

FUSION ACTIVITIES

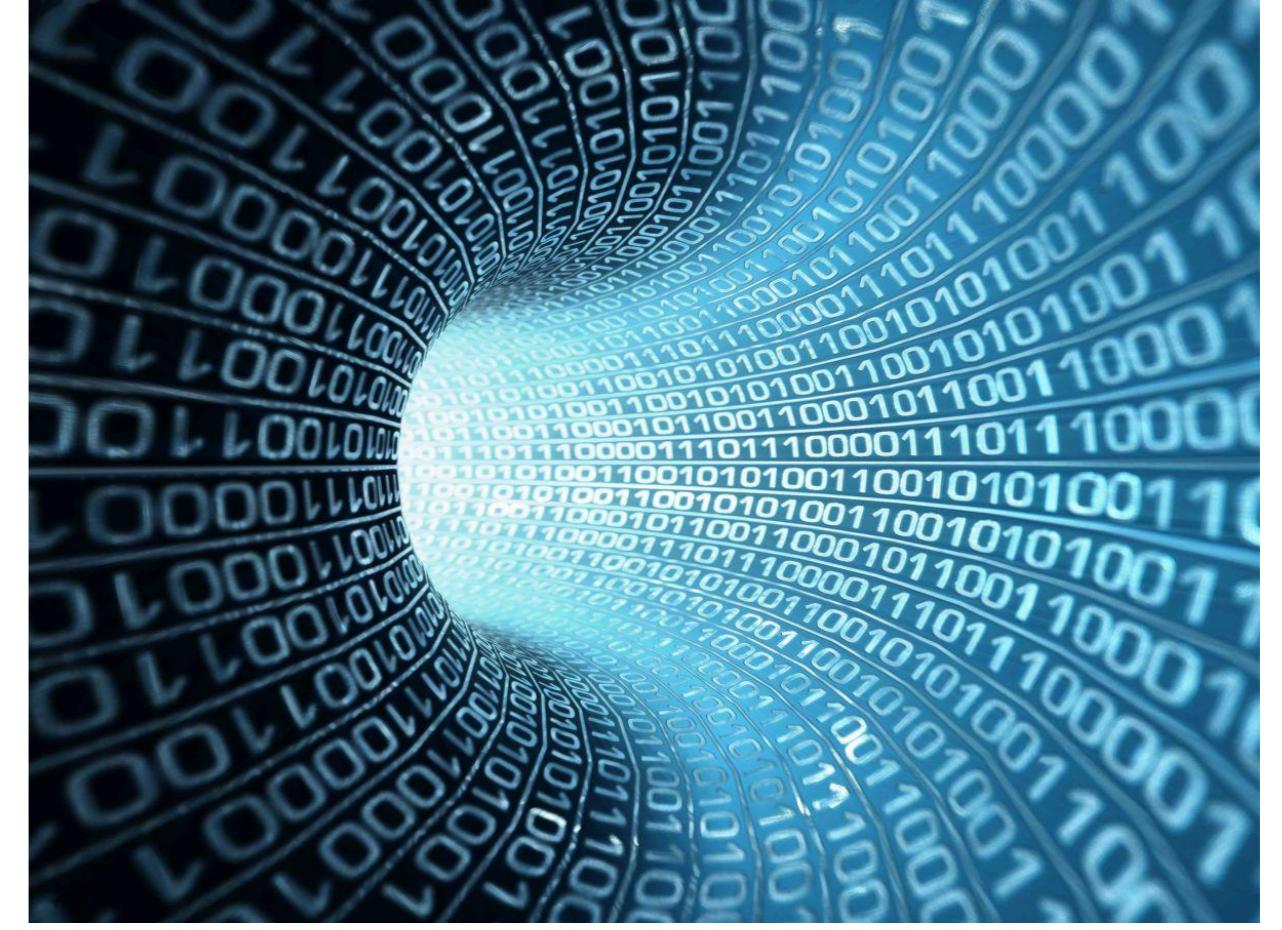
@ UGENT

Geert Verdoolaege, EFTC 2019, October 7, 2019

RESEARCH

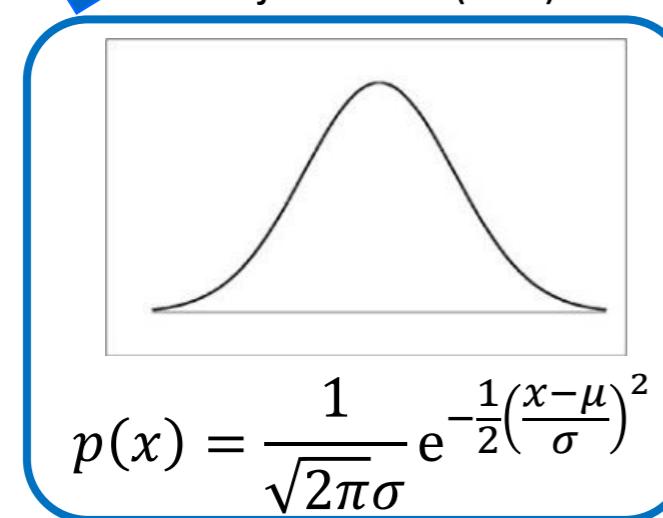
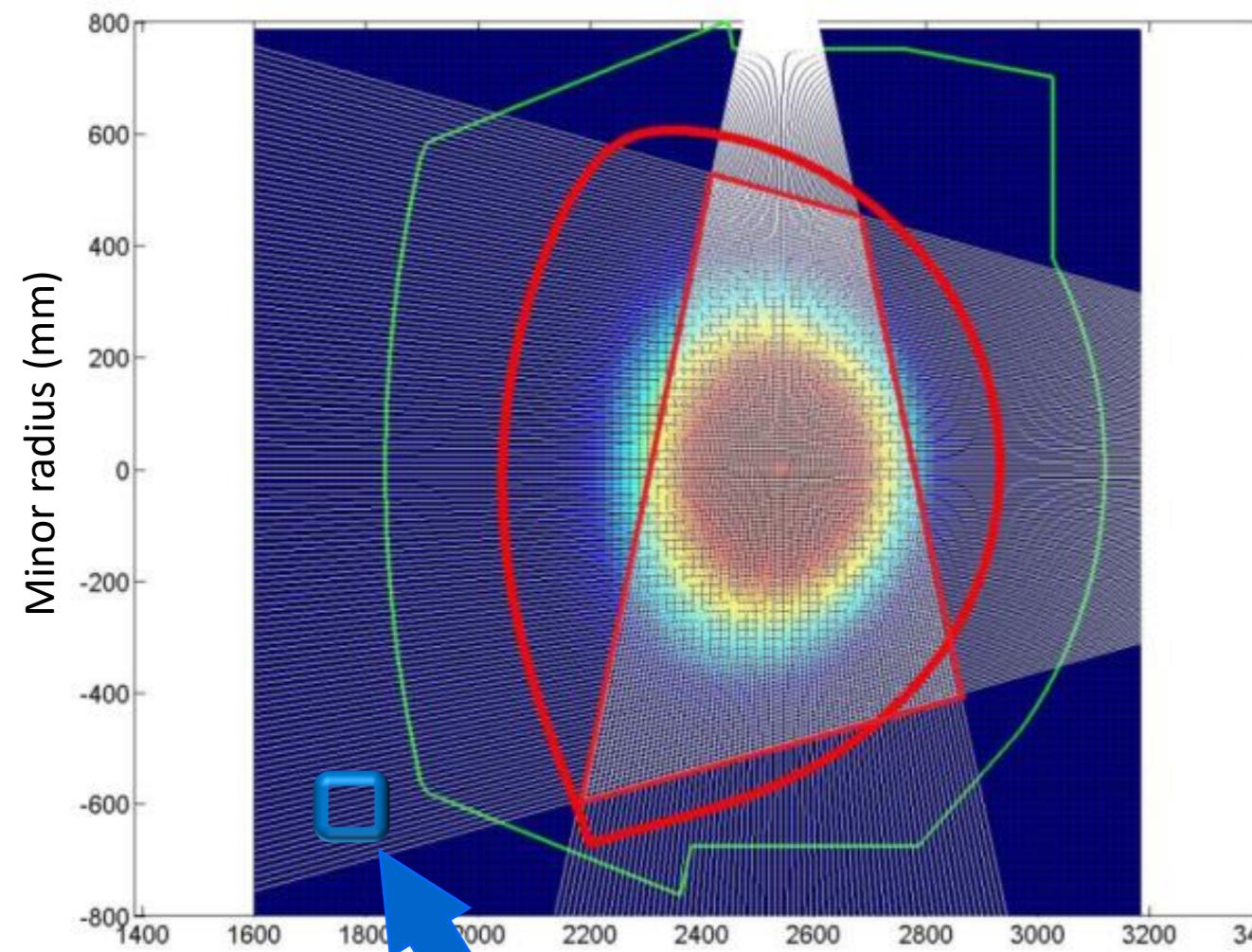
FUSION DATA SCIENCE

