Motivation and analysis steps

Predictive transport analysis of JET and AUG hybrid scenarios

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This work concentrates on isolating the impact of s/q at outer radii (x>~0.4) on core confinement in *low-triangularity* JET and ASDEX Upgrade (AUG) hybrid scenarios. Motivation is also to validate prediction (with GLF23) of significant impact of q-profile shaping on ITER hybrid scenario core confinement.

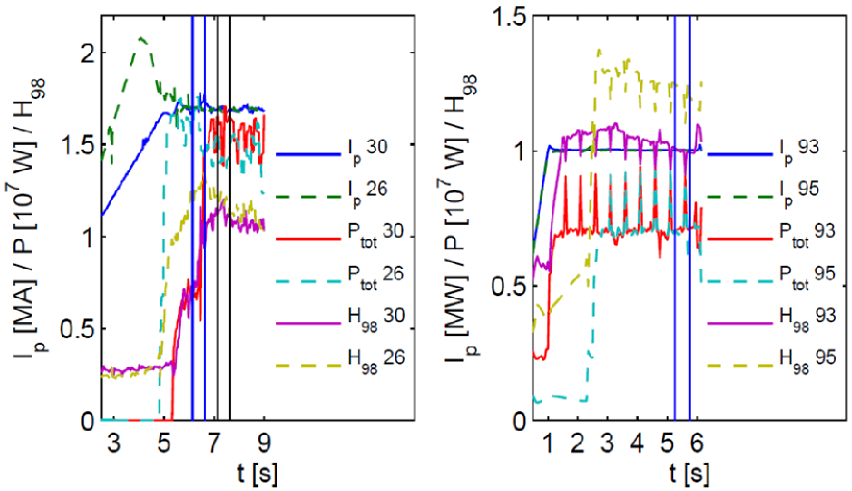
- **Two pairs of discharges were chosen (JET 79630/79626 and AUG 20993/20995).**
- **The discharges within each pair have similar pedestal confinement yet differ in core confinement .**
- **Variations in q-profile achieved by current overshoot (JET) and variation in auxiliary heating timing (AUG)**

Analysis steps

- **Interpretative runs of all shots with CRONOS, using NEMO/SPOT for NBI deposition and PION for ICRH**
- **Predictive runs *on the energy confinement timescale during representative temporal windows* with CRONOS & GLF23. s/q effect isolated by repeating runs following substitution of the input q-profile. Both *heat only* and *heat and particle* transport cases studied**
- **QuaLiKiz linear threshold analysis of the JET pair at one representative radial position**

