VisualStart: GUI-Aided Unified Initialization Tool for Hybrid (MHD + Particle) Simulations

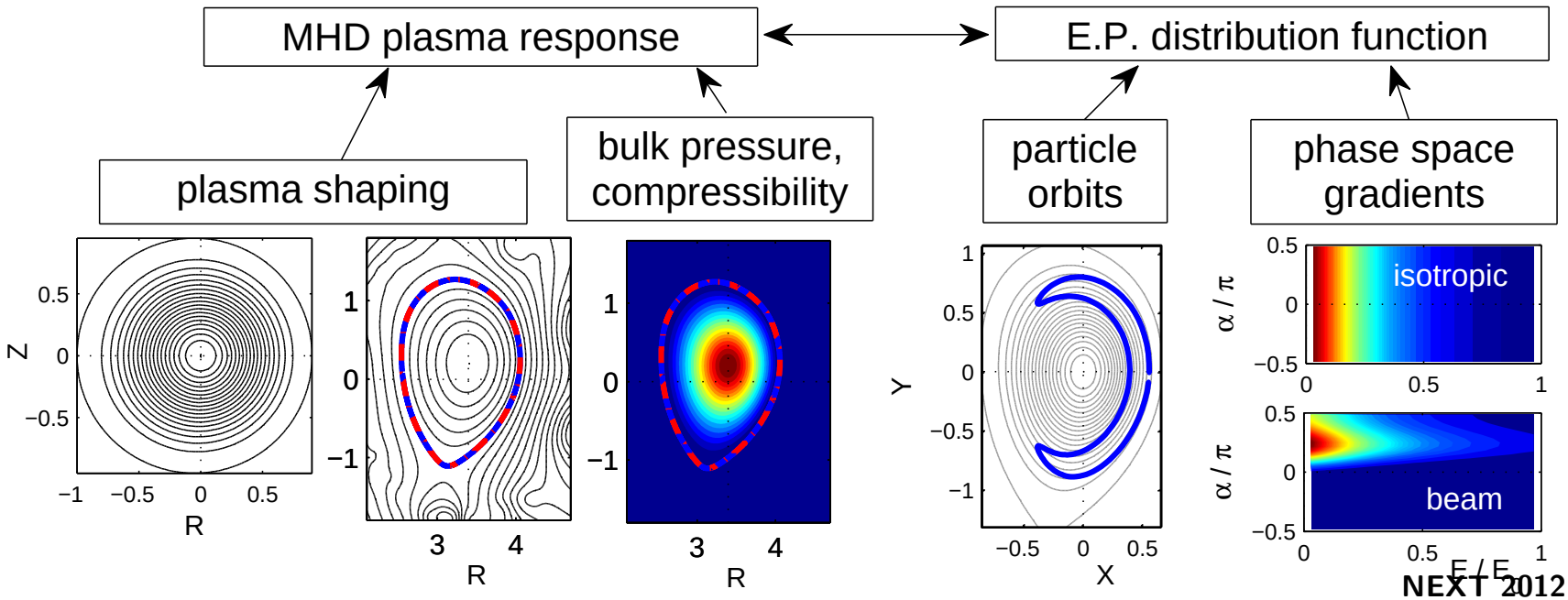
Andreas Bierwage
Japan Atomic Energy Agency, Aomori, Japan

17th NEXT Meeting, Kashiwa, Japan, Mar 15 – 16, 2012

This work is partially supported by Grants from Japan Society for Promotion of Science.

