Operational Directorate 4
“Solar Physics and Space Weather”

Royal Observatory *of* Belgium

David Berghmans
Head Of Scientific Service

Mission Statement

1. **Research:** to increase our understanding of the **Sun** and its influence on the solar system.

2. **Observations:** to have a full understanding of the complete data acquisition and calibration process.

3. **Services:** to have an active, leading role in European space weather services

http://sidc.be/aboutSIDC

Thematics

1. Ground-based telescopes
2. Solar Radio Physics
3. Space based instruments
4. Advanced technology
5. Data Processing
6. Space Weather services

Thematics

1. Ground-based telescopes
2. Solar Radio Physics
3. Space based instruments
4. Advanced technology
5. Data Processing
6. Space Weather services

TYPICAL SETUP:

structurally supported by an STCE funding line

managed by a contractual scientist

encouraged to grow through project money

Thematics

1. Ground-based telescopes
2. Solar Radio Physics
3. Space based instruments
4. Advanced technology
5. Data Processing
6. Space Weather services

Fundamental Research

Dissemination

TYPICAL SETUP:

structurally supported by an STCE funding line

managed by a contractual scientist

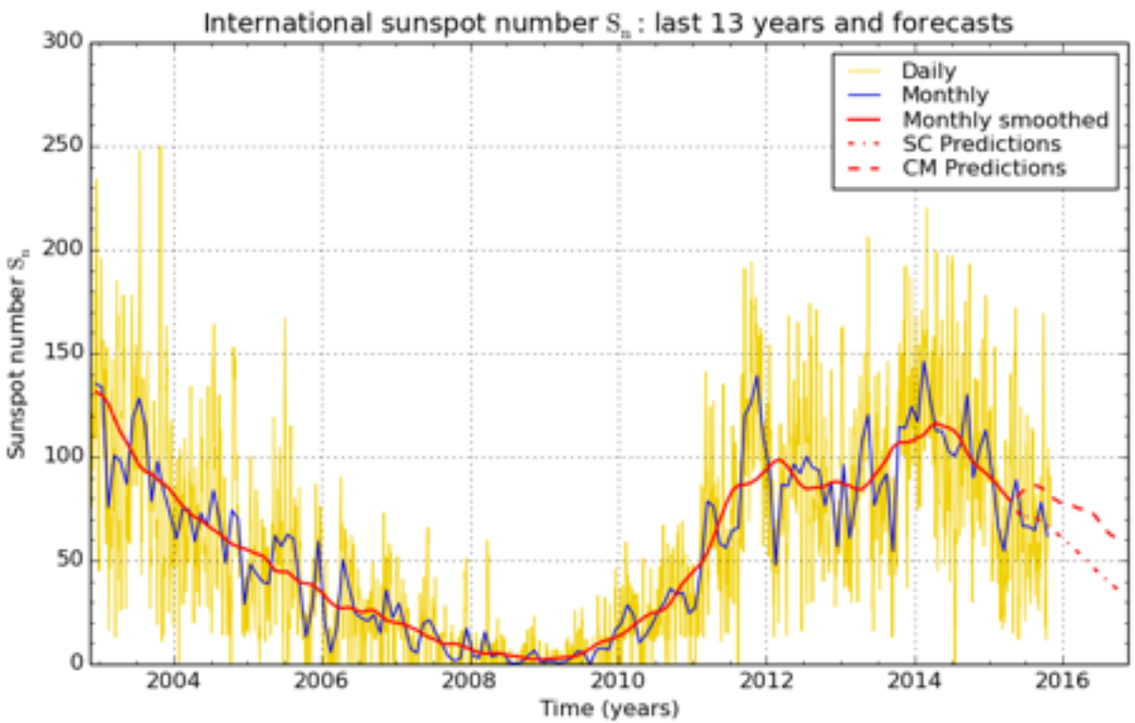
encouraged to grow through project money

Thematics

1. **Ground-based telescopes**
2. **Solar Radio Physics**
3. Space based instruments
4. Advanced technology
5. Data Processing
6. Space Weather services

since 1950s

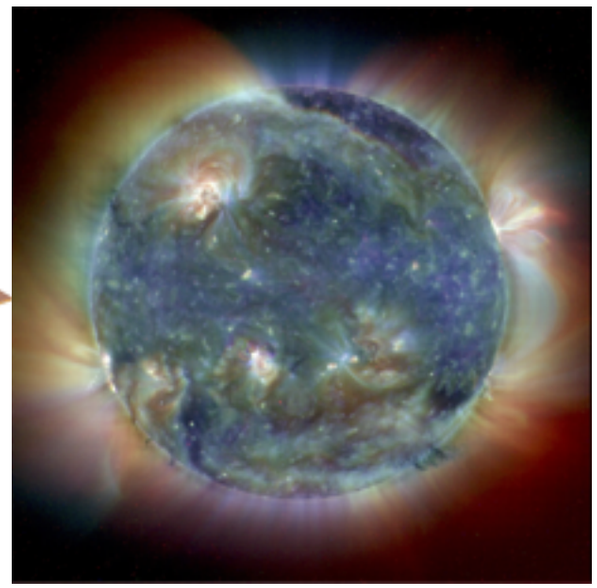
since 1981



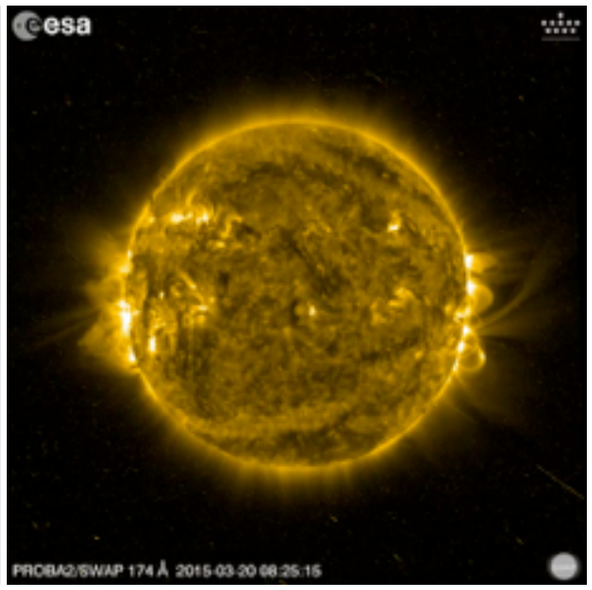
Thematics

1. Ground-based telescopes
2. Solar Radio Physics
3. **Space based instruments**
4. **Advanced technology**
5. Data Processing
6. Space Weather services