- Data science methods in fusion
- Young but growing field
- Solid mathematical foundations
 - Bayesian probability theory
 - Machine learning
 - Information geometry



$$p(\theta|x, I) = \frac{p(x|\theta, I)p(\theta|I)}{p(x|I)}$$

BAYESIAN ANALYSIS OF FUSION DIAGNOSTICS

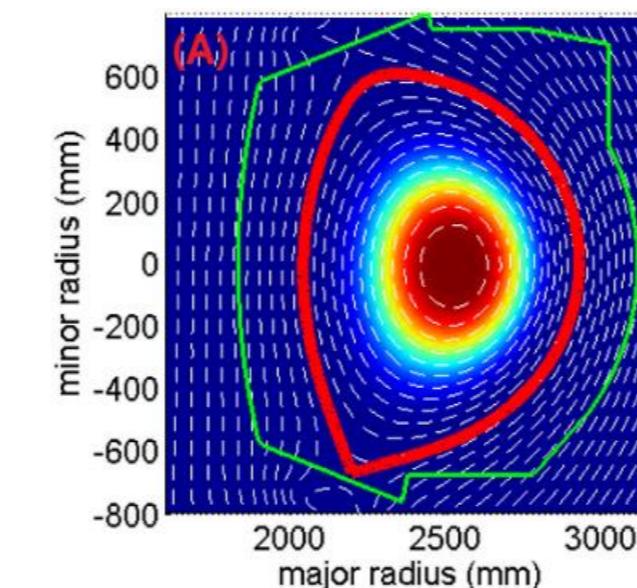


Soft X-ray tomography

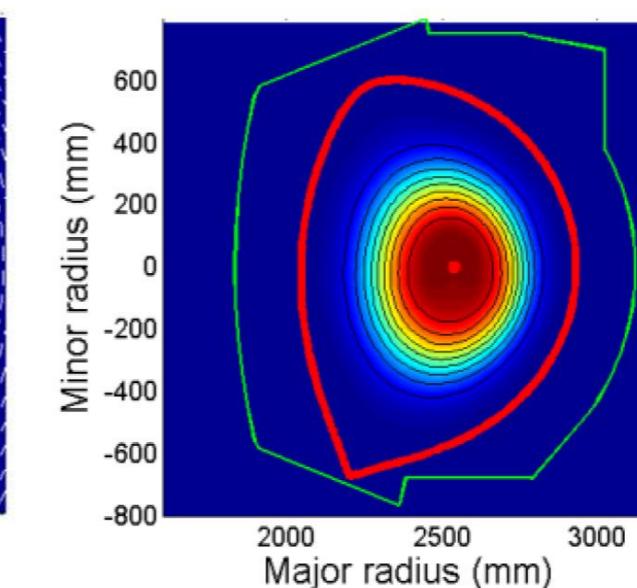
T. Wang *et al.*, Rev. Sci. Instrum. **89**, 063505, 2018

