Recent results from ISTRA+ experiment

IHEP-INR-JINR Collaboration

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K → μ ν γ decay. Motivation.

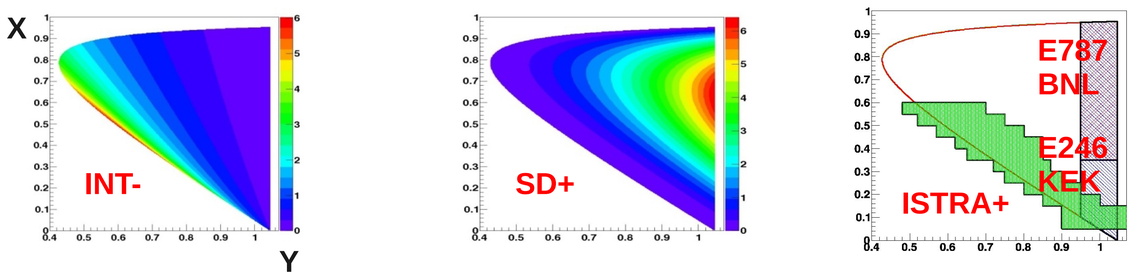
Photon emission:
- Bremsstrahlung IB
- Structure-dependent SD± (depending on γ polarization)

And their interference terms

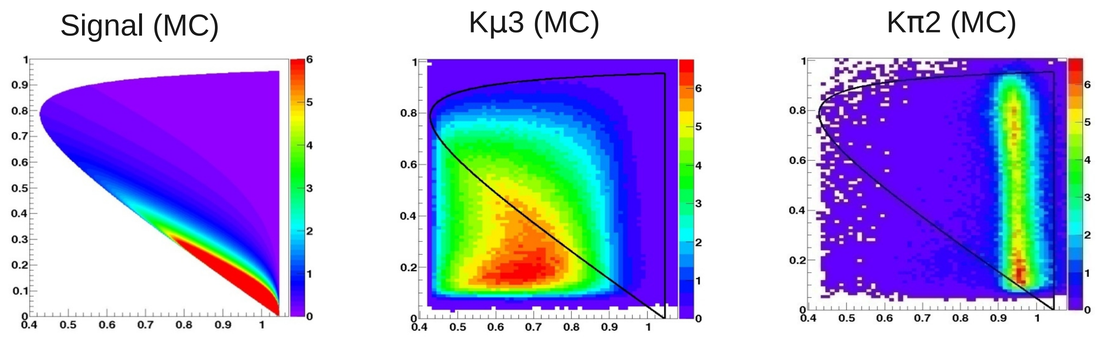
Structure-dependent term:
- Sensitive to EW structure
- Good test of ChPT
- INT± (SD± - IB) depend on F_V and F_A

$$\frac{d\Gamma}{dxdy} = A_{IB} f_{IB} + A_{SD}\left[(F_V+F_A)^2 f_{SD+} + (F_V-F_A)^2 f_{SD-}\right] - A_{INT}\left[(F_V+F_A) f_{INT+} + (F_V-F_A) f_{INT-}\right]$$

Focusing on INT- region. Complementary with previous experiments



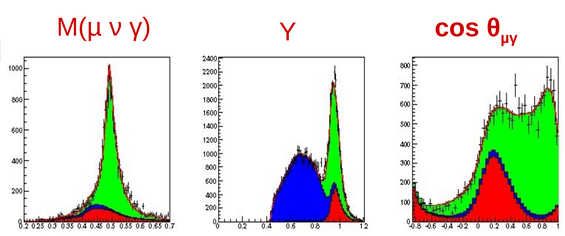
Backgrounds and signal extraction



M(μνγ) peaks at 0.494 GeV for signal
Simultaneous fit of M(μ ν γ) , γ and cos θμγ is done in x-stripes

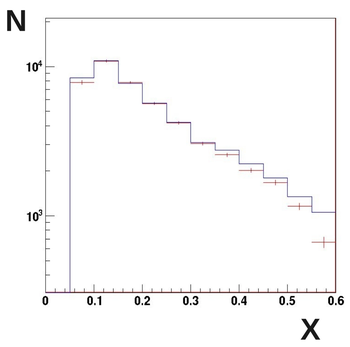
Example for **0.05 < x < 0.1**

In total 22k events extracted



green – signal, blue – Kμ3, red – Kπ2

Final X-spectrum and results



N is taken from fits in x-stripes
Blue histogram – IB
Lack of events for large x due to INT- term
Negative sign of INT- clearly seen

