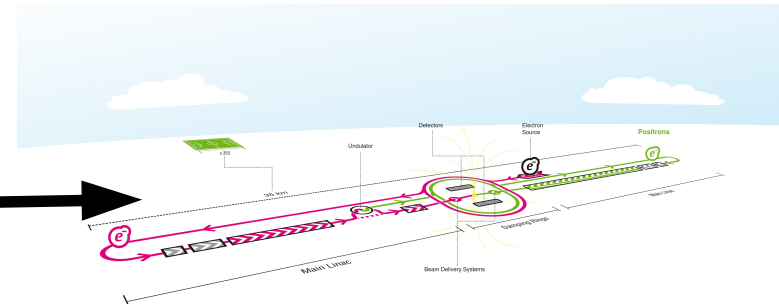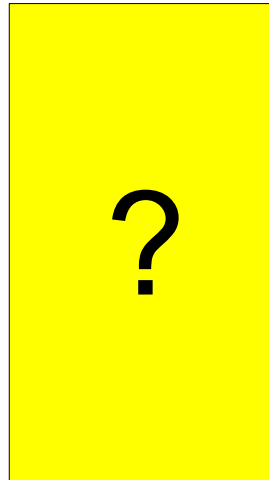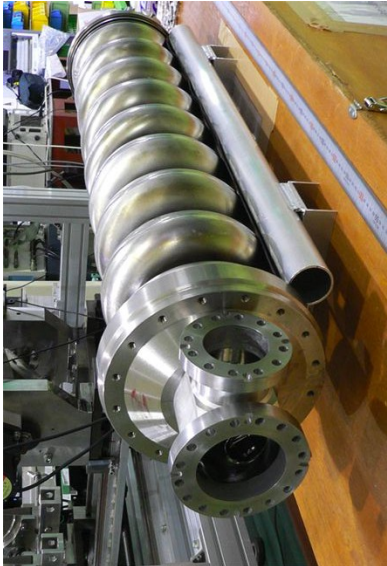# Realistic Maps of Wakefields in RF Cavities

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Boulder, CO

in collaboration with: J. Amundson, P. Spentzouris FNAL

Presently, the HEP community lacks a tool to link detailed EM codes with particle tracking codes
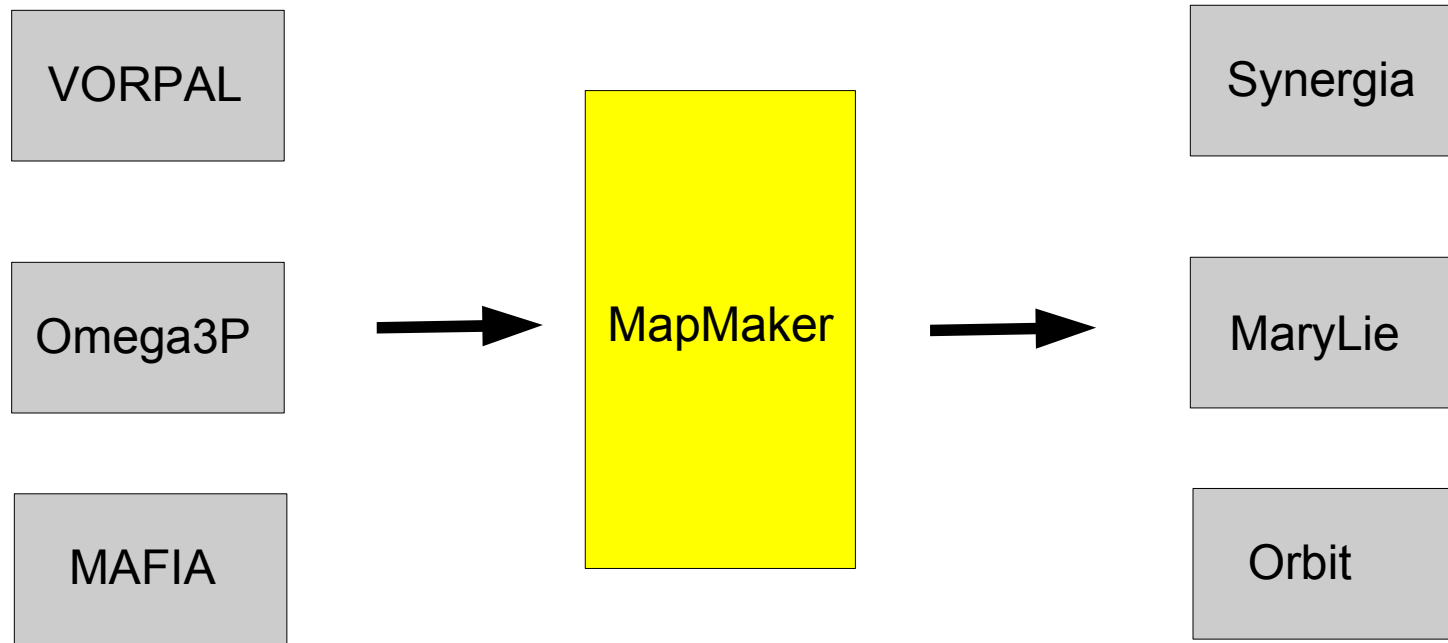

