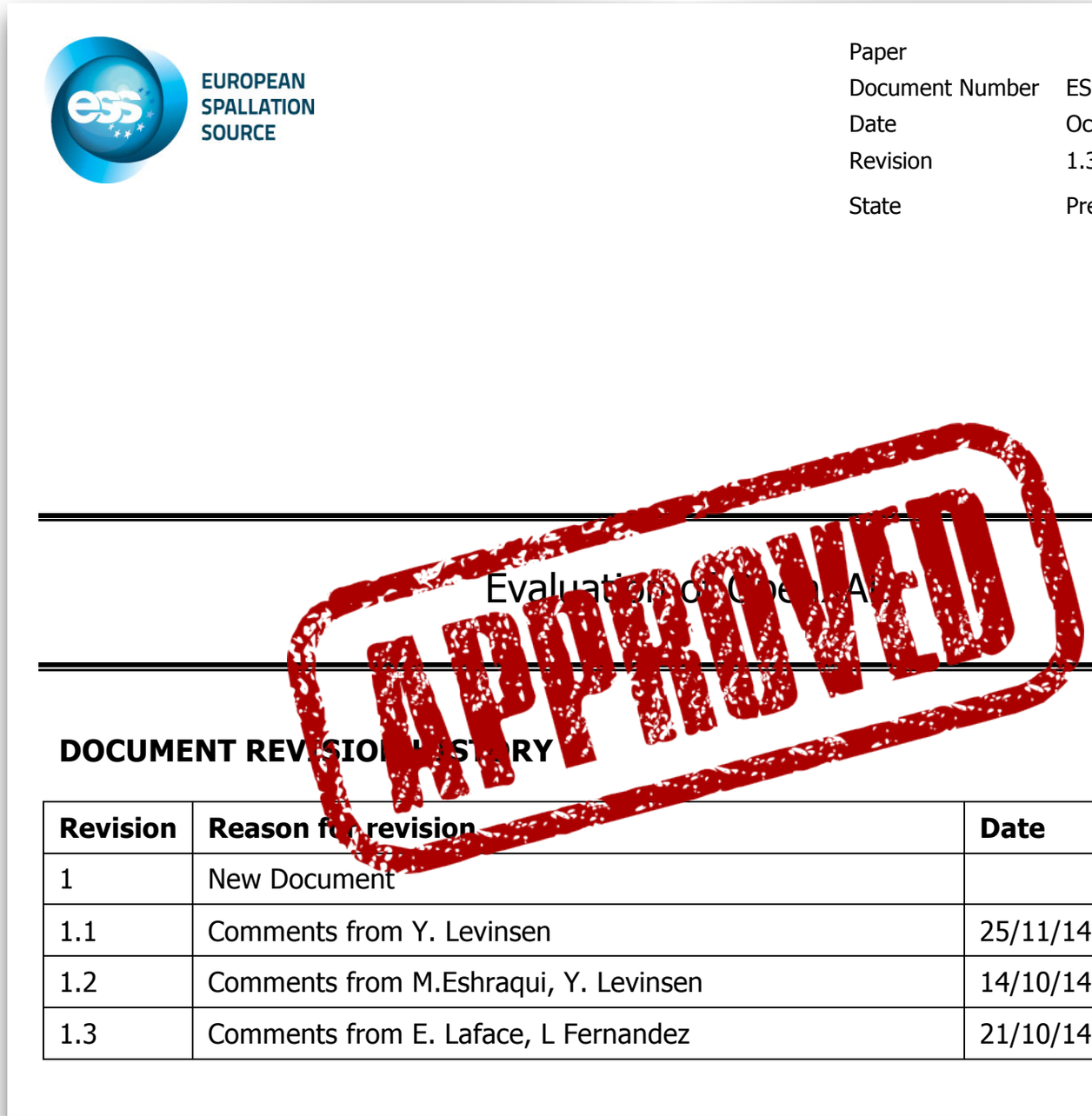
Open Source

Includes an online model

Several applications already available

OpenXAL

As framework for physics applications we agreed, to use OpenXAL.



EUROPEAN SPALLATION SOURCE

Paper
Document Number ESS-0017729
Date Oct 2, 2014
Revision 1.3 (1)
State Preliminary

Evaluation of OpenXAL

APPROVED

DOCUMENT REVISION HISTORY

Revision	Reason for revision	Date
1	New Document	
1.1	Comments from Y. Levinsen	25/11/14
1.2	Comments from M.Eshraqui, Y. Levinsen	14/10/14
1.3	Comments from E. Laface, L Fernandez	21/10/14

Our OpenXAL

Since 2014 we worked hard to improve the existing version of OpenXAL in three directions

