OKA:
Status of the experimental program with RF-separated K beam at U-70 Protvino, Russia.

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Representing the OKA collaboration
(IHEP-INR-JINR)

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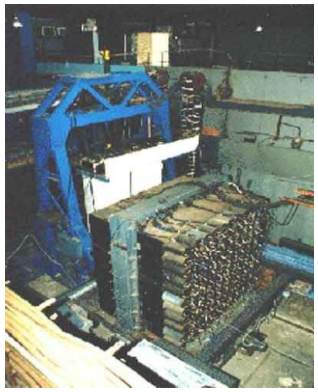
Outline

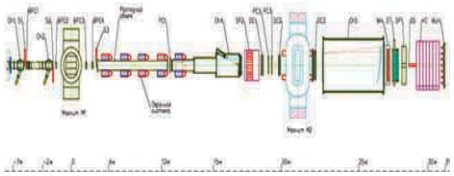
- The OKA beam and detector
- Statistics and data processing
- Very preliminary results on $K^+ \to \pi^0 e^+ \nu$

GAMS: Meson Spectroscopy



SPHINX: Baryon Spectroscopy

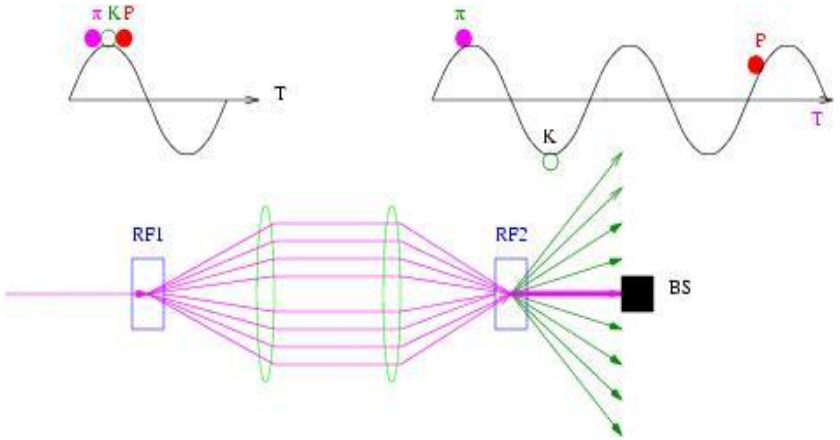
ISTRA+: Kaon Decays

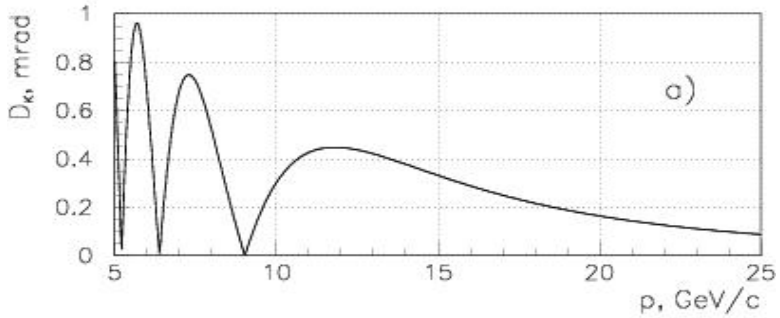


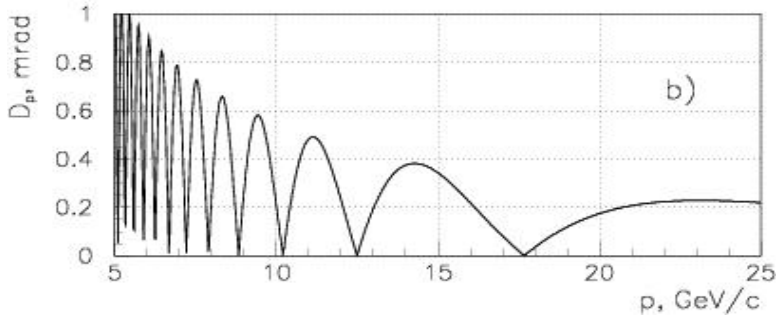
OKA

Experiments with KAons

OKA Beam: Scheme of RF-separation (Panofsky).







Two main working points
12.5 and 17.7 GeV/c

K+ decays in the decay volume: 16% (11%)

The OKA Detector

1. Beam spectrometer:

   1mm pitch PC, ~1500 channels; Cherenkov counters
2. Decay volume with veto system:

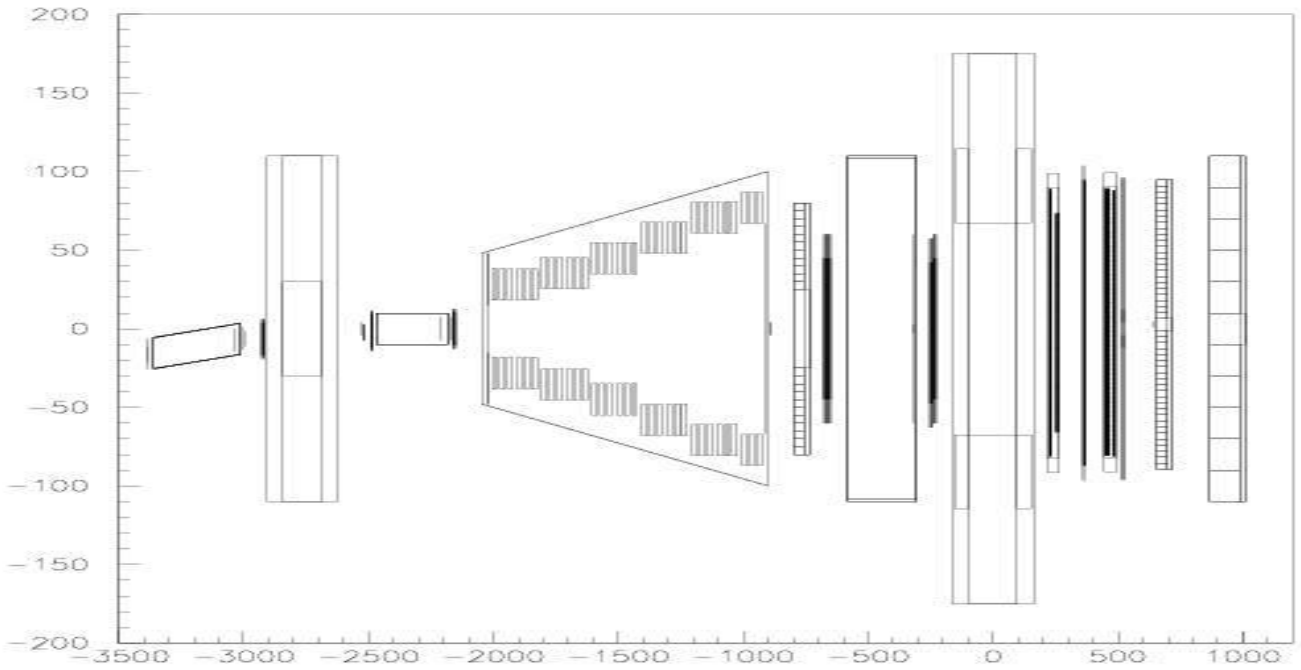
   11m; Veto: 670 Lead-Scintillator sandwiches 20* (5mm Sc+1.5 mm Pb), WLS readout
3. PC's and DT's for magnetic spectrometer:

   ~5000 ch. PC (2 mm pitch) + 1300 DT (1 and 3 cm)
4. Pad Hodoscope ~300 ch.
5. Magnet: aperture 200*140 cm2
6. Gamma detectors:

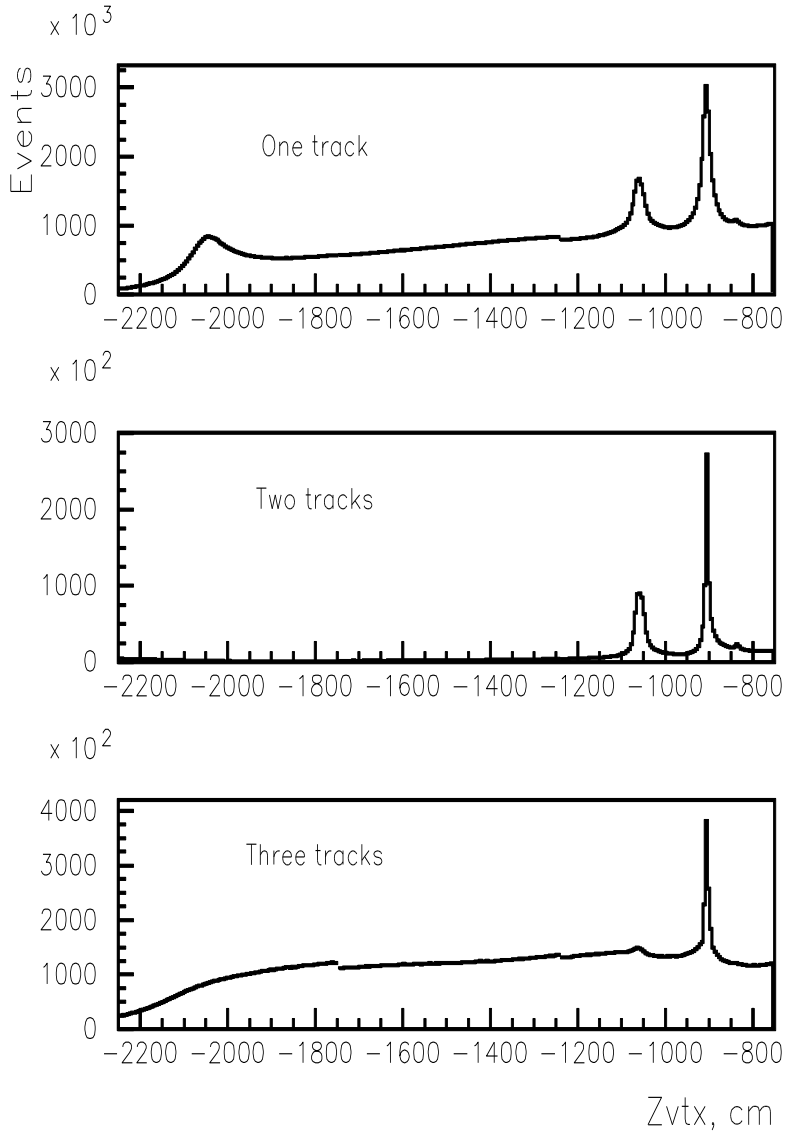
   GAMS2000, EHS-backward EM cal. ~ 4000 LG + 256PWO crystals.
7. Muon identification:

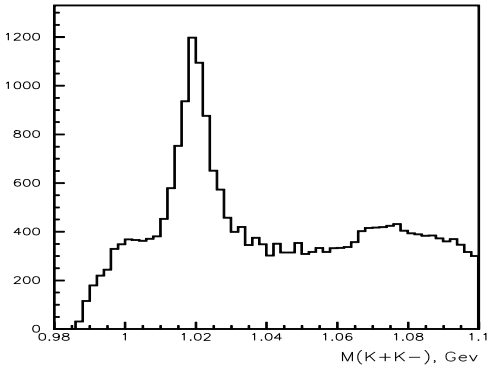
   GDA-100 + 4 muon trigger counters

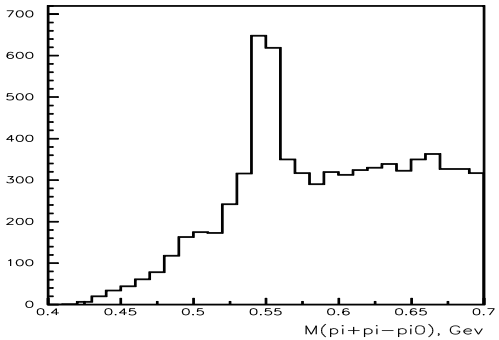
The OKA Detector

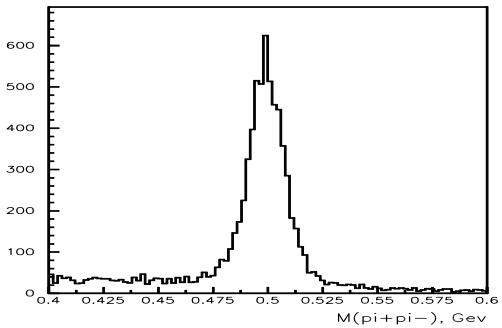


Decay/Interaction Vertex

