Why Fusion in EGEE?

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On behalf of:

CEA (France), CIEMAT (Spain), EFDA (EU), ENEA (Italy), KISTI (Korea), Kurchatov Institue (Russia)

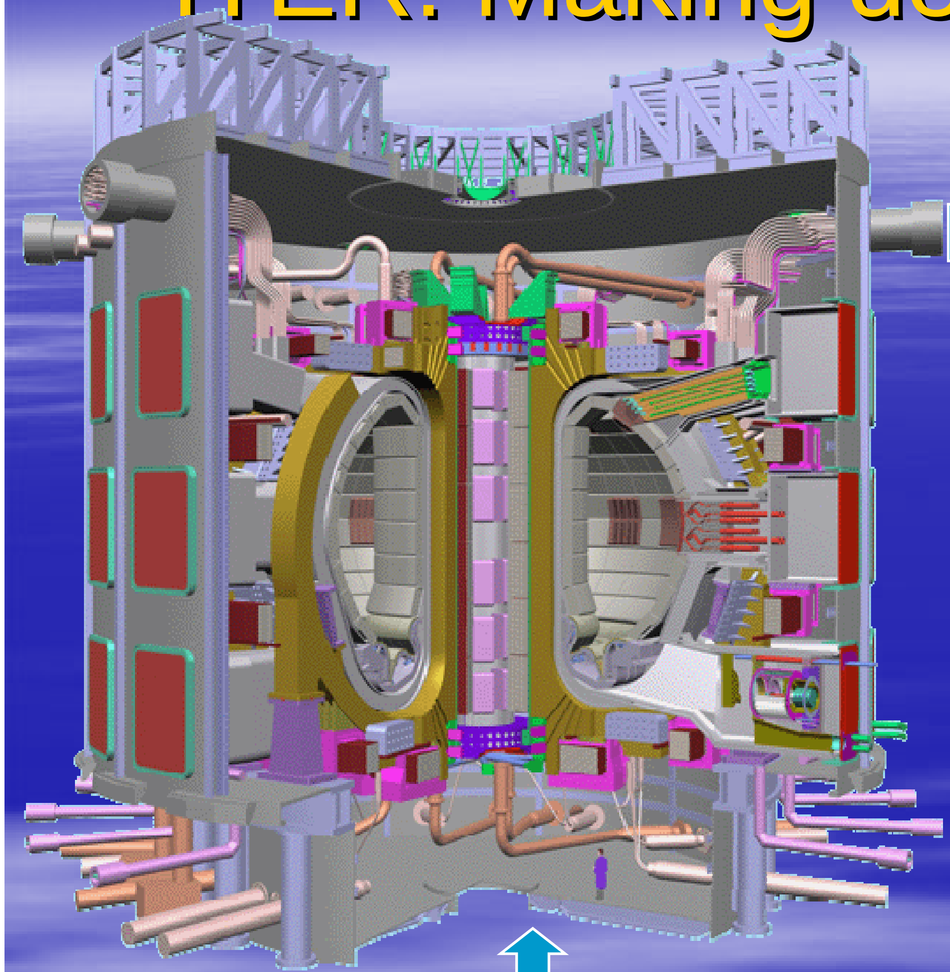
Special thanks to Igor Semenov (Kurchatov Institute)

EGEE-4, Pisa, 2005

Outline

- Motivation
- Partners.
- Applications: Computing in Plasma Physics.
- Data storage and handling.
- Strategy.
- Final Remarks.

ITER: Making decisions in real Time !!



Data Acquisition
and Storage (GRID)

Data Analysis and Reduction:
Artificial Intelligence, Neural Network,
Pattern Recognition

Simulation: Large codes in different platforms (Grid, Supercomputers)

Decision for present/next shot

Motivation

- Large Nuclear Fusion installations: International Cooperation among a lot of Institutes.
- Generate ~ 1-10 GB/sec. Less than 30% of data goes into processing.
- Distributed data storage and handling needed.
- Massive Distributed Calculation: A new way of solving problems. (Problems still without solution).
- Fusion community (Science and Technology) needs new IT approaches to increase research productivity.

PARTNERS of this PROPOSAL

- CEA-Cadarache (France)
- CIEMAT (Spain) (plus BIFI and UCM)
- KISTI (South Korea)
- Kurchatov (Russia)
- EFDA (European Union) >> International Tokamak Modelling Group
- ENEA (Italy).

- Possible new Partners: University of Sao Paolo (Brazil)

- Contact with Japan, USA and China Institutes is desirable and possible.

- Experience in using and developing Fusion Applications.
- Experience in porting applications and developing Grid Technologies.
- Clusters for Testing applications:

ITER Partners

ITER Cadarache
ELE. Barcelona

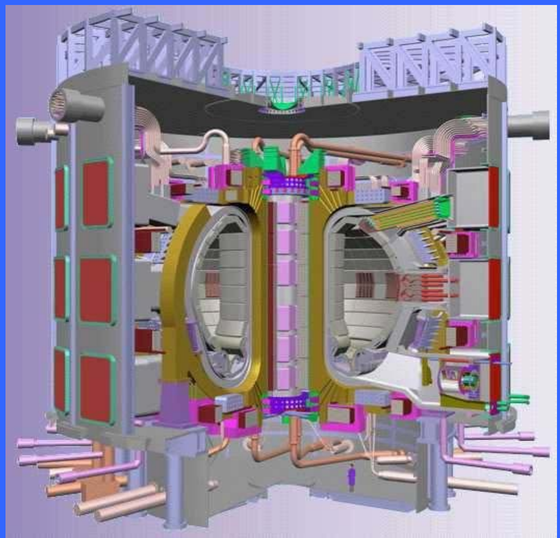
Para ver esta película, debe
disponer de QuickTime™ y de
un descompresor TIFF (LZW).

ITER

Distributed Participation.
Data access. Remote Control Rooms?

