Search for a $K^{-}pp$ Bound State with FOPI

◇

Status of the Experiment

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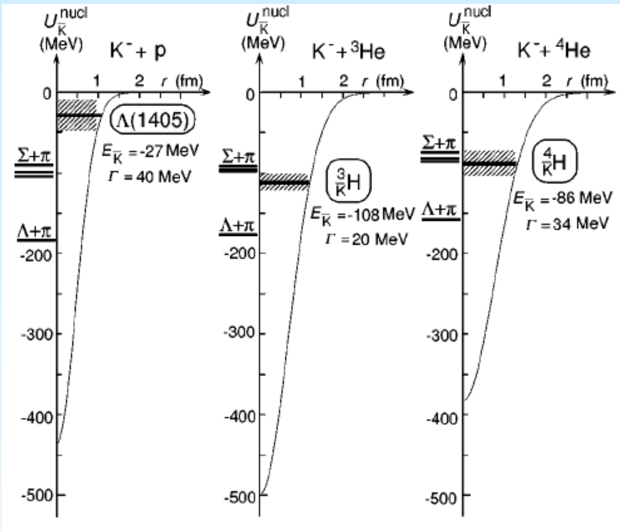
Outline

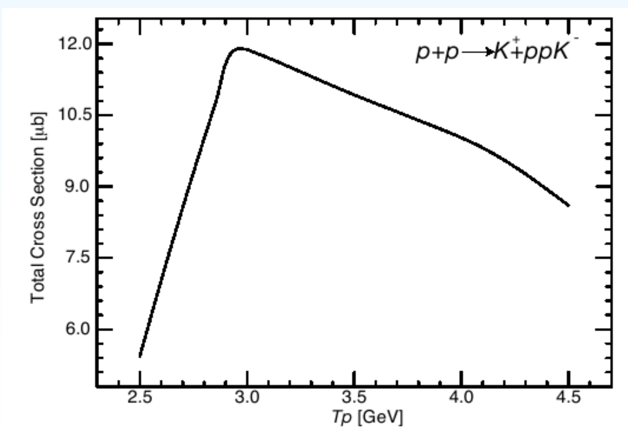
- Introduction
  - Bound State in p+p Collisions?
- The FOPI Detector at GSI-SIS
  - Additional Hardware
- Test Experiments and Production Run
  - Performances and Data Analysis
- Outlook
  - Strangeness Production and Propagation in Pion induced Reactions

Introduction

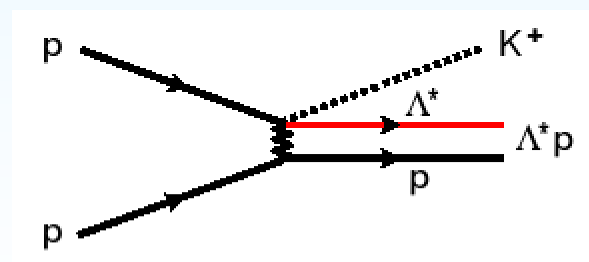


Y. Akaishi & T. Yamazaki, PRC65(2002) prediction of bound states with small width involving strangeness

Y.A. and T.Y., PRC76(2007) enhanced production of K^-pp in p+p collisions predicted



beam energy > 2.9 GeV



Introduction

Production and Decay of a $K^{-}pp$ State

$$p + p \rightarrow K^{+} + K^{-}pp$$

≥ 3 µb

proton + charged decay products of a Λ hyperon

charged kaon

$$K^{-}pp \rightarrow \begin{cases} \Lambda + p & \rightarrow \pi^{-} + p + p \quad 50\% \\ \Sigma^{0} + p & \rightarrow \pi^{-} + p + \gamma + p \\ \Sigma^{+} + n & \end{cases} \Big\} \; 50\%$$

background

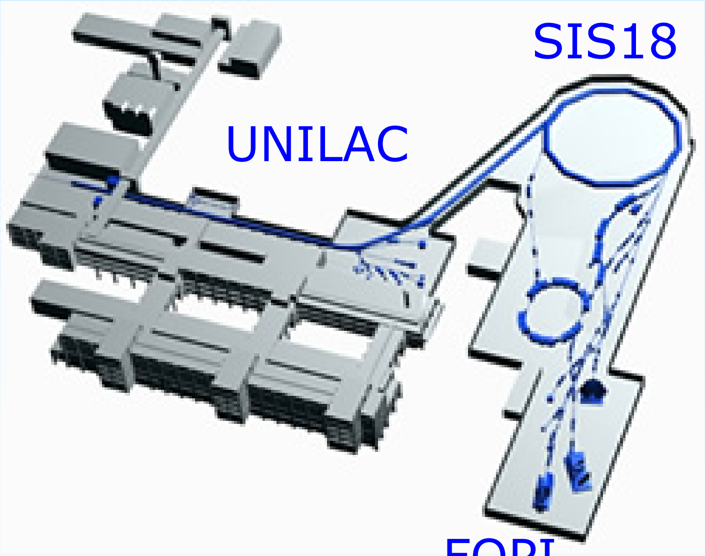
total cross section ≈40 mb

$$p + p \rightarrow K^{+} + \Lambda + p \qquad 40\ \mu b$$

$$p + p \rightarrow K^{+} + \Sigma^{0} + p \qquad 15\ \mu b$$

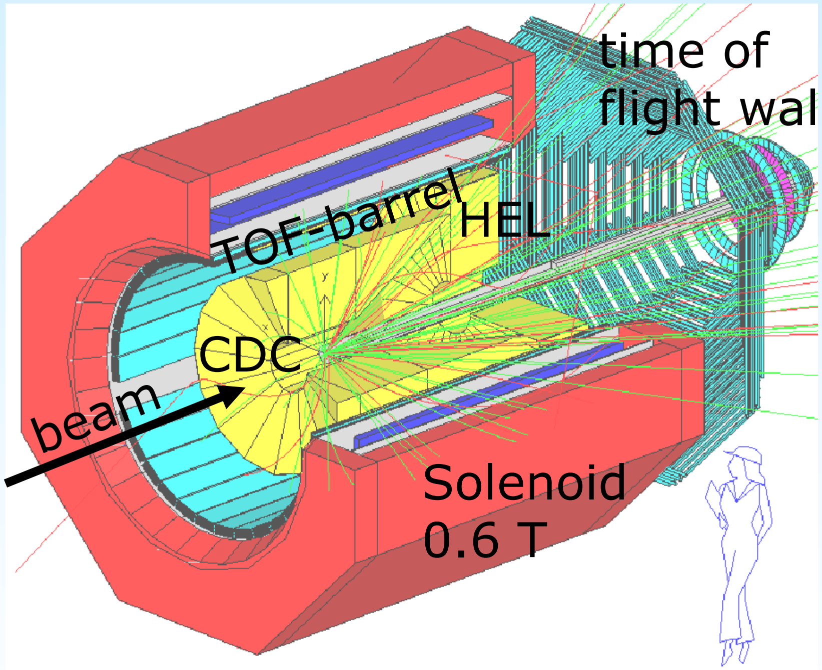
detect a final state out of four charged particles