SOHO/EIT since 1995



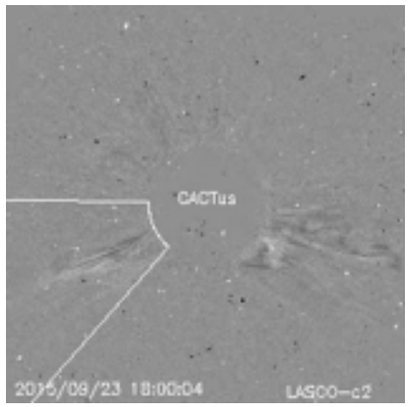
PROBA2 since 2009

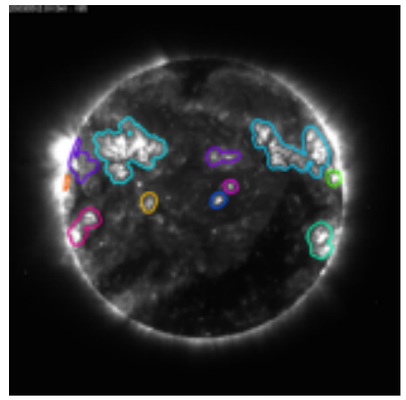


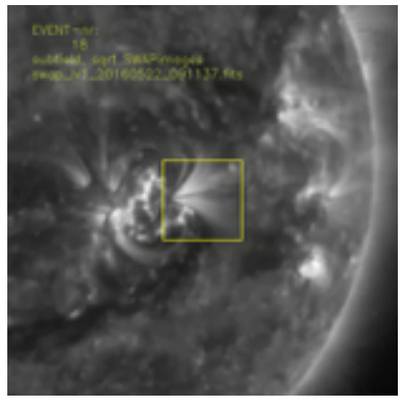
Thematics

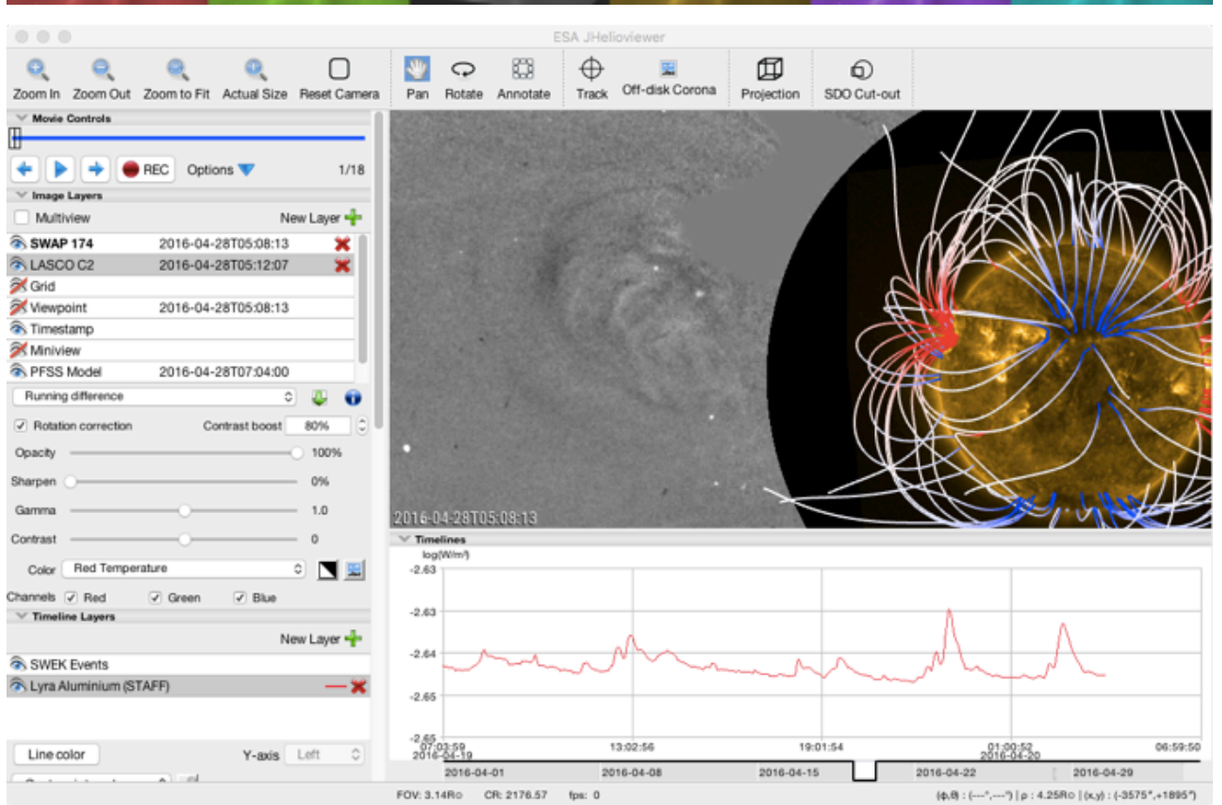
1. Ground-based telescopes
2. Solar Radio Physics
3. Space based instruments
4. Advanced technology
5. **Data Processing**
6. Space Weather services

since 2002









Thematics

1. Ground-based telescopes
2. Solar Radio Physics
3. Space based instruments
4. Advanced technology
5. Data Processing
6. **Space Weather services**

since 2000

ISES
International Space Environment Service

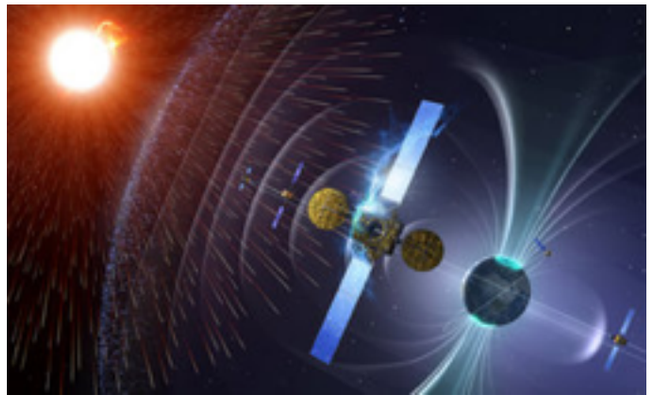
- daily space weather forecast
- weekly review of activity

since 2006

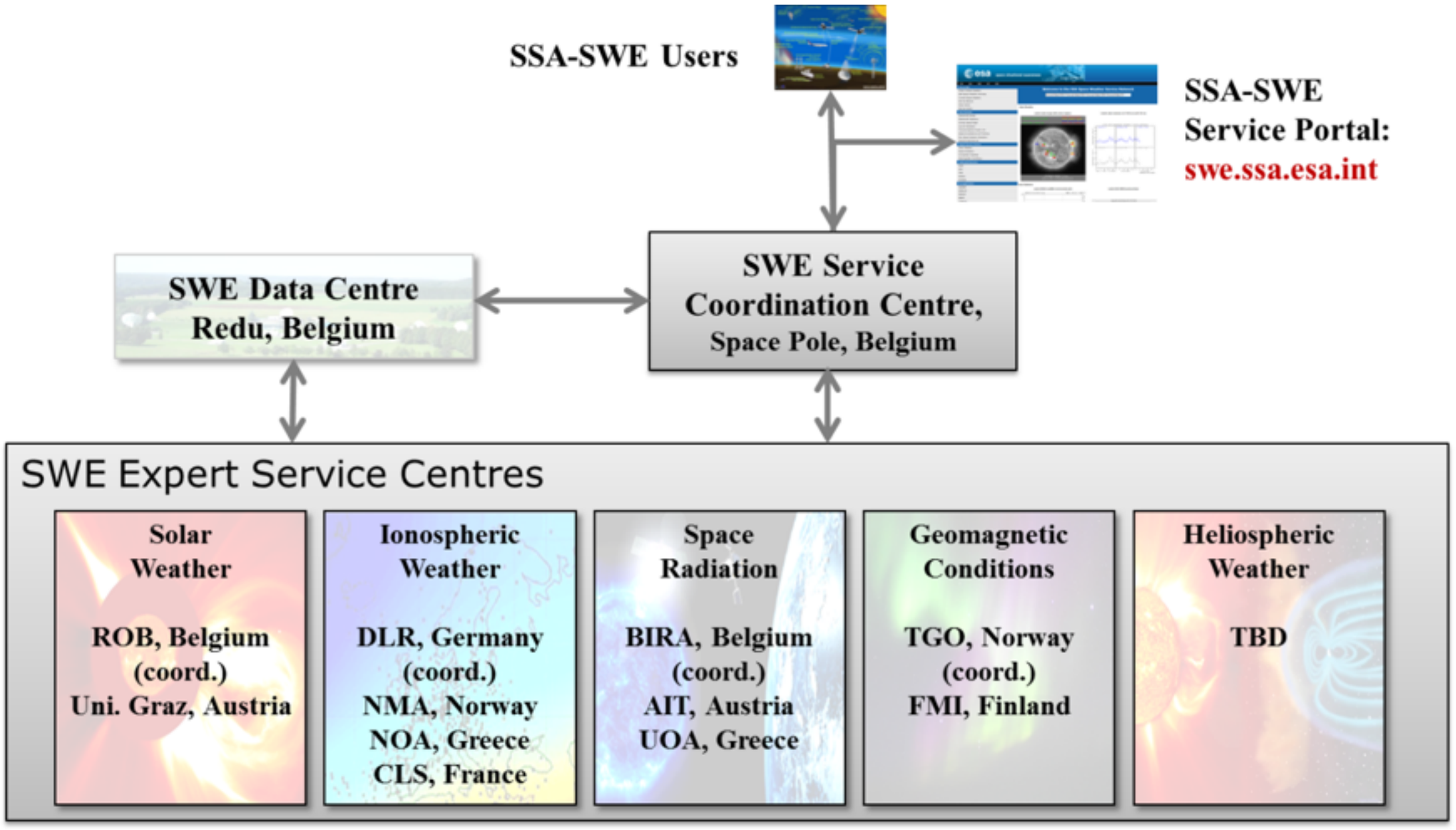
European Space Weather Week

since 2010

ESA Space Situational Awareness



ESA Space Situational Awareness



+ instrument prototype projects
+ modelling efforts
+ PROBA2 operations

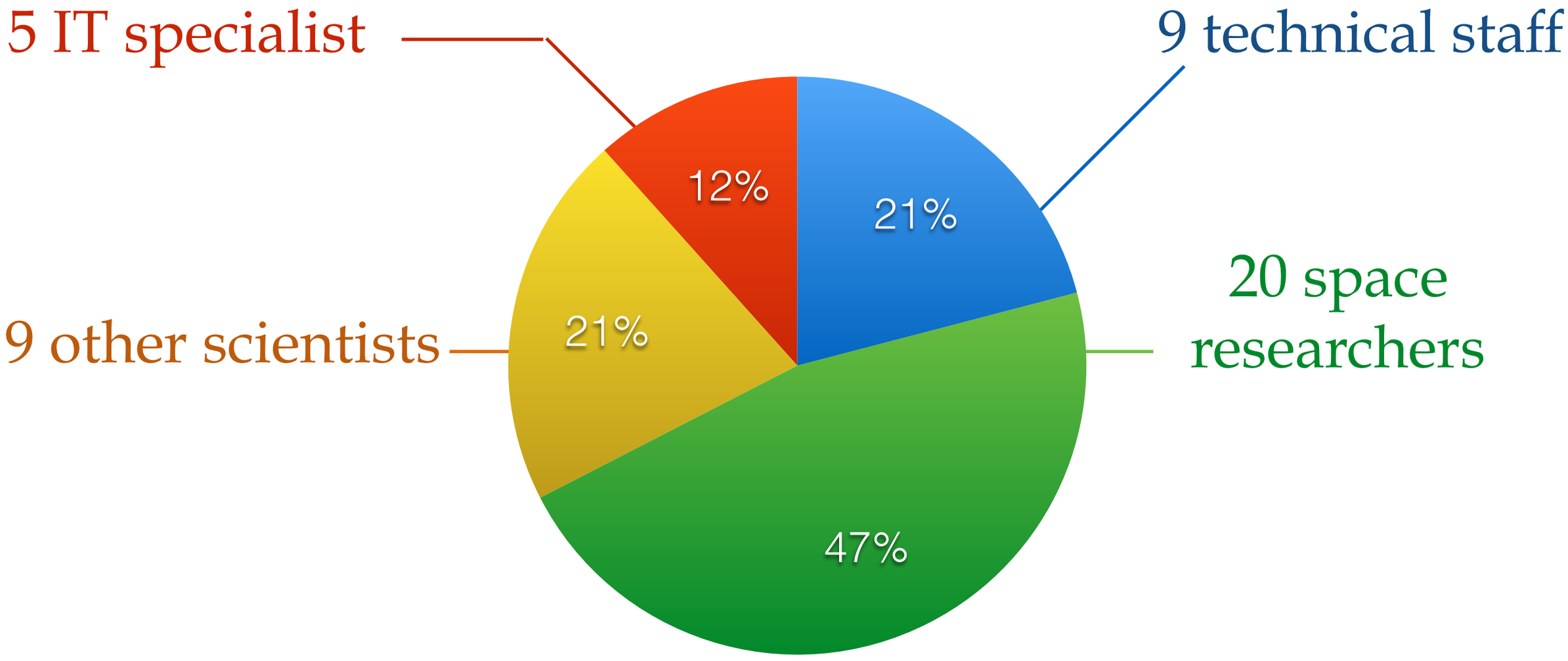
statistics on personnel, budgets, performance

