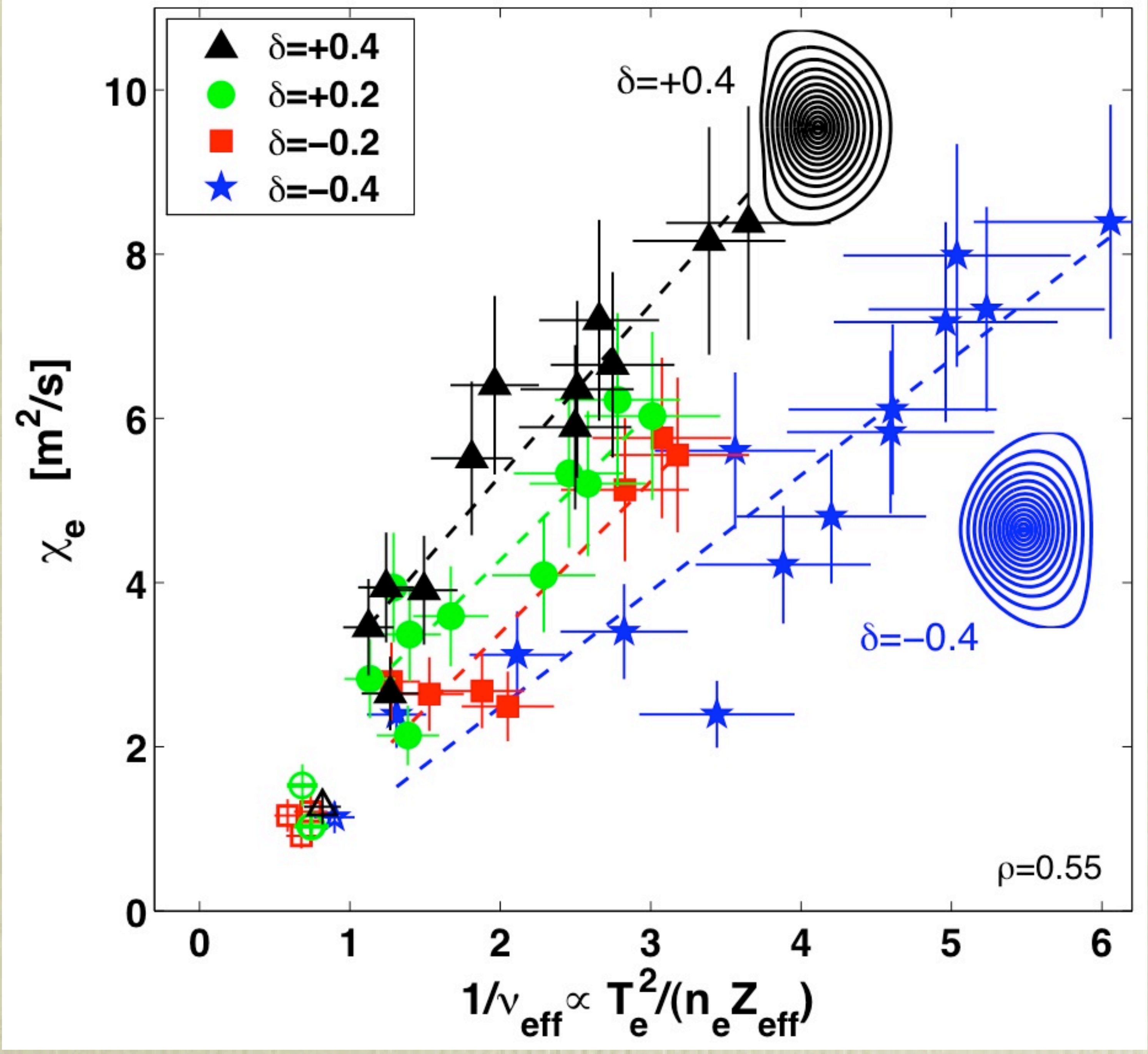
The effect of plasma triangularity on turbulent transport:

modelling TCV experiments by linear and non linear gyrokinetic simulations

Motivation

Negative triangularity improves electron heat transport in low density L-mode plasmas



