Dependence of ELM energy distribution in double-null discharges on up/down magnetic balance in DIII-D [1],

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In this study we show the effect on ELM divertor heat flux of changing continuously from a lower single null to an upper single null discharge. The up/down split of ELM deposited energy on the divertor plates is well controlled by adjusting the relative locations of the flux surfaces on which the upper and lower magnetic nulls lie. The distance between these surfaces at the outer midplane (D_{rsep}) is changed to adjust the magnetic balance. (For a magnetically balanced discharge $D_{rsep}=0$.) We examine the effect of adjusting D_{rsep} on the location of the ELM deposited energy profiles in both divertors. The scale length of D_{rsep} changes which affect the heat flux is greater than the heat flux scrape-off width at the outer midplane.

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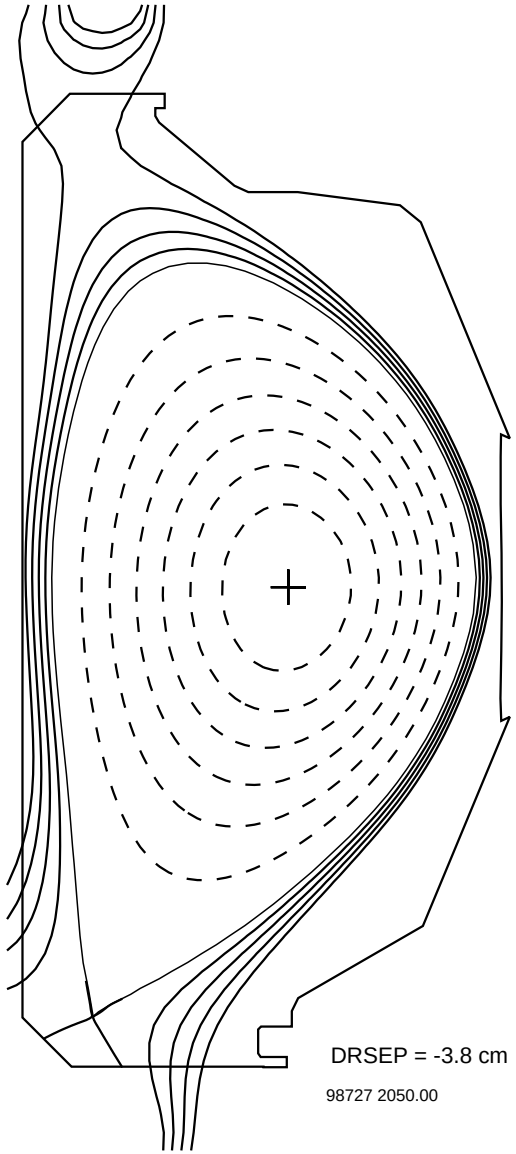
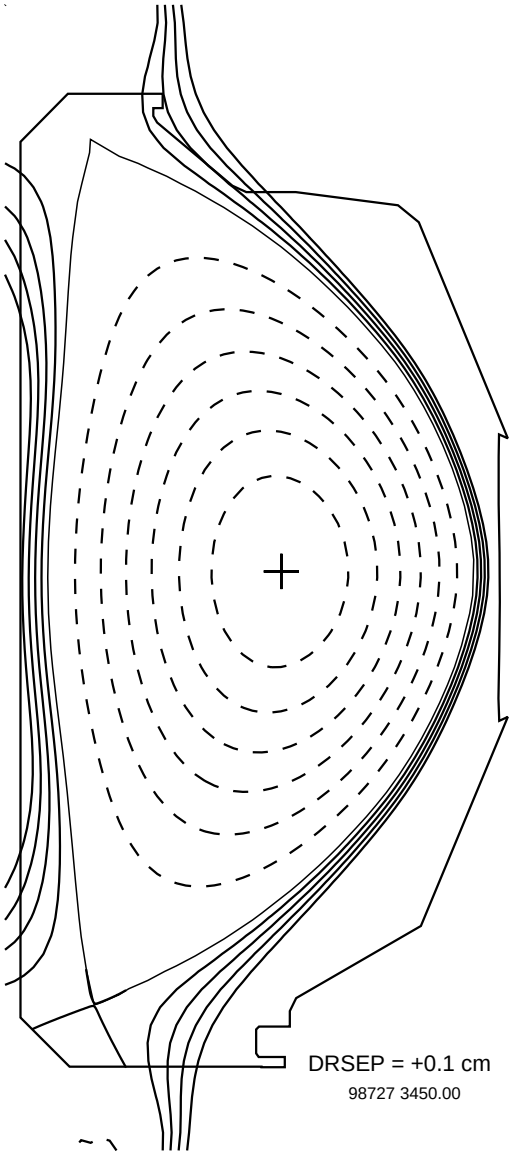
Definition of Magnetic balance

- DRSEP = radial distance at the outer midplane between the flux surfaces connected to the upper and lower X-points