The FOPI Detector at GSI-SIS



proton beams up to 3.5 GeV
slow extraction up to 10 s
extracted beam intensities
up to $O(10^{10})$ particles/spill

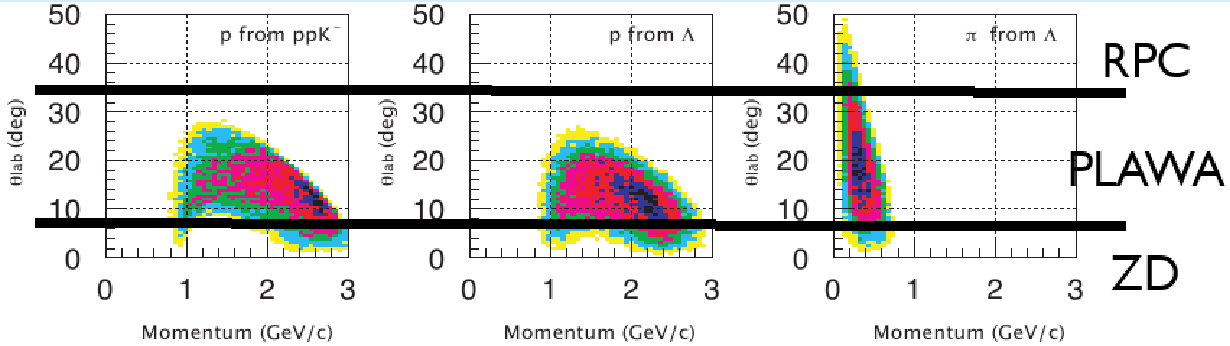
FOPI Setup



CDC, HEL: drift chambers

FOPI Detector Setup

Acceptance



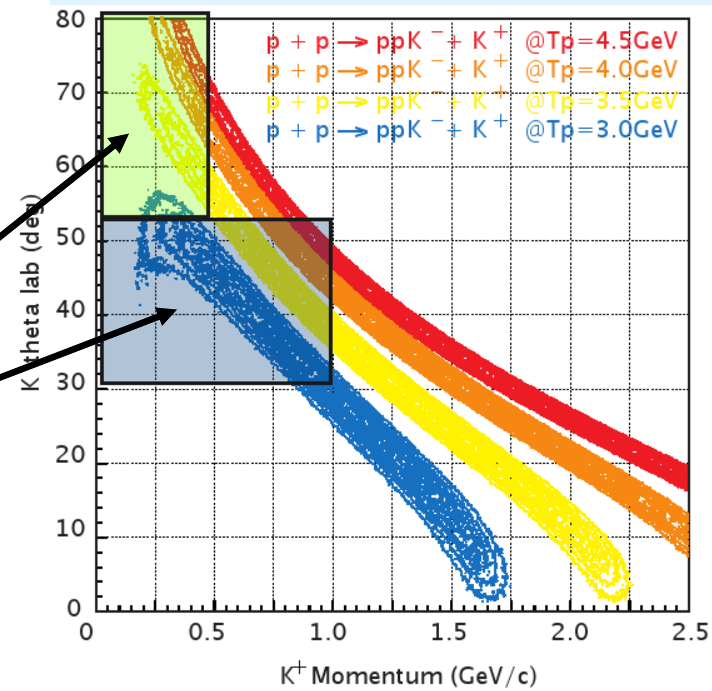
acceptance for protons and π^-

FOPI provides the necessary acceptance coverage

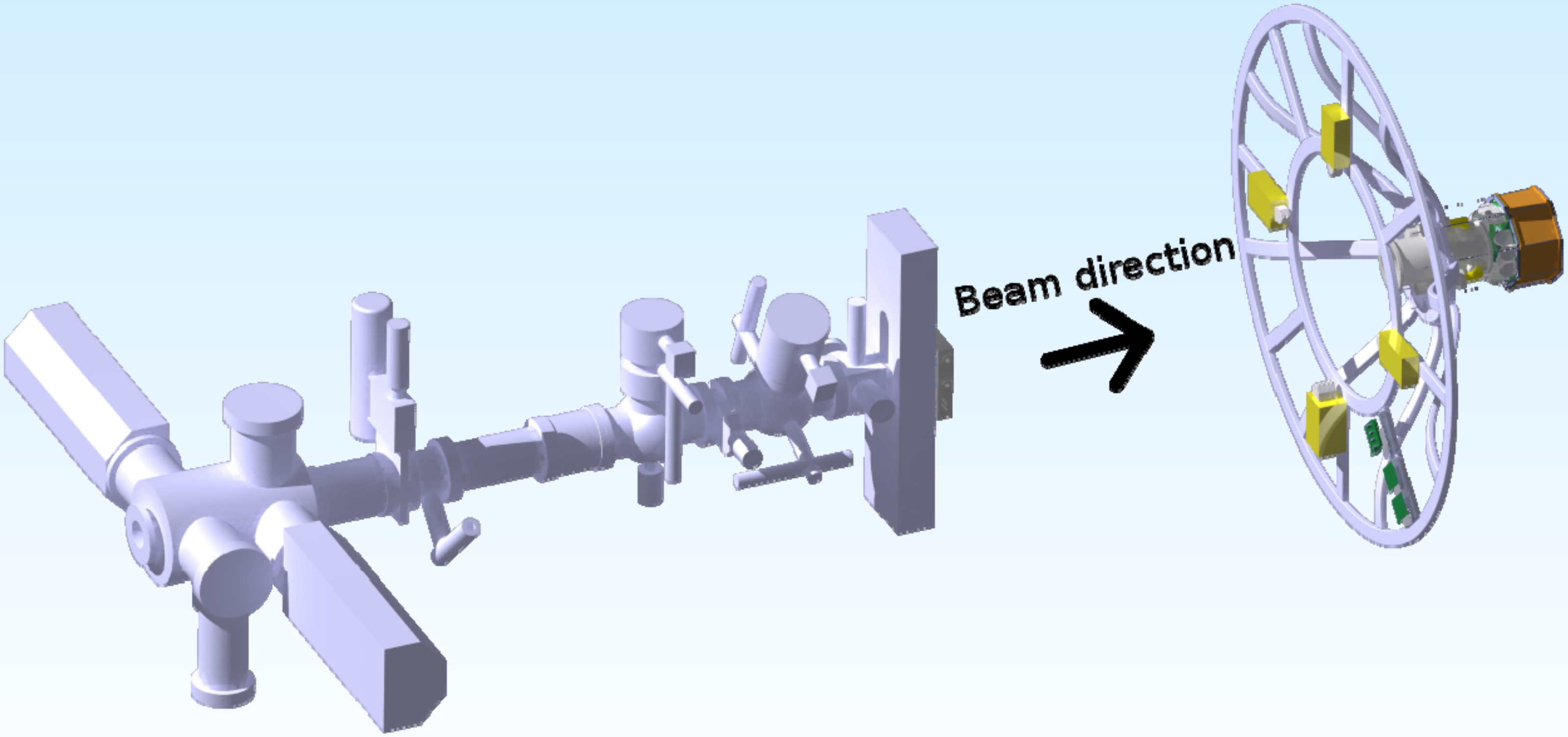
plastic barrel

RPC

