

# Symmetry Breaking Field Errors Status

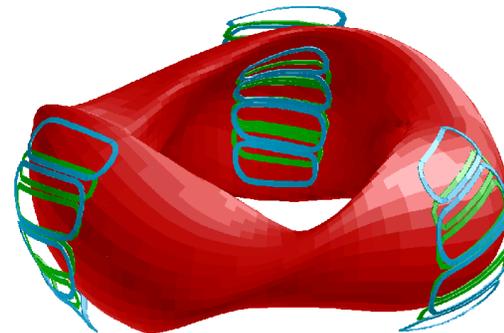
NCSX Project Meeting

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Art Brooks

# Background

- Trim Coil Design Efforts thru the PVR have focused on Healing Islands caused by Symmetry Preserving Field Errors
  - Period Symmetry
  - Stellarator Symmetry ( ie only sine terms present in  $B_n$  )
- Separate Sets of Trim Coils were Designed for Suppressing dominate modes
  - $3/5$ ,  $3/6$  resonances



# Present Efforts & Future Plans

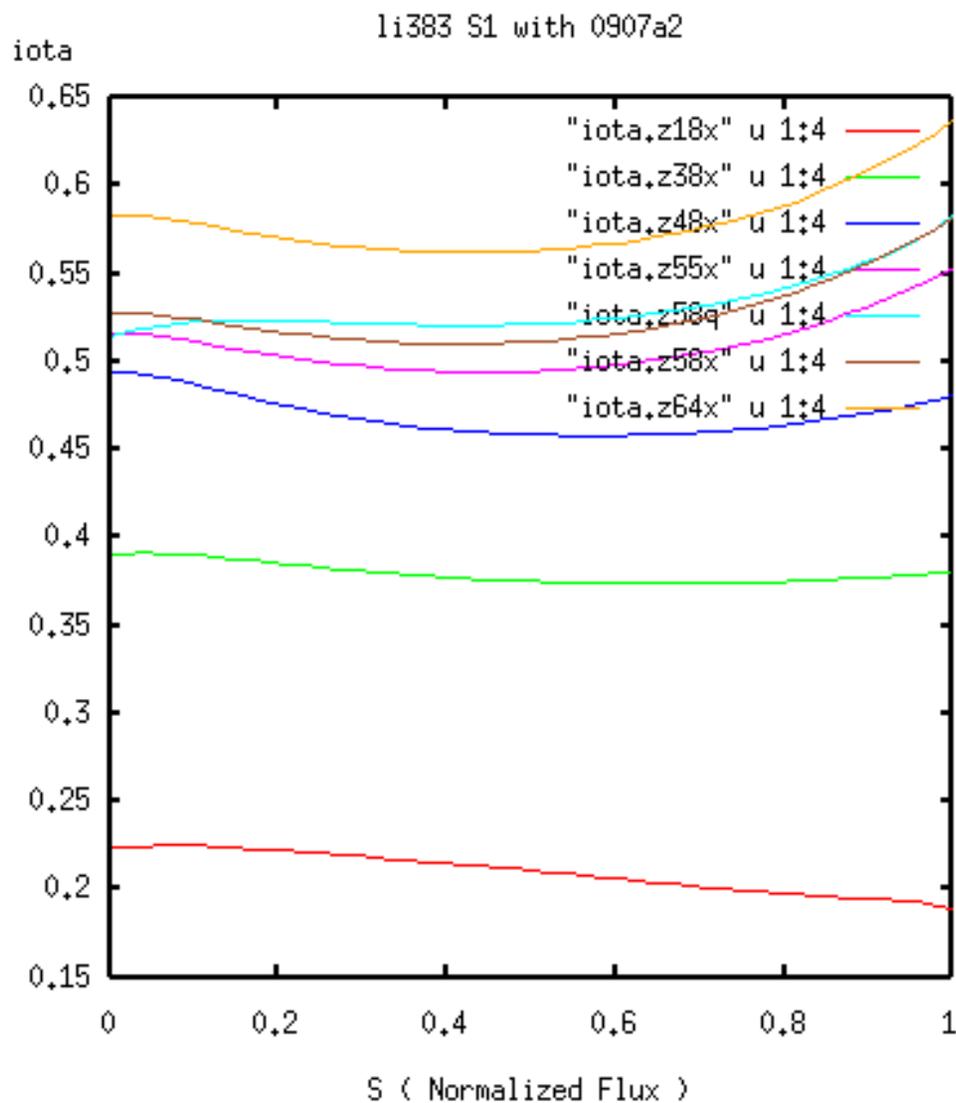
- Assess need for trim coils to correct field errors from Coil Fabrication and Assembly tolerance
  - Coil Positioning or Alignment Errors
  - Distortions in Coil geometry
- In general, field errors introduced will be neither periodic symmetric nor stellarator symmetric
  - Need to be concerned with low order resonances such as  $1/2$ , and possibly  $1/3$  and  $2/3$
  - $B_n$  contains both sine and cosine terms producing Islands with X and O points offset from period boundary

