# The design of a Master Thesis
# Appendix: Thesis Defence

Andrea Donini
(curso organizado y supervisado con Pilar Hernández)

# General view

1. Online class(es) on basic rules to write the Master's thesis
2. Practical exercise: organising the Thesis (email submission)
3. Correction of the practical exercise (either by mail or skype)
4. Presentation to the class of one or two exercises
5. Online class on basic rules to present your Master's thesis

# Outline of the lecture

1. **STARTING**
    1. Choosing a language
    2. Choosing a presentation software
2. **ORGANIZATION OF THE SLIDES**
    1. Understanding your subject
    2. What is “old”
    3. Appendices
    4. What is “new”
    5. Introduction and conclusions
3. **GRAPHICS AND EQUATIONS**
    1. Drawing and inserting plots
    2. Equations
4. **REFERENCING**

1.

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# What this class it is not

We are not teaching you to speak in public

We are not teaching you the language you use to speak (english…?)

We are not teaching you physics

# Part I: STARTING

## 1. Choose a language to talk

**Possible choices:**

**ENGLISH**

**CASTELLANO**

**VALENCIÁ**

# Part I: STARTING

## 1. Choose a language to talk

**Possible choices:**

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**I strongly suggest ENGLISH:**

1. It is the language of science
2. You read books and articles in english
3. It may be your first chance to TALK in english
4. Possibly, you have written the thesis in english…

# Part I: STARTING

## 2. Choose a presentation software

**In this case, the choice mainly depend on the hardware on which you work**

**MAC: Keynote or Powerpoint, or …**

**WINDOWS: Powerpoint or …**

**LINUX: whatever works for you**

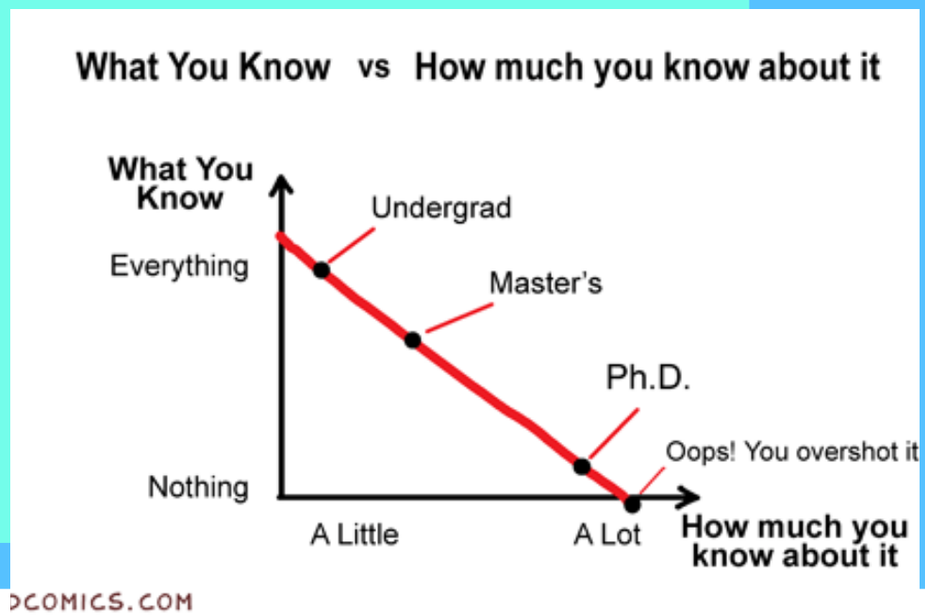
**I am using Keynote, but what I will say does not depend on the particular software**

# Part II:ORGANIZATION

## 1. Understanding your subject

**Usually, you and your advisor are the two persons that understand most of your thesis**

**Sometimes, only your advisor understand (most of) your thesis**



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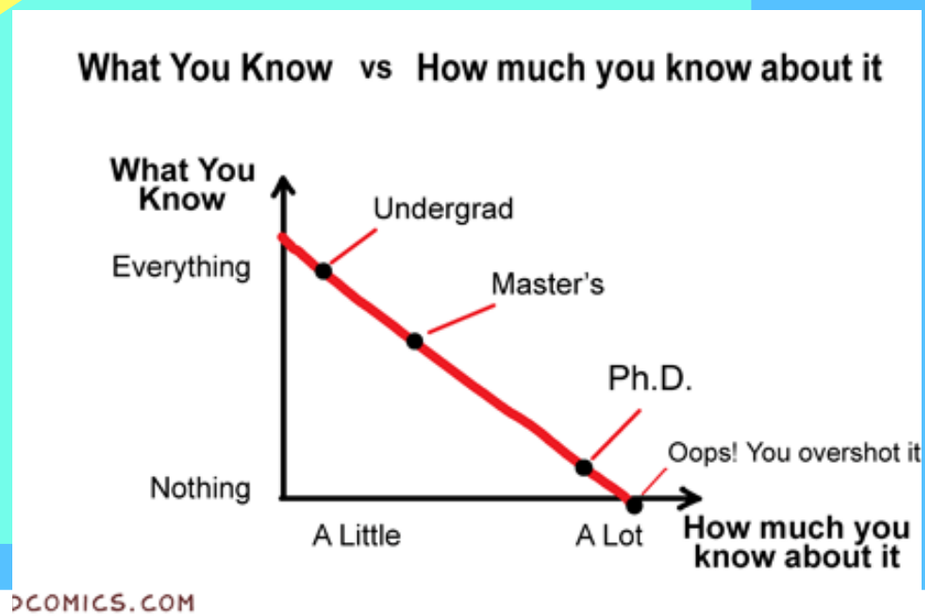

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**The rest of the physicists divide into:**
**those that know the subject**
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The jury that will examine you will be composed by both

# Part II:ORGANIZATION

## 1. Understanding your subject

THIS IS ALSO STILL TRUE!

Usually, you and your supervisor are the two persons that will work most of your thesis

The way physicists divide into:
those that know the subject
and those that do not know the subject

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# Part II:ORGANIZATION

**THIS GROUP IS THE PUBLIC ON WHICH YOU MUST FOCUS**

**subject**

**he two**
**ur thesis**

**The rest of the physicists divide into:**
**those that know the subject**
**and those that do not know the subject**

**The jury that will examine you will be composed by both**

# Part II:ORGANIZATION

## 1. Understanding your subject

**You should imagine that those that read have read**

**STILL DO NOT KNOW DEEPLY THE SUBJECT OF YOUR THESIS**
**(give an overview of the subject)**

**but**

**THEY KNOW AND UNDERSTAND THE BASICS**
**(do not start with undergraduate stuff)**

# Part II:ORGANIZATION

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**but**

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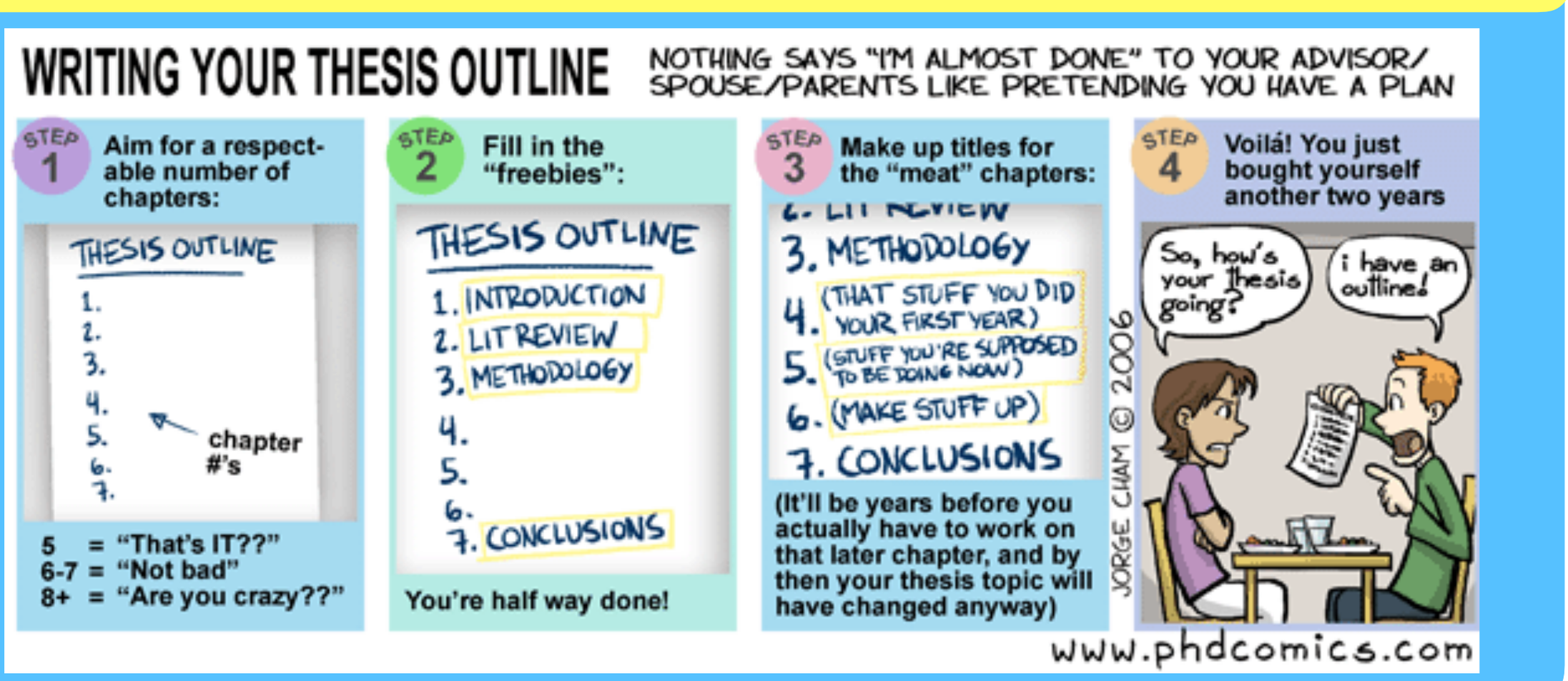
**SAME AS WHEN WRITING!**

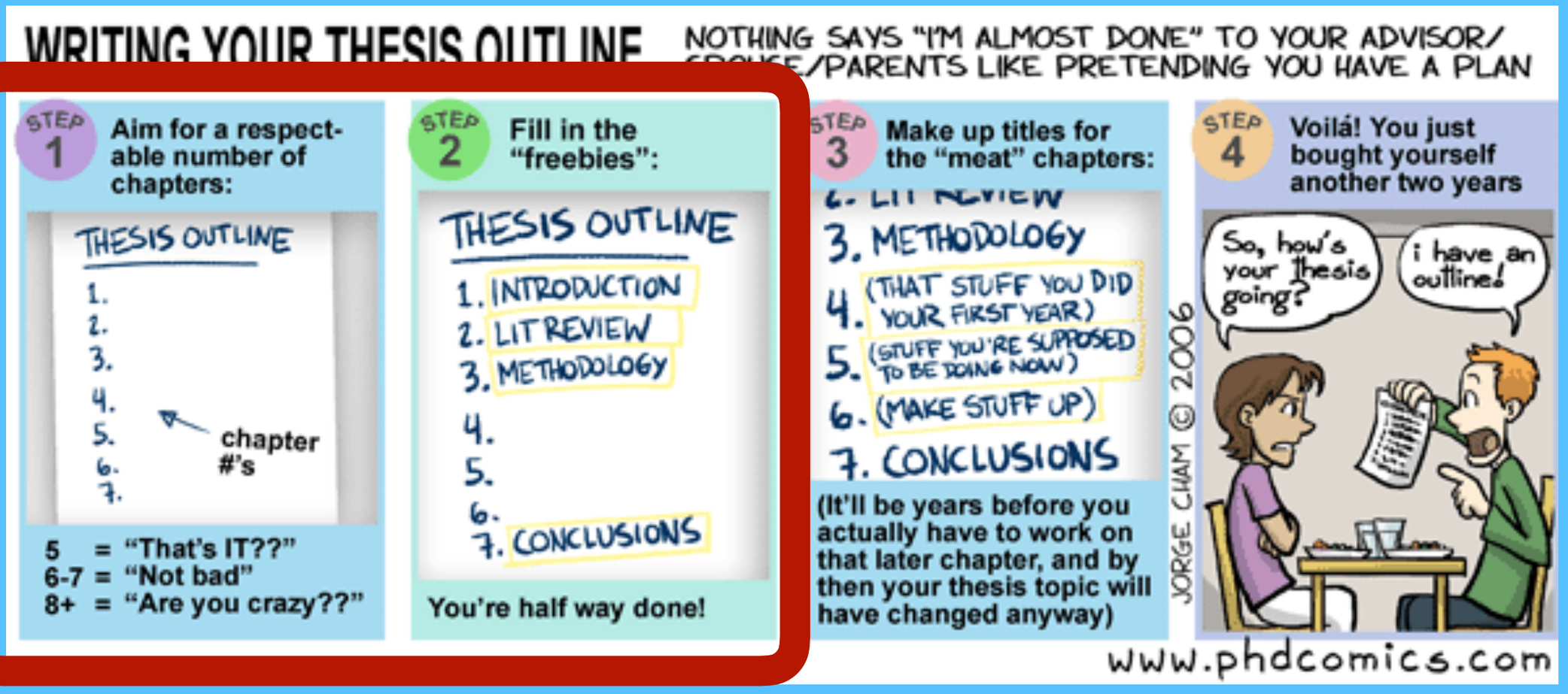
# Part II:ORGANIZATION

**Do you remember this? It is still the same: old, new, intro and conclusions…**



# Part II:ORGANIZATION

**Make a plan! Do not start writing from page 1**



# What you need to know

**First thing to know when you prepare a presentation:**

**How much time do I have?**

**This is an easy question with an easy answer….**

**Second thing to know:**

**How much time do I spend on each slide?**

**This is not an easy question, and it has multiple answers…**

# First: how many slides?

**Hypothetical syllogism:**

**1. You have 20 minutes**

**2. More or less, a slide takes you 1 minute**

**3. Then, you have to prepare 20 slides**

**NOT ALWAYS TRUE!**

**You should modify these inputs according to your specific situation, in order to derive a reasonable output. Make some tests…. Remember that you will be a bit nervous, and nervous people use to speak FASTER!**

