

# LIP Internships: Notion + Github

## Notion for the LIP summer students!

Study case: LIP group **NUC-RIA**.

### Walk through

1. What is Notion?
2. How the NUC-RIA group uses Notion
3. Uses for you and for this internship
4. Hands-on

## Part 1: What is Notion?

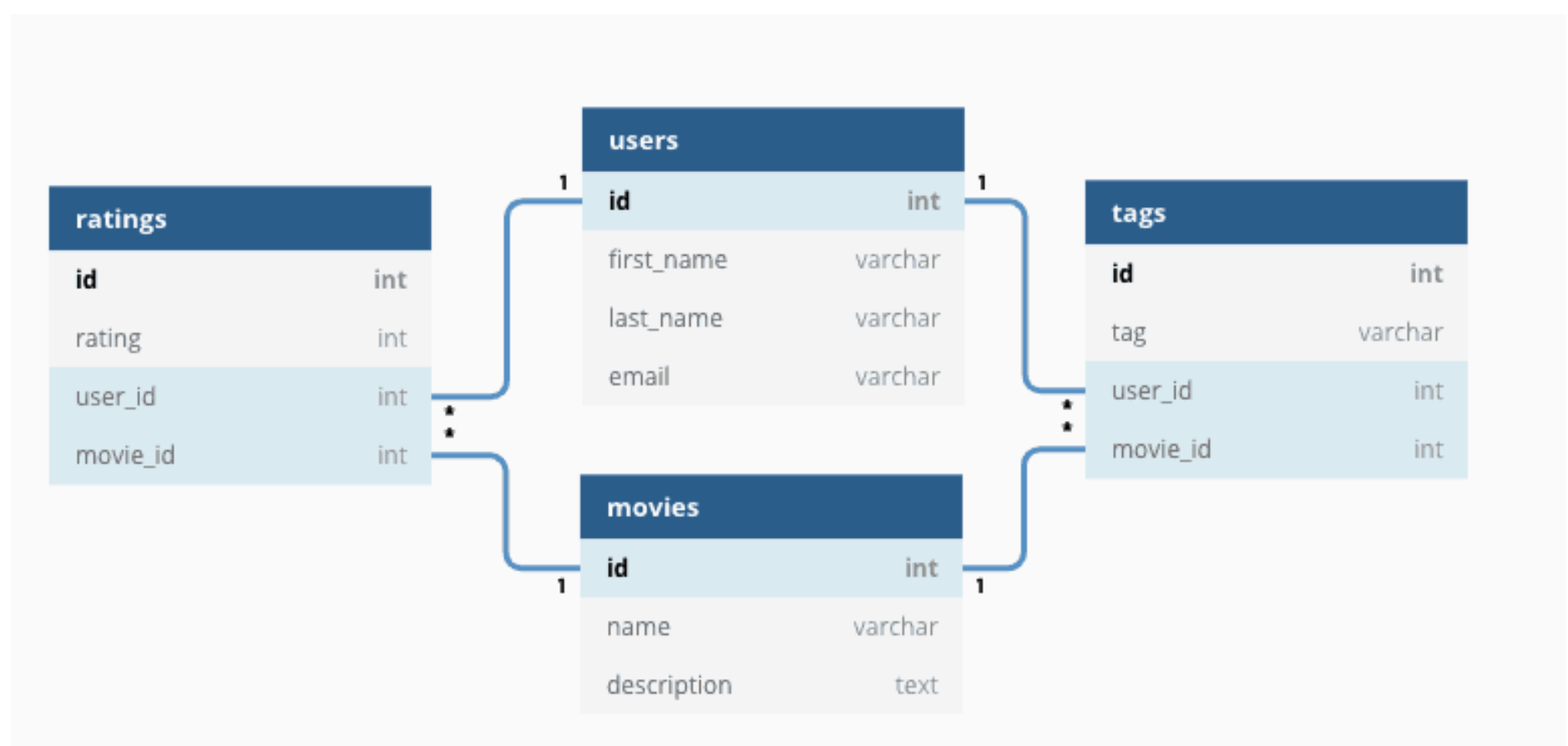
It is essentially a productivity tool

- Note-taking
- Task management
- Bookmarking (Meeting minutes, Organization)
- Database

## Relational Databases

| *A relational database stores and organizes data points that are related to one another.*

### General example



In our case, from this...

# Main Database

↩ 1 backlink

📅 Default view 📅 Calendar 📊 Board 📅 Timeline

## Database

↓ Created time ▾

⚙ State ▾

Aa Name	👤 Responsible	⚙ State	☰ Type	📅 Deadline	🕒 Created time
📄 Minutes 17/3/2023	👤 Daniel Galaviz	● Done	Group Meeting	March 17, 2023	March 24, 2023 8:11
📄 Conferência Austria	👤 Francisco G. Barba 👤 Daniel Galaviz	● In progress	Linkedin		March 22, 2023 11:33
📄 CLEAR 💬 1	👤 Daniel Galaviz 👤 Beatriz Amorim 👤 Francisco G. Barba 👤 Ricardo Matoza Pires	● Done	Linkedin		March 22, 2023 11:33
📄 Minutes 10/3/2023	👤 Daniel Galaviz	● Done	Group Meeting	March 10, 2023	March 17, 2023 8:30
📄 Website publication	👤 Ricardo Ferreira da Silva 👤 Carolina Felgueiras 👤 Tomás Sousa	● To-do	Linkedin		March 10, 2023 11:10
📄 Minutes 03/3/2023	👤 Daniel Galaviz	● Done	Group Meeting	March 3, 2023	March 10, 2023 8:24
📄 Minutes 24/2/2023	👤 Daniel Galaviz	● Done	Group Meeting	February 24, 2023	March 3, 2023 8:15
Rita's farewell	👤 Carolina Felgueiras	● To-do	Linkedin		February 24, 2023 9:30
📄 Masterclasses	👤 Carolina Felgueiras	● Done	Linkedin		February 24, 2023 9:30
📄 Carina's poster 💬 3	👤 Carolina Felgueiras 👤 Daniel Galaviz 👤 Carina Coelho	● Done	Linkedin		February 24, 2023 9:30

...we get this...

