PSPA
Platfom for Simulation of Particle Accelerators

On behalf of the PSPA Team:

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PSPA @ LAL

PSPA

- **PSPA** (**P**latfom for **S**imulation of **P**article **A**ccelerators) is a user-friendly interactive web-based platform built at IN2P3-LAL for the design of accelerators

- PSPA aims at containing the tools to make a start-to-end simulation of any accelerator, and run interactively most commonly used simulations codes available worldwide:
  - suitable for testing different physical models
  - avoid time-consuming and error prone process of translating data formats between codes
  - useful for students training in accelerator design

PSPA Team

- Several accelerator physicists, engineers and computer science experts joined forces to develop the PSPA platform at LAL:

- **PSPA Team (FTE):**
  - *Francois Touze, SI, LAL* (60%)
  - *Antoine Perus, SI, LAL* (20%)
  - *Marc Nicolas, SI, LAL* (40%)
  - *Marica Biagini, SI/DEPACC, Bourse D'Alembert and INFN-LNF (80%)*

- **PSPA consultants:**
  - *Hayg Guler, DEPACC, LAL*
  - *Christian Helft, LAL, retired*
  - *Guy Le Meur, LAL , retired*
  - *Alessandro Variola, Accelerator Division, INFN-LNF*

Blue: expertise in accelerator design

PSPA objectives

- Final goal is to get a flexible tool that allows to easily link different models, corresponding to different physics problems, in a unique description, allowing for complex systems analysis and start-to-end simulations in intricate environments

- PSPA is not just a data conversion tool but a real design and simulation instrument

PSPA features

- Possibility to load an input file (*user's file format from the available codes*) or interactively design a lattice just by adding components like bricks

- Tests of the accelerator model by varying parameters and performing several commands with different codes

- Each simulation code is available in the form of a "*black box*", the user is free to choose among the proposed codes, which are usually run standalone, the more suitable to his needs ☛ code benchmarking

Available codes at present

TRANSPORT
A COMPUTER PROGRAM FOR DESIGNING
CHARGED PARTICLE BEAM TRANSPORT SYSTEMS

http://lss.fnal.gov/cgi-bin/find_paper.pl?nal-091

PARMELA LAL version

(Phase and Radial Motion in Electron Linear Accelerators)

http://laacg.lanl.gov/laacg/services/serv_codes.phtml

MAD

http://madx.web.cern.ch/madx/

elegant

ASTRA

A Space Charge Tracking Algorithm

http://www.desy.de/~mpyflo/

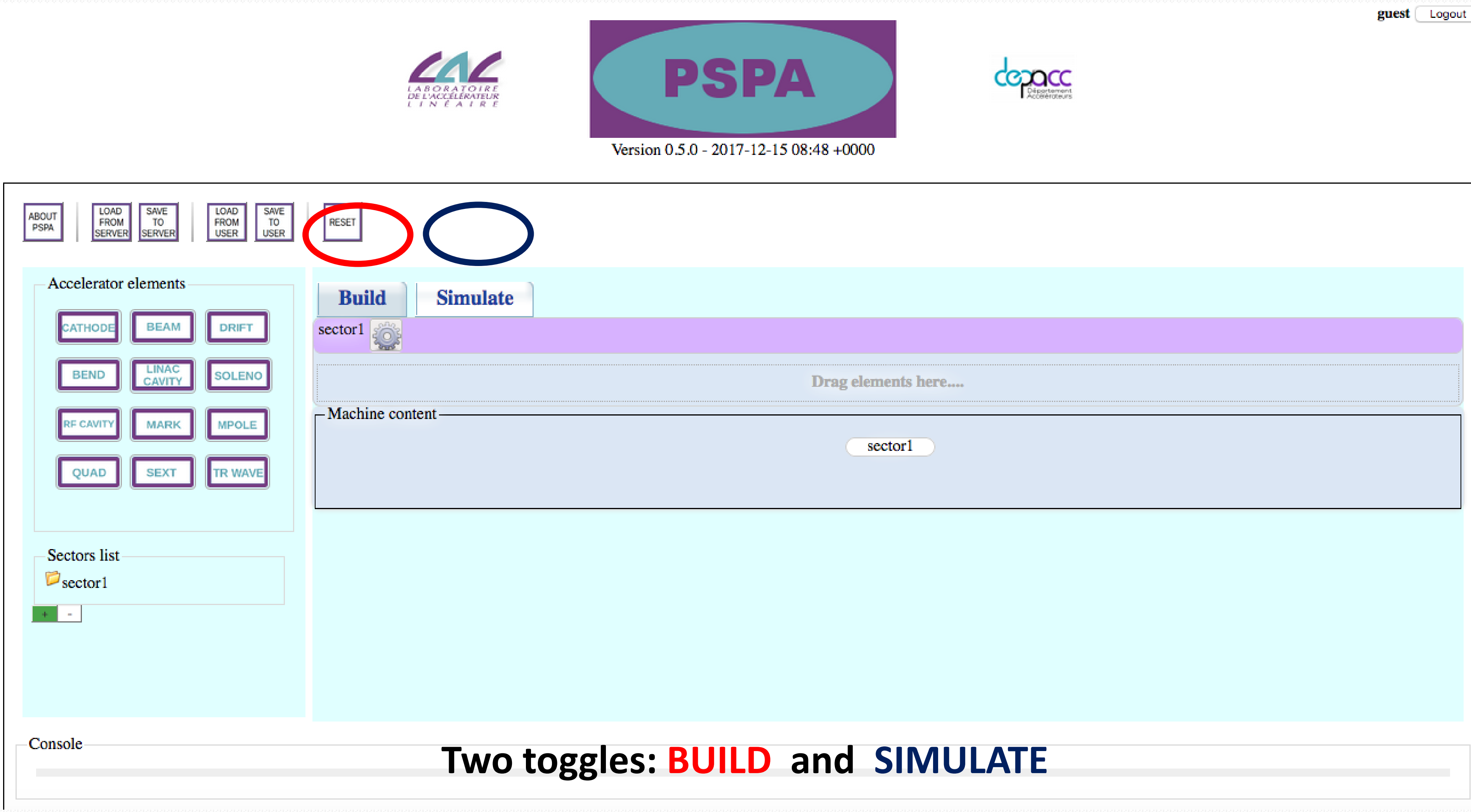
http://www.aps.anl.gov/Accelerator_Systems_Division/Accelerator_Operations_Physics/software.shtml

