Session Identifier: S*46* – ‚NBI heating/NC transport‘

Primary aims: 1) Characterise NBI heating/fuelling (> 1sec NBI)
2) Explore Er changes and power to ions/electrons with NBI vs ECRH

Some changes of boundary conditions:
- Much of P_{ECRH}/n_e parameter space already covered by S25-S30.
- NBI Extension already to 1.2s in High Mirror, probably to 6s by S45.
- 30MJ energy limit in High Mirror due to Baffle heat load.
  --> *Keep ECRH phases as short as possible to avoid waiting for cool down.*
- Only modest dT_i and dE_r (core) seen in most cases of NBI.
- Significant NBI heating (Wdia / Ti) seen in some extreme cases, mechanism and differences not yet fully understood:
  - ion-electron heat coupling (Ti ~ Te) ?
  - Electron temperature gradients?
  - Only at low density?

- Switch of S46 and S47: LBO on MPM, rather than FILD: Impurity transport but no fast ion loss .
  +liva_001 B Measurements, (TESPEL would be good!, covered in S40?)
  +???? (Transport group, LBO, TESPEL??)
  -boz_024 Measurment of fast ion losses wth FILD in H-plasmas
  -sjamsa_010 Measurement of fast ion loss-patterns and validation of ASCOT predictions

We need to compare NBI fuelling/heating/E_r in corners of operating space.
with profile and transport measurements in all cases:
- TS, CXRS, XICS: Te/Ne profiles
- CXRS: He, C, O, B profiles
- CXRS, XICS, Reflectometry: Radial field
- LBO: Impurity injection for impurity transport
- Turbulence measurements??

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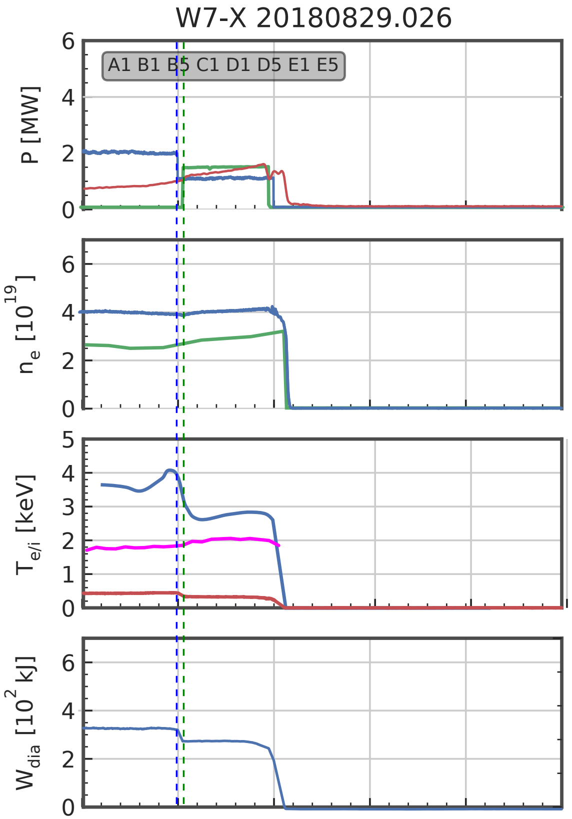
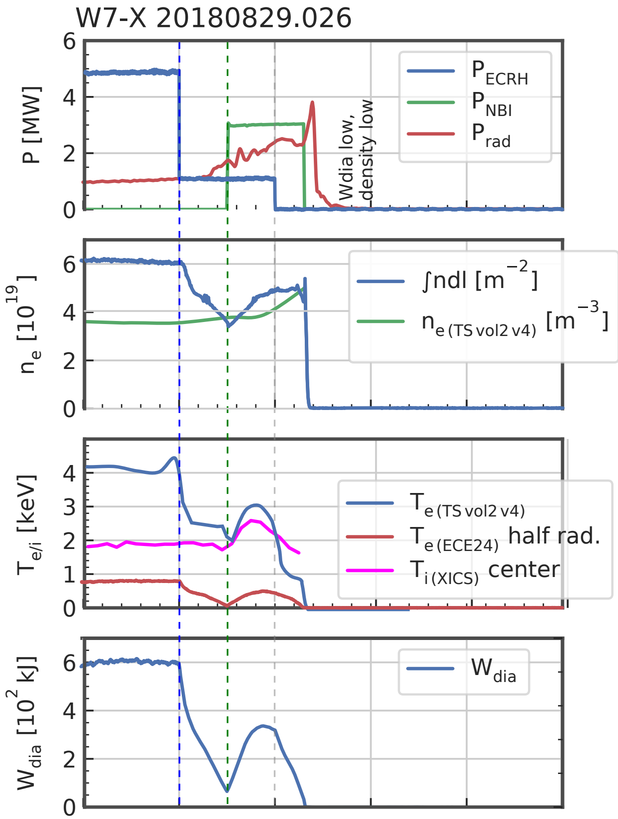
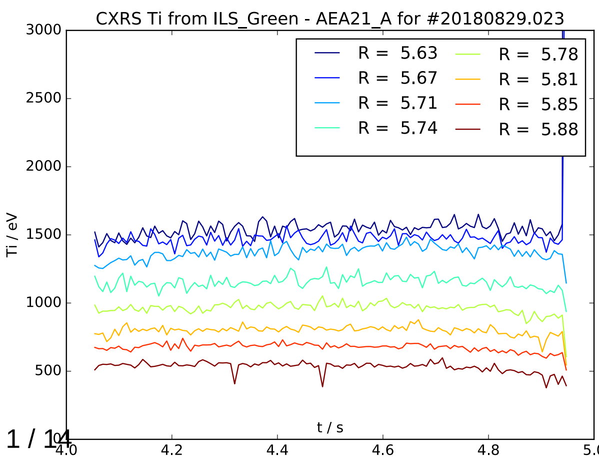