# Approach

Since VMEC and PIES enforce stellarator symmetry, studies will be done in vacuum using field line tracing, with Field Errors evaluated using CURROPT

- Choose ( or generate ) a reference vacuum configuration that contains the low order resonance(s)
  - For  $\frac{1}{2}$  resonance, use Mike Z's li383m2.1.z55x case
- Perturb the coil set geometry
  - Simple code for manipulating coils has been written
- Observe Induced Islands with Field Line tracing
  - Use TRACE code
- Target Islands with CURROPT using existing trim coils
  - CURROPT has been modified to handle symmetry breaking field errors
- Introduce additional trim coils
  - Follow Coupling Matrix Approach for Design

# Using Vacuum State to Test Trim Coils



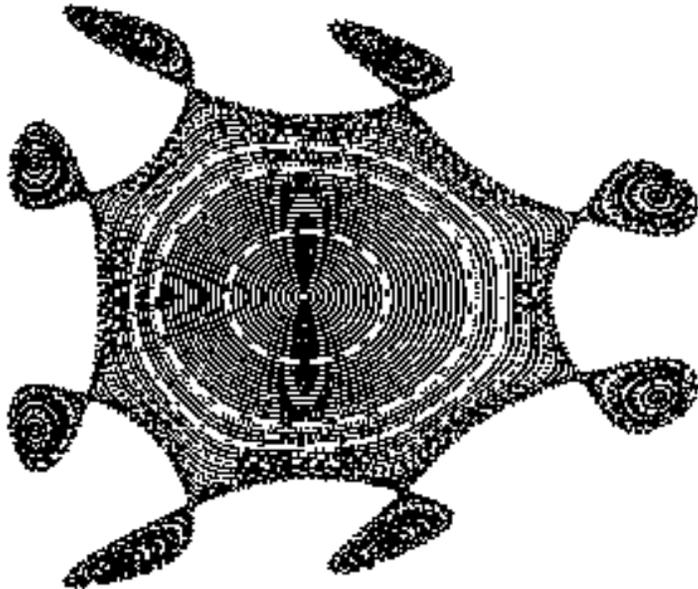
Data from iota  
Scan by Mike Z

Only **z64x** and **z55x**  
Cross iota= **.6** or **.5**

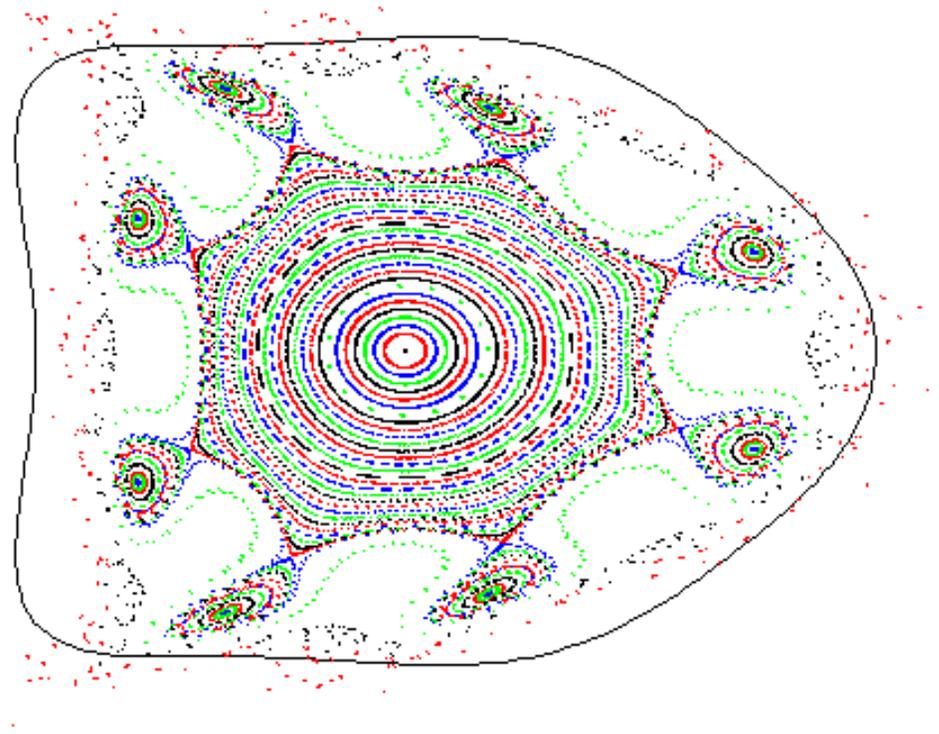
All present difficulties  
due to low shear

# Benchmark Of TRACE with PIES

Pies



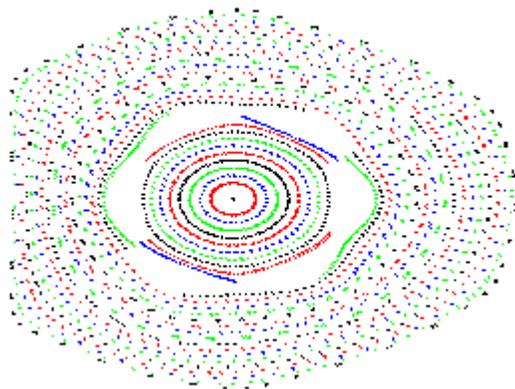
Trace



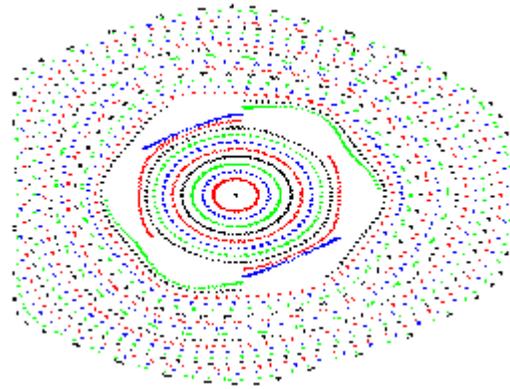
Vacuum Configuration li383m2.1.z38x

# Symmetric [6,3] Island Present in z55x vacuum configuration with Modular Coils ( 0907h2 )

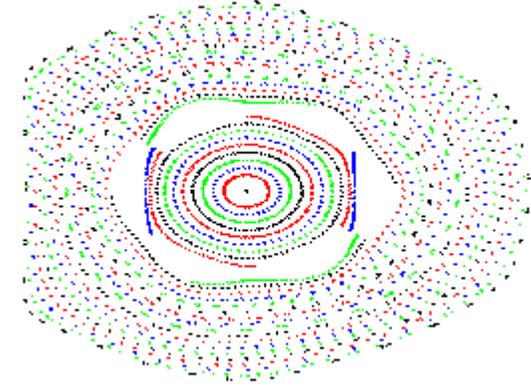
( additional [6,3] resonance at edge has significantly reduced plasma volume )



