Metoda ukrštenih snopova i otkriće J/ψ čestice te šarma

Hadroni: barioni i mezoni

- Leptoni
- Hadroni

hiperprodukcija elementarnih čestica

Počeci

- Hiperon – klasa bariona s bar jednim stranim kvarkom
- Hiperjezgra – jezgra s bar jednim hiperonom
- 1953. M. Danysz i J.Pniewski otkriće u fotografskoj emulziji na visini od 26km
- Modovi raspada Λ hiperona

$$\Lambda \rightarrow \mathrm{p}\pi^{-} \quad (63.9 \pm 0.5\%)$$

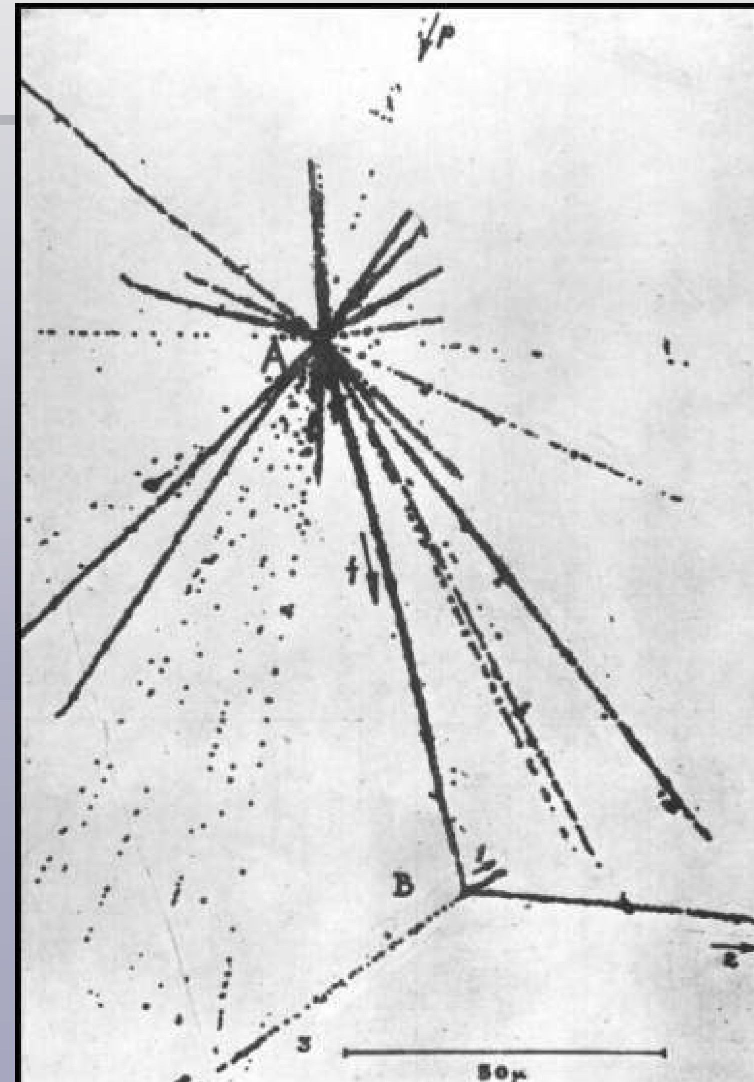
$$\Lambda \rightarrow n\pi^{0} \quad (35.8 \pm 0.5\%)$$

$$\Lambda \rightarrow n\gamma \quad (1.75 \pm 0.15 \times 10^{-3})$$

$$\Lambda \rightarrow \mathrm{p}\pi^{-}\gamma \quad (8.4 \pm 1.4 \times 10^{-4})$$

$$\Lambda \rightarrow \mathrm{pe}^{-}\overline{\nu}_{e} \quad (8.32 \pm 0.14 \times 10^{-4})$$

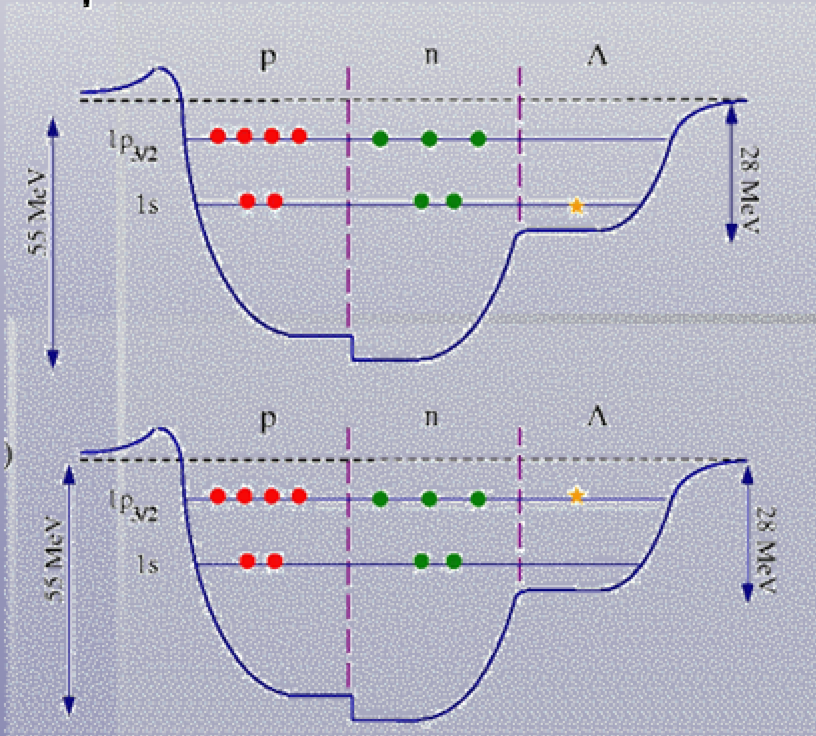
$$\Lambda \rightarrow \mathrm{p}\mu^{-}\overline{\nu}_{\mu} \quad (1.57 \pm 0.35 \times 10^{-4})$$

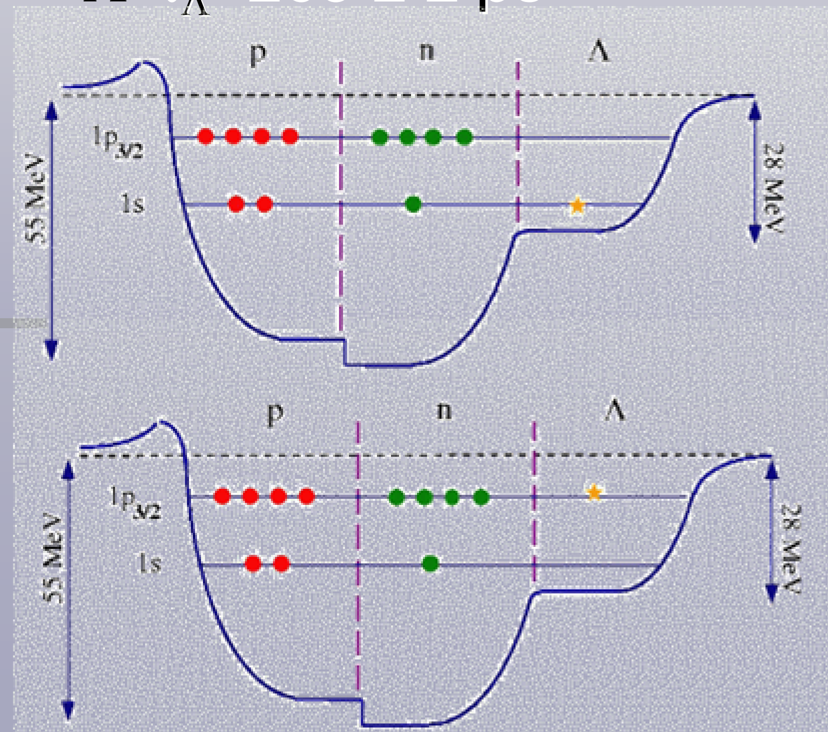


Λ čestica; najinteresantniji hiperon!

