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Results from XP-602

"Long-pulse development at reduced density w/ EF correction" + impact of higher toroidal field operation

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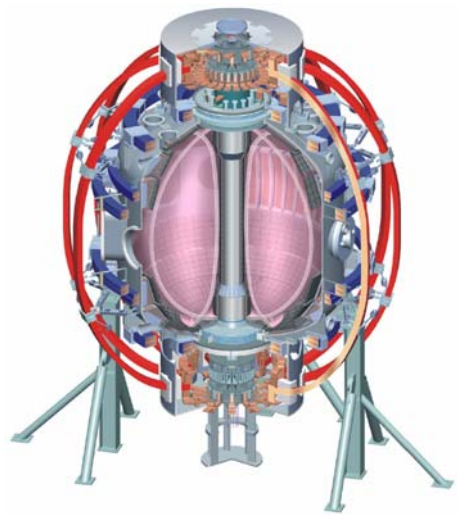
NSTX Results Review
July 26, 2006
PPPL – Princeton, NJ

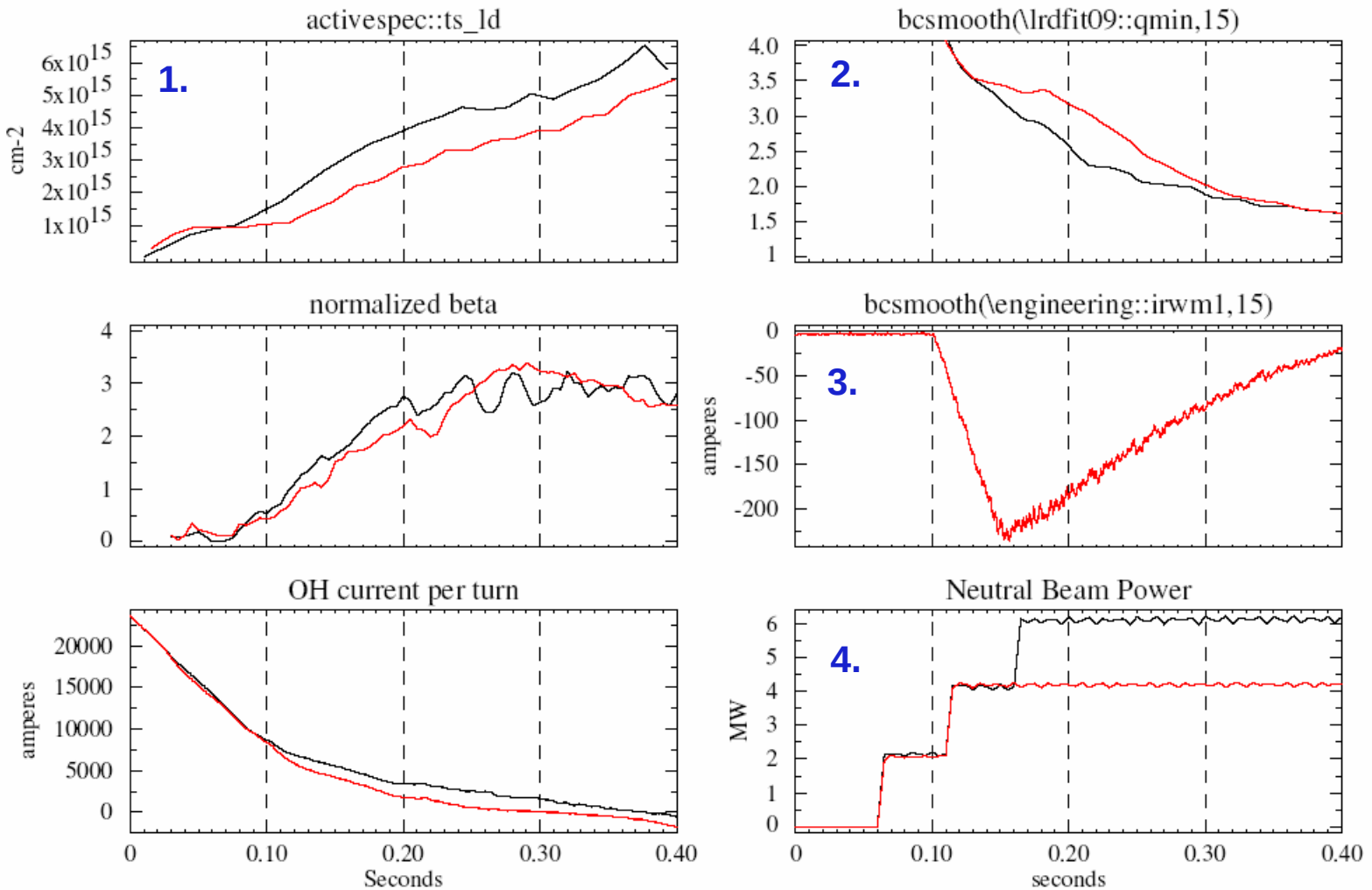


XP602: Long-pulse development at reduced n_e using EFC

Changed 2005 PF1B LSN reference shot 116313 to rtEFIT iso-flux control

1. Developed shot with 30% lower early density – lower fueling, delayed H-mode
2. q-min higher initially even with lower heating
3. EFC for OHxTF used from early phase of shot to end of shot
4. Lower P_{NBI} needed to avoid disruption in flat-top – 10-15% higher τ_E

