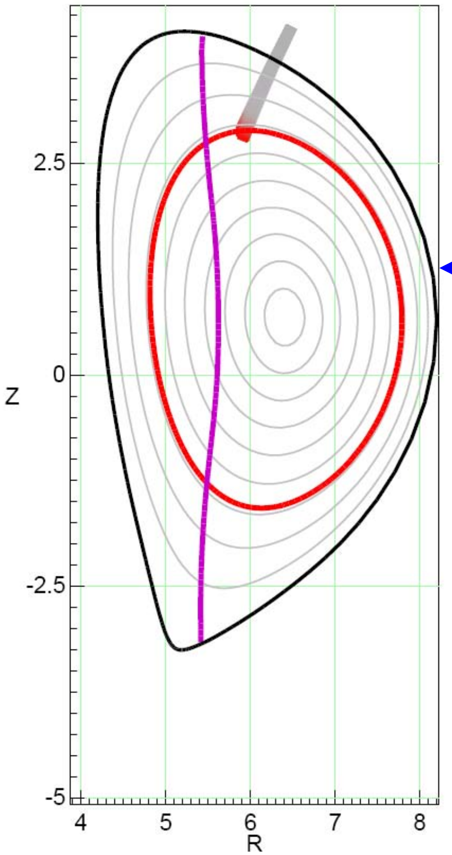
TRAVIS: physics and approaches

- Each RF-beam is discretized by the bandle of rays
- The ray trajectory is calculated with anomalous dispersion taken into account
- Absorption is calculated in fully relativistic approach
- ECCD is calculated through the adjoint approach
- *dP/dV* is decomposed in contributions from trapped and passing electrons
- The velocity range of electrons responsible for absorption is also estimated
- TRAVIS code is well benchmarked:
  „old“ W7-AS ray-tracing code, WR_RTC, TORBEAM;
  predictions for Scenario-2 collected by R. Prater
  (TORAY, CQL3D, GRAY, etc.)

ECCD calculations

- To date, there are two ways for estimations of ECCD:
  - ✓ beam/ray-tracing with implemented adjoint aproach
  - ✓ Fokker-Planck simulations
- The mostly accepted model of the adjoint approach is the Cohen model (high-speed-limit, no momentum conservation)
- Simple algorithm for the Spitzer problem with momentum conservation taken into account was developed (Rome´, 1997)
- The adjoint model with momentum conservation is implemented in the new ray tracing code TRAVIS
- TRAVIS code is quite well benchmarked:
  „old“ W7-AS ray-tracing code, WR_RTC, TORBEAM;
  predictions for Scenario-2 collected by R. Prater

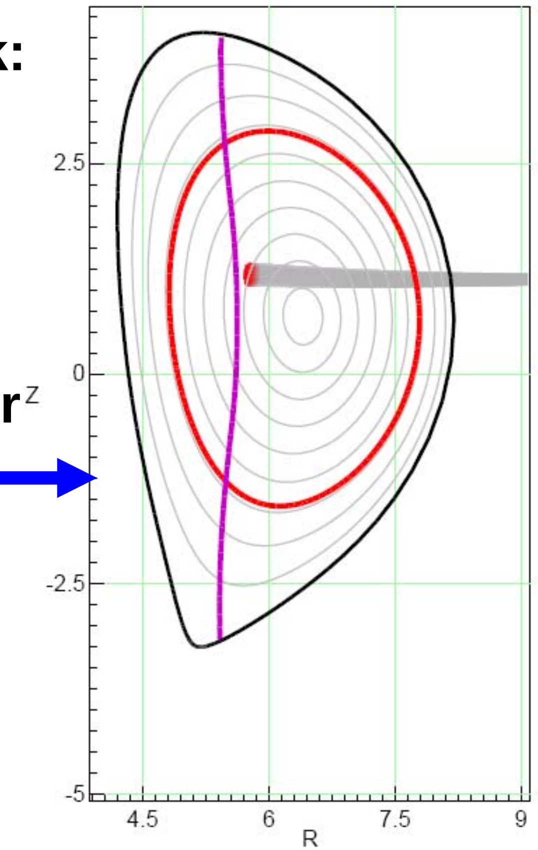
ITER: checked scenarios



Only two launch ports we look:

1) the upper launcher (NTM control)

2) the equatorial (top) launcher (on/off axis current drive)

