Finite beta effects in global, electromagnetic, gyrokinetic, linear and nonlinear simulations of Alfven eigenmodes and microturbulence

EPFL - SPC - Baruch Rofman

Together with

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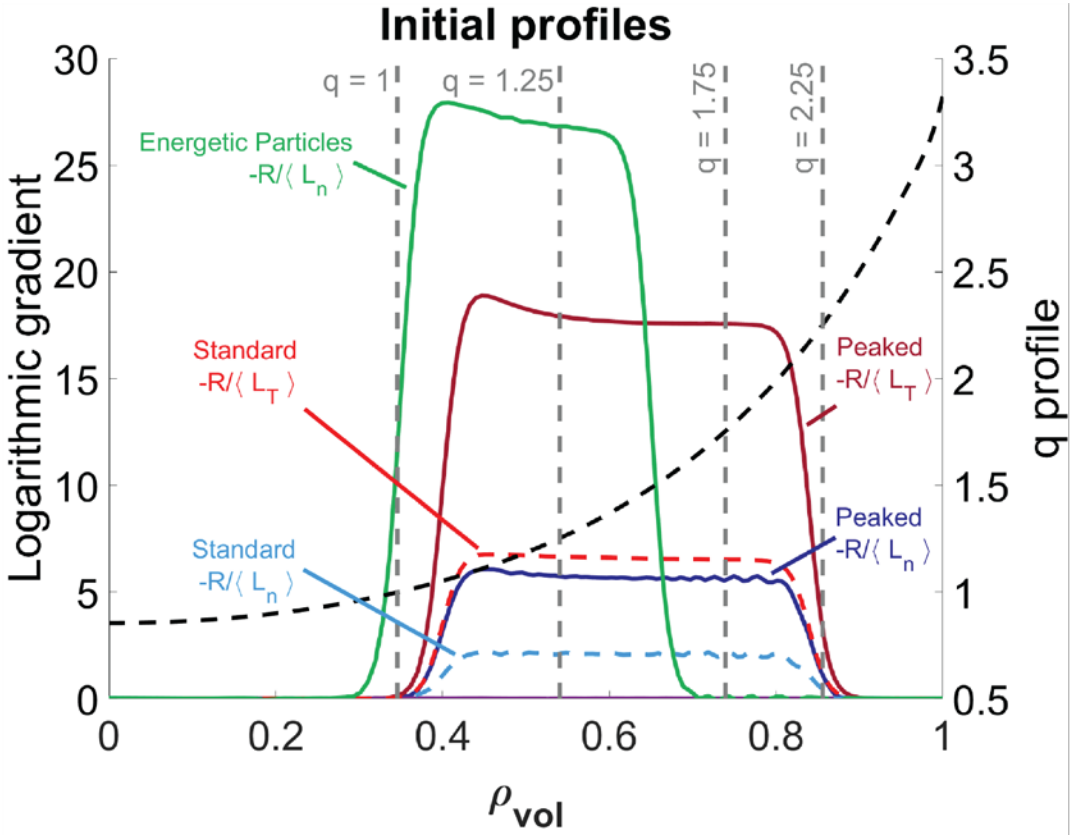
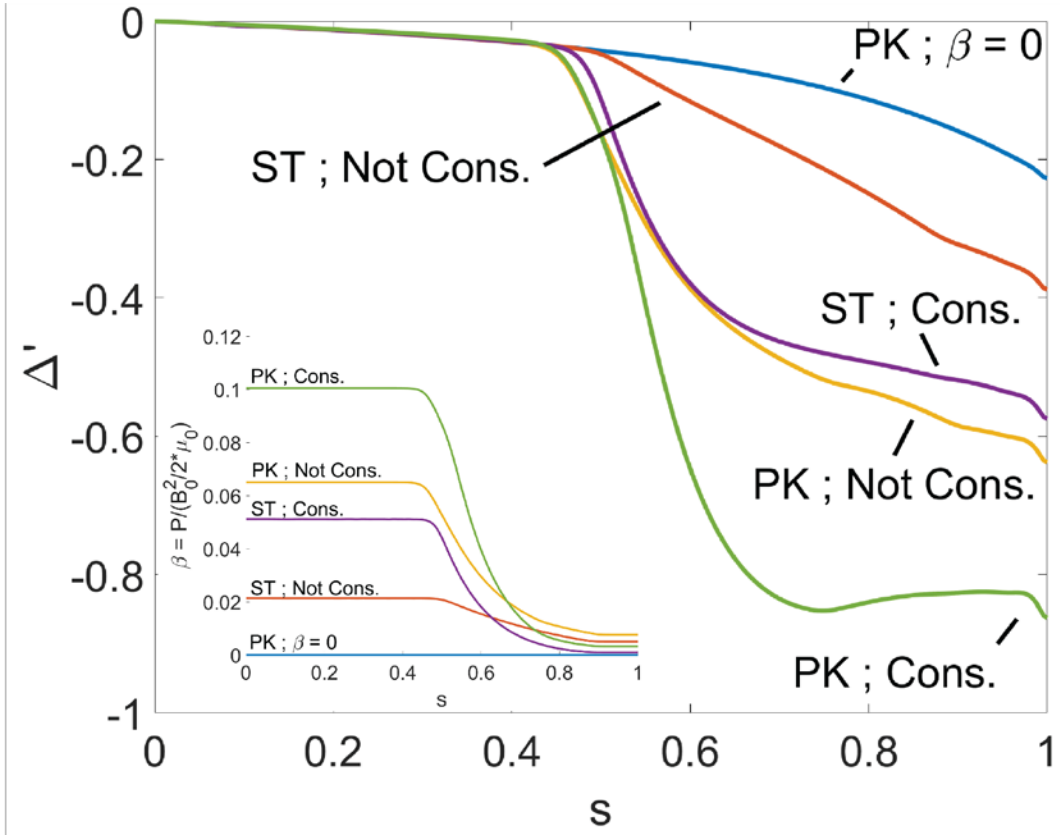
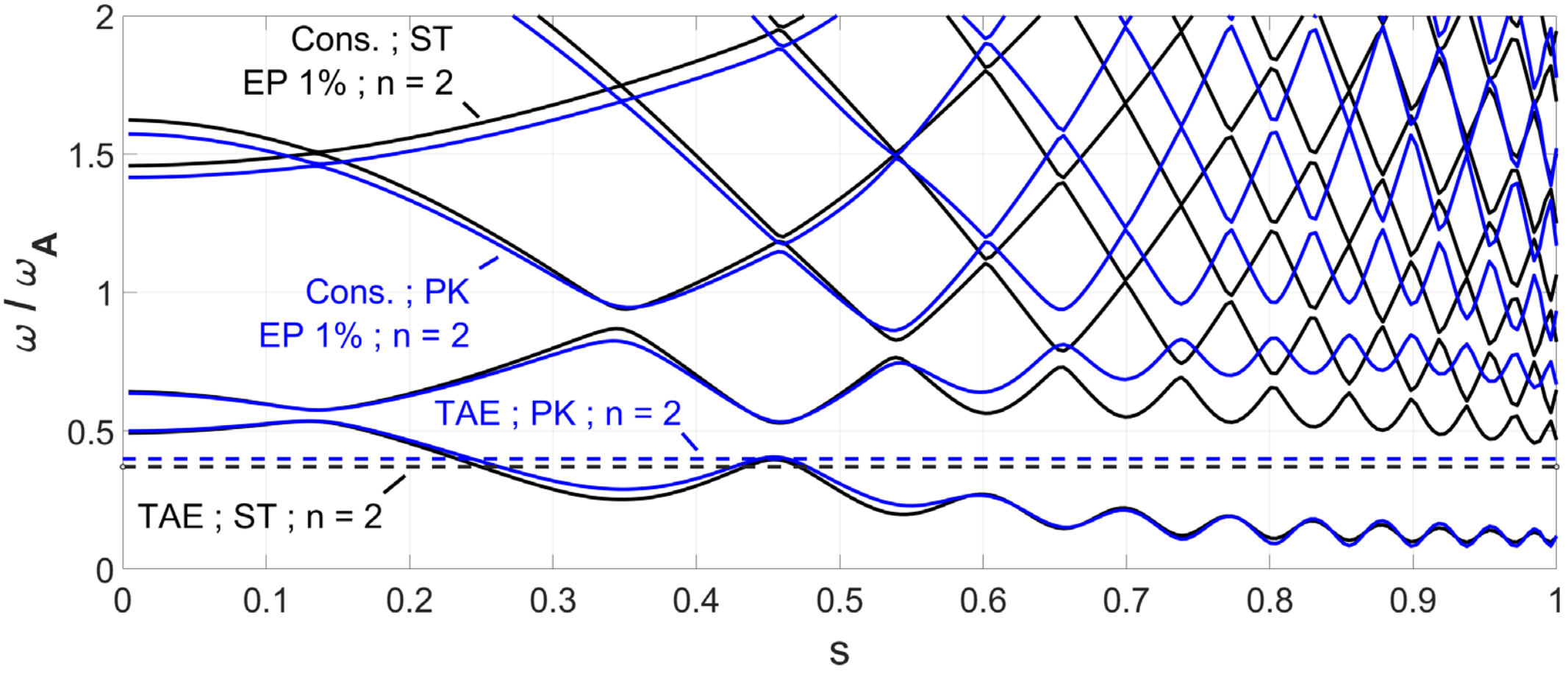
Initial profiles and MHD equilibria

