# Experiments on ECWs Scattering

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Debriefing

**July 04th-05th 2019**

# Main purposes of the Scattering Experiments

1- **Demonstrate the recently envisaged low power threshold Parametric Decay Instabilities of EC waves at non-monotonous density profile locations**

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2- **Demonstrate for the first time in FTU the measurement of the thermal bulk ions distribution function with Collective Thomson Scattering measurements**

# Studies of the Experimental Days

1- Demonstrate the recently envisaged low power threshold Parametric Decay Instabilities of EC waves at non-monotonous density profile locations

2- **Demonstrate for the first time in FTU the measurement of the thermal bulk ions distribution function with Collective Thomson Scattering measurements**

## PLASMA TARGET

- **7.2 T - 500-700 kA**
- **In a first phase**: NO ROTATING ISLANDS, in order to demonstrate a Collective Scattering measurement.
- **In a second phase**: in case of success of the first phase → possible request of islands, with Pellet injection + Free density ramp-down, to investigate the effects on CTS signals.

# Operations – day 1

- after the day 26/06/2019 of operations with CTS with fixed probe injection ($\alpha$=0, $\beta$=0), tests on the launcher on last Monday -> poloidal scattering probe steering injection (not toroidal ($\beta$=0))

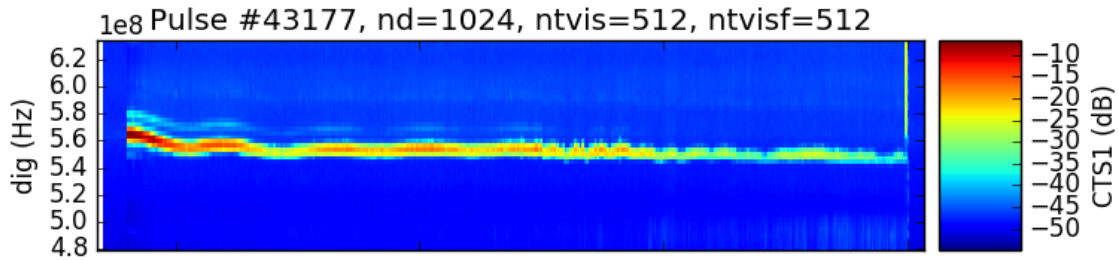
- $B_T$ = 3.6 T (no commutation)

- ECRH on non-resonant plasma (as without plasma) + ECRH on no plasma

- gas from the wall + no commutation -> only breakdown (for std discharges too)

- EC assisted breakdown (ECRH from 70 ms) -> last discharge OK

- measurements of gyrotron frequency



# Operations – day 2

- $B_T$ =5.3 T, 500 kA

- **In a first phase**: NO ROTATING ISLANDS, in order to demonstrate a Collective Scattering measurement.

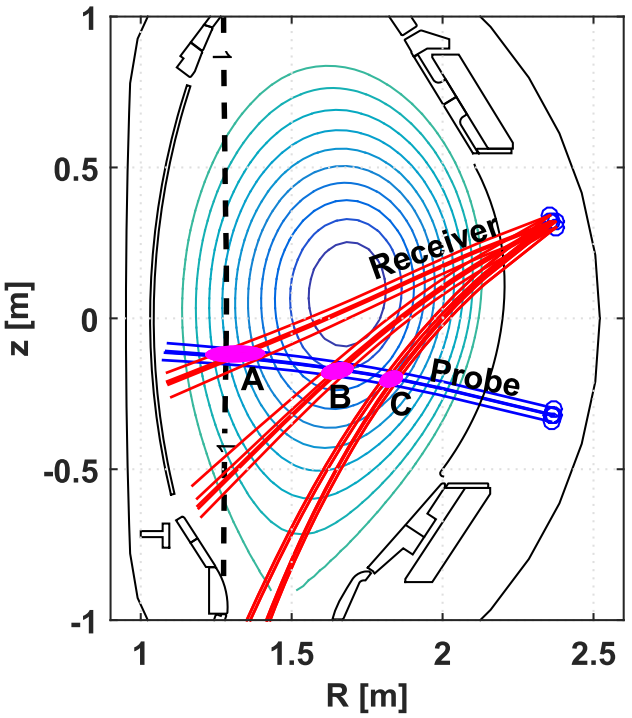
- **In a second phase**: request of islands, still with Pellet injection + Free density ramp-down, to investigate the effects on CTS signals.

