Cosmic Vision
Fundamental Physics in Space

- Introduction: B Schutz (AEI/FPAG)
- Beyond General Relativity, towards Quantum Gravity
  - Science Vision: T Damour (IHES)
  - Roadmap: M Sandford (RAL/FPAG)
- Beyond the Standard Model
  - Science Vision: W Schleich (Ulm)
  - Roadmap: W Ertmer (Hannover/FPAG)
- Gravitational Wave Universe
  - Science Vision: K Danzmann (AEI)
  - Roadmap: H Ward (Glasgow/FPAG)
- Summary: S Vitale (Trento)

Science Vision:
What are the issues, challenges, goals?

Roadmap:
Possible missions, based on input from community.

Mission ideas presented will require technological development. Some will be modest, some expensive. All are well-motivated and can only be viable if done in space.

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.

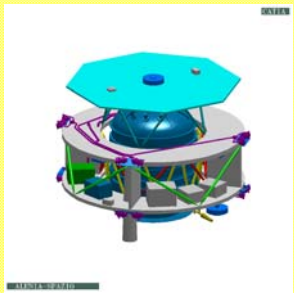
Reach of Fundamental Experiments: Lense-Thirring

- GP-B now measuring spin-spin gravitational coupling (aspect of *gravitomagnetic* field), more accurate measurements may be possible in future using cold atom technology.
- What do such experiments really measure? Isn't GR sound?
- GR value of L-T precession requires:
  1. Newtonian gravity
  2. Special relativity
  3. Post-Newtonian source of gravity:

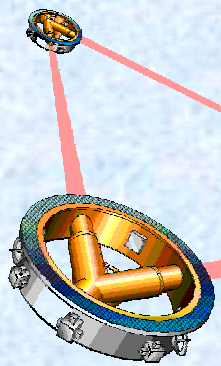
     active gravitational mass = $\rho + 3\,p/c^2$
- The source is key to inflation: the negative pressure p of dark energy makes $\rho + 3\,p/c^2$ negative, which drives the expansion.
- A failure of Lense-Thirring would undermine the foundations of inflation theory.

Them n Fundamental P ics

Equivalence principle ,
Pioneer anomaly,
weak-field tests of GR.
looking for the Planck scale:
fluctuations & decoherence



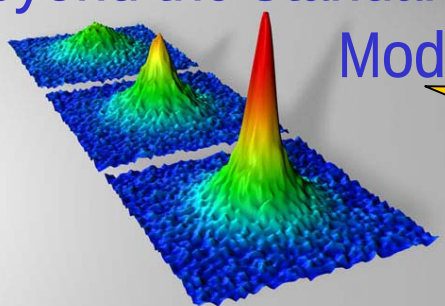
Beyond GR/Towards
Quantum Gravity



Observing the Big Bang, probing the high red shift Universe, exploring the dark Universe

