OAK RIDGE National Laboratory

Spherical Tokamak Boundary Science Activities on ST40

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more details in white paper "Proposed Boundary Science Activity on the ST40 Spherical Tokamak" 10/10/2018

Open FES Boundary Science Activities that are Aligned with ST40 Mission in Programme 3

PRIMARY GOALS:

- (P1) characterize how the divertor heat flux width scales as a function of poloidal field
- (P2) characterize achievable pedestal pressure as a function of toroidal & poloidal field

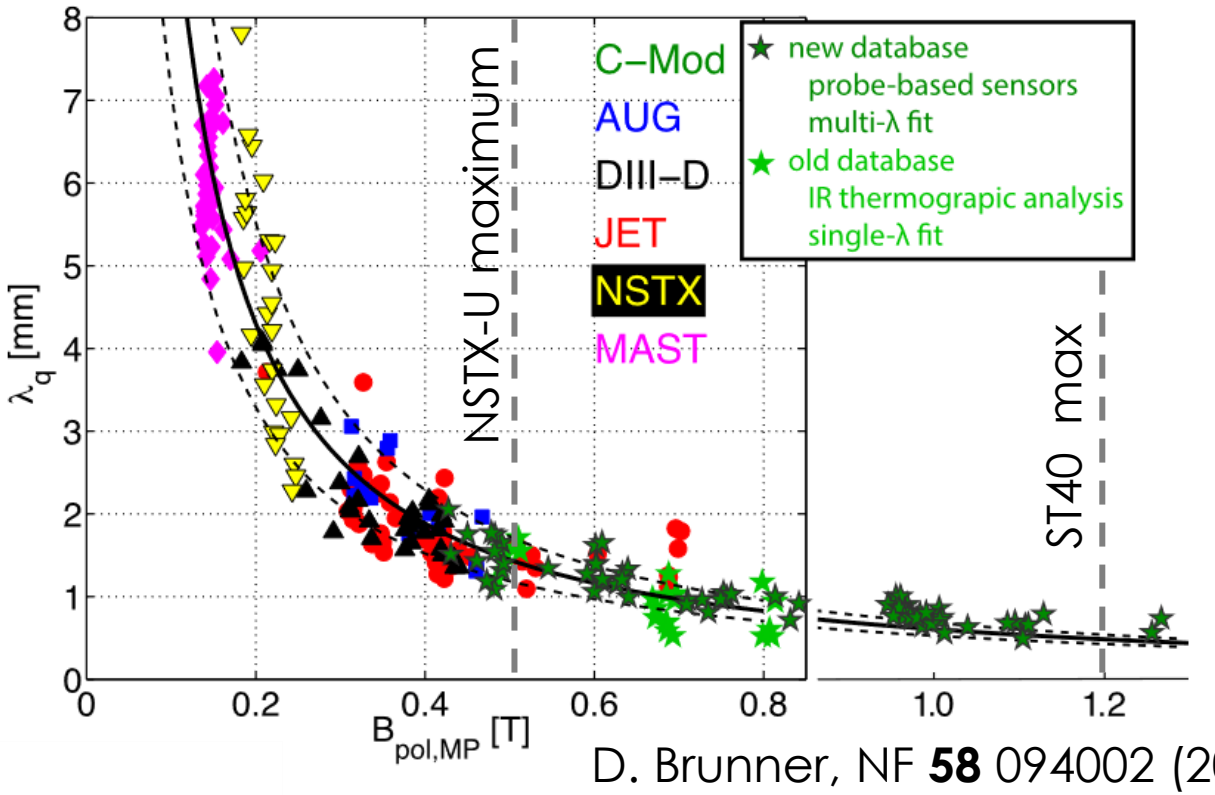
SECONDARY GOAL:

