

Some Random History of Geant4's Place in ESA's Space Activities

Eamonn Daly
ESA
with >2 decades of support from many

11 April 2017

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History of ESA Needs/Function and Early Steps



- Space Environments & Effects function established mid-80's
> mainly radiation environments; doses; SEE
- More complex shielding geometry analyses:
sectoring method
- Investigation of tools: Shieldose, CHARGE, TIGER, - mainly US tools
- **Geant 3** seen as a possible addition
> CERN visit March 1985 (European partner)
> COMPTTEL needs (ESTEC+UNH > MPI)
> STEP/LISA applications



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In 1986 ESA was busy with a comet



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Investigation of rad effects on XMM (DERA contract)



- THE ANALYSIS OF **XMM** INSTRUMENT BACKGROUND INDUCED BY THE RADIATION ENVIRONMENT IN THE XMM ORBIT, Final Report for ESTEC, by Spacecraft Environment & Protection Group, Space Department, UK Defence Research Agency, 19 Dec. 1995

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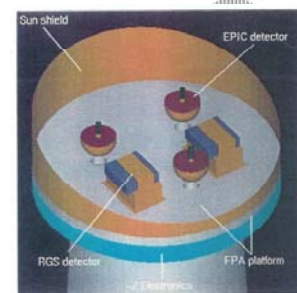
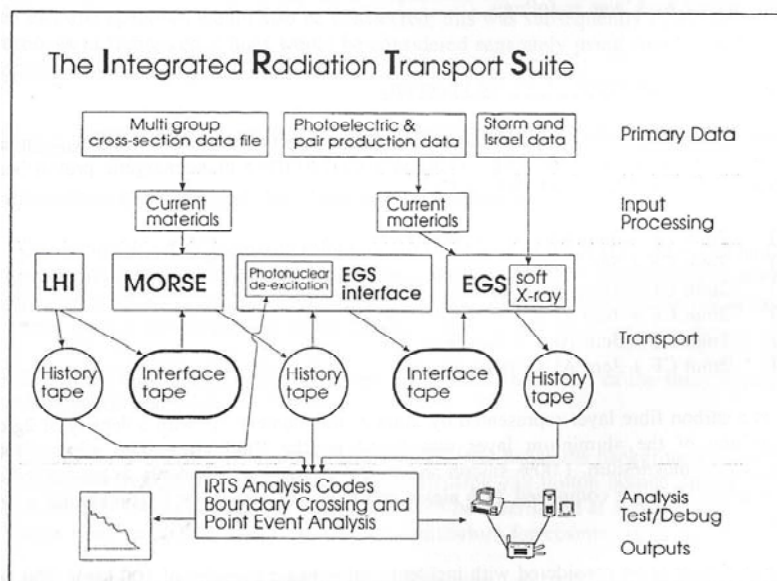


Fig 25 View of the PPA structure without the +Z electronics

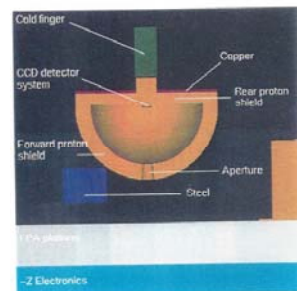


Fig 26 Sectioned side view of the EPIC detector.

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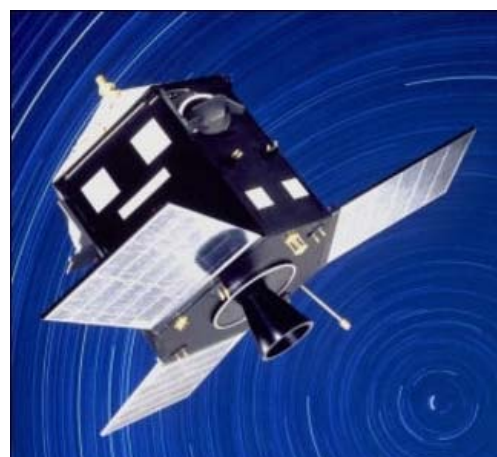
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The age of fantasy and solid achievement



