

A charming exploration of a t-channel model of dark matter

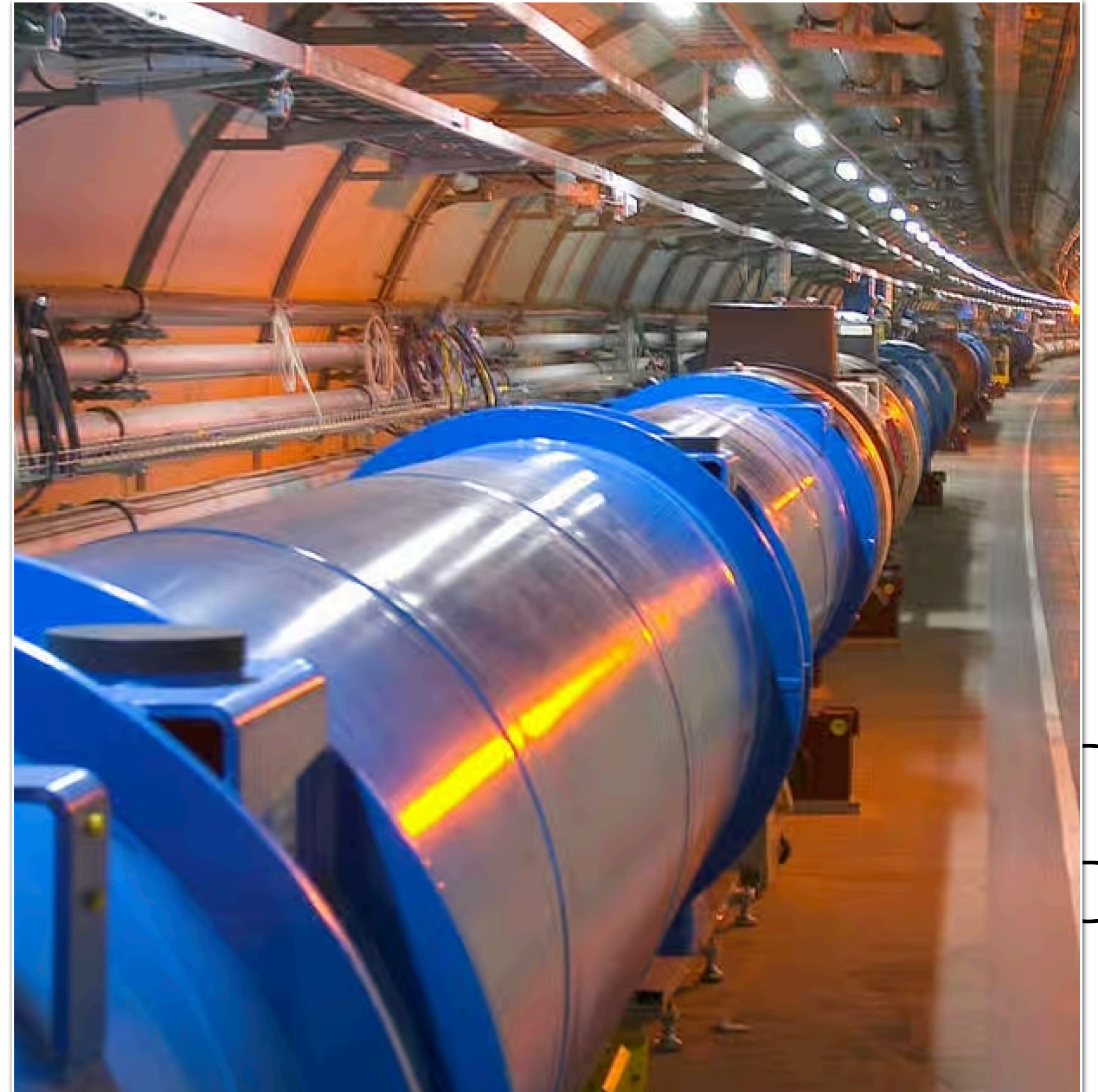
Internship supervisor : Benjamin Fuks

Léandre Munoz



Plan

- Introduction
 - The standard model and beyond
 - Our model of study
 - The numerical tools
- Exclusion diagrams
- Observables and errorbars
- Conclusion



... and beyond?

	masse →	charge →	spin →					
QUARKS	$\approx 2.3 \text{ MeV}/c^2$	$2/3$	$1/2$	u up	$\approx 1.275 \text{ GeV}/c^2$	$2/3$	$1/2$	c charm
					$\approx 173.07 \text{ GeV}/c^2$	$2/3$	$1/2$	t top
					0	0	1	g gluon
					$\approx 126 \text{ GeV}/c^2$	0	0	H boson de Higgs
					$\approx 4.8 \text{ MeV}/c^2$	$-1/3$	$1/2$	d down
					$\approx 95 \text{ MeV}/c^2$	$-1/3$	$1/2$	s strange
LEPTONS					$\approx 4.18 \text{ GeV}/c^2$	$-1/3$	$1/2$	b bottom
					0	0	1	γ photon
					$0.511 \text{ MeV}/c^2$	-1	$1/2$	e électron
					$105.7 \text{ MeV}/c^2$	-1	$1/2$	μ muon
					$1.777 \text{ GeV}/c^2$	-1	$1/2$	τ tau
					$91.2 \text{ GeV}/c^2$	0	1	Z^0 boson Z^0
				$< 2.2 \text{ eV}/c^2$	0	$1/2$	ν_e neutrino électronique	
				$< 0.17 \text{ MeV}/c^2$	0	$1/2$	ν_μ neutrino muonique	
				$< 15.5 \text{ MeV}/c^2$	0	$1/2$	ν_τ neutrino tauique	
				$80.4 \text{ GeV}/c^2$	± 1	1	W^\pm boson W^\pm	

The succes

Discovery of W and Z bosons, gluons and top/bottom quarks

...

... and beyond?

	<p>masse → $\approx 2.3 \text{ MeV}/c^2$</p> <p>charge → $2/3$</p> <p>spin → $1/2$</p> <p>u</p> <p>up</p>	<p>$\approx 1.275 \text{ GeV}/c^2$</p> <p>$2/3$</p> <p>$1/2$</p> <p>c</p> <p>charm</p>	<p>$\approx 173.07 \text{ GeV}/c^2$</p> <p>$2/3$</p> <p>$1/2$</p> <p>t</p> <p>top</p>	<p>0</p> <p>0</p> <p>1</p> <p>g</p> <p>gluon</p>	<p>$\approx 126 \text{ GeV}/c^2$</p> <p>0</p> <p>0</p> <p>H</p> <p>boson de Higgs</p>
QUARKS	<p>$\approx 4.8 \text{ MeV}/c^2$</p> <p>$-1/3$</p> <p>$1/2$</p> <p>d</p> <p>down</p>	<p>$\approx 95 \text{ MeV}/c^2$</p> <p>$-1/3$</p> <p>$1/2$</p> <p>s</p> <p>strange</p>	<p>$\approx 4.18 \text{ GeV}/c^2$</p> <p>$-1/3$</p> <p>$1/2$</p> <p>b</p> <p>bottom</p>	<p>0</p> <p>0</p> <p>1</p> <p>γ</p> <p>photon</p>	
	<p>$0.511 \text{ MeV}/c^2$</p> <p>-1</p> <p>$1/2$</p> <p>e</p> <p>électron</p>	<p>$105.7 \text{ MeV}/c^2$</p> <p>-1</p> <p>$1/2$</p> <p>μ</p> <p>muon</p>	<p>$1.777 \text{ GeV}/c^2$</p> <p>-1</p> <p>$1/2$</p> <p>τ</p> <p>tau</p>	<p>91.2 GeV/c^2</p> <p>0</p> <p>1</p> <p>Z^0</p> <p>boson Z^0</p>	<p>BOSONS DE JAUGE</p>
	<p>$< 2.2 \text{ eV}/c^2$</p> <p>0</p> <p>$1/2$</p> <p>ν_e</p> <p>neutrino électronique</p>	<p>$< 0.17 \text{ MeV}/c^2$</p> <p>0</p> <p>$1/2$</p> <p>ν_μ</p> <p>neutrino muonique</p>	<p>$< 15.5 \text{ MeV}/c^2$</p> <p>0</p> <p>$1/2$</p> <p>ν_τ</p> <p>neutrino tauique</p>		

The succes

Discovery of W and Z bosons, gluons and top/bottom quarks

...

The problems :

Neutrino masses

Hierarchy problem

No DM in the standard model

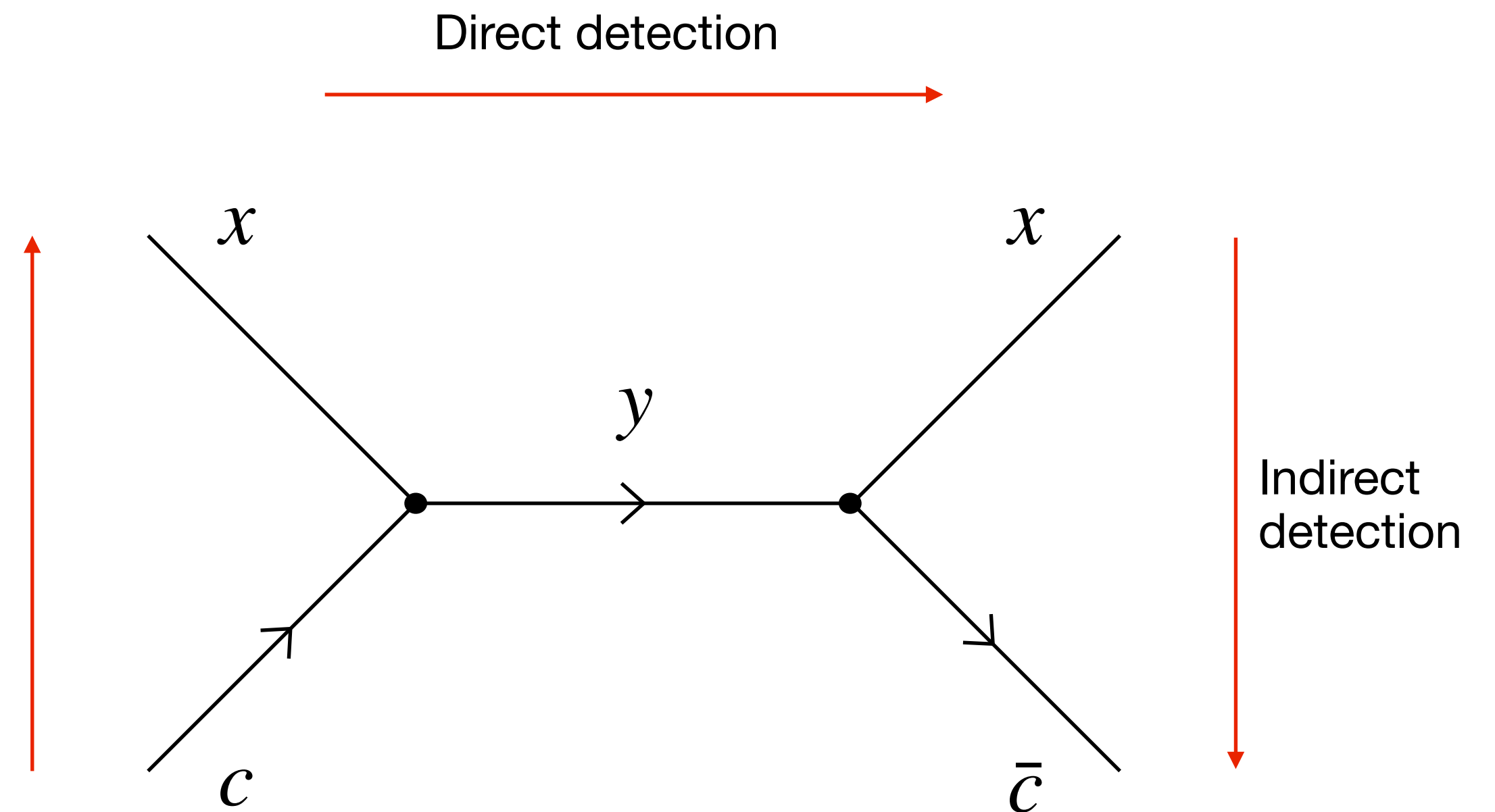
...