# Weekly Meetings

The meetings are every Friday at 9:15 in ZOOM

📅 Group Presentations

📅 Table

## Database

Aa Name	👤 Attending	📅 Deadline	☰ Type	👤 Responsible	⚙ State
📄 Minutes 24/3/2023	👤 Daniel Galaviz 👤 Manuel	March 24, 2023	Group Meeting	👤 Daniel Galaviz	● Done
📄 Minutes 17/3/2023	👤 Daniel Galaviz 👤 Manuel	March 17, 2023	Group Meeting	👤 Daniel Galaviz	● Done
📄 Minutes 10/3/2023	👤 Daniel Galaviz 👤 Manuel	March 10, 2023	Group Meeting	👤 Daniel Galaviz	● Done
📄 Minutes 03/3/2023	👤 Daniel Galaviz 👤 Manuel	March 3, 2023	Group Meeting	👤 Daniel Galaviz	● Done
📄 Minutes 24/2/2023	👤 Daniel Galaviz 👤 Manuel	February 24, 2023	Group Meeting	👤 Daniel Galaviz	● Done
📄 Minutes 10/2/2023	👤 Daniel Galaviz 👤 Manuel	February 10, 2023	Group Meeting	👤 Daniel Galaviz	● Done
📄 Minutes 03/2/2023	👤 Daniel Galaviz 👤 Manuel	February 3, 2023	Group Meeting	👤 Daniel Galaviz	● Done
📄 Minutes 27/1/2023	👤 Daniel Galaviz 👤 Manuel	January 13, 2023	Group Meeting	👤 Daniel Galaviz	● Done
📄 Minutes 13/1/2023	👤 Daniel Galaviz 👤 Manuel	January 13, 2023	Group Meeting	👤 Daniel Galaviz	● Done
📄 Minutes 23/12/2022	👤 Daniel Galaviz 👤 Manuel	December 9, 2022	Group Meeting	👤 Daniel Galaviz	● Done

...and this...

# nRPC: Development of a Thermal Neutron Detector using RPCs

🕒 Presentation May 2021

🌿 ANTS2

📅 Table

## 📌 Database

≡ 3 rules

Aa Name	👥 Attending	🕒 Created time	📅 Deadline	👤 Responsible	⚙️ State	≡ Type
📄 Paper PIADA 5		October 14, 2022 11:03	October 18, 2022	🕒 Carina Coelho 🧑 Lia Pe	🟠 To-do	🟢 Publications
Presentations for the internships		June 24, 2022 13:54	August 5, 2022	🕒 Rita Pestana	🟠 To-do	🟠 Presentations
📄 Notícia bolsa IAEA		February 19, 2022 11:15	February 21, 2022	🕒 Rita Pestana 🧑 Daniel C	🟢 In progress	🟡 Grant
Detector design for (multi) beta-delayed neu		December 7, 2021 9:02	February 28, 2022	🕒 Rita Pestana 🧑 Daniel C	🟠 To-do	🟢 Publications
Meeting with Silvia		October 29, 2021 13:56	November 2, 2021 10:00 AM	🕒 Rita Pestana	🟠 To-do	🟠 Meeting
Meeting with Biochemistry Group		October 26, 2021 11:20	November 3, 2021 10:00 AM	🕒 Rita Pestana 🧑 Lia Pere	🟠 To-do	🟠 Meeting
📄 Schedule weekly meetings with Dani 5		October 19, 2021 13:11	October 22, 2021	🧑 Daniel Galaviz 🕒 Eli 🧑	🟢 In progress	🟠 Meeting
Meeting with Fede		October 18, 2021 9:49	November 8, 2021 10:00 AM	🕒 Carina Coelho 🧑 Lia Pe	🟠 To-do	🟠 Meeting
📄 Ciências Research Day 2021 19		October 18, 2021 9:47	October 27, 2021	🧑 Daniel Galaviz 🕒 Manue	🟠 To-do	🟠 Presentations
Meeting with Silvia		October 15, 2021 16:35	October 25, 2021 3:00 PM	🕒 Rita Pestana 🧑 Daniel C	🟠 To-do	🟠 Meeting
📄 LIP @ FCUL Meeting - 27/10/2021		October 12, 2021 6:38	October 20, 2021	🧑 Daniel Galaviz 🕒 Eli 🧑	🟠 To-do	🟠 Meeting
Find paper about low energy proton beam c		October 4, 2021 11:07	October 8, 2021	🧑 Daniel Galaviz 🕒 Rita P	🟠 To-do	🟠 MsC
📄 Provisory thesis name and plan 3		September 30, 2021 16:40	October 15, 2021 → Novembe	🧑 Lia Pereira 🧑 Ricardo M	🟠 To-do	🟠 MsC Grant

+ New

## ...through filtering & sorting

### 📌 Database

↓ Deadline | ≡ 3 rules

Where

👤 Respon... ▾

Contains ▾

🕒 Rita Pestana 🕒 Carolina Felgueiras ▾

...

And ▾

≡ Type ▾

Does not contain ▾

Linkedin ▾

...

And

⚙️ State ▾

Is not ▾

Done ▾

...

+ Add filter rule ▾

Delete filter

## Database views

Databases are the bread and butter of Notion, knowing how to use them is 75% of this tool.

## List

 List view  Board 4 more...


## Example database

 [Item 1](#)

tag2

 [Item 2](#)

tag1

 [Item 3 - Click me](#)

tag1

tag2


## Board

 List view  Board 4 more...

## Example database

tag1 2


 [Item 2](#)

 [Item 3 - Click me](#)

+ New

tag2 2

 [Item 1](#)

 [Item 3 - Click me](#)

+ New

 No Tags 0

+ New

## Timeline

 List view  Timeline 4 more...

## Example database

>> March 2023

Month  < Today >

22

23

24

25

26

27

28

29

30

31

1

2

3

4

5

6

7

8

 Item 1

Item 2

Item 3 - Click me

+ New

## Calendar



## Example database

March 2023

<

Today

>

Sun	Mon	Tue	Wed	Thu	Fri	Sat
26	27	28	Mar 1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
	Item 1			Item 2		
26	27	28	29	30	31	Apr 1
Item 2		Item 3 - Click me				

## Table

### Example database

Aa Name	🕒 Created	📅 Date	@ Email	🏷 Tags	+ ...
📄 Item 2	June 15, 2022 3:42 PM	March 23, 2023 → March 27, 2023		tag1	
📄 Item 1	June 15, 2022 3:42 PM	March 20, 2023 → March 24, 2023		tag2	
📄 Item 3 - Click me	June 15, 2022 3:42 PM	March 26, 2023 → March 30, 2023	jeff-bezos@gmail.com	tag1 tag2	
+ New					

## Gallery

## Example database



📄 Item 2



📄 Item 1

You can write inside any of these items! And in the **top left corner** you can open this page as full page!

