



Remote Experiment with WEST from ITER Remote Experimentation Centre

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Outline

- Introduction - Background
- Preparations
- Remote Experiment
- Feedback - Lessons learnt
- Summary

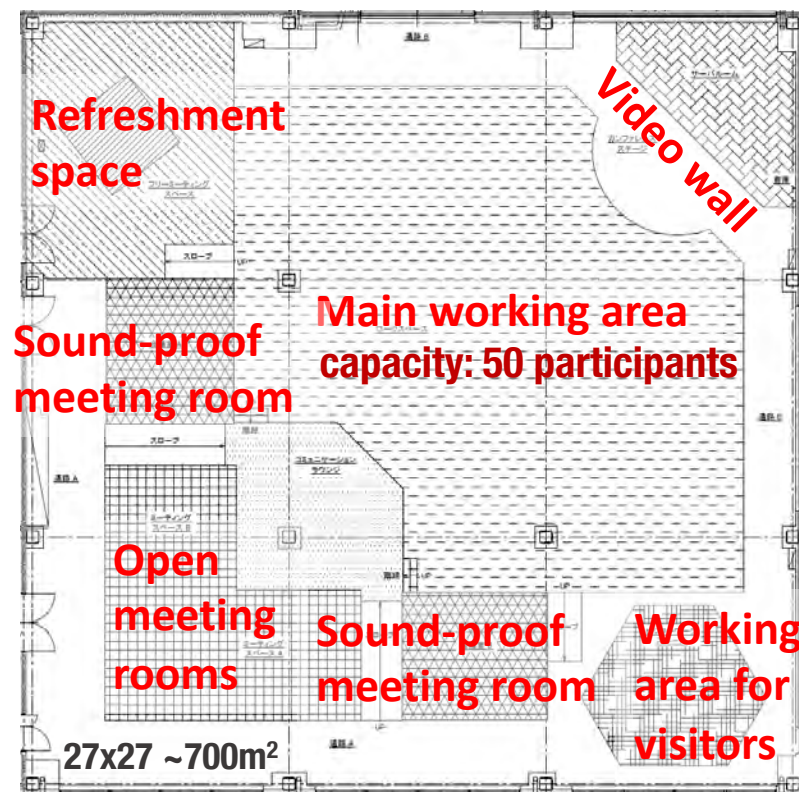
Background

- A large number of fusion researchers are living thousands km away from ITER. **Remote Participation (RP) technology will be essential to promote effective global research activity in ITER.**
- **ITER Remote Experimentation Centre (REC)** has been constructed in Rokkasho, Japan. It is a sub-project of International Fusion Energy Research Centre (IFERC) as part of the **Broader Approach (BA) activities between JA and EU.**
- As an important milestone of the REC project, **RP test with WEST tokamak** was implemented.
- **WEST is located in CEA Cadarache next to IO site.**
WEST-REC test is a precious opportunity to have a practical experience in a similar situation as RP to ITER.

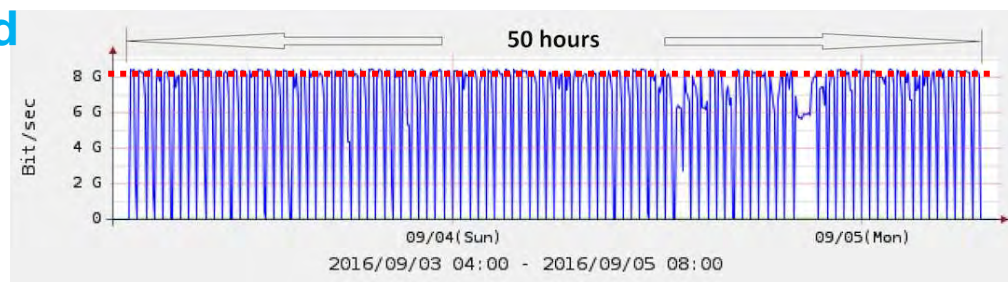
Introduction

ITER Remote Experimentation Centre

- Construction of REC has been completed in 2017. [Data transfer tests](#) from ITER (2016) and JET(2018), a [function test](#) with JT-60SA (mock test with control system) (2017) and a [remote experiment test](#) with Univ. of Tokyo: TST-2 (2017) have been carried out.



