CRPP

Study of plasma fluctuations in new closed flux-surface configurations of the TORPEX experiment

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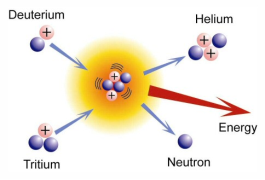
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

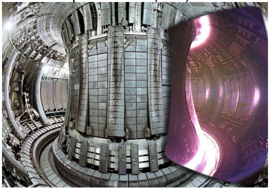
Joint Annual Meeting of the Austrian Physical Society and Swiss Physical Society, September 5, 2013, JKU Linz

Anomalous transport in fusion devices

Tokamaks are the most promising option to produce electricity from fusion energy in the near future.



Joint European Torus (JET)



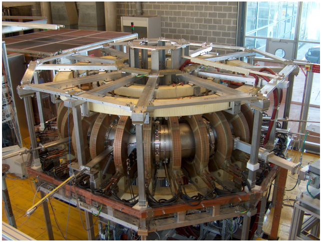
Source: EFDA JET

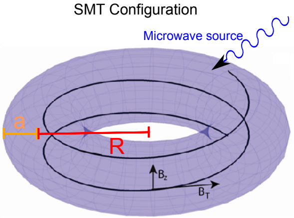
A key issue is the transport of:

- Particles;
- Momentum;
- Heat;

$\Rightarrow$ Study of plasma turbulence and instabilities is difficult on tokamaks because of the limited diagnostic access.

TORoidal Plasma EXperiment[1]





- $R = 1m,\ a = 0.2m$
- H_2, He, Ne, Ar
- $B_T \approx 76mT$
- $B_V \approx mT$
- $n_e \approx 10^{16} m^{-3}$
- $T_i \leq T_e \approx 5eV$

[1] Fasoli *et al.* PPCF 2010.

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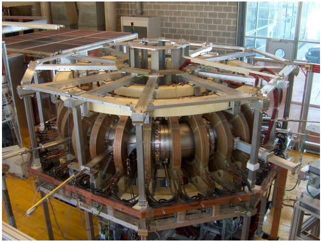
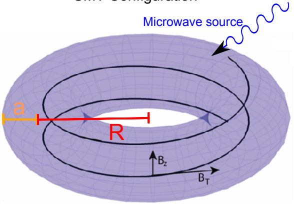


SMT Configuration



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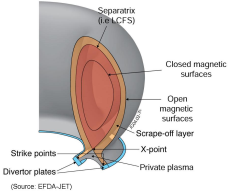
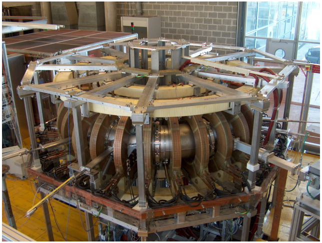


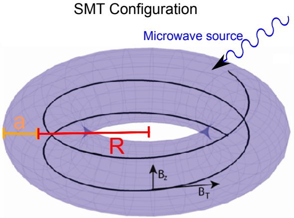
Main features of a tokamak SOL:

- Density gradients;
- Magnetic field gradients;
- Magnetic field curvature;

[1] Fasoli *et al.* PPCF 2010.

TORoidal Plasma EXperiment[1]





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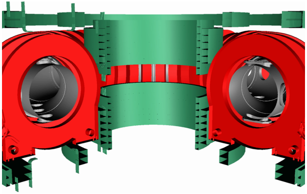
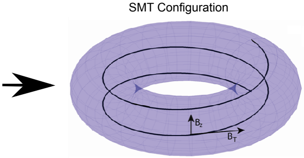
Advantages:

- Direct measurements on the whole plasma volume.
- High plasma reproducibility.
- High flexibility of the control parameters.

[1] Fasoli *et al.* PPCF 2010.

How do we close the flux surfaces?





