

# Three-Dimensional Equilibrium Reconstruction: The V3FIT Code

James D. Hanson, John Shields, Stephen F. Knowlton  
*Auburn University*

Steven P. Hirshman, Edward A. Lazarus  
*Oak Ridge National Laboratory*

Lang Lao  
*General Atomics*

# Equilibrium Reconstruction

- MHD Equilibrium

- Input:

- External B Field
    - Current profile
    - Pressure profile
    - Toroidal flux

- Output:

- Flux surface geometry  
(*Key* to further computations)

- Equilibrium Reconstruction:

- Use *observed* diagnostic signals  $S^o$  to *determine*:

- External B Field
    - Current profile
    - Pressure profile
    - Toroidal flux

# Equilibrium Reconstruction

- A classic Inverse Problem
  - Forward problem, determine signals, given parameters.  
Known Function  $\mathbf{S}^m(\mathbf{p})$  - Model signals.
  - We know (observe) the signals  $\mathbf{S}^o$ . What are the parameters?  
Determine Inverse Function  $\mathbf{p}(\mathbf{S}^m, \mathbf{S}^o)$
  - Use Maximum Likelihood / Least Squares.
  - Minimize  $g^2$ :

$$g^2(p) \equiv \sum_i w_i \left( \frac{S_i^o(p) - S_i^m(p)}{\sigma_i} \right)^2$$

# V3FIT Code Design Goals

- Primary Goal - Useful for the Stellarator Community
  - Fast
    - Want reconstructions between shots
  - Flexible
    - Written in Fortran 95
    - Modular coding, clear and consistent data flow
    - Extensive use of derived types
    - Easy to understand, maintain, and modify
  - Extensible
    - Initial Equilibrium Solver - VMEC
    - Localize VMEC code assumptions, so that could use a different equilibrium solver in the future
    - Initial Signals - Magnetic Diagnostics
    - Microwave interferometry and polarimetry signals - in development
    - Other diagnostics can be added

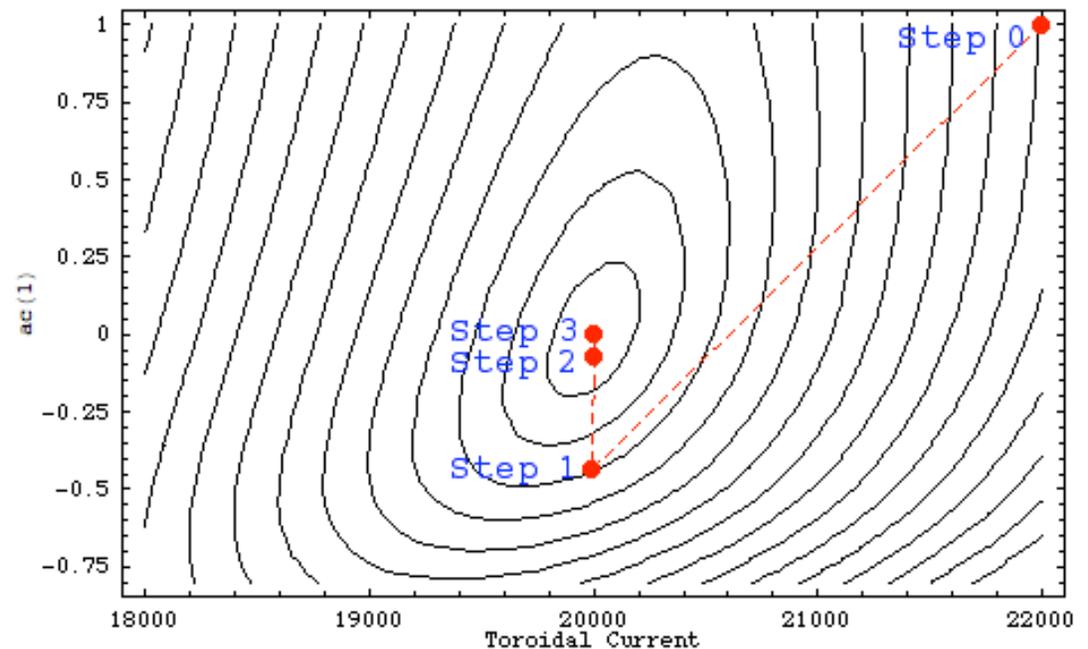
# V3FIT Code Status

- Code structure in place and functional
- First reconstructions - November 2006
- Not ready for outside users

First Reconstruction:

Contour plot of  $g^2$  as a function of two reconstruction parameters.

Red dots and dashed line:  
- reconstruction path



# NCSX Collaboration

- How can we make the code most useful for NCSX?
- What is most useful, convenient way to:
  - Get experimental data in to V3FIT
  - Present V3FIT reconstruction results
- What Signals Types are most important to add?
  - ✓ Magnetic Diagnostics (Volume integral over plasma region)
  - ✓ Microwave Interferometry and Polarimetry (Line integrals)
    - » Parameter Constraints
    - » Geometric Constraints (Limiters, plasma boundary location)
  - ¿ Other Signals ?