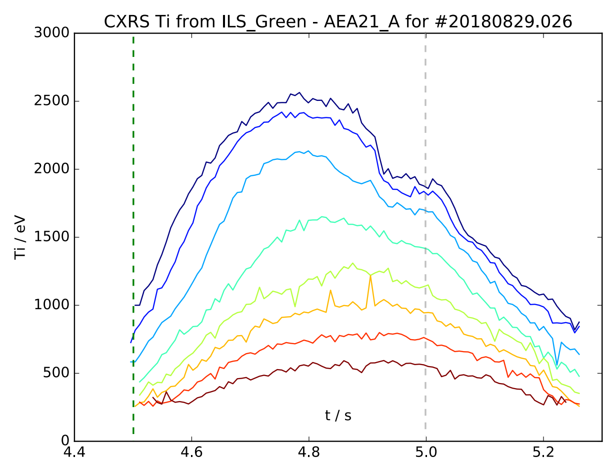


- Significant NBI heating (Wdia / Ti) seen in some extreme low n_e cases. 29.8.18, #23, #26

Similar conditions other than Te profiles, $2xP_{NBI}$ but 10x dTI:

	#23	#26
P_{ECRH}	1MW	1MW
P_{NBI}	1.5MW	3MW
ne dl	$4x10^{19}$	$3.5x10^{19}$
Core ne	$3x10^{19}$	$3.5x10^{19}$
Core Te	3keV	2.5keV
Core Ti	2keV	2keV
Edge Te	500eV	100eV
dTi	**100eV**	**>1keV**





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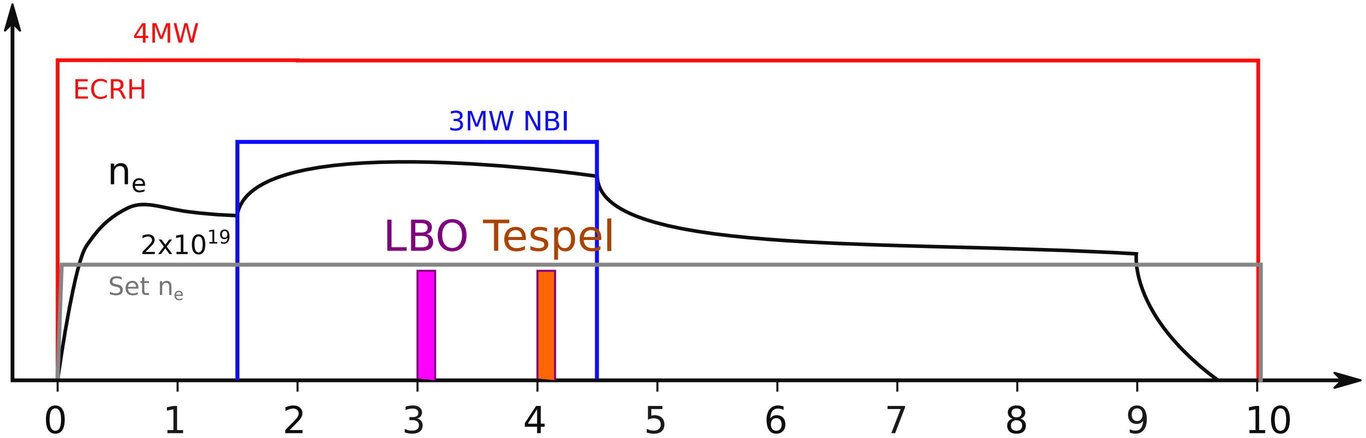
Cleaning discharges to get down to ne < 2.5e19

#1-3

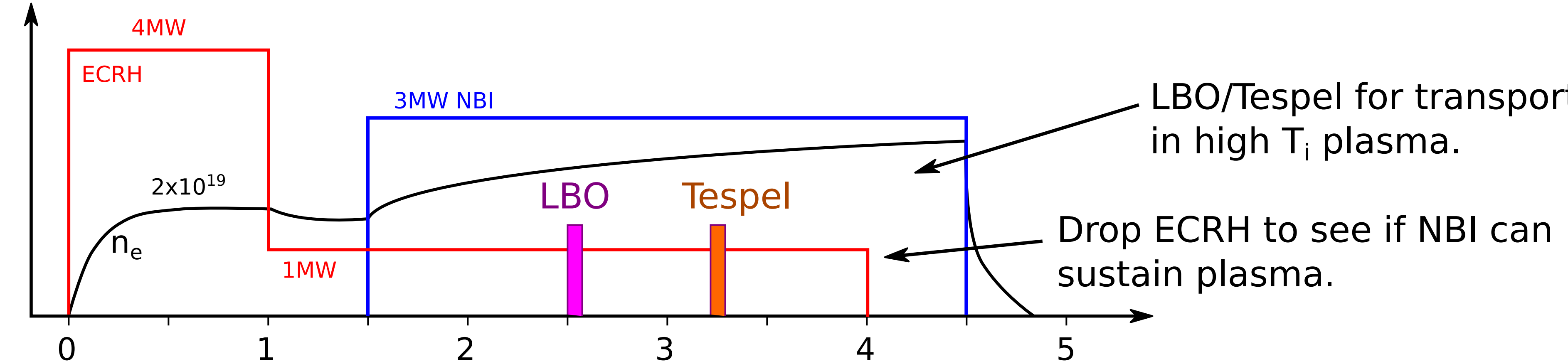


Alternatively: Just use reference discharge.
If NBI is still preparing at this stage, don't wait and run without NBI.