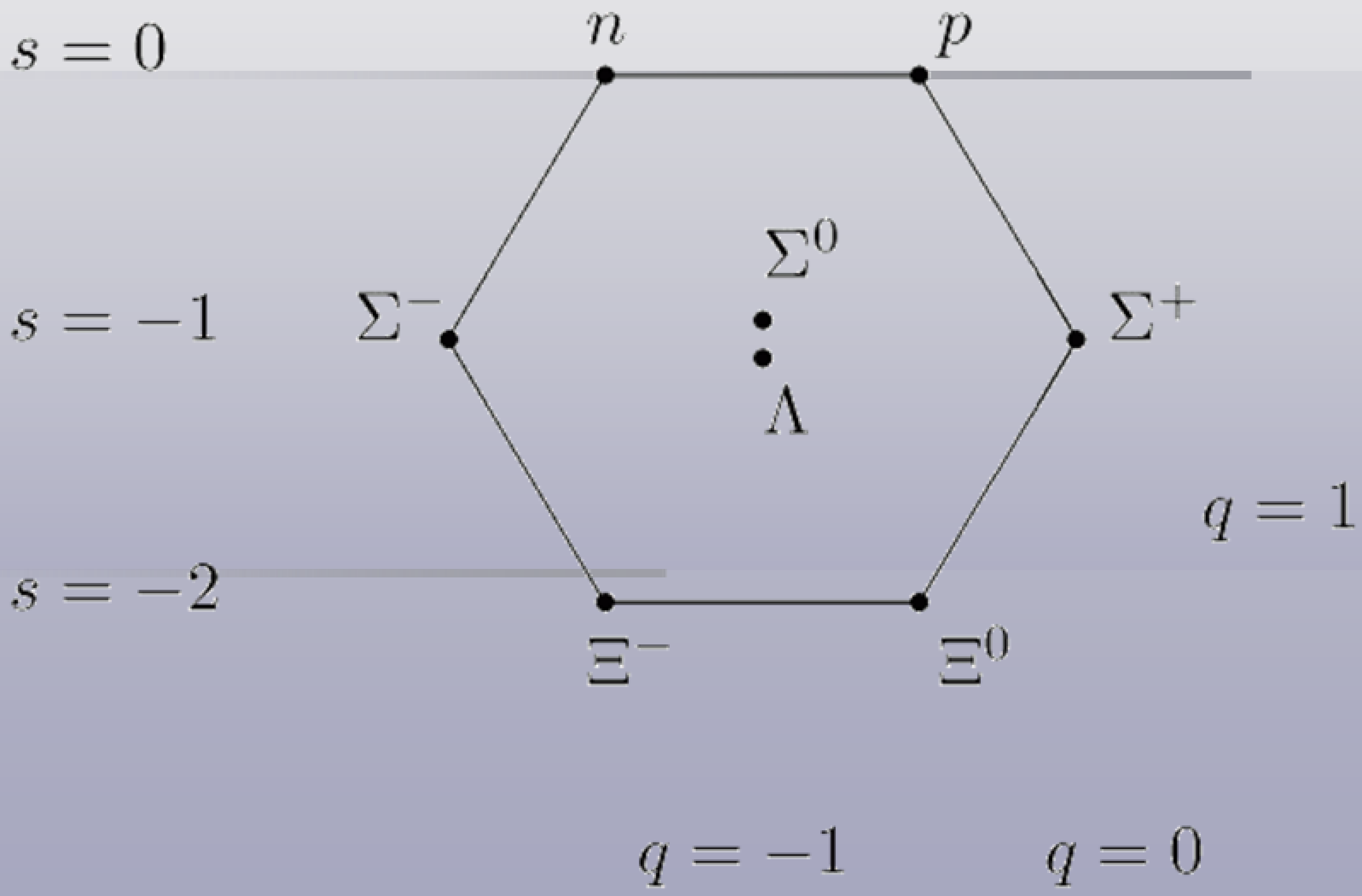
- najlakši hiperon
- 1115.684 ± 0.006MeV
- masa cca 20% veća od protona ili neutrona

