

Magnetic reconnection at the base of relativistic jets

PIC → GRMHD

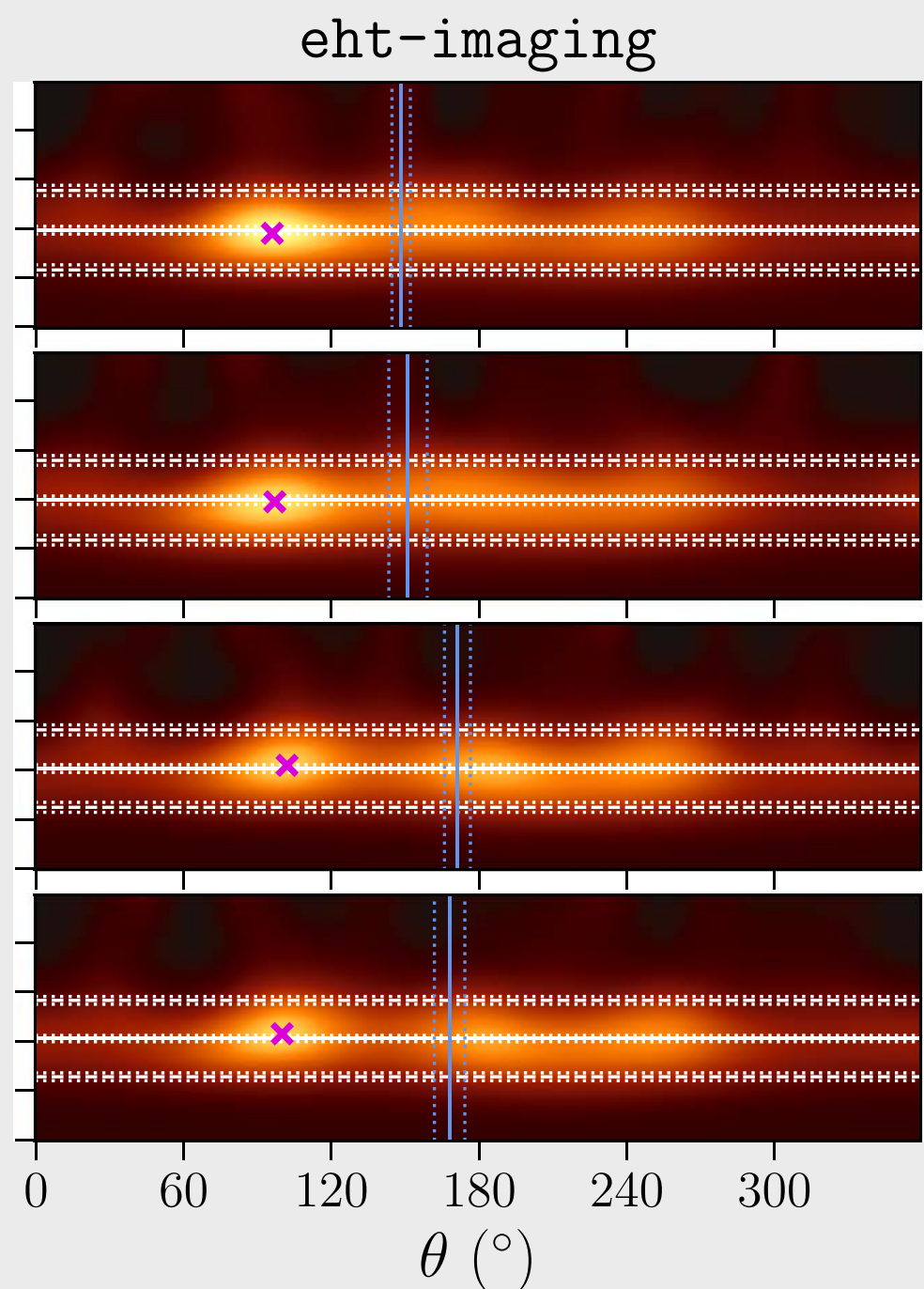