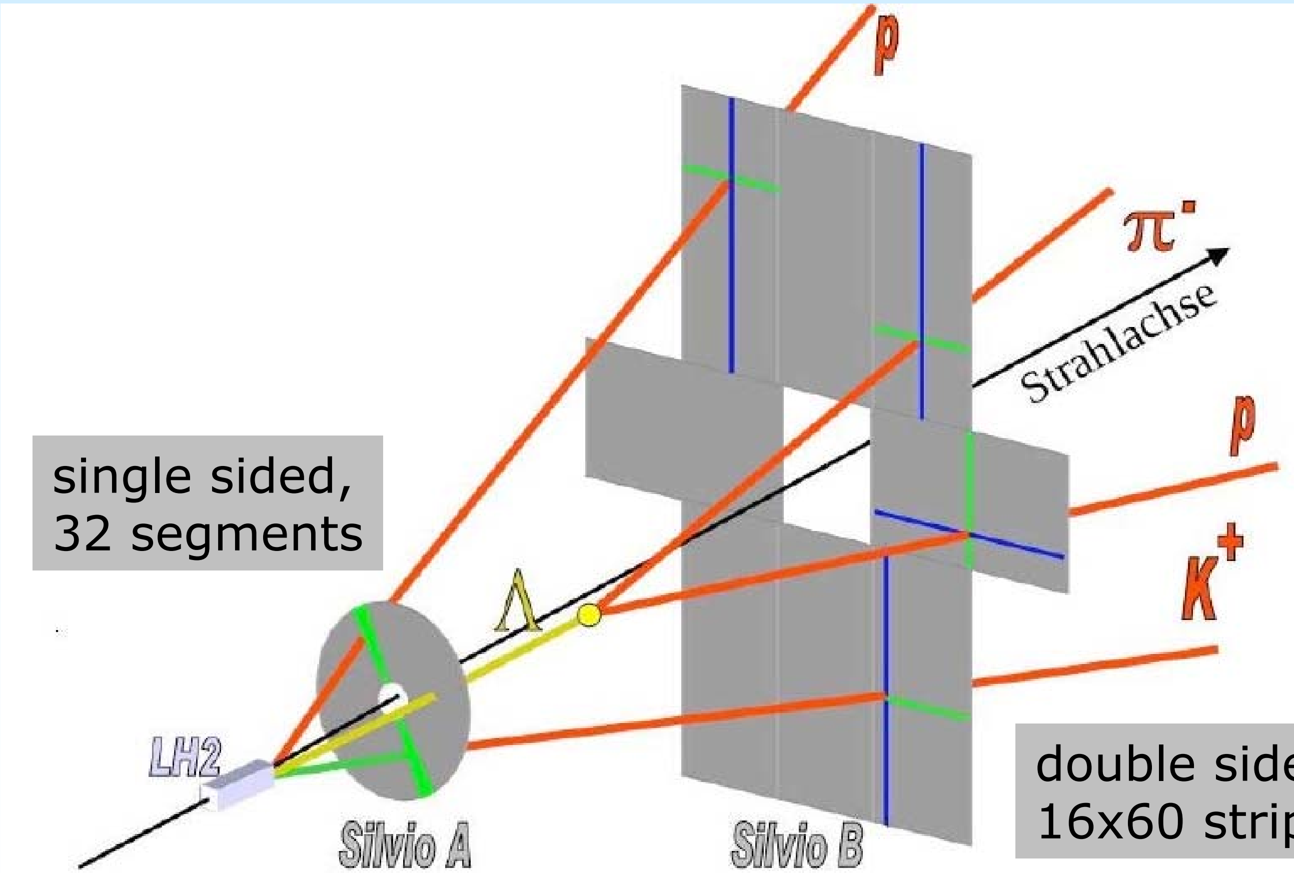
acceptance for K^+



FOPI Detector Setup
Extensions



FOPI Detector Setup
Λ-Trigger



single sided, 32 segments

double sided, 16x60 strips

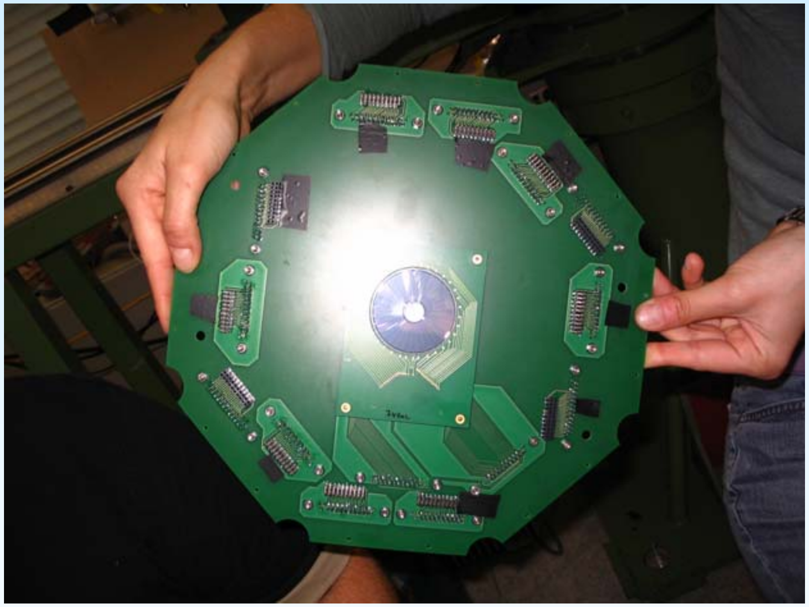
two layers of silicon strip detectors

online comparison of charged particle multiplicities

enhance Λ final states

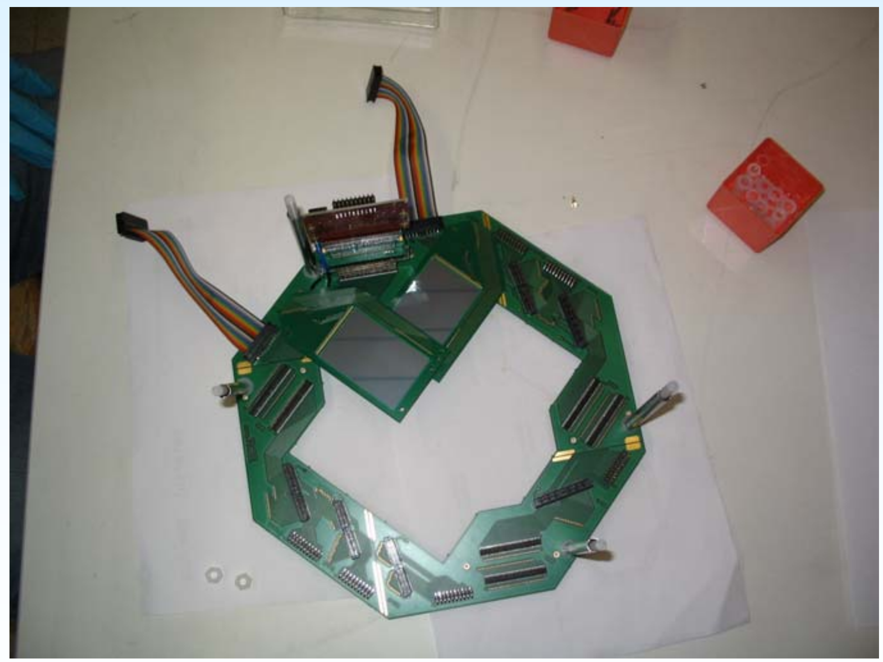
FOPI Detector Setup

Λ-Trigger SIΛVIO

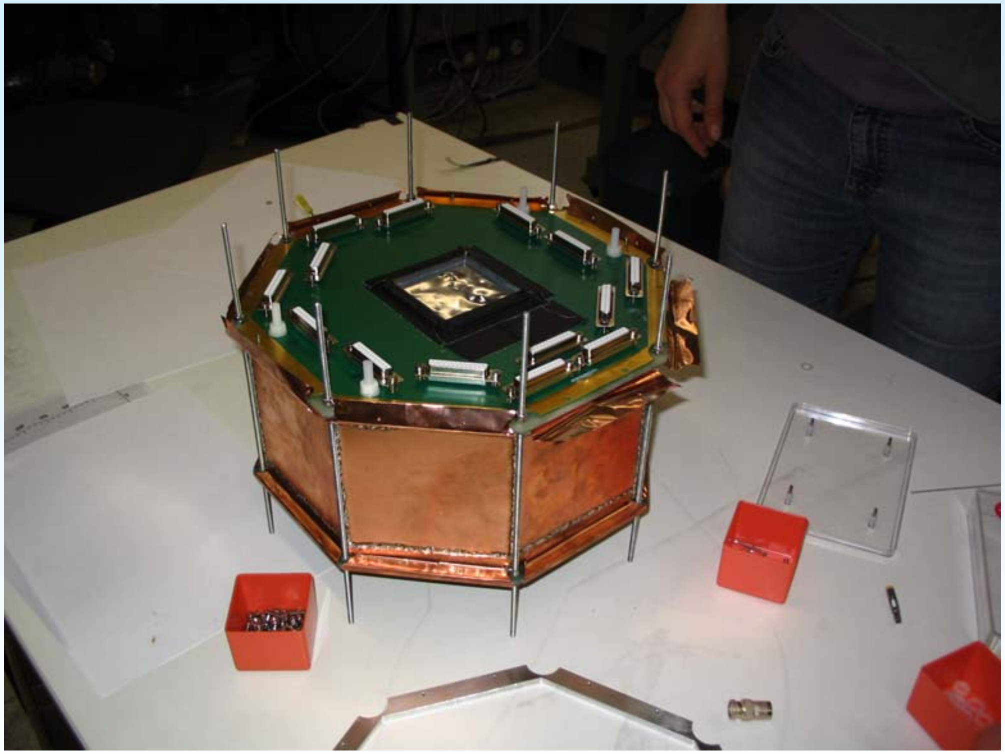


SIΛVIO A mounted on its board