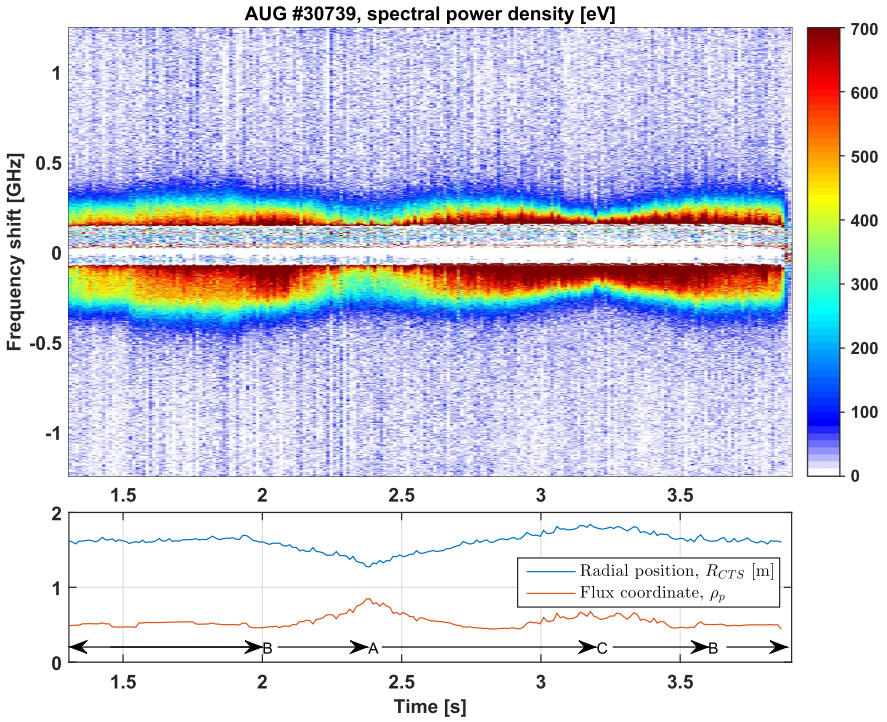
- operations delay / several discharges with only breakdown/abort

# 1- Thermal CTS

## Theoretical Expectations:

also in presence of EC resonance in the plasma it is possible to investigate the thermal spectrum due to the Collective Thomson Scattering (M Stejner *et al* 2017 *Plasma Phys. Control. Fusion* **59** 075009)

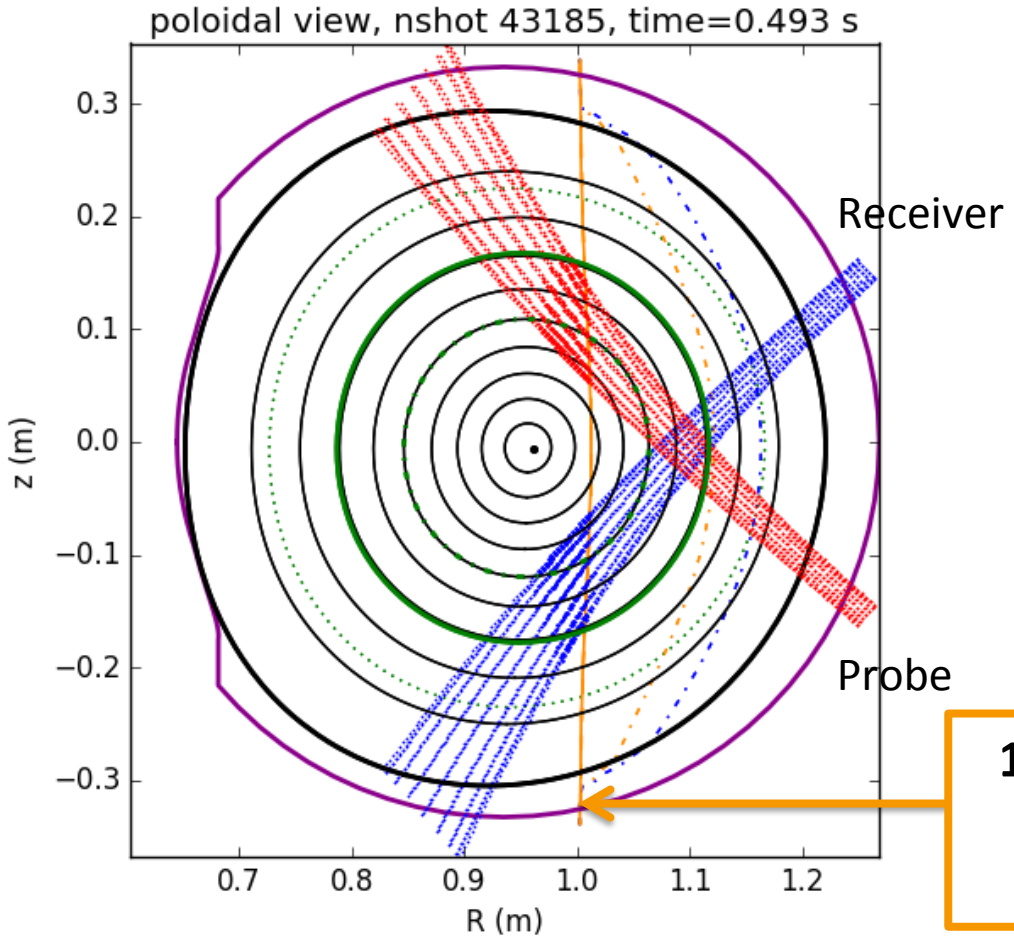



*Experiments on ECWs Scattering*

# 1- Thermal CTS

## Scattering Layout in the Plasma:




- symmetric configuration
- a/2: far enough from the plasma edge and from the EC resonance

