Toroidally asymmetrical disruptions on the COMPASS tokamak

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1. MOTIVATION

Disruptions:

- Loss of magnetic confinement
- Destructive: Mechanical and thermal loads to the vacuum vessel [1,2]

Here we discuss:

- Possibilities of disruption studies using magnetic diagnostics on COMPASS

2. INTRODUCTION: DISRUPTIONS

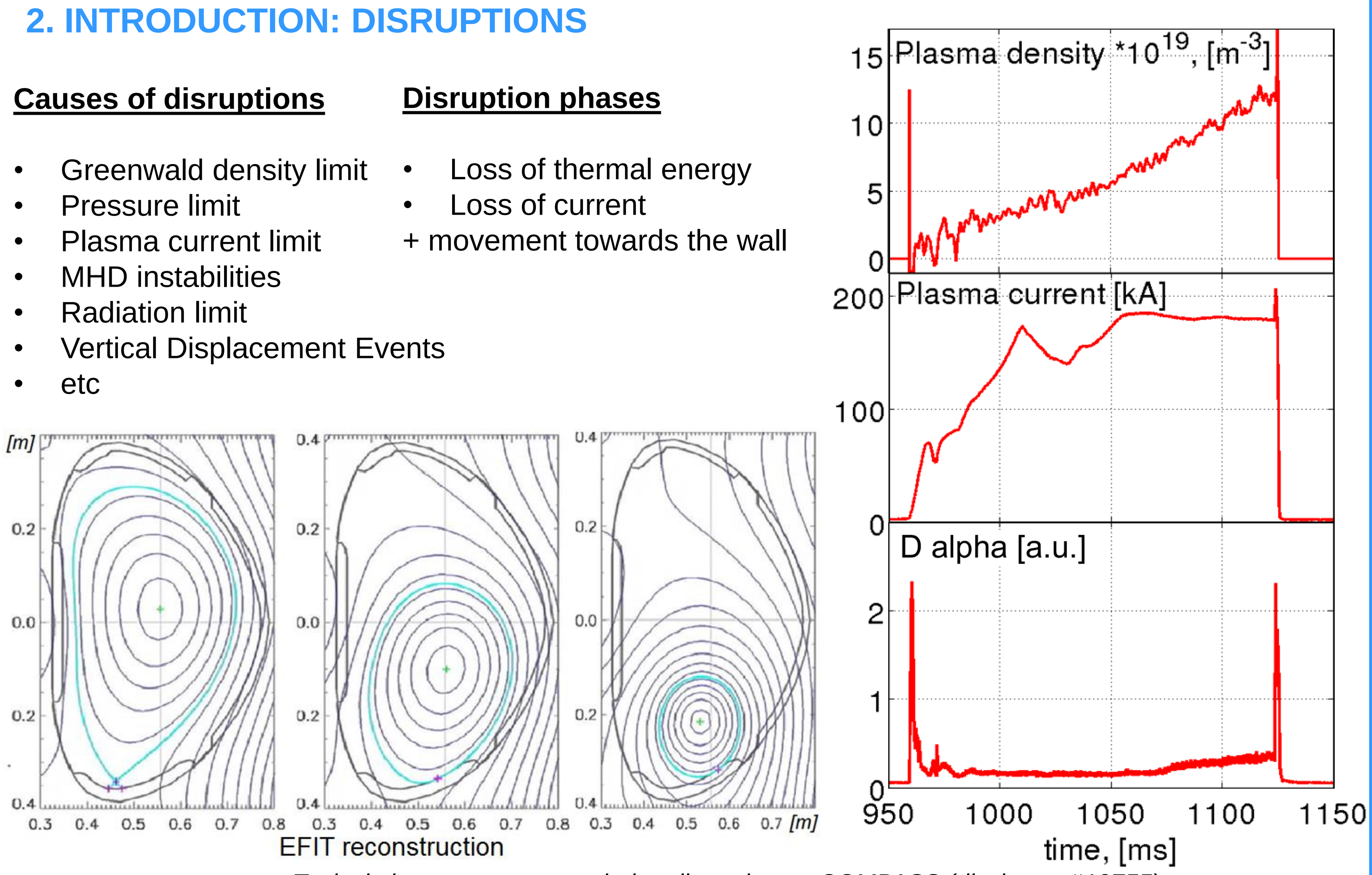
Causes of disruptions

- Greenwald density limit
- Pressure limit
- Plasma current limit
- MHD instabilities
- Radiation limit
- Vertical Displacement Events
- etc

