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Cosmic Vision 2015-2025: ESA's long term programme in space sciences

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Abstract. ESA's space science programme is briefly reviewed, with a particular emphasis on its long term plan, "Cosmic Vision 2015-2025". The strategy for implementing the plan is outlined, as well as the programmatic and international context. The mission selection process is presented together with the current status of the different projects selected and currently under assessment or under definition.

Key words. Stars: Space vehicles: instruments Telescopes

1. Introduction

The Science Programme is a mandatory programme of the European Space Agency to which all 18 member states must contribute in proportion to their Gross National Product (GNP). Every three years, the Council of Ministers decides by unanimity the Level of Resources (LoR) for the next 5 years. The council of ministers met in November 2008 and allocated a total budget of 2.327 billion Euros for the 5-year period 2009-2013. This corresponds to a LoR of 464.8 MEuros/year at current Economic Conditions. Since payloads are generally built and funded nationally, to be exhaustive one should add to this figure the space science expenditures of ESA member states. Because of different accountability systems, the latter is not straightforward to establish. Furthermore, it varies substantially from year to year. Nevertheless, a recent study commissioned by the European Science Foundation shows that in recent years, European member states globally spend on average 250 to 300 MEuros/year on space science (in addition to their mandatory contribution to ESA).

The content of the science programme is defined by the European scientific community through open calls for mission concepts followed by peer review and the eventual selection of future missions to be developed and launched 10 to 15 years later. The selection is performed by the Astronomy Working Group (AWG), the Solar System & Exploration Working Group (SSEWG), the Physical Science Advisory Group (PSAG) and the more senior Space Science Advisory Committee (SSAC). Each working group analyse new mission concepts in its discipline and provide a scientifically ranked list to the SSAC. Based on the Working Groups (WG) recommendations, the SSAC performs a final selection across the 3 disciplines. The SSAC and the WGs are groups of European scientists chosen for their scientific excellence and who are expected to represent the views of the European

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scientific community as a whole rather than any particular national interest. The cycle is repeated every 10 years or so. Two previous cycles established the Horizon 2000 and Horizon 2000+ science programmes, in 1984 and 1994-1995, respectively. The current selection cycle, *Cosmic Vision 2015-2025* (CV in short) was initiated in 2004.

2. The current programme: missions in operations or development

ESA is currently operating 13 scientific satellites which were selected and developed as part of the Horizon 2000+ programme: SOHO (1995), XMM-Newton (1999), the 4 Cluster spacecrafts (2000), INTEGRAL (2002), Mars-Express (2003), Rosetta (2004), Venus-Express (2005), Herschel (2009), Planck (2009) and Proba-2 (2009), where the figures in parenthesis refer to the launch year. In addition, ESA is a partner in two NASA missions currently in operations - Hubble (1990) and Cassini-Huygens (1997) one Chinese mission - Double Star (2003) - three JAXA missions Suzaku (2005) Akari (2006) and Hinode (2006) as well as the CNES-led mission CoRoT (2006).

Four other H2000+ missions are currently under development:

– LISA Pathfinder is a technology demonstrator for the LISA mission or any mission aimed at detecting gravitational waves. When launched in early 2014, it will demonstrate the feasibility of putting two free-floating test masses in pure free-fall along true geodesics, protected from electromagnetic, solar wind or any other perturbations. LISA Pathfinder will also validate the technology required to measure the relative positions of the two test masses to picometer accuracy. LISA Pathfinder is currently undergoing integration and testing. There are still problems with the delicate mechanism which holds the tests masses during launch and releases them with near zero velocity once in orbit. The micropropulsion system required for the spacecraft to follow the motion of the test masses is also experiencing difficulties.
– Gaia is the successor of the successful Hipparcos Astrometric mission. When launched in May 2013, it will measure the parallax and proper motions of a billion stars down to micro-arcsec accuracy as well as their radial velocity and energy distributions over the 320-1000 nm range. This will allow the reconstruction of the formation and accretion history of the milky-way. Among other things, Gaia will also detect tens of thousand of Jupiter-size exo-planets as well as thousands of asteroids, comets and trans-Neptunian objects in our own solar system. Gaia is currently under integration and testing. All performances measured so far are as expected, except for stars brighter than magnitude 10 where the astrometric accuracy at the end of the 5-year mission may be 9 microarcsec rather than 7.
– Through ESA, Europe is collaborating with NASA on the James Web Space Telescope (JWST). Europe is currently developing the Near-IR Spectrograph NIRSpec as well as half of the Mid-IR Instrument MIRI. On behalf of NASA, ESA will also launch the JWST spacecraft on an Ariane V rocket. Both NIRSpec and MIRI have been integrated and are currently undergoing cryogenic test before their delivery to NASA in late 2011. All indications are that the performances of the instrument will meet their specifications. The 5-microns detectors of all three JWST instruments suffer from an increasing number of hot pixels and will be exchanged with new and better devices later on. At NASA, the JWST programme suffered from large cost overruns and repeated delays. At the time of writing, the overall cost at completion exceeds 7 B$ and the earliest possible launch date is in 2018.
– Bepi-Colombo is a collaborative venture with the Japanese Space Agency JAXA whereby ESA provides the Mercury Planetary Orbiter (MPO) and JAXA develops the Mercury Magnetospheric Orbiter (MMO). Thanks to its sophisticated instruments and relatively low orbit, Bepi-Colombo will provide high resolution im-

