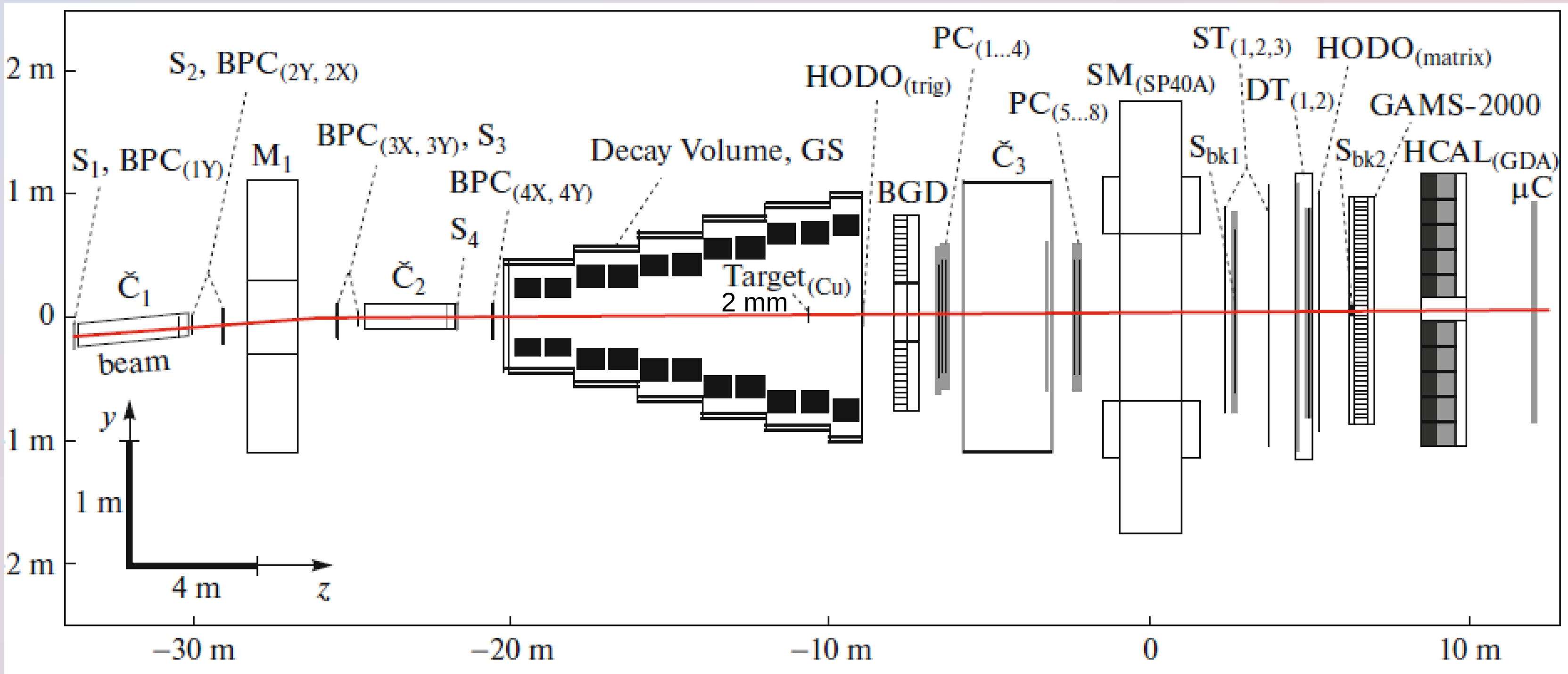
Evidence for WZW anomaly in the coherent reaction K^+ Cu → $K^+ \pi^0$ Cu