two detector units of SIΛVIO B mounted on the board

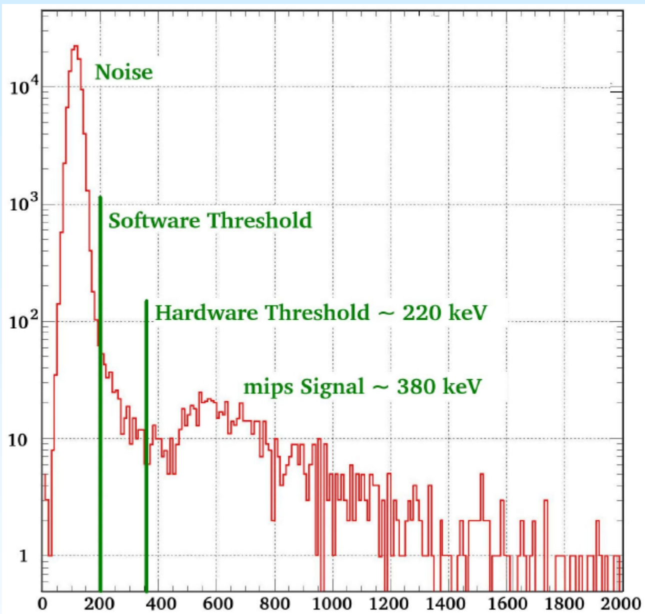


FOPI Detector Setup
Λ-Trigger SIΛVIO



the completely assembled SIΛVIO detector in its housing ready for being mounted and connected

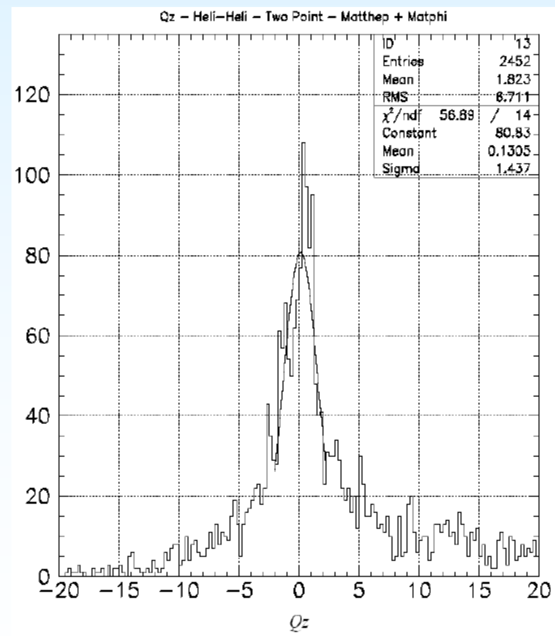
Λ-Trigger SIΛVIO



typical ADC spectrum
of one strip (in beam);
MIP peak well separated

geometrical matching with tracks from the for-ward drift chamber allows for vertex reconstruction

