

INVESTIGATION OF FILAMENT DYNAMICS USING HIGH-SPEED VIDEO SHOOTING IN THE GLOBUS-M2 TOKAMAK

¹V.M. TIMOKHIN

^{1,2}M.K. BUTS, ¹V.YU. SERGEEV, ²A.N. NOVOKHATSKY, ¹D.D. KOROBKO and ²GLOBUS-M2 TEAM

¹Peter the Great St. Petersburg Polytechnic University

²Ioffe Institute

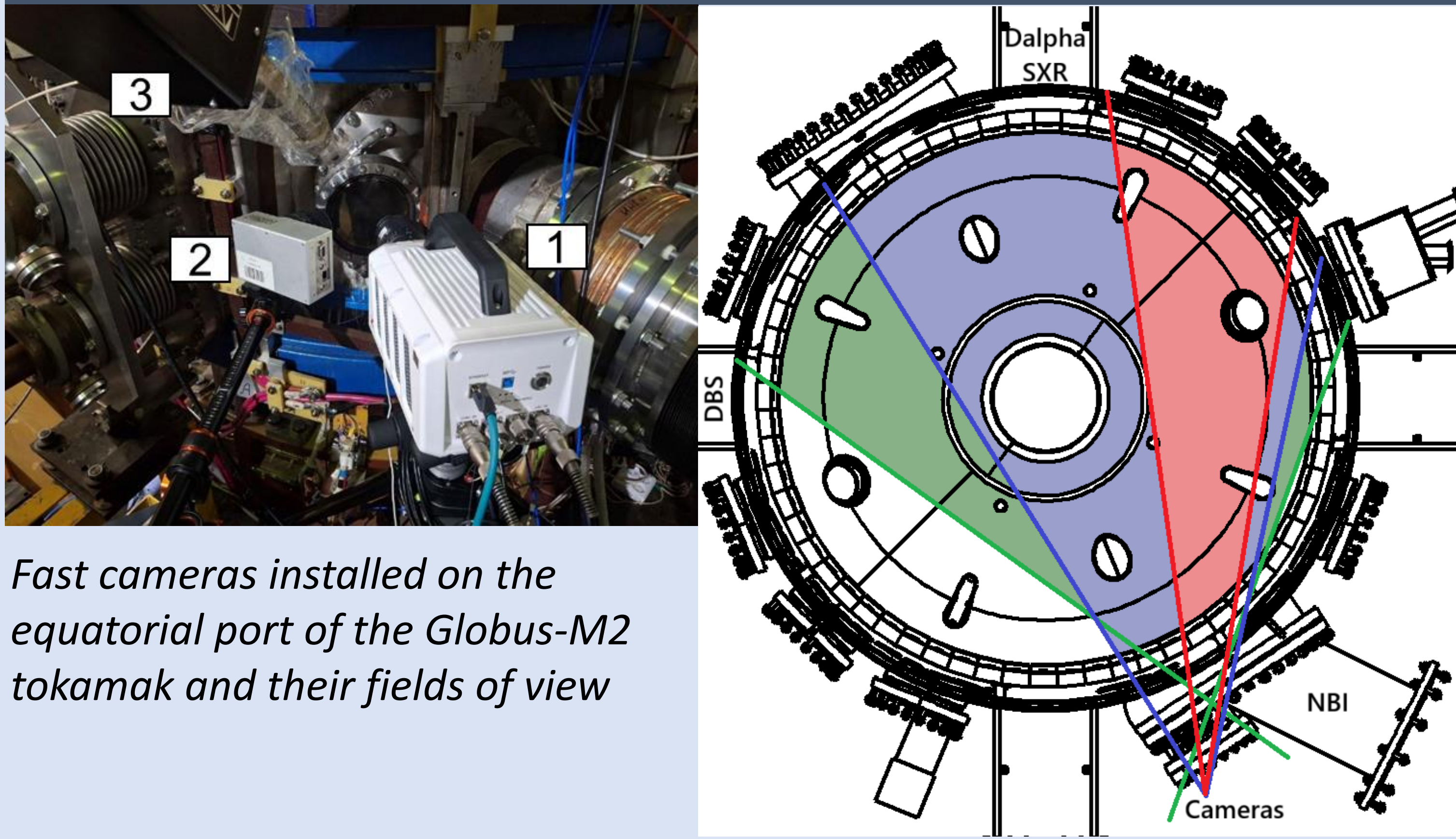
Saint-Petersburg, Russian Federation

v.timokhin@spbstu.ru

ABSTRACT

- High-speed camera setup has been integrated into the Globus-M2 tokamak diagnostic system.
- Processes occurring during the growth of edge localized instability modes (ELMs) in Globus-M2 tokamak's peripheral plasma were registered in the visible spectral range.
- Filaments' key parameters were estimated, including transverse dimensions, velocity, and the total number of filaments at the low field side.

