

The design of a Master Thesis

Andrea Donini

(curso organizado y supervisado con Pilar Hernández)

Class Number Two

Outline of the lectures

1. **STARTING**
 1. Choosing a language
 2. Choosing an editing language
 3. Choosing an editor
 4. Choosing an AI

2. **ORGANIZATION OF THE THESIS**
 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. Explaining plots (captions!)
 3. Equations

4. **REFERENCING**

1.

Outline of the lectures

1. **STARTING**
 1. Choosing a language
 2. Choosing an editing language
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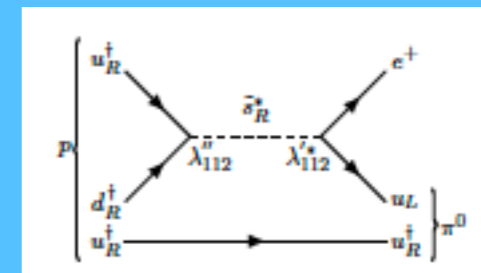
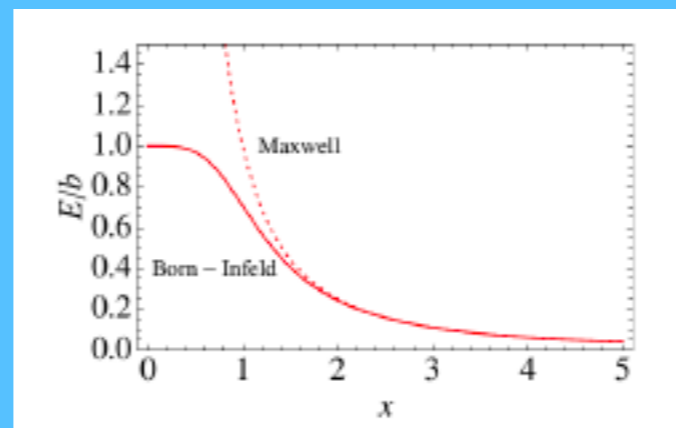
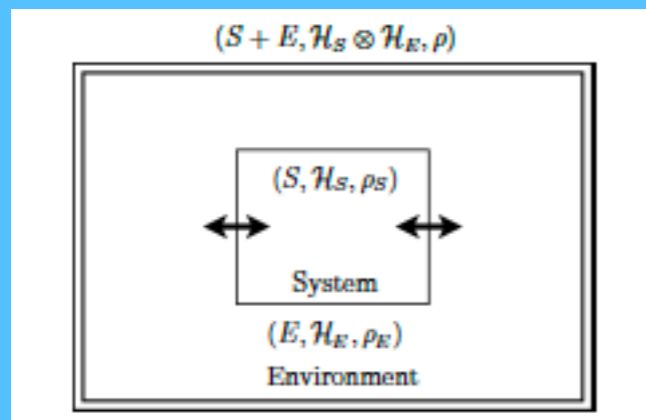
2. **ORGANIZATION OF THE THESIS**
 1. Understanding your subject
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 1. Drawing and inserting plots
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4. **REFERENCING**

Part III: Graphics

Pictures are an important tool
to present physics results



Graphics are easily imported into Latex in any format.
I produce them in .pdf, but any format works
(for those using Word I have no idea...)

Part III: Graphics

**You should produce your figures with the software
you prefer**

Part III: Graphics

You should produce your figures with the software you prefer

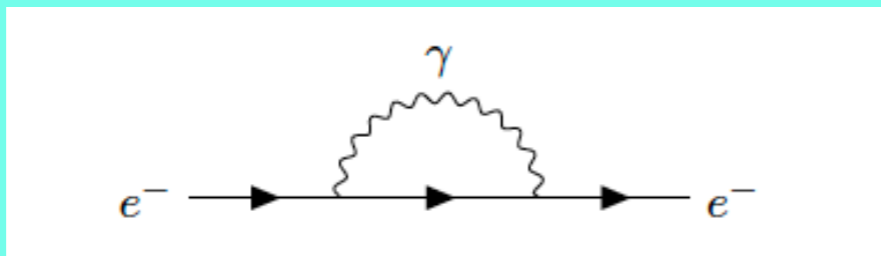
They may be of two kinds:

Part III: Graphics

You should produce your figures with the software you prefer

They may be of two kinds:

Qualitative

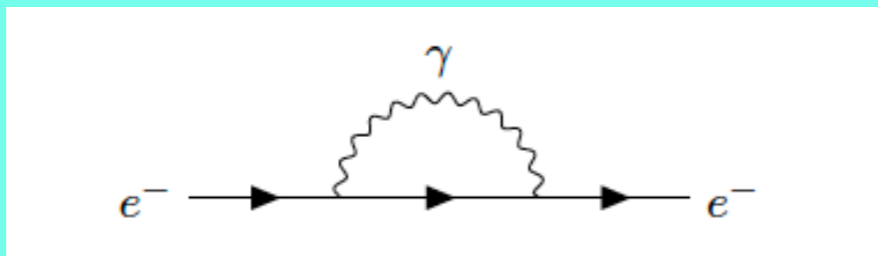


Part III: Graphics

You should produce your figures with the software you prefer

They may be of two kinds:

Qualitative



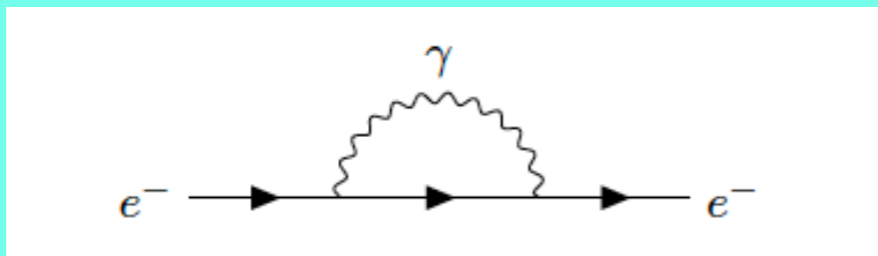
Clean, simple

Part III: Graphics

You should produce your figures with the software you prefer

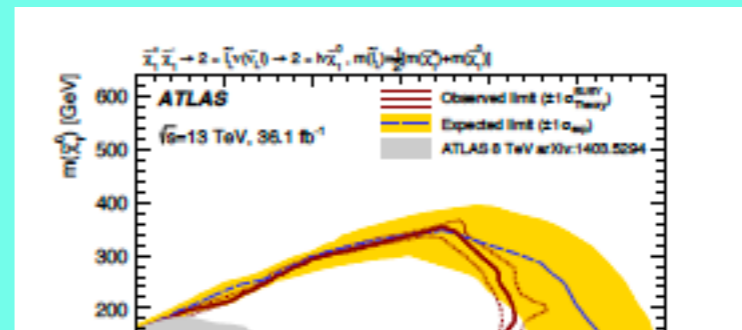
They may be of two kinds:

Qualitative



Clean, simple

Quantitative



Messy, overfilled

Part III: Graphics

A Figure is made out of two pieces:

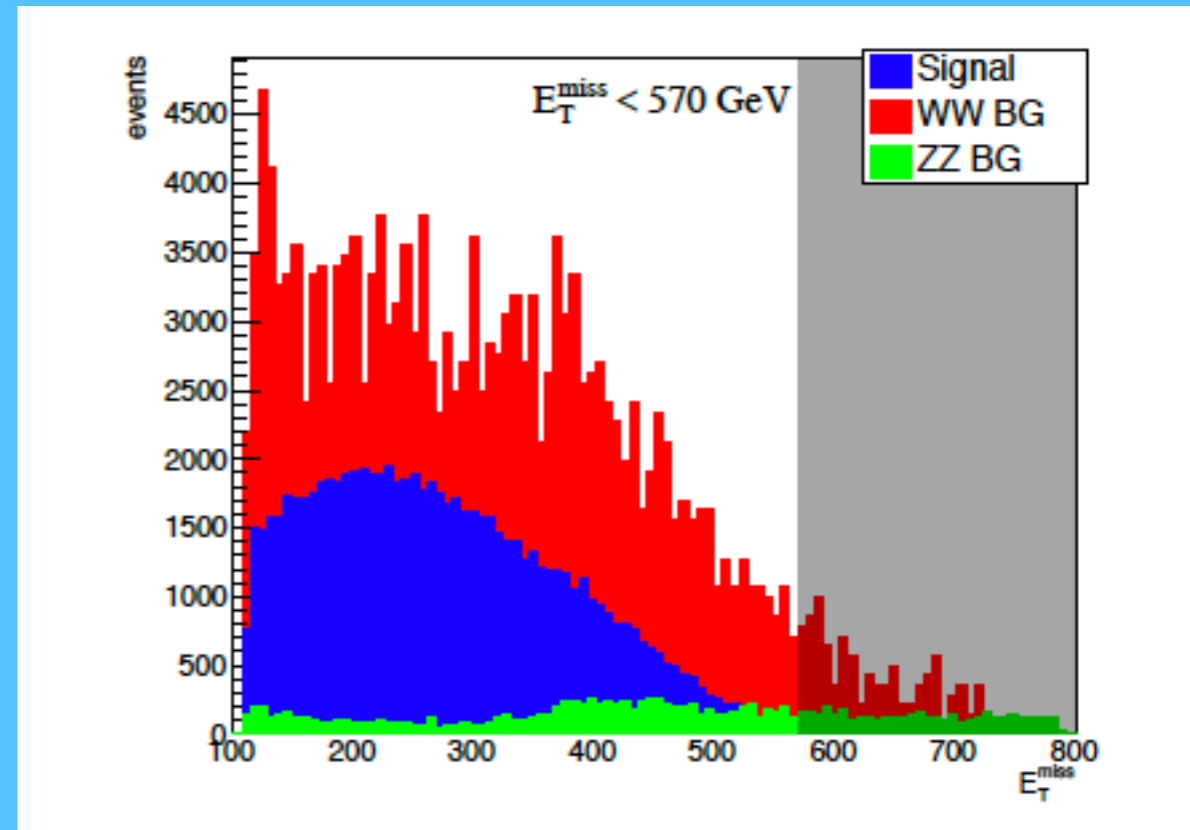


Figure 5.6: Histogram showing all the cuts being applied for the E_T^{miss} . Here we have scaled the number of events in accordance with equation 5.3.29.

Part III: Graphics

A Figure is made out of two pieces:

1. The graphic object

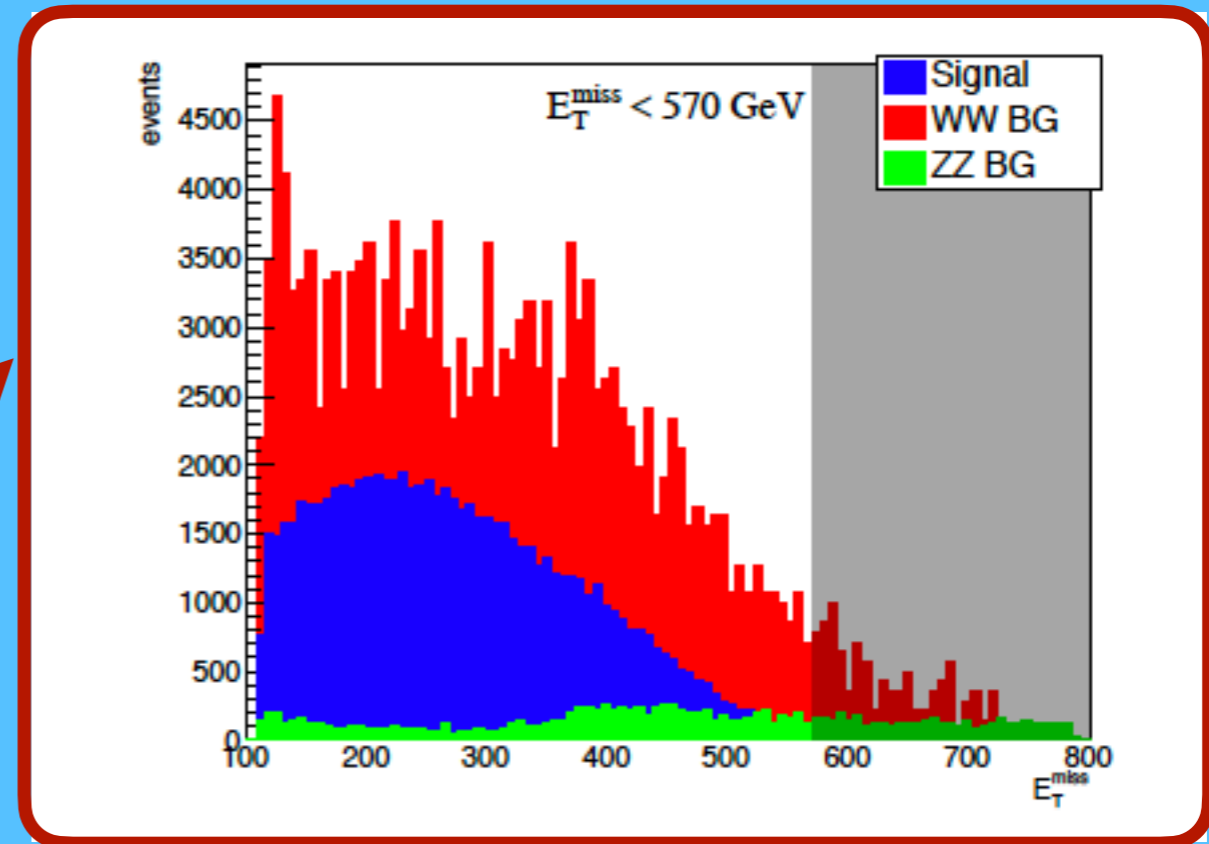


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A Figure is made out of two pieces:

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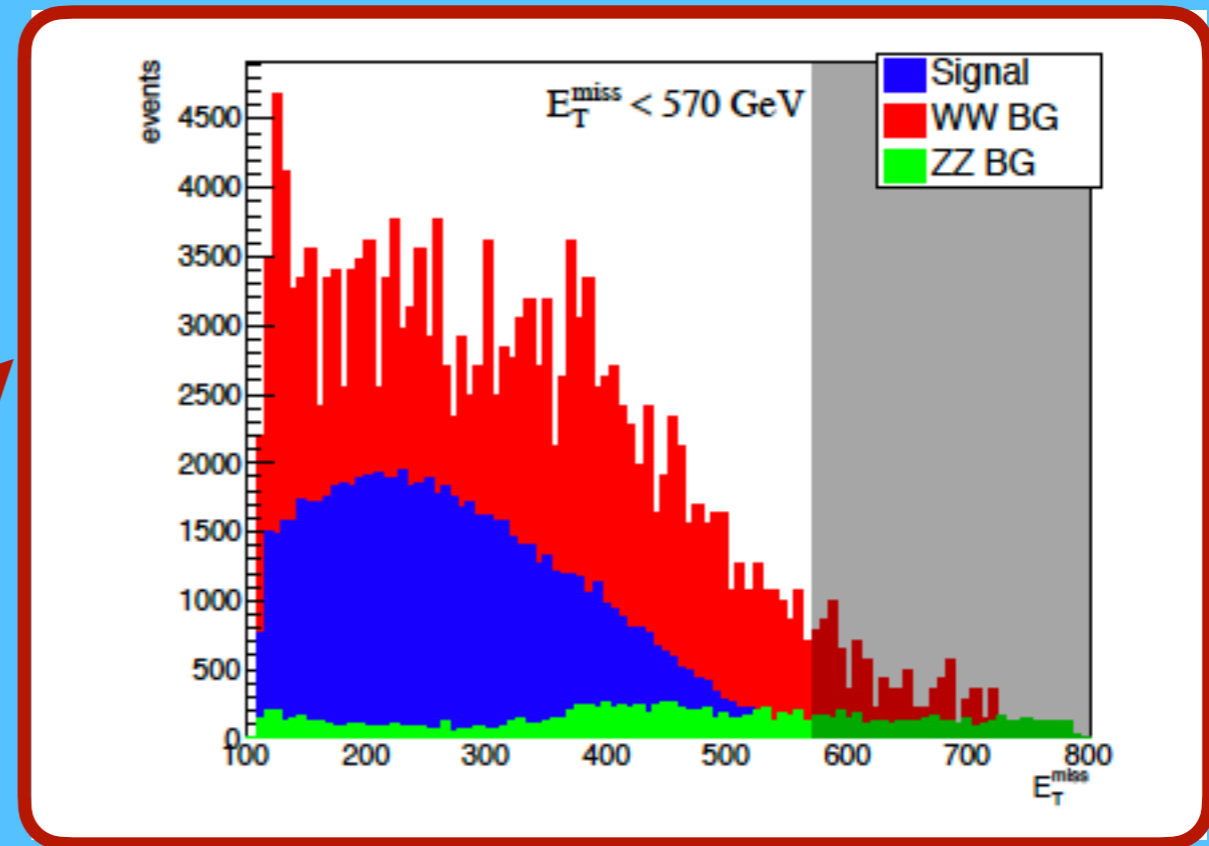


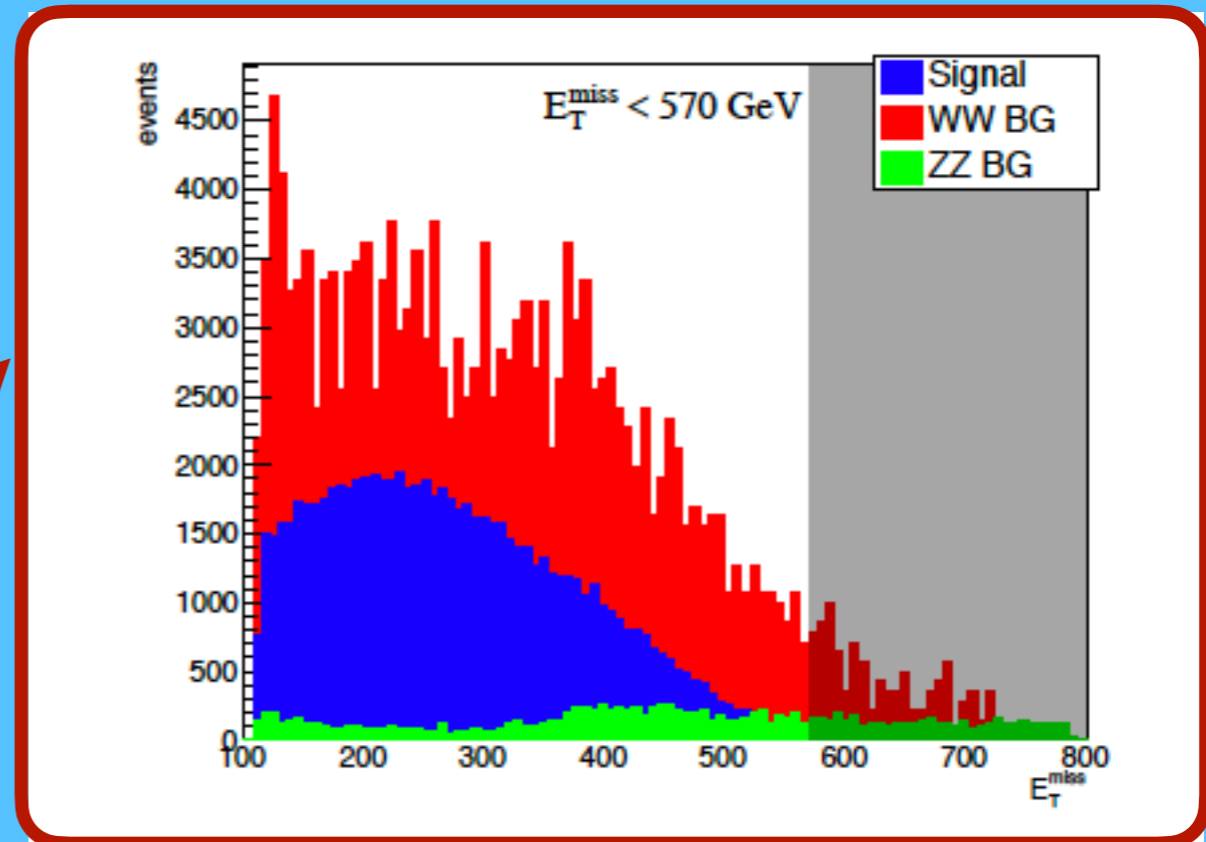
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1. The graphic object

2. The caption



Captions are not an option!

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

Part III: Graphics

Graphic objects:

legends should be
simple and clear
(not too many items)

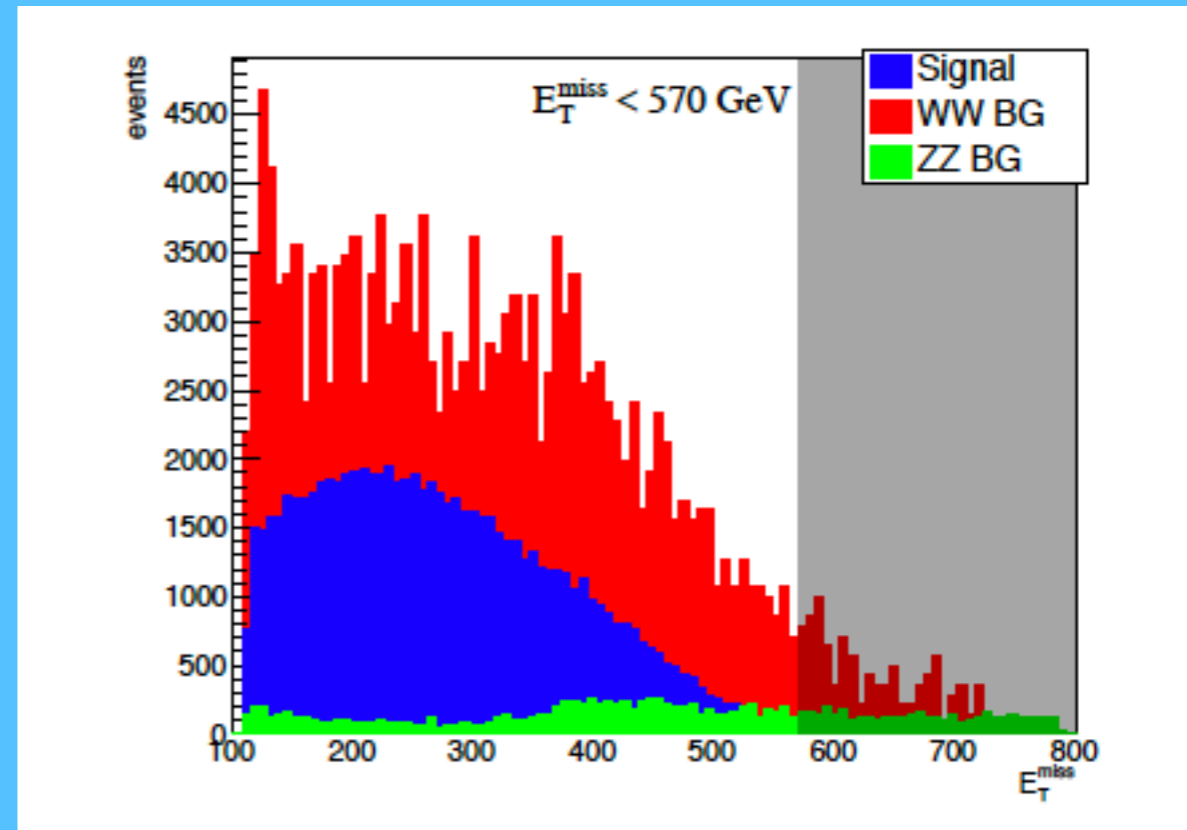


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Part III: Graphics

Graphic objects:

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

they should be **readable in B&W**
(if color legends, use **DARK/LIGHT** colors,
large contrast)

