EUROfusion

WP PWIE ADC SP G

Disclaimer: no access to mdsplus server since Dec. 23rd 2022

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Outline

Task title: Experimental assessment of PEX solutions and modelling interpretation

Deliverable title (D2)*: Initial reduced model from experimental ADC (WPTE) 3D edge simulations and experimental data to scaling laws applicable to DEMO size machine (EFPL, CEA, MPG)

- Discussion of XPR as exhaust solution: Choice of the model?

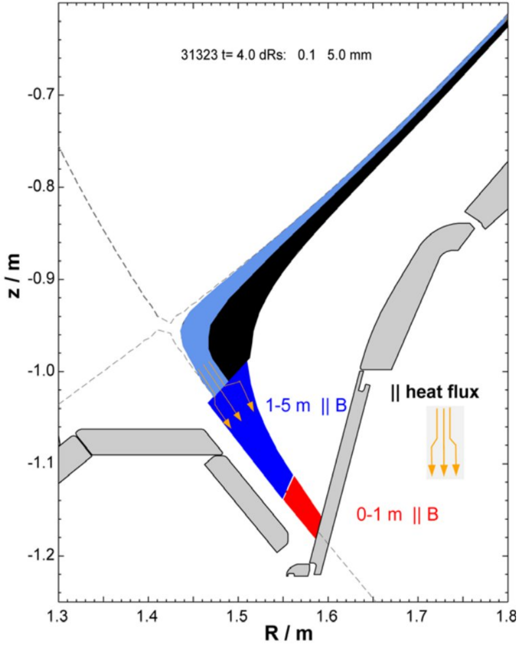
Reduced models:
- Kallenbach SOL model
- Stroth XPR model

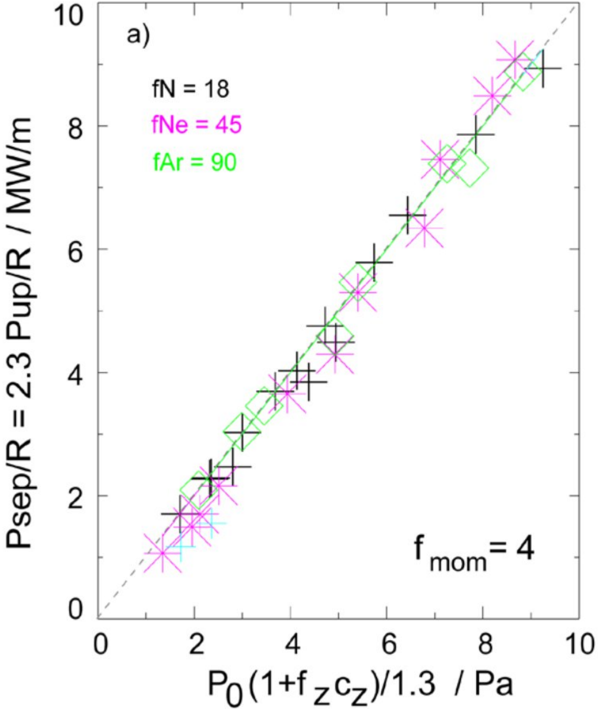
Compact radiative divertor experiments & simulations

*** For Deliverable 3 cf. F.Subba's presentation**

1D-models: Kallenbach model

Model:
Geometry: 1D
Plasmaphys: particle,mom. & energy
Neutrals: 2 mono-energ.
SOL width: $l_q \ll l_{int}$
Features: det. onset $T_{e,OT}$=2.5eV





Output:

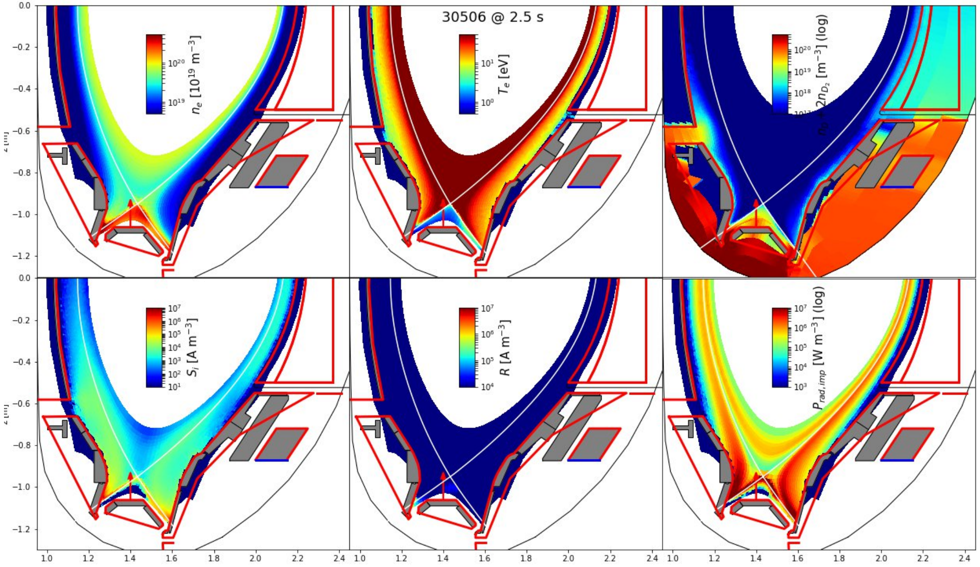
$$q_{\rm det} = P_{\rm sep}/R\ (p_0 + 18 p_{0,\rm N})^{-1} \times 1.3\ \rm Pa\ m\ MW^{-1}$$

