Exotic Hadrons

International Workshop, February 21 -24, 2005, Trento, Italy

COSY-TOF research on ? $^{+}$

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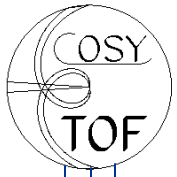
for the COSY-TOF collaboration

supported by German BMBF and Forschungszentrum Jülich



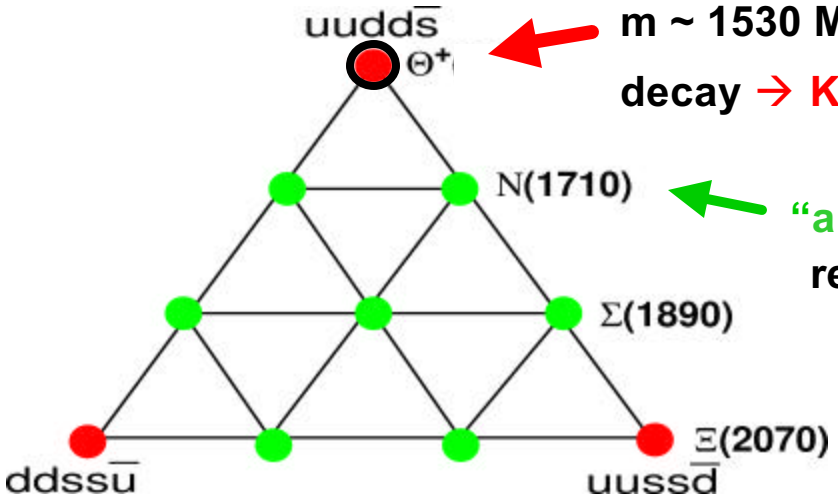
Content

- Introduction
- The COSY-TOF experiment
- Evidence on T^+ from pp → S^+K^0p
- Ongoing and new activities
- Outlook

Introduction

Chiral soliton model → antidecuplet including exotic states

D. Diakonov, V. Petrov, and M. Polyakov, Z. Phys. A 359 (1997) 305



m ~ 1530 MeV, G ~ 15 MeV , S = + 1, $J^p = ½^+$

decay → $K^0p + K^+n$

"anchor" → mass spacing

related width: G ~ 50 MeV

Numerous calculations in various models:

different masses and widths, splitting, mixing → **many questions!**

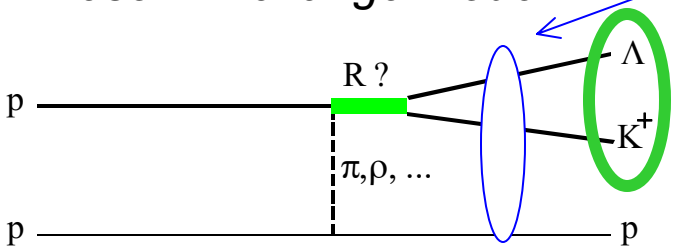
Introduction

Strangeness production at COSY-TOF: pN → KYN

Information: dynamics + structure → degrees of freedom

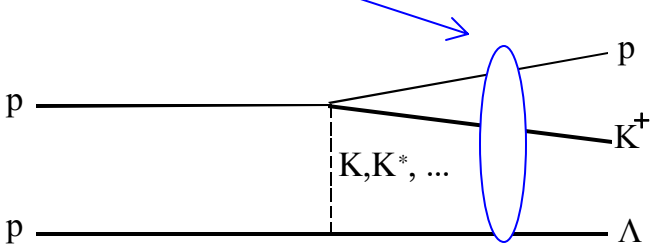
different reaction channels : N = p, n Y = Λ, Σ^0, Σ^+, Σ^-

Meson Exchange Model

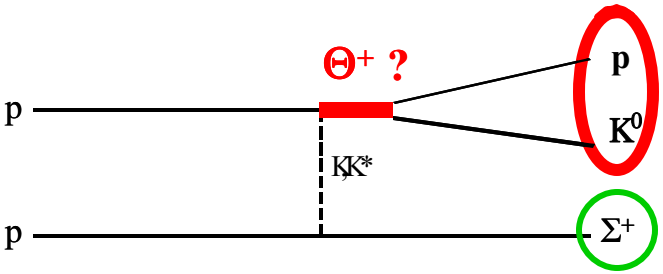


+

final state interaction



Search for exotic Θ+ ⟷



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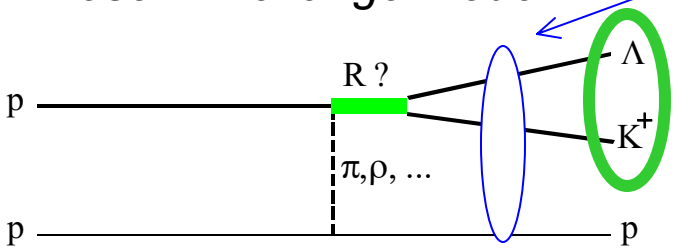
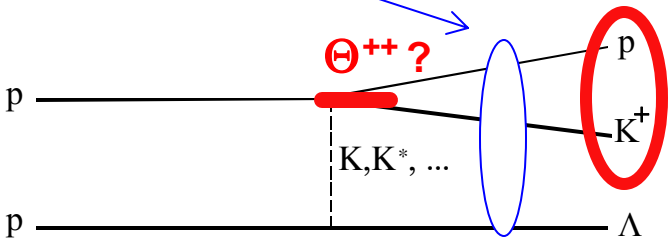
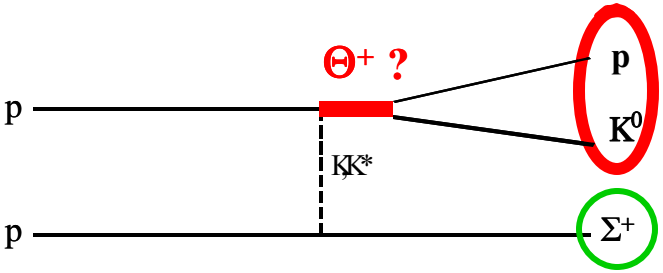


final state interaction



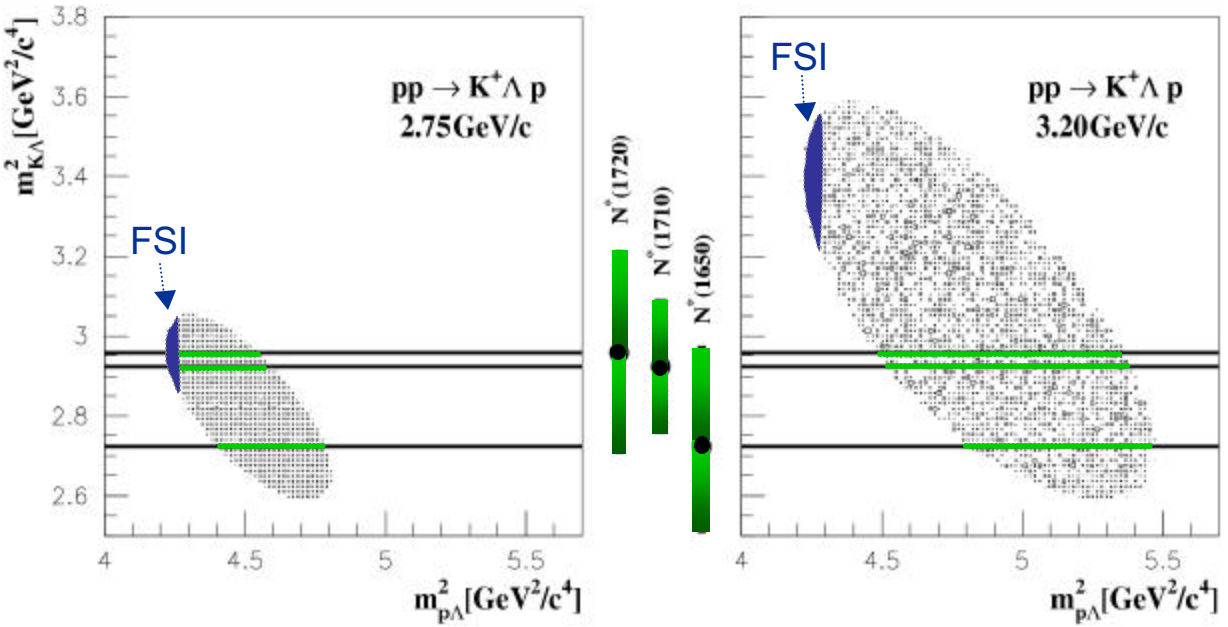
Search for exotic Θ+



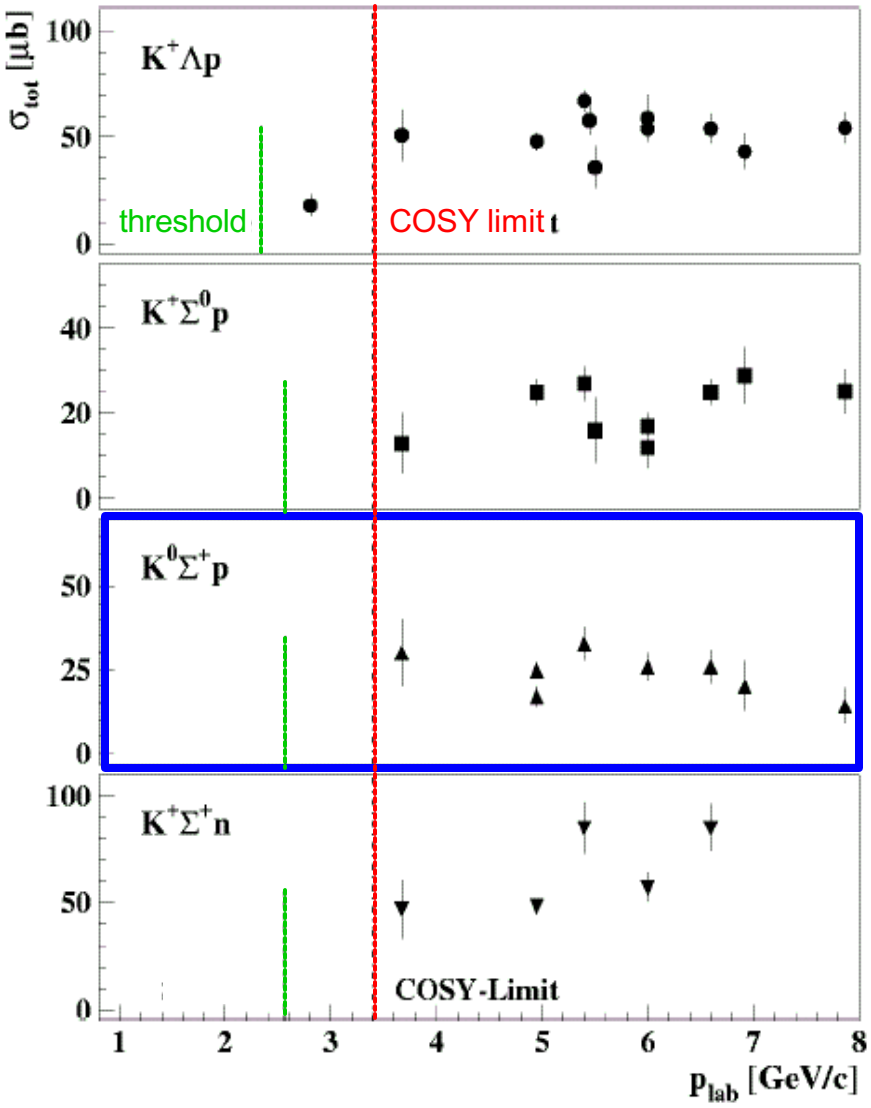
Introduction

Strangeness production at COSY-TOF:

- exclusive observables
- full phase-space → Dalitz Plots
- polarization: Hyperon-polarization, polarized beam, (polarized target)
- threshold region → only few partial waves, no Y*



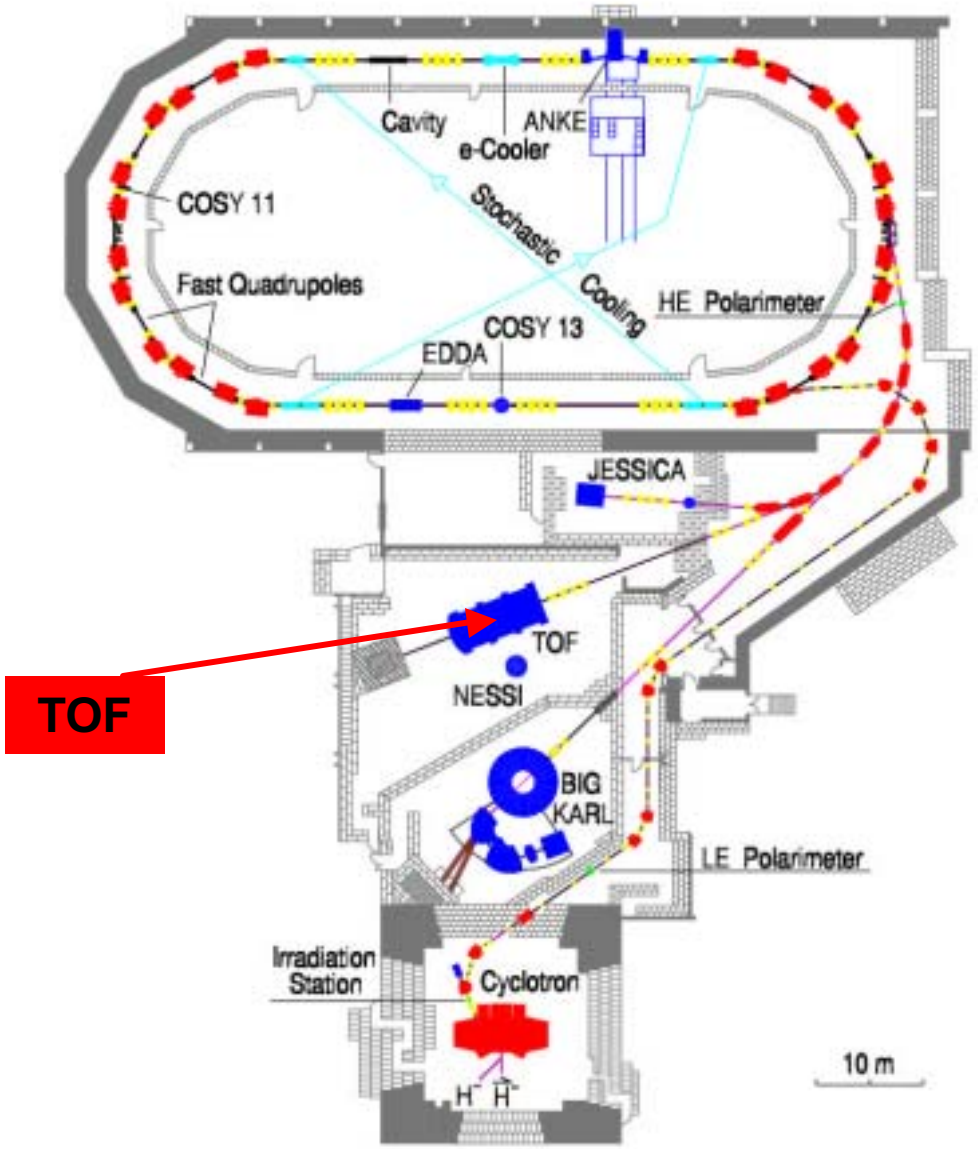
Introduction



Strangeness production in pp → KYN reactions before COSY:

almost no data in threshold region

COSY - Facility



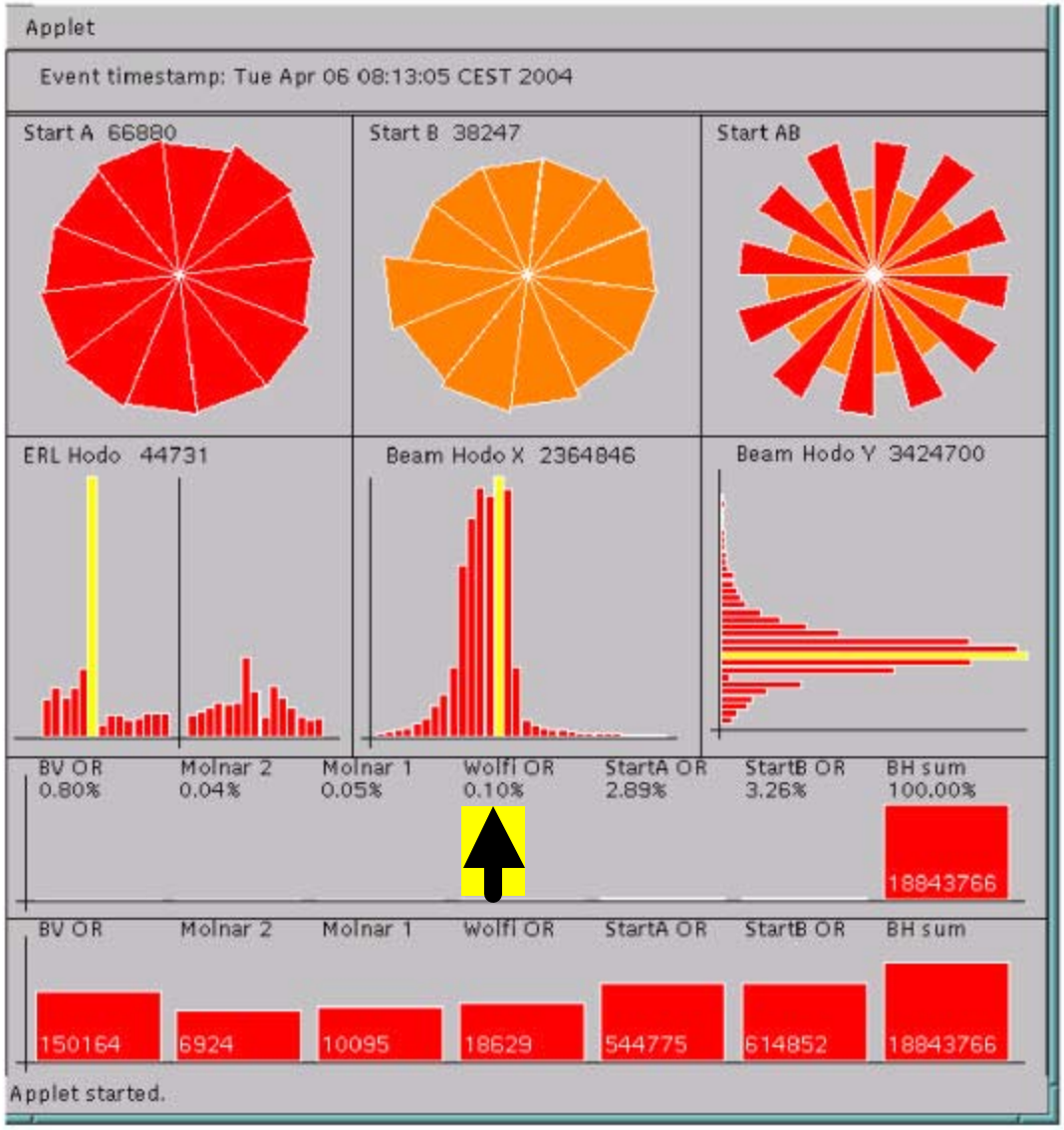
Cooler Synchrotron Jülich

Circumference: 180 m

Phase space cooling: electron and stochastic

Beam momentum: maximum: 3.6 GeV/c

COSY - beam



Beam-Quality

Veto-detector

with 2 mm hole

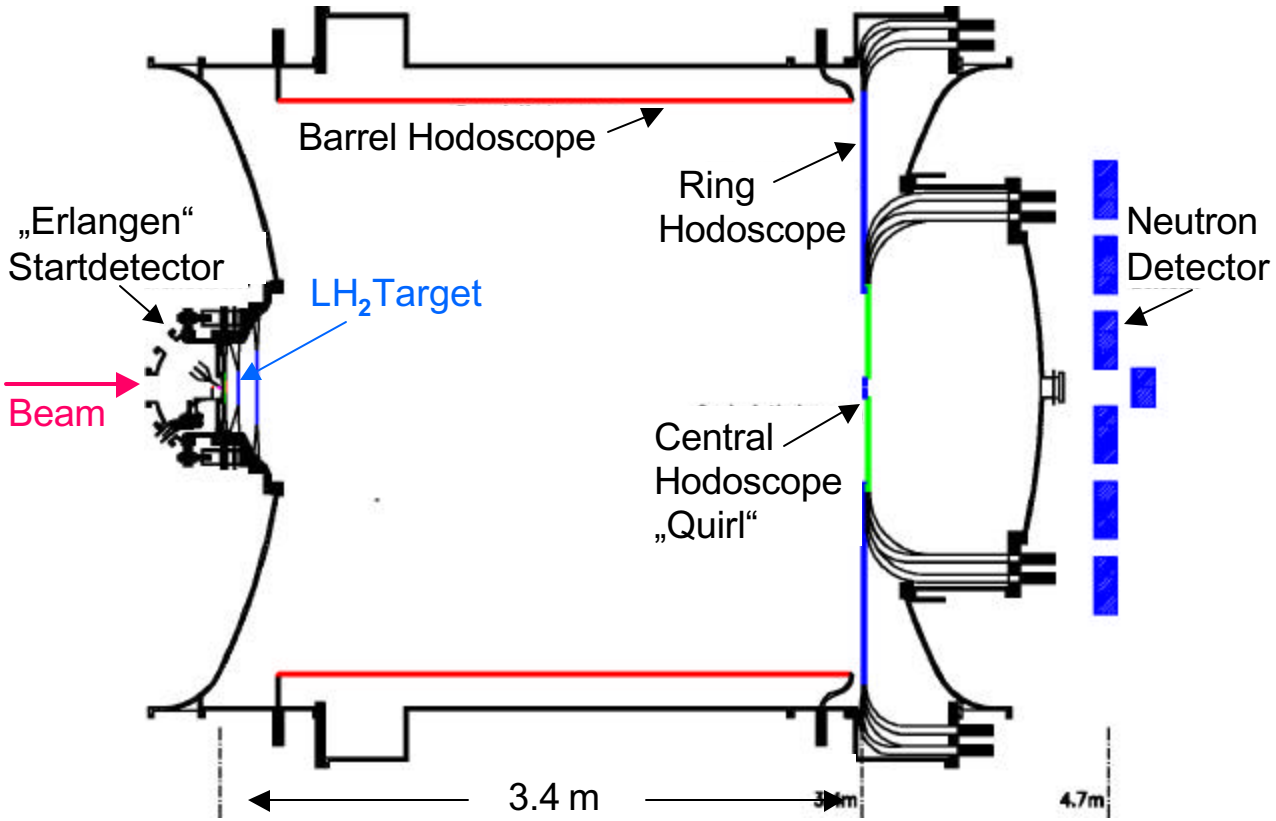
0.1% intensity

Beam-Intensity

used

1 - 3 x 10^7 p/s

COSY - TOF



large angle (non magnetic) spectrometer

modular vacuum vessel

tiny liquid hydrogen target

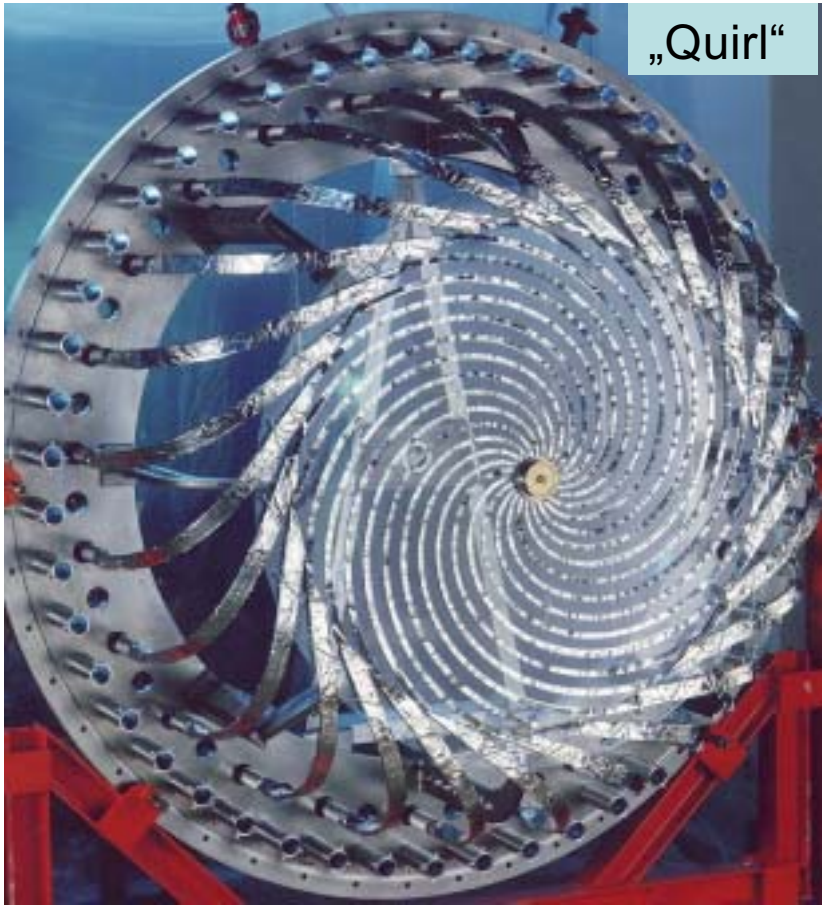
startdetector system

stopdetector system

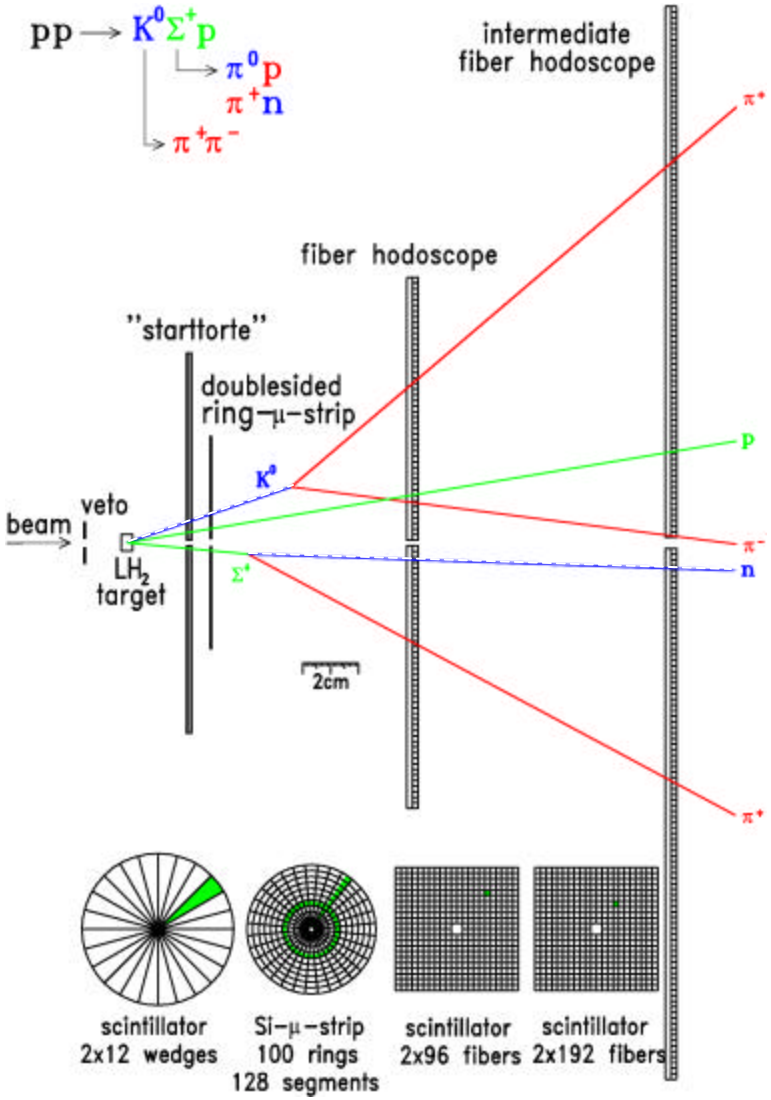
COSY-TOF - Stop-Detector

TOF

„Quirl“



The „Erlangen Start Detector“



delayed decays of K^0, ?

