Helical structures and improved confinement in the MST RFP

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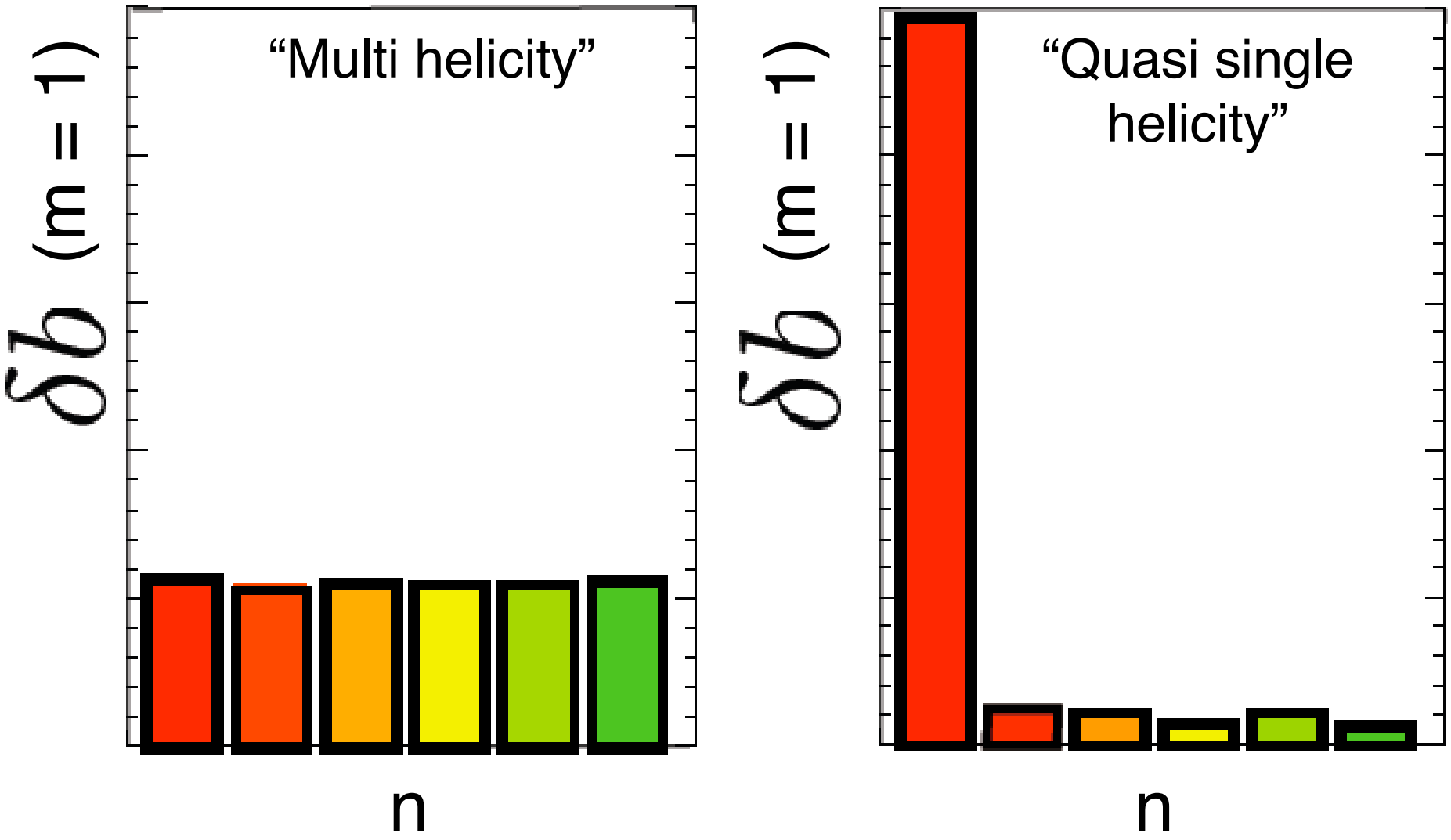
A range of tearing spectra emerges spontaneously in MST