[Kallenbach PPCF 2016]

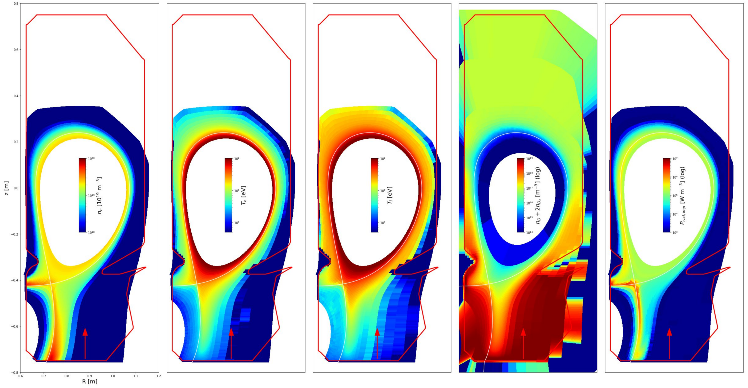
1D-models: Kallenbach model

Simulation database:

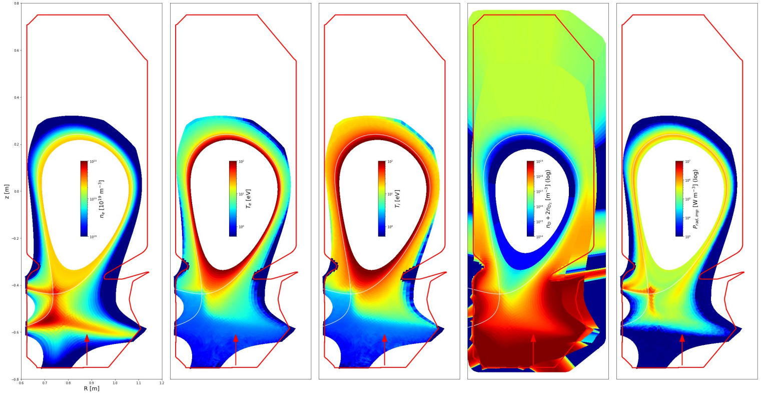
AUG SN (EMC3)



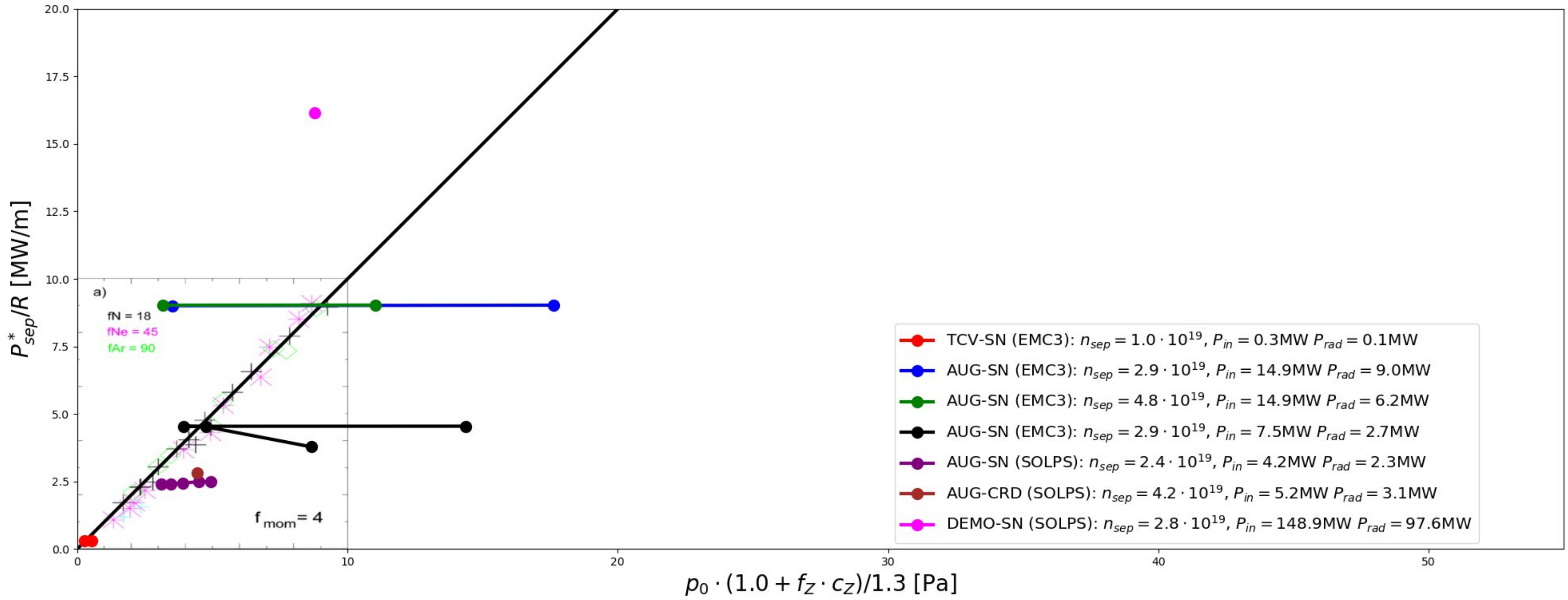
TCV SN (EMC3)



