

VKS experiment :

dynamo regimes with global rotation

VKS collaboration: CEA – CNRS - ENS Paris - ENS Lyon



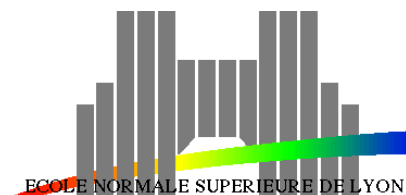
F. Daviaud, A. Chiffaudel, B. Dubrulle, S. Aumaitre,
C. Gasquet, V. Padilla, L. Marié, F. Ravelet, R. Monchaux

CEA, DSM/DRECAM/SPEC

in collaboration with DEN/DTN/STPA, CEA Cadarache



S. Fauve, F. Pétrélis, N. Mordant, M. Berhanu
ENS-Paris, Laboratoire de Physique Statistique

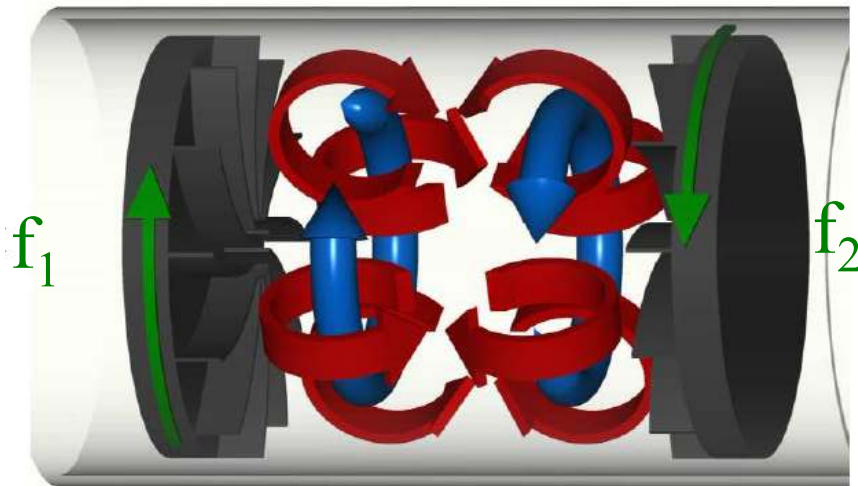


J.-F. Pinton, P. Odier, M. Bourgoïn, R. Volk, M. Moulin,
N. Plihon

ENS-Lyon, Laboratoire de Physique

VKS2 experiment

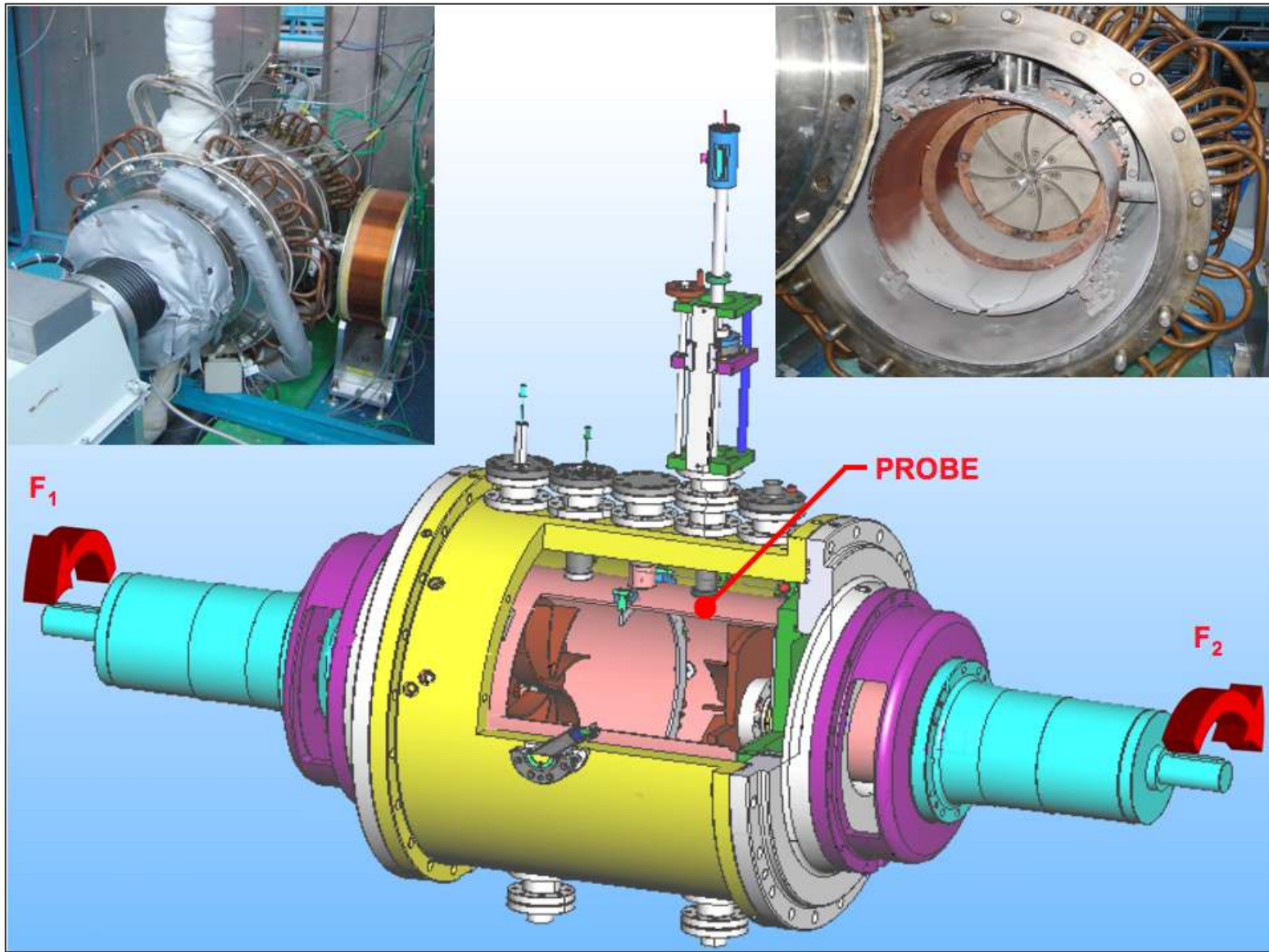
- von Karman flow in a cylinder filled with liquid sodium between 2 counter rotative propellers



- cylinder $L = \varnothing = 0,6$ m
→ 160 l sodium
- power $P = 300$ kW
- 2 propellers f : 0 à 30 Hz
- cooling system 120° - 160° C
- mechanical seals special Na

