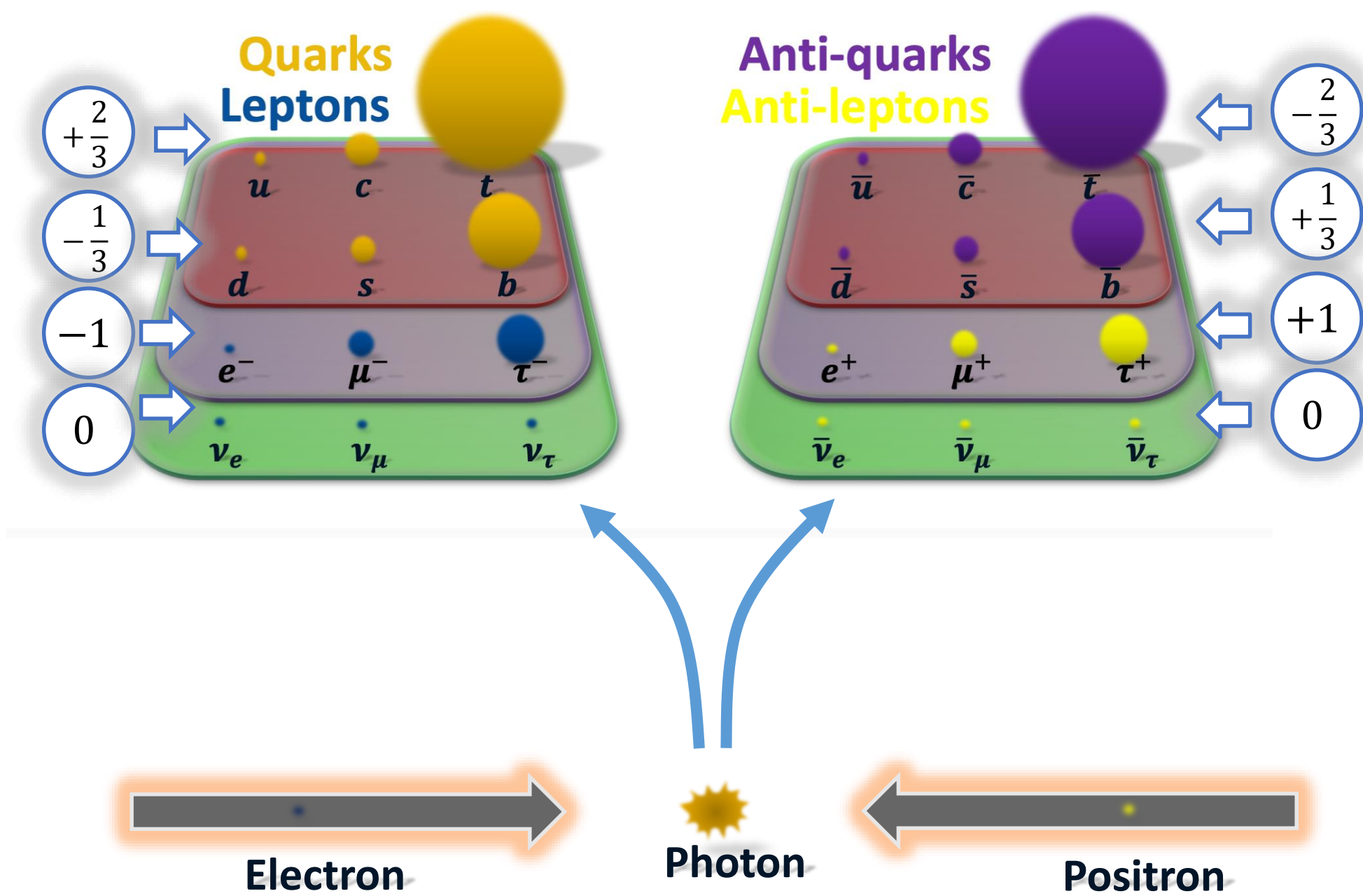


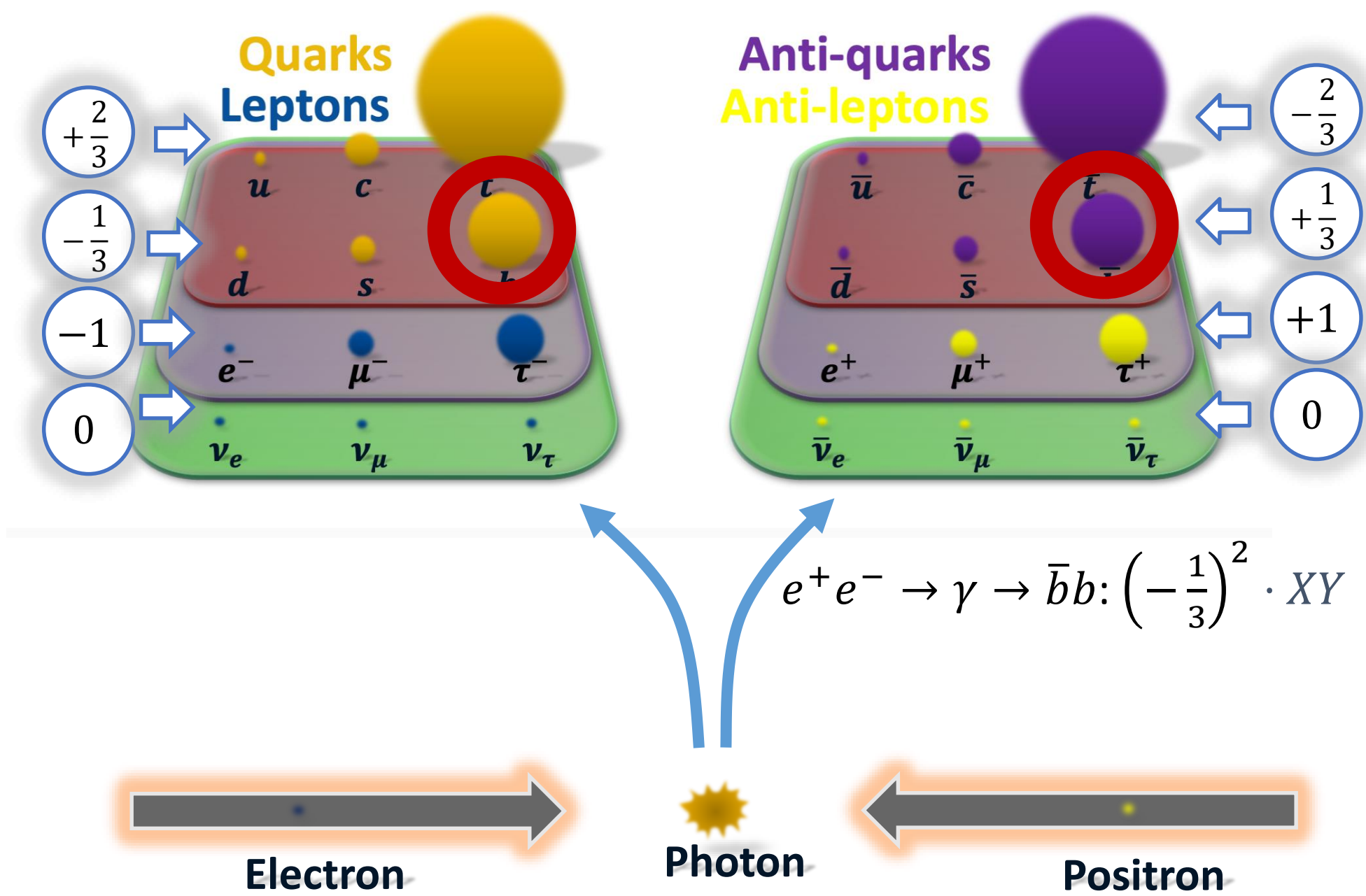
Masterclass Belle II 2025

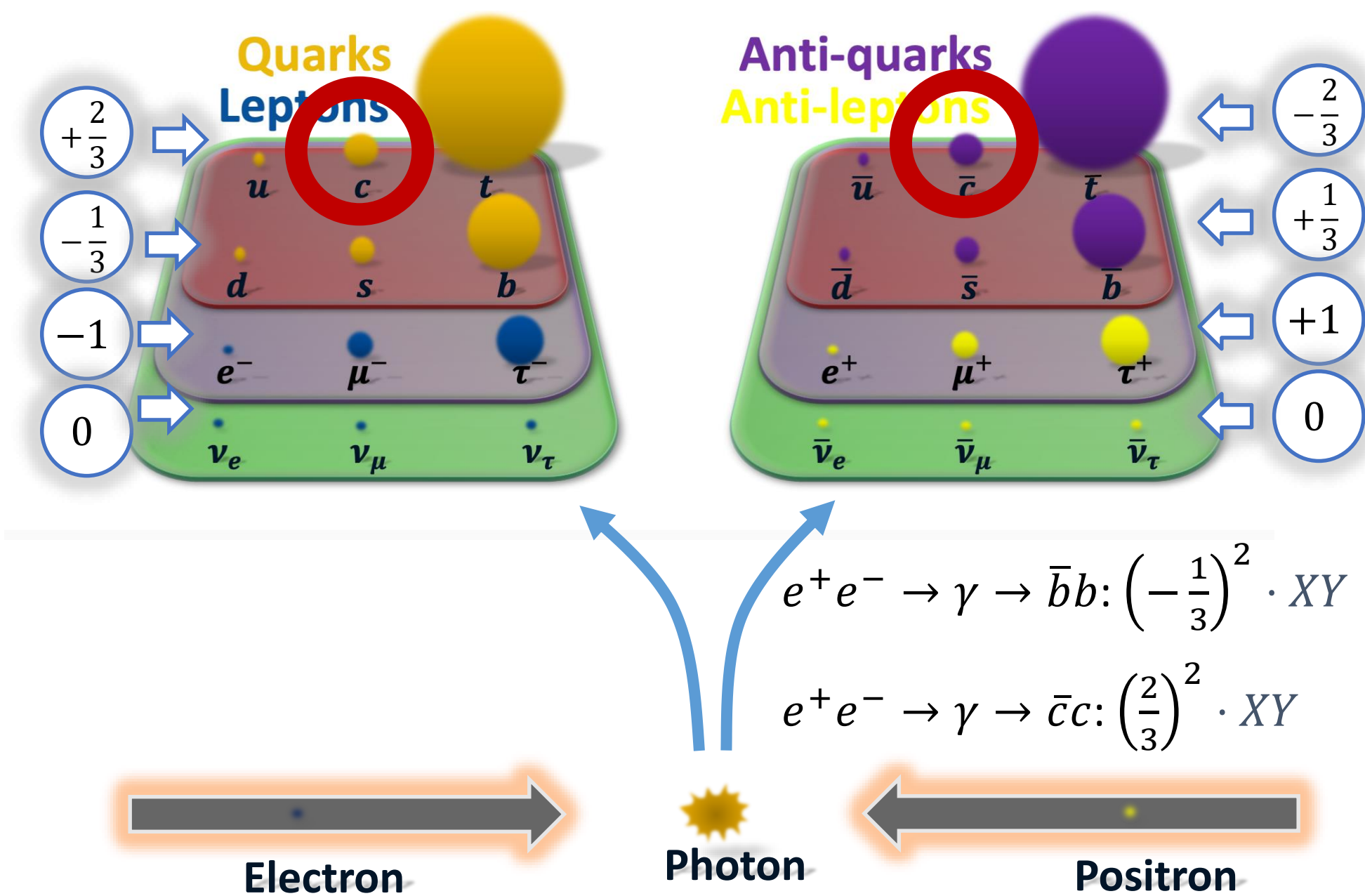
