RUSSIAN PROTOTYPE OF ITER REMOTE PARTICIPATION CENTER

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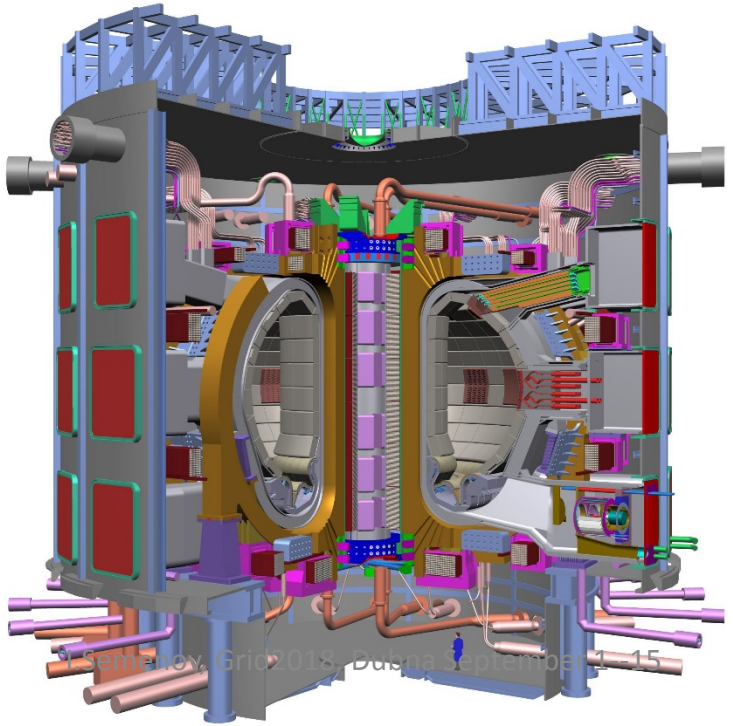
Work founded by Rosatom №Н.4а.241.9Б.17.1001

ITER

2008 Site preparation start
2025 First Plasma
2034 Start of D-T operation

European Union
India
Japan
China
South Korea
Russia
United States

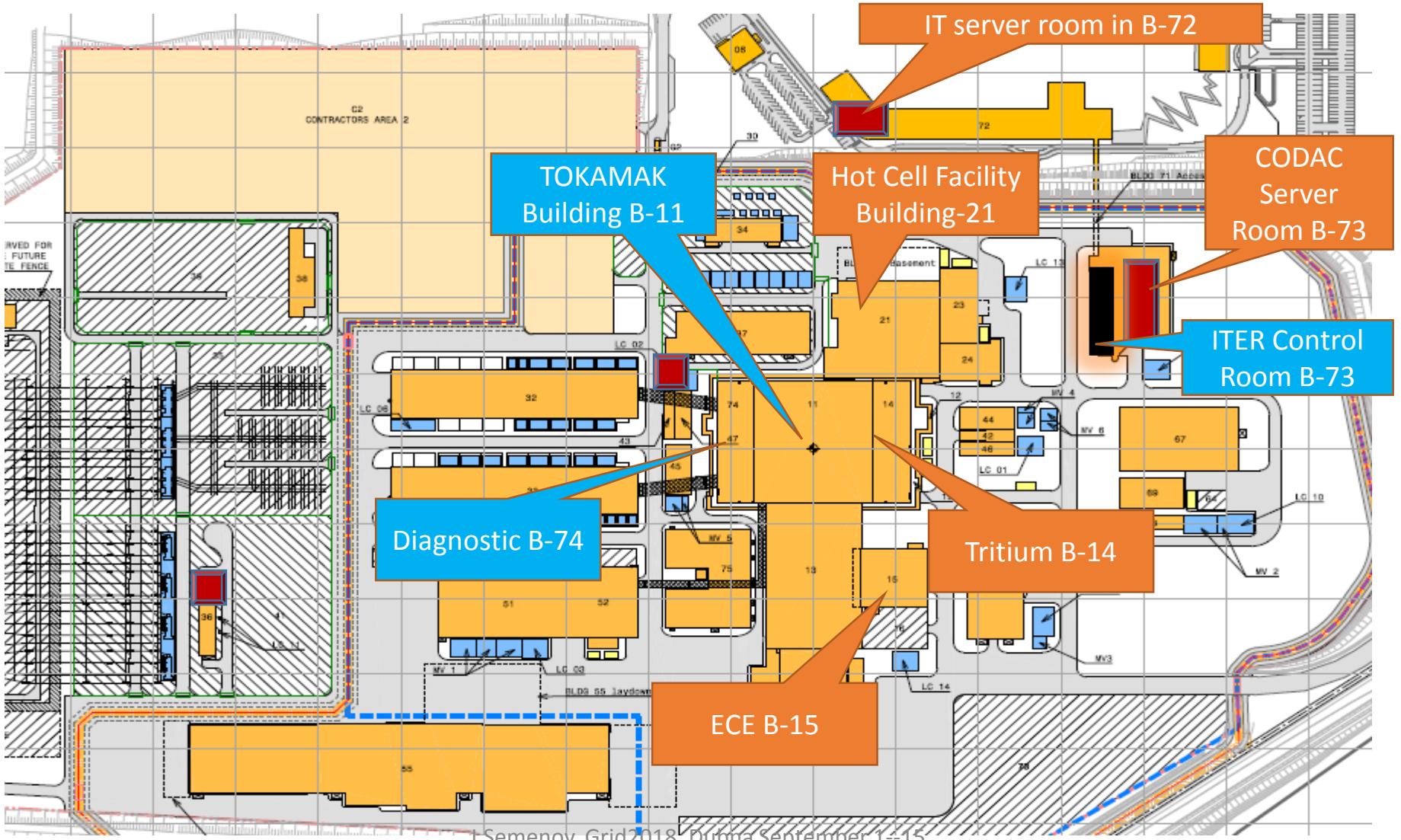
- R - 6.2 м
- a - 2.0 м
- Elongation – 1.75-1.86
- Plasma current- 15 MA
- Plasma volume- 815 $м^3$
- B_T - 5.3 T
- Pulse> 400 s
- On-off time ratio -1800 s



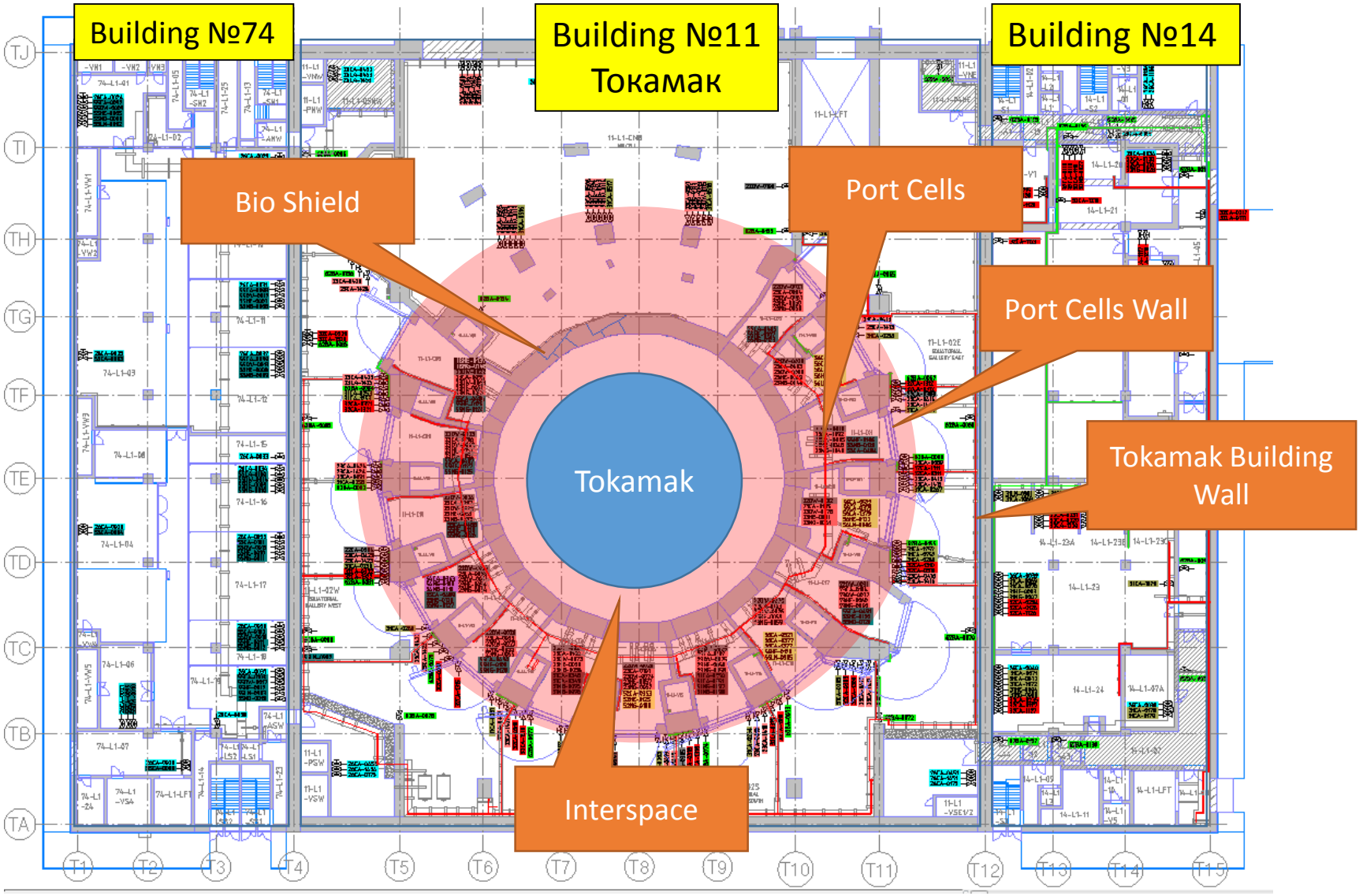
Fusion Parameters :

