平成26年度合同会合
2014.8.1 筑波大学　大学会館

モデリングの現状
トカマクダイバータシミュレーション

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原子力機構

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1. 国際的進展（PSI2014概要）

http://psi2014.nifs.ac.jp/talks.html　を参照してください。

2. 国内活動（原型炉ダイバータシミュレーション）

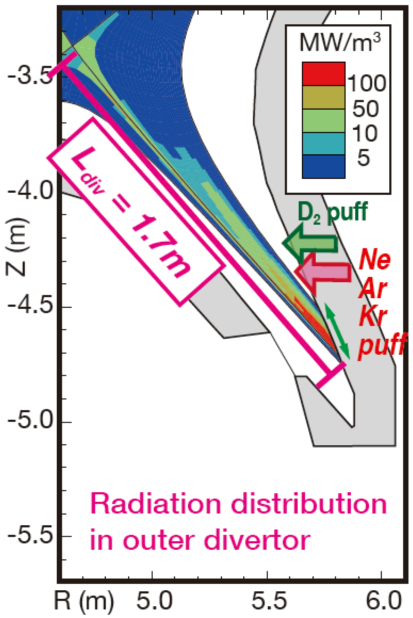
Power exhaust study for SlimCS (P_{fus} = 3GW) in 2012

- **Enhancement of P_{rad}^{div} and $P_{rad}^{SOL+edge}$ and "Full detachment" were required.**

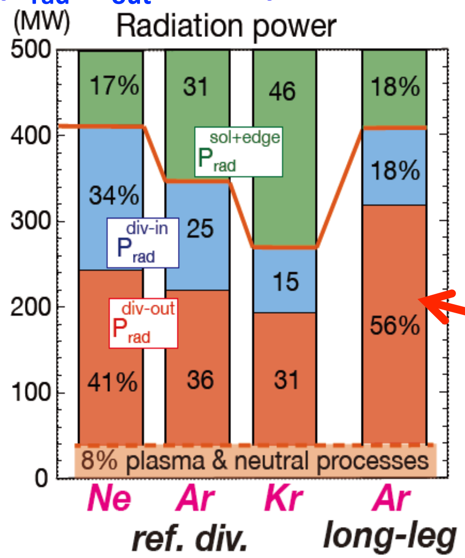
⇒ **Divertor operation consistent with q_{target} (incl. radiation load) < 10MWm^{-2} was seen *only in specific conditions such as enhanced diffusion.***

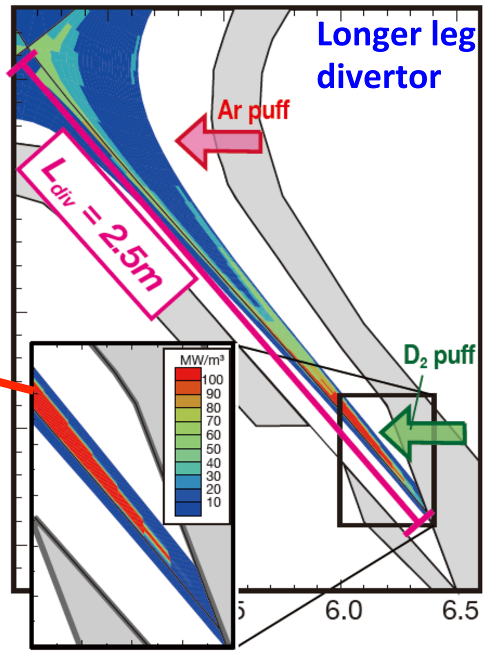
- **Seeding impurity selection: higher Z (Ar/Kr) is preferable to increase P_{rad}^{SOL}**
  issue: dilution in core plasma, and potentially, P_{rad}^{edge} restriction for good confinement.
- **Longer leg divertor design: effective for full detachment and P_{rad}^{div} enhancement**
  issues: reduction in ion and neutral fluxes, and optimization with He exhaust
- **Plasma diffusion – large impact on detachment and energy dissipation, suggesting that *global/ local enhancement* promotes full detachment. Issues: extrapolation to Demo, techniques.**