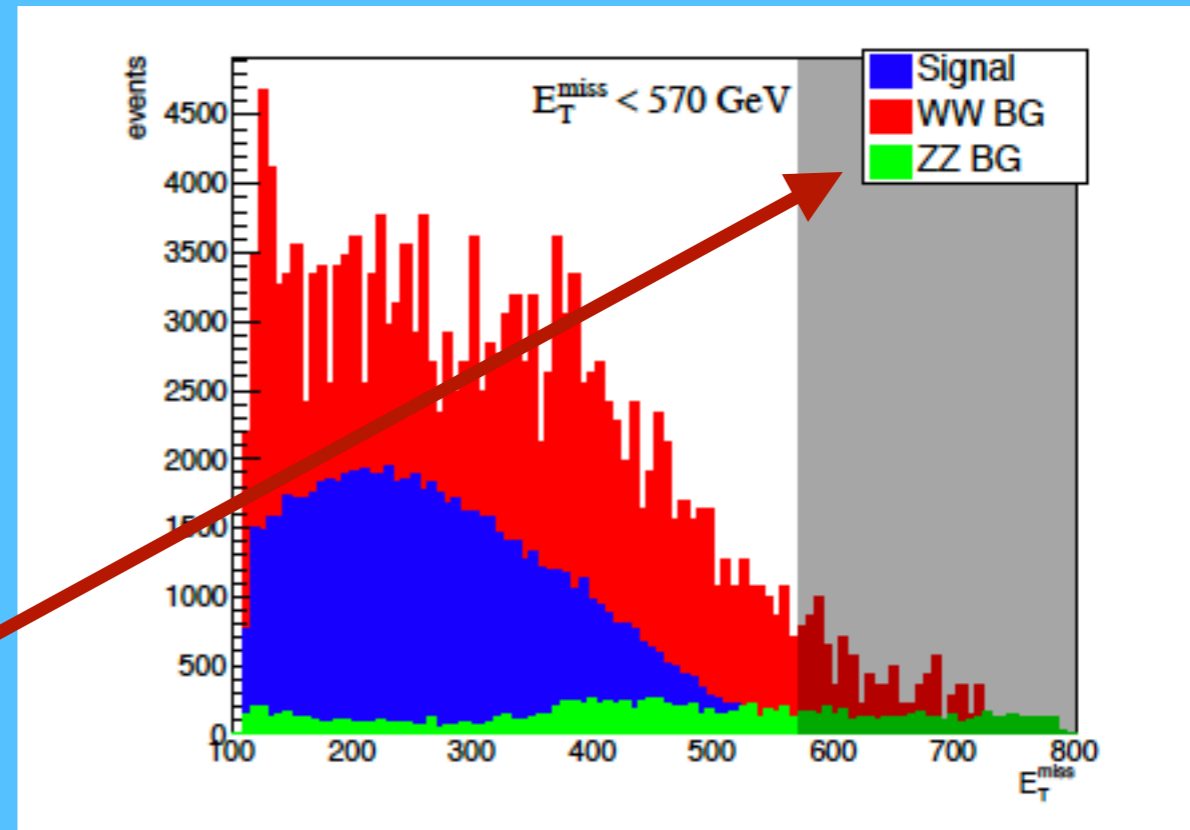


Figure 5.6: Histogram showing all the cuts being applied for the E_T^{miss} . Here we have scaled the number of events in accordance with equation 5.3.29.

Part III: Graphics

Captions: you have two choices

A) SELF-CONTAINED:
all the information needed
to understand the picture

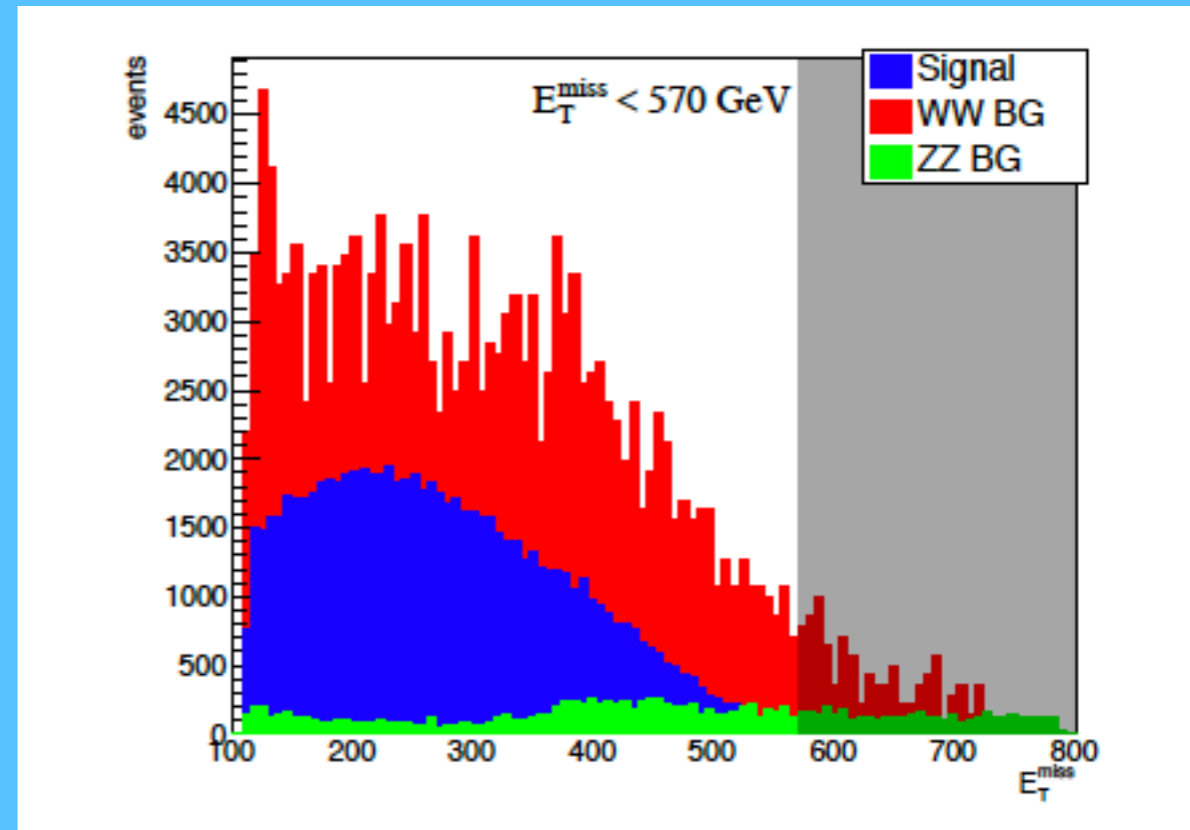


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Part III: Graphics

Captions: you have two choices

A) SELF-CONTAINED:
all the information needed
to understand the picture

B) REFER TO THE TEXT:
only basic information
and refer to the main text

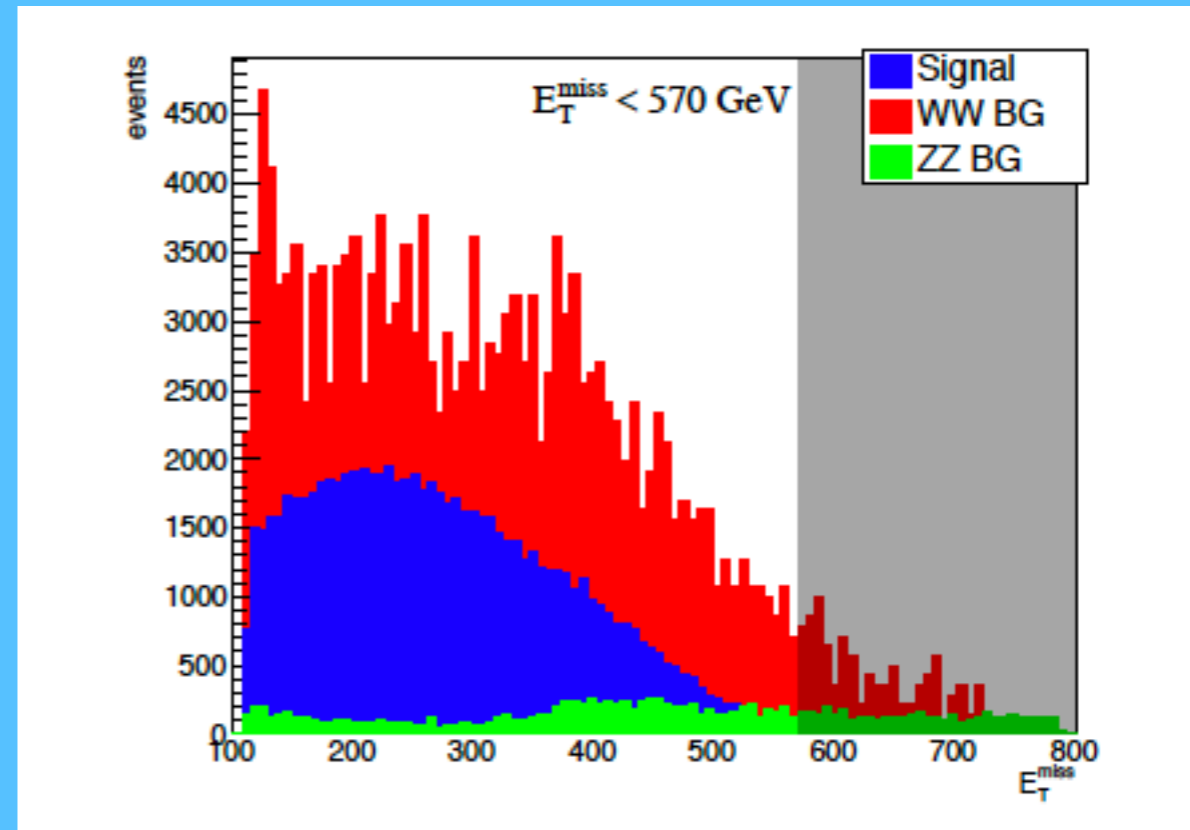


Figure 5.6: Histogram showing all the cuts being applied for the E_T^{miss} . Here we have scaled the number of events in accordance with equation 5.3.29.

Part III: Graphics

Captions: you have two choices

A) SELF-CONTAINED:
all the information needed
to understand the picture

In a thesis, much better
the first option.
Remember that you should
help the reader!

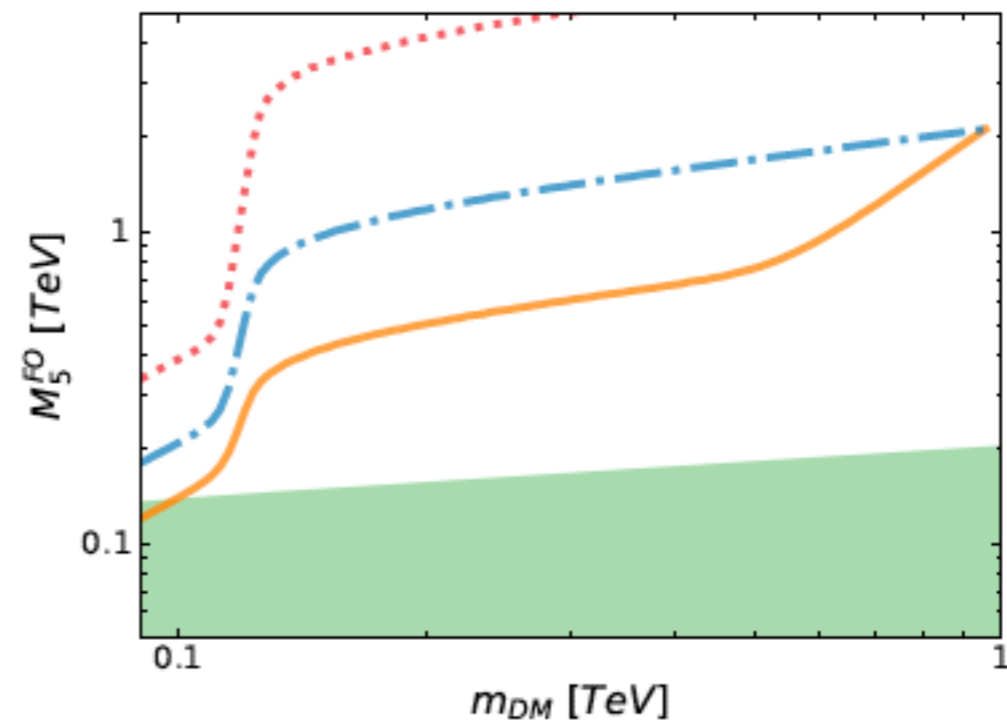


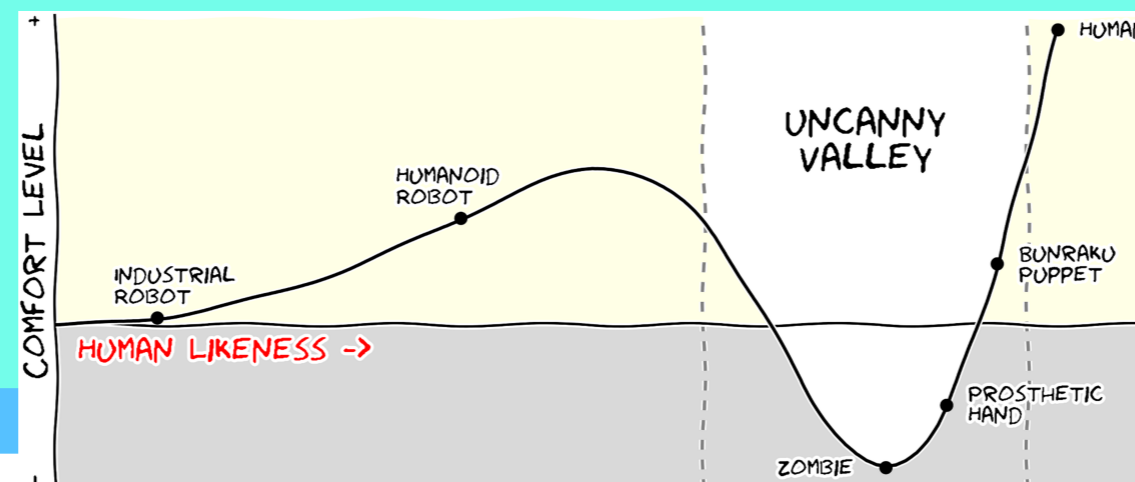
Figure 5. The scale needed to achieve the freeze-out relic abundance, M_5^{FO} , as a function of the DM mass m_{DM} , for $k = 250$ GeV. Solid orange, dot-dashed blue and dotted red lines correspond to scalar, fermion and vector DM, respectively. The green-shaded area, on the other hand, is the experimental bound in the (m_{DM}, M_5) plane from XENON1T [56].