~10s cm

Finite element,
finite difference

~10s km

Maps, particle
tracking

A paper by D Abell gives an analytic method for generating maps from detailed EM simulations

VORPAL

Omega3P

MAFIA

MapMaker

Synergia

MaryLie

Orbit

Our work to develop MapMaker is funded by a Phase II SBIR project from DoE HEP

- Maps require expanding (for example in a Taylor Series), and this requires derivatives

- Calculating derivatives from numerical results is prone to noise

- Abell's technique replaces on-axis derivatives with approximations from off-axis Fourier terms

- The technique is low noise, but requires knowing mode structure

Test: single cell srf cavity in accelerating mode
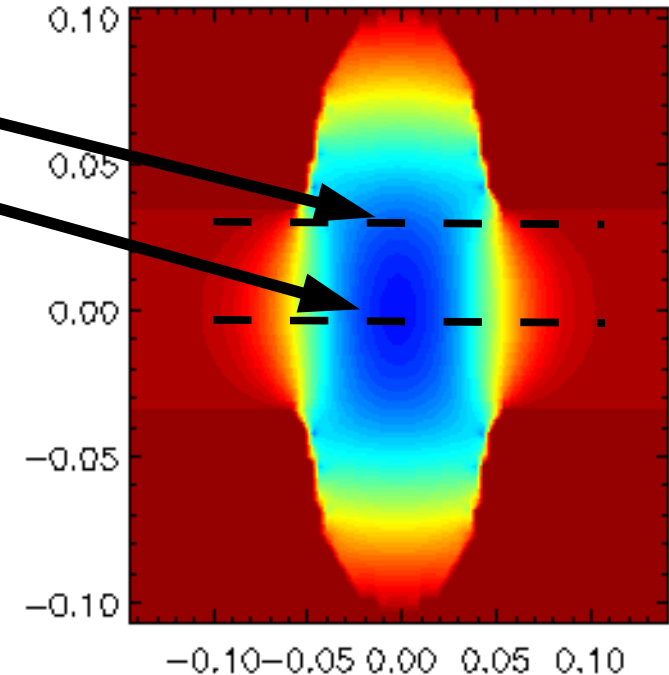
- Goal of the example:
  - Take an off-axis field slice as input
  - Try to reproduce the on-axis field