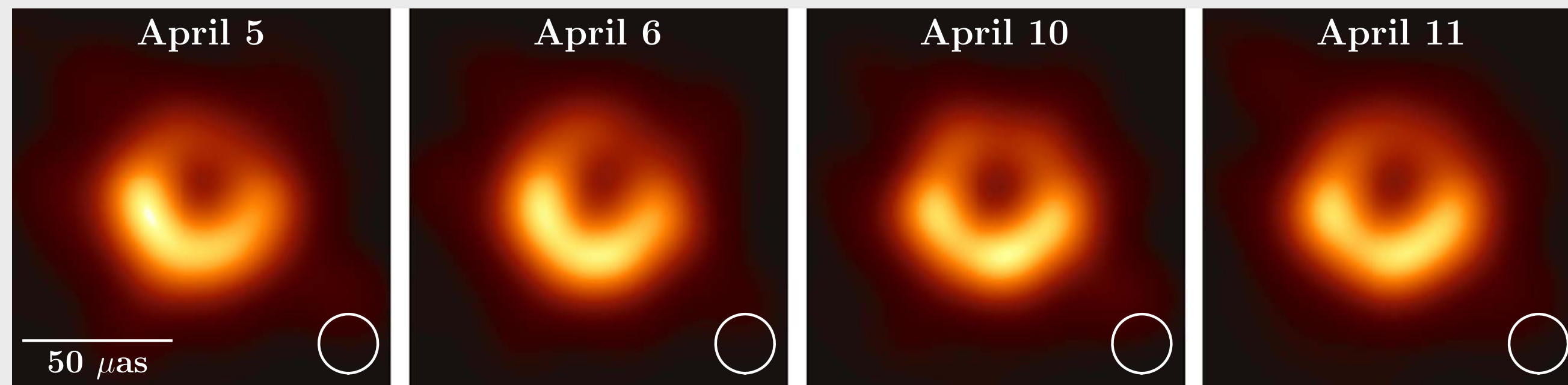
2023 report of Krzysztof Nalewajko

