

Messages sent by Community

- **Go Outward!** Explore the outer Solar System
(Jupiter, Europa, and beyond)
- **Look at Small Scales!** Understand Space Plasmas
(Magnetospheres, Heliosphere & Solar magnetic fields)
- **Seek Ground Truth!** Land on NEOs, Moons, Planets
(Look below surface and return samples)
- **Look for Life!** Everywhere in Solar System
(Any possible evidence)

Themes identified by SSWG

- On the basis of 30 best-rated proposals, SSWG identified 3 themes, each with 3 topics + 1 outlook
 - ❶ From Sun to Earth and Beyond: the Plasma Universe
 - ❷ Tracing the Origin of the Solar System
 - ❸ Life and Habitability in the Solar System and Beyond

Theme 1: Space Plasmas


From Sun to Earth and beyond: the Plasma Universe

- Coupling from electron to interplanetary scales
- Solar magnetic fields and solar particle acceleration
- Dynamics of non-terrestrial magnetospheres
- ➤ ➤ ➤ Heliospheric boundaries and ISM

Theme 2: Outer Solar System


Tracing the Origin of the Solar System

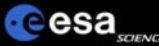
- Formation and dynamics of giant planets
- Structure and evolution of icy satellites
- Composition and structure of minor bodies
- ➤ ➤ ➤ Solar System beyond Saturn

 Theme 3: Life & Habitability

Life and habitability in the Solar System and beyond

- Evolution of Solar System environments
- Traces of life in the solar system
- Comparison with extra-solar habitable worlds
- ➤ ➤ ➤ Look deep below surfaces (Mars, Europa)

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 Cross – Theme Connections

➤ Community's cross-theme favorites, within SSWG: :

- ① Multi-satellite missions for multi-spatial scales
- ② Outer planets – Jupiter, Europa, and beyond
- ③ Sample return
- ④ Subsurface exploration

...and with AWG

- ⑤ Extra-solar habitable planets

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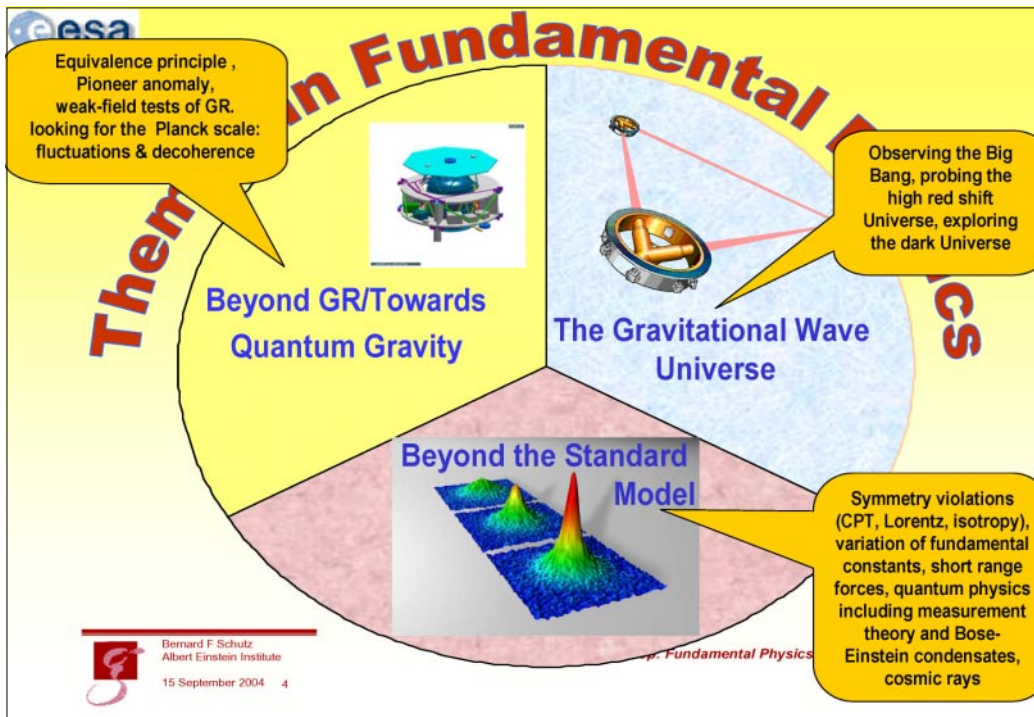
Fundamental Physics: Moving into Space

