Research & Coordination Activity

N. Vianello

Consorzio RFX, Associazione Euratom-ENEA sulla Fusione, Padova, Italy

June 01 2012

ITER Research Plan framework

- European Fusion Research focused on unresolved physical and technological problems in support of ITER
- ITER research plan (IRP) individuated 12 top operation risks which should be addressed by the world-wide fusion program *(L. Horton FED 2012)*

1. Inadequate disruption mitigation
2. H-mode power threshold at high end of uncertainty range
3. Inadequate ELM mitigation schemes
4. Inadequate vertical stability control
5. Lack of reliable high power heating during non-active phase of program
6. Unacceptable divertor performance with tungsten PFCs
7. Lack of plasma rotation leading to a degradation of plasma performance
8. High levels of tritium retention requiring more frequent tritium removal procedures than foreseen
9. Incompatibility of core plasma requirements for Q=10 with radiative divertor operation
10. Inability to achieve densities near Greenwald value for required Q=10
11. Inadeguate particle control to sustain high-Q plasma scenario

ITER Research Plan framework

- European Fusion Research focused on unresolved physical and technological problems in support of ITER
- ITER research plan (IRP) individuated 12 top operation risks which should be addressed by the world-wide fusion program *(L. Horton FED 2012)*

1. Inadequate disruption mitigation
2. H-mode power threshold at high end of uncertainty range
3. Inadequate ELM mitigation schemes
4. Inadequate vertical stability control
5. Lack of reliable high power heating during non-active phase of program
6. Unacceptable divertor performance with tungsten PFCs
7. Lack of plasma rotation leading to a degradation of plasma performance
8. High levels of tritium retention requiring more frequent tritium removal procedures than foreseen
9. Incompatibility of core plasma requirements for Q=10 with radiative divertor operation
10. Inability to achieve densities near Greenwald value for required Q=10
11. Inadequate particle control to sustain high-Q plasma scenario

Personal research interest

- Actively involved in fusion plasma science since the M.Sci. thesis in 1999
- Personal research interests can be summarized into three main macro-areas

  (A) Flows & Turbulence induced transport
  $\Rightarrow$ points 2,7

  (B) Emerging of electromagnetic structures
  $\Rightarrow$ points 2,7

  (C) 3D physics and helical plasmas
  $\Rightarrow$ points 2,3,7,10

Flows & Turbulence induced transport

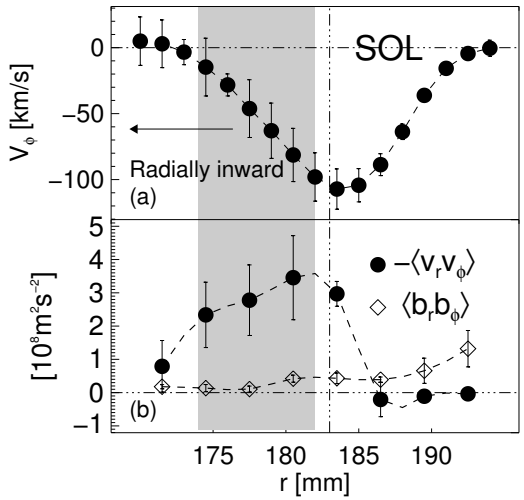
- The principal results may be summarized as follows:

Flows & Turbulence induced transport

A

- The principal results may be summarized as follows:

(i) Momentum flux generated by off-diagonal terms in the stress tensor: Reynolds stress, Maxwell stress and non-linear momentum flux $\langle \tilde{v}_\perp \tilde{v}_r \tilde{n} \rangle$



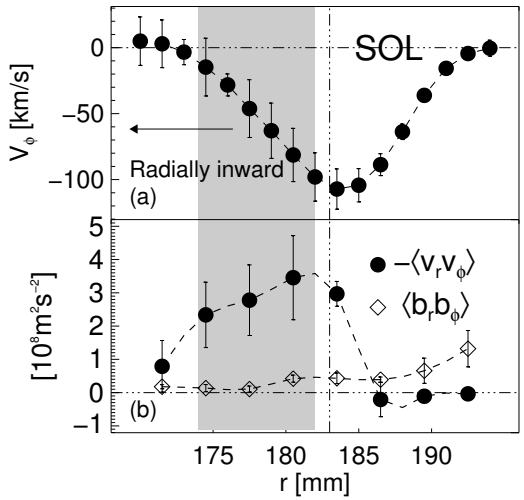
*PRL **94** (2005), NF **45** (2005), PPCF **48** (2006)*

