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Summary of WP12 PPPT-SYS02 tasks on

DEMO1 profile consistency and sensitivity studies by METIS

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DEMO1 studies by METIS code

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1. Check the consistency of the density, temperature and impurity concentration profiles
2. Sensitivity analysis of the simulations codes on the assumptions made on the simplified modeling
3. METIS, a fast (min. timescale) Integrated Modeling Code with simplified assumptions that solves mixed 0D and 1D equations:
   - Current diffusion 1.5D with moment equilibrium
   - Input : Power waveforms, I_P, plasma density, Z_{eff} , LCMS geometry
   - Output : the same 1D and 0D data usually produced by a transport code

   NB: METIS can be used for preliminary scenario design, to prepare full integrated modeling simulations (CRONOS suite)

DEMO1 profile consistency

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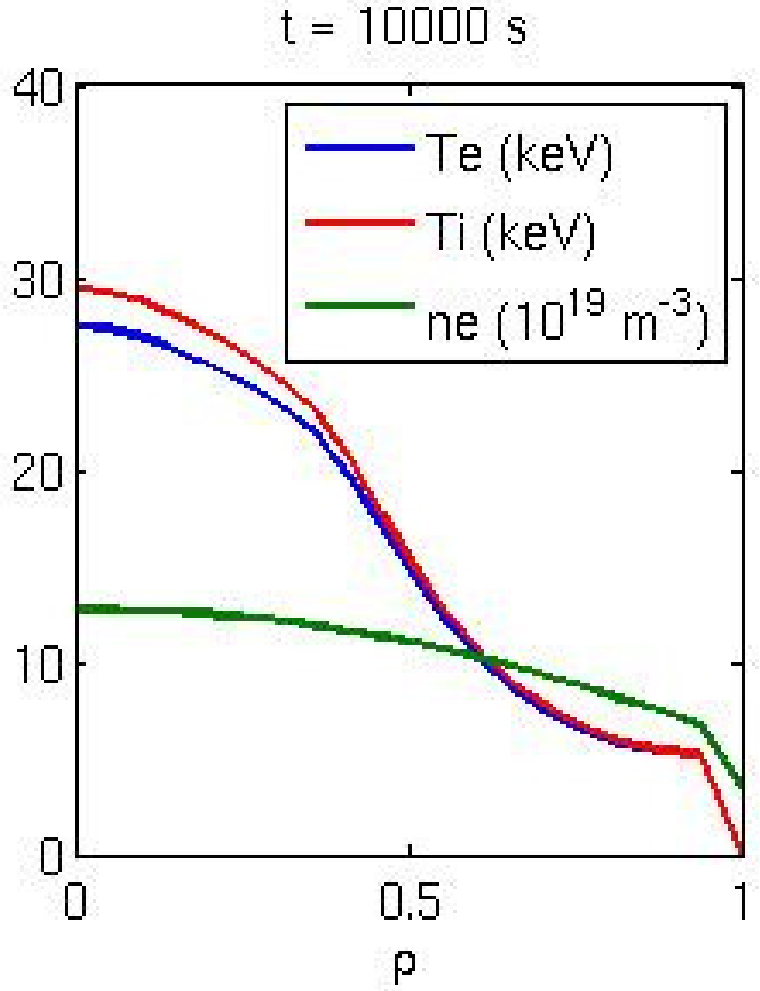
• METIS studies supported the overall SYS02 activity by providing a simplified, but integrated 0.5D description of DEMO plasmas.