BETA

http://irfu.cea.fr/Sacm/logiciels/index6.php

PSPA web interface

http://pspa-dev.lal.in2p3.fr/?_=/pspa

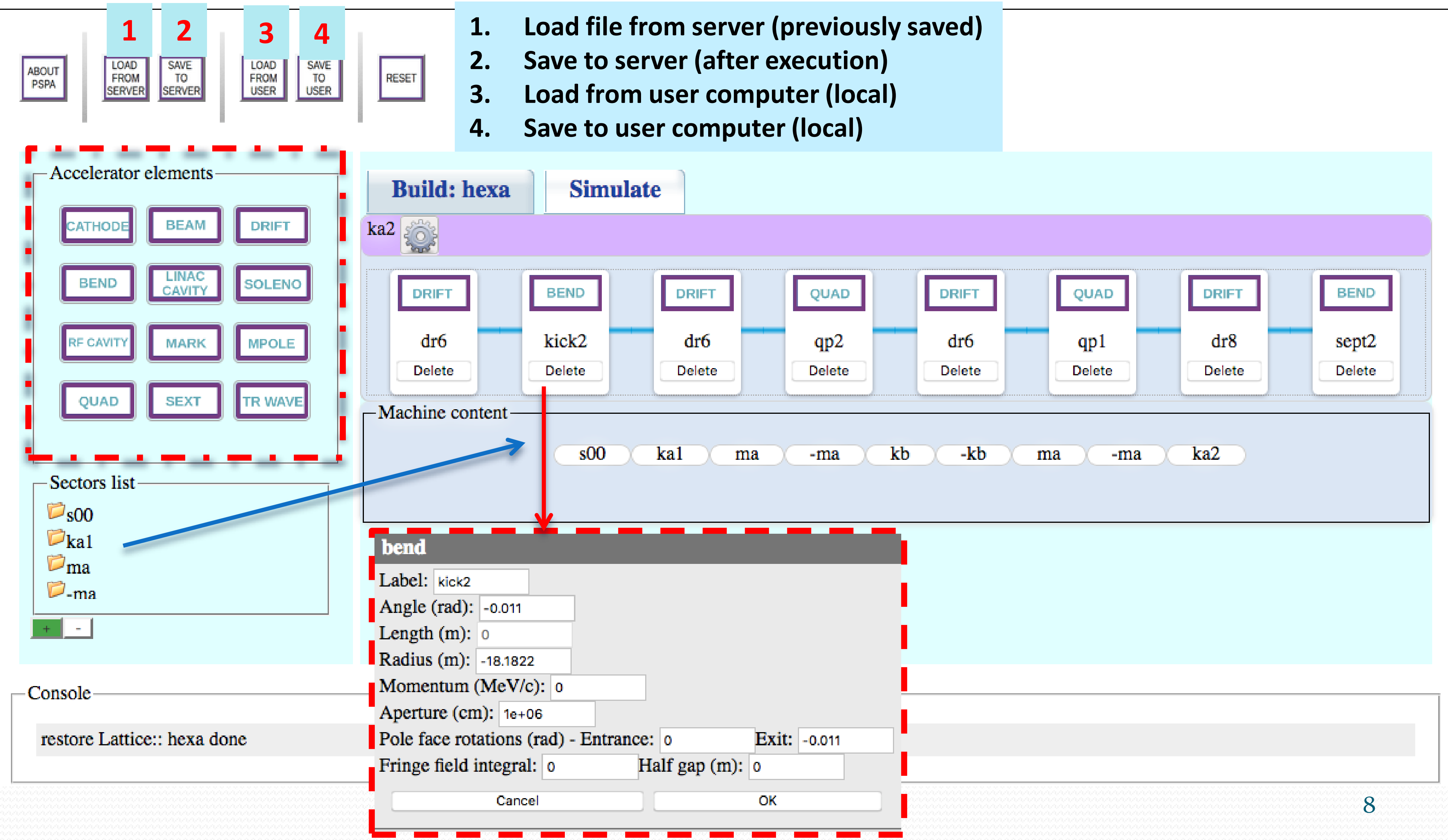


Two toggles: BUILD and SIMULATE

PSPA windows: BUILD

