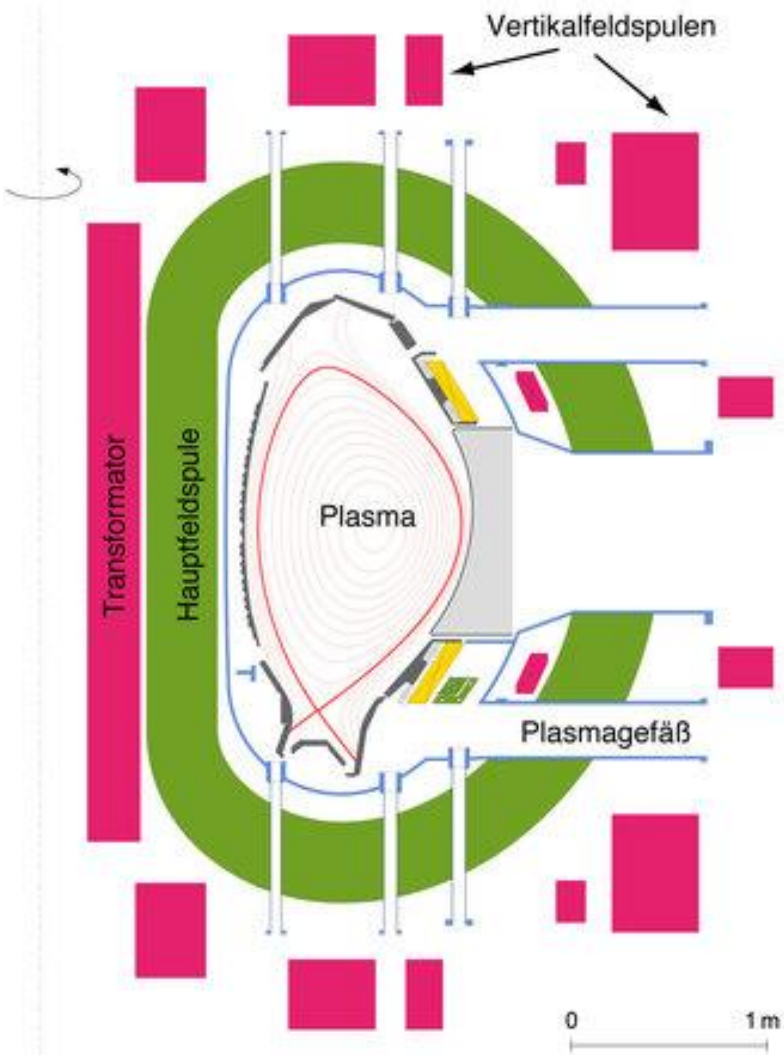
Predizione delle disruzioni a AUG e JET

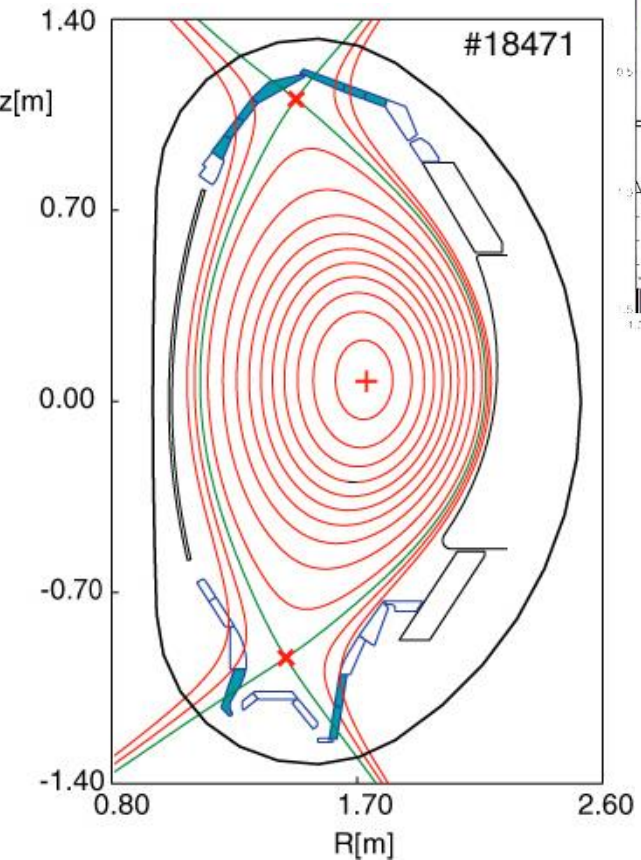
ASDEX Upgrade

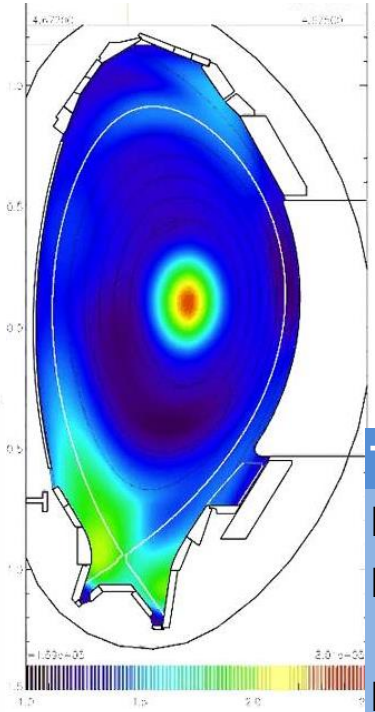


Tecnical data	
Total height of the experiment	9 m
Total radius over all	5 m
Weight of the experiment	800 t
Material of the first wall	carbon
Number of toroidal field coils	16
Number of poloidal field coils	12
Maximum magnetic field	3.1 T
Plasma current	0.4 MA - 1.6 MA
Pulse duration	< 10 s
Time between pulses	15 - 20 min
Amount of data / pulse	approx. 0.5 GByte
Plasma heating:	up to 27 MW

