# Target power loads during disruptions in ASDEX Upgrade

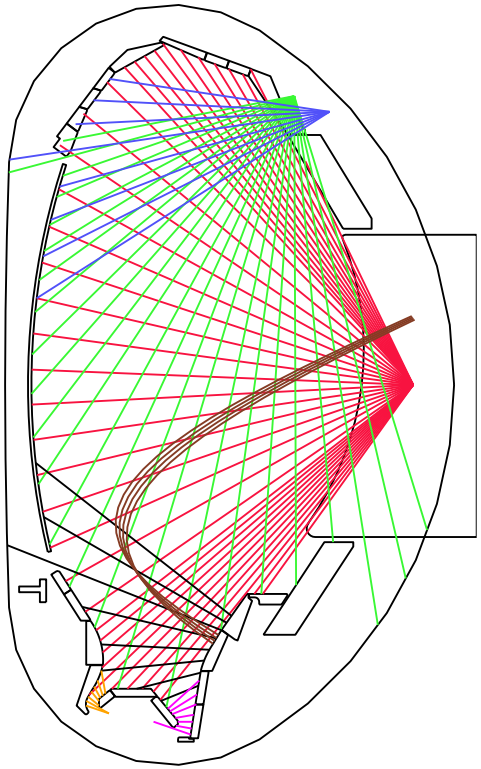
Arne Kallenbach

on behalf of G. Pautasso, A. Herrmann and C. Fuchs

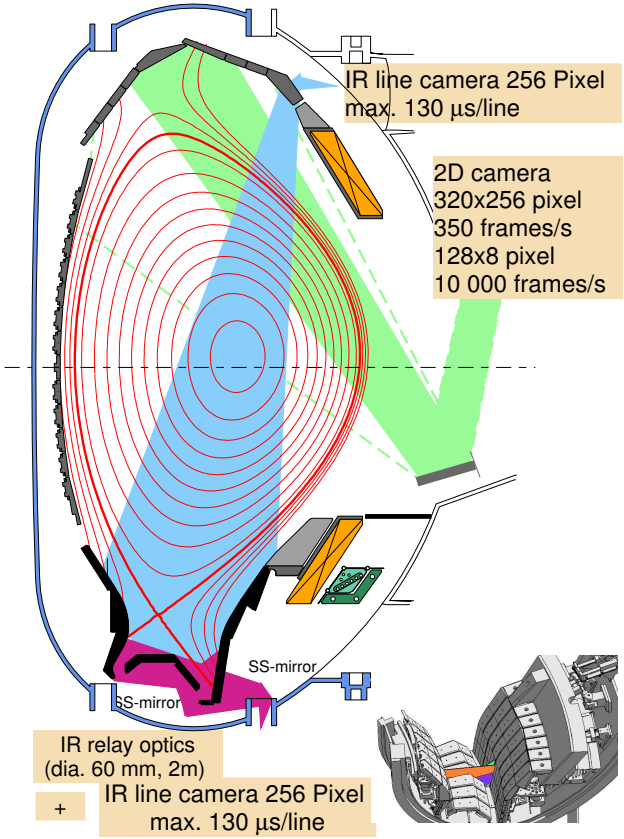
- database on power load in ASDEX Upgrade lower div II and div IIb
- temporal evolution of the disruption
- spatial distribution of power
- role of radiation on power load

# bolometers and thermography for power balance

100 bolometer chords
time resolution 1 ms

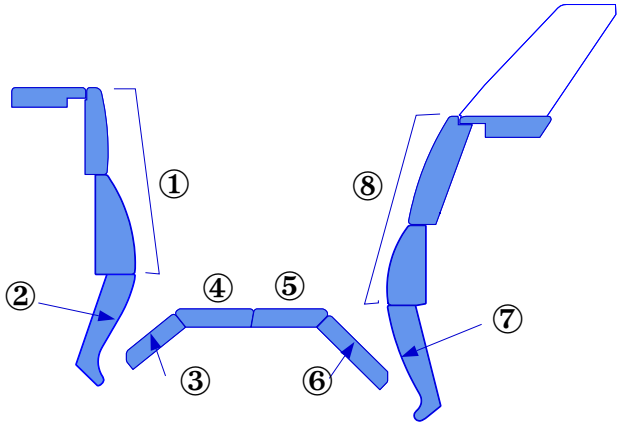


2 IR cameras for the lower target
time resolution 0.12 - 1 ms
spatial resolution 1-2 mm

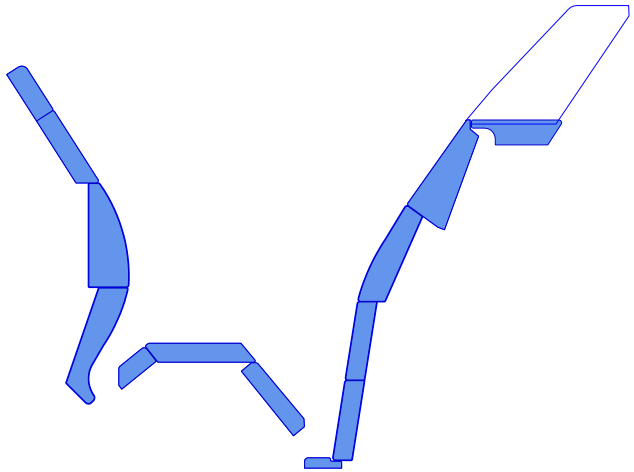


# divertor geometries

the power deposition on the lower divertor (Div. II and Div. II-b) is analysed in this work.