- This requires two steps:
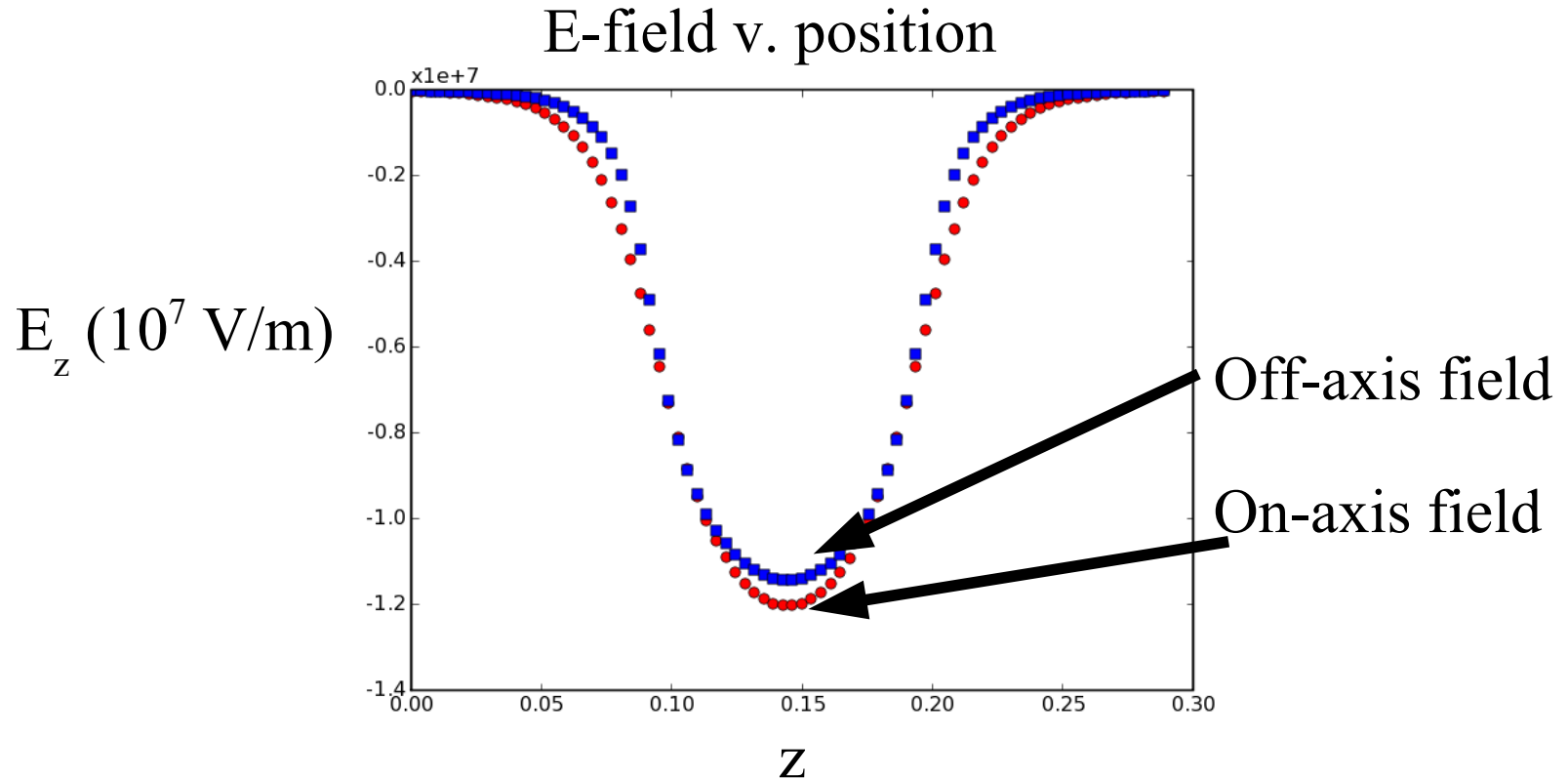 - Calculate Fourier terms using Ez off-axis:

$$\tilde{e}_m(k) = \frac{1}{R_m(k, R)} \int_{-\infty}^{\infty} \frac{dz}{\sqrt{2\pi}} e^{-ikz} E_{zcm}(R, z)$$

  - Use those to get derivatives on-axis:

$$\frac{d^n}{dz^n} E_z(0, z) = \int_{-\infty}^{\infty} \frac{dk}{\sqrt{2\pi}} e^{ikz} (ik)^n \tilde{e}_0(k)$$

Goal: to see how well Abell technique reproduces on-axis fields using off-axis values