TCV SF (EMC3)



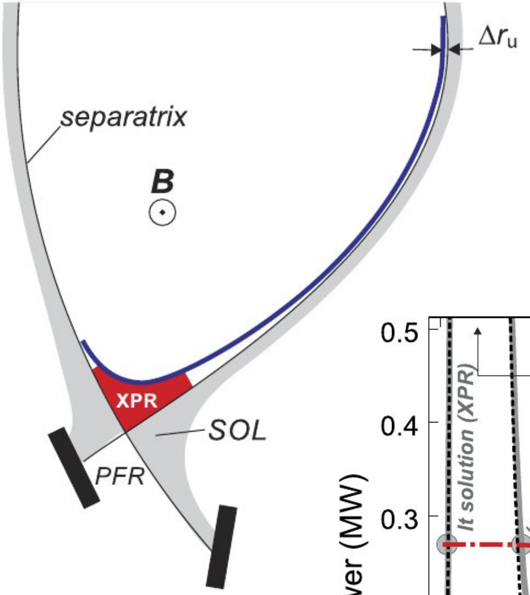
1D-models: Kallenbach model

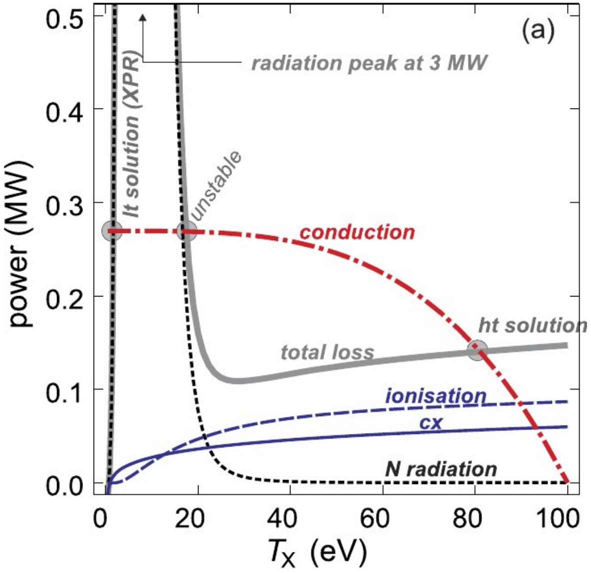


Overall tendency roughly captured by the model, but
EMC3-EIRENE does not find stable solutions in the T_e=2.5 eV range

1D-models: Stroth XPR model

XPR-model:
Geometry: 1D
Plasma: energy balance only
Neutrals: input
Radial l_q included only indirectly