Introduction

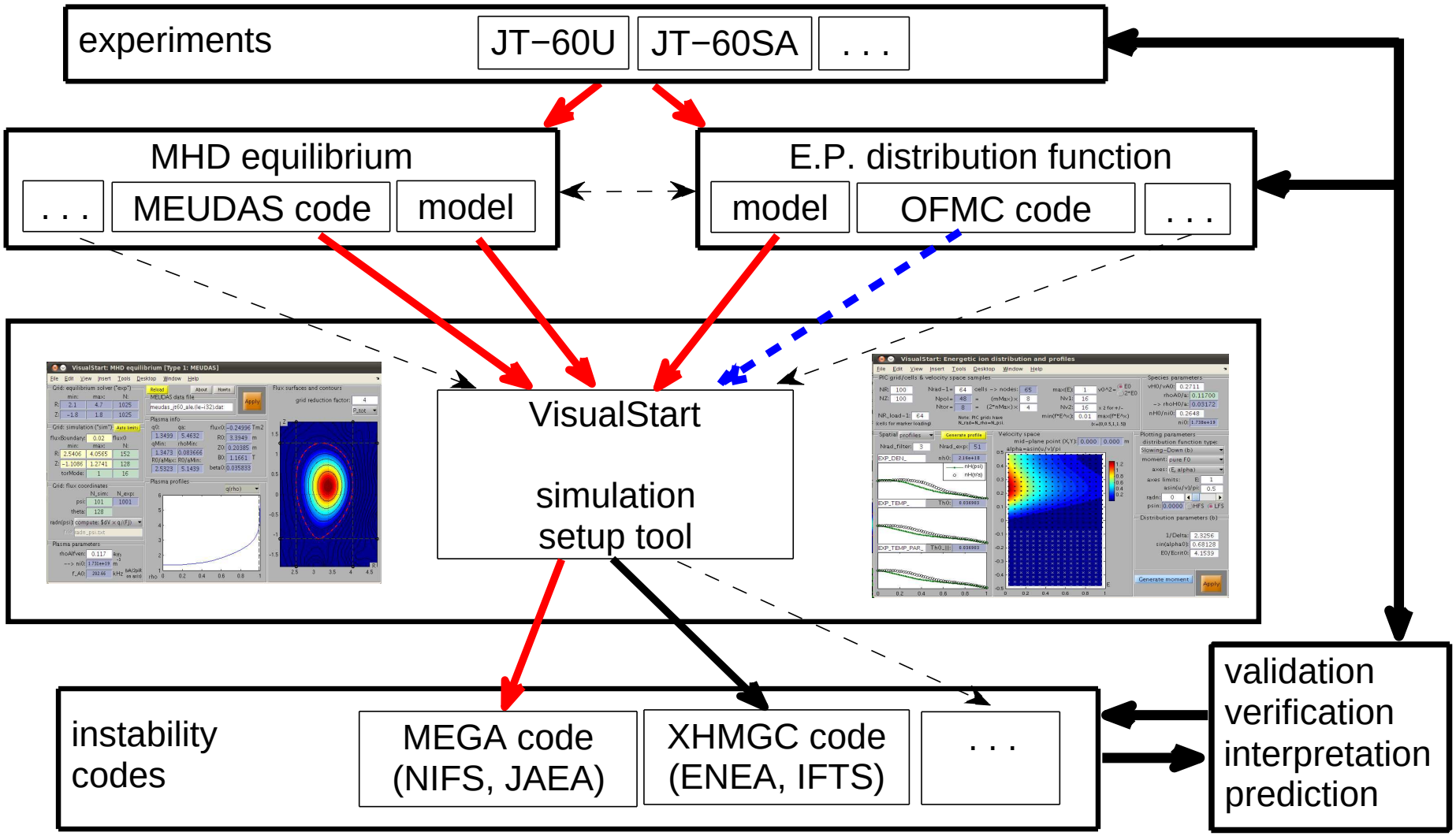
- **Motivation:** Predictive simulations ...
  - Require complex models for the initial state and dynamic evolution.
  - Amount of input data can be large and often requires preprocessing
  - Preprocessing such as data conditioning and matching of parameters require interaction with the user.
- **Approach and Scope:**
  - A GUI-aided software tool is developed that assists the user with the task of designing a simulation scenario.
  - Focus on global nonlinear hybrid codes used to study Alfvén mode and energetic particle (E.P.) dynamics in tokamaks.