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Geant4



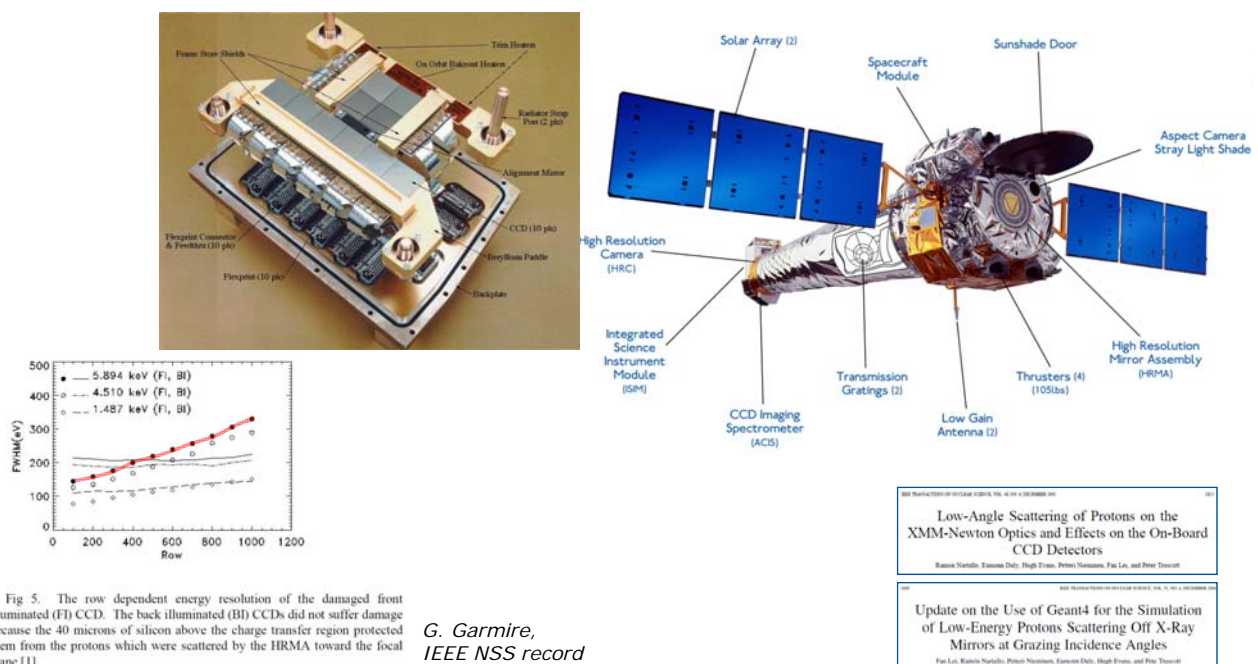
- meeting of Eamonn Daly with Simone Giani 1 April 1996 at CERN
- proposed ESA as a "collaborator"
- ESA "manpower" commitment to be provided via R&D contracts
- ESA contract 96/97 to DERA, U. Southampton, CERN
"Evaluation and development of Spacecraft Radiation Shielding Tools", allowing Clive Dyer to contact Simone to further discuss space as a key application area
- CERN accept ESA as collaborator in RD44 and
 Petteri Nieminen invited to talk at G4 workshop Niigata
- MoU drafted '98, signed by ESA '99;
- Collaboration workshop 1999 at ESTEC, coincided with **Chandra's anomalous detector degradation** (launched July '99)
- XMM launch Dec '99 > crash action to verify safe operation of detectors
- Independent review of G4 in 2001 chaired by Uffe Mortensen (ESA)

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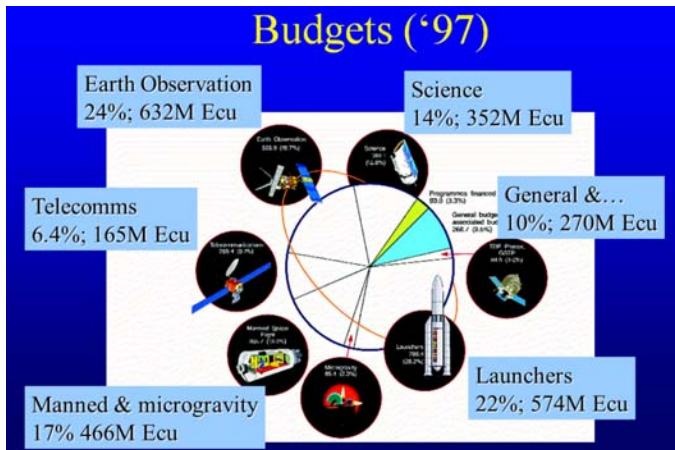