$$R_m = 2 \pi K \mu_0 \sigma R^2 f$$

VKS2 experiment

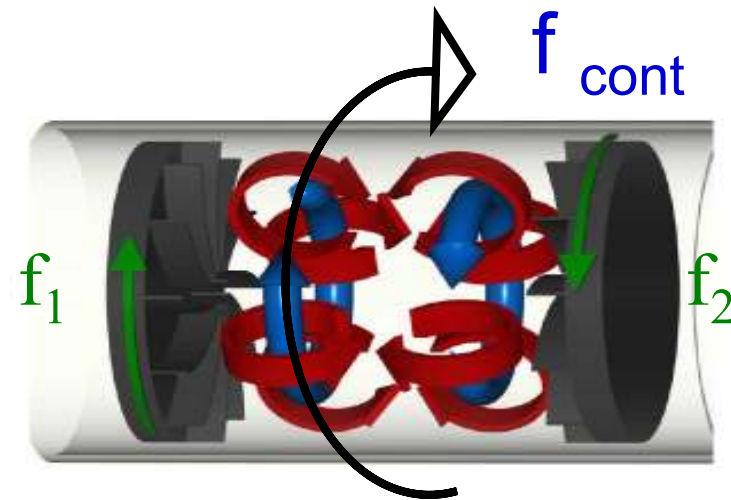


Global rotation : propellers with $f_1 \neq f_2$

$$f_1 \neq f_2 \text{ and } f_{\text{cont}} = 0$$

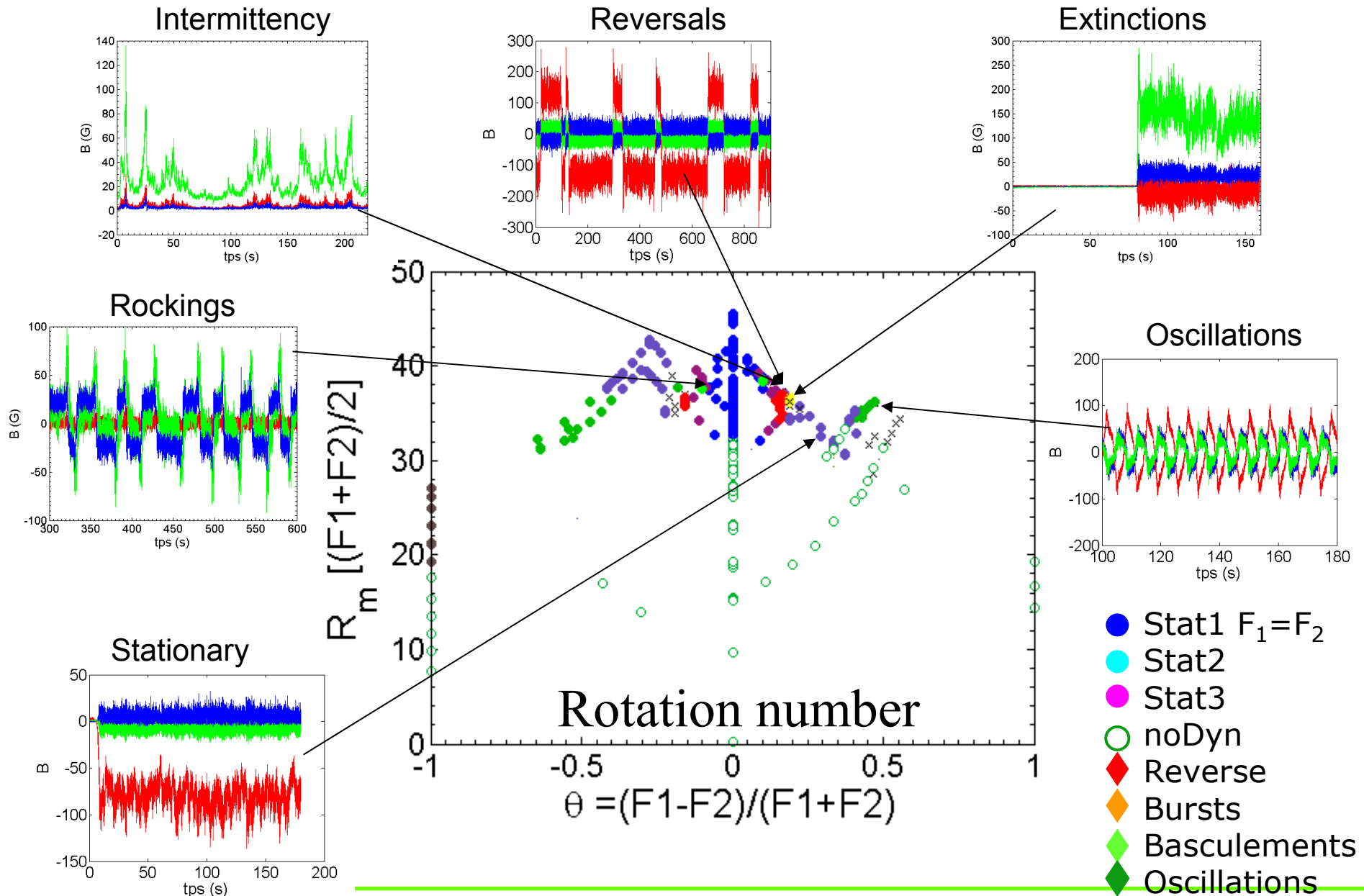


$$f_1 = f_2 \text{ and } f_{\text{cont}} = \frac{1}{2} (f_1 - f_2)$$

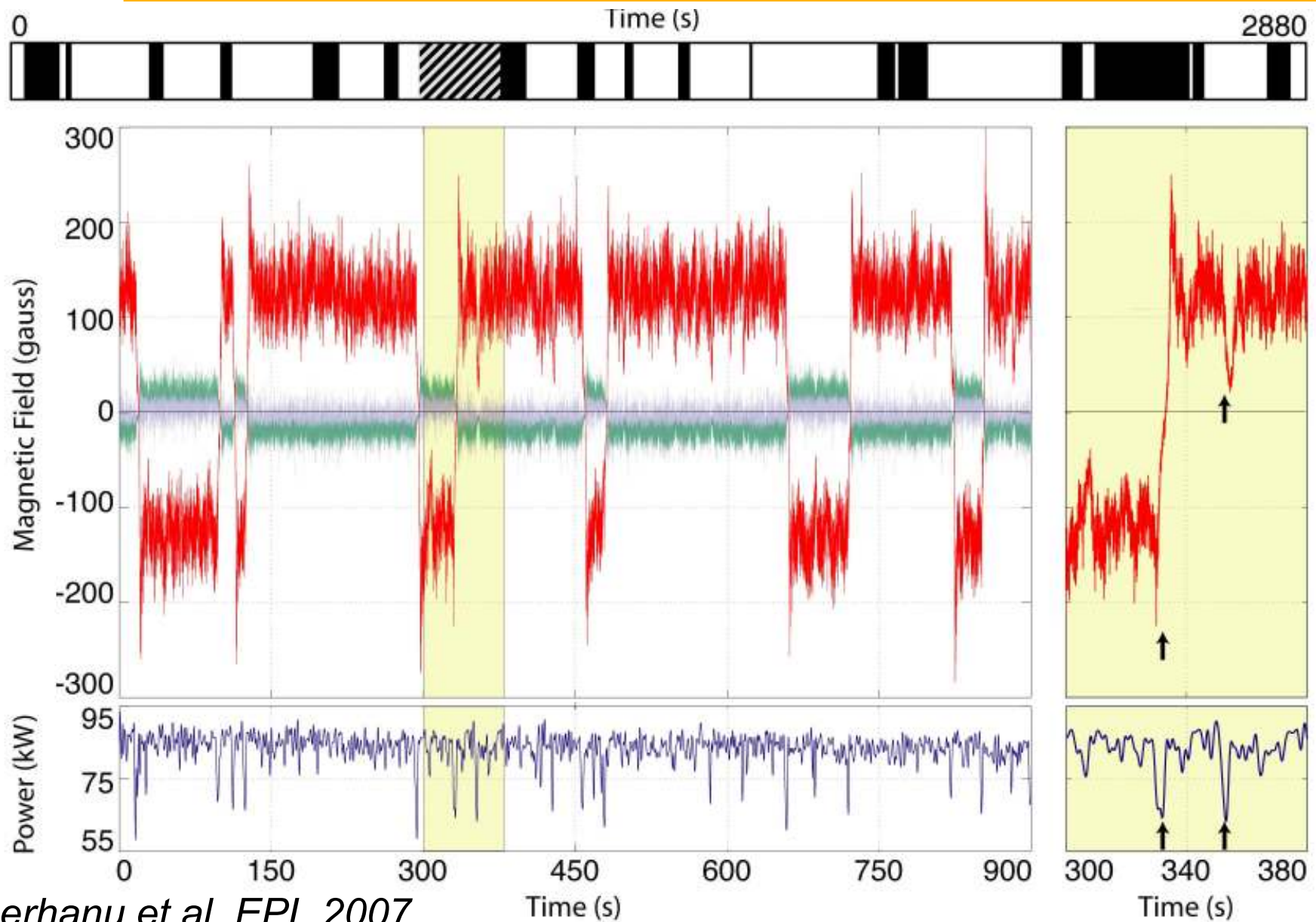


L.Marié PhD