- K. Nalewajko „Rotation of the crescent image of M87* and polarization of its ESE hotspot”, 2023, proceedings of the 16th Marcel Grossmann Meeting
- D. A. Kann, N. E. White, et al. „Fires in the Deep: The Luminosity Distribution of Early-Time Gamma-Ray Burst Afterglows in the Light of the Gamow Explorer Sensitivity Requirements”, submitted to A&A
- S. M. Wagner, J. D. Scargle, G. Madejski, A. Gokus & K. Nalewajko „High-energy variability of the gravitationally lensed blazar PKS 1830-211”, in prep.
- New lecture „Radiative processes”, part of „Introduction to Astrophysics” (Oct 2023, 8 hours)
- Special session „Relativistic Magnetospheres” at EAS in Kraków (13 Jul 2023, SOC chair)
- secretary of the Scientific Council
- 3 conference talks (1 invited)
- supercomputing allocation: 2 MSU at Ares (Cyfronet ACK)

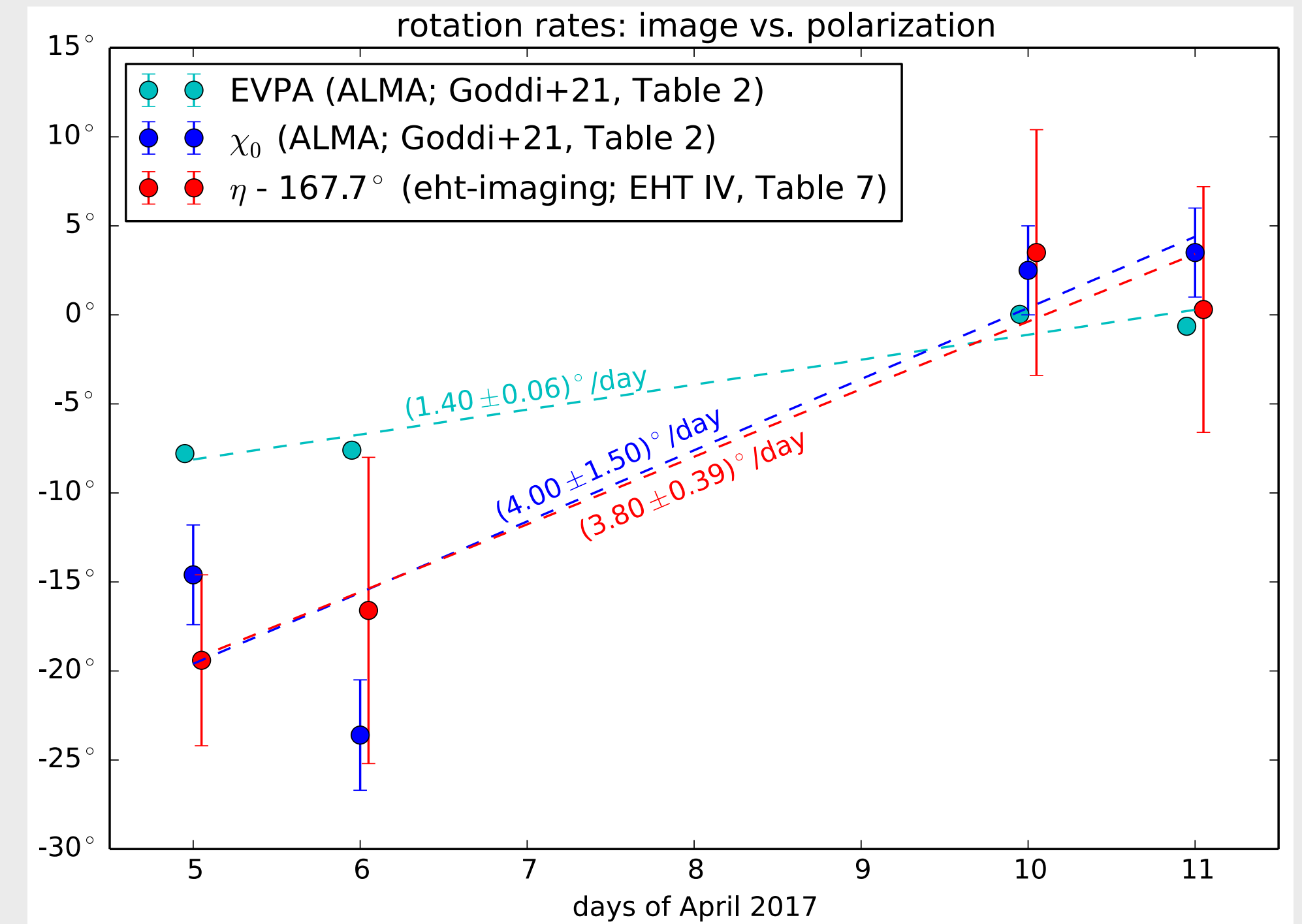
Rotation of the crescent image of M87* and polarization of its ESE hotspot

proceedings of the 16th Marcel Grossmann Meeting (arXiv:2111.07735)

The crescent image of M87* might have rotated by $\sim 24^\circ$ during the 6-day EHT campaign in 2017. This rate coincides with the rotation of unresolved Faraday-corrected polarization measured by ALMA. Such rate would be strongly sub-Keplerian at ISCO for $a=0$.



EHT M87 paper IV (2019)

