Needs for predictive scenario modeling

Francesca M. Poli

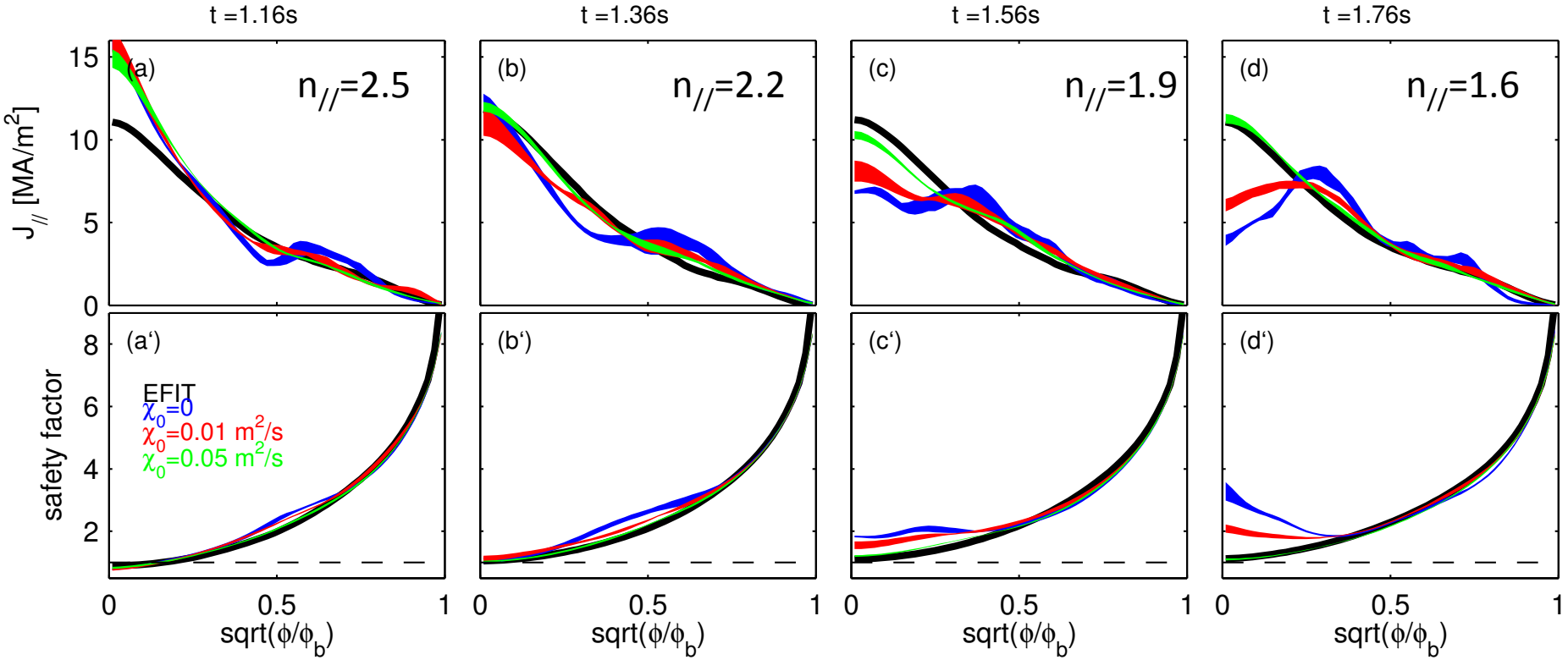
Significant effort going on to improve predictive capabilities

- LHCD with Fokker-Planck and multi-antenna
- EP stability
- RF-fast ion interactions
- NTM analysis and control
- Core-pedestal => EPED1 lookup table, NN
- Pellet ablation
- Impurity transport