- Q=0
- I=0
- S=-1
- τ_{Λ}=263 ± 2 ps

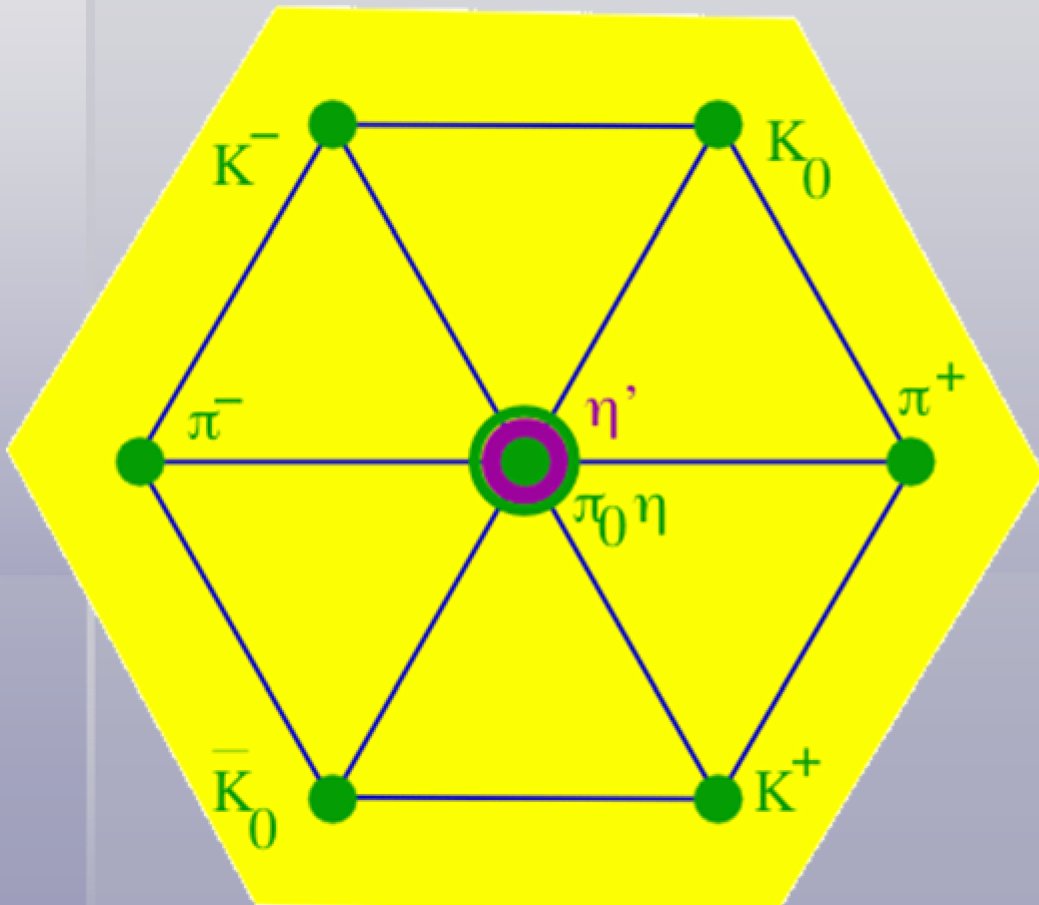




Spin 1/2 barionski oktet

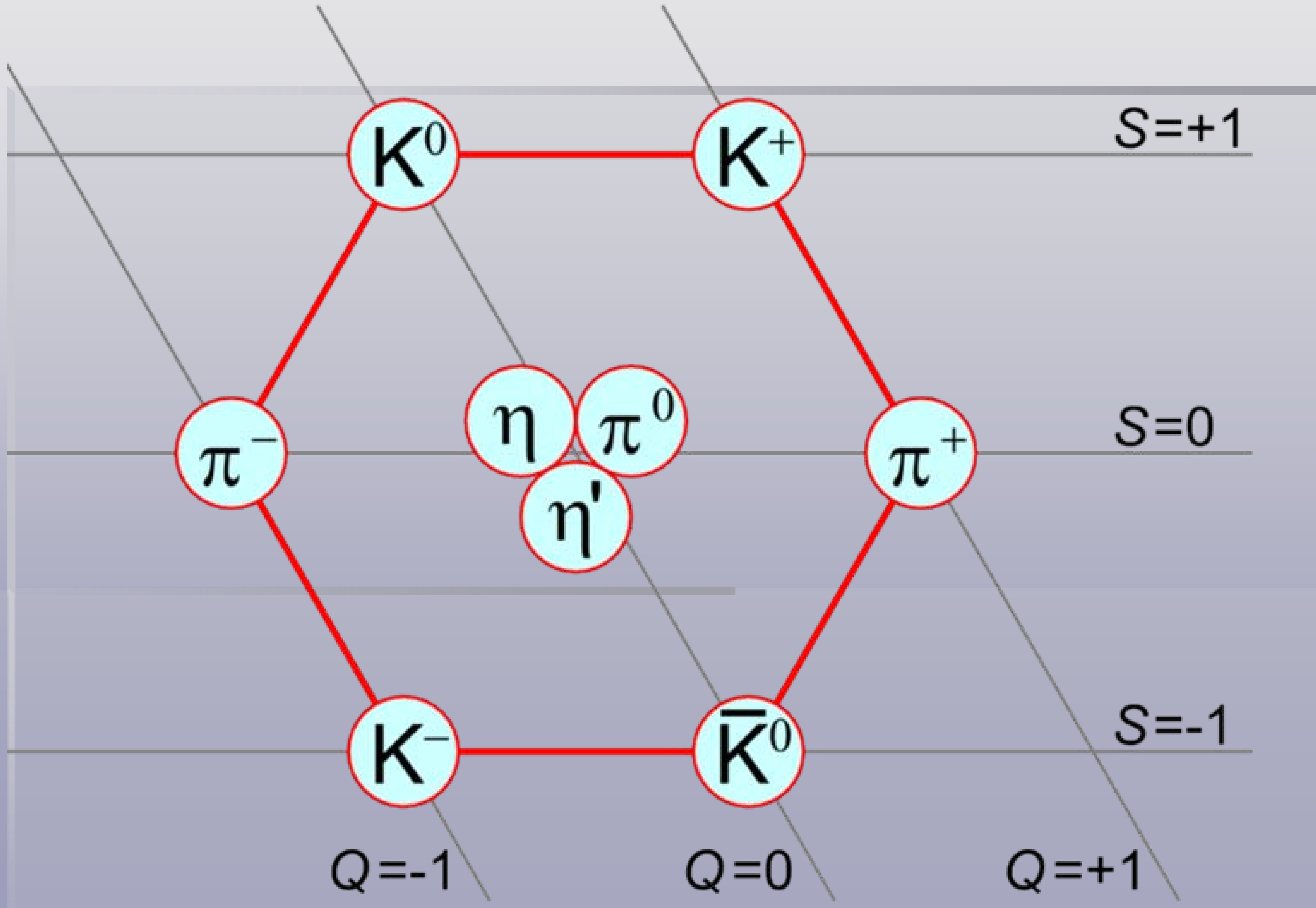


Pseudoskalarni mezonski nonet

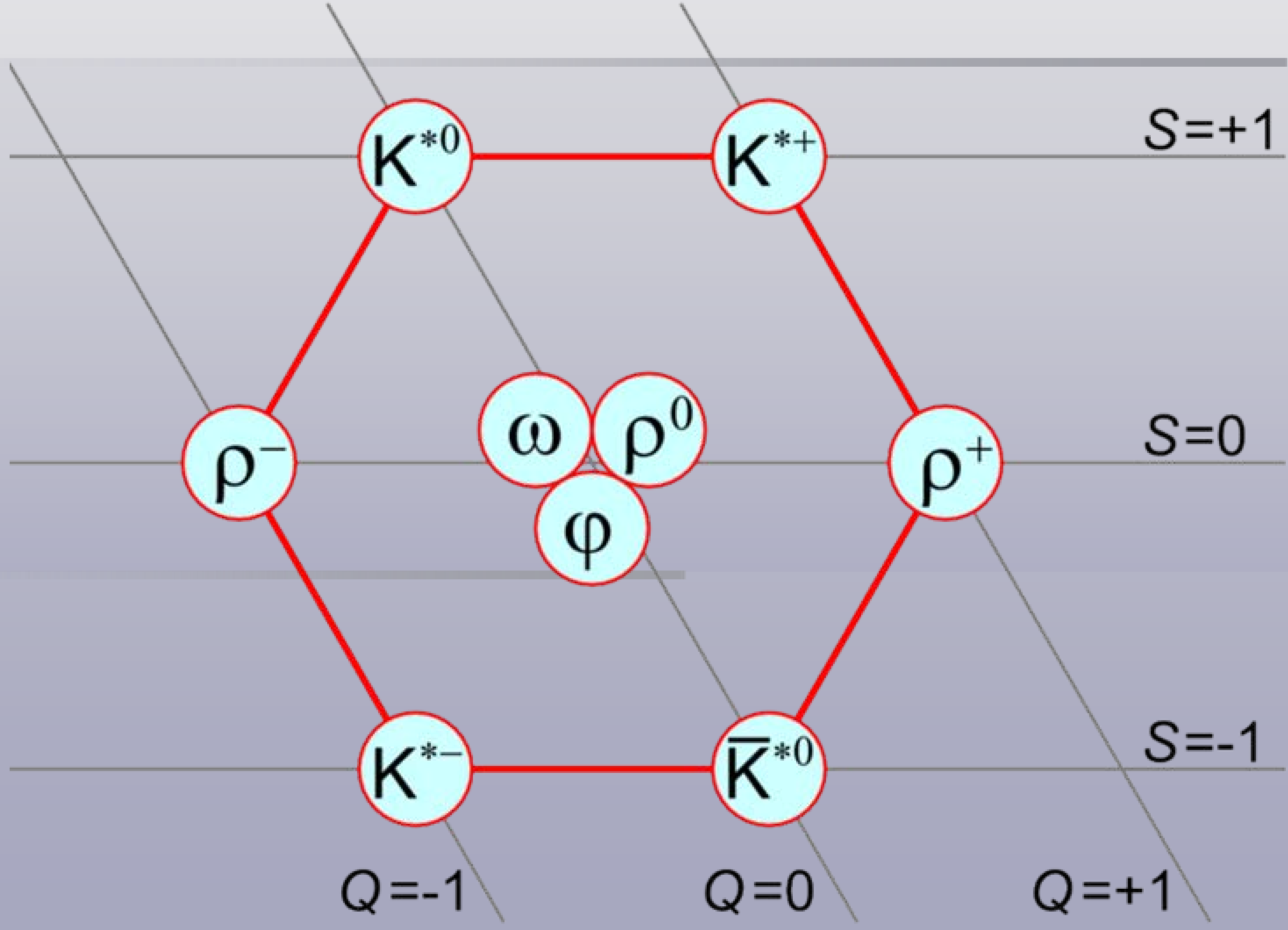


- Članovi okteta: zelemo
- Singlet: magenta

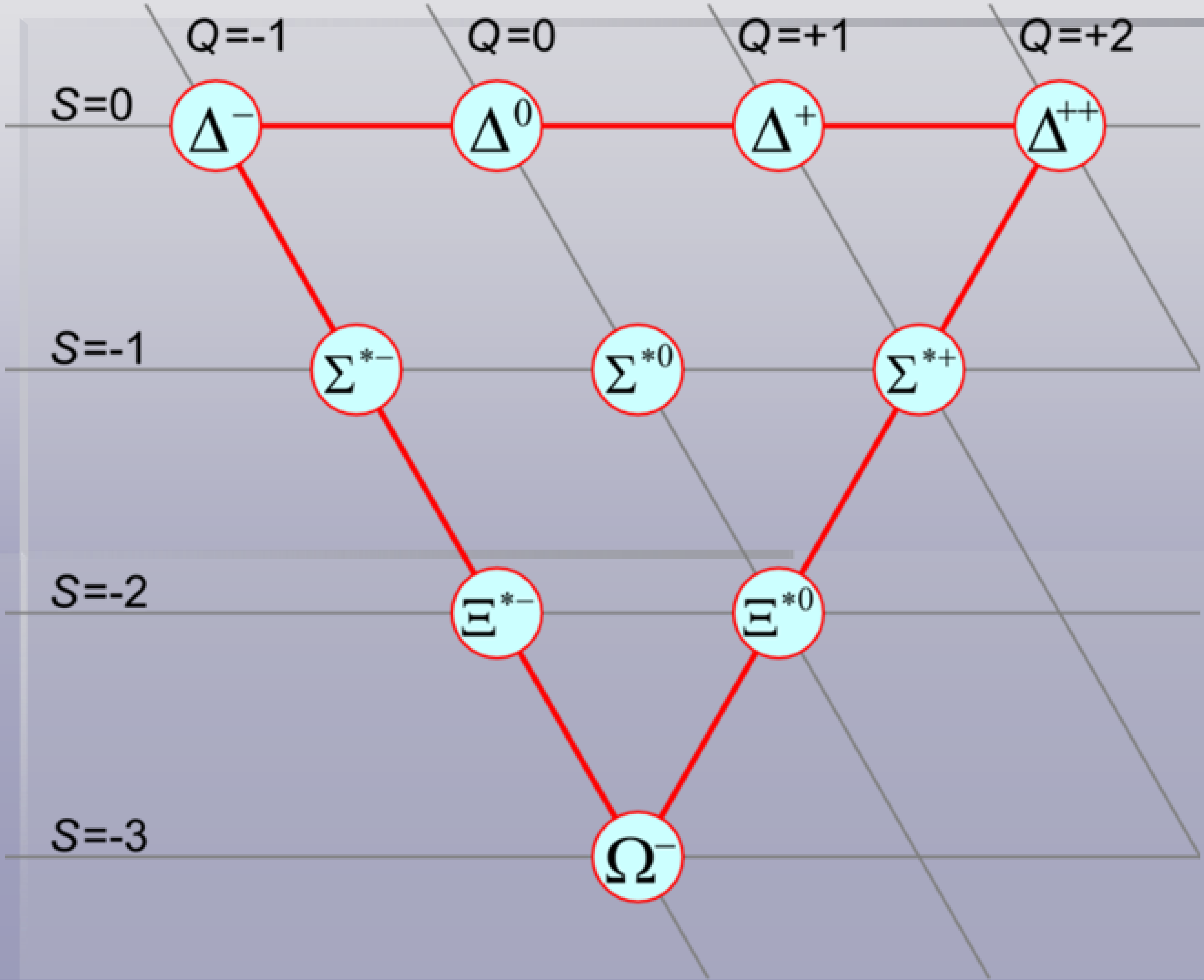
Mezoni spina 0 (nonet)



Mezoni spina 1 (nonet)



Spin 3/2 barionski dekuplet



Kvarkovska shema SU(3)

Okus	Ime	Oznaka	Naboj	Masa (MeV/c^2)
I_z=+½	Up	u	+⅔	1.5 – 4.0
I_z=-½	Down	d	-⅓	4 – 8
S=-1	Strange	s	-⅓	80 – 130

Udarni presjek

- N- broj raspršenja u sekundi
- B- ulazne čestice u vremenu τ
- T- broj čestica mete na površini P

