U.S. DEPARTMENT OF ENERGY | Office of Science

NSTX-U

Observation of divertor peak heat flux reduction with edge oscillation during the inter-ELM and ELM-free phase in NSTX

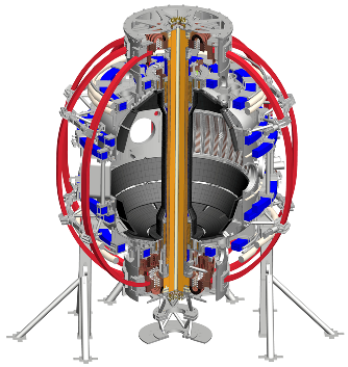
K.F. Gan[1], J-W. Ahn[2], T.K. Gray[2], R. Maingi[3], S.J. Zweben[3], E.D. Fredrickson[3], V.A. Soukhanovskii[4], B.D.Wirth[1]

[1]UTK, [2]ORNL, [3]PPPL, [4]LLNL

18th International Spherical Torus Workshop
Princeton University, USA
Nov 3 – 6, 2015

THE UNIVERSITY OF TENNESSEE KNOXVILLE

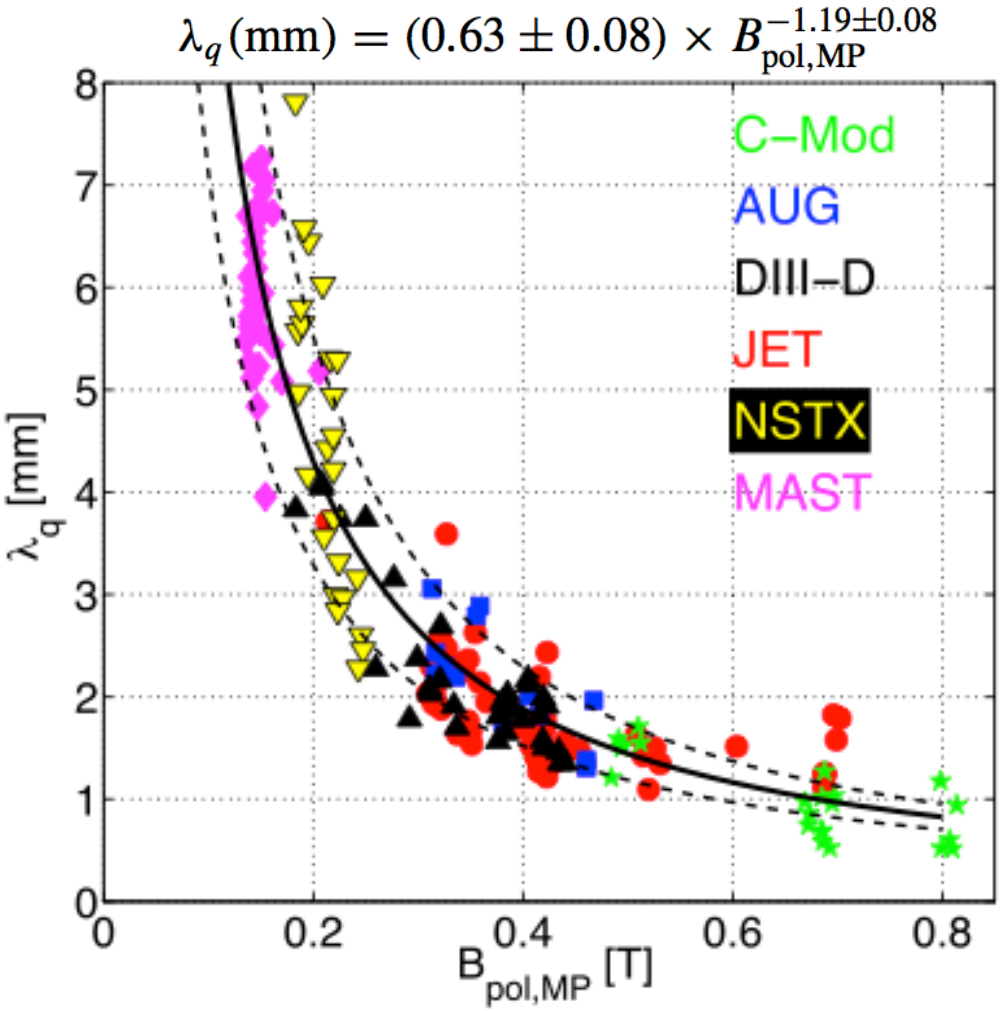
PPPL



Outlines

- Background and diagnostics
- Experiments observation for reduced peak heat flux during ELM-free phase
- Edge oscillation during inter-Type I ELM
- Summary and question

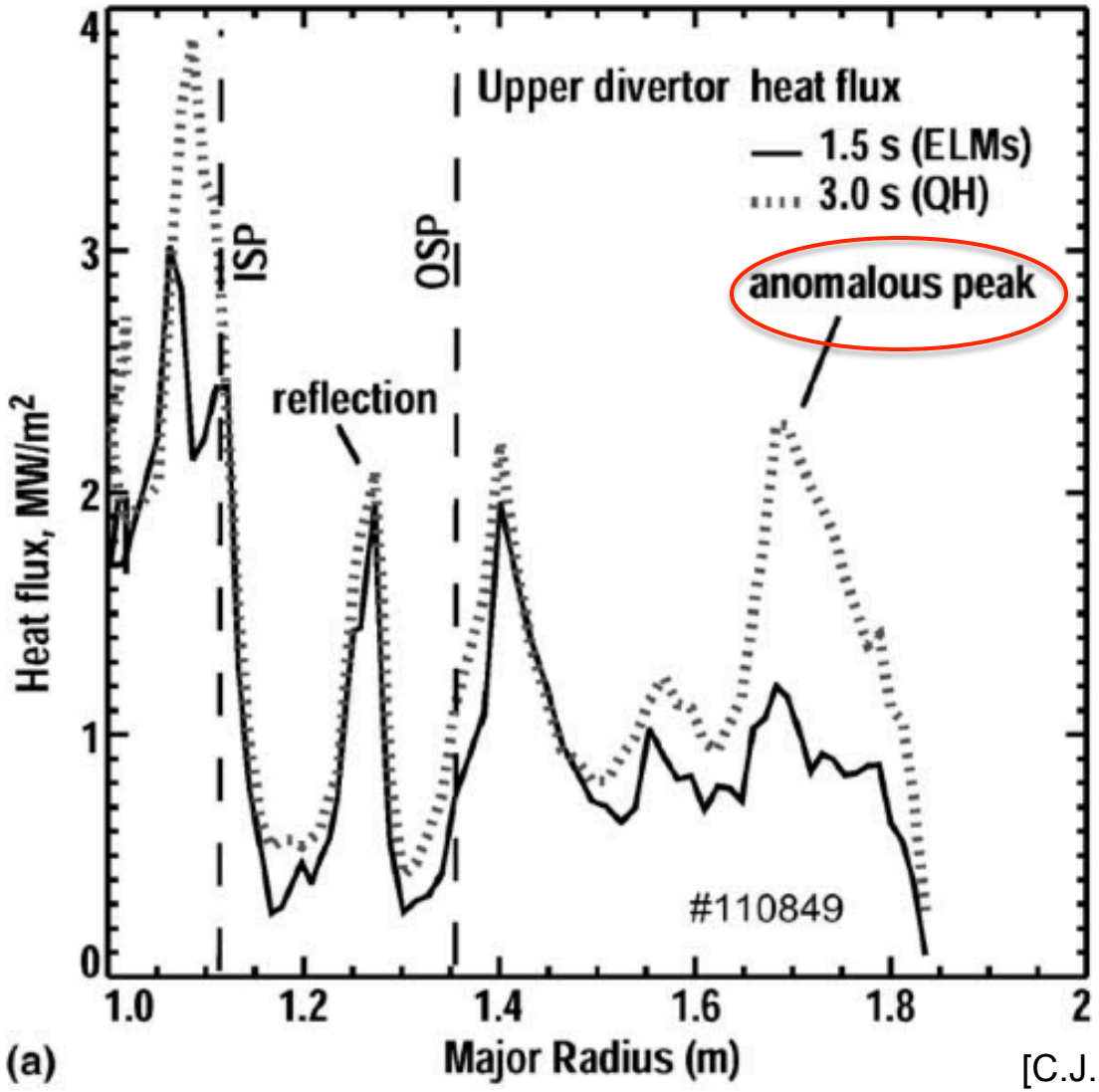
SOL H-modes power width research



[T.Eich, 2013NF]

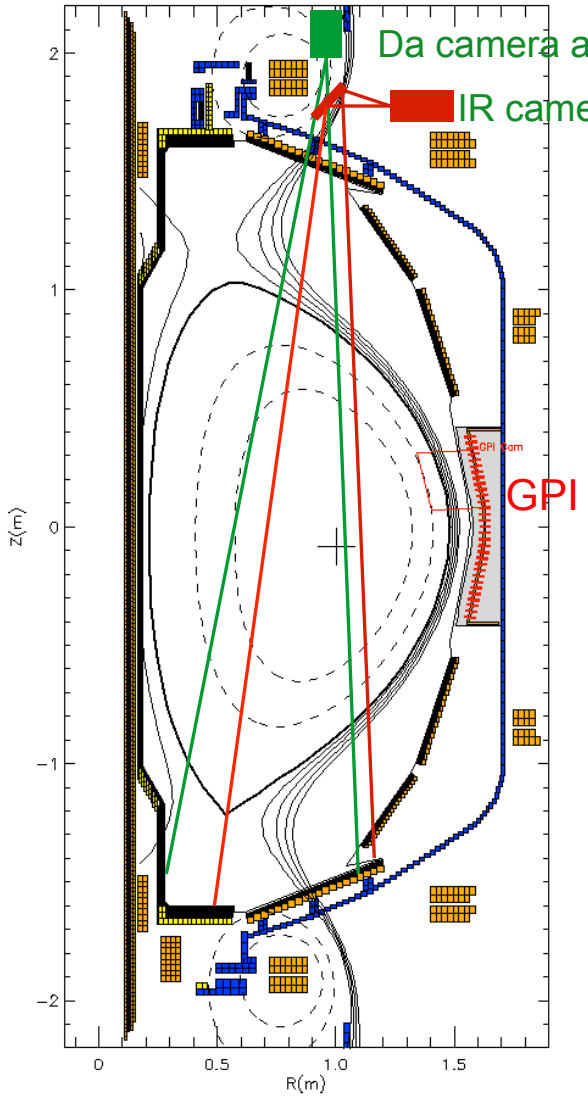
Recent research indicates that the midplane Scrape-off Layer (SOL) power fall-off length (λq) for ITER is expected to be very narrow, ~1mm .