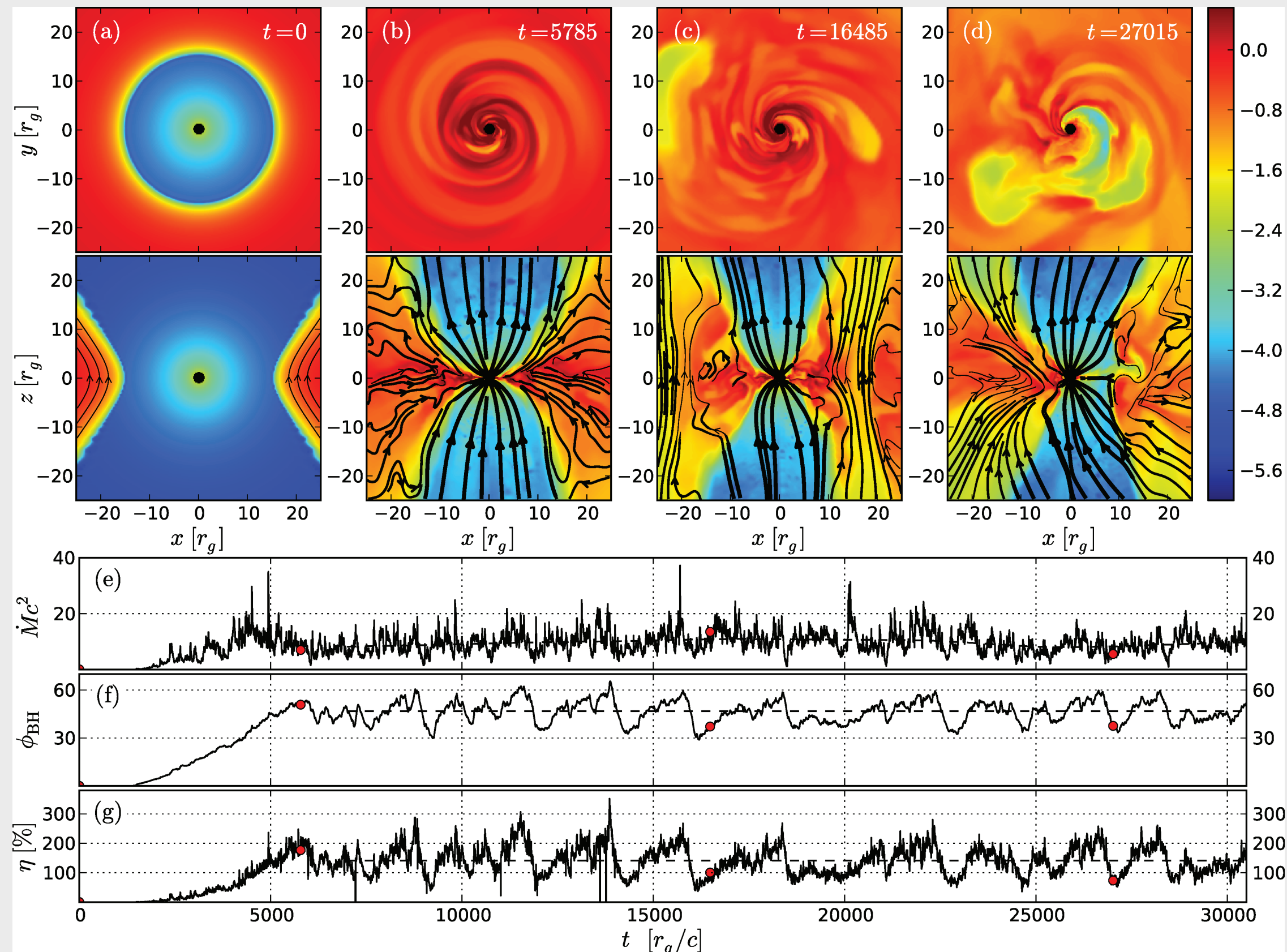


$3.9^\circ/\text{day}$ for M87 means $P \simeq 2.7P_{\text{ISCO}} \simeq 250 R_g/c$
(KN 2021, arXiv:2111.07735)