ages of Mercury and in situ measurements that will vastly improve our knowledge of the mysterious planet. The payload also includes an experiment that measures Mercurys motion with a very high accuracy, thereby providing a stringent test of General Relativity. The two Bepi-Colombo probes will be launched together by a single Ariane-V rocket in August 2014 and arrive at Mercury in 2020. Bepi-Colombo is currently under development. The main challenge is to build a system that can operate under the extreme temperatures encountered at ~ 0.3 AU from the Sun.

Except JWST which has been delayed to 2018, the current programme does not contain any projects to be launched after 2014. Given the long time required to select and develop new missions, ESA initiated in 2004 the process to define its programme for the following 10 year-period, *Cosmic Vision 2015-2025*.

3. The Cosmic Vision process: selection of scientific themes

In April 2004, ESA issued a Call for Cosmic Vision science themes, i.e. for important scientific questions that are likely to remain unresolved at the horizon 2015-2025. The European community responded massively and submitted 151 novel ideas, more than twice as many as for H2000.

The Space Science Advisory Committee (SSAC), assisted by its three thematic working groups, analysed the responses from the community and pre-selected a few themes. These themes were presented and discussed at a workshop in Paris in September 2004 which more than 400 scientists attended. The SSAC prepared a first version of the Cosmic Vision plan which was presented to the scientific community during a workshop in May 2005. The plan was further elaborated during the summer and eventually published in October 2005 as ESA-BR 247[1]. The plan identifies four main scientific themes:

- What are the conditions for planet formation and the emergence of life?
- How does the Solar System work?
- What are the fundamental physical laws of the Universe?
- How did the Universe originate and what is it made of?

4. Cosmic Vision implementation strategy

Based on the Cosmic Vision (CV) plan, ESA elaborated a strategy for its implementation that is compatible with the financial constraints imposed by the Level of Resources and missions currently under development or in operations. The plan was eventually endorsed by the Science Programme Committee (SPC), the senior body that governs the implementation of ESA Science programme and where each member states is represented by one national delegate.

The strategy foresees:

- Three Call for mission proposals, with roughly one call being issued every ~ 3.5 years over the period 2007 to 2015.
- Each Call has a financial envelope of 950 MEuro, to be spent into one Large (L) and one Medium (M) class mission.
- The cost to ESA of an L-class mission is capped to 650 MEuro at 2006 economic conditions (EC).
- The cost to ESA of an M-class mission is capped to 300 MEuro (2006 EC)
- As a rule, M missions must have their technology ready at the time of their selection, whereas some technology development is acceptable for the more complex and ambitious L missions.
- As a baseline, payloads continue to be developed and financed by national member states.
- Two missions, extensively studied as part of H2000+ but never implemented for lack of resources, compete with new CV projects: the gravitational wave observatory, LISA, and Solar Orbiter, which are in the L and M class category, respectively.

Based on the Cosmic Vision Plan elaborated by the SSAC and WG and on the strategy proposed by ESA and approved by the SPC,

[1] http://www.esa.int/esapub/br/br247/br247.pdf

the first of the 3 Cosmic Vision Calls for mission proposals was issued in March 2007.