model

scripting

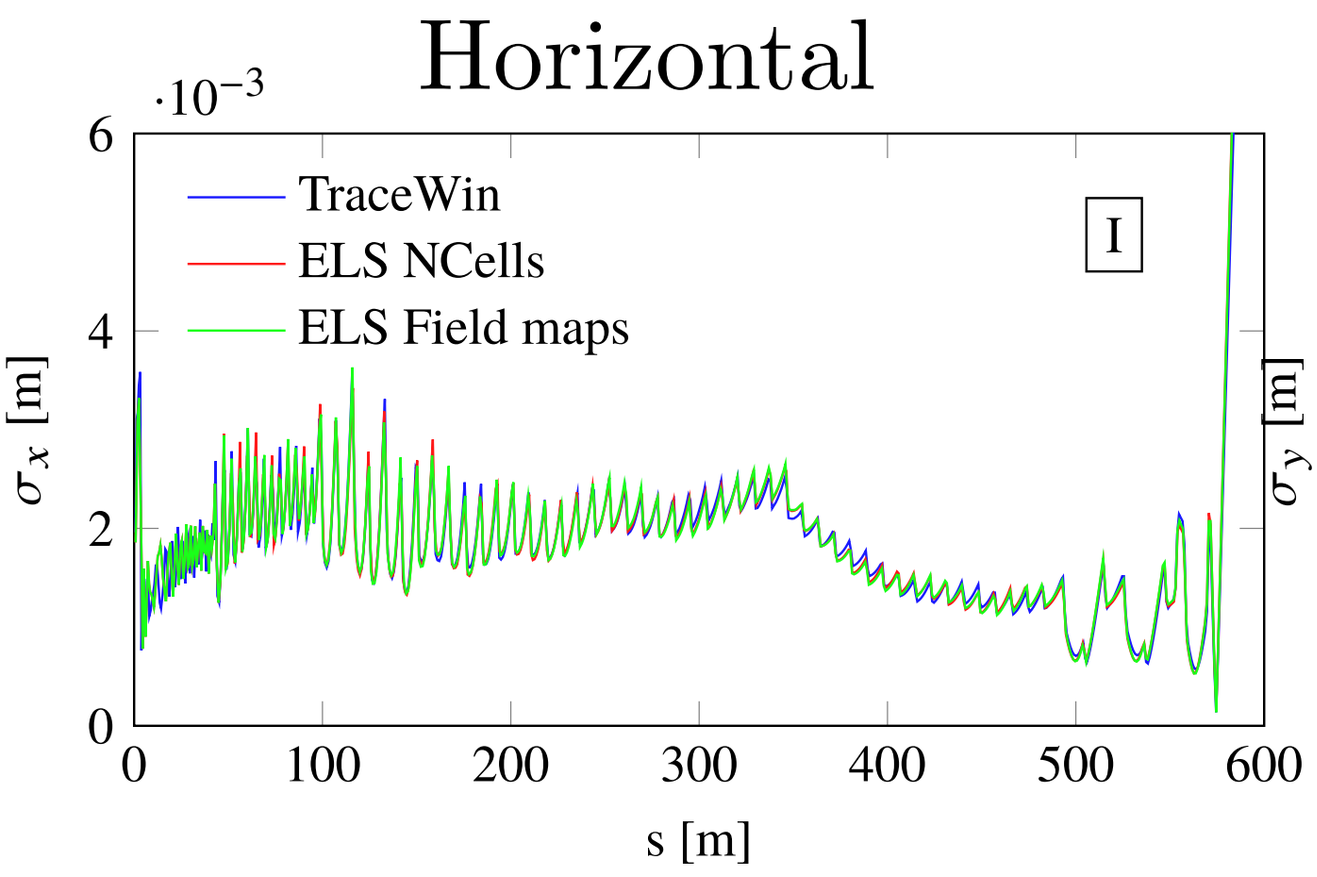
infrastructure integration

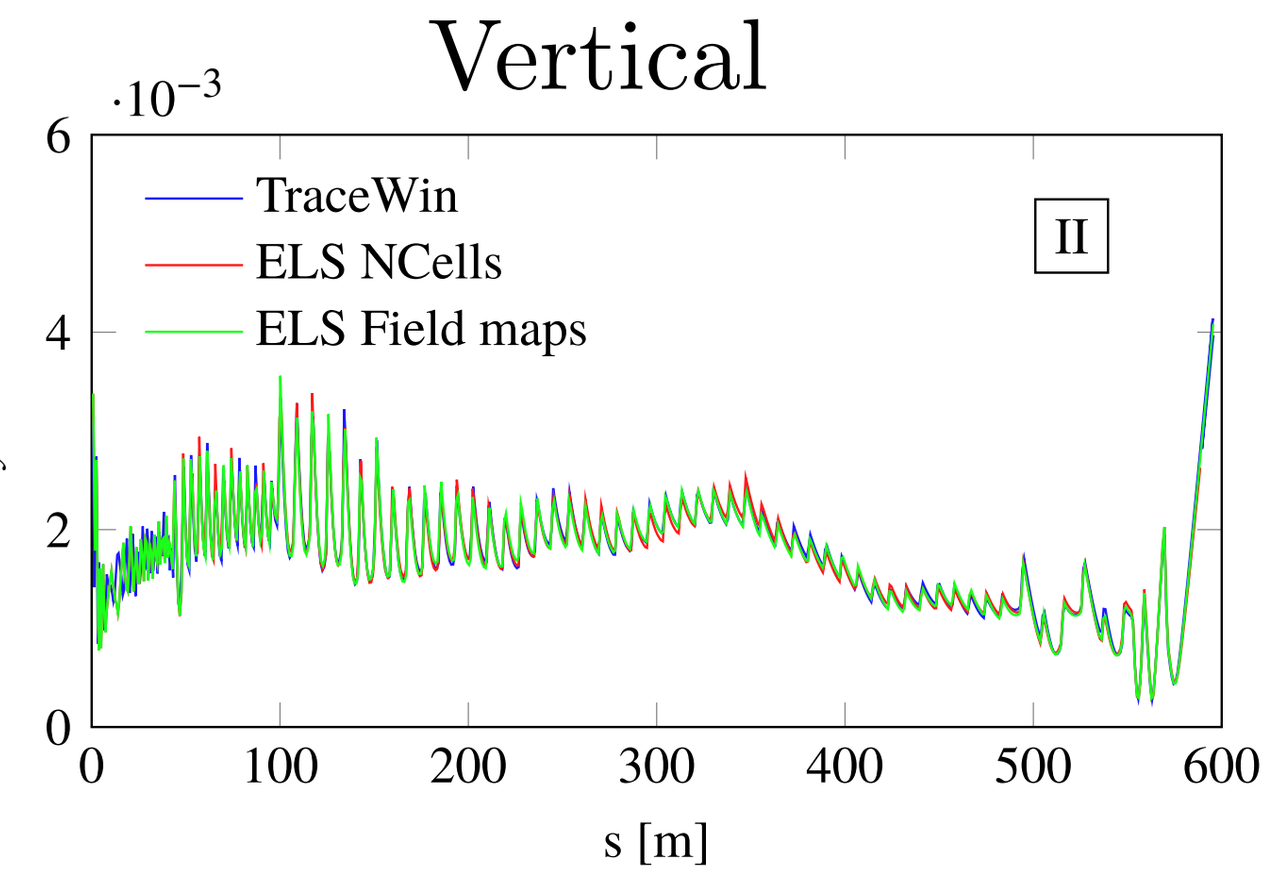
OpenXAL model (ELS)

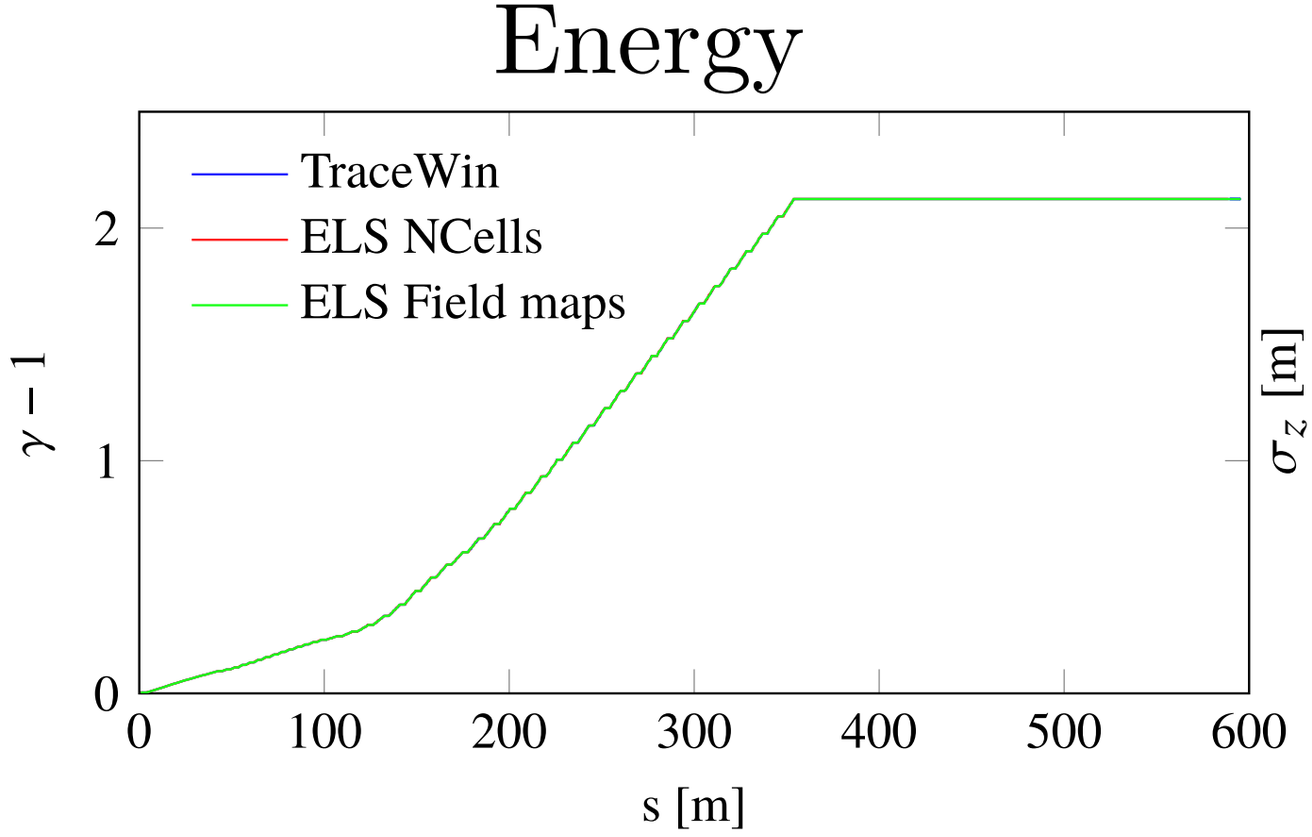
The model was rewritten in the space charge part and the acceleration. Today it includes a KV space charge and the linearization of a gaussian kick. It also has a NCELL acceleration mechanism and a Filed Map integrator for cavities.

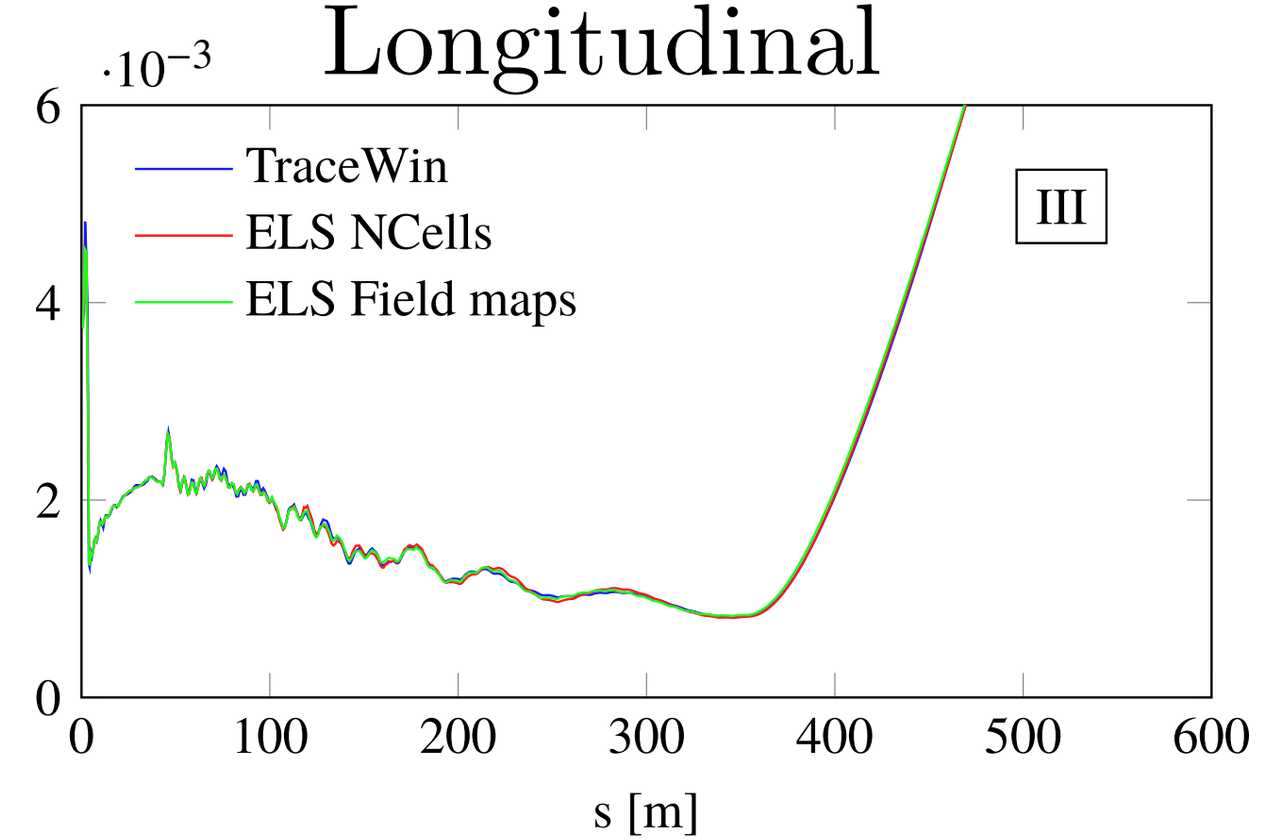
Many issues in other elements (such as bending magnets) were reviewed and corrected.

The model was extensively tested vs. TraceWin.









