# Call for Proposals for 2019 KSTAR Experimental Campaign

## 1. Experimental goals

After the successful campaign of the year 2018, KSTAR will continue physics research and advanced operation maximizing the unique machine capabilities of KSTAR. The main physics goals of KSTAR 2019 campaign would be addressed through the following working groups:

A. Main Physics Research Goals (6 Working-Groups)
   The main Physics research topics will be categorized by 6 Working-Groups(WGs) and the detail research topics for each WG will be specified below.
   - WG 1 : Advanced Operation Scenario (AOS)
   - WG 2 : MHD Stability (MHD)
   - WG 3 : 3D Field Physics (3DF)
   - WG 4 : Tokamak Boundary Physics (DIV)
   - WG 5 : Plasma Commissioning (COM)
   - WG 6 : General Physics (GEN)

## 2. Campaign Schedule*

| Operation steps | Aug | Sep | Oct | Nov | Dec | Jan |
|---|---|---|---|---|---|---|
| Evacuation and wall conditioning | | | | | | |
| Magnet cool-down and test | | | | | | |
| **Plasma experiments (from middle of Oct. to middle of Dec, ~2 months)** | | | | | | |
| Magnet warm-up | | | | | | |

*This schedule is subject to change depending on the status of the machine preparation.

**Key dates**
**10 Apr 2019 :** Proposal website open (https://kstar.nfri.re.kr)
**14 June 2019: Due date of proposal submission**
**26-27 June 2019 : Research Opportunity Forum at NFRI** (remote participation available)
**31 July 2019**: Announcement of selected proposals and experimental schedule

## 3. Working-Groups

In 2019 run-campaign, similar as 2018', six Working-Groups as listed below are organized to facilitate the management and coordination of the experimental proposals under limited runtime resources.

| WGs | Research Topics | WG leaders |
|---|---|---|
| WG 1: Advanced Operation Scenario (AOS) | • Development of high beta steady state scenarios<br>- High beta poloidal, Hybrid, ITER Baseline, ITB, etc<br>- Fully non-inductive scenario<br>- Thermal and fast ion confinements<br>- Optimization of heating and current drive<br>• Development of integrated advanced operation scenarios<br>- Advanced scenarios with ELM suppression | Jinil Chung (jinil@nfri.re.kr)<br><br>Deputy : Yong-Su Na (ysna@snu.ac.kr) |