- Gas D+T
- $T_e=T_i=$ 15 keV
- $n_e=10^{20}\ m^{-3}$
- D-T Power – 500 MW

ITER SITE

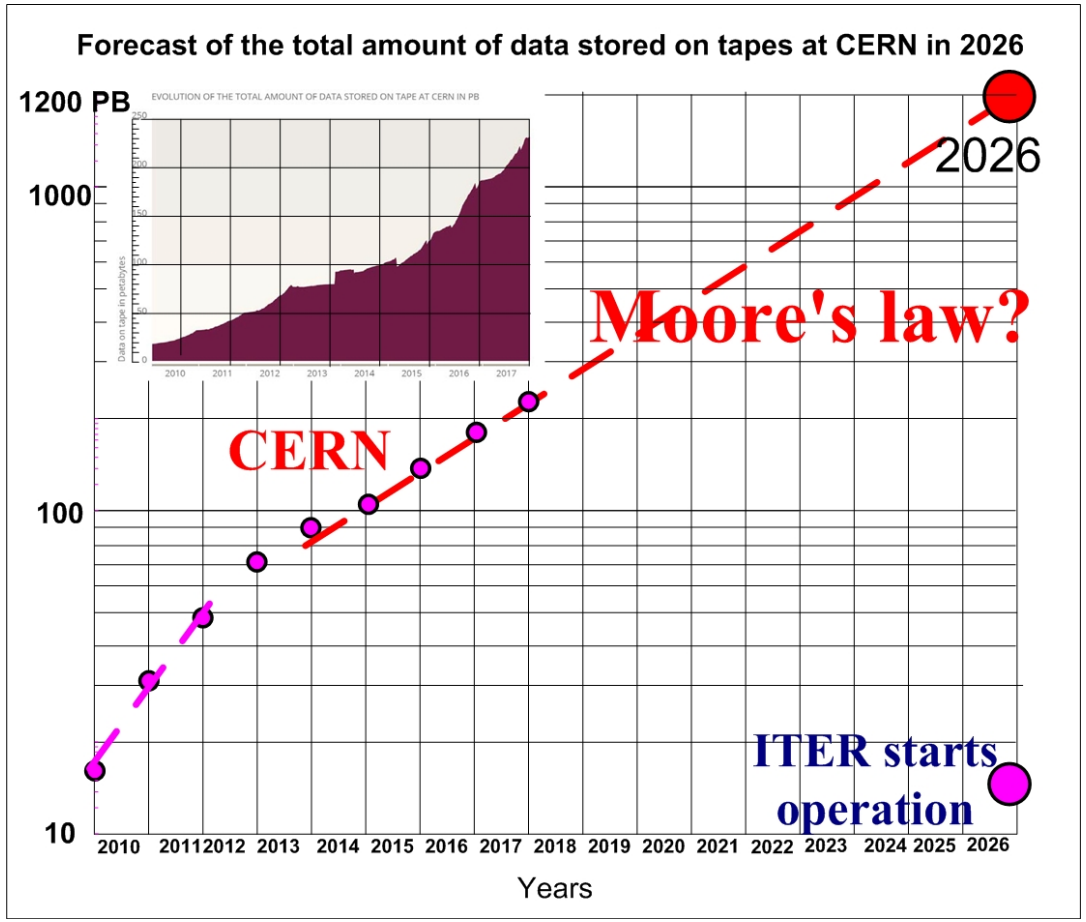

IT server room in B-72
TOKAMAK Building B-11
Hot Cell Facility Building-21
CODAC Server Room B-73
ITER Control Room B-73
Diagnostic B-74
Tritium B-14
ECE B-15

TOKAMAK Building




C5

ITER
Remote Experimentation Centre (REC)

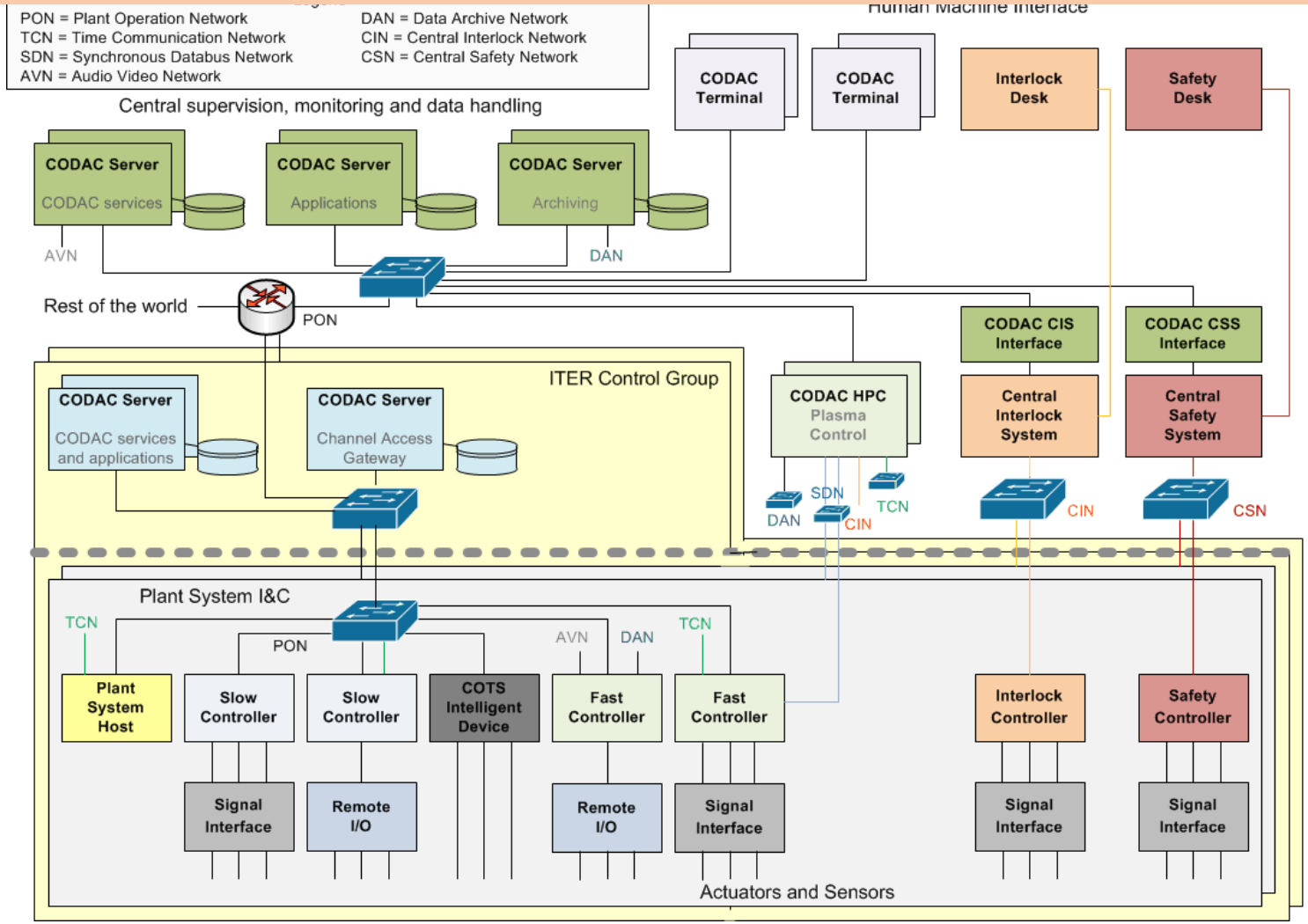


Moore's law proves that data amount & network speed increase 10 times higher in every 5 years.

