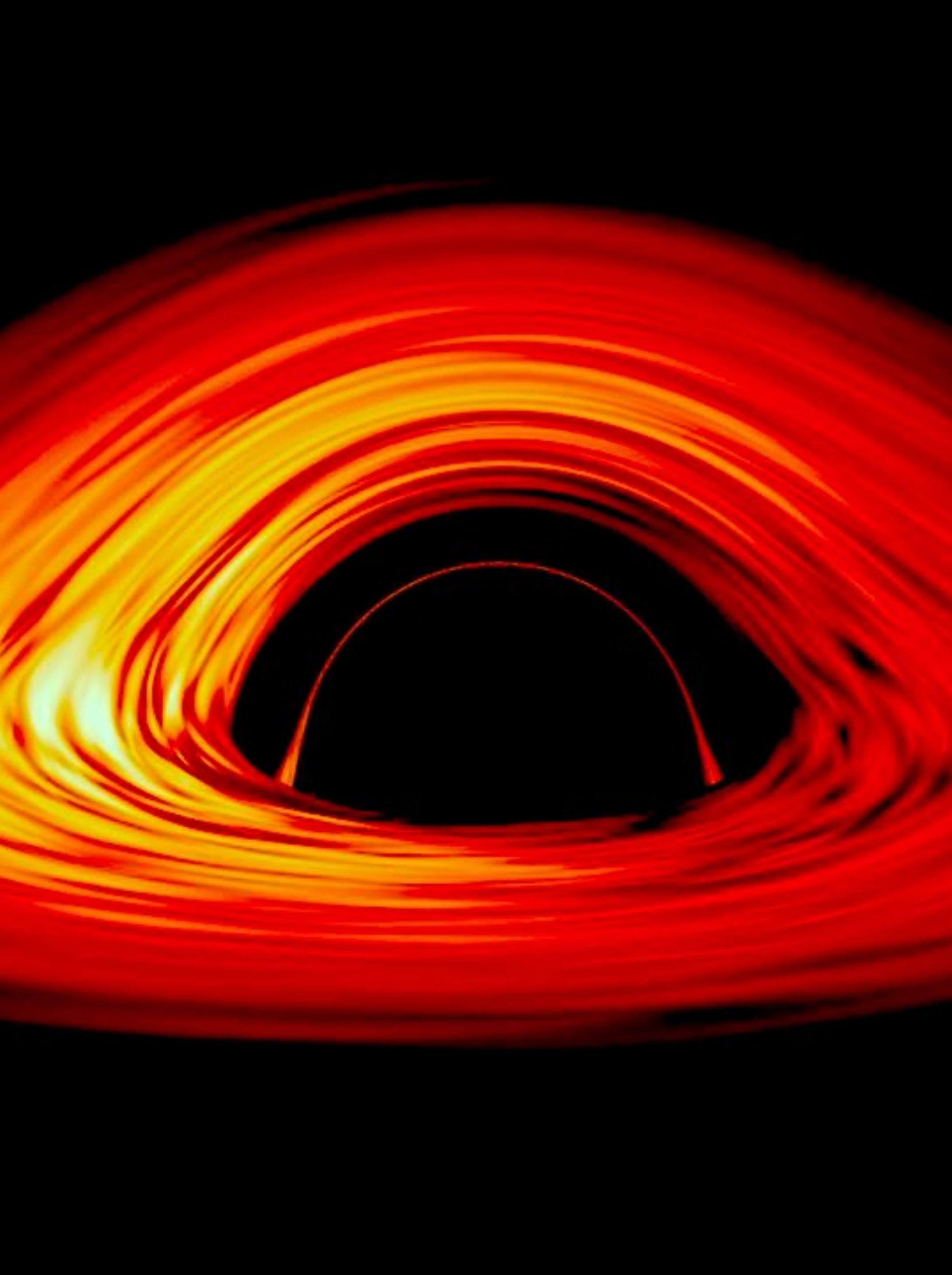




LISA

Anna Heffernan

14th Iberian Gravitational Wave Meeting

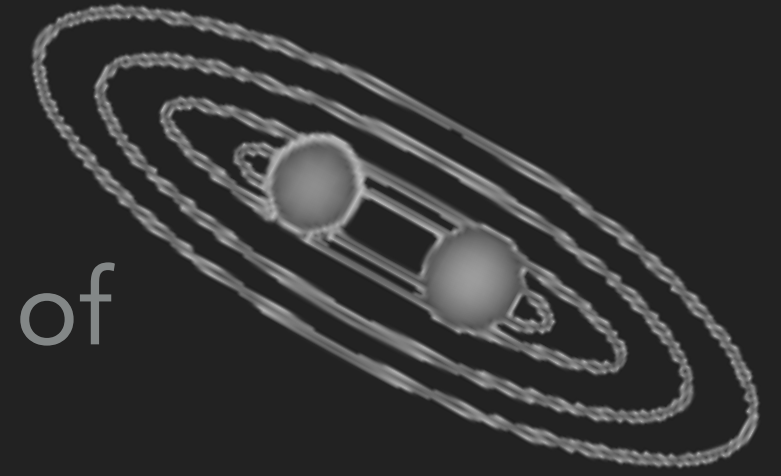


LISA

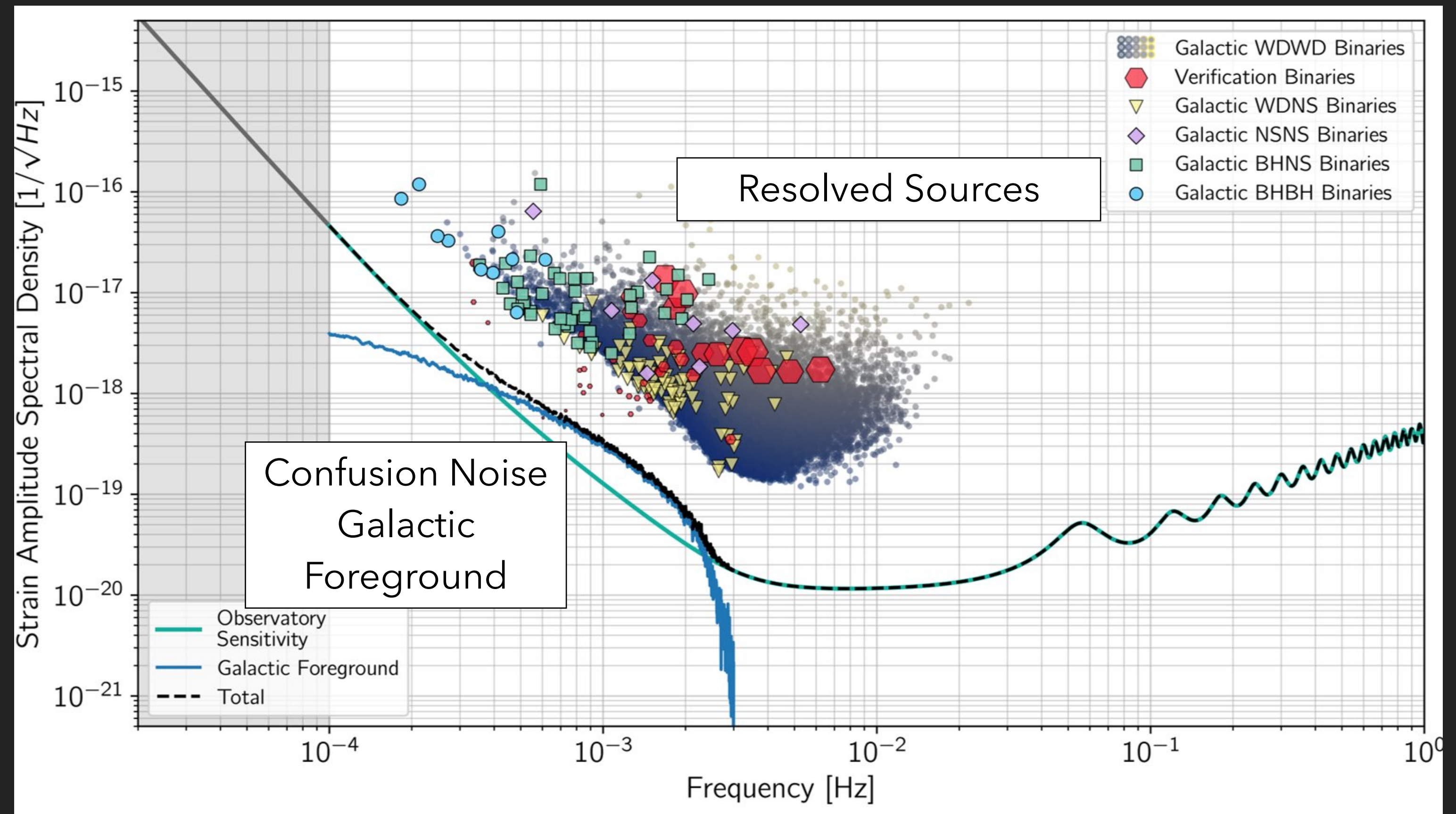
SCIENCE

LISA SCIENCE OBJECTIVES

OBJ1: Study the formation and evolution of **compact binary stars** and the structure of the Milky Way Galaxy



- 10^4 detectable binaries
- 10^7 form foreground
- Undetectable from EM
- Continuous signals
- Mostly white dwarfs but
~100 with NS or BH
- Formation / evolution via
kicks and common
envelope
- Galaxy mass distribution
- Mass transfer and tides

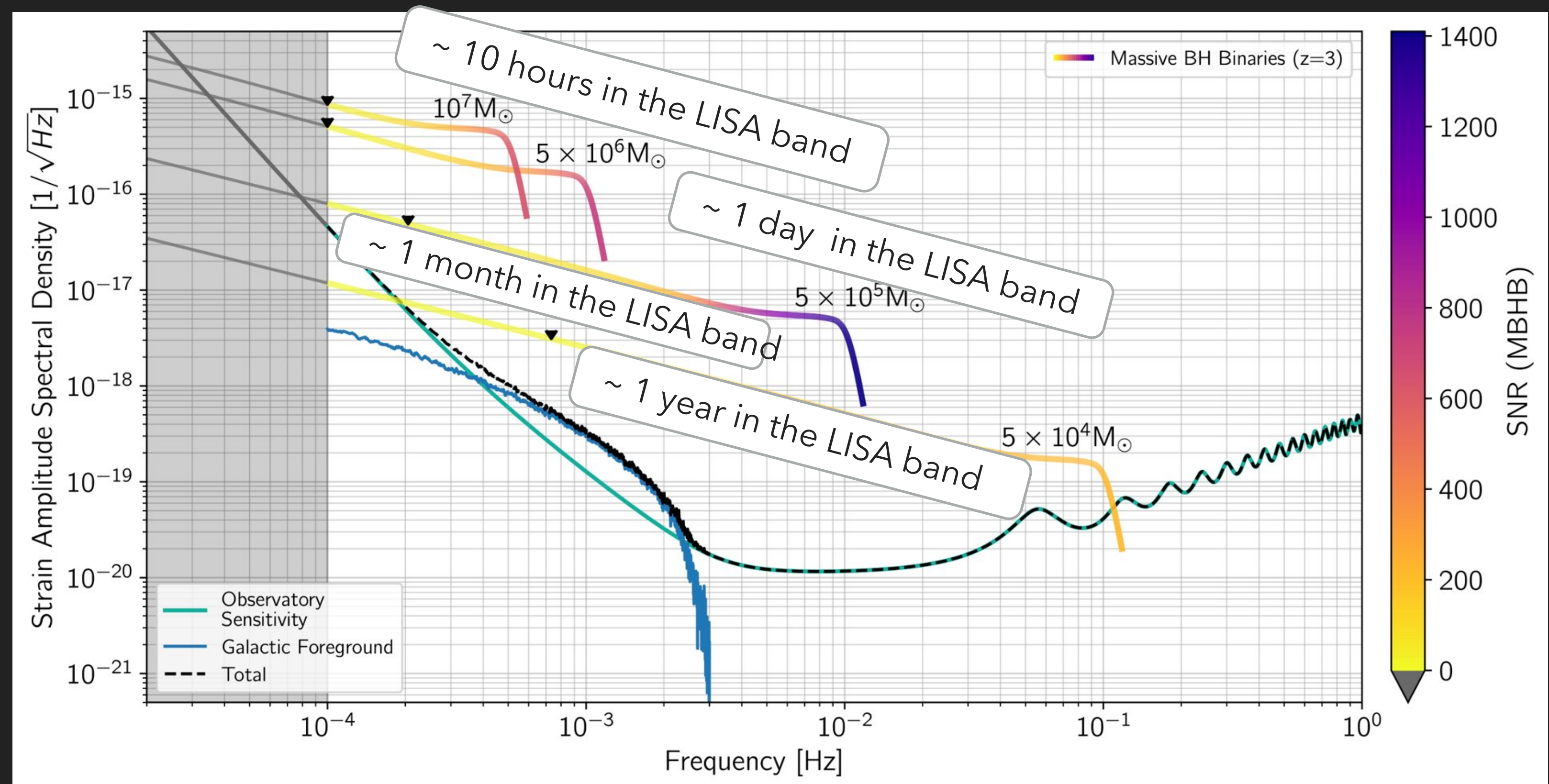


LISA SCIENCE OBJECTIVES

1.OBJ2: Trace the origins, growth and merger histories of **massive Black Holes** across cosmic epochs

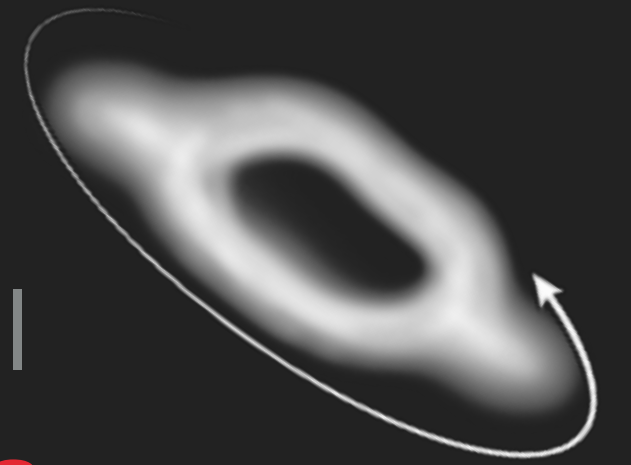


- Between 10^4 and 10^7 solar masses
- Detection would Inform hierarchical growth
- Few per year
- Mass ratio up to 1000 (bulk <10)
- Expected high eccentricities
- Population census



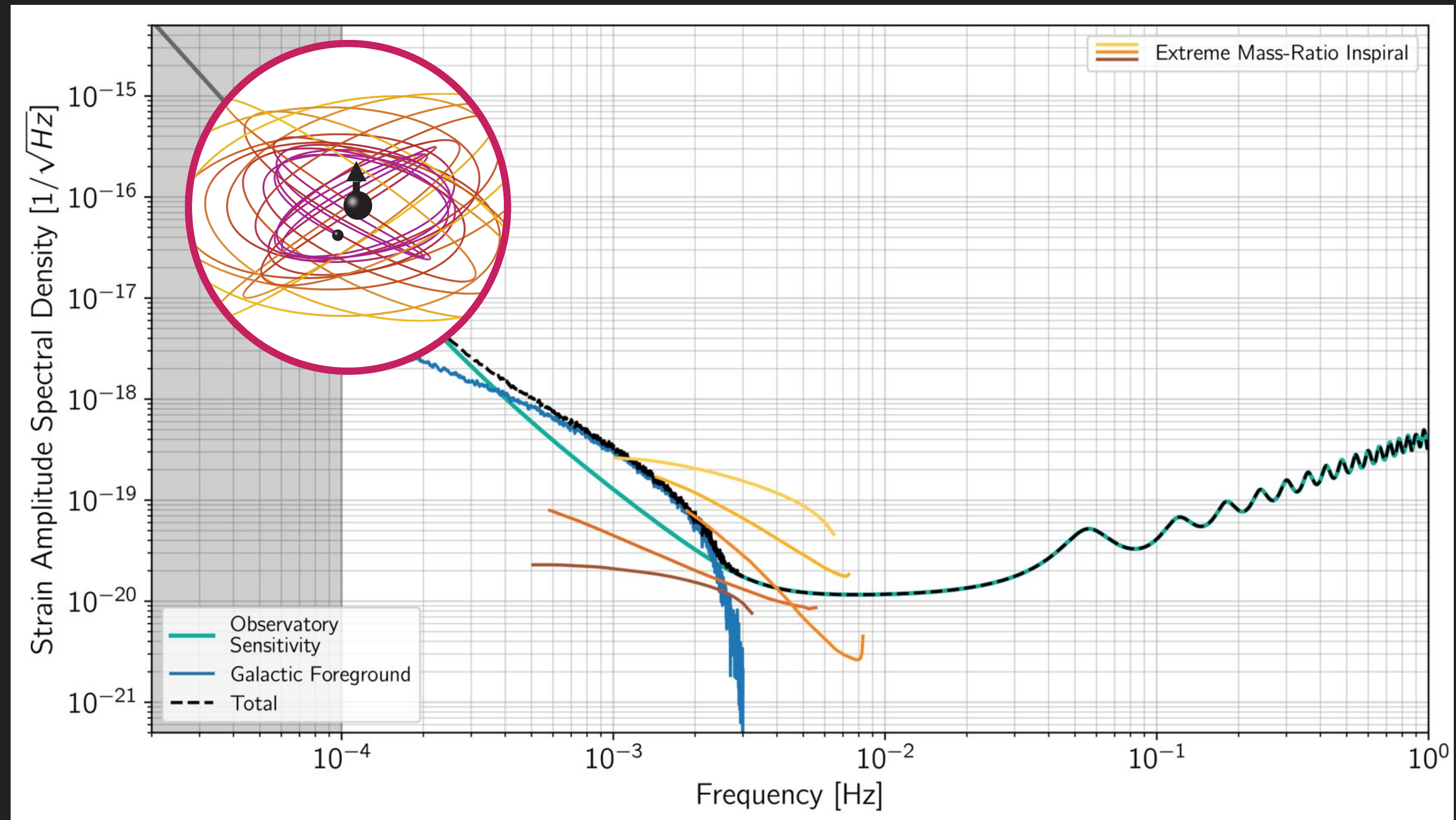
LISA SCIENCE OBJECTIVES

1.OBJ3: TProbe the properties and immediate environments of Black Holes in the local Universe using **extreme mass-ratio inspirals** and **intermediate mass-ratio inspirals**



EMRIs (mass ratio $10^5 - 10^8$)

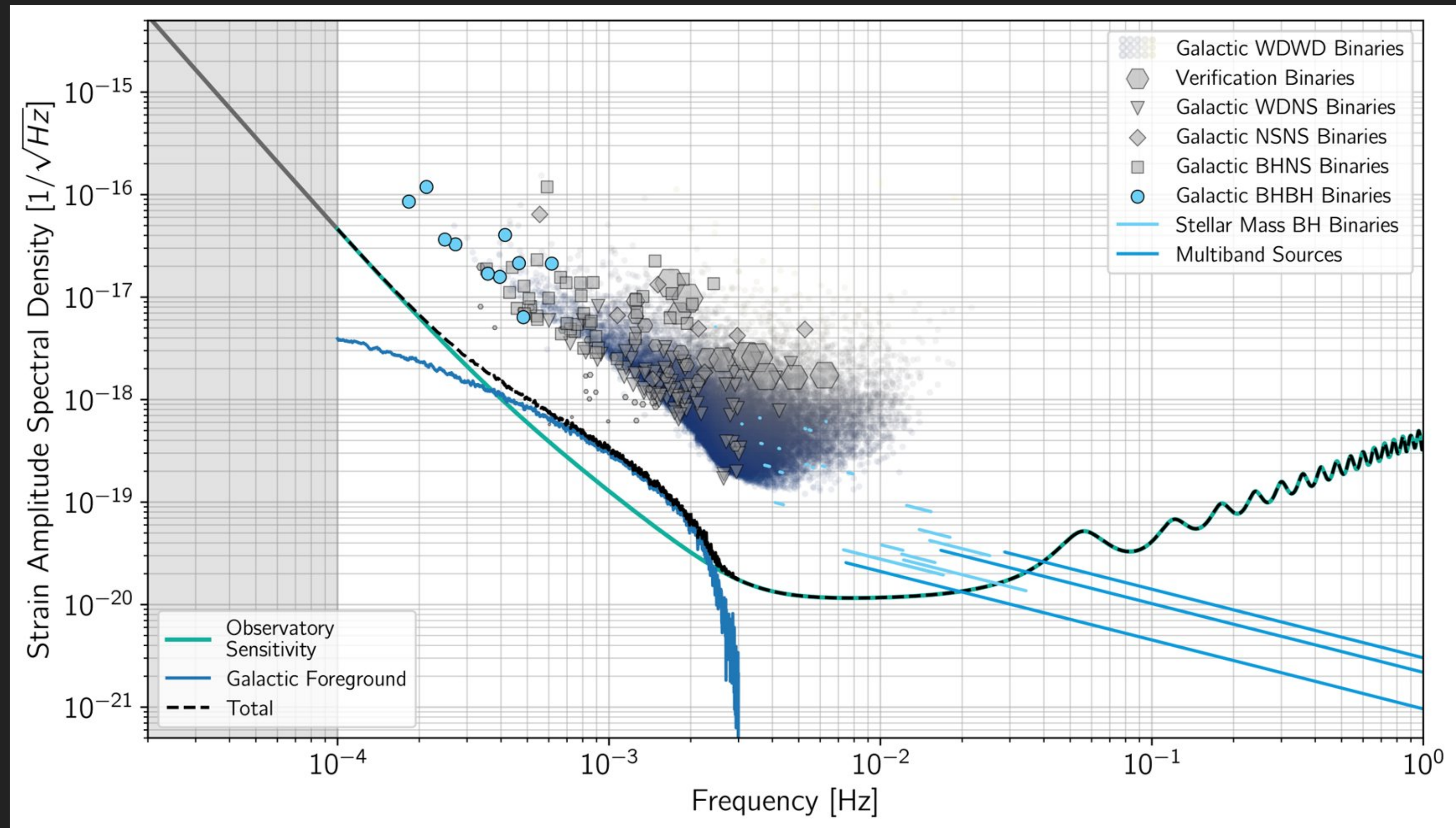
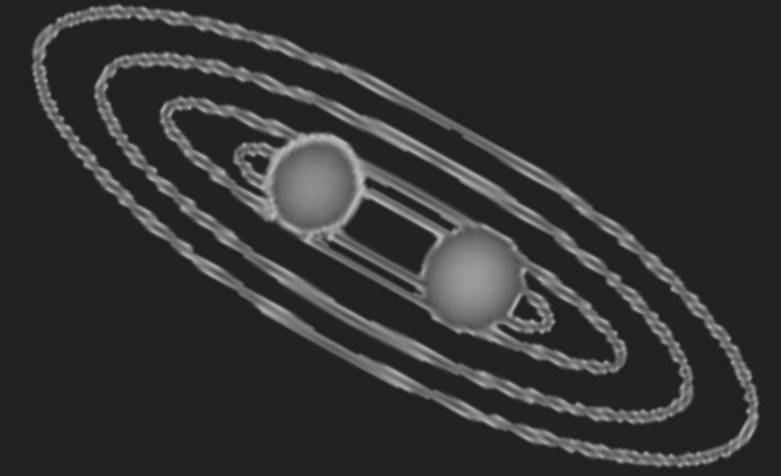
- Environmental information
- Galaxy and BH evolution
- Eccentricity and spin vary on formation channel
- 1-1000 per year
- SNR $\sim 100 \Rightarrow$ sky location 0.05deg^2