→ charged multiplicity 2 → 4

→ trigger

vertex reconstruction

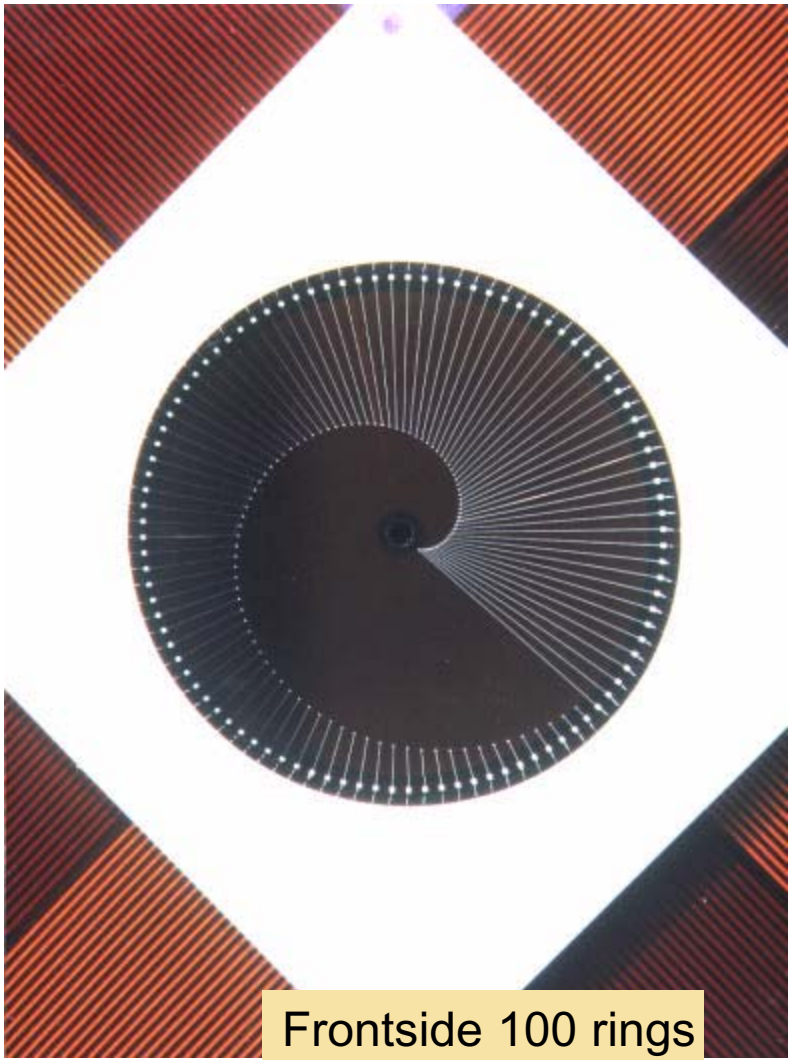
identification of K^0_s:
decay → „V“

identification of S^+:
decay → kink in track

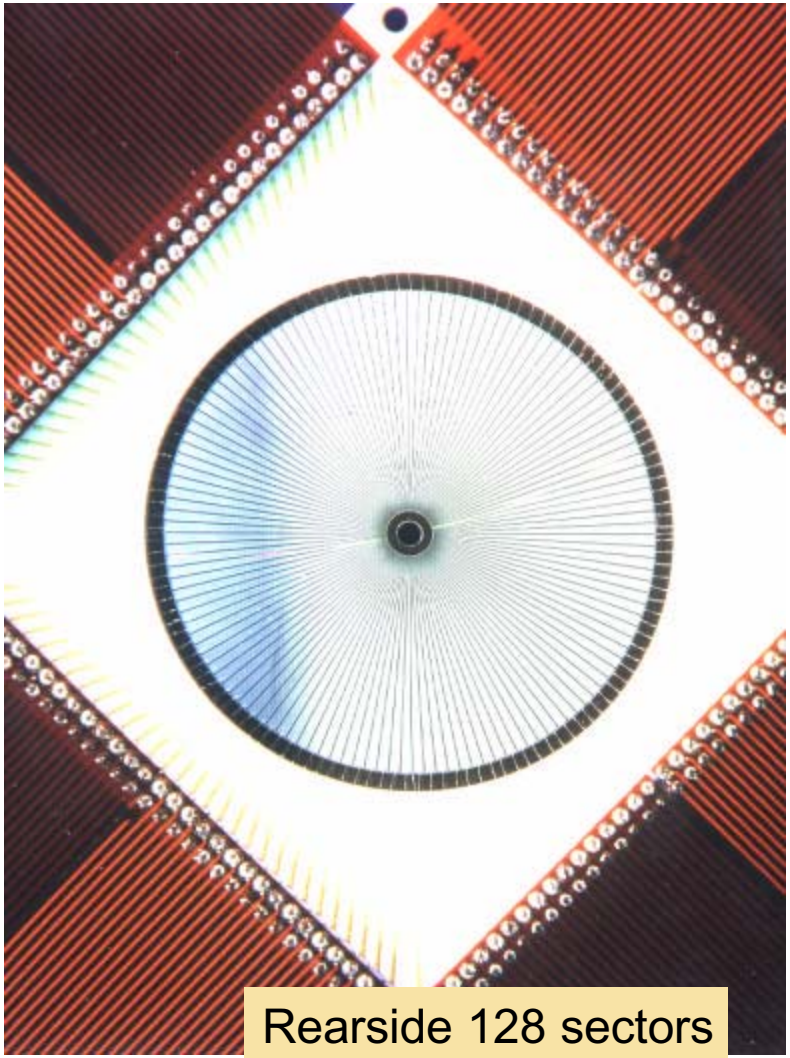
complete geometric reconstruction

„4p“ cover

„Erlangen Start Detector“: Ring microstrip detector

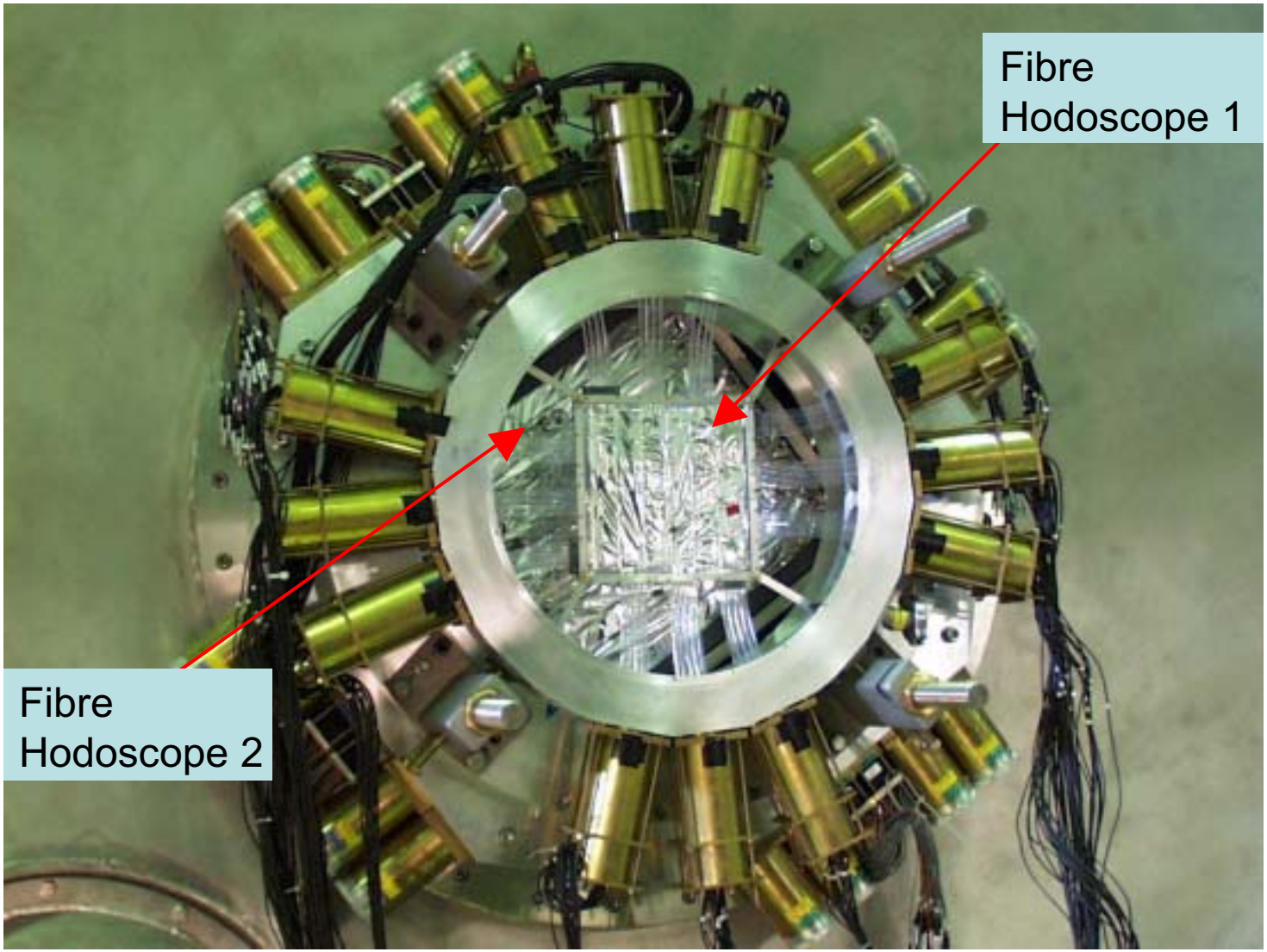


Frontside 100 rings



Rearside 128 sectors

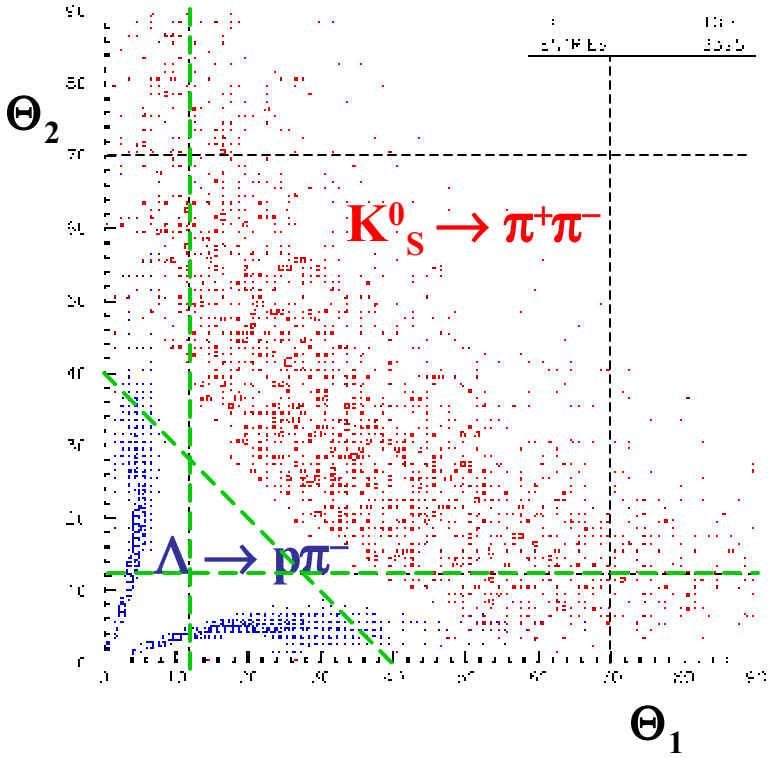
„Erlangen Start Detector“: Fibre Hodoscopes