Session Identifier: S*46* – ‚NBI heating/NC transport'

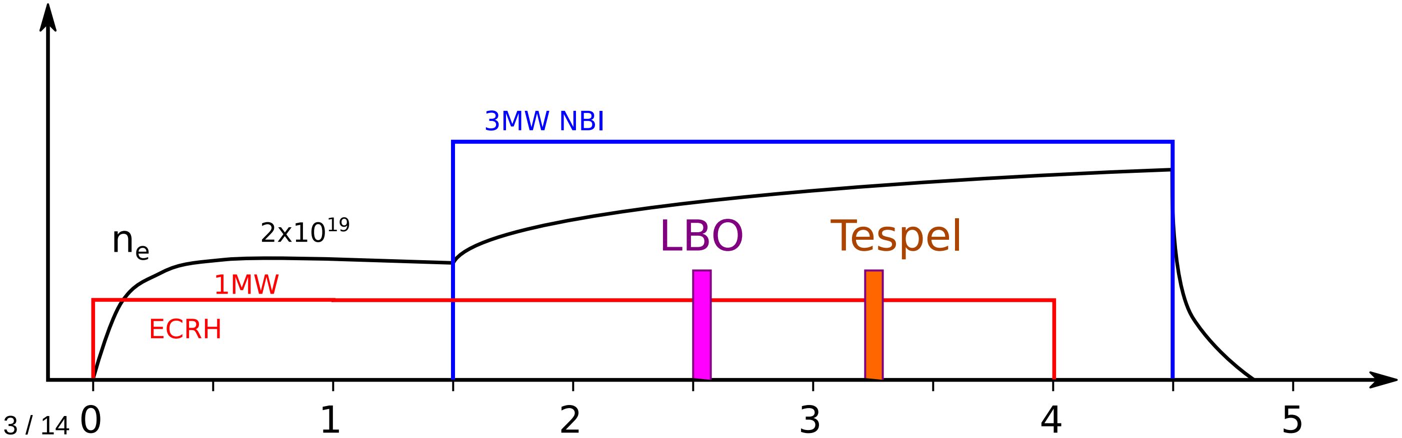
Task 1: Reproduce high heating shot in simpler (not dying) plasma:

#4

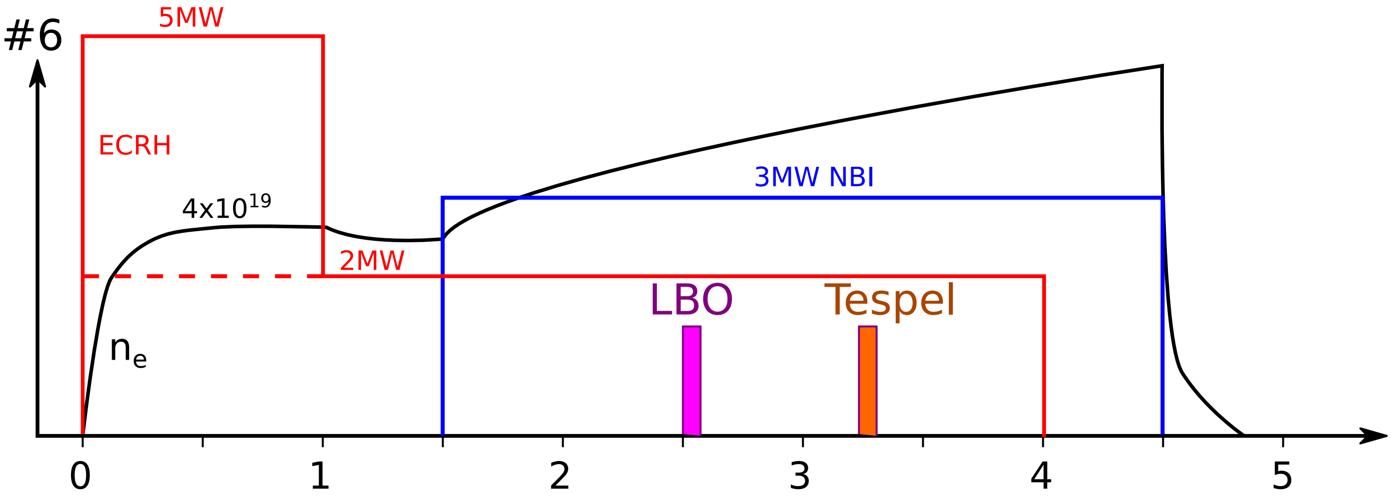


Q: Is only low-n_e important, or do T_e gradients, T_e vs T_i matter?)
Repeat without ECRH step-down:

#5



Repeat at higher n_e / P_{ECRH}:



Contribution to proposals:
- dih_008 NBI characterization
- olfo_010 NBI fuelling characterisation
- ajvv_001 Passive FIDA measurements at W7-X
- liva_001 Core low-Z impurity and transport (He, C, B, N)
- npablant_014 Core energy and impurity transport with NBI
- olfo_016 Parallel ion flow vs. neoclassical predictions
- ???? - Impurity injection.

