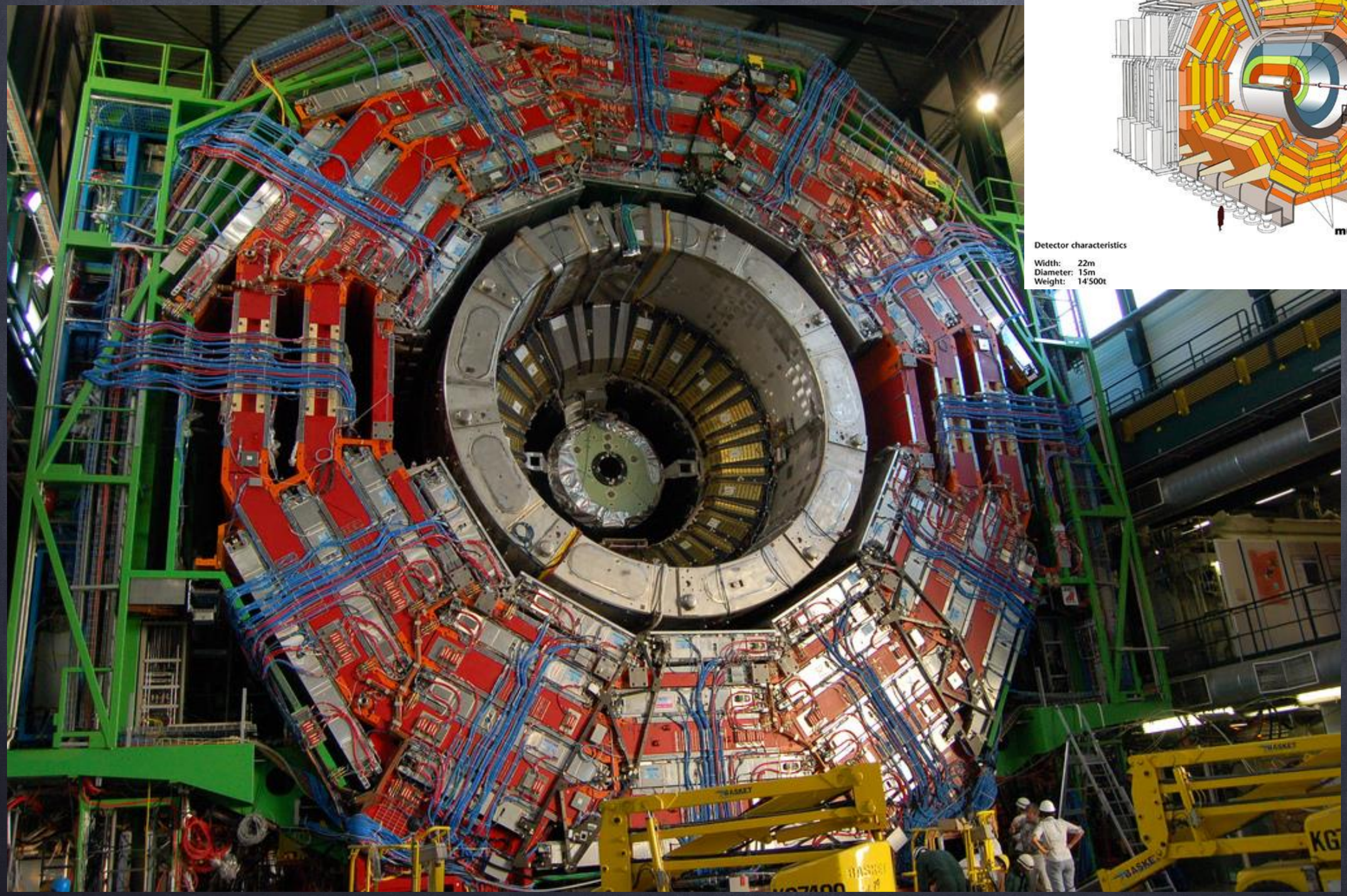
CMS Masterclasses

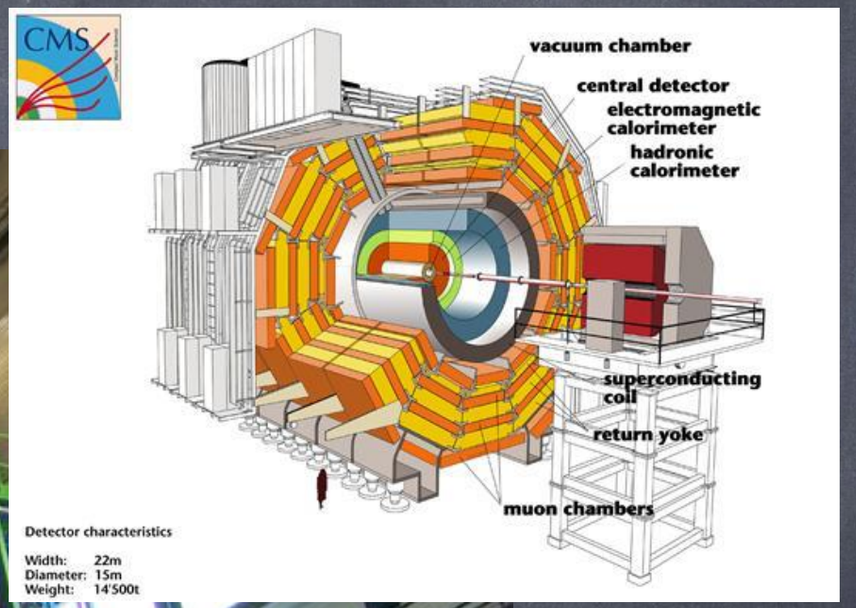
2018

Što ćemo raditi?

- Upoznat ćemo se s metodama detektiranja čestica u CMS eksperimentu.
- Svaki par studenata će analizirati stvarne podatke.
- Prezentacija i diskusija rezultata na videokonferenciji.

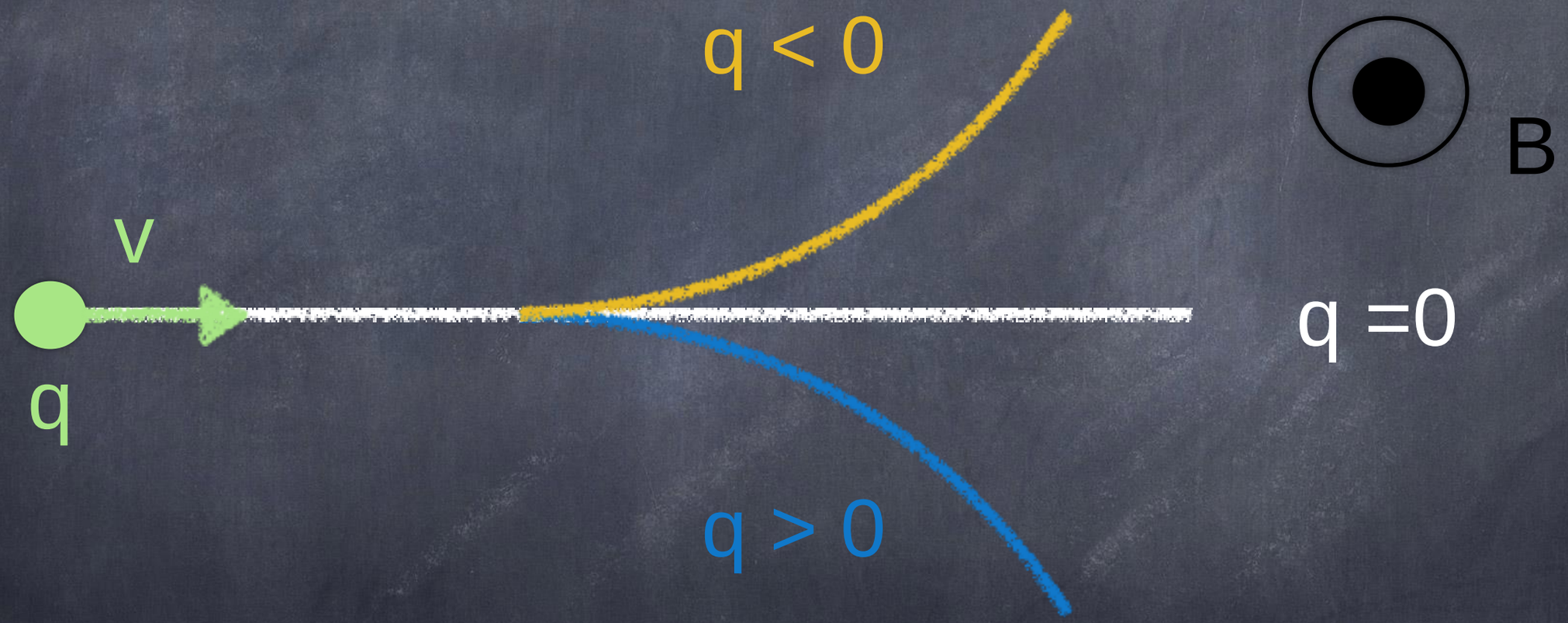
CMS detektor





Zašto je bitno magnetsko polje?

- Lorentzova sila $F = q*vxB$

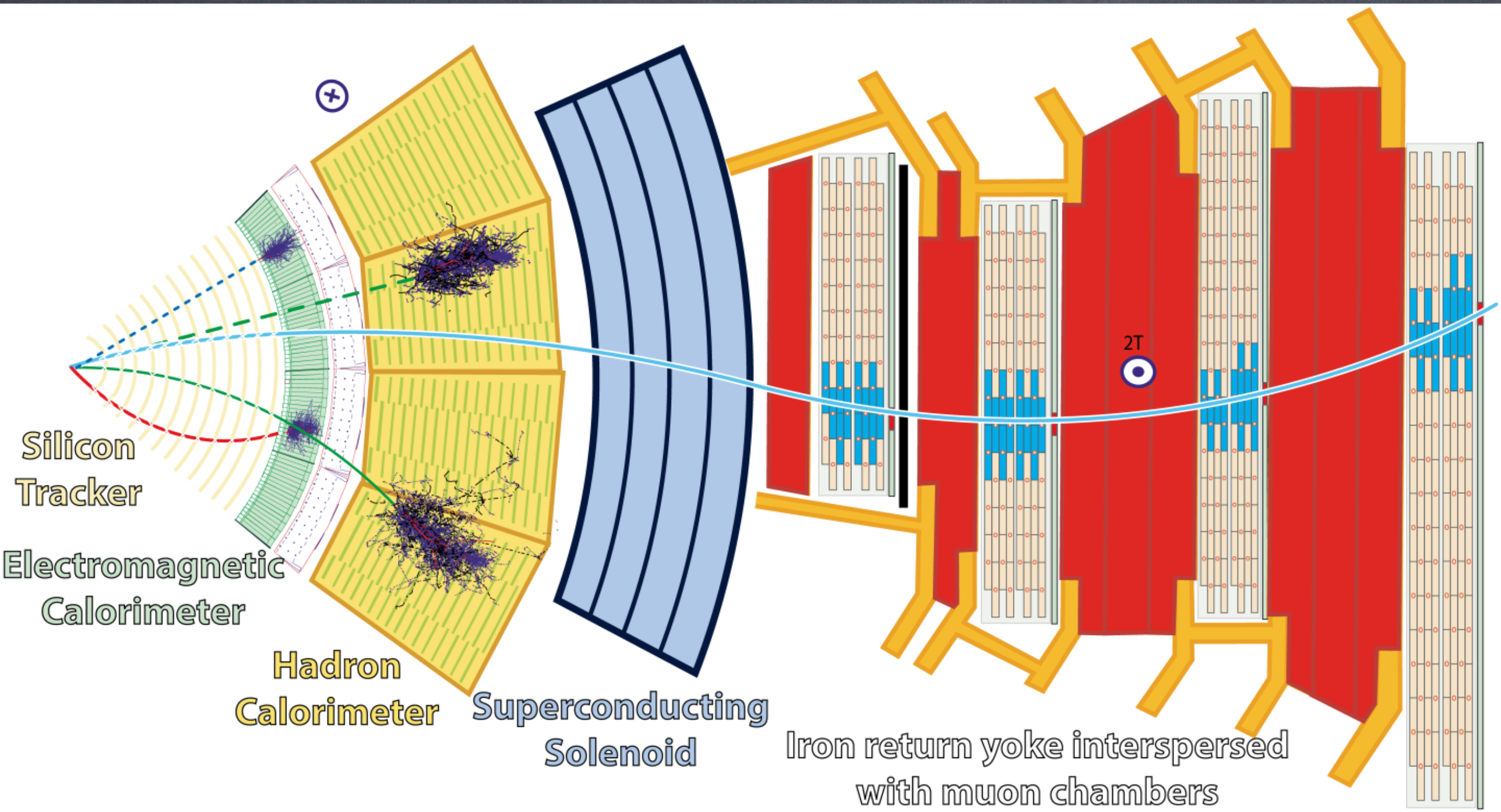


- Predznak naboja čestice određujemo iz smjera zakretanja putanje => $F = q*vxB$

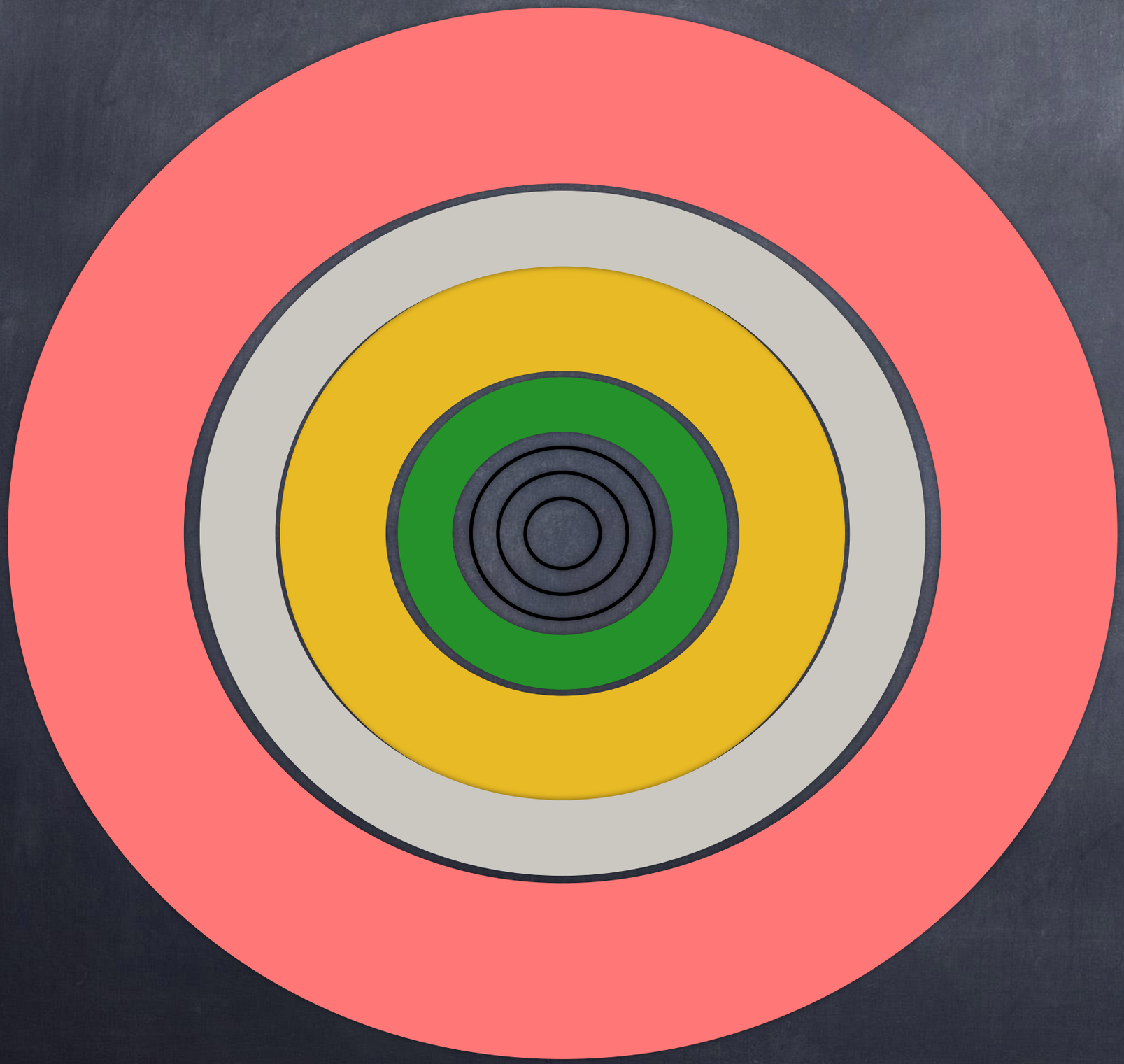
Što ćemo tražiti?