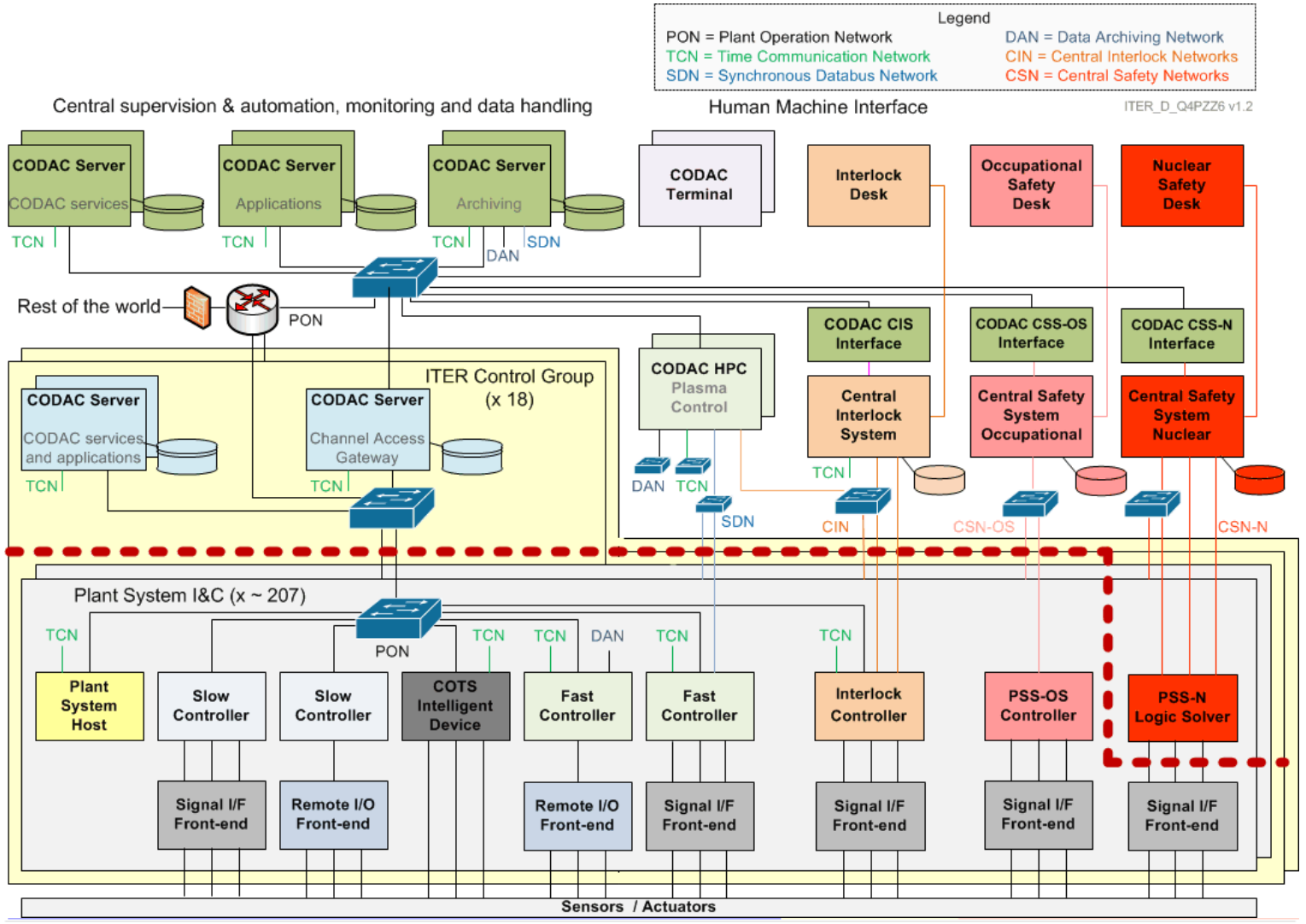
ITER I&C R&D are needed up to the first plasma.

CODAC

(CODAC – **CO**ntrol **D**ata **A**ccess and **C**ommunications)



CODAC Architecture



Main Challenges in Tokamak Operation Zone

Equpment Location. Some front-end electronics cannot be relocated outside operation zone of installation because of long cables induce noise on experimental signals.

Aggressive Environment. Sensors and front-end electronics located near ITER installation (Port Cells, Galleries) works in strong magnetic (~0.2 Tesla), neutron (~ 10^7 $n.cm^{-2}.s^{-1}$), and Hard X-ray fields. In addition, this equipment must have good electromagnetic shielding (EMC) because located near megawatt radiofrequency oscillators (up to 170 GHz).

Radiation protection of electronic parts. In ITER the number of different electronics parts in radiation zone is very large ~500, compared with about 20 different parts in ATLAS detector. Development of special radiation-hard electronics parts for ITER is very expensive and ***not appropriate for the project***.

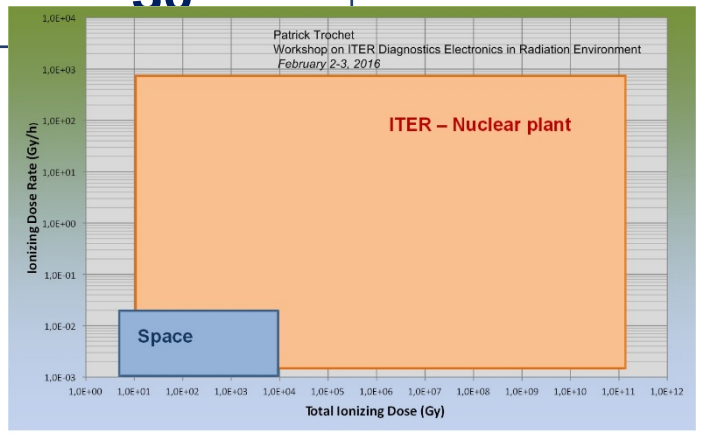
Networks restrictions. Some multi channel diagnostics generate huge amount of experimental data (~ 100-500 GB/sec) which have to be transmitted in to CCS in real time. Estimations show the required data transmission velocity is more than 10 times accedes the channel capacity of existing ETHERNET and computer buses (~10 Gb/sec). Also, it is necessary to take into account not only data transmission velocity but also latency and packets collision between plant system and supervisor and between plant systems.

Radiation and Magnetic Shielding Requirements (Port cell)

(Vincent Martin, *Work performed in the frame work of the F4E-FPA-407 contract)*

Non critical equipment

Radiation type	Radiation level at B11/L1/PC	Threshold for electronics from ITER policy*	**Needed Attenuation factor**
Total Integrated Dose (Gy)	10^3	10^1	**100**
Neutron Flux (n/cm^2/s)	10^5	10^2	**1000**
Static Magnetic Field (mT)	150	5	**30**



Radiation is MAIN HEADACH !!!

*IO IDM RAKTPP, values for non-critical electronics (QC>2)

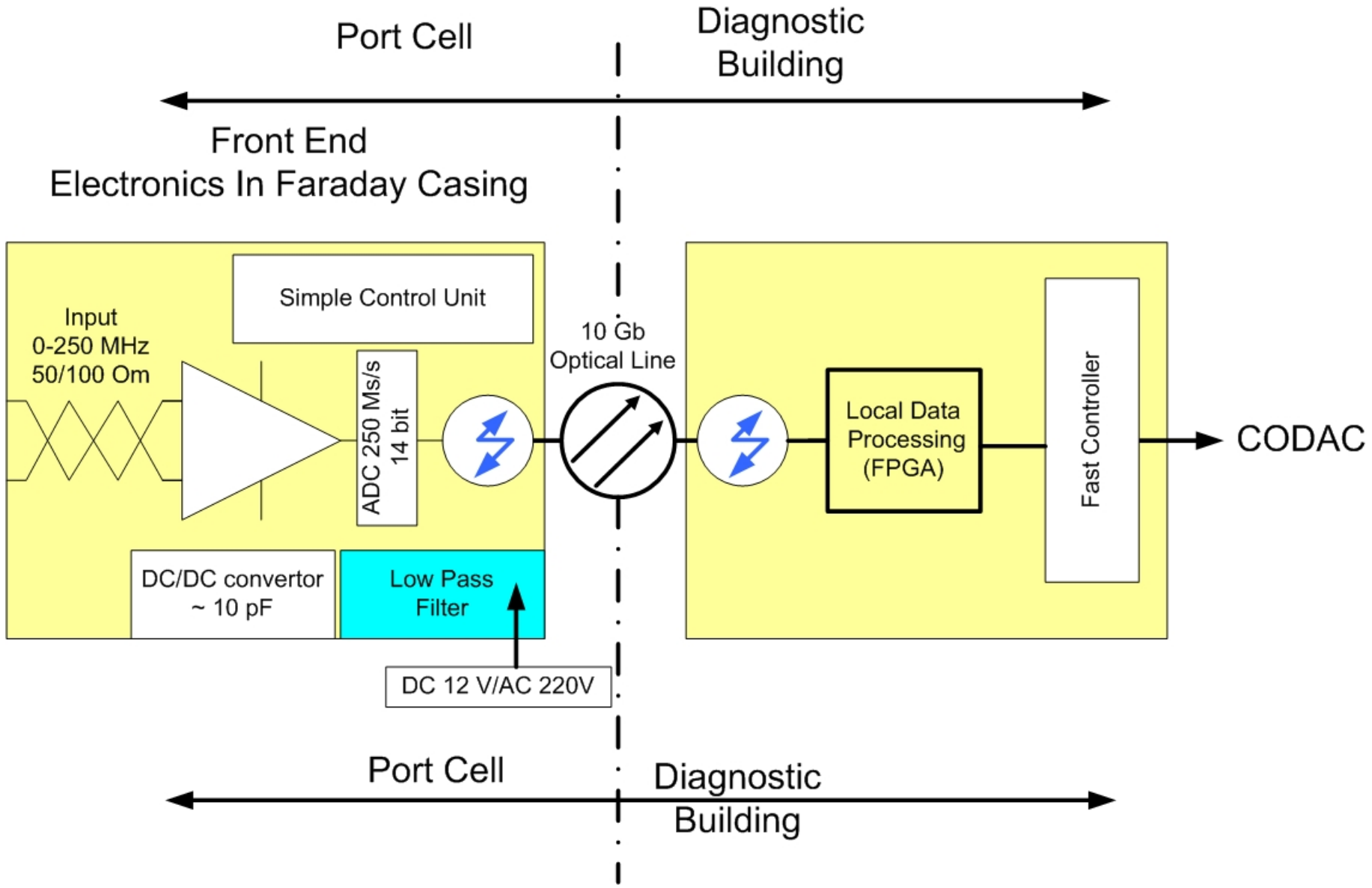
Local Shielding Design (Shielded cabinet)