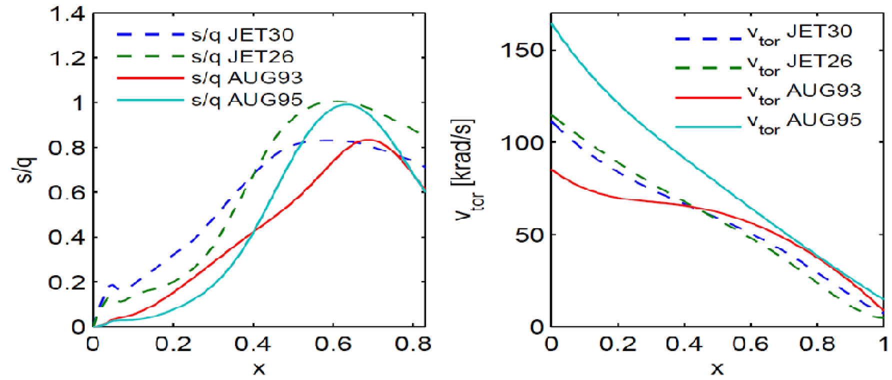
Experimental discharges

Evolution of I_p, P_{tot}, and confinement factor H_{98}



Vertical bars signify time-averaging of profiles for analysis

s/q and rotation profiles used in analysis



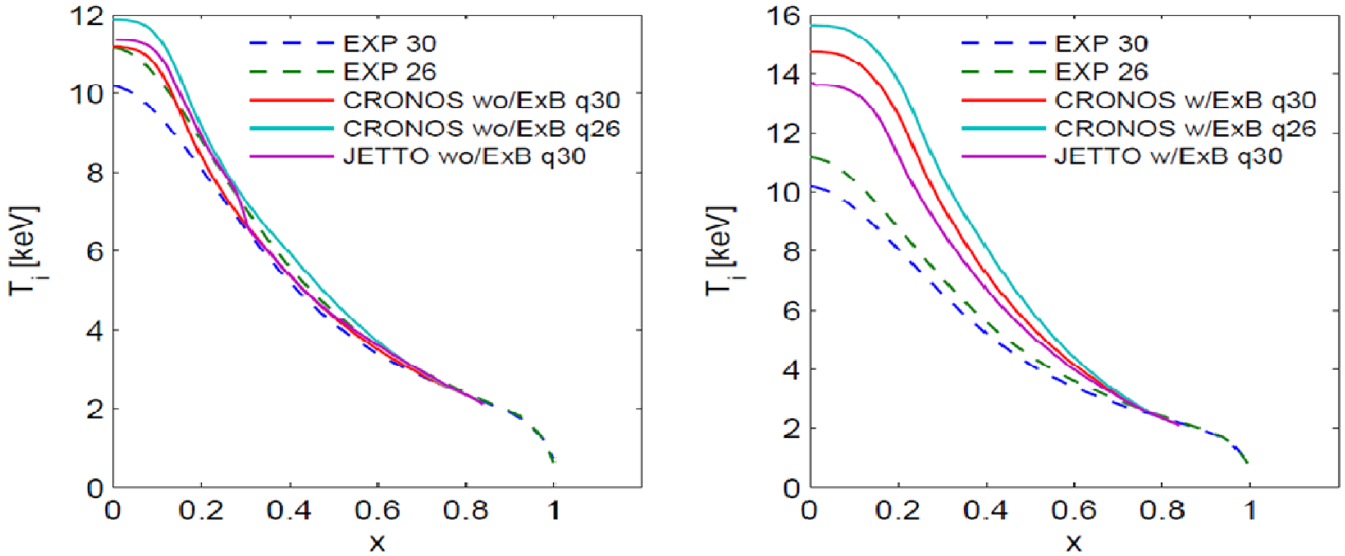
JET rotation profiles similar.
AUG rotation profiles differ in low magnetic shear region x<0.4

Shot	B_T [T]	I_p [MA]	$\beta_p(W_{th})$	$\beta_p(W_{dia})$
JET 79630	2	1.7	1.9	2.6
JET 79626	2	1.7	2.1	2.8
AUG 20993	2.4	1	1.6	1.9
AUG 20995	2.4	1	1.9	2.3

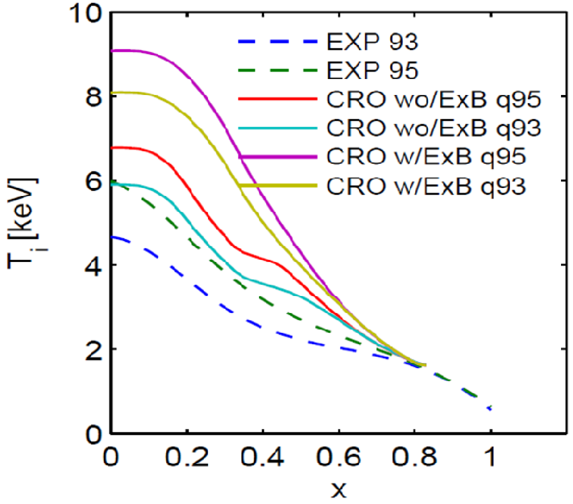
Are the s/q differences in x>0.4 responsible for the observed difference in core confinement?