$\nu=1/6$



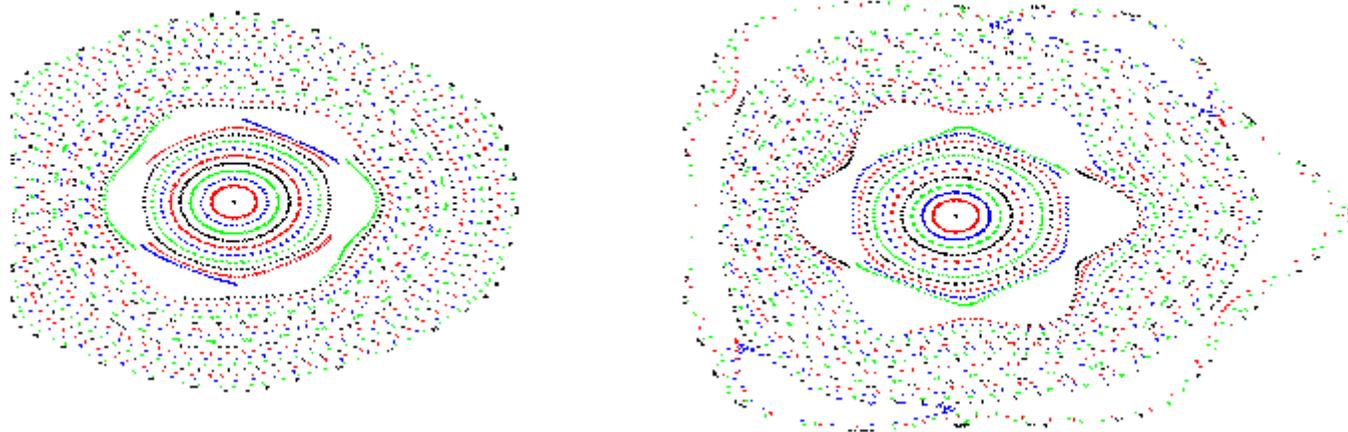
$\nu=3/6$



$\nu=5/6$

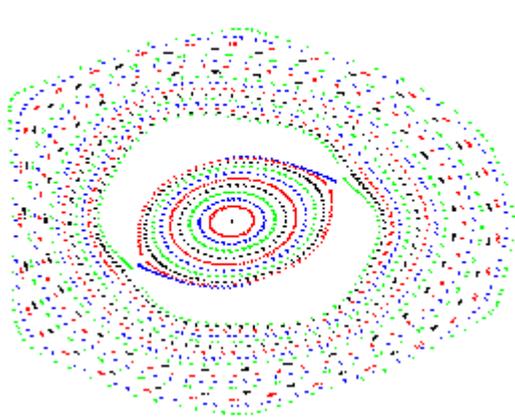
Islands are both 3 period symmetric and stellarator symmetric  
( small differences in plots due to start and length of tracing )

# Targeting Edge and Interior [6,3] resonance with CURROPT improves Edge but excites Interior

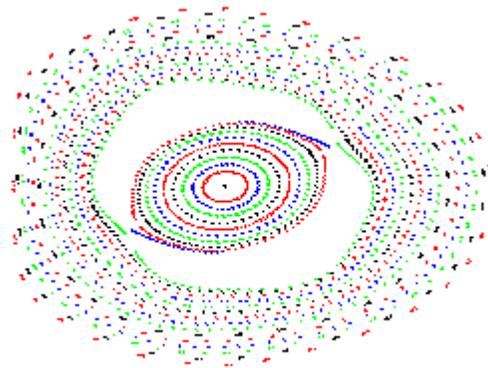


Unhealed will be used for present studies until a clean vacuum configuration with monotonic  $\iota$  can be generated