https://www.youtube.com/watch?v=QCK51vqWunU

ASDEX Upgrade

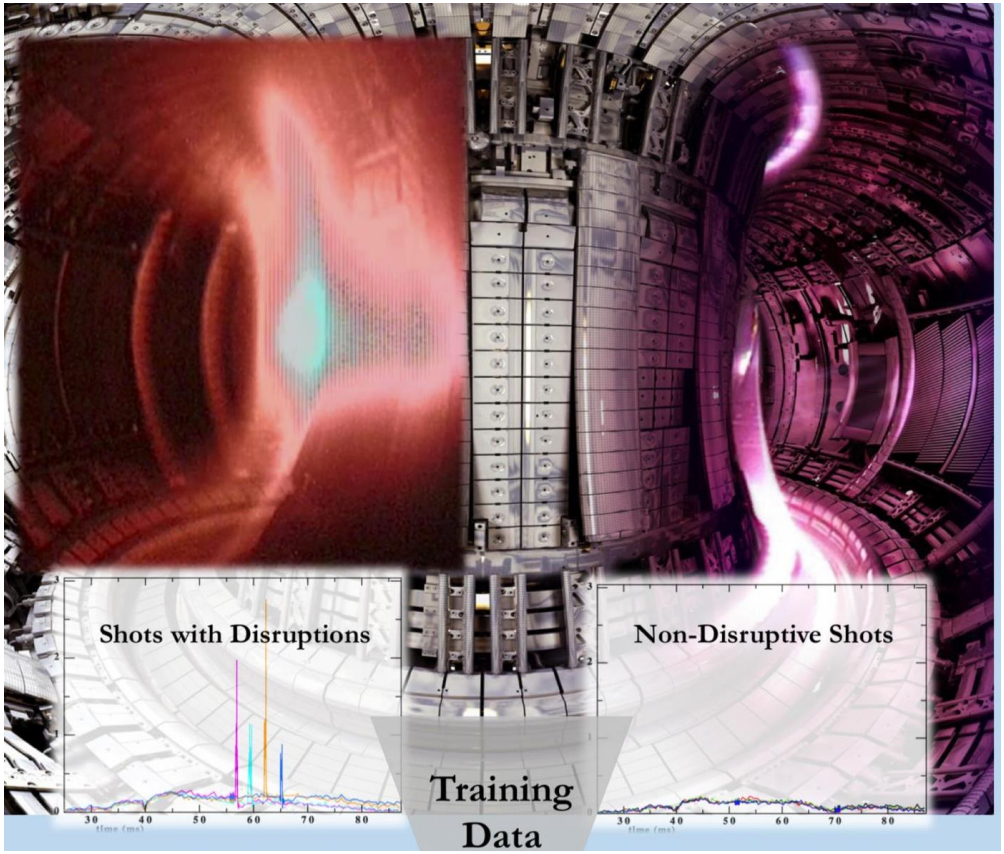




Typical plasma parameters:	
Major plasma radius $\mathbf{R_0}$	1.65 m
Minor horizontal plasma radius **a**	0.5 m
Minor vertical plasma radius **b**	0.8 m
Plasma types	deuterium, hydrogen, helium
Plasma volume	14 m^3
Plasma mass	3 mg
Electrondensity	1 x 10^{20} m^{-3}
Plasma temperature	60 to 100 million degree

PLASMA DISRUPTION

Disruption: instability leading to fast and irreversible loss of the plasma confinement; the energy stored in the plasma is rapidly released on the rest of the experimental system.