Build a lattice from scratch or from file, modify lattice and parameters

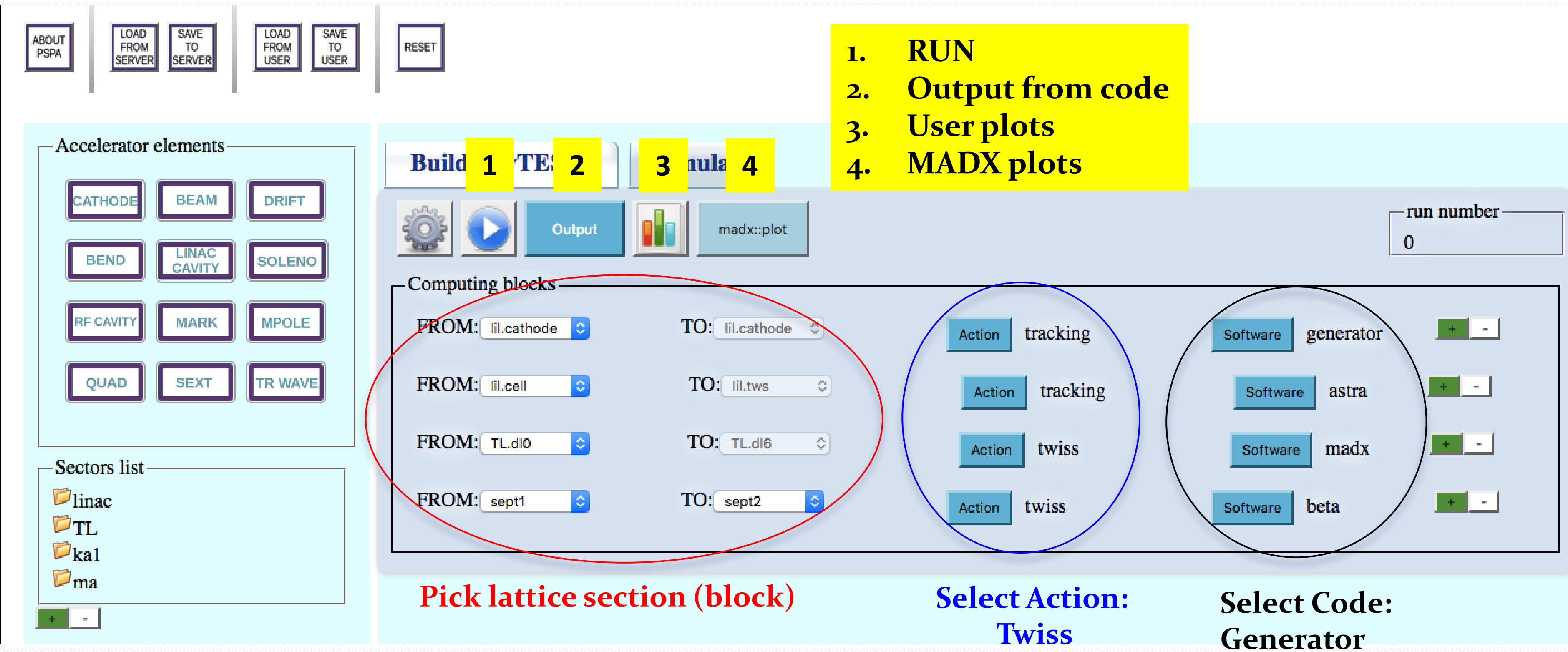
1. Load file from server (previously saved)
2. Save to server (after execution)
3. Load from user computer (local)
4. Save to user computer (local)



