Získané výsledky počas vedeckého pobytu v zahraničí

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Prezentácia ako príloha záverečnej individuálnej správy k zmluve o poskytnutí dotácie zo štátneho rozpočtu medzi MŠ SR a FÚ SAV na pobyt vedeckých pracovníkov v organizácii CERN

Predpovedanie priebehu formfaktora nabitého piónu v priestoru-podobnej oblasti

Motivácia:

- V priestoru-podobnej oblasti sú údaje o formfaktore menej presné ako v času-podobnej oblasti.
- Jestvujú dôvody pre pochybnosti ohľadom dôveryhodnosti publikovaných údajov v priestoru-podobnej oblasti.
- Piónový formfaktor je základný objekt na popis elektromagnetickej štruktúry nabitého piónu a teda jeho skúmanie je zaujímavé samo o sebe.

Metóda:

- Využitie analytických vlastností formfaktora spolu s experimentálnymi údajmi v času-podobnej oblasti na predpovedanie priebehu formfaktora v priestoru-podobnej oblasti.

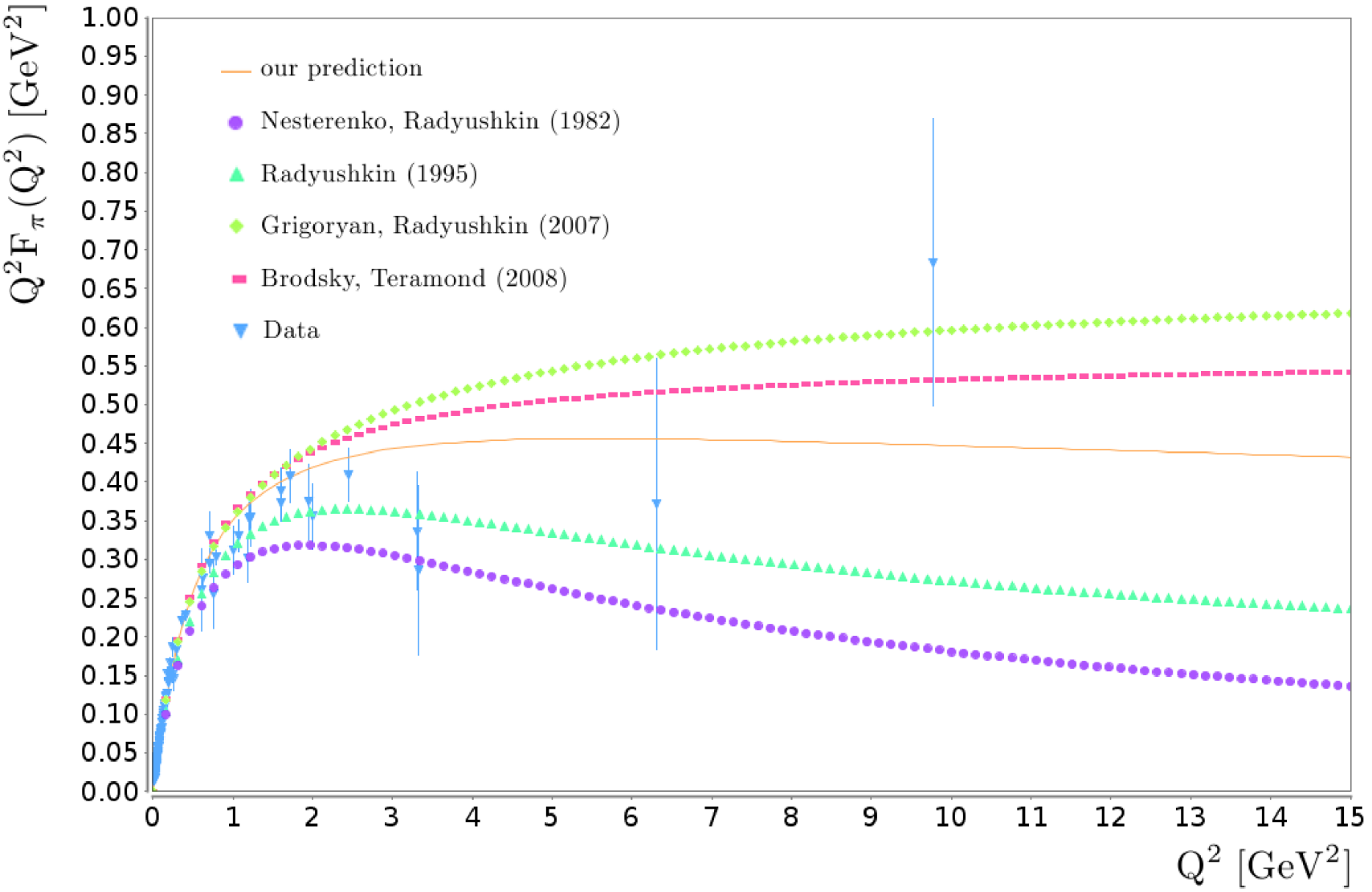
Ciele:

