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Investigation of some MHD events in the SUNIST Spherical Tokamak

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OUTLINES

- **Magnetic Diagnostic System**
- **Experimental results of Ohm discharge**
- **MHD events in SUNIST**

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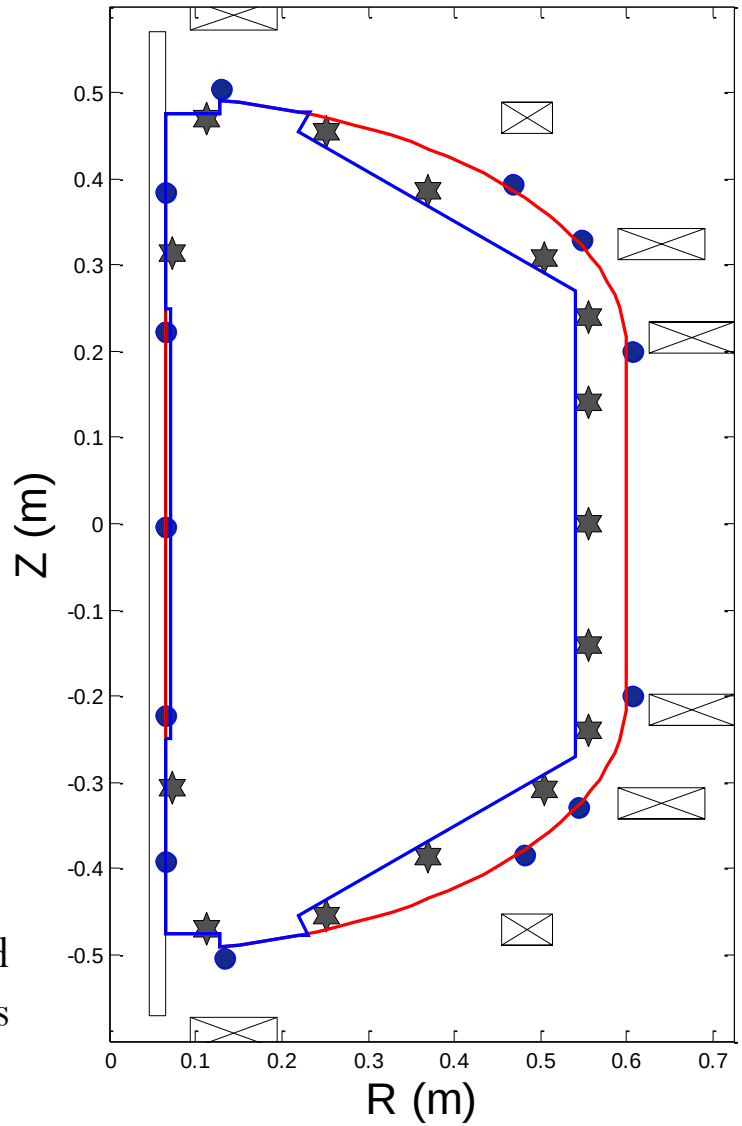
Magnetic Diagnostic System

- **A new magnetic measure system, including 15 poloidal magnetic coils, 6 toroidal magnetic coils and 13 flux loops, was designed and installed inside the vessel.**



Circles represent flux loops and pentagram s represent magnetic probes

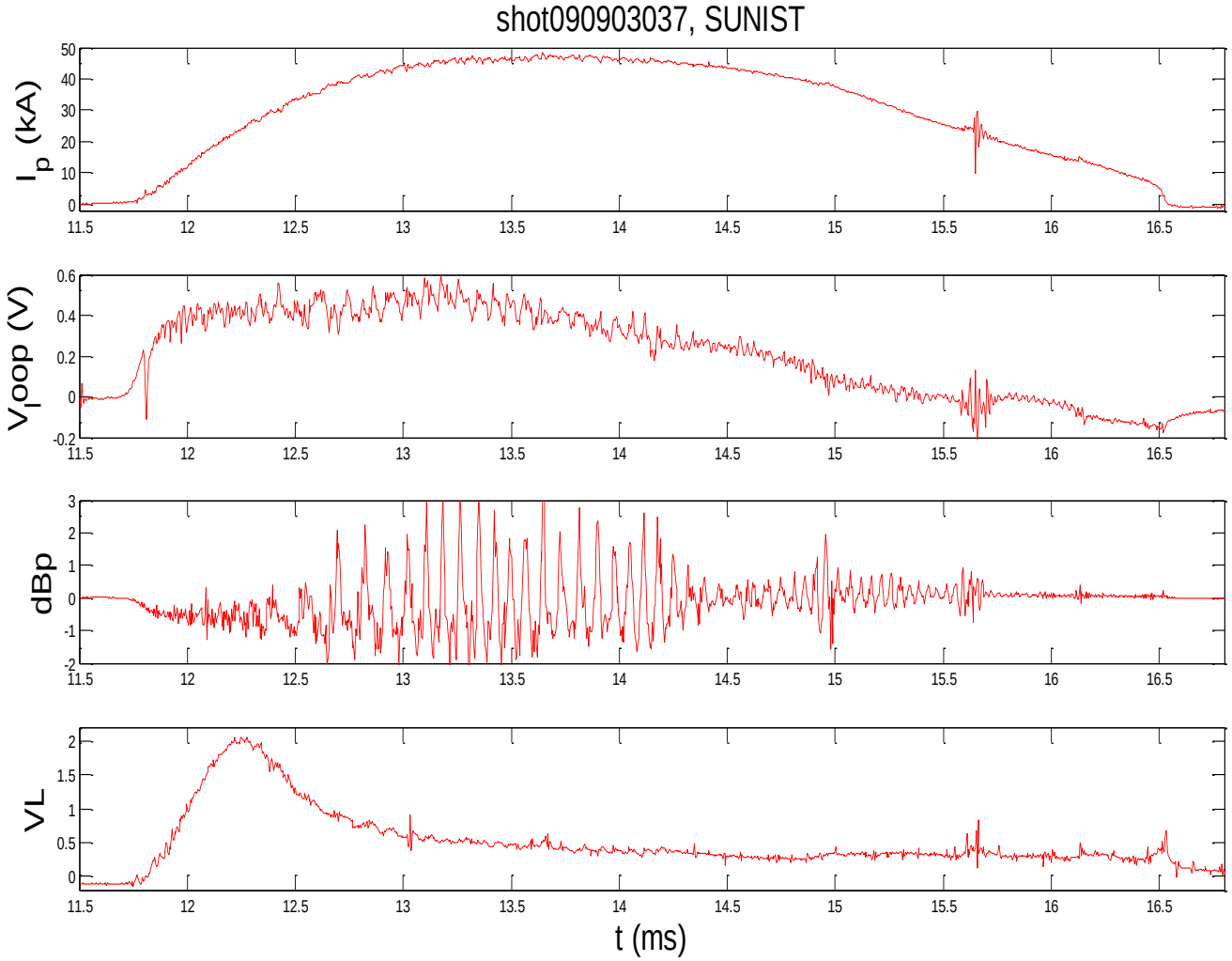
OUTLINES

- Magnetic Diagnostic System
- **Experimental results of Ohm discharge**
- MHD events in SUNIST