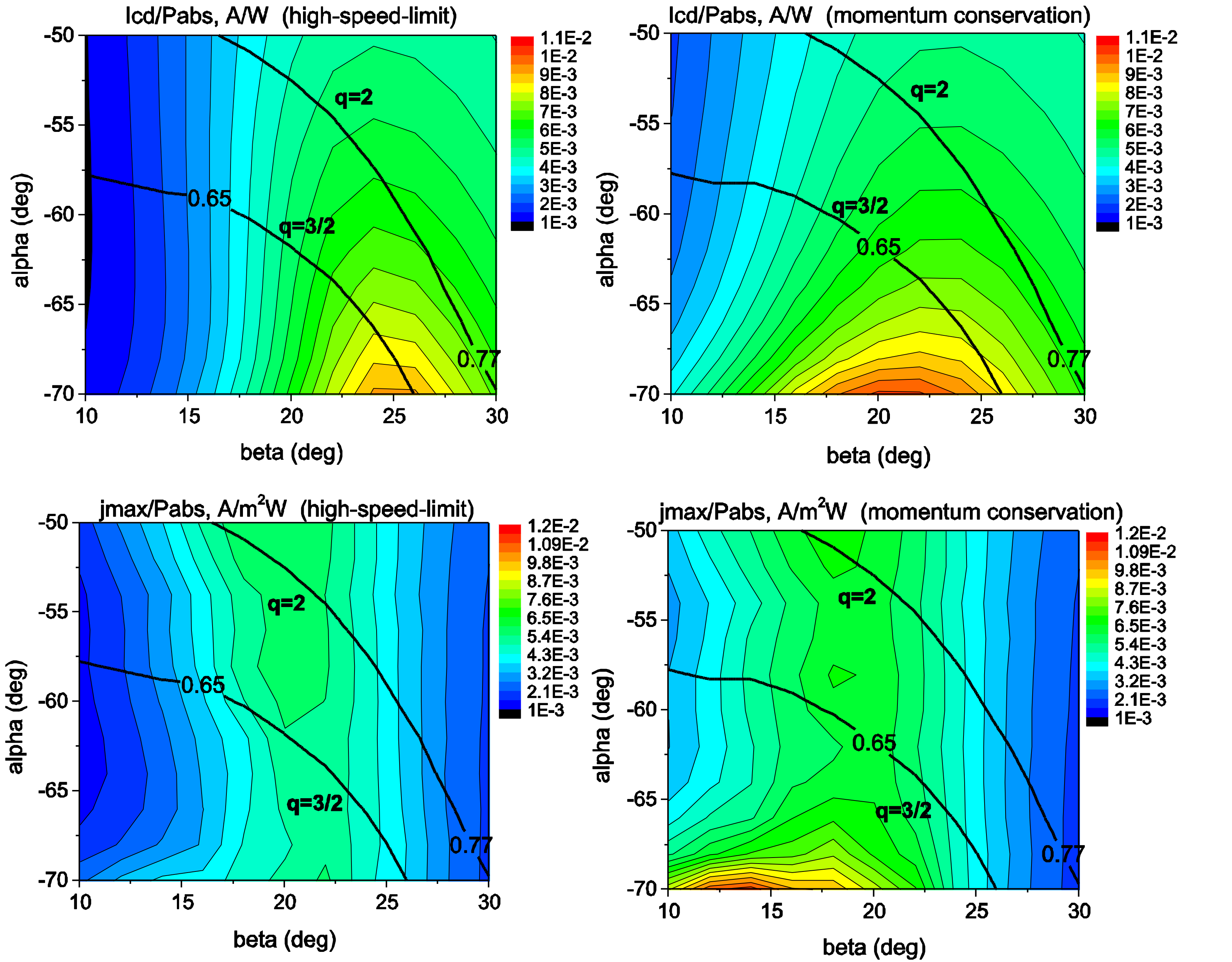


For comparison, ECCD is calculated with help of both

i) high-speed-limit model, and

ii) model with parallel momentum conservation

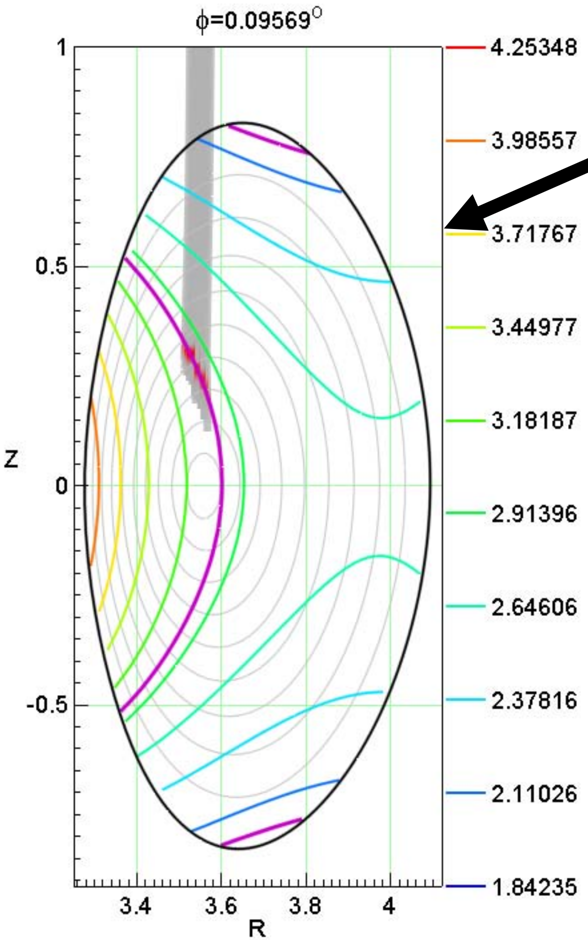
ITER: ECCD efficiency for the upper launcher