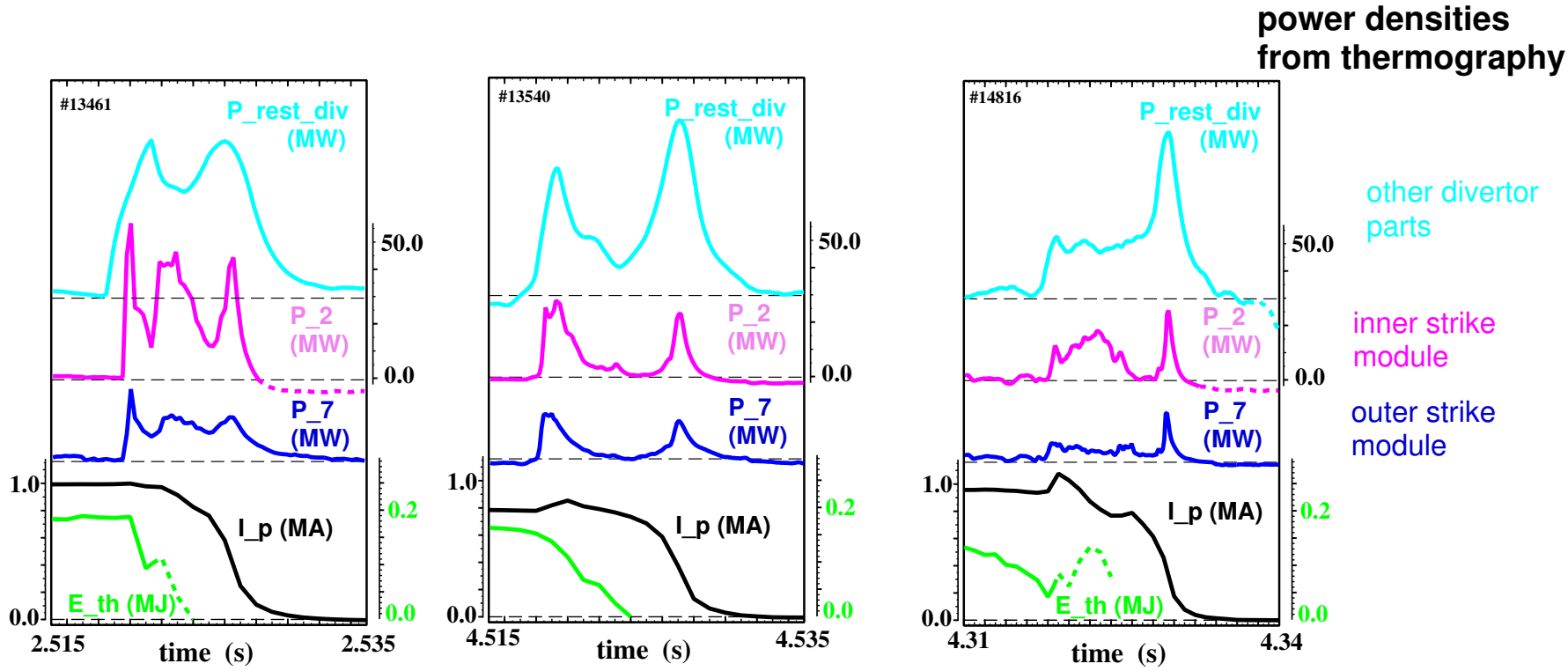



**Divertor II**



**Divertor II-b**

# variety of time histories during disruptions




**the power deposition on the divertor plates during the thermal quench lasts 2-3 ms.**

**there is no one typical power deposition time history during disruption but a variety of them.**

# disruption database for Divertor II and II-b

**shot range: 13000-17500 (Jan. 2000 - Mai.2003)**

**Divertor II-lyra configuration: 30 discharges**
**(shot # < 14200)**

**Divertor II-b configuration: 14 discharges**
**(shot # > 14200)**

**Parameters:**

**plasma current (I_p) = 0.6 - 1 MA**

**q_95 = 2.5 - 6**

**thermal energy (E_th) = 50 - 500 kJ**

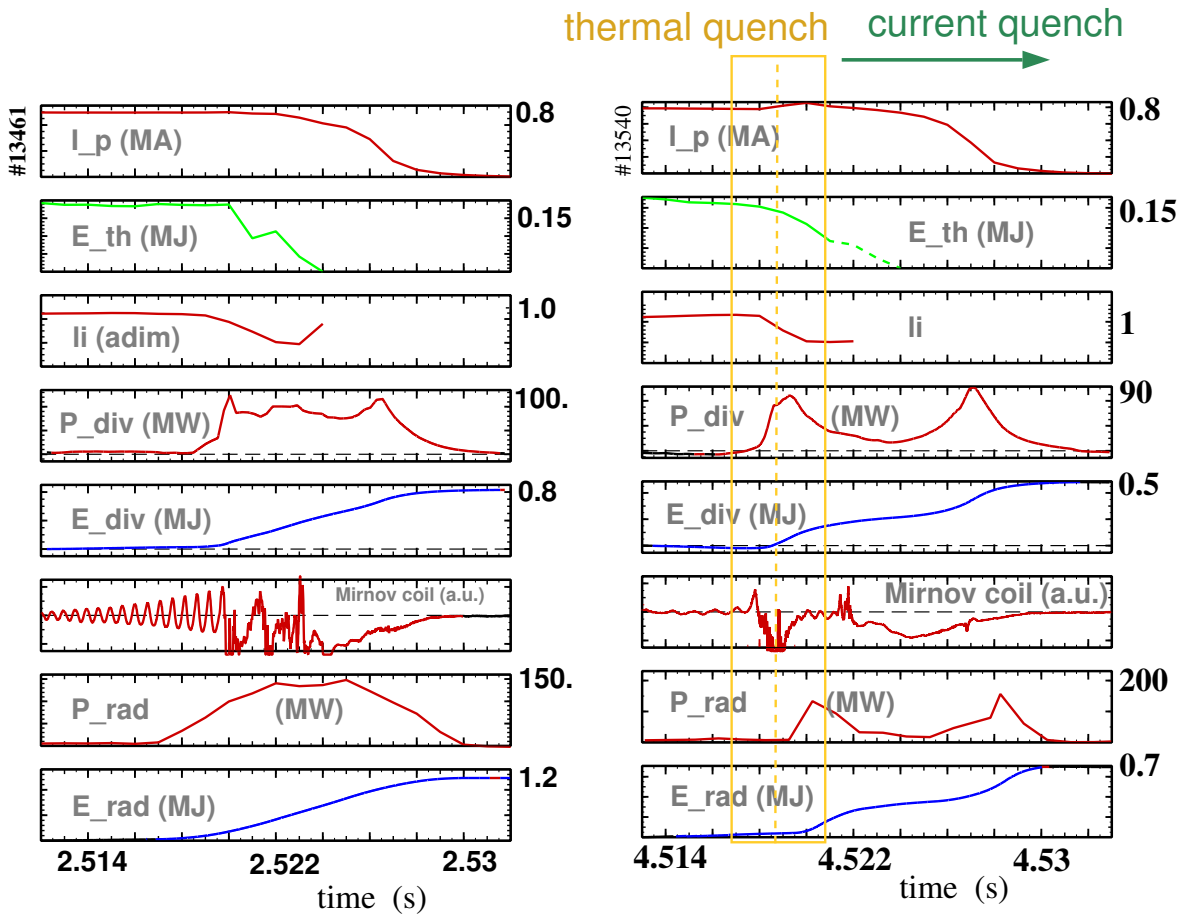