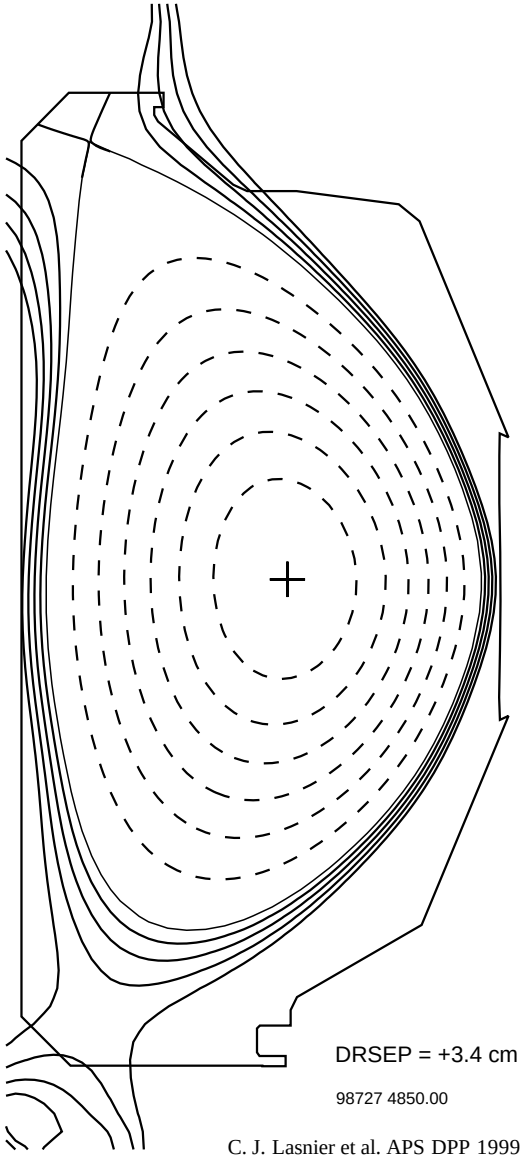
DRSEP = -3.8 cm
lower single null



DRSEP = +0.1 cm
double null



DRSEP = +3.4 cm
upper single null



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- Plasma parameters:
  - $I_p = 1.4$ MA
  - $B_T = 2.0$ T
  - Ion ∇B drift downward
  - $n_e \cong 5 \times 10^{13}$ m^{-3} (varying)

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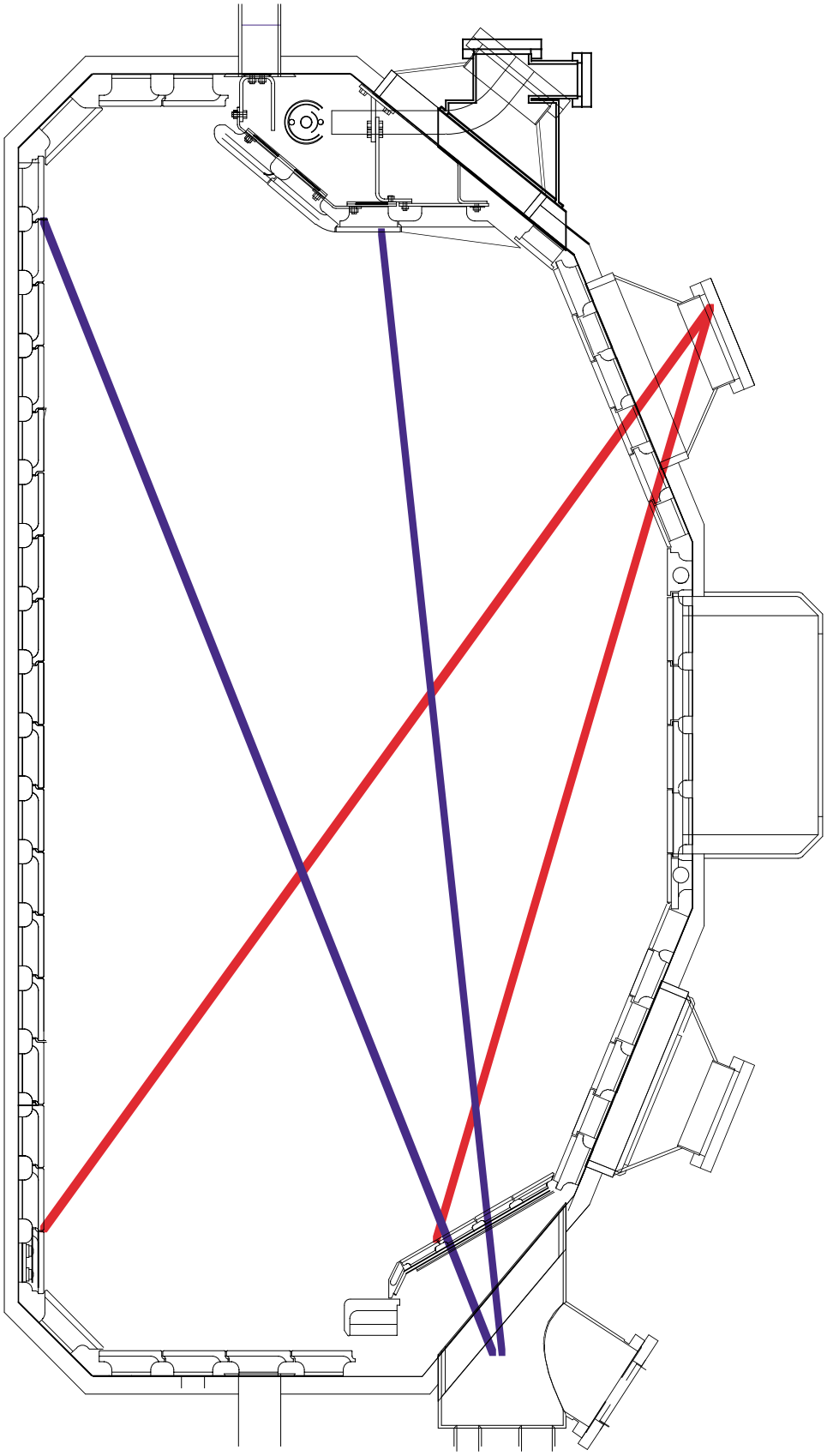
IRTV sightlines