EXPERIMENTAL SETUP



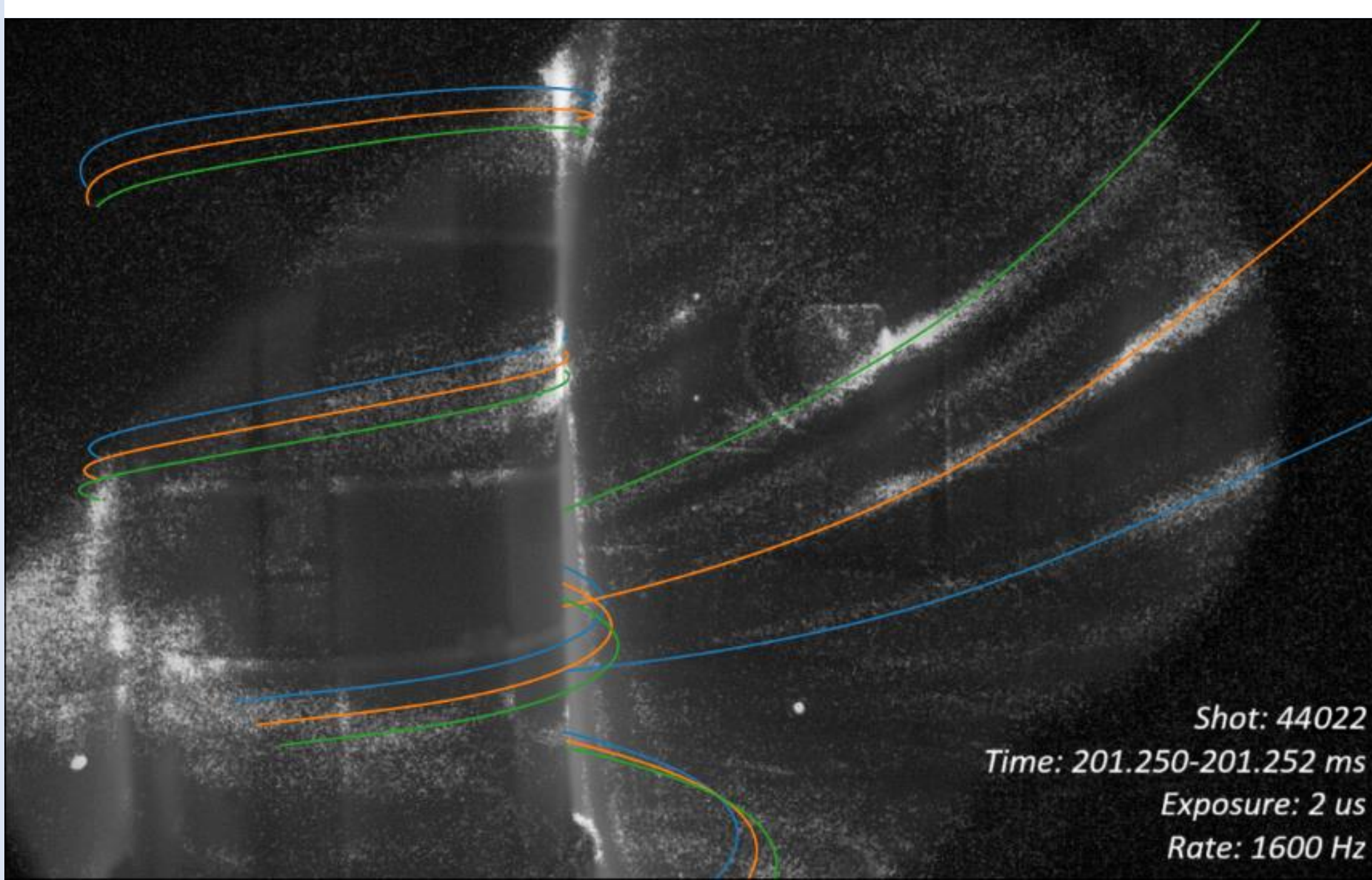
Fast cameras installed on the equatorial port of the Globus-M2 tokamak and their fields of view