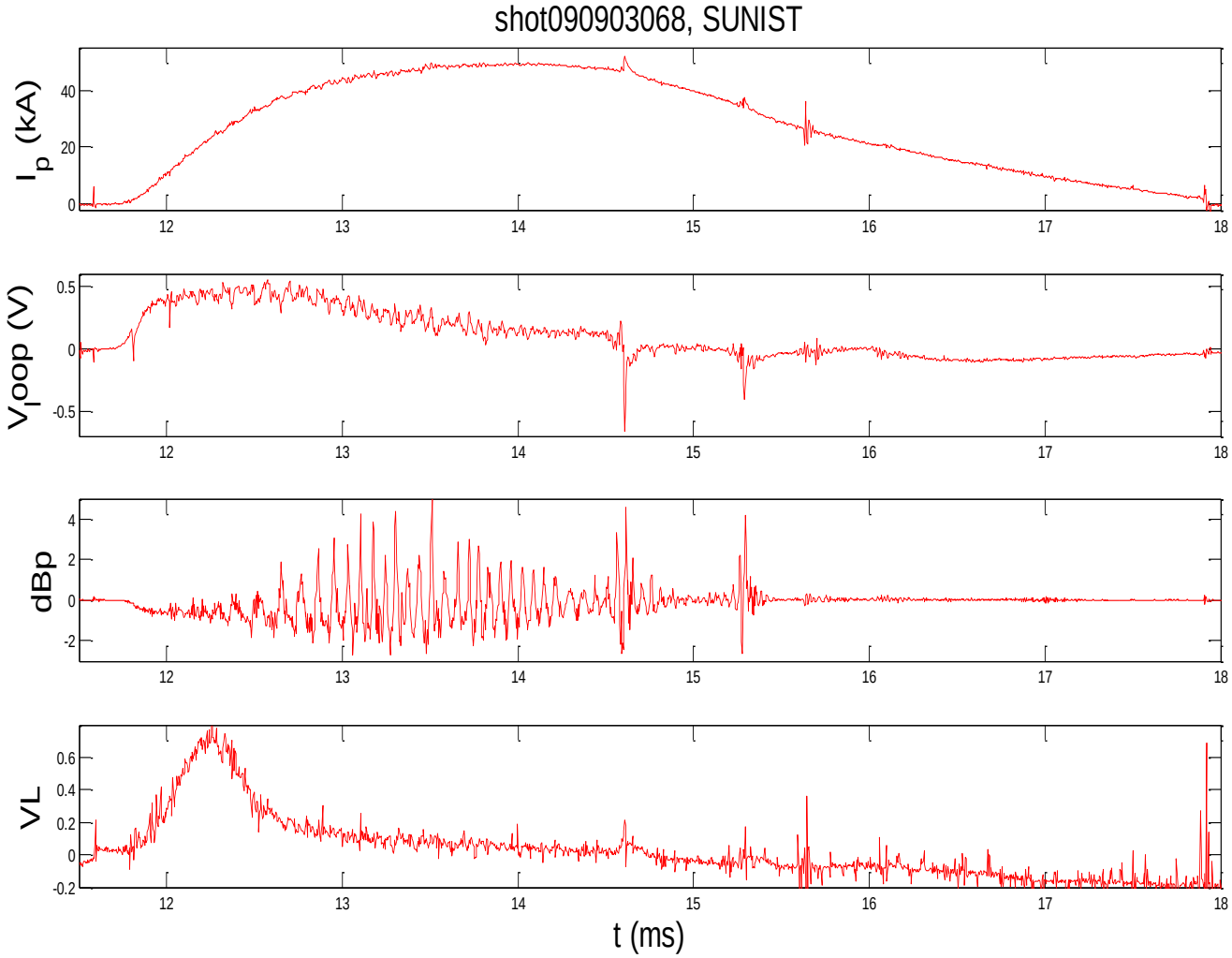
Experimental results of Ohm discharge

- **Three types of typical discharges**
  - Normal discharge
  - Discharge with current spike
    - there are current spikes during discharges;
  - Runaway discharge
    - Ramp-up of the plasma is steep, but ramp-down is slowly damped.

