U.S. DEPARTMENT OF ENERGY | Office of Science

NSTX-U

Update on NSTX-U Plasma Operations

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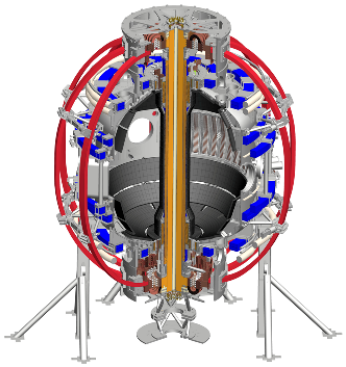
On Behalf of the NSTX-U team

NSTX-U Monday Physics Meeting
March 7, 2016

PPPL



Summary of NSTX-U Plasma Operations

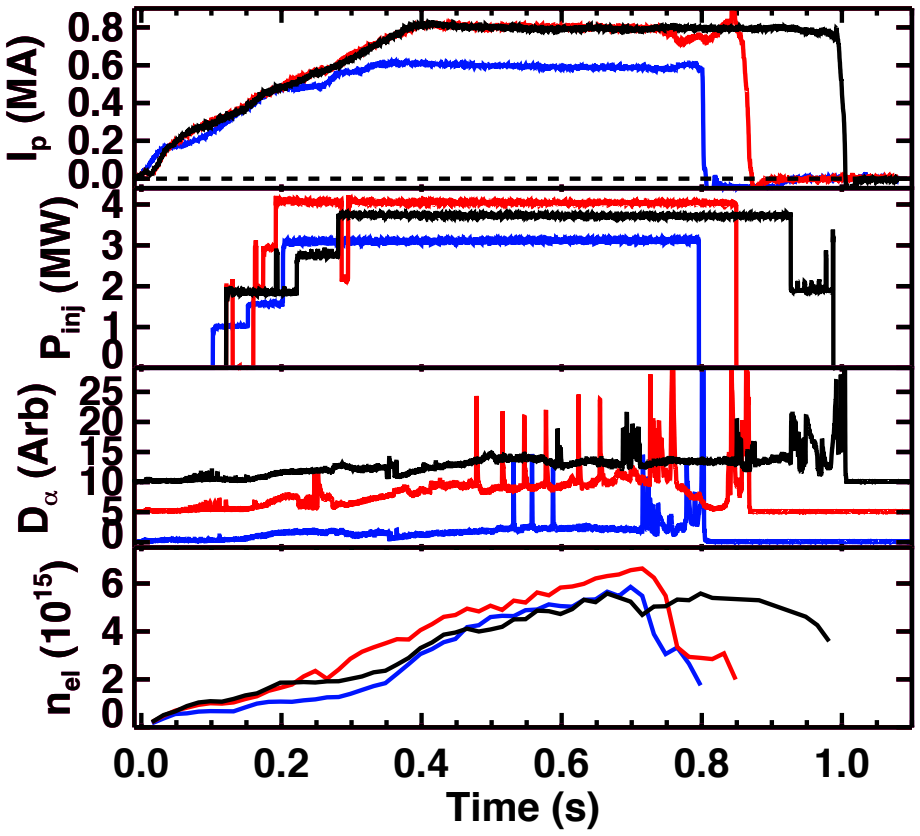
- 3 weeks of operations December - January
  - Neutral beam heating: typically 3MW total from four sources
  - Diverted L-mode and H-mode operations at I_p = 600 kA
  - Gap and I_p control, simple vertical position control
  - Followed by 2 weeks of maintenance

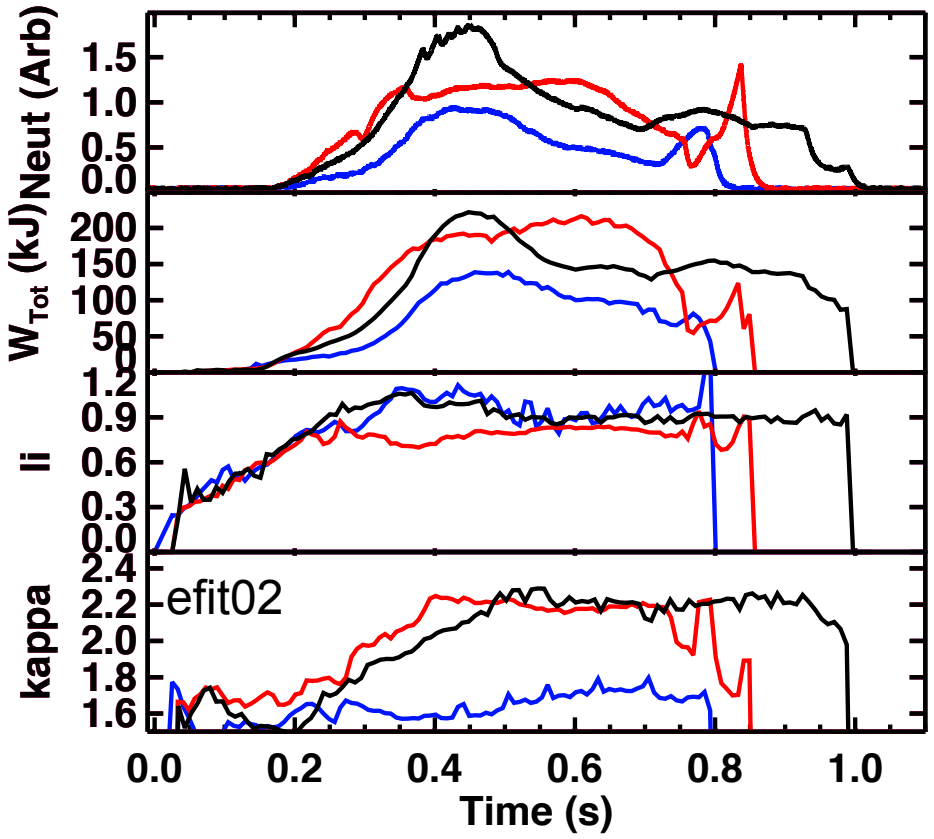
- 3 weeks of operations in February – early March
  - Neutral beam heating: up to 4MW total from three sources
    - Beamline 1B routinely runs at 90kV
  - Diverted L-mode (0.8 – 1.0MW) and H-mode (I_p = 0.8 MA)
  - ISOFLUX, vertical position improvements, error field correction commissioned
  - Now starting another 2 weeks of maintenance