Code framework

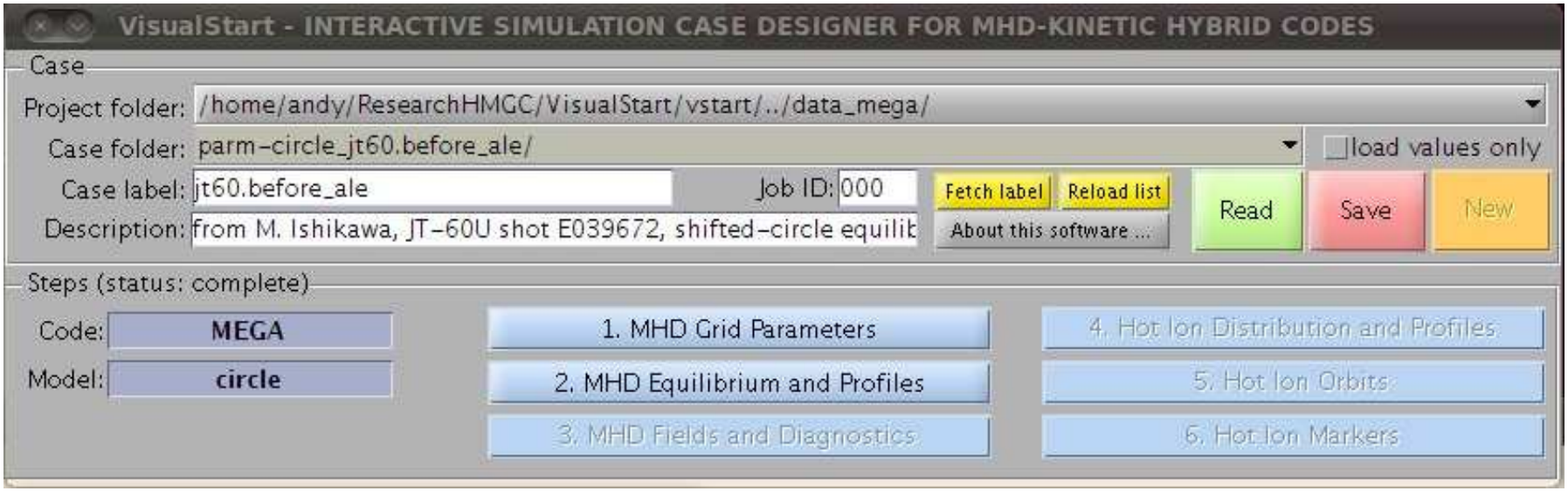
— active, --- planned
— here, --- underway

- **Modular simulation toolbox**

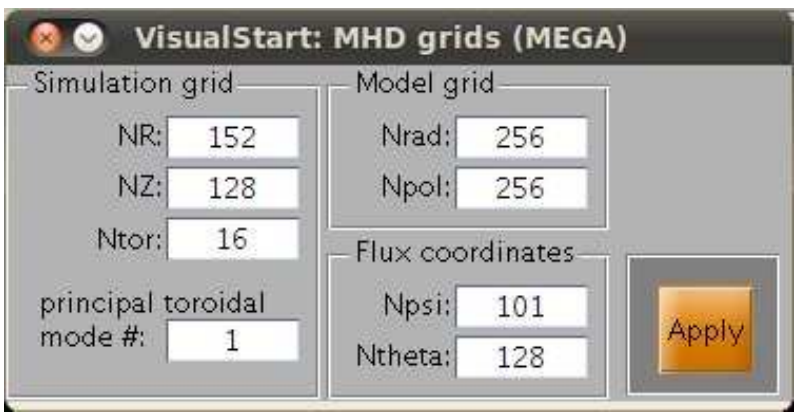


- The tool is capable of initializing different codes with the same initial state. This simplifies and improves benchmarking activities.