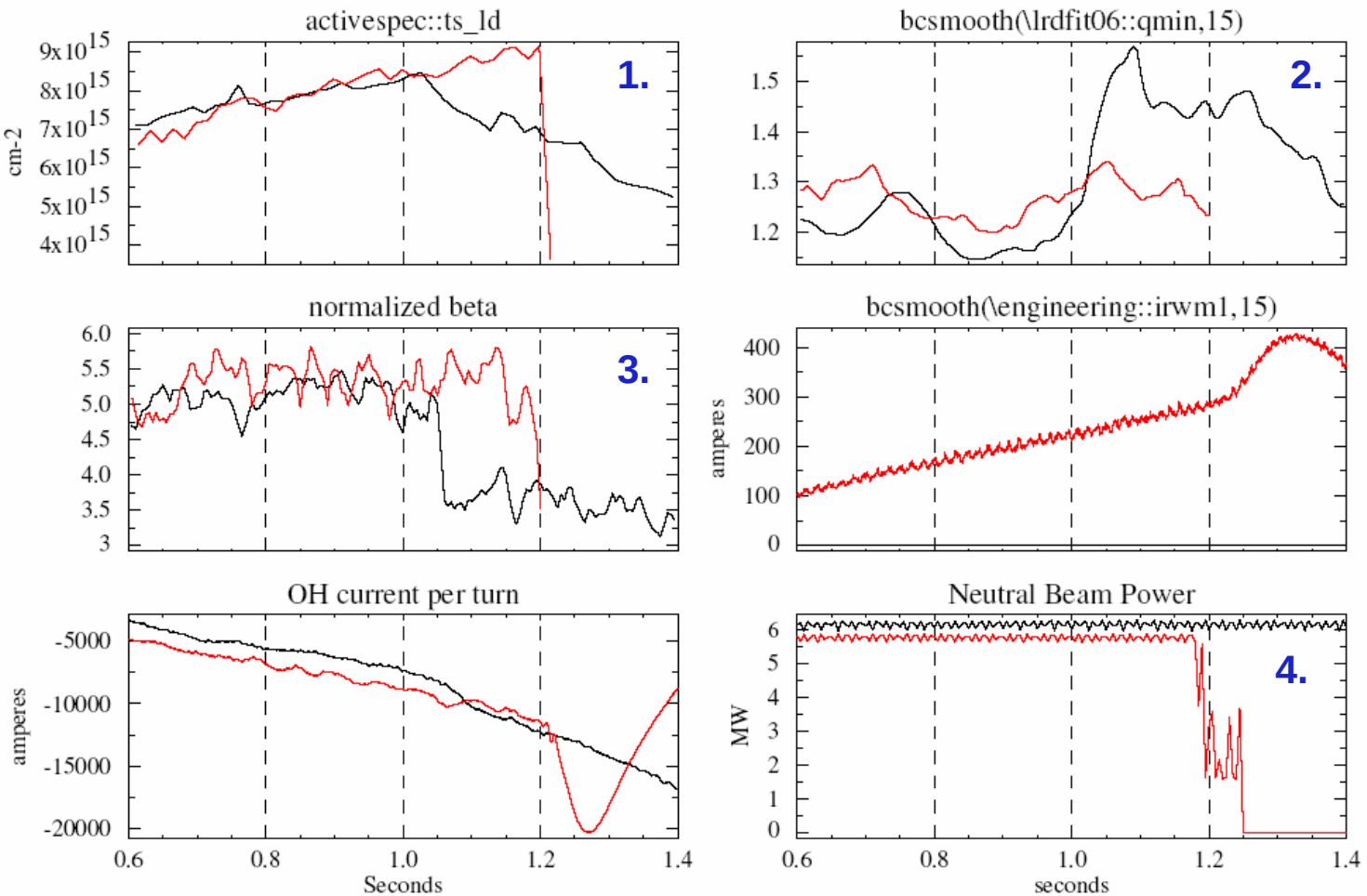
116313
119922



XP602: Long-pulse development at reduced n_e using EFC

1. Density eventually evolves to match 2005 reference value – need a pump!
2. q_{MIN} higher than reference from t=0.6-1s – due to delayed source C?
3. **High β_N sustained up to 1.2s – core n=1 delayed, from higher q_{MIN} ?**
4. …but NBI turned off prematurely + not enough run-time to revisit scenario

