Software infrastructure for developing superattenuator prototypes

Virgo-ET Pisa internal workshop
2024/05/23

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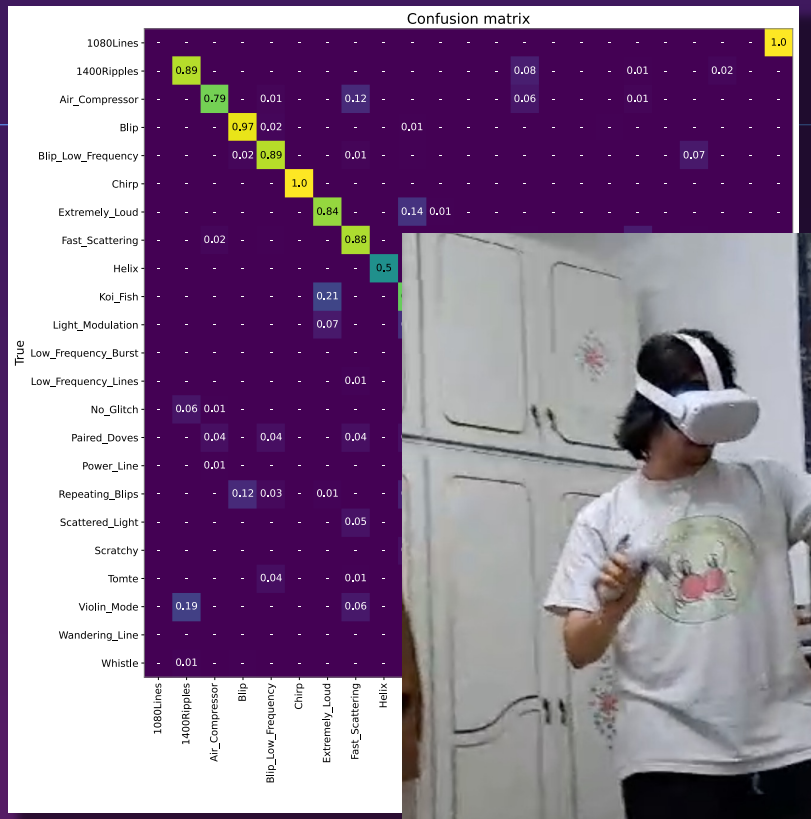
Me in a nutshell

About me:

- PhD student (38th cycle) with Massimiliano and Francesco, PNRR-ETIC fundings
- Very much *Pisano* (Bachelor and Master degrees, now PhD)
- Worked on DetChar (glitches) with machine learning
- Now moving to the **study of seismic noise attenuation**
- Participating in RRT shifts, LOC for GWADW23 and GraSP23