E. Laface and I. List “Field map model for the ESS Linac Simulator”, IPAC 2015

OpenXAL model (ELS)

We had also the possibility to test it at SNS. Two set of measurements were performed:

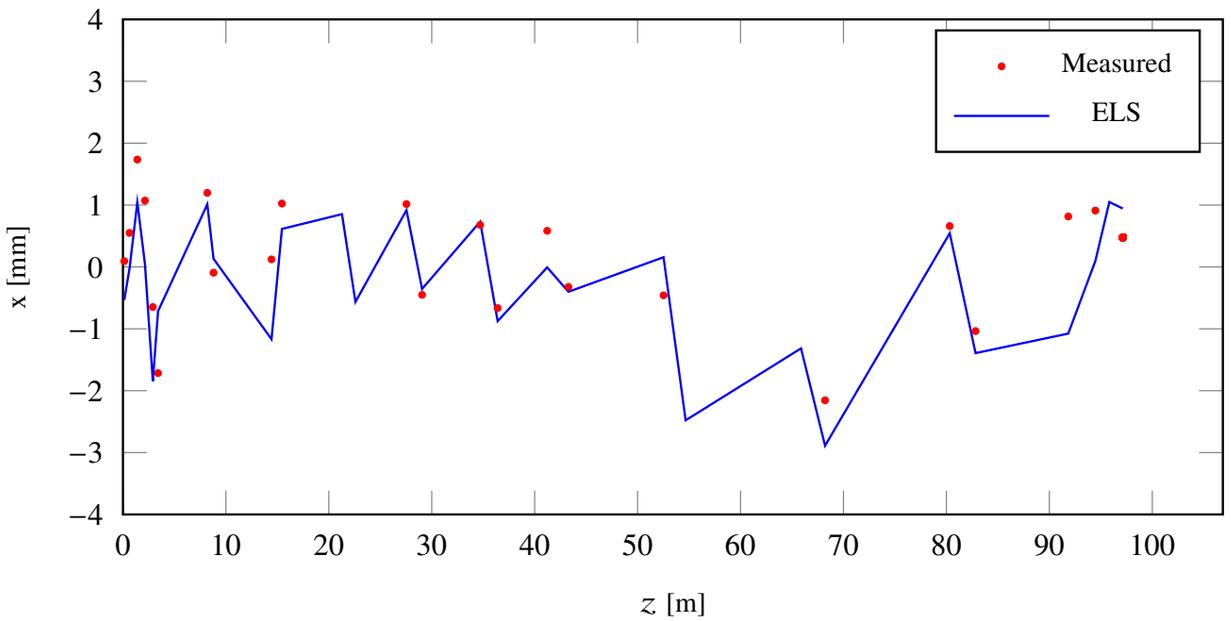
the excitation of a kicker at the beginning of the accelerator to see the beam oscillation downstream;

the phase scan of four CCL cavities;

