3-D VMEC calculations for DIII-D

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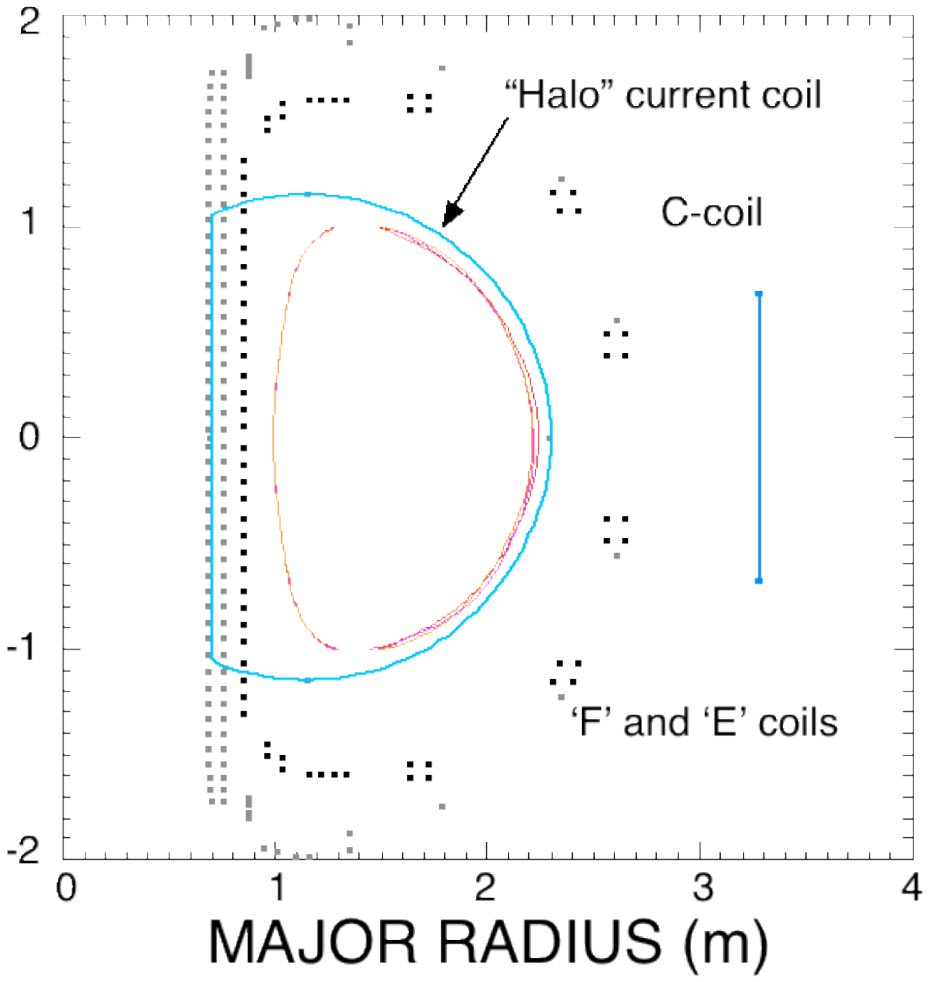
Introduction

- Apply 3-D equilibrium code, VMEC to DIII-D.
- Presently VMEC requires stellarator symmetry; only up-down symmetric equilibria (at principal symmetry plane) and only restricted types of non-axi-symmetric coils are allowed.
- C-coils and a 'halo current coil' are added to the symmetrized DIII-D coil set.
- Distortions of plasma boundary studied vs. current in non-axisymmetric coils, beta, separation.

