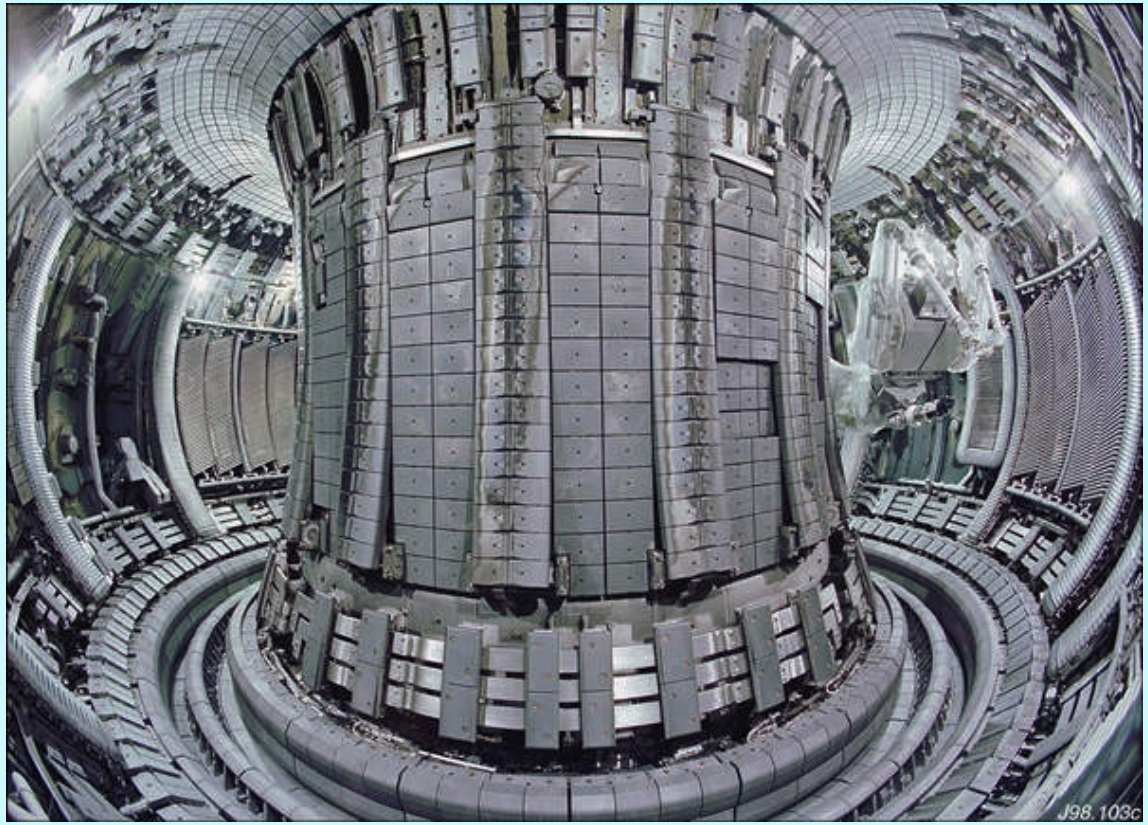
Recent Helium Plasma Operation on JET



A view inside the JET Vacuum Vessel

Aims of Pure He Plasma Experiments on JET

- Improve the understanding of:
  - Confinement and transport
  - L-H transition and edge physics
  - Divertor physics and its link with plasma wall interactions
    - Remove chemical pathways in the erosion of carbon
- Provide a data base for possible H-mode Helium plasma operation for the low activation phase of ITER

