EC-14 TECNOLOGY SUMMARY

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Hosts
of
EC-15
Somewhere
to
be
determined

17 Posters and 12 oral contributions

Gyrotrons: 12
Big experiments: 2
Great ideas: 1
The great ITER launcher war: 8 or 9

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GYROTRONS

A.G. Litvak:
170 GHz ITER gyrotron development doing well
2 frequency gyrotron 140 GHz 0.9 MW
105 GHz 0.7 MW
J.G. Pagonakis:
Better simulations for gyrotron beam tunnels shows improvements in gyrotron design codes still being made
G.E. Anastassiou:
Novel use of gyrotron rf beam to pump an electron sheet and generate higher power
J. Nielson
Launchers for step tunable gyrotrons with high efficiency, 0.99 at 140 GHz and 0.98 at 105 GHz (similar result at Gycom)
K.A. Avramides, V.I. Zaginaylov, Z.C. Ioannidis and G.P. Anastasiou
Design procedures and codes for coaxial cavity gyrotrons moving toward higher single unit power
K. Felch
Analyses of gyrotron collectors, failures and improvements
H.O. Prinz
Explanation of the bifurcation of the rf beam from a 118 GHz gyrotron
K. Sakamoto
0.5 MW operation for 100 sec no boost
0.2 MW operation for 1000 sec with boost
Stable operation of $TE_{31,12}$ cavity at 1.5 MW for 170 GHz gyrotron
V.E. Zapevalov
What are the limits for gyrotron power anyway?

R.J. Temkin

1.67 MW operation of a 110 GHz $TE_{22,6}$ gyrotron at short pulse, but with parasitic oscillations near 100 MHz

B. Piosczyk

Short pulse tests of the 2 MW coaxial prototype have yielded 1.15 MW and led to plans to proceed with a real tube. Parasitic oscillations were suppressed.

G. Dammertz

Test results for the Thales 140 GHz 1.0 MW tube for W7-X showed 0.9 MW output at eff 45% with depression and 30 min pulse length. Sounds good, but the second identical tube has had problems. It's possible that better quality control at the manufacturers meeds to be performed

IAP
GYCOM
INF

ITER gyrotron. Results of 2004

Output power in $TEM_{00\ mode}$	Pulse duration		Current	Cathod e voltage	Depression voltage	Efficiency (with SDC)
	_, s	Limited by				
1.15 MW	0.1 s		49 A	84 kV	29 kV	42
0.9 MW	19 s	Load arcing	38 A	81 kV	28 kV	44
0.7 MW	42 s	MOU arcing	30 A	80 kV	28 kV	44
0.5 MW	80 s	Load arcing	26 A	76 kV	22 kV	40

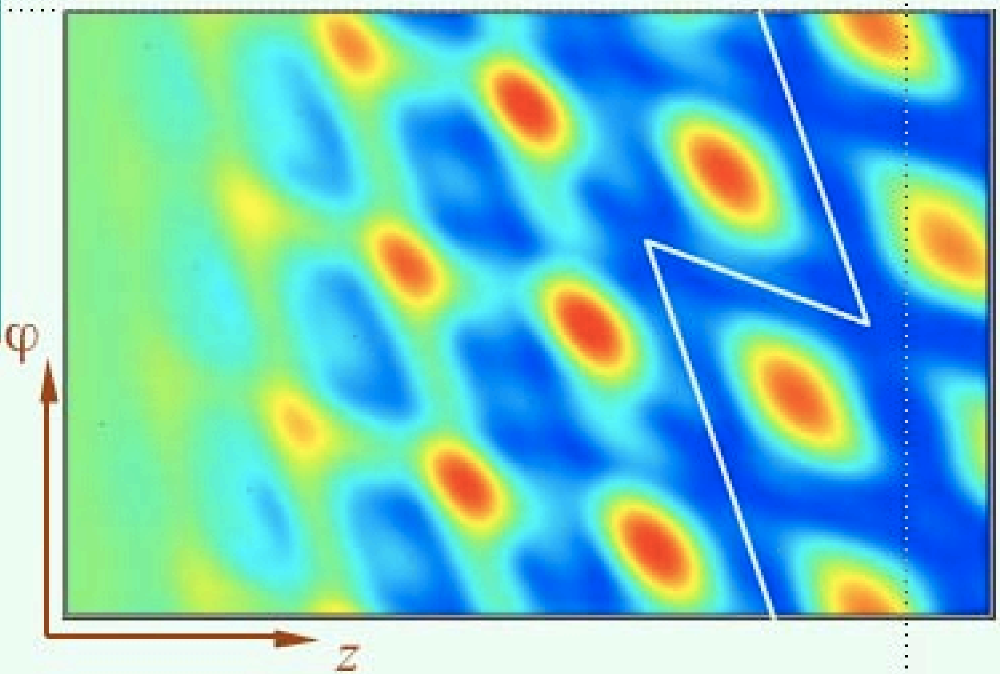
Oscillation frequency Small frequency shift during pulse	169.94GHz ~ 50MHz	+
High level of stray radiation	10%	-