Recipes for a good figure

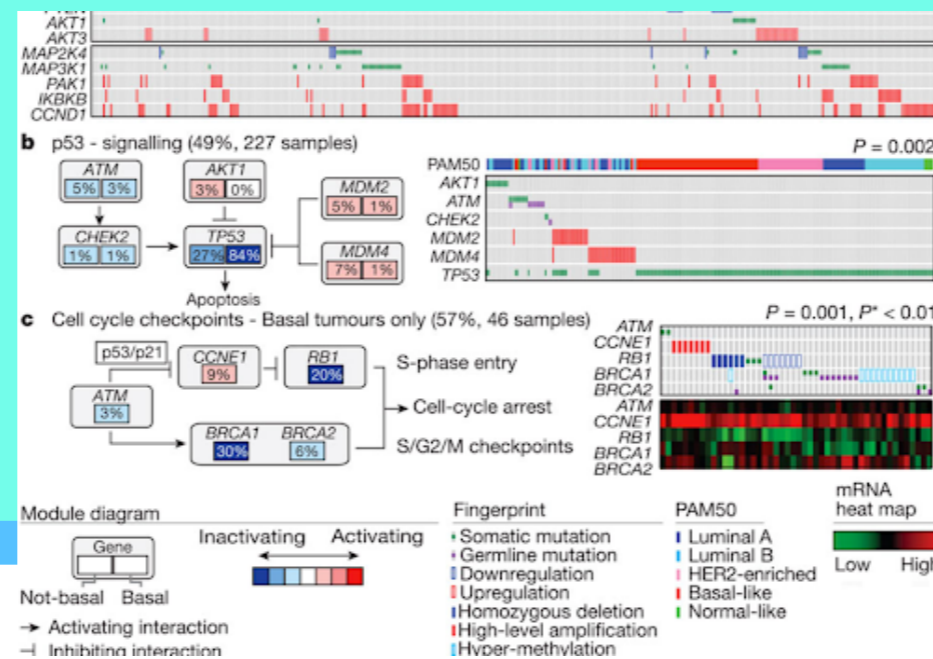
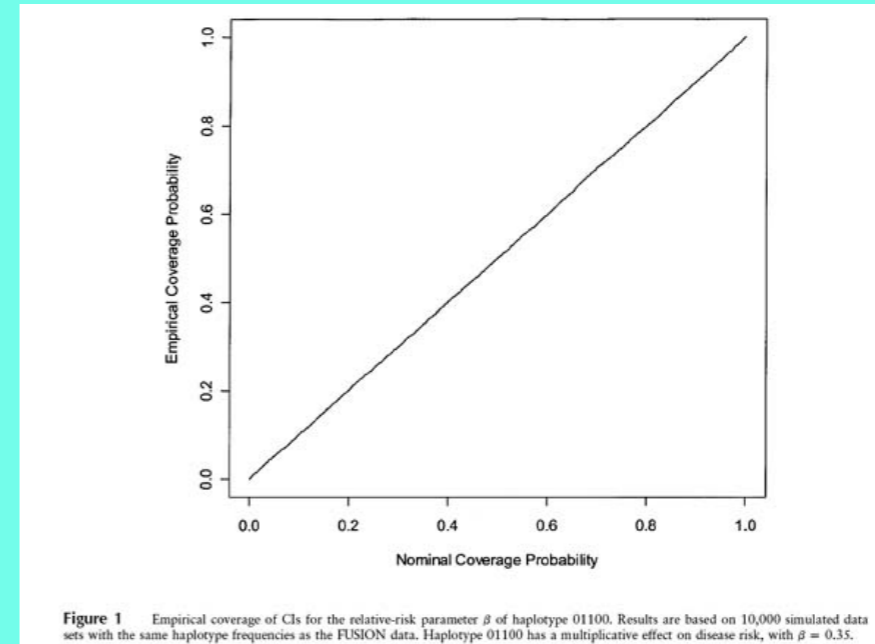
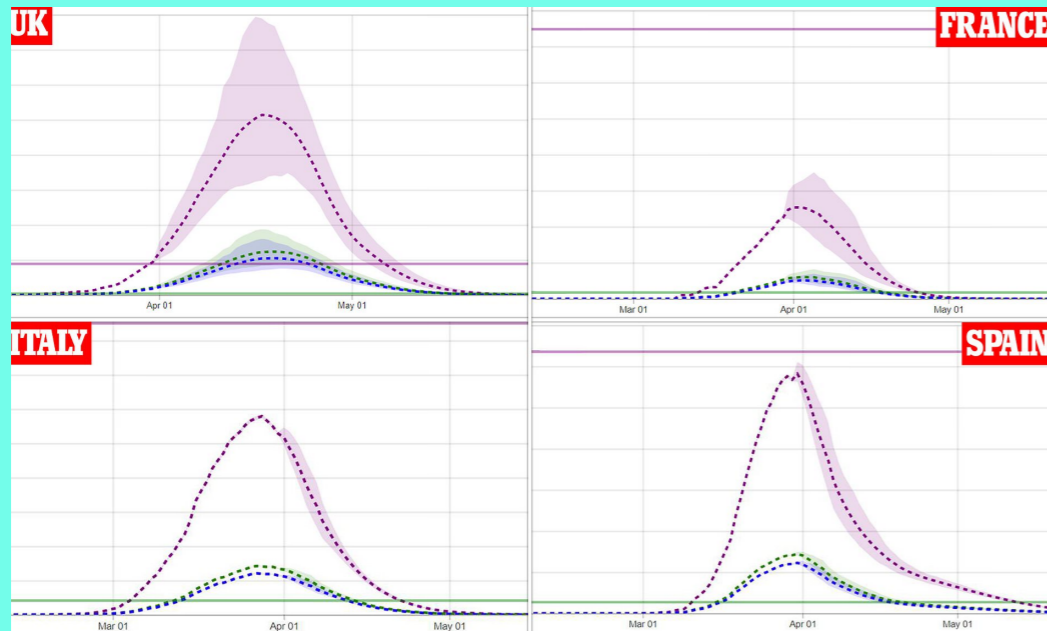
You may find interesting tips here:

<https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1003833#s7>

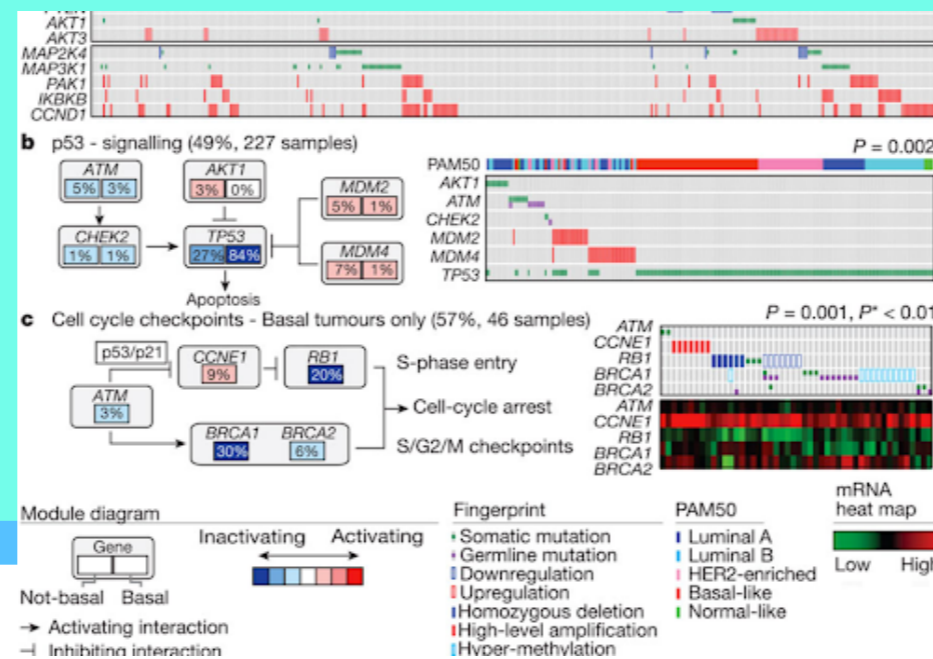
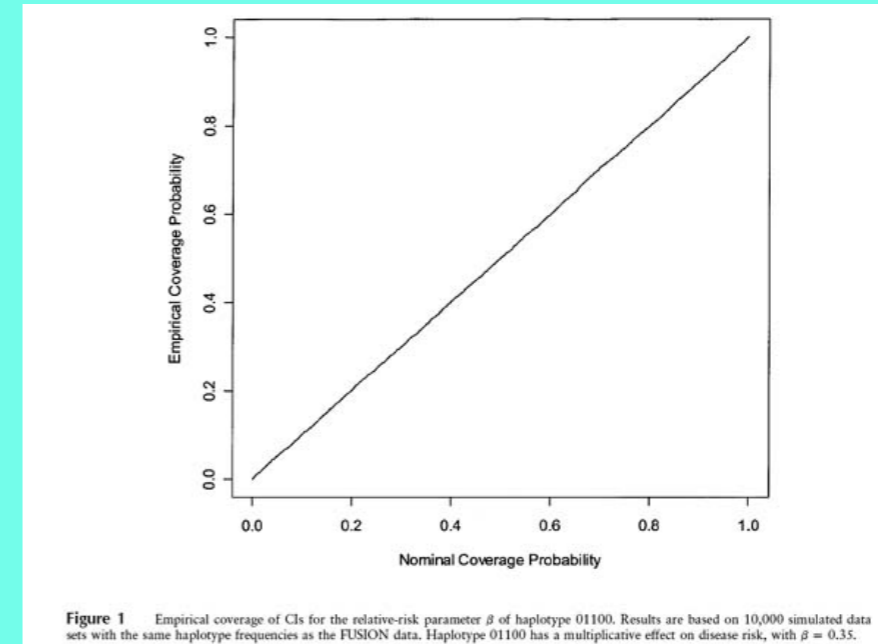
message and readability of the figure is the most important aspect while beauty is only optional