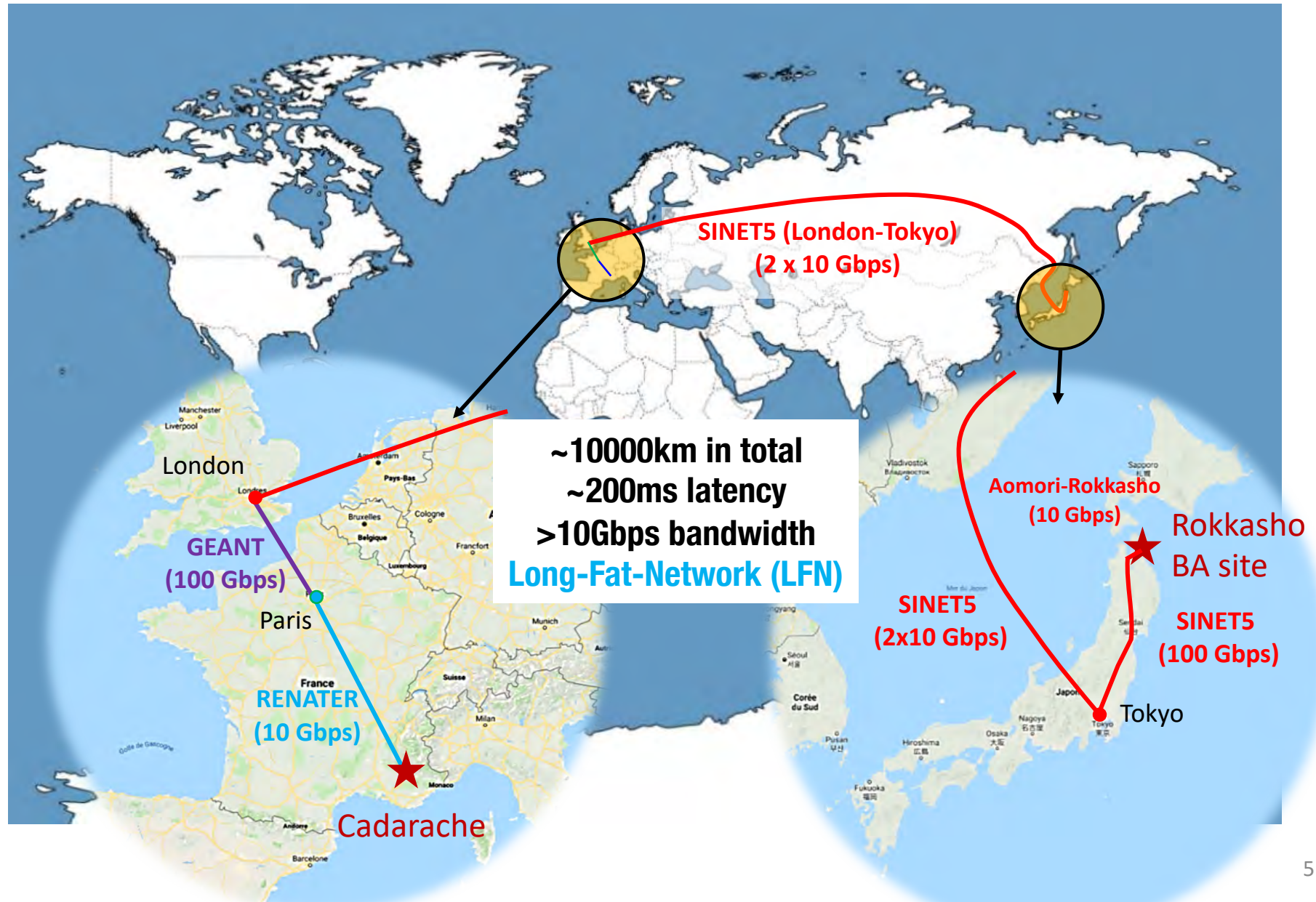
- Its system is connected to [high-speed scientific network SINET5](#).
- Using **MMCFTP**, average 7.9 Gbps data migration speed within 8 Gbps bandwidth via L2VPN connection from ITER to REC had been proved. 105TB data was transferred in 50h.



