Gyrokinetic turbulence modelling for JT-60SA

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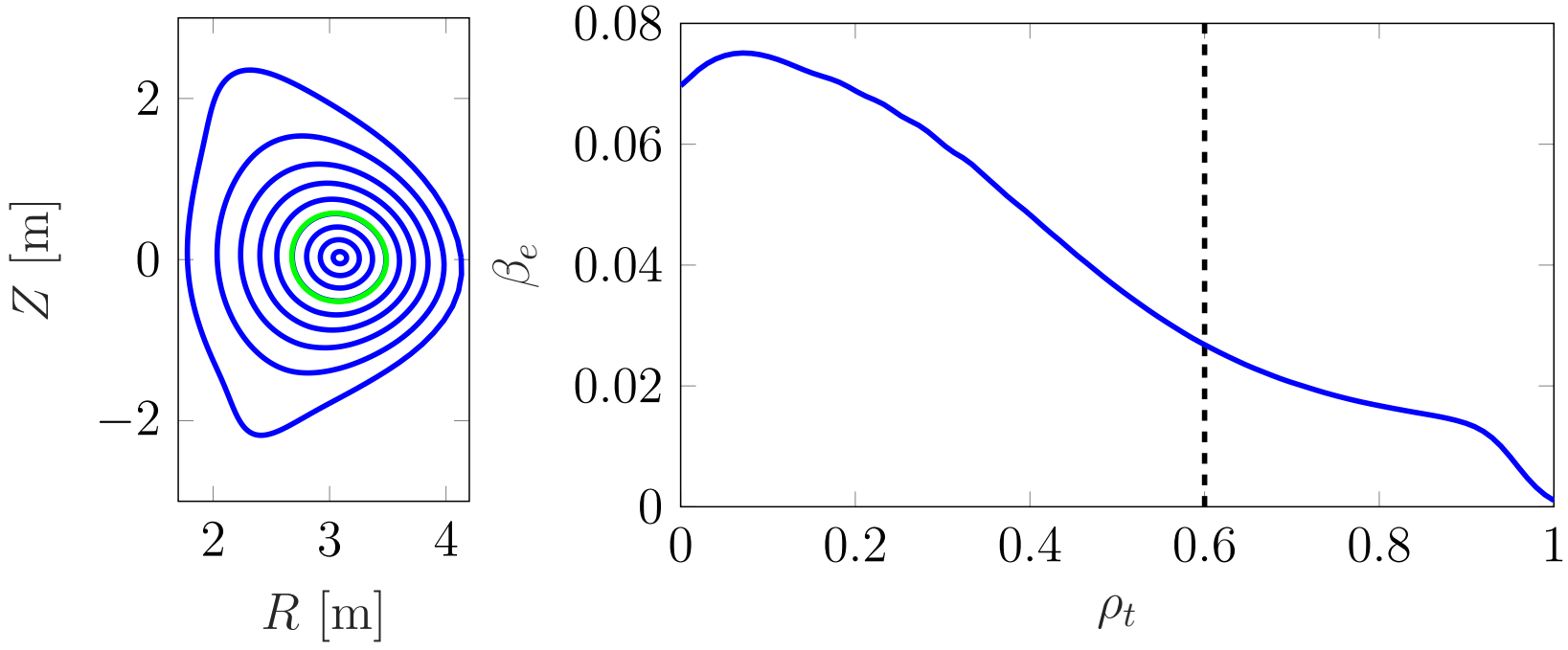
Outline

The scenario

1. Predicted JT-60SA discharge.
2. Double-Null with 41 (34 NBH + 7 ECH) MW heating $\Longrightarrow$ fast ions (Maxwellian at larger T).