CPPM

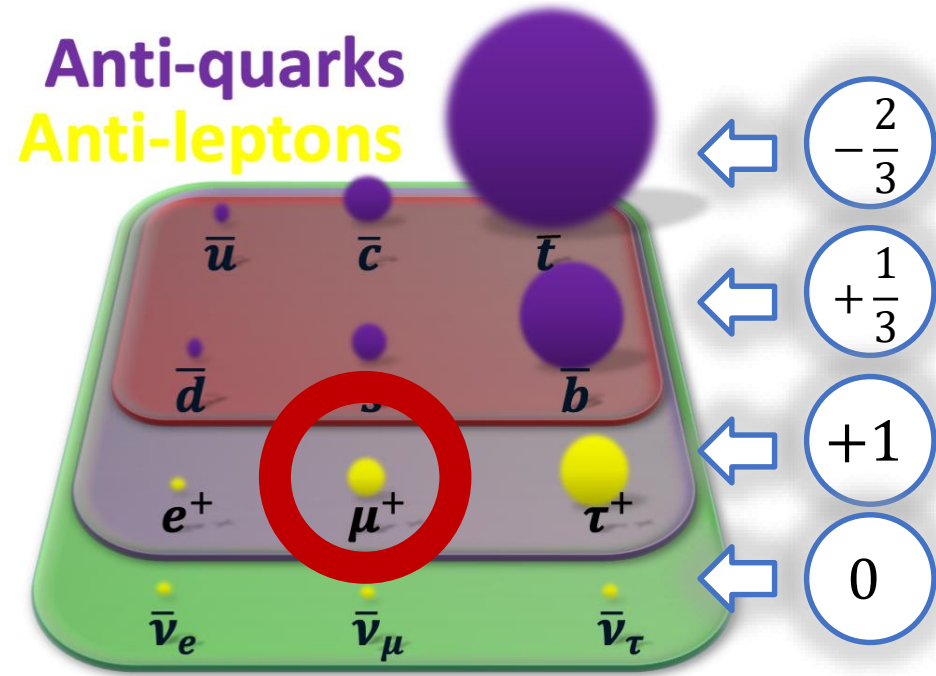
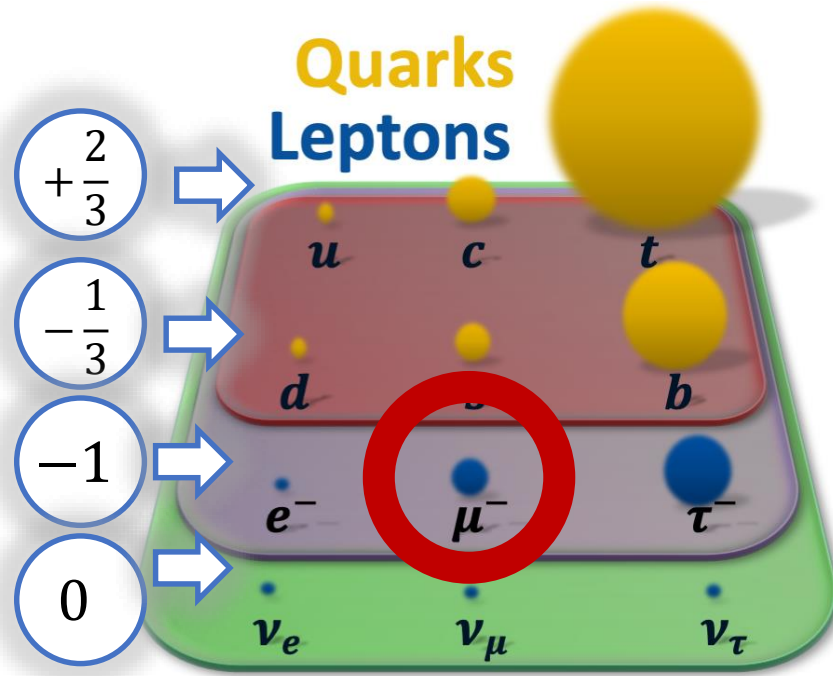
<https://belle2.ijs.si/public/home/quark-colors/>