T. Wang *et al.*, Rev. Sci. Instrum. **89**, 10F103, 2018

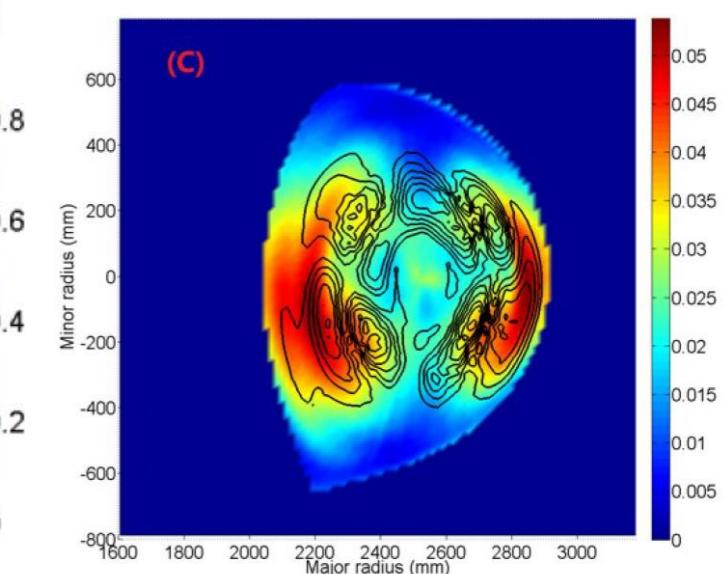
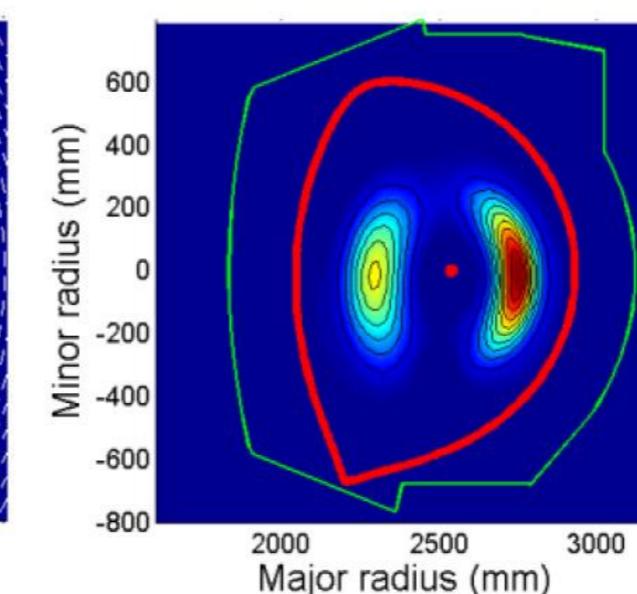
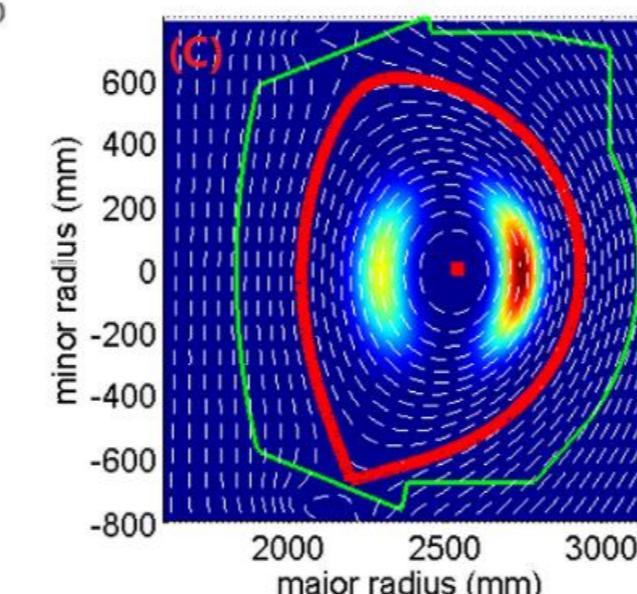
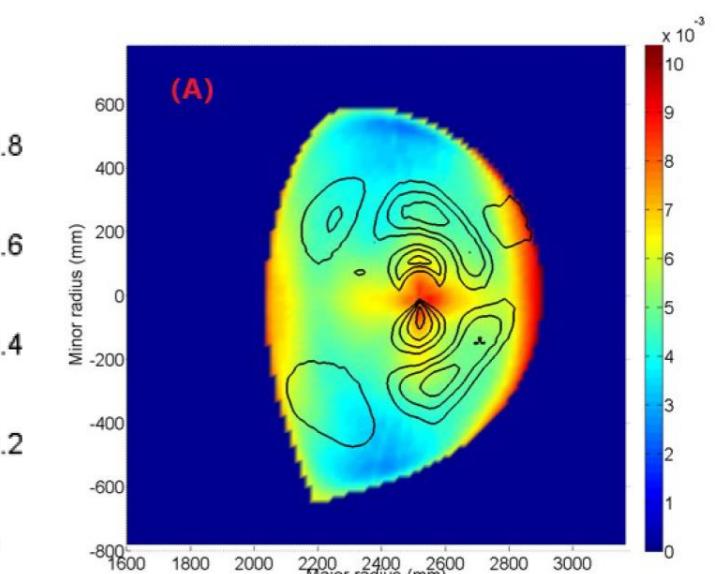
Original synthetic



Reconstruction

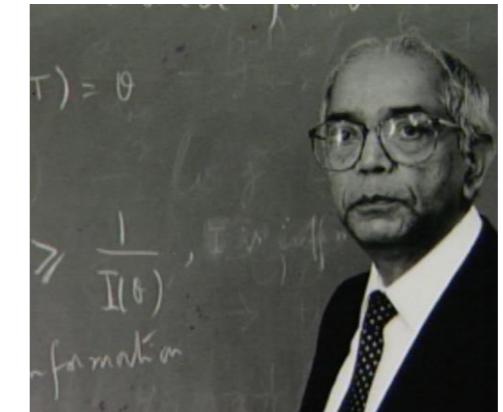
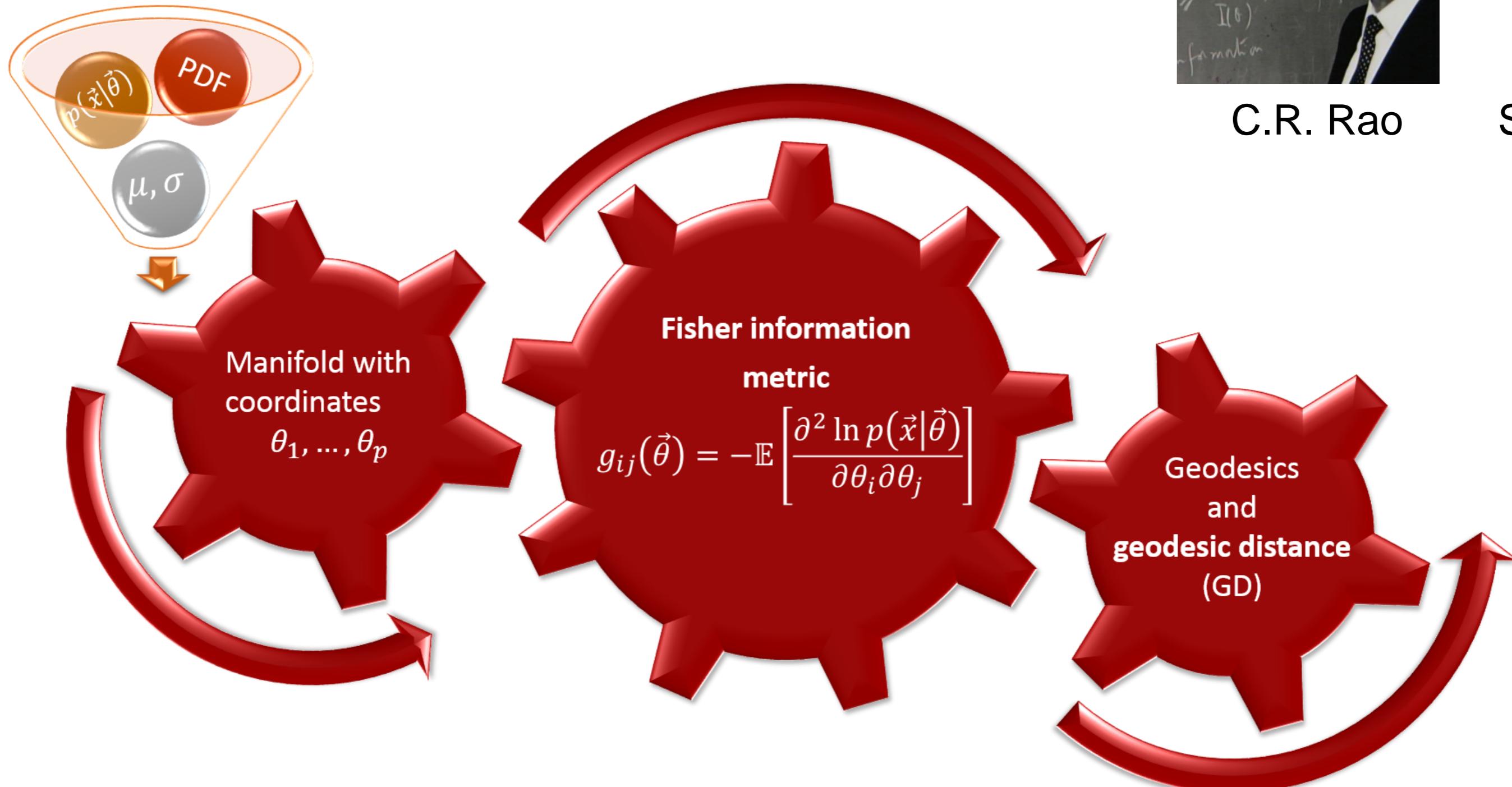