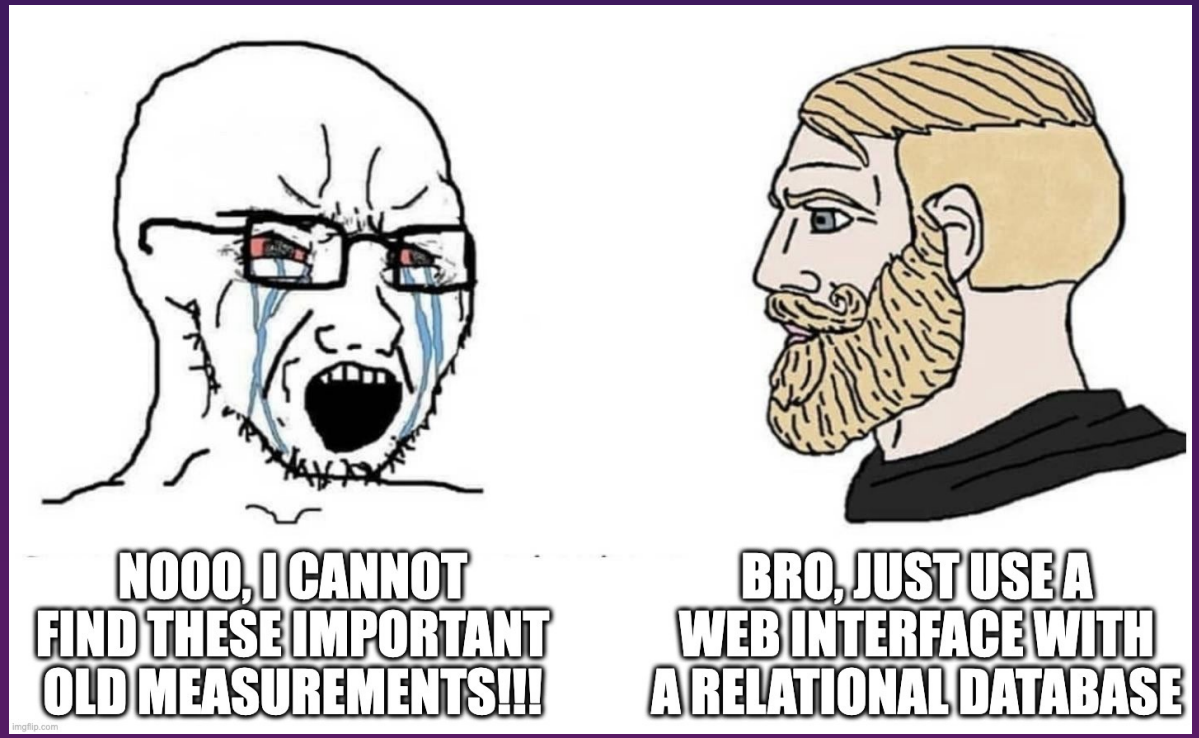
Also about me:

- Board games, RPGs, TV-series, hiking
- Cheat code to befriend me: ***Food***



My past and current work: laboratory database

Work in collaboration with Lorenzo, Alessio, Massimiliano and Francesco



Motivations:

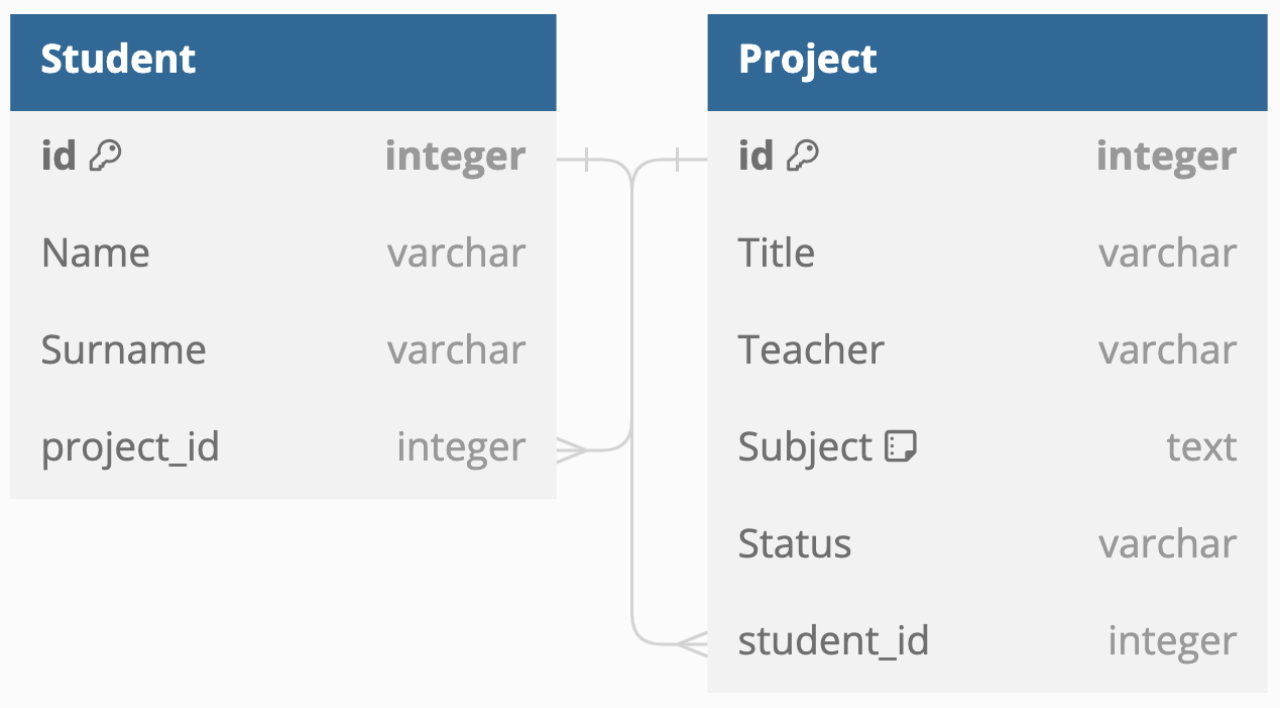
- Support **development of suspension-related prototypes** such as the PIP (see e.g. Francesco and Lorenzo's talks).
- **Track components** for prototypes and their history.
- Useful to **sort datasets, media, projects** etc...