- (S1) characterize the impact of high-Z impurities on ST40 plasmas

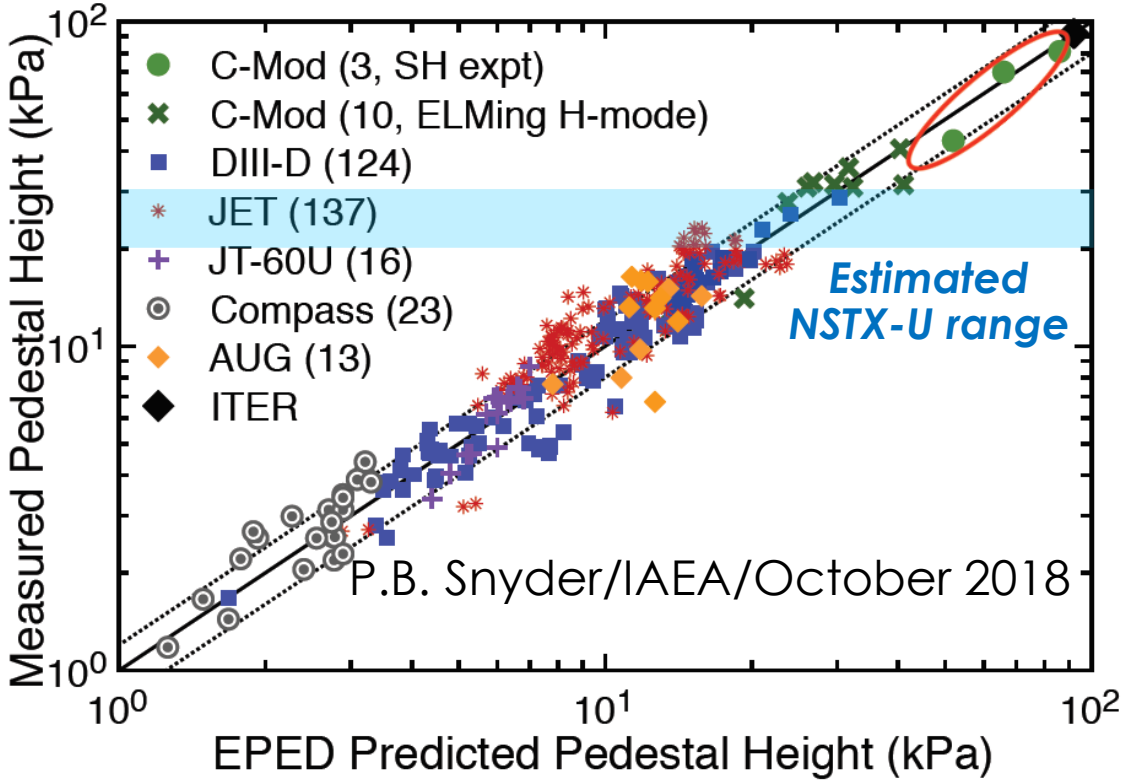
These correspond to activities that are proposed as part of the NSTX-U and MAST-U research programs, connecting limited ST40 experiments to more in-depth investigations using government-sponsored user-facilities

ST40 is to NSTX-U as Alcator C-Mod was to DIII-D

- x3 higher field, x2.4 smaller size allows access to similar ρ^*, higher pressures, likely at higher ν^*
- λ_q scaling and EPED validation benefited from combined use of DIII-D and Alcator C-Mod, indicates the role of ST40 w/ NSTX-U

