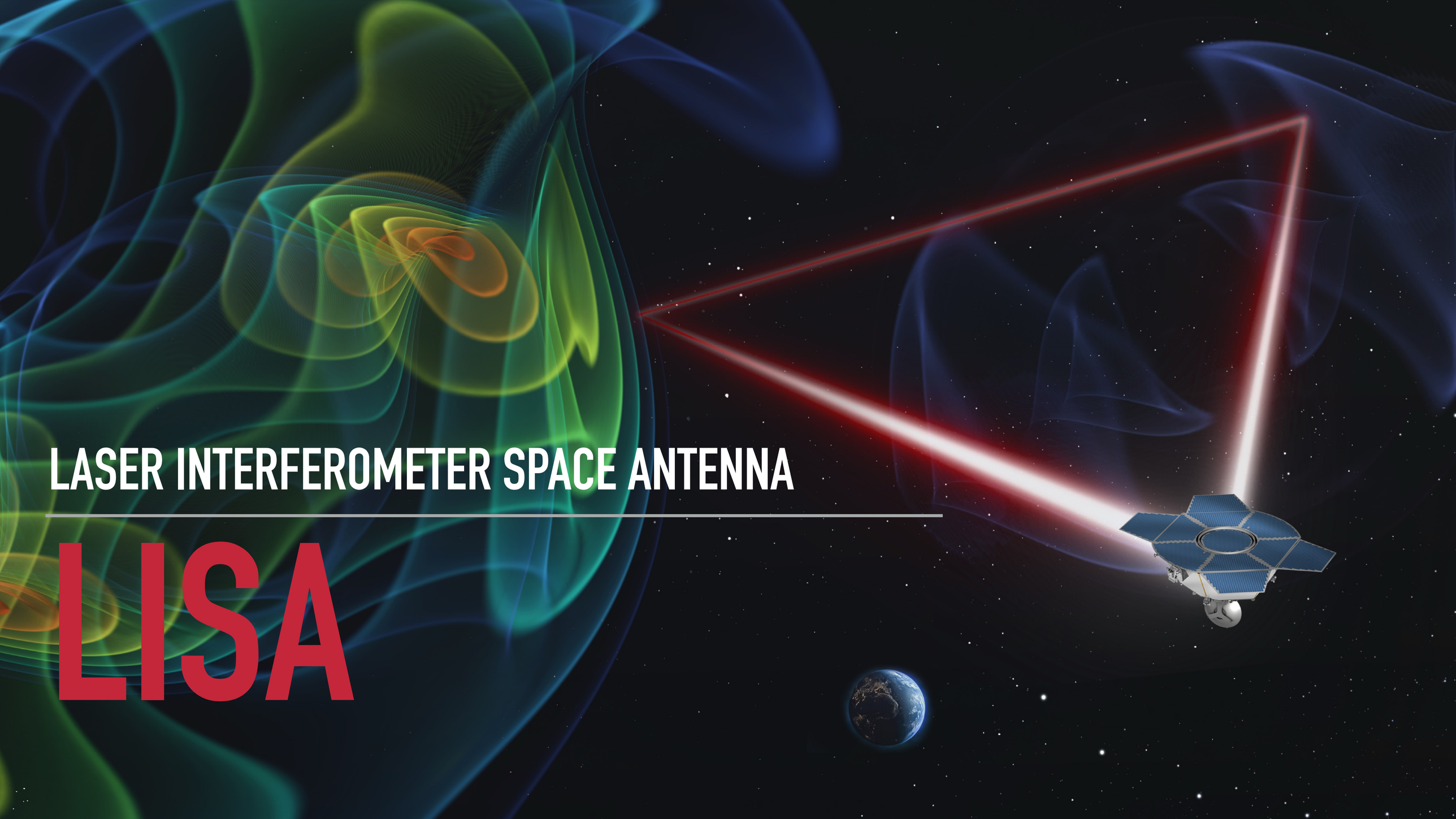
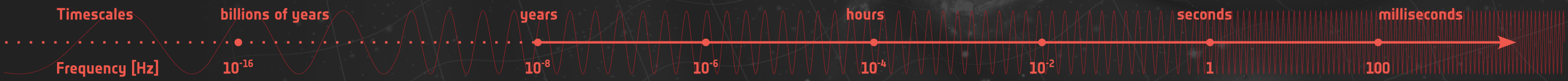
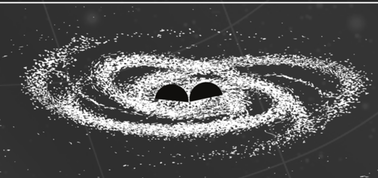

LASER INTERFEROMETER SPACE ANTENNA
LISA



THE SPECTRUM OF GRAVITATIONAL WAVES



Cosmic fluctuations in the early Universe



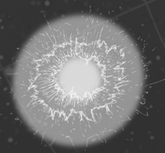
Merging supermassive black holes



Compact object and supermassive black hole systems



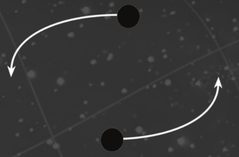
Pulsar



Supernova



Galactic Binaries



Merging stellar-mass black holes



Merging neutron stars

esa

WHY INTO SPACE?

Cosmic microwave background polarisation



Pulsar timing array



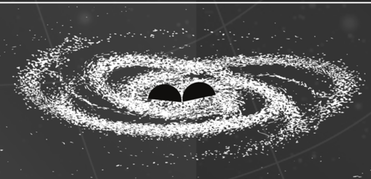
Ground-based experiments



Timescales: billions of years | years | hours | seconds | milliseconds

Frequency [Hz]: 10^{-16} | 10^{-8} | 10^{-6} | 10^{-4} | 10^{-2} | 1 | 100

Cosmic fluctuations in the early Universe



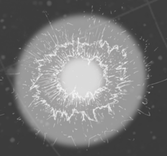
Merging supermassive black holes



Compact object and supermassive black hole systems



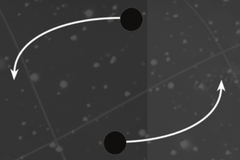
Pulsar



Supernova



Galactic Binaries



Merging stellar-mass black holes



Merging neutron stars

esa

WHY INTO SPACE?

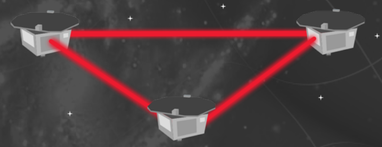
Cosmic microwave background polarisation



Pulsar timing array



Space-based observatory



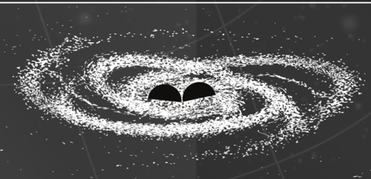
Ground-based experiments



Timescales — billions of years — years — hours — seconds — milliseconds

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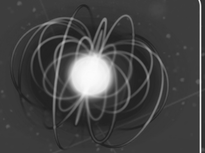
Cosmic fluctuations in the early Universe



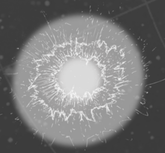
Merging supermassive black holes



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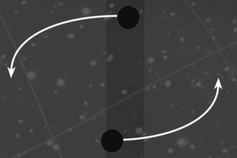
Pulsar



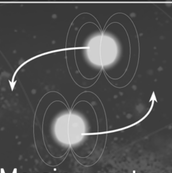
Supernova



Galactic Binaries



Merging stellar-mass black holes



Merging neutron stars

esa

THE WAY TO LISA

FIRST IDEAS TO MEASURE GW IN SPACE

BENDER

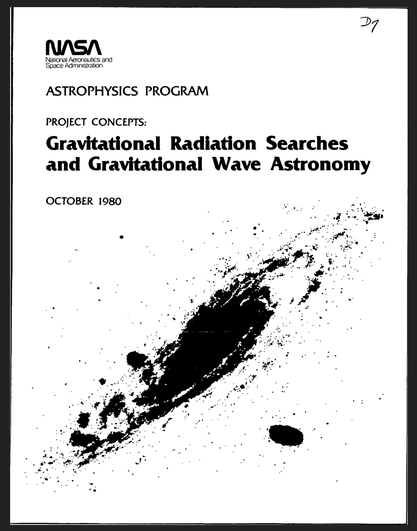
1974

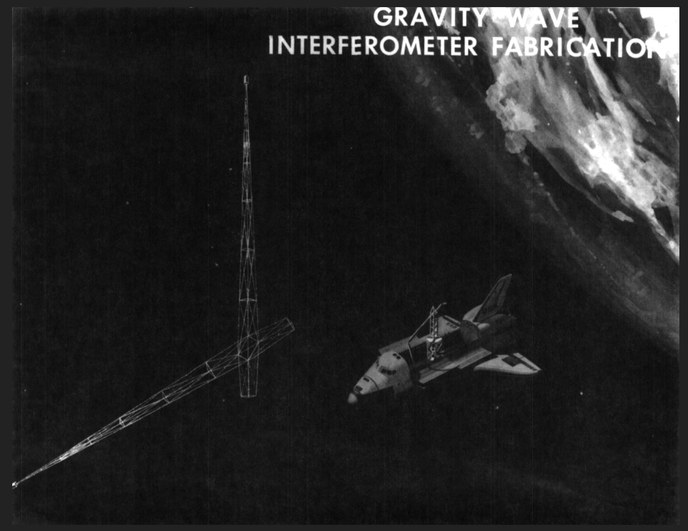




1980

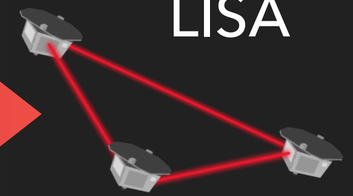
SOME COOL IDEAS...