Achieved H-mode scenarios at larger I_p, kappa and stored energy

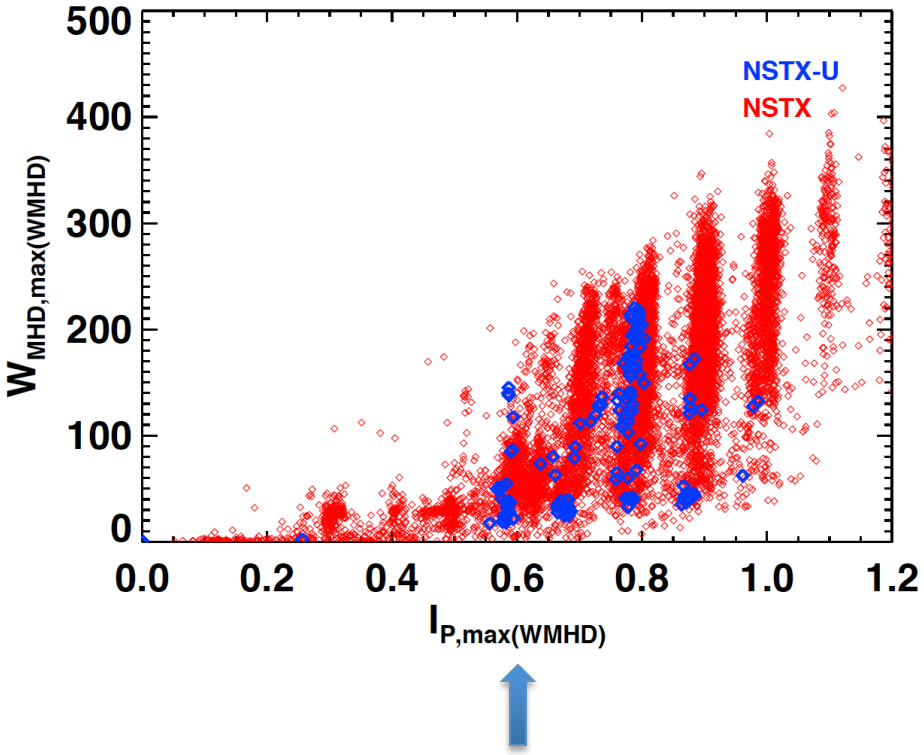
- Steady progress toward 1.4MA ELMy H-mode goal

202946: Best H-mode in January period
203655 and **203679**: Best H-mode in Feb-March period



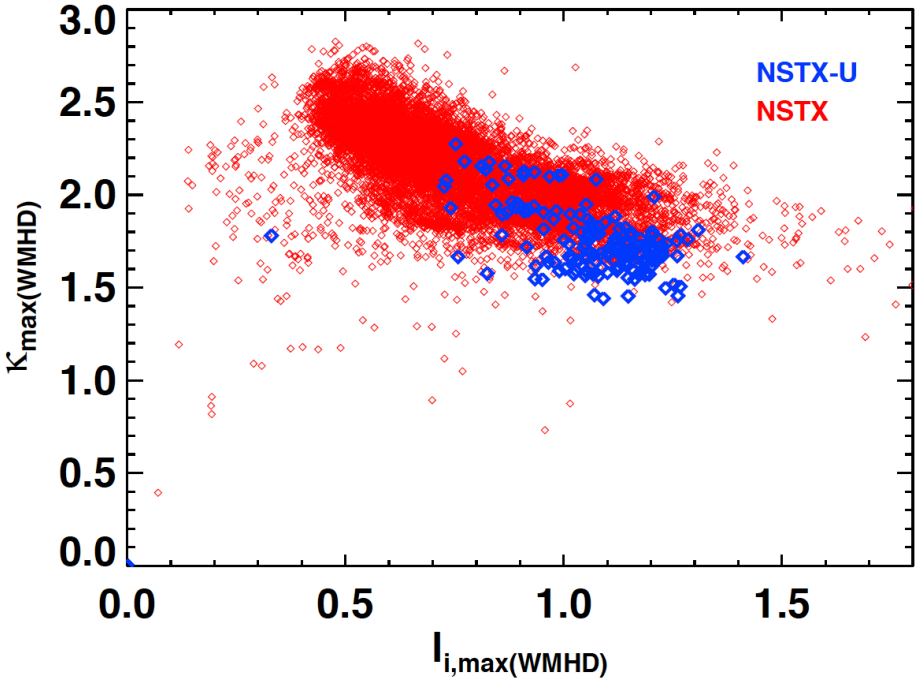


Making Progress in Shaping And High Stored Energy



Are approaching vertical stability boundaries similar to NSTX

(*but at higher A*)