Again, the scientific community responded massively, submitting a total of 50 proposals by the 29 June 2007 deadline, more than twice as many as for H2000+. Over the summer, the SSAC and the WGs evaluated the proposals and eventually selected 4 M and 3 L mission concepts for assessment, plus one "mission of opportunity", i.e. a mission whose cost to ESA is ≤ 150 MEuro. The selection was announced in October 2007.

5. The first selection of M-class Mission Concepts M1 & M2

The M-class missions selected for assessment studies are Euclid, PLATO, Marco-Polo, and Cross-Scale, plus the SPICA mission of opportunity.

Together with Solar Orbiter, the selected M missions underwent an 18-months assessment study which was completed in September 2009. The assessment studies concluded that all 7 projects are technically feasible but that their cost to ESA largely exceeds the 300 MEuro envelope initially envisaged for M missions. The SPC agreed to raise the M-class ceiling to 470 MEuro. The study reports were published on December 2, 2009 and simultaneously presented in front of an audience of ≥ 450 scientists from all over Europe and beyond.

In February 2010, the WG and SSAC down-selected three of them for a definition study: Euclid, PLATO and Solar Orbiter. A decision on SPICA was deferred to a future date when it gets approved for implementation in Japan. The three M missions and their payload underwent an 18 months definition study by industry, while payloads were subjected to parallel studies in ESA member states. Elaborating on the earlier assessment study, the aim of a definition study is to define sub-system by subsystem the architecture of the mission and verify that it can meet the scientific objectives as laid down in the assessment study report. The definition studies were completed in June 2011 and the study reports are in preparation.

The WG and SSAC will further evaluate the three M mission candidates and, in October 2011, they will recommend two of them for implementation. An invitation to tender will then be issued for industry to prepare development proposals for the two missions including a committing price. The most advantageous proposals will be retained and in July 2012 the SPC will formally adopt the two M missions for implementation. The current schedule foresees the launch of one mission, M1, in 2017 and the second mission, M2, in 2018.

6. The 3 medium-class missions competing for the M1 & M2 launch

As stated above, the three M missions currently in competition for the M1-M2 slots are Euclid, PLATO and Solar Orbiter.

Euclid is a high precision survey mission aimed at constraining the Dark Energy (DE) equation of state and its evolution as a function of cosmic time. It combines two proposals from the community, DUNE & SPACE. The DUNE concept proposed an imaging and photometric survey in the visible to near IR in order to map the total amount of matter (luminous and dark) and therefore the growth of structure as a function of redshift. The amount of matter along the line-of-sight is inferred through the Weak gravitational Lensing (WL) distortion of galaxy shapes and orientations it induces. The overall distortion is small and requires sub-arcsec angular resolution to be measured to the required level of accuracy. The larger the galaxy sample, the more accurate the results. The second proposal, SPACE, aims at constraining the DE equation of state through its effect on the growth of cosmic structures as a function of time. More specifically, it measures Baryonic Acoustic Oscillations (BAO) as a function of look-back time. BAO are small amplitude modulations (5-10%) in the distribution of matter imprinted at early stages of the universe when radiation and matter decoupled shortly after the big-bang ($z \sim 1000$). This initial imprint seeded the subsequent growth of structures in the Universe. The later evolution of BAO depends on the competing effects of gravity, which accelerates the formation of galaxies and clusters, and DE which tends to rip them apart. This is precisely the effect which SPACE aims at measuring by correlating the redshifts of half a billion galaxies up to $z \sim 2$. Euclid aims at constraining the DE equation of state to 1% accuracy, sufficient to distinguish between competing hypotheses for its origin. Since the systematic errors which limit the power of the WL and BAO methods are "orthogonal", Euclid is more powerful that the sum of DUNE & SPACE. Furthermore, it is theoretically possible that BAO and WL yield conflicting results, which would be a strong indication that General Relativity breaks-down on very large scales. Euclid features a 1.2 m diameter telescope feeding an optical imaging channel ($\sim 0.16''$ resolution), a NIR (Y, J, H) photometric channel and a 1-2 μm slitless spectrograph with a resolution $\lambda/\Delta\Lambda$= 250. During 7 years, Euclid will survey 20,000 deg^{2}s down to 24.5 magnitudes in the visible and measure the photometric redshift of half a billion galaxies as well as the spectroscopic redshift of a subsample of 10^8 galaxies brighter than AB = 22.