LISA



THE WAY TO LISA

FIRST IDEAS TO MEASURE GW IN SPACE

BENDER

1974



LISA PROPOSED TO ESA AS M3 MISSION TO DETECT GWs AND OBSERVE THE UNIVERSE

DANZMANN ET AL.

1993

LISA PROPOSED TO ESA AS FLAGSHIP L3 MISSION

LISA CONSORTIUM

2017



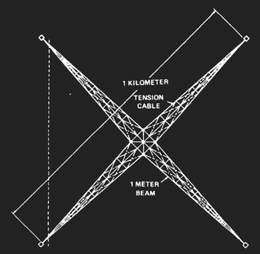
LISA

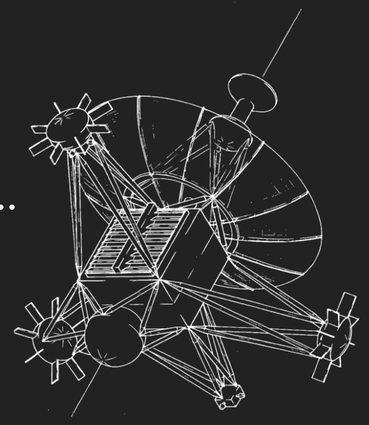


1980

SOME COOL IDEAS...



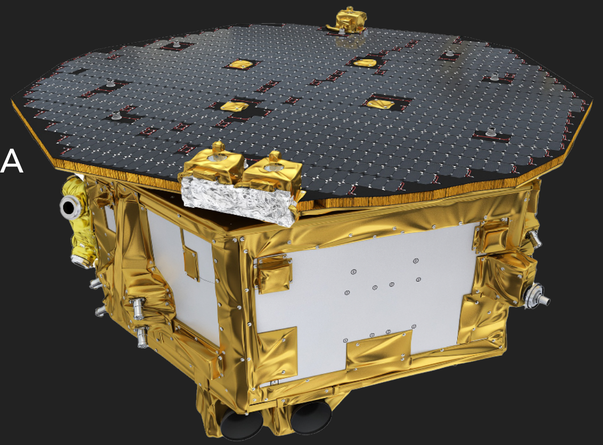




2015

LAUNCH OF LISA PATHFINDER

VITALE ET AL.



2024

LISA ADOPTION

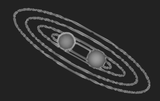
COLPI ET AL.



Redbook: https://www.cosmos.esa.int/web/lisa/lisa-redbook

LISA SCIENCE OBJECTIVES

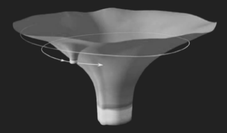
1. Galactic Binaries



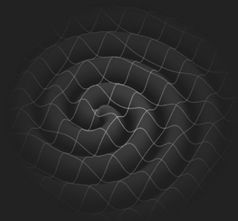
2. Massive Black Holes



3. Extreme and Intermediate mass-ratio Inspirals



4. Stellar Mass Black Holes



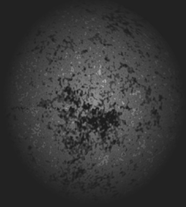
5. Fundamental nature of gravity



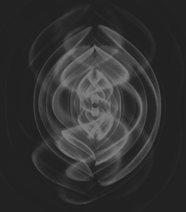
6. Expansion of the Universe



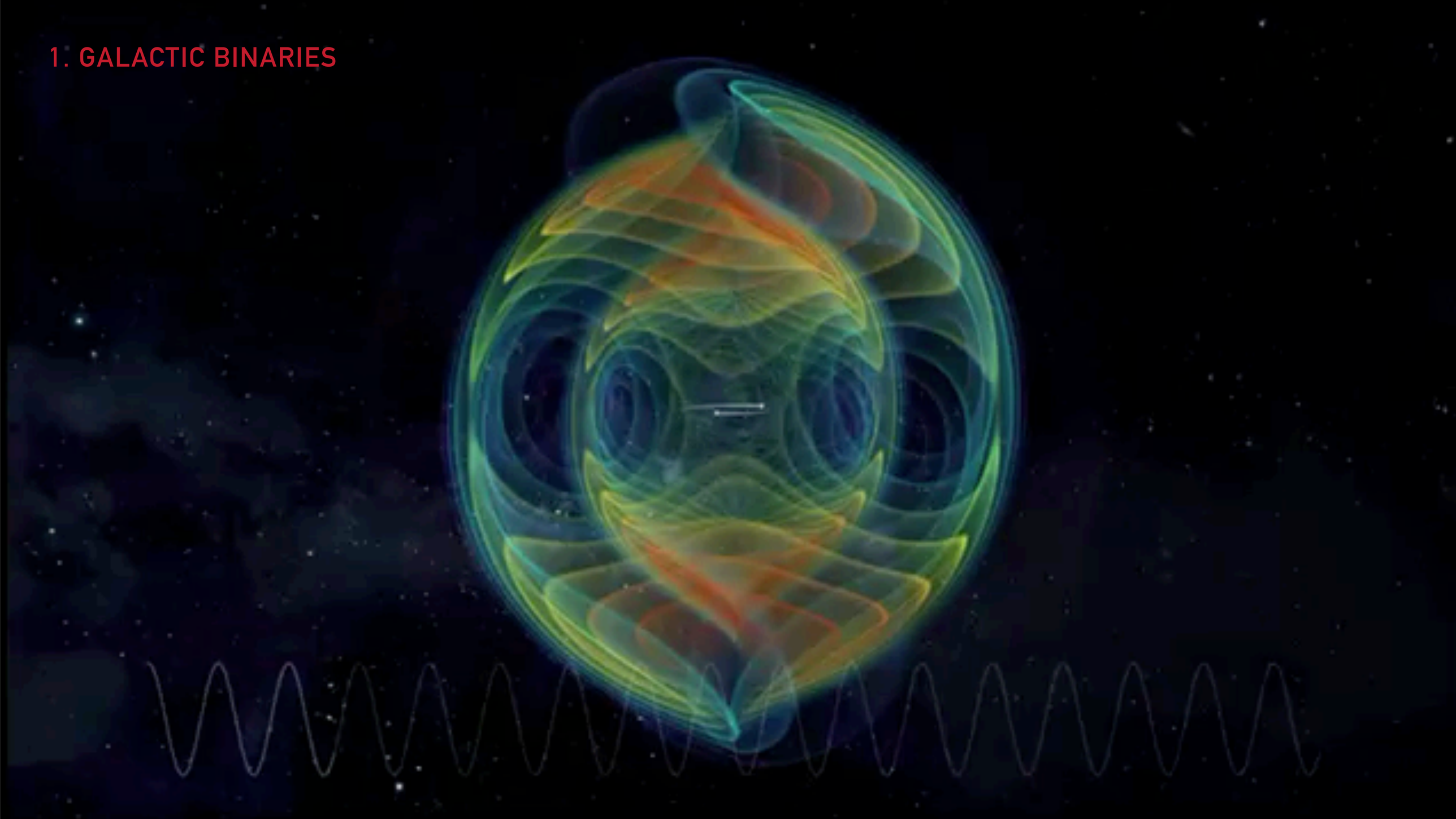
7. Stochastic gravitational wave backgrounds



