

**Future NA48 Programs - CP Violation and Rare
Decay Measurements in K_S and K^\pm Decays**

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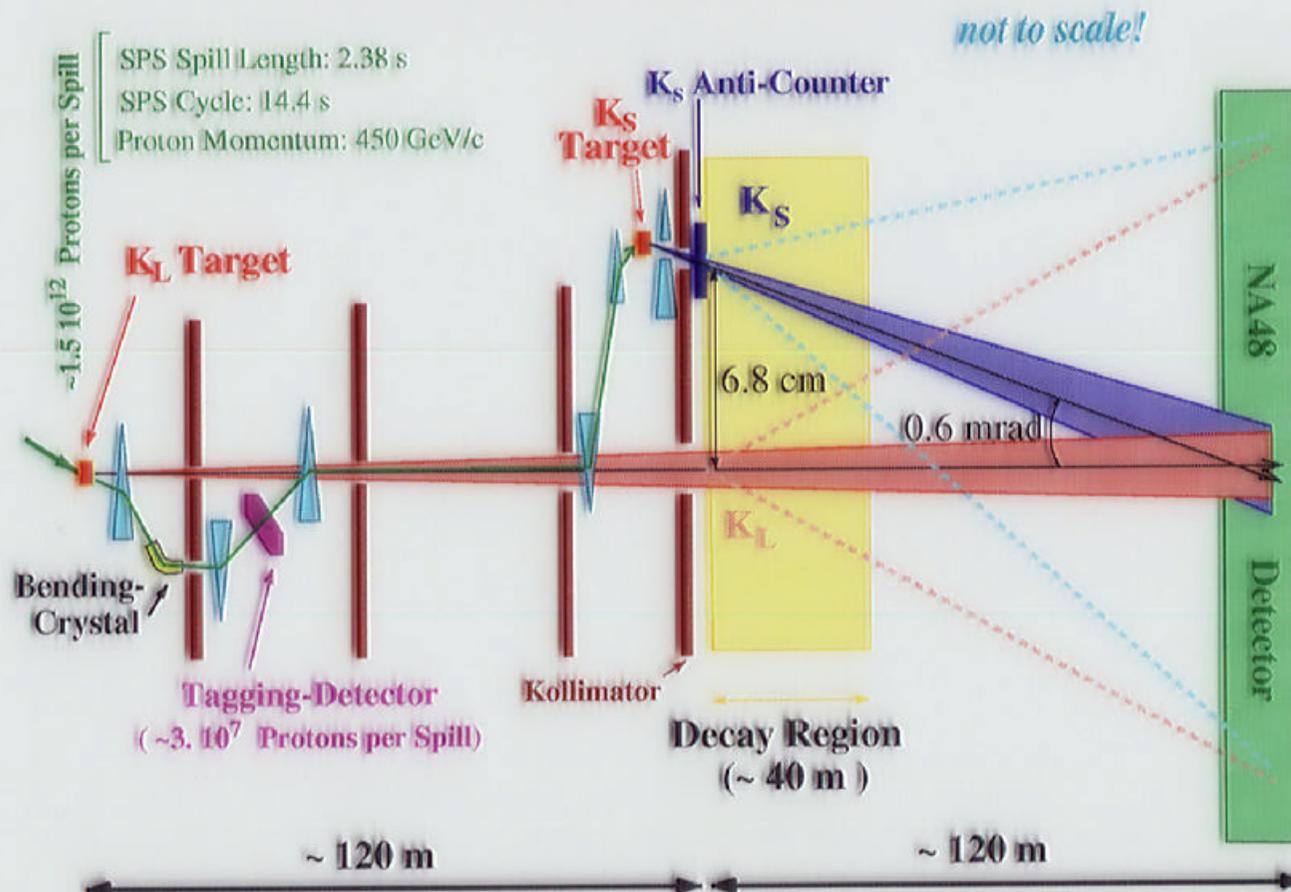
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NA48 - A short Introduction