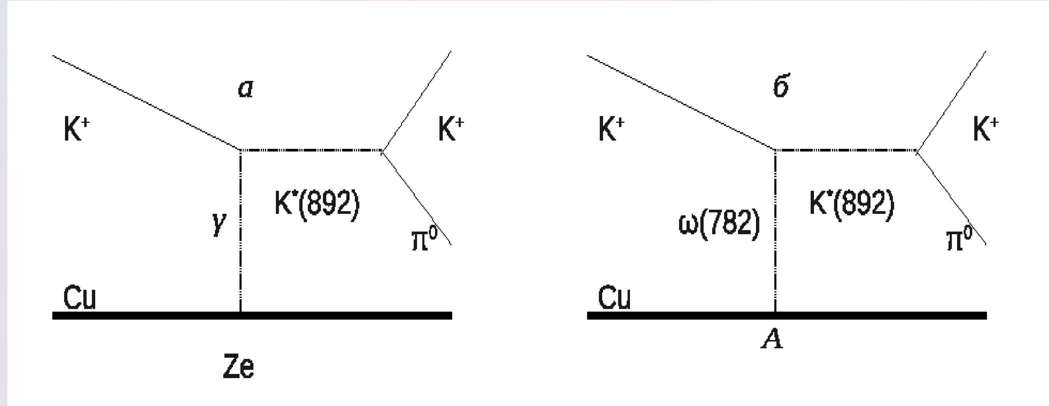
V. Obraztsov on behalf of the OKA collaboration

The OKA Experiment

- Fixed target experiment at У-70 PS
- Primary 50 GeV/c proton beam
- Secondary beam: RF-separated 18 GeV/c (3 MHz with 13% K^+)



Theoretical introduction



$$M_\gamma = 4eZ\frac{g_{K\gamma}g_{K\pi}}{q^2}\frac{\varepsilon^{\mu\nu\alpha\beta}p_{1\mu}q_\nu b_\alpha f_\beta}{w - m_*^2 + im_*\Gamma_*}\frac{wF_C(q^2)}{m_*^2 - im_*\Gamma_*} - \frac{2\alpha Z}{\pi F_\pi^3 q^2}\varepsilon^{\mu\nu\alpha\beta}p_{1\mu}q_\nu b_\alpha f_\beta$$

$$M_\omega = \frac{g_{N\omega}g_{K\omega}g_{K\pi}A_{Cu}^{2/3}}{q^2 - m_\omega^2 + im_\omega\Gamma_\omega} \times \frac{\varepsilon^{\mu\nu\alpha\beta}p_{1\mu}q_\nu b_\alpha f_\beta}{w - m_*^2 + im_*\Gamma_*}F_S(q^2)$$

From WZW anomaly

K^+ Cu → $K^+ \pi^0$ Cu Main selection cuts

One good beam and secondary track with the vertex in the target

Two showers in GAMS-2000 $110 < m_{\gamma\gamma} < 160$ MeV

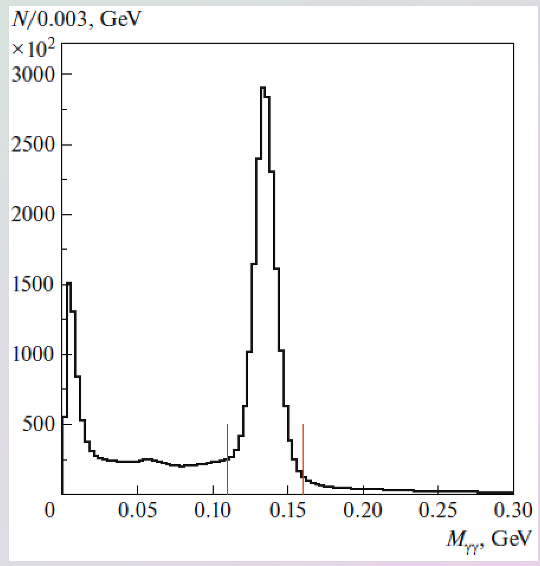
Veto cuts: $E_{BGD} <$ 100 MeV $E_{GS} <$ 40 MeV