He versus D operation

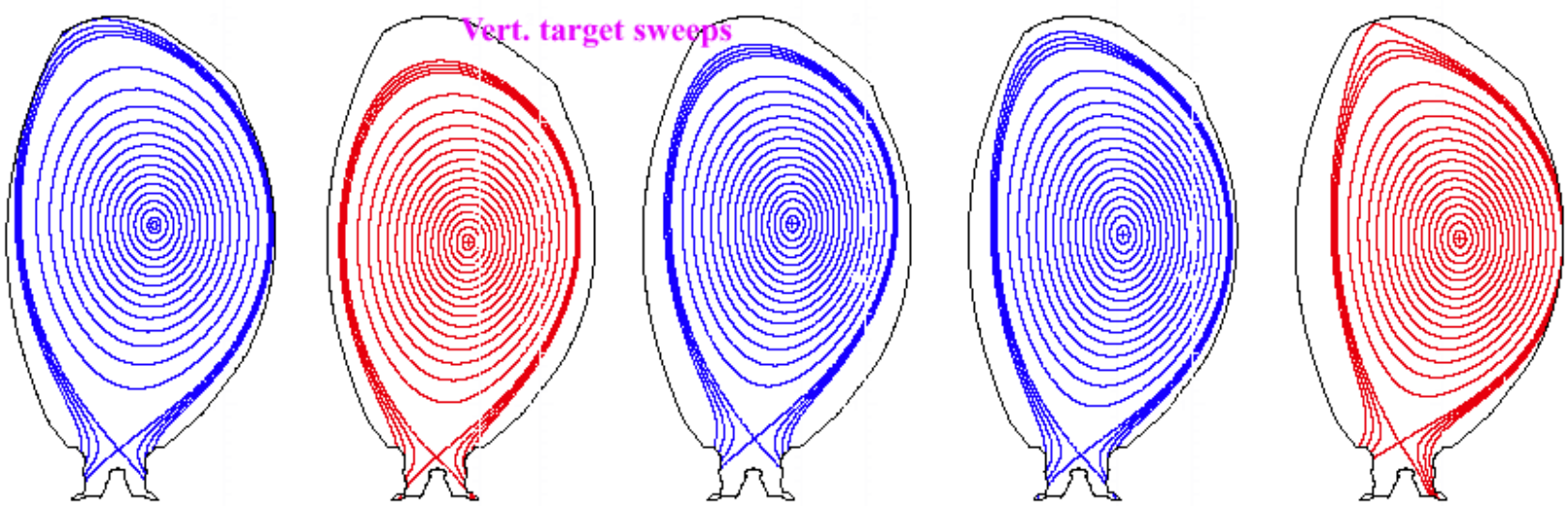
- Scaling in mass and Z
- No chemical effects in plasma wall interaction
- Less charge-exchange neutral fluxes

Boundary conditions

  - No helium wall pumping
  - Mostly no He-divertor pumping unless Ar-frosting
    - Leads to poor density control, higher edge densities

Comparison of D and He Operation

- **Choose a range of operating regimes and discharge configurations for similar cases exist in both D and He (all for Mark IIGB)**
  - **83 discharges, 41 in D, 42 in He**
  - **Multiple time sampling in each discharge - data averaged over ~0.5 s**
  - **Limited and diverted (ohmic, L- and H-mode) phases**