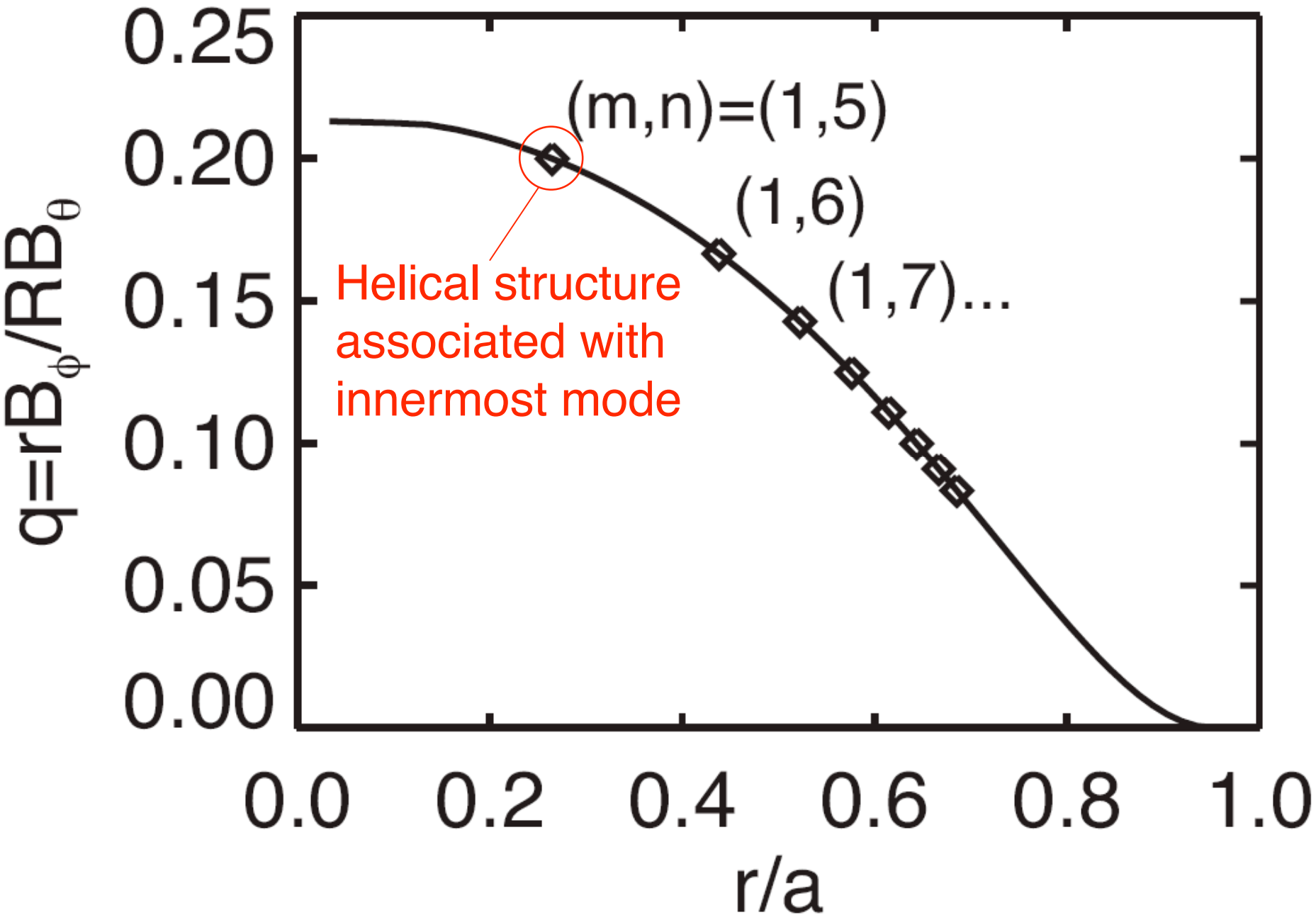


- Helical structure observed over entire range

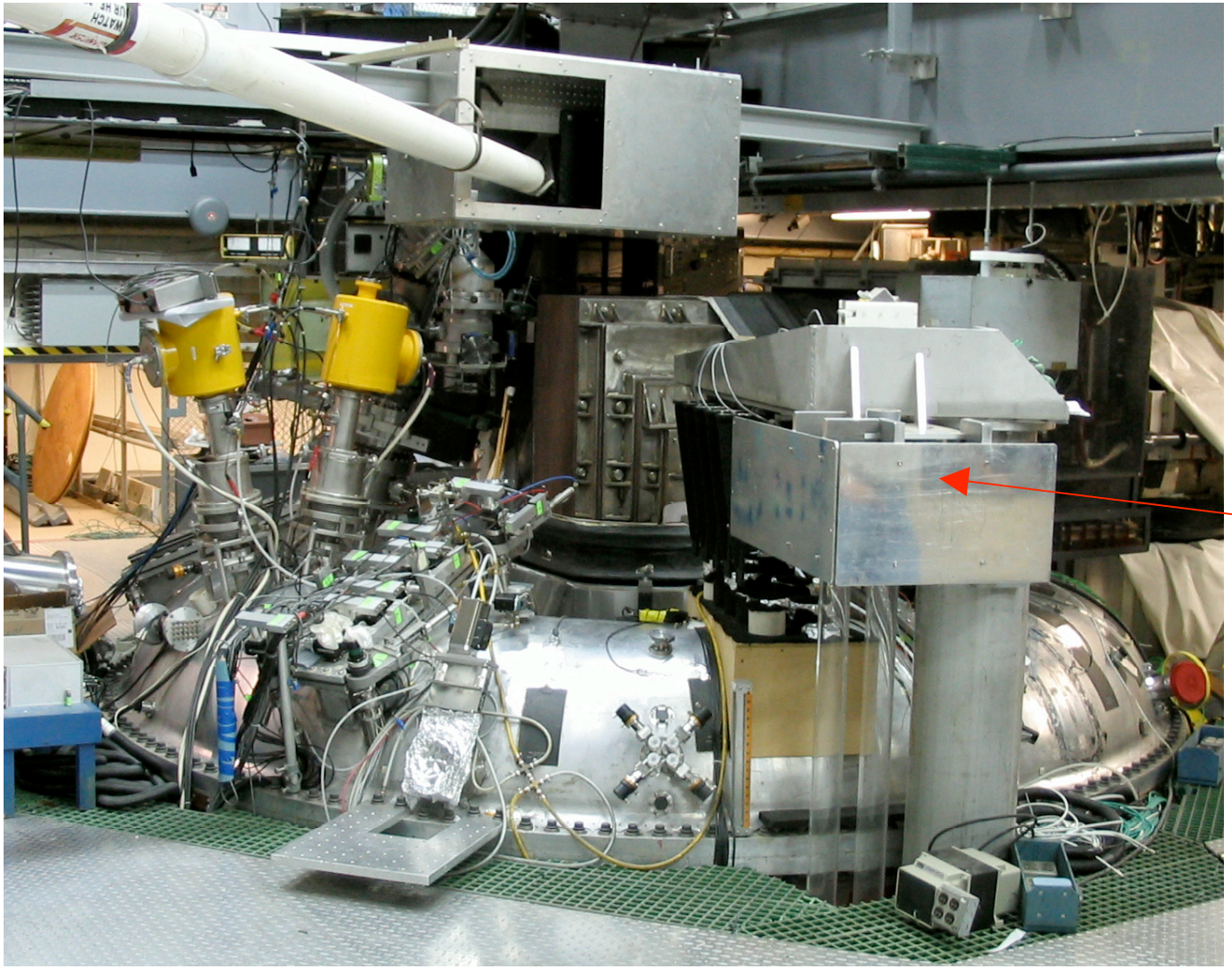
Outline

- RFP equilibrium
- MST device
- Helical structure with flat spectra
- Helical structure with peaked spectra
- Helical equilibrium with very peaked spectra
  - internal detection of change in magnetic topology

Equilibrium provides many resonant surfaces



MST = Madison Symmetric Torus



- R = 1.5 m
- a = 0.52 m

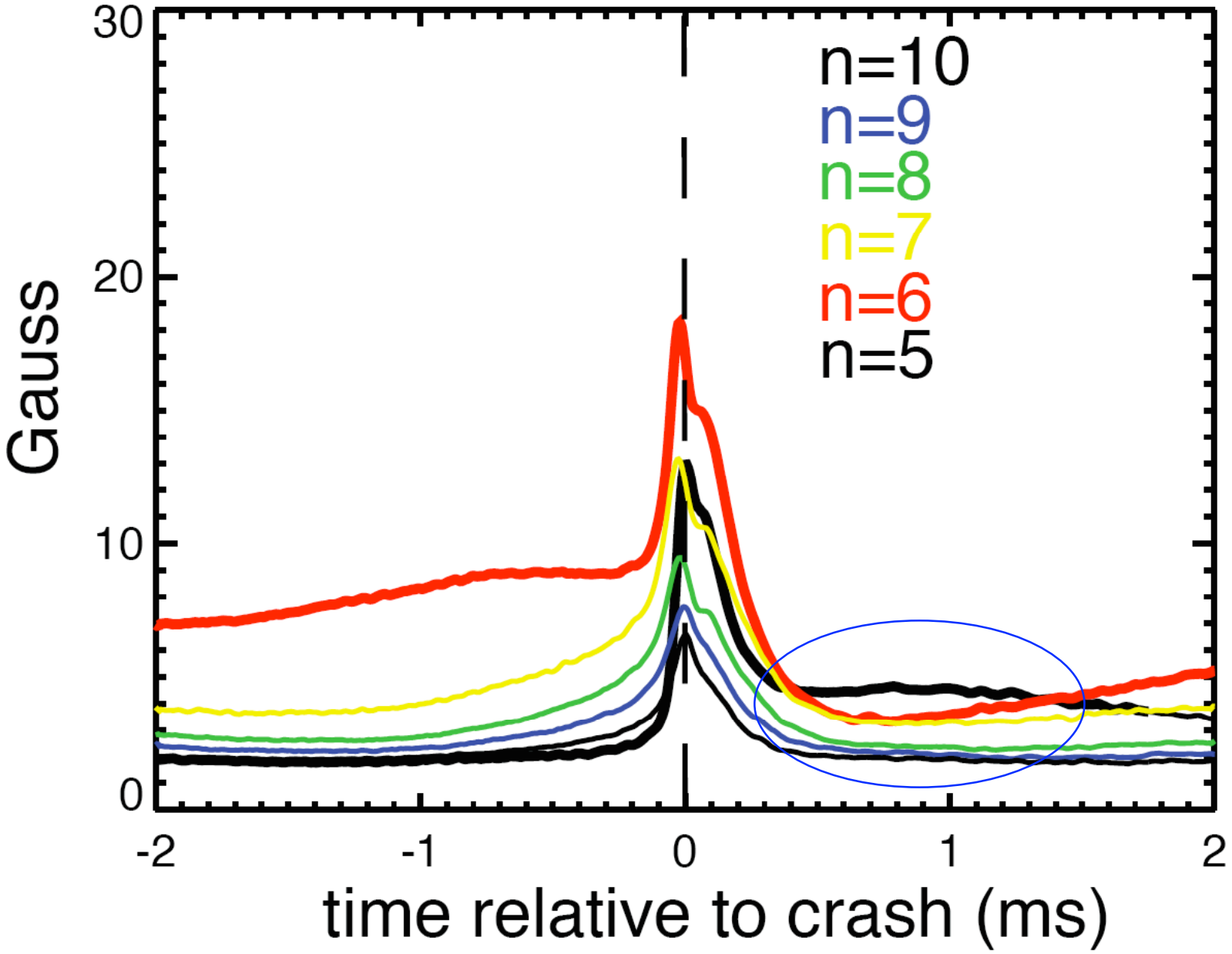
- Magnetic field diagnosis by:

  (1) Faraday rotation

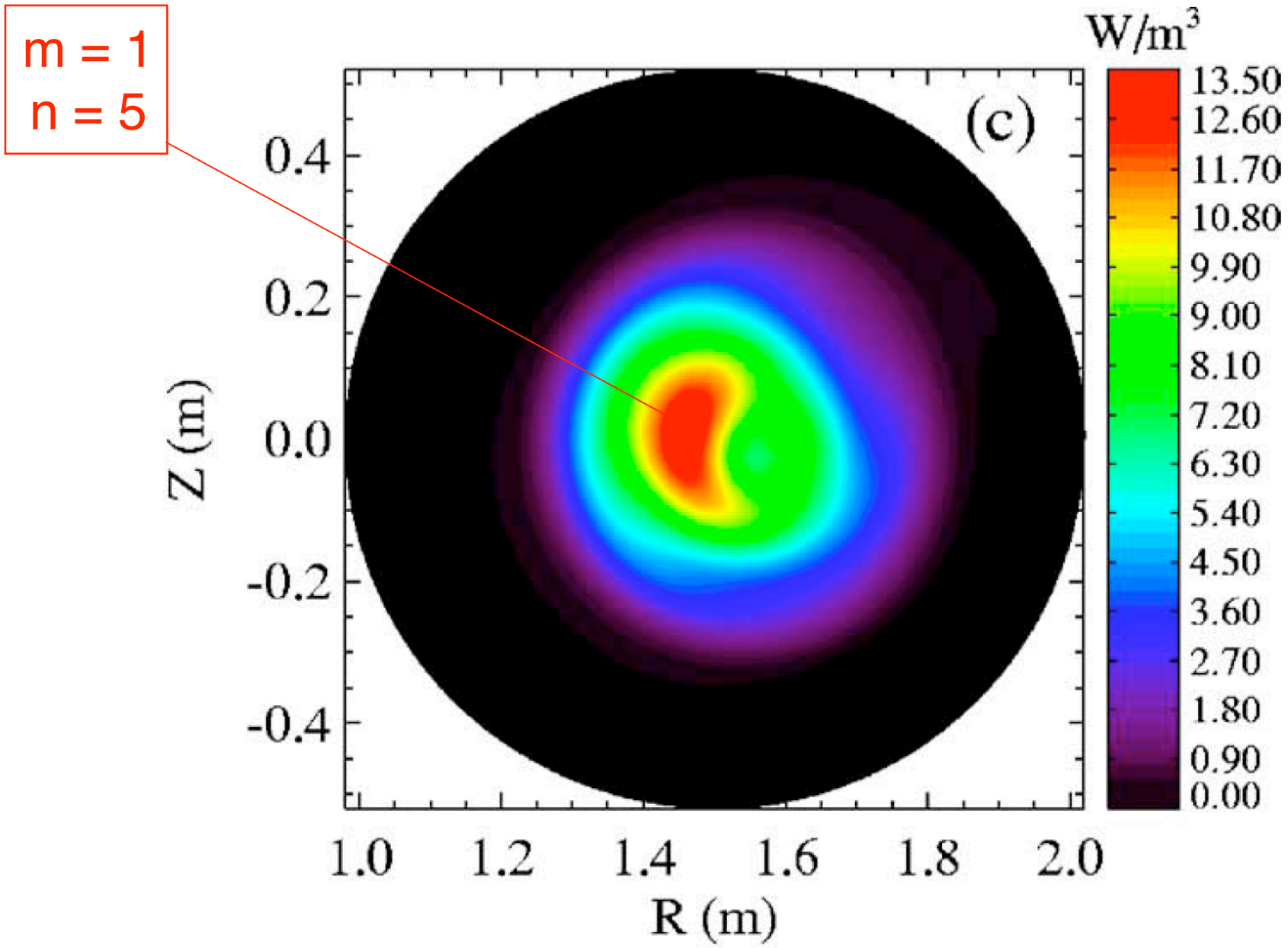
  (2) sensing coils at plasma boundary

Helical structure with flat mode spectrum

Spectrum fairly flat after sawtooth crashes

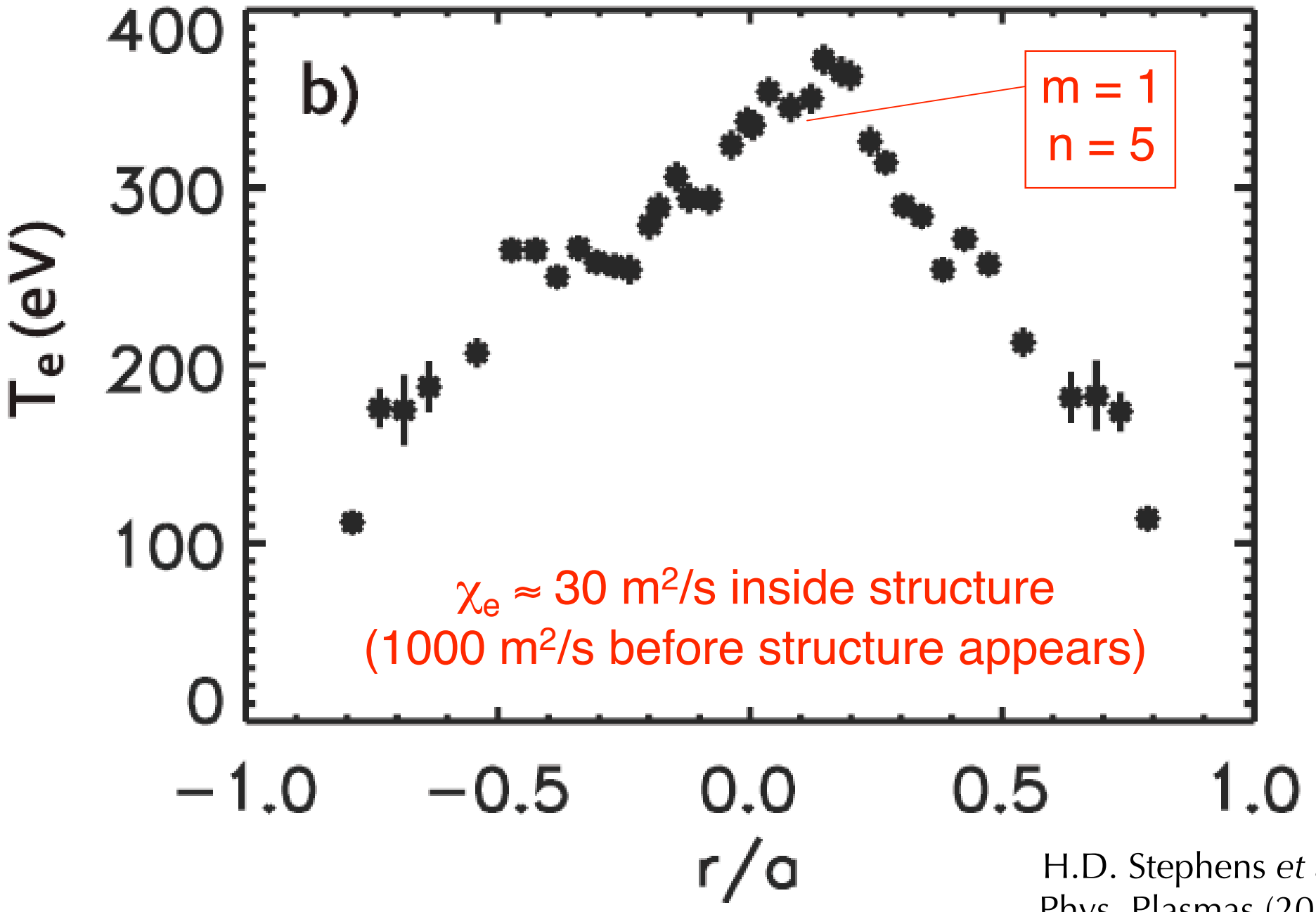


SXR structure observed post crash



P. Franz *et al.*, Phys. Plasmas (2006)

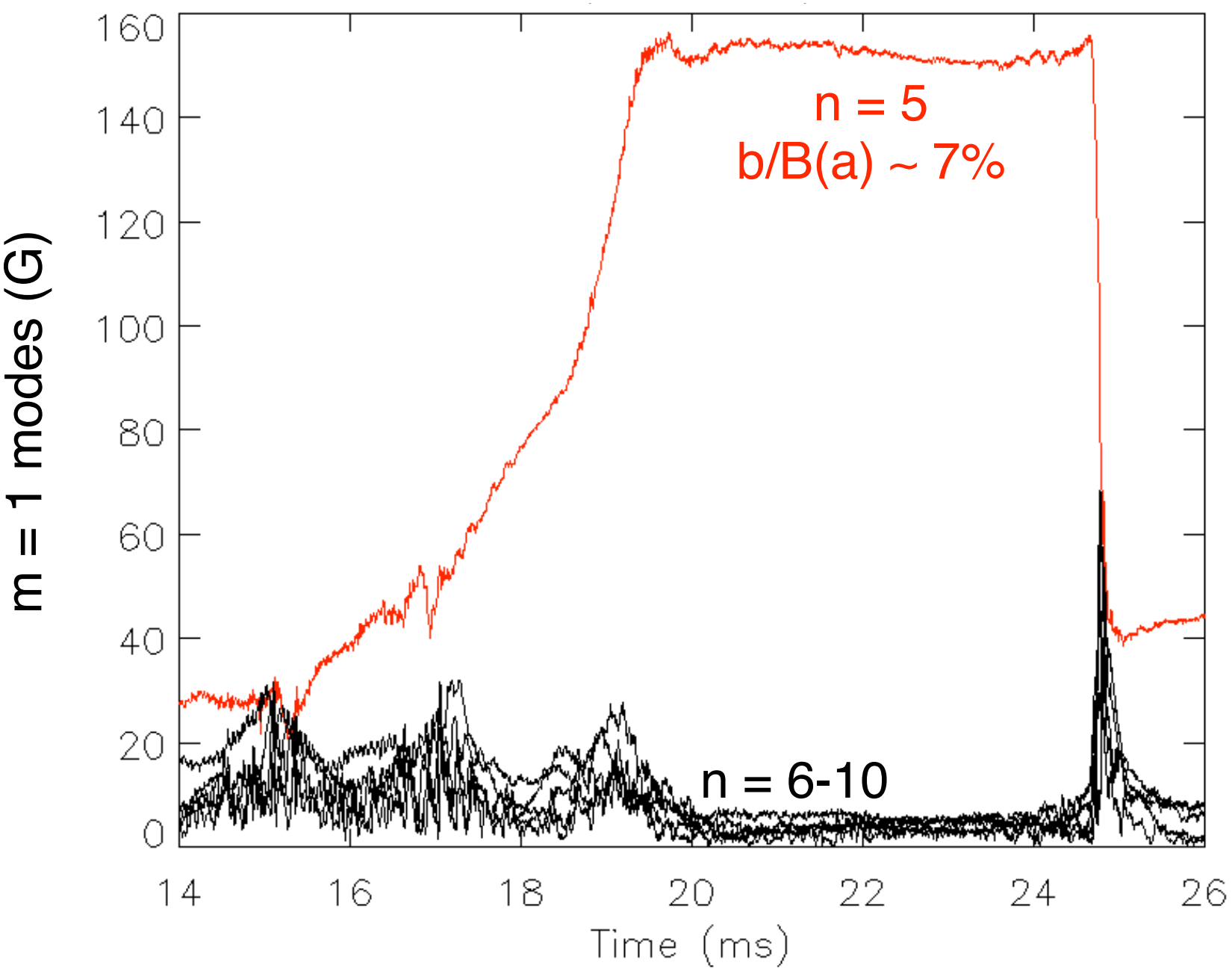
Te structure observed post crash



H.D. Stephens *et al.*,
Phys. Plasmas (2010)