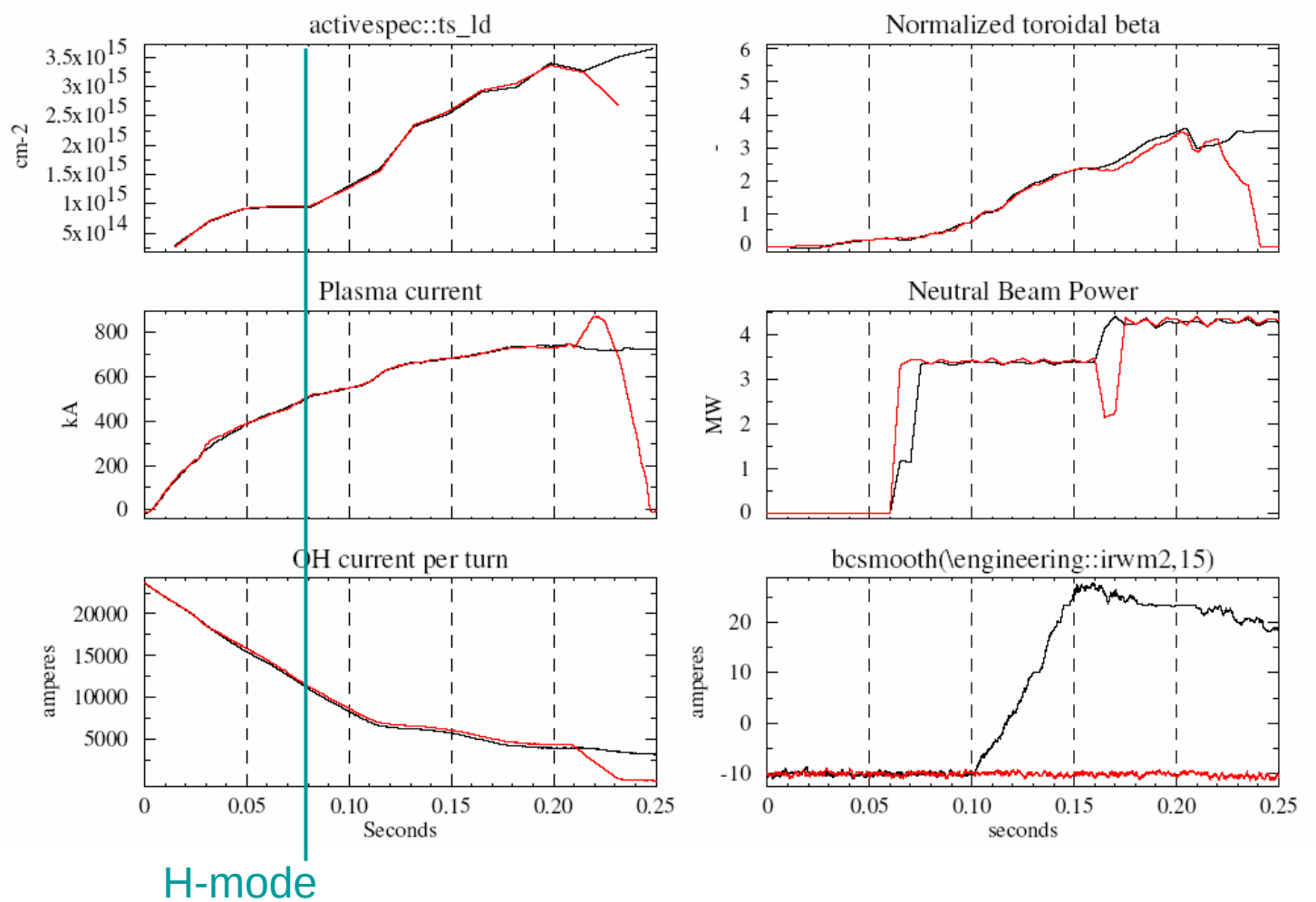
116313
119922



XP602: Long-pulse development at reduced n_e using EFC

1. Very early H-mode (85ms) has higher P_{THRESH} at reduced early density
   - Add 70kV Src C → 3-3.5 MW B+C by 60-70ms → transition by 85ms
2. Use as target to compare EFC to no EFC early in shot
3. **Applying early EFC may reduce disruptivity in rampup (see below)**