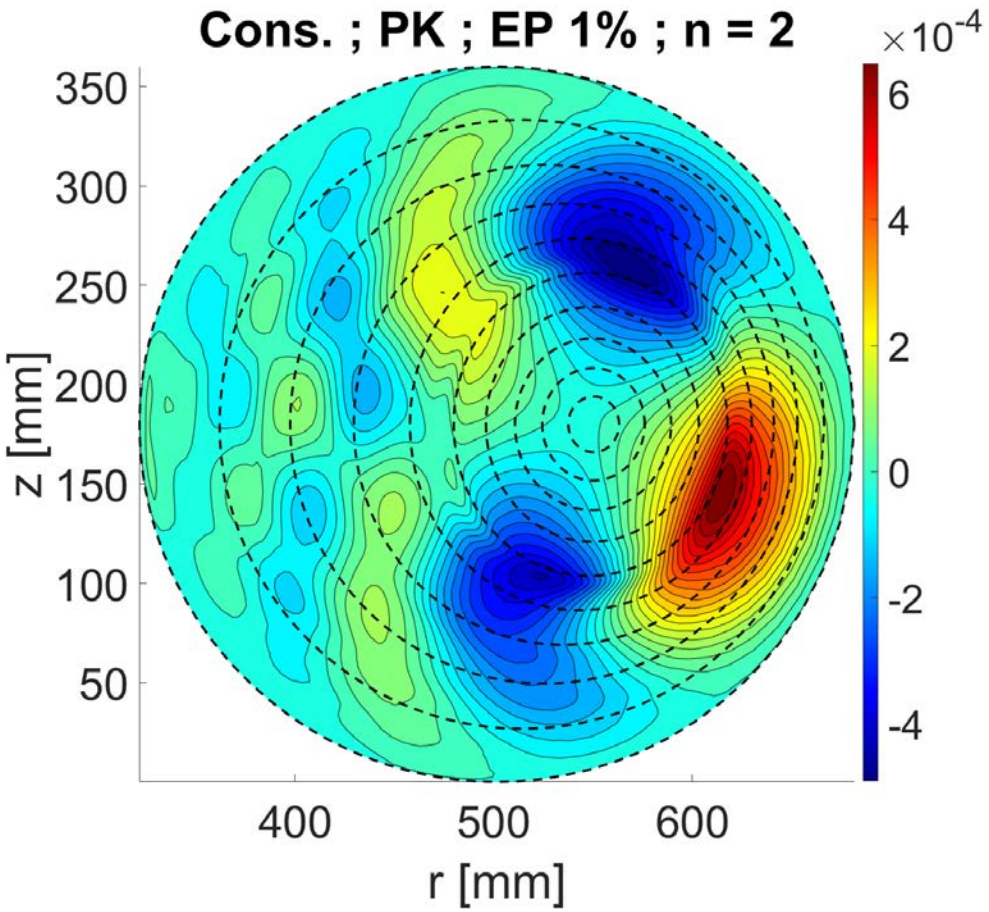


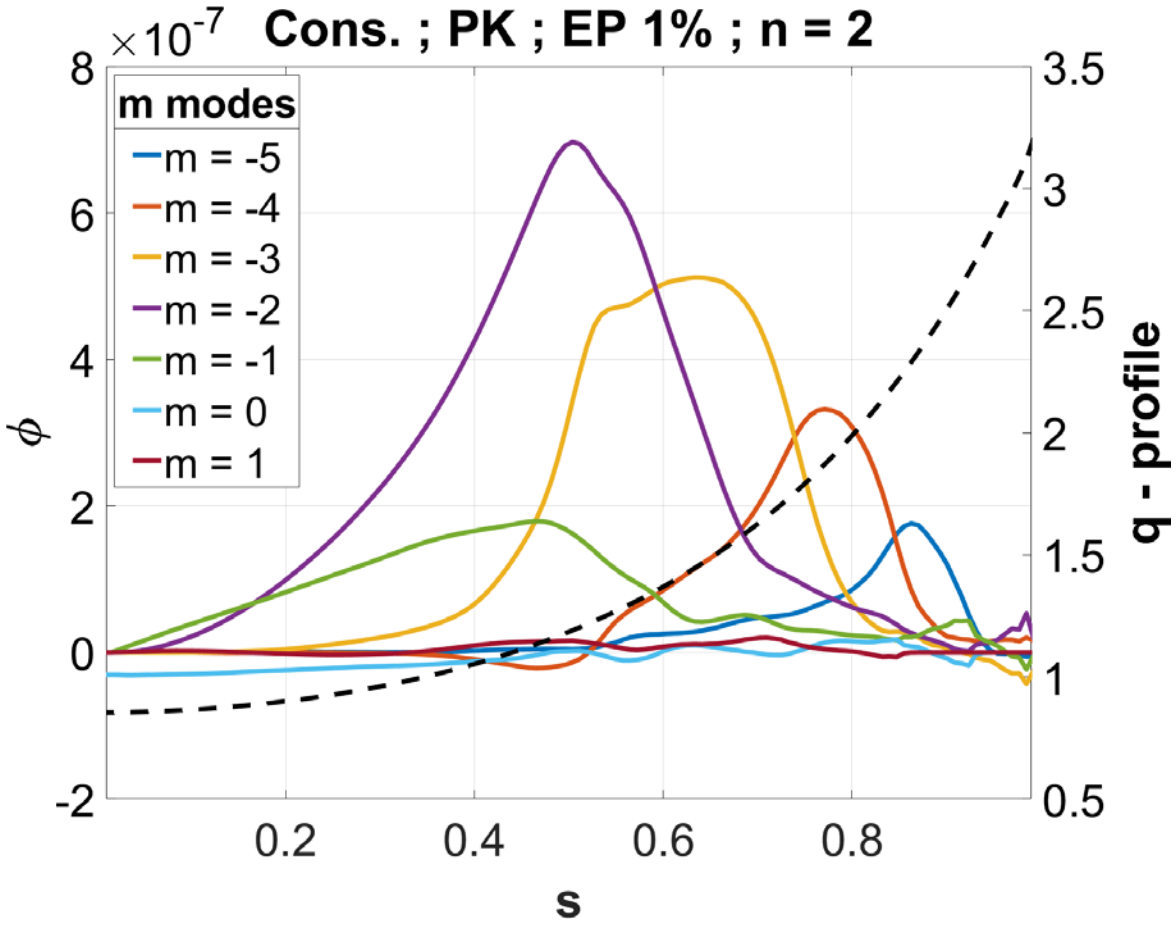


Linear TAE – Alfven continuum

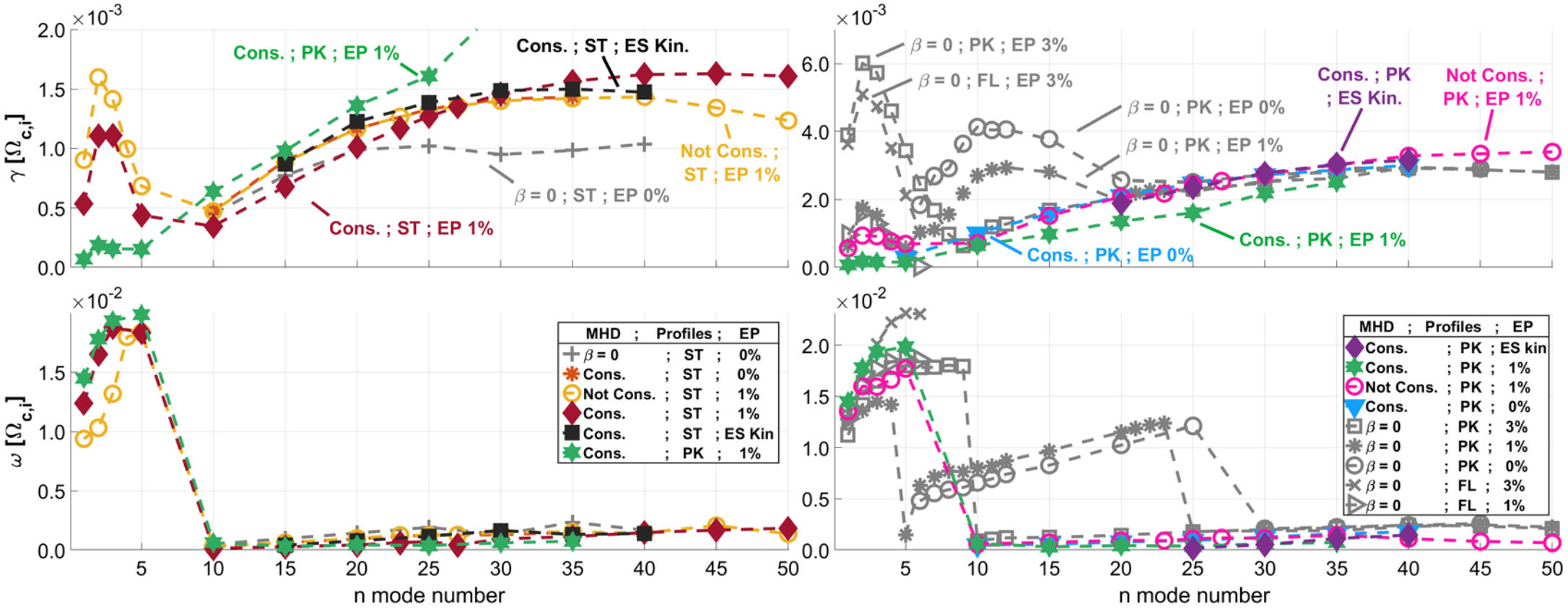


Linear TAE

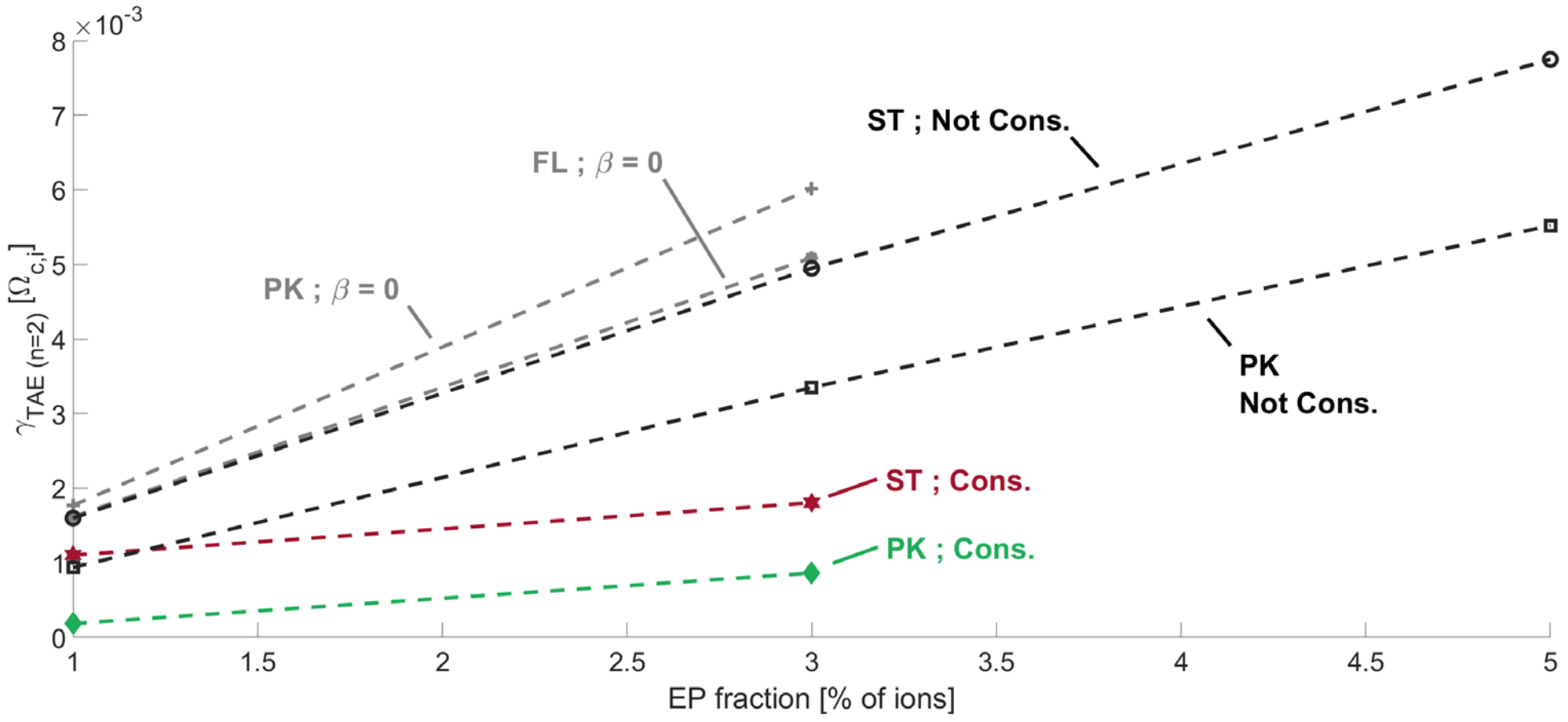

Cons. ; PK ; EP 1% ; n = 2
×10^-4
6
4
2
0
-2
-4
350
300
250
200
150
100
50
z [mm]
400
500
600
r [mm]


×10^-7
Cons. ; PK ; EP 1% ; n = 2
m modes
m = -5
m = -4
m = -3
m = -2
m = -1
m = 0
m = 1
8
6
4
2
0
-2
ϕ
0.2
0.4
0.6
0.8
s
3.5
3
2.5
2
1.5
1
0.5
q - profile