Thematics

1. Ground-based telescopes & long term monitoring
2. Solar Radio Physics
3. Space based instruments
4. Advanced technology
5. Data Processing, incl visualisation
6. Space Weather services, incl. dissimenation

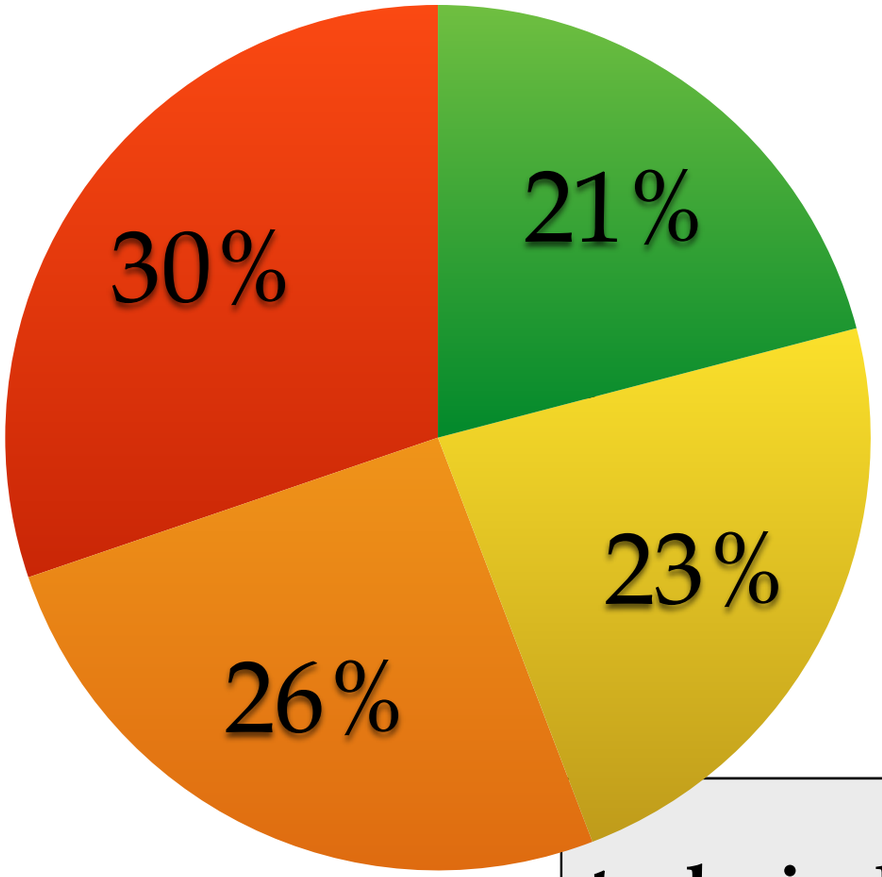
Technical staff	space researcher	Other scientist	IT specialist
3	3	0	0
1	2	1	0
1	10	4	1
0	1	2	0
2	1	0	4
2	3	2	0

43 people



~25 FTE researchers of which 1 PhD student (KULeuven)
~ 12 nationalities, most < 45 years

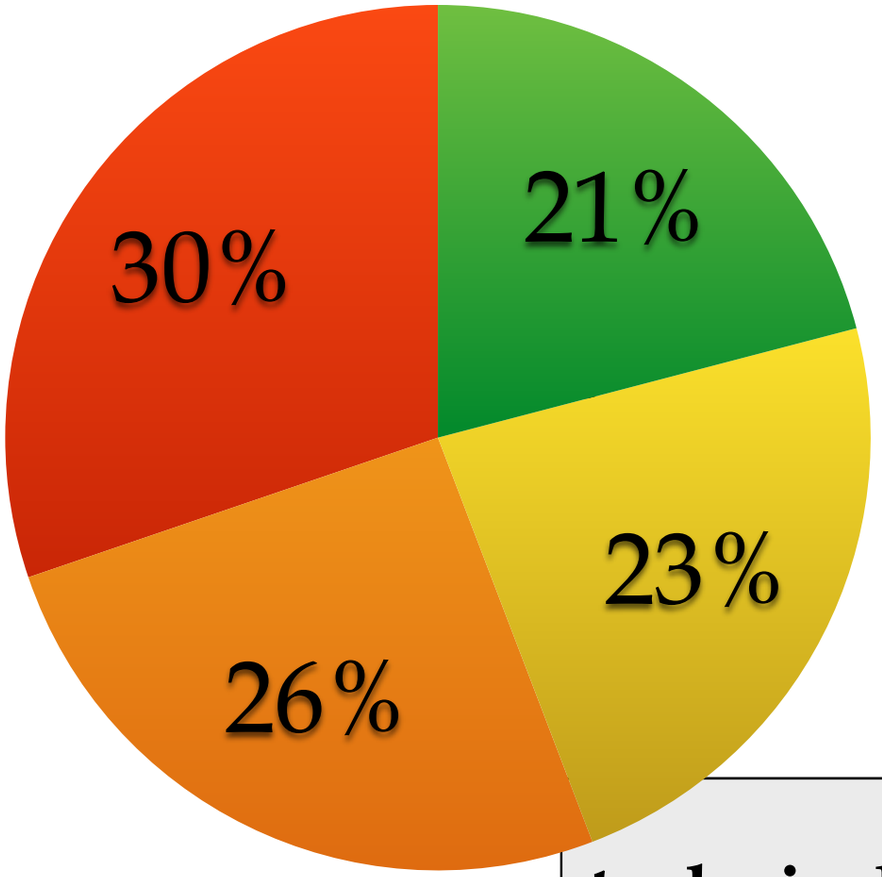
financing: 2016



	ESA, H2020, IUAP **brain.be**	PRODEX	STCE	ROB
technical staff	1	0	2	6
scientific staff	12	11	8	**2**+(1)