Shots:
120335
120341



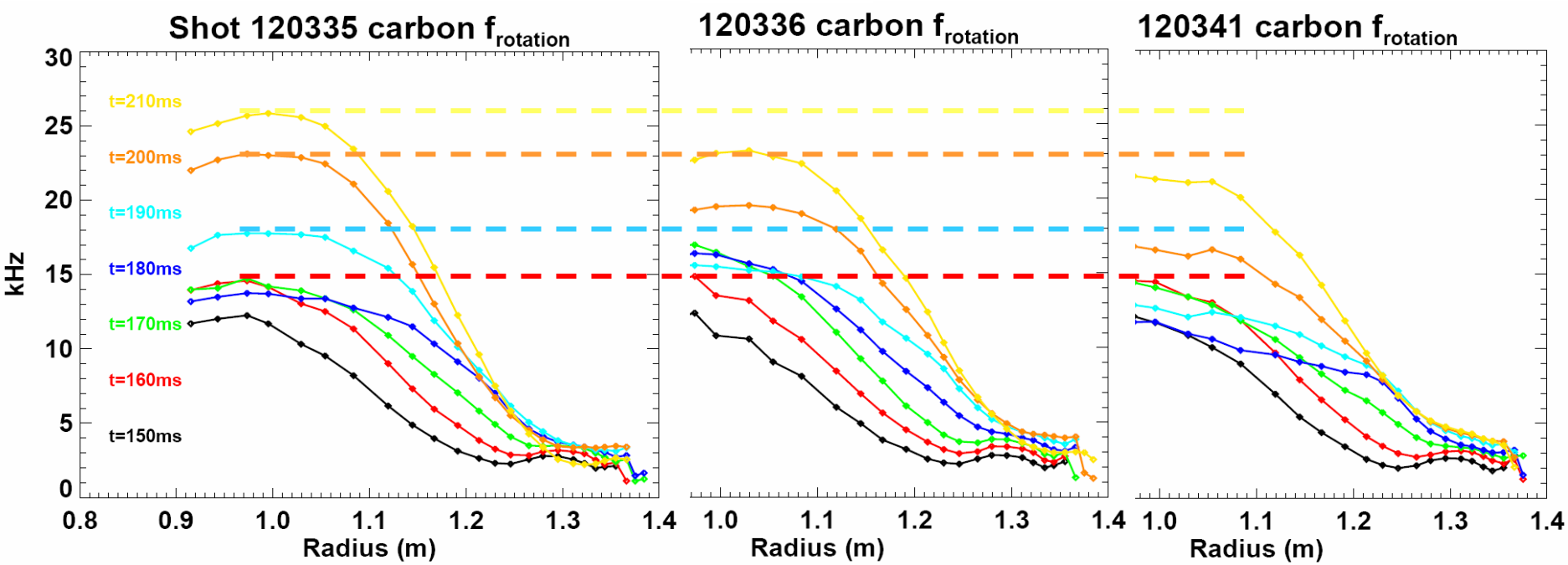
XP602: Long-pulse development at reduced n_e using EFC

1. Applying early EFC can increase early plasma rotation
   - For disruptive shot (120341), combination of no EFC and beam drop-out reduces rotation as much as 30%

