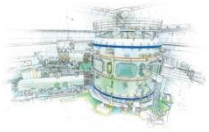
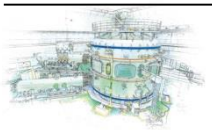


Status of between-shots TRANSP at KSTAR

H. H. Lee[a], L. Terzolo[a], F. Poli[b], J. H. Ahn[b,c], S. Sabbagh[b,c], J. K. Lee[d], J. S. Park[a], D. S. Lee[a], J. M. Kwon[a], B. H. Park[a], Y. K. Oh[a], H. Park[a] and the KSTAR team

[a]*National Fusion Research Institute, Korea*
[b]*Princeton Plasma Physics Laboratory, USA*
[c]*Columbia Univeristy, USA*
[d]*Korea University of Science and Technology, Korea*

jdfm@nfri.re.kr



TRANSP for KSTAR

NFRI

Applications of TRANSP for KSTAR

1. Particle, heat and momentum transport analysis of the KSTAR experimental data (in between-shots)
2. Development of advanced discharge scenarios such as ITB, QH-mode, high-β_p, low-q discharges, etc.
3. Giving guideline for the KSTAR upgrade design
4. Development of long pulse discharge scenarios > 100 secs
5. Input for stability computations and disruption prediction analysis

Personnel involved in the project for implementing TRANSP in KSTAR

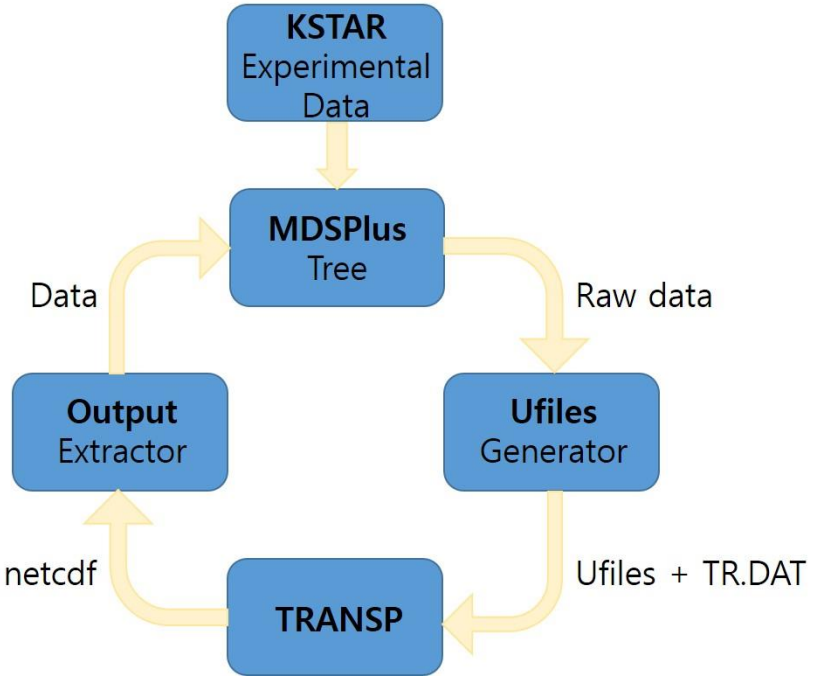
1. Project managers: H. Park, Y. K. Oh
2. Coordinators: H. H. Lee, J. M. Kwon, B. H. Park
3. TRANSP code/interfaces: L. Terzolo, S. Sabbagh (Columbia U.), J. K. Lee
4. Physics Validation: H. H. Lee, F. Poli (PPPL), L. Terzolo, H. S. Kim
5. For TRANSPgrid: M. Gorelenkova (PPPL), K. Silber (PPPL), F. Poli (PPPL),
6. IT and networks: D. S. Lee, J. S. Park

Between-shots TRANSP in KSTAR

Recently, we have launched the project to develop the interfaces for automatic running of TRANSP for between-shots analysis of KSTAR experimental data

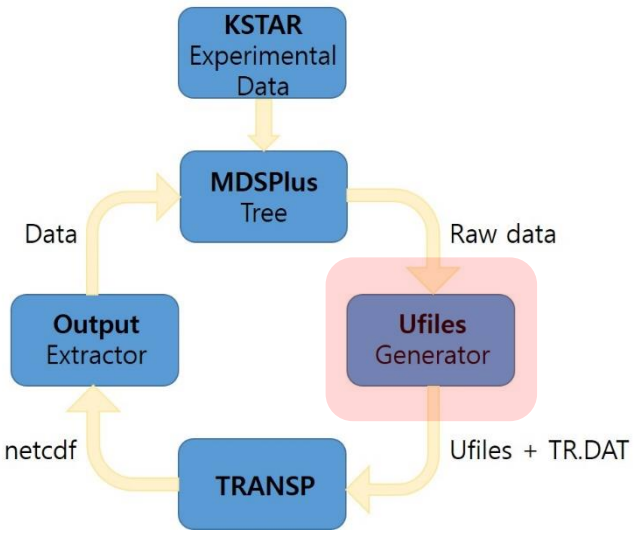
This task involves developments of

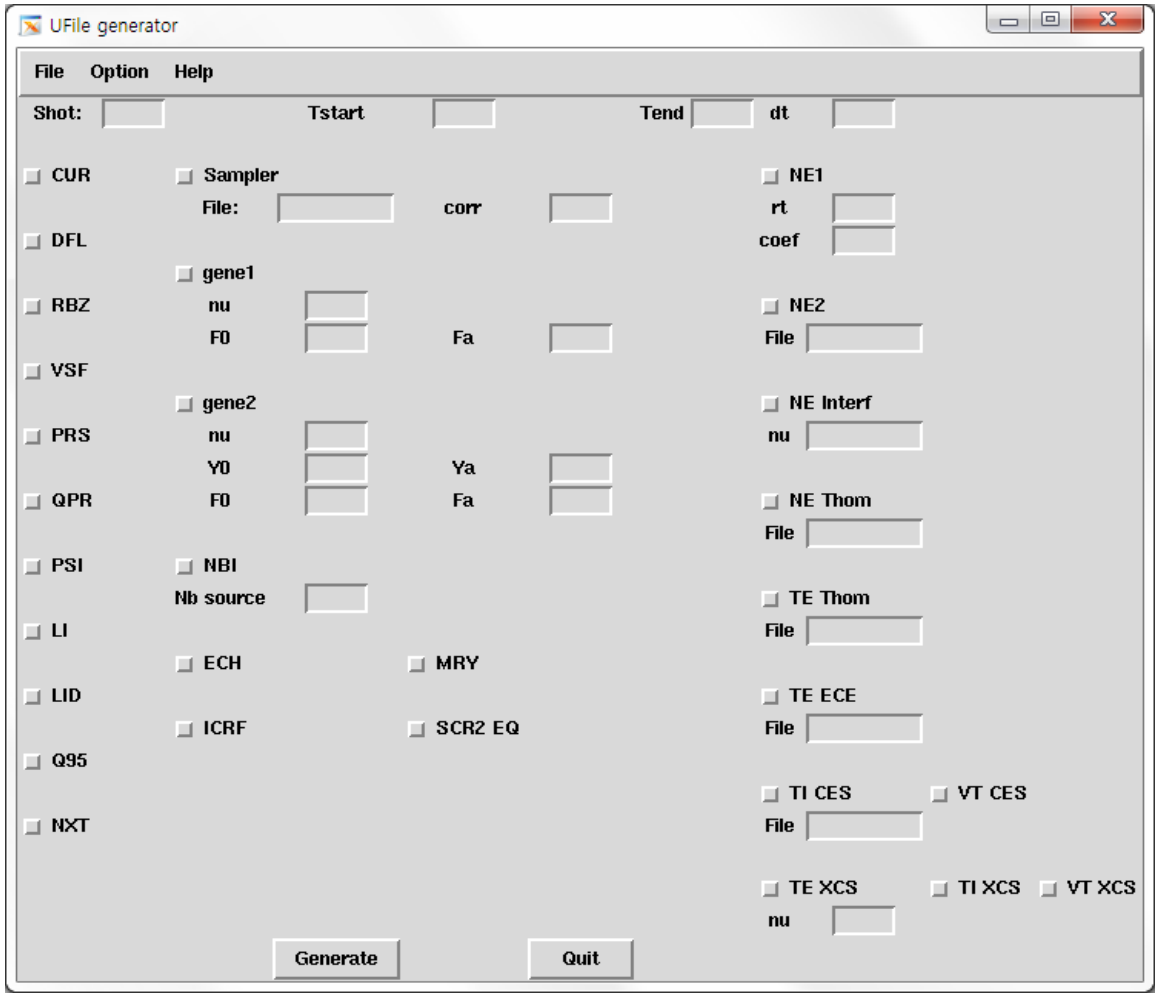
1. MDSplus data retrieving and UFILEs and TR.DAT generator programs
2. a fitting or outliers removing program for improving profile data quality
3. an uploading program of the TRANSP calculation results to MDSplus
4. interfaces for integrating and automatic running of above programs