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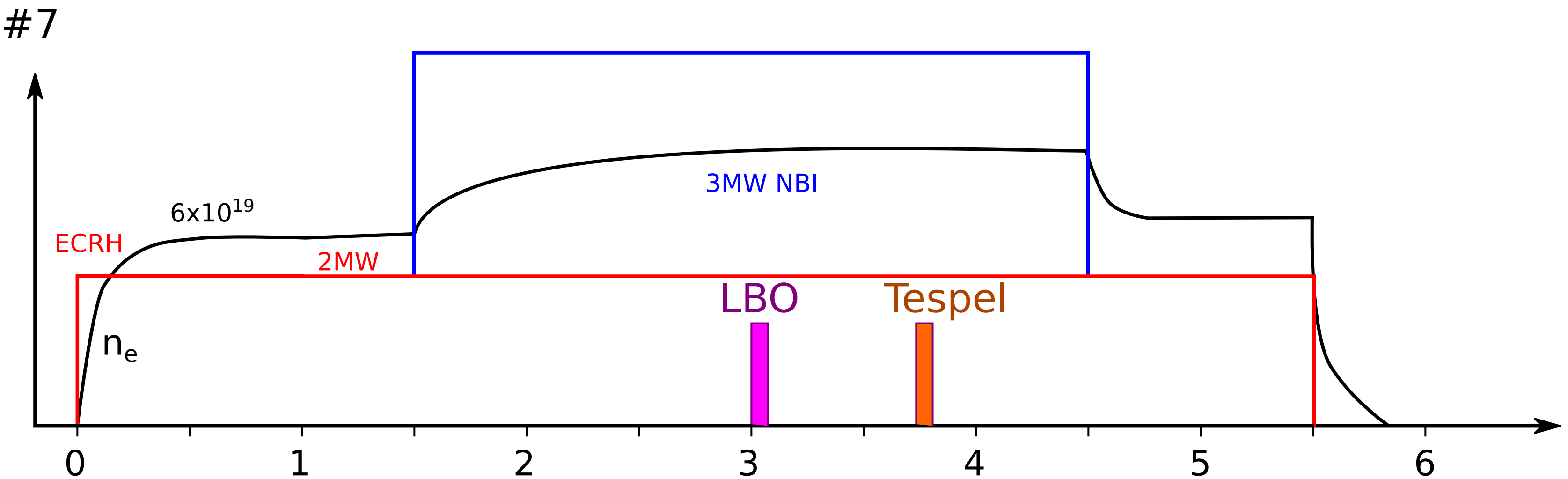
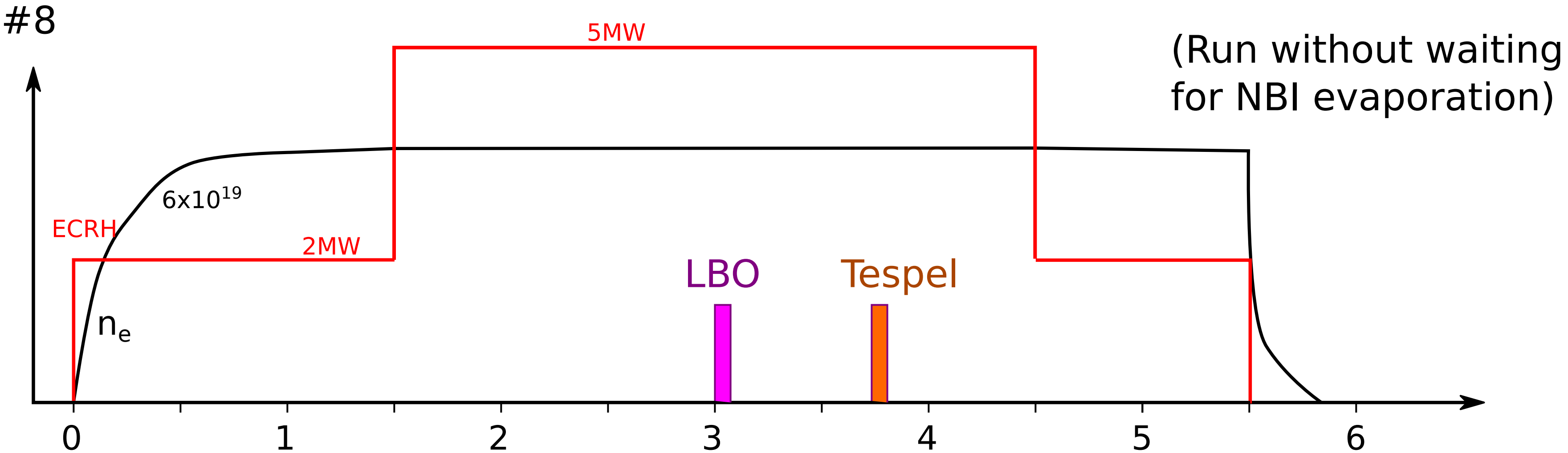
Task 2: Direct comparison of dW_{Dia}, dT_i in 3MW NBI vs 3MW of ECRH step:



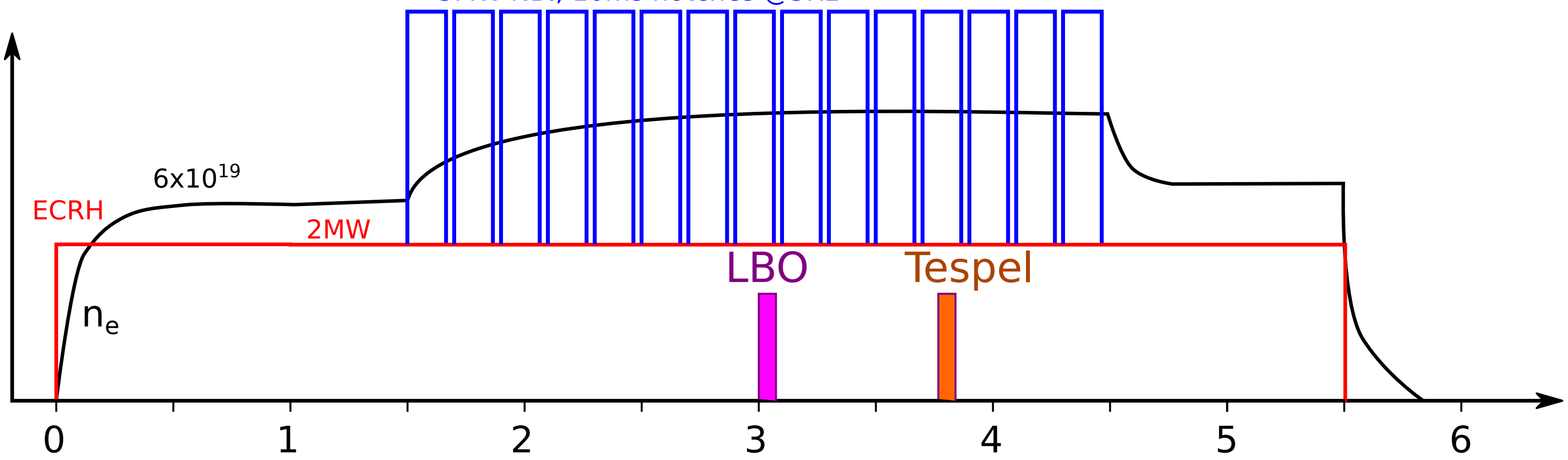
Repeat, setpoint n_e to same as NBI fuelling achieved (to remove n_e effect from W_{dia}):



