

Programul European de Fuziune Termonucleara Controlata pentru Energie

Probleme actuale si de perspectiva ale Asociatiei EURATOM-MEdC

F. Spineanu, Head of Research Unit

1. Fizica fuziunii

- Tokamak
- Reactor de fuziune

2. Structuri Europene

- EURATOM
- DG Research J Energy (EURATOM)
- EFDA, Associations
- Documentele de baza

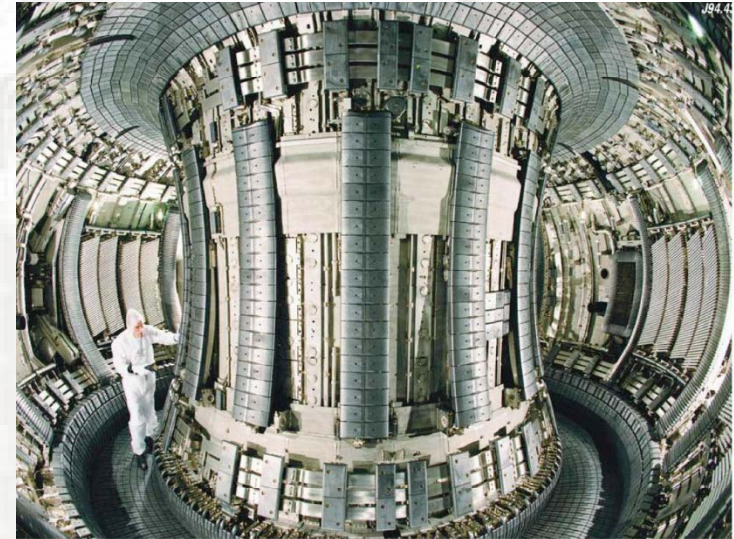
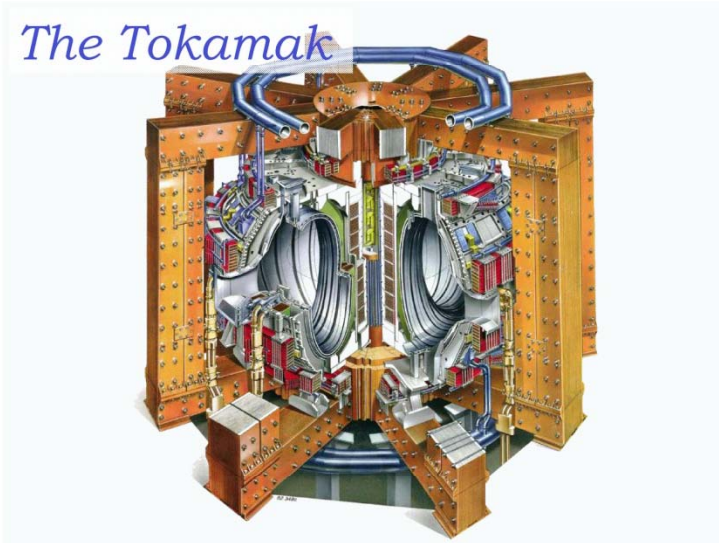
3. Asociatia EURATOM – MEdC Romania

- Structura
- Realizari
- Program 2010 si perspective

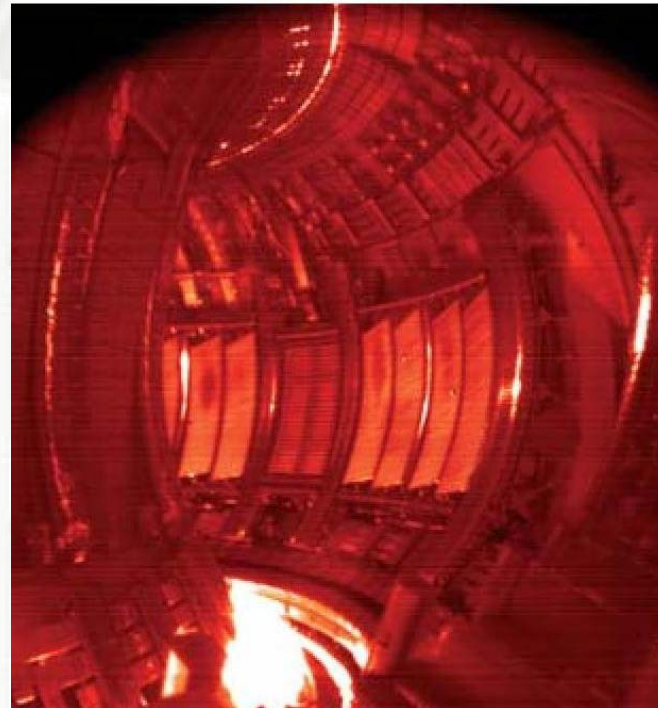
4. ITER

Fuziunea termonucleară controlată în plasma confinată magnetic În geometrie toroidală (Tokamak)

The Tokamak



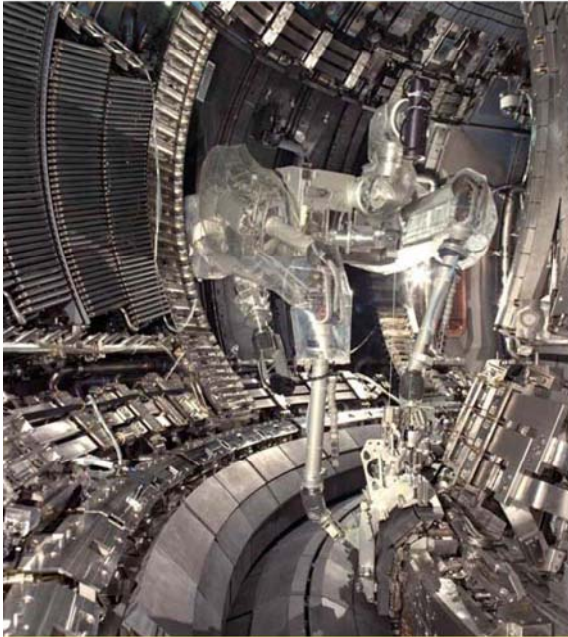
Tamm, Zakharov, Yavlinsky, Artsimovich, 1962
“Toroidal Camera with Magnetic Coils” (Golovin)



JET

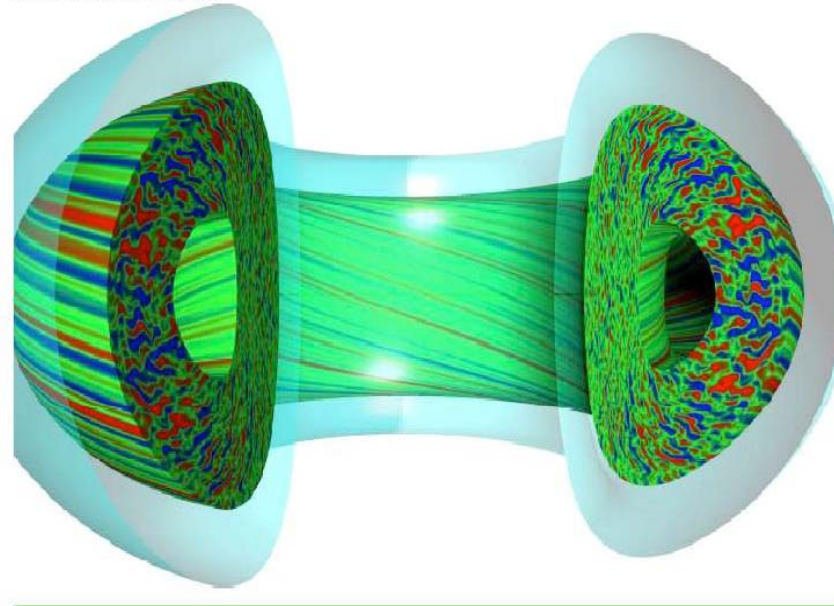
Joint European Torus
(Culham, UK)

Deuteriu, 1/1000 din densitatea atmosferei
Temperatura 200,000,000 grade in centru, ~300 grade la perete
Curent 4,500,000 Amperi
Camp magnetic 3 – 4 Tesla



in- vessel MASCOt manipulator

at.com/compservlet/figures/apetons-li-2.jpg



Transport : confinement, H-mode, ELMs
Equilibrium and stability, tearing, saw-teeth, major disruptions
Heating and *current drive* NBI, ICRH, ECRH
Diagnostics
Scenarios for access to high confinement states

Scientific problems of high relevance for the present state of fusion physics

Plasma physics

- instabilities, turbulence, transport ▪
- MHD instabilities ▪
- L to H transition ▪
- Edge Localized Modes ▪
- Internal Transport Barriers

Plasma heating

- Ion Cyclotron Resonance Heating ▪
- ECRH
- Neutral Beam Injection
- LH (current profile)

Plasma rotation

- poloidal rotation ▪
- toroidal rotation

▪ = Participation
Of the MEdC Assoc.