**magnetic energy (E_mag) = 0.7 - 1.8 MJ**

**disruption duration = 10 - 30 ms**

different disruption causes,
not yet analysed

# power and energy balance

$$\Delta E_{mag} + \Delta E_{th} + \Delta E_{in} = \Delta E_{rad} + (\Delta E_{div} - \Delta E_{div\_rad}) + \Delta E_{em}$$




Energy balance in the ❶ thermal quench and ❷ overall

#13461

| (MJ) | ΔE_mag | + ΔE_th | ≈ ΔE_con | + ΔE_rad | + ΔE_struc |
|---|---|---|---|---|---|
| ❶ | > 0 | 0.19 | < 0.25 | 0.16 | ~ 0 |
| ❷ | 1.7 | 0.19 | (0.8-0.5=0.3) | 1.2 | ~ 0.15 |

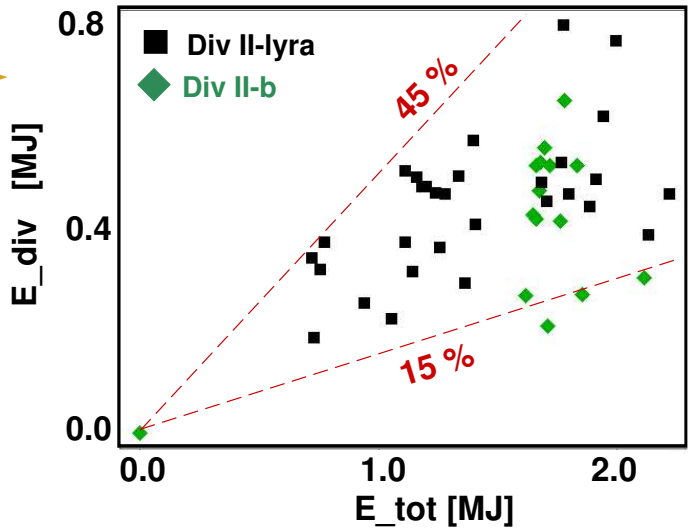
#13540

| (MJ) | ΔE_mag | + ΔE_th | ≈ ΔE_con | + ΔE_rad | + ΔE_struc |
|---|---|---|---|---|---|
| ❶ | > 0 | 0.16 | < 0.15 | 0.13 | ~ 0 |
| ❷ | 1.0 | 0.16 | (0.5-0.4=0.1) | 0.7 | ~ 0.15 |