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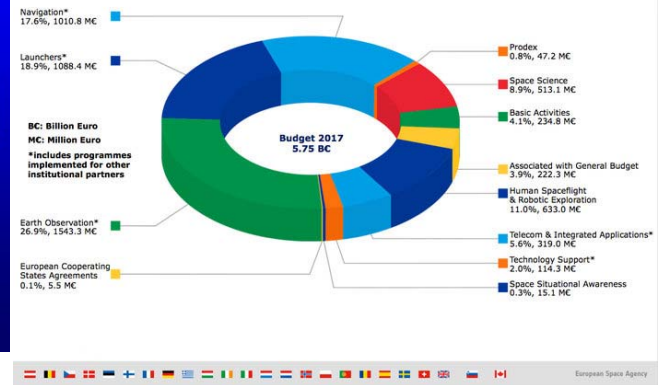
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ESA budget for 2017: by domain



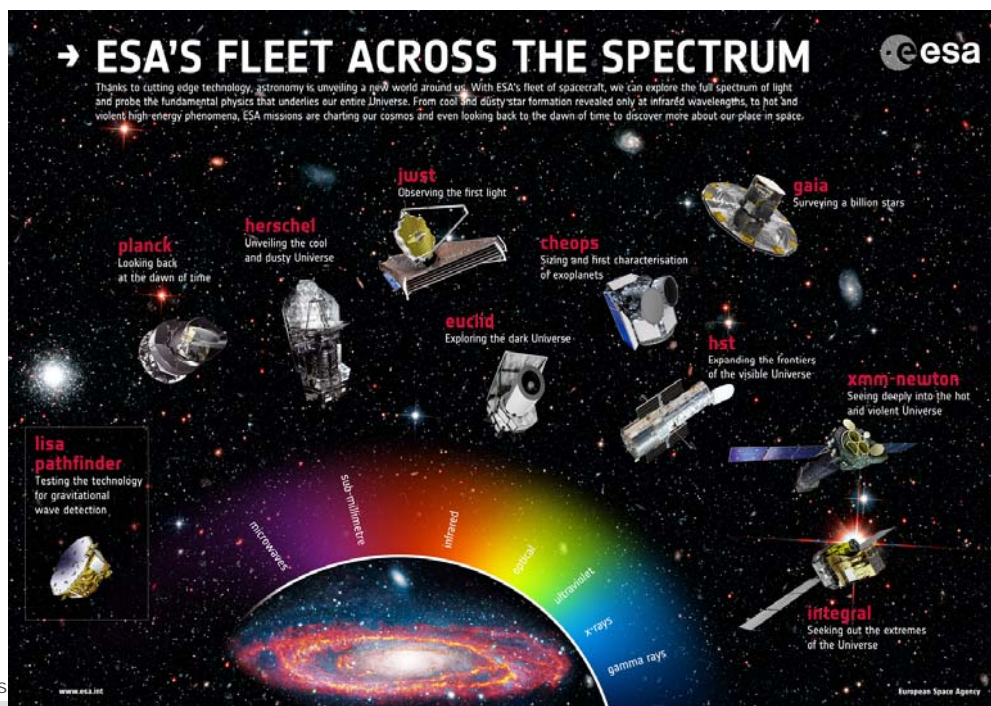
1.37B€ (1985) → 2.46B€ (1997) → 5.75B€

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Search for "Geant4" in IEEE paper abstracts



Years	No. papers in IEEE
1990-1995	0
1996-2000	1*
2001-2005	139
2006-2010	315
2011-2015	285
2016- now	24

*** *Geant4 - a new Monte Carlo toolkit for
simulating space radiation shielding and effects***

P. Truscott; Fan Lei; C. Dyer; C. Ferguson; R. Gurriaran; P. Nieminen; E. Daly; J. Apostolakis; S. Giani;
M. G. Pia; L. Urban; M. Maire, *IEEE Radiation Effects Data Workshop 2000,*
in conjunction with IEEE Nuclear and Space Radiation Effects Conference

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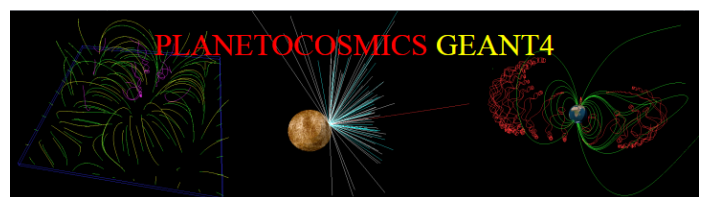


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Developments in many areas



- Mars environment
- Magnetocosmic/planetocosmics
- STEP/LISA (test mass charging)
- Failure analysis
 HRPT on METOP-A
- Detector studies (ubiquitous)
- Manned spaceflight – Desire, G4 for bio systems etc.;
 but hadronics was/is a concern?
- ESA sponsored tools
 REAT-MS; RESTSIM; SSAT; GMAT; MULASSIS; GRAS; CIRSOS