Scientific problems of high relevance for the present state of fusion physics (2)

Numerical simulations

- plasma confinement ▪
- gyrokinetics ▪
- everything

Plasma scenarios

- bootstrap controlled
- density limit (Grunewald)
- q-profile (advanced tokamak)

Diagnostics ▪

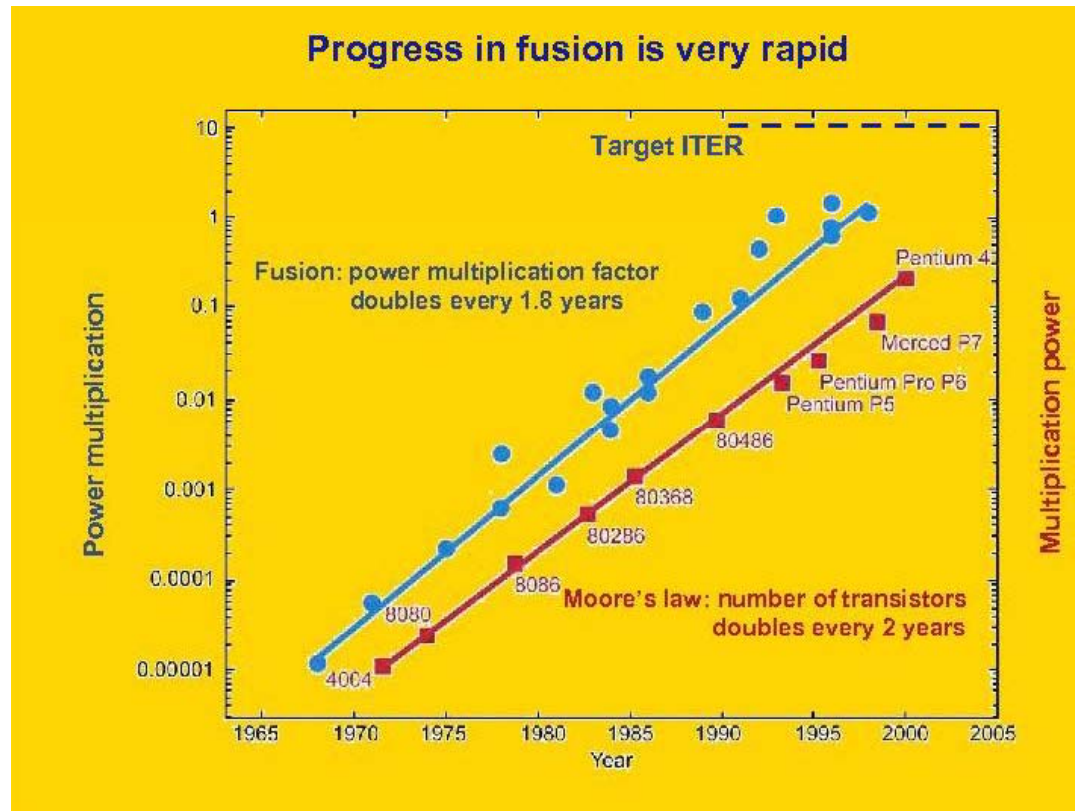
- IR (density)
- Thompson scattering (Te)
- Magnetic coils (Mirnov)
- nuclear and Data ▪

Materials ▪

- IFMIF ▪ EVEDA (all) + Supraconductibility ▪

Reactor regime

Faster than computers



1/21/2010

Source: Lopez Cardoso

F. Spineanu

8

Structuri Europene destinate fuziunii

EURATOM: peste 90% din activitatea sa este destinata Fuziunii Termonucleare

Contract of Association; 27 Asociatii

Consultative Committee EURATOM – Fusion CCE-FU

Comisia Europeana

DG Research J Energy (EURATOM)

European Fusion Development Agreement

Fusion for Energy (F4E)

Research DG

Directorate A - Inter-institutional and legal matters

Directorate B - European Research Area: research progr and capacity

Directorate C - European Research Area: knowledge based economy

Directorate D - International Cooperation

Directorate E - Biotechnologies, Agriculture, Food

Directorate F - Health

Directorate G - Industrial technologies

Directorate H - Transport

Directorate I - Environment

Directorate J - Energy (EURATOM)

Directorate K - Energy

Directorate L - Science, economy and society

Directorate R - Resources

Directorate S - Implementation of the “Ideas” programme

Directorate T - Implementation of activities to outsource

Directorate Energy (EURATOM)

- **Directorate J - Energy (Euratom)**
Director: *Octavio Quintana Trias*
- **J.1: Horizontal aspects and coordination**
Head of Unit: *Angel Perez Sainz*
- **J.2: Fission**
Head of Unit: *Simon Webster*
- **J.3: Joint development of fusion**
Head of Unit: *Serge Paidassi (acting)*
- **J.4: Fusion association agreements**
Head of Unit: *Yvan Capouet*
- **J.5: Administration and finance**
Head of Unit: *Eduard Rille*

Cercetarea Europeana de fuziune este condusa direct de Comisia Europeana prin DG Research J Energy (EURATOM)

- stabileste Planul de Lucru, unic pentru toate Asociatiile
 - realizat de EFDA, aprobat de *EFDA Steering Committee*
 - aprobat de Comitetul Consultativ EURATOM CCE-FU
- aproba Planul de Lucru al fiecarei Asociatii
- aproba bugetul fiecarei Asociatii
- stabileste contributia Comisiei la *Baseline* (Amendment to CoA)
- stabileste Additional Support pentru unele teme speciale
- Controleaza finantele fiecarei Asociatii (vizita + Audit)
- Controleaza activitatea profesionala: *Steering Committee +.*



Documente de baza:

Contract of Association

European Fusion Development Agreement

JET Implementing Agreement

Mobility Agreement

Association EURATOM-MEdC

Fondata in 1999

Unitatea de Cercetare (in 2010):

4 Institute Nationale

Inst. National de Fizica Laserilor, Plasmei si Radiatiei (INFLPR)

Inst. National de Tehnologii Criogenice si Isotopice (ICSI)

Inst. National de Fizica si Ingineria Nucleara (IFIN – HH)