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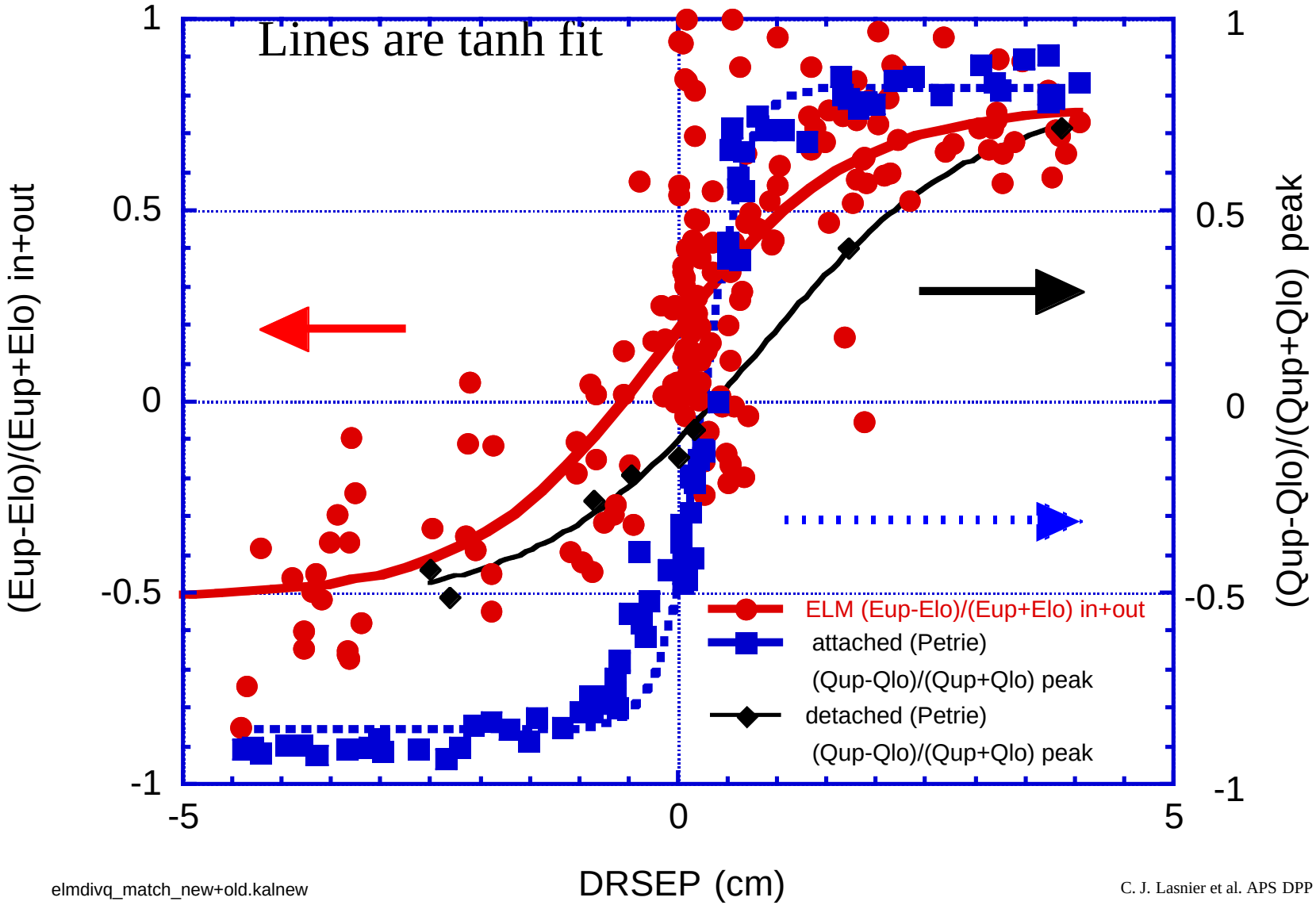
Total deposited energy