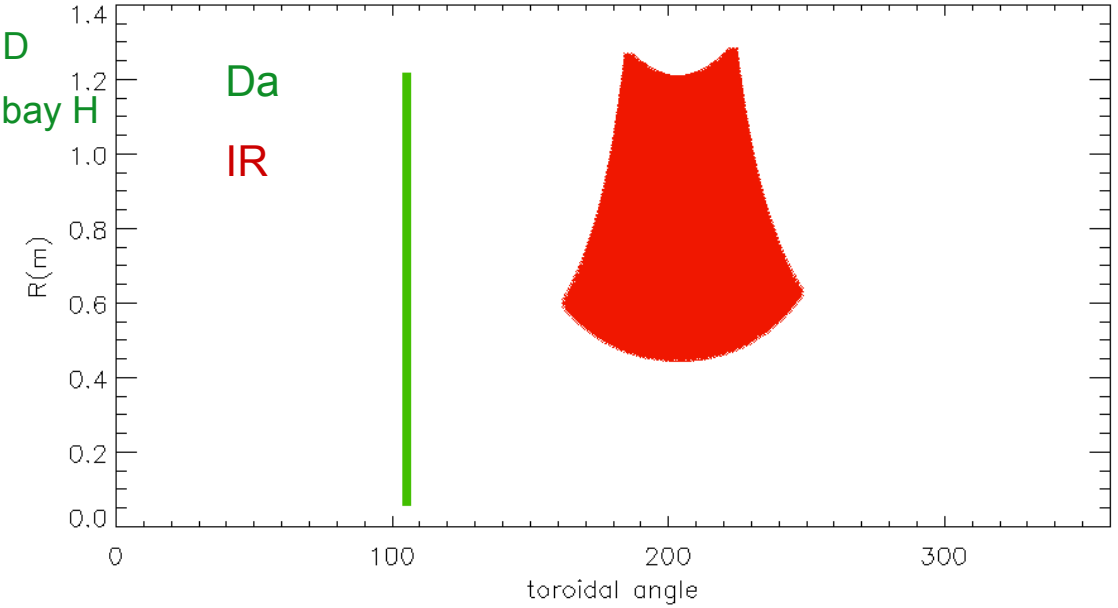
Divertor heat flux during QH modes on DIII-D



[C.J. Lasnier, 2003JNM]

Divertor heat flux, Da and GPI measurement in NSTX





Divertor heat flux measurement (J-W. Ahn, RSI, 2010)

- Frame speed: 1.6(128x128)-6.3(96x32) khz
- spatial resolution: 5-7mm
- 2D heat flux calculation (TACO)

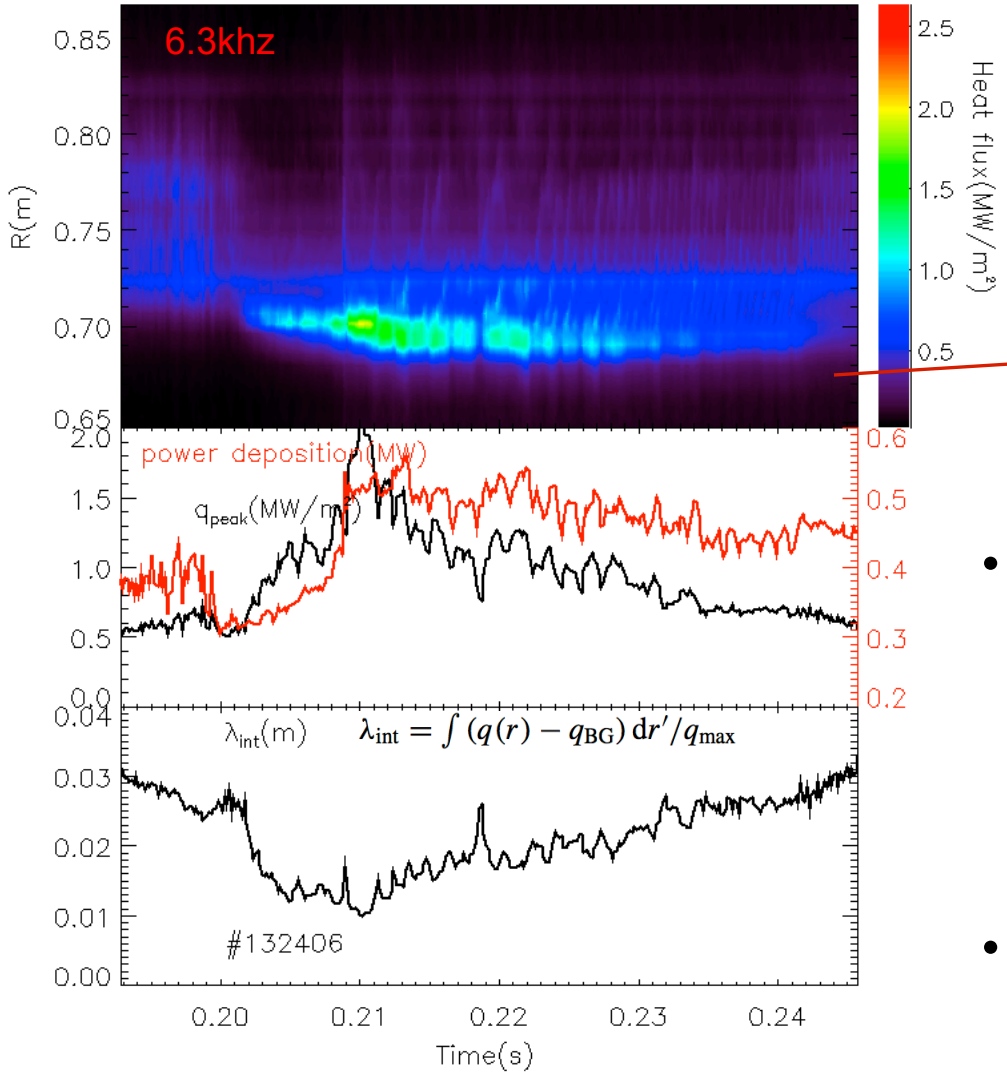
Divertor Da measurement (V.A. Soukhanovskii,2003RSI)

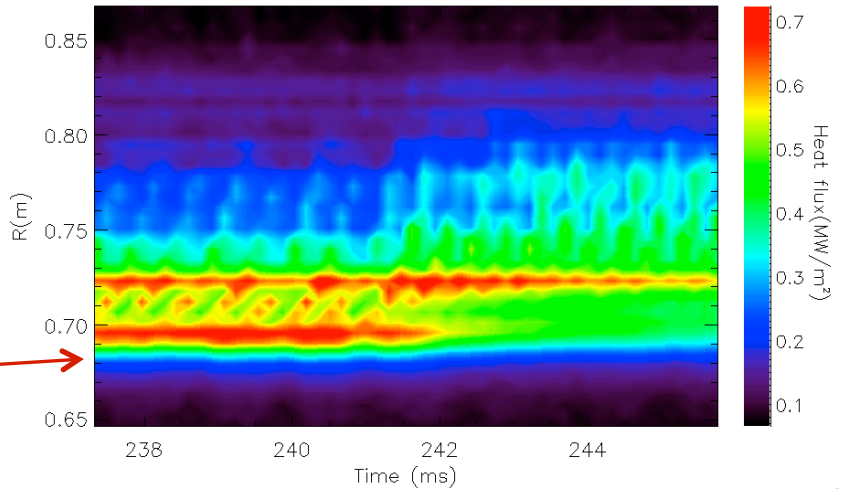
- 2048 channels, 4khz

GPI measurement (S.J. Zweben, 2004RSI)

- 64*64 pixel, 8 or 9 μs for time resolution

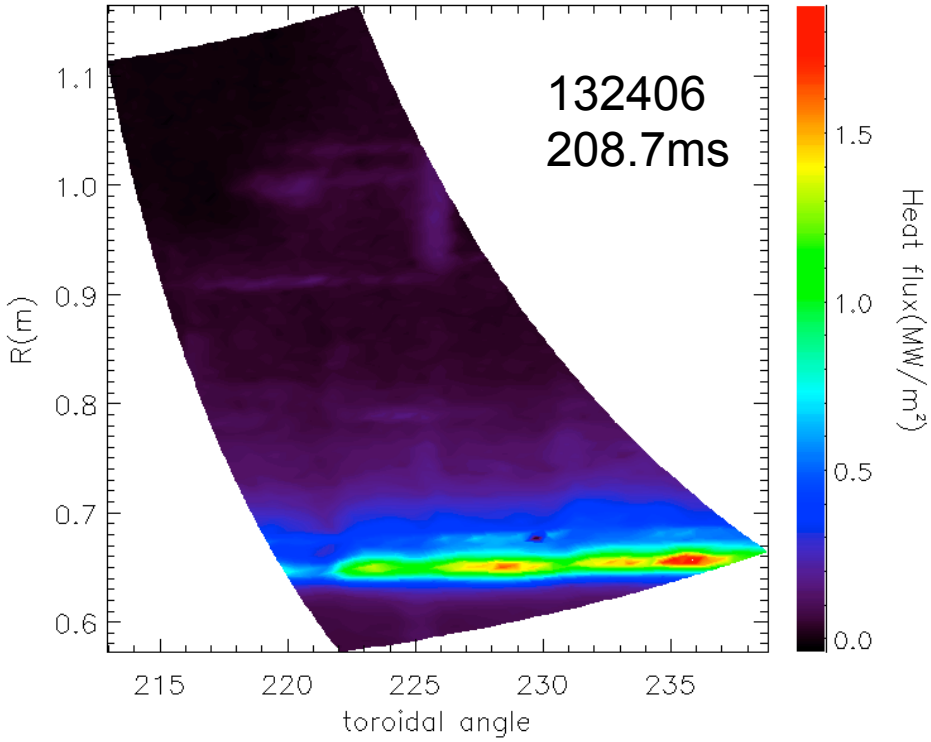
Deceased peak heat flux during inter-ELM