# Second: make a time-sheet

**Once you know how many slides you need,
you must organise your time and space**

| | | |
|---|---|---|
| Introduction/motivation | → | Some pages |
| “Old” stuff | → | Some pages |
| “New” stuff (your work) | → | Some pages |
| Conclusions and outlook | → | Some pages |

# A trick: make a time-sheet

**The title page does not count.**

| | | | | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**Example with 20 slides**

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|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**Example with 20 slides**

# A trick: make a time-sheet

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| Outline | Which is my field | The SM of my field | Which open problem? | Why do I do what I do? |
|---|---|---|---|---|
| | | | | |
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| | | | | |
| | | | | |
| | | | | |

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| What I can change | My model | Virtues of my model | How I solve The problem | Parameters, ranges, … |
| | | | | |
| | | | | |

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| “Old vs new” plot | Advantages | Still to do | | |

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| Results 1 | Results 2 | Plot 1 | Plot 2 | Comparison with literature |
| “Old vs new” plot | Advantages | Still to do | Conclusions | Outlook |

**Example with 20 slides**

# Third: start to fill

**Once you have a reasonable layout of the talk, you could start to prepare a “storyboard”**

**You need not to be an artist! It is just to organise things, having a general overview**

# Select plots

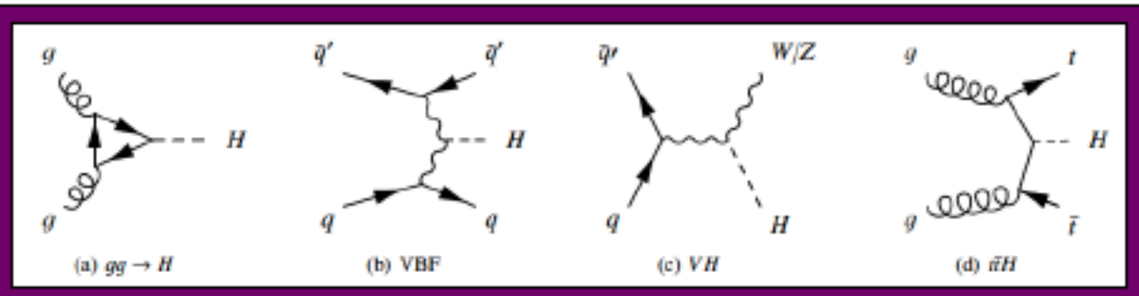
**When preparing the talk, you should understand that:**

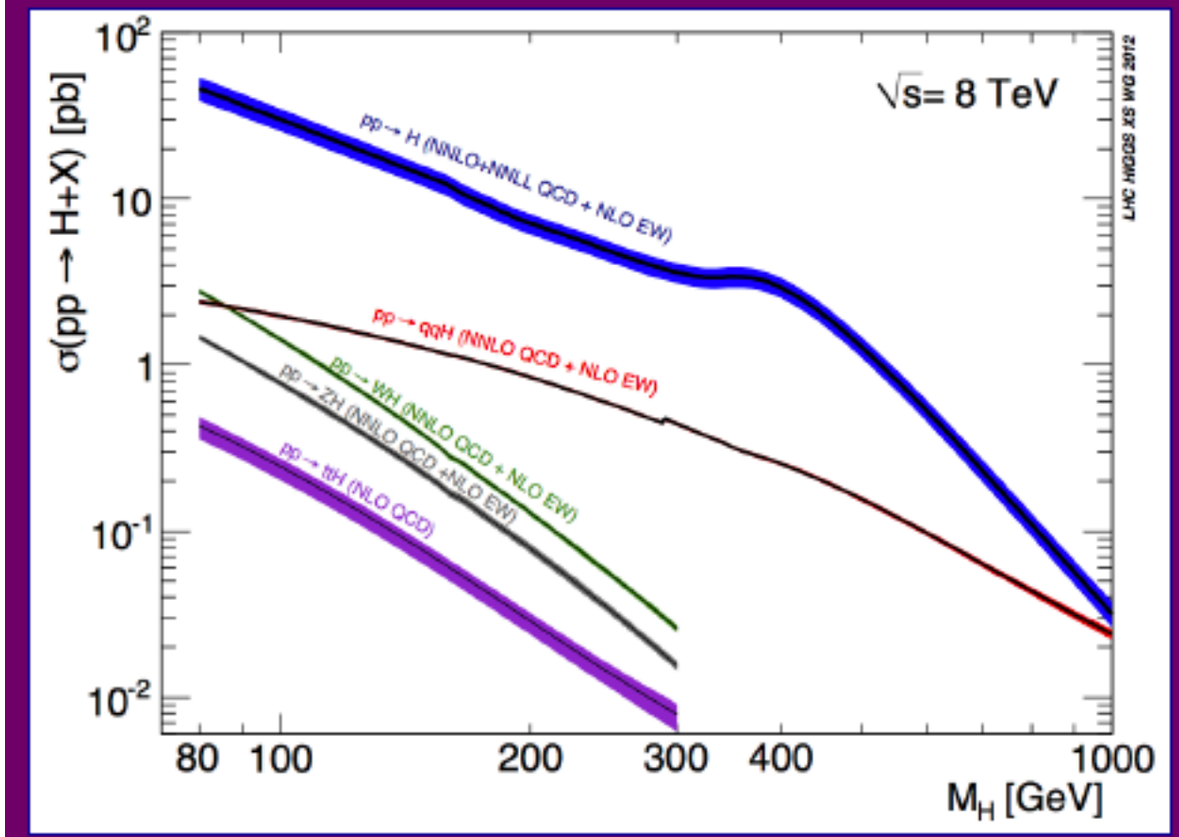
**PLOTS are the most important TOOL a physicist may use to present and explain results (more than equations)**

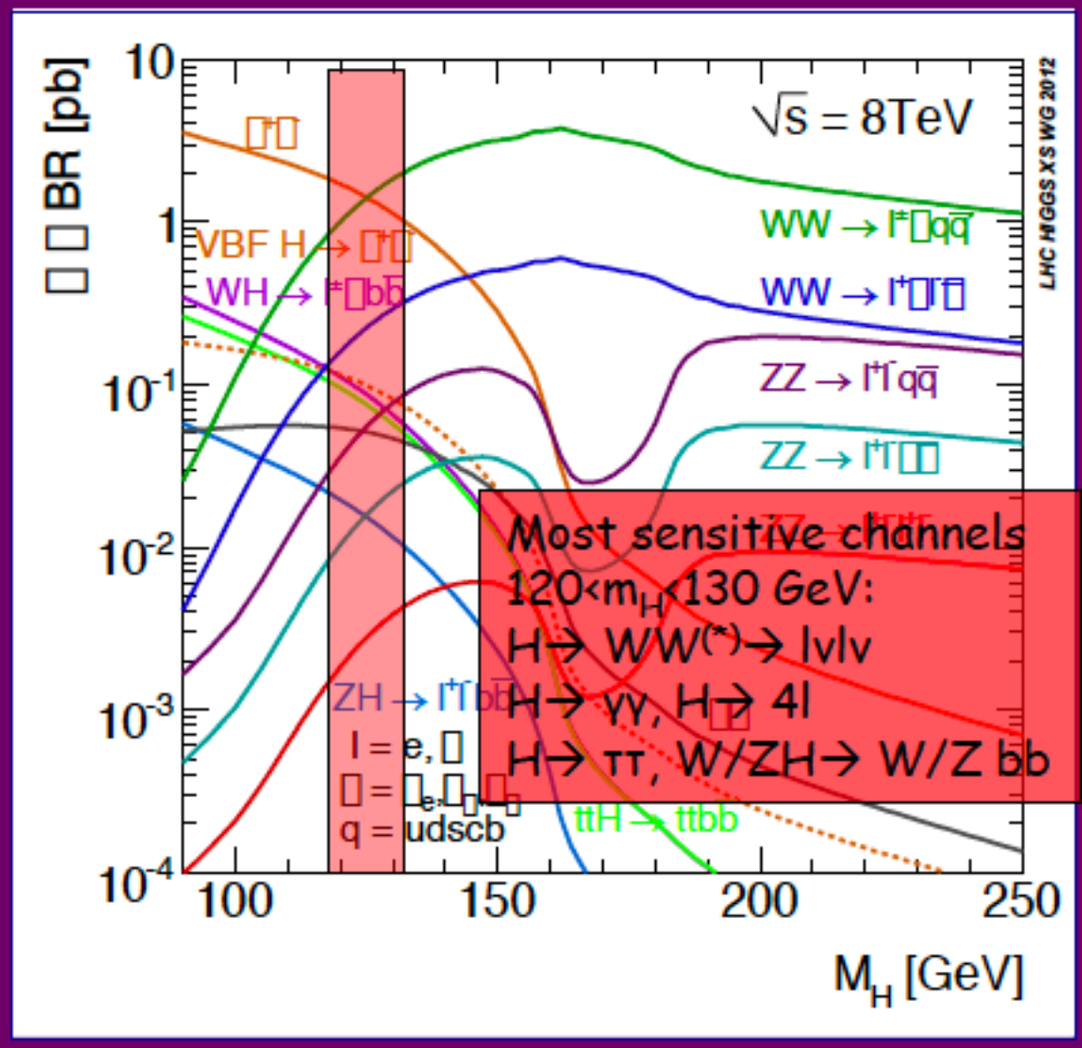
**PLOTS are tricky**
**You cannot put too many!**

**EXPERIMENTALISTS, BEWARE!**

# SM Higgs production cross-section and decay modes



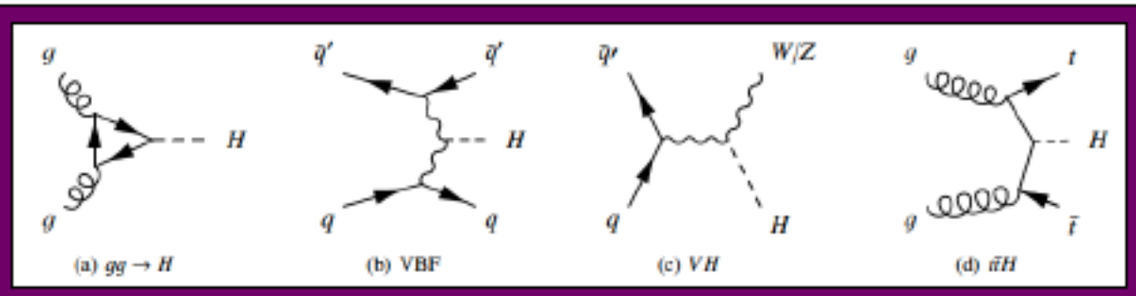

√s=7 → 8 TeV:

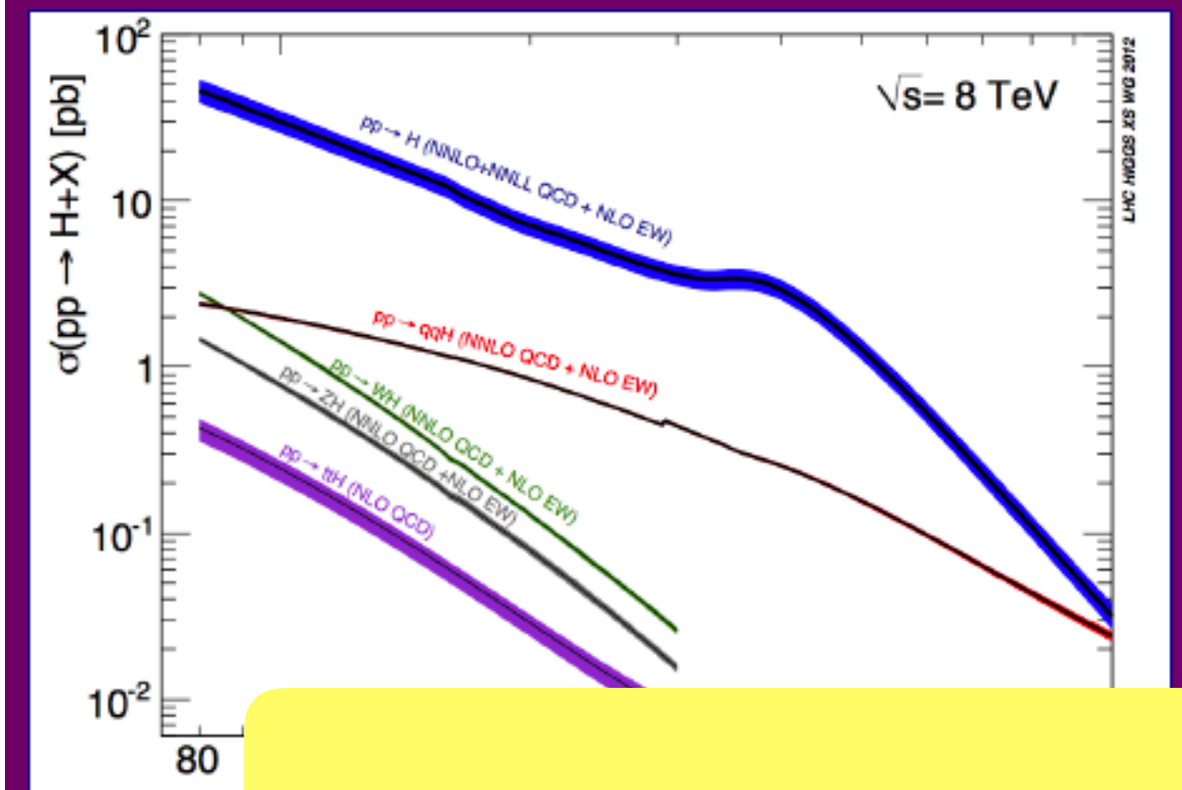
- Higgs cross-section increases by ~ 1.3 for $m_H$ ~ 125 GeV
- Similar increase for several irreducible backgrounds: e.g. 1.2-1.25 for γγ, di-bosons
- Reducible backgrounds increase more: e.g. 1.3-1.4 for tt, Zbb