📄 Item 3 - Click me

+ New

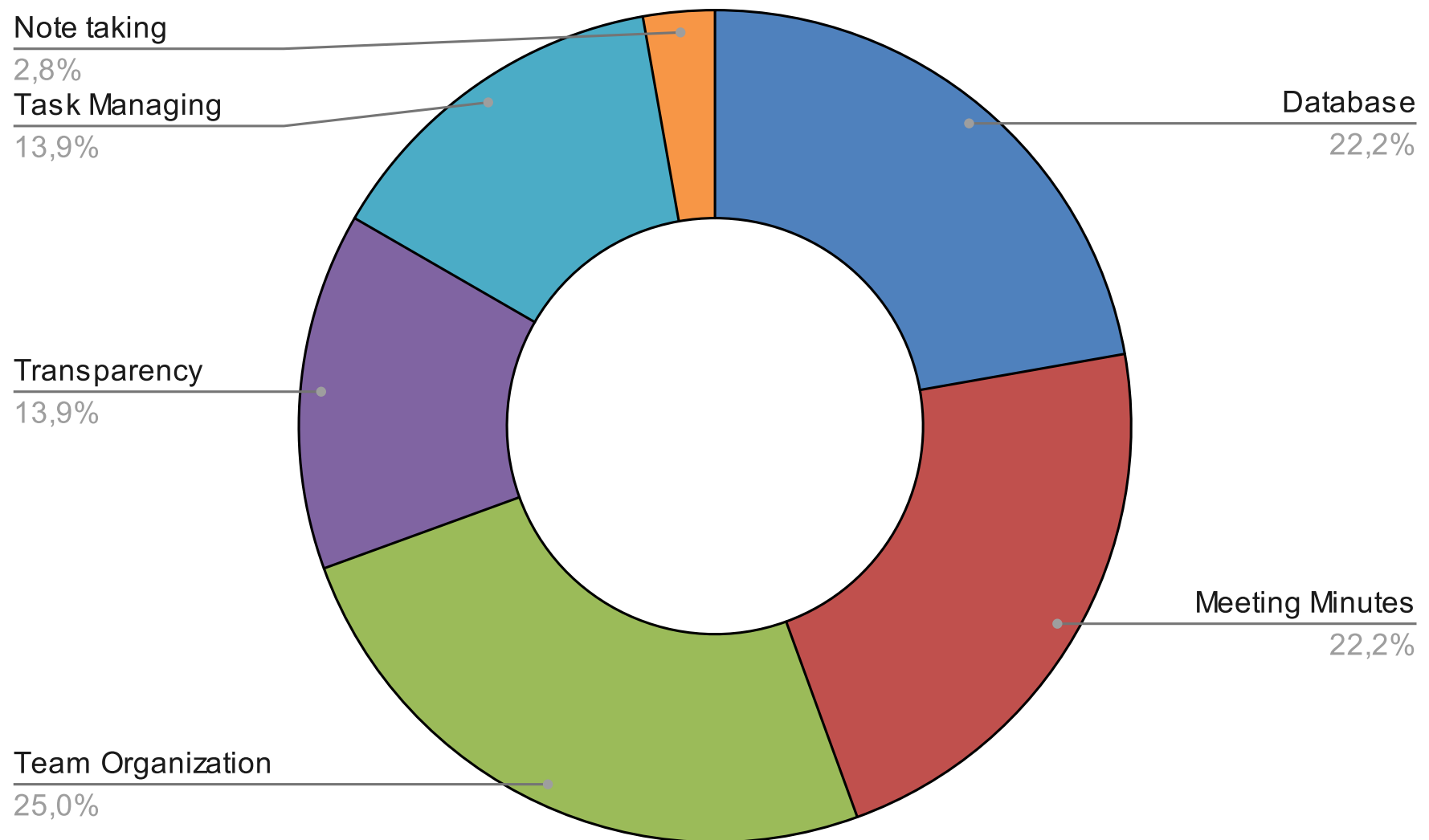
## Each of this items can be a page

The screenshot shows a Notion workspace with a database titled 'LIP Internships 2023 / Notion Workflow'. The database is in 'Gallery' view. One item, 'Item 3 - Click me', is selected and expanded into a full-page view. The expanded page has a title 'Item 3 - Click me' and the following properties:

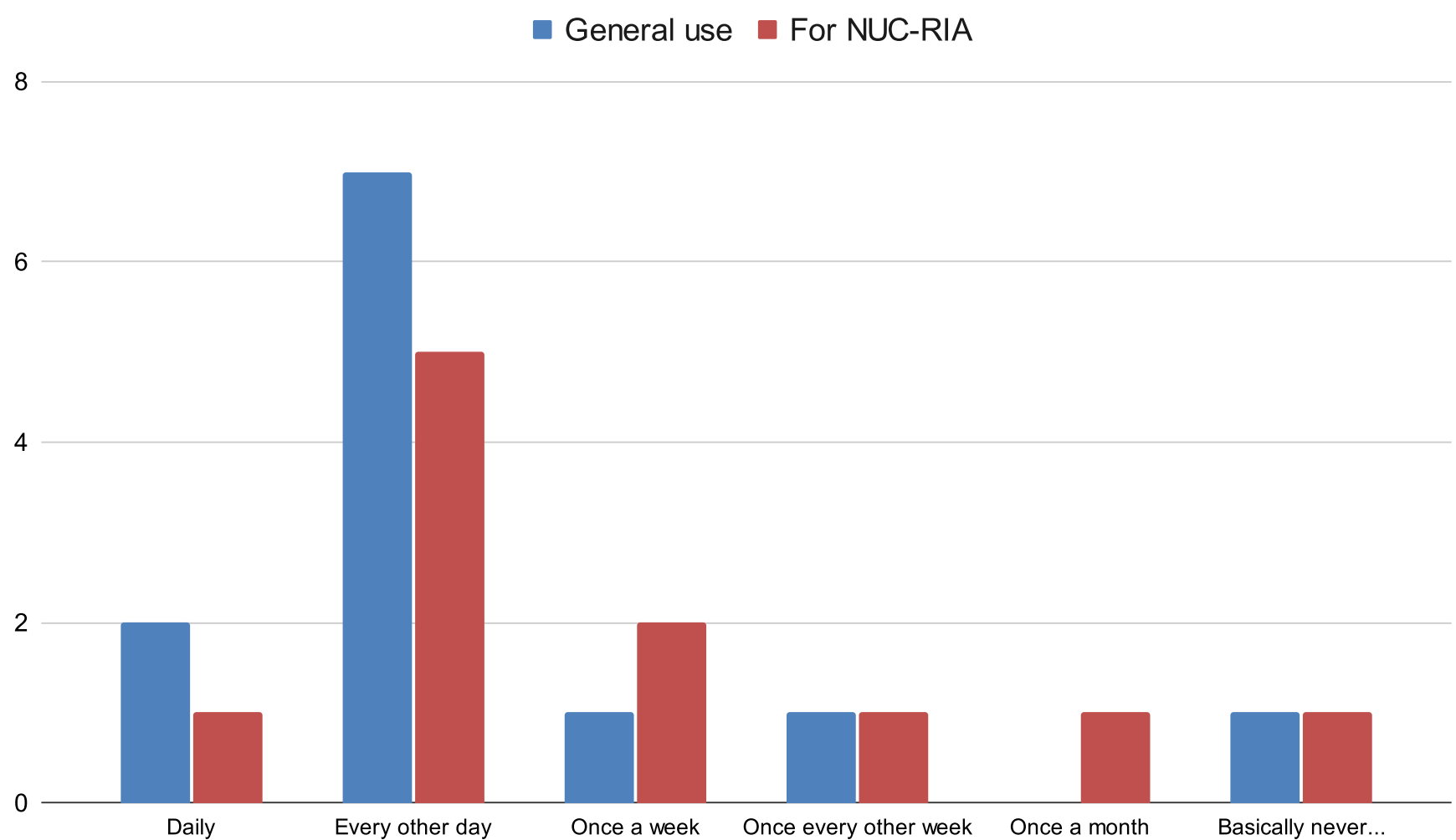
- Created: June 15, 2022 3:42 PM
- Tags: tag1, tag2
- Email: jeff-bezos@gmail.com
- Date: March 26, 2023 → March 30, 2023