Magnetic balance controls ELM energy deposition similar to attached Q_{peak}, wider scale length



elmdivq_match_new+old.kalnew

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ELMs have wider effective scrape-off length

- ELM energy deposition DRSEP scale length: 1.9 cm
- Attached time-averaged heat flux 0.4 cm (Petrie, this meeting paper GO2.11)
- Detached time-averaged heat flux 2.2 cm (Petrie GO2.11)

Up/down balance does not Affect ELM energy distribution as strongly as time-averaged heat flux

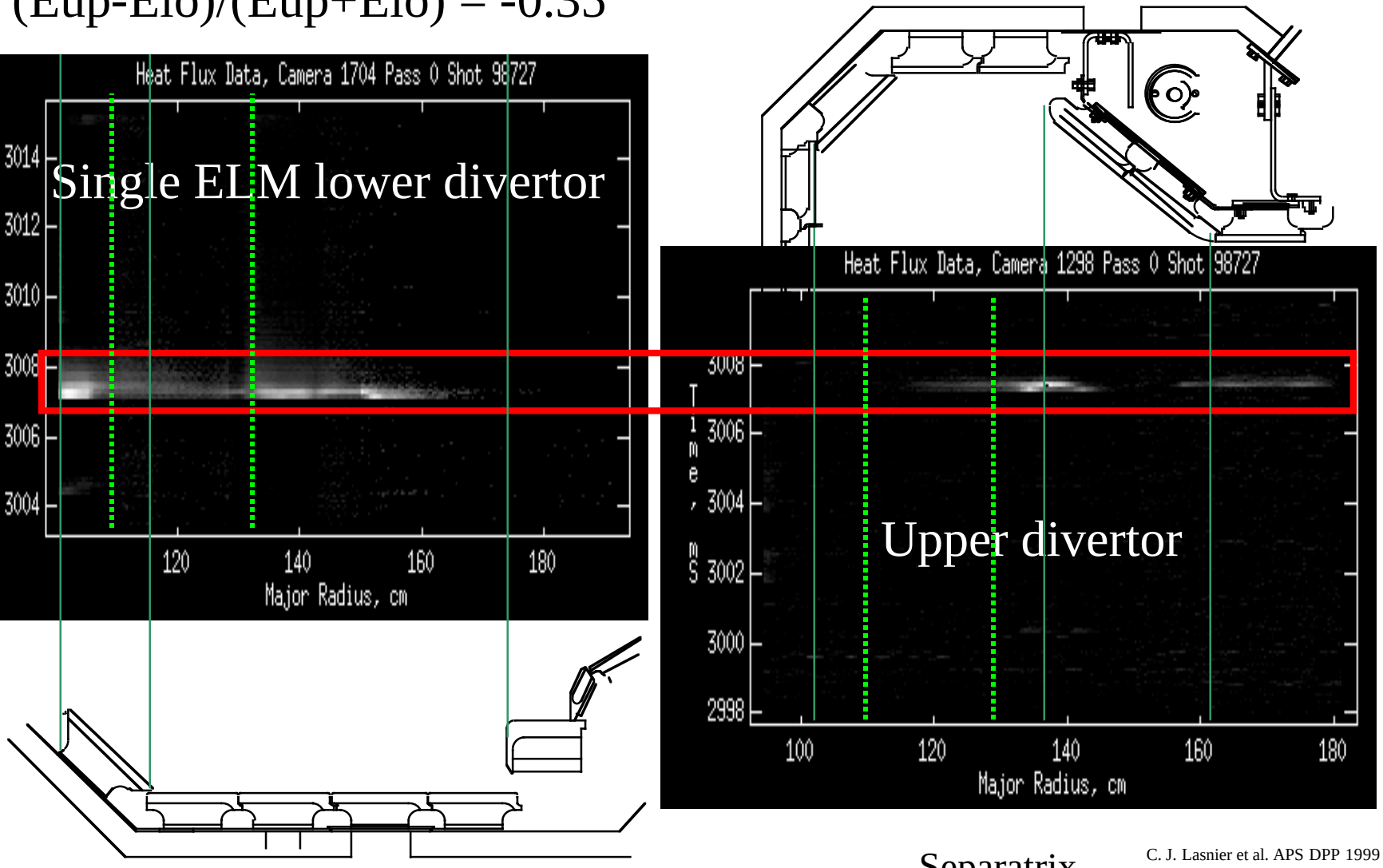
- Upper divertor is similar to time-average.
- Lower divertor is less dominant.
- This is probably not caused by reflections in the upper divertor, due to geometry.
- Upper divertor still shows a hot spot during ELMs on the nose of the upper baffle.