UFILEs and TR.DAT generators

Previously, an automatic MDSplus data retrieving and UFILEs and TR.DAT generating GUI interface was developed. Now, this interface can be automatically operated and repeated while monitoring the MDSplus data server and checking the heating scenario





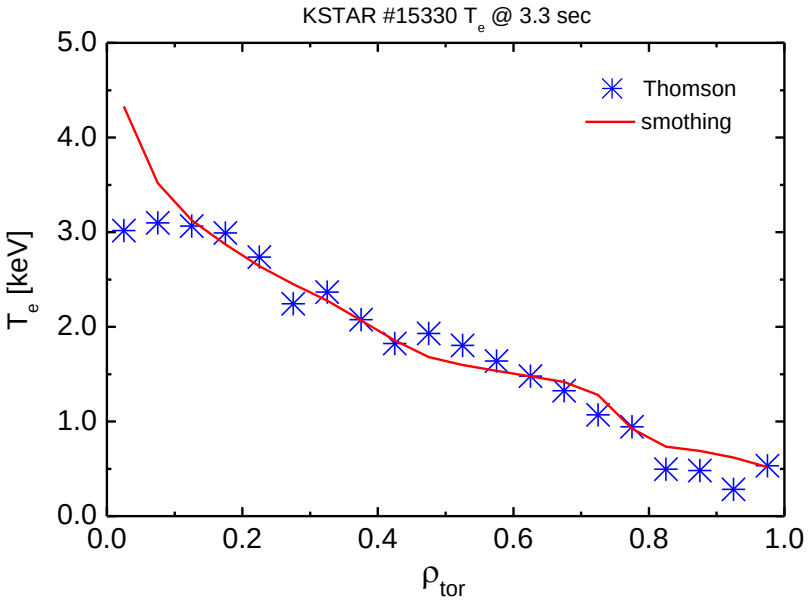
UFILEs and TR.DAT generators

For the TRANSP run, we now use

1. EFIT data (CUR, RBZ, QPR, MMX, LIM, GRB, PRS, TRF, PLF, VSF)
2. Electron temperature profile from Thomson (default) or ECE
3. Electron density profile from Thomson (default) or prescribed profile
4. Ion temperature profile from Charge Exchange Spectroscopy
5. Toroidal rotation velocity profile from Charge Exchange Spectroscopy

Profile data is automatically fitted by gsmoo2 (3-point average)

But, we still frequently struggle with many outliers in Thomson profiles. We still need to handle these outliers to improve the accuracy of the TRANSP result (see p. 7 introducing the collaboration with Columbia)



UFILEs and TR.DAT generators

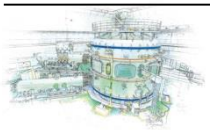
TR.DAT is automatically generated with default settings and NBI configurations (other heating systems such as ECRH and ICRH will be included soon)

Example of 'in_fast_input'

jdfm@sophie:~/my-transp/fast

```
&INPUT_P
nshot=15330,        shot number
tstart=3.d0,        start of simulation
tend=7.d0,          end of simulation
dt=0.1,             sampling time for output data (SEDIT)
epath='EFIT01',     EFIT branch in MDSPlus Tree
smooth=3,           smoothing parameter for gsmoo2
nbpart=5000,        number of Monte Carlo ions (NPTCLS)
dtbeam=0.1,         beam time step (DTBEAM)
/
-- INSERT --                                  1,9           All
```

Now, from MDSplus data retrieving to TRANSP background job creation can be done automatically by 'one-command-execution'



Advances in automatic TRANSP workflow

New Columbia U. grant on Disruption Prediction and Avoidance in KSTAR aiding TRANSP workflow

(Supported by U.S. DOE grant DE-FOA-0001498)

- Motivation
  - Fully automated, more general TRANSP workflow needed to support stability calculations and disruption prediction analysis (KSTAR kinetic equilibrium reconstruction w/MSE also a task of this research)

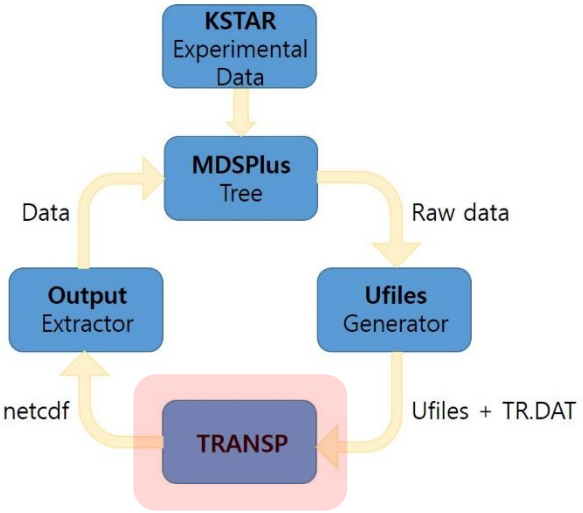
- TRANSP utility expansion supporting first-year research
  - Terzolo workflow code (including GUI) now generalized to accept more needed inputs (e.g. arbitrary EFIT MDSPlus tree choice, smoothing,...)
  - Automated regrouping of Ufiles corresponding to runID input to GUI
  - Pre-processor written to eliminate errant channels (with time-dependence) using systematic error analysis (e.g. for Thomson)
  - GUI choice to allow additional profile smoothing (with gsmoo2)
  - STATUS: Codes are working! First TRANSP runs using this workflow at PPPL now being checked using variety of Columbia U. shots on KSTAR (e.g. NBI, ECH-only, high β_N, NTV, etc.)

J.H. Ahn, S.A. Sabbagh, Y.S. Park, J.W. Berkery (Columbia U.); L. Terzolo (NFRI)

TRANSP calculation

- At the moment, a local TRANSP of 2009 ver. is used for between-shots analysis
- Now, the local TRANSP is installed in a little-bit old (and very slow) cluster (7 processors of Intel Xeon CPU X5550 @ 2.67 GHZ) which had been used for MDSplus data access (jScope), EFITviewer, etc.
- We have realized that the TRANSP calculation time is mostly dominated by the NUBEAM calculation time (which can be controlled by 'DTBEAM' or 'NPTCLS').
- For 4 secs calculation (#15330)

