Study of rare decays at OKA and NA62 experimental setups

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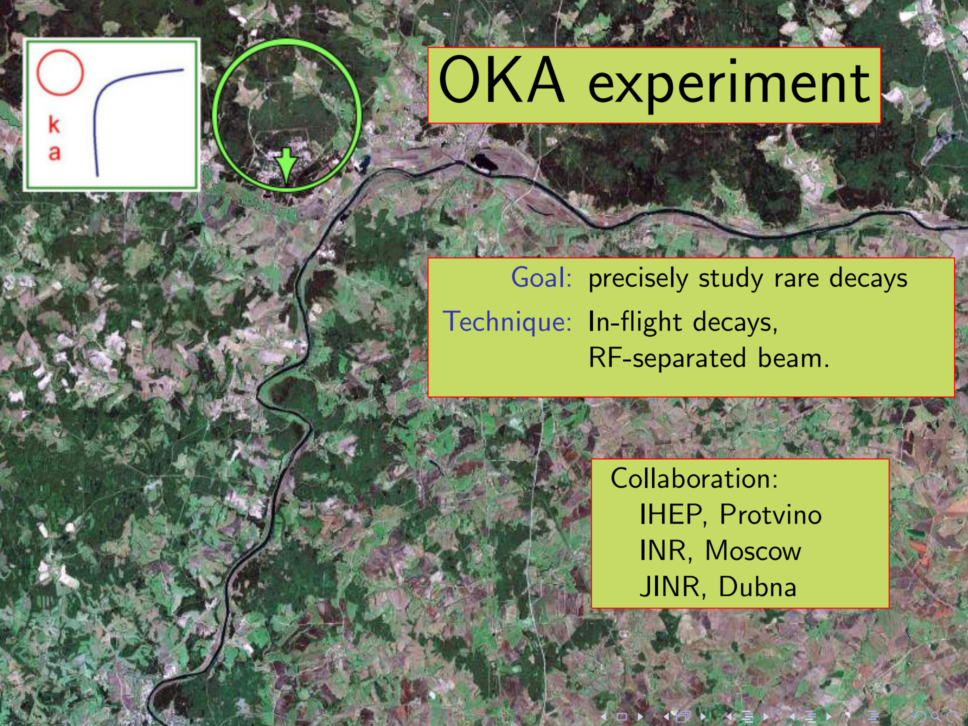
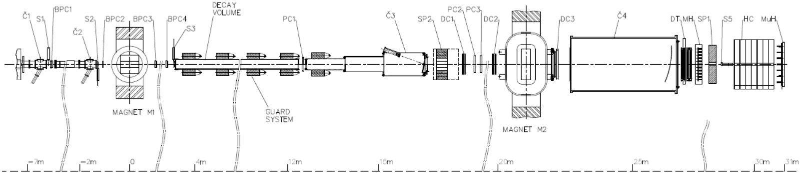
Outline

- OKA
  - Experiment overview
  - Separated beam
  - Experimental setup
  - Physical program
- NA62
  - Experiment overview
  - Physical program


k
a
OKA experiment
Goal: precisely study rare decays
Technique: In-flight decays,
RF-separated beam.
Collaboration:
IHEP, Protvino
INR, Moscow
JINR, Dubna

ISTRA+ experiment

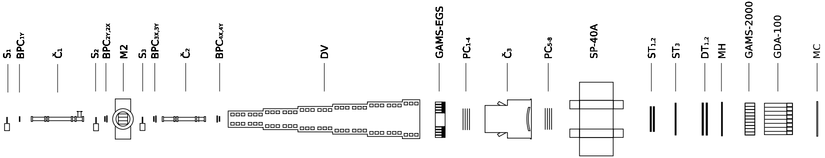
ISTRA+ is predecessor of OKA experiment.



	ISTRA+	OKA
p (GeV/c)	25	12.6 (18)
Intensity	$3 \cdot 10^6$	$4 \cdot 10^6$
% $K^\pm$	3% K^-	25% K^+
$K^\pm$ per spill	$9 \cdot 10^4$	10^6
part of decayed $K^\pm$	6%	9%

10-30 times increase in statistics is expected.

OKA experimental setup



- p = 12.6 GeV/c (or 18 GeV/c)
- Intensity $\sim 4 \cdot 10^6$ per spill
- 25% K^+ in the beam.

Separated beam: pro and contra

$+$

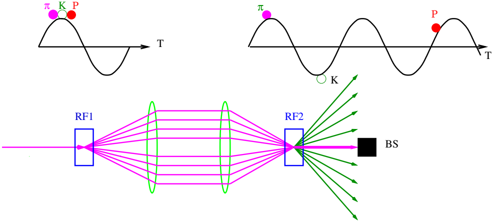
- Absence of trigger efects
- Possibility of fixed target program

$-$

- Long and complicated beam line
- Relatively low intensity

Scheme of separation

Panofsky-Montague-Schnell scheme of separaion:



$$\frac{m_p^2 - m_\pi^2}{m_K^2 - m_\pi^2} \sim 4 \Rightarrow$$

protons are supressed for free.

