SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

EUROPEAN
SPALLATION
SOURCE

Belgian Science Policy Office
belspo

ESS and Big Science Infrastructures

relevance for Society, Science and Technology Development

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What is Big Science ?

*"**Big Science** refers to the style of scientific research developed during and after World War II that defined the organization and character of much research in **physics** and **astronomy** and later in the **biological sciences**.*

But more important :

Big Science is characterized by large-scale instruments and facilities, supported by funding from government or international agencies, in which research is conducted by teams or groups of scientists and technicians."

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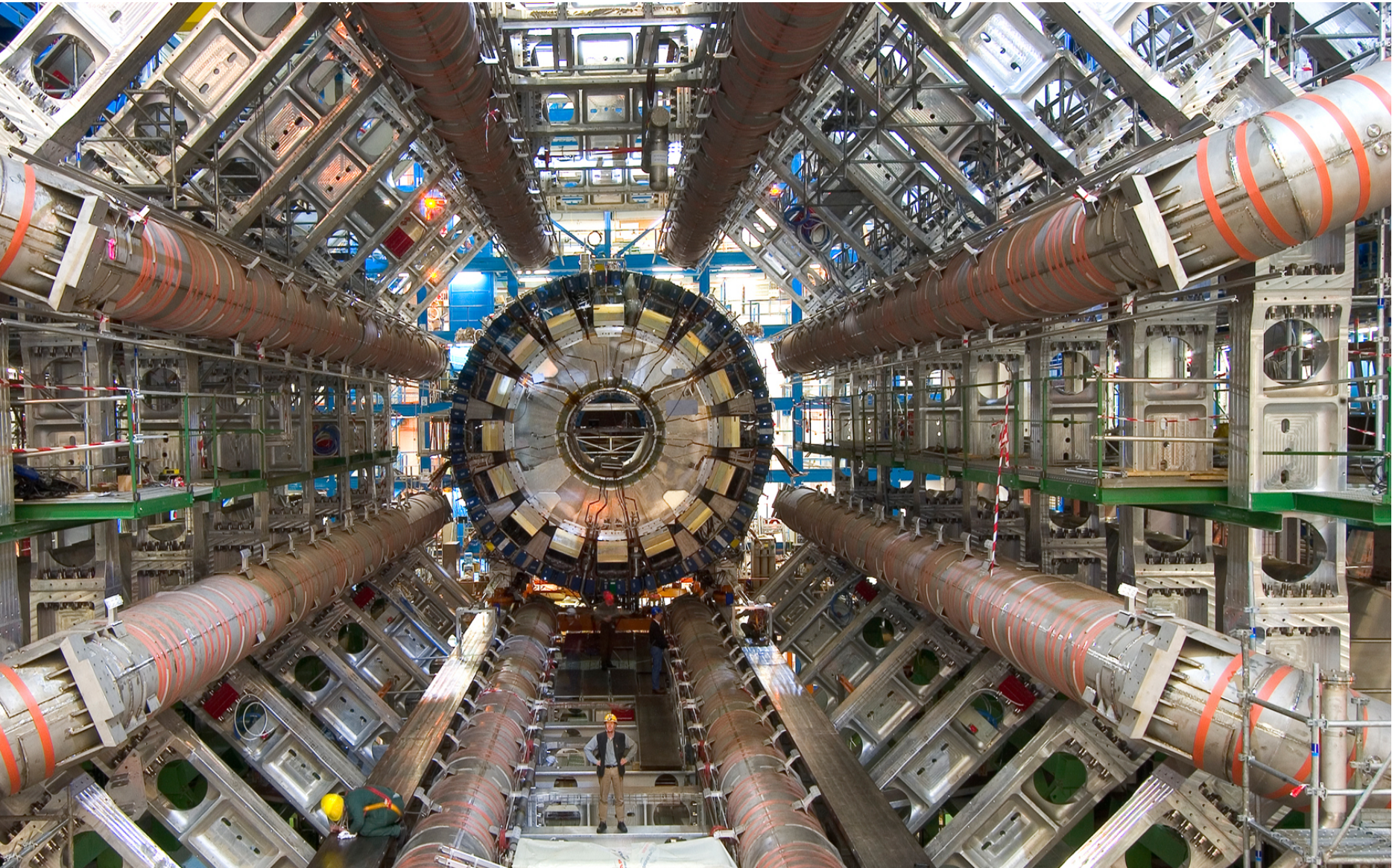
CERN – **C**onseil **E**uropéen pour la **R**echerche **N**ucléaire



Accelerator infrastructure for particle physics :
- fundamental particles
- 4 fundamental forces
- their interaction
- e.g. origin of mass of subatomic particles (Higgs boson)
- application field: Alpha to Omega: from “subatomic” to “stars”

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CERN – **C**onseil **E**uropéen pour la Recherche **N**ucléaire

Example:
“CLOUD” experiment
Cosmics **L**eaving **O**utdoor **D**roplets

The primary goal of CLOUD was to understand and reproduce the influence of galactic cosmic rays (GCRs) on aerosols and clouds, and their implications for climate.

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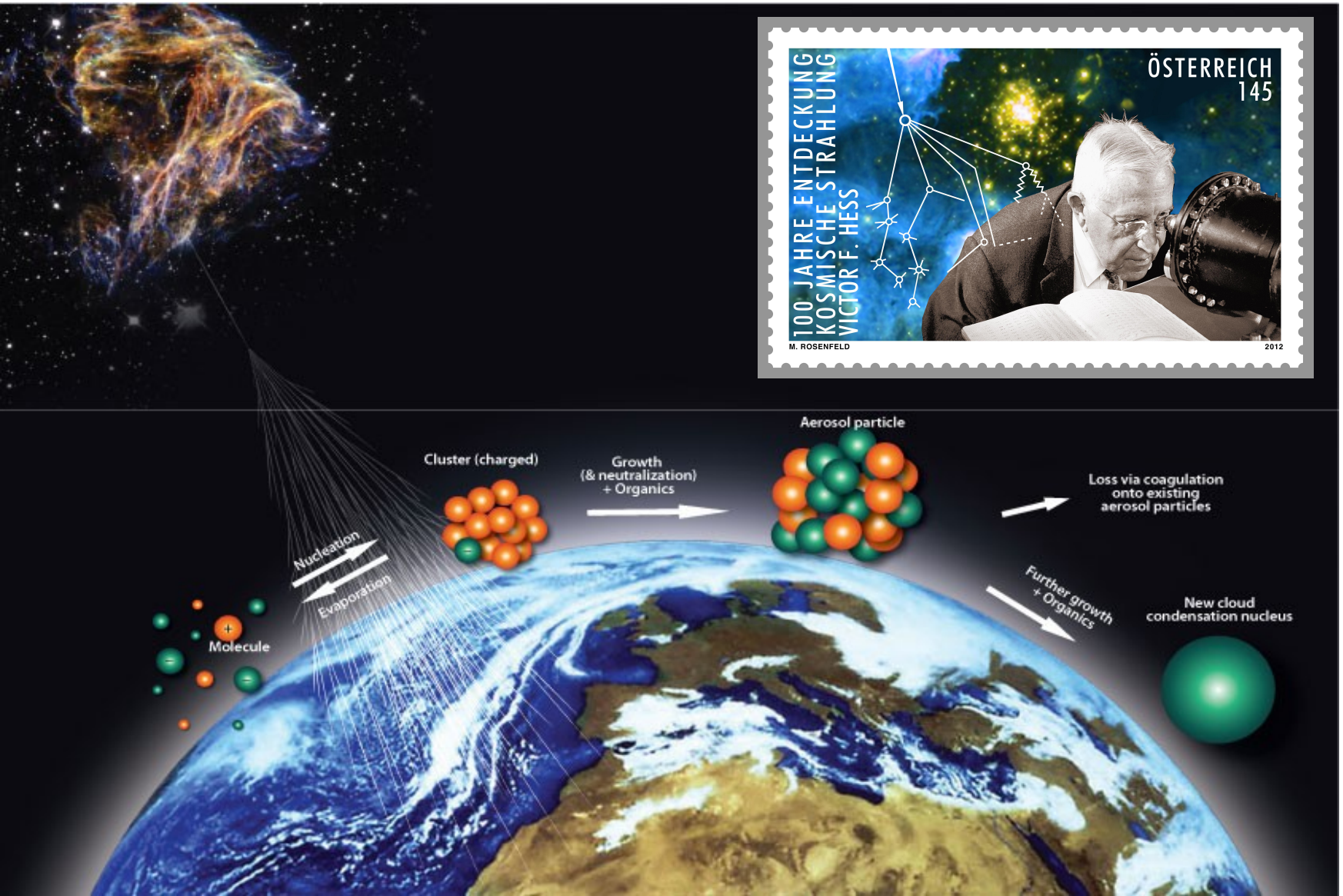
CERN – Conseil Européen pour la Recherche Nucléaire



CLOUD experiments at CERN have shown the physics behind the high correlation measured between "**cosmic ray**" impact and "**cloud formation**" (and thus albedo, and thus climate)