Data transfer test from ITER (2016)

Preparation

Connection between WEST and REC

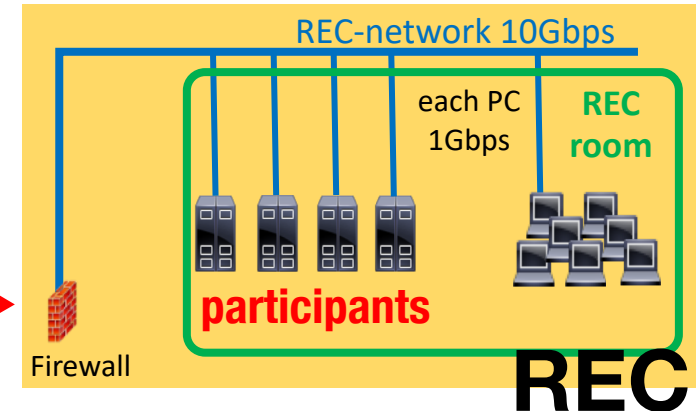
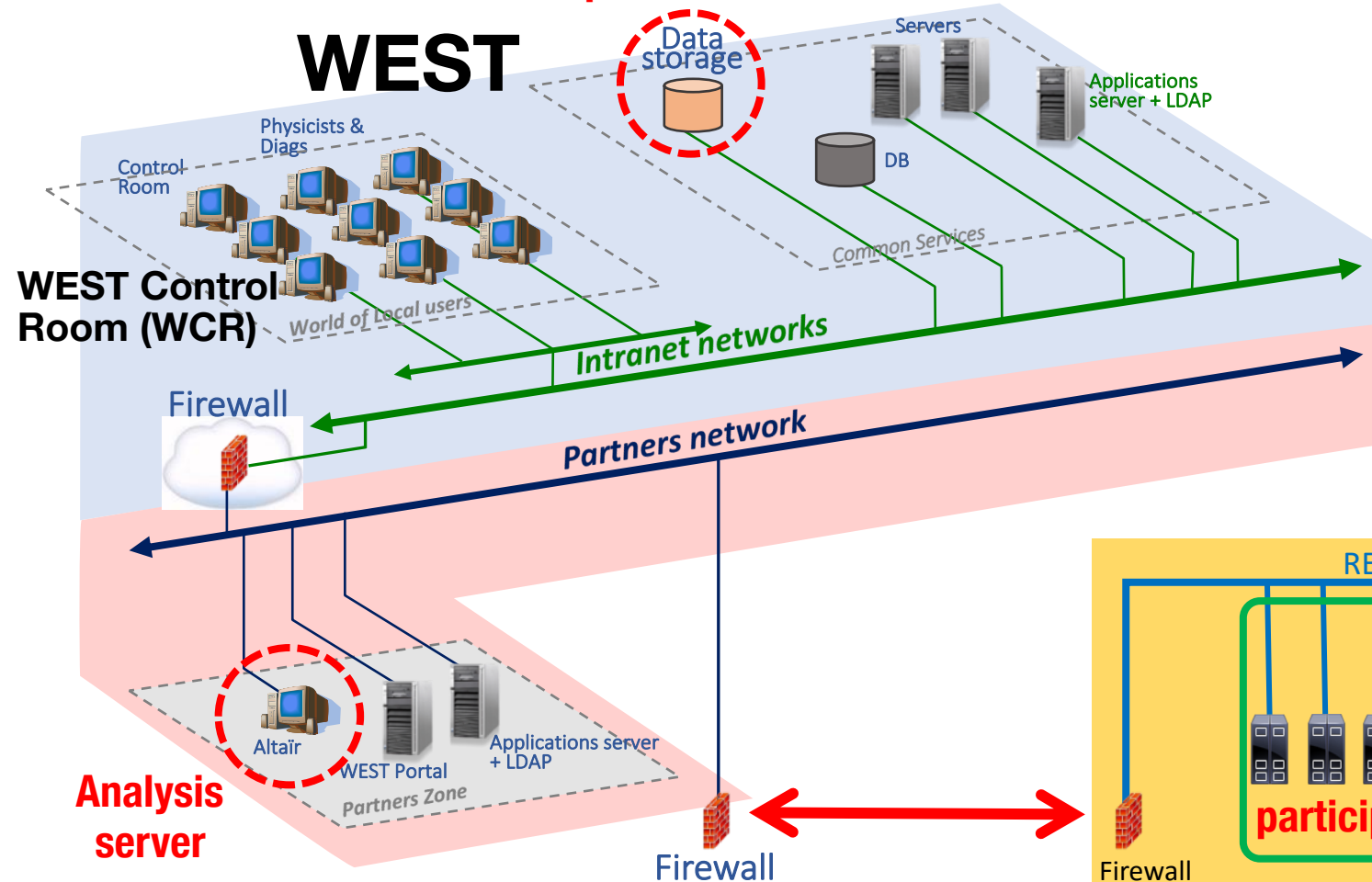