Inst. National de Fizica Materialelor (INFM)

si 3 Universitati

Universitatea din Craiova

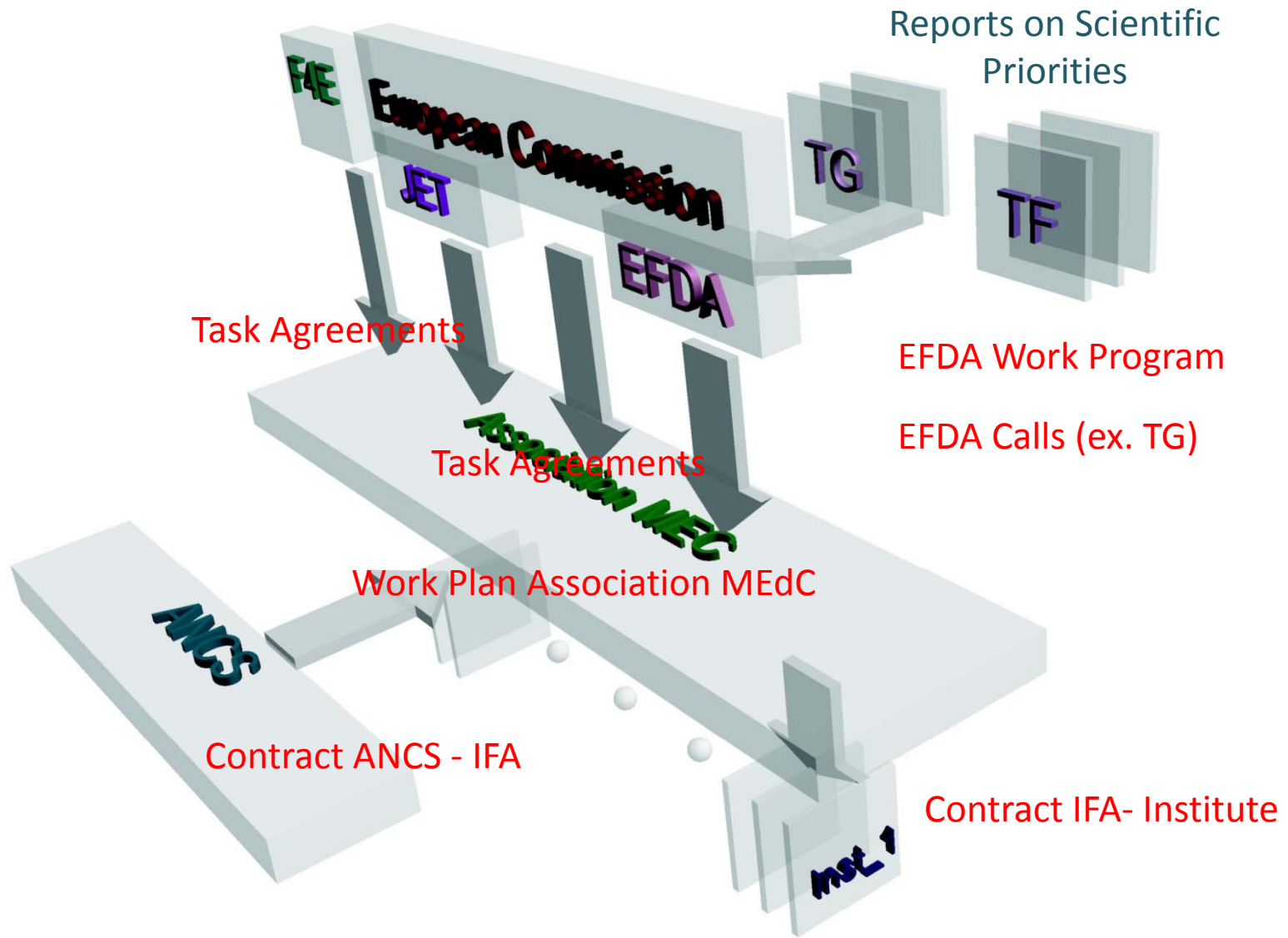
Universitatea “A.I. Cuza” din Iasi

Universitatea Tehnica din Cluj-Napoca

In 2009 staff: 81 persoane (27 ppy)

Valoare Contract 2009:	3,731,553 Lei (ANCS) +
	2,104,521 Lei (Comisie)
Total:	5,836,074 Lei (36% de la Comisie)

Web page: <http://www.ifa-mg.ro/euratom> (+ Sign In)



Institut	Tema/Responsabil	Cod	TA/Baseline	Observatii	
INFLPR	RWM/Atanasiu	BS_1	Baseline	WP09-MHD-05/01/MEdC + ITM	
	RWM feedback/ Miron	BS_13	Baseline	WP09-MHD-05/01/MEdC	
	Equilibrium flows/ Spineanu	BS_2	Baseline	WP09-MHD-04/01/MEdC +ITM	
	ExB drift/ Vlad Madalina	BS_14	Baseline	WP09-TGS-02a/01/MEdC + ITM	
	ITM Portal /Pais	BS_4A	Baseline	preferential Support	
	ITM-AMNS /Stancalie	BS_4B	Baseline	preferential Support	
	PWI/Lungu 1	BS_AS_2	WP09-PWI-07-01/BS	Baseline din Preferential Support	
	PWI/Lungu 2	BS_AS_3	WP09-PWI-07-02/BS	Baseline din Preferential Support	
	PWI/Dinescu	BS_AS_4	WP09-PWI-02-05/BS	Baseline din Preferential Support	
	PWI/Tiseanu 1	BS_AS_6	WP09-PWI-01-01/BS	Baseline din Preferential Support	
	PWI/Tiseanu 2	BS_AS_7	WP09-PWI-04-01/BS	Baseline din Preferential Support	
	PWI/Lungu 1	AS_2	WP09-PWI-07-01/PS	Preferential Support	
	PWI/Lungu 2	AS_3	WP09-PWI-07-02/PS	Preferential Support	
	PWI/Dinescu	AS_4	WP09-PWI-02-05/PS	Preferential Support	
	PWI/Tiseanu 1	AS_6	WP09-PWI-01-01/PS	Preferential Support	
	PWI/Tiseanu 2	AS_7	WP09-PWI-04-01/PS	Preferential Support	
	TGS/ Ruset	AS_1	WP08-TGS-01-04	Preferential Support	
	Tomography GRC/Teddy	BS_9.1	JW8-O-MEC-12	Notification JET Campaign C26	
	SHFD/ Zoita	BS_5.1	JW8-O-MEC-12	Notification JET Campaign C26	
	Tungsten Errosion/Ruset	BS_12	JW8-NFT-MEC-12	Notification JET Project EP2	
	W on CFC/ Ruset	TT12_5.1b	JW6-TA-EP2-ILC-04	5.1b Notification JET Porject EP2	
	Beryllium Inconel/ Lungu	TT19_5.1b	JW6-TA-EP2-ILB-03	5.1b Notification JET Porject EP2	
	W on CFC- ORDER/Ruset	TT12_O	JW6-OEP-MEC-06A	Order JET	
	Beryllium on inconel - ORDER/	TT19_O	JW6-OEP-MEC-09C	Order JET	
GRC Mission/ Zoita	BS_7A_O	JW9-OEP-MEC-13_Mis	Order JET Missions GRC		

ICSI	KN3-NA/ Curuia	BS_7(A+B)	JW6-TA-EP2-GRC-02	JET Notification (ICSI+INFLPR)
	KM6T/ Soare	BS_15	JW6-TA-EP2-GRC-02	JET Notification
	TRI-TOFFY/ Brad	AS_8	WP08-GOT-TRI-TOFFY	Preferential Support Training
	GRC-ORDER/ Curuia	BS_7B_O	JW8-OEP-MEC-13	Order Procurement & Missions

IFIN - HH	GRS/ Olariu	BS_8	JW6-TA-EP2_GRS-03	JET Notification
	GRS-ORDER/ Olariu	F8_O	JW7-OEP-MEC-11	Art. 6.3 Order
	Tritium Depth AMS /Stan-Sion		JW9-NFT-MEC-16	JET Notification

Ucv	Anomaious 1r/ Ucv	BS_3	Baseline	Baseline
	TGS/Steinbrecher	AS_5	WP08-TGS-01-06	Preferential Support

UAIC	Plasma Sheath/ Claudiu	BS_6	Baseline	
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List of activities and Task Agreements WP 2009

Sursele bugetului Asociației EURATOM - MEdC

ANCS;

Volumul finanțării este precizat prin
Contractul ANCS - IFA

Comisia Europeană;