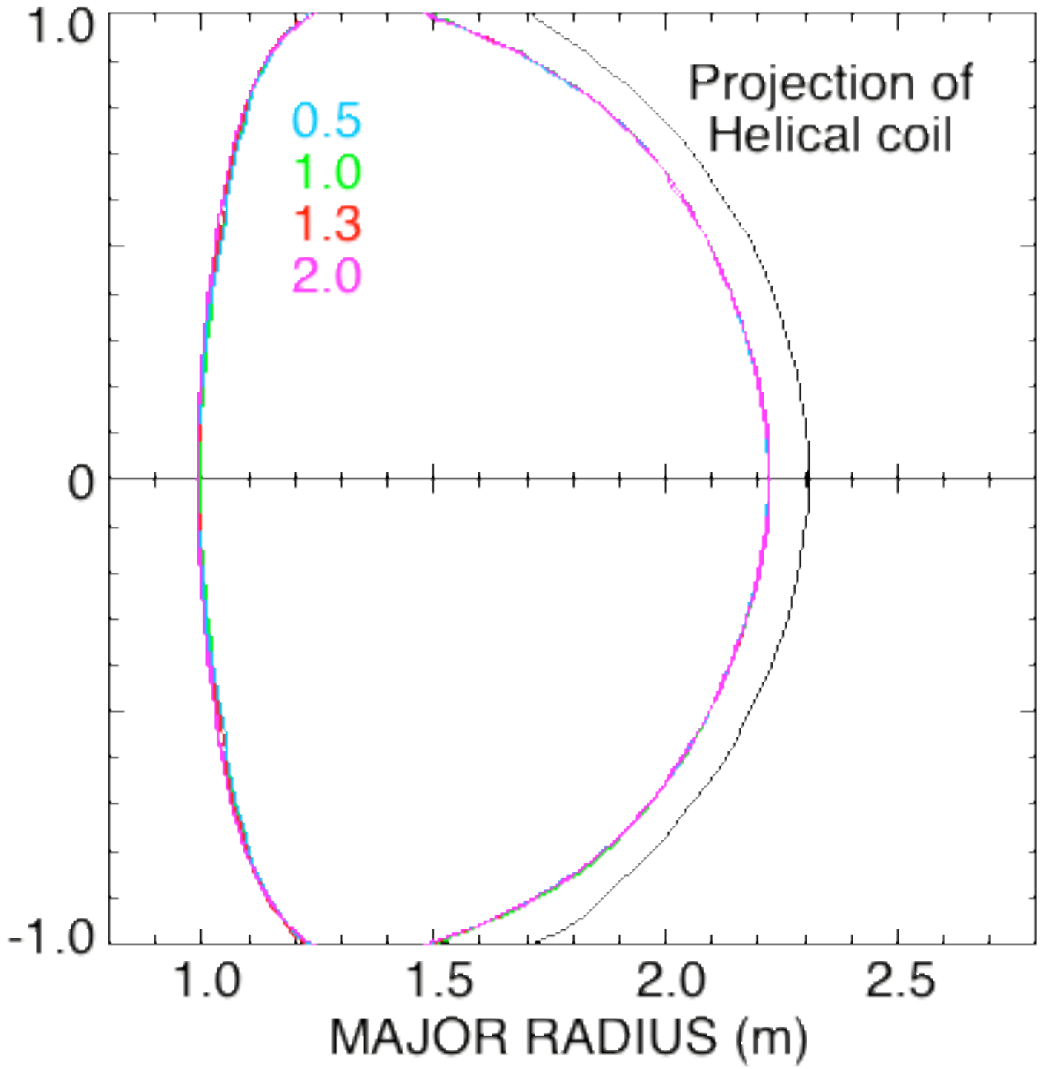
Model of DIII-D coils with coil simulating the halo-current and C-coil

- VMEC requires stellarator symmetry - limits kinds of non-axisymmetric coils.
- Halo current m=1/n=1.
- Only up-down symmetric plasmas can be modeled.
- Template from efit02 109892_2300 with $\beta_n \approx 2.07$, $\ell_i \approx 0.84$.