Preparation

LAN in both sites

Experiment data

WEST



Connection from external users to the partner zone performed through a firewall

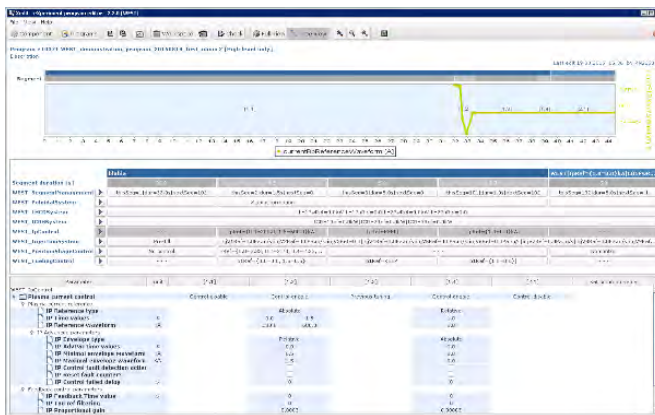
Remote Experiment



Remote Experiment

1. Pulse Preparation

- This remote experiment was devoted to test the ITER plasma-facing components and their shaping under high heat flux. Three pulses were made considering the previous pulse result.
- Pulse schedule editor on Altair was operated from REC based on RCA manner using NoMachine.
- The remote Session Leader (SL) edited pulse from REC successfully.** No supplementary editing task by local SL in WCR was needed. The scheduled pulse was executed **after check and approval by the EiC in WCR.**
The Pulse schedule Editor was smoothly operated from REC.
- The latest **machine status information** (available diagnostics and actuators) were provided via **WOSS (web)** running on the WEST portal server.



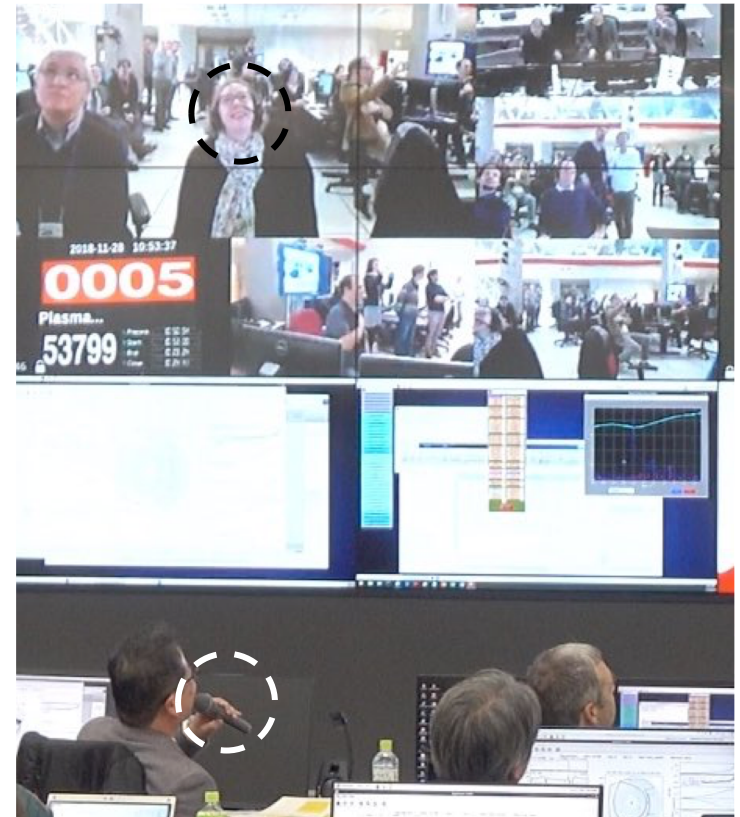
Pulse schedule editor (Xedit) on Altair

DPILOTE	DBARO	DBOLO	DGAZ	DGENE
DHALLP	DHYB	DINTM...	DINTRP...	DIR1
DIR3	DIR4	DLANG	DMAG	DMAG...
DNEUT...	DPOLO	DREFL...	DREFR...	DSIR
DSURVIE	DTURB	DVECE	DVIDEO	DVIS
DVIS1	DVIS2	DVIS4	DVME1	DVSPX
DWMS				