Predictive OHxTF EFC on by t=150ms

No EFC

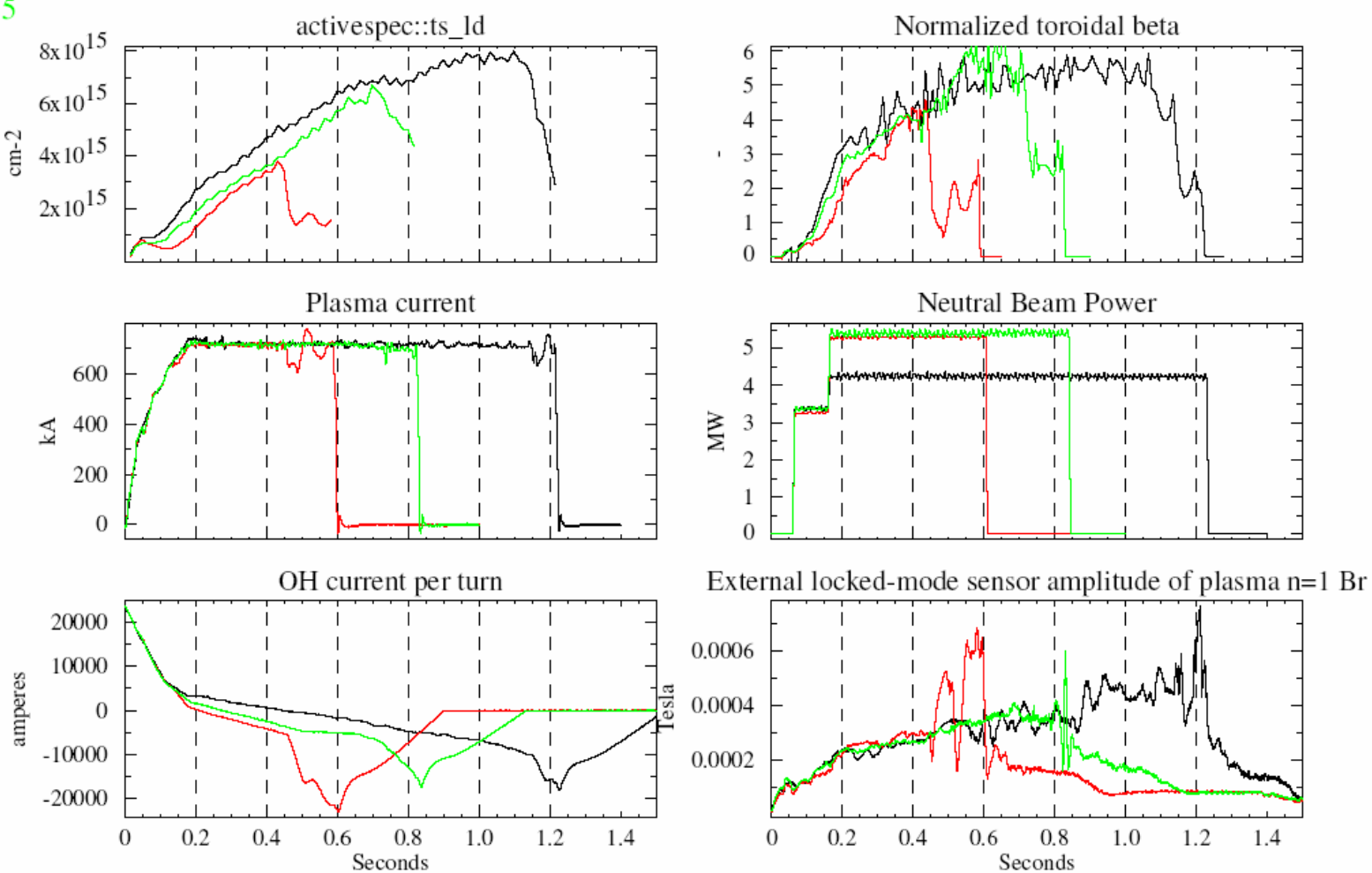
No EFC + 10ms beam drop-out



XP602: Long-pulse development at reduced n_e using EFC

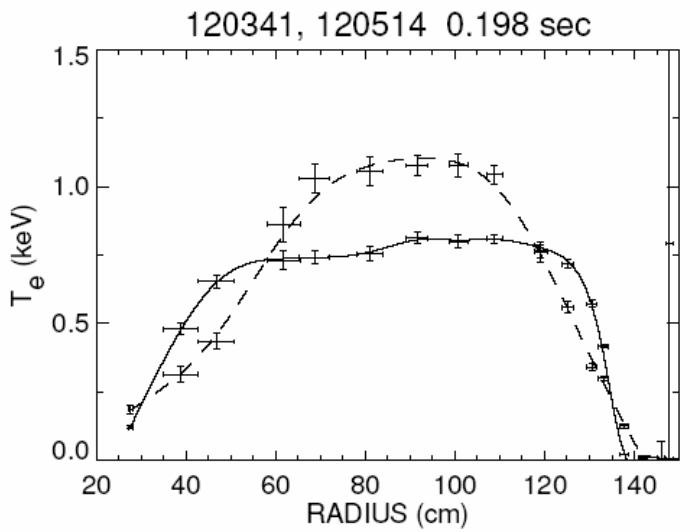
- He + Li conditioning lowers density 3x early in long-pulse
  - delayed H-mode increases flux consumption
  - beta limit apparently lower at lower early density (compare green/red)