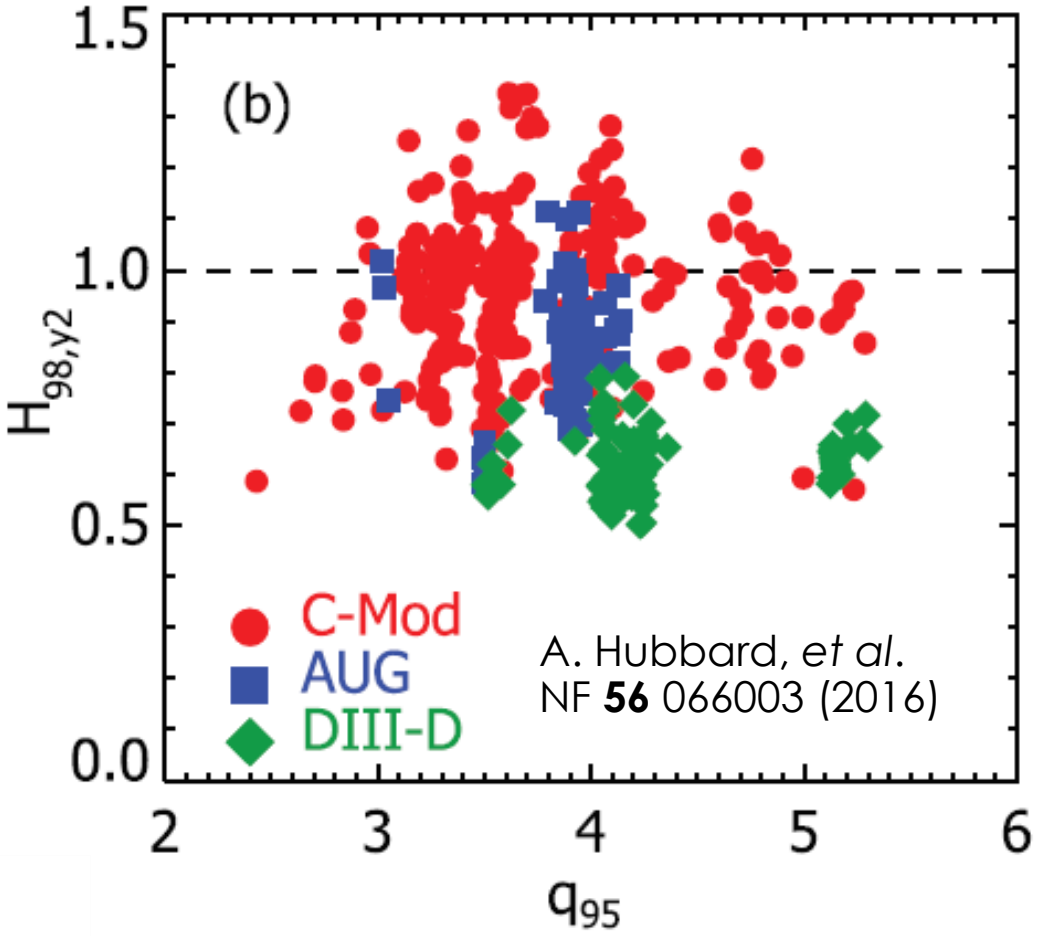


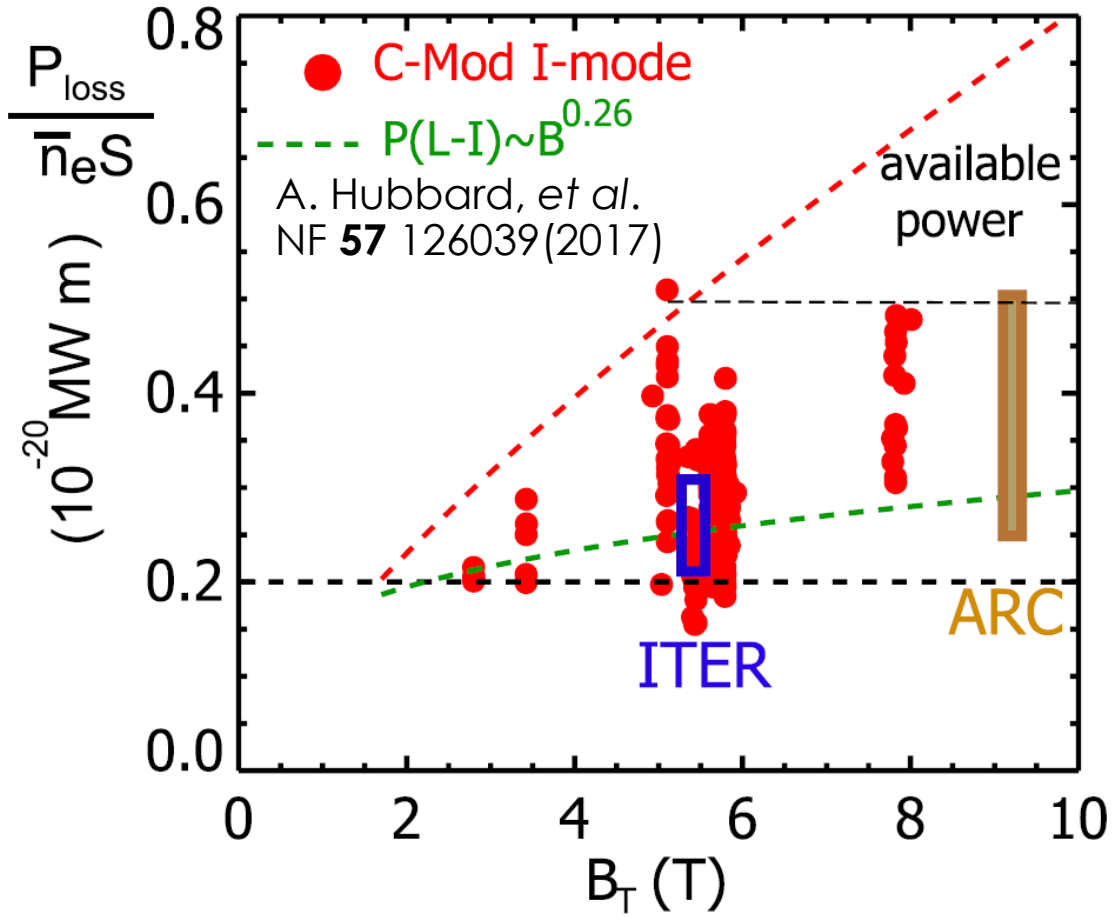
D. Brunner, NF **58** 094002 (2018)



Exploration of the I-Mode Regime on ST40 and NSTX-U?

the I-mode regime has yet to be investigated on ST's, but intra and inter-machine comparisons show B_T as a means to open an I-Mode operating space between L and H-mode in unfavorable ∇B





Proposed Activities during 2019-2020

- operational capabilities necessary to explore Primary Goals will available starting in Programme 3 in CY20
- presently available/envisioned ST40 diagnostics insufficient
  - plans for Thomson scattering, what is required/proposed ped. resolution?
  - is there space for IR cameras, sub-surface fiber or thermocouples for ΔT?
- partner with TokEng for diagnostic design and fabrication in 2019 for deployment and experiments on ST40 during 2020
- there is also interest in contributing to ST40 divertor design, but this type of work possibly not supportable by FES
  - is it basic science that helps everyone or does it help TokEng specifically?
  - could pursue with SPP, possible emerging options for GAIN-style vouchers
  - materials for divertor design isolates if Secondary Goal is achievable

EXTRA SLIDES

Comparison of ST40, MAST-U and NSTX-U

	ST40	MAST-U	NSTX-U
Aspect ratio	1.70	1.56	1.70
Major radius R_0 [m]	0.40	0.82	0.94
Minor radius [m]	0.24	0.53	0.55
Plasma elongation κ	2.50	2.50	2.75
Plasma triangularity δ	0.35	0.50	0.50
Plasma current [MA]	2.00	2.00	2.00
Toroidal field at R_0 [T]	3.00	0.78	1.00
Average B_p [T]	0.89	0.40	0.35
Estimated $B_{p,OMP}$ [T]	1.21	0.54	0.48
Maximum Pulse Duration [s]	2.00	5.00	5.00
Volume [m^3]	0.83	8.51	11.73
Greenwald Density [10^{20} m^{-3}]	11.50	2.30	2.08

Table 1: Comparison of engineering parameters for ST40, MAST-U and NSTX-U. Data from J. Menard, et al. IAEA 2018.