Secondary K^+ id: $P_{sec} > 7$ GeV (to ensure C_3 π eff.), no signal in C_3

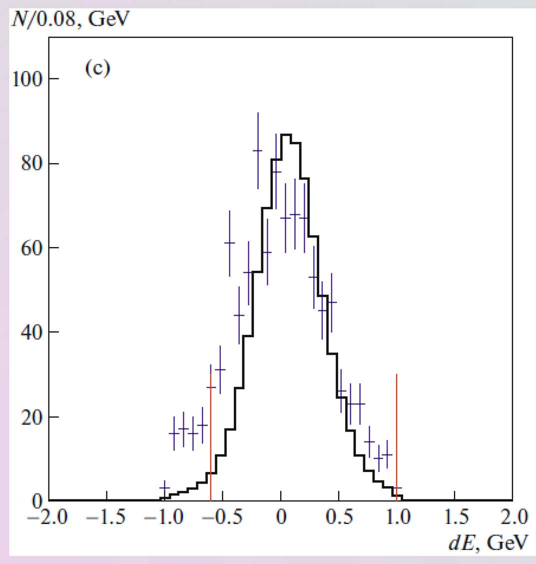
The energy balance $-0.6 < dE = E_K + E_\pi - E_b < 1$ GeV

The main background is from the $K^+ \to \pi^+ \pi^0$ decays in the region of the target. To suppress that the regions $150 < p^*_{\pi+}$, $p^*_{\pi 0} < 220$ MeV are excluded. On top of that the subtraction of the remaining background is done using the statistics without target.