#54000, t = 58 s
Standard fat

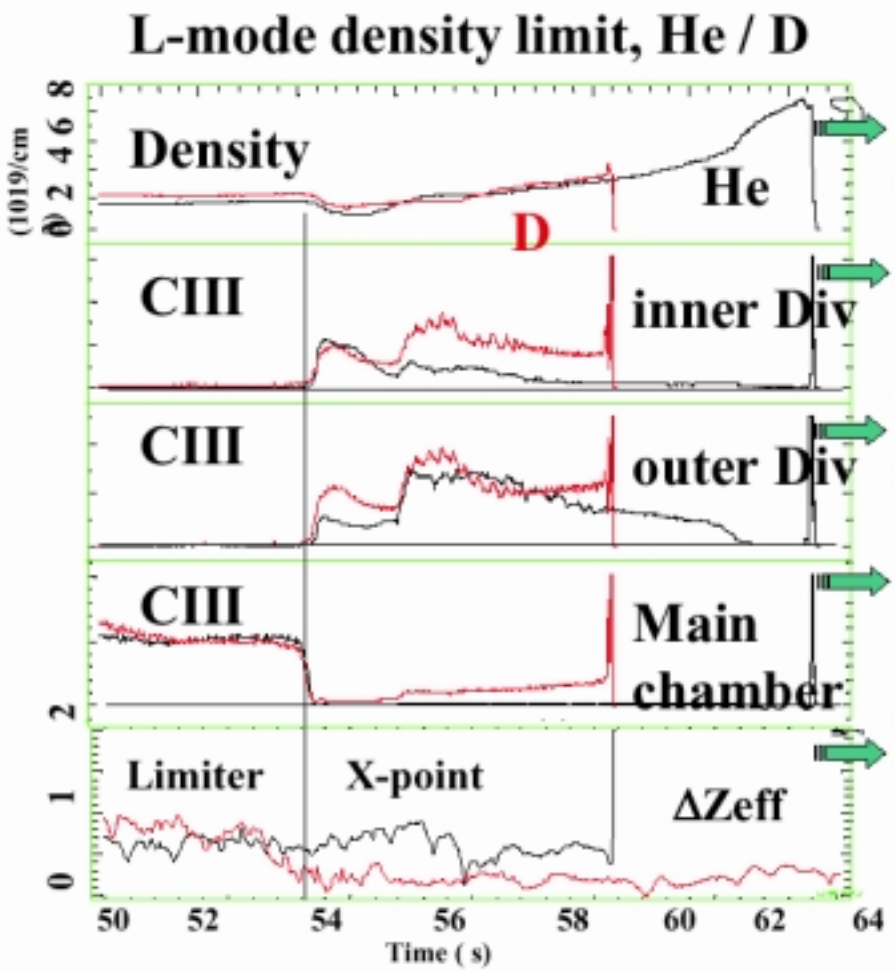
#54143, t = 60 s
High clearance

#54143, t = 68 s
High clearance

#54157 t = 60 s
High triangularity

#54214, t = 60 s
ITER-like

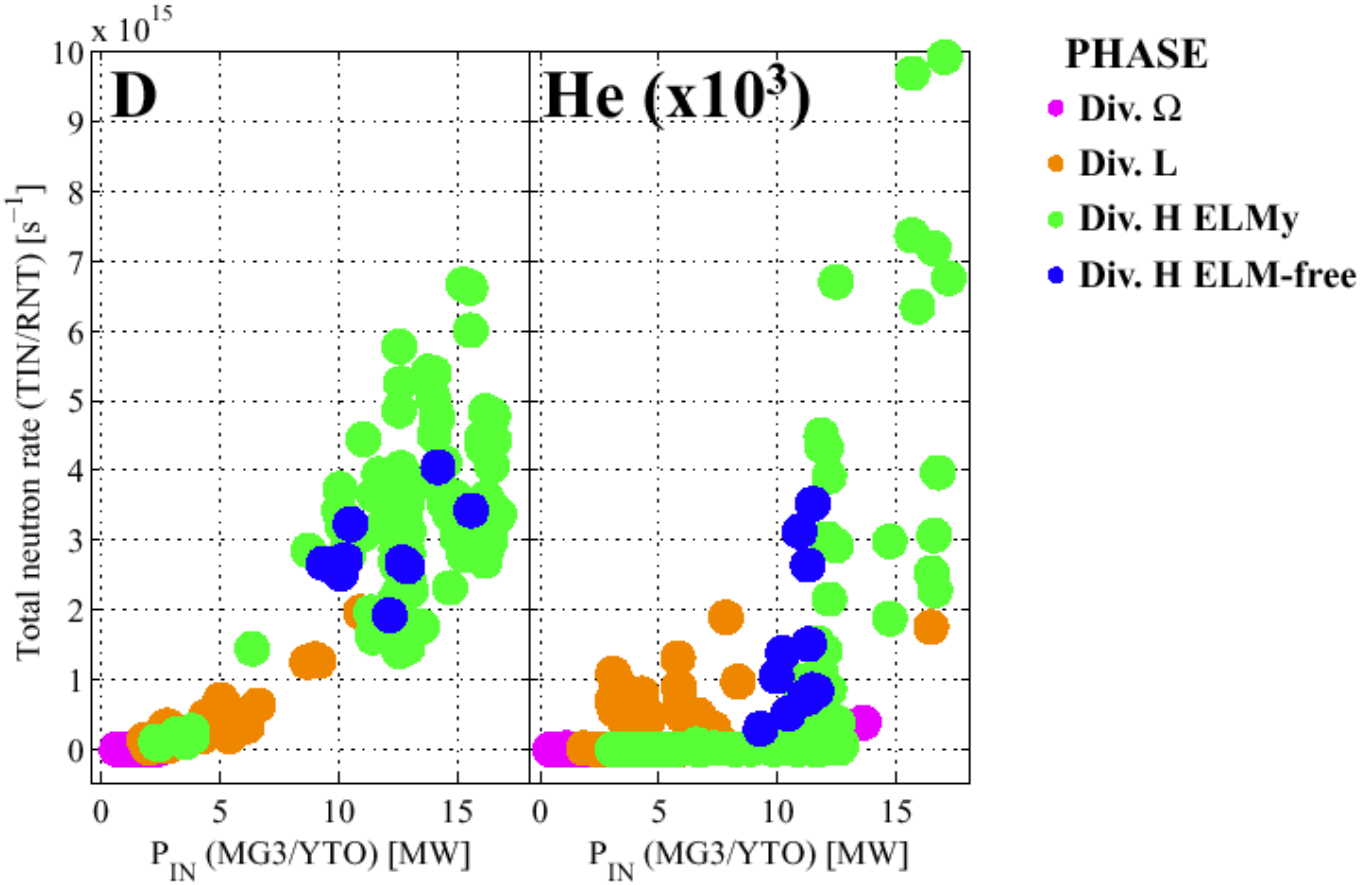
Carbon release and Zeff (L-mode) for D and He Plasma Operation