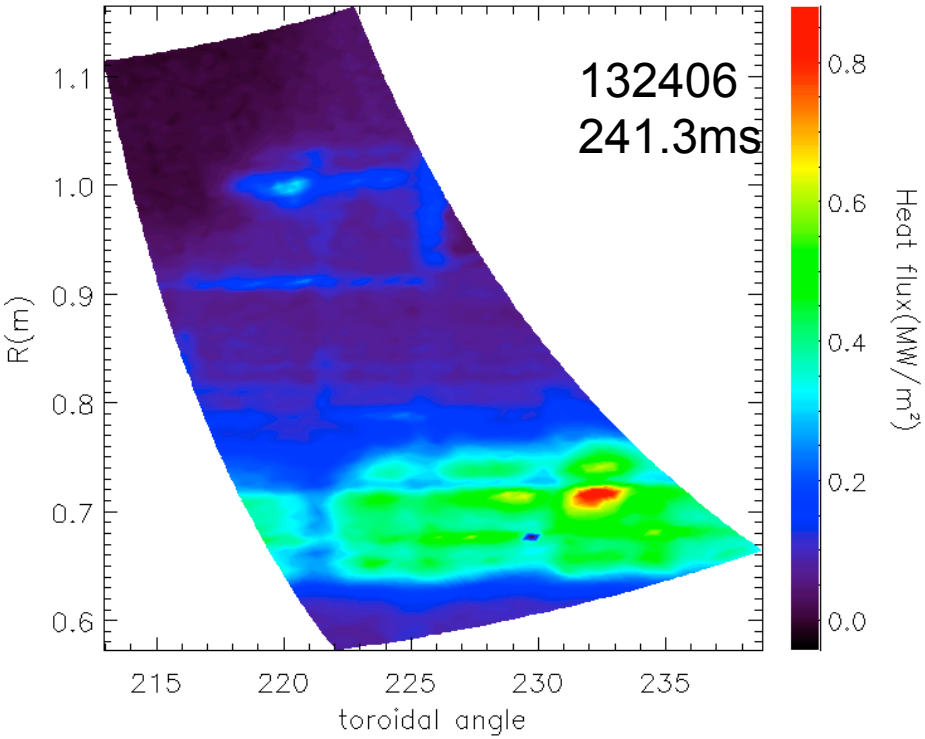




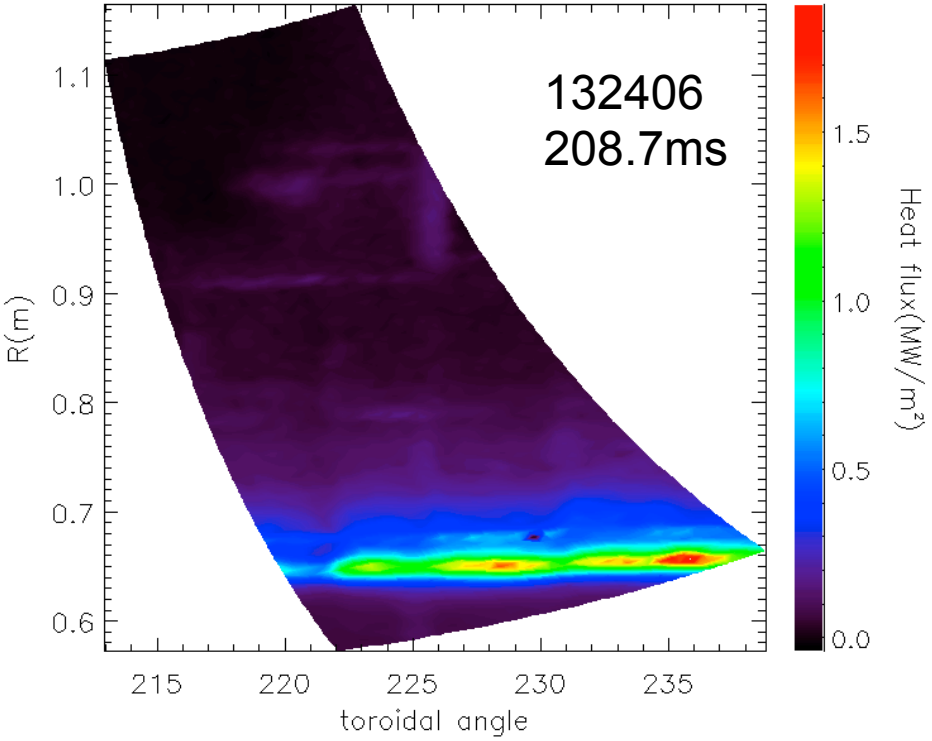
- Divertor heat flux decreased gradually during ELM-free with little change on power deposition (from 2MW/m^2 to 0.6MW/m^2).
- λ_{int} increase from 1cm to 3cm during ELM-free