E-field v. position

E_z (10^7 V/m)
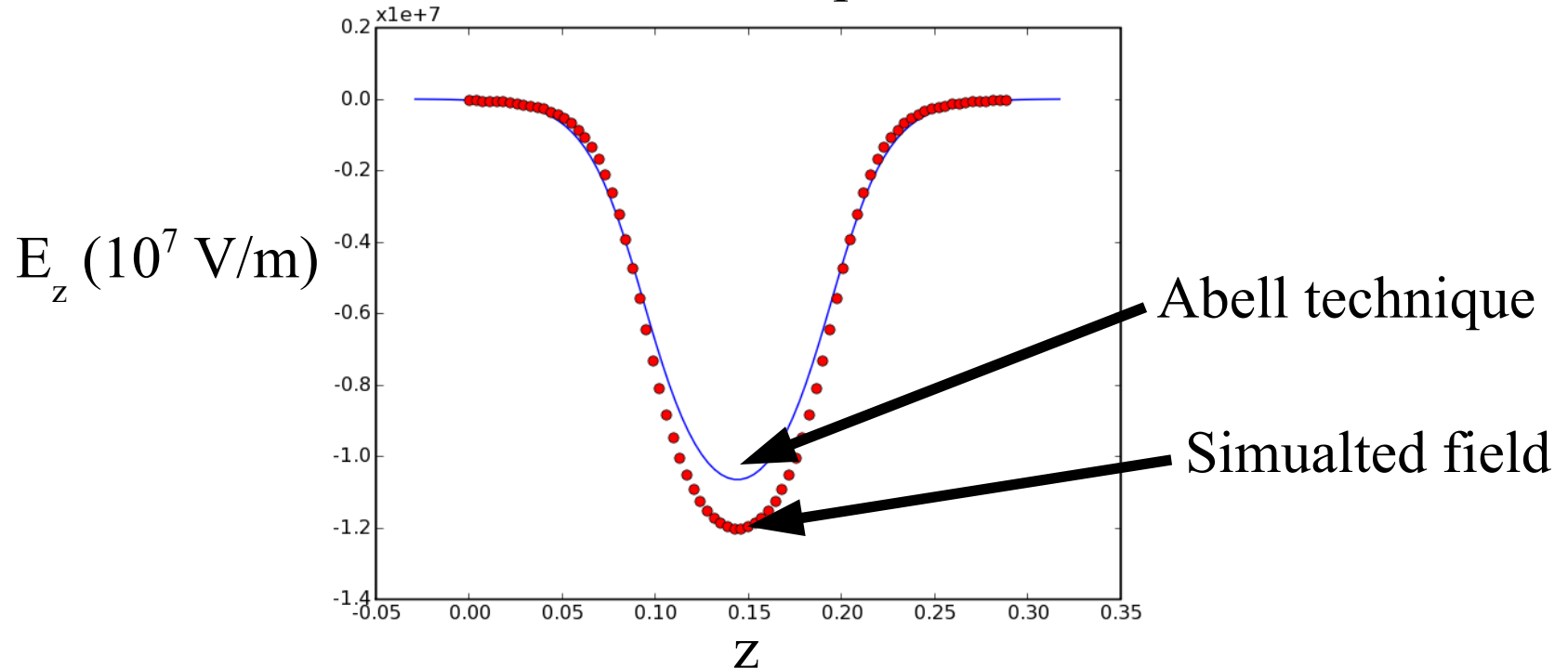
Off-axis field

On-axis field

z

As a benchmark, we will attempt to use off-axis values (blue) from VORPAL simulation to reproduce on-axis values (red)

# Abell technique gives good agreement with field profile, but 10-20% error in peak field strength

On-axis field v. position

E_z (10^7 V/m)

Abell technique

Simualted field

Keeping roughly 100 Fourier terms gives the right shape, but wrong peak field strength

Value from Abell technique is lower than off-axis value (not a pure mode?...or just pilot error!)

field v. position

E_z (10^7 V/m)