Below the properties is a section for comments with the text 'Add a comment...'. At the bottom of the page, there is a note: 'You can write inside any of these items! And in the **top left corner** you can open this page as full page!'.

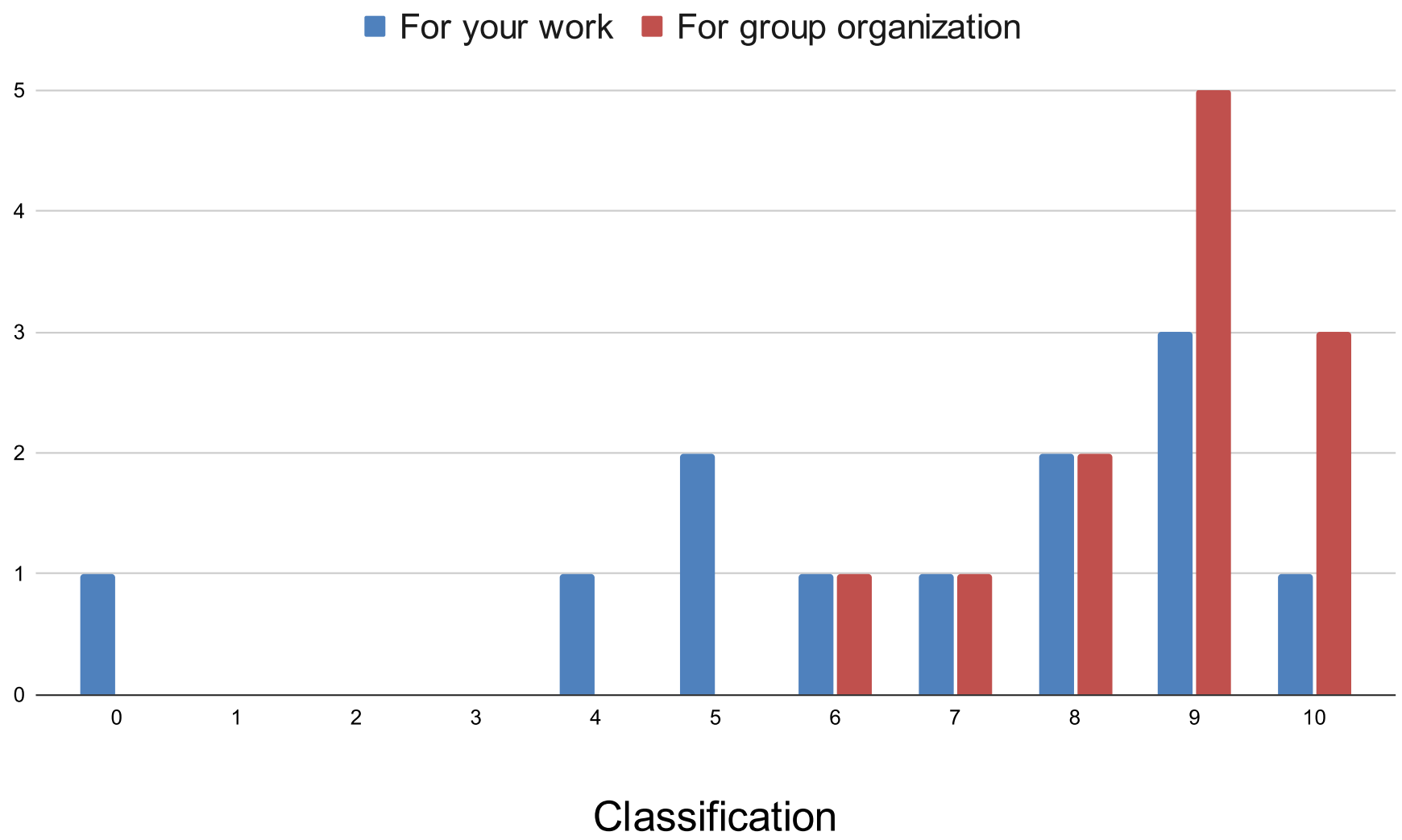
## Part 2: How the NUC-RIA group uses Notion



## How regularly do they use it?



## How useful is it?



# NUC-RIA Workflow

Ok... but how about NUC-RIA?



