Comparison of 2D VUV Emission Profiles with Simulations at High and Low Triangularity in DIII-D

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DIII–D NATIONAL FUSION FACILITY SAN DIEGO

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Abstract

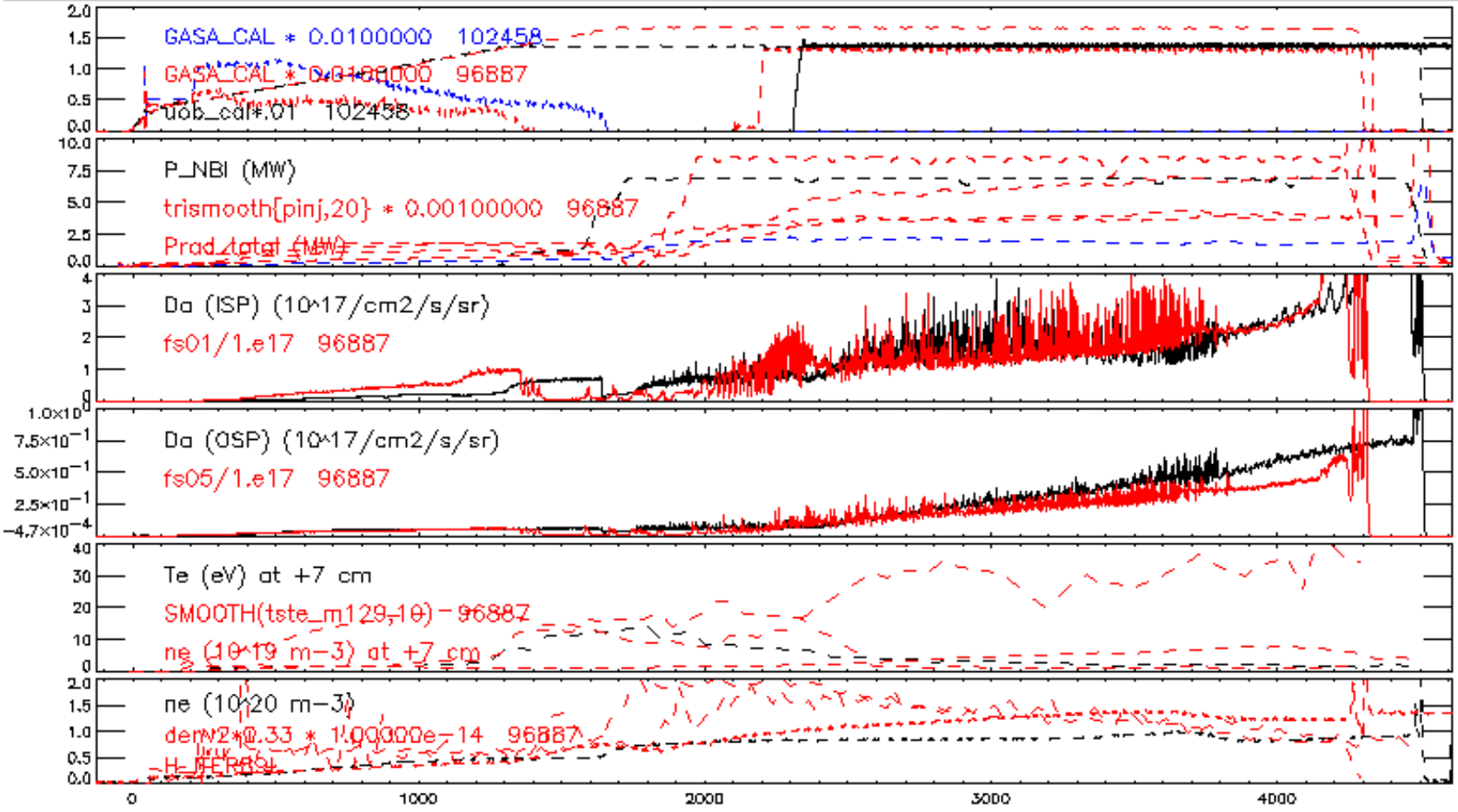
- One of the dominant radiators in the DIII-D divertor during both attached and detached divertor operation is CIV VUV emission at 155 nm [1]. The 2D emission profile of this CIV radiation is obtained from a unique tangentially viewing VUV camera [2] Analysis of the evolution of the 2D CIV profile has improved our understanding of the power balance leading to divertor detachment [3]. Recent CIV measurements in high triangularity (high-δ) plasmas will be compared with the previous measurements for low-δ shapes in both attached and detached operation. The measured profiles will also be compared with simulations of CIV emission using the UEDGE fluid code [4].
  - *Work supported by U.S. DOE Grant DE-FG02-97ER54451, Contracts DE-AC03-99ER54463 (General Atomics), W-7405-ENG-48 (LLNL), and DE-AC05-00OR22725 (ORNL)
  - [1] R.D. Wood, EPS, Kiev, 1996.
  - [2] D.G. Nilson, Rev. Sci. Inst., 738, 1999.
  - [3] M.E. Fenstermacher, EPS, Maastricht, 1999.
  - [4] T.D. Rognlien, J. Nucl. Mat., 347, 1992.

Introduction

Carbon is an important contributor to the physics of the divertor. CIV (~ 155 nm) is one of the dominant radiators in the DIII-D divertor contributing more than 50% of the radiation in some cases. A knowledge of carbon behavior in the divertor during both attached and detached operation is essential in understanding the power balance in the divertor.

We have compared the 2D profiles of CIV emission in the DIII-D divertor for high triangularity (shot 102458) to profiles for low triangularity (shot 96887) for both attached and detched plasmas.

Time History
Shot 96887 &102458



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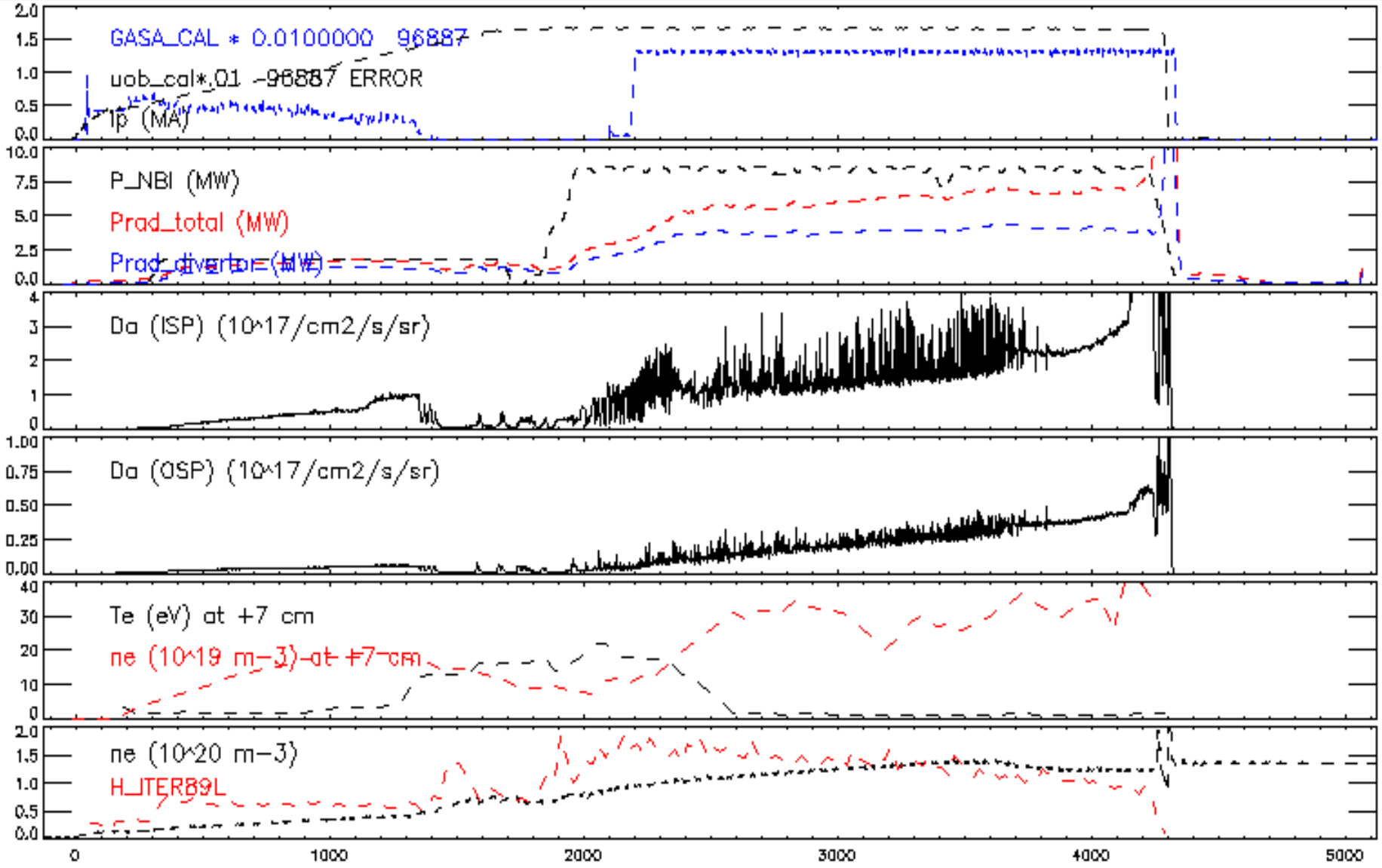
SUMMARY OF RESULTS

- 2D profiles of CIV radiation at 155 nm agree, in general, with profiles of the total radiated power as measured by bolometers arrays
- These profiles show different distributions of the CIV radiation for high triangularity and low triangularity shot
- For the high triangularity case, maximum intensity of CIV is in the outer SOL for both attached and detached plasmas and below the x-point
- For the low triangularity case, maximum intensity of CIV is located in the inner SOL near the x-point for the attached plasma and in the closed flux region, above the x-point for the detached plasma
- Comparison of the 2D profiles with profiles calculated using the UEDGE fluid code