| | | |
|---|---|---|
| | - Advanced scenarios with divertor detachment<br>- Long-pulse advanced scenarios<br>- Advanced scenarios with profile/MHD control | |
| WG 2:<br>MHD Stability<br>(MHD) | • Control of MHD in high beta plasma<br>  - Avoidance/control of Neoclassical Tearing Mode<br>  - Stability study near & above no-wall limit<br>  - Real time MHD Spectroscopy<br>• Disruption mitigation & avoidance<br>  - Development of forecast techniques<br>  - Disruption & RE mitigation with material injection<br>  - Energetic electron & wave interaction<br>  - EM force by induced current during disruption<br>• Energetic particle physics<br>  - Control of energetic particle driven modes<br>  - Fast ion loss and transport associated with MHD and 3D field | Byoung-Ho Park<br>(bhpark@nfri.re.kr)<br><br>Deputy :<br>Gunsu Yun<br>(gunsu@postech.ac.kr) |
| WG 3:<br>3D Field<br>Physics<br>(3DF) | • RMP ELM control<br>  - RMP ELM control in ITER-relevant conditions with particular emphasis on radiative/detached plasmas, divertor heat flux broadening, ITER-like shape, etc<br>  - Physics mechanism: plasma shaping, rotation, pedestal collisionality effects<br>  - Confirmation of a predictive model for the RMP ELM suppression with experiments<br>  - Cross-machine comparison in RMP ELM control<br>- Exploration of ELM-free or small ELM regimes<br>  - QH-mode, I-mode, Grassy ELMs, Impurity injection<br>- Pedestal and Rotation physics<br>  - RMP-driven turbulence influence on pedestal<br>  - NTV offset and 3D transport (incl. EF)<br>  - Rotation shear with RMP/NRMP | Gun-Young Park<br>(gypark@nfri.re.kr)<br><br>Deputy :<br>Yongkyoon In<br>(inyongkyoon@unist.ac.kr) |
| WG 4:<br>Tokamak<br>Boundary<br>Physics<br>(DIV) | • Characterization of Scrape-off Layers<br>  - SOL heat/particle decay width<br>  - Far-SOL turbulence transport<br>• Divertor physics<br>  - Access and dynamics of detachment<br>  - Radiative divertor with impurity injection<br>• Impurity transport and recycling<br>  - Impurity injection and confinement improvement<br>  - Wall conditioning techniques | Hyung-Ho Lee<br>(jdfm@nfri.re.kr)<br><br>Deputy :<br>Wonho Choe<br>(wchoe@kaist.ac.kr) |
| WG 5:<br>Plasma<br>Commissioning<br>(COM) | • Optimization of plasma control system<br>  - Axisymmetric magnetic control<br>  - Extension of operational boundary<br>• Commissioning of Diagnostics<br>  - Validation of diagnostic data<br>• Commissioning of heating and current drive systems<br>  - Heating and current drive efficiency | Woong-Chae Kim<br>(woong@nfri.re.kr)<br><br>Deputy :<br>Hyunsun Han<br>(hyunsun@nfri.re.kr) |
| WG 6:<br>General Physics<br>(GEN) | • All the physical topics which are not covered by other working groups<br>  - Basic plasma physics<br>  - Physics of confinement transition<br>  - Experiment for theory and code validation | Min-Jun Choi<br>(mjchoi@nfri.re.kr)<br><br>Deputy :<br>Jae-Min Kwon<br>(jmkwon74@nfri.re.kr) |

*Before submitting your proposals, it is strongly encouraged to discuss them in detail with the WG leaders or your personal contacts at NFRI.

## 4. Contacts for project managements and general supporting

| Role or position | Name | Email |
|---|---|---|
| Director of KSTAR Research Center | Si-Woo Yoon | swyoon@nfri.re.kr |
| Experimental coordinator | Won-Ha Ko | whko@nfri.re.kr |
| Experimental coordinator (Deputy) | Son-Jong Wang<br>Yong-Un Nam | sjwang@nfri.re.k<br>yunam@nfri.re.kr |
| Webmaster | Jin-Seop Park | linupark@nfri.re.kr |
| External relations & logistics supports | Seok In Yoon | siyoon@nfri.re.kr |

## 5. KSTAR machine status

### Plasma machine operation parameters

| | |
|---|---|
| TF field | 1.5 – 3.0 T (typically at $B_t$=2.0T at R = 1.80 m) |
| Plasma current | Up to 1 MA (typically $I_p$=0.5-0.8 MA) |
| Major/minor radius | R=1.8 m, a=0.4 – 0.45 m |
| Density | Up to $5 \times 10^{19}$ $m^{-3}$ |
| Pulse length | Up to 60/20 sec at 0.4/0.8 MA respectively |
| Gas species | D (main), H (minority) |
| Plasma shape | DN or SN, elongation <2.0 peak (typically upto 1.8), triangularity < 0.8 |

### Heating and current drive system available in 2019 campaign

| Name | Specification | Contact Person |
|---|---|---|
| ECH/ECCD | 105/140 GHz, 2 MW, steady-state | Joung Mi (whitemi@nfri.re.kr) |
| NBI/NBCD ($D_0$) | NBI-1 : 5.5 MW @ 100/95/95 keV, 10 s<br>NBI-1 : 4.0 MW @ 90/80/80 keV, steady-state<br>NBI-2 : 2.0 MW @ 60/80/60 keV, 10 s (tentative) | Jinhyun Jeong (jhjeong@nfri.re.kr) |