See further ESA for the tools to measure both cosmic rays and clouds…

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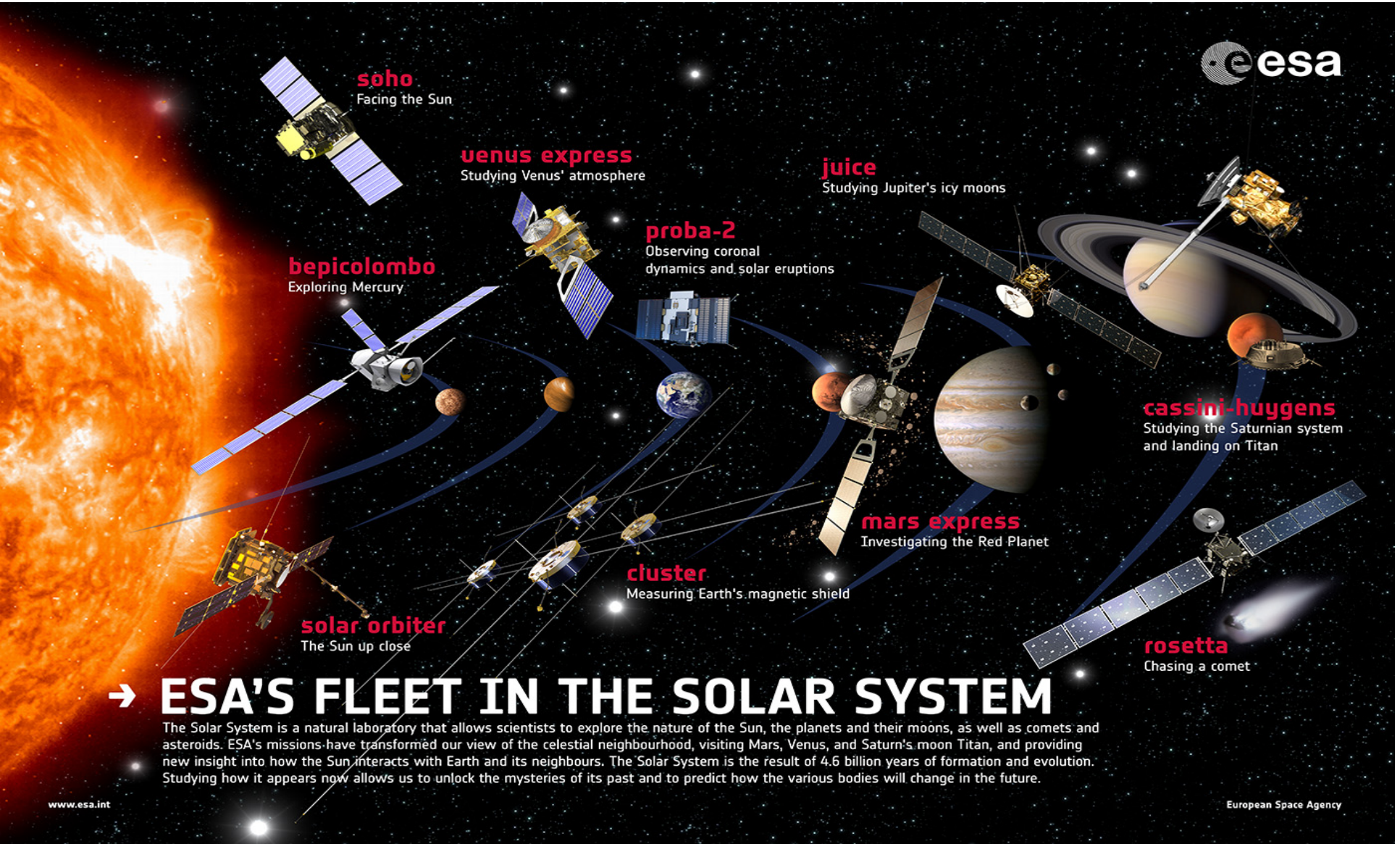
ESA – European Space Agency



Study of
- the nature of the sun, the planets and their moons, comets and asteroids
- the interaction of the Sun and earth
-phenomena on the earth (greening of the earth, ice sheets, …)

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ESA – European Space Agency: application fields

• Energy output variations of the sun	ACRIMSAT
• Air temperature, humidity, clouds & surface Temp	AIRS
• Ocean salt concentrations	AQUARIUS
• High resolution images of the earth	ASTER
• Earth's atmosphere and weather	CLOUDSAT
• Gravitational field of earth (water & ice distributions)	GRACE
• Heights of the water in the oceans	JASON 1
• Multi-angle Imaging Spectro-Radiometer	MISR
• Ozone depletion by chlorine chemistry	MLS
• CO2 distributions and increases in the atmosphere	OCO
• Heights of the water in the oceans	JASON 2
• Weather monitoring (e.g. wind speeds)	QUIKSCAT
• Troposphere and ozone monitoring	TES

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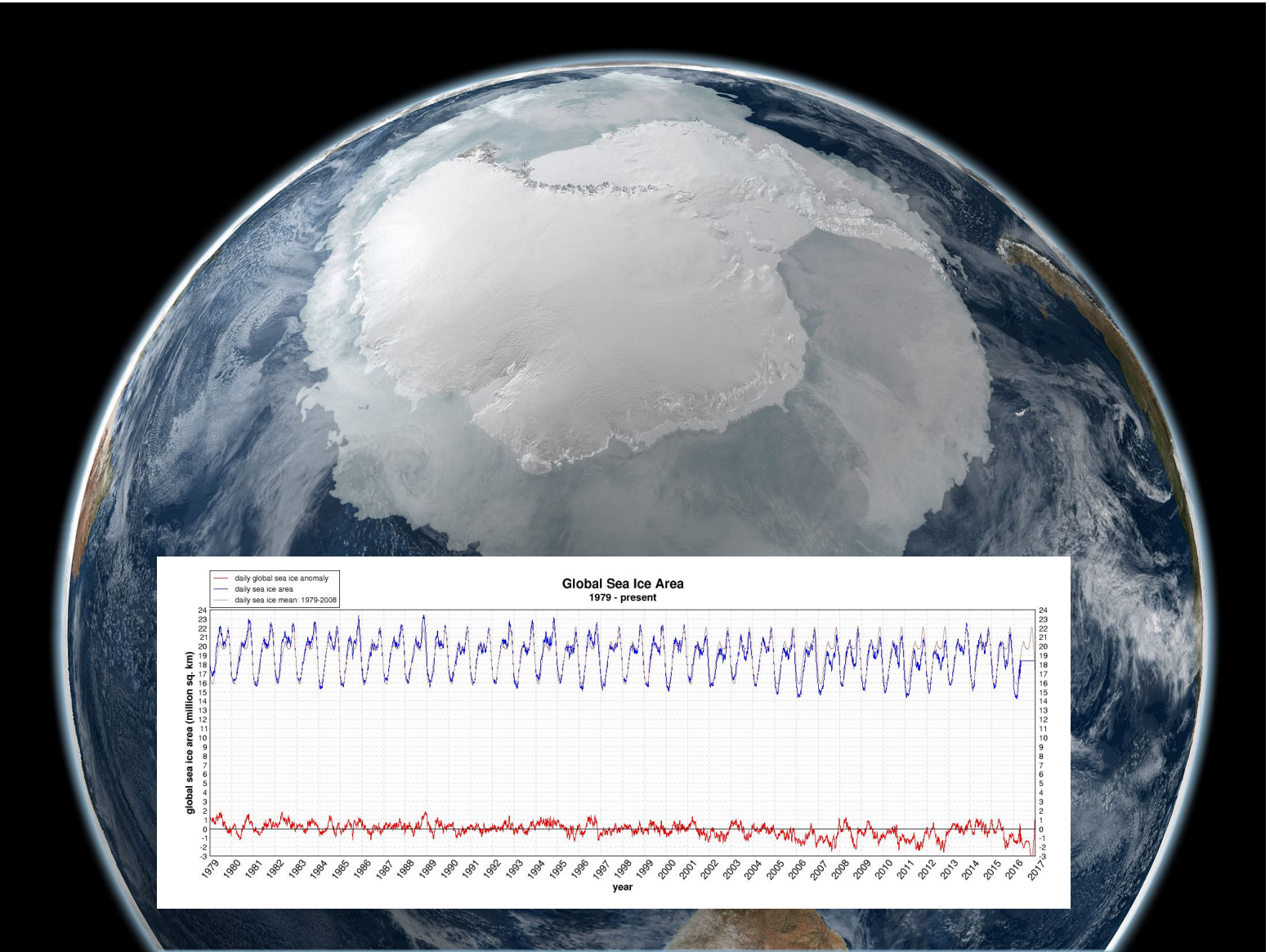
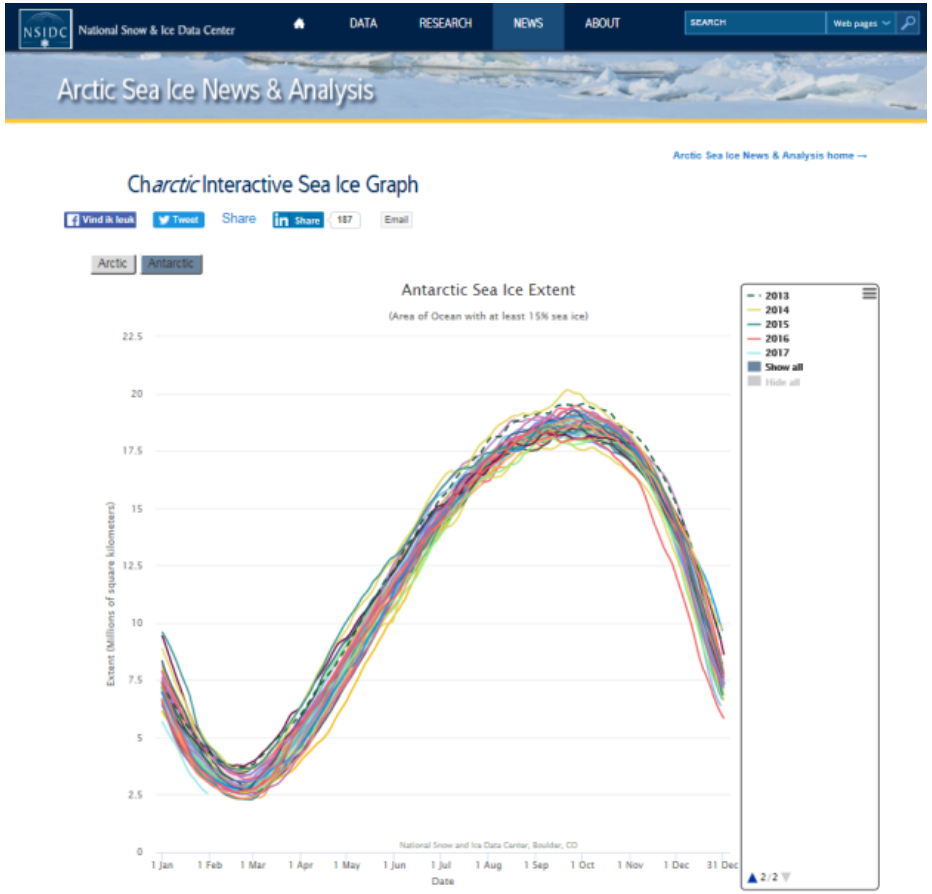
ESA – European Space Agency: application fields