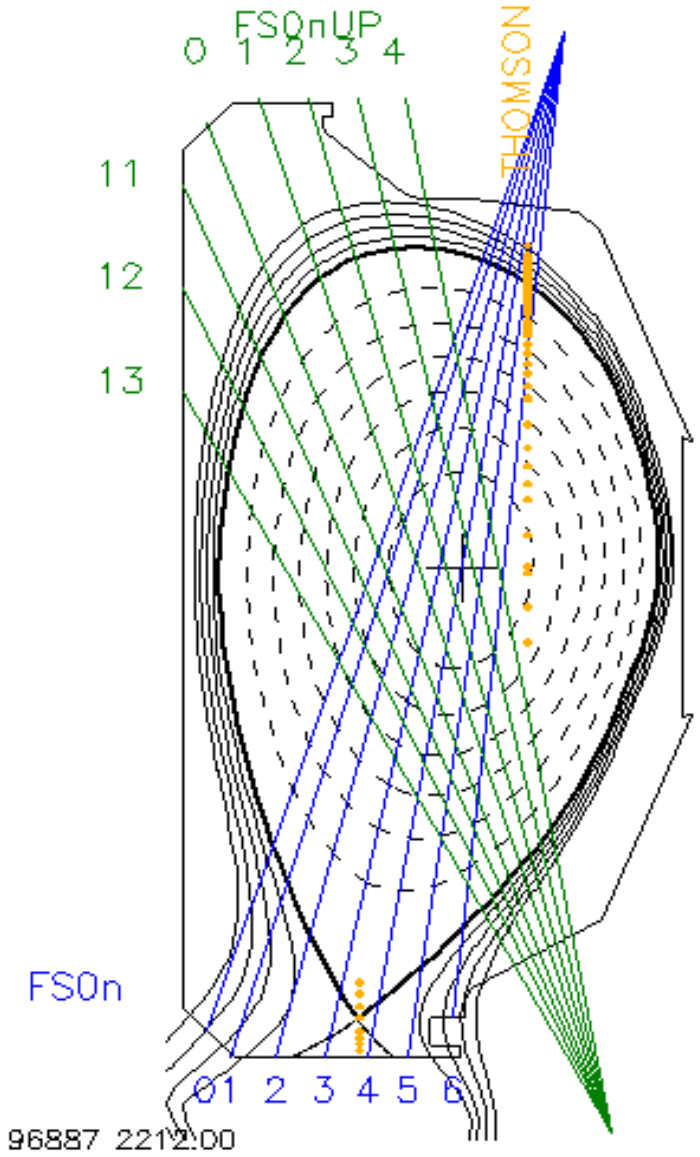
Low Triangularity

Time History Shot 96887



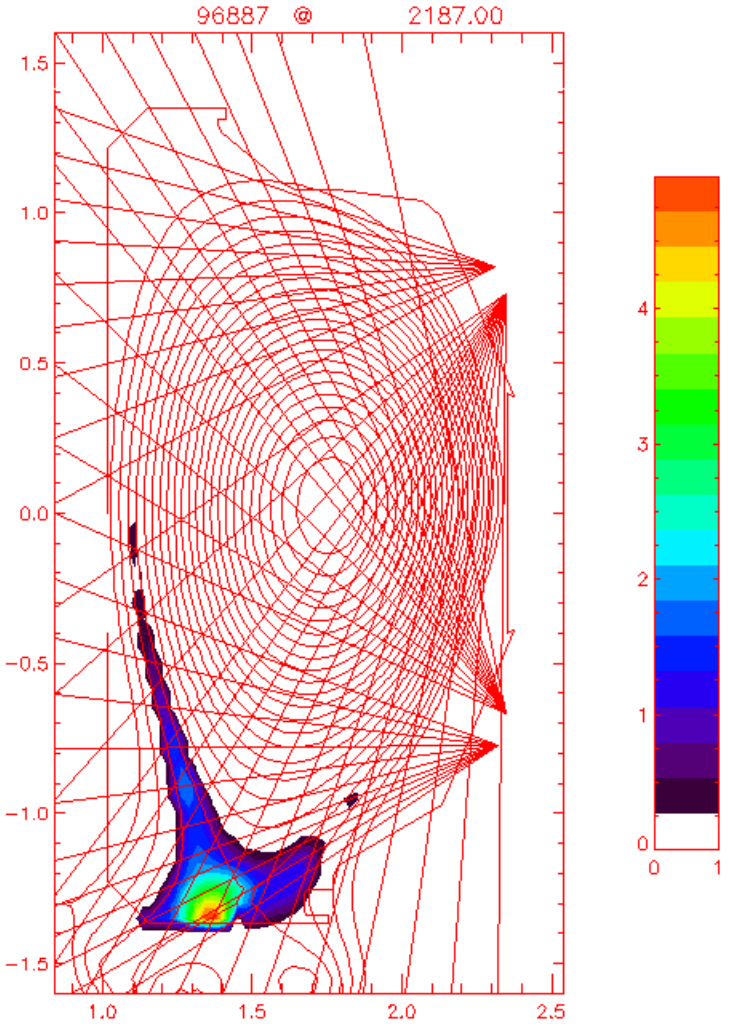
MAGNETIC EQUILIBRIUM POSITION

- X-Point is located at the Thomson Scattering position
- Both inner and outer strike points are on the divertor floor



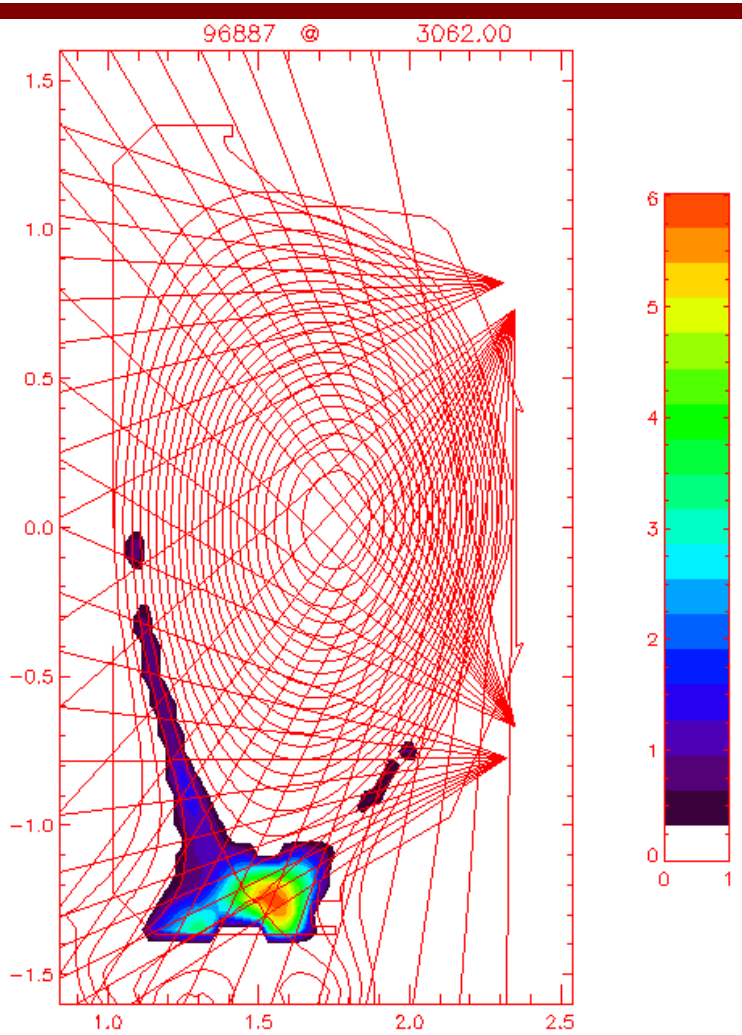
TOTAL RADIATION

- Maximum radiation is located along the inner leg
- Maximum intensity is near the inner strike point



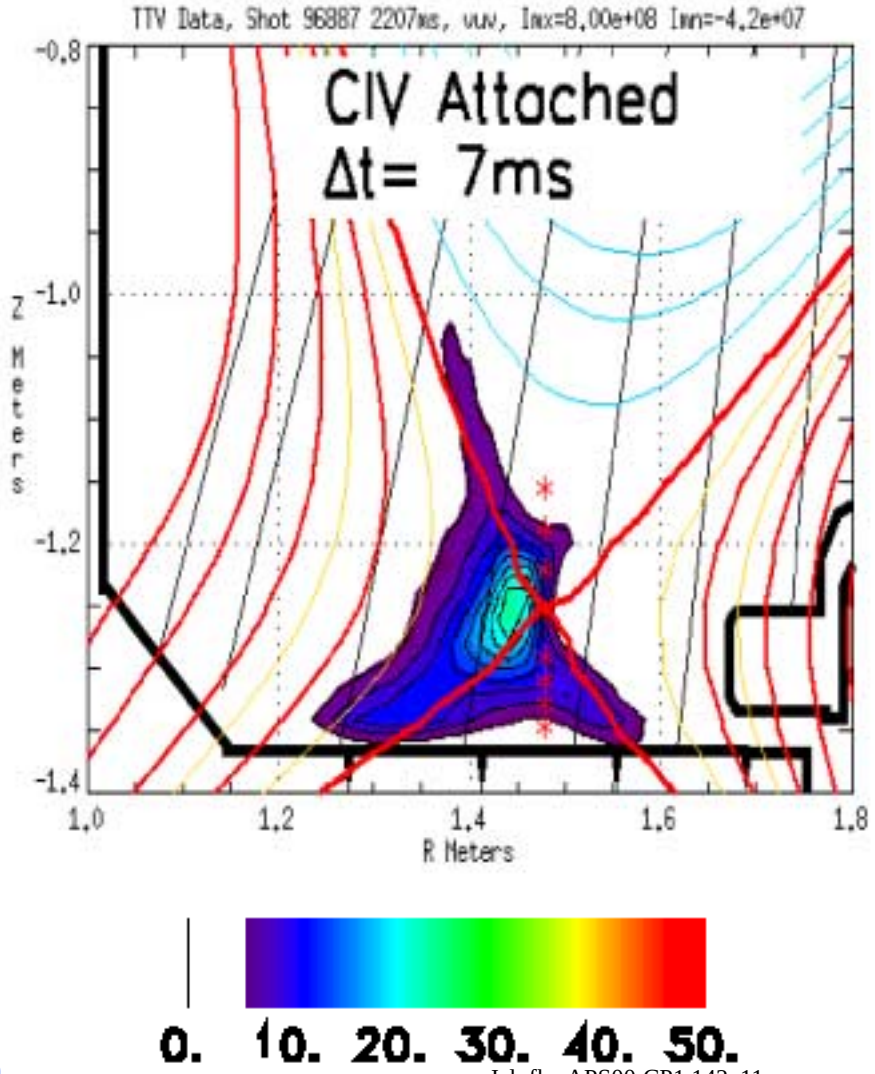
TOTAL RADIATION DETACHED PLASMA

- Maximum radiation is located near the x-point
- Radiation extends along both inner and outer legs to the divertor floor



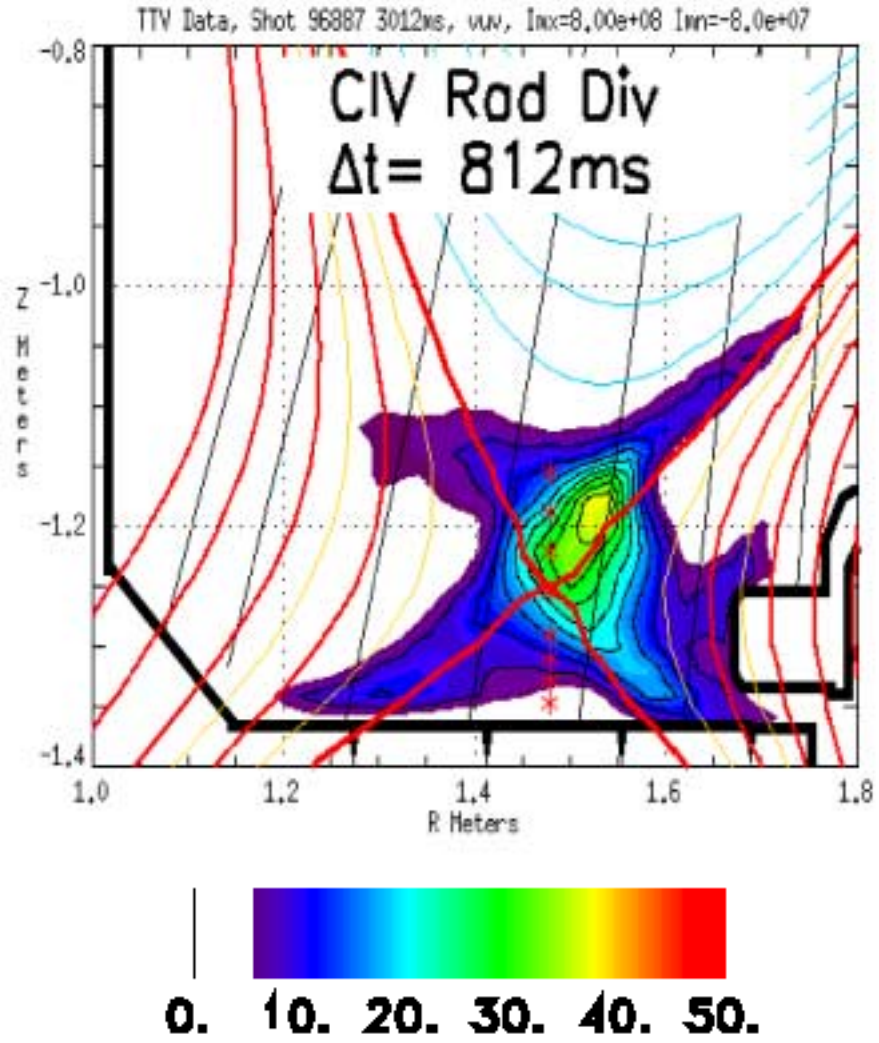
CIV 155 nm RADIATION ATTACHED PLASMA

- CIV radiation is concentrated to the left of the x-point
- Radiation extends along the inner and outer legs to the floor