The main goal of PLATO is to discover a large number of close-by earth-size exoplanets and characterise their mass and radius with 1% accuracy. Depending on the industrial design, PLATO features between 12 and 54 small telescopes, providing a total collecting area of 0.3 m^2 and a very large Filed of View (FOV) of up to 1,800 deg^2. Two fields will be observed for 2 and 3 years, respectively in order to collect the light-curves of $\sim 20,000$ F, G & K stars to a relative photometric accuracy of 10^{-6}/month, and 500,000 stars to somewhat less precision. The light-curves will be searched for the small dimming produced by a planet as it transits in front of its parent star. The light-curves will also be subjected to astroseismologic analysis in order to precisely determine the age, mass and size of the stars. This will in turn allow performing comparative planetology on a very large sample of systems. The determination of the age of the systems to 300 million-year accuracy will shed light on the evolutionary sequence of planetary systems. Because it focuses on stars brighter than magnitude 11, PLATO will detect a significantly larger number of earth-size planets than the NASA Kepler mission and, most importantly, it will be able to characterise their mass and radius. The emphasis on bright stars also greatly facilitates follow-up radial velocity studies from the ground. PLATO will be put into a large amplitude orbit around the Sun-Earth L2 point by a Soyuz-Fregat launcher.

Solar Orbiter is the successor to the very successful ESA-NASA SOHO mission. Unlike SOHO however, Solar Orbiter orbits the Sun with a perihelion of 0.28 AU only. It is thus able to resolve details as fine as 200 km on the solar surface and follow their temporal evolution. Another advantage of Solar Orbiter is its highly inclined orbit which brings it 30 degrees above the ecliptic and thereby allows direct observations of polar regions. The spacecraft contains a suite of 10 complementary instruments which permit to perform both remote sensing of the solar photosphere and in situ measurements of the local heliospheric plasma. After a 3.4 years inter-planetary cruise, Solar Orbiter will initially be put in a 168 day-long elliptical orbit. The spacecraft will perform a close approach of the Sun every 5 months. Around closest approach, Solar Orbiter will remain for several days roughly positioned over the same region of the solar atmosphere as the Sun rotates on its axis. It will therefore be able to watch storms building up in the atmosphere and follow their evolution. Ground controllers will repeatedly fly Solar Orbiter close to Venus, and use the planet's gravity to nudge the spacecraft into higher inclination orbits. After 7.4 years, Solar Orbiter will view the poles from solar latitudes higher than 30 degrees.

7. The L-class missions

In October 2007, beside the M missions, the SSAC and WG also selected three L mission concepts for an assessment study:

– LISA: the LISA gravitational wave observatory is a very ambitious collaborative mission with NASA the purpose of which is to detect and measure gravitational waves in the astrophysically interesting 0.1 – 10^{-4} Hz frequency range, inaccessible from the ground. LISA features a constellation of 3 identical spacecrafts in a 1 AU orbit around the sun. Separated by 5 million kilometres, the 3 S/C form an equilateral triangle that is inclined by 60 degrees with respect to the ecliptic plane and trails the earth by 50 millions kilometres. The passage of gravitational waves through the solar system distorts spacetime and therefore the 3 sides of the triangle by a minute amount which depends on the strength of the GW source, its distance and its direction. This is precisely this minuscule deformation which LISA measures via laser interferometry with picometer accuracy. Through phase and amplitude modulation, LISA provides an angular resolution of up to 1 arcmin for the strongest sources and an estimate of the mass and (luminosity-) distances accurate to better than 1 %. It sensitivity is sufficient to detect coalescing massive black-hole binaries up to z = 20 at very high signal to noise ratio and follow their evolution for several months before they finally merger. In 2014, LISA Pathfinder will hopefully demonstrate most of the technologies required by LISA.