Main panel, Step 1: Grid setup

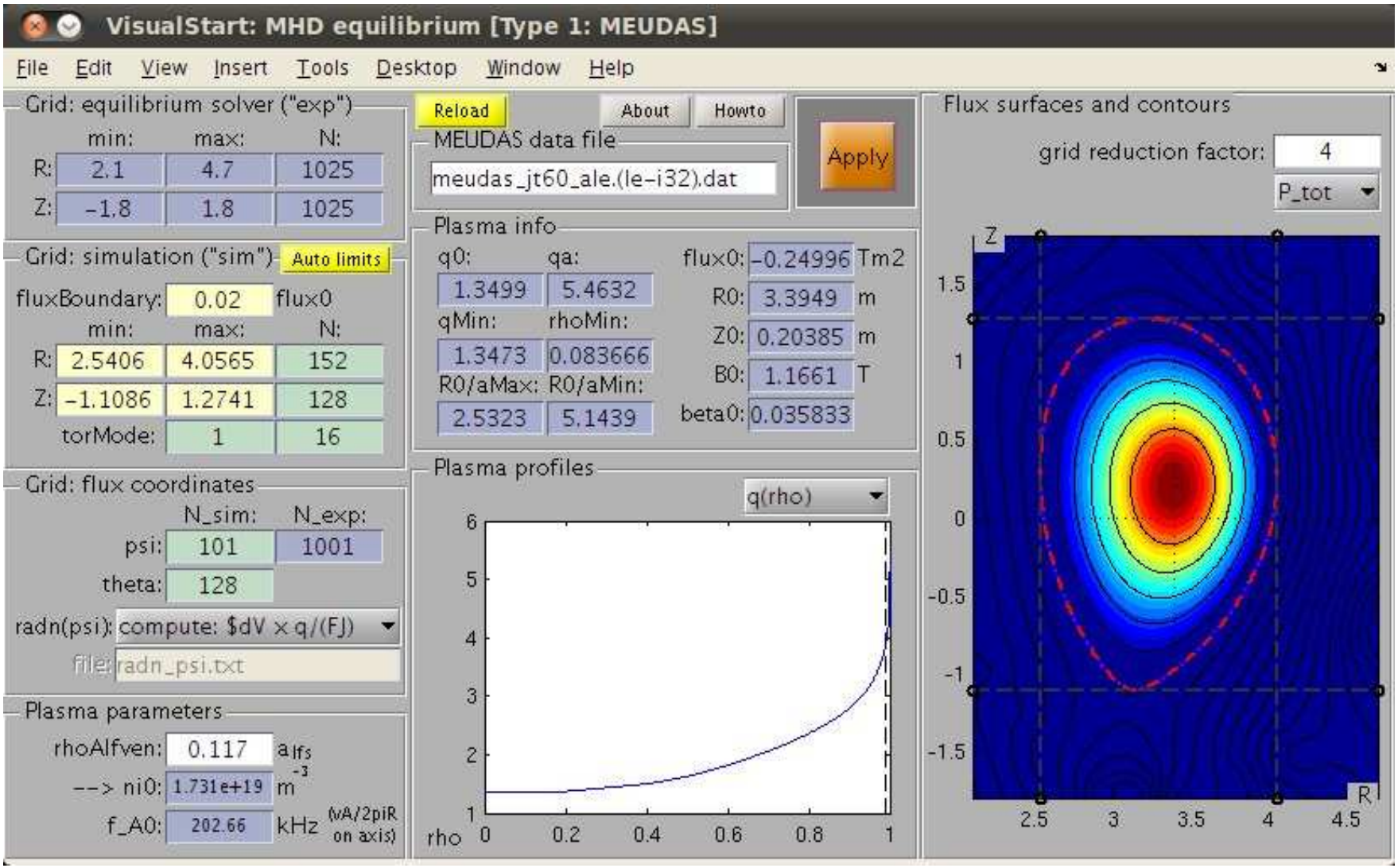


- Project file management
- Navigation



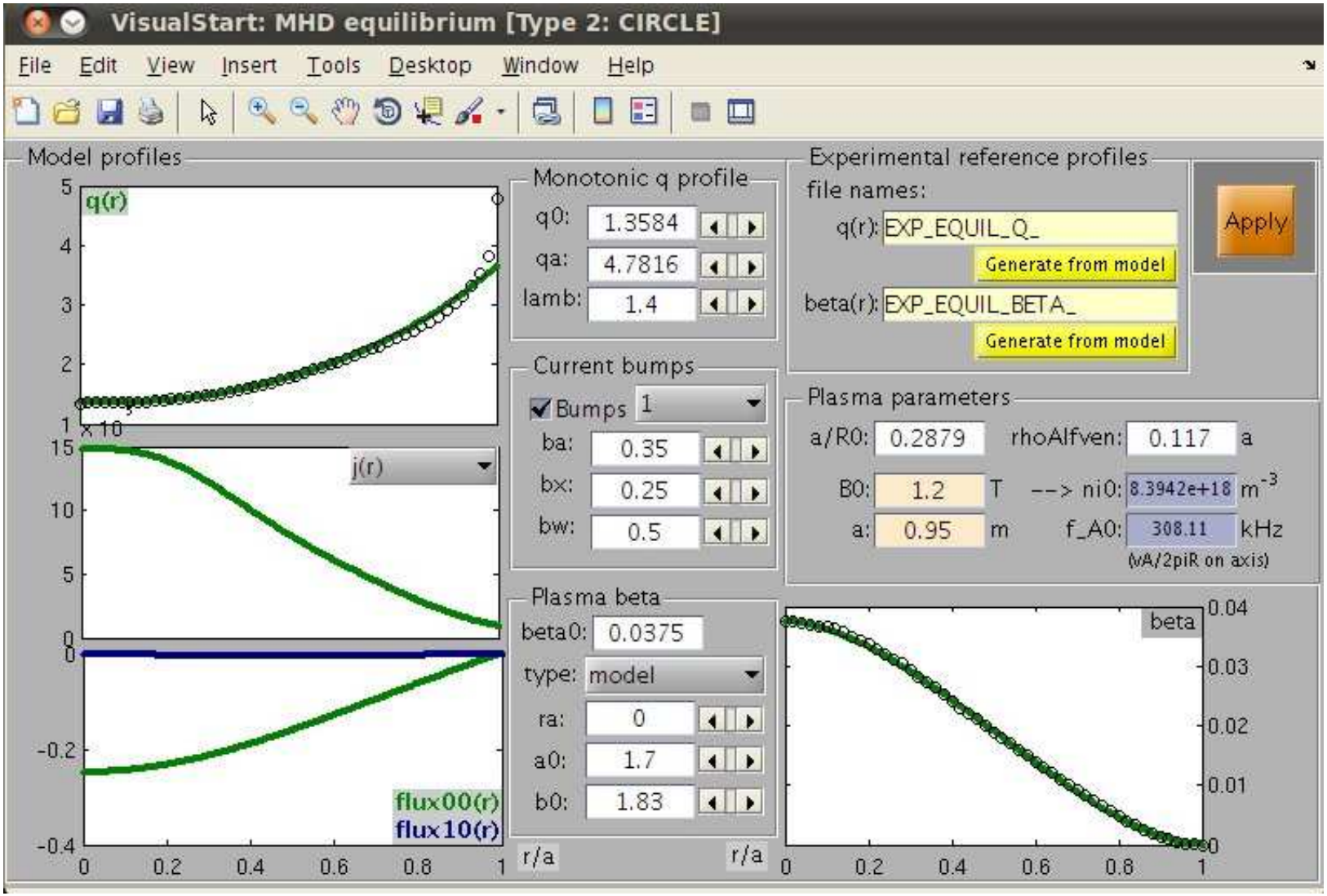