CIV 155 nm RADIATION DETACHED PLASMA

- CIV radiation is concentrated near the x-point
- Radiation extends along the outer leg to the floor
- Radiation extends along the inner leg almost to the floor



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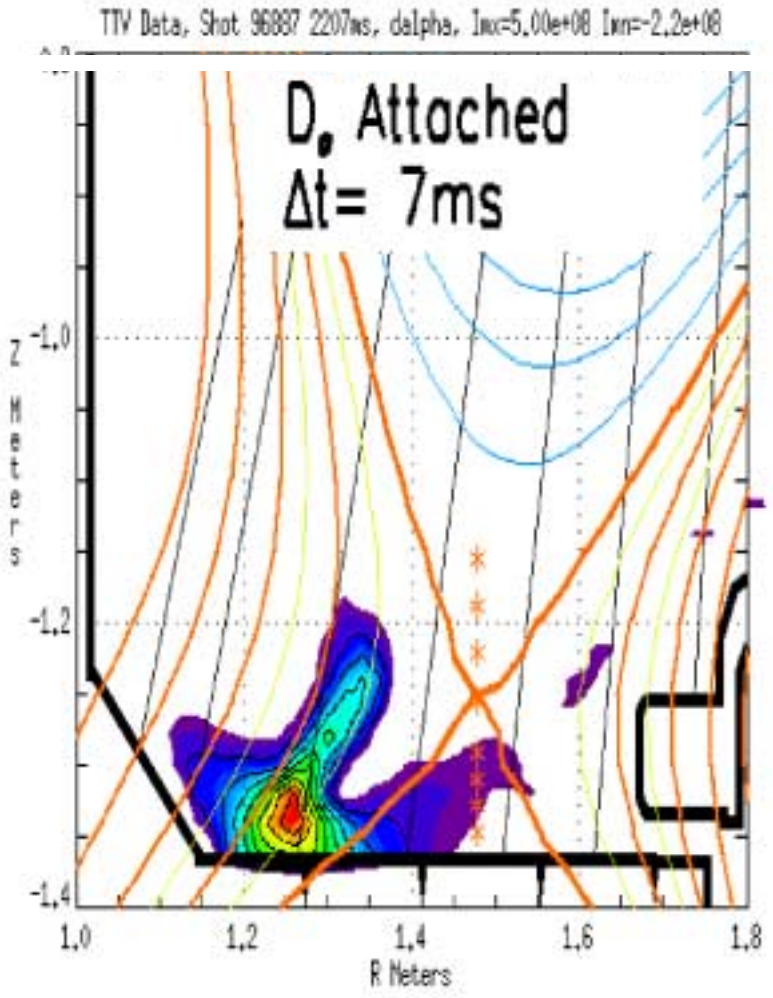
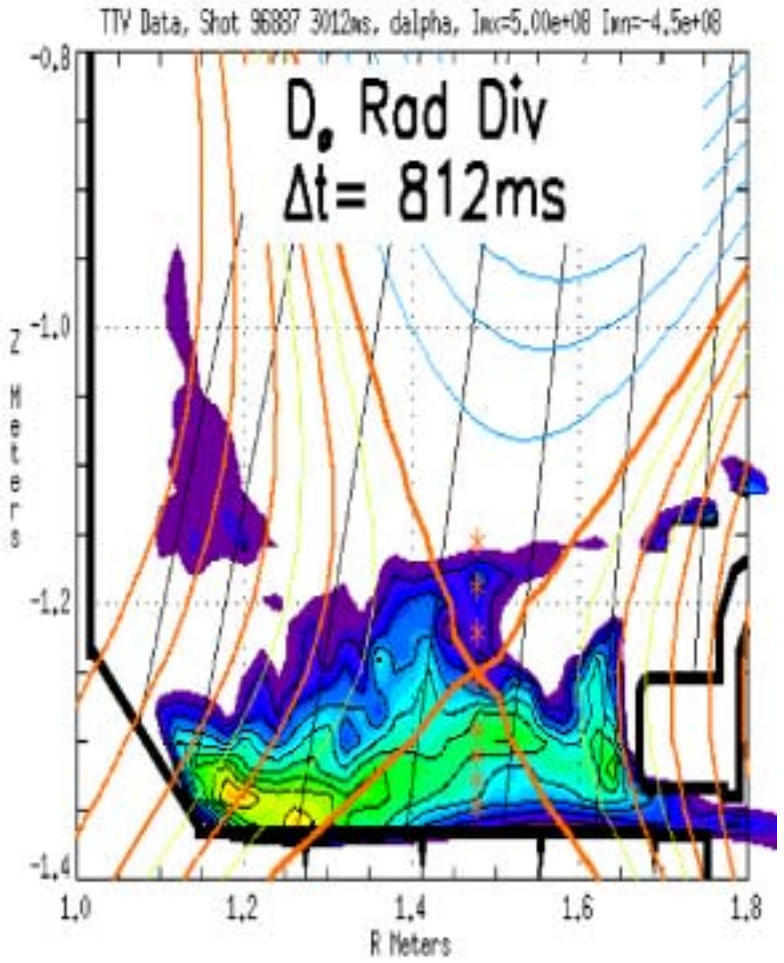
D-ALPHA RADIATION ATTACHED PLASMA