Combien existe-t-il de couleurs de quark ?









$$e^+ e^- \rightarrow \gamma \rightarrow \mu^+ \mu^-: (-1)^2 \cdot XY$$

$$e^+ e^- \rightarrow \gamma \rightarrow \bar{b} b: \left(-\frac{1}{3}\right)^2 \cdot XY$$

$$e^+ e^- \rightarrow \gamma \rightarrow \bar{c} c: \left(\frac{2}{3}\right)^2 \cdot XY$$



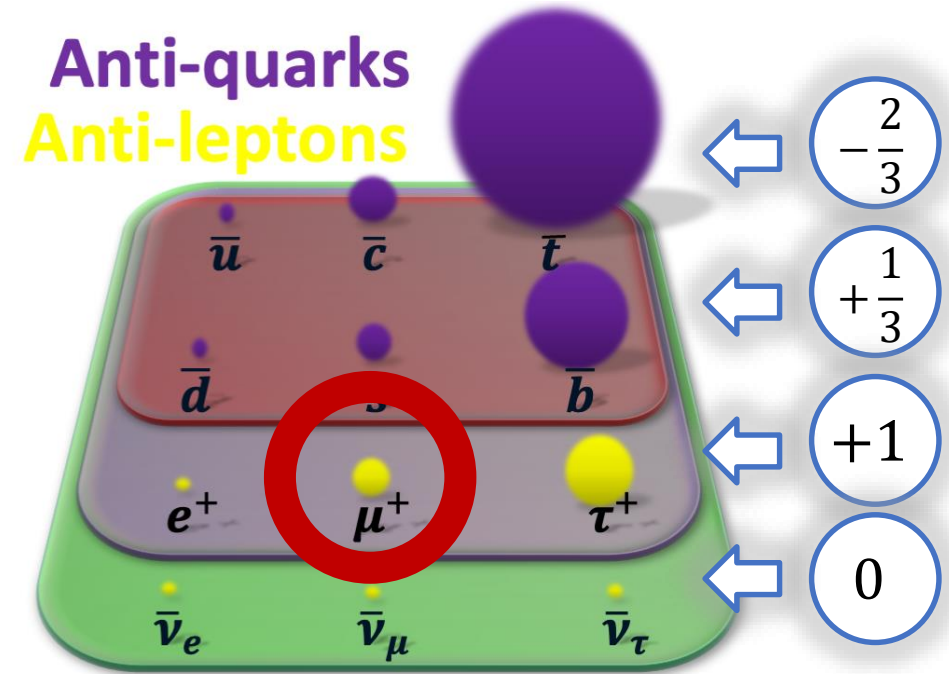
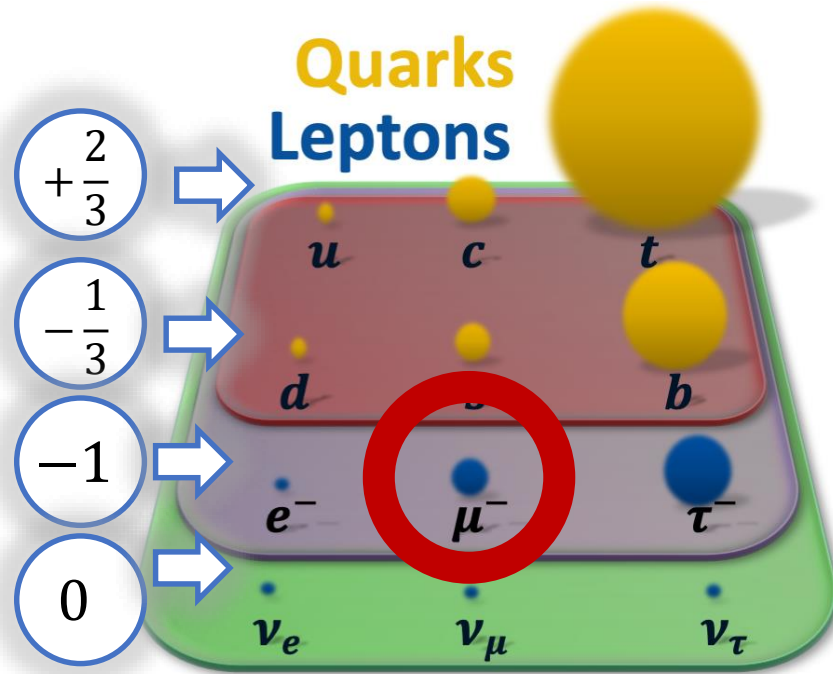
Electron



Photon



Positron



$$e^+ e^- \rightarrow \gamma \rightarrow \mu^+ \mu^-: (-1)^2 \cdot XY$$

$$e^+ e^- \rightarrow \gamma \rightarrow \bar{b} b: \left(-\frac{1}{3}\right)^2 \cdot XY \times N_c$$

$$e^+ e^- \rightarrow \gamma \rightarrow \bar{c} c: \left(\frac{2}{3}\right)^2 \cdot XY \times N_c$$



Electron



Photon



Positron

Rapport R

$$R = \frac{N(e^+e^- \rightarrow \gamma \rightarrow \bar{u}u, \bar{d}d, \bar{s}s, \bar{c}c)}{\frac{1}{2} [N(e^+e^- \rightarrow \gamma \rightarrow \mu^+\mu^-) + N(e^+e^- \rightarrow \gamma \rightarrow \tau^+\tau^-)]} = \mathbf{N_c} \cdot \mathbf{1.111} \dots$$

Pourquoi on n'utilise pas les événements $e^+e^- \rightarrow b\bar{b}$?