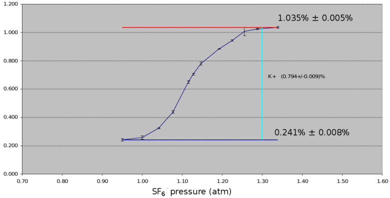
OKA uses superconductive RF deflectors for beam separation. They were build in Karlsruhe and were used on SPS, CERN in 1978-1981.

- Working frequency 2865 MHz
- Field strench ~ 1 MV/m
- Working temperature 1.8K

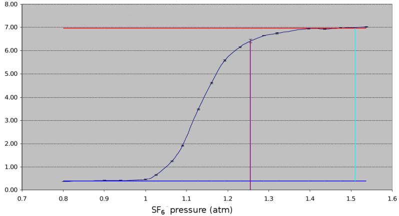
Separated beam

Threshold curve of $\check{C}_2$

Unseparated beam ($0.794\% \pm 0.009\%$)



Separated beam ($6.967\% \pm 0.039\%$)



2009:

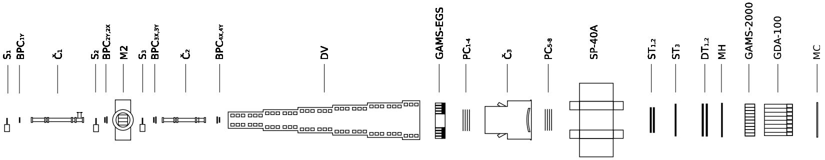
Stable separated beam.

- 25% K^+
- $I \sim 2 \cdot 10^6$ per spill

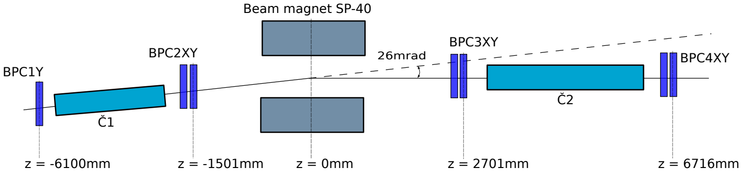
2010:

Currently deflectors are being cleaned in order to increase separation effeciency and beam intencity.

OKA: experimental setup overview



OKA: beam spectrometer



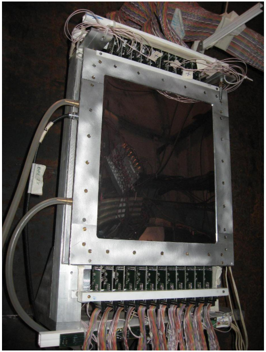
Purpose:

- Reconstruct track of primary particle.
- Measure momentum of primary particle with $\delta p/p \sim 1\%$
- Identify primary particle

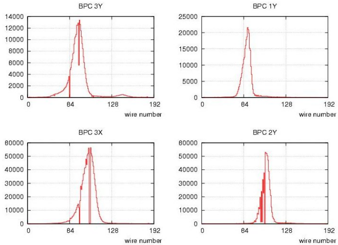
Detectors:

- 7 fast wire proportional chambers.
- Beam magnet (~ 1 Tm)
- 2 cherenkov counters for partile identification.
  π^+ rejection — filled with air at 1 atm.
  K^+ identification — filled with SF_6 at 1.6 atm.

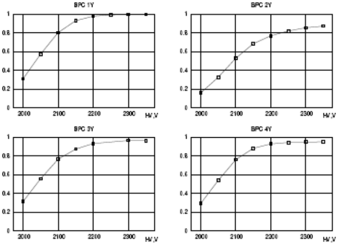
OKA: Beam proportional chambers



- $20 \times 20\text{cm}^2$
- 188 wires, 1.084mm step
- 80% freon-14 (CF_4), 20% isobutane (C_4H_{10})

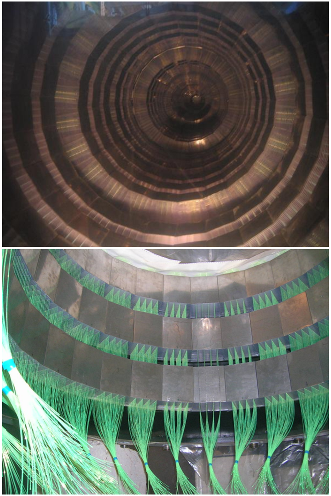


BPC profiles



BPC efficiency

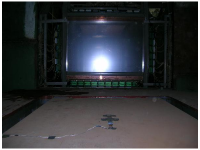
OKA: Decay volume



- 11m long
- Filled with He at 1 atm
- Guard system registers γ at large angles.
- $\sim$200 sandwich veto counters with fiber readout.
  5 mm scintillator 1.5 mm Pb
- Retractable target for study of K^+N interactions.