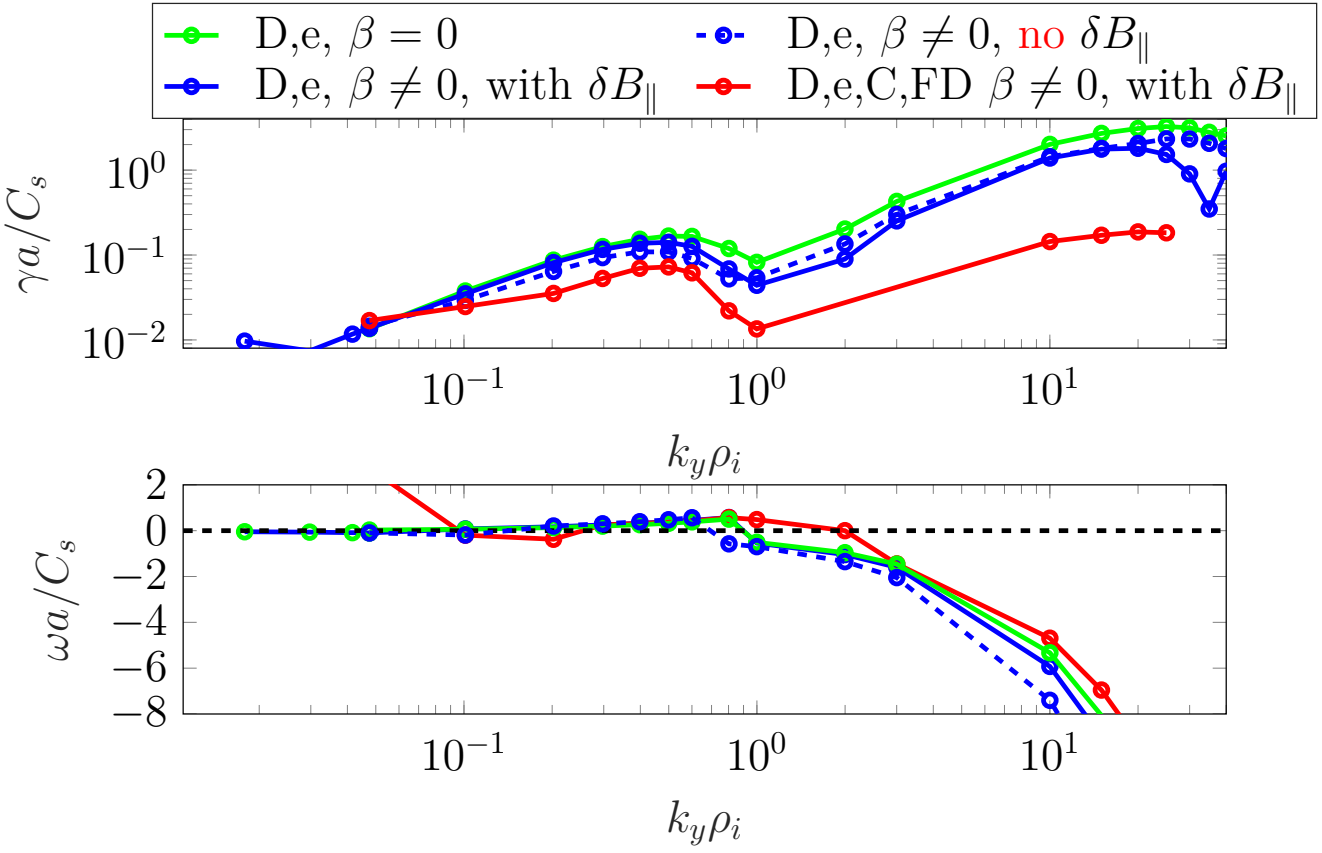
Simulation input

Input at $\rho_t = 0.6$

$n_e[10^{19}\mathrm{m}^{-3}]$	5.87	T_i/T_e	1.0	$a/L_{n,\mathrm{C}}$	0.7224	q_0	1.1571
$T_e[\mathrm{keV}]$	6.27	$a/L_{T,e}$	2.094	$a/L_{n,\mathrm{NBH}}$	1.7231	$\hat{s}$	1.5528
n_i/n_e	0.7671	$a/L_{T,i}$	2.093	T_NBH/T_e	10.2	$\epsilon = r/R$	0.51
n_C/n_e	0.033	$a/L_{n,e}$	0.7224	Z_eff	2.0	a [m]	1.58
n_NBH/n_e	0.033	$a/L_{n,i}$	0.6795	β_e	2.7 %	$B_0[\mathrm{T}]$	2.35

Local gyrokinetic simulations are done with the GENE code.