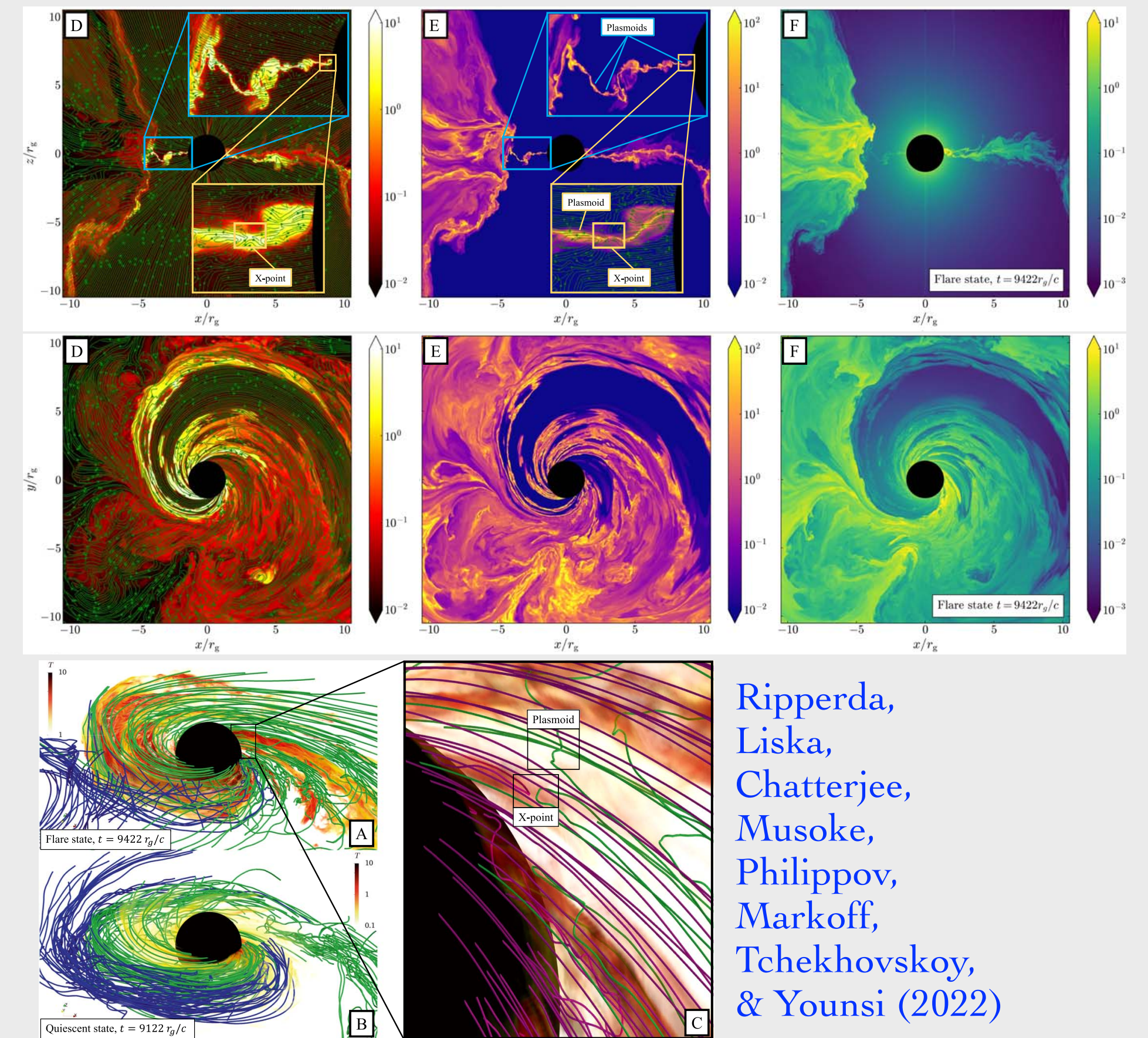
however, in GRMHD simulations, rotation rate of patterns is not sensitive to BH spin (Conroy et al. 2023)

Magnetic flux eruptions at magnetically saturated black holes

- Relativistic jets powered by spinning BH with large magnetic fluxes (Blandford & Znajek 1977).
- Magnetic fluxes accumulated from accretion flows are limited by a saturation mechanism involving magnetic flux eruptions (Tchekhovskoy et al. 2011).
- Magnetic flux eruptions are driven by magnetic reconnection (Ripperda et al. 2022).



Tchekhovskoy, Narayan & McKinney (2011)