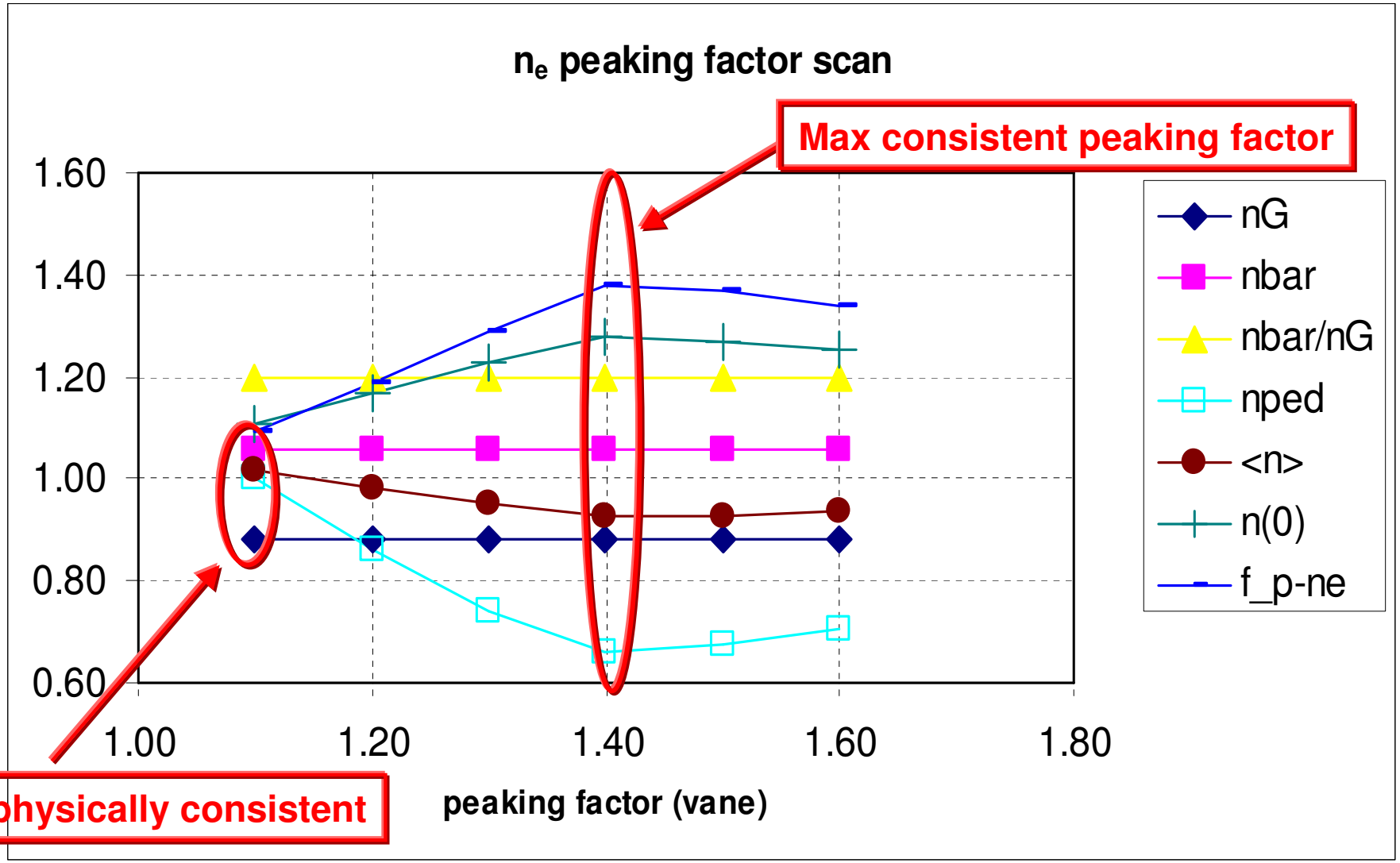
• Reference DEMO1 scenario for 2012 studies was the PROCESS 2011 work point with the following main modifications:

- Paux = 100 MW NBI (1 MeV)
- Impurities: Ar + W,
- Tped ~ 5 keV
- 50 MW ECCD during ramp up