- Elektron (q = +1/-1)
- Mion (q = +1/-1)
- Foton (q = 0)
- Nedostajuća energija (Missing Et)

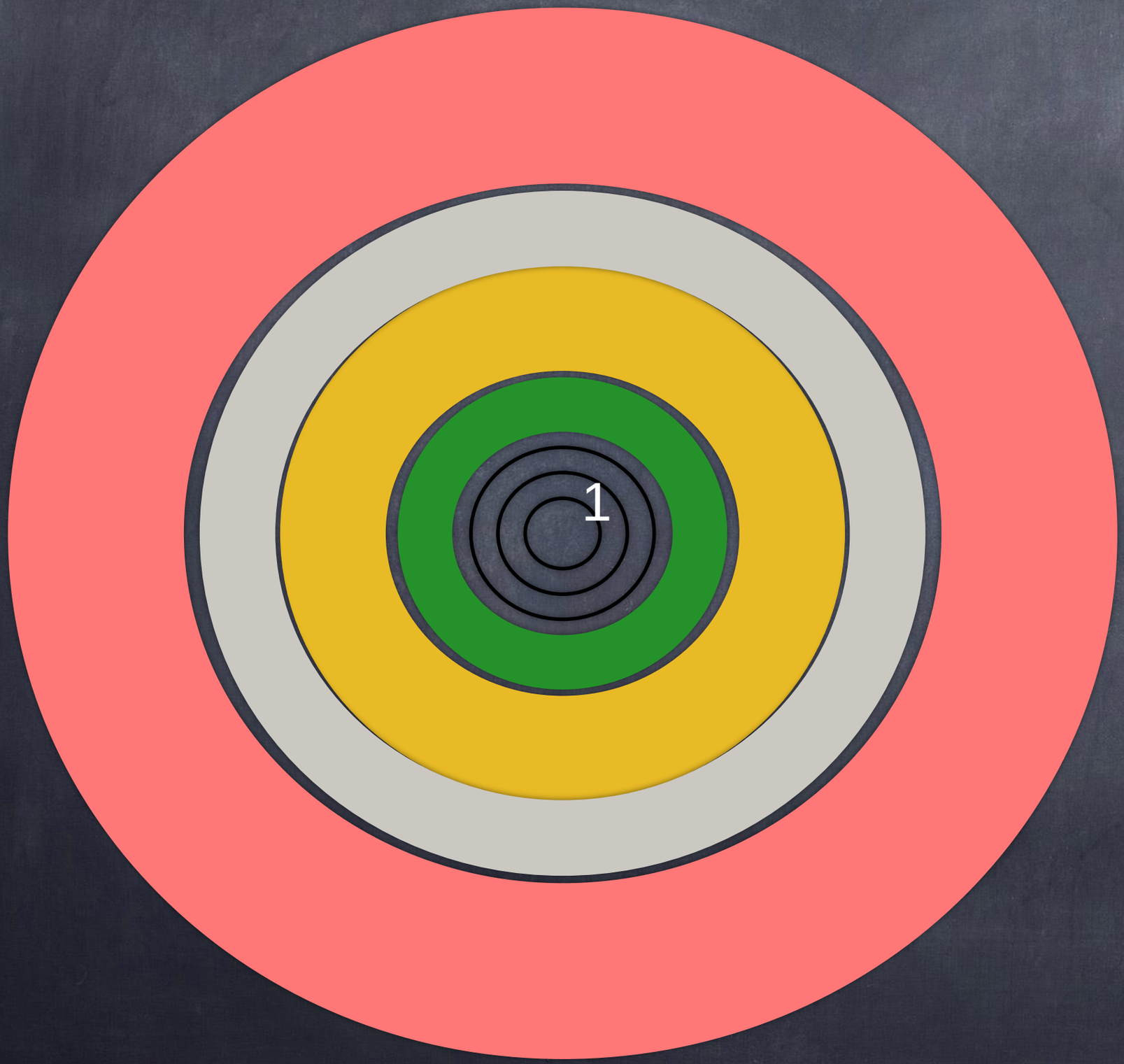
Napomena:
Elektrone (mione) pozitivnog i negativnog naboja mi ovdje suptilno stavljamo u istu kategoriju. Ipak, valja napomenuti kako su to dvije različite vrste čestica !


Silicon Tracker
Electromagnetic Calorimeter
Hadron Calorimeter
Superconducting Solenoid
2T
Iron return yoke interspersed with muon chambers
Muon
Electron
Charged hadron (e.g. pion)
Neutral hadron (e.g. neutron)
Photon

Skica CMS detektora

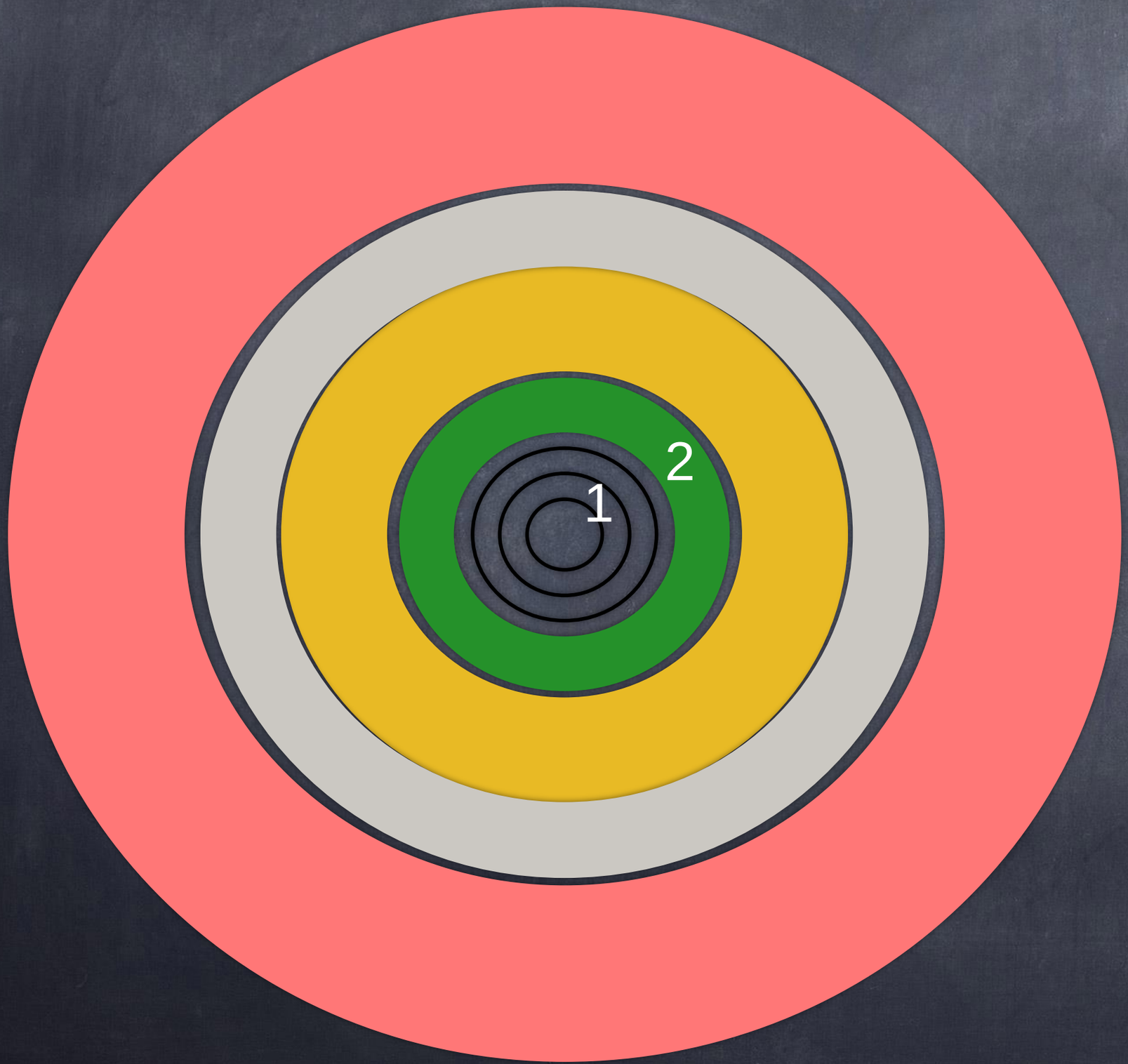


Skica CMS detektora



1. Tracker: Osjetljiv na nabijene čestice, određujemo putanju.

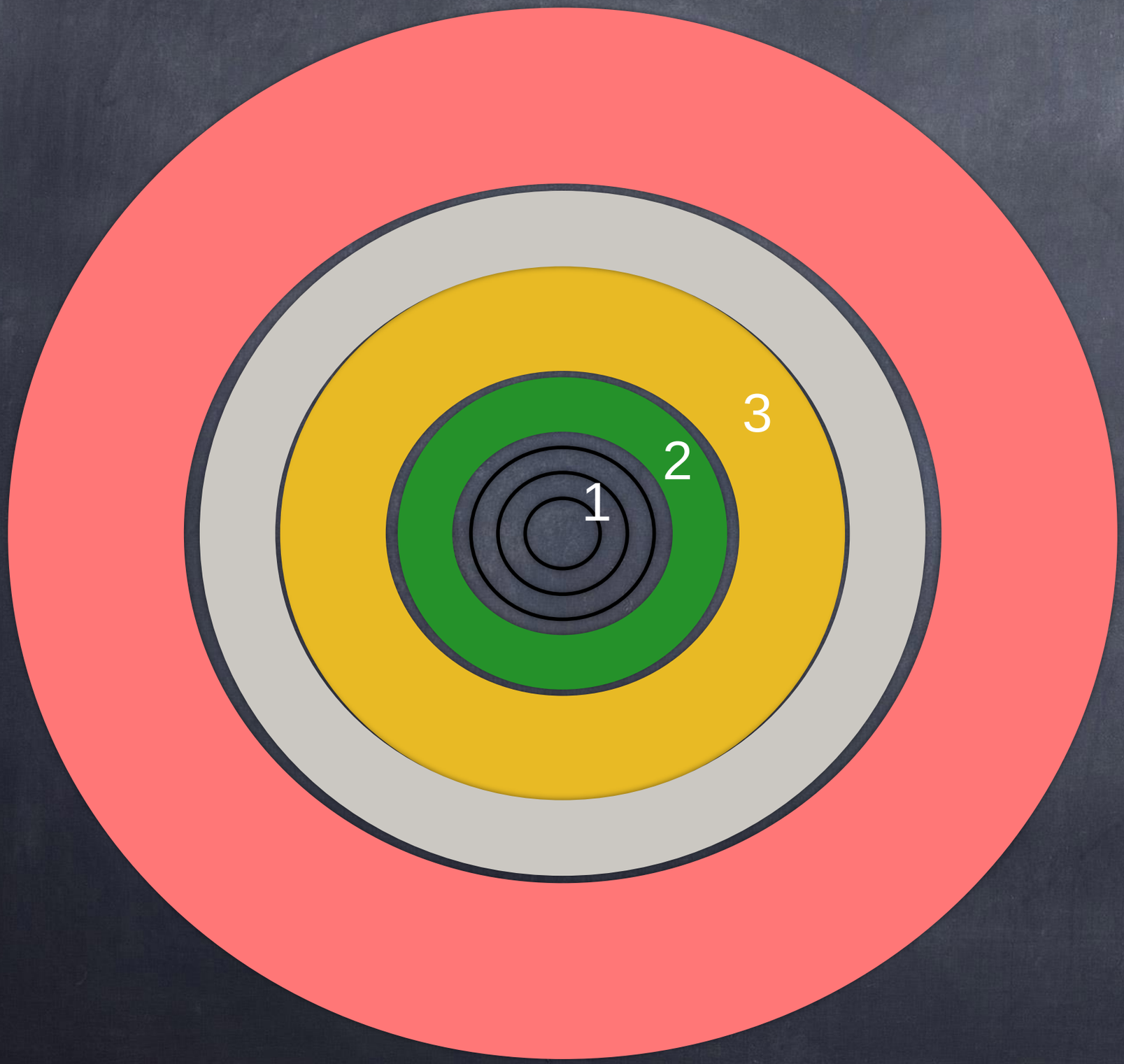
Skica CMS detektora



1. Tracker: Osjetljiv na nabijene čestice, određujemo putanju.

2. EM kalorimetar: Mjerimo energiju elektrona i fotona

Skica CMS detektora

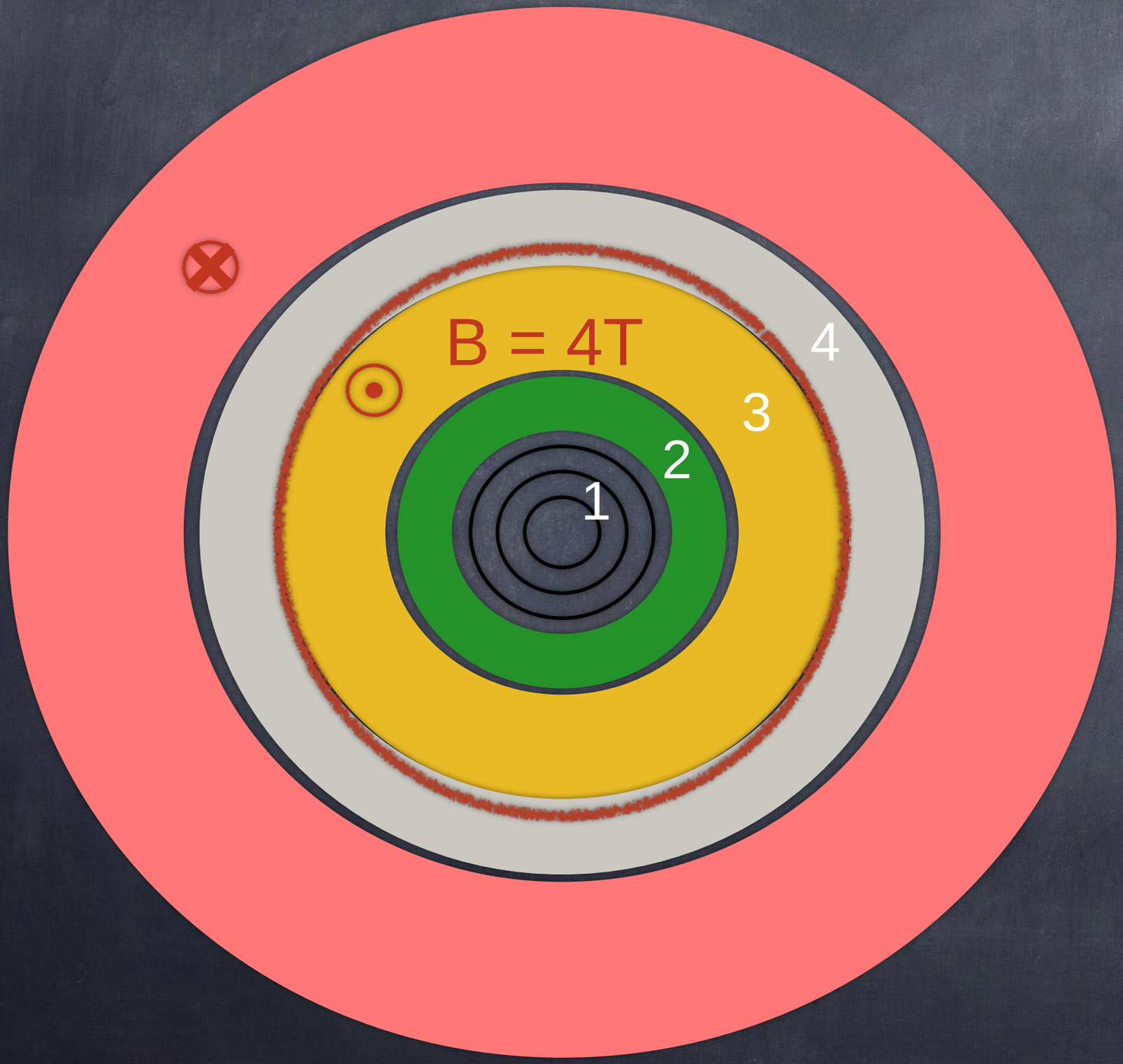


1. Tracker: Osjetljiv na nabijene čestice, određujemo putanju.

2. EM kalorimetar: Mjerimo energiju elektrona i fotona

3. Hadronski kalorimetar: Mjerimo energiju hadrona

Skica CMS detektora



1. Tracker: Osjetljiv na nabijene čestice, određujemo putanju.

2. EM kalorimetar: Mjerimo energiju elektrona i fotona

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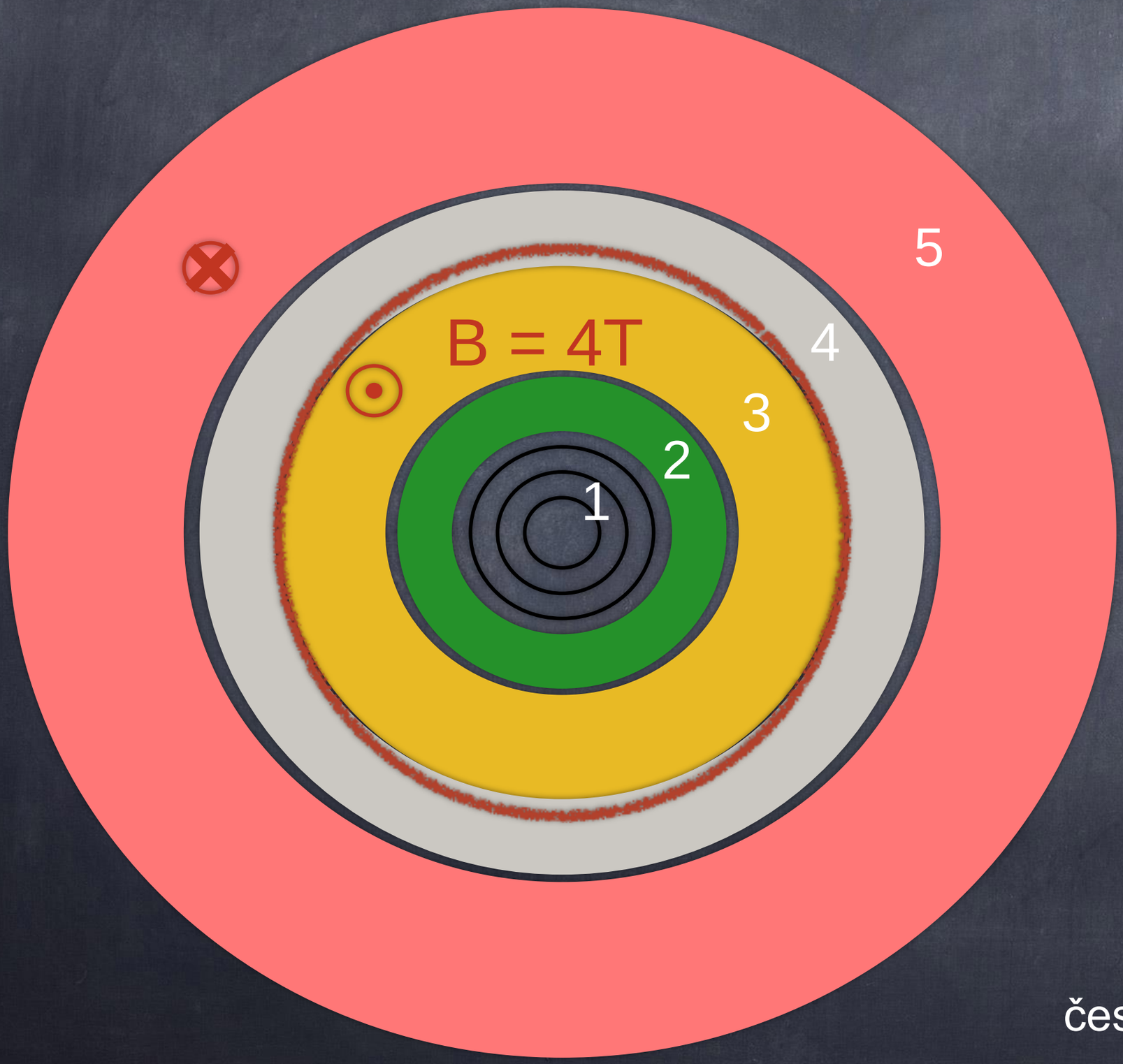
4. Zavojnica
Stvara magnetsko polje