TOTAL
43 people, of which 2 permanent scientists

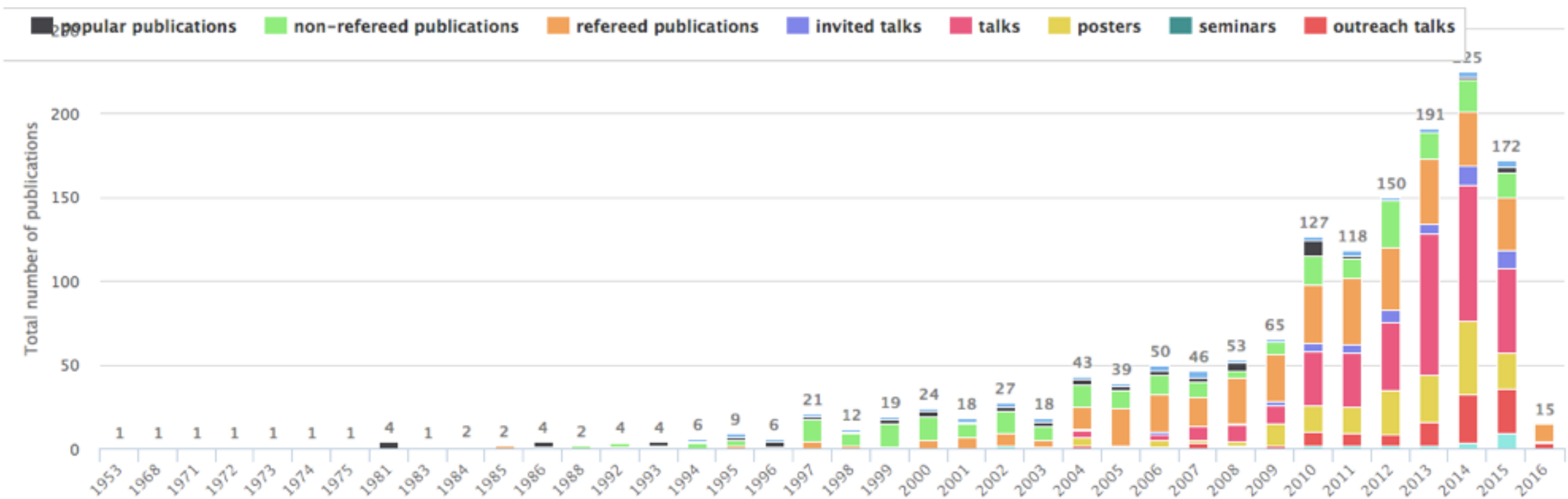
financing: 2016



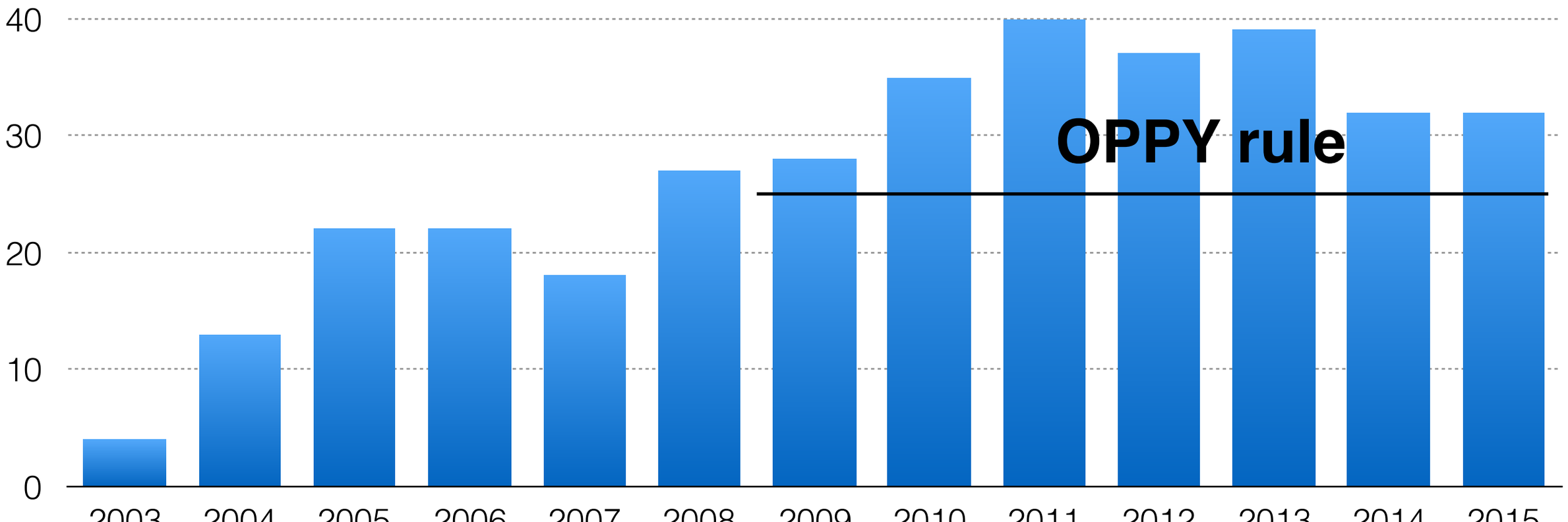
TOTAL
43 people, of which 2 permanent scientists

	ESA, H2020, IUAP brain.be	PRODEX	STCE	ROB
technical staff	1	0	2	6
scientific staff	12	11	8	**2**+(1)
evolution ?	**increased competition, end of IUAP, brain.be**	**less research, more technical mission preparation**	**erosion**	**erosion**

key performance indicators



research papers in international refereed journals

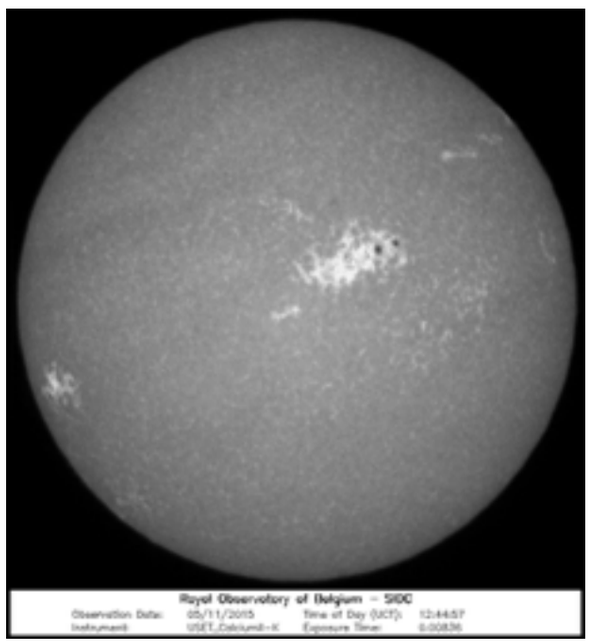


Outgoing space weather services

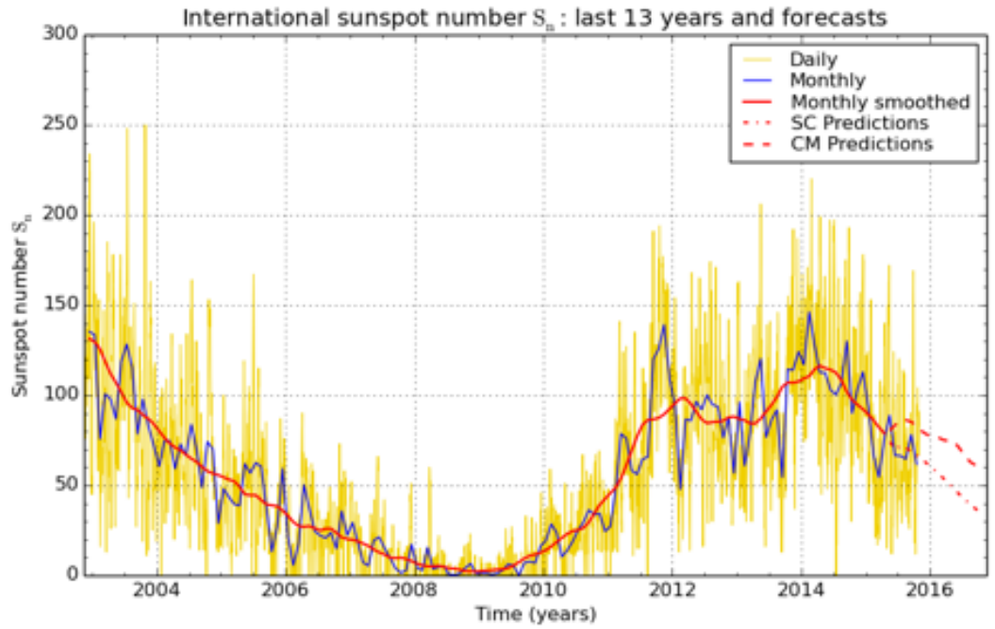
Message	**# per year**	**# clients**
fast space weather alerts	150	950
daily space weather forecast	365	709
weekly reviews	52	507
monthly sunspot index bulletin	12	684

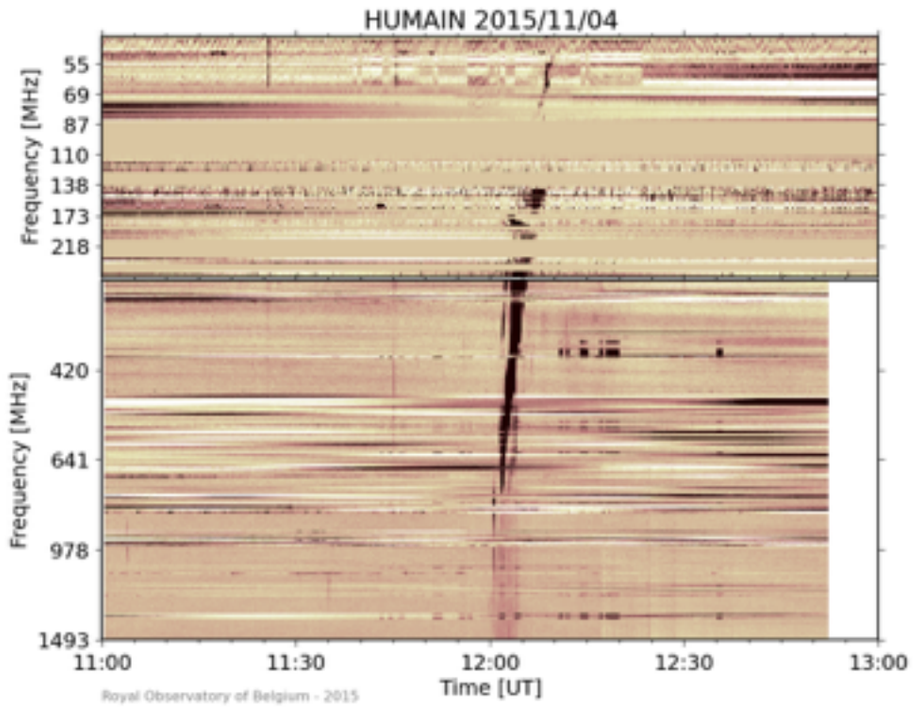
Scientific Production: data set collection