Linear simulations of the most unstable mode



- ITG($\omega > 0$), TEM ($\omega < 0$) and ETG ($\omega < 0$).
- Stabilising : fast ions + impurities and β_e.
- Destabilising/Stabilising : $\delta B_{\parallel}$.

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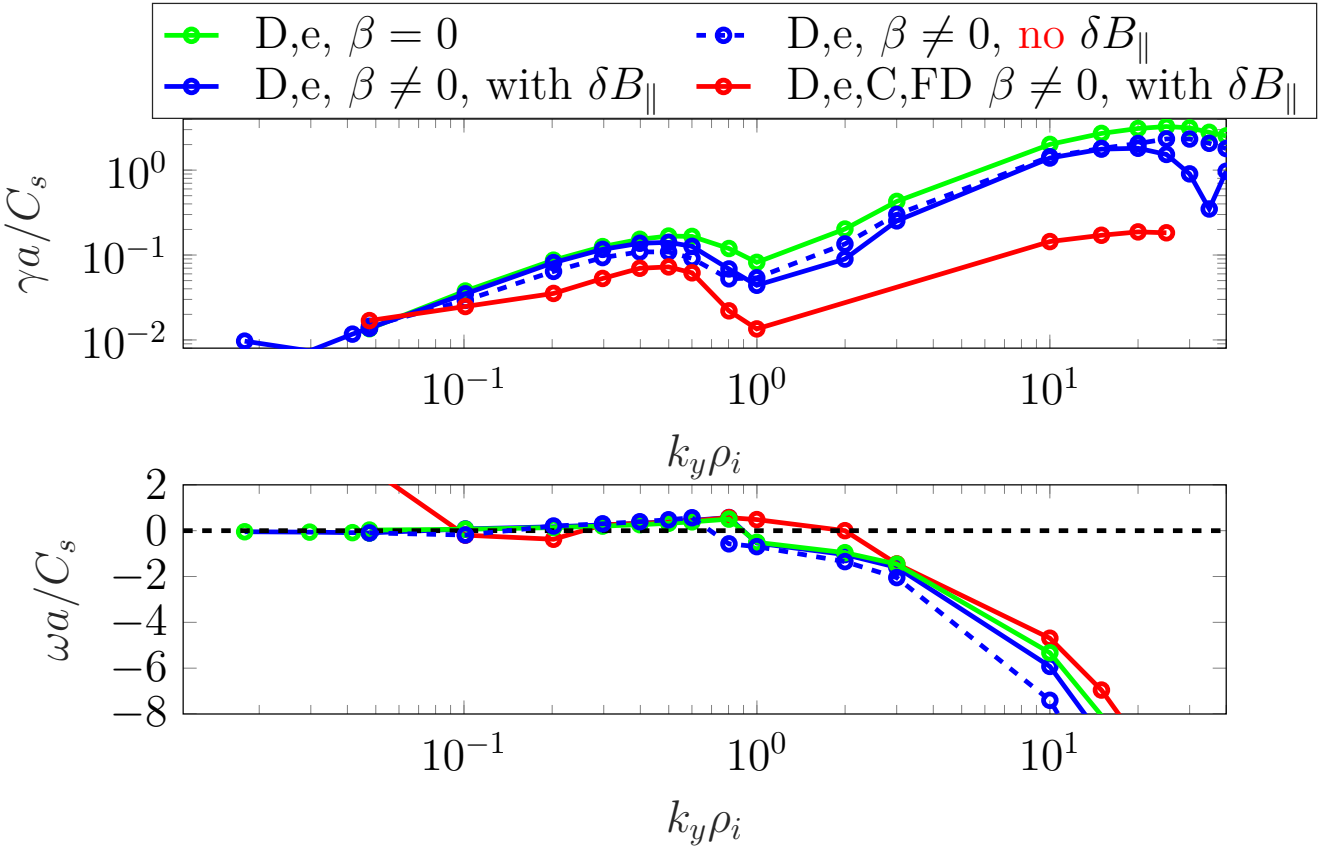
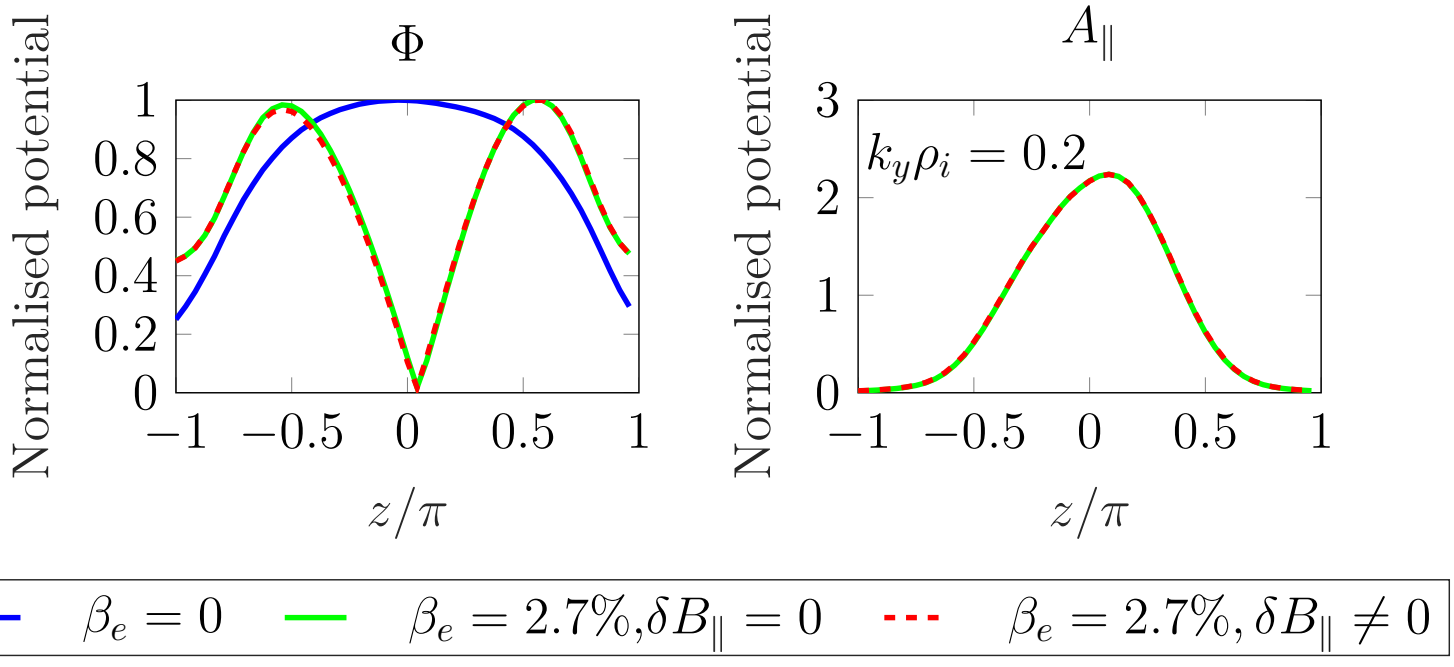