Abell technique

Simulated off-axis field

Simulated on-axis field

z
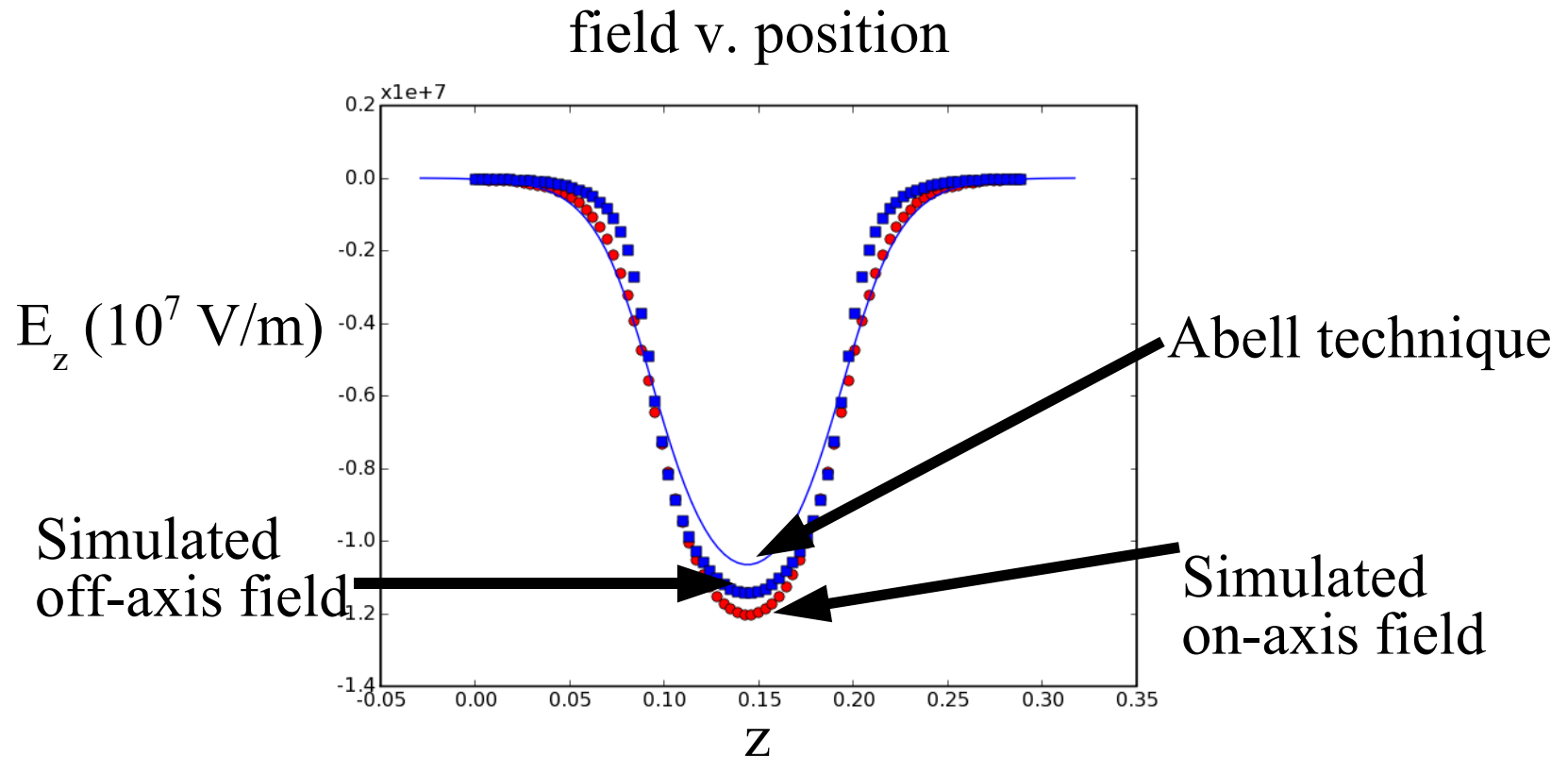
Field strength from Abell technique is lower than off-axis value (indicating another mode present or maybe a bug in my implementation?)

# Before MapMaker can create a wakefield map, we need eigenmodes and frequencies and TPS library

• Need a 3D implementation (Fourier in azimuth)

• Need ability to extract individual modes from a simulation (would be easy with frequency-domain code like Omega-3P, for time-domain codes, see talk tomorrow by S. Ovtchinnikov)