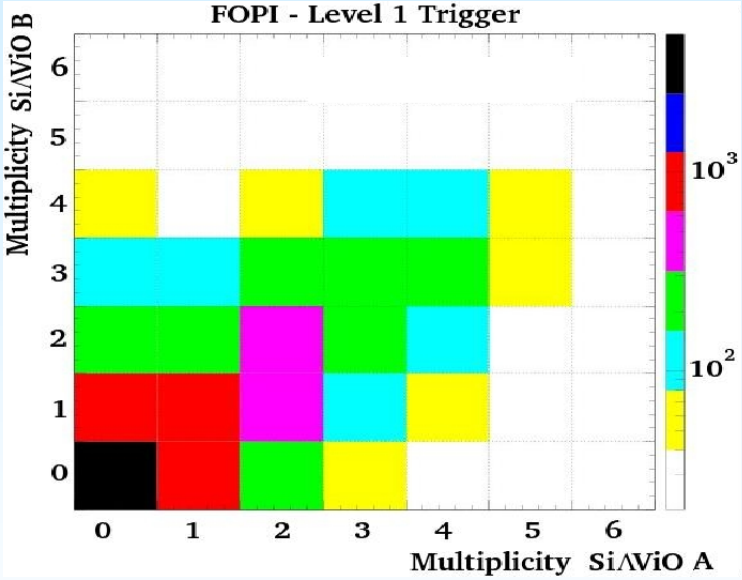
R. Münzer

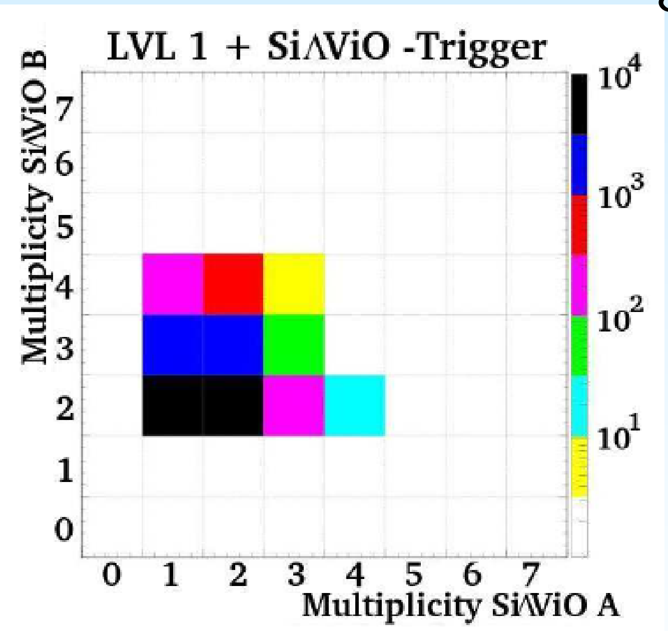


SIΛVIO Trigger Performance

R. Münzer

multiplicity of first vs. second layer





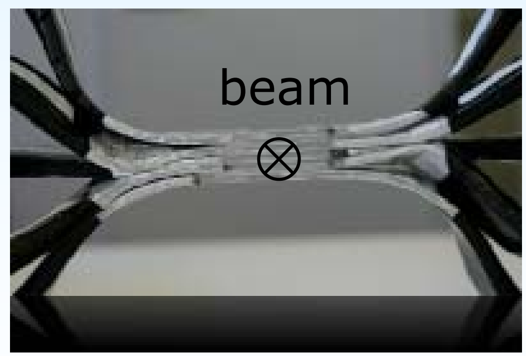
trigger w/o threshold on SIΛVIO ("level 1")

with (hardware) multiplicity condition set

FOPI Detector Setup
New Start Detector System

wish to run with high beam current → construction of a segmented start counter

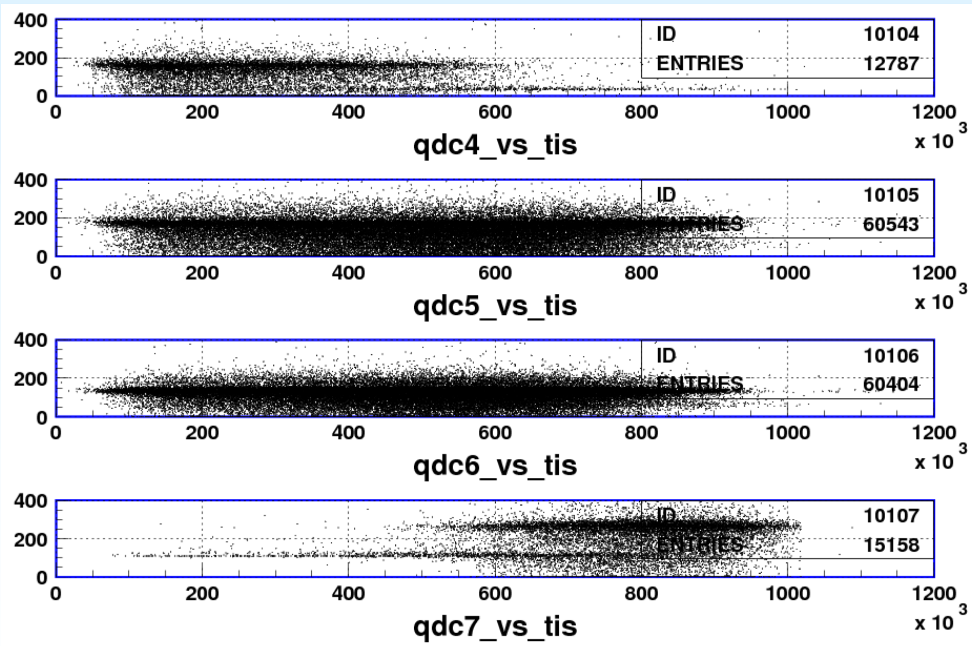
iron tubes and box for magnetic field shielding