Posterior variance



INFORMATION GEOMETRY

Differential geometry → probability

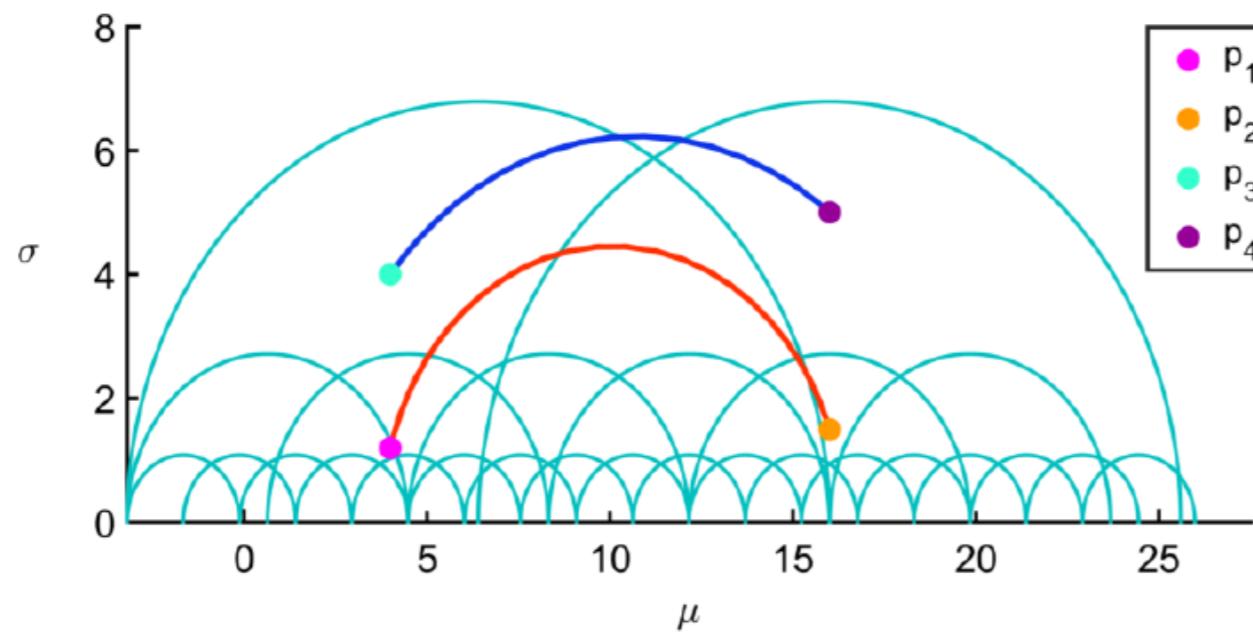
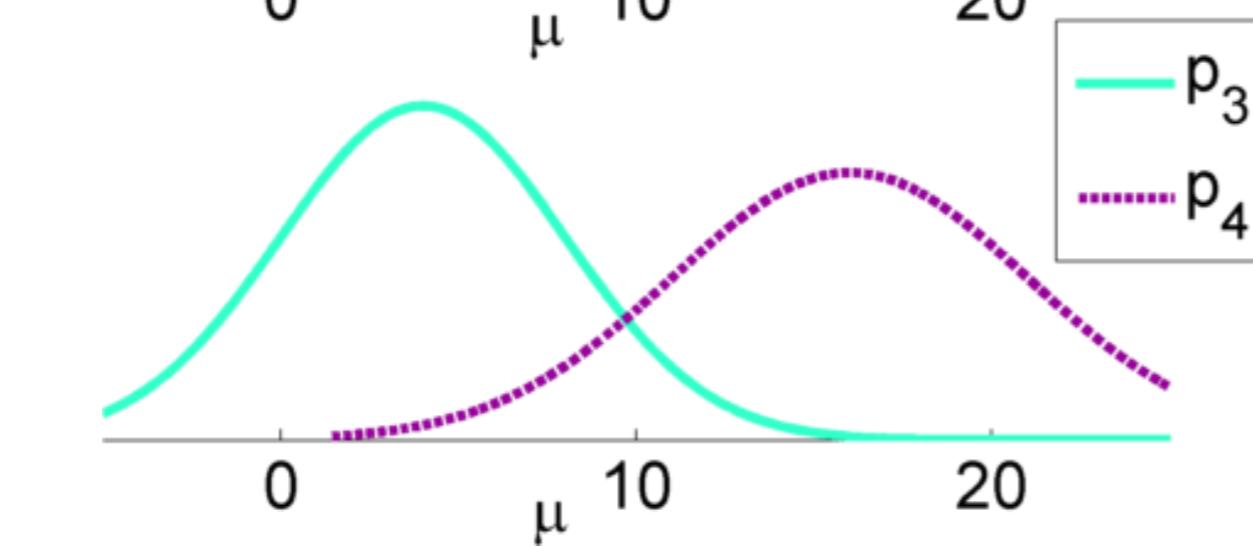
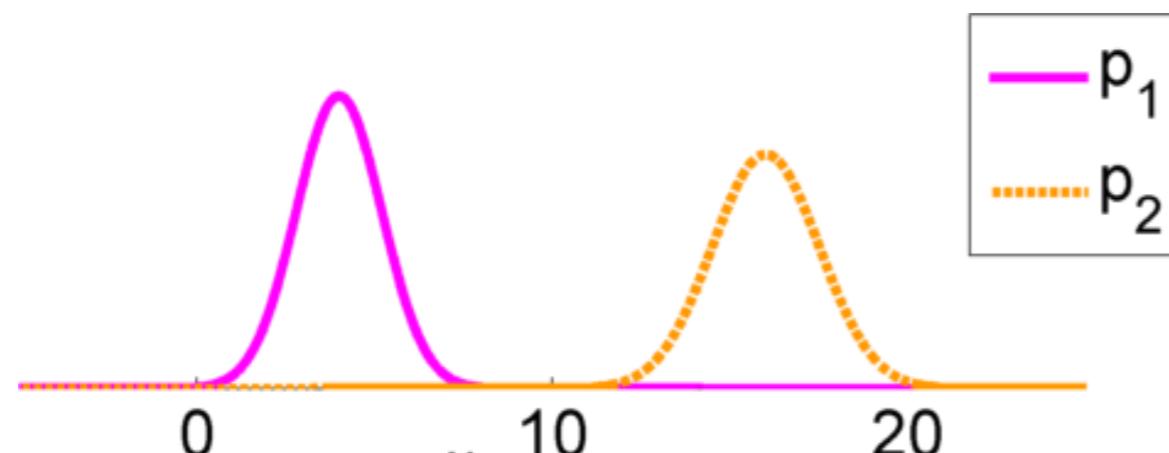