- D-alpha radiation is located to the left of the x-point and near the floor



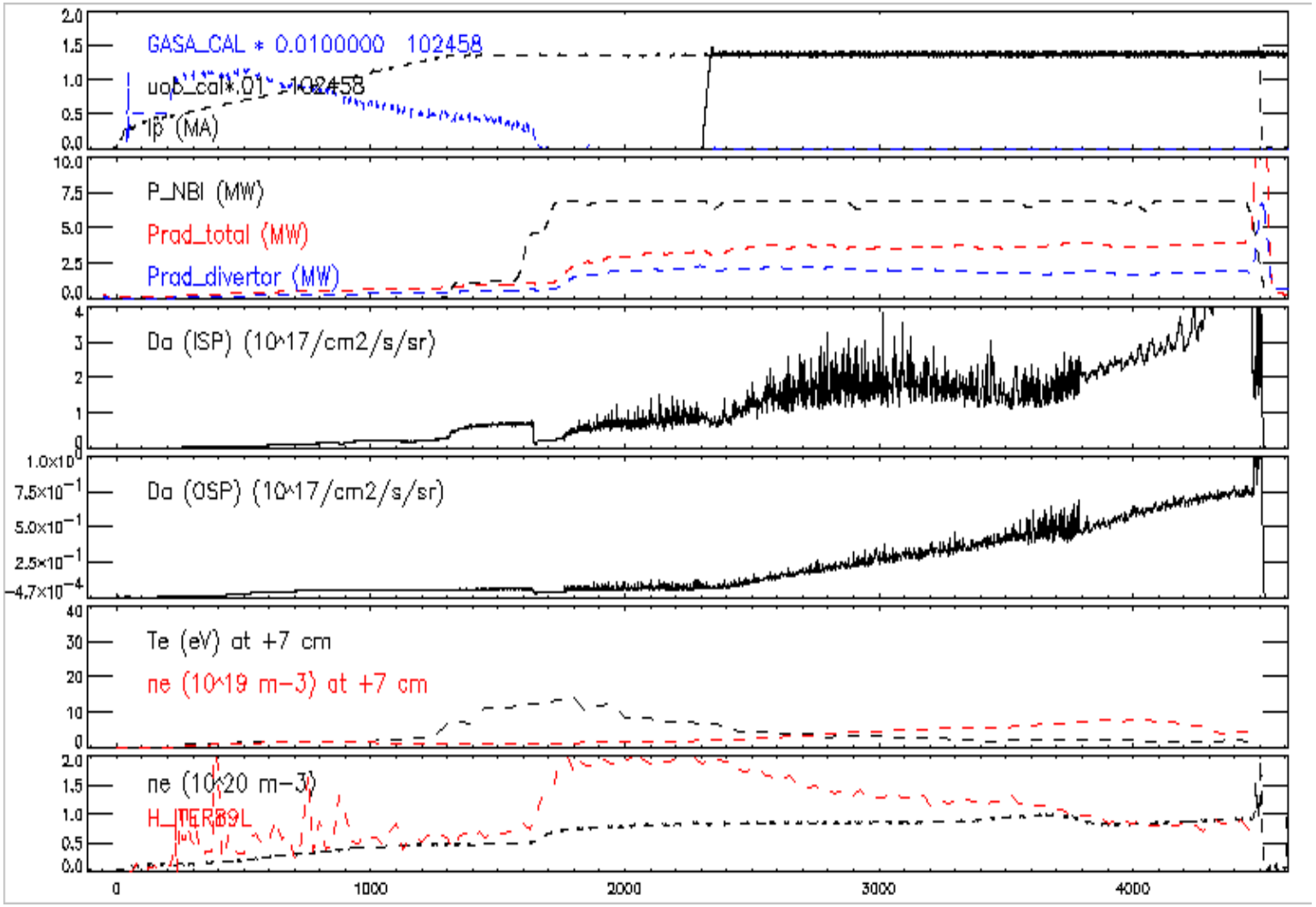
D-ALPHA RADIATION DETACHED PLASMA

- D-alpha radiation is located below the x-point and near the floor



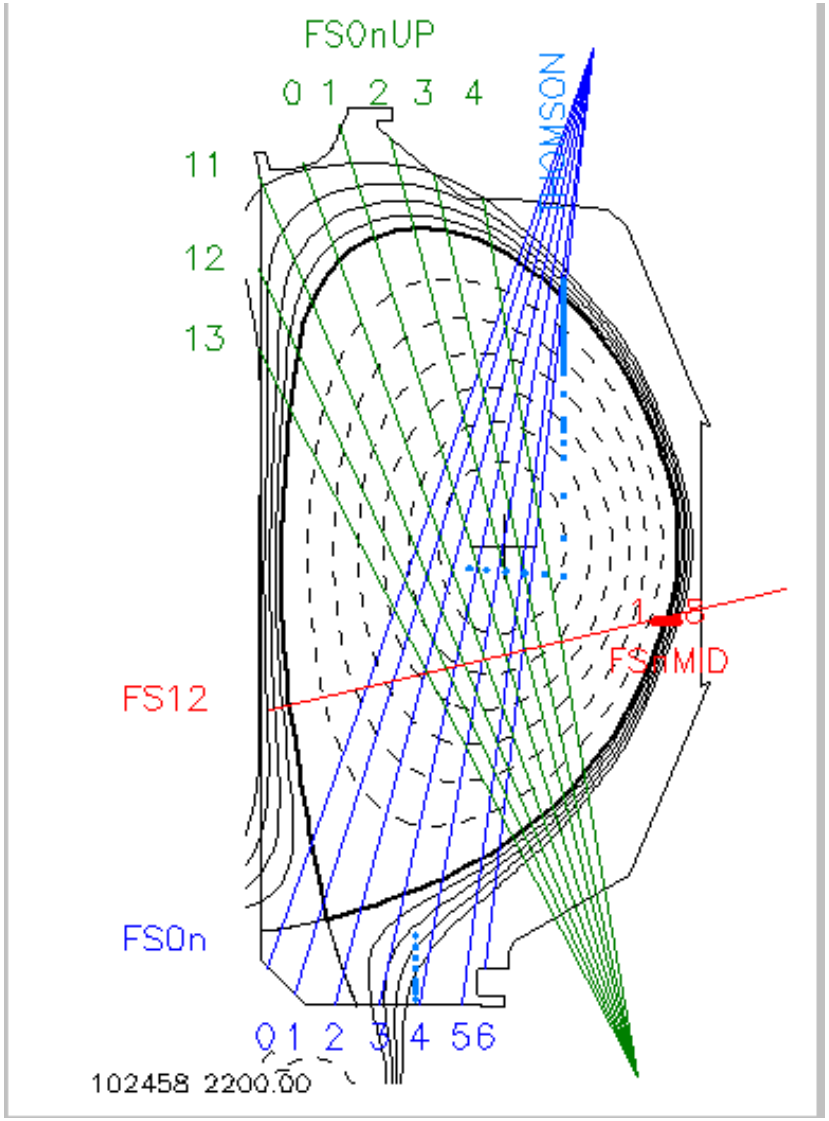
High Triangularity

Time History Shot 102458



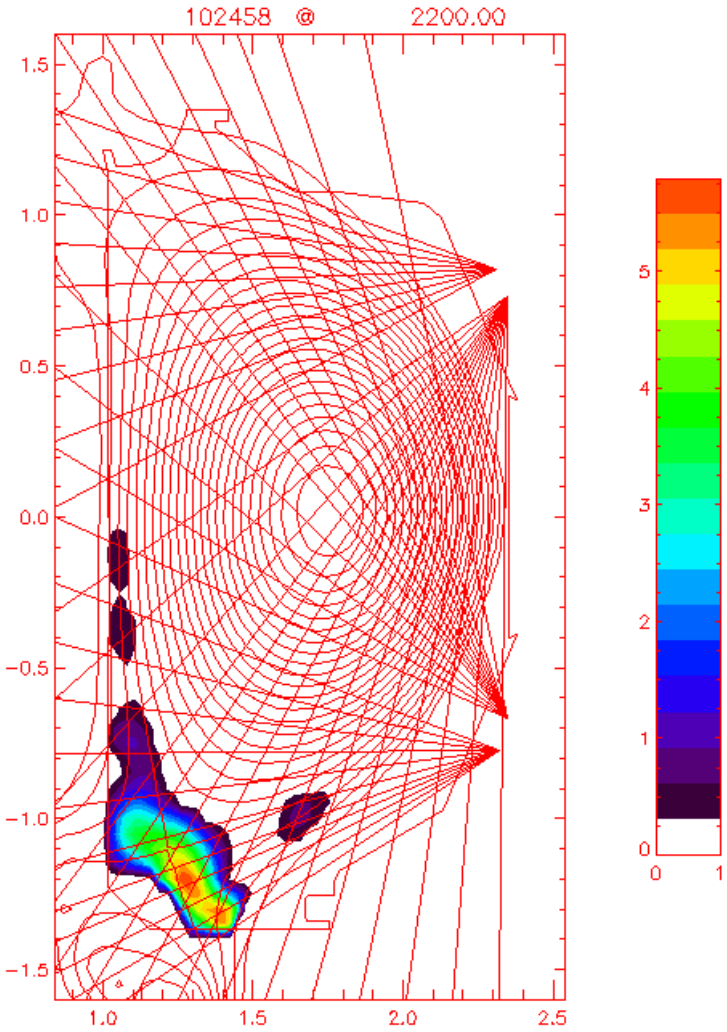
EQUILIBRIUM POSITION

- X-Point is far to the left of Thomsen Scattering location
- Inner strike point is on the vertical wall



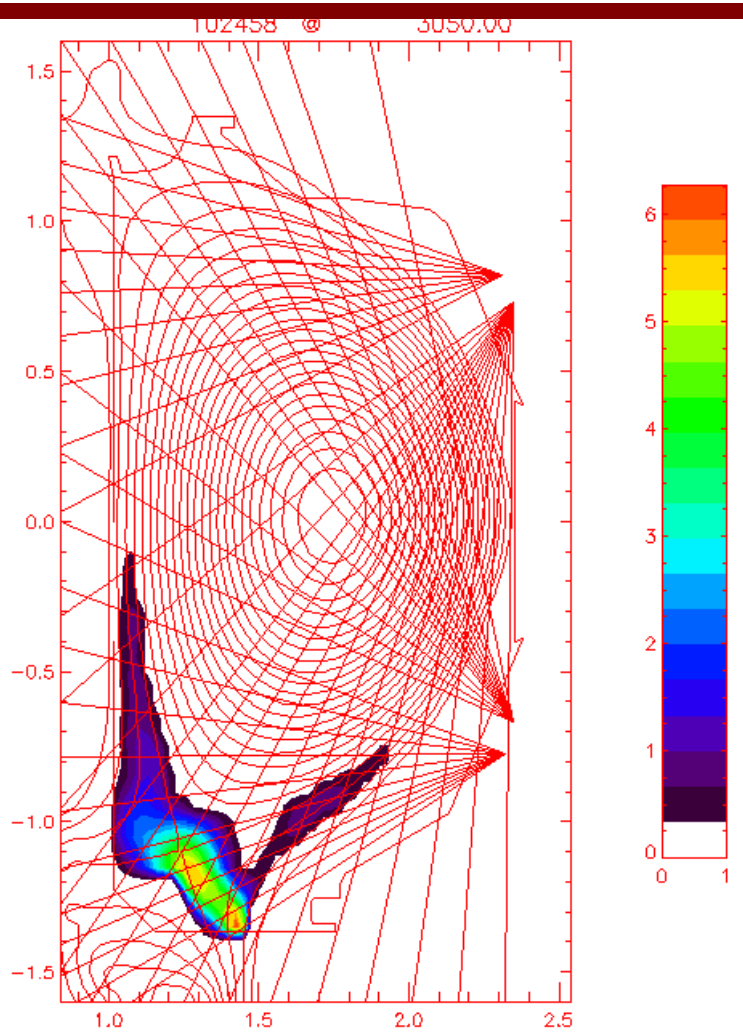
TOTAL RADIATION

- Maximum radiation is located along outer leg
- Maximum CIV radiation is below the x-point and to the right of the outer leg
- Chords represent line of sight for the bolometer arrays



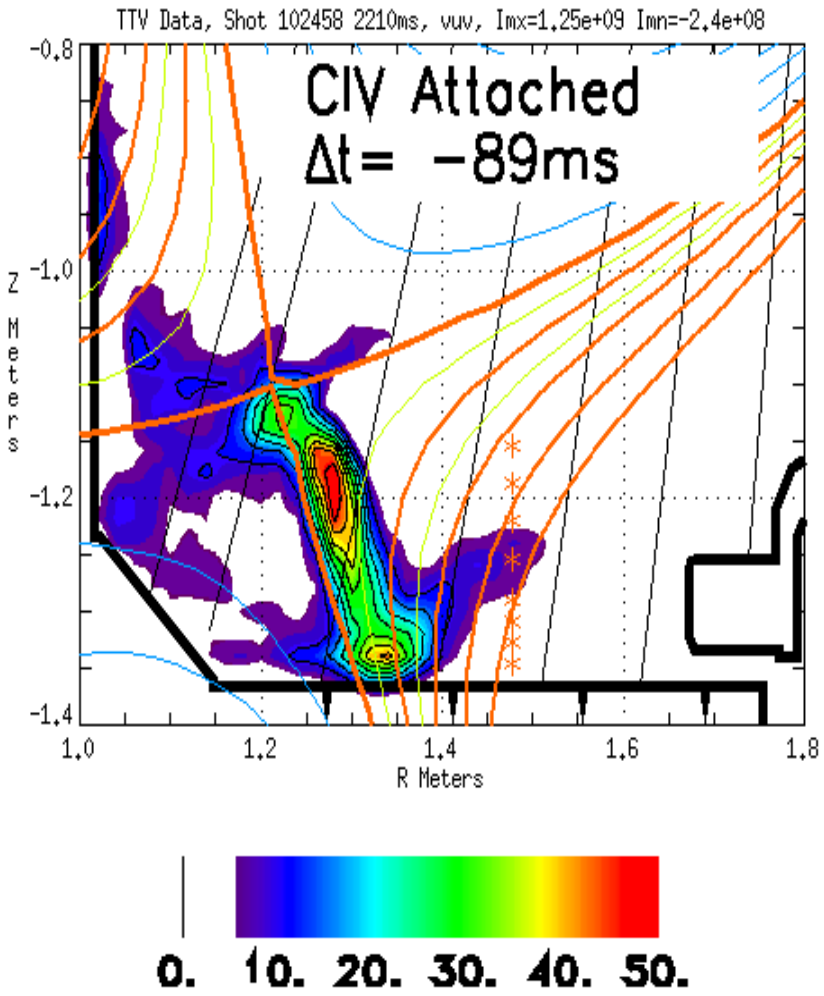
TOTAL RADIATION DETACHED PLASMA

- Maximum radiation is located just below the x-point and along the outside part of the outer leg
- A hot spot also appears near the floor near the outer strike point



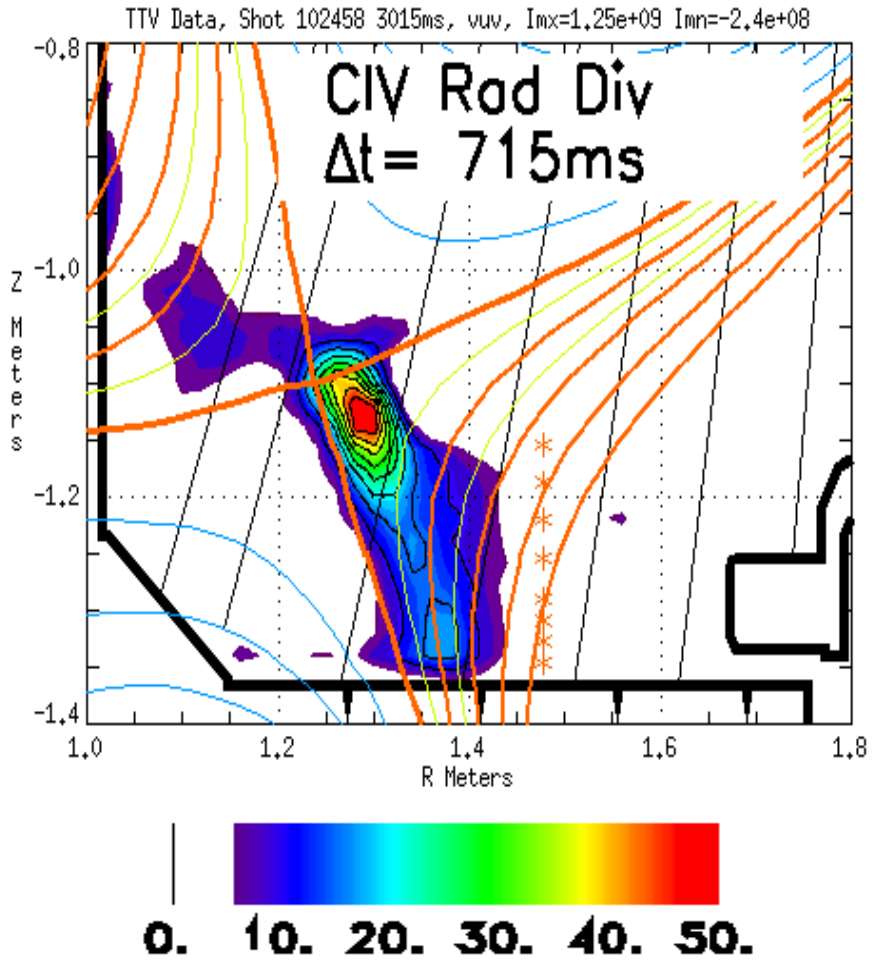
CIV 155 nm RADIATION ATTACHED PLASMA

- Maximum CIV radiation intensity occurs in the outer Scrape Off Layer and extends along the outside of the outer leg to the divertor floor