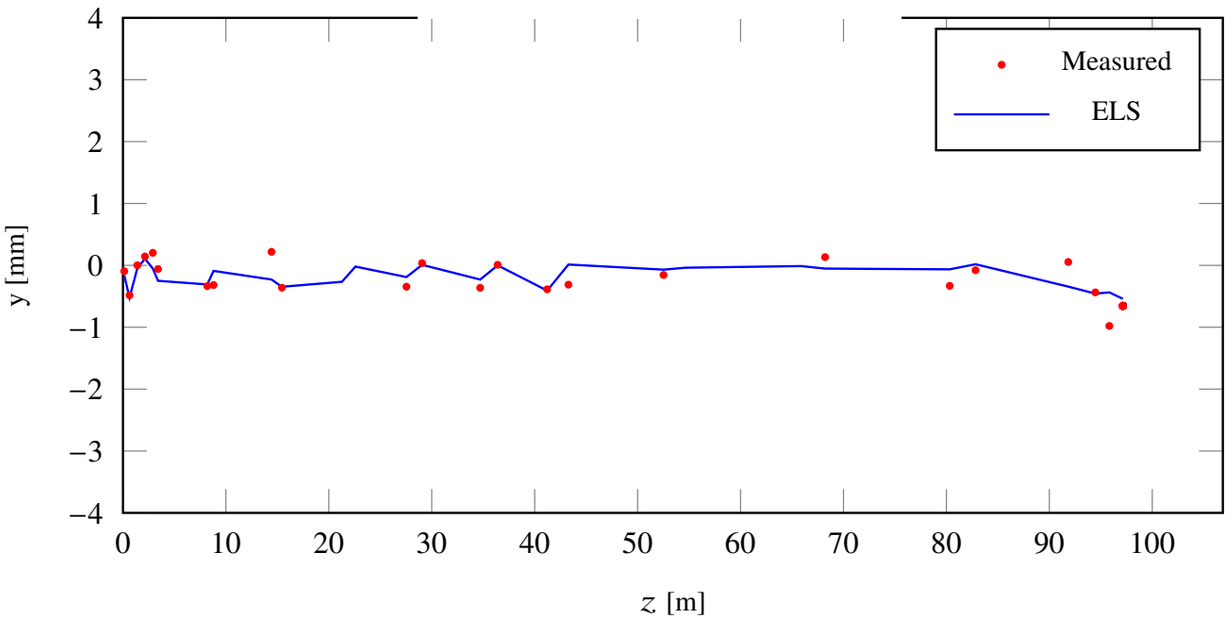
Kick of the beam in the MEBT

Normal conducting

Horizontal

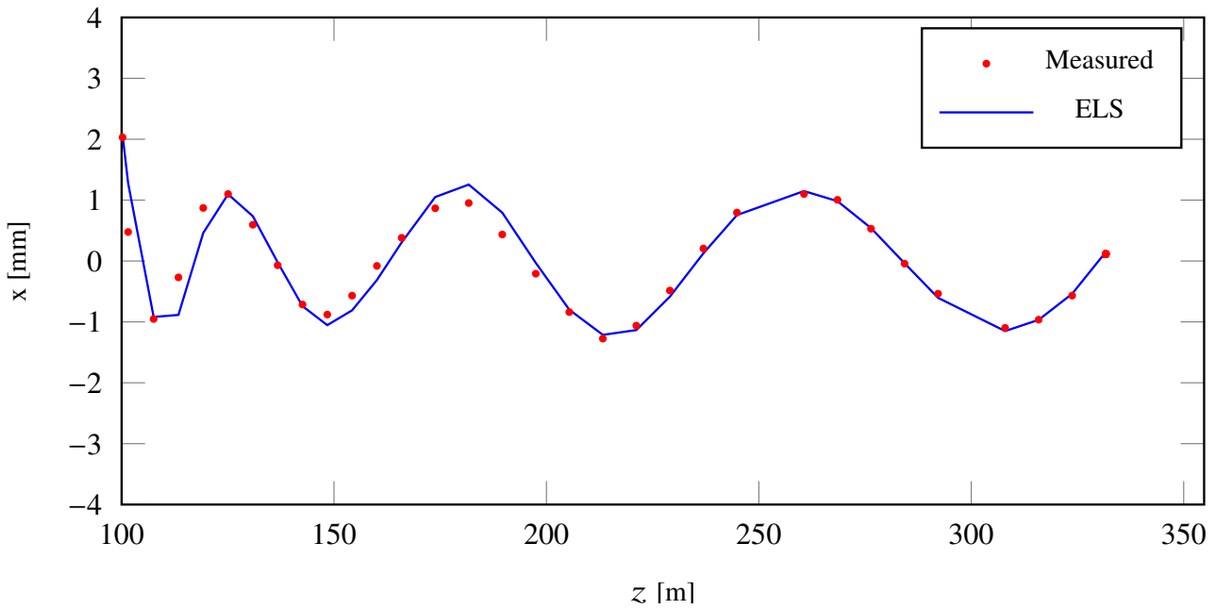


Vertical

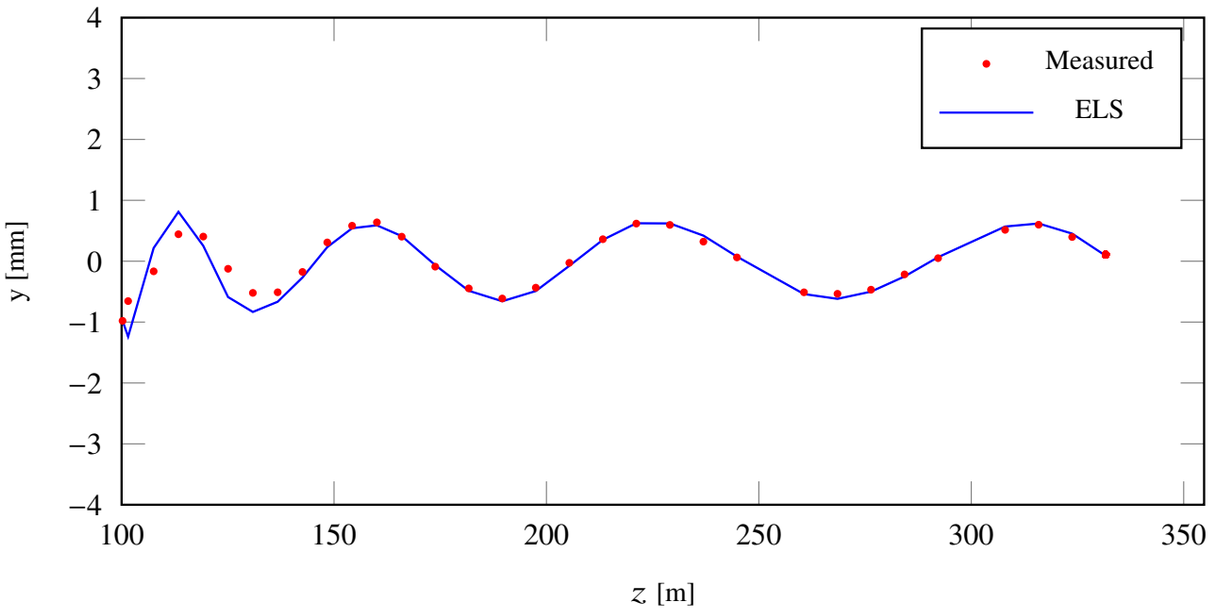


Super conducting

Horizontal

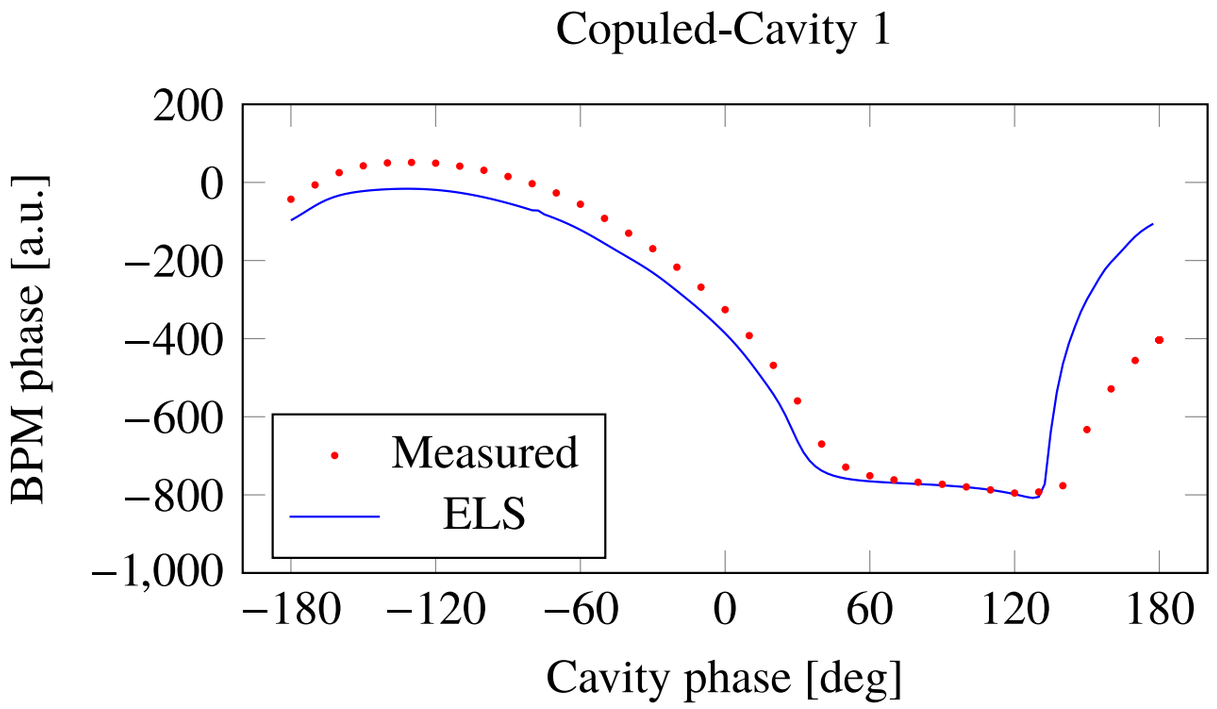


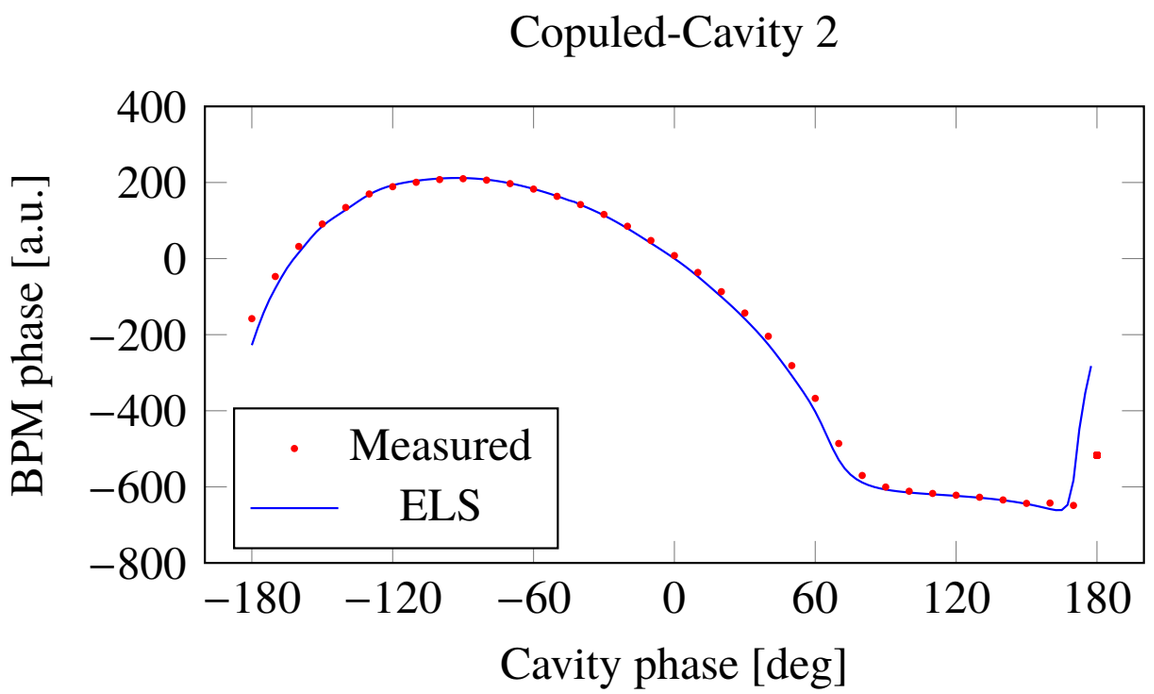
Vertical

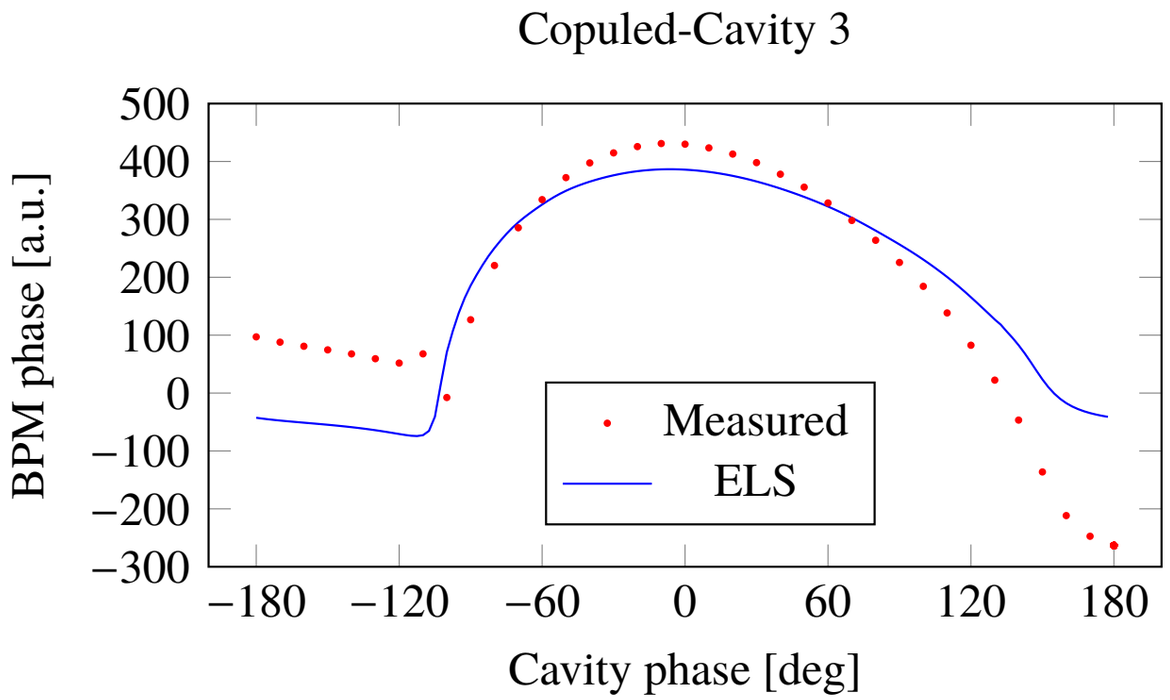


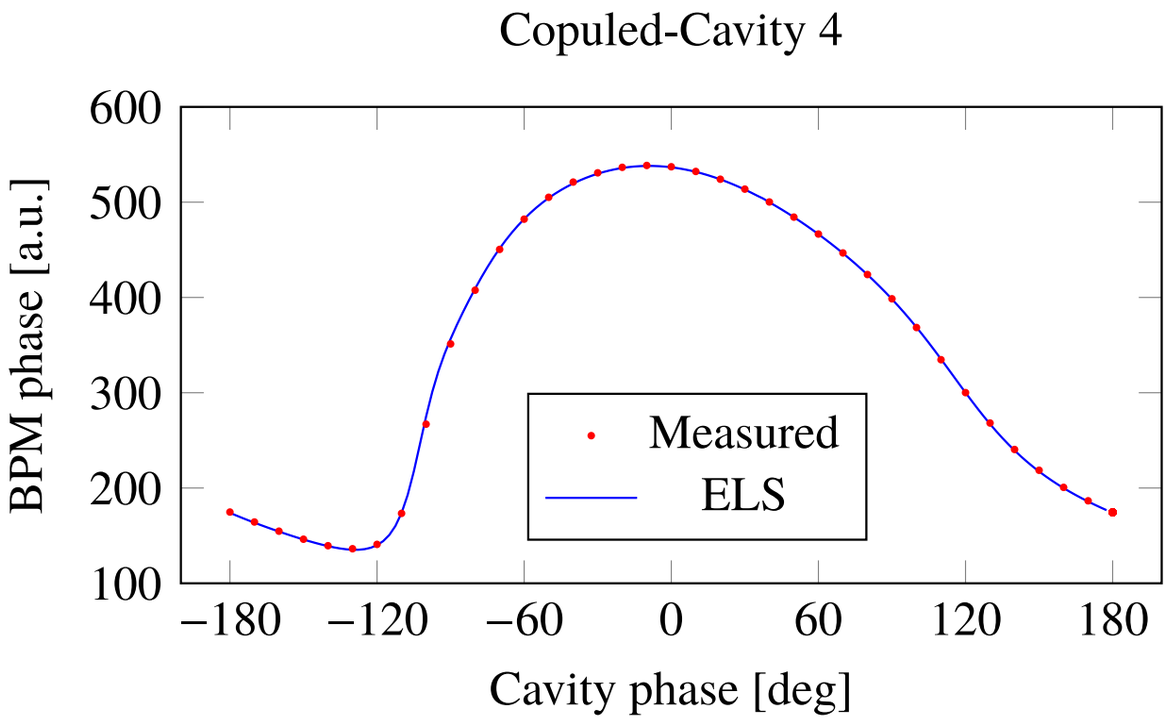
E. Laface et. al “Comparing the transverse dynamics of the ESS Linac Simulator and the Spallation Neutron Source Linac”, IPAC 2016

Phase scan of four CCL cavities.









E. Laface et. al “Comparing RF-Cavity Phase-Scan simulations in the ESS Linac Simulator with measurements taken in the Spallation Neutron Source Coupled-Cavity Linac”, IPAC 2016

Scripting