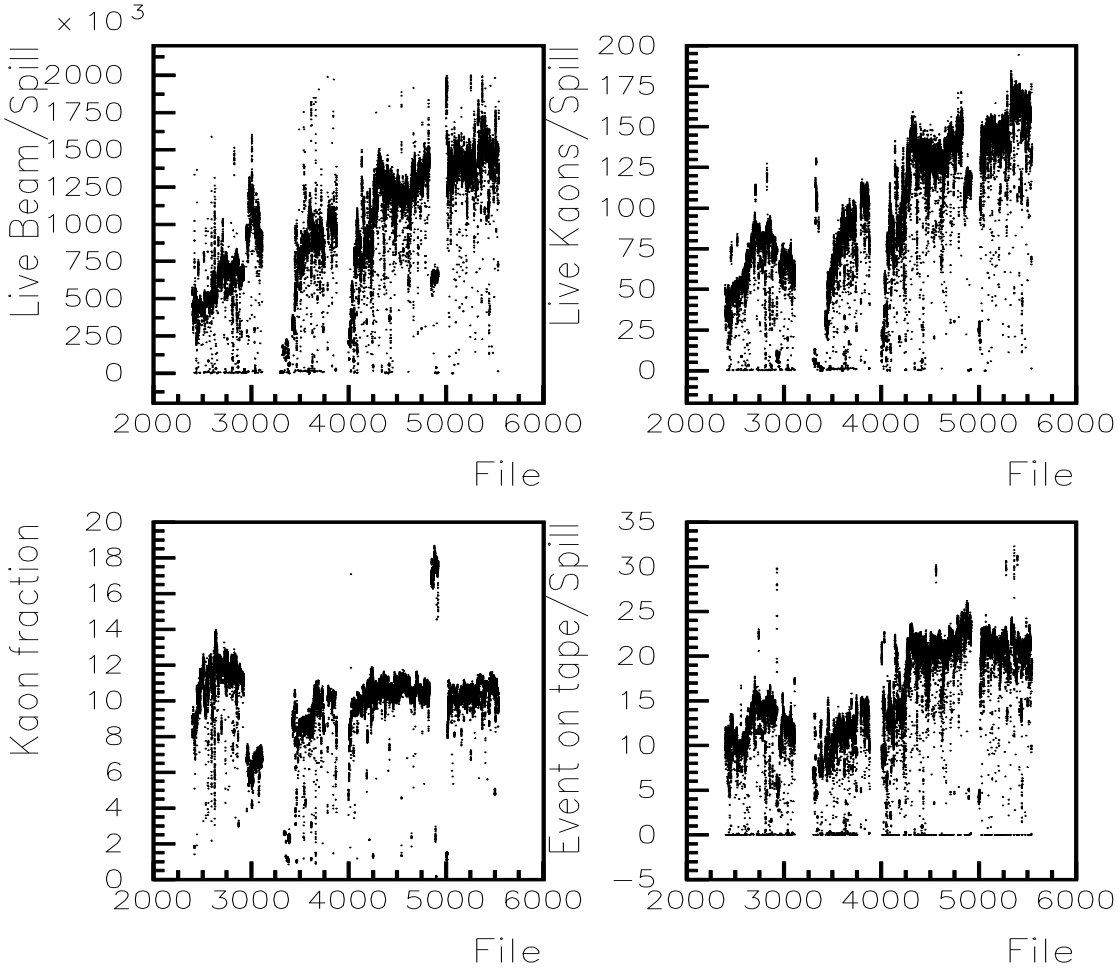








OKA Statistics (2010-2013)

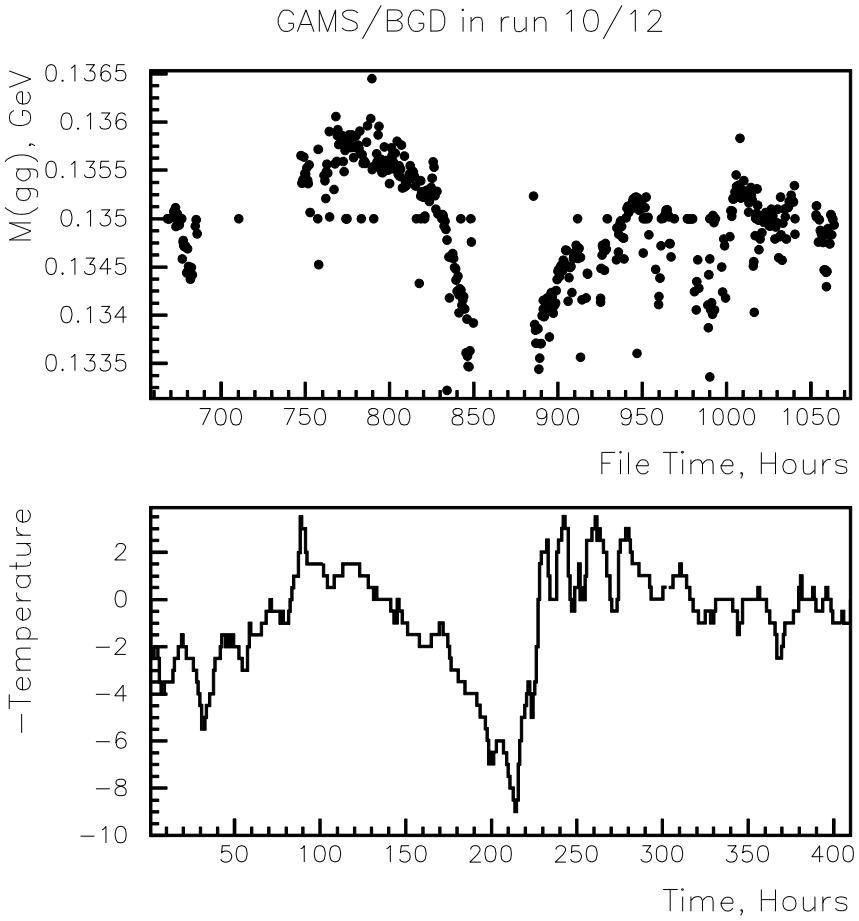


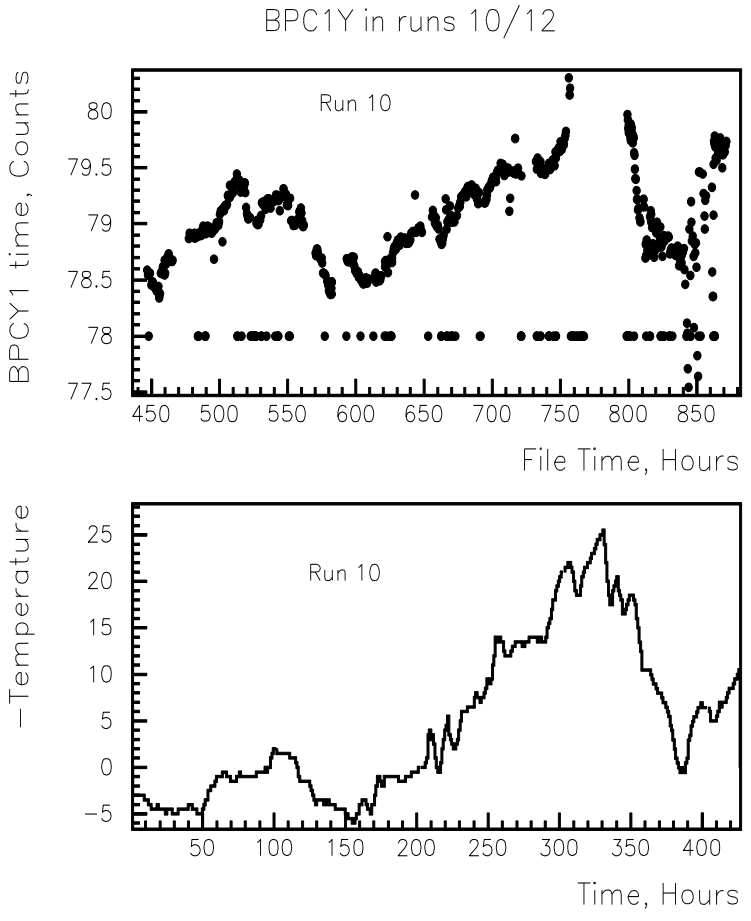
OKA Statistics (2010-2013)