The Gravitational Wave Universe

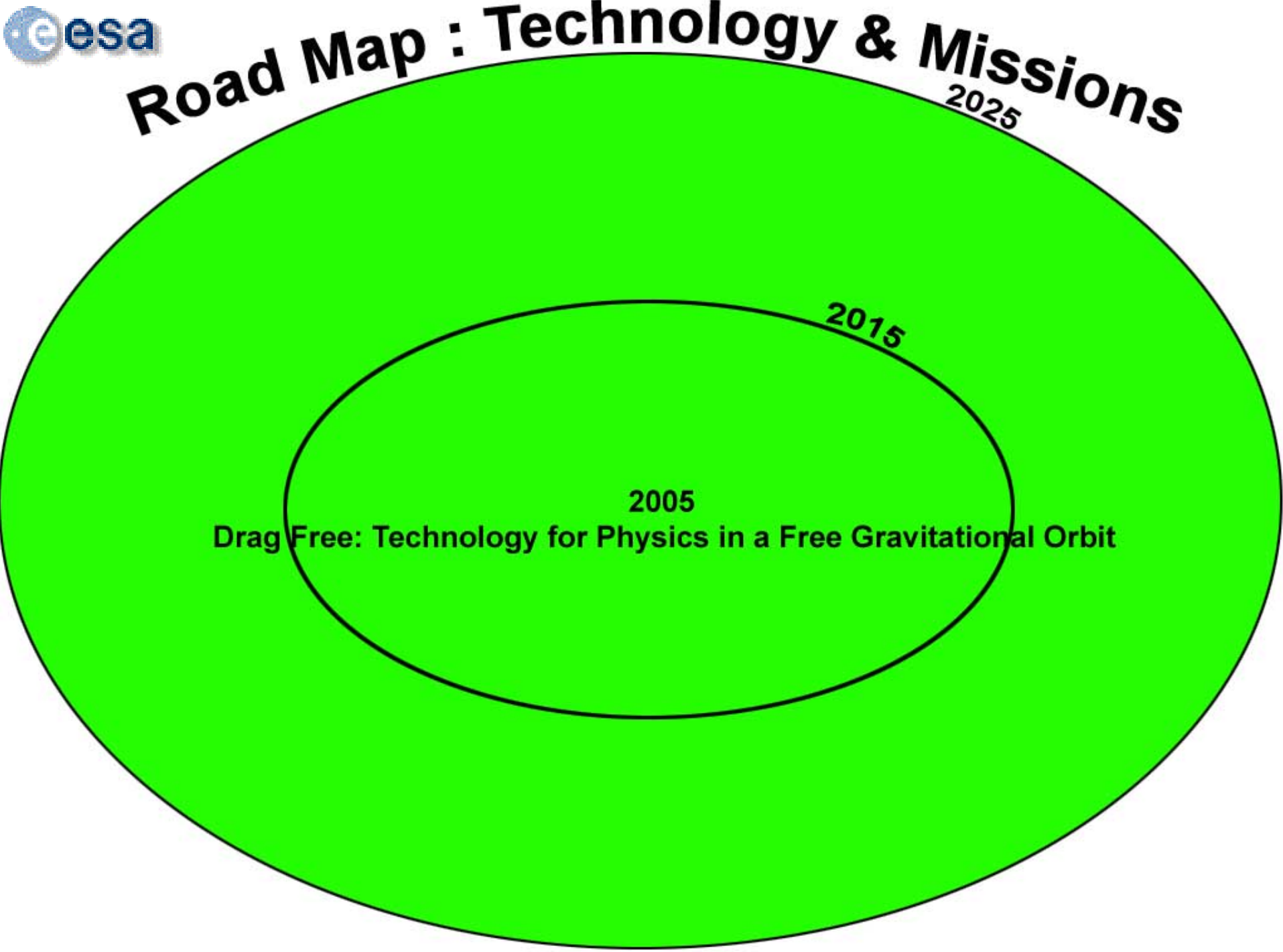
Beyond the Standard Model



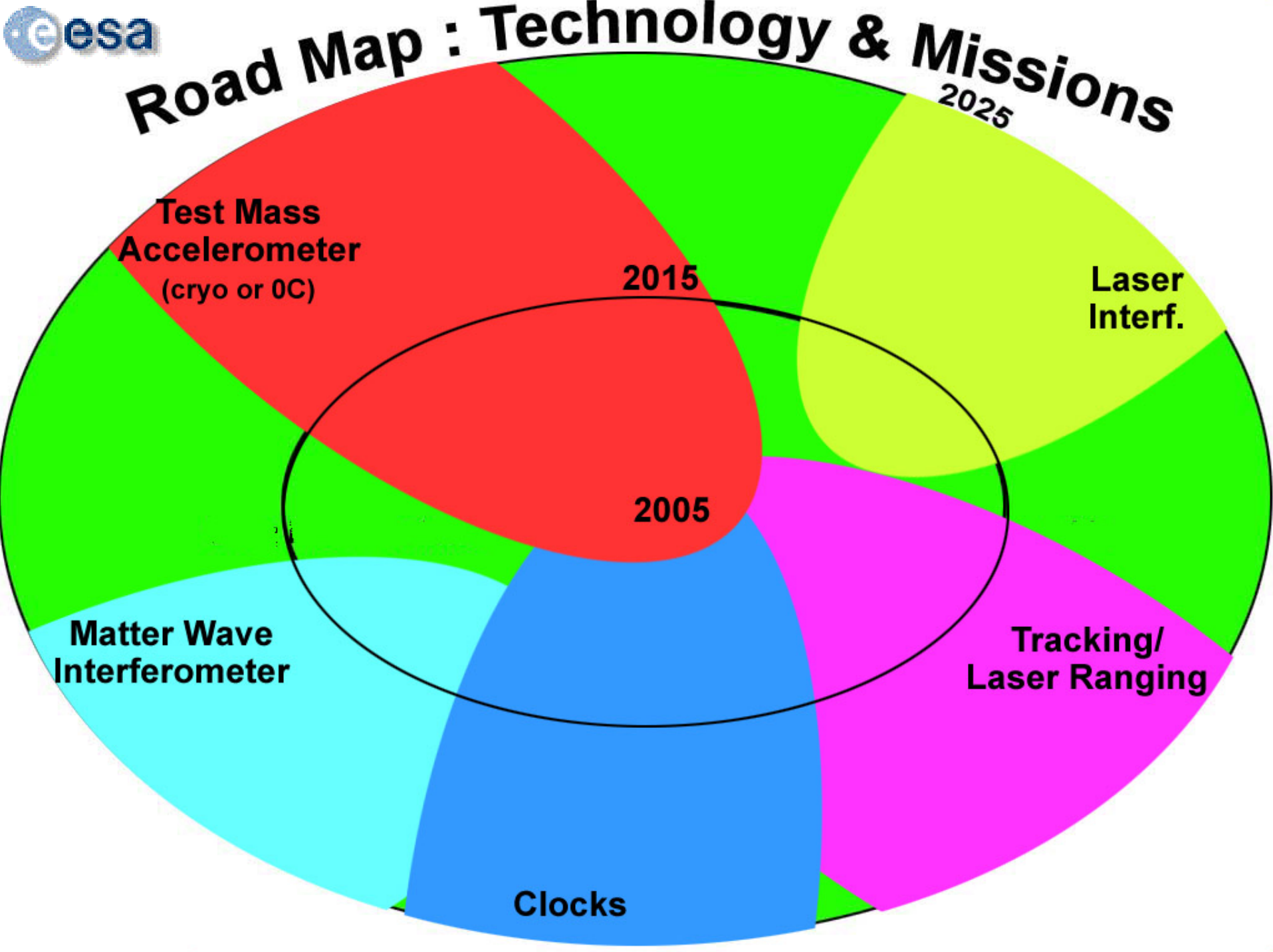
Symmetry violations (CPT, Lorentz, isotropy), variation of fundamental constants, short range forces, quantum physics including measurement theory and Bose-Einstein condensates, cosmic rays