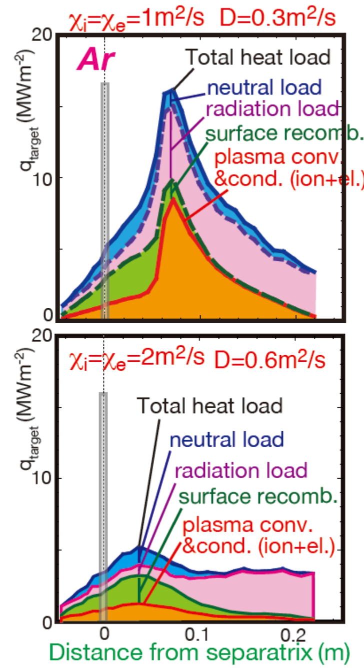
[1] K. Hoshino, et al. Contrib. Plasma Phys. 52 (2012) 550. [2] N. Asakura, et al. Nucl. Fusion, 53 (2013) 123013.



Power distribution summary (P_{rad}/P_{out} = 0.92)



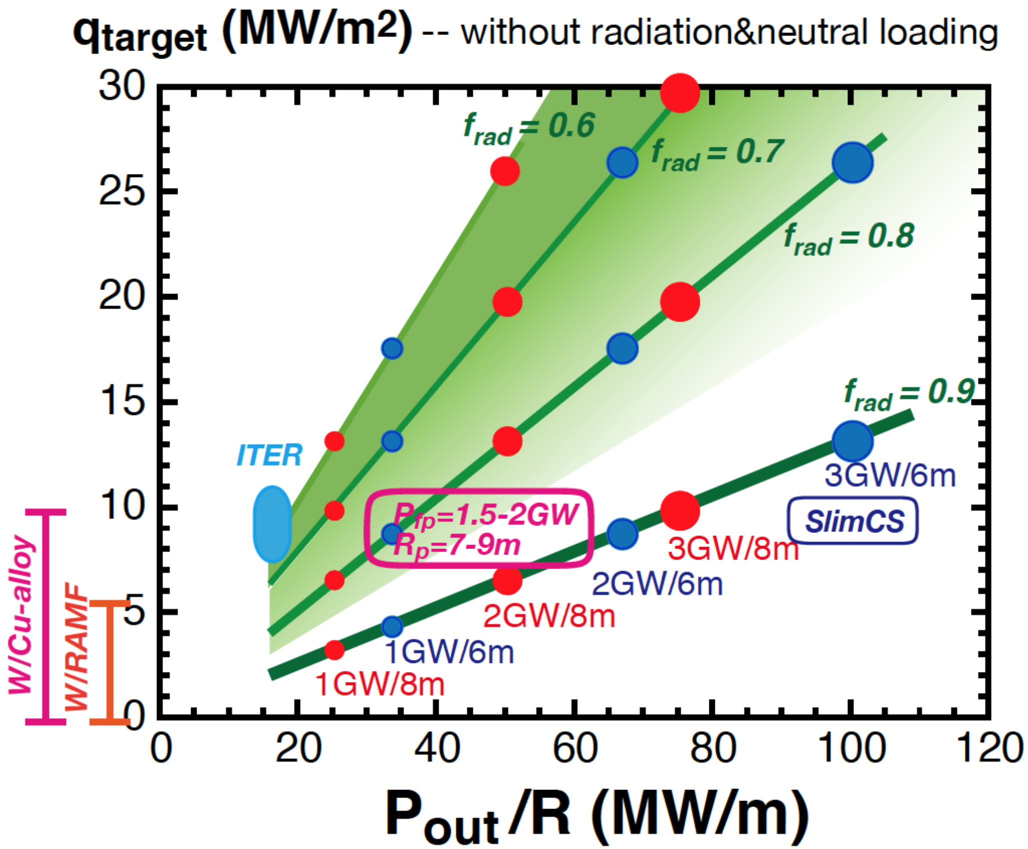




Demo design for P_{out}/R = 30-60 started from 2013

- Design parameters for power exhaust with **P_{out}/R = 30-60:** 2-4 times larger than ITER **P_{fus} = 1.5-2GW level (P_{out} = 300-400MW)** and **R = 7-9 m**.

- **Large f_{rad} = 0.8-0.9 and ITER divertor technology (W&Cu-alloy) will be still required,** while experiments with high H-factor and radiation loss are limited up to **f_{rad}= 0.7-0.8**.
  ⇒ Developments of the divertor physics and engineering/technology are necessary.