Main features:

- Developed with **Flask**, maps URLs to Python functions.
- Utilities for handling **HTTP, security** and templates.
- **Hosted on virtual machine**, code is on GitLab (in production now!).

Pills on Relational Databases

- **Structured Query Language (SQL):** defining, querying and manipulating data. Provides a standardized way to interact with data.
- **Data Integrity:** constraints between tables (primary and foreign keys, triggers) ensure that data is consistent and allow to represent complex relationships.
- **Security:** robust security features, including user authentication, access control, and encryption.



Users:
- Name, email
- Affiliation
- Privileges

Components:
- Physical data
- Relationships with other comps
- Media and history

Media:
- Type (png, pdf, csv)
- Notes

History:
- Author
- Actions performed
- Related database entities

Report:
- Author(s)
- Activities
- Related comps, media etc...

Overview of component "PIP_001"

Component Type: PIP

Materials: al

Weight (Kg): 200.0

Designer: All

Arrival Date: 2024-03-15

List of subcomponents:

Label	Component Type	Weight (Kg)	Materials	Mounted on
IP_Leg_003	IP_Leg	0.0	Alluminium, steel	PIP_001
IP_Leg_002	IP_Leg	0.0	Aluminium, steel	PIP_001
IP_Leg_001	IP_Leg	0.0	Aluminium, steel	PIP_001

Overview of component "Colonna_003"

Component Type: Colonna

Materials: Stainless steel

Weight (Kg): 8.6

Designer: Andrea Basti

Arrival Date: 2023-10-26

Mounted on:

Label	Component Type	Weight (Kg)	Materials	Mounted on
IP_Leg_003	IP_Leg	0.0	Alluminium, steel	PIP_001

Overview of component "IP_Leg_003"

Component Type: IP_Leg

Materials: Alluminium, steel

Weight (Kg): 0.0

Designer: Andrea Basti

Arrival Date: 2023-10-26

Notes:

The IP_Leg_003 is composed by several components. It is installed on the support and we are collecting data.

Mounted on:

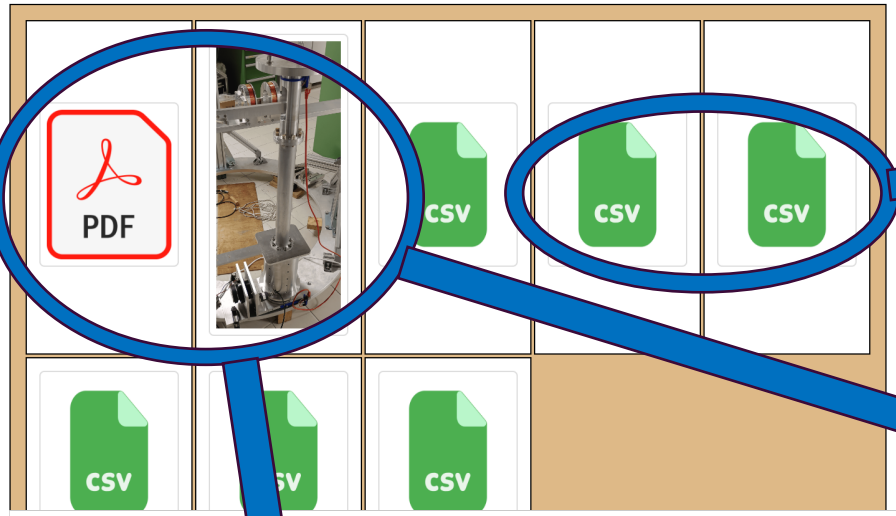
Label	Component Type	Weight (Kg)	Materials	Mounted on
PIP_001	PIP	200.0	al	None