• Need a truncated power series library to convert numerically calculated derivatives into terms in a map
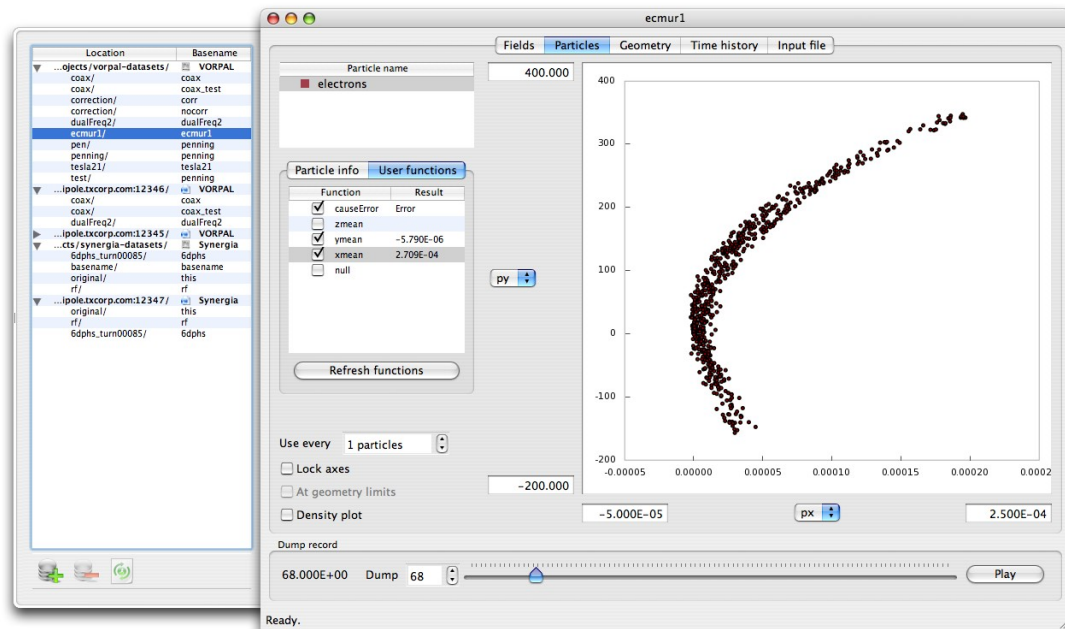
We are working on a cross-platform, code-independent GUI as well

- Qt-based (so should work on any platform)