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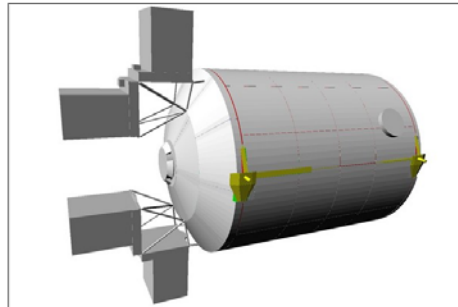
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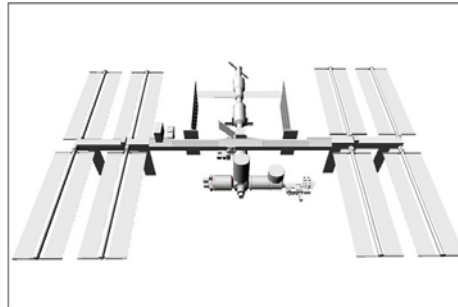
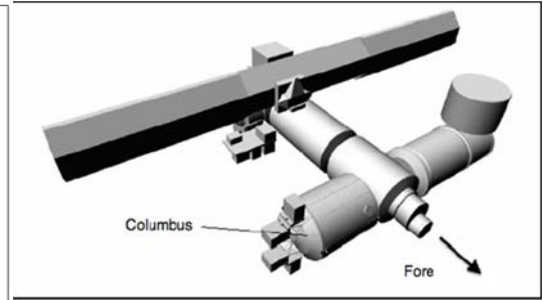
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DESIRE

Tore Ersmark



The Giant Columbus model. Columbus has a total mass of 16750 kg and the implemented model consists of approximately 800 volumes.



Giant model of ISS in the 14A configuration. The Columbus module is located at the front, slightly to the left of the central ISS axis. ISS (excluding Columbus) has at this stage a mass of approximately 352 tons and the model above consists of approximately 350 volumes.

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ESA Science Programme has needed and supported G4

Good internal ESA debates
on technology needs for
future missions

e.g.

XMM

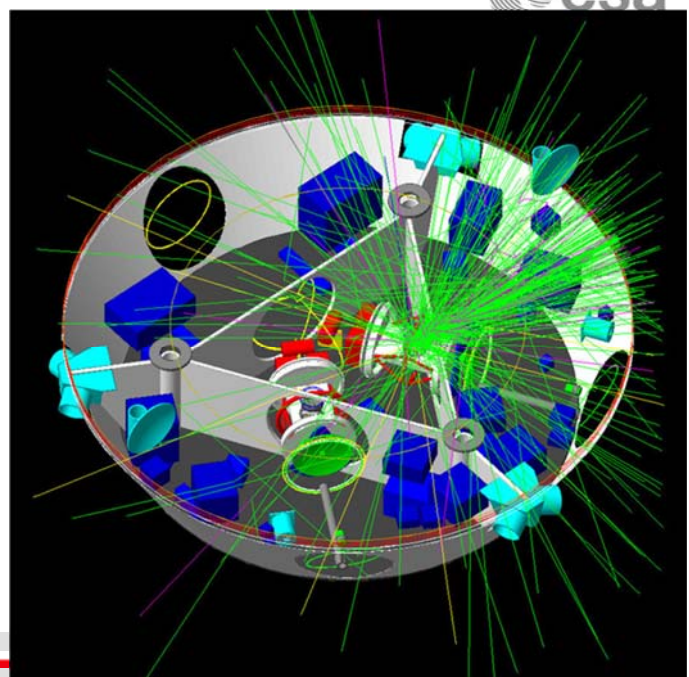
INTEGRAL

JUICE

ATHENA

(e)LISA

*Peter
Wass
IC*



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Non-exhaustive dump of past ESA-funded activities