Volumul finanțării este fixat prin
Contract of Association (+ [Amendments](#))
Baseline : 20% + 80% (limita critică)
Orders (Proiect și Secondment) + Additional Support

Comisia recunoaște două tipuri de cheltuieli ale Asociației:

1. Eligibile: necesare Asociației și la care participă
2. Ne-Eligibile: necesare Asociației, dar la care NU participă (Ex: TVA, taxe, o parte din Overhead-uri)

Finantarea de catre Comisia Europeana si de catre EFDA
/JET
a Task Agreement-urilor
EFDA / JET – Asociatia EURATOM MEdC

1. Enhancement Project EP2 JET

- A. [Notificare de Proiect \(anterior 5.1b\)](#) 40% + 60%
- B. [Order de Proiect \(Jet Fund +Comisia\)](#) 100%
- C. Misiuni pentru Proiect 100%

2. Campanii experimentale JET (Art.6.3)

- A. [Order de Campanie](#) (Jet Fund) 100%
- B. [Notificare de Campanie](#) 20% + 80%

Structura verificarii profesionale

TG, EFDA Work Programme + JET Work Programme, Calls

Task Agreements (Contracte Comisie – Association MEdC):

Rapoarte intermediare

Rapoarte finale

Project Board Meetings

Work Plan al Association MEdC :

Steering Committee

Aprobarea WP de catre Comisia Europeana

Annual Report pe pagina web a Comisiei Europene

Monitorizare profesionala:

EFDA Steering Committee

STAC (Scientific and Technical Advisory Committee)

CCE-FU

Meetings ale Head of Research Units

Structura verificarii financiare

Task Agreements

Order: Individual Task description (Sume, termene)
Notificari: Project Management Plan (Sume, termene)
Project Board Meetings

Bugetul Asociatiei

Steering Committee
Annual Accounts
Indicative Outturn
Contract Monitoring

Mobilities

Steering Committee
Comisia, prin Plan si Raport

Secventa verificarii financiare

Situatia finaciara se trimite TRIMESTRIAL la Comisa Europeana

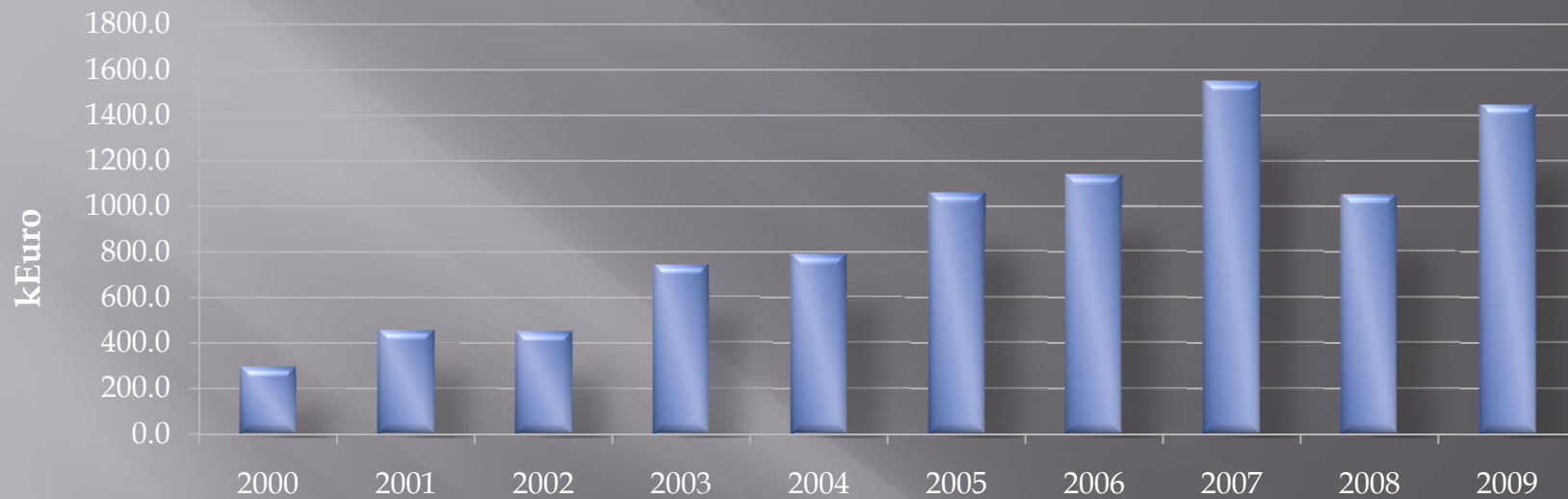
Postcalcule la Contractele IFA – Institute

1. Annual Accounts, Contract Monitoring, Staff
2. Se invita doua persoane de la CE Directoratul J, de la Finante
3. Se face Audit de catre o firma agreata de CE
4. Se transmite Certificatul de Audit la CE
5. Dupa 45 zile se aproba si se pot formula CALL for FUNDS

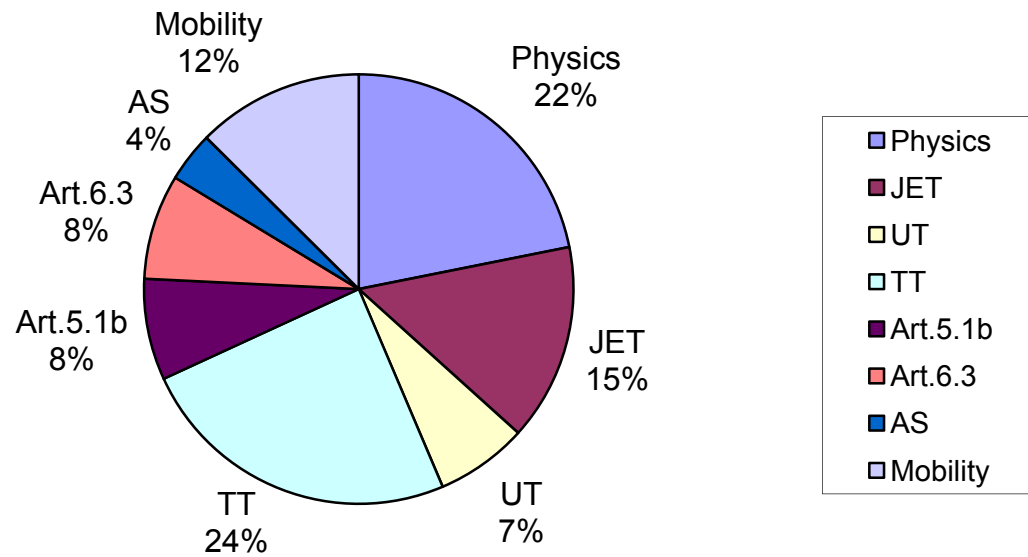
Essentials of the history of ten years expansion

- 1999: Assessment of our expertise.
What Romania can offer to the fusion community?
- 2005: 42 researchers, 1,053 million Euro, 9 Associations
- 2009: 28 Task Agreements (contracts with EFDA and EFDA-JET)
Topical groups (transport, MHD, diagnostics, etc.)
Plasma Wall Interaction
Integrated Tokamak Modeling
Materials