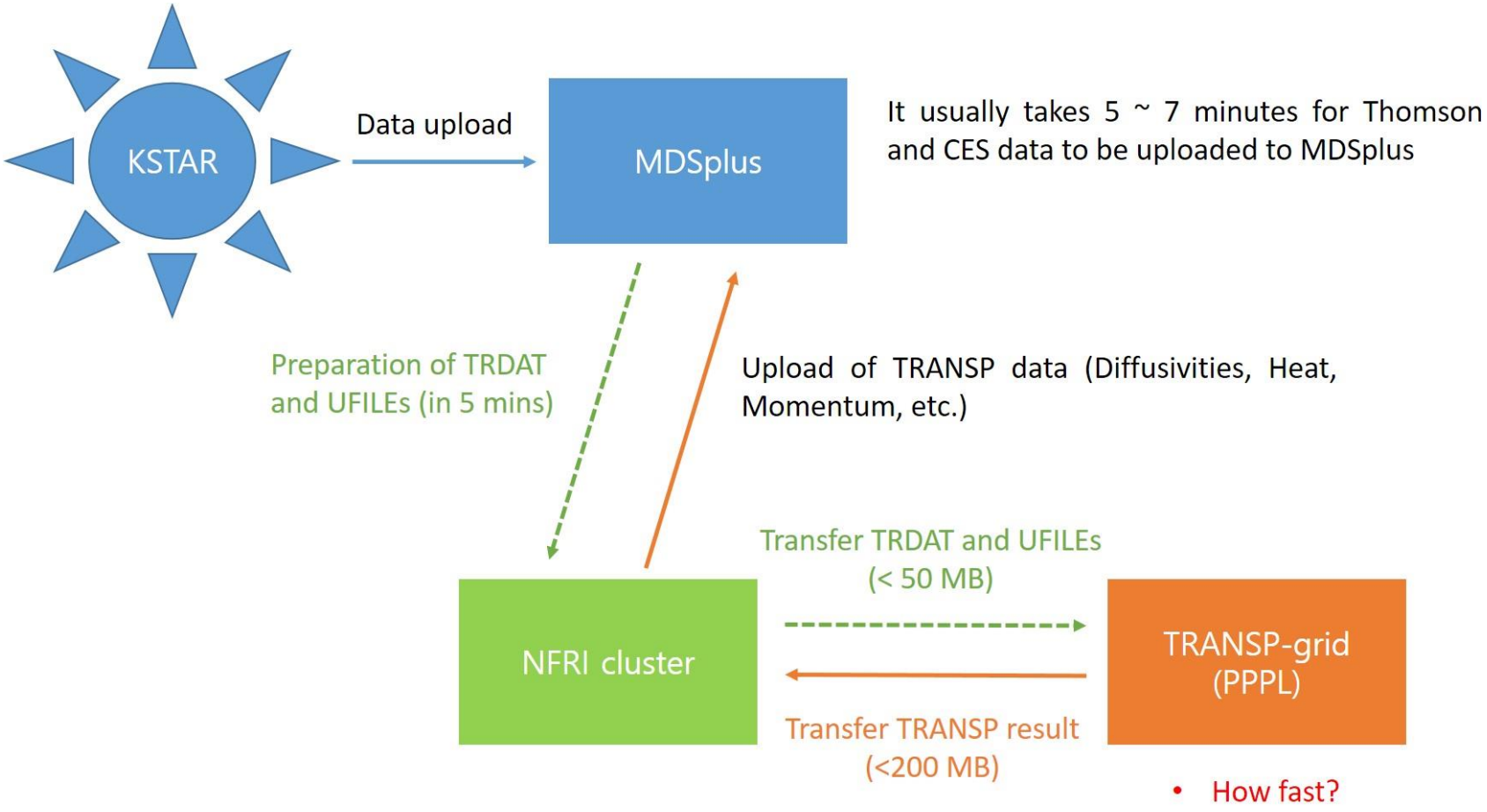
DTBEAM (s)	TRANSP run time	
	NPTCLS =10000	5000
0.005	3 hrs	
0.1	36 mins	20 mins
0.2	22 mins	12 mins



✓ For the purpose of between-shots analysis, DTBEAM should be in the order of 0.1 sec.
✓ Or, we need to upgrade the cluster for between-shots TRANSP
✓ Can TRANSPgrid be an another option for KSTAR?

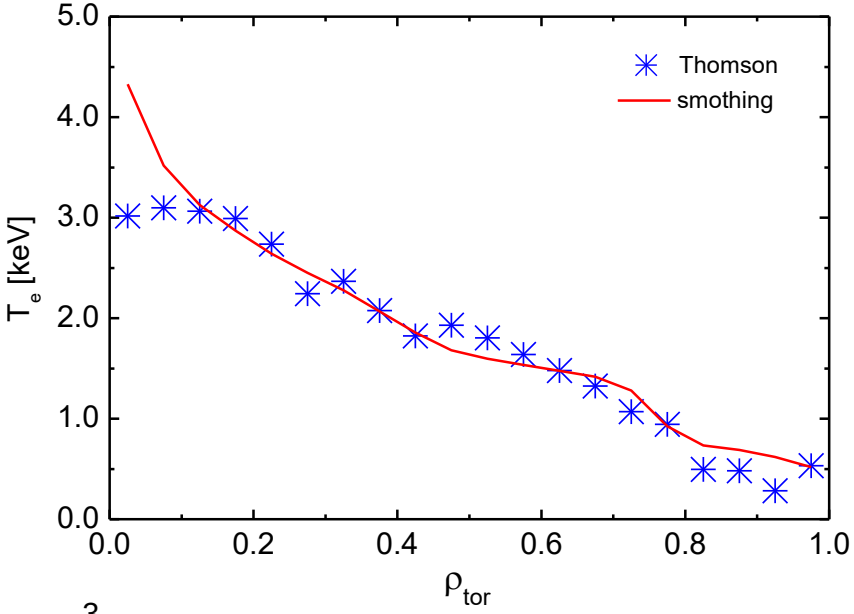
TRANSP calculation

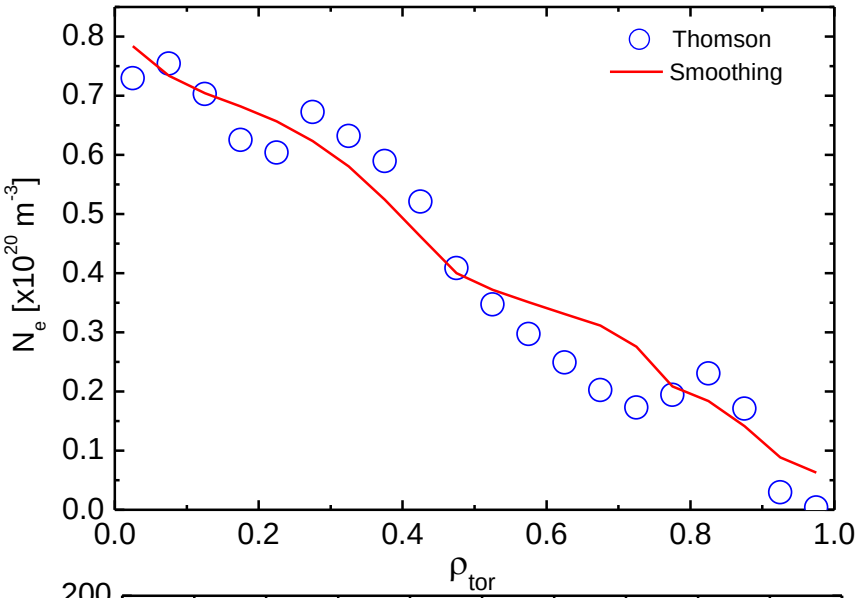
If TRANSPgrid can be applied for KSTAR between-shots analysis,