Session Identifier: S46 – ‚NBI heating/NC transport‘

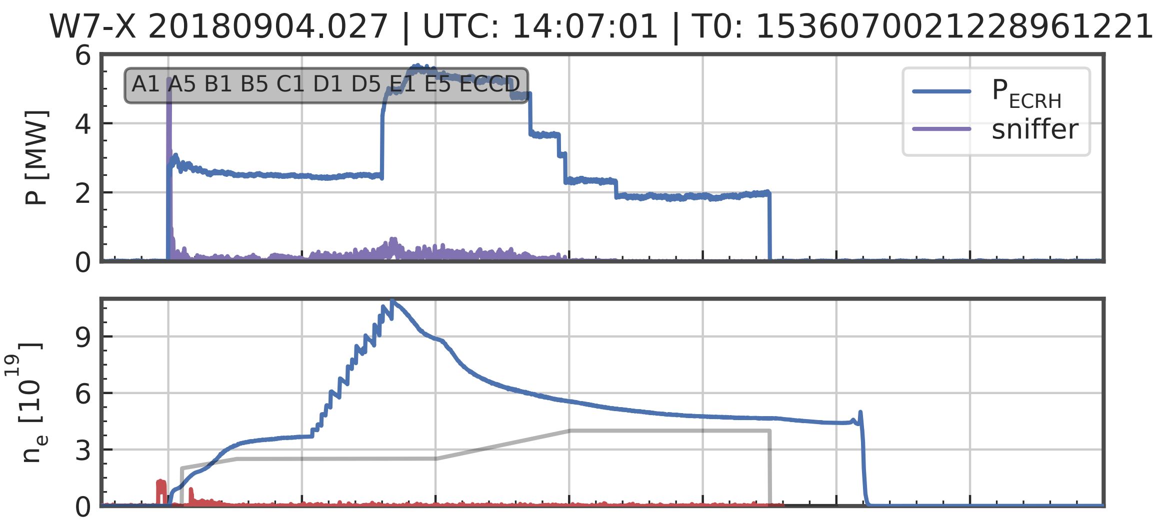
Task 3: Do notches/modulation significantly inhibit dW_{Dia} rise (as in 20180821.20)

#9

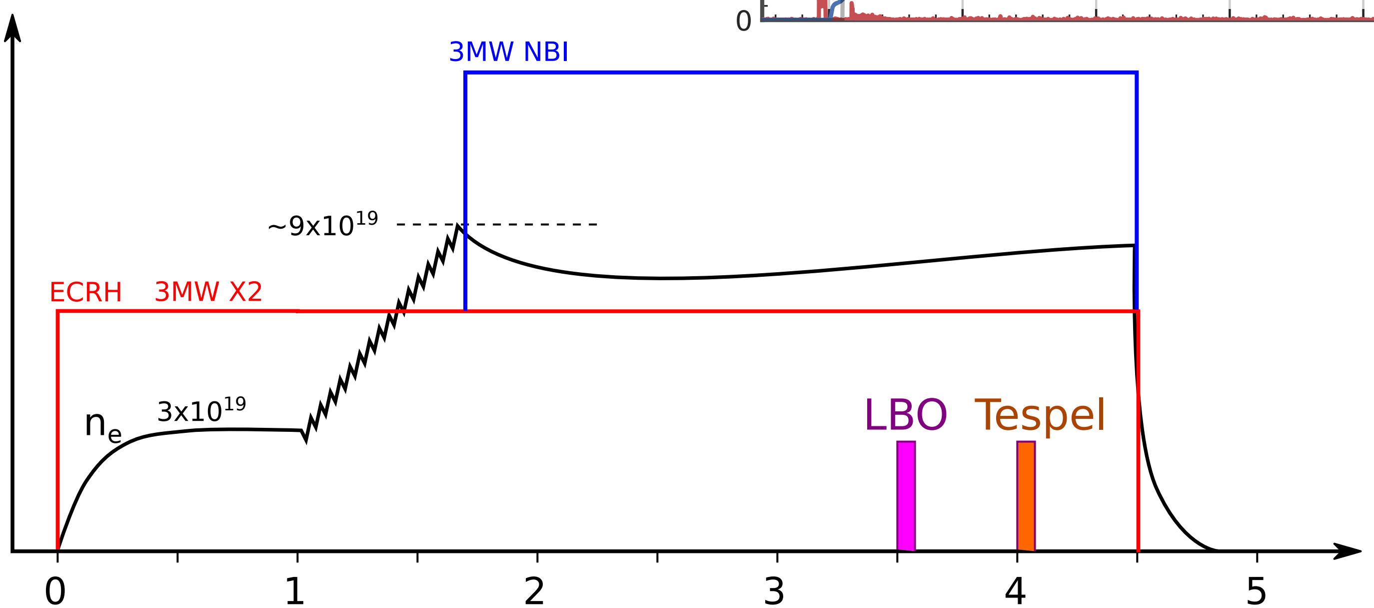


Task 4: NBI Fuelling: NBI deposition into peaked ne profiles (after pellets):
Repeat #20180904.27, replacing ECRH step-up after pellets with NBI:

(X2 only, ne stays below cut-off)



#10, 11, (12)