Improved mode converter for 170 GHz gyrotron

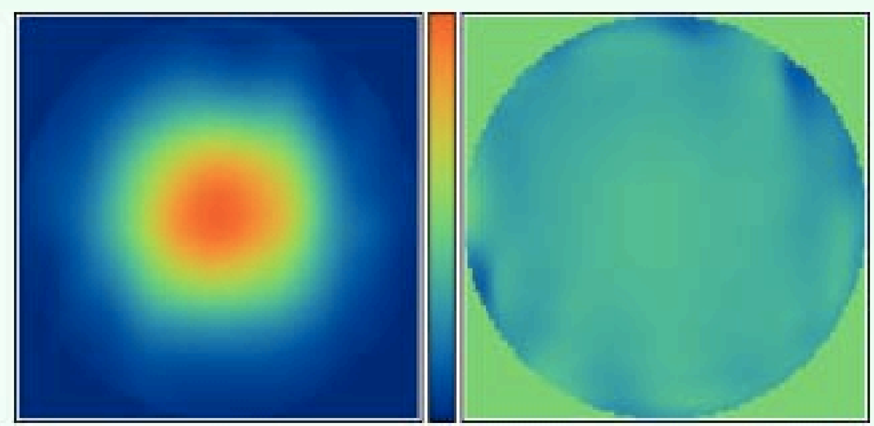
- Pre-shaping
- Slightly conical launcher
- Profiled mirrors

Gaussian mode content: η=99,5 %
(Ax=14.92 м м , Ay=14.58 м м)
Total diffraction losses: ΔP < 2%

H_z field component distribution at the launcher wall



Field amplitude and phase distribution at the gyrotron window
Aperture=120x120mm^2



MACHINES

J. Lohr
DIII-D complex struggling toward a 6 gyrotron system 110 GHz at nominal 6 MW. Several problems but latest gyrotron conditioned up rapidly to 5.0 sec operation at 80 kV, 40 A.
V. Erckmann
W7-X will be the largest gyrotron complex and progress continues on the 140 GHz tubes. Both CPI and Thales met the 0.9 MW 30 min requirement

GREAT IDEAS

W. Kasparek and A. Bruschi
High power diplexer to switch rf power between two launch systems to realize increased efficiency for NTM and other gyrotron applications