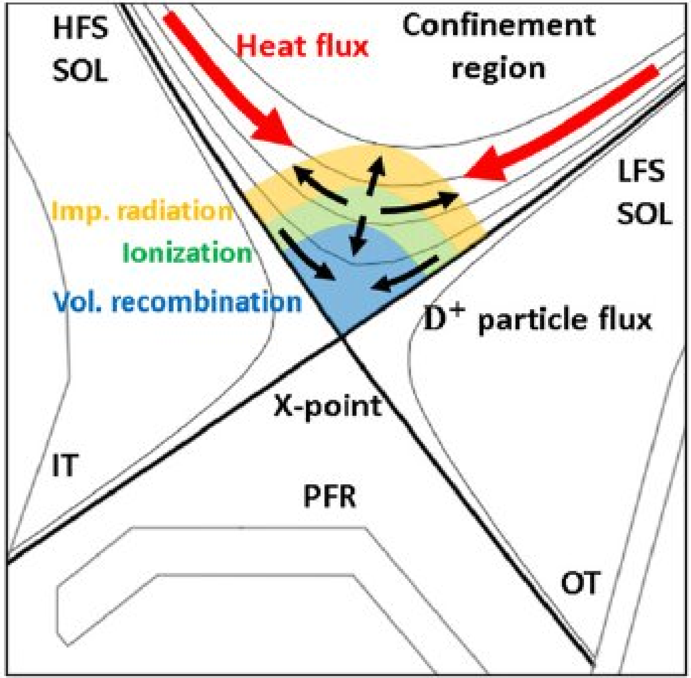




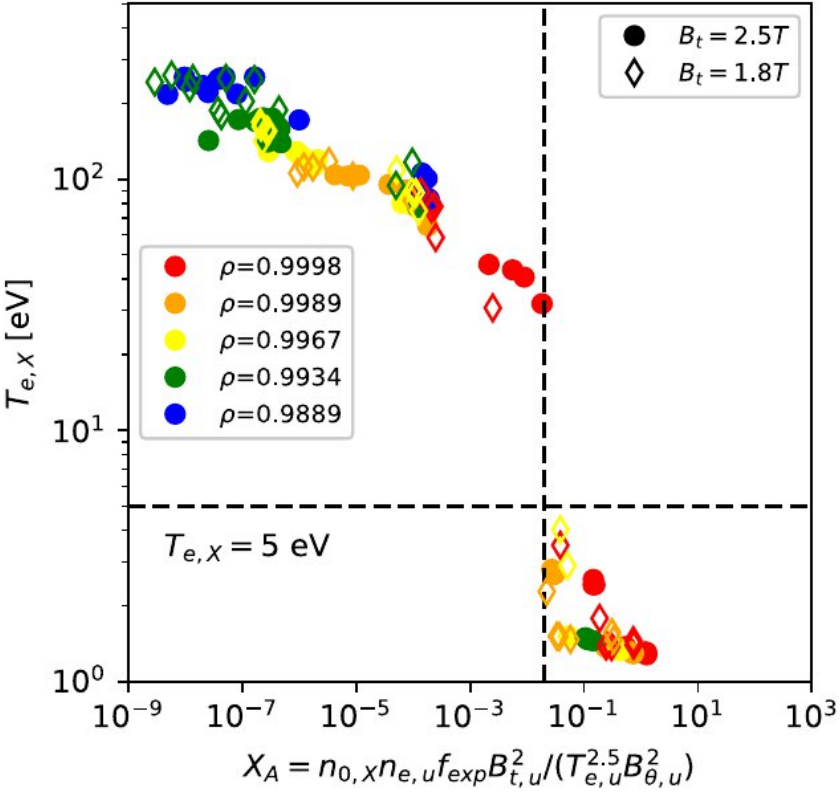
[Stroth NF 2022]

Output:
Minumum c_Z
Minimum n_0
Access conditions: $X_A \sim \frac{R_0^2 q_s^2 f_{\mathrm{exp}}}{a} \frac{n_u n_0}{T_u^{5/2}}$