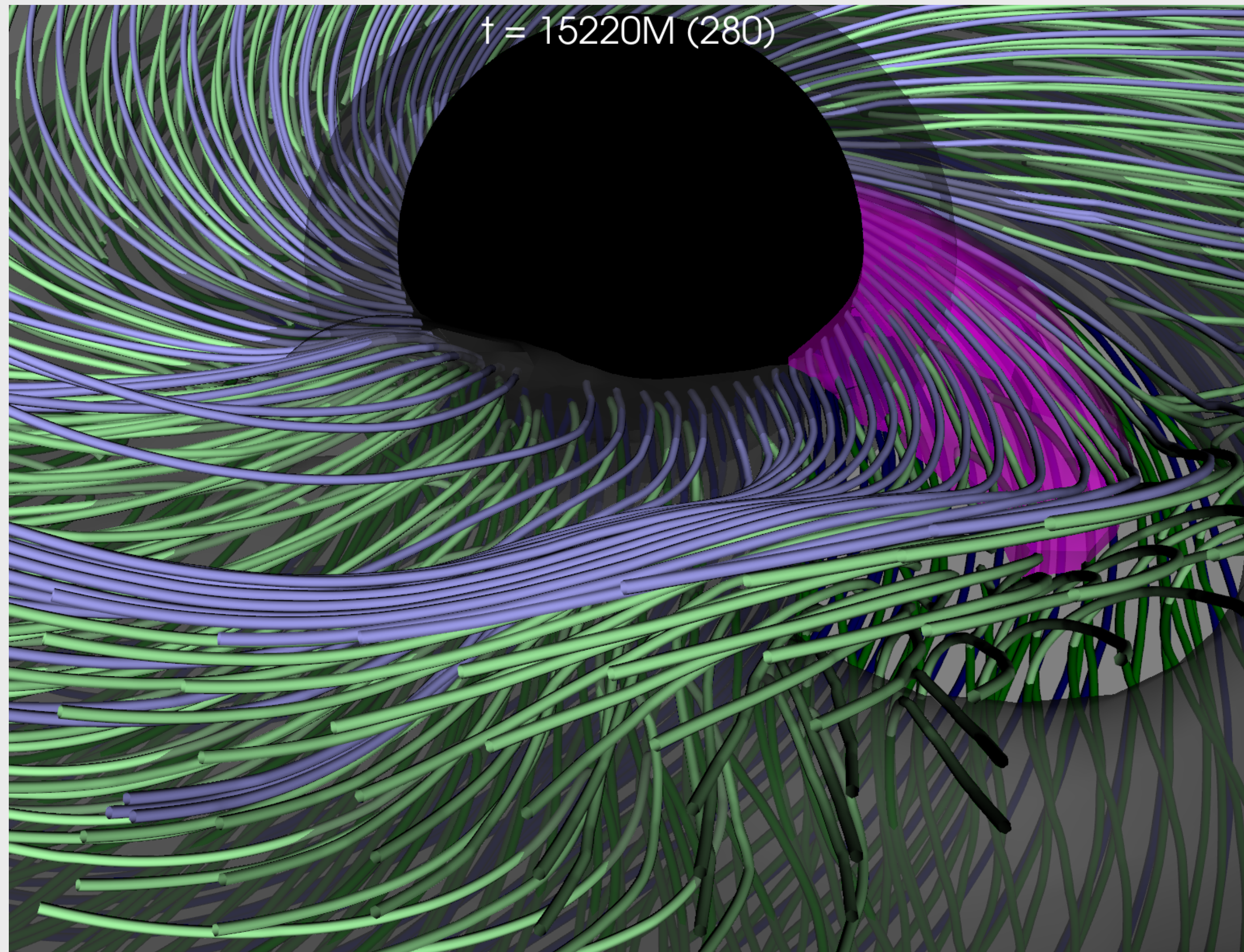
Ripperda, Liska, Chatterjee, Musoke, Philippov, Markoff, Tchekhovskoy, & Younsi (2022)

probably the best reconnection site in the Universe, but how is it triggered?

