

# Granger causality on the base of measured signals

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# What is the cause and what is the effect? How to decide about it on the base of measured signals?

1. The cause must precede the effect in time!
2. In 1956 Norbert Wiener introduced the notion that one variable (or time series) could be called 'causal' to another if the ability to predict the second variable is improved by incorporating information about the first (Wiener, 1956).
3. Clive Granger in 1969 suggested to make the prediction for linear systems using AR modeling. -- > Nobel price in economy 2003

# GRANGER CAUSALITY

**Definition :** Granger causality or G-causality is a measurable concept of causality or directed influence for time series data, defined using predictability and temporal precedence. A variable **Y** causes another variable **X** if the prediction of **Y**'s values improves when we use past values of **Y**.

Let's define:

$$X_{t-1}^m = X_{t-1} \oplus \dots \oplus X_{t-m}$$

$$Y_{t-1}^m = Y_{t-1} \oplus \dots \oplus Y_{t-m}$$

$\oplus$  denotes concatenation

$m$  : order

Let's consider the pair of regression models:

$$X_t = AX_{t-1}^m + \varepsilon_t$$

$$X_t = B(X_{t-1}^m \oplus Y_{t-1}^m) + \varepsilon'_t$$

**Granger  
causality can  
be defined as :**



$$F_{Y \rightarrow X} = \ln \frac{\text{var}(\varepsilon_t)}{\text{var}(\varepsilon'_t)}$$

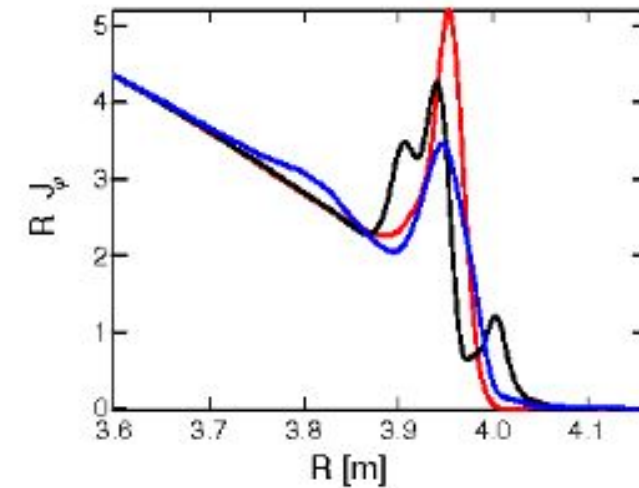
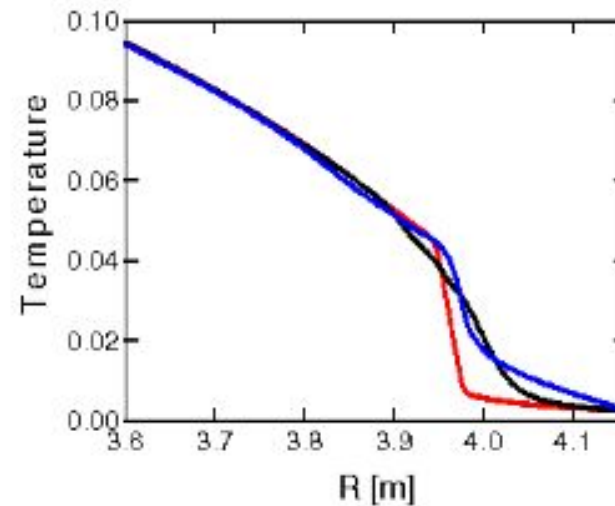
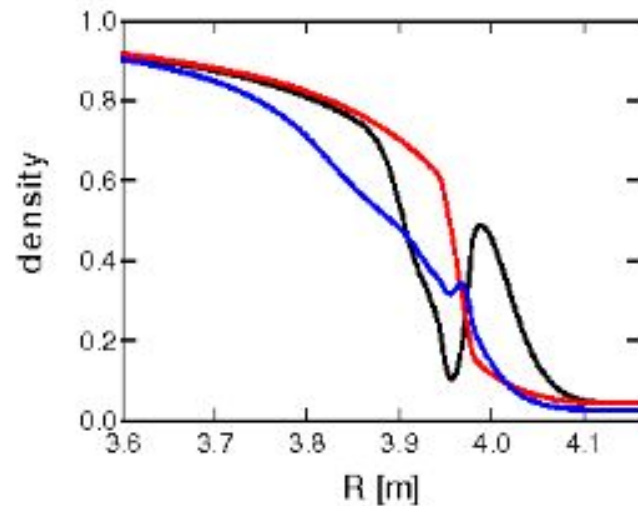
**But, how to calculate the order  $m$ ?**

- Order calculation on the base of auto – correlation (tau\_corr)
- Order calculation on the base of Akeike information criterion (AIC)

# ELM physics

## Peeling – ballooning model

1. Increase of edge current -- > increase of Temperature -- > increase of pedestal Pressure --- peeling
2. Destabilisation of the pedestal --- ballooning
3. Release of particles and energy from confined plasma



Our idea:

- a) increase of current can be seen on magnetic diagnostics (Mirnov coil signals)
- b) release of particles can be seen on plasma density measured by Li – BES

Scientific question:

Is there any causality between Mirnov signals and Li – BES signals?