Pourquoi on n'utilise pas les $e^+e^- \rightarrow e^+e^-$?



Belle II experiment

- <https://belle2.ijs.si/public/home/quark-colors/>



HOME

INTRO

BELLE II

RECONSTRUCT B MESONS

MEASURE QUARK COLORS

EVENTS

WHAT YOU LEARNED



How many colors does a quark come in?

The exchange particle of the electroweak force is the photon. It couples to particles of the electroweak force, the gluon, couples just like the to particles that carry a so called **color charge**.

Today we want to experimentally determine the number of possible color charges (or colors) of quarks.

To that end we should first approach the subject from the theoretical side. To start with we should take a look at the so called *R*-value.

- [What is the *R*-value?](#)

After that we're ready to look at the experimental measurement, to determine the number of color charges.

- [Example Events](#)
- [Practice Task](#)
- [Measurement with data from the Belle II experiment](#)

HOW MANY COLORS DOES A QUARK COME IN?

WHAT IS THE *R*-VALUE?

EXAMPLE EVENTS

PRACTICE TASK: TRY IT OUT!

MAIN TASK

ADDITIONAL MATERIAL FOR TUTORS

can either be positive or negative. The exchange particle of the strong

experiment.

ABOUT

Belle II collaboration

High Energy Accelerator Research Organization, Tsukuba, Japan

SEARCH



ABOUT THIS SITE

This site enables exploration of a Belle II public data set to get an insight what Belle II researchers are working on.

But: trouver combien de couleurs un quark peut avoir

Comment : en comptant les évènements qui se produisent dans chaque catégorie : e^+e^- , $\mu^+\mu^-$, $\tau^+\tau^-$, uu , dd , ss , cc , bb

Pour cela, il faut regarder leurs propriétés : nombre de particules, énergie manquante, rectitude (entre 0 et 1), impact dans le détecteur à muon

The exchange particle of the electroweak force is the photon. It couples to particles with an electromagnetic charge. This charge can either be positive or negative. The exchange particle of the strong force, the gluon, couples just like the to particles that carry a so called **color charge**.

Today we want to experimentally determine the number of possible color charges (or simply colors) with data of the **Belle II experiment**.

To that end we should first approach the subject from the theoretical side. To start with we should take a look at the so called R -value.

- [What is the \$R\$ -value?](#)

After that we're ready to look at the experimental measurement, to determine the number of color charges.

- [Example Events](#)
- [Practice Task](#)
- [Measurement with data from the Belle II experiment](#)



Example Events

How do the different particle-antiparticle pairs look in the detector?

Here you can look at the different processes in form of example videos and pictures.

1. [electron/positron events](#)
2. [muon/antimuon events](#)
3. [tauon/antitauon events](#)
4. [light quark events](#)
5. [\$b\$ -quark/antiquark events](#)

After you've done that you can test your new knowledge by [clicking here](#) and trying to sort the example events yourself.

ABOUT

Belle II collaboration

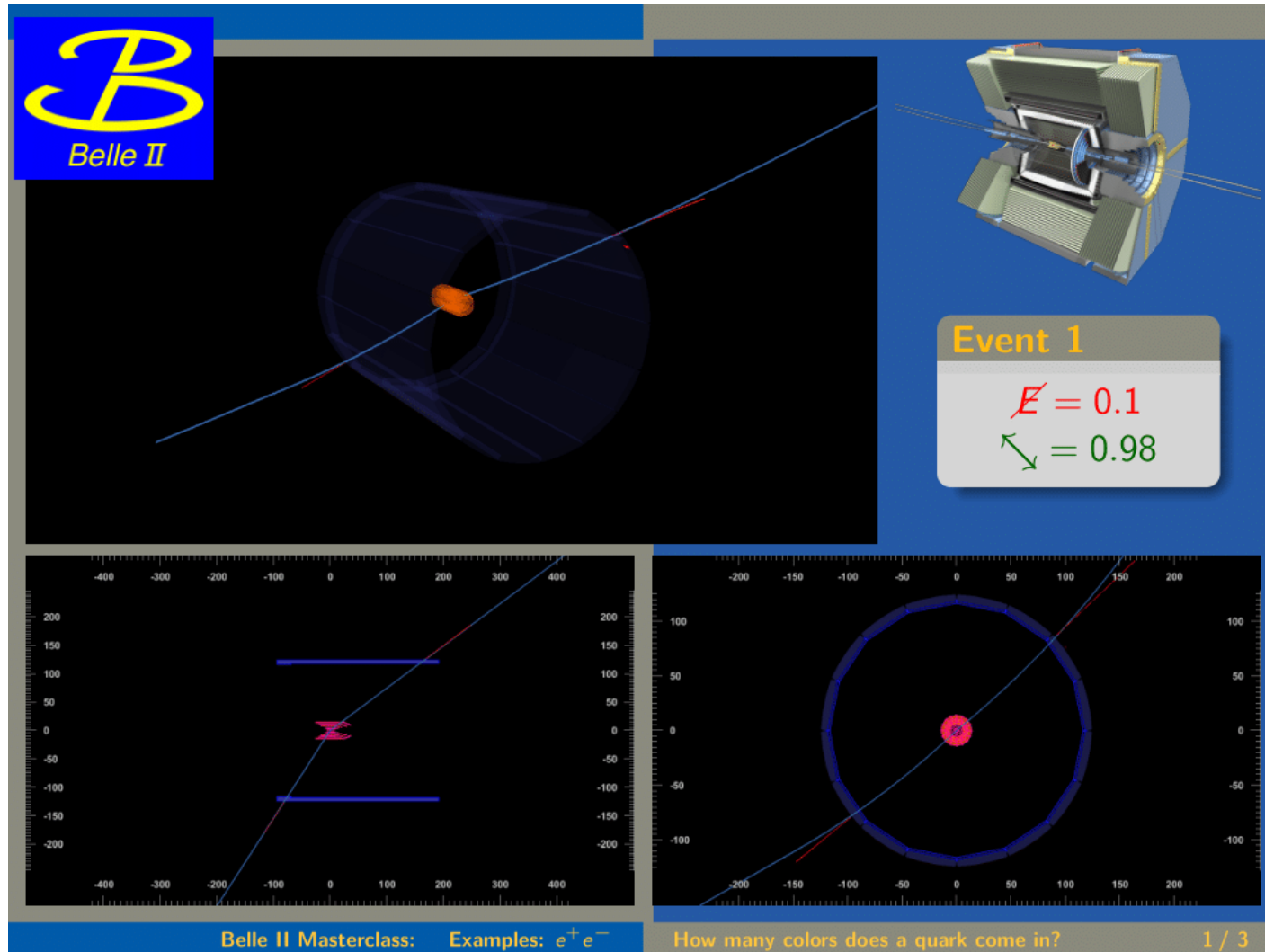
High Energy Accelerator Research Organization, Tsukuba, Japan