Skica CMS detektora



1. Tracker: Osjetljiv na nabijene čestice, određujemo putanju.

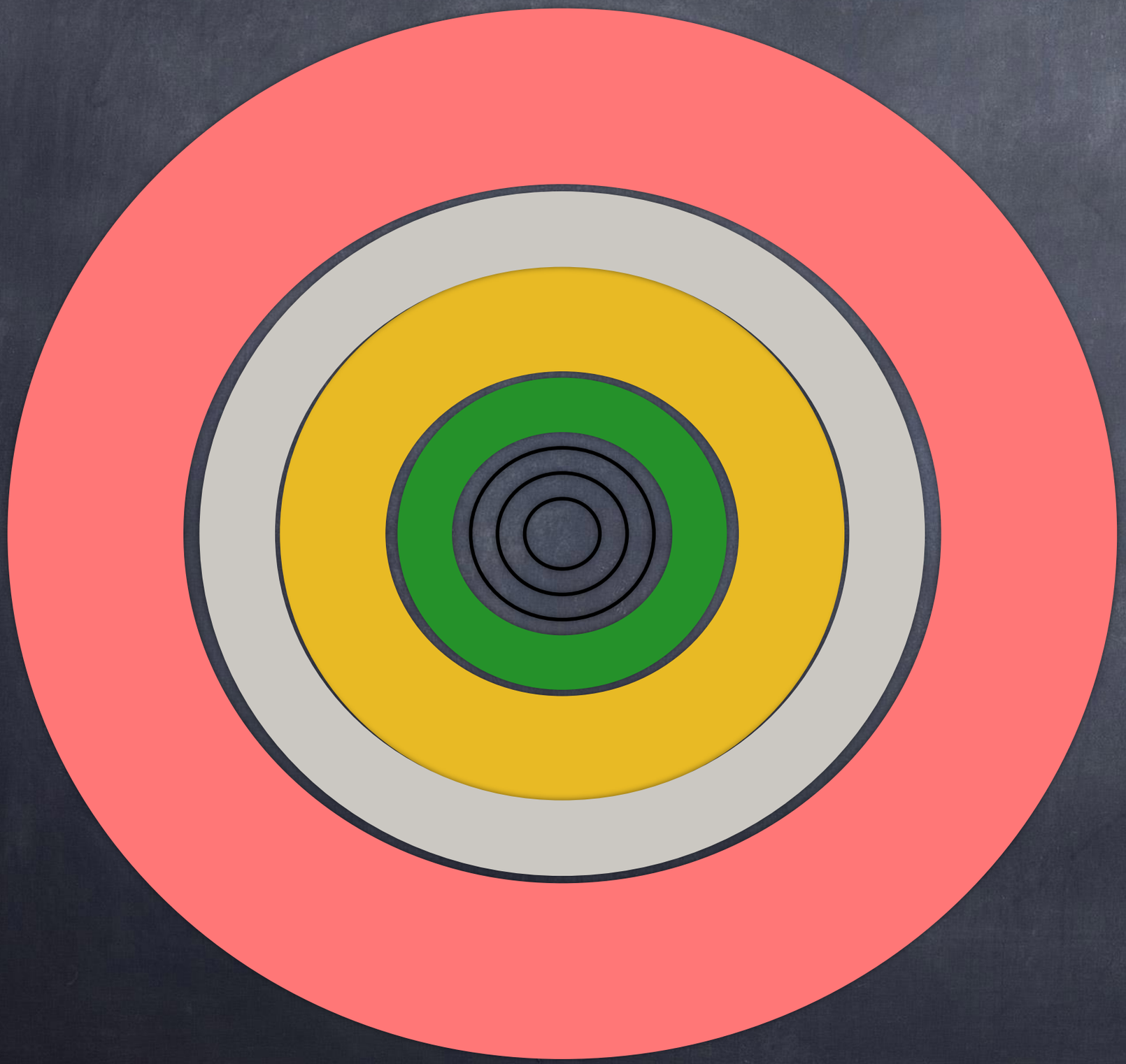
2. EM kalorimetar: Mjerimo energiju elektrona i fotona

3. Hadronski kalorimetar: Mjerimo energiju hadrona

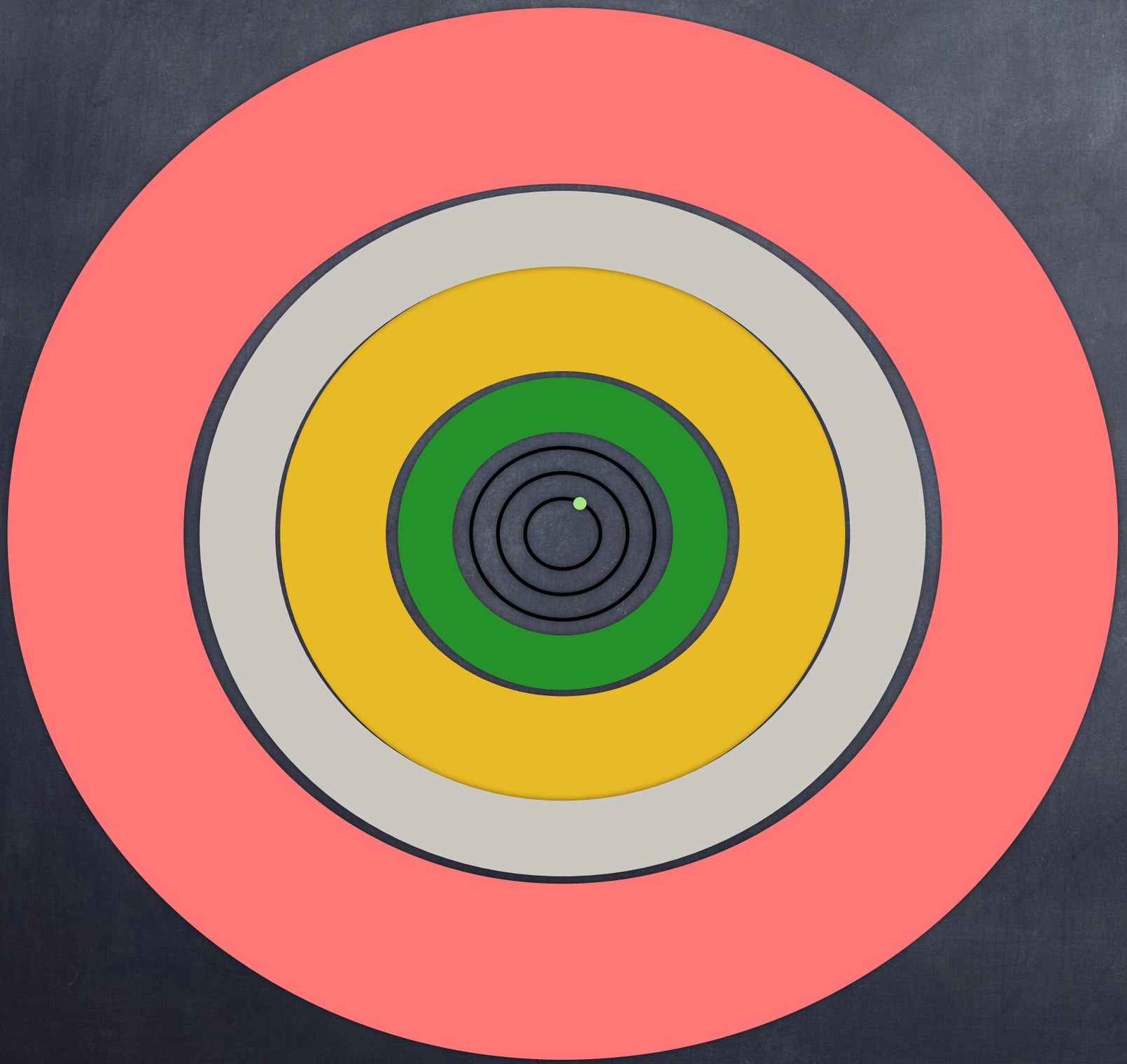
4. Zavojnica
Stvara magnetsko polje

5. Mionske komore:
Osjetljive na nabijene čestice, dopiru “samo” mioni

Elektron

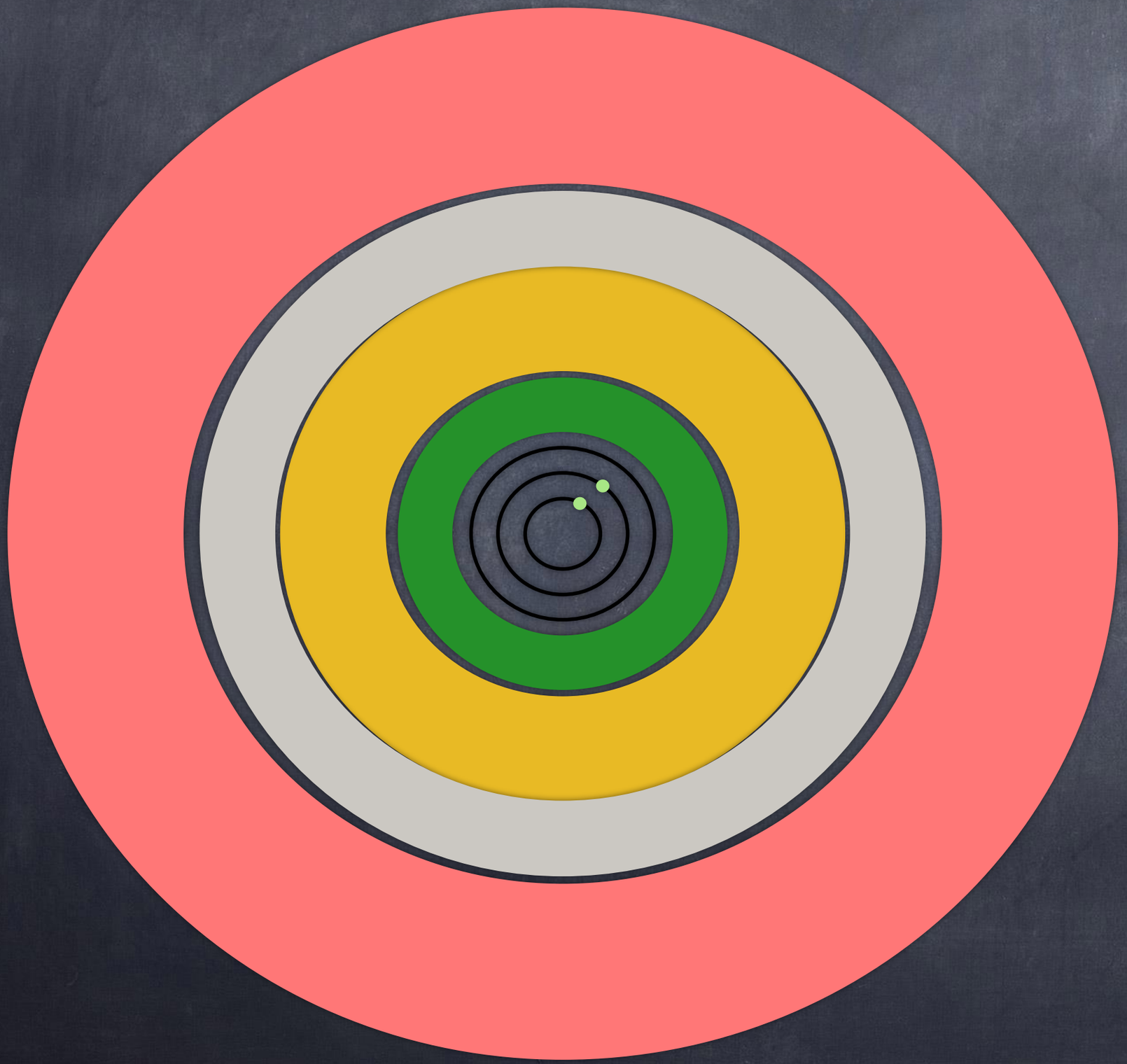


Elektron



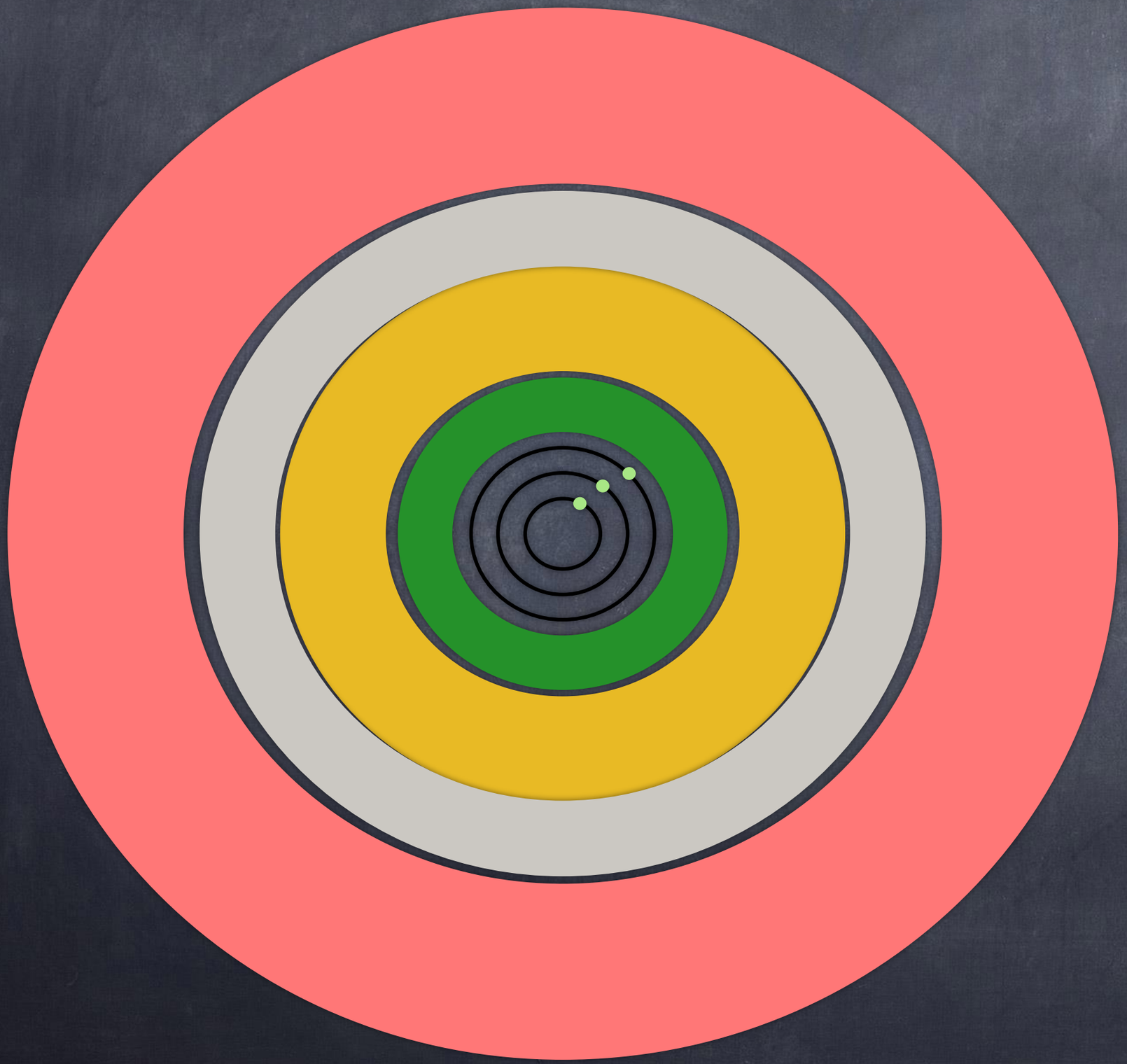
Elektron je nabijena čestica te ostavlja trag u trackeru.