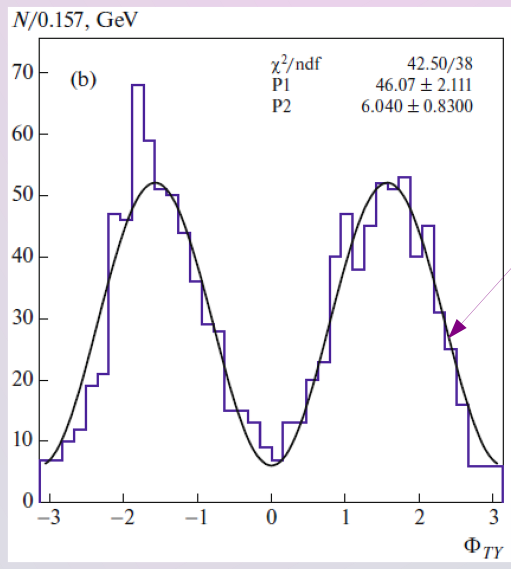
K^+ Cu → $K^+ \pi^0$ Cu selection



$m_{\gamma\gamma}$



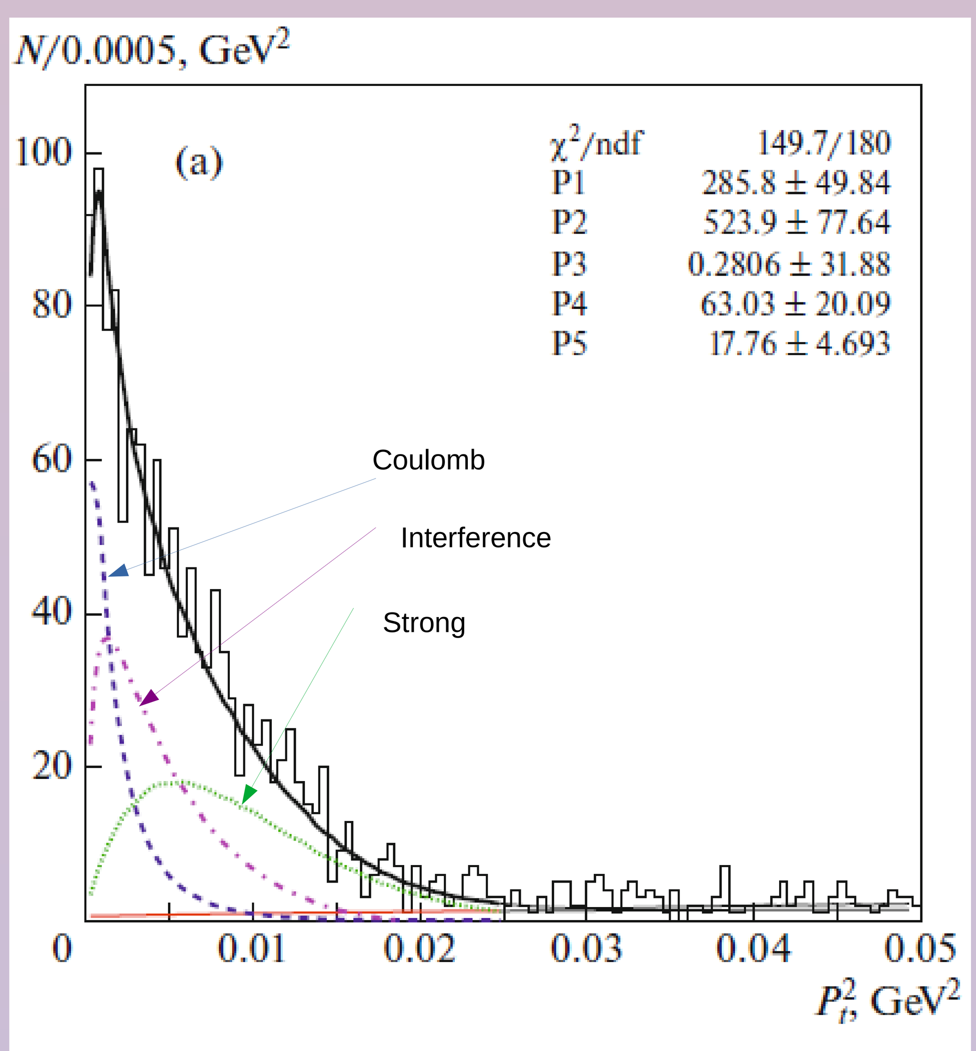
$dE = E_K + E_\pi - E_b$



$p_1 \sin^2(\Phi_{TY}) + p_2$

$\sim \sin^2(\Phi_{TY})$ expected for a vector exchange

Φ_{TY} – Treyman-Yang angle.

