



# FELIX (Friendly Enhanced LISA Information Retrieval). An AI assistant for LISA

~~Performance & Operations task~~

~~Constellation approximation: correlation and mission performance formulation~~

J. Martino & l'équipe Info de l'APC  
M.Lejeune, P. Zakharov, S.Dong



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# FELIX

Friendly Enhanced LISA Information eXplorer

*⚠ Disclaimer: The information provided here is not public and must remain within the LISA Project.*

## Performance & Operations

> Document Corpus

### What do you need to know about LISA today? ⇄

*FELIX is your on-demand technical knowledge base for the LISA mission. Ask it anything about instrument performance, noise budgets, operational procedures, or system specifications, and get precise answers grounded in the mission's own documentation.*

*Always verify the answers before using them.*

> Show Sources Used

Ask a question...



Describe the brownian noise and provide formula. Is this noise stationary ?



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Brownian noise (specifically Brownian force noise) in the LISA mission arises from the impacts of residual gas molecules colliding with the Test Mass (TM). It is a dominant noise source at **mHz** frequencies and is a function of the residual gas pressure around the Test Mass.

## Physical Model and Formula

The Brownian noise can be described using a Model Based Estimate (MBE) or Current Best Estimate (CBE). The MBE value of  $1.7 \text{ fm/s}^2/\text{Hz}^{1/2}$  is obtained directly from the following equation, assuming a residual pressure requirement of  $p = 2 \text{ }\mu\text{Pa}$ :

$$S_g^{Br} = \alpha_{Br} \left(1 + \frac{\pi}{8}\right) \frac{s_{TM}^2}{m_{TM}^2} p \left(\frac{512 m_0 k_B T}{\pi}\right)^{1/2} = \left[1.7 \text{ fm/s}^2/\text{Hz}^{1/2} \times \left(\frac{p}{2 \text{ }\mu\text{Pa H}_2\text{O}}\right)^{1/2}\right]^2 \quad (1)$$

Where:

- $\alpha_{Br} \approx 13$ : Brownian noise geometrical amplification factor due to the proximity of the electrode housing (EH) surfaces to the TM.
- $s_{TM}$ : Test Mass size.
- $m_{TM}$ : Test Mass mass.
- $p$ : Residual gas pressure.
- $m_0$ : Effective molecular weight of the gas species (likely water,  $\text{H}_2\text{O}$ ).
- $k_B$ : Boltzmann constant.
- $T$ : GRS temperature.

Alternatively, the analytical model (MBE or CBE) is represented as:  $\sqrt{\alpha_{noise} \times (1 + \pi/8) \times (TMsize/TMmass)^2 \times VacuumPressure \times \sqrt{512 \times H2Omo \times KB \times T\_GRS/\pi}}$  (Source: LISA Constellation Performance Model, IRD2-GRS-04600)

## Stationarity

The provided documents do not explicitly state whether this noise is stationary; however, they indicate that the noise level is expected to change over time. The pressure (and thus the noise) is expected to decrease following a slow power law after the cruise time, specifically:  $\sim (t - t_{vent})^{-0.8}$  (observed in LPF) or  $\sim (t - t_{vent})^{-0.5}$  (literature values) (Source: LISA Constellation Performance Description Document: ESA-



c'est quoi IRD2-IDS-09270 ?



c'est quoi IRD2-IDS-09270 ?



L'IRD2-IDS-09270 (**Line of Sight Alignment**) est une exigence relative à la contribution du sous-système IDS (Interferometric Detection Subsystem) à l'alignement de la ligne de visée (LoS).

Voici les détails techniques associés :

- **Description** : Cette exigence définit la contribution de l'IDS à l'angle entre le vecteur RX tel que construit (as-built) et la normale du Test Mass (TM) telle que construite, mesuré dans le référentiel de l'Optical Bench (OB)/OIRF/Telescope (TEL).
- **Valeurs limites** : Les composantes de cet angle doivent être inférieures à :
  - $R_y \leq \pm 75 \mu\text{rad}$
  - $R_z \leq \pm 75 \mu\text{rad}$
- **Justification (Rationale)** : L'Optical Bench (OB) contribue à l'alignement de la LoS. L'alignement total de la LoS considéré dans le modèle de performance est de  $100 \mu\text{rad}$  dans le budget BGT-SYS-26100.
- **Note additionnelle** : Cette exigence contribue également au budget d'alignement angulaire OB-GRS (BGT-SYS-05100) à l'entrée BGT-SYS-05110.

Source: IDS IRD2: ESA-LISA-EST-IDS-RS-0002, IRD2-IDS-09270

Not satisfied

Why ?



# Large Project Documentation



Usually it's a mess !

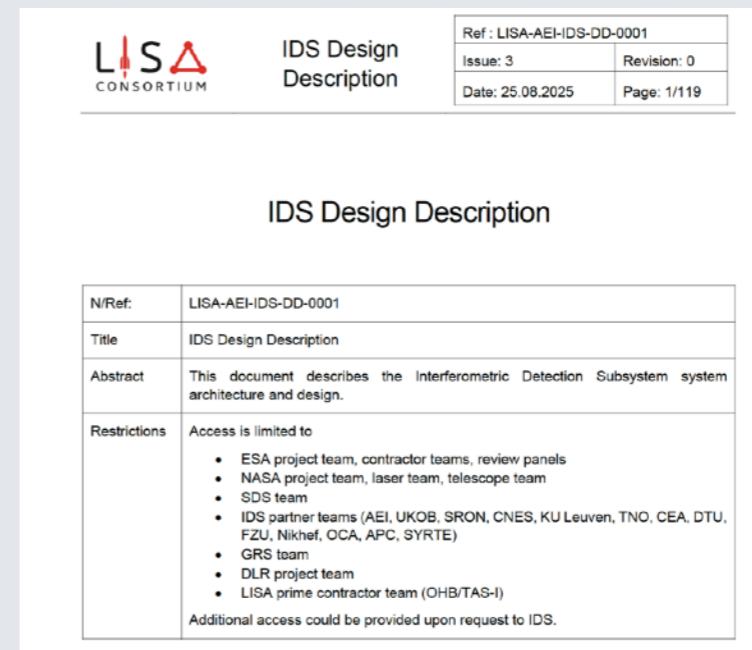
Where can I find reliable and up to date information ?

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**O5 Technical Design Report**



**IDS PDR datapack**

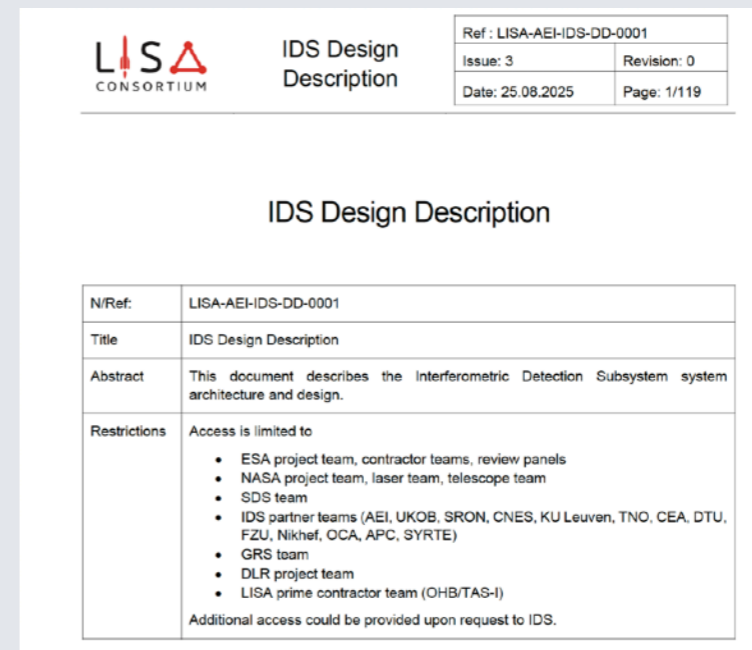
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- > Everything in 959 pages
- > Not self consistent
- > rarely updated
- > Technical information mixed up with non relevant information



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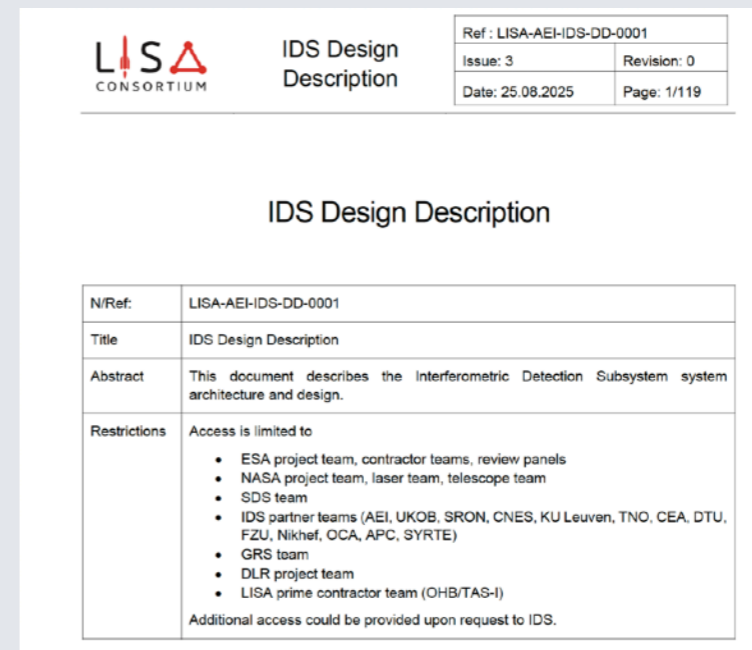
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## IDS PDR datapack

- > Everything in 126 documents !
- > Information is scattered around and redundant (prone to error)
- > Multiple versions of each documents
- > Not easily understandable from outside the project.

A LLM to answer the user query based  
on Project Database

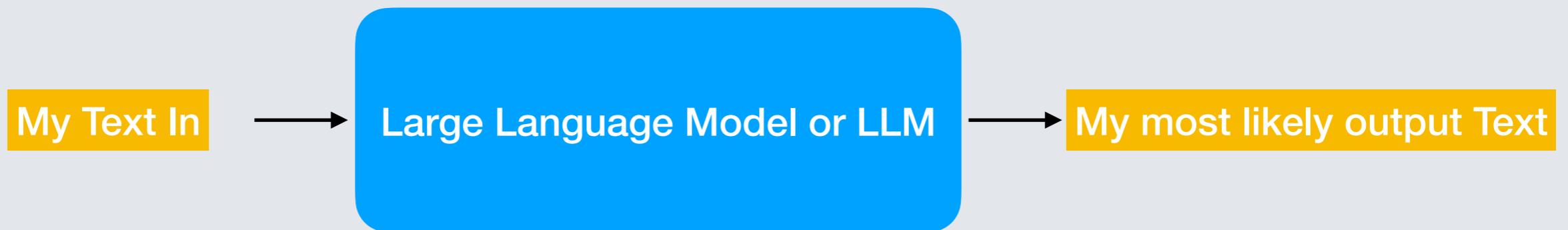
## A LLM to answer the user query based on Project Database

### The engine

Large Language Model or LLM

## A LLM to answer the user query based on Project Database

**The engine**



## A LLM to answer the user query based on Project Database

### The engine

My Text In



Large Language Model or LLM



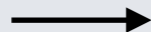
My most likely output Text

- Query
- Context
- Assistant Role
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- history
- etc...