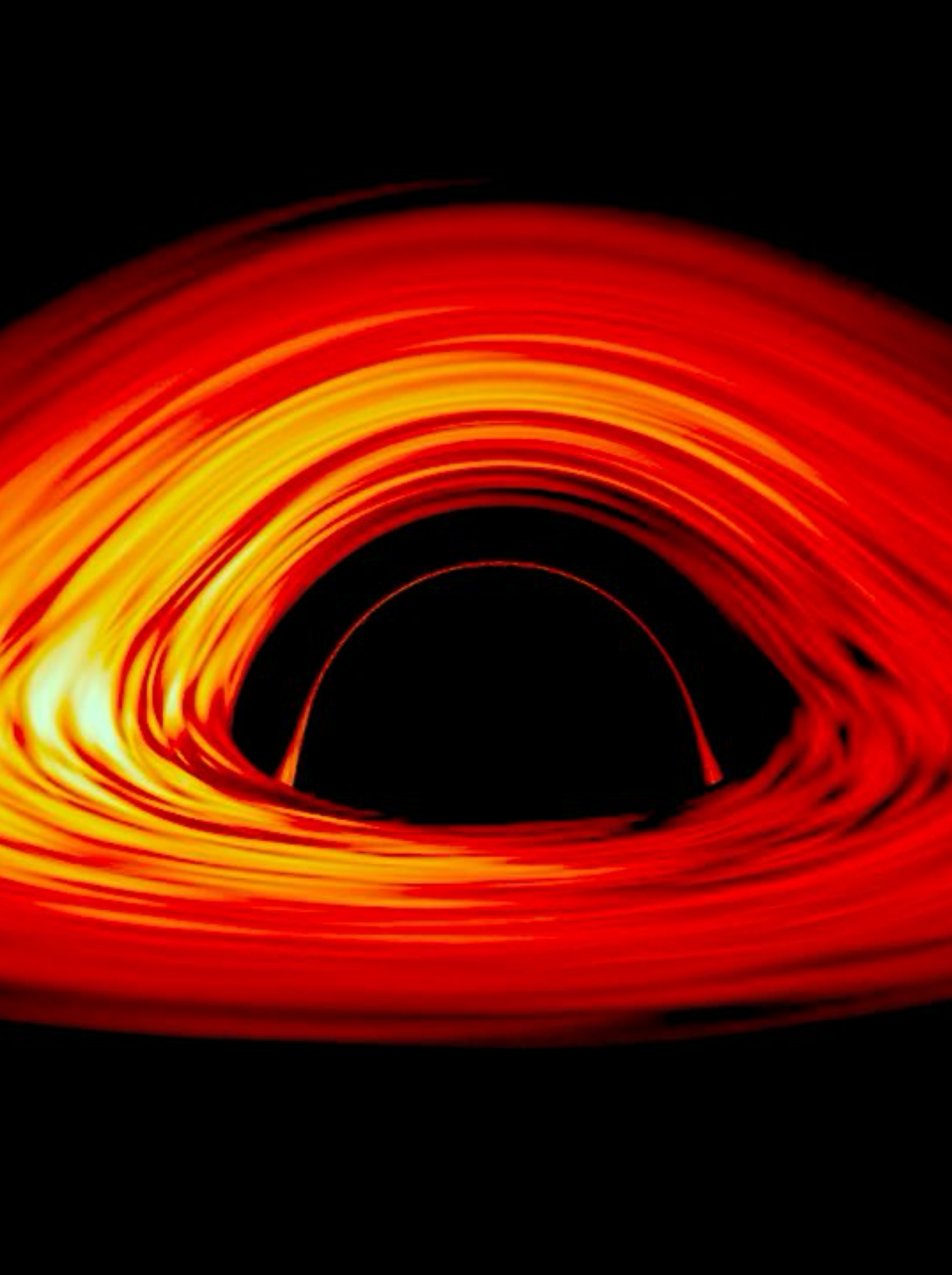


LISA SCIENCE OBJECTIVES

1.OBJ4: Understand the astrophysics of **stellar-mass Black Holes**

- BHs of 50-100 solar masses and 10^5 cycles
- Eccentricity will inform formation channels
- Environment / centre of mass acceleration inform pair instability mass gap
- Possible multi-band astrophysics

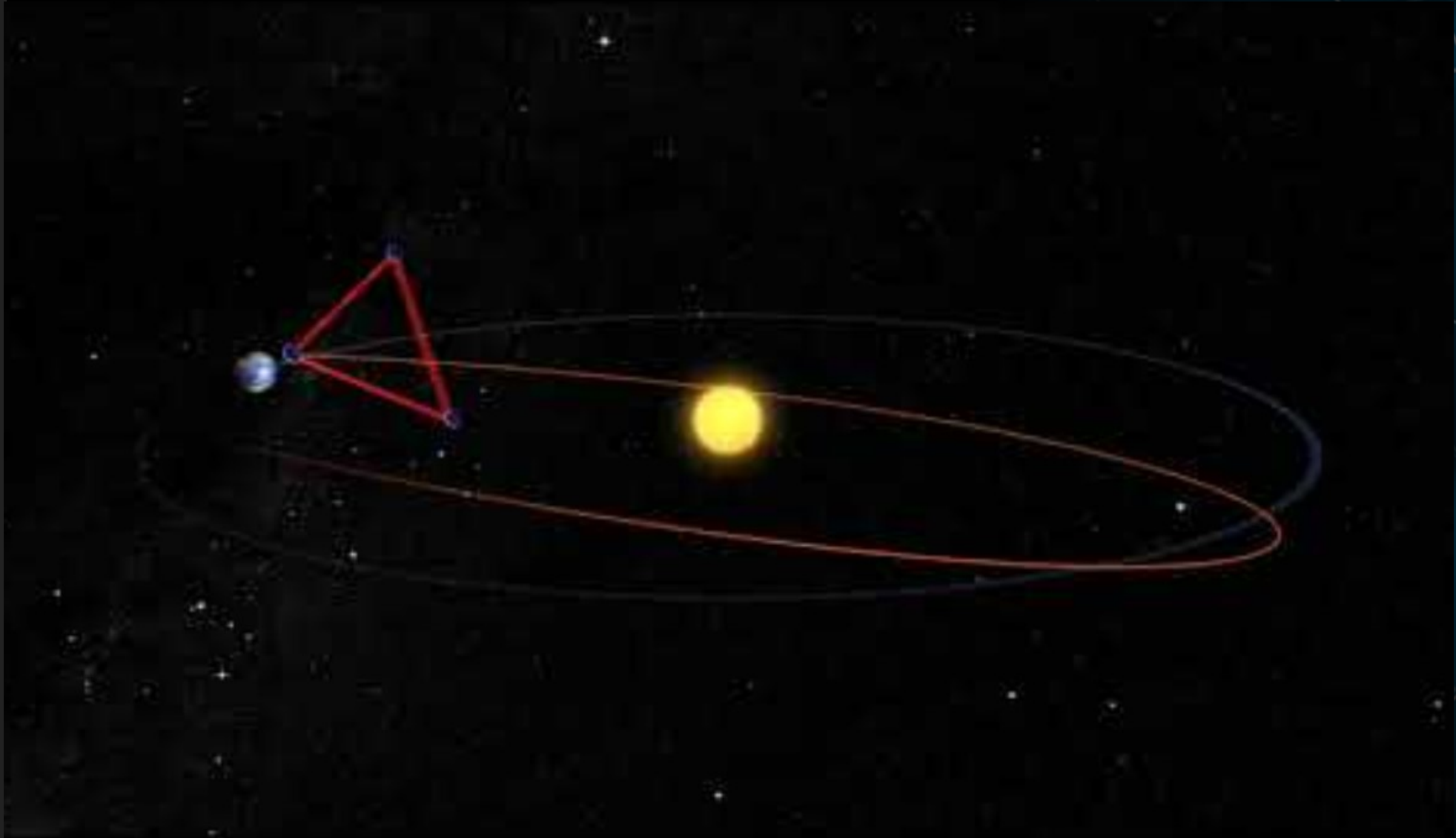




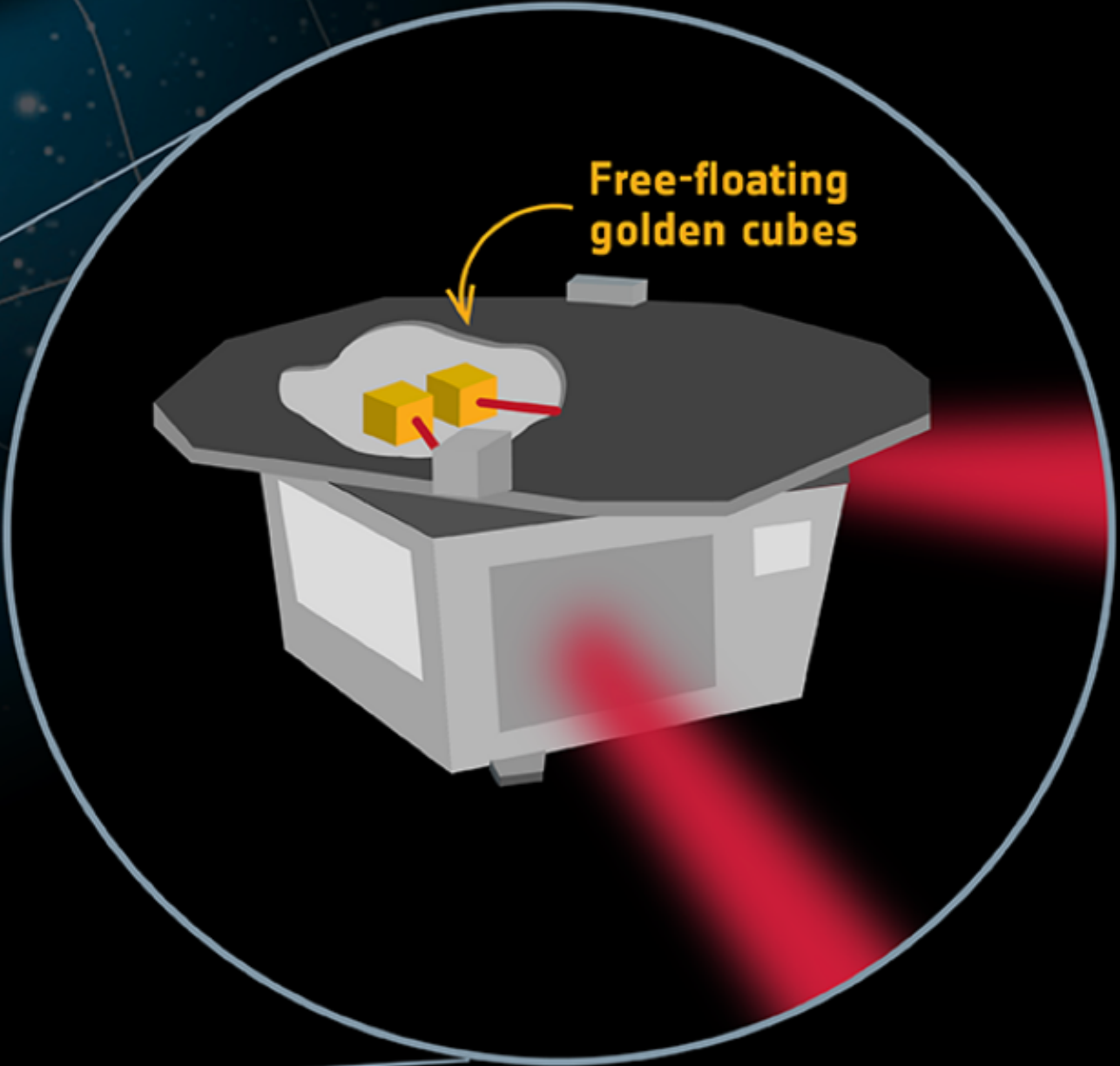
LISA

MISSION

MISSION DESIGN



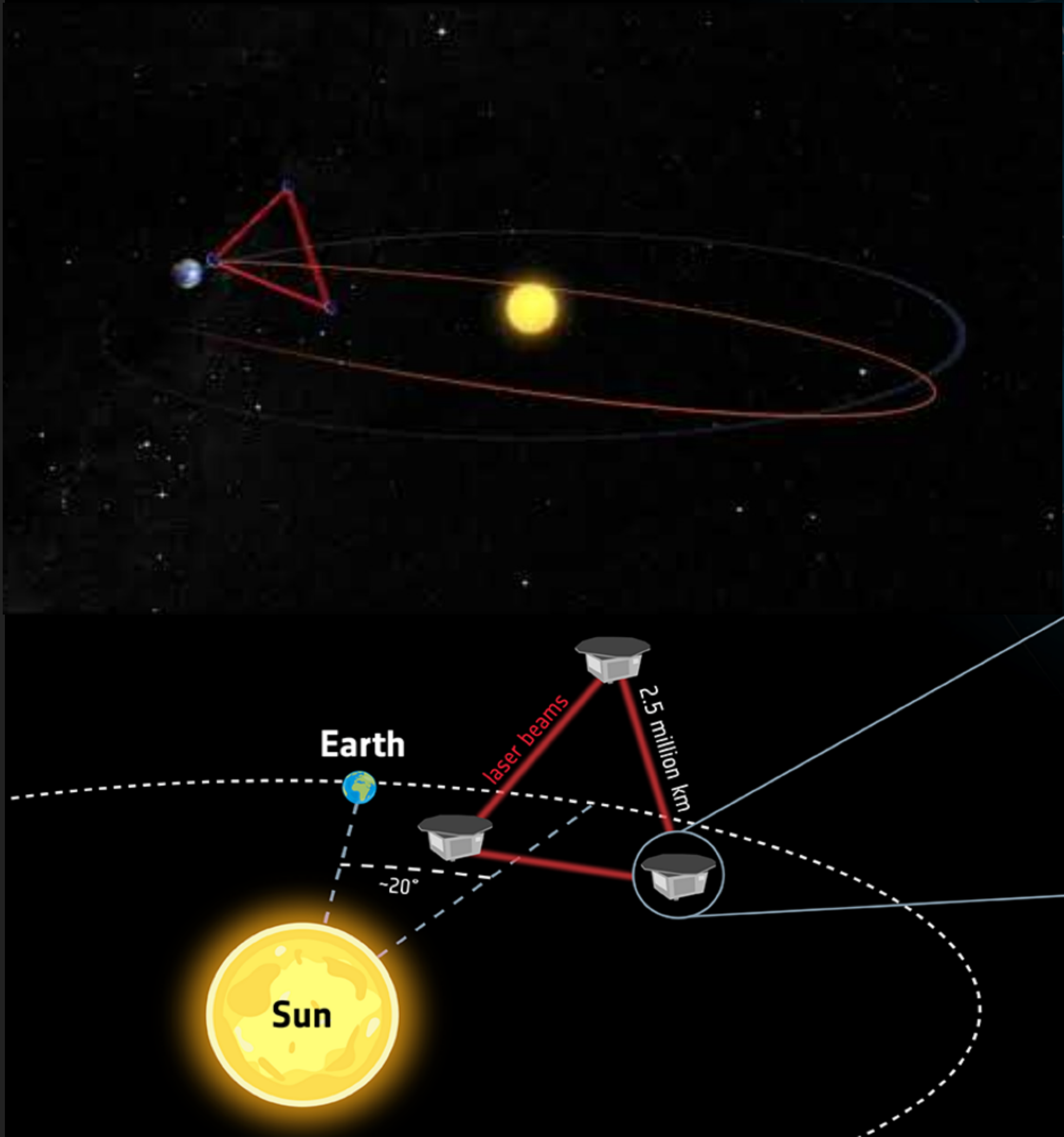
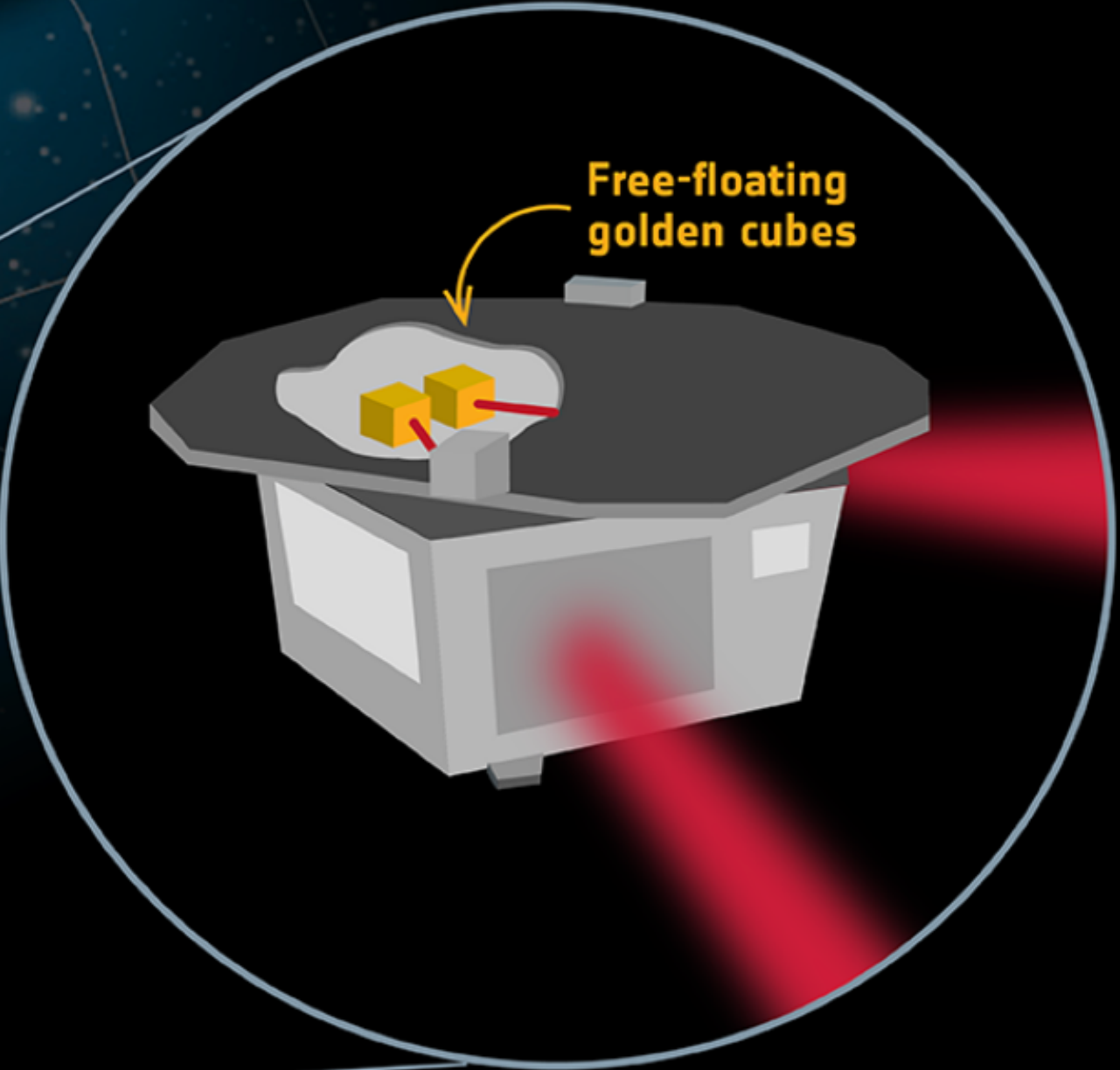
Powerful events such as **colliding black holes** shake the fabric of spacetime and cause gravitational waves



