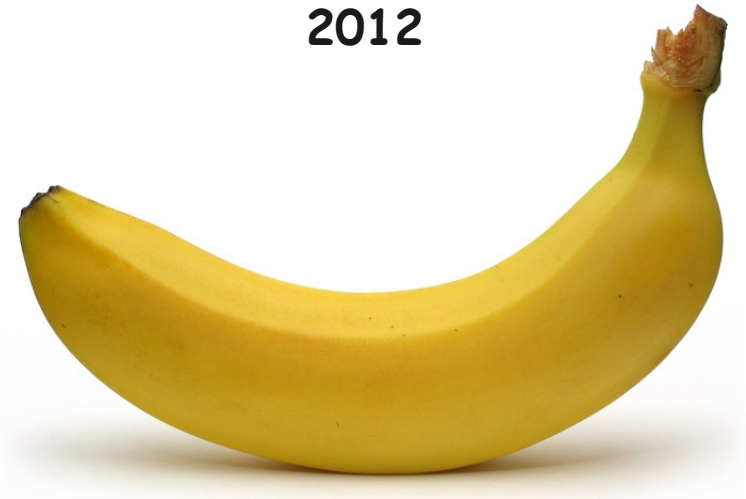
Podivný mikrosvet

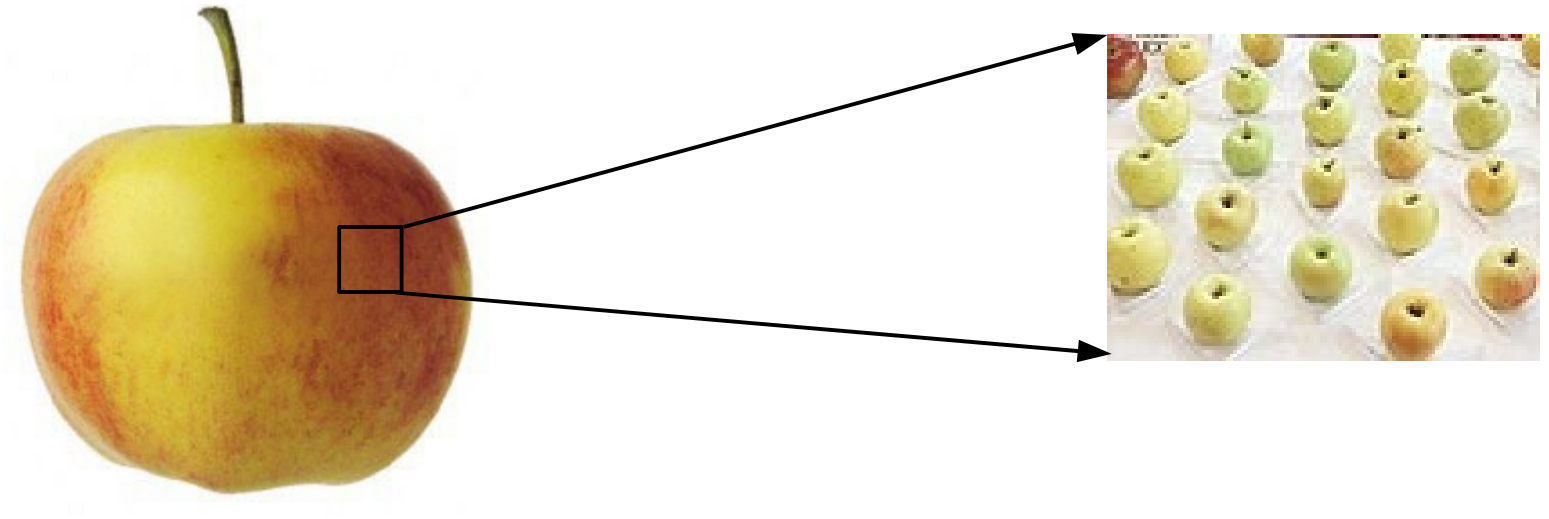
Mikuláš Gintner
Katedra fyziky
Žilinská univerzita
2012

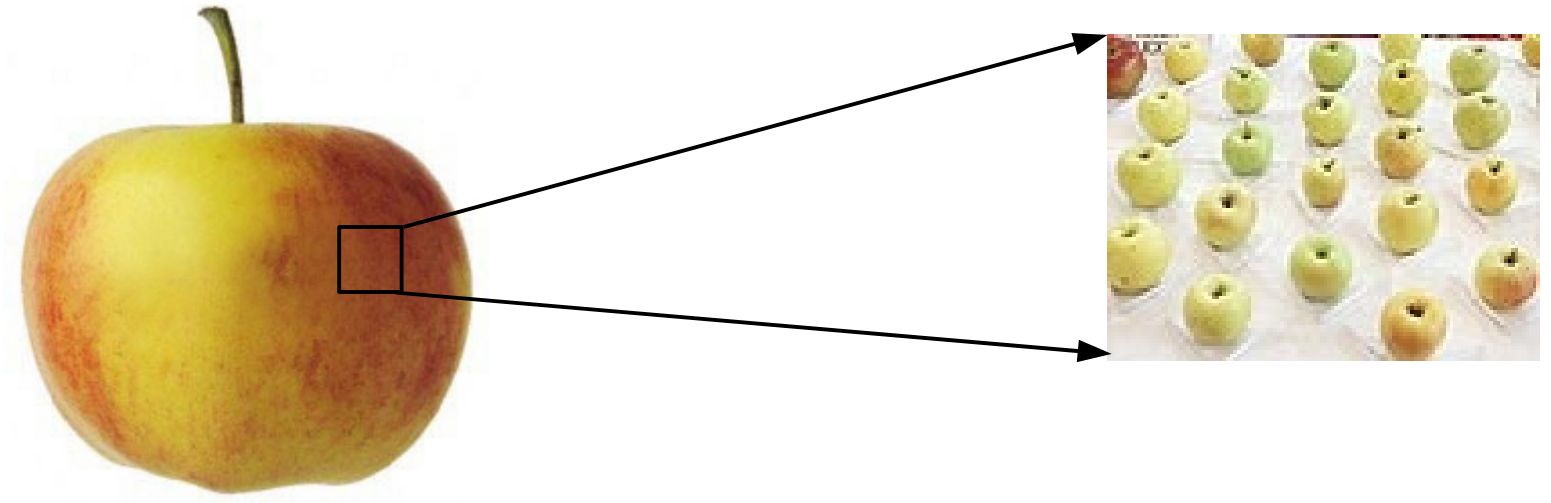


Svet

MAKRO

- klasický





atómy

elektróny

jadro

protón

neutrón

u u d

u d d

kvarky

Svet

MAKRO

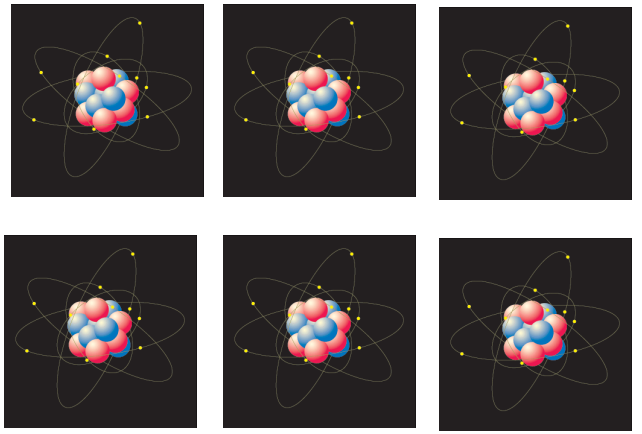
- klasický

Svet

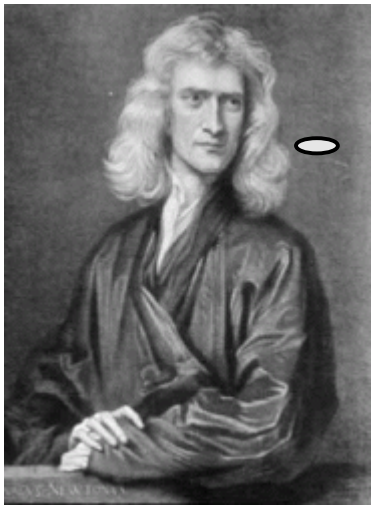
MAKRO

- klasický

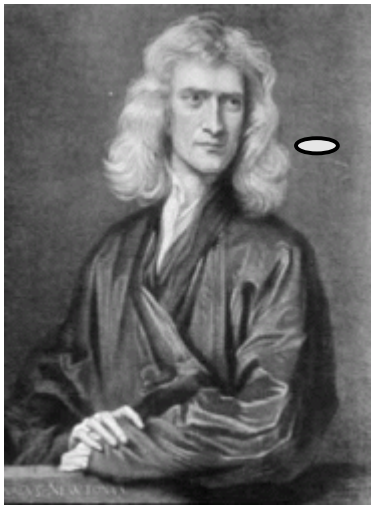
mikro



- kvantový
- relativistický

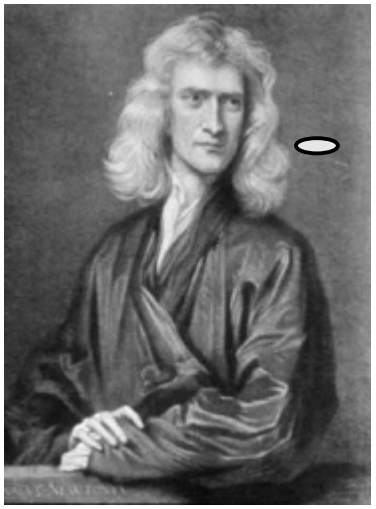


Sily!