Elektron



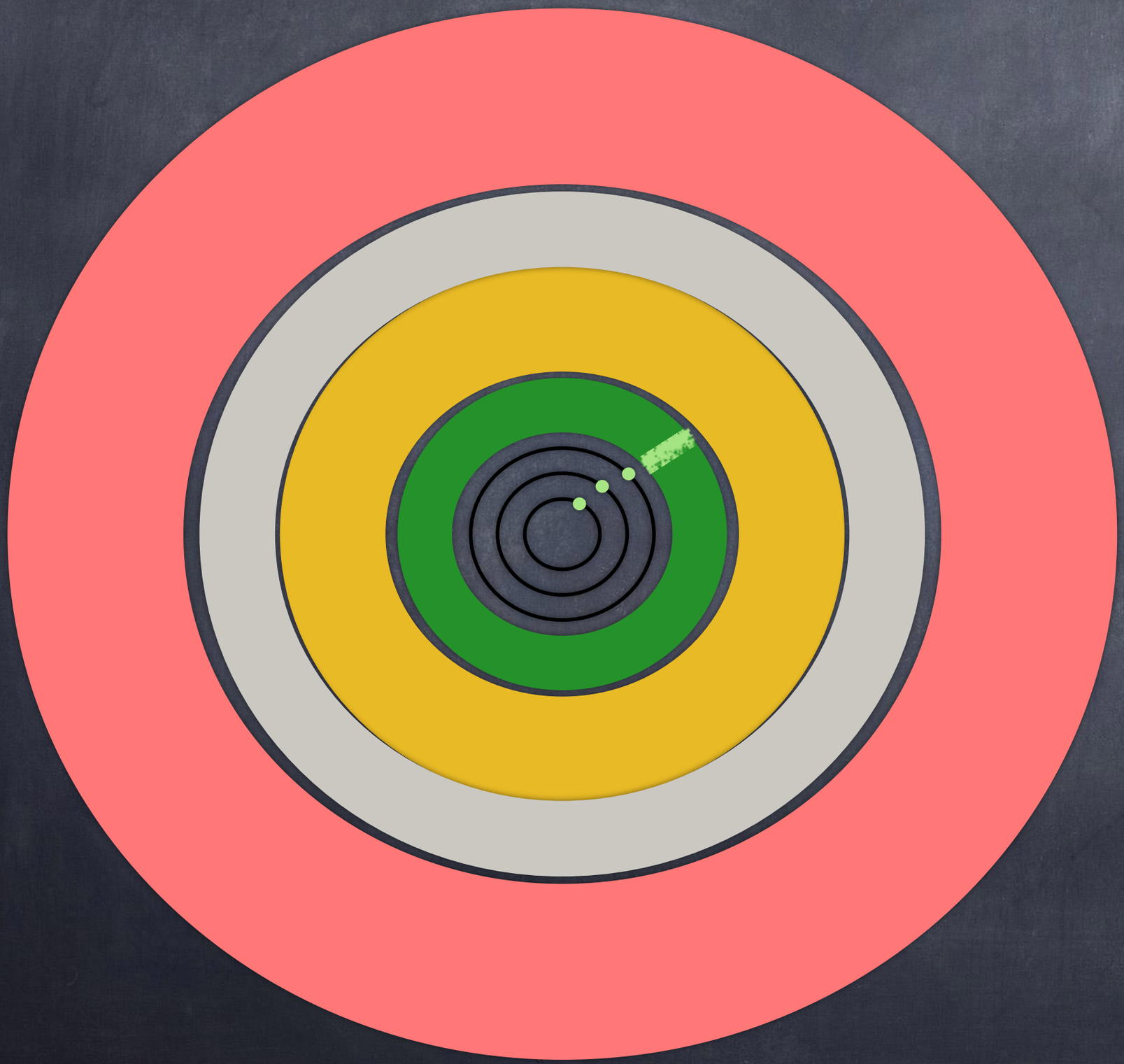
Elektron je nabijena čestica te ostavlja trag u trackeru.

Elektron



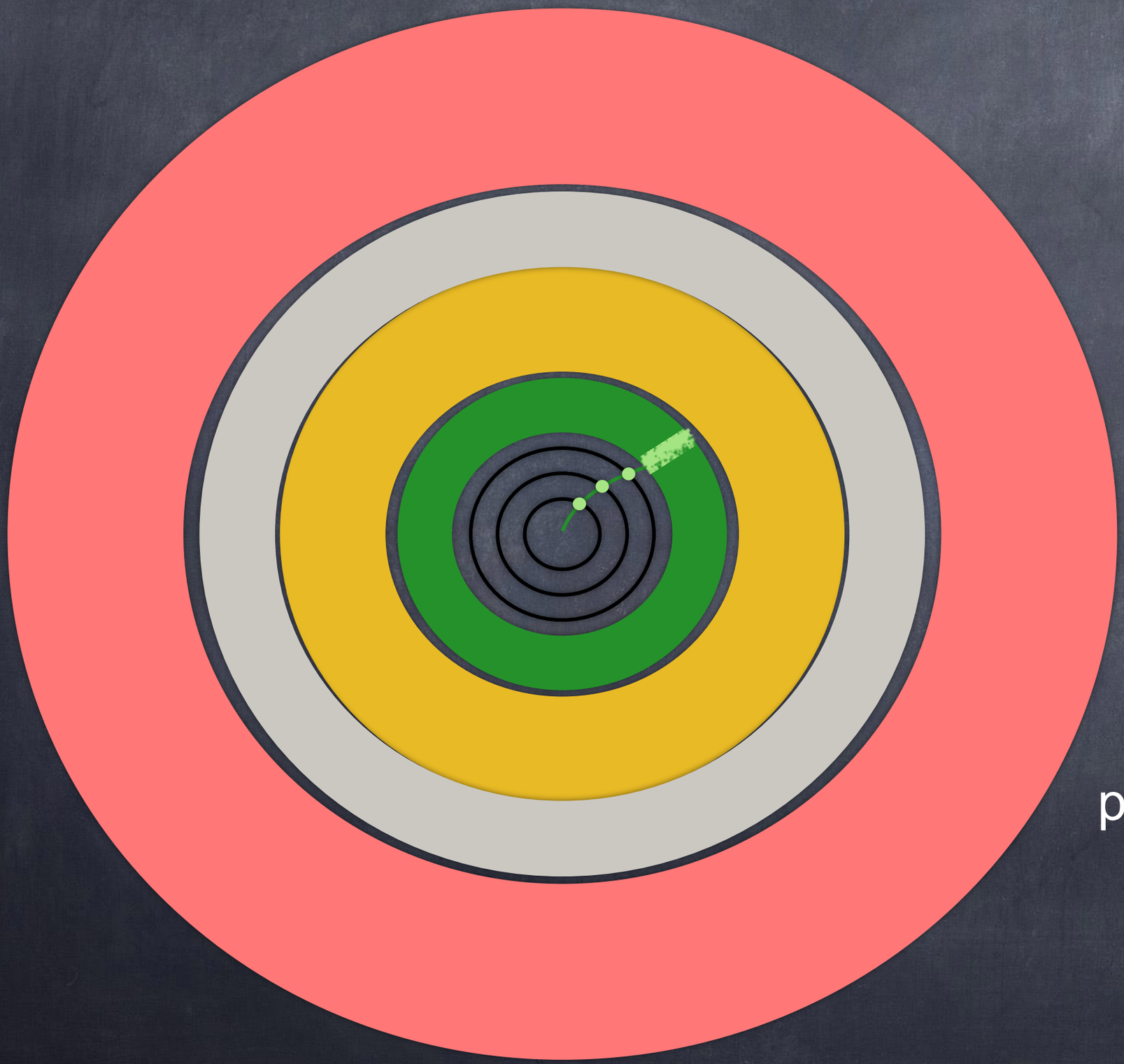
Elektron je nabijena čestica te ostavlja trag u trackeru.

Elektron



Elektron ostavlja svoju energiju u elektromagnetskom kalorimetru.

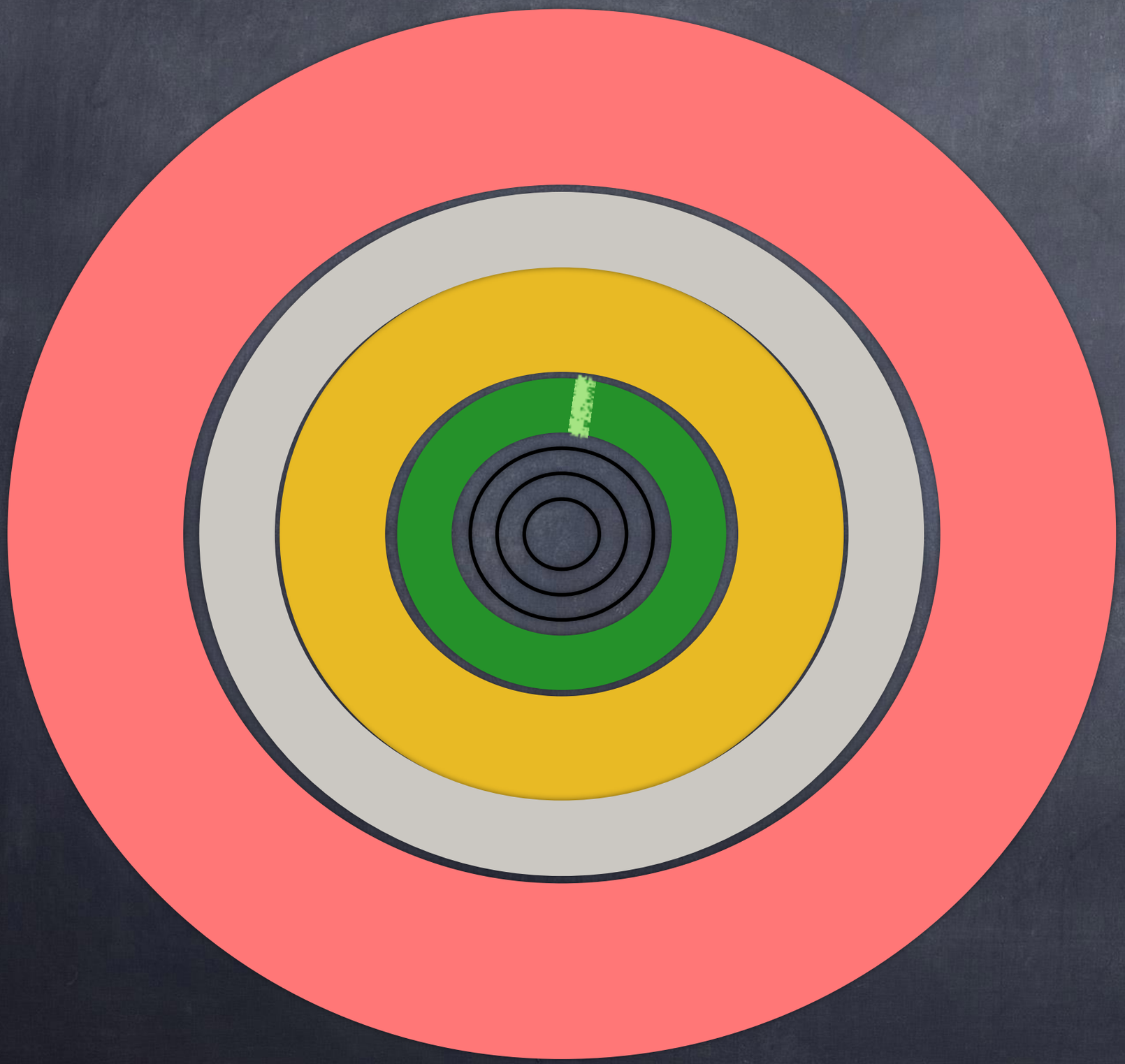
Elektron



Na temelju informacija iz detektora, korištenjem posebnih algoritama rekonstruiramo elektron.

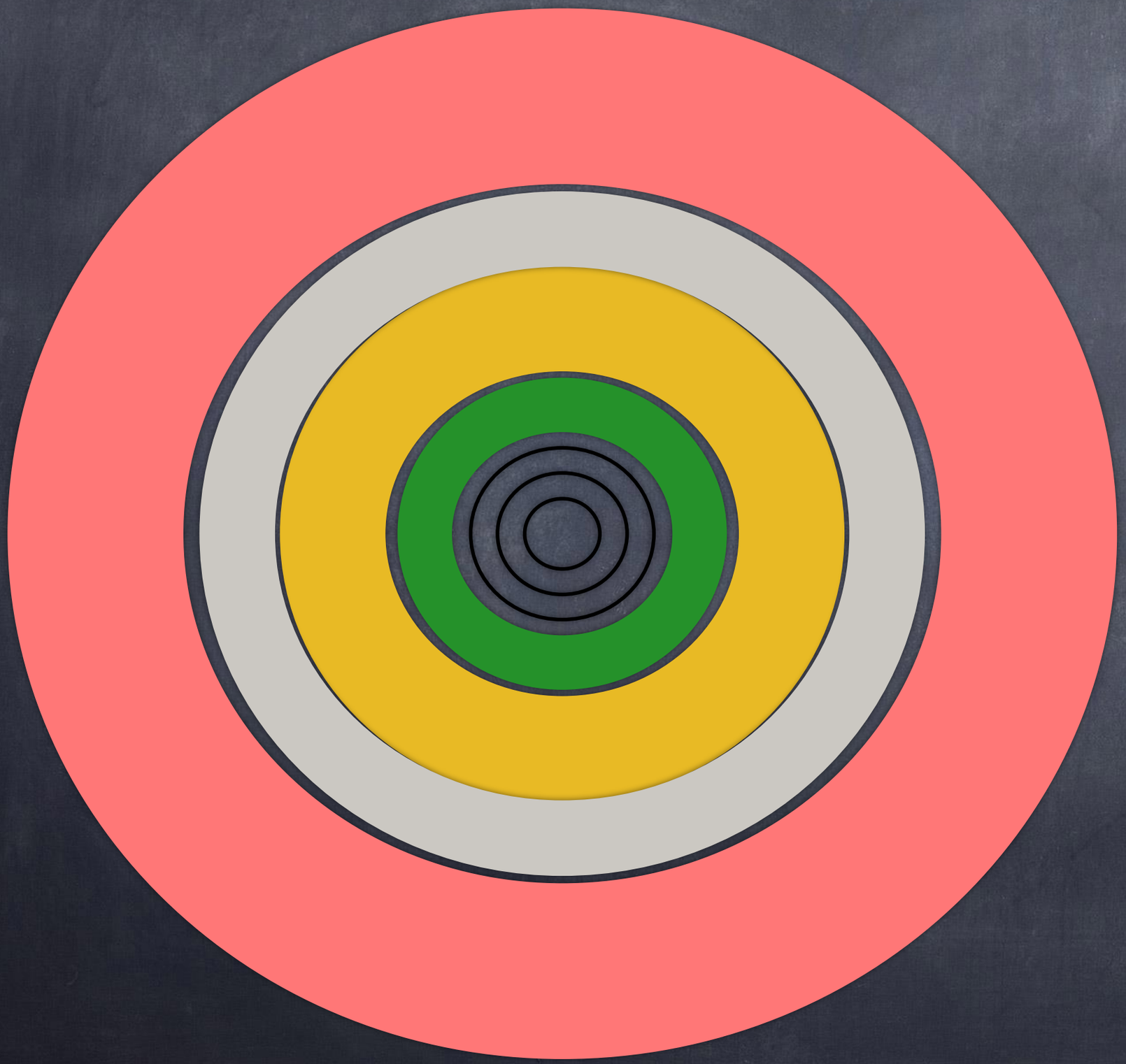
U ovom primjeru je putanja čestice zakrenuta u smjeru kazaljke na satu.
Stoga, q = +1.

Foton

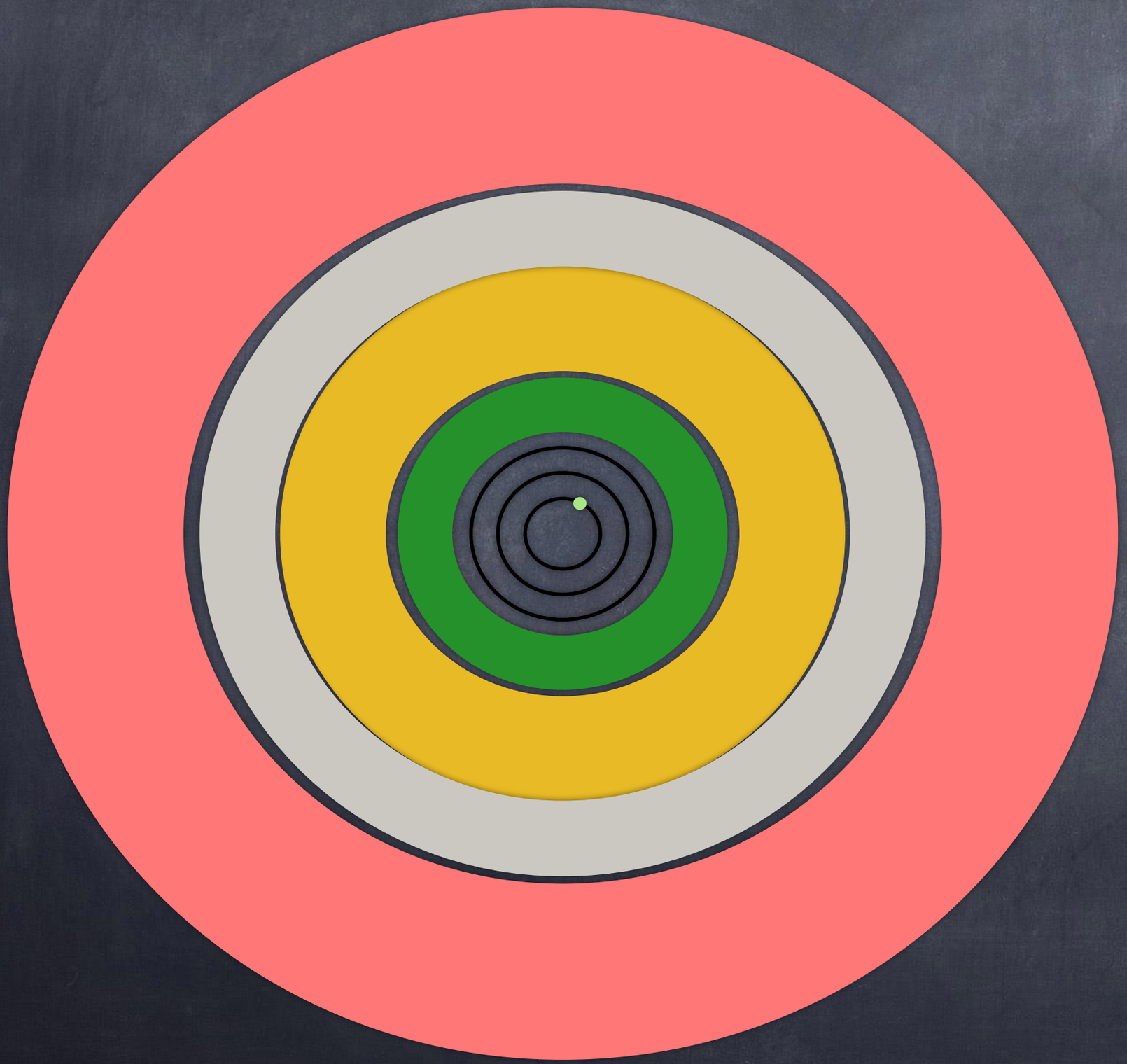


Foton nije nabijena čestica te ne ostavlja trag u trackeru već svoju energiju ostavlja u EM kalorimetru.