Simple estimation of peak heat load:

Demo design ↓ *$n_e^{SOL\&div}$, Imp. seeding* ↓

$$q_{target} = \frac{P_{out}}{R}\,\frac{(1 - f_{rad})}{4\pi\lambda_q^{mid}}\,\frac{\sin\theta_{div}}{f^{exp}_{div}}$$

↑ *Transport & Detachment* ↑ *Geometry design*

Divertor physics design study will decrease q_{target} in Figure.

Nearly full-detachment was obtained in reduced P_{fus}

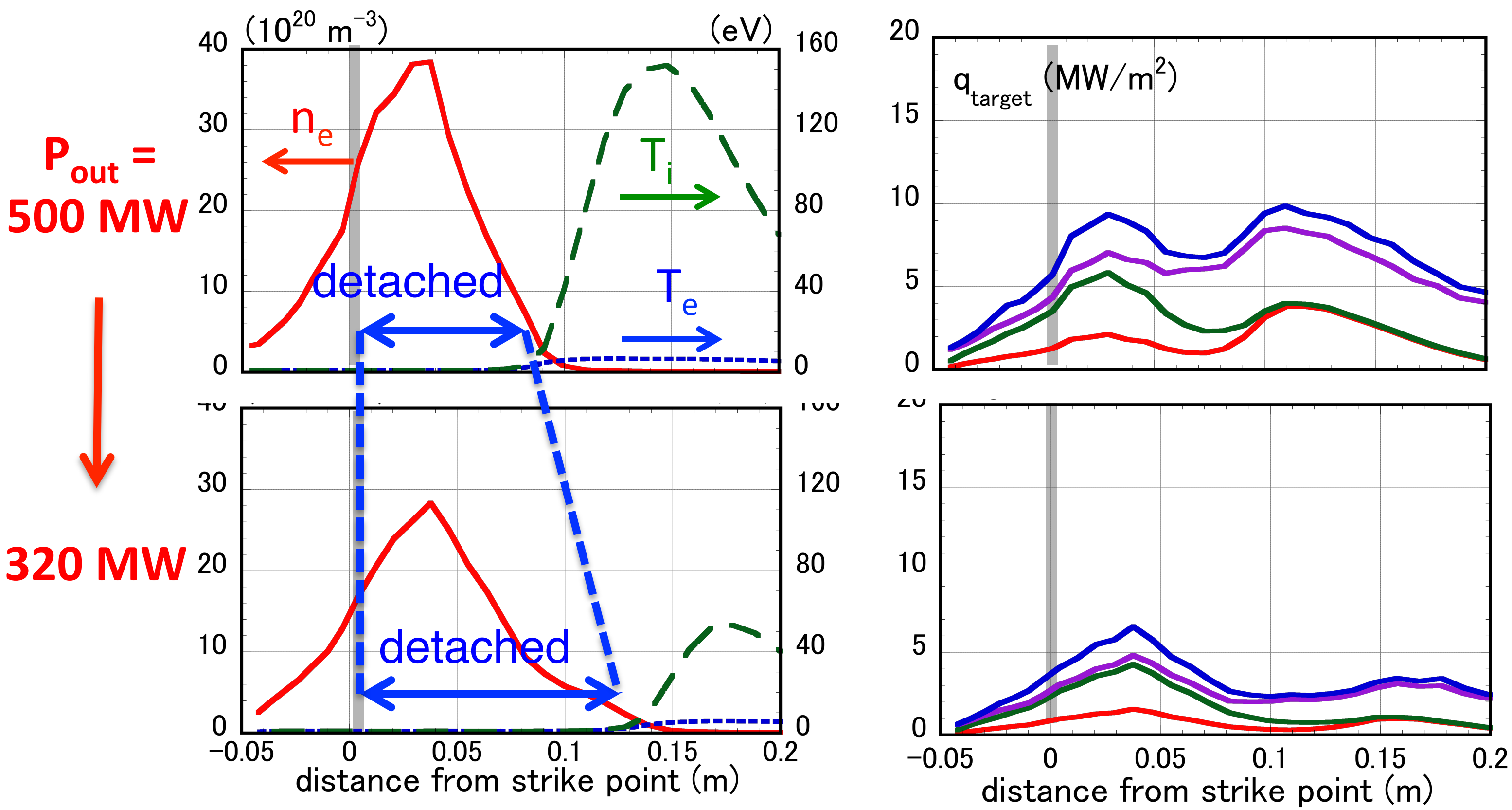
P_{out} = 500 ⇒ 320MW (P_{fus} decreases from 3GW to 2 GW)