C.R. Rao

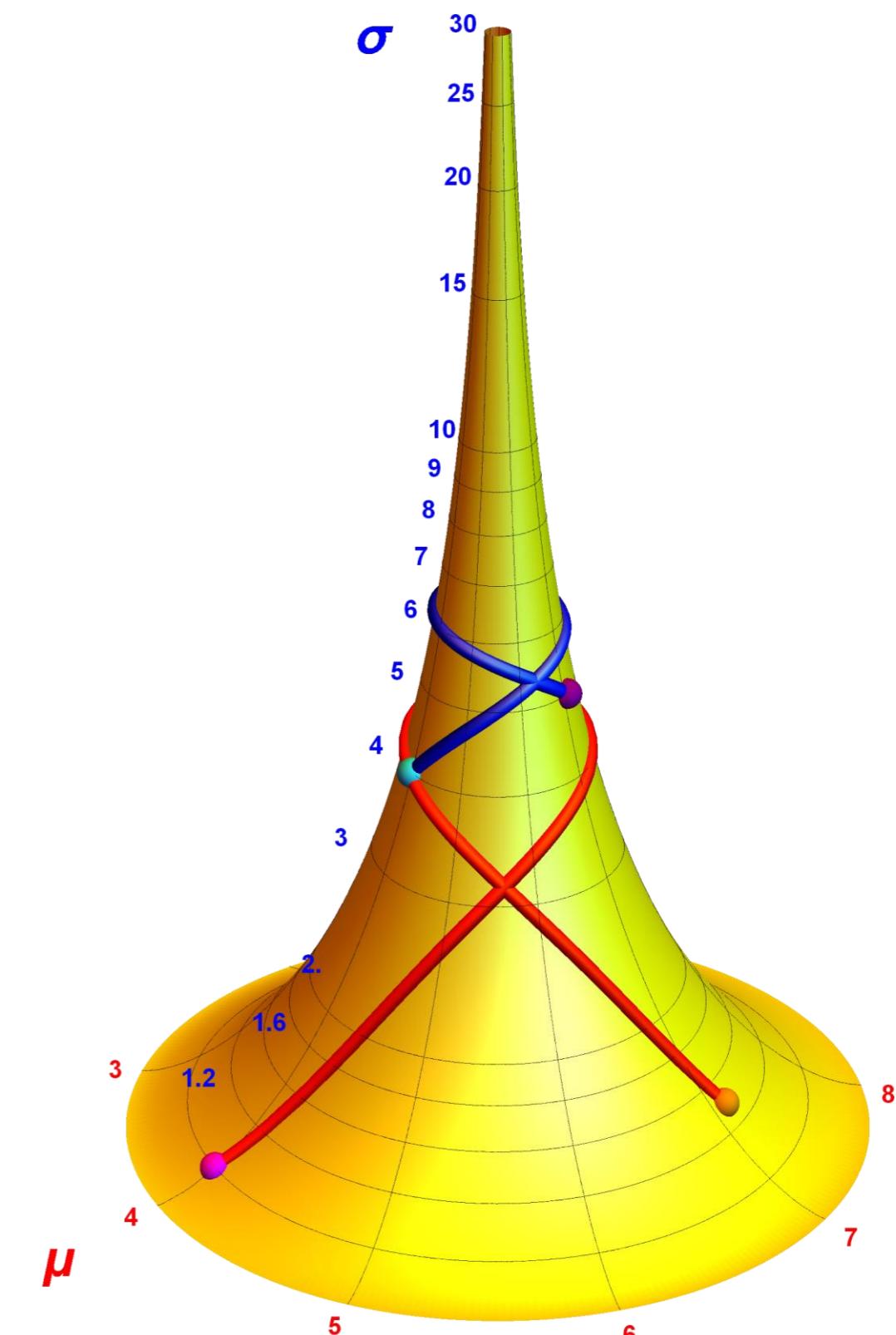


S.-I. Amari

DISTRIBUTION SIMILARITY MEASUREMENT



Poincaré half-plane



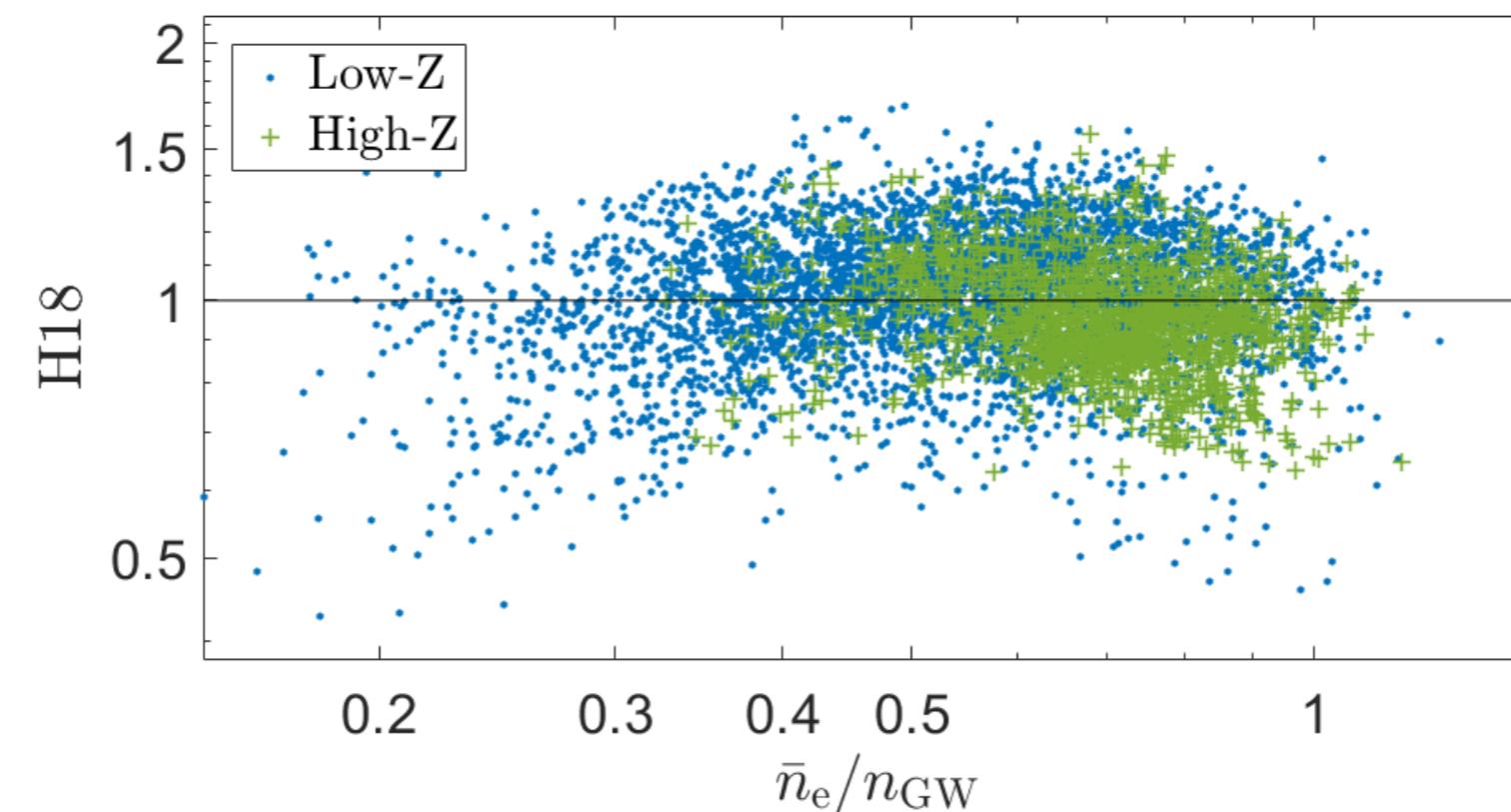
Pseudosphere (tractroïd)

REGRESSION ANALYSIS FOR SCALING LAWS

- **Geodesic least squares regression (GLS)**
- Energy confinement (revision IPB98)