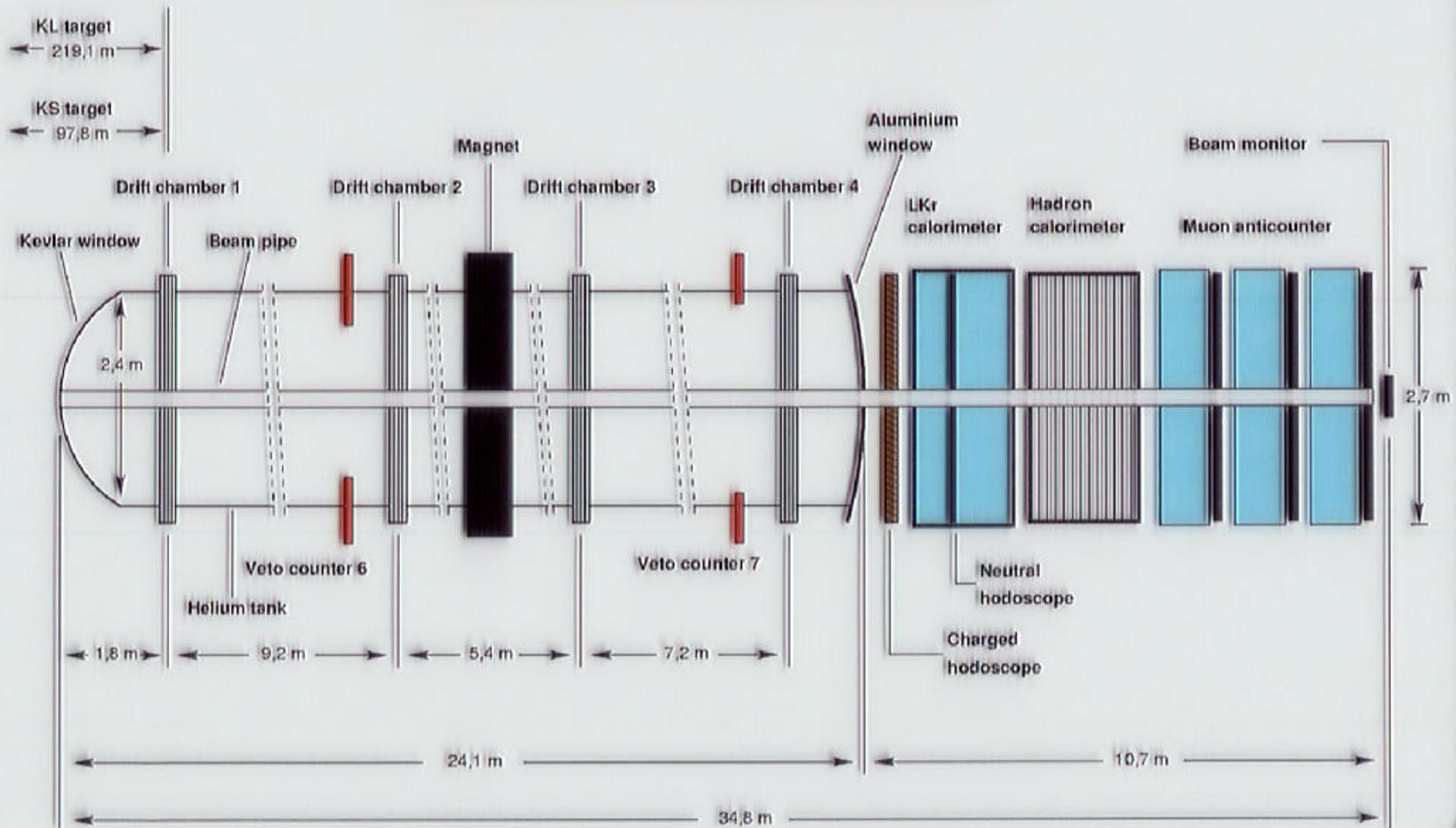
NA48 originally designed to measure the parameter $\text{Re}(\epsilon'/\epsilon)$ with an accuracy $\sim 2 \times 10^{-4}$

- 2 neutral almost collinear kaon beams with 1.5×10^{12} protons / spill to the K_L -target and 3×10^7 protons / spill to the K_S -target to measure K_S and K_L decays simultaneously.
 - magnet spectrometer with very good momentum and space resolution
 - Liquid Krypton calorimeter with excellent energy, space and time resolution
- ↪ device also very useful to measure rare kaon (and other) decays.