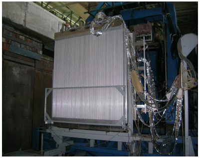
OKA: Spectrometer

- Wire proportional chambers
  - 2 mm step ($\sigma_x \sim 600\mu$m)
  - 2 stations before magnet
- Magnet
  - Field integral $\sim$ 2 Tm
- Straw tubes
  - space resolution $\sigma_x \sim 300\mu$m
  - 3 planes (2 layers each)
- Drift tubes
  - Space resolution $\sigma_x \sim 400\mu$m
  - 2 planes (3 layers each)



Wire proportional chambers

Straw tubes



Drift tubes

OKA: Matrix hododscope

Detector purpose:

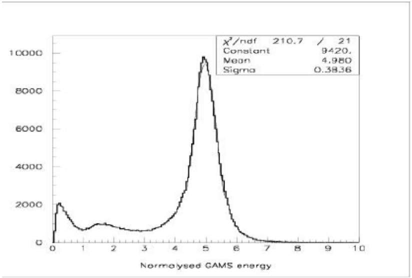
- Resolve XY ambiguity
- Trigger on number of secondary charged tracks
- Provide time tagging for tracks

Construction:

- 16×16 scintillation pads
- Inner section: 6×6 pads
- Light is registered using APD
- Efficiency exceed 95%

OKA: Electromagnetic calorimeter

- 20 X_0
- $\frac{\delta E}{E} \approx \frac{5\%}{\sqrt{E}}$
- $\sim$ 4000 lead glass and 256 PWO crystals



Energy spectrum for 5 GeV e^+ test beam

Physical program

Baseline: ISTRA+ program on larger statistics.

Main direction	method
χPT tests, deviations from SM	Branching and/or dalitz-plot in K_{l2}, $K_{l2\gamma}$ and K_{l3} decays
T-odd effects	T-odd assymetries in 4-body decays
Sgoldstino search	$K^+ \to \pi^+\pi^0 P$ decay. Peak in $(P_K - P_{\pi^+} - P_{\pi^0})^2$ distribution.
Fixed target program	

Program is being tuned by latest result from NA48/2, NA62, KLOE

T-odd correlations

Search for T-odd correlations in 4-body decay $K^+ \to e^+(\mu^+)\nu\pi^0\gamma$
(J. Gervais, J. Iliopoulous, J. Kaplan 1966)

T-odd variable: $\xi = \frac{1}{M_K^3}\vec{p}_\gamma \cdot (\vec{p}_\pi \times \vec{p}_l)$, $A_\xi = \frac{N(\xi>0)-N(\xi<0)}{N(\xi>0)+N(\xi<0)}$

Standard model predictions:	
$K \to e\nu\pi^0\gamma$	$A_\xi \approx 0.5 \cdot 10^{-4}$
$K \to \mu\nu\pi^0\gamma$	$A_\xi \approx 10^{-4}$

Some SM extension predict larger values: $A_\xi \sim 3 \cdot 10^{-4}$
(Braguta et al. Phys.Rev.D68,2003)

Current measurements:	
$A_\xi(K_{e3\gamma}) = -0.015 \pm 0.0213$	(ISTRA+)
$A_\xi(K_{\mu3\gamma}) = -0.03 \pm 0.13$	(ISTRA+)

Program with fixed target

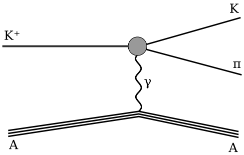
Separated beam makes possible study of K^+N interactions

Target: thin ($\sim 0.1X_0$) aluminium disk inside the decay volume.

- Searches for exotic states with hidden strangeness
  F. Close and P. Page predict $s\bar{s}g$ with $J^{PC} = 2^{-+}$,
  $\Gamma = 120\text{MeV} \to K_2^*(1430)K$
  OKA can look for this state in $K^-p \to K^+K^-\pi^0\Lambda$
- Searches for pentaquark $uuss\bar{s}$
  CERN (2m) and Argone (15ft) bubble chambers saw narrow
  ($\Gamma < 20\text{MeV}$) state in the reaction $K^-p \to Y^{*+}\pi^-$; $Y^{*+} \to \Sigma K\bar{K} + 2\pi$
- Spectroscopy of light mesons
  $K^+p \to f_2(1515) + \Lambda$; $f_2(1515) \to \phi\gamma$; $f_1(1285) \to \phi\gamma$
  $K^+p \to f_0(600-1200) + \Lambda$; $f_0 \to \pi\pi; K\bar{K}$