PSPA windows: SIMULATE

Simulate different Actions with different Codes

1. RUN
2. Output from code
3. User plots
4. MADX plots



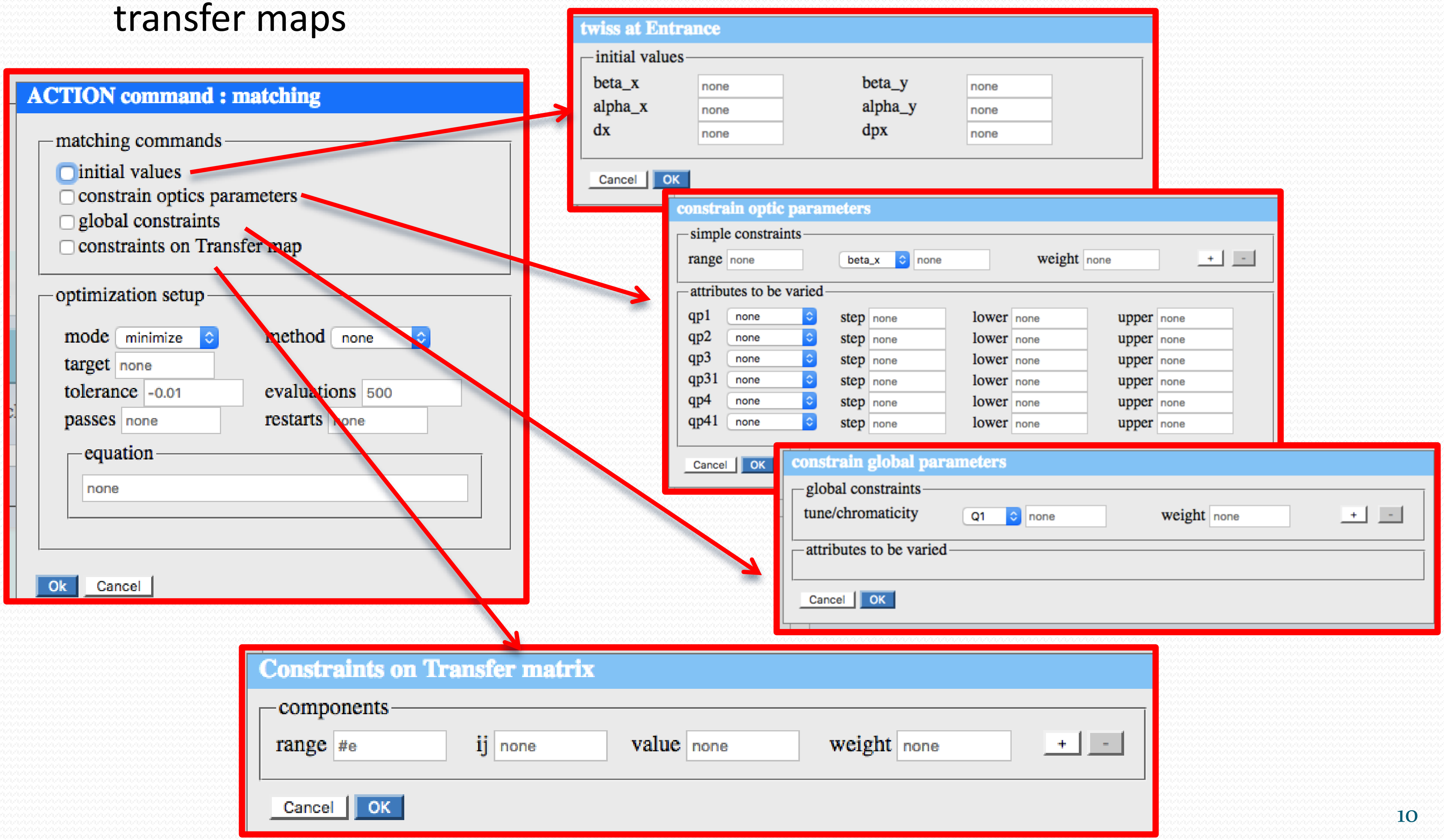
Pick lattice section (block)

Select Action:
Twiss
Matching
Tracking
Emittance

Select Code:
Generator
ASTRA
Transport
Beta
MADX
Elegant

PSPA actions: Matching

- Matching: optical functions, global parameters (tunes, chromaticity), transfer maps