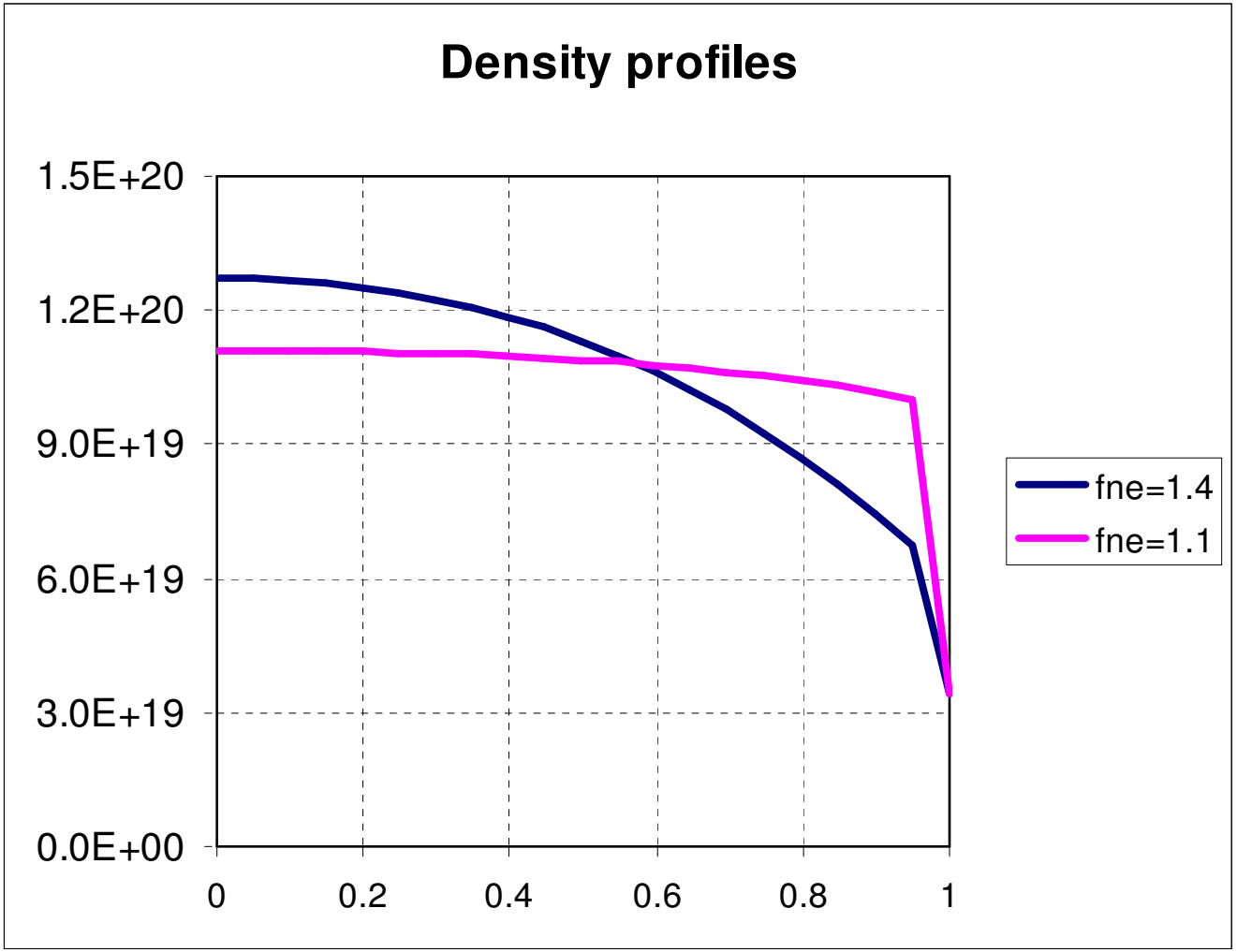
September 2012 DEMO1 reference case: density and temperature profiles.