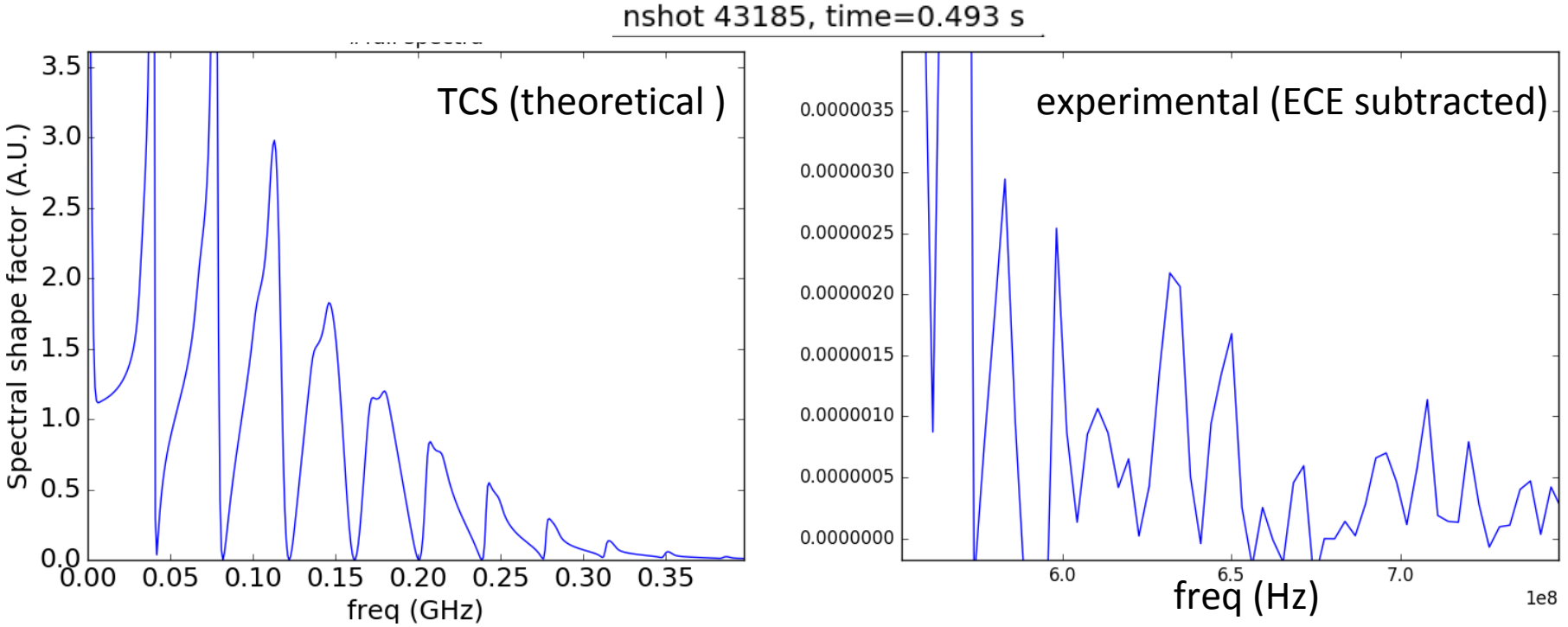
problems:

- low volume
- strong ECE
- $\beta$=0

**1st Harmonic Resonance @5.3 T**

# 1- Thermal CTS

## First predicted and experimental spectra (temporal slices):



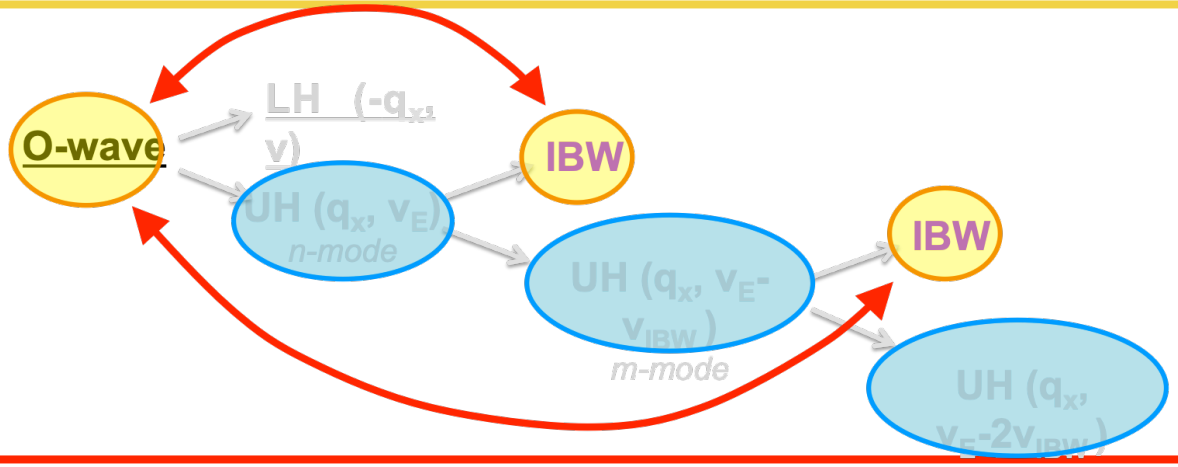

- β=0 -> high peaks due to ion characteristics
- **rough similarity of descendent peaks structure**
- predicted: Df~0.03 GHz, experimental Df~0.022 GHz
- work in progress, more discharges needed