Flows & Turbulence induced transport

A

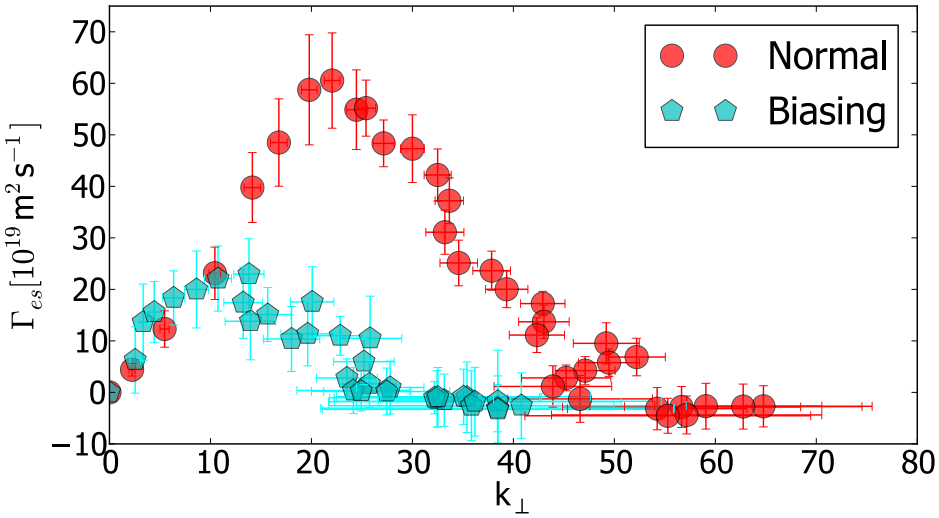
- The principal results may be summarized as follows:

(i) Momentum flux generated by off-diagonal terms in the stress tensor: Reynolds stress, Maxwell stress and non-linear momentum flux $\langle \tilde{v}_\perp \tilde{v}_r \tilde{n} \rangle$