SEARCH

ABOUT THIS SITE

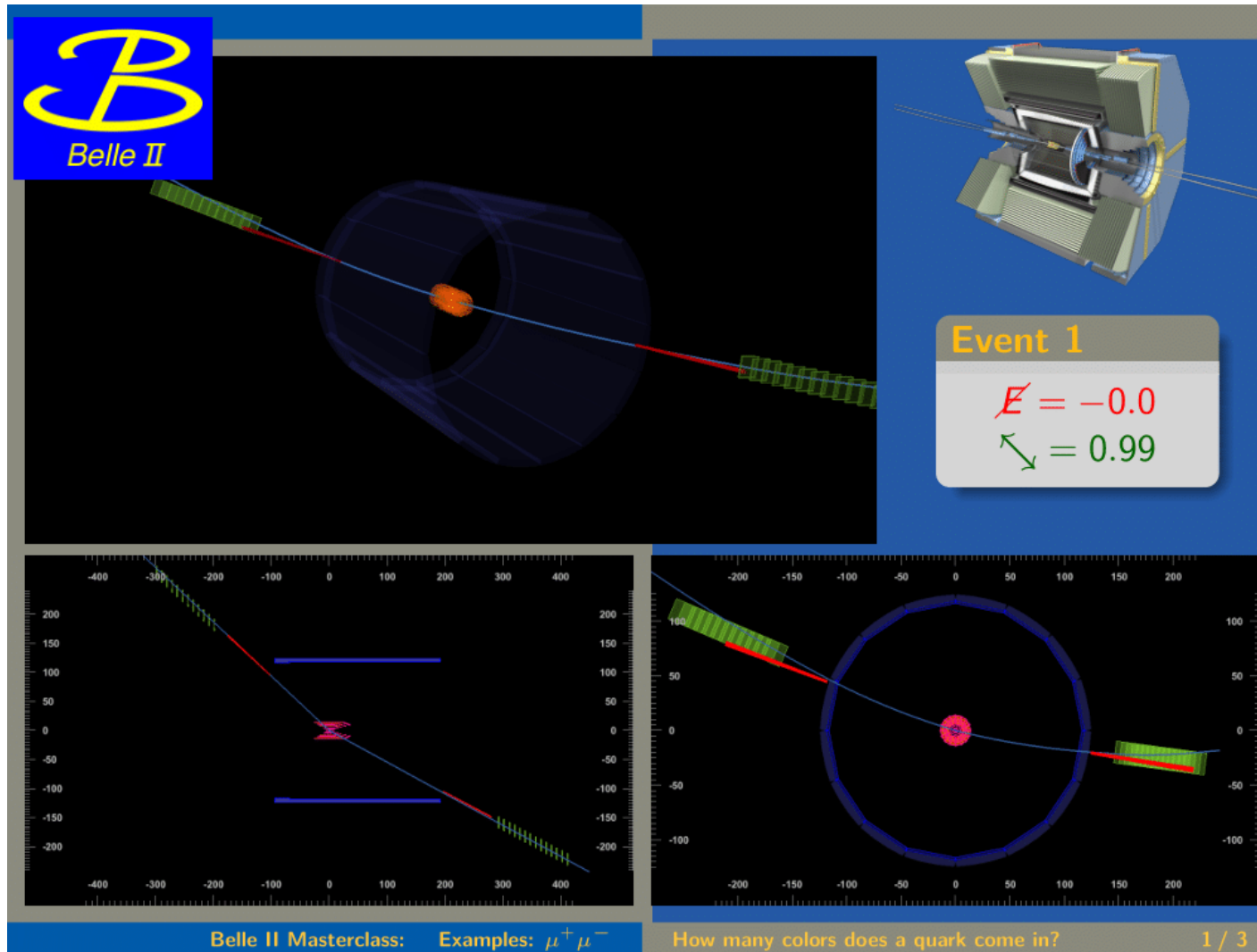
This site enables exploration of a Belle II public data set to get an insight what Belle II researchers are working on.

e^+e^-



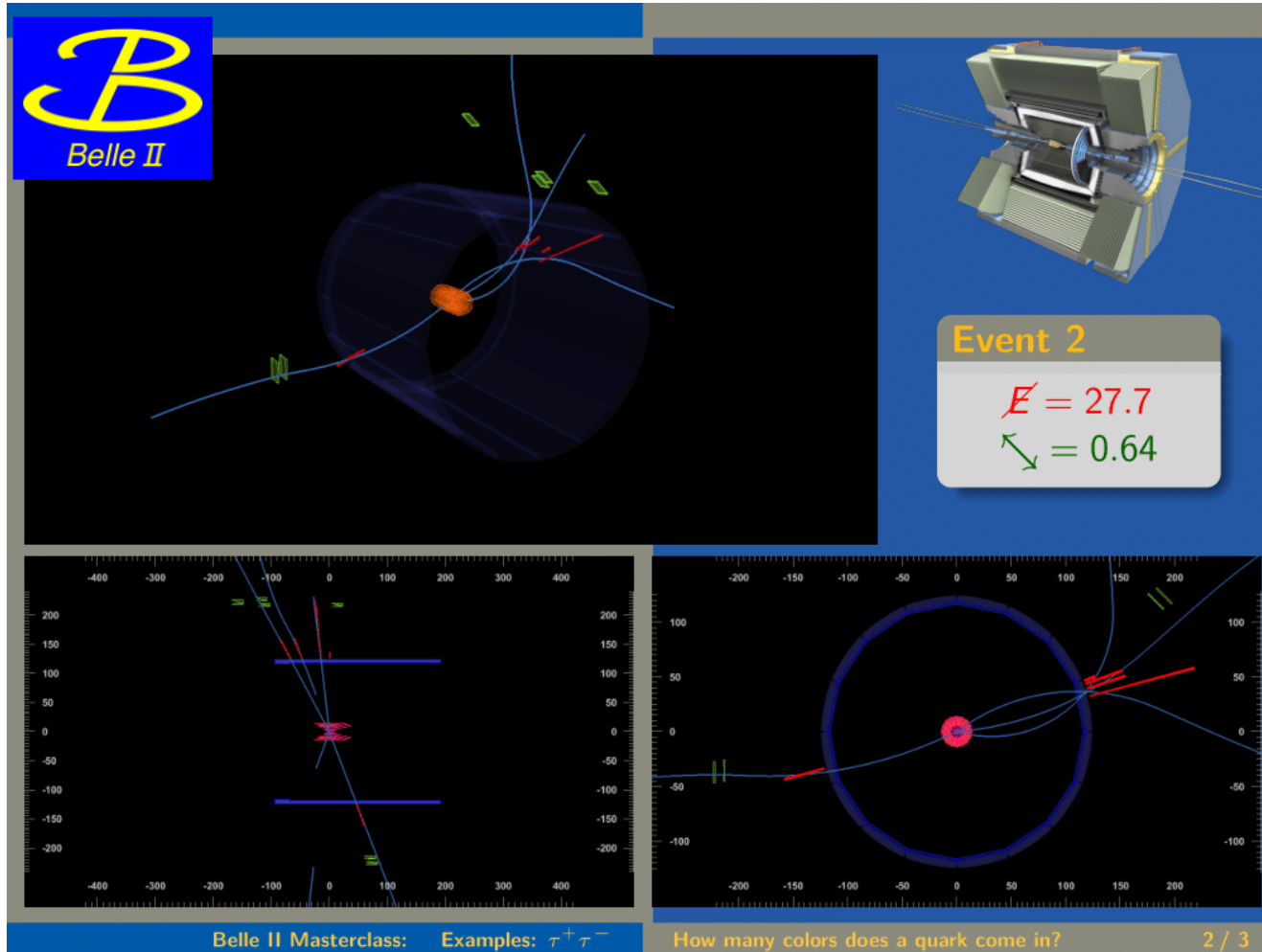
2 particules
Faible énergie manquante
Tres grande rectitude