FAST CAMERAS BASIC PARAMETERS

	Optronis CR3000X2	Phantom Miro M110	Revealer X213
Sensor type		CMOS	
Pixel size, μm	8	20	14.6
Sensor resolution, pxs	1696x1710	1280x800	1280x1024
Dynamic range, bits	8	12	8
Max. frame rate at full resolution, fps	543	1630	13 600
Max. frame rate at reduced resolution, fps (frame size, pxs)	142 857 (8x8)	400 200 (64x8)	1 000 000 (1280x8)
Minimal exposure time, μs		2	0.1

SET OF IMAGE PROCESSING SOFTWARE

- Analyzing and processing experimental data FCV (Fast Camera Viewer). Convenient video display and synchronization with other diagnostic data.
- The original algorithm for increasing the contrast of the filaments on the images.
- Spatial calibration of the camera's field of view, spatial anchoring and sizing of filaments.
- Tracing and projection of magnetic field lines on an experimental image with filaments.



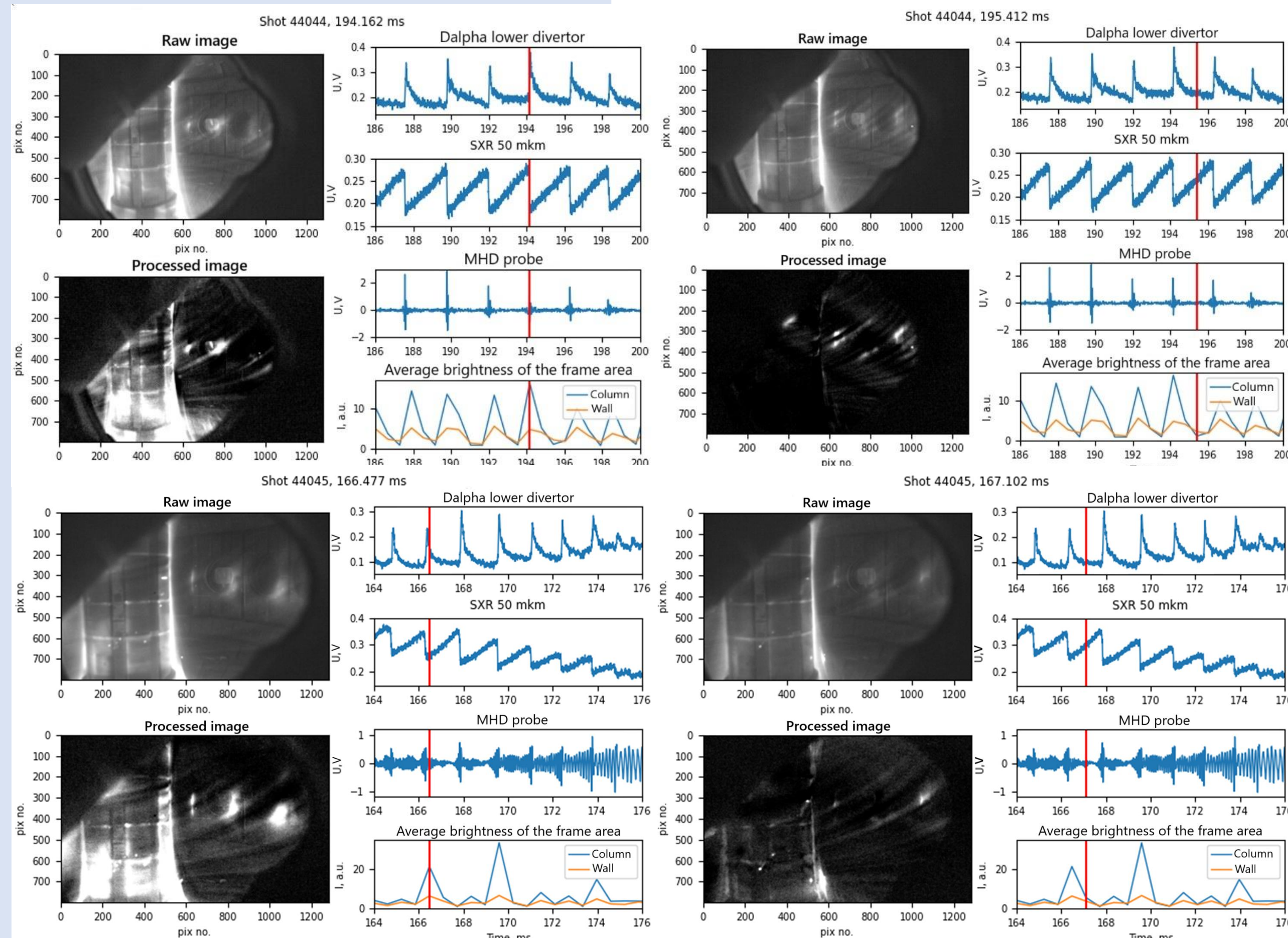
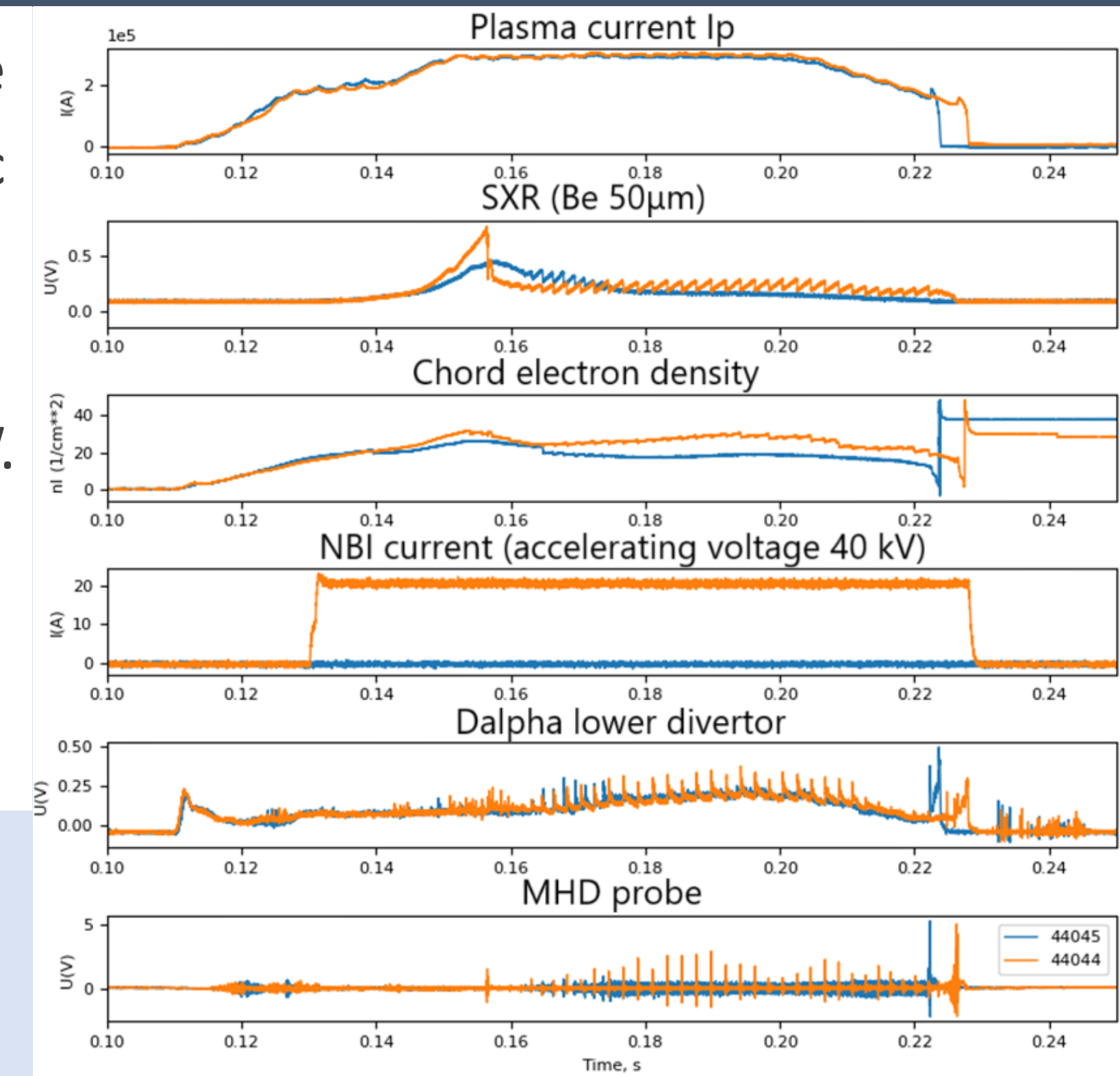
- Filamentary structures coincide in direction with the magnetic field lines lying nearby the separatrix with good accuracy (1-2 cm).

