Notes on Divertor Integration

SNL, ORNL, UCLA , ANL, others
Richard Nygren, leader/presenter

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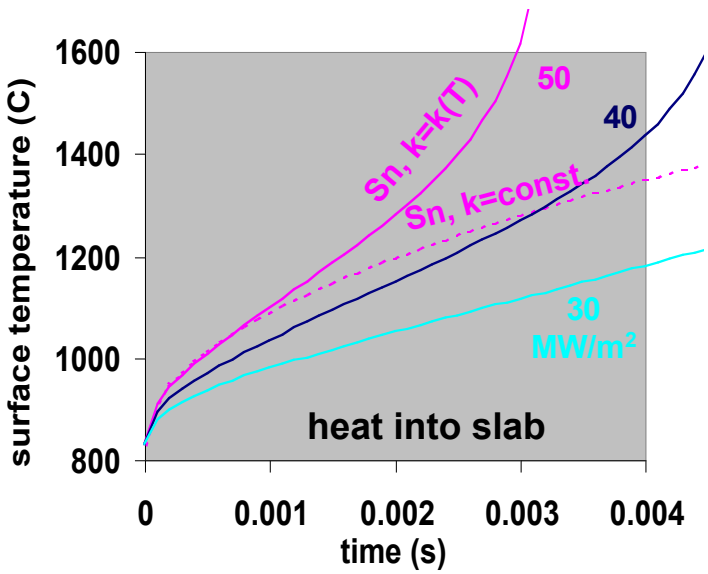
Status: APEX Divertor Integration

- *Heat seems manageable with Sn divertor!*
- *Outboard deflector location may be better!*
- *MHD will control heat removal and affect drain system*



- *"Runaway" hot spot problem?*
- *?Better configuration*
- *?Better material, e.g. Ga*

metal	T_m ºC	T_{100Pa} ºC	*range* ºC	*k* W/m-K	*κ(diff.)* m^2/s
Sn	505	1865	1360	33	3.4E-6
Ga	303	1590	1287	66	3.0E-5

- ***MHD will control heat removal!!***

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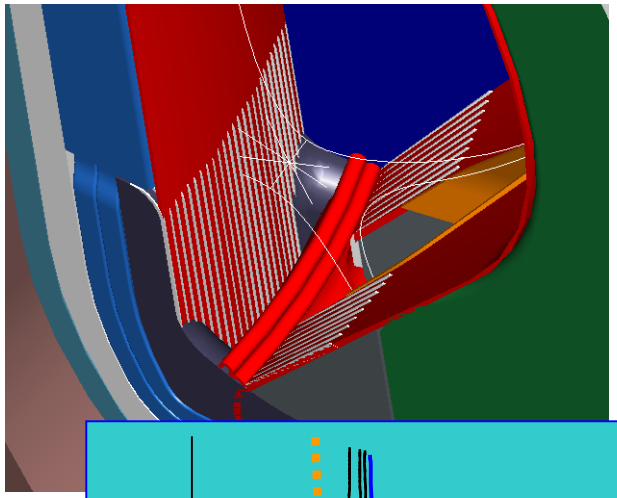
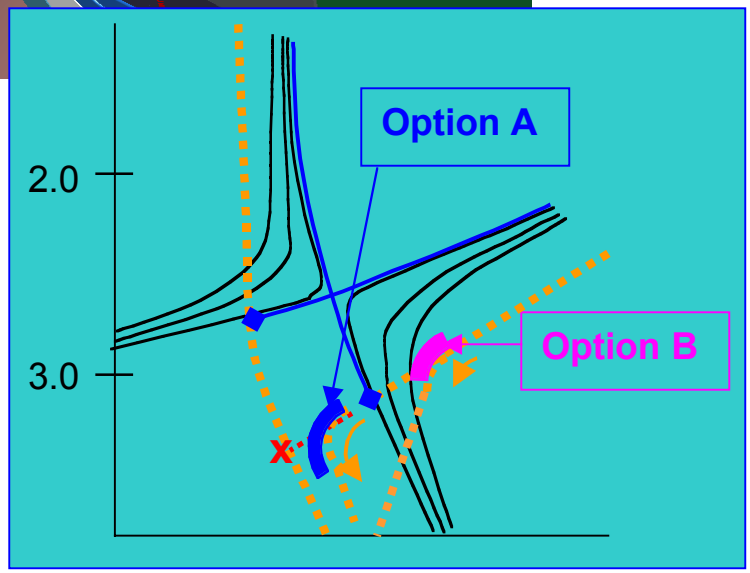
Divertor deflector location





Deflector (outer div.)