LHD: X2-scenario, quasi-vertical launch

For the high density scenarios, the thermal bending of the ray trajectory is of high importance (anomalous disperion effects).

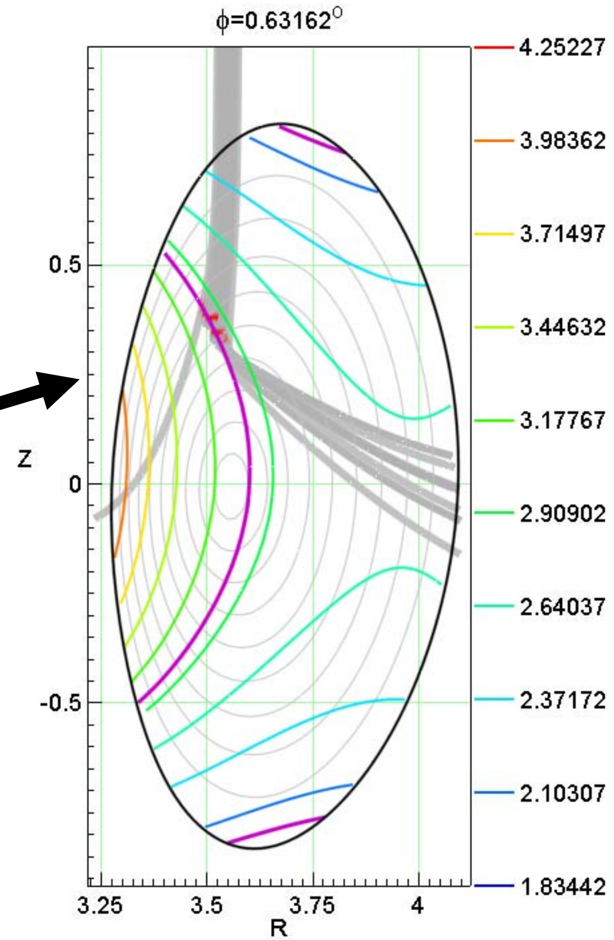
The single-pass absorption can be significantly reduced