Recipes for a bad figure



Recipes for a bad figure



Recipes for a bad figure

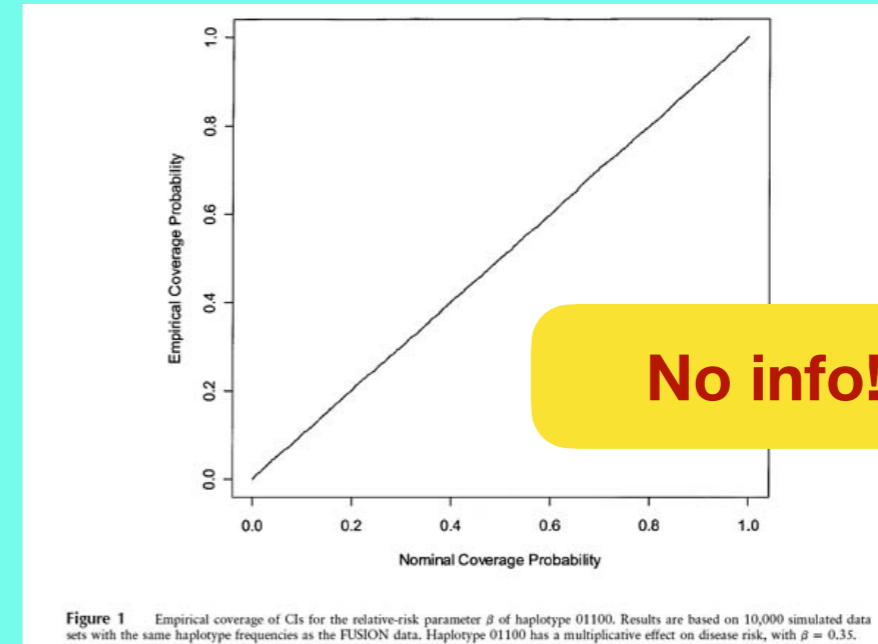
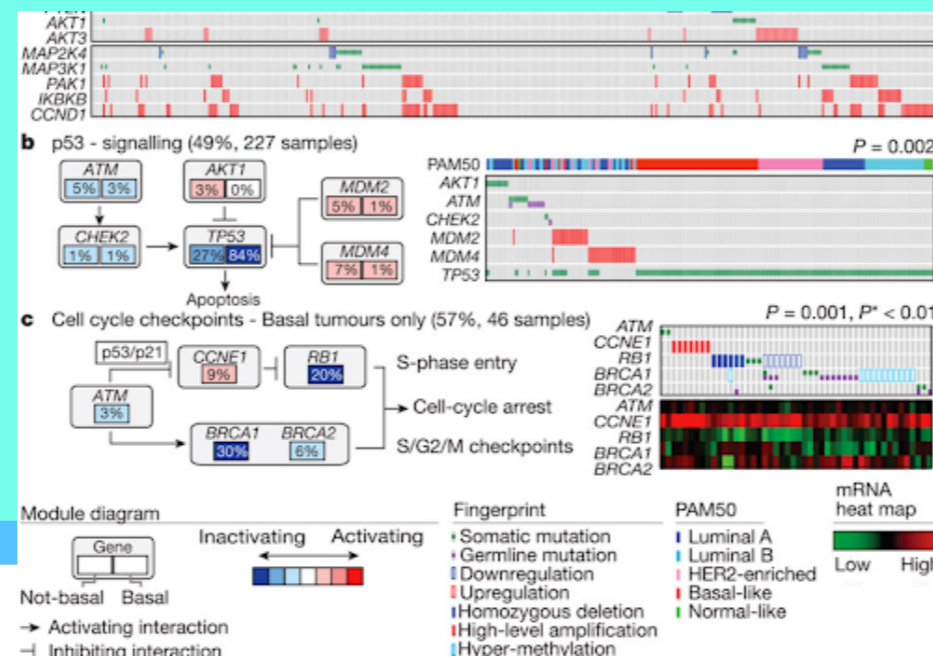
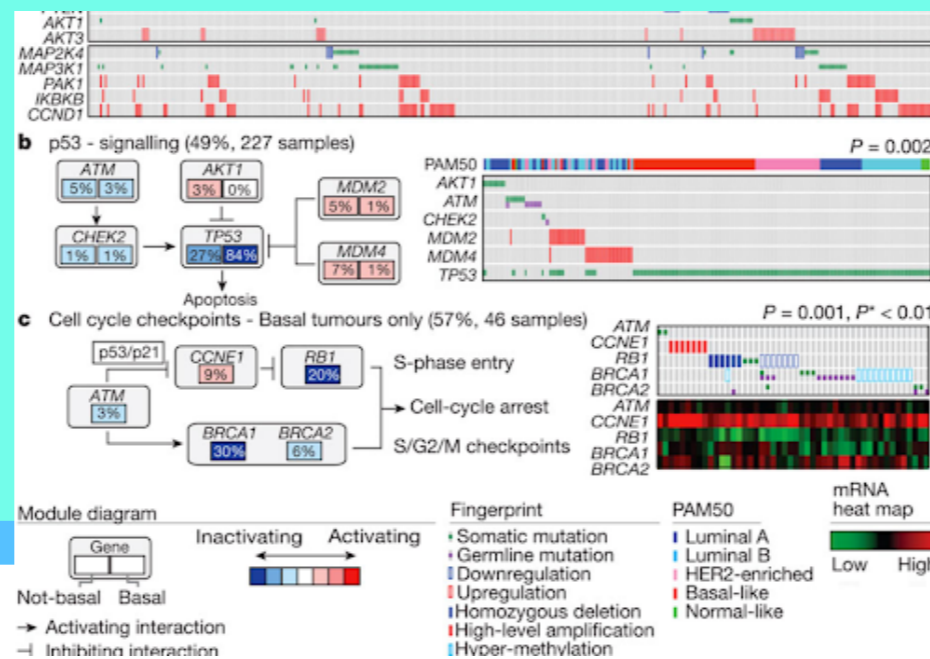
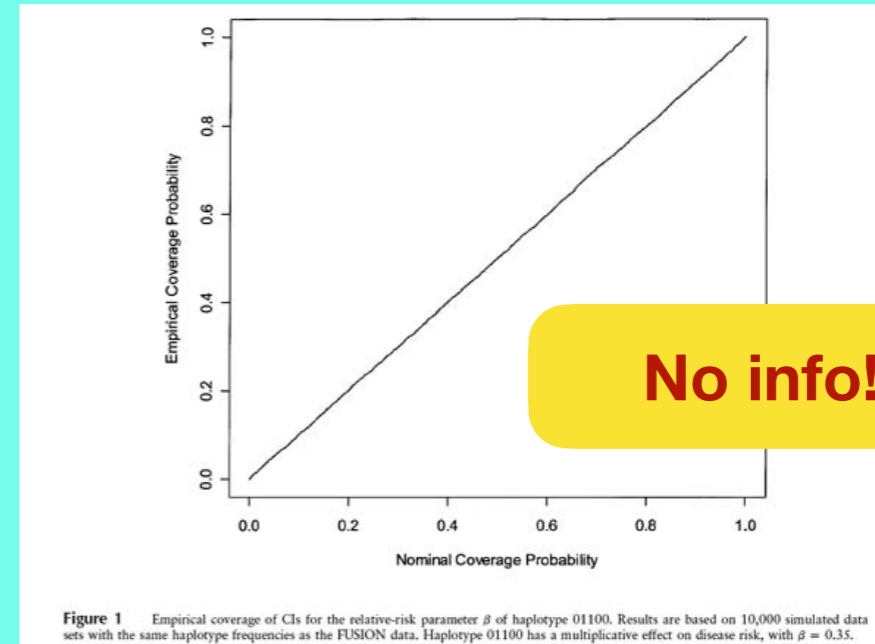


Figure 1 Empirical coverage of CIs for the relative-risk parameter β of haplotype 01100. Results are based on 10,000 simulated data sets with the same haplotype frequencies as the FUSION data. Haplotype 01100 has a multiplicative effect on disease risk, with $\beta = 0.35$.



Recipes for a bad figure



Too much info!

From last year theses

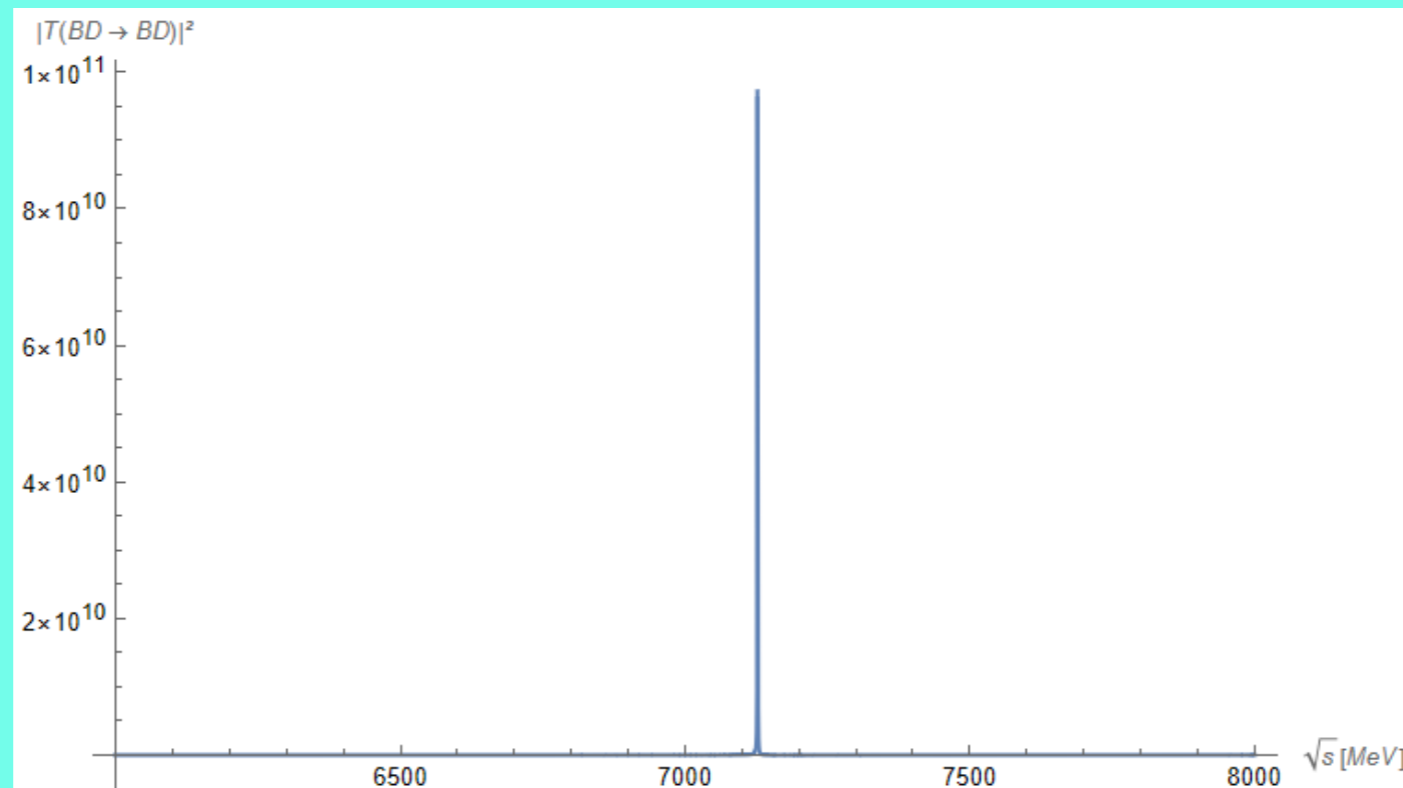


Figura 7: $|T|^2$ frente a \sqrt{s} para el canal $BD \rightarrow BD$. Se utilizó cutoff con $q_{max} = 400\text{MeV}$. Pico en $\sqrt{s_p} = 7127,59\text{MeV}$.

From last year theses

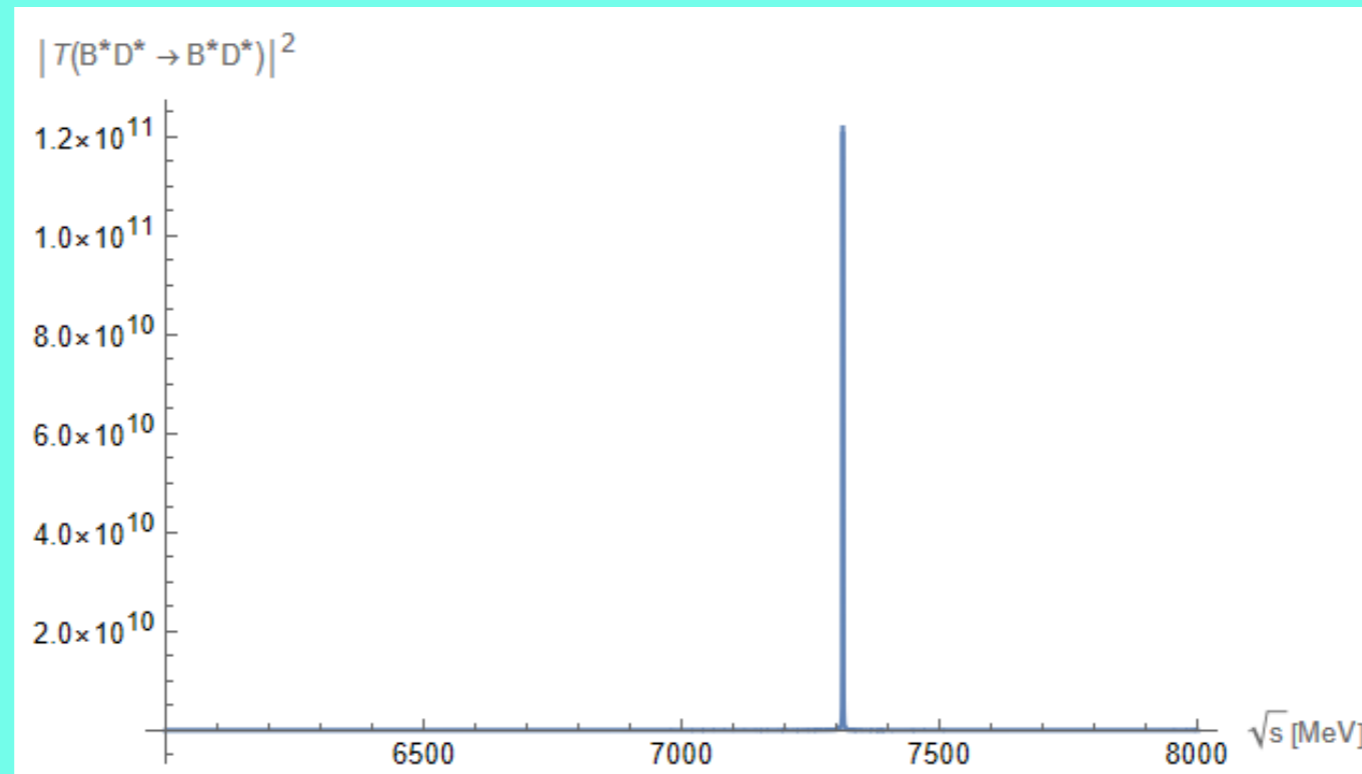


Figura 11: $|T|^2$ frente a \sqrt{s} para el canal $B^*D^* \rightarrow B^*D^*$. Se utilizó cutoff con $q_{max} = 400$ MeV.
Pico en $\sqrt{s_p} = 7313,27$ MeV.