International Experimental Thermonuclear Reactor (ITER) project

1-10 GB/sec



- High speed networks
- Data bases
- Grid and Supercomputers
- Access centers
- New Soft

FUSION GRID as prototype of ITER GRID

International Tokamak (ITPA) and Stellarator (SIA) collaborations.

Russia:

T-10 (Kurchatov)

Globus (Ioffe)

T-11M (TRINITI)

L-2 (Gen. Inst. Phys.)

EGEE Project

USA:

Alcator C-Mod (MIT)

DIII-D (San Diego)

NSTX (Princeton)

NCSX (Princeton)

HSX (Wisconsin)

QPS (Oak-Ridge)

USA Fusion Grid (GLOBUS, MSPLUS)

EU:

JET (EFDA)

ASDEX (Ger.)

TORE SUPRA (Fran.)

MAST (UK)

TEXTOR (Ger.)

TCV (Switz.)

FTU (Italy)

W7-X (Ger.)

TJ-II (Spain)

EGEE Project

Japan:

JT-60 (Naka)

LHD (Toki)

CHS (Nagoya)

H-J (Kyoto)

GRID Project ?

China, Brazil, Korea, India:

KSTAR (Korea)

TCBRA (Bra.)

H-7 (China)

U2A (China)

SST1 (India)

EGEE Project

Joint collaboration requires COMPATIBILITY

- Identical representation of data bases.
- Identical graphical interfaces.
- Identical standards of codes for data processing and simulations.
- Identical programming languages.
- Identical Tool kit for codes development.

COMPUTING in the GRID

- Transport Analysis of multiple shots (typically 10^4 shots) or Predictive Transport with multiple models: e. g. ASTRA. (IPP(Ger) + Kurchatov(Rus) + CIEMAT(Spa) + EFDA(UE) + …)
- Transport and Kinetic Theory: Monte Carlo Codes*.
- Multiple Ray Tracing: e. g. TRUBA*.
- Neutral Particle Dynamics: e. g. EIRENE*.

*Examples.

Kinetic Transport

- Following independent orbits

$$\vec{V}_D = \frac{\vec{E} \times \vec{B}}{B^2} + \frac{m}{2q}\left(2v^2 - v_\perp^2\right)\frac{\vec{B} \times \nabla\left|\vec{B}\right|}{B^3}$$

- 30 x 10^6 ions followed.
- Montecarlo techniques: Particles distributed according to experimental density and ion temperature profiles (Maxwellian distribution function)
- SUITABLE PROBLEM FOR CLUSTER AND GRID TECHNOLOGIES

Kinetic Transport

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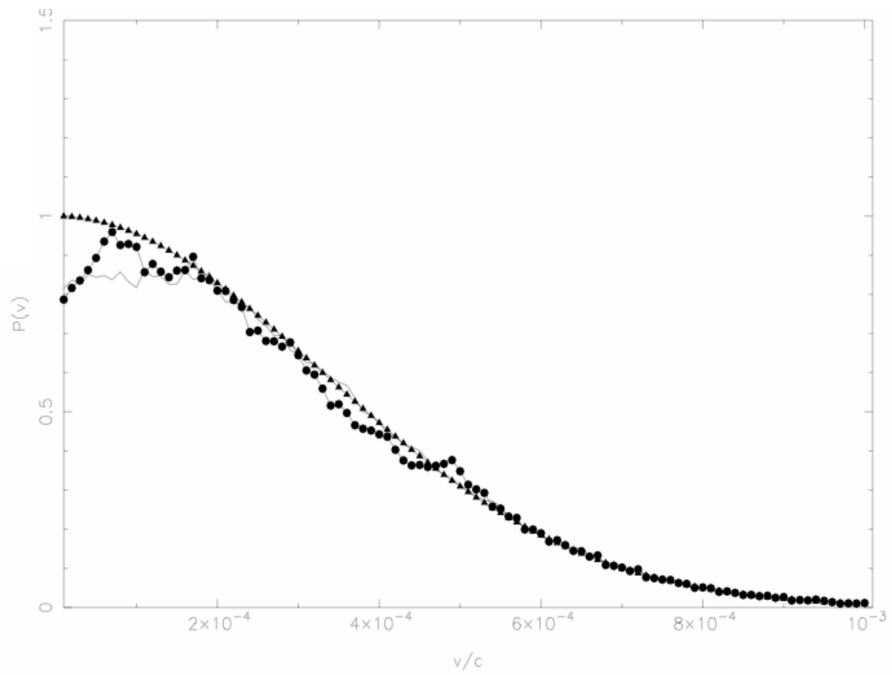
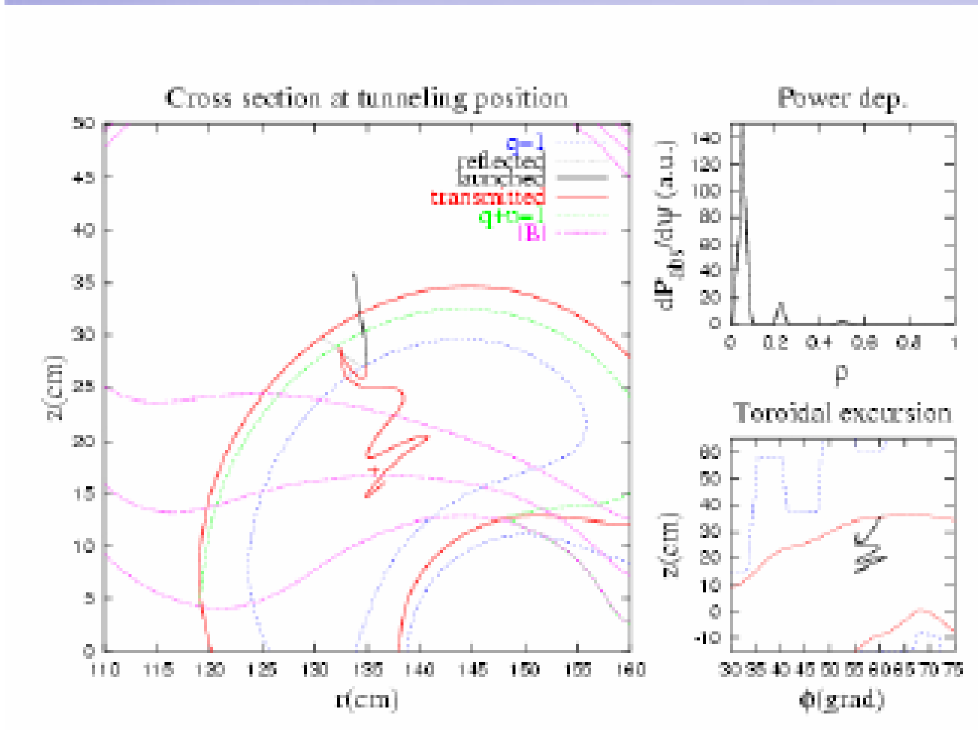
Example of orbit in the real 3D TJ-II Geometry (single PE).