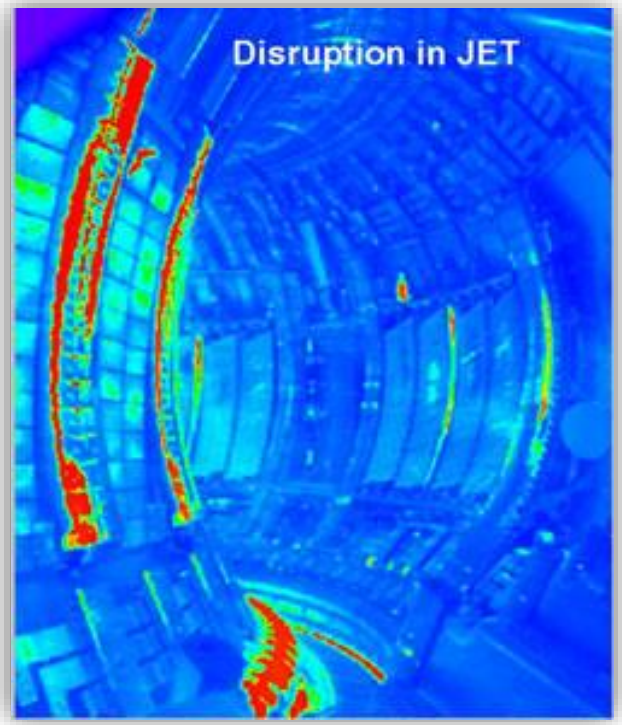
PLASMA DISRUPTION

No analytical models -> data based models

Tasks for Tokamak development

- Disruptions prediction
- Identification of characteristic regions

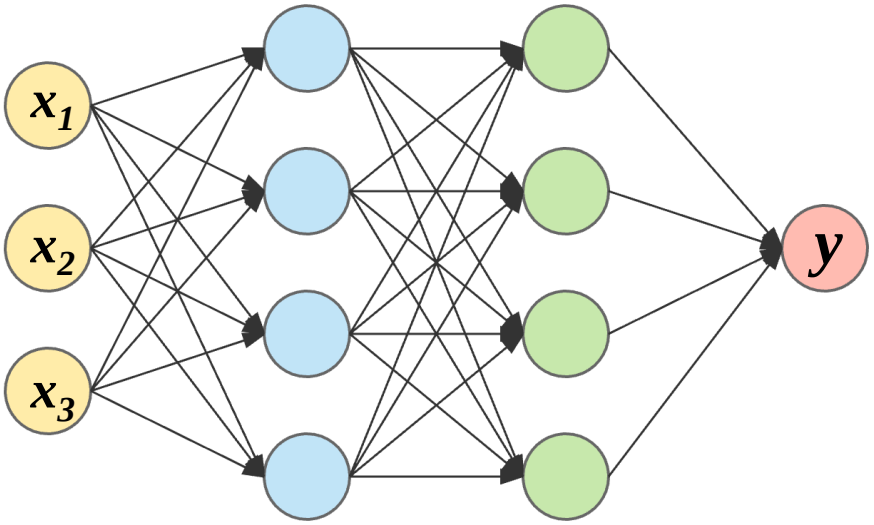
in the operational space

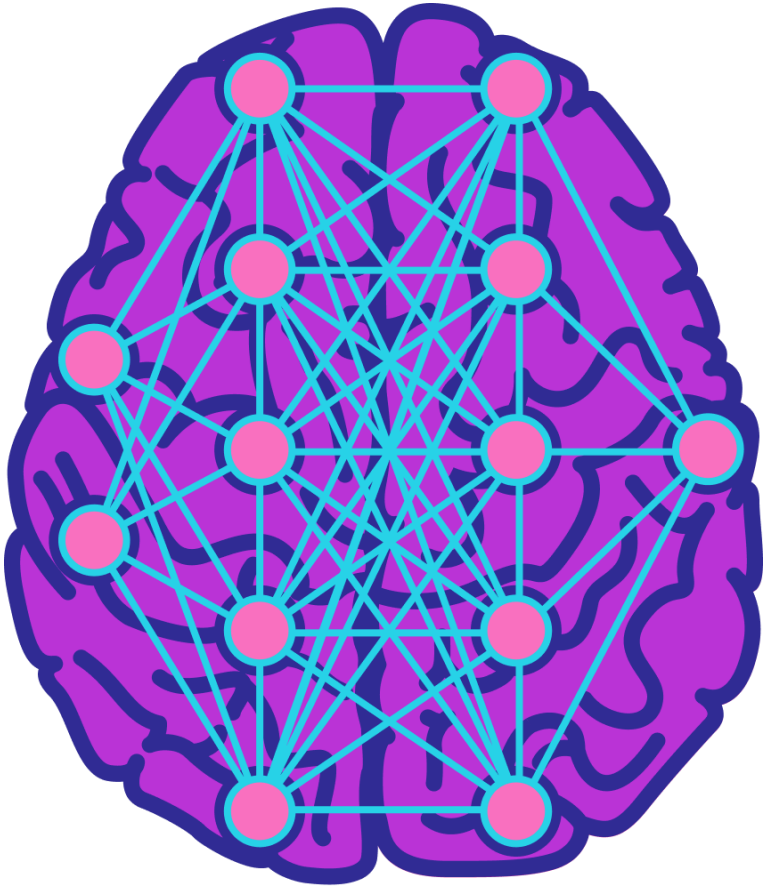


Plasma wall interaction
(X-ray tomography of a
disruption in JET Tokamak)