# 2- Anomalous signals with CTS diagnostic

## Theoretical Expectations:

Low-power threshold non-linear phenomena, such as Parametric Decay Instability (PDIs) of a pump wave, can be found in the presence of **a finite-width beam**, **ordinary/extraordinary polarized**, reaching a locally non-monotonic density profile (e.g. **large magnetic islands**)

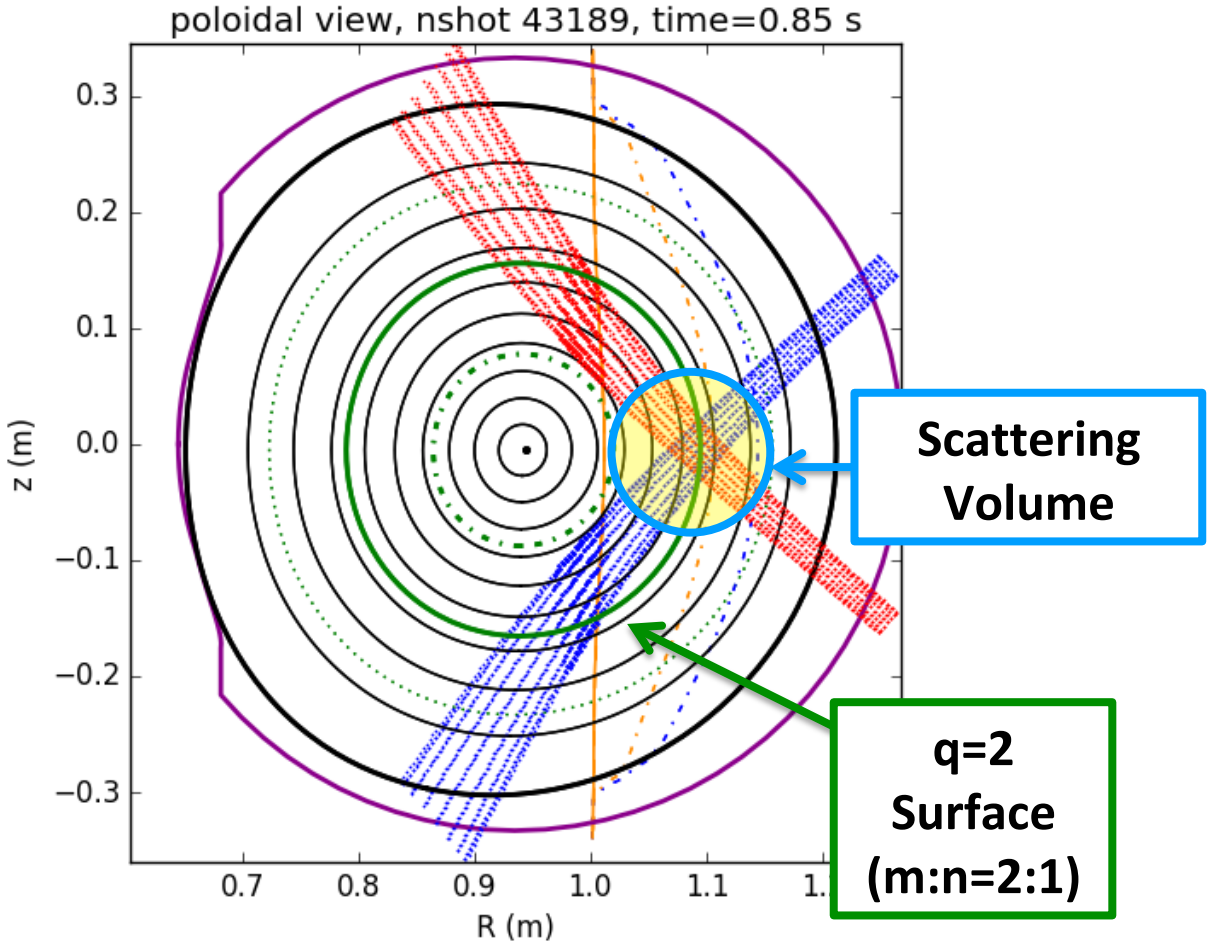
A possibility in FTU consists in a **first PDI of the O-wave into Upper Hybrid (UH) and Lower Hybrid (LH) wave**, followed by a **secondary PDIs of UH into UH and IBW**.