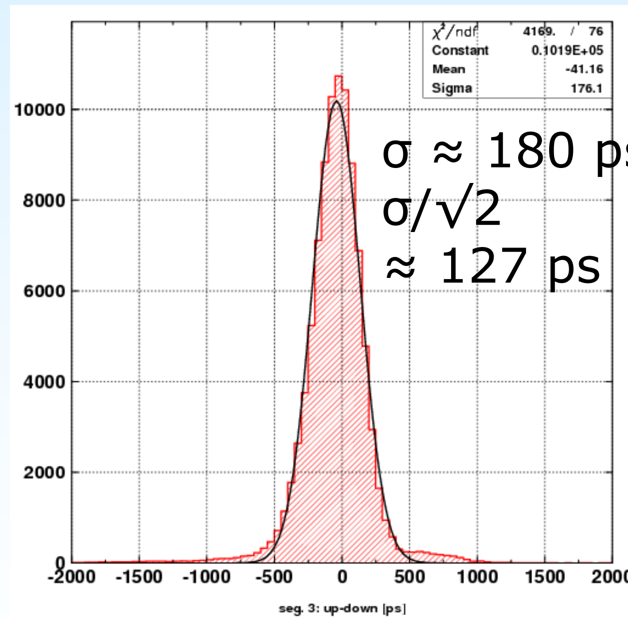
five scintillator strips, 2 mm wide

FOPI Detector Setup
Start Detector Performance

intensity distribution – mostly strip no. 3 (QDC 5+6) is hit



time resolution:
time difference between both end of the strip in the center (no. 3)

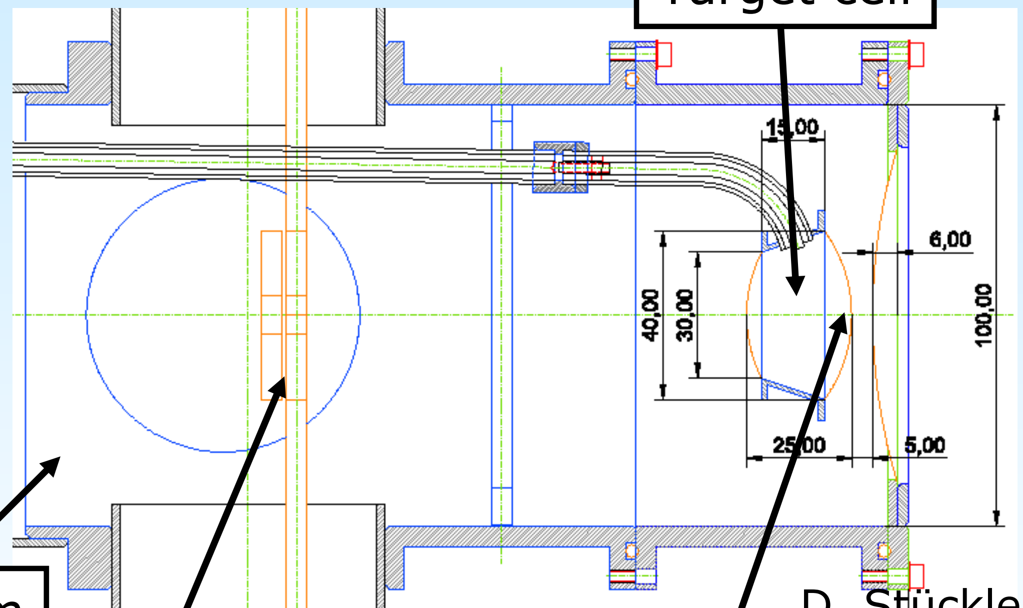


σ ≈ 180 ps
σ/√2
≈ 127 ps

P. Bühler

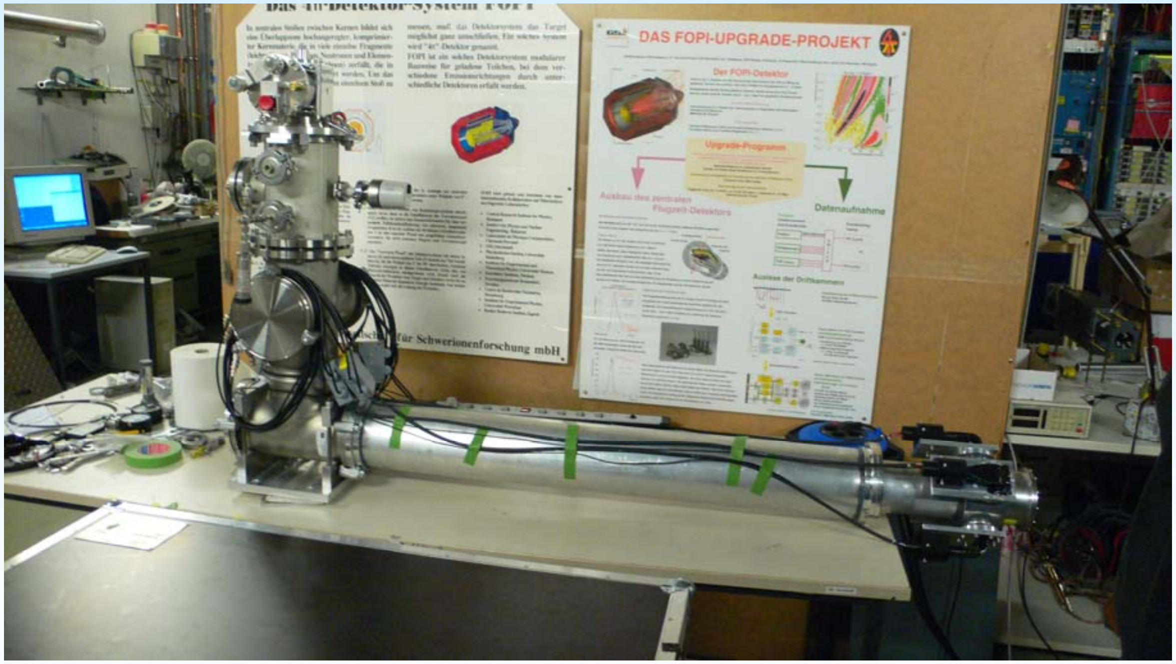
FOPI Detector Setup
Liquid Hydrogen Target

2.5 cm effective length
of the target cell
(1.8% interaction)