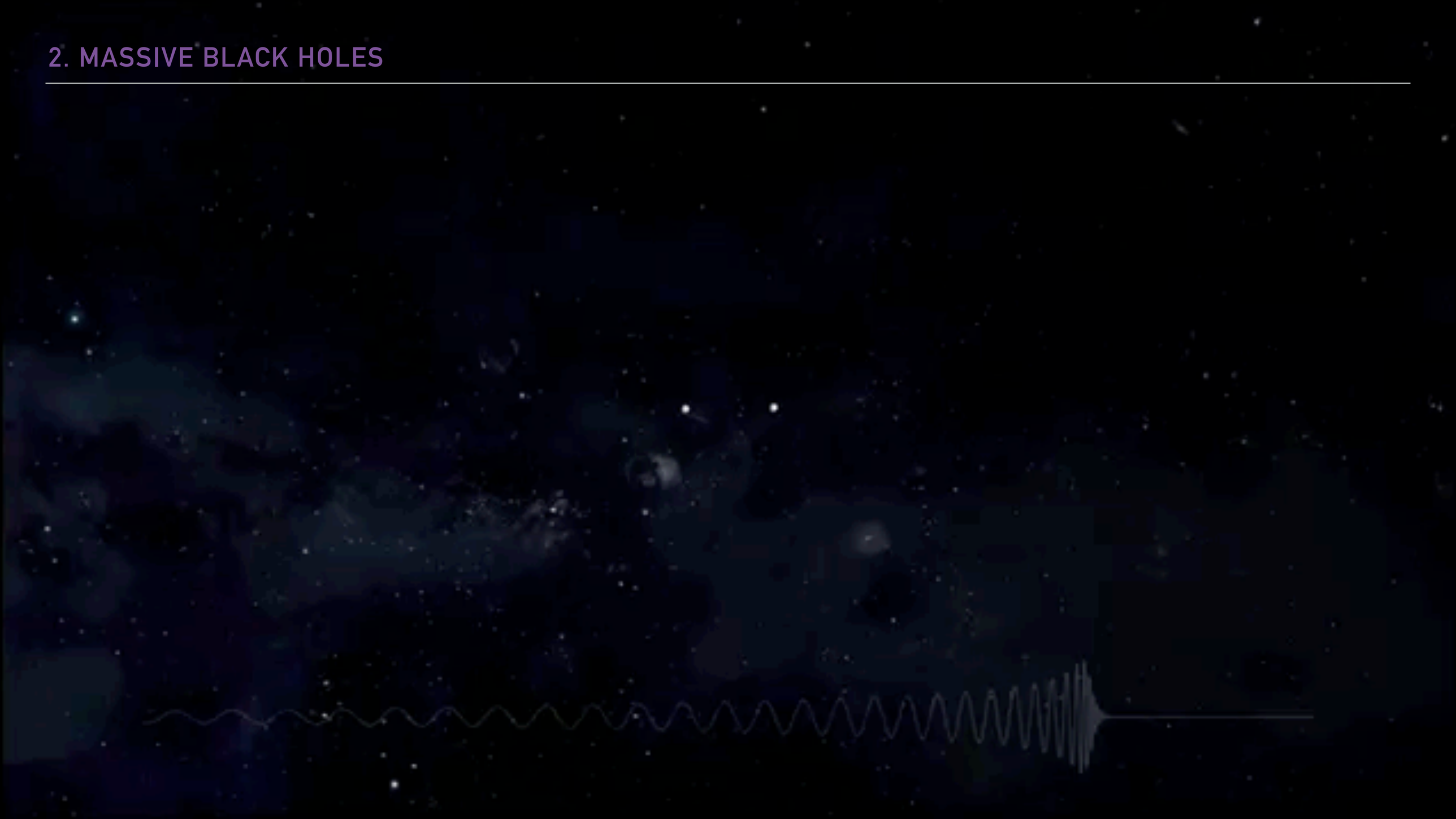
8. Unforeseen sources



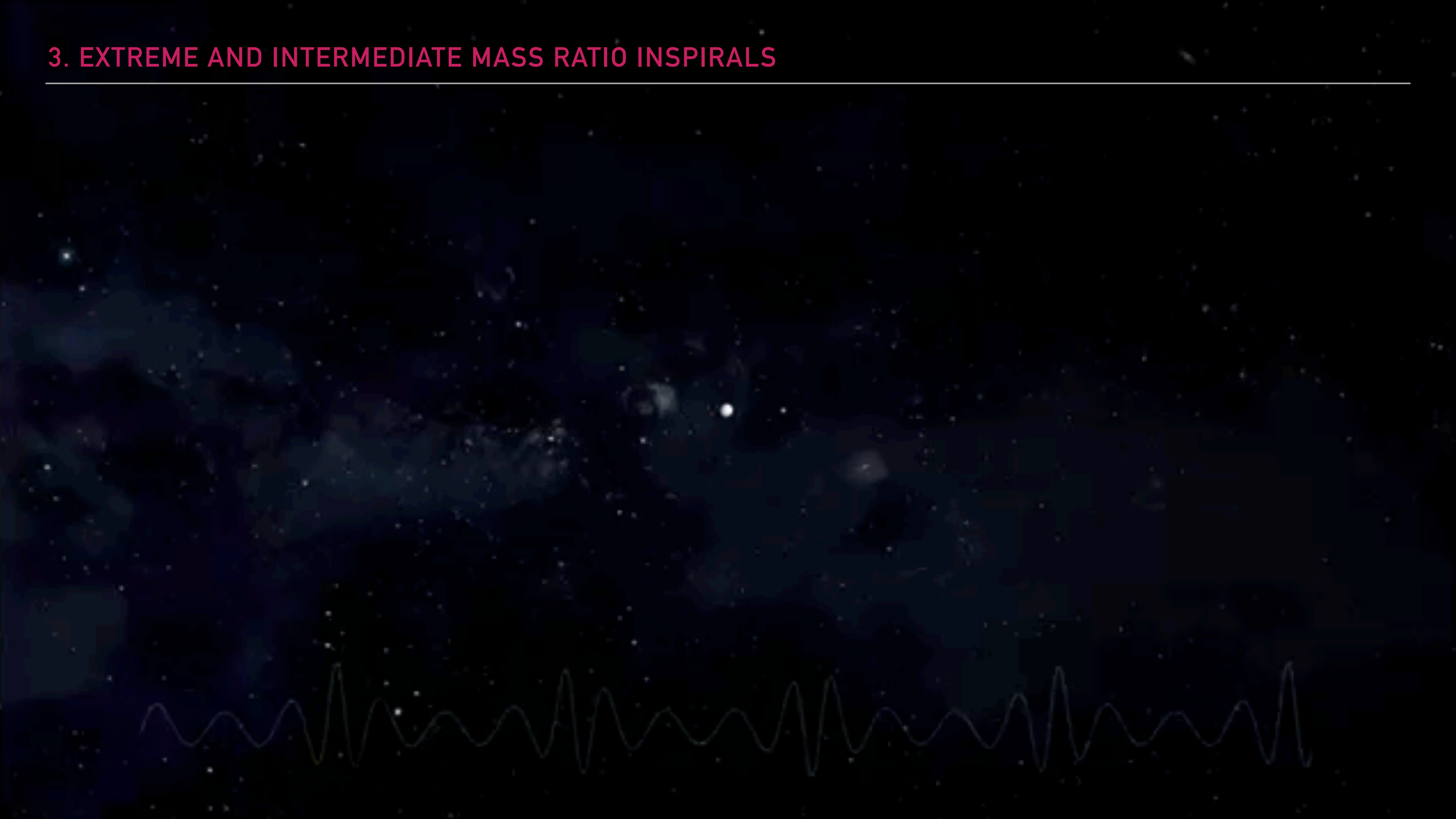
1. GALACTIC BINARIES



2. MASSIVE BLACK HOLES



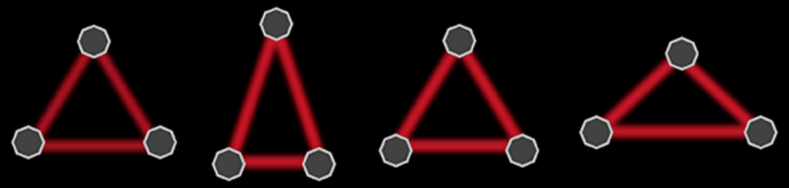
3. EXTREME AND INTERMEDIATE MASS RATIO INSPIRALS



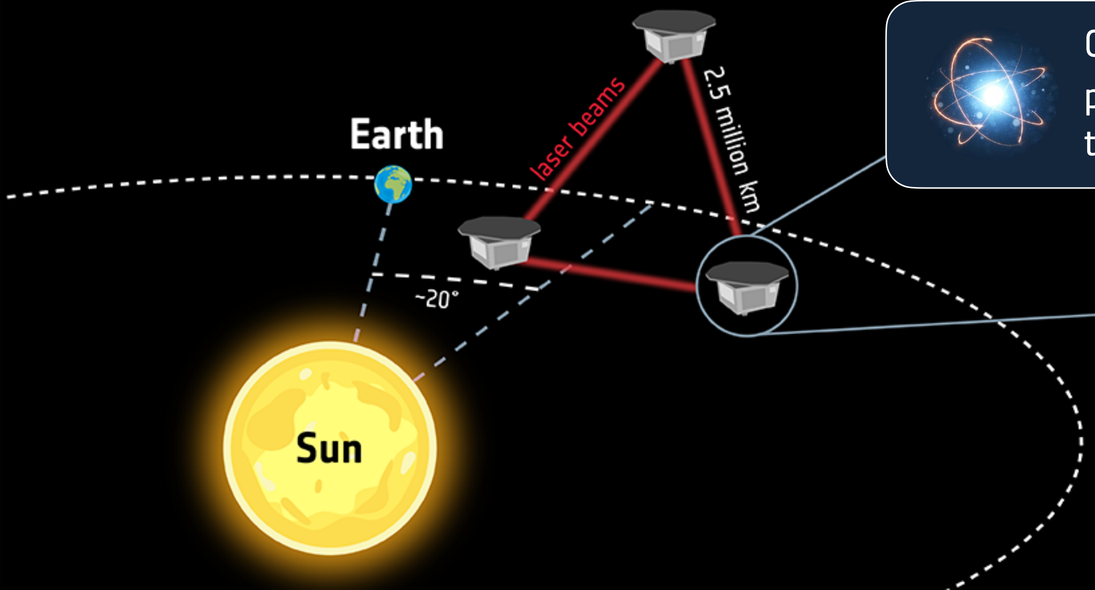
LISA - LASER INTERFEROMETER SPACE ANTENNA

Gravitational waves are ripples in spacetime that alter the distances between objects. LISA will detect them by measuring subtle changes in the distances between **free-floating cubes** nestled within its three spacecraft.