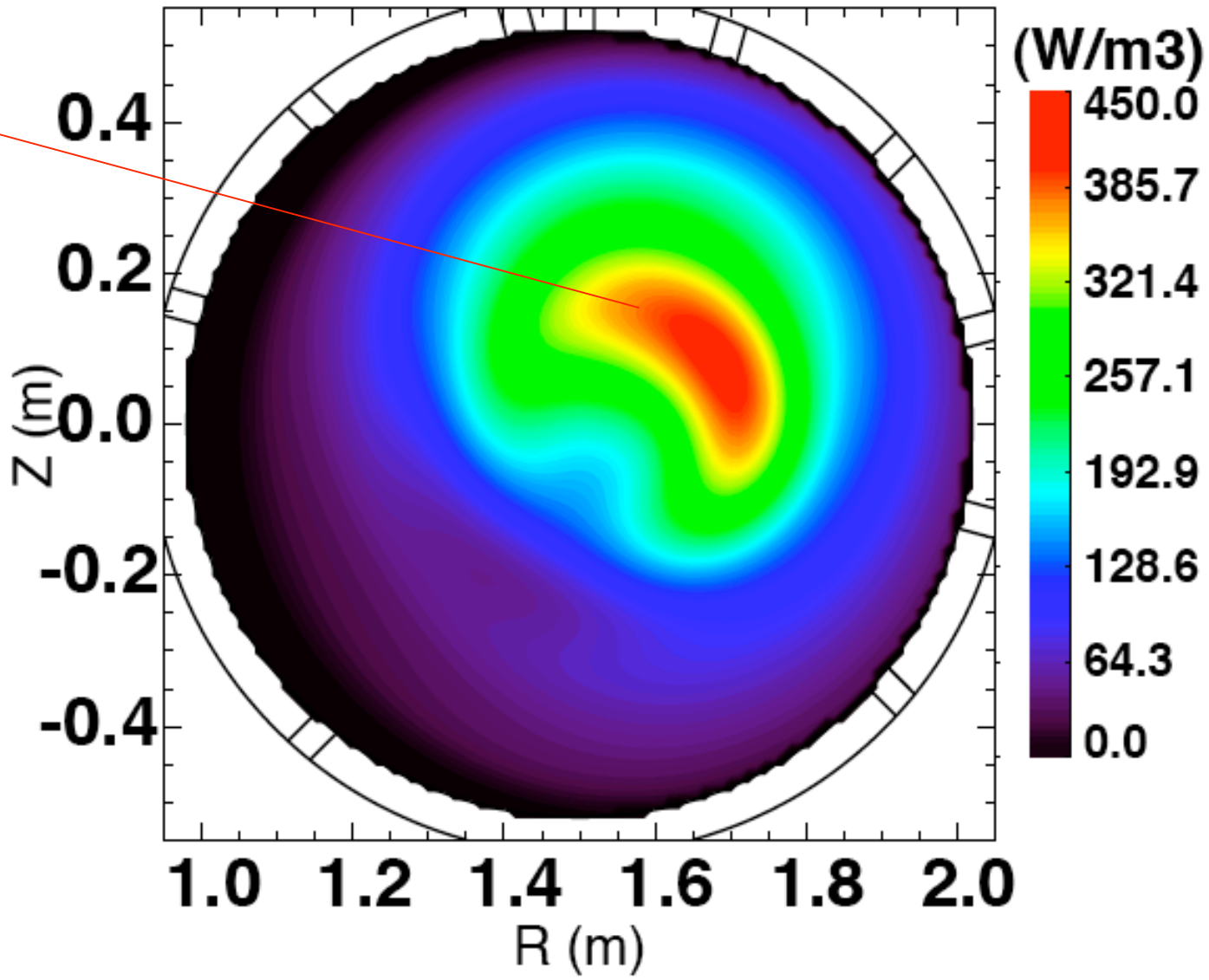
Helical structure with peaked mode spectrum

