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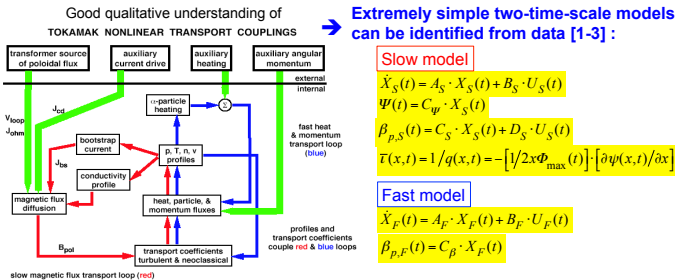
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## OUTCOME

- i) First experimental demonstration of kinetic control using the ARTAEMIS Model-Predictive-Control (MPC) algorithm [1] on EAST : Tracking of the safety factor on axis and of the poloidal pressure parameter,  $\beta_p$ , with 4.6 GHz LHCD.
- ii) METIS simulations using LHCD, ECRH and NBI Pulse-Width-Modulation.

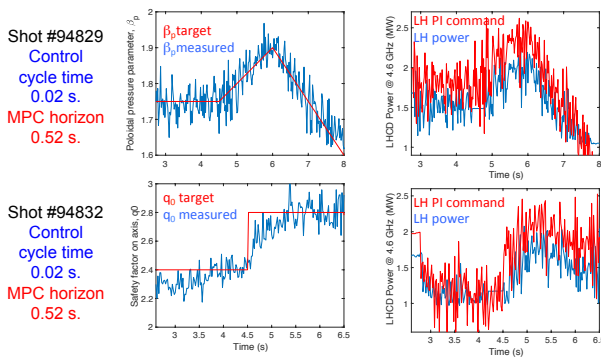
## 1. ARTAEMIS Data-Driven Models: ideal for MPC



MPC Controller commands are based on a prediction time horizon [4-5]. MPC takes into account, in real time, actuator constraints, state estimation and model errors through a classical Luenberger observer. Simple disturbance model + state observer  $\rightarrow$  Offset-free MPC control [6].

## 3. First Experiments on EAST MPC control of $q(0)$ and $\beta_p$ with LHCD

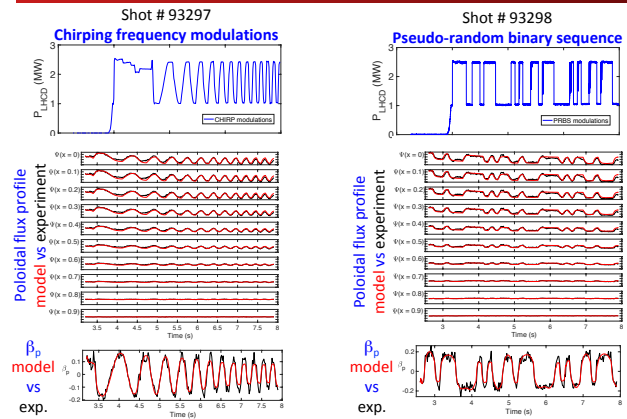
Actuator : 4.6 GHz LHCD with Internal Model Proportional + Integral power control.



## 5. Conclusion

- > The ARTAEMIS Model-Predictive-Control approach:
  - uses extremely simple data-driven models + singular perturbation methods.
  - provides a technique of minimal complexity for plasma kinetic control.
- > It works: First experimental demonstration on EAST for tracking  $q(0)$  and  $\beta_p$  using 4.6 GHz LHCD.
- > With NBI actuators: METIS simulations show excellent  $q$ -profile control with the combined ARTAEMIS MPC and NBI PWM algorithms.
- > For the kinetic time scale, high frequency NBI Pulse-Width-Modulation and a smaller control cycle time are required. This may need faster computation.
- > Further experiments are foreseen on EAST to test the combined ARTAEMIS MPC and NBI PWM algorithms, together with 4.6 GHz and 2.45 GHz LHCD.

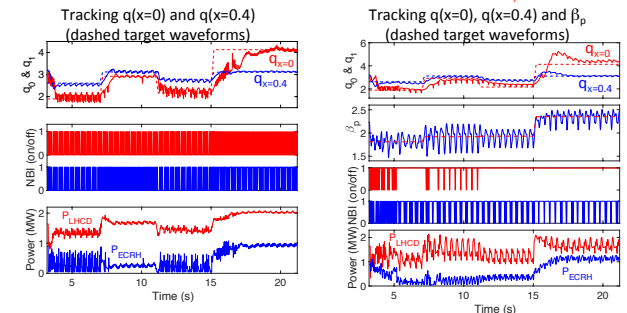
## 2. Model Identification Experiment on EAST



System identification is performed with an iterative predictive-error method [7] until the model fits the poloidal flux profile and  $\beta_p$  data. Slow model: 5 eigenmodes. Characteristic time of the first eigenmode: 1.05 s. Fast model: 1 eigenmode with a characteristic time of 0.017 s.

## 4. METIS Simulations : MPC control of $q(0)$ and $\beta_p$ with LHCD, ECRH and NBI in EAST

- > The ARTAEMIS MPC algorithm was implemented in the METIS plasma simulator [8].
- > NBI Pulse Width Modulation (PWM) assuming minimum on/off periods of 0.04 s.
- > NBI commands averaged over 0.4 s.
- > Controller cycle time = 0.02 s : ok for  $q(x)$  control but too long for  $\beta_p$  control.



## Acknowledgements / References

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