DEMO1 density profile consistency



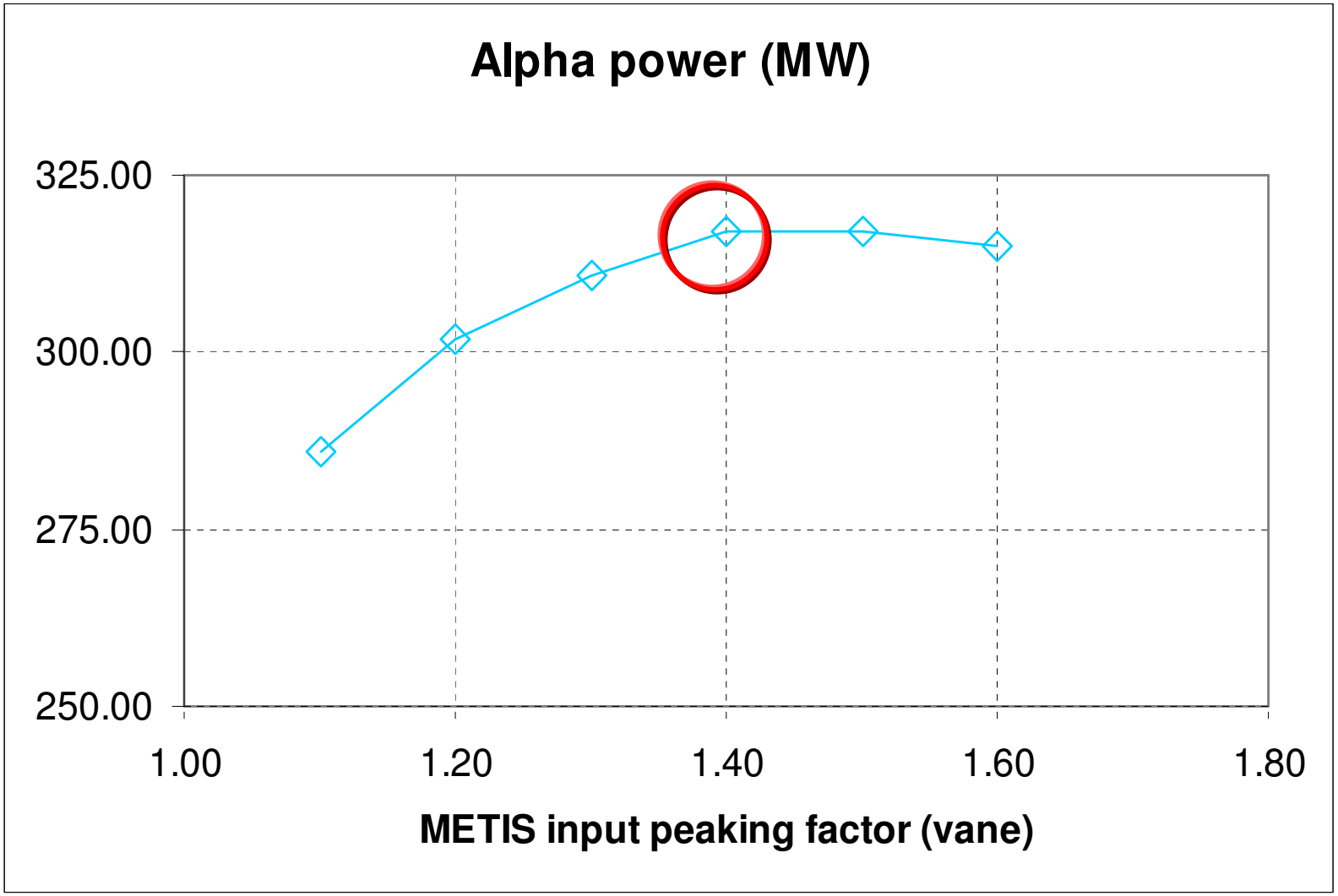
Working at fixed n/n_G=1.2, a density peaking of 1.4 is the most consistent choice (scan performed at fixed pedestal pressure).

DEMO1 density profile consistency



Resulting density profiles for 2 different peaking factors. Note that a density peaking factor of 1.1 leads to a pedestal density larger than n_G and is though to be not realistic.

DEMO1 density profile consistency: α power



The generated α power is evaluated consistently.

DEMO1 sensitivity studies

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- Sensitivity studies of the Sept. 2012 DEMO1 reference scenario included:

  - NBI power, energy and geometry scans: a subset of results was also compared with RISK/SPOT runs where a more detailed description of the beams are included.

  - scan on n/n_G by changing the line integrated density reference value.

  - Line radiated power scans. Note: in these initial scan W/Ar ratio was kept =1 and Zeff=1.97.