energy balance is consistent within uncertainties

# energy balance

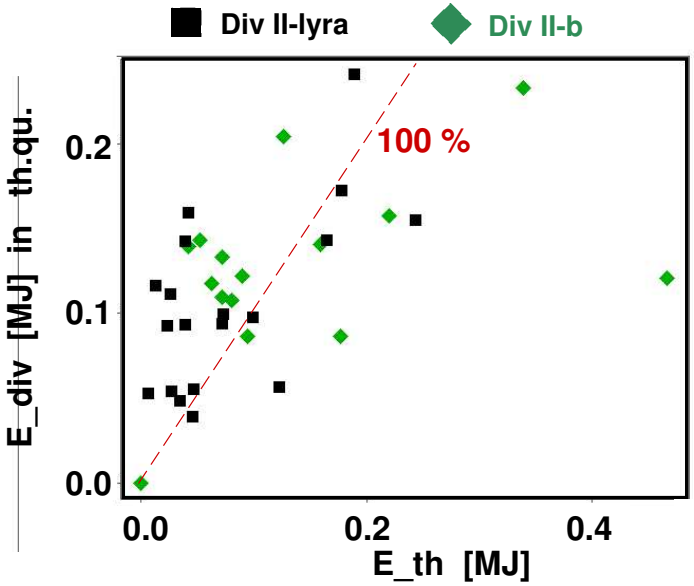
❒ The amount of energy deposited on the divertor plates during the whole disruption is 30 % in average (up to 45 %).

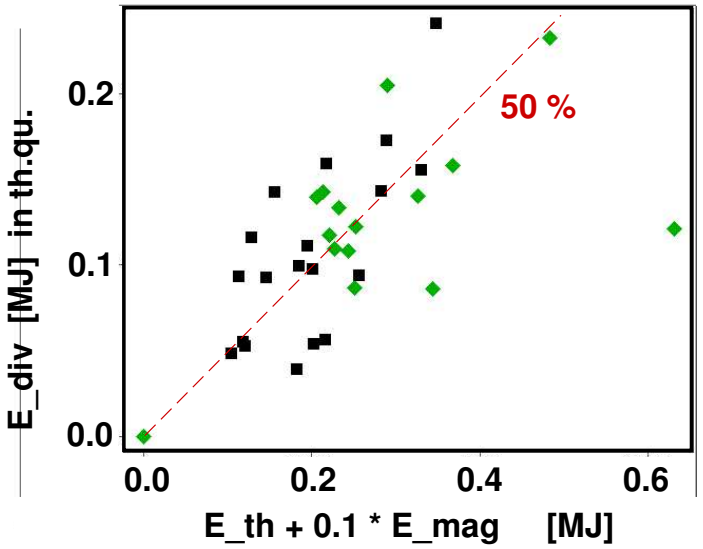



❒ During the 4 ms about the thermal quench E_div is:

① in average 90 % of pre-disruptive E_th.
➪ Part of the magnetic energy is already dissipated in this phase.

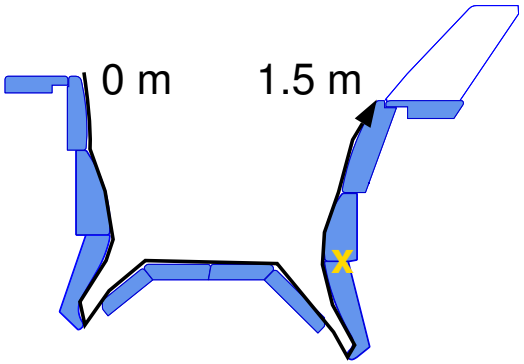
② in average 50 % of (E_th + 0.1 * E_mag).