Disruption phases

- Loss of thermal energy
- Loss of current

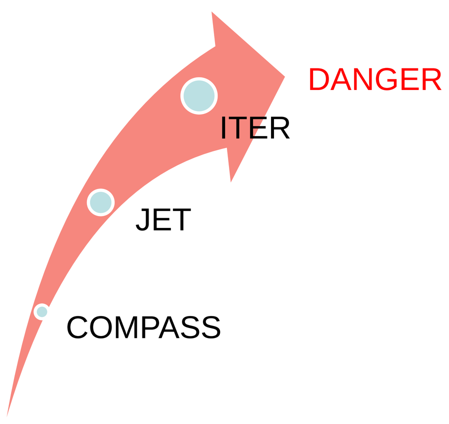
+ movement towards the wall



Typical plasma parameters during disruption on COMPASS (discharge #12755)

Disruption consequences

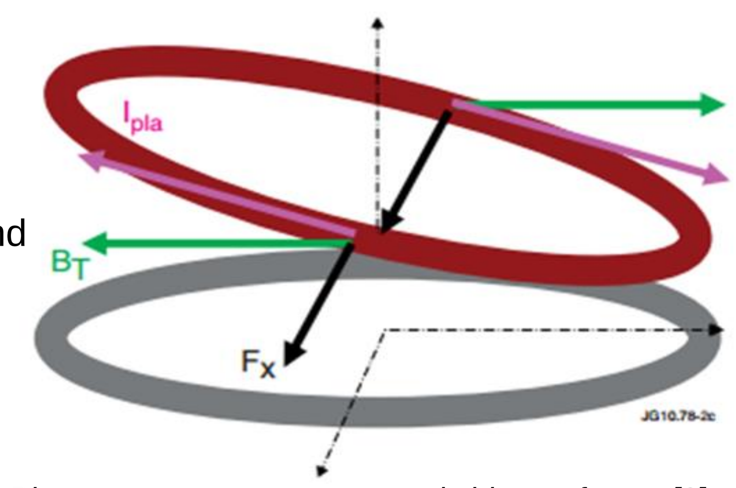
- Mechanical load: Stress due to currents in the wall coupled with magnetic fields
- Thermal loads: Radiative dissipation of the plasma magnetic energy
- Runaway electrons: High localization of the beam, thermal damage to the vessel
- Toroidal rotation of the mode: Possible resonance with eigen-frequencies of the vessel
- Limitation of the range of operation in current and density
- Damage to electronics



	COMPASS	JET	ITER
Time scale	~1 ms	~60 ms	~1s
Sideway force	1t	400 t	10 000 t
Thermal energy	Several kJ	12 MJ	350 MJ
Plasma current	0.4 MA	4 MA	15 MA