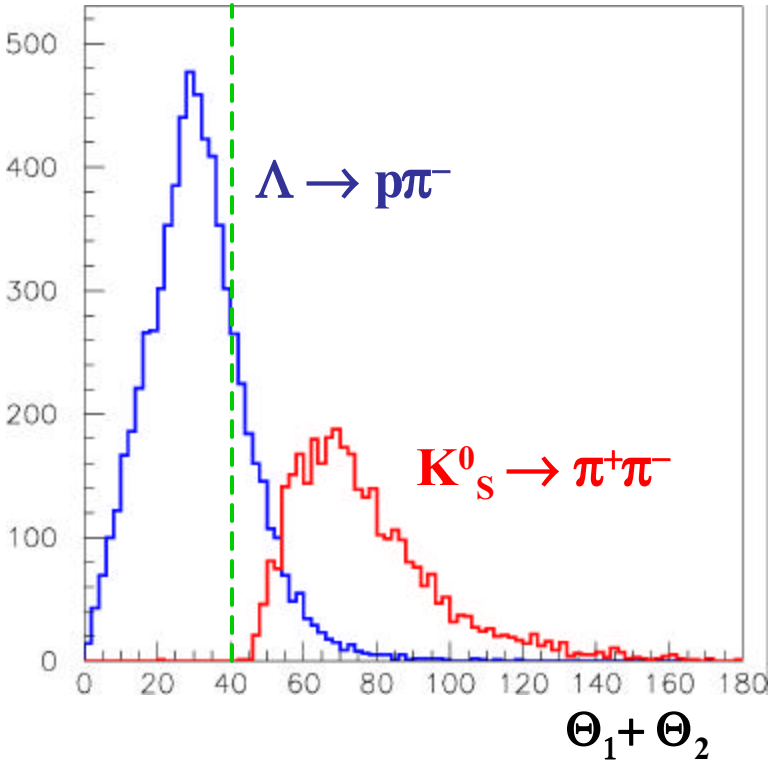


pp → S^+K^0p: background separation

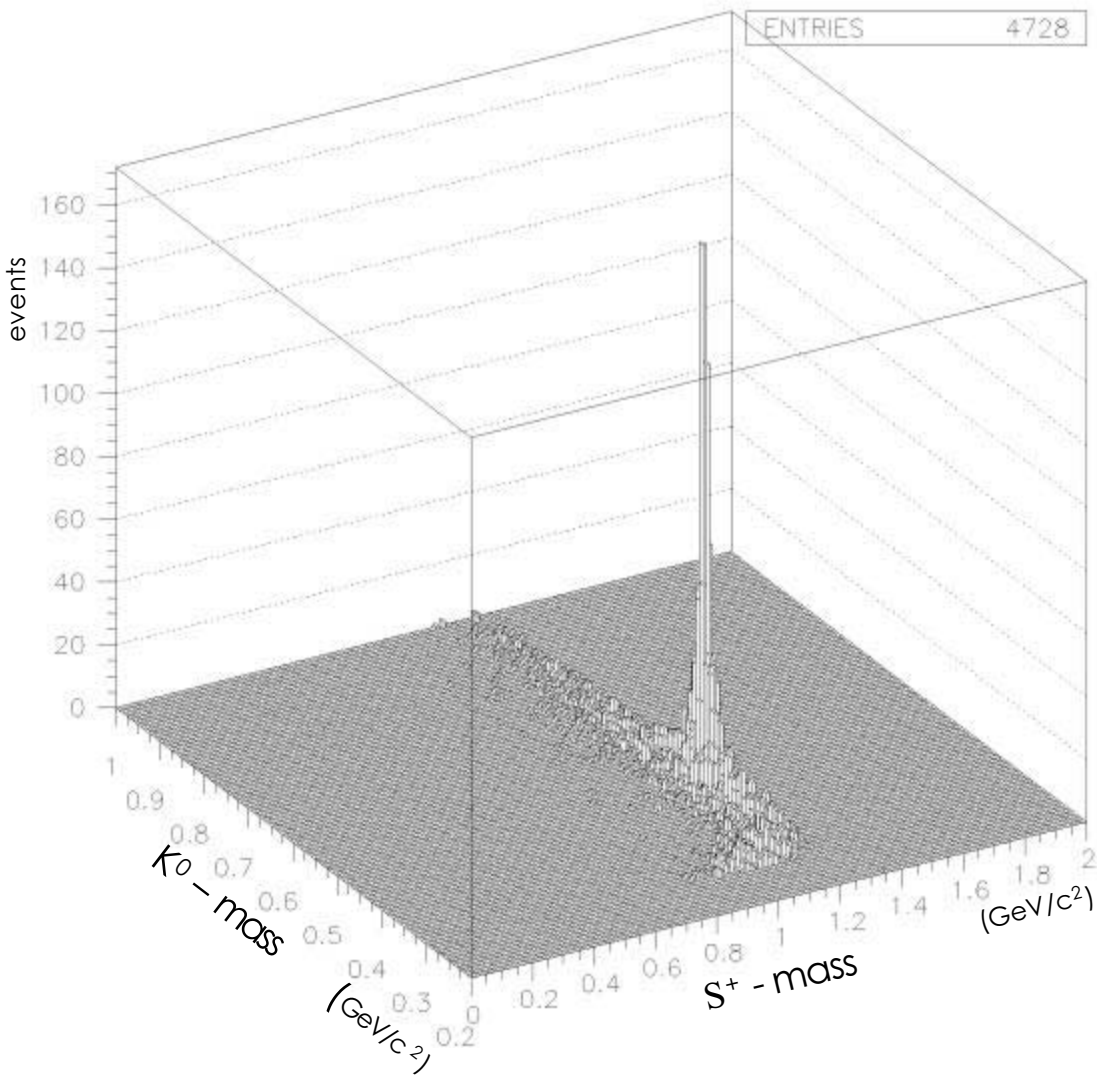
Separation of pp → $pK^0\Sigma^+$ from pp → $pK^+\Lambda$ and $pK^+\Sigma^0(\to\gamma\Lambda)$