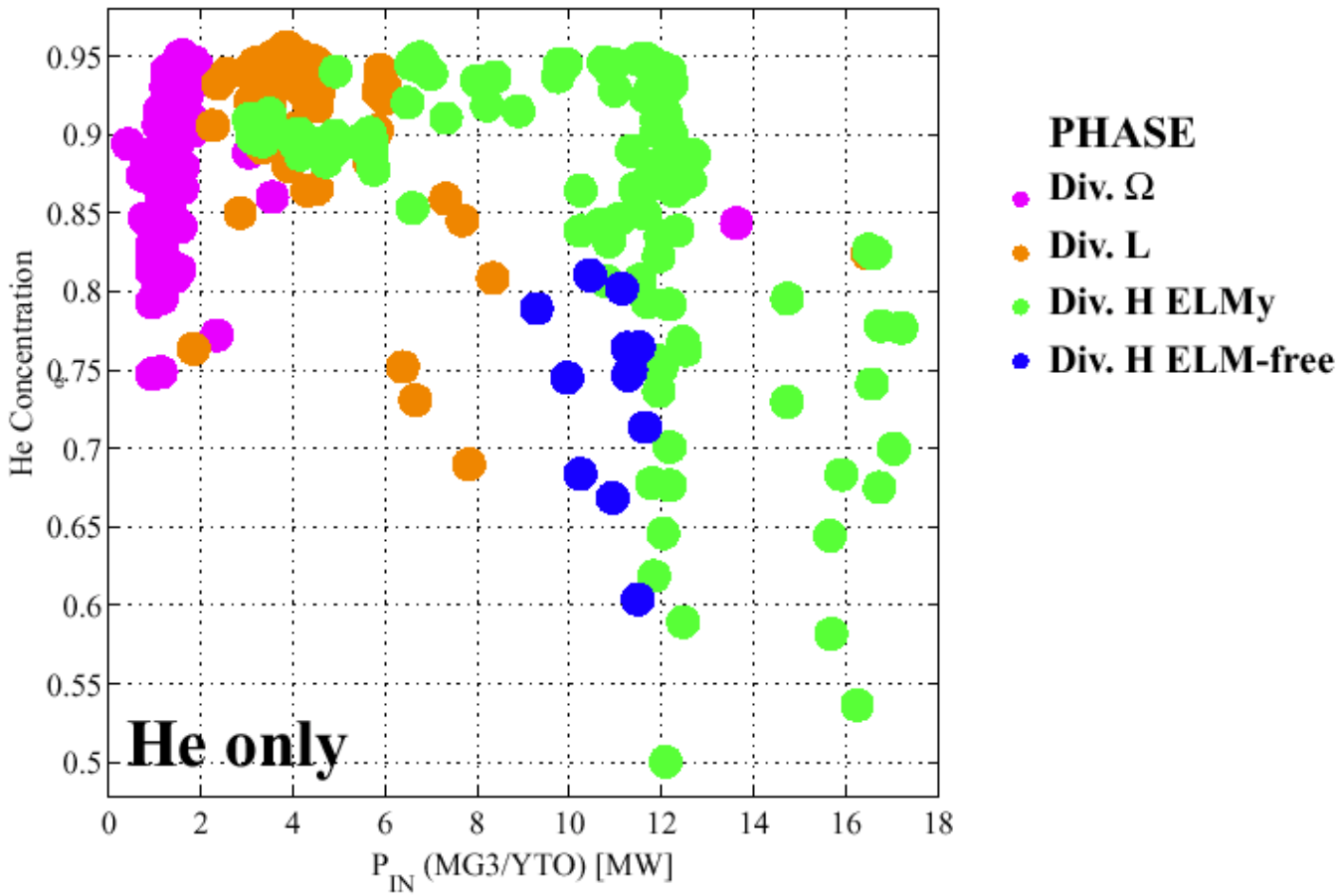
Comparison He-D

- Density limit increases by factor 2
- Carbon decreases by factor 3-5
- Carbon similar at lower densities but decreases with density
- Carbon similar in limiter phase but decreases by factor 10 and more
- Zeff decreases strongly during X point phase