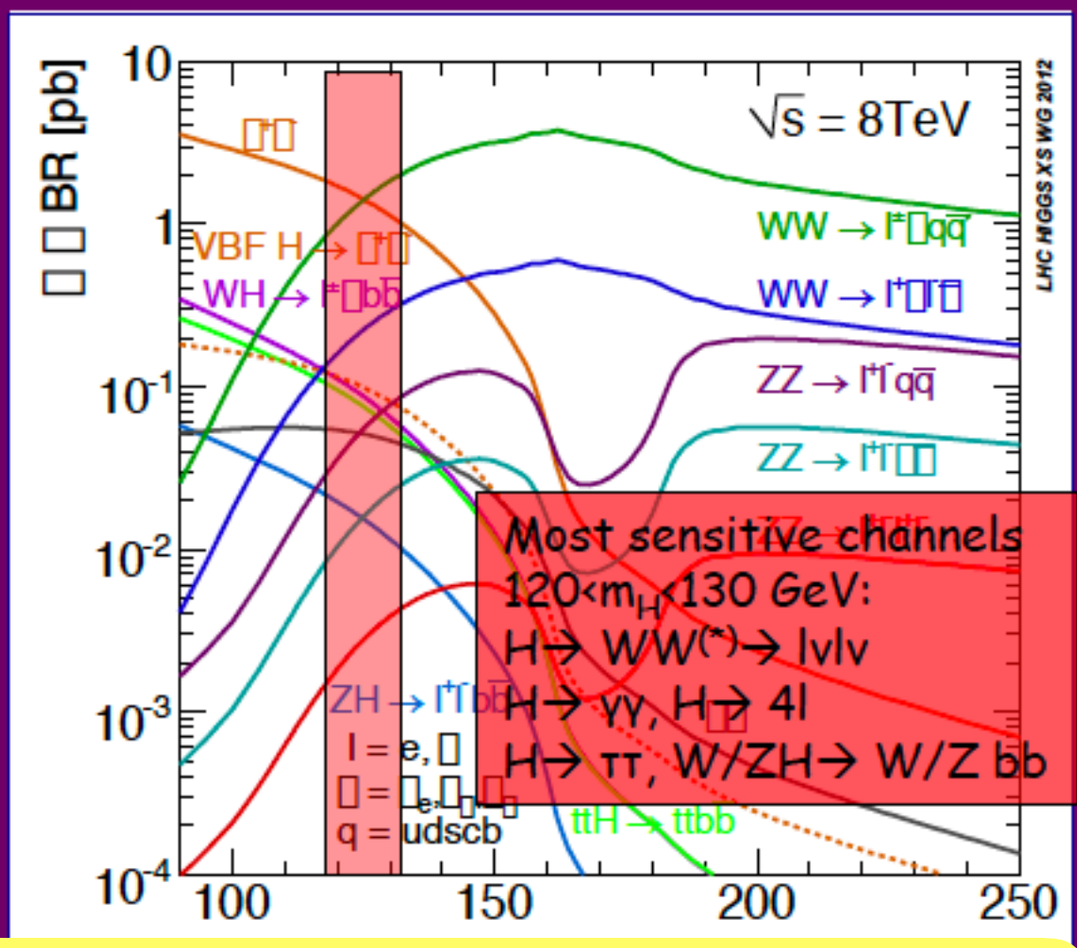
→ Expected increase in Higgs sensitivity: 10-15%

Note: huge efforts and progress from theory community to compute NLO/NNLO cross-sections for Higgs production and for (often complex !) backgrounds

# SM Higgs production cross-section and decay modes




**This is a very much typical experimentalist's slide**

**(Talk on the Higgs discovery at LHC,
July 4th, 2012, CERN Auditorium)**

**TOO MANY PLOTS, WITH THE ILLUSION TO COVER EVERYTHING
FROM THEORY TO ALL POSSIBLE SIGNALS**

√s=7 →
- Higg
- Simi
- Redu

→ Expe

Note: hu
cross-sections for Higgs production and for (often complex !) backgrounds

# SM Higgs production cross-section and decay modes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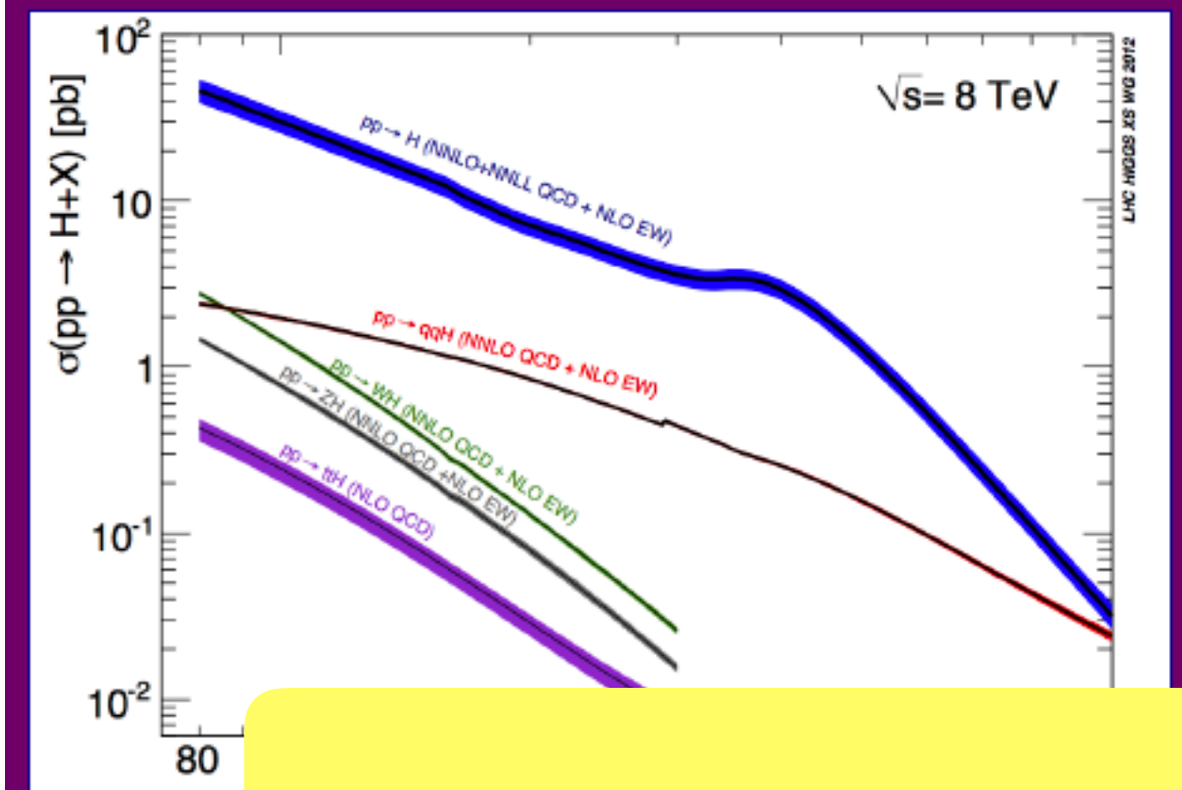


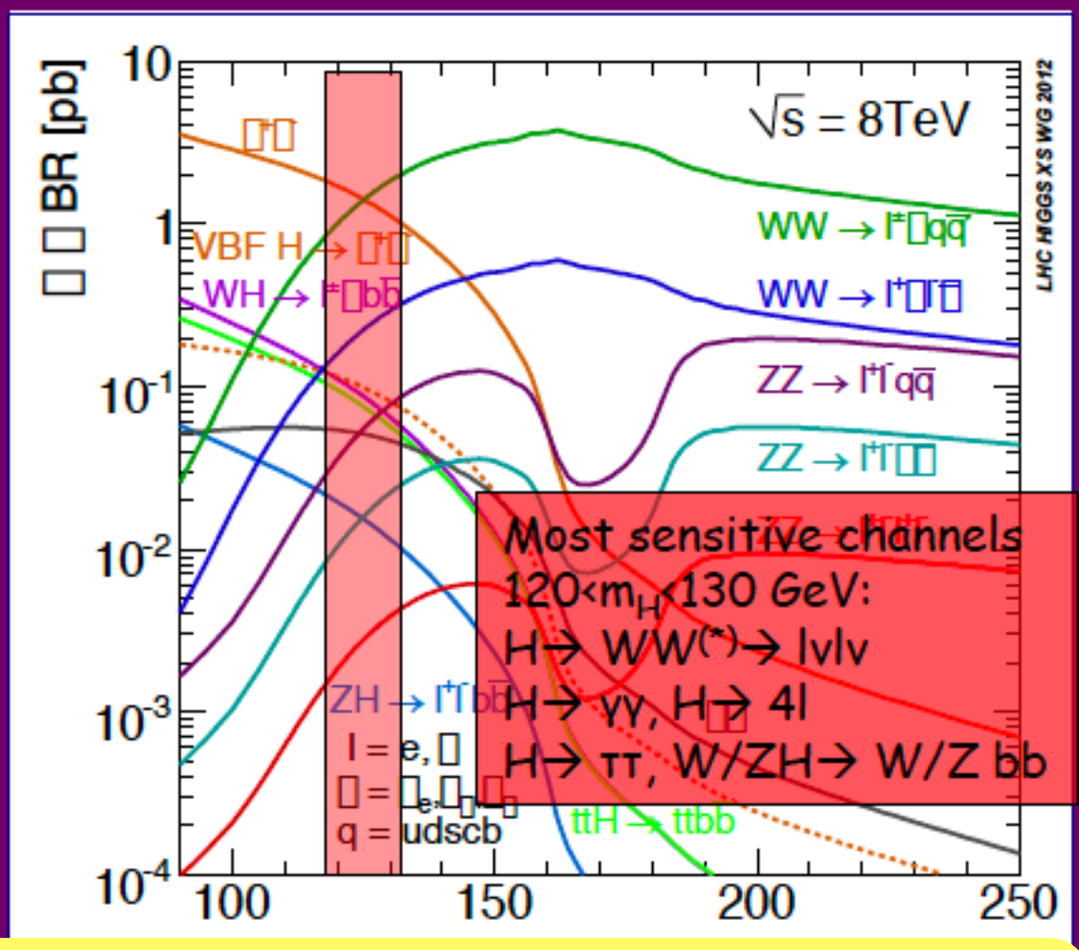


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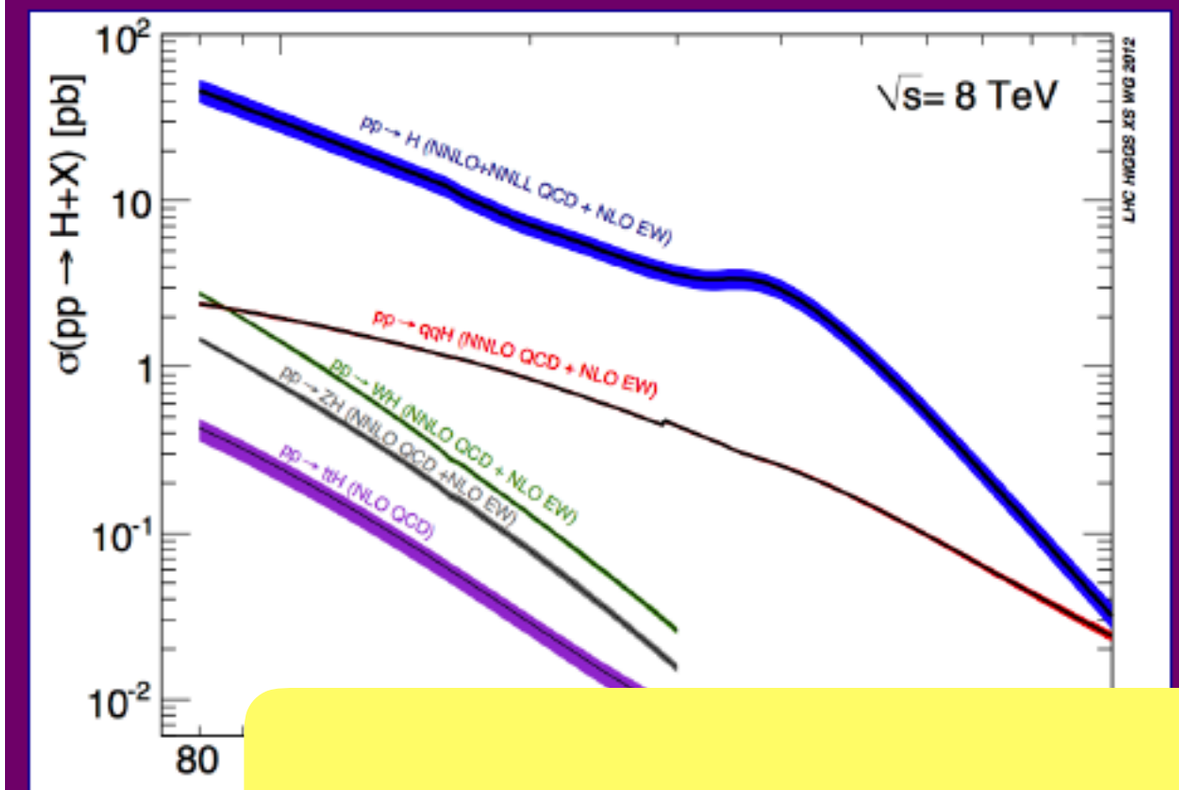