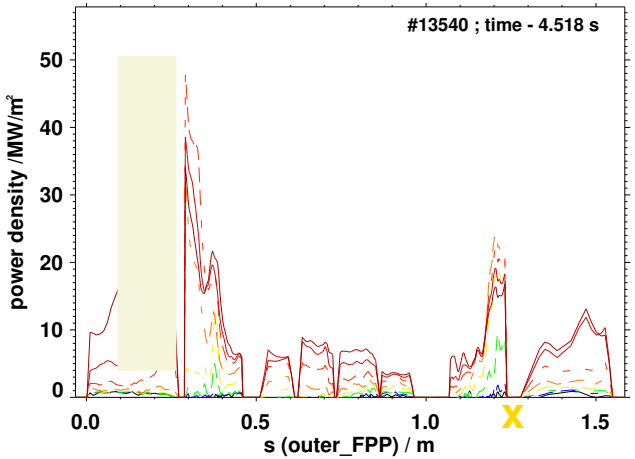


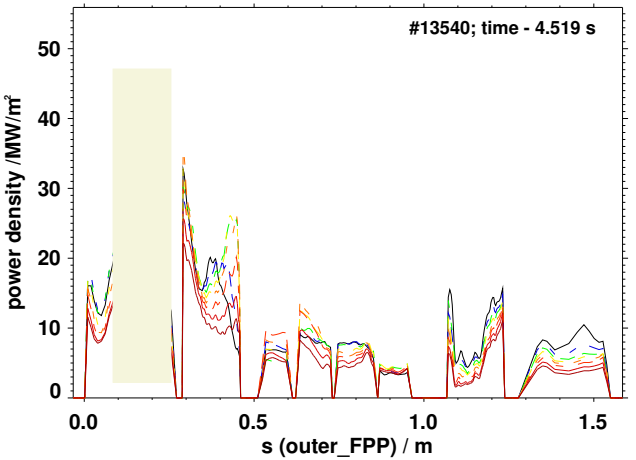



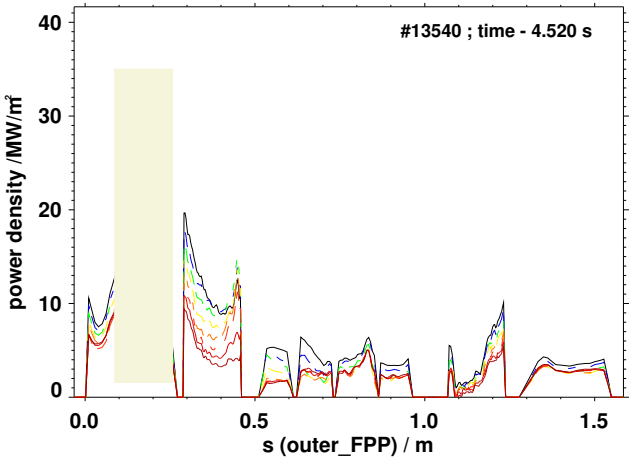
# time evolution of power load

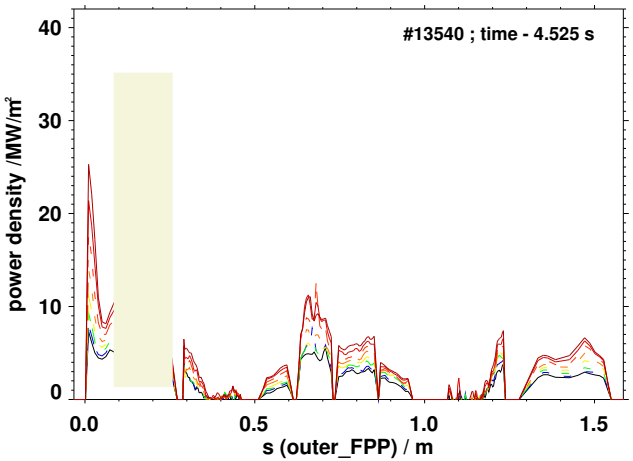
**s-coordinate along target**

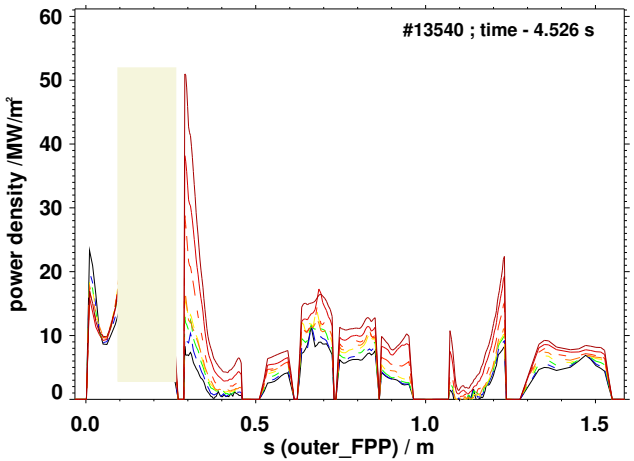