USET telescopes

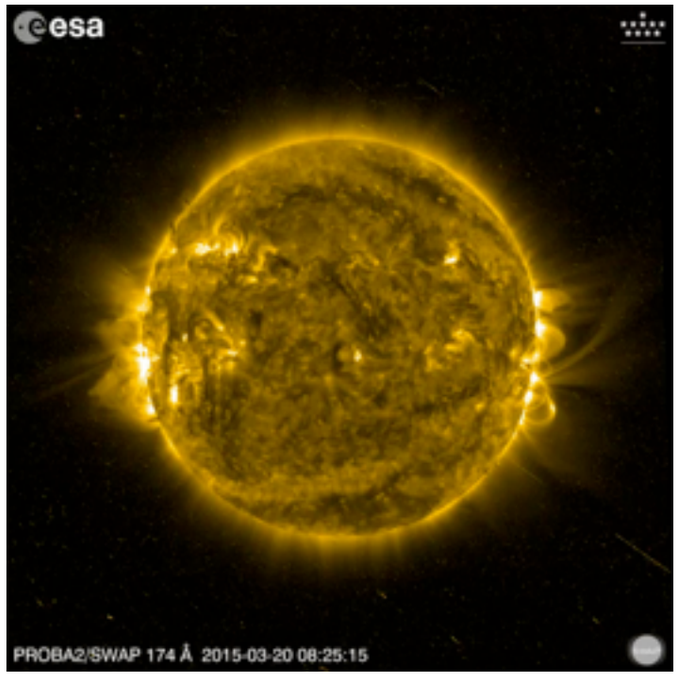


International Sunspot Index





Humain radiospectrographs



PROBA2: SWAP & LYRA

OD4 “SOLAR PHYSICS AND SPACE WEATHER”

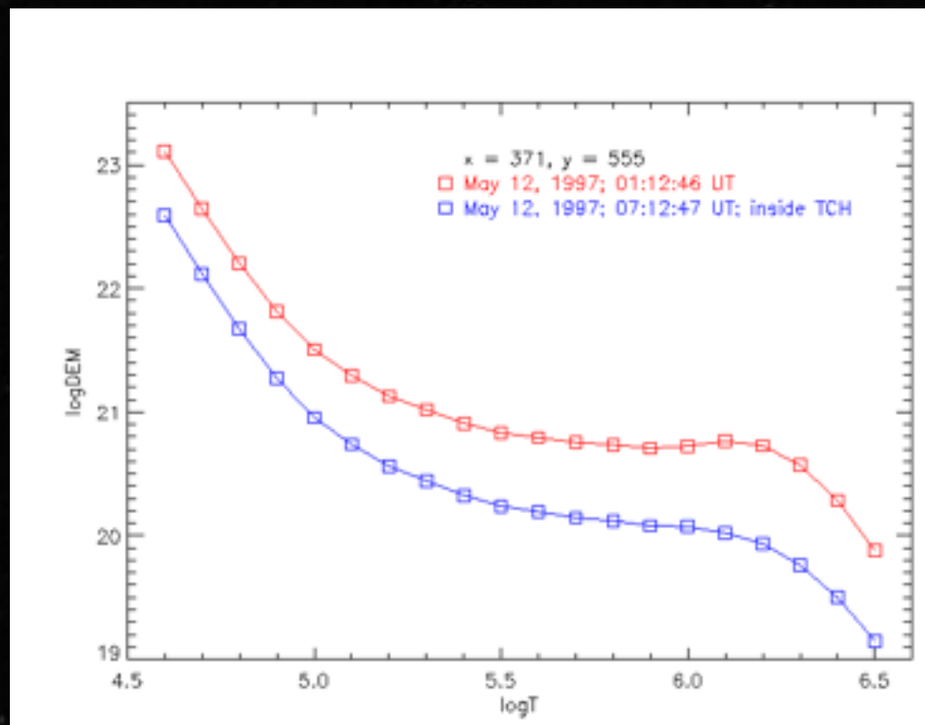
SPACE RESEARCH

PRESENTED BY ANDREI ZHUKOV

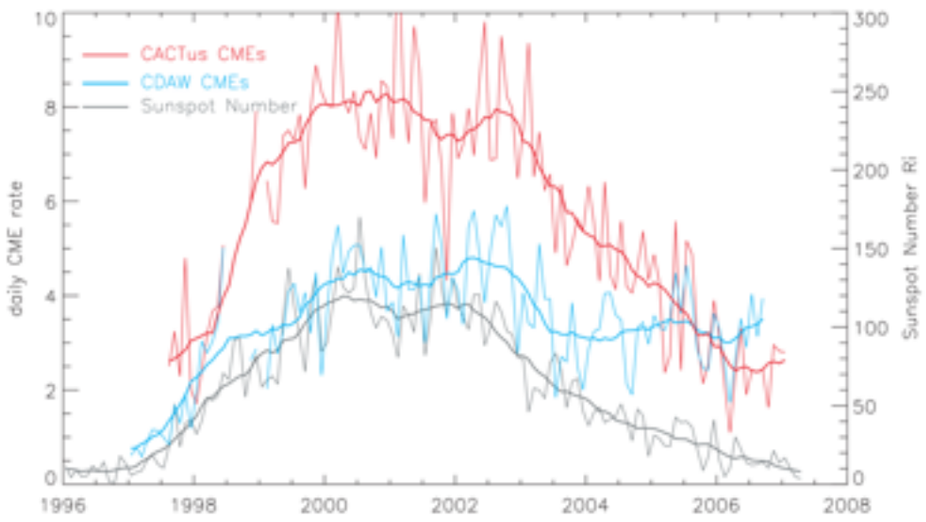
INVOLVEMENT IN SOLAR SPACE MISSIONS (1)

(funded by PRODEX and STCE)

SOHO

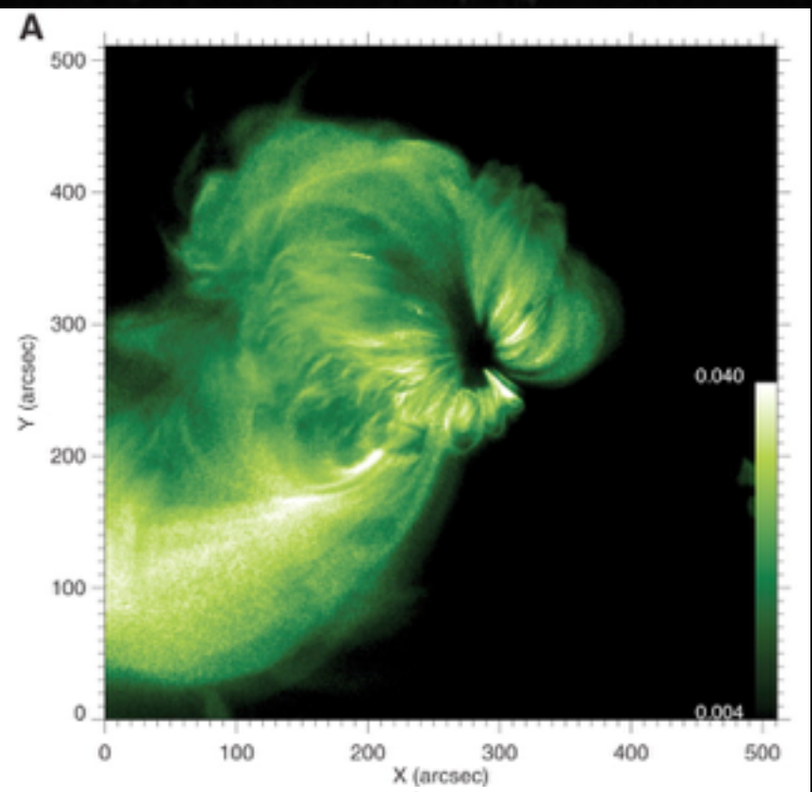


Sources of the CME mass (*Zhukov & Auchère 2004*)

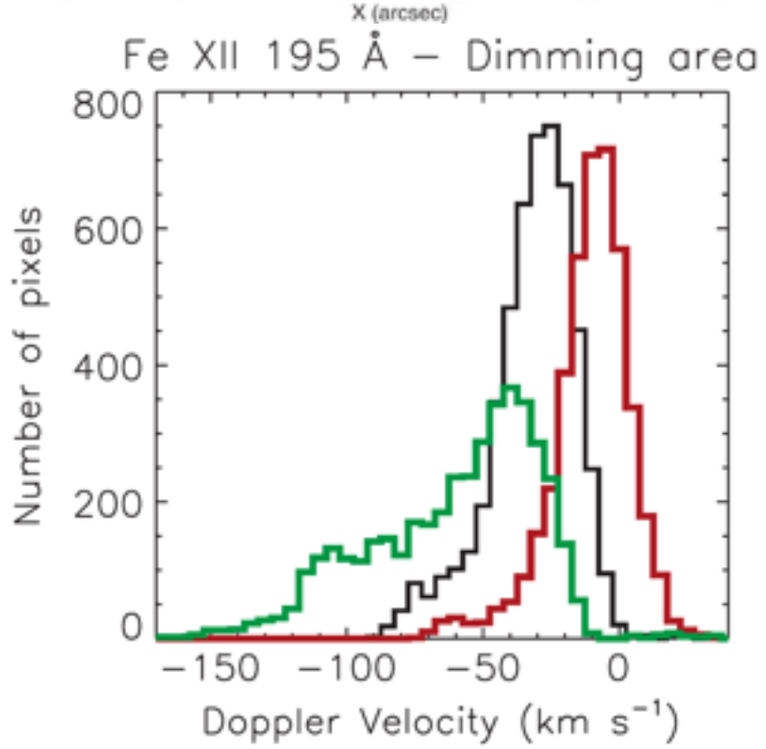


CME statistics over the solar cycle (*Robbrecht et al. 2009*)