Global rotation: observed dynamics

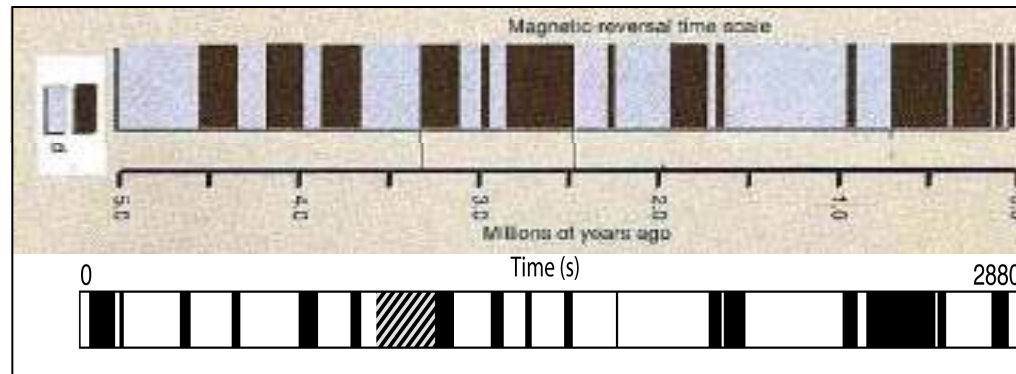


Erratic inversions of B

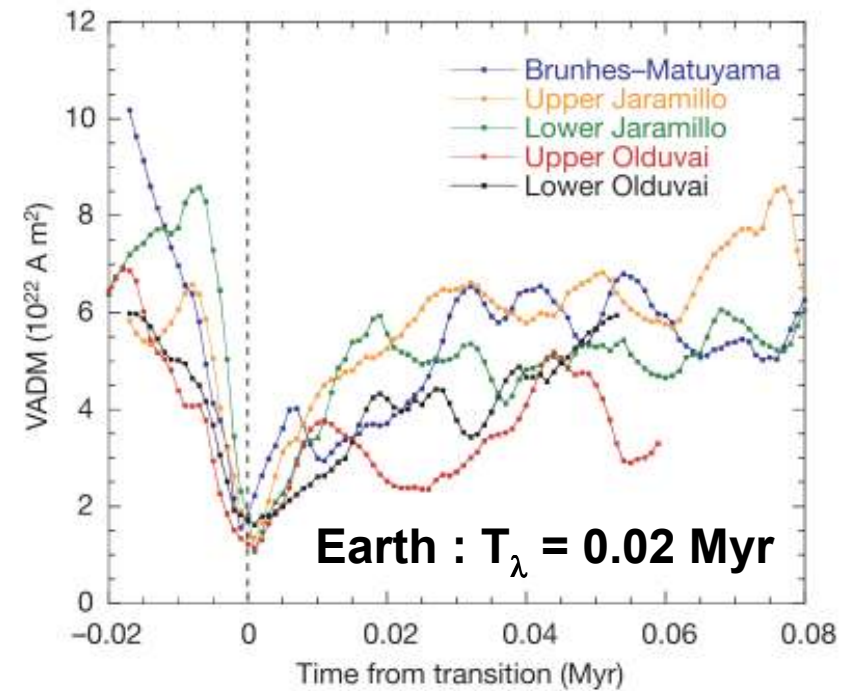
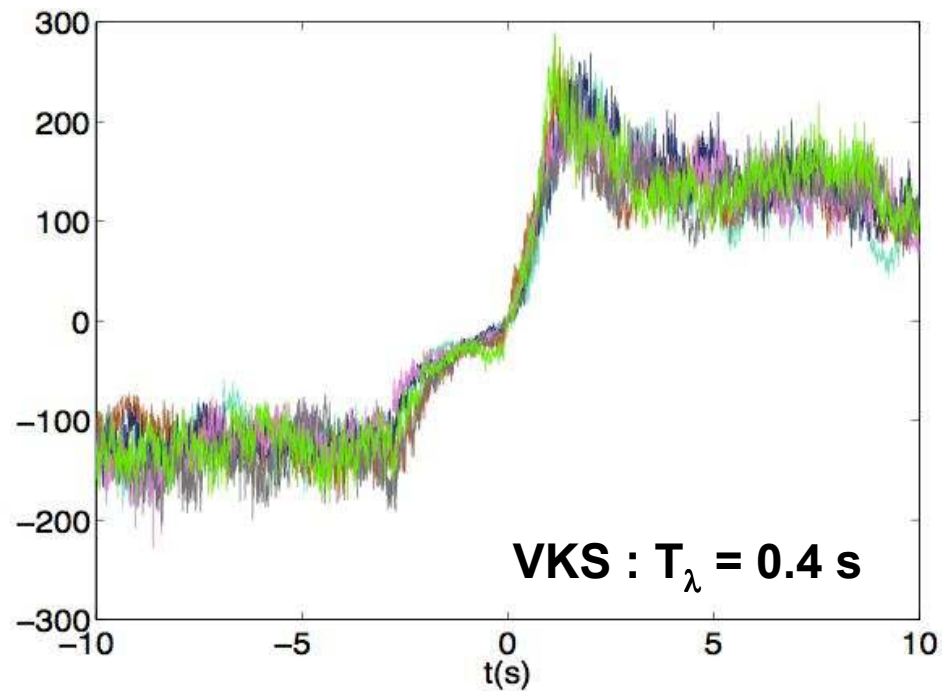


Berhanu et al. EPL 2007

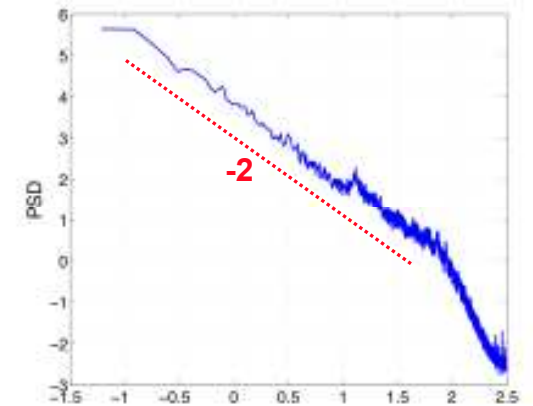
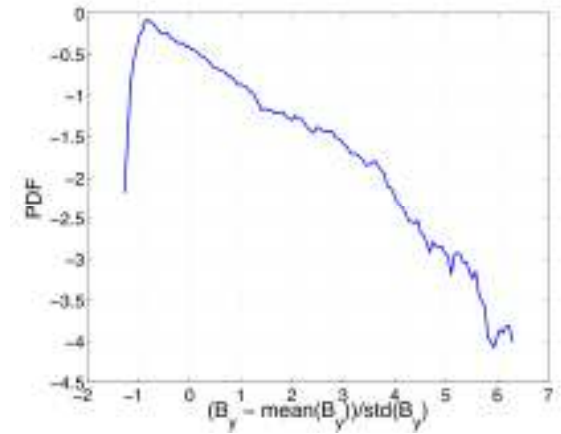
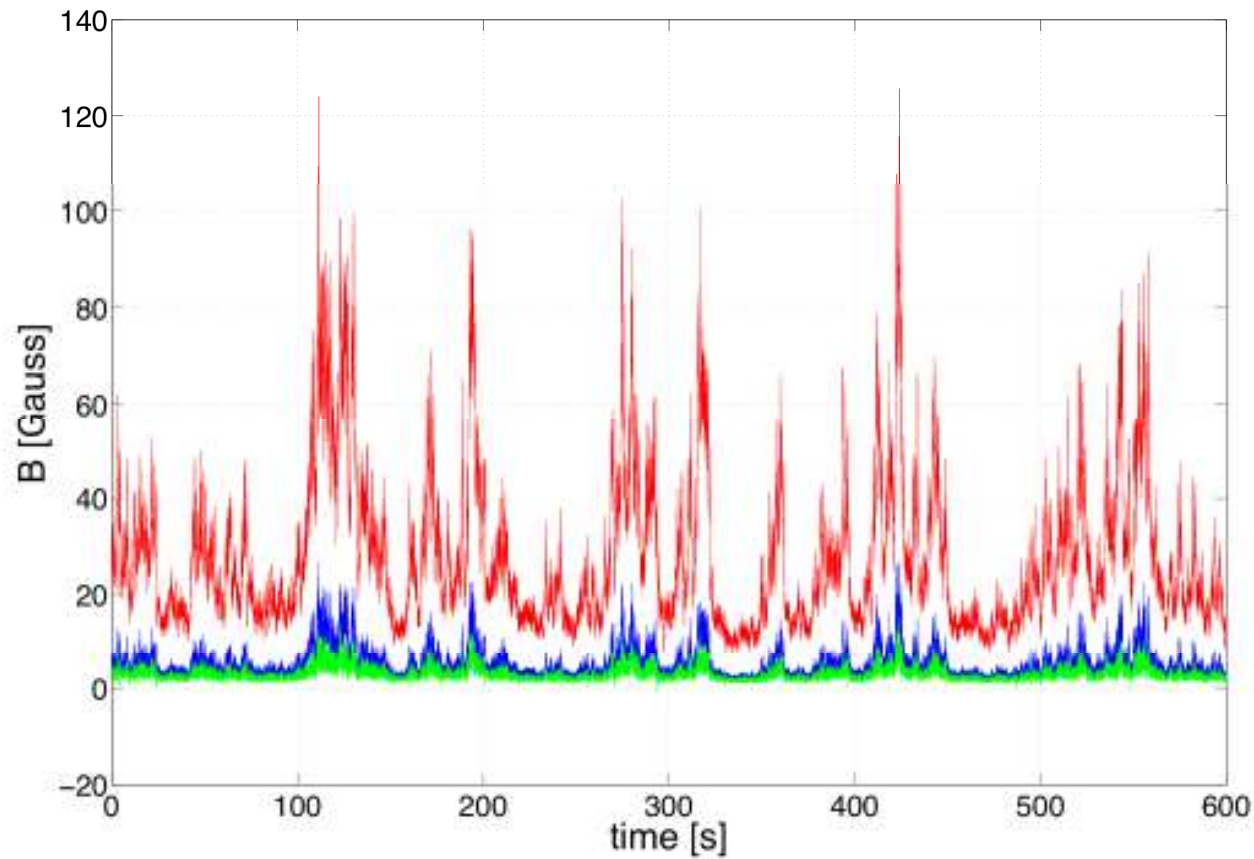
Erratic inversions of B: VKS / Earth