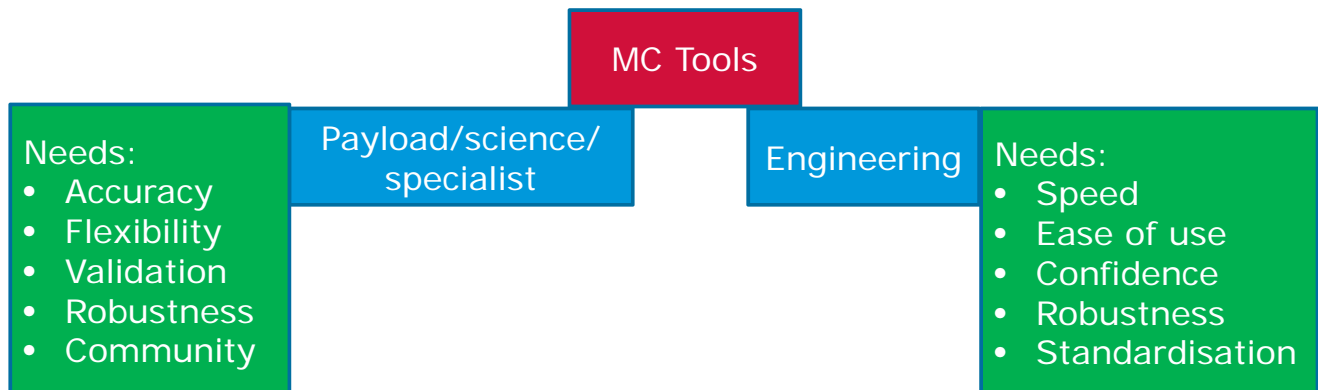
Radiation Shielding Analysis Software
Development, Implementation and Use of Low-energy Geant-4 Software Modules
Radiation Effects Analysis Tools
Radiation Effects on Advanced Technologies: Models and Software
Energetic Particle Shielding and Interactions Software
Martian radiation environment models
Radiation Effects on Sensors and Technologies for Cosmic Vision SCI Missions (REST-SIM)
Rapid Reverse Monte Carlo and Ion Physics for Dose and SEE
Physics models for biological effects of radiation and shielding
Energetic electron shielding, charging and radiation effects
Radiation biological end effects models and interfaces to physics models
GEO telecoms radiation tools efficiency improvement with methods and geometry exchanges for industrial tools
Collaborative iterative radiation shielding optimisation system (CIRSOS)



Use in routine satellite engineering?

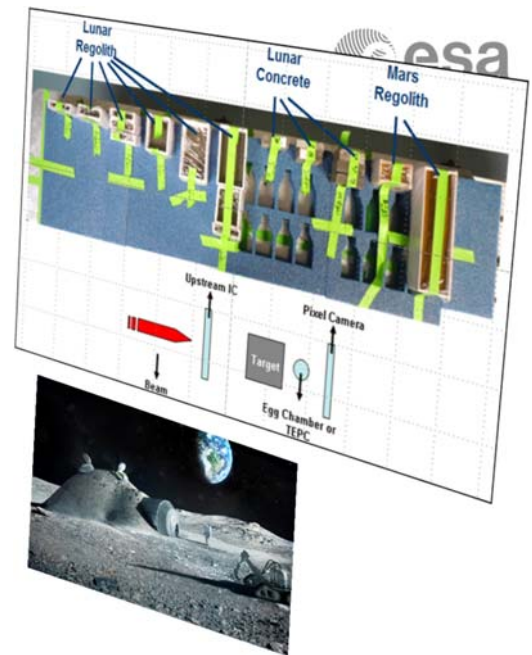
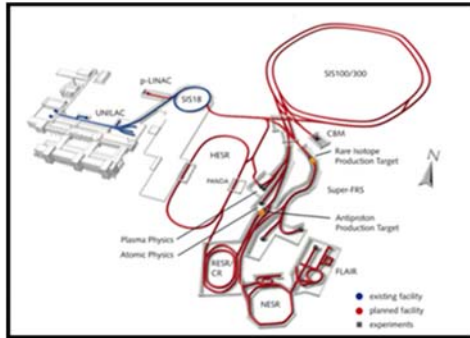