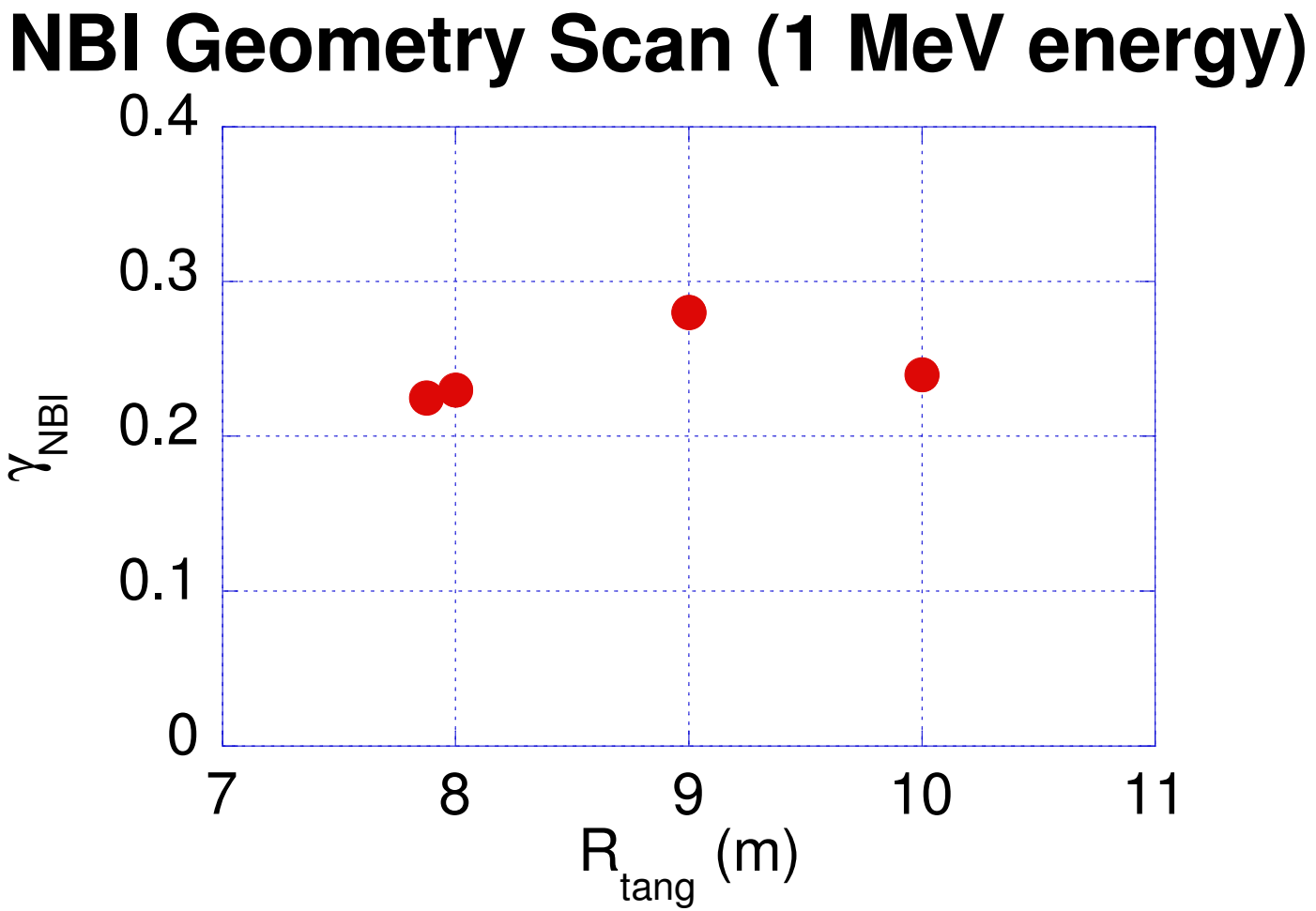
  - scans on W/Ar ratio and, for a given ratio, on Zeff

  - scan on H factor

- All these scans showed that the working point is very sentivtie to **radiation assumptions**, leading very easily to an unstable H-mode.