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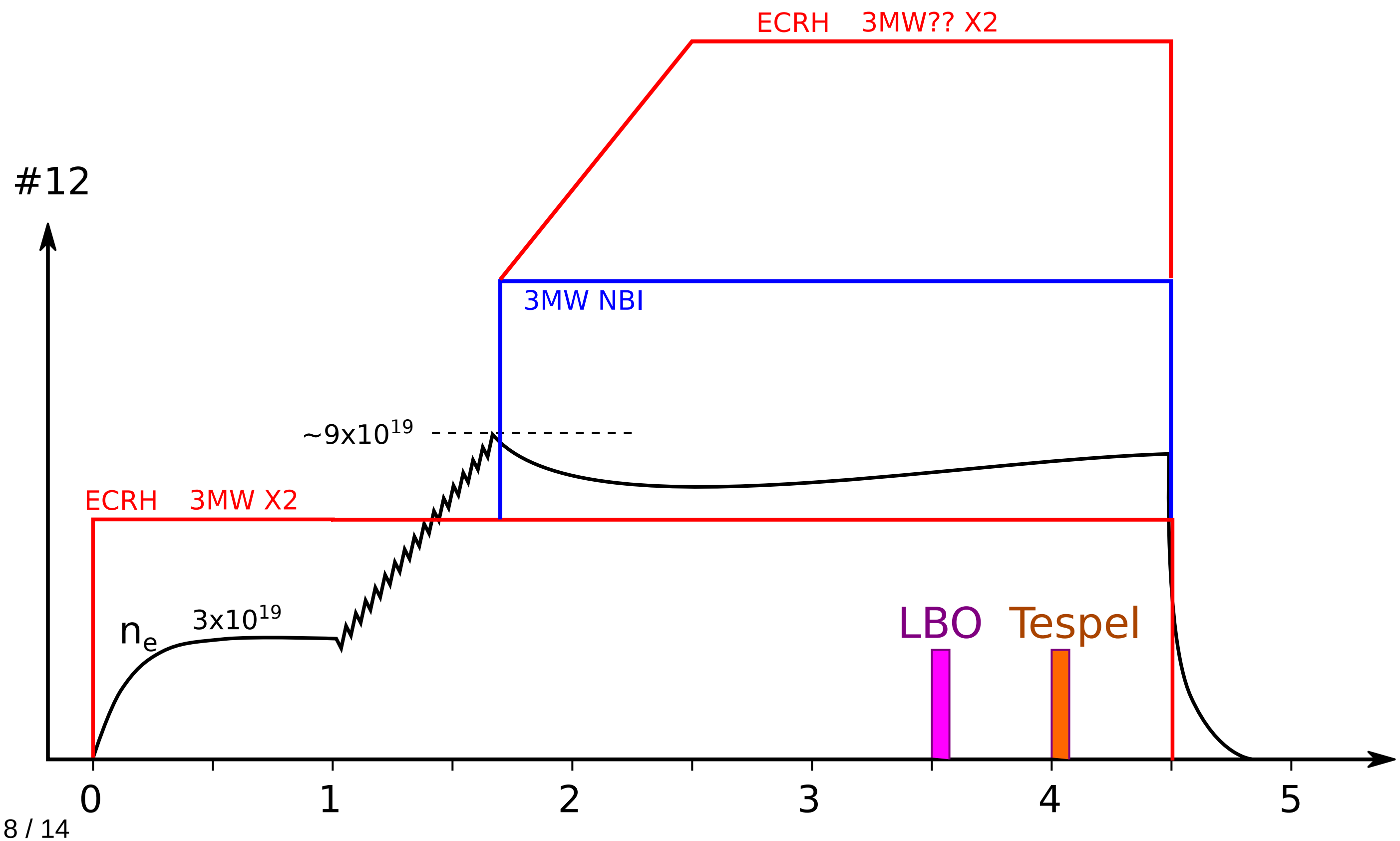
If #10/11 successful in 2 shots:

#12: Repeat including ECRH for corner n_e/P_{ECRH} point (P_{tot} = 8MW)

As in S47 (previous), possibly with ECRH ramp

(X2 only, ne stays
below cut-off)



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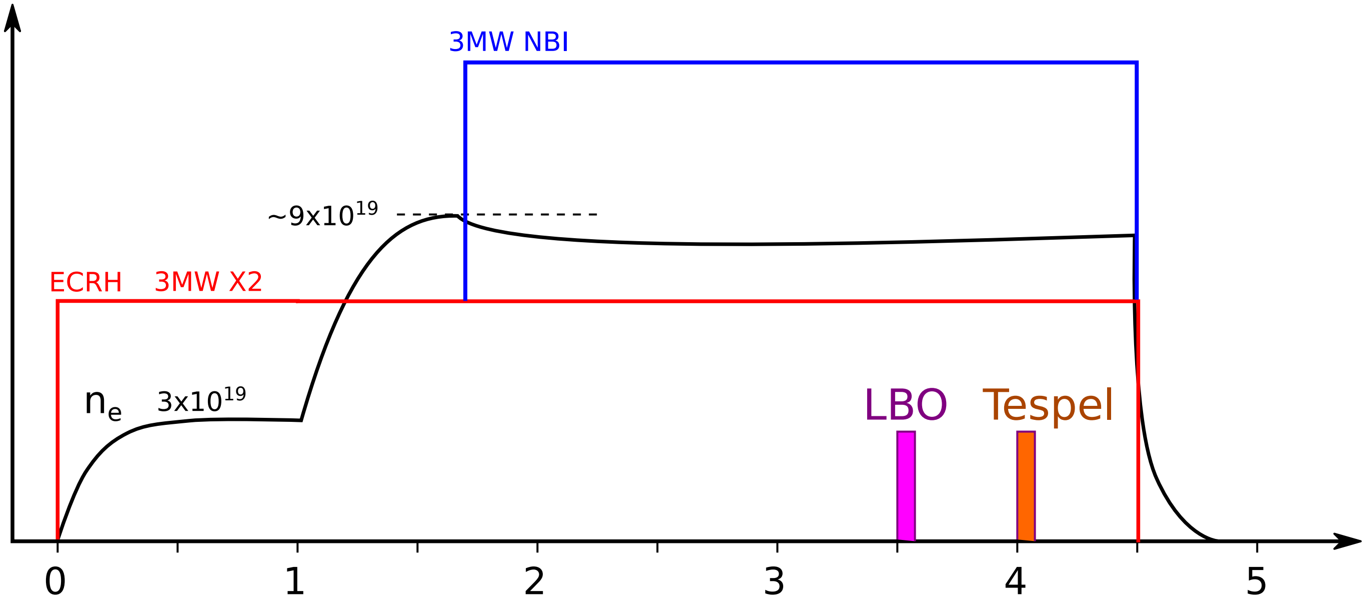
Repeat with gas fuelling to similar ne to compare with pellets:

#13



Session Identifier: S*46* – ‚NBI heating/NC transport‘

#14,15,16 Reserved for modulation, Heat-wave etc.

bgeiger_004 Fast-ion transport studies in W7-X using NBI modulation (for P. Poloskei)
ajvv_001 Passive FIDA measurements at W7-X
dih_008 NBI characterization
liva_001 Core low-Z impurity content and transport studies (He, C, B, N)
npablant_014 Investigation of core energy and impurity transport with neutral beam heating
olfo_010 NBI fuelling characterisation
dih_008 NBI characterization
olfo_016 Parallel ion flow measurements and comparison with neoclassical predictions

See slide from P.Poloskei
Shots "1", "2", "3" --> #14, #15, #16)

NBI modulation studies – P. Poloskei [bgeiger004]

Aim:

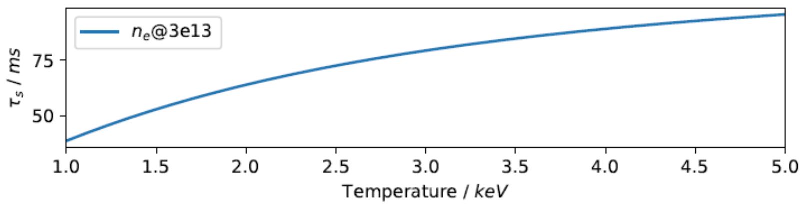
- Study heat deposition due to NBI and investigate (turbulent) fast ion transport

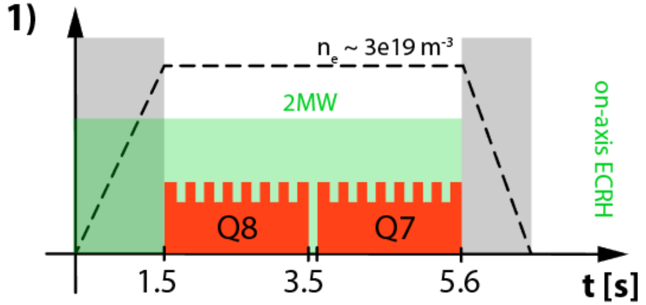
Requirements:

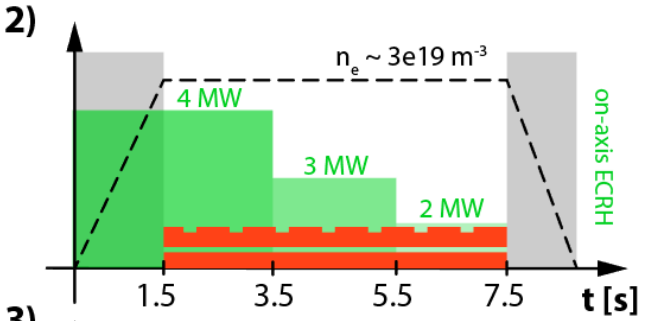
- Low electron density **~3e19 m^{-3}**
  - Maximizing effect on ΔT_i and ΔT_e
  - Better SNR on FIDA (lower Bremsstrahlung)
- **Modulated NBI sources (Q8\Q7) for transport studies**, high frequency **~70 Hz**

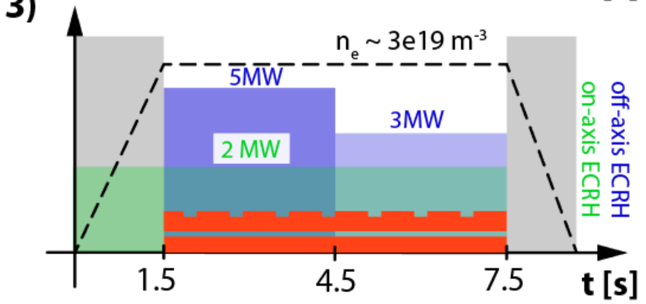
Experimental plan:

1. Start with **on-axis ECRH heating / 2 MW**,
   Q8 modulated for 2 s then **Q7** modulated for 2 s (source difference testing)
2. Turbulence studies with **on-axis ECRH heating / 4 MW** on-axis (stepwise reduction of heating), matching upcoming experimental profiles
   Q8 fast modulation, **Q7** continuously operated; beam notches (3 x 2 x 50 ms) on Q7 for background reduction to CXRS
3. Turbulence studies with **off-axis ECRH heating**, match core temperature to earlier discharge **2 MW on-axis**, **5 MW and 3 MW off-axis**
   Q8 fast modulation, **Q7** continuously operated; beam notches (2 x 3 x 50 ms) on **Q7** for background reduction to CXRS