Valet et al. Nature 2005

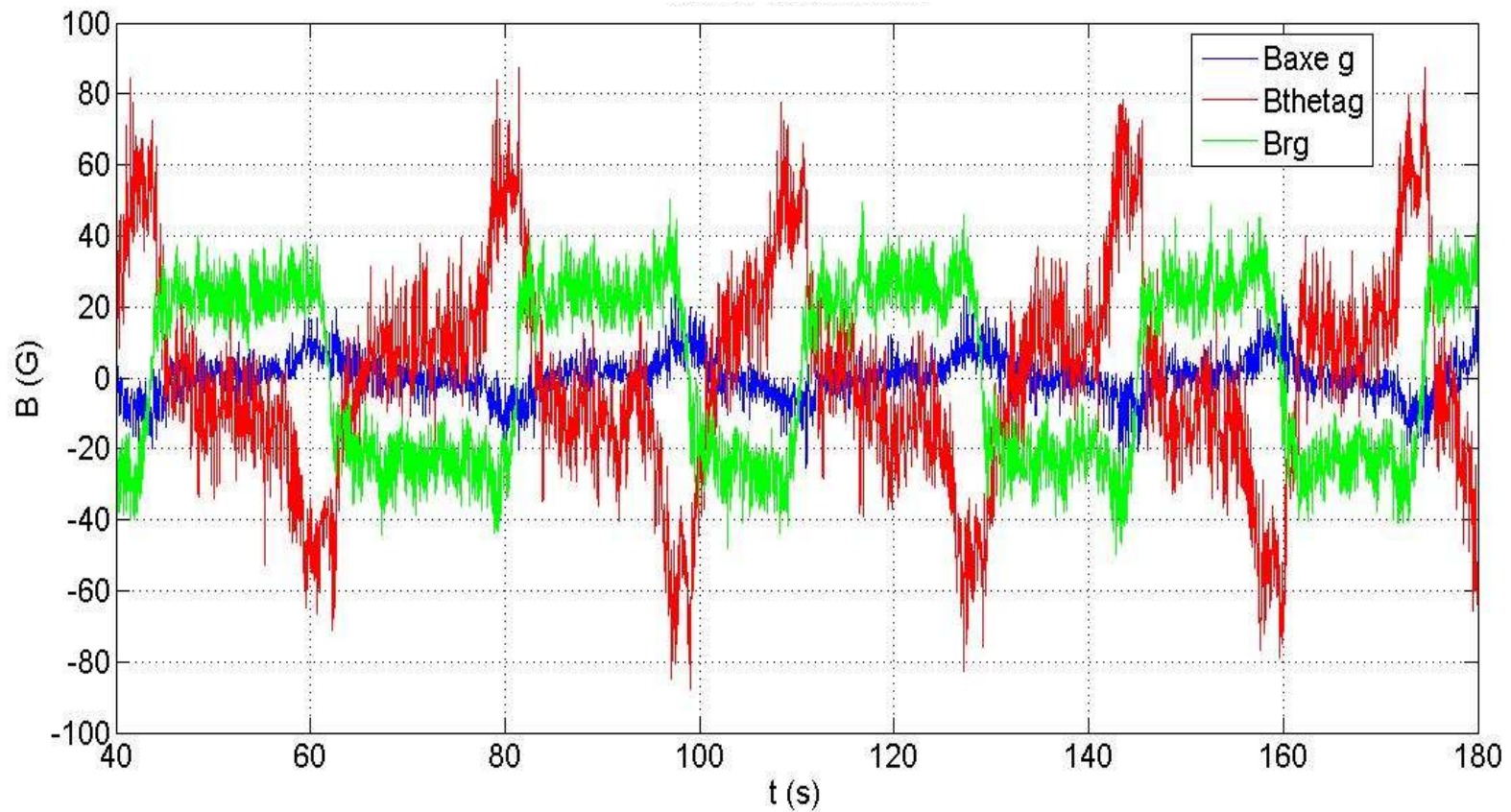


Dynamos bursts

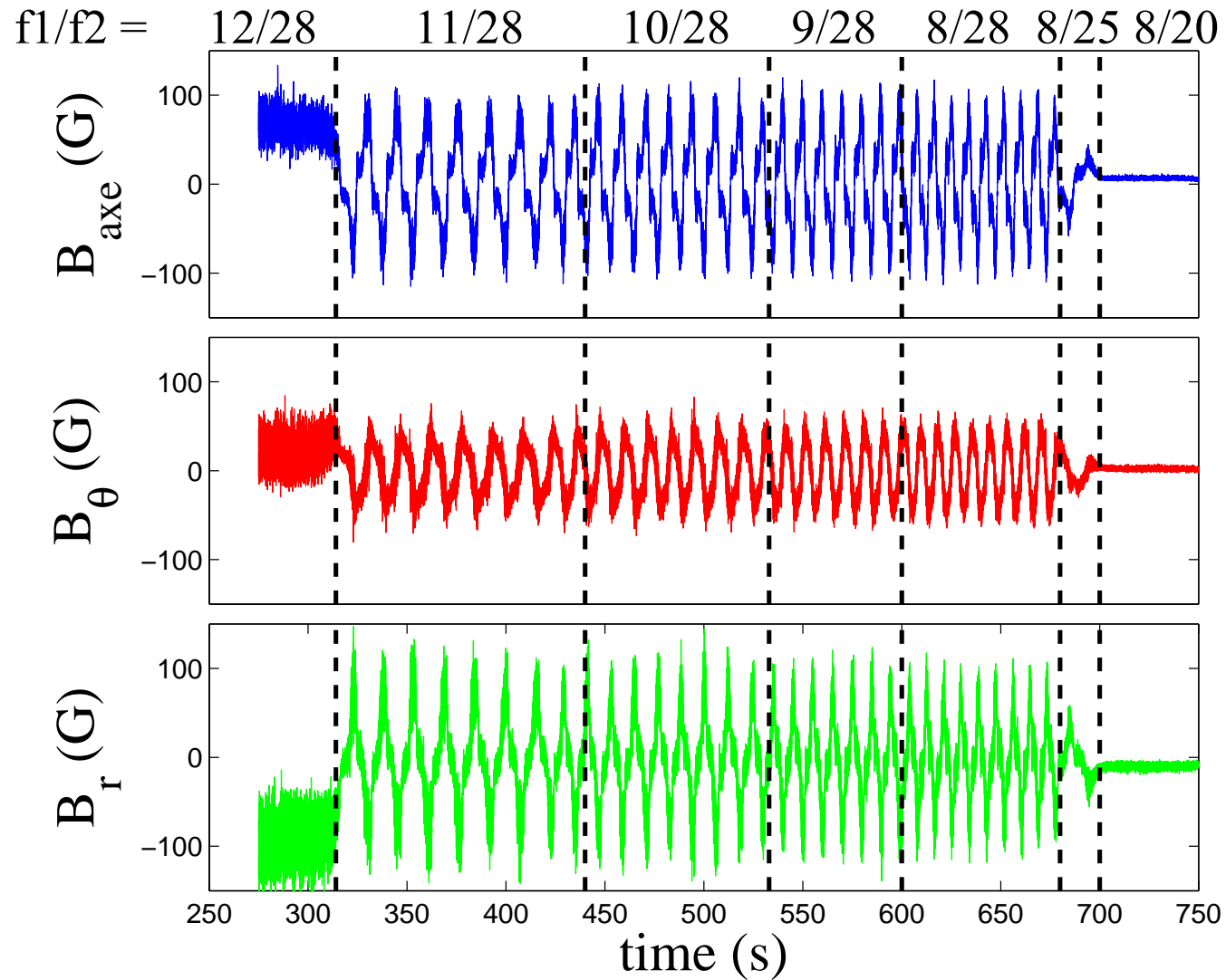


15/22, $\theta = 0.19$

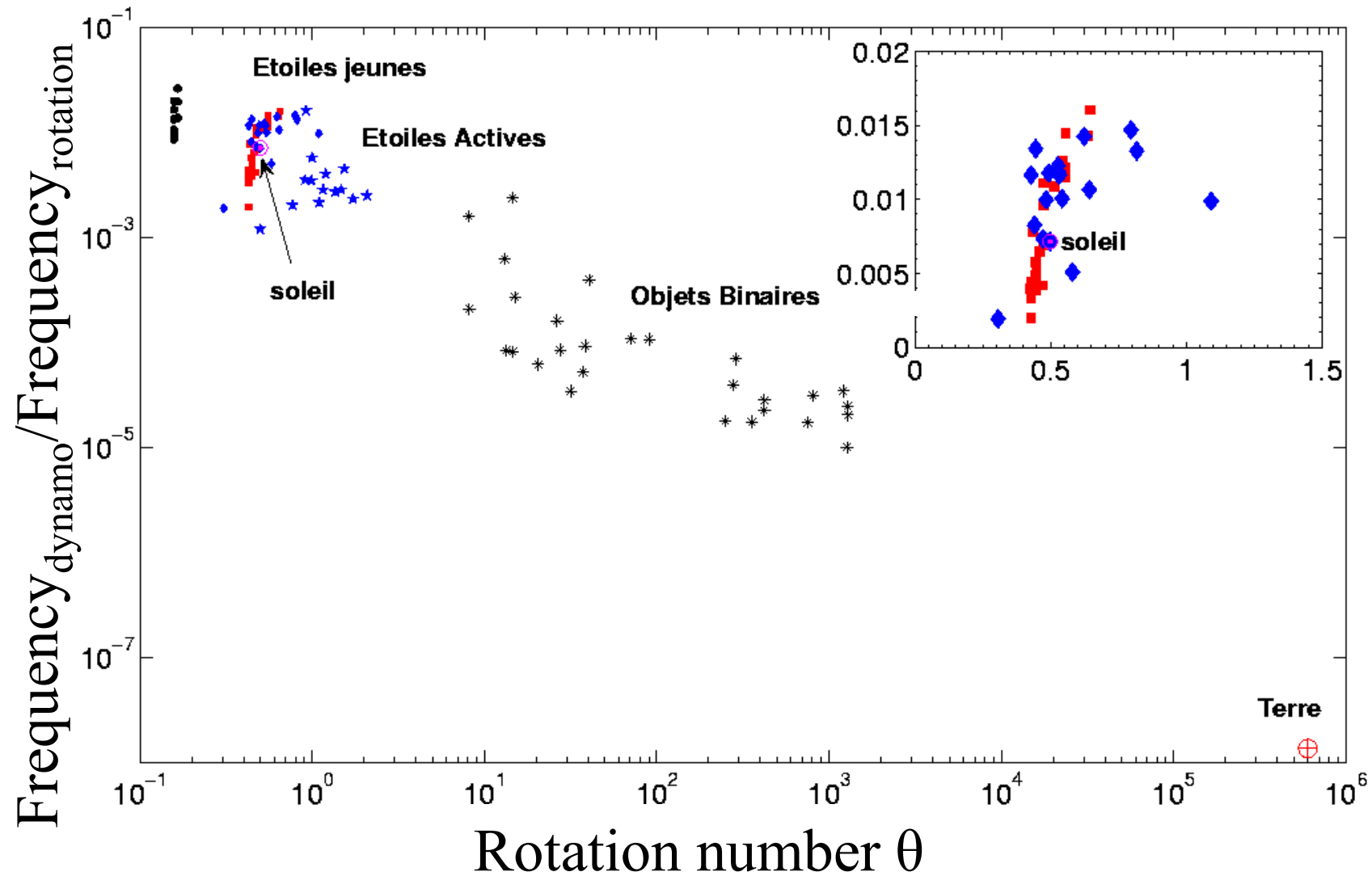
Oscillating dynamos



Oscillating dynamos