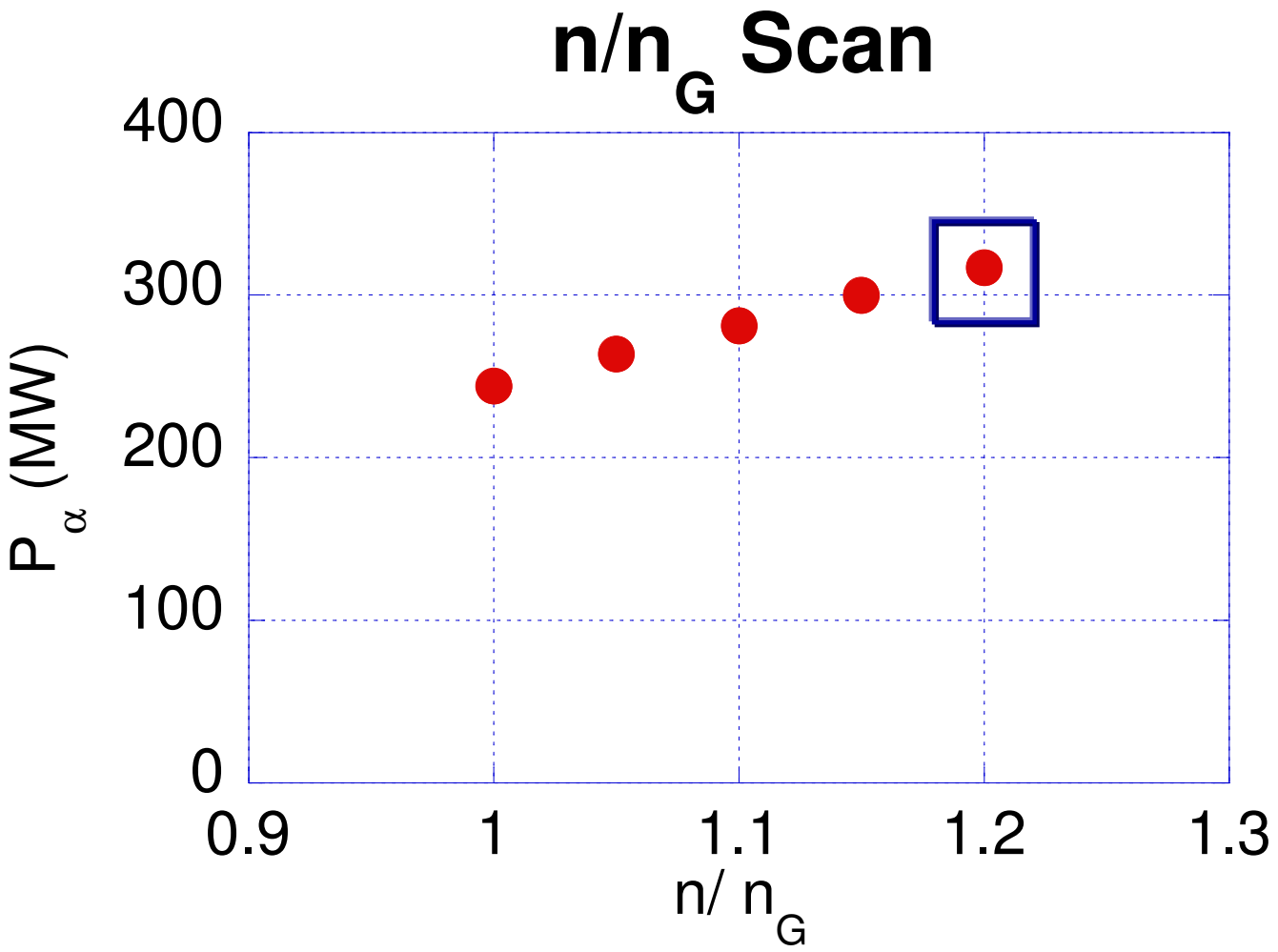
- At the same time also the **plasma ramp-up** confirmed to be critical, with 50MW of EC power very important and high energy NBI not adequate.