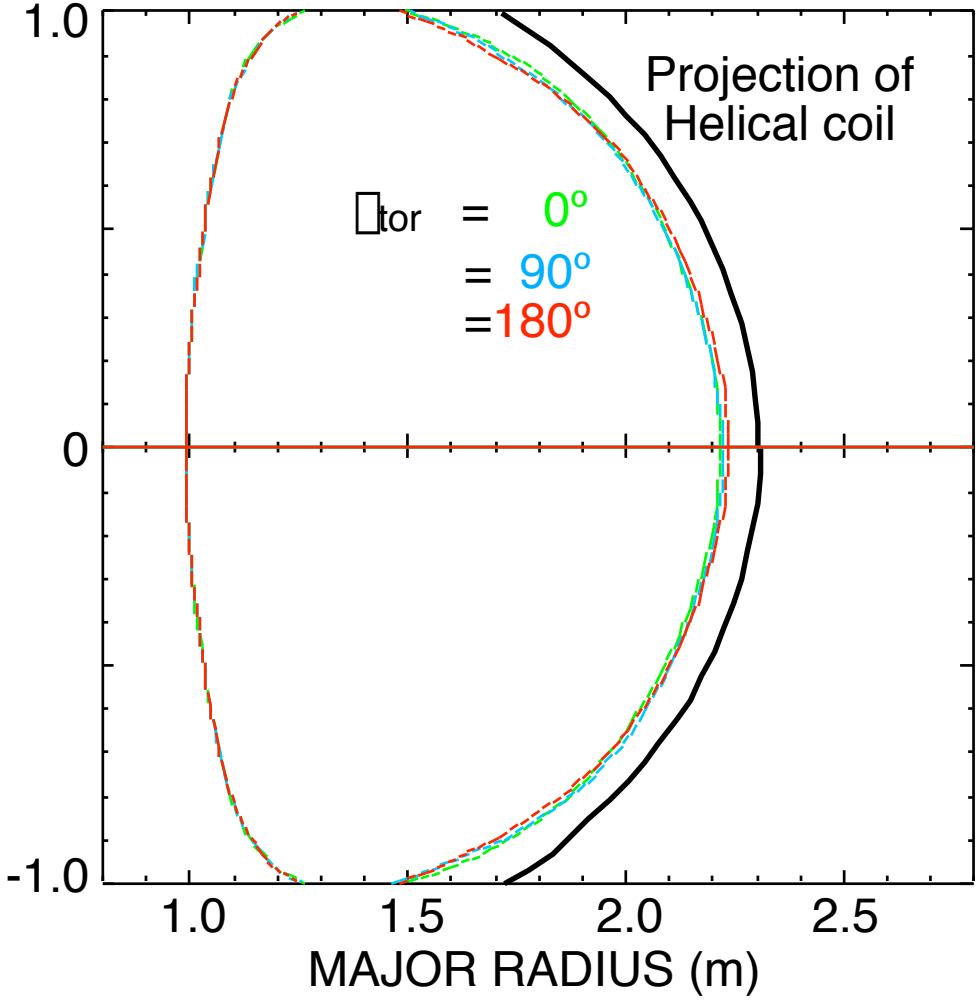
Four equilibria generated with similar boundary shapes spanning □ limit

- Numbers in figure correspond to multiplier on EFIT pressure profile.
- Highest pressure equilibrium has □n□3□5□4.
- Plasma response is then investigated as a function of □.