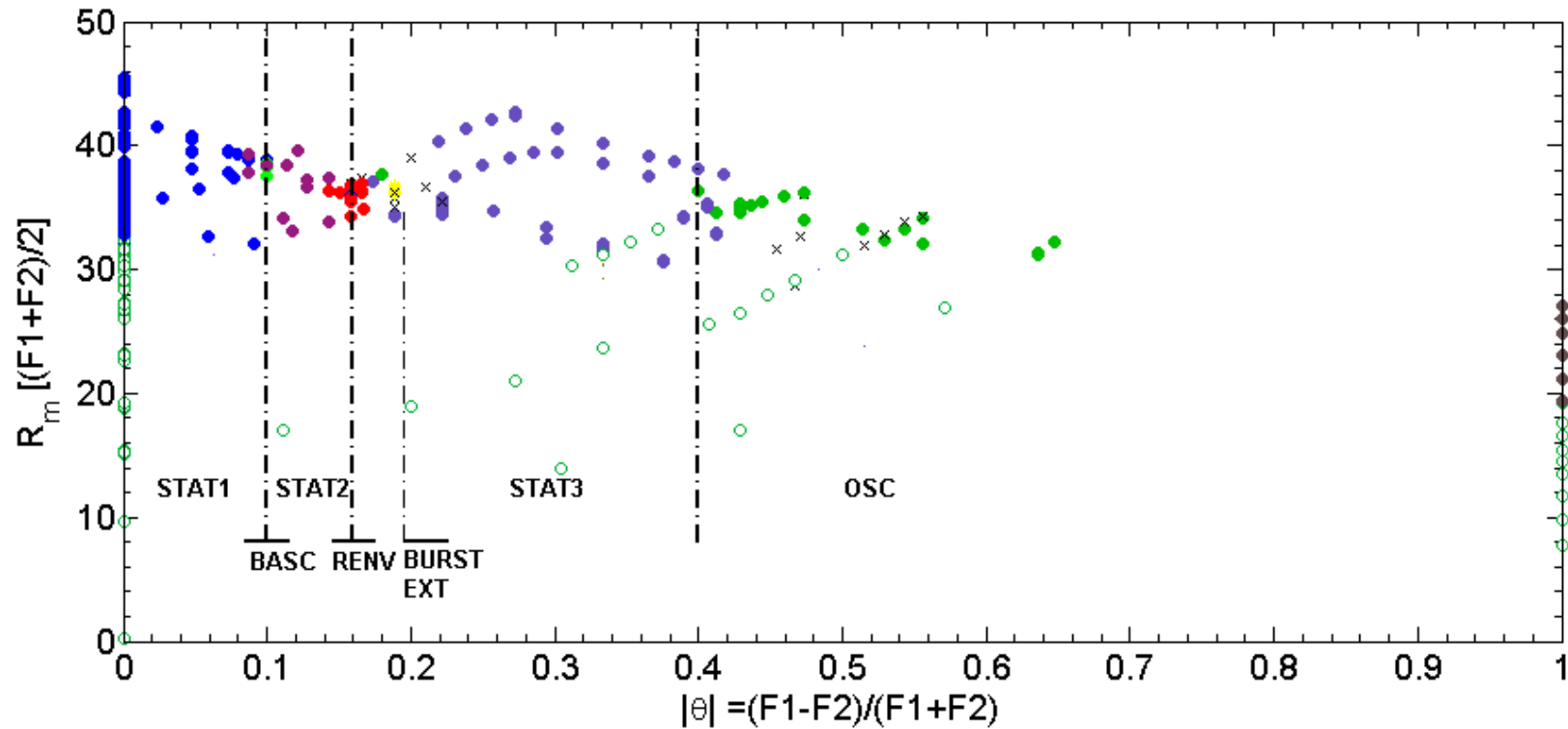
Oscillating dynamos : VKS / stars



Global rotation: states diagram

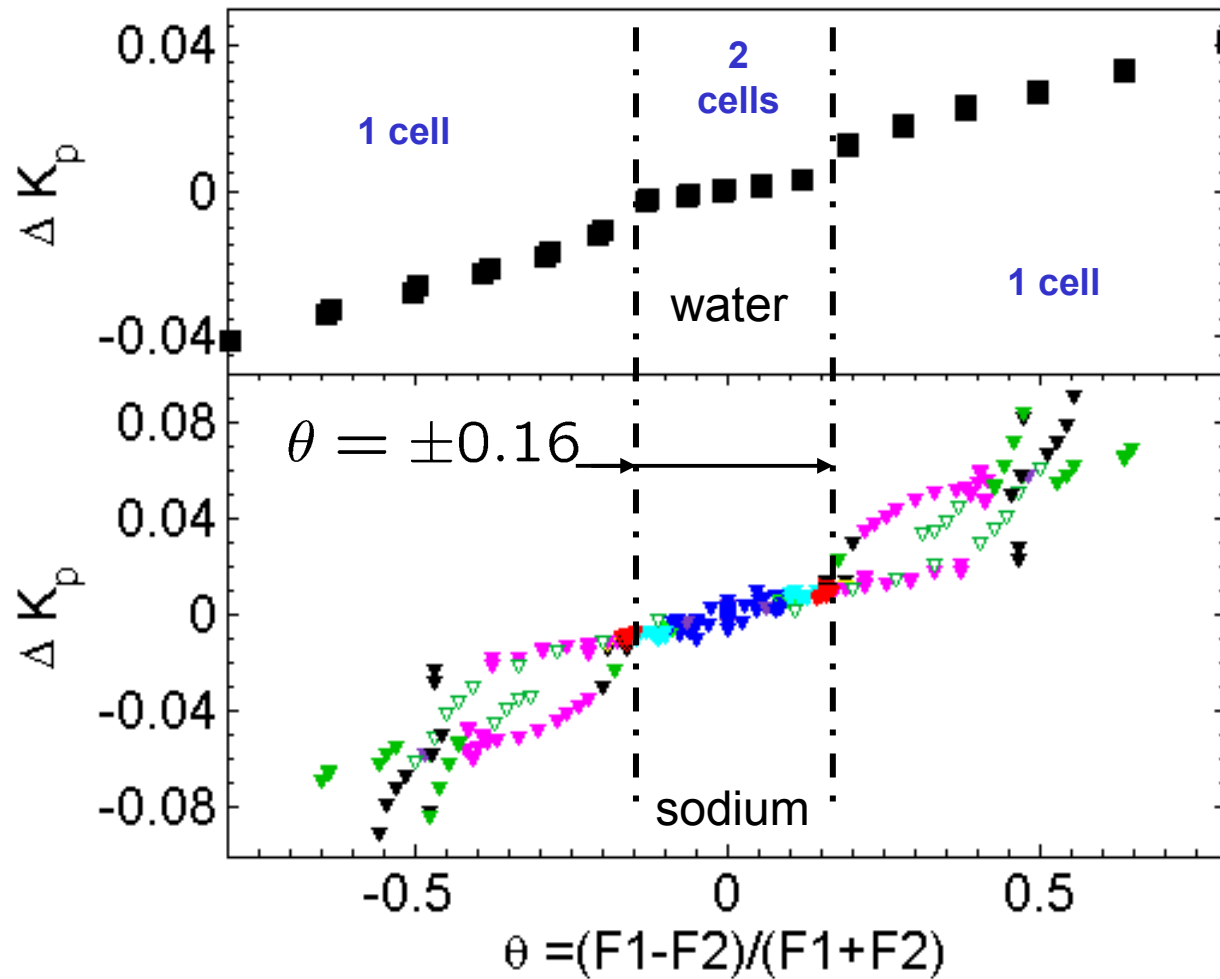
- $\theta = (f_1 - f_2) / (f_2 + f_1)$
- $R_m = 2\pi K\mu_0\sigma R^2 (f_1 + f_2)/2$