PRL ***94*** *(2005), NF* ***45*** *(2005), PPCF* ***48*** *(2006)*

(ii) Transport reduction induced by active modification of sheared flow

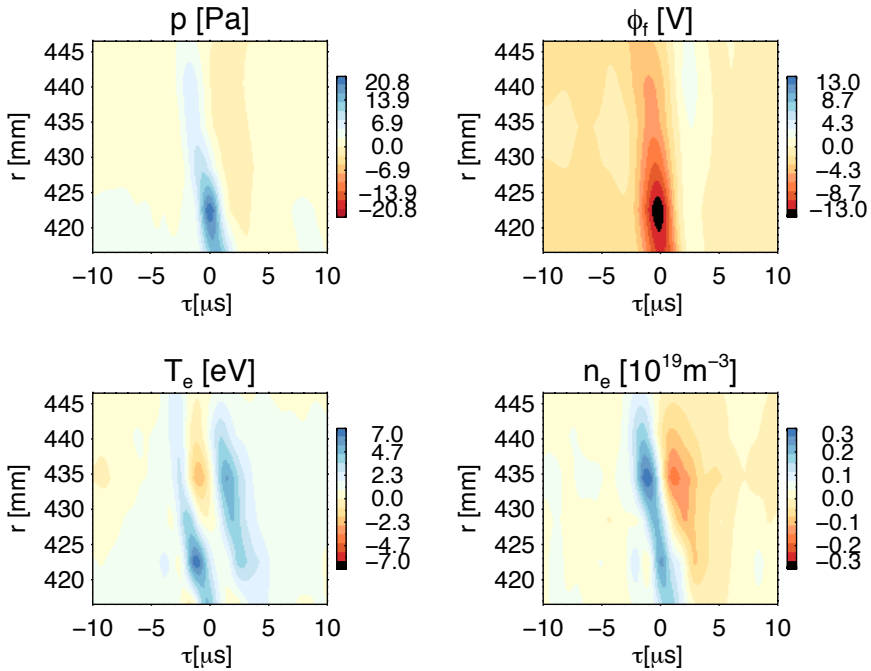


PPCF ***42*** *(2000)*

Coherent structures characterization

B

- Complete electrostatic characterization of intermittent blobs

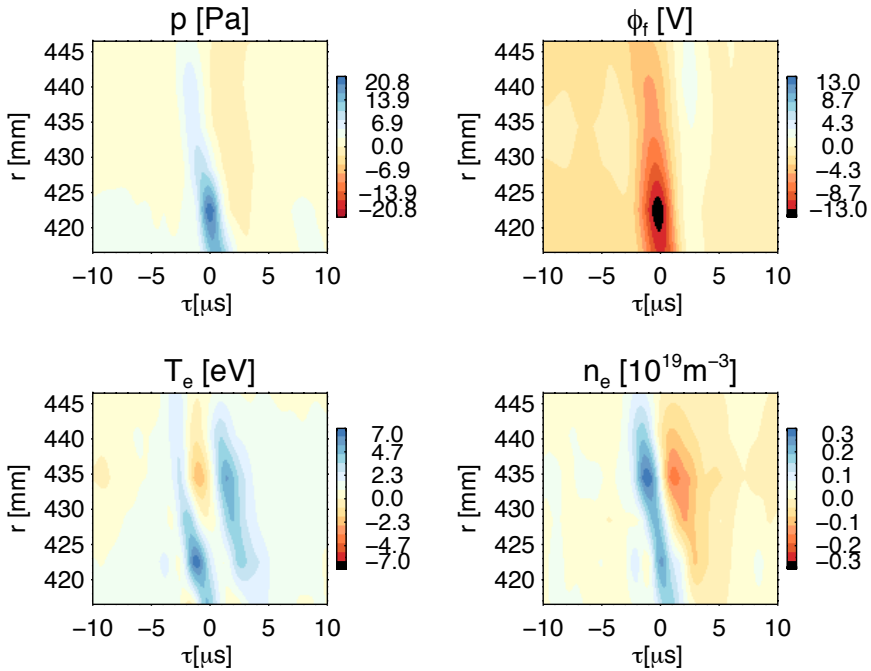


*NF **50** (2010)*

Coherent structures characterization

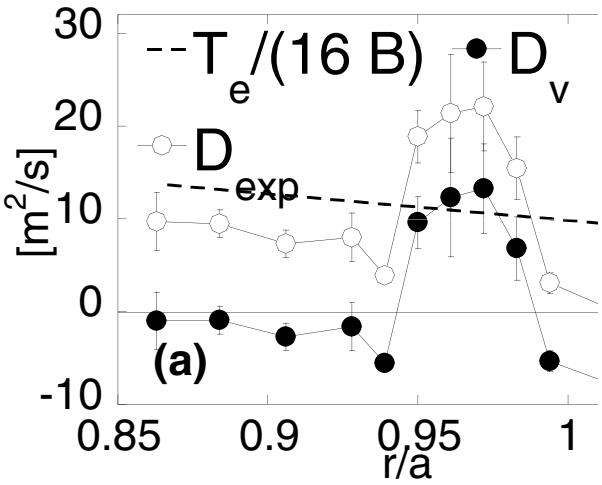
B

- Complete electrostatic characterization of intermittent blobs



*NF **50** (2010)*

- Evaluation of transport contribution due to coherent structures

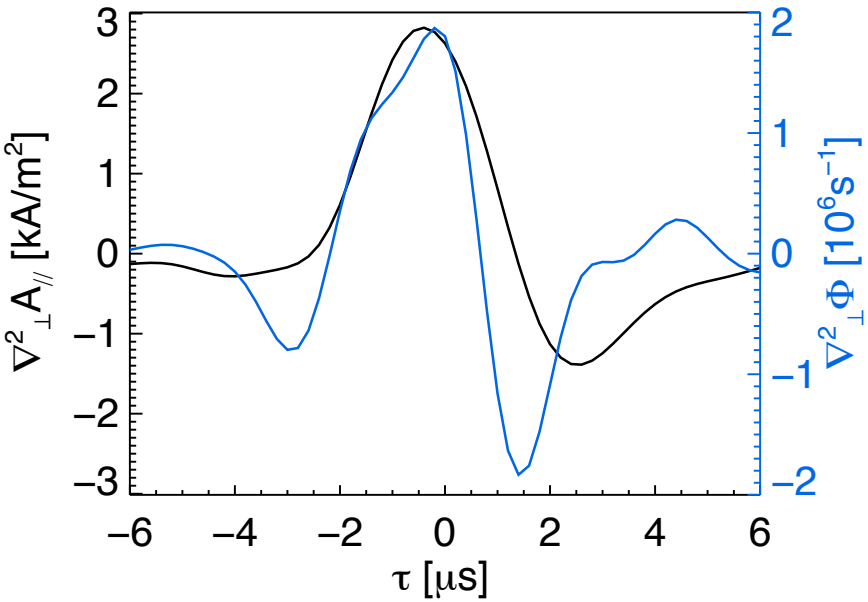


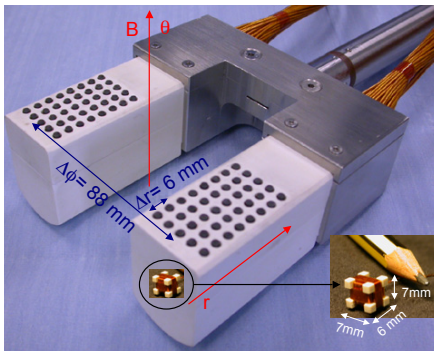
*PRL **93** (2004), PoP **9** (2002)*

Current filaments

B

- Measurements of parallel plasma current associated to *blobs* & *filaments* in different experiments with different magnetic configurations