$$N = \frac{T}{P}\frac{B}{\tau}\sigma$$

Lumnozitet

$$N = L\sigma$$

$$L = \frac{T}{P}\frac{B}{\tau}$$

$$P = 4\pi\sigma_x\sigma_y$$

$$N^+; N^-$$

$$J^- = N^- fB_b$$

$$L = \frac{N^+ N^-}{4\pi\sigma_x\sigma_y} fB_b$$

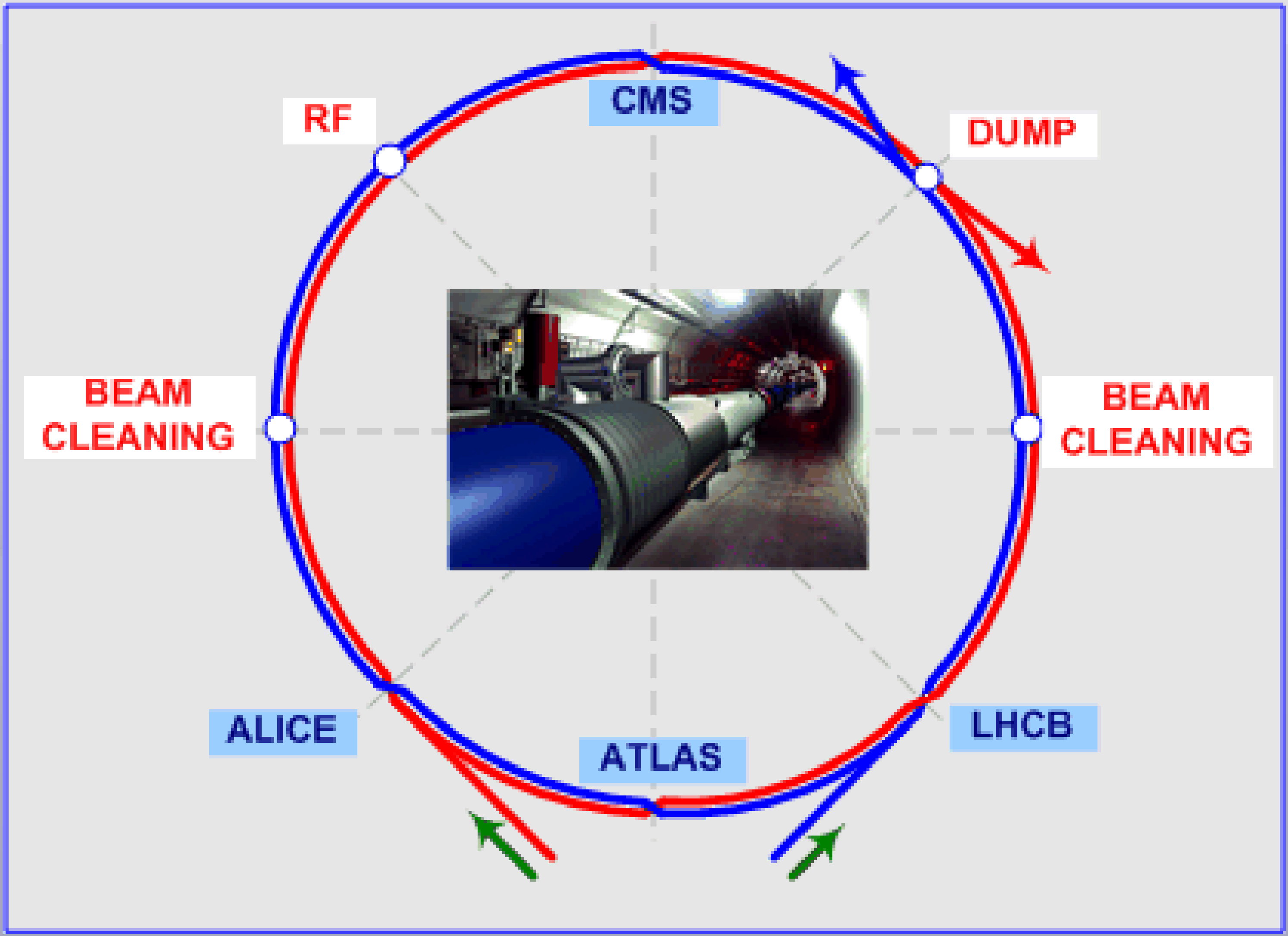
$$L = \frac{J^+ J^-}{4\pi\sigma_x\sigma_y fB_b}$$

Luminoziteti nekih sudarivača

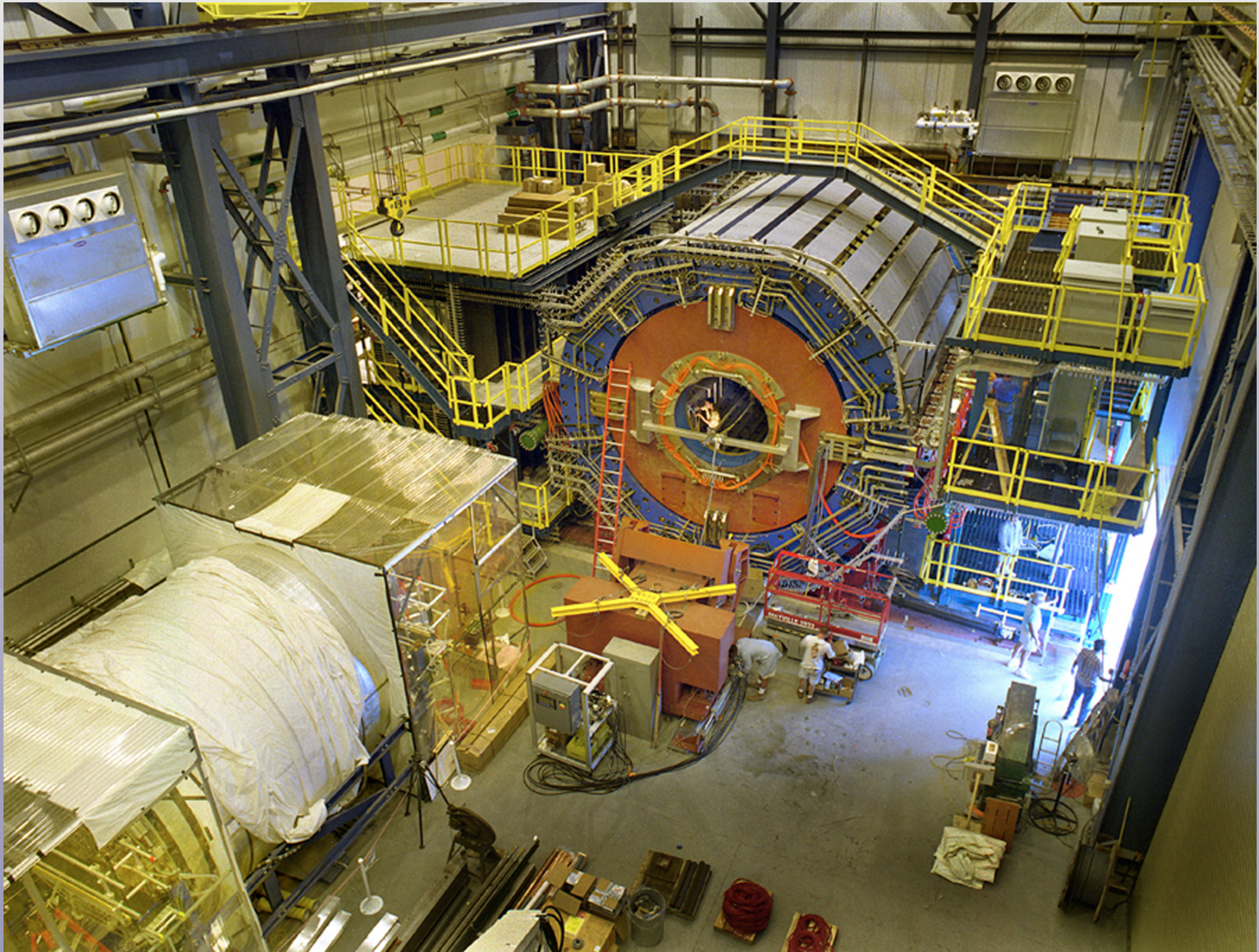
Ime	država	čestice	*E* [GeV]	L [$10^{32}cm^{-2}s^{-1}$]
DAFNE	Italija	e^+e^-	2 x0.7	5
CESR	USA	e^+e^-	6.0	6
PEP-2B	USA	e^+e^-	3.1 + 9.0	
KEK-B	Japan	e^+e^-	3.5 + 8.0	100
PETRA	Njemačka	e^+e^-	2 x 40	
LEP	Europa	e^+e^-	100	0.6
HERA	Njemačka	e^-p	12 + 40	0.1
RHIC	SAD	$p\underline{p}$, Ions	2x250(*p*)/(Au^+)	0.1 (*p*)
Tevatron	SAD	$p\underline{p}$	2 x 1800	1.8
LHC	Europa	$p\underline{p}$	2 x 7000	100