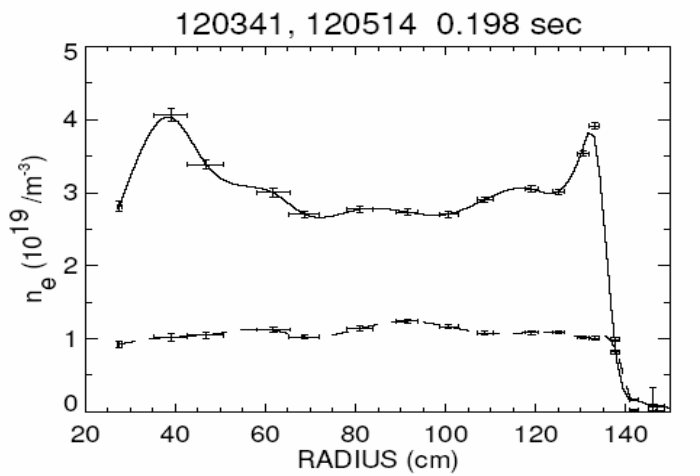
120339
120514
120515

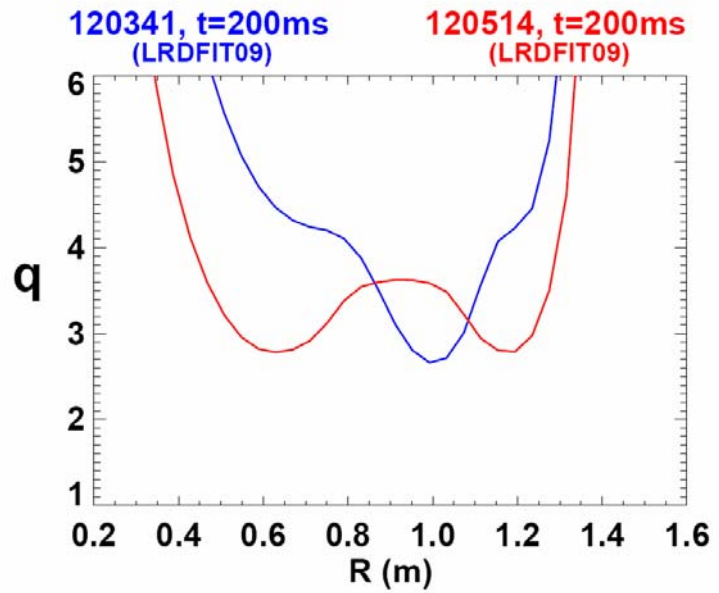


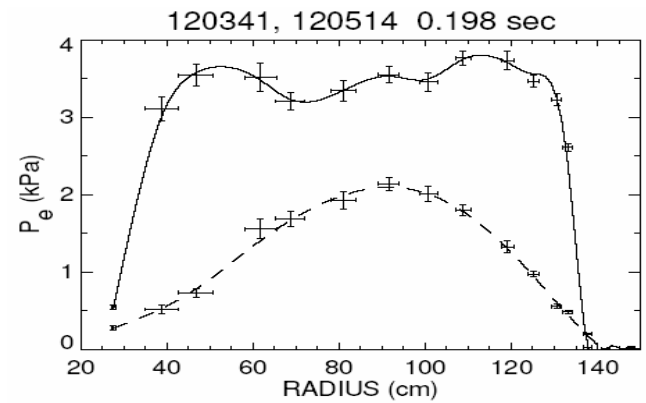
XP602: Long-pulse development at reduced n_e using EFC

- He +Li conditioning lowers density 3x early in long-pulse
  - delayed H-mode increases pressure profile peaking
  - Higher Te ←→ reversed shear → peaked p profile → lower β limits(?)