$n_e=0.2\times10^{20}$ m^{-3}, T_e=6 keV

$n_e=1\times10^{20}$ m^{-3}, T_e=1 keV

$B_0 \approx 3.0$ T, 168 GHz



O2-scenario in LHD: proposal for experiment

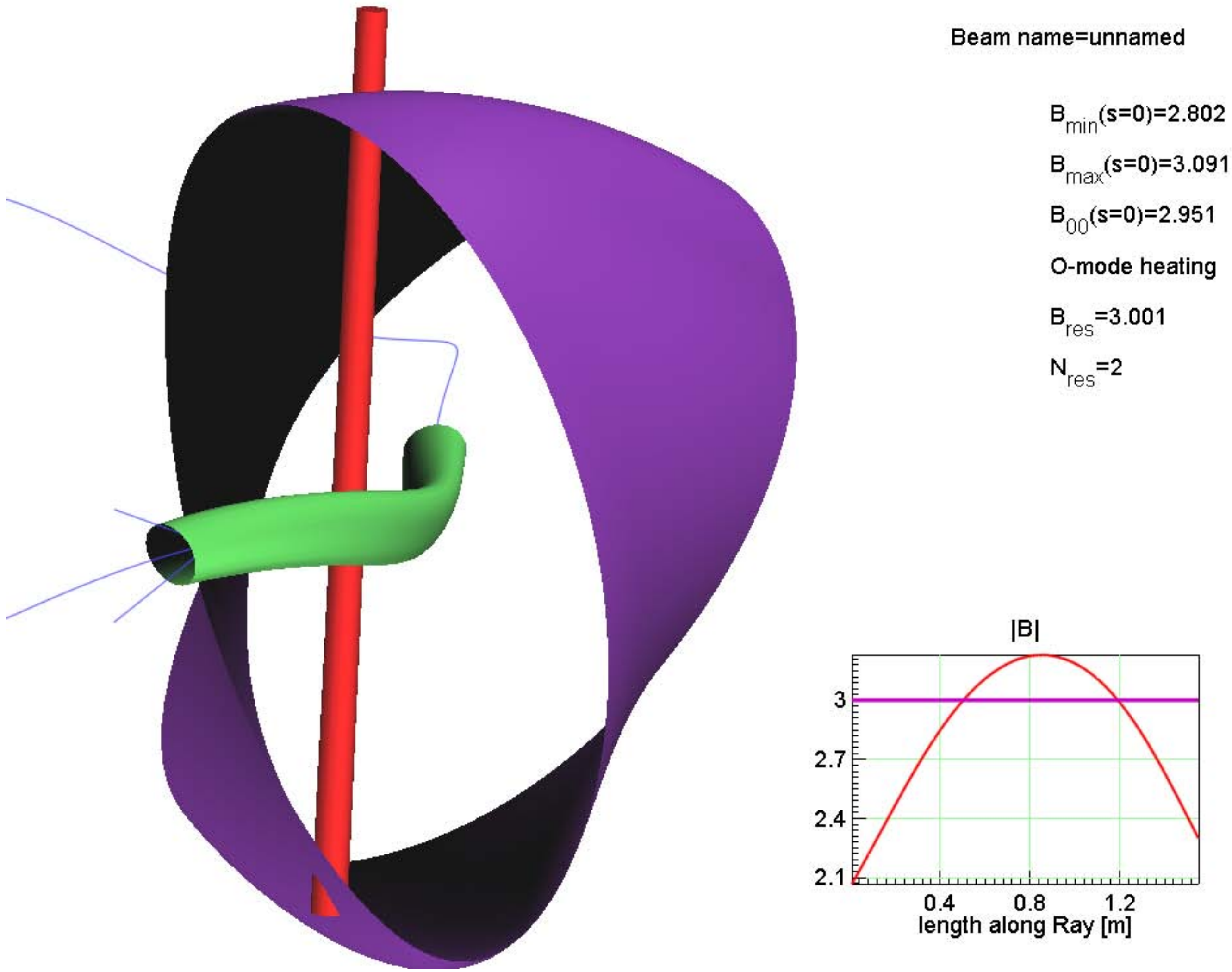
+ very preliminary (but promissing) estimations

Motivations:

- Possibility to apply ECRH in higher density range, where the X2-scenario may be critical
- In NIFS, all necessary experimental tools are available
- Optimistic theoretical expectations
- Absence of the real experience (to date, no experiments were performed)