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- Clarification
- Query Parsing
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**FELIX**

**The engine**

**My Text In**

**Large Language Model or LLM**

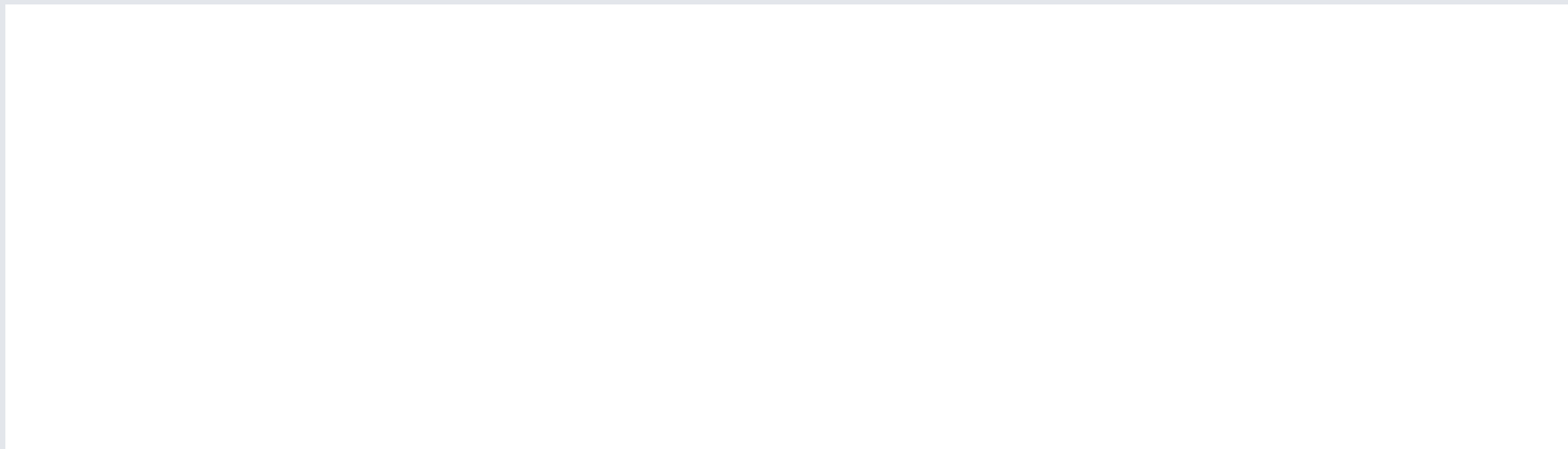
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<b>Application</b>	<b>Underlying model(s)</b>
<b>Claude.ai</b>	Claude Sonnet, Opus, Haiku...
<b>ChatGPT</b>	GPT-4o, GPT-4, o1...
<b>Microsoft Copilot</b>	GPT-4o (via Azure OpenAI)
<b>Gemini (gemini.google.com)</b>	Gemini 1.5 Pro/Flash...

A statistical model trained to predict the next word (~ token) in a sequence



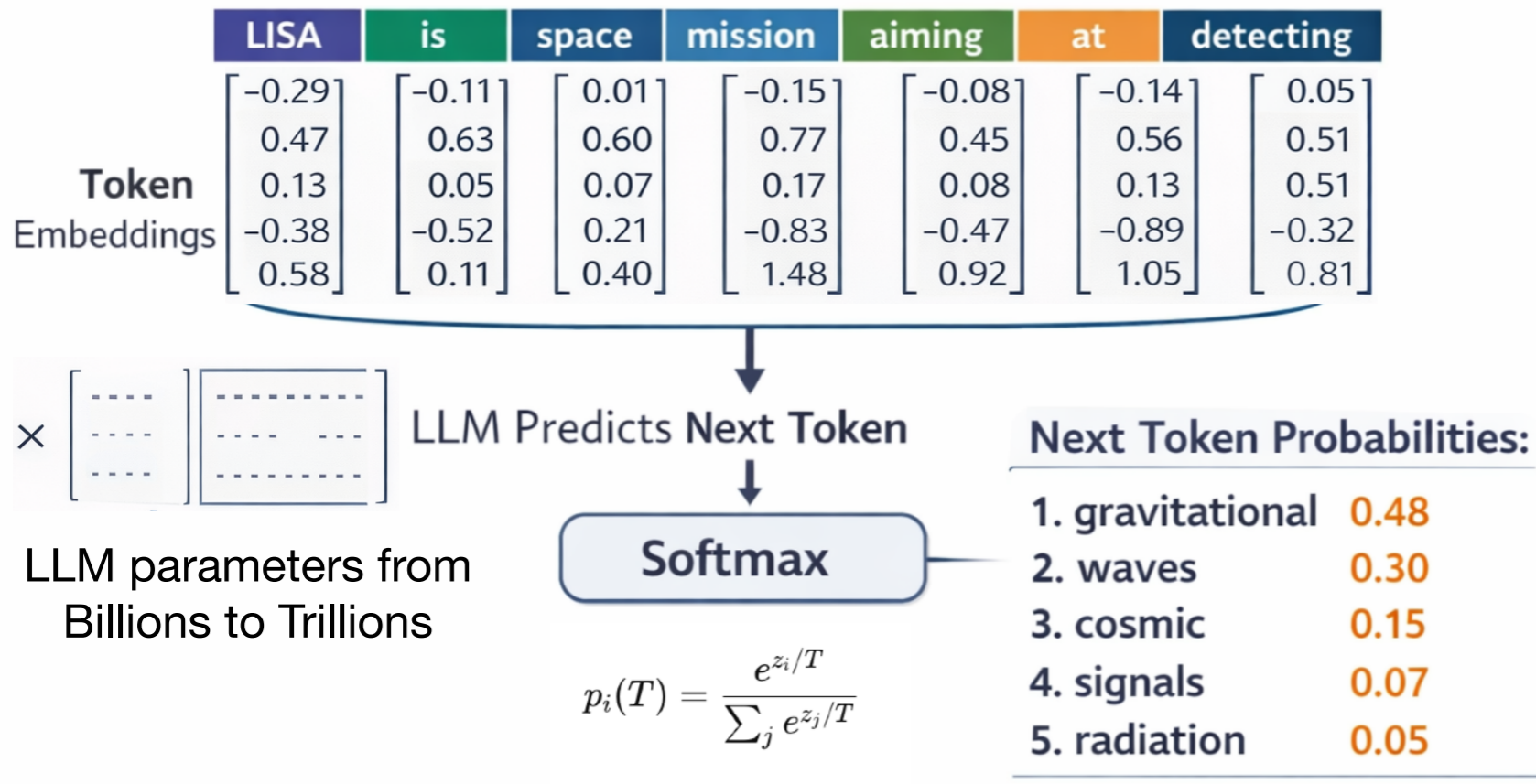
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LISA is a space mission aiming at detecting ...?

	LISA	is	space	mission	aiming	at	detecting
Token Embeddings	$\begin{bmatrix} -0.29 \\ 0.47 \\ 0.13 \\ -0.38 \\ 0.58 \end{bmatrix}$	$\begin{bmatrix} -0.11 \\ 0.63 \\ 0.05 \\ -0.52 \\ 0.11 \end{bmatrix}$	$\begin{bmatrix} 0.01 \\ 0.60 \\ 0.07 \\ 0.21 \\ 0.40 \end{bmatrix}$	$\begin{bmatrix} -0.15 \\ 0.77 \\ 0.17 \\ -0.83 \\ 1.48 \end{bmatrix}$	$\begin{bmatrix} -0.08 \\ 0.45 \\ 0.08 \\ -0.47 \\ 0.92 \end{bmatrix}$	$\begin{bmatrix} -0.14 \\ 0.56 \\ 0.13 \\ -0.89 \\ 1.05 \end{bmatrix}$	$\begin{bmatrix} 0.05 \\ 0.51 \\ 0.51 \\ -0.32 \\ 0.81 \end{bmatrix}$

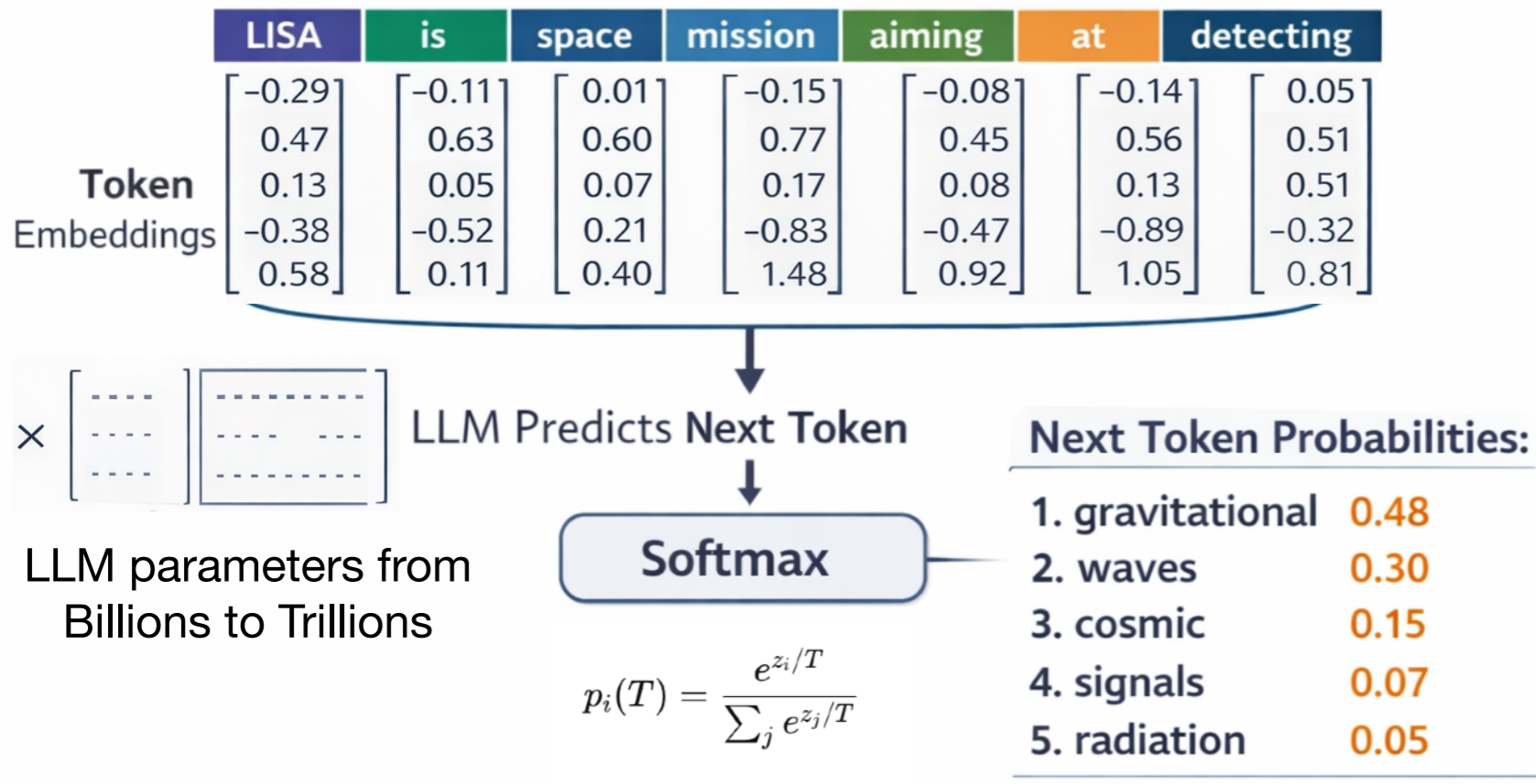
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## LISA is a space mission aiming at detecting ...?



A statistical model trained to predict the next word (~ token) in a sequence

## LISA is a space mission aiming at detecting ...?



LISA is a space mission aiming at detecting gravitational ...

A statistical model trained to predict the next word (~ token) in a sequence

## LISA is a space mission aiming at detecting ...?

Token	LISA	is	space	mission	aiming	at	detecting
Embeddings	$\begin{bmatrix} -0.29 \\ 0.47 \\ 0.13 \\ -0.38 \\ 0.58 \end{bmatrix}$	$\begin{bmatrix} -0.11 \\ 0.63 \\ 0.05 \\ -0.52 \\ 0.11 \end{bmatrix}$	$\begin{bmatrix} 0.01 \\ 0.60 \\ 0.07 \\ 0.21 \\ 0.40 \end{bmatrix}$	$\begin{bmatrix} -0.15 \\ 0.77 \\ 0.17 \\ -0.83 \\ 1.48 \end{bmatrix}$	$\begin{bmatrix} -0.08 \\ 0.45 \\ 0.08 \\ -0.47 \\ 0.92 \end{bmatrix}$	$\begin{bmatrix} -0.14 \\ 0.56 \\ 0.13 \\ -0.89 \\ 1.05 \end{bmatrix}$	$\begin{bmatrix} 0.05 \\ 0.51 \\ 0.51 \\ -0.32 \\ 0.81 \end{bmatrix}$



LLM parameters from Billions to Trillions

LLM Predicts Next Token



$$p_i(T) = \frac{e^{z_i/T}}{\sum_j e^{z_j/T}}$$

Next Token Probabilities:

- 1. gravitational **0.48**
- 2. waves **0.30**
- 3. cosmic **0.15**
- 4. signals **0.07**
- 5. radiation **0.05**

### Key Properties

- Natural language understanding
- Intrinsically statistical
- Trained on a large corpus of « public » data.