- Stat1 $F_1 = F_2$
- Stat2
- Stat3
- noDyn
- ◆ Reverse
- ◆ Bursts
- ◆ Basculements
- ◆ Oscillations

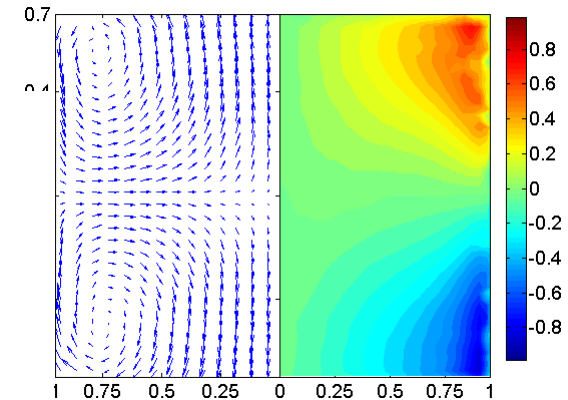


Couplings MHD - hydrodynamics

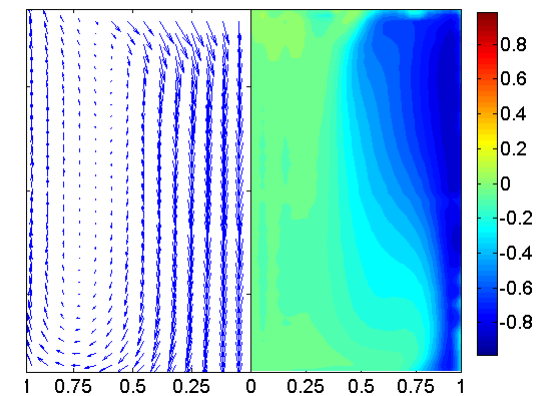
$$K_p = \text{Torque} / \rho R_c^5 (2\pi f)^2$$



$|\theta| < 0.16 \Rightarrow$ deux cellules

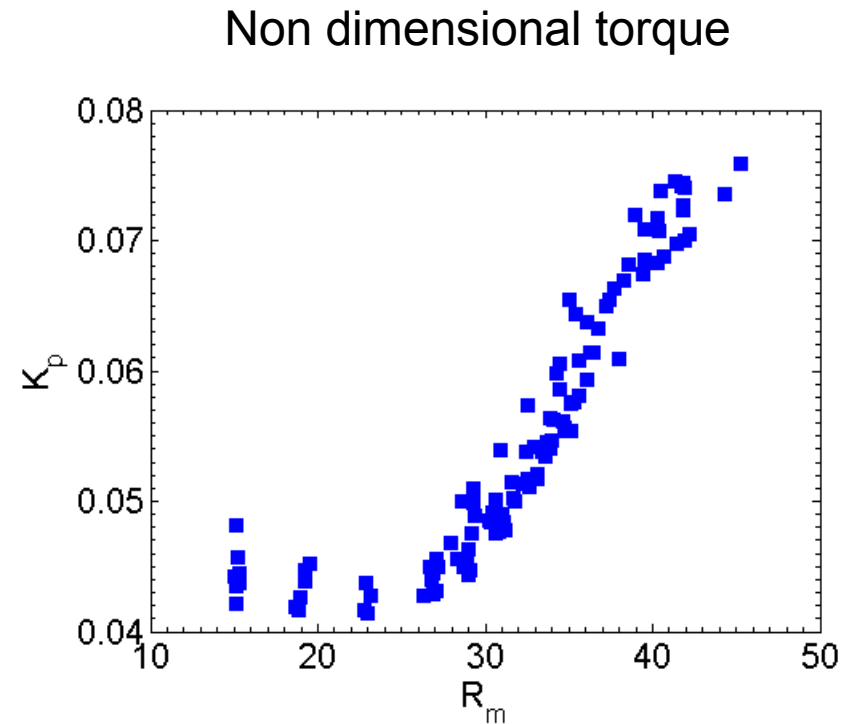
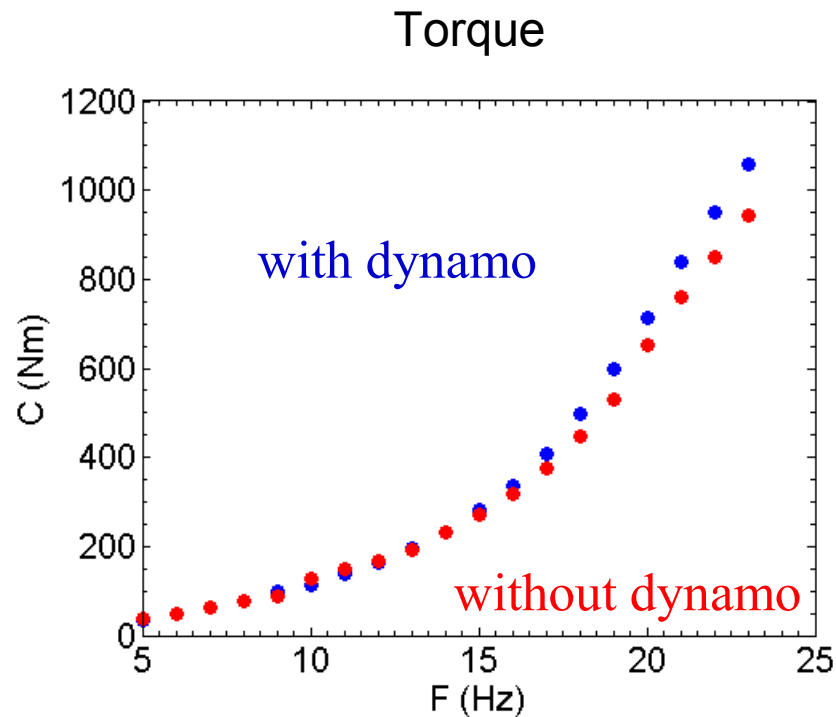