RHIC

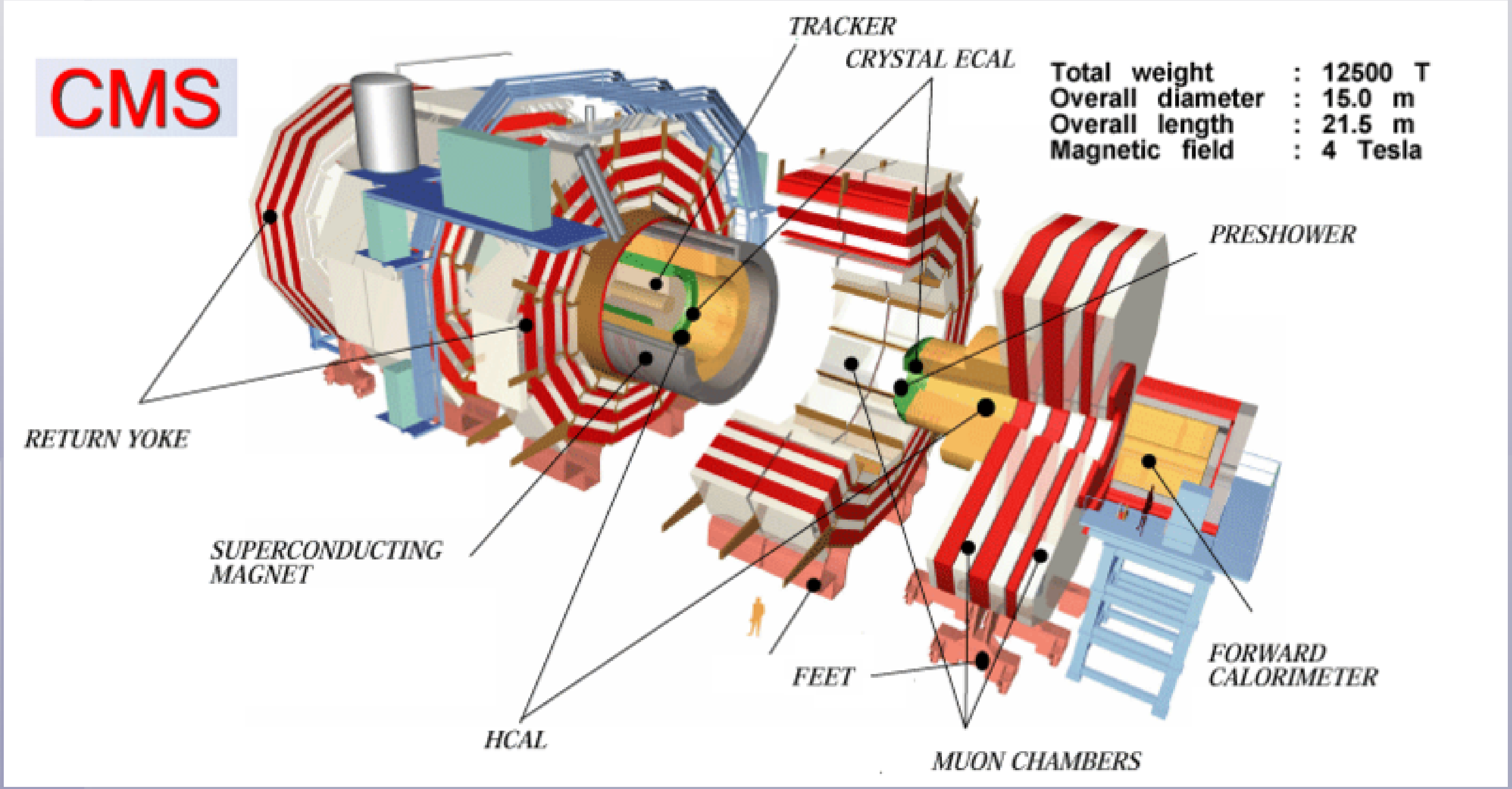
LHC shema sudarivača i detektora



CMS detektor

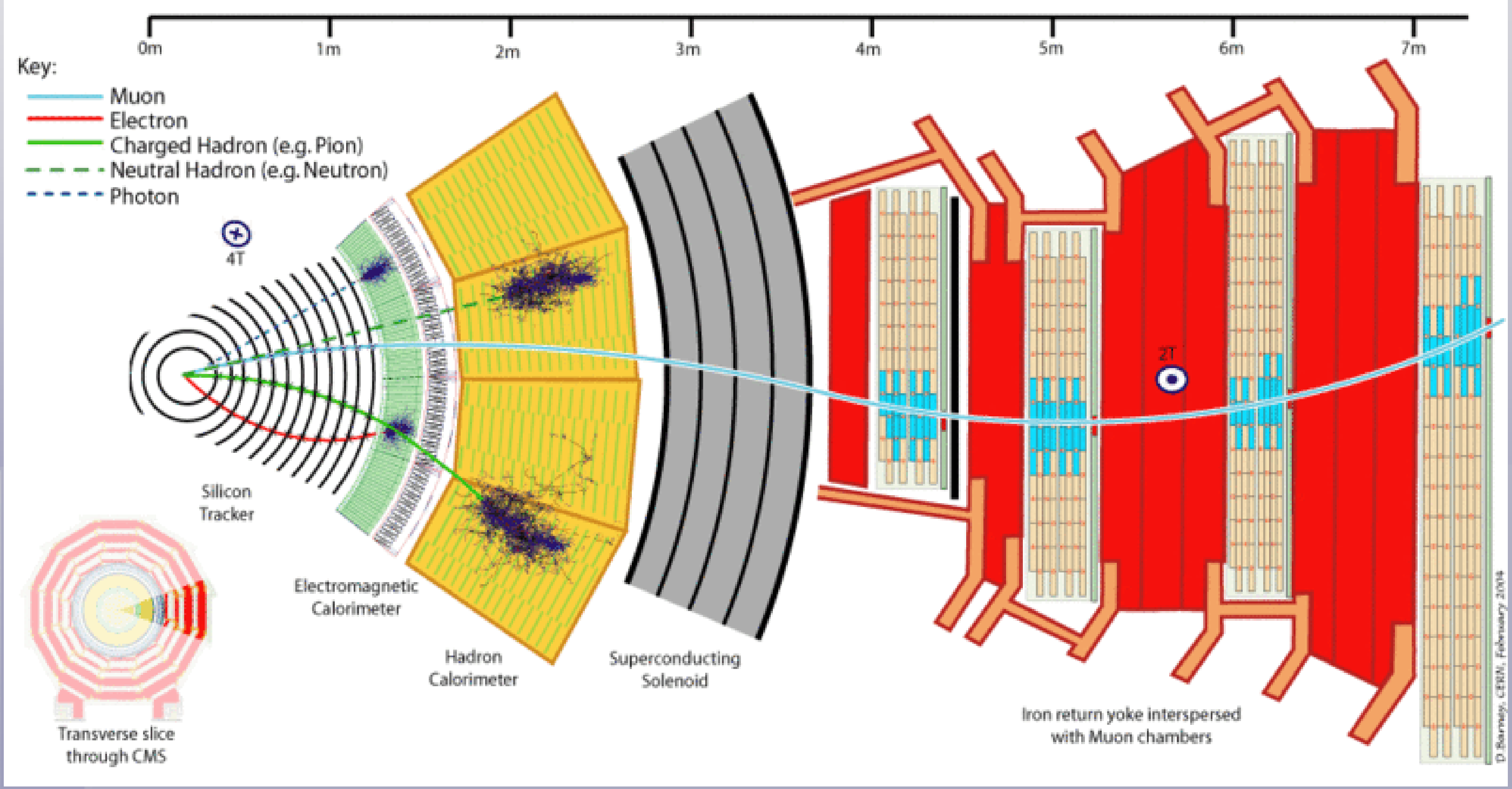


The set up of the CMS.
In the middle, under the so-called barrel there is a man for the scale.
(HCAL=hadron calorimeter, ECAL=electromagnetic calorimeter)