The NA48 Beam Lines



The NA48 Detector



The Performance of the Detector

- Liquid Krypton Calorimeter (LKr)

- $\frac{\sigma_E}{E} \simeq \frac{3.2\%}{\sqrt{E}} \oplus \frac{0.10}{E} \oplus 0.5\%$

- $\sigma_t < 300ps$

- $\sigma_{x,y} \simeq 1.3mm$

- Magnetic Spectrometer

- $P(kick) \simeq 265MeV/c$

- $\sigma_P/P \simeq 0.5\% \oplus 0.009\%(P(GeV/c))$

- $\sigma_{x,y}^{vertex} \simeq 2mm, \sigma_z^{vertex} \simeq 50cm, \sigma_t^{trk} \simeq 200ps$

K_S beam parameters

Beam	K _L + K _S (Re(ε'/ε))		Intense K _S beam	
Year	1999		2000	2002
SPS momentum (GeV/c)	450		400	400
Duty Cycle (s/s)	2.5/14.4		2.5/14.4	5.0/19.2
Protons per pulse on target	1.5 × 10 ¹²	3 × 10 ⁷	5 × 10 ⁹	1 × 10 ¹⁰
Production angle α (mrad)	+2.4	-4.2	-4.2	-2.5
Total beam flux K's/pulse	~ 2 × 10 ⁷ + ~ 3 × 10 ²		~ 5 × 10 ⁴	~ 1.5 × 10 ⁵
K-decays in Δp _K /pulse	1.0 × 10 ⁵ + 1.8 × 10 ²		4.0 × 10 ⁴	1.1 × 10 ⁵
K-decays in Δp _K /year (0.5 × 120 days)	3.6 × 10 ¹⁰ + 6.5 × 10 ⁷		1 × 10 ¹⁰	3.0 × 10 ¹⁰