~1 GBy data, 24 h x 512 PE

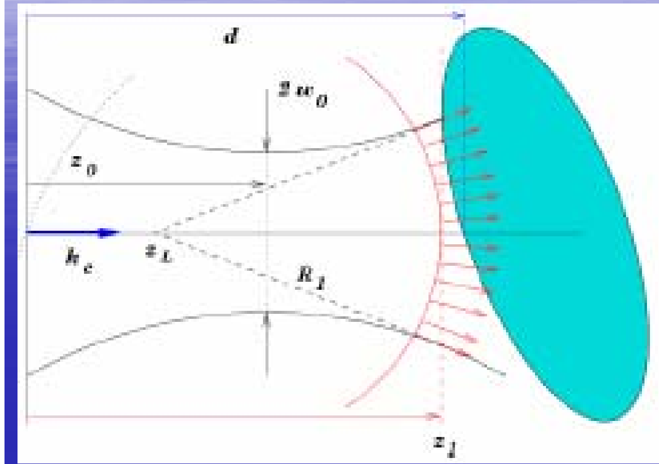
Distribution function of parallel velocity at a given position (Data Analysis).



Multiple Ray Tracing: TRUBA

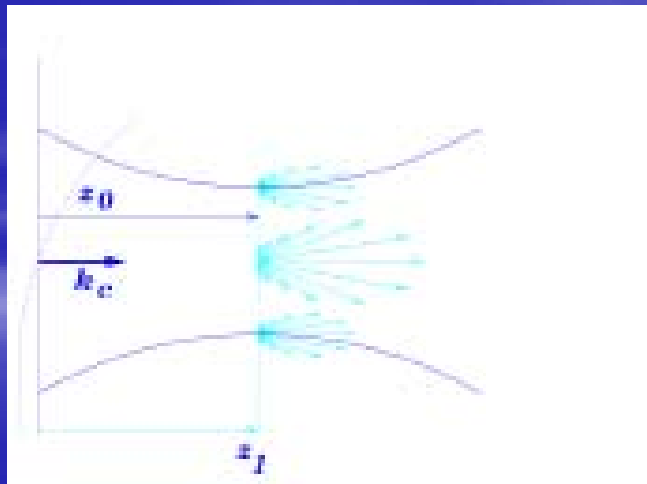


Single Ray (1 PE):
Hamiltonian
Ray Tracing Equations.



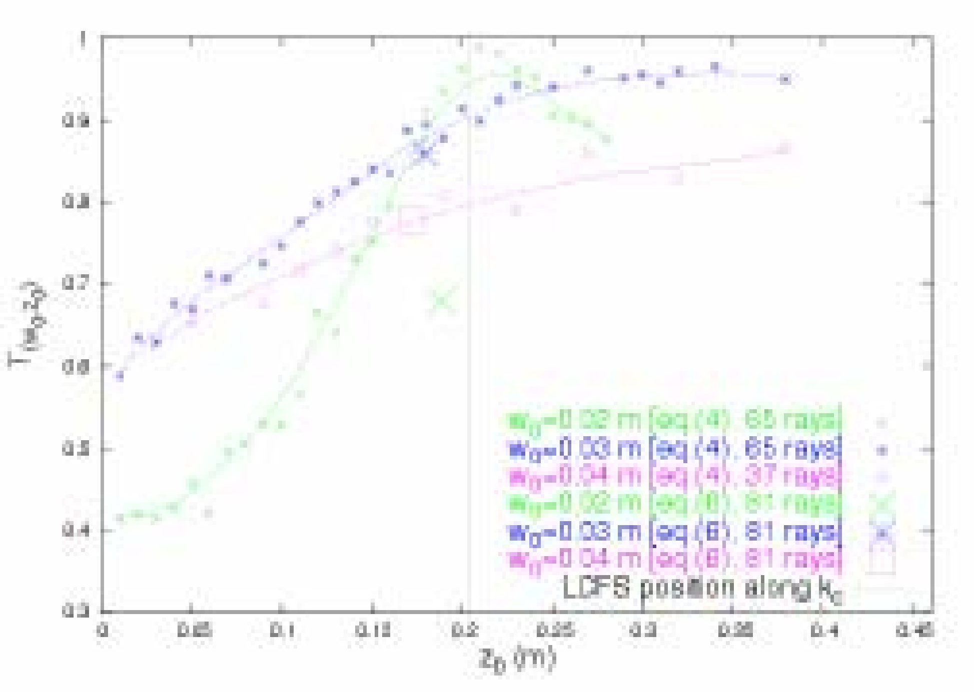
Beam Simulation:

Bunch of rays with beam waist far from the critical layer (100-200 rays)



Bunch of rays with beam waist close to the critical layer (100-200 rays) x (100-200 wave numbers) ~10^5
GRID PROBLEM