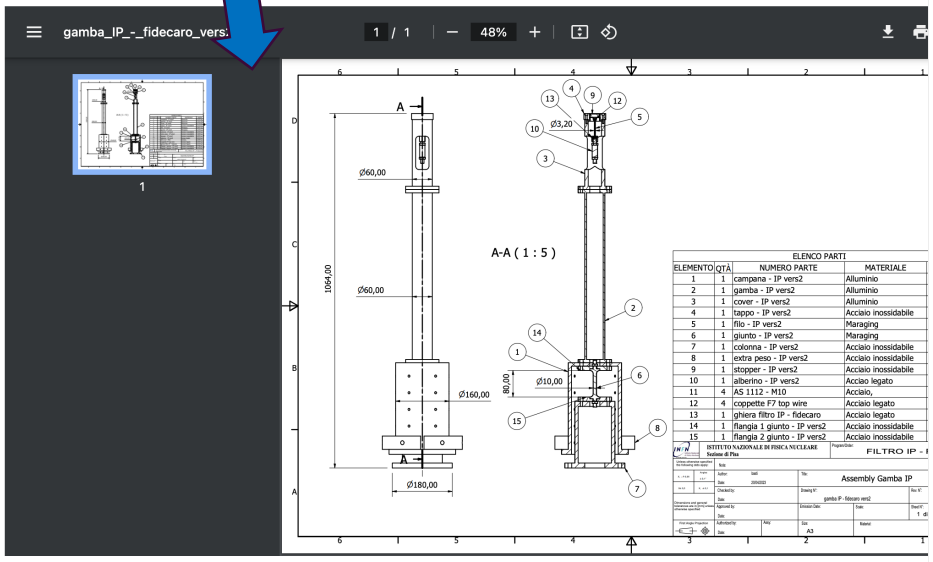
List of subcomponents:

Label	Component Type	Weight (Kg)	Materials	Mounted on
Campana_003	Campana	0.0	Alluminium	IP_Leg_003
Colonna_003	Colonna	8.6	Stainless steel	IP_Leg_003
Giunto_003	Giunto	0.0	Maraging steel	IP_Leg_003
Flangia1_003	Flangia1	0.748	Stainless steel	IP_Leg_003
Flangia2_003	Flangia2	0.724	Stainless steel	IP_Leg_003
Gamba_003	Gamba	1.531	Alluminium	IP_Leg_003
Cover_003	Cover	0.779	Alluminium	IP_Leg_003
TestComp2	Cover	1.0	al	IP_Leg_003

Overview of component "IP_Leg_003"