Nearly Matching the NSTX Stored Energy for the Same Plasma Current

(at higher B_T, but lower volume)

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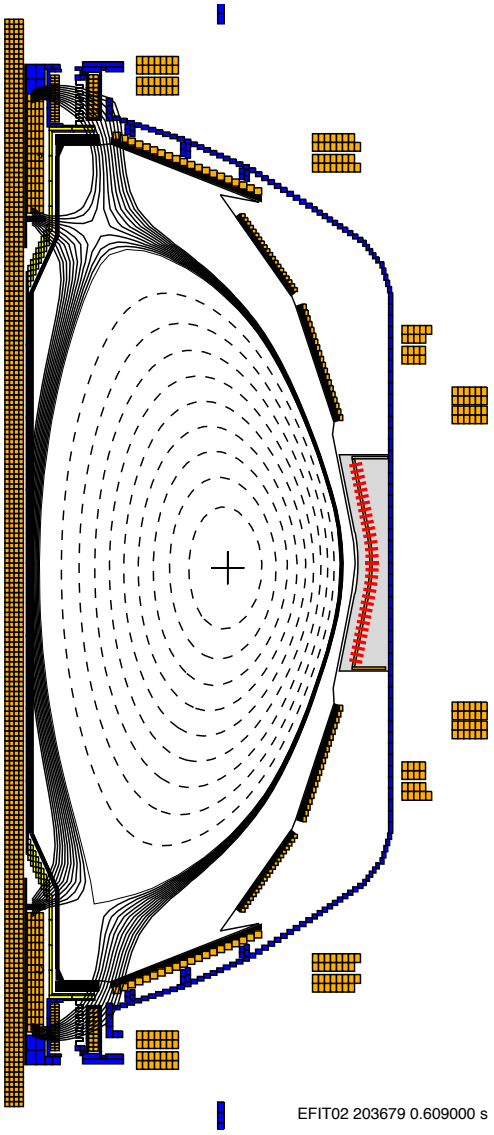
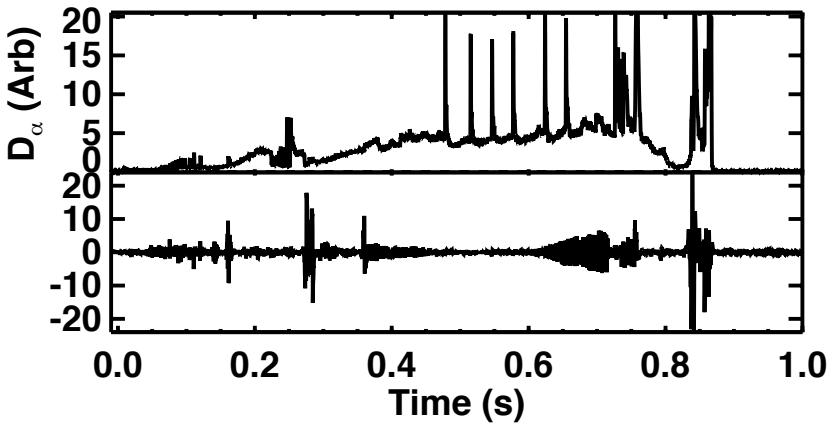
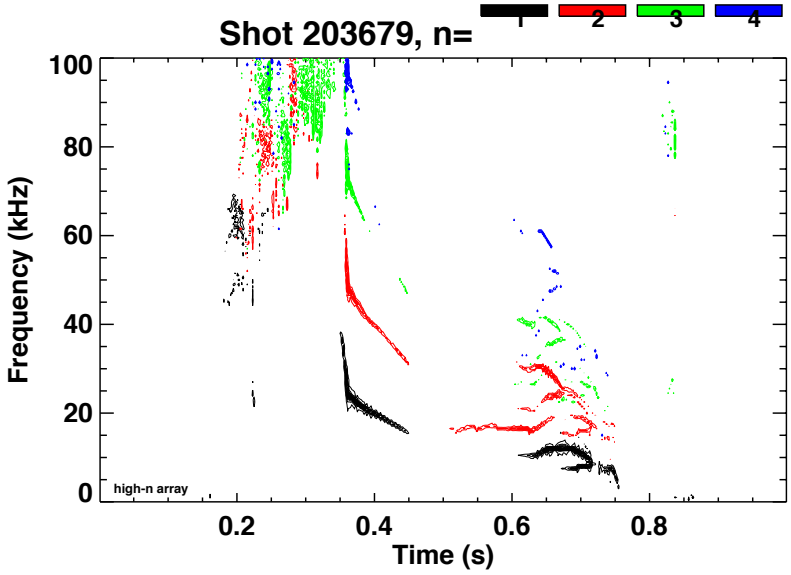
ELMy H-mode shot with quiescent period achieved with highly-shaped LSN discharge