Normalizing on IB we got:

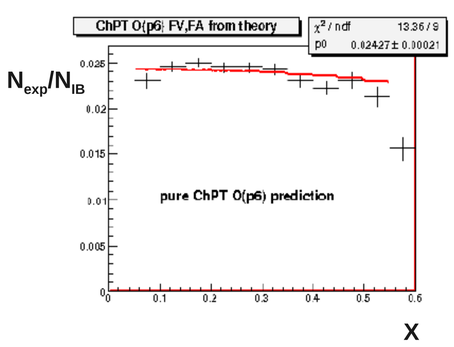
$F_V - F_A = 0.16 \pm 0.04(stat) \pm 0.05(syst)$

ChPT O(p4) → $F_V - F_A = 0.052$ → *1.7σ above ChPT O(p⁴)*

Comparison with ChPT O(p6)
F_V, F_A taken from theory

$\chi^2/ndf = 13.4 / 9$

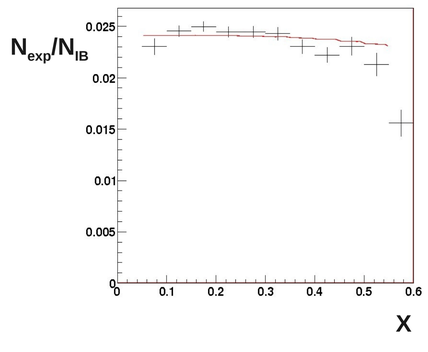
1σ from χ^2=1



Comparison with LFQM
F_V, F_A taken from theory

$\chi^2/ndf = 15.8 / 9$

1.6σ from χ^2=1



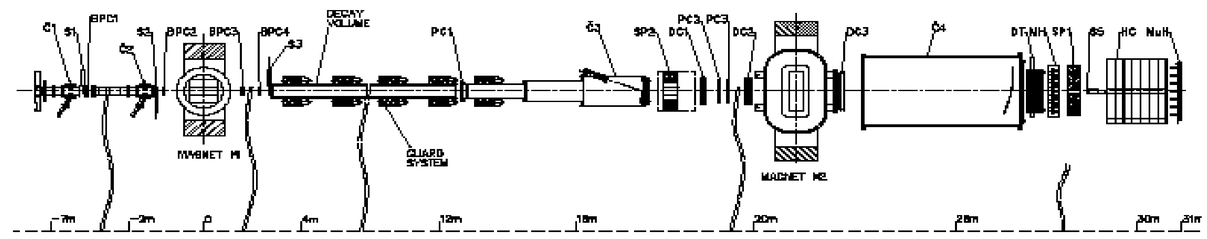
Conclusion

K → μ ν γ decay is observed at ISTRA+ setup in a new kinematical region

The event number observed is 22K (the largest statistics in the world)

First measurement of INT- term gives F_V-F_A= 0.16 ± 0.04(stat) ± 0.05(syst)

The sign of INT- is negative



$p \sim -25$ GeV ; $\Delta p/p \sim 1.5\%$; $K^- \sim 3\%$; $I \sim 3 \cdot 10^6/1.9$ sec

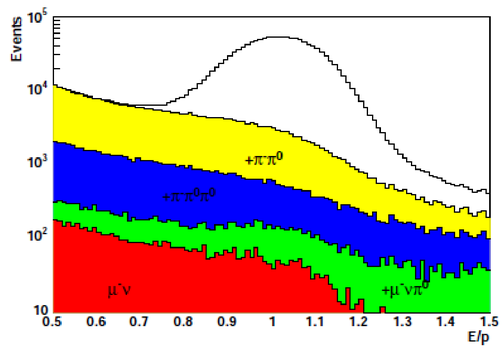
K → e ν π⁰ decay. Motivation.

One of the best sources of information about V_{us} of CKM matrix.
Strong interest to high statistics/low systematics measurements after E865 (BNL) reported **2.5σ** branching increase with respect to PDG value.