MC for engineering applications was difficult but is the way forward



Validation is receiving emphasis

- Sign of maturity
- Expensive



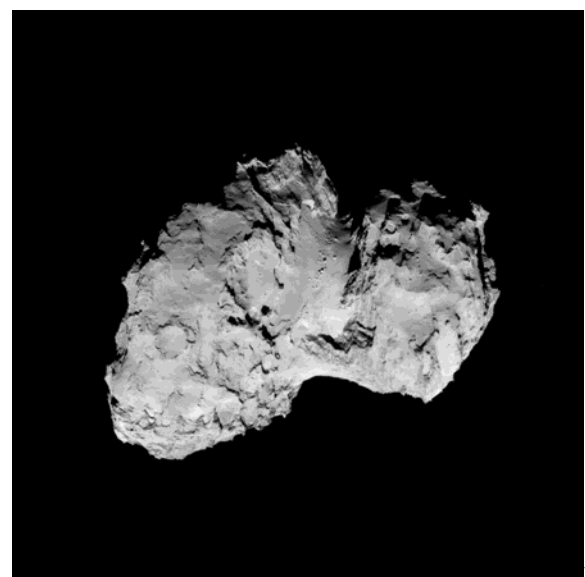
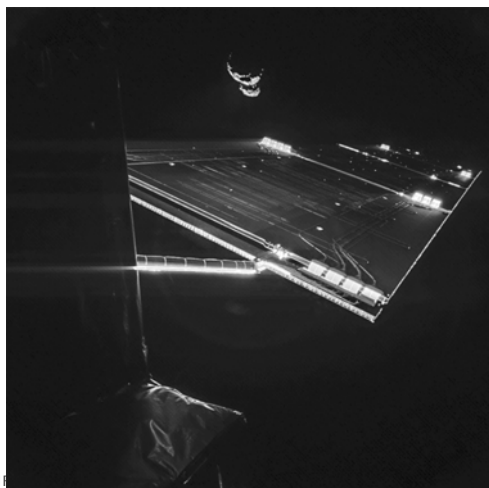
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ESA was still busy with comets in 2016

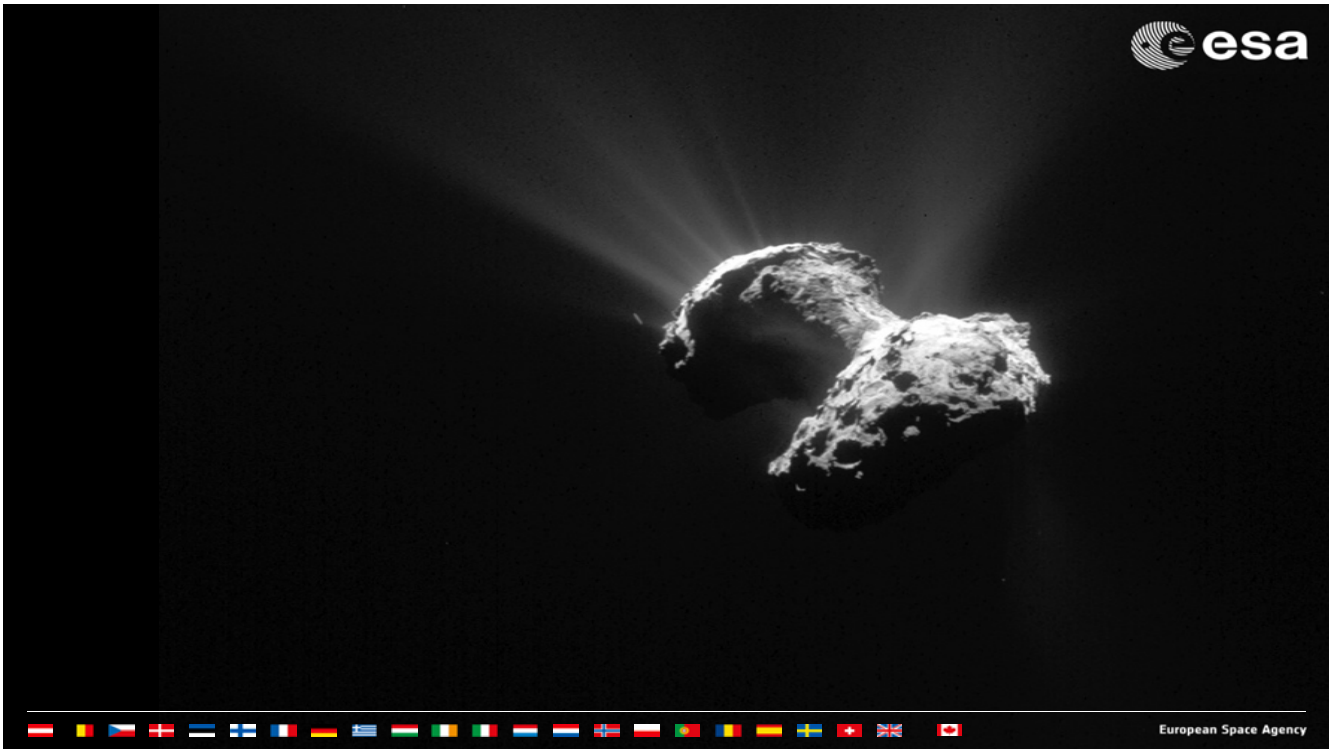


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