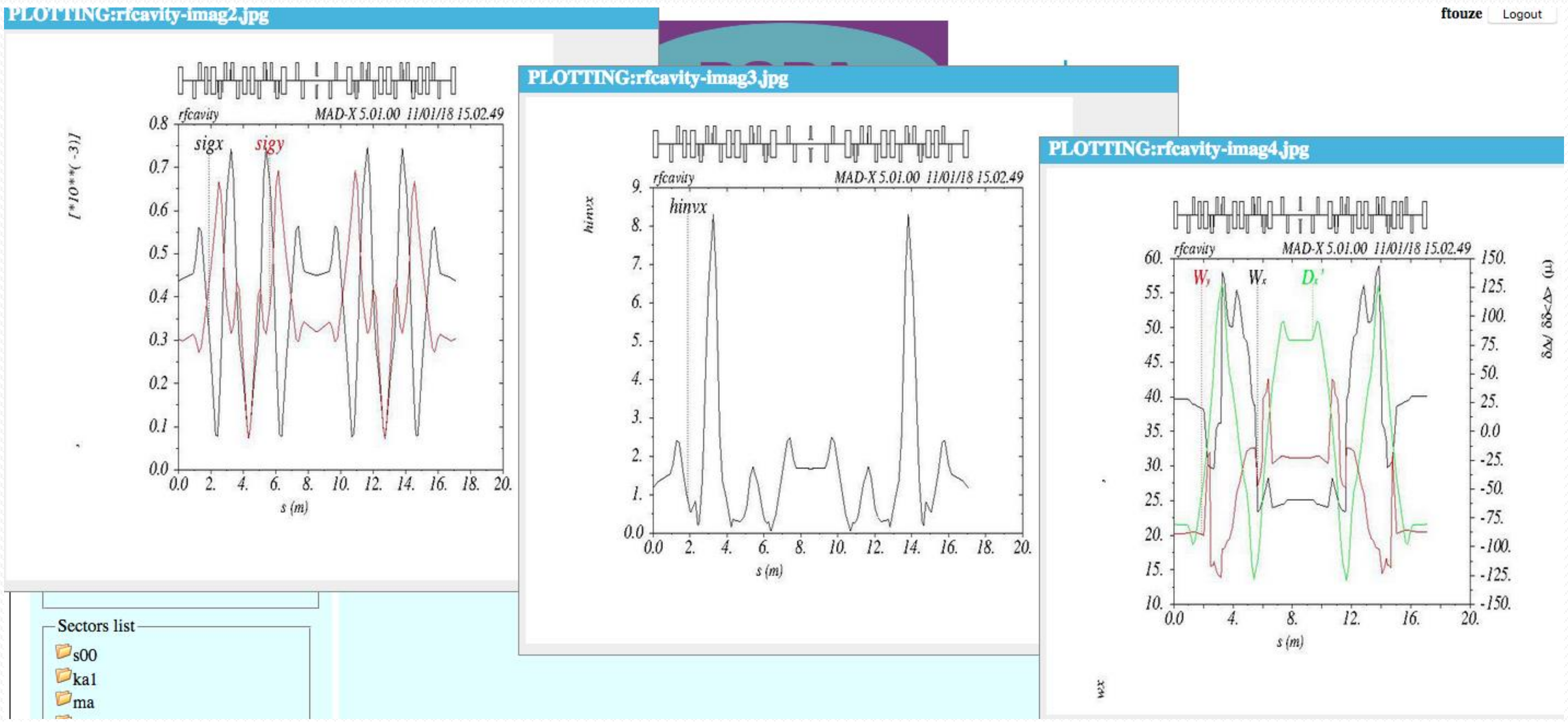


PSPA actions: Twiss

- Twiss: optical functions calculation. Plots available: user, MADX

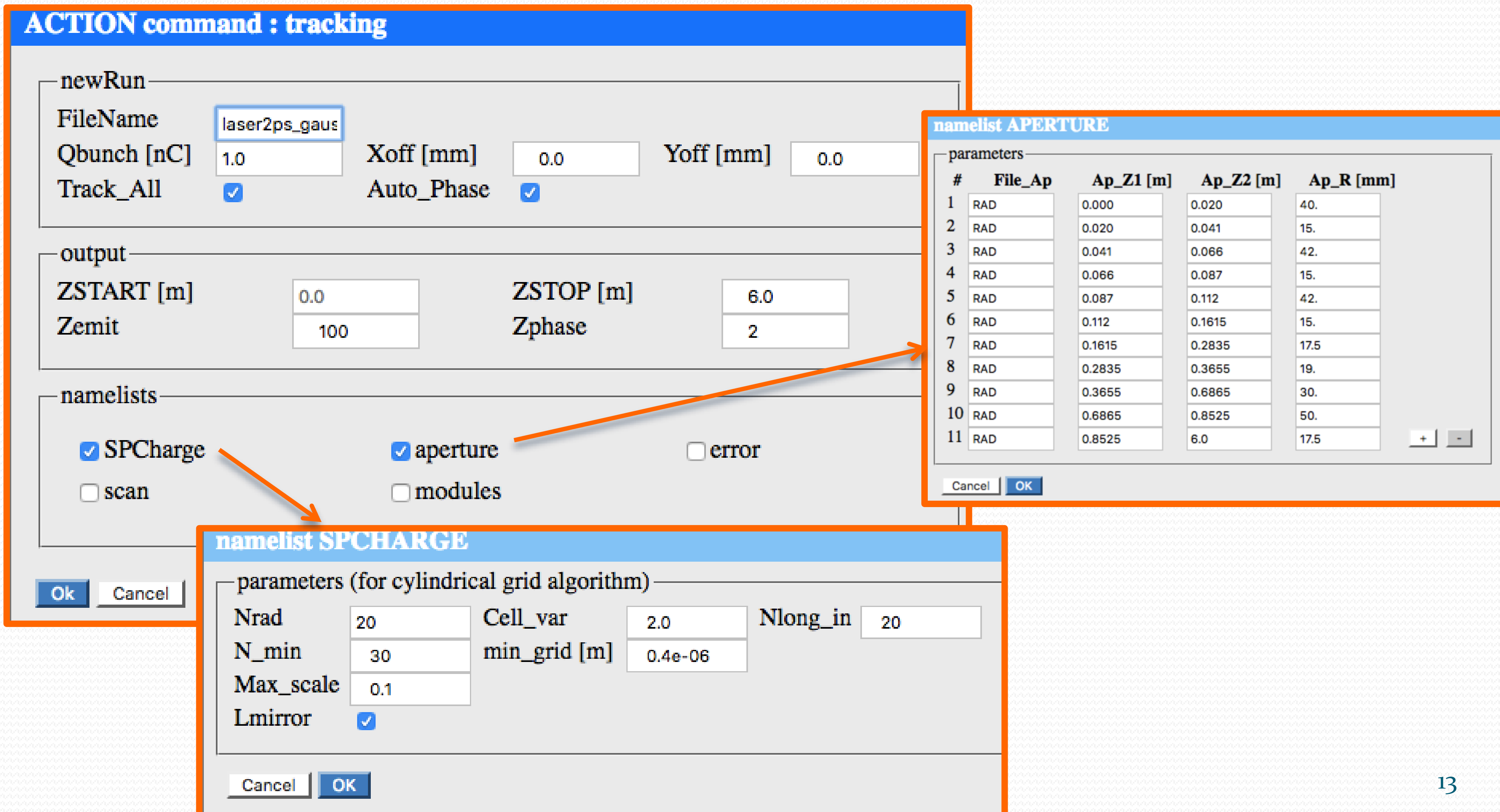
PSPA actions: Twiss

- Twiss: calculation of:
  - ✓ beam sizes
  - ✓ H invariant
  - ✓ chromatic W functions, second order dispersion



PSPA actions: Tracking

- Tracking: in Linac, gun. Defines beam parameters, output file, integration steps and range, actions (space charge, aperture)