## 6. Diagnostics status

| Name | Contact Person | Remark |
|---|---|---|
| MD (Rogowskii coil, Flux loop, Magnetic field probe, Lock mode coil / Saddle loop, Diamagnetic loop, Mirnov coil, Halo current monitor) | Jun-Gyo Bak (jgbak@nfri.re.kr) | • Rogowskii coil: 10kA ~1.0MA<br>• Flux loop: 45 ch, 1-10V<br>• Magnetic field probe: 84 ch, 0.001-0.03T<br>• Locked mode coil/Saddle loop: ~ 0.05 Wb<br>• Diamagnetic loop: 0.1 – 10mWb<br>• Mirnov coil : @ 100 kHz (default)<br>• Halo current measurement : 32 ch |
| Fast Reciprocating Probe | | • SOL profile(4ch), Te < 100eV, ne < $2x10^{19}$ $m^{-3}$ |
| Fixed probe array | | • Poloidal profile of ion saturation current (bottom side :default) |
| Visible cameras 1,2 | Hanmin Wi(hanmin@nfri.re.kr) | • 210 fps |
| Visible survey spectro. | Yong Un Nam (yunam@nfri.re.kr) | • 5 ch / 20 Hz (narrow), 1 ch / 50 ch (wide), 200-800nm |
| Visible bremsstrahlung | | • Tor. 10 ch, Pol. 7 ch, 10kHz |
| D-alpha monitor | | • Tor. 20 ch, Pol. 20ch, 20kHz ~ 500kHz (on req.) |
| Filterscope | | • Tor. 8 ch, Pol 4 ch, (C, O, etc), 20kHz |
| Thomson scattering | Jong-Ha Lee (jhlee@nfri.re.kr) | • 31 ch, 20eV~20keV |
| ECE radiometer | Kyu-Dong Lee (kdlee@nfri.re.kr) | • 76 ch, 78-162 GHz, 0.1-5 keV |
| mm-Wave interferometer | June woo Juhn (jwjuhn@nfri.re.kr)<br>Kwan Chul Lee (kclee@nfri.re.kr)<br>Yong Un Nam (yunam@nfri.re.kr) | • Line-integrated density : $5x10^{17}$ - $5x10^{19}$ $m^{-2}$ |
| TCI(Two-color interferometer) | | • Up to 3 tangential channels. Tangency radii will be announced again. |