(Vincent Martin, *Work performed in the frame work of the F4E-FPA-407 contract)*

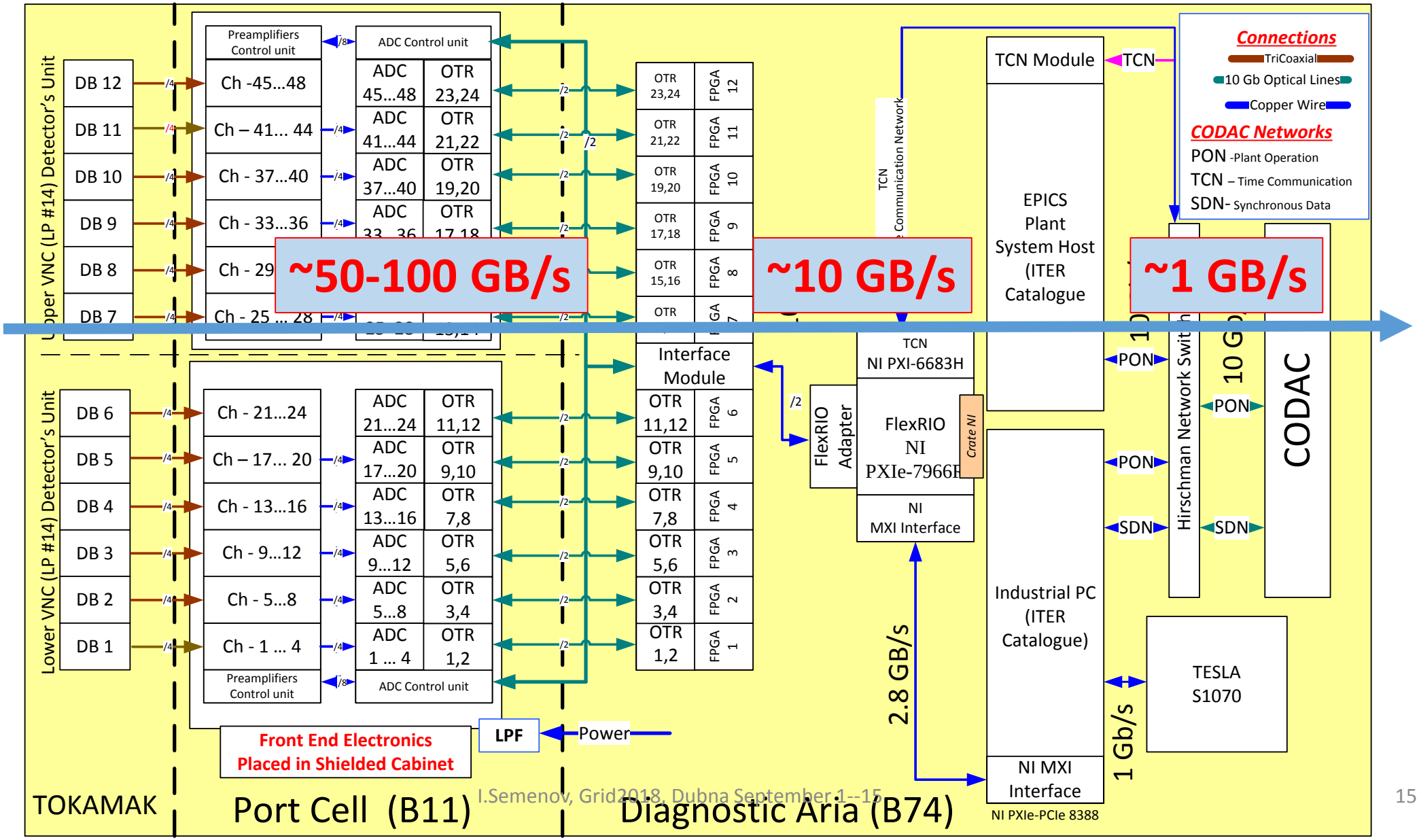
- Local shielding against neutrons: moderator for fast neutrons (e.g. polyethylene or concrete) and absorber for thermal neutrons (e.g. Cadmium).
- Attenuation of gamma dose rate: 7.5 cm of Tungsten for a factor 100.
- Shielding against magnetic field: pure iron

Non critical equipment

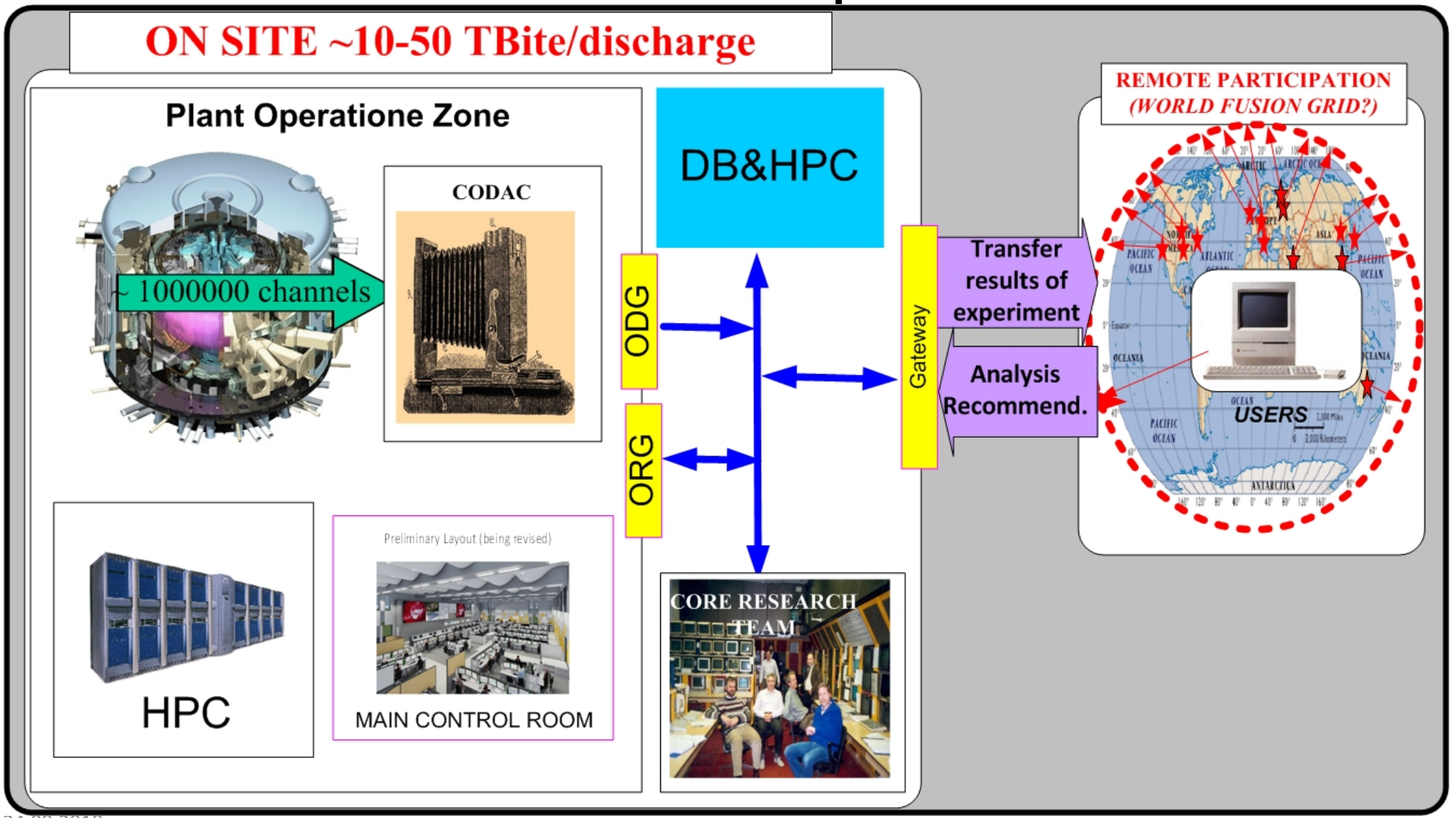
Layer # (from outside)	Cabinet Side	Composition	Thickness (cm)	Role
1	left, right and back	Concrete	5	Fast neutrons (14 MeV) moderator
	plasma side		30	
2	All sides	Cadmium	0.5	Absorber of thermalized neutrons
3	All sides	Tungsten	7.5	Attenuation of gamma dose
4	All sides	Pure Iron	2	EM shielding