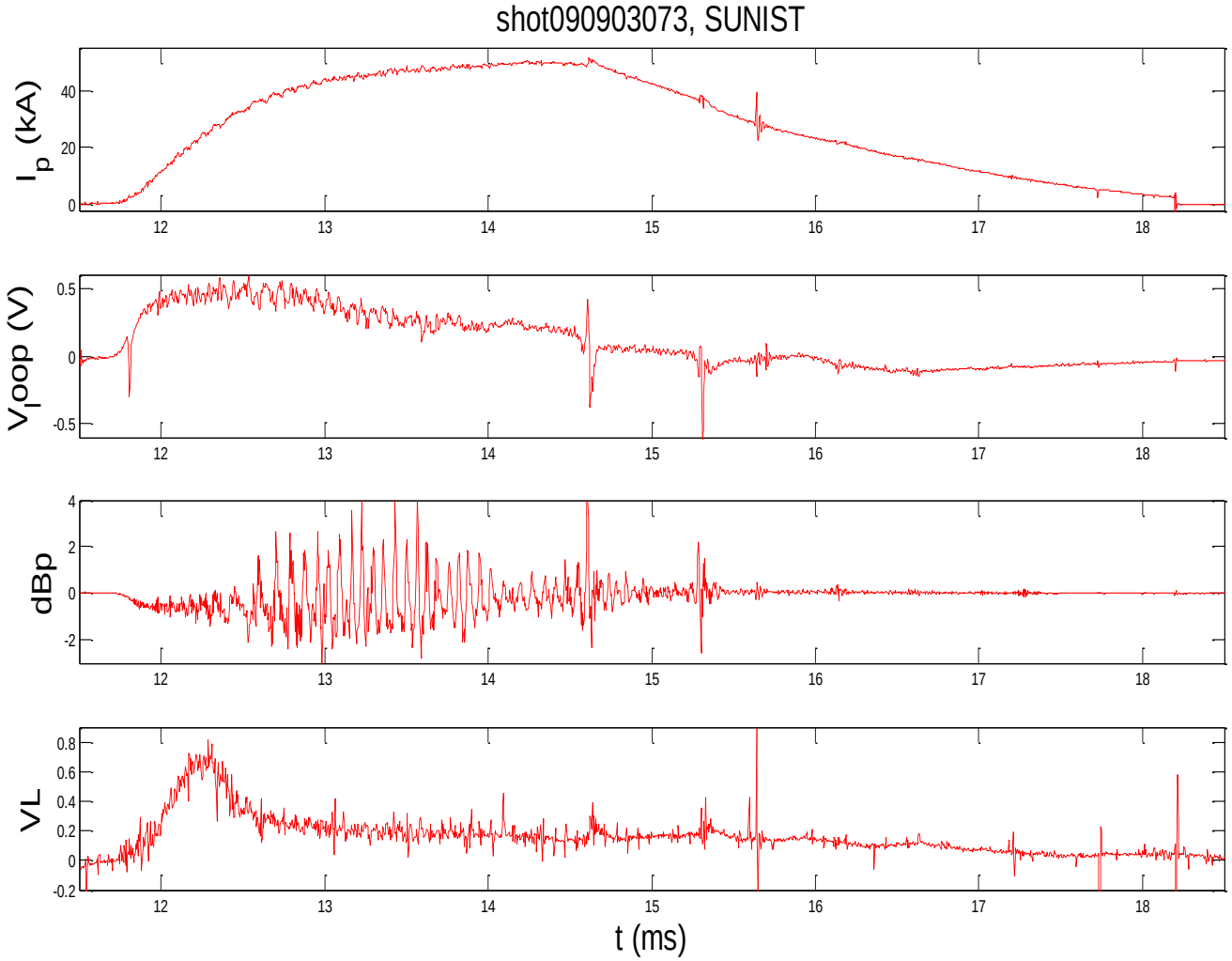
Normal discharge



Discharge with current spike



Runaway discharge

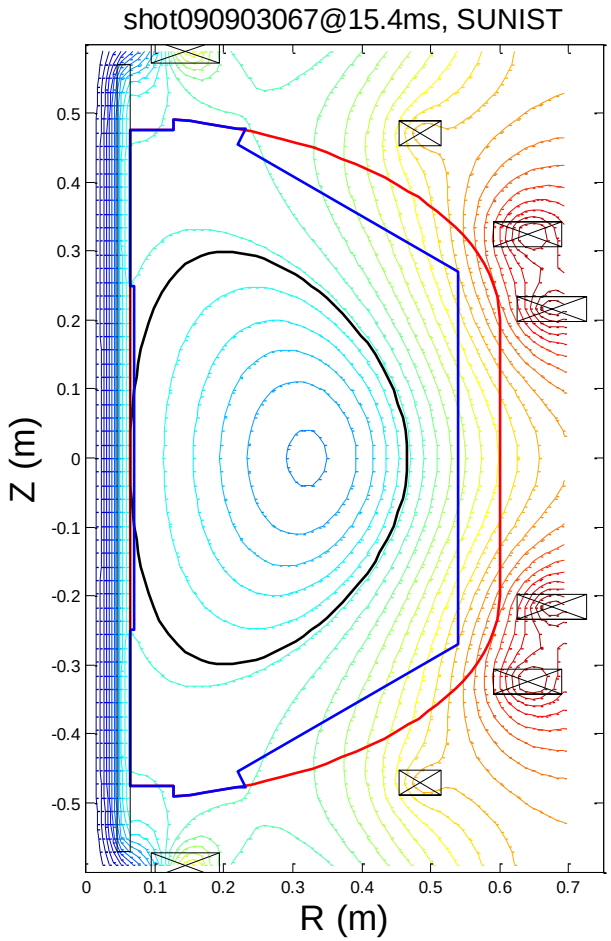


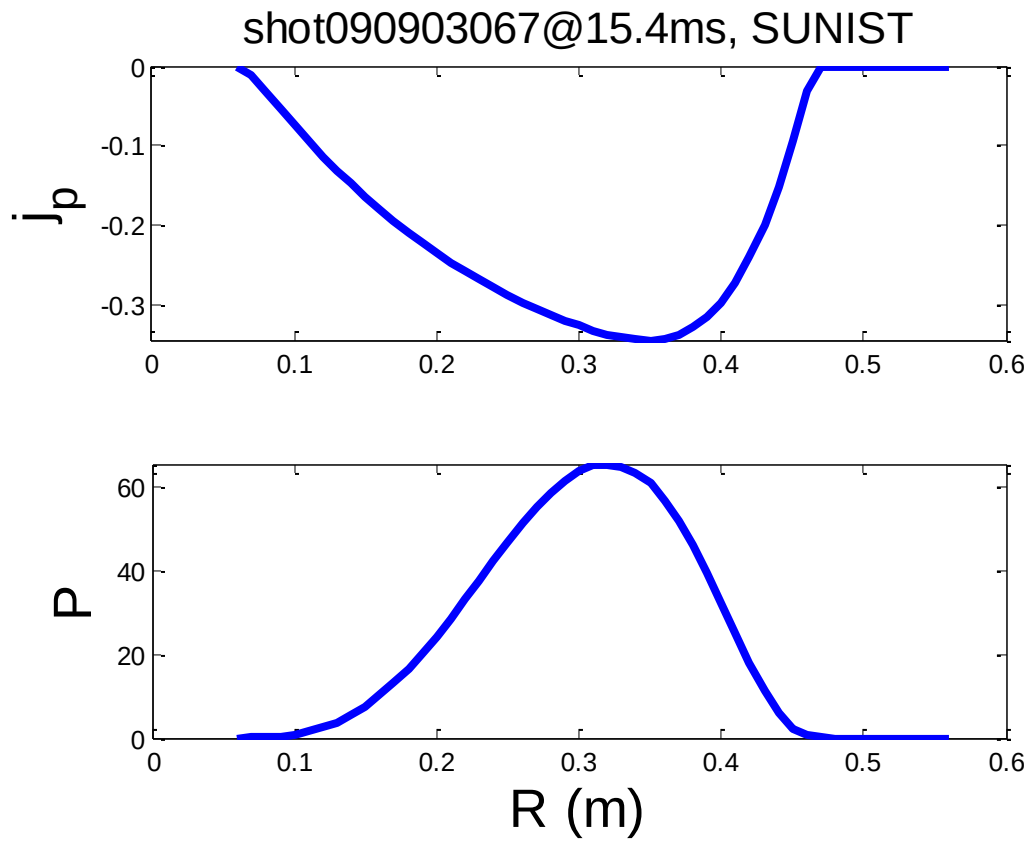
Plasma Equilibrium Reconstruction

- **Equilibrium properties of plasmas in SUNIST**
  - Limiter configurations: outside limiter configurations and inside limiter configuration;
  - The evolution of the plasma equilibrium is analysed between discharges with the EFIT code;
  - the SUNIST vessel: the center stack and the outer vessel electrically isolated from each other; the outer vessel also seperated into two parts along toroidal direction.