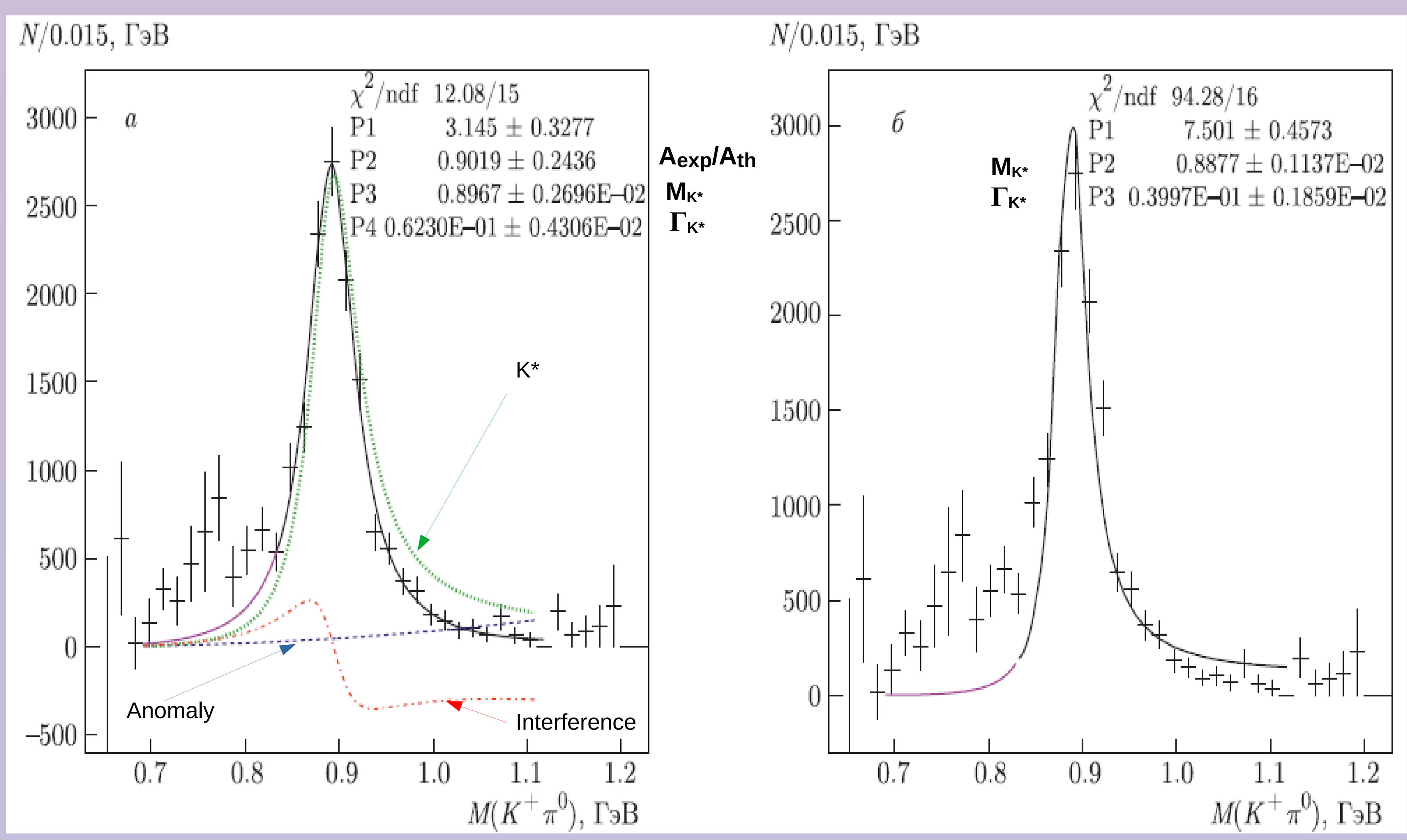


а) Fit of the distribution over P^2_T after all selections.

From the fit:

$\sigma_C = 26.6 \pm 2.2 \pm 4.5$ μb
$\sigma_S = 64.2 \pm 4.3 \pm 11.2$ μb
$\sigma_I = 49.4 \pm 2.6 \pm 6.6$ μb
$\sigma_{coh} = 137.2 \pm 5.3 \pm 16.4$ μb

Main syst. because of α – angle between Coulomb and strong amplitudes. For ω exchange it is $\sim \Gamma_\omega/m_\omega \sim 0°$, Regge theory gives $\pi(1-\alpha_\omega)/2 \sim 50.4°$ is determined badly from the fit (p_3)



а) The distribution over $K^+\pi^0$ mass after the background substraction and corrections for the efficiency with the results of the fit with a function, which includes contributions from Coulomb, coherent strong, chiral anomaly and their interference. б) The same as а) but with a fit without chiral anomaly. The black curve- the result of the fit, rose curve – an extrapolation from the fit region (0.83-1.1) GeV into the region (0.7-0.83) GeV. Blue curve – the contribution of the chiral anomaly. Green curve – the contribution of the diagrams with K*(892) meson.The red curve – contribution of the interference.

Summary

On the statistics of $\sim 1.7 \cdot 10^8$ interactions of positively charged kaons on copper nuclei coherent events of the $K^+ \pi^0$ - system production are selected.

Cross sections for the Coulomb, coherent strong components and their interference in the region of K(892)-meson are measured.

The partial width for the decay $K^{*+}(892) \to K^+\gamma$ is determined:

$$\Gamma_{K^+\gamma} = 55.6^{+4.8}_{-4.4}(\text{stat.})\,^{+11.5}_{-7.3}(\text{syst.})\ \text{keV}$$

When studying the mass spectrum of the $K^+ \pi^0$ - system (Fig.1), an effect is found, which can be interpreted as the interference of the chiral anomaly and the K*(892) amplitudes. This gives an estimate for the ratio of the observed amplitude of the chiral anomaly to the theoretical one:

$$A_{exp}/A_{th} = 0.9 \pm 0.24(\text{stat.}) \pm 0.3\ (\text{syst.}).$$

References

R.Rogalyov Phys. Atom. Nucl. 64 (2001) 68.
V. Burtovoy, Phys. Atom. Nucl. 76 (2013) 450.
M. Vysotsky, E. Zhemchugov, Phys. Rev. D 93, 094029 (2016).
V.S. Burtovoy et al., (OKA) J.Exp.Theor.Phys. 131 (2020) 6, 928-939

Acknowledgments:

This work is supported with RSF grant 22-12-0051.

Poster presented at the International Conference on Kaon Physics KAON2022, 13 – 16 September 2022, Osaka, Japan