TRUBA: Multiple Ray Tracing

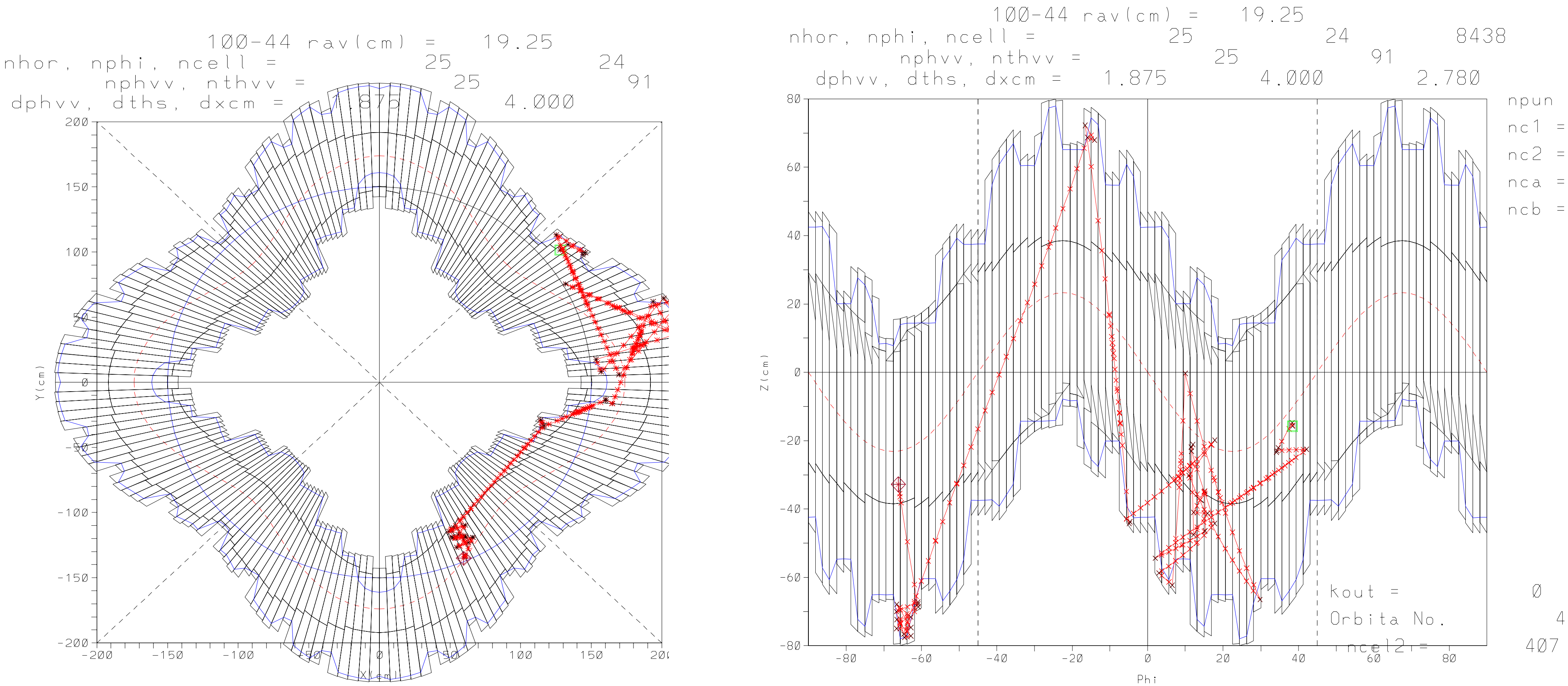


Different results with the two approximations.

(Also useful tool for looking for Optimum Launching Position in complex devices)

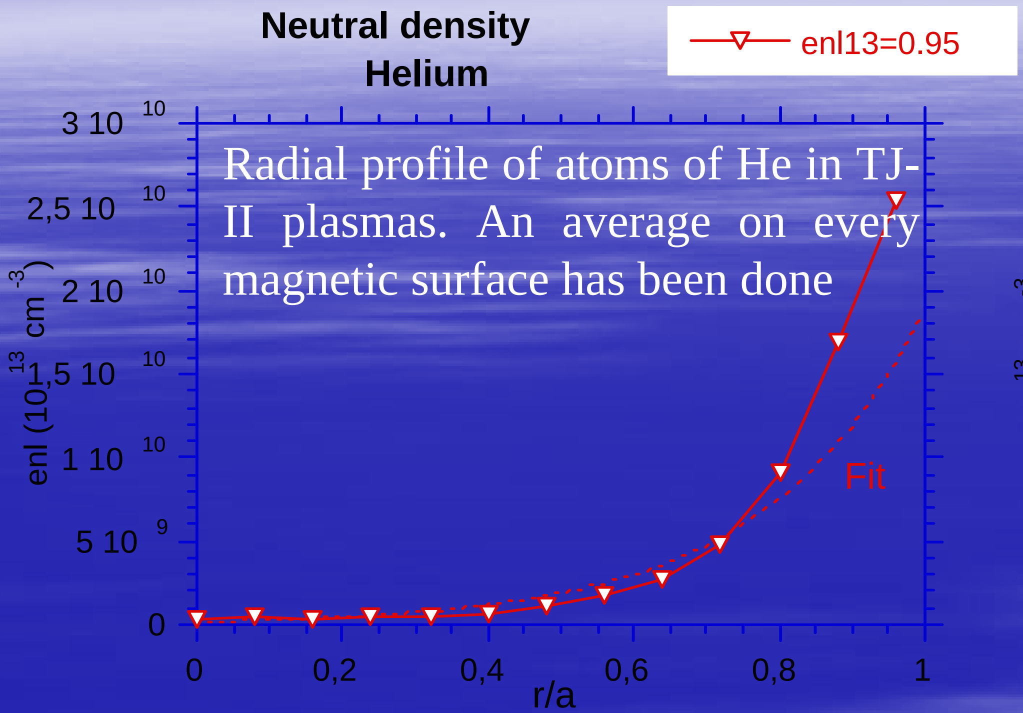
TRUBA for EBW:
Collaboration between Kurchatov and CIEMAT.
Useful for all Institutes with EBW heating (Culham, Princeton, Greifswald, CIEMAT,…)