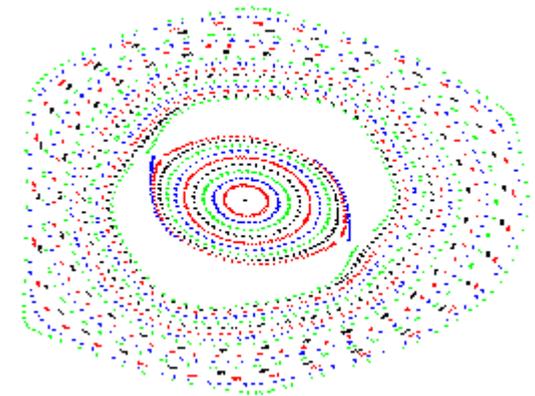
# Non Symmetric [2,1] Island induced by displacing All Modular Coils 1 cm in 'x'



$$\nu=1/6$$



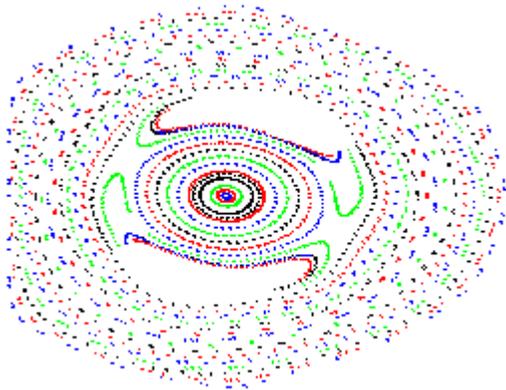
$$\nu=3/6$$



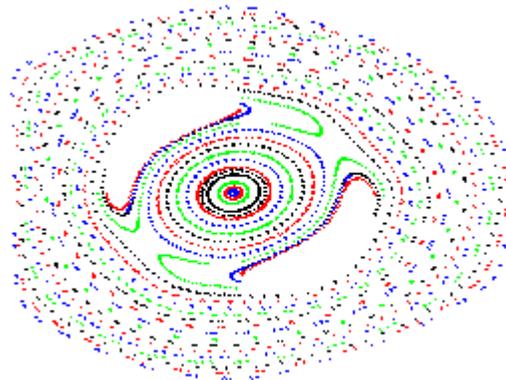
$$\nu=5/6$$

Islands are not 3 period symmetric but are still stellarator symmetric

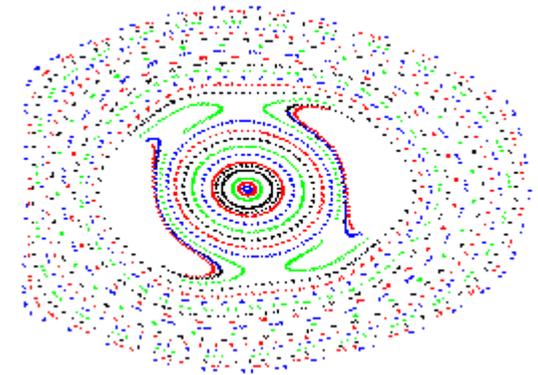
# Non Symmetric [2,1] Island induced by displacing All Modular Coils 1 cm in 'y'



