Recherche de nouvelle physique dans des désintégrations de mésons beaux en trois corps sans particule charmée

Thomas Grammatico, Eli Ben-Haïm, Matthew Charles

Mon sujet

Recherche de nouvelle physique dans des désintégrations de mésons beaux en trois corps sans particule charmée

Search for New Physics in three-body charmless B-meson decays

Mon sujet

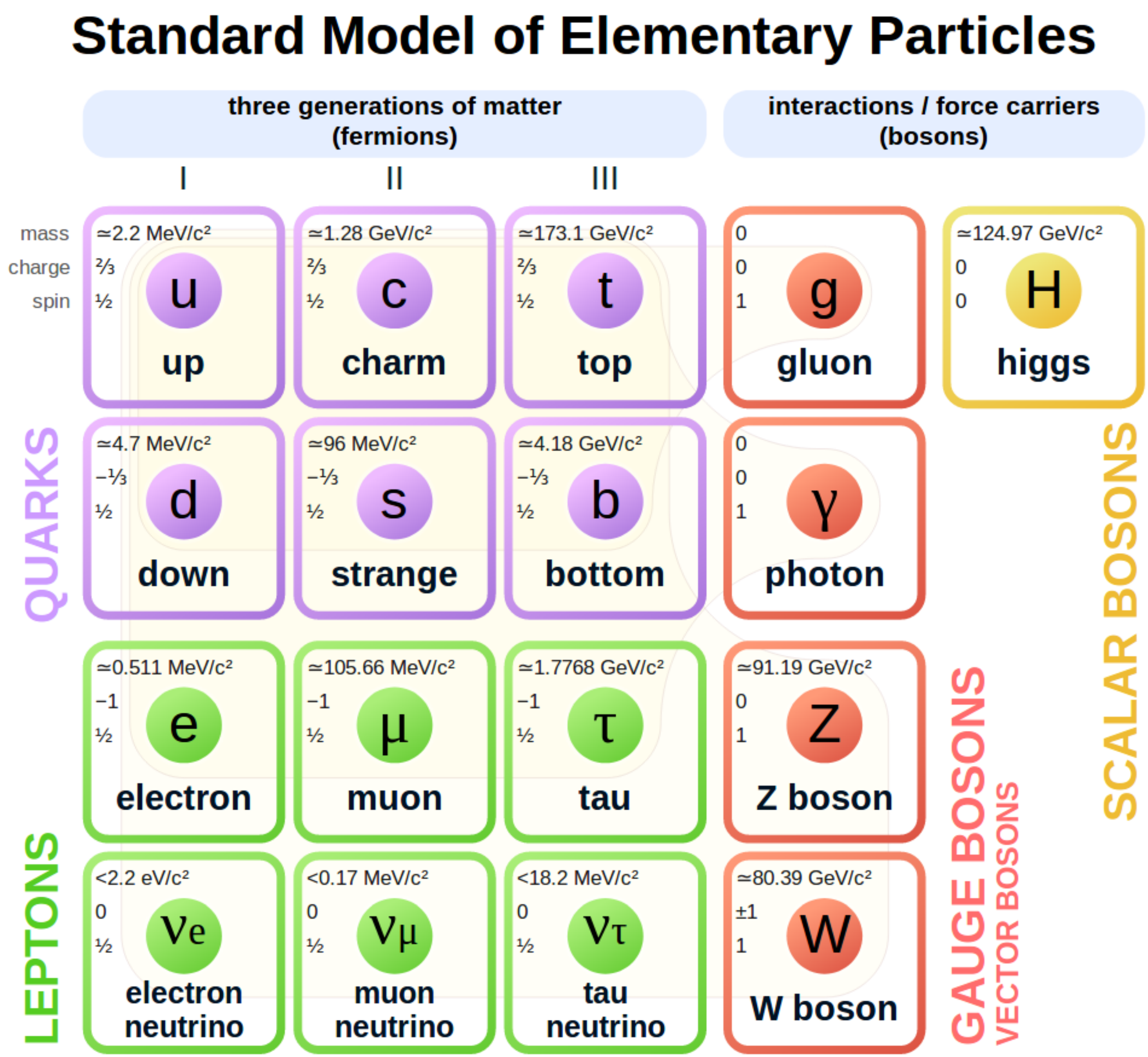
Physique de la beauté sans charme