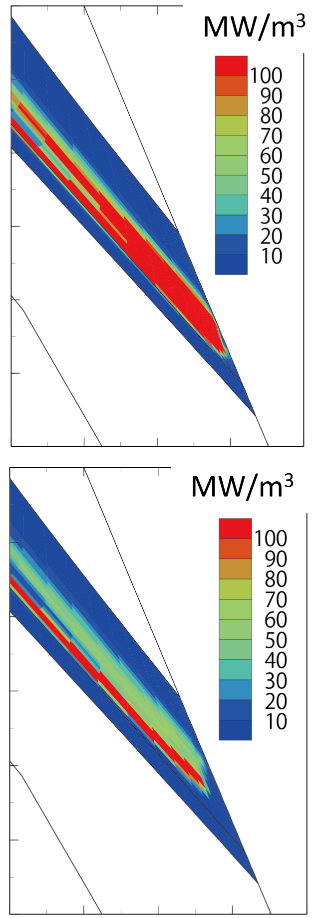
SONIC solution of f_{rad} ~ 92% (P_{rad}=295MW) was obtained by Ar puff of 10 Pa/m^{3}s

Impurity radiation moves upstream ⇒ detached region further extends to 12cm.

⇒ The peak heat load decreases to 6MW/m^2.

Note: thermal instability at the divertor will be investigated in future.





Divertor operation (< 10MWm^{-2}) is expected at f_{rad} > 80%

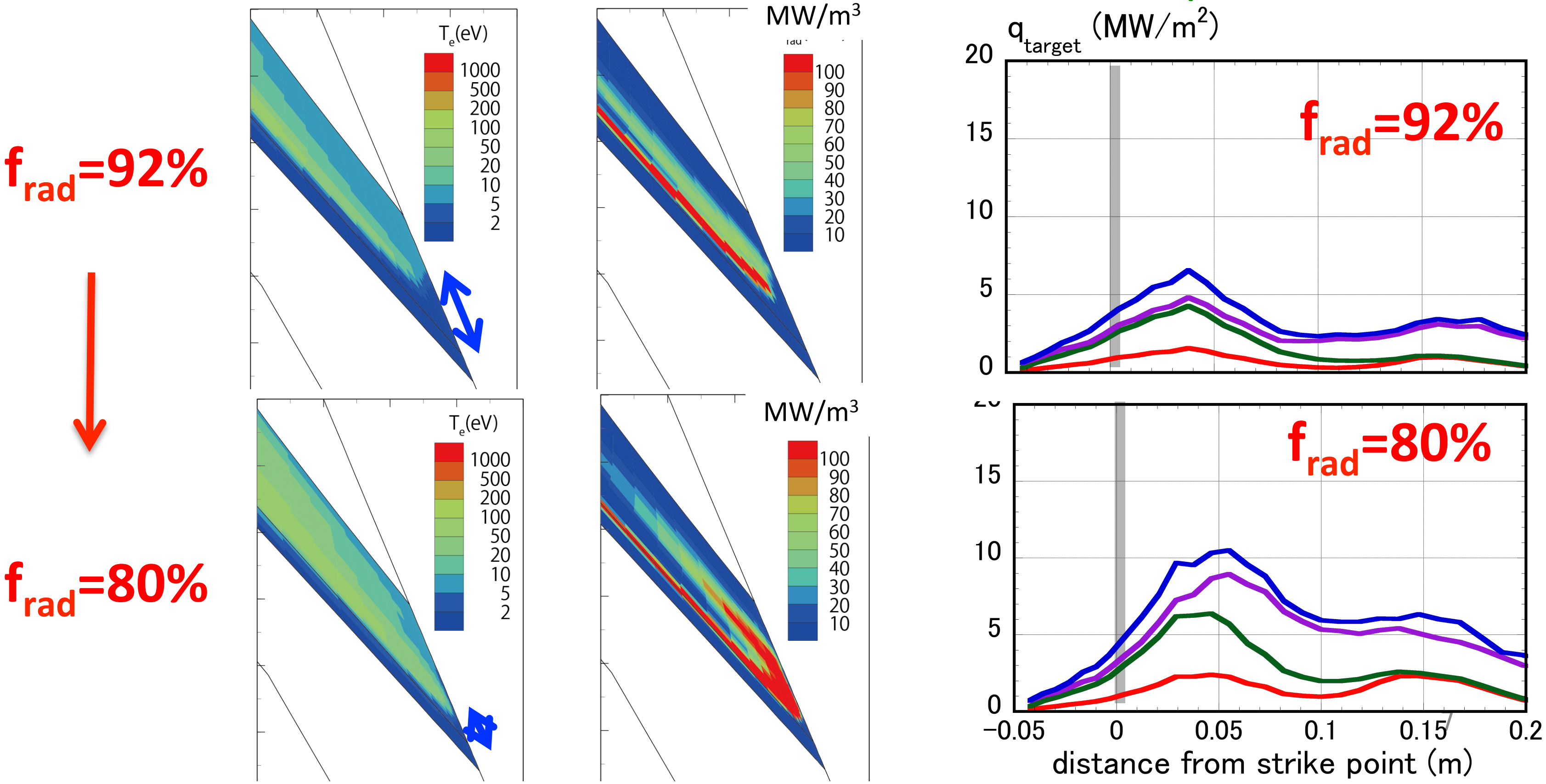
Radiation region moves near target with reduction from f_{rad} = 92% (P_{rad}^{tot} = 295MW) to 80% (256MW), where nearly full-detached plasma becomes partially-detached.