Magnetic flux eruptions at magnetically saturated black holes

with Mateusz Kapusta and Agnieszka Janiuk

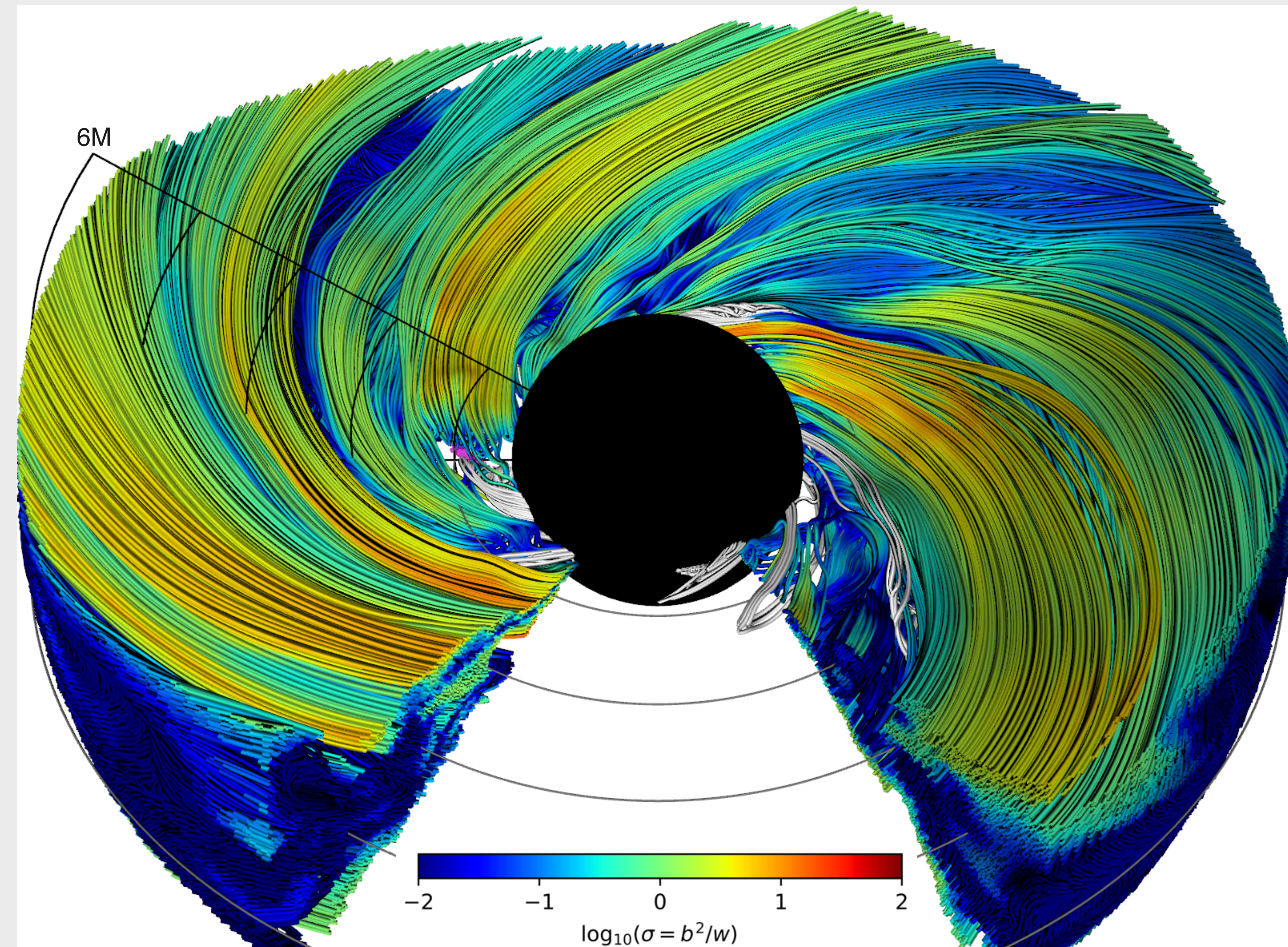
- 3D GRMHD simulations by [Agnieszka Janiuk & Bestin James \(2022\)](#)
- 2022 summer student program → Mateusz Kapusta
- 2023 presentations at PTA & HEPRO



- GRMHD low-res demo ($a = 0.9$, prograde torus)
- magnetic field lines **connected** or **disconnected** from the BH horizon
- tongue of **relativistic temperature** within density gap
- self-similar eruption from thinning plasma density activating equatorial current layer
- thinning by elevated winds or diffusion

Magnetic flux eruptions at magnetically saturated black holes

with Mateusz Kapusta and Agnieszka Janiuk



- standard-res, $a = 0.9$, disconnected (colored by σ) or doubly-connected lines (white)
- regular double-spiral lines anchored at equatorial current layer
- chaotic disconnection of high- σ lines
- sub-Keplerian θ -stratified plasma plunge along disconnected field lines and equatorial current layer
- rigid disconnected field lines rotate very slowly, insensitive to BH spin (**M87***)
- 3D accretion flows are **not arrested (MAD)**, **not choked**, but **magnetically channeled**

2024 - invitations

- **Simons Collaboration on Extreme Electrodynamics of Compact Sources**
(SCEECS; <https://www.simonsceecs.com/>)
PIs: Roger Blandford, Alexander Philippov
annual meeting at Flatiron/CCA (NYC, USA), Feb 29th - Mar 1st
- **Fifth Purdue Workshop on Relativistic Plasma Astrophysics**
(<https://www.physics.purdue.edu/~lyutikov/workshop-24/>)
chair: Maxim Lyutikov
West Lafayette, IN, USA, May 6th - 9th