LISA is a space mission aiming at detecting gravitational ...

- Not authoritative on LISA specific material

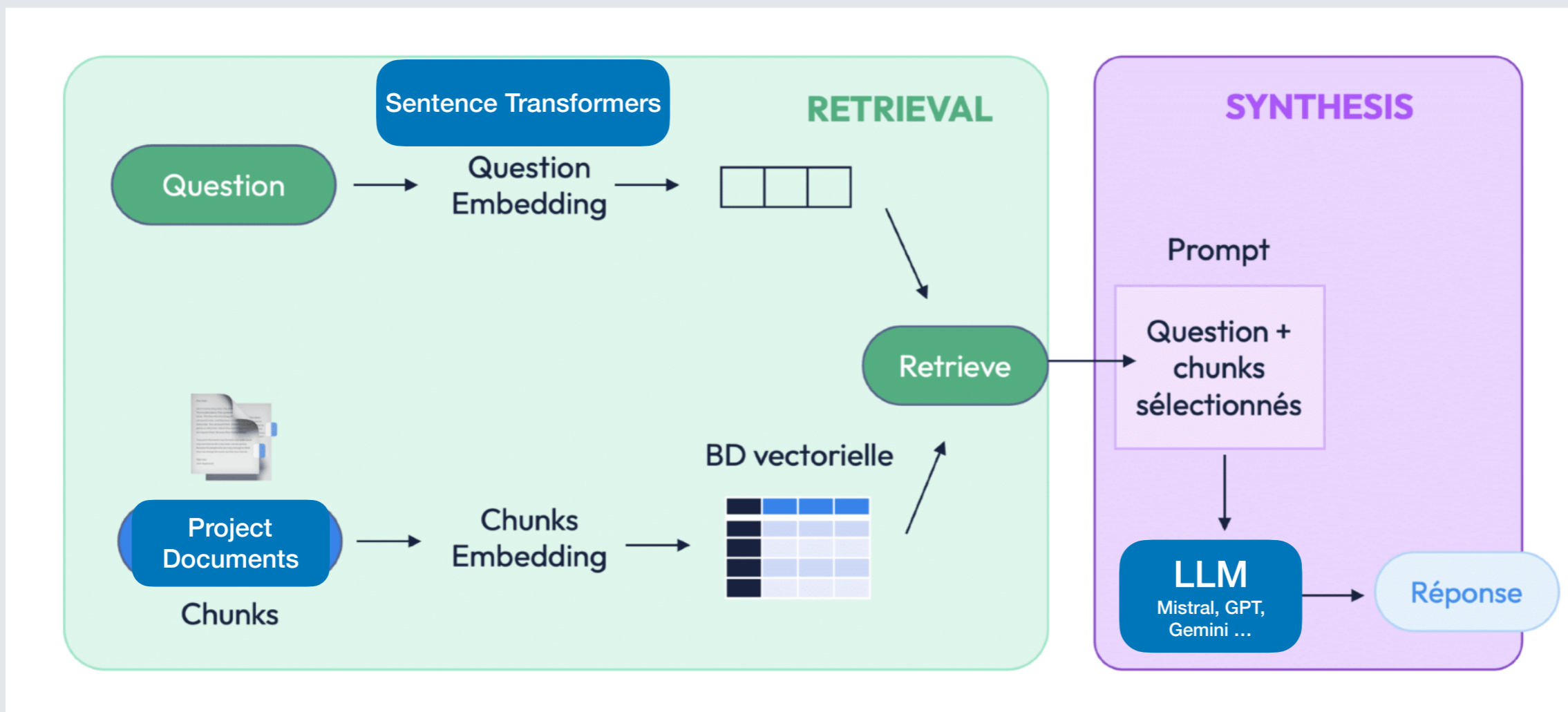
*TDI -> Trouble Dissociatif de l'Identité*

*TDI -> Texas Department of Insurance*

- No access to up-to-date project information (Models are too large to be trained continuously)
- Hallucination
- No Traceability - Link to official documents.

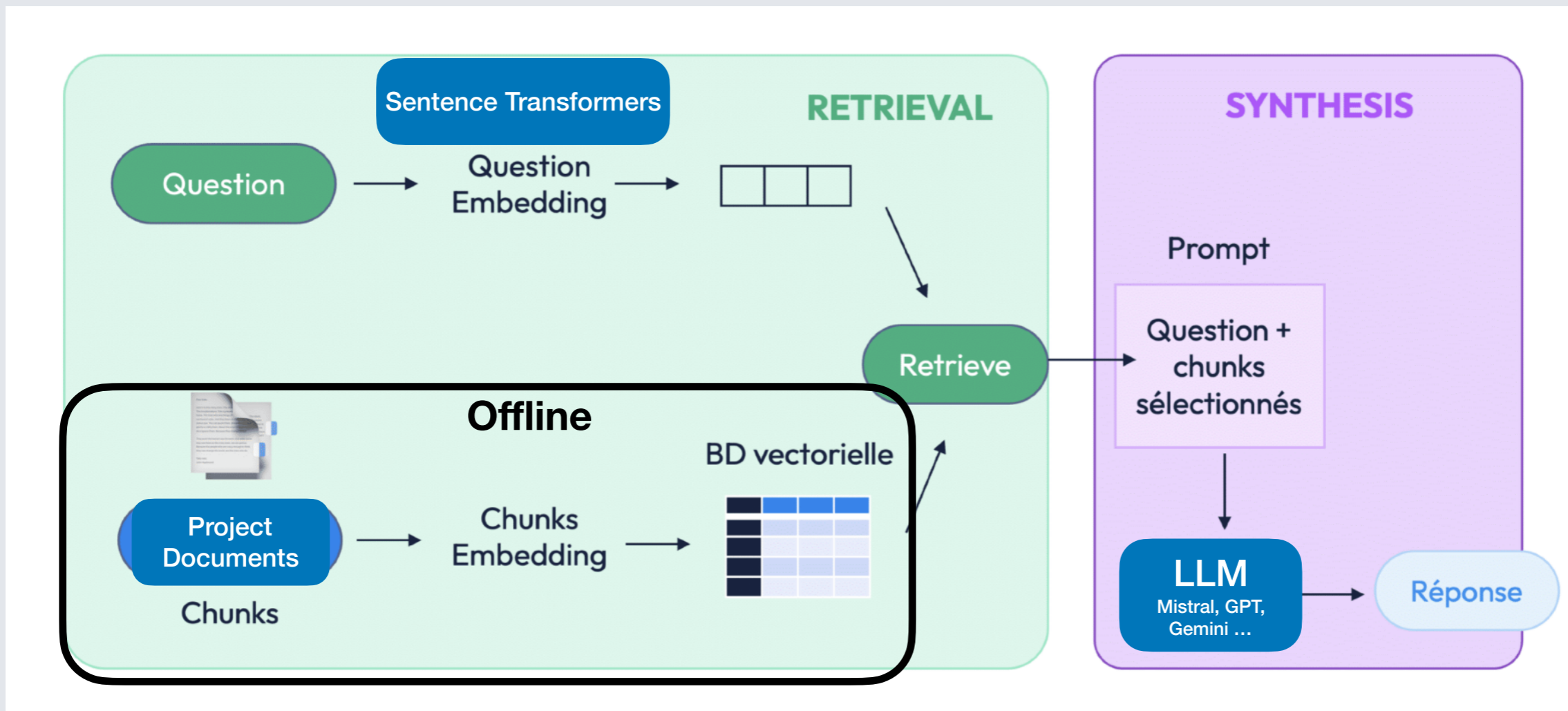
**Core idea:** Query to LLM + explicit access to curated documents

1. Retrieve relevant chunks of data from a corpus
2. Generate an answer grounded in those sources



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**Query:** how does the PAAM work ?