The dark matter

The detection methods

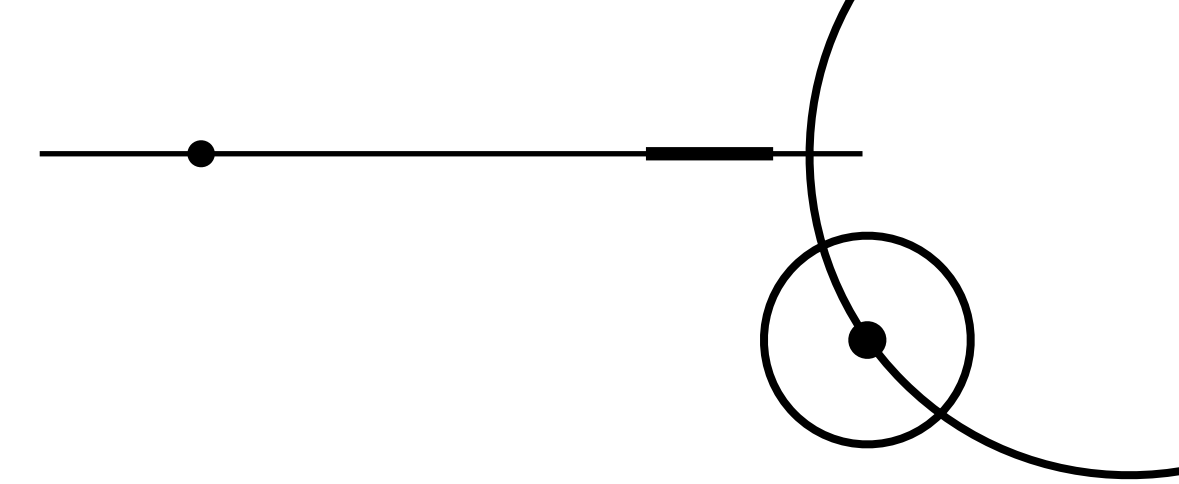
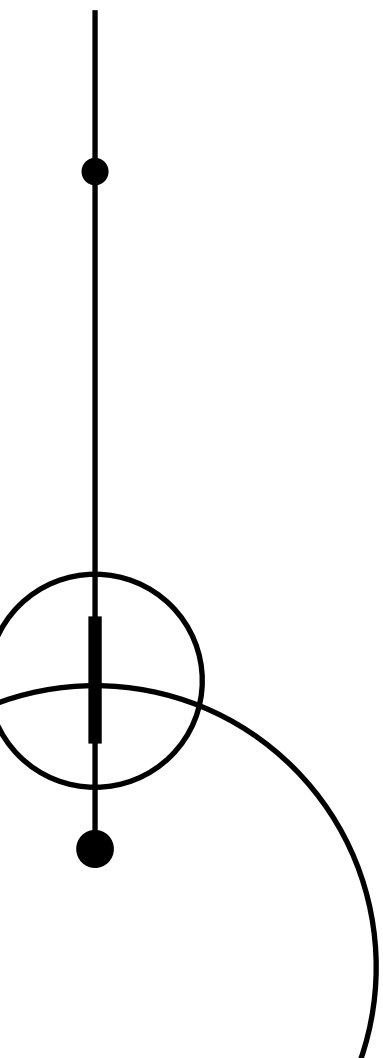
- Direct detection
- Indirect detection
- *Cosmology*
- Artificial creation
- *Accelerators / Collider*

Artificial
creation
(LHC)

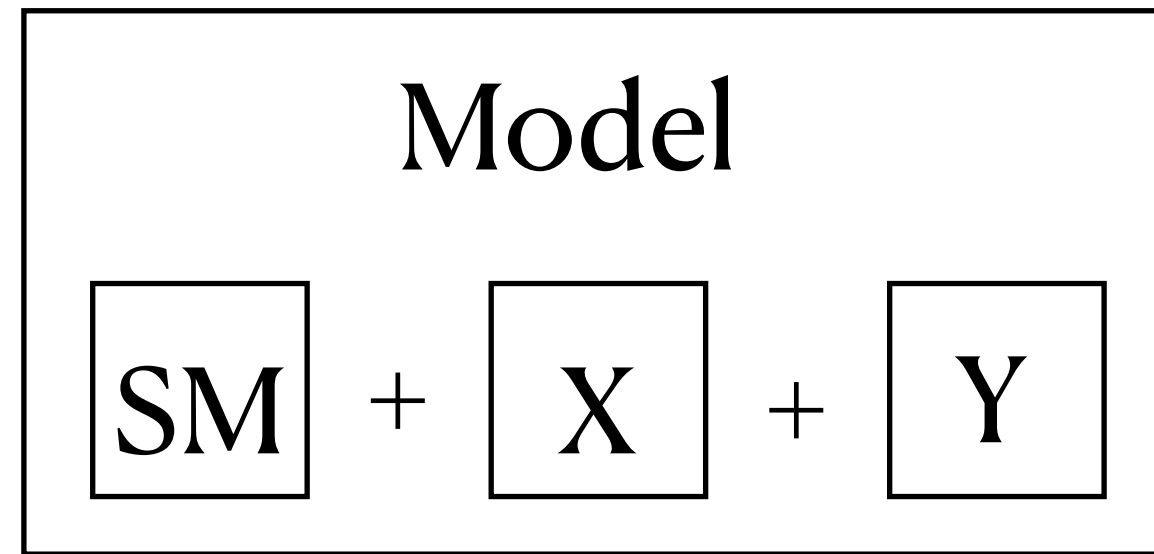
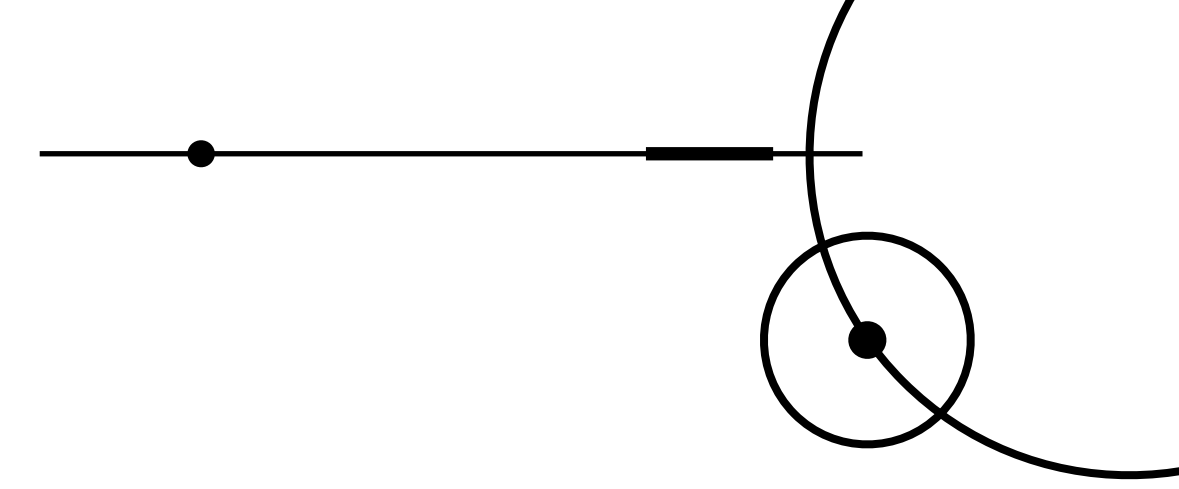