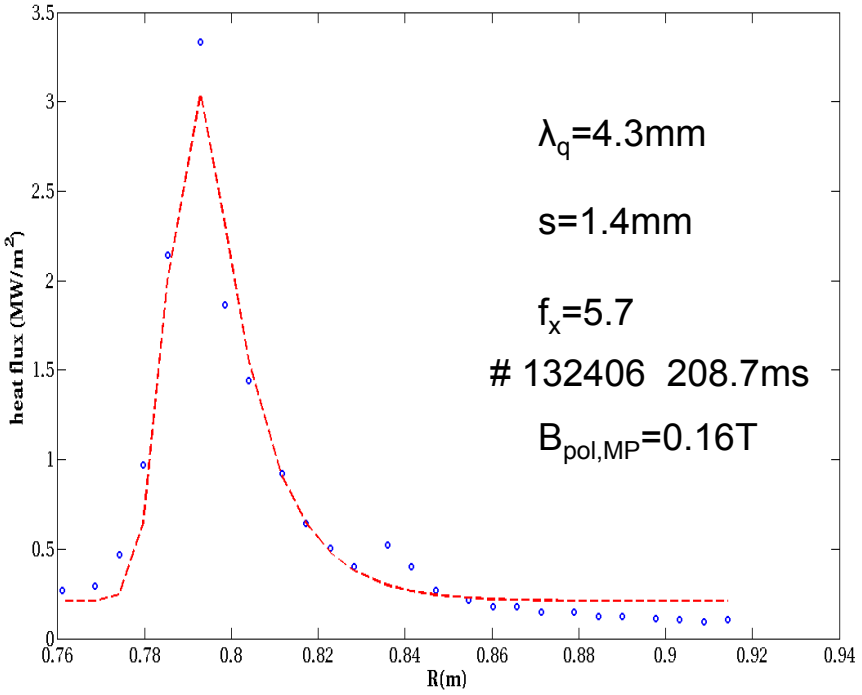
2D heat flux distribution





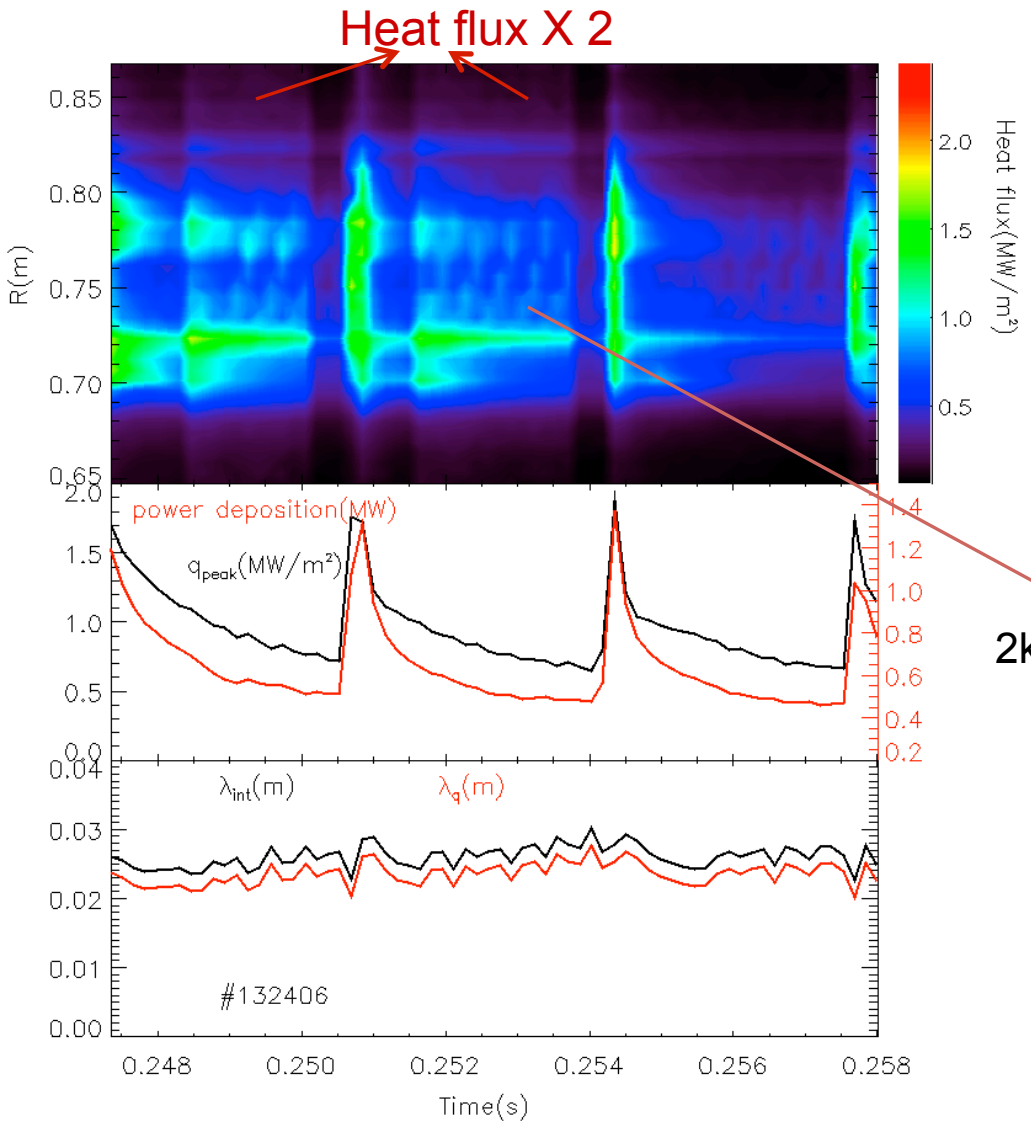
Eich fit for λ_q during inter-ELM





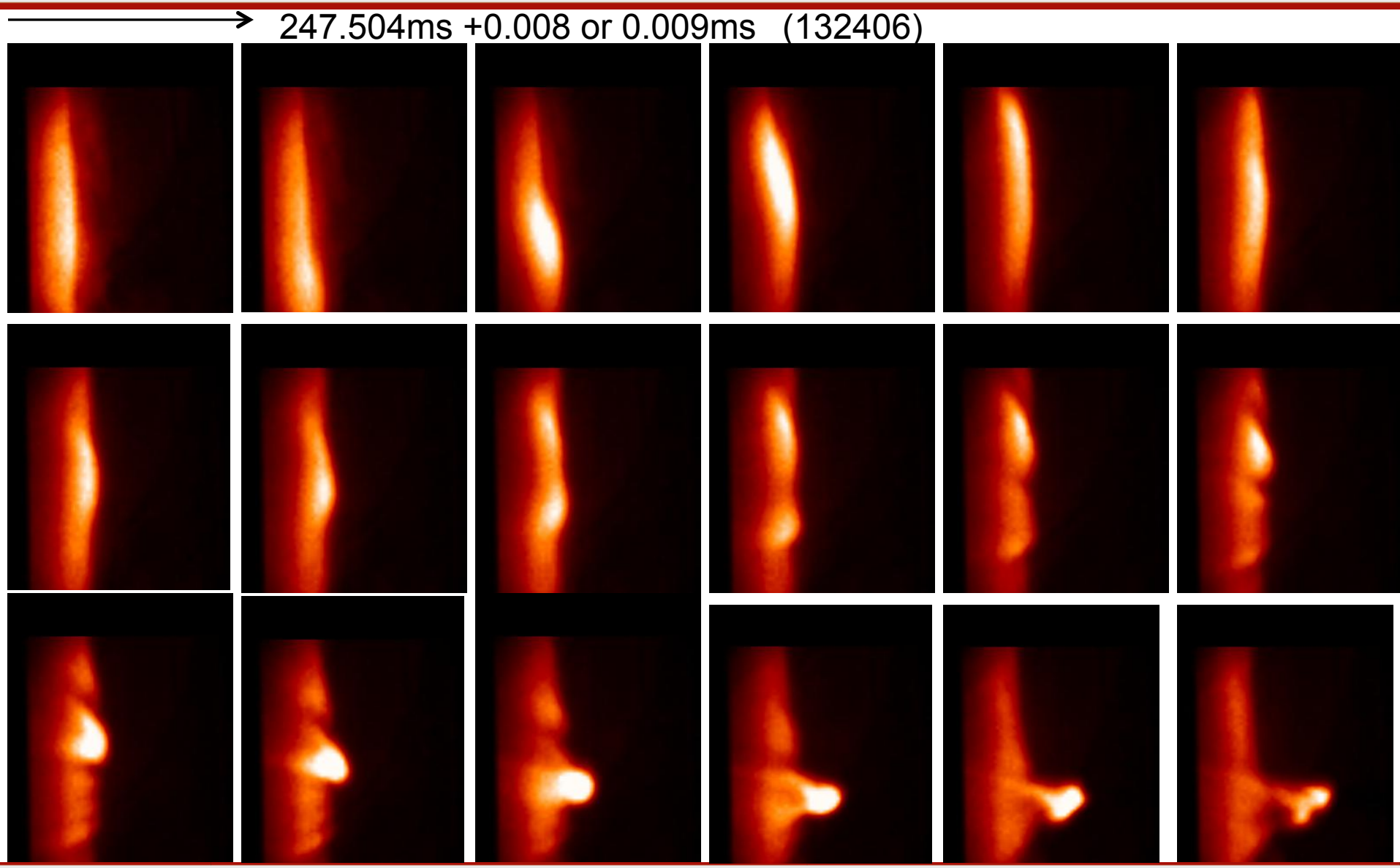
At the initial of the ELM-free phase, the heat flux deposition is narrow, the calculated λ_q is consistent with the current prediction.

Divertor heat flux evolution during inter type-III ELMs

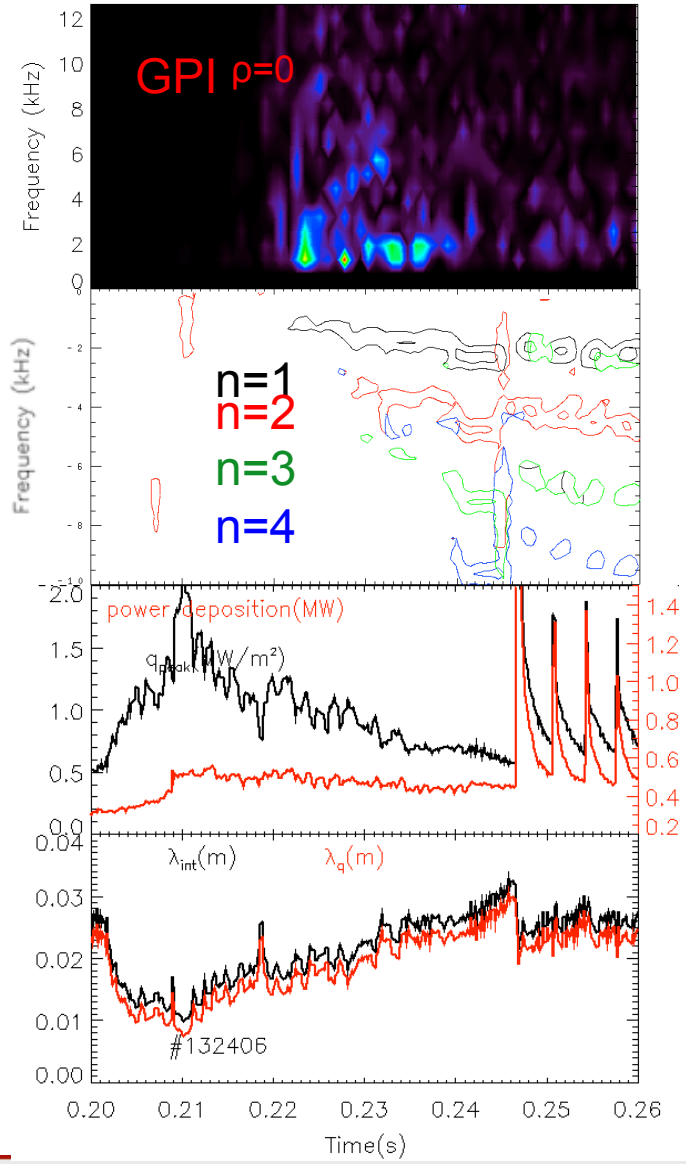


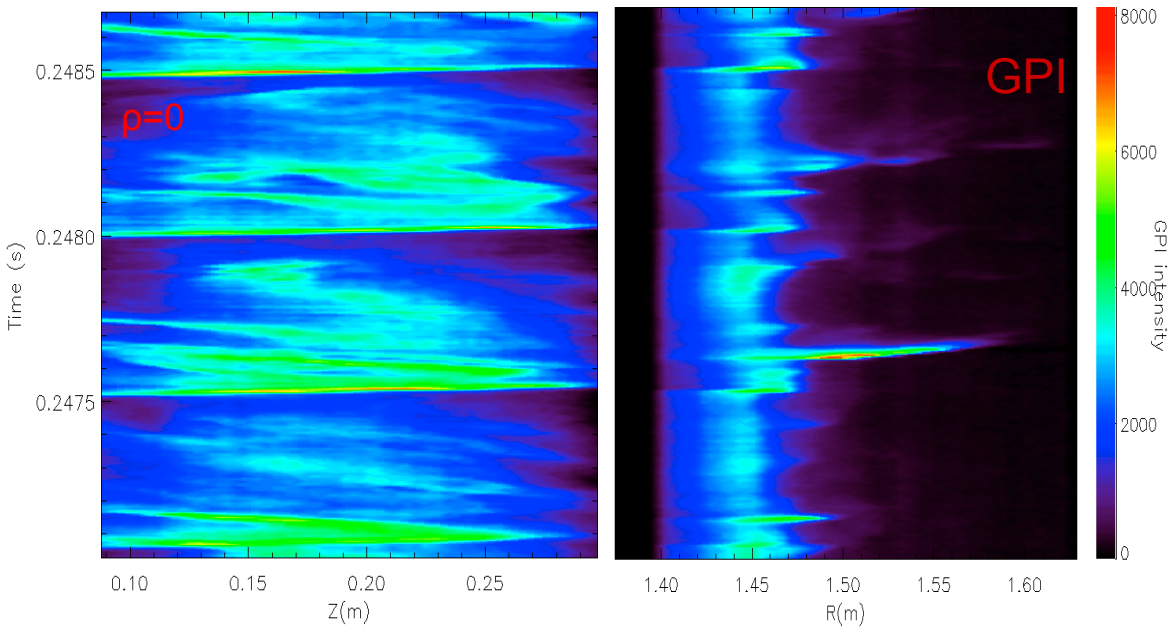
2khz filamentary heat flux

Observation of edge oscillation from GPI



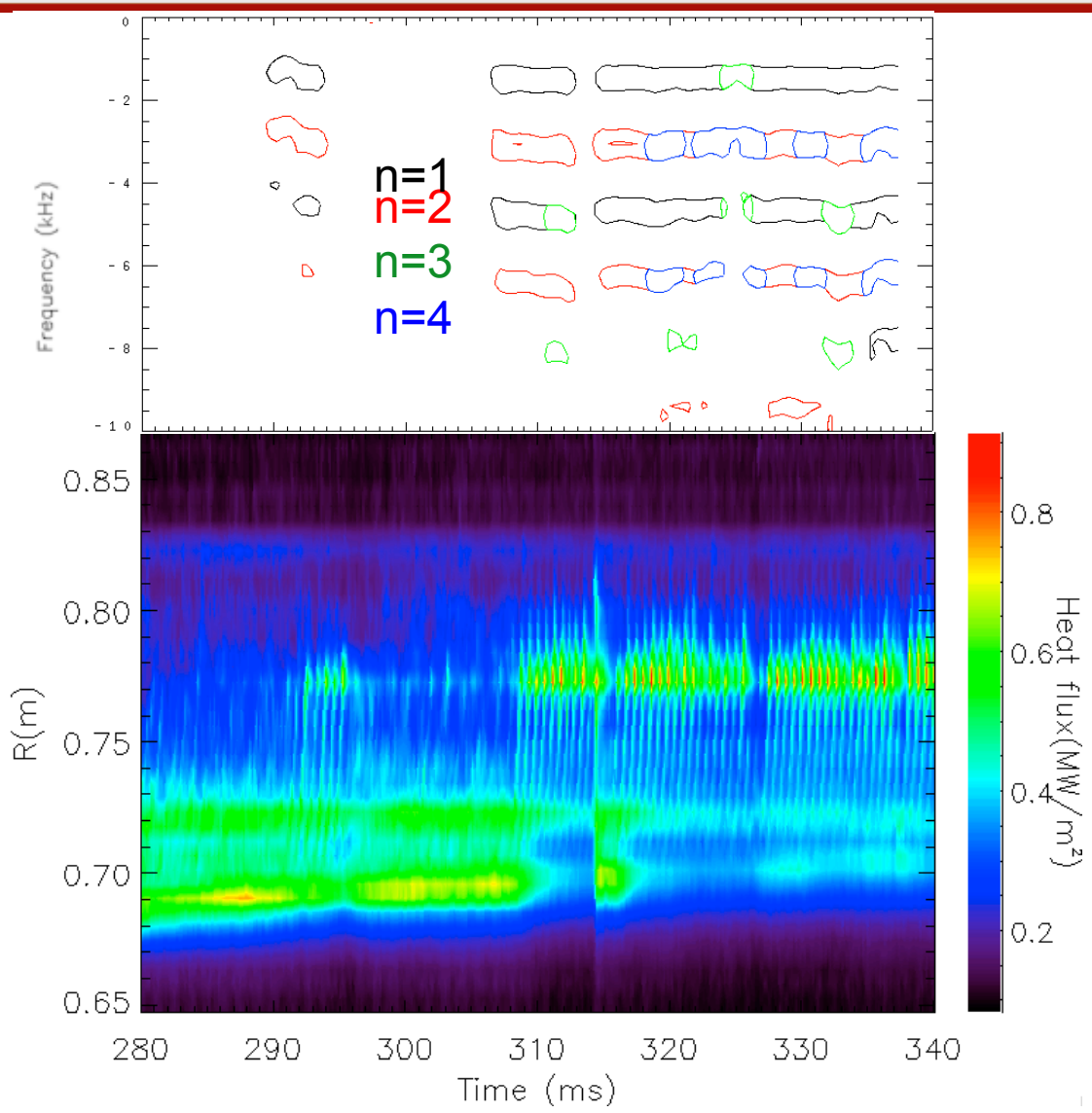
EHO induced the 2khz edge and divertor heat flux oscillation?