The **non-linear coupling of the daughter IBWs with the pump O-wave** can lead to the excitation of the **anomalous scattering** signal, down-shifted in frequency

# 2- Anomalous signals with CTS diagnostic

## Scattering Layout in the Plasma and Plasma Target:

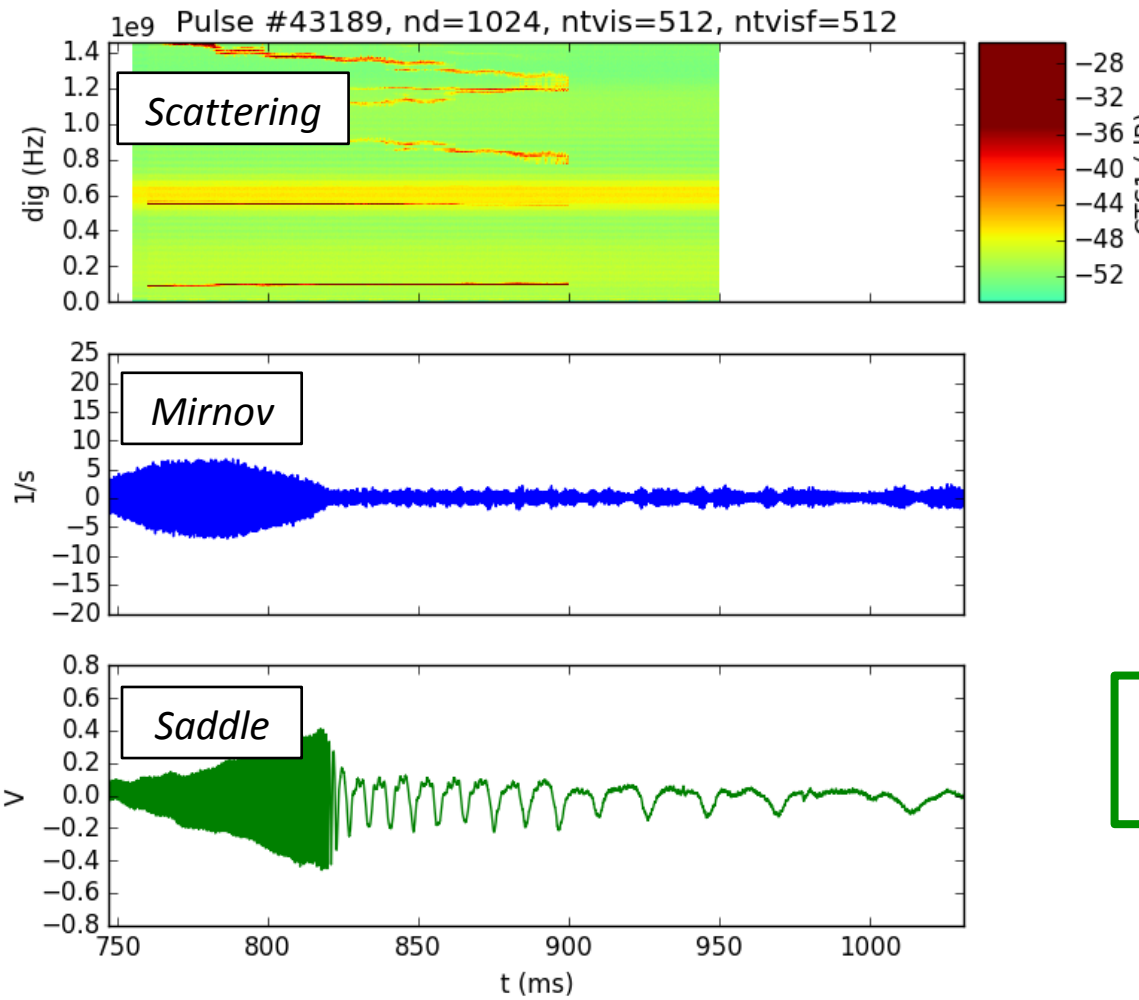


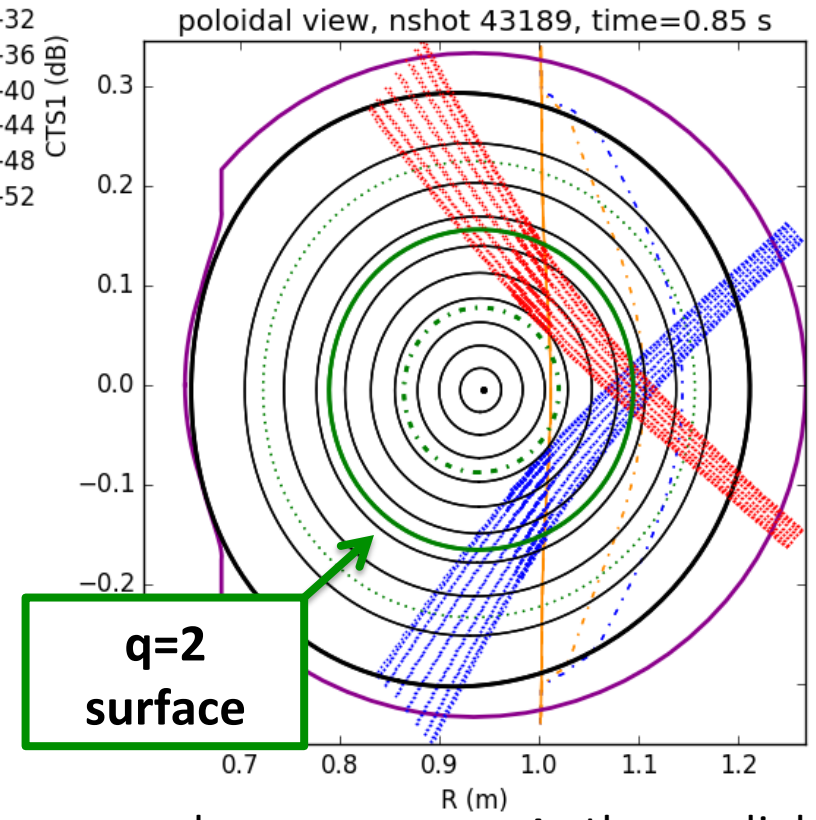

Rotating **m:n=2:1 tearing modes** stimulated by:

**Pellet injection + Free density ramp-down**

to induce fast rotation of the mode typically followed by slowing down, **even down to hundreds of Hz**