Physics in the High Intensity K_S Experiment

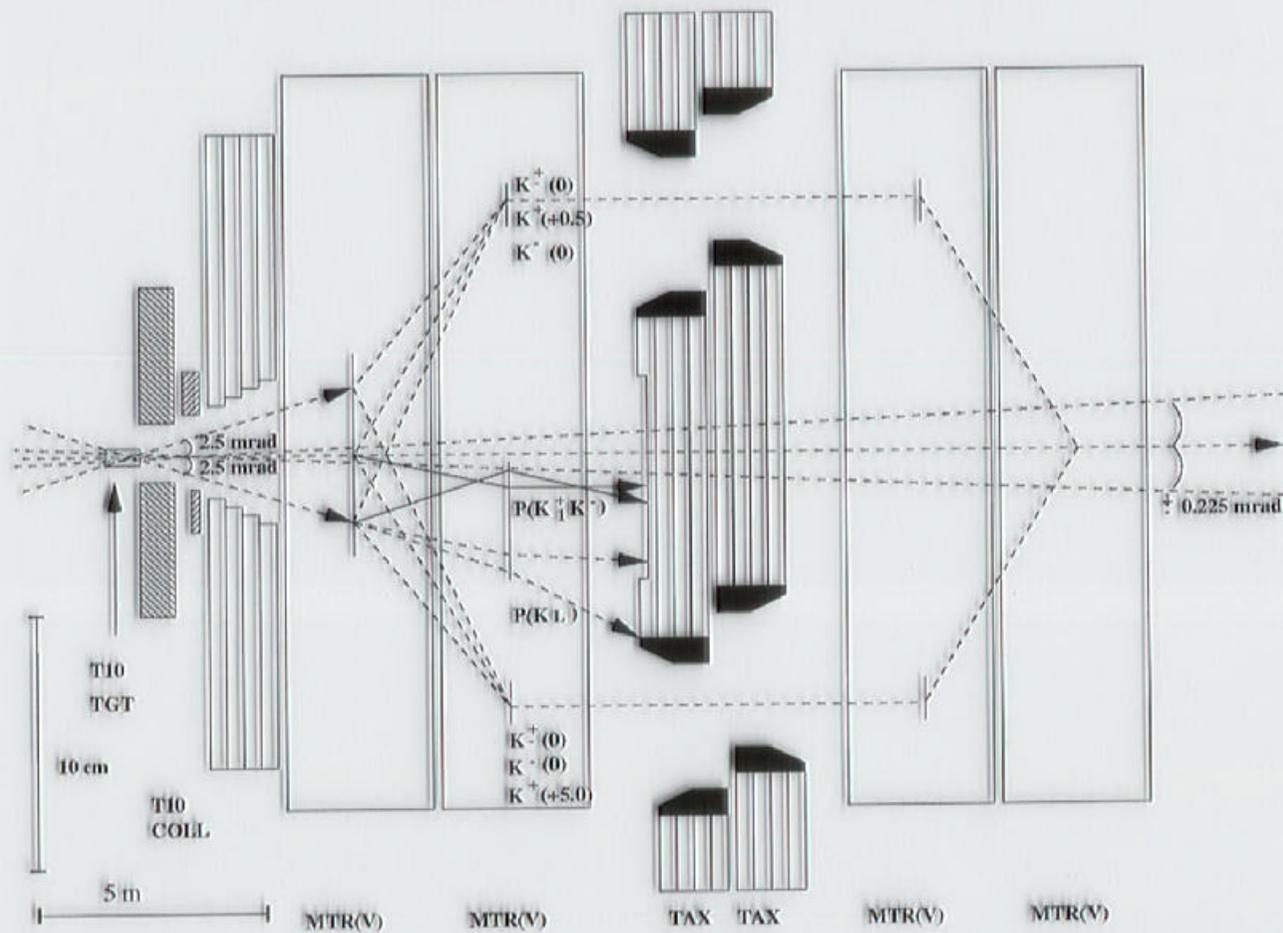
	Motivation	Results from 1999 Test (40k)	2002 Run
$K_S \rightarrow \pi^0 e^+ e^-$	Important input to $K_L \rightarrow \pi^0 e^+ e^-$	$BR < 1.4 \cdot 10^{-7}$ (50% CL) (preliminary)	~ 10 events $\rightarrow BR$
$K_S \rightarrow 3\pi^0$	CP ~ 1000		Expected Acc. $\sim 1\%$
$K_S \rightarrow \gamma\gamma$	Ch PT - Test	$BR = (2.6 \pm 0.4 \pm 0.2) \cdot 10^{-6}$	~ 24000 euts
$K_S \rightarrow \pi^0 \gamma\gamma$	Ch PT - Test		~ 100 euts
$K_S \rightarrow \pi^+ \pi^- e^+ e^-$	BR and Asymmetry	$BR = (4.3 \pm 0.2 \pm 0.3) \cdot 10^{-3}$ $A^S = (-0.2 \pm 3.4 \pm 1.4) \%$	} preliminary
$\Xi^0 \rightarrow \Lambda \gamma$	Branching Ratios and Asymmetries	$BR = (1.92 \pm 0.03 \pm 0.14) \cdot 10^{-3}$ (preliminary)	
$\Xi^0 \rightarrow \Sigma^0 \gamma$			
$\Xi^0 \rightarrow \Sigma^+ e^- \bar{\nu}_e$	Form Factors	~ 60 euts	~ 20000 euts