5 kA of halo current 8 cm from plasma surface cause 2 cm displacement

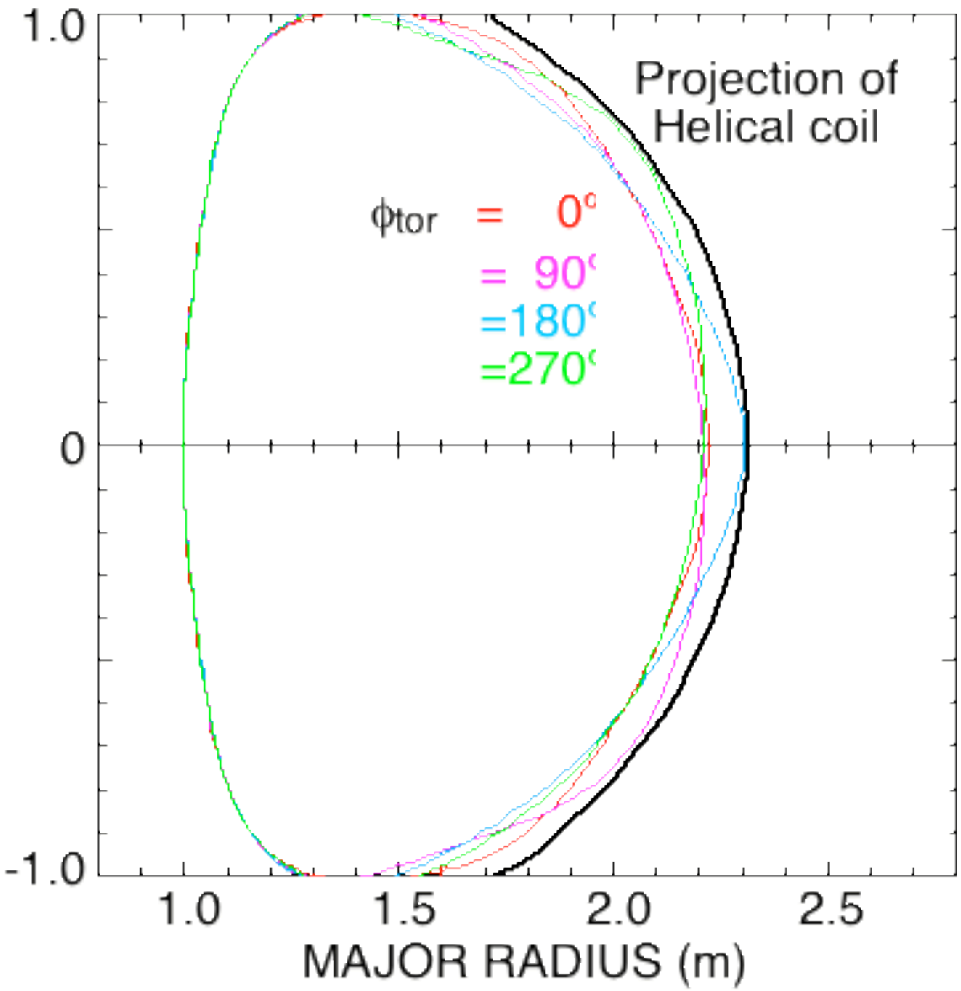
- Separation from plasma surface equivalent to distributing (smearing) current filament.
- Pattern of displacement doesn't seem to match "halo coil" trajectory.
- Outboard pitch in rough agreement with Takahashi's calculation*.



*See H. Takahashi's talk later in meeting

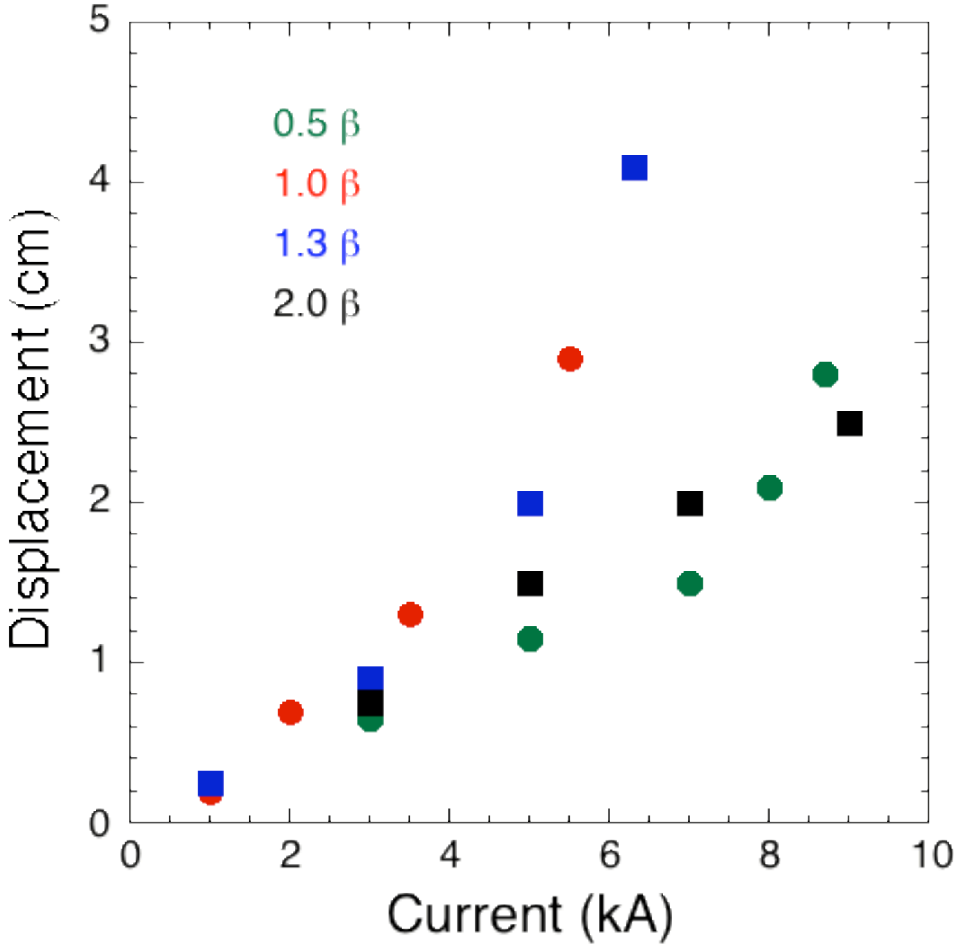
Sharp threshold displacement response for positive currents