Add comment





















## NUC-RIA Main Page

 Main Database

### 📅 Weekly Meetings

## Projects

- 🌟 [Proton activations at CTN](#)
- 🖥️ [NNT : P process simulation](#)
- 🔬 [nRPC: Development of a Thermal Neutron Detector using RPCs](#)
- 👤 [SMODA: Development of a Standard Methodology for Online Dose Calculation in Air](#)
- 🧠 [PIADA: Proton radiation Impact on Amyloid structures against Alzheimer.](#)
- 📖 [BESN: Correction on Energy deposition on Thin Singlesided Silicon Strip Detector](#)
- 👤 [SCORE - Short range CORrelations on Exotic nuclei at R3B/FAIR using tRPCs](#)
- 👤 [Evaporator facility](#)
- 🏠 [CALIFA@CTN](#)
- 🖥️ [C4F: Characterization of CsI\(Tl\) Crystals and Implementation of tools for the CALIFA calorimeter at FAIR.](#)
- 👤 [Inverse Alpha - IS698](#)
- 🔬 [RPCs for CALIFA](#)
- 🖥️ [ATOMIK : Atomic inputs for kilonovae modeling](#)
- 📖 [Muon detection with a scintillator-PMT based setup](#)
- 🖥️ [Interface](#)

-  LinkedIn
  -  Papers
  -  CTN
  -  LIP Internship Proposals 2023
  -  Photos
  -  Conferences & Workshops
  -  Group Presentations
  -  Contacts
  -  Proposals for Research Projects
  -  Ciência ID
  -  Lab 8.5.15
  -  NUC-RIA - The movie
  -  Grants and Applications
  -  Masterclass
  -  Updates Weekly
  -  Annual Reports LIP
  -  Useful Tools: IT for beginners
  -  Website
  -  Group's Task Forces
  -  Opportunities in Nuclear Physics / BioNuclear ...

## Calendar

Table Calendar Timeline

## ➤ Database

February 2023

< Today >

Sun	Mon	Tue	Wed	Thu	Fri	Sat
29	30	31	Feb 1	2	3	4
		<div>Characterization of the res... 🗨️ Pamela Teubig 🗨️ Daniel G</div>			<div>🗨️ Minutes 03/2/2023 🗨️ Daniel Galaviz</div>	
5	6	7	8	9	10	11
					<div>🗨️ Minutes 10/2/2023 🗨️ Daniel Galaviz</div>	
12	13	14	15	16	17	18
19	20	21	22	23	24	25
					<div>🗨️ Minutes 24/2/2023 🗨️ Daniel Galaviz</div>	
26	27	28	Mar 1	2	3	4
	<div>🗨️ R3BRoot Workshop 🗨️ 2 🗨️ Daniel Galaviz 🗨️ Tomás S</div>				<div>🗨️ Minutes 03/3/2023 🗨️ Daniel Galaviz</div>	

## Miscellaneous

- ? [How to use the @Main Database](#)
- 🌀 [Internships Notion Workflow](#)
- 📁 [Archive](#)



# Contacts



## Contacts

**Tomás Sousa** Oct 30  
@Diogo Miguel @Carolina Felgueiras preciso que coloquem aqui os vossos contactos

Add a comment...

✓ 1 resolved comment

It is very important to add your CV

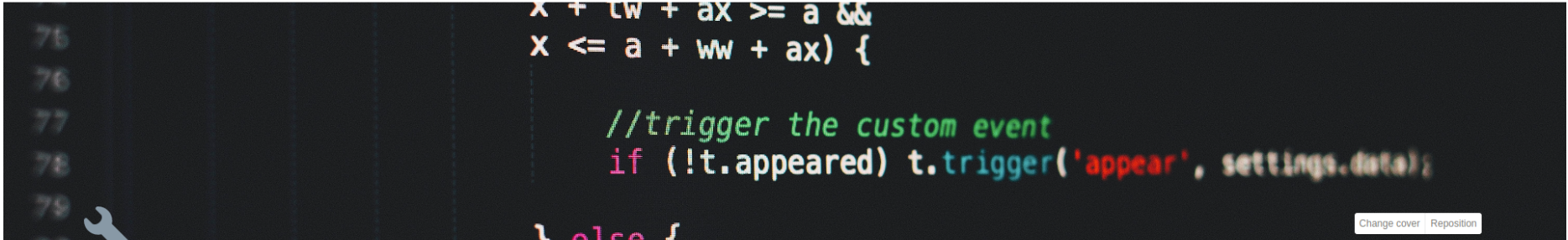
Gallery view

### Our Members

 _Right Click and "duplicate"	 Pedro Copeto	 Beatriz Amorim	 Ricardo Ferreira da Silva	 Carolina Felgueiras
 Diogo Miguel	 Pamela Teubig	 Eli Galiana	 Daniel Galaviz Redondo	 Carina Coelho
 Francisco Geraldes Barba	 João Jantarada	 Lia Pereira	 Manuel Xarepe	 Tomás Sousa
 Rita Pestana	 Ricardo Pires	 Margarida Paulino	 + New	



# IT Tools for beginners



Add comment

# Useful Tools: IT for beginners

This is the page dedicated to serve as a database of the main software, useful pieces of code, websites and computational tools, from the most basic to the more advanced ones, used by our group. Everyone is invited to contribute to this page by adding new information or reviewing what we have so far.

This should be a place where new learners come to start getting in touch with things such as Linux, Virtual Machines, Git, Python, C++, GEANT4, etc. But also for the "senior" people to keep sharing knowledge on their most useful tools

Below there is a set of pages covering the more interesting topics for beginners (e.g.: [Linux](#) ).

There is an extended [Useful Tools Main Database](#) with everything classified with Tags and Flavors.

In the end, there is a view of the database filtered by categories (Tags or Flavors).

**How to contribute?**

Go to the [Useful Tools Main Database](#) and add a new entry. Besides its name, also define "Tags" and "Flavors". Additionally you can add a header description to it, relevant files and URL, or you can simply start typing in the page.

If you want that entry to be on the spot, you can copy and paste the link to that page in the set already existing below.

New entries on the main data base are automatically added to the overview.

Useful Tools Main Database

Linux

Virtual Machines

Docker

ROOT-CERN

GEANT4

TOPAS

C++

Git and GitHub

VS Code

Overview Tags

Overview Flavor

Name

Tags

Code/Script 6

Software 13

Website/App 5

Workshop 3

Presentation 1

No Tags 0

ArXivFetcher

Event muon generator

Map2root

ROOT related files

SciToFloat

TOPAS geometries

+ New

BASH

C++

Docker

GEANT4

Git and GitHub

Linux

NUC-RIA Virtual Machine

R3BRoot Docker Container

ROOT-CERN

Task Spooler

Load more

+ New

Hex Tech

Lucid Chart

Miro

Quilbot

Research Rabbit

+ New

Introduction Class for Geant4

Machine Learning applied to Nuclear Physics

Notion Workshop

+ New

Cell culture room procedures

+ New

Archive  
Useful Tools Main Database

## Group’s Task Forces

LIP Internships: Notion + Github

11





 Add cover  Add comment

## Group's Task Forces

Here are the identified the various tasks distributed among the group, such that whenever a person is leaving (or is very busy and cannot do the job) or somebody new is coming, we do have an overview on **who** is doing **what**, and we see also the need for a replacement.