Some spectra are very peaked

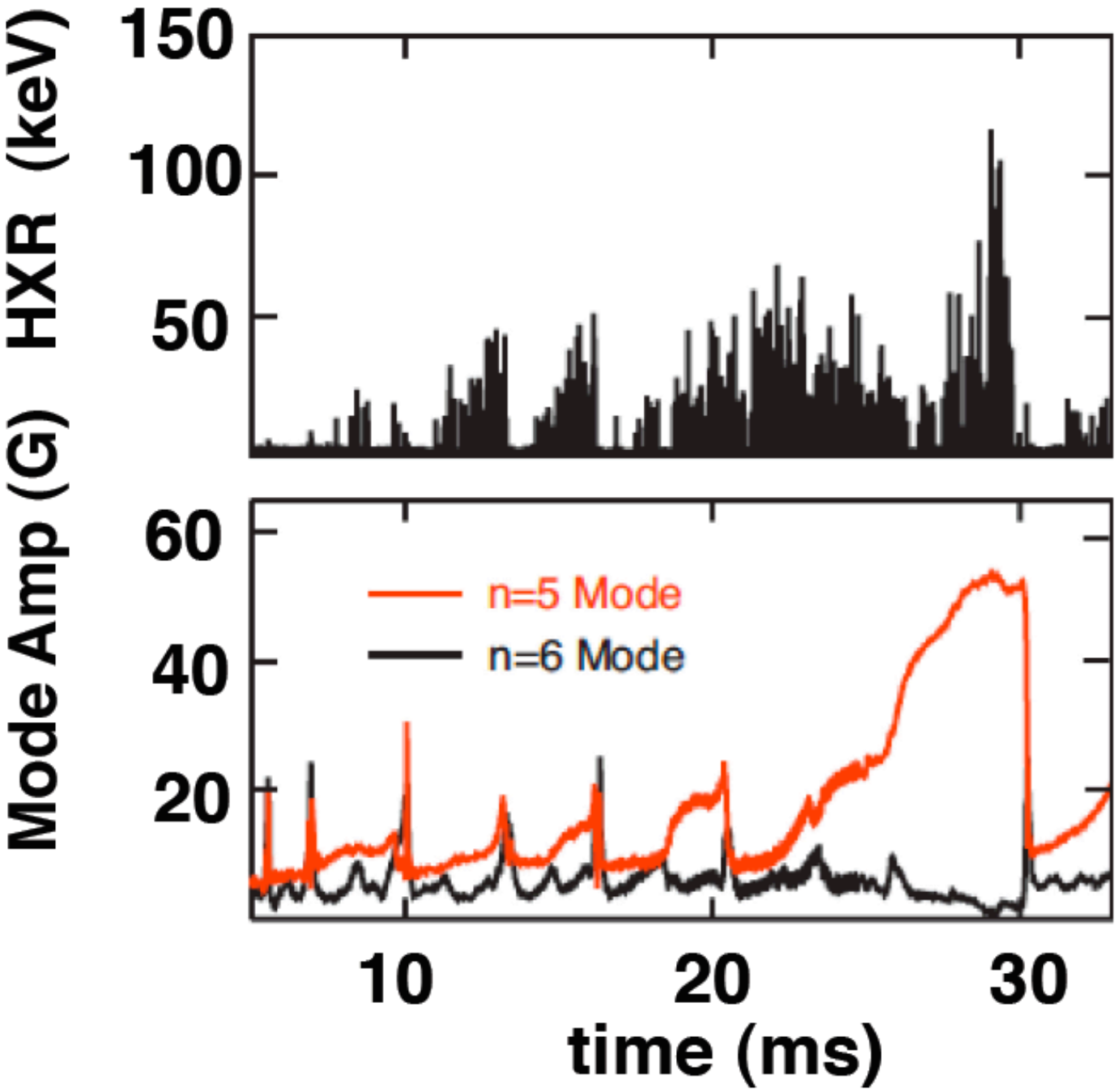


SXR structure observed with peaked spectra

m = 1
n = 5



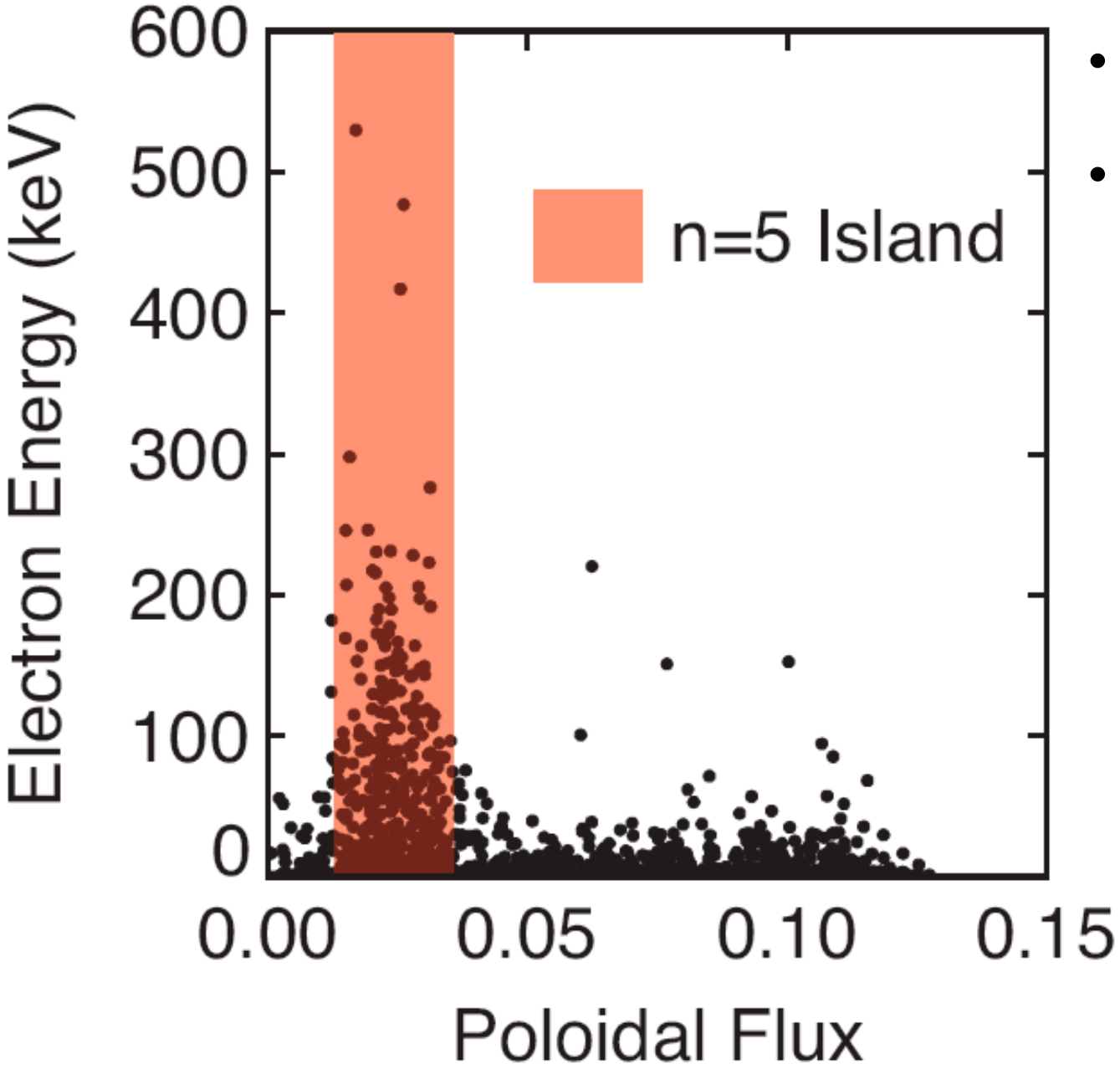