Y.Camenen Nucl. Fusion 47 (2007), 510

OUTLINE

Electron heat transport

- Linear analysis
- Non-linear simulations
- Insight on particle drifts

Linear simulations

Sign of real frequency

Most unstable kinetic specie

Spectral region of most unstable modes

Instability of trapped and passing particles

Linear simulations

Sign of real frequency

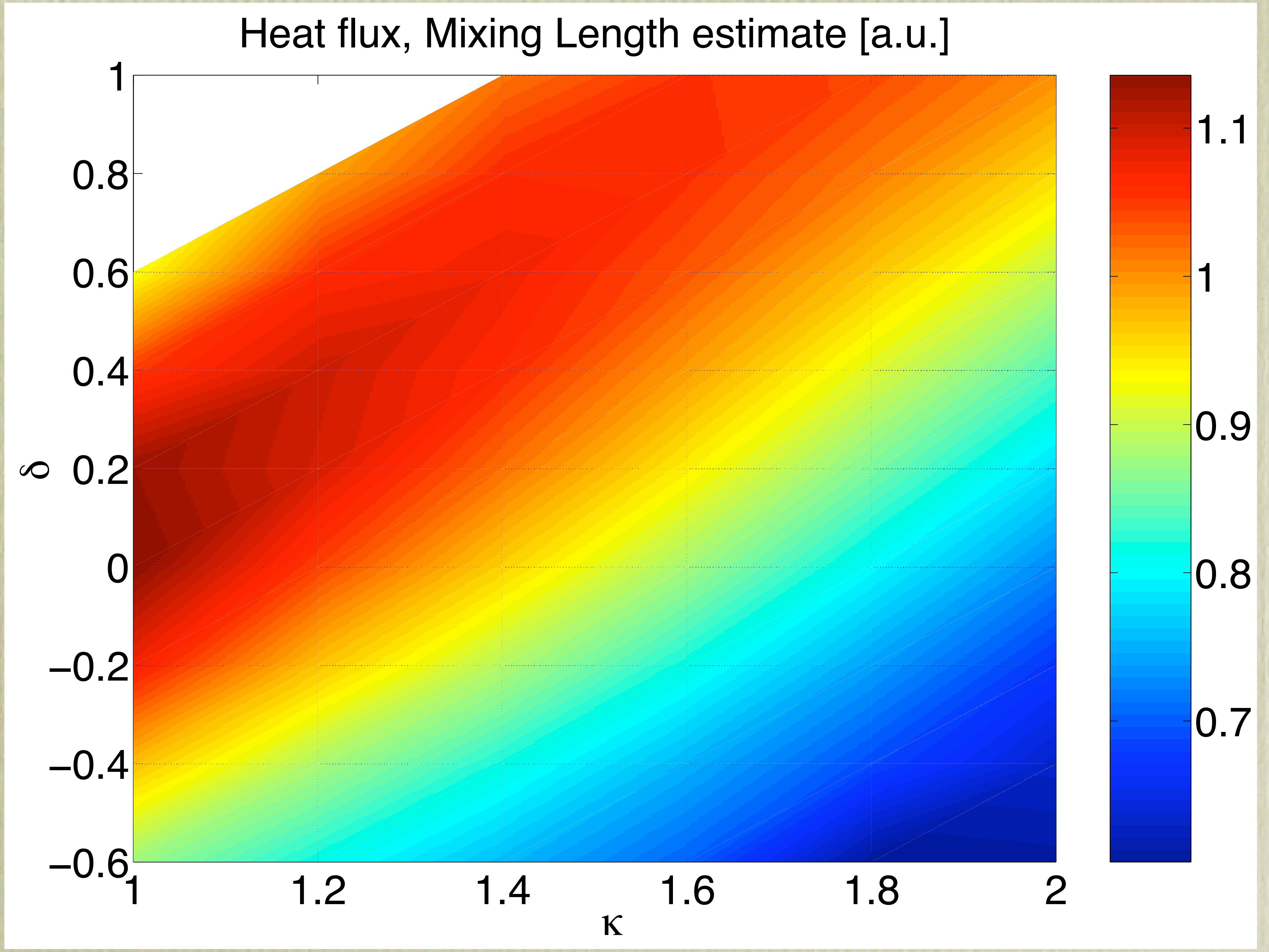
Most unstable kinetic specie

Spectral region of most unstable modes

Instability of trapped and passing particles

Trapped Electron Mode dominated

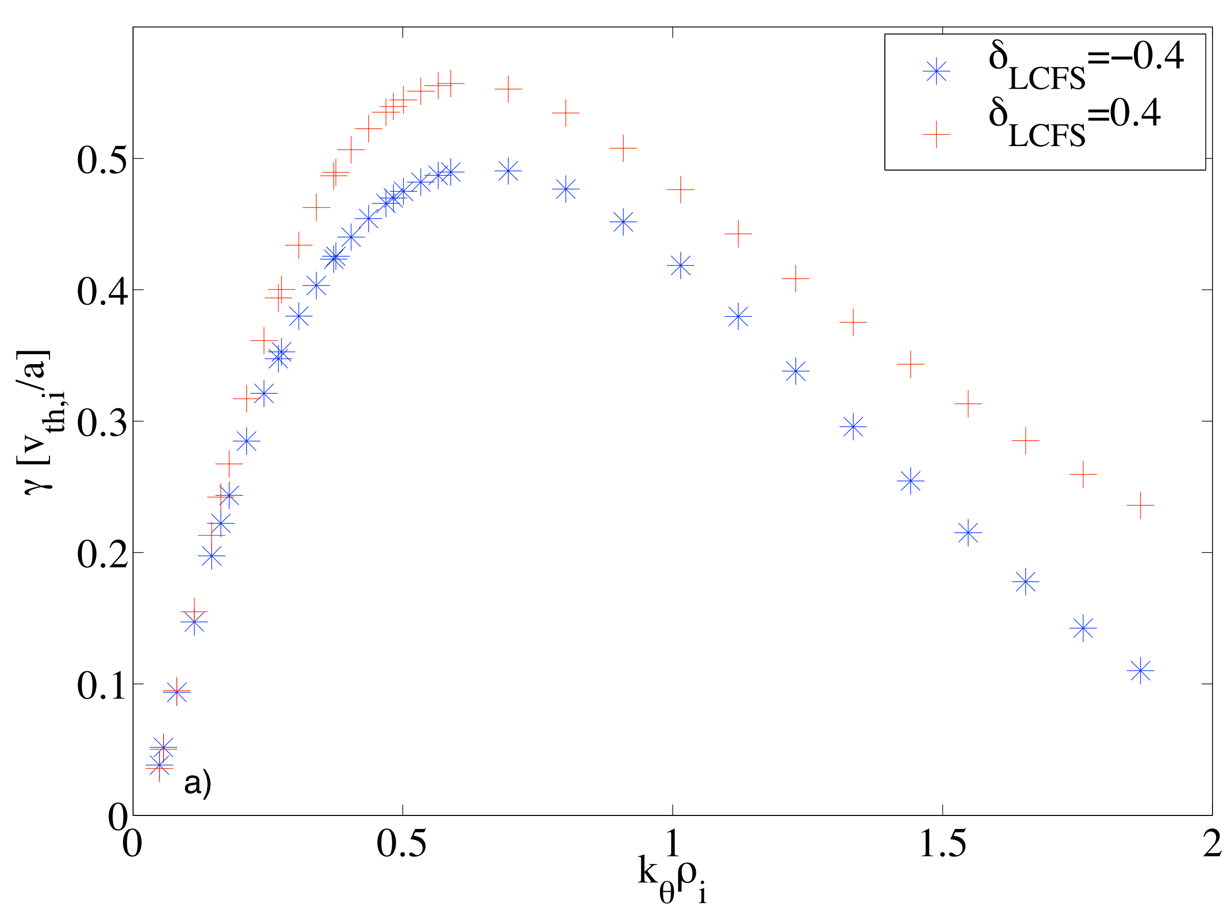
Linear simulations



- Same current and pressure profiles
- Change the shape of the LCFS
- Numerical equilibrium read by GS2