Toroidally asymmetrical disruptions

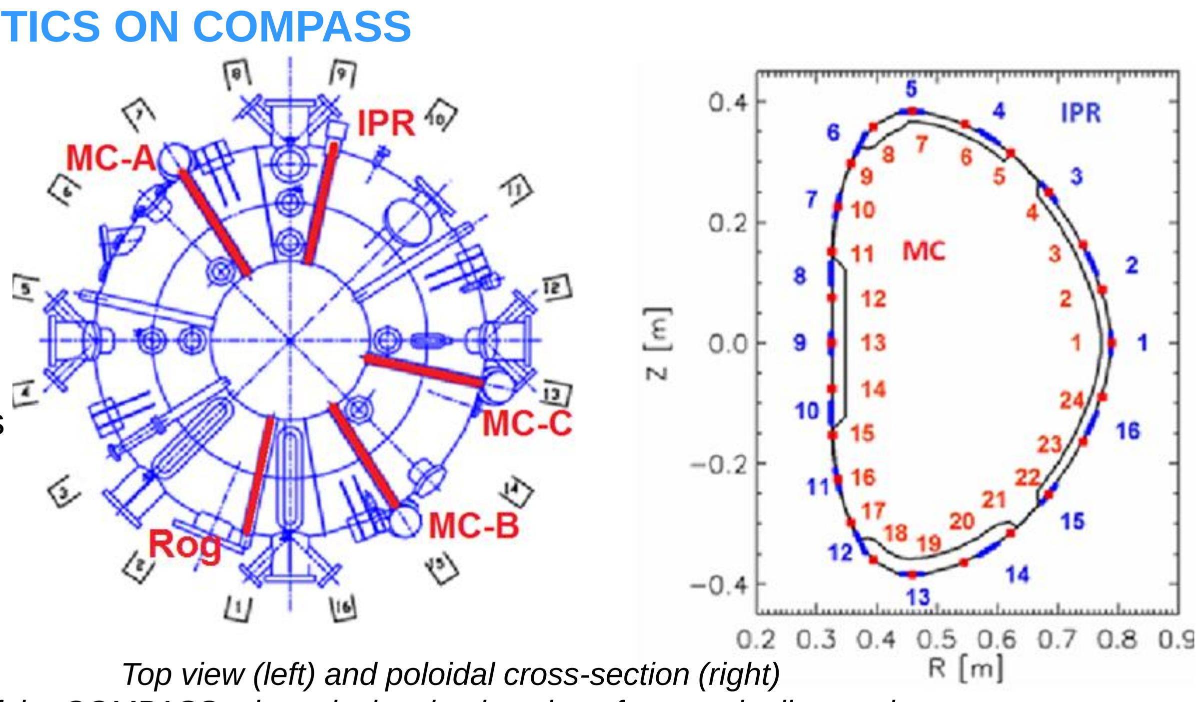
- Possible rotation of asymmetry
- Resonance with natural frequencies of the vessel and amplification of the forces
- Additional forces due to asymmetry of currents in the vessel



Plasma current asymmetry and sideway forces [3]

3. MAGNETIC DIAGNOSTICS ON COMPASS

- Internal partial Rogowski coils (16 coils) (IPR)
- Rogowski coil (full coil) (Rog)
- 3 rings of Mirnov coils (24 coils each) (MC)
- Plasma current measurements in 5 toroidal locations
- Plasma current asymmetry measurements



Top view (left) and poloidal cross-section (right) of the COMPASS tokamak showing location of magnetic diagnostics

4. PREVIOUS RESULTS: PLASMA CURRENT ASYMMETRY

Many of COMPASS disruptions are asymmetrical [4]

Obtained data:

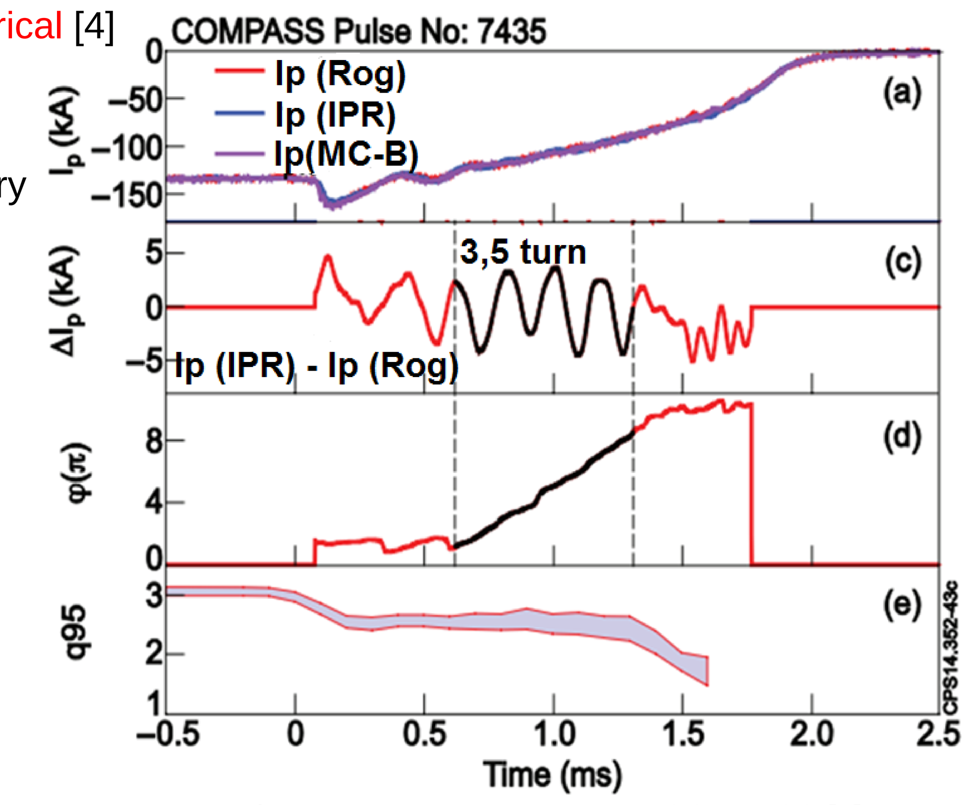
- Plasma current asymmetry
- Toroidal phase of plasma current asymmetry
- Asymmetry rotation and "locked" modes
- q_{95} drops before asymmetry development