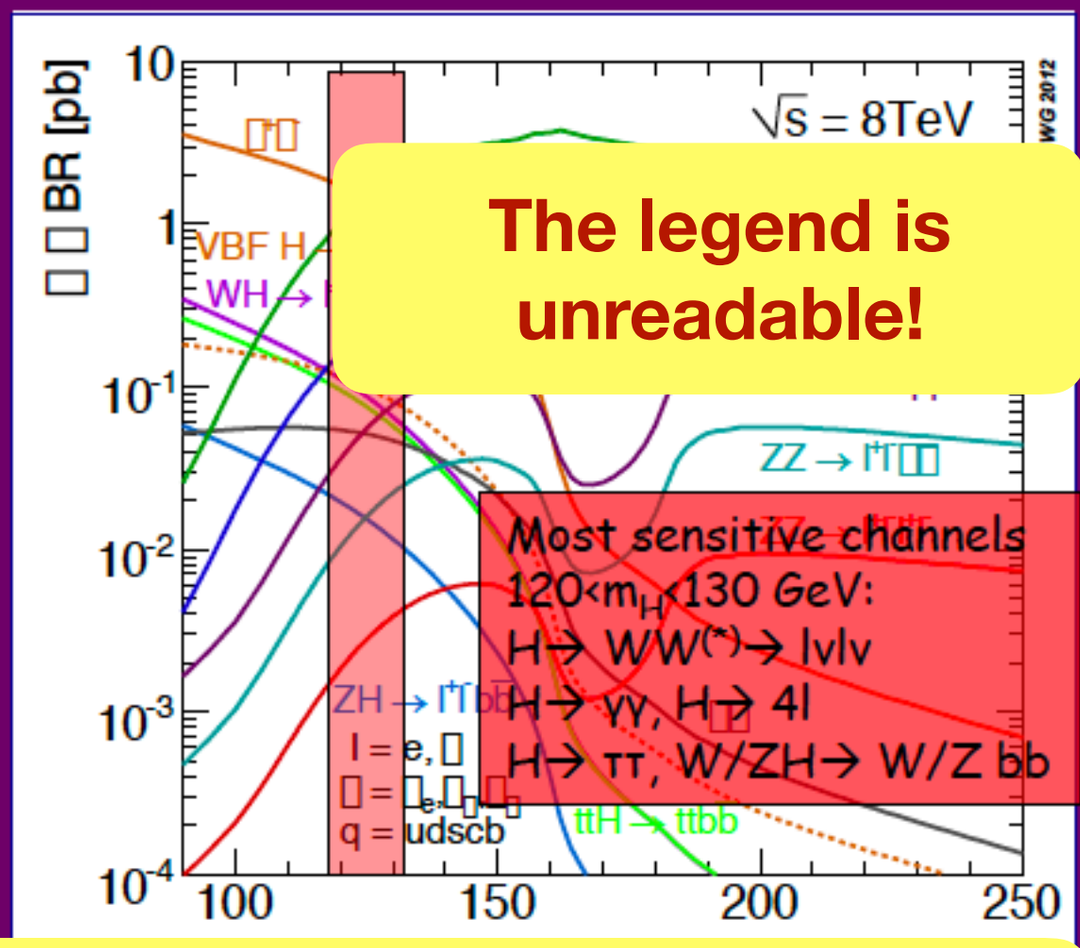


**The legend is unreadable!**

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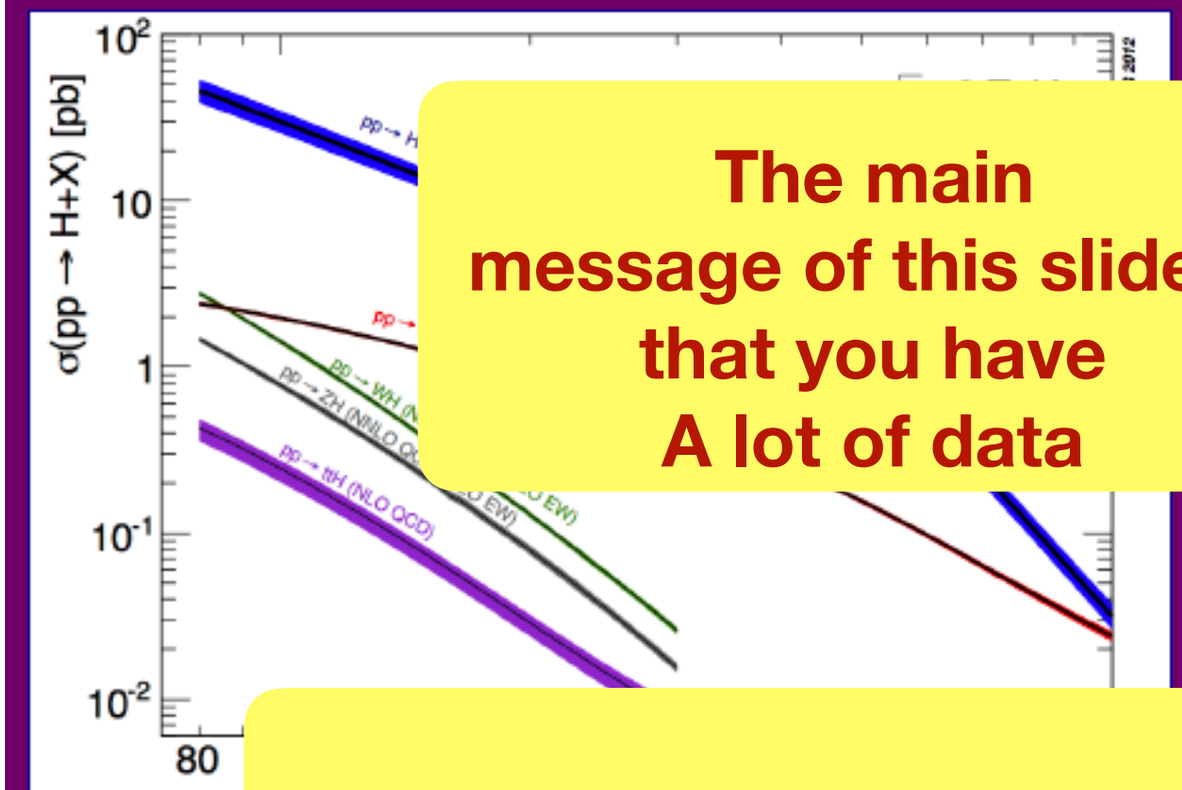
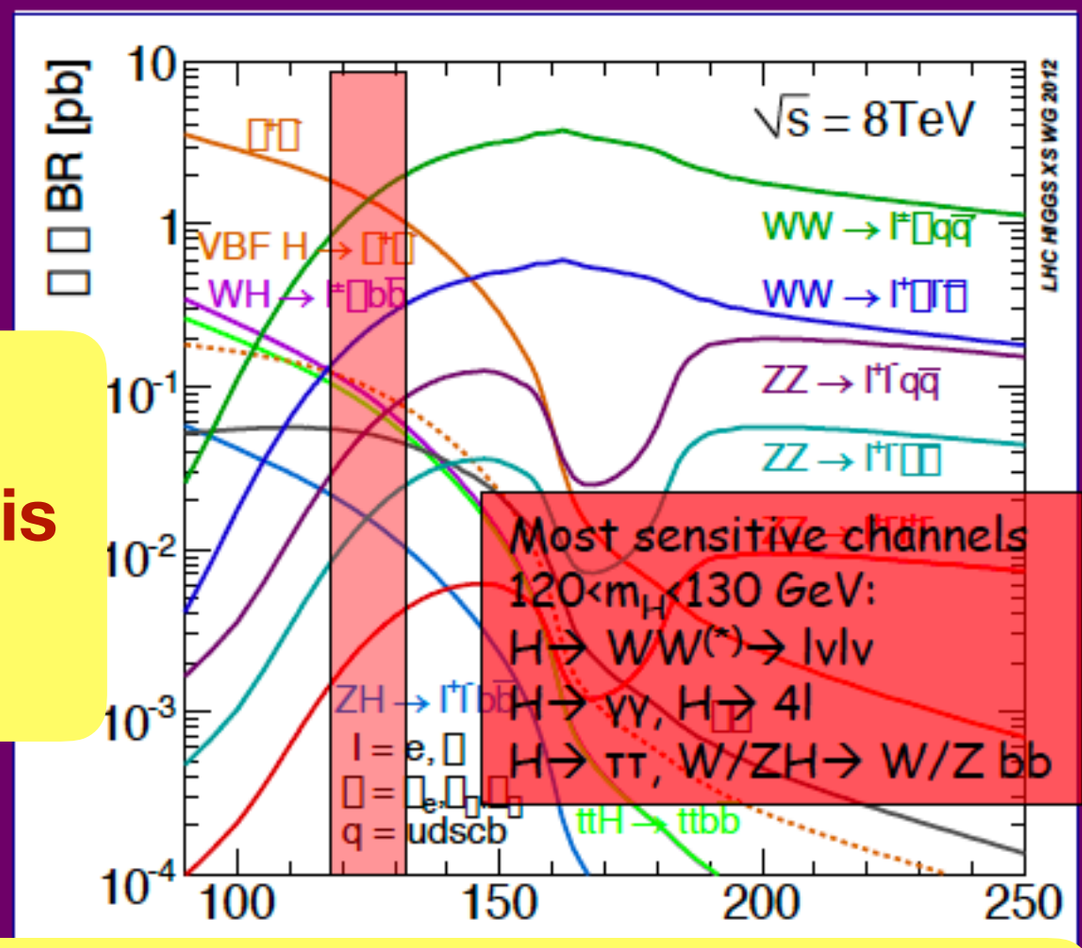



**The main message of this slide is that you have A lot of data**

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Note: hu
cross-sec

# Select equations

**When preparing the talk, you should understand that:**

**EQUATIONS are the second most important TOOL a physicist may use to present and explain results (more than sentences)**

**EQUATIONS are also tricky**
**You cannot put too many!**

**THEORISTS, BEWARE!**

# Model independent approach to $b \to s\ell\ell$

$$\mathcal{H}_{\text{eff}} = -\frac{4G_F}{\sqrt{2}} V_{tb}V_{ts}^* \sum_i \mathcal{C}_i \mathcal{O}_i$$

$$\mathcal{O}_7 = \frac{e}{16\pi^2} m_b (\bar{s}\sigma_{\mu\nu} P_R b) F^{\mu\nu},$$

$$\mathcal{O}_{7'} = \frac{e}{16\pi^2} m_b (\bar{s}\sigma_{\mu\nu} P_L b) F^{\mu\nu},$$

$$\mathcal{O}_{9\ell} = \frac{e^2}{16\pi^2} (\bar{s}\gamma_\mu P_L b)(\bar{\ell}\gamma^\mu \ell),$$

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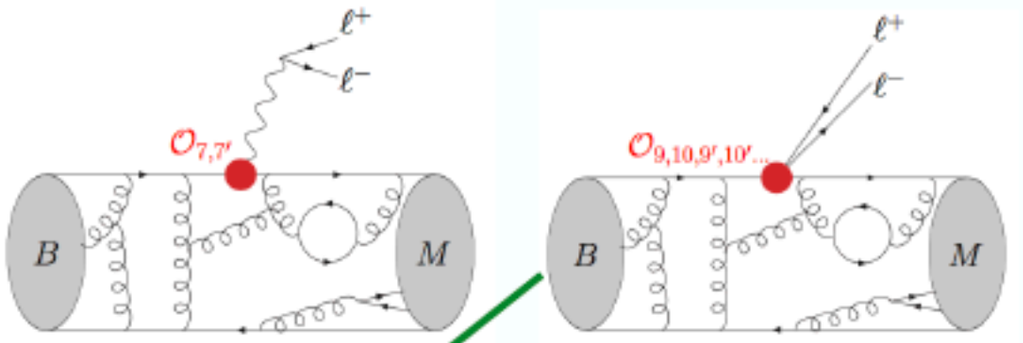
$$\mathcal{O}_{10\ell} = \frac{e^2}{16\pi^2} (\bar{s}\gamma_\mu P_L b)(\bar{\ell}\gamma^\mu \gamma_5 \ell),$$

$$\mathcal{O}_{10\ell'} = \frac{e^2}{16\pi^2} (\bar{s}\gamma_\mu P_R b)(\bar{\ell}\gamma^\mu \gamma_5 \ell),$$

At the $\mu_b = 4.8$ GeV scale:

$$\mathcal{C}_7^{\text{SM}} = -0.29,\ \mathcal{C}_9^{\text{SM}} = 4.1,\ \mathcal{C}_{10}^{\text{SM}} = -4.3$$




$$\mathcal{C}_i = \mathcal{C}_i^{\text{SM}} + \mathcal{C}_i^{\text{NP}}$$

**Interesting Directions:**

$$\mathcal{C}_9 = -\mathcal{C}_{10} \quad \Rightarrow \quad L_q \otimes L_\ell$$

$$\mathcal{C}_{9'} = -\mathcal{C}_{10'} \quad \Rightarrow \quad R_q \otimes L_\ell$$

$$\mathcal{C}_9 = -\mathcal{C}_{9'} \quad \Rightarrow \quad A_q \otimes V_\ell$$

**We explore not only directions BUT new BASIS**

=>standard muon and electron basis
=> new LFUV and LFU basis

# Model independent approach to $b \to s\ell\ell$

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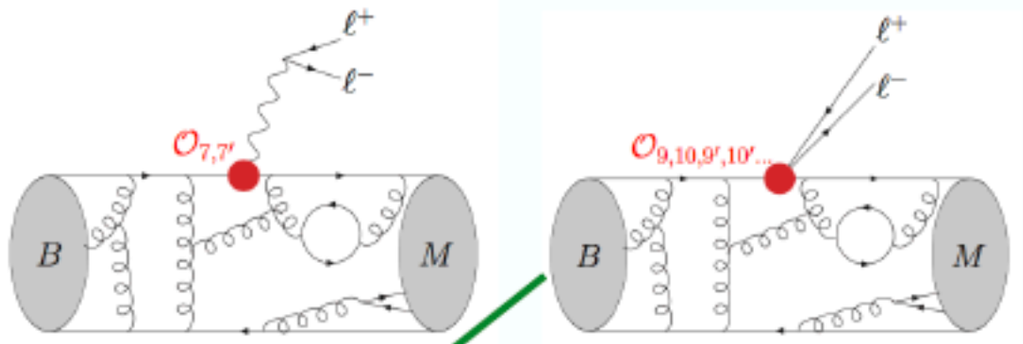
$$\mathcal{O}_{10\ell}$$

$$\mathcal{O}_{10\ell'}$$

$$\mathcal{C}_7^{\text{SM}} =$$




$$\mathcal{C}_i = \mathcal{C}_i^{\text{SM}} + \mathcal{C}_i^{\text{NP}}$$

**Interesting Directions:**

$$\mathcal{C}_9 = -\mathcal{C}_{10} \quad \Rightarrow \quad L_q \otimes L_\ell$$

**This is a very much typical theorist's slide**

**(Talk on Flavour Anomalies)**
**TOO MANY EQUATIONS, TRYING TO CONVEY THE ILLUSION THAT THE THEORETICAL APPROACH IS COMPLETE**
**(IF COMPLETE, WHERE ARE OPERATORS FROM 1 TO 6?**