1D-models: Stroth XPR model validation

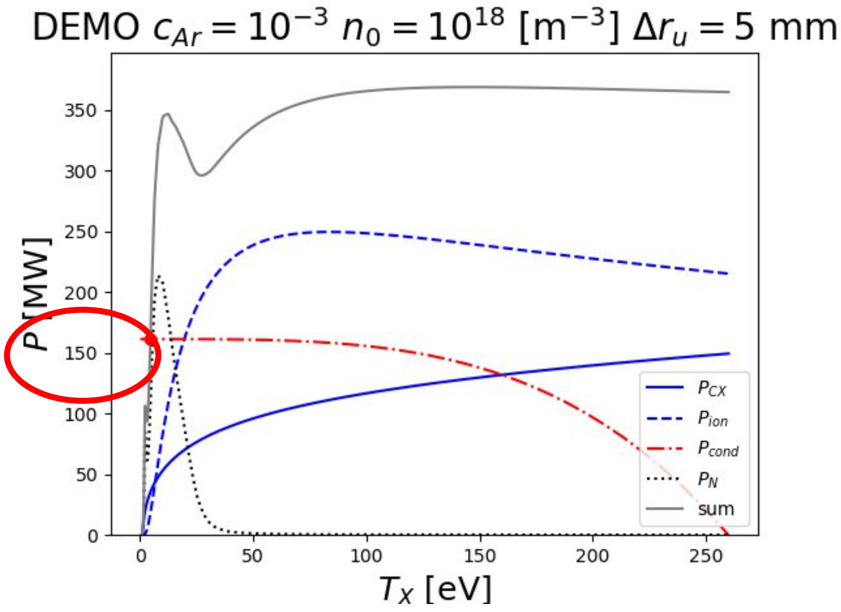


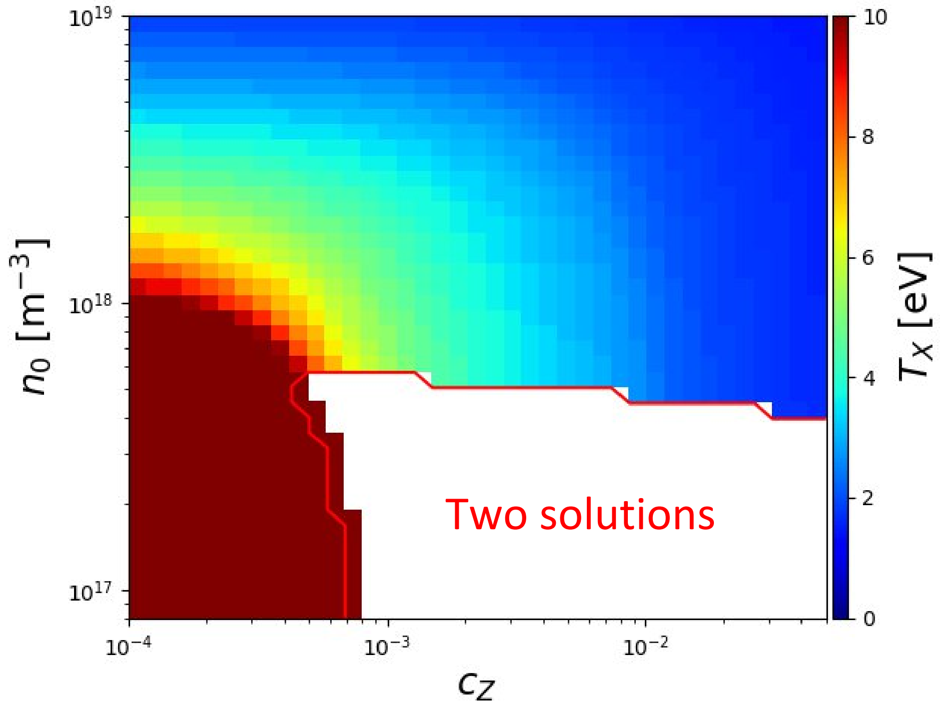
[Pan NF 2023]



Test against SOLPS-ITER DEMO simulations? (as soon as mdsplus server available)

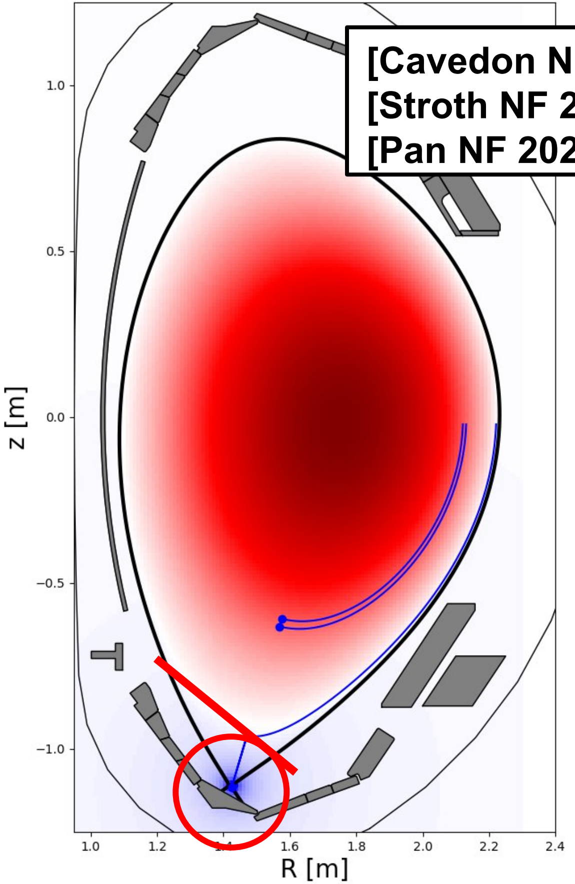
1D-models: Stroth XPR model applied to DEMO

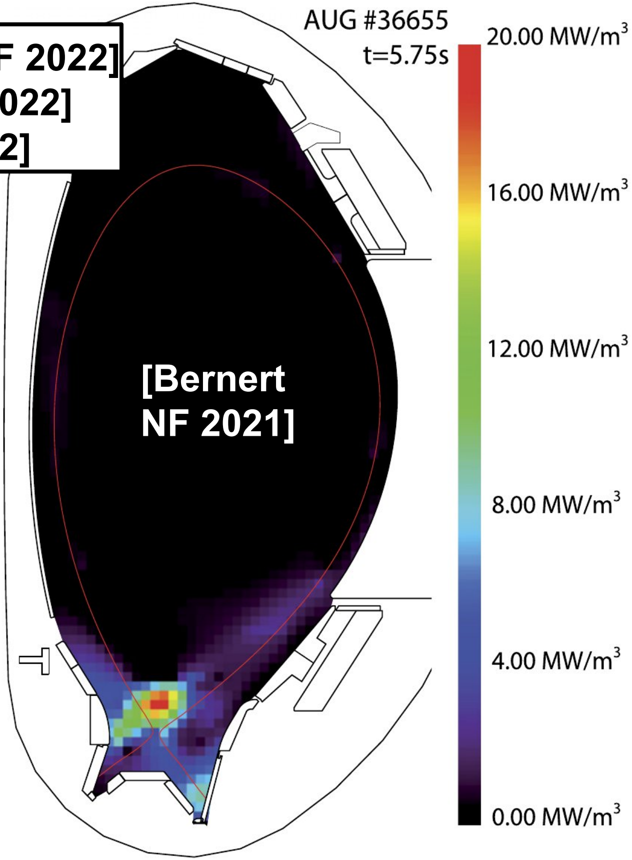




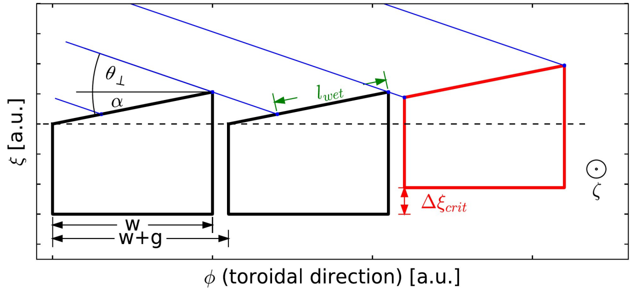
- a neutral density of ~6×10^{17} m^{-3} required to access XPR
- CRD may help