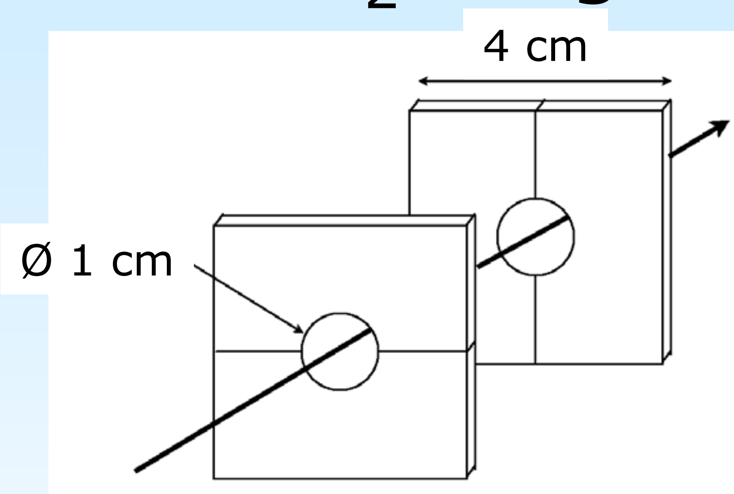
FOPI Detector Setup

Liquid Hydrogen Target



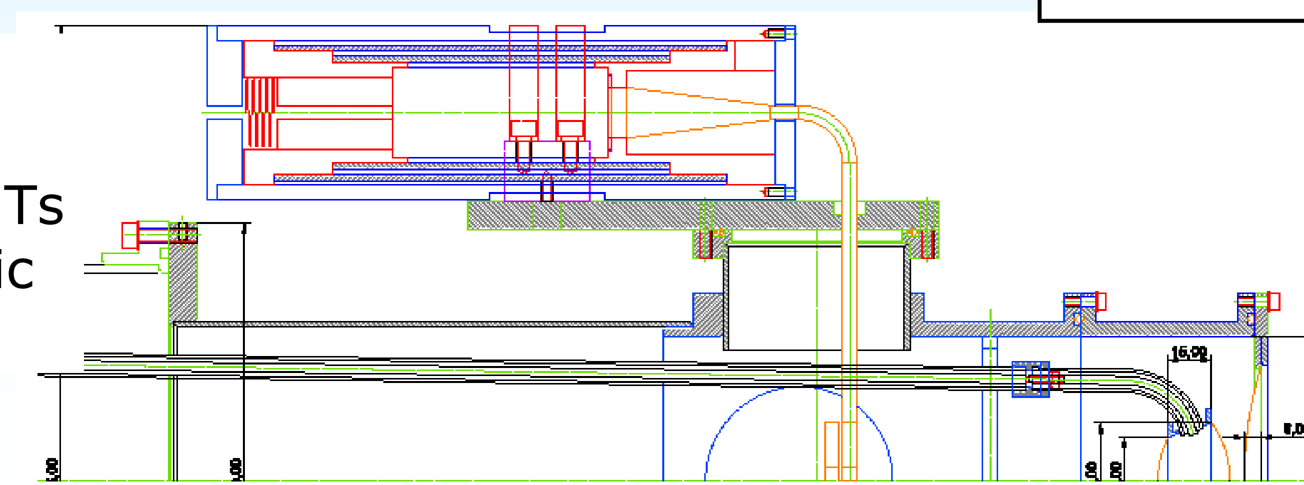
FOPI Detector Setup

LH_2 Target and VETO Detector



VETO Detector: exclude off-axis particles by four scint. paddles forming a 1 cm hole

readout by fine-mesh PMTs (magnetic field)



Test Experiments and Production Run

April 2009:
test experiment with 3 GeV proton + $CH_3(CH_2)_nCH_3$

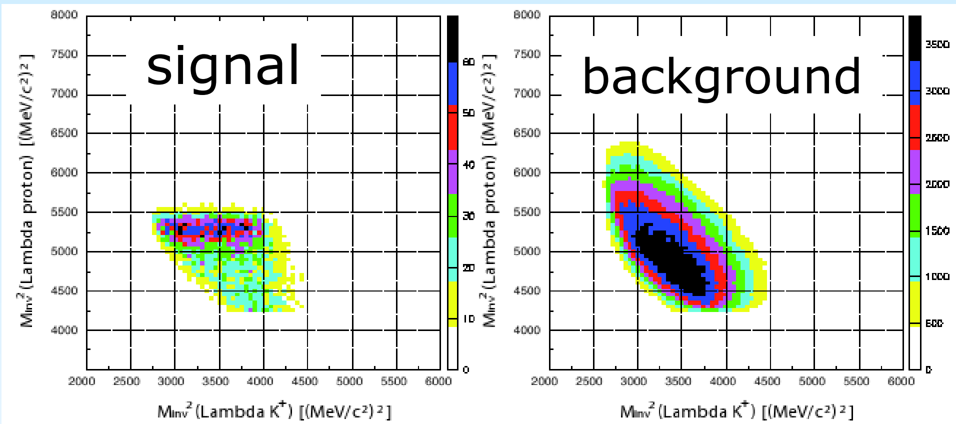
DISTO

August/September 2009: 14 days production run; 3.1 GeV proton + LH_2

~ $80 \cdot 10^6$ "Λ-trigger" events (LV.2) recorded
reduction level 1/level 2: factor 11-12
~ 20.000 "forward Λ" expected

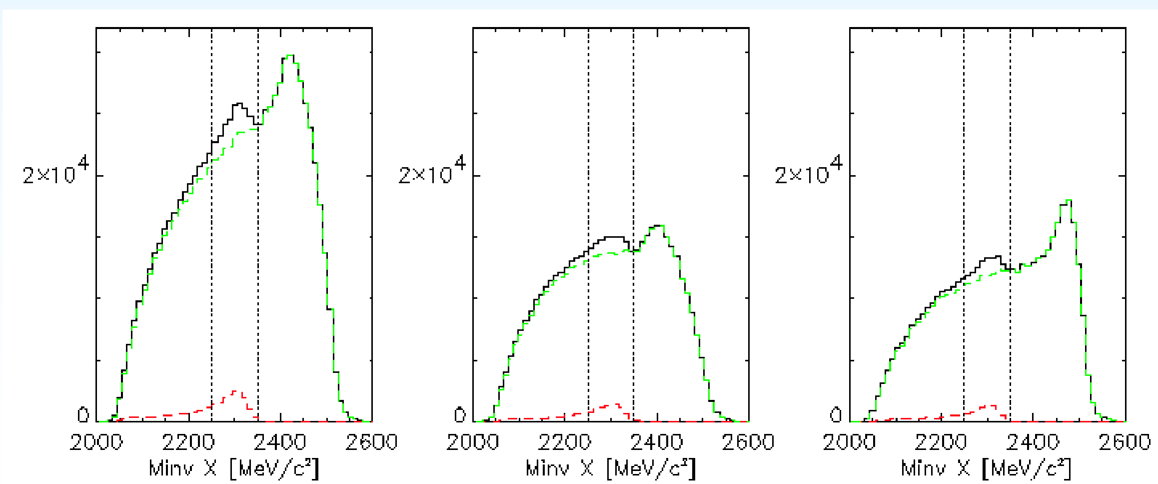
Calibration for the various subdetectors is still in progress!