- directs fluid momentum into exhaust duct
- prevents orthogonal collision with inner divertor stream (x)

Option A - private flux site:

- more protected from plasma
- more flux expansion.

Option B - outboard site:

- target incline to spread heat
- less flux expansion (benefit)

☆ modified free surface

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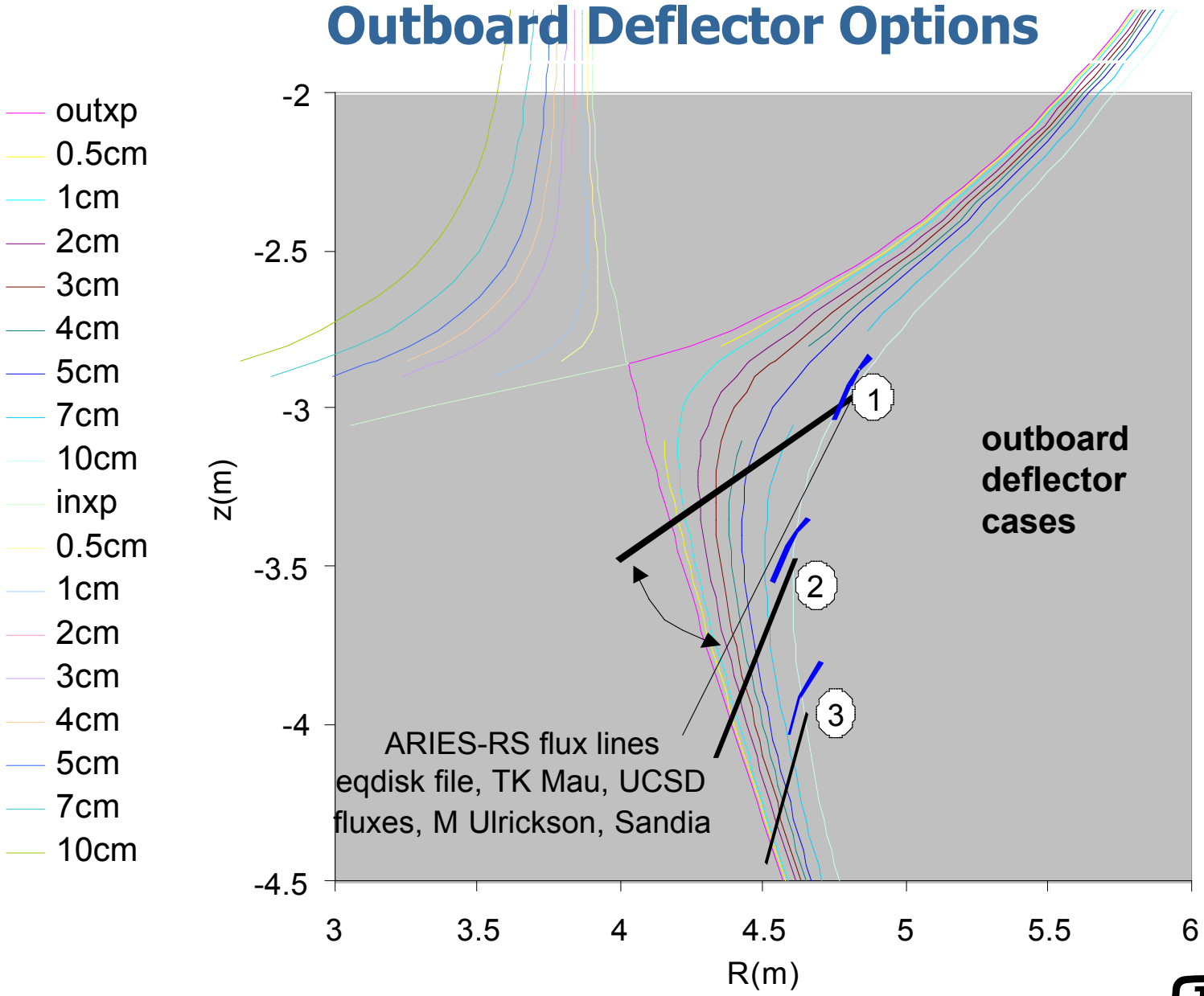
Outboard Deflector Options