# Spectrograms and relative beam tracing- #43189

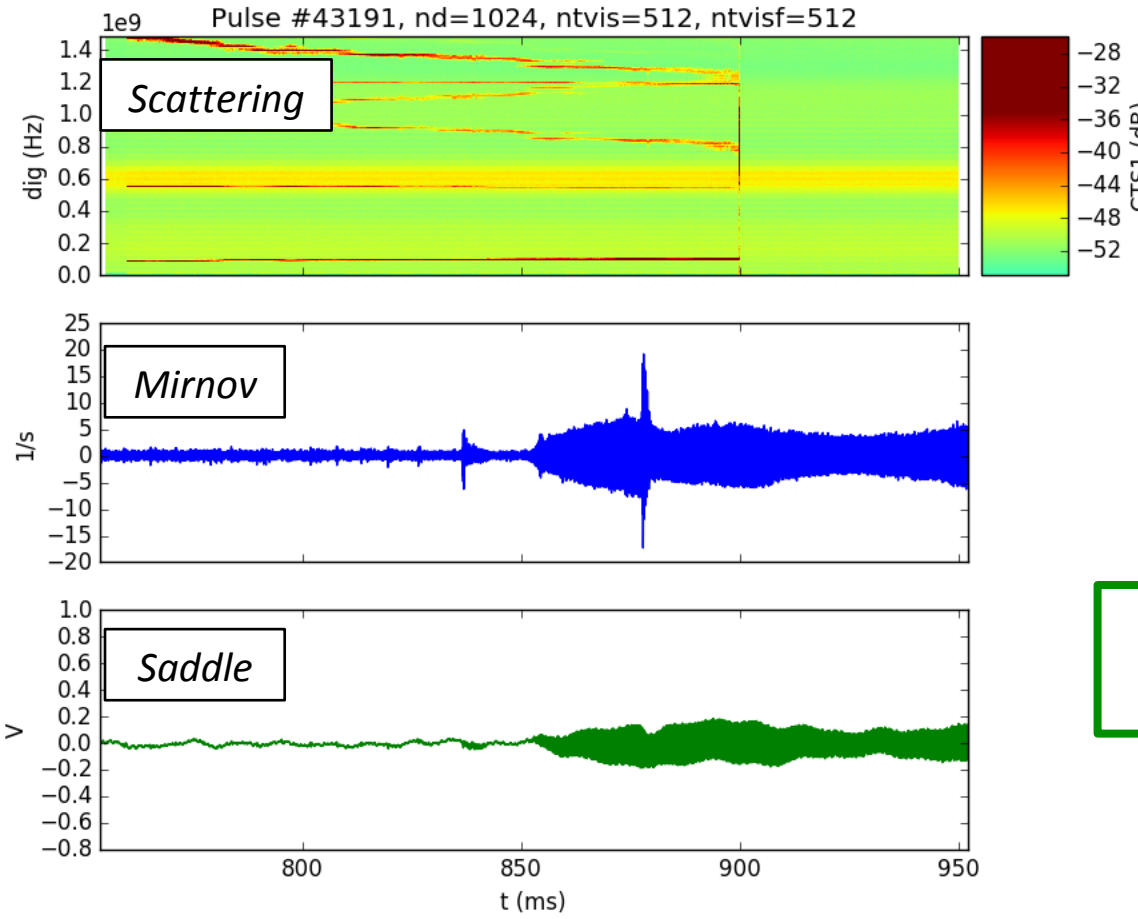


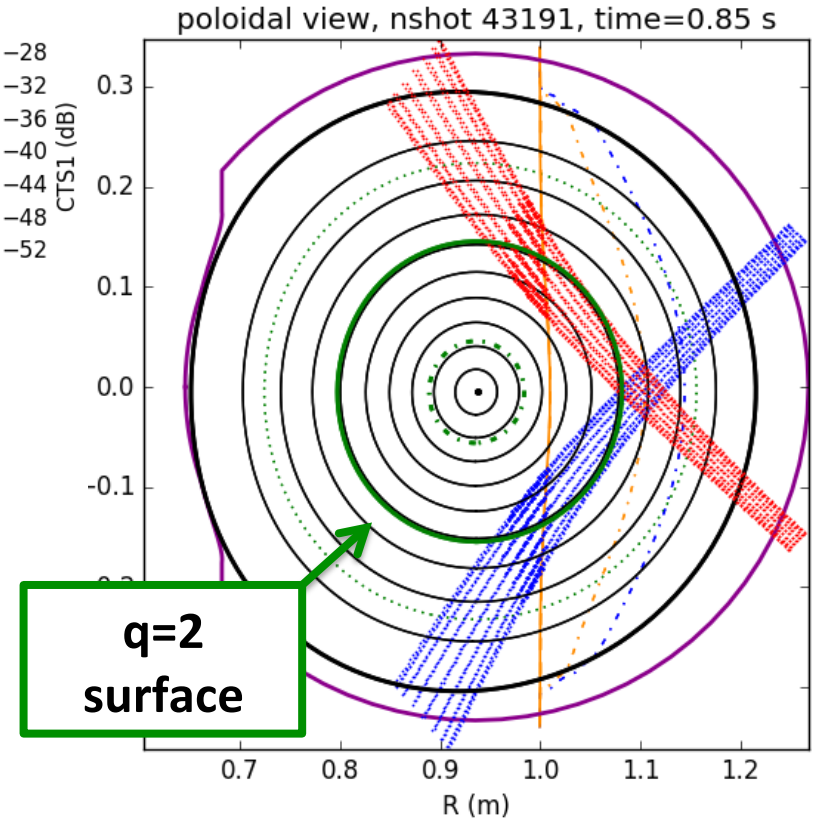




beams cross **at** the radial position of the **q=2** position

**good MHD** but **not significant anomalous emissions** in the time and frequency ranges measured in the shots (work