- Získať priebeh formfaktora v priestoru-podobnej oblasti.
- Porovnať s jestvujúcimi experimentálnymi údajmi v tejto oblasti.
- Porovnať s predpoveďami modelov iných autorov.

Výsledok:

- Graf na nasledujúcej strane.

Priebeh formfaktora piónu v priestoru-podobnej oblasti: výsledný graf



Nezávislé určenie parciálnych šírok rozpadu $\Gamma(P \to 2\gamma)$ pre častice $P = \pi^0, \eta, \eta'$.

Motivácia:

- Šírka rozpadu – základná charakteristika častice, jej presné určenie je dôležité.
- Prechodové formfaktory pre pseudoskalárne mezóny – možnosť nezávislého overenia parciálnych šírok.

Metóda:

- Využiť súvis medzi parciálnou šírkou rozpadu na dva fotóny a normalizáciou formfaktora (hodnota formfaktora v nule).
- Normalizáciu formfaktora získať fitovaním experimentálnych údajov za pomoci unitárneho a analytického modelu.

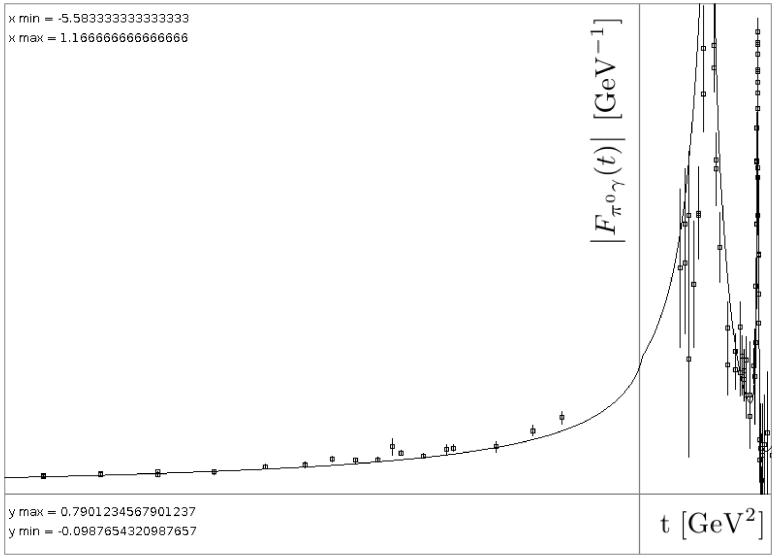
Ciele:

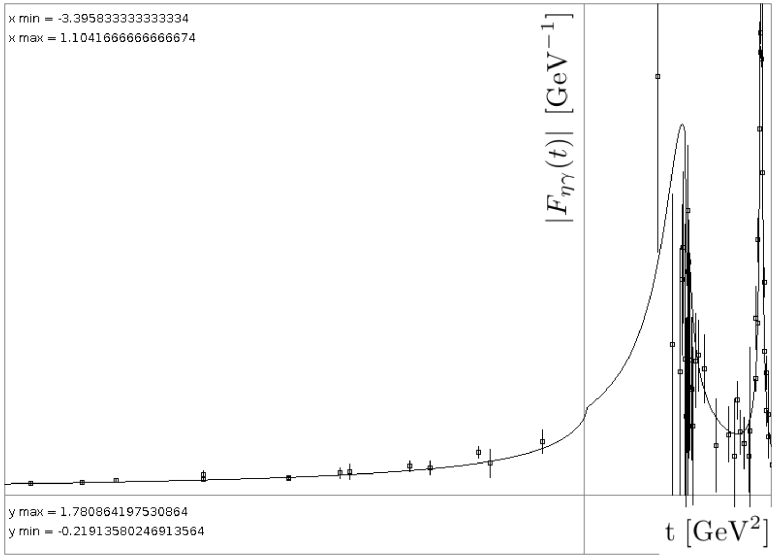
- Nezávislým spôsobom overiť hodnoty šírok, ktoré sú uvádzané vo fyzikálnych tabuľkách PDG.
- Preukázať prínos unitárneho a analytického modelu a prístupu vôbec.

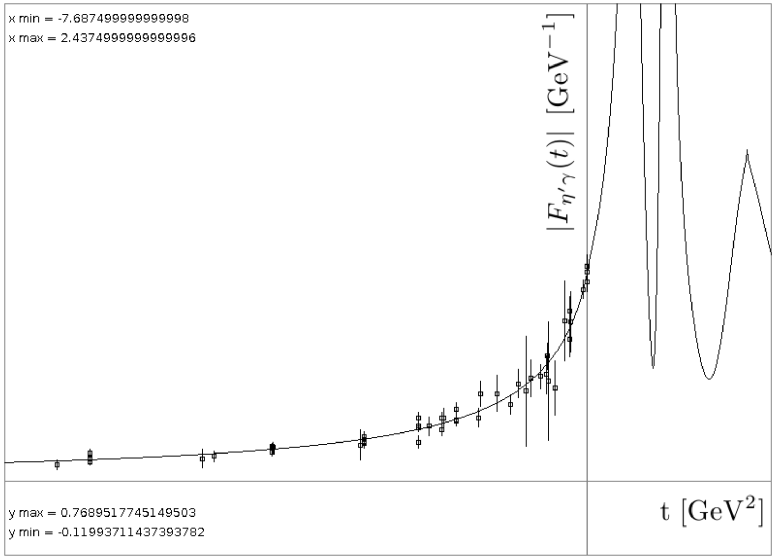
Výsledky:

- Preverenie tabuľkových hodnôt pre častice η, η', v prípade η' získanie hodnoty s menšou chybou.
- Nesúhlas s tabuľkovou hodnotou v prípade π^0, zaujímavý výsledok poukazujúci pravdepodobne na podhodnotenie chýb v experimentoch.
- Získanie popisu experimentálnych údajov za pomoci modelu formfaktora (grafy na nasledujúcej strane).

Určenie šírok rozpadu Γ(P→2γ): popis experimentálnych údajov modelom pre P = π^0, η, η', výsledková tabuľka







$P =$	π^0	η	η'
$F_{\gamma P}(t)\|_{t=0}$	$0.2050^{-0.0016}_{+0.0016}$	$0.2780^{-0.0072}_{+0.0087}$	$0.3379^{-0.0100}_{+0.0084}$
$\Gamma^{U\&A}_{P\to\gamma\gamma}$	$4.3230^{-0.0713}_{+0.0697}$ eV	$0.5316^{-0.0278}_{+0.0333}$ keV	$4.1968^{-0.2501}_{+0.2107}$ keV
$\Gamma^{U\&A,\,Alt.}_{P\to\gamma\gamma}$	5.28 ± 0.26 eV	0.4283 ± 0.0637 keV	4.1428 ± 0.2740 keV
$\Gamma^{PDG}_{P\to\gamma\gamma}$	7.744 ± 0.553 eV	0.511 ± 0.028 keV	4.284 ± 0.399 keV
$\Gamma^{PDG}_{P\to\gamma\gamma} - \Gamma^{U\&A}_{P\to\gamma\gamma}$	3.420 ± 0.557 eV	-0.020 ± 0.041 keV	0.087 ± 0.460 keV