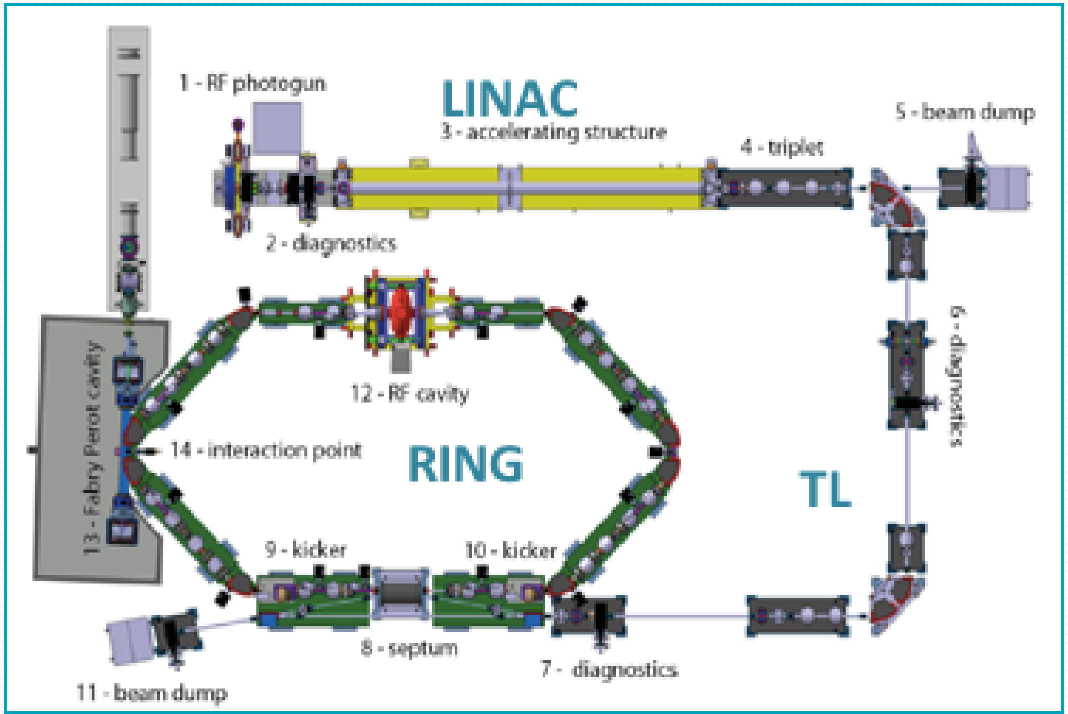


PSPA actions

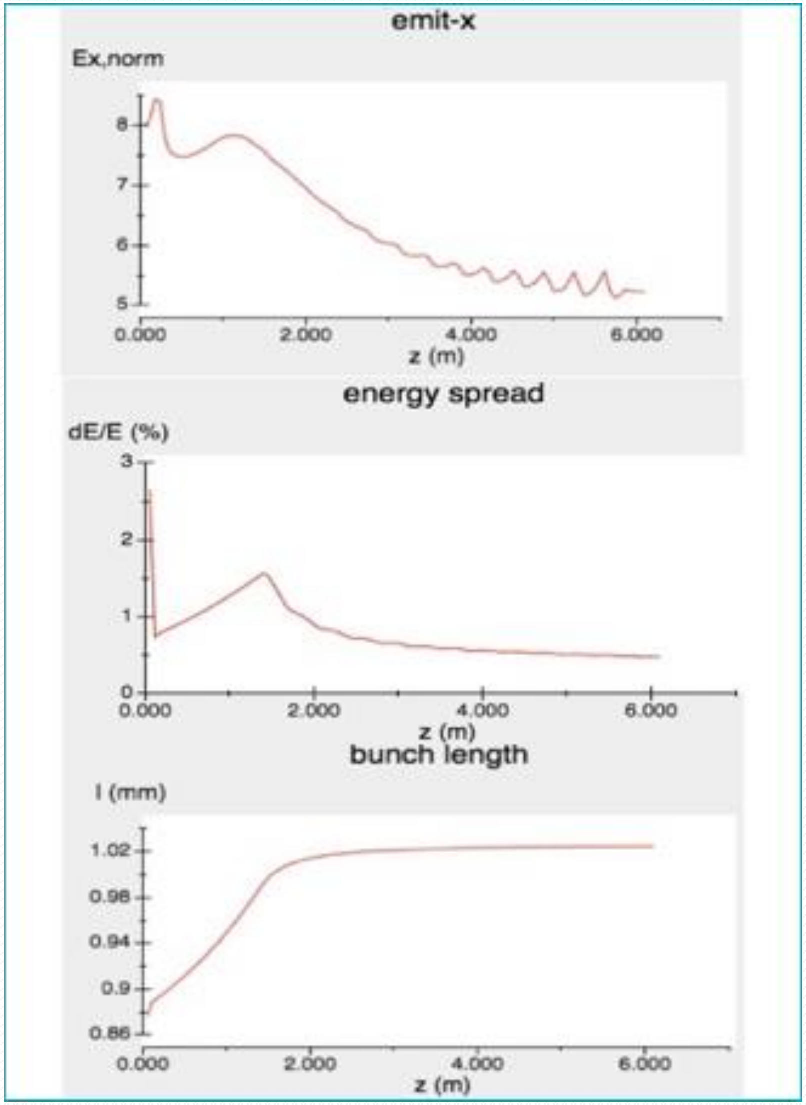
- ➢ Available EMIT (calculation of emittance, damping times etc…) within MADX
- ➢ In progress implementation of:
  - tunes and optical functions dependence on momentum
  - tunes dependence on particle amplitude

Application to ThomX

- The ThomX project revealed itself as a real-world use case of choice for PSPA: Gun + Linac + Transfer Line + Ring
- ASTRA code was used to simulate beam dynamics from the RF gun to the end of the Linac, BETA code for the TL dynamics, and MADX code for the ring ☛ PSPA makes it easier and faster!