CRITICAL TECHNOLOGY THAT OFTEN GETS OVERLOOKED

M. Pretelli
Solid state body supply for gyrotrons

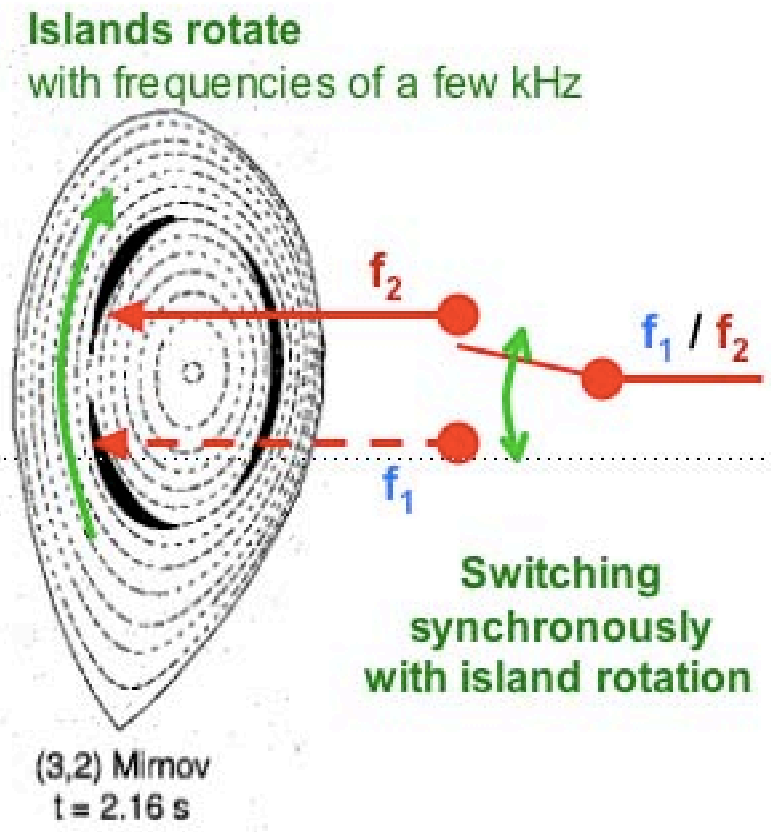
Synchronous NTM stabilization using a FAst DIrectional Switch

For optimum NTM stabilization:
EC current drive in the O-point of the islands only
(at least results similar to non-modulated ECCD)

==> modulated current drive synchronized with the frequency of the island rotation

==> for power modulation: installed gyrotron power is partly wasted,

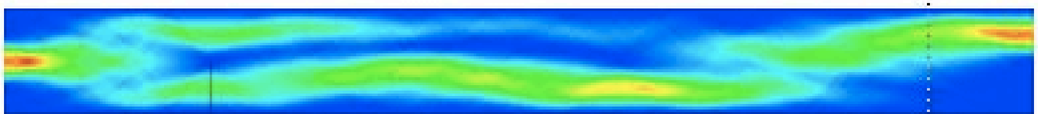
==> **possible solution:**
CW power is switched between two launchers, which are directed to locations in the plasma where the island phase differs by about 180° (toroidally or poloidally)



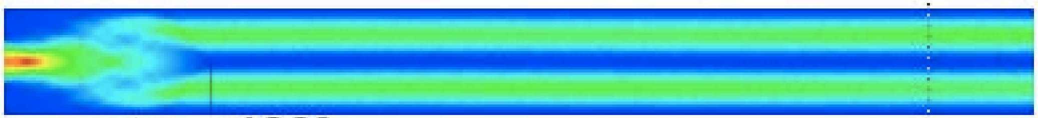
==> Attempt to develop a (mass-less) switch (FADIS) based on a **frequency diplexer** and a **small frequency modulation of the gyrotron ($f_1 - f_2 << f_1$)**

Calculations and measurements for the waveguide diplexer

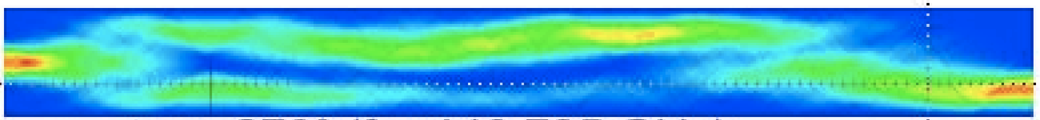
Calculation of field distribution:



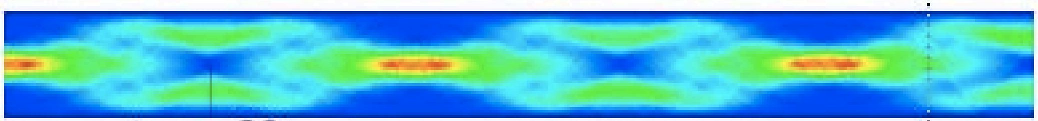
$\Delta\varphi$ = 90° (f = 140.650 GHz)