DEMO1 sensitivity studies: NBI geometry scan



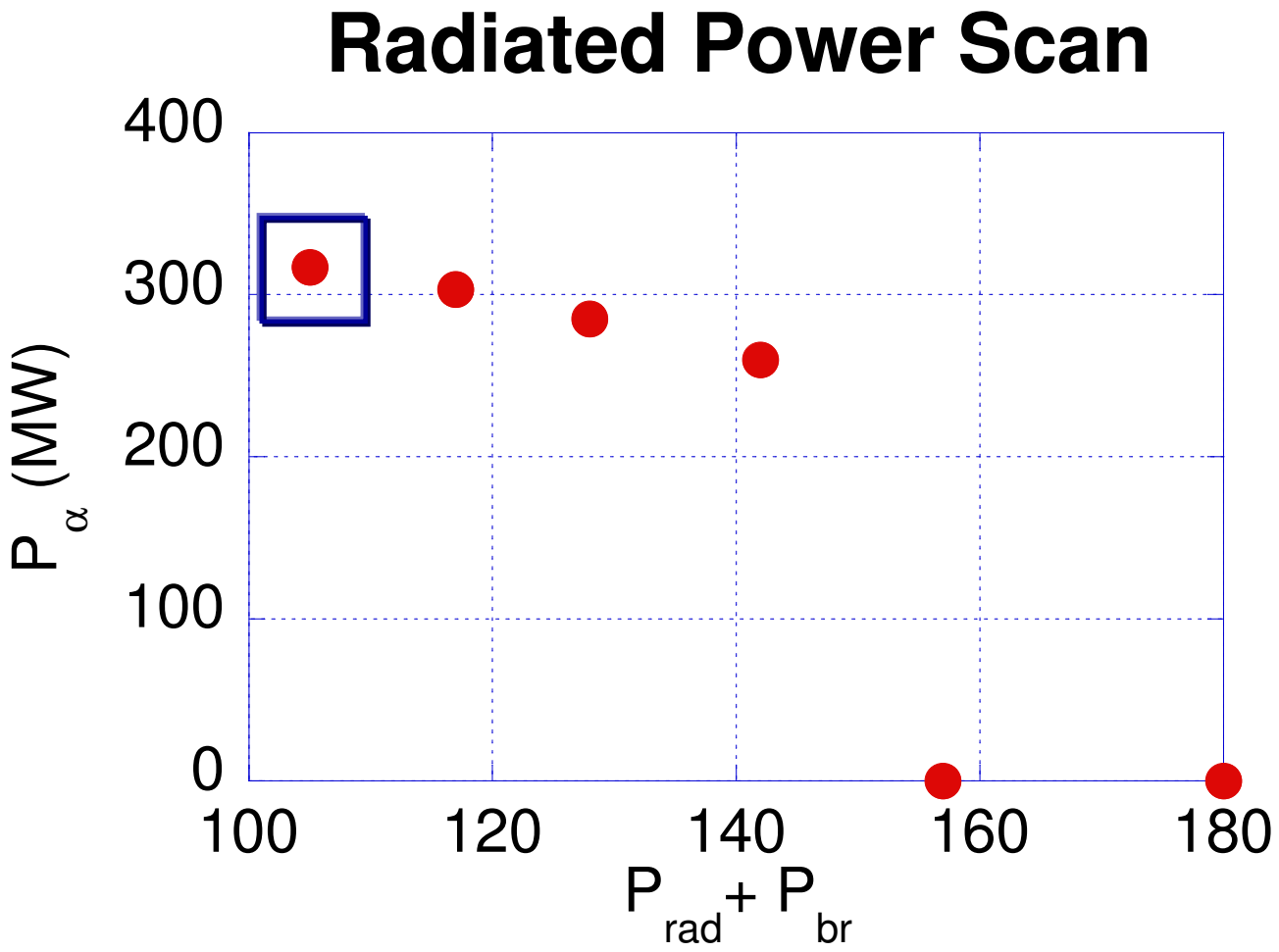
CD efficiency for different tangency radii, 1 MeV energy case.
1.5 MeV case investigated as well.

DEMO1 sensitivity studies: n/n_G scan



Alpha power for different n/n_G values. The reference value is 1.2.

DEMO1 sensitivity studies: radiated power scan



Line radiated power scan. As expected, P_α decreases for increasing radiated power values.

Summary of 2013 results

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- The range of physically consistent density peaking factors is bounded between 1.1 and 1.4.

- DEMO1 reference scenario appears to be very sensitive on impurity and radiation assumptions.

- H&CD assumptions are critical, even for the conservative DEMO1 model:
  - without ECCD in the current ramp, L-H transition can be problematic;
  - on the other hand less than 100 MW NBI power during the flat top would lead to a marginally stable scenario.

- 1 MeV NBI energy seems to be adequate to the DEMO1 prescribed scenario. Higher beam energies would improve the CD efficiency, but not dramatically the overall scenario performance.

Directions for 2013

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- Support the search for a new DEMO1 reference scenario. More sensitivity studies on different aspect ratio (i.e. different minor radius choices)? Focus on start-up and flat top H&CD effects on pulse length.

- Sensitivity studies on new reference point. Targets: assess the robustness of the working point and suggest recovering capability of the system if the scenario is lost, in terms of the requested CD power (very likely not a full time-dependent scenario control study).

- New model for impurity concentration and radiation implemented in METIS could also suggest new sensitivity studies.

- DEMO2 studies?