Charmless beauty physics

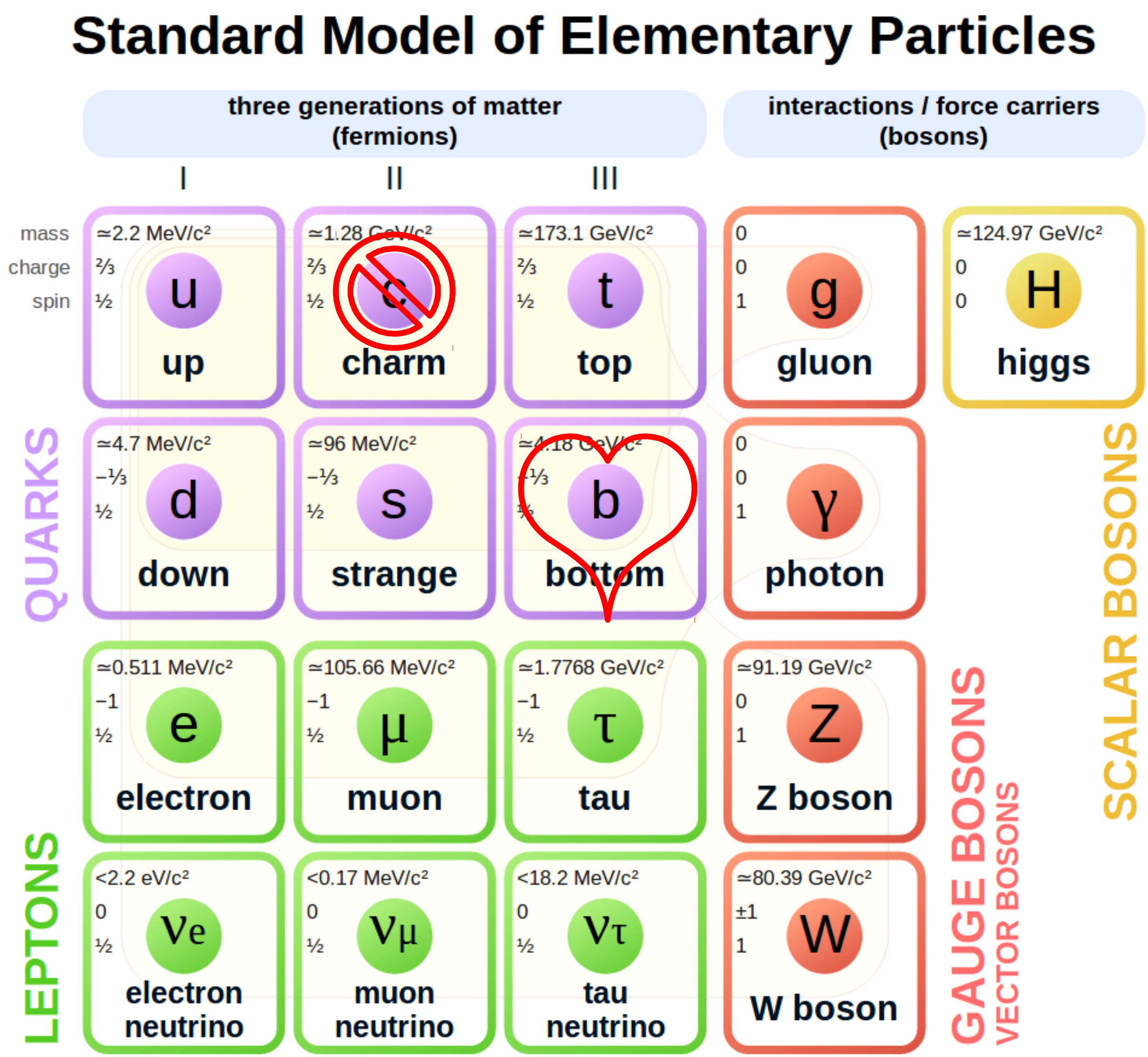
Mon sujet

Physique de la bea

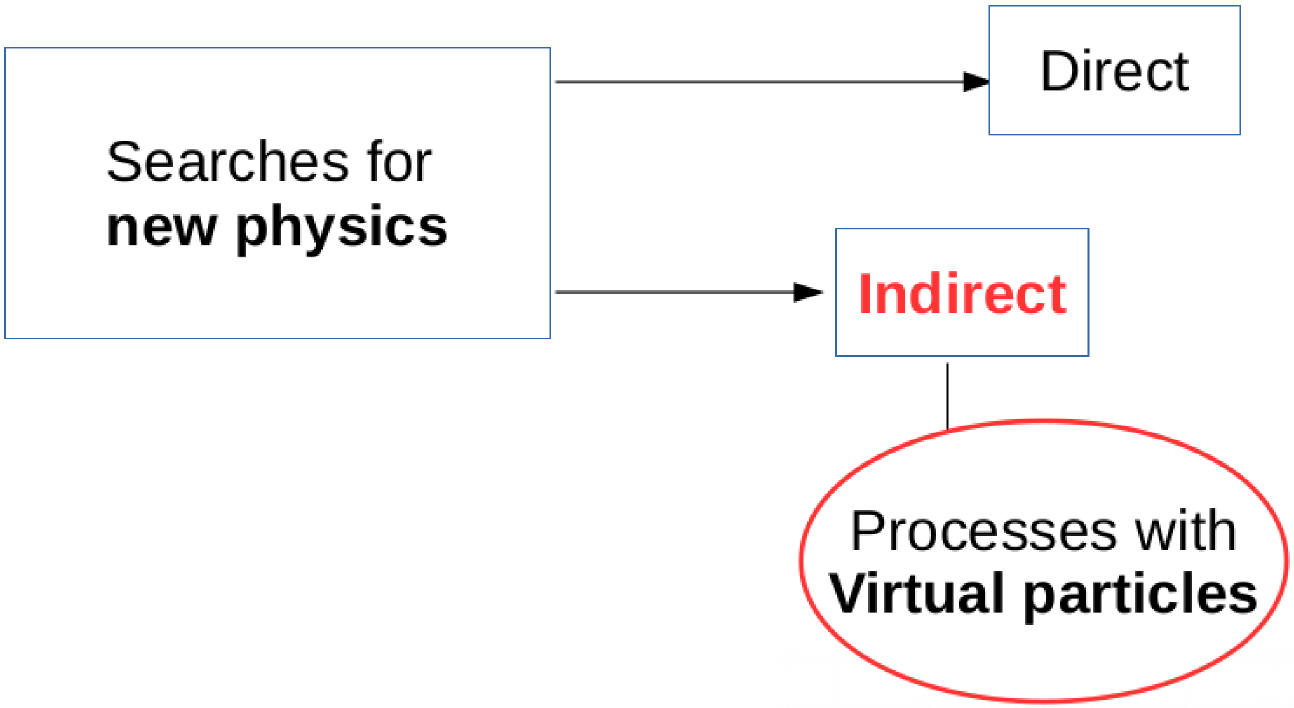
Physique de la beauté sans charme



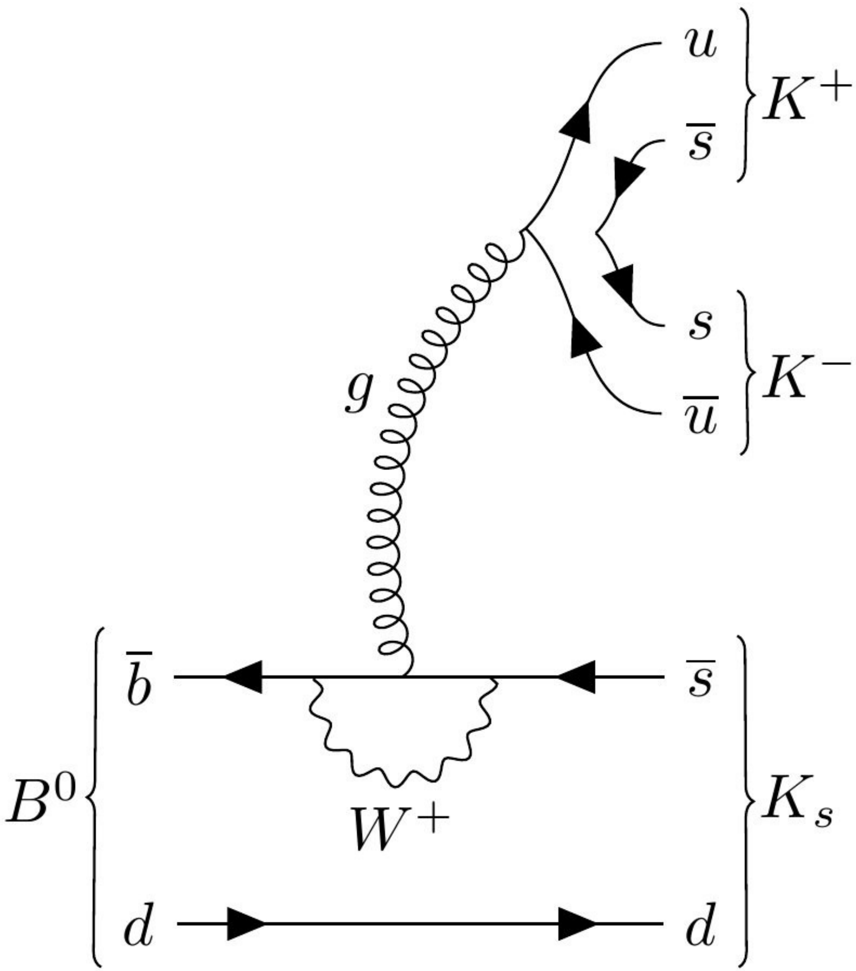