still in progress)

# Spectrograms and relative beam tracing- #43191



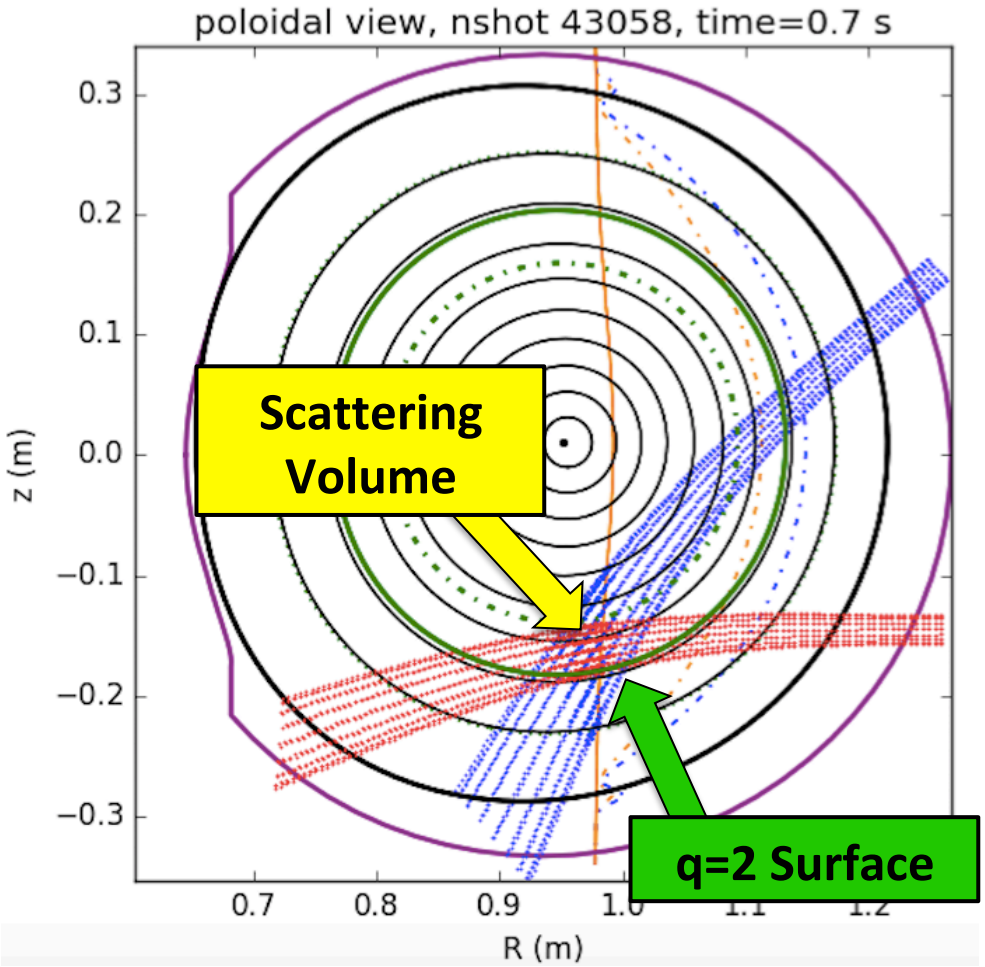

beams cross in an **outer** radial position wrt the **q=2** position

**good MHD** but **not significant anomalous emissions** in the time and frequency ranges measured in the shots (work still in progress)