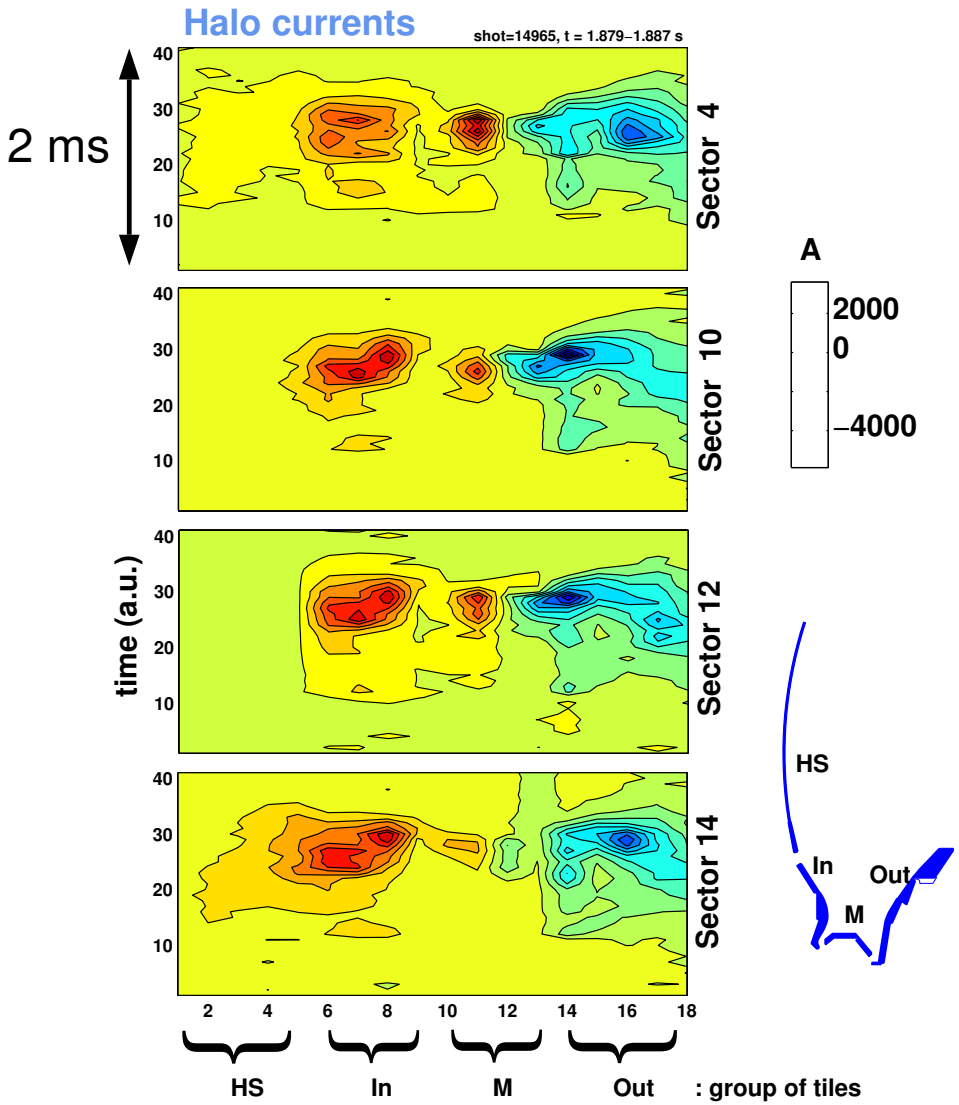



# halo currents distribution

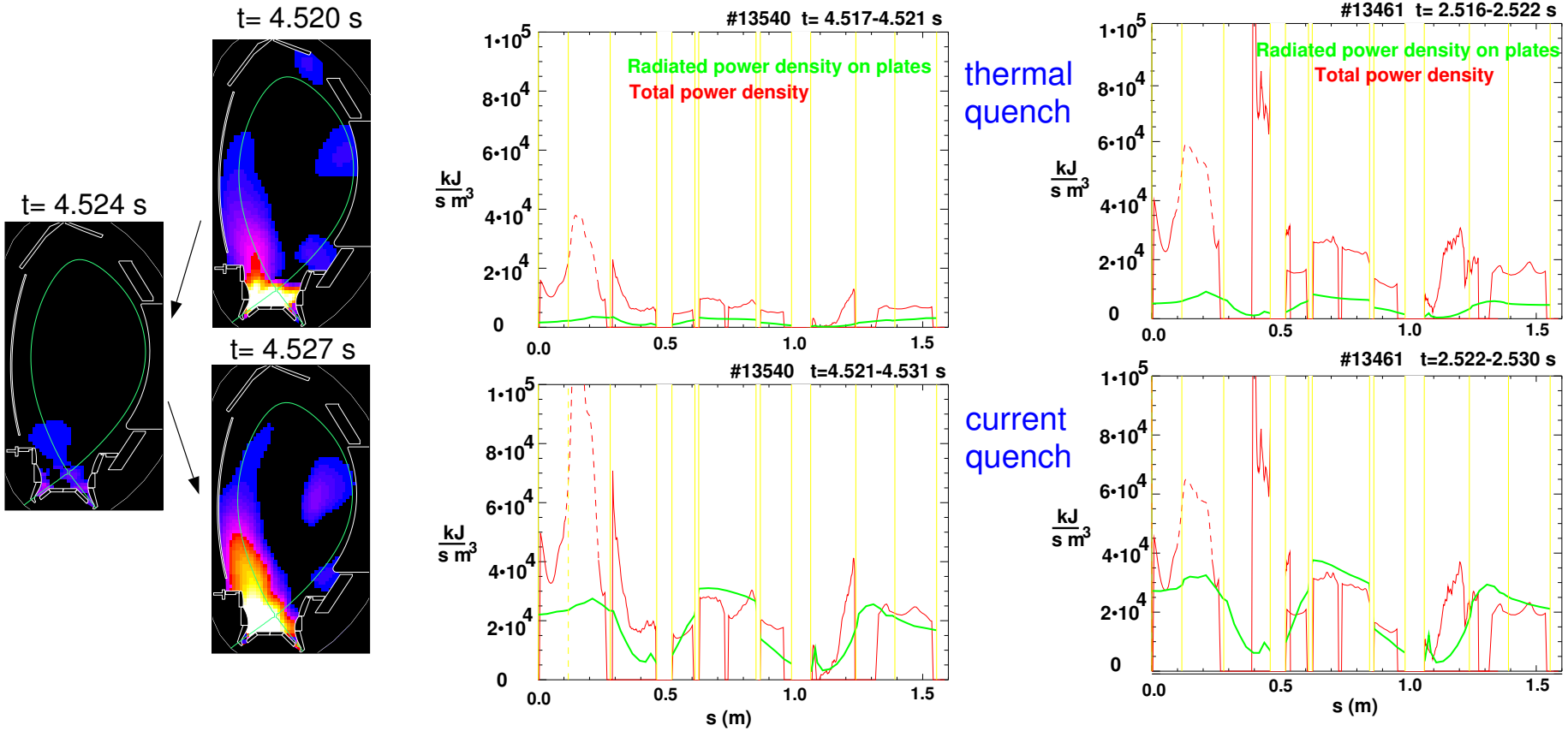



◊ moderate currents flow outside divertor

◊ quite symmetric in toroidal direction on time scales > 1 ms