MISSION DESIGN



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

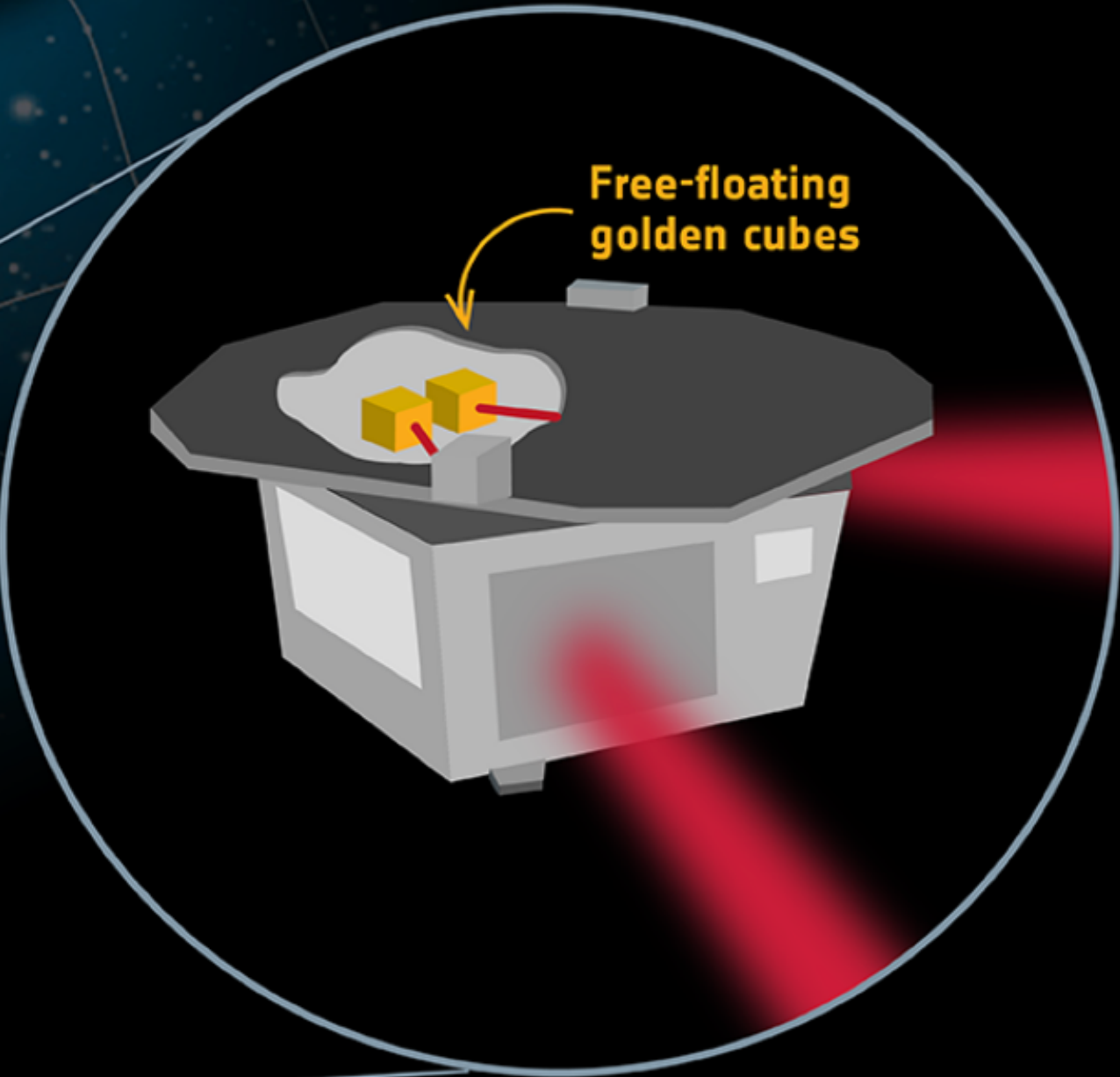


MISSION DESIGN

Video: AEI / Milde Marketing

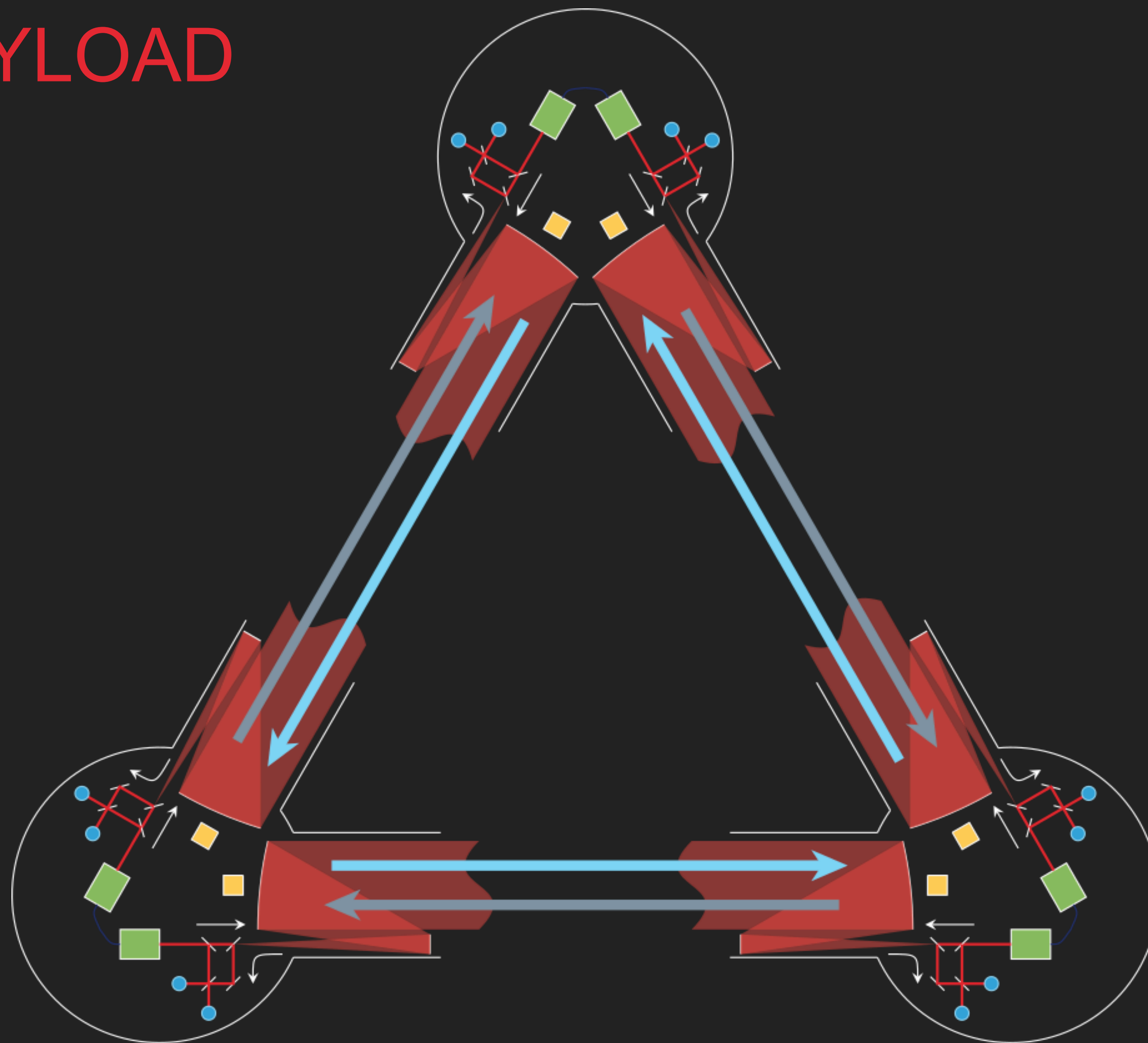


Powerful events such as **colliding black holes** shake the fabric of spacetime and cause gravitational waves

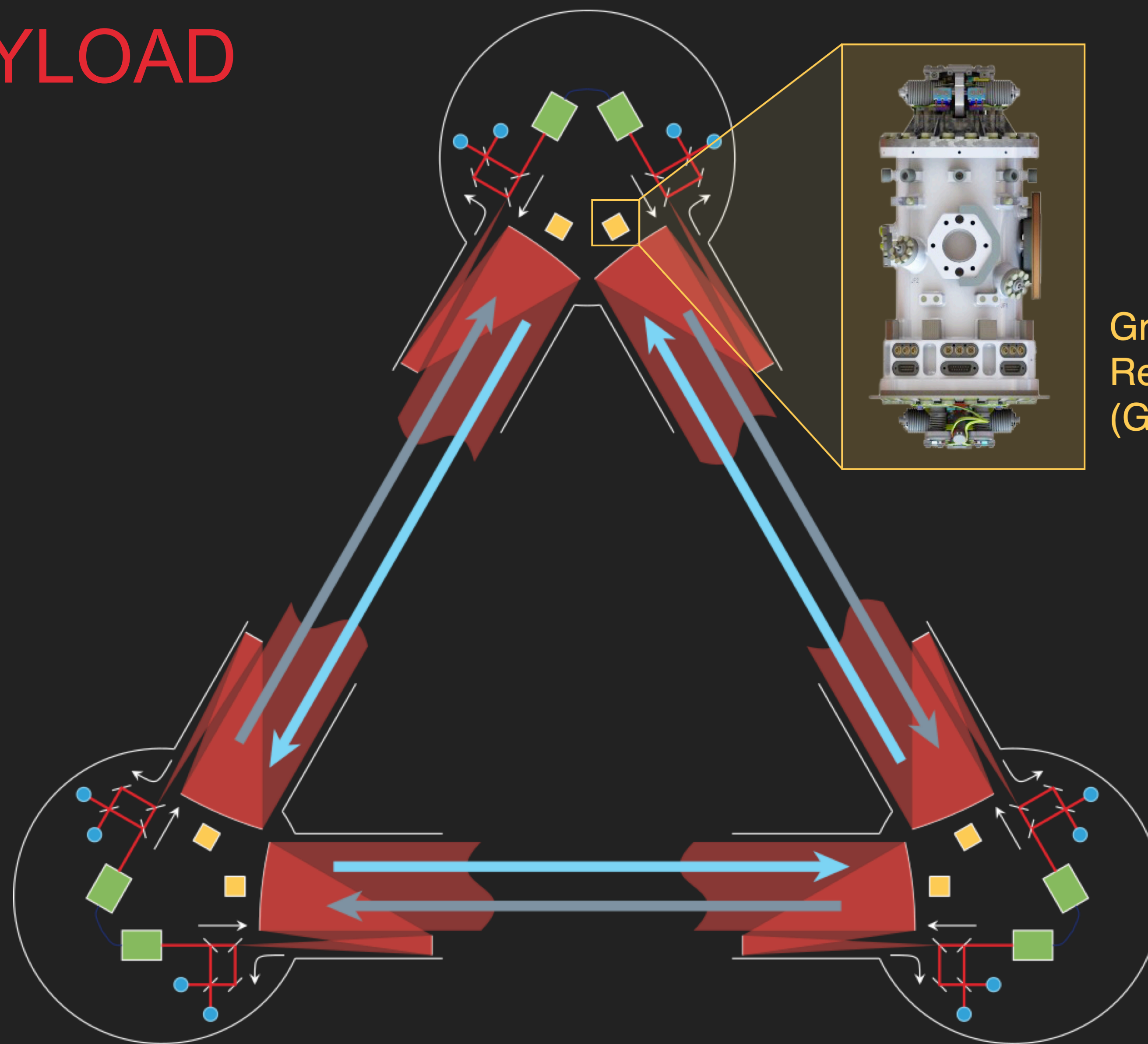


MISSION PAYLOAD

MISSION PAYLOAD

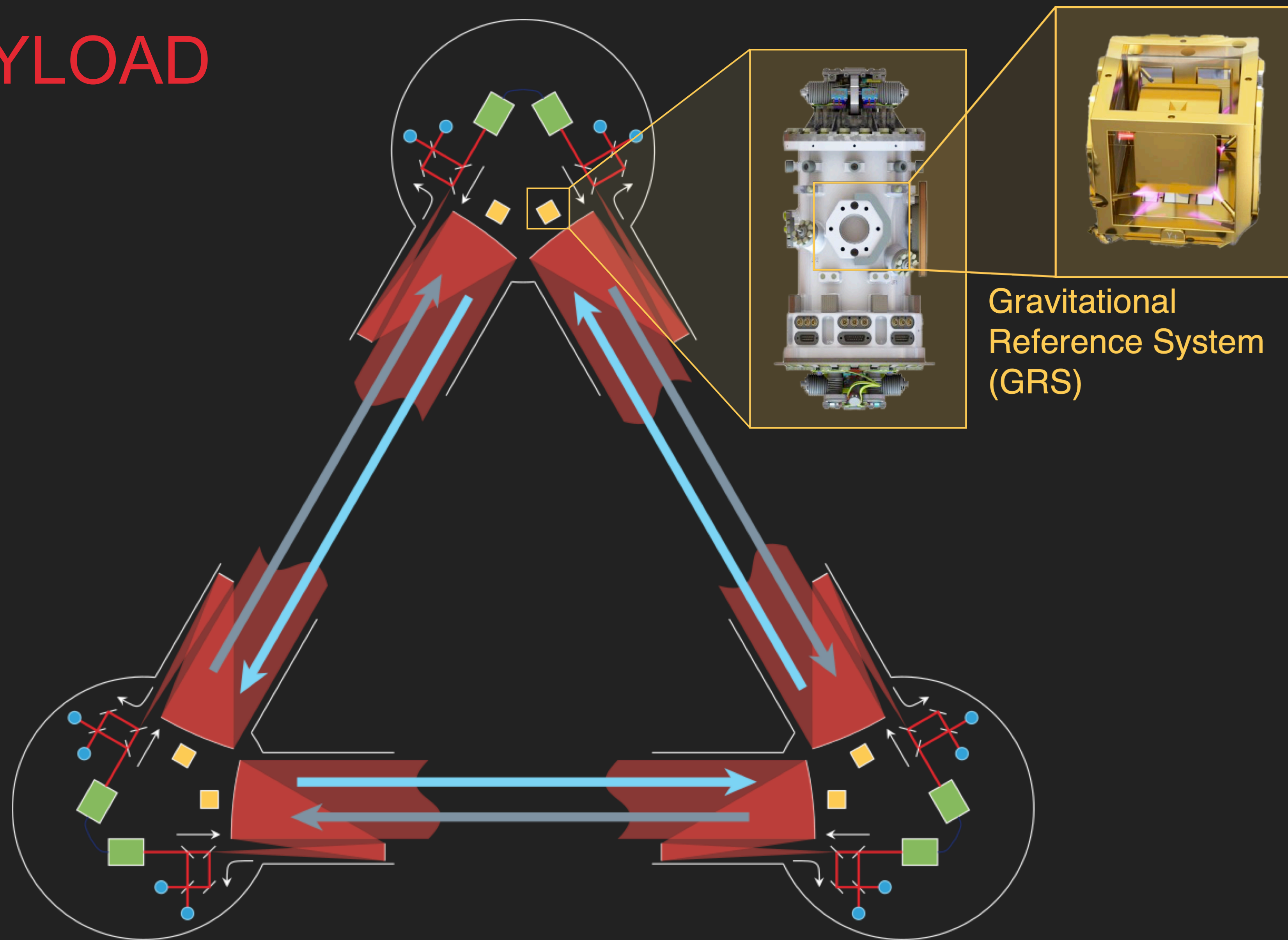


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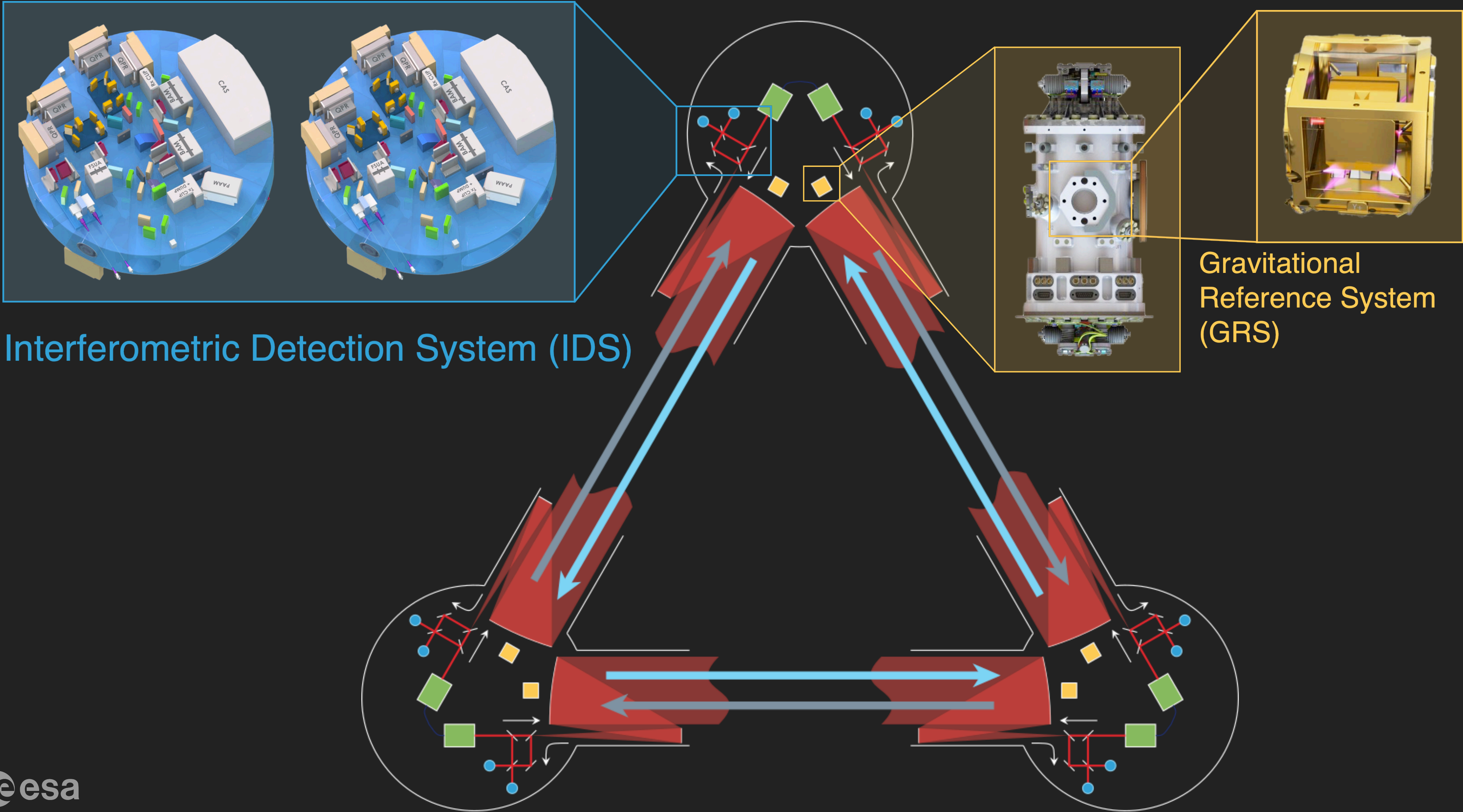
Gravitational
Reference System
(GRS)