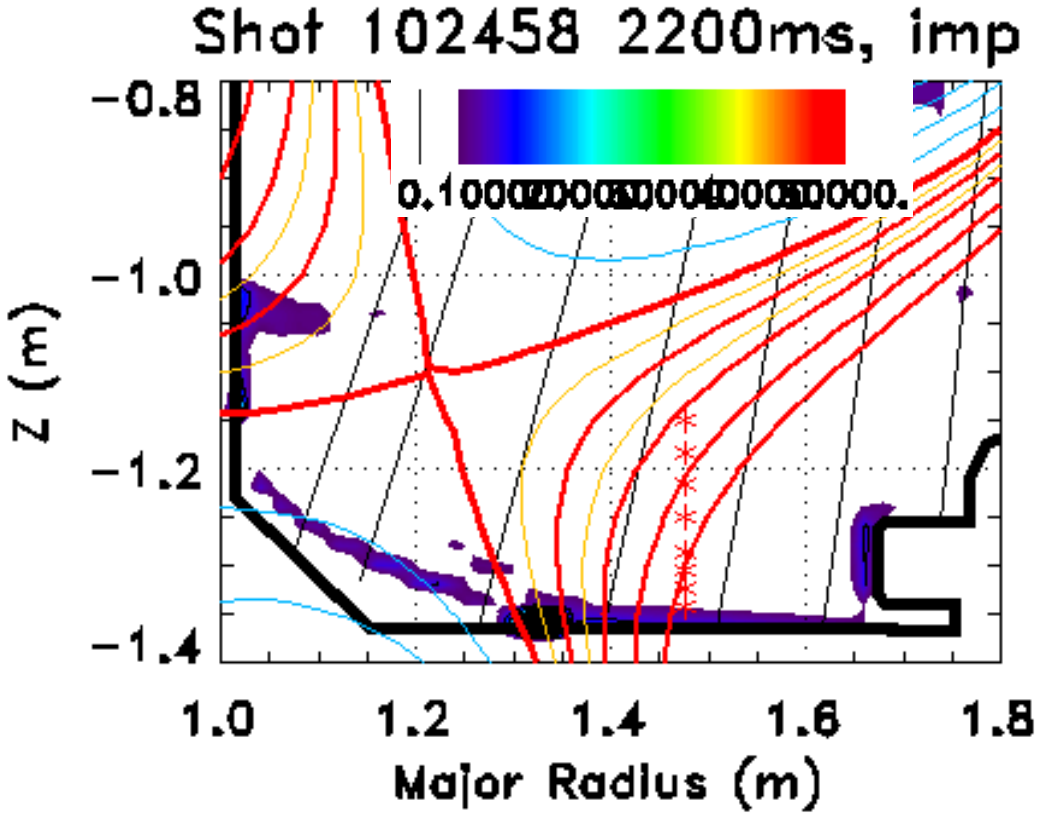
CIV 155 nm RADIATION DETACHED PLASMA

- CIV radiation is concentrated in the outer Scrape Off Layer, below the x-point
- Radiation extends along the outer leg to the floor



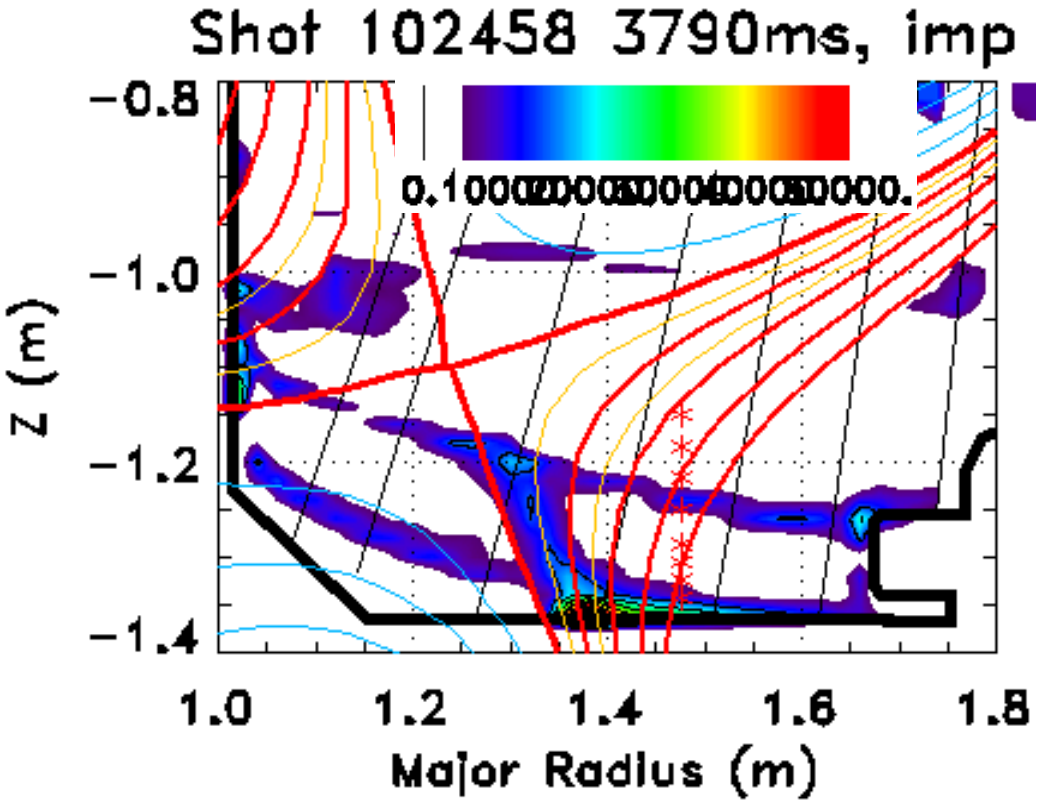
D-ALPHA RADIATION ATTACHED PLASMA

- D_alpha emission is very localized at the target plates



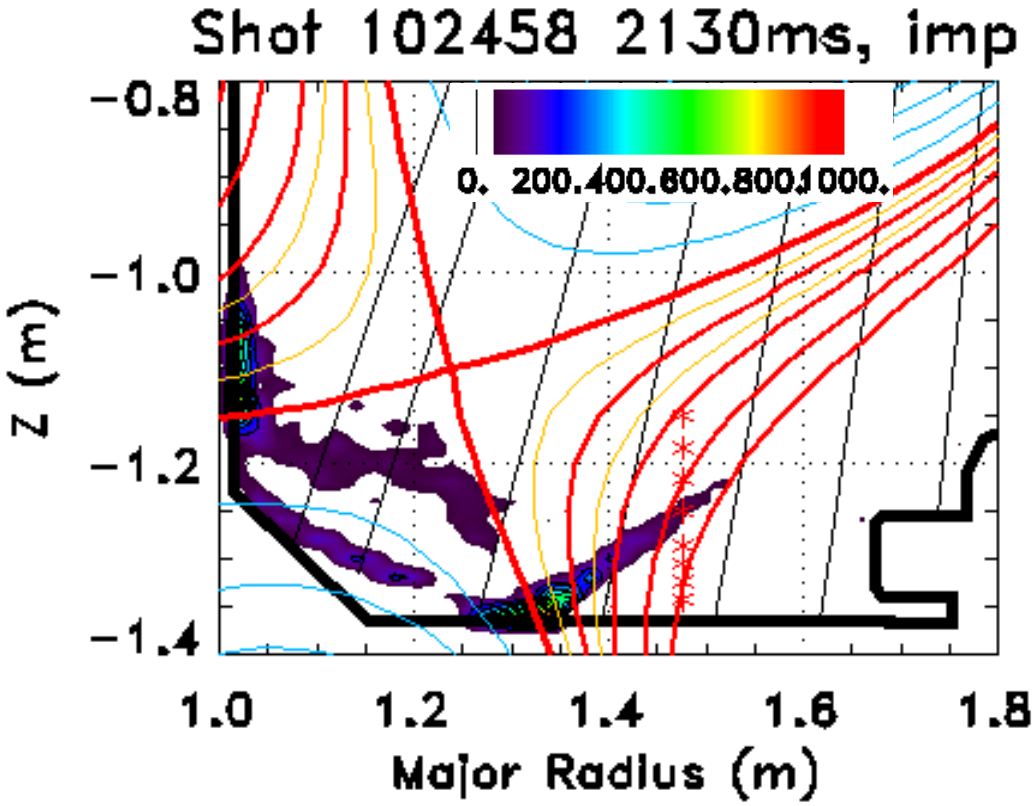
D-ALPHA RADIATION DETACHED PLASMA

- D_alpha emission appears to extend somewhat more along outer leg than in attached case.



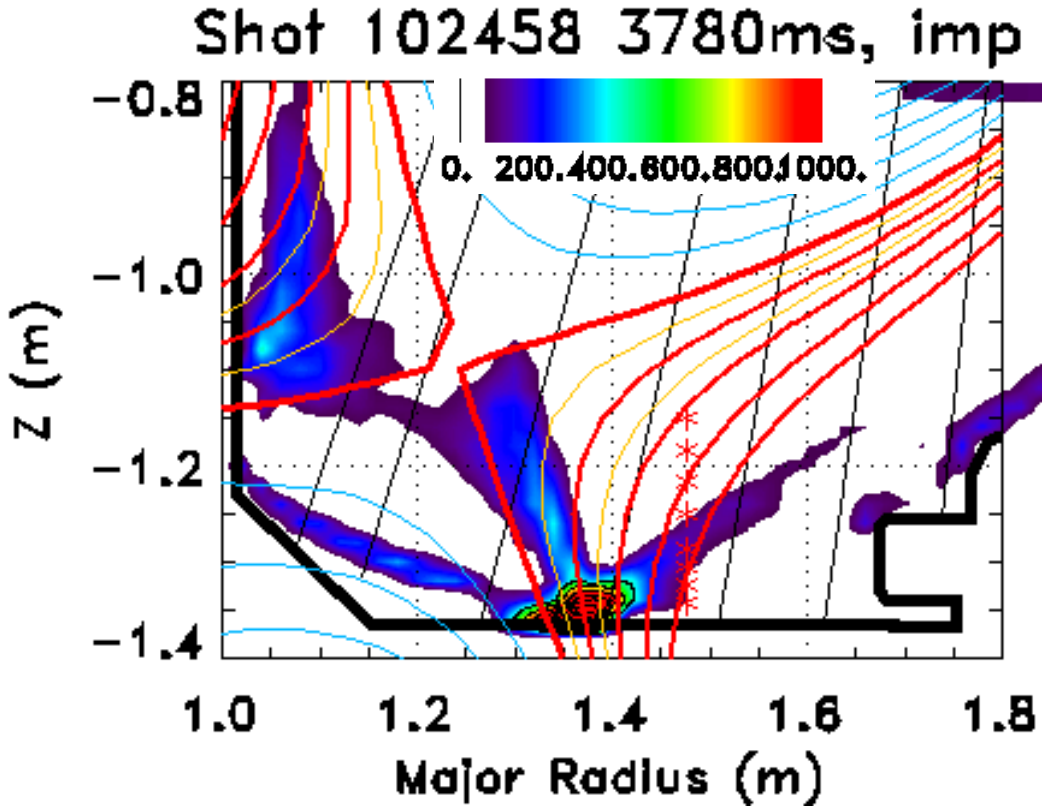
D_gamma emission in attached divertor

- Emission is local to targets near strikepoints.