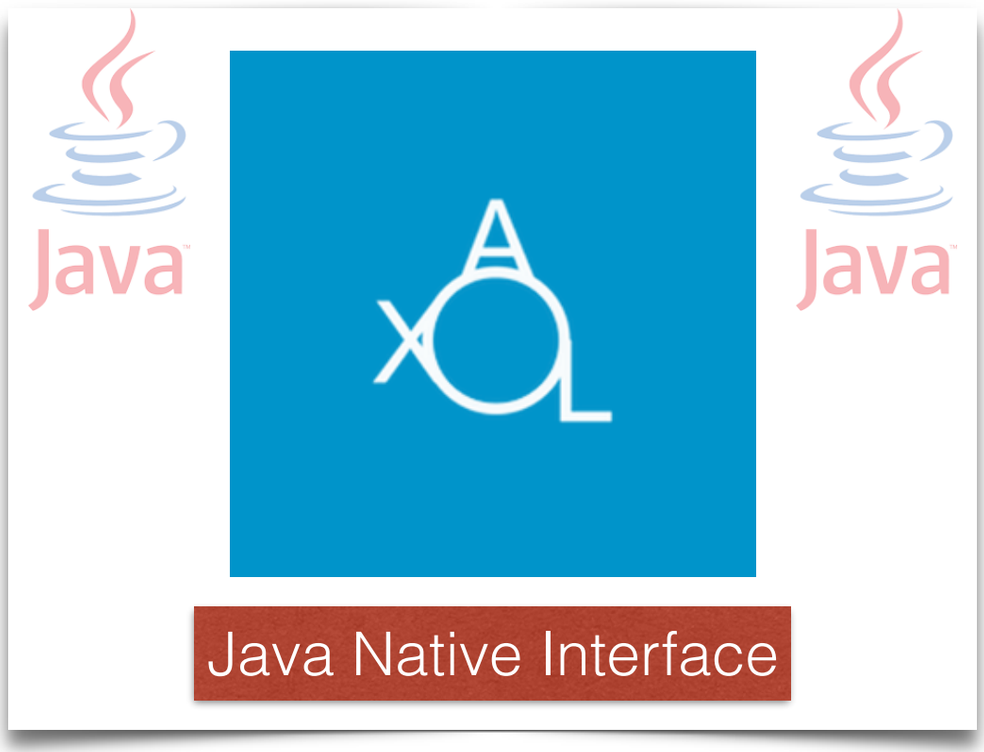
OpenXAL is in Java but Beam Physics requires a scripting environment to speedup creation of tools.

The solution adopted is to invoke OpenXAL from Pyhton through the Java Native Interface (JNI).
The Java Classes are connected to Python Classes using the JPype library.

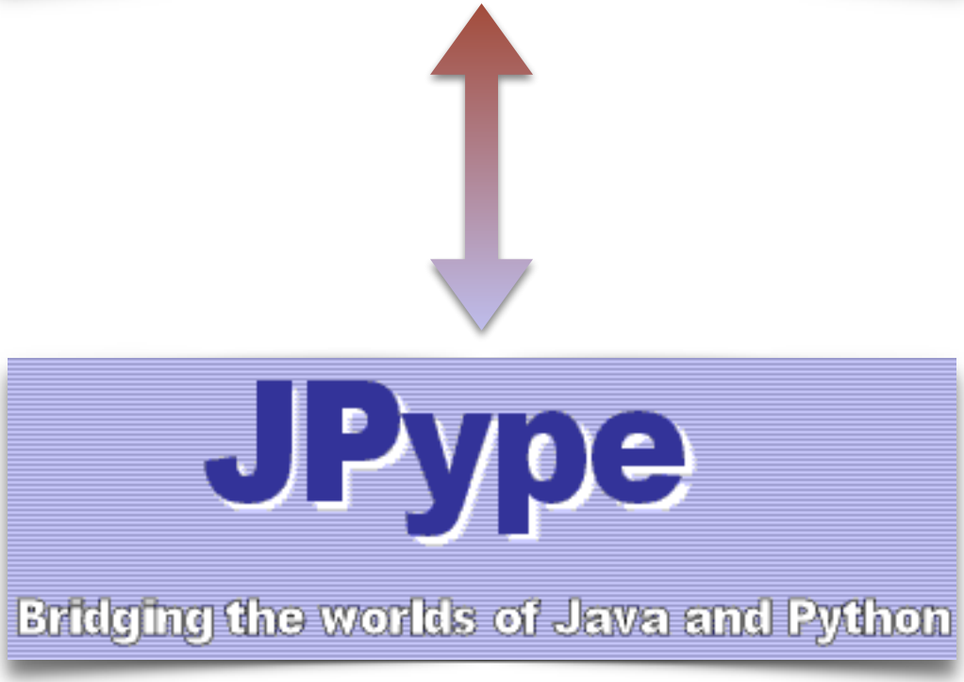
The result is a pure Python environment capable to interact with OpenXAL.

This service is centralised and accessible trough web browser in a Jupyter Hub installation.

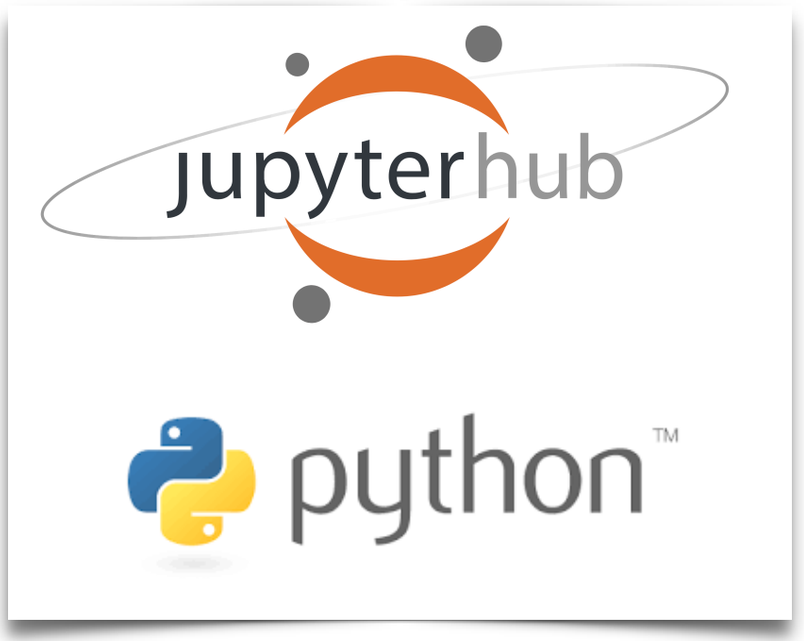
Scripting



Access from any browser.



Java Classes to Python Classes



Python infrastructure

Infrastructure

OpenXAL is integrated in the ecosystem of ESS applications and relies on different services.