Port Cell
Diagnostic Building
Front End Electronics In Faraday Casing
Simple Control Unit
Input 0-250 MHz 50/100 Om
ADC 250 Ms/s 14 bit
10 Gb Optical Line
Local Data Processing (FPGA)
Fast Controller
CODAC
DC/DC convertor ~ 10 pF
Low Pass Filter
DC 12 V/AC 220V
Port Cell
Diagnostic Building

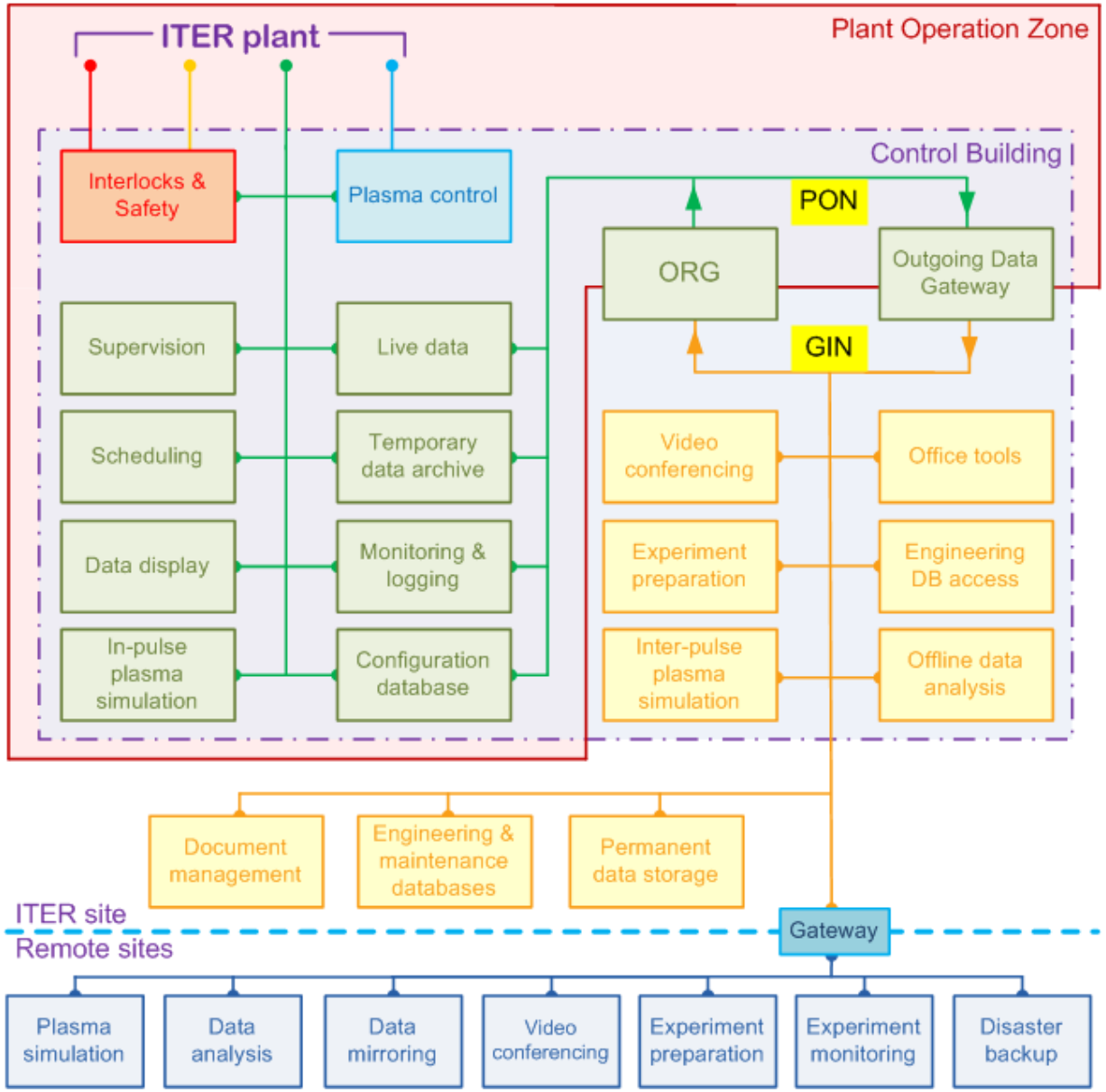
RF_DA Multi channel real time 48 channels nutron registration system (for non-critical electronics (QC>2)



Remote Participation



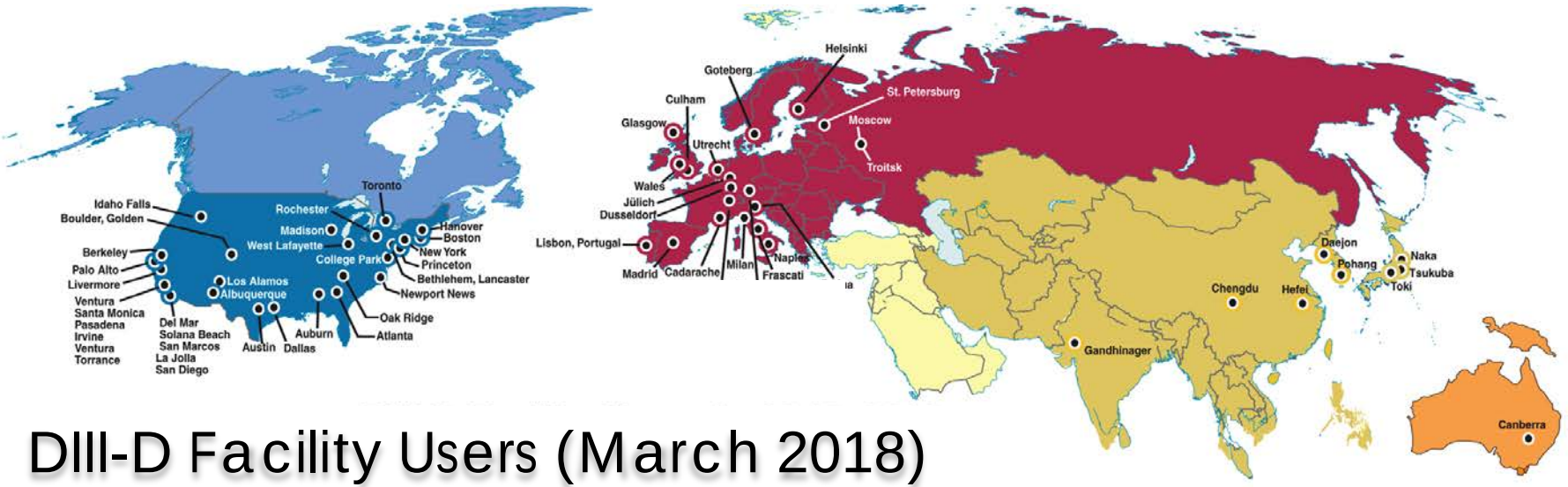
Remote Participation



ITER Main Control Room
Preliminary Layout (being revised)

Typical Scientific Cooperation (Large tokamak (US DIII-D))