	R10 Nov2010	R12 Nov2011	R14 Nov2012	R15 APR2013	Total
Beam, GeV/c	12.5 +17.7	17.7	17.7 +12.5	17.7	-
Live Kaons , 10E9	6.2	5.1	17.4	12.2	40.9
Gb on tape	1809	1250	3700	2200	8950
Events on tape , 10E9	1.2	0.8	2.8	1.7	6.5
K2pi, 10E6	15.2	15.5	61	42	134
Ke3, 10E6	2.5	2.0	8.1	~5	~17

ISTRA+ : Ke3 0.92

KMN : Ke3 1.1


GAMS/BGD in run 10/12
M(gg), GeV
0.1365
0.136
0.1355
0.135
0.1345
0.134
0.1335
700
750
800
850
900
950
1000
1050
File Time, Hours
−Temperature
2
0
−2
−4
−6
−8
−10
50
100
150
200
250
300
350
400
Time, Hours


BPC1Y in runs 10/12
BPCY1 time, Counts
Run 10
80
79.5
79
78.5
78
77.5
450
500
550
600
650
700
750
800
850
File Time, Hours
−Temperature
Run 10
25
20
15
10
5
0
−5
50
100
150
200
250
300
350
400
Time, Hours

Main ISTRA+ Results

3 сеанса в 1999-2001 гг. $\sim$ 1000 M событий; $\sim$ 500 M событий Geant-3 MC.

- Изучение на большой статистике распадов $K^- \to e^-(\mu^-)\nu\pi^0$
  K_{e3}: Phys. Lett. B589(2004)111 ; $K_{\mu 3}$: Phys. Lett. B581(2004)31
- Измерение параметров Вайнберга в распаде $K^- \to \pi^-\pi^0\pi^0$
  Phys. Lett. B567(2003)159
- Поиски легкого псевдоскалярного сголдстино в распаде $K^- \to \pi^-\pi^0 P$
  Phys.Lett.B602(2004)149-156
- Измерение доли структурного излучения в распаде $K^- \to \pi^-\pi^0\gamma$
  ЯФ 69 N1(2006)1.
- Первое наблюдение распада $K^- \to \mu^-\nu\pi^0\gamma$
  hep-ex/0506023, Препринт ИФВЭ 2005-20, ЯФ 70 N1(2007)1-7
- Исследование на большой статистике распада $K^- \to e^-\nu\pi^0\gamma$
  hep-ex/0510064, Препринт ИЯИ 1150/2005, ЯФ 70 N4(2007)734-740
- Точное измерение Br $K^- \to e\nu\pi^0$
  hep-ex/07041863, Препринт ИФВЭ 2007-5
- Измерение интерференционного члена INT- в радиационном распаде каона $K^- \to \mu^-\bar{\nu}\gamma$
  Препринт ИФВЭ 2008-27

Поиски тяжелого нейтрино в распаде K -> μνγ
Phys.Lett. B710 (2012) 307-317

- Measurement of the K^{+}_{e3} decay form factor

Motivation (picture from R.Fantechi at EPS 2013)

Master formula to access V_{us}

$$\Gamma(K_{l3(\gamma)}) = \frac{G_f^2 m_K^5}{192\pi^3} C_K^2 S_{EW} |V_{us}|^2 |f_+(0)|^2 I_K^l (1 + 2\delta_{SU(2)}^l + 2\delta_{EM}^l)$$

The phase space integral (I^l_K), including the form factor variation over the phase space, is an important ingredient to be measured accurately

Determined by the theory:

$f_+(0)$: Hadronic form factor at $q^2=0$ (different for $K^\pm$ and K^0)

δ^l_{SU2}, δ^l_{EM} : Corrections for SU(2) breaking and long-distance EM interactions

Two form factors in K_{l3} decays: $f_+(t)$, $f_-(t)$

$$M = \frac{G_F}{2} V_{us} \left(f_+(t)(P_K + P_\pi)^\mu \bar{u}_l \gamma_\mu (1+\gamma_5) u_\nu + f_-(t) m_l \bar{u}_l (1+\gamma_5) u_\nu \right)$$

f_+ = vector form factor
f_0 = scalar form factor

$$f_0(t) = f_+(t) + \frac{t}{(m_K^2 - m_\pi^2)} f_-(t)$$

$f_+(0)$ cannot be measured directly
- Given by theory
- Only relative form factors experimentally accessible

