Status and plans for Joint Experiment EP-8

Validation of Neutral Beam Current Drive and projections to ITER

M. Podestà – NSTX-U, USA

D. Testa – TCV, Lausanne CH

C. Hopf, B. Geiger – ASDEX-U, GE

D. Keeling – MAST, UK

C. Collins, L. Bardoczi, W. Heidbrink – DIII-D, USA

A. Cappa – TJ-II, Spain

20th ITPA Topical Group on Energetic Particles

ITER HQ, Cadarache - France

September 23-25, 2018

Goals of JEX EP-8

- Assess NB-CD efficiency vs. NBI parameters
  - Include conditions for which EP behavior departs from 'classical'
- Develop/validate modeling tools to predict NB-CD in future devices (ITER and DEMO)
  - Include tools to account for 'non-classical' effects
  - Consider enhanced EP transport by instabilities, microturbulence

Progress in last ~6 months: extending modeling tools to low-f instabilities

- NSTX/NSTX-U
  - Analysis of sawtoothing plasmas continues *[Kim, IAEA-TCM-EP 2017] [Liu, IAEA-TCM-EP 2017]*
    - Goal: improve sawtooth model in TRANSP
  - Started dedicated activity on NTM, fishbone, kink modeling *[Podestà US TTF 2018]*
    - Goal: develop "self-contained" module for TRANSP
  - Progress in development, benchmark of Quasi-Linear model RBQ1D

- DIII-D
  - Progress in diagnostics (see M. VanZeeland's talk)
  - Recent experiment on "AE mitigation in high-q_{min} discharges"
    - Goal: explore mitigation/suppression techniques
    - Assess predictive capabilities of reduced EP transport models (US JRT 2018)
    - Analysis started
  - Progress in validating "kick model" for NTMs *[Heidbrink, IAEA-EP 2017] [Heidbrink, US TTF 2018] [Bardoczi, US TTF 2018]*
    - Goal: develop self-contained module for TRANSP

Progress in last ~6 months: New experiments, analysis ongoing

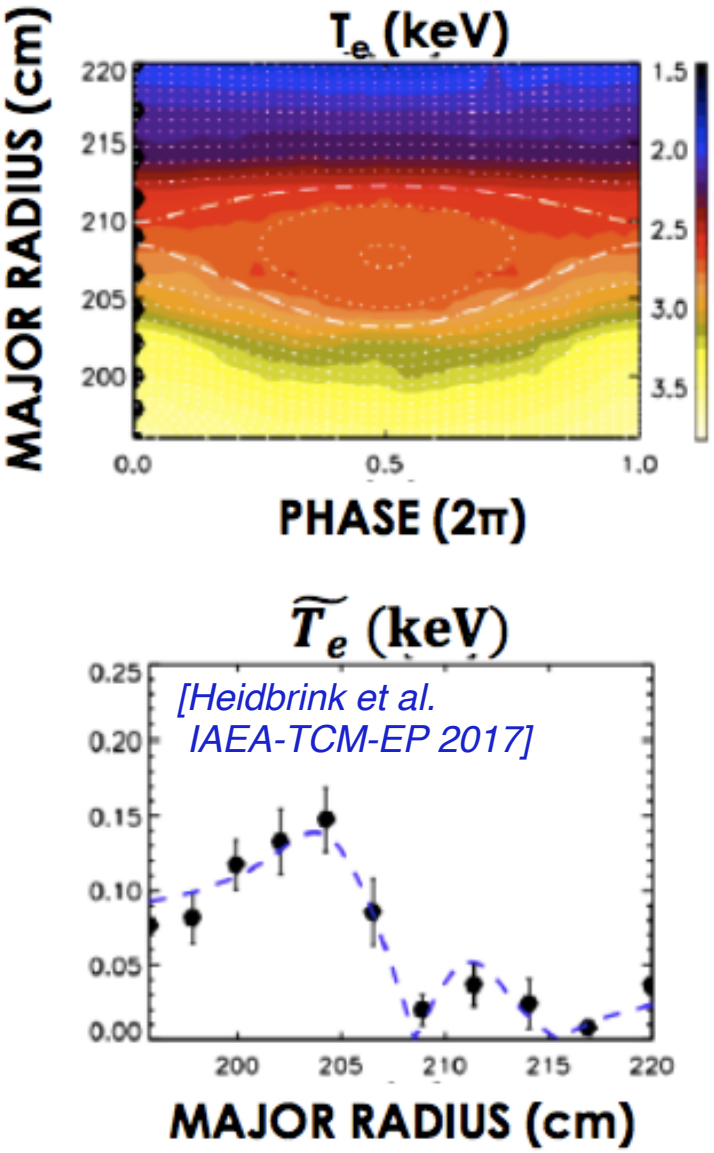
- ASDEX-U/TCV (MST1 programme)
  - High-q_{min} scenarios with high NI fraction on AUG
  - Preliminary results: good agreement between measured & simulated MSE, Vloop
    - Neoclassical, in spite of strong MHD activity,
  - However: enhanced EP transport required to match neutrons, W_{mhd}, FIDA
    - Results in disagreement for MSE, current!
  - *See B. Geiger's presentation*