Task	Responsible	Page in Notion
Linkedin & Social	@Carolina Felgueiras	<a href="https://www.notion.so/nuc-ria/Linkedin-2b4ca018372a44bb8e94c2c2d6e8b465">https://www.notion.so/nuc-ria/Linkedin-2b4ca018372a44bb8e94c2c2d6e8b465</a>
Group Seminars	@Ricardo Ferreira da Silva	
Papers	@Pamela Teubig	<a href="https://www.notion.so/nuc-ria/Papers-bc1b8fd199ba4fb48202e50b76232fb5">https://www.notion.so/nuc-ria/Papers-bc1b8fd199ba4fb48202e50b76232fb5</a>
Website	@Tomás Sousa, @Ricardo Ferreira da Silva @Carolina Felgueiras	<a href="https://www.notion.so/nuc-ria/Website-88a332c0627441e198a5d6f4582da3b7">https://www.notion.so/nuc-ria/Website-88a332c0627441e198a5d6f4582da3b7</a>
Conferences and Workshops	@Pamela Teubig	<a href="https://www.notion.so/nuc-ria/Conferences-Workshops-5d1dfb241ace4490a1c00ccc01f59654">https://www.notion.so/nuc-ria/Conferences-Workshops-5d1dfb241ace4490a1c00ccc01f59654</a>
Grants	@Carina Coelho @Ricardo Ferreira da Silva @Francisco G. Barba @Manuel Xarepe @Pamela Teubig	<a href="https://www.notion.so/nuc-ria/48bb055a82914447bf8d50ae32e103ca?v=9d906b61ae9e43fb8659fcea407e762">https://www.notion.so/nuc-ria/48bb055a82914447bf8d50ae32e103ca?v=9d906b61ae9e43fb8659fcea407e762</a>
Lab	@Tomás Sousa @Ricardo Matoza Pires	<a href="https://www.notion.so/nuc-ria/Lab-8-5-15-13d64d71b829499ab29c9c89693fec2">https://www.notion.so/nuc-ria/Lab-8-5-15-13d64d71b829499ab29c9c89693fec2</a>

# Part 3: Uses for you and for this internship

## Note-taking

You can obviously create notes for your work!

## 9. Photomultiplier Tubes

### From Requirements

- 5.1 Introduction
- 5.2 The photocathode: parts A, B, C, D
- 5.3 Electron multiplier: parts A, C, D
- 5.4 Ancillary equipment required with photomultiplier tubes: parts A, B

### To-do List

### I. Introduction

The widespread use of scintillation counting in radiation detection and spectroscopy would be impossible without the availability of devices to convert the extremely weak light output of scintillation pulse into the corresponding electrical signal. The photomultiplier (PM) tube converts light signals into usable current, even if the light signal is only a hundred photons! A great variety of commercially available PM tubes are sensitive to radiant energy in the ultraviolet, visible and near infrared regions of the EM spectrum.

The two major elements of a typical PM are the photocathode and electron multiplier; these two structures are coupled.

The photocathode serves to convert as many incident photons as possible into low-energy electrons (if the light consists of a pulse will also be a pulse of similar time duration). Being a weak electron signal it requires amplification to be measurable and is coupled with the electron multiplier, not only to amplify them, but also to collect them. After amplification the electrons are collected in the anode (element 13 in Fig. 9-1). Most photomultipliers perform this charge amplification in a very linear manner, producing an output signal proportional to the number of original photoelectrons over a wide range of amplitudes. Not only that but much of the timing information is retained! Let's now deal with the two main elements of the PM.

### II. The Photocathode

#### A. The Photoemission Process

The first step to be performed in a PM tube is the conversion of photons into electrons. There are three main steps that describe this process:

1. The absorption of the incident photon and transfer of energy to an electron within the photoemissive material.
2. The migration of that electron to the surface.
3. The escape of the electron from the surface of the photocathode.

The energy that can be transferred from the photon to an electron is the first step is given by the quantum energy of the photon  $h\nu$  ( $\sim 3\text{eV}$  for blue light). In step 2, some of that energy will be lost through electron-electron collisions in the migration process. Finally, in step 3, there must be sufficient energy left for the electron to overcome the inherent potential barrier which always exists at any interface between material and vacuum, called the "work function". This function is normally lower in semiconductors than in metals, so they're usually used.

The stopping power of electrons moving to the surface should be as low as possible, but the thickness of the material should be enough to maximize the depth of material in which electrons originate. It is a balance. Given the two conditions, only a very thin layer of material with thickness equal to the escape depth (minimum depth for electrons to escape a potential barrier) will contribute to photoelectrons (metals few nm; semi-conductors  $\sim 25\text{nm}$ ).

Because of this thickness, photocathodes are semi-transparent, only less than half of the visible light will interact.

#### B. Thermionic Electron Emission

The potential barrier influences another important property of the photocathode: thermionic noise. Electrons have a temperature distribution given by the Maxwell-Boltzmann distribution, and in the tail of the distribution, the faster electrons, have enough thermal energy to escape the potential barrier. Electrons that escape the barrier by this effect create noise, in metals this effect is considerably low ( $\sim 100\text{mA}$ ), however, considerable in semi-conductors ( $\sim 10^3\text{mA}$ ).

### Easy images

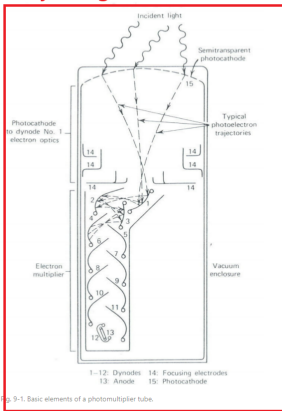


Fig. 9-1. Basic elements of a photomultiplier tube.

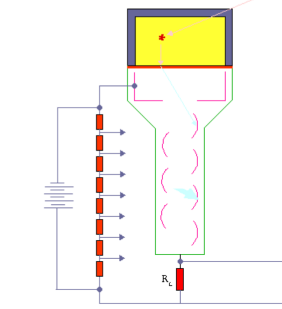


Fig. 9-2. Sequence of functioning between a scintillator and PM.

#### C. Fabrication of Photocathodes

Photocathodes can be constructed as either opaque or semitransparent layers. Each type is utilized in a somewhat different geometric arrangement!