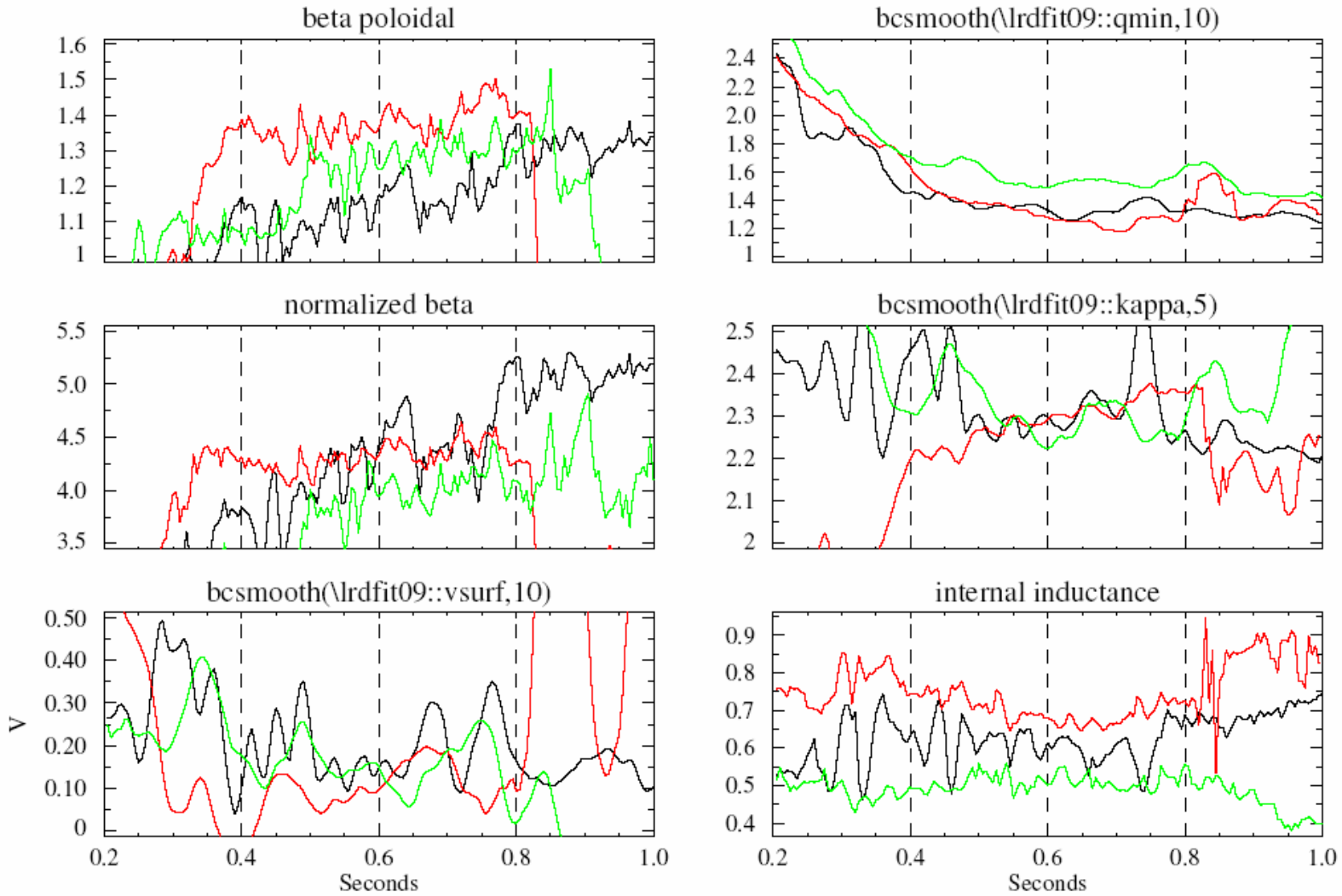




Higher B_T=5.2kG: developed quiescent 700kA shot w/ V_{SURF}=0.1V

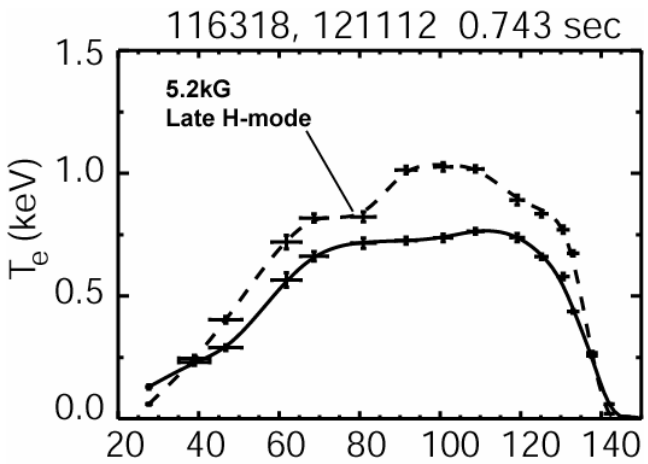
- Achieved higher β_P than 2005 reference, but peak β_N was lower
- 116318 = 4.5 kG, 700kA, 121112 = late H-mode, 121120 = early H-mode

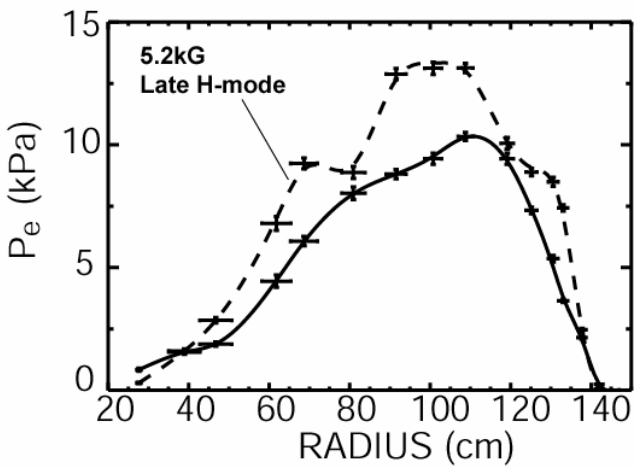
116318
121112
121120

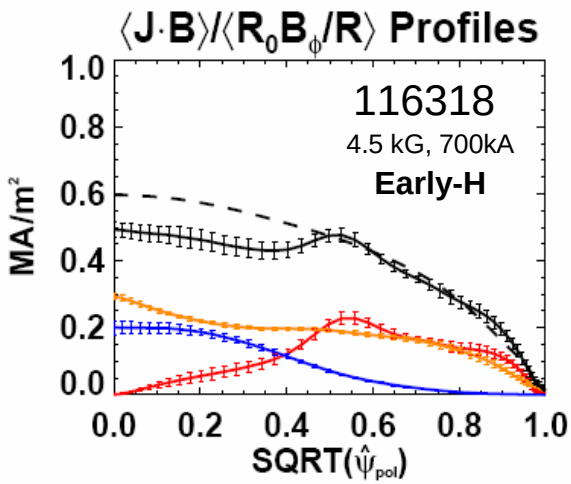


Current profile analysis consistent with modest increase in J_{BS} and NI current fraction – need higher β_P (κ, β_N, B_T)

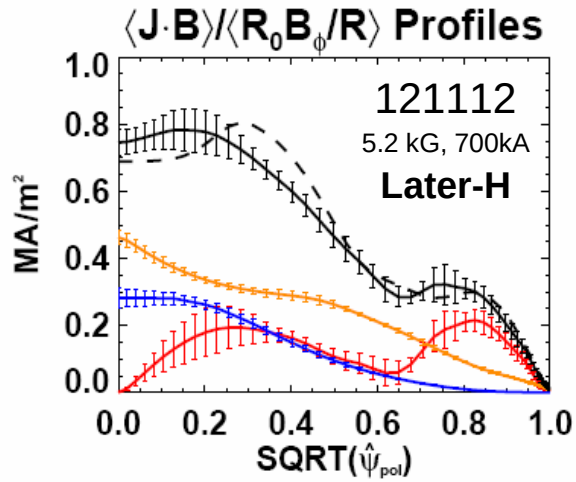
- Late H-mode (5.2kG) has higher central Te, lower ∇p_e at ½ radius from ears + core "barrier"
  $\Rightarrow$ Increased central J_{NBI} and J_{OH}, decreased J_{BS} at ½ radius → contributes to higher li
- Increase in f_{BS} consistent w/ increase in β_P $\Rightarrow$ **need higher β_P for more NICD at this n_e & T_e**