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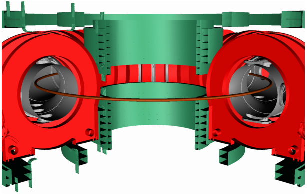
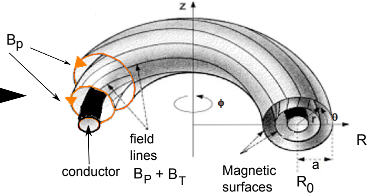


TORPEX configuration with the toroidal conductor



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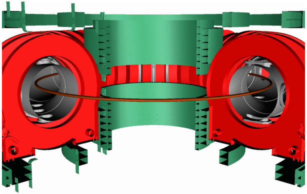
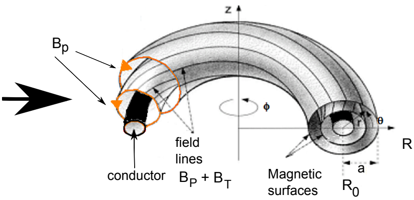
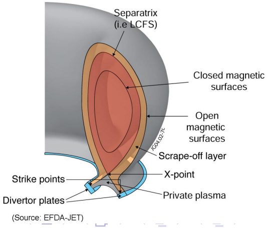




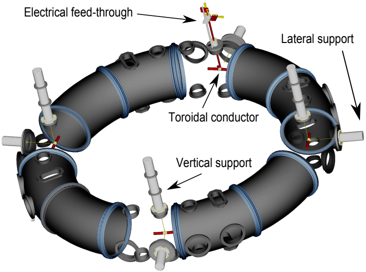
Why? To study plasma instabilities in a configuration closer to that of a tokamak.

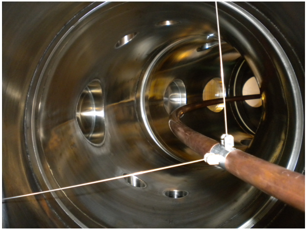
- Introduce a rotational transform.
- Scrape-Off Layer physics.
- Closed-to-open magnetic surfaces transition.
- Core region.

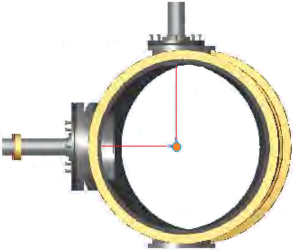


Experimental set-up

- 1cm radius toroidal copper conductor;
- 1 mm stainless steel supports: 3 vertical, 4 lateral;
- 1 vertical coaxial feed-through;
- up to $1kA$ of current with 1300A/sec slew rate;







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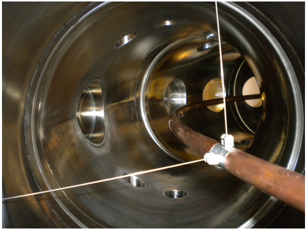

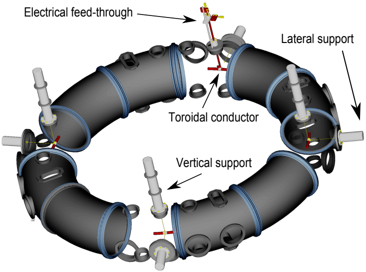

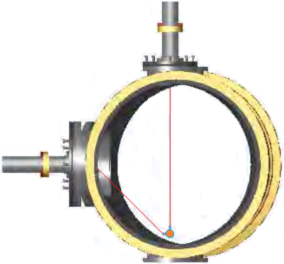

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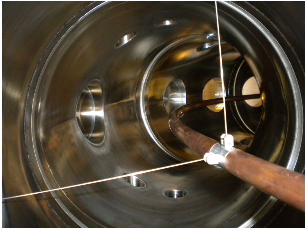
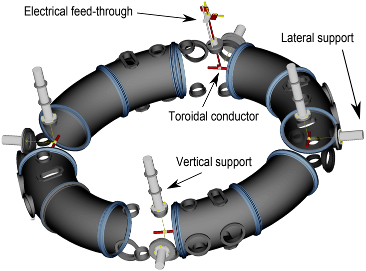
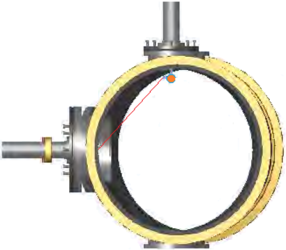