WOSS diagnostic status
available via web browser

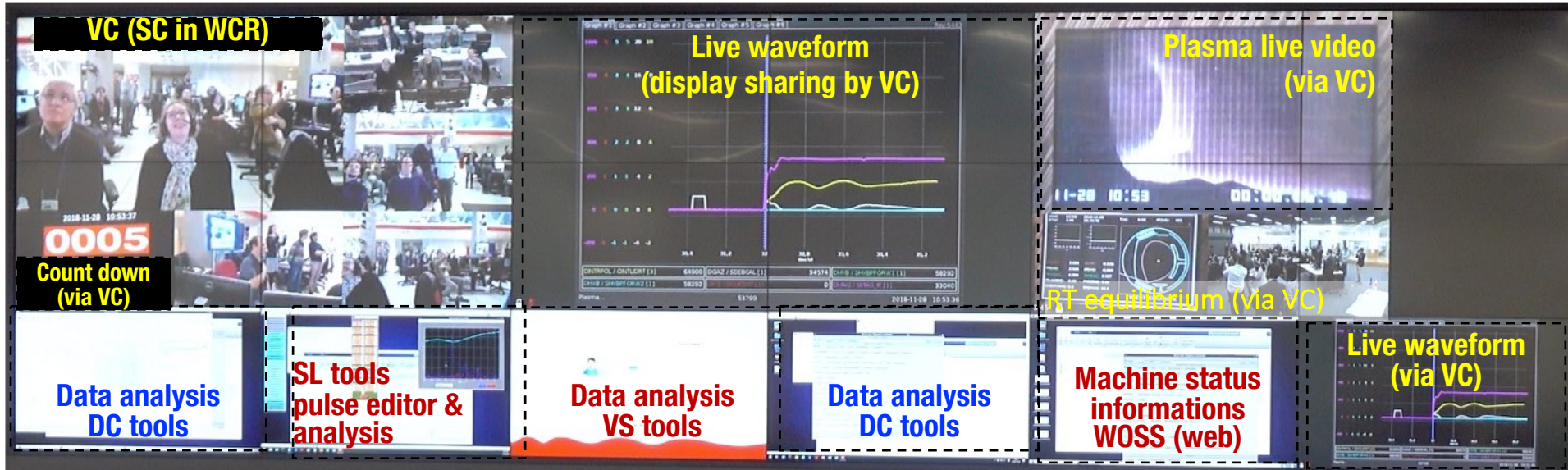
2. Human Communications

- **Capability of face-to-face discussion is indispensable** for researchers.
- Communication between WCR and REC had been enabled by VC systems (fusionTV and Skype).
- **Headsets** prepared for the local SL & scientific coordinator (SC) in WCR worked well for discussion with remote SL and researchers in REC.
- One-by-one communication between local and remote Data Acquisition experts (DAPs) by Skype also worked well. This kind of **specific role-oriented channel is useful**.
- Importance of noise control was confirmed.