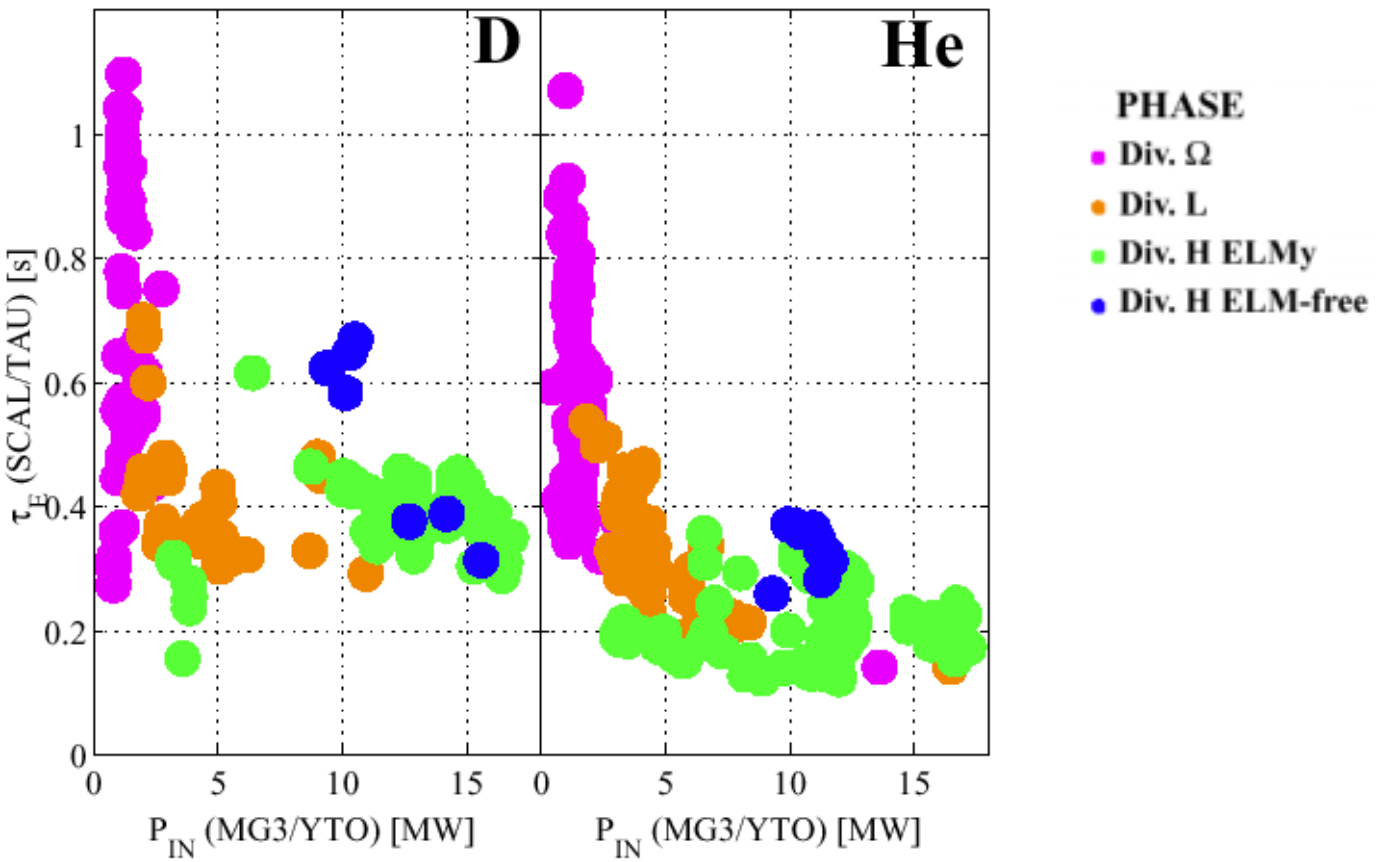
Total neutron rate vs. Power:
criteria for low activation satisfied