Improved agreement for LHCD model/exps obtained with self-consistent calculation of $E_{//}$

$$\frac{\partial}{\partial p_{||}} D_{rf}(p_{||}) \frac{\partial f_e}{\partial p_{||}} + C(f_e, p_{||}, p_{\perp}) + eE_{||} \frac{\partial f_e}{\partial p_{||}} + \Gamma_s \delta(p_{||}) + \frac{1}{r} \frac{\partial}{\partial r} r \chi_f \frac{\partial f_e}{\partial r} = \frac{\partial f_e}{\partial t}$$

NEVER NEVER NEVER RUN LHCD CALCULATIONS WITH LEVGEO=8



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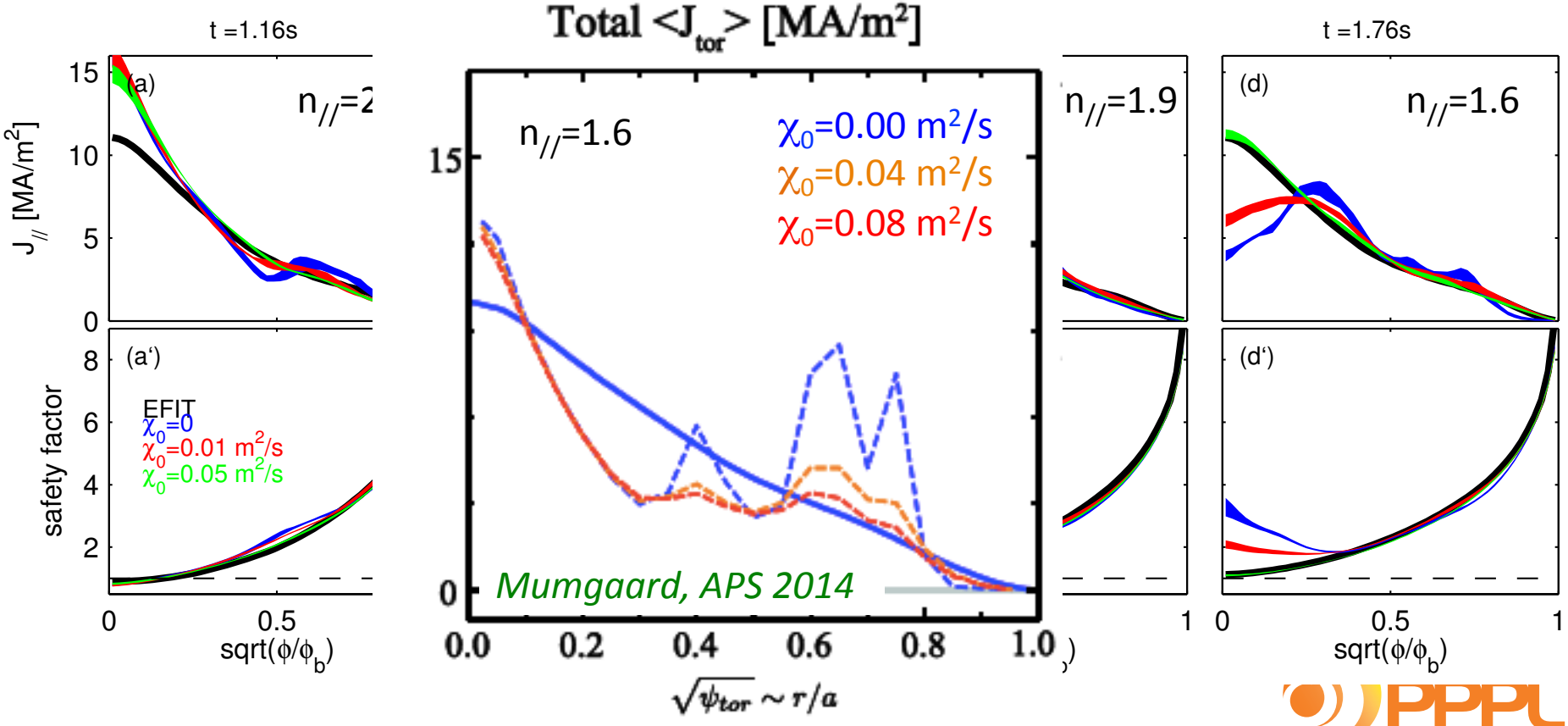