- Computational grid setup

Step 2: MHD equilibrium [Type 1: MEUDAS]



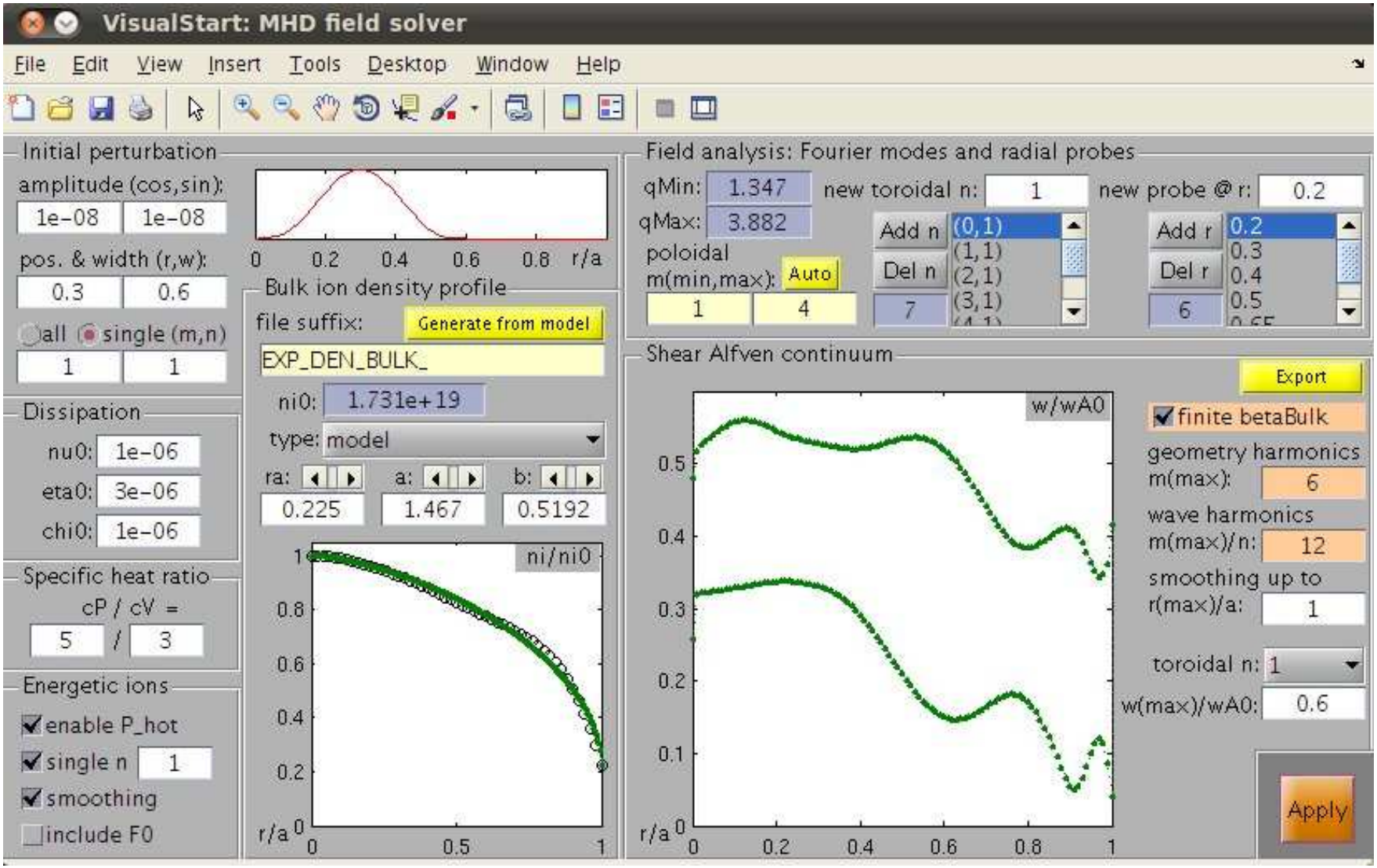
- Import equilibrium files
- Set computational domain