⇒ Peak heat load increases from 6 to 10 MW/m^2.

Lower f_{rad} < 80% seems to be difficult in the SlimCS-size divertor.

Studies in 2014:

- **Impurity (Ne/Ar/Kr) seeding and long-leg option will be compared to P_{fus} = 3GW.**
- **Divertor operation in similar geometry for New concept design (R_p~ 8m)**



Divertor simulation of new design: R_p~ 8m, P_{out} = 320 MW

SONIC simulation of the divertor plasma in the new Demo design with reduced P_{fus}:
large radiation loss case (f_{rad}=92%) showed that full detached was enhanced.
⇒ thermal instability of the divertor plasma occurs.

Calculations of lower radiation cases (f_{rad} = 70-85%) are now in progress.

Input parameters are the same

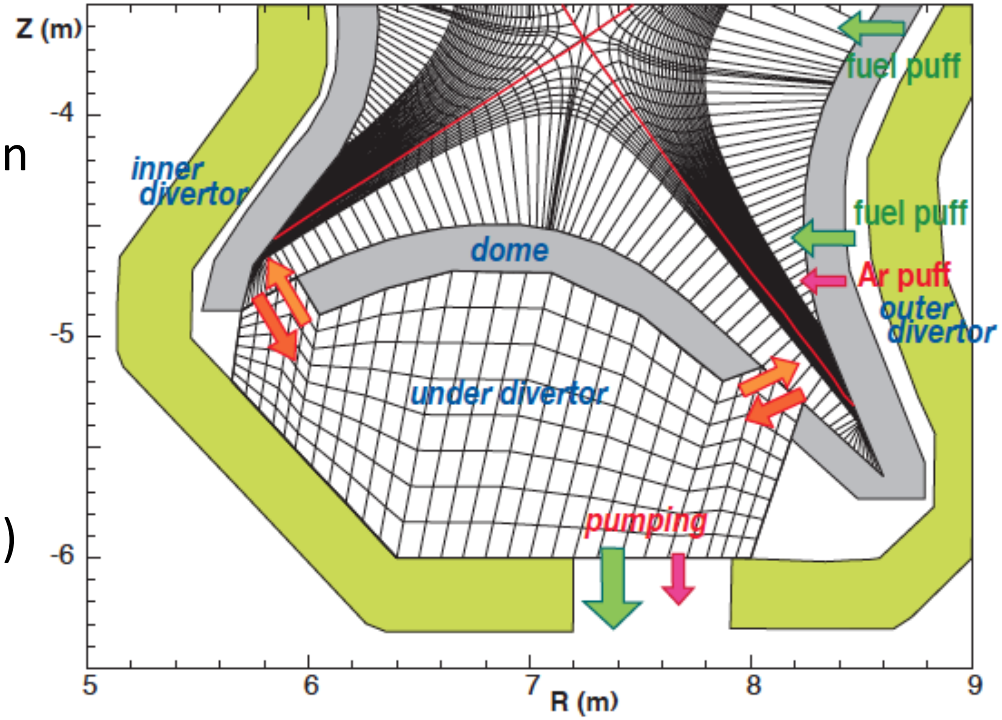
At core boundary r/a~0.95:

Exhausted power from core P_{out} is given
n_{D+}=7.0x10^{19} m^{-3}

Transport coeff. (same as ITER calc.):
D=0.3m^2/s, c=1.0m^2/s

D gas puff: G_{puff}=0.8x10^{23} s^{-1} (div. + sol)

pumping speed: S_{pump}=200 m^3/s



3.日欧共同研究

Benchmaking of Pumping speed evaluation

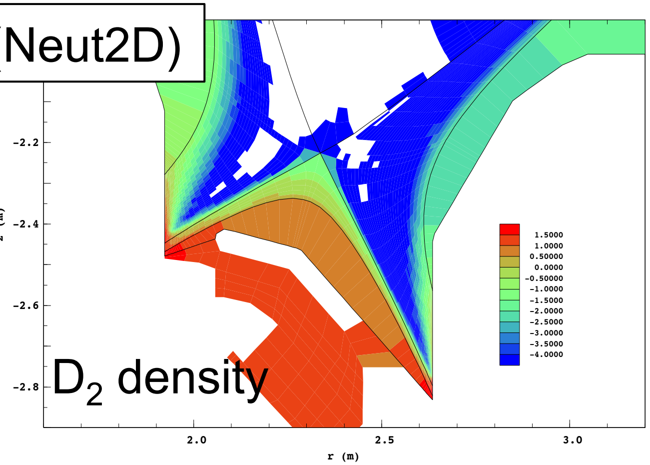
Comparison DSMC and NEUT2D for subdivertor gas flows in JT60-SA

Kick-off meeting at JET on 22/3/2014

C. Gleason-González, S. Varoutis, K. Hoshino, H. Utoh , N. Asakura, T. Nakano

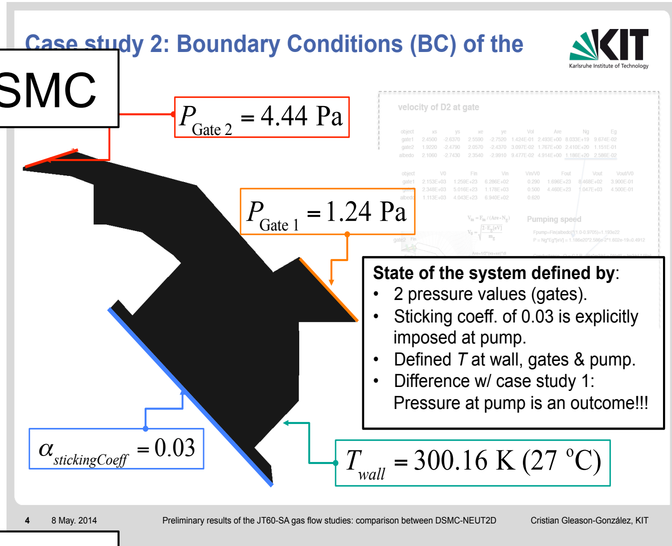
Boundary conditions defined and given:

SONIC (Neut2D)



D_2 density

DSMC



2[nd] meeting (remote) on 8/5/2014

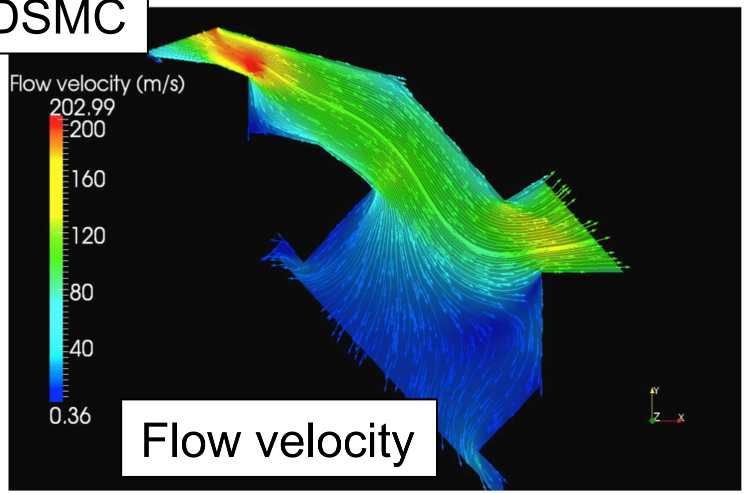
C. Gleason-González, S. Varoutis, K. Hoshino, K. Shimizu, S.Sakurai, N. Asakura, T. Nakano