D_gamma emission in detached divertor

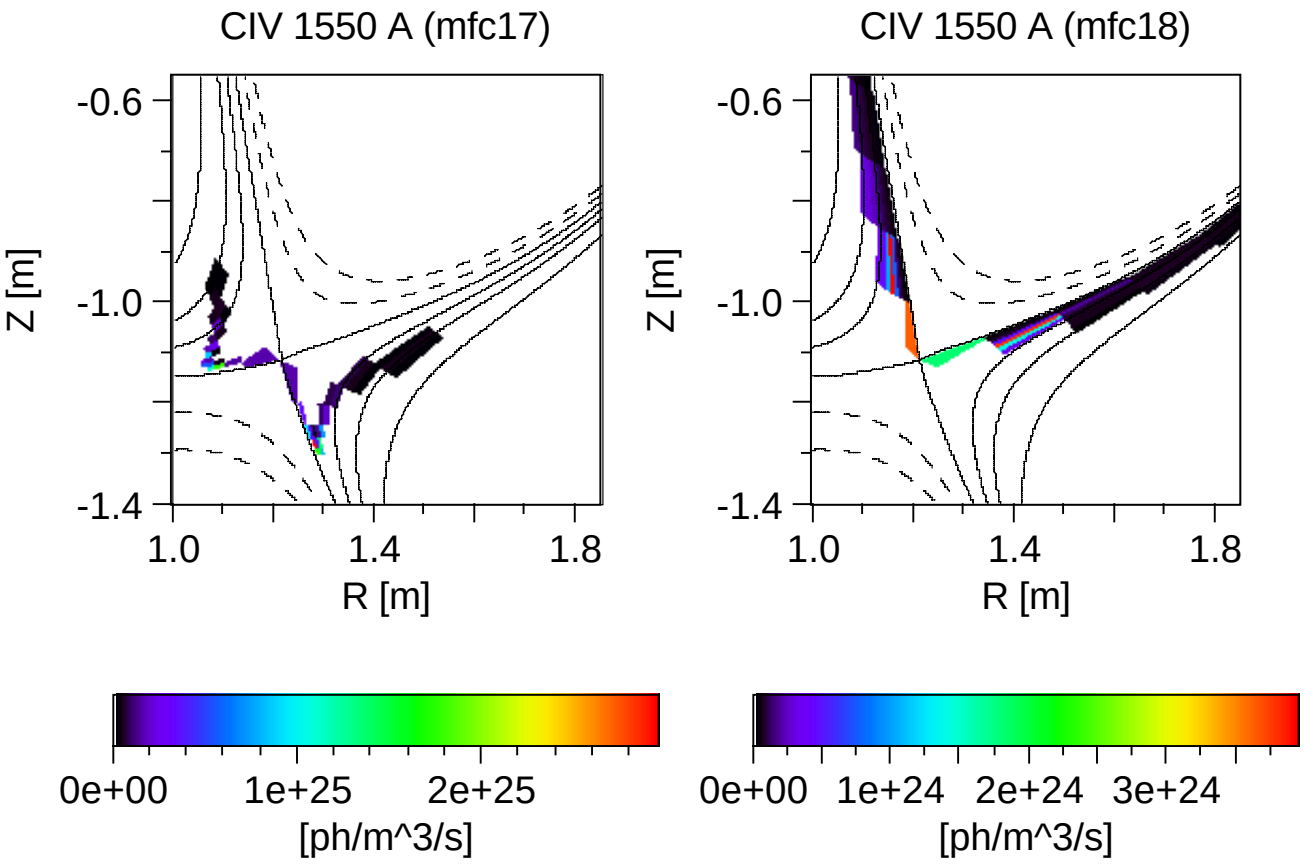
- Emission broadens along target on inner leg side and extends along outer leg separatrix.



UEDGE

- We have also compared the experimental profiles with simulations of CIV emision using the UEDGE fluid code

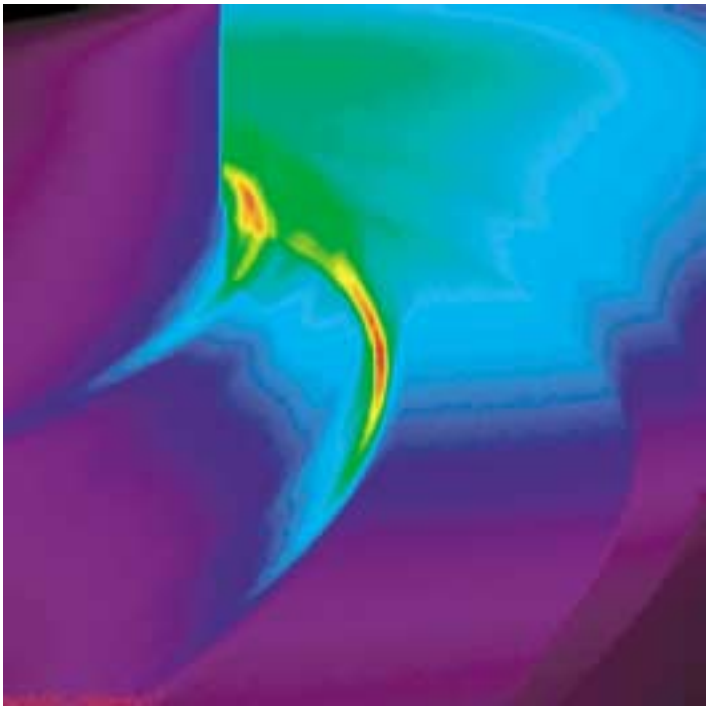
VUV CIV profiles show strong sensitivity to divertor neutral albedo.



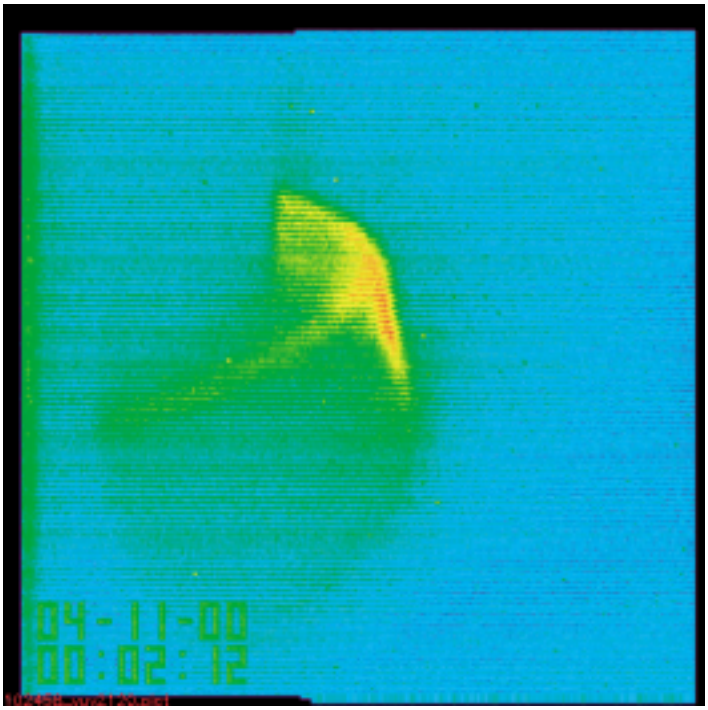
- Change in neutral sticking coefficient along divertor walls from 2% (mfc17) to 1% (mfc18) changes UEDGE solution from attached to detached outer leg profile.

CIV: UEDGE 2% albedo (mfc17) solution not completely consistent with pre-puff data

UEDGE attached (mfc17)



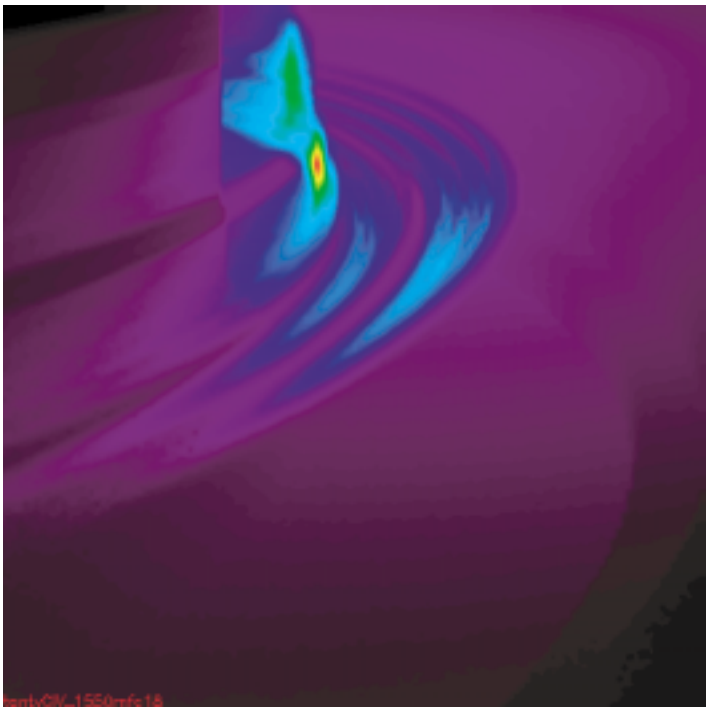
DATA: Shot 102458 2120 ms



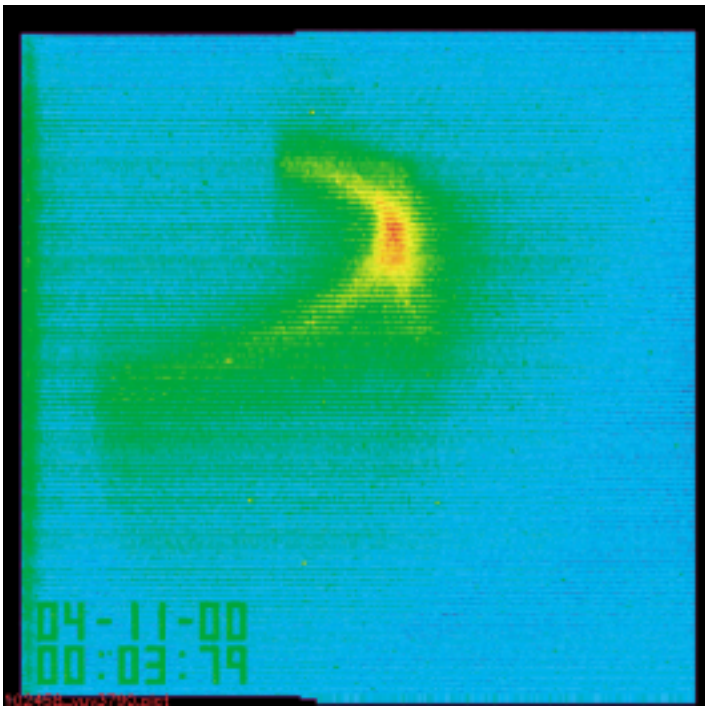
- Extension of CIV data along outer leg not reproduced by UEDGE solution
- Local emission at strikepoints in UEDGE not seen in data.