## Interrogate P&O Documentation Corpus

- GRS IRD1: ESA-LISA-EST-GRS-RS-0001
- GRS IRD2: ESA-LISA-EST-GRS-RS-0002
- IDS Design Description: LISA-AEI-IDS-DD-0001
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- LISA Science Requirement Document: ESA-LISA-EST-SCI-RS-0001
- Laser IRD1: ESA-LISA-EST-LS-RS-0001
- Laser IRD2: ESA-LISA-EST-LS-RS-0002
- SIRD: ESA-LISA-ESAC-SGS-RS-001
- SRD: ESA-LISA-EST-SYS-RS-0001
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## Retrieve top 10 chunks

```

Source: LISA Definition Study Report
Version: v1.0
section_parent: 5 The LISA Instrument > 5.3 Optical metrology interferometry i
page: 90
section_title: 5.3.2 Optical Bench
Description: and (2) are detected by a pair of QPRs (QPR1/QPR1'
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Fibre Switching Unit
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Source: LISA Constellation Performance Description Document: ESA-LISA-EST-MIS-
Version: August 2025
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**Query:** how does the PAAM work ?

## Interrogate P&O Documentation Corpus

- GRS IRD1: ESA-LISA-EST-GRS-RS-0001
- GRS IRD2: ESA-LISA-EST-GRS-RS-0002
- IDS Design Description: LISA-AEI-IDS-DD-0001
- IDS IRD1: ESA-LISA-EST-IDS-RS-0001
- IDS IRD2: ESA-LISA-EST-IDS-RS-0002
- LISA Constellation Description Document: ESA-LISA-EST-MIS-TN-0001
- LISA Constellation Performance Description Document: ESA-LISA-EST-MIS-DD-0002
- LISA Constellation Performance Model
- LISA Constellation Performance Parameters
- LISA Definition Study Report
- LISA Mission Requirement Document: ESA-LISA-EST-MIS-RS-0001
- LISA Science Requirement Document: ESA-LISA-EST-SCI-RS-0001
- Laser IRD1: ESA-LISA-EST-LS-RS-0001
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- SIRD: ESA-LISA-ESAC-SGS-RS-001
- SRD: ESA-LISA-EST-SYS-RS-0001
- Telescope IRD1: ESA-LISA-EST-TEL-RS-0001
- Telescope IRD2: ESA-LISA-EST-TEL-RS-0002

## Retrieve top 10 chunks

Source: LISA Definition Study Report **metadatas**

Version: v1.0

section\_parent: 5 The LISA Instrument > 5.3 Optical metrology interferometry i

page: 90

section\_title: 5.3.2 Optical Bench

Description: and (2) are detected by a pair of QPRs (QPR1/QPR1' and QPR2/QPR2', respectively.)

light going to the Test Mass (TM).

Point-Ahead-Angle-Mechanism

The point-ahead angle mechanism (PAAM) is a mechanism that allows the transmit be launched at an angle with the receive (RX) beam. The required angle is dete dynamics and appears due to the change of position of the Spacecraft (SC) over (see Figure 5.13).

The TX beam steering angle needs to be adjusted at least once every few minute of about 10 nrad to ensure the beam is received by the distant spacecraft. The per Optical Bench (OB), with two piezo stacks and capacitive sensors for redun control. The PAAM will be controlled via a dedicated control unit commanded by computer (OBC). As the PAAM is in the beam path of the transmit laser beam and of the Science Interferometer (SCI IFO) it needs to be mounted directly on the alignment stability.

Fibre Switching Unit

Source: LISA Constellation Performance Description Document: ESA-LISA-EST-MIS- Version: August 2025

section\_title: PAAM Piston

parents: TDI and Post-Processing Noises > Thermo-mechanical noise

Description: Time-Delay Interferometry (TDI) Transfer Function:  $H_2^{xx}$

The Point Ahead Angle Mechanism (PAAM) is required to correct for the variati

$$\tilde{s}_T \text{Therm,PAAM} = \sqrt{2} \cdot \tilde{s}_T$$