Form factor parametrizations (picture from R.Fantechi at EPS 2013)

- Parameters with physical meaning
  - Pole parametrization

    Assumes exchange of vector (1^-) or scalar (0^+) resonances with masses mv and ms

    $f_+(t) \rightarrow K^*(892)$

    $f_0(t) \rightarrow$ no dominating resonances

$$f_{+,0}(t) = \frac{m_{V,S}^2}{m_{V,S}^2 - t}$$

  - Dispersive parametrization

    Free parameters Λ_+ and lnC

    Polynomial approximation for the dispersive integrals G(t) and H(t) available

    PLB638 (2006) 480, PRD 80 (2009) 034034

$$\bar{f}_+(t) = \exp\left[\frac{t}{m_\pi^2}(\Lambda_+ + H(t))\right]$$

$$\bar{f}_0(t) = \exp\left[\frac{t}{\Delta_{K\pi}}(\ln C + G(t))\right]$$

- Parameters without a physical meaning
  - Expansion in the momentum transfer

    Linear/Quadratic as a Taylor series

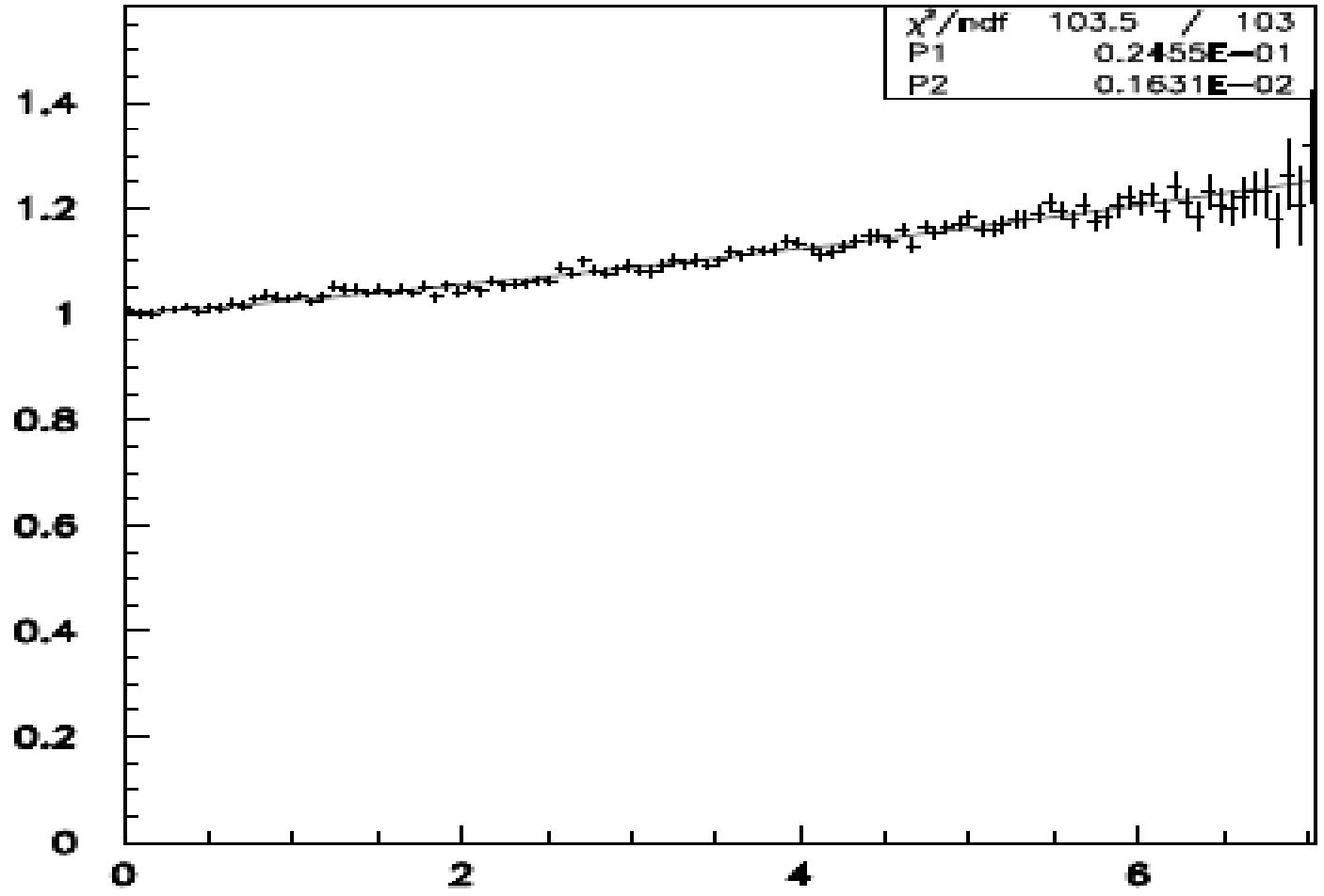
    Widely used in the past

    Large correlations between parameters (for quadratic expansion)