- Plasma boundary balloons to “surface” of halo-current coil (from 5.5 to 5.6 kA).
- Response is saturated - further increases in current give same result.
- Negative current response saturates at similar level.



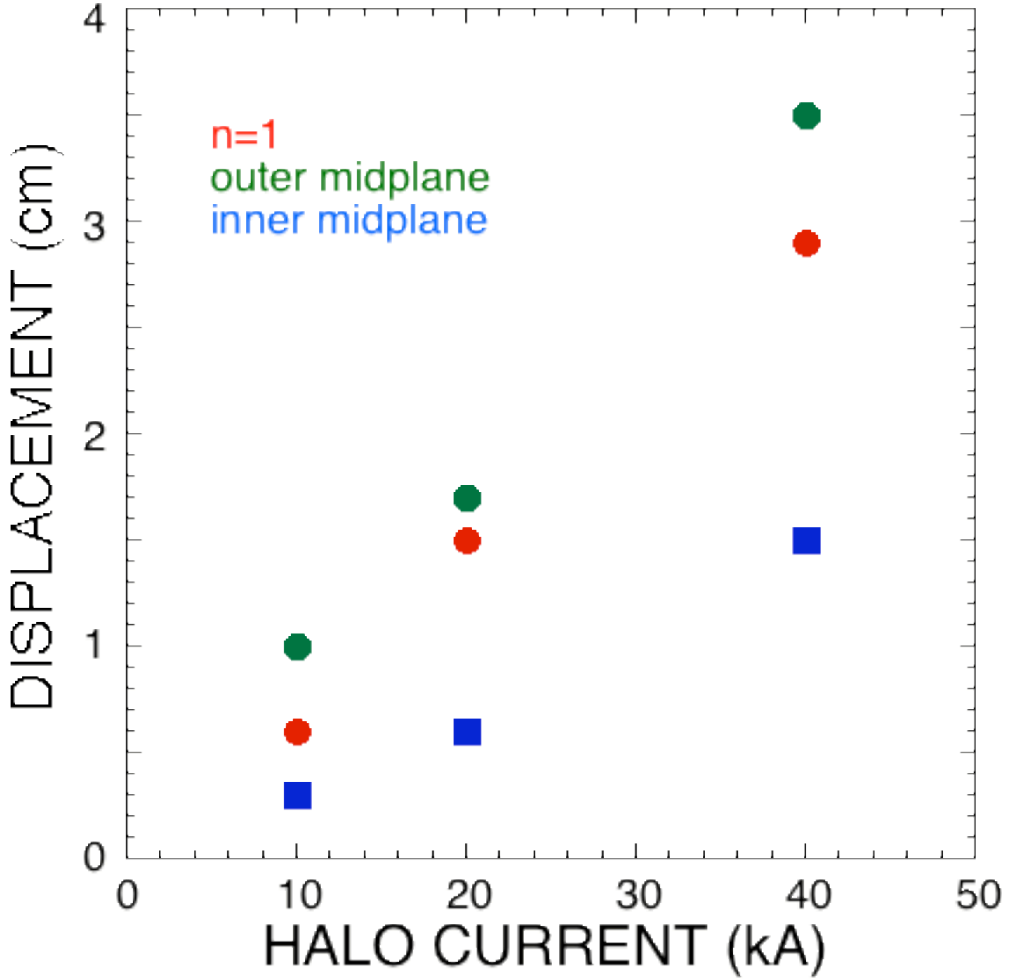
Displacement vs. current nearly linear - up to "threshold" level

- Displacement depends weakly on □, but dependence is non-linear.
- Weakest displacement at lowest and highest □'s
- May reflect alignment of halo-coil pitch with outer field line pitch?
- Highest $□_n \approx 4.9$, max. response at no-wall limit?