x : dark matter c : quark charm
 y : mediator \bar{c} : quark anticharm

Indirect
detection



Our model of dark matter



DMSimpt_NLO_v1_2_UFO-F3S_cr



DM : Dark matter

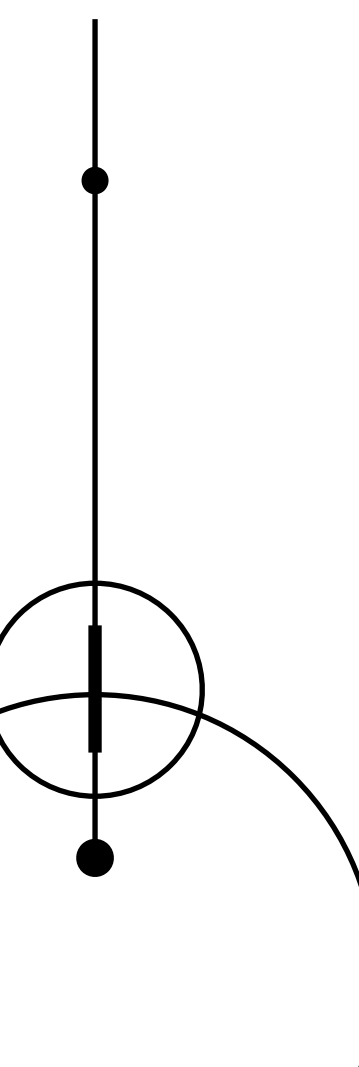
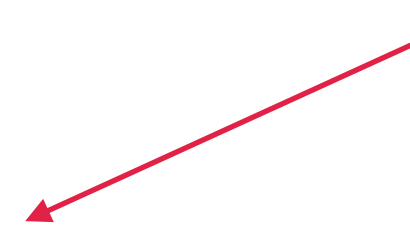
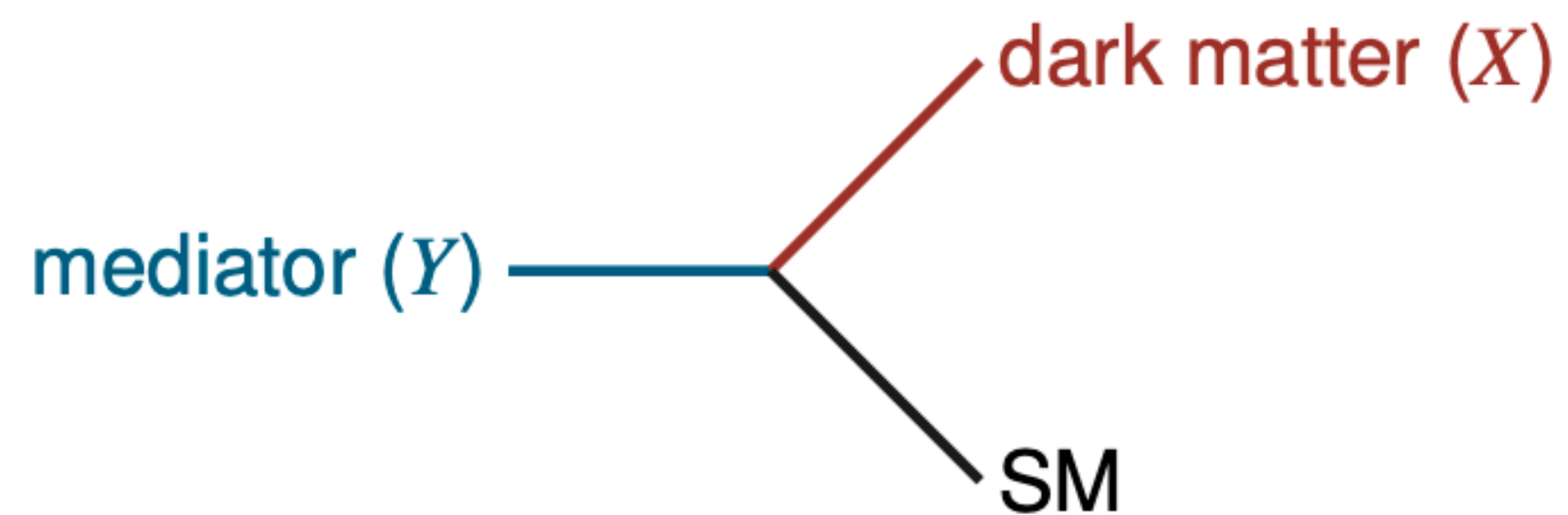
Simp : simplified

T : t-channel model

UFO : Universal Feynman Output

F3S : mediator is a fermion and dark matter a scalar

Cr : implies a charm quark



Our model of dark matter

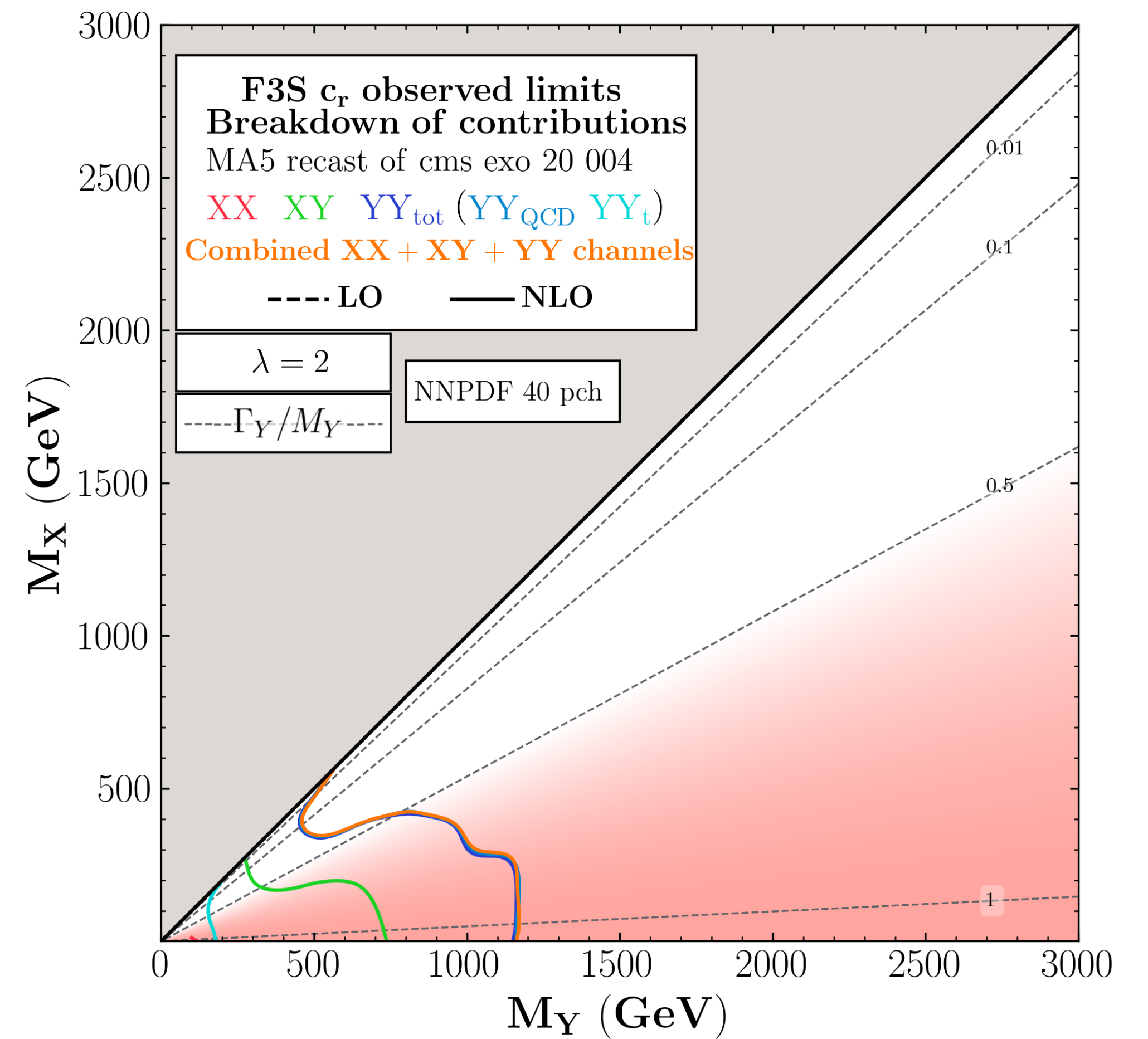
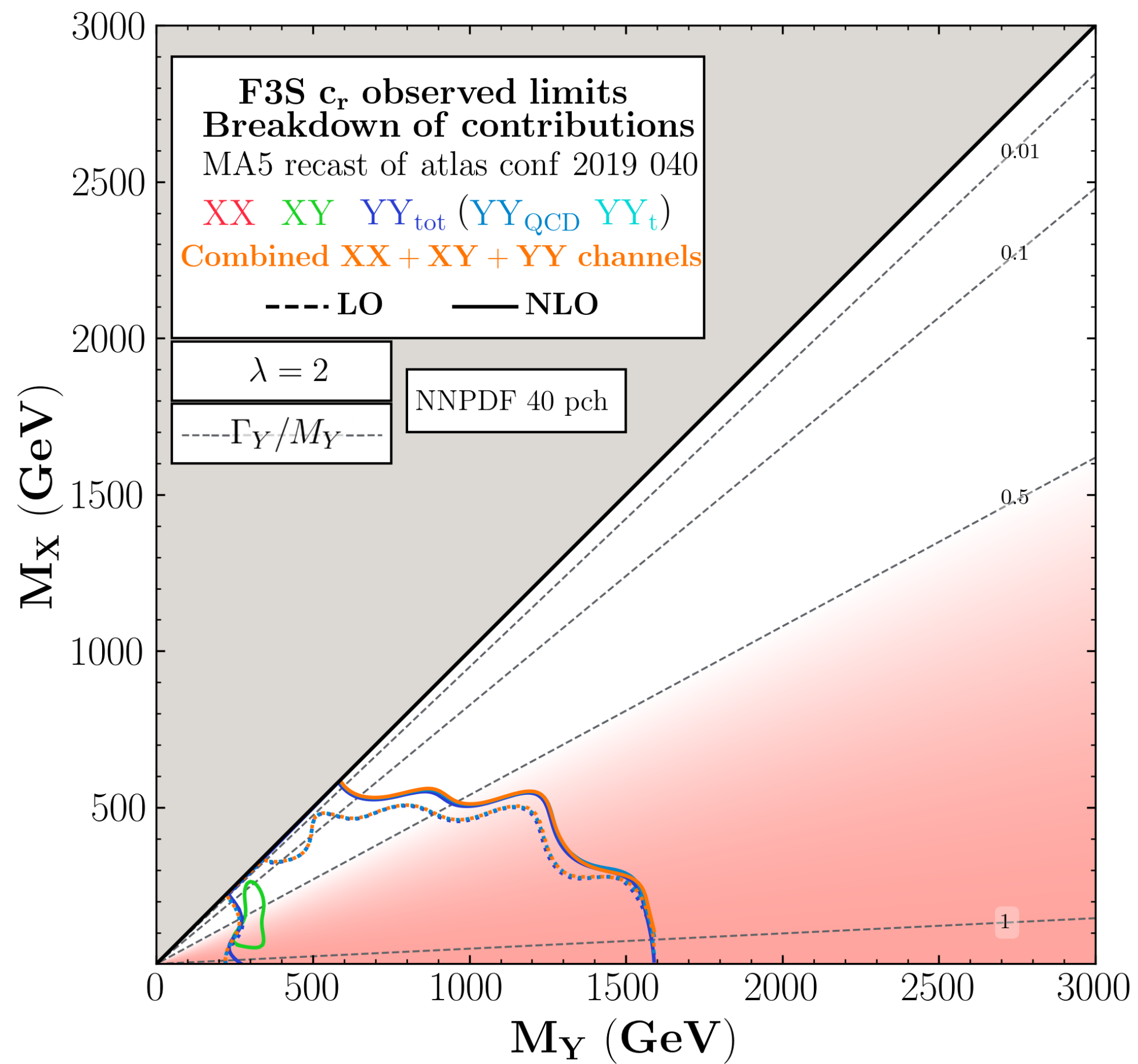
3 process :