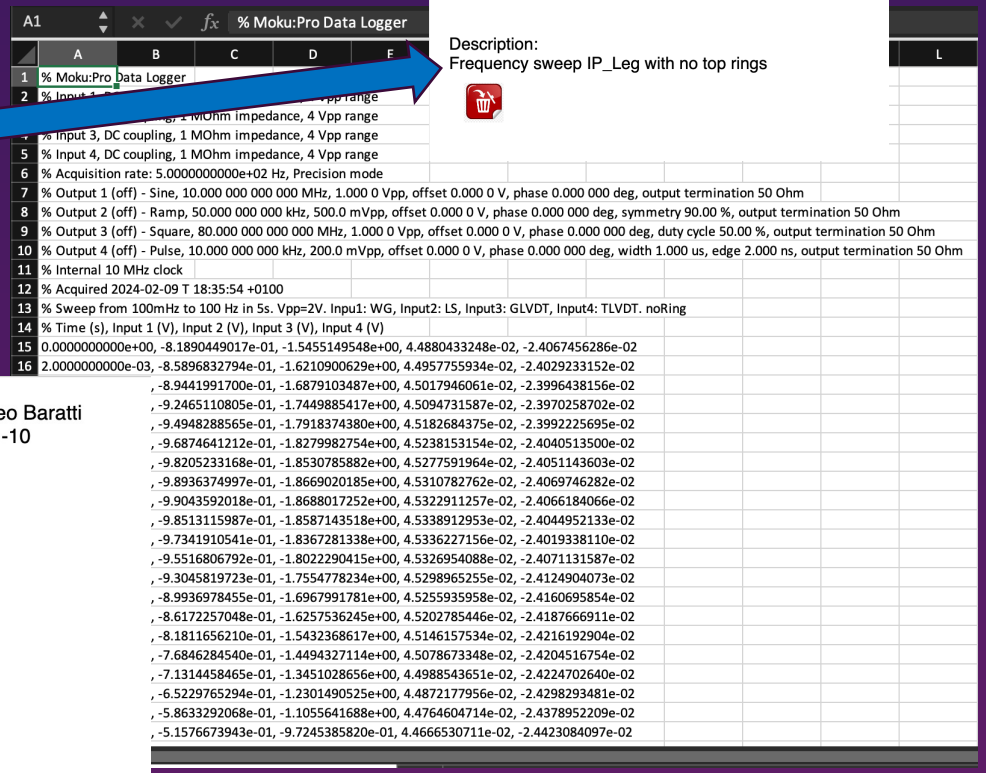
Media Gallery (click on picture to see more info): Upload New Media

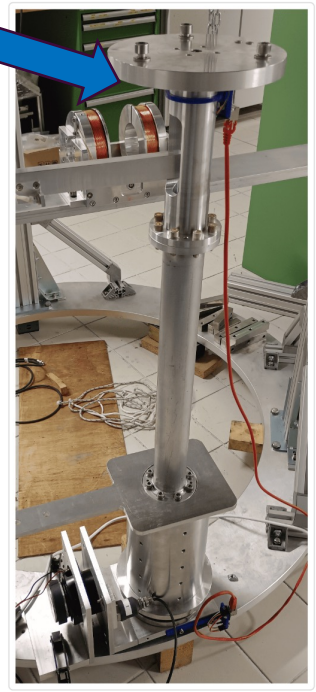




Sweep_12Kg_noRing_20240209_183554.csv
Authors: Lorenzo Bellizzi
Date: 2024-02-09

Description:
Frequency sweep IP_Leg with no top rings





Authors: Matteo Baratti
Date: 2023-11-10

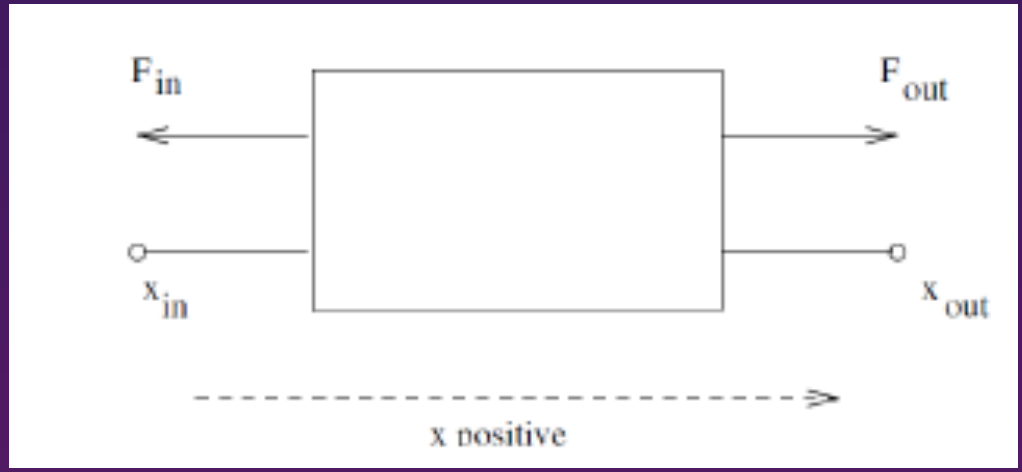
Description:
First IP leg

Accurate depiction of us learning HTML:
https://imgur.com/a/volume-control-eWbBK

My future work: Octopyus simulations

Developed within the PRIN BHETSA, to provide a user-friendly simulator (M. Razzano et al 2024 in prep)