High Purity He Discharges achieved

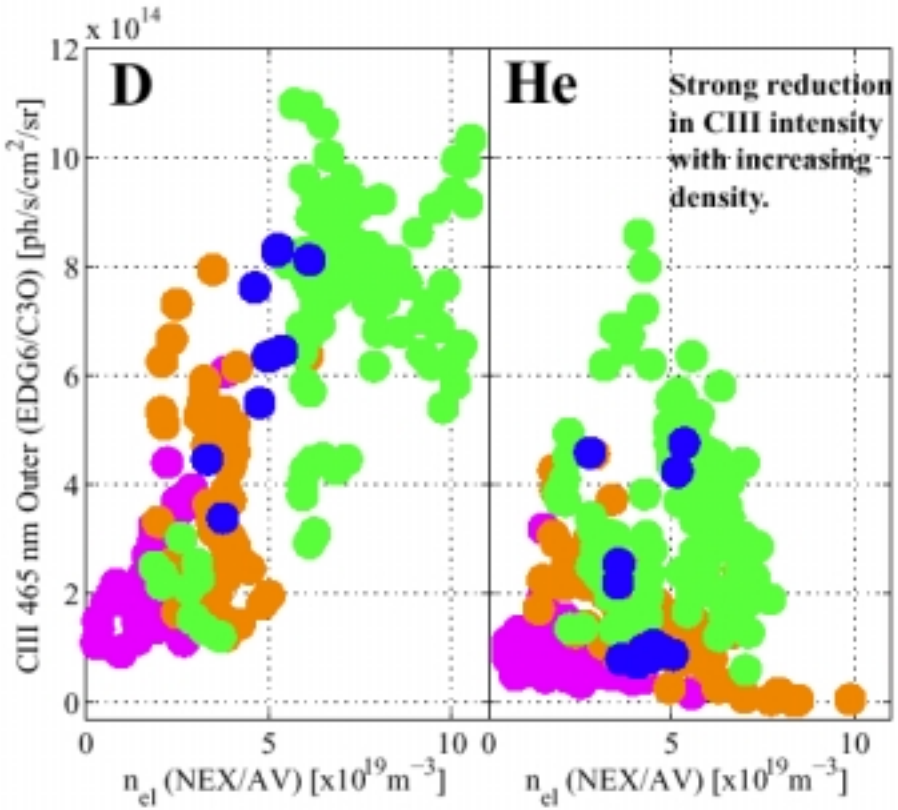


Energy Confinement vs. Power



General reduction in confinement between D and He

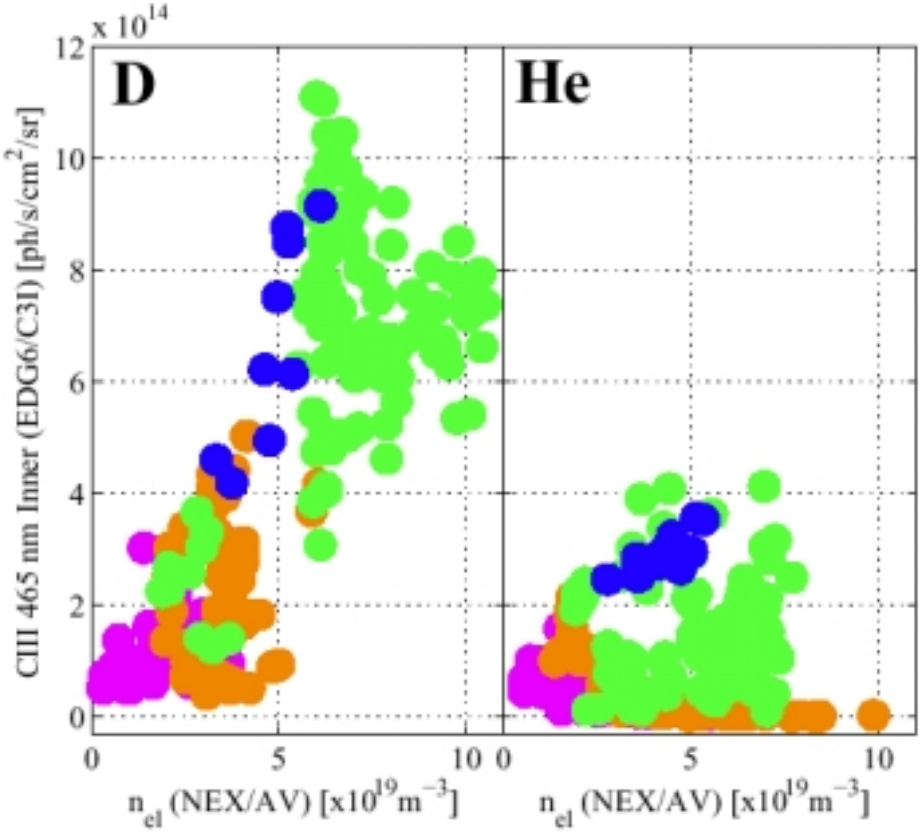
CIII outer divertor versus n_e



Although outer target carbon source lower in He than D, emission higher during H-mode than at inner target - increasing importance of physical sputtering at outer target?