$\mu^+\mu^-$



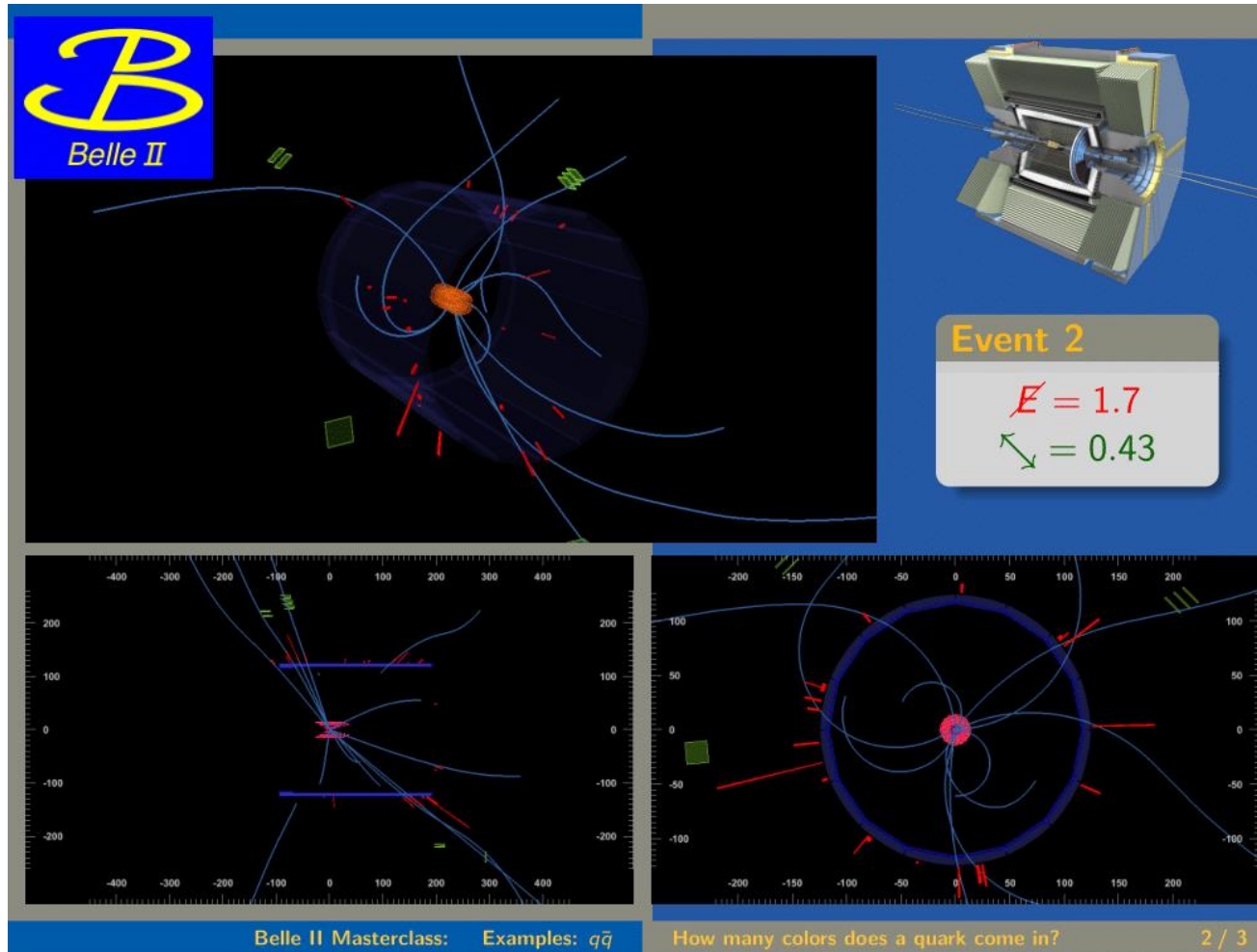
2 particules
Faible energie manquante
Tres grande rectitude
Trace dans le detecteur à muons