# One Possible Reason for Absence of Emissions (from experiments of 26/06/2019)

The spectrograms seem **not** to evidence **significant anomalous emissions** in the time and frequency ranges measured in the shots (work is still in progress in this sense).

forced to inject the probe at:
$(\alpha, \beta) = (0°, 0°)$
we were probably **crossing the beams** in an **inner** radial position **wrt the q=2** position.



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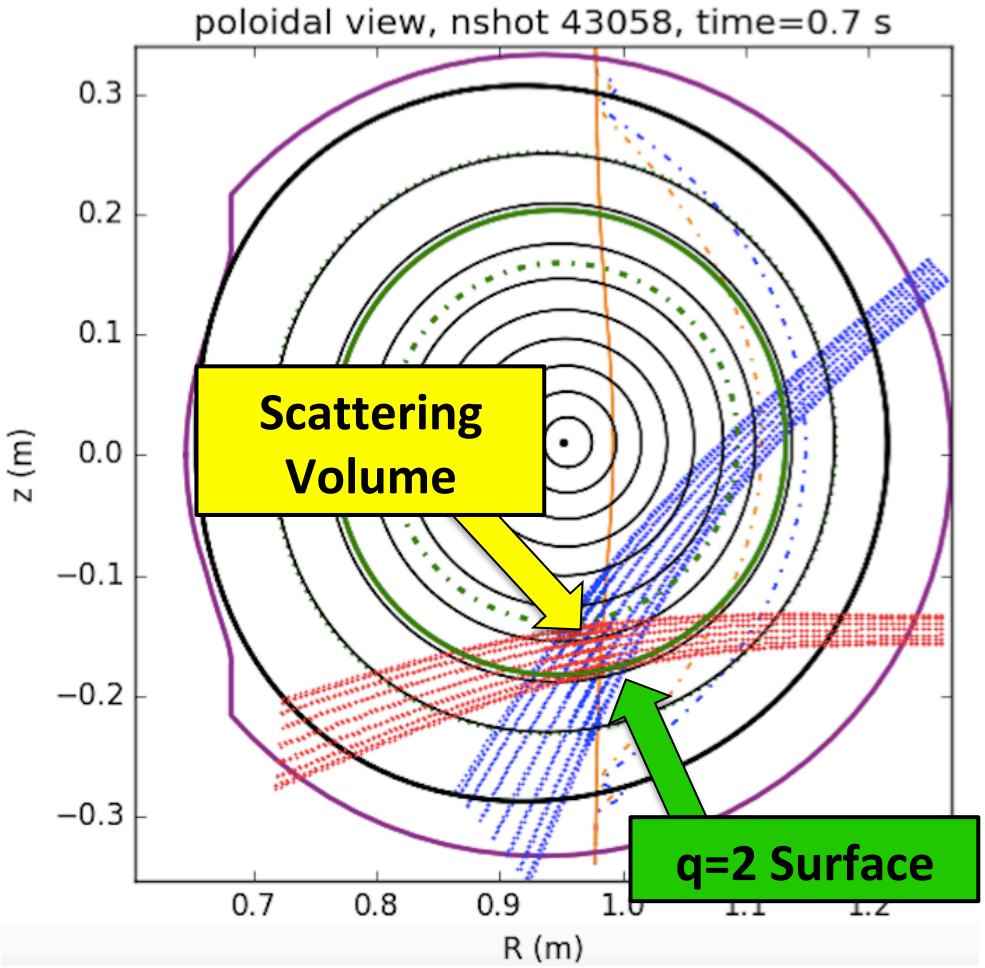
$(\alpha, \beta) = (0°, 0°)$
we were probably **crossing the beams** in an **inner** radial position **wrt the q=2** position.

also with α not null
and **crossing the beams** in an **outer** radial position **wrt the q=2 position** **significant anomalous emissions** are **not** found.




Such reason seems to **lose reliability**

# Another Possible Reason for Absence of Emissions

A crucial factor to expect PDIs due to trapped waves in non-monotonous local density profiles with a finite-width O-mode pump scenario consists of a **small (but still finite) electric field component perpendicular to the magnetic field** of the trap, which, according to theory, **would provide the pump wave non-linear coupling to the quasi-perpendicular IB and UH waves**.

See, for instance: *E.Z. Gusakov and A.Yu. Popov, Phys. Plasmas **25** (2018)*

In our scenario **such perpendicular field component was absent**, due to the fixed toroidal steering angle of line #4 which forced non-oblique probe injection.

However, anomalous scattering due to launching O mode (without any X mode conversion) is still to be demonstrated. Work in progress..