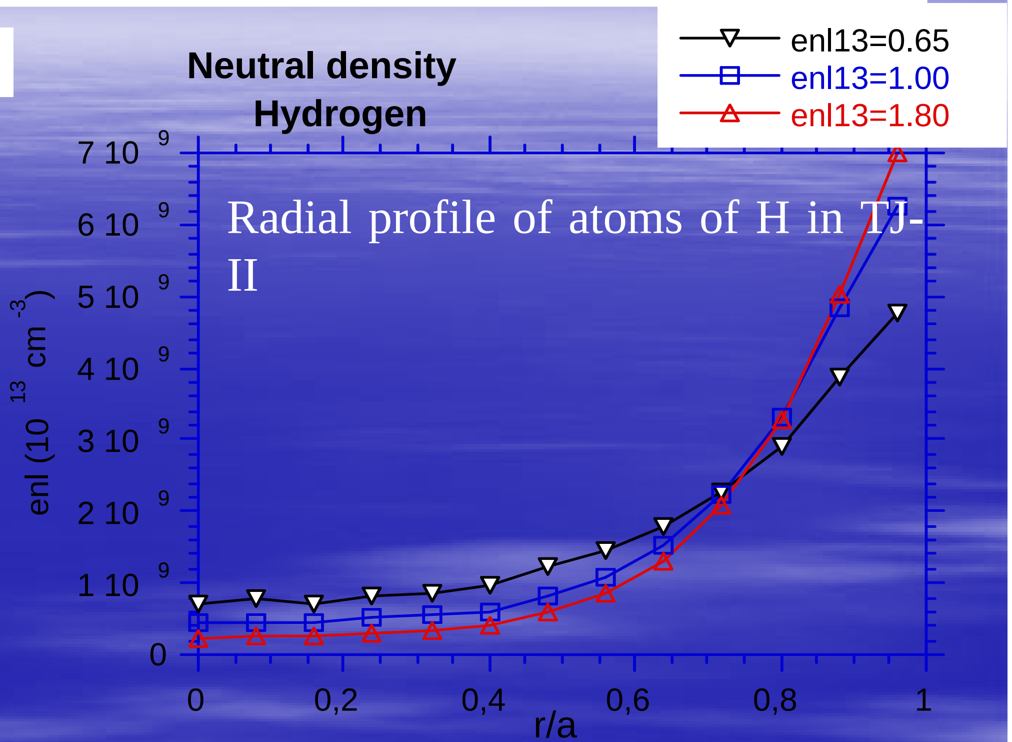
EIRENE Code



Trayectory of a He atom in TJ-II. Vertical and horizontal proyections. It starts in the green point and is absorbed in the plasma by an ionization process.
The real 3D geometry of TJ-II vacuum chamber is considerd.

EIRENE Code

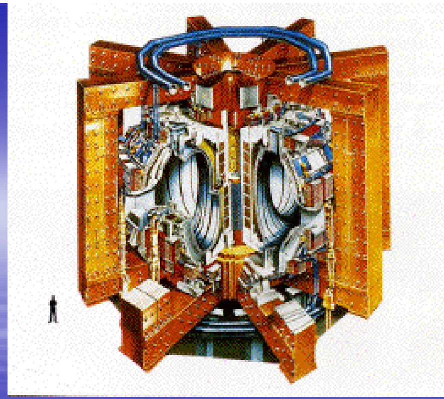




Two parts: 1) Following trajectories (Totally distributed) --> GRID
2) Reduction to put all together.

EIRENE Code comes from IPP (Jülich, Germany) and is extensively used by Fusion community.

DATA HANDLING



Storage:

Large data flux: 10^4 sensors x 20-50 kHz sampling=

1-10 GBy per second raw data

x 0.5 h= 3 TBy per shot in ITER every 1,5 h

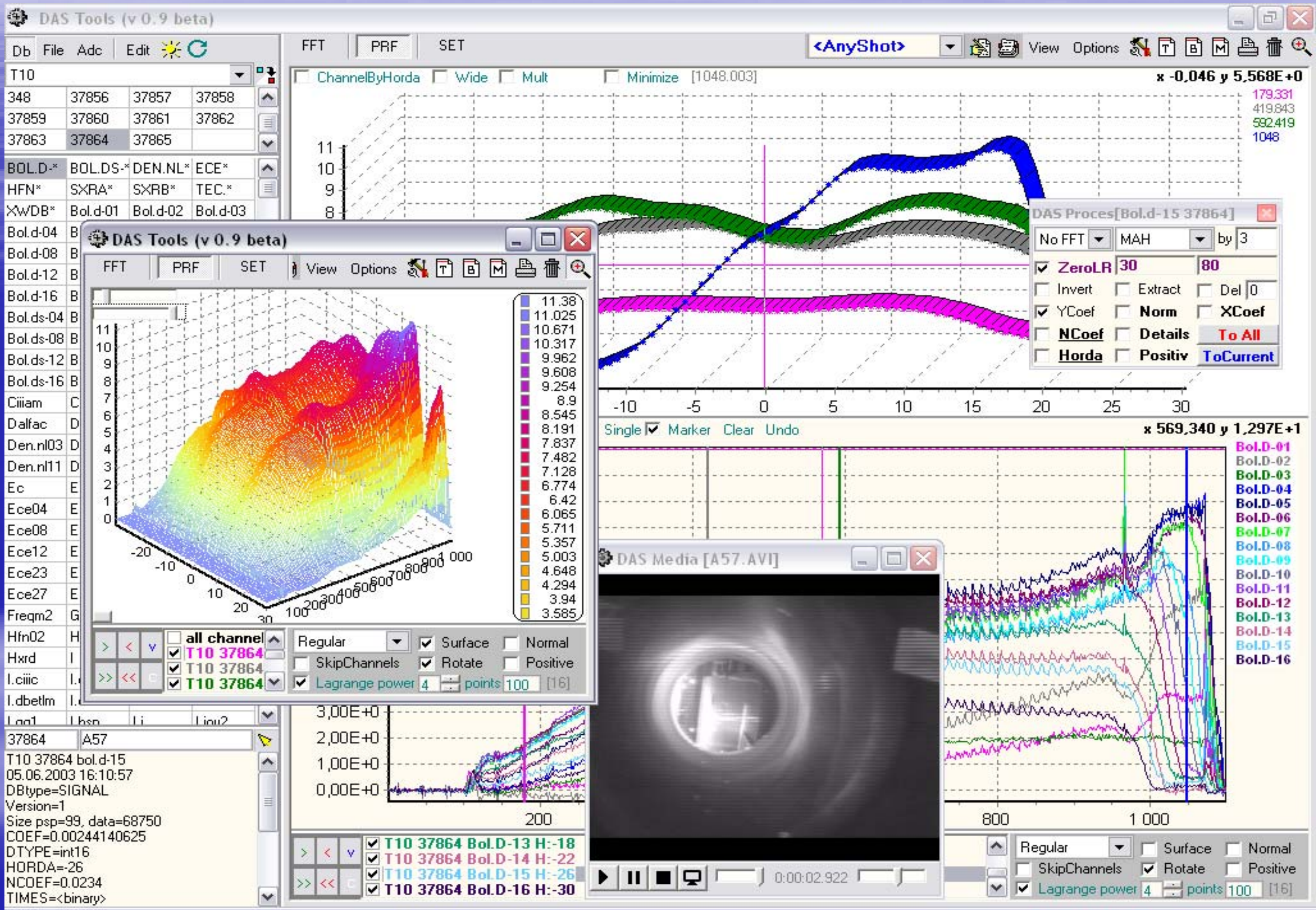
Supercomputing and Grid Computing -->

Data Storage: Scratch and permanent.

Access & Sharing Data :

Large Cooperative Experiments

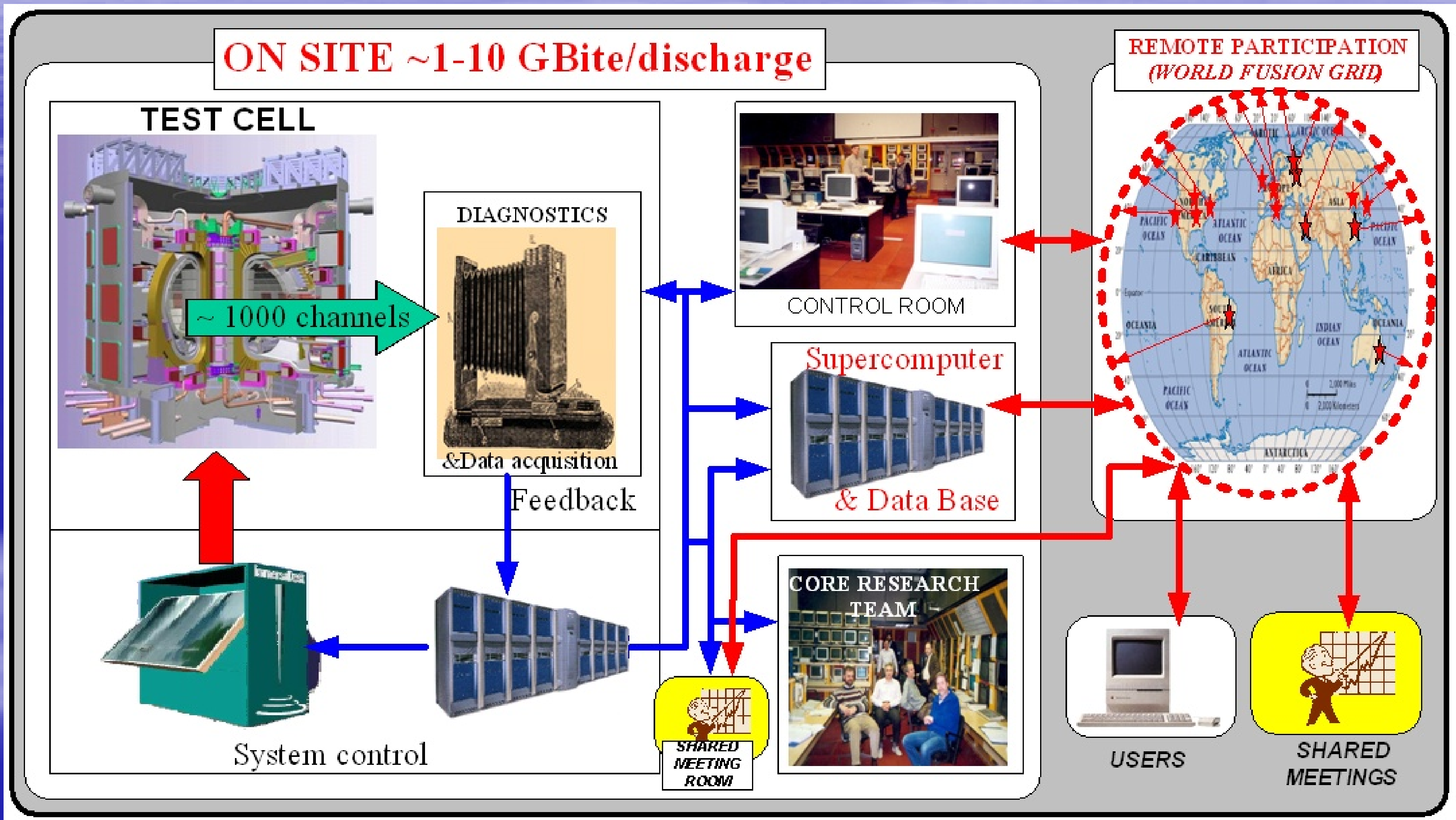
DAS Tools: Visualization, DAQ and processing