Experimental parameters

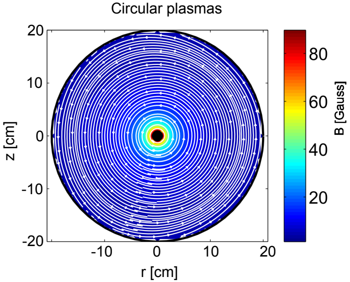
Fixed parameters:

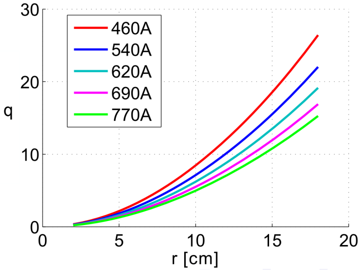
- Hydrogen plasma;
- $P_M \approx 200W$;
- $B_T \approx 800$ Gauss ($R_{EC} \approx 0.9m$);
- Toroidal conductor at $(r = 0, z = 0)cm$;

Scan parameters:

- $I_{t.c.} \approx (460 \div 770)A$;

$$q = \frac{\#toroidal\ turns}{\#poloidal\ turns}$$

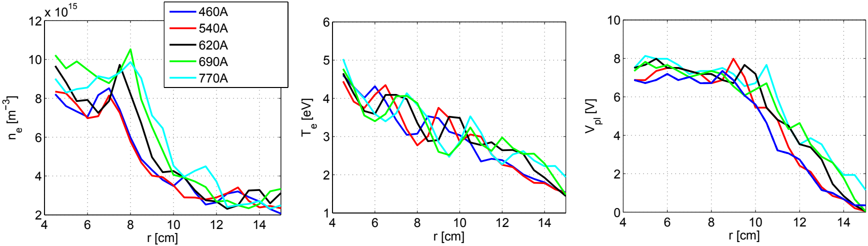




Background plasma parameters radial profiles at z=0

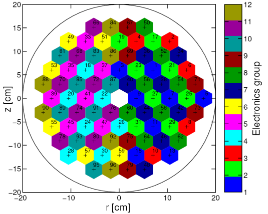
Using a Langmuir probe in sweeping voltage.

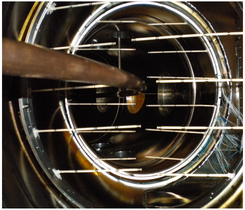
- $n_e \approx (10^{15} \div 10^{16}) m^{-3}$;
- $T_e \approx (3 \div 5) eV$;

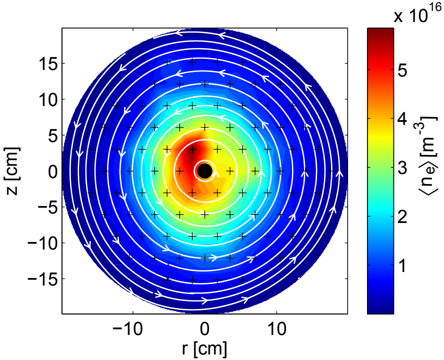


2D background plasma density profile

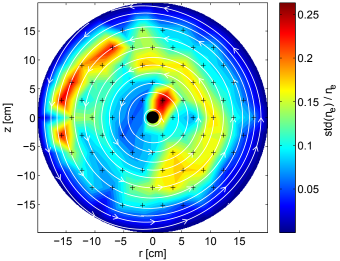
The HEXagonal Turbulence Imaging Probe (HEXTIP), composed of 85 Langmuir probes, was used in I_{sat} regime.