G. Verdoollaeghe, Entropy **17**, 4602, 2015

G. Verdoollaeghe *et al.*, Nucl. Fusion **55**, 113019, 2015



G. Verdoollaeghe *et al.*, IAEA FEC 2018

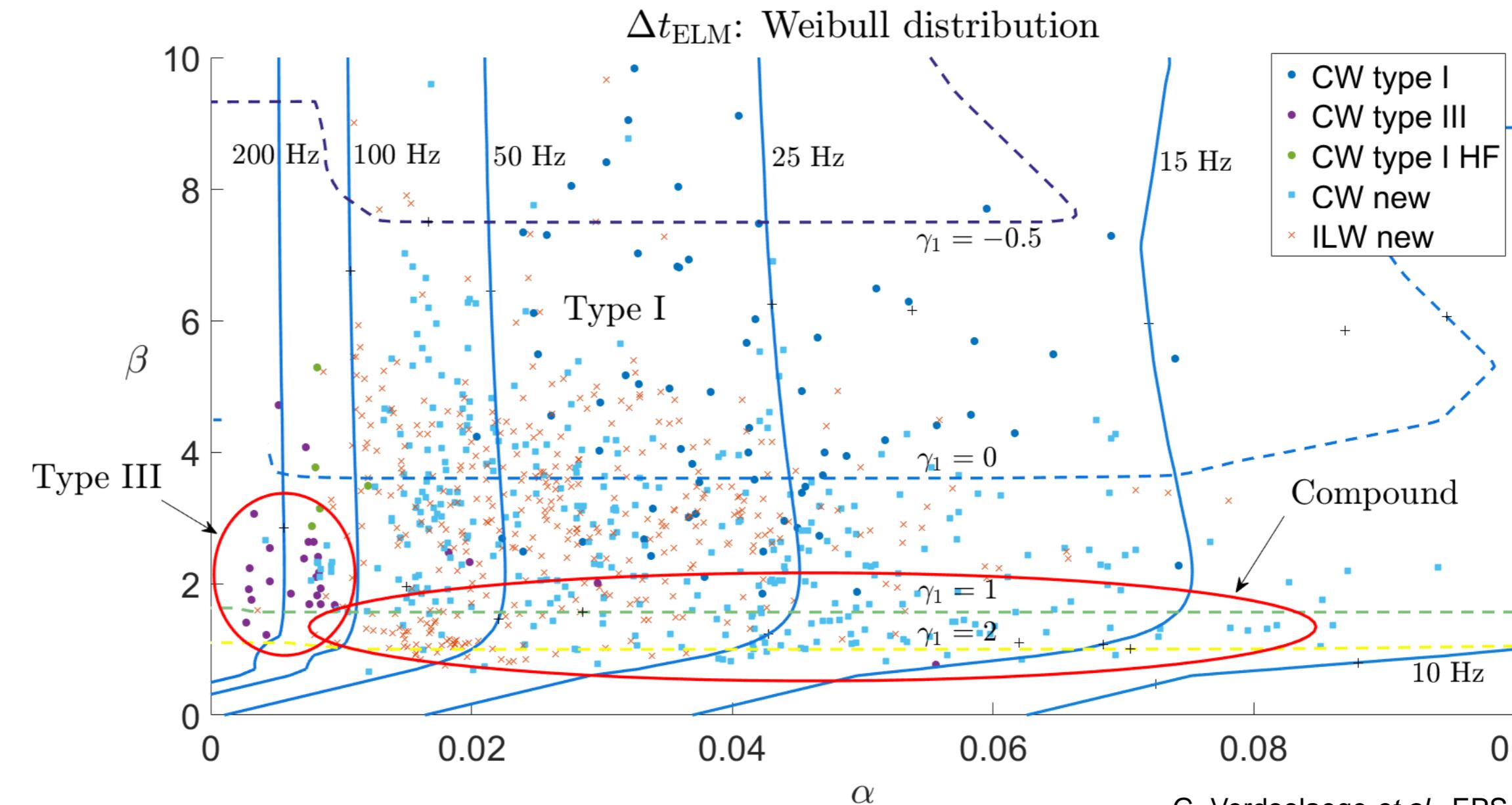
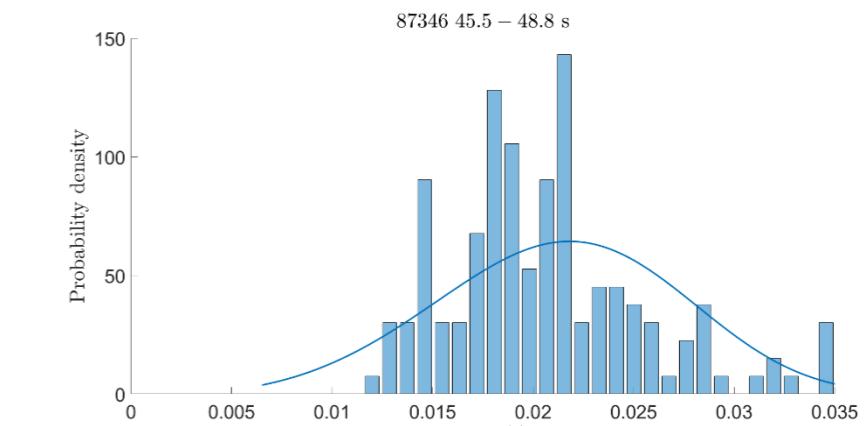
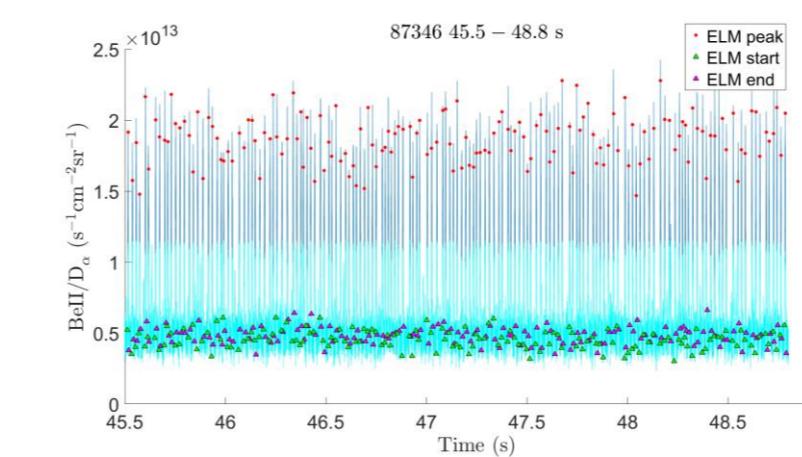