Hinode



Thermal structure of active regions (*Reale et al. 2007*)

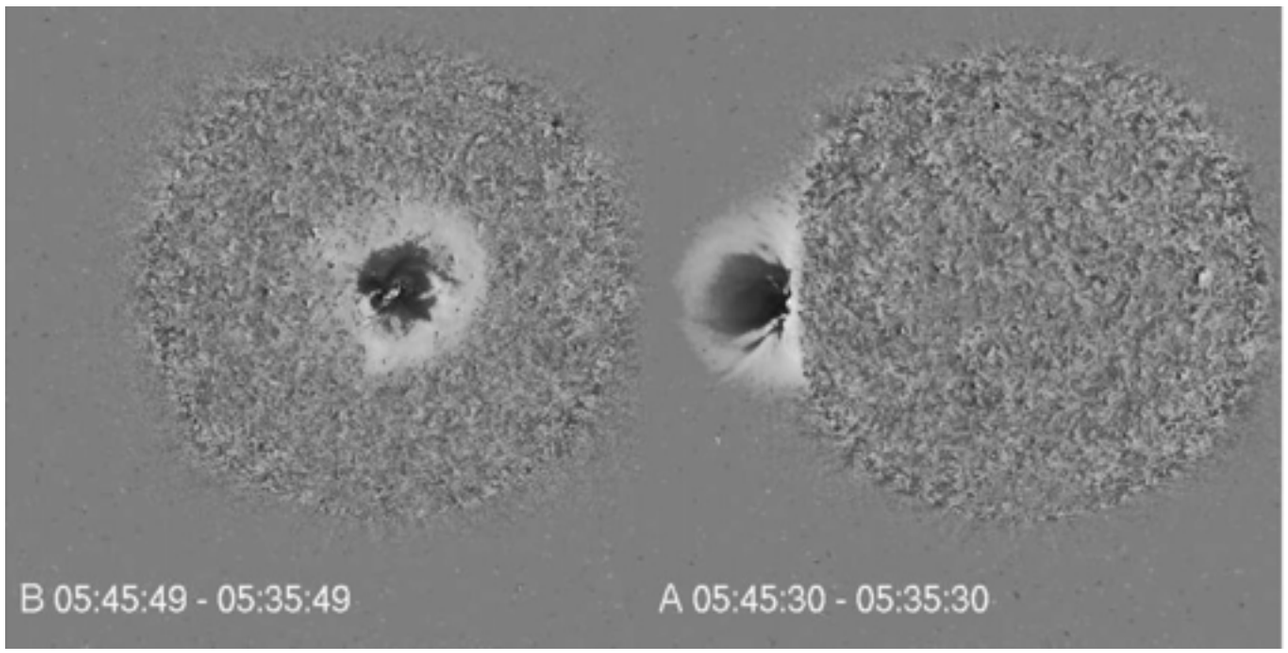


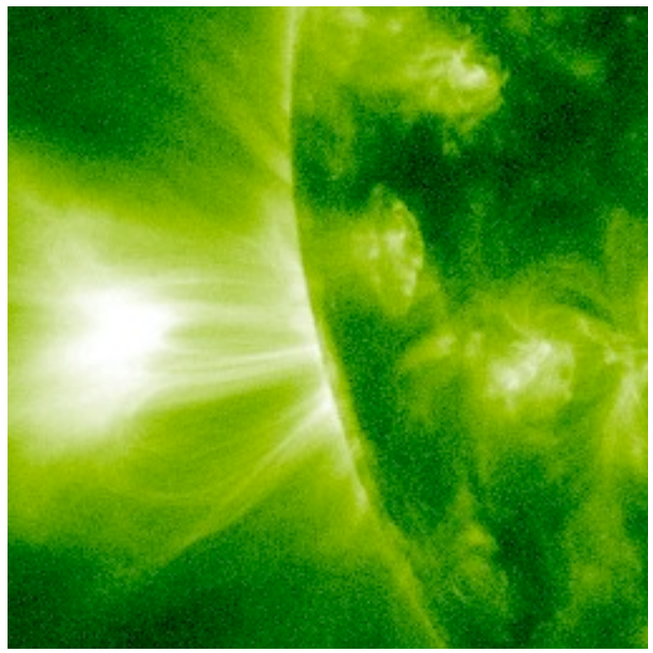
Multi-component outflows in coronal dimmings (*Dolla & Zhukov 2011*)

INVOLVEMENT IN SOLAR SPACE MISSIONS (2)

(funded by PRODEX and STCE)

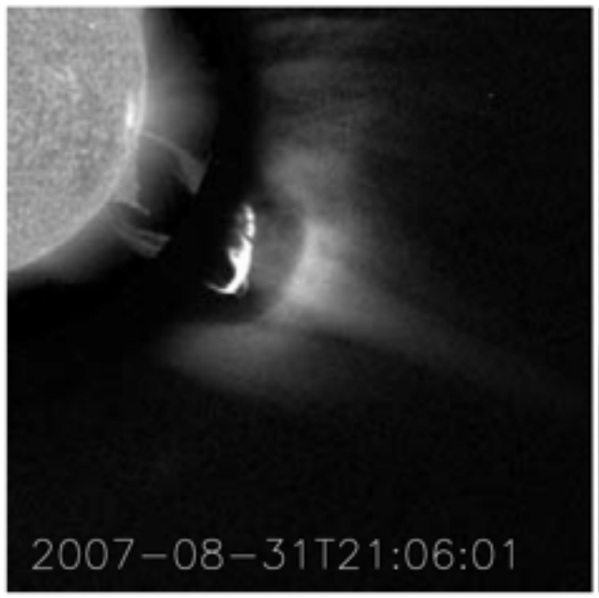
STEREO **SDO**

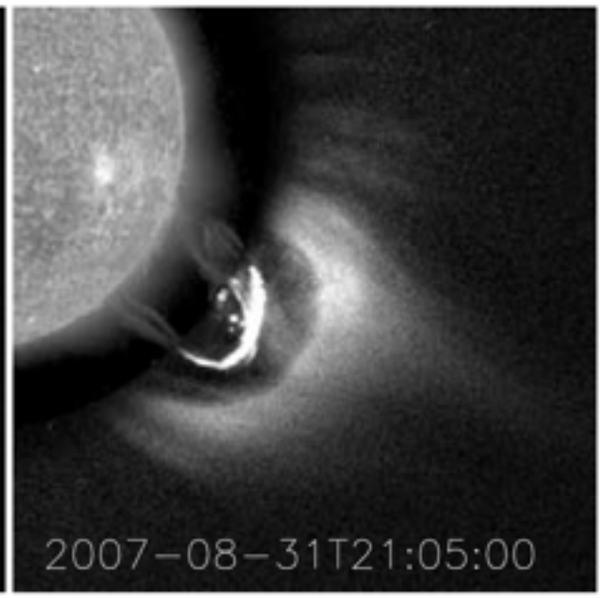




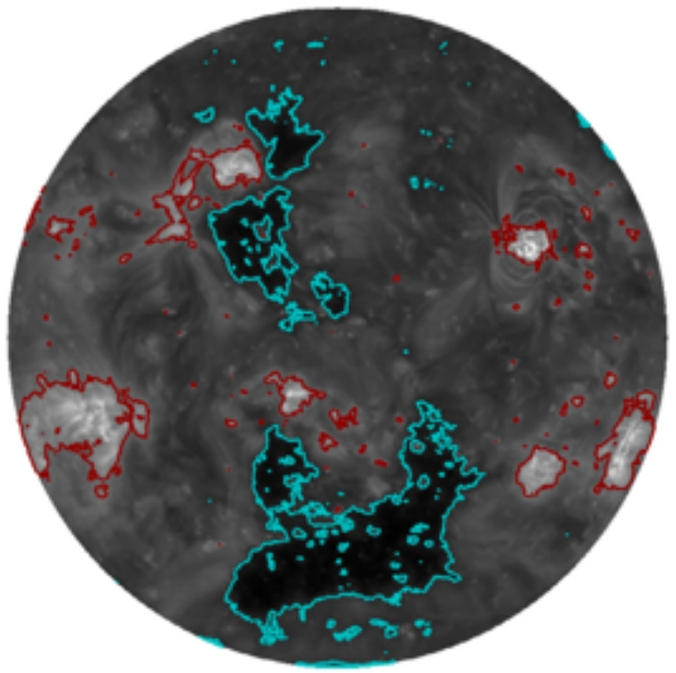
3D structure of "EIT waves" (*Zhukov 2011*)

Giant and hot post-eruptive loops (*West & Seaton 2014*)