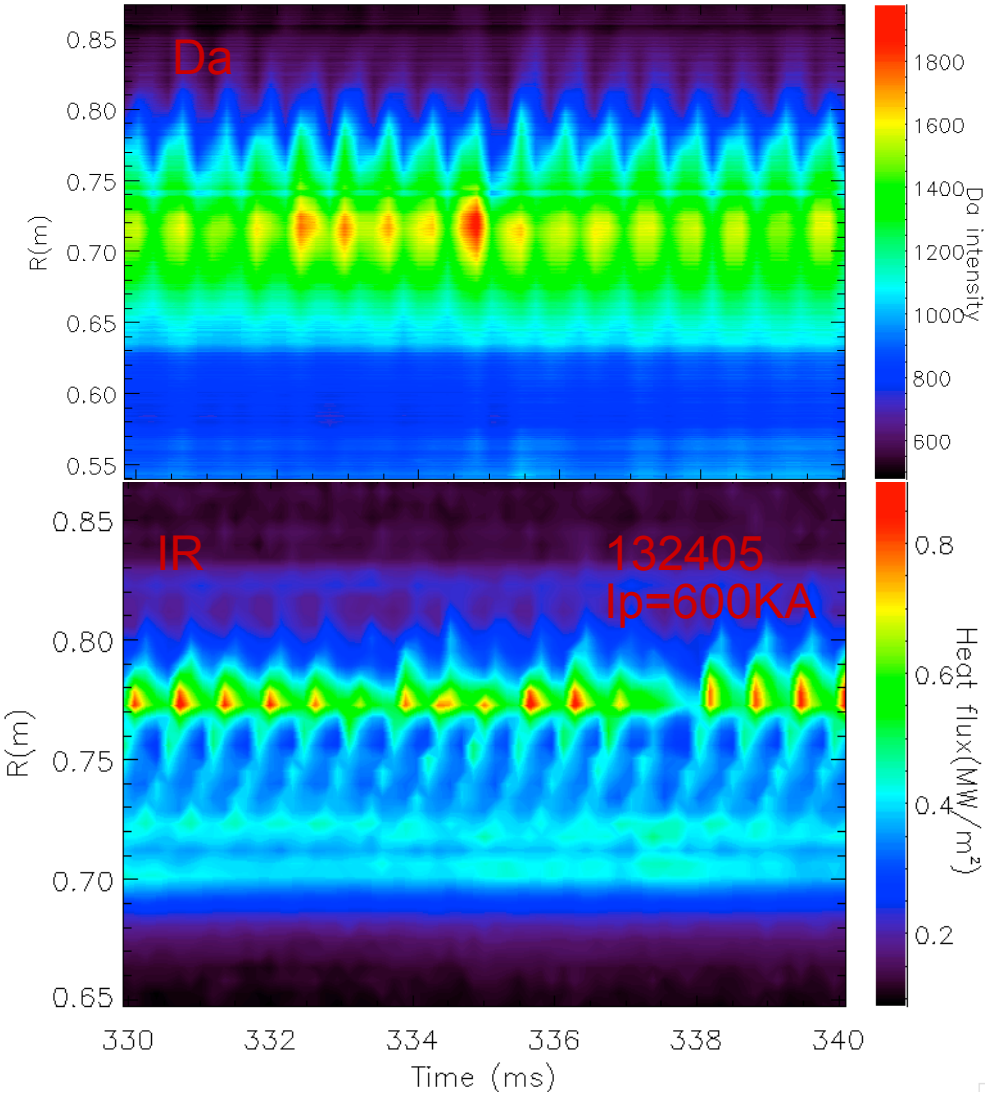


- The reduced peak heat flux accompanied by EHOs (edge harmonic oscillation)
- The frequency for filamentary divertor heat flux ~2khz is consistent with GPI results and n=1 spectra.
- The GPI movies for single EHOs events is similar as GPI movies during ELM

The time consistent between divertor filamentary structure and n spectra

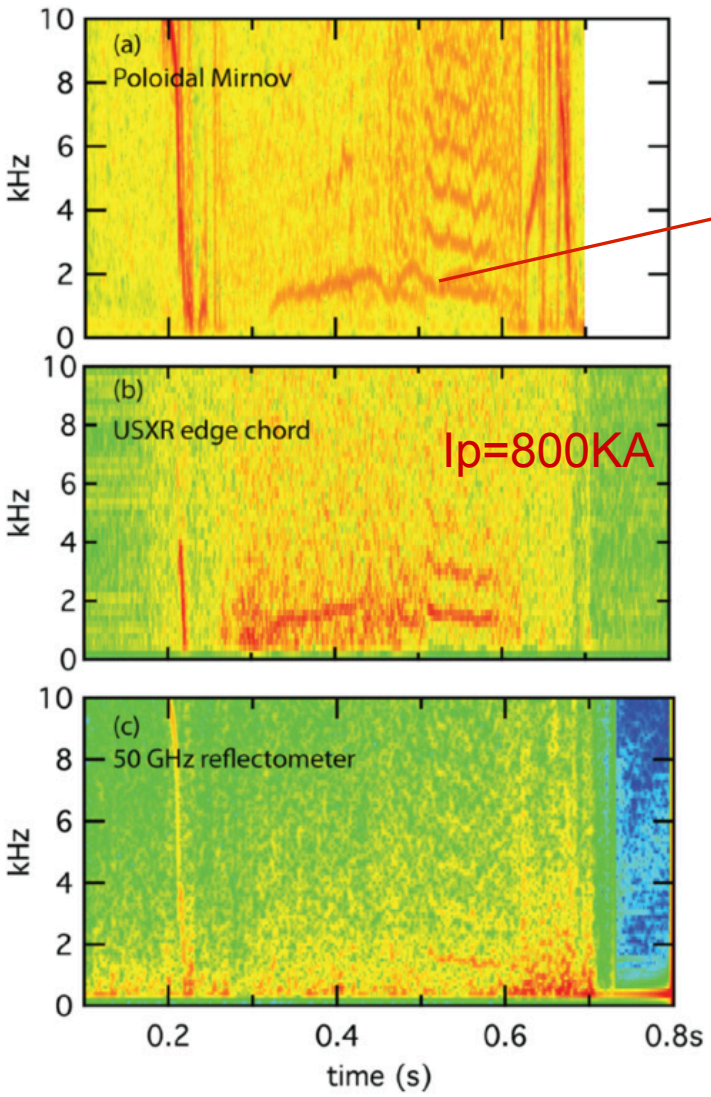


Divertor Da results

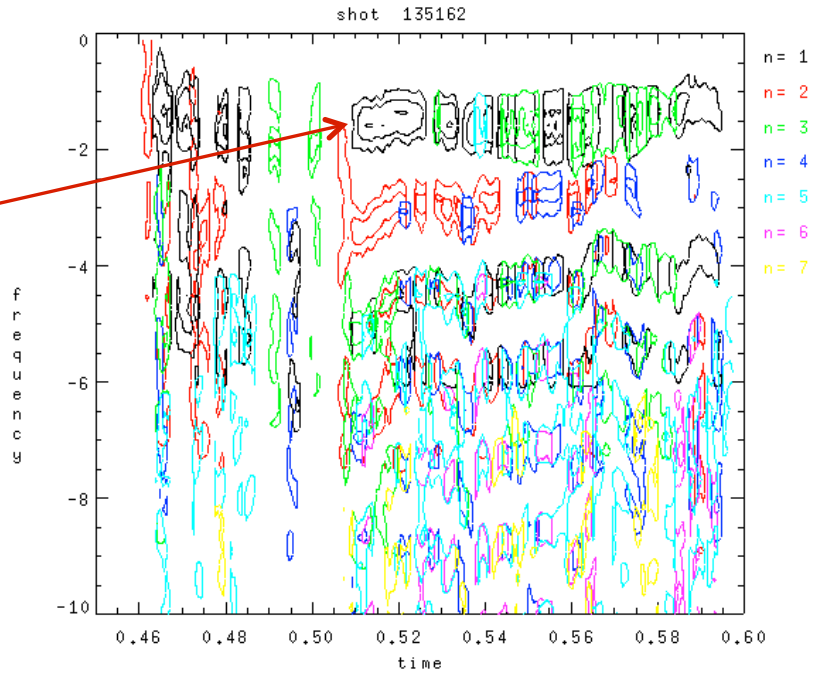


The filamentary structure was not observed by Da camera for 132405.