Remote Experiment

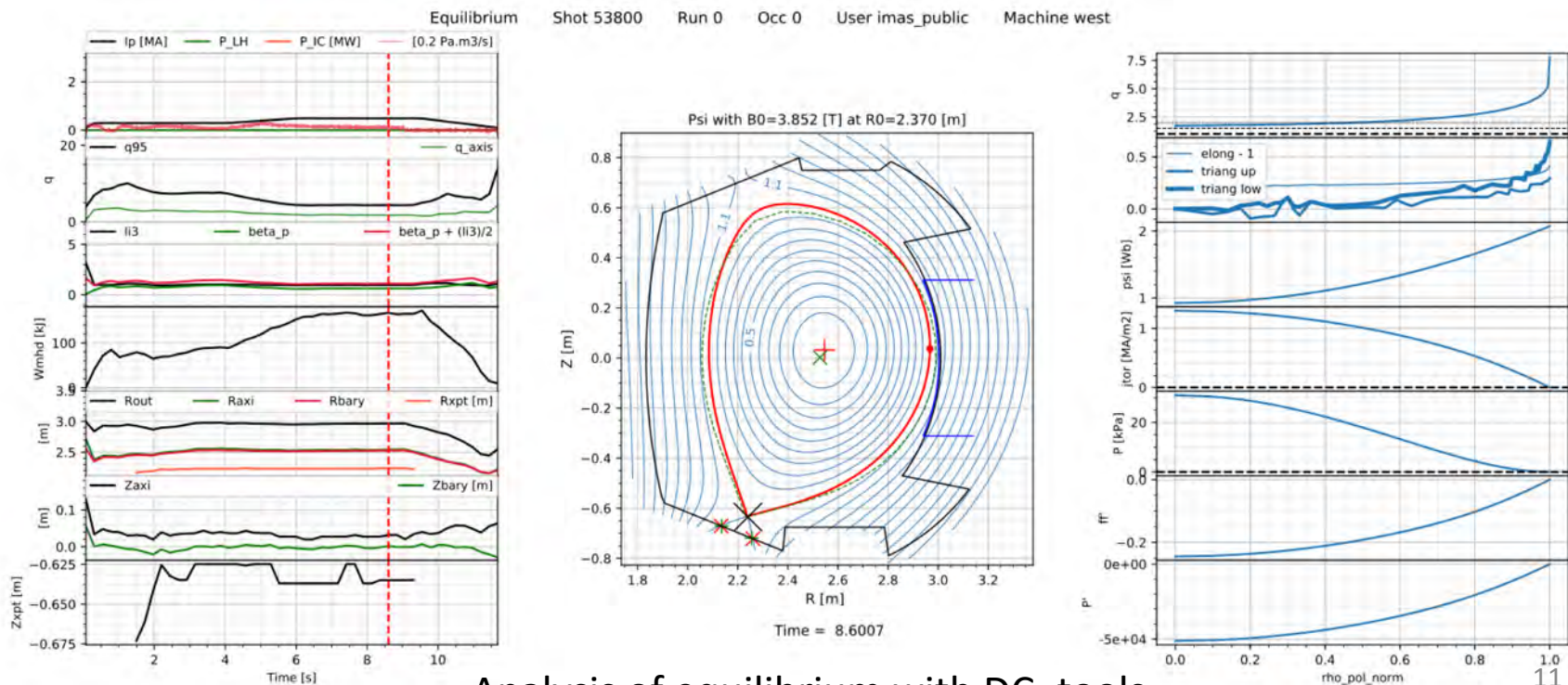
3. Live data monitoring



- The **live data being shown in WCR was also monitored on the videowall in REC** by display sharing function of VC system. Clear waveform was shown in remote site with sufficiently small time lag. **Flexibility for remote site to choose what to monitor** will be demanded in future.
- Latency of the **countdown** via WOSS(web) was not negligible. It was monitored via VC system (Re-photographed) with sufficiently small time lag.
- In-vessel **live camera view** was also monitored from REC using VC system. (Re-photographed).

4. Post-pulse data analysis(1)

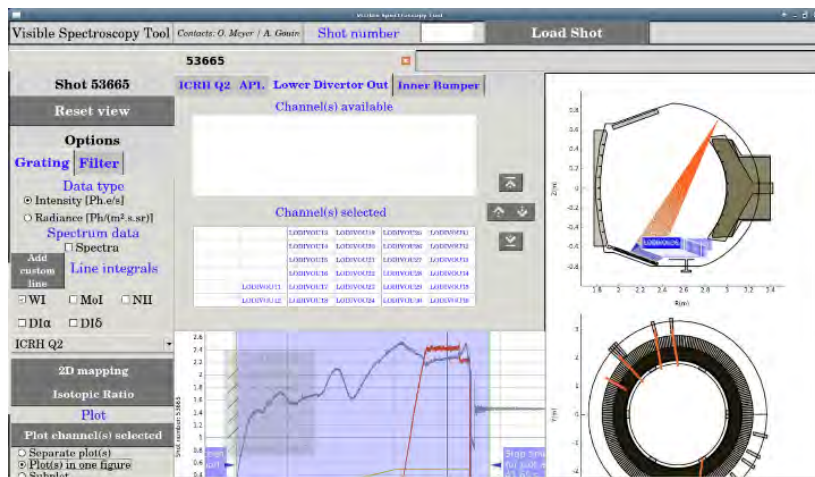
- **Post-pulse analyses were possible after ~5min** of pulse. (~2min for data acquisition, additional 3-5 minutes for post discharge data processing).
- **Intershot (~30 min interval) analysis was feasible** on Altair from REC.
- Variety of analysis software had been prepared on Altair. In particular, DC_tools (Matlab), Visible Spectroscopy tools (python), were extensively used. Analysis on equilibrium, transport, and so on were carried out.