		LO	NLO
XX :	$p p \longrightarrow x x$	<p>Diagram showing a quark q and an antiquark \bar{q} interacting via a Y boson (dashed blue line) to produce two X particles (red wavy lines).</p>	<p>Diagram showing a quark q and an antiquark \bar{q} interacting via a gluon g (curly black line) and a Y boson (dashed blue line) to produce two X particles (red wavy lines).</p>
XY :	$p p \longrightarrow x y$ ou $p p \longrightarrow x \bar{y}$	<p>Diagram showing a quark q and a gluon g interacting via a Y boson (dashed blue line) to produce an X particle (red wavy line) and a Y particle (dashed blue line).</p>	<p>Diagram showing a quark q and a gluon g interacting via a gluon g (curly black line) and a Y boson (dashed blue line) to produce an X particle (red wavy line) and a Y particle (dashed blue line).</p>
YY :	$p p \longrightarrow y \bar{y}$	<p>Diagram showing two gluons g interacting via a Y boson (dashed blue line) to produce a \bar{Y} particle (dashed blue line) and a Y particle (dashed blue line).</p>	<p>Diagram showing a quark q and a gluon g interacting via a gluon g (curly black line) and a Y boson (dashed blue line) to produce a \bar{Y} particle (dashed blue line) and a Y particle (dashed blue line).</p>

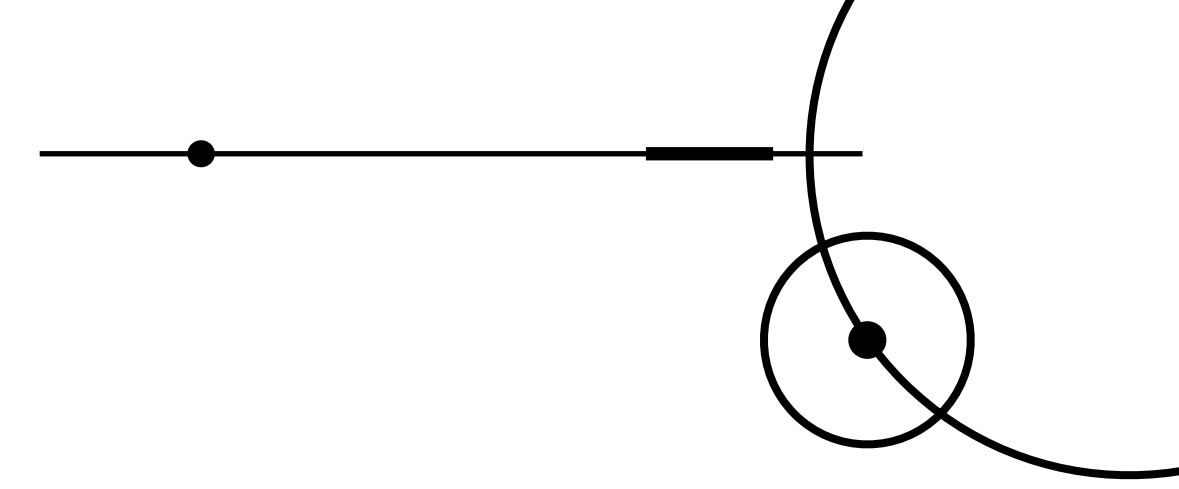
Exclusion diagrams

→ Two free parameters : the masses m_X and m_Y

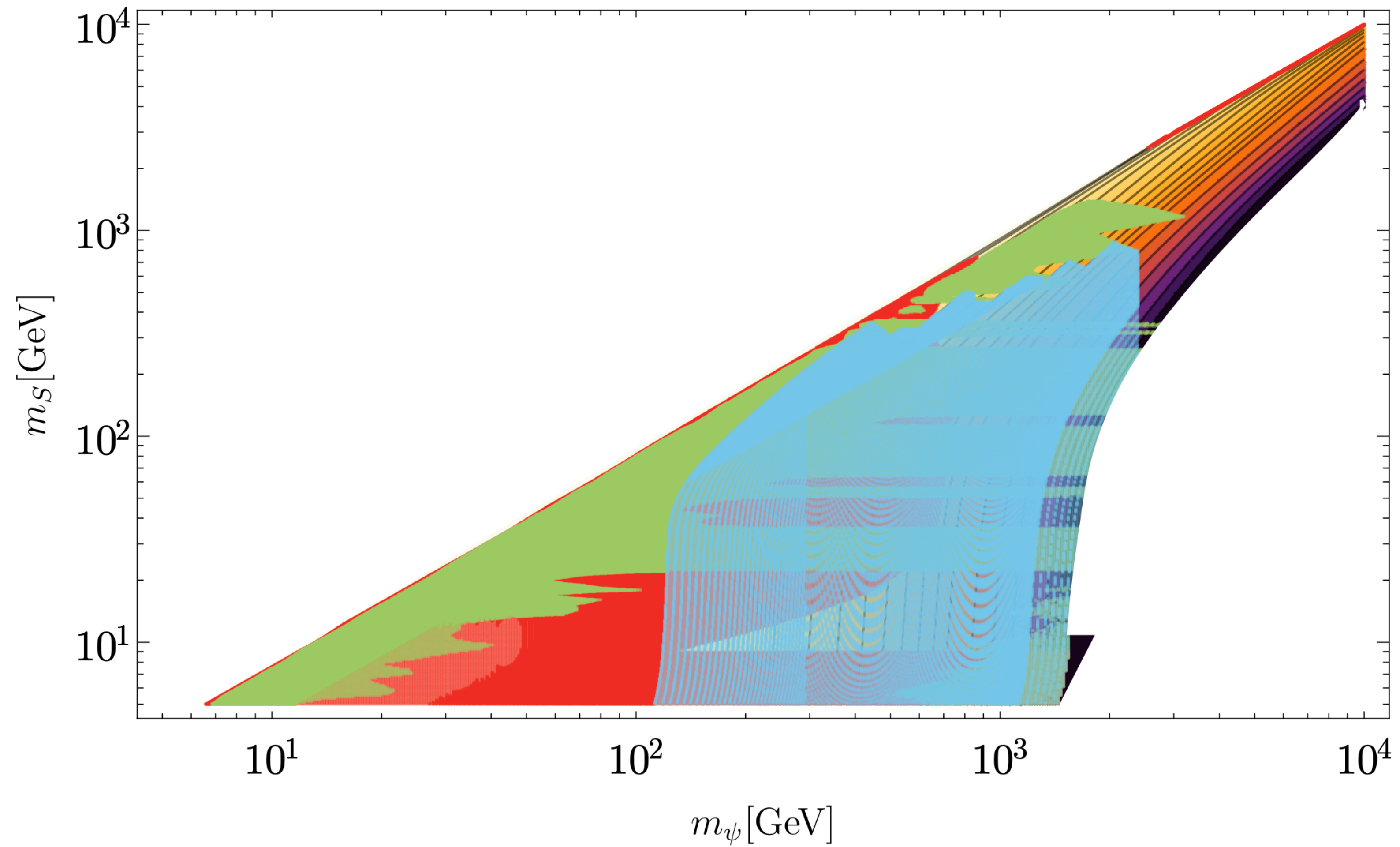
$$0 \leq \text{CLs}(m_X, m_Y) \leq 1$$



Exclusion diagrams



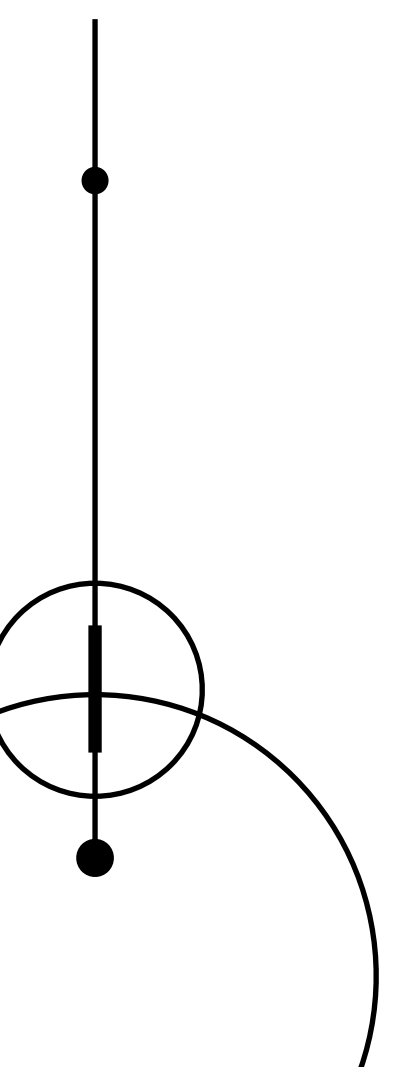
→ Sharing of results between accelerators and cosmology