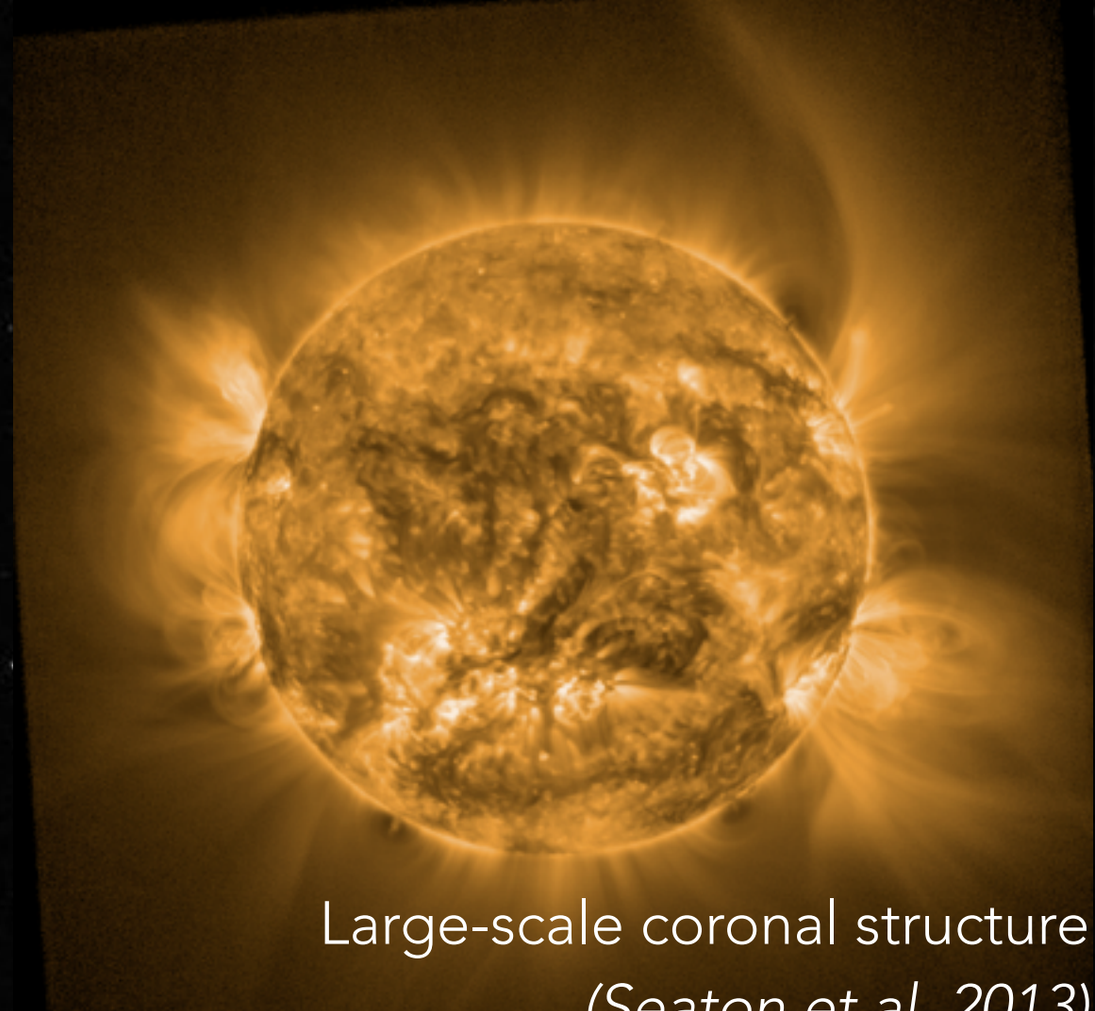
3D reconstruction of CMEs (*Mierla et al. 2010*)



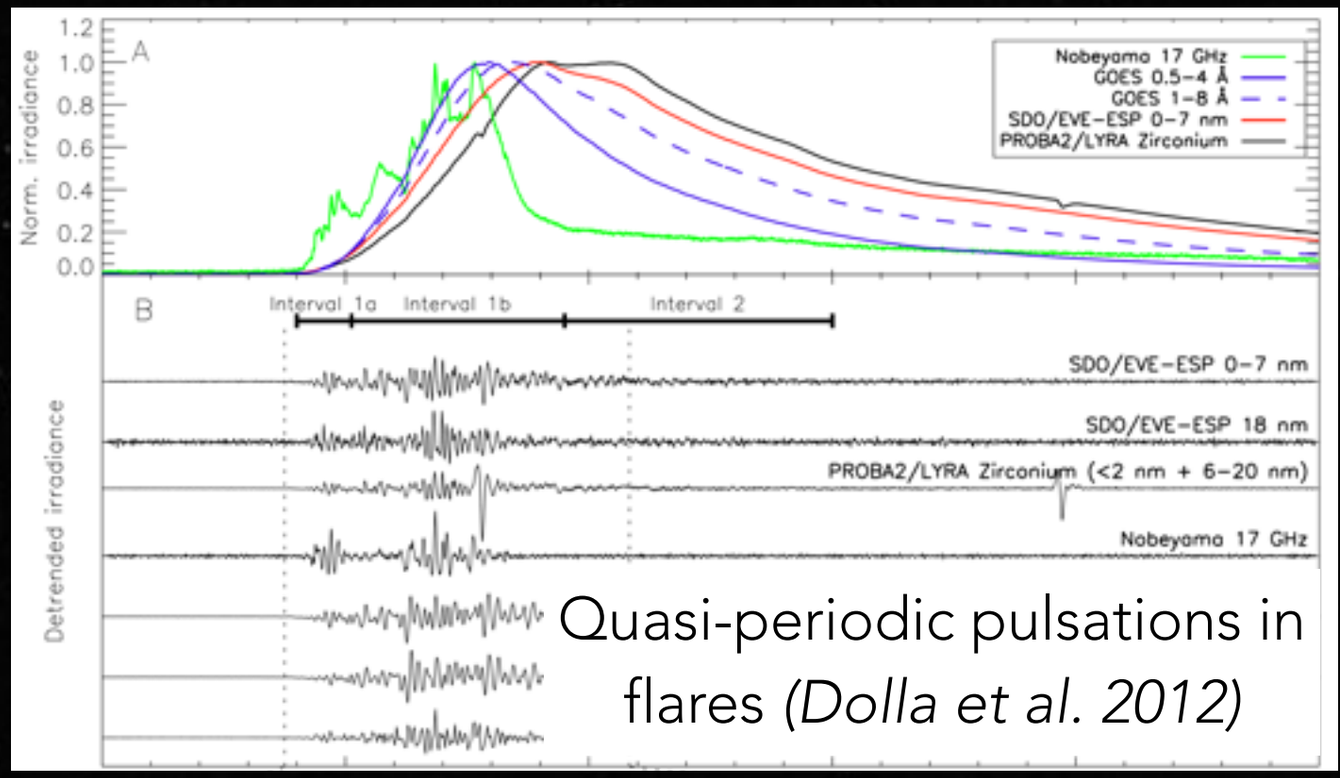
Supervised classification of solar features (*De Visscher et al. 2015*)

PROBA2

- OD4 has the PI-ship of the SWAP and LYRA instruments funded by PRODEX.
- PROBA2 Science Center (P2SC) hosted by ROB operates the scientific payload. The development and operations of the P2SC are funded by PRODEX, STCE, ESA D/SRE, and SSA.
- A special issue of *Solar Physics* dedicated to PROBA2 was published in 2013.
  - Co-edited by the OD4 team members.
  - A number of papers were co-authored by the OD4 researchers.



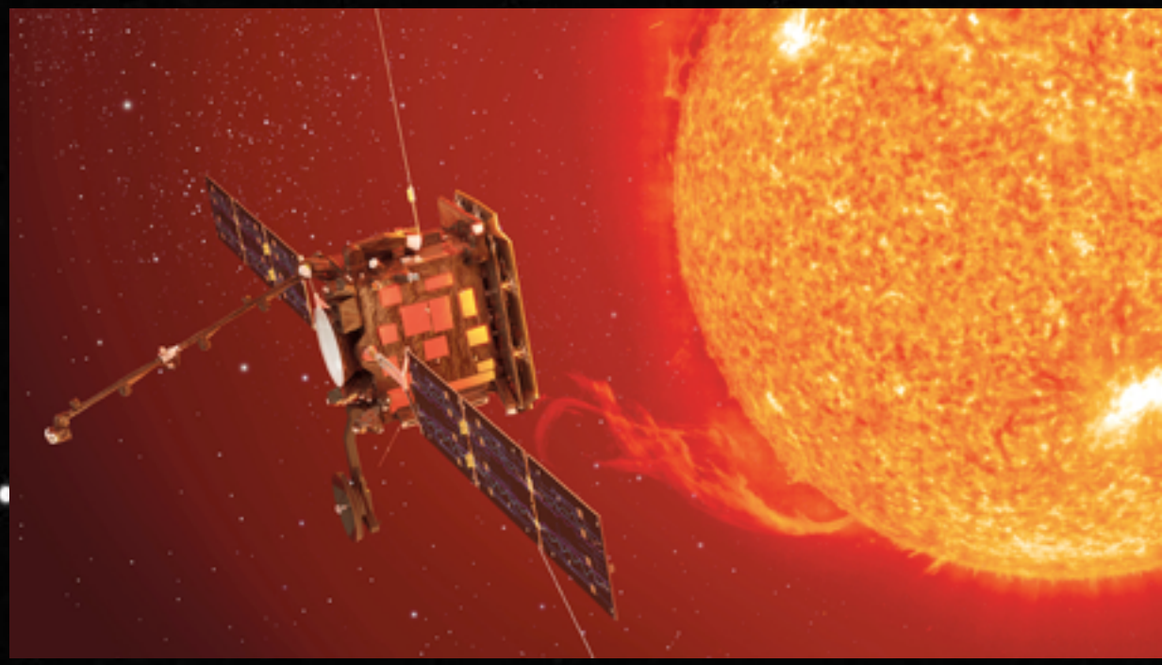
Large-scale coronal structure *(Seaton et al. 2013)*