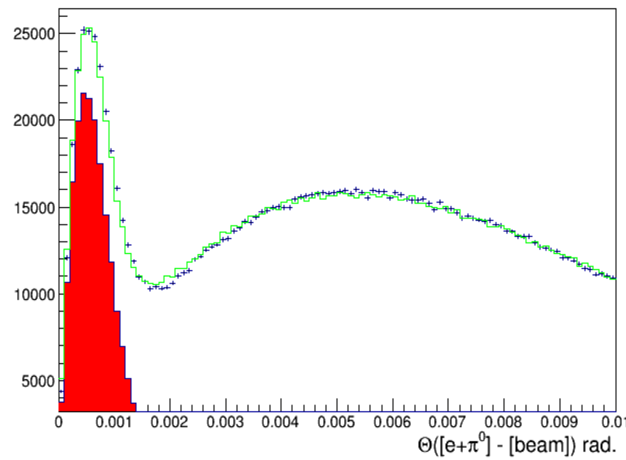
$$f_{+,0}(t) = \left[1 + \lambda_{+,0}\frac{t}{m_\pi^2}\right]$$

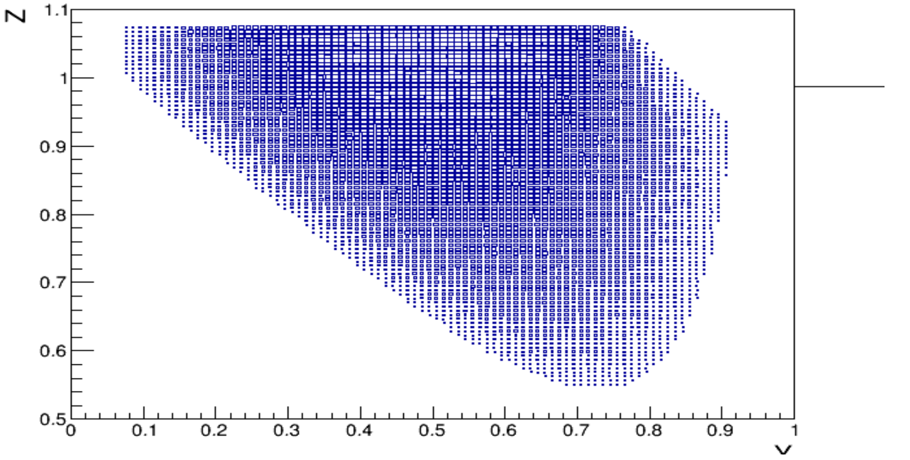
$$f_{+,0}(t) = \left[1 + \lambda'_{+,0}\frac{t}{m_\pi^2} + \frac{1}{2}\lambda''_{+,0}\left(\frac{t}{m_\pi^2}\right)^2\right]$$

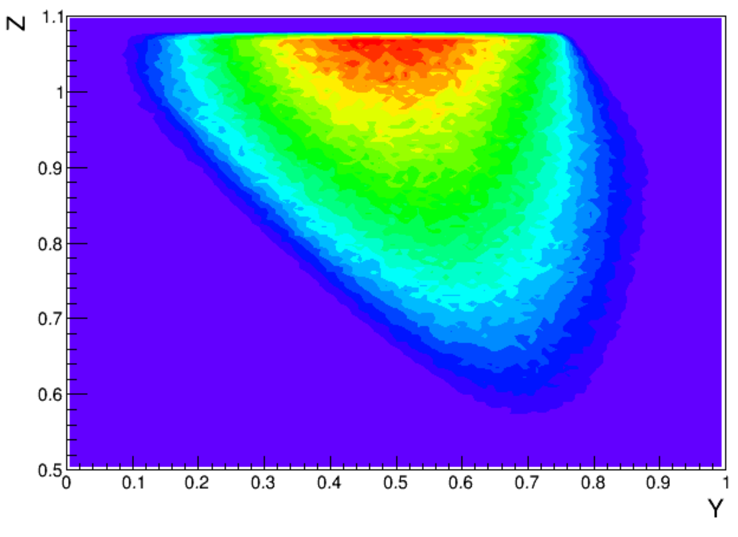
Ke3 R10 (RAS-2012), 12.5 GeV/c

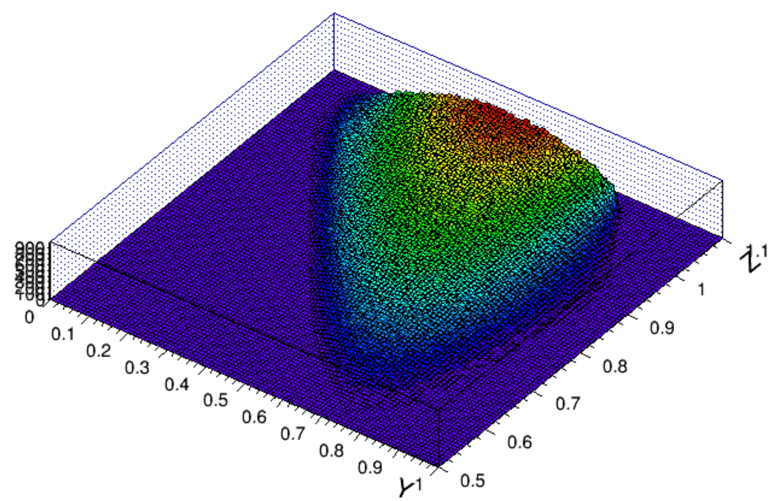


Ke3 R12, 17.7 GeV/c









OKA R12 Preliminary

OKA (1.59M)