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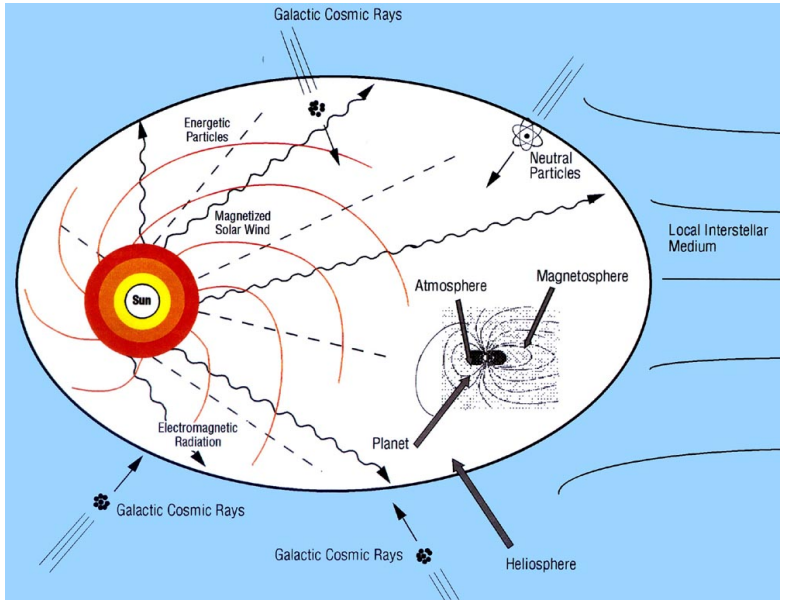
ESA – European Space Agency



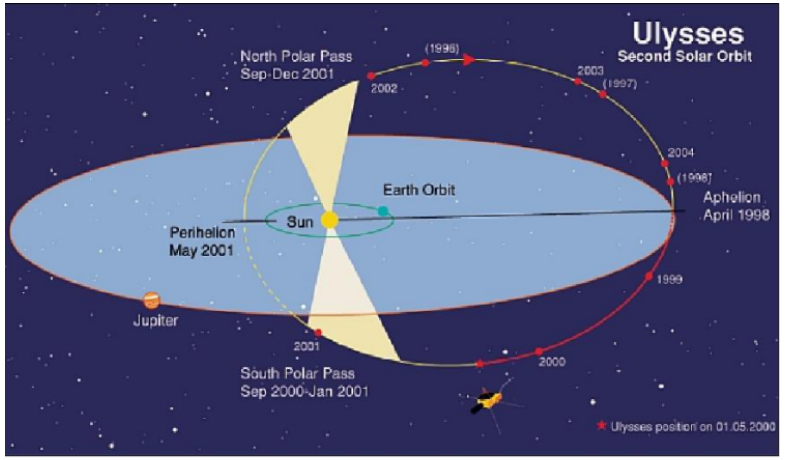


Figure 10: Second solar orbit of Ulysses as viewed from 15° above the ecliptic plane (image credit: ESA)

Ulysses (Pu 238 driven, ESA/NASA) allowed to measure variations in solar wind affecting cosmic ray impact on earth

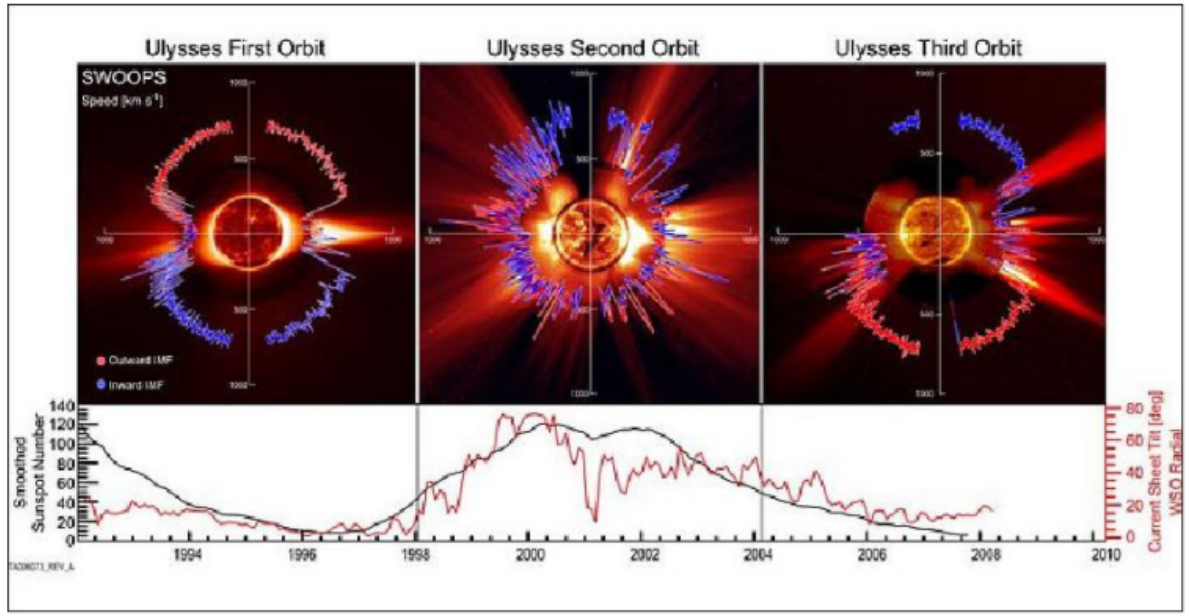


Figure 13: Variation in the solar wind as observed by Ulysses over a solar cycle (image credit: SwRI)

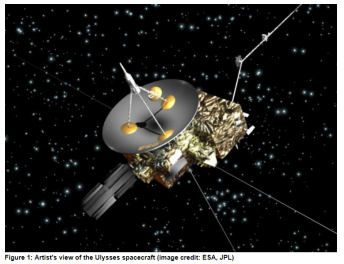


Figure 1: Artist's view of the Ulysses spacecraft (image credit: ESA, JPL)

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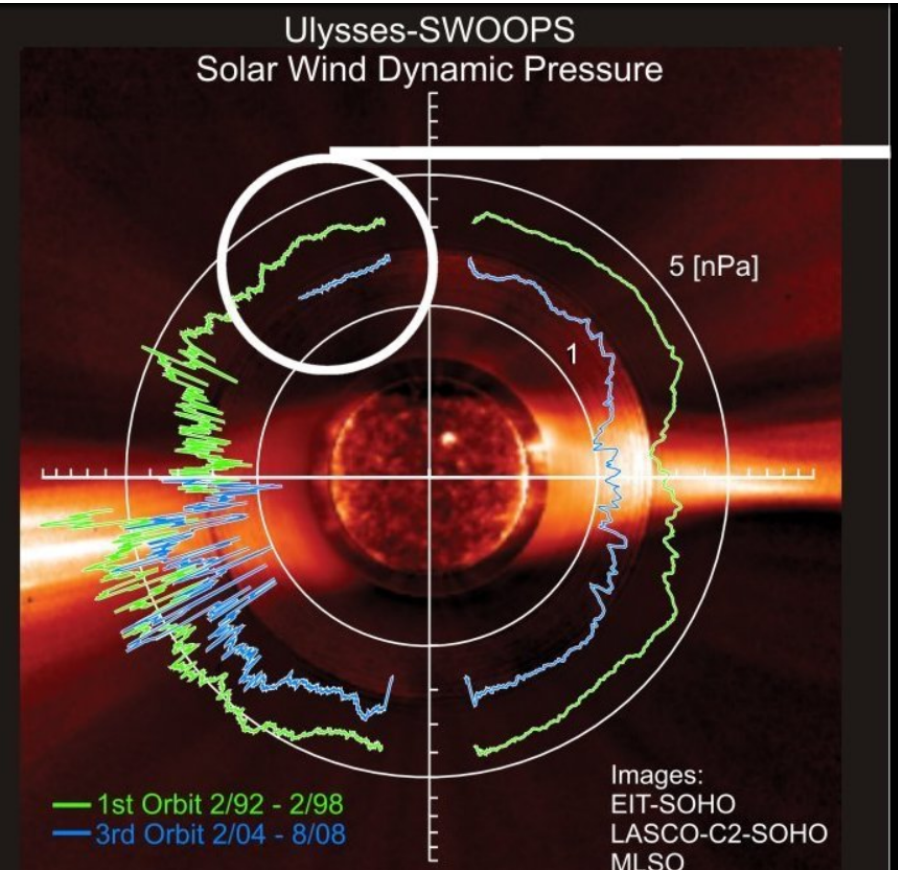
ESA – European Space Agency



Between 1992 and 2008

Solar wind 13% cooler
and 20% less dense.