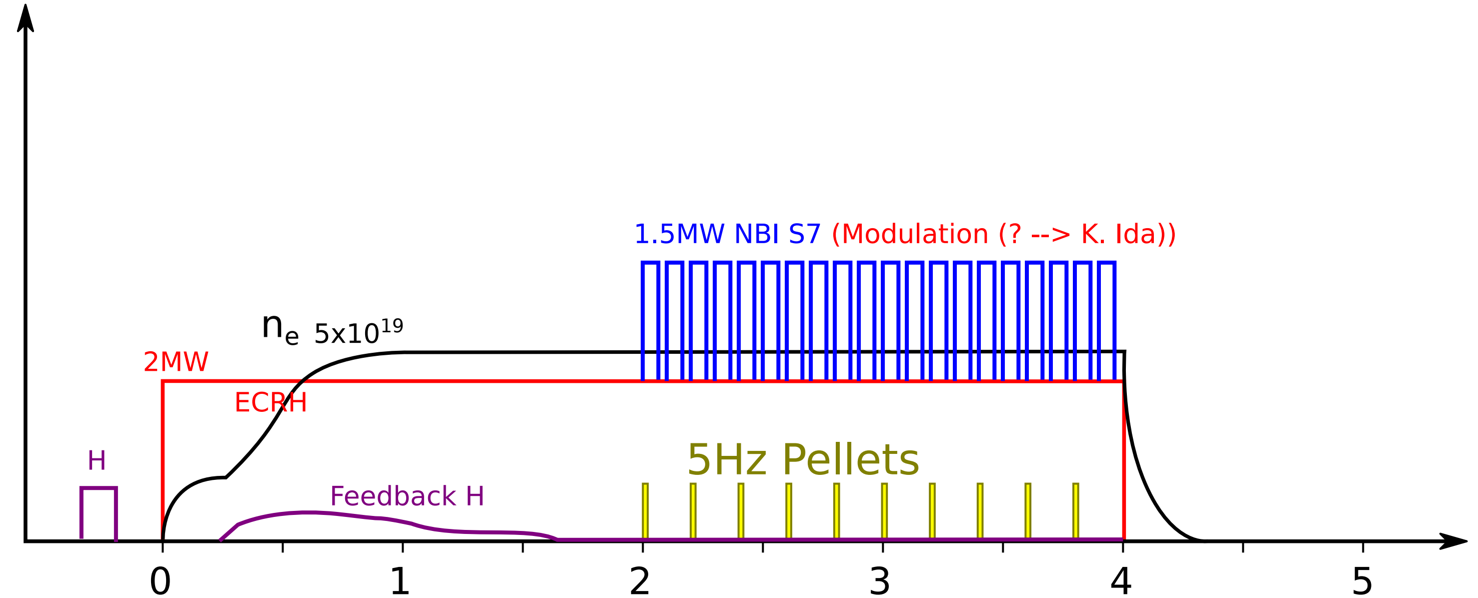


Task 5: Helium operation, NBI into He, CXRS H/He calibration, H/He Transport
- Require: > 60% He, NBI + 'clean termination' for CX calibration.
- Require: low freq pellets into pure He plasma to examine H/He transport ratio.
- Desired: Some scan of H/He ratio for calibration and transport.

5.1: Low frequency pellets into pure H/He NBI plasmas:

dih_008 NBI characterization
olfo_010 NBI fuelling characterisation
olfo_012 Effect of additional heating schemes on radial electric field profile.
liva_001   Core low-Z impurity content and transport studies (He, C, B, N)
K.Ida (olfo_013) - H/He ratio commissioning
K.Ida (olfo_014) - H/He transport - H pellets into pure He.

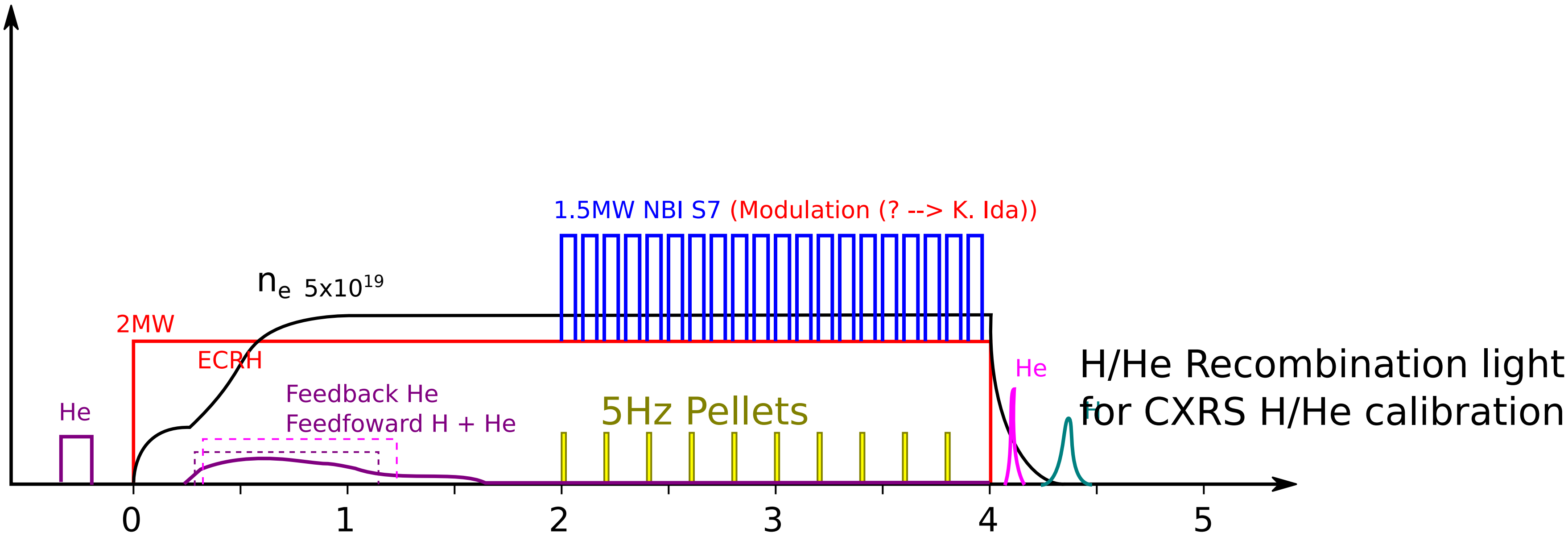
#17: Reference in pure H (Before He)



Introduce Helium: (based on #20180829.054)
- He prefill and setpoint He density 5e19

If:
- a) H Recycling dominates (Low % He) --> Repeat with more He
- b) He puff dominates (High % He)
  --> Copy feedback He to feed forward, Add H feedback.

#18-20: Scan H/He ratio (Increasing either H or He)



Full NBI power into pure He plasma
(dih_008)

dih_008 NBI characterization
olfo_010 NBI fuelling characterisation
olfo_012 Effect of additional heating schemes on radial electric field profile.
liva_001 Core low-Z impurity content and transport studies (He, C, B, N)

#21 (Performed after #18 if #18 if full He)