Ben Penaflor

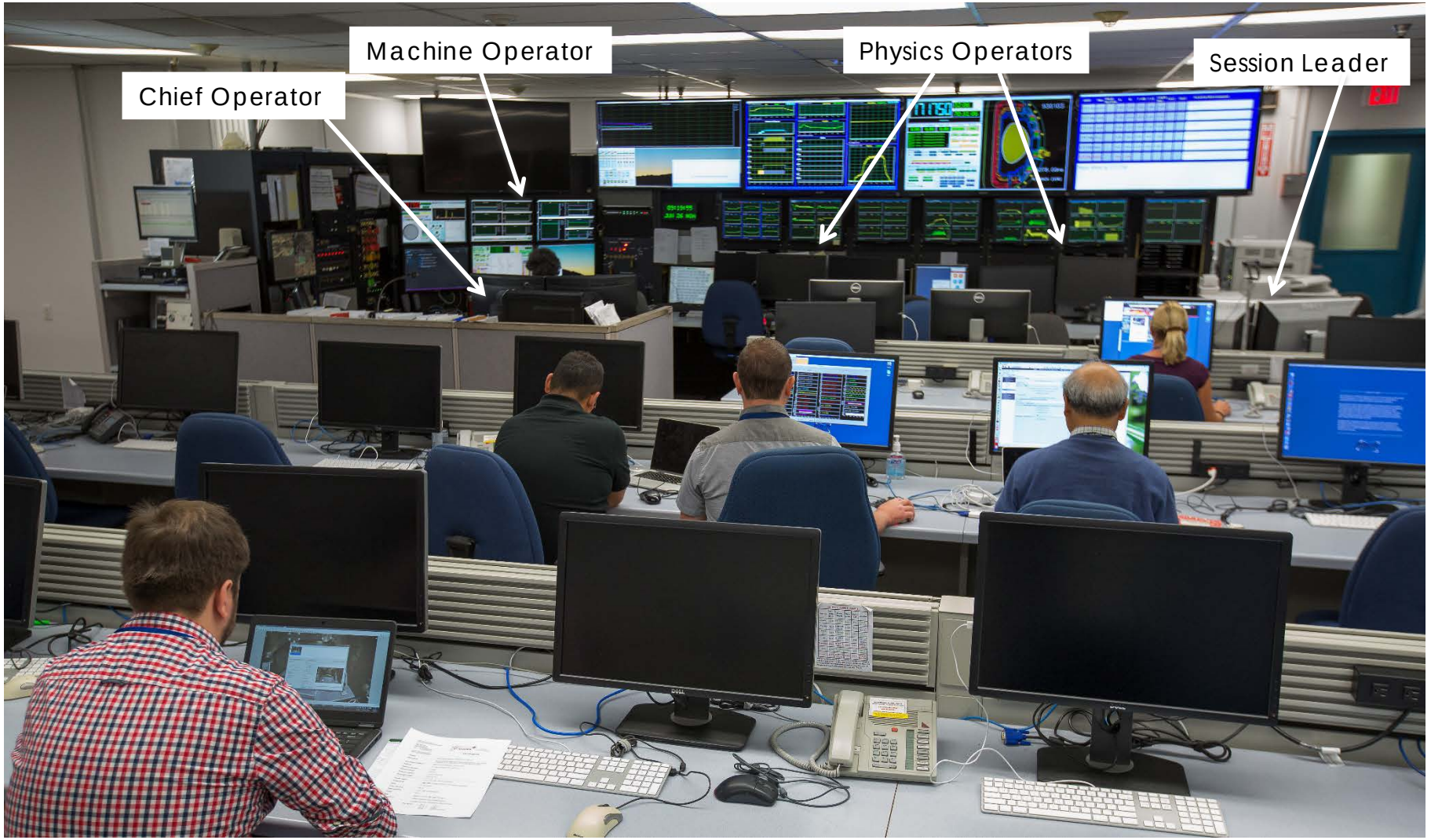


DIII-D Facility Users (March 2018)

- 683 Research Users
- 323 On-site and 360 Remote
- 24 Countries
- 108 Institutions
- 95 Graduate Students
- 68 Post Doctoral Fellows

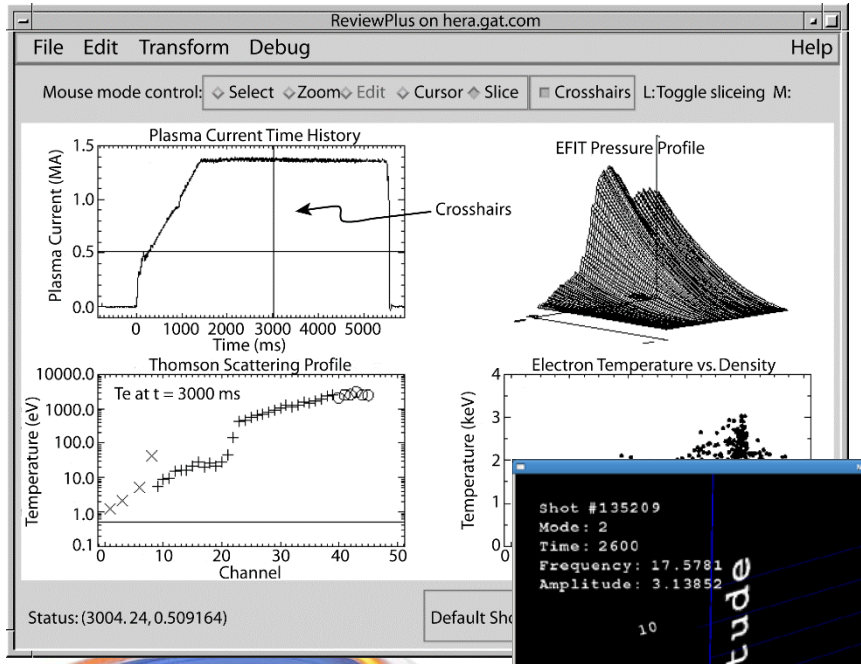
US DIII-D Control Room: Typical Exp't Team View

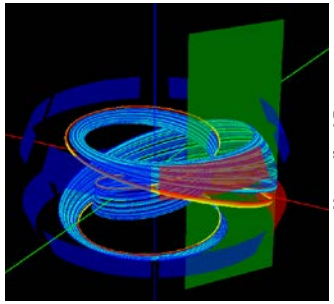
Ben Penaflor

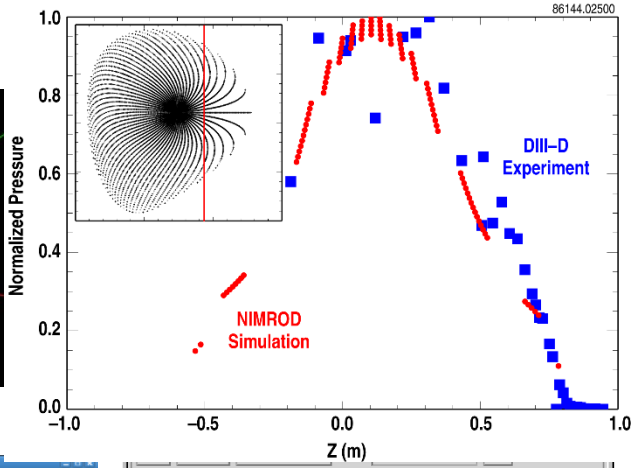


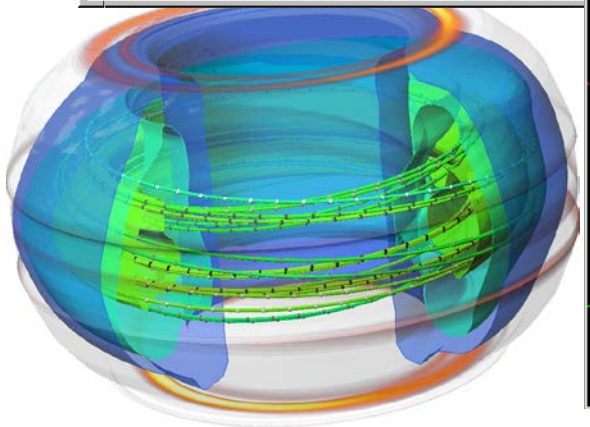
DIII-D Data Management with search and events