Physique de la beauté sans charme



Pourquoi ?


Searches for
new physics
Direct
Indirect
Processes with
Virtual particles

Pourquoi ?



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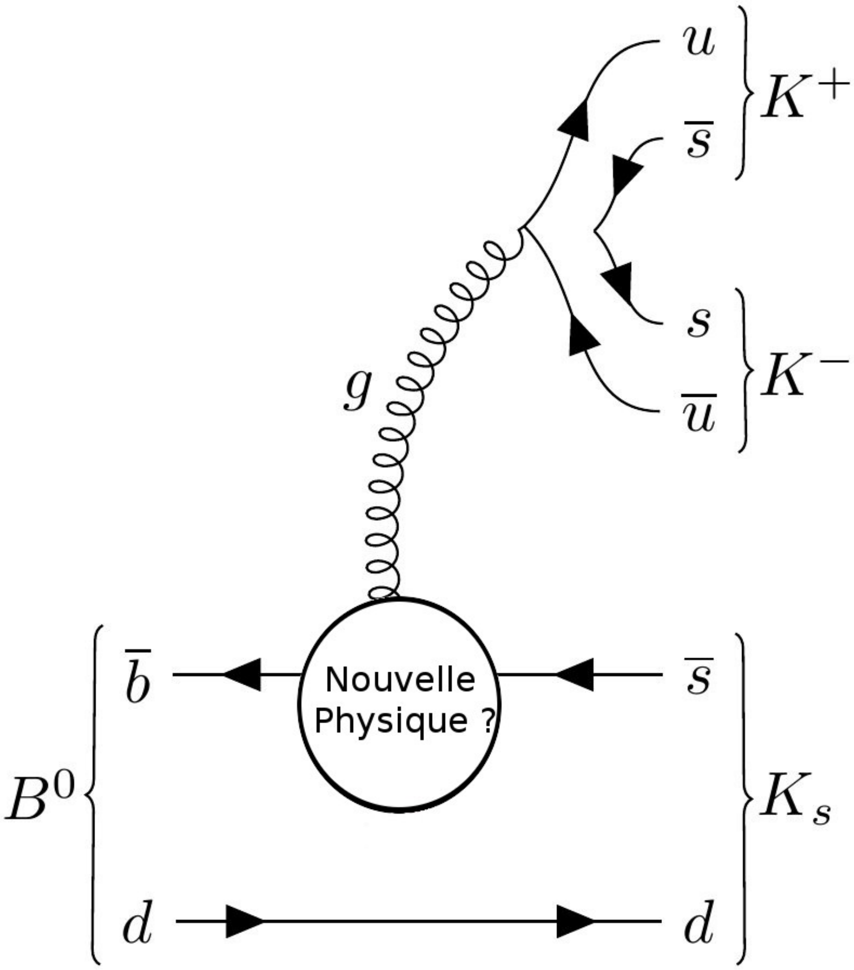