◊ toroidal asymmetries by factor 4 observed on very short time scales (0.2 ms)

# most of the disruption power is radiated in divertor region

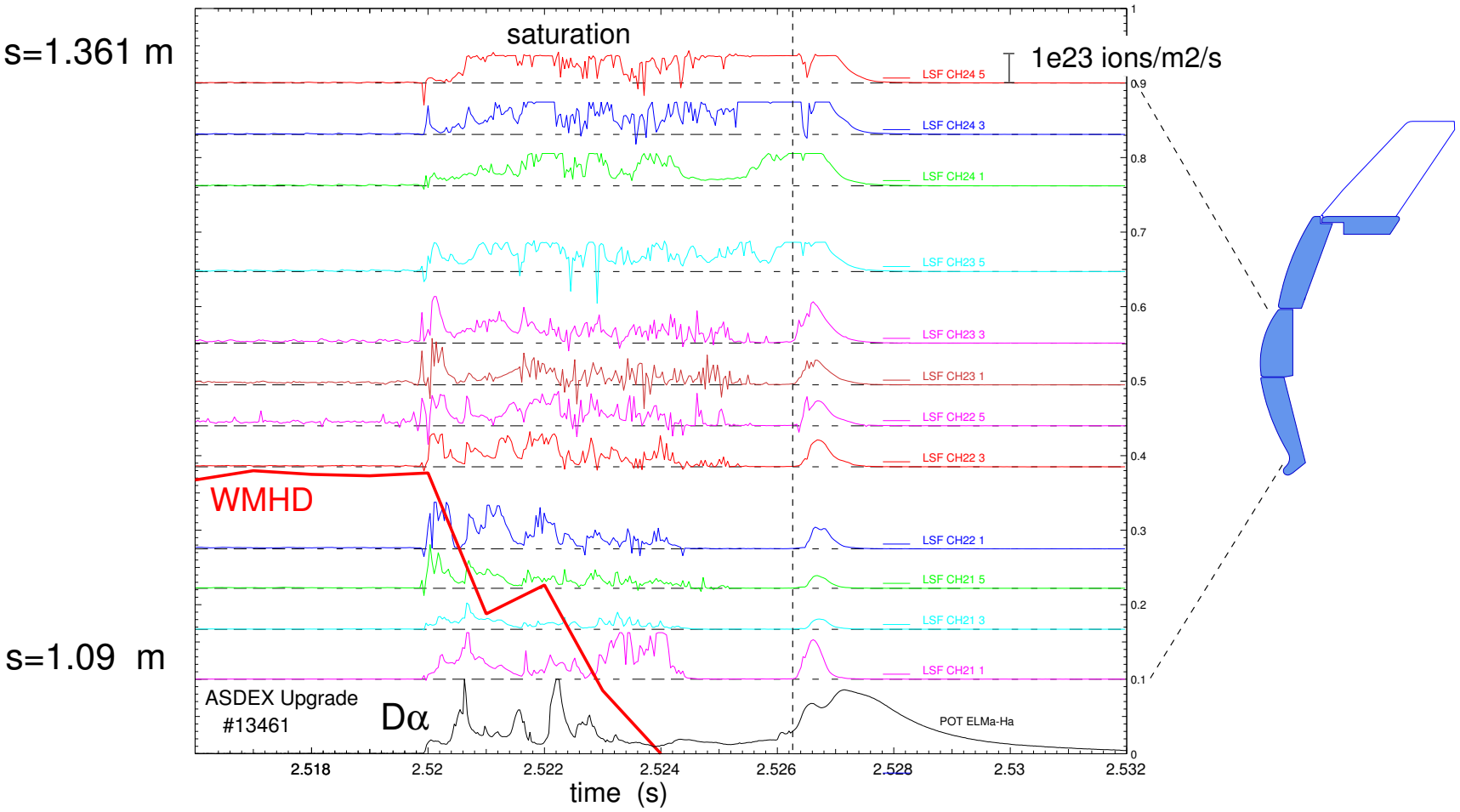



❒ **Most of the energy deposited on the divertor plates during thermal quench is conducted/convected.**