Sily!

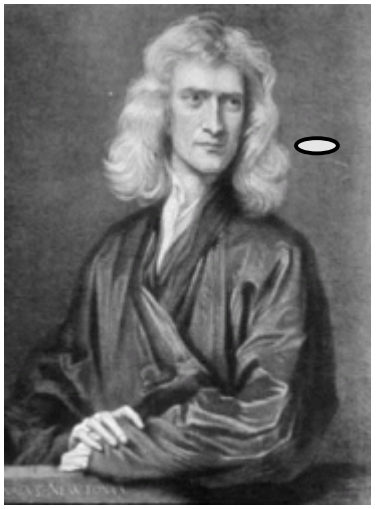
gravitácia



Sily!

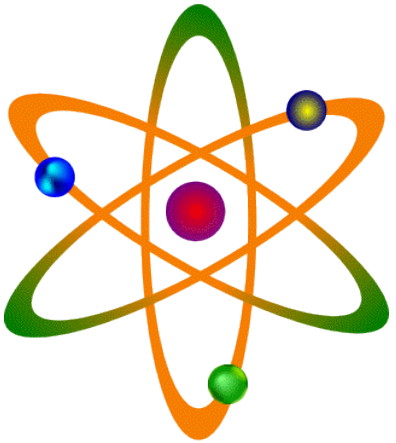
gravitácia

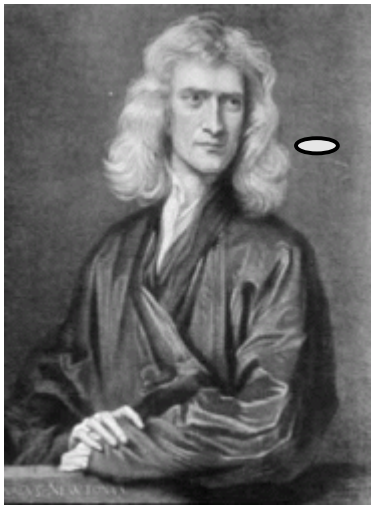
1 m



Sily!

elmag sila

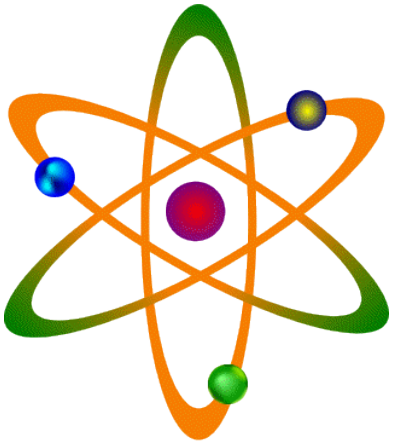


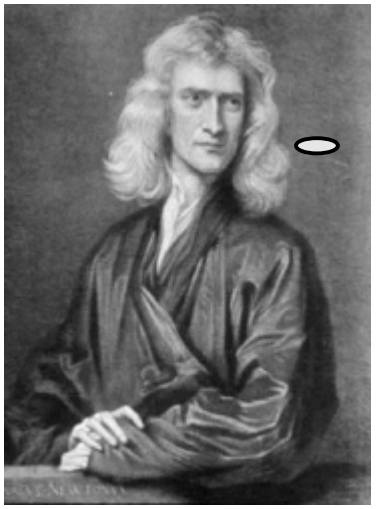


Sily!

elmag sila

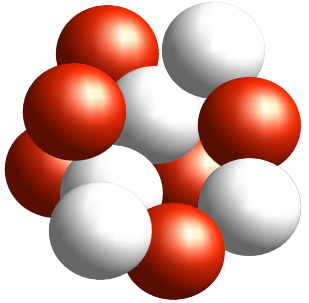
10^{-10} m

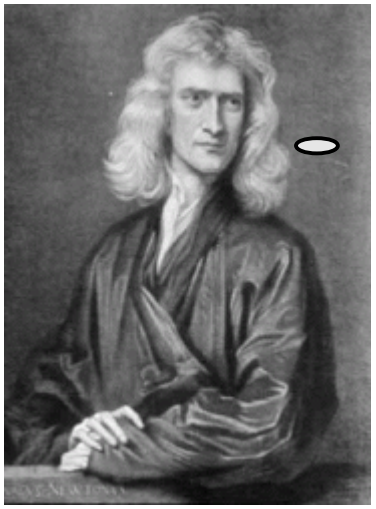




Síly!

silná síla
(jadrová)

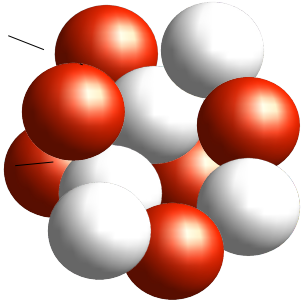


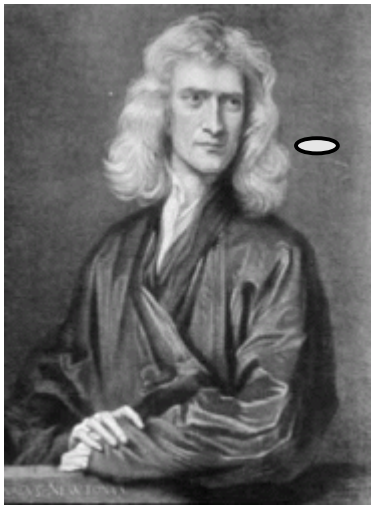


Síly!

silná síla
(jadrová)

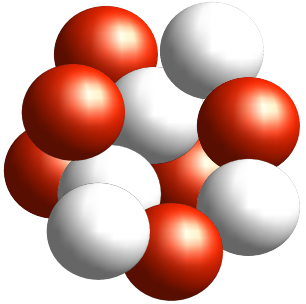
10^{-15} m

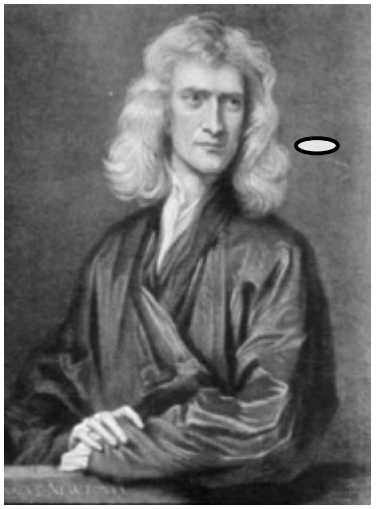




Síly!

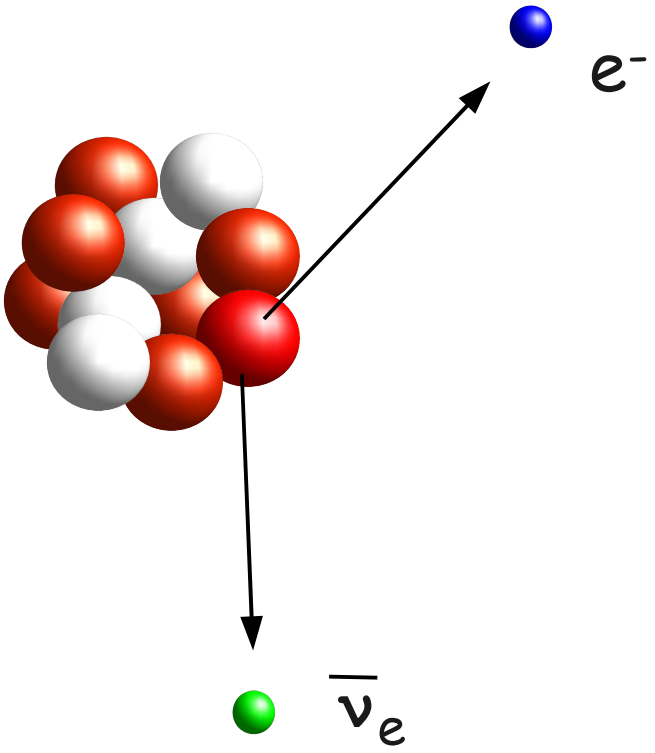
slabá síla

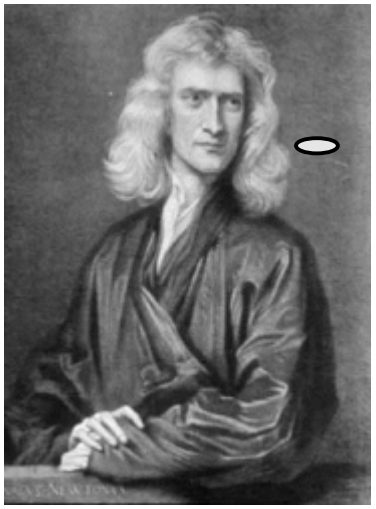




Síly!