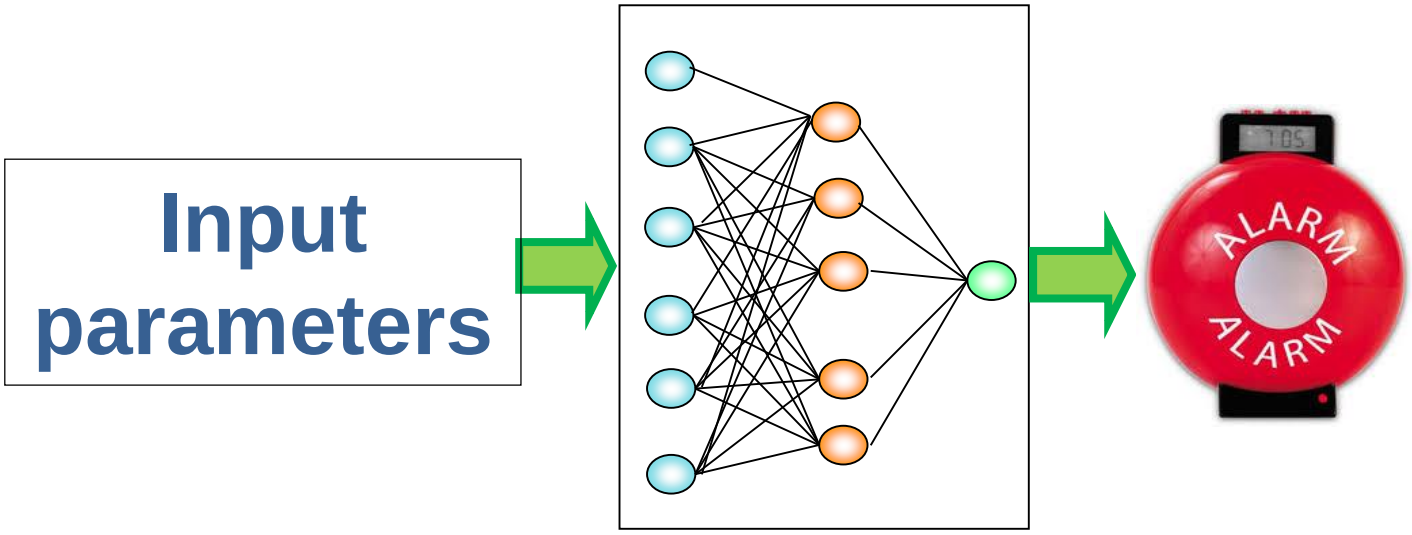
Neural Network models

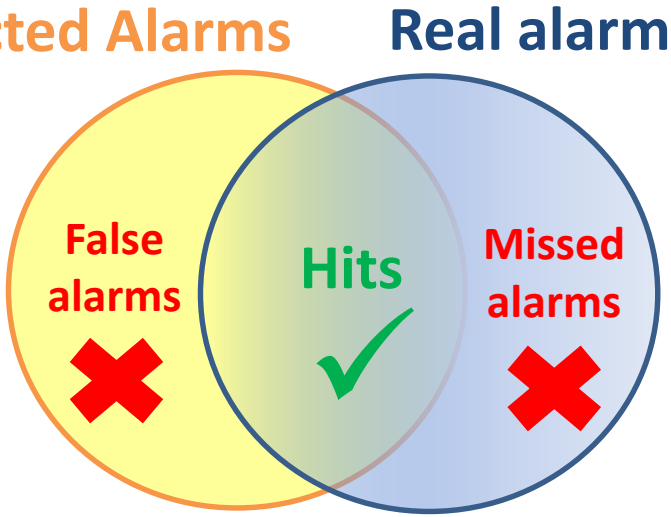
$$y=f(x_1, x_2, x_3)$$





Dispruption prediction



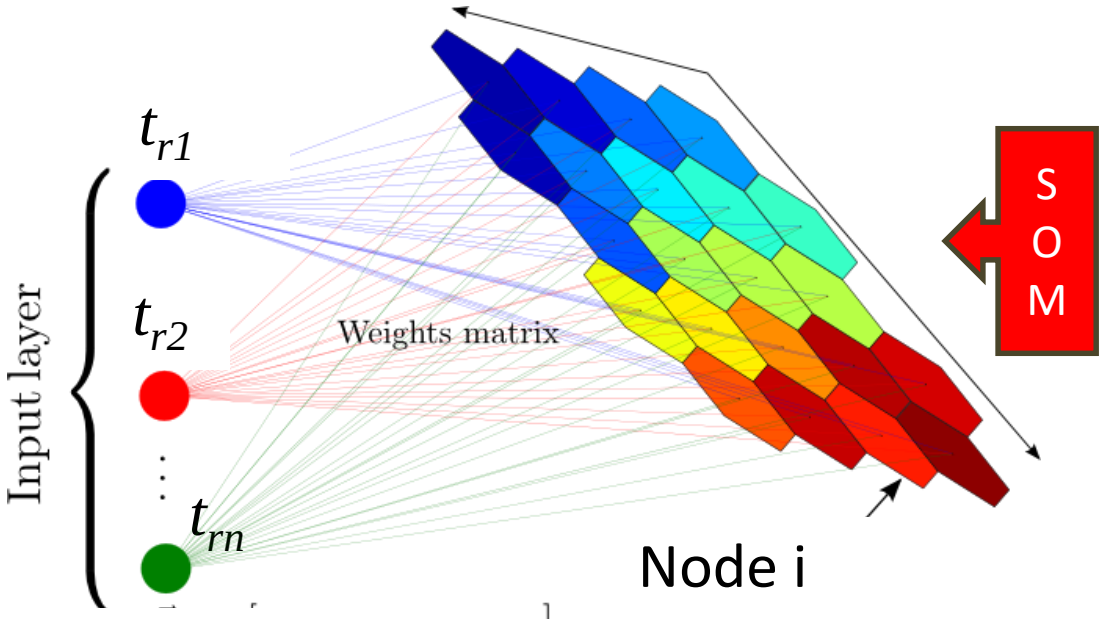


The automatic detection method is designed to

- maximize the corrected predictions (hits)
- minimize missed and false alarms, premature detecions

Mapping of the space of key plasma parameters