Runaway electrons occur with peaked spectra



- Runaways not common in RFP
- Imply region of reduced stochasticity

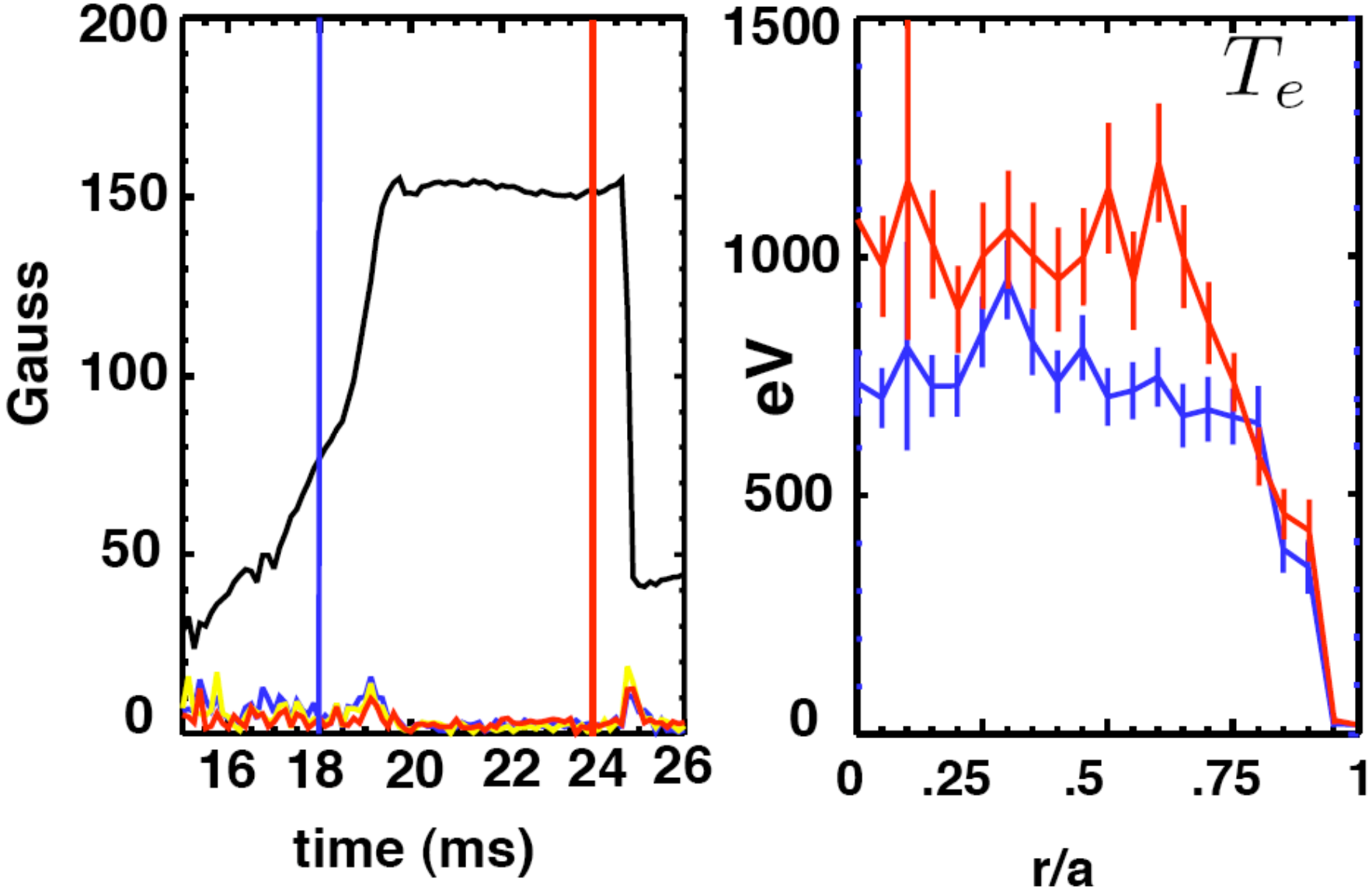
D.J. Clayton *et al.*, Phys. Plasmas (2010)