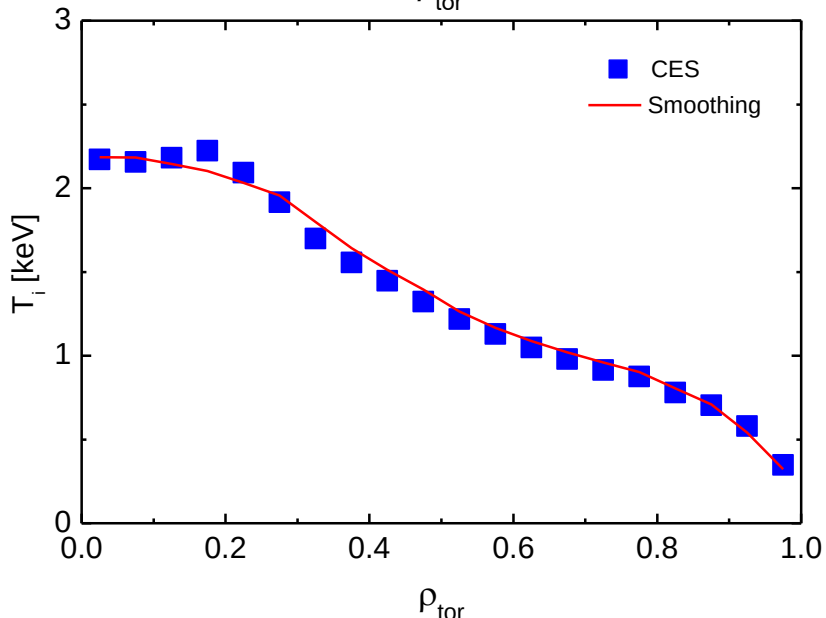


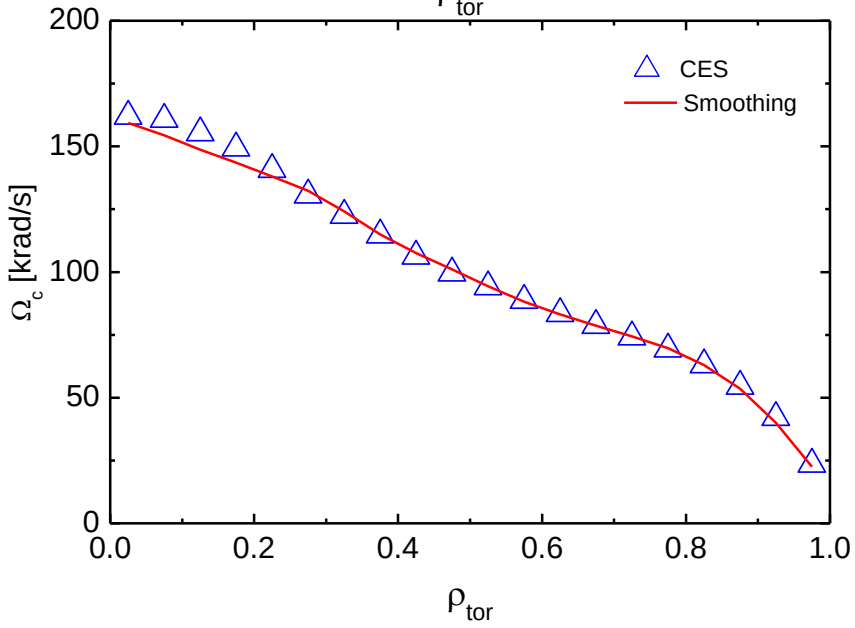
Between-shots TRANSP result

Input profile data (H-mode, #15330@3.3 s, comparison between raw and smoothed)



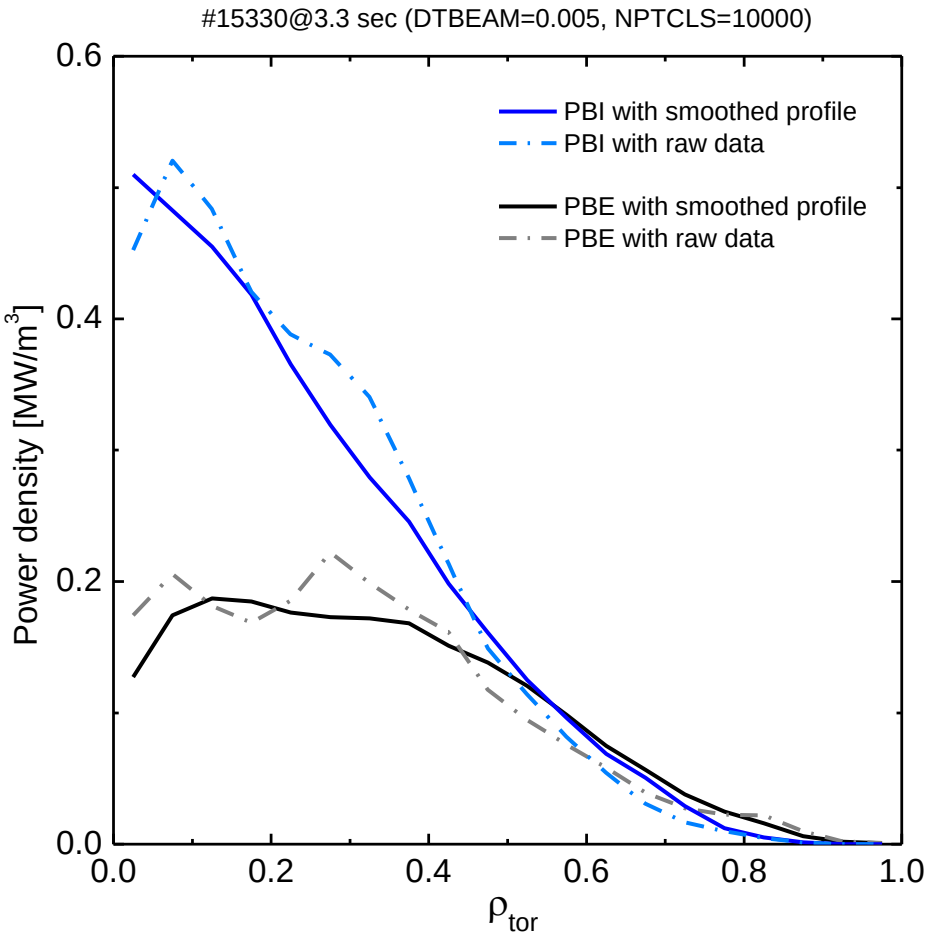


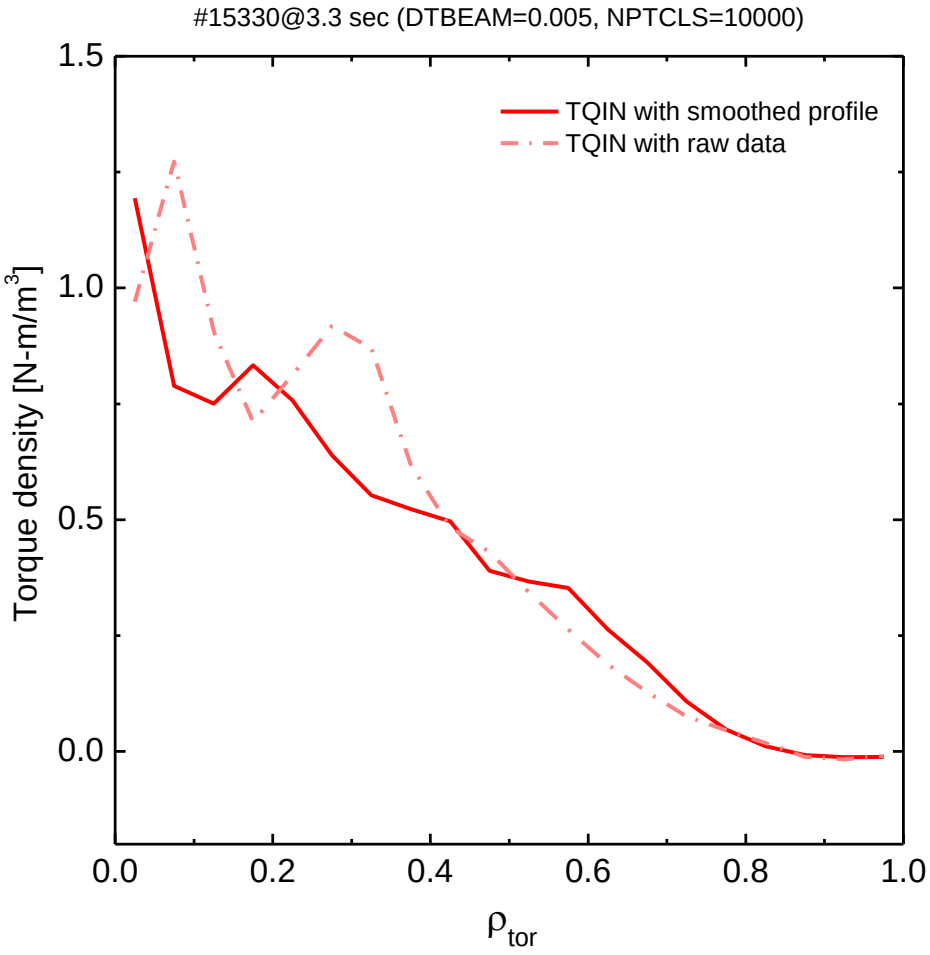




Between-shots TRANSP result

NBI profiles comparison (smoothed profiles vs. raw data)