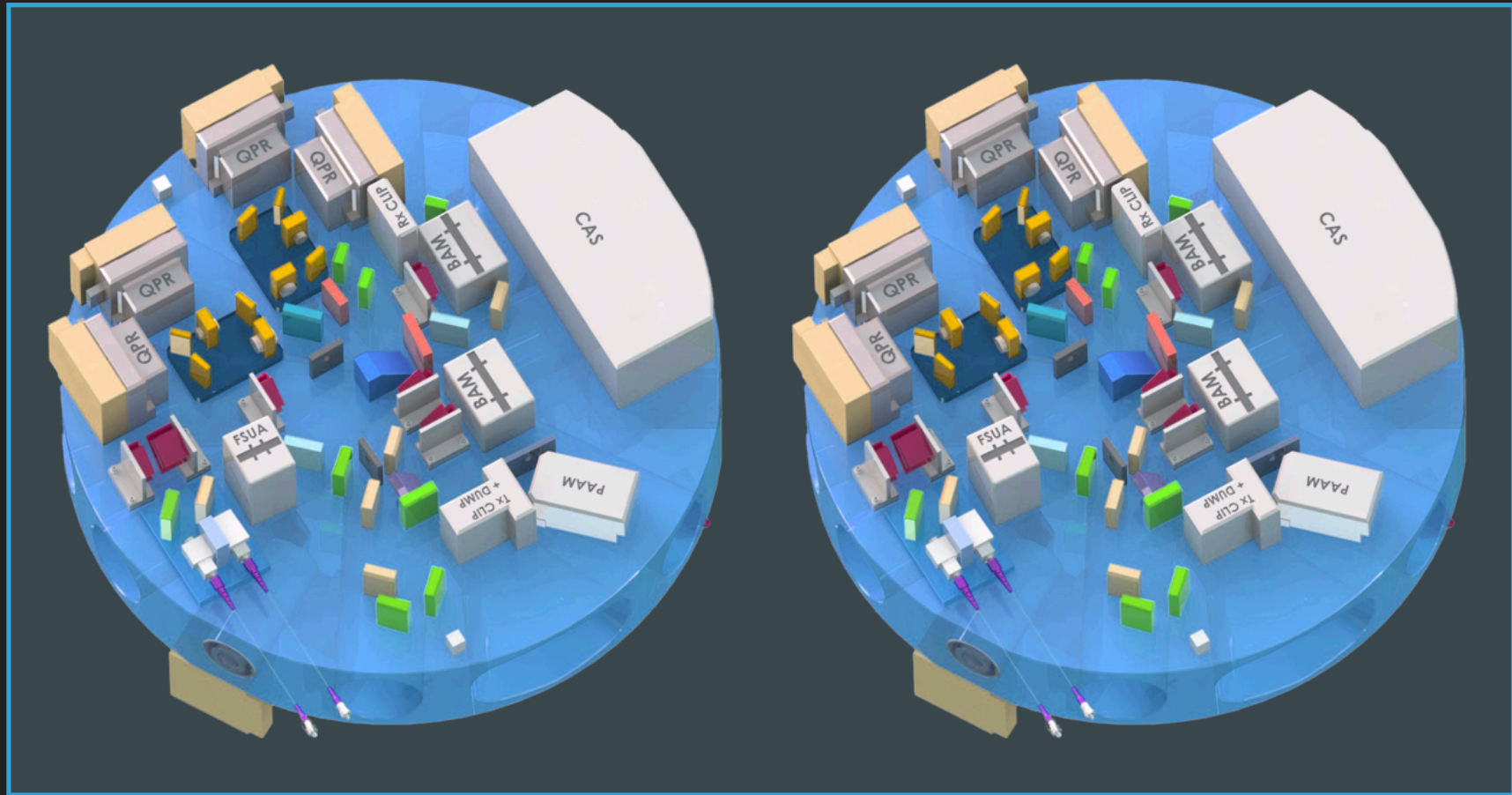
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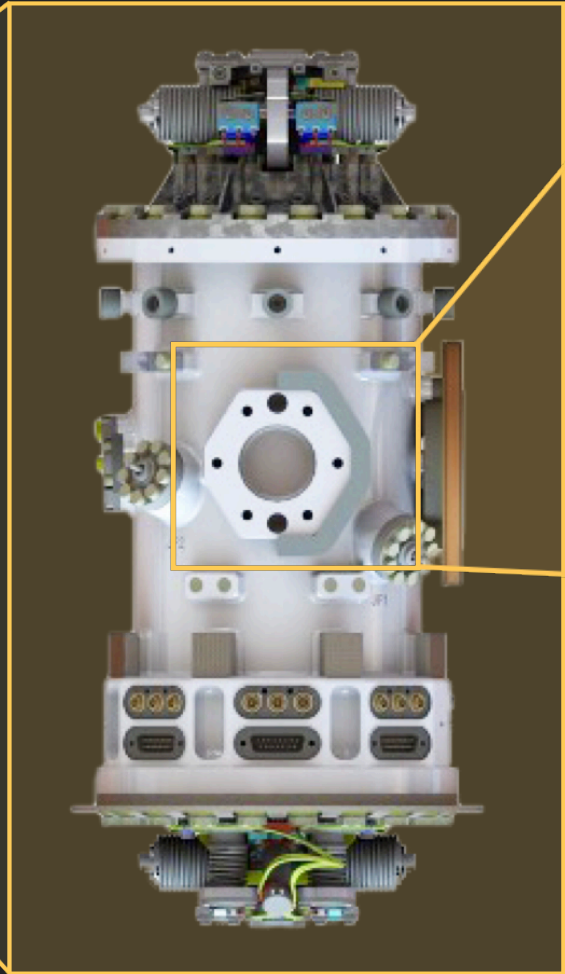
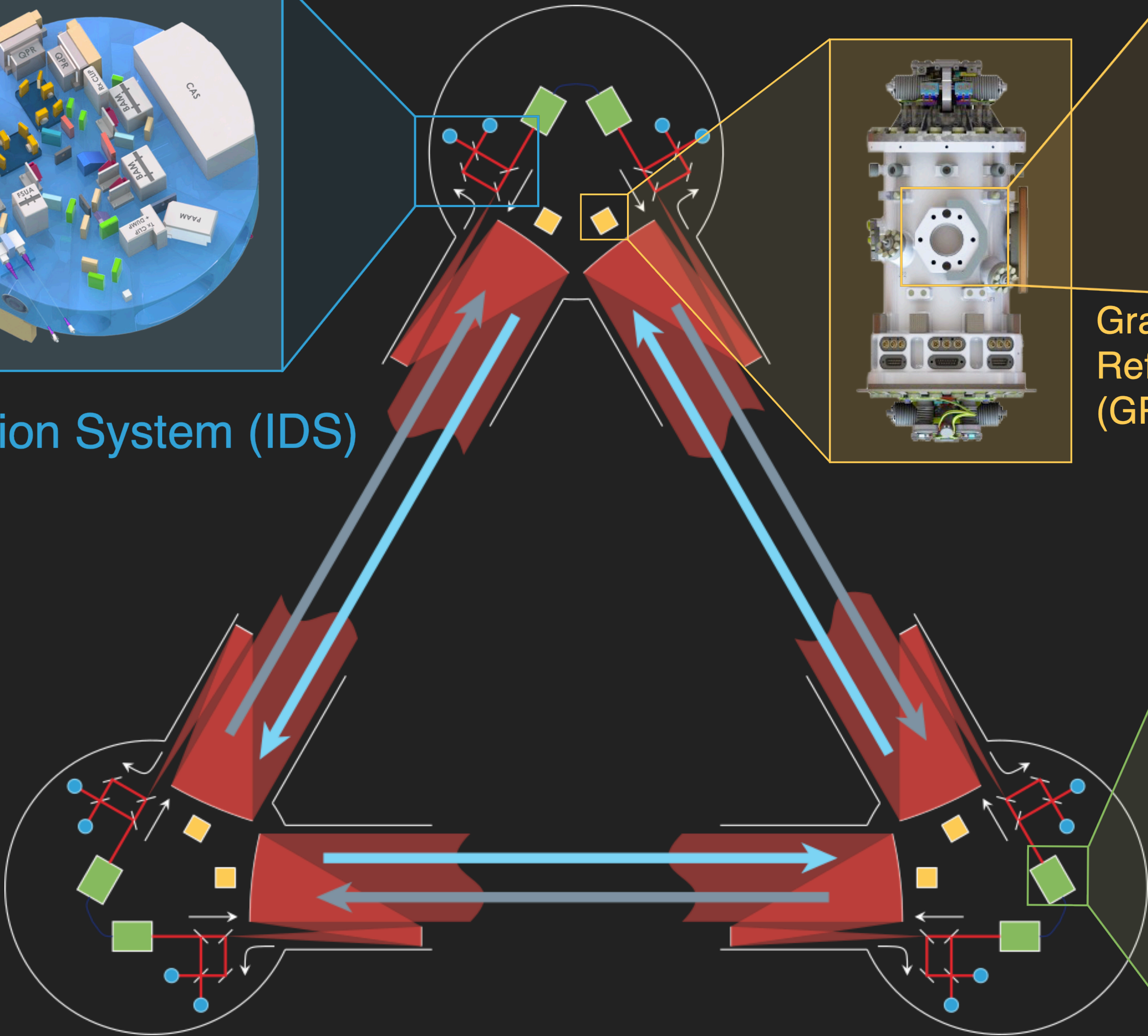
Test Masses

Gravitational
Reference System
(GRS)

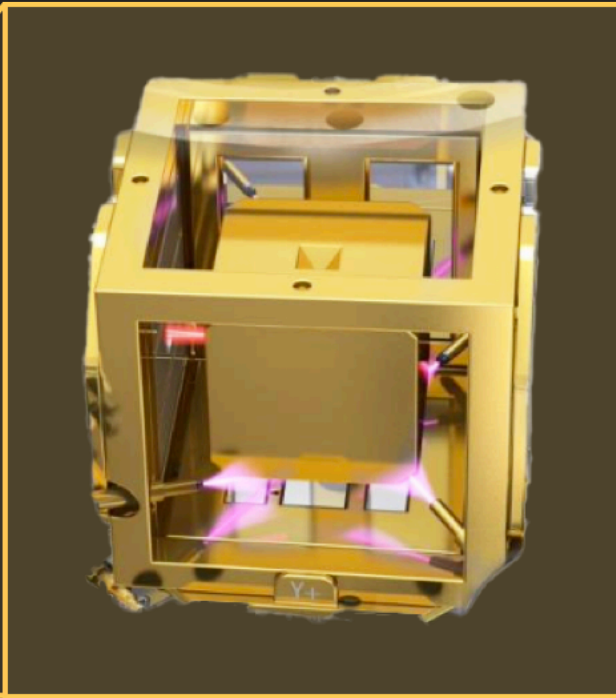




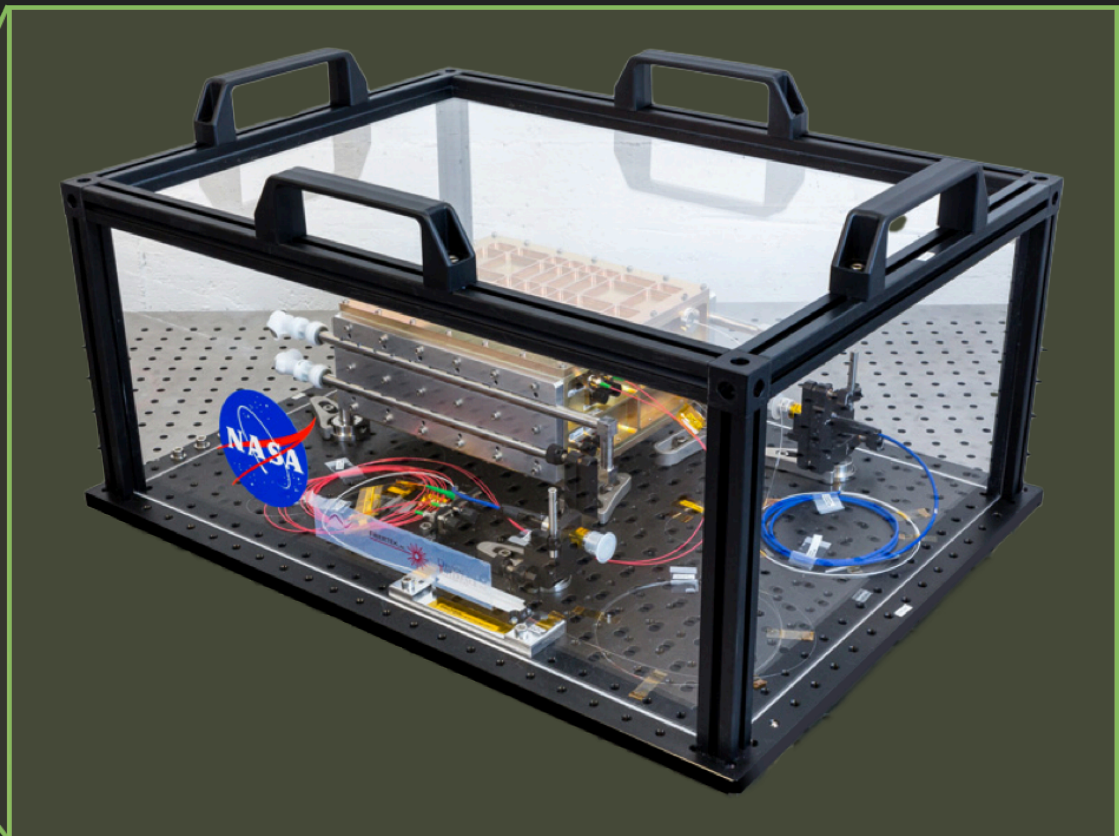
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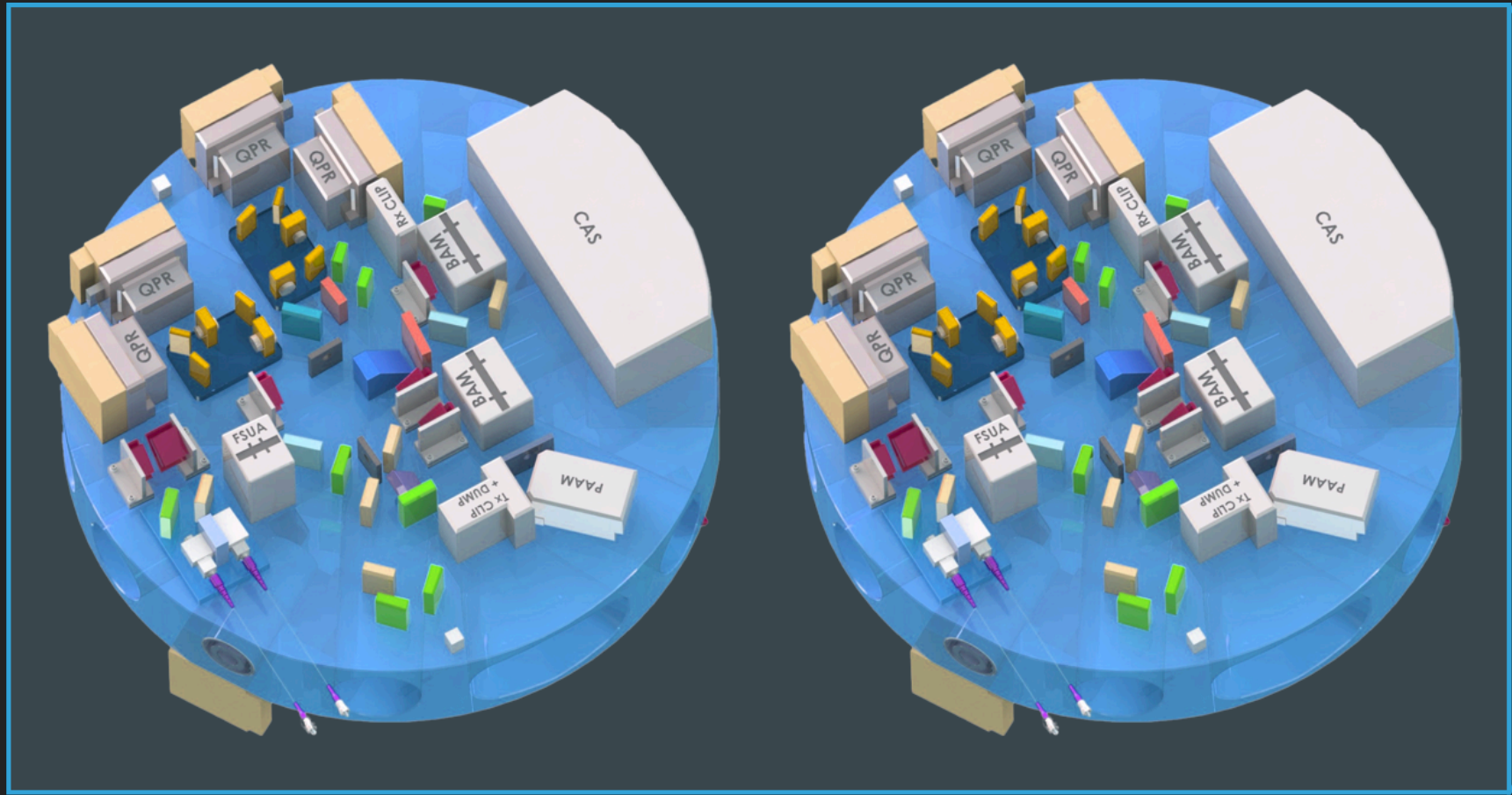
Gravitational Reference System (GRS)



Test Masses

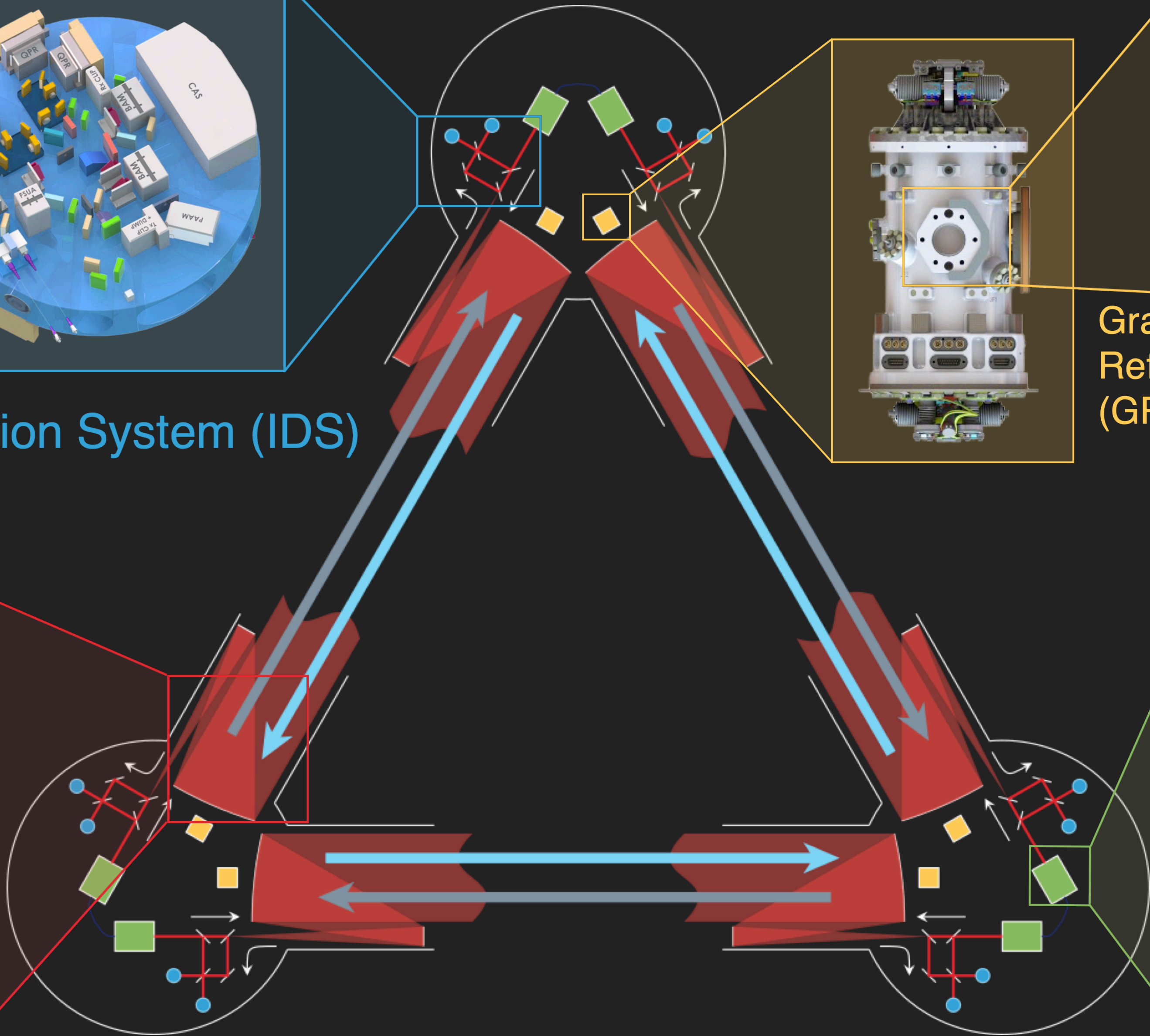


Lasers

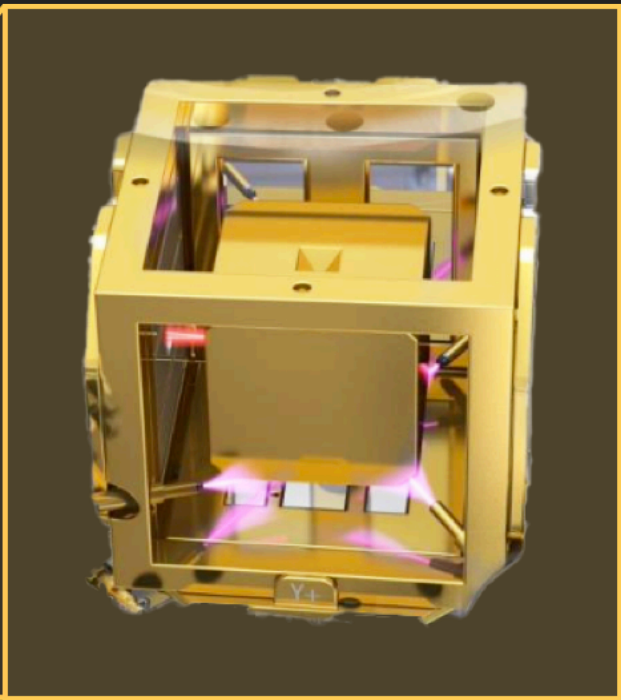


Interferometric Detection System (IDS)

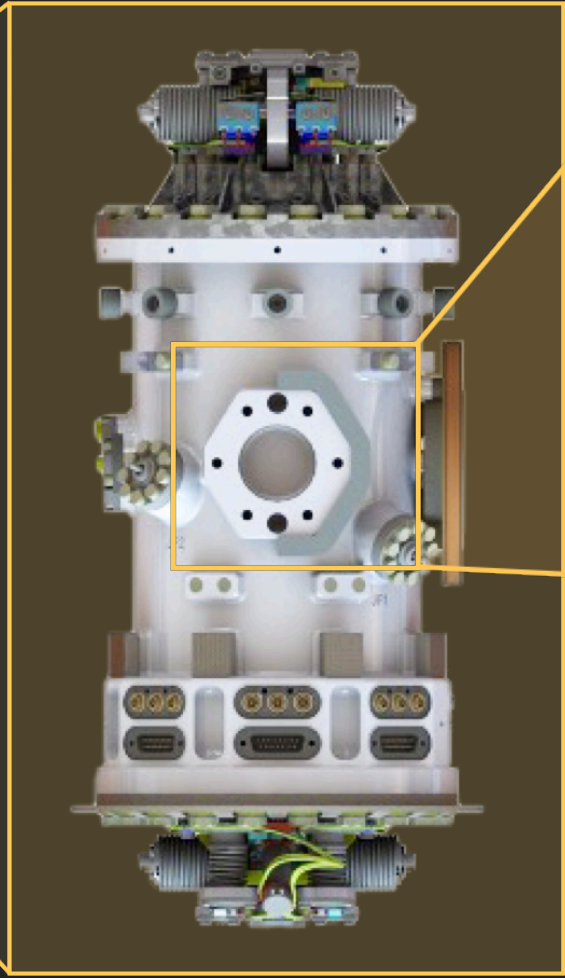
Telescopes



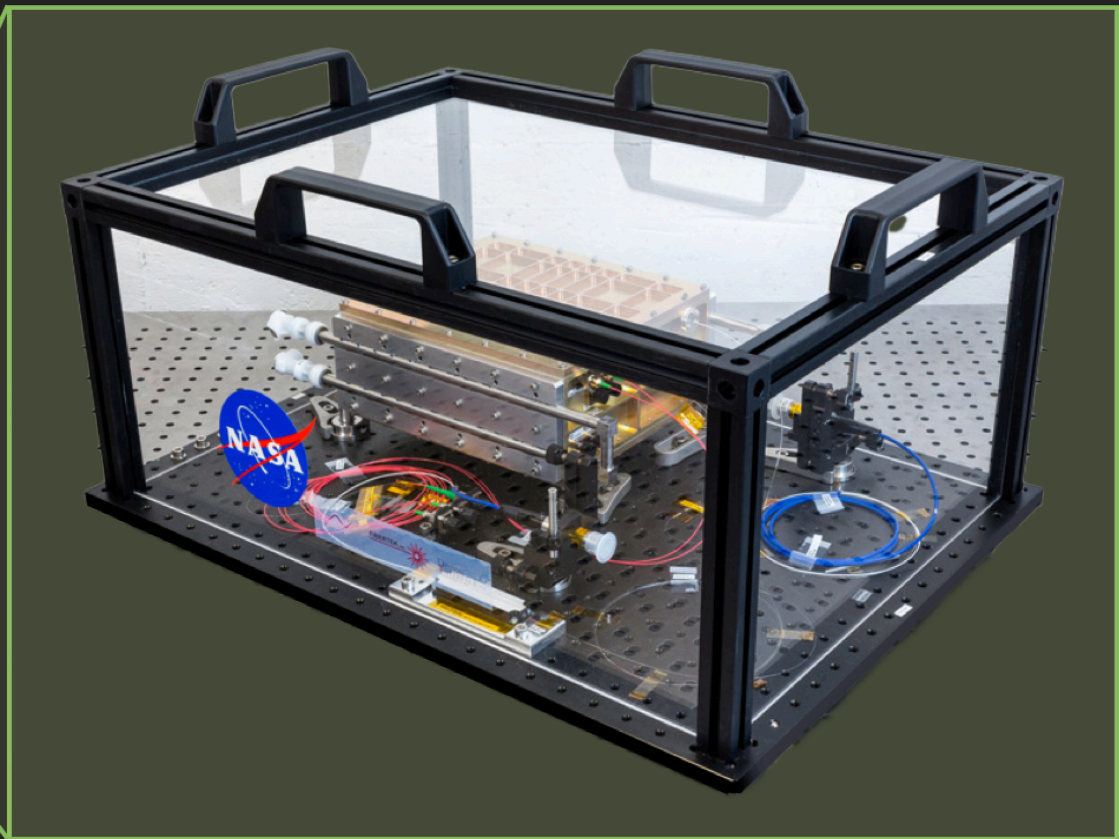
Test Masses



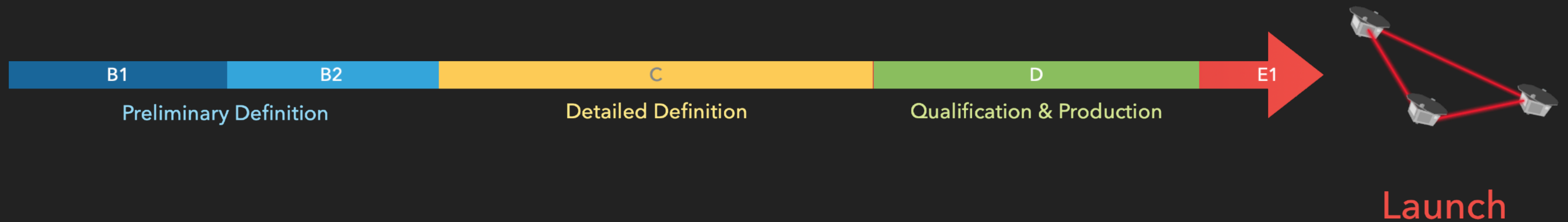
Gravitational Reference System (GRS)