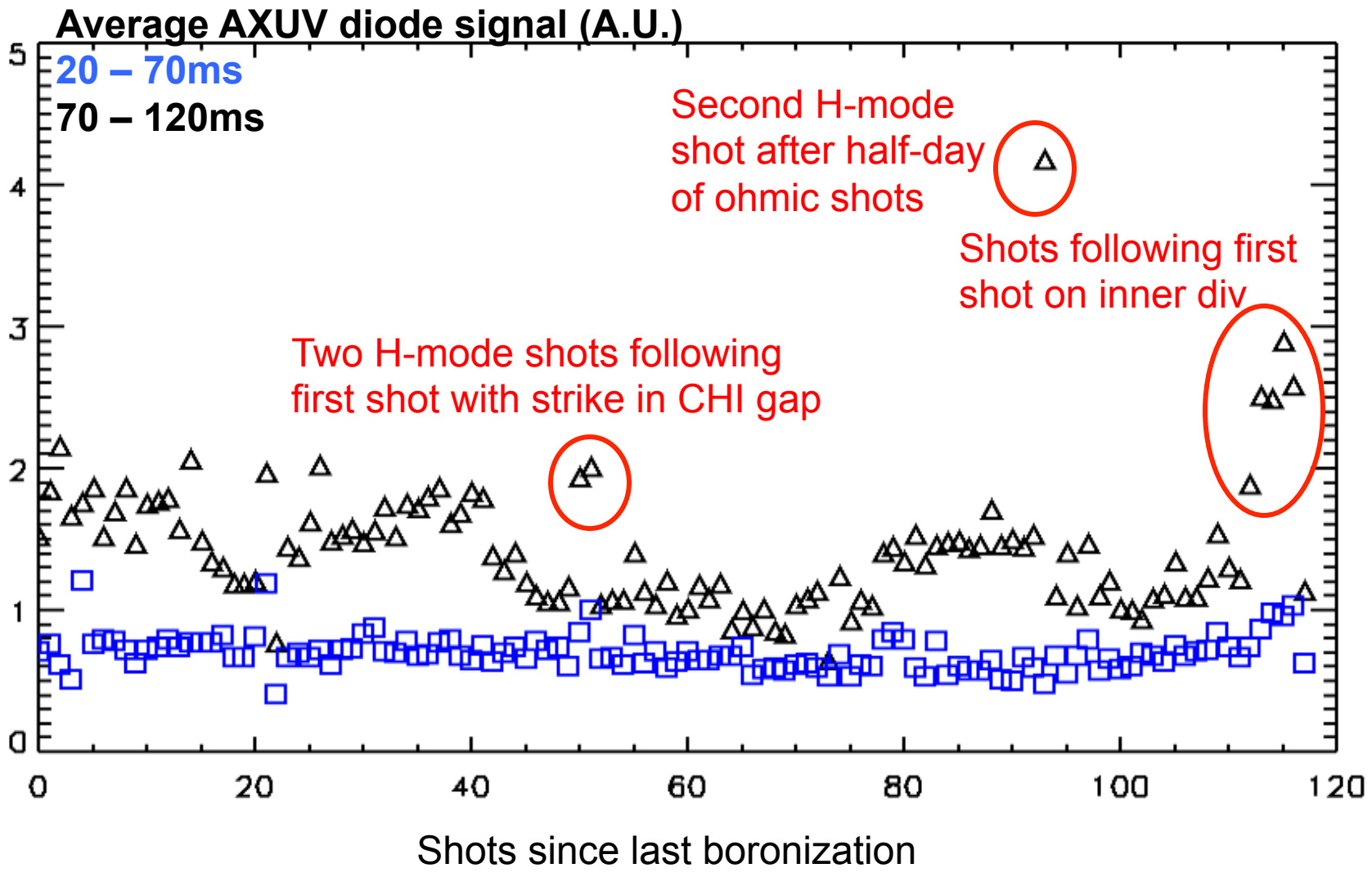
I_p	0.78 MA
B_{T0}	0.61 T
P_{NBI}	4 MW
P_{OH}	0.2 MW
A	1.58
κ	2.18
l_i	0.83
δ_{lower}	0.64
W	206 kJ
β_T	7.84%
β_P	1.14%
β_N	3.58
τ_e	50 ms