Stabilizing effect of triangularity and elongation

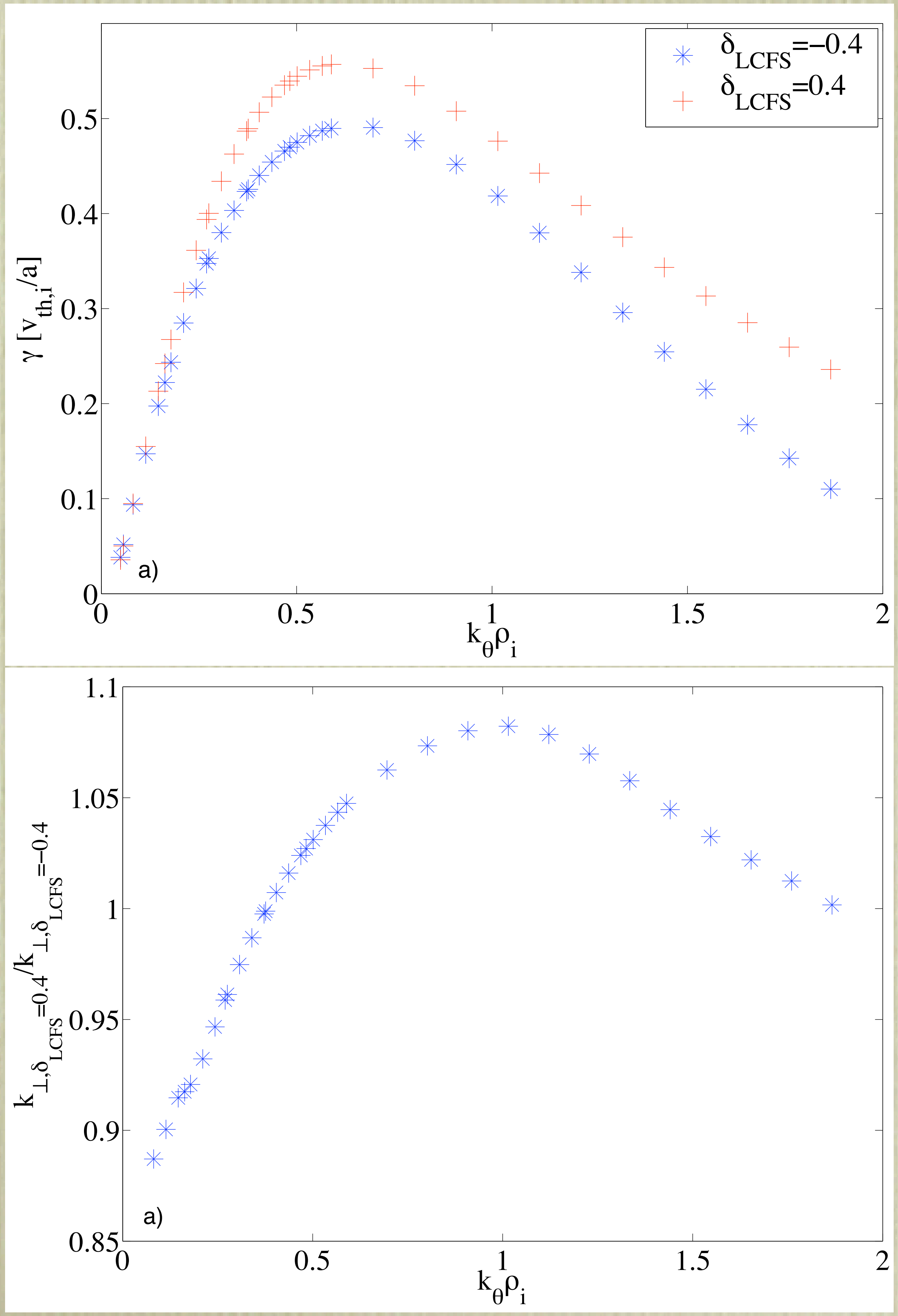
Linear simulations



Negative delta

Less unstable

Linear simulations

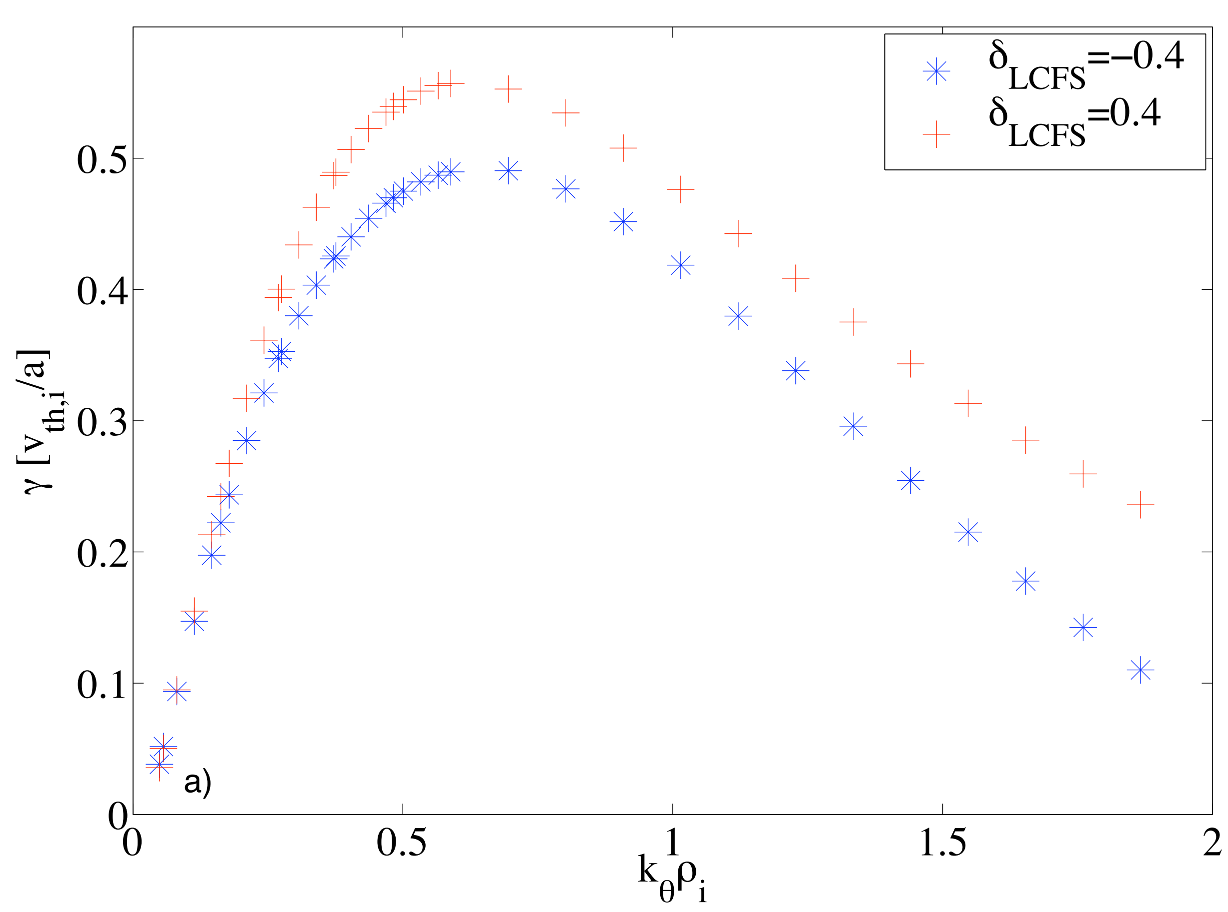


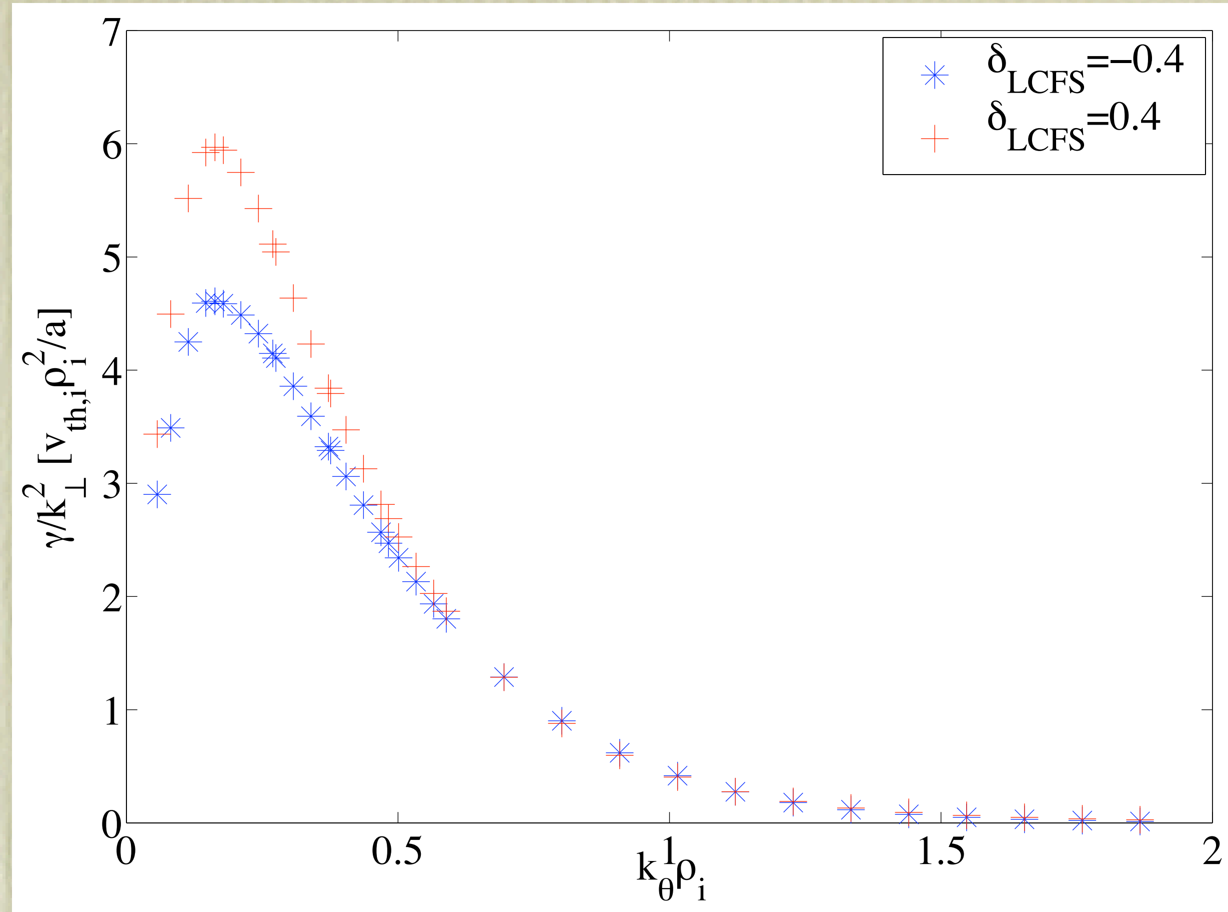
<u>Negative delta</u>

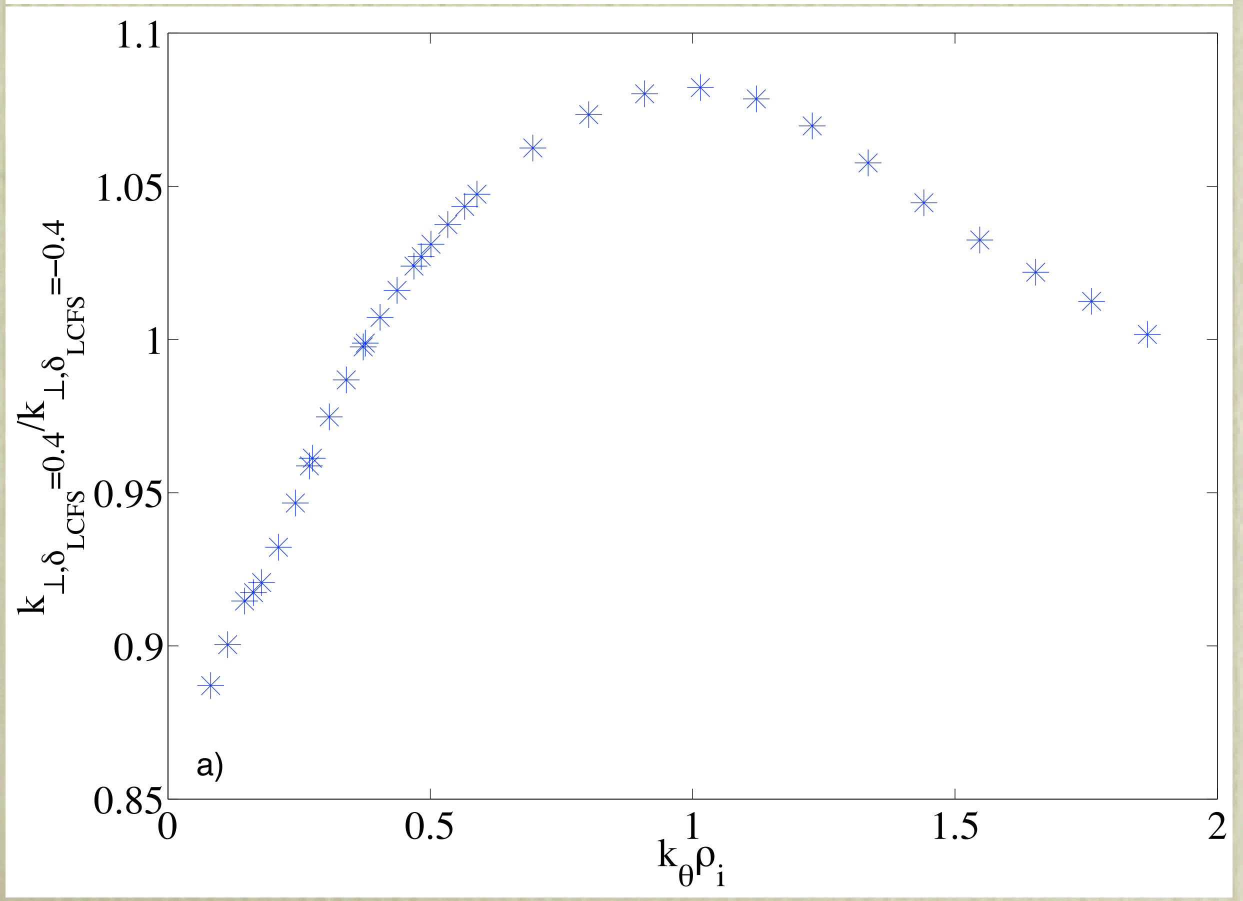
Less unstable

Shorter perpendicular wavelengths

Linear simulations