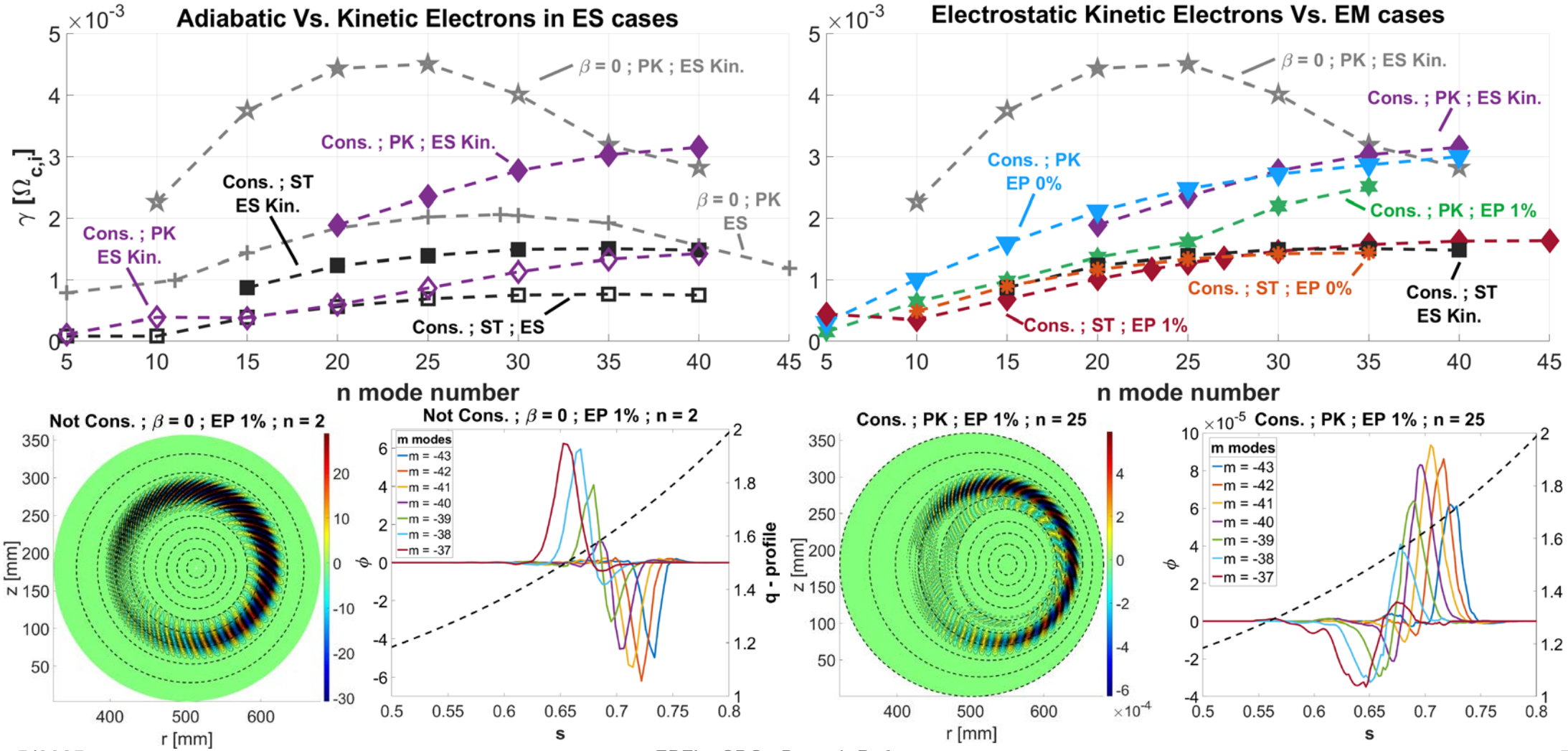
Linear dispersion relation



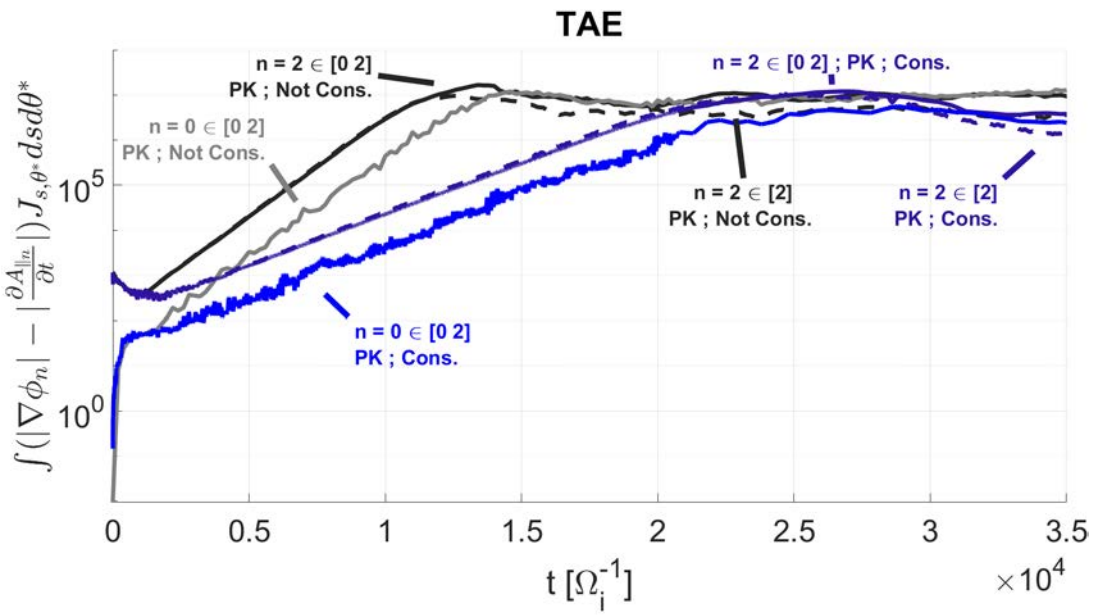
Linear EP scan

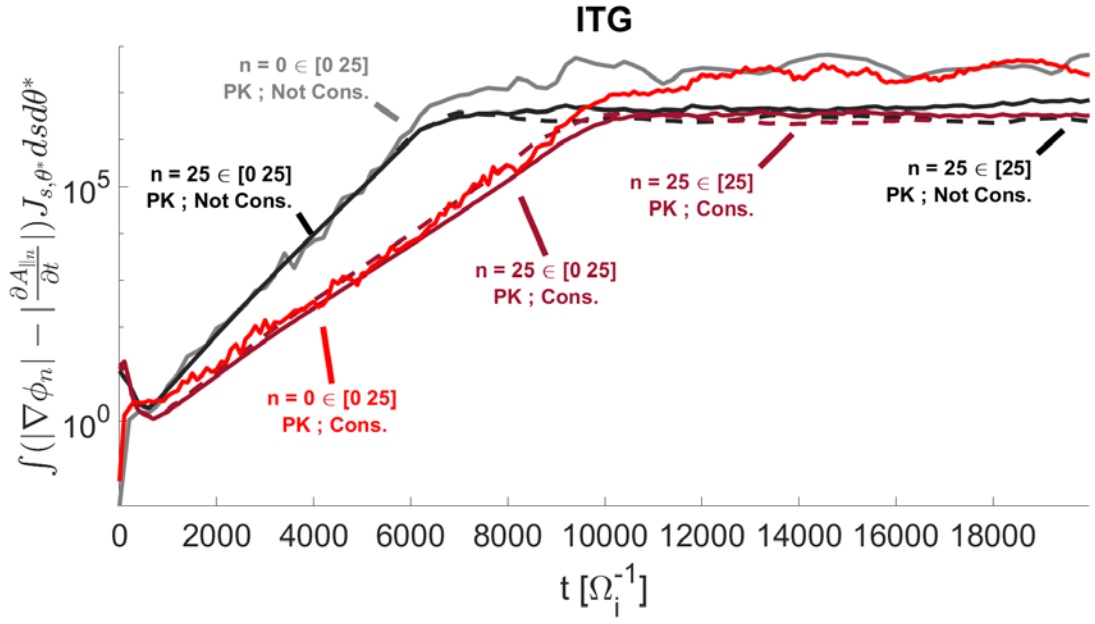


Linear ITG

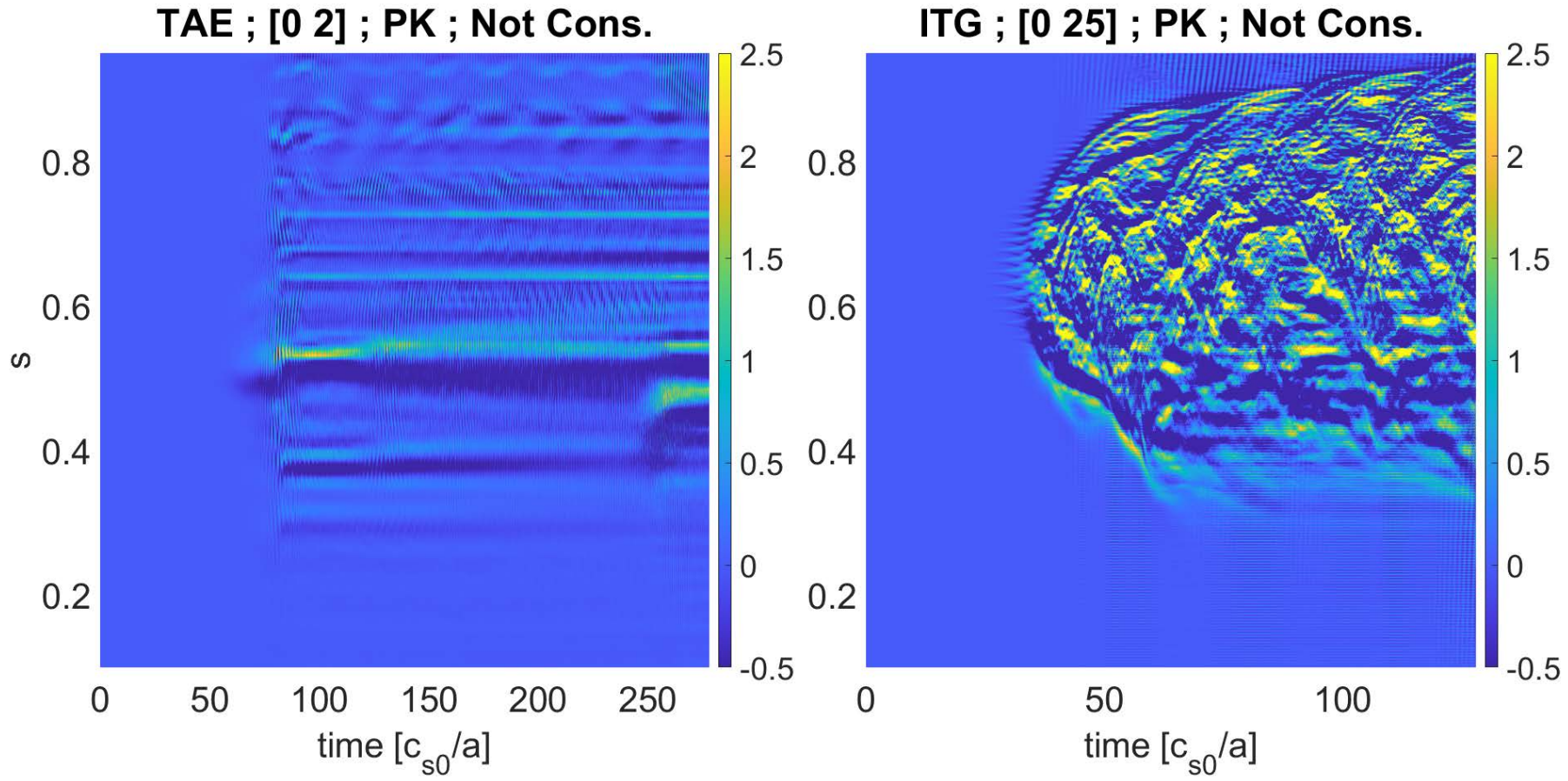

Adiabatic Vs. Kinetic Electrons in ES cases
$\times 10^{-3}$
γ [$\Omega_{c,i}$]
β = 0 ; PK ; ES Kin.
Cons. ; PK ; ES Kin.
Cons. ; ST
ES Kin.
β = 0 ; PK
ES
Cons. ; PK
ES Kin.
Cons. ; ST ; ES
n mode number
Electrostatic Kinetic Electrons Vs. EM cases
$\times 10^{-3}$
β = 0 ; PK ; ES Kin.
Cons. ; PK ; ES Kin.
Cons. ; PK
EP 0%
Cons. ; PK ; EP 1%
Cons. ; ST ; EP 0%
Cons. ; ST ; EP 1%
Cons. ; ST
ES Kin.
n mode number
Not Cons. ; β = 0 ; EP 1% ; n = 2
z [mm]
r [mm]
Not Cons. ; β = 0 ; EP 1% ; n = 2
m modes
m = -43
m = -42
m = -41
m = -40
m = -39
m = -38
m = -37
ϕ
s
q - profile
Cons. ; PK ; EP 1% ; n = 25
z [mm]
r [mm]
$\times 10^{-4}$
$\times 10^{-5}$ Cons. ; PK ; EP 1% ; n = 25
m modes
m = -43
m = -42
m = -41
m = -40
m = -39
m = -38
m = -37
ϕ
s
q - profile