EFIT02 now available between shots

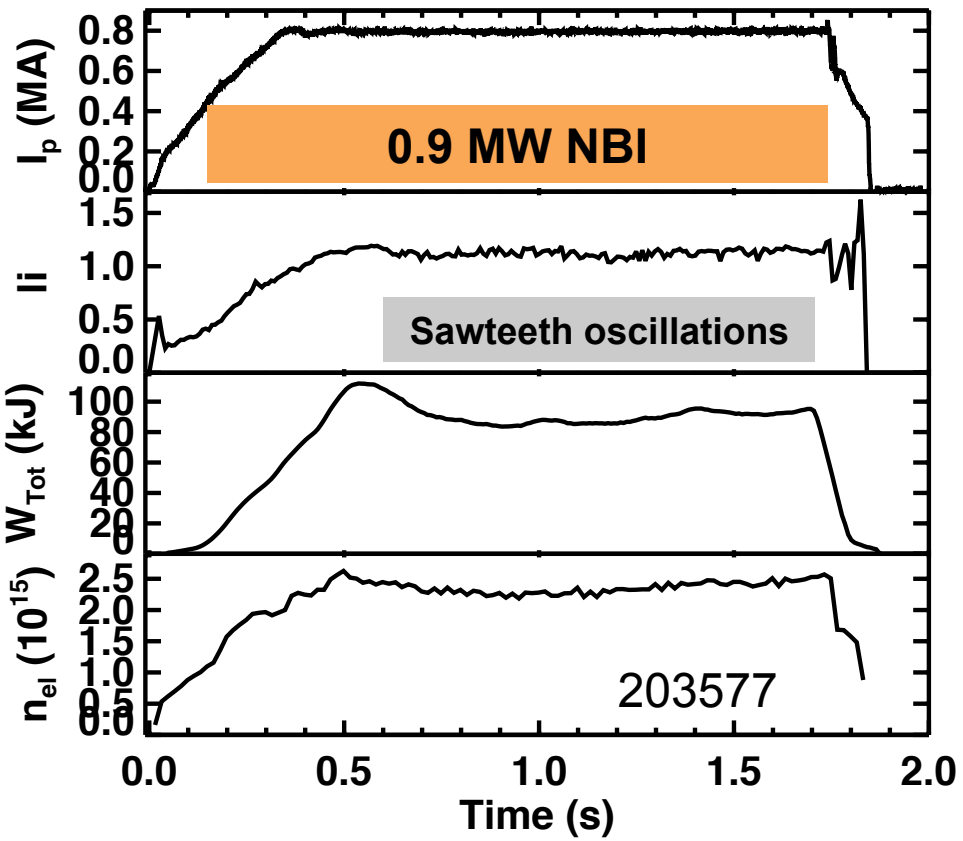


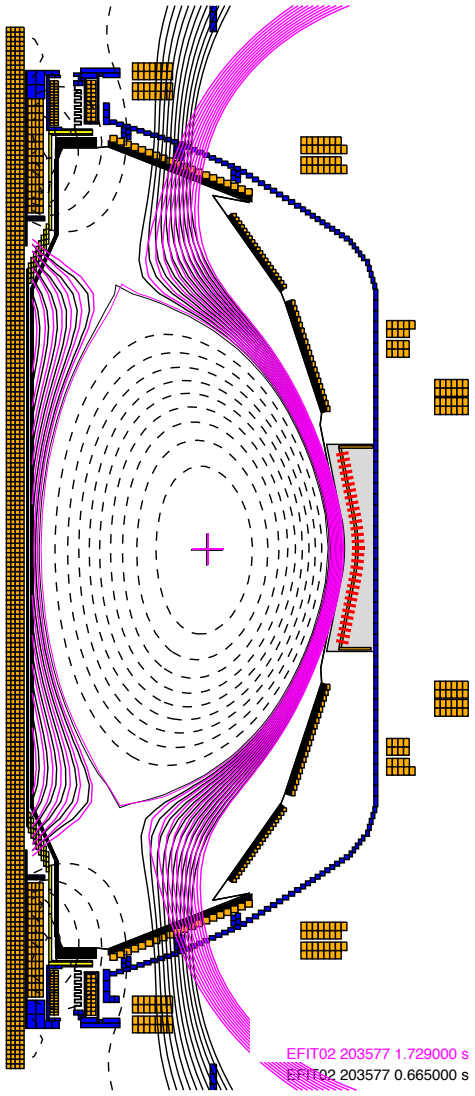


But, putting power on new divertor surfaces requires some “clean up” time



Stationary diverted L-mode operations have been extended to flattops > 1s

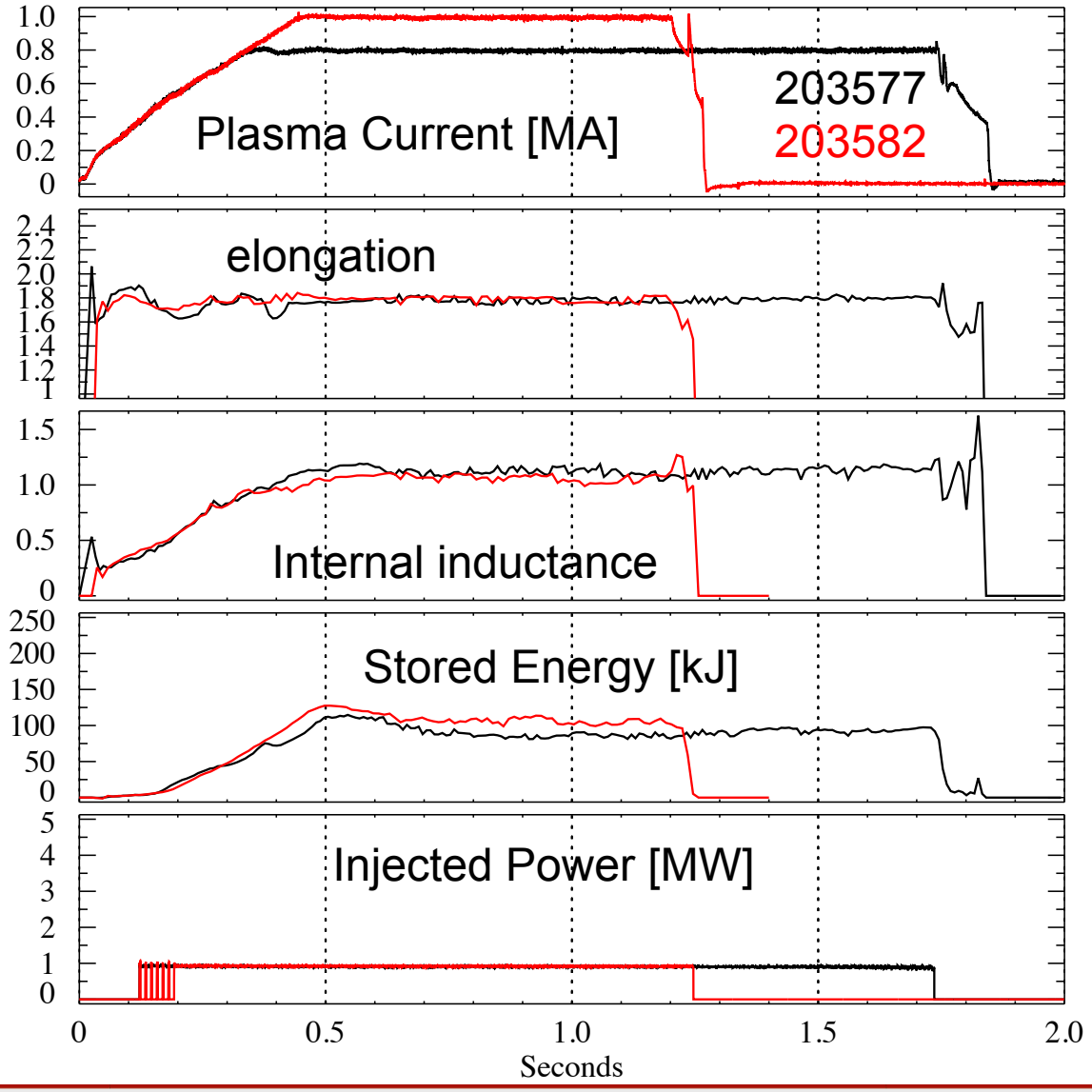




OH swings ± 19 kA