Step 2: MHD equilibrium [Type 2: CIRCULAR]



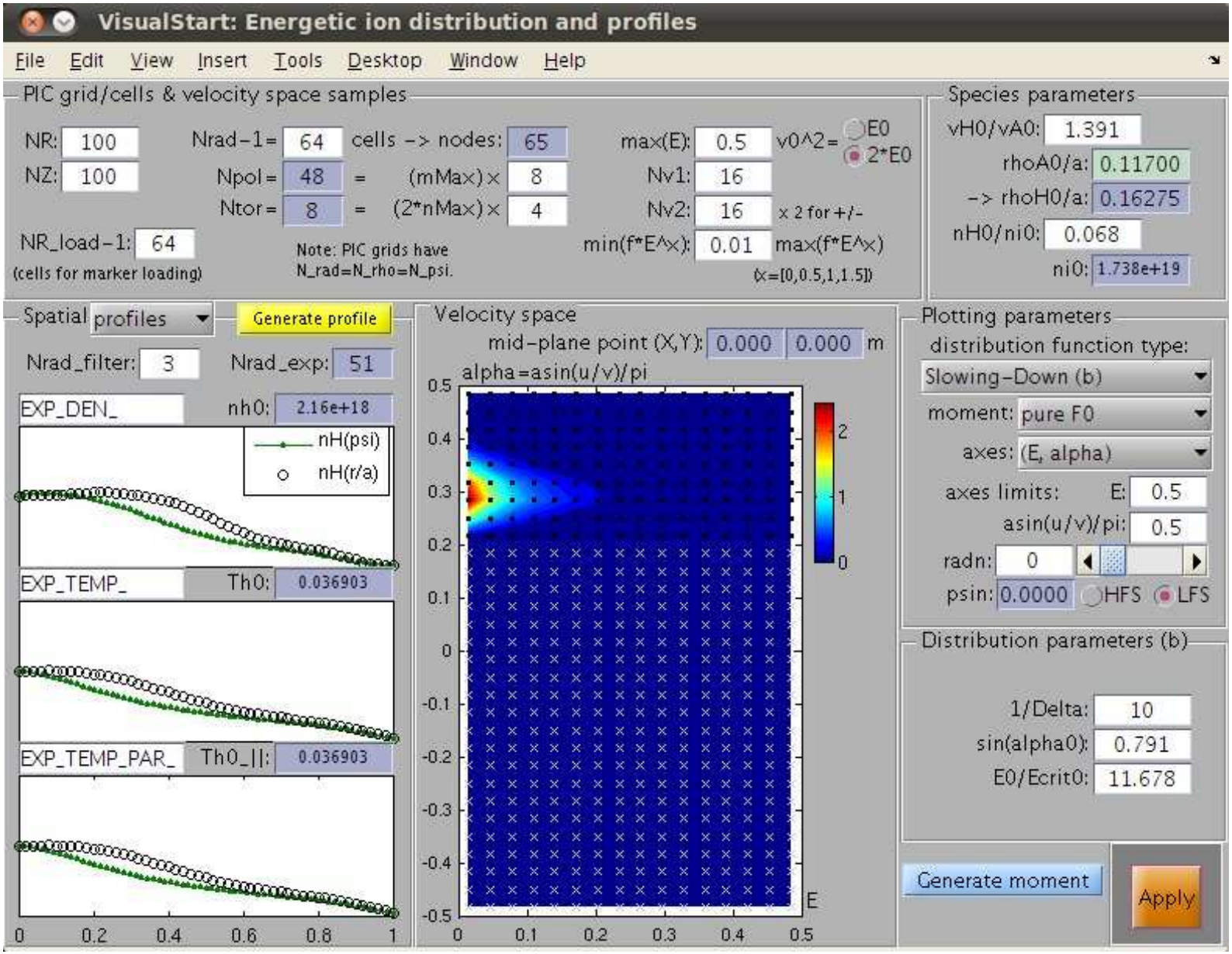
- Match reference profiles
- Set model parameters