Underlying magnetic
field weaker by 30%

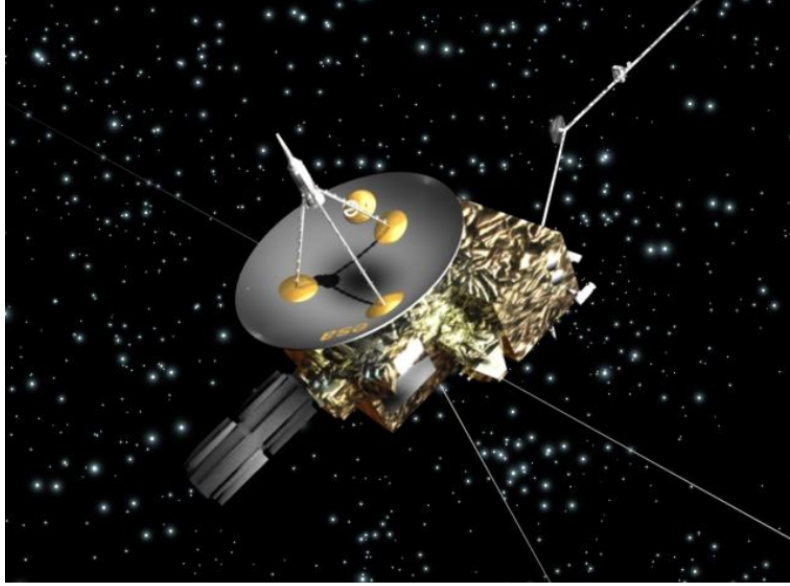


Figure 1: Artist's view of the Ulysses spacecraft (image credit: ESA, JPL)

Between 1992 and 2008

High-energy electrons
in the giga-electron-volt range
(part of galactic cosmic rays)
increased in numbers by 20%

ESS – European Spallation Source

ESS will be the world's most powerful neutron source

Why looking at neutrons and building expensive accelerator machines to do so ?

What do we use neutrons for?

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ESS – European Spallation Source

- To study hydrogen based structures (for fuel cells)
- To optimize PV polymers
- To study Li ion migration in cellphone batteries
- To study interaction (super)conductivity (at room T) and magnetism
- To study behavior of shampoo or turbine blades in divers conditions
- To develop Ga nitride based LED displays
- To develop paints (stick to adhere brush, thin enough to spread..)
- To develop alternative detergents than those based on zeolites
- To develop sun screen and pain relief creams
- To study DNA, proteins, skeleton build-up, blood, cell membranes,
- To develop gen therapy, find solutions for Altzheimer, new medicines etc.

That’s a lot of useful things !

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The Myrrha accelerator

SCK•CEN is actively working on designing and building a new multifunctional research installation: MYRRHA as in *Multi-purpose hYbrid Research Reactor for High-tech Applications.*

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ESO – European Southern Observatory

ESO has the purpose to support astronomy , looking at the stars and understanding the birth and death of them

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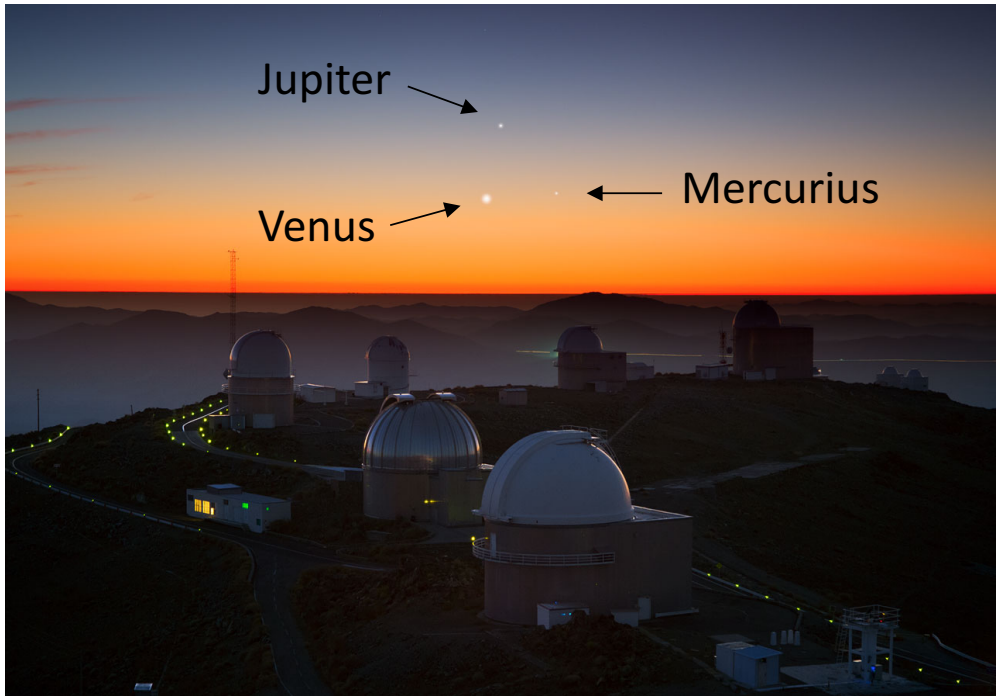
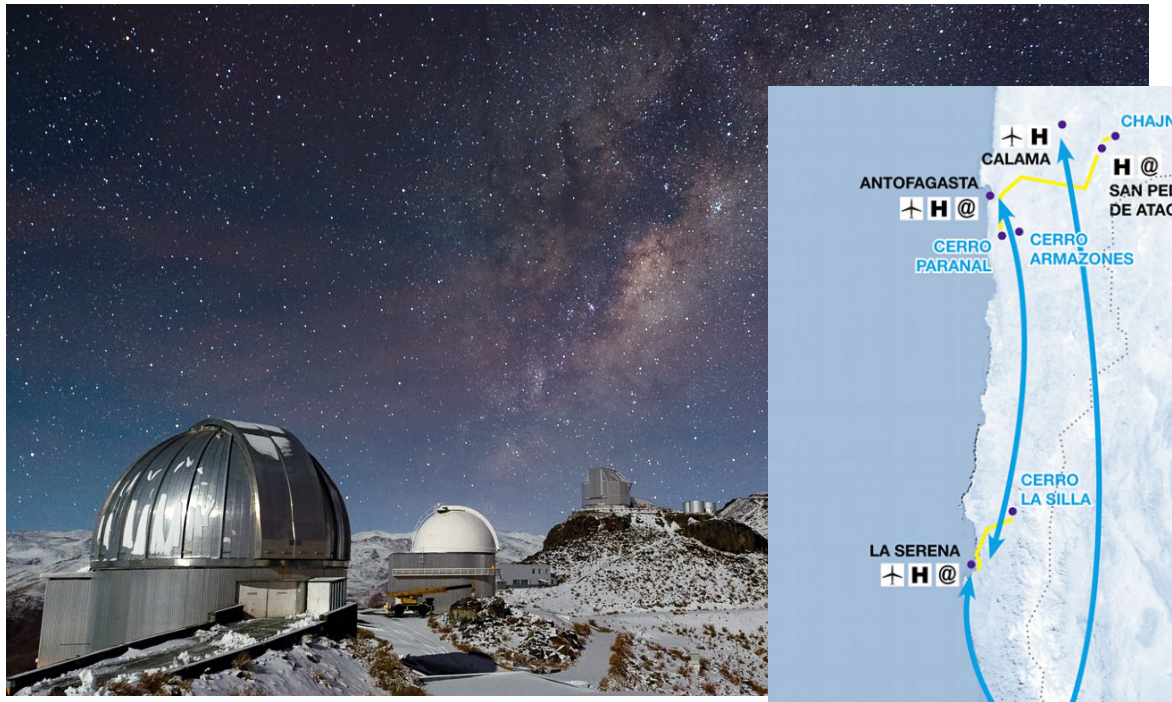
ESO – European Southern Observatory





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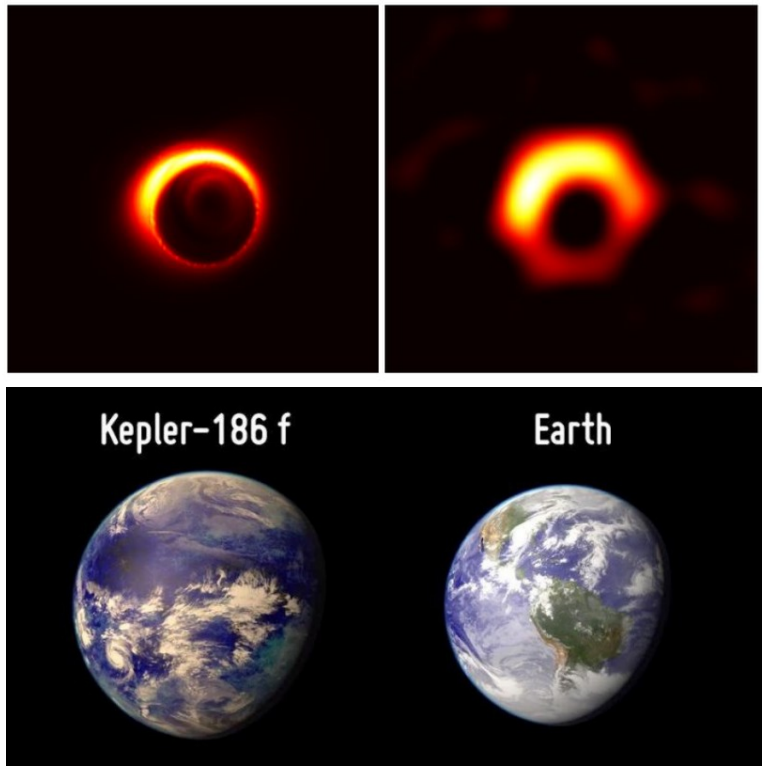
ESO – European Southern Observatory