**WHAT ABOUT OPERATORS WITH q AND NOT $\ell$?)**

# Model independent approach to $b \to s\ell\ell$

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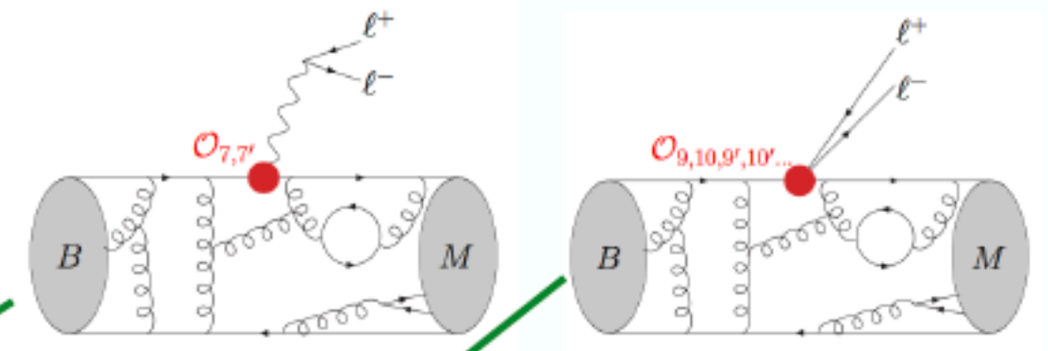


**Do you understand from these graphs the difference between Penguins and Current-Current Operators?**

$$\mathcal{C}_9 = -\mathcal{C}_{10} \quad \Rightarrow \quad L_q \otimes L_\ell$$

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# Plots and equations

**MY SUGGESTION:**

**One plot per slide (two only if you are comparing them)**

**NEVER EVER put plots representing different things on the same slide; it breaks the flow of your speech**

**Identify the really relevant equations;**
**no passages to go from eq. 1 to eq. N,**
**(only if your original work is to derive eq. N)**

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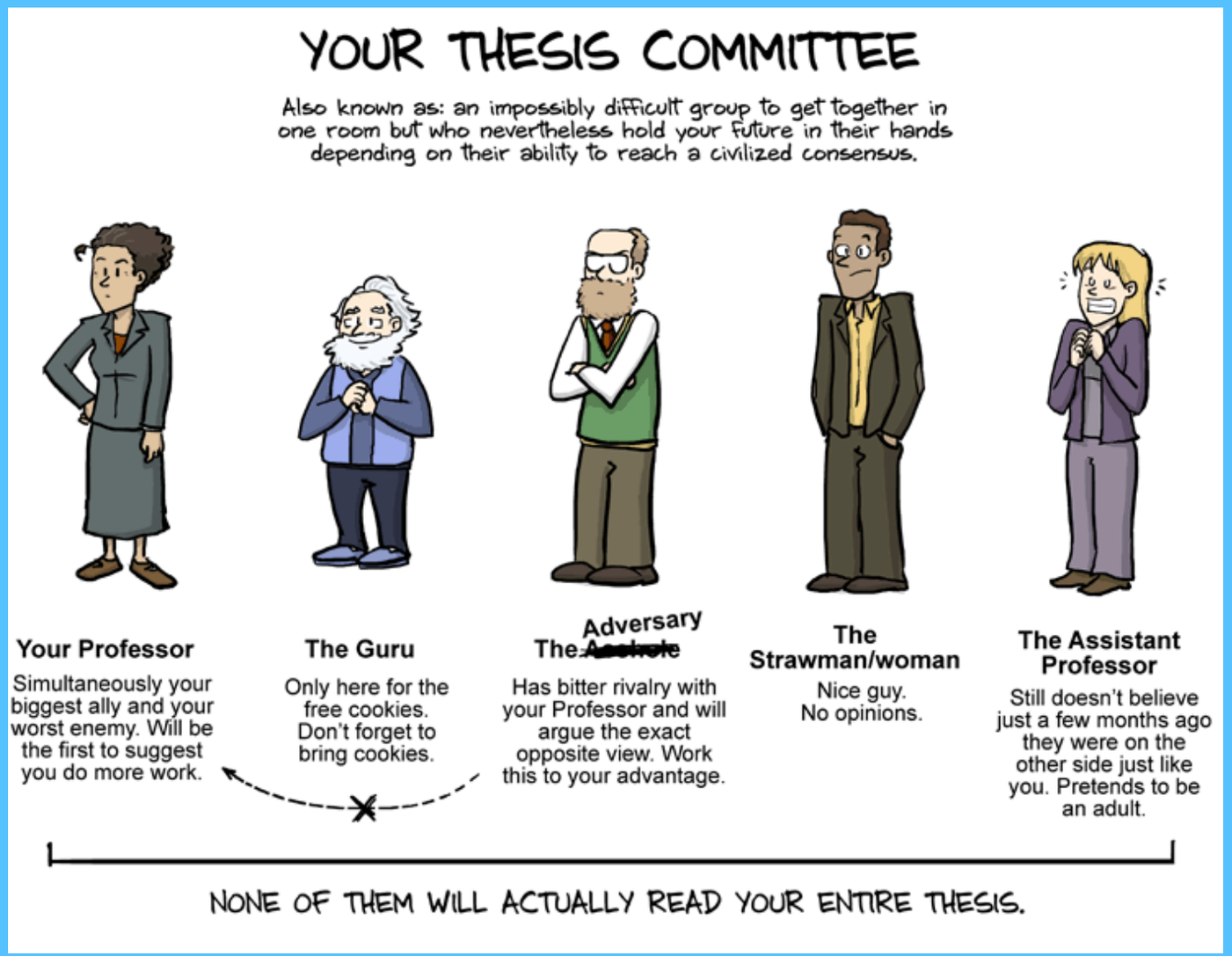
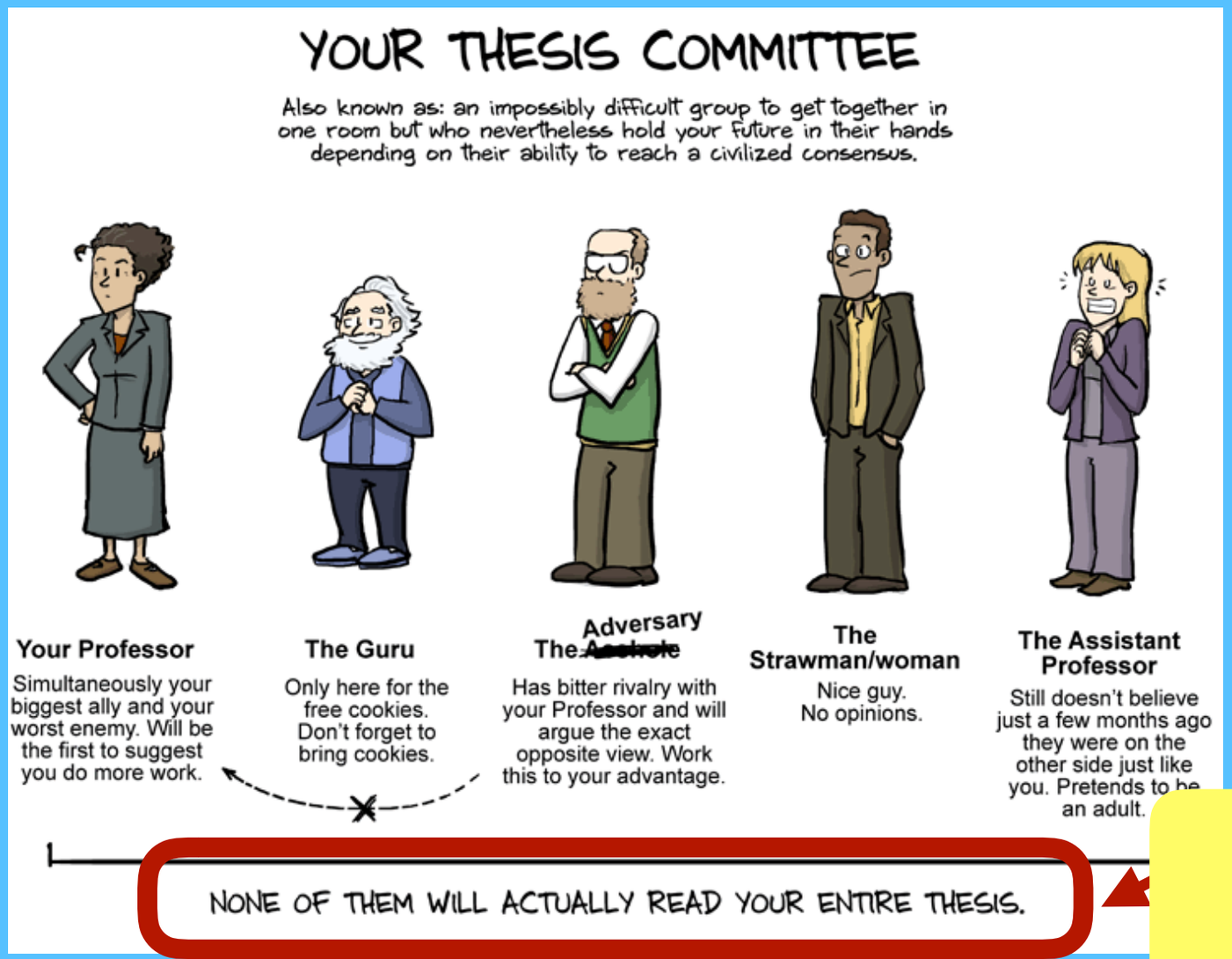
**(o q. N)**

**This is even more important than in the Thesis**

# Introduction



# Introduction




**This sounds as a joke, but many times overlaps one-to-one with reality**

**This means that now it is the time to explain them what you have done**

# Introduction

**It is a complete summary of the thesis:**
**one should understand what is written in the main body just from reading this. If you succeed, the reader will feel happy!**

# Introduction

It is a complete… …the thesis:
one should understand w… …in the main body just from
reading this. If yo… …e reader will feel happy!

NOT TRUE IN A PRESENTATION!

This time, you present your field,
explain the existing status,
review briefly the open problems
and
MOTIVATE YOUR OWN WORK
(before or after this, give an outline of the talk)

# Introduction

**It is a complete… …the thesis:**
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**Some text framing your area of research**

**Examples:**

**“Standard Model”**
**“General Relativity”**
**“Complex systems”**

>

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Examples:

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Motivation for your specific research

Most important part of the Introduction:
show that you know WHY you have done what you have done!

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**Examples:**

**“Standard Model”**
**“General Relativity”**
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**Motivation for your specific research**

**Most important part of the Introduction: show that you know WHY you have done what you have done!**

**Short summary of your results**

**“We have found that… within this hypothesis… this problem may/may not be solved”**

# Introduction

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NOT TRUE IN A PRESENTATION!