CRD introduction of the concept



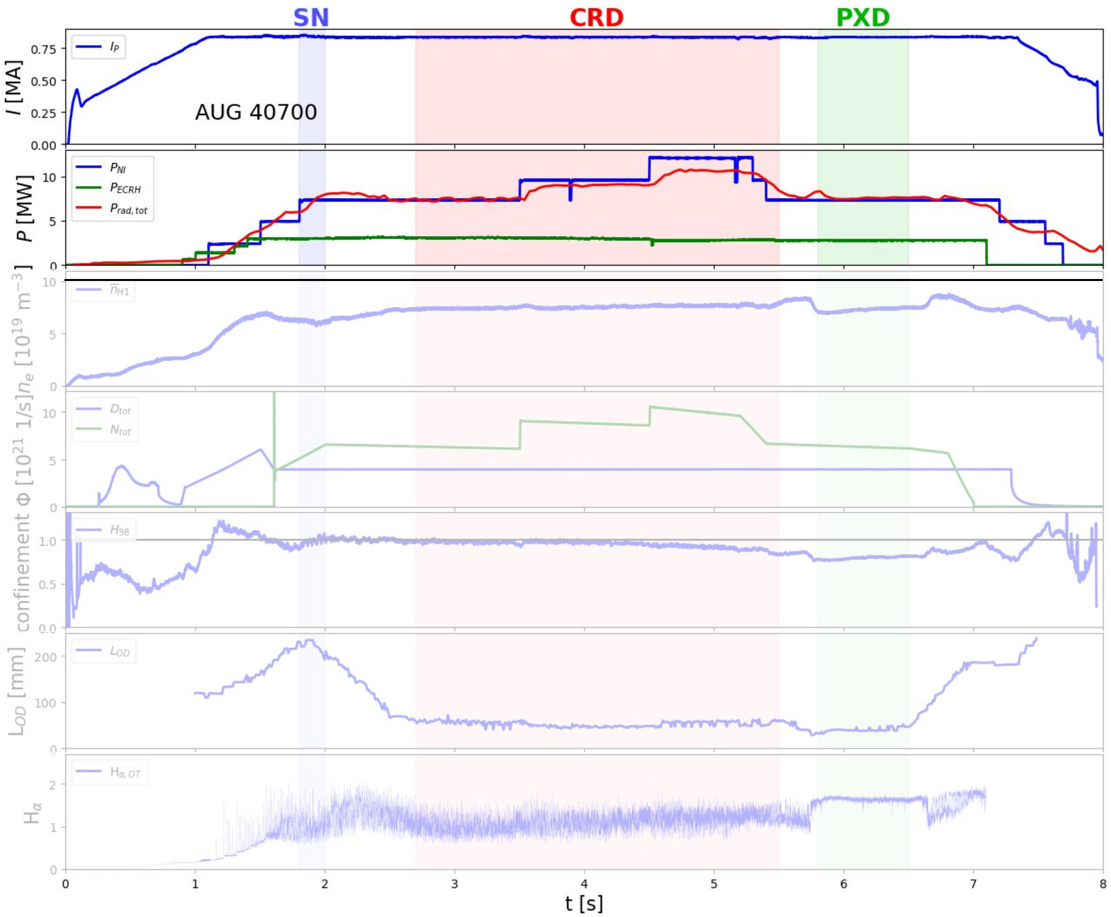


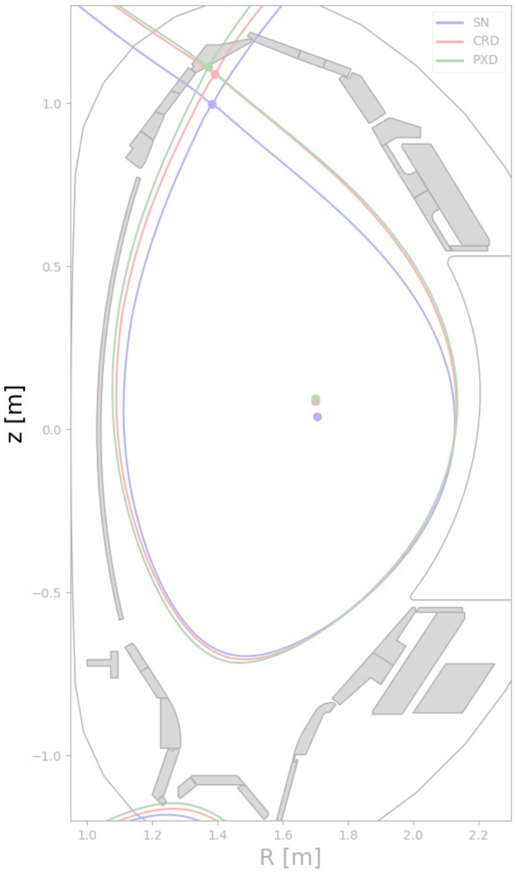
Challenge:



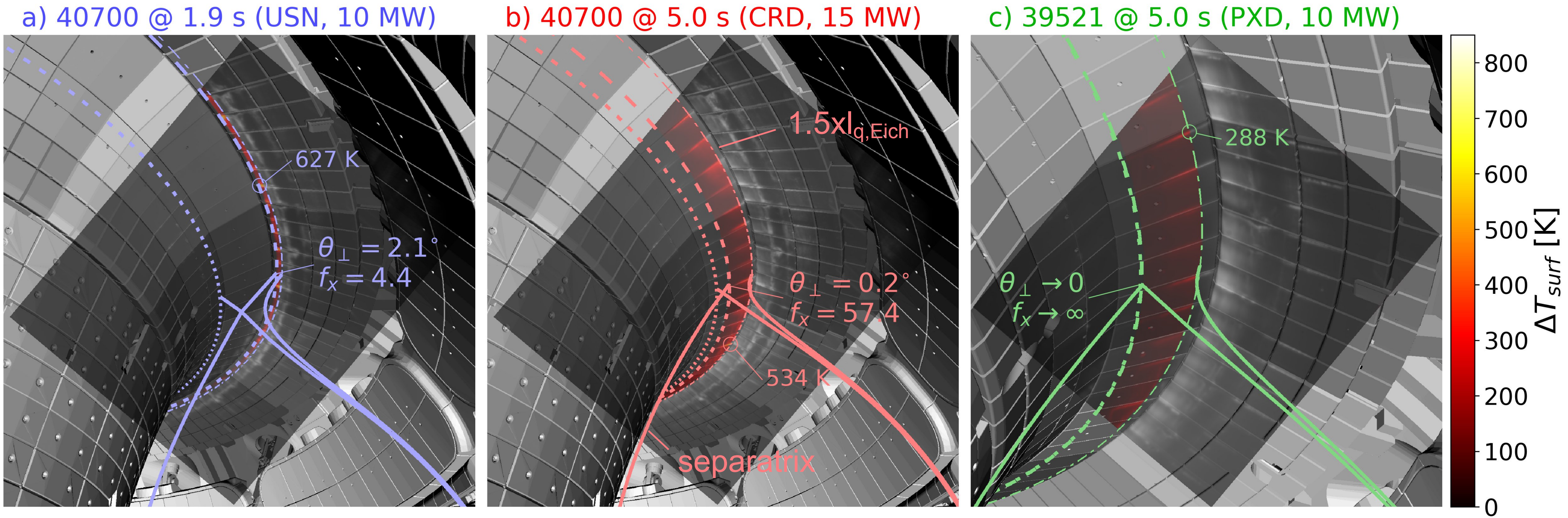
EMC3-EIRENE: shallow angles might not be problematic in detachment [Lunt PSI 2021]

CRD: Experiments – discharges





CRD: Experiments – IR thermography



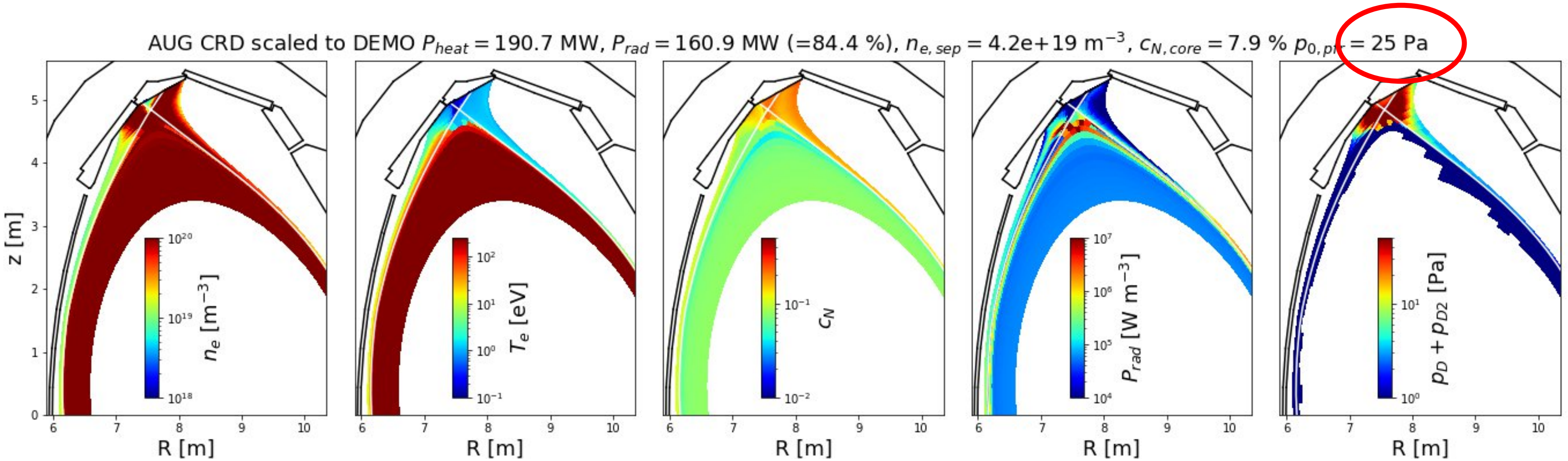
IR camera images superimposed to 3D-CAD drawings