European Spallation Source

LinacLego

XML based Lattice Description

GitHub

Atlassian Bitbucket

ELOG

JIRA

Confluence

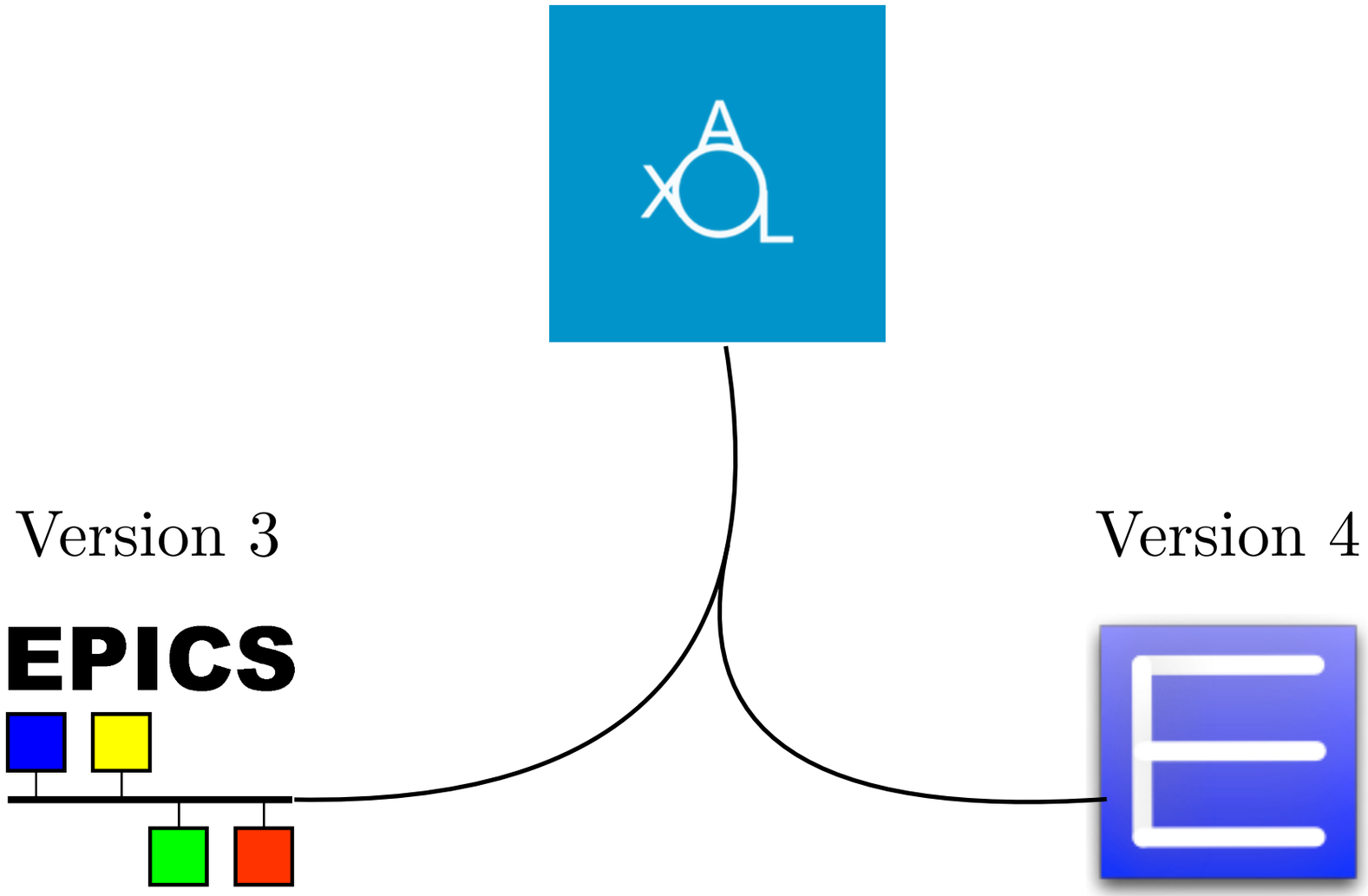
Role Based Access Control (RBAC)

ICS databases

Jenkins

Infrastructure

The current version of OpenXAL support both EPICSv3 and EPICSv4 (Channel Access and PV Access).



Applications

Planned applications

Application	Similar applications	First needed	Comments	Priority
Launcher	Launcher	LEBT	Already works well	1
Correlation Tool	Scan1D Scan2D	LEBT	Existing applications perhaps sufficient for commissioning	4
Phase Scan	Pasta (SNS)	MEBT		2
Trajectory Correction	Orbit Correction	MEBT	Existing already useful	2
Matching Tool	Optimisation (GANIL)	MEBT or later		4
Model Manager	Model Manager (SLAC)	LEBT?	Already feature rich. Requires database	3
Virtual Accelerator	Virtual Accelerator	MEBT		1
Optics Editor	Optics Editor		Primarily use TraceWin or LinacLego to edit optics	5
Aperture+Envelope display		After Commissioning	To look at max beam size in the accelerator when e.g. scrapers are moved. Might be covered by A06	6
Raster Control	TargetBeamSizeCont (SNS)	A2T	CSS might be sufficient	3

Courtesy of Y. Levinsen

Planned applications

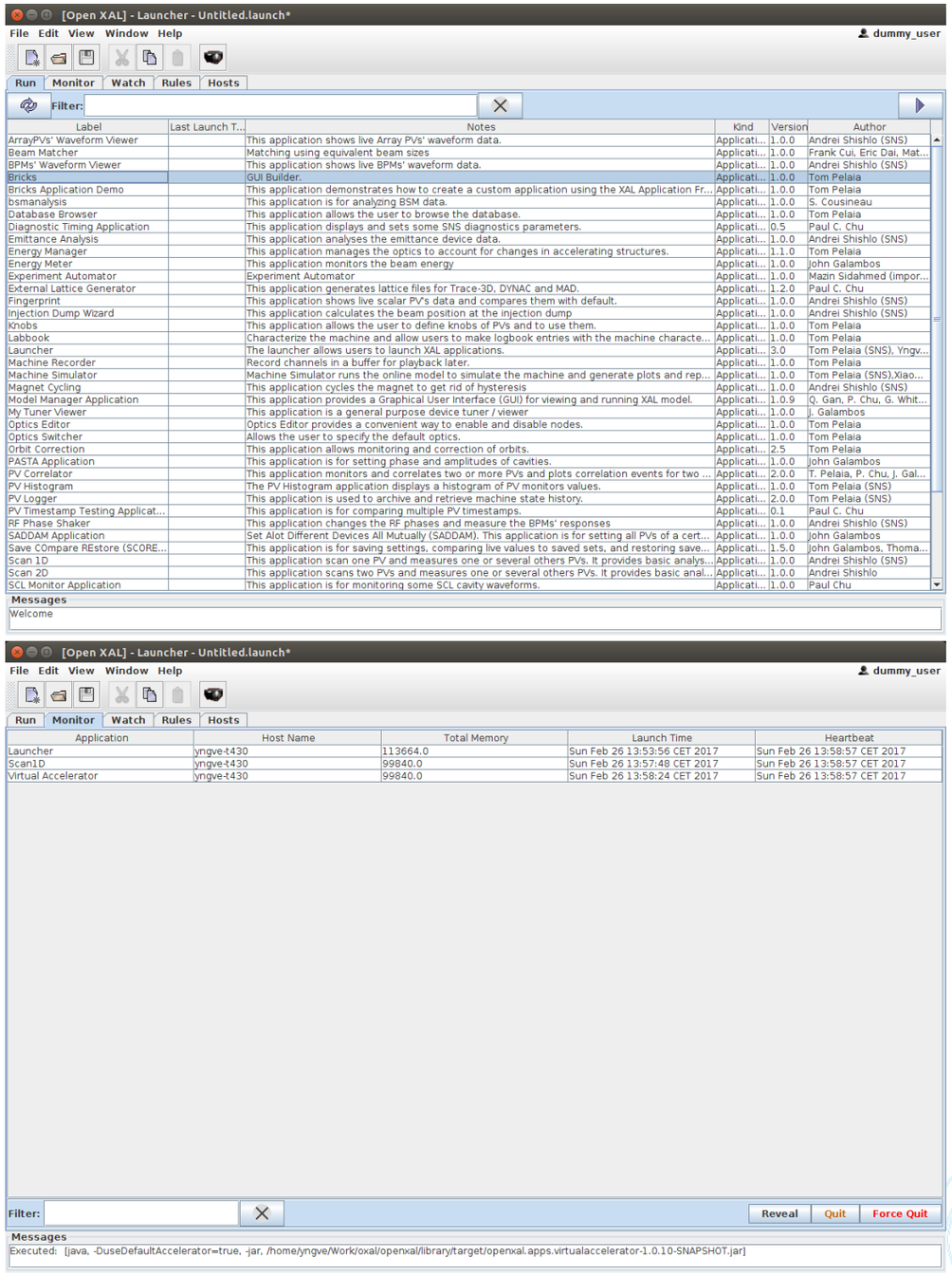
1. Orbit Display and Fitting. Plot beam monitors' X, Y, TMIT data by Z, with orbit fitting; save such orbits; load past orbits and compare to present
2. Orbit Correction, aka "Steering." GUI to help user plot beam monitor data and find corrector settings to minimize orbit RMS (absolute or difference to a saved orbit from 1 above) [3]
3. Correlation Tool. GUI to help user select and scan PVs in 1 or 2 dimensions and acquire many PVs; plot, fit, save/load data for offline analysis [2]
4. Model optics. Track lattice with design or existing PV values, plot, save Twiss and R-mats to database. Model service allows other applications to get optics from that database
5. Bumps. Calculates corrector settings to achieve user desired local orbit offsets and angles; settings then deployed using "knobs" so user can finely control extent of implementation
6. Wire scans. GUI to help user select type of scan (quad etc); make scan, plot and fit results; save/load data for offline analysis
7. Emittance scans. GUI to help users measurement of slice or projected emittance at selected wire or profile monitor; scan, plot, fit, save/load data for offline analysis
8. Profile Monitor. GUI to help user select camera or profile monitor, display transverse beam profile, select region of interest, fit giving beam sigmas; save/load data for offline analysis
9. Z-plot. Simply plot PV values by Z, for example all quad settings, or all vacuum. User gives PV name pattern, then all matching PVs are plotted by Z position
10. Linac Energy Management (LEM). Calculates and systematically corrects quadrupole settings for changes in beam rigidity due to changes in phase or amplitude of RF
11. Feedback. GUI to help calculate and set orbit and energy etc feedback setpoints.
12. Archive Viewer. A GUI to help users get the past recorded values of one or more PVs, between some start to end time, from the archive data store, and to display those values. Should be able also to plot all 1 or more PVs against common time axis, values of simple expressions by time (eg PV1 / sin PV2), one PV against the other (scatter plot), histogram of PV
13. Configuration data save and restore. GUI to help operations save the values (actual and desired) of all PVs of a given device type in a given region. E.g. all magnets in MEBT, or even in whole machine. Ideally do BPM and other beam pulse synced device values too – i.e. saved reference orbits (see Orbit Display above) may be handled by this tool.