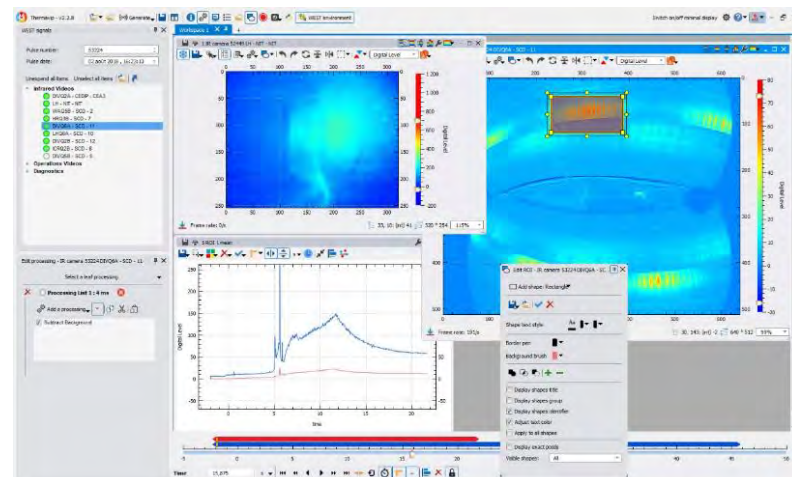
Remote Experiment

4. Post-pulse analysis (2)

- The latency of OS on Altair itself was sufficiently small. (RTT~200ms)
- However, delay of response of some visualization software was not negligible.
Computational load on Altair server for analyses by ~20 users simultaneously seemed to be large.
- ThermaVIP for wall temperature analysis was not capable as intershot analysis. Its **data was too large to download**, in other word, data throughput was insufficient for it.
- **TCP setting optimization for LFN will be important** to avoid degradation of throughput due to high-latency.
- **Firewall is one of the possible bottleneck of throughput** as well.



Visible Spectroscopy Tools



ThermaVIP (incapable in this REC test)

Feedback Lessons Learnt

- **Information about the phase of pulse** (checking, preparation, running, end of pulse and between pulses) should be available. What is going on in the other site is difficult to confirm.
- It was difficult to call the SC and local SL in WCR, when they were away leaving the headset behind to talk with the others.
→ **text message** and **notification** would be useful.
- **Display (plots) sharing capability for scientific discussion** based on analysis results will be useful, to say “Look at this”.
- “What the local control room wants to monitor” and “what the remote researchers want to monitor” would be different.
Live monitoring based on real-time data transfer will be preferable.
- **Sufficient computation resource for analyses** and **sufficient network throughput** used by **a lot of remote researchers simultaneously will be the key** for effective experimental studies by remote participants in future.

Summary

- **Remote experiment with WEST from ITER Remote Experimentation Centre (REC)** has been successfully carried out under the framework of **Broader Approach activities with cooperation of CEA/IRFM**. We obtained successful results and useful suggestions for future reference.
- **The latency** (<200ms) itself was not a serious problem for human action. However, the high-latency **can restrict the capability of analyses with large data in remote site by reducing throughput**. Firewall can be another possible bottleneck.
- **Sufficient computation resource of analysis server and sufficient network throughput for a number of remote participants** will be essential issues toward to RP to ITER. Distributed analysis system based on high-speed data transfer network would be reasonable.

Nov. 28, 2018



Thank you for your attention!!