with  $\left( \frac{dx}{dT} \right)_{\text{PAAM}}$

, the coupling from temperature to piston of the PAAM mirror. The value used f

**Query:** how does the PAAM work ? **A (dim =1024)**

$$\text{cosine similarity} = \cos(\theta) = \frac{A \cdot B}{\|A\| \|B\|}$$

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Query + Top 10 chunks -> LLM

**-> Answer:**

The Point-Ahead Angle Mechanism (PAAM) is a mechanism that adjusts the angle of the transmit (TX) beam to compensate for the change in position of the Spacecraft (SC) over the light-travel time, ensuring the beam is received by the distant spacecraft.

The PAAM works by steering the TX beam at an angle with the receive (RX) beam. The required angle is determined by orbital dynamics and appears due to the change of position of the Spacecraft (SC) over the light-travel time.

The PAAM needs to be adjusted at least once every few minutes with an accuracy of about 10 nrad to ensure the beam is received by the distant spacecraft. There will be one PAAM per Optical Bench (OB), with two piezo stacks and capacitive sensors for redundancy and closed-loop control. The PAAM will be controlled via a dedicated control unit commanded by the on-board computer (OBC).

The PAAM is mounted directly on the optical bench to ensure alignment stability, and it sits directly in the picometre stable path of the Optical Bench (OB). The piston stability of the PAAM therefore enters directly into the performance budget.

The PAAM shall operated in a step and stare mode, with a nominal operational step size of the PAAM shall be 15 nrad on the sky.

Further details about Point-Ahead Angle Mechanism (PAAM) operations can be found in [ESA-LISA-EST-MIS-TN-0005] and [LISA TTL STOP Model and Budget].

Source: LISA Definition Study Report, LISA Constellation Performance Description Document: ESA-LISA-EST-MIS-DD-0002, LISA Ground Segment Requirement: Point-Ahead Angle Mechanism (PAAM) Mode of Operations, LISA Constellation Description Document: ESA-LISA-EST-MIS-TN-0001, IDS IRD2: ESA-LISA-EST-IDS-RS-0002, LISA Ground Segment Requirement: Point-Ahead Angle Mechanism (PAAM) Operational Step Size.

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- Use by default LISA material (tunable with temperature parameter).
- Access to up-to-date project information depending on the user choice to update the document corpus -> No Additional training
- Reduce Hallucination

## - Example with ChatGPT 5.2

what is the BAM in LISA ?

In LISA (Laser Interferometer Space Antenna), the **BAM** is the **Backlink Assembly**.

### What is the BAM?

The **Backlink Assembly (BAM)** is an **optical metrology system inside each LISA spacecraft** that measures the **relative phase (or optical pathlength)** between the two outgoing lasers sent to the *other two spacecraft*.

Each LISA spacecraft has **two optical benches**, each pointing toward a different distant spacecraft. The BAM links these two benches **internally**.

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Type your question here:

what is the BAM in LISA?

> Show raw retrieved parameters

## Mistral Answer

The Beam Alignment Mechanism (BAM) in LISA is a mechanism that provides the capability to laterally shift the Transmit (Tx) and Receive (Rx) beams in two degrees-of-freedom. It is used to adjust the beams in order to introduce a Tilt-to-Length (TTL) coupling, which can be used to offset many of the inherent sources of Tilt-to-Length coupling across the LISA constellation. The BAM is primarily intended for calibration during the in-flight commissioning and calibration activities.