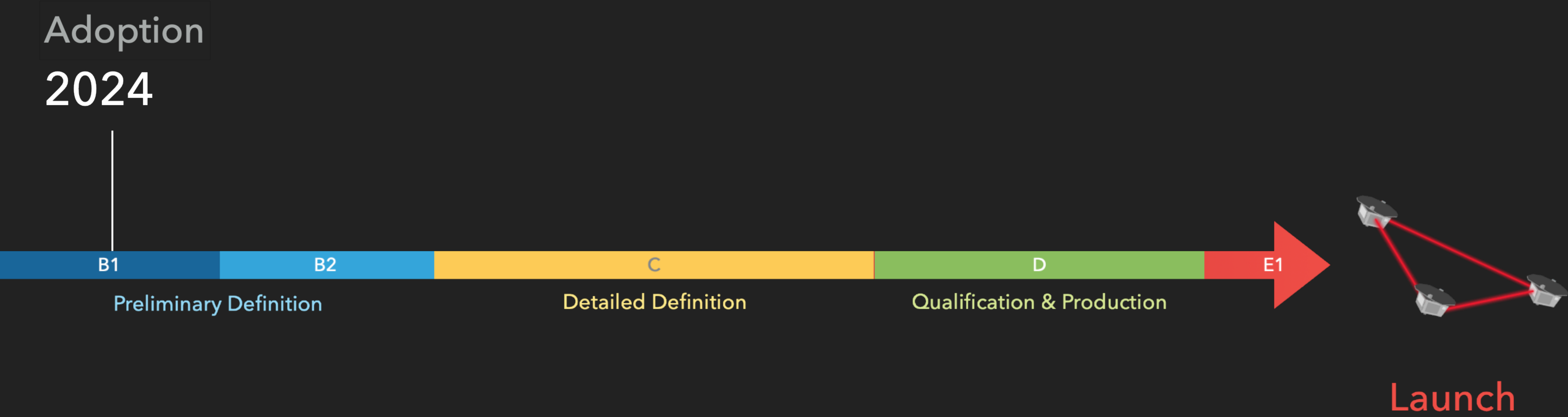
Lasers



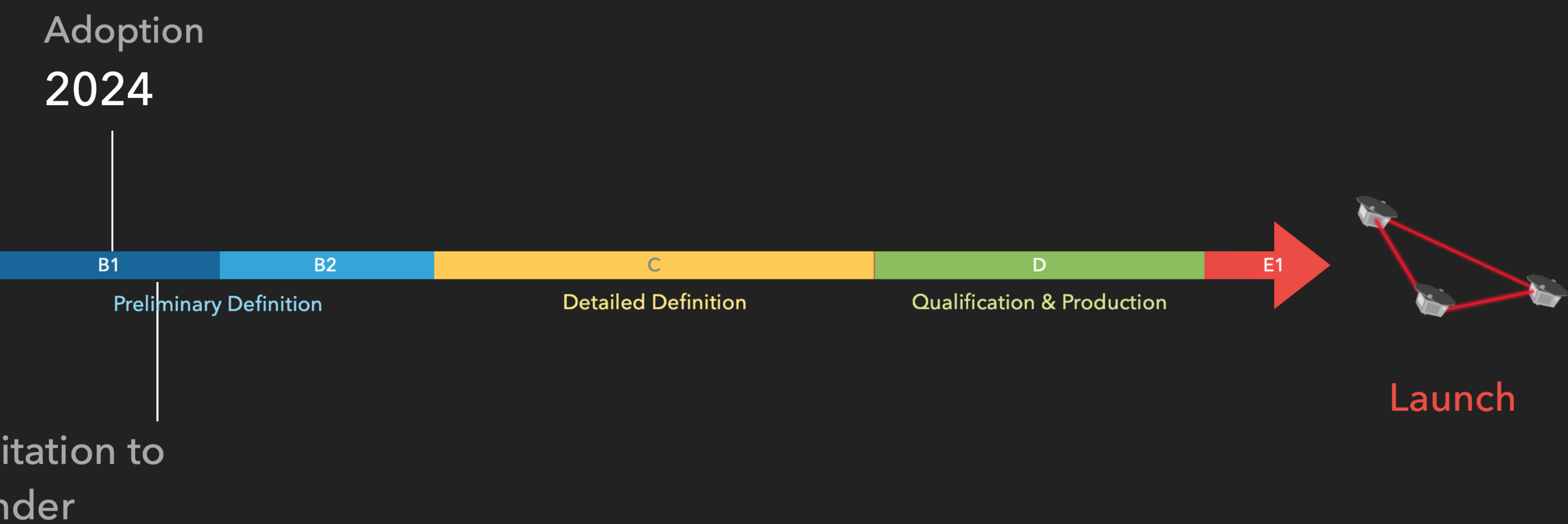
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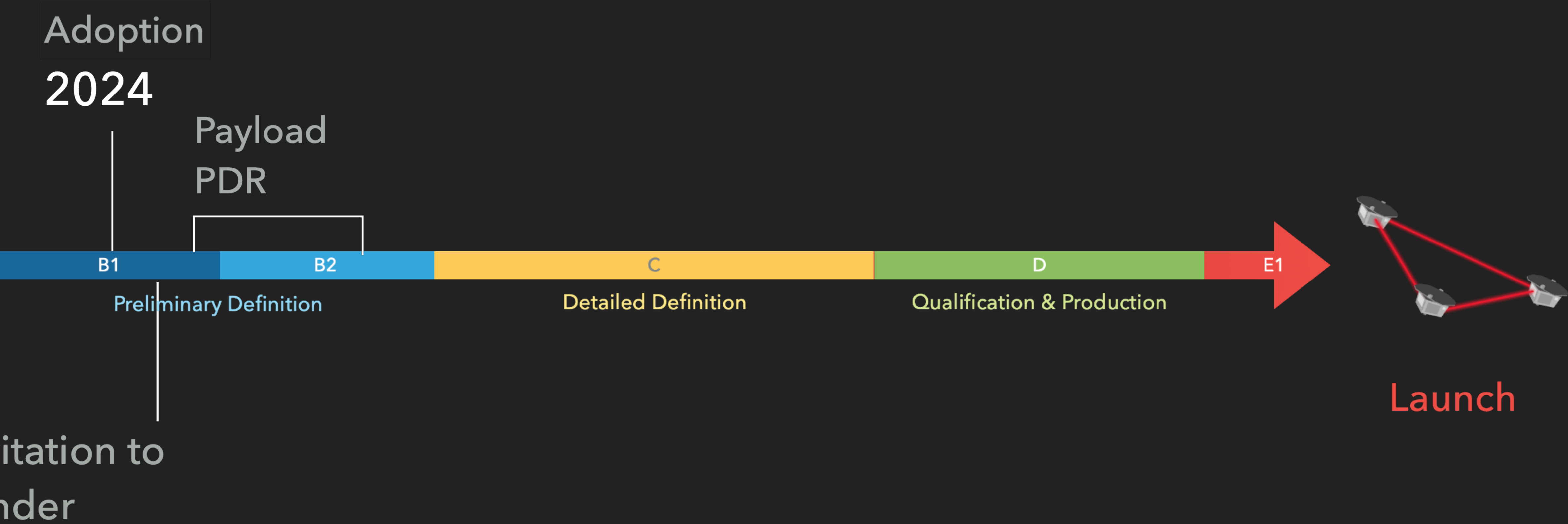
MISSION TIMELINE