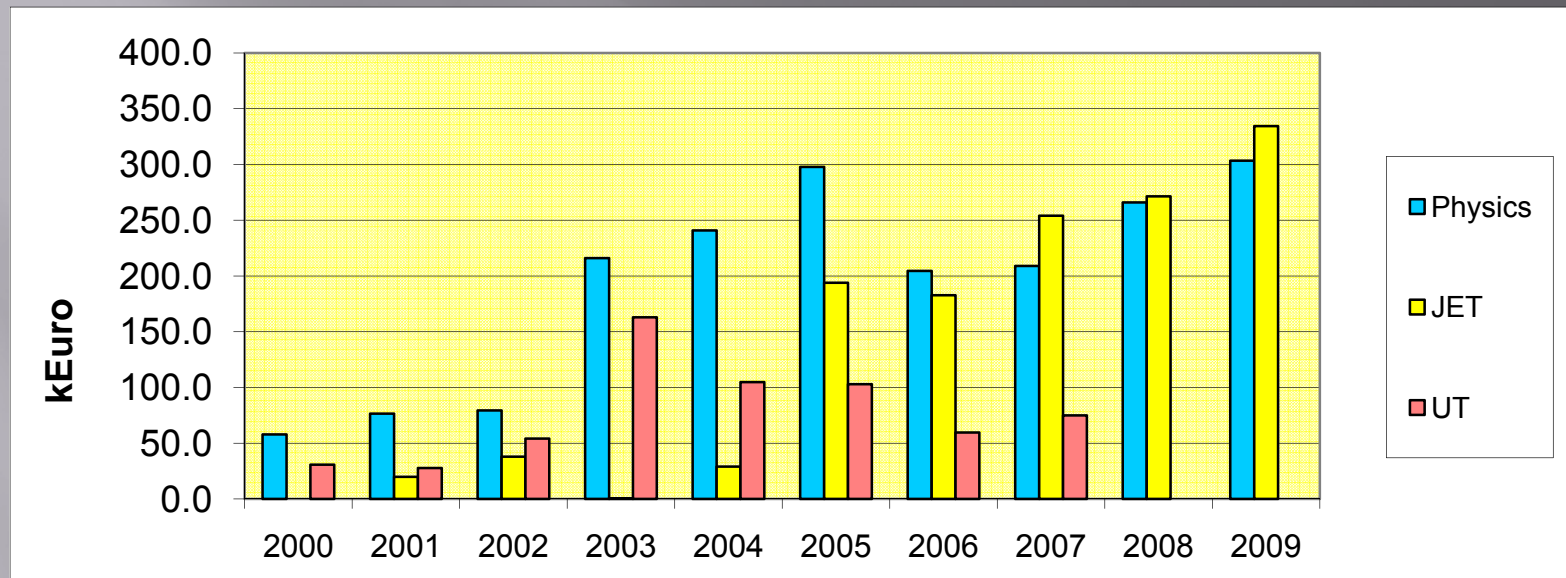
Association EURATOM - MEdC Annual Expenditure



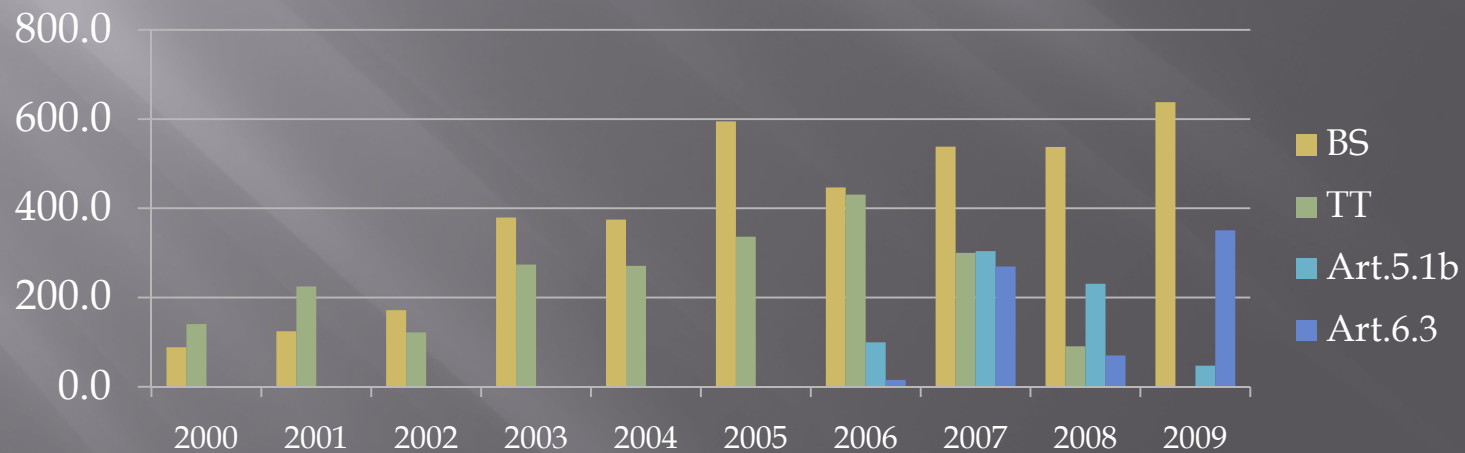
Expenditure categories (2000-2009)



Baseline expenditure structure (Physics, JET Notifications, UnderliTechnology)

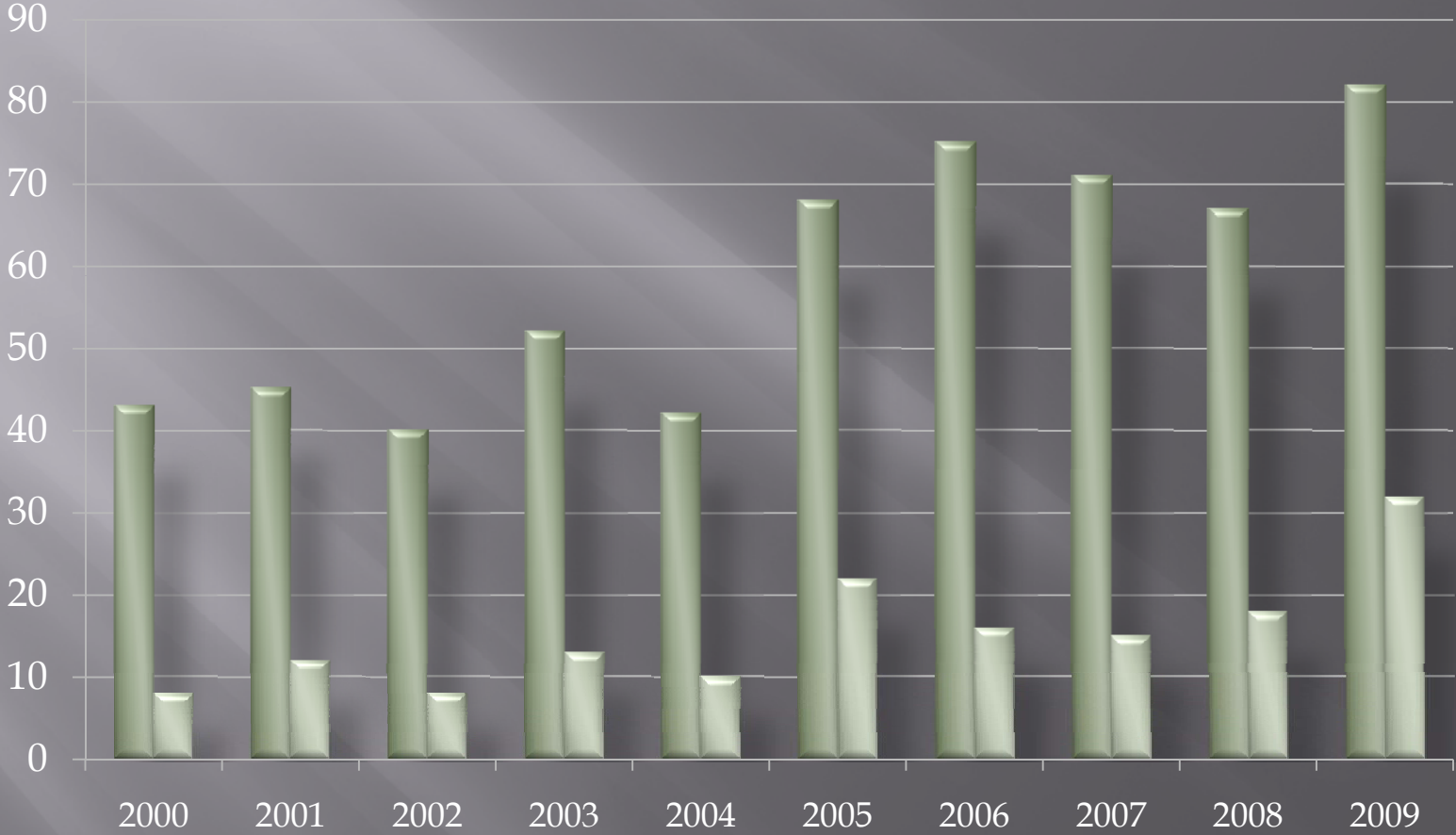


Expenditure structure evolution (Baseline, Technology Tasks, Art. 5.1b, Art. 6.3)