Unusual multirotational discharge:

- Circular discharge
- Disruption caused by large MHD instability
- 1/1 island and q_{95} drop to 1 are expected
- 3.5 turn rotation (usually about 1 rotation)

Future steps:

- Repeat the discharge with strong rotation of asymmetry
- Verify the mode number
- Investigate q_{95} behavior

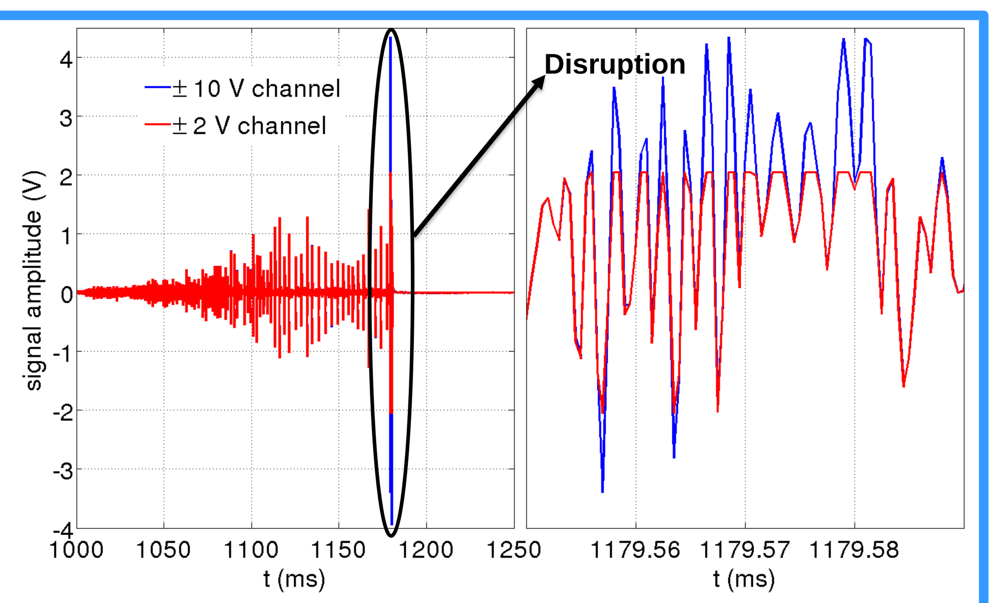


Plasma current asymmetry on COMPASS [4]