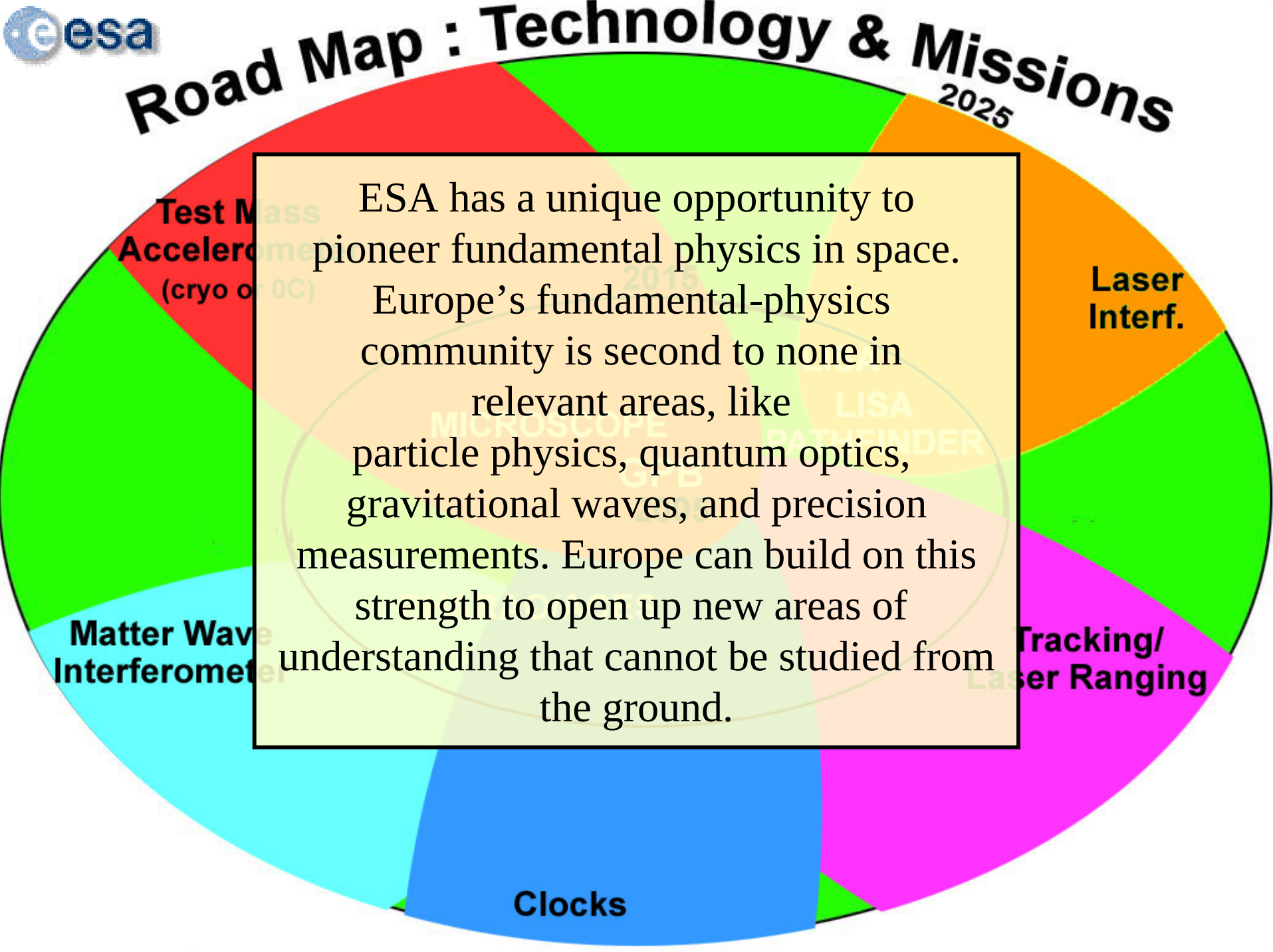
p. Fundamental Physics

Road Map : Technology & Missions



Road Map : Technology & Missions




Road Map : Technology & Missions
2025
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Tracking/
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Clocks
ESA has a unique opportunity to pioneer fundamental physics in space. Europe's fundamental-physics community is second to none in relevant areas, like particle physics, quantum optics, gravitational waves, and precision measurements. Europe can build on this strength to open up new areas of understanding that cannot be studied from the ground.

Road Map for Technology & Missions

2025

STEP 2

VISION 1

Pioneer Anomaly

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Drag Free: Technology for physics in free gravitational orbit

Measurement of Small Forces

2015

STEP

MICROSCOPE

BEC PATHFINDER

LISA PATHFINDER

PHARAO/ACES

LISA

Cold Atom/Atom Laser Interferometry

Clocks

COLD ATOM Missions

Ultra Stable Clock

LISA Medium Freq

Big Bang Observer

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	