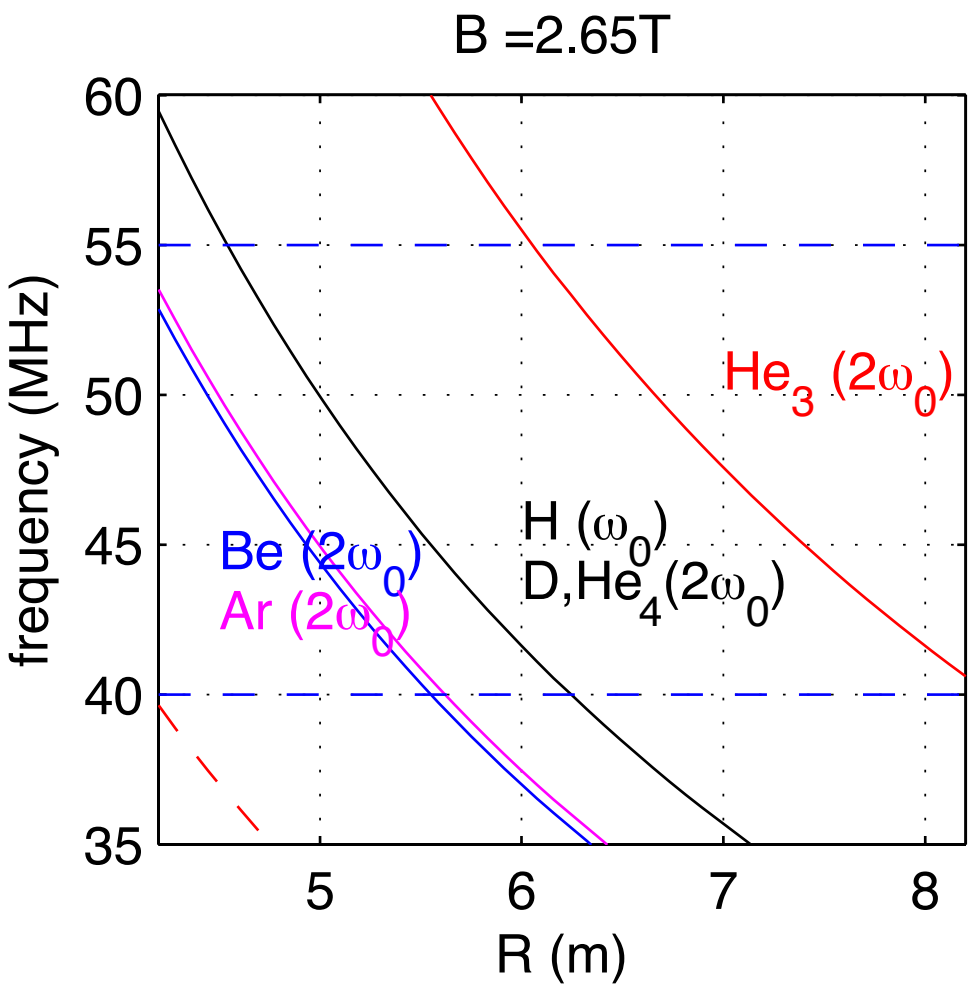
Needs for "predictive EP behavior" in TRANSP, including effects of instabilities

[M. Podesta']

- Big Leap Forward already implemented with "kick model" infrastructure
  - At present, OK for "interpretive analysis", limited power for "predictive"
  - Short-term need: implement feedback scheme on "mode amplitude scaling factors" similar to what already exists for AFID (simple task)
  - Also to be done: improve "TRANSP power balance" by taking into account power damped to thermal plasma through MHD damping mechanisms