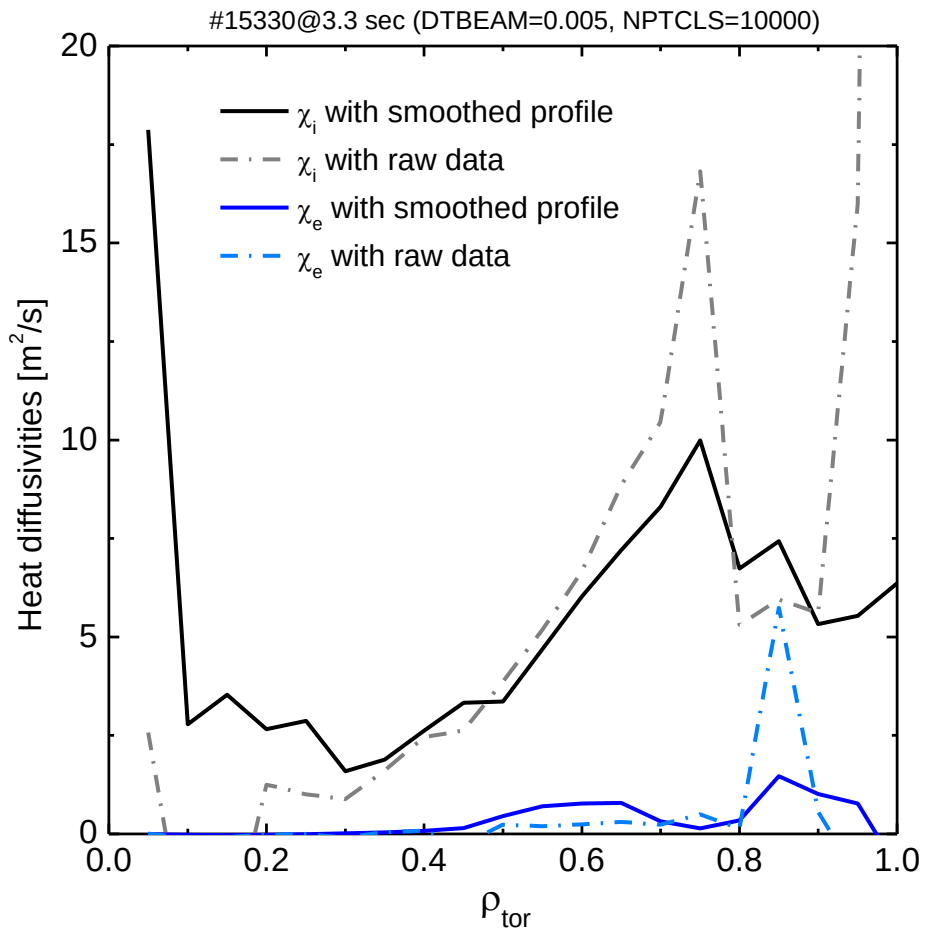


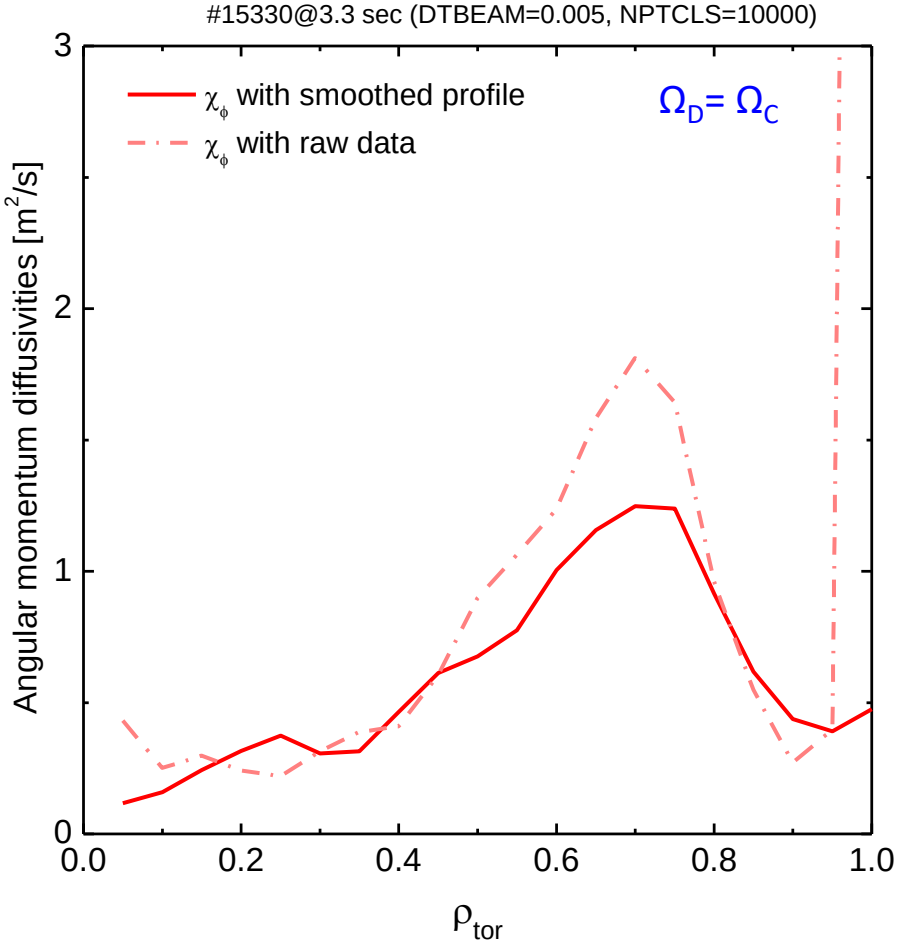


NUBEAM calculation results do not show much difference, but …

Between-shots TRANSP result

Diffusivities comparison (smoothed profiles vs. raw data)