SOMs transform a pattern of arbitrary dimension $\mathbf{t}=[t_1, t_2, ..., t_n]$ into a $d < n$ **discrete map topologically ordered**.



Node i

$\mathbf{x_i}=[x_{i1}, x_{i2}, ..., x_{in}]$

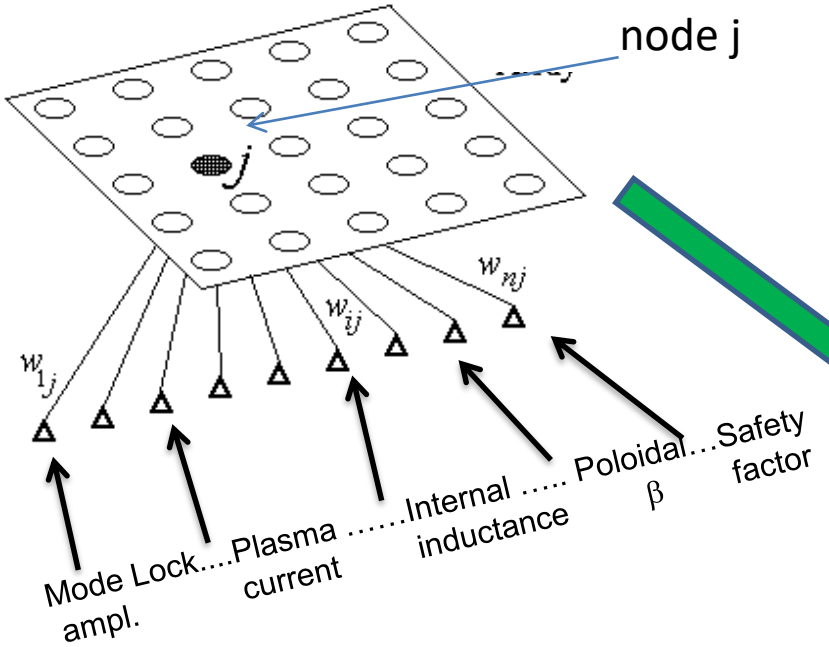
Input r

$\mathbf{t_r}=[t_{r1}, t_{r2}, ..., t_{rn}]$

Data Clusteing

Each input **t** is associated to a node of the map characterized by a vector **x** (barycenter of the inputs mapped in the node).

