Preliminary Confinement Studies with ECRH in TCV

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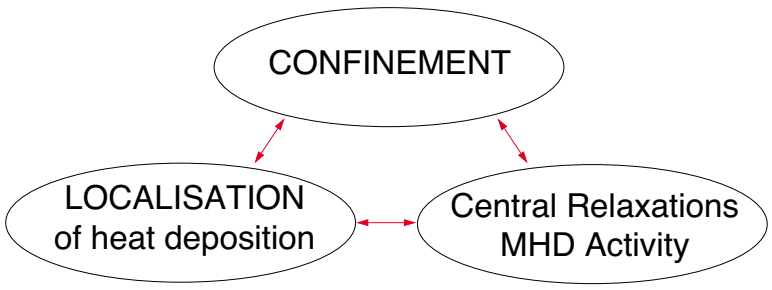
ABSTRACT



ROLE of q=1

HEATING, CONFINEMENT and MHD-ACTIVITY are shown to depend strongly on the LOCALISATION of the EC power deposition (studied by varying beam angle, plasma vertical position and magnetic field).

CONFINEMENT studied as a function of localisation (B), basic plasma parameters (n_e, q, P_{EC}), and plasma shape (κ, δ)

HEATING properties, MHD-activity depend on the location of power deposition relative to the q=1 surface.

Power absorption efficiency measurements and optimisation.

Present power used: 1MW, 1s, with ability to change angles of mirrors during shot.

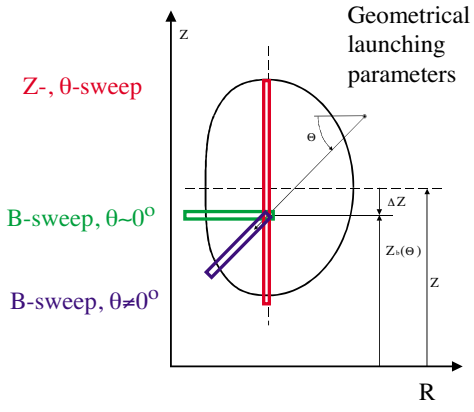
POWER DEPOSITION LOCALISATION TOOLS

Location of power deposition changed by sweeping of
- the vertical plasma position Z at fixed beam
- the poloidal mirror angle θ
- the magnetic field

Z-, θ-sweep

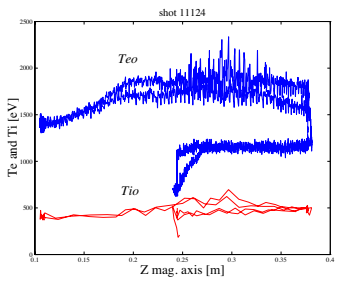
B-sweep, θ~0°

B-sweep, θ≠0°



Geometrical launching parameters

Example: Z-sweep



ECH

OH

ELECTRON CYCLOTRON WAVE SYSTEM on TCV: X2 side- and X3 top-launch

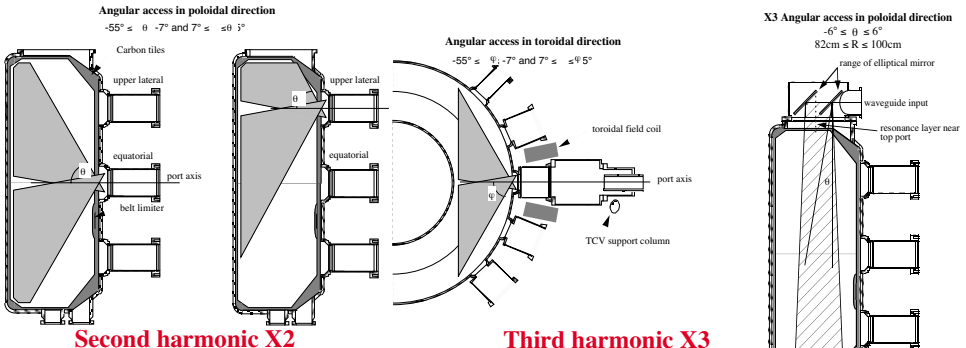
TCV Aims:
- Study of operational limits in shaped low collisionality plasmas (β-limits, current-limit, etc.)
- Study the benefit of plasma shaping on confinement and stability
- ECRH, CD as a tool for the creation of various plasma shapes (high elongations, doublets, etc) by current profile tailoring

ECRH System: - two frequencies for efficient heating and current drive, and for access to high densities

3.0 MW, 2 sec. 82.7 GHz second harmonic X2, cut-off density = 4.25×10^{19} m^{-3}

1.5 MW, 2 sec. 118 GHz third harmonic X3, cut-off density = 11.5×10^{19} m^{-3}

Total power : 4.5 MW, 2 seconds



Second harmonic X2
6 gyrotrons, 82.7 GHz
4 upper lateral and 2 equatorial ports
6 independent mirrors (θ, φ)
for heating and current drive, off-axis heating at high density

Third harmonic X3
3 gyrotrons, 118 GHz
one large top port
1 single mirror (R, θ)
for access to high density heating

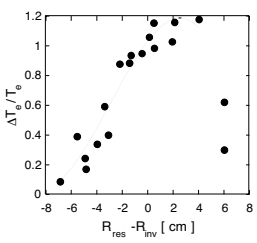
CONFINEMENT

Confinement studies were started with a weakly shaped plasmas (κ =1.3, δ = 0.2) and quasi horizontal launch in order to simplify refraction problems (θ=18°, upper lateral launchers).
n_{eo} = 2-2.3 10^{19} m^{-3}, ($X2_{cutoff}$ density = 4.25 10^{19} m^{-3}).
Full absorption guaranteed by ray-tracing up to n_{e0} = 4.0 10^{19} m^{-3}.

