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Development of High Non-Inductive Fraction H-Modes

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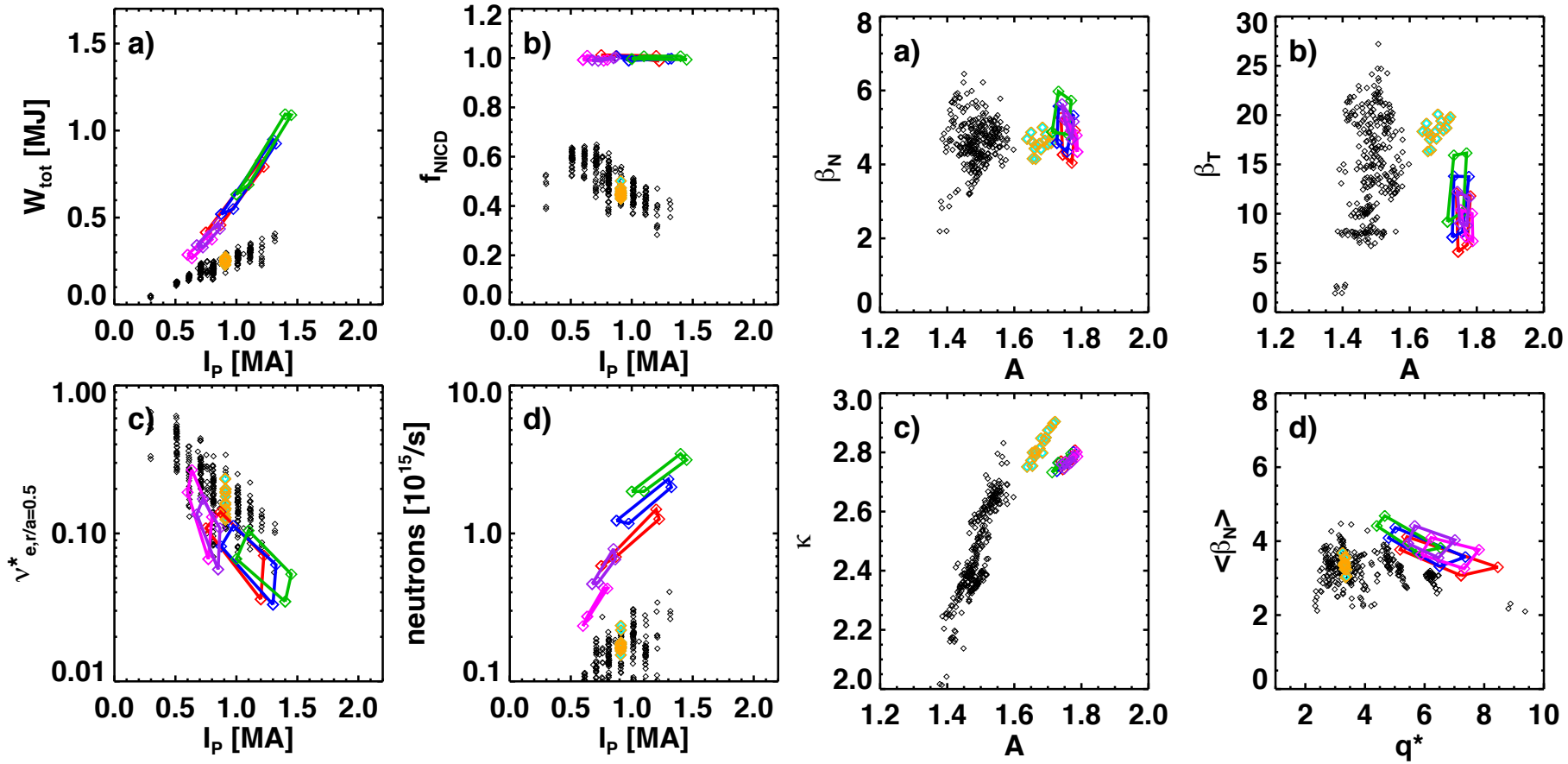
Outline and General Process

- Goal: Develop a high non-inductive fraction H-mode scenario, ideally achieving full non-inductivity.
- Features of the XP idea:
  - Fix the I_P request, and continue to do I_P feedback via the loop voltage.
  - Use standard inductive current ramps.
    - Develop the non-inductive state after SoFT.
  - Beam heating only…no RF requested.
  - Use the highest TF allowable.
  - 10-15 cm outer gaps, highest elongation that can be reasonably achieved.