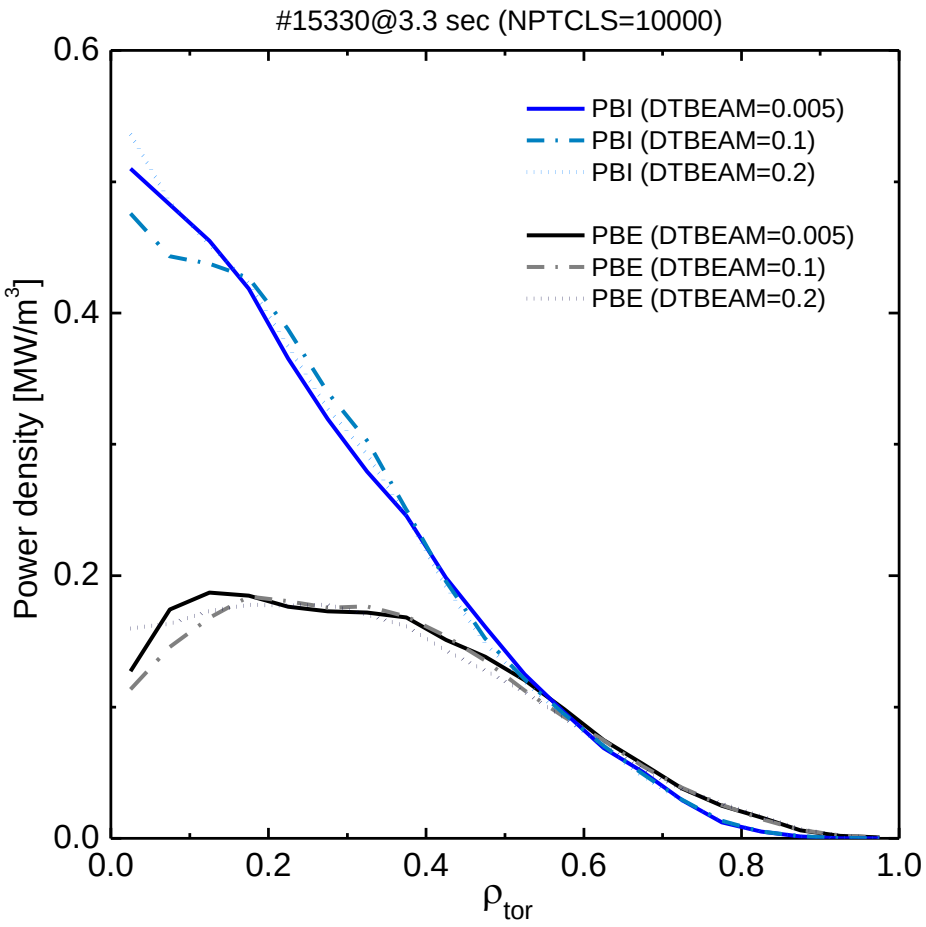


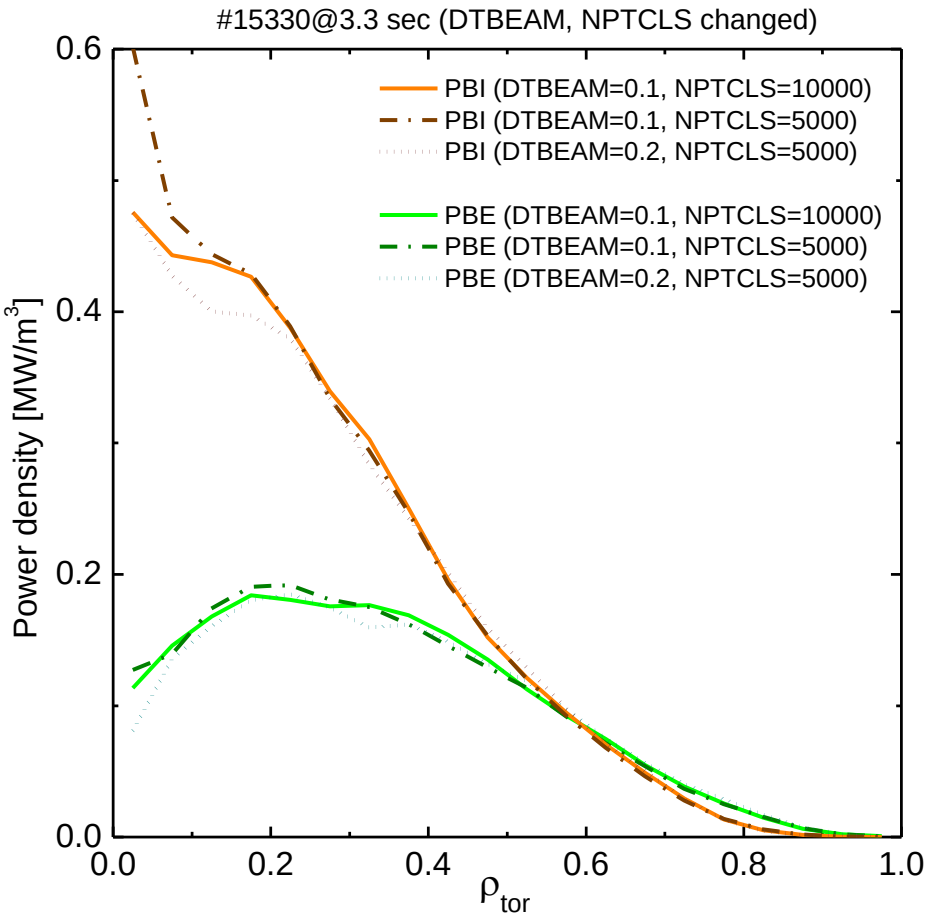


NUBEAM calculation results do not show much difference, but, heat diffusivity profiles with raw data show negative values at some regions

Between-shots TRANSP result

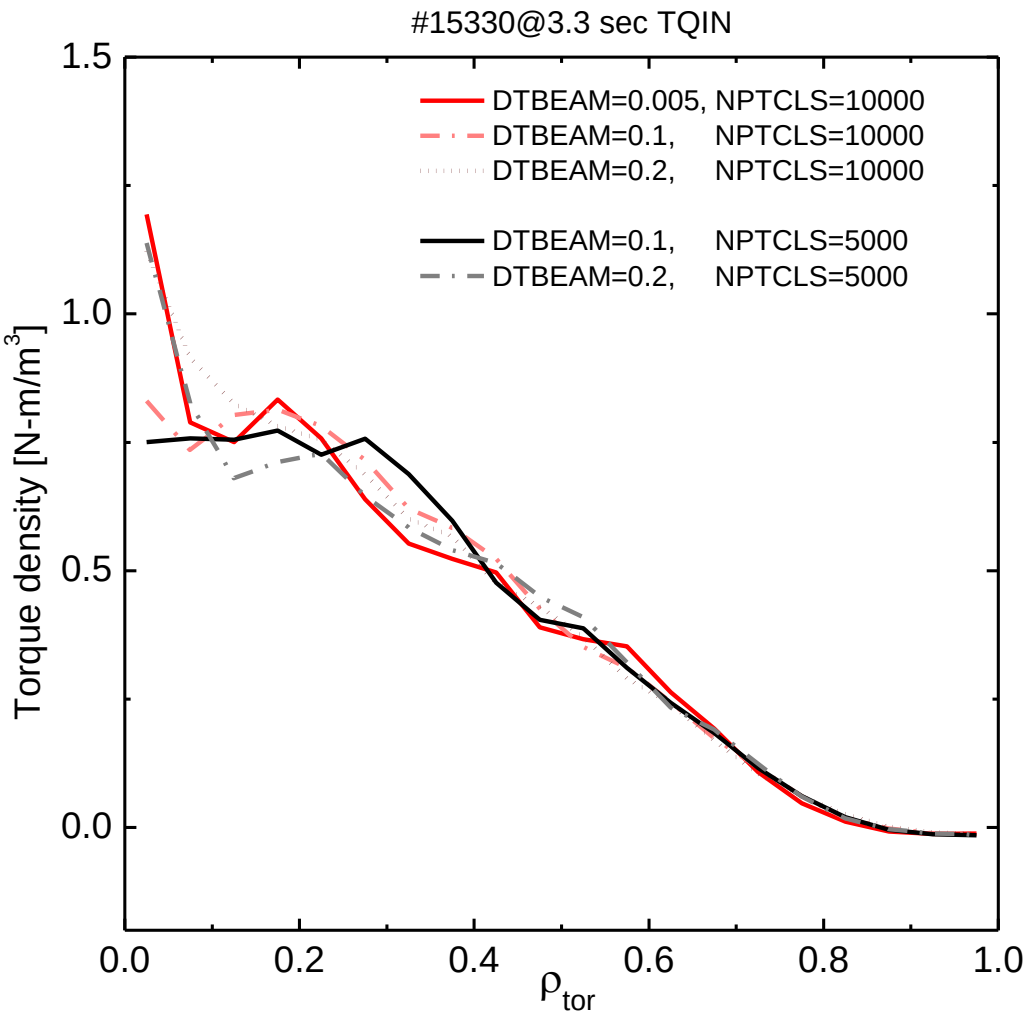
NBI profiles comparison (according to NUBEAM options)