Courtesy of G. White

Available Applications Today

Launcher

- Lists all installed applications
- Monitors running applications
- Removes need for menu items in OS
- Does not show script-based applications from JPype

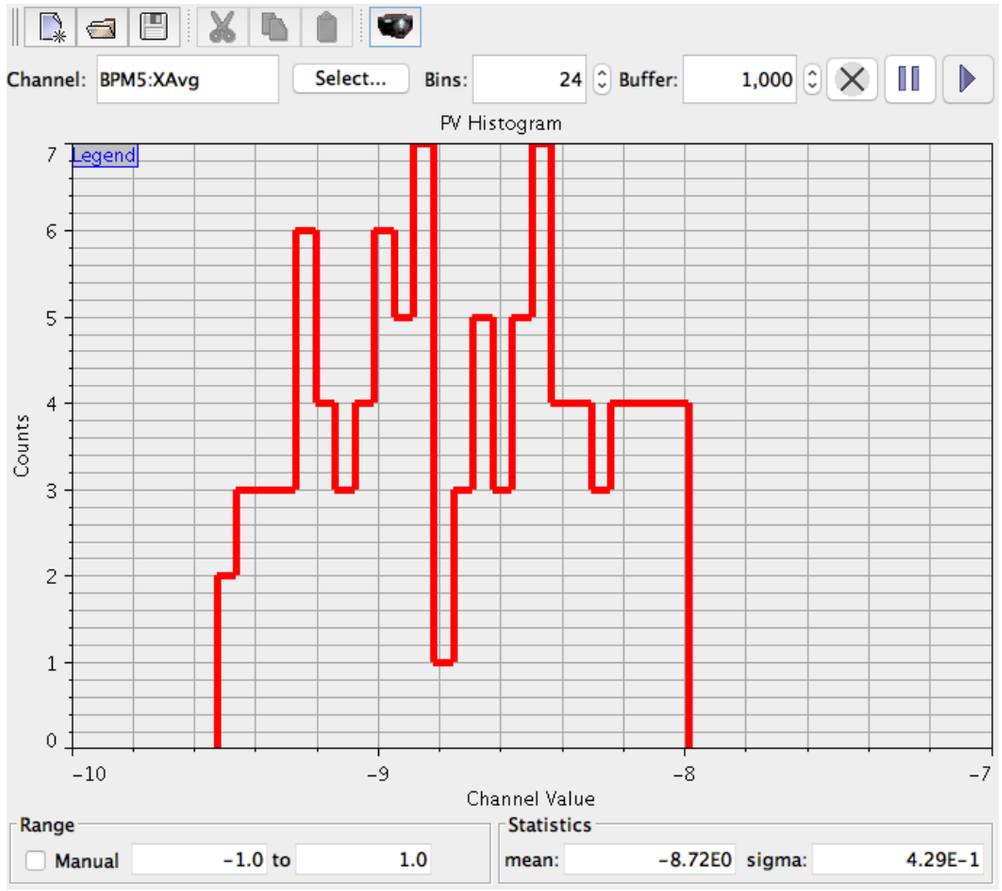


Courtesy of Y. Levinsen

Available Applications Today

PV Logging

- Generic PV access applications
- Data logger, histograms, correlations
- Of these, onlyPV Histogram works out of the box

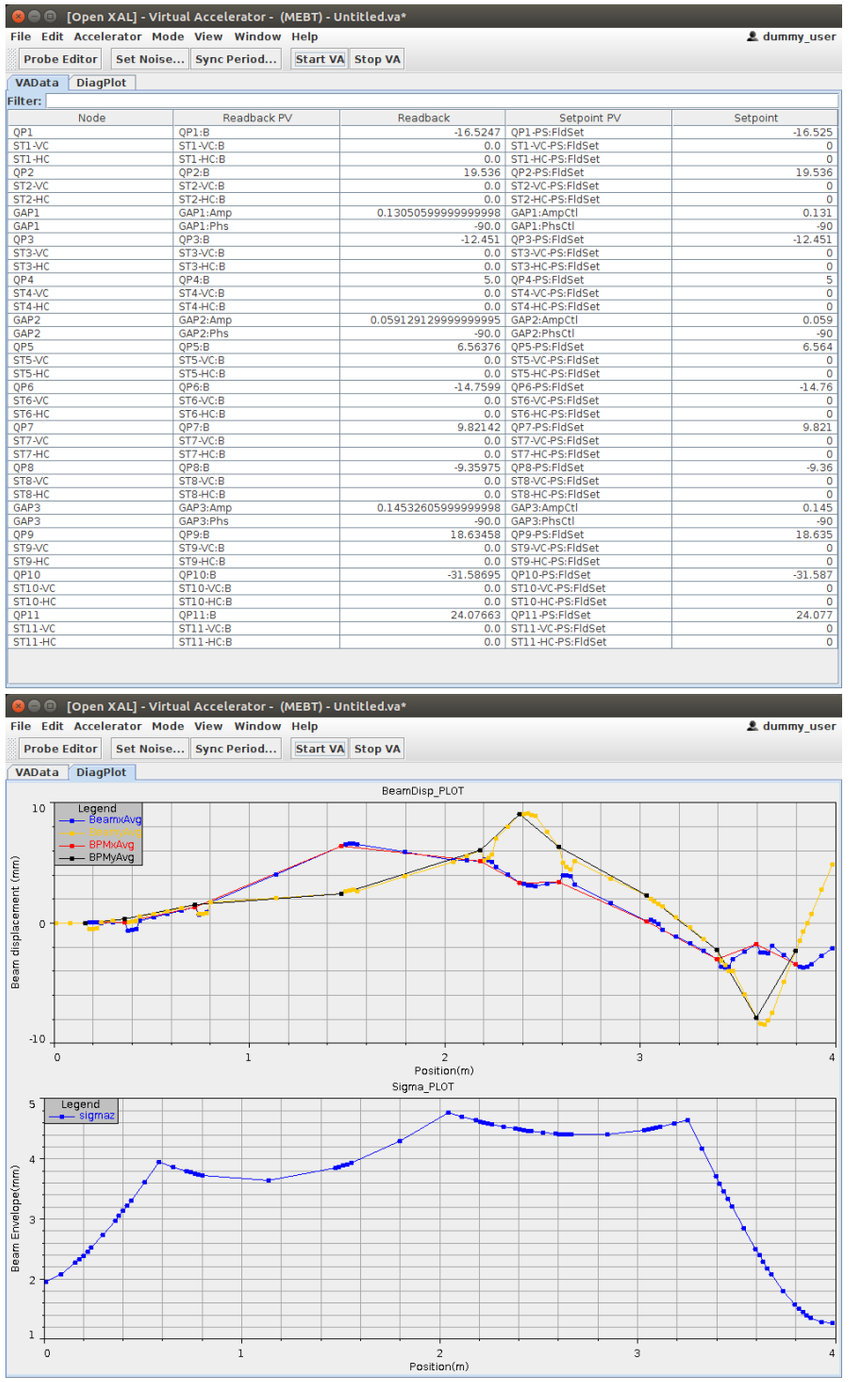


Courtesy of Y. Levinsen

Available Applications Today

Virtual Accelerator

- Runs a virtual machine based on model
- Displays simulated beam displacement and envelope
- EPICS channels which other applications can communicate from/to
- Misalignments and signal noise (static and dynamic)
- BPM positions compared to simulated orbit