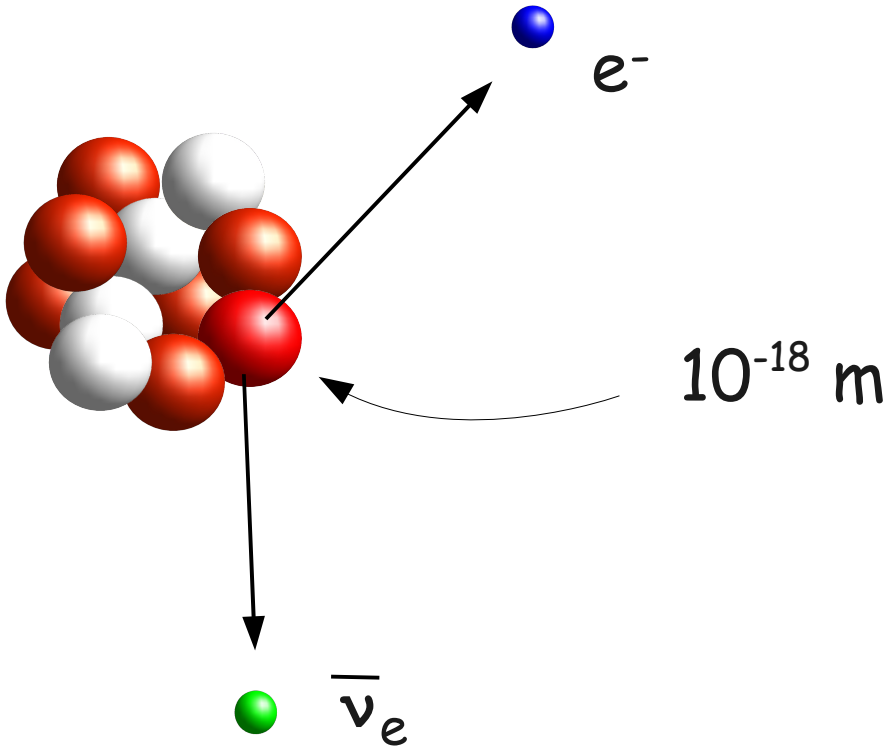
slabá síla

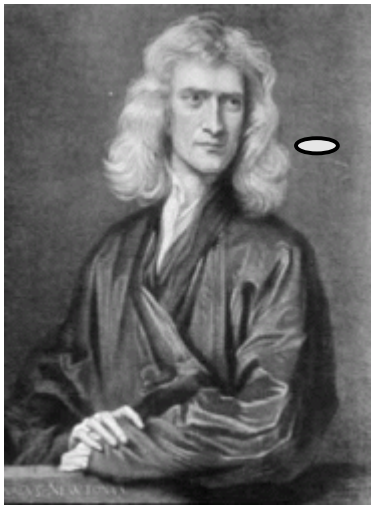




Sily!

slabá sila





Sily!

gravitačná

elmag

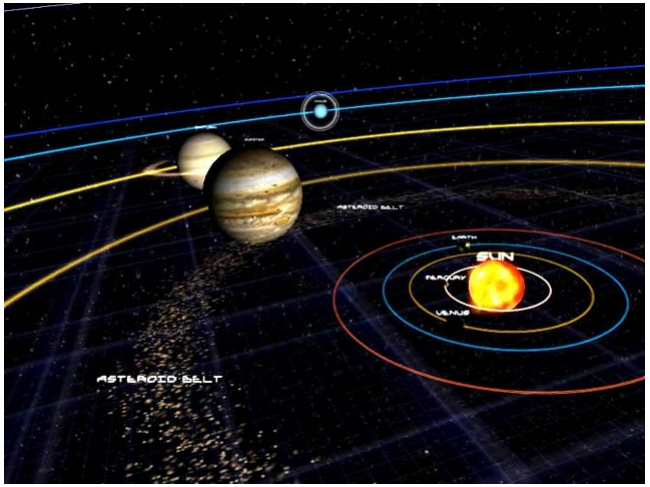
silná

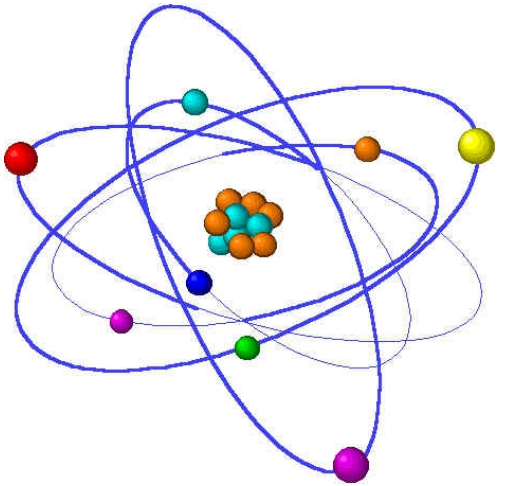
slabá

Sila

MAKRO

mikro

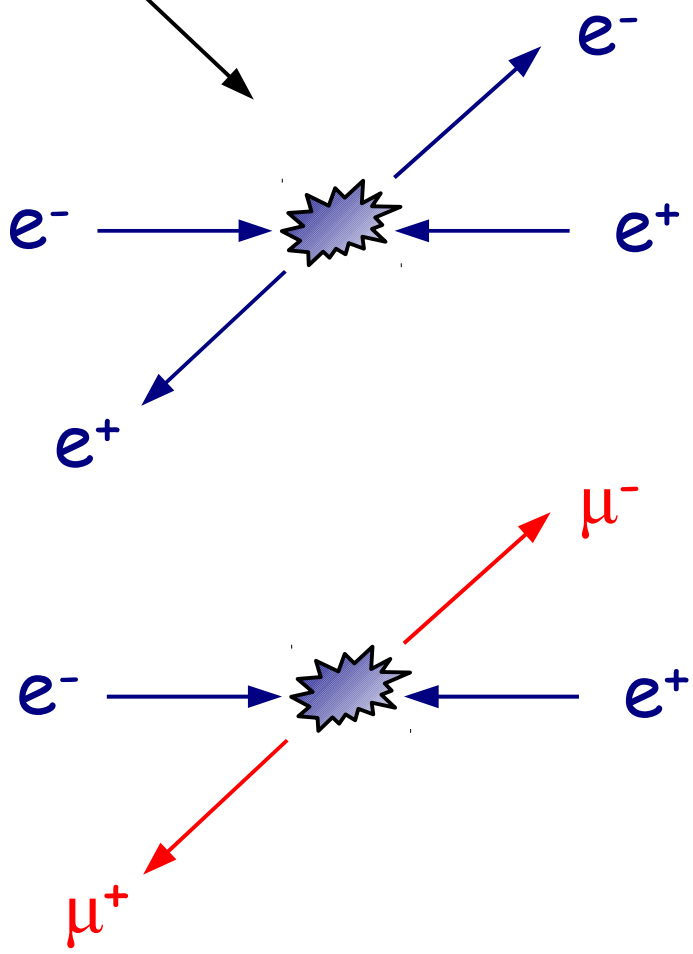




Sila

MAKRO

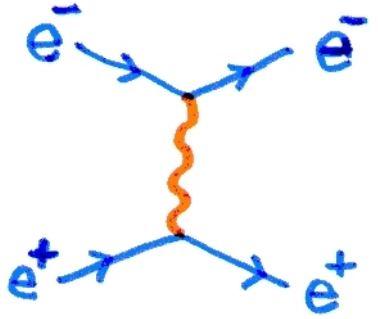
mikro

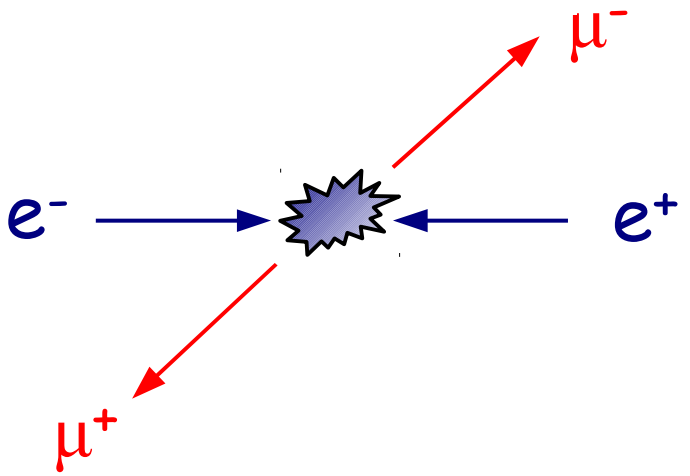


Sila

MAKRO

mikro

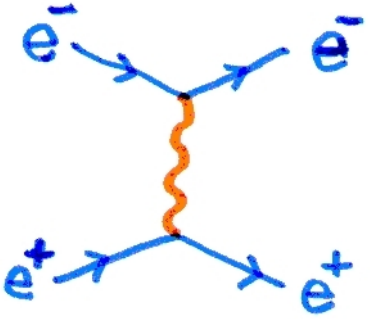


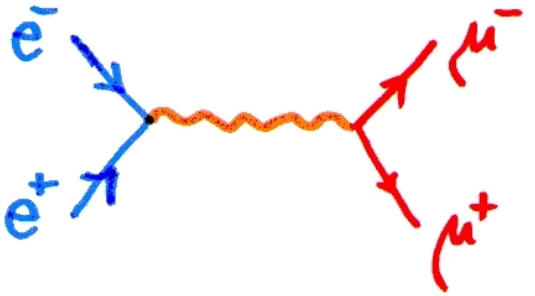


Sila

MAKRO

mikro





sila:		silóny:
• elmag	→	fotón
• silná	→	8 gluónov
• slabá	→	W^+, W^-, Z (bozóny)