CIV: UEDGE 1% albedo (mfc18) solution not completely consistent with PDD data

UEDGE detached (mfc18)

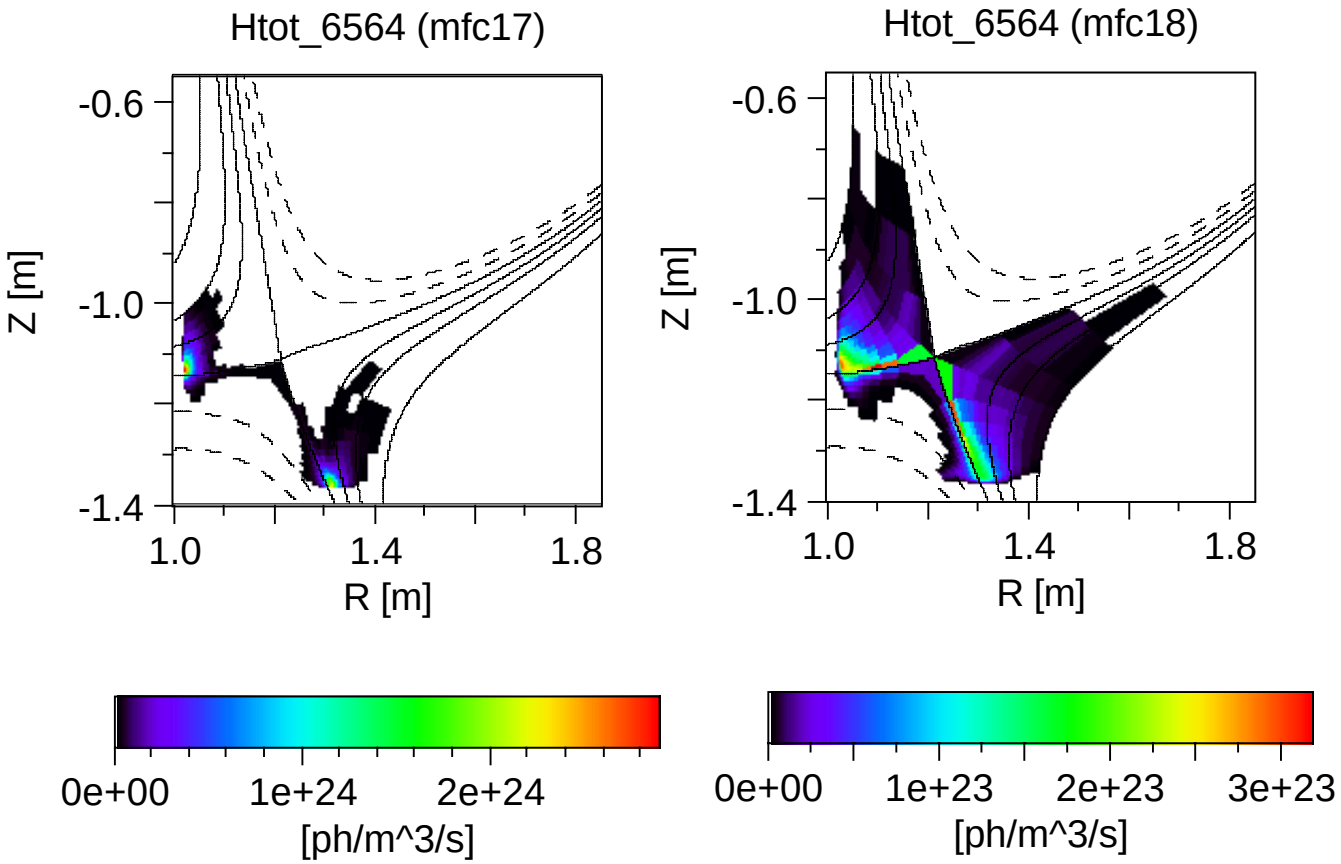


DATA: Shot 102458 3790 ms



- Localization of CIV in ring outboard of X-point not precisely reproduced by UEDGE solution

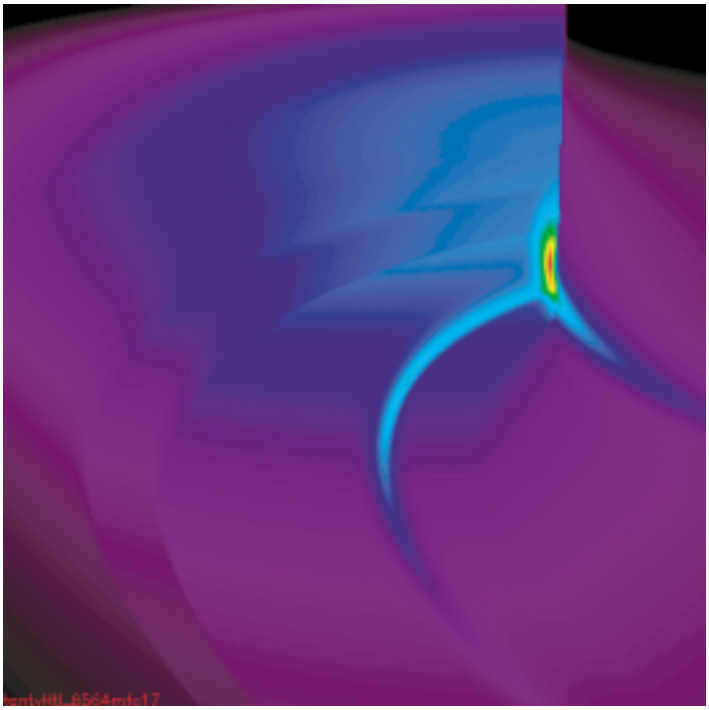
D_α profiles also show sensitivity to divertor neutral albedo.



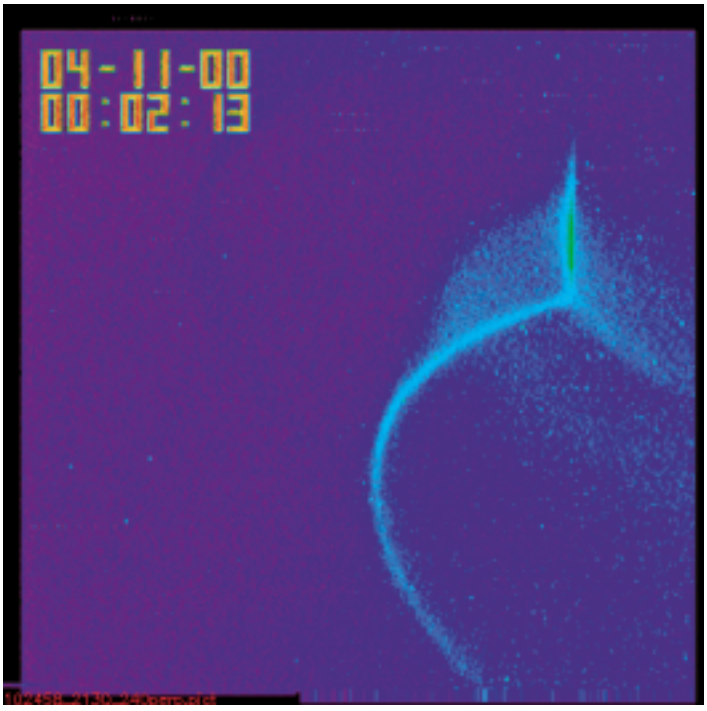
- These two solutions match experimental data profiles well in attached and detached phases (see below).

D_α: UEDGE 2% albedo (mfc17) solution matches very well with pre-puff data.

UEDGE attached (mfc17)



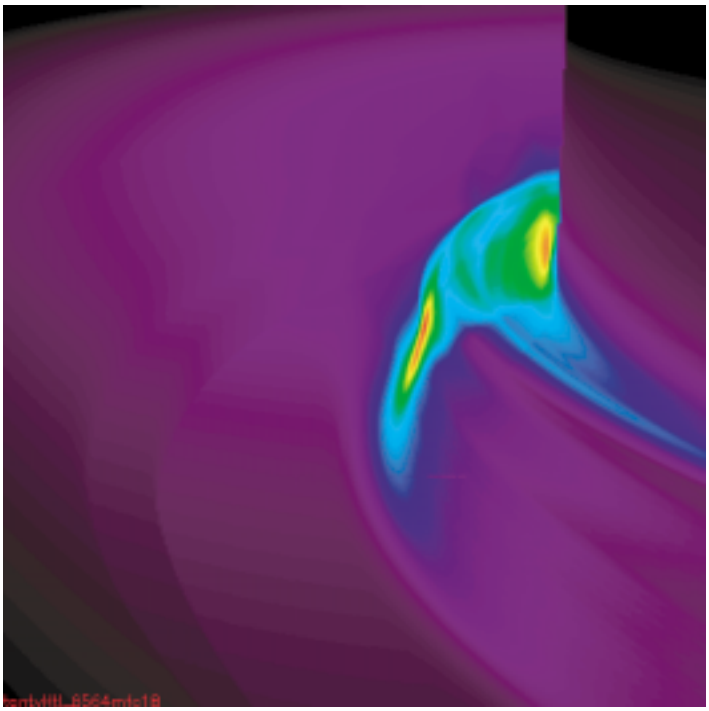
DATA: Shot 102458 2120 ms



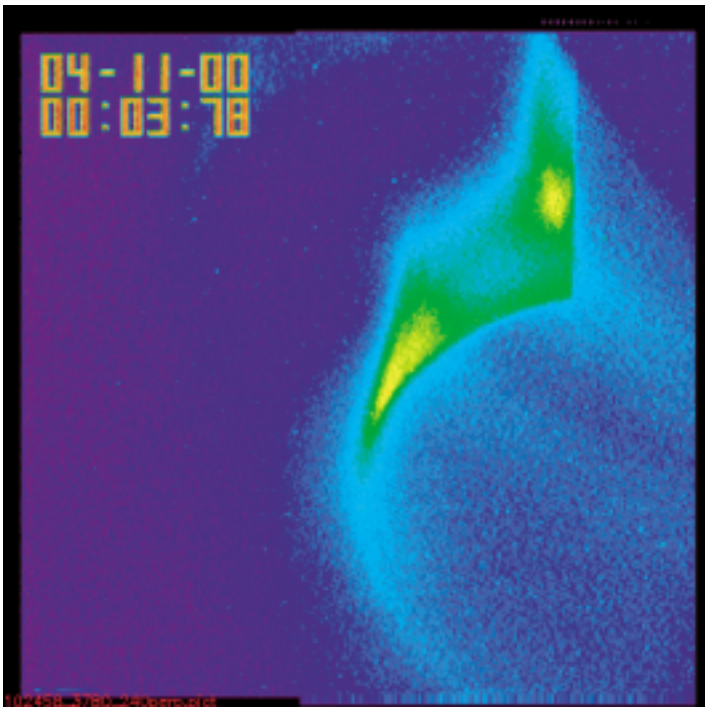
- Local emission at strikepoints in UEDGE matches data image well.
- Fade of OSP in foreground of UEDGE solution may indicate smaller vertical extent of radiation than in data image.

D_α: UEDGE 1% albedo (mfc18) solution matches very well with data during detached phase.