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Deflector Options - continued

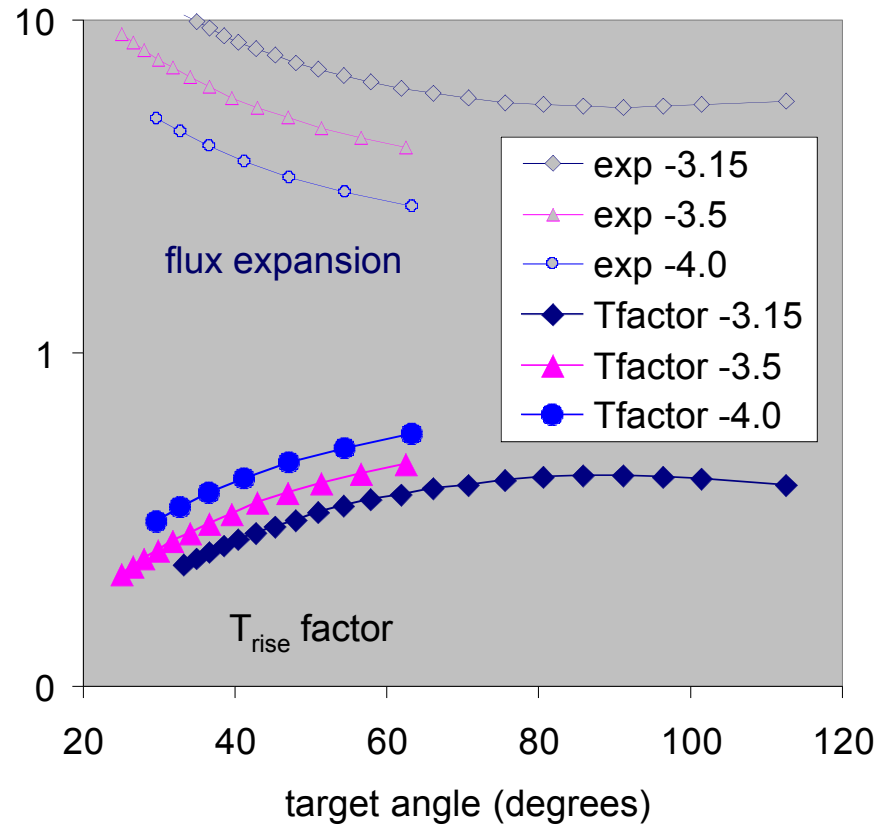
Flux expansion and target incline reduce local heat flux, but the comparative reduction in temperature rise is modest.

$$T_{rise,surf} \cong \frac{q\sin(\theta)}{k}\sqrt{\frac{\kappa t}{\Pi}}$$

$$t = \frac{L_0}{\sin(\theta)v}$$

$$\cong q\sqrt{\frac{1}{\Pi k \rho C_p v}}\sqrt{\frac{\sin(\theta)}{L_0}}$$

$$T_{rise,surf} \propto \sqrt{\frac{\sin(\theta)}{flux_exp.}}$$



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Recent EMF/MHD Considerations

- A conducting divertor that "short circuits" field lines causes redistribution of plasma potential. Result is thermoelectric currents that flow through divertor, e.g. C-MOD (per Brian LaBombard, MIT).
- Divertor intercepts flux and therefore has strong B_{normal} (unlike FW).
- *Arguments by Bob Woolley, PPPL:*

  1. In a continuous toroidal divertor, downward LM flow induces a toroidal current (J_T=UxB$_\perp$). This in turn would affect the poloidal field and retard flow.
  2. In a divertor flow with breaks, a strong E field is generated through the thickness of the flow (UxB$_T$ currents do not close). At the breaks (zero flow) there is no E field created. Therefore, EMF-driven toroidal currents will retard flow.

- A poloidal current (J_pxB$_\perp$) might overcome the retarding forces (like EM-assisted propulsion scheme, per Zakharov, PPPL).

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