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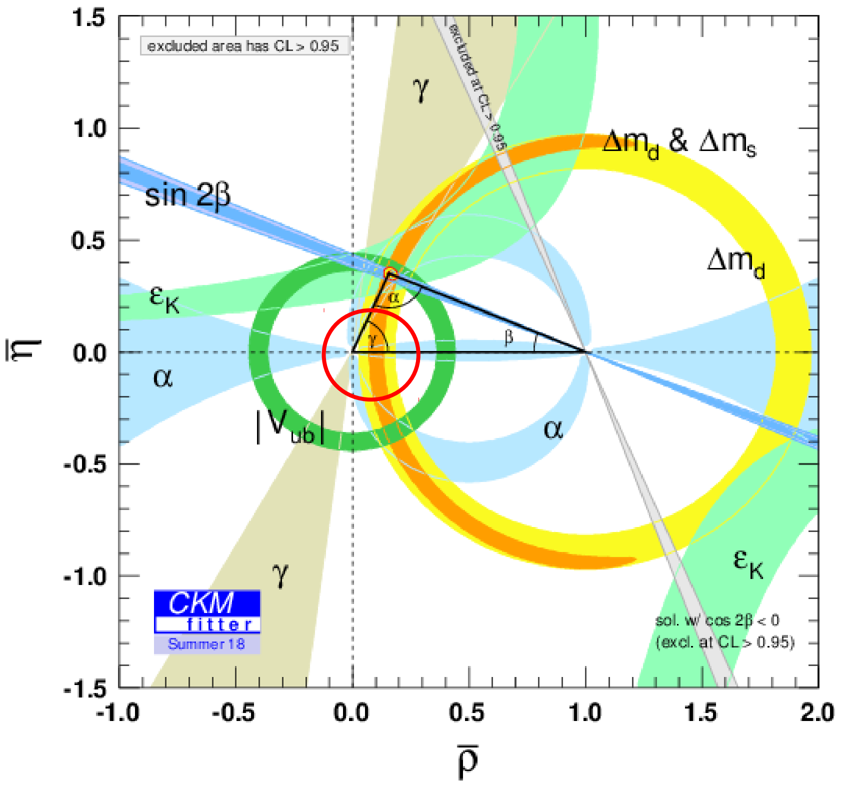
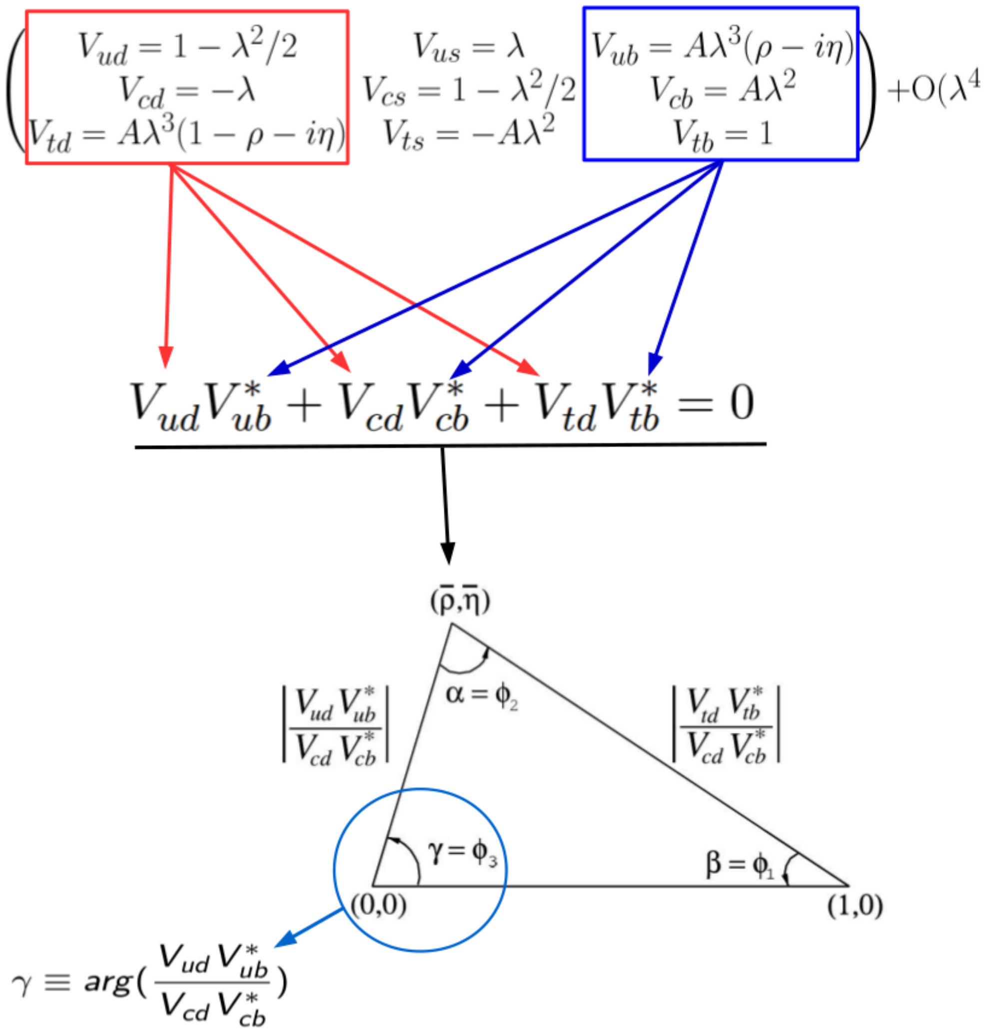
Extraire γ des désintégrations du méson B en trois corps sans particule charmée