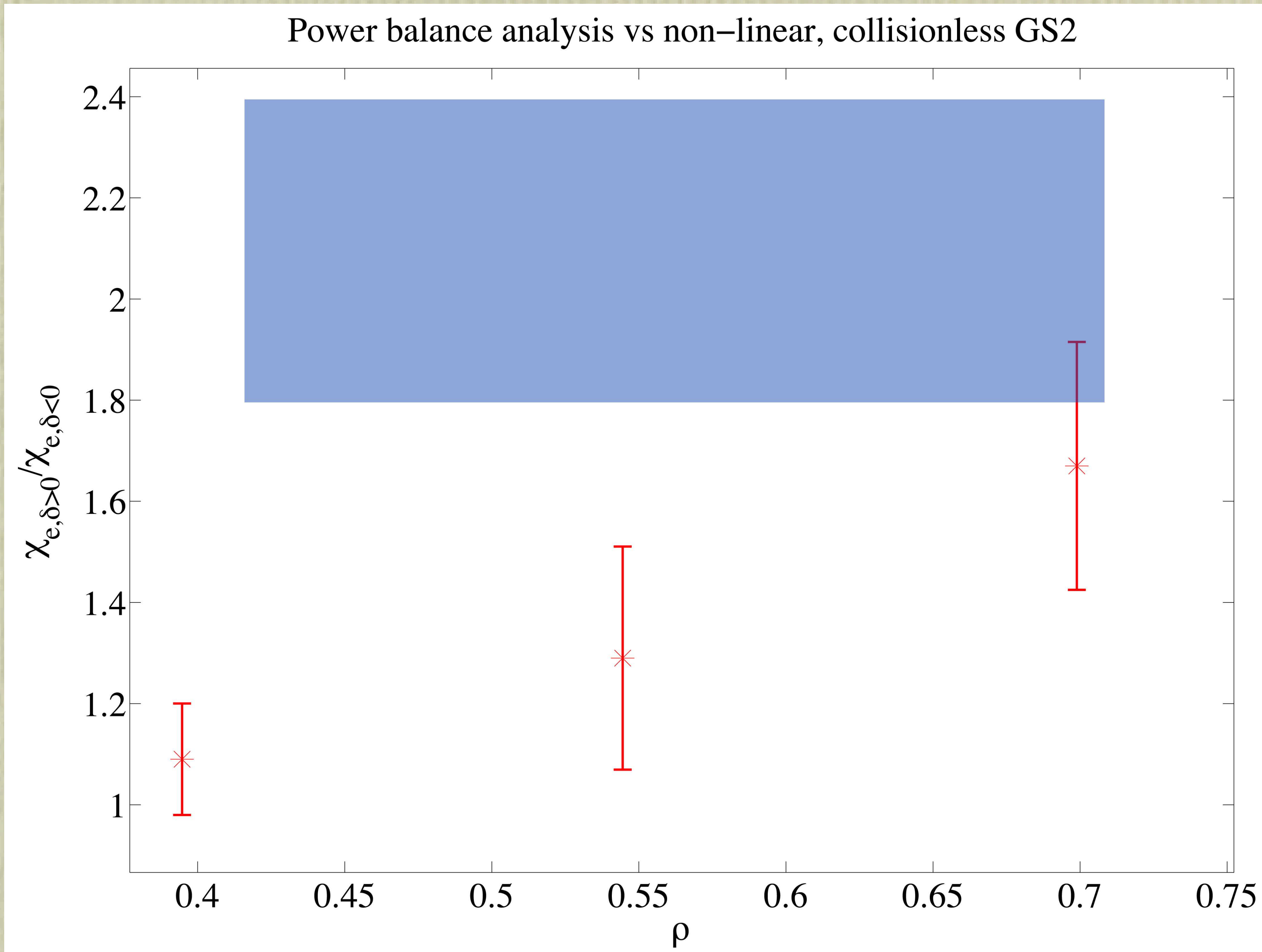
<u>Negative delta</u>

Less unstable

Shorter perpendicular wavelengths

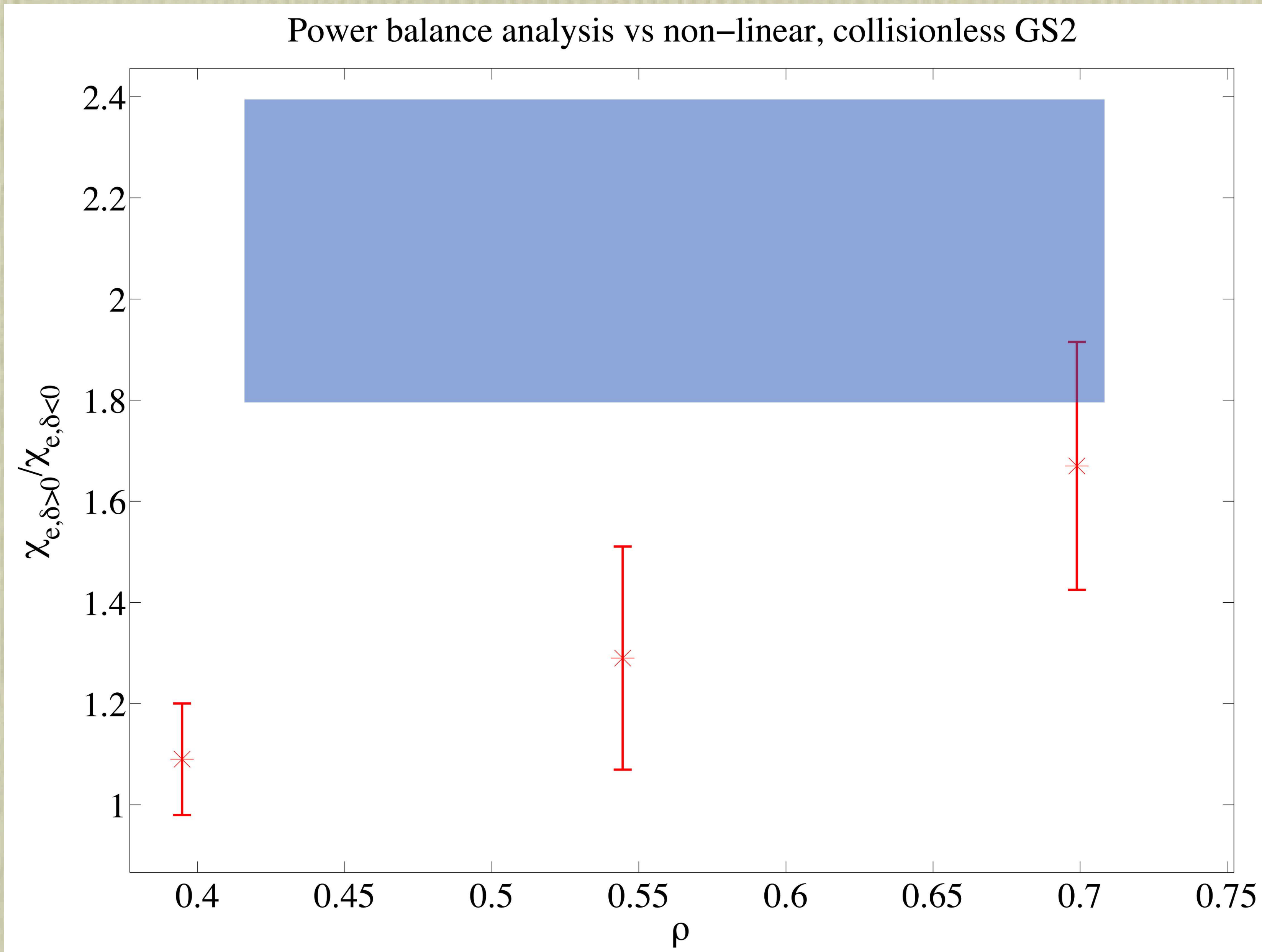
Reduced transport

Non linear simulations



Satisfactory agreement only close to the plasma edge

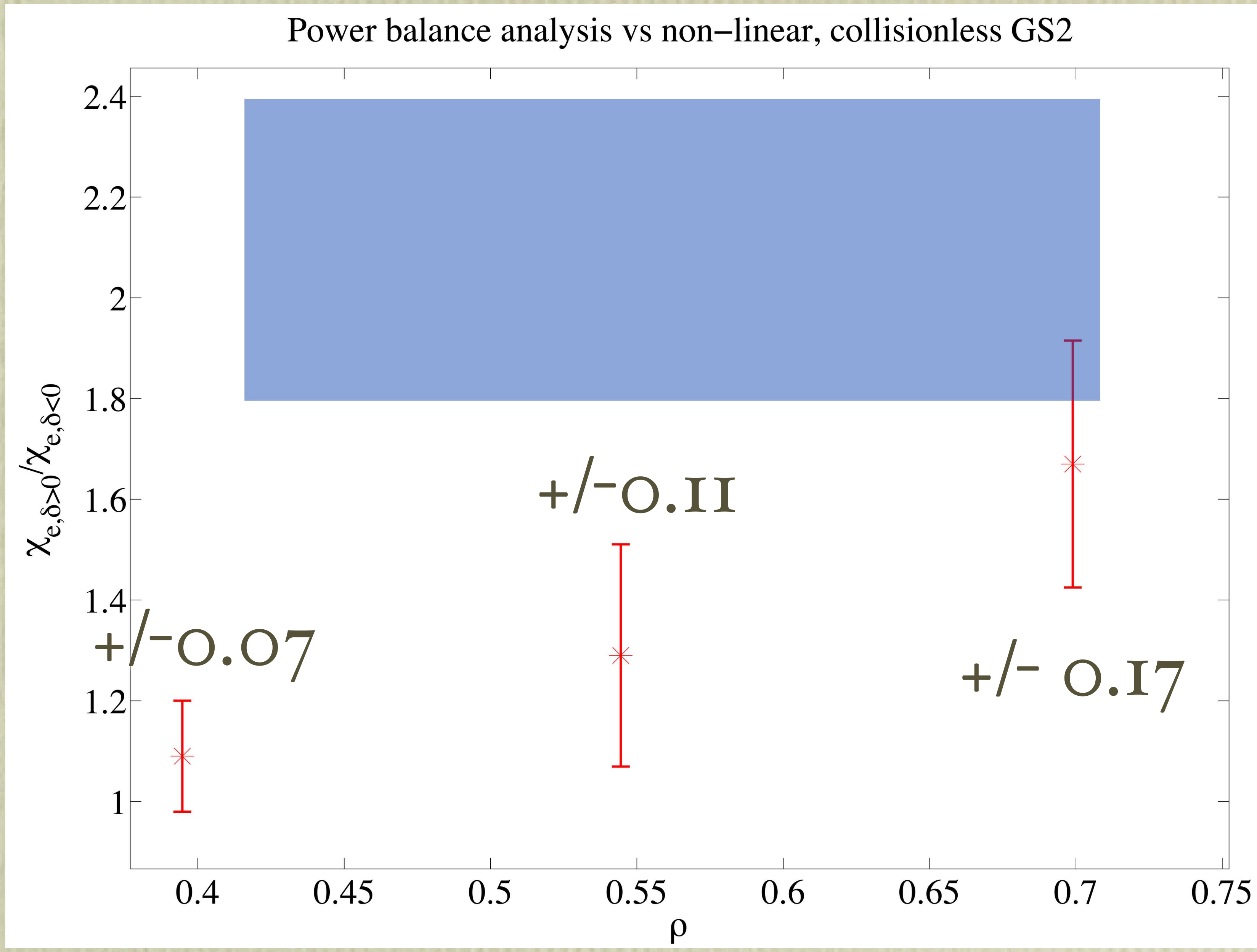
Non linear simulations



Satisfactory agreement only close to the plasma edge

finite penetration depth of triangularity?