- Existing projects (LISA, GP-B, STEP) conceived and designed 10-20 years ago.
- Recent revolution in cosmology: Universe requires explaining (dark matter, dark energy), needs fundamental physics.
- Big HEP labs taking an interest in cosmology and novel experiments: CERN, SLAC, ...
- Fundamental physics has reached the point where it needs to go into space (think of astronomy in the '60's and '70's):
 - Ground-based quantum physics community has made huge strides in precision, resolution.
 - Space gives access to higher energies, longer ranges, quieter environments.
- Very active European community: 45-50 submissions. Often a strong synergy with astronomy, and many opportunities for cooperative missions with solar system exploration.



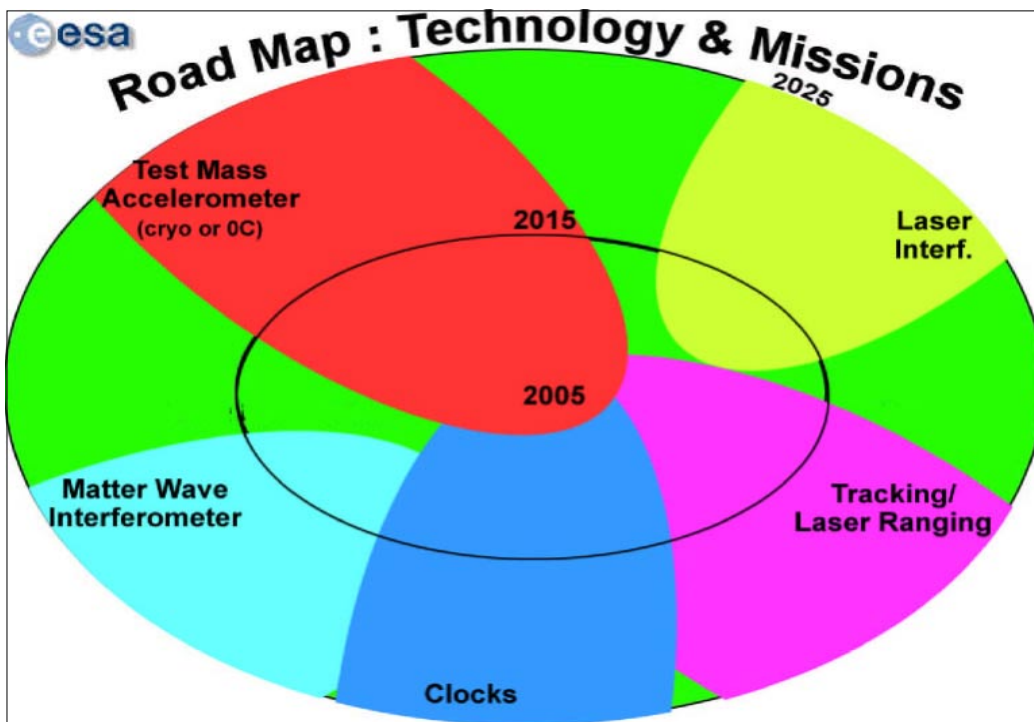
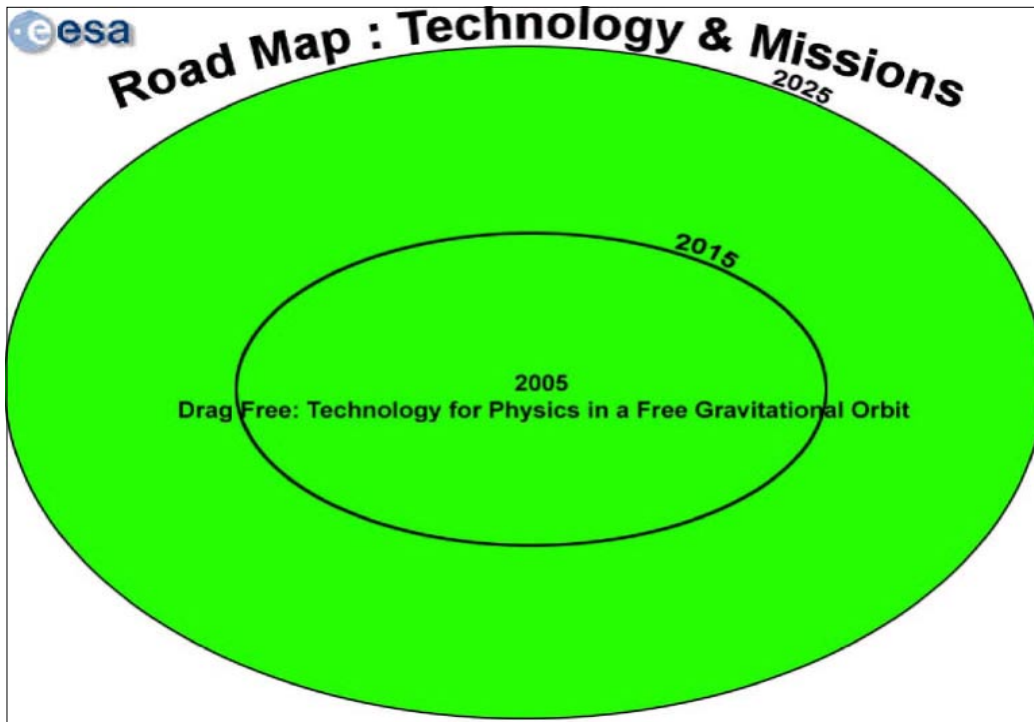
Bernard F. Schutz
Albert Einstein Institute
15 September 2004 2