1[st] output from DSMC code:

Some difference found

- The boundary conditions are being checked
- Simplified calculation model was suggested

DSMC



Flow velocity

JET modelling by SONIC

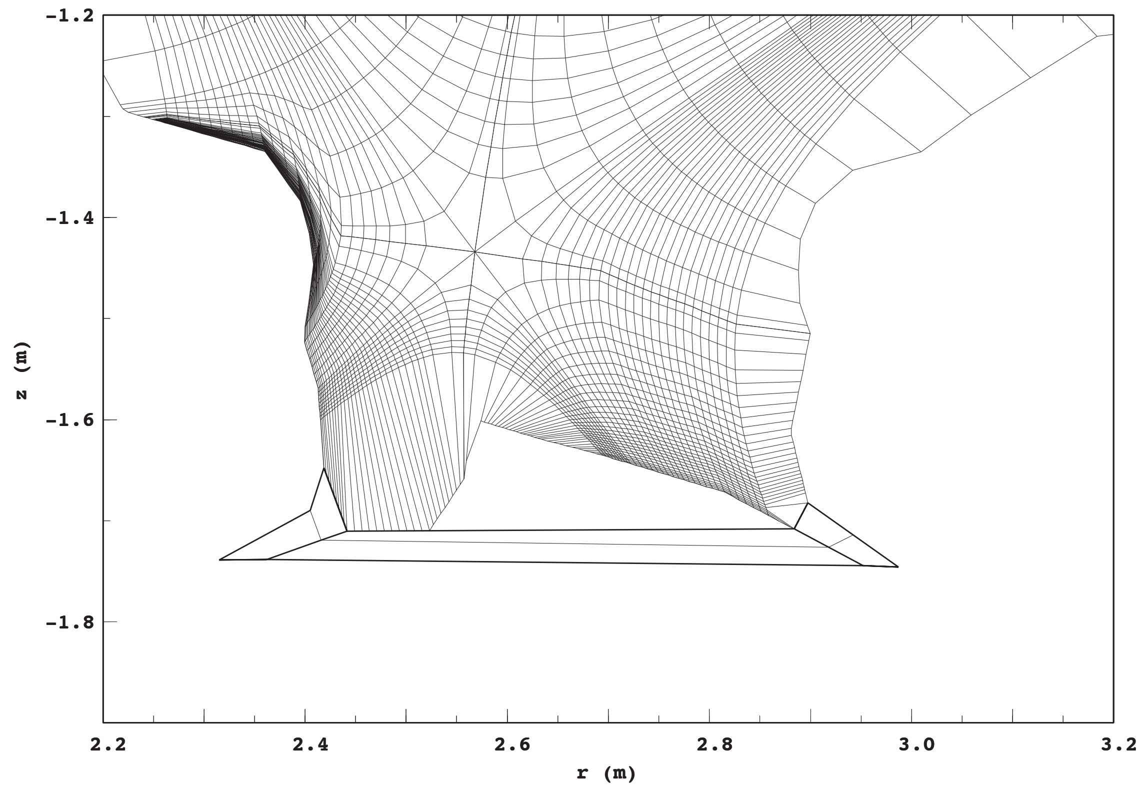
デタッチメントモデリングの改善を目標に、今年からコード間ベンチマークを再開

（cf. ITPA DSOL mtg. 2009 ）

すでにSOLPSやEDGE2Dで解析の進んでいるJET-ILWを対象に、
SONICシミュレーションに着手

初期結果について、10月の
ITPA（DSOL)で報告予定

SONIC mesh for JET-ILW



まとめ

1. 国際的進展

実験データを補完的に用いた解析が精力的に進められている。実験データの再現性は高くなってきているが、unconventional assumptionによるところが大きいと思われ、今後モデリングが必要。

2. 国内活動

原型炉ダイバータとしては、原型炉仕様の再検討を受け、パラメータサーベイを開始。課題はあるものの2GW P_{rad}/P_{out}=92%で現状の工学設計と取り合いができる可能性が見えてきた。

JT-60SAの解析については、燃料・不純物ガスの組み合わせを変えたようなパラメータサーベイが進行中。またW壁の解析も始められている。

3. 日欧共同研究

サブダイバータの中性粒子輸送、デタッチメントモデル改善に向けたコード間ベンチマークが進行中