- CIII flux lower in He than D

CIII inner divertor versus n_e

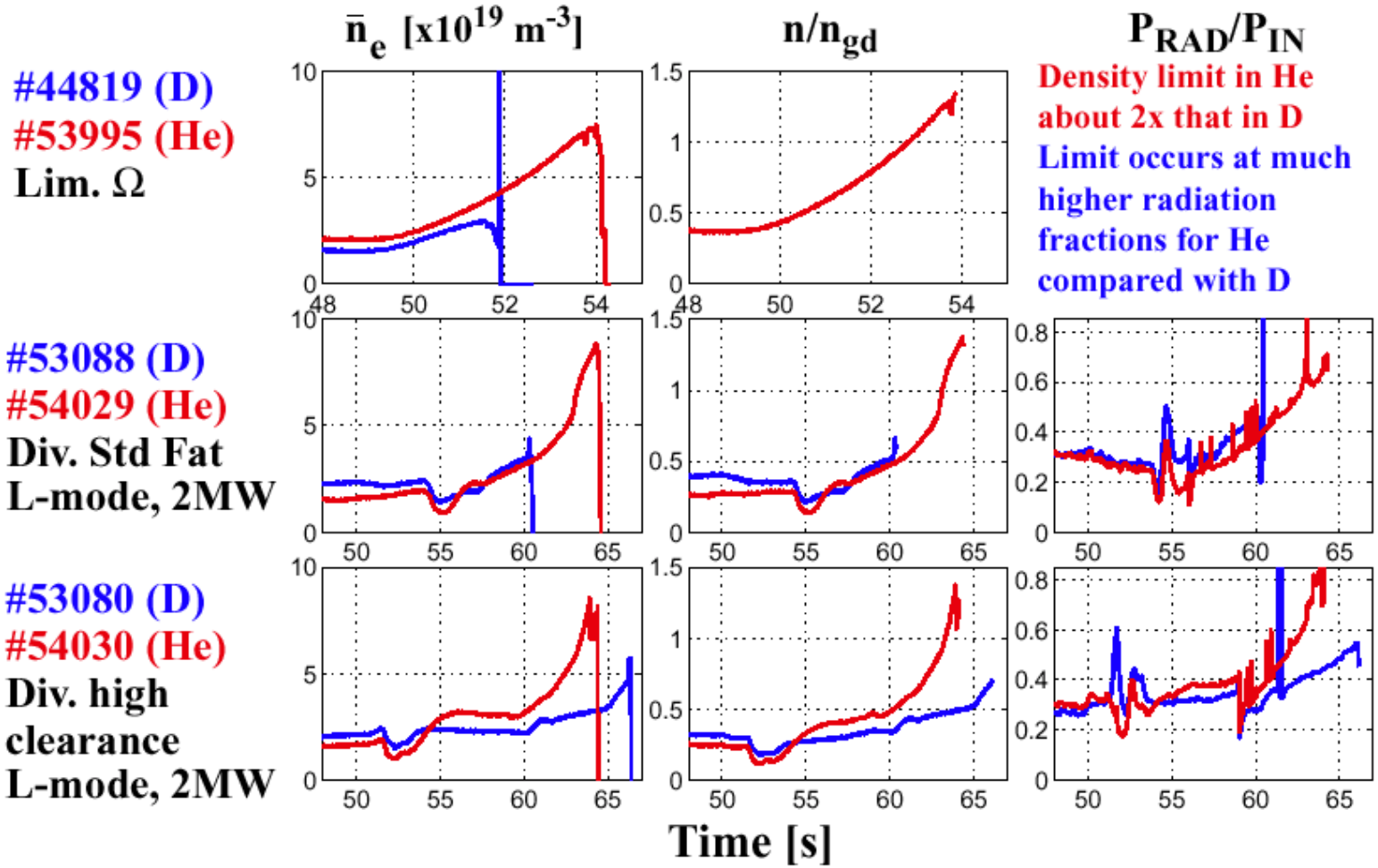


PHASE
- Div. Ω
- Div. L
- Div. H ELMy
- Div. H ELM-free

Inner divertor carbon source much lower in He than D for all densities and conf. regimes. Clear indication of large reduction in chemical sputtering at inner target.