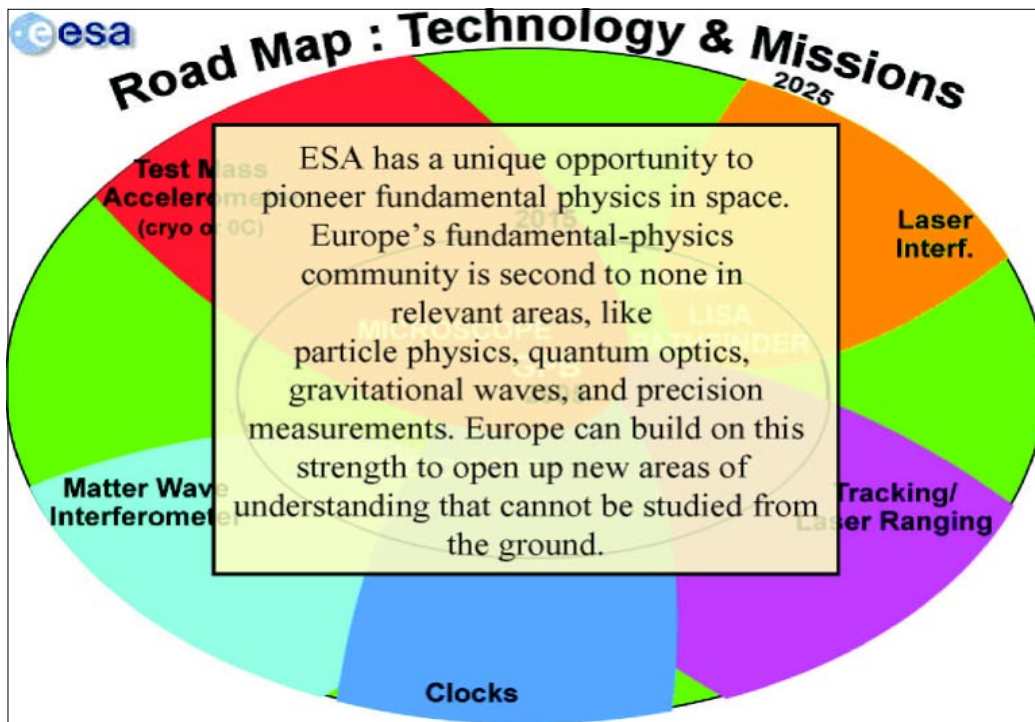
Cosmic Vision Workshop: Fundamental Physics




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Cosmic Vision Workshop: Fundamental Physics





Towards Quantum Gravity	Beyond the Standard Model	The Gravitational Wave Universe
Probing the limits of classical GR EP , Pioneer Anomaly		Observing the Big Bang
Looking for the Planck Scale: Space-Fluctuations & Decoherence	Symmetry Violations (CPT Lorentz, Isotropy)	Probing the high red shift universe
	Fundamental Constants	Exploring the dark Universe
	Short Range Forces	
	Quantum Physics of BECs	
	Cosmic Rays	
 Bernard F. Schutz Albert Einstein Institute 15 September 2004	<i>Cosmic Vision Workshop: Fundamental Physics</i>	