Small ELM research on NSTX

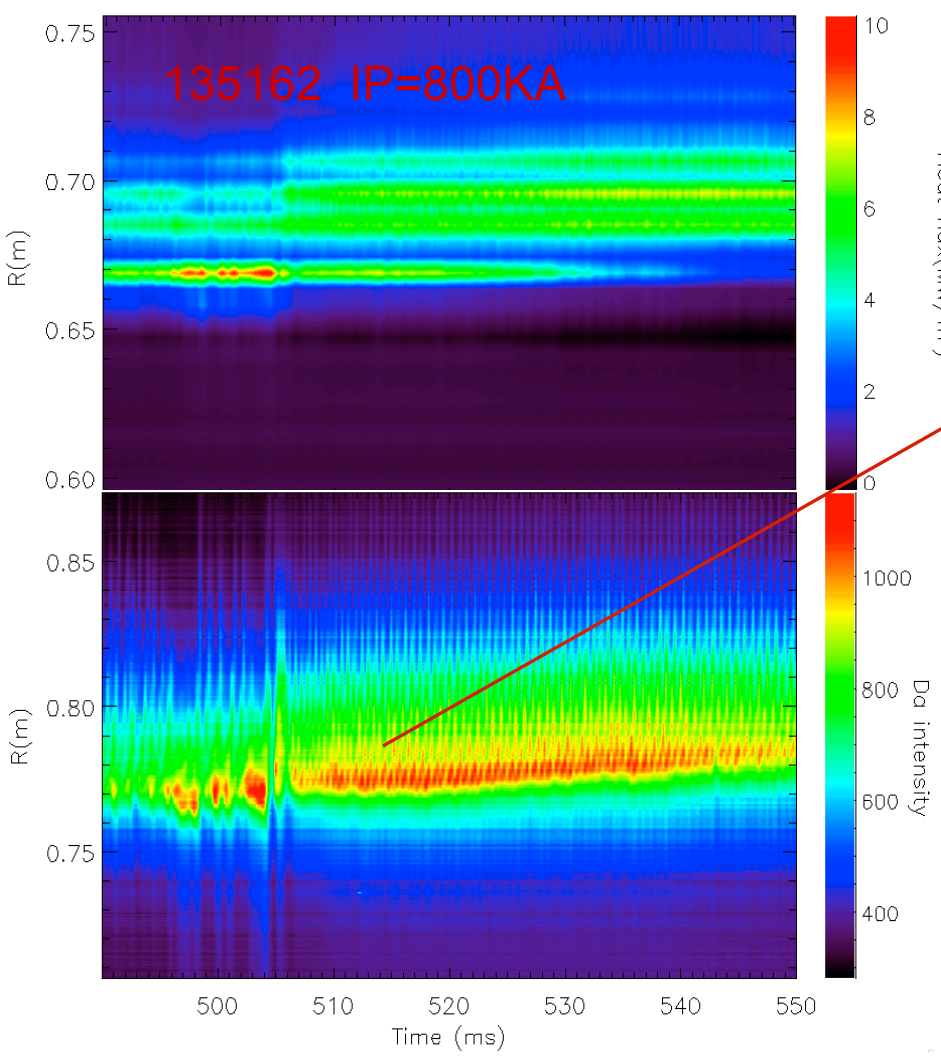


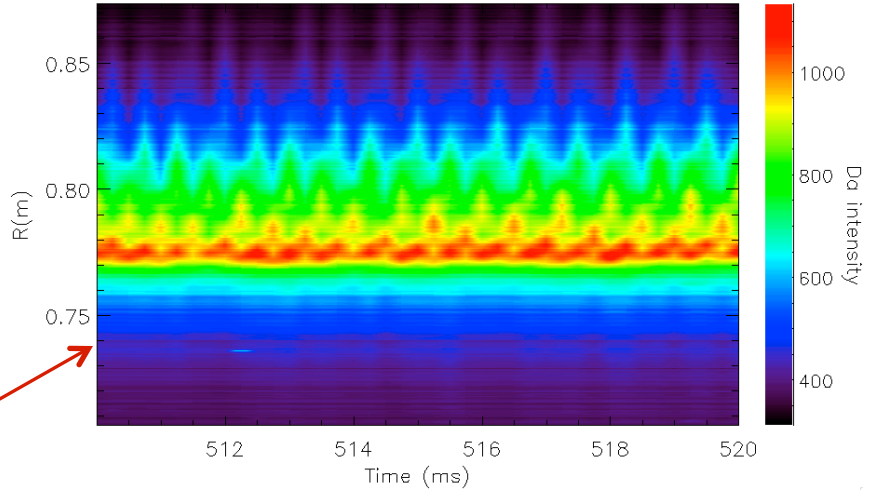
[A.C. Sontag, 2011NF]



EHO appears at 0.51s

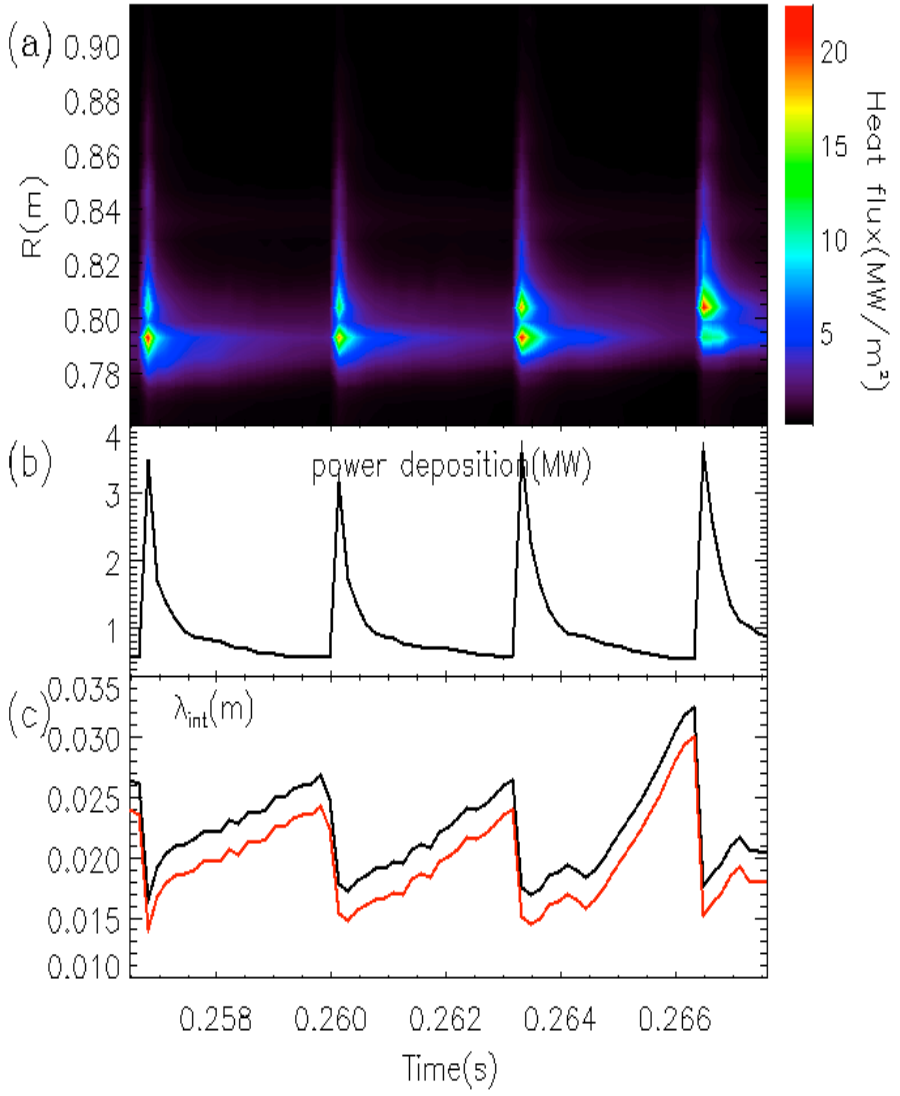
The filamentary structure found by Da measurement





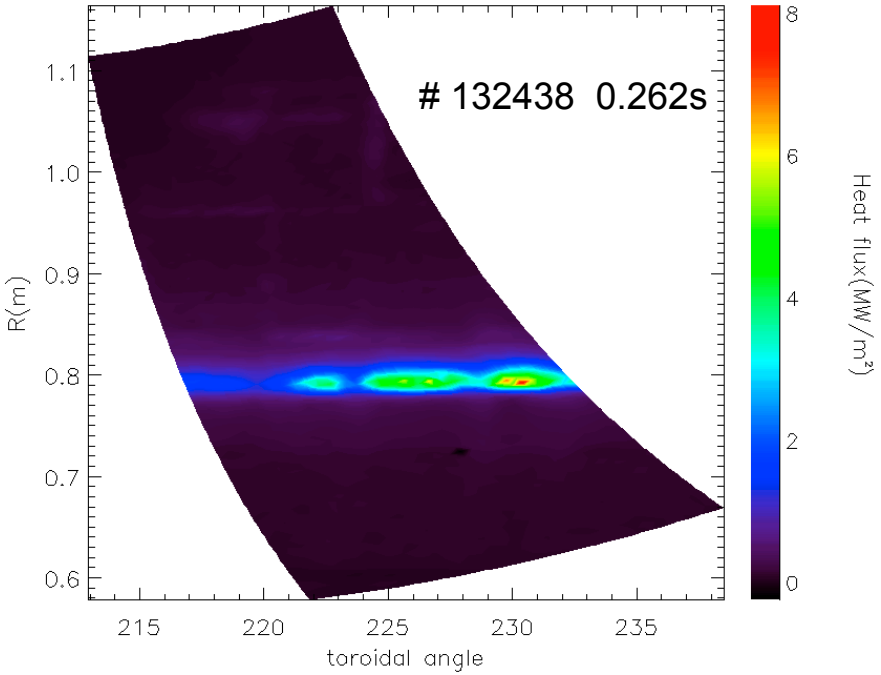
- The filamentary structure appeared on Da measurement.
- The filamentary heat flux structure varies in time; beginning to deposit heat onto the near SOL and then further out to the far SOL at a later time during the cycle.
- These filamentary were not shown in IR measurement.