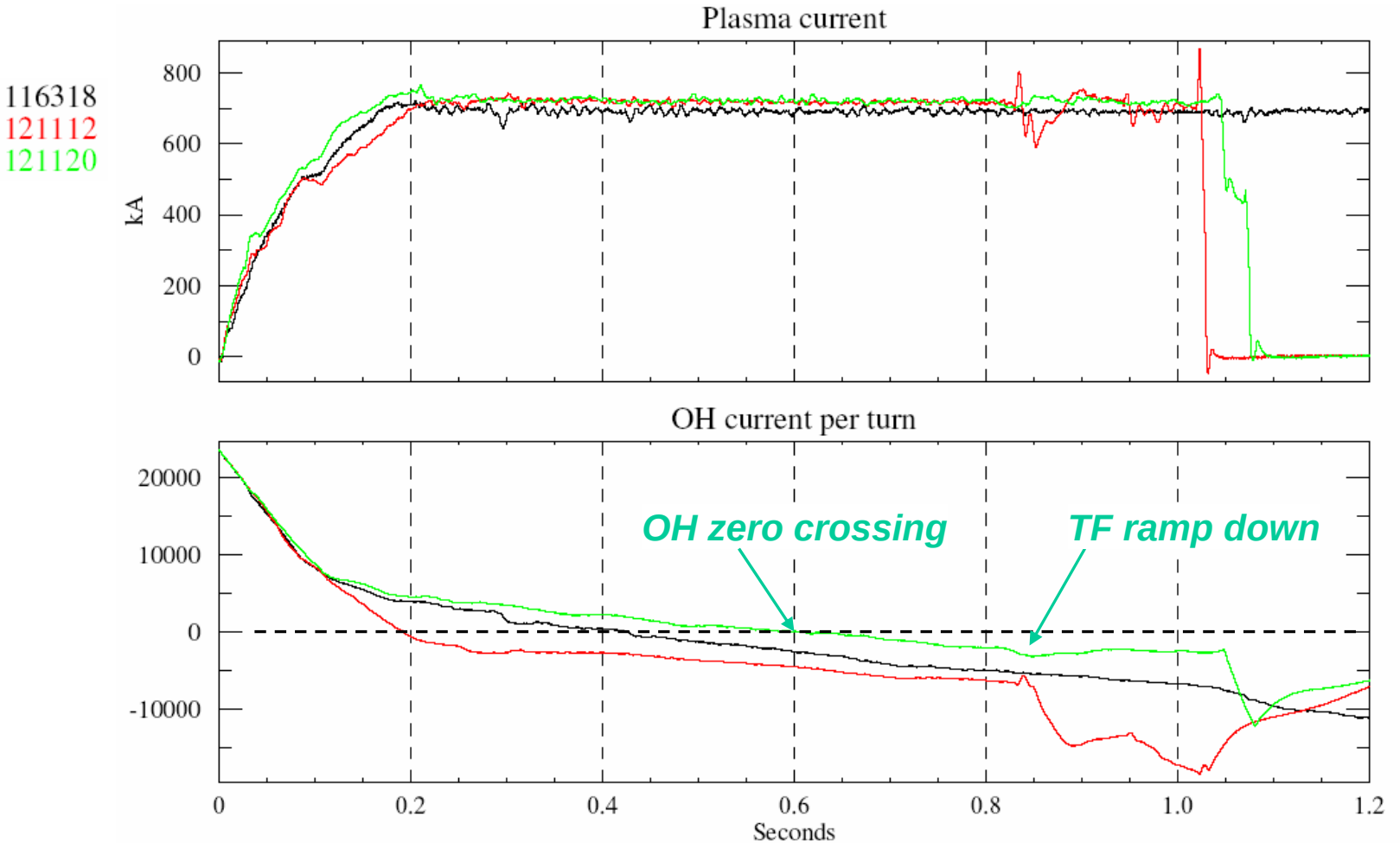
NI Total = 57.8%
BS = 42.2%
NBI = 9.45%
P.S.+Diam. = 6.10%
Ohmic = 41.9%



NI Total = 61.9%
BS = 46.7%
NBI = 10.5%
P.S.+Diam. = 4.77%
Ohmic = 38.0%

B_T=5.2kG early H-mode has very low early flux consumption

- 116318 = 4.5 kG, 700kA, 121112 = late H-mode, 121120 = early H-mode
- **NEED to increase confinement & β_N in early H-mode scenario**
  - **Get rid of continuous MHD (NTM?) in flat-top**



Summary

- Developed/explored scenarios with lower early density
- Predictive EFC helps to increase early rotation, modestly improving early stability of discharge
  - May be q-profile / scenario dependent
- Very low early density delays/eliminates early H-mode
  - Reversed shear + peaked pressure → lower stability limits
- Higher TF (i.e. q) increased β_P and f_{BS}
  - Need to optimize electron pressure profile shape (clip ears)
  - Higher β_N and κ could also help increase β_P and f_{BS}