Mion



Mion



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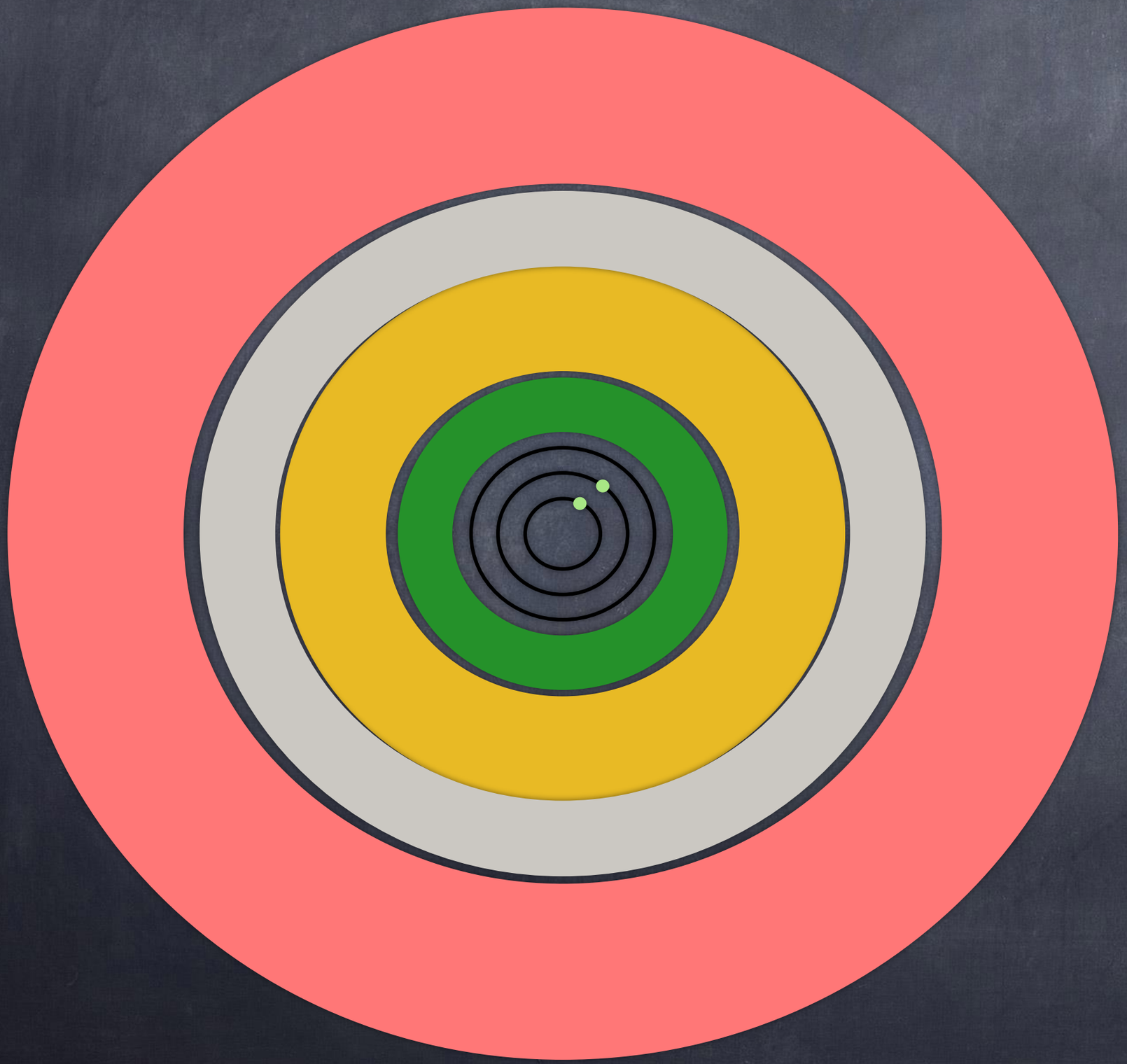
Mion



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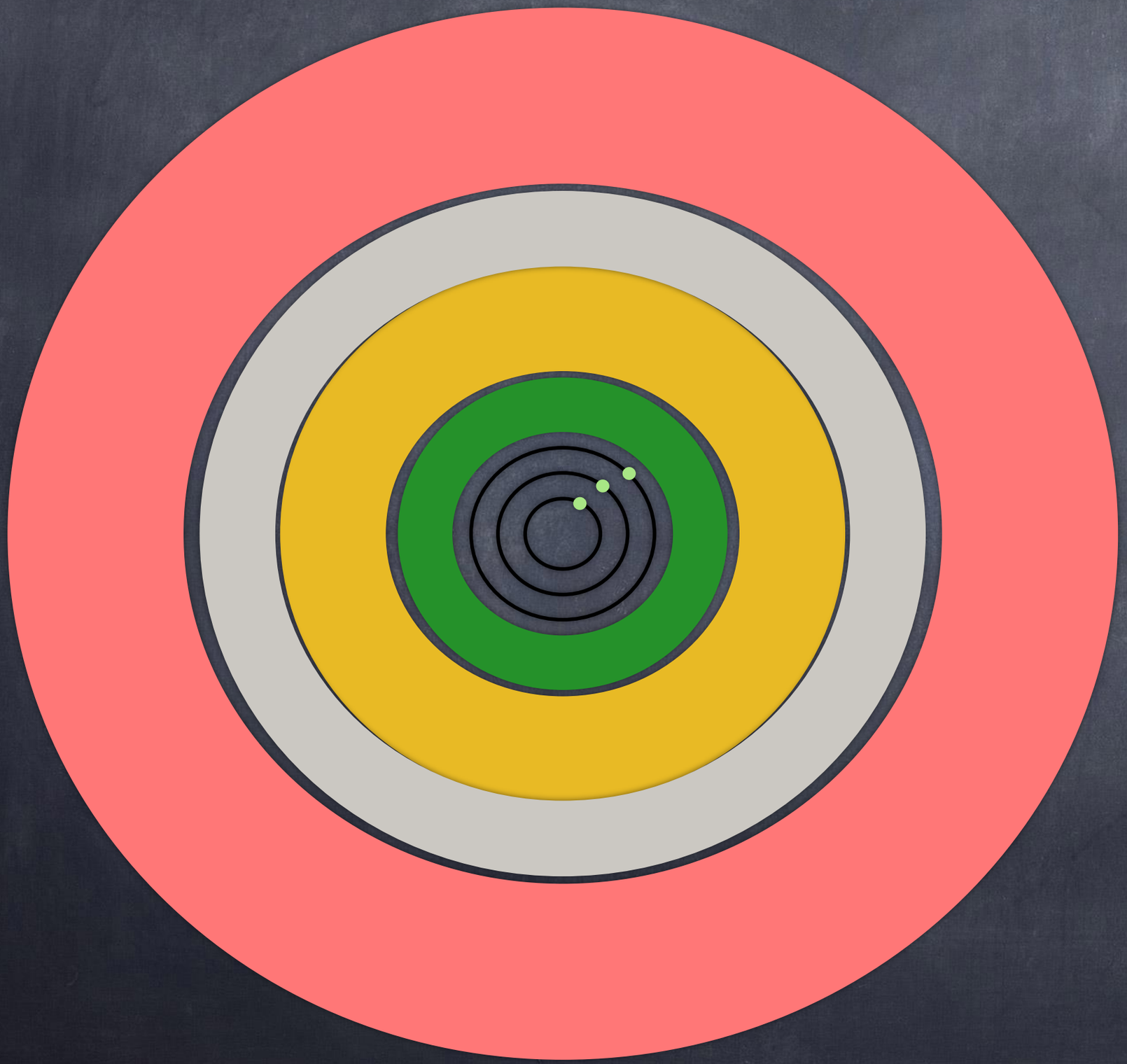
Mion



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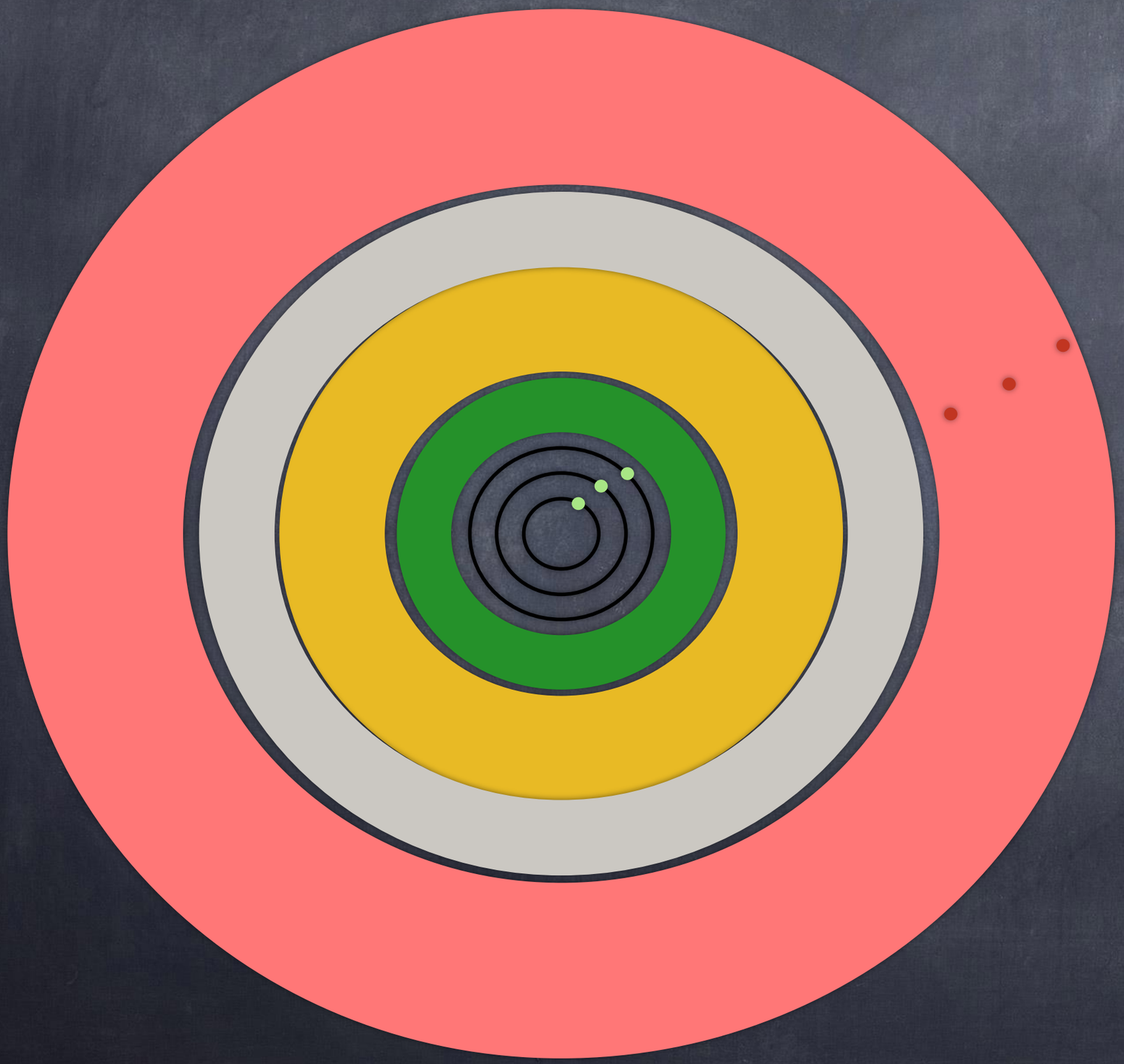
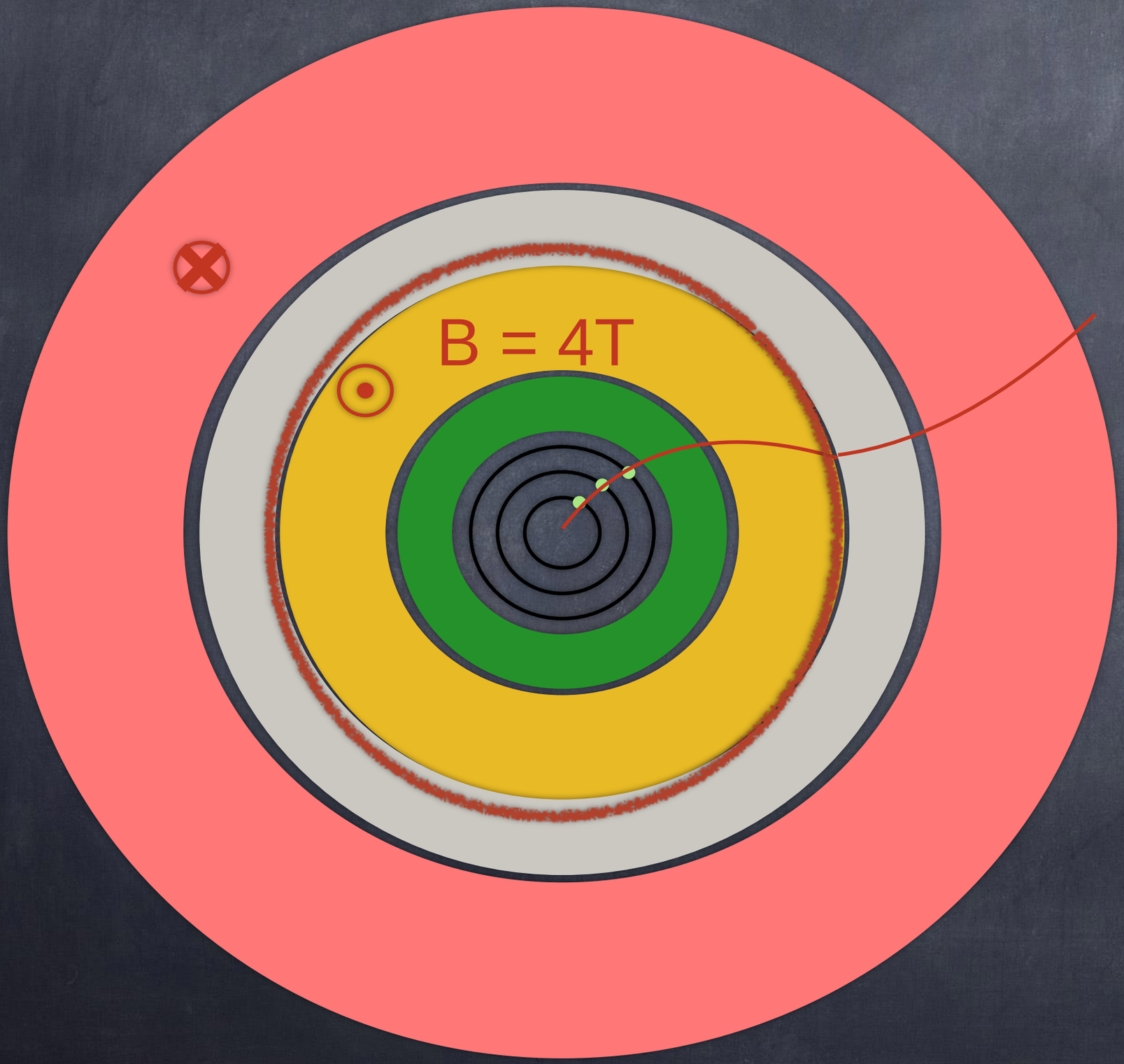
Mion



Mion ostavlja trag u mionskim komorama.

Mion



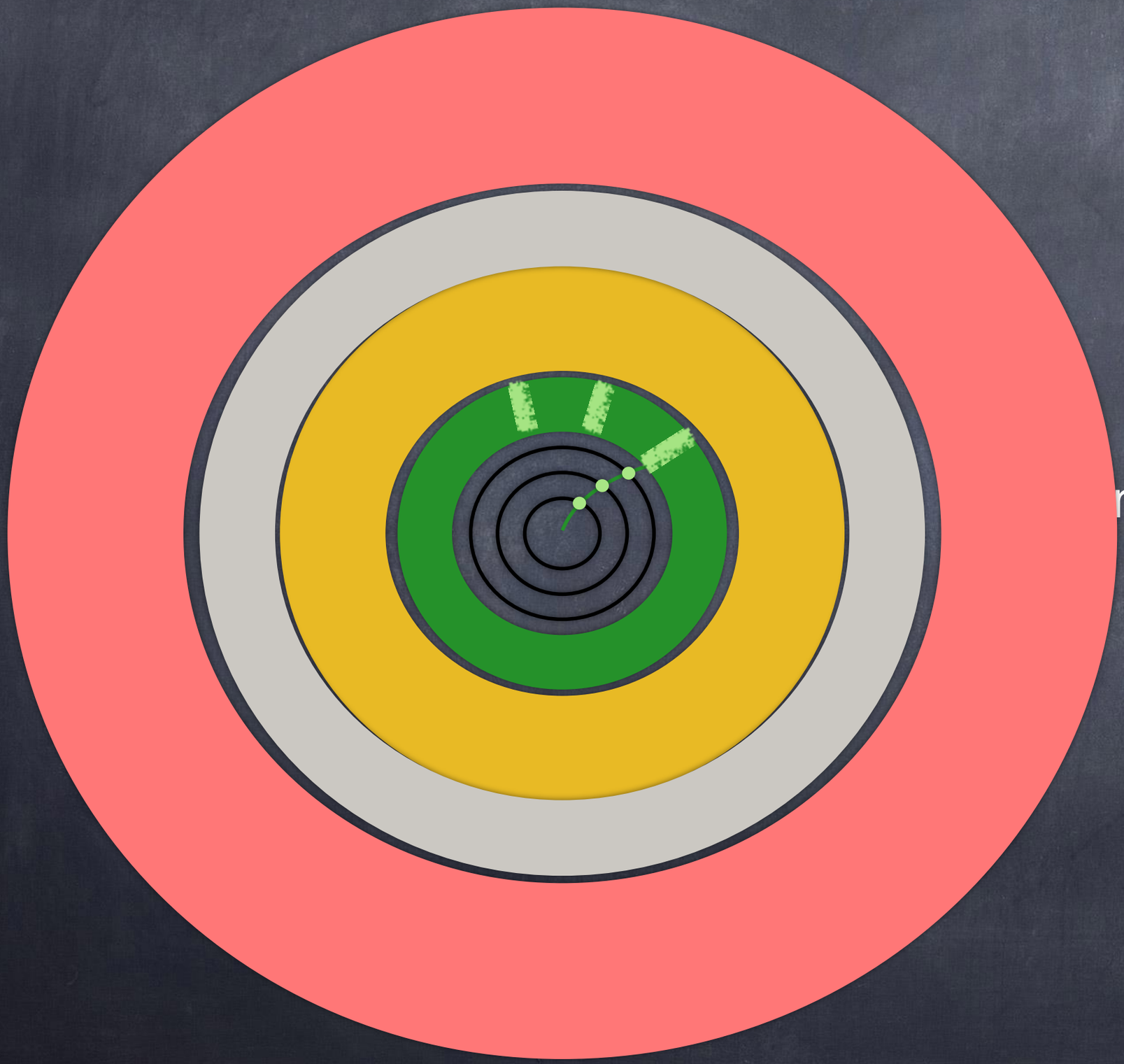
Na temelju informacija iz detektora, korištenjem posebnih algoritama rekonstruiramo mion.