- ITG($\omega > 0$), TEM ($\omega < 0$) and ETG ($\omega < 0$).
- Stabilising : fast ions + impurities and β_e.
- Destabilising/Stabilising : $\delta B_{\parallel}$.
- $\frac{\gamma}{k_y}|_{\text{ion}} \ll \frac{\gamma}{k_y}|_{\text{electron}} \implies$ limited multi-scale interactions.

Electromagnetic modes at $k_y \leq 0.2$

Signature of microtearing like electromagnetic modes @ $k_y \leq 2$

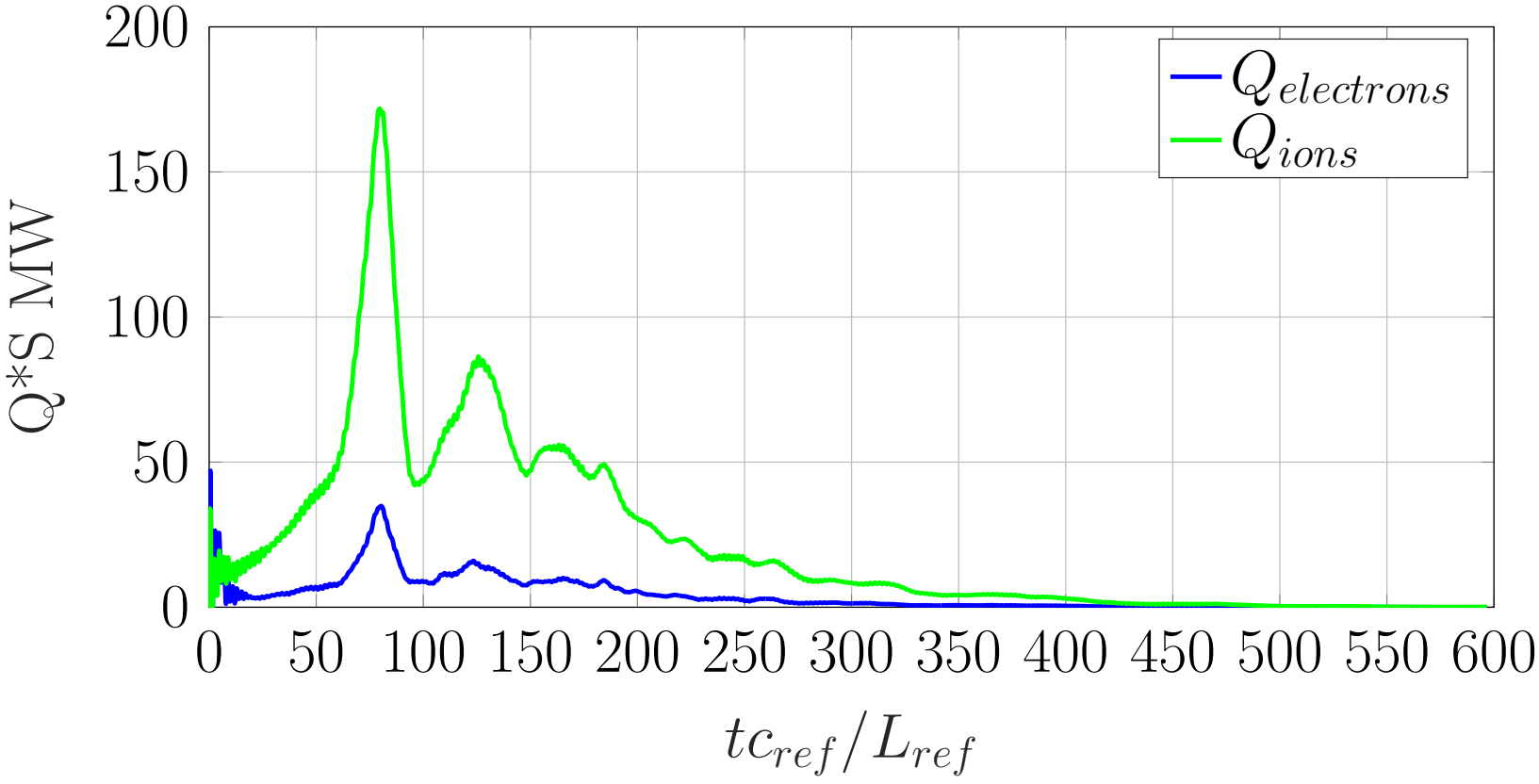


Settings for non-linear simulations

- Local GENE simulation at $\rho_t = 0.6$
- Including 4 kinetic species : e, D, C and fast D ions.
- Including collisions.
- Including $\beta = 2.7\%$ and $\delta B_{\parallel}$ fluctuations.
- $\frac{\gamma}{k_y}|_{\text{ion}} \ll \frac{\gamma}{k_y}|_{\text{electron}} \implies$ only including ion scale modes, $\max(k_y \rho_i = 1.6)$

Simulations at nominal parameters $\Longrightarrow$ too low heat flux

Turbulent heat flux should match injected power of 41 MW...