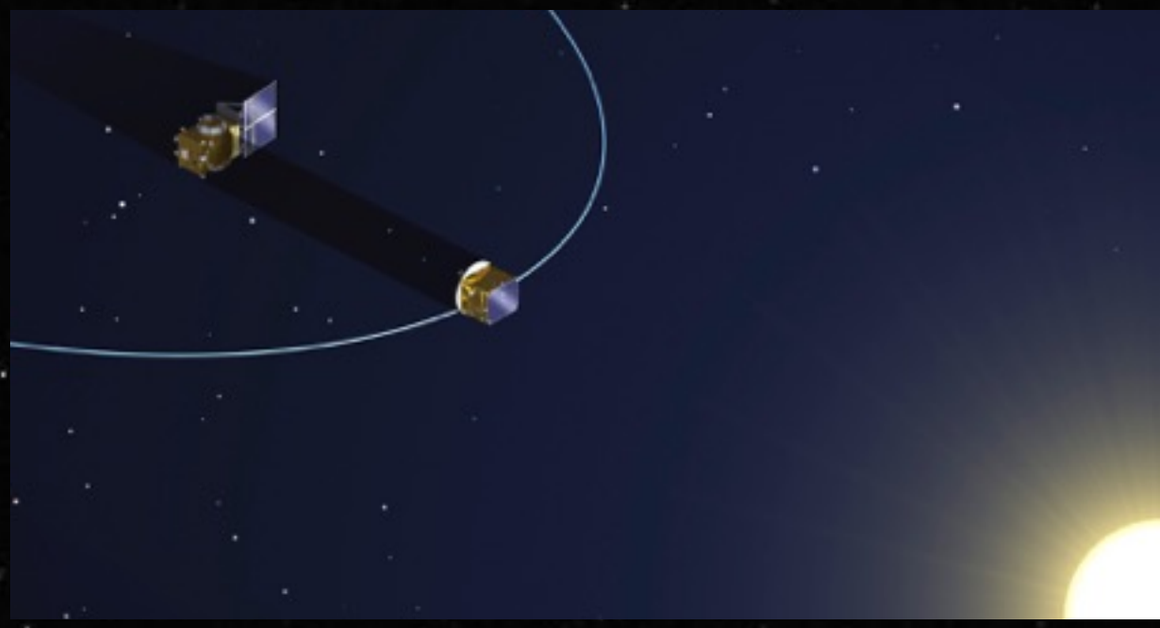
Quasi-periodic pulsations in flares *(Dolla et al. 2012)*

PREPARATION OF FUTURE ESA MISSIONS

- **Solar Orbiter** *(to be launched in October 2018)*
  - The mission will establish how the Sun creates and controls the heliosphere.
  - OD4 has the CoPI-ship of the Extreme Ultraviolet Imager (EUI) funded by PRODEX.
  - The EUI PI-ship is now with CSL but will be transferred to OD4 after the launch.



- **PROBA-3** *(to be launched in the end of 2019)*
  - The mission will have the best straylight rejection ever achieved by a solar coronagraph, allowing us to observe structures very close to the solar limb.
  - OD4 has the PI-ship of the ASPIICS coronagraph funded by PRODEX.
  - CSL leads the industrial consortium that is building ASPIICS, funded by GSTP.



SPACE TECHNOLOGY & CALIBRATION LABORATORIES (STCL@STCE)

funded by STCE

Two complementary groups:

- STCE WP **ROB** A.5 : "Advanced Technology for Solar Observations" (led by Dr A. BenMoussa)
- STCE WP **BISA** A.4 : "Optics Laboratory facilities" (led by Dr D. Bolsée)

agree to join their efforts to support the design, development & calibration of instruments (from soft X-ray to IR).

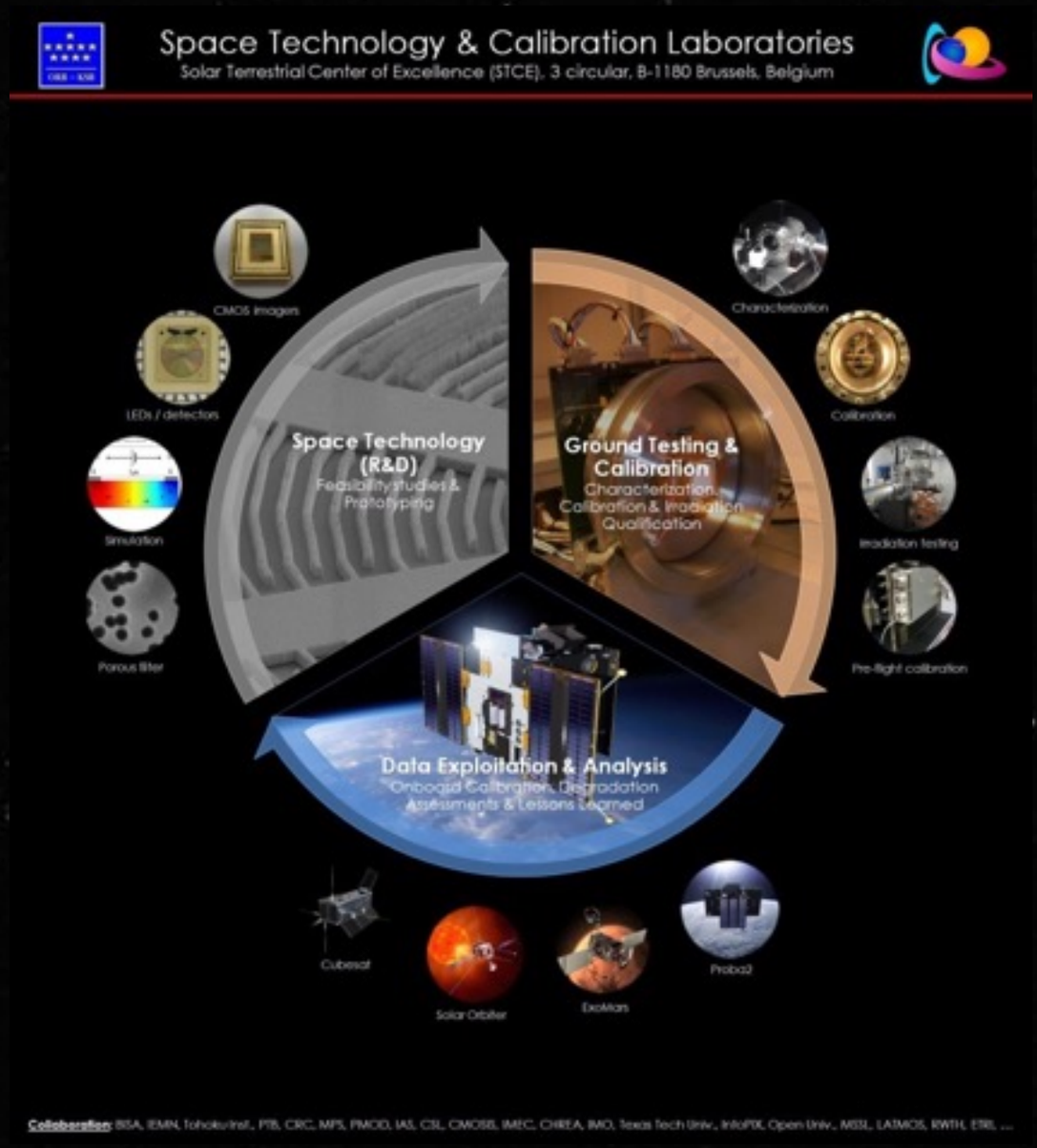
More specifically:

-1- High-quality calibration of space- and ground-based instruments

- Pre-flight sub-system and end-to-end calibration,
- In-flight calibration systems and operations,
- Co-operation with European and international organizations for calibration/metrology standards,

-2- Design next generation of space-based instruments

- R&D in advanced technologies (e.g., wide bandgap detectors, CMOS active pixel sensor, UV LEDs, optical filters, FPGA, …),
- Scientific data compression, processing, and exploitation,
- Instrument ageing effects: space-environment irradiation testing, lesson learned from past and present space missions, contamination/ cleanliness issues, modeling & simulation.



Interdisciplinary team

Dr Ali BenMoussa (STCE, ROB)
Dr David Bolsée (STCE, BISA)
Dr Samuel Gissot (ROB)
Dr Boris Giordanengo (ROB)
Nuno Pereira (BISA)

More information:
http://www.stce.be/projects/WP/STCL.php
http://bold.oma.be/

Points of attention

Ussual problems

- high dependence on soft money
- push towards applied research at the expensive of services
- inappropriate civil servant context

collaborations with universities

- KULeuven, CmPA.
  Joint PhDs, Provision of Numerical codes, joint research projects

- ULiege, CSL
  Space hardware support

Contractual staff & management

- Of the 26 permanent scientists at ROB, only 2 are at OD4 while it is the biggest directorate. 2 permanent scientists is not sufficient to secure the management.

- A number of contractual scientists on semi-hard money (STCE) take up management roles, despite lack of personal promotion possibilities.

- The permanent & contractual management together are succesfull in attracting soft money for the other half of the group.

- The whole construction is sensitive to departure of contractuals with key-roles