1. Linear fit

λ+ = 2.94 +- 0.038;

2. Quadratic fit.

λ+' = 2.54 +-0.127

λ+'' = 0.161 +-0.049

3. Tensor.

F_T/F_0 = -1.61 +-1.83

4. Scalar.

F_S/F_0 = -0.36 +-0.31

ISTRA (0.919M)

1. Linear fit

λ+ = 2.966 +- 0.05+-0.034

2. Quadratic fit.

λ+' = 2.485 +-0.163 +-0.034

λ+'' = 0.192 +-0.062 +-0.071

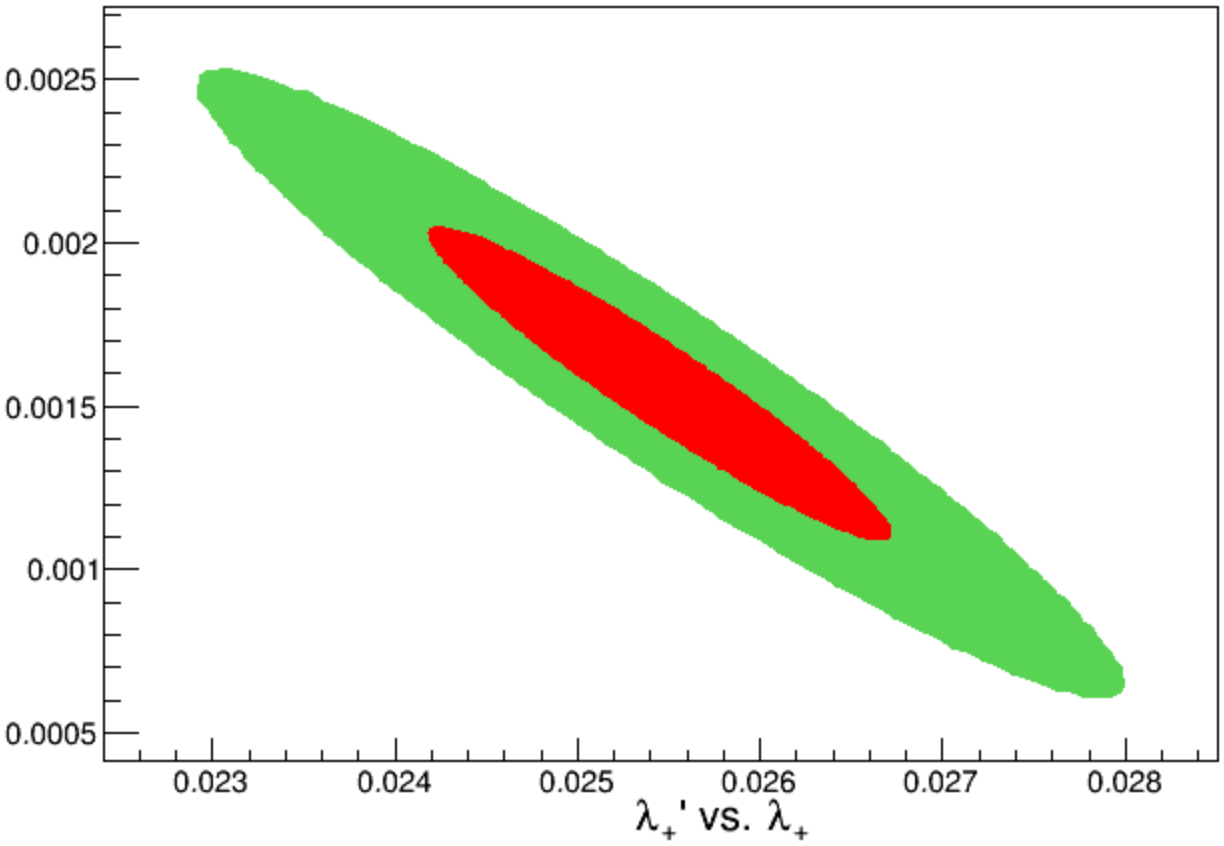
3. Tensor.

F_T/F_0 = -1.2 +-2.1+-1.1

4. Scalar.

F_S/F_0 = -0.37 +-0.61+-0.41

OKA R12 Preliminary



Summary and outlook

- OKA has taken data in 2010-2013
- The reconstruction of the full data set is nearly complete

- With data collected in 2011, we has studied the semileptonic decay $K^+ \to \pi^0 e^+ \nu$
- Preliminary results on the form factor parametrization and search for anomalous interactions have been presented
- More K^+ data collected by OKA in 2010-2013 are ready to be analyzed

  Expected to have $O(10^7)$ K^+_{e3} decays