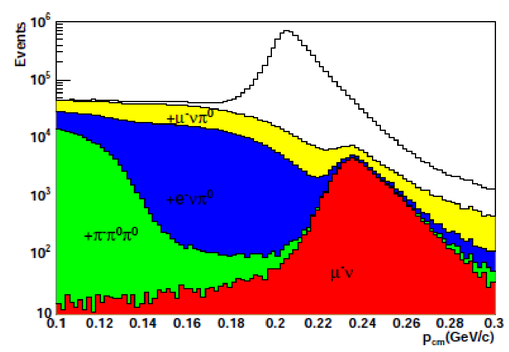
Observations:
- **K → e ν π⁰** is a dominant source of electrons in kaon decays.
- All other decays contribute much less than 1% of electrons.
- Electron ID is performed by ECAL

Method:
- Number of electrons is obtained from E/p in calorimeter.
- No need to reconstruct **π⁰**
- Only tracks are considered
- **K → π⁻ π⁰** is identified by **P_{cm}** peak

Method verification (MC)



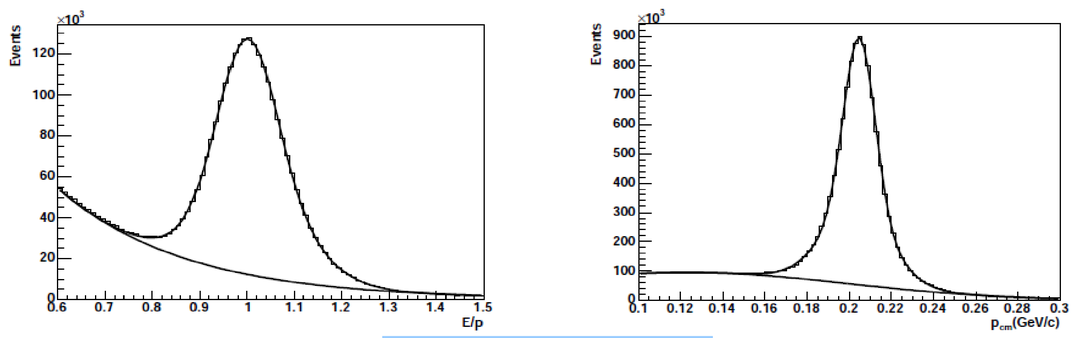
E/P in calorimeter for charged tracks
E/P=1 peak due to signal



P_{cm} for tracks assuming pion mass
Peak due to **K → π⁻ π⁰** decay

In both cases peak is approximated by a sum of two Gaussians and background as simple exponential (E/P) and as 4-th order polinomial (Pcm)

Real data. In total, **2.2M K → e ν π⁰** events were extracted



Results

Br(Ke3)/Br(Kπ2) = 0.2449± 0.0004(stat)±0.0014(syst)

Br(Ke3) = 5.124±0.009(stat)± 0.029(norm)±0.030(syst)%

Recent cross-check with complete **π⁰** reconstruction gives:
Br(Ke3)/Br(Kπ2) = 0.2417±0.0014±0.0036

$|V_{us}|$ extraction

$K^{\pm}_{e3}$ decay rate can be expressed as: $\Gamma(K^{\pm}_{e3}) = \frac{Br_{K^{\pm}_{e3}}}{\tau(K^{\pm})} = \frac{G_\mu^2}{384\pi^3} M_K^5 |V_{us}|^2 |f_+(0)|^2 I^e_{K+} S_{EW}(1+\delta_{SU2}+\delta^e_+)^2$

where corrections are absorbed in: $S_{EW}(1+\delta_{SU2}+\delta^e_+)^2$

Decay phase space integral $I^e_{K+} = \int_0^{(M_K-M_\pi)^2} dt \frac{1}{M_K^8} \lambda^{3/2} (f_+(t)/f_+(0))^2$, where $\lambda = (M_K^2 - t - M_\pi^2)^2 - 4tM_\pi^2$

contains t-dependent form-factor and is calculated using our results from **Phys.Lett. B589 (2004), 111**, where the quadratic non-linearity was measured for the first time: I^e_K = 0.15912±0.00084(stat)±0.00114(syst)

Putting everything together we get: **$|V_{us} f_+(0)| = 0.2186 \pm 0.0009_{Br} \pm 0.0012_{th}$**

Using theoretical value f+(0) = 0.961±0.008, finally we obtain:
$|V_{us}| = 0.2275 \pm 0.0009_{Br} \pm 0.0022_{th}$