10 Major discoveries at ESO

- Stars orbiting the Milky Way black hole
- Accelerating Universe
- Planet Found in Habitable Zone Around Nearest Star, Proxima Centauri
- Revolutionary ALMA image reveals planetary genesis
- First image of an exoplanet
- Oldest star known in the Milky Way
- Direct measurements of the spectra of exoplanets and their atmospheres
- Cosmic temperature independently measured
- Record-breaking planetary system
- Gamma-ray bursts – connections with supernovae and merging neutron stars



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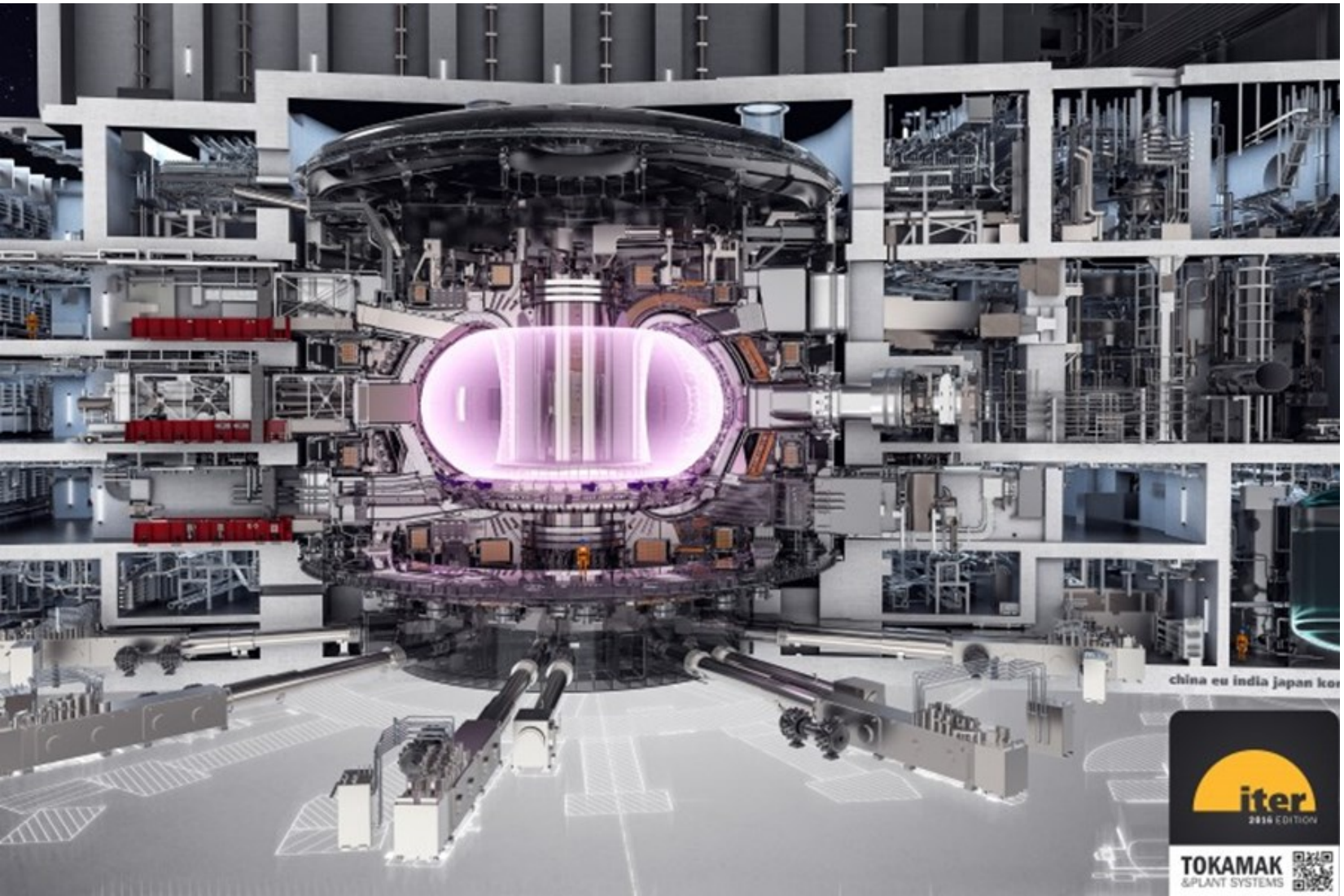
ITER – (International Thermonuclear Experimental Reactor), now The Way (Latin)



The purpose of ITER is to prove technical feasibility of producing energy from fusion reactions, which drive the energy production of the stars, however
at much higher temperatures because of limited plasma volumes

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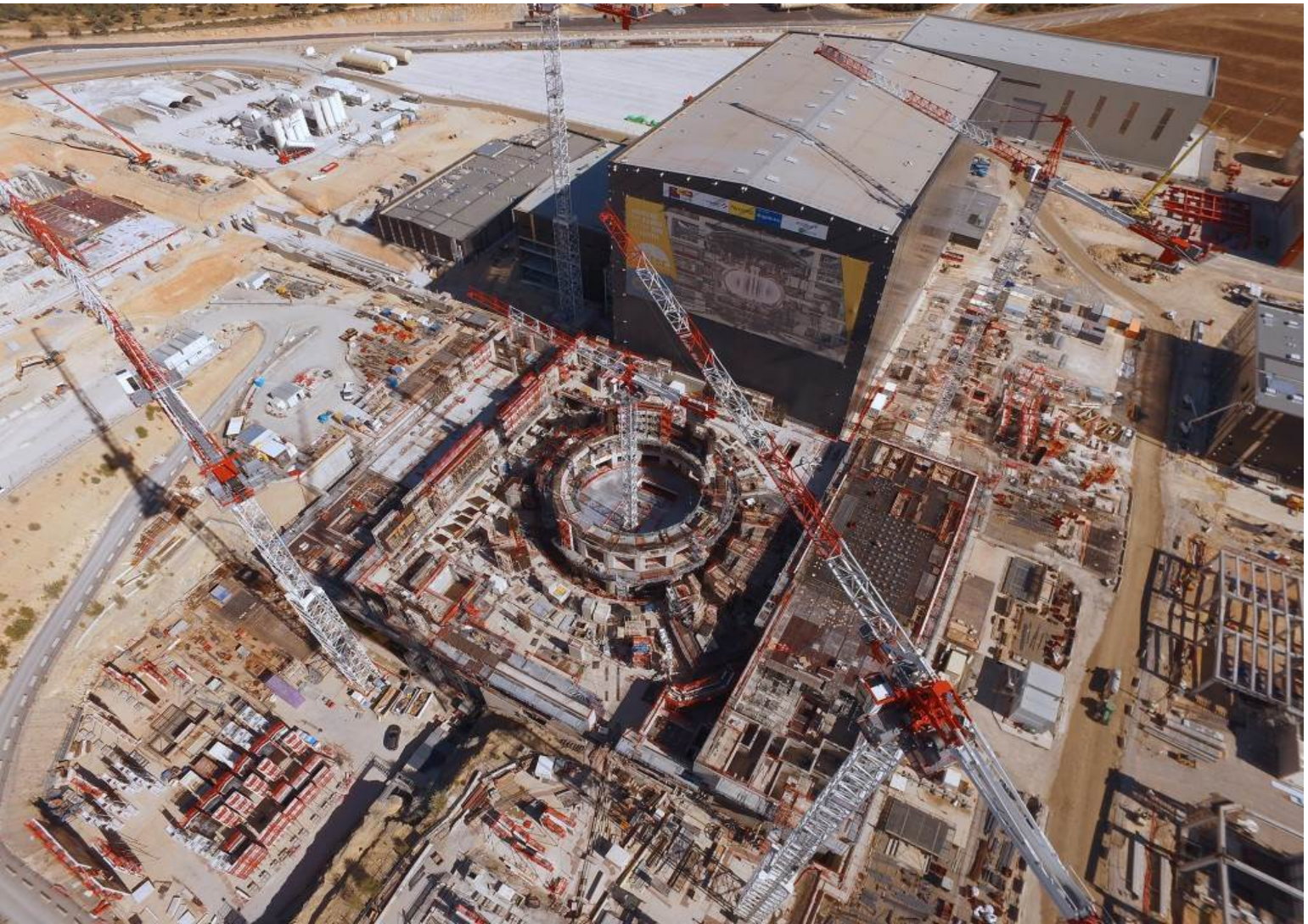
ITER – (International Thermonuclear Experimental Reactor), now The Way (Latin)