Mapping of the space of key plasma parameters

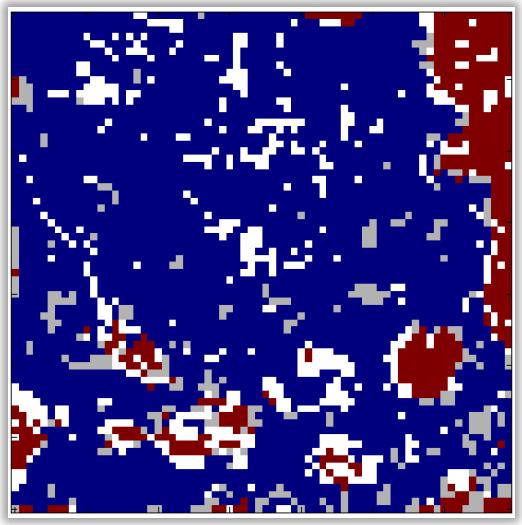


JET-C

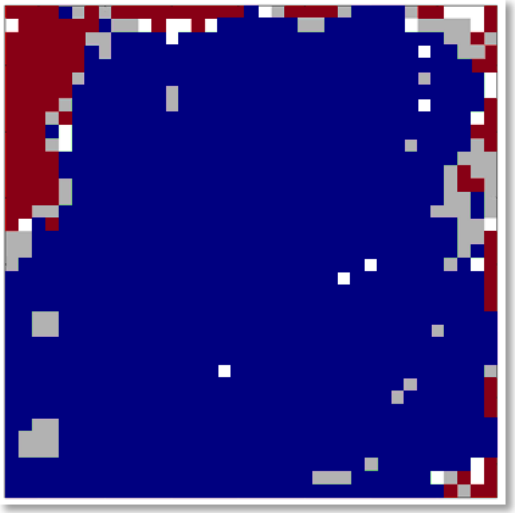
- 70 x 70 NODES
- 10D INPUT SPACE

AUG

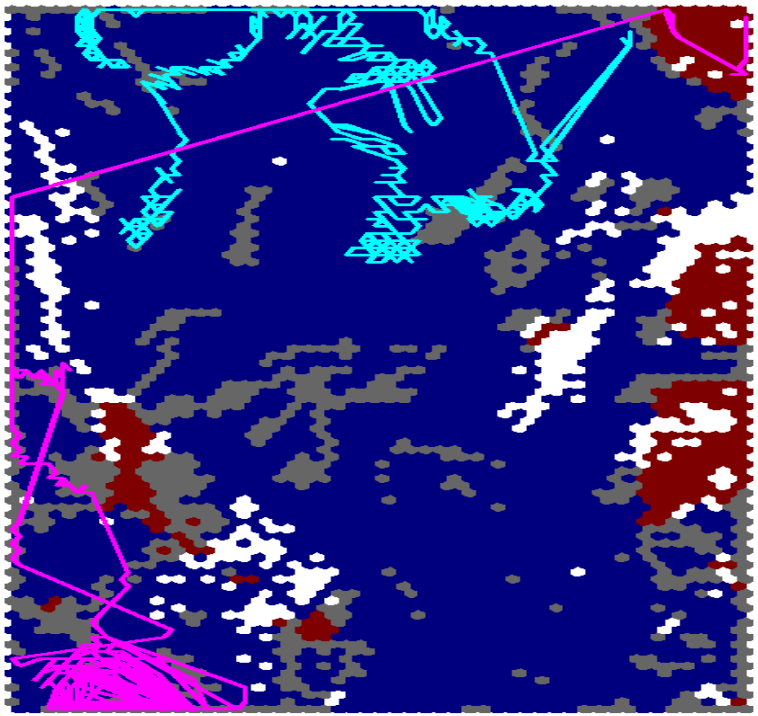
- 37 x 37 NODES
- 7D INPUT SPACE



- **blue node: safe samples**
- **red node: disruptive samples**
- white node: empty
- **grey node: safe & disruptive samples**



Discharge tracking



Trajectory of a safe pulse

Trajectory of a disruptive pulse

- The map can be used to display the dynamics of the shots.
- The temporal sequence of the samples forms a trajectory on the map.
- **Following the trajectory on the map it is possible to recognize when the shot goes in a region with high risk of disruption .**
- The safe shot evolves within the safe region, never going into the disruptive one.
- The disruptive shot evolves in the safe region before ending in a disruptive one

- The maps are not black-box as neural networks
- The maps gives elements to reconstruct the chain of events leading to a disruption, hence the causes.