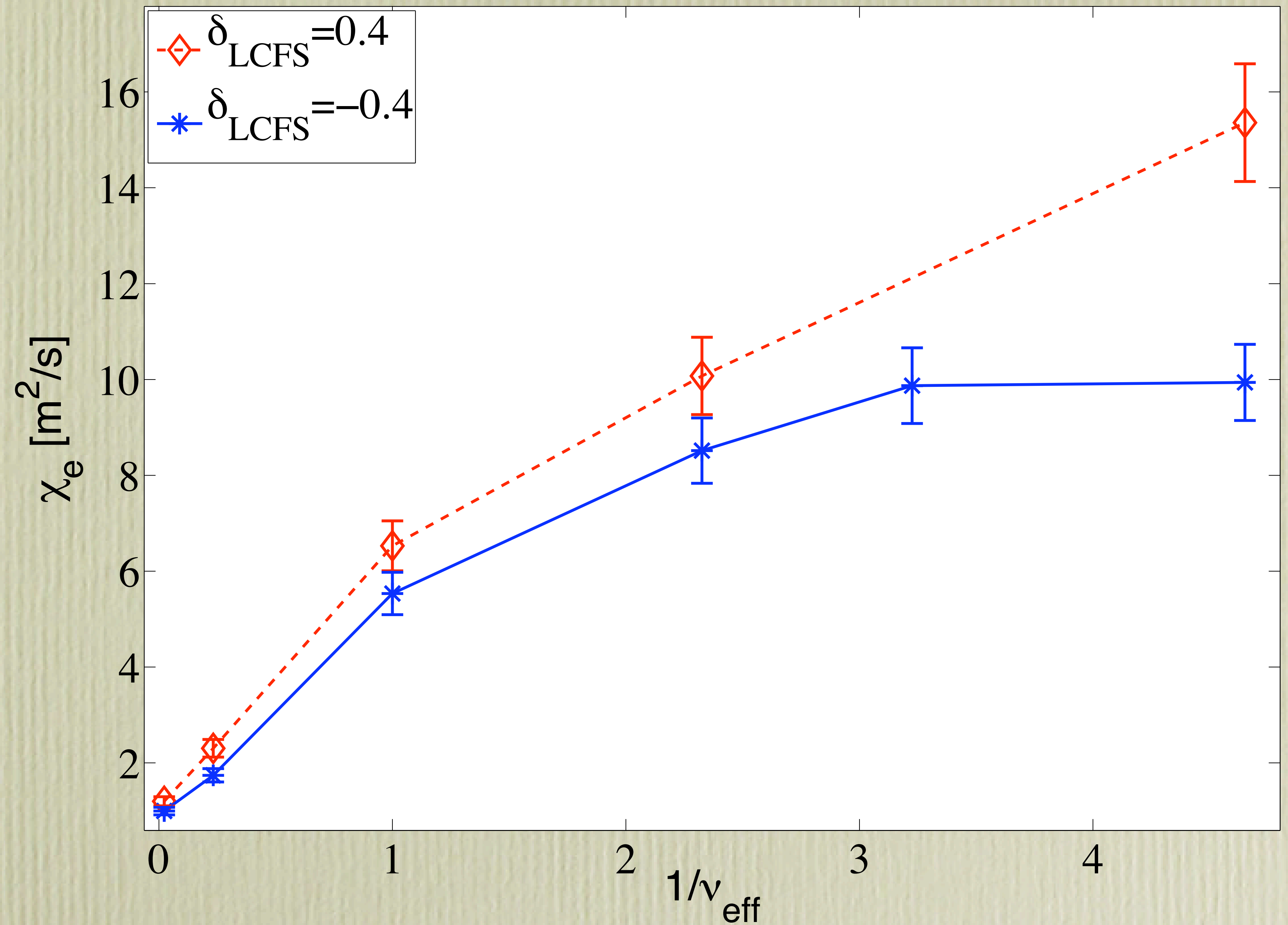
Non linear simulations



Satisfactory agreement only close to the plasma edge

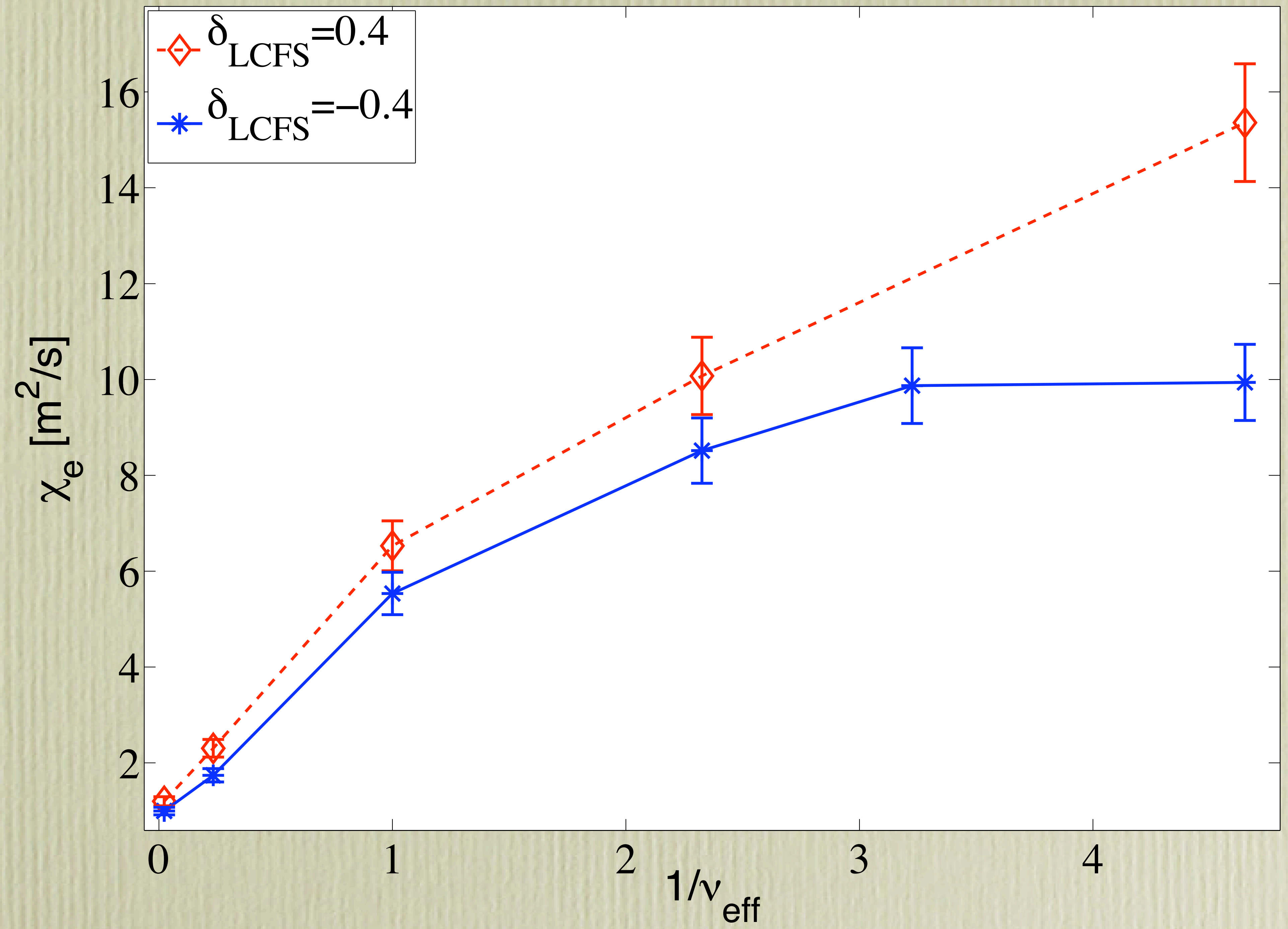
finite penetration depth of triangularity?

TEM and collisionality



No influence at high collisionality

TEM and collisionality

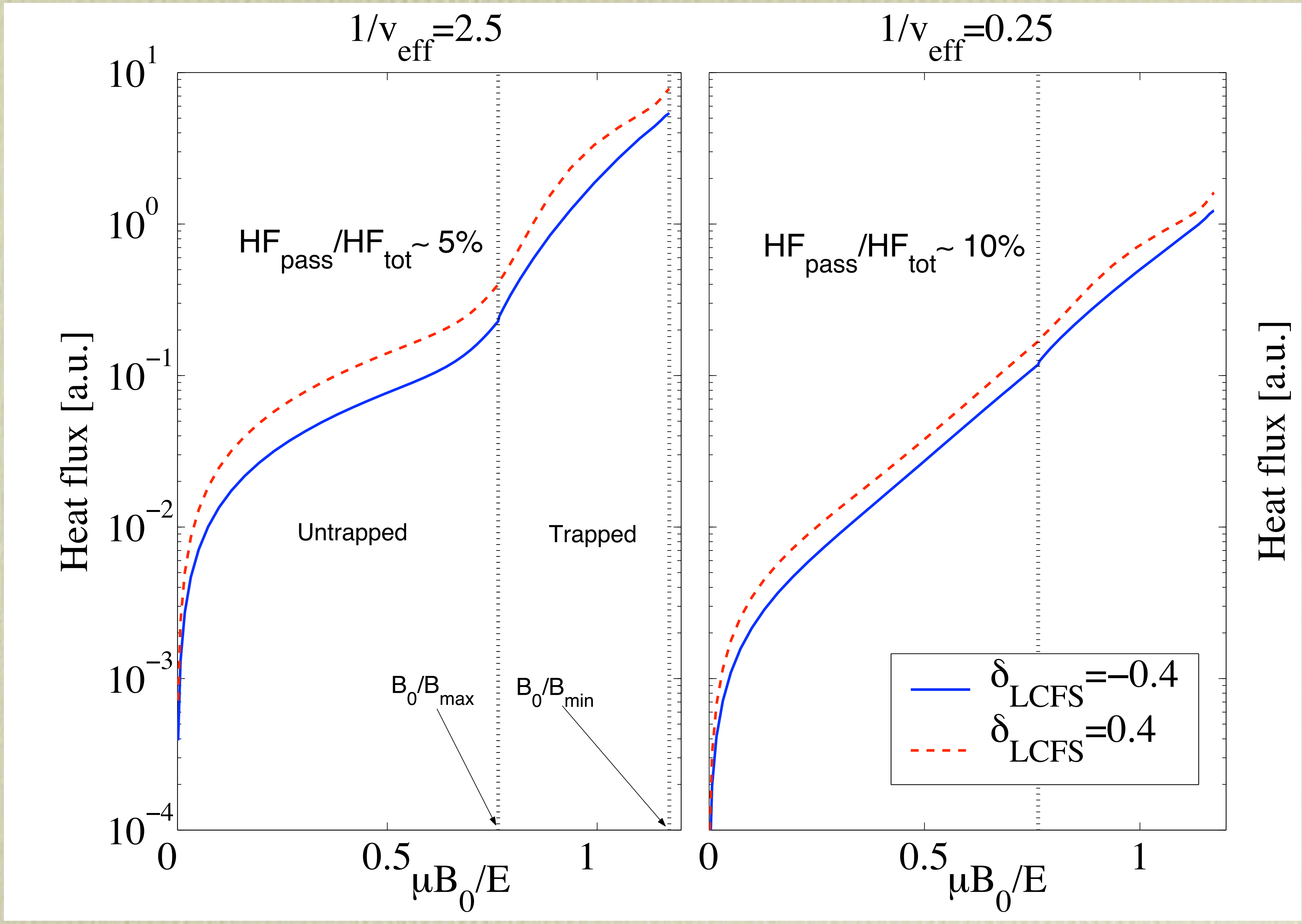


No influence at high collisionality

At low collisionality, its effect depends on triangularity

Phase space

Cumulative integral



Reduced difference between barely passing and barely trapped electrons as collisionality is increased