From last year theses

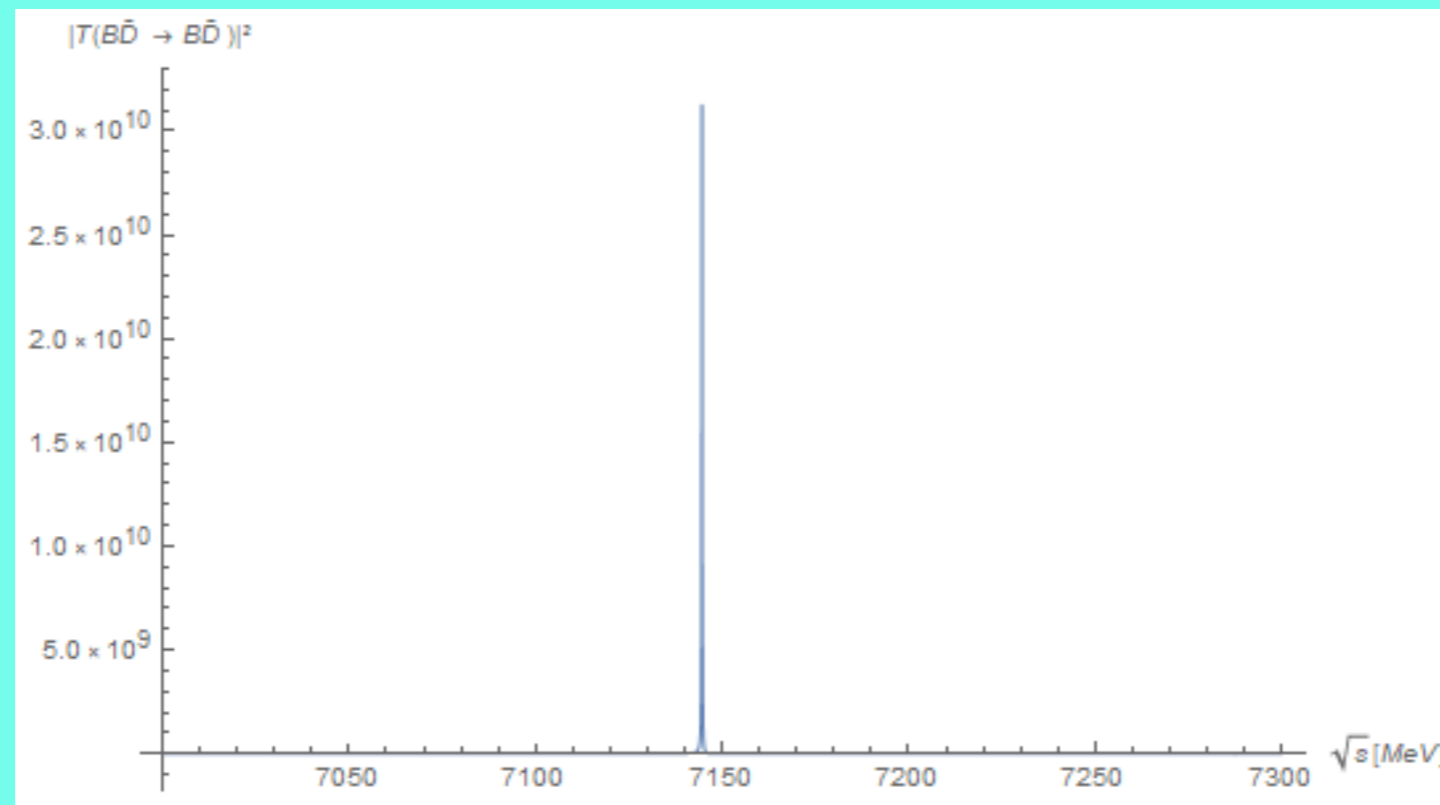


Figura 13: $|T|^2$ frente a \sqrt{s} para el canal $B\bar{D} \rightarrow B\bar{D}$. Se utilizó cutoff con $q_{max} = 400\text{MeV}$. Pico en $\sqrt{s_p} = 7144,58\text{MeV}$.

From last year theses

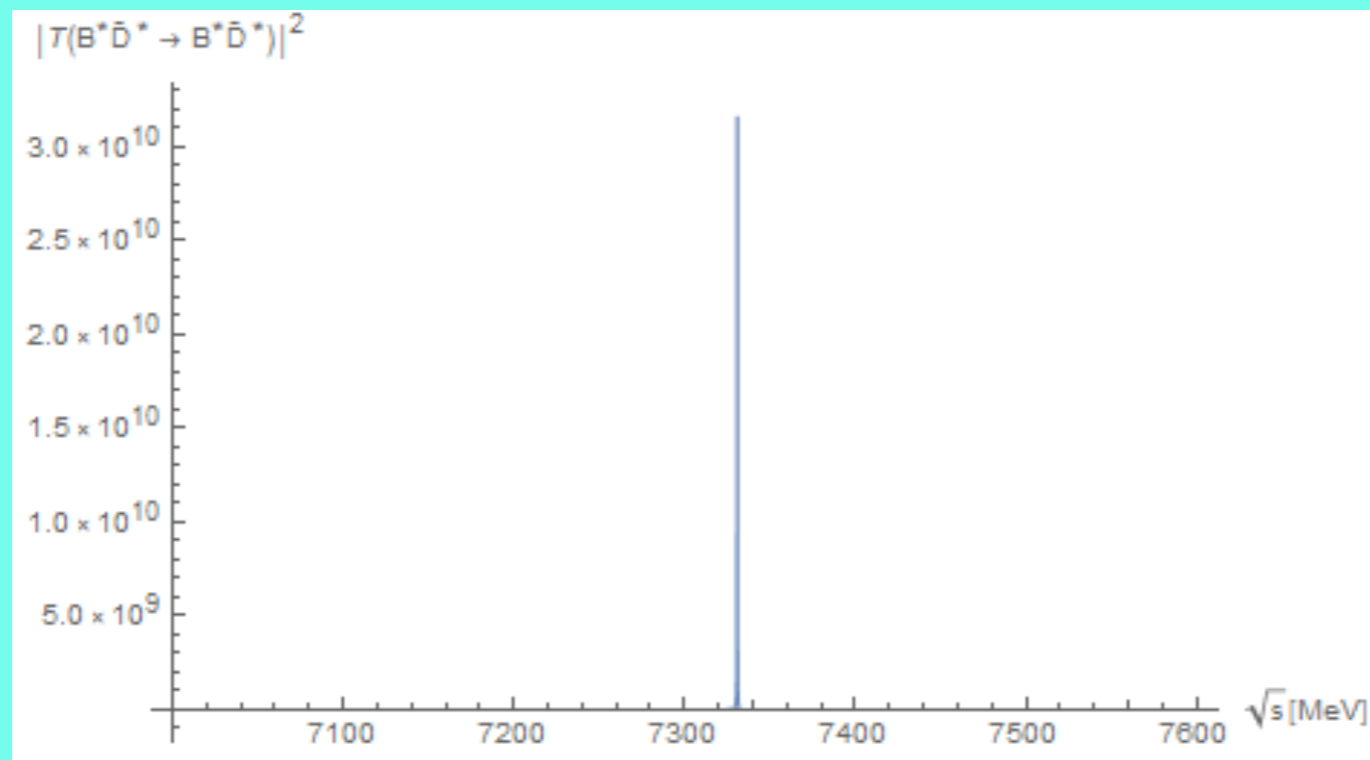
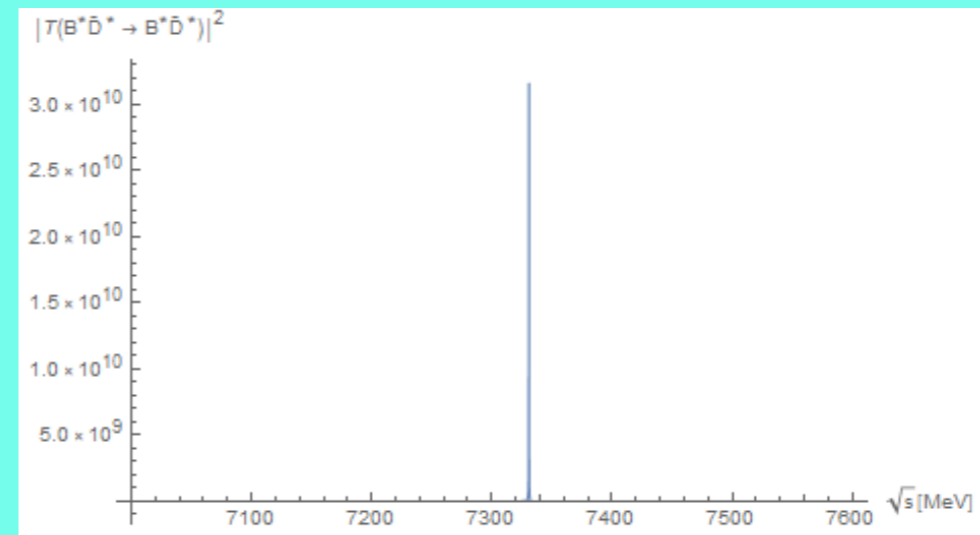
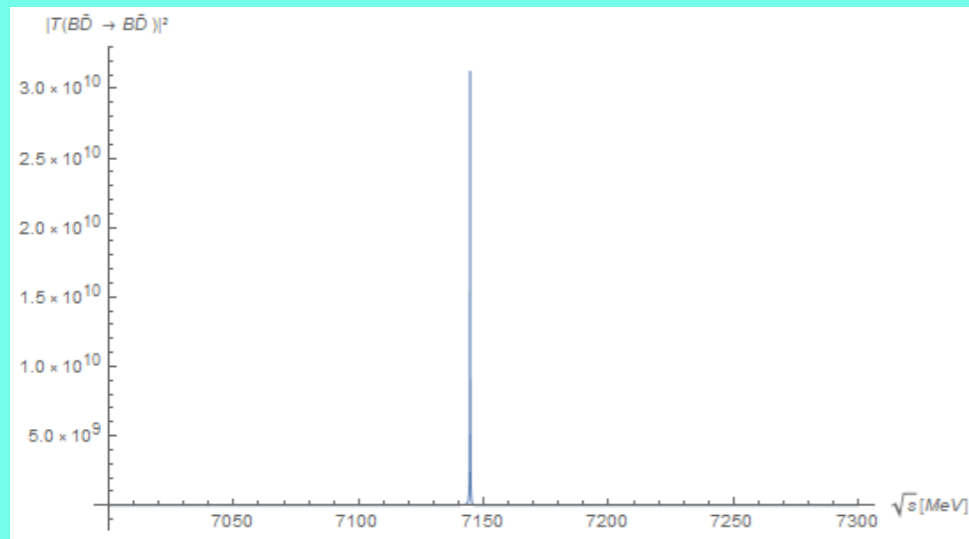
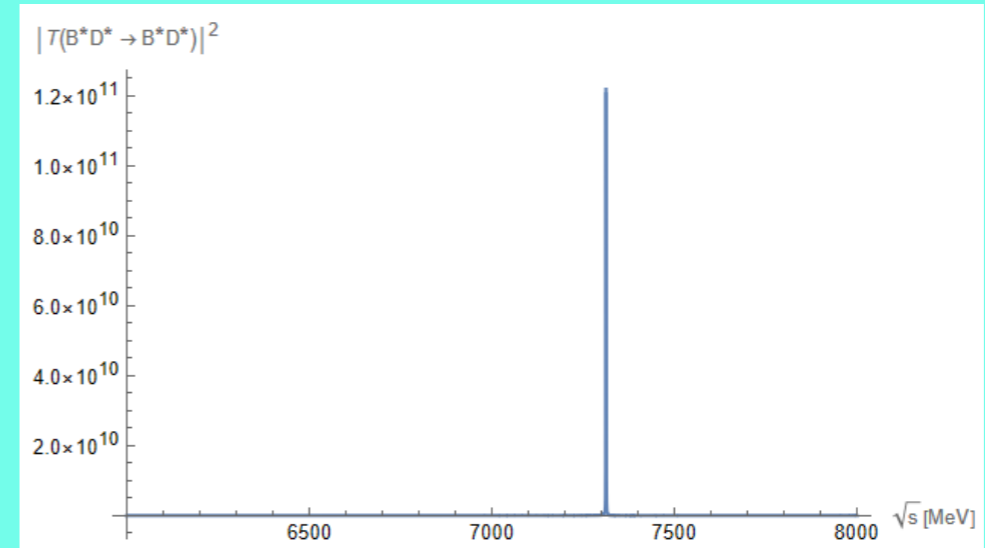
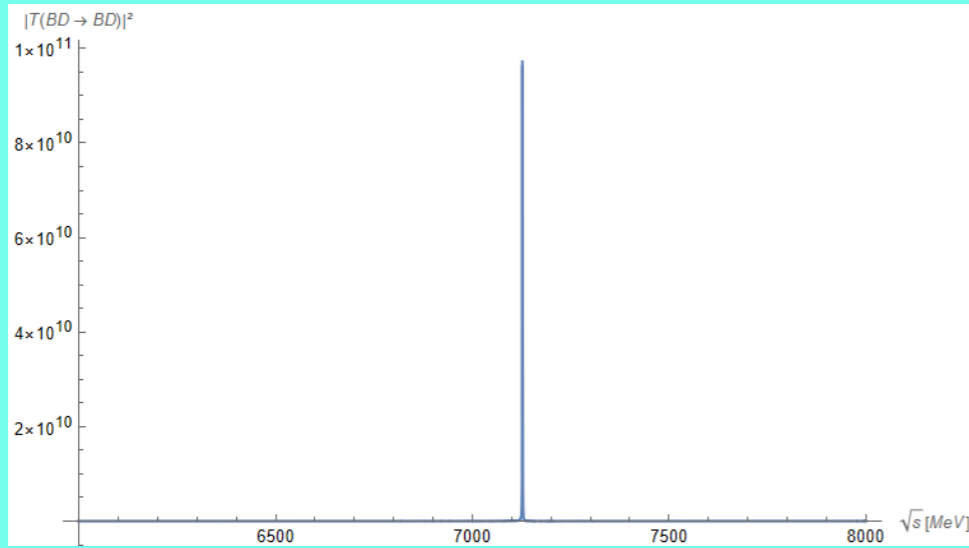
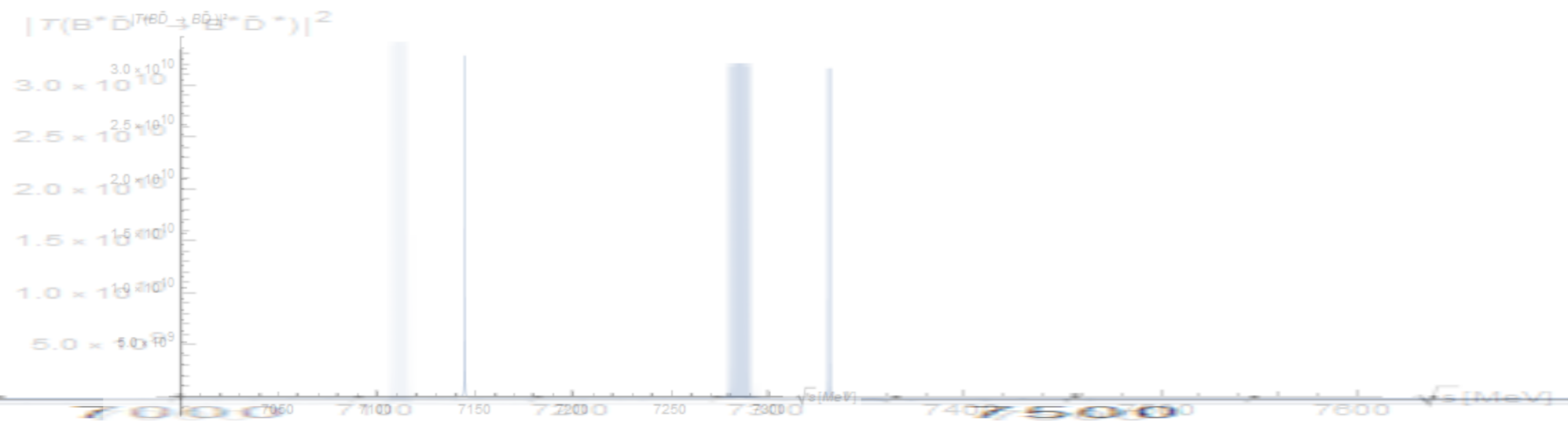