v prírode nepozorujeme voľné *kvarky* a gluóny

v prírode nepozorujeme voľné *kvarky* a gluóny

mezóny $q\,\bar{q}$

baryóny qqq

hadróny

v prírode nepozorujeme voľné *kvarky* a gluóny

mezóny $q\bar{q}$

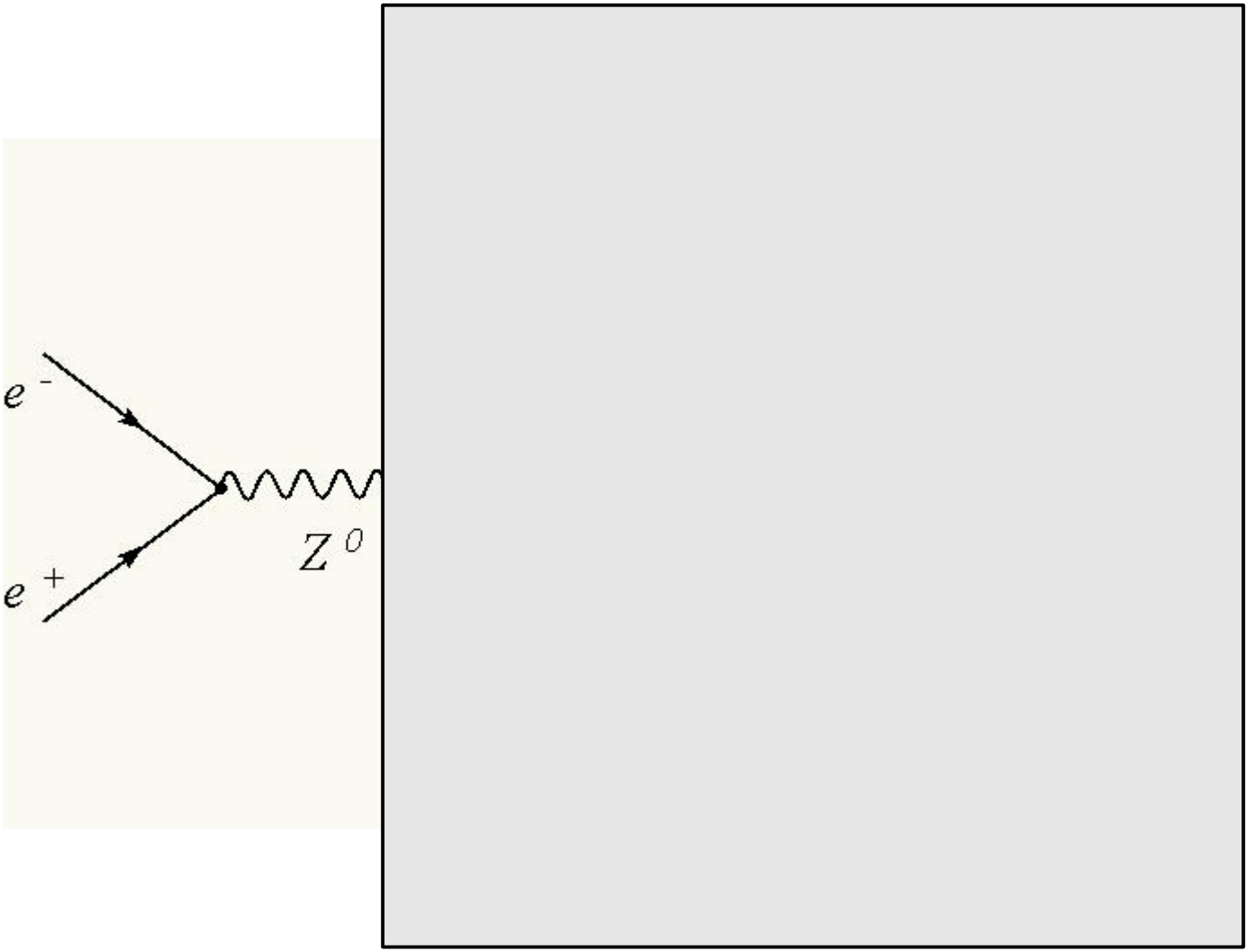
baryóny qqq

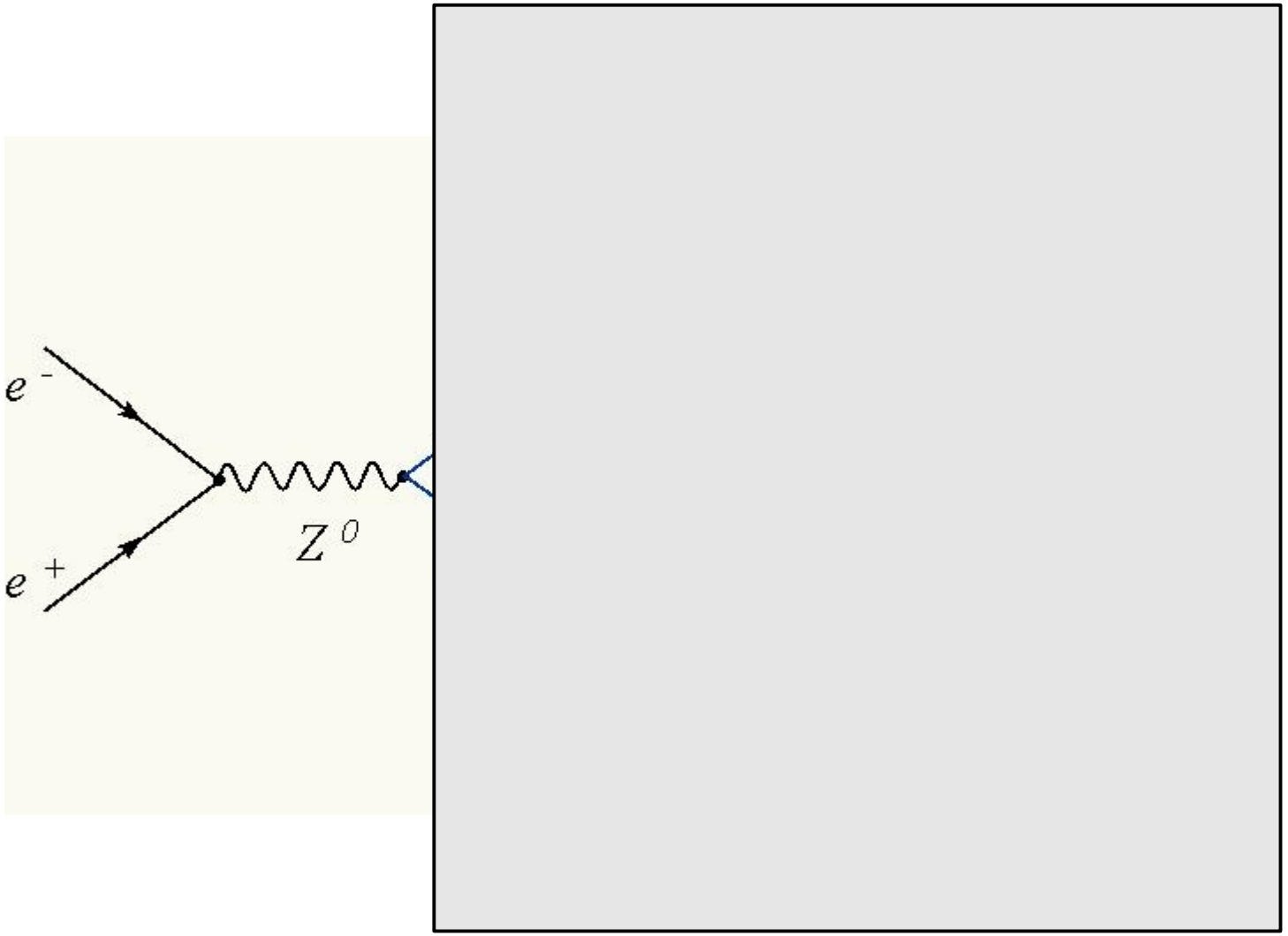
hadróny

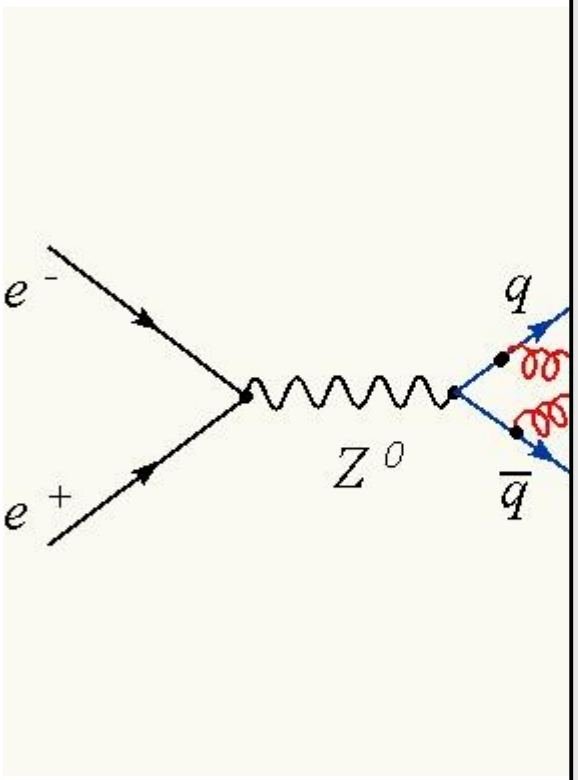
protón ... uud

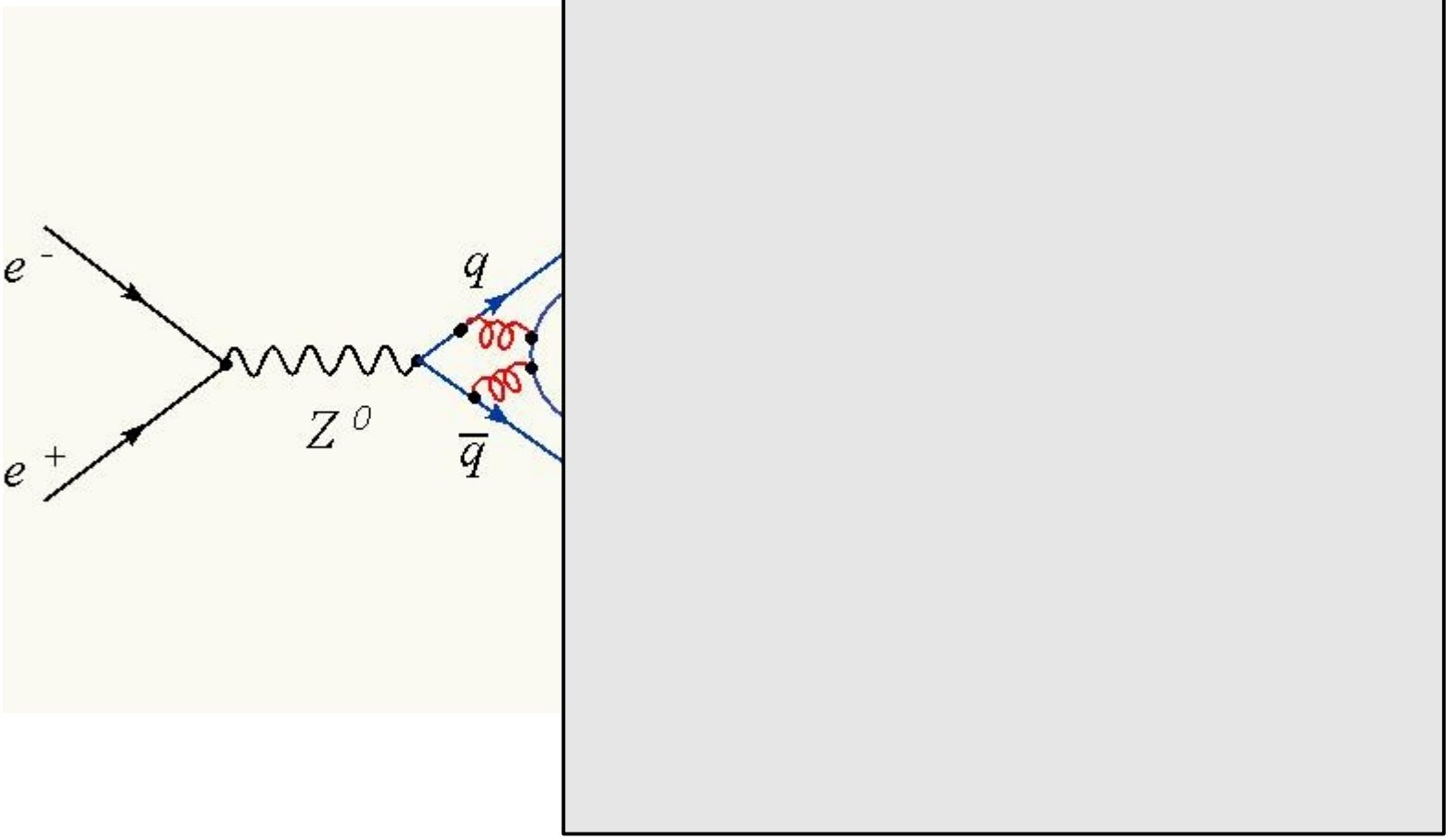
neutrón ... udd

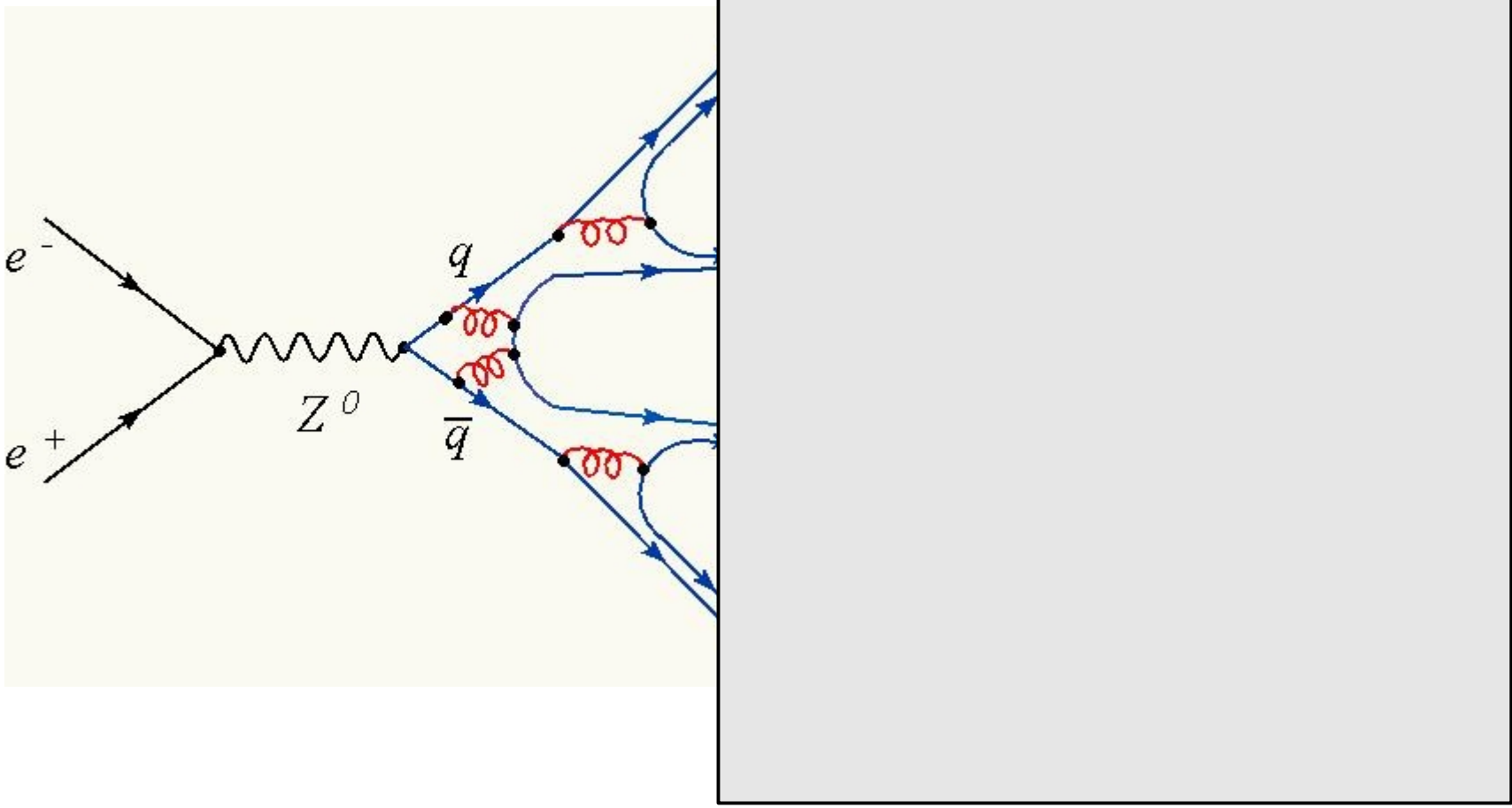
pión ... $u\bar{d}$

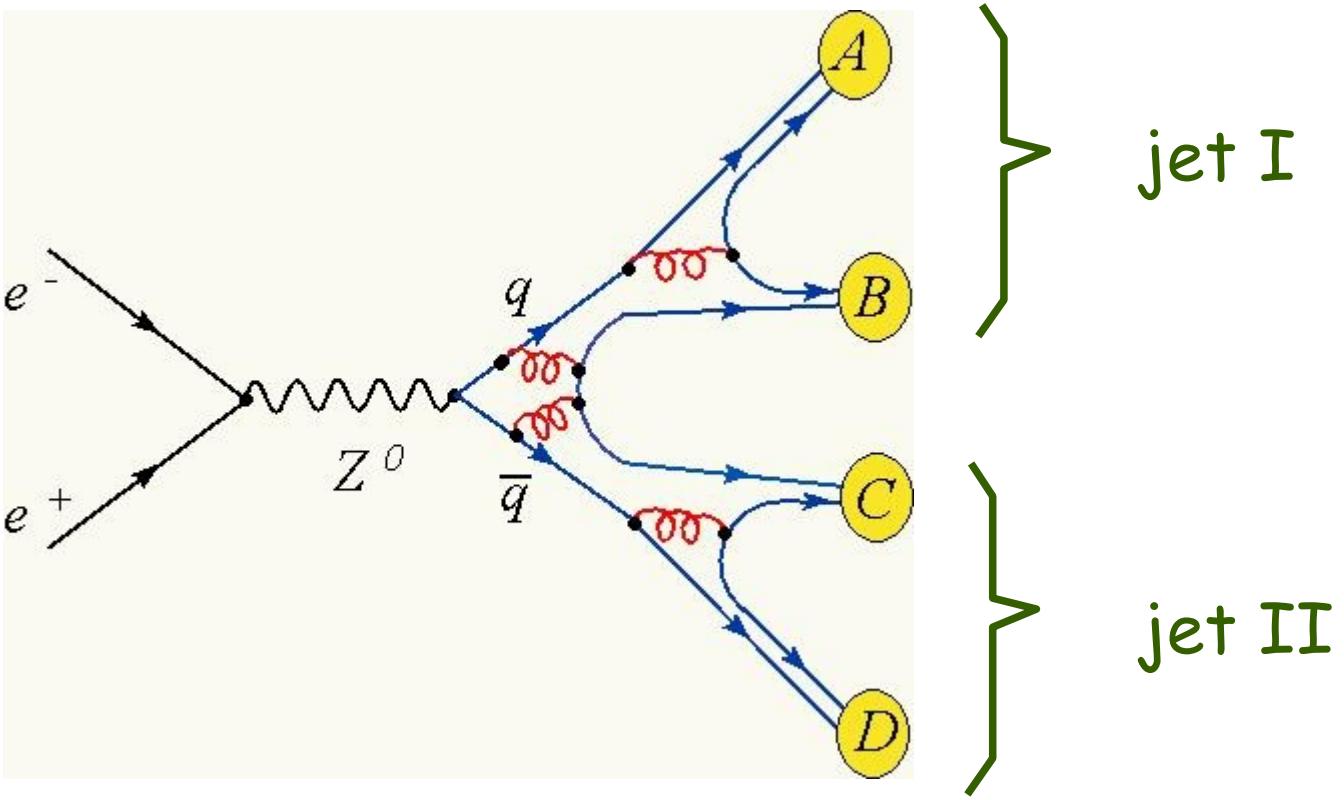

e -
e +
Z 0


e -
e +
Z 0


e -
e +
Z 0
q
q̄


e -
e +
Z 0
q
q̄

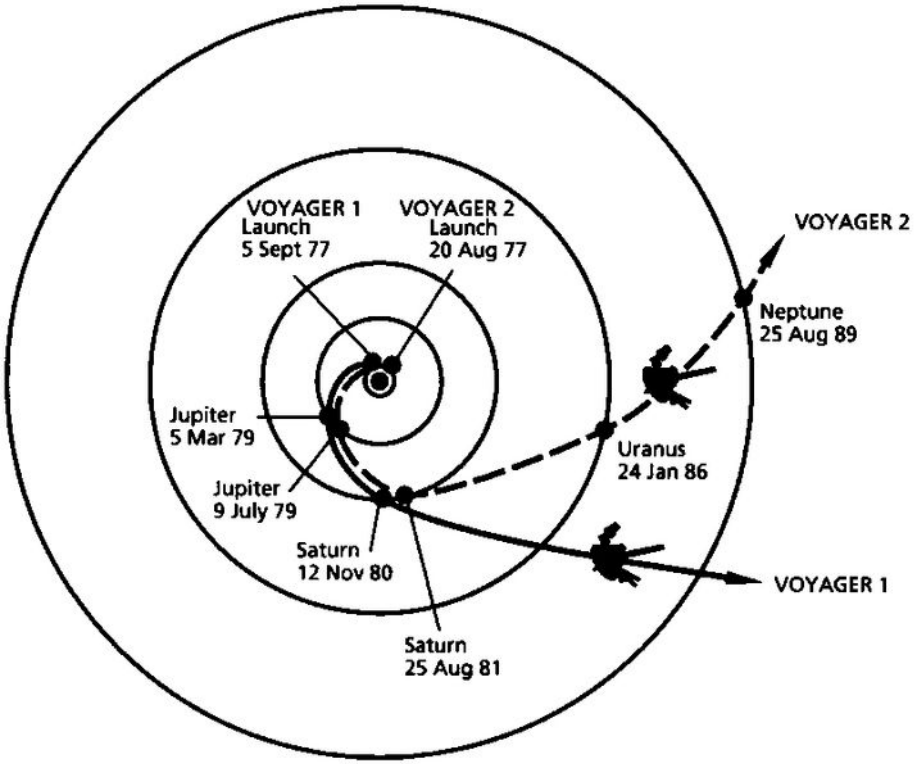

e -
e +
Z 0
q
q̄

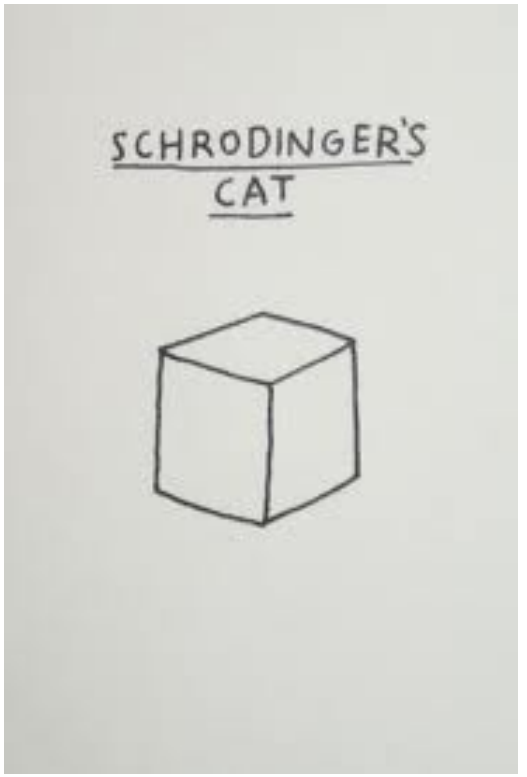

e -
e +
Z 0
q
q̄
A
B
C
D
jet I
jet II

Predpoved'

MAKRO

mikro





