Summary of the 11th IAEA TM on Control, Data Acquisition and remote participation in fusion research

A. Winter on behalf of the program committee
Some statistics:

• 106 registered participants from Europe, Asia and the US with 25 nations represented

• 56 posters and 47 oral presentations of which 3 were invited talks
Plasma Control – 3 scales, 3 Continents

• 18 orals, 20 papers
• 3 new (or massively upgraded) machines came online within the last 2 years – SCR-1, WEST and W7X
  – Overview and first results of CODAC for Wendelstein 7X
  – Status of the WEST control system
  – Control and Data Acquisition System for SCR-1 Stellarator
• PCS–plant co-simulations was proposed for ITER through various case studies and experience at DIII-D. Requirements for prediction/reproduction accuracy are pointed out.
Plasma Control – "from East to West"

- Development and results from EAST, KSTAR, QUEST, TCV and DIII-D
  - PCS upgrade at EAST for radiation heat load control toward SSO with reduction of divertor heat loads in quasi-snowflake discharges.
  - KSTAR is adopting ITER technologies for networks
  - Upgrade of PCS at QUEST for long pulses – wall temperature Invited talk on divertor control at DIII-D
  - TCV adopted ELM pacing with vertical kicks in H-mode

- Trends:
  - FPGA application for fast control or timing synchronization is now a definite technical trend.
  - Divertor control is one of the “hot topics” in plasma control.
  - Systems are starting to use GPU-based fast/real-time computations for plasma feedback control.
  - ATCA, microTCA, and virtual reality are used in a number of places.
Plasma and machine Control for ITER

• A dedicated session for ITER PCS development present and future
  – Preliminary design is complete – Overview, architecture and event handling presented
  – Outlook to final design ~2020

• A second session on machine control for ITER
  – Final design of the real-time infrastructure is complete and now in the implementation phase with public release early 2019
  – Overview of the ITER Interlock system
  – Integration of the electrical network I&C into CODAC – 2 main components (PPEN and SSEN) with 40 subsystems using S7 PLCs, IEC 61850 and CODAC Core System
  – Support of I&C Integration using the ITER Control System Model

• Bottom line: Integration of plant system I&C has really started and PCS is moving forward through its design phases
Machine Control, Monitoring, Safety and Remote Manipulation

- 7 oral presentations, 3 posters
- Details on the W7X CODAS system – integration of user models as plug-ins to the CODAS infrastructure
- Upgrade of the Integrated Radiation Monitoring and Interlock System for the LHD Deuterium Experiments
- Status update on the I&C system for the Neutral Beam Test facility in Padova
- Plus one session on ITER related machine control
Tour of W7X
Data Acquisition & Signal Processing

- 4 oral presentations and 14 posters
- Sophisticated electronic design (detector-preamp-ADC) to avoid noise interference. (U3M)
- DAQ and online processing in strong radiating conditions at ITER neutron diagnostics
- DAQ & processing framework for LINUX FPGA SoC
- Integrated Data Analysis - Concept & Applications
DAQ & Signal Processing Trends

• Quite a number of dedicated solutions for special problems in 14 poster contributions:
  • a number of ITER developments
  • renewal of diagnostics at existing machines
  • dedicated board and form factor (ATCA) developments
  • special functions - hot plug-ability, FPGAs,
  • video DAQ and corresponding tools including immersion into mechanical machine models
  • algorithm developments: compression, discrimination, FPGA adoption
Database Techniques for Information storage and retrieval

• 10 oral presentations and 6 posters
• description of continuous data acquisition on W7-X
  – History, current solution (GPFS) with focus on scalability
• Web based live data monitoring
  – Distributed architecture for live data displays with Low Latency, scaling through adding intermediate nodes replacing the Multicast based tools
• Study of Data and Statistics and Retrieval for EAST MDSplus Data System
  – Overview of EAST Data amounts and performance and its tools to mine statistics about data system and populate database and viewers / browsers for the collected data
Database Techniques for Information storage and retrieval

• ITER Unified Data Access (UDA)
  – Description of libraries to access heterogeneous ITER data stores
  – Distributed meta data indexers
  – String based data request descriptions (URIs)

• Evaluation of the ITER Data Archiving Network API on the DIII-D Tokamak
  – Testing at DIII-D which was successful and DAN API was found to generally work well with the usual issues you find during testing
  – Important to do these real tests
Storage

• MDSplus Yesterday, Today, and Tomorrow
  – History of MDSplus given – 31 years and going strong with improvements underway

• Hierarchical Dynamic Containers for Fusion Data
  – A new runtime oriented library for exchange of tree structured scientific data among different threads/processes/cluster nodes with language support for C, C++, Fortran, and Python

• Distributed Database for Future Fusion Data Management
  – J-TEXT Cloud Database (JCDB)
  – MongoDB combined with a distributed storage engine (Cassandra)
  – Modular with plug-ins for different data types & metadata management functions
Storage

- TokSearch - A Search Engine for Fusion Experimental Data
  - API for performing principled, parallelized search and analysis over many shots and initial studies have demonstrated horizontal scaling

- Navigational Data Management
  - Creating the next level of abstraction for data management
  - Tools to describe the relationships between heterogeneous data artifacts and data discovery through the exploration of the graphs constructed with these tools
  - Not science domain specific - applicable to a wide variety of subjects/datasets
advance computing and massive data analysis

• 2 oral contributions and 6 posters
• MARCONI FUSION: The new High Performance Computing Facility for European Nuclear Fusion Modeling
  – HPC facility delivered in 2 phases (1 PFlop in operation since July 2016, and 5 PFlops foreseen for July 2017)
• Methodology for the Implementation of Real Time Image Processing Systems Using FPGAs and GPUs
  – FPGA based signal acquisition from the camera
  – Integration using nominal device support as abstraction layer
• Poster focus on Off-line data analysis, processing and visualization which require the implementation of automatic feature extractions in the massive fusion databases
Remote Participation and Fast Network Technology

• 6 oral contributions and 5 posters

• Status update on the ITER remote experiment center
  – project now complete at Rokkasho as machine agnostic remote control room

• Presentations on Assessing Remote Data Access for ITER REC (long distance data sync issue) and on-Demand file transfer (over long distance via multiFTP)

• Remote Operation of EAST (from San Diego)
  – 3 shift operation with remote control room at DIII-D
  – Works well but still requires on-site support at EAST

• Posters emphasize Web techniques and Virtual Reality
Remote Participation and Fast Network Technology

• Real-time Internode Communications using PCIe for NSTX-U
  – Increase of demand for large tightly coupled computation power for real-time applications limited by availability of cost effective hardware.
  – Use of PCIe interconnects demonstrates a low jitter and low latency solution which allows flexible scaling of computing power

• Inter-application Communications for short consecutive discharges on LHD
  – Overview of the various types of network communications used both implicitly and explicitly with their pros and cons.
  – Choice of the communications technologies depends on the application but also the scale of the data transfers required
Last but not least…

• The local organizing committee with Hans-Stephan Bosch and his team did an outstanding job at hosting this meeting.

• A special thank you to Mareen and Andrea – this would not have been possible without your outstanding support.

• The IAEA – as always - provided excellent support in the organization of this conference. A big thank you to Sehila Gonzalez de Vicente and the agency for their support in realizing this conference.

• Apart from the rich and interesting scientific program, the discussions and poster sessions, we had an excellent time in Greifswald.

Thank you to the local organizing team
A walk down memory lane to the ancestors of modern control...
Also intense discussions on material science