- **Opaque:** Their thickness is somewhat larger than the escape depth. They are mounted on a thick material and photoelectrons are collected on illuminated surface.
- **Semitransparent:** Their thickness does not exceed the escape depth, mounted on a transparent material and photoelectrons are collected in the non-illuminated surface.

It is crucial that their thickness is uniform over the entire area, variations on uniformity may give rise to corresponding changes in the sensitivity of the photocathode  $\rightarrow$  loss in resolution!

### Callouts



Fig. 9-3. Examples of photocathodes.

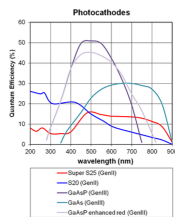


Fig. 9-4. Dependence of  $\lambda$  on QE.

#### D. Quantum Efficiency and Spectral Response

The sensitivity of photocathodes can be quoted in several ways, in particular, when applied to DC light measurements, it is traditional to quote an overall photocathode efficiency in terms of current produced per unit flux on its surface (amperes per lumen). For this let's introduce quantum efficiency (QE):

$$QE = \frac{\# \text{ of photoelectrons emitted}}{\# \text{ of incident photons}}$$

for practical photocathodes this value is a maximum of 20-30%

This efficiency will be a strong function of wavelength (shown in Fig. 9-4), for lower  $\lambda$  this efficiency will drop since photoelectrons won't have sufficient energy to escape the potential barrier. But at higher  $\lambda$ , the glass window of the photocathode might be opaque to that radiation and the efficiency is cut off! In this case the window is substituted for a silica or quartz to extend into the UV region (520 in Fig. 9-4).

In order to estimate the effective quantum efficiency of a photocathode, when used with a particular scintillator, the QE curves must be averaged over the emission spectrum of the scintillator.

An alternative measure of quantum efficiency is: # of photoelectrons produced from a given photocathode per keV of energy loss by fast electrons in a NaI(Tl) crystal scintillator from which nearly all the light is collected. For photocathodes with 20-30%, this measurement gives about 8-10 photoelectrons per keV energy loss. Therefore, the average energy loss required to create one photoelectron is about 100-120 eV.

**▲** i.e. the energy loss required to produce one basic information carrier in a typical scintillator detector is much larger than the equivalent value in gas-filled or semiconductor detectors!

### II. Electron Multiplication

#### A. Secondary Electron Emission

Electrons from the photocathode are accelerated, by an electrical potential  $V$ , into a surface material capable of producing secondary emission electrons. This surface is called dynode.

An electron that leaves the photocathode has on average 3eV and to excite electrons from the valence band to conduction band it is needed  $\sim 2\text{eV}$ -3eV (bandgap energy)! So this means that an electron of 100eV can create about 30 excited secondary emission electrons.

Ultimately, only a small fraction of the excited electrons reach the surface of the dynode and contribute to the continuous amplification of the signal, this fraction is given by the overall multiplication factor  $\delta$ :

$$\delta = \frac{\# \text{ of secondary electrons emitted}}{\# \text{ primary incident electron energy}}$$

**▲** The multiplication value is energy dependent and normal values  $\sim 5$ -10 for optimum incident electron energy!

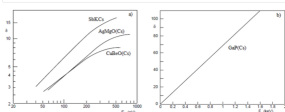


Fig. 9-5. Variation of the secondary emission yield with primary electron energy.

#### C. Multiple Stage Multiplication

In order to achieve electron gains on the order of  $10^6$ , all PM tubes employ multiple stages, electrons leaving the photocathode are attracted to the first dynode and produce  $\delta$  electrons for each incident photoelectron.

This process can be repeated many times, with low-energy secondary electrons from each dynode accelerated toward the following dynode. If  $N$  stages are provided in the multiplier section the overall gain for the PM tube is given by:

$$\text{Overall Gain} = \alpha \delta^N$$

where  $\alpha$  is the fraction of all photoelectrons collected by the multiplier structure.

**▲** The overall gain of a PM tube is a sensitive function of applied voltage  $V$ .

#### D. Statistics of Electron Multiplication

If  $\delta$  were strictly a constant, each photoelectron would be subject to exactly the same multiplication factor. But...

The emission of secondary electrons is a statistical process, and therefore the specific  $\delta$  value at a given dynode will fluctuate from event to event about its mean value.

The shape of the single photoelectron pulse-height spectrum observed from a real PM tube is an indirect measure of the degree of fluctuation in  $\delta$ .

In the most simple model, the production of secondary electrons at a dynode can be assumed to follow a Poisson distribution about the average yield. For a single photoelectron incident on the first dynode, the number of secondaries produced has a mean value of  $\delta$  and std  $\sigma$  of  $\sqrt{\delta}$ .

For  $N$  identical stages of the PM tube, the mean number of electrons collected at the anode is given by  $\delta^N$ . It can be demonstrated from the properties of Poisson statistics that the relative variance in this number is now:

$$\frac{1}{\delta} + \frac{1}{\delta^2} + \frac{1}{\delta^3} + \dots + \frac{1}{\delta^N} \approx \frac{1}{\delta-1}$$

### Equations

Thus if  $\delta \gg 1$ , the relative variance or spread in the output pulse amplitude is dominated by fluctuations in the yield from the first dynode where the absolute number of electrons is smallest.

#### V. Ancillary Equipment Required with Photomultiplier Tubes

##### A. High-Voltage Supply and Voltage Divider

An external voltage source must be connected to the photomultiplier tubes in such a way that the photocathode and each succeeding multiplier stage are correctly biased with respect to one another.

Multicell battery is in principle usable to power dynodes individually, but not favored because of high current drawn, in the vast majority of cases we use a resistive voltage divider and single source of high voltage (Fig. 9-6).

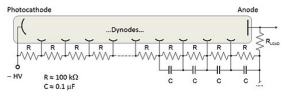


Fig. 9-6. Resistive voltage divider and single source of high voltage.

The figure represents this case where direct current is passed through divider string, divider current should be high enough compared to internal current in tube due to electron pulse to avoid variations in amplification; stabilizing capacitances  $C$  deliver dynode current during pulse and get recharged in between pulses.

**Example:** Assume we start with a scintillation event that liberates 1000 photoelectrons from the photocathode of the PM tube. Further assume that the PM tube provides an overall gain of  $10^6$ , so that  $10^9$  electrons per pulse leave the last dynode and are collected by the anode. If these scintillation pulses are occurring at a rate of  $10^3$  per second, then the average dc anode current can easily be calculated as:

$$I_{avg} = 10^9 \frac{\text{electrons}}{\text{pulse}} \times 1.6 \times 10^{-19} \frac{\text{coulomb}}{\text{electron}} \times 10^3 \frac{\text{pulses}}{\text{second}} = 1.6 \times 10^{-5} \text{ A} = 0.016 \text{ mA}$$

Because this current appears in discrete pulses, however, the peak current during a pulse is substantially larger. As an extreme case we can consider  $I_{peak} \sim 32 \text{ mA}$ .