ORBIT: largest electron energy in island region



- Particles initially placed in island region
- Particle trajectories evolved for about 2 ms

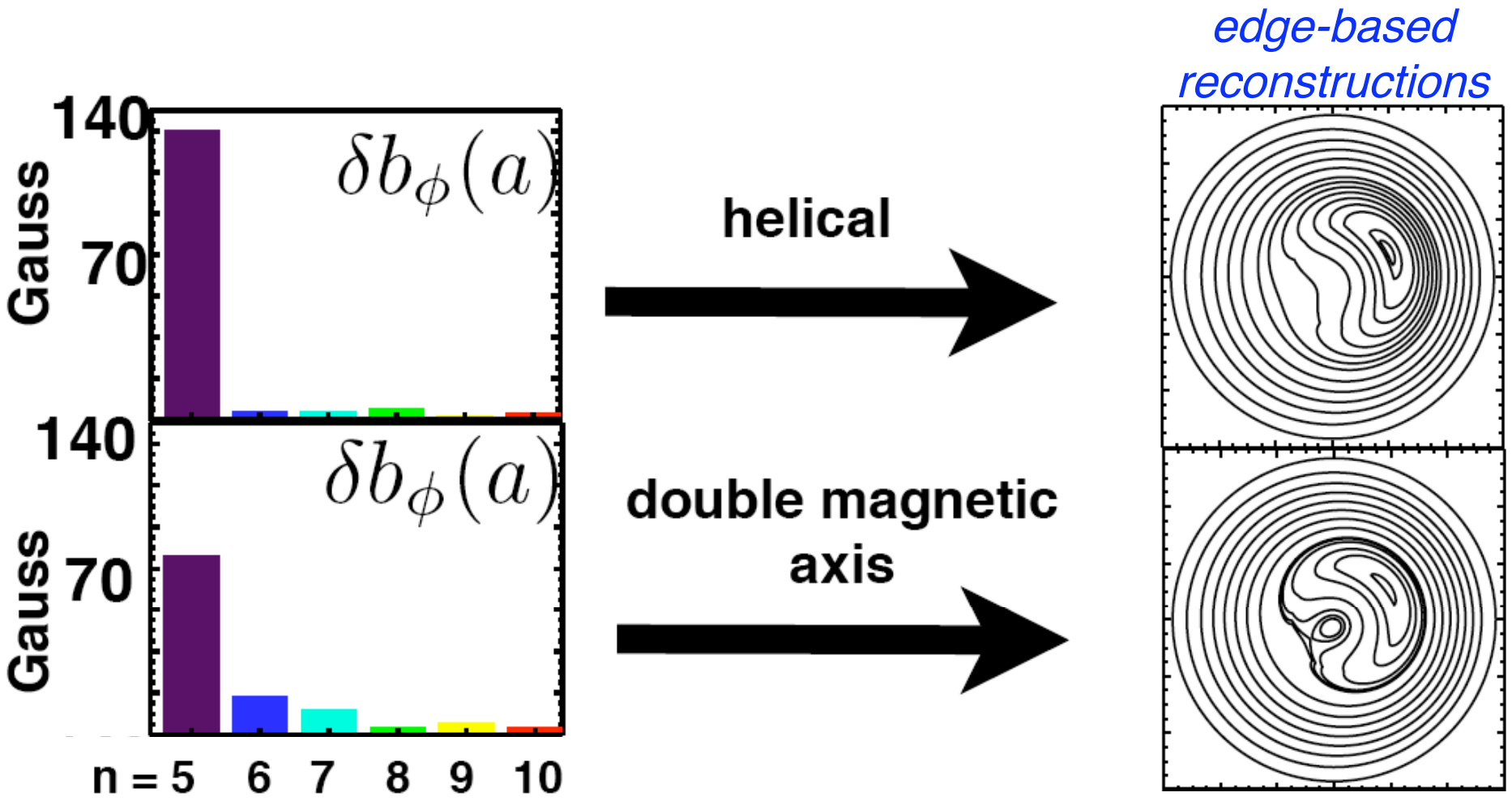
Core Te increases with peaked spectra



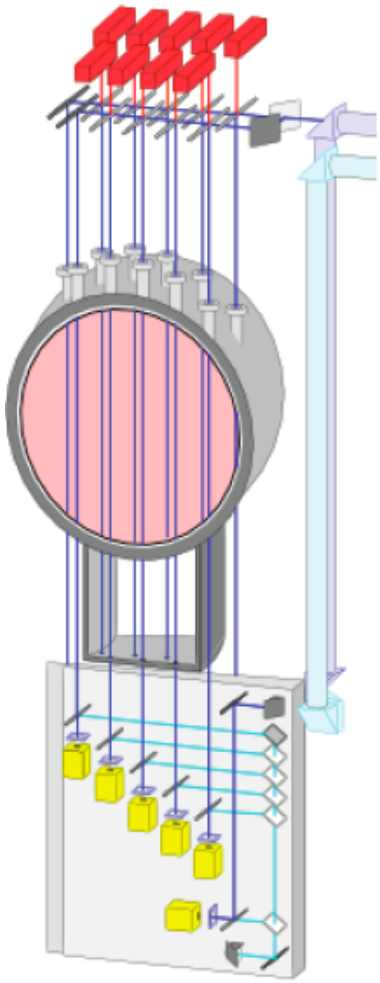
- Global energy confinement likely increased several fold