- Three major ingredients needed for resolving EP+MHD behavior:
  - Mode structure, drive & damping rates
- Including all three in TRANSP is possible, but simulation time will go up +++
- Reasonable targets: achieve *semi-predictive* capabilities, e.g.
  - Provide "transport probability matrices" and damping rates -> predict mode saturation -> resulting EP transport
  - Provide "transport probability matrices" and mode structures, *compute* damping rates -> predict mode saturation -> resulting EP transport
- All these options are feasible - but will/would require (considerable) development time to include stripped-off MHD modules

We need to model the RF-fast ion interactions



Because life is not always easy…

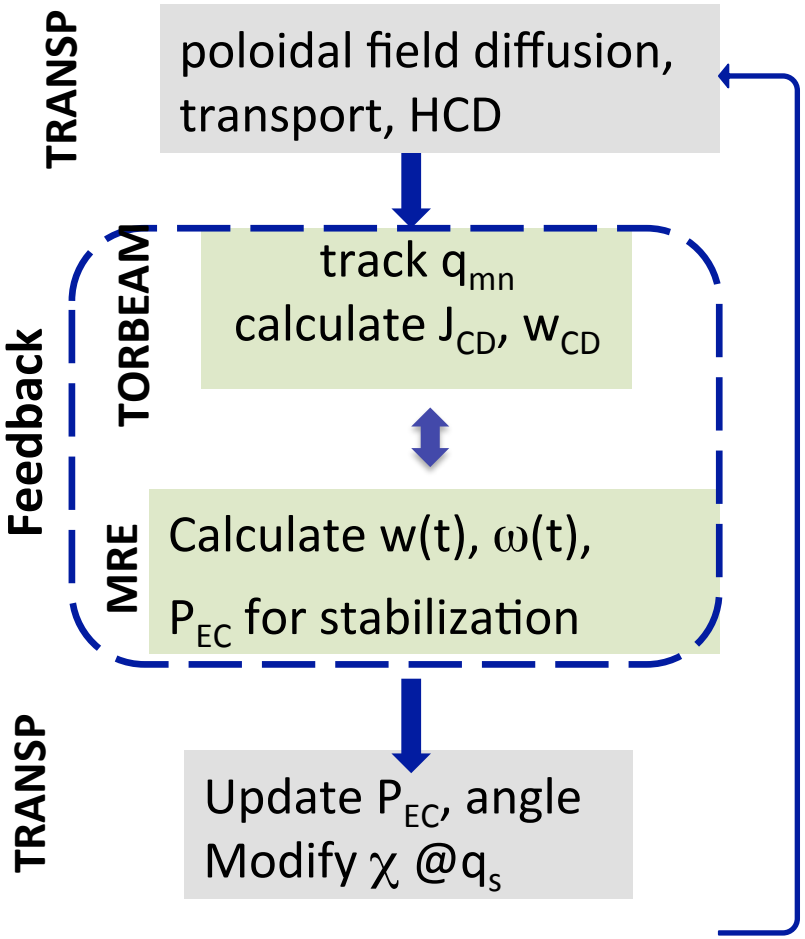
f_{IC} = 42 MHz @ 2.65T / 7.5MA

H: ω_0
D: $2\omega_0$
^{4}He: $2\omega_0$

Absorption to fast ions,
orbit losses up to 20%
EP stability might be an issue

Self-consistent evolution of NTMs and plasma profiles can help designing stable discharges and more robust control schemes

[F. Poli, E. Fredrickson]



In TRANSP the classical tearing stability term is calculated from the integration of the perturbed helical flux