Primakoff physics

Study of kaon scattering in coulomb potential of nuclea.



$$K^+\gamma^* \to K^+\pi^0$$
$$K^+\gamma^* \to K^0\pi^+$$

$^{*)}$ γ's are virtual

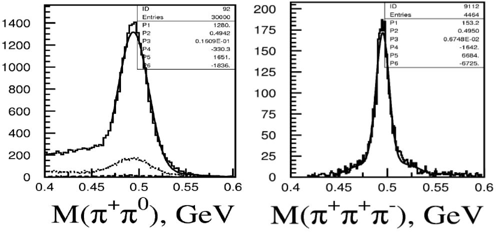
Rogalyov (Phys.Atom. Nucl. 64(2001)) compared cross sections of processes above near threshold. First process is affected by Wess-Zumino-Witten(WZW) anomaly.

$$\sigma_{K^+\pi^0}/\sigma_{K^0\pi^+} \approx 80\text{nb}/15\text{nb}$$

There is no experimental data for kaons!

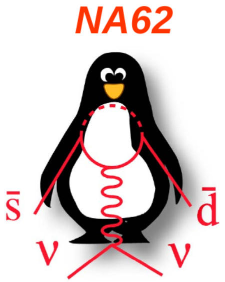
OKA: Current status

Event reconstructions from commisioning runs:



- Experimental setup commisioning is complete.
- Autumn 2010 — start of data taking.

NA62 experiment



Experiment goal:

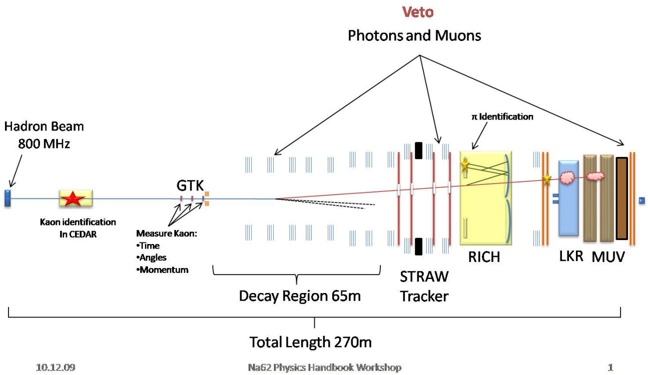
Measure branching of ultra-rare decay $K^+ \to \pi^+ \nu \bar{\nu}$.

Technique:

Very high intesity beam.

- Beam intensity — $\sim 2.5 \cdot 10^9$ per spill.
- Unseparated beam (K^+ content $\sim 5\%$)
- $p = 75$ GeV/c
- Setup is optimized for searches for $K^+ \to \pi^+ \nu \bar{\nu}$ decay.

NA62: Experimental setup



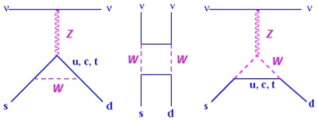
Experimental strategy:

- Hermeticity for γ in order to supress $K^+ \to \pi^+\pi^0$.
- Efficient particle identification. Particulary μ rejection.
- Redundant momentum measurements.

Physical program

- Decays go via penguin and box diagrams (loop induced FCNC)
- Hadronic matrix elements are extracted from $K^+ \to e^+\nu\pi^0$ decay
- Uncertainties are only from charm quark contributions
- Highly sensitive to New Physics.

Decay $K \to \pi\nu\bar{\nu}$



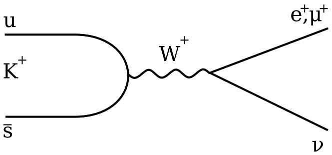
$\text{Br}(K^+ \to \pi^+\nu\bar{\nu})$:

E949	$(1.7 \pm 1.1) \cdot 10^{-10}$
Br_{SM}	$(8.0 \pm 1.1) \cdot 10^{-11}$

Aim is to measure O(100) events with 10% background

- Extract V_{td} element with 10% precision.
- Check V_{CKM} unitarity.
- New Physics?

Lepton universality



- Sub-permille accuracy due to cancellation on hadronic uncertainties.
- Strong helicity supression of $e\pm$ mode enhances sensiticity to New Physics.
- $K \to e\nu\gamma$(IB) is included into R_K by definition.

Standard model prediction:

$$R_K = \frac{\mathrm{Br}(K^{\pm}\to e\pm\nu(\gamma))}{\mathrm{Br}(K^{\pm}\to \mu\pm\nu(\gamma))} = (2.477 \pm 0.001) \cdot 10^{-5}$$

NA62 plans to measure R_K with precision better that 0.5%. Data was recoded in 2007-2008.

OKA could achieve same level of precision.

Thank you