Kvantová teória:

- kombinácia možností
- viac možných výsledkov merania
- len pravdepodobnosť

Kvantová teória:

- kombinácia možností
- viac možných výsledkov merania
- len pravdepodobnosť

$Z \rightarrow$	e^+e^-	$\mu^+\mu^-$	$\tau^+\tau^-$	$\nu\bar{\nu}$	$q\bar{q}$
%	3.4	3.4	3.4	20.0	69.9

Kvantová teória:

- kombinácia možností
- viac možných výsledkov merania
- len pravdepodobnosť

$Z \rightarrow$	e^+e^-	$\mu^+\mu^-$	$\tau^+\tau^-$	$\nu\bar{\nu}$	$q\bar{q}$
%	3.4	3.4	3.4	20.0	69.9

energia zrážky*	1	2	3	4	5
$e^+e^- \rightarrow \mu^+\mu^-$	10^5	180	78	44	29
$e^+e^- \rightarrow W^+W^-$	0	924	734	525	394

*v násobkoch M_Z

Hmotnosť

MAKRO

mikro

nezachováva sa!

$$e^{+}_{1} + e^{-}_{1} \rightarrow \mu^{+}_{210} + \mu^{-}_{210}$$

$$Z^{0}_{182400} \rightarrow \mu^{+}_{210} + \mu^{-}_{210}$$

Hmotnosť

MAKRO

mikro

nezachováva sa!

∃ nulová hmotnosť

Hmotnosť

MAKRO

mikro

nezachováva sa!

∃ nulová hmotnosť

$$E = \sqrt{m^2 c^4 + p^2 c^2}$$

Časticová ZOO

1.generácia	2.generácia	3.generácia	elekt. náboj
ν_e	ν_μ	ν_τ	0
e	μ	τ	-1
u	c	t	$+2/3$
d	s	b	$-1/3$

hmotnosť

Časticová ZOO

1.generácia	2.generácia	3.generácia	elekt. náboj
ν_e	ν_μ	ν_τ	0
e	μ	τ	-1
u	c	t	$+2/3$
d	s	b	$-1/3$

hmotnosť

... + antičastice: rovnaká hmotnosť, opačný náboj

Časticová ZOO

elektrón	1	0.5 MeV
protón	1880	1 GeV
t kvark	344000	175 GeV
jadro Au	370000	
jablko	$1x10^{29}$	

Higgsov bozón

- prečo majú elem. častice hmotnosti ?
- rôzne hypotézy
- H.b. je bočný produkt najjednoduchšej hypotézy
- … nepredpovedá hmotnosť Higgsa !!!