Step 3: MHD field analysis and solver parameters



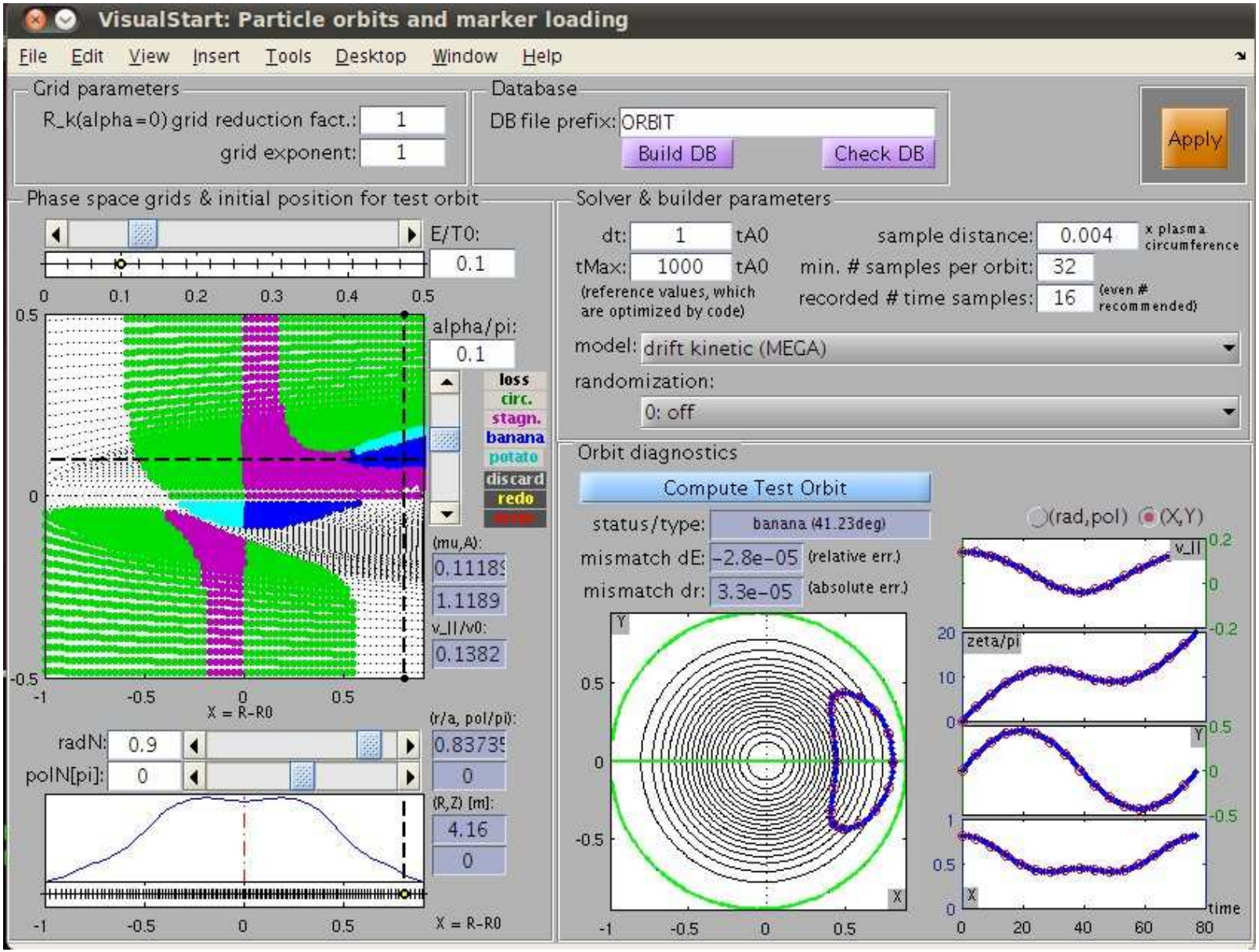
- Match reference profile for bulk density
- Compute continuous shear Alfvén spectrum