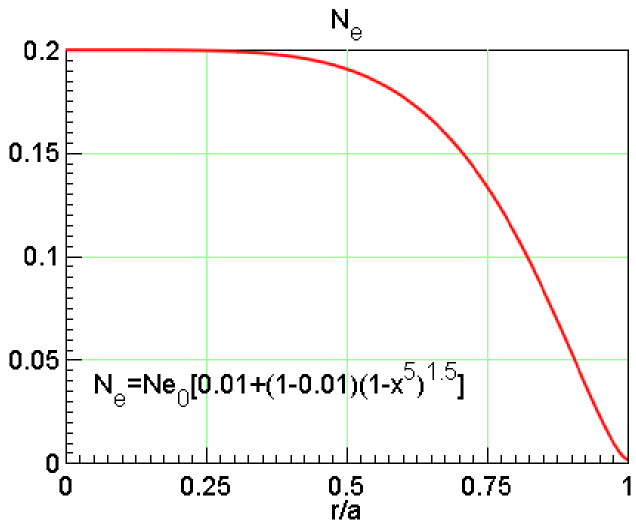
LHD: upper launch port, 168 GHz, 1.3 MW

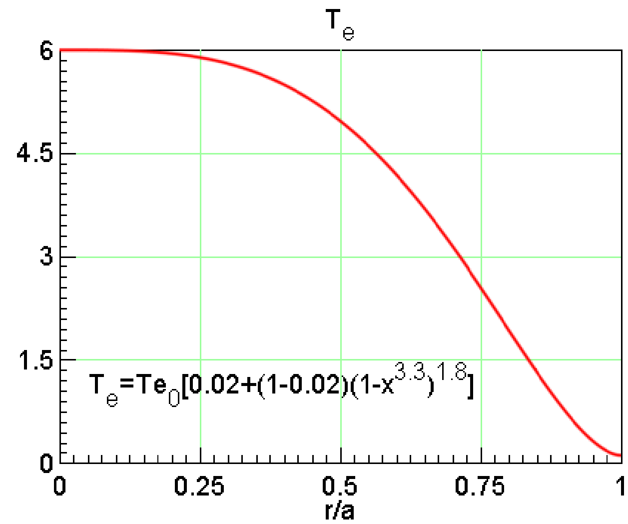
Inward shifted configuration with Rax = 3.50 m, B0 ≈ 3.0 T

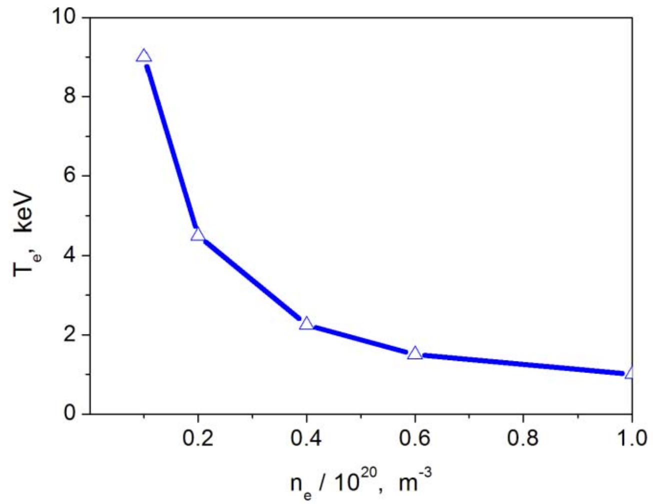


- NBI-plasma, supported by the O1 heating (U-port)
- Density and target point (direction) scan

Plasma profiles:



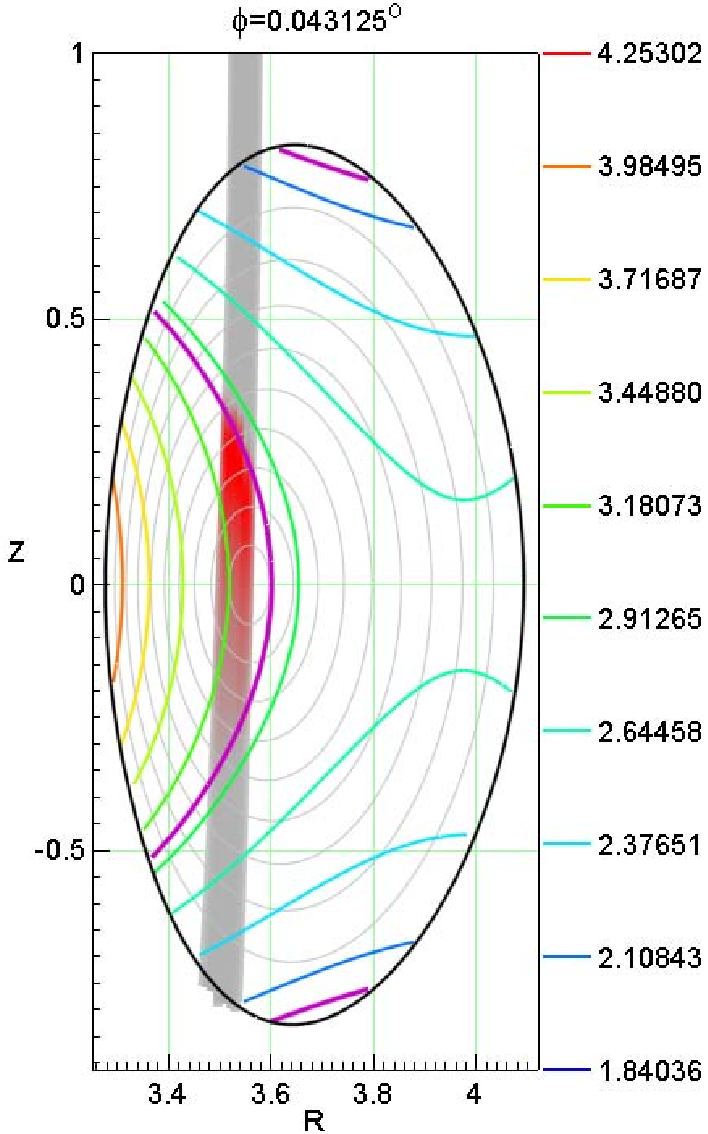




Scan over density with $n_e T_e \approx$ Const

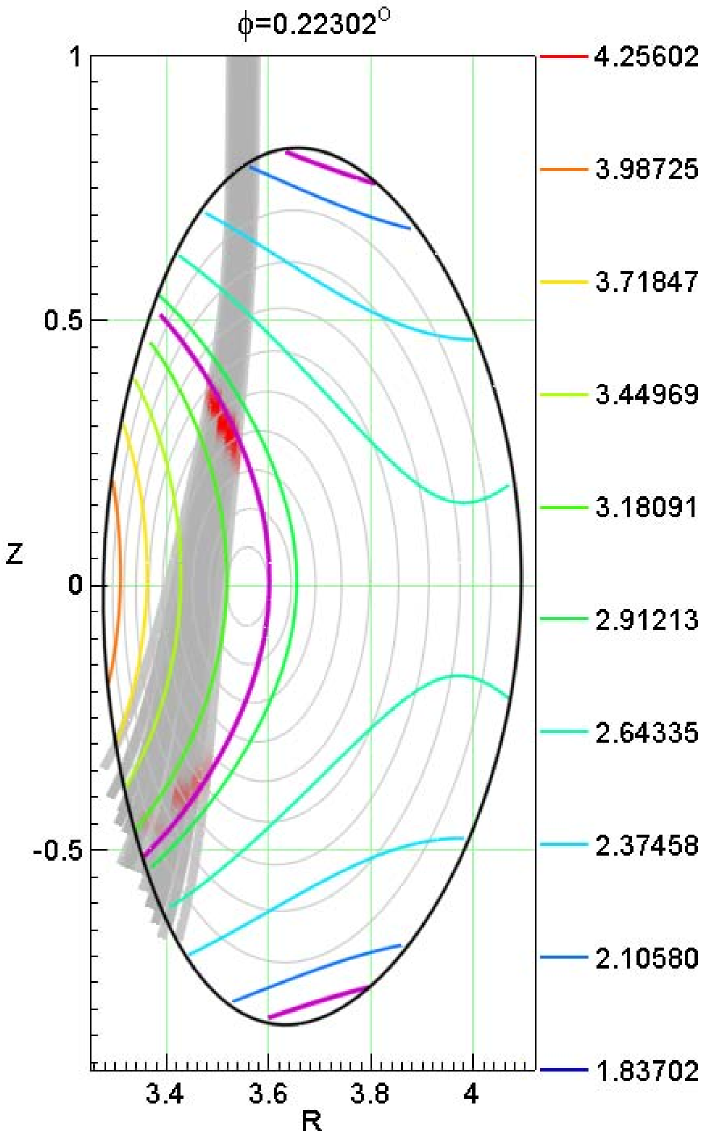
Quasi-vertical launch of the O2-mode: the same direction, different densities

n_e=0.2×10^{20} m^{-3}, T_e=6 keV



R_{targ} = 3.54 m

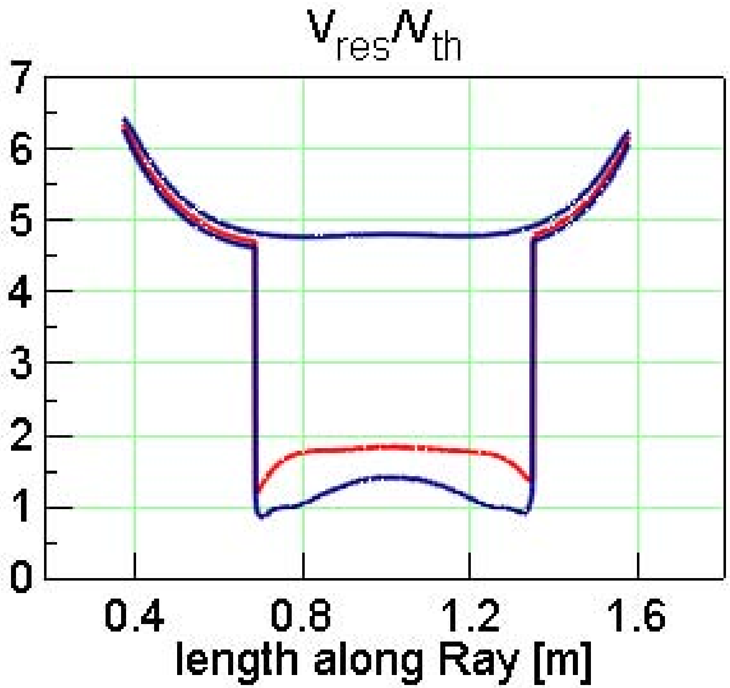
n_e=1.0×10^{20} m^{-3}, T_e=1 keV



Optimization of the scenario:

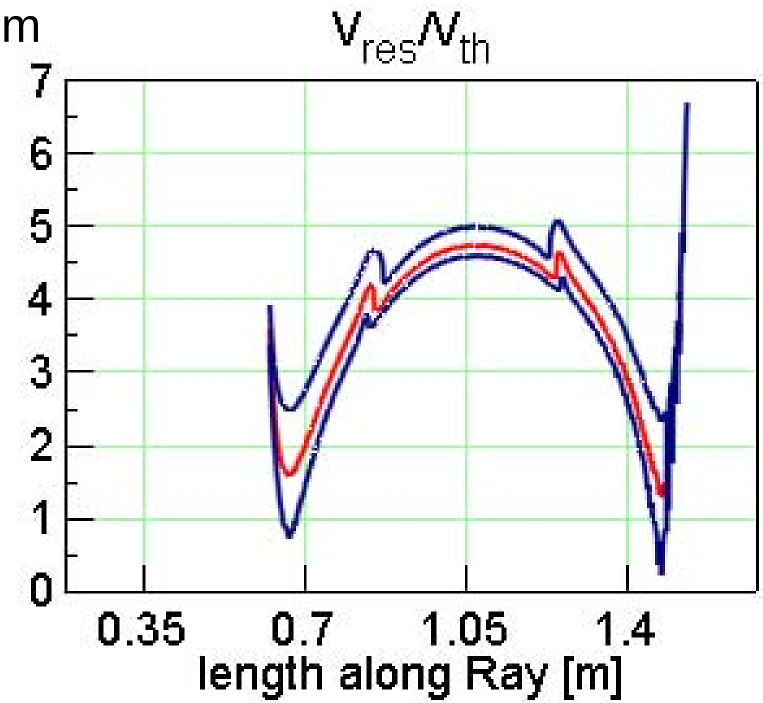
- increasing the length for effective resonance interaction
- decreasing the distance to the resonant surface