Particle drifts

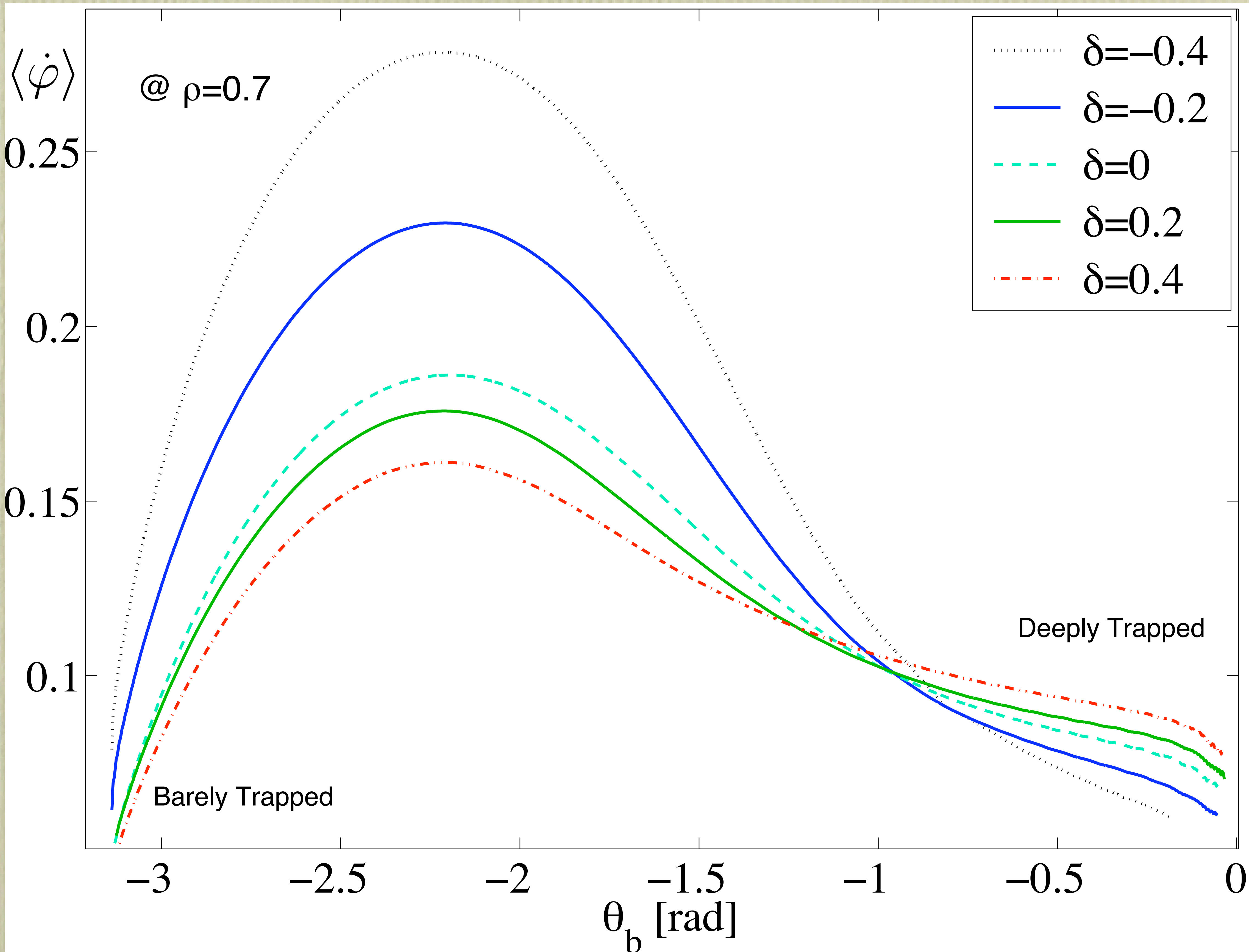
TEM are destabilized by the resonance between the fluctuation and the toroidal precessional drift of trapped electrons

B. B. Kadomtsev and O.P. Pogutse, Zh. Eksp. Teor. Fiz. 51 (1966), 1734 [Sov. Phys. JETP 24 (1967), 1172]

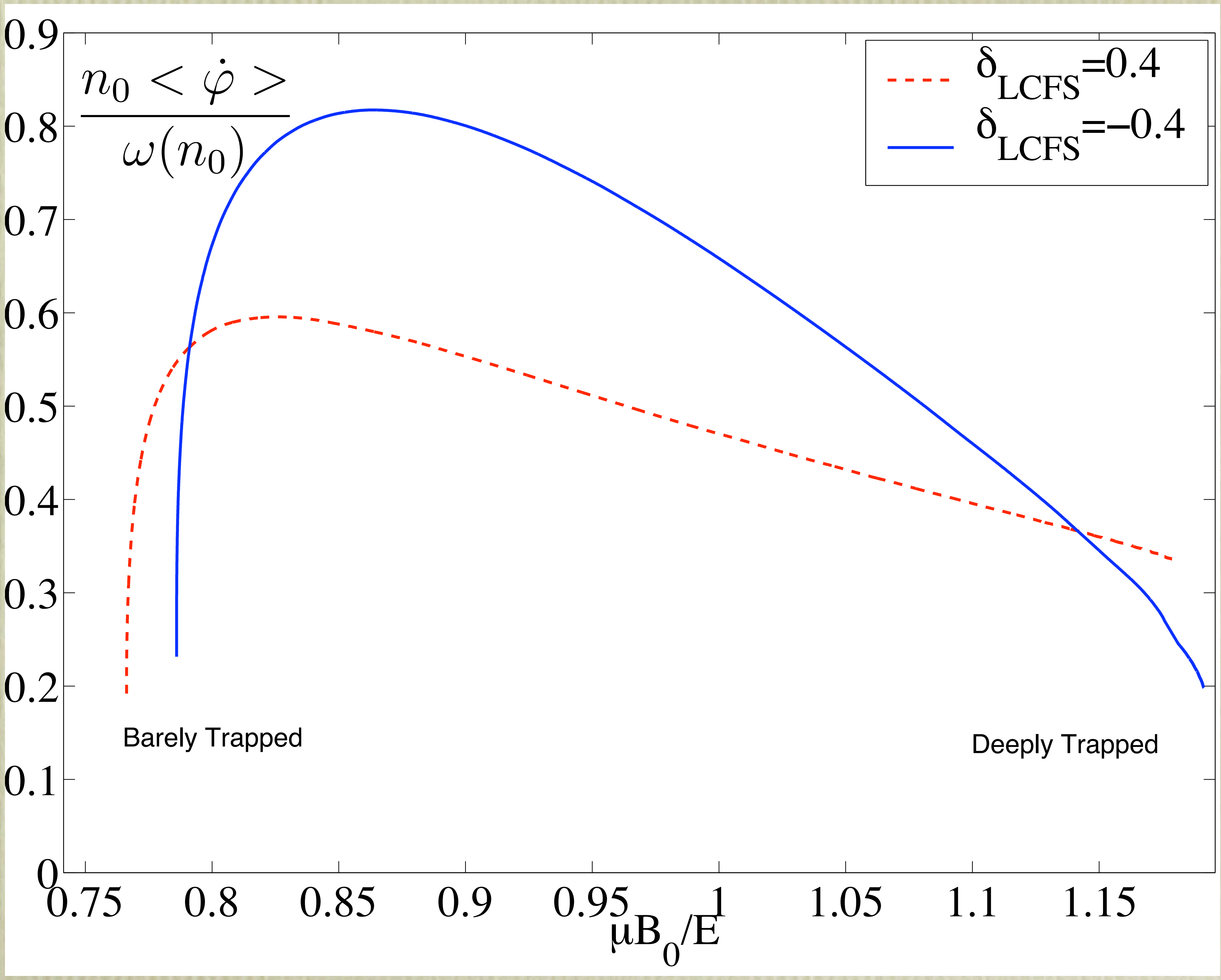
$$\langle\dot{\varphi}\rangle(\psi, E, \mu) = \frac{1}{e}\frac{\partial I_{\|}/\partial\psi}{\partial I_{\|}/\partial E} = f(\psi, \mu, shape)\frac{E}{Te}$$

M.Rosenbluth and M.L.Sloan, Phys Fluids 14 (1971), 1725

Particle drifts

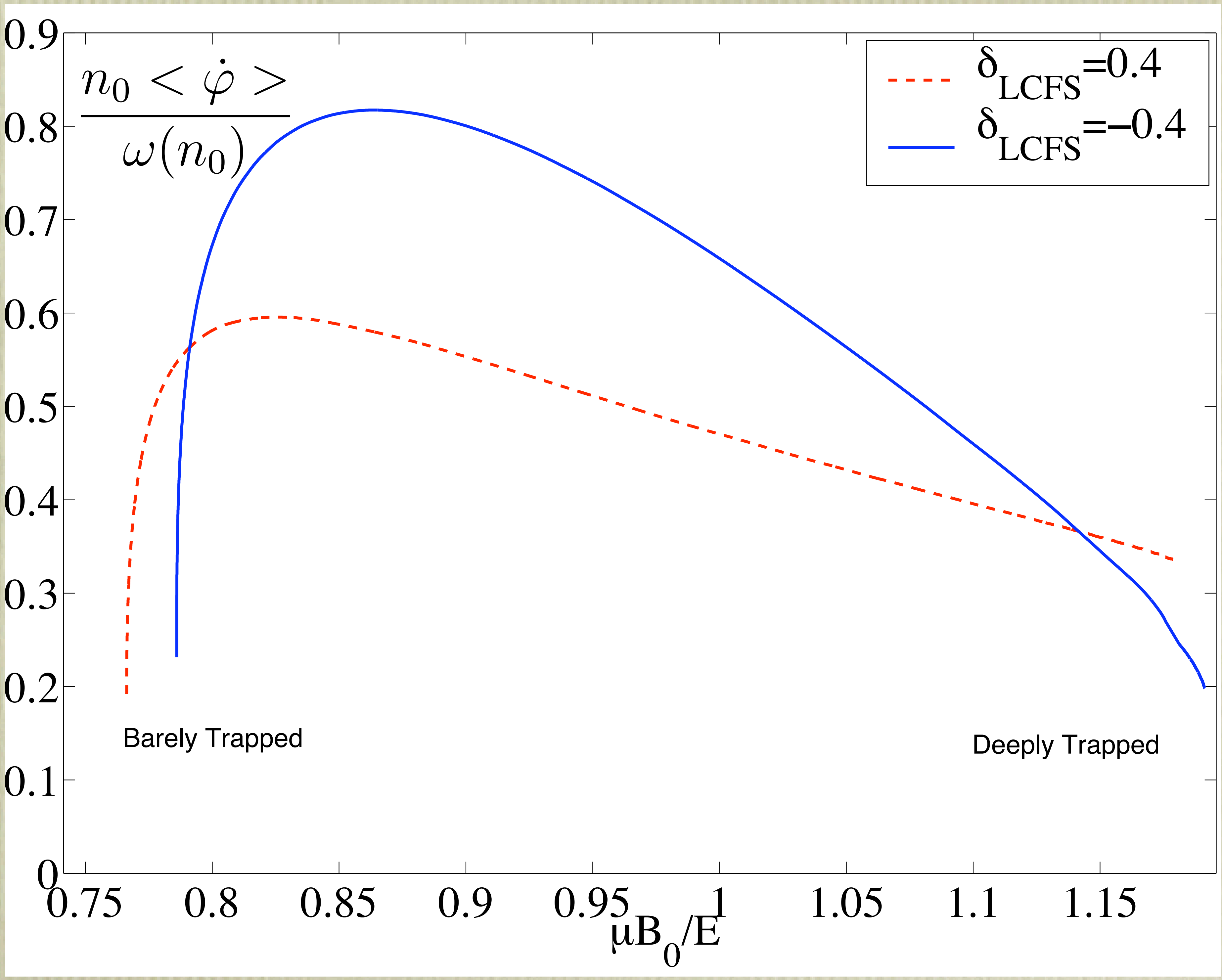


Resonance?