Čestica u CMSu

CMS_ Slice.swf
CMS Assembly final.mpg



Naivni partonski model u procesima:

Feynman 1969; Bjorken 1969;

Drell 1971; Landshof 1971

- $e^+ + e^- \rightarrow X$ (elektron-pozitron anihilacija)
- $e + N \rightarrow e + N$ (duboko neelastično raspršenje)
- $N+N \rightarrow \mu^+ + \mu^- + X$ (Drell-Yan procesi)
- $p+\underline{p} \rightarrow$ jests veliki p_T $+X$

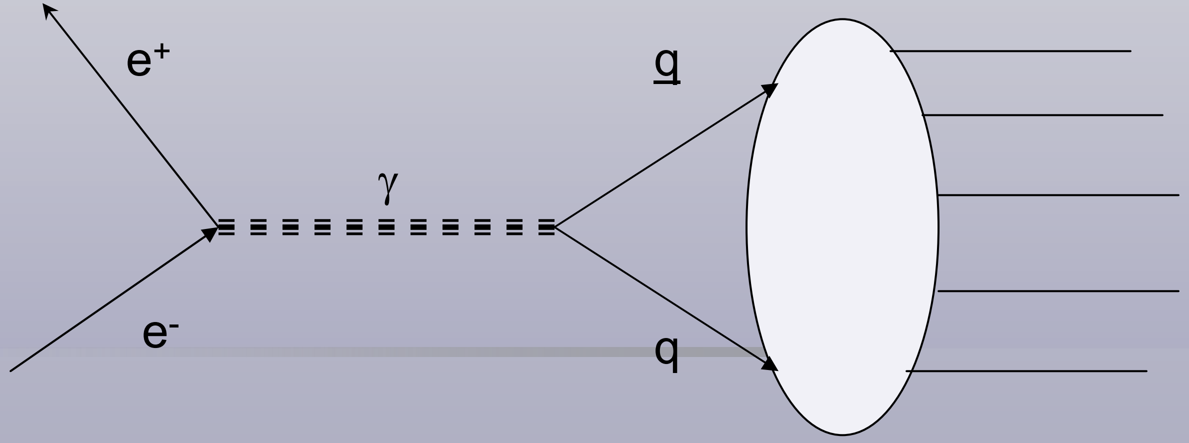
Naivni partonski model pretpostavke:

- Brzi hadron nakupina partona koji djele energiju i gibaju se u istom smjeru
- Impulsna aproksimacija – partonska reakcija nekoherentno sumirana preko doprinosa svih partona

Naivni partonski model

- $e^+ + e^- \to q + \underline{q}$ slično kao $e^+ + e^- \to \mu^+ + \mu^-$

$$\sigma(e^+e^- \to \mu^+\mu^-) = \frac{4\pi\alpha^2}{3}\frac{1}{s}$$



- $\alpha = e^2/4\pi$
- energija u centru mase $s >> m_{e,}\ m_\mu$

Naivni partonski model

$$\frac{\sigma(e^+e^- \to q\overline{q})}{\sigma(e^+e^- \to \mu^+\mu^-)} = Q_q^{\ 2}$$

$$\frac{\sigma(e^+e^- \to hadrons)}{\sigma(e^+e^- \to \mu^+\mu^-)} = \sum_q Q_q^{\ 2} + \sum_{q'} Q_{q'}^{\ 2}$$

$$R(s) = \frac{\sigma(e^+e^- \to hadrons)}{\sigma(e^+e^- \to \mu^+\mu^-)} = \sum_q Q_q^{\ 2} + \sum_{q'} Q_{q'}^{\ 2}$$