Profiles

Downward bias gave broad ELM profile in lower divertor

DRSEP = -2.2 cm

(Eup-Elo)/(Eup+Elo) = -0.35



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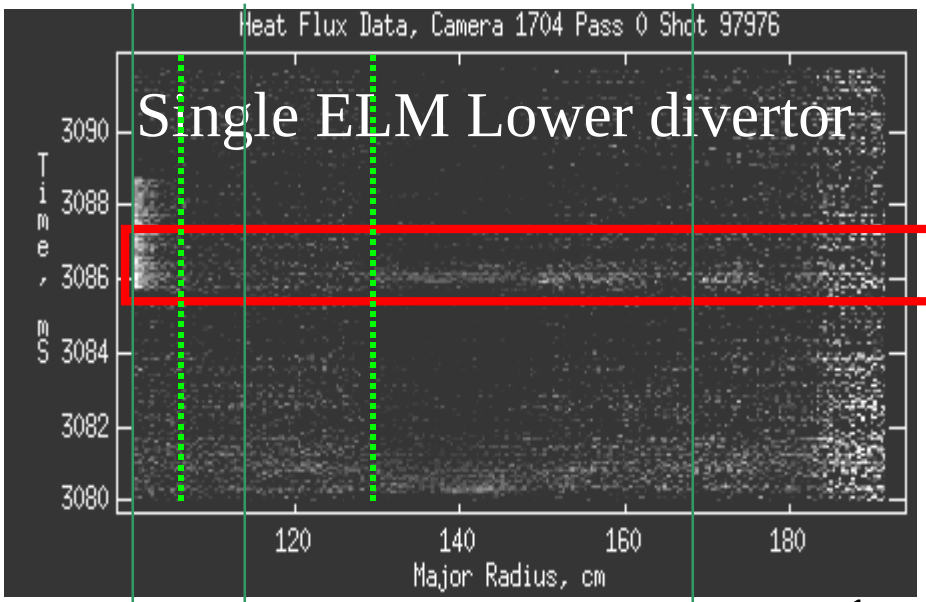
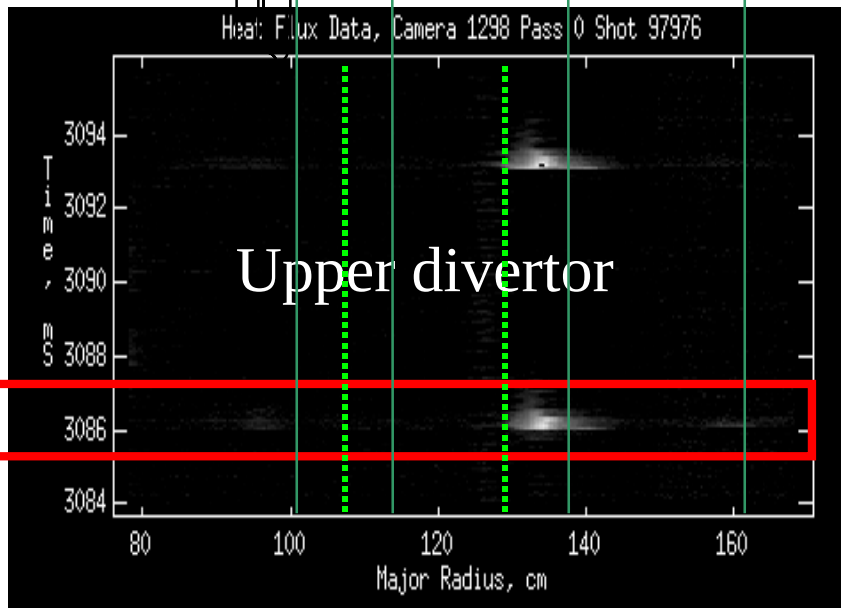
Upward bias gave local hot spot