- CIII flux much lower in He than D

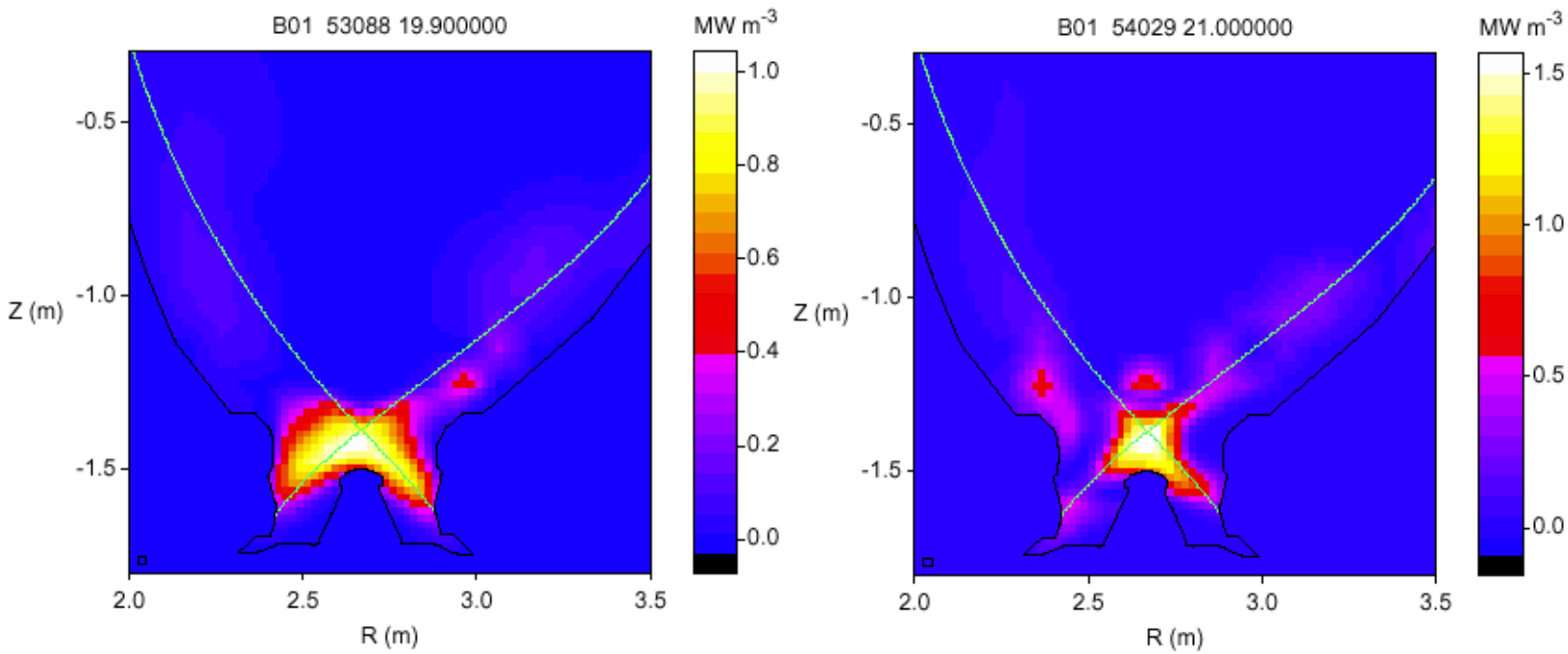
Density Limits



Density limit in He about 2x that in D

Limit occurs at much higher radiation fractions for He compared with D

Divertor radiation: D to He comparison



#53033 (D)
(near disruption)

$\bar{n}_e = 3.5 \times 10^{19}\ m^{-3}$

#54028 (He)

Radiation tends to accumulate nearer strike zones in D but nearer X-point in He.

Summary- a comparison of D and He plasmas

- Very different impurity production than found with D
  - Much reduced or absent chemical sputtering at inner target
  - Much lower main chamber CX fluxes
  - Incremental Zeff lower
- Density limits about a factor 2 higher in He:
  - Radiation distributions very different near disruption
- Detachment very different in He:
  - Power flux detaches before particle flux
  - Outer target particle flux detaches more easily than in D
- Confinement in He drops by about 15-20%
- L-H Threshold in He about 50% above that in D

Summary- Helium Operation for ITER

- Advantages of He for ITER low activation phase:
  - Much lower chemical erosion of C (ie lower Zeff)
  - Spreading of power on divertor appears better
  - Density limit is higher
- Disadvantages of an ITER phase in He
  - L-H power threshold is ~50% higher and confinement is ~17% lower than D
  - Detachment not partial but “complete” when it occurs
  - Density control appears to be difficult

This research is a collaborative work performed by:

ORNL & EFDA-JET 2000 workprogramme contributors*

[1]Oak Ridge National Laboratory- ornl

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Contributors

D.L. Hillis [1],V. Phillips [3], R. Pitts [4],P. Andrew [2],Y. Andrew [2], M. Becoulet [8], M. Brix [3], J. Cordey [2], D. Coster [7], D.C. McDonald [2], T. Eich [3], S.K. Erents[2], M.E. Fenstermacher [9], W. Fundamenski [2], A. Herrmann[3], A. Huber[3], C. Ingesson [2], S. Jachmich [3], K. Lawson [2], T. Loarer [8], A. Loarte [7], P. Lomas[2], G.F. Matthews [2], G.M. McCracken [2], A. Meigs [2], P. Morgan [2], A. Pospieszczyk [3] , J. Rapp [3] , D. Reiser [3] , V. Riccardo [2], E. Righi [7], G. Saibene[7], R. Sartori [7], M. Stamp [2], M. Wischmeier [4], K.D. Zastrow [2] & EFDA-JET workprogramme contributors*

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EFDA EUROPEAN FUSION DEVELOPMENT AGREEMENT JET

Affiliations

1) ORNL, Oak Ridge, TN 37831, USA
2) EURATOM/UKAEA Fusion Association, Culham, UK
3) IPP, Forschungszentrum Julich GmbH, EURATOM Association, Jülich, Germany+
4) CRPP/EPFL, CH-1015 Lausanne, Switzerland
5) Max-Planck IPP, EURATOM Association, Garching, Germany
6) DIII-D National Fusion Facility, San Diego, CA, USA
7) EFDA-CSU, Garching, Germany
8) CEA Cadarache, F-13 108 St Paul lez Durance, France
9) LLNL, Livermore, California USA

+Partners in the Trilateral Euregio Cluster (TEC).

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