(80% of maximum flux)

DN plasma boundary is steady for > 1 second as OH swings:
0.66 seconds **1.73 seconds**

L-Mode discharges have run with I_p = 1MA for a 700ms flattop

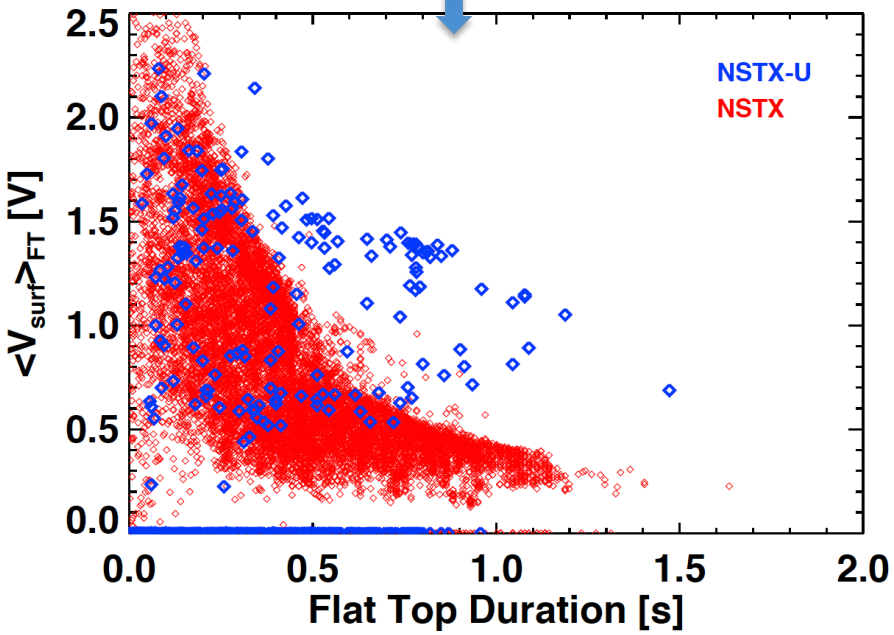


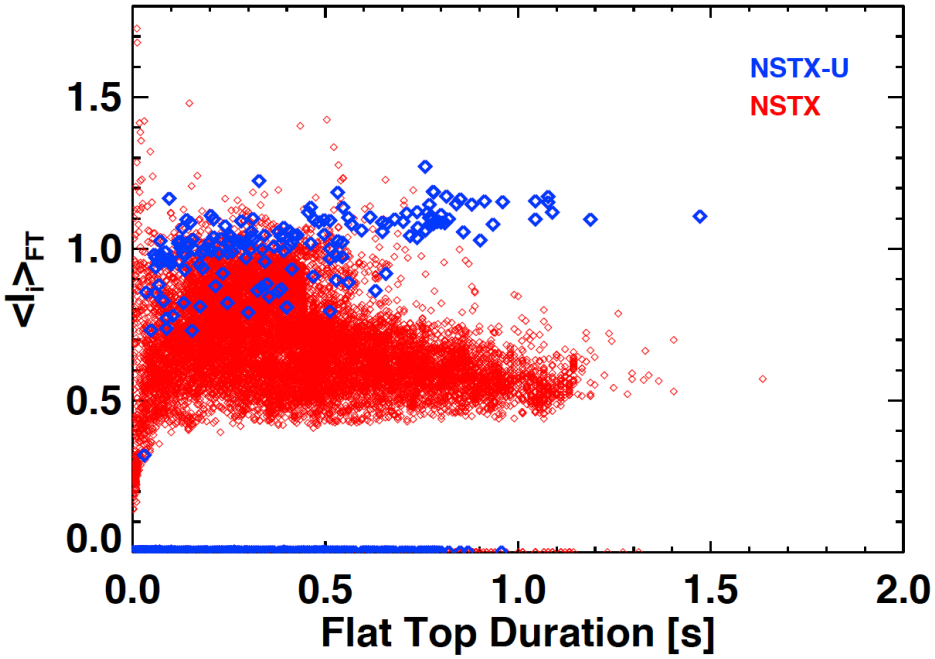
Both discharges have sawteeth and use the full OH flux swing