Emergence and detection of helical equilibrium on MST

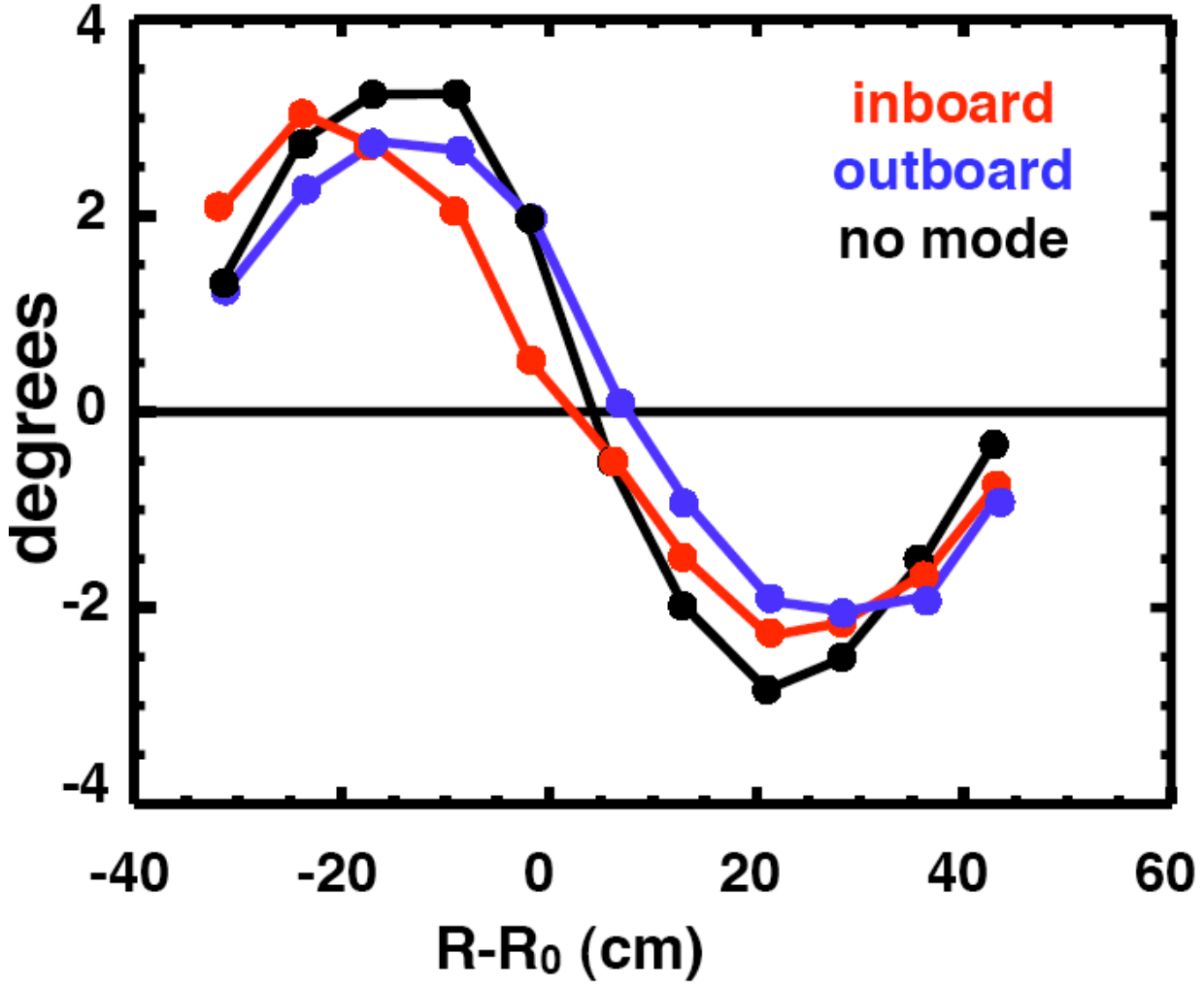
In most-peaked spectra, equilibrium is helical



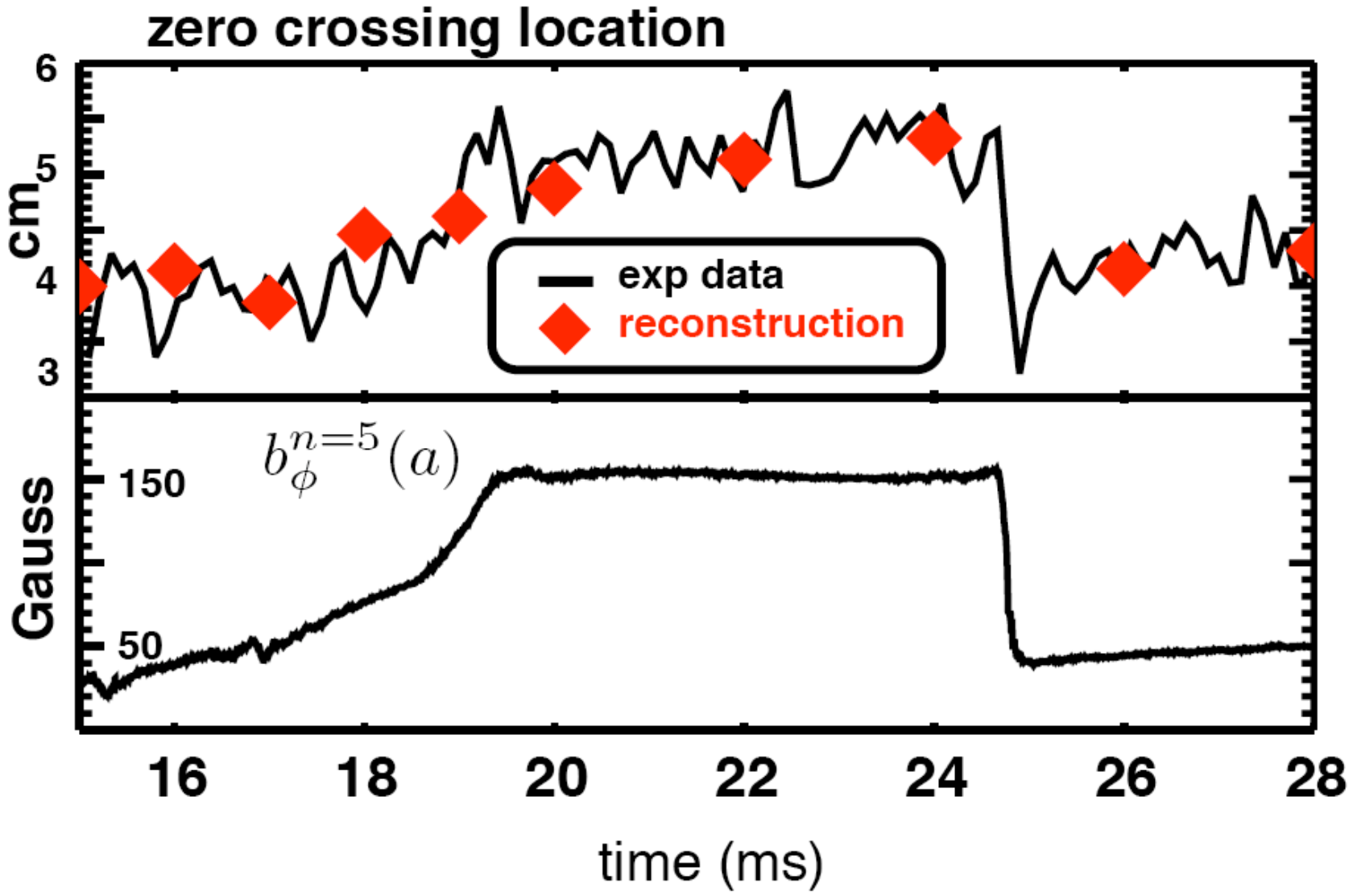
Faraday rotation diagnostic sensitive to change in equilibrium



$$\Psi \propto \int n_e B \cdot dl$$



Magnetic reconstructions track evolution of Faraday rotation zero crossing



- Faraday rotation not a constraint in the reconstructions

Summary

- Helical structures common in MST
- Associated with confinement improvement

- Most-peaked spectra produce helical equilibrium
- Alteration of equilibrium detected by Faraday rotation
- Increases confidence in edge-based magnetic reconstructions