Anticipate Developing 100% Non-Inductive Scenarios at the 500-700 kA Range



All: f_{GW}=0.7, f_{NI}=100%, 15 cm outer gap
6x80 kV, B_T=1 T
6x90 kV, B_T=1 T
6x100 kV, B_T=1 T
4x80 kV, B_T=0.75 T
4x90 kV, B_T=0.75 T

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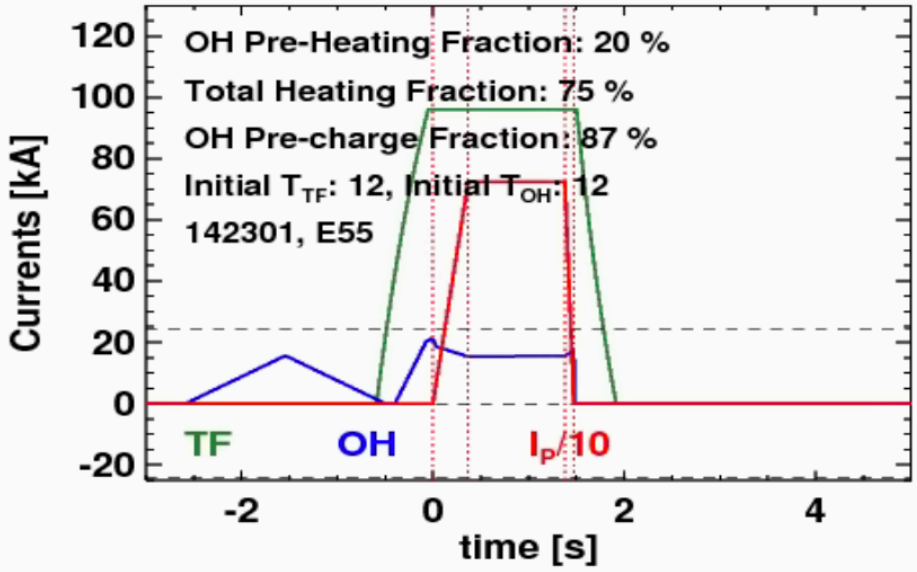
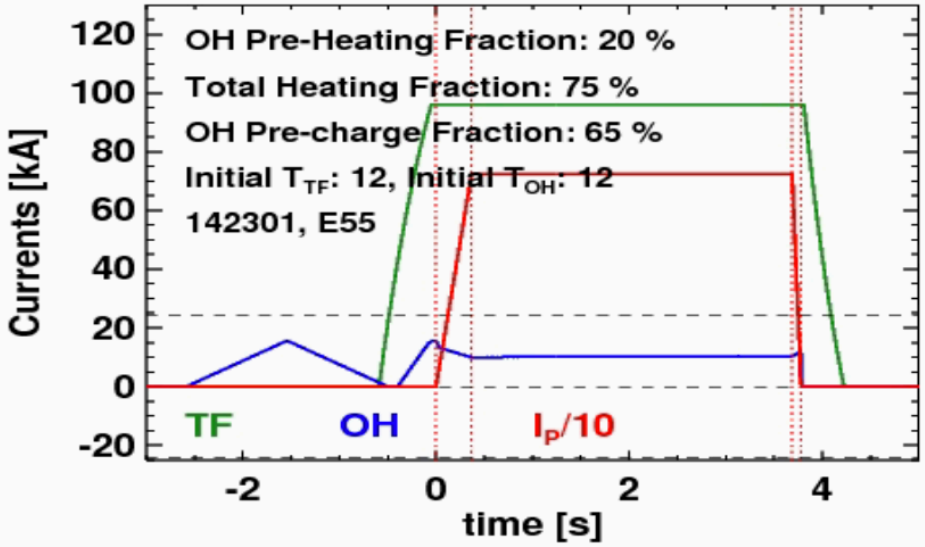
4x90 kV, B_T=0.75 T