RFX-mod Reversed Field Pinch

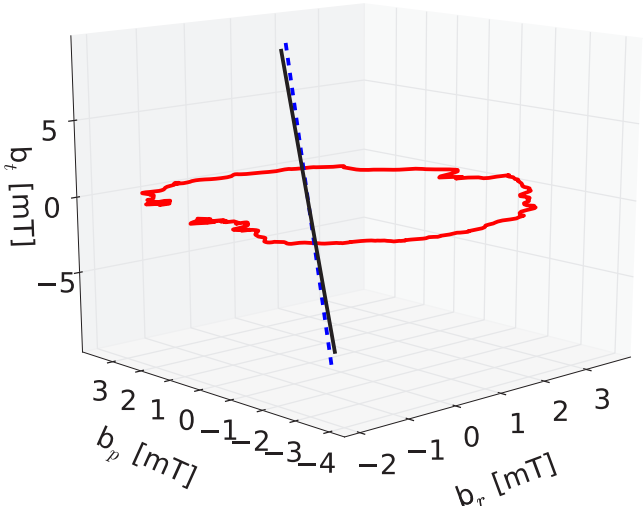
- First direct measurements of current filaments associated to plasma blob identified as DKA vortex

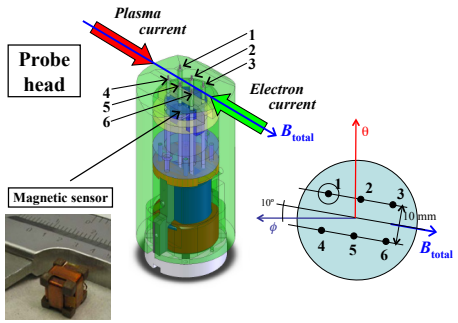
*PRL **102** (2009), NF **50** (2010)*

Current filaments

B

- Measurements of parallel plasma current associated to *blobs* & *filaments* in different experiments with different magnetic configurations





ASDEX-Upgrade Tokamak

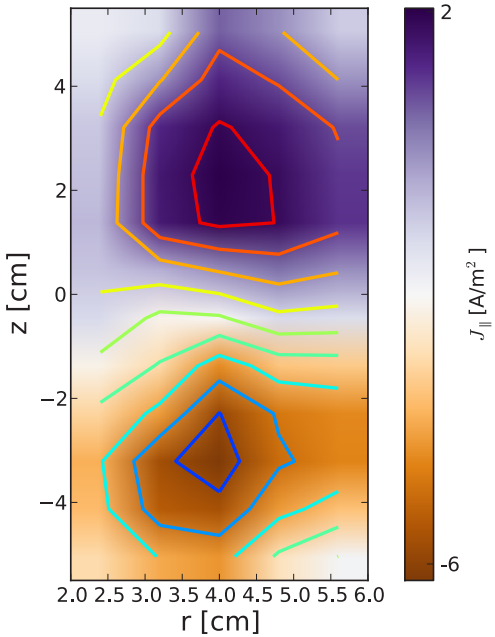
- First direct measurements of current asociated to type-I filaments

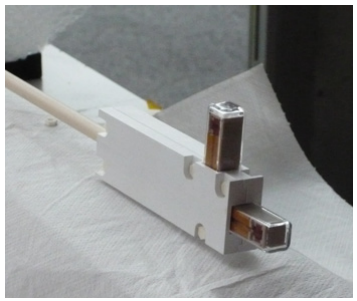
*PRL **106** (2011)*

Current filaments

B

- Measurements of parallel plasma current associated to *blobs* & *filaments* in different experiments with different magnetic configurations





TORPEX simple magnetized torus

- First direct 2D map of parallel current associated to an interchange-induced plasma blob

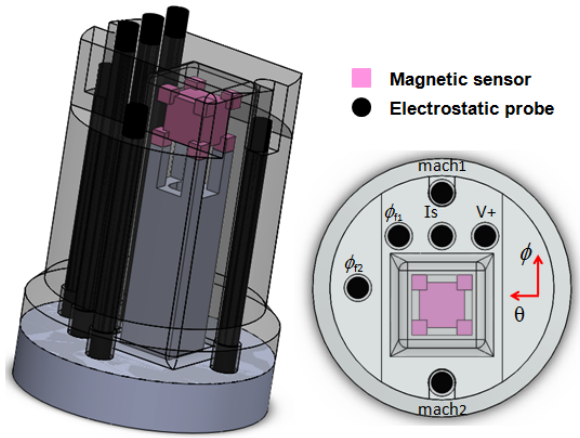
PRL ***106*** *(2011)*

Current filaments

B

- Collaboration established to extend studies of current filaments to other devices, namely `TJ-II stellarator`, with a probe which combines vorticity and current measurements and `EAST tokamak` for the studies of ELMs