Plasma Equilibrium Reconstruction

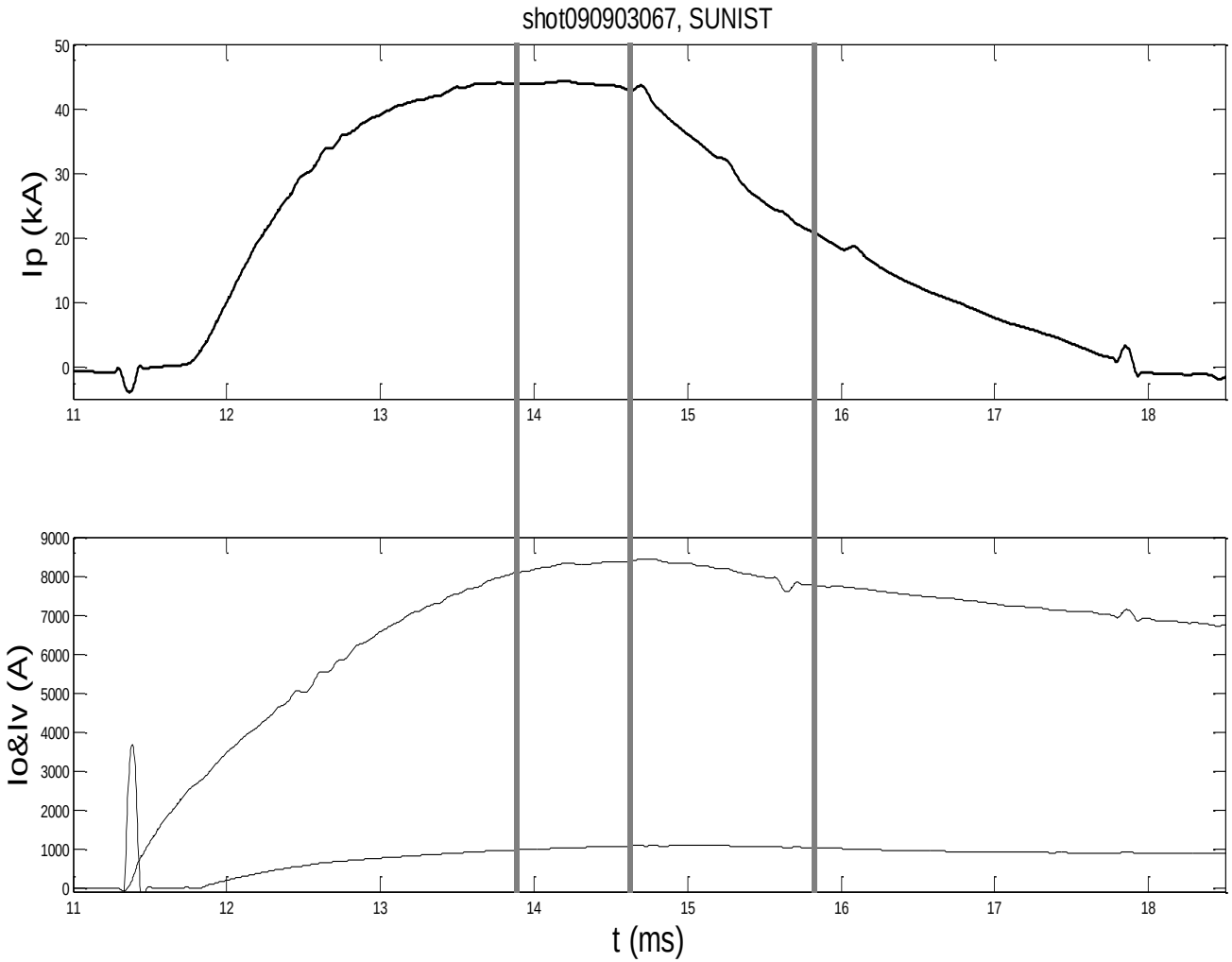
- **An example to reconstruct the equilbrium**