P_{beam} = 2.95 GeV/c Monte Carlo simulations





pp → S^+K^0p: reconstructed masses

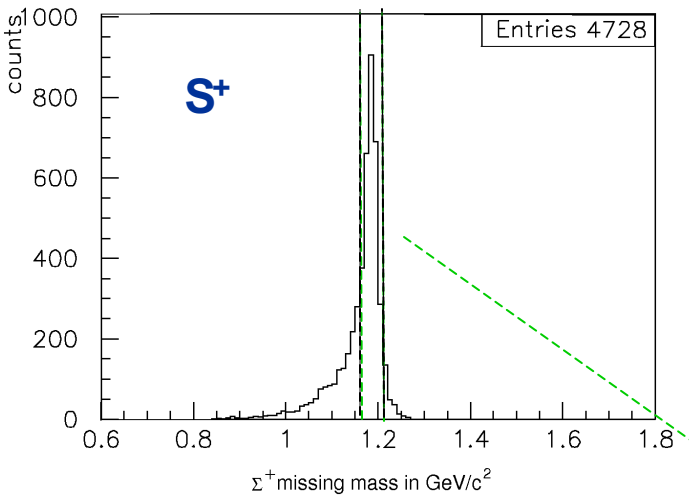


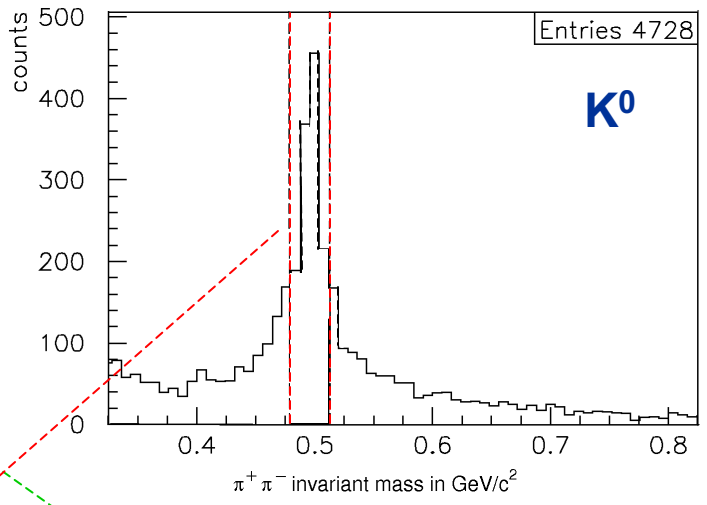
P_{beam} = 2.95 GeV/c

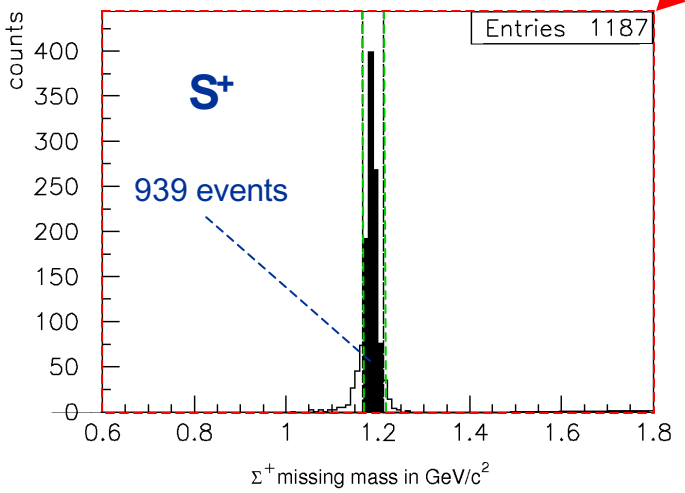
Runs 2000 + 2002

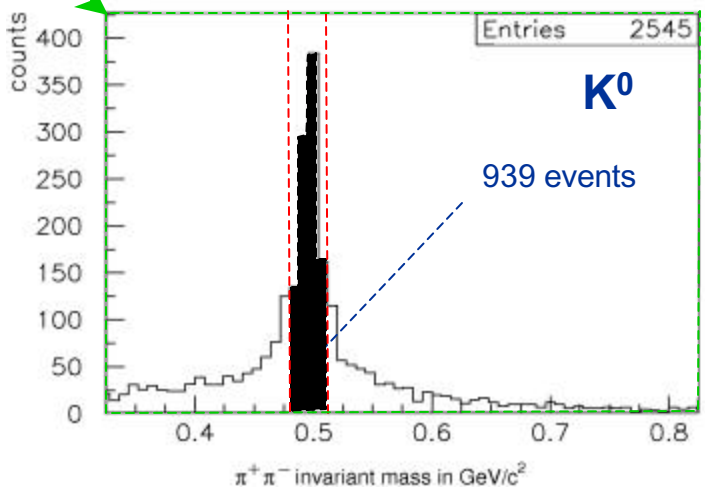
pp → S^+K^0p: cuts on masses

P_{beam} = 2.95 GeV/c **Run 2000 + Run 2002**



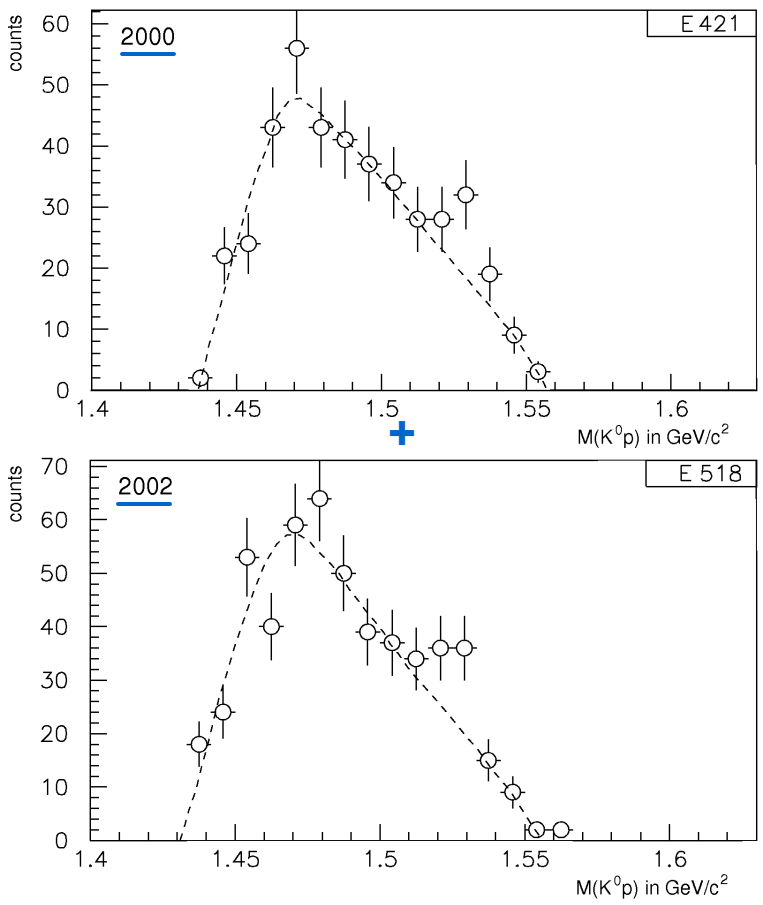






pp → S^+K^0p: K^0p mass spectra

P_{beam} = 2.95 GeV/c



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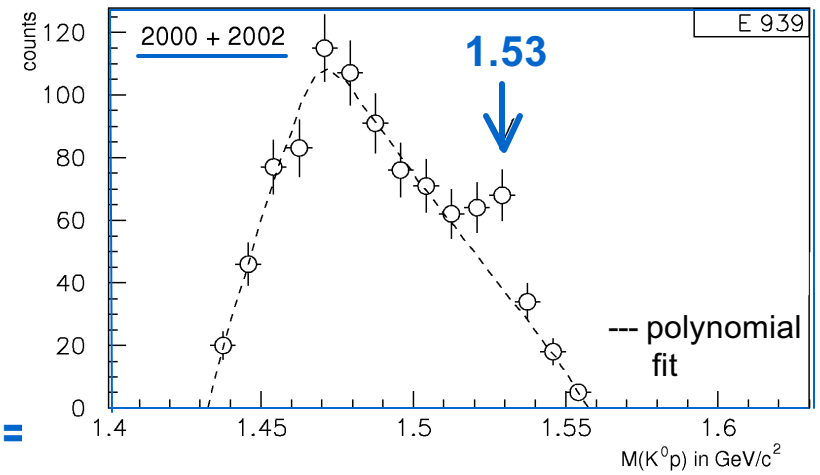


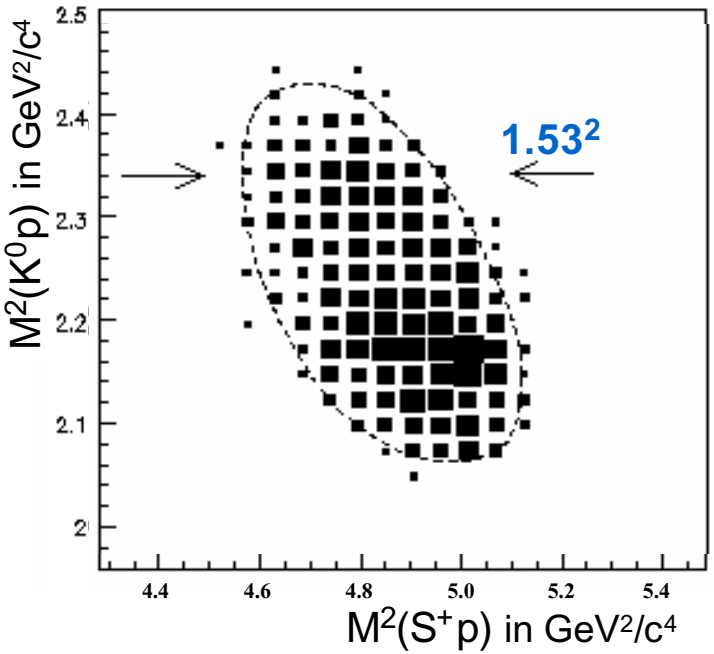
significance: 4 – 6 s

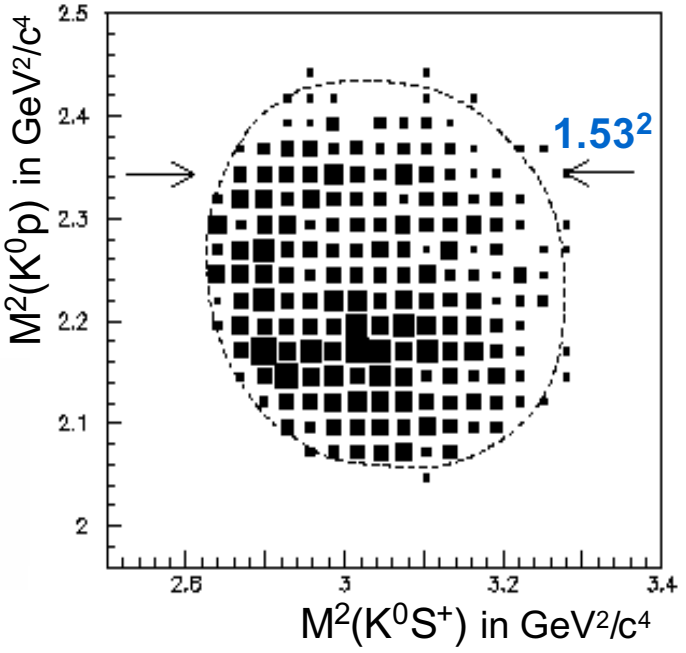
(depending on method)

$NS / \sqrt{NB}$	$5.9\,\sigma$
$NS / \sqrt{NS + NB}$	$4.7\,\sigma$
$NS / \sqrt{(NS + NB) + NB}$	$3.7\,\sigma$