TJ-II Stellarator



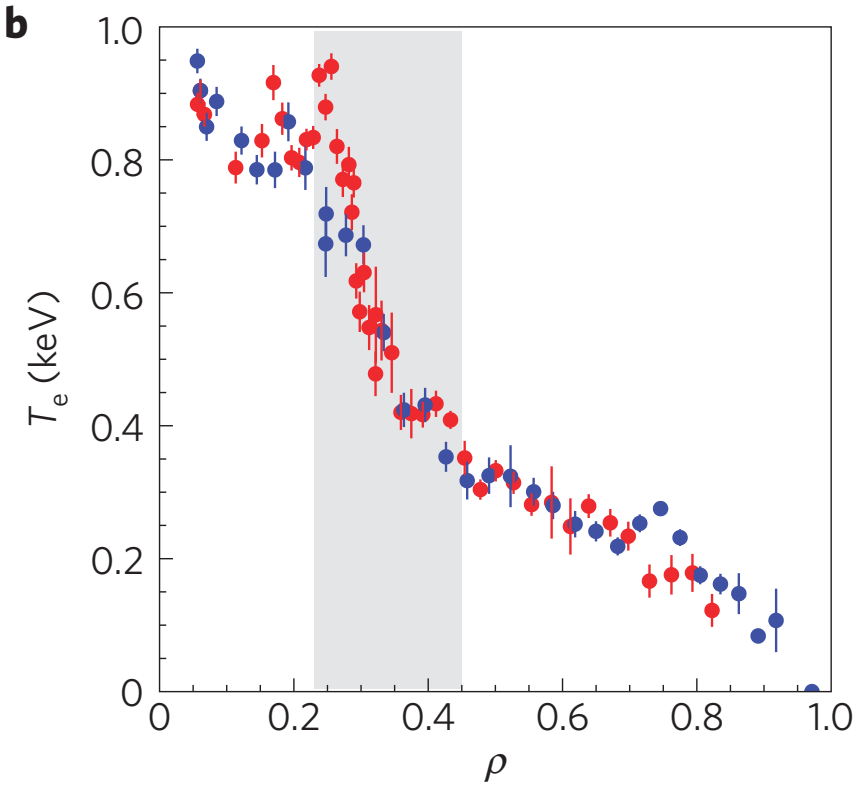
EAST-Tokamak

Helical plasmas

- Observation and characterization of spontaneous helical plasmas developed in high current Reversed Field Pinch operation

Nat. Phys. ***5*** *(2009)*

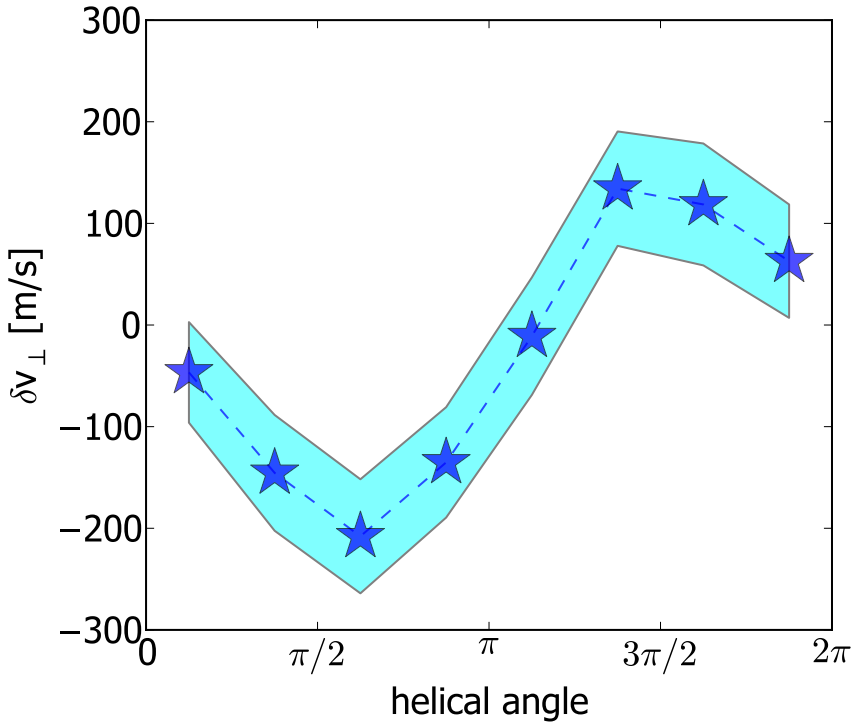
Helical plasmas



- Helical core associated with a transport barrier located in the region of a local maxima of *q* value