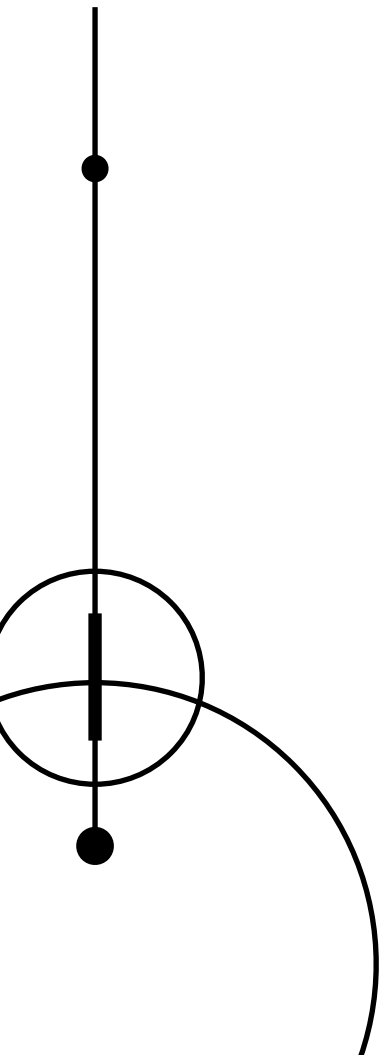
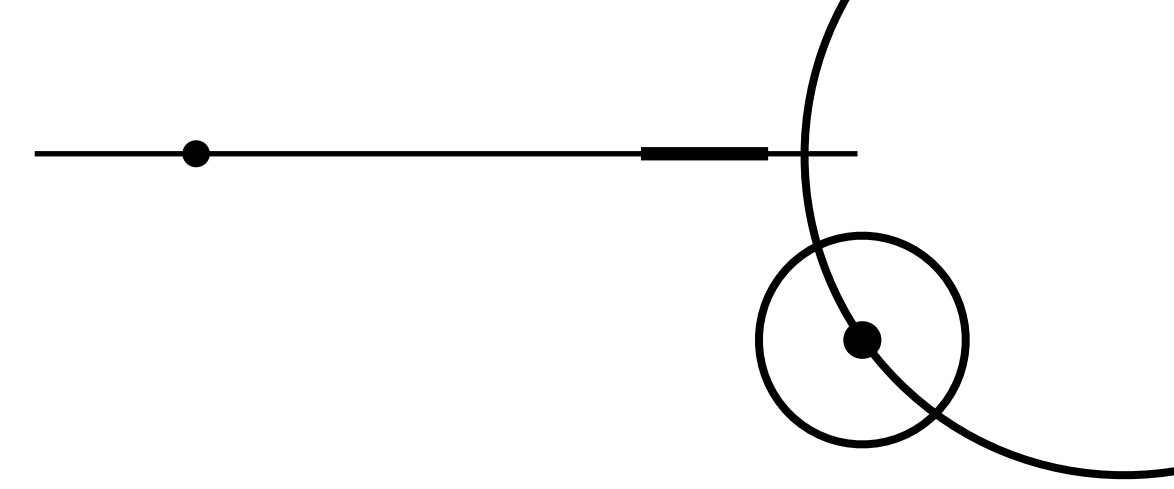
- Direct detection excluded
- Indirect detection excluded
- Collider excluded



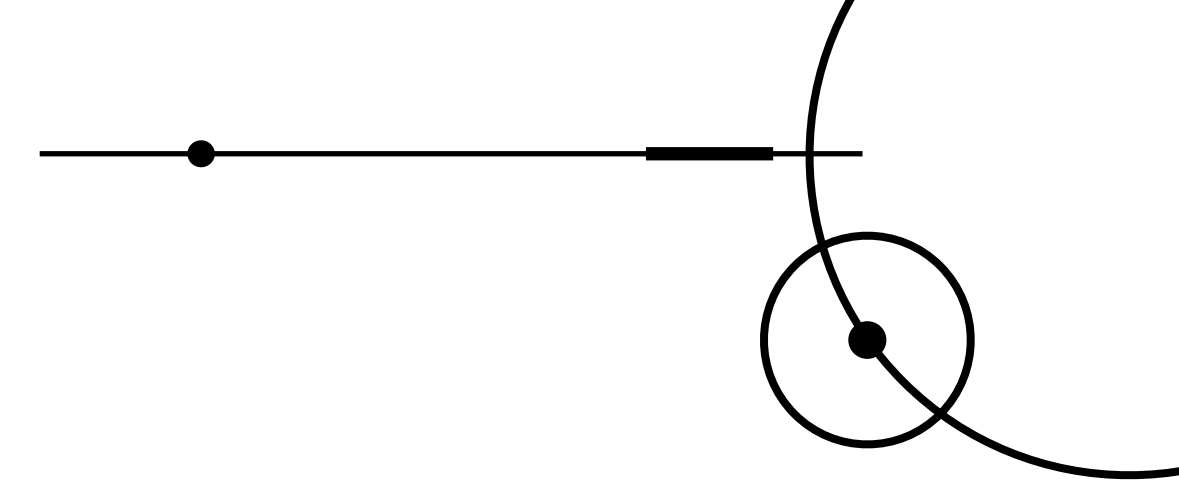
Simone Tentori



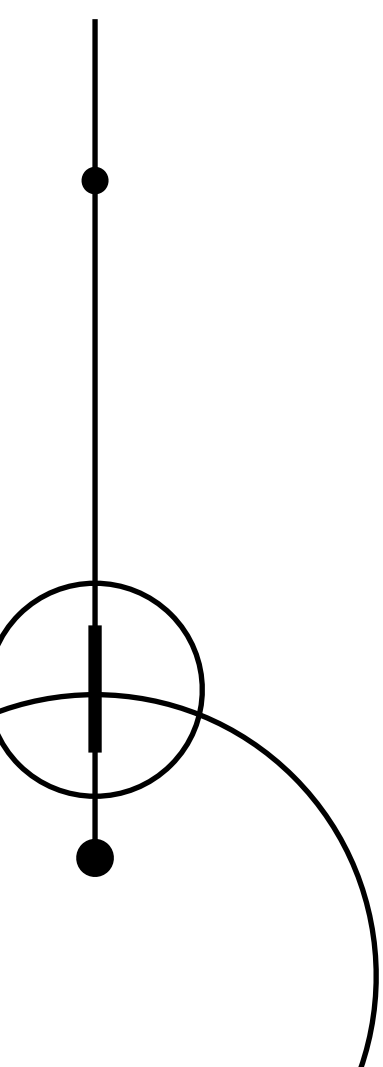
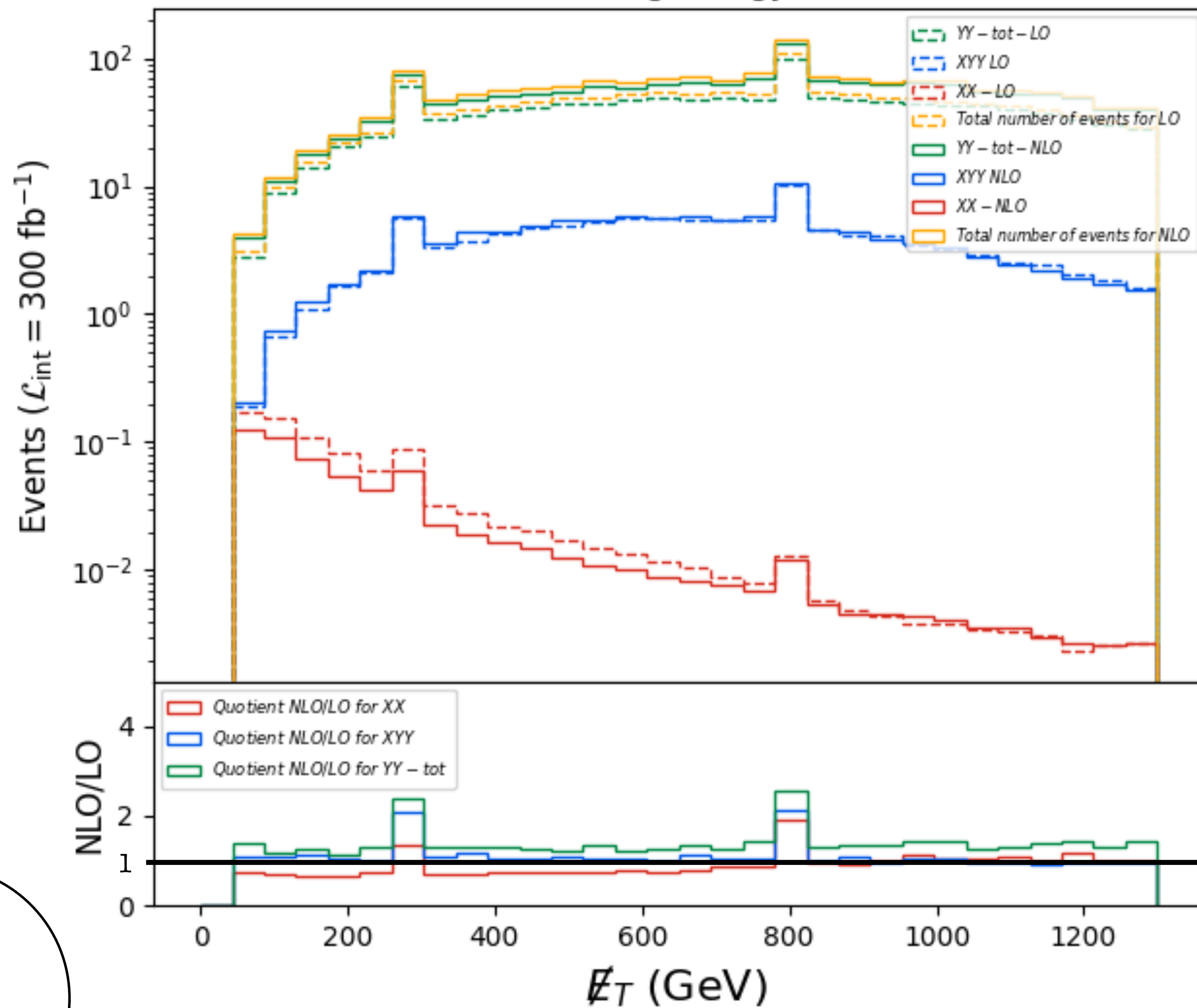
Observables and errorbars