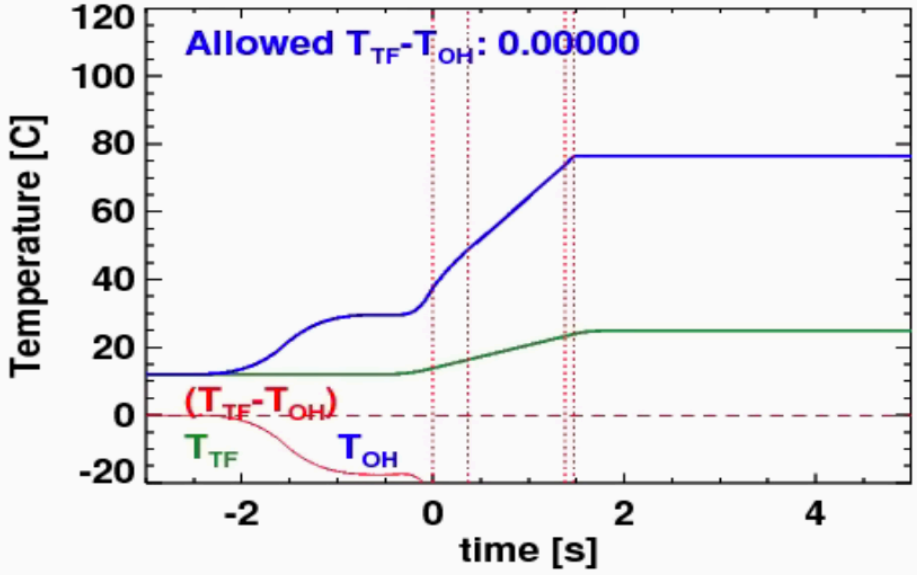
Discharge Considerations (I)

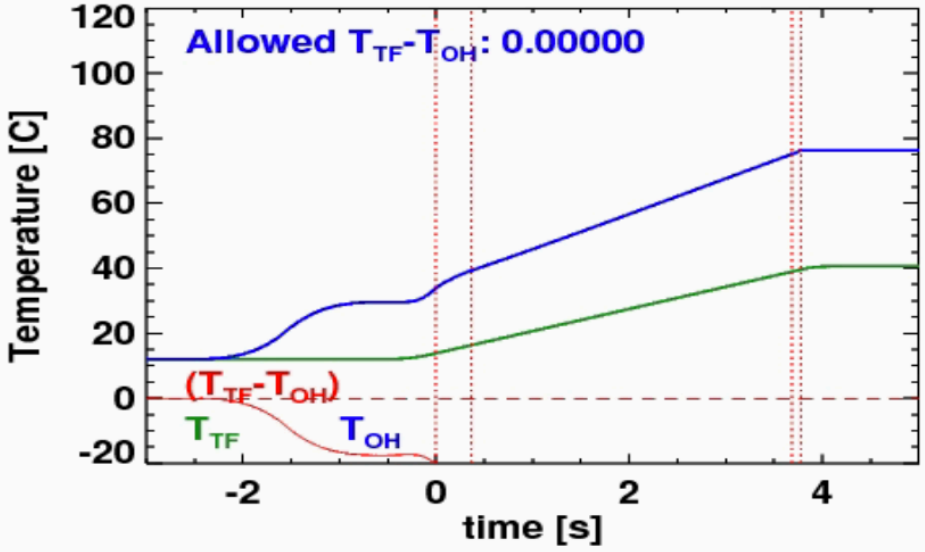
- Density: Target f_{GW}~0.6-0.8, but in the end will take what we can get.
  - Use whatever fuelling scheme seems most reliable at that time, but would prefer to minimize the HFS fuelling to the extent that it is possible.
- PFC conditioning:
  - Would prefer to do this in both Boronized and Lithiumized PFCs.
  - Boronized case with ELMs provides Z_{eff} control, but maybe D_2 accumulation.
    - Call this Day 1 in the later plans.
  - Lithiumized case provides higher confinement and D_2 control, maybe with too high a Z_{eff}.
    - Call this Day 2 in the later plans.
  - If the granule injector proves capable of triggering ELMs in the Lithiumized state, then may want to use that on a few shots.
- OH coil dynamics…will have essentially a flat I_{OH} waveform during the flat-top (And see next slides…)