2

J/ψ

$$1\text{ GeV} \lesssim \sqrt{s} \lesssim 3\text{ GeV}. \quad (18.13)$$

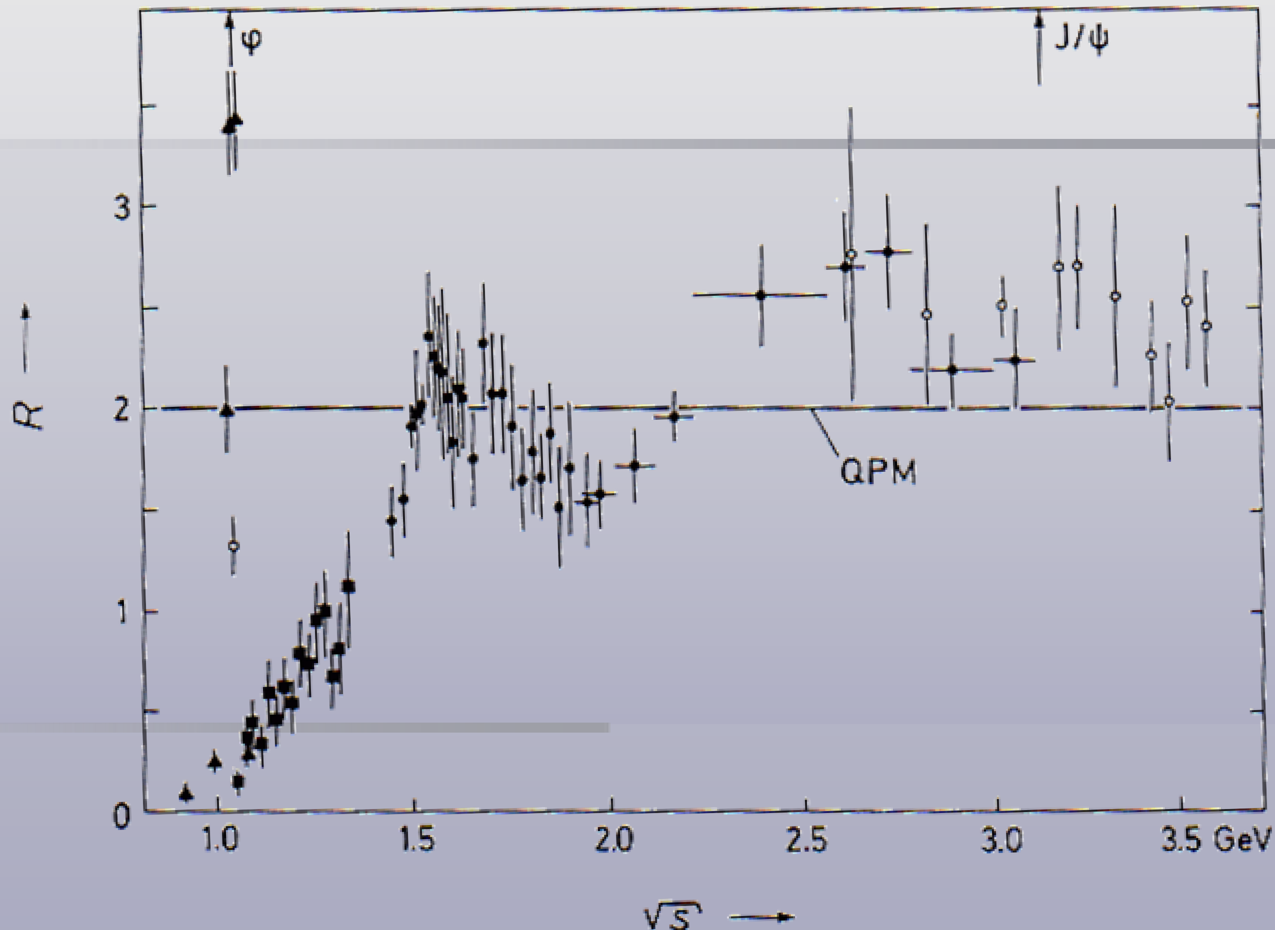


Figure 18.3 Data for $R(s) = \sigma(e^+e^- \to \text{hadrons})/\sigma(e^+e^- \to \mu^+\mu^-)$ at center of mass energies $\sqrt{s}$ less than 3.5 GeV (Bacci 1979). The prediction of the quark–parton model (QPM) for this energy region is $R(s) = 2$.

J/ψ

J/ψ karakteristike	
Sastoji se od:	2 Kvarka Šarm 1 ; Antišarm 1
Porodica:	Hadron
Grupa:	Mezon
Masa:	5.5208×10^{-27} kg 3.096 916 GeV/c^2
Naboj:	0C
Spin:	1

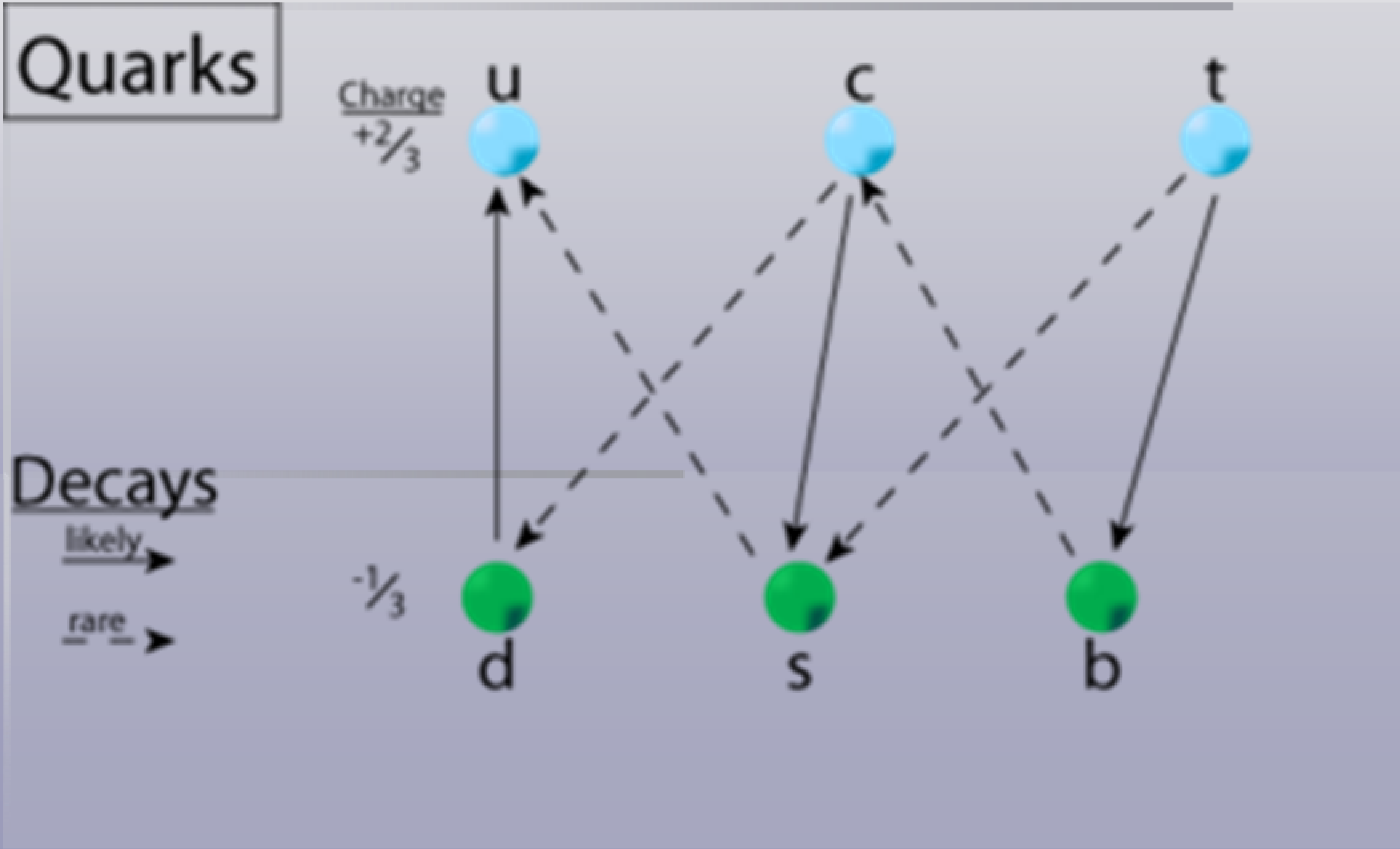
J/ψ karakteristike

- J/ψ masa mirovanja 3096.9 MeV/c^2
- poluživot 7.2×10^{-21}s.
- Poluživot tisuću puta dulji od očekivanog

J/ψ Hystorical facts

- Its discovery was made independently by two research groups, one at the Stanford Linear Accelerator Center, headed by Burton Richter, and one at the Brookhaven National Laboratory, headed by Samuel Ting.
- They accidentally discovered they had found the same particle, and both announced their discoveries on November 11, 1974.
- The importance of this discovery is highlighted by the fact that the subsequent, rapid changes in high-energy physics at the time have become collectively known as the "November Revolution".
- Richter and Ting were rewarded for their discovery with the 1976 Nobel Prize in Physics.

Hadroni i kvarkovi



Kvarkovska shema

	Weak Isospin	Flavor	Ime	oznaka	naboj	Masa MeV·c^{-2}
1	+½	I_z=+½	Up	u	+⅔	1.5 – 4.0
1	-½	I_z=-½	Down	d	-⅓	4 – 8
2	-½	S=-1	Strange	s	-⅓	80 – 130
2	+½	C=1	Charm	c	+⅔	1150 – 1350
3	-½	B=-1	Bottom	b	-⅓	4100 – 4400
3	+½	T=1	Top	t	+⅔	170900 ± 1800