Extraire γ des désintégrations du méson B en trois corps sans particule charmée



Et pour quoi faire ?

- Tester une nouvelle méthode d’extraction de γ

- Sensible à NP

- γ présente de larges incertitudes ; $\alpha = (86.4_{-4.3}^{+4.5})°$, $\beta = (22.14_{-0.67}^{+0.69})°$, $\gamma = (72.1_{-5.7}^{+5.4})°$

- Test a new γ extraction method

- Sensitive to NP

- γ has large encertainties ; $\alpha = (86.4_{-4.3}^{+4.5})°$, $\beta = (22.14_{-0.67}^{+0.69})°$, $\gamma = (72.1_{-5.7}^{+5.4})°$

Extracting γ from three-body charmless B-meson decays

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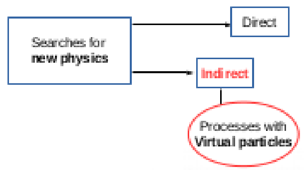
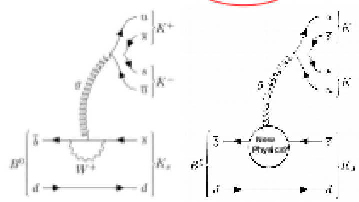
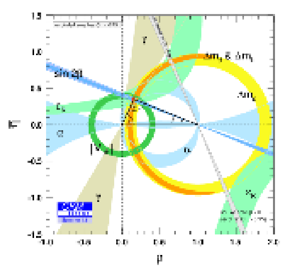
LPNHE

Overview





The studied observable is the **γ angle**
It appears in the **unitarity triangle** from the **CKM matrix**

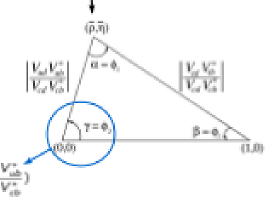


CKM matrix and unitarity triangle

The **CKM matrix** describes the couplings between the quarks, here in Wolfenstein parametrization

$$\begin{pmatrix} V_{ud}=1-\lambda^2/2 & V_{us}=\lambda & V_{ub}=A\lambda^3(\rho-i\eta) \\ V_{cd}=-\lambda & V_{cs}=1-\lambda^2/2 & V_{cb}=A\lambda^2 \\ V_{td}=A\lambda^3(1-\rho-i\eta) & V_{ts}=-A\lambda^2 & V_{tb}=1 \end{pmatrix}+O(\lambda^4)$$

$$V_{ud}V_{ub}^*+V_{cd}V_{cb}^*+V_{td}V_{tb}^*=0$$



$$\gamma=\arg\left(\frac{V_{ud}V_{ub}^*}{V_{cd}V_{cb}^*}\right)$$

Extracting γ
Basics of the method

The method is based on three-body **charmless** B-meson decays (**loop** processes) [1]

Decay amplitudes contain strong and weak dynamics

γ can be extracted if there are more **observables** than **theoretical parameters**