Pre-Heating/Pre-Charge Scenarios…

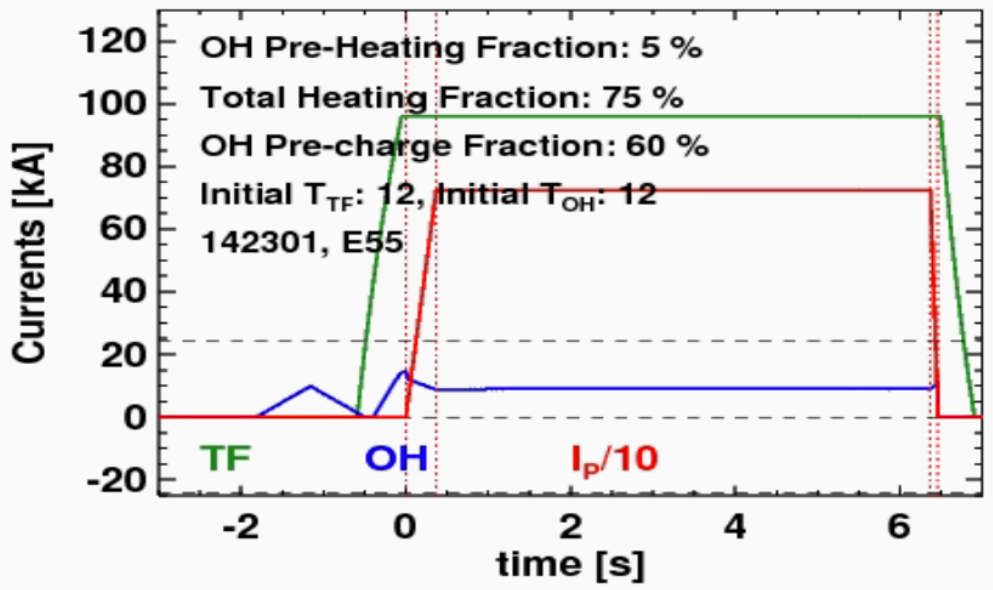


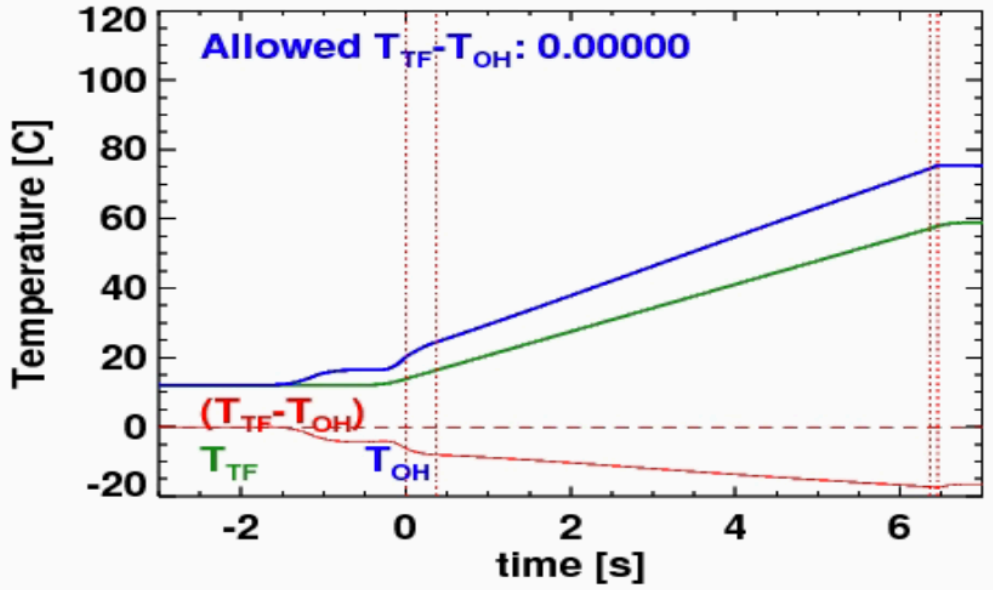






Pre-Heating/Pre-Charge Scenarios…





- Need to pick a value of the pre-charge that will result in OH heating at about the same rate as the TF heats.
- Can possibly tolerate only 5-10% pre-heat
- May want to have a small precharge, so that we swing through zero and have negative I_{OH} during the flat-top (?).
  - makes returning I_{OH} to zero easier.
  - Makes the scenario more forgiving to changes in the ramp-up flux consumption (?).
- Need a better code to model this…

Discharge Considerations (II)

- Shape
  - Will probably start with the highest elongation shot that exists.
  - If high enough, then may just leave it alone, otherwise may bump it up…
  - Increase the triangularity as much as possible, near or perfect DN shape.
- EFC and RWM control
  - Will probably use the best settings available…
- H-mode timing
  - Probably good enough if it is simply at SoFT, given the low current values.
  - Probably no need to optimize for earliest H-mode at these fields and currents.
    - Do not allow l_i to get too low!
- Diagnostics
  - Need both slow magnetics (reconstructions) and fast magnetics (MHD that can modify the CD)
  - "Required" Kinetic Measurements:
    - MSE-CIF, MPTS, S_n , Z_{eff}, filterscopes, and core bolometry measurements.
    - Willing to modulate to get CHERS data, but not sure what exactly to specify right at the moment.
  - Luxury diagnostics:
    - MSE-LIF, BES, FIDA, T-FIDA, S-FLIP, SSNPAs, various impurity spectroscopy

Roughest Shot Plan For XP (Slide 1)

- From modeling, determine a likely operating point.
  - Right now, I think 0.65 T, 600 kA, 6-8 MW made up of [60,70,130] + other sources.

Day 1 Plan: Boronized PFCs

- Step 1: Establish baseline at this field and current, ~65-75% of the baseline power.
  - Reduced power to start with in order to avoid hard beta limits.