U ovom primjeru je putanja čestice zakrenuta u smjeru kazaljke na satu.
(unutar zavojnice)
Stoga, q = +1.

Nedostajuća energija (Missing Et)

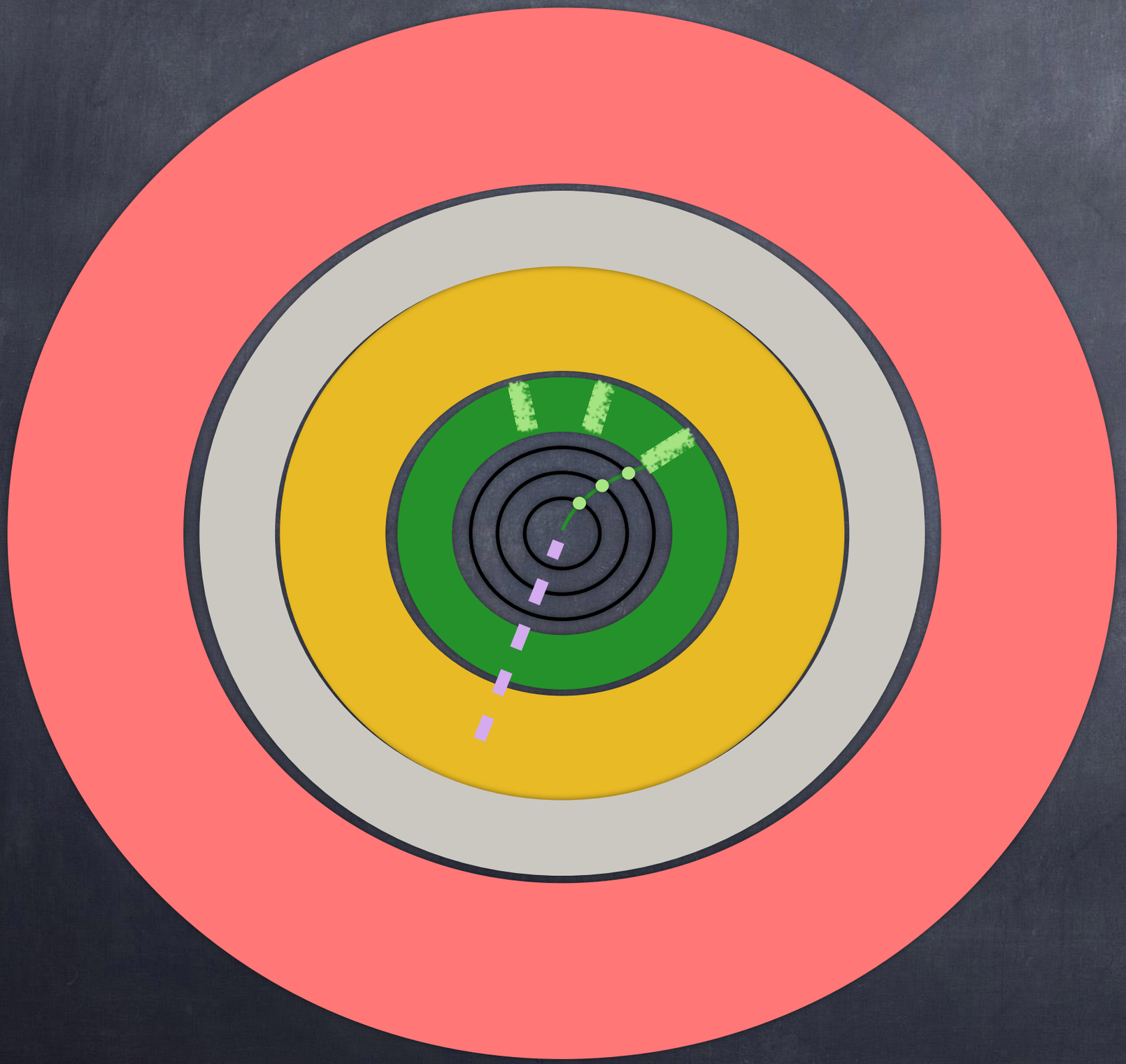
- Što nam zakon očuvanja impulsa kaže o slikama vatrometa ?
- Što kada se ovakva situacija s gornje slike dogodi u detektoru?

Nedostajuća energija



Zakon očuvanja impulsa nam govori kako očito nešto nedostaje u donjem dijelu detektora !

Nedostajuća energija

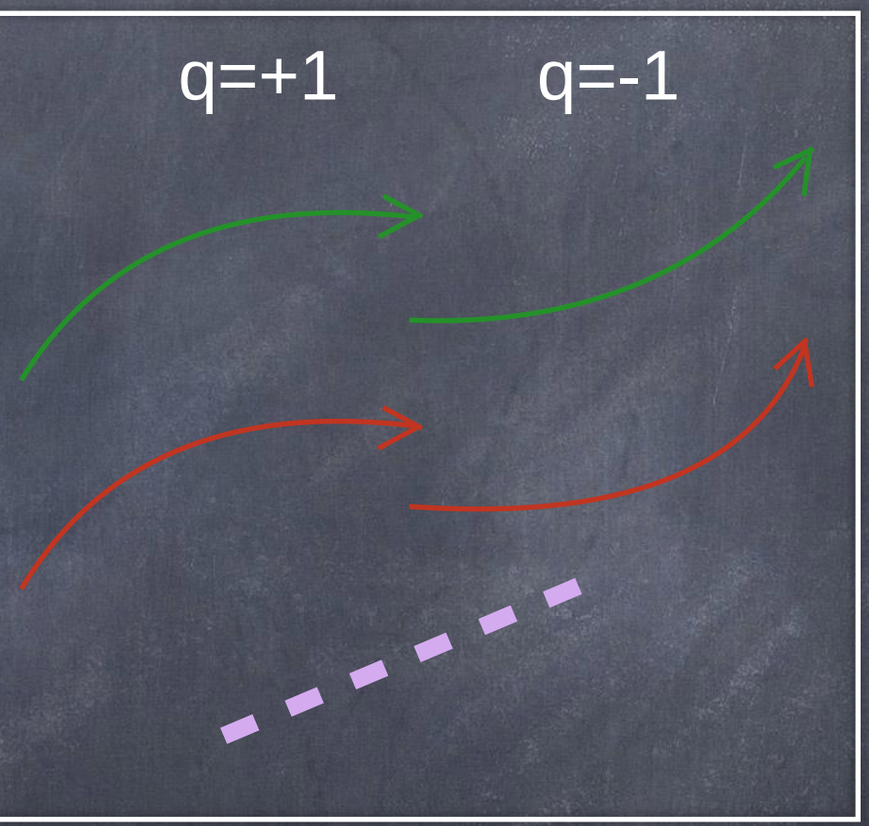


Moguće objašnjenje?
Čestica koja uopće ne interagira s našim detektorom
= neutrino ν!

Prema zakonu očuvanja impulsa izračunava se nedostajući impuls, “Missing Et”.

Sažetak

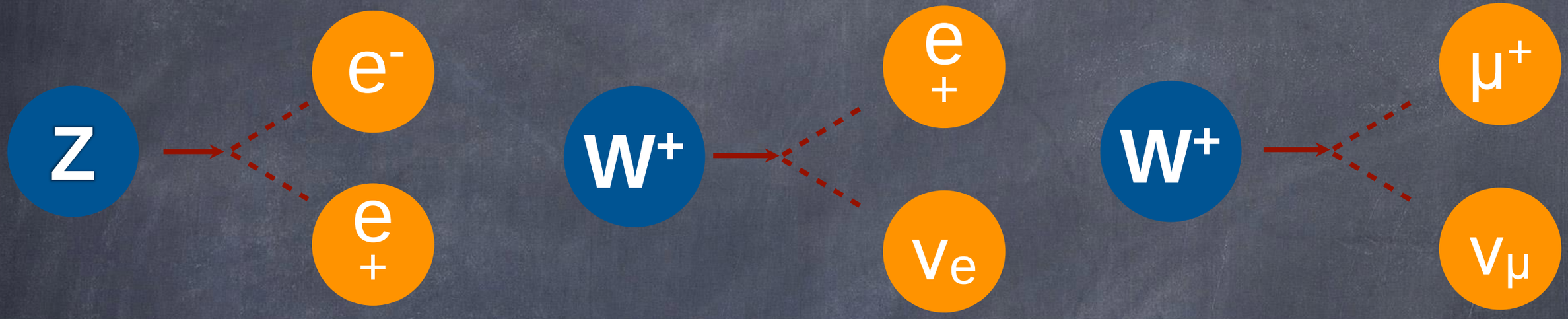
- Elektron
- Mion
- Missing Et

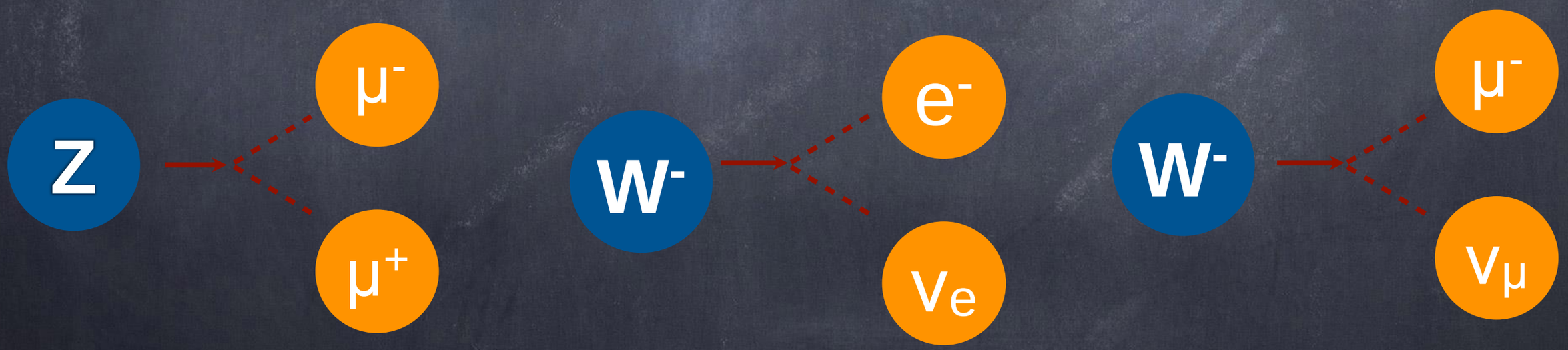


Zašto mjeriti baš elektrone, mione, nedostajuću energiju, fotone, …?

- Čestice poput Higgsovog bozona, W bozona, Z bozona nije moguće direktno mjeriti te nam jedino preostaje tražiti rezultate njihovog raspada, a to su elektroni, mioni, neutrini, fotoni …
- Vrijeme života Higssovog bozona:0.000000000000000000000016 s

Raspadi koje tražimo





Raspadi koje tražimo

Napomena:
Postoji još mnoštvo procesa/raspada u okviru Standardnog modela koje ovdje nismo spomenuli. Neke od njih ćete tijekom vježbe možda i susresti, međutim mi ih nećemo analizirati.

Uključite računala!

1

Otvorite link https://goo.gl/8rDQbh

CIMA

CMS Instrument for Masterclass Analysis

RWTH AACHEN UNIVERSITY

UNIVERSITY OF NOTRE DAME

2. Odaberite.

3. Odaberite.

Choose your location	Choose your group
Budapest2018A	81
Genova2018A	82
Lyon2018A	83
Manila2018A	84
Perugia2018A	85
	86
	87
	88
	89
	90
	91
	92
	93
	94
	95
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	98
	99
	100

imn/lk
LasMatas-28Oct20
DürenJan2018
Budapest-07
PracticeTables-IMC2
IDWGS-12Feb201
CERN-10Feb2018
Roma-22Feb2018
CERN-19Feb2018
CERN-20Feb2018
CERN-22Feb2018
CERN-28Feb2018
CERN-02Mar2018
CERN-06Mar2018
CERN-08Mar2018
CERN-14Mar2018
CERN-19Mar2018
CERN-23Mar2018
CERN-26Mar2018
DürenFeb18
DürenMärz18

4

Odaberite broj svoje grupe.

CMS

ELT

INTERNATIONAL MASTERCLASSES
hands on particle physics

QuarkNet

International Particle Physics Outreach Group

Back | Events Table (Group 81) | Mass Histogram (Manila2018A) | Results (Manil | Event Display

Masterclass: CERN-06Mar2018
location: Manila2018A
Group: 81

Instructions (also available as screencast):

1. For each event, identify the final state and select a primary stat
   - For Higgs or Zoo candidate, no final state is chosen
   - If you cannot decide between W+ and W-, choose W instead
2. If you think the final state is a neutral particle (like a Z), but you don't know its exact type, select NP for "neutral particle." Find its mass from the Event Display and enter it.
3. Once you have selected everything, click "Submit".

In case of an error, double clicking the data line will reload it; you can then try it again.

Select Event
Event index: 1
Event number: 81-1

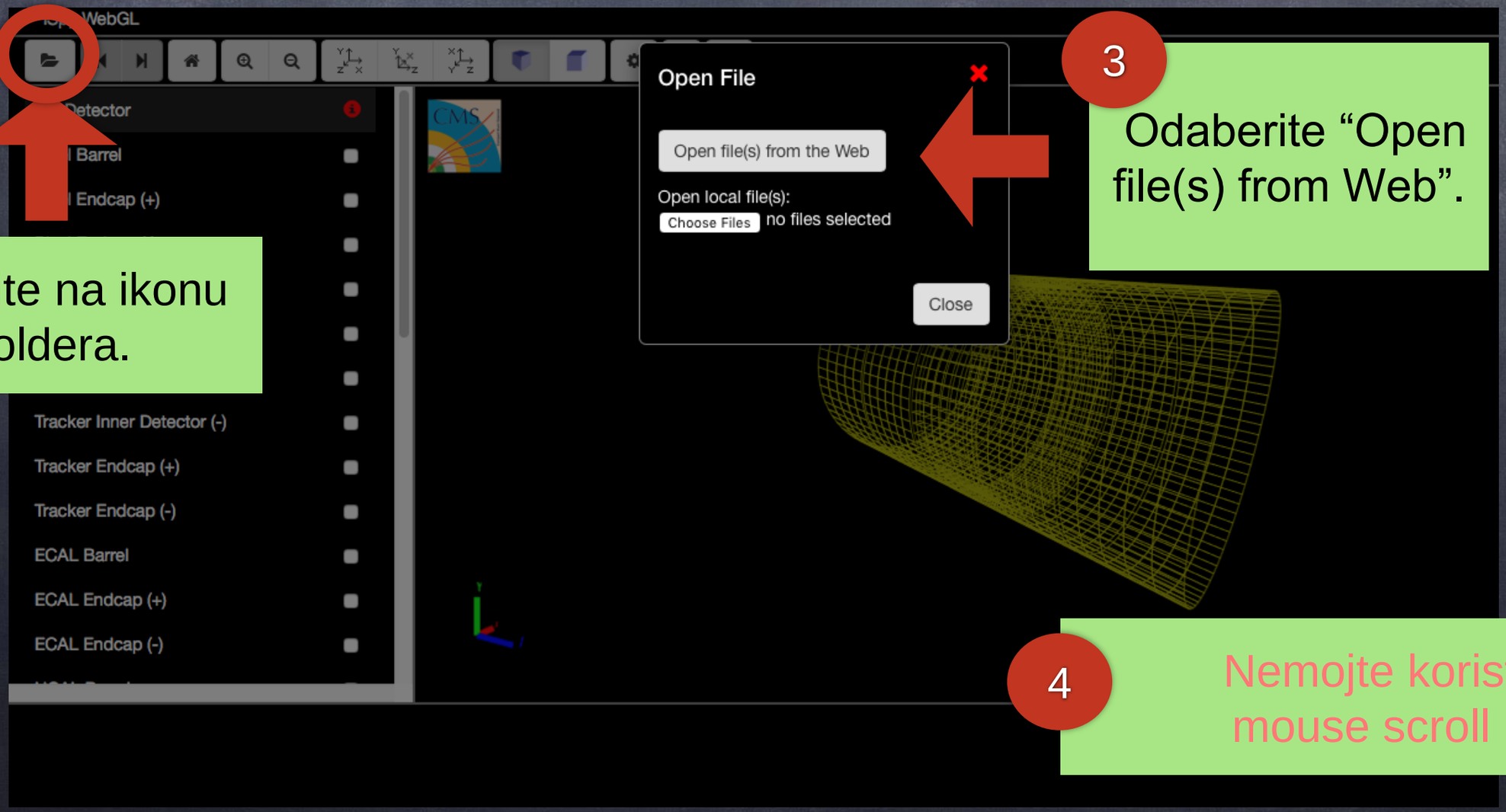
final state
Electron
Muon (μ)