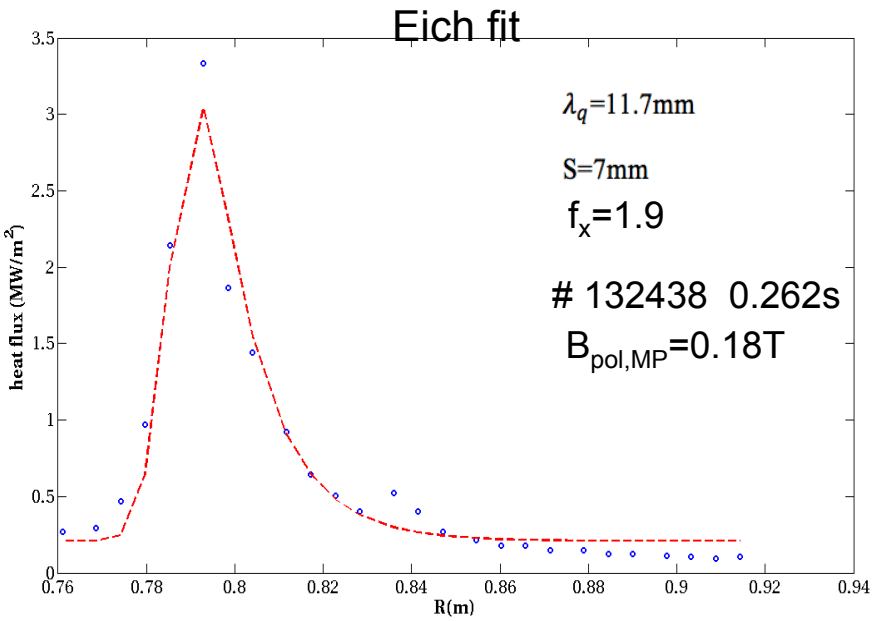
Wide divertor heat flux width during inter type I ELM