Shot: 44022
Time: 201.250-201.252 ms
Exposure: 2 μs
Rate: 1600 Hz

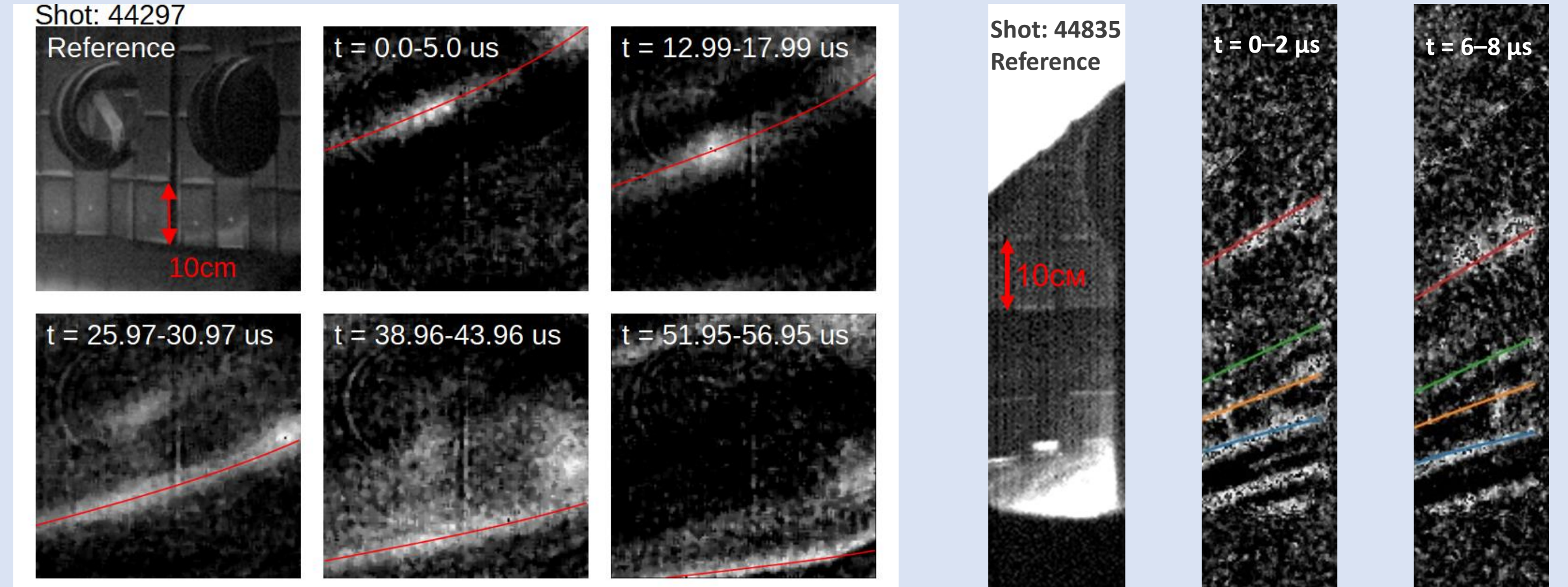
EXPERIMENTAL RESULTS

- ## 44044 & 44045 consecutive discharges, identical in basic parameters, with & without NBI.
- $B_t = 0.7 \text{ T}$, $I_p = 300 \text{ kA}$, $\langle n_e \rangle = 5.5 \times 10^{19} \text{ m}^{-3}$, $P_{\text{NBI}} = 0.8 \text{ MW}$.
- Phantom camera: full resolution (1280x800), exposure time 2 ms, frame rate 1600 Hz.

Instant images of filamentous structures with & without a $D\alpha$ signal flash moment



Dynamics of filament motion and estimation of the poloidal velocity



Phantom, 5 μs , 77 kHz, 128x128 pxs

Revealer, 2 μs , 167 kHz, 384x72 pxs

CONCLUSION

- The diagnostic complex for high-speed plasma imaging and the set of programs for video processing and data comparison with other diagnostics of the Globus-M2 tokamak were created.
- Typical filament parameters were measured: size 2-3 cm, velocity $\sim 3\text{-}15 \text{ km/s}$, full number 10-25.
- A correlation between the number and brightness of filaments and sawtooth oscillations and $D\alpha$ signal bursts is not always observed.

ACKNOWLEDGEMENTS

This work was supported by the Ministry of Science and Higher Education of the Russian Federation as part of the state assignment in the field of science under Project № FSEG-2024-0005. The research utilized the Federal Center for Collective Use "Materials Science and Diagnostics in Advanced Technologies" at the A.F. Ioffe Physical-Technical Institute, which includes the Unique Scientific Facility "Globus-M Spherical Tokamak". The development of high-speed camera diagnostics was supported by Rosatom State Corporation and the Ministry of Education and Science of Russia within the framework of Federal Project 3 (FP3), project № FSEG-2025-0002 "Development of principles and systems for control and diagnostics of tokamak plasma using substance injection".