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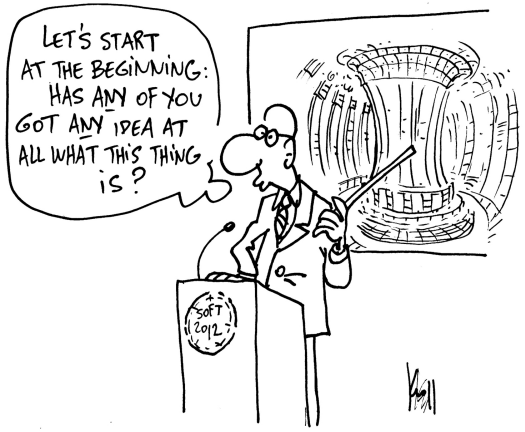
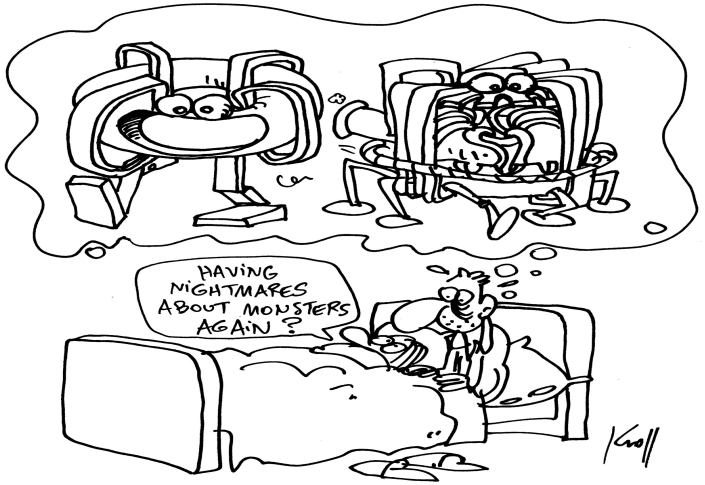
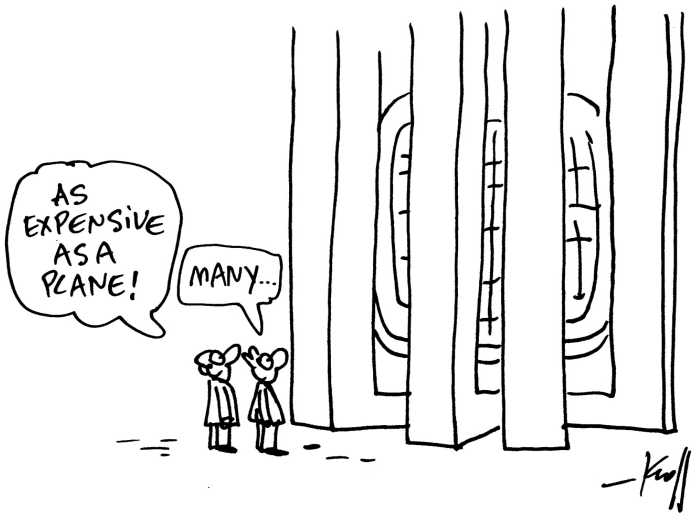
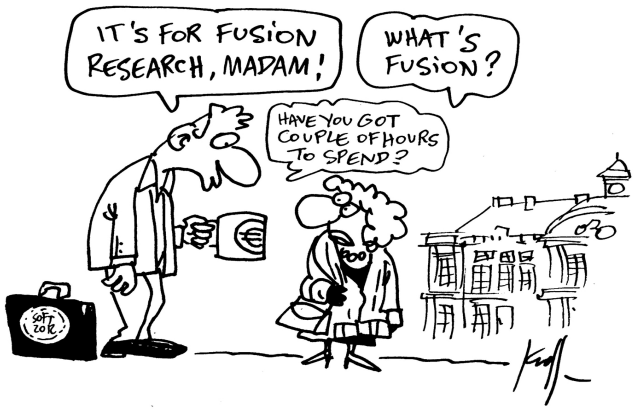
Common challenges for the Big Science world

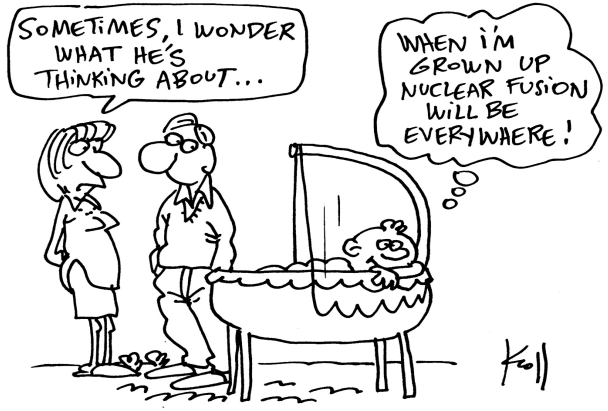






Complex science > Complex technology > Costs of infrastructures





Sustained funding < Time to realise

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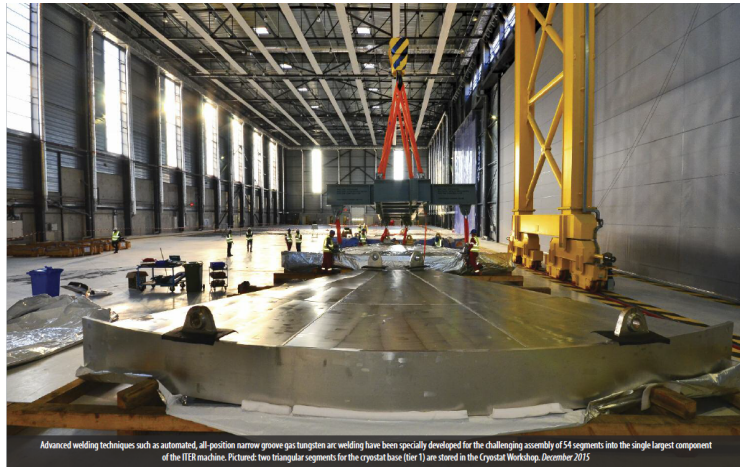
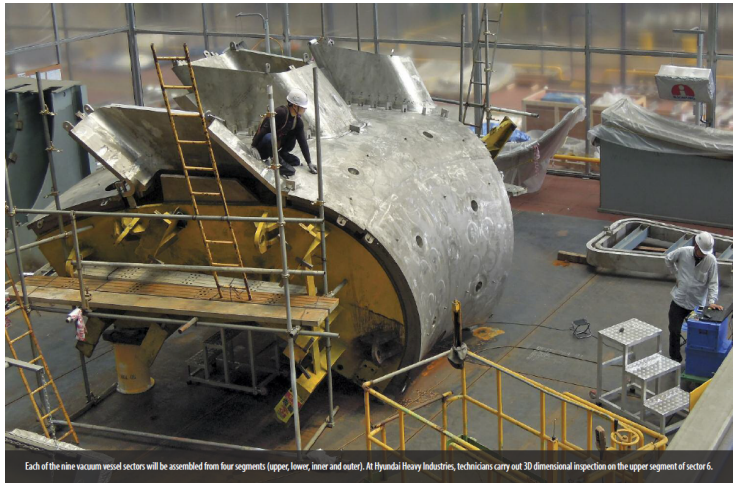
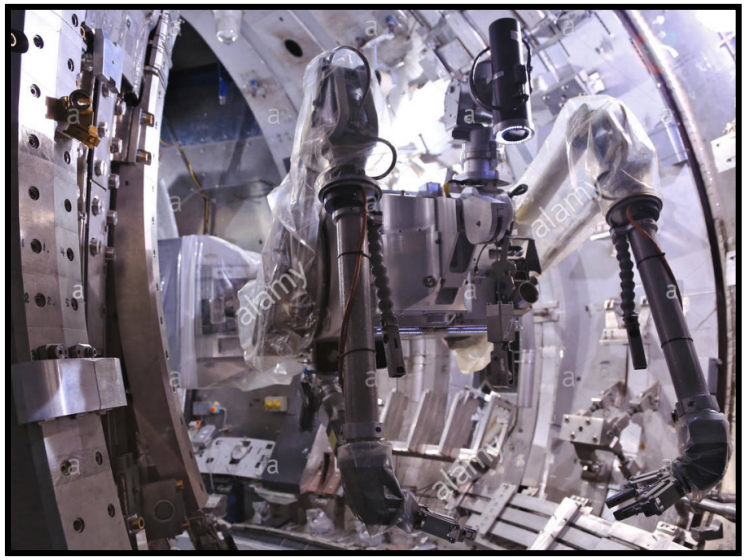
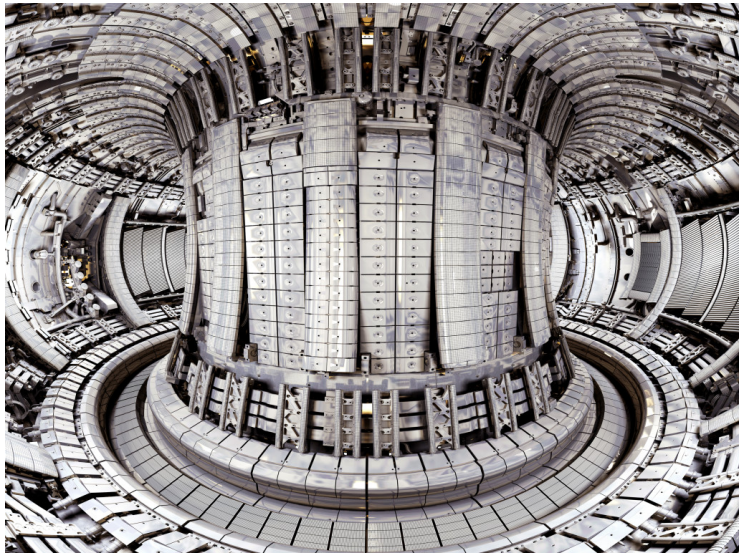
Big science projects are multidisciplinary