λ_{int} decrease during ELM

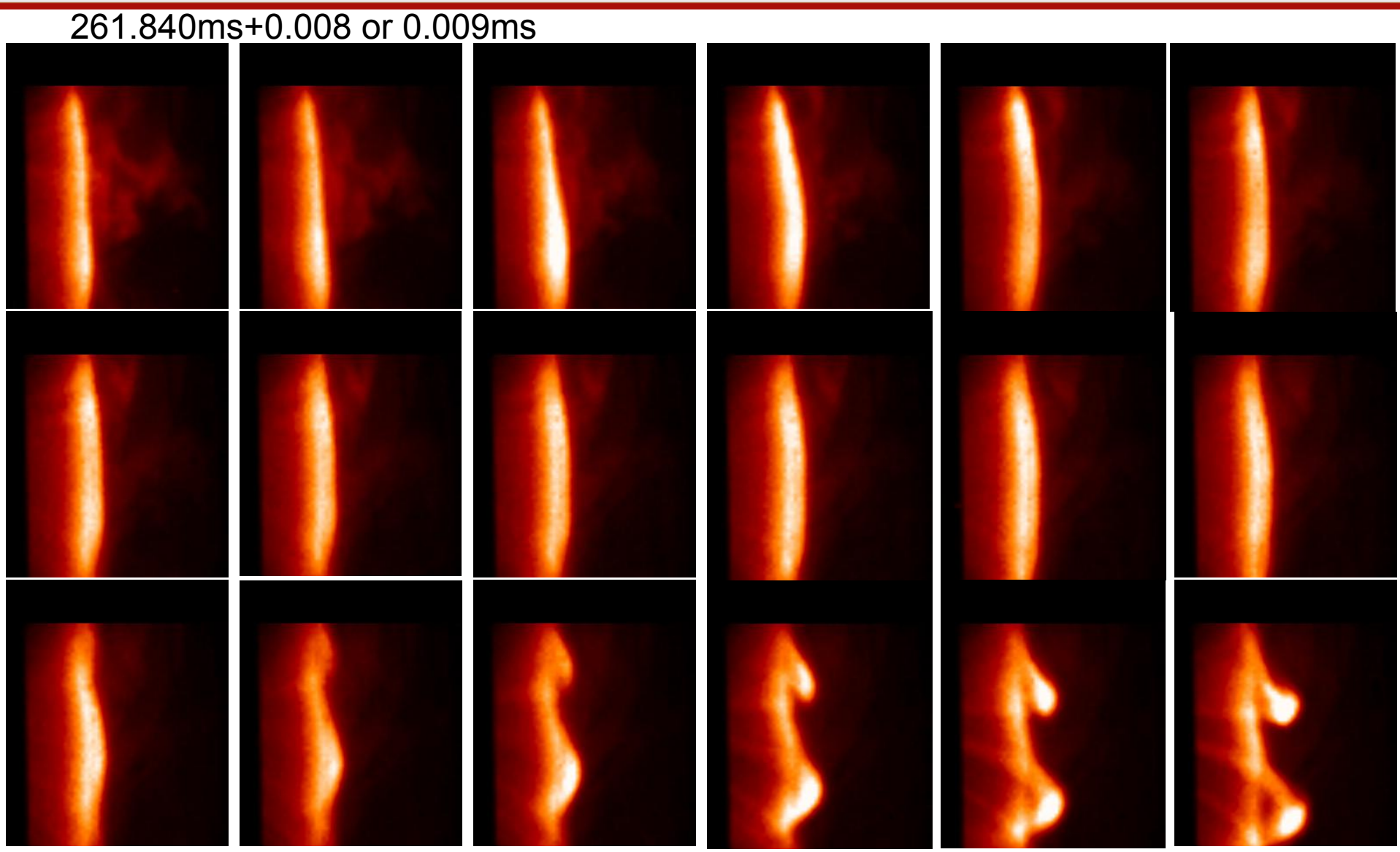
Eich fit for λ_q during inter-ELM



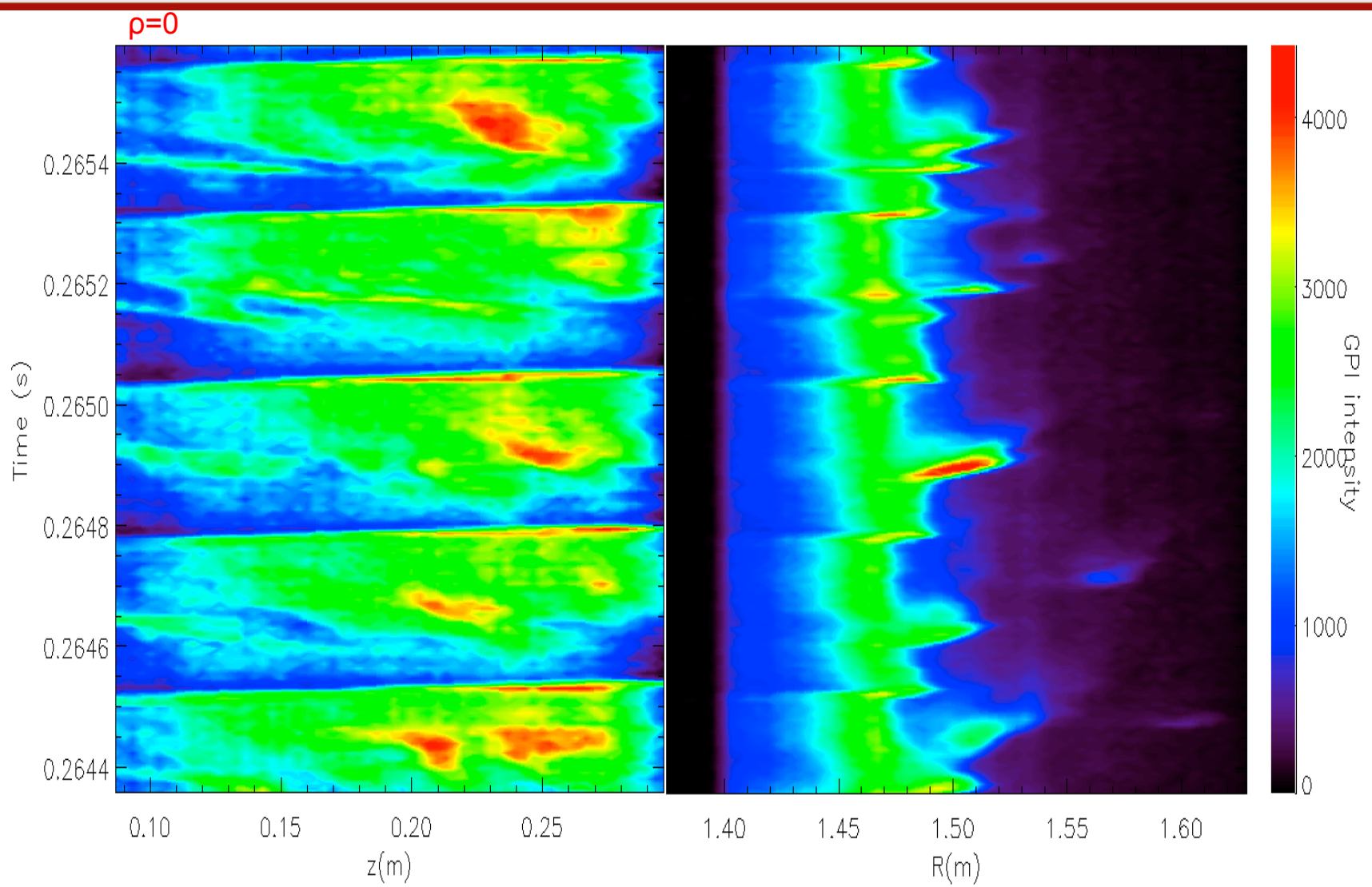


The λ_q =11.7mm is much larger than currents prediction

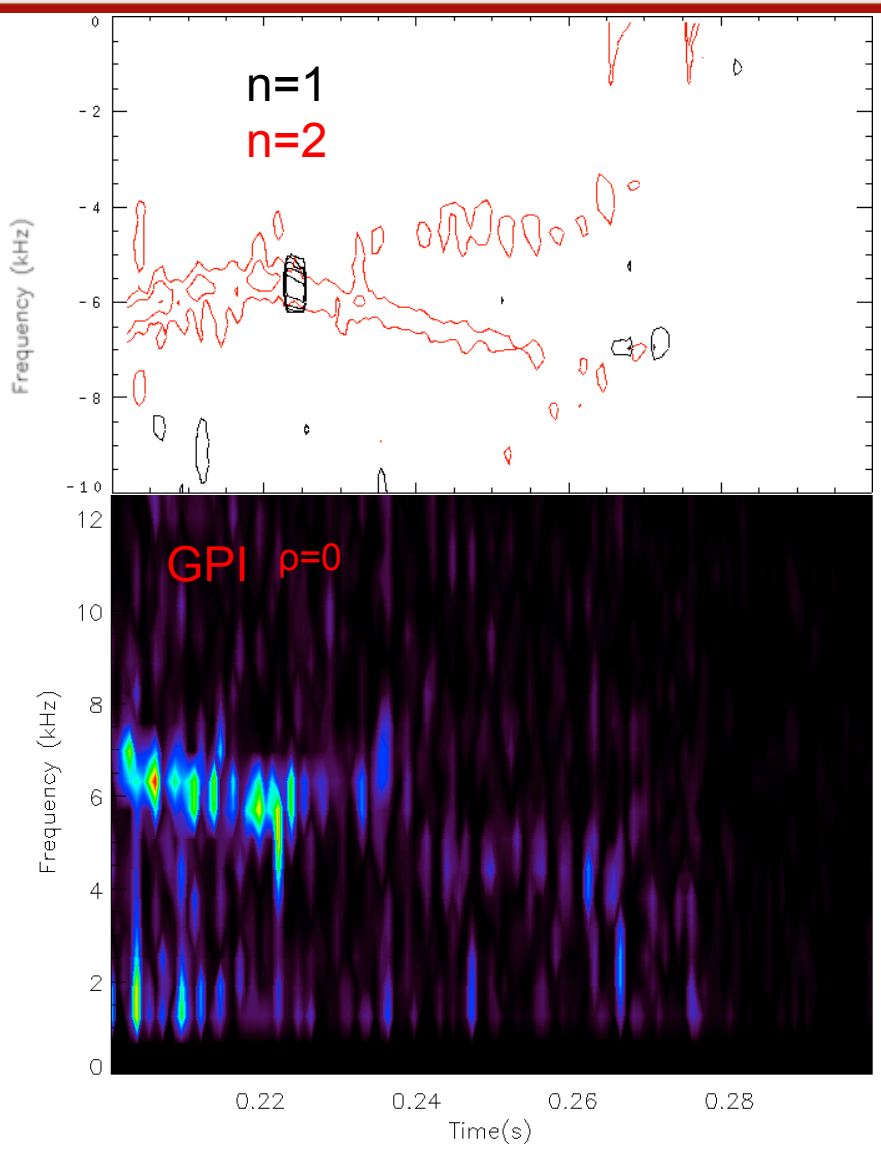
The GPI observation of edge oscillation for #132438



Time evolution of GPI data



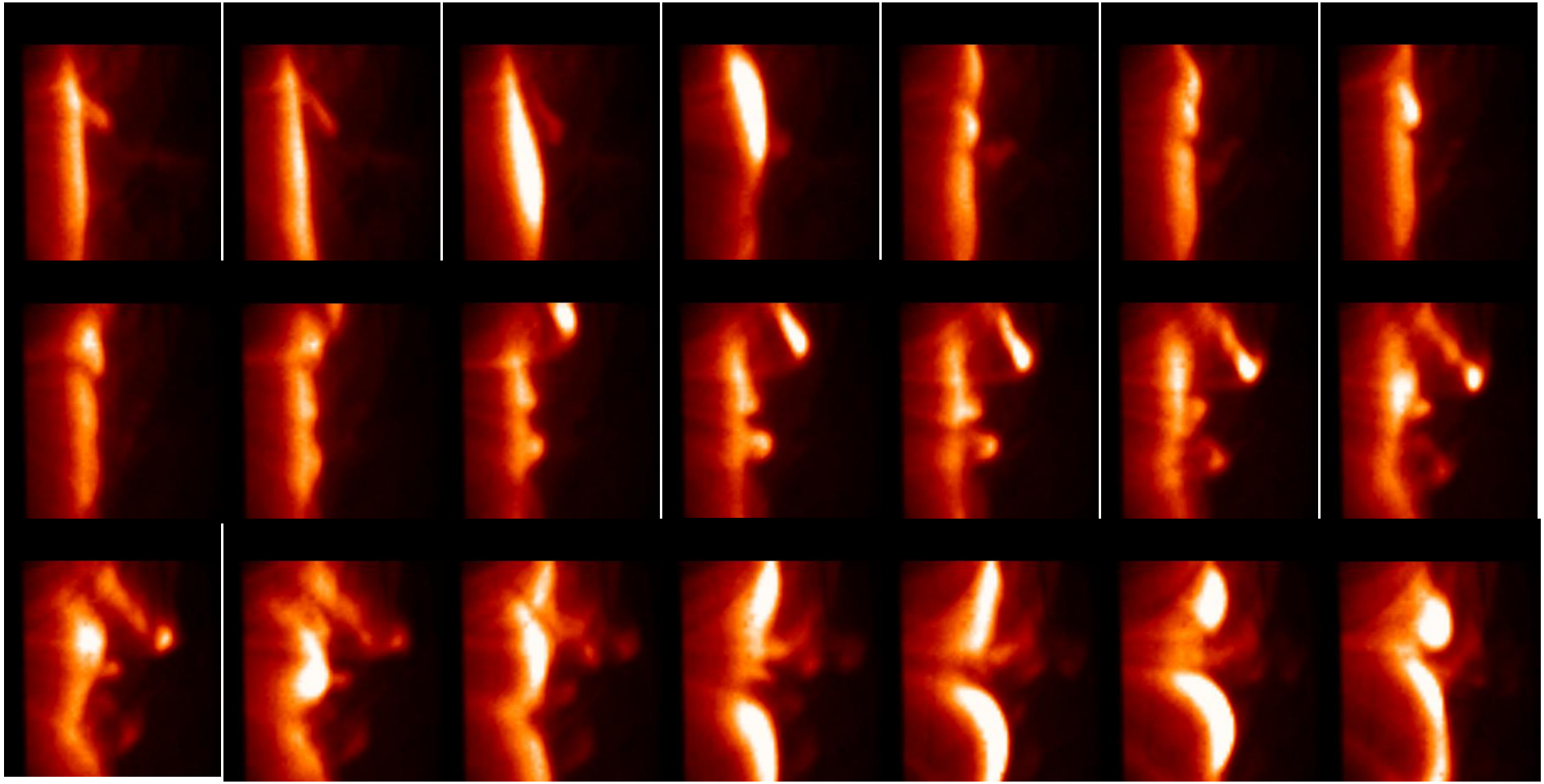
n=2 has the same frequency with the edge oscillation



- The frequency of edge oscillation changed with time 7khz @0.2s, 4khz @0.265s.
- The frequency of edge oscillation is consistent with n=2 frequency.
- Too fast events for IR and Da camera measurements.

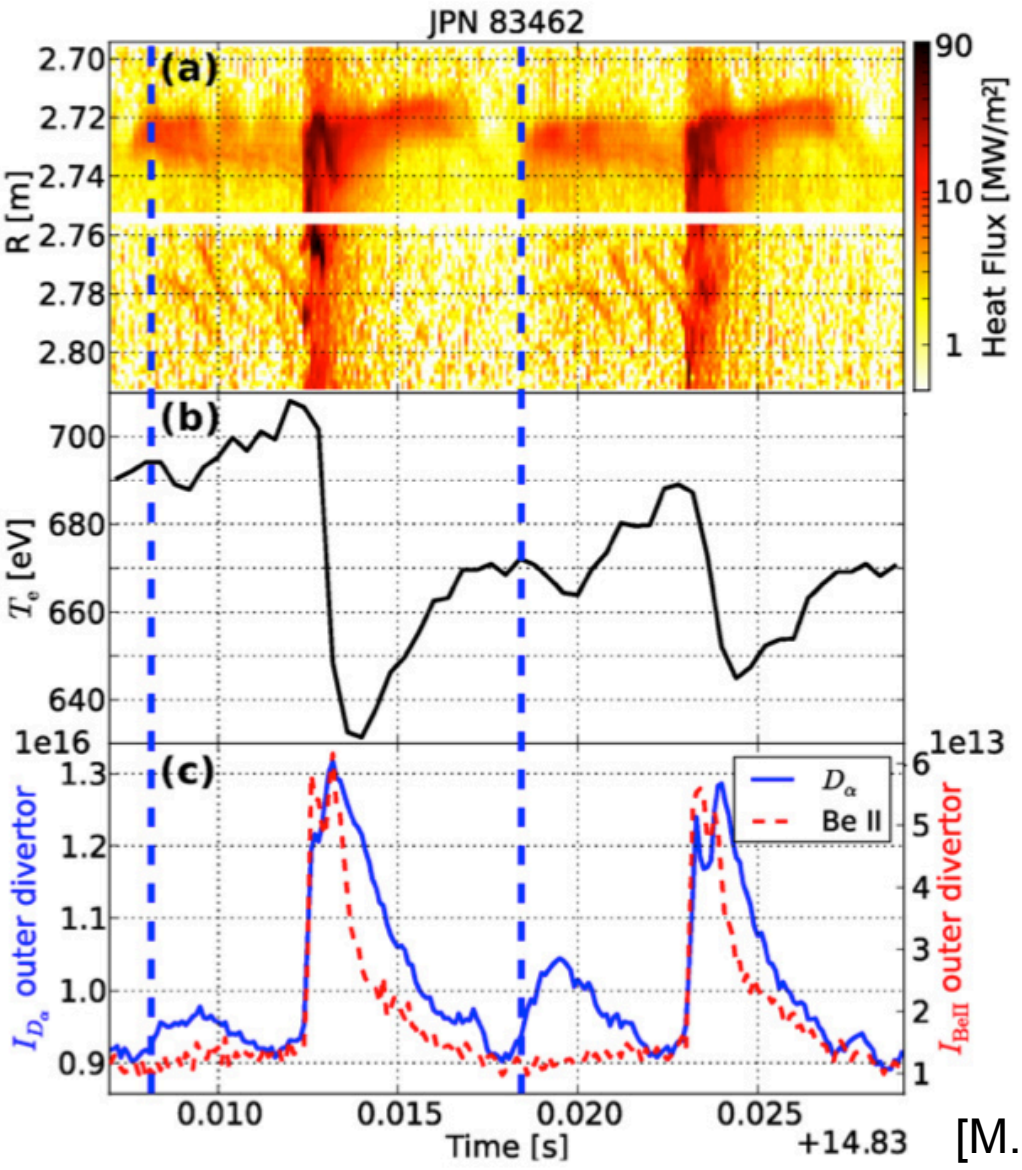
GPI observation during type I ELM

262.591ms+0.008 or 0.009ms



The behavior from GPI movie is similar between edge oscillation and type I ELM

Similar observation on JET



T_e drops and Da increase before ELM

↓

Thermoelectric Current

↓

magnetic topology change

[M. Rack, 2015NF]

Summary and question

- The edge oscillation during ELM-free can significantly increase the divertor heat flux width and decrease the peak heat flux .
- The λq during inter-ELM become wider by current experiments prediction with edge oscillation.
- How to explain the radial propagation of divertor heat flux?
- What is mechanism for the different divertor profile behavior among different toroidal location?