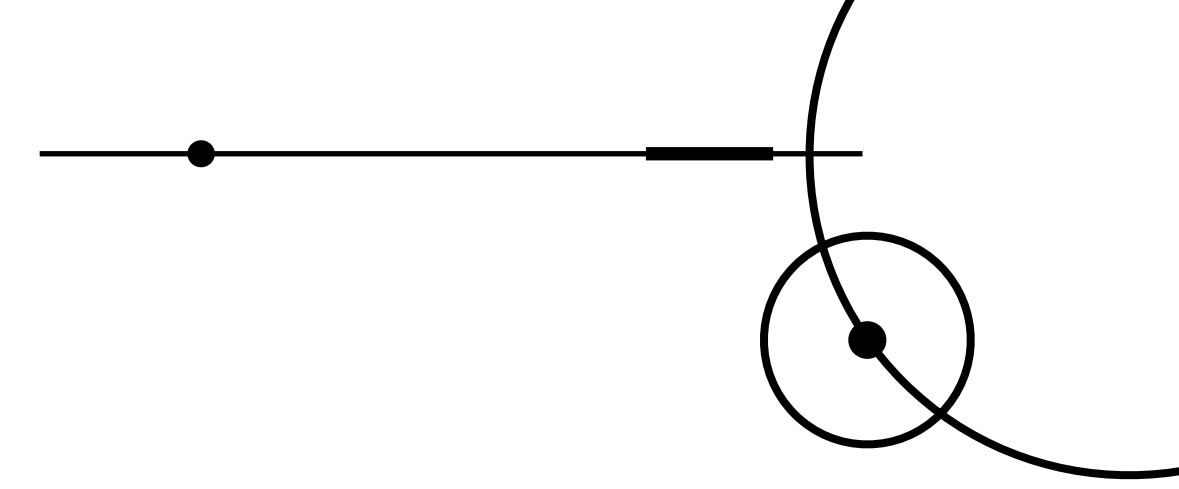
Observables and errorbars



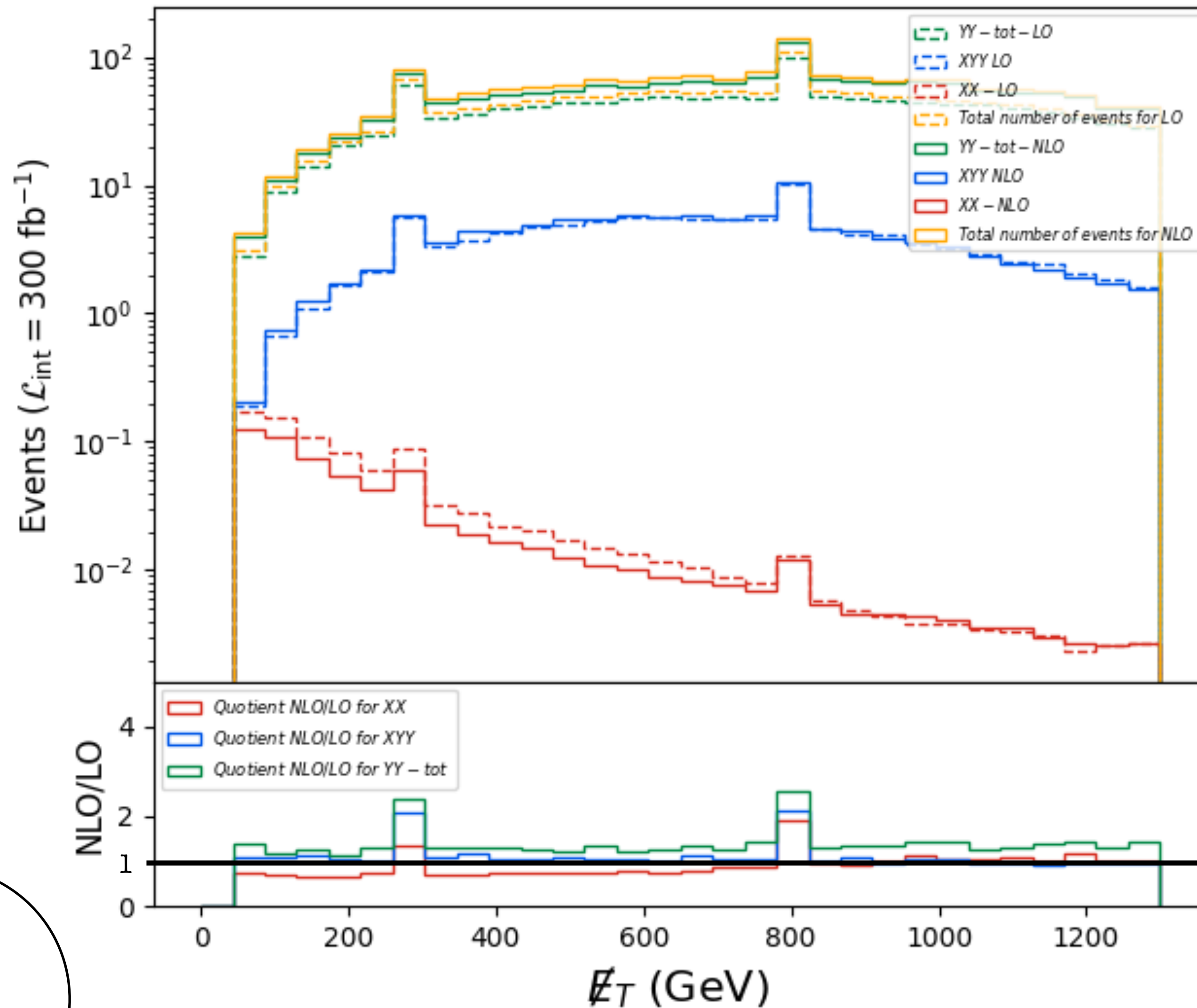
N. of events in function of missing energy for LO and NLO calculations



Observables and errorbars



N. of events in function of missing energy for LO and NLO calculations

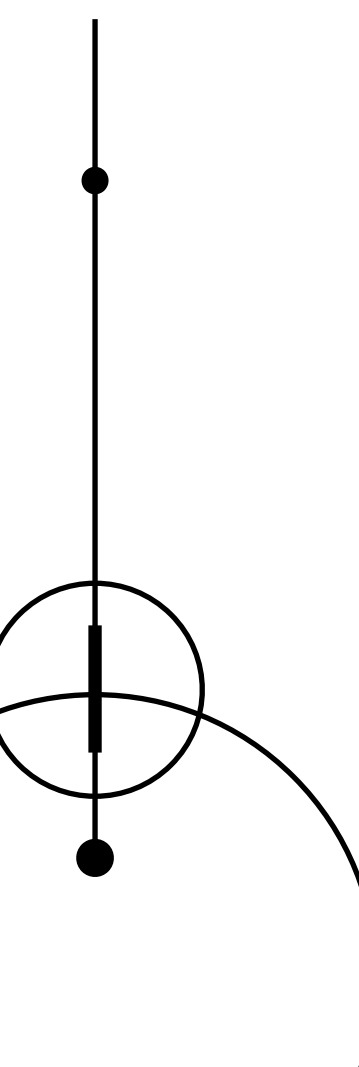


→ $M_X = 900 \text{ GeV}$

$M_Y = 1300 \text{ GeV}$

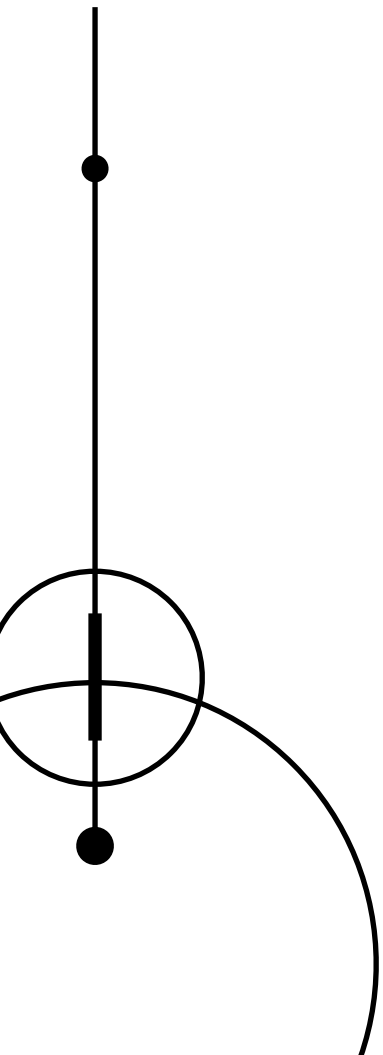
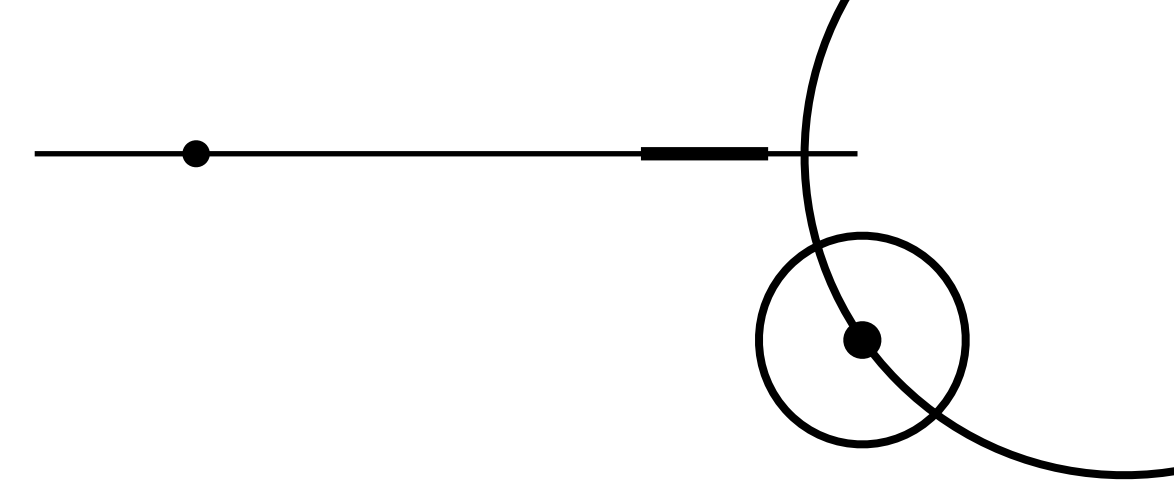
→ Some contributions are negligible

→ Importance of NLO



Observables and errorbars

→ Errorbars ?



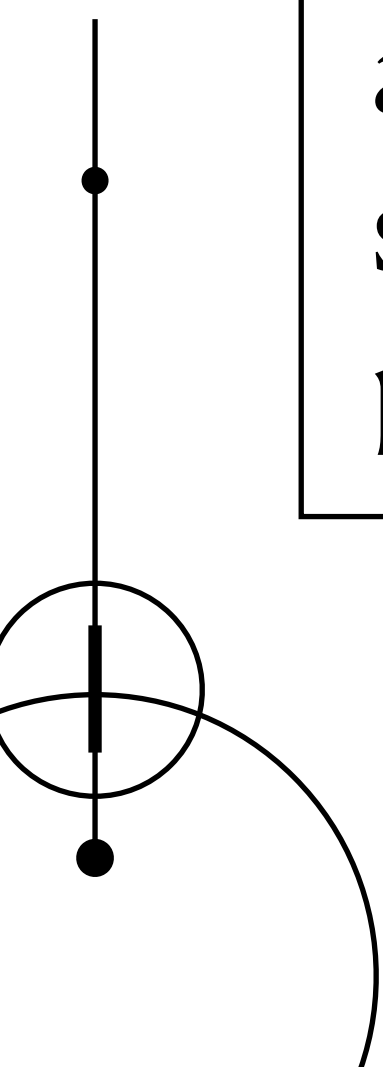
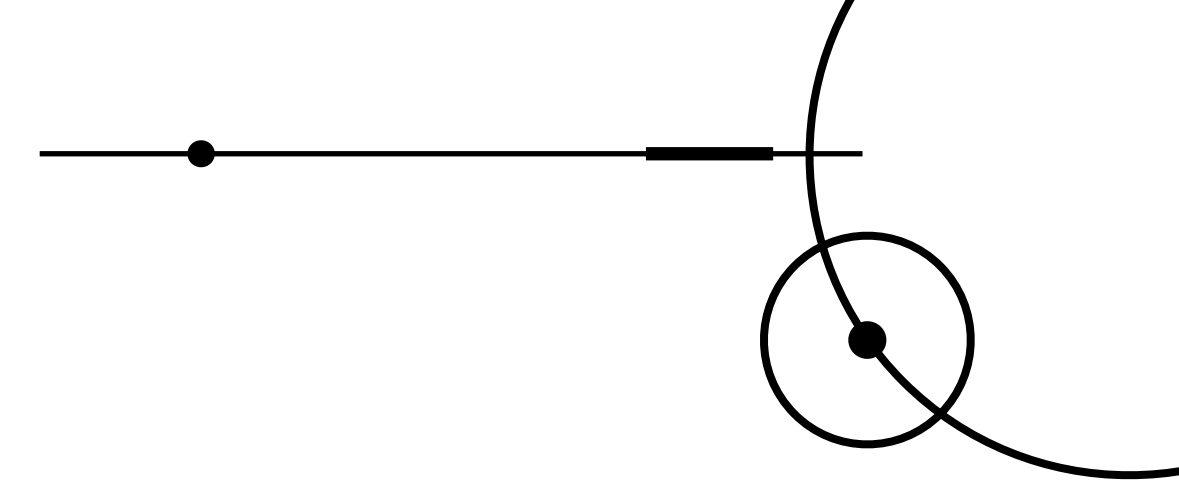
Observables and errorbars

→ Errorbars ?