$|\theta| > 0.16 \Rightarrow$ une cellule



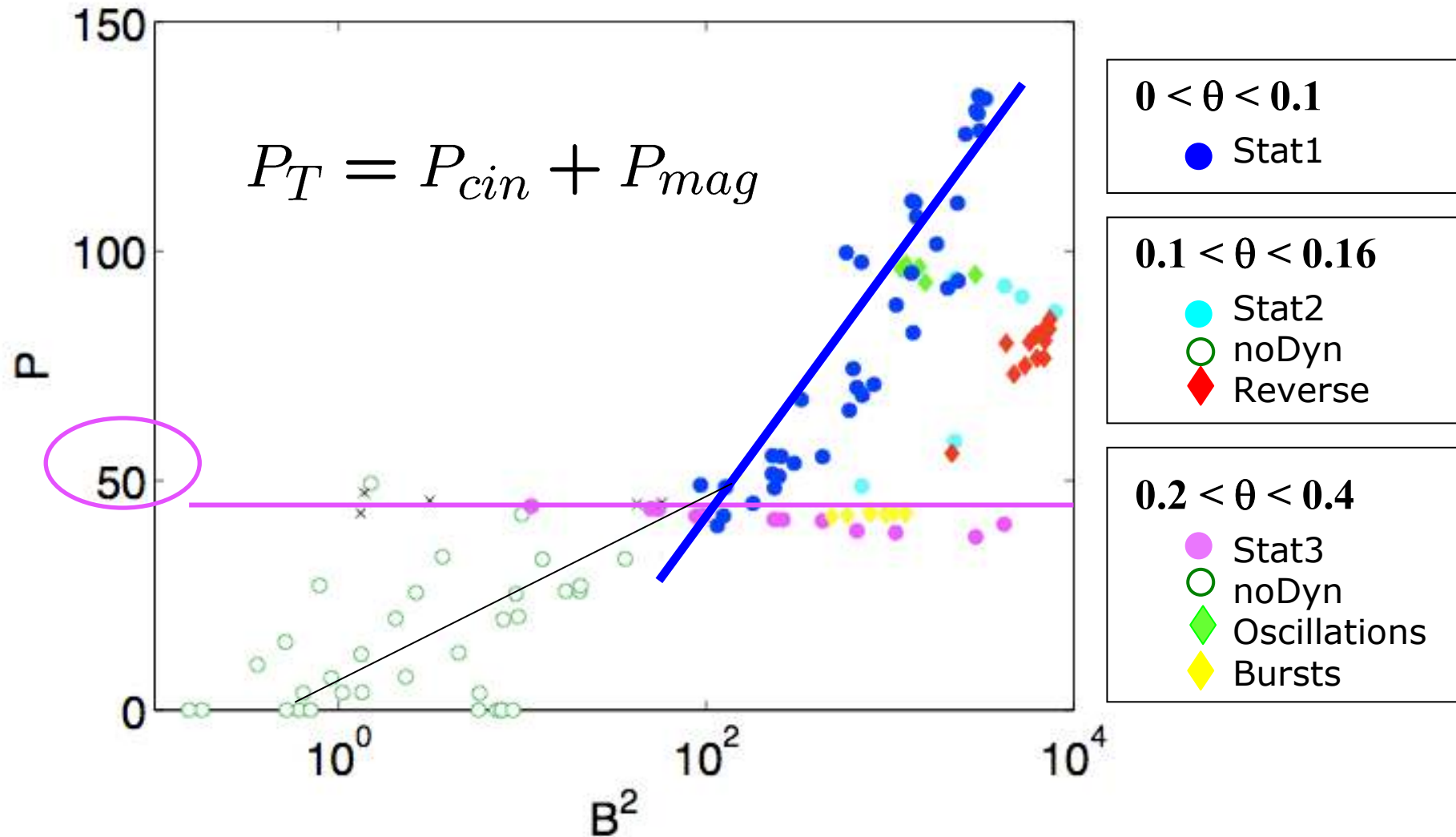
Power budget in VKS

Dynamo power: $P_T = P_{cin} + P_{mag}$



dynamo = increase of power 15%

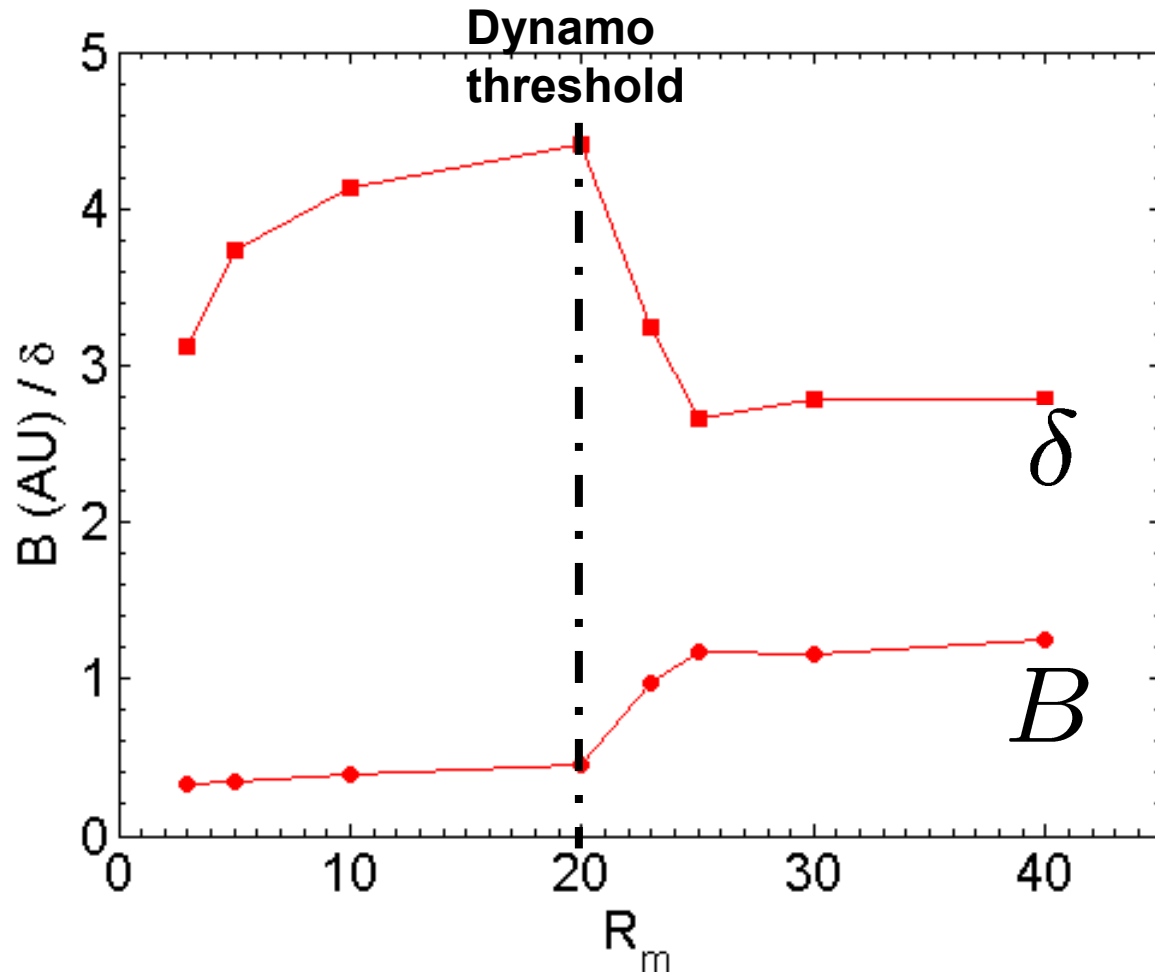
Power budget in VKS



⇒ Does B kill turbulent fluctuations?

B feedback on the flow

- numerical simulations of Taylor-Green flow



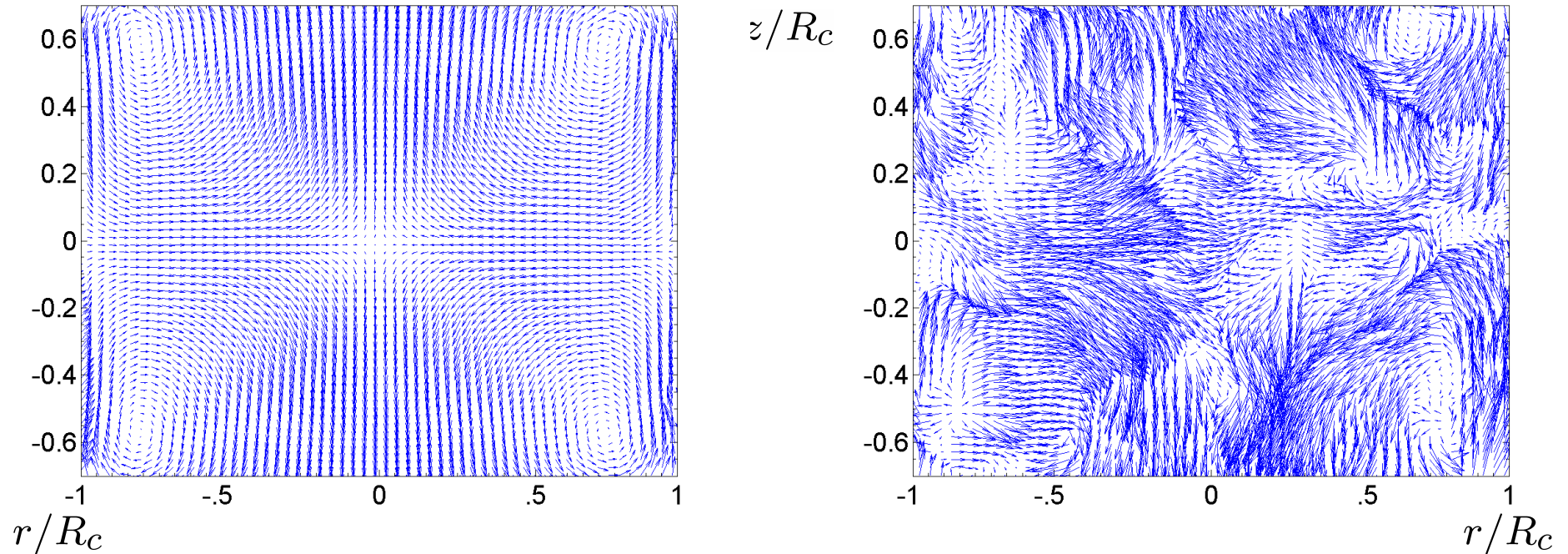
δ : fluctuations
measurements

Laval et al.
PRL 2007
NJP 2007

→ decrease of fluctuations at dynamo threshold

Turbulent fluctuations in water

von Karman water experiment (SPIV)