Goal: find the **transfer function** of complex systems with **impedance matrix** approach (G. Cella & A. Vicerè 2001, Ruggi et al to be published)



$$\begin{pmatrix} \vec{x}_{out}(\omega) \\ \vec{F}_{out}(\omega) \end{pmatrix} = \begin{pmatrix} A(\omega) & B(\omega) \\ C(\omega) & D(\omega) \end{pmatrix} \begin{pmatrix} \vec{x}_{in}(\omega) \\ \vec{F}_{in}(\omega) \end{pmatrix}$$

$$T(\omega) = \frac{\vec{x}_{out}(\omega)}{\vec{x}_{in}(\omega)} = [{}^{t}D(\omega)]^{-1}$$

Graphical User Interface

Configuration

Mechanical Network Representation

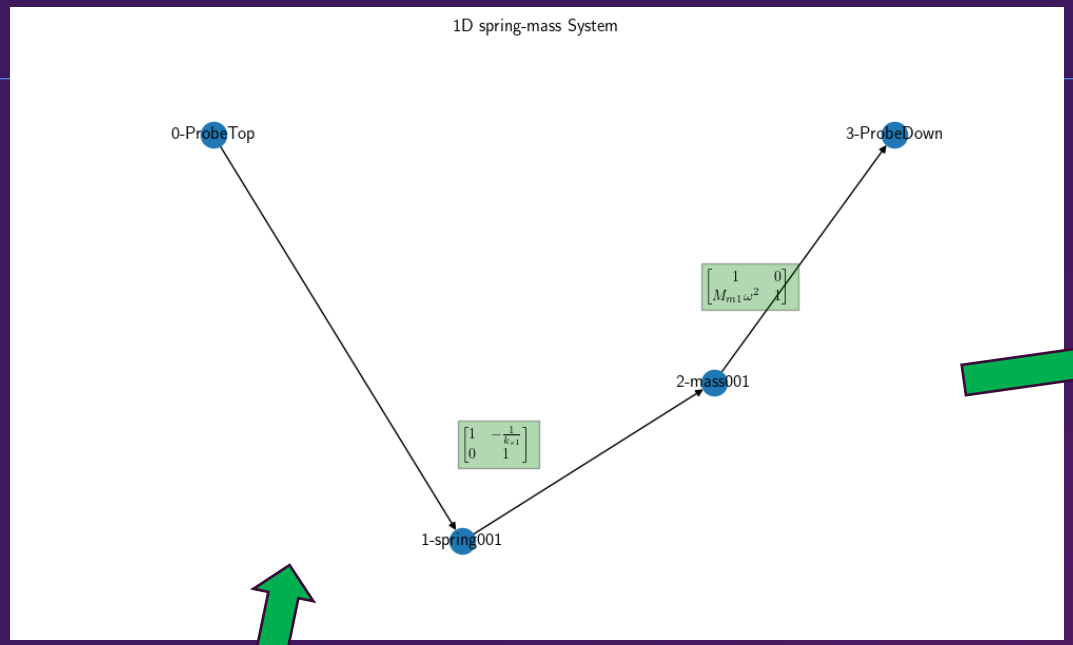
Solve network