$n_e = 0.2\times10^{20}$ m^{-3}, $T_e = 6$ keV

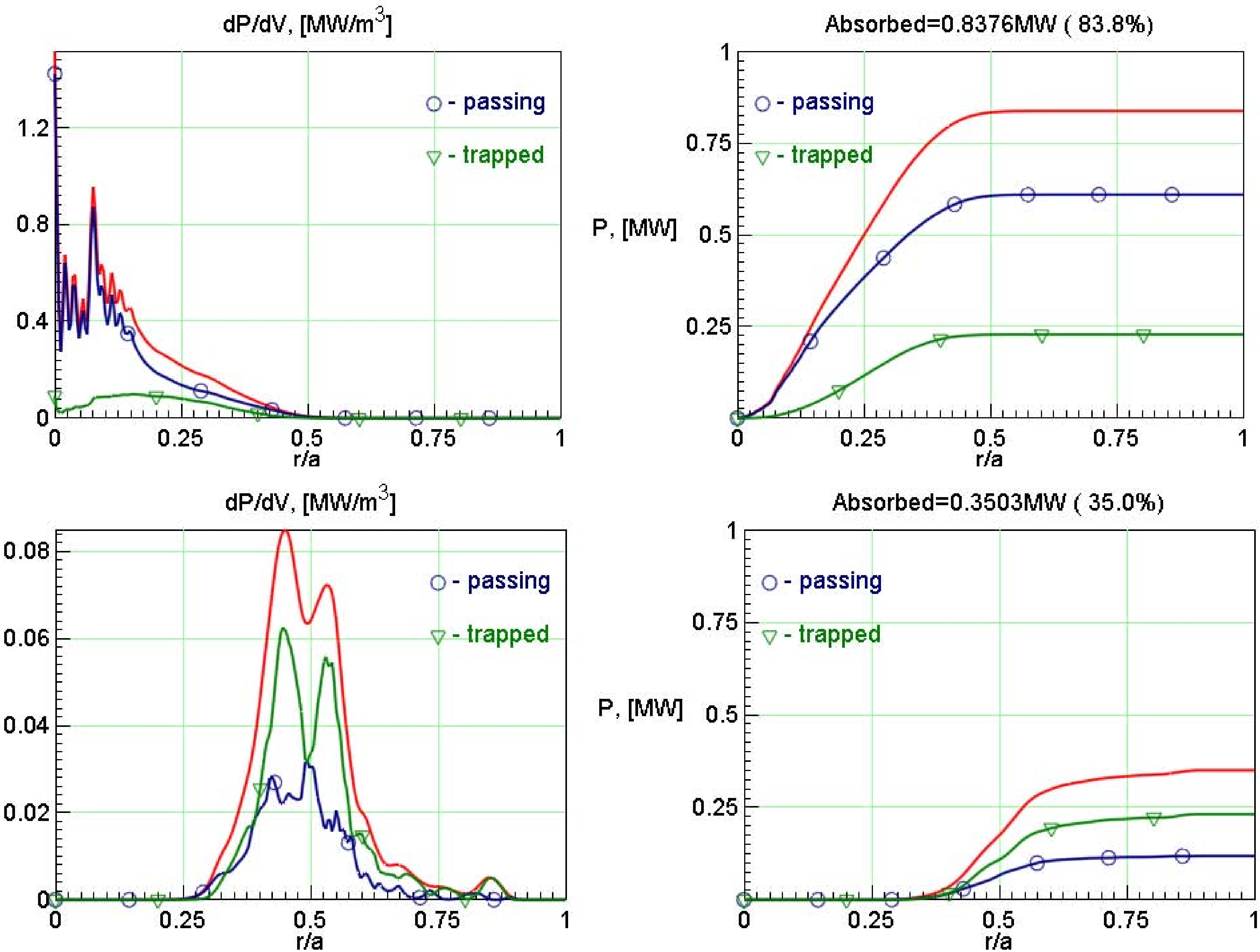


$R_{targ} = 3.54$ m

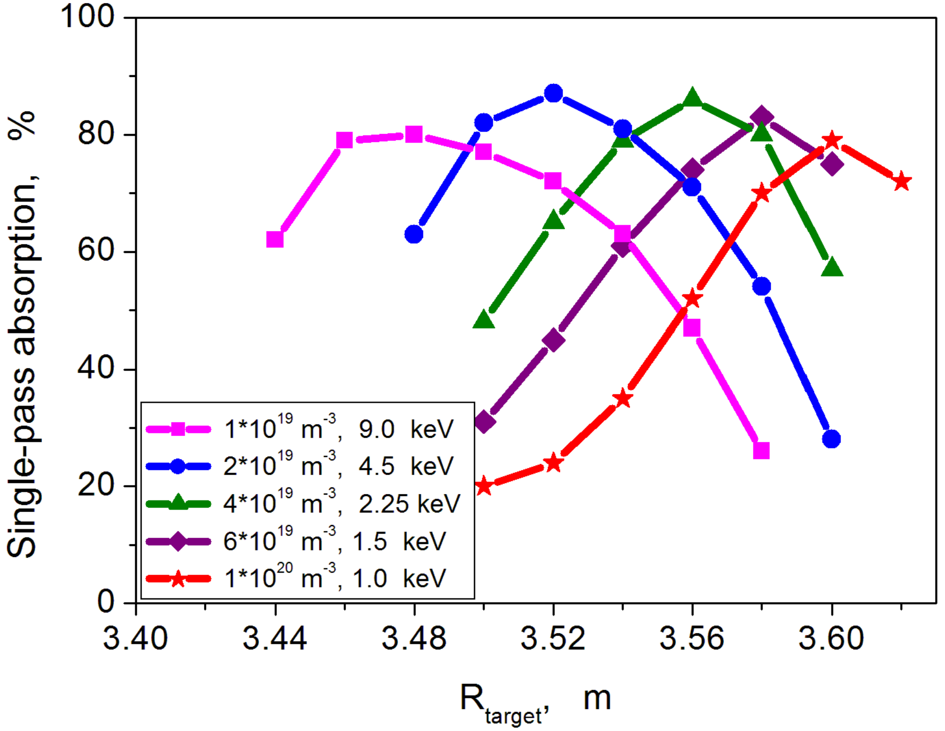
$n_e = 1.0\times10^{20}$ m^{-3}, $T_e = 1$ keV



Low density (top) *vs* high density (bottom) scenario: deposition profiles



Scan by direction (target point) for different densities



Single-pass absorption up to 90% seems as reachable value