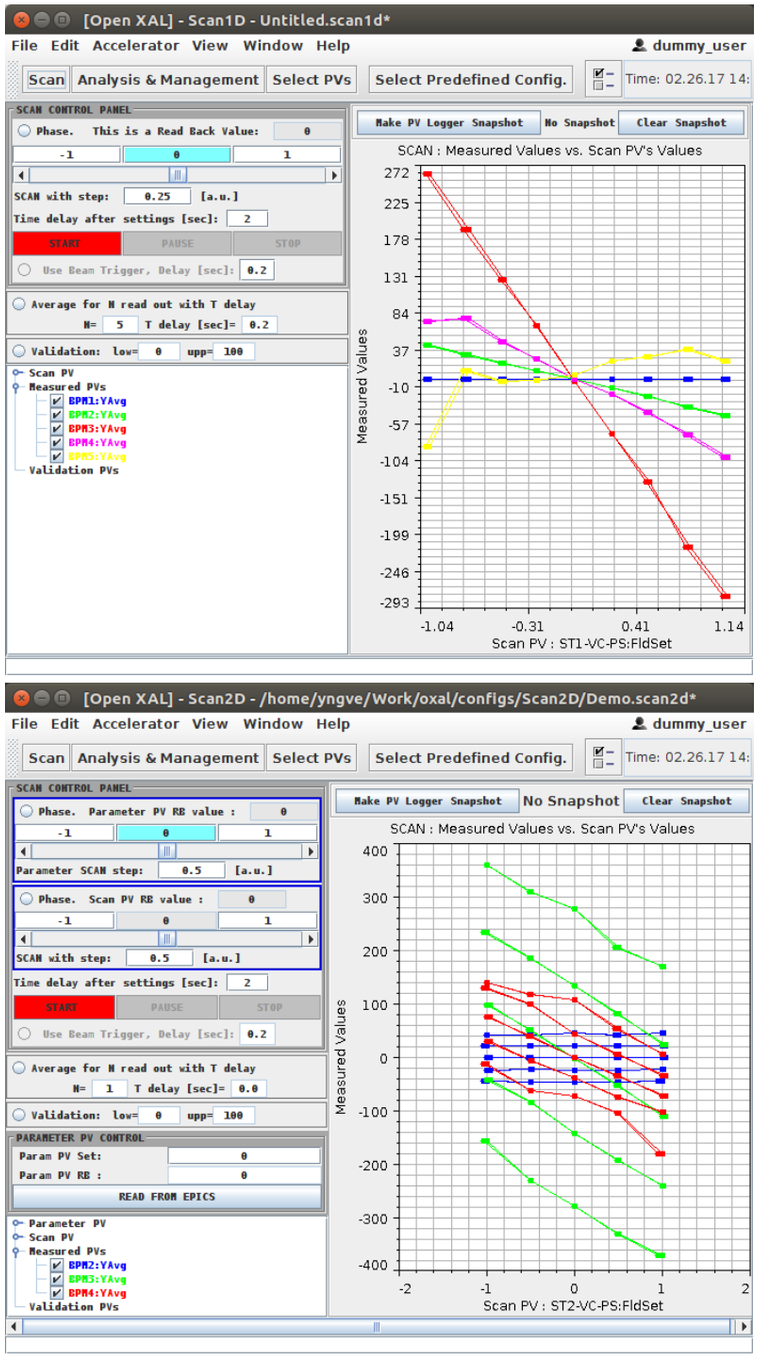


Courtesy of Y. Levinsen

Available Applications Today

Scan

- Scan1D, Scan2D, Scan1D-Scatter
- Allows to scan 1 or 2 variables
- Allows simple data editing (remove point, curve etc)
- Generic
- Expect to use this frequently during commissioning
- Merge into one application?

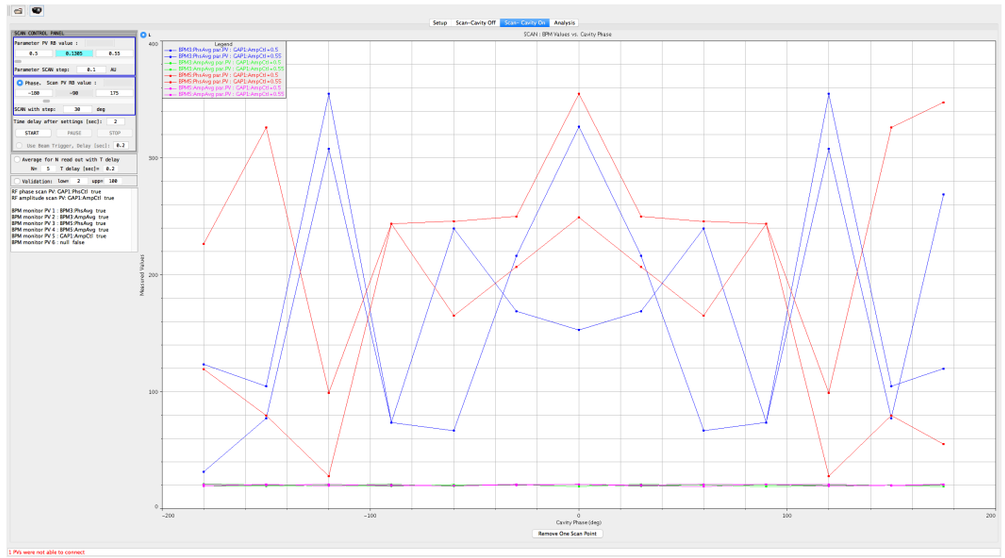


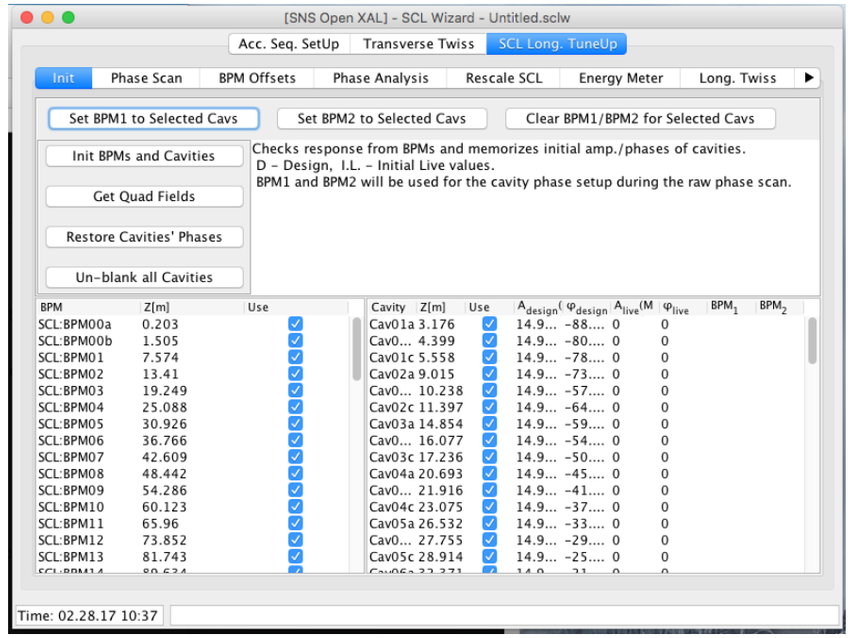
Courtesy of Y. Levinsen

Available Applications Today

RF Scan

- PASTA, SCL Wizard, WL RF Wizard
- PASTA seems to be mostly functional
  - We do not have BCM in our current model
  - VA currently does not simulate BPM phase&amplitude
- Wizard scripts (jython) will be useful as templates for our own automated procedures





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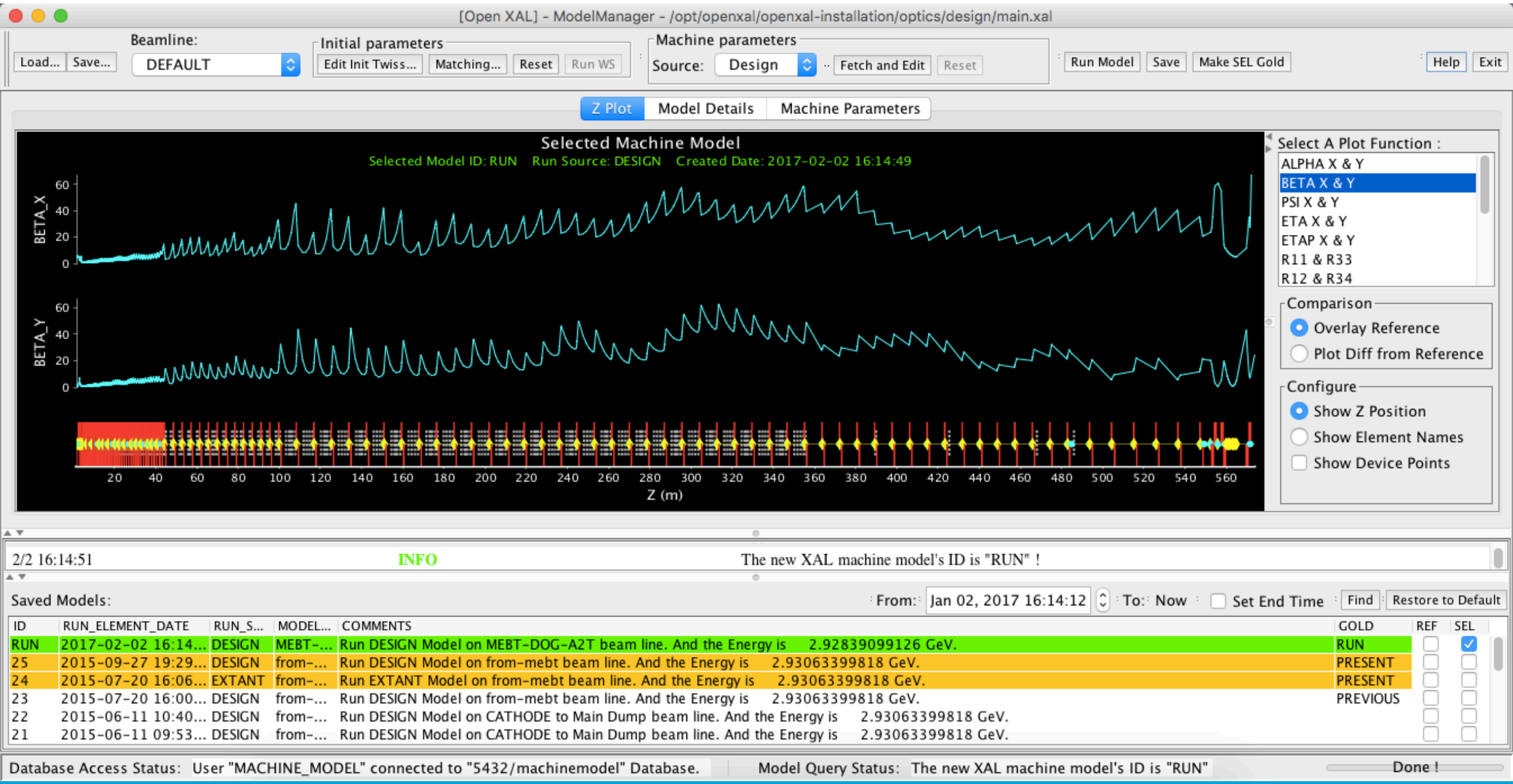
Available Applications Today

Model Manager



Thanks