    - Probably 4 MW of 1A and 2A if those are available.
  - Adjust fuelling, NB timing to achieve desired duration and density.
    - Need a minimum of 1 second of steady conditions, 2 seconds would be more desirable.
  - ***6 Shots***
- Step 2: Increase the power towards the non-inductive value, until either fully non-inductive, or reaching beta limit.
  - Might begin by adding 1B modulating 50% time, then go to 100%, then add 2B at 50%, then 2B 100%.
    - Will consider having 1C and 2C at 70 kV if modulations are not desired.
  - May need to drop fuelling to keep the density the same?
  - ***6 shots***

Roughest Shot Plan For XP (Slide 2)

- Contingency 1: If it becomes clear that non-inductivity is not possible at this current, then reduce the plasma current and power, and repeat the power scan.
  - Drop to 500 kA, use 4 MW total from 1A and 2A.
  - ***6 shots***
- Step 3: If a "near non-inductive" operating point is found, then:
  - Scan the beam sources around that operating point.
  - For different beam sources, make small modifications to the plasma current request around that operating point, to account for different beam current drive efficiencies.
  - ***6 shots***, for instance, if got 100% non-inductive with [1A,1B,2C], then:
    - Try [1A,2B,2C], 3 shots for current scan.
    - Try [1A,1B,2B], 3 shots for current scan.

Roughest Shot Plan For XP (Slide 3)

- Contingency 2: If non-inductive operating point is established at the target current (600kA?) then:
  - Raise current by 100-200 kA, keep input power level of the previously established non-inductive operating point.
    - 2 Shots
  - Increase beam power in increments to demonstrate a new non-inductive operating point.
    - 4 shots.
  - If new non-inductive point is achieved, vary beam selection and perform small I_P scans.
    - 8 shots

18 shots in steps 1-3
20 shots in contingency
28 total shots
3 shots/hour * 8 hours = 24 shots

Day 2 Plan: Lithiumized PFCs

- Repeat Day 1 plan