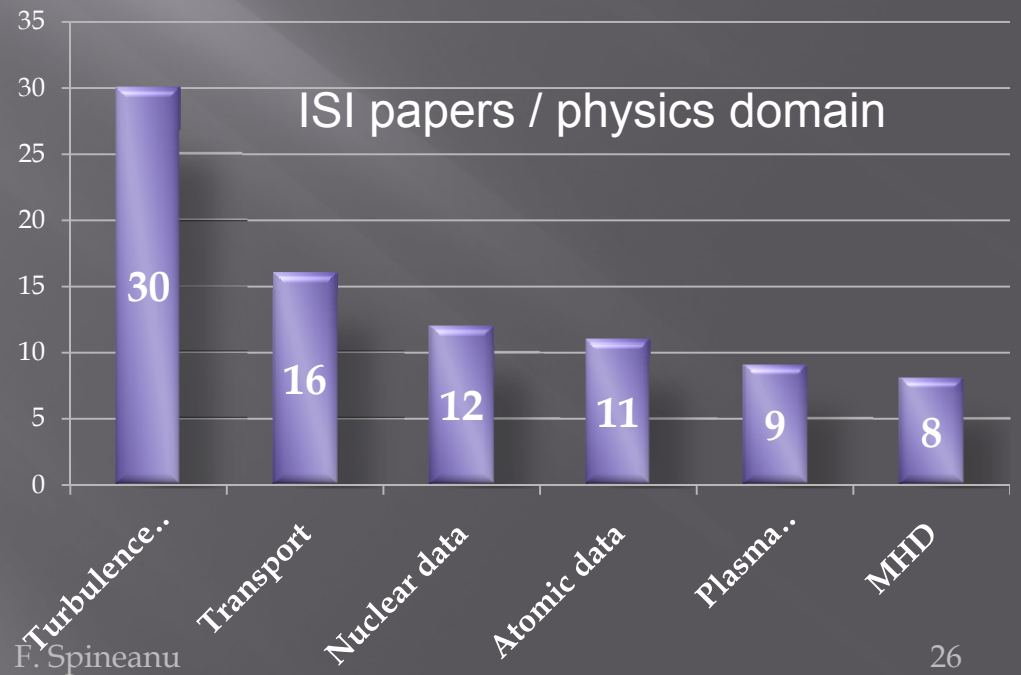
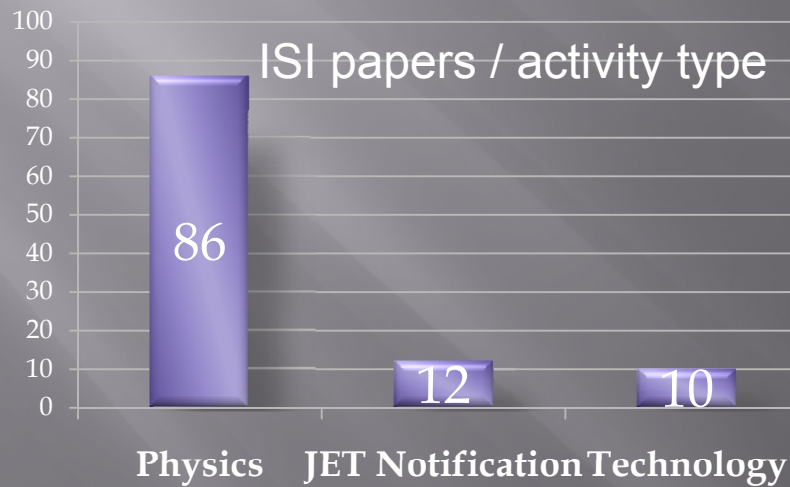
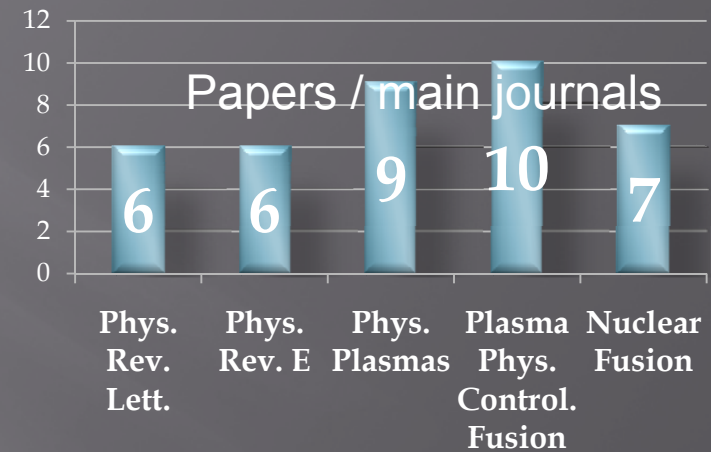
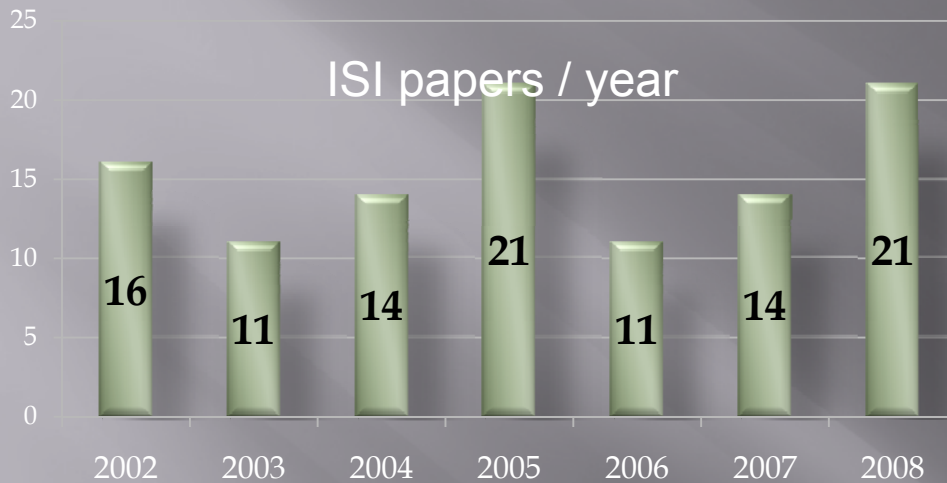


Staff evolution

Professional
Non-professional



PUBLICATIONS 2002-2008: 194 articles (including 108 in ISI journals)
219 contributions at conferences



Major research fields where MEdC Association has made contributions

- Basic physics of fusion plasma
 - Transport, MHD, diagnostics, sheaths
- Physics Integration (ceramics, optical fibers)
- Magnet structure and integration
- Tritium inventory control
- Tritium Breeding and Materials
 - Materials Development
 - IFMIF, Test Facilities
 - IFMIF, Design Integration
- Fuel Cycle
- Atomic and Nuclear data bases
- Plasma Facing components (JET)
- ITER-like Wall Project (JET)

Optimization and Manufacturing of 10 μm W-coatings for the CFC tiles to be installed in JET