MISSION TIMELINE



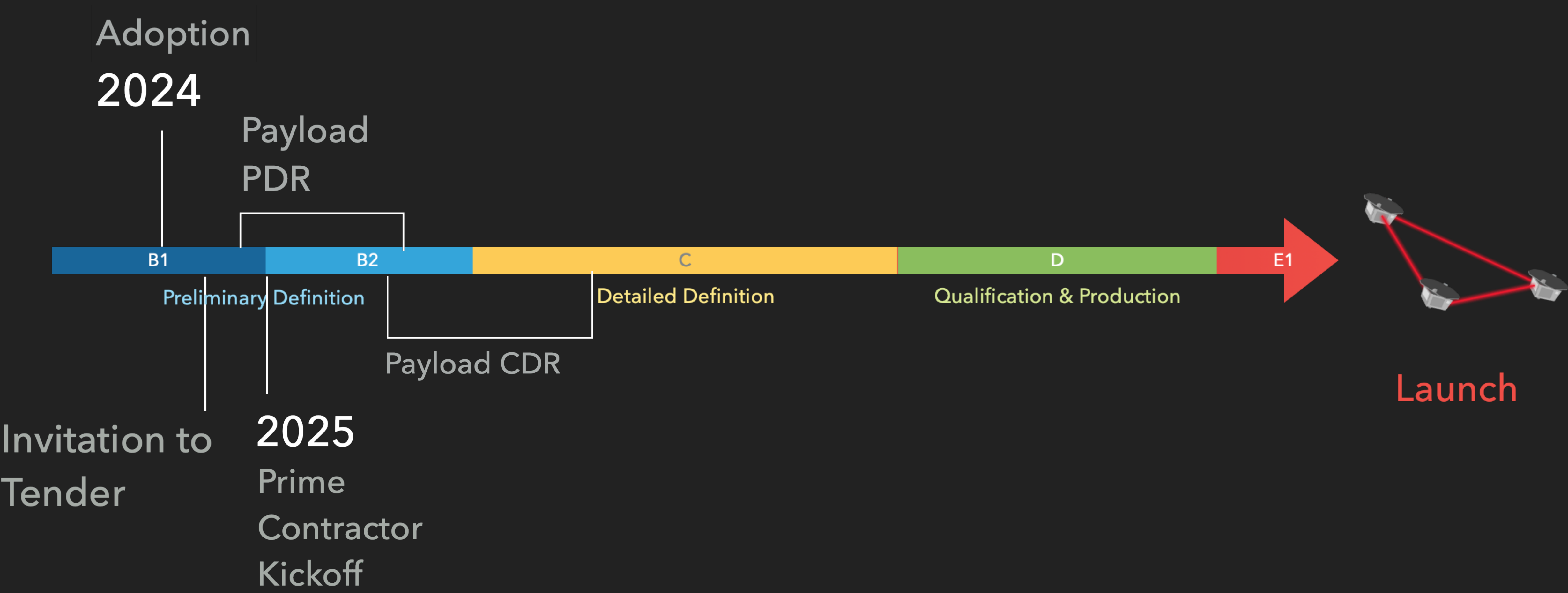
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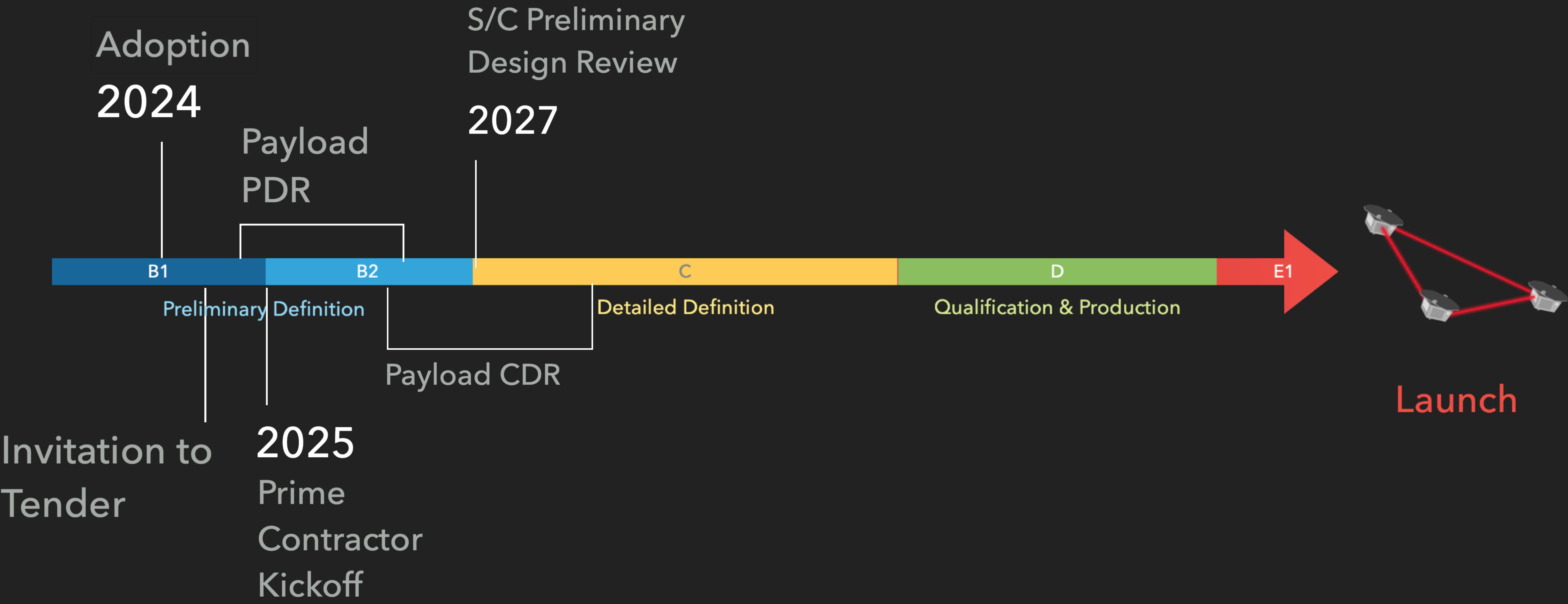
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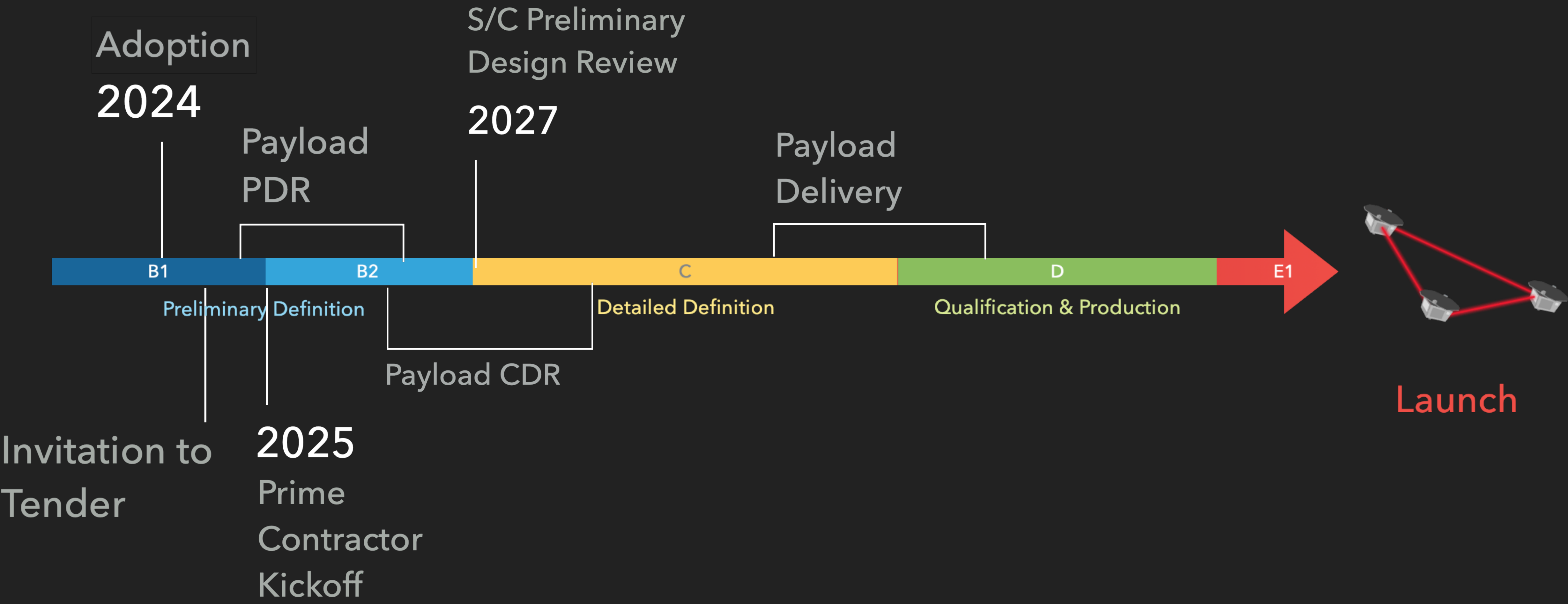
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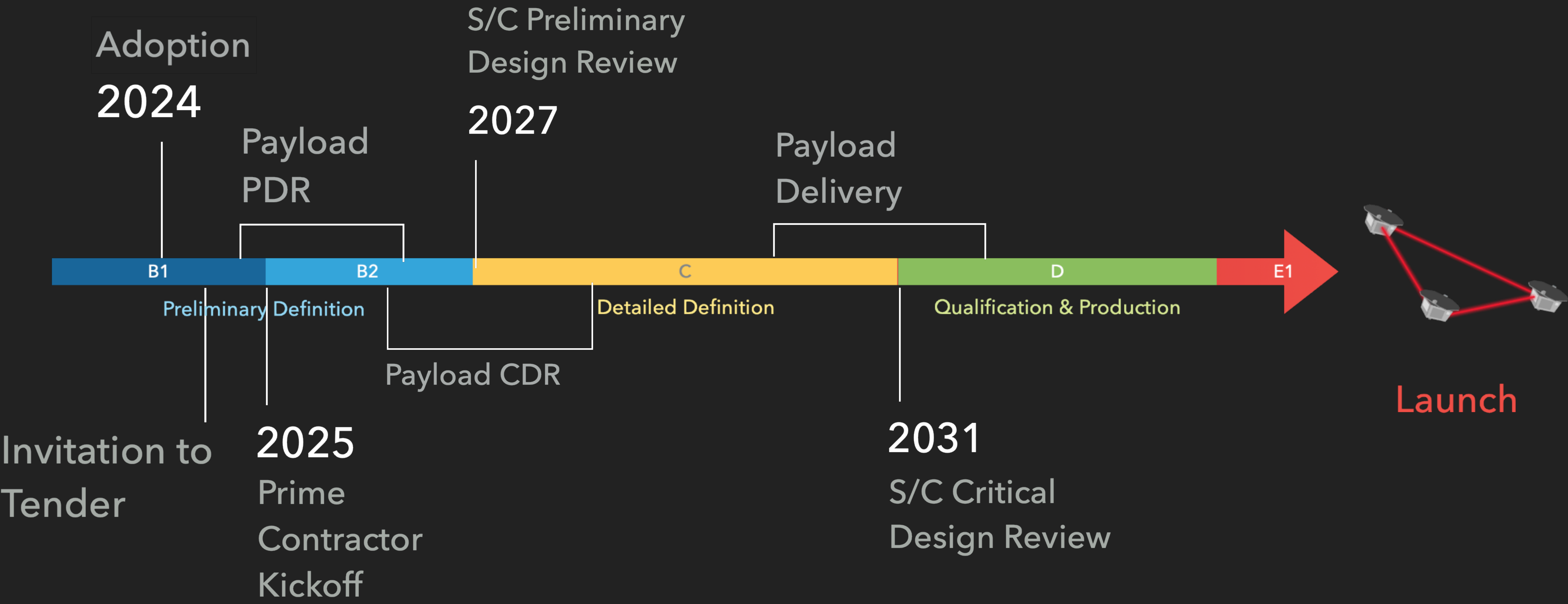
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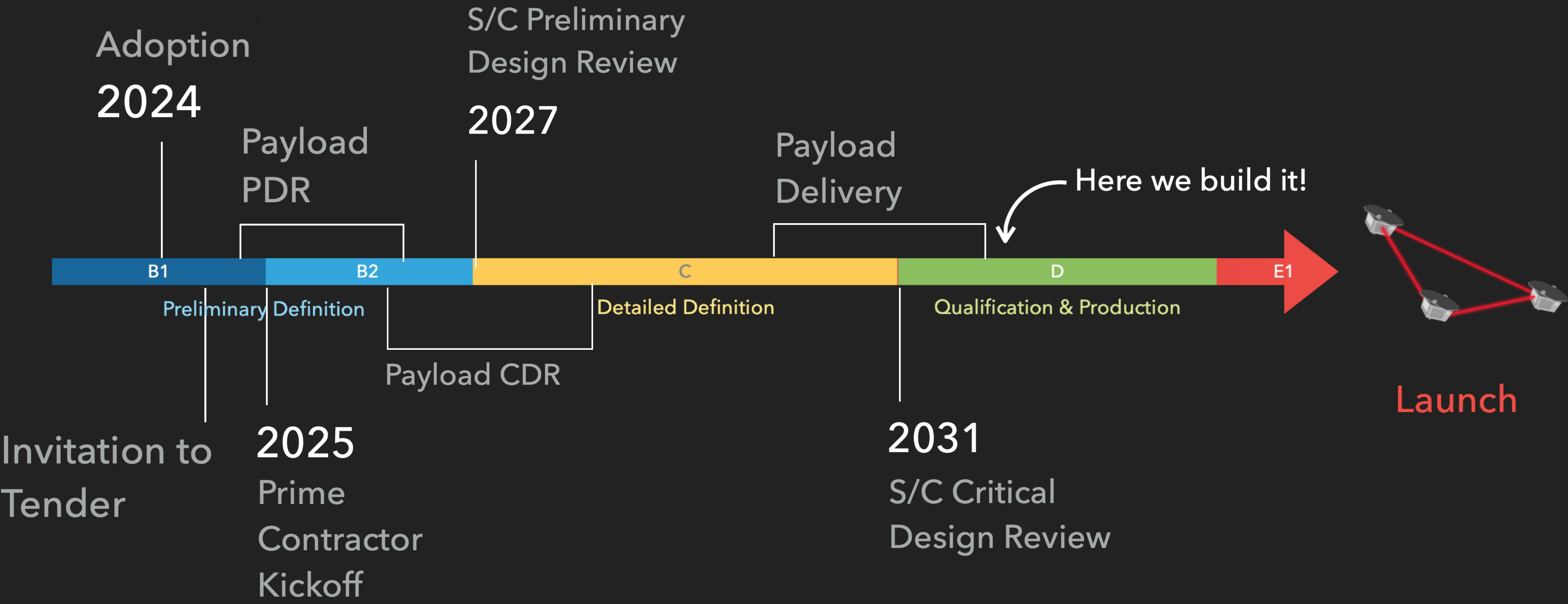
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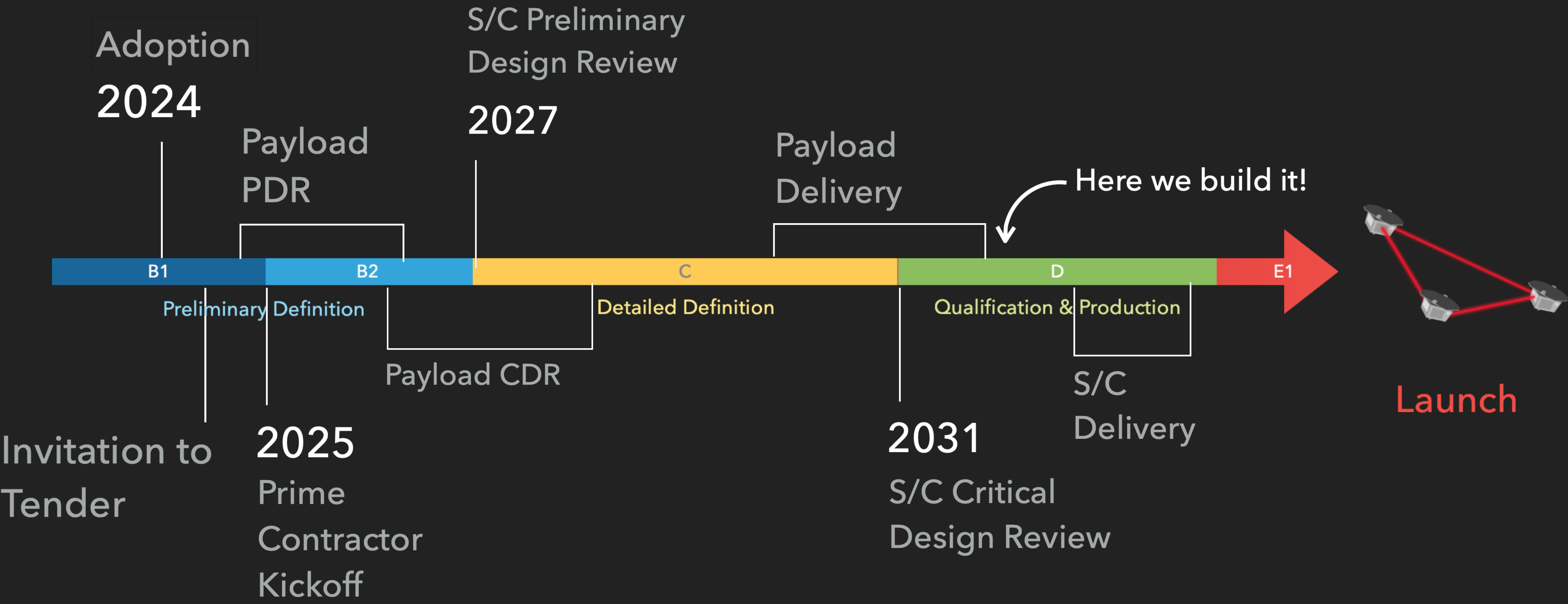
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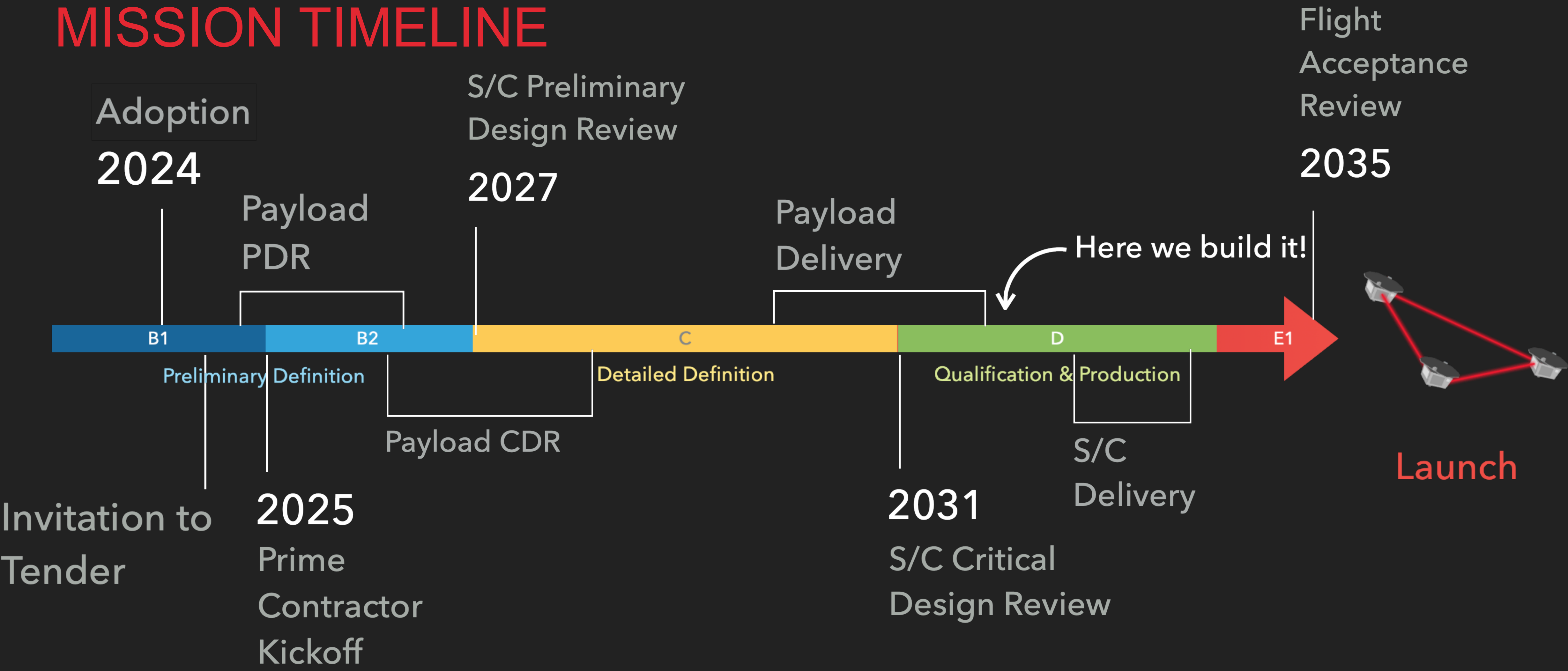
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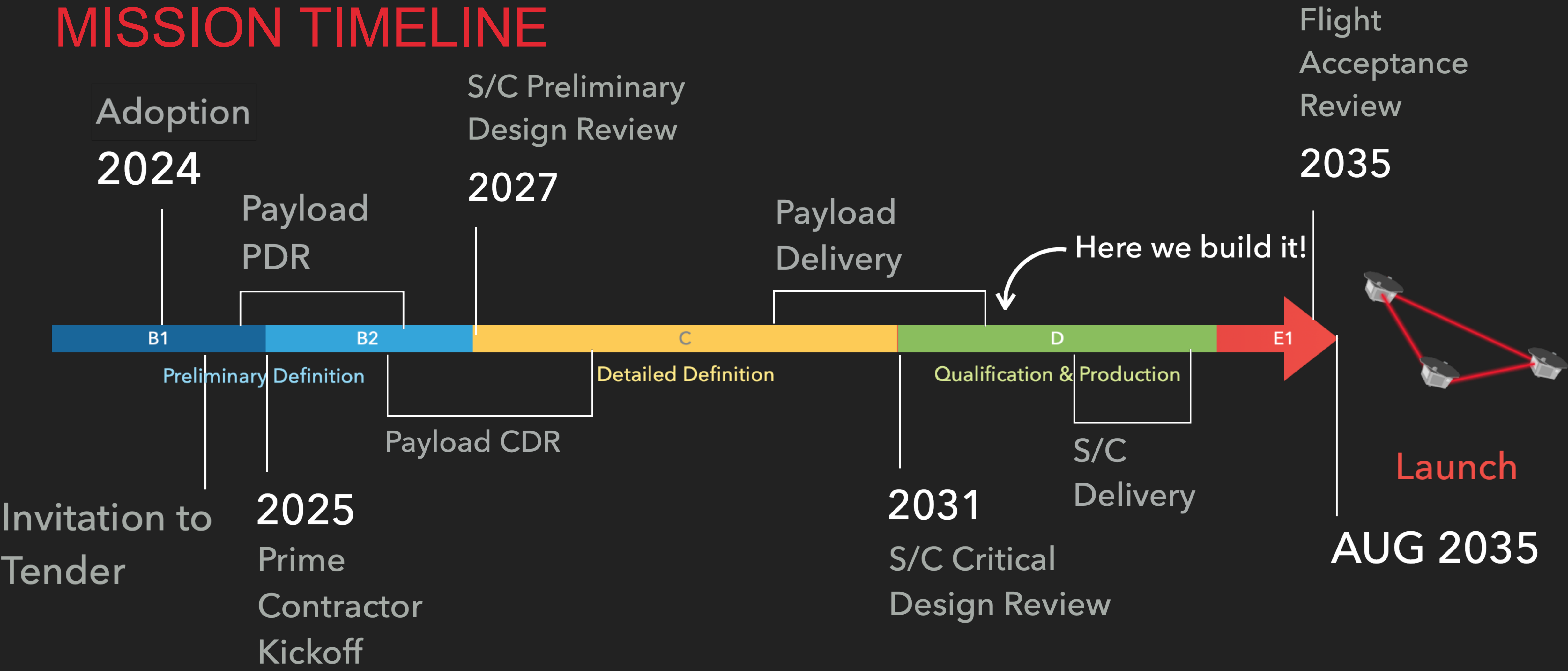
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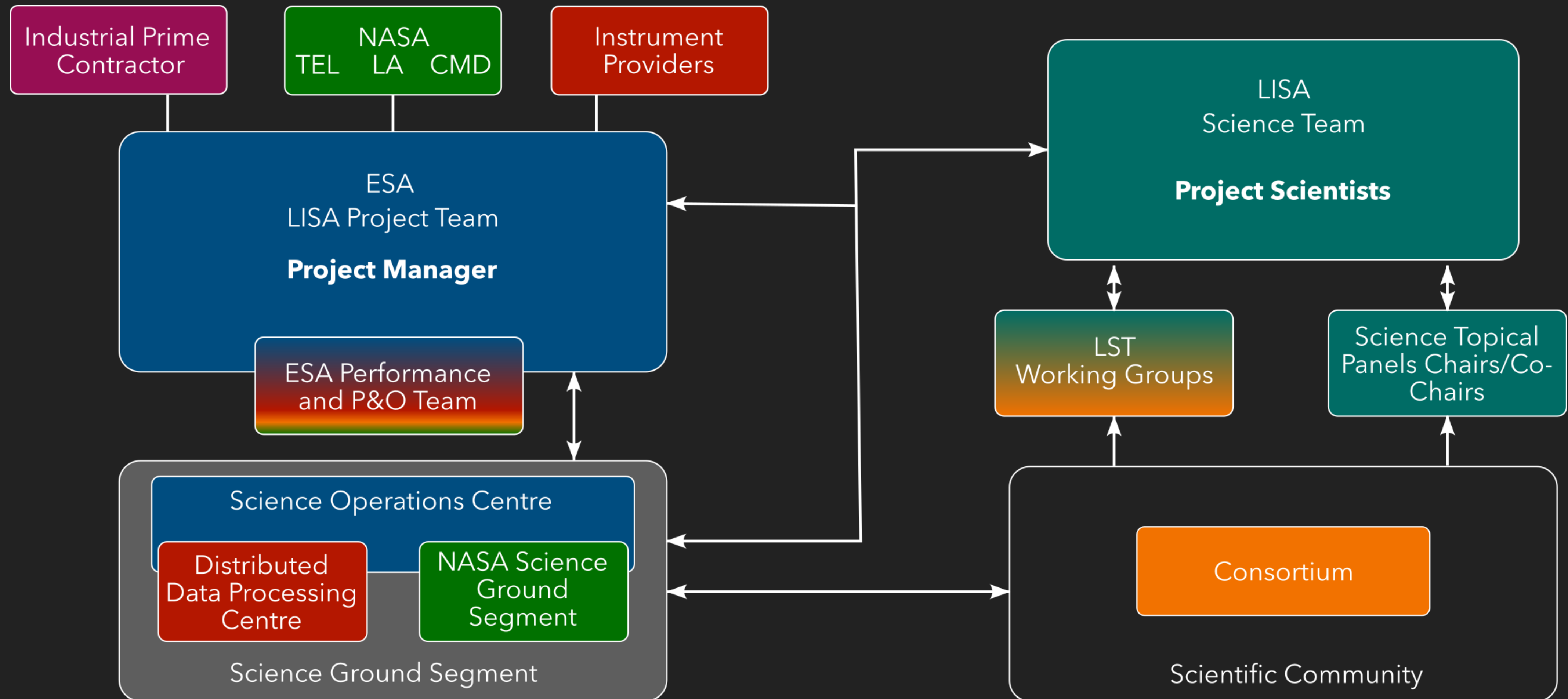
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MISSION TIMELINE

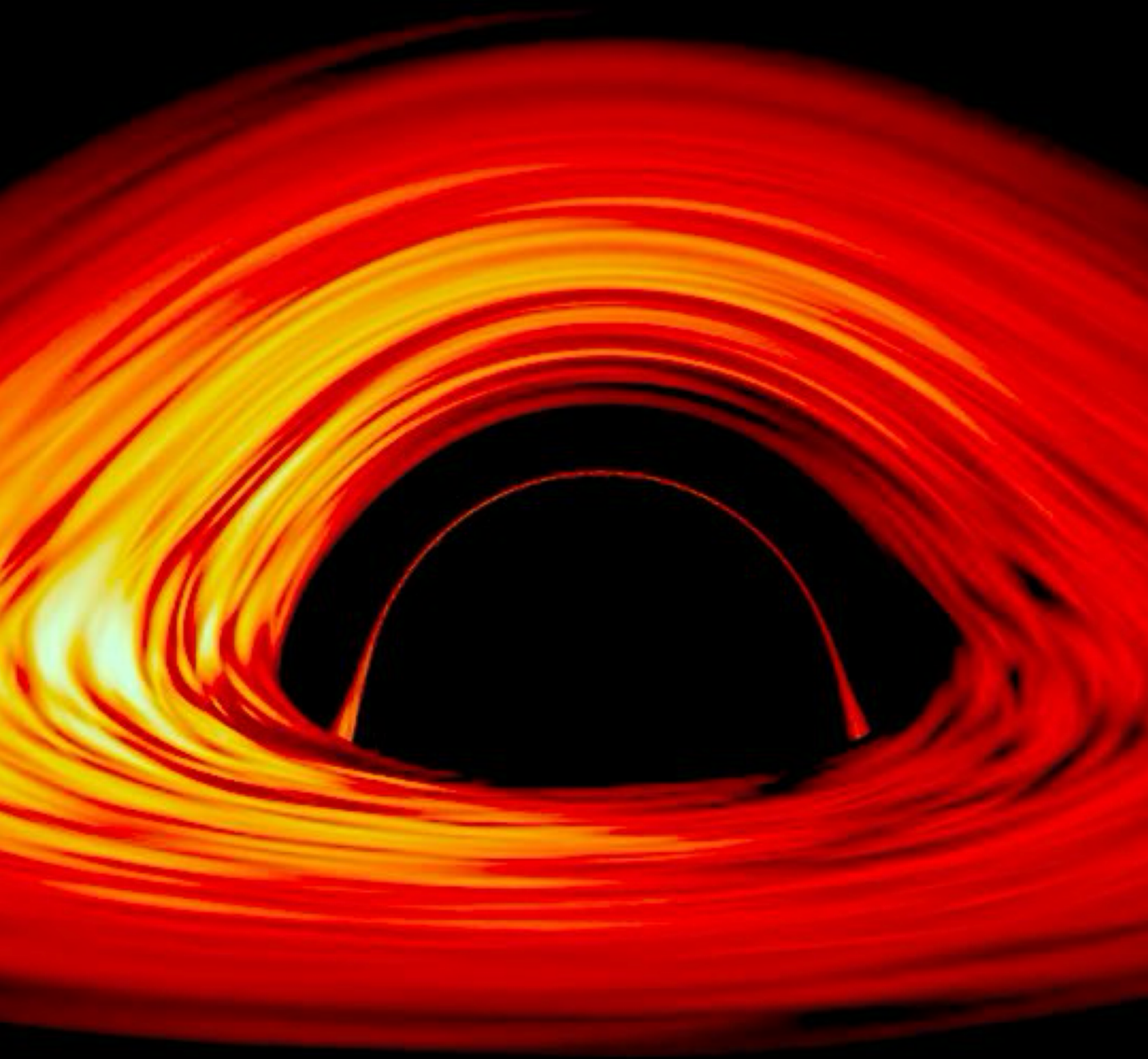


OVERALL STRUCTURE (IMPLEMENTATION PHASE)



LISA

SCIENCE TEAM



TERMS OF REFERENCE (SMP)

Terms of Reference:

- Maximising the scientific return of LISA
- Optimising:
 - The scientific performance of the instrument and spacecraft;
 - The gravitational wave calibration strategy (formulating and maintaining also);
 - Access to the data via the mission archive(s);
 - Analysis and utilisation of LISA data;
- Overseeing the generation of the Level-3 source catalogue from Level-2 data products;
- Authorising the release of scientific data products to the community;
- Establishing Working Groups;
- Establishing and managing the Science Topical Panels (STPs) of the Early Release Science Time;
- Promoting public awareness

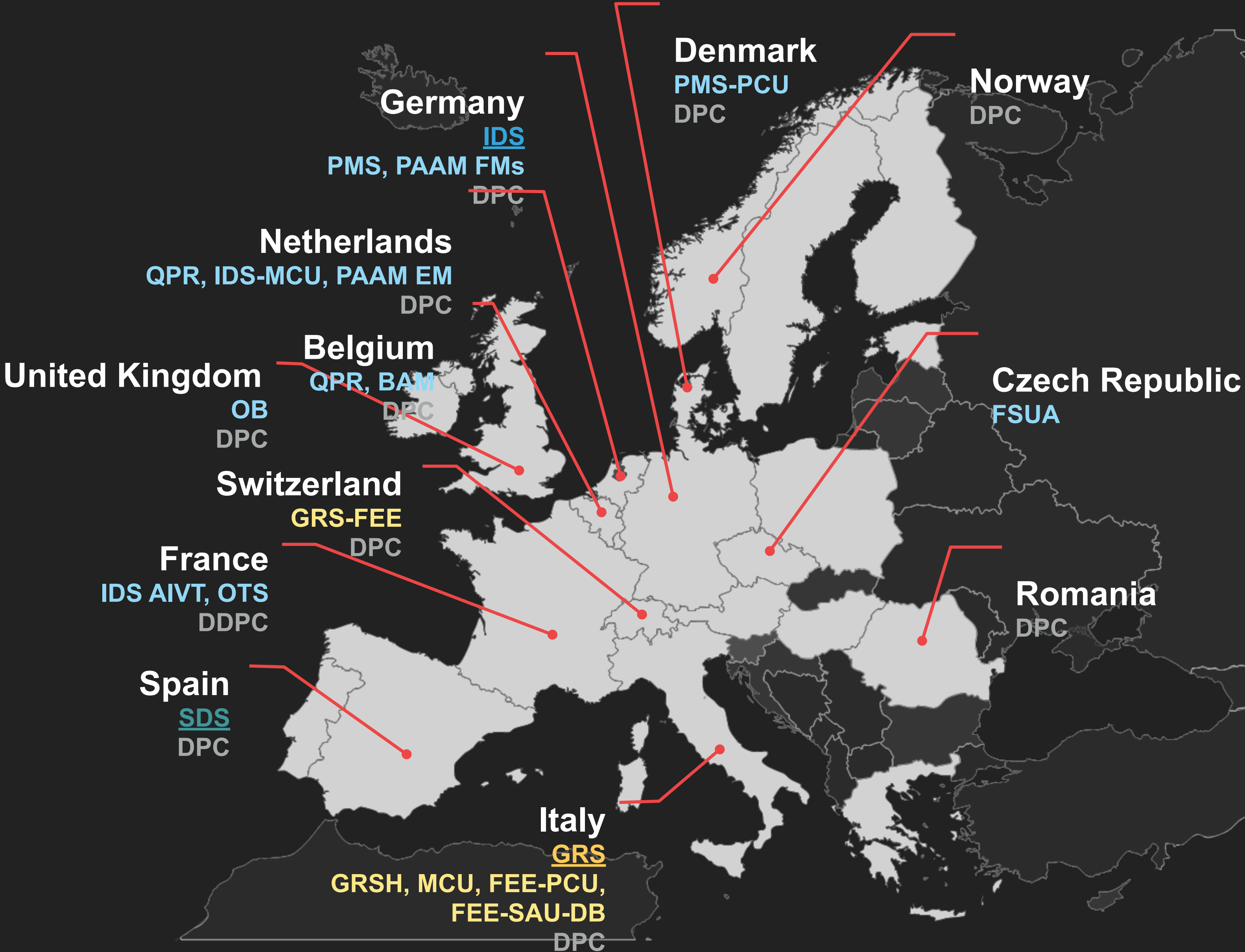
RESPONSIBILITIES

Contributions as per MLA/MoU:

TEL, LAS, GRS, IDS, SDS - System responsibility

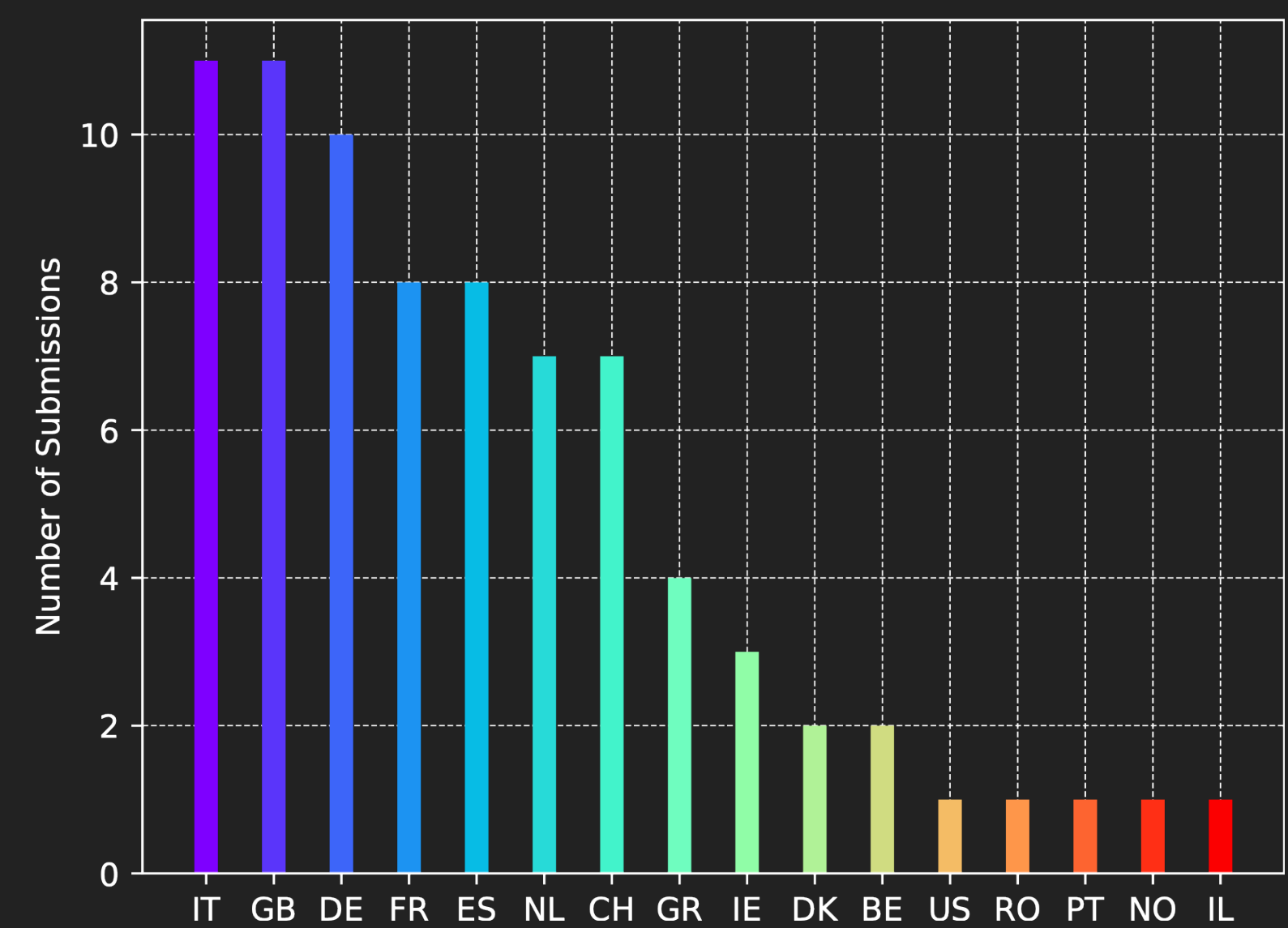
PMS, GRSH - Hardware Contributions

DPC - Ground Segment/Data Processing Contribution

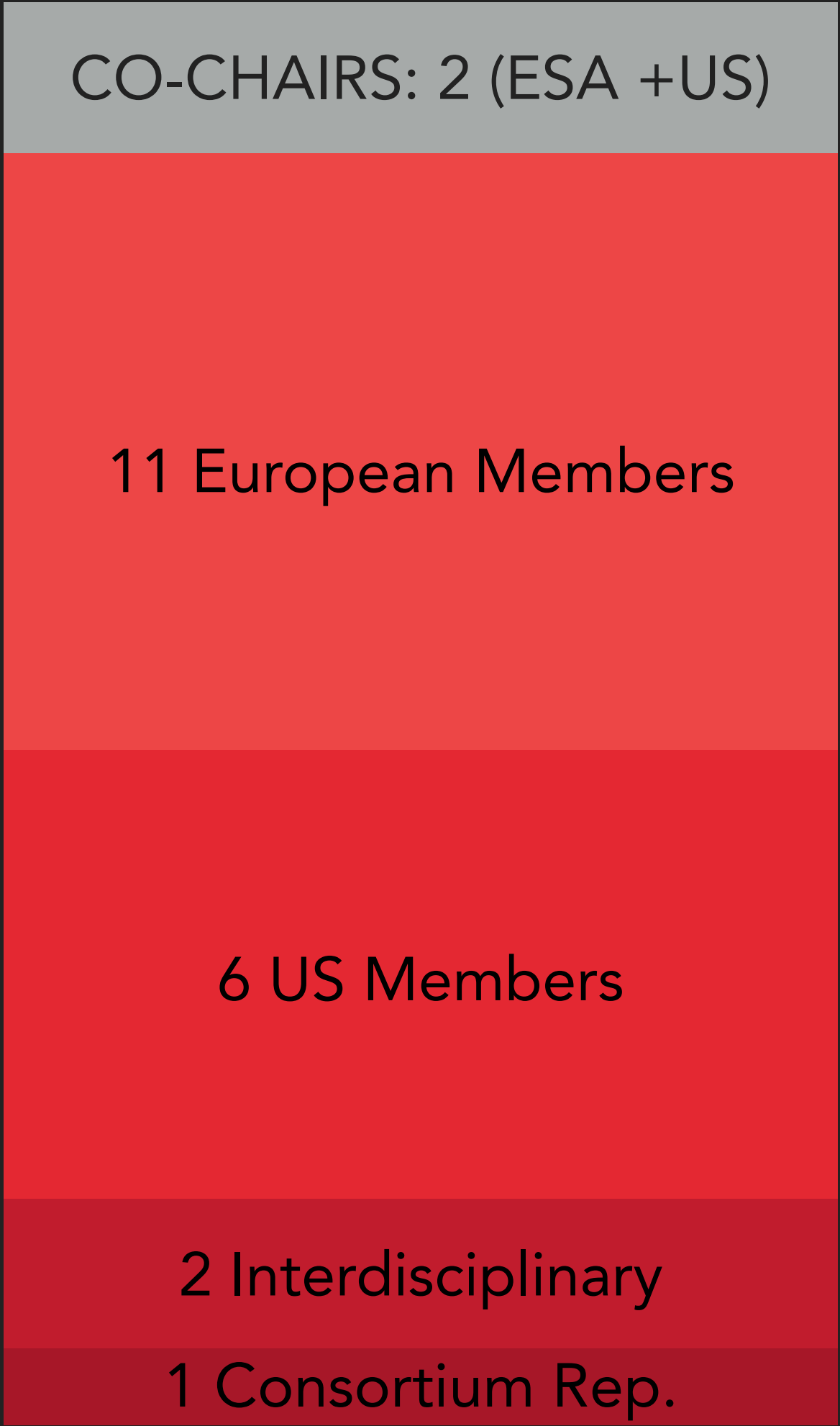
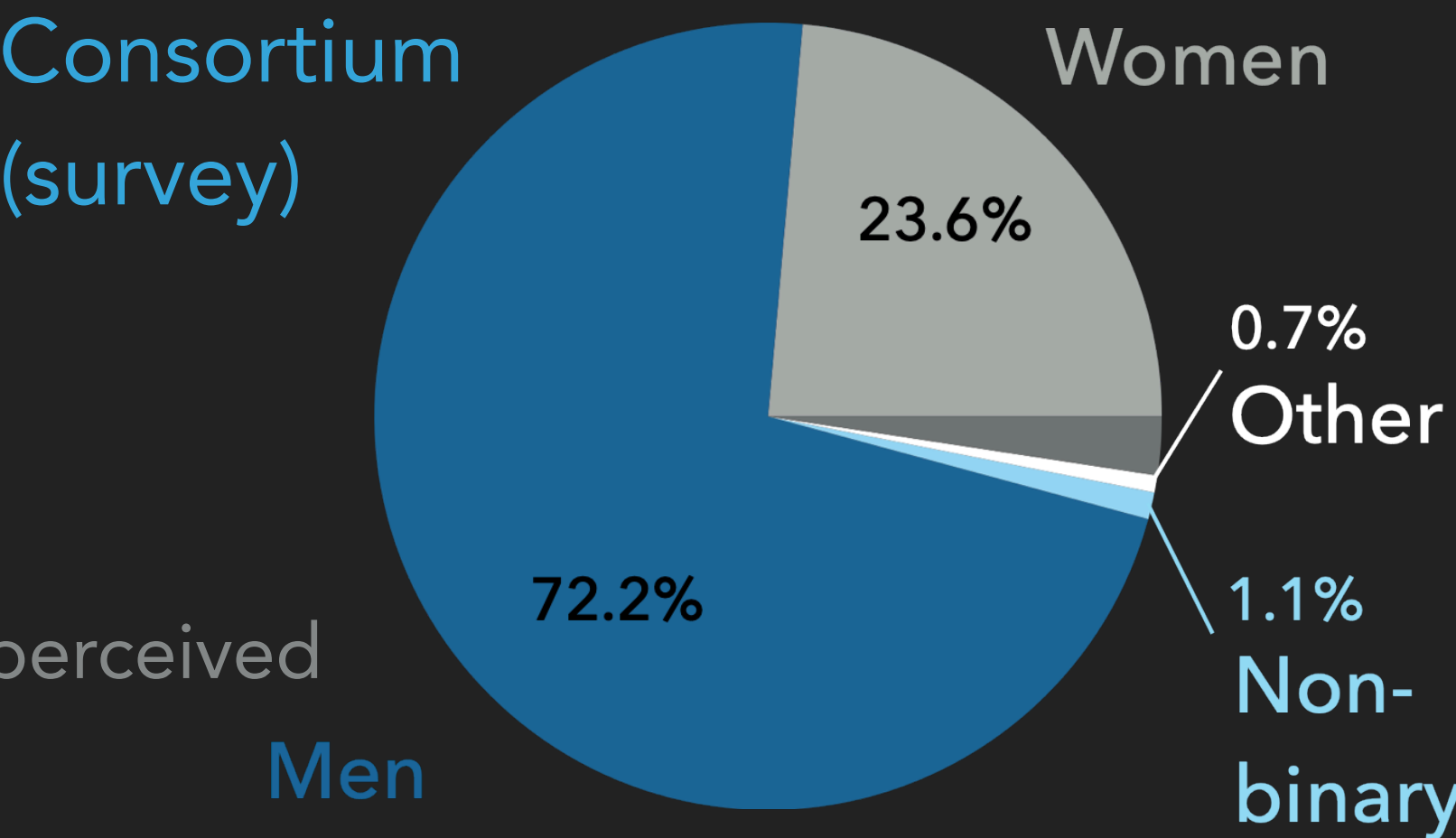
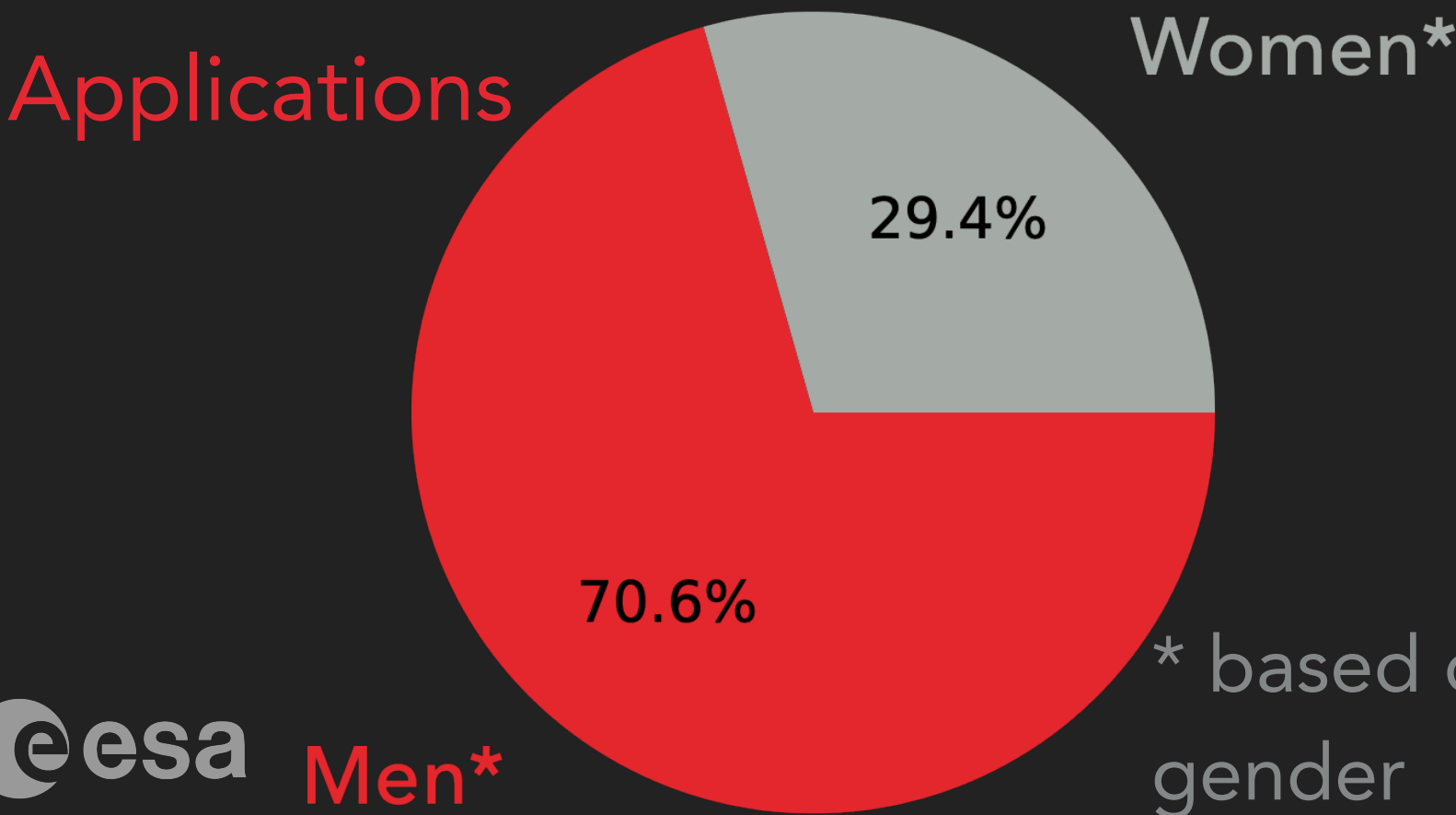
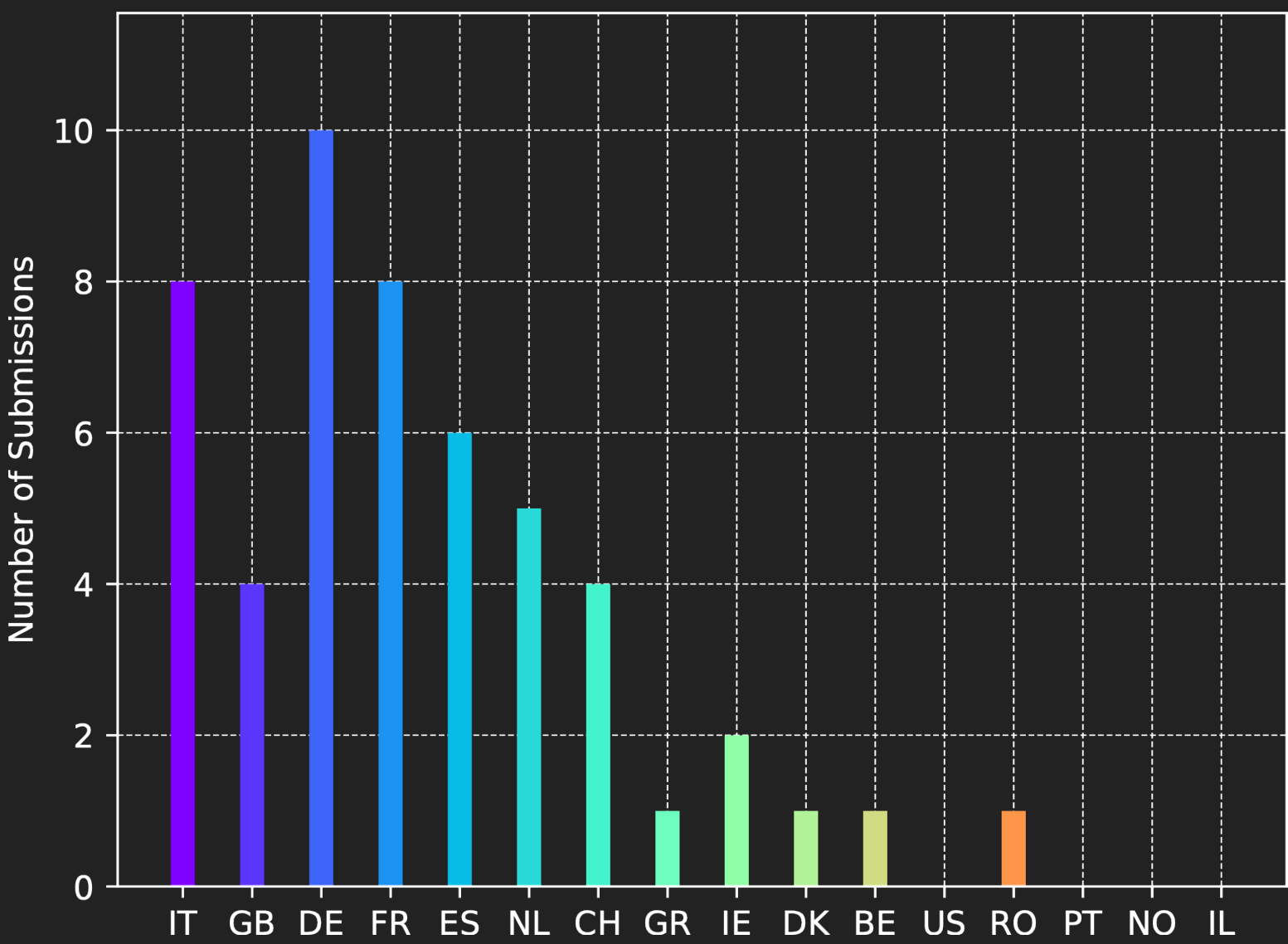


SELECTION OF LISA SCIENCE TEAM: ESA

Letters of Intent (78)



Applications (51)





LISA SCIENCE TEAM MEMBERS

Chiara Caprini

Cosmology
Université de Genève, CH



Guido Müller

Instrumentation - IDS
Albert Einstein Institute, DE



William Joseph Weber

Instrumentation - GRS
University of Trento, IT



Deirdre Shoemaker

Waveforms
UT Austin, US



Anna Heffernan

Waveforms
University of the Balearic Islands, ES



Antoine Petiteau

Data Analysis
CEA - Centre de Saclay, FR



Neil Cornish

Astrophysics
MT State, US



Stephen Taylor

Data Analysis
Vanderbilt, US



Nikolaos Karnesis

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Aristotle University of Thessaloniki, GR