**Some text framing your… …arch**

**Ex…**

**“S…ndar… …l”**
**“Ge… …vity”**
**“Complex systems”**

**Motivation for your sp… …rch**

**Mos… …ant …t of t… …odu…**
**sho… that… …ow WH… …done what you have done!**

**Short summary of …our resul…**

**“We have …nd that… with in thi… …othesis… th… prob…m may/may not be solved”**

# The “old” section

**Again, you should determine which amount of basic information is needed to introduce the subject**

**Who is your audience:** a physicist that understand what you are doing, **but do not know the** basic literature on the subject **(except for textbooks)**

# The “old” section

**This time it may be useful to design “old” and “new” sections together**

**Do you have a plot to compare them?**
**Do you have an equation that differ by just one new term?**
**Prepare to use them to COMPARE “old” and “new”**

**YOUR GOAL: LET THEM UNDERSTAND WHAT YOU HAVE DONE!**

# Usage of equations

## Two ways to scan the Earth

- Neutrino oscillations (< 1 TeV)

$$P_{ee}^{\pm} = 1 - \left(\frac{\Delta_{23}}{B_{\mp}}\right)^2 \sin^2(2\theta_{13}) \sin^2\left(\frac{B_{\mp} L}{2}\right) - \left(\frac{\Delta_{12}}{A}\right)^2 \sin^2(2\theta_{12}) \sin^2\left(\frac{A L}{2}\right)$$



See, e.g., W. Winter, Nucl. Phys. B 908 (2016) 250; Km3Net, PoS ICRC2017 (2018) 1020

- Neutrino flux attenuation (> 1 TeV)

$$\frac{d\phi_\nu(E,\tau)}{d\tau} = -\sigma_{tot}(E)\phi_\nu(E,\tau)$$



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- Neutrino flux attenuation (> 1 TeV)

$$\frac{d\phi_\nu(E,\tau)}{d\tau} = -\sigma_{tot}(E)\phi_\nu(E,\tau)$$

$\sigma_{tot} = \sigma_{\nu N} \times \rho$

Gonzalez-García, Halzen, Maltoni, Tanaka, Phys. Rev. Lett. 100 (2008)

# The “new” section

**It must be very clear**
**WHAT is NEW, and WHAT is NOT NEW**

**A typical question at the defense:**

**“Ok, very nice. But….**
**Can you explain me PRECISELY which is the difference between what YOU have done and the LITERATURE?”**

# The “new” section

**Literature: first section**

**Your work: last section**

**INTRODUCE WHAT IS OLD**

**You should have written this first; it is useful for you to explain differences**

# The “new” section

**Literature: first section**

**Your work: last section**

**INTRODUCE WHAT IS OLD**

**COMPARE WITH WHAT IS OLD**

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# The “new” section

**Literature: first section**

**INTRODUCE WHAT IS OLD**

**You should have written this first; it is useful for you to explain differences**

**Your work: last section**

**COMPARE WITH WHAT IS OLD**

**ELABORATE ON THIS: feel free!**

# Graphics

**A Figure is made out of two pieces:**

**1. The graphic object**

**2. The caption**

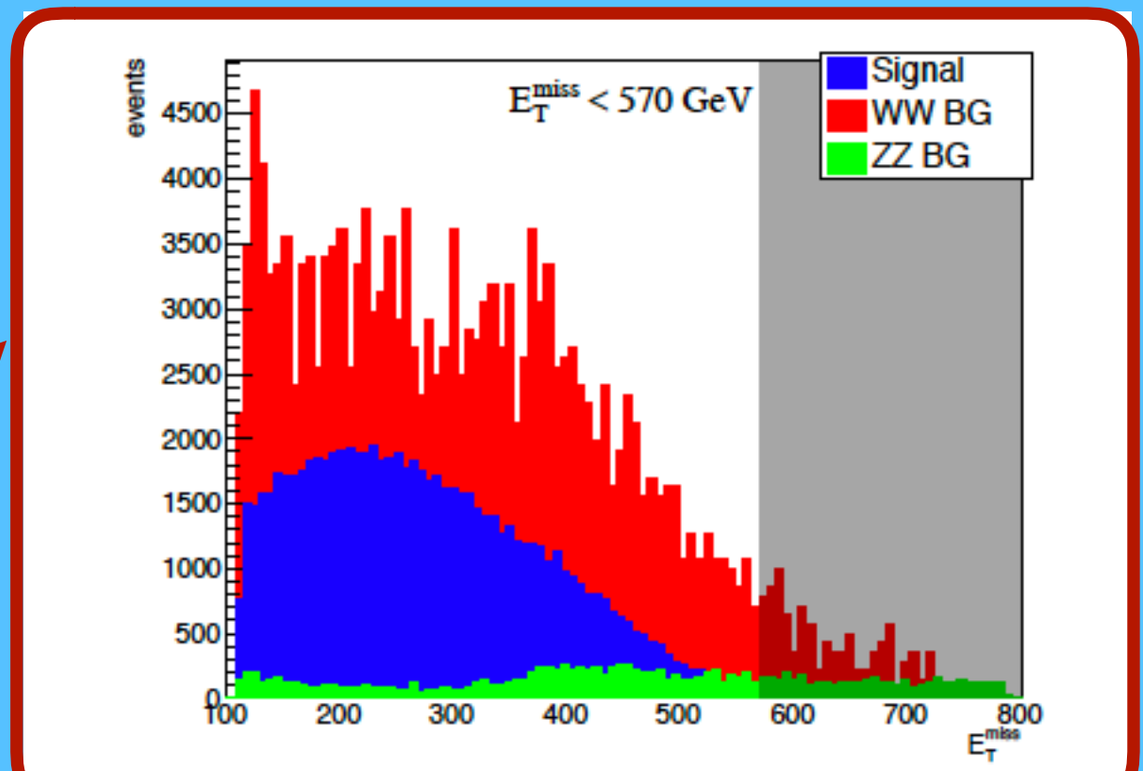


Figure 5.6: Histogram showing all the cuts being applied for the $E_T^{\text{miss}}$. Here we have scaled the number of events in accordance with equation 5.3.29.

# Graphics

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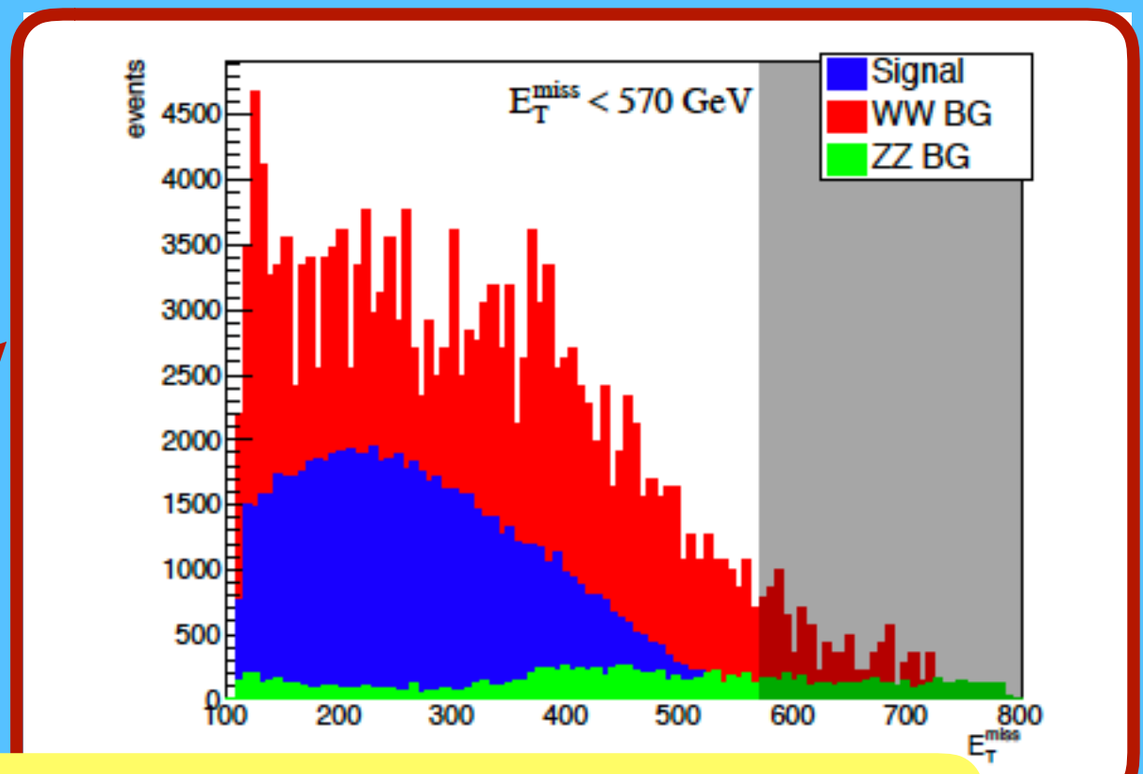



**NO REAL NEED FOR A CAPTION!**
**What you need is a GOOD LEGEND and CLEAR AXES LABELS**

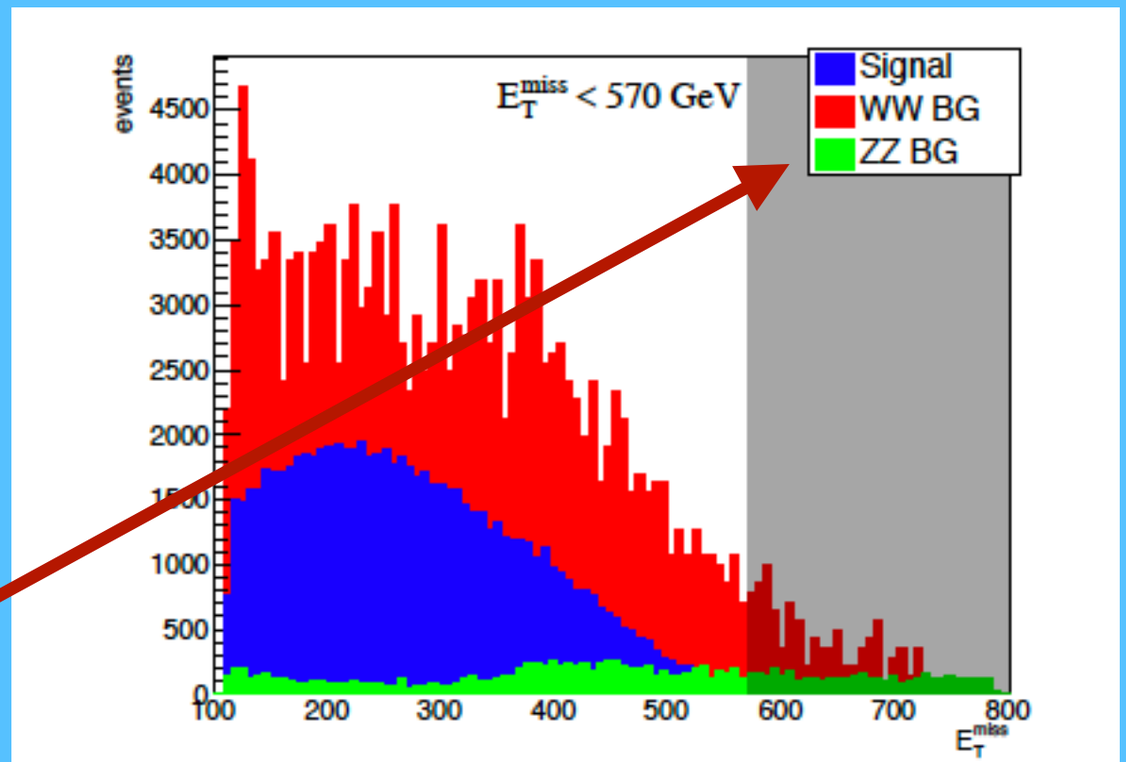
the number of events in accordance with equation 5.3.29.

# Graphics

**Graphic objects:**

**legends should be simple and clear (not too many Items)**

**This time, take full advantage of colours!**

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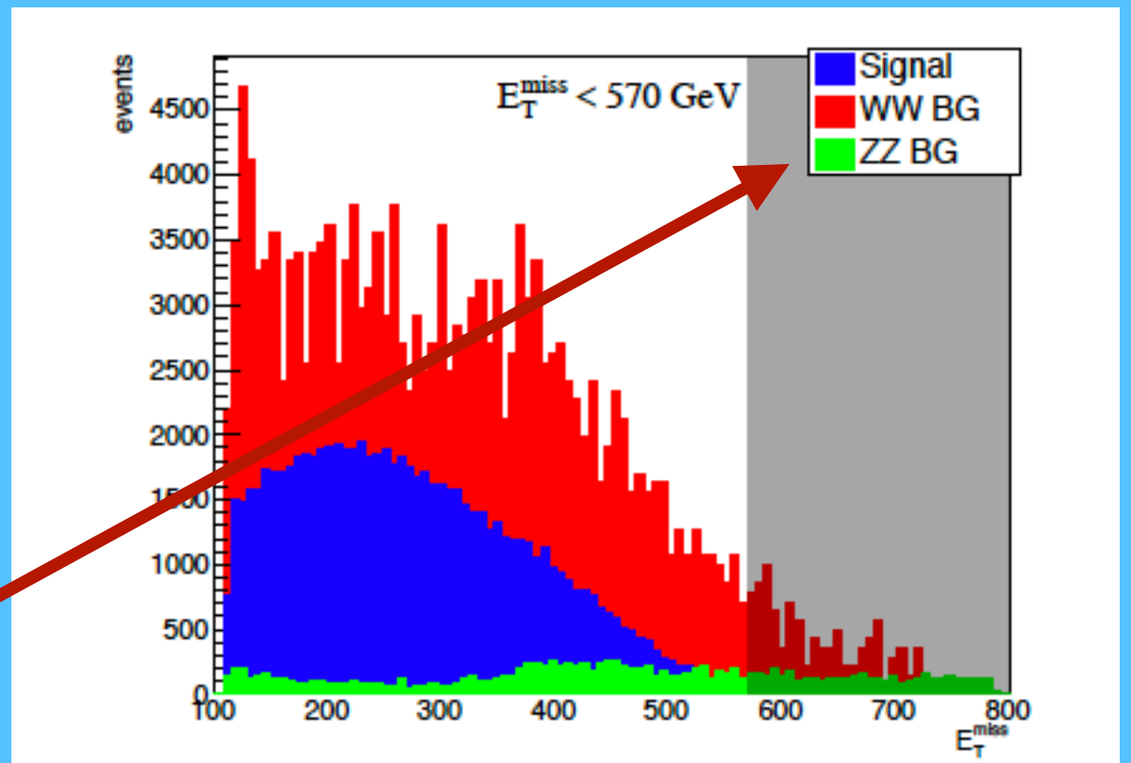