3 identical spacecraft exchange **laser beams**. Gravitational waves change the distance between the **free-floating cubes** in the different spacecraft. This tiny change will be measured by the laser beams.

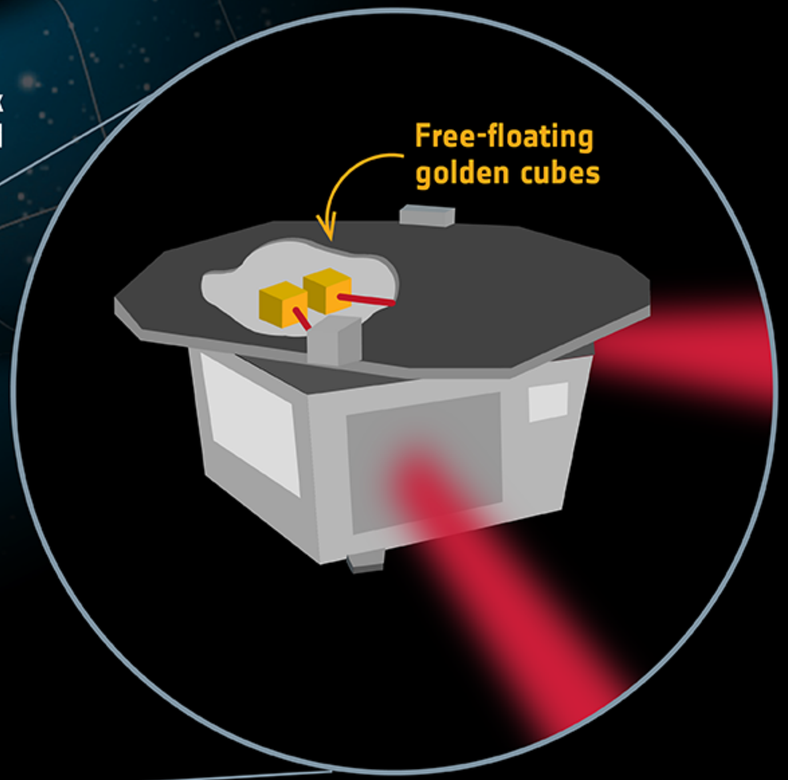


* *Changes in distances travelled by the laser beams are not to scale and extremely exaggerated*



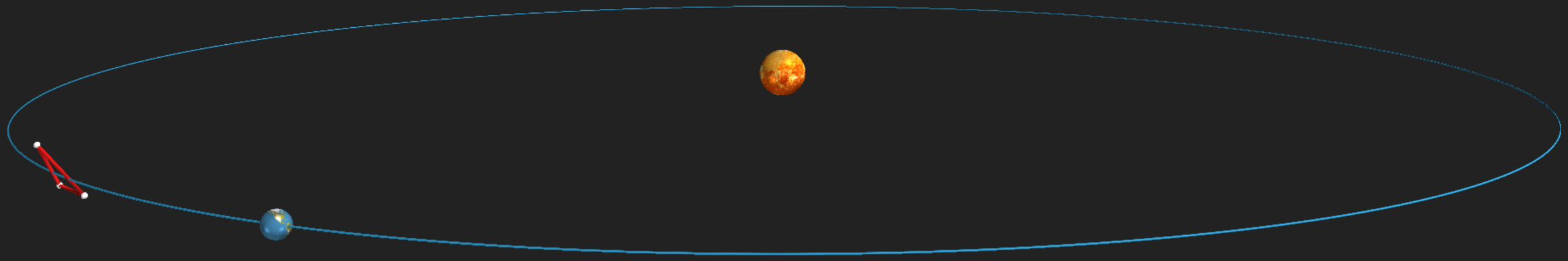
Changes in distance of the order of picometres (10^{-12}) — about the size of the **core of an atom**!

Powerful events such as **colliding black holes** shake the fabric of spacetime and cause gravitational waves