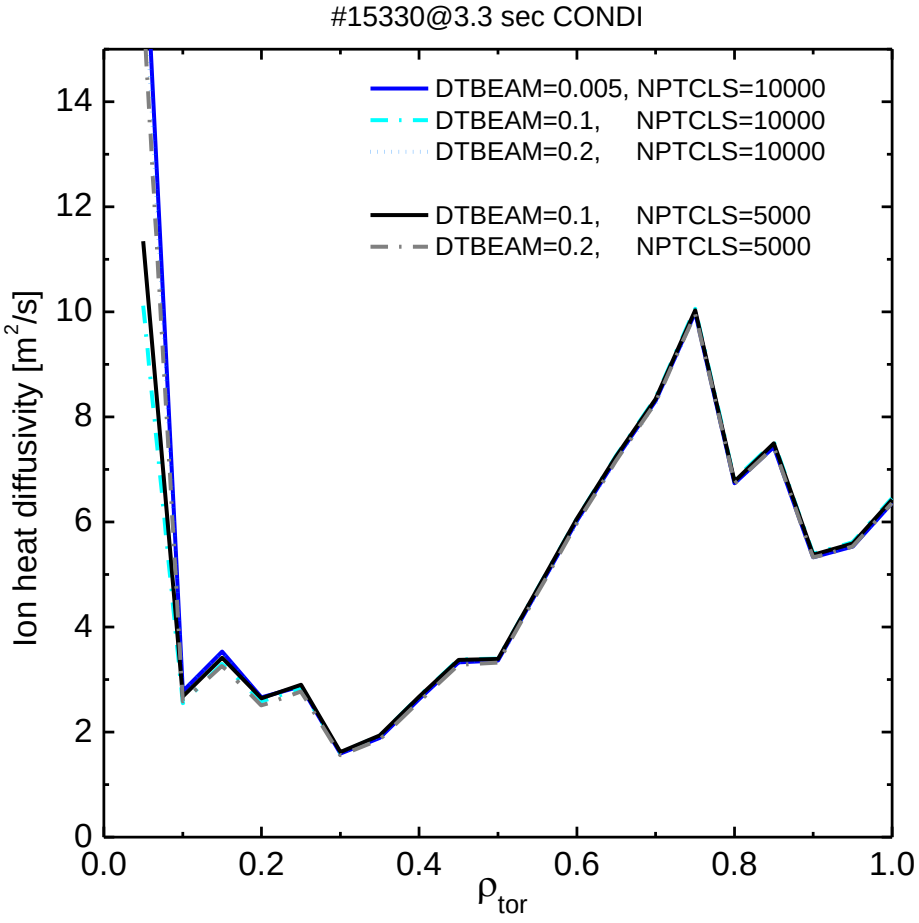
Between-shots TRANSP result

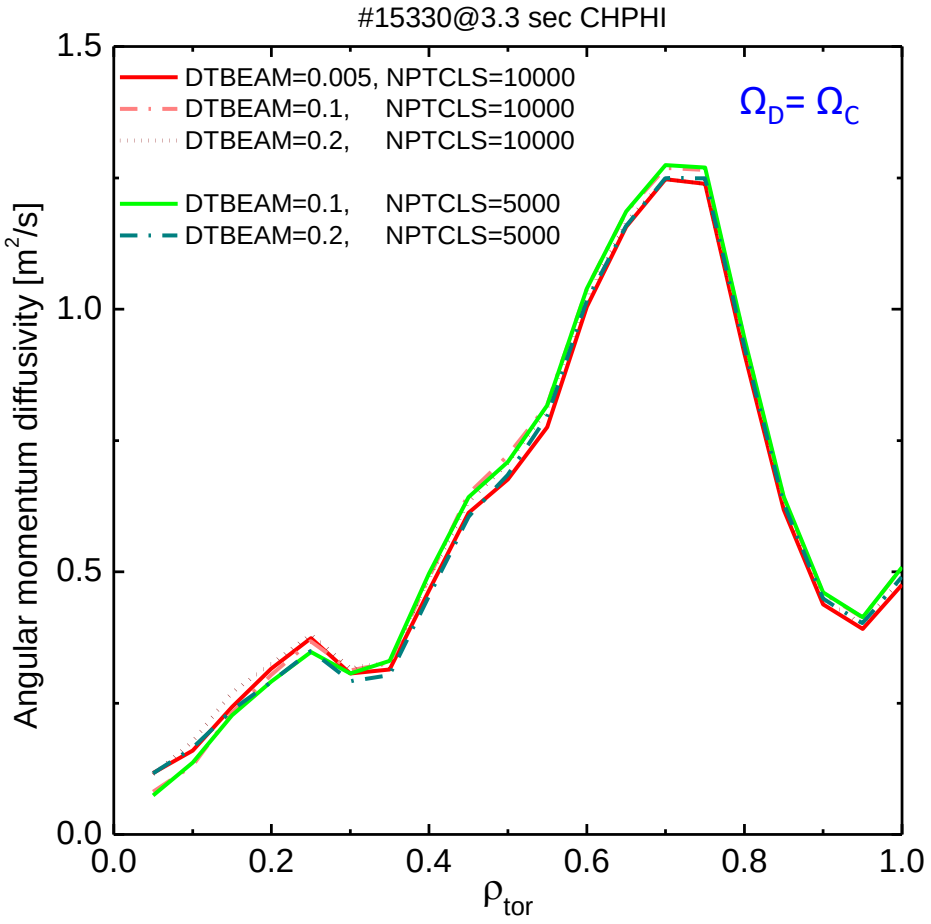
NBI profiles comparison (according to NUBEAM options)



Between-shots TRANSP result

Diffusivities comparison (according to NUBEAM options)

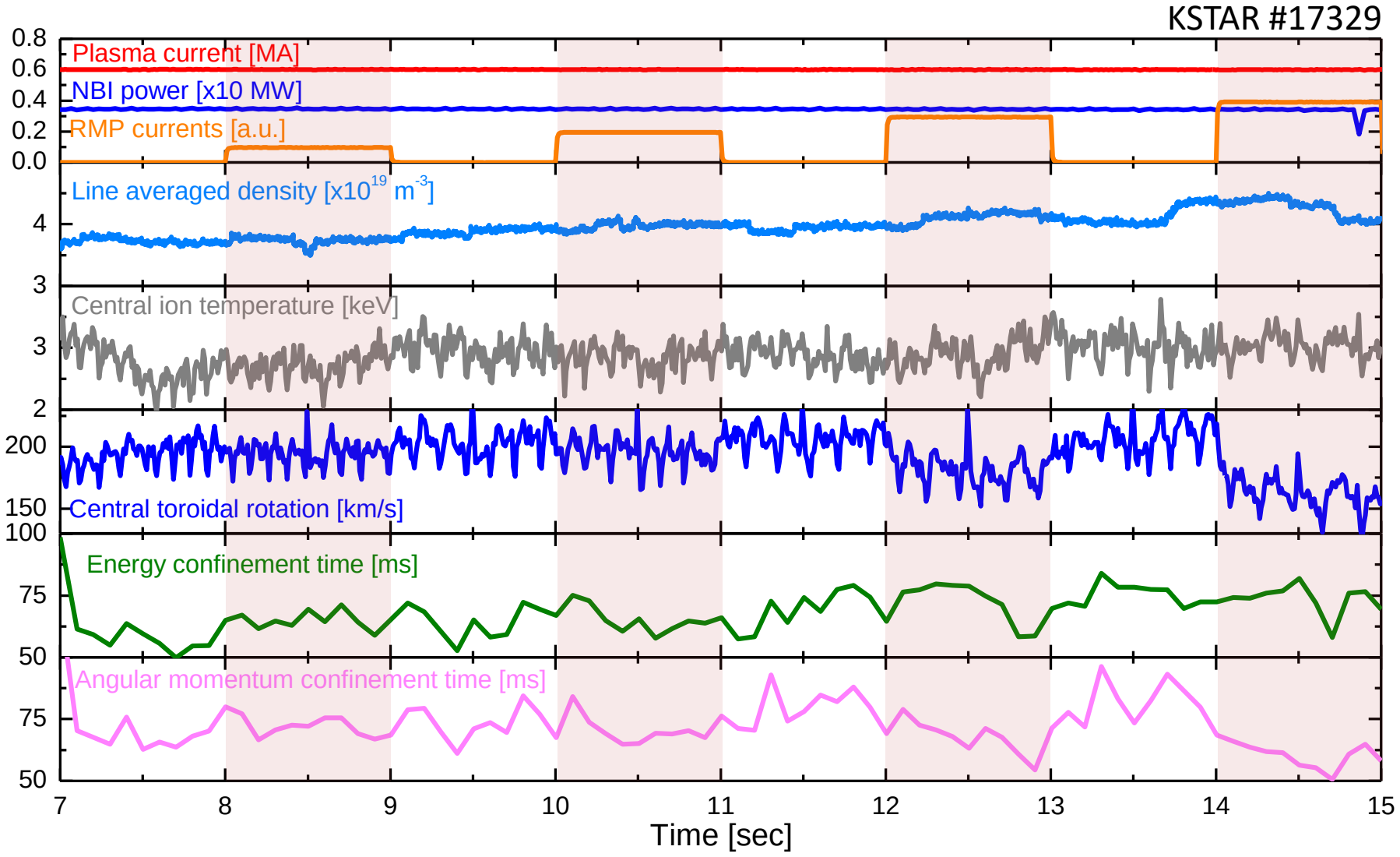




There are almost no differences in diffusivities profiles between NUBEAM settings