PDF : Partonic Distribution Function



Necessary to calculate
analytically the cross
section (Amount of
production)

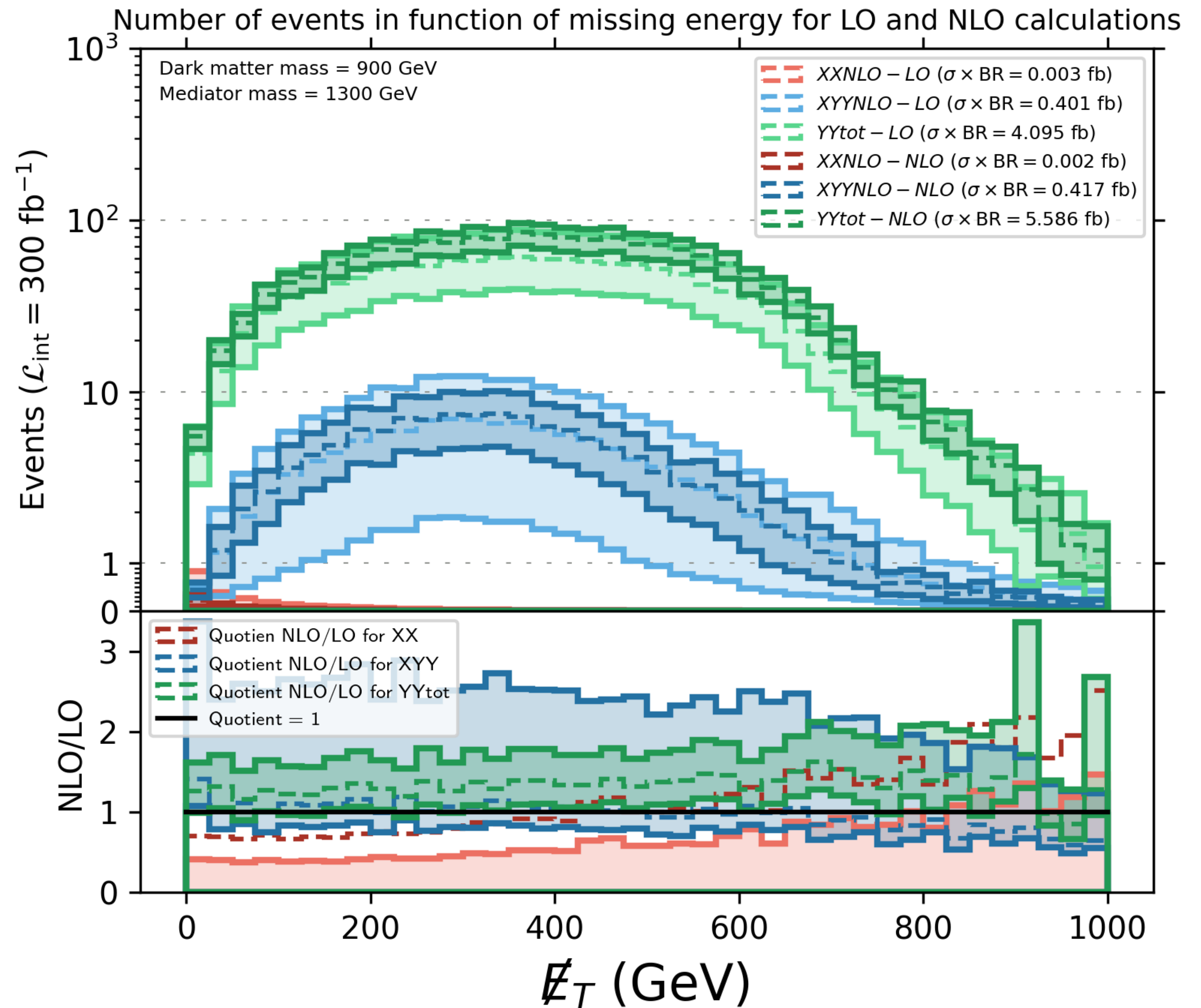


Observables and errorbars

→ Errorbars ?

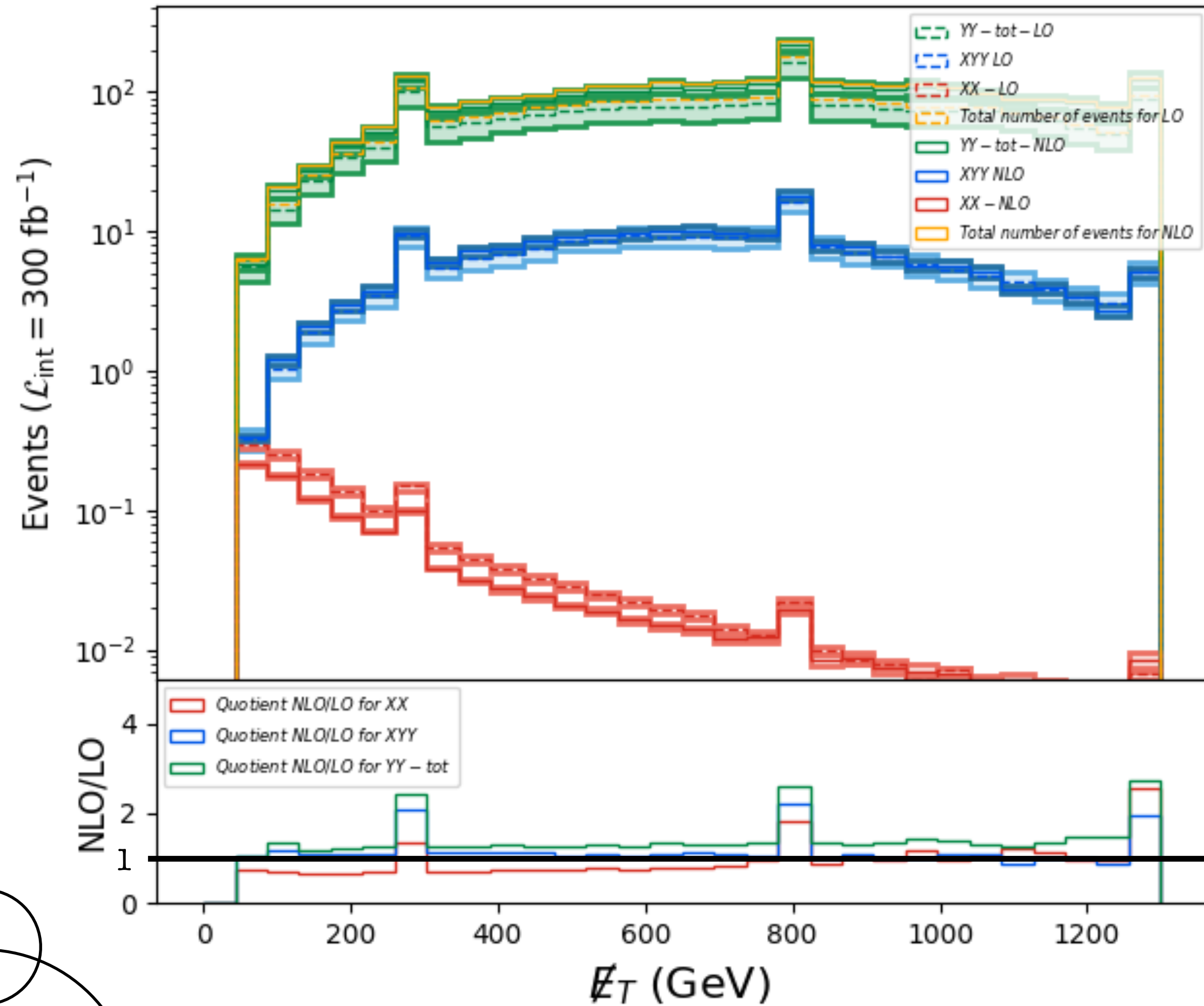
PDF : Partonic Distribution Function

Necessary to calculate analytically the cross section (Amount of production)