PSPA simulations of Thomx linac with ASTRA code

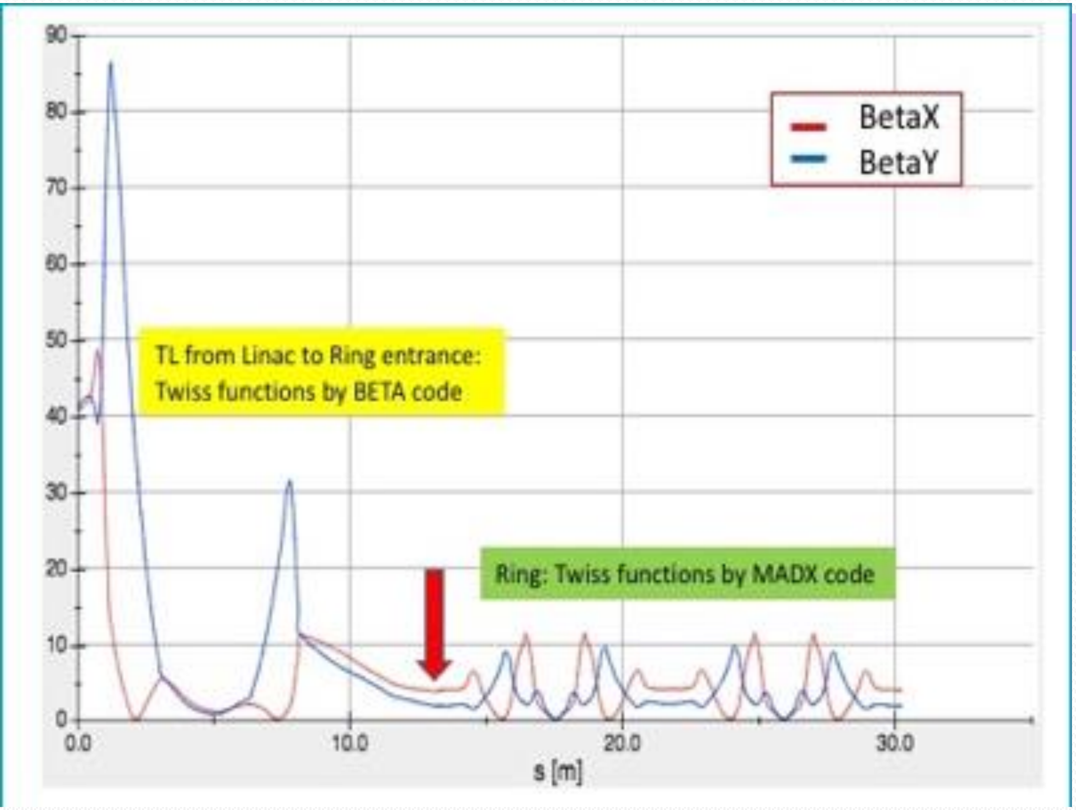


Evolution of horizontal normalised emittance (top), energy spread (middle) and bunch length (bottom) in ThomX Linac as computed by ASTRA code in PSPA

Since ASTRA computing time can be long, depending on the number of particles and space charge, it is possible to store the results from one run to be used later

PSPA simulations of ThomX Transfer Line and Ring with BETA and MADX

Example of codes concatenation



Optical functions from Linac end through TL and ThomX Ring (computed by Beta and MADX codes) The red arrow shows the concatenation point of the two codes

Each time a simulation is performed the variables are updated, and the results can be saved for a single part or for the whole

PSPA WEBSITE

To be completed with a "demo" (in progress) and some documentation

https://groups.lal.in2p3.fr/pspa/

Would like to add a "forum" for exchanges of information, updates and debugging

PSPA: Platform for Simulation of Particle Accelerators

Laboratoire de l'Accélérateur Linéaire, IN2P3, Orsay, France

PSPA: Design your Accelerator! | Simulation Codes | Documentation | Who are we | Contact us

PSPA: Design your Accelerator!

PSPA is a web-based platform to design accelerators and simulate beam physics

PSPA aims at optimizing the work of accelerator designers by factoring once and for all the time-consuming and error prone process of translating data formats between the various codes involved in the modelling of a machine, controlling the repeated execution of these models by easily varying some parameter and managing the associated data and finally provide a convenient mean for testing different physical models of a given part of a machine (a truly innovative feature).

With PSPA you will be able to:

- describe parts of, or a whole, accelerator using a construction kit and a collection of elementary components such as magnets, accelerating cavities, and so on ;
- import an existing machine (lattice) in several standard formats;
- assign a modeling program to each component or group of components, to be chosen from a range of standard codes available;
- change setting parameters;
- run a simulation of the machine;
- simulate several beam physics processes;
- look, plot, save results for further use;
- export results and files on user area;
- simulate the same device/lattice with different codes for modeling and comparison.

To be noted: PSPA is NOT a simple "translator" from code to code, but a real accelerator design tool

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

depacc Département Accélérateurs

PSPA

What’s next

- Several improvements and new features are on the PSPA road map:
  - improved **user interface** and **user experience** (UI/UX)
  - capability to add/run user-written codes
  - plot of the machine geometric layout
  - use of Cloud/Grid computational resources
  - add errors in Astra and tracking in Elegant

Lesson learned

- For the success of PSPA it is very important to have a close interaction between:
  - software experts: build the interface in all its aspects (coding, graphical interface, user requests, website, server management, etc…)
  - machine experts: suggestions on what to implement, how to improve the physics processes, tests, inputs on other existing tools in the accelerator community
  - users: feedback on problems, reports on user-friendliness, suggestions for new features

PSPA ergonomics improvement

- To make PSPA a tool widely used by the accelerator community we need an improvement of its interface ☛ make it more "user friendly" from the point of view of accelerator designers:
  - easy to use
  - intuitive
  - offering most used simulation and graphics tools

For the ergonomics of the platform 4 companies are being scrutinized, work will start in February by the chosen one

Conclusions

- PSPA aims at becoming a useful tool both for accelerator designers and accelerator physics beginners
- Its first stage is ready to be released
  - lattice design, tracking and matching
- The close interaction with accelerator designers is essential to develop in PSPA the needed physics applications: user needs?
- For PSPA dissemination we need a better and more intuitive user interface ☛ new ergonomics soon