primary state candidate
W^- NP
W^+ W
Higgs
Zoo

NP Mass: GeV/c²
Submit

Event index	Event number	Chosen Values	Mass

1 Kliknite Event Display.



2 Kliknite na ikonu foldera.

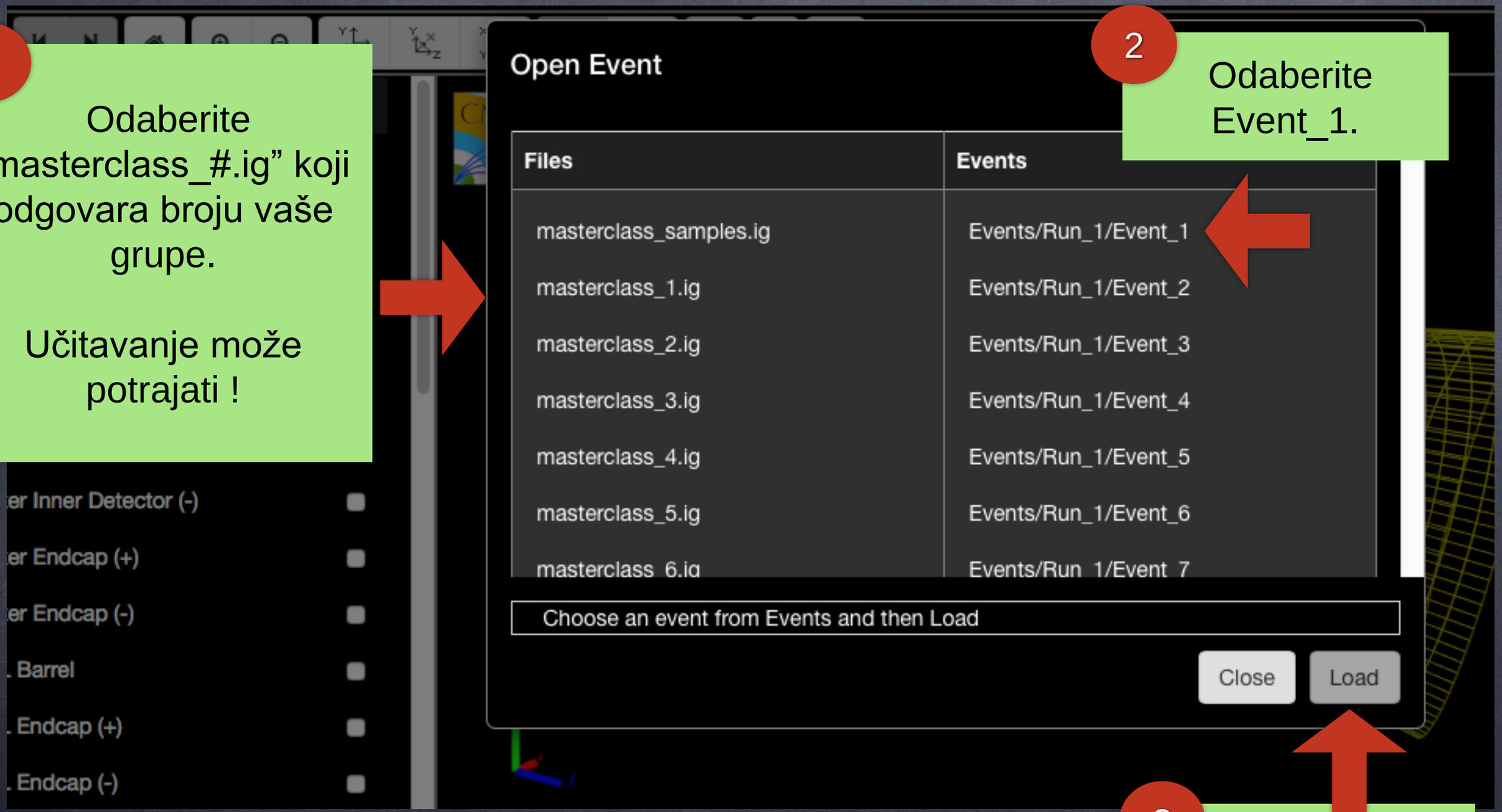
3 Odaberite “Open file(s) from Web”.

4 Nemojte koristiti mouse scroll !!!

1

Odaberite “masterclass_#.ig” koji odgovara broju vaše grupe.

Učitavanje može potrajati !



2

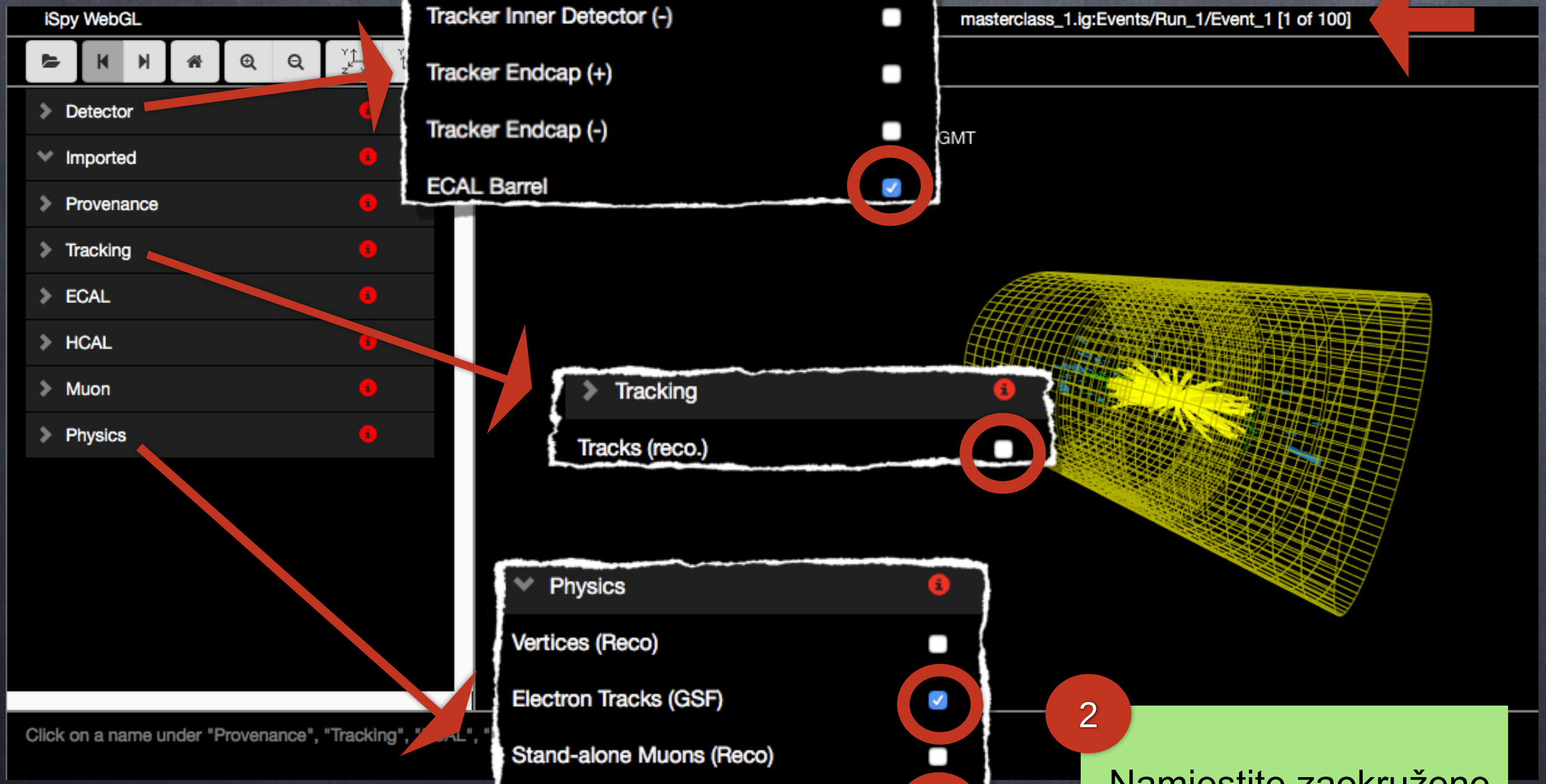
Odaberite Event_1.

3

Kliknite Load !

1

Provjerite # broj vaše grupe masterclass_#.ig i da je event_1 [1 of 100].

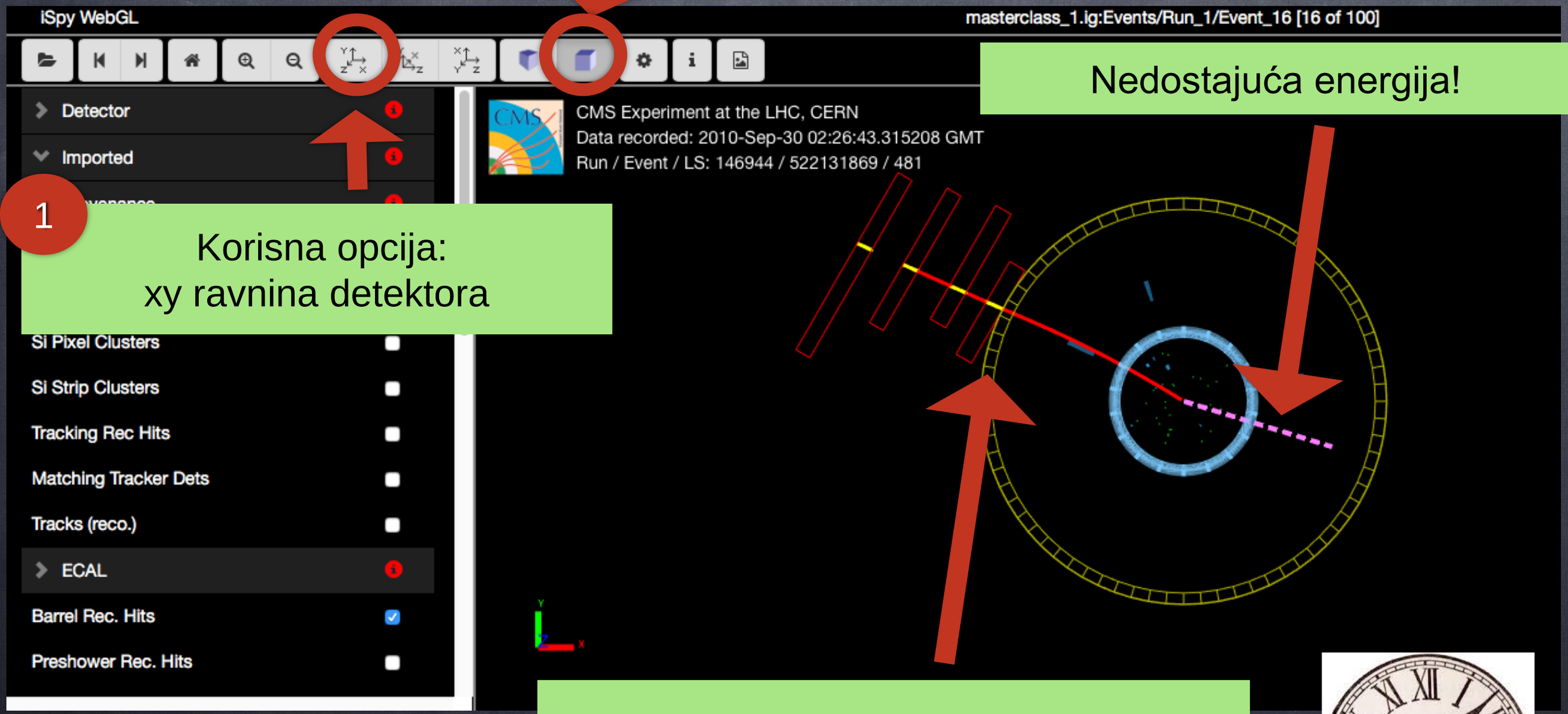


2

Namjestite zaokružene gumbe pod padajućim opcijama.

Što vidimo ovdje? #1

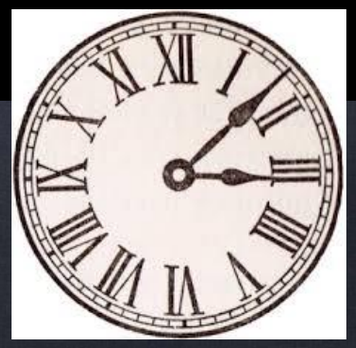
2 Odaberite !



1 Korisna opcija:
xy ravnina detektora

Nedostajuća energija!

Mion u konačnom stanju zakrenut u suprotnom smjeru od kazaljke na satu! => Q = -1



Kako unosimo rezultate?

2

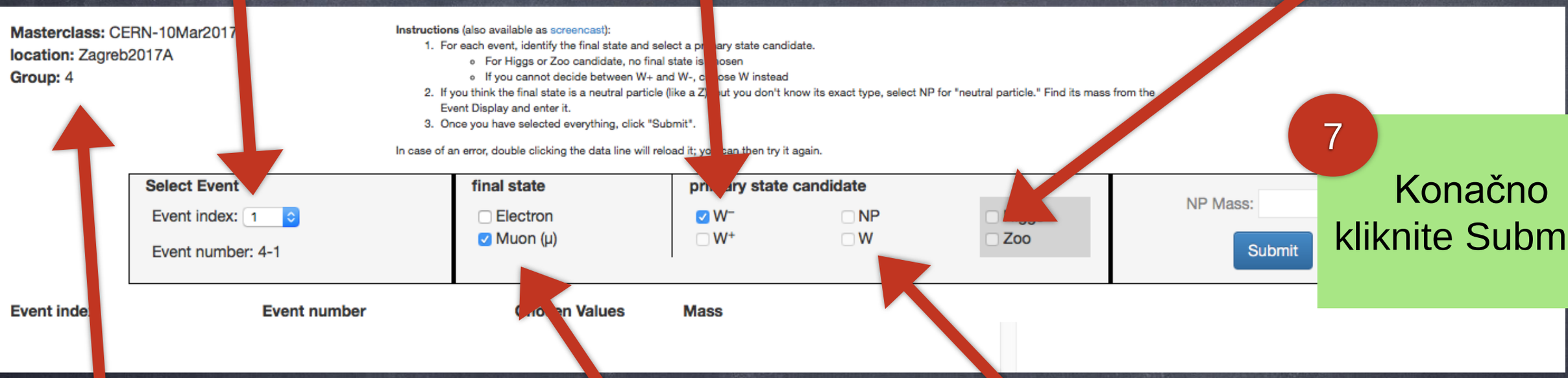
Pazite na redni broj događaja za koji unosite podatke.

4

Ovisno o naboju čestice u konačnom stanju odaberite +/-.

6

Ako niti jedna od opcija ne odgovara onom što vidite odaberite Zoo !



7

Konačno kliknite Submit!

1

Broj vaše grupe.

3

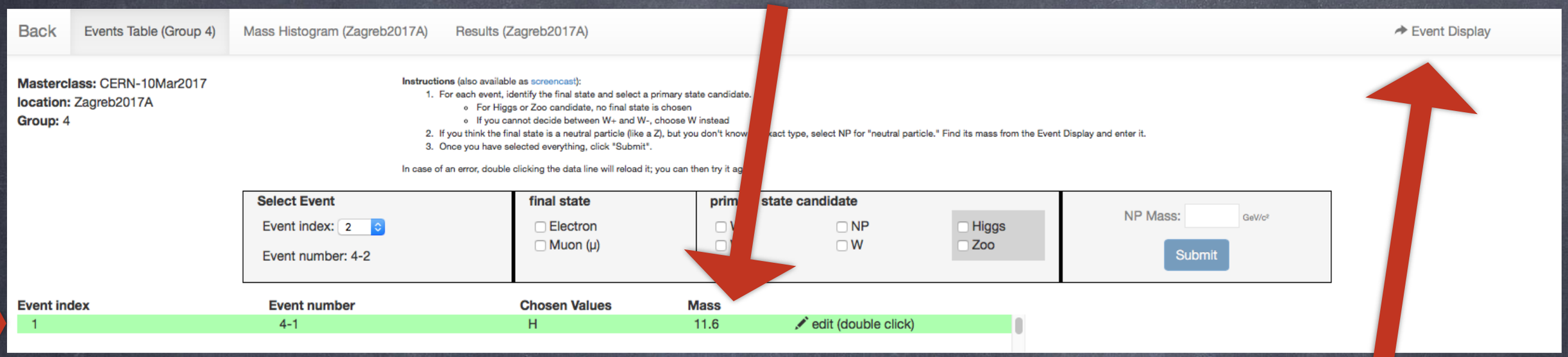
Odaberite što ste vidjeli u konačnom stanju.

5

Ako niste sigurni za +/- odaberite W!

2

Ako želite izbrisati pojedini unos, kliknite na njega dvaput brzo.



1

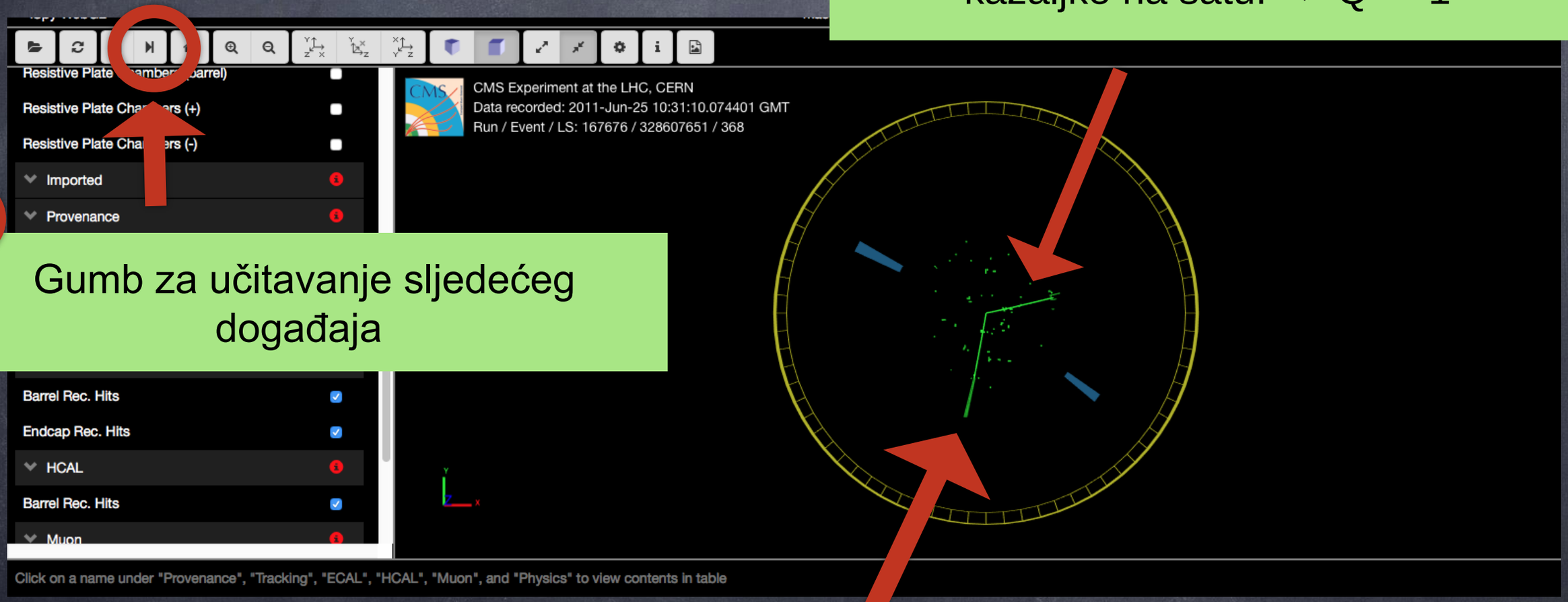
Nakon što kliknete Submit pojavit će se vaš rezultat u tablici.