Thermal electrons are more unstable in the negative delta case

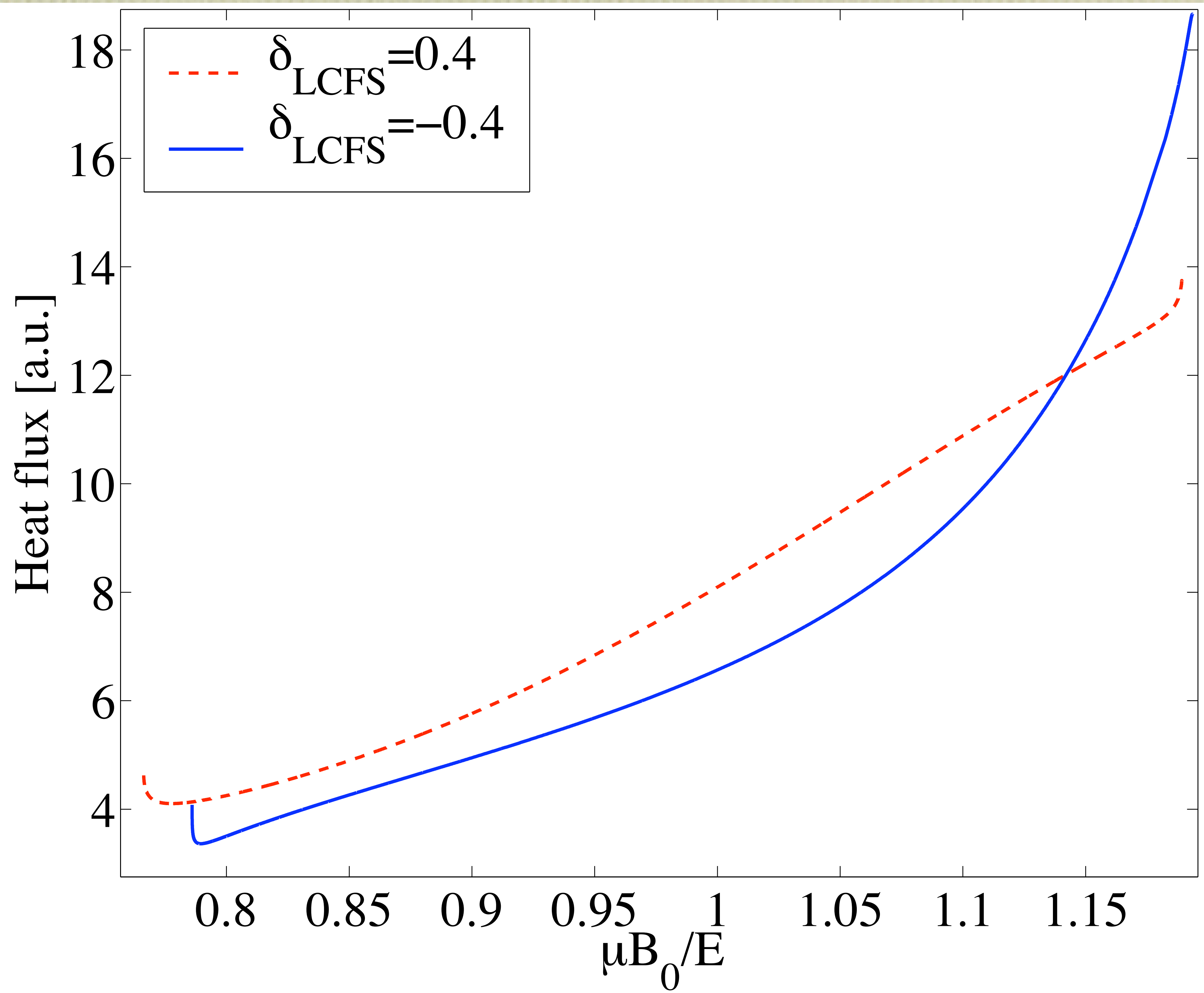
Resonance?



Thermal electrons are more unstable in the negative delta case

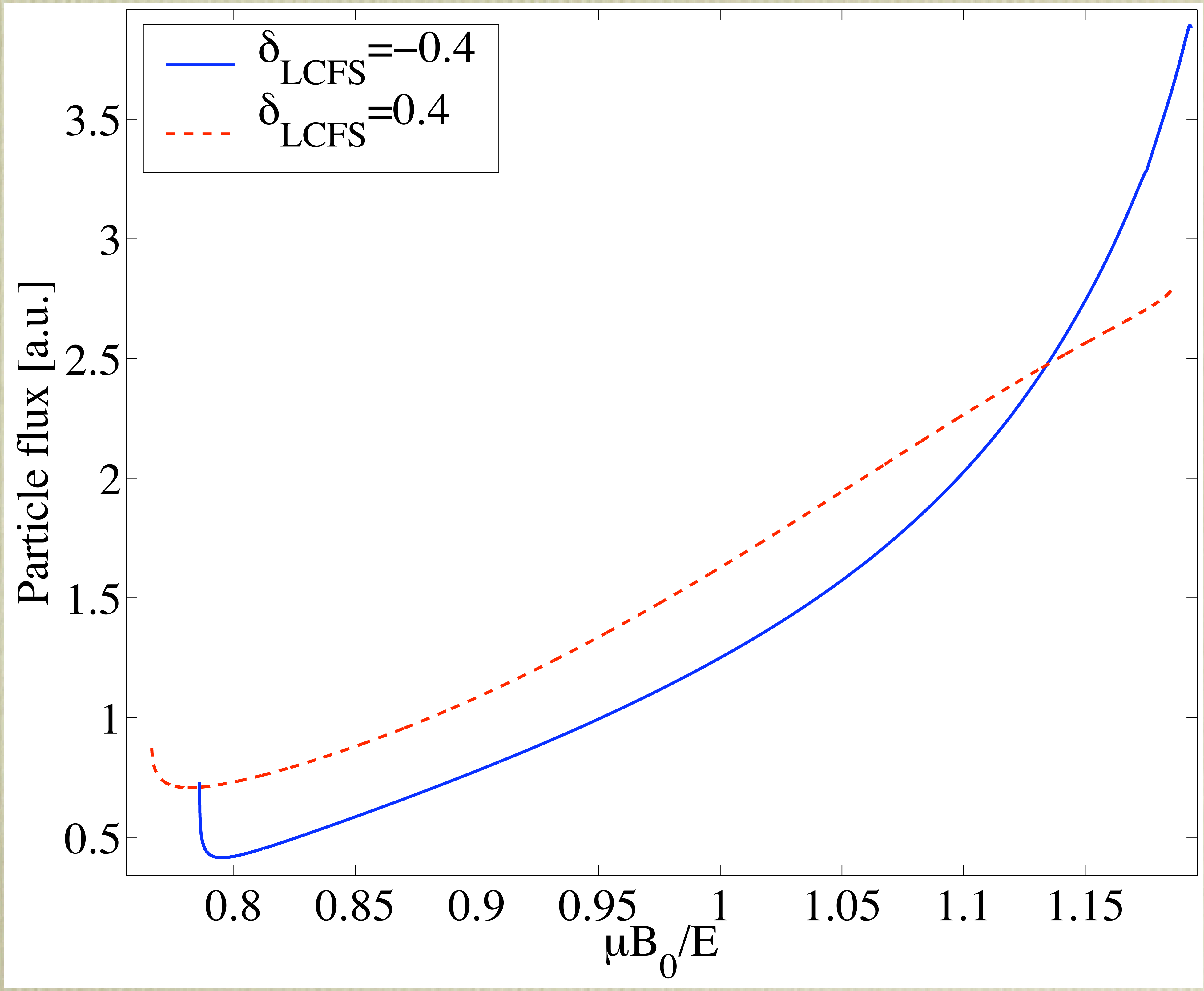
At which energy the instability is more effective?

Resonance?