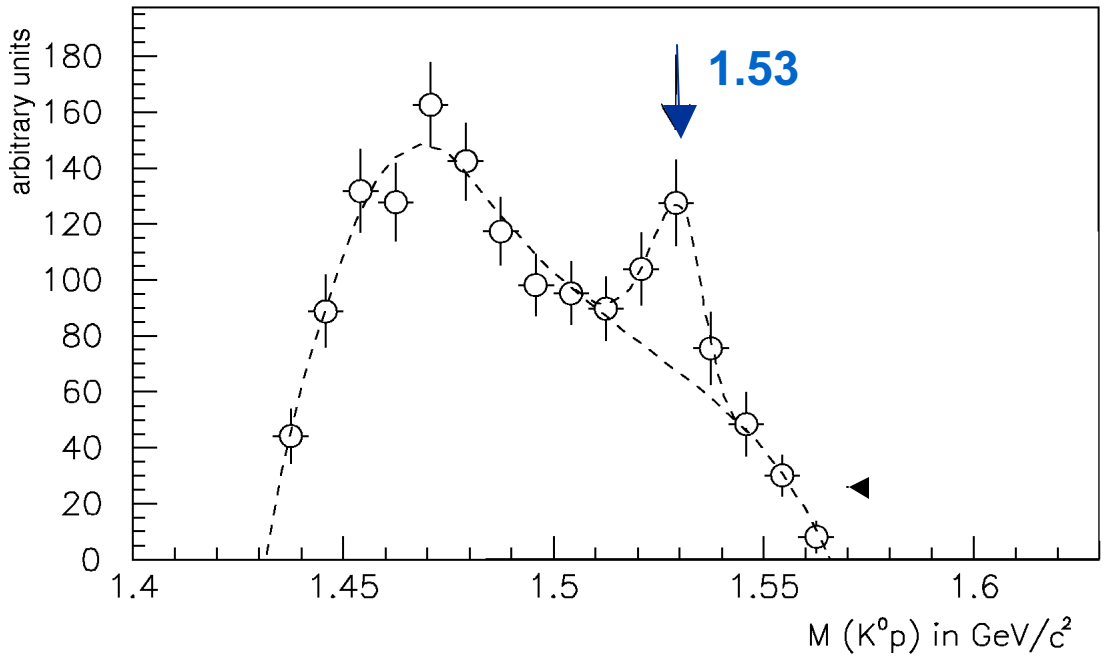
pp → S^+K^0p: Dalitz plots

P_{beam} = 2.95 GeV/c





pp → S^+K^0p: efficiency corrected K^0p spectrum



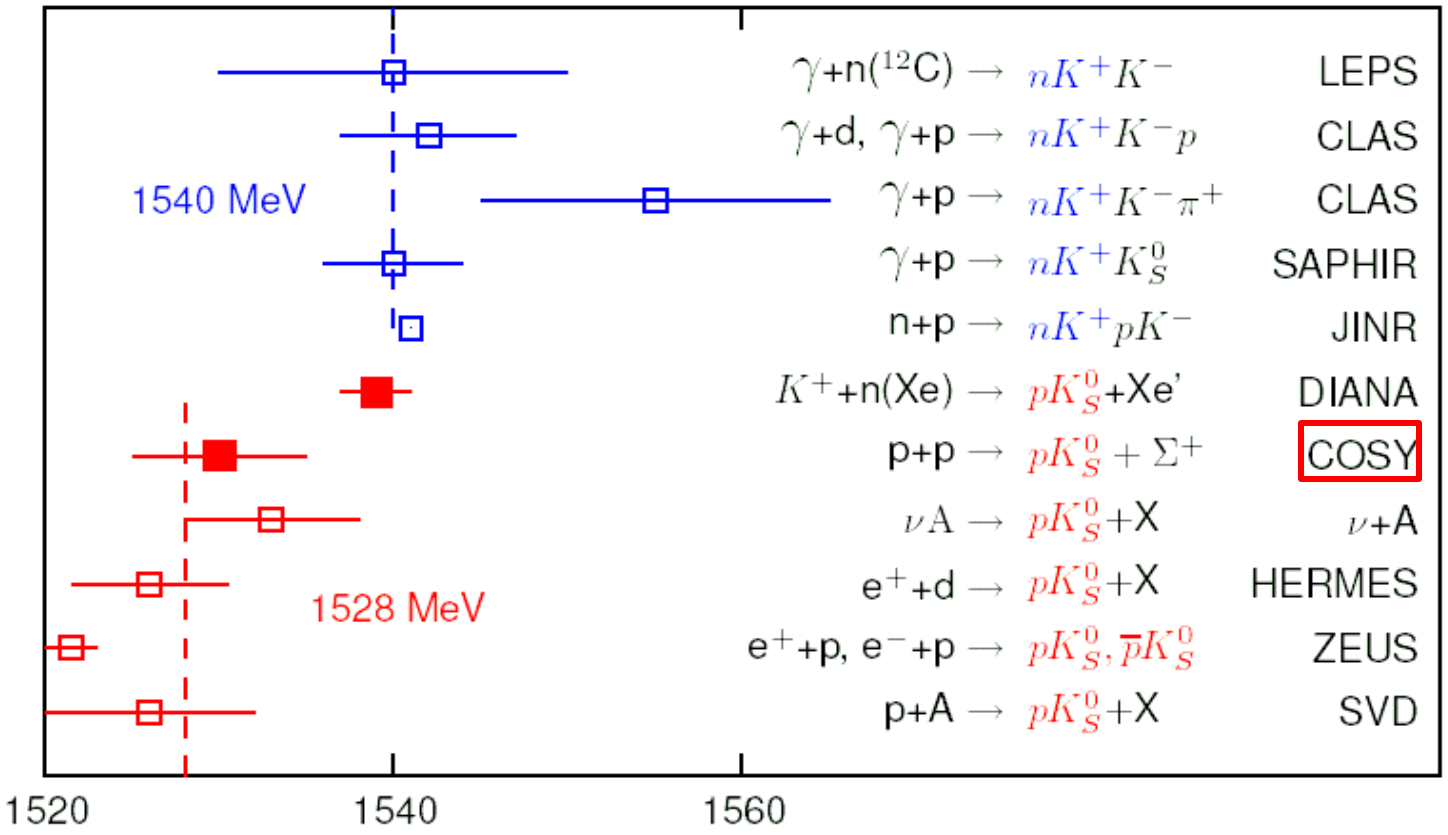
Background:
Polynomial fit

Peak:
Gaussian fit

Mass 1530 ± 5 MeV/c²
Width = 18 ± 4 MeV/c² (FWHM)
Strangeness S = + 1
Cross section: $0.4 \pm 0.1_{stat} \pm 0.1_{sys}$ μb

***hep-ex/0403011, Phys. Lett. B* 595 (2004), 127**

Evidence for Θ^+



Negative results especially from high energy experiments

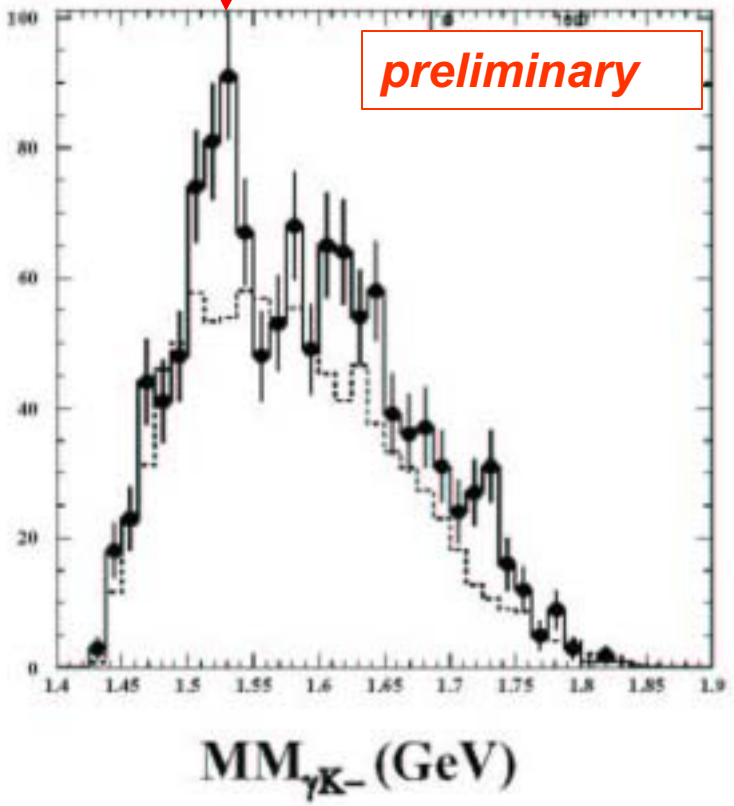
LEPS

New Results on LD2: Nakano et al. Pentaquark04

- Data taken from Oct. 2002 to Jun. 2003.

LD2 target. → Less Fermi motion effect.

1.53 GeV !



- Background level around 1.53 GeV in 4 bins is ~220 events IF we take the mixed event BG method.
- The excess above the BG level is ~90 events.
- The peak position, width, significance strongly depends on the BG shape.

COSY-TOF: Ongoing and new activities

In progress

Search for possible isospin partners Θ^{++} and Θ^{+++}

Investigation of N* resonances, especially width of N*(1710)

Experiment upgrade

2004: Fibre hodoscope with three layers

New Measurement

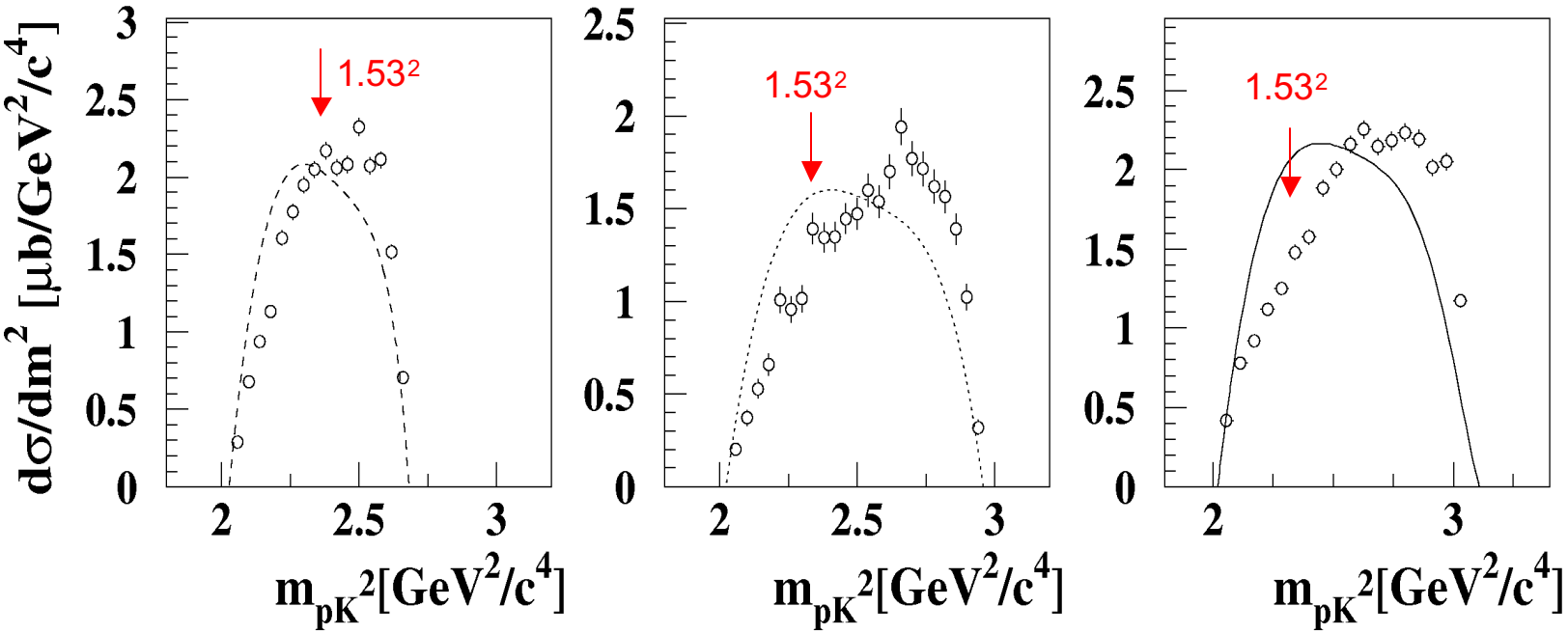
2004: $pp \rightarrow S^{+}K^{0}p$ with much higher statistics