- Data reader is decoupled from GUI (so should work with any code)
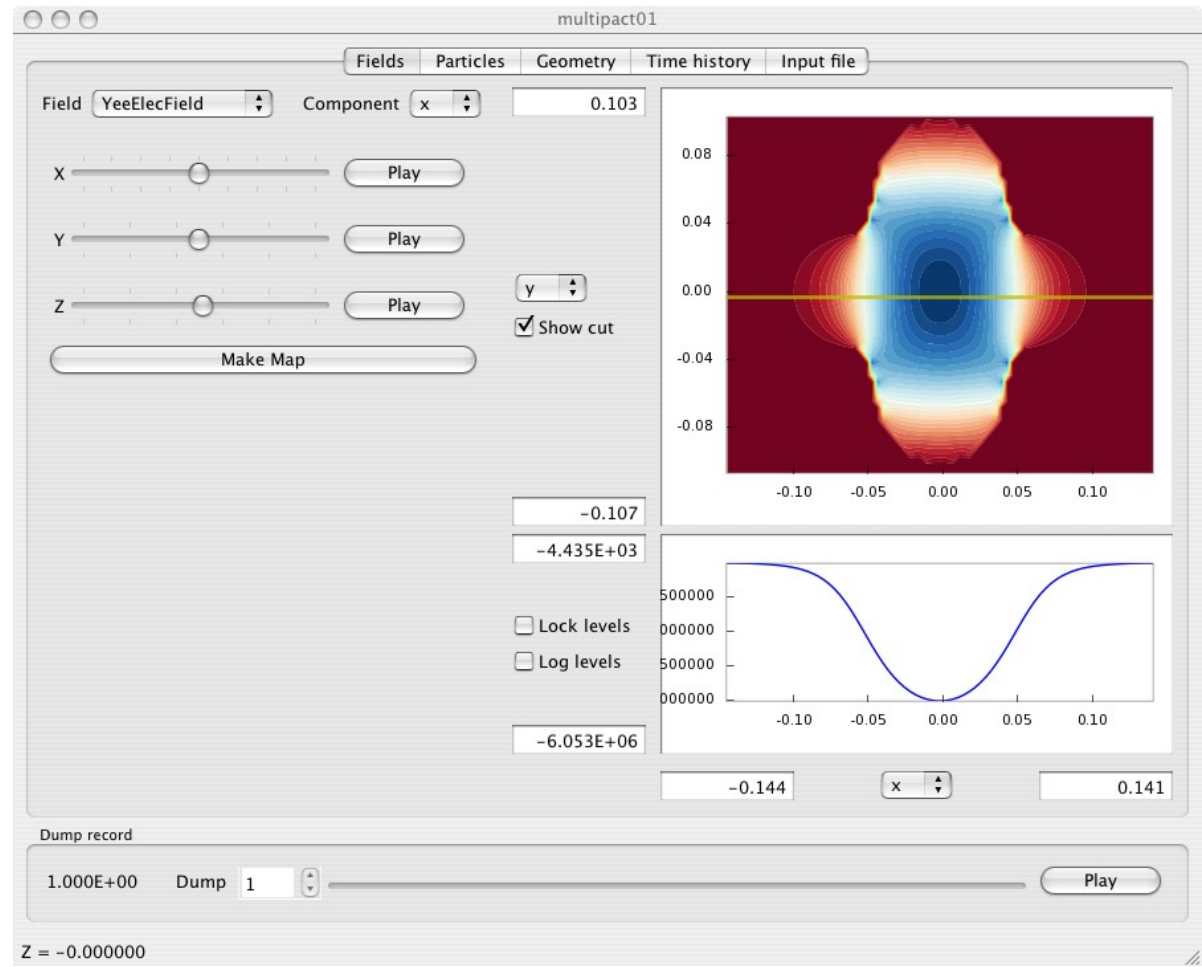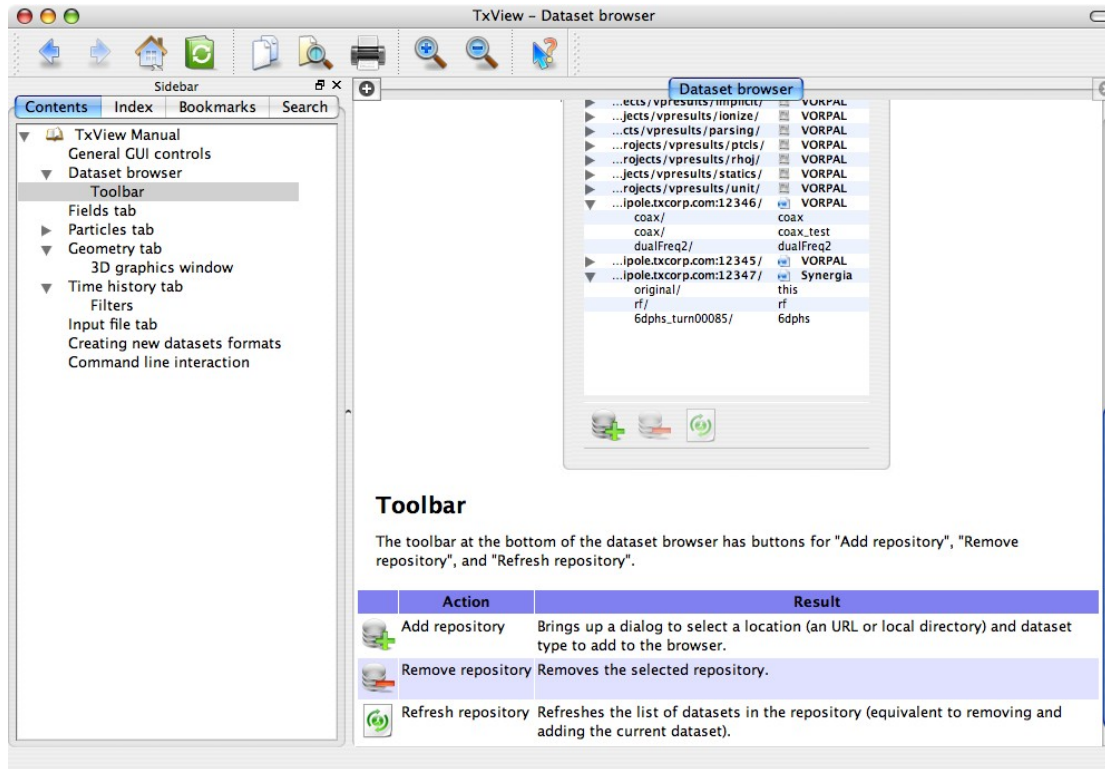
Some features of the GUI are (i) remote data access, and (ii) user-defined functions

- Data Access Protocol (developed by NASA) gives users access to remote data sets as though they were local

- Users can write their own functions and have the GUI display the results

We have even written documentation!