| | | |
|---|---|---|
| Edge reflectometer | Seong-Heon Seo (shseo@nfri.re.kr) | • 3 ch, (Q, V, and W bands, $7x10^{19}m^{-3}$) |
| CES (charge exchange spectroscopy) | Won-Ha Ko (whko@nfri.re.kr)<br>Hyungho Lee (jdfm@nfri.re.kr) | • 100eV-20 keV, 4km/s ~ 500 km/s<br>• Tor. 32ch, Pol. 16ch |
| XICS (X-ray image crystal spectroscopy) 1, 2 | Sang Gon Lee (sglee@nfri.re.kr) | • Te,Ti : 300eV – 4 keV; Vt 10 – 500 km/s (Ar) |
| MSE | Jinseok Ko (jinseok@nfri.re.kr) | • 25 ch, q profile |
| Spectral MSE | | • $\Delta t$ = 350 msec with 2 Hz, 8 ch |
| ECEI (electron cyclotron emission imaging) 1, 2 | Jaehyun Lee (jaehyun@nfri.re.kr) | • ECEI 1: Dual poloidal images of Te. Vertical span = 25~50cm. Radial span (total) = 10~25cm, Radial range = 180+/-50cm. Bt range = 1.8~3.5T Sampling rate/span = 500kHz ~ 2MHz (10s~2.5s)<br>• ECEI2: Single poloidal image of Te (18.5 deg toroidally separated from ECEI1). Vertical span = 25~50cm. Radial span (total) = 10~25cm, Radial range = 180+/-50cm. Bt range = 1.8~3.5T Sampling rate/span = 500kHz ~ 2MHz (10s~2.5s) |
| RF Spectrometer | Gunsu Yun (gunsu@postech.ac.kr)<br>Minho Kim (minhokim@nfri.re.kr) | • Channel (center freq., MHz) : 40, 60, 100, 150, 200, 250, 300, 400, 500, 600, 700, 800<br>• BW : 10% of the center freq., dt > 10$\mu$sec |
| MIR (microwave imaging reflectometry) | Woochang Lee (wclee@nfri.re.kr)<br>Don-Jae Lee (djlee124@nfri.re.kr) | • 4 x 16 ch (radial x poloidal)<br>• Radial range = center to outer edge (depending on density and Bt). Poloidal coverage ~ 10 cm centered at midplane. Sampling rate = 500 kHz (20 s) – 4 MHz (2.5 s) |
| BES (beam emission spectroscopy) | Yong Un Nam (yunam@nfri.re.kr)<br>Jae-Wook Kim (ijwkim@kaist.ac.kr) | • 4 x 16 ch, $1cm^2$ spatial res., 500kHz bandwidth<br>• Measuring position can be adjusted |
| PFAA (Poloidal Filtered AXUV Array) | Juhyeok Jang (jjh4368@nfri.re.kr) | • 2 arrays in D-port, 2 arrays in O-port<br>• 20 ch. per array (for tomography), <1MS/Sec<br>• SPI radiation detection |
| TFAA (Toloidal Filtered AXUV Array) | | • 4 arrays inside vacuum vessel<br>• 1 ch. per array, < 1MS/Sec<br>• SPI radiation detection |
| Survey IRTV | Dongcheol Seo (dcseo@nfri.re.kr) | • 0-1500 ℃ |
| Divertor IRTV | Hyungho Lee (jdfm@nfri.re.kr) | • 1 kHz full frame rate available (frame rate can be increased up to 10 kHz with reduced viewing region)<br>• Time resolution or viewing region can be adjusted as requested |
| AXUV | Seungtae Oh (stoh@nfri.re.kr) | |
| IRVB | | |
| Fast ion loss detector (FILD) | Junghee Kim (kimju@nfri.re.kr)<br>Jeongwon Yoo (jwyoo@nfri.re.kr) | • $D^+$ 40~500 keV, pitch-angle: 10-87°, max. 2000 fps (CMOS), 2 MS/sec (PMT) |
| Fast ion D-alpha (FIDA) | | • Commissioning, 8 ch / array, 2 arrays, mid-plane tangential views for NBI1 |
| VUV survey spectrometer | Younghwa An(younghwaan@nfri.re.kr) | • 15 - 60 nm, Time resolution: 10 ms |
| Hard X-ray monitor | Hee-Soo Kim (hskim21@nfri.re.kr) | • NaI(Tl) Scintillator |
| Neutron Diagnostics | Young Seok Lee (yslee@nfri.re.kr)<br>MunSeong Cheon (munseong@nfri.re.kr)<br>Hee-Soo Kim (hskim21@nfri.re.kr) | • He counter 3ch, fission chamber 3ch, neutron spectrometer<br>• Neutron camera, flux monitor, activation system |

## 1. Scope and requirements for participation in KSTAR joint experimental research

○ KSTAR joint experiment research

- As the KSTAR device is utilized as a joint experimental device in which both domestic and international researchers participate, the purposes of the KSTAR device are to resolve salient issues of the world fusion community and to raise the capability of domestic fusion research through it.
- The KSTAR device offers the joint researchers all the required circumstances for the joint experiments to fulfill these purposes.
- The joint researchers can participate in experiments and analyze the obtained data. Furthermore, they can develop, install, and operate equipment such as diagnostics for creative research.