New Capabilities Already Evident When Flat-Top Averages Are Plotted

New solenoid has much greater capability

(and we are only allowing use of 80% of the available flux)





Can sustain L-mode plasma for physics studies much longer

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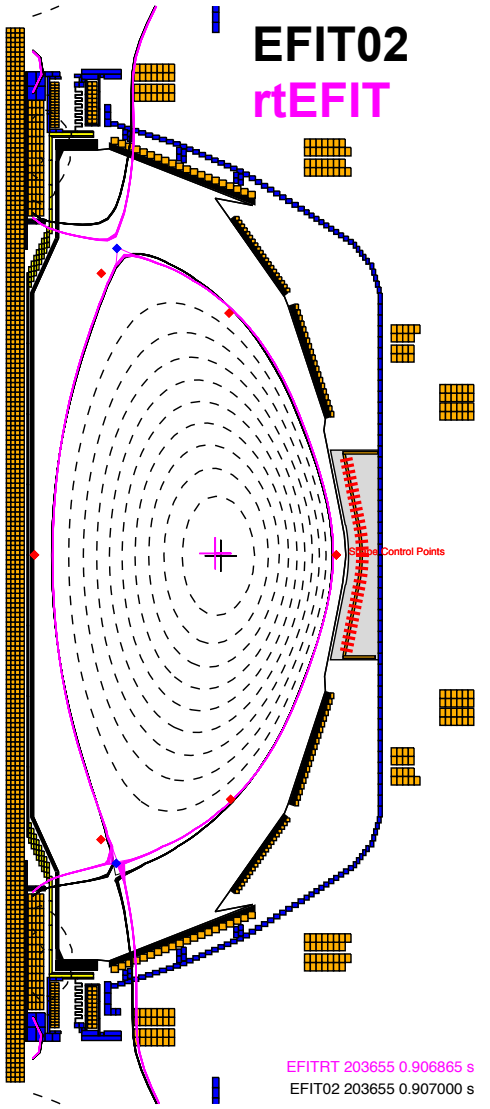
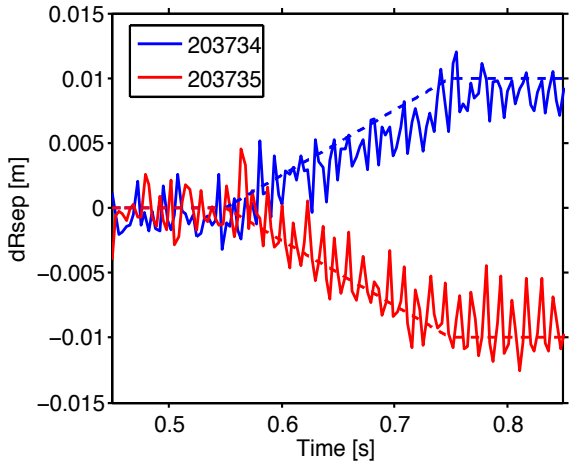
Scenario development enabled by commissioned control tools

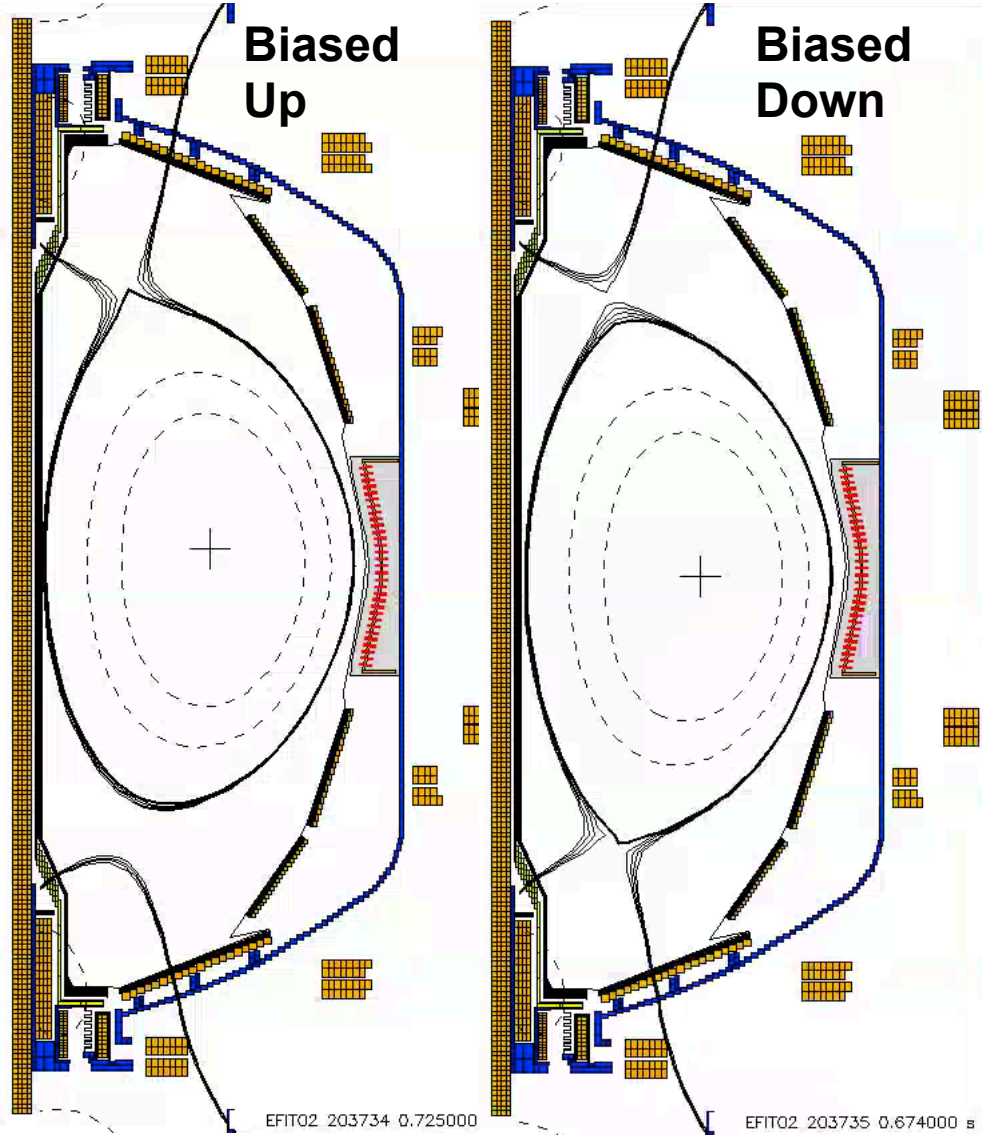
- rtEFIT / ISOFLUX shape control
  - See Dan Boyer's Science talk from 2/22
  - PF5 and PF3s control outboard boundary (outer gap, kappa)
  - X-points, inner gap controlled via PF1As and PF2s versus I_p and I_{OH}
- Improved vertical control tools
  - Multi-sensor Z*dZ/dt measurement
  - Filtering to remove power supply noise
  - Signal conditioning to improve signal-to-noise
  - Tools have not been fully exploited