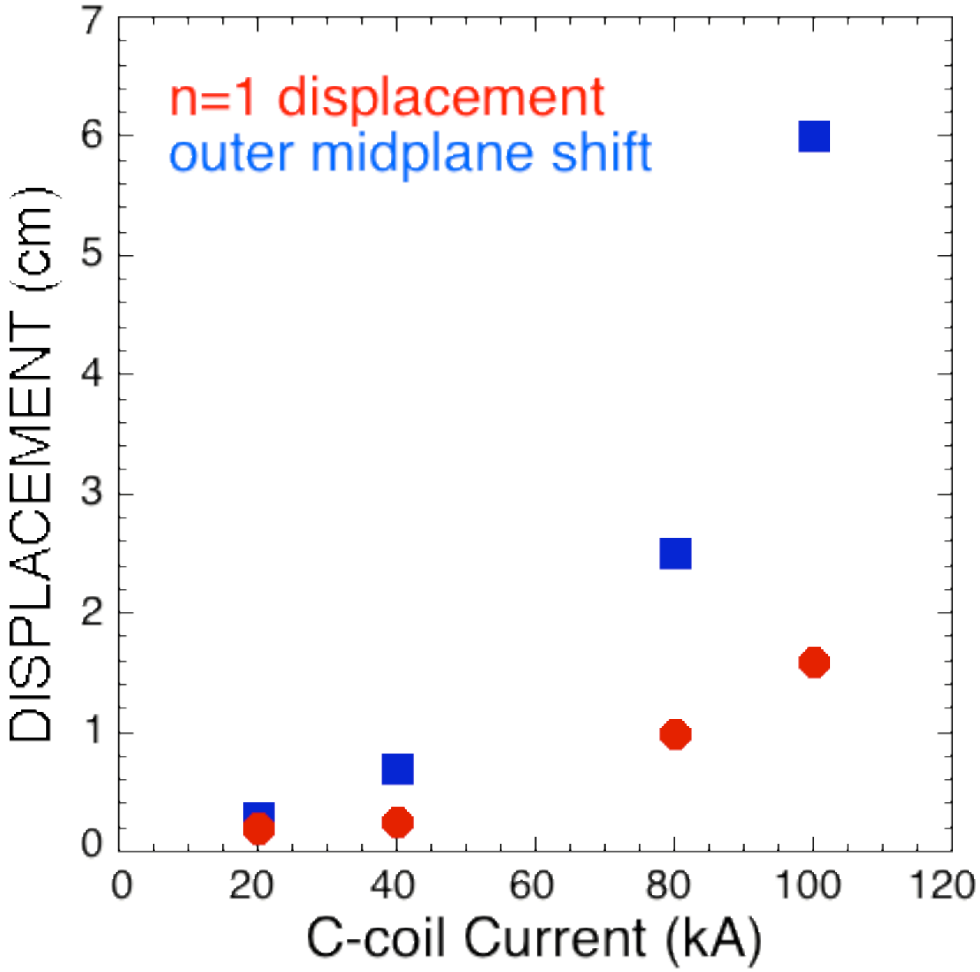
Increased plasma-halo current separation reduces displacement

- Increased separation equivalent to more distributed halo current.
- Plasma-coil separation for this example is ≈18□m.
- Significant displacement of outer flux surface is also seen.



C-coil is even less effective at generating displacements

- Displacement is vs. peak in sinusoidally distributed currents.
- Lowest current point is full current for C-Coil.
- Even greater shift of outboard midplane flux surface.
- Response is non-linear?



Summary

- Non-axisymmetric distortions of plasma surface have been calculated for DIII-D like plasma equilibrium.
- Coils simulating the DIII-D C-coils and approximating halo currents (a few cm from plasma surface) have been studied.
- Expected asymmetrical distortions of less than a cm are expected from C-coils (combined with comparable symmetrical distortions.
- Halo currents could cause distortions of up to a few cm, with a possible strong non-linearity.

Summary (cont.)

- Increasing displacement with β (up to no–wall β limit?) has been seen.
- Future planned work includes:
  - Investigate effect on interior flux surfaces
  - Vary pitch of halo current coil
  - Apply PIES and Terpsichore to equilibria
  - Full 3-D VMEC?
  - Introduce I-coil, other F-coil distortions?
  - NSTX?