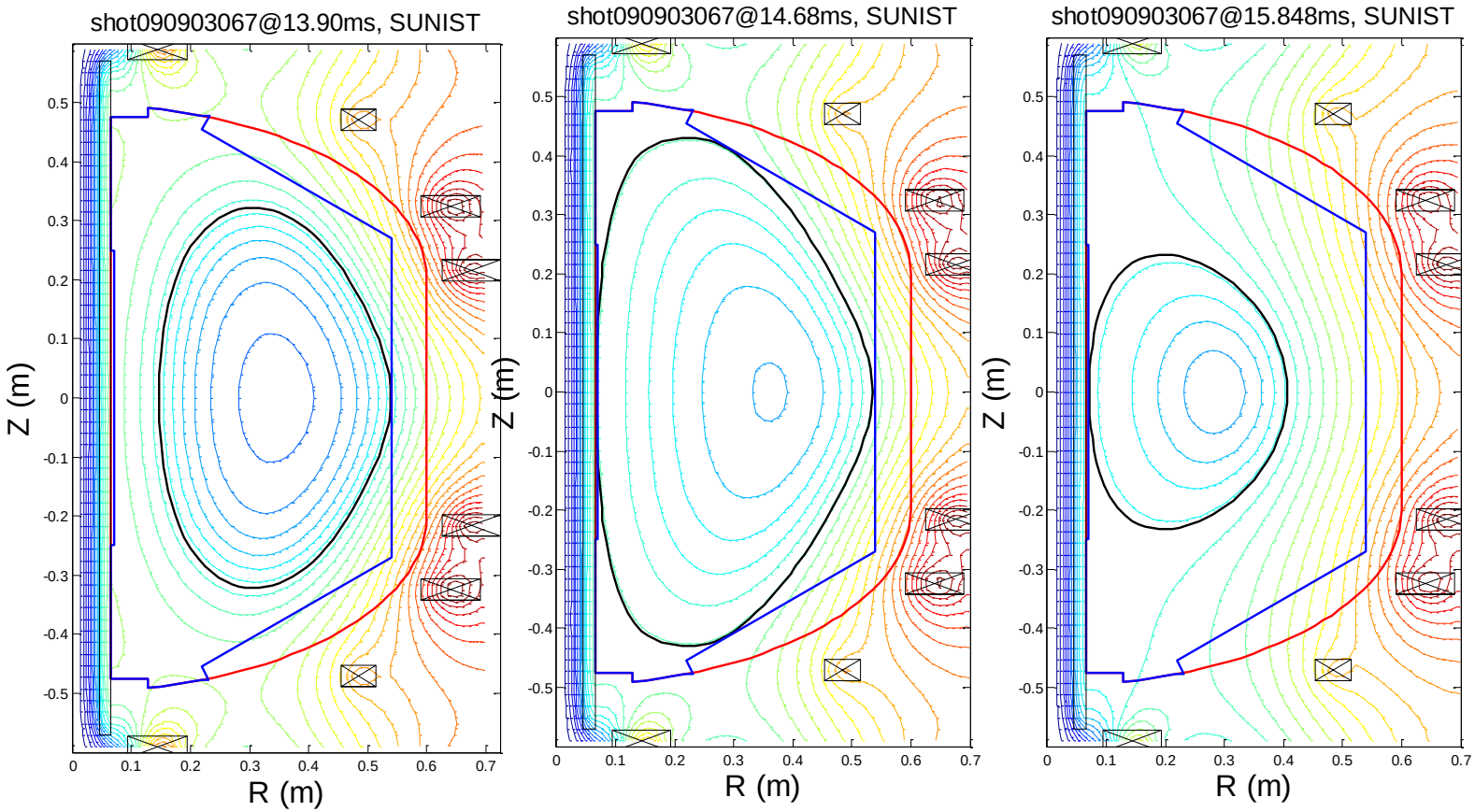


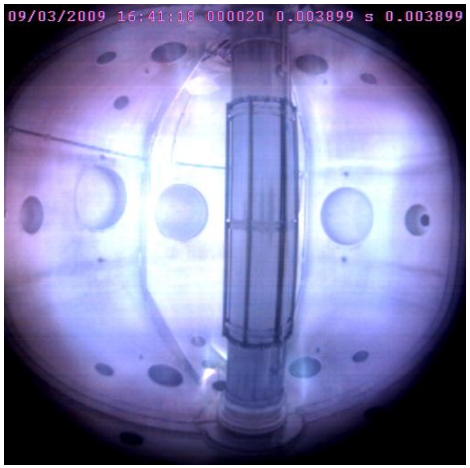


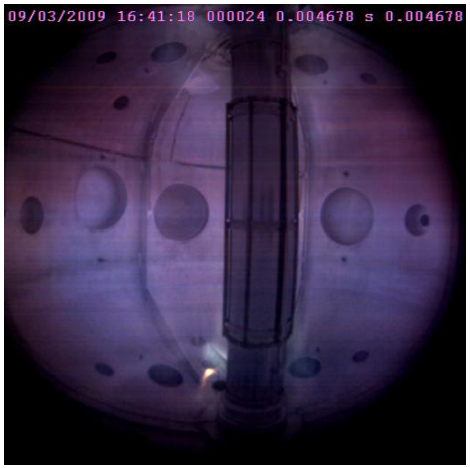
Equilibrium Reconstruction for an Ohmic Discharge

- **Shot090903067**




shot090903067@13.90ms, SUNIST
shot090903067@14.68ms, SUNIST
shot090903067@15.848ms, SUNIST
Z (m)
R (m)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

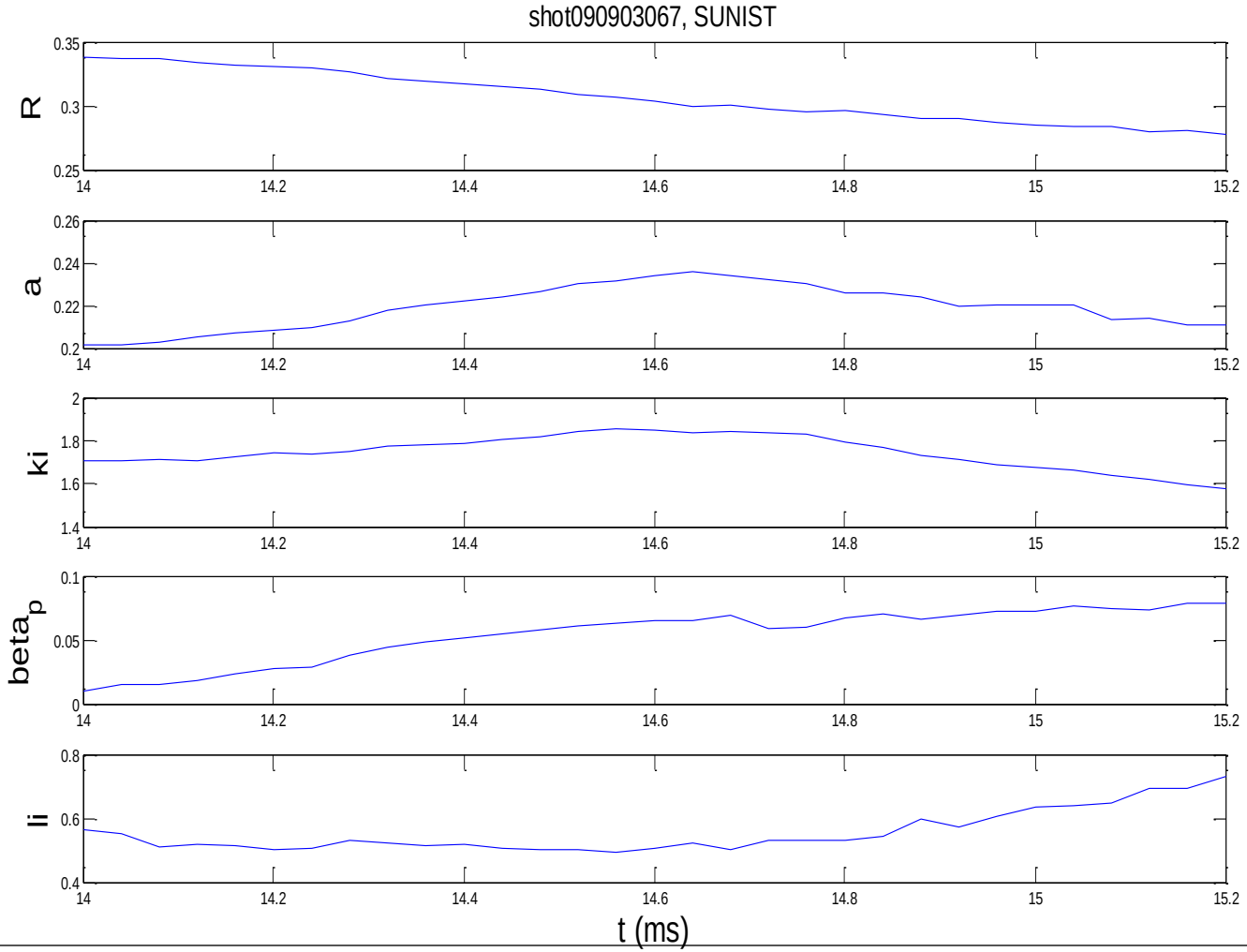

09/03/2009 16:41:18 000020 0.003899 s 0.003899


09/03/2009 16:41:18 000024 0.004678 s 0.004678

09/03/2009 16:41:18 000030 0.005848 s 0.005848

Time evolution of plasma parameters

- **major/minor radius, elongation, poloidal beta, internal inductance**



Properties of SUNIST discharges (1)

- **During Ohm discharge, the plasma is generated outside the vacuum vessel at the beginning. Then, the plasma moves to inner side of the vacuum vessel and disappears near the central column, which is consistent to the observation from high-speed CCD camera;**

- **A plasma elongation in the range $1.4 \leq \kappa \leq 1.8$ and a triangularity in the range $0.20 \leq \delta \leq 0.35$ have been sustained.**

OUTLINES

- Magnetic Diagnostic System
- Experimental results of Ohm discharge
- **MHD events in SUNIST**