HEXTIP 2D fluctuations profiles



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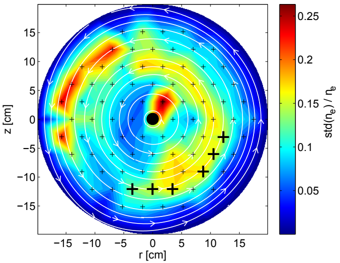

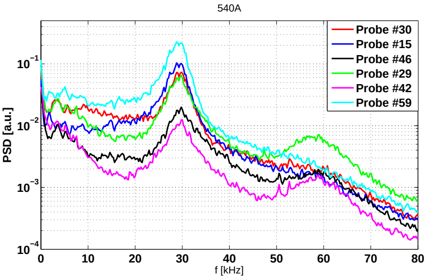

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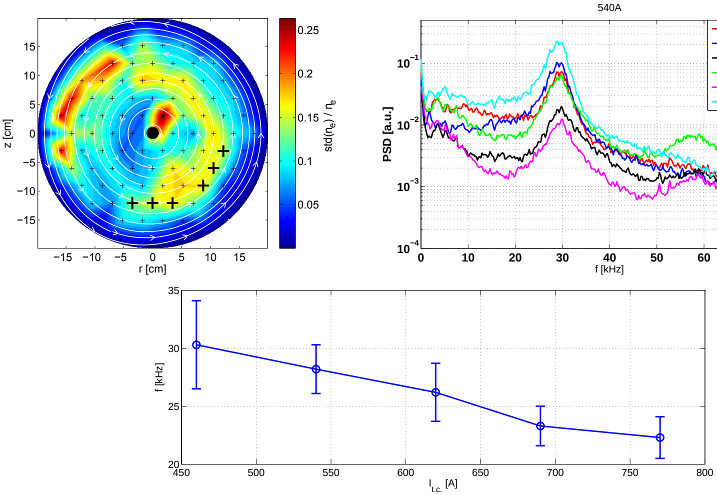

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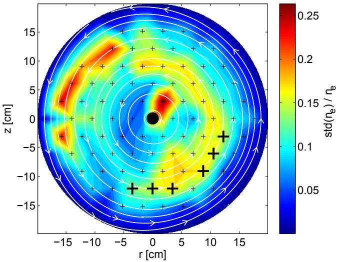
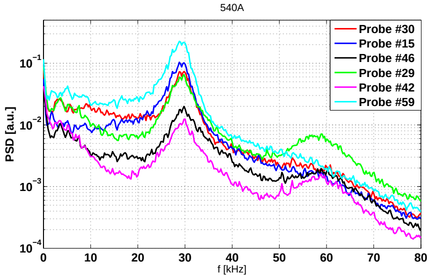
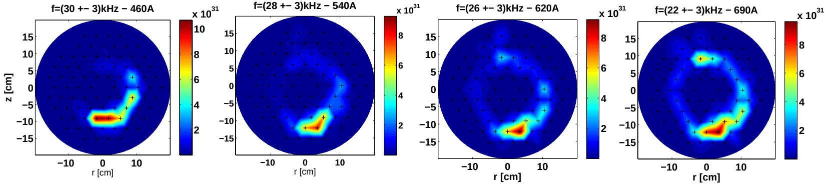


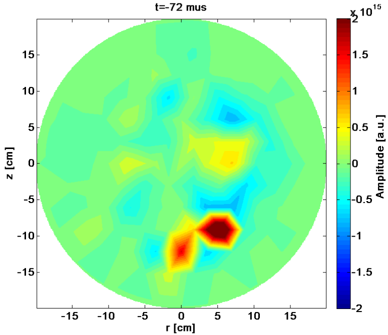


Coherent plasma fluctuations localized on the LFS



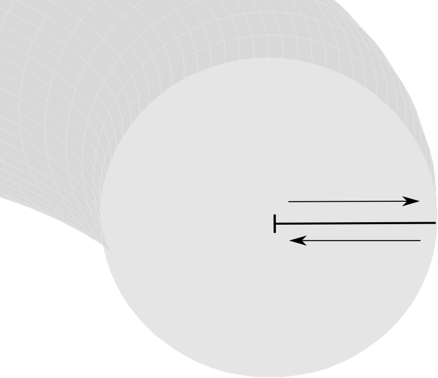
HEXTIP CAS

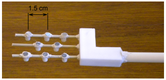
Using the conditional average sampling technique on HEXTIP data.



k_θ measurements

Calculating the statistical dispersion relation at $z = 0$, at the radial position of maxima fluctuations.