	I_p[kA]	V_{IOH} [V]	V_{IEC}[V]	P_{EC}/P_{OH}
q=5	170	1.05	0.5	14.3
q=2.5	325	1.5	0.95	3.1

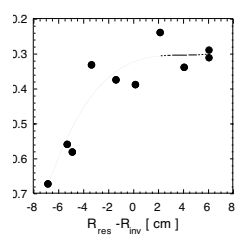
CONFINEMENT versus LOCALISATION of power deposition

Relative electron temperature variation versus heating position (2<q<6)



T_{eo} maximum for heating slightly inside q=1

Electron confinement time variation versus heating position (2<q<6)

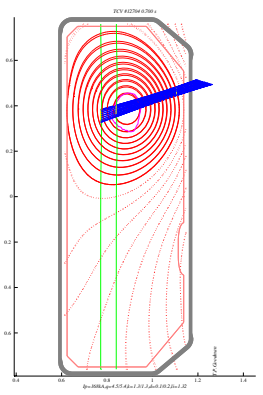


Good confinement for heating inside q=1

B-scan around q=1
(q=2.5-5, P=0.35-1 MW)

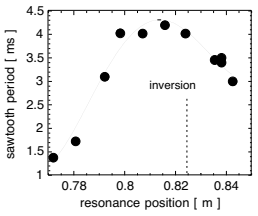
Exploration of heating around the inversion surface

(Note the typical 3.5 cm resolution of SXR tomography diodes.)



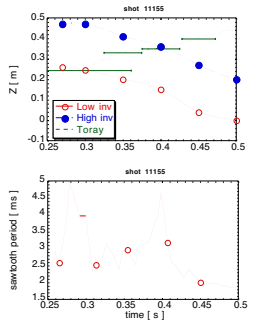
q=1 surface and range of EC resonance locations for the 0.35 MW B-field scan.

Sawtooth period versus heating position (B-scan, P_{EC}=360kW, κ=1.32, q=5, $n_{eo}=2\times10^{19}m^{-3}$)

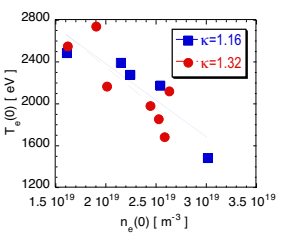


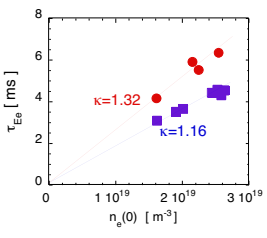
Sawtooth period τ_{ST} maximum for heating slightly outside q=1

Sawtooth period versus heating position (Z-sweep)



CONFINEMENT versus DENSITY n_{eo} (and Elongation κ)





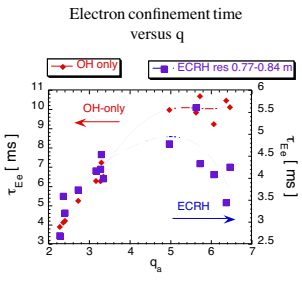
Heating near inversion radius at R=84 cm,
P_{EC}=500kW
κ=1.16, 1.32
q=4.7, 5.2
δ=0.07, 0.16

- $\tau_{Ee} \sim n_e^{0(1)}$
- Neo-Alcator like
- Beneficial effect of elongation

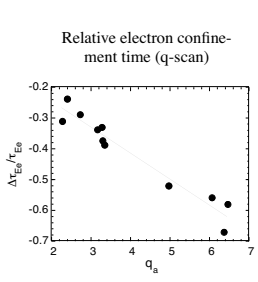
CONFINEMENT versus SAFETY FACTOR q_a

0.5 MW, κ=1.31, Z=0.38m

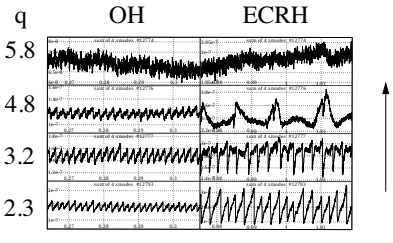
Electron confinement time versus q



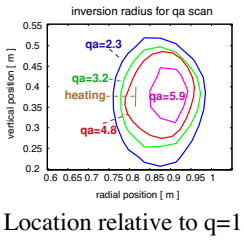
Relative electron confinement time (q-scan)



- saturation at high q in ohmic
- Neo-Alcator q behaviour
- drop at high q, partly-due to outside q=1 deposition



Sawteeth disappearing at high q



Location relative to q=1