ESA | NASA
lisa

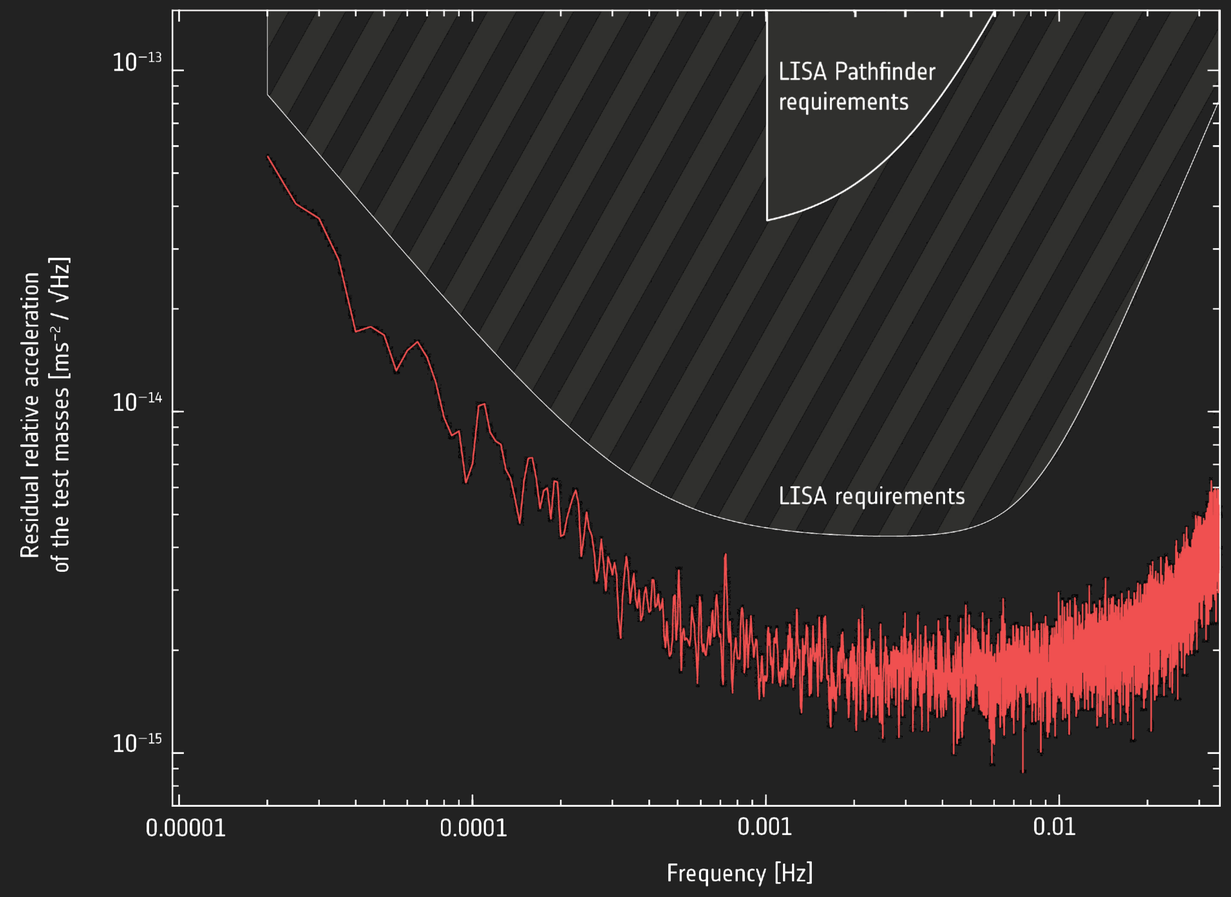
LISA MISSION CONCEPT

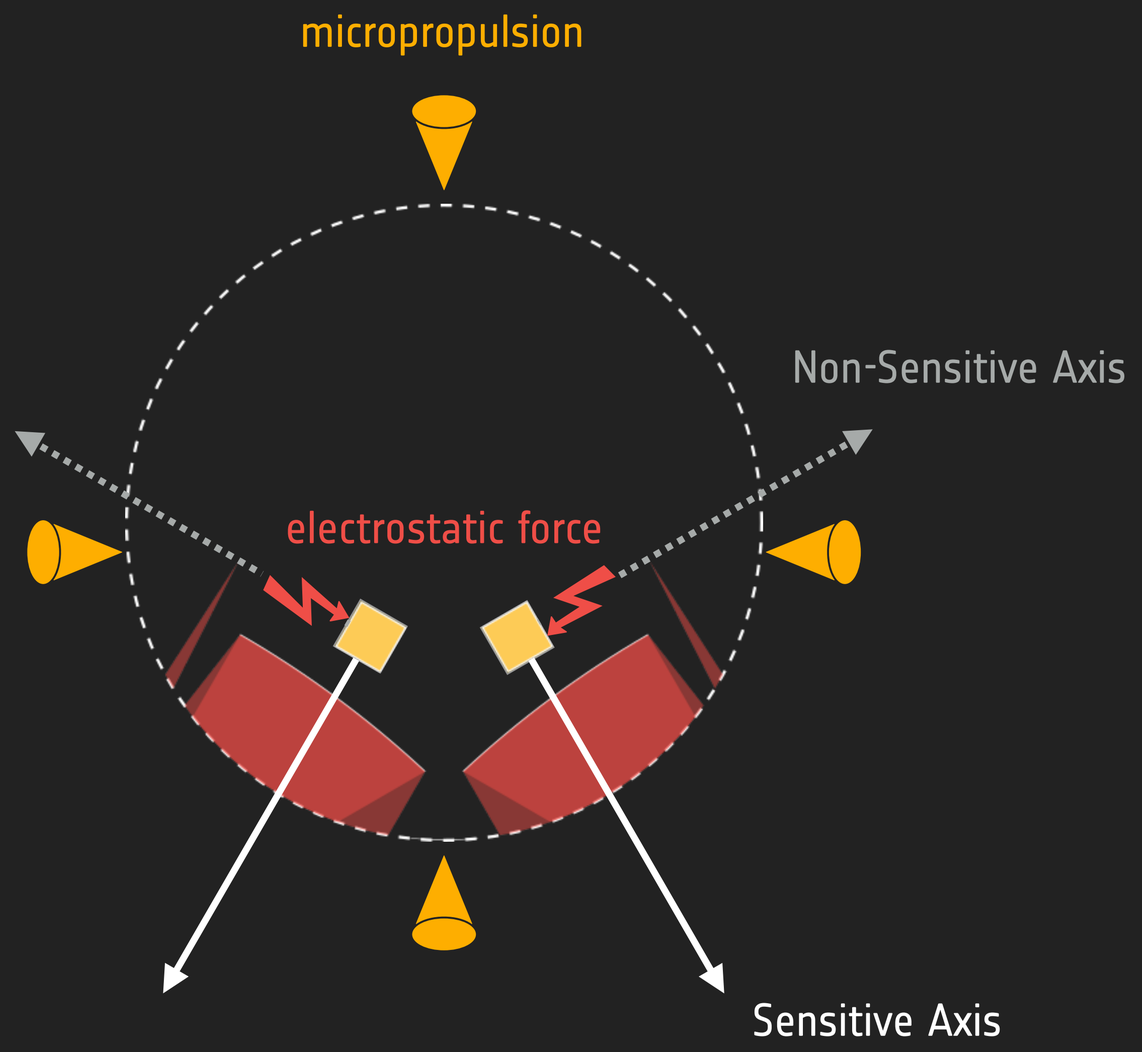


esa

FREE-FALLING TEST MASSES

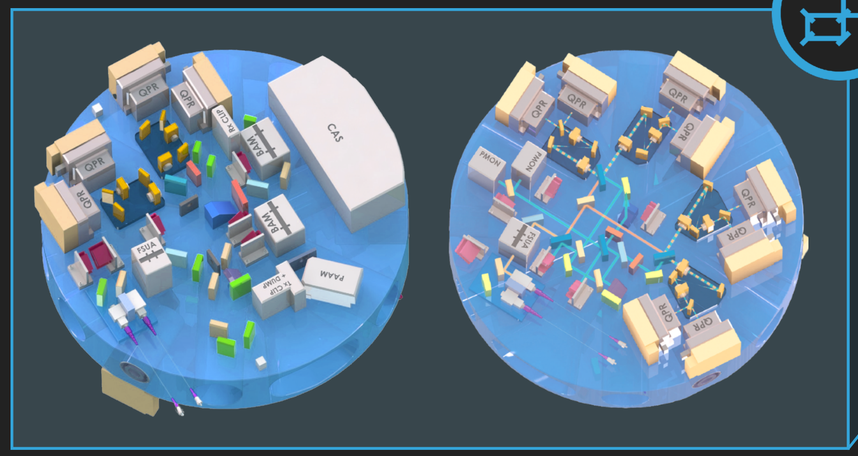
Drag-Free Attitude Control System (DFACS)