$\tau^+\tau^-$



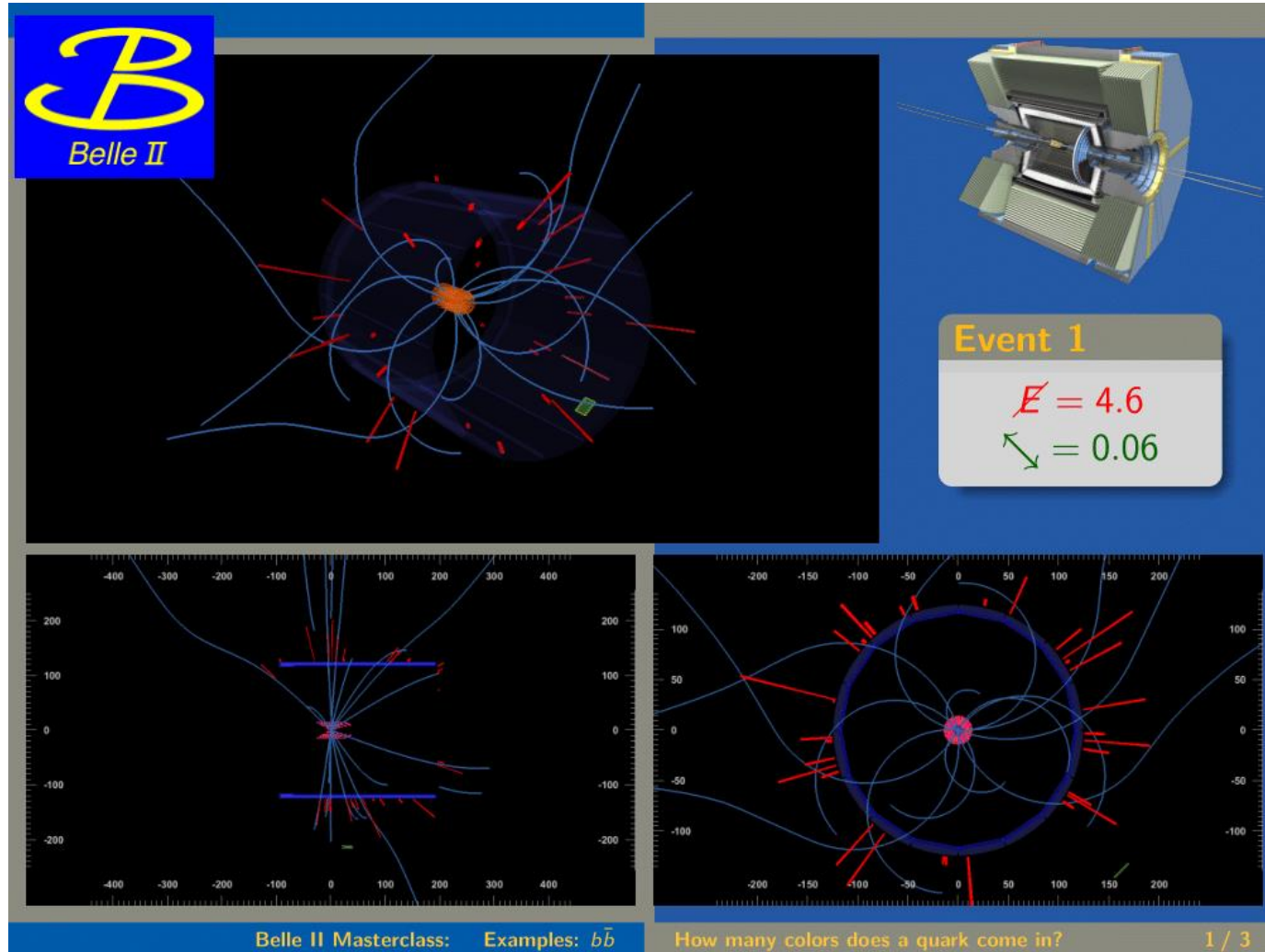
Entre 2 et 6 particules
énergie manquante (neutrinos!)
Rectitude moyenne
Trace dans le détecteur à
muons, parfois

quark-anti-quark légers

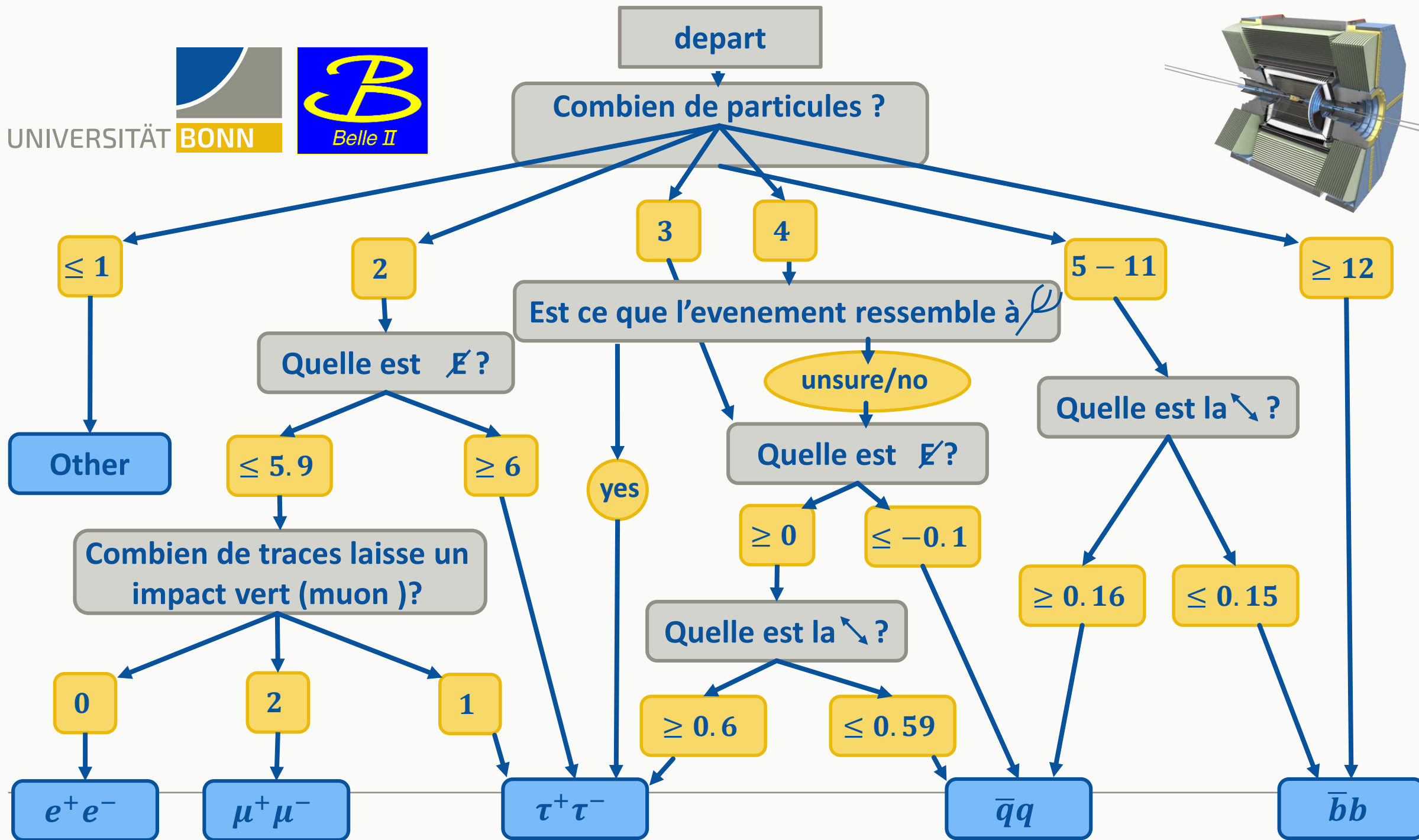
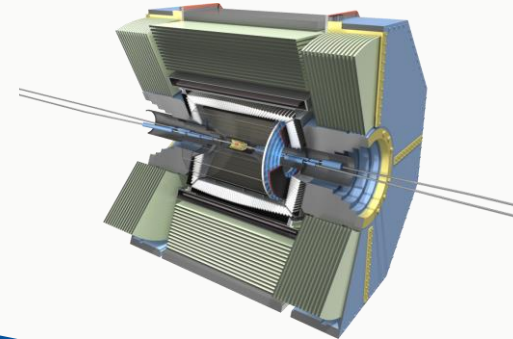


Entre 3 et 11 particules
peu d'énergie manquante
Rectitude faible
Trace dans le détecteur à
muons, parfois

B- anti-b



Plus de 5 particules
énergie manquante
Rectitude très faible
Trace dans le détecteur à
muons, parfois