Nonlinear time evolution

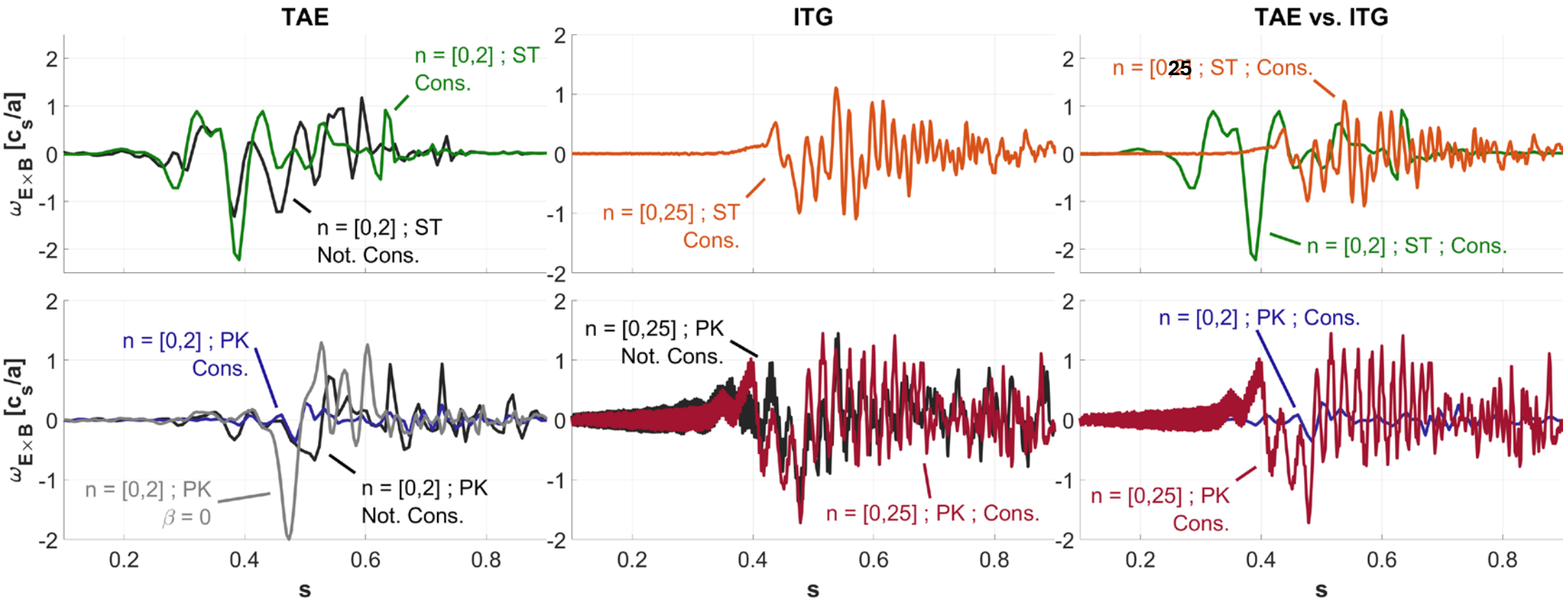




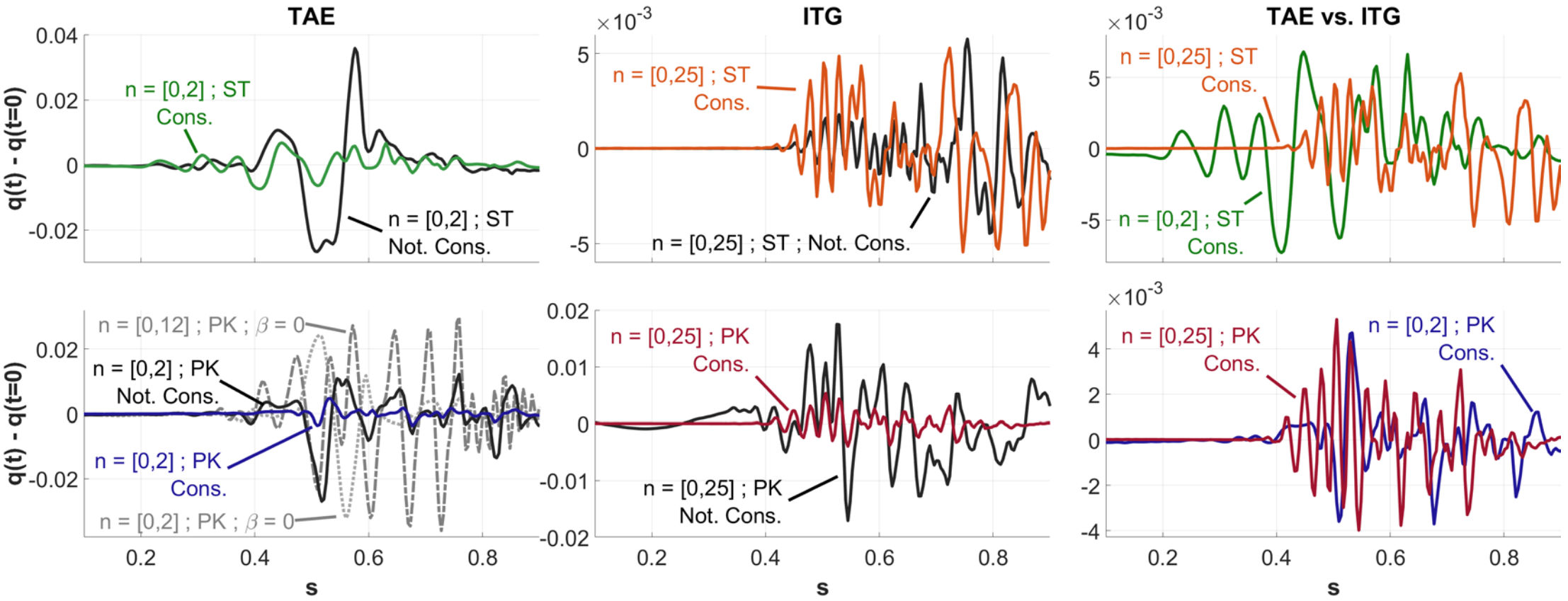
ω_{ExB} sharing rate – Time evolution



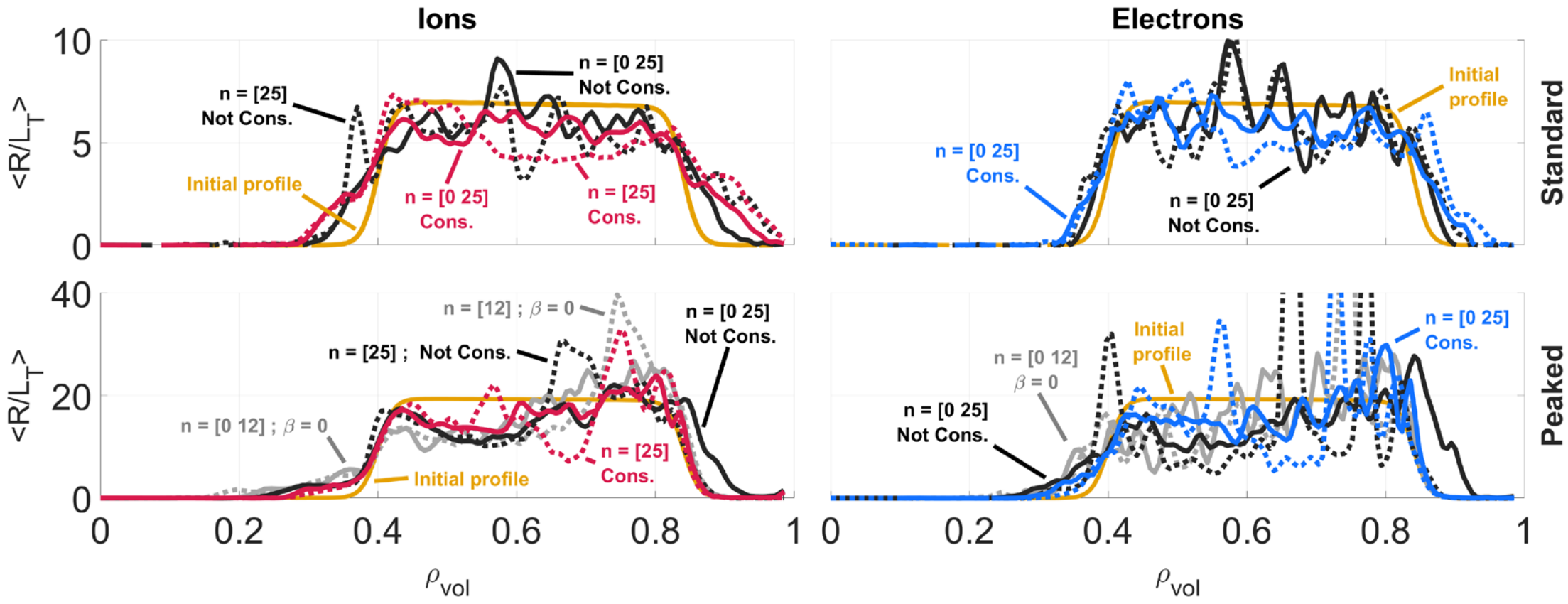
Time average - ω_{ExB} sharing rate



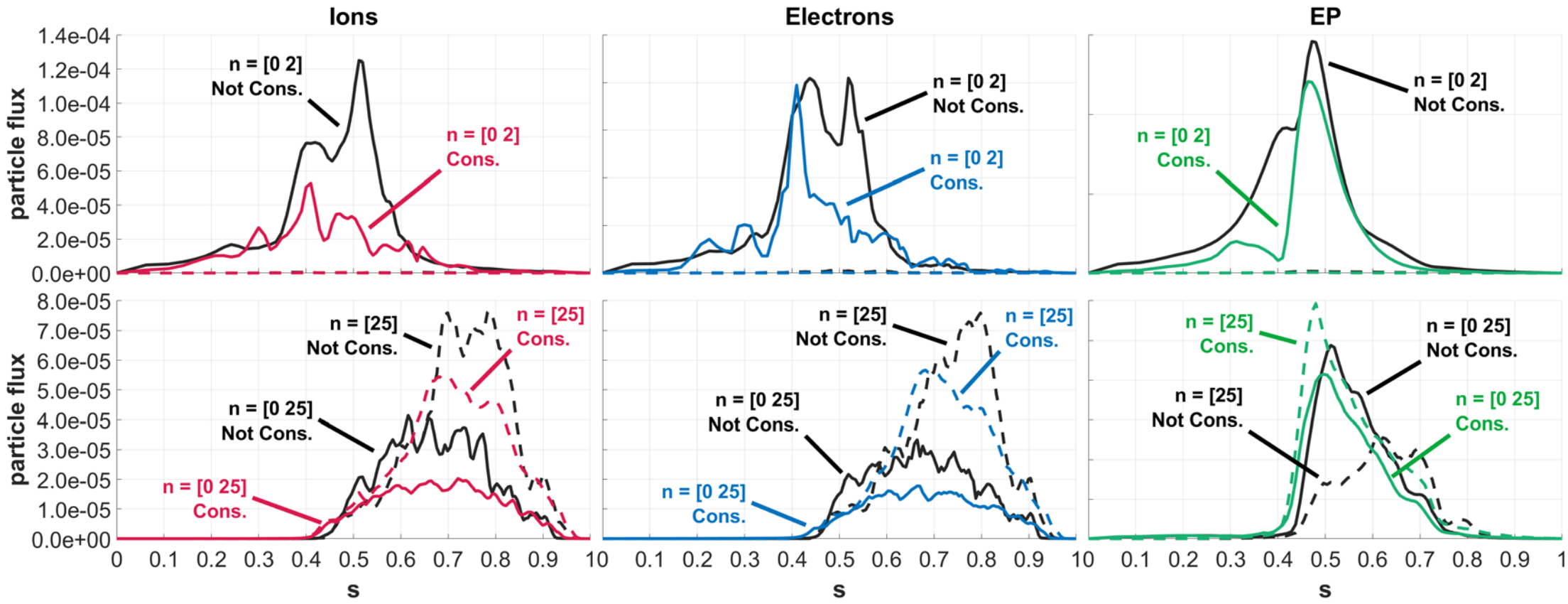
Nonlinear modification of the **q-profile**



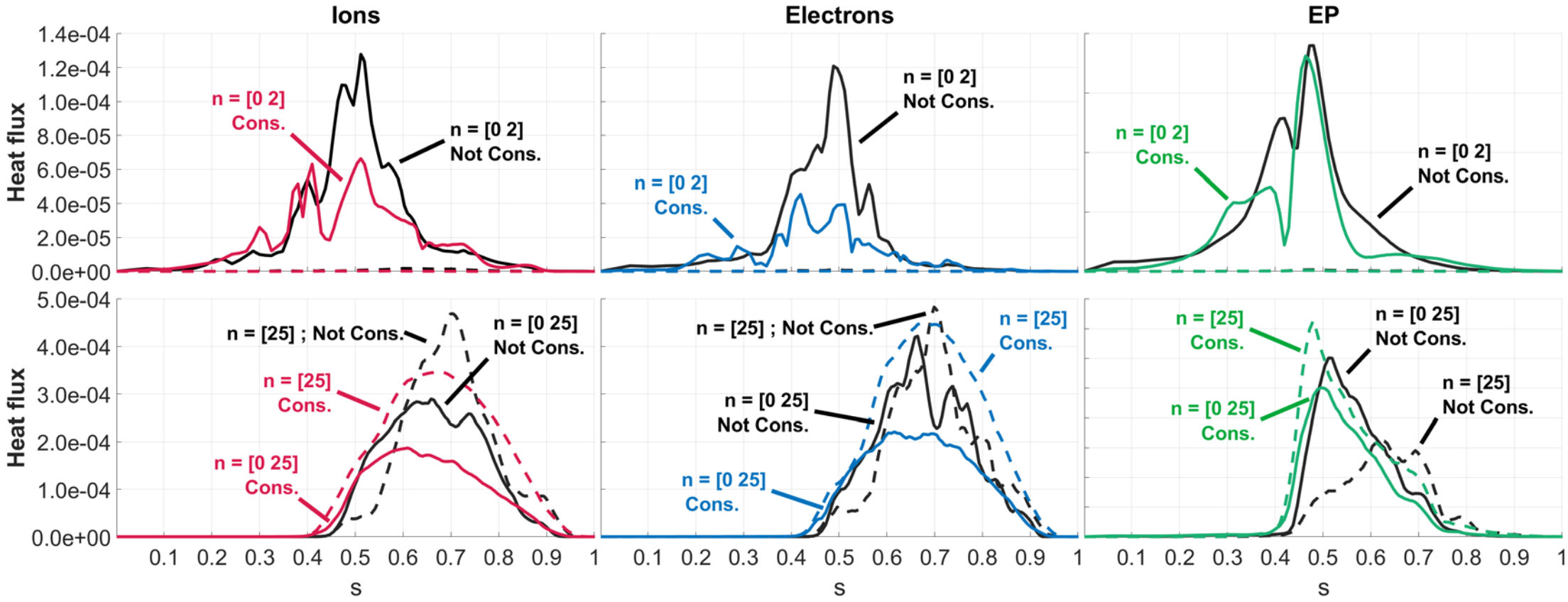
Nonlinear modification of the $\mathbf{R/L_T}$



Nonlinear practical flux - Standard profiles (ST)



Nonlinear heat flux – Standard profiles (ST)



Conclusions

- Linear
  - TAE growth rates decrease dramatically in consistent MHD
  - ITG growth rates are much less sensitive.
  - Kinetic electrons in self consistent MHD capture well the dispersion relation.
- Nonlinear
  - Both ZF and consistent MHD are necessary to avoid strong spikes that appear unrealistic. The electrons are mode sensitive.
  - Heat and Particle fluxes are decreased with beta (when ZF included)
  - TAE (n=2) - Heat and Particle fluxes increase with ZF (n=0)
  - ITG (n=25) - Heat and Particle fluxes decrease with ZF (n=0)