Independent Analyses

Related topic: Search for possible isospin partners

Search for Θ^{++} : $pp \rightarrow \Theta K^+ p$

P_{beam} : 2.95 GeV/c 3.20 GeV/c 3.30 GeV/c

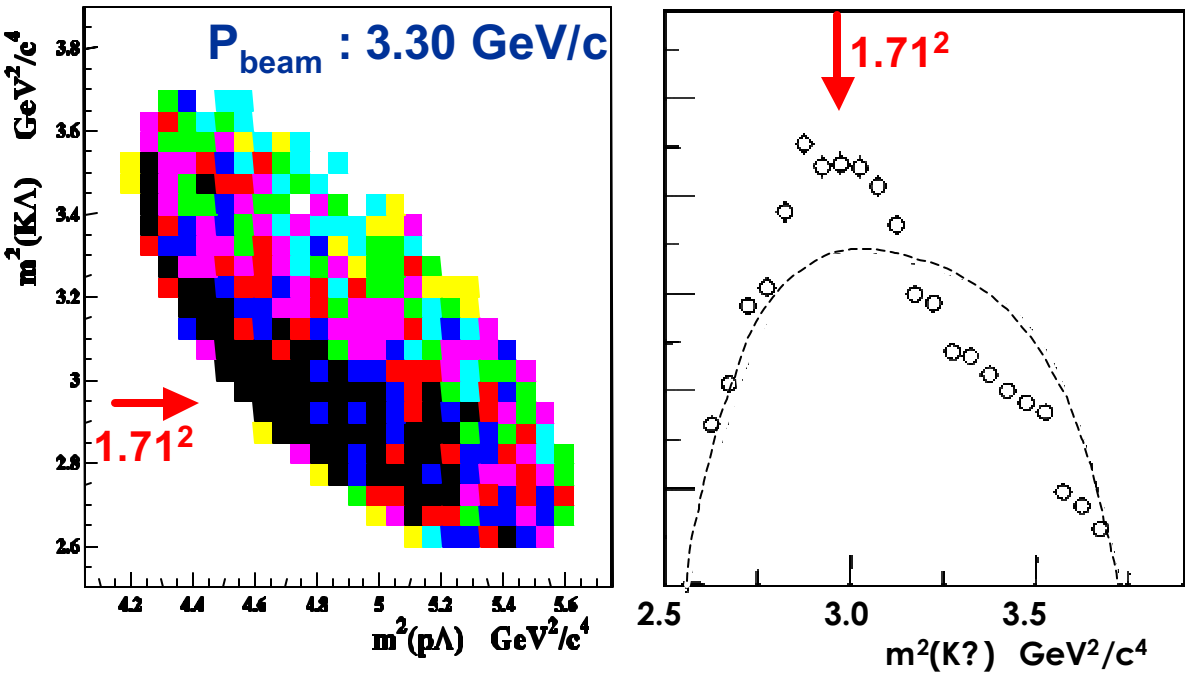


Preliminary: no evidence for Θ^{++} in pK^+ spectra

Search for Θ^{+++} : $pp \rightarrow \Sigma^- \Theta^{+++}$

Related topic: Width of N*(1710) resonance

pp → ?K⁺p



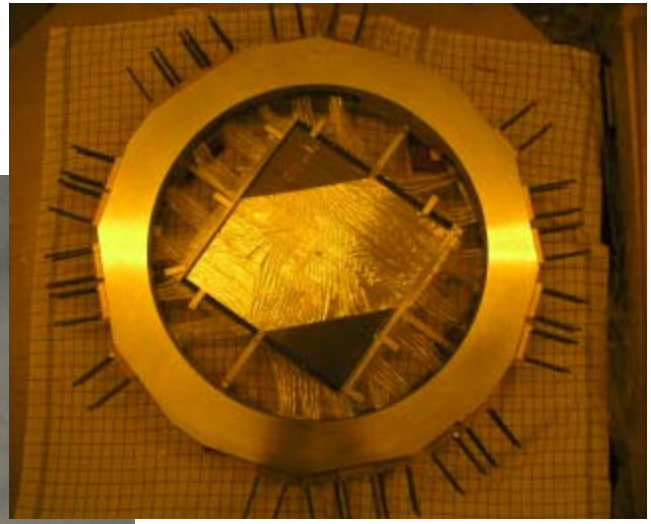
N*(1710) contributes strongly

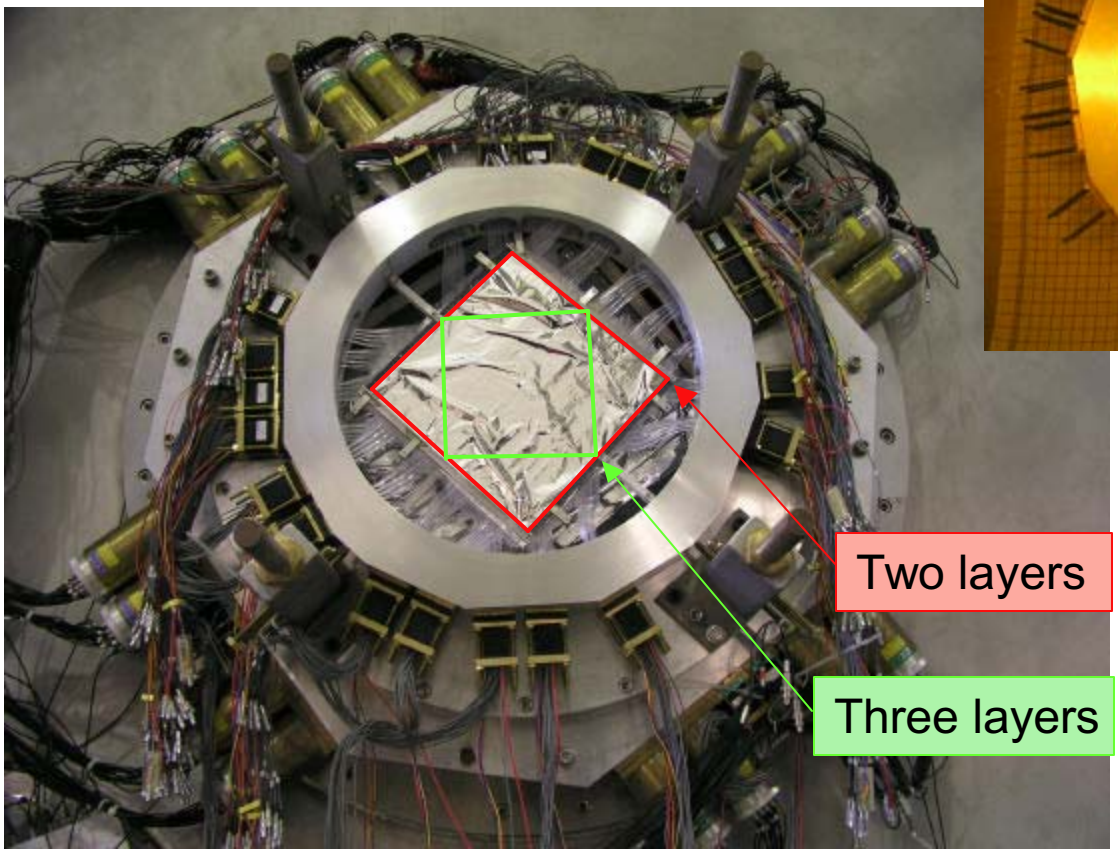
Influence of p?-FSI

In progress: Investigation of Dalitz plots → **width**

Experiment upgrade

New fibre hodoscope with three layers





? increase of efficiency and purity

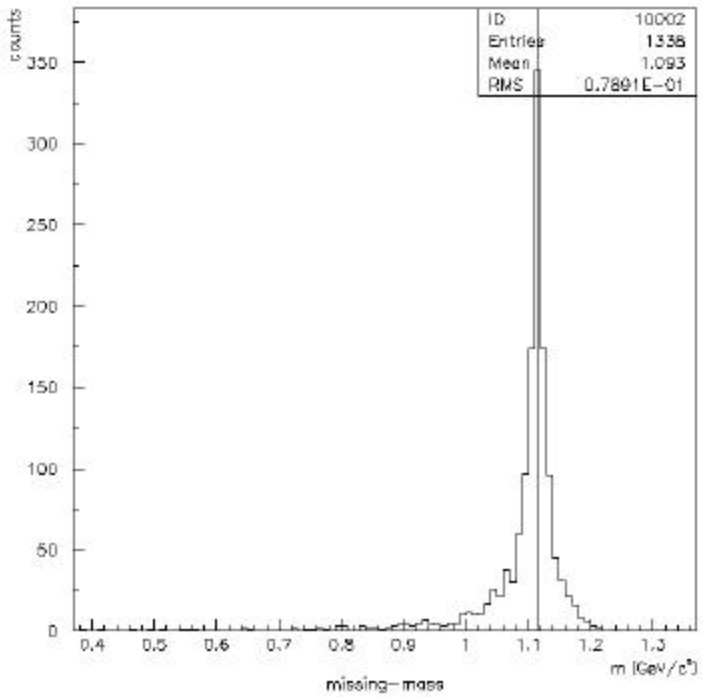
Measurement (Oct./Nov. 2004): pp ? K^0 S^+ p

P_{beam} = 3.05 GeV/c

Estimate of output:

Reference: reaction channel pp ? K^+ ? p

Preliminary analyses of 4 hours run: ? missing mass



Expected overall gain for pp ? K^0 S^+ p: Factor of ~ 5 more events compared to existing data (in agreement with the proposal)

Outlook

New results expected in the near future

confirmation of T^+ !? → more insight

CLAS: high-statistics runs
(done, waiting for results)

COSY-TOF: high-statistics run $pp \rightarrow S^+K^0p$
(done, waiting for results)

KEK E559: π^+p ? $K^-\Theta^+$ (run in 2005)

?
?
?

Outlook COSY-TOF

In the positive case of T^+ confirmation

Future measurements

2005: $\vec{p}n \rightarrow \Lambda K^0 p$ using a LD_2 target, successful tests in 2002/04

pol. beam + Λ-polarization → towards parity of Θ^+

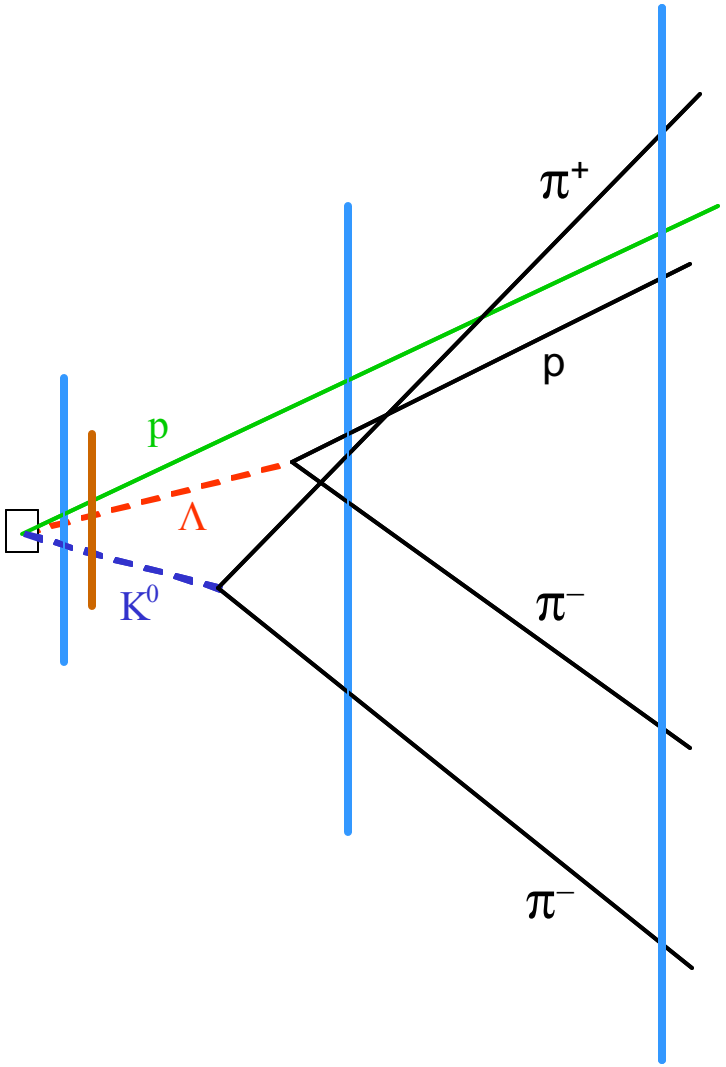
2005/6: $\vec{p}\vec{p} \rightarrow S^+ K^0 p$ polarized beam + polarized target → Θ^+ parity

Experiment upgrade

2005/6: additional tracker

2005/6: polarized target

pn(p) → pK⁰? (p)



Unique signature:

2 „V's" corresponding to

delayed decays

of ? and K^0

into charged particles

pp → S^+K^0p: reconstructed masses

P_{beam} = 2.95 GeV/c Run 2000 ? Run 2002