MHD Events in SUNIST

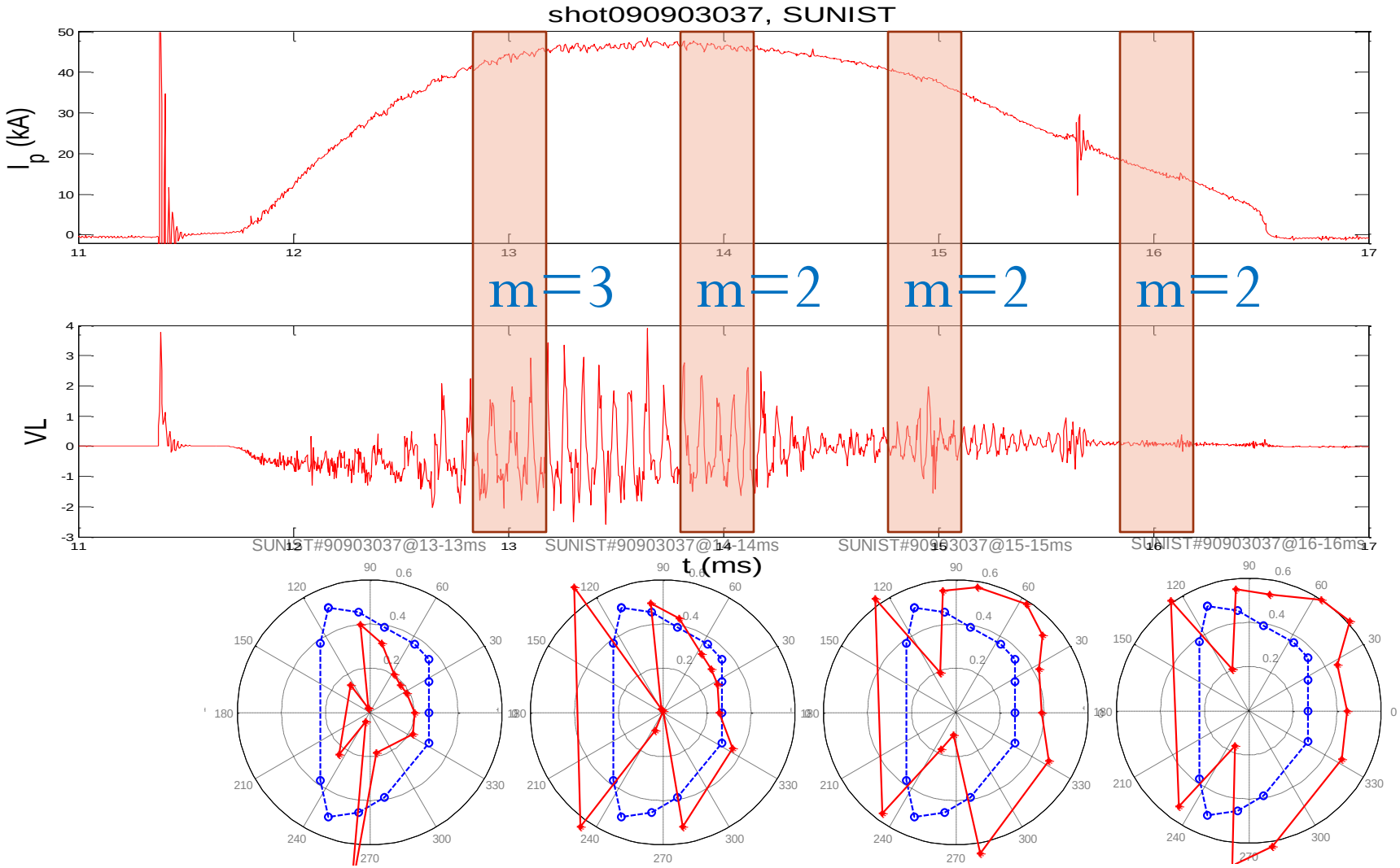
- **Mode structures during MHD events in SUNIST are revealed by means of singular value decomposition**
- **Singular Value Decomposition**
  - Consider a matrix $A(M \times N)$:

$$A = U \Sigma V^T$$

  - Σ, U and V are called the singular value (power of the ith mode), chrono, and topo; Chrono and topo show common waveforms for all channels (temporal eigenmodes) and distribution of chrono (spatial eigenmodes), respectively.
  - Time evolutions of each decomposed mode (i.e., chrono) and its spatial distribution (i.e., topo) can be extracted in this way.