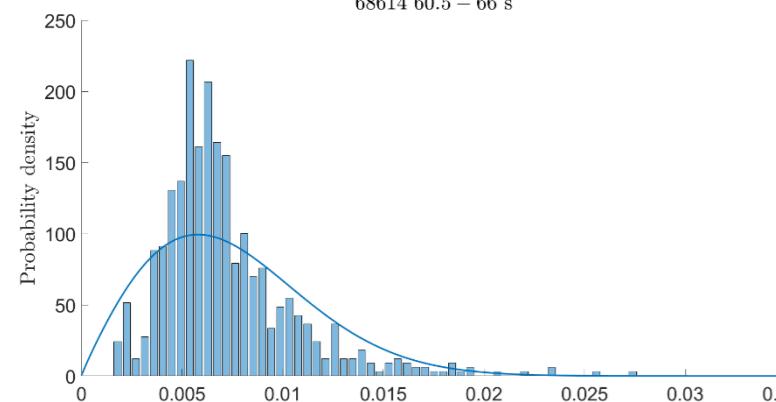
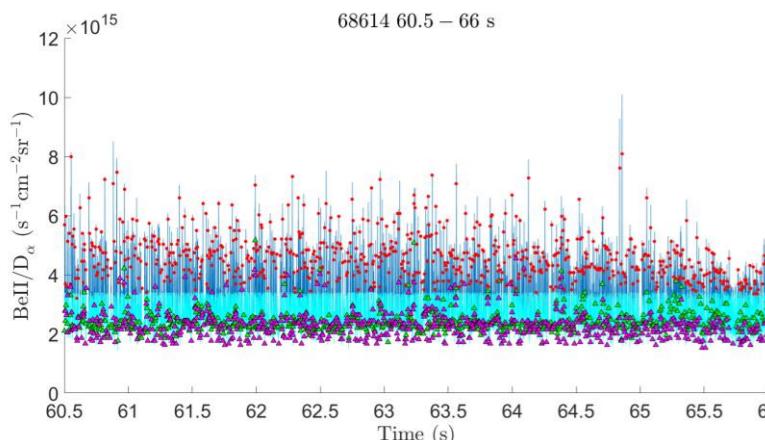
- P_{LH} , pedestal characteristics, SOL width...

MODELING OF STOCHASTIC EVENTS

Type I ELMs

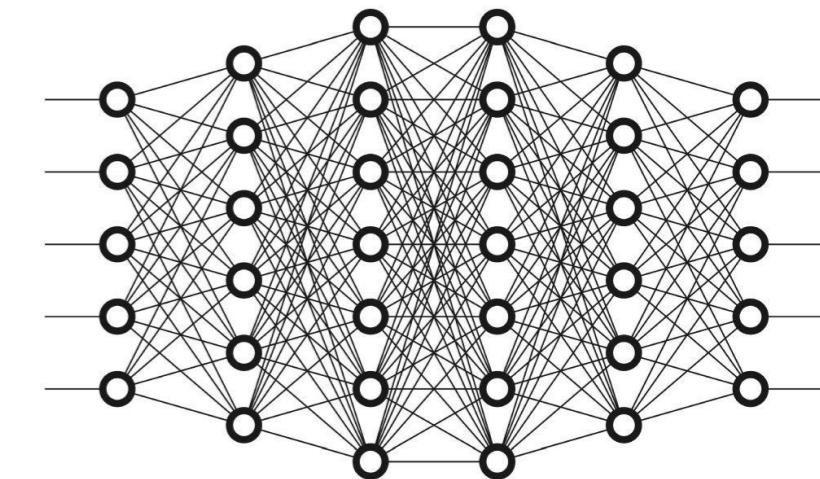
ELMs, turbulent fluctuations, ...