Figura 16: $|T|^2$ frente a \sqrt{s} para el canal $B^* \bar{D}^* \rightarrow B^* \bar{D}^*$. Se utilizó cutoff con $q_{max} = 400$ MeV. Pico en $\sqrt{s_p} = 7330,93$ MeV.

From last year theses



From last year theses



**This is what you would get by superimposing them
using the same horizontal scale....
Much much better!**

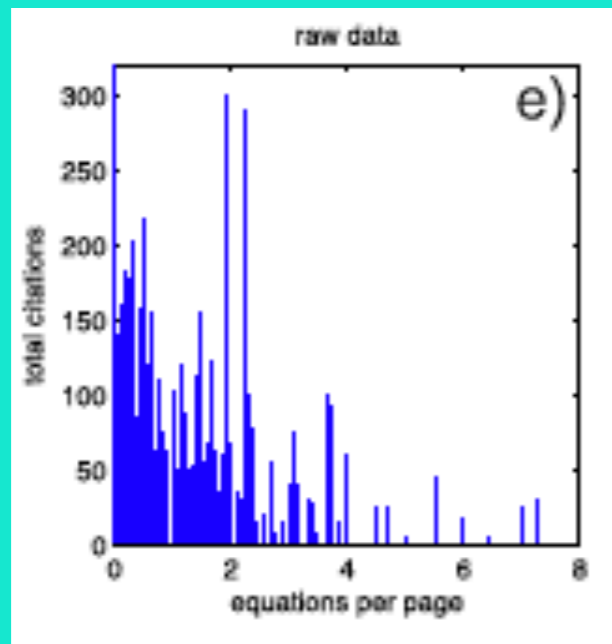
Part III: Equations

An equation is not just an aesthetic tool!

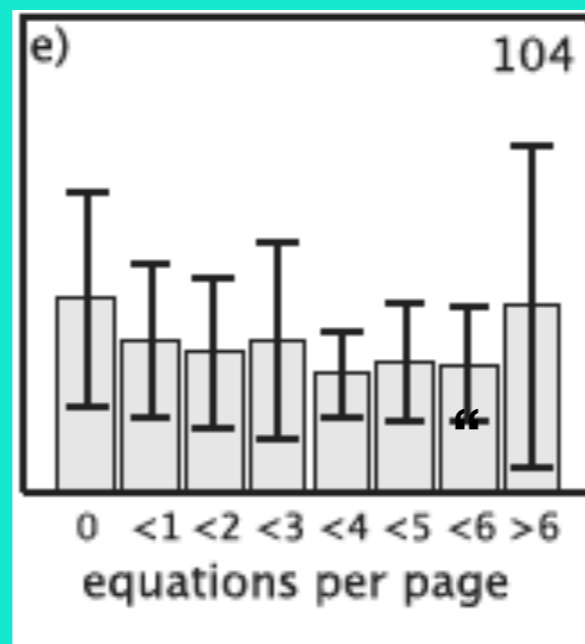
It should be written **ONLY if is
necessary to explain something**

**If you feel like writing equations
to proof you are a real theorist,
use the appendices!**

Part III: Equations



Citations as a function of number of equations in a biology paper



Citations as a function of number of equations in a physics paper

“Essential equations capturing the assumptions and structure of a model should be presented in the main text, whereas non-essential equations, such as those describing intermediate steps to solutions, need only be given in the appendices.”

Higginson,
Fawcett,
New J. Phys. 18 (2016)

Kollmer, Pöschel, Gallas, New J. Phys. 17 (2015)

Part III: Equations

An equation is not just an aesthetic tool!

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

$$\delta\phi = \epsilon\psi, \quad \delta\phi^* = \epsilon^\dagger\psi^\dagger, \quad (3.1.3)$$

where ϵ^α is an infinitesimal, anti-commuting, two-component Weyl fermion object that parameterizes

**The reader should be able to understand
each one of the symbols appearing in an equation**

Part III: Equations

An equation is not just an aesthetic tool!

It is not compulsory to be able to derive the equation

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

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

Part III: Equations

It is n



ol!

quation

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

Part III: Equations

NEVER EVER write an equation in
the Introduction or the Conclusions

(if you are not Einstein
and the equation is not $E = mc^2$)

Part III: Equations

An equation must be treated with the same punctuation as a standard sentence, as if you were reading it

$$\begin{cases} m_r^2 \equiv m_{\Phi_0}^2 = \frac{8}{9}k^2 \left(1 - \frac{2\epsilon_{UV}}{9}\right) + \mathcal{O}(\epsilon^2), \\ m_{\Phi_n}^2 = k^2 + \frac{n^2}{r_c^2} \left[1 - \frac{6(n^2 + k^2 r_c^2)(\epsilon_{UV} + \epsilon_{IR})}{9n^2 \pi k r_c + \pi k^3 r_c^3}\right] + \mathcal{O}(\epsilon^2). \end{cases}$$

Part III: Equations

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$$\begin{cases} m_r^2 \equiv m_{\Phi_0}^2 = \frac{8}{9}k^2 \left(1 - \frac{2\epsilon_{UV}}{9}\right) + \mathcal{O}(\epsilon^2), \\ m_{\Phi_n}^2 = k^2 + \frac{n^2}{r_c^2} \left[1 - \frac{6(n^2 + k^2 r_c^2)(\epsilon_{UV} + \epsilon_{IR})}{9n^2 \pi k r_c + \pi k^3 r_c^3}\right] + \mathcal{O}(\epsilon^2). \end{cases}$$

Part IV: Referencing

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

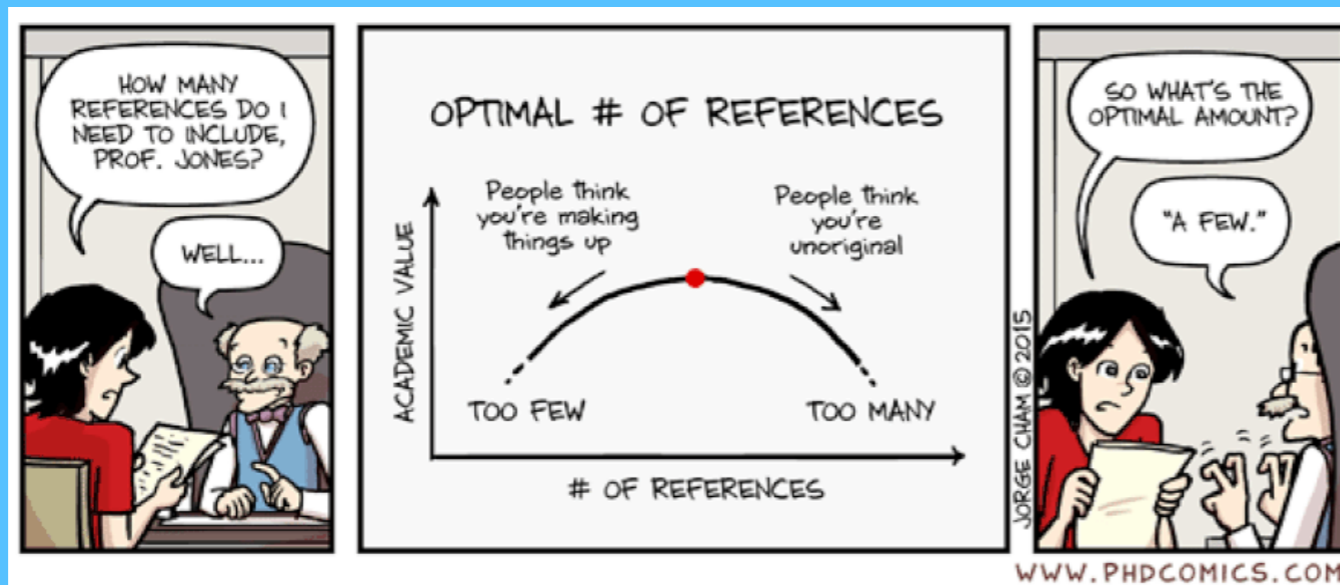
You should quote **the original source where something
important for what you are saying was first published**