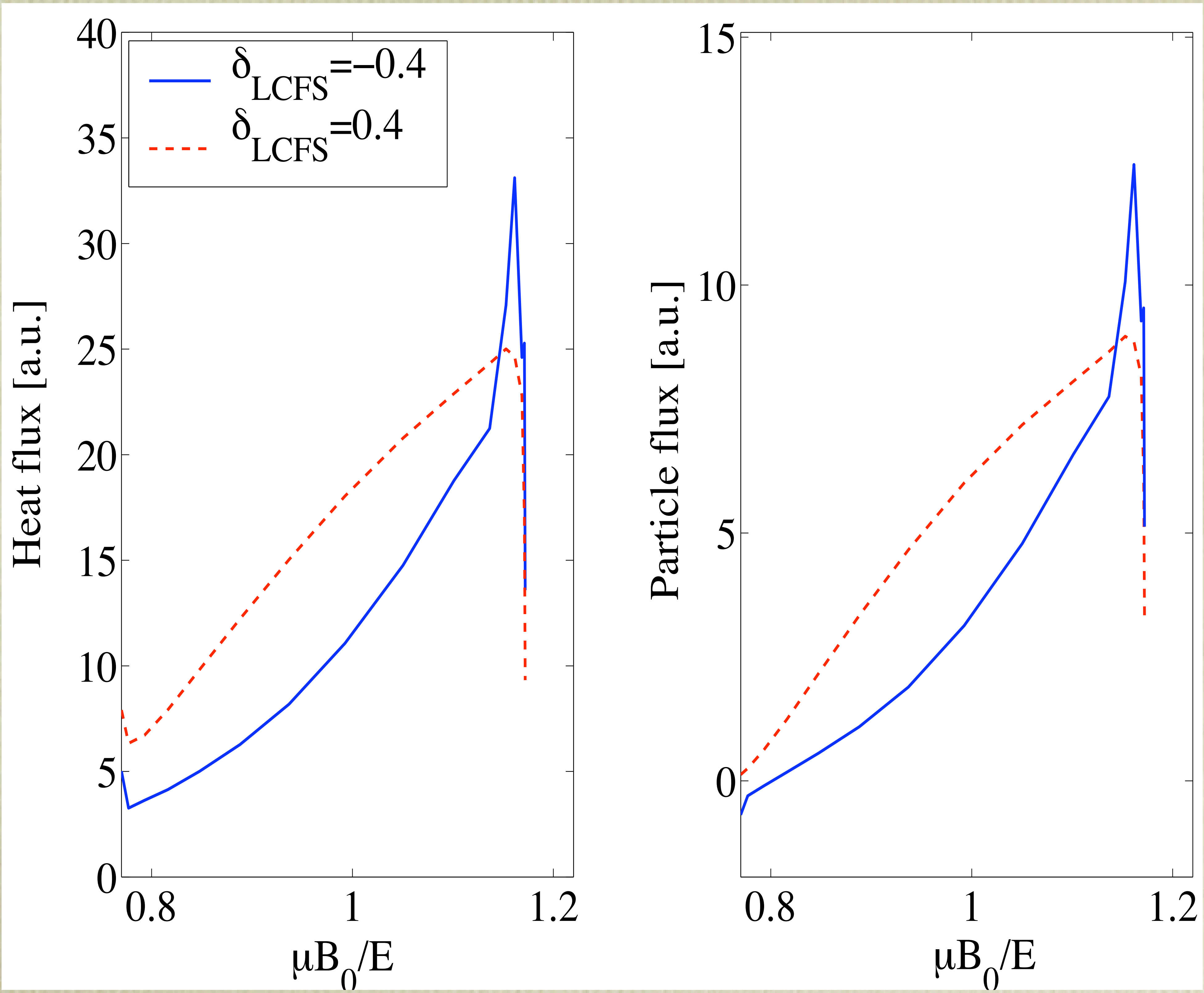
δ_{LCFS}=0.4
δ_{LCFS}=−0.4
Heat flux [a.u.]
$\mu B_0/E$
18
16
14
12
10
8
6
4
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15

Resonance?



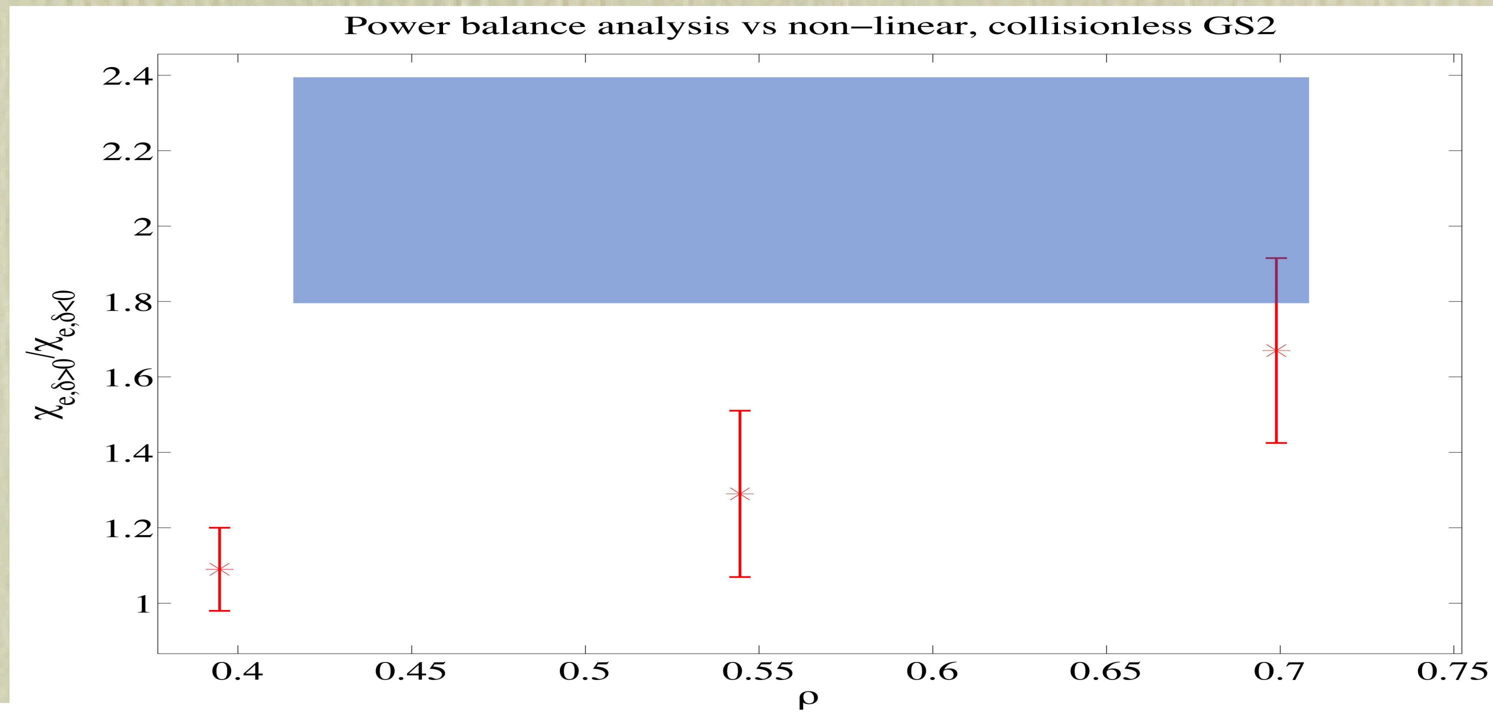
δLCFS=−0.4
δLCFS=0.4
Particle flux [a.u.]
3.5
3
2.5
2
1.5
1
0.5
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
μB0/E

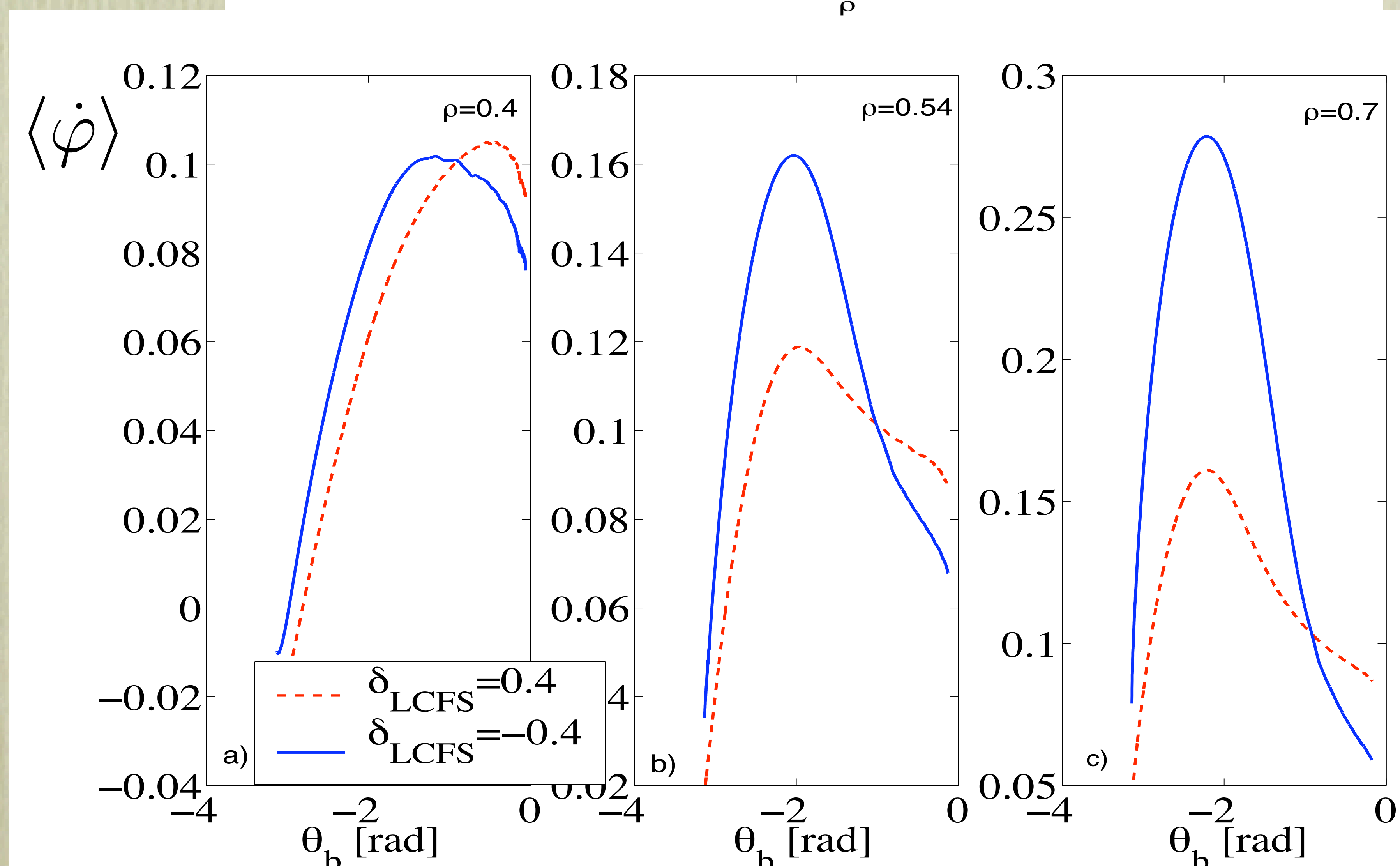
Resonance?



40
35
30
25
20
15
10
5
0
Heat flux [a.u.]
0.8
1
1.2
μB0/E
δLCFS=−0.4
δLCFS=0.4
15
10
5
0
Particle flux [a.u.]
0.8
1
1.2
μB0/E

Particle drifts





Conclusions

- negative triangularity stabilizes L-mode TEM dominated plasmas through perpendicular drift and effective perpendicular size of perturbation
- Non-linear terms are important for quantitative comparisons
- Interplay of collisionality and triangularity
- Toroidal processional drift and triangularity: peculiar effect in the phase space
- Finite penetration length?