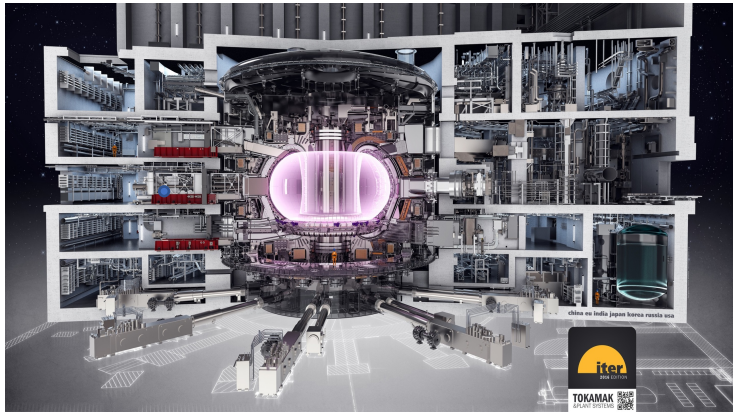
(examples shown: Belgian companies in ITER)











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How to get industry into Big Science Projects:

1. create awareness on their existence, projects mapping

1. ESO – European Southern Observatory
2. ITER – International Thermonuclear Experimental Reactor
3. ESS – European Spallation Source
4. LOFAR – Low Frequency Array
5. CTA – Cherenkov Telescope Array
6. CERN – Conseil Européen pour la recherche nucléaire
7. EU-XFEL – European x-ray free electron laser
8. DESY – Deutsches Elektronen-Synchrotron (German Electron Synchrotron)
9. ESRF – European Synchrotron Radiation Facility
10. ILL – Institut Laue-Langevin
11. ESA – European Space Agency

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How to get industry into Big Science Projects:

2. organise the technology offer towards Big Science

- a common national platform for all BS projects entries
- a joint team consisting of all ILO's on national level
- easy access to project specific procurement policies
  (in kind, juste retour, value for money, access requirements,…)
- a common and transparent classification of generic technologies
- recrute and allocate companies to the classification
  (classifications may be project specific)

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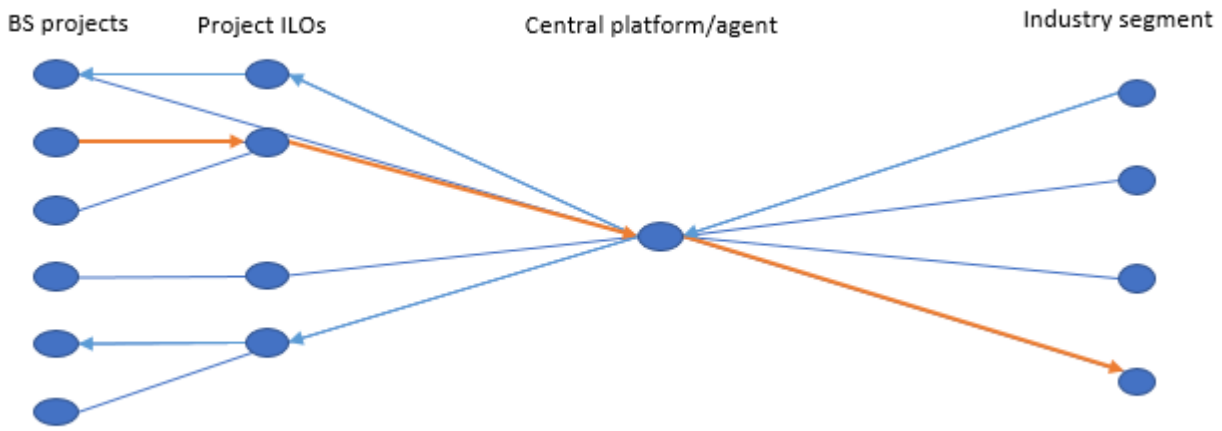
How to get industry into Big Science Projects:
3. promote the technology offer to the demand side

- Towards Big science procurement officers
- Towards tier 1 contractors and major industry players
- Towards each other (for partnerships, synergies etc.)



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Example of project specific Mapping of ESA Tender Offer

- On-Board Data Systems
- Space System Software
- Spacecraft Electrical Power
- Spacecraft Environment & Effects
- Space System Control
- RF Payload & Systems
- Electromagnetic Technologies & Techniques
- System Design & Verification
- Mission Operation & Ground Data Systems
- Flight Dynamics & GNSS (Global Navigation Satellite System)
- Space Debris
- Ground Station System & Networks
- Automation, Teleprescence & Robotics
- Life & Physical Sciences
- Mechanisms & Tribology
- Optics
- Optoelectronics
- Aerothermodynamics (ATD)
- Propulsion
- Structures & Pyrotechnics
- Environmental Control & Life Support,and In-Situ Resource Utilisation
- EEE Components & Quality
- Materials & Processes
- Quality, Dependability & Safety
- Services & Other Items

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Comment:

The tender offers mapping are highly oriented to spatial terminology, it is not following a generic mapping.

Mapping of the Swedish Big Science industry

Researchmatch.se

Research match

Start Erbjudande Upphandlingar Match-Ring Big Science Suppliers Nyheter

Forskningsanläggningar

- FAIR
- XFEL
- ILL
- ESO
- ESRF
- CERN
- ESS
- ITER
- MAXIV

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Mapping of the Swedish industry

Researchmatch.se

1. Administration
2. Construction
3. Electrics / Electronics
4. Control / Operations Monitoring
5. Nuclear Power Technology
6. Mechanical Engineering
7. Assembly, installation, logistics
8. Project Management/Services
9. Security / Quality
10. Survey/Research
11. Operation/support
12. IT / Big Data / CAD
13. Power supply / Infrastructure
14. Magnets
15. Environmental Technology/Energy Efficiency
16. Optics / Sensors
17. Repair / Maintenance
18. Test/Actuation
19. Vacuum

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Mapping of the Danish industry

BigScience.dk

GENVEJEN TIL BIG SCIENCE MARKEDET

Tilmeld

Søg

Forside | Om os | Bliv leverandør | Big Science organisationer | Nyheder | Arrangementer | English

CERN ESS ESO ESRF ESA EU-XFEL ITER MAX IV STFC

CERN

CERN har et årligt budget på ca. 6,5 mia. kr. og køber varer og tjenester årligt for mellem 1,5 og 2,5 mia. kr. Danmark bidrager til CERN's finansiering med ca. 120 mio. kr. årligt...

Læs mere

European Spallation Source

European Spallation Source (ESS) er en stærk neutronkilde, populært kaldt et neutronmikroskop, der skal bruges til undersøgelse af materialer ved brug af neutroner. ESS kommer til ...

Læs mere

European Space Agency

Den europæiske rumorganisation, ESA, har til formål at udvikle og fremme fredelig anvendelse af rumteknologi og rumforskning. ESA koordinerer medlemslandenes finansielle og intell...

Læs mere

European X-ray Free Electron Laser

European XFEL kommer til at fungere som en ultra-intens røntgenkilde, der muliggør studier på atomart niveau inden for f.eks. materialevidenskab, medico og biologi. Den høje intens...

Læs mere

European Southern Observatory

European Southern Observatory (ESO) er det førende internationale videnskabscentrum for astronomi og kører ambitiøse programmer, der fokuserer på at designe, bygge og drive de stør...

Læs mere

European Synchrotron Radiation Facility

European Synchrotron Radiation Facility (ESRF), der ligger i Grenoble i Frankrig, er et center for videnskabelig ekspertise, støttet og delt af 19 lande. Siden åbningen i 1994 har...

Læs mere

ITER

ITER er et internationalt fusionsenergieksperiment, som opføres i Frankrig med det primære formål at vise, at man kan bruge fusionsenergi som en fremtidig energikilde. Den danske a...

Læs mere

MAX IV

MAX IV er et [illegible] synkotronstrålingsanlæg i Sverige. Den vil erstatte det eksisterende laboratorium bestående af MAX I, II og III lagerringe, som blev lu...

Læs mere

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Mapping of the Danish industry Bigscience.dk

1. Civil Engineering and Building
2. Coating, Joining and Casting
3. Cranes & Trucks
4. Electronics, RF- & microwave technologies
5. Magnets
6. Materials processing
7. Mechanical Engineering
8. Optics, sensors & diagnostic
9. Power Supply
10. Remote Handling
11. Software & Control Systems
12. Support services
13. Utilities and Installations
14. Vacuum and low temperature technologies

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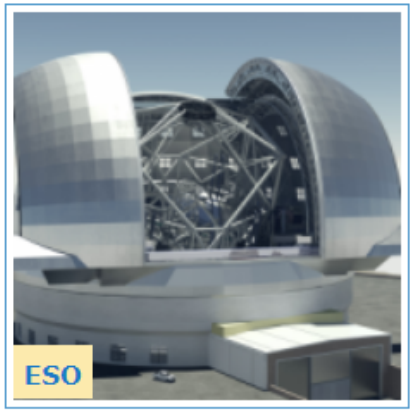
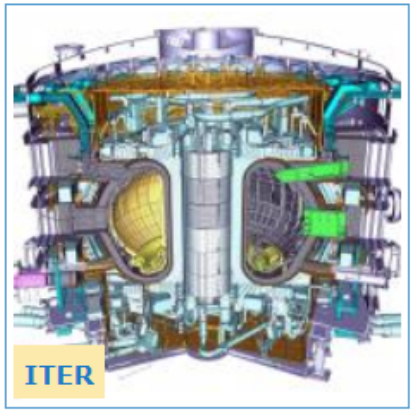
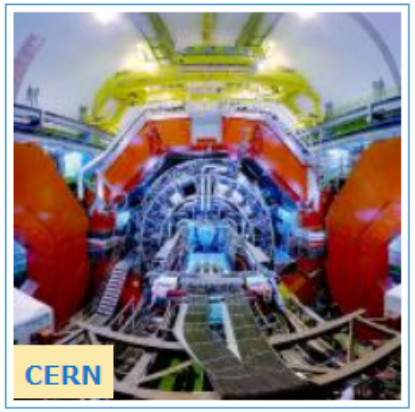
Mapping of the Dutch industry