○ Requirements for participation in joint experimental research

- Basically, the KSTAR device supports the collaboration of both domestic and international researchers as much as possible.
- It shall conclude a Memorandum of Understanding (MOU) with each collaborating institution in order to assure the quality of the experiment operations and the outcome of research.
- International and domestic collaborating institutions can also participate in the KSTAR joint experiments.
- Access to KSTAR network and experimental data will be granted after the Non-Disposal Agreement (NDA) is submitted to National Fusion Research Institute (NFRI).

○ Process of participation in joint experiments

- The following two items should be submitted to the NFRI in proposal form:
  (1) A detailed plan of the joint experiments; and
  (2) Names of participating researchers and a list of required resources.
- The KSTAR Experimental Committee (Project management and TF/WG leaders) shall review the submitted proposals, coordinate the KSTAR operation schedule, and assign the resources. If necessary, the committee can request another relevant department to analyze and review the proposals.

## 2. Support to conduct the KSTAR joint experimental research

○ Support from NFRI

- NFRI offers all available conveniences to external collaborators for successful research.
- Basically, NFRI pays all the expenses accompanied with operation and management of the KSTAR device and the equipment.
- NFRI properly offers the offices and use of internet and telephones which are needed for the long-term stay of external collaborating researchers for the performance of their assignments.

○ Support from joint research institutions

- Responsibility for payment of personnel expenses such as salary, research expenditures, travel expenses, living expenses, and insurance of the researchers who participate in the joint experiments belongs to the assigned institution.
- Basically, all expenses related to installation and development costs of equipment accompanying the joint experiments belong to the relevant research funds and the assigned institution, provided that the expenses

concerning the interface to the KSTAR device and the equipment can be supported by NFRI in accordance with the mutual agreement.

- In the case of computers and software required for joint research, the assigned institution provides them as a rule, provided that NFRI's internal resources can be shared depending on the researcher's participation or assignment details.

## 3. Safety supervision of KSTAR joint experiments

○ Access to KSTAR experimental equipment and safety supervision

- During the visits, the participants of joint experiment research are under an obligation to fulfill the NFRI regulations for the security of the KSTAR device and safety supervision.
- NFRI shall offer the orientation required for use of KSTAR research equipment such as electrical, fire, and radiation safety and network security. The external researchers should participate in this orientation.
- As a rule, the researchers and the assigned institution are responsible for all personnel and/or financial losses derived from carelessness of the joint researchers.

○ Quality assurance of the installation of joint experiment equipment

- For installation and utilization of the equipment developed for joint research, it is necessary to have the review and approval of NFRI's quality control. The external researchers are required to cooperate with this review.
- As a rule, the equipment installed on KSTAR for joint research is open to other researchers who participate in KSTAR joint experimental research.

## 4. Outcome management of KSTAR joint experimental research

○ Management of experimental data

- All raw data from the experiment belong to NFRI in principle.
- All experimental data from joint research are available to the other KSTAR joint researchers.

○ Conference presentations and submission of papers of the results of joint experimental research

- The right of a joint researcher to be the first author has to be respected for the results of KSTAR joint experimental research.
- The experimental data and the analyzed results from joint experimental research should be investigated and approved through NFRI's courtesy review prior to public disclosure in addition to the review process of the researcher's group and assigned institution.
- Although the research is related to the KSTAR device, the research equipment and analysis resources are mainly offered by external institutions, so that the relevant courtesy review can be performed by the relevant institution. (Even in this case, the results from experiments are supposed to be reported to the KSTAR administrative committee without undue delay.)

○ Right of intellectual property derived from the results of joint experiments

- In principle, NFRI has joint ownership on the right of intellectual property such as patent applications and merchandising of the results from joint experimental research.
- The partition of the right of intellectual property can be coordinated according to the national R&D regulations and mutual agreement between the relevant institutions.