- MAST-U: plans unchanged from previous meeting
  - Experimental programme coordinated within EU-MST1
  - *Fast Ions and Current Drive* studies are prominent part of it

Progress in last ~6 months: Experimental data available, modeling tools needed

- TJ-II
  - Database on NBCD available from past years
  - No new experiments in last ~year (fixing technical issues)
  - Analysis of experimental data starting
  - *Main issue: lack of modeling tools!*
    - Need to improve maturity of modeling tools for NBCD to same level as those available for axi-symmetric configurations

Coordinated NSTX-U/DIII-D effort has started to understand & model EP transport by NTMs



Ongoing validation of "kick model" with NTMs (L. Bardoczi, DIII-D)

Goal: predictive model for EP transport by NTMs

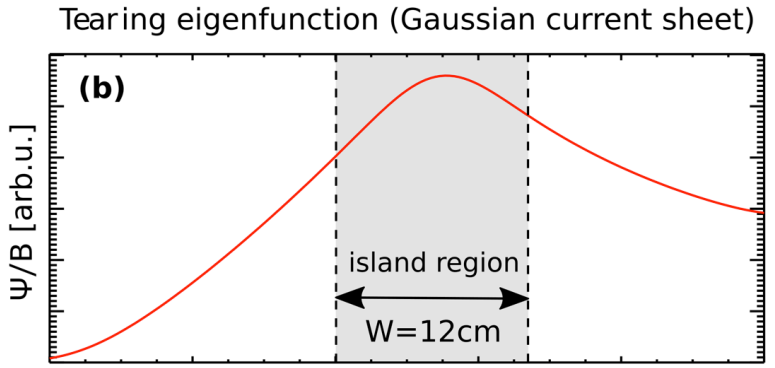
Experiment ⇦

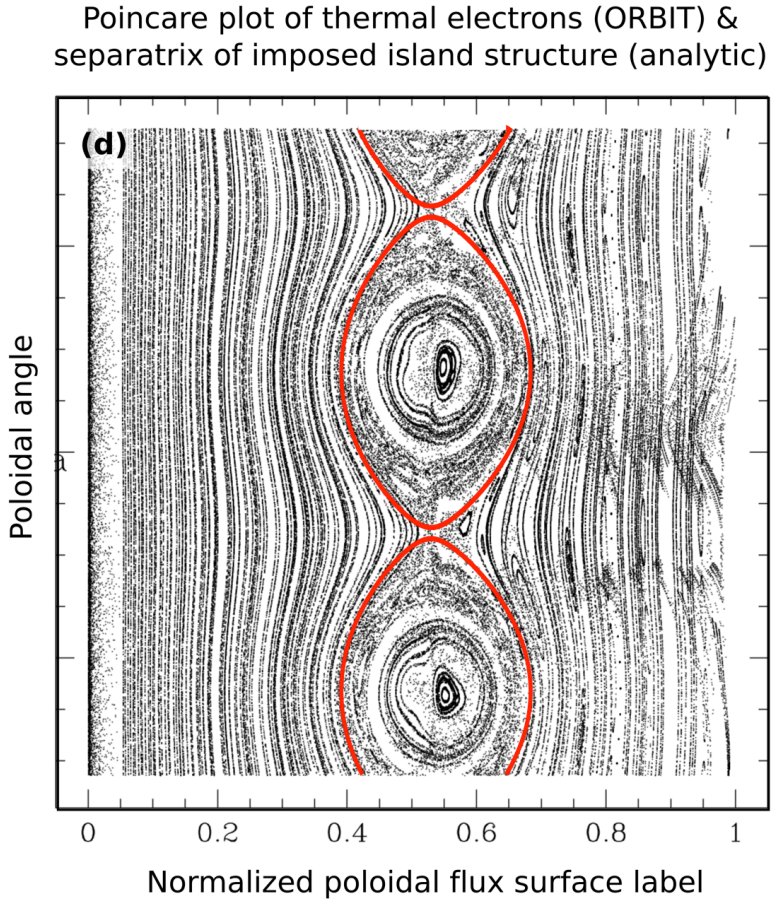
⇩

modeling ⇨

⇩