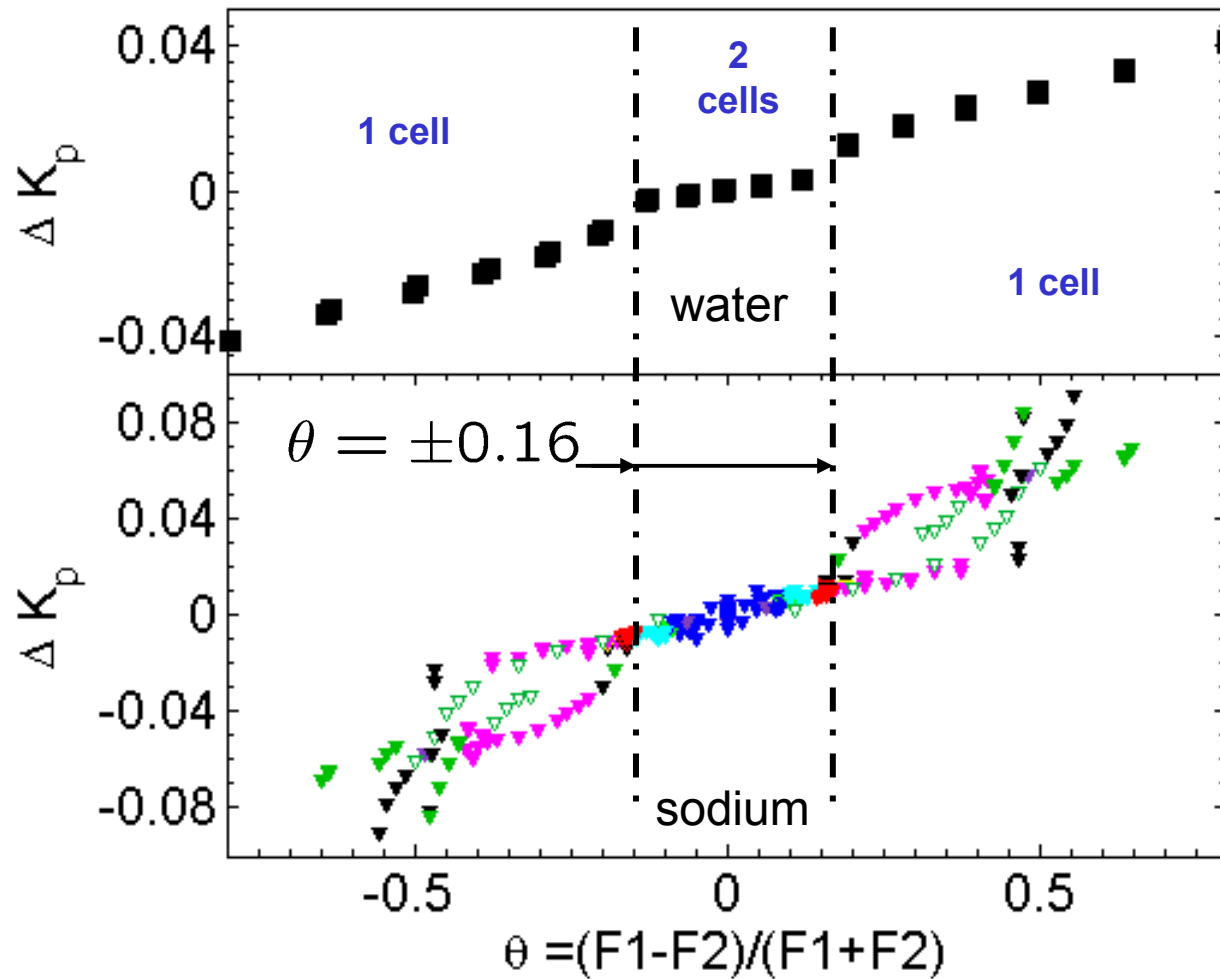


Quantifying difference between mean and instantaneous field:

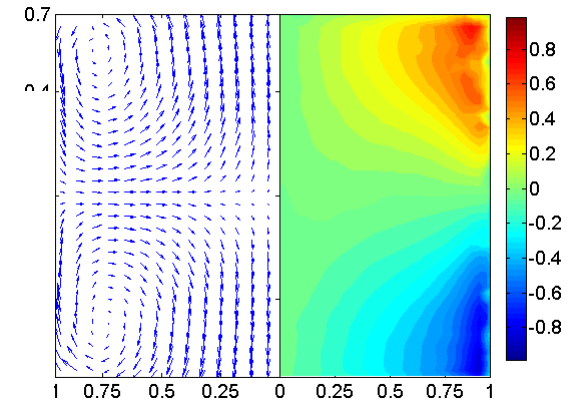
$$\delta = \frac{\overline{E_c(u(t))^t}}{E_c(\overline{u(t)})}$$

Couplings MHD - hydrodynamics

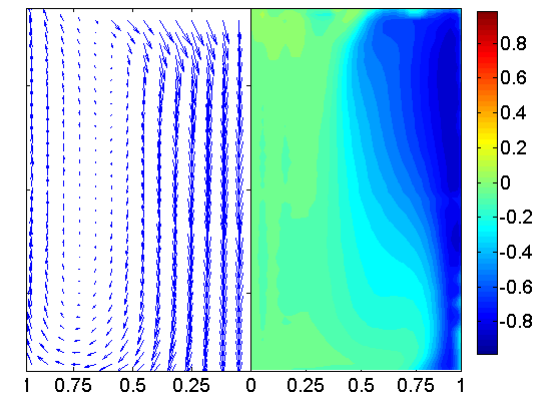
$$K_p = \text{Torque} / \rho R_c^5 (2\pi f)^2$$



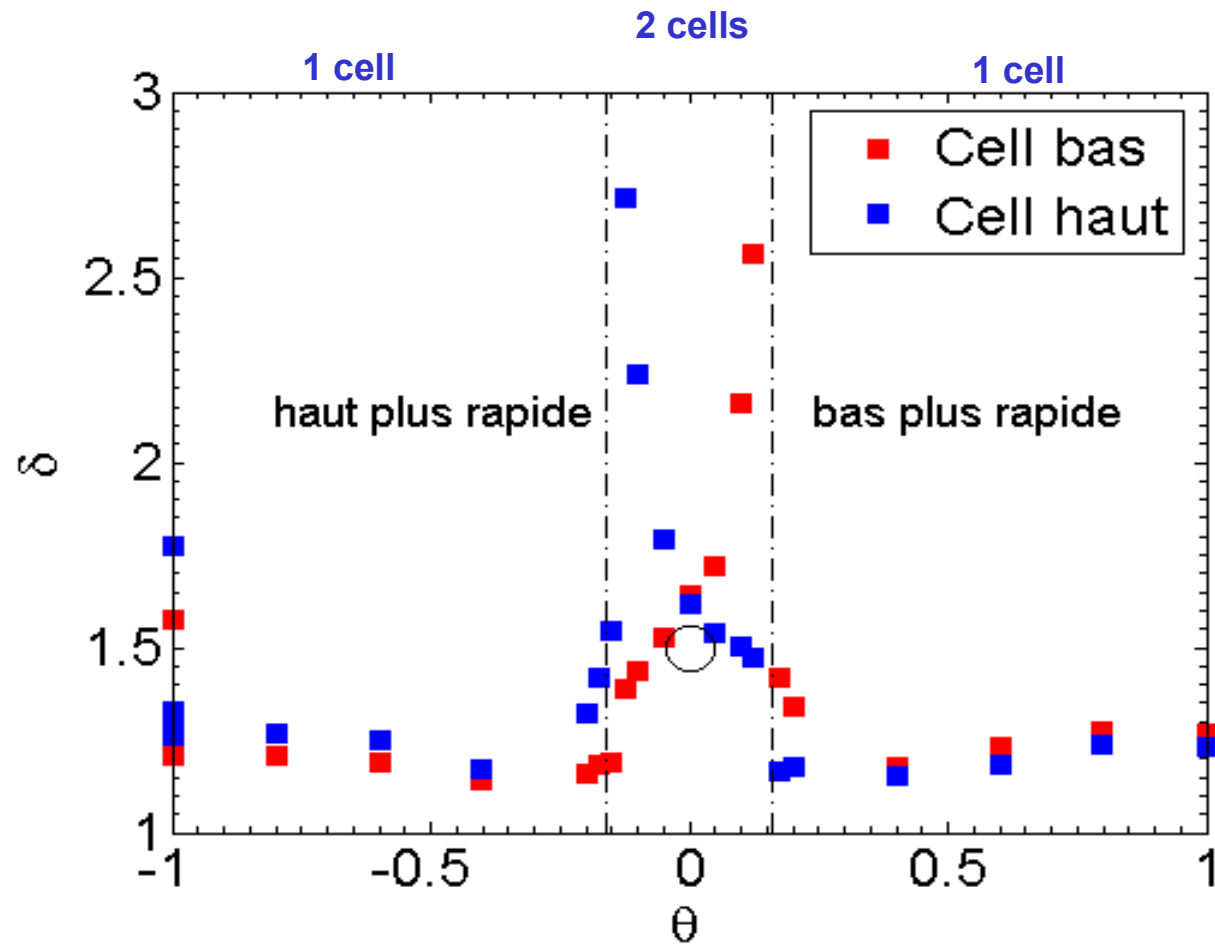
$|\theta| < 0.16 \Rightarrow$ deux cellules



$|\theta| > 0.16 \Rightarrow$ une cellule



Turbulent fluctuations in water



Influence of turbulent fluctuations on B dynamics ?