By imposing **flavour SU(3) symmetry**, the number of parameters is reduced

Peguin and **tree** diagrams are now proportionnal

$$P_{EW\alpha}=\kappa T_\alpha \text{ et } P^C_{EW\alpha}=\kappa C_\alpha$$

In this framework 6 states can be built :

$$|S\rangle \propto |123\rangle+|231\rangle+|312\rangle+|321\rangle+|213\rangle+|132\rangle$$

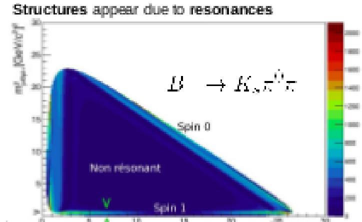
$$|A\rangle \propto |123\rangle+|231\rangle+|312\rangle-|321\rangle-|213\rangle-|132\rangle$$

Four mixed states

Amplitude analysis in the Dalitz Plane

In the **three-body** case : more degrees of freedom, with spin 0 particles, **Dalitz plane** are needed

Amplitude depends on two **invariant squared masses**
Structures appear due to **resonances**



Observables and theoretical parameters
Antisymmetric states

3 observables :

$$X(m^2_{ab},m^2_{bc})=|\mathcal{A}_{|A\rangle}(m^2_{ab},m^2_{bc})|^2+|\bar{\mathcal{A}}_{|A\rangle}(m^2_{ab},m^2_{bc})|^2$$
$$Y(m^2_{ab},m^2_{bc})=|\mathcal{A}_{|A\rangle}(m^2_{ab},m^2_{bc})|^2-|\bar{\mathcal{A}}_{|A\rangle}(m^2_{ab},m^2_{bc})|^2$$
$$Z(m^2_{ab},m^2_{bc})=Im[\mathcal{A}^*_{|A\rangle}(m^2_{ab},m^2_{bc})\bar{\mathcal{A}}_{|A\rangle}(m^2_{ab},m^2_{bc})]$$

5 decay channels :

$B^+\to K^+\pi^+\pi^-$, X et Y
$B^+\to K^0\pi^+\pi^0$, X et Y
$B^0\to K^0\pi^+\pi^-$, X, Y et Z
$B^0\to K^+\pi^0\pi^-$, X et Y
$B^0\to K^0K^+K^-$, X, Y et Z

This results in **12 observables** and **10 parameters** [1]:
5 effective diagrams :
-5 diagrams magnitude
-4 strong relative phase
-1 weak phase

How to extract γ

We want to perform a **fit** on a given point of the **Dalitz plane**

Fix γ to consecutive values **[0° ,360°]**, other parameters are free with **random** value

Hundreds of such fit are realized on a given point of the Dalitz Plane

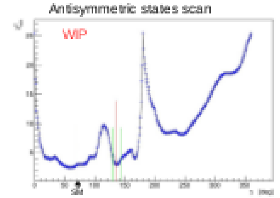
For each fit, the **lowest chi squared** is kept → **γ Scan**

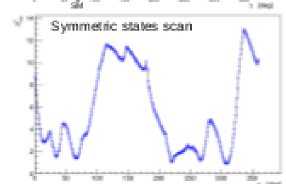
From chi squared profile we extract **minima**