3

Za analizu sljedećeg događaja, vratite se ponovno na Event Display !

Što vidimo ovdje? #2

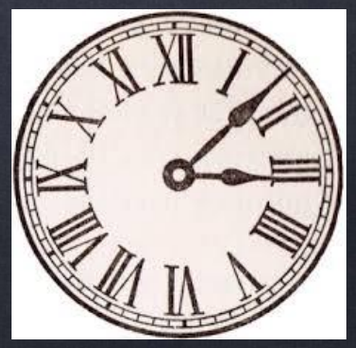
Elektron u konačnom stanju zakrenut u suprotnom smjeru od kazaljke na satu! => Q = -1



1

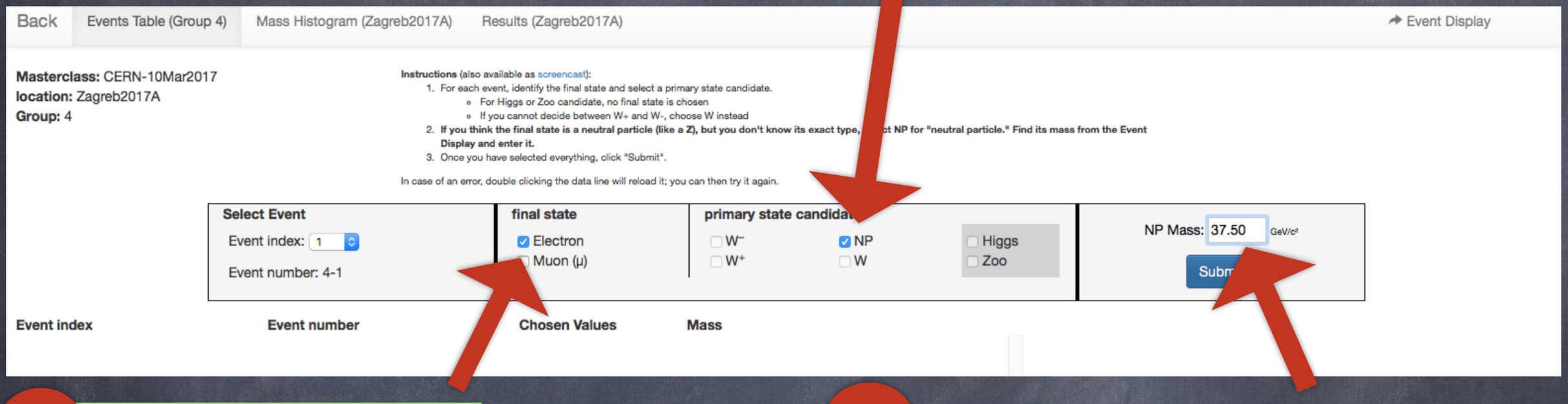
Gumb za učitavanje sljedećeg događaja

Elektron u konačnom stanju zakrenut u smjeru kazaljke na satu! => Q = +1



2

Kandidat za Z bozon koji je neutralna čestica (NP)!



1

Elektron u konačnom stanju.

3

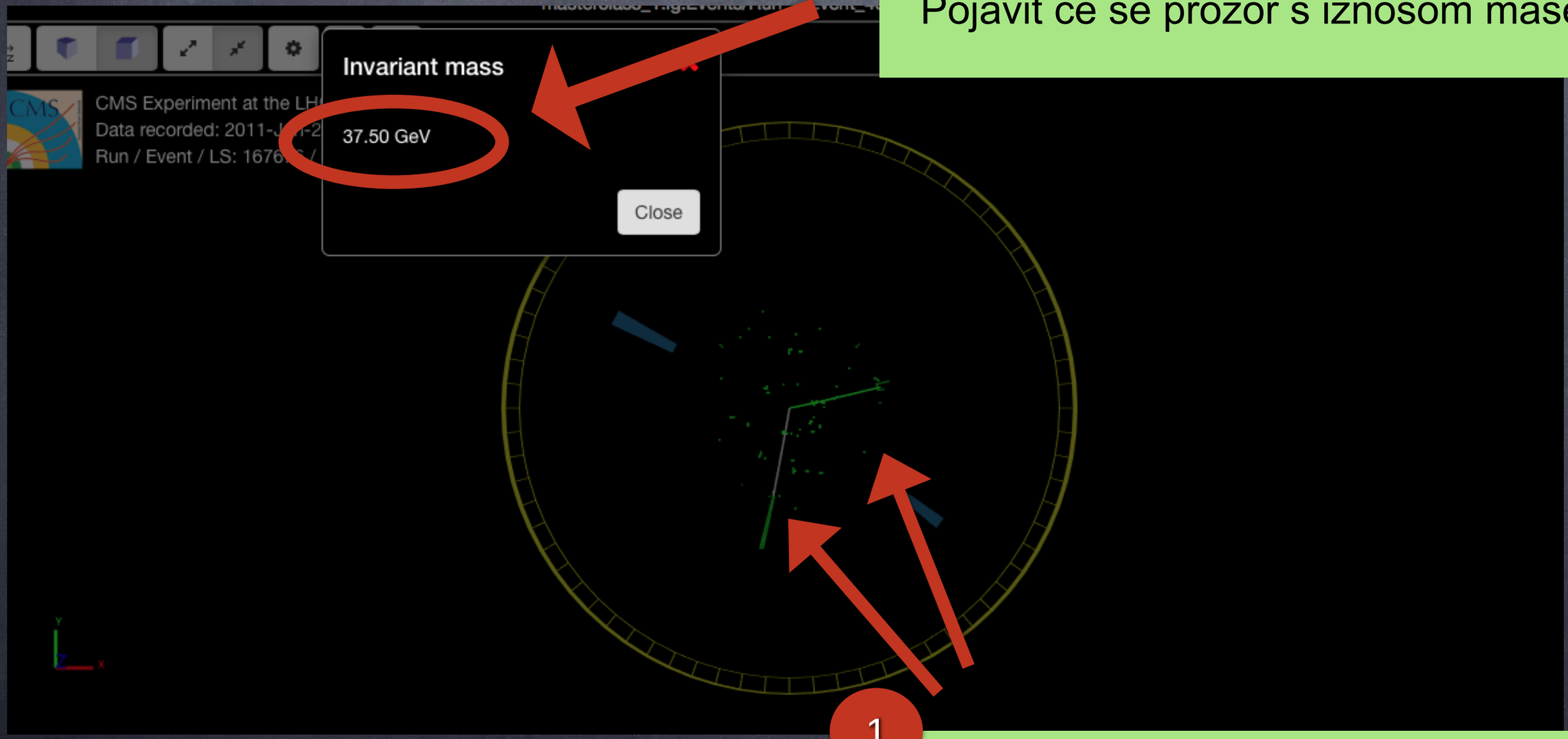
Kako određujemo iznos mase?

Napomena:
Ovaj postupak računanja radimo samo za neutralne čestice (NP). Za Higgs kandidata dovoljno je samo pritisnuti Submit.

Kako određujemo iznos mase neutralne čestice NP?

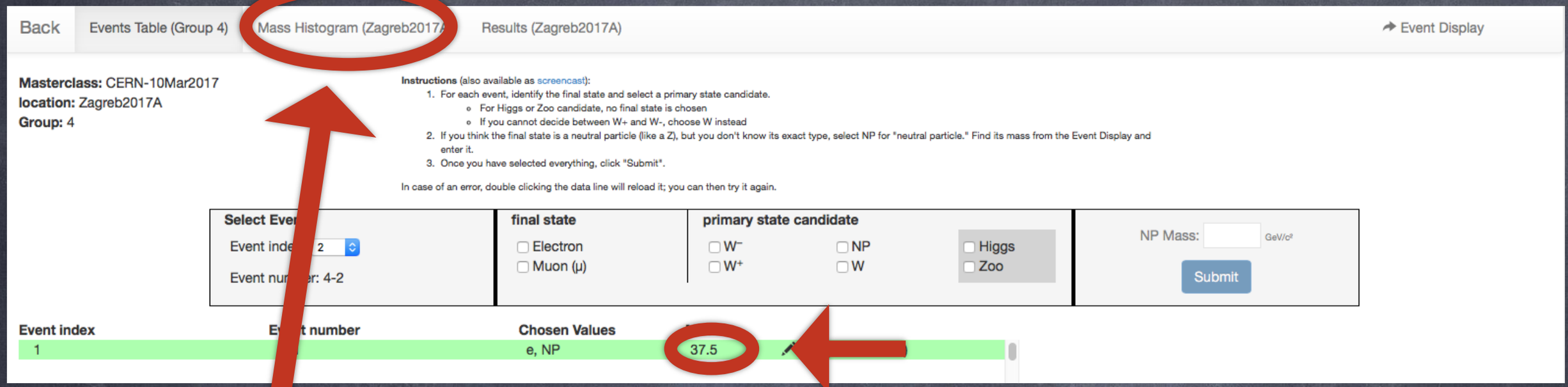
2

Pojavit će se prozor s iznosom mase.



1

Držite tipku SHIFT i kliknite mišem na vaše kandidate.



2

Kliknite na Mass Histogram

1

Kada ispunjavate tablicu, masu zaokružite na najbliži neparni broj => 37.

2

Ako želite izbrisati pojedini unos,
jednom ctrl + click na željeni stupac !

1

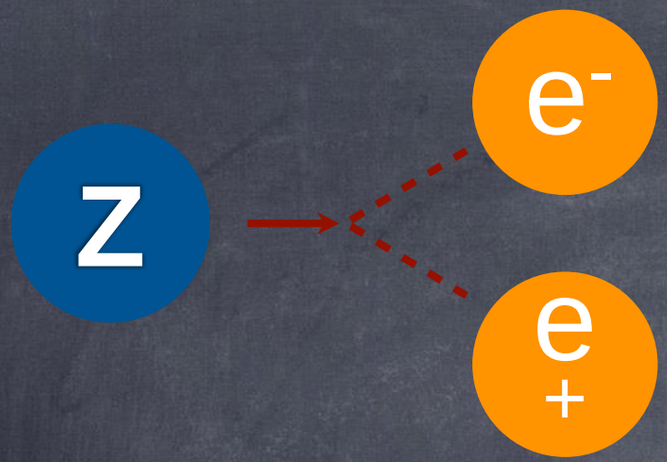
Unesite rezultat klikom na stupac iznad odgovarajuće mase.

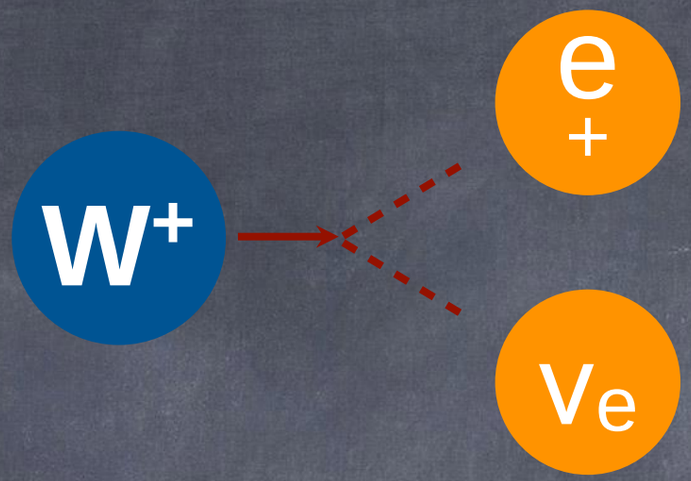
3

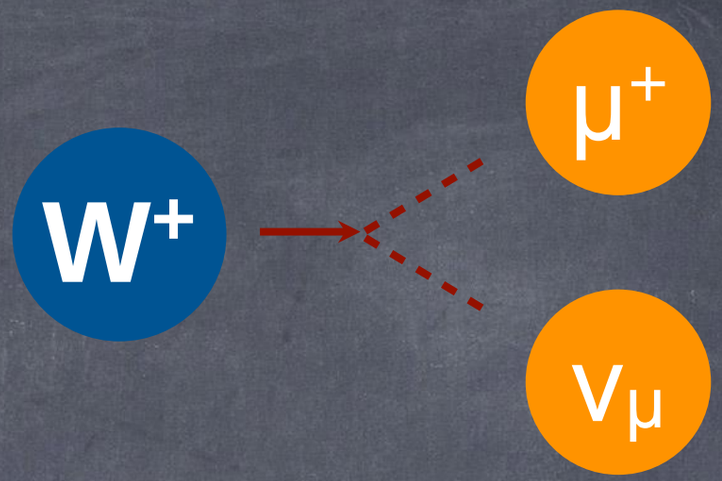
Oprez:
Histogram popunjavaju sve grupe zajedno !!!

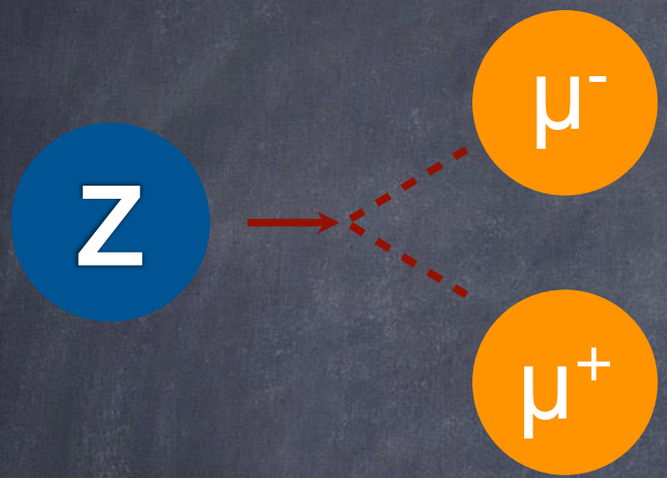
Go!

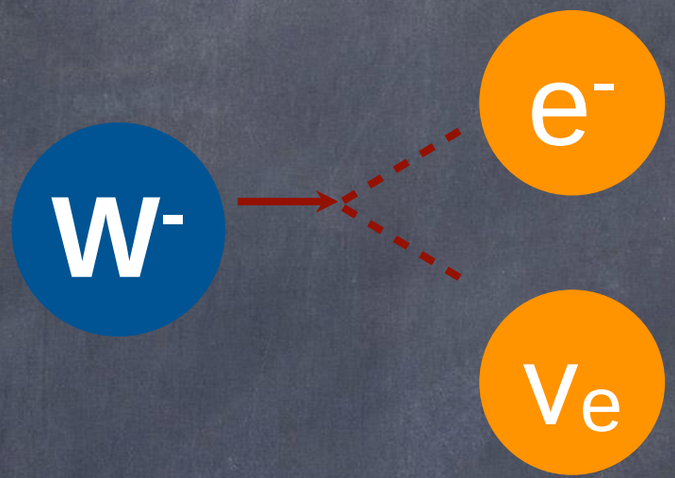
Korisni materijali: https://goo.gl/K48JQd

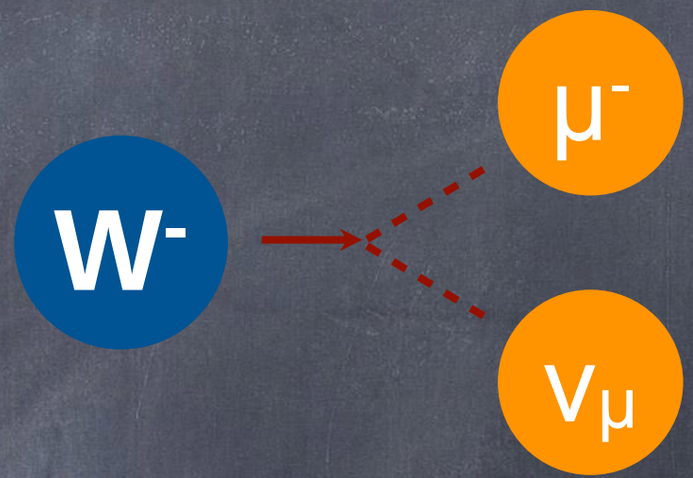


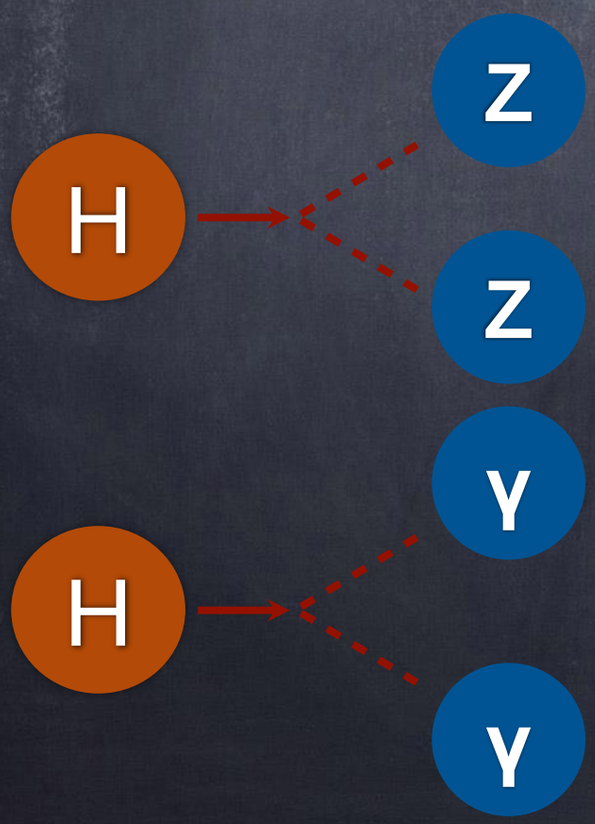












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