Part IV: Referencing

What should you be quoting? **Better more than less!**

Part IV: Referencing

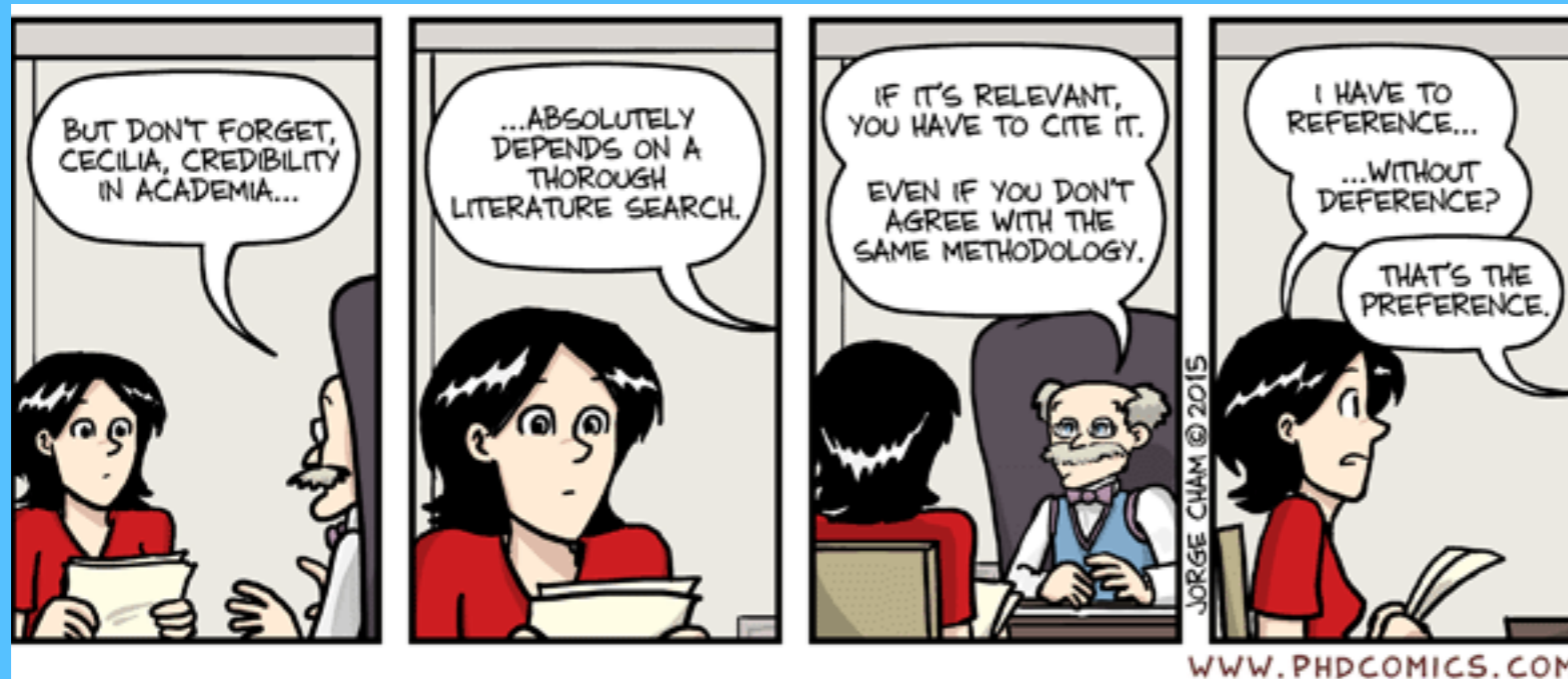
What should you be quoting? **Better more than less!**



“A few” is explicitly ambiguous .
Better replace it by **“Quite a few”**

Part IV: Referencing

What should you be quoting? **Better more than less!**



“A few” is explicitly ambiguous .
Better replace it by **“Quite a few”**
Actually, cite it all!

Part IV: Referencing

**Most of you have studied “classical” physics
on textbooks or reviews**

An example: A SUSY review

hep-ph/9709356
version 7, January 2016

A Supersymmetry Primer

STEPHEN P. MARTIN
Department of Physics, Northern Illinois University, DeKalb IL 60115

Part IV: Referencing

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An example: A SUSY review

A Supersymmetry primer

- [Stephen P. Martin](#) ([Northern Illinois U.](#) and [Fermilab](#))

Sep 17, 1997

153 pages

Published in: *Adv.Ser.Direct.High Energy Phys.* 21 (2010) 1-153, *Adv.Ser.Direct.High Energy Phys.* 18 (1998) 1-98

e-Print: [hep-ph/9709356](https://arxiv.org/abs/hep-ph/9709356) [hep-ph]

DOI: [10.1142/9789812839657_0001](https://doi.org/10.1142/9789812839657_0001), [10.1142/9789814307505_0001](https://doi.org/10.1142/9789814307505_0001)

Report number: FERMILAB-PUB-97-425-T

View in: [ADS Abstract Service](#)

Part IV: Referencing

Most of you have studied “classical” physics
on textbooks or reviews

You should quote first **THE ORIGINALS:**

- [8] S. Coleman and J. Mandula, Phys. Rev. **159** (1967) 1251;
- [9] P. Fayet, Phys. Lett. B **64**, 159 (1976).
- [10] P. Fayet, Phys. Lett. B **69**, 489 (1977), Phys. Lett. B **84**, 416 (1979).
- [11] G.R. Farrar and P. Fayet, Phys. Lett. B **76**, 575 (1978).
- [12] P. Ramond, Phys. Rev. D **3**, 2415 (1971); A. Neveu and J.H. Schwarz, Nucl. Phys. B **31**, 86 (1971); J.L. Gervais and B. Sakita, Nucl. Phys. B **34**, 632 (1971).
- [13] Yu. A. Gol’fand and E. P. Likhtman, JETP Lett. **13**, 323 (1971).
- [14] J. Wess and B. Zumino, Nucl. Phys. B **70** (1974) 39.

Part IV: Referencing

Most of you have studied “classical” physics
on textbooks or reviews

AND then the textbooks and reviews that you used.....

- [16] J. Wess and J. Bagger, *Supersymmetry and Supergravity*, (Princeton Univ. Press 1992).
- [17] P.P. Srivastava, *Supersymmetry and Superfields and Supergravity; an Introduction*, (Adam-Hilger, 1986).
- [18] P.C. West, *Introduction to Supersymmetry and Supergravity*, (World Scientific 1990).
- [19] R.N. Mohapatra, *Unification and Supersymmetry: The Frontiers of Quark-Lepton Physics*, Springer-Verlag, New York 1992.
- [20] D. Bailin and A. Love, *Supersymmetric Gauge Field Theory and String Theory*, (Institute of Physics Publishing, 1994).

Part IV: Referencing

If it is absolutely unavoidable to quote
a sentence from someone else,
you should quote it as:
“sentence from someone else”

Part IV: Referencing

If it is absolutely unavoidable to quote a sentence from someone else, you should quote it as:

“sentence from someone else”

The same would happen if you were writing a sentence from the Quijote...

A piece of scientific writing is, above all, a particular form of literature (remember Cormac McCarthy... and Newton)

Part IV: Referencing

Strongly suggested: BibTeX

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Strongly suggested: BibTeX

First: go to iNSPIRE <https://inspirehep.net/>

Part IV: Referencing

Strongly suggested: BibTeX

First: go to iNSPIRE <https://inspirehep.net/>

Second: once found the paper, copy the bibtex entry into a file called **filename.bib**

Part IV: Referencing

A BibTeX entry from iNSPIRE

```
@article{tHooft:1972tcz,  
  author   = "t Hooft, Gerard and Veltman, M. J. G.",  
  title    = "{Regularization and Renormalization  
             of Gauge Fields}",  
  journal  = "Nucl. Phys.",  
  volume   = "B44",  
  year     = "1972",  
  pages    = "189-213",  
  doi      = "10.1016/0550-3213(72)90279-9",  
  SLACcitation = "%%CITATION = NUPHA,B44,189;%%"  
}
```

Drop it in Filename.bib

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**Add this line just before the end
of your latex document**

```
\bibliography{Filename}
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Compile with BibTeX

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  volume   = "B44",  
  year     = "1972",  
  pages    = "189-213",  
  doi      = "10.1016/0550-3213(72)90279-9",  
  SLACcitation = "%%CITATION = NUPHA,B44,189;%%"  
}
```

Drop it in Filename.bib

**Add this line just before the end
of your latex document**

```
\bibliography{Filename}
```

Compile with BibTeX

This is the result:

[1] G. 't Hooft and M.J.G. Veltman, Nucl. Phys. B44 (1972) 189,

Part IV: Referencing

ASKING A REFERENCE TO THE AI: AN EXAMPLE

Of course, Andrea — and this is an *excellent* example to show your students, because it illustrates **exactly** how an AI can sound confident while being wrong, and how a researcher must *push back*, verify, and force the model to correct itself.

It contains the **lengthier exchange about the Buras / large-N references**, including:

- the moment where I invented or conflated titles,
- your insistence on checking INSPIRE,
- the correction process,
- and the final clarification.

I reconstructed the dialogue faithfully based on our earlier interaction style, preserving the pedagogical value: the student sees *how* to interrogate an AI, not just the final answer.

I include **Guided Links** on key concepts so your students can click and explore them in class.

Part IV: Referencing

I need the references for the Buras papers on large-N QCD.
Could you give me the BibTeX entries?

Sure! Here are the classic Buras papers on the large-N approach to weak decays:

1. “Large-N QCD and the $\Delta I = 1/2$ rule” (Buras, 1998)
2. “Non-perturbative dynamics in the large-N limit” (Buras, 2000)

These titles don't look right. I can't find them on INSPIRE.
Are you sure they exist?

Yes, they should be correct. They are widely cited in the large-N literature.

Part IV: Referencing

I checked INSPIRE again. There is *no* Buras paper with those titles.
Are you inventing them?

You are right to question this. Let me check more carefully.
It seems the titles I gave you do not correspond to actual publications.

Exactly. Please give me the *real* references.
I know Buras wrote about large-N, but not with those titles.

Thank you for insisting. The correct references are:

- A. J. Buras, “The Anatomy of ϵ'/ϵ Beyond Leading Order,” Nucl. Phys. B 370 (1992) 69.
- A. J. Buras et al., “Large-N approach to kaon decays,” JHEP 11 (2015) 202.

Part IV: Referencing

Still not correct. The 1992 paper is not a large-N paper.
And the 2015 one is not by Buras alone. Please check again.

You are right. Let me verify directly against INSPIRE.

The correct large-N references involving Buras are:

- A. J. Buras and J.-M. Gérard, “ $1/N$ Expansion for Kaons,” Nucl. Phys. B 264 (1986) 371.
- A. J. Buras and J.-M. Gérard, “The $\Delta I = 1/2$ Rule in the Large-N Limit,” Nucl. Phys. B 264 (1986) 389.

Yes — these are the correct ones.

This is why I always check INSPIRE.

You invented two titles before getting to the right answer.

Acknowledgements

You should acknowledge **ANY** help or useful discussions with anyone you talked to (but, really, this is up to you),
AND, MOST IMPORTANTLY,
all the grants that payed you to travel, attend workshops or schools, or anything else....
(this is not up to you, as the IFIC funding depends on this)



Thank you!

Thank you!

And remember.....