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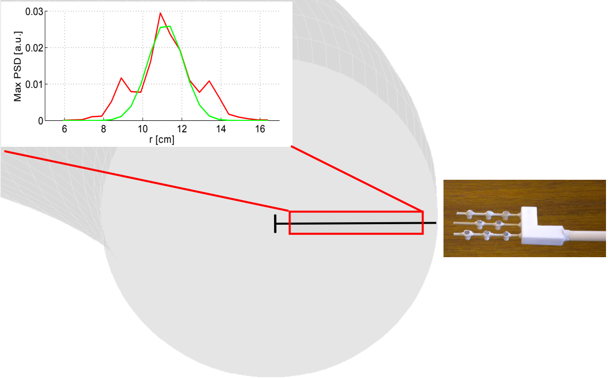

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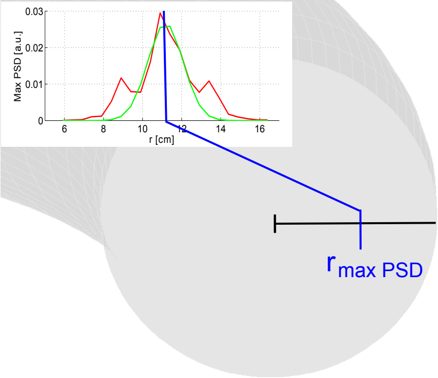

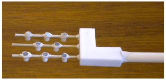

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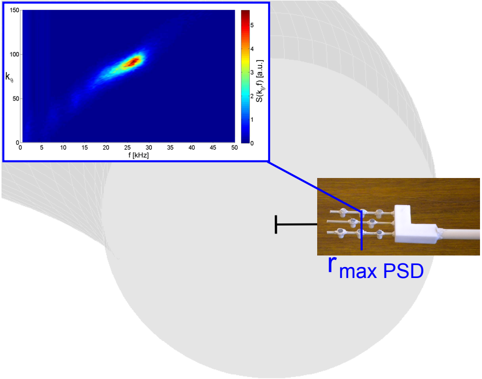
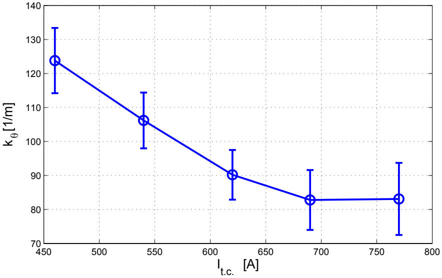


k_θ measurements

This is done for each value of the conductor current.

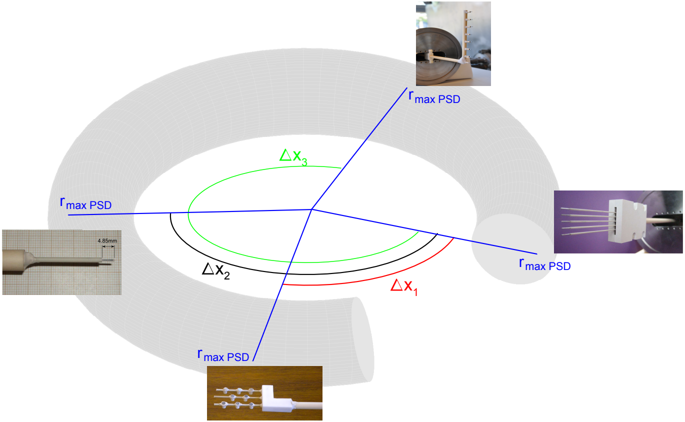


$$\lambda_\theta \in (5.1 \div 7.6)cm$$

$$m \in (12 \div 9)$$

k_ϕ measurements

Measuring k_ϕ from the phase shift between Langmuir probes set at different toroidal angles, but at the same radial position.