$\Delta\varphi$ = 180°

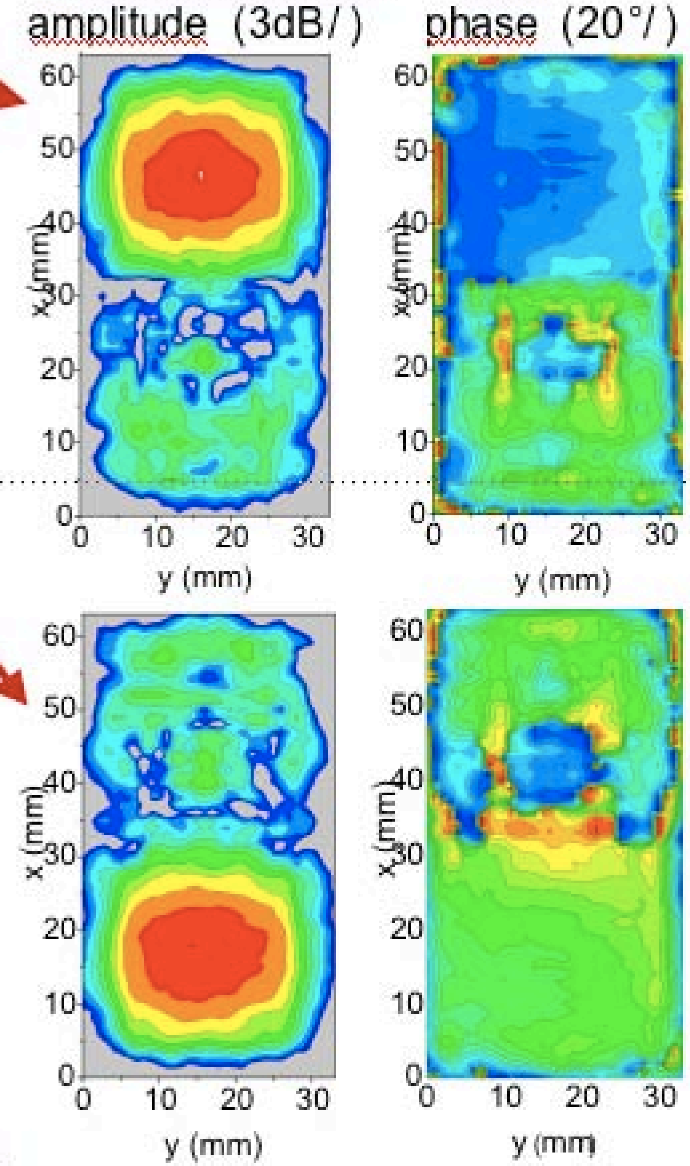


$\Delta\varphi$ = 270° (f = 140.735 GHz)



$\Delta\varphi$ = 0°

Measurements at exit:



- clear confirmation of principle
- power contrast about 96 : 4
- HE11 mode efficiency from mode analysis ≈ 80% (preliminary due to mechanical precision, measurement)
- many other designs possible, see poster by A.Bruschi