$$\nu=1/6$$



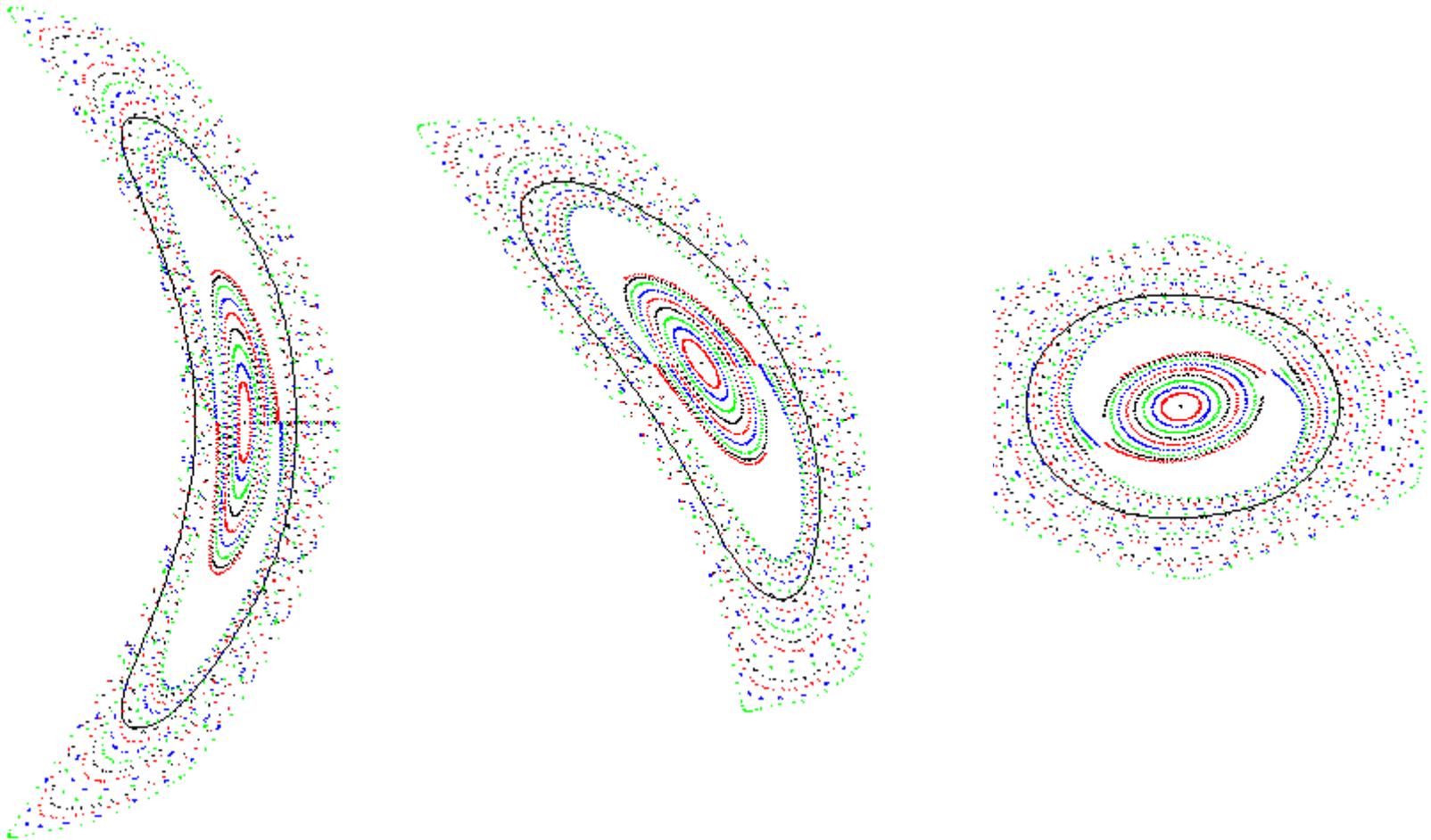
$$\nu=3/6$$



$$\nu=5/6$$

Islands are neither 3 period symmetric nor stellarator symmetric

Healing of Islands with CURROPT not yet successful.  
Difficulties may lie in disagreement with VMEC as to  
where resonant surface is located.



# Summary

- Need to get a better reference vacuum configuration before present approach can succeed
  - Good agreement on resonant surface location a requisite
  - Recent discussions with Steve and Mike providing some insight on disagreement with VMEC
- An other alternative being pursued is to construct target surface thru island chain
  - Follow approach taken by Stuart