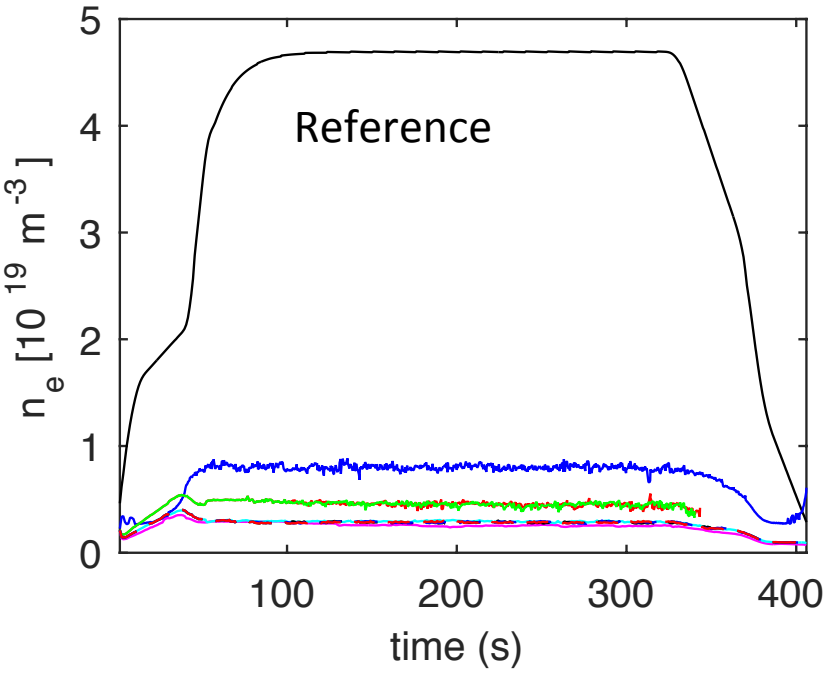
⇒ It responds to local variations of magnetic equilibrium and current profile

⇒ IN PROGRESS

NTV term, beam torque

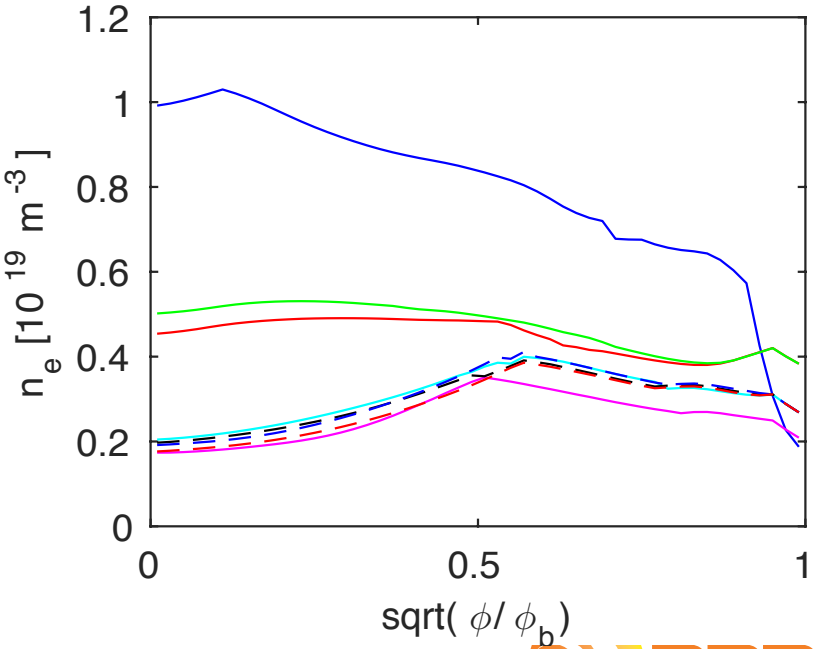
MISSING: interactions between modes

The model in TRANSP responds to gas puffing and to recycling, but is not sufficient for density prediction



$$n_e = \sum_i Z_i n_i$$

$$n_e Z_{eff} = \sum_i Z_i^2 n_i$$



$$\frac{dN_i}{dt} = S_{bi} + S_p + G_{0i} + R_{0i} - F_i$$

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- Impurity transport
- Core-pedestal-edge => in the pipeline

Couple TRANSP/OEDGE for core-edge simulations

[in collaboration with S. Lisgo]