The K^\pm Program

After ending the K_S program in 2002 the break during the winter will be used to set up the charged Kaon Program. Some bigger modifications are required:

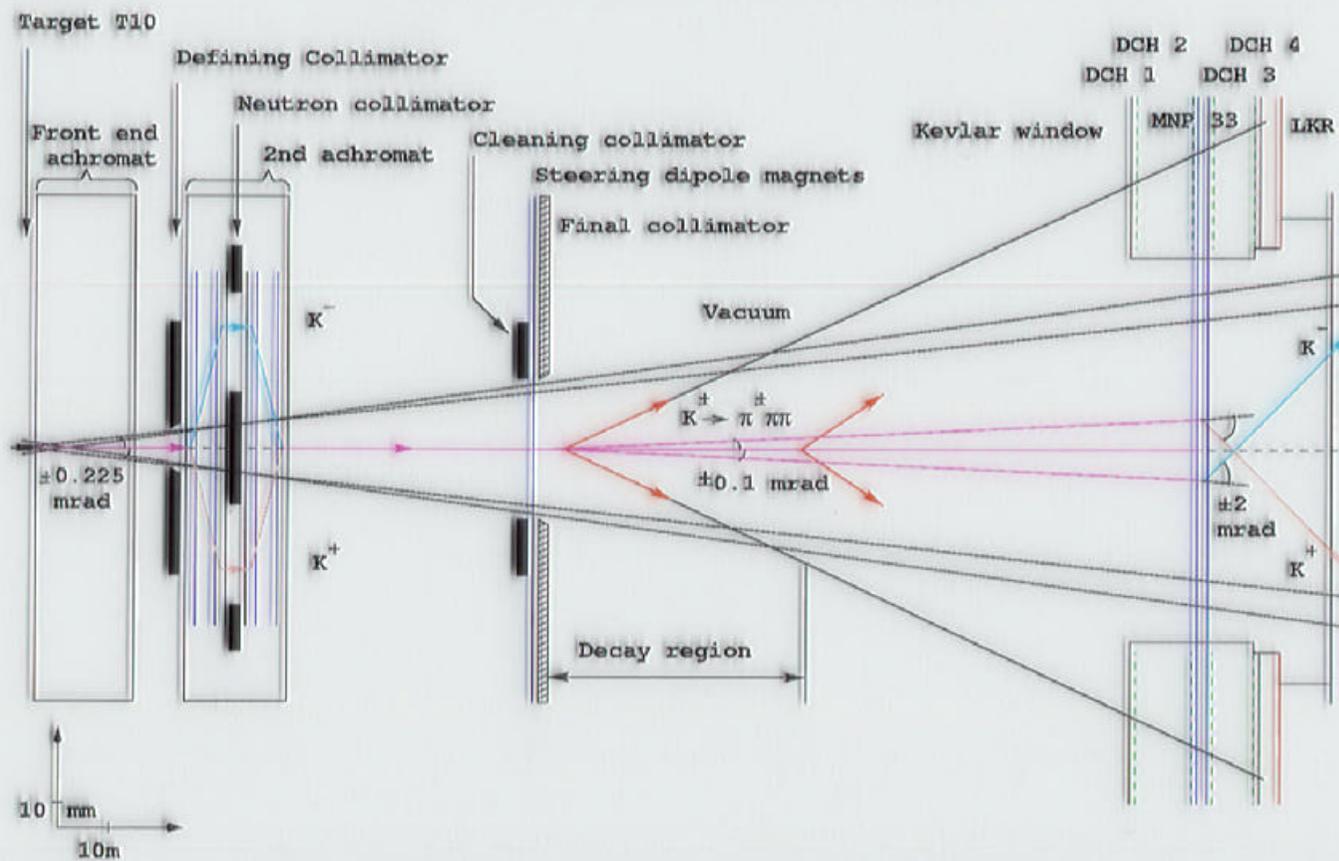
- New setup of the beamlines to obtain simultaneous K^\pm beams
- Add Transition Radiation Detector (TRD) to the detector
- Beam spectrometer - measure parent kaon momentum

Beam Line Modification



Beam Line Modification II

Schematic layout of K^+ and K^- beams



Charged kaon beams

	K ⁺	K ⁻
Energy	400 GeV/c	
Duty cycle	5s/19.2s	
Proton per pulse	10 ¹²	
Production angle, mrad	0.0	
Production angle, mrad	0.0	
Acceptance angle, mrad	±0.225	
Momentum, GeV/c	60±6	
proton flux/pulse (10 ⁶)	7.5	-
pion flux/pulse (10 ⁶)	29.0	17.3
kaon flux/pulse (10 ⁶)	1.9	1.1
kaon decays/year (10 ¹⁰)	5.5	3.1

Parameters of the beams

Detector Upgrade

- Add beam spectrometer at second achromat
→ measure parent kaon momentum
need: high rate capability, good momentum and space resolution and minimum material along the beam
→ Micromegas like detector is under study
- Add Transition Radiation Detector (TRD) in front of Liquid Krypton calorimeter
→ improve electron detection
Possibility: Reuse NOMAD TRD

Prospects from the K^\pm program

- More than 2×10^9 $K^\pm \rightarrow \pi^\pm \pi^\pm \pi^\mp$ and 1.2×10^8 $K^\pm \rightarrow \pi^0 \pi^0 \pi^\pm$ fully reconstructed decays will be collected
 \leadsto a_0 can be measured with a precision better than 2.2×10^{-4}
- More than 10^6 K_{e4} decays will be collected
 \leadsto Measure a_0 with an accuracy of 0.01
- $\sim 10^5$ $K^\pm \rightarrow \pi^\pm \pi^0 \rho$ and $\sim 10^4$ $K^\pm \rightarrow \pi^\pm \rho \rho$ decays are to be expected
- Collect $\sim 10^8$ K_{e3} events (scalar and tensor form factors)

Summary

- Both, the K_S and the K^\pm Programs have been approved at the end of 2000
- K_S data taking for ~ 120 days in 2002
Topics: $K_S \rightarrow \pi^0 e^+ e^-$, γ_{00} , $K_S \rightarrow \pi\pi \dots$, Hypothesis
- K^\pm data taking in 2003 and 2004 after beam line and detector upgrade
Topics: $K^\pm \rightarrow \pi^\pm \pi^\pm \pi^\mp \rightarrow$ Measurement of A_S
 K_{e4} , K_{e3} , Rare decays