5. MIRNOV COILS DIAGNOSTICS

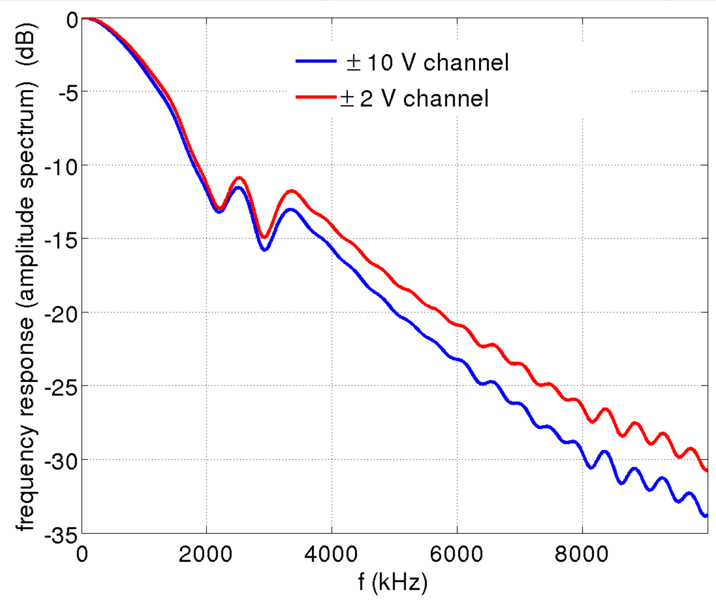
Requirements: Good quality of raw data

- Small scale of plasma current asymmetry (about 5% of predisruptive current)
- High precision of raw data is required
- Accumulation of small errors of raw data makes impossible to determine plasma current asymmetry
- Need to cope with drastic changes of voltage between discharge flat top and disruption

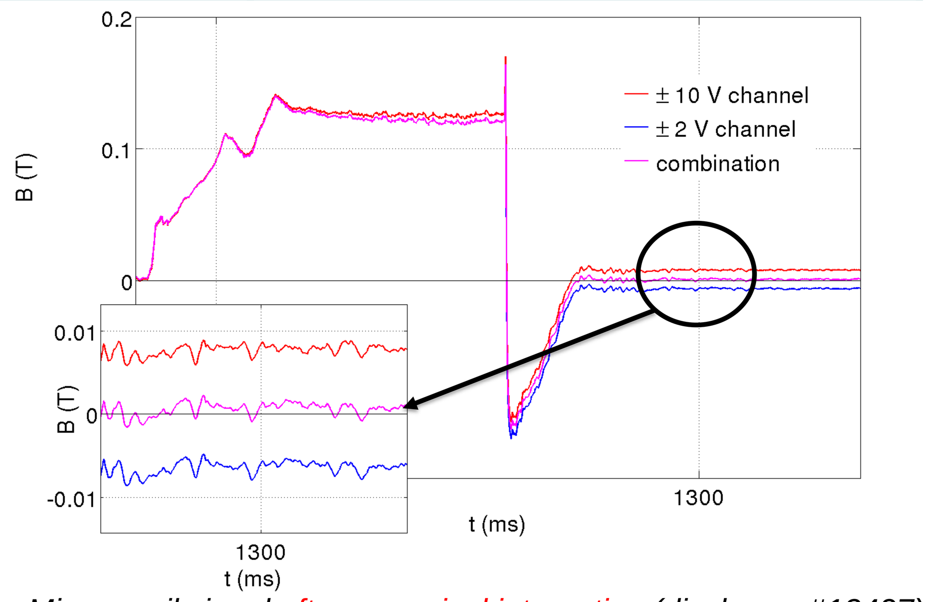


Raw Mirnov Coil signal (discharge #13427). Saturation of ±2 V channel raw signal during disruption

	Present acquisition system: Single channel		**Proposed** acquisition system: Combination of two channels with different settings
Channel	±10 V acquisition range	±2 V acquisition range	±2 V channel data is replaced during saturation by ±10 V channel data
Reliable region	disruption	flat-top of the discharge	whole discharge
Resolution	0.3 mV/bit	0.06 mV/bit	
Challenges	accumulation of small errors during flat top	raw signal is saturated during disruption	need to take into account different calibration, offset and filter characteristics of the channels
Numerically integrated signal	unwanted offset after disruption	unwanted offset after disruption	no unwanted offset after disruption
Plasma current data reliability	not reliable	not reliable	Reliable, but the algorithm of channels combination is not straightforward



Filter characteristic of ±10 V and ±2 V channels



Mirnov coil signal after numerical integration (discharge #13427). Combination of DAQ channels improves integrated data.

6. SUMMARY

Improvement of Mirnov coils data:

- Combination of two acquisition channels with different settings allows to decrease unwanted offset of numerically integrated signal and provides reliable data.

Future steps:

- Application of channels combination method to each unintegrated Mirnov coil.
- Determination of typical parameters of asymmetrical disruptions:
  - plasma position asymmetries
  - plasma current moment asymmetries
  - sideway forces
  - phase amplitude distribution
  - phase diagram of plasma current and current moment asymmetries

REFERENCES

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