Choice of polarity of voltage divider is in principle arbitrary:

- +HV: photocathode close to scintillator at ground level, i.e. easy to handle.
- -HV: photocathode at high voltage, there's a danger of pseudo-pulses from high voltage leaks through entrance window to grounded components, or pseudo-pulses from electro-luminescence in the glass, with this there's no need for the coupling capacitance near the anode.

The very large changes in gain that accompany changes in voltage with a photomultiplier tube are often a great convenience in setting up a counting system! Although the timing properties are distorted by this effect, linearity and relative signal-to-noise of the signal are not. So it allows a tuning system to the experimenter wishes!

##### B. Magnetic Shielding

**▲** It is necessary to have magnetic shielding because photomultiplier tubes are particularly sensitive to stray magnetic fields, this is because of the low energy electrons ( $\sim 100\text{eV}$  max). Even the earth's magnetic fields is sufficient to appreciably affect the trajectories of these electrons.

## Collaborative work

If you're working with somebody else, this may be very helpful!

HUB / ... / Laboratórios Avançados / Microscopia de força atômica (AFM)

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# Microscopia de força atômica (AFM)

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Dúvidas

A variação na fase é toda a amplitude ou metade?

Cálculo do módulo de Young

Data de entrega do relatório

21. Scanning Probe Microscopy – Principle of Operation, Instrumentation, and Probes

Part 2: 21

Bharat Bhushan, Othmar Marti

Since the introduction of the STM in 1981 and the AFM in 1985, many variations of probe-based microscopes, referred to as SPMs, have been developed. While the pure imaging capabilities of SPM techniques initially dominated applications of these methods, the physics of probe-sample interactions and quantitative analyses of tribological, electronic, magnetic, biological, and chemical surfaces using SPMs have become of increasing interest in recent years. SPMs are often associated with nanoscale science and technology, since they allow investigation and manipulation of surfaces down to the atomic scale. As our understanding of the underlying interaction mechanisms has grown, SPMs have increasingly found application in many fields beyond basic research fields. In addition, various derivatives of all these methods have been developed for special applications, some of them intended for areas other than microscopy.

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Trabalho de microscopia de força atômica

8 de Março de 2021

1 Muito breve introdução

A microscopia de força atômica (AFM, do inglês atomic force microscopy) é uma técnica inventada nos anos 80 após a invenção da microscopia por efeito túnel. Ambas as técnicas tem a capacidade de realizar imagens com resolução atômica, e são intrinsecamente tridimensionais, embora aqui as dimensões tenham que ser vista com alguma imaginação, visualizar nestas escalas é necessariamente distinto daquilo a que estamos habituados. Estas técnicas tem como base a medição da interação entre uma ponta fina e uma amostra que se queira estudar. As forças superficiais como as forças de contacto, químicas ou van der Waals dependem

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LaTeX Relatório Grande

Tomás Sousa

Parte 2 - Disco, 19.1

Rita Pestana

Parte 1 - Grafite, G28

David Lima

Force Volume - Mathematica



Tomás Sousa

Ler Cap.AFM Livro

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Introdução do relatório

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## Task and project management

Timelines are great when tight schedules for posters or abstracts arrive!

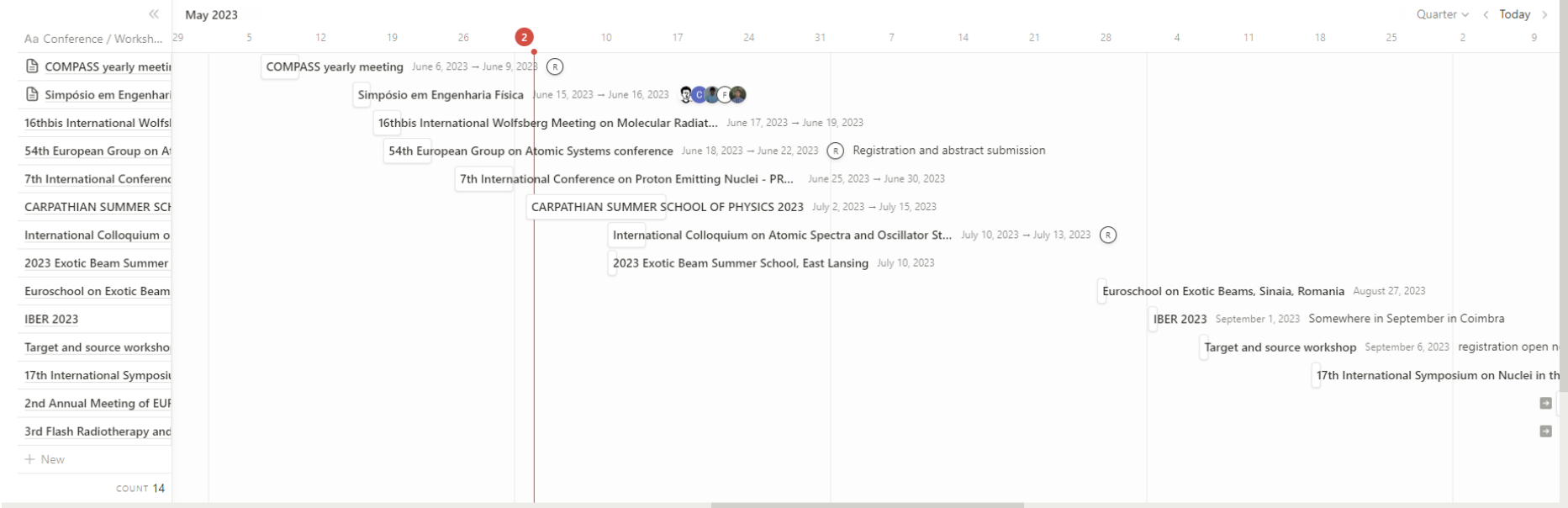
# Conferences & Workshops

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Rules for travel - LIP

Table Timeline Calendar

## Conferences & Workshops



## Part 4: Hands-on!

Go to <https://bit.ly/lip-notion-2023>

## Thank you for your attention!

This presentation was made using Notion 😊

Tomás Sousa, [tsousa@lip.pt](mailto:tsousa@lip.pt)

👏 Hands-on!

[INTERNSHIP NAME]