THE GREAT ITER LAUNCHER WAR

In this corner, THE REMOTE STEERERS

A.G.A. Verhoeven, A. Bruschi, M.F. Graswinckel, A. Moro, I. Danilov

And in this other corner, THE FRONT STEERERS

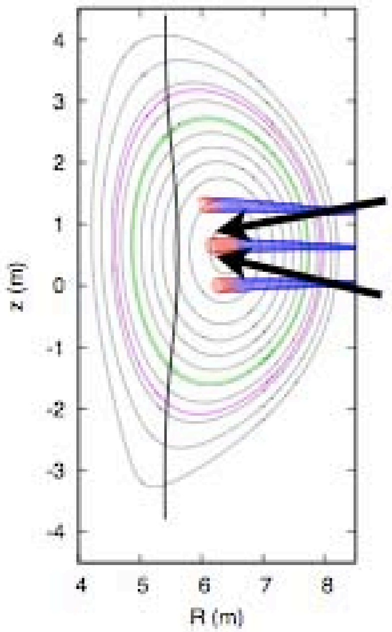
M.A. Henderson, H. Shidara,

And in both corners,

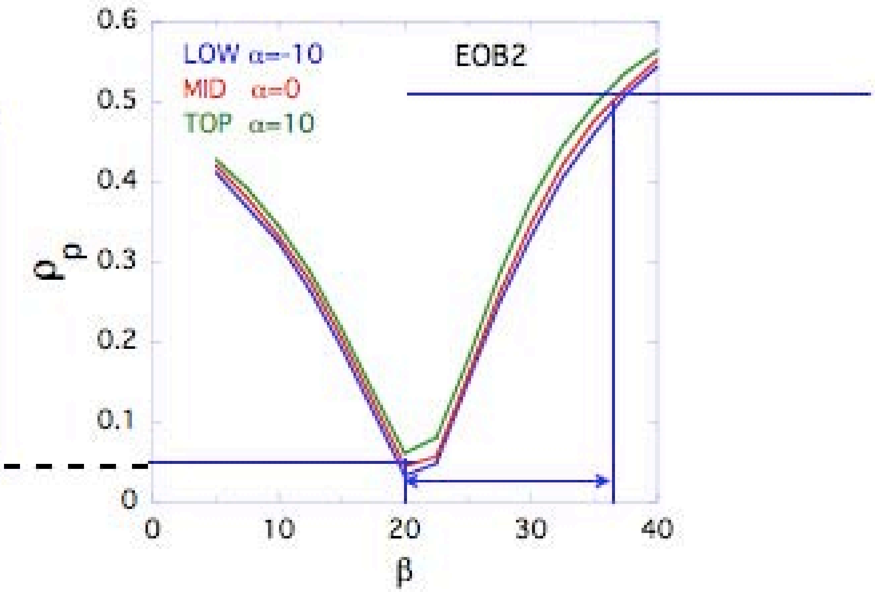
R. Heidinger, K. Takahashi (representing the equatorial launcher)

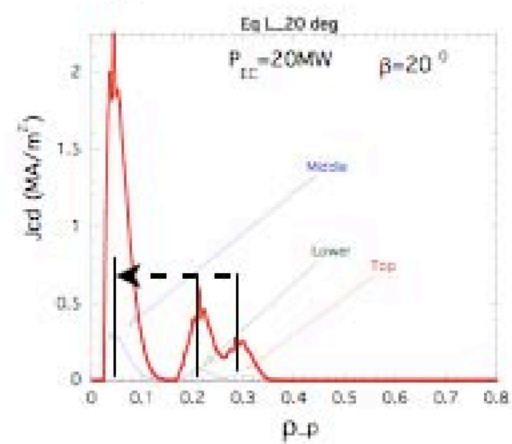
Poloidal Tilt provides central access of all 20MW