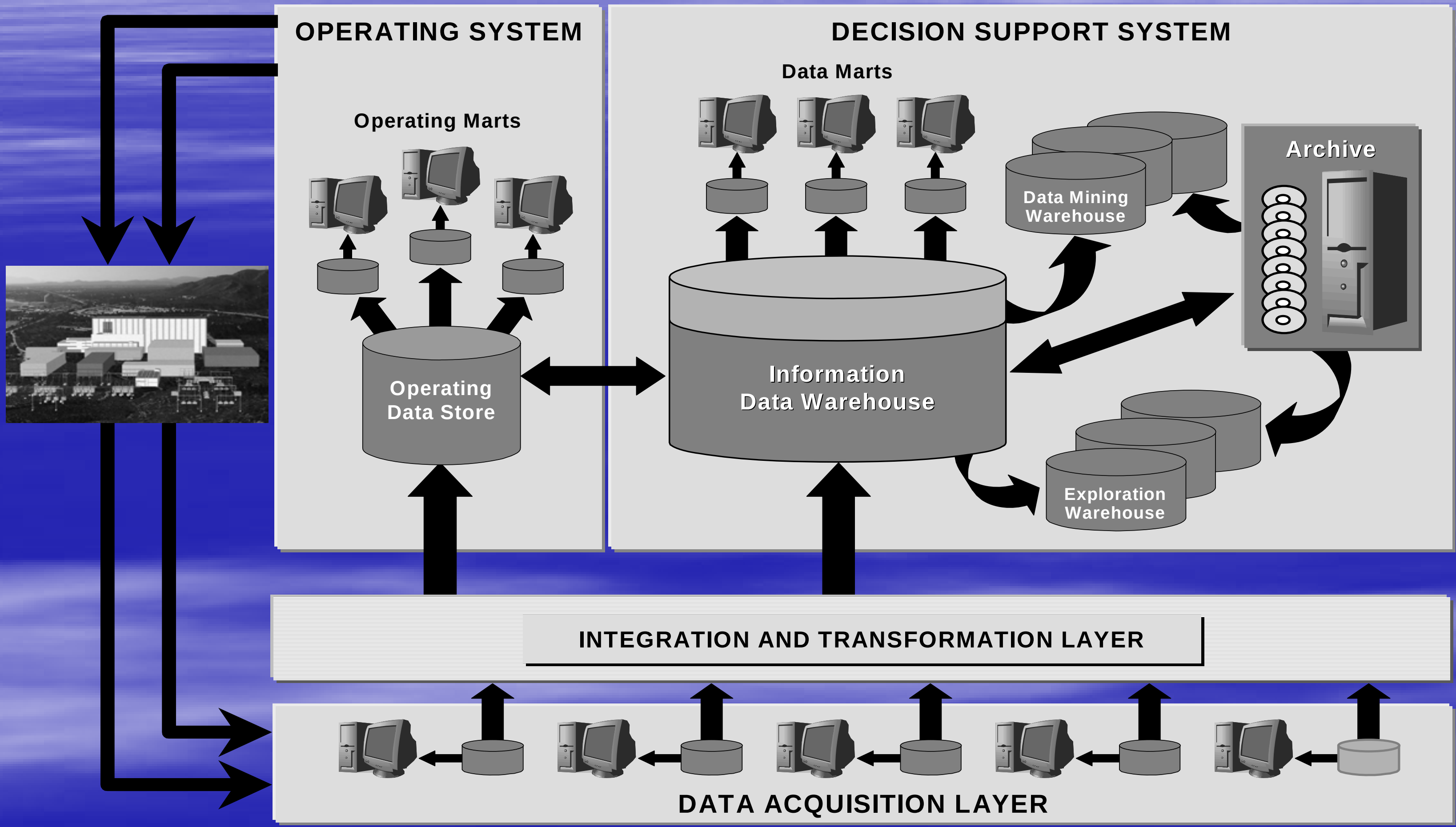
To add grid-aware protocols for:

- **Data navigation and mining**
- **Data exchange**
- **Data search**
- **Event catch**

Schematic data flow in Fusion

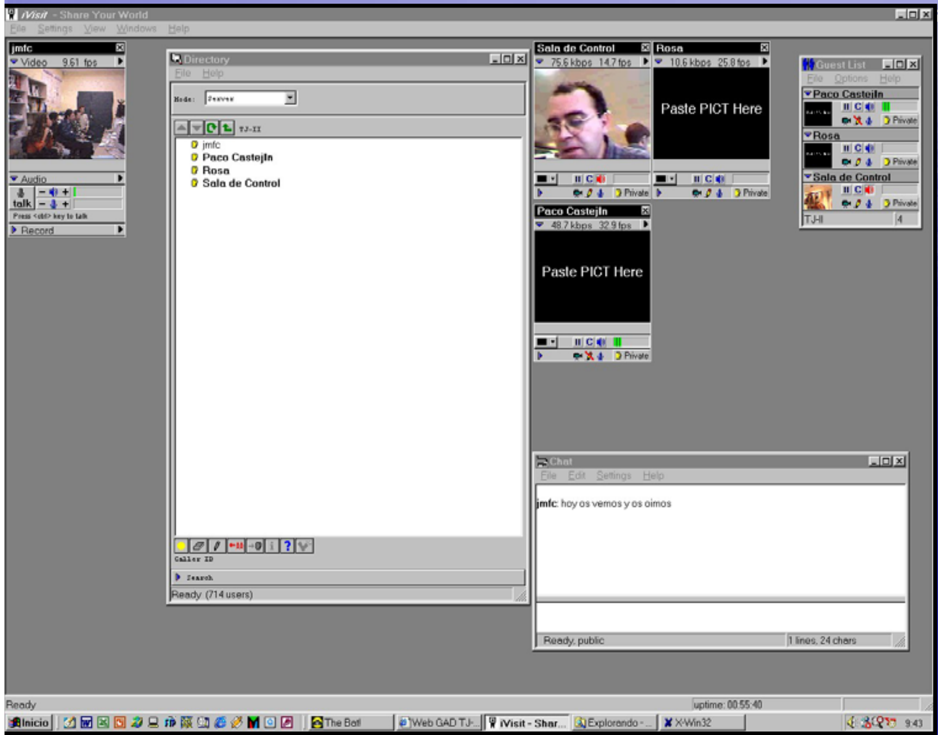


A proposal for data storage components of the ITER Information Plant



N. Putvinskaya et al ,Fus. Science and Tech. 47 (2005) 806

Communications



Remote Participation tools:

Data Access

Local Visualization

Video Conferences and Chats

Remote Control

SECURITY & ROBUSTNESS

Strategy

- Computing:
  - Identify common Codes suitable for GRID.
  - Adapt codes to the GRID.
  - Exploit them.

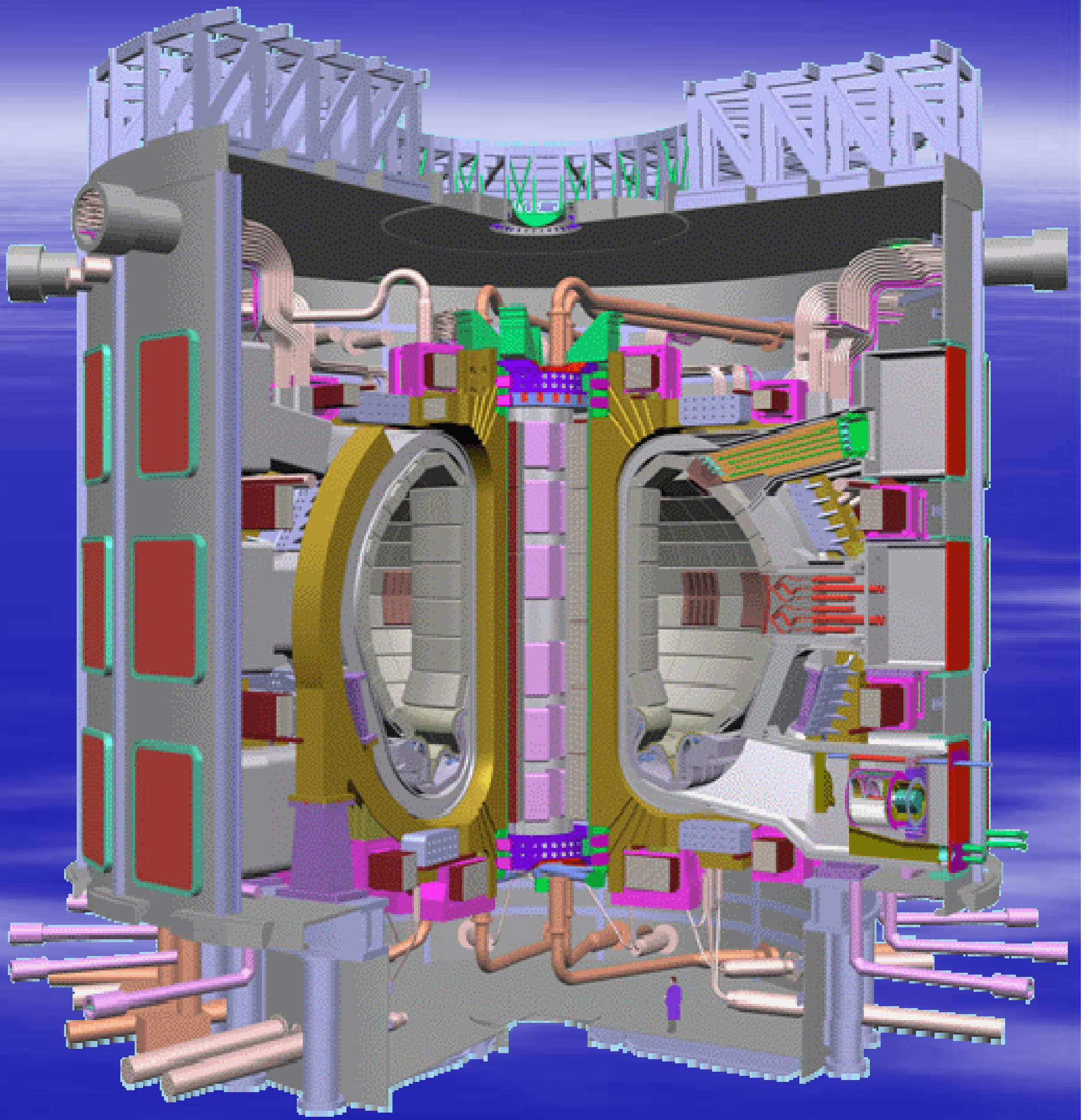
- Data handling:
  - Define strategies for data storage.
  - & database organization.
  - Protocol for data Access.
  - Standard SCADA (Improve MSPLUS?)

Final Remarks

- GRID technologies will enhance Fusion Research: computing and data handling.
- GRID technologies will win visibility when applied to large Fusion Experiments (like ITER).
- The partners that support this proposal have enough experience in GRID implementing and Fusion Physics to make it succesful.

- Demonstration effect: If Fusion-Grid is succesful, GRID technologies will be extensively used by Fusion Community in the future.

Para ver esta película, debe disponer de QuickTime™ y de un descompresor TIFF (LZW).



TORB: Gyrokinetic Code

- Toroidal cut of plasma

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- Development of Fourier Harmonics of turbulent field.

TORB: Gyrokinetic Code

- Weak scaling with number of processors. Suitable code for GRID test.

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- Collaboration between IPP (Germany), CRPP (Switzerland) and CIEMAT (Spain).