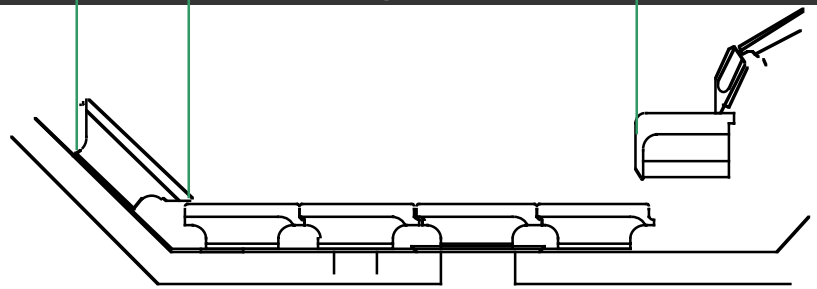
DRSEP = + 2.3 cm

(Eup-Elo)/(Eup+Elo) = 0.69

Contrast and brightness expanded for lower divertor image







Separatrix

Time

Radius

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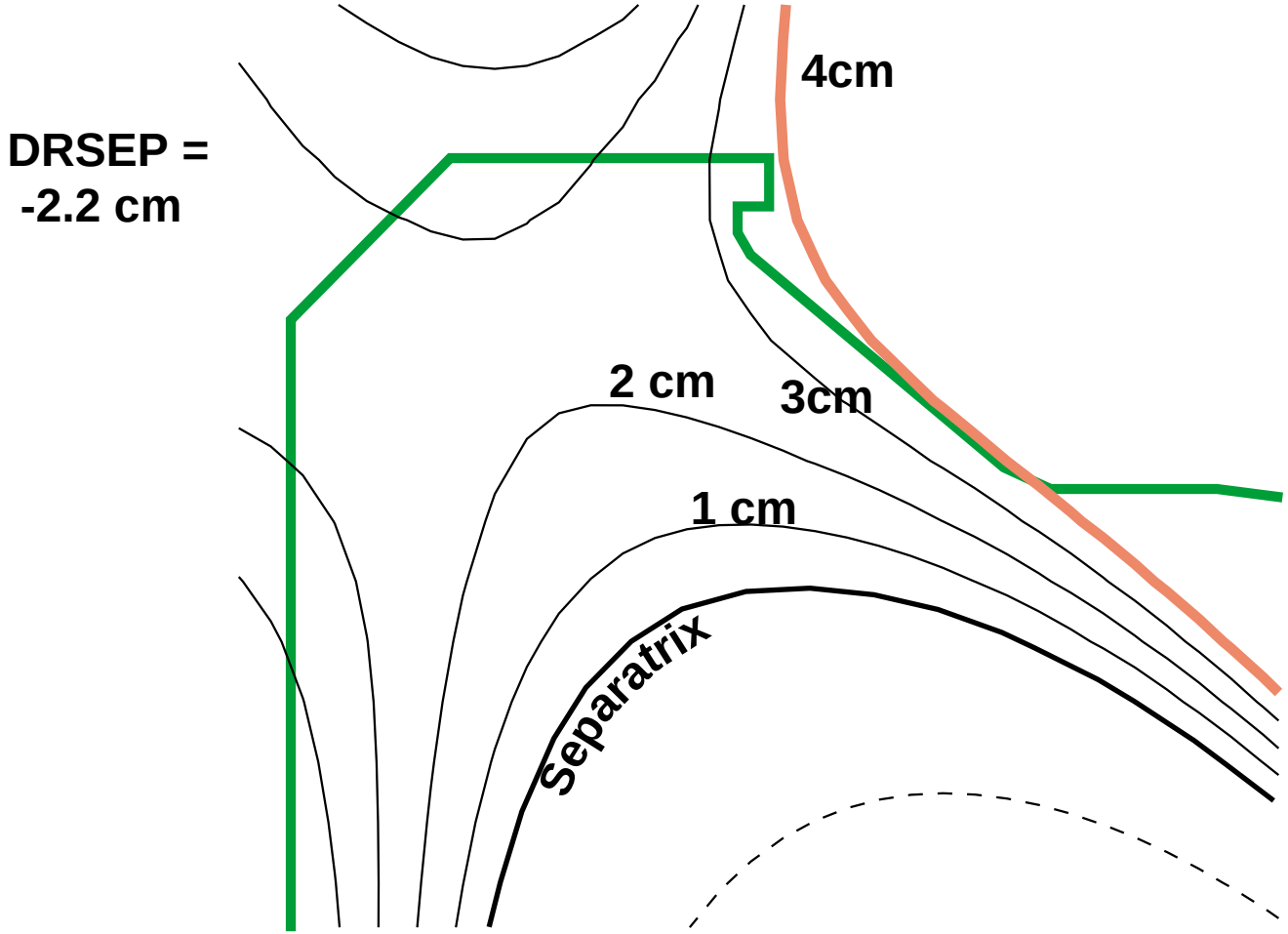
The 4 cm flux line intersects the upper baffle for DRSEP = - 2.2 cm