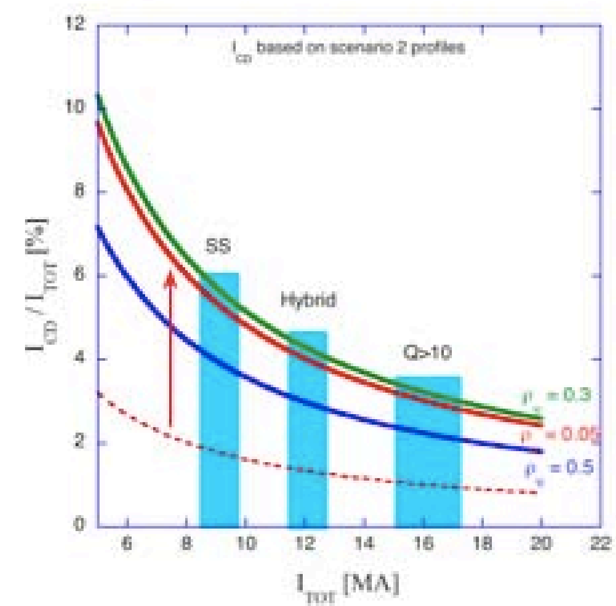
~10° tilt in poloidal plane



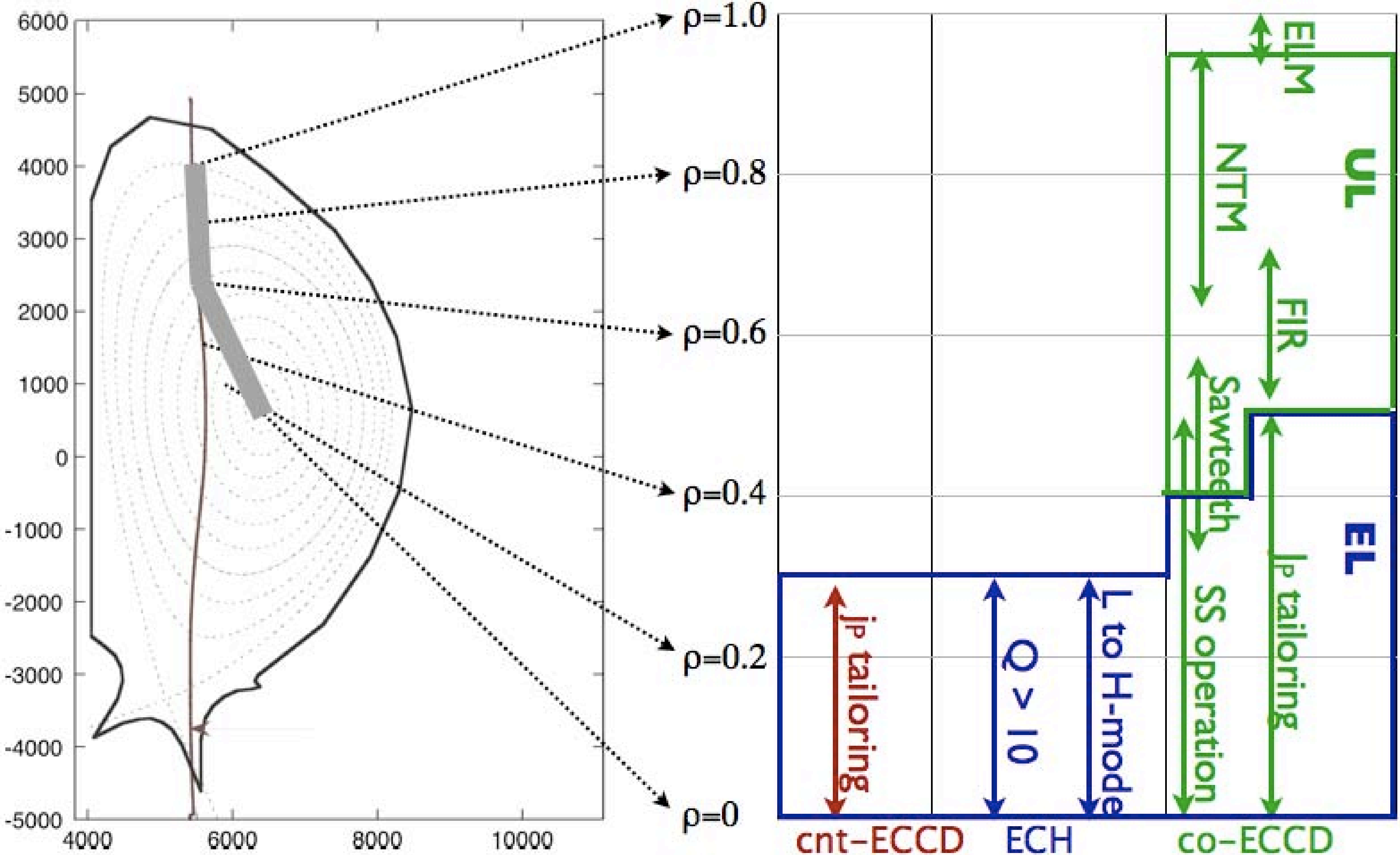
Full coverage over
$0.05 \leq \rho_\psi \leq 0.5$
of all 20MW