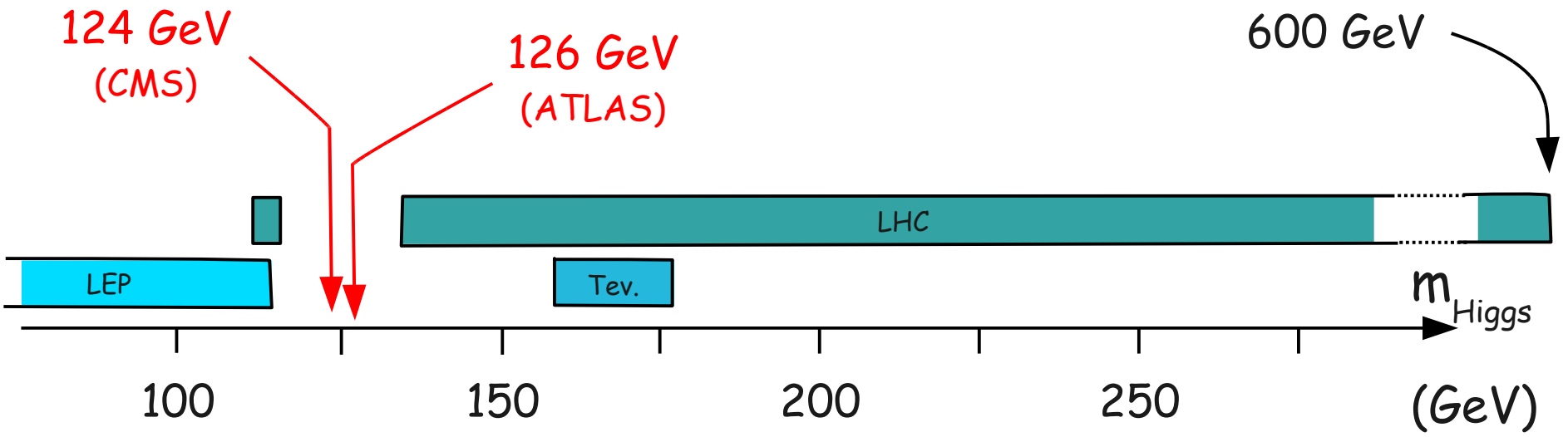
$$m_{Higgs} < 1\ TeV$$

Hl'adanie Higgsa

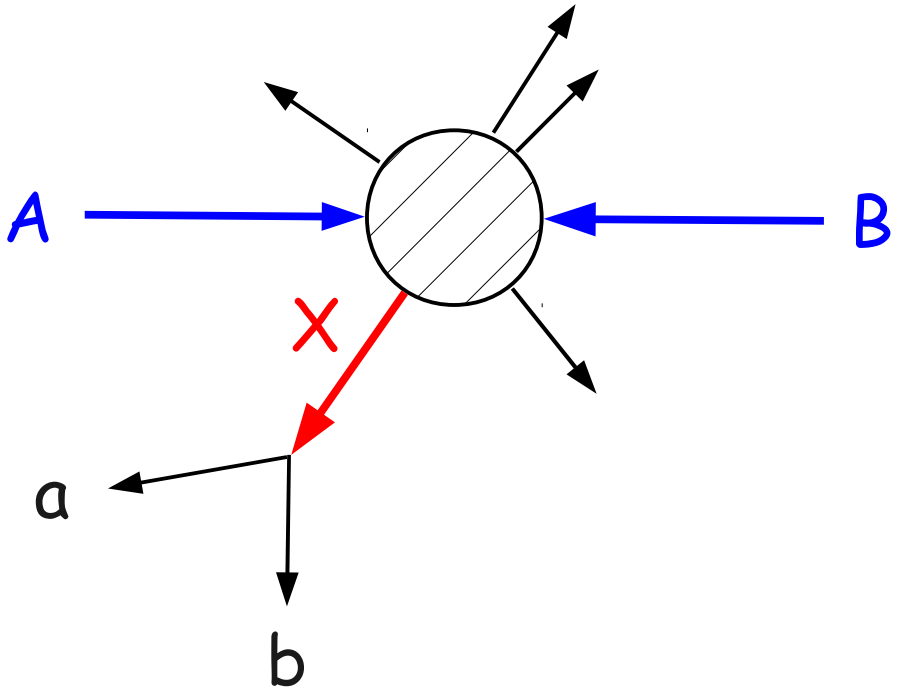
- LEP e^+e^- (1989-2000)
- Tevatron $p\bar{p}$ (1983-2011)
- LHC pp (2010-)

Hl'adanie Higgsa

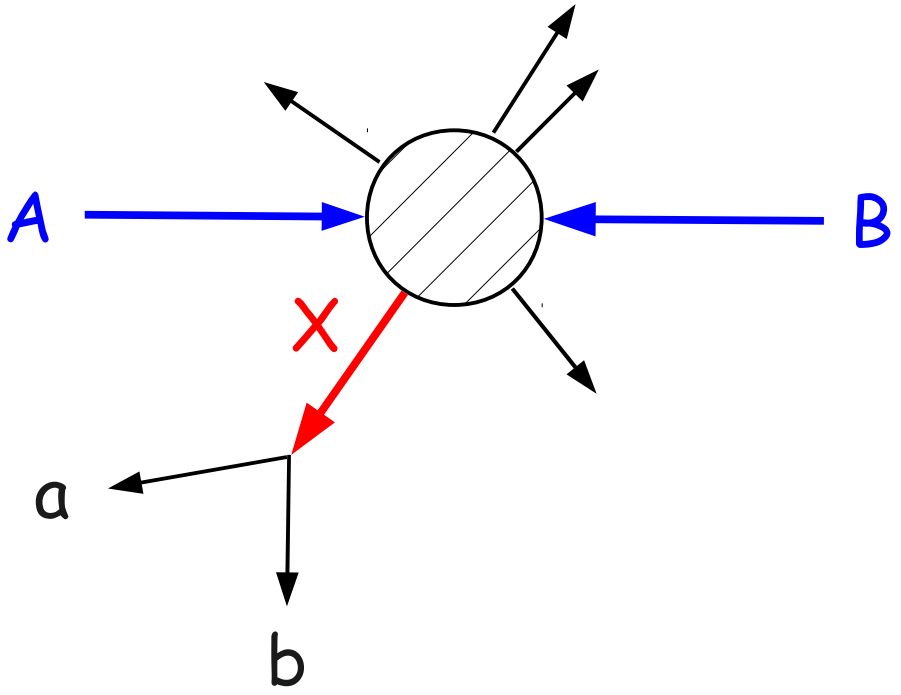
- LEP e^+e^- (1989-2000)
- Tevatron $p\bar{p}$ (1983-2011)
- LHC pp (2010-)