**You may want to modify your plots for the presentation!**

re we have scaled

# Graphics

**Graphic objects:**

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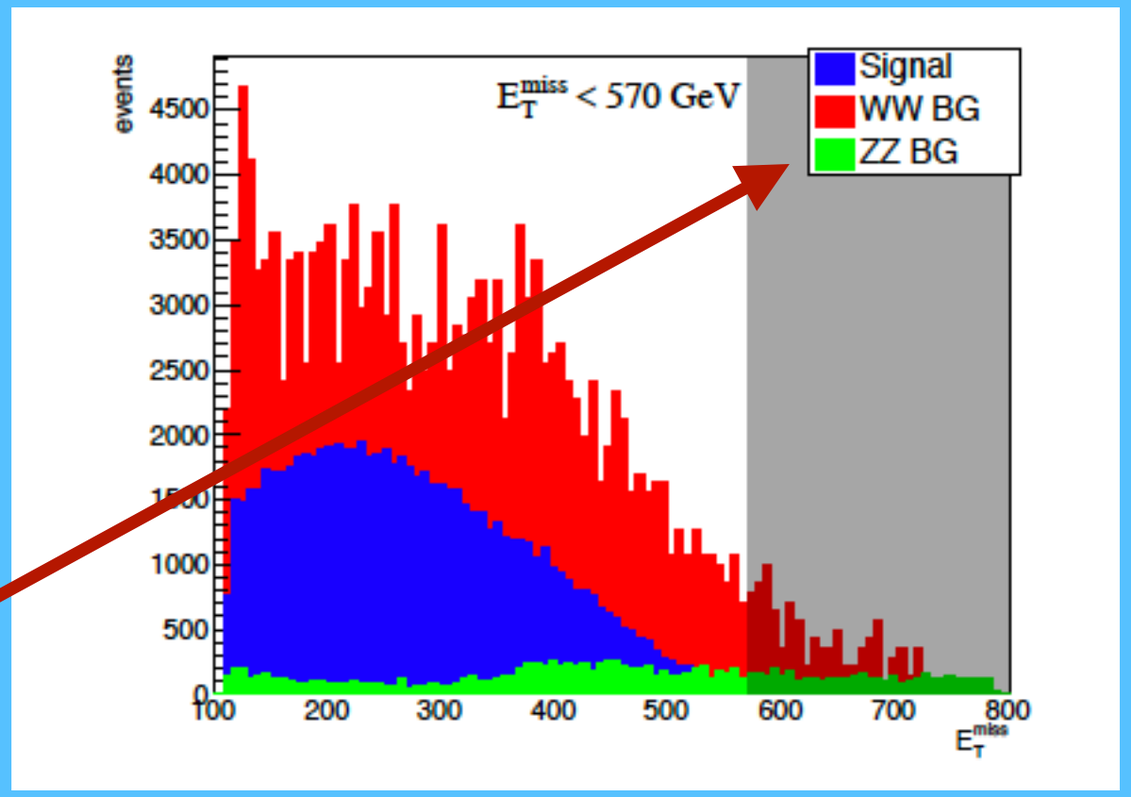



**If the audience need to understand the plot, you should take time to explain it (but then, the slide will last longer: take note of this)**

# Equations

**An equation is not just as an aesthetic tool!**

**It should be written ONLY if is necessary to explain something**

**Put intermediate equations, or supplementary ones, in the BACKUP SLIDES!**

# Equations

**An equation is not just as an aesthetic tool!**

**You should define ALL of the elements in an equation**

**NOT TRUE IN A PRESENTATION!**

$$\delta\phi^* = \epsilon^\dagger \psi^\dagger, \tag{3.1.3}$$

where $\epsilon^\alpha$ is an infinitesimal, anticommuting, two-component Weyl fermion object that parameterizes

**If the audience need to understand**
**the equation, you should take time to explain it**
**(but then, the slide will last longer: take note of this)**

# Equations

**An equation is not just an aesthetic tool!**

**It is not compulsory to be able to derive the equation**

$$\frac{dn_{\rm DM}}{dt} = -3H(T)\, n_{\rm DM} - \langle \sigma v \rangle \left[ n_{\rm DM}^2 - (n_{\rm DM}^{eq})^2 \right]$$

**However, you should be able to explain what the equation means (what are left and right hand sides)**

# Referencing

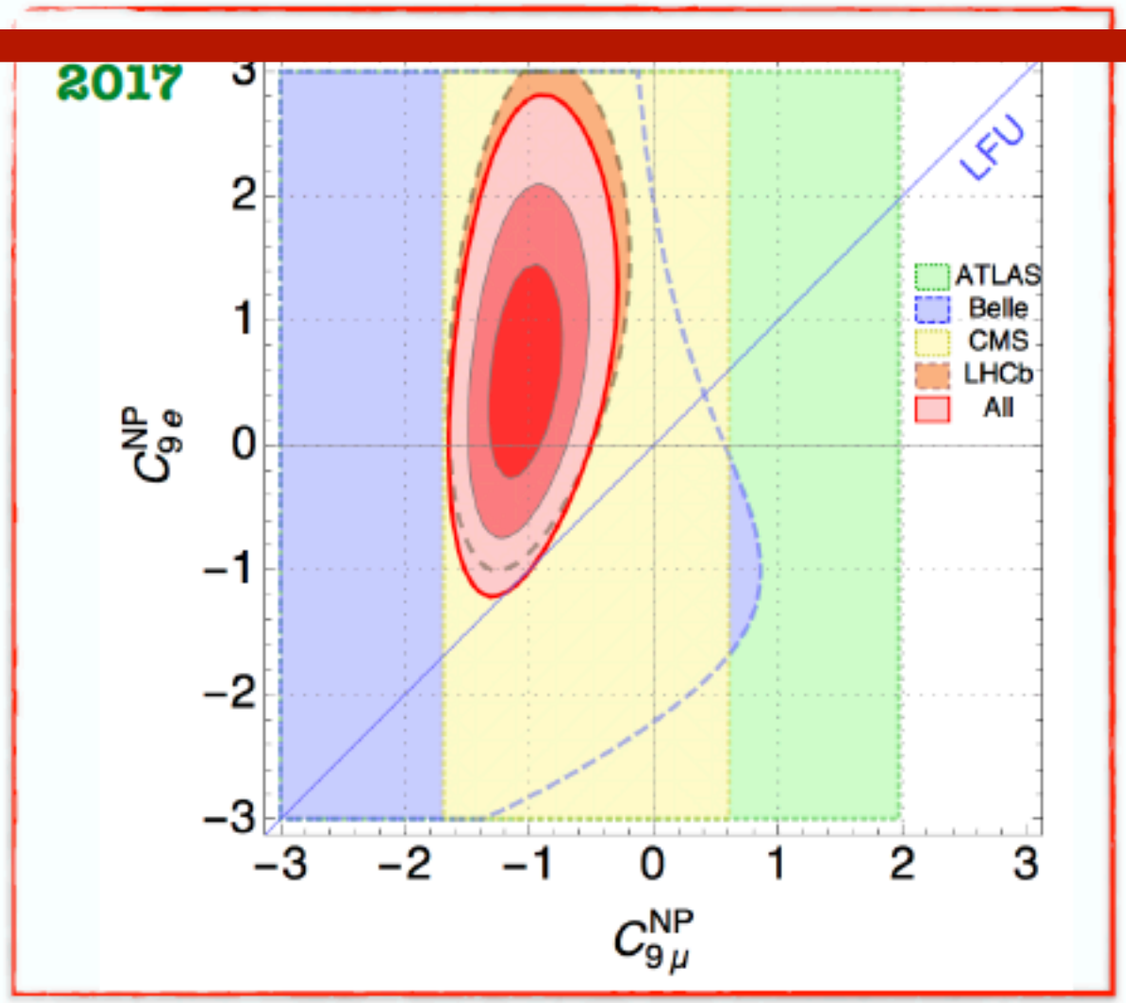
**It is extremely important to quote the relevant bibliography in a thesis!**

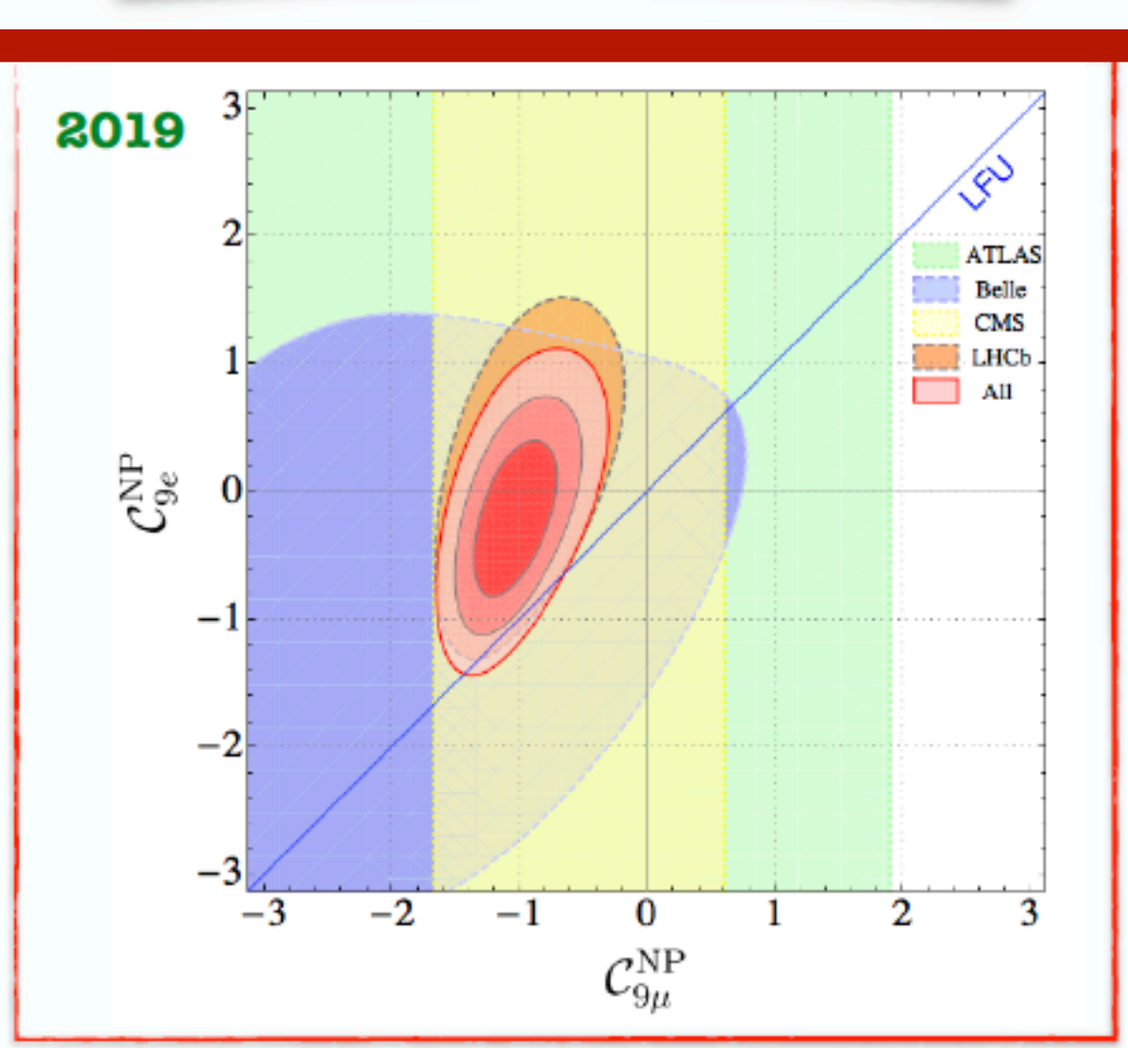
**You should quote the original source where something important for what you are telling was first published**

# Implications of the new updates on $R_K$, $R_{K^*}$, $B_s \to \mu\mu$

New Physics in electrons slightly more compatible with zero.

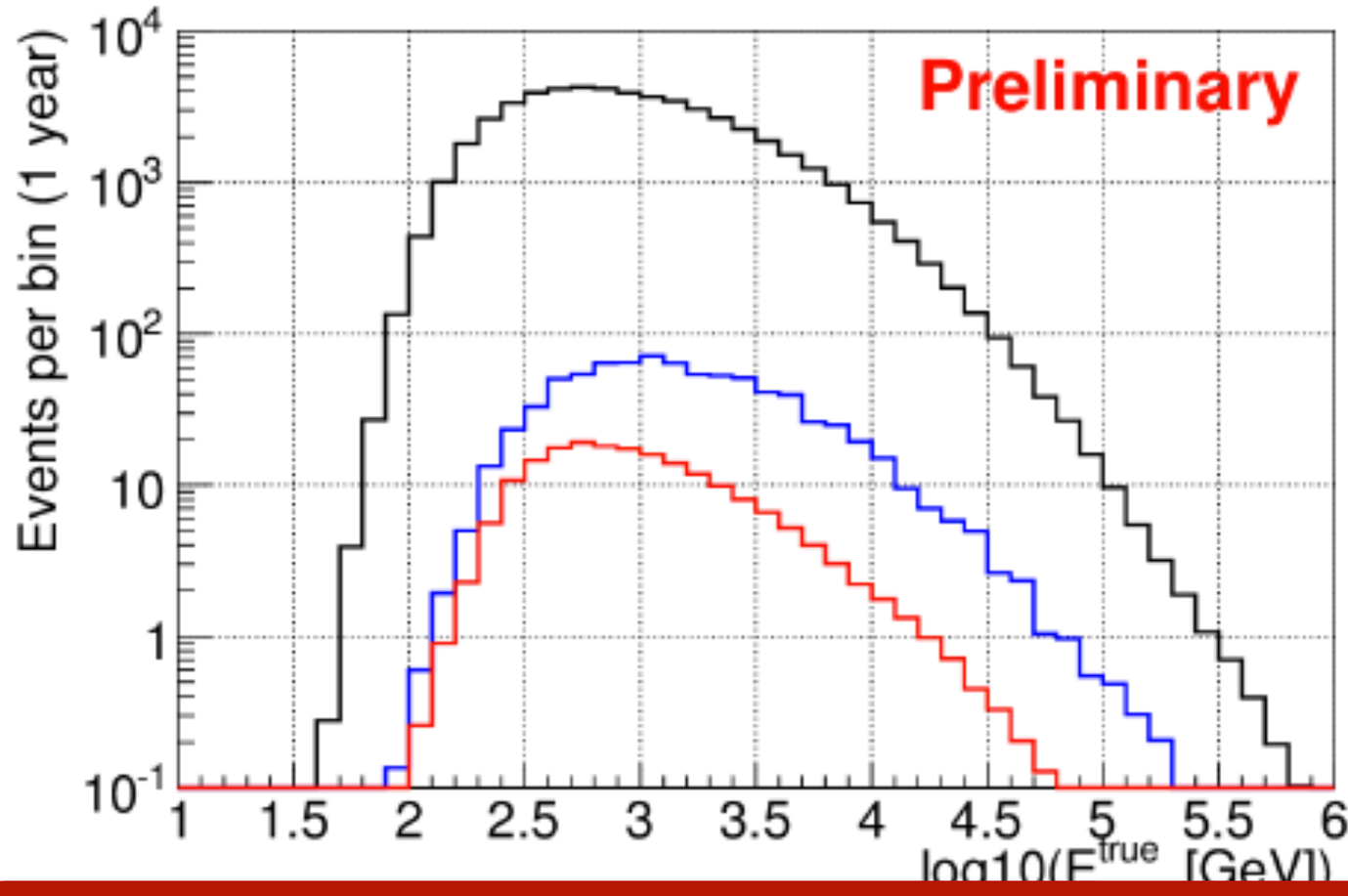
[JHEP 1801(2018) 093] → [1903.09578]