BigScience for business







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Mapping of the Dutch industry Bigscience.nl

Overview of companies

	*	Speciality		Management/ systems eng	Development	Engineering	Production	Test & measurement	Technical consultancy	Area						
		Discipline	Technique							Metal		Mechatr.	Cryo	Vacuum	Electronics	Software
										Large	Small					
Amsterdam Scientific Instruments	S	*Radiation imaging*	*Hybrid pixel detectors*	x	x	x	x	x	x							embedded
BKB Precision																
BOA Nederland BV	M	*Metal hoses and bellows*	*Assemblies, cleaning and testing*	x	x	x	x	x	x		x	x	x	x		
Boekenkool	S					x	x		x				x			
Ceratec Technical Ceramics BV		*Ceramics*	*Machiningicasting*		x	x	x									
Deems Nederland B.V.																
Delta Elektronika	S	*DC power supplies*			x	x		x						power supplies		
Demaco Holland BV	M		*Technical consultancy*		x	x	x					x	x			
DH Industries BV	M	*Cryogenic cooling systems*	*Stirling cryogenerators/ hega fanlich, pumt*		x	x	x						x			
Diamond Kimberlit B.V.		*Optical Fiber Technology*	*Manufacturing special fiber-optic inter-connecting parts*		x	x	x	x			x	x	x	Feedtrough		
ECMT					x	x	x		x	x	x					
FMI High Tech Solutions					x	x	x	x	x	x	x	x	x			
Hauck Heat Treatment Eindhoven B.V.			*Heatreating, brazing*		x	x	x		x	x	x	x	x	x		
Hositrad Vacuum Technology	S	*Vacuum*	*Ceramics*		x	x	x	x				x	x			x
IBS Precision Engineering		*systems engineering*		x	x	x	x	x	x			x			x	x
Imtech Industry Int.	L		*Tailot Made power conversion systems*		x	x	x	x						Power		

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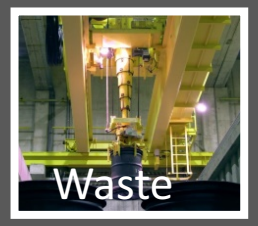
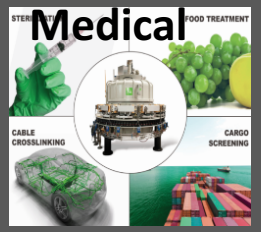
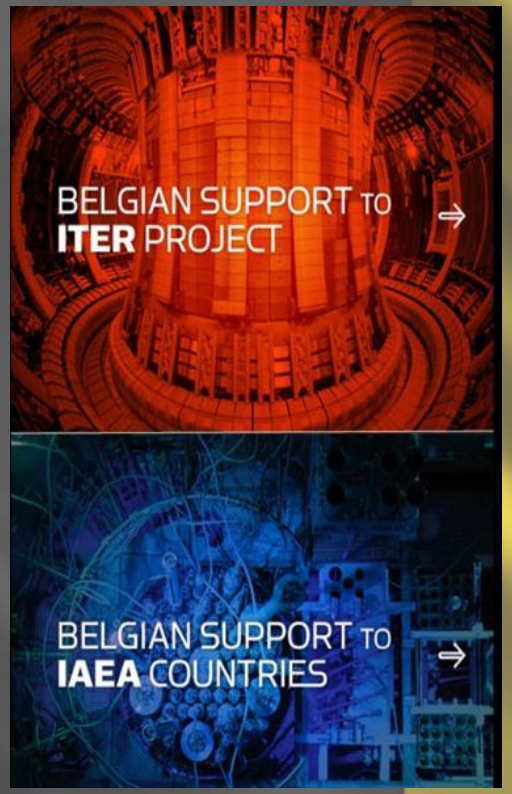
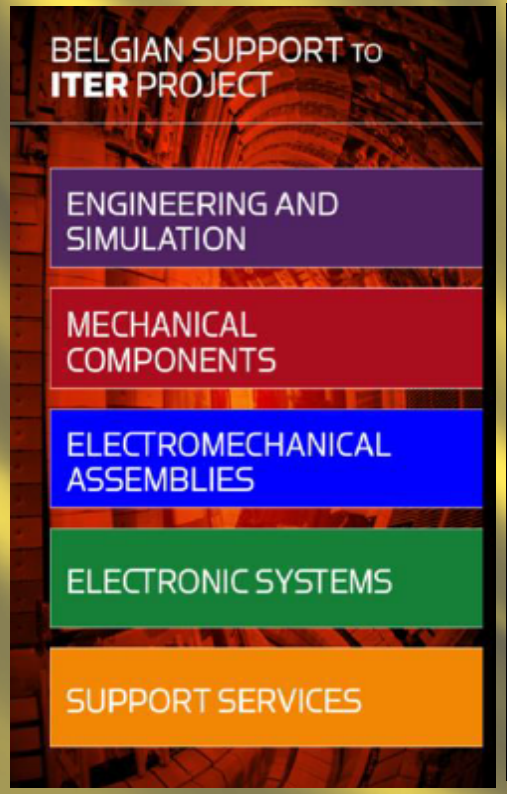
Example of Belgian mapping: Iter and Nuclear









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conclusions

- The societal relevance of Big Sience projects is there
- multi-billions of € are being spent on Big Science infrastructures
- There should be homeland ROI for the financial contribution to Big Science projects and infrastructures
- This requires visibility from research demand side and technology offering side
- Critical mass in visibility is crucial, in particular for the technology industry in smaller countries
- efforts should be bundled to match the offer side from technology industry with the demand side (technology needs) from of the research community (the market)
- Examples for technology clustering and classification are available from NL, DK, SE etc.
- Next step: to develop “Big Science Belgium”
- Let’s profile Belgian Big Science technology at the first combined Big Science Business Forum at Copenhague (2018)

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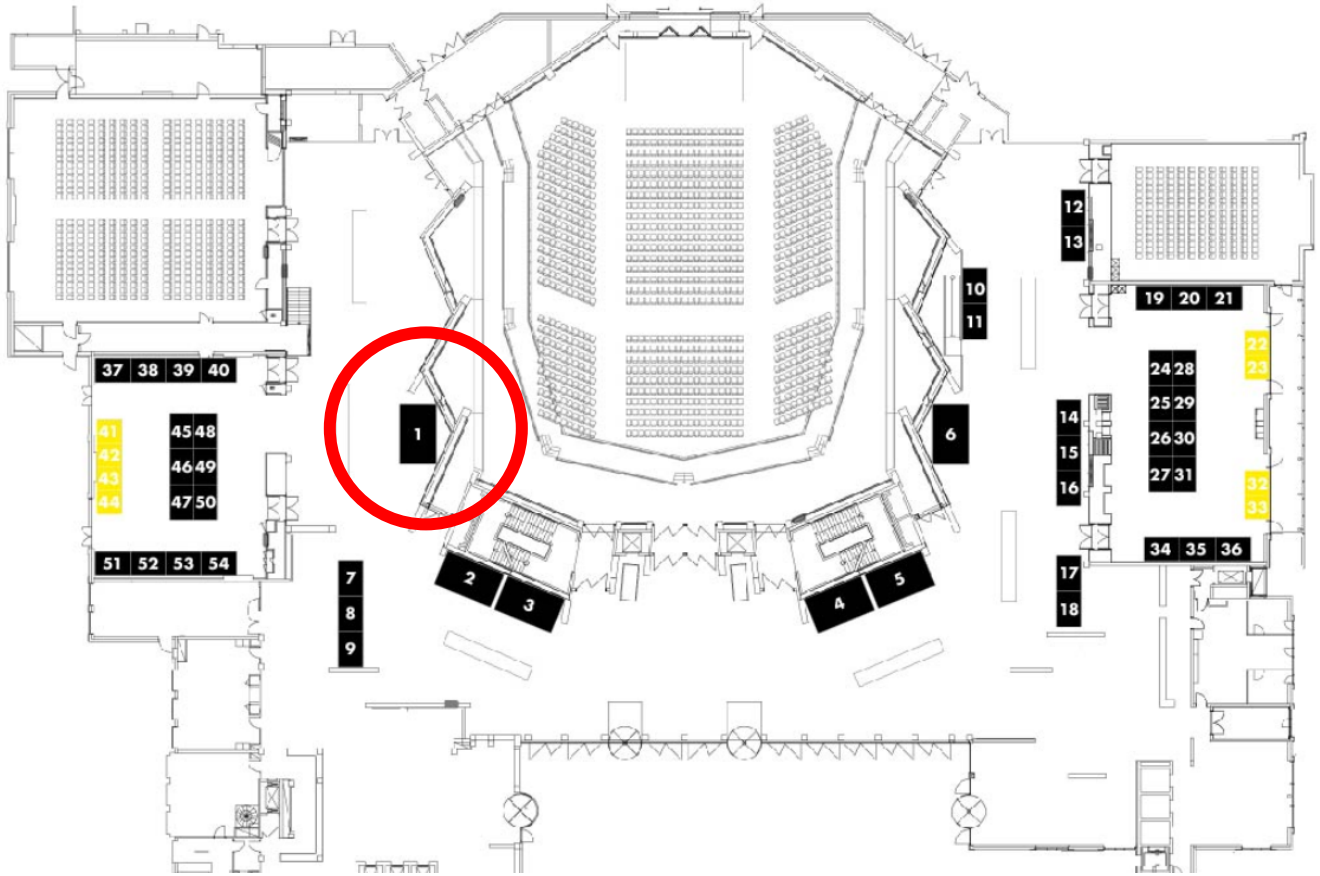
From analysis to implementation at BSBF 2018



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