Many points over the Dalitz plot are used to reduce statistical uncertainties

Results

Antisymmetric states scan





The whole process is reproduced **500 times**

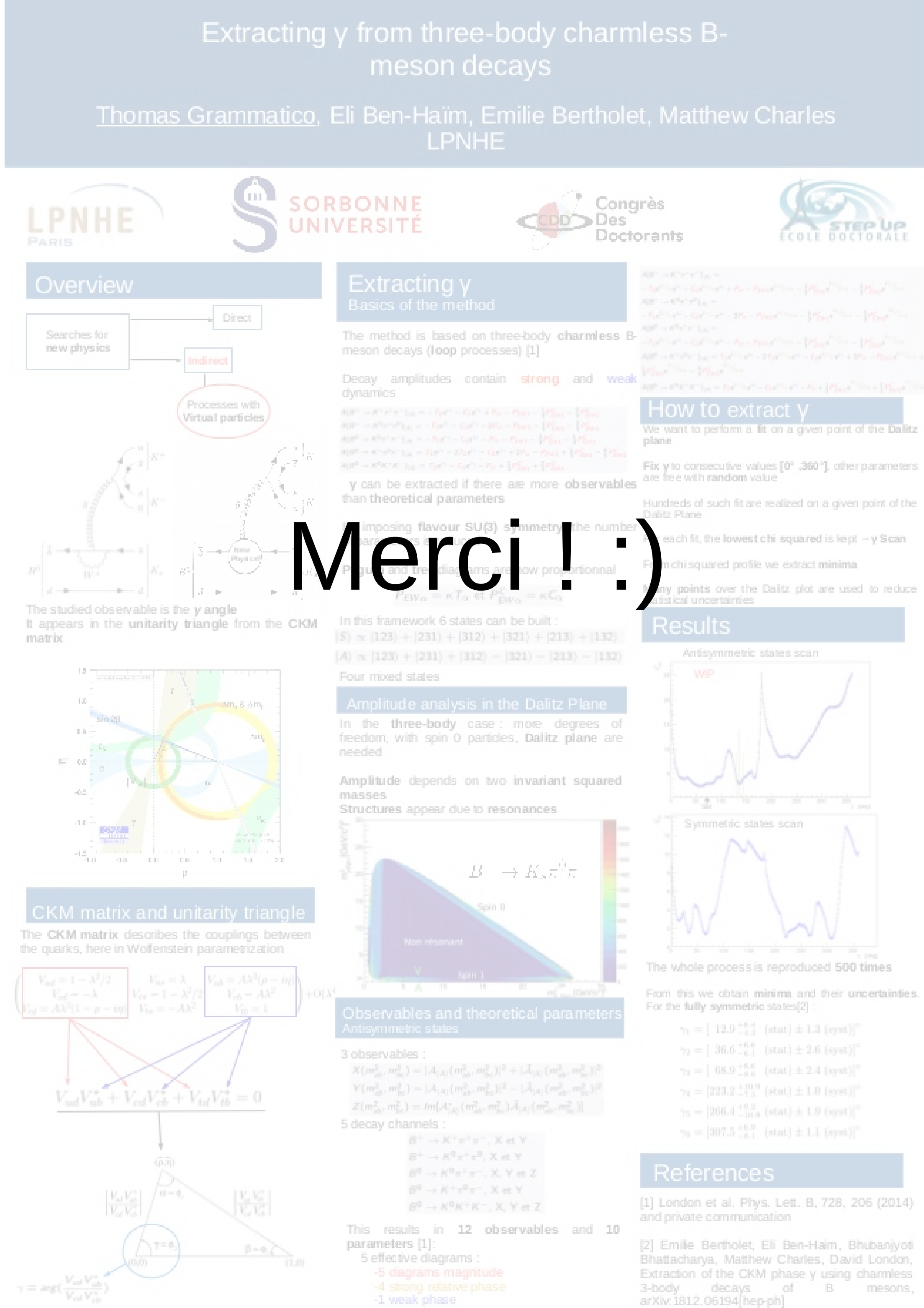
From this we obtain **minima** and their **uncertainties**. For the **fully symmetric** states[2] :

$$\gamma_1=[\ 12.9^{+8.4}_{-4.3}\ (stat)\pm1.3\ (syst)]^\circ$$
$$\gamma_2=[\ 36.6^{+6.6}_{-6.1}\ (stat)\pm2.6\ (syst)]^\circ$$
$$\gamma_3=[\ 68.9^{+8.6}_{-8.6}\ (stat)\pm2.4\ (syst)]^\circ$$
$$\gamma_4=[223.2^{+10.9}_{-7.5}\ (stat)\pm1.0\ (syst)]^\circ$$
$$\gamma_5=[206.4^{+9.2}_{-10.8}\ (stat)\pm1.9\ (syst)]^\circ$$
$$\gamma_6=[307.5^{+6.9}_{-8.1}\ (stat)\pm1.1\ (syst)]^\circ$$

References

[1] London et al. Phys. Lett. B, 728, 206 (2014) and private communication

[2] Emilie Bertholet, Eli Ben-Haim, Bhubanjyoti Bhattacharya, Matthew Charles, David London, Extraction of the CKM phase γ using charmless 3-body decays of B mesons, arXiv:1812.06194[hep-ph]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Merci ! :)