$DT_{surf}=T_{surf}-T_{surf,0}$, $T_{surf,0}=373 \pm 30$ K

<u>Large toroidal coverage: Df=70°</u>

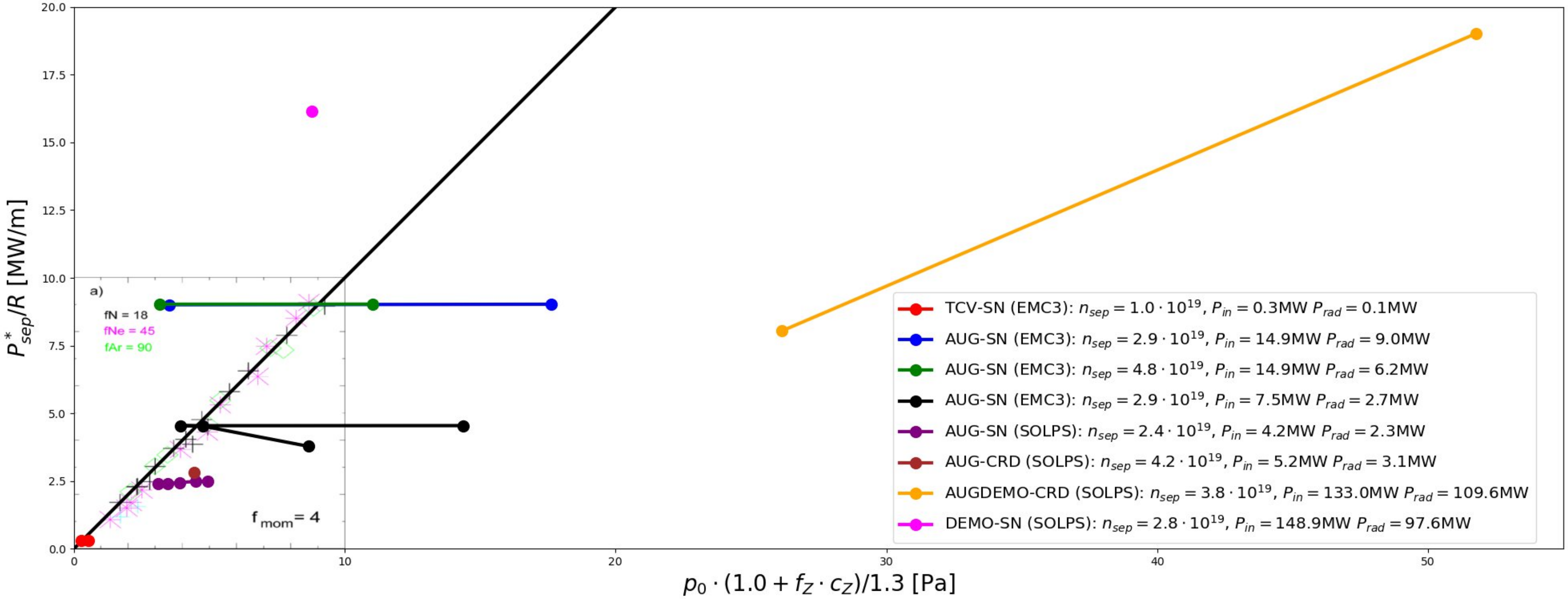
[Lunt, Bernert et al. submitted to PRL]

DEMO-size CRD simulations



[first (preliminary) simulations by Ou Pan]

1D-models: Kallenbach model



Compact radiative divertor (CRD)

Benefits

+ possible way to access XPR in DEMO
+ Optimize plasma volume @ given machine size ☾ best performance at given costs
+ reduced currents in the divertor coils ☾ less superconductor and support material needed
+ improve vertical stability (or even become completely stable) ☾
 probablity and severeness of disruptions reduced, no/less volume for stabilizer plates required
+ stable divertor operation experimentally shown ☾ power- and particle exhaust solution
+ ‚AC operation' possible ☾ decrease down-times between discharges

Challenges (likely to be overcome)

+ guarantee detachment at all times (maybe easier than in a conventional SN)
+ little space left to accomodate diagnostics (like in a reactor 🏝)
+ P_{LH} increased (but not dramatically)