Ako sa hľadá častica

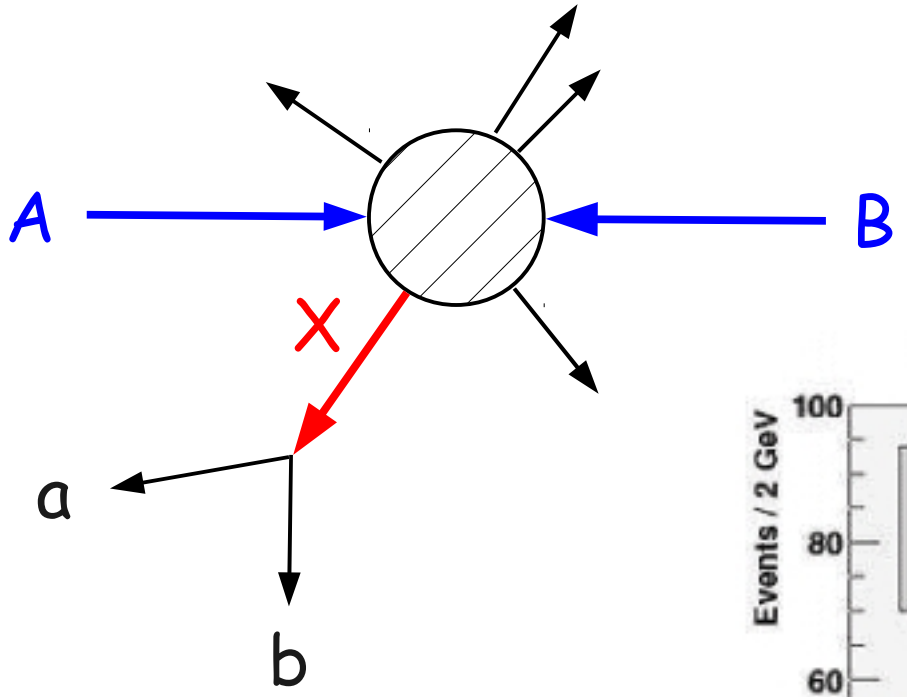


Ako sa hľadá častica

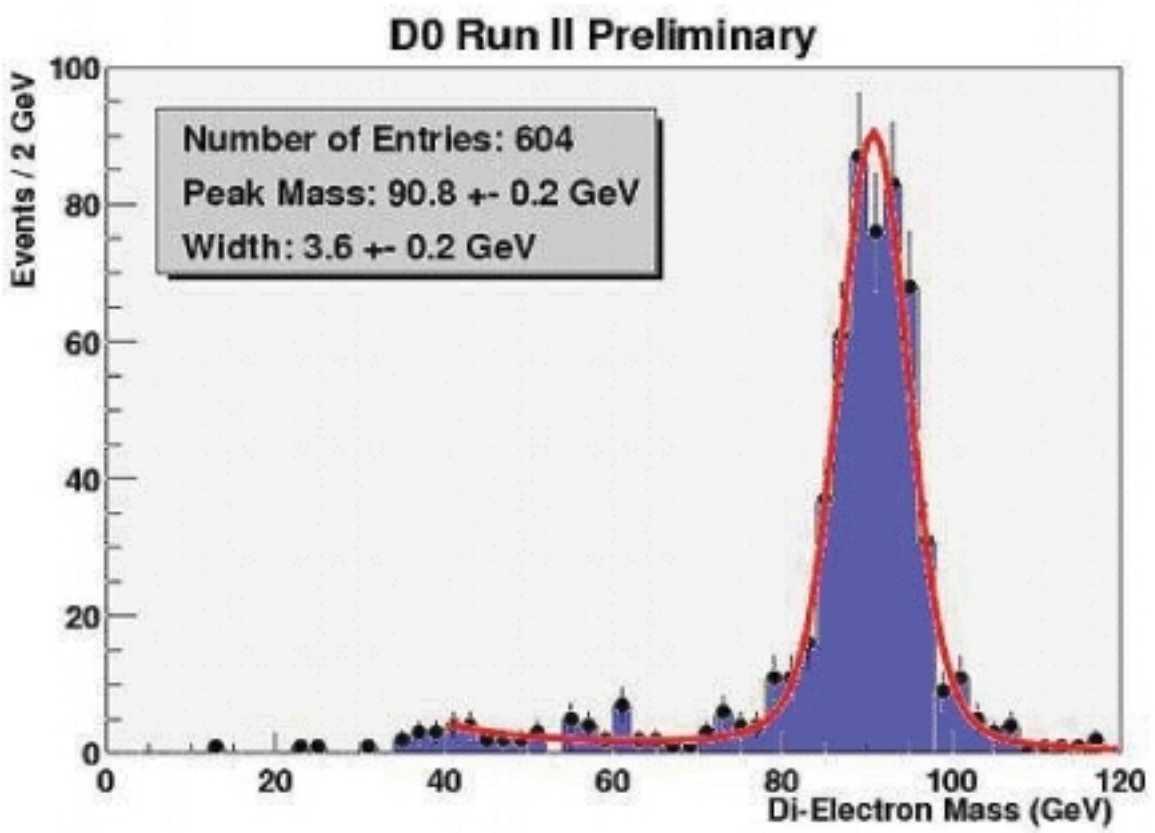


$$M_{ab} = [(E_a+E_b)^2-(\vec{p}_a+\vec{p}_b)^2]^{1/2}$$

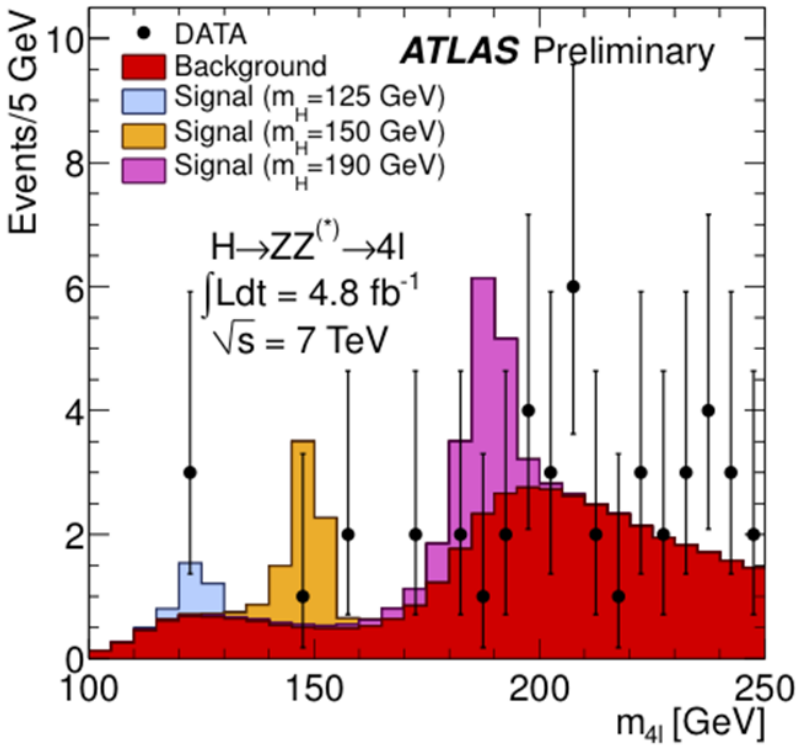
Ako sa hľadá častica

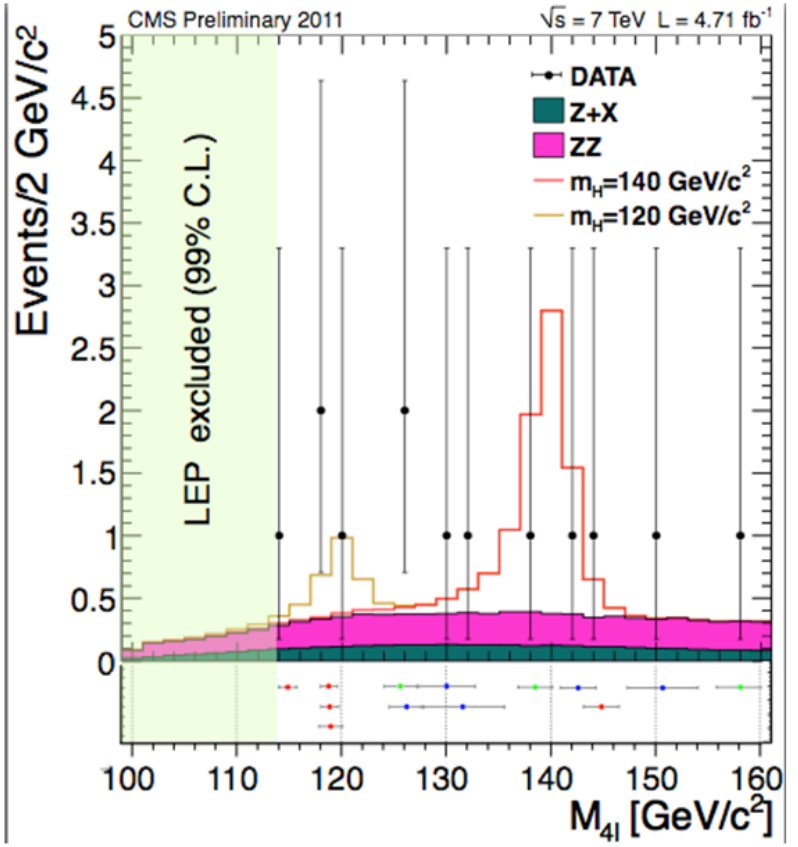


$$M_{ab} = [(E_a+E_b)^2-(\vec{p}_a+\vec{p}_b)^2]^{1/2}$$



Hl'adanie Higgsa





Otvorené otázky:

- zahrnutie gravitácie

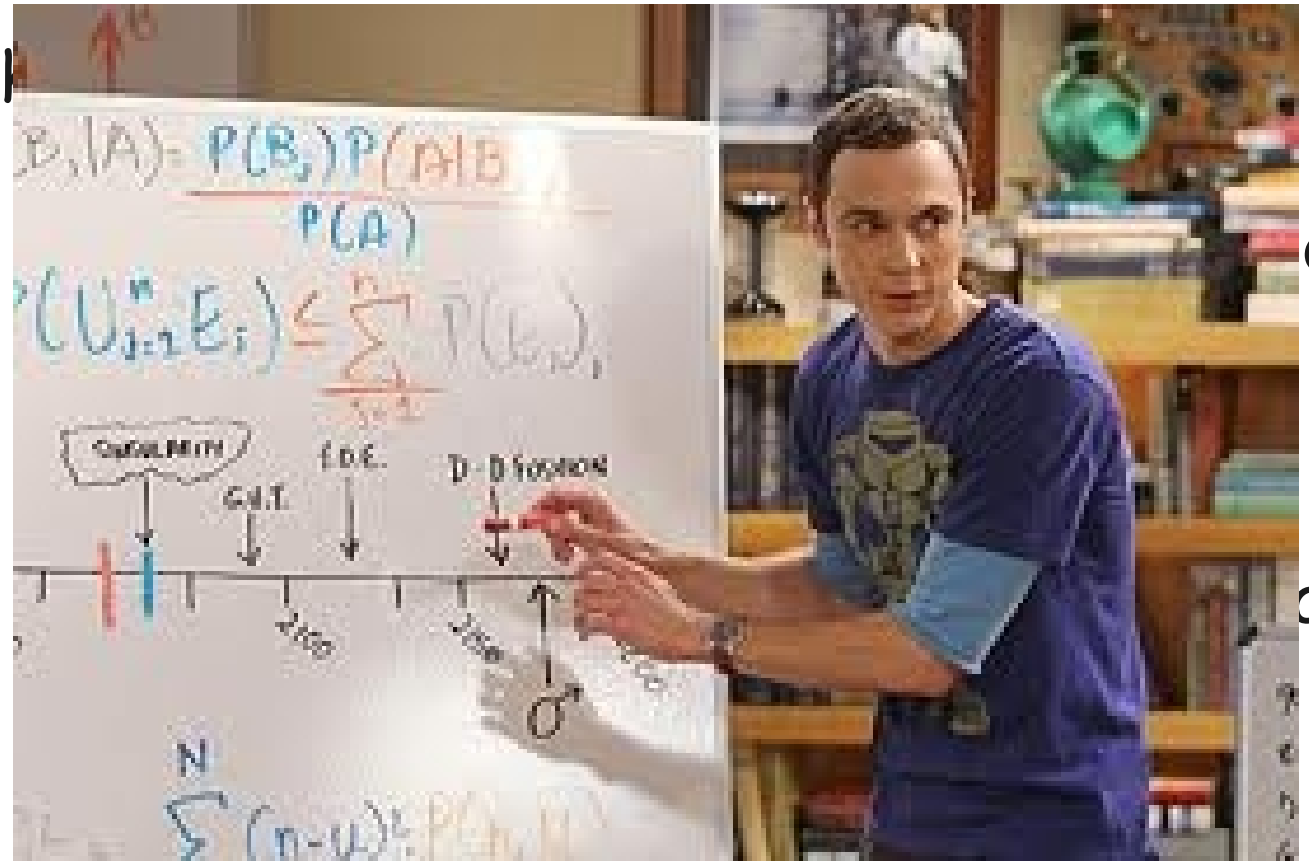
- odkiaľ majú častice hmotnosť, Higgsov bozón

- prečo práve tri generácie

- ako súvisia všetky parametre

Otvorené otázky:

- zal



ov bozón

arametre