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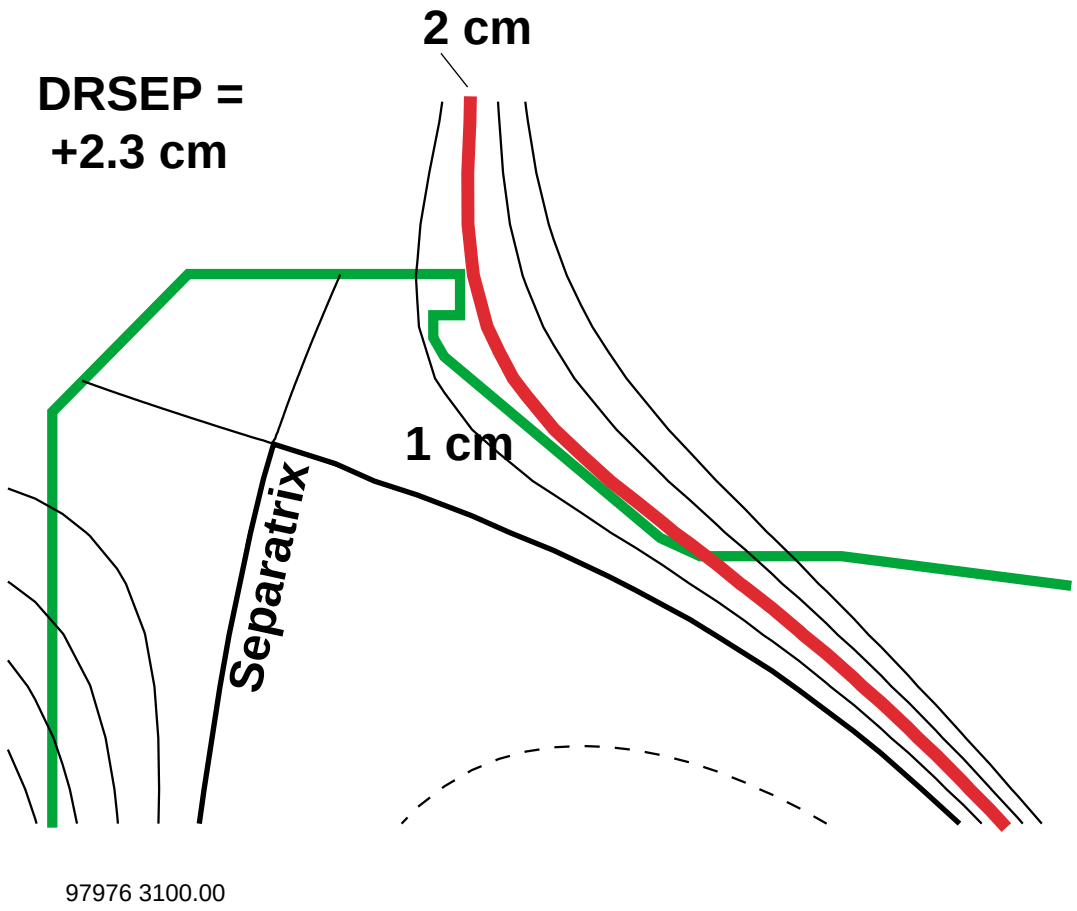
The 2 cm flux line did not clear the baffle for DRSEP = +2.3 cm



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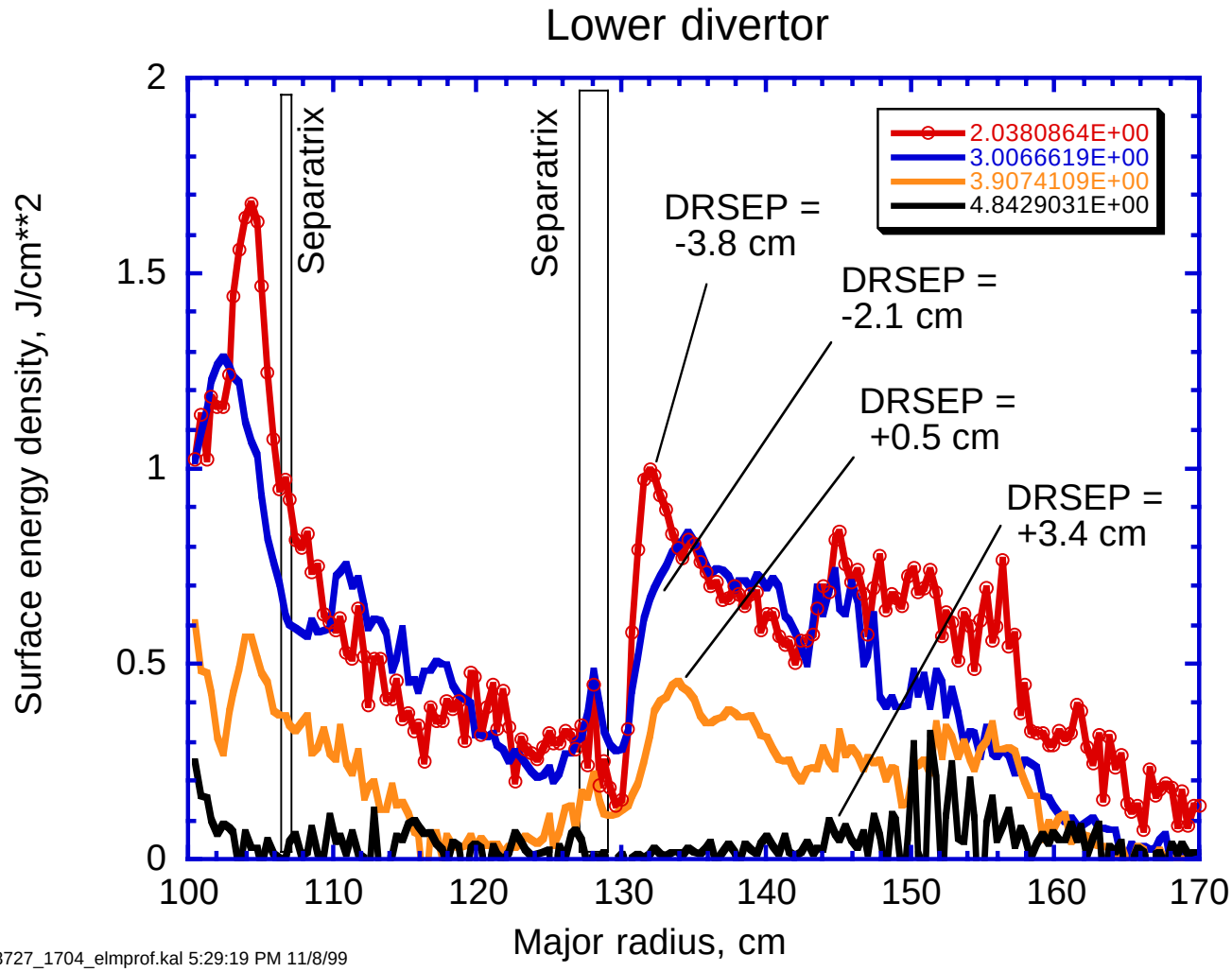
Changing from lower to upper bias shunts ELM heat near the separatrix