ITER-like Wall at JET

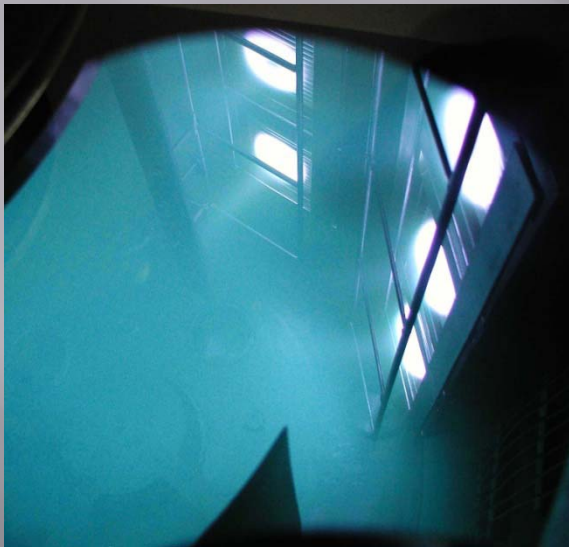


CMSII coating equipment general view

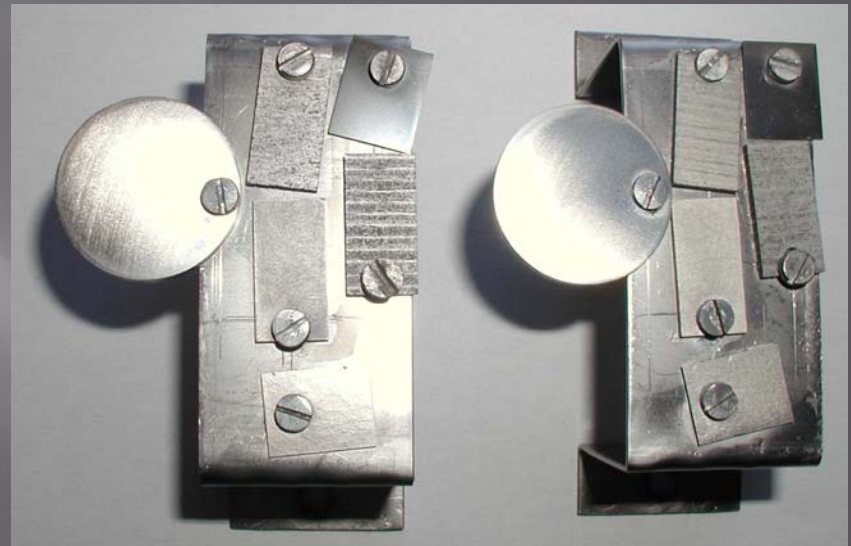


W coated tiles during the HHF test

Extension to JET divertor 2009



CMSII discharge with
6 magnetrons running

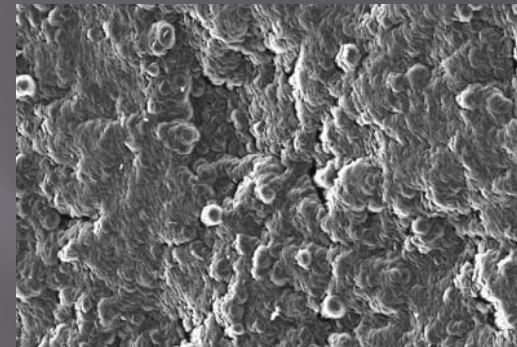
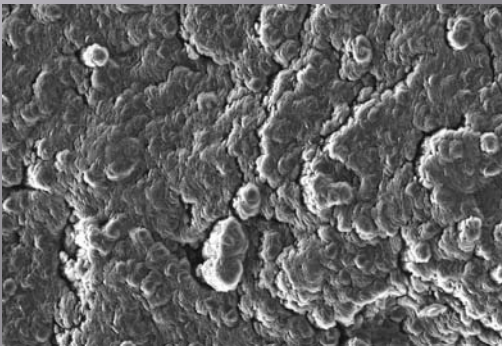


Tungsten markers deposited on various
substrates by CMSII technology

To measure net erosion of W on
divertor tiles

PRODUCTION OF BERYLLIUM COATINGS FOR INCONEL CLADDING AND BERYLLIUM TILE MARKERS FOR THE ITER-LIKE WALL PROJECT

Thermionic vacuum arc (TVA) method



Beryllium coatings on inconel: (a) “as produced”; (b) after HHF test of 20 MJ m⁻².

Interest expressed by Fusion for Energy, for ITER applications (2009)



Photograph of the equipment used for Beryllium tile Markers coatings

Asociatia EURATOM – MEdC in 2010

Planul de Lucru este aprobat de catre Comisie (18 dec. 2009)

Task Agreements 11 in continuare
 19 noi
 4 trimise la EFDA, cu reale sanse
 3 in asteptare (supraconductibilitate)

Valoare Contract: 3,262,000 Lei (ANCS estimare in 2008)
 1,473,540 Lei (Comisie) (32%)

Problemele Asociației EURATOM – MEdC Romania

Termen scurt

- finanțarea suficientă a Task Agreement-urilor
- găsirea de resurse pentru co-finanțare, până la rambursarea de către Comisie
- rezolvarea problemei Task Agreements care apar în cursul anului
- îmbunătățirea Managementului

Termen scurt și mediu

- identificarea altor teme și a altor grupuri de cercetare care pot participa
- atragerea de persoane tinere

Termen lung

- strategie pentru conservarea expertizei științifice în perioada de până la ITER
- strategie pentru ITER

ITER

International Thermonuclear Experimental Reactor

Site: Cadarache (France)

First plasma : 2018 (Scenario 1; modified to 2026 D + T)

Cost: unknown. Now: 8,5 bilion Euro

High commitment: Europe, Japan, China, Korea, India, Russia, USA

Fusion for Energy

European Domestic Agency for Fusion, F4E (Barcelona)