Step 4: Energetic ion distribution function



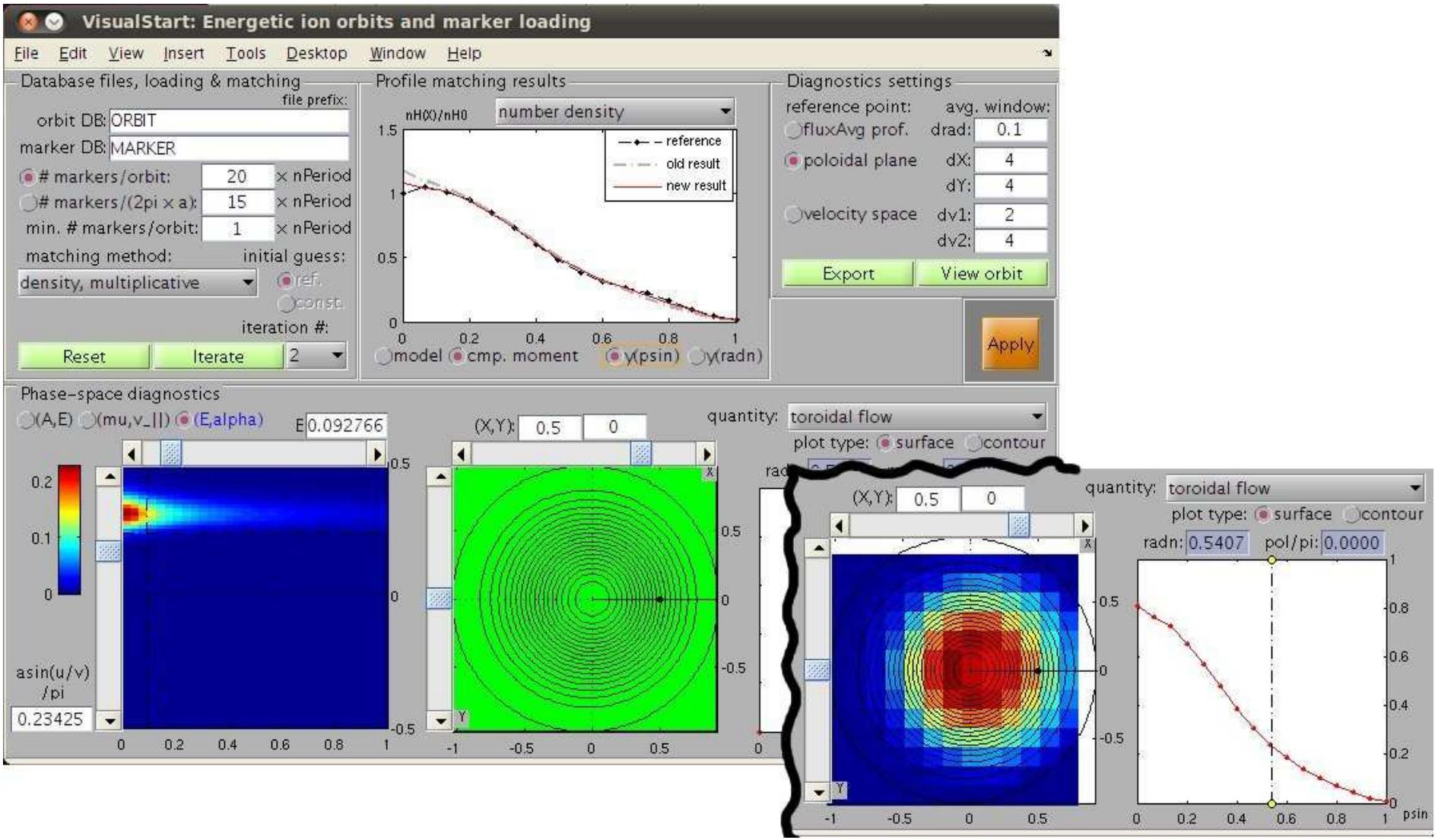
- Set up phase space mesh and model distribution function

Step 5: Orbit analysis and database



- Sample constant-of-motion space and create orbit database

Step 5: Marker loading and weighting



- Load phase space markers along orbits
- Adjust weights to match reference profiles

Summary

Developed :

- Versatile tool to set up initial state hybrid simulation codes
- Design process supported by interactive GUI
  $\Rightarrow$ provides convenient control, detailed information and feedback
- Steps 4+5+6: Implementation of new marker loading scheme:
  Bierwage *et al.*, *Comp. Phys. Comm.* **183** (2012) 1107–1123
  "Orbit-based representation of equilibrium distribution functions for low-noise initialization of kinetic simulations of toroidal plasmas"
  - Low noise initialization (time-independent marker distribution)
  - Exact equilibrium distribution function (fct. of constants of motion only)
  - Moments match given reference profiles (interactive iterative matching)
- Output files in portable and self-explanatory NetCDF format

Extensions underway:

- Step 4: Interface with OFMC solver to import and pre-process numerical distribution function

Planned extensions:

- Step 2:Interfaces with other MHD equilibrium solvers (e.g., for DIII-D tokamak)