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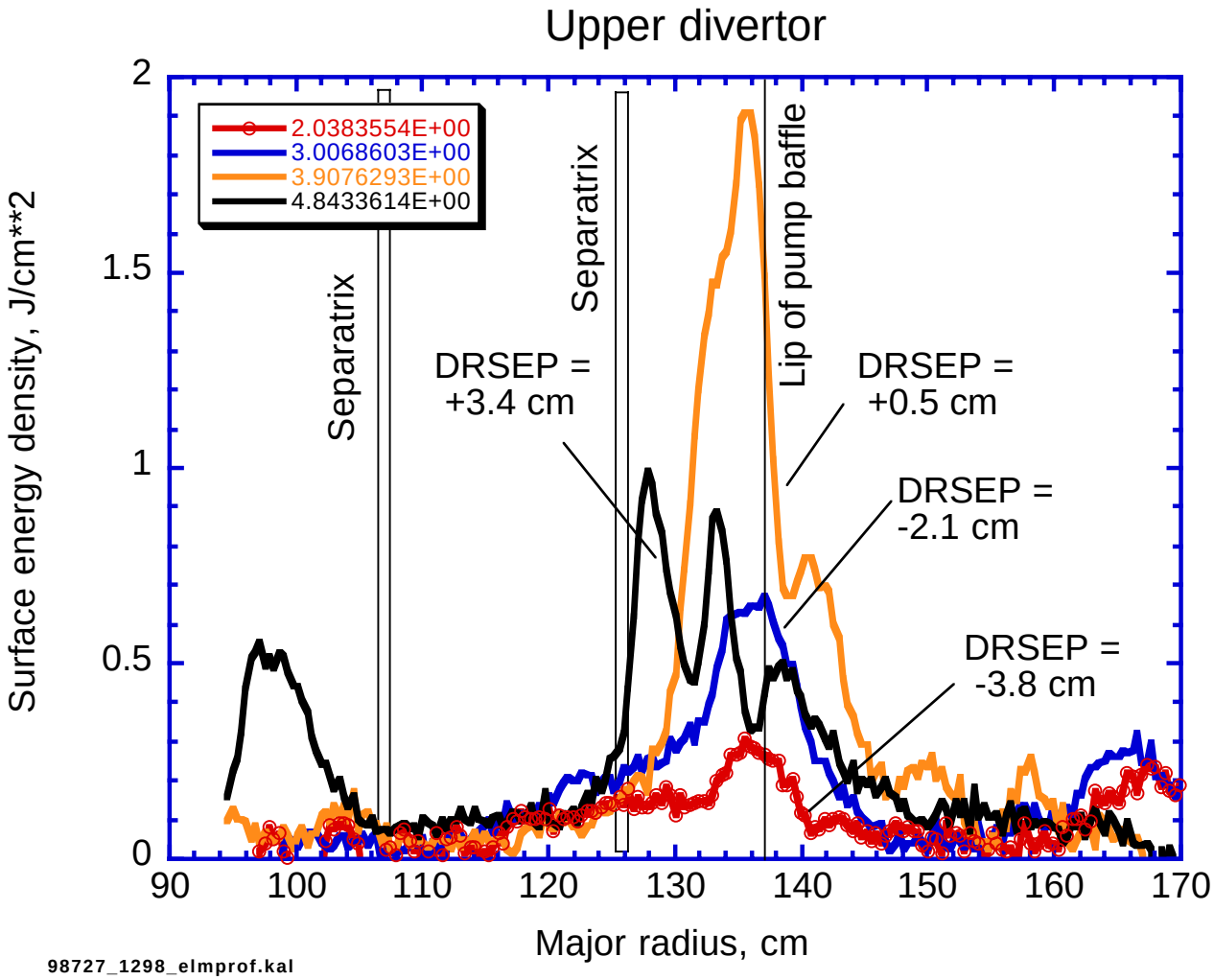
Upper divertor shows ELM heat on baffle



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Discussion

- The ELM energy behaves similarly to the peak heat flux when DRSEP is changed.
- ELM deposited energy in the divertors is strongly affected by magnetic balance, but the effective scale length is longer than for time-averaged attached peak heat flux.
- During downward bias, there is still a hot spot on the upper baffle during ELMs.
- The energy deposited near the separatrix in the lower divertor is most strongly affected.