(Source: IDS Design Description: LISA-AEI-IDS-DD-0001, Version: v3.0 - 25/08/2025)

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- Traceability - Link to official documents.
- Intelligence is in the Corpus of Documents provided in Context
  - -> Good performance with smaller models.

## Open Source Model with smaller number of parameters

- Mistral-small (French)
- **Gemma4 (Google) -> 26B (Mixture of Expert 4B)**
- Deepseek (Chinese)
- Llama (Facebook)
- Qwen (Alibaba)
- Granite (IBM)

## Keep Control over data privacy

More controllability on the pipeline - tailored to the database -> best performance.

Energy Efficient - for domain specific questions: 7B models ~ 1T models

Simplistic rule of thumb if Energy ~ Nparams  
-> 0.7% of the energy consumption.

PDF

Latex

XML  
(performance  
Model)

Jama (ESA  
database for  
Requirements)

Excel  
(Parameters and

PDF

Latex

XML  
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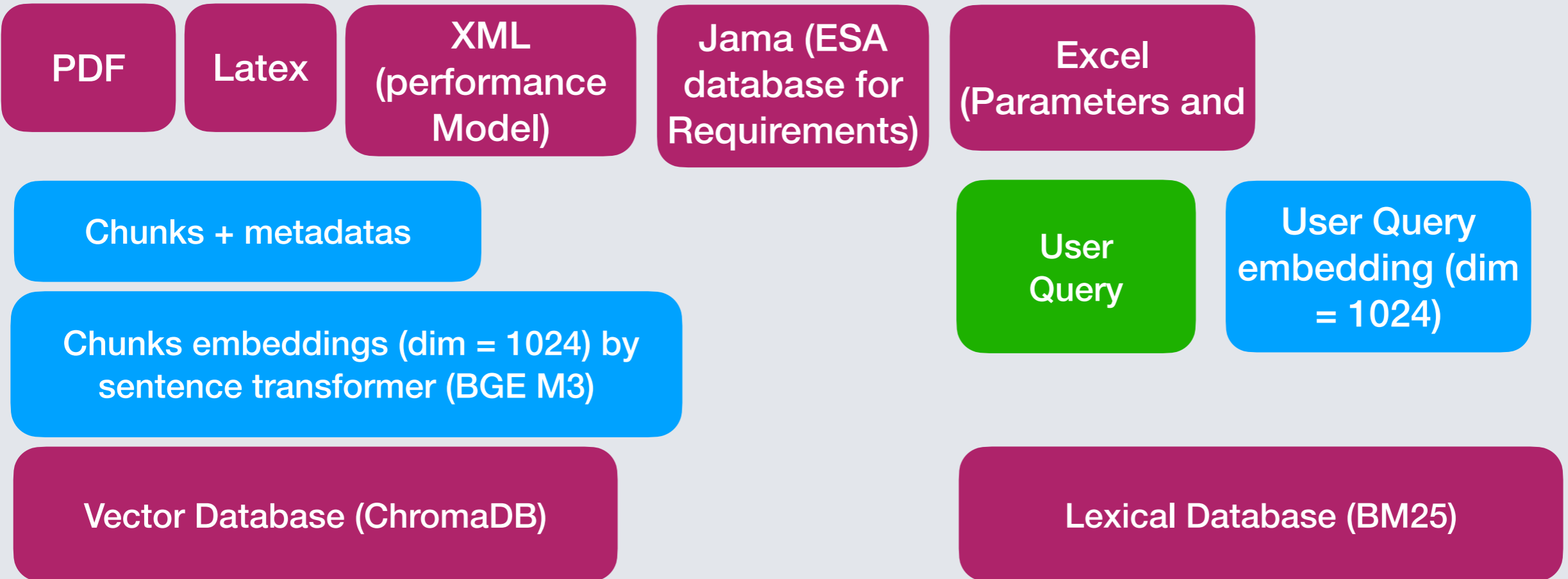
Chunks + metadatas

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User  
Query

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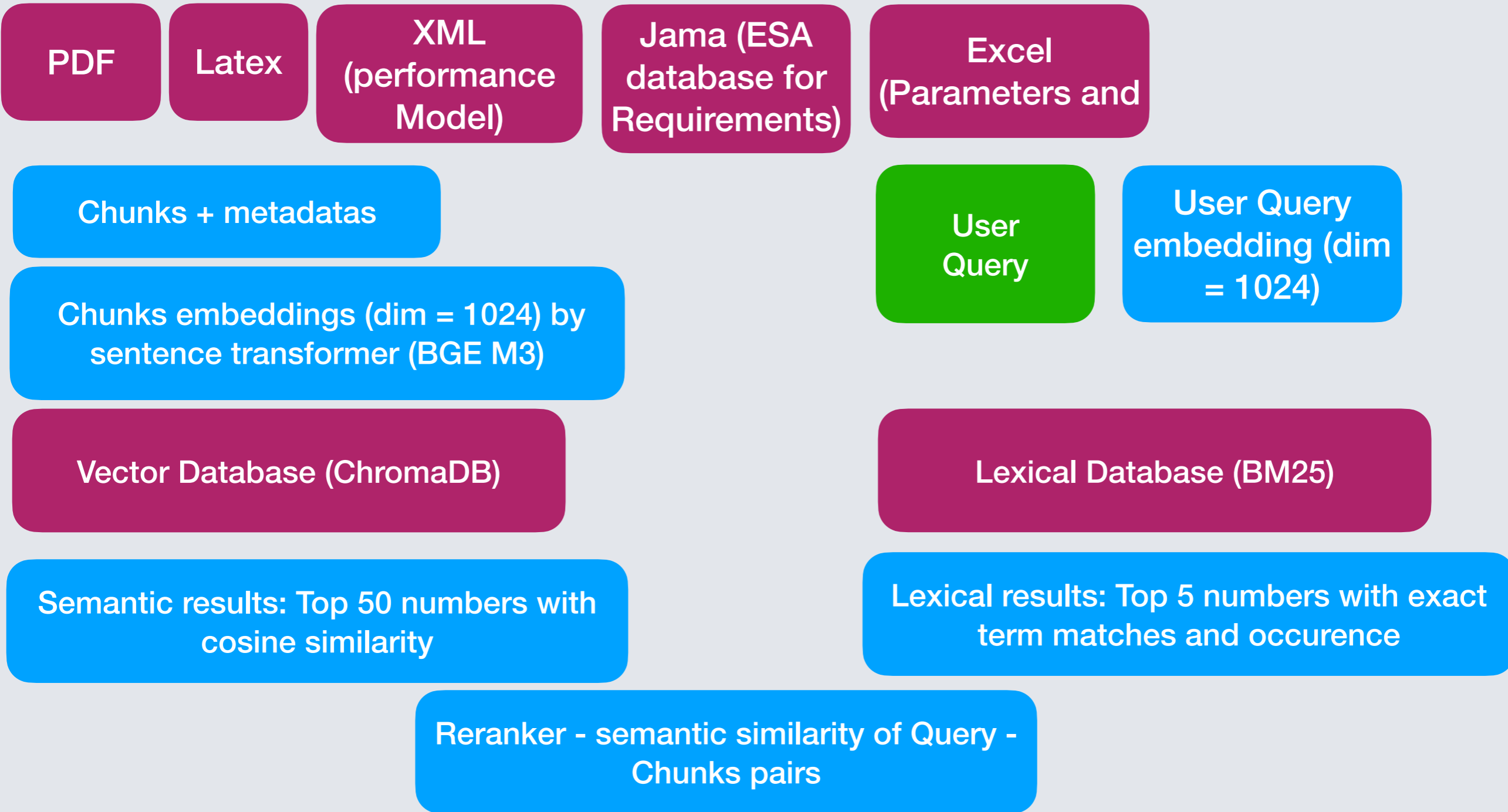
Semantic results: Top 50 numbers with  
cosine similarity

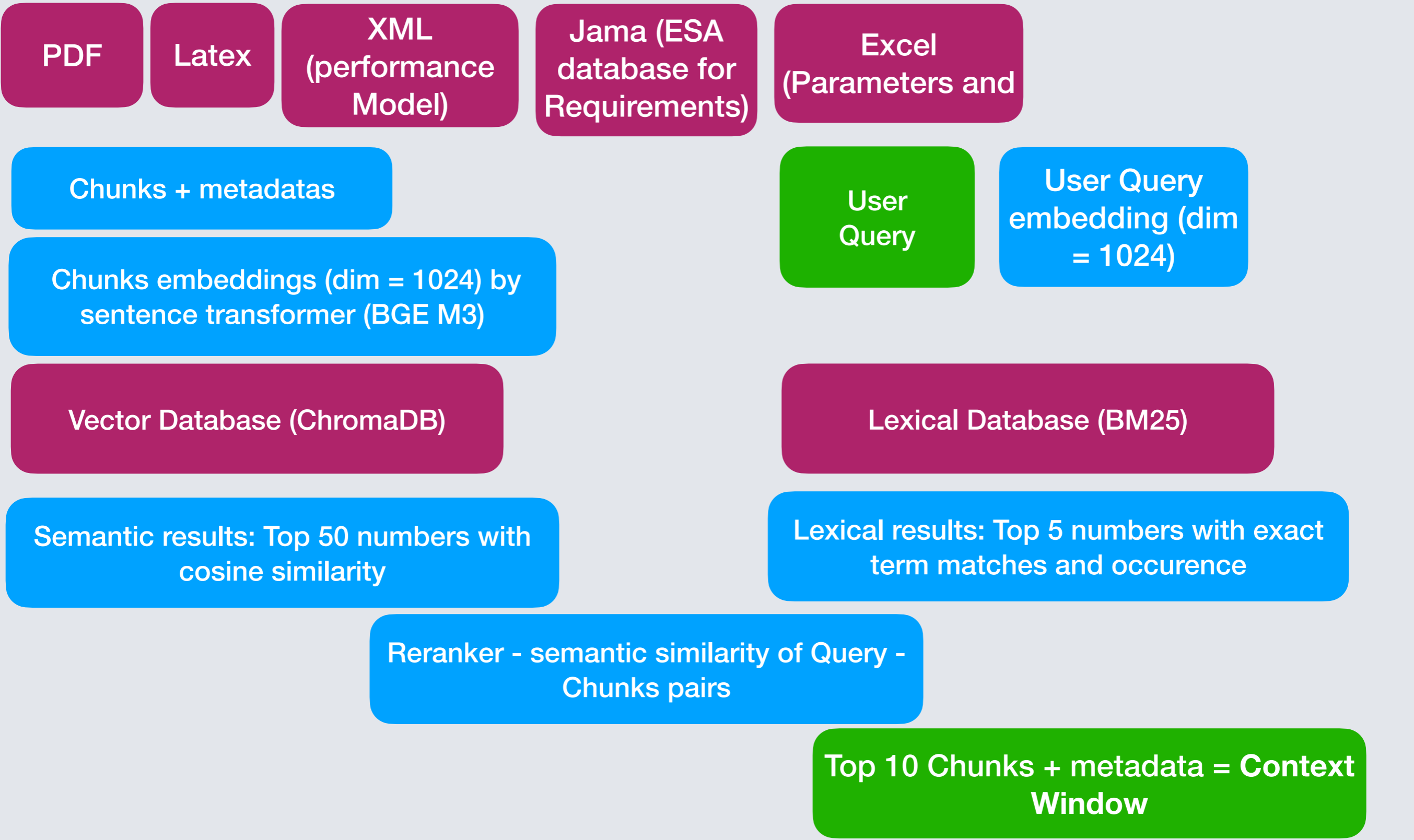
User  
Query

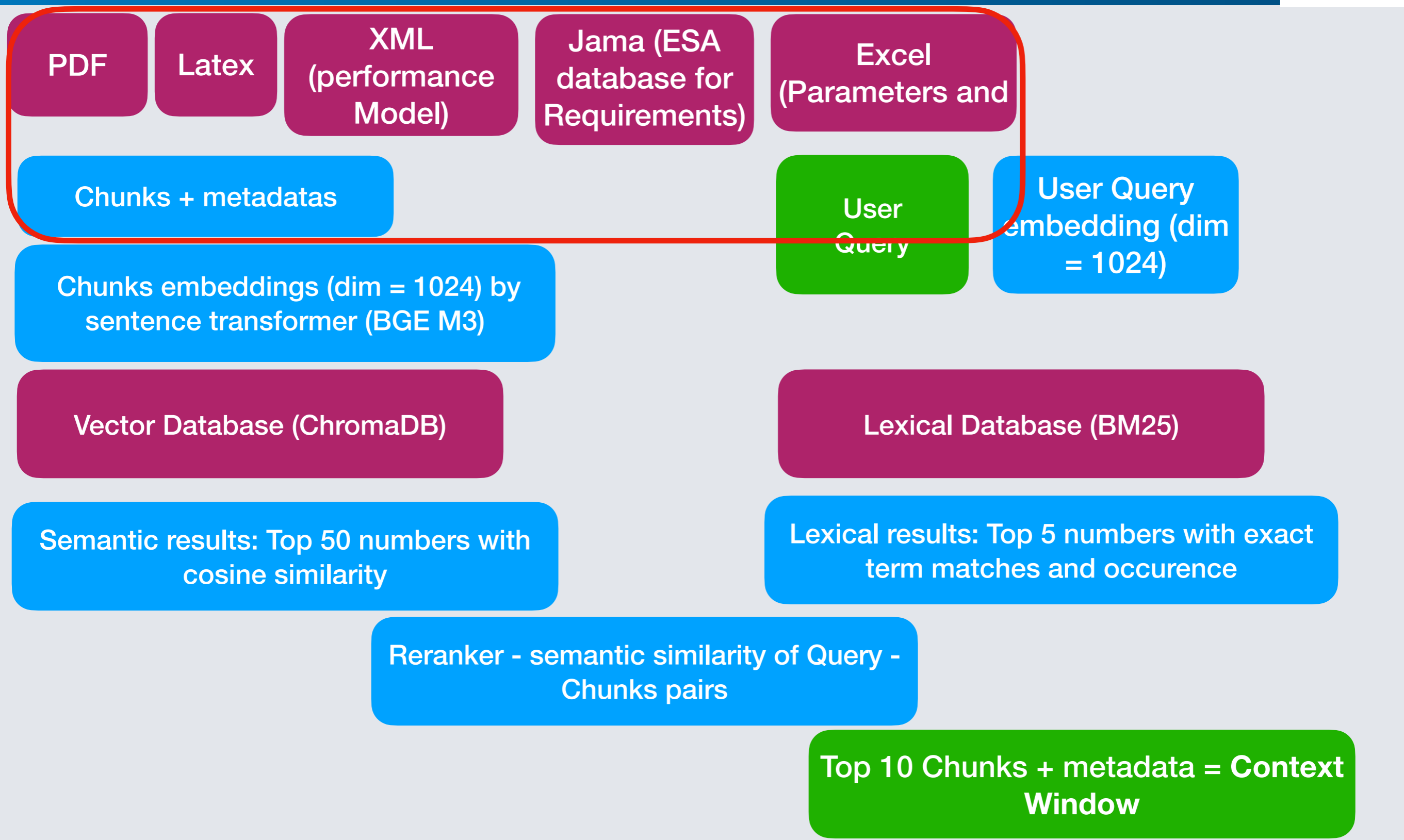
User Query  
embedding (dim  
= 1024)

Lexical Database (BM25)

Lexical results: Top 5 numbers with exact  
term matches and occurrence







PDF

Latex

XML  
(performance  
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Requirements)

Excel (Parameters  
and constants)

Chunks + metadatas

**Where most of value is: your own DATA** (Performance and Operations corpus)

- Use cases -> good knowledge of the database is mandatory (coherent dataset)
- Structured the Data -> improve performance of the tool

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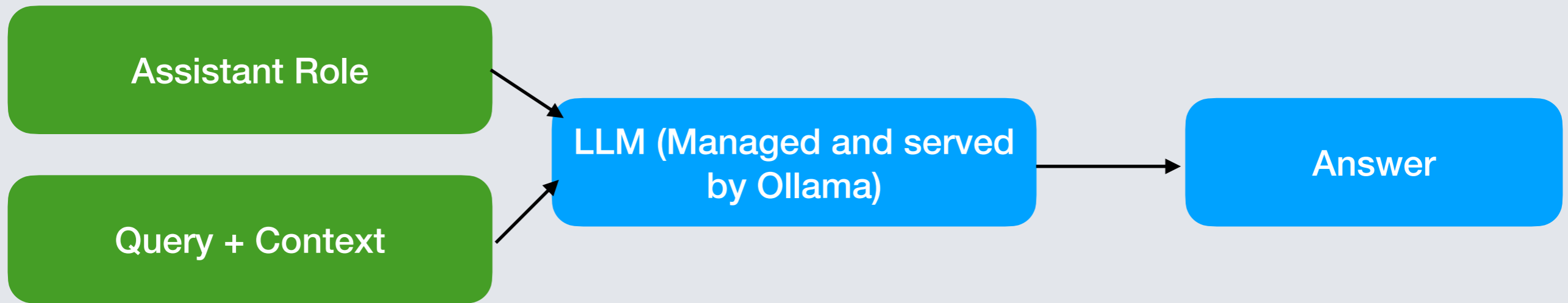
Chunks + metadatas

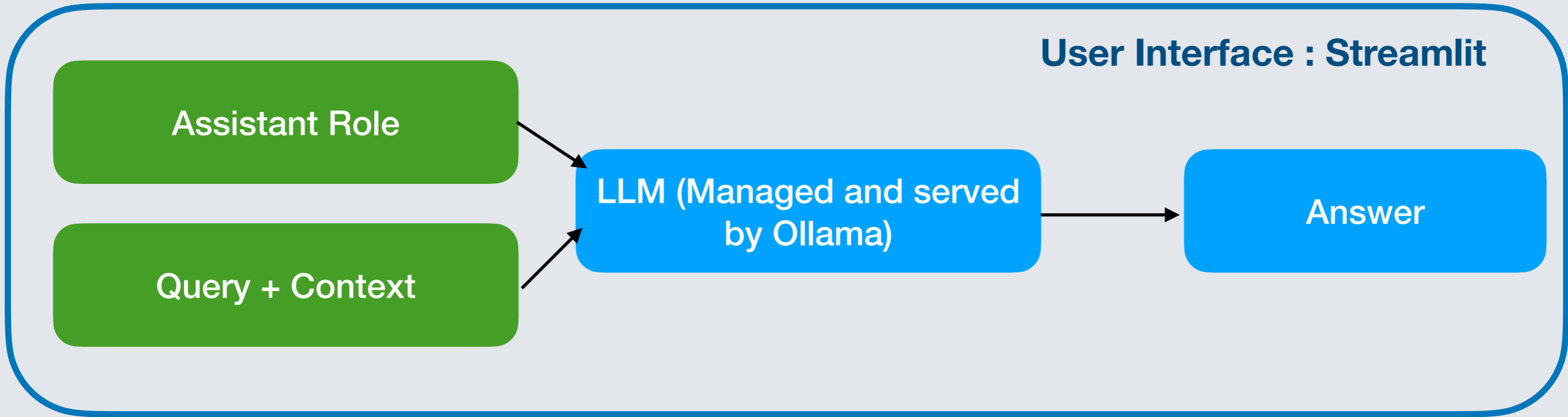
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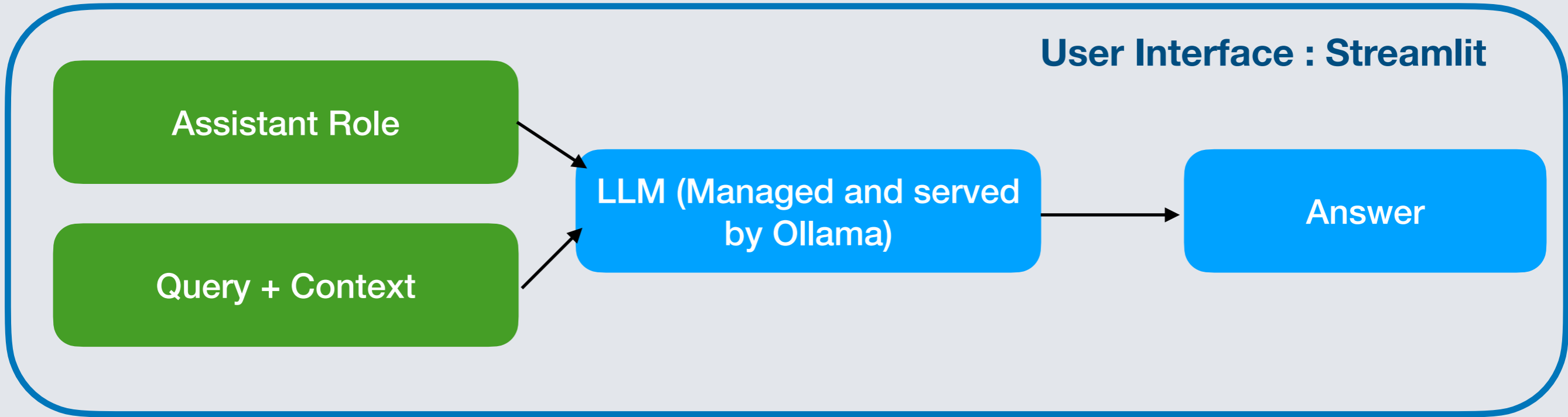
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## Technical difficulties:

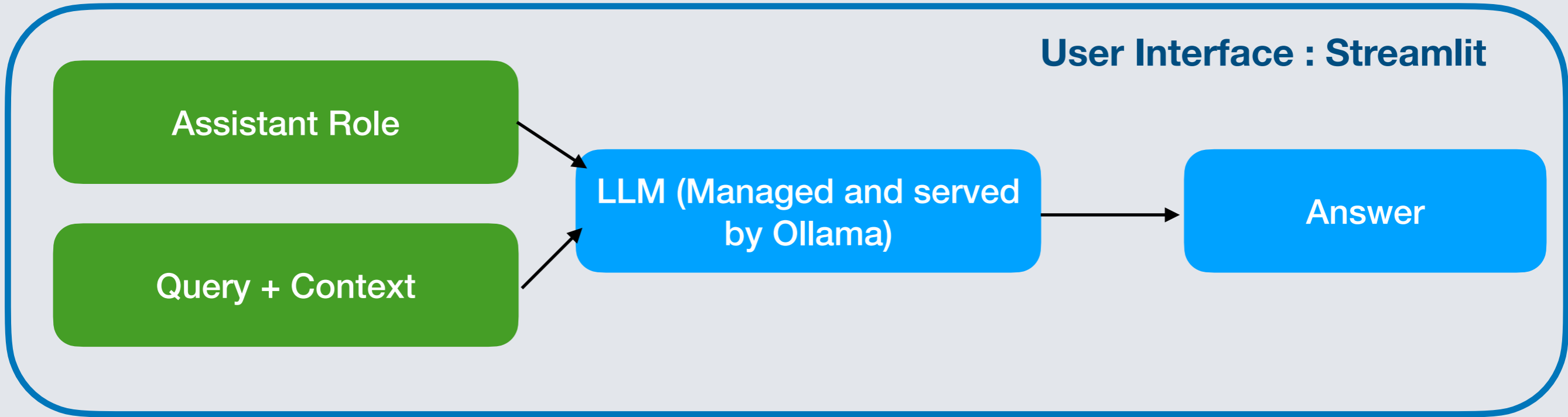
- No standard ingestion and cleaning tool (outline, header, table, figures)
  - how to chunk data/split the information
  - what metadata vs what vector
  - Dealing with equations/tables
- How to deal with domain specific information (Science IFO vs Science IFO Sb)



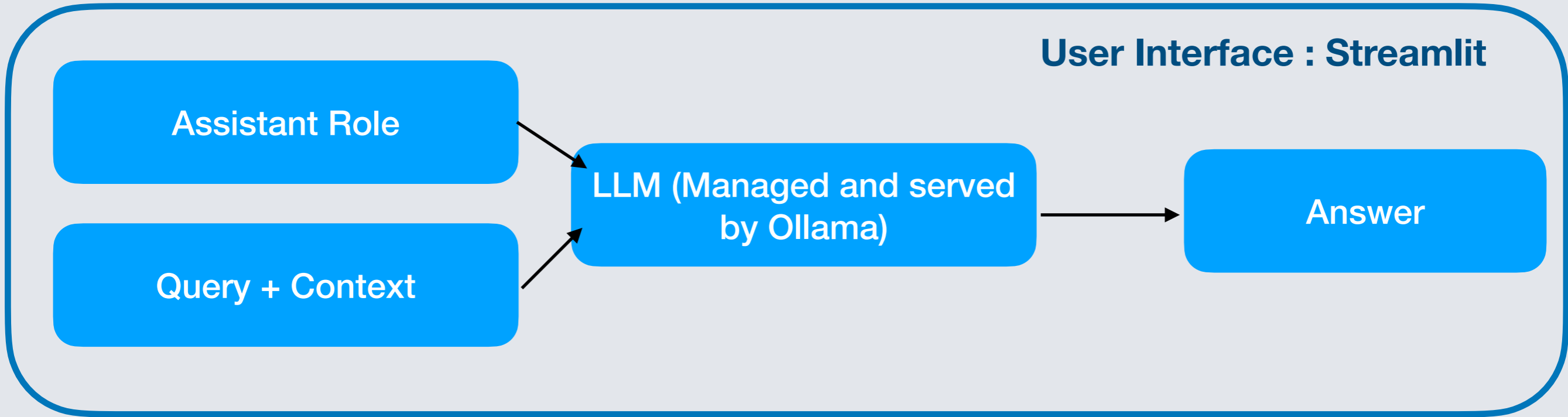


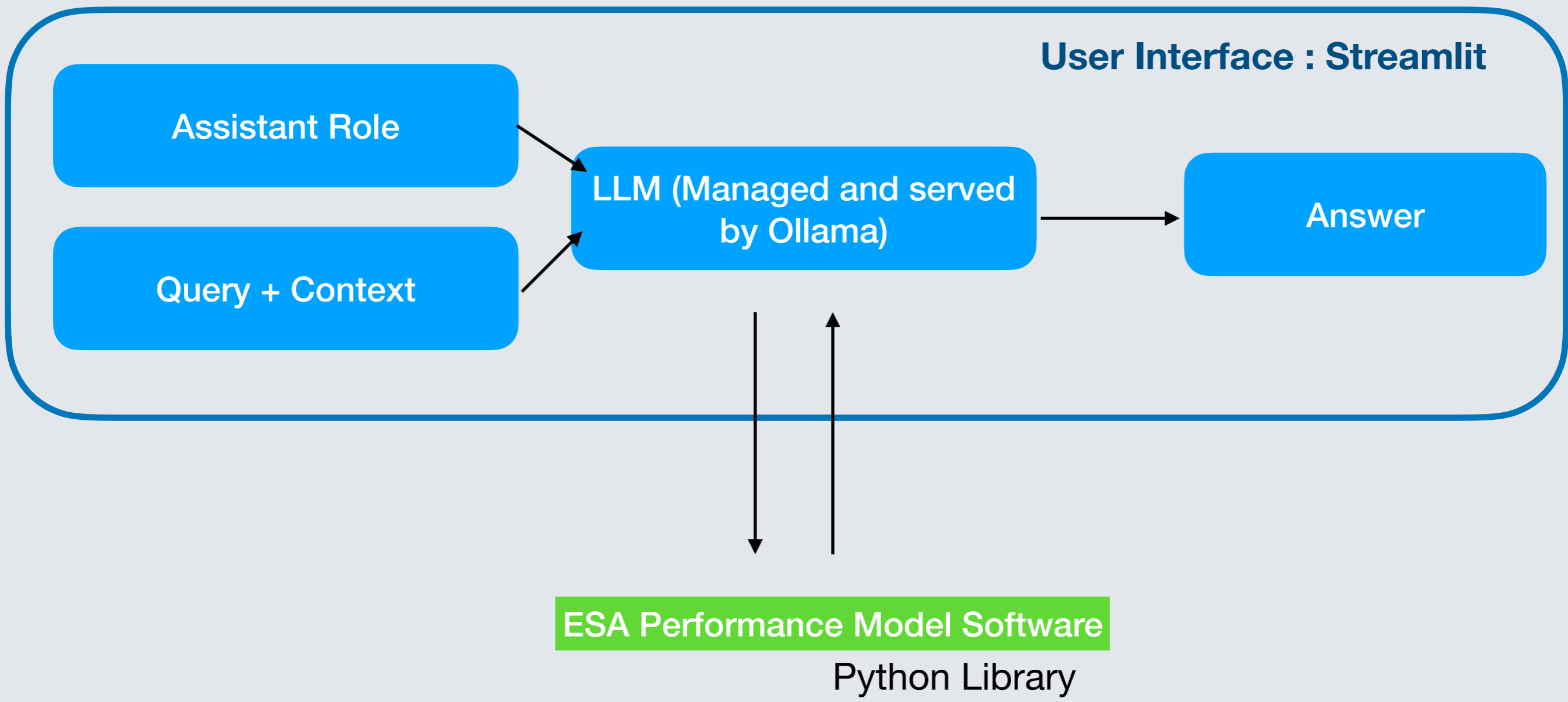


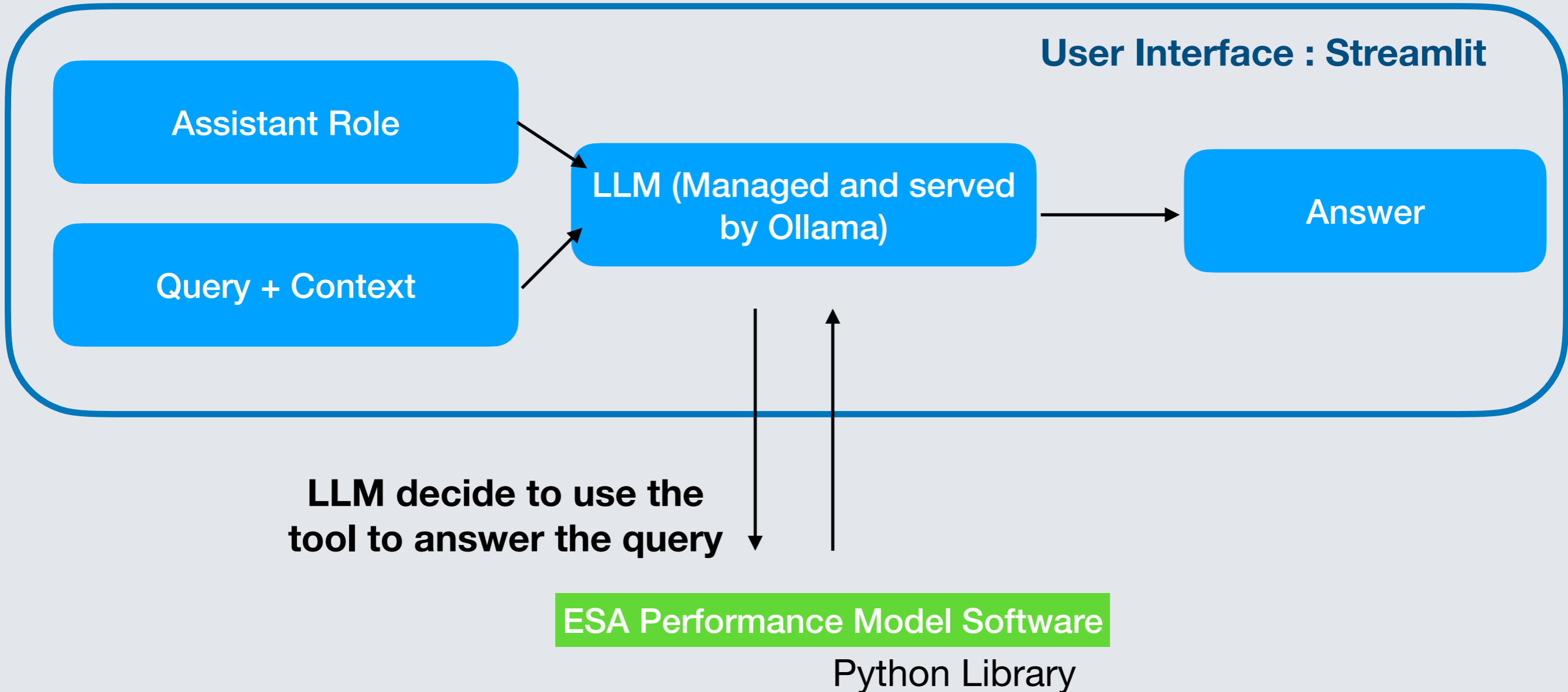
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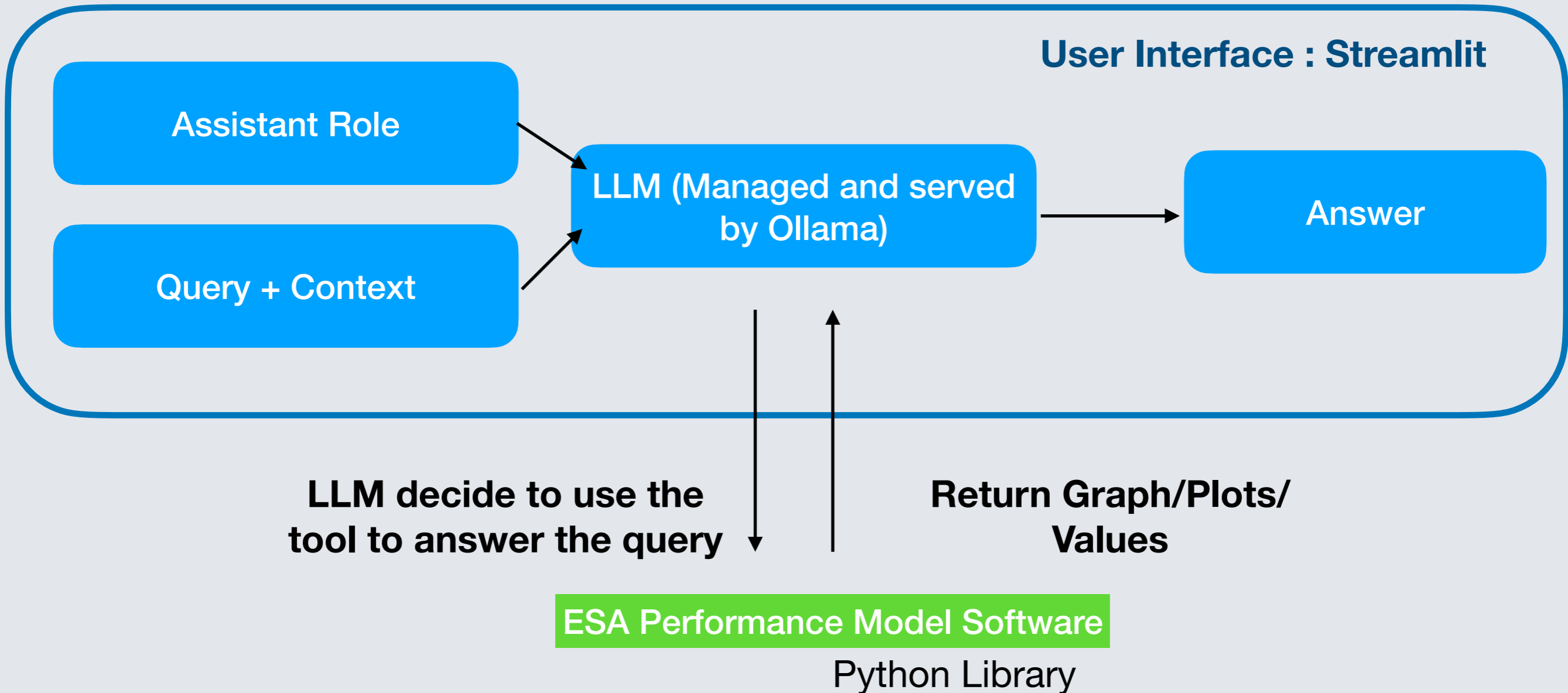


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Graph of QPR noise in the SCI IFO at 10mHz



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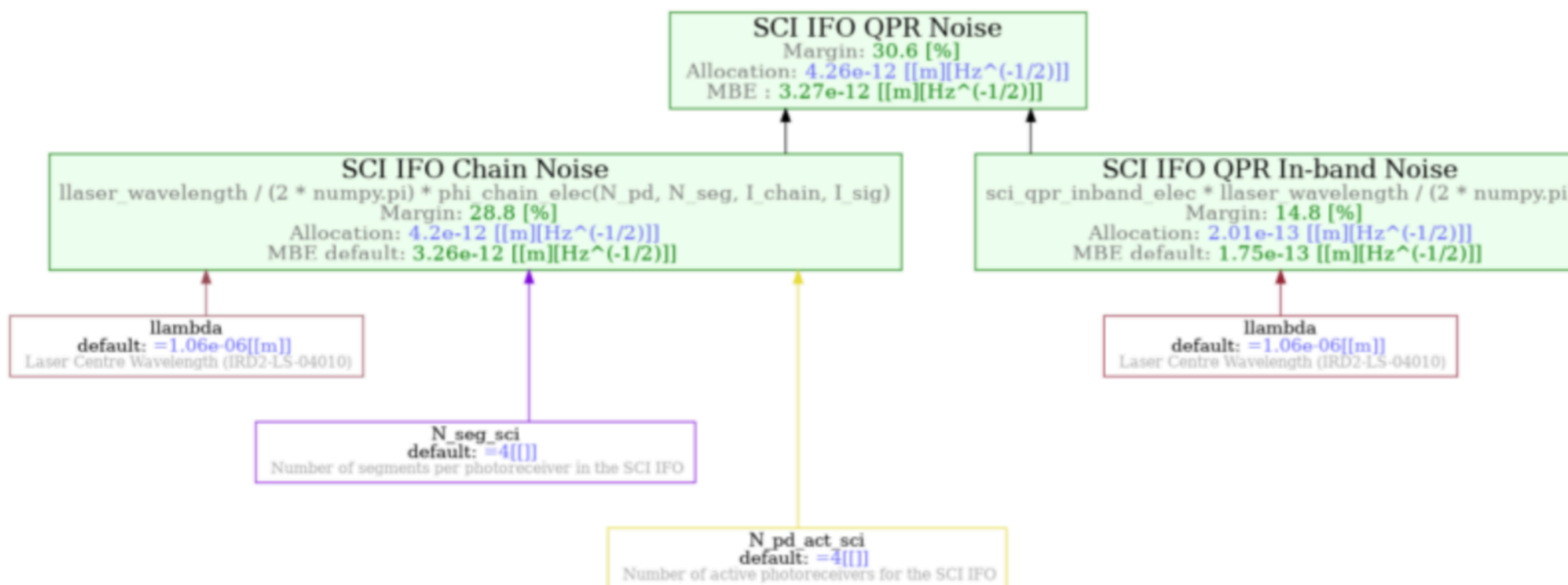
The SCI IFO QPR Noise, which represents the total phase noise from the Science Interferometer QPRs, is modeled as an uncorrelated sum of the SCI IFO Chain Noise and the SCI IFO QPR In-band Noise. The top-down performance allocation for this noise source is:

$$4.26 \times 10^{-12} \cdot \sqrt{1 + \left(\frac{2 \times 10^{-3}}{f}\right)^4} \text{ [m][Hz}^{-1/2}\text{]}$$