It is then natural to expect some impact in the significance of LFUV+LFU scenarios

# Let’s use atmospheric neutrinos!




IceCube contribution to ICRC 2015, arXiv:1510.05223

# Referencing your own work

**In the “new” section, usually you may quote your own publications**

**First possibility:**
**the trick to put**
**your initials only**

**Second possibility:**
**to quote it as**
**any other reference**

# Linking charged and neutral anomalies (step 1)

Let's move to SMEFT ($\Lambda_{NP} >> m_{t,W,Z}$) [Grzadkowski, Iskrzynski, Misiak, Rosiek; Alonso, Grinstein, Camalich]

- **NP contribution to :** $[\bar{c}\gamma^\mu \mathbf{P_L} b][\bar{\tau}\gamma_\mu \mathbf{P_L}\nu_\tau]$ ⟶ $R_D/R_D^{\rm SM} \simeq R_{D^*}/R_{D^*}^{\rm SM}$

$G_F$ rescaling

**BUT who order that (at high energy)?** Only Two $SU(2)_L$ invariant operators in SMEFT @ 1st order

$$\mathcal{O}^{(1)}_{ijkl} = [\bar{Q}_i\gamma_\mu Q_j][\bar{L}_k\gamma^\mu L_l], \qquad \mathcal{O}^{(3)}_{ijkl} = [\bar{Q}_i\gamma_\mu\sigma^I Q_j][\bar{L}_k\gamma^\mu\sigma^I L_l],$$

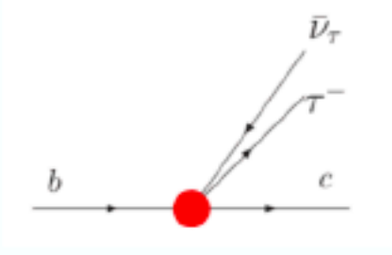
After EWSB i=2, j=k=l=3 **if $C^{(1)}=C^{(3)}$** [Capdevila, Crivellin, SDG, Hofer, JM, PRL'18]

**b→c**

Accommodate charged $R_{D(*)}$.

OK **constraints**:

- Bc lifetime, q2 distributions, but also **$B\to K^*\nu\bar{\nu}$**, direct searches and EWP data.

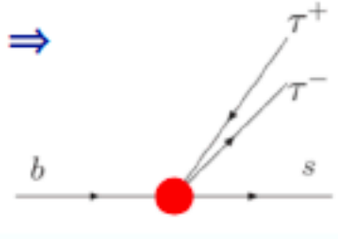



**b→s**

Contribution to neutral b→s ττ with a pattern: $C_{9(10)\tau} \simeq C_{9,10}^{SM} - (+)\Delta$ (40)

$$\Delta = 2\frac{\pi}{\alpha_{em}}\frac{V_{cb}}{V_{tb}V_{ts}^*}\left(\sqrt{\frac{R_X}{R_X^{SM}}} - 1\right) \simeq \mathcal{O}(100)$$

- 10% NP w.r.t. tree-level SM ⇒ Huge contrib. w.r.t. loop-induced SM.



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**BUT who order that (at high energy)?** Only Two $SU(2)_L$ invariant operators in SMEFT @ 1st order

$\mathcal{O}_{lq}^{(1)} = [\bar{Q}_j\gamma_\mu Q_j][\bar{L}_l\gamma^\mu L_l]$ $\mathcal{O}_{lq}^{(3)} = [\bar{Q}_j\gamma_\mu \sigma^I Q_j][\bar{L}_l\gamma^\mu \sigma^I L_l]$

**Lost within all of this informations, there is a self-citation….**

[Capdevila, Crivellin, SDG, Hofer, JM, PRL'18]

**b⟶s**

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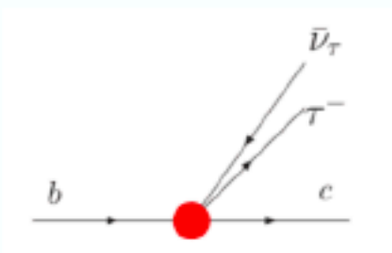


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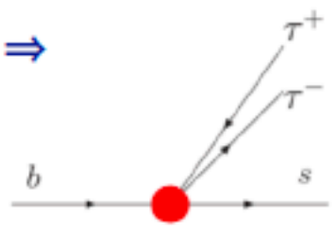
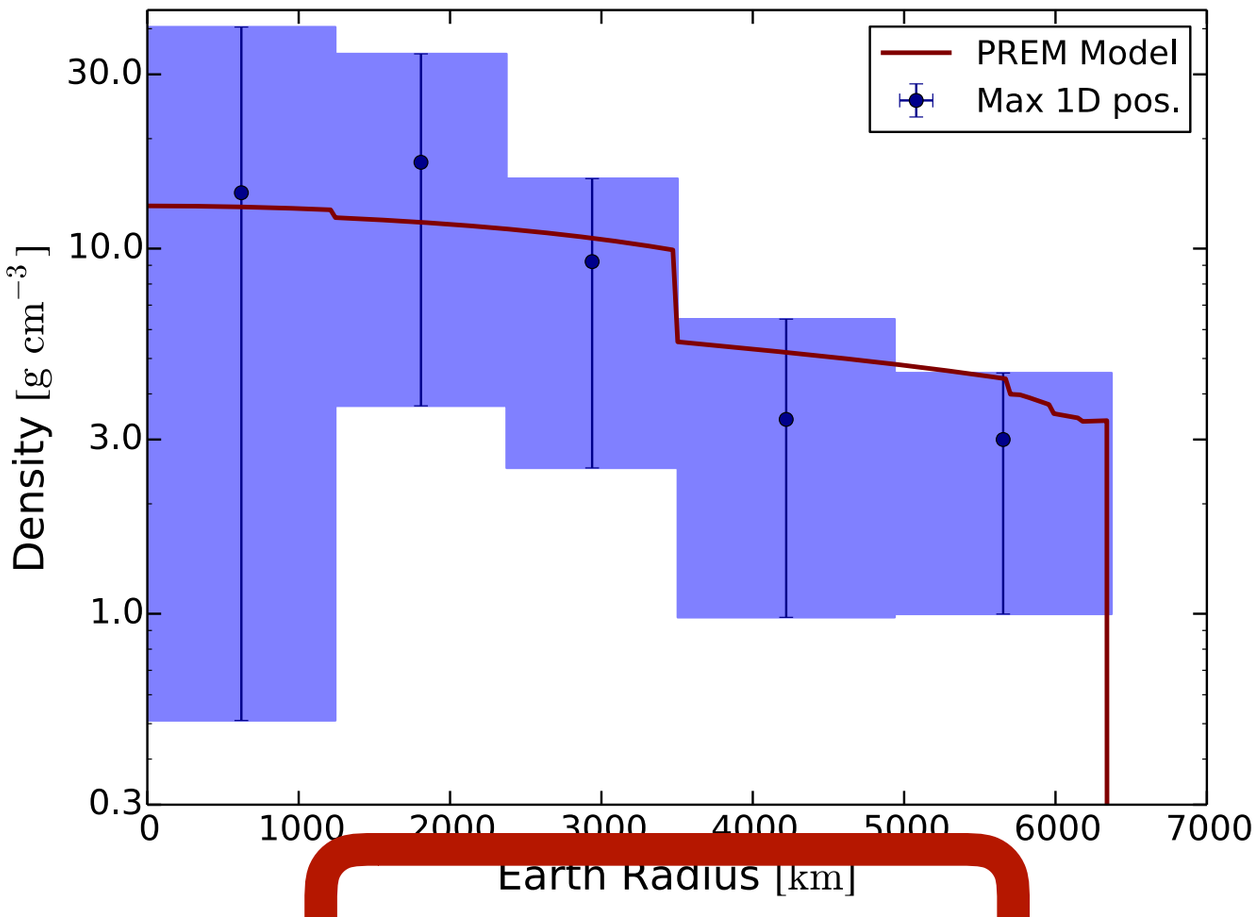


# First 1-d density profile with neutrinos




Nature Physics 15 (2019) 37

Analysis performed with MultiNest

5 Earth layers densities

and

4 systematic errors:

- Flux normalization
- Pion-to-kaon ratio
- Spectral shape
- DOM Efficiency

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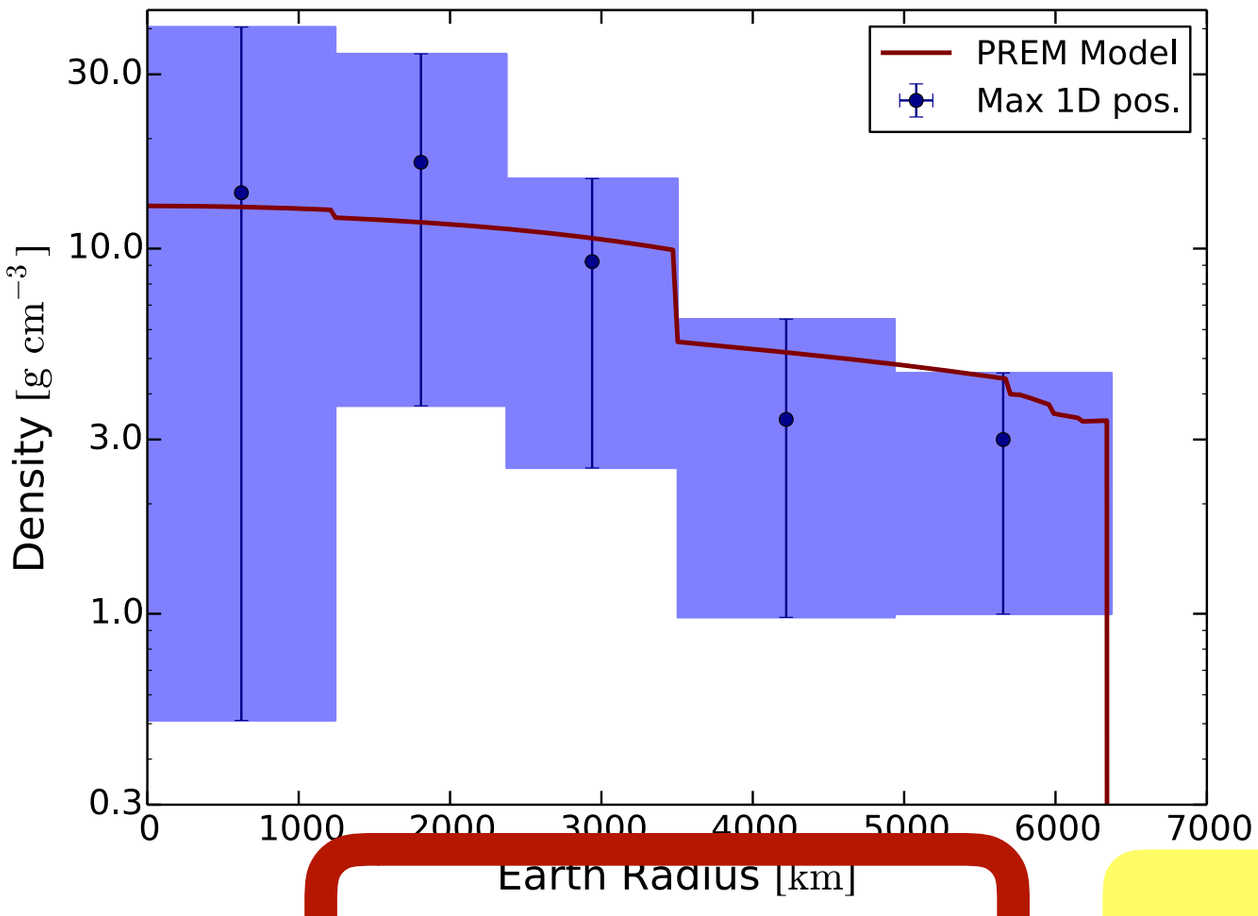


Nature Physics 15 (2019) 37

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5 Earth layers densities

and

4 systematic errors:

- Flux normalization
- Pion-to-kaon ratio
- Spectral shape

**(A. Donini, S. Palomares-Ruiz, J. Salvado)**

# Conclusions

**It is a short summary of the thesis:**
**remind shortly the motivation and the results with respect to the literature**

**This is the place to insert your work as just one single brick in a big construction**

**Use a few words (or an extra slide) to explain possible future development, "beyond the scope of this thesis."**

# Once your done…

**TAKE YOUR TIME**
**TO**
**PRACTICE!**

**In particular, TIMING!**

# Once your done…

**Try to foresee**
**the possible questions**
**and**
**prepare BACKUP SLIDES for them**

# Appendices become BACKUP SLIDES

**They are the place where you must move TECHNICAL STUFF that you used but is:**

**A) boring to explain in the talk**

**B) something that may be skipped**

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**B) something that may be skipped**

**As many as you need….**

# Thank you!

**And remember……**

# Thank you!

**And remember……**

**Try to avoid your worst nightmare: the “sleeping member” of the Jury**