To do list

<https://belle2.ijs.si/public/home/quark-colors/>

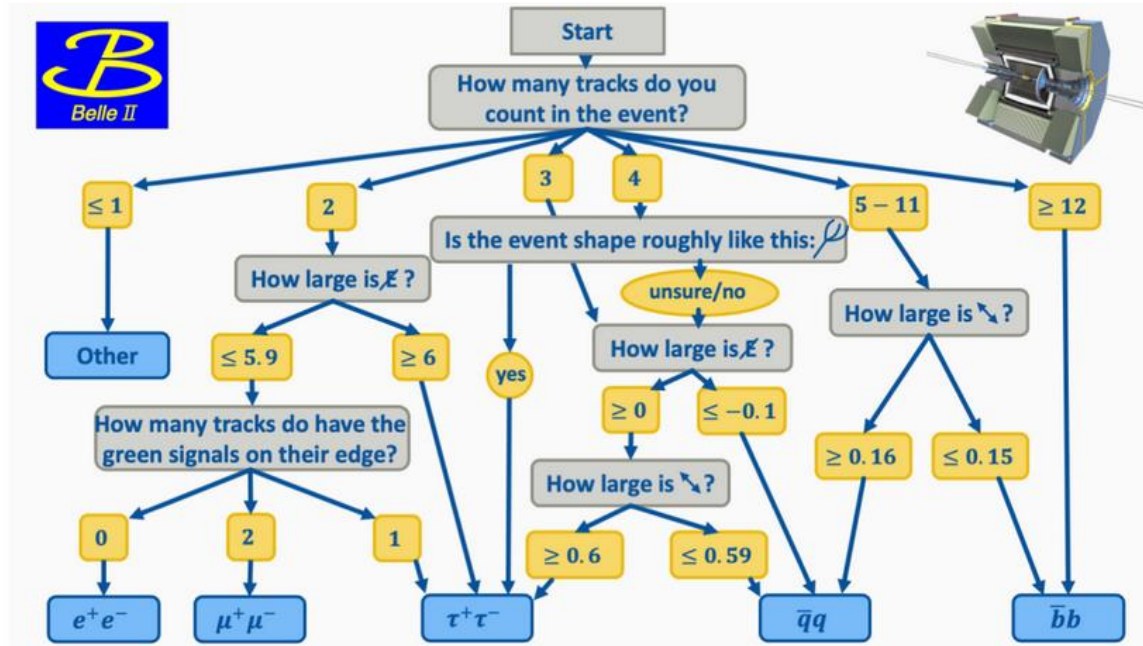
- Exemples events
- Practices task
- Main task: measurement with data from Belle II
 - 50 évènements à classer bar binôme/trinôme (pas obliger de finir mais plus vous en faites, plus le resultat sera précis!)
 - Remplir les resultats ici (pour votre groupe!):
https://docs.google.com/spreadsheets/d/15M_bWh2ggx-vwF-rkCQ0oZTEM7Rle3XricCwkZsTL4g/edit?usp=sharing
On comparera les résultats avec les autres classes

Main Task

Select the data set that the facilitators assigned to you out of the ones linked below. Try to sort all of the 50 events from the set. Like in the practice task, it is helpful to use the event-identification-flowchart for that.

Enter your results into [this table](#).

If you are unsure, take another look at the [example](#)– or [practice events](#) and/or don't hesitate to ask the facilitators.



- [Data set A](#)
- [Data set B](#)
- [Data set C](#)
- [Data set D](#)
- [Data set E](#)
- [Data set F](#)
- [Data set G](#)
- [Data set H](#)
- [Data set I](#)
- [Data set J](#)
- [Data set K](#)

Choisissez le dataset correspondant à votre groupe!



Menus



100%



123

Arial



18



A1:H1

Dataset Q

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Dataset Q																		
2	Event type																		
3	Event	Assigned	ee pair	$\mu\mu$ pair	$\tau\tau$ pair	qq pair	bb pair	Other											
4	1		☐	☐	☐	☐	☐	☐											
5	2		☐	☐	☐	☐	☐	☐											
6	3		☐	☐	☐	☐	☐	☐											
7	4		☐	☐	☐	☐	☐	☐											
8	5		☐	☐	☐	☐	☐	☐											
9	6		☐	☐	☐	☐	☐	☐											
10	7		☐	☐	☐	☐	☐	☐											
11	8		☐	☐	☐	☐	☐	☐											
12	9		☐	☐	☐	☐	☐	☐											
13	10		☐	☐	☐	☐	☐	☐											
14	11		☐	☐	☐	☐	☐	☐											
15	12		☐	☐	☐	☐	☐	☐											
16	13		☐	☐	☐	☐	☐	☐											
17	14		☐	☐	☐	☐	☐	☐											
18	15		☐	☐	☐	☐	☐	☐											
19	16		☐	☐	☐	☐	☐	☐											
20	17		☐	☐	☐	☐	☐	☐											
21	18		☐	☐	☐	☐	☐	☐											
22	19		☐	☐	☐	☐	☐	☐											
23	20		☐	☐	☐	☐	☐	☐											
24	21		☐	☐	☐	☐	☐	☐											
25	22		☐	☐	☐	☐	☐	☐											
26	23		☐	☐	☐	☐	☐	☐											
27	24		☐	☐	☐	☐	☐	☐											
28	25		☐	☐	☐	☐	☐	☐											
29	26		☐	☐	☐	☐	☐	☐											
30	27		☐	☐	☐	☐	☐	☐											
31	28		☐	☐	☐	☐	☐	☐											
32	29		☐	☐	☐	☐	☐	☐											
33	30		☐	☐	☐	☐	☐	☐											
34	31		☐	☐	☐	☐	☐	☐											
35	32		☐	☐	☐	☐	☐	☐											
36	33		☐	☐	☐	☐	☐	☐											
37	34		☐	☐	☐	☐	☐	☐											
38	35		☐	☐	☐	☐	☐	☐											
39	36		☐	☐	☐	☐	☐	☐											
40	37		☐	☐	☐	☐	☐	☐											
41	38		☐	☐	☐	☐	☐	☐											
42	39		☐	☐	☐	☐	☐	☐											
43	40		☐	☐	☐	☐	☐	☐											
44	41		☐	☐	☐	☐	☐	☐											
45	42		☐	☐	☐	☐	☐	☐											
46	43		☐	☐	☐	☐	☐	☐											





HEP2025

MARSEILLE



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11
JULY
2025

EPS-HEP CONFERENCE
07-11 JULY, 2025
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Événements pendant la conférence

Fresque des deux infinis (8-9 juillet 2025)	▼
Exposition photo La frontière de l'intensité : sonder l'inconnu (8-9 juillet 2025)	▼
Speed-Dating Scientifique (8-9 juillet 2025)	▼
Performance Art & Science: 95%, La Danse des Infinis (8 juillet 2025)	▼
Conférence grand public (9 juillet 2025)	▼

<https://dev.ouvreboite.fr/epshep/communication-gp/>