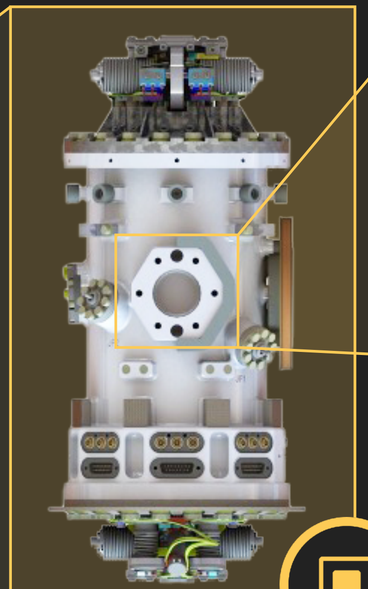


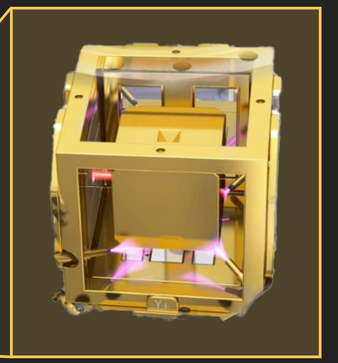
esa





Interferometers

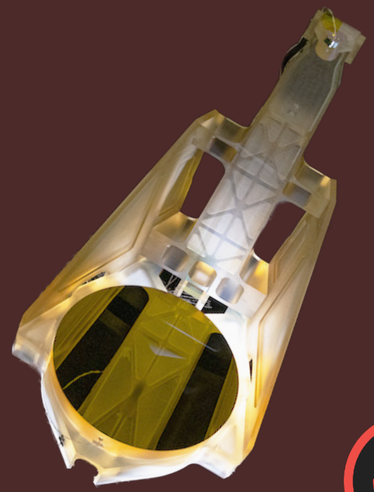




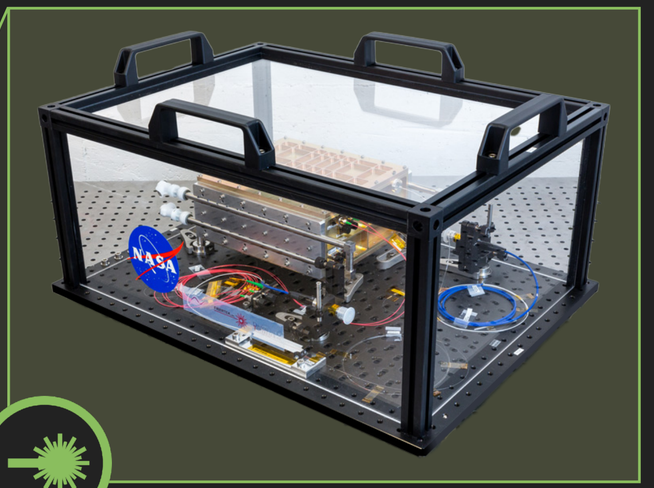
Test Masses

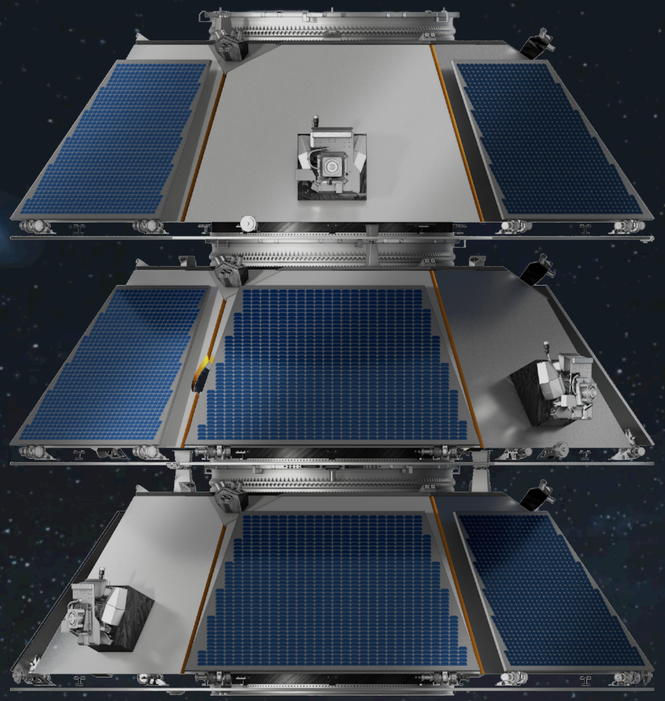
Gravitational Reference System (GRS)

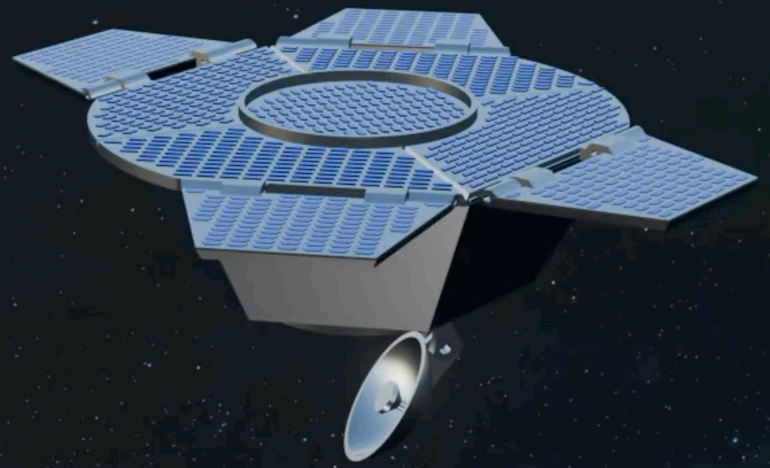
Telescope



Laser

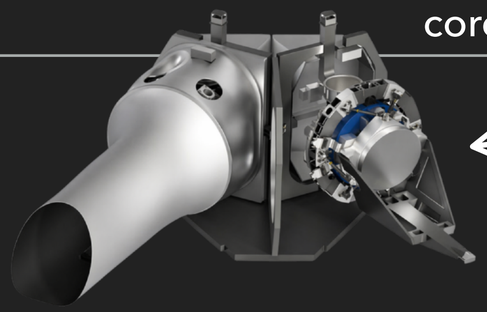


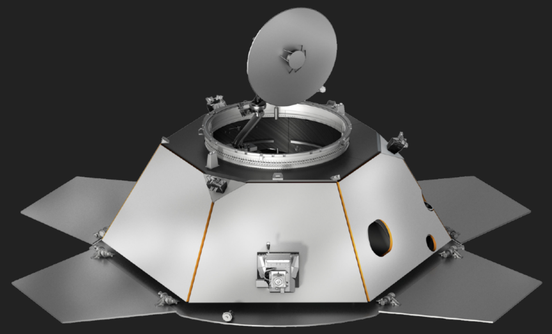




TIMELINE

Building and testing the interface verification model of the LISA core assembly





We are here

Adoption
2024

Payload
PDRs

Mission **P**reliminary
Design **R**eview
2027

Payload
Delivery

Here we build it!

Flight
Acceptance
Review
2035



B1 | B2 | C | D | E1

Preliminary Definition

Detailed Definition

Qualification & Production

Invitation to
Tender

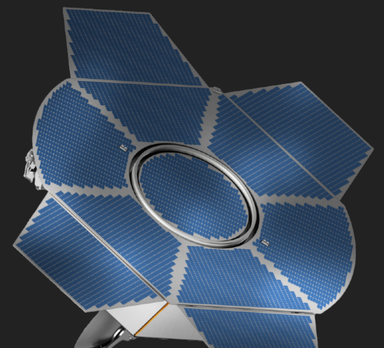
2025
Prime
Contractor
Kickoff

Payload CDRs

2031
Mission **C**ritical
Design **R**eview

S/C
Delivery

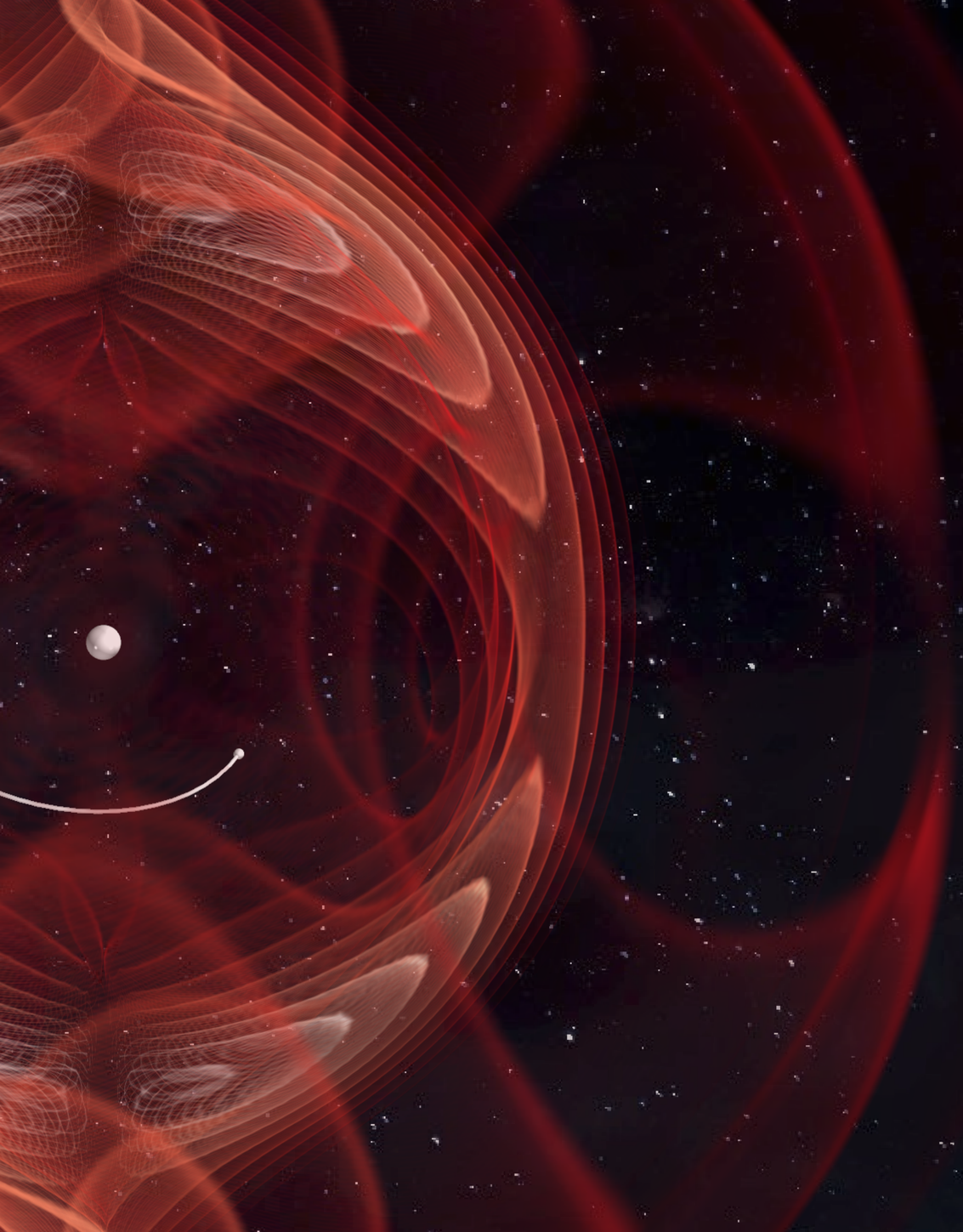
Launch
AUG 2035



OHB

esa


Thank You!