ITER main components

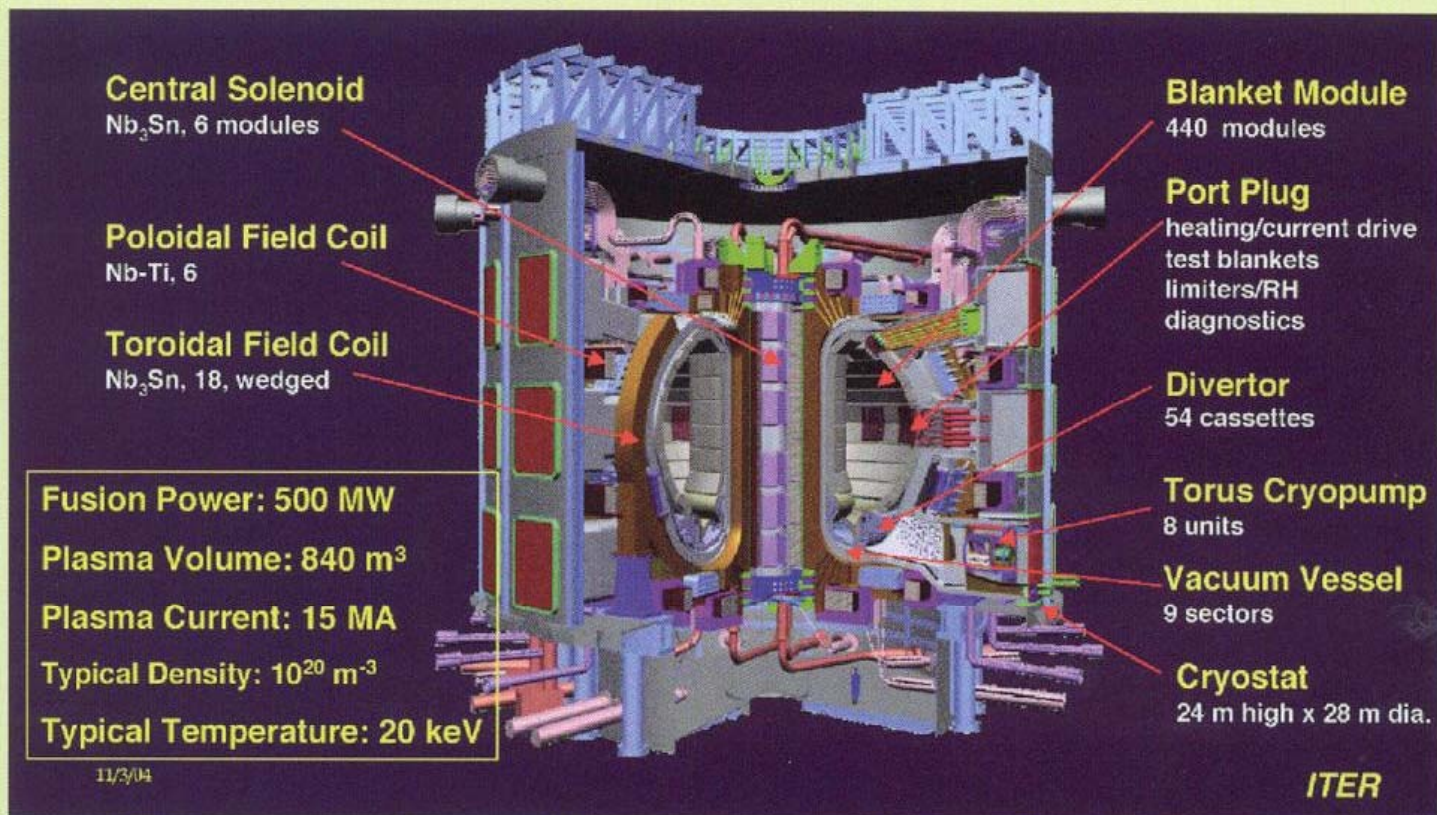


Figure 4 - ITER Tokamak Assembly - Main Components and Parameters

R&D projects in support of ITER

Figure 1 -
R&D projects in
support of ITER
feasibility

Completed 7 Large R&D by July 2001.

CENTRAL SOLENOID MODEL COIL
Radius 3.5 m
Height 2.8 m
 $B_{max} = 13$ T
0.6 T/sec

VACUUM VESSEL SECTOR
Double-Wall,
 ± 5 mm

BLANKET MODULE
HIP Joining Tech
1.6 m x 0.93 m x
0.35 m

REMOTE MAINTENANCE OF BLANKET
4 tonne
 ± 0.25 mm

TOROIDAL FIELD MODEL COIL
Height 4 m
Width 3 m
 $B_{max} = 7.8$ T

DIVERTOR CASSETTE 20 MW/m²

REMOTE MAINTENANCE OF DIVERTOR CASSETTE
Attachment Tolerance ± 2 mm

ITER

Procedure to join a project for ITER

- Watch the F4E calls
- Strong connection with a major team in that field
- Proposal sent in bilateral form to collaborators
- Creation of a Consortium of Association
- Work for the Project to be submitted to F4E
- Expect hard competition

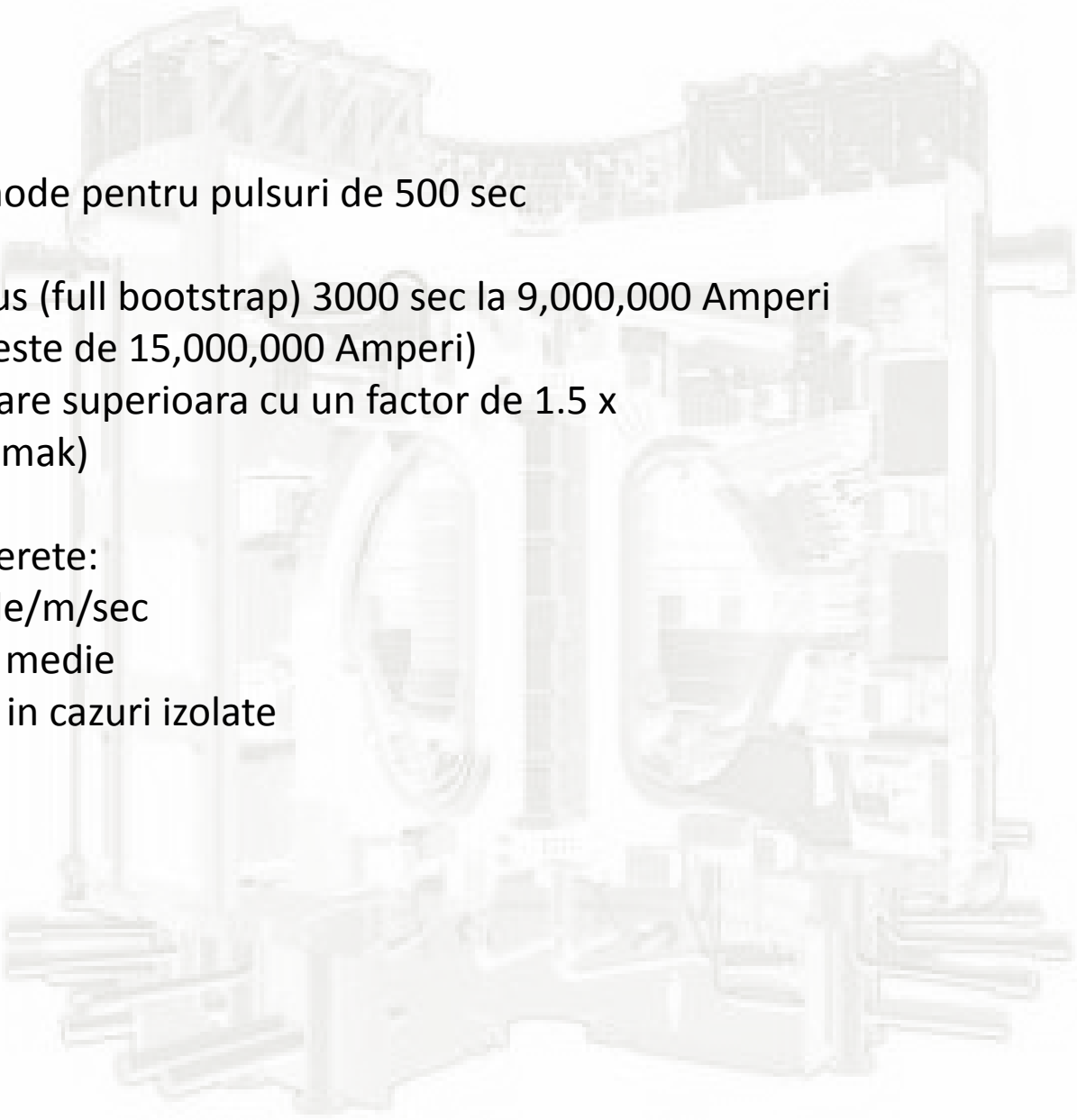
The Association MEdC is *never* informed by F4E about a Call.

Participation to F4E can be made :

1. via the Association (in Consortia)
2. on institutional “individual” basis

Three projects:

Nuclear Data (via IFIN-HH) and
ITER Tritium Plant (IO) ICSI via Association MEdC
Be coating BECOAT (INFLPR – Lungu)



ITER: ELMy H-mode pentru pulsuri de 500 sec

Fara curent indus (full bootstrap) 3000 sec la 9,000,000 Amperi
(curent maxim este de 15,000,000 Amperi)

Necesita confinare superioara cu un factor de 1.5 x
(Advanced Tokamak)

Flux la primul perete:

- 10^{24} particule/m/sec
- 10 MW/m² in medie
- 1000 MW/m² in cazuri izolate

Conclusions

Major achievements:

physics: decorrelation trajectory method
W- and Be – coating on JET Wall
micro-tomography
diagnostics

Missed opportunities

High Performance Computer for Fusion Physics

Perspectives

ITER participation with Tritium, Beryllium and Nuclear data

Still to solve:

Do-we have a strategy for ITER?
Are-we at the periphery or on the main stream?
How to conserve the physics expertise