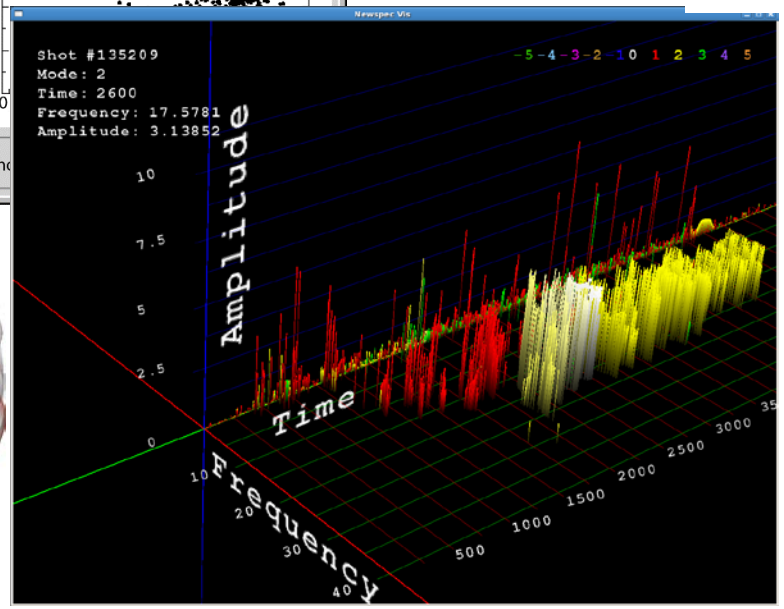
Ben Penaflor

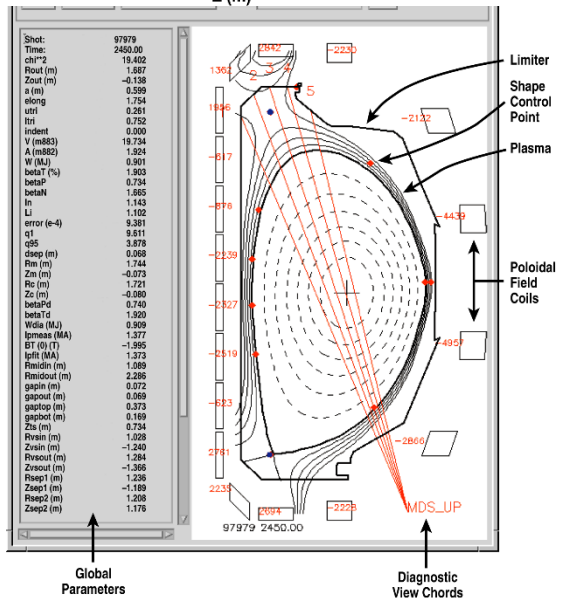


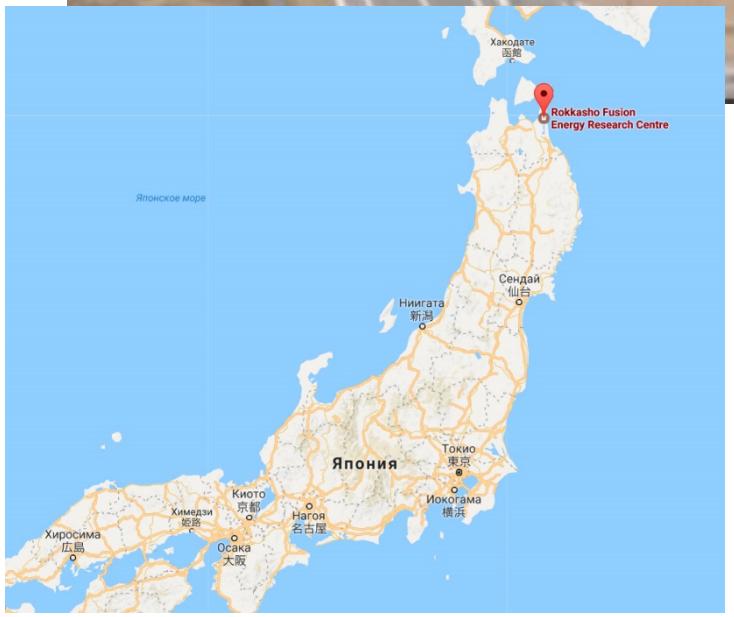






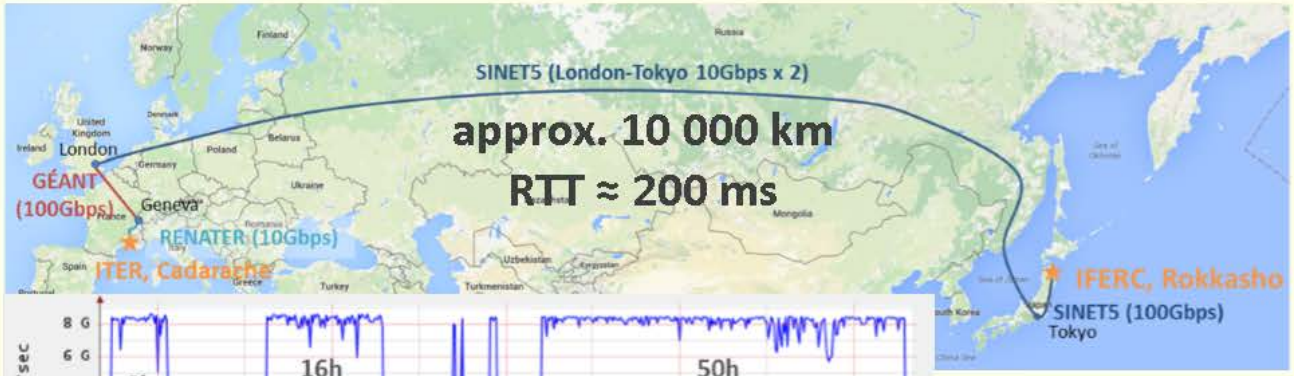


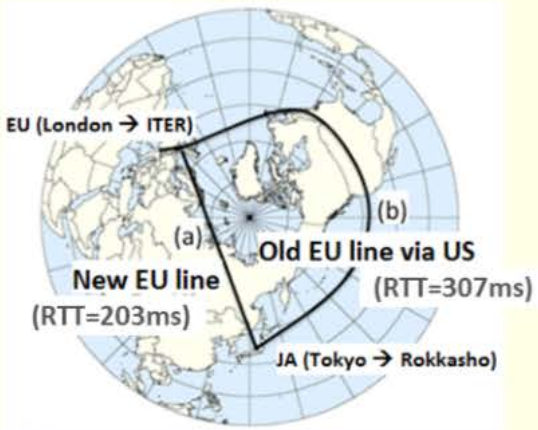


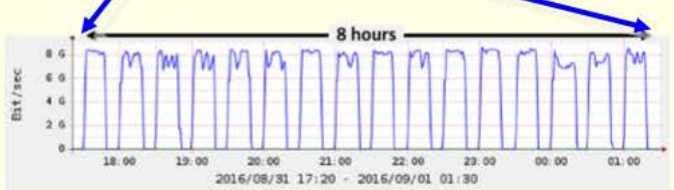

Хакодате
函館
Rokkasho Fusion
Energy Research Centre
Японское море
Сендай
仙台
Ниигата
新潟
Япония
Токио
東京
Киото
京都
Химедзи
姫路
Нагоя
名古屋
Иокогама
横浜
Хиросима
広島
Осака
大阪

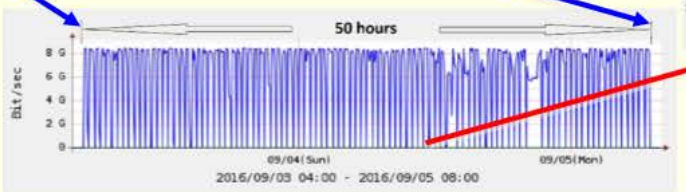
Demonstrated Results (ITER → REC)

JW Farthing









- **Achieved transfer speed: max. 7.97 / ave. 7.17 / min. 5.48 Gbps**
- **50 TB/day is the world record of inter-continental long transfer.**

☞ **REC as ITER full data replication site is realistic!**

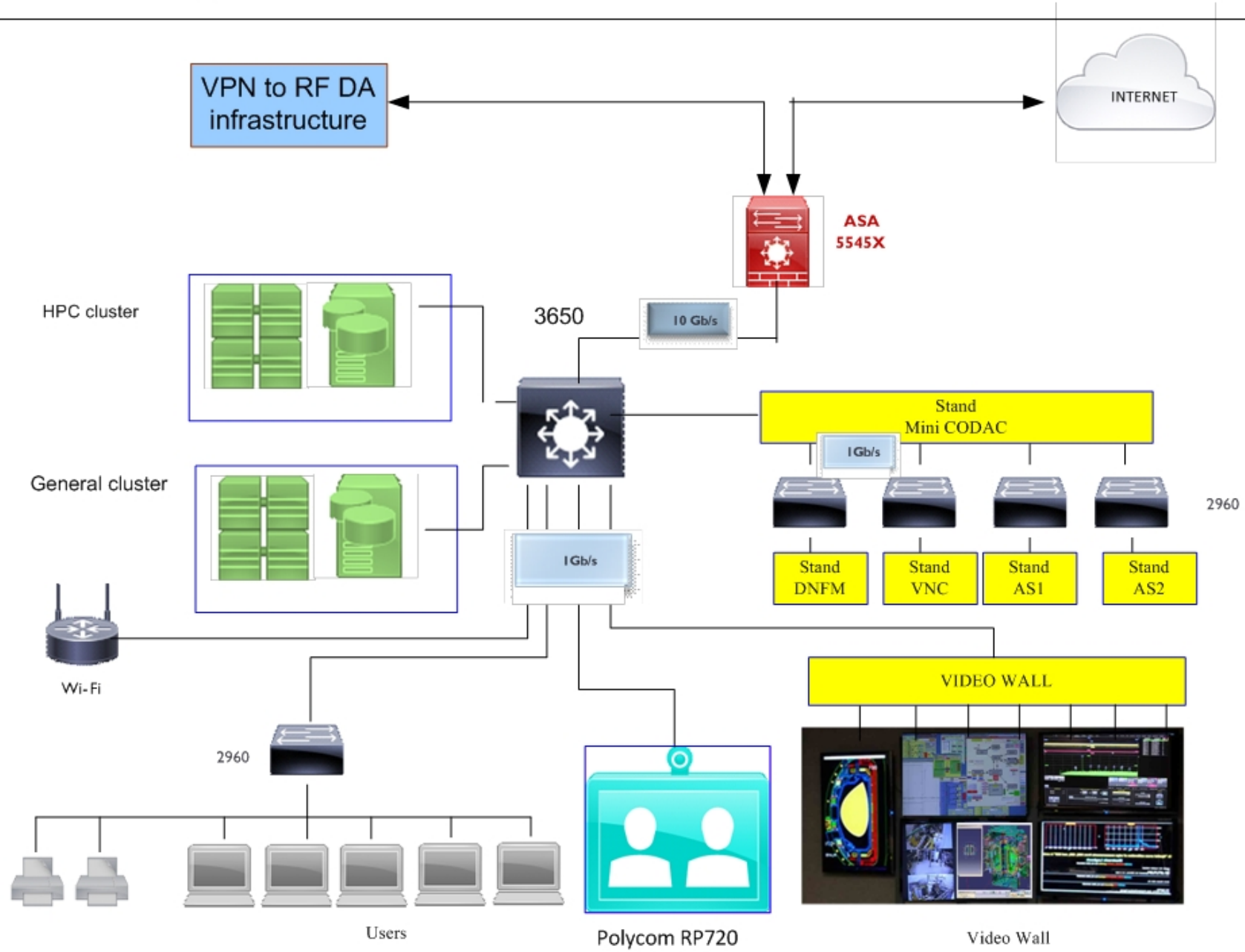
- **Bottlenecks would exist in long sustained read/write performances of huge storage.**

The first results of long distance bulk data transfer (Japan-France)

H.Nakanishi, Maximos Tsalas

1. MMCFTP **(**Massively Multi-Connection File Transfer Protocol).
   achieved the highest speed record of 231 Gbps in Dec. 2017.
2. Collaboration with academic carriers such as **GÉANT, ESnet, and SINET** will be needed
3. L2VPN is advantageous for point-to-point bulk data transfer between IO and DA sites.
4. For making full use of network bandwidth, optimization on both side storage systems will be necessary for faster read/write buffering and absorbing the speed differences.
5. Modern 100 Gbps network backbones can transfer 4 or 5 duplicated streams of 2 GB/s initial ITER data, but cannot to 7 individually.