The graph shown below illustrates how the actual noise levels compare against this requirement across the frequency spectrum.

## From Performance Model - SCI IFO QPR Noise

LCPM\_SCI IFO QPR Noise  
generated with Python : Thu Apr 23 19:08:35 2026  
Configuration: default  
Evaluated at f = 0.01 Hz



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**Infrastructure (Done):** Deployment of a dedicated GPU server (NVIDIA DGX GB10 Spark, 128GB unified memory), enabling local LLM inference.

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- In the specific case of P&O, where physical models comes from multiple stakeholders. Collective review is major risk mitigation.
- RAG architecture (FELIX) allow access to up-to-date information and can significantly improve LLM answers by using semantic search over authoritative corpus of data.
- Full control of the RAG chain -> **Simple architecture but robust and data privacy.**
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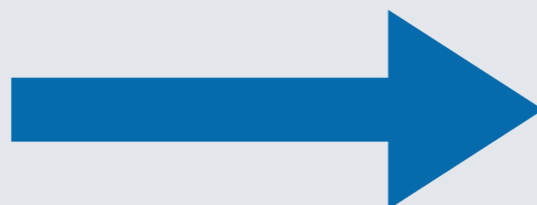
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- Similar effort on LIGO: <https://ligogpt.mit.edu/marvel/> - <https://arxiv.org/abs/2601.03436>

**And more ...**



 Is the Test Mass mass consistent across the documents ? Provide the answer in a report



# Report on Test Mass (TM) Mass Consistency

An investigation of the provided documentation regarding the Test Mass (TM) mass reveals several different values and specifications depending on the nature of the entry (requirement, allocation, or physical model).

## 1. Physical Models and Estimates (MBE/CBE)

The following values represent physical models or best estimates:

- **LISA Constellation Performance Parameters:**
  - Nominal Value: 1.9328 kg
  - Minimum Value: 1
  - Maximum Value: 1.9428 kg
  - (Source: LISA Constellation Performance Parameters)
- **LISA Constellation Performance Model:**
  - Allocation: 1.92 kg
  - (Source: LISA Constellation Performance Model, requirement\_id: IRD2-GRS-01210)

## 2. Requirements (Allocations)

The formal requirements specify the mass as follows:

- **GRS IRD2:**
  - The mass shall be 1933 g  $\pm$  10 grams.
  - (Source: GRS IRD2: ESA-LISA-EST-GRS-RS-0002, requirement\_id: IRD2-GRS-01210)

## Summary of Inconsistencies

The values are not strictly consistent across documents as they represent different types of data:

- **Requirements** specify a range of 1923 g to 1943 g (derived from 1933 g  $\pm$  10 g).
- **Allocations** (Performance Model) specify a lower value of 1.92 kg.
- **Physical Models** (Performance Parameters) provide a nominal value of 1.9328 kg, which falls within the requirement range, but the bounds (1.9228 to 1.9428 kg) also overlap with the requirement.



Provide a python implementation for Brownian noise



## Provide a python implementation for Brownian noise



To implement the Brownian noise model in Python, you can use the mathematical expression provided in the **LISA Constellation Performance Model** (Source: LISA Constellation Performance Model).

The analytical model (MBE) for the Brownian noise is defined as: **Brownian Noise** =

$$\sqrt{\alpha_{\text{noise}} \times \left(1 + \frac{\pi}{8}\right) \times \left(\frac{TM_{\text{size}}}{TM_{\text{mass}}}\right)^2 \times \text{VacuumPressure} \times \sqrt{\frac{512 \times H_2 O_{\text{mo}} \times K_B \times T_{\text{GRS}}}{\pi}}}$$



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Below is the Python implementation:

```
import math

def calculate_brownian_noise(alpha_noise, tm_size, tm_mass, vacuum_pressure, h2o_mo, kb, t_grs):
    """
    Calculates the Brownian noise based on the MBE analytical model.

    Parameters:
    alpha_noise (float): Brownian noise amplification factor due to EH surfaces proximity
    tm_size (float): Test Mass (TM) size
    tm_mass (float): Test Mass (TM) mass
    vacuum_pressure (float): Residual Pressure around Test Mass
    h2o_mo (float): Molecular weight of water
    kb (float): Boltzmann constant

    Returns:
    float: Brownian noise in [m][s^-2][Hz^-1/2]
    """

    # term1: alpha_noise * (1 + pi/8)
    term1 = alpha_noise * (1 + math.pi / 8)

    # term2: (TMsize / TMmass)^2
    term2 = (tm_size / tm_mass)**2

    # term3: sqrt(512 * H2Omo * KB * T_GRS / pi)
    term3 = math.sqrt((512 * h2o_mo * kb * t_grs) / math.pi)

    # Combine all terms under the outer square root
    brownian_noise = math.sqrt(term1 * term2 * vacuum_pressure * term3)

    return brownian_noise

# Example usage with values from GRS Characteristics and Performance Model
if __name__ == "__main__":
    # Values derived from provided context
    alpha_noise_val = 13 # From ESA-LISA-EST-MIS-DD-0002
    tm_size_val = 0.044 # Example: Size in meters (Context implies TM size is a parameter)
    tm_mass_val = 2.0 # Example: Mass in kg
    vacuum_pressure_val = 2e-6 # 2 uPa from ESA-LISA-EST-MIS-DD-0002
    h2o_mo_val = 0.018 # Molecular weight of water in kg/mol
    kb_val = 1.38e-23 # Boltzmann constant
    t_grs_val = 293 # 293K from ESA-LISA-EST-MIS-DD-0002
```

```
noise = calculate_brownian_noise(
    alpha_noise_val, tm_size_val, tm_mass_val,
    vacuum_pressure_val, h2o_mo_val, kb_val, t_grs_val
)

print(f"Calculated Brownian Noise: {noise} m/s^2/Hz^1/2")
```

### Notes on parameters:

- $\alpha_{\text{Br}}$  (or  $\alpha_{\text{noise}}$ ): Approximately 13 (Source: ESA-LISA-EST-MIS-DD-0002).
- $T_{\text{GRS}}$ : 293 K (Source: ESA-LISA-EST-MIS-DD-0002).
- $p$  (Vacuum Pressure): The model uses  $p$  as a driver; the requirement value used for MBE calculation is 2  $\mu\text{Pa}$  (Source: ESA-LISA-EST-MIS-DD-0002).



# BACKUP

Welcome, Joseph Martino

### Filters

Select LLM(s):

- felix-gemma... x
- gemma4:26b x
- mistral x
- mistral-smal... x

Select collection(s):

- Performanc... x
- Performanc... x

Search in query, answer, or context:

Date range:

2025/11/21 – 2026/04/23

> Query: How does the laser frequency noise enter the Time-Delay Interferometry (TDI) performance ? - [mistral]

> Query: What are the performance requirements related to Master Clock (MCLK) noise ? - [mistral]

▼ Query: What is the chain noise in the Test Mass (TM) IFO ? - [mistral]

**Answer:** The chain noise in the Test Mass (TM) Interferometric Frequency Observatory (IFO) is a contribution arising from the electronics of the instrument, specifically from the charge-coupled device (CCD) or similar detectors used to read out the optical signals. This noise is quantified by the TM IFO Chain current noise, which is  $2e-12 \text{ A/Hz}^{(1/2)}$ .

The chain noise is affected by the number of active photoreceivers in the TM IFO ( $N_{pd\_act\_tmi}$ ), as it is inversely proportional to the square root of this number. Therefore, increasing the number of active photoreceivers will help reduce the chain noise.

The total shot noise in the Test Mass IFO is calculated using the following equation:

$$tmi\_shot\_noise = tmi\_shot\_noise\_per\_qpr / \sqrt{N_{pd\_act\_tmi}}$$

where  $tmi\_shot\_noise\_per\_qpr$  is the shot noise per quadrant photoreceiver. The unit for the total shot noise is meters per square root Hertz ( $m/Hz^{(1/2)}$ ).

**Model used:** mistral

**Date:** 2025-11-21

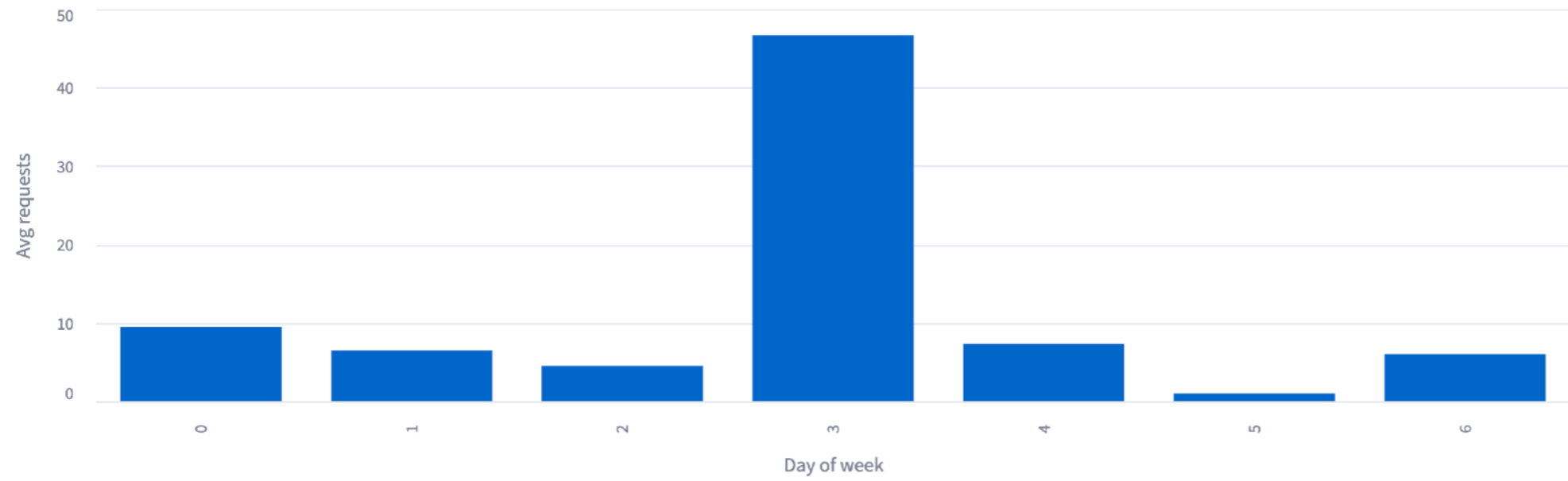
**Collection used:** Performance\_and\_Operation\_DB4

> Retrieved context:

Delete this entry

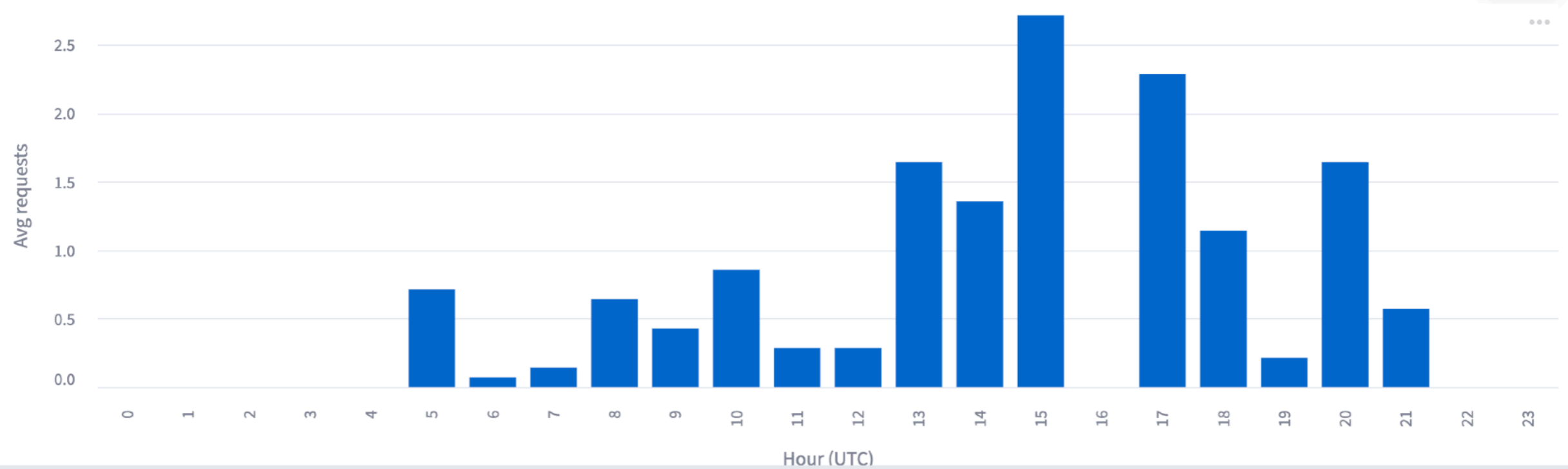


## Average requests by day of week



Day	Avg requests
Monday	9.5
Tuesday	6.5
Wednesday	4.5
Thursday	46.67

## Average requests by hour of day (UTC)



# Performance & Operations ?

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- ESA Performance Team
- NASA (development Team ?)
- Scientific Institute committing to P&O activities
- (Prime ?)

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## Gérer la Performance de la constellation

- Modèle de performance Constellation
- Lien requirements - modèle perfo
- Evaluation des impacts (violations, descope, différentes configurations ...)

## Valider le Performance

- Simulation end-to-end
- Stratégie de vérification mission
- Suivi des campagnes de tests sol

## Opérations

- System commissioning
- Outils de monitoring mission
- Calibrations

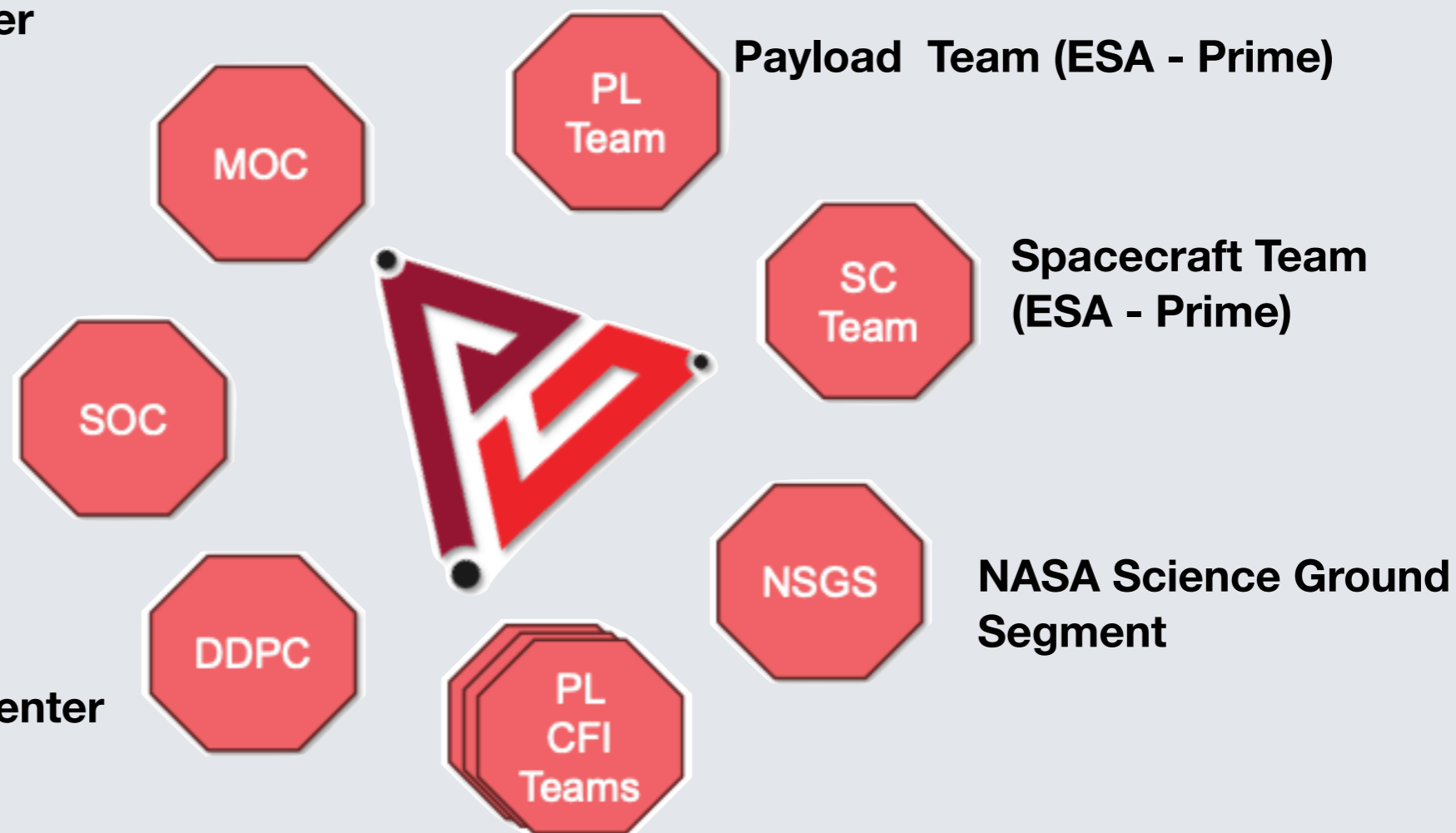
## Mission Operation Center (ESA)

- Dynamique du vol
- Operation du Satellite

## Science Operation Center (ESA)

- Calibration
- Preprocessing des données

## Distributed Data Center



## Hardware Sous Systèmes