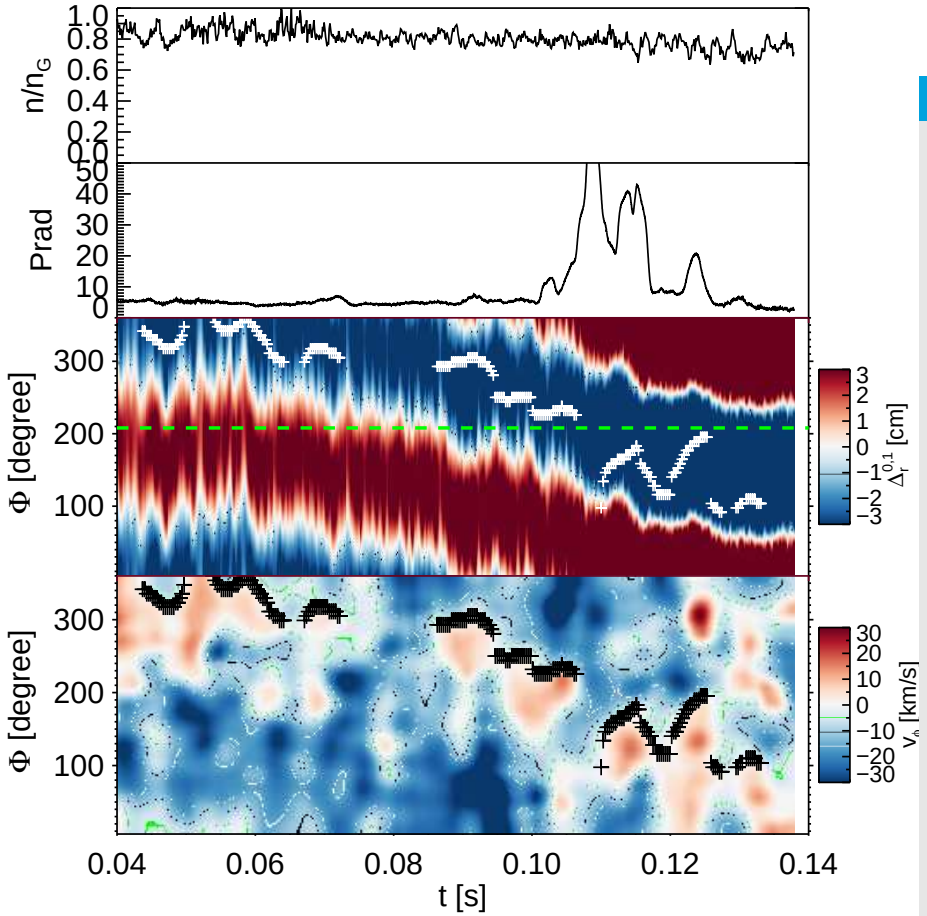
Nat. Phys. ***5*** *(2009)*

Helical plasmas



- Ambipolar electric field builds up as a response to the magnetic perturbation causing a perpendicular flow with the same periodicity as the helical magnetic perturbation