Total heat flux $< 1\mathrm{MW}$

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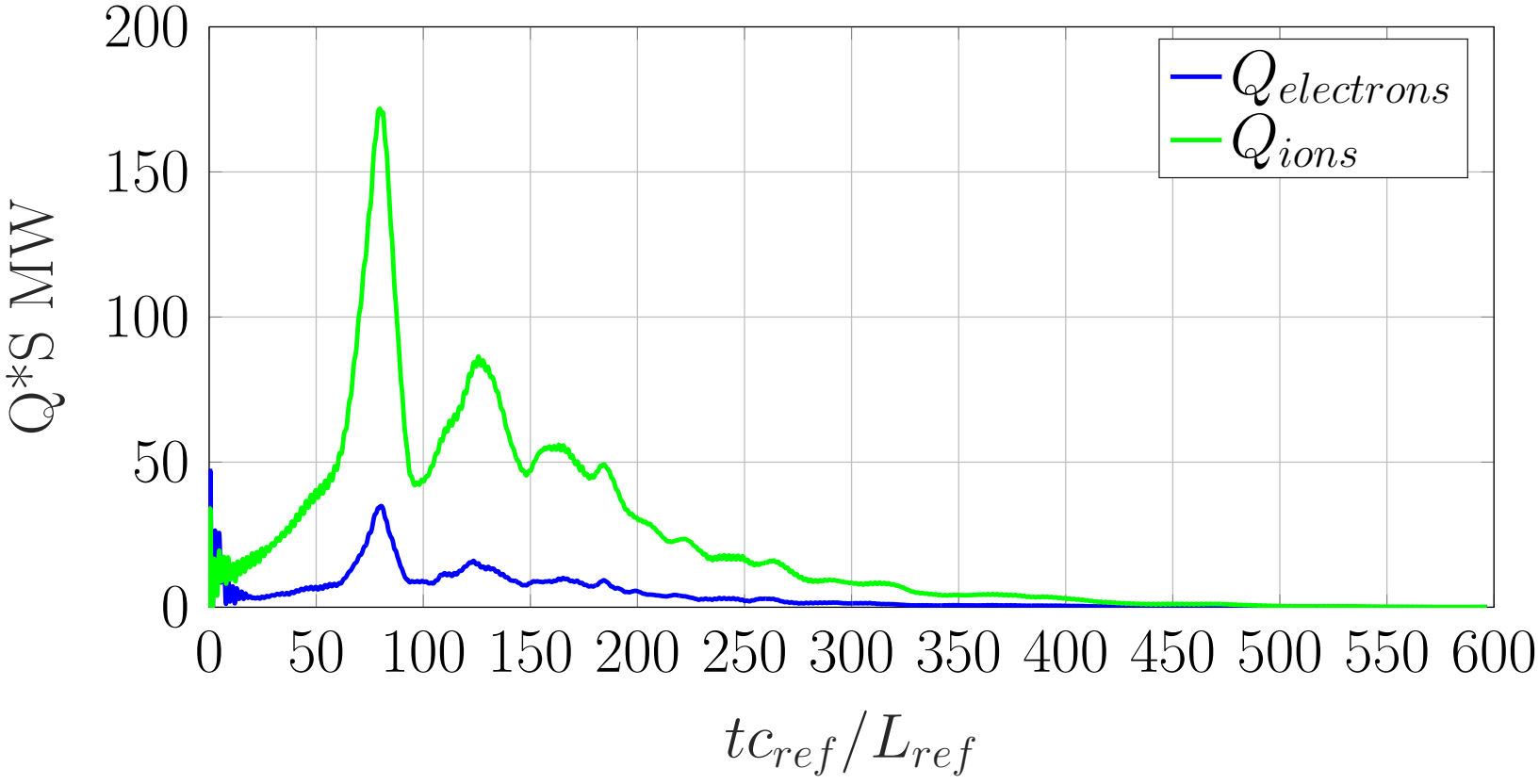
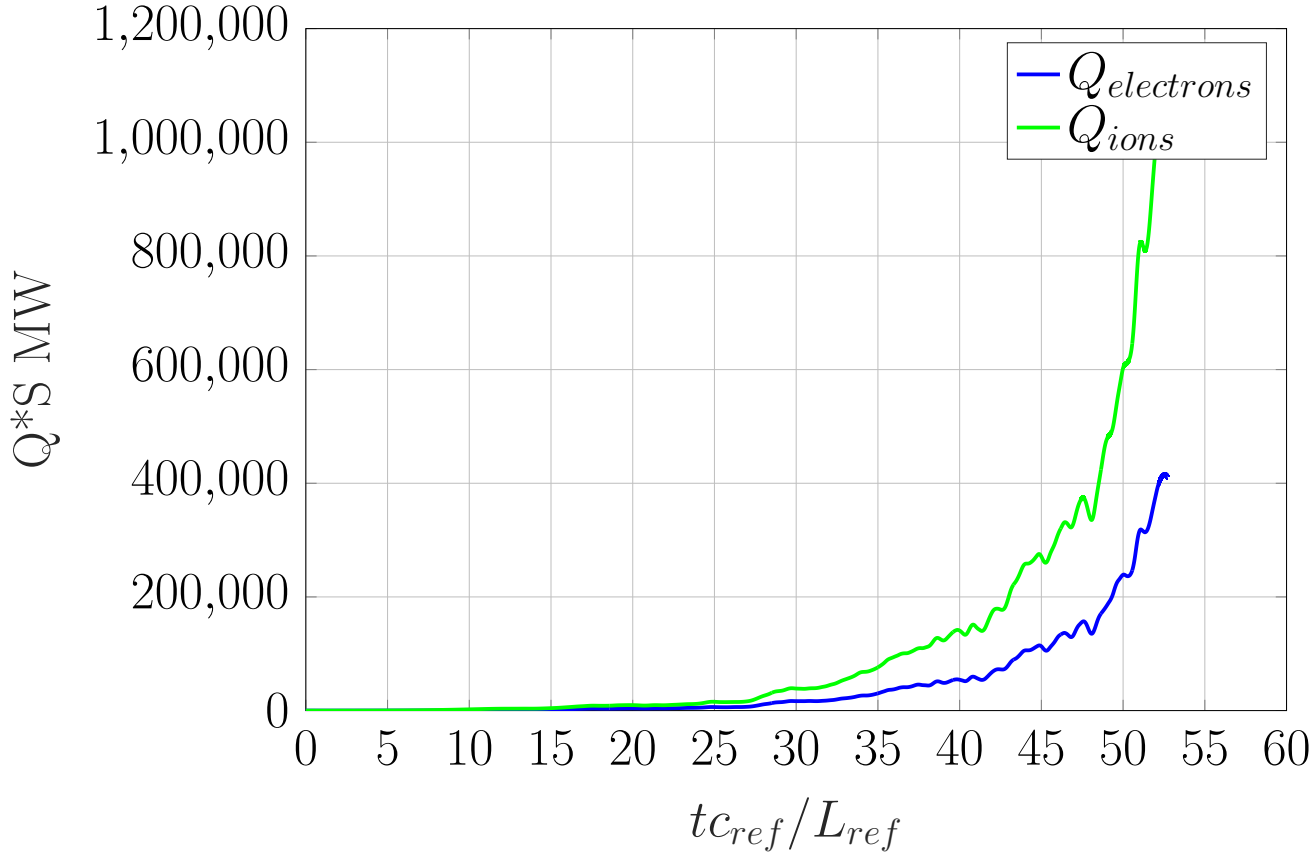