❒ **Most of the energy deposited on the divertor plates during current quench is radiated.**

# Langmuir probes measure strong ion flux during current quench

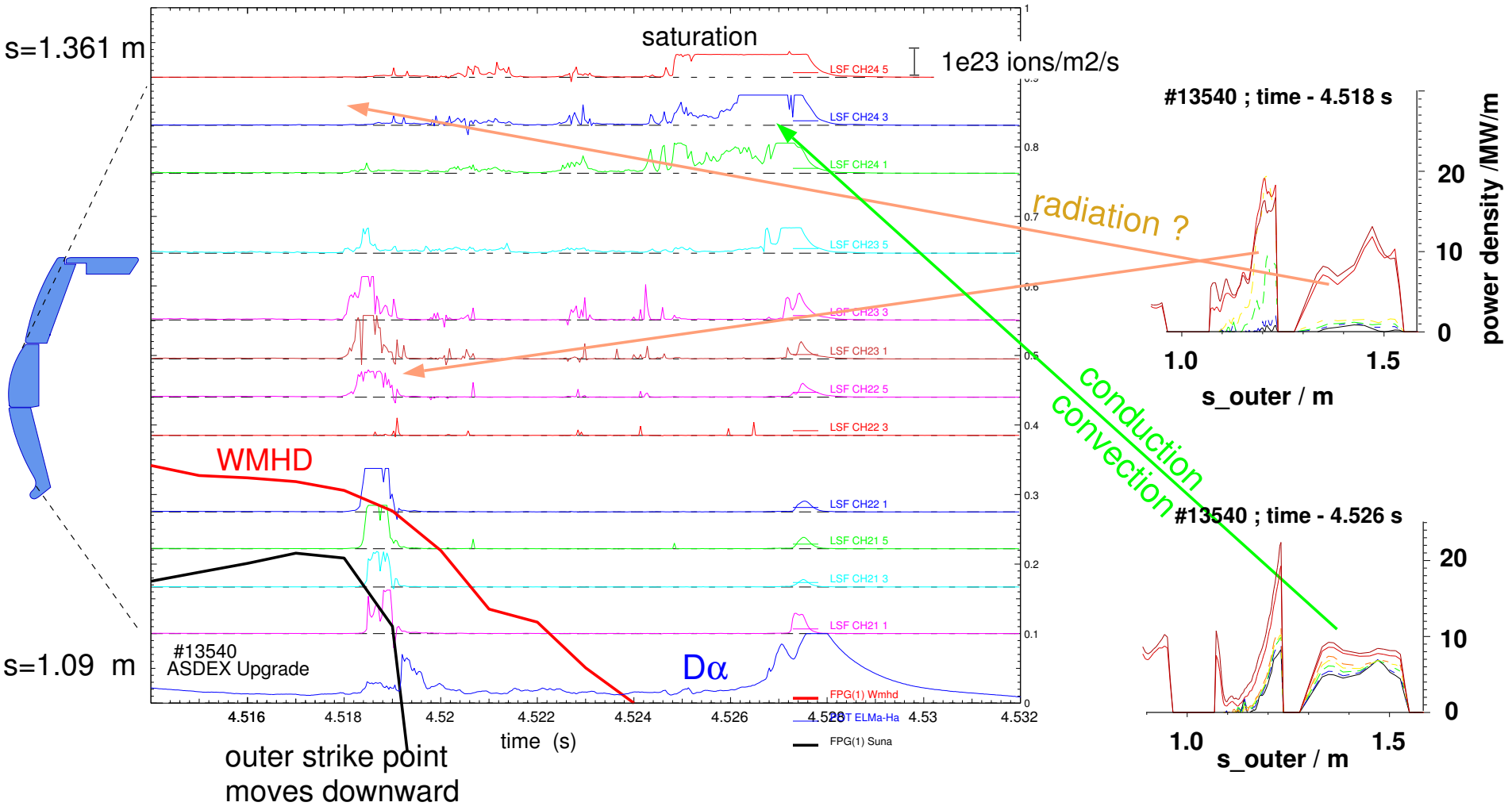
- largest ion fluxes on top end of divertor
- quiet phase in lower part of divertor between thermal and final quench
- strong ion fluxes during current quench suggest convective/conductive load



# comparison of Isat and thermography during energy and current quench

◊ absence of ion flux in upper div suggests dominant radiation there during this phase
- clear correlation of ion flux and power footprint in lower part

◊ strong ion fluxes in upper part during currrent quench - not all radiative load



# Conclusions on disruptions in ASDEX Upgrade divertors II + II-b

- the time history of the power deposition on the lower divertor plate may change from shot to shot
- the thermal quench phase lasts 2-3 ms
- the power profile is broad and extends outside of the divertor plates
- the energy balance is consistent within the uncertainties
- an amount of energy equivalent and larger than the thermal energy of the pre-disruptive plasma is found on the divertor during the thermal quench. this energy is mostly deposited by convection and conduction
- up to 45% of the total energy of the plasma is found on the divertor plates most of it is deposited as radiation
- the divertor plates are rather uniformey loaded with power (on a time scale $\geq$ 4 ms).