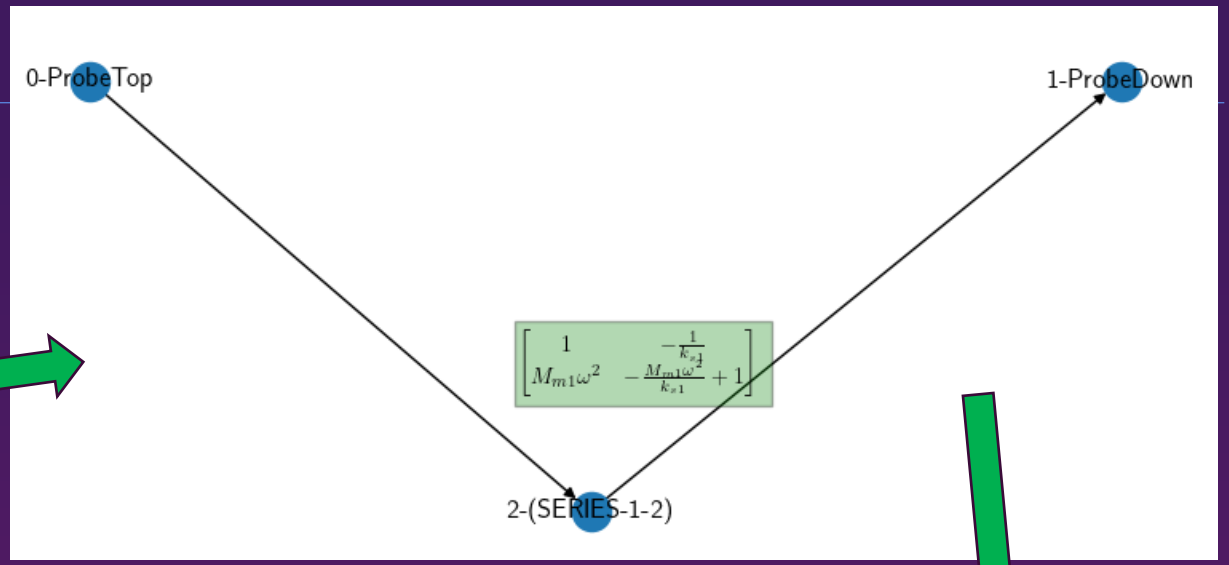
Transmission Matrix $Z(\omega)$

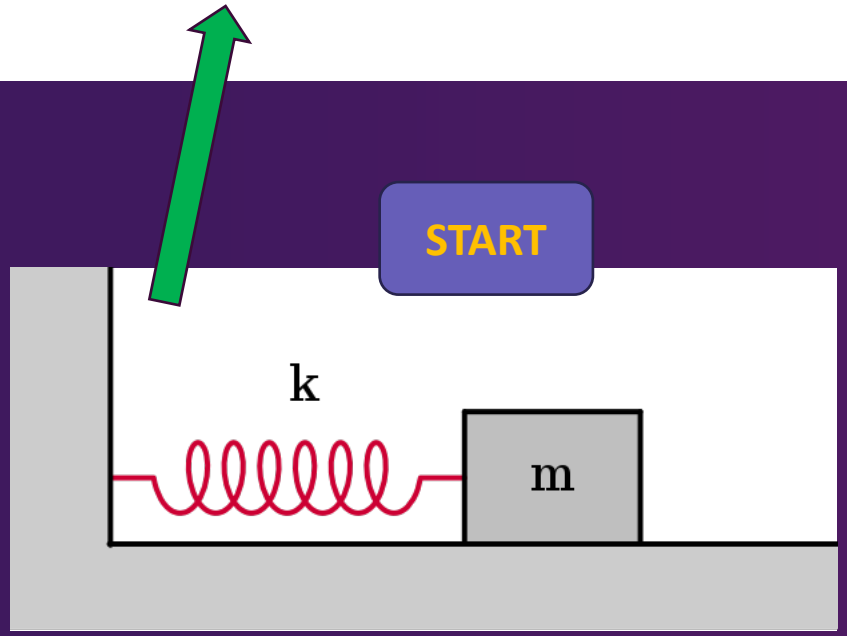
Transfer Function(s) $T(\omega)$

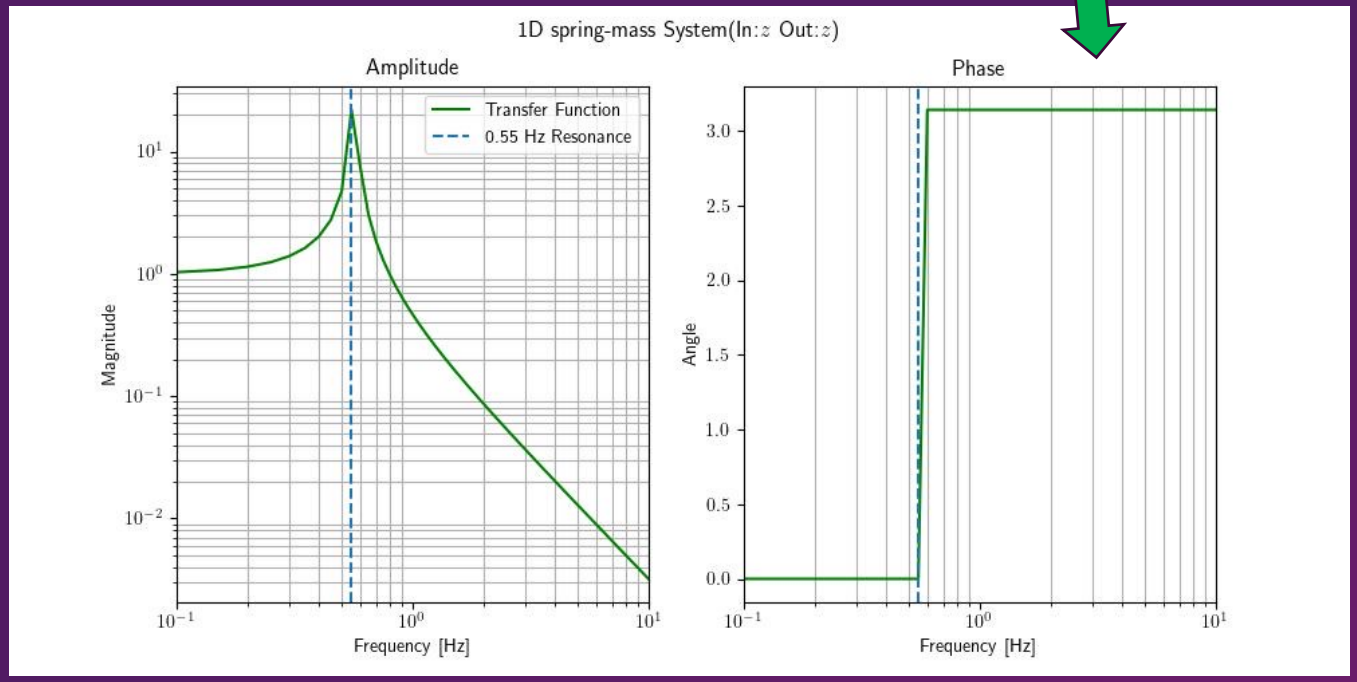
Optimization

Crosscheck with measurements


1D spring-mass System
0-ProbeTop
3-ProbeDown
2-mass001
1-spring001


0-ProbeTop
1-ProbeDown
2-(SERIES-1-2)


START
k
m


1D spring-mass System(In: z Out: z)
Amplitude
Transfer Function
0.55 Hz Resonance
Magnitude
Frequency [Hz]
Phase
Angle
Frequency [Hz]

"Hey ChatGPT, resume Michele's talk in one slide (and no memes...)"

Database-wise:

- Database implemented, 3-level development (local/staging/production)
- Python Web application **up and running**
- Already **filling with data and using to track activities**

IN THE FUTURE...

- Finalize **history and logbook**
- Complete structure for **groups and projects**
- Possibility to use it in other GW labs (discussing with CAOS)

Simulations-wise:

- Implemented **graph representation** and **symbolic calculation** to solve network and compute transfer functions
- Basic workflow done

- Refine simulations and apply to a full-scale PIP
- Develop **novel optimization techniques** (e.g. PINNs)

Suggestions for the group?