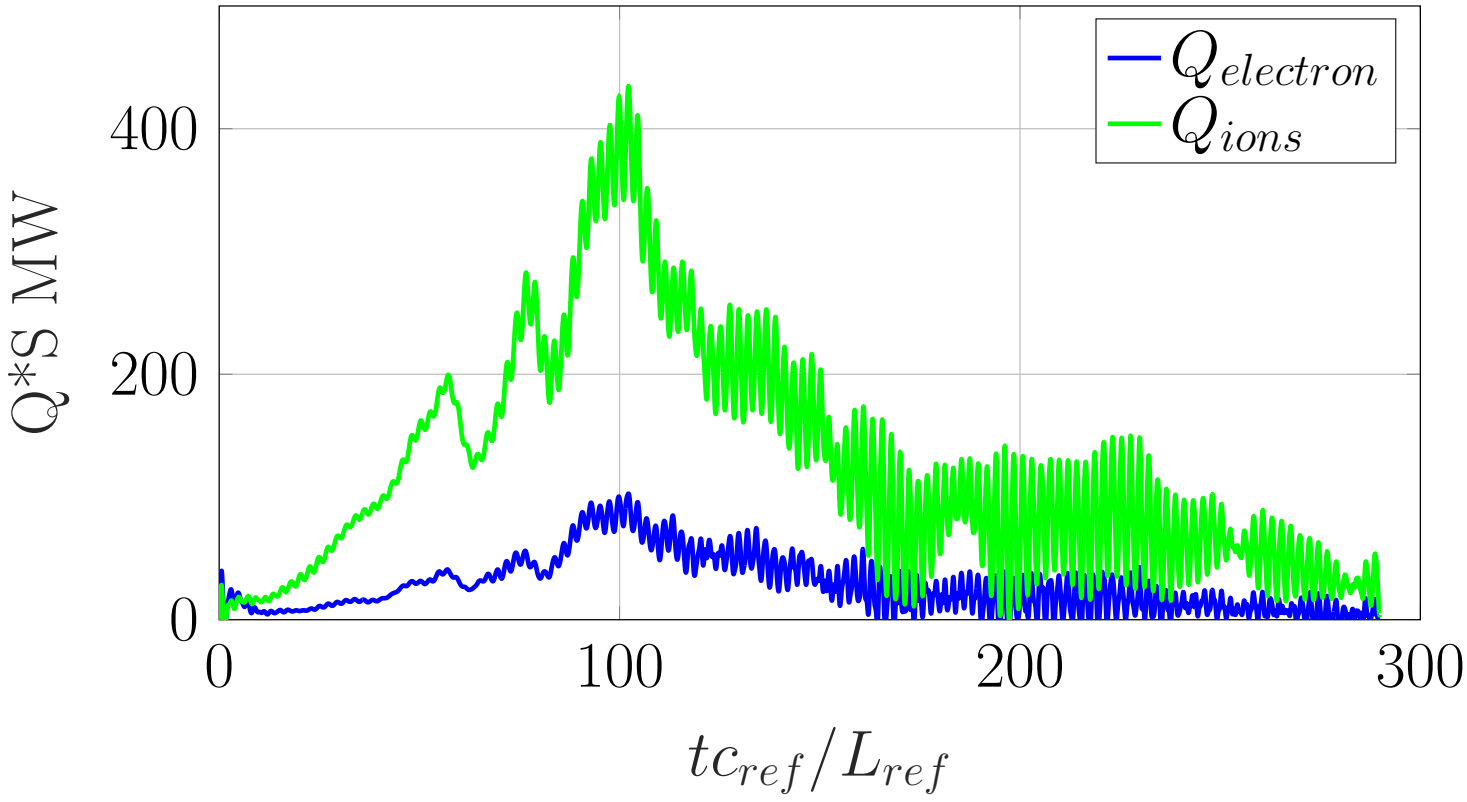
Total heat flux $< 1\mathrm{MW}$ $\Longrightarrow$ need to increase gradients.

Increasing gradients $\Longrightarrow$ non-saturation

@ 20% larger $n_{e,i} + T_{e,i}$ gradients $\Longrightarrow$ heat fluxes do not saturate.



Trying at 10% increased gradients ...



High frequency oscillation linked to fast ions and β.

Proposed work for 2021

- **Find parameters s.t predicted turbulent heat flux matches 41 MW of input power**
  - Compare results with predictions from reduced transport modelling
  - Vary gradients to estimate profile stiffness.
- **Post process simulations with a synthetic diagnostic to model measurements from a Phase Contrast Imaging (PCI) diagnostic.**
  - PCI : one of the key fuctuation diagnostics on JT-60SA.
  - Synthetic diagnostic already developed for post processing GENE results.
  - PCI signals include measurements from different ρ_t $\Longrightarrow$ simulations @ different ρ_t

Summary

- Gyrokinetic GENE simulations to estimate turbulent transport in a JT-60SA scenario.
- Nominal parameters $\Longrightarrow$ too low heat flux.
- Near marginal stability and the non-zonal transition.
- Future plan : comparison with transport models and prediction of PCI signals.

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Thank you for your attention !