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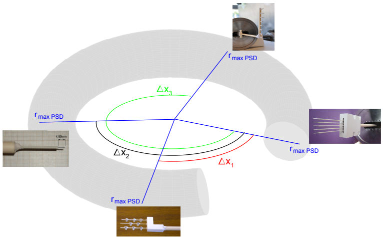

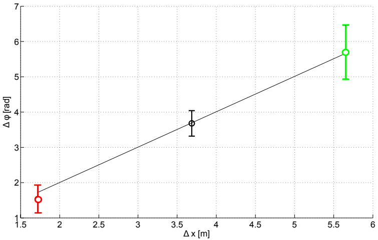

$$k_\phi = \frac{d\phi}{dx}$$

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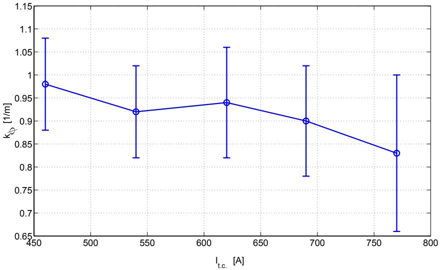
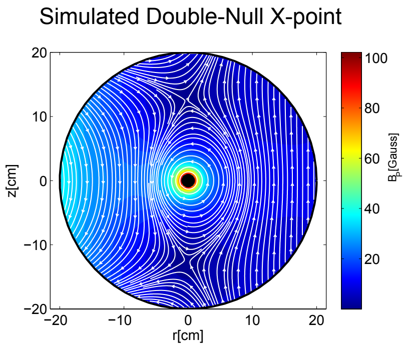


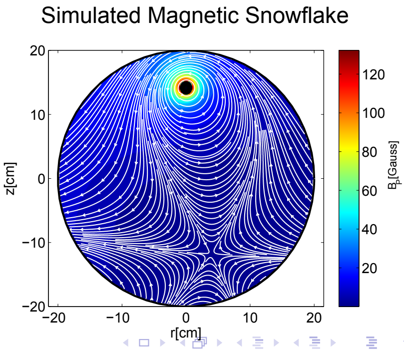
$$\lambda_\phi \in (6.4 \div 7.6)m$$

$$n \simeq 1$$

Outlook

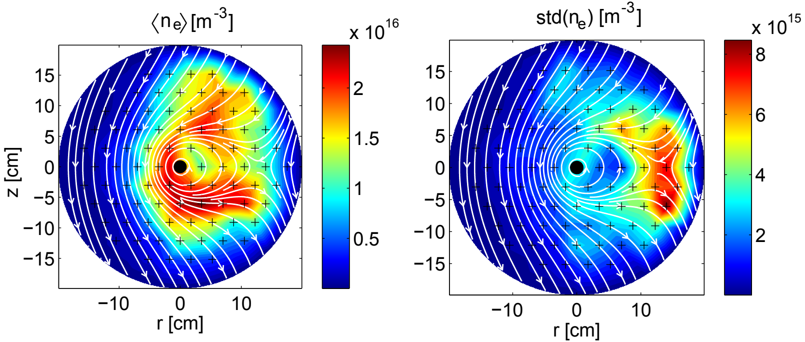
- Comparison with linear/ non-linear 3D GBS code;
- Turbulence investigations for different experimental parameters;
- Exploration of more advanced magnetic field configurations;





Outlook

First experimental single-null X-point.



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Conclusions

- Introduced the TORPEX in-vessel toroidal conductor;
- Discussed the background plasma parameters with almost closed flux surfaces;
- Analyzed the spectral properties of the dominant coherent modes, to be compared with 3D fluid simulations;
- Introduced the new accessible magnetic configurations that can be now explored on TORPEX;

Thanks to my supervisors Dr. Ivo Furno and Prof. Ambrogio Fasoli,
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THANK YOU FOR YOUR ATTENTION