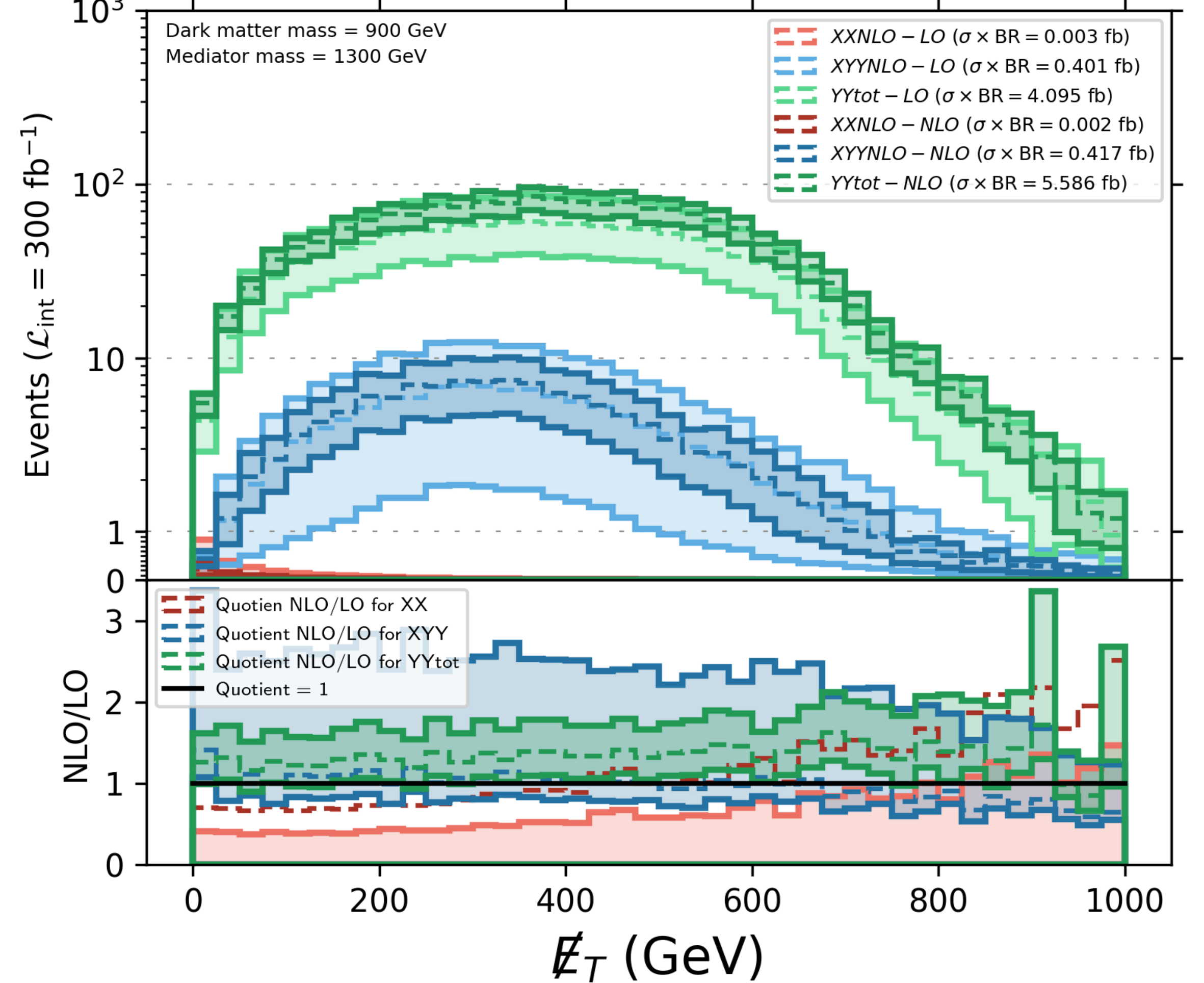


Observables and errorbars

N. of events in function of missing energy for LO and NLO calculations - MA5_

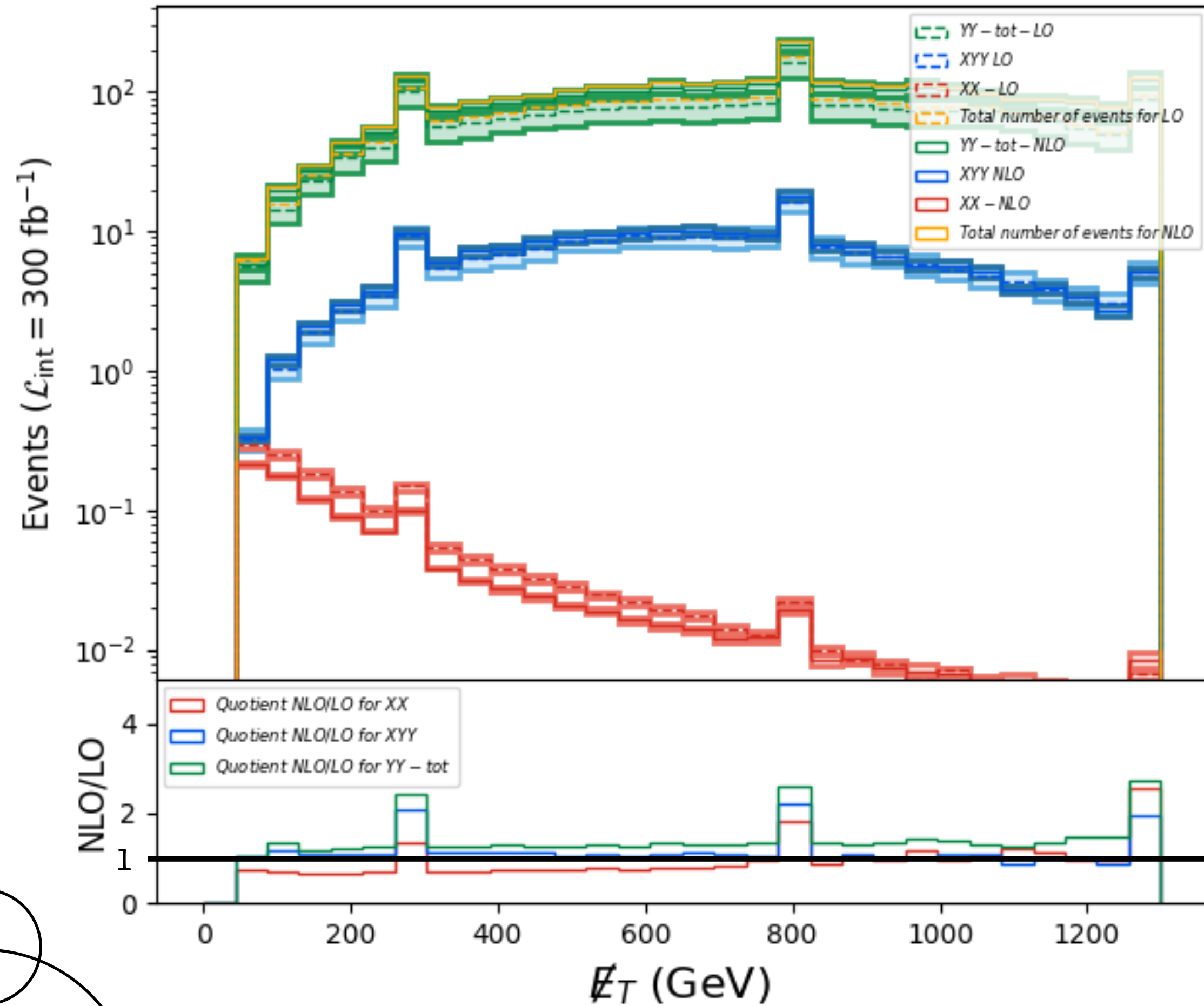


Number of events in function of missing energy for LO and NLO calculations

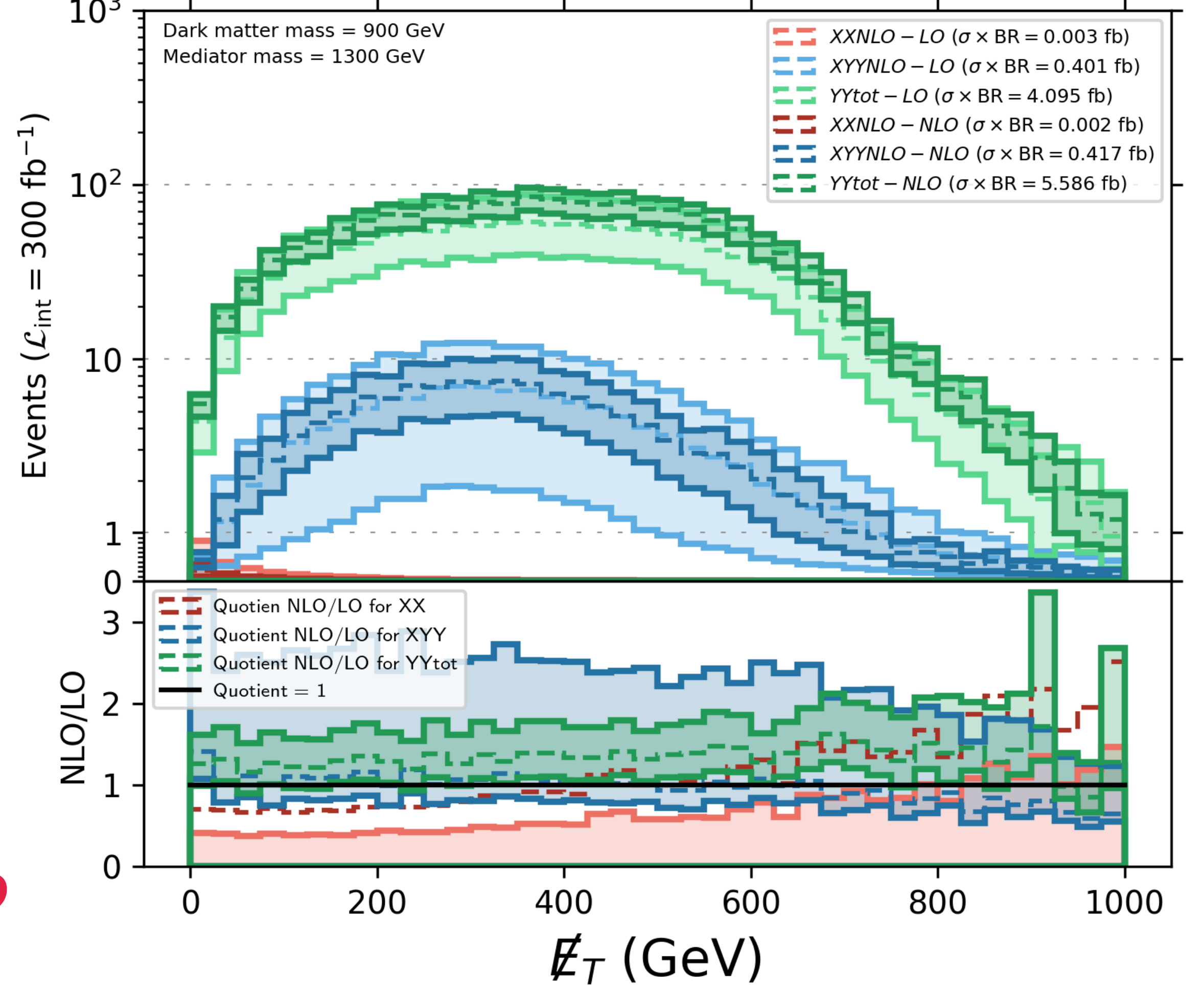


Observables and errorbars

N. of events in function of missing energy for LO and NLO calculations - MA5_



Number of events in function of missing energy for LO and NLO calculations



?

Conclusion