Elena Maria Rossi

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University of Leiden, NL



Krista Lynne Smith

Astrophysics
Texas A&M, US



Catia Grimani

Space Weather, Complementary
Università di Urbino, IT



Valeriya Korol

Astrophysics
Max Planck Institute for Astrophys., DE



Alberto Sesana

Astrophysics
University of Milano Bicocca, IT



Joey Shapiro Key

Astrophysics
UW Bothell, US



Zoltán Haiman

Multi-messenger, Complementary
ISTA, AT



Astrid Lamberts

Astrophysics
Observatoire de la Côte d'Azur, FR



Alberto Vecchio

Astrophysics
University of Birmingham, UK



Erin Kara

Astrophysics
MIT, US



Gijs Nelemans

Consortium Representative
Radboud Universiteit, NL



LISA
CONSORTIUM



LISA SCIENCE TEAM MEMBERS

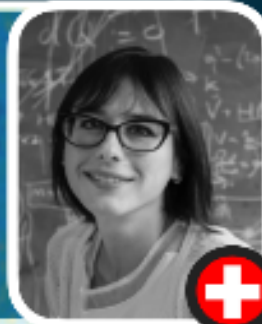


THE CHAIRS:

Oliver Jennrich (ESA)
Nora Lützendorf (ESA)
Ira Thorpe (NASA)

Chiara Caprini

Cosmology
Université de Genève, CH



Guido Müller

Instrumentation - IDS
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Gijs Nelemans

Consortium Representative
Radboud Universiteit, NL



LST COMPLETED TASKS



LST COMPLETED TASKS

Team selected by ESA & NASA

LISA SCIENCE TEAM 2024-2027





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

LISA SCIENCE TEAM MEMBERS

Chiara Caprini Cosmology Université de Genève, CH	Guido Mueller Instrumentation - IDS Albert Einstein Institute, DE	William Joseph Weber Instrumentation - GRS University of Trento, IT	Deirdre Shoemaker Waveforms UT Austin, US
Anna Heffernan Waveforms University of the Balearic Islands, ES	Antoine Petiteau Data Analysis CEA - Centre de Saclay, FR	Neil Cornish Astrophysics MT State, US	Stephen Taylor Data Analysis Vanderbilt, US
Nikolaos Karnesis Data Analysis Aristotle University of Thessaloniki, GR	Elena Rossi Astrophysics University of Leiden, NL	Krista Lynne Smith Astrophysics Texas A&M, US	Gijs Nelemans Consortium Representative Radboud Universiteit, NL
Valeriya Korol Astrophysics Max Planck Institute for Astrophys., DE	Alberto Sesana Astrophysics University of Milano Bicocca, IT	Joey Shapiro Key Astrophysics UW Bothell, US	Interdisciplinary Scientist Expertise University, Country
Astrid Lamberts Astrophysics Observatoire de la Côte d'Azur, FR	Alberto Vecchio Astrophysics University of Birmingham, UK	Erin Kara Astrophysics MIT, US	Interdisciplinary Scientist Expertise University, Country



LST COMPLETED TASKS

Team selected by ESA & NASA

Call and selection of new LST members

LISA SCIENCE TEAM 2024-2027





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LISA SCIENCE TEAM MEMBERS

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LST COMPLETED TASKS

Team selected by ESA & NASA

Call and selection of new LST members

Priority Working Groups formed:



LST COMPLETED TASKS

Team selected by ESA & NASA

Call and selection of new LST members

Priority Working Groups formed:

- Communications
- LISA Author List



LST COMPLETED TASKS

Team selected by ESA & NASA

Call and selection of new LST members

Priority Working Groups formed:

- Communications
- LISA Author List
- L3 catalogue



LST COMPLETED TASKS

Team selected by ESA & NASA

Call and selection of new LST members

Priority Working Groups formed:

- Communications
- LISA Author List
- L3 catalogue
- Figures of Merit



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Call and selection of new LST members

Priority Working Groups formed:

- Communications
- LISA Author List
- L3 catalogue
- Figures of Merit
- Science Topical Panels



LST COMPLETED TASKS

Team selected by ESA & NASA

Call and selection of new LST members

Priority Working Groups formed:

- Communications
- LISA Author List

- L3 catalogue

- Figures of Merit

- Science Topical Panels

LISA summary report for European Strategy for Particle Physics

Science of the LISA mission: A Summary for the European Strategy for Particle Physics

Chiara Caprini*, Anna Heffernan for [The LISA Science Team](#)

Additional authors:

Richard Brito, Gabriele Franciolini, Germano Nardini, Nicola Tamanini, Daniele Steer

April 22, 2025

Abstract

The LISA mission is an international collaboration between [ESA](#), its member states, and [NASA](#), for the detection of gravitational waves from space [1]. It was adopted in January 2024 and is scheduled for launch in the mid-2030's. It will be a constellation of three identical spacecraft forming a near-equilateral triangle in an heliocentric orbit, transferring laser beams over $2.5 \cdot 10^6$ km long arms. Laser interferometry is used to track separations between test masses, thus measuring spacetime strain variations as a function of time. LISA Science Objectives tackle many open questions in astrophysics, fundamental physics and cosmology, including ESA's Cosmic Vision questions [2] "What are the fundamental laws of the universe?" and "How did the universe originate and of what is it made?". In this contribution, based on the LISA Red Book [1], we present a summary of the LISA Science Objectives relevant for the European Strategy for Particle Physics.

WORKING GROUPS: L3 CATALOGUE

Chairs: Astrid Lamberts (OCA), Nikolaos Karnesis (AUFh)

Members from LST: Krista Smith (TAMU), Neil Cornish (MTS), Chiara Caprini (UG), Steve Taylor (Vanderbilt), Gijs Nelemans (Radboud), Deirdre Shoemaker (UT Austin) + **Experts:** A. Renzini, E. Castelli, J. Kanner, J. Baker, M. Volonteri, N. Webb



OBJECTIVES

- Requirements / Definitions on the catalogues by 2026:
 - Content
 - Quantities
 - Tools
- Status: Started with the definition of the "Golden Catalog"
- Sources with high confidence. (list of sources all Global Fits on).



WORKING GROUPS: FIGURES OF MERIT (FoM)

Chairs: Antoine Petiteau (CEA), Alberto Sesana (UMB)

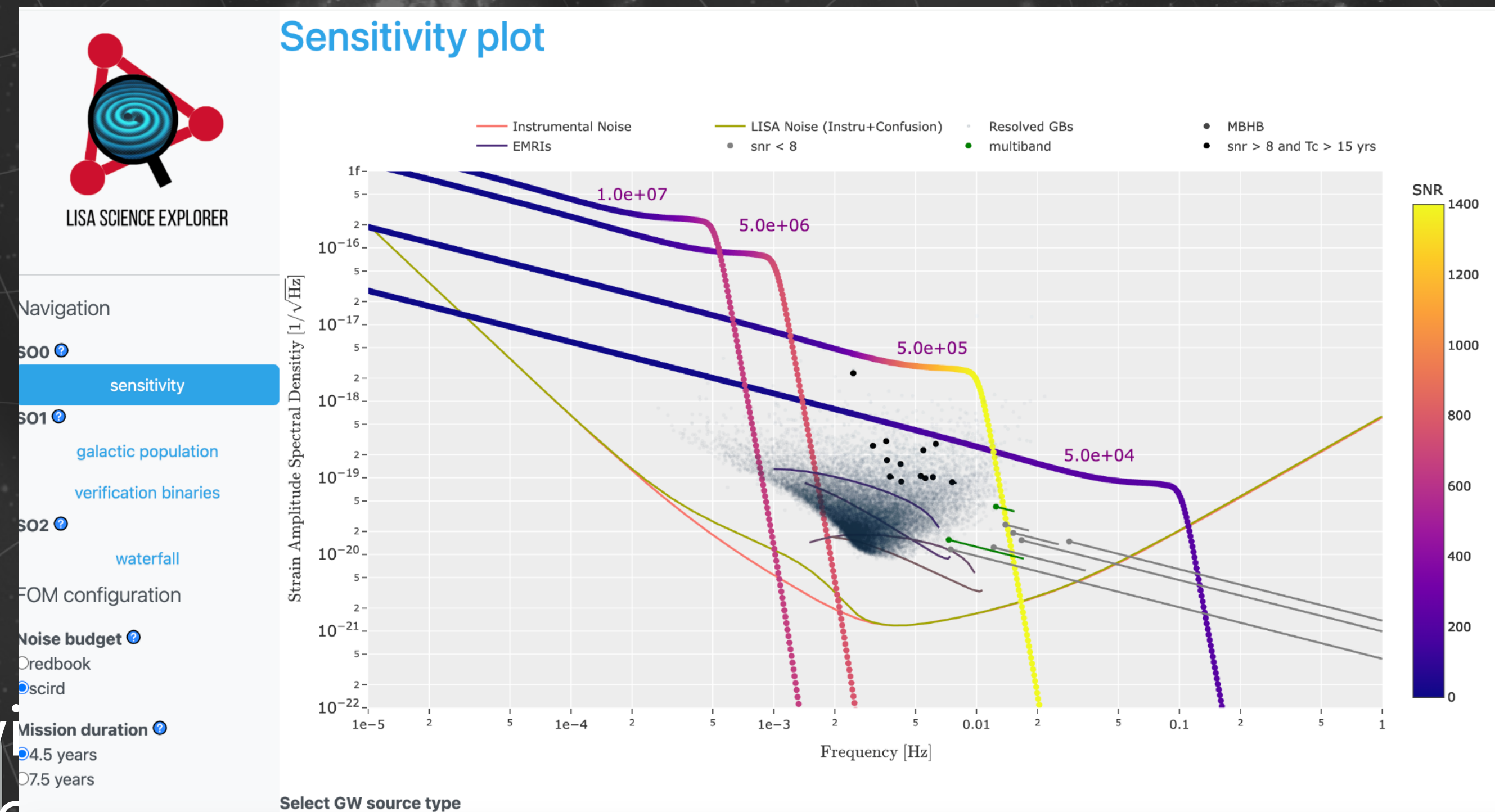
Members: Chiara Caprini (UG), Elena M. Rossi, (UL), William J. Weber (UT), Alberto Vecchio (UB)

EXISTING FOM TOOL

- Result of years of development in the LISA Consortium
- Organised by Science Objectives and Science Investigations
- Was used for the LISA Redbook
- 2 versions: Static and interactive (dev)

THIS WORKING GROUP

- Endorse a (sub)set of FoM that LST will use for assessing science performance
- Review process for their calculation
- Identify scenarios for assessment (gaps, etc.)



Interactive (in development):

<https://lisa-science-explorer.in2p3.fr/so0-sensitivity>

Static:

https://wiki-lisa.in2p3.fr/fom-sites/dc_82_fmin_1e-4/site/

WORKING GROUPS: COMMUNICATIONS

Chairs: Anna Heffernan (UIB), Krista Smith (TAMU)

Members: Gijs Nelemans (RU), Joey Shapiro Key (UWB), Valeriya Korol (MPG), Ann H. Cardiff (NASA)

OBJECTIVES

- Establish communication channels with the consortium and the community
- Get overview on all ongoing calls and meetings
 - Maintain a system for LST members to join important calls / meetings
- Interactions with GWIC, DDPC, NSGS

COMMUNICATION AVENUES

- ❖ Online presence:
 - ESA, NASA
 - LISA Consortium (wiki & public)
- ❖ Conferences / meetings
 - LST members available
- ❖ Contactable (email)

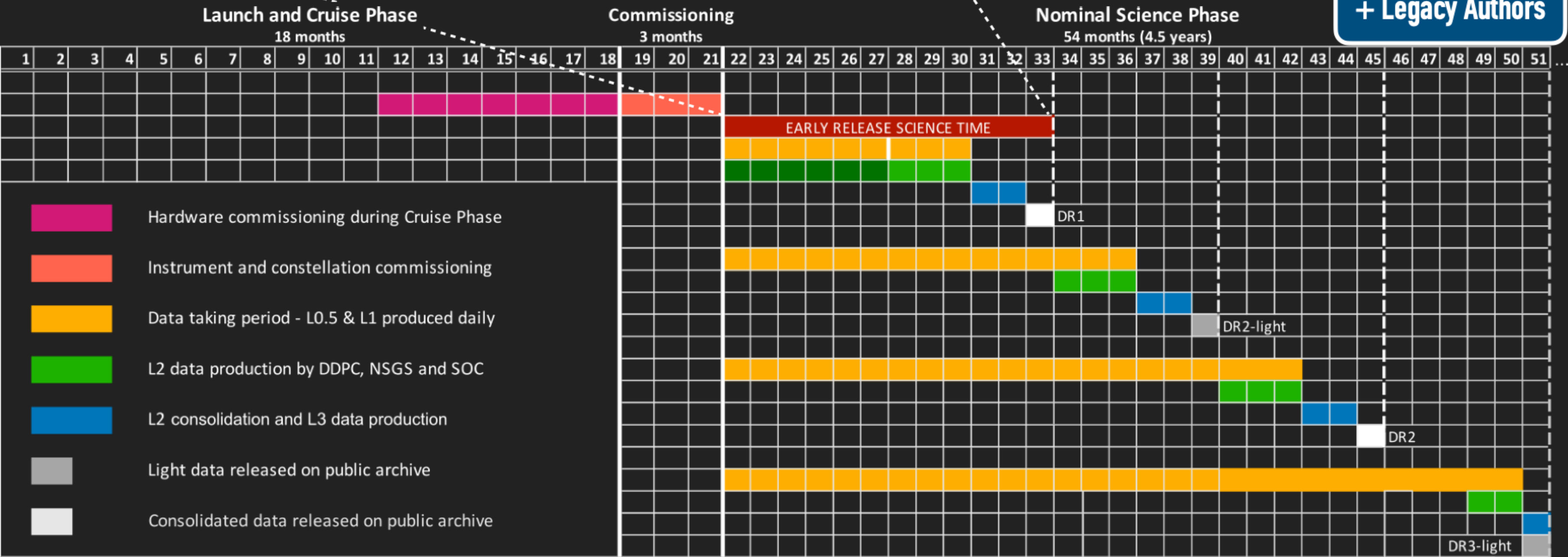
WORK TO DATE

- ❖ Summary document (work to date)
- ❖ RTQ / FAQ doc
- ❖ Living slides (these)
- ❖ List of:
 - Community calls
 - Conferences / Meetings

WORKING GROUPS: SCIENCE TOPICAL PANELS

Chairs: Elena M. Rossi (UL),
Members: Stephen Taylor (VU), Chiara Caprini (UG), Anna Heffernan (UIB), William J. Weber (UT),
Alberto Vecchio (UB), Nikolaos Karnesis (AUT), Erin Kara (MIT), Joey Shapiro Key (UWB)

DATA POLICY



OBJECTIVES

Selection process for:

- Topics / Themes
- Members
- Size
- End of life

WORKING GROUPS: AUTHOR LISTS

Chairs: Gijs Nelemans (RU), Neil Cornish (MTS)

OBJECTIVES

Determine process / rules for creating and maintaining the LISA mission author lists

EXPECTED PAPERS (OUTLINED IN SCIENCE MANAGEMENT PLAN)

- A set of pre-defined instrument / science verification papers will be released with each formal data release.
- There will be a few first high impact discovery papers

AUTHOR LISTS (OUTLINED IN SCIENCE MANAGEMENT PLAN)

- LISA heritage author list: Members of the community that made a significance contribution to the mission (no expiration date)
- LISA member author list: Scientists and engineers working on the mission at time of science operations (roll-off period of 2 years after leaving mission)

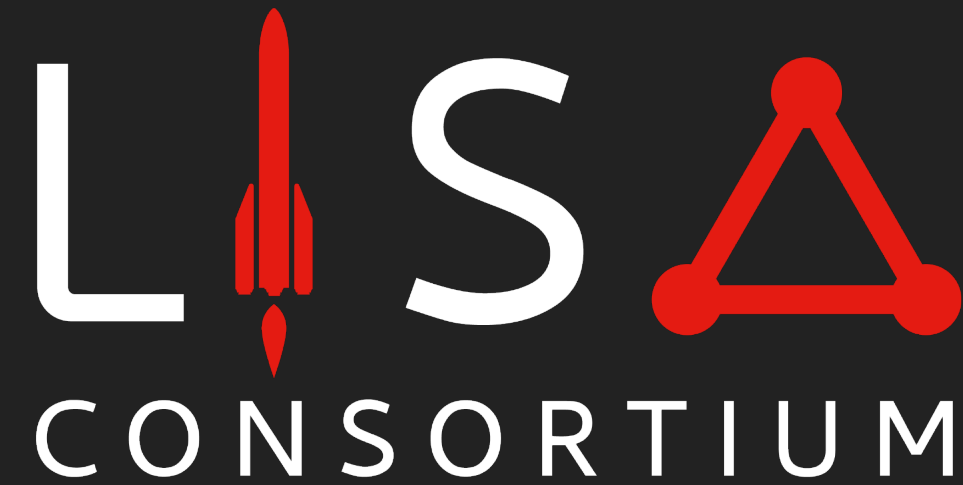
DIFFERENCES BETWEEN CONSORTIUM AND LST

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- Collaboration of community members
- Working on optimally preparing and harvesting LISA data
- Supporting the LISA mission informally (i.e. without formal agreement with ESA)
- Promoting LISA and LISA science
- Community building

DIFFERENCES BETWEEN CONSORTIUM AND LST



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LISA
Science Team



- Formal link between ESA / NASA and community
- Responsible for STP formation
- Responsible for keeping legacy author list
- Responsible for data releases and content (in particular catalogues)
- Appointed by ESA/NASA
- LST working groups can involve community

LISA

CONSORTIUM



CURRENT STATUS



All Members

- Involved and informed
- Directory and email lists
- Workshops and meetings
- Announcements and LISA communications

Community Members

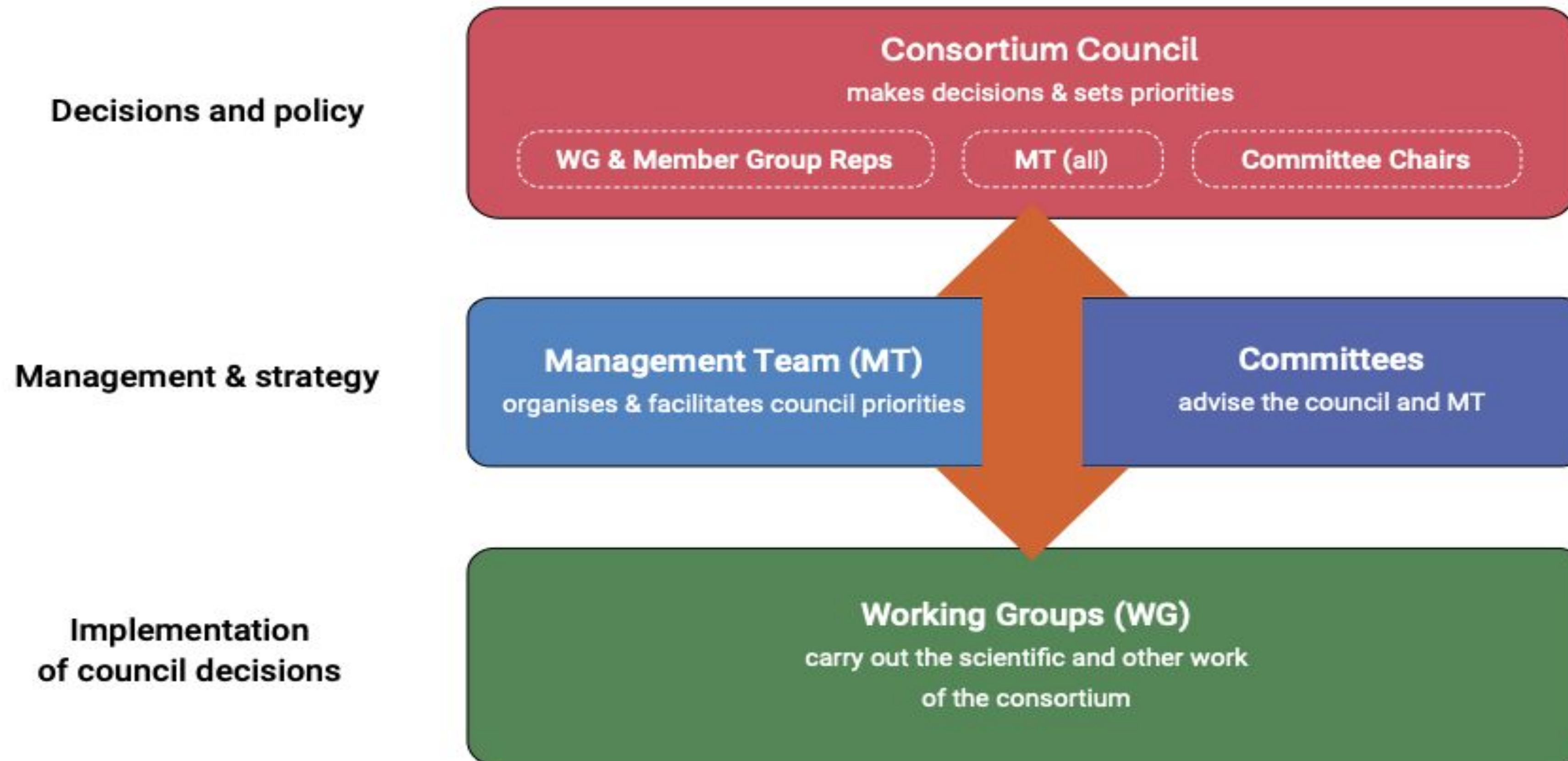
- No deliverables required
- No membership reviews
- No automatic right to opt in as authors
- Cannot be attached to member

Core Members

- Deliverables required
- Membership reviews
- Opt-in to author list of consortium papers
- Can self-organise into member groups

CURRENT STATUS

Consortium Organisation Chart



THE END

Thanks!

This work was supported by the Universitat de les Illes Balears (UIB); the Spanish Agencia Estatal de Investigación grants PID2022-138626NB-I00, RED2022-134204-E, RED2022-134411-T, funded by MICIU/AEI/10.13039/501100011033 and the ERDF/EU; and the Comunitat Autònoma de les Illes Balears through the Conselleria d'Educació i Universitats with funds from the European Union - NextGenerationEU/PRTR-C17.I1 (SINCO2022/6719) and from the European Union - European Regional Development Fund (ERDF) (SINCO2022/18146).

A. Heffernan is supported by grant PD-034-2023 co-financed by the Govern Balear and the European Social Fund Plus (ESF+) 2021-2027