TRANSP

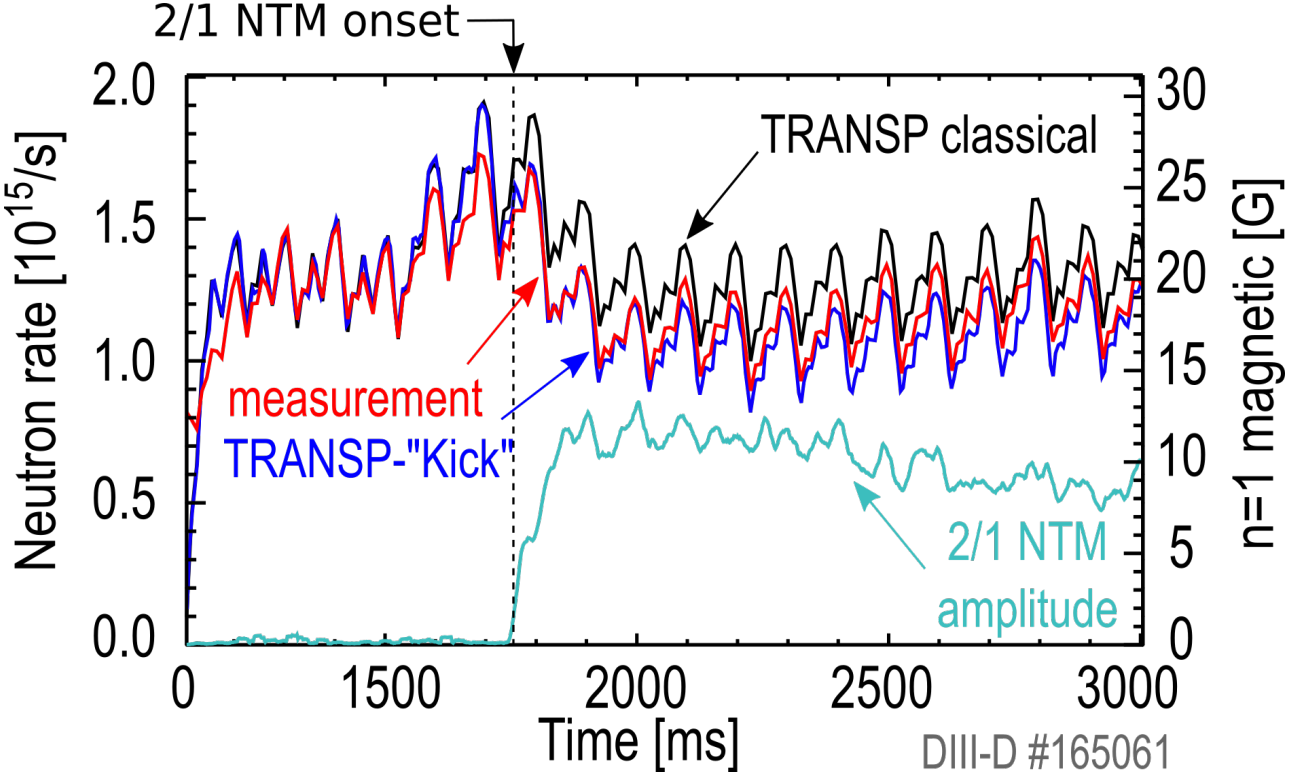


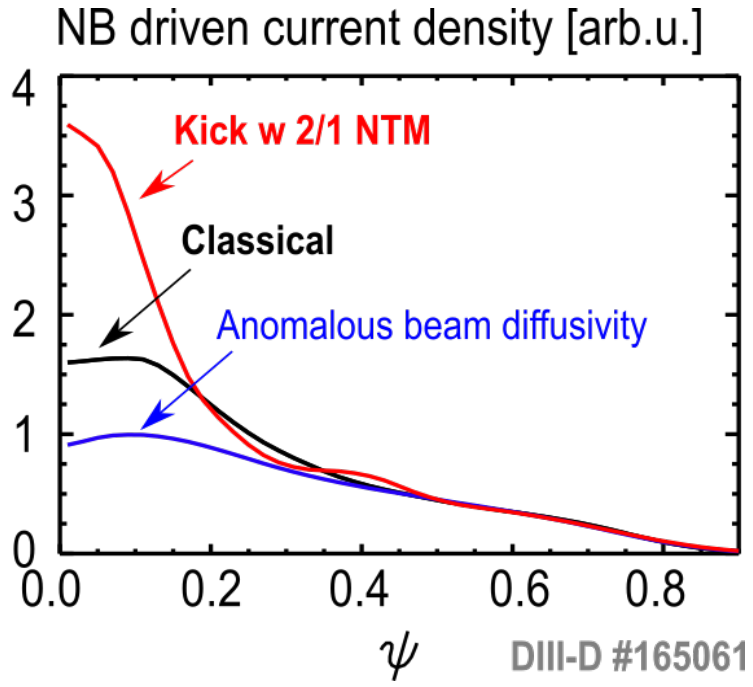


Leverage work by Poli & Fredrickson to include NTM stability model in TRANSP

Example: interpretive TRANSP analysis, *no free parameters*

- NTM island width from measurements
- Reproduce neutron rate, stored energy





- NB current redistribution depends on NTM spectrum
  - e.g. core peaking vs broadening predicted for 2/1 vs 3/2 NTMs

(L. Bardoczi, DIII-D – US TTF 2018)

Plans

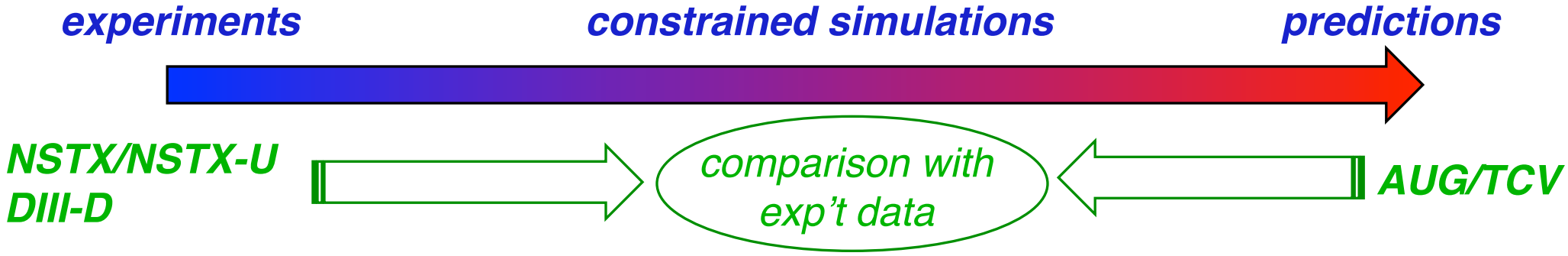
- Applying new modeling tools for EP transport by low-f instabilities
  - Assess resulting NBCD degradation
  - Assess synergy between low-f modes and AEs
- Working to make modeling tools (*kick model*) available to broader community
- Assessment of predictive capabilities would benefit from coordination with ITPA IOS
  - Joint meeting in the near future (1day overlap)?
- *Need quantitative NBCD modeling tools for non-axisymmetric configurations!*

Backup slides

Continuous progress in NB-CD database and analysis tools

- NSTX/NSTX-U/DIII-D
  - Database on NB-CD expanded
  - Focusing on identification of "critical parameters" for reliable, quantitative CD predictions
- ASDEX-Upgrade, TCV
  - Progress in experiments with MSE, FIDA data with NBI
  - Analyzing discharges with high non-inductive current fraction, look for effects of instabilities on NB-CD performance

> *Converging to similar methodology:*



Open issue: relax constraints in TRANSP simulation degrades prediction accuracy

> Remove additional constraints in TRANSP simulations, check agreement with "reference" run

- Unconstrained V_{surf} leads to similar NB-driven current profile, but "large" discrepancy in predicted q-profile
  - *Ongoing work: assess role of computed resistivity [F. M. Poli, D. Kim]*