This work benefits from the already-established collaborations of the COMPASS SciDAC

VORPAL		**Synergia**
Omega3P →	**MapMaker** →	**MaryLie**
MAFIA		**Orbit**
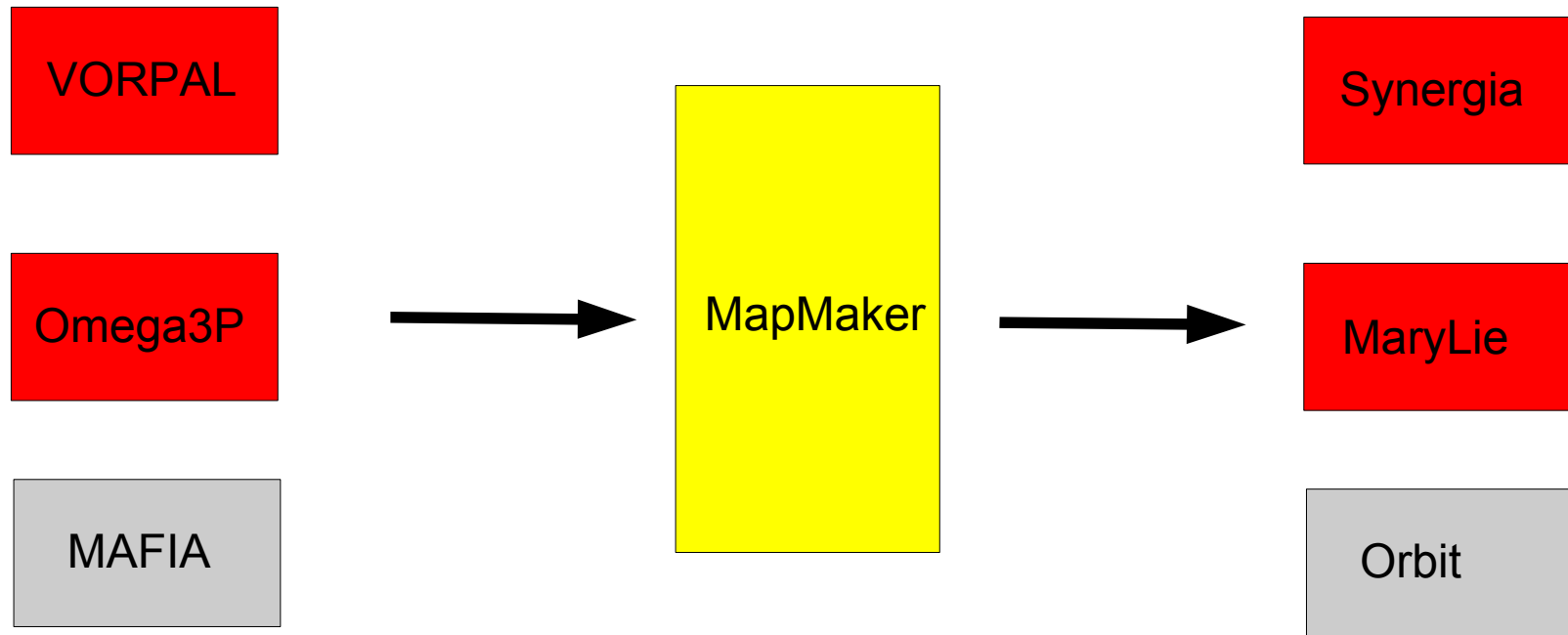
COMPASS SciDAC codes are listed in red. This work benefits from the already established collaboration there.

The reason this project is not further along...