Publikovanie výsledkov, záver

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- Titulné strany (prezentácia z konferencie, 2 články) :

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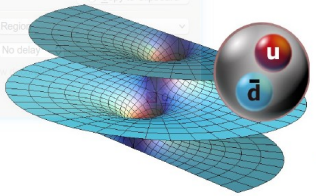
Prediction of the pion form factor behavior in the space-like region with small model dependence

based on the time-like experimental data and analyticity.



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TWO-PHOTON DECAY RATES OF TRUE NEUTRAL PSEUDOSCALAR MESONS FROM DATA ON THEIR TRANSITION FORM FACTORS

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By means of the universal unitary and analytic model of electromagnetic structure of hadrons the two-photon decay rates of $P = \pi^0, \eta, \eta'$ mesons are determined in an alternative way from data on their transition form factors.

I. INTRODUCTION

There are three true neutral particles ($P = \pi^0, \eta, \eta'$) from the nonet of pseudoscalar mesons, which decay into 2γ. The $\pi^0 \to 2\gamma$ channel with branching ratio $(98.798 \pm 0.032)\%$, $\eta \to 2\gamma$ channel with branching ratio $(39.31 \pm 0.20)\%$ and $\eta' \to 2\gamma$ channel with branching ratio $(2.10 \pm 0.12)\%$, corresponding to the following decay widths: $\Gamma_{exp}(\pi^0 \to 2\gamma) = (7.84 \pm 0.56)eV$, $\Gamma_{exp}(\eta \to 2\gamma) = (511.03 \pm 27.79)eV$ and $\Gamma_{exp}(\eta' \to 2\gamma) = (4305.00 \pm 424.95)eV$, respectively.

They are an average of repeated measurements at different experiments exploiting the Primakoff effect and $e^+e^- \to e^+e^-P$ process; in the case of $\eta'(958)$ also $e^+e^- \to e^+e^-\pi^+\pi^-\gamma$, $e^+e^- \to e^+e^-\eta\pi^+\pi^-$ and $e^+e^- \to e^+e^-\eta\pi^0\pi^0$ processes.

In this contribution we demonstrate a more effective method of a determination of 2γ decay widths of π^0, η and η'. More concretely, by a description of existing data on the corresponding transition form factors (FFs) in space-like and time-like regions simultaneously with the elaborate in [1] Unitary and Analytic ($U\&A$) model of π^0, η and η' transition FFs.

The main idea consists in the following: The behavior of the meson-photon transition FF $F_{\gamma P}(Q^2)$ for $Q^2 \to 0$

$$lim_{Q^2 \to 0} F_{\gamma P}(Q^2) = \frac{1}{4\pi^2 f_P} \tag{1}$$

can be determined from the axial anomaly in the chiral limit of QCD, where f_P is the meson weak decay constant and $Q^2 = -q^2 = -t$. However, in order to take into account the fact that f_η and $f_{\eta'}$ (unlike $f_\pi = 93MeV$) are not directly measurable quantities, employing the relation for the two-photon partial width

$$\Gamma(P \to \gamma\gamma) = \frac{\alpha^2}{64\pi^3 f_P^2} m_P^3 \tag{2}$$

of the pseudoscalar meson P, one comes to a redefinition of the FF norm

$$F_{\gamma P}(0) = \frac{2}{\alpha m_P}\sqrt{\frac{\Gamma(P \to \gamma\gamma)}{\pi m_P}} \tag{3}$$