LISA

BACKUP

THE LISA SCIENCE TEAM 2024-2027



THE CHAIRS:
Nora Lützgendorf (ESA)
Oliver Jennrich (ESA)
Ira Thorpe (NASA)
Ann Hornschemeier (NASA)

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Anna Heffernan
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Valeriya Korol
SRON, NL



Alberto Sesana
University of Milano Bicocca, IT



Joey Shapiro Key
UW Bothell, US



Zoltán Haiman (Complementary)
ISTA, AT



Astrid Lamberts
Observatoire de la Côte d'Azur, FR



Alberto Vecchio
University of Birmingham, UK



Erin Kara
MIT, US



Jonathan Gair (Consortium Rep.)
AEI Potsdam, DE



Galactic Binaries
EMRIs
Fundamental Physics
Stochastic Backgrounds
Multiband GWs
Waveforms
Interferometry
Massive Black Holes
Stellar Mass BHs
Expansion of the Universe
Multimessenger
Data Analysis
Cosmic Ray Physics
Free-falling Test Masses

MAJOR REVIEWS

PAYLOAD | MISSION | GROUND SEGMENT

SYSTEM REQUIREMENTS REVIEW

Are the objectives and requirements clearly defined, complete (flown down), and realistic?

Design

PRELIMINARY DESIGN REVIEW

Is the proposed design consistent, mature, and able to meet the mission requirements?

Prototype

CRITICAL DESIGN REVIEW

Is the design finished and ready to be built and tested?

Flightmodel

FLIGHT ACCEPTANCE REVIEW

Are we ready to launch?

RECENT PROGRESS

SPACECRAFT

- Build-up of spacecraft industrial consortium **progresses nominal**

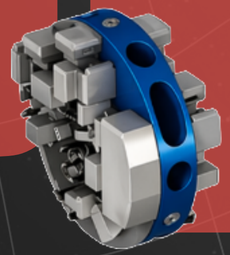
➡ See talk by JuanPa



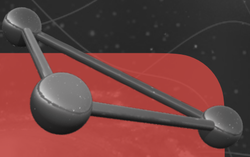
PAYLOAD



- **Gravitational Reference System PDR** completed 23 April
- **Interferometric Detection System PDR** delta review June/July
  - Significant reorganisation ongoing (see next slides)
- **Optical Bench Assembly**
  - **PDR** review cycle of hosted units initiated
  - Responsibility tranfer from UKSA to ESA in September



ESA



- **Mission PDR**
  - Analysis loop started, kick-off in November
- **Ground Segment SRR**
  - Planned for Q1-2027
- New baselane for **Optical Assembly Tracking Meachnism** (OATM)
  - ➡ See next slide

esa

DEVELOPMENTS

New Optical Assembly Tracking Mechanism (OATM) Baseline

OATM stability/jitter directly impacts the performance of the wave-front sensing

Problem

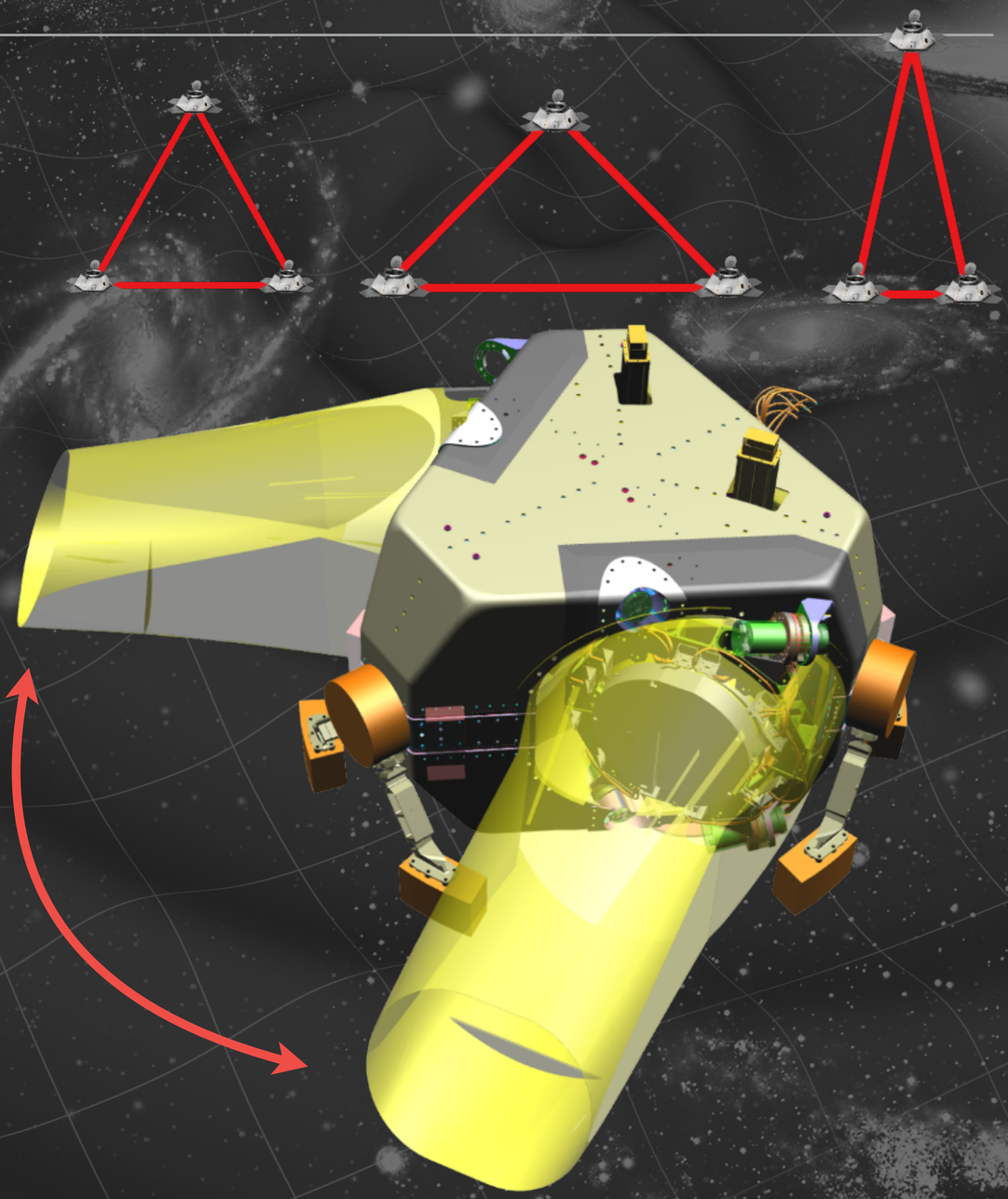
- Two actuators were unstable and drifted → low-frequency performance at risk.

Fix

- Use only one actuator; keep the other fixed.
- Use spacecraft rotation for larger adjustments.