UEDGE detached (mfc18)

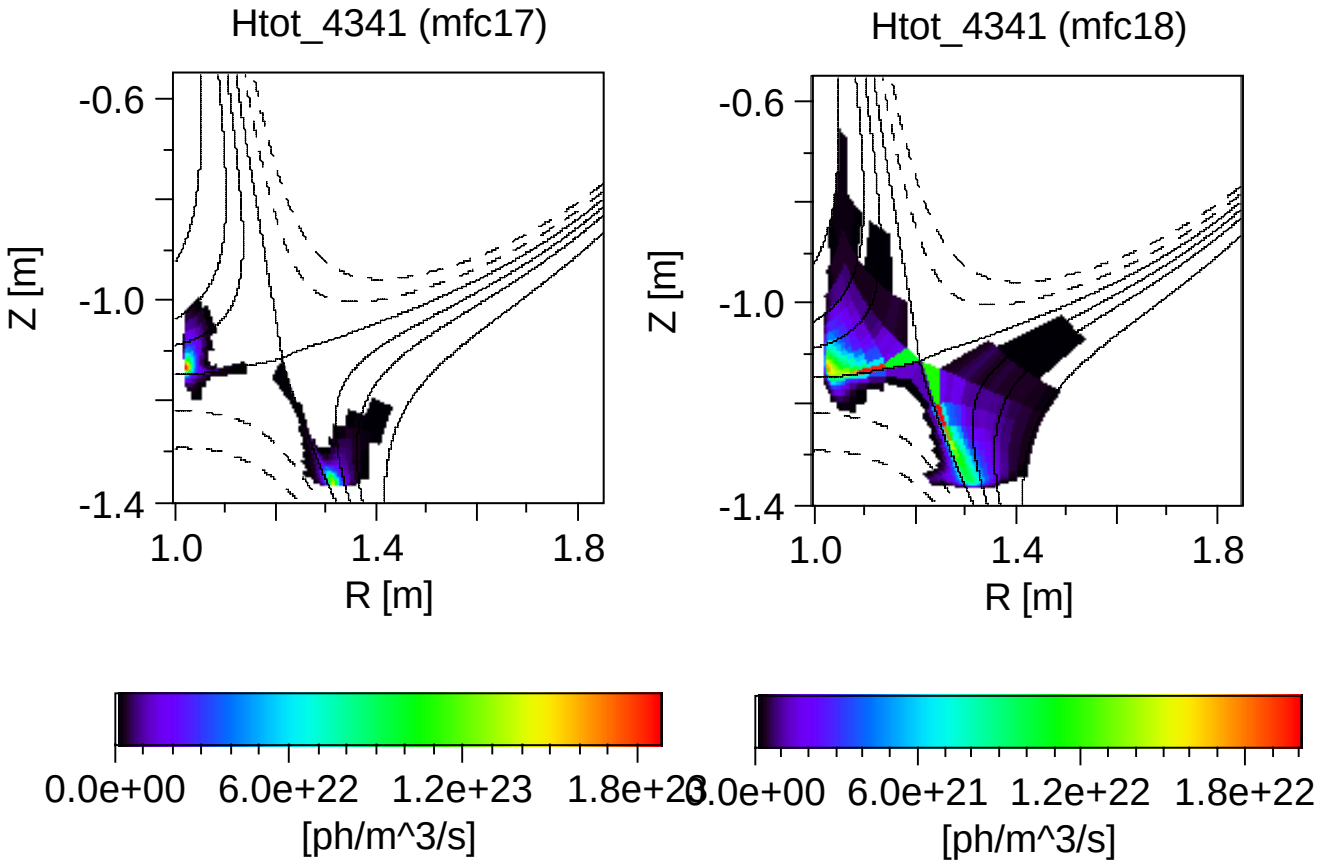


DATA: Shot 102458 3780 ms



- Emission at ISP and along outer leg in UEDGE solution well matched to data.
- D_α emission extended along outer leg up from OSP is a strong indicator of detachment.

D_γ profiles also show sensitivity to divertor neutral albedo.

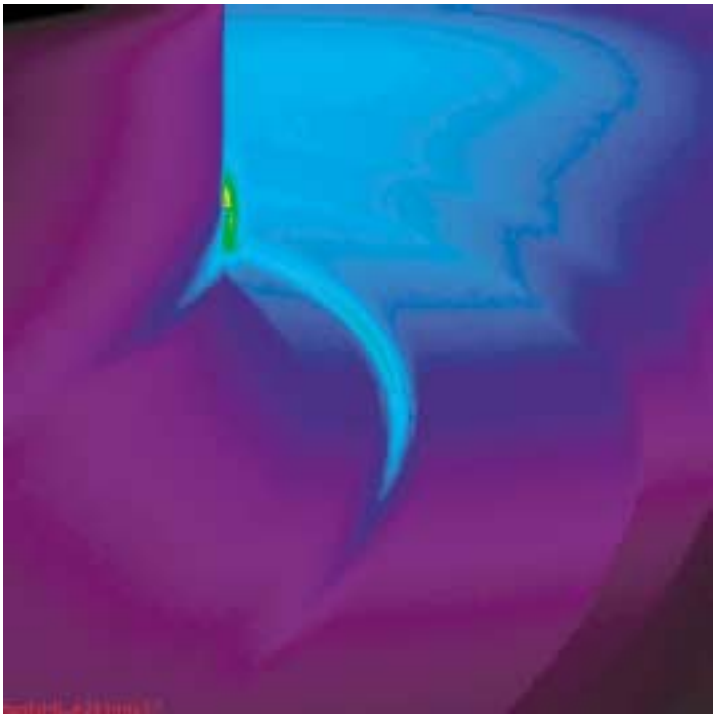


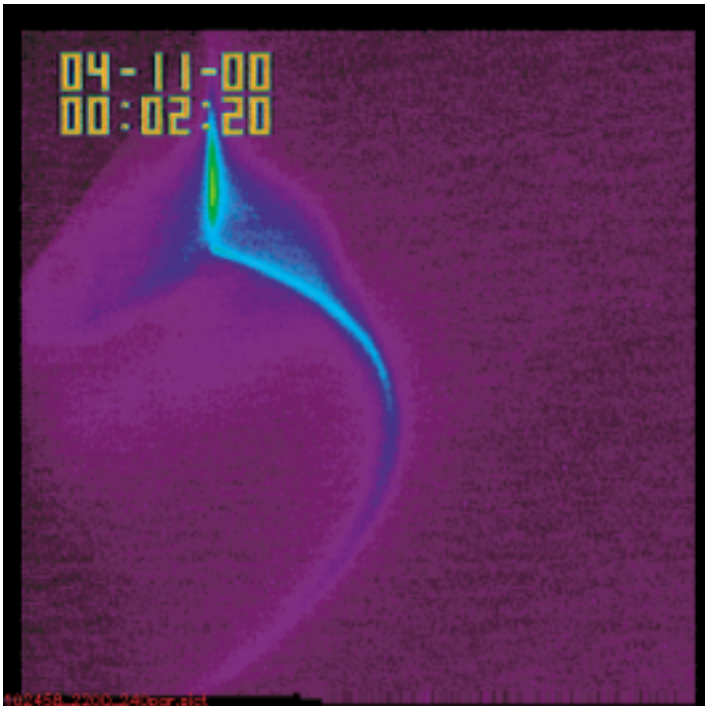
- Increase of Dγ along both divertor legs is a strong indicator of recombination regions.
- UEDGE solutions match data images well (see below).

D_γ: UEDGE 2% albedo (mfc17) solution matches very well with pre-puff data.

UEDGE attached (mfc17)

DATA: Shot 102458 2120 ms

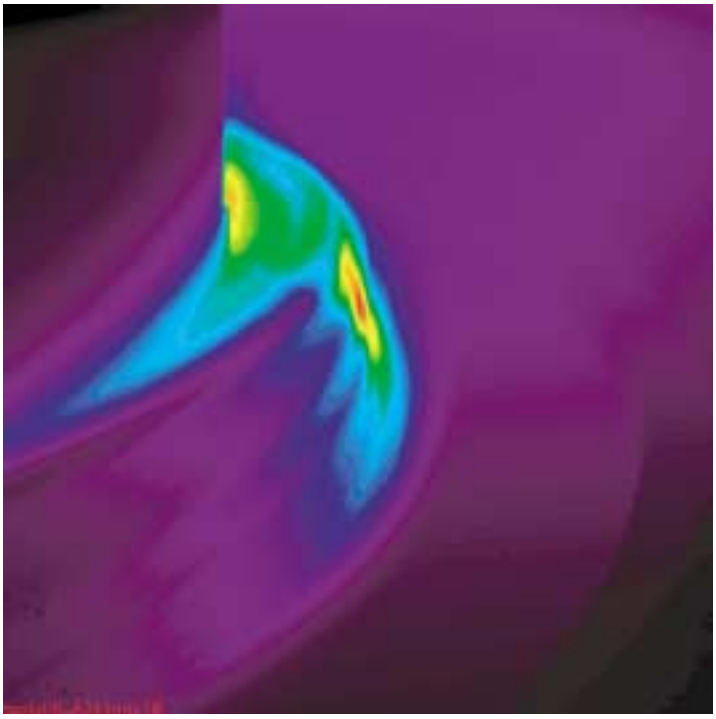




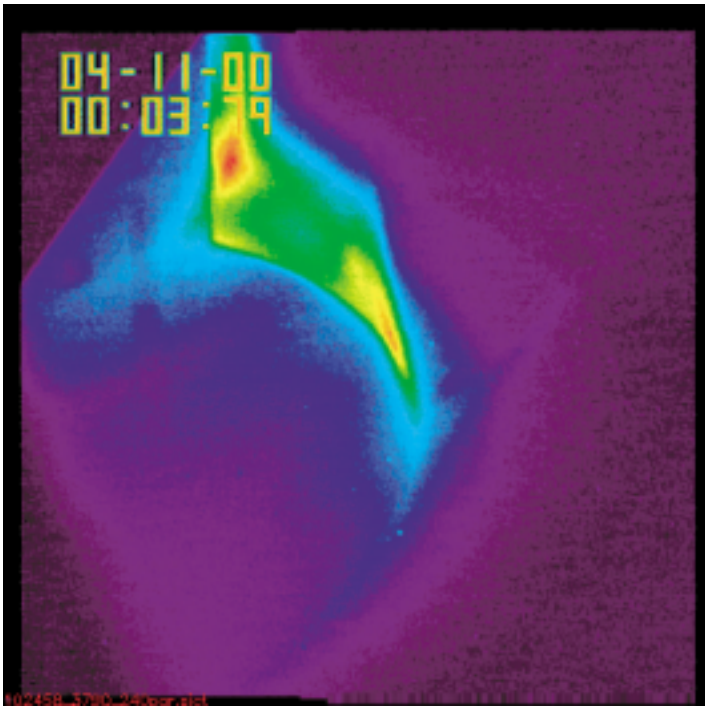
- Local emission at strikepoints in UEDGE matches data image well.
- Broad emission at top of UEDGE image may be reconstruction artifact (does not appear on 2D UEDGE solution).

D_γ: UEDGE 1% albedo (mfc18) solution matches very well with data during detachment phase.

UEDGE detached (mfc18)



DATA: Shot 102458 3790 ms



- Local emission at inner strikepoint and along outer leg in UEDGE matches data image well.

SUMMARY OF RESULTS

- 2D profiles of CIV radiation at 155 nm agree, in general, with profiles of the total radiated power as measured by bolometers arrays
- These profiles show different distributions of the CIV radiation for high triangularity and low triangularity shot
- For the high triangularity case, maximum intensity of CIV is in the outer SOL for both attached and detached plasmas and below the x-point
- For the low triangularity case, maximum intensity of CIV is located in the inner SOL near the x-point for the attached plasma and in the closed flux region, above the x-point for the detached plasma
- Comparison of the 2D profiles with profiles calculated using the UEDGE fluid code