Prototype of RF DA Remote Participation Center



Russian prototype of ITER
Remote Participation Centre (RPC)

Technical Tasks:

- ***Investigation of the high-speed data transfer*** via existing public networks (reliability, speed accuracy, latency)
- ***Test of ITER remote participation interfaces*** (Unified Data Access, Data Visualisation and Analysis tool, etc.).
- ***Local Large-capacity data storage system*** **(**Using CERN experience)
- ***Remote monitoring*** of Russian plasma diagnostics and technical systems in scope of warranty coverage and maintenance support.
- ***Security***
- ***Training personal*** for work at ITER installation

Russian prototype of ITER Remote Participation Centre (RPC)

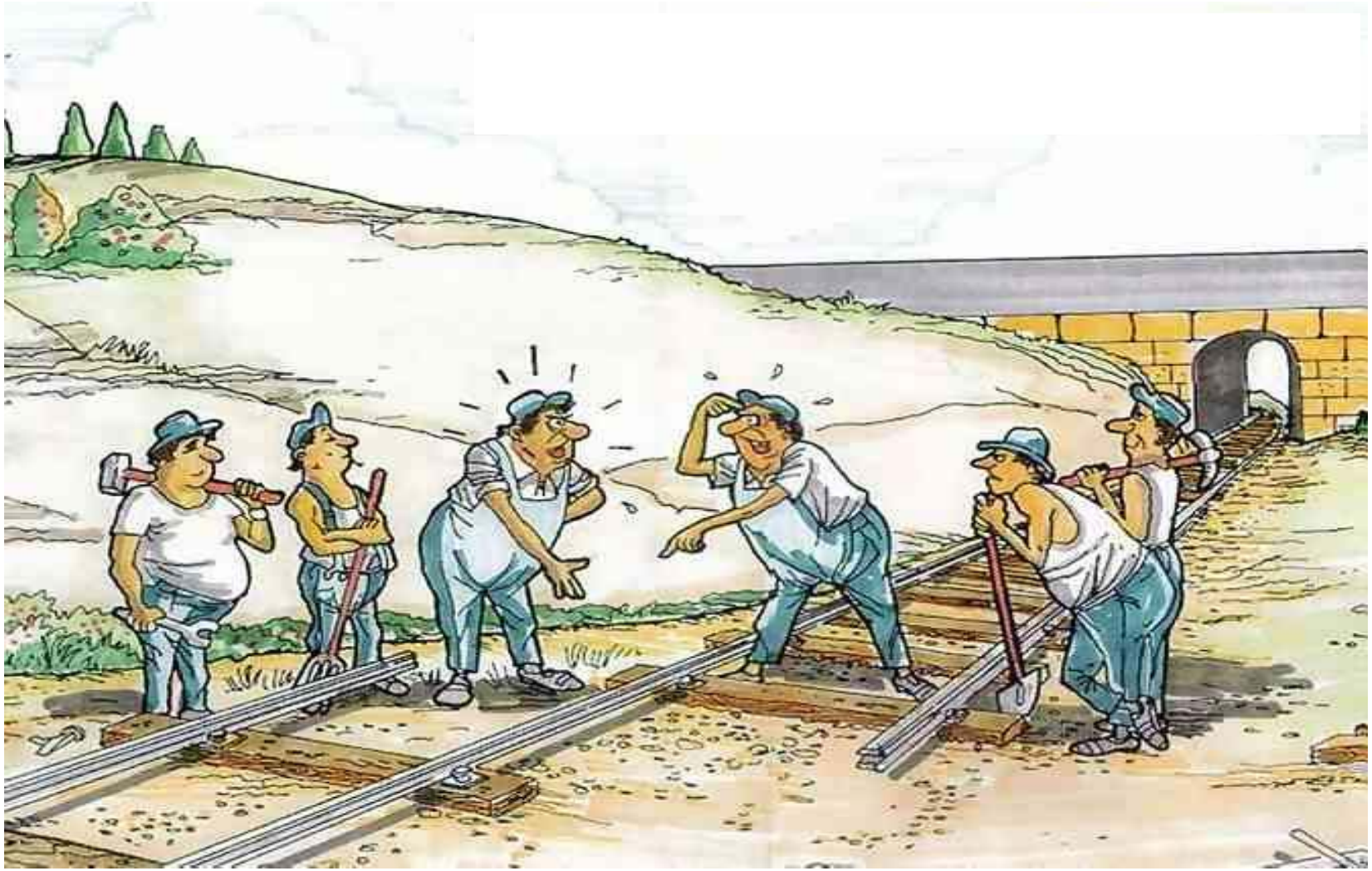
Scientific tasks:

- ***Participation*** in ITER main control room activities (remote copy of central screens and diagnostics HMI),
- ***Access*** to experimental data.
- ***Local data processing*** with integration of existing data processing software (visualization, analysis, etc.).
- ***Scientific data analysis*** remotely by ITER remote participation interfaces.
- ***Plasma simulator:*** customisation of existing software, development of Tokamak Simulator

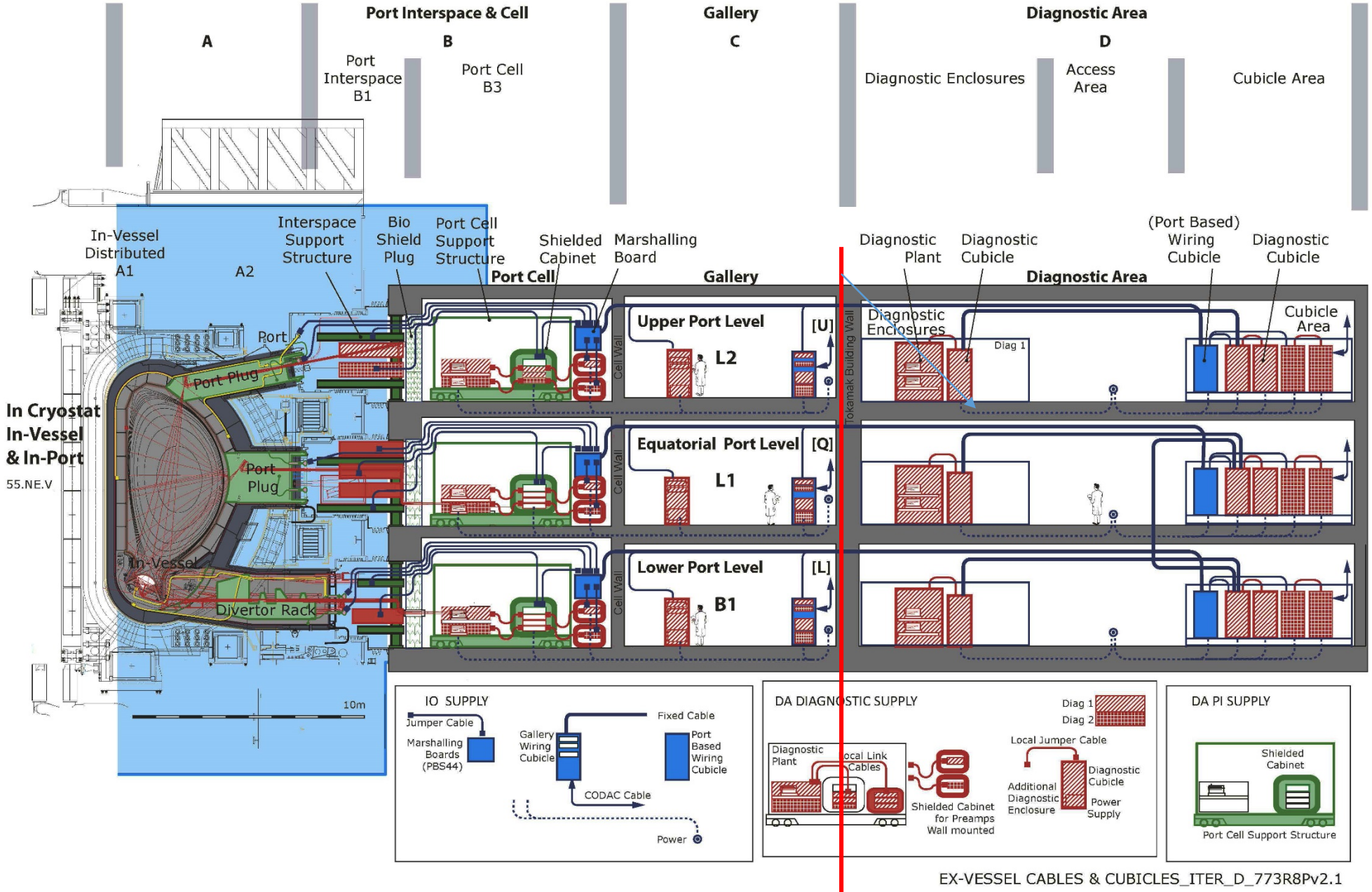
Russian Remote Participation Center

Global

Management interface problems




LHC ITER
THANK YOU
21:13:50 UTC



Tokamak operation zone

Simplified ITER data archiving model