Result

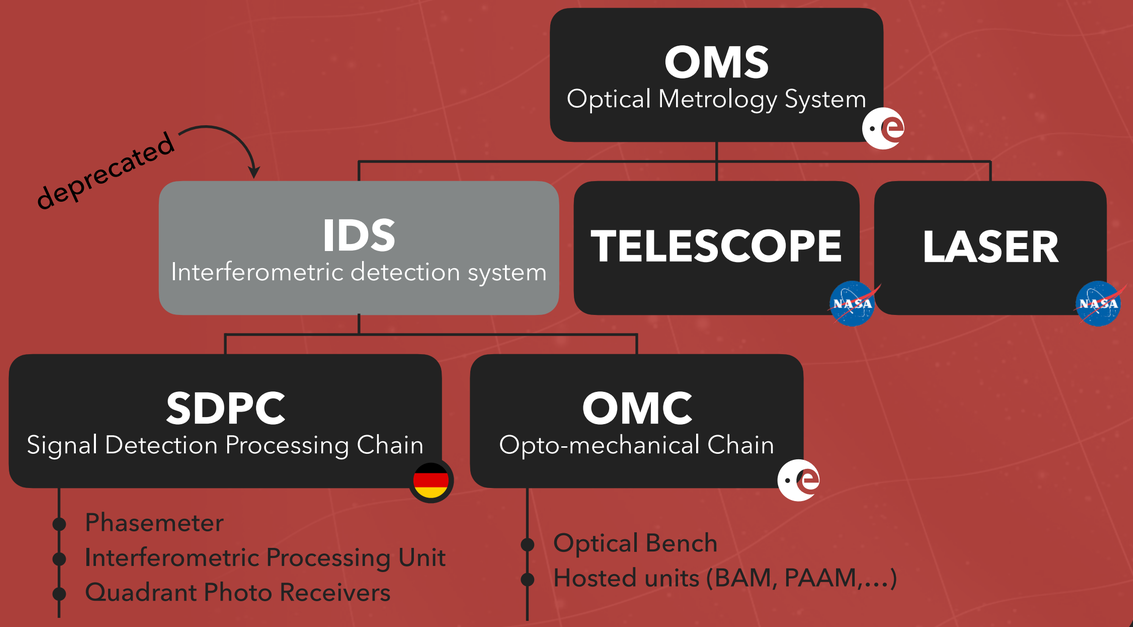
- Simpler and more robust; meets performance (especially low frequency).



DEVELOPMENTS

IDS RESTRUCTURING

- To align to changes in responsibilites , expertise and verification



NASA MITIGATION ACTIVITIES

- **Telescope**
  - Phased contract signed with TAS (FR)
  - **SRR** June, first breadboard Q3-2026
- **Laser System**
  - Phased contract signed with STI (DE)
  - EM under TVAC testing for early performance verification
- **Charge Management Device**
  - Kicked-off by TAS (CH)

➡ **All European elements comply with the project need dates for a launch in summer 2035**

MAJOR REVIEWS

PAYLOAD | MISSION | GROUND SEGMENT

SYSTEM REQUIREMENTS REVIEW

Are the objectives and requirements clearly defined, complete (flown down), and realistic?

Design

PRELIMINARY DESIGN REVIEW

Is the proposed design consistent, mature, and able to meet the mission requirements?

Prototype

CRITICAL DESIGN REVIEW

Is the design finished and ready to be built and tested?

Flightmodel

FLIGHT ACCEPTANCE REVIEW

Are we ready to launch?

MISSION TIMELINE

SRR CDR
PDR FAR

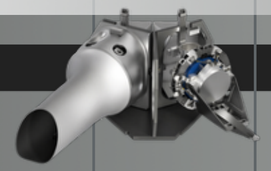
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

PAYLOAD

GRS HOSTED UNITS

SDS BAM PAAM PCU IPU

INTERFACE VERIFICATION MODEL (IFVM) OF THE LISA CORE ASSEMBLY



MISSION

MISSION PDR

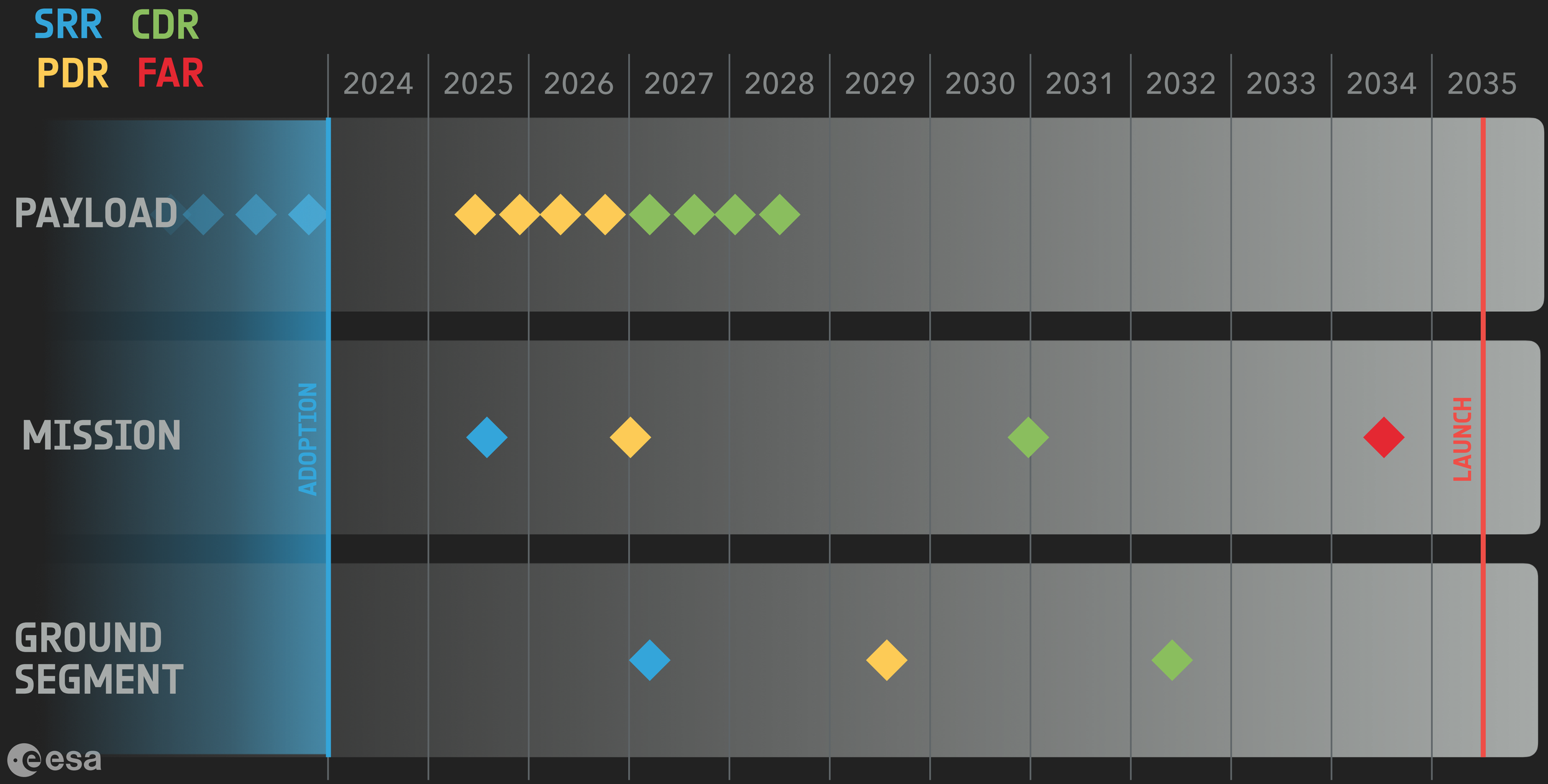
GROUND SEGMENT

DDPC iRR

PM#2 PM#3

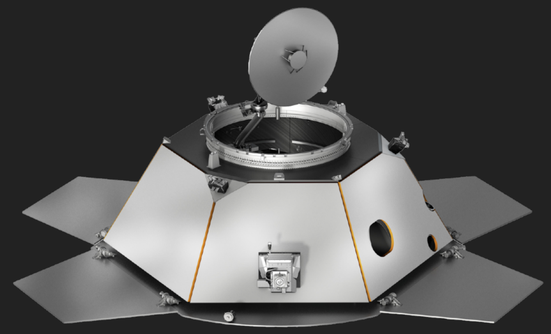
esa

MISSION TIMELINE



esa

TIMELINE



We are here

Adoption
2024

Payload
PDRs

Mission **P**reliminary
Design **R**eview
2027

Payload
Delivery

Here we
build it!

Flight
Acceptance
Review
2034

B1 | B2 | C | D | E1

Preliminary Definition

Detailed Definition

Qualification & Production

Invitation to
Tender

2025
Prime
Contractor
Kickoff

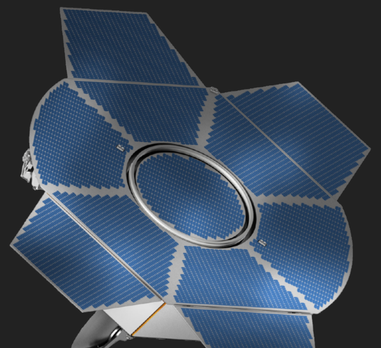
Payload CDRs

S/C
Delivery

2031
Mission **C**ritical
Design **R**eview

Launch
AUG 2035





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OHB