How do/could the Data look like?



invariant mass (Λ, K^+)

Simulation K^-pp (Γ=60 MeV)

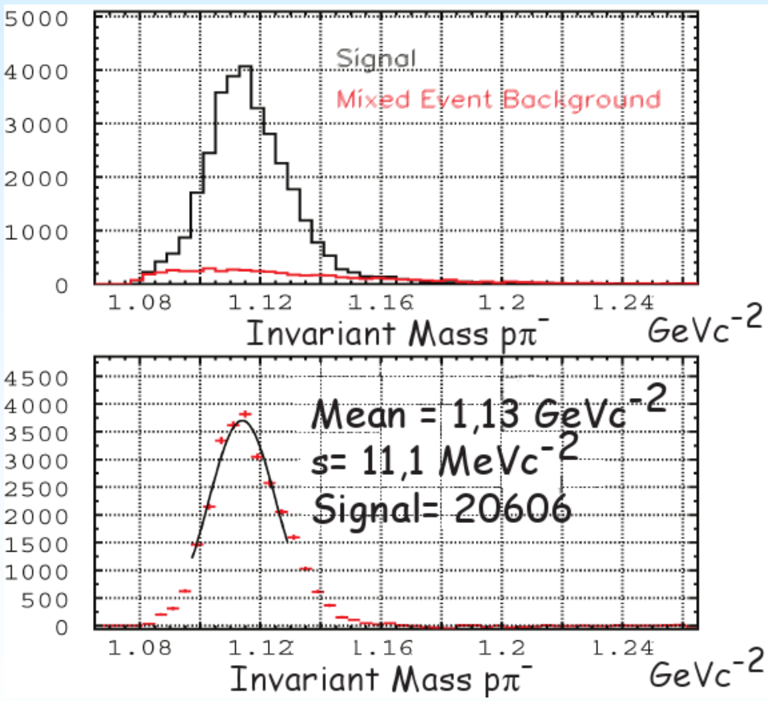


background

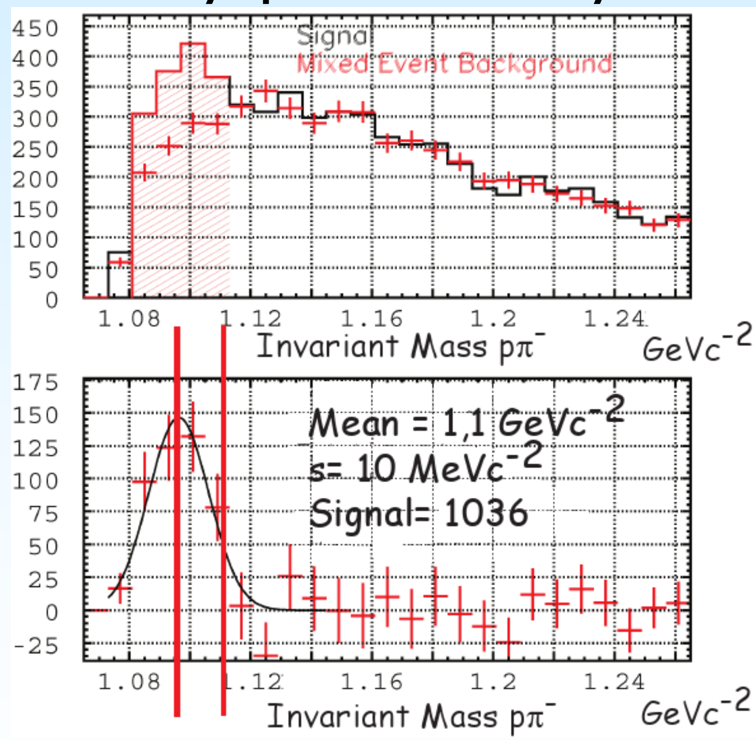
signal

Data Analysis: Λ Reconstruction

full-scale GEANT simulation for $pK^+\Lambda$



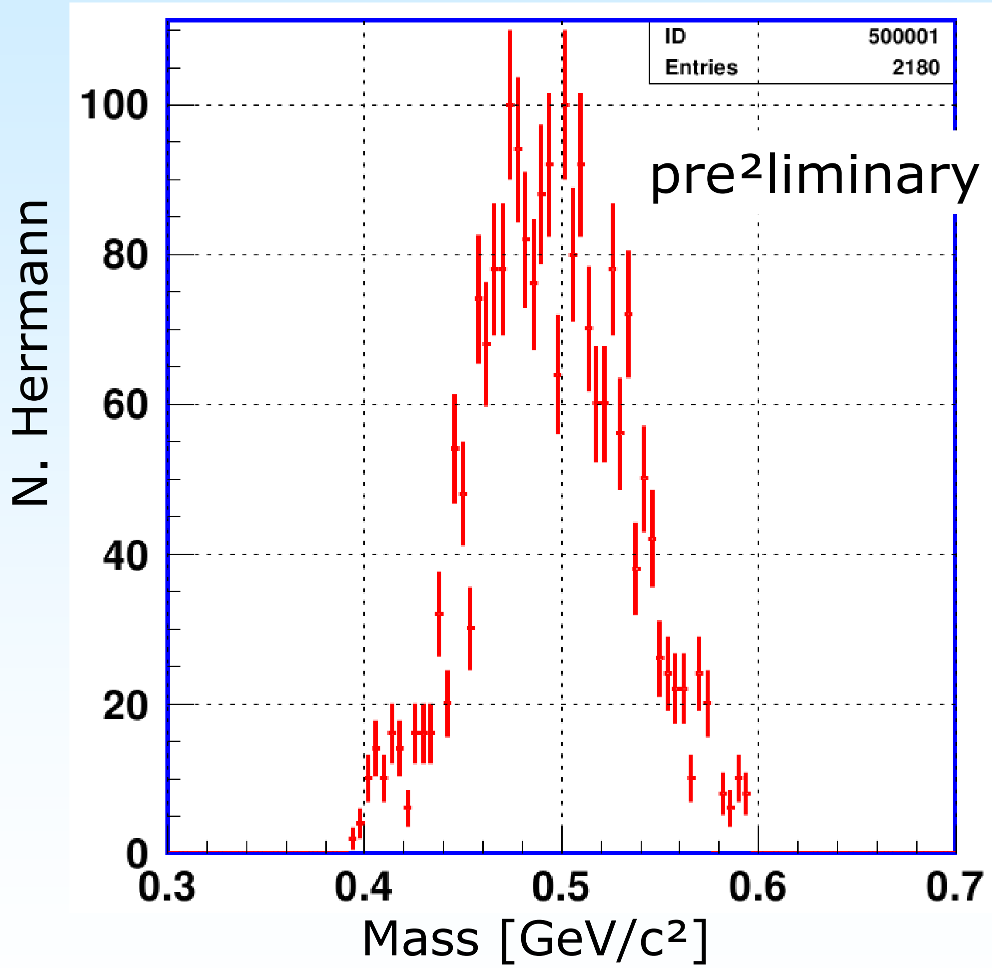
S349 aug/sep 09 very preliminary



R. Münzer

Λ decay products under forward angles

Data Analysis: K^+