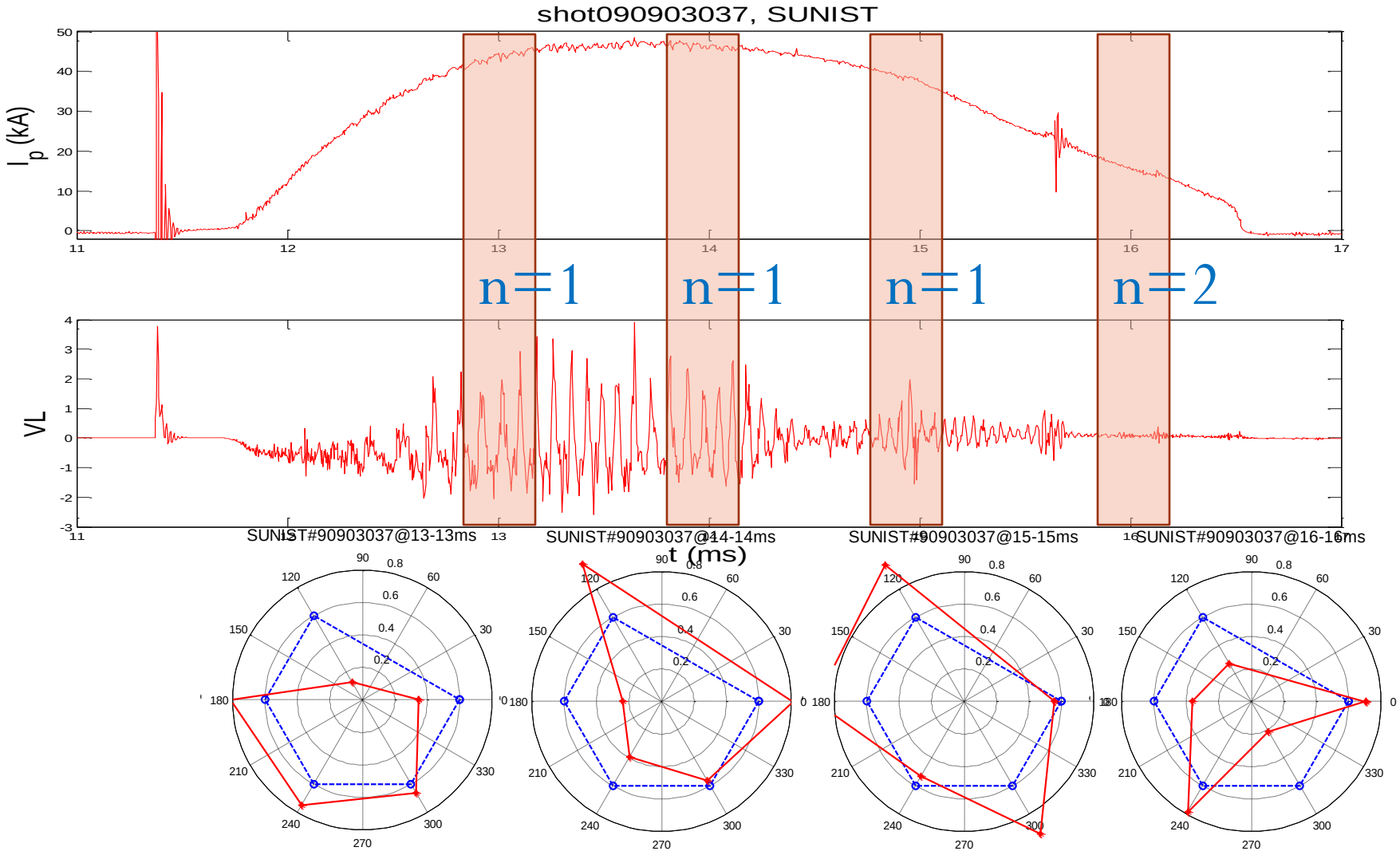
Mode Analysis for an Ohmic Discharge

- **Shot090903037: Poloidal mode**



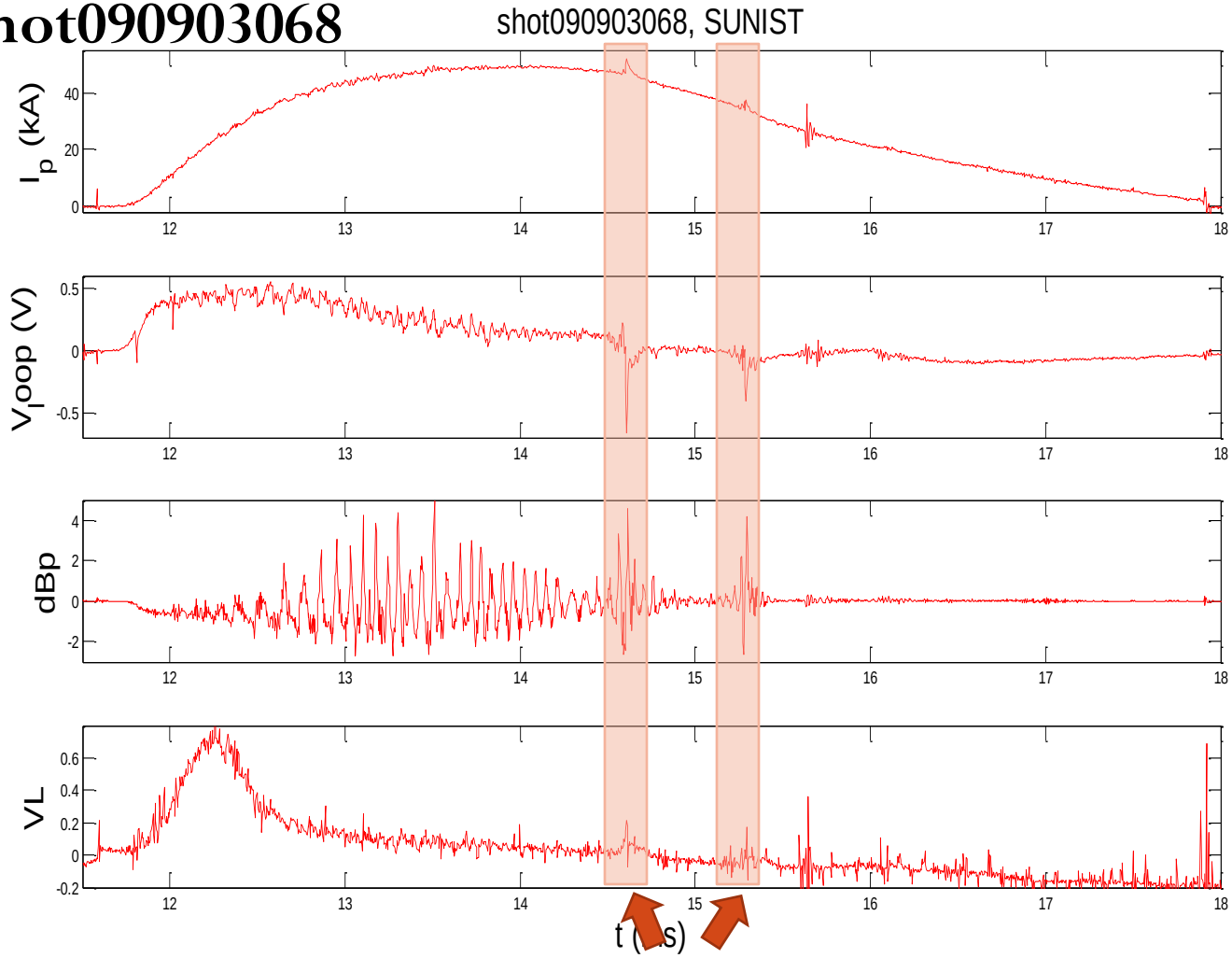
Mode Analysis for an Ohmic Discharge

- **Shot090903037: Toroidal mode**

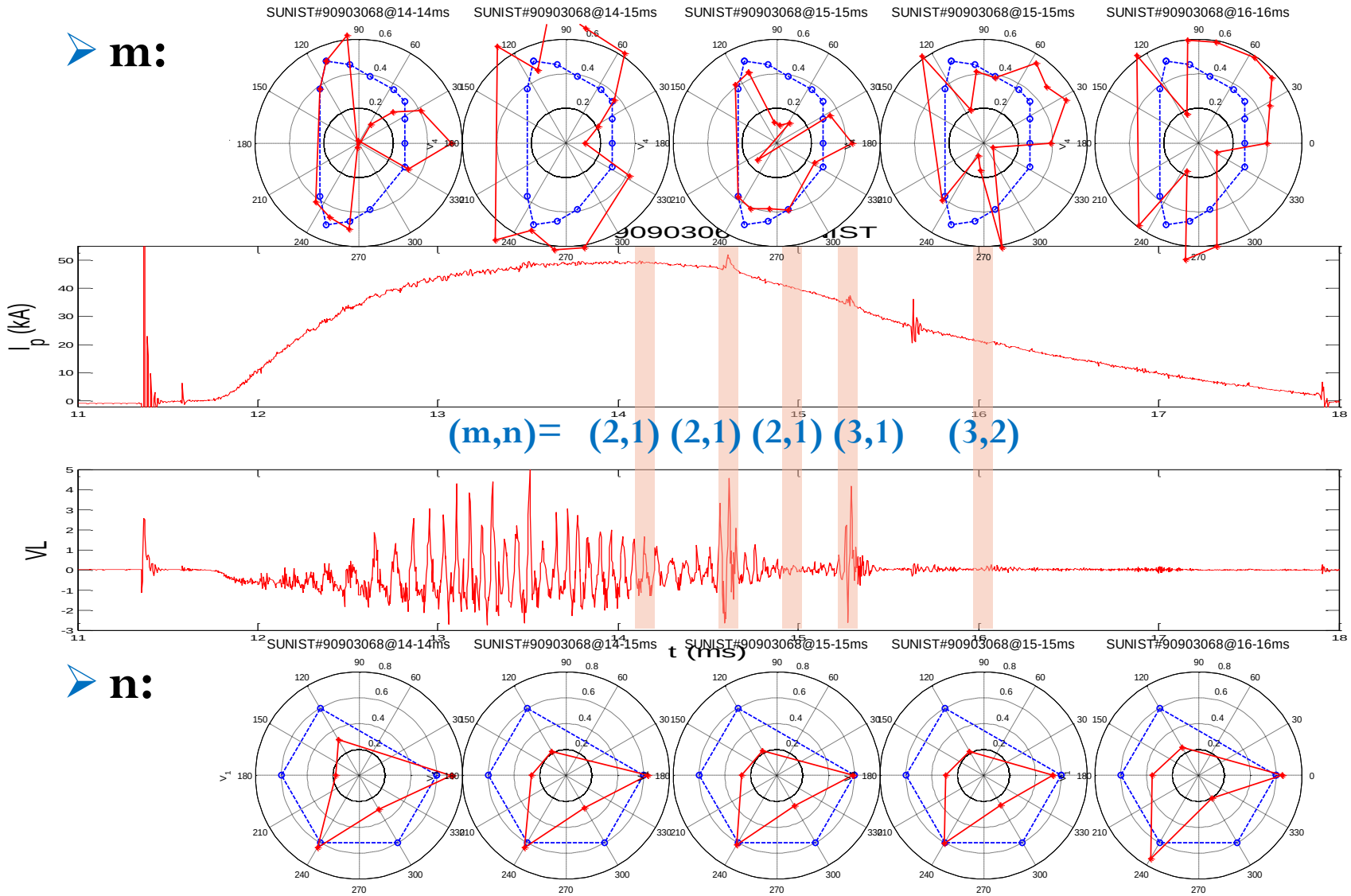


Internal Reconnection Events

- **shot090903068**

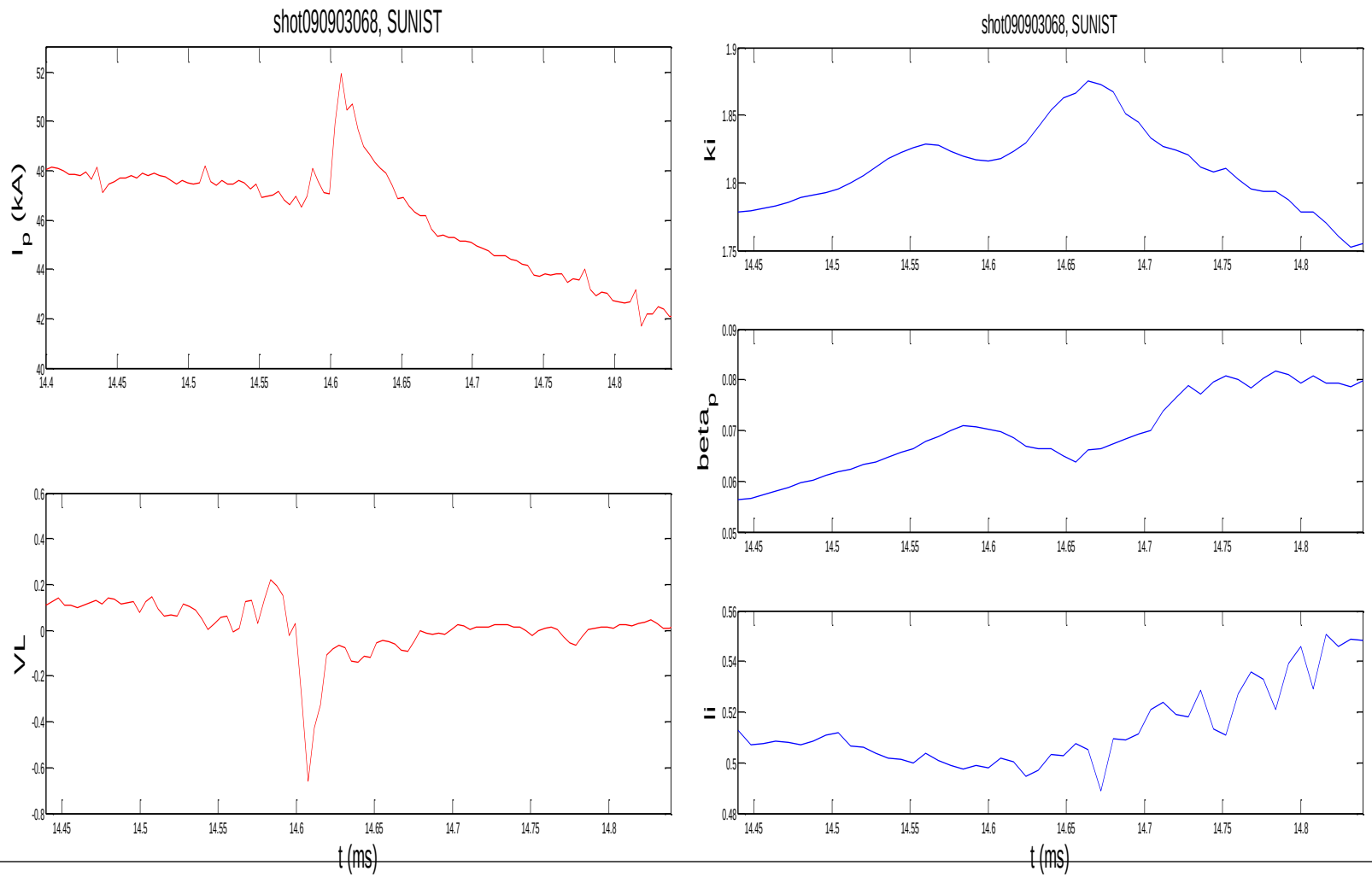


Mode Evolution



Evolution of Plasma Parameters

- **Evolution of Plasma Parameters during IRE**



Properties of SUNIST discharges (2)

- **There is clear change in poloidal mode numbers and toroidal mode numbers during Ohm discharge.**
- **The edge mode, which is m=3/n=1 or m=2/n=1, , can be seen by edge magnetic coil array.**
- **Internal reconnection events, characterized by a perturbation of the I_p, V_{loop} and *H*_alpha evolutions, have been confirmed on SUNIST.**
- **The evolution of MHD activities during the IRE was observed.**

Summary

- **The evolution of the plasma equilibrium is analyzed with the EFIT code;**
- **The results are consistent to the observation from high-speed CCD camera;**
- **The edge mode, which is m=3/n=1 or m=2/n=1, can be seen by edge magnetic coil array;**
- **Internal reconnection events, characterized by a perturbation of the I_p, V_{loop} and *H*_alpha evolutions, have been confirmed on SUNIST.**