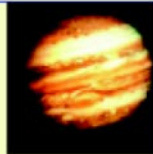
Answers to the call for ideas

Illustration of the strong expectation of the community from the ESA Science Programme:

In astronomy

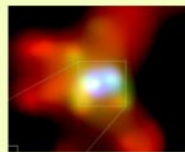
1983: Horizon 2000	29 answers
1993: Horizon 2000+	28 answers
2004: Cosmic Vision 2015-2025	47 answers

Context, science

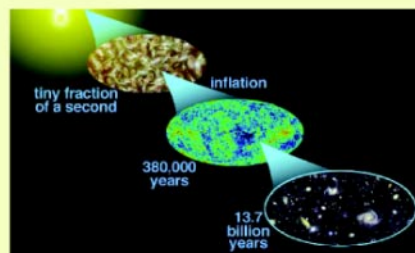


- > discovery of 134 exo-planets (118 systems), down to $\sim 15 M_{\text{Earth}}$
- > very different from the planets in the Solar System
- > high diversity

- > observations at higher and higher redshifts
- > new cosmological parameters, more and more accurate
- > dark energy dominates the Universe, now



- > cosmological nature of γ ray bursts
- > diagnostics of strong field gravity
- > discovery of binary black holes



Three main themes identified

1. Other worlds and life in the Universe
Placing the Solar System into context
 - Formation of stars and planetary systems
 - Detection, census and characterization of exo-planets
 - Search for extraterrestrial life
2. The Early Universe
 - Probing inflation
 - Investigating Dark Energy
 - The observable Universe taking shape
3. The evolving violent Universe
 - Black holes and galaxy evolution
 - Matter under extreme conditions
 - Supernovae and the life cycle of matter

Strong connections with

- Solar System Working Group
 - * what are the conditions for formation and evolution of planetary systems ?
 - * what are the conditions for life ?
 - * which life forms ?
- Fundamental Physics Advisory Group
 - laws of physics under extreme conditions
 - possible imprints of the very early Universe
 - properties of Dark Energy

Theme 1: Other worlds and life in the Universe

Placing the Solar System into context

- **Formation of stars and planetary systems**
- **Detection, census and characterization of exo-planets**
- **Search for extraterrestrial life**

- Stars are forming: why ? how ? where ?
Planets are forming: why ? how ? where ? IR, mm, X-rays, UV, radio

- Exo-planets exist: learn more about them !
Detect and characterize (spectroscopy) all possible types of exo-planets
Find planets in the habitable zone
Make a census of terrestrial planets in the solar neighbourhood
Image exo-planets optical, IR, UV

- Find life outside the solar system. Detect biomarkers
What are the conditions for life ? IR, optical

Theme 2: The early Universe

- **Probing inflation**
- **Investigating Dark Energy**
- **The observable Universe taking shape**

- What happened in the early phases of the Universe ?
What are the imprints of the period of inflation ?
sub-mm to mm, CMB polarisation, gravitational waves

- Less than 5 % of the content of the Universe has been identified.
What makes up the remaining 95 % ? optical, IR, X-rays

- How did the very first stars form ?
How did the first structures take shape ?
How did the first super-massive black holes form ? IR, X-rays, UV

Theme 3: The evolving violent Universe

- Matter under extreme conditions
- Black holes and galaxy evolution
- Supernovae and the life cycle of matter
- Strong gravity, ultradense matter, accretion/ejection flows X-rays
- How and when did the first black holes form ?
How do they grow ? What happens when they merge ?
- What is the relation between galaxy and black hole evolution ?
X-rays, gravitational waves, IR, γ -rays
- What is the origin of γ -ray bursts ?
- What is the role of supernovae in the life cycle of matter ?
- Image a black hole X-rays, γ -rays, IR

From themes to the programme

The proposals illustrate different kinds of missions and underline the importance to have a balanced programme with

- big missions based on European leadership
 - major impact in their main scientific domain
 - wide range of scientific objectives serving a broad community
 - involve long term technology developments
- medium-sized missions
 - medium-term missions with more focussed scientific goals
- and missions of opportunity for flexibility
 - possibility to participate in missions led by other agencies