Heat transport results

JET heat transport GLF23 simulations

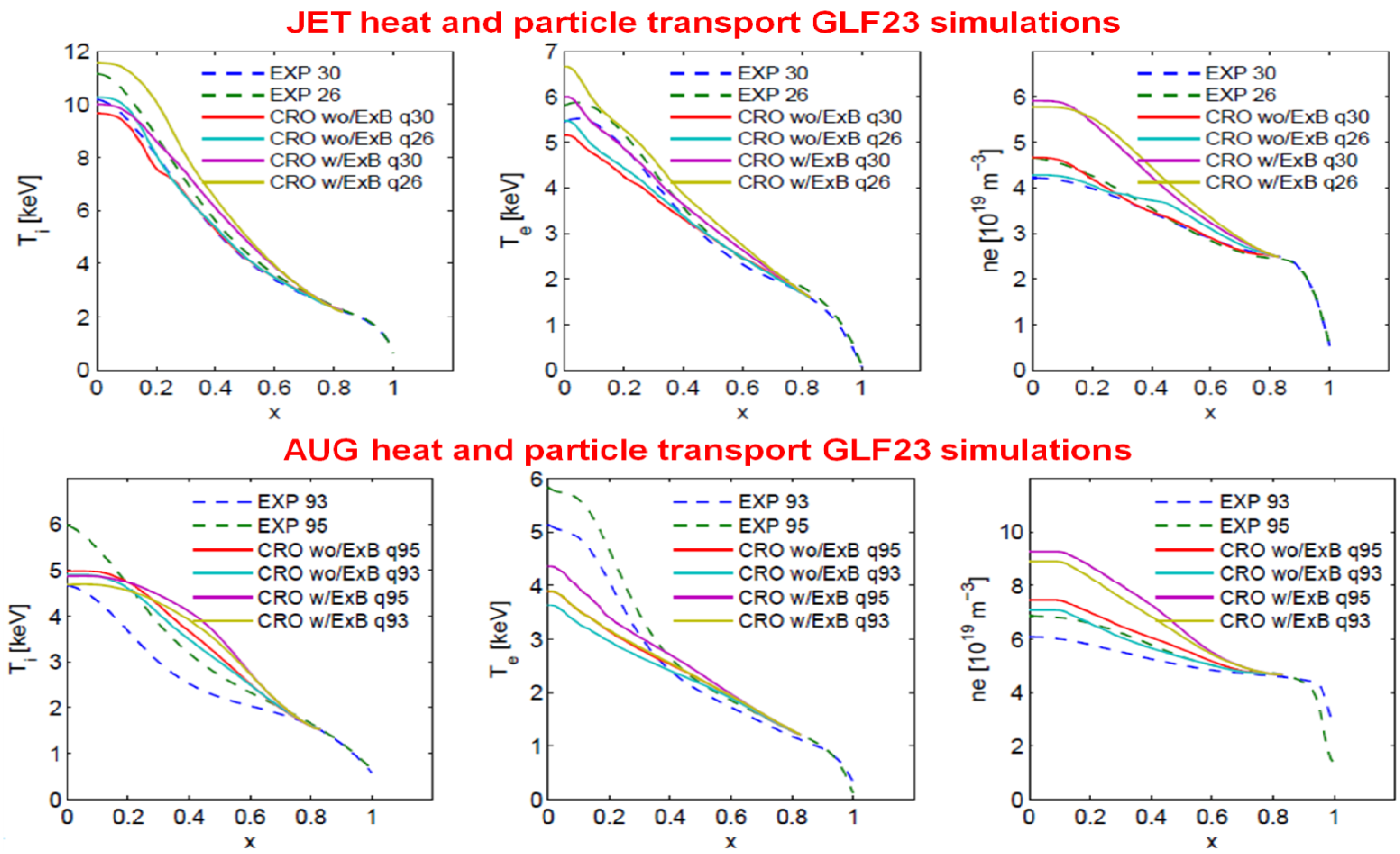


AUG heat transport GLF23 simulations



For both JET and AUG, T_i is overpredicted when ExB shearing is included.
This overprediction is reproduced by JETTO
However, difference in T_i due to s/q effect at x>0.4 consistent with observations

Heat and particle transport results



When particle transport is included, difference in n_e profiles consistent with observations. However, a concurrent rise in T_i is not observed due to high sensitivity of transport to density gradients in GLF23. Inclusion of ExB shearing leads to n_e overprediction.

Result summary and conclusions

Summary of GLF23 simulations in terms of predicted core energy content [MJ], compared with observations

	Heat transport only		Heat and particle	
	no ExB	with ExB	no ExB	with ExB
79630 (q30)	1,71	2,37	1,71	2,68
79630 (q26)	1,9	2,62	1,83	3,03
Ratio	1,11	1,11	1,07	1,13
W_{core} 79630/79626 = 1,67/1,97 MJ			ratio = 1,17	

	Heat transport only		Heat and particle	
	no ExB	with ExB	no ExB	With ExB
20995 (q95)	0,36	0,48	0,34	0,47
20995 (q93)	0,3	0,43	0,29	0,41
Ratio	1,20	1,12	1,17	1,15
W_{core} 20993/20995 = 0,22/0,33 MJ			ratio = 1,5	

For JET

QuaLiKiz R/L_{Ti} predictions at x=0.65

	79630	79630 (q26)
QuaLiKiz	7,32	8,08
Experiment $(R=(R_{in}-R_{out})/2)$	5,90±0,5	6,30±0,3
Experiment $(R=R_{out})$	7,5±0,6	8,10±0,4

- **Significant proportion of improved core confinement in JET/AUG hybrid scenarios (~60/30% respectively) is predicted by GLF23 due to s/q increase at x>0.4.**

- Including ExB shear leads to significant overprediction of the kinetic profiles: in T_i for heat transport cases, and in n_e when including particle transport. **Effect of s/q remains, regardless of ExB shear assumption.**

- **Analysis with QuaLiKiz predicts the degree of improvement of R/L_{Ti} at x=0.65 for the JET pair.** However, experimental errors hampers detailed analysis at a given position, even following averaging over 0.5s of data.

Where could the remaining core confinement improvement come from?

- Slight differences in pedestal confinement could also be significant (due to changing the 'height' from which core confinement is calculated), this will be examined in future analysis.

- In the JET pair, the R/L_{Ti} difference is located at x>0.4 (high magnetic shear region), consistent with the s/q difference. In the AUG pair, there is a R/L_{Ti} difference in both the high and low shear region (between x=0.3-0.6). The AUG rotation profiles differ for x<0.4 (low magnetic shear region), where the 20993 V_{tor} profile is flat. Could the rotation difference at low shear lead to differing stiffness and stored energy for x<0.4?

- AUG 20993 has a 3/2 NTM at x~0.5, which could also reduce core confinement. Indeed GLF23 overpredicts 20993 for all ExB