to be expressed through the $\Gamma(P \to \gamma\gamma)$. So, fitting all existing data on $F_{\gamma\pi^0}(t)$, $F_{\gamma\eta}(t)$, $F_{\gamma\eta'}(t)$ in space-like and time-like regions by the sophisticated $U\&A$ models simultaneously, one finds normalization points values $F_{\gamma\pi^0}(0)$, $F_{\gamma\eta}(0)$, $F_{\gamma\eta'}(0)$ and then, finally, by means of (3) the most reliable values of $\Gamma(\pi^0 \to \gamma\gamma)$, $\Gamma(\eta \to \gamma\gamma)$ and $\Gamma(\eta' \to \gamma\gamma)$.

II. EXPERIMENTAL DATA ON PSEUDOSCALAR MESON TRANSITION FORM FACTORS

One of the first measurements of π^0, η and η' transition FFs in the space-like region was carried out by CELLO Colab. [2], where really the π^0 transition FF in the space-like region was observed for the first time. An extension

Solid pion electromagnetic form factor space-like behavior

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By taking advantage of the analyticity the experimental information on $\sigma_{tot}(e^+e^- \to \pi^+\pi^-)$ is transferred into the space-like region and a solid pion electromagnetic form factor behavior, to be compared with some QCD inspired model predictions, is obtained.

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Keywords: electromagnetic interactions, electromagnetic form factors

The pion electromagnetic (EM) form factor (FF) $F_\pi(Q^2)$ ($t = -Q^2$ being the squared four momentum transfer) is the most simple object of investigations in strong interaction physics. However, there is no theory able to explain all its known features. On one hand, in the framework of the pQCD, the unambiguous asymptotic behavior of $F_\pi(Q^2)$ in the space-like region ($t < 0$)

$$F_\pi(Q^2)_{Q^2 \to \infty} \sim \frac{64\pi^2 f_\pi^2}{(11 - 2/3n_f)Q^2 \log \frac{Q^2}{\Lambda^2}} \tag{1}$$

with $f_\pi = 93$ MeV, the quark number flavor n_f and the QCD scale parameter Λ was predicted [1]-[3]. On the other hand, any attempts to reach experimentally measurable region by various QCD inspired models [4]-[9] have led to mutually inconsistent results.

Therefore, in this paper the recently measured up in Frascati [10] and Novosibirsk [11] improved experimental information on $\sigma_{tot}(e^+e^- \to \pi^+\pi^-)$ is transferred by means of the analyticity into the space-like region providing in this manner the almost model independent behavior of $F_\pi(Q^2)$ to be useful in a confrontation with the QCD inspired model predictions.

We start from the analytic properties of the pion EM FF, which by means of the Cauchy formula and assuming the validity of the QCD asymptotic behavior (1) in all directions of the complex t-plane can be transformed into the dispersion relation without any subtractions

$$F_\pi(Q^2) = \frac{1}{\pi}\int_{4m_\pi^2}^{t_{s0\omega}} \frac{Im^E F_\pi(t')}{t' + Q^2} dt' + \frac{1}{\pi}\int_{t_{s0\omega}}^{\infty} \frac{Im^A F_\pi(t')}{t' + Q^2} dt', \tag{2}$$

from which by a utilization of the normalization condition $F_\pi(0) = 1$ a sum rule for the pion FF imaginary parts

$$1 = \frac{1}{\pi}\int_{4m_\pi^2}^{t_{s0\omega}} \frac{Im^E F_\pi(t')}{t'} dt' + \frac{1}{\pi}\int_{t_{s0\omega}}^{\infty} \frac{Im^A F_\pi(t')}{t'} dt' \tag{3}$$

Záver:

- Získané výsledky (okrem iných prínosov) svedčia o dosiahnutí stanovených cieľov a o efektívnom využití poskytnutej dotácie.