Type III ELMs

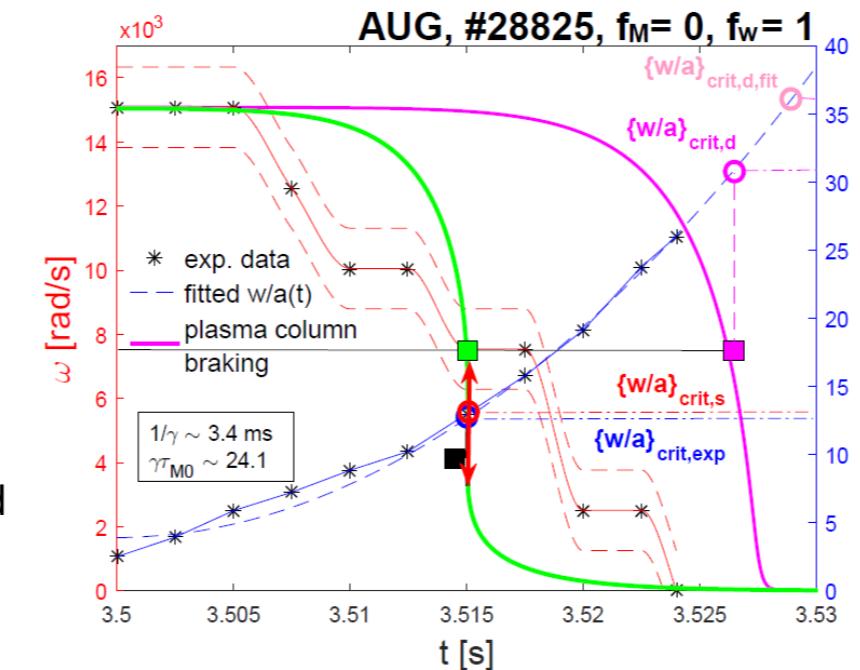


MACHINE LEARNING APPLICATIONS

- Neural network modeling of transport simulations

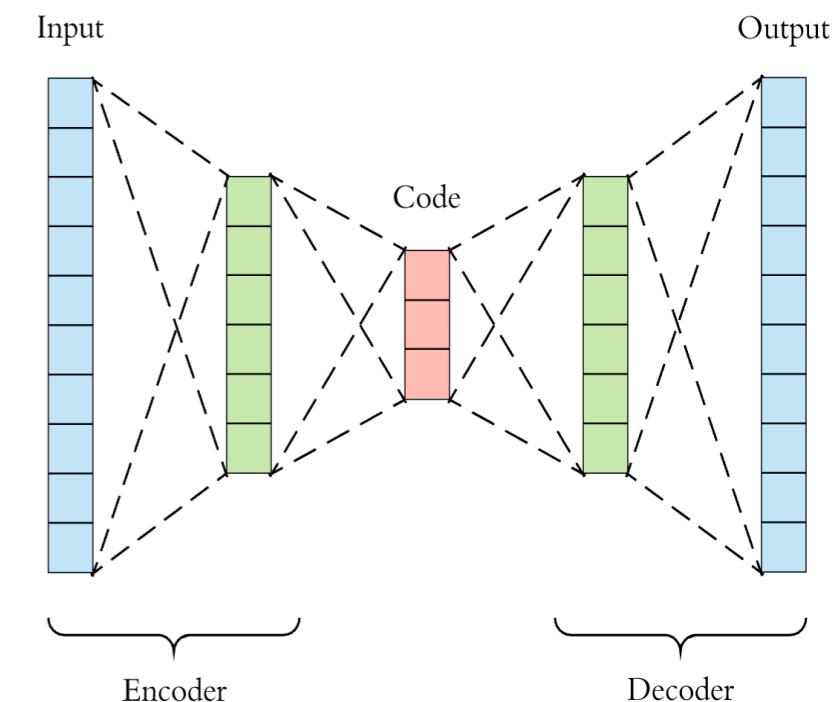


- Uncertainty quantification

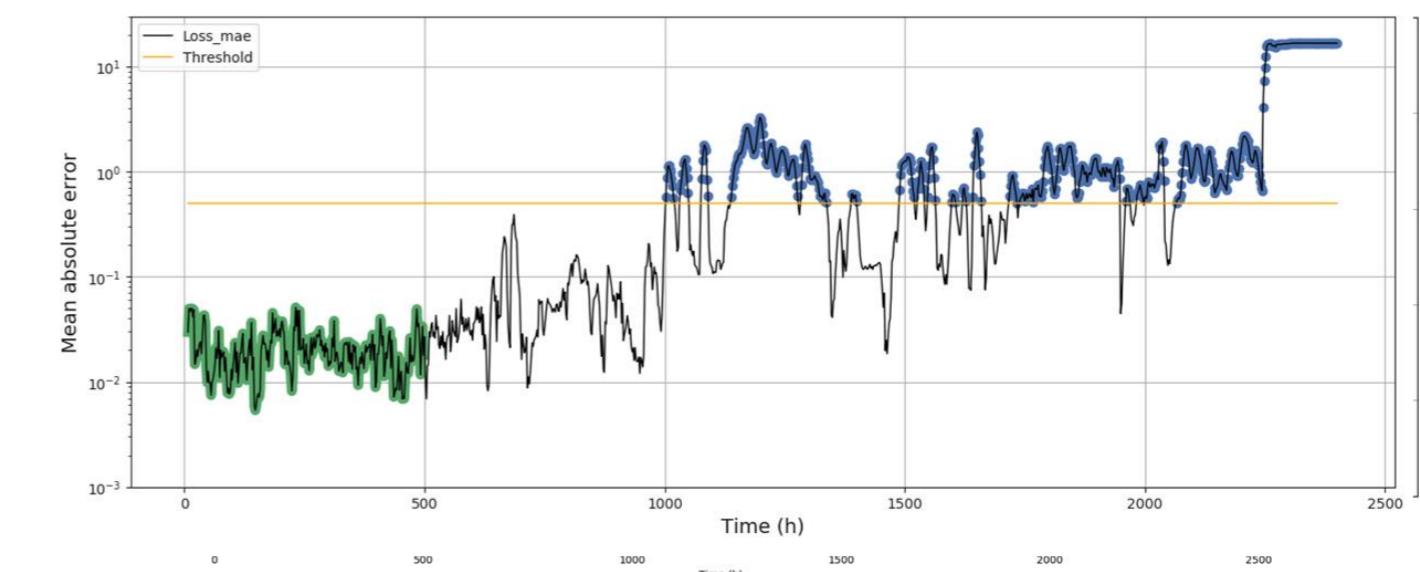


V. Klevarova *et al.*, Nucl. Fusion, submitted

- Predictive maintenance:
JET turbopumps and poloidal field switches



A. Rousseau *et al.*, IAEA TM FDPVA,
2019



EDUCATION

FUSION EDUCATION

- **FUSION-EP:**
 - European Master of Science in Nuclear Fusion and Engineering Physics
 - 8 EU full partners, 18 associate worldwide (incl. ITER IO)
 - Coordinated at Aix-Marseille Université
- **FUSION-DC:**
 - International Doctoral College in Fusion Science and Engineering
 - 9 EU full partners, 34 associate partners worldwide
- **PhDs:** ion-cyclotron heating, plasma-wall interaction, wall materials, ...
- **UGent:** Plasma Physics, Plasma and Fusion Technology, Plasma Diagnostics, Continuum Mechanics



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