– The International X-ray Observatory IXO: IXO represents the next-generation general purpose X-ray observatory. With ≥ 3 m^2 effective area at 1 keV and advanced focal plane detectors, its sensitivity improves by one to two orders of magnitude upon the highly successful XMM-Newton and Chandra missions. IXO main scientific objectives are to investigate how supermassive black-holes formed and grew in the early universe, how this influenced the formation of galaxies, how large scale structures evolved and how they became chemically enriched. IXO has a ≥ 20 m deployable optical bench that provides the required focal length and high energy sensitivity. The diameter of the mirror is 3.3 m. The payload consists of several focal plane instruments, including a Wide-Field Imager, a Narrow-Field Imager and a high-resolution grating spectrometer. IXO was to be put into a halo orbit around L2 by an Ariane-V or an Atlas V launcher. It is obviously a very ambitious and therefore costly mission. For this reason, it was conceived as a joint venture between ESA, NASA and JAXA.
– The Europa-Jupiter system Mission EJSM-LAPLACE: the objective of EJSM-Laplace is to carry out an in-depth study of the Jovian system and its four largest satellites, with particular emphasis on Ganymede and Europa. It utilizes two spacecraft, the Jupiter Ganymede Orbiter (JGO) and the Jupiter Europa Orbiter (JEO), flying on complementary trajectories and carrying complementary instruments. The mission has the following science objectives: characterize Ganymede and Europa as planetary objects and potential habitats; study Ganymede, Europa, Callisto and Io in the broader context of the system of Jovian satellites; and focus on the science of Jupiter itself including the planet, its atmosphere, magnetosphere, irregular satellites and rings. As LISA and IXO, EJSM-Laplace was conceived as collaborative project whereby ESA provides the Jupiter Ganymede Orbiter (JGO) and NASA provides the JEO.

LISA, IXO and EJSM-Laplace underwent a two-year assessment study which was completed in September 2010. The study reports were published on February 2, 2011 and simultaneously presented to a large audience in Paris. The conclusion from the assessment studies is that all three projects are technically feasible but that their total cost is well above the 650-MEuro envelope of an L mission, thereby confirming the necessity to develop them in collaboration with another agency.

The next step would have been for the WG and SSAC to down-select two of the three L missions for a definition study. However, a rapid evolution of the international context forced a drastic revision of the plan:

– In September 2010, the US National Academy of Science (NAS) Decadal Survey Committee for astronomy and astrophysics released its report "New world, New Horizon" which outlines the priorities of the US scientific committee for the next decade. LISA and IXO ranked third and fourth, respectively in the report. In March 2011, the NAS Planetary Science Decadal Survey Committee published its report "Vision and Voyages" which sets the US priorities for planetary science. Again, EJSM-Laplace did not come on top of the priority list.

– The US presidential request for 2012-2016 shows a rather constrained NASA space science budget. Furthermore, because of delays and cost overruns, JWST will continue to siphon 375 M$ of that budget until its launch in 2018. As a consequence, NASA does not have the funds to implement any other mission than those on top of the decadal surveys priority lists.

In March 2011, NASA informed ESA that it was no longer in a position to collaborate on any of the three L missions. Since their cost is well above 650 MEuro, LISA, IXO and EJSM-Laplace therefore had to be abandoned.

In order not to loose the benefit from the assessment studies and the investments made in developing enabling technologies, the decision was taken to redirect the studies toward descoped version of the 3 missions feasible by Europe on its own. The Europe-only versions of IXO, LISA and EJSM were provisionally baptised ATHENA (Advanced Telescope for High ENergy Astrophysics), NGO (New Gravitational wave Observatory) and JGO (Jupiter Ganymede Orbiter), respectively. The cost cap was raised to 850 MEuro (2008 economic conditions). Short studies were initiated in April to try and define designs that halve the cost of the former L missions while retaining their core scientific objectives. Since these studies have just started, it is too early to describe what these missions will look like. The current plan is to submit the results of the studies to the WG in November 2011 for their scientific assessment and ranking. In February 2012, the SSAC will down-select two of them for a 2 years definition study. If everything goes according to plan, in early 2014 one of them will be selected for development and launch in 2021.

8. The second Call for medium-class missions

On July 29, 2010, ESA issued a Call for the second slice of the Cosmic Vision programme, requesting concepts for an M-class mission to be launched in the time-frame 2020-2022, the so-called M3 mission. A total of 47 proposals were received by the deadline of December 3, 2010. Following an assessment by the WG and SSAC, 4 mission concepts were eventually selected for an 18 months assessment study:

– EChO, the Exo-planet Characterisation Observatory; the aim of EChO is to perform spectroscopy of known transiting exo-planets in order to characterise their atmosphere. Echo features a 1.2 m diameter Cassegrain telescope passively cooled to 50 K which feeds a six-channels spectrograph operating over the 0.4 - 16 μm range at a resolution $\lambda/\delta\lambda = 600$. Beside CCD, it contains HgCdTe IR detectors actively cooled to 30 K. Time resolved spectra obtained during the main and the secondary transits permit to identify the main chemical constituents of the planetary atmosphere, to measure its temperature profile and the albedo of planets as small as 1.5 earth radii orbiting F, G, K and M stars. Temporal evolution is used to search for day-night as well as seasonal variations and to study the climate of the exo-planet. EChO requires a very high photometric accuracy $\delta F/F \leq 10^{-5}$ which sets stringent requirements on the pointing accuracy of the satellite as well as on its thermal stability. Echo will be launched by a Soyuz rocket in a Lissajous orbit around the L2 Sun-Earth Lagrange point.
– STE-QUEST (Space Time Explorer & QUantum Equivalence Space Test); the primary objective of STE-QUEST is to test two aspects of General Relativity to an unprecedented level of accuracy. First, by measuring the evolution of a high precision atomic clock as a function of the gravitational potential along a highly elliptical geocentric orbit and comparing its rate with that of ultra-high precision clocks on the ground, STE-QUEST performs a

test of Local Lorentz Invariance and Local Positional Invariance. In effect, it measures the earth gravitational redshift to a fractional accuracy better than 1.6×10^{-7} and that of the Sun to better than 6×10^{-7}, two orders of magnitude better than existing or planned experiments. Second, STE-QUEST tests the universality of free-fall to an accuracy of one part in 10^{15}, two orders of magnitude better than torsion pendulum or laser ranging experiments. This second test is performed by comparing the time of free-fall of two Rubidium isotopes in two otherwise identical atomic interferometers. The payload thus consists of two instruments: an atomic clock with an accuracy of 5×10^{-16} and a dual Mach-Zender matter-wave interferometer functioning with ^{85}Rb and ^{87}Rb. The atomic clock is derived from the PAHARAO clock currently under development which will be flown in 2014 on the space station as part of the ACES mission.

- The Large Observatory For x-rays Timing (LOFT); LOFT is a general purpose X-ray observatory optimised for high time resolution spectroscopy. It is a follow-up to RXTE but with a 20 times better sensitivity. One of LOFT's main goals is to determine the masses and radii of accreting millisecond pulsars to an accuracy of 5 % by resolving their pulse profiles. This in turn allows setting strong constraints on the equation of state of matter inside neutron star. Another important objective is to perform time resolved spectroscopy of kHz Quasi Periodic Oscillations (QPO) in black-holes and neutron stars, so as to study the formation of QPO's and follow their evolution. Such studies will permit to distinguish between competing QPO models. Through timing measurements, LOFT can also determine the mass and spin of black-holes. LOFT features two instruments: the Large Area Detector (LAD) has a very high effective area, up to 12 m^2 in the 2-10 keV range and 1.3 m^2 at 30 keV, which endows it with a 10 μs time resolution. This is possible thanks to the new Silicon Drift Detector (SDD) technology initially developed for the ALICE experiment at the CERN Large Hadron Collider. The main characteristic of LAD is their lightness which makes it possible to deploy a geometric area as large as 20 m^2 in space. LAD have an energy resolution $\leq$ 260 eV at 6 keV but almost no angular resolution. It is however possible to restrict their FOV to less than 30 arcmin. The second instrument on-board LOFT is the Wide Field Monitor (WFM) which operates over the range 2-50 keV with an energy resolution of 300 eV. Thanks to its coded mask telescope, WFM achieves a spatial resolution of 1 arcmin over a 3 steradian FOV. LOFT will be put into low earth orbit (600 km) by the new VEGA launcher currently being developed at ESA.
- Marco-Polo R is a mission to return a sample of material from a primitive near-Earth asteroid (NEA) for detailed analysis in ground-based laboratories. The scientific data would help to answer key questions about the processes that occurred during planet formation and the evolution of the rocks which were the building blocks of terrestrial planets.

9. Discussion

JIM BEALL: What is the status of Silicon Drift Detectors for spaceflight ?

JEAN CLAVEL Silicon Drift Detectors (SDD) were developed for and are currently being used in the ALICE experiment of the Large Hadron Collider at CERN. By construction, they are radiation hardened and validated for doses $\geq$ 14 krad, much higher than required for LOFT in LEO. They have been operated in temperature range between -30 and + 30 degrees C. Hence, in principle, the detectors only need to be space-qualified and in particular tested under the vibration level expected from the VEGA launcher. In addition, the design of the detectors will be slightly modified and optimised for LOFT, to improve their soft-X-ray response and to reduce their power consumption.