On Friday, dr-sep control was demonstrated

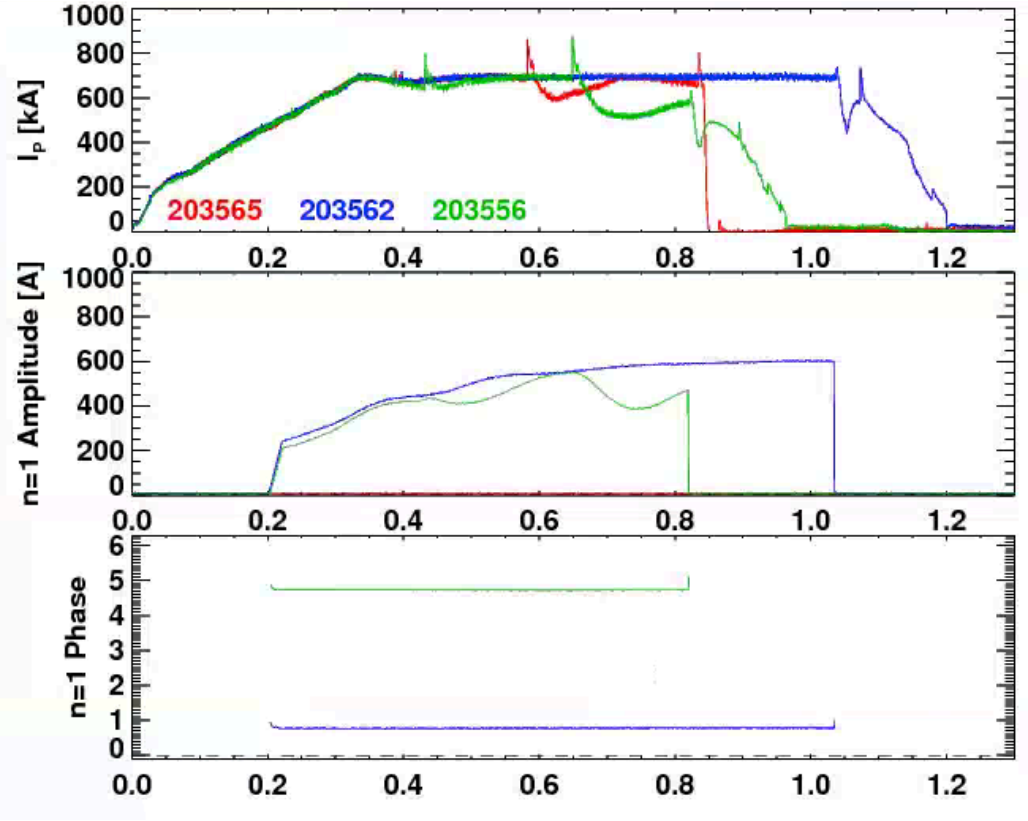
- dr-sep controls bias of plasma toward X-points
  - Critical parameter for boundary and pedestal physics studies





n=1 Error Field Correction Has Shown Success

- EFC proportional to PF5
  - See Clayton Myers Science meeting talk from 2/29
  - Correct for PF5 out-of-roundness
- n=1 fields applied with various phases
  - Reference shot 203565 disrupts at t=0.6
  - 203562 uses correcting phase, extended duration.
  - 203556 uses anti-correcting phase, shorter discharge.



Key Accomplishments of Second Operations Period

- Made rtEFIT a reliable tool every shot
- Commissioned ISOFLUX plasma control
  - Outer-gap control through the PF-5 coil.
  - Elongation control via PF-3 coils.
  - Vertical position and dr-sep control via PF-3 coils
- Improved fast vertical position control
- Developed error field correction strategy
- Developed long pulse and high current L-mode scenarios with ISOFLUX control
- Developed H-mode scenarios with ISOFLUX control, at higher elongation and reduced internal inductance