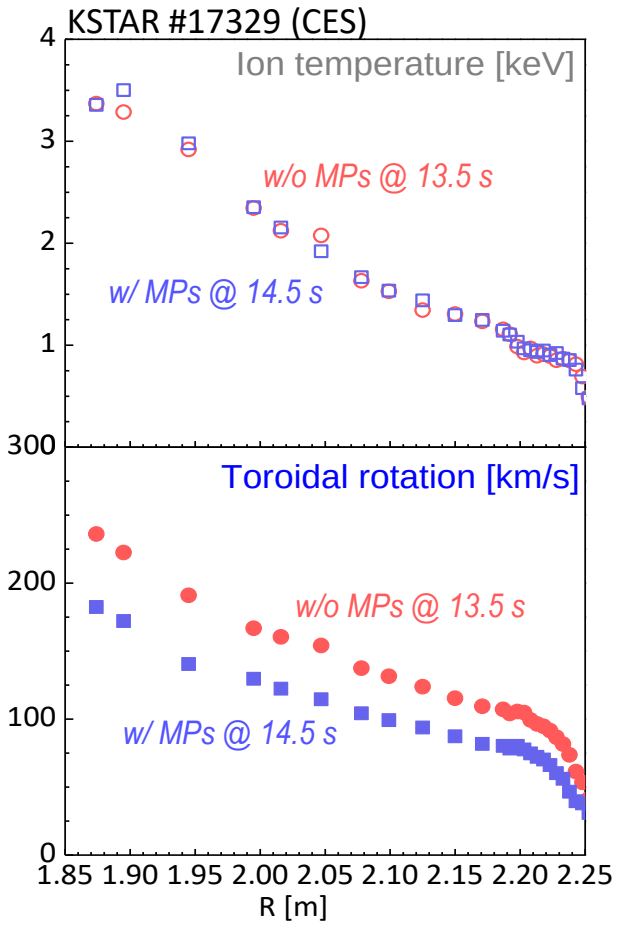
Between-shots TRANSP result

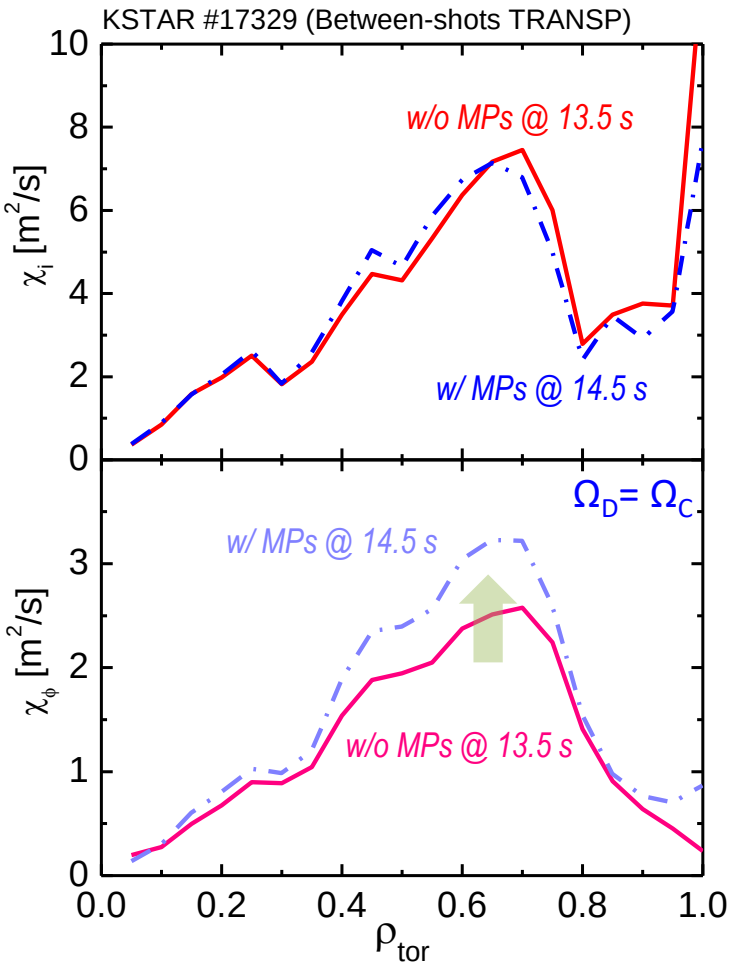
Application of the KSTAR between-shots TRANSP on the NTV experiment



Between-shots TRANSP result

Application of the KSTAR between-shots TRANSP on the NTV experiment

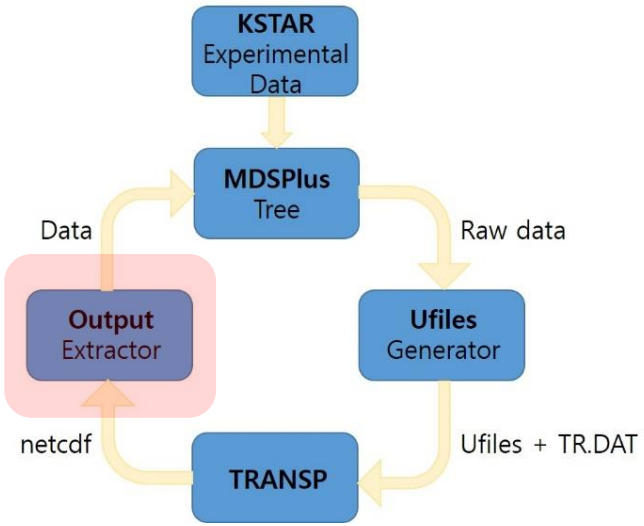




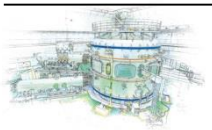
- ✓ It is clearly shown that the momentum diffusivity significantly increases due to the external magnetic perturbations while there is no significant change in the ion heat diffusivity. *But, the change may be mainly due to the neoclassical toroidal viscosity enhanced by the external magnetic perturbations*

Data upload

- A program to extract specific result from .cdf file is ready
- MDSplus data uploading module will be integrated into the program soon
- For KSTAR users, several TRANSP result will be served via MDSplus server (can be updated by request)



	Node Name	Description
1D	tr_IPBE	Integrated beam heating power of electrons
	tr_IPBI	Integrated beam heating power of ions
	tr_ITQ	Integrated beam torque
	tr_TEE	Electron energy confinement time
	tr_TEI	Ion energy confinement time
	tr_TAUE	Energy confinement time
	tr_TAUPHI	Angular momentum confinement time
2D profile	tr_Rho01~50	Toroidal rho
	tr_CONDE01~50	Electron heat diffusivity profile
	tr_NCCONDE01~50	Neoclassical electron heat diffusivity profile
	tr_CONDI01~50	Ion heat diffusivity profile
	tr_NCCONDI01~50	Neoclassical ion heat diffusivity profile
	tr_CHPHI01~50	Angular momentum diffusivity profile
	tr_NE01~50	TRANSP electron density profile
	tr_TE01~50	TRANSP electron temperature profile
	tr_NI01~50	TRANSP ion density profile
	tr_TI01~50	TRANSP ion temperature profile
	tr_PBE01~50	Beam heating power of electrons profile
	tr_PBI01~50	Beam heating power of ions profile
	tr_TQ01~50	Beam torque density profile



Future plan

- We hope a new cluster for between-shots TRANSP can be available soon
- The connection between NFRI cluster and transp-grid will be established under the support of M. Gorelenkova, K. Silber, F. Poli in PPPL
- PPPL collaborators will be provided with the direct access to NFRI cluster in order to effectively resolve some issues
- Columbia U./PPPL collaboration will complete checkout of automated TRANSP workflow and analysis results (aimed to support stability/disruption analysis) and will contribute code changes for general use. Development of further capabilities will continue.
- Predictive modeling by TRANSP is being prepared in collaboration with F. Poli
- TRANSP user group for KSTAR will be organized and promoted soon