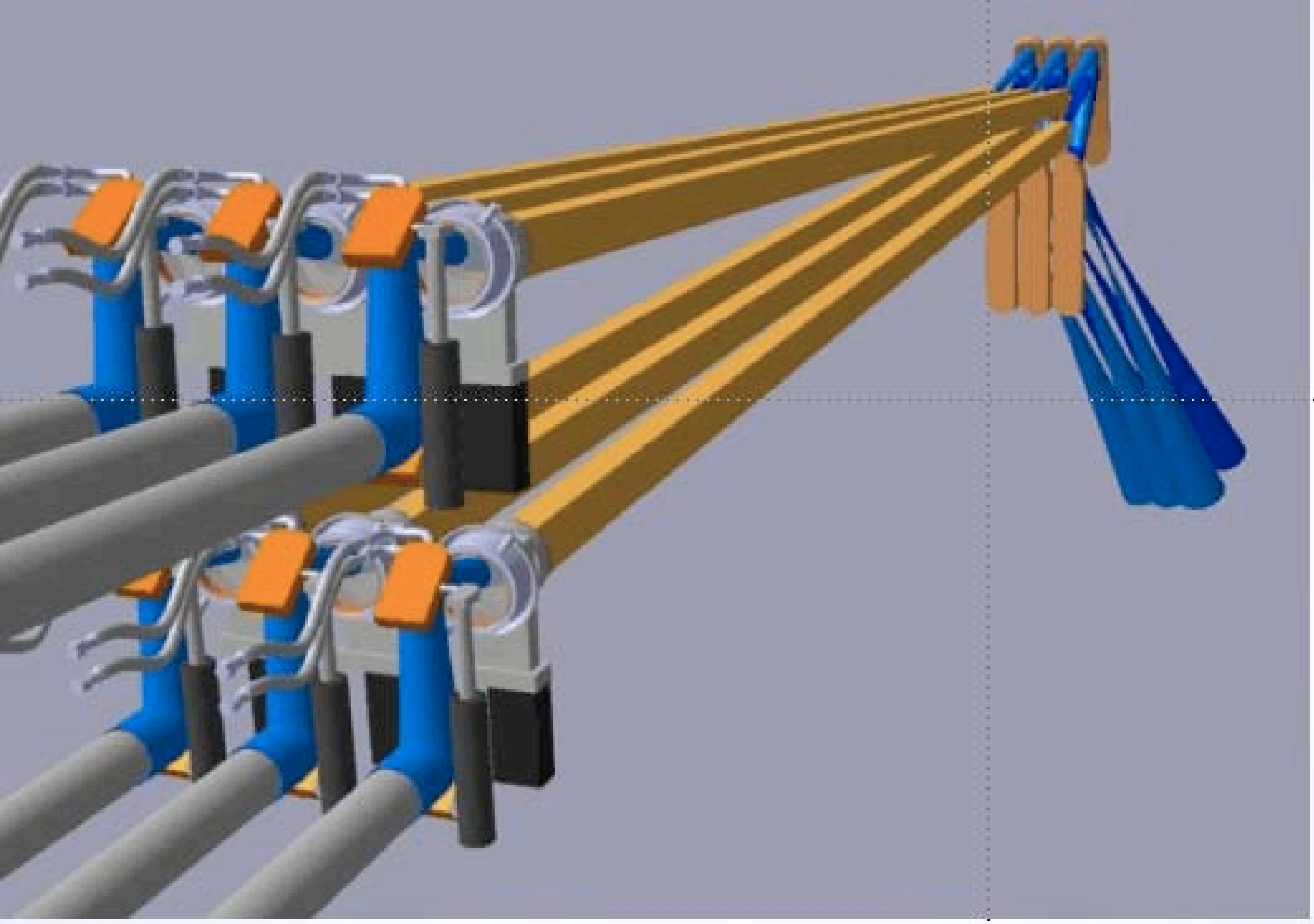






Synergy between UL and EL





- intro remote steering (RS)
- maintenance and handling
- critical design issues
- mm-wave beam optimization
- long waveguide option
  - improved performance

Plasma performance improvement

of long waveguide dog-leg ITER RS launcher

Efficiency for stabilizing NTMs: $\eta_{NTM} = j_{ECCD}/j_{bs}$

Early designs had not sufficient NTM stabilisation efficiencies

October 2005 RS dogleg (4 port/ 6 short wg)	Scenario 2	Scenario 3a	Scenario 5
q=1.5	0.56	0.36	0.53
q=2	1.27	0.69	0.91

December 2005 RS dogleg (4 port/ 6 long wg)	Scenario 2	Scenario 3a	Scenario 5
q=1.5	1.36	1.01	1.06
q=2	2.07	1.54	1.18

(December 2005 calculated with Torbeam [Poli] by Westerhof April 2006)

Taking into account not only the current-drive effect, but also the positive stabilization effects of heating inside the islands, would make all values at least 20 % higher [Westerhof and Classen, earlier this week]

Higher current-drive efficiency expected by taking into account full relativistic calculations [Poli, earlier this week]