Helical plasmas

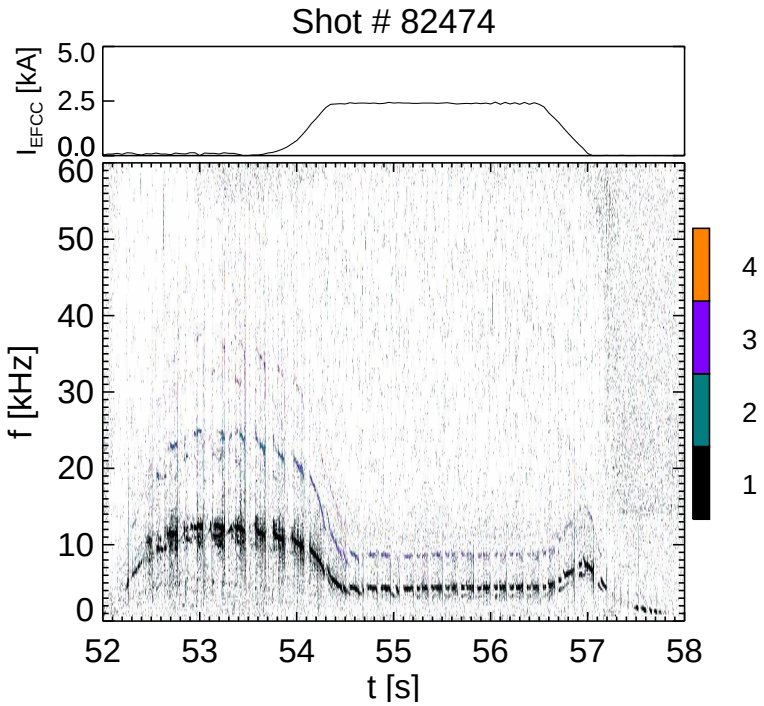


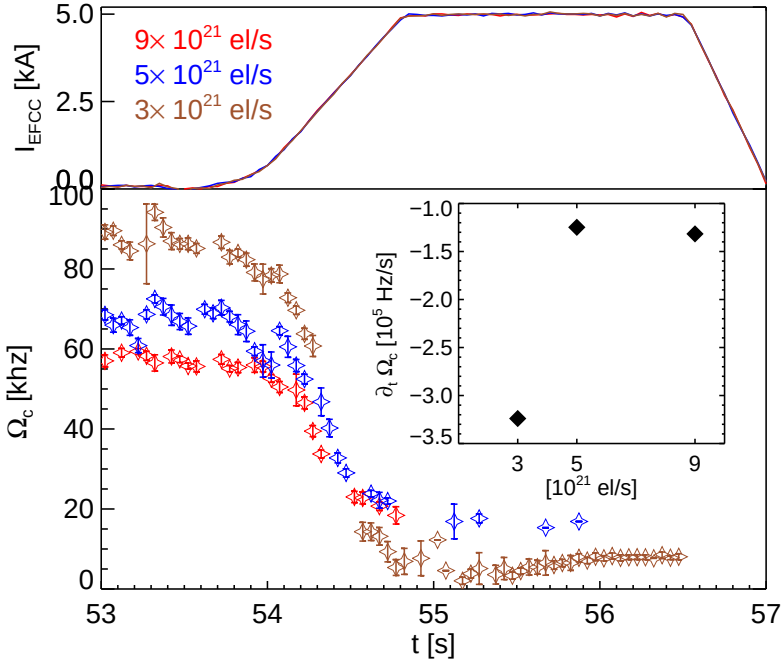
- Similar phenomenology appears in High density regime
- In this case, radiative collapse caused by density accumulation induced by perpendicular flow inversion
- Accumulation point coincides with the X-point of the magnetic islands

*NF **52** (2012)*

Toroidal braking during EFCC experiment in ILW

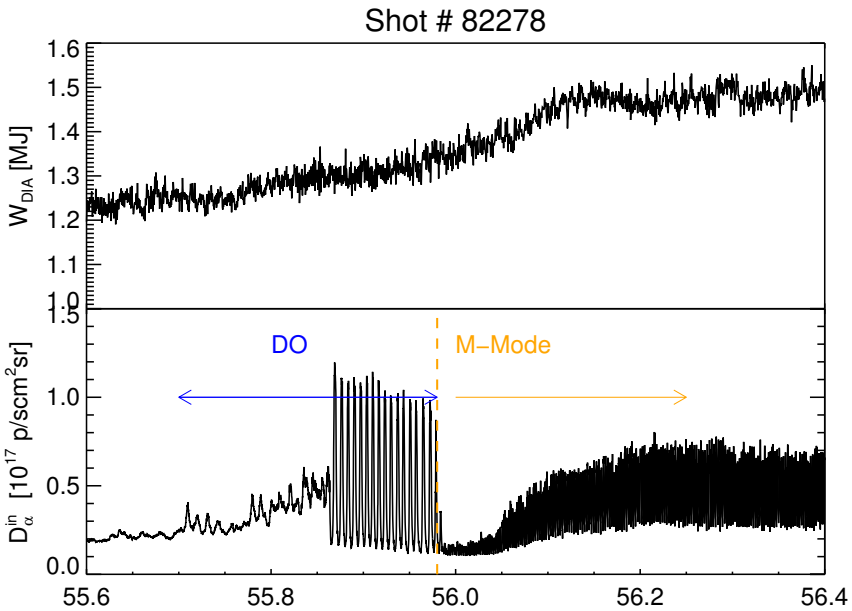
- Toroidal rotation braking estiamated from magnetic including diamagnetic correction
- Different braking observed as a function of dosing rate

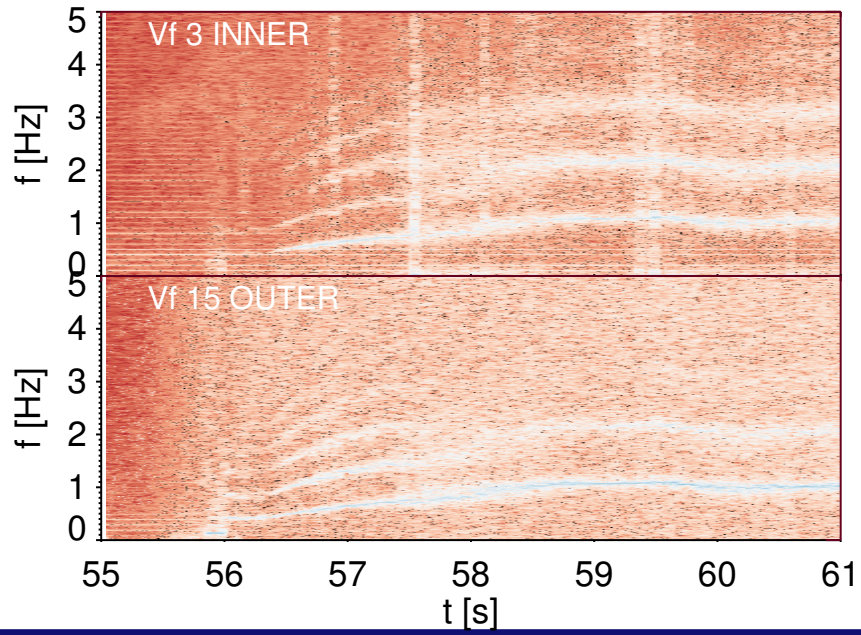




Divertor oscillations and M-Mode

- ICRH plasmas exhibit oscillations in the divertor D_α signals
- They are sort of *precursor* for the M-mode n=0 mode at few kHz





Coordination experience:RFX-mod

- RFX-mod scientific program is coordinated by Task Force Leaders in collaborations with Scientific Coordinators

Coordination experience:RFX-mod

- RFX-mod scientific program is coordinated by Task Force Leaders in collaborations with Scientific Coordinators
- Scientific objectives are determined on the basis of experimental proposals (around 100 experimental proposals for each year)

Coordination experience:RFX-mod

- RFX-mod scientific program is coordinated by Task Force Leaders in collaborations with Scientific Coordinators
- Scientific objectives are determined on the basis of experimental proposals (around 100 experimental proposals for each year)
- Experimental time allocated on the basis of scientific priorities and machine condition in order to optimize the experimental time

Coordination experience:RFX-mod

- RFX-mod scientific program is coordinated by Task Force Leaders in collaborations with Scientific Coordinators
- Scientific objectives are determined on the basis of experimental proposals (around 100 experimental proposals for each year)
- Experimental time allocated on the basis of scientific priorities and machine condition in order to optimize the experimental time
- I’ve been appointed task force leader for two subsequent years:

Coordination experience:RFX-mod

- RFX-mod scientific program is coordinated by Task Force Leaders in collaborations with Scientific Coordinators
- Scientific objectives are determined on the basis of experimental proposals (around 100 experimental proposals for each year)
- Experimental time allocated on the basis of scientific priorities and machine condition in order to optimize the experimental time
- I've been appointed task force leader for two subsequent years:

  2009 Task force Particle, momentum and energy transport

Coordination experience:RFX-mod

- RFX-mod scientific program is coordinated by Task Force Leaders in collaborations with Scientific Coordinators
- Scientific objectives are determined on the basis of experimental proposals (around 100 experimental proposals for each year)
- Experimental time allocated on the basis of scientific priorities and machine condition in order to optimize the experimental time
- I've been appointed task force leader for two subsequent years:

  2009 Task force Particle, momentum and energy transport
  2010 Task force Physics integration for high performance RFP

Coordination experience: EFDA TTG

- In 2011 I've been appointed as coordinator of the working group *3D field effects in edge and SOL and diagnostic development* for the EFDA Transport-topical group
- Duties and responsabilities
  - Monitoring and coordination of activities from 11 different European Associations
  - Discussion stimulated through remote meetings and shared wiki pages information
  - Activities monitored and reported to STAC committee
- Programme commitee of the forthcoming 17th Joint EU-US Transport Task Force Meeting: chairman of the session on *Edge and SOL turbulence and transport*

Scientific objectives I

Using draft of JET 2013 work program the following scientific topics have to be pursued

Headline 2.2 **Assess plasma scenario with regards to power loads, their mitigation and control**

- Complete the characterization of the ELMs in ILW. Why do they seem *slower*? Is this related to different pedestal pressure/current profile?
- Determine the plasma flow response to RMPs highlighting differences with respect to collisionality. Can eventual differences account for different behavior with respect to collisionality?
- Determine the role of MHD islands in the density limit. Is radiative collapse really determined by density accumulation?

Scientific objectives II

Headline 3.4 **Confinement pedestal and ELM physics**

- Complete characterization of ILW pedestal.
- Determine the reason for *cooler* pedestal. Different/enhanced thermal transport mechanism?
- If the pedestal is the result of a balance between $\omega_{E\times B}$ and turbulence determine flow profiles in ILW and compare with CW.
- Is there any correlation with a different SOL? Different neutral profiles determine different conditions at the separatrix?
- Why L-H power threshold is lower in ILW? Is it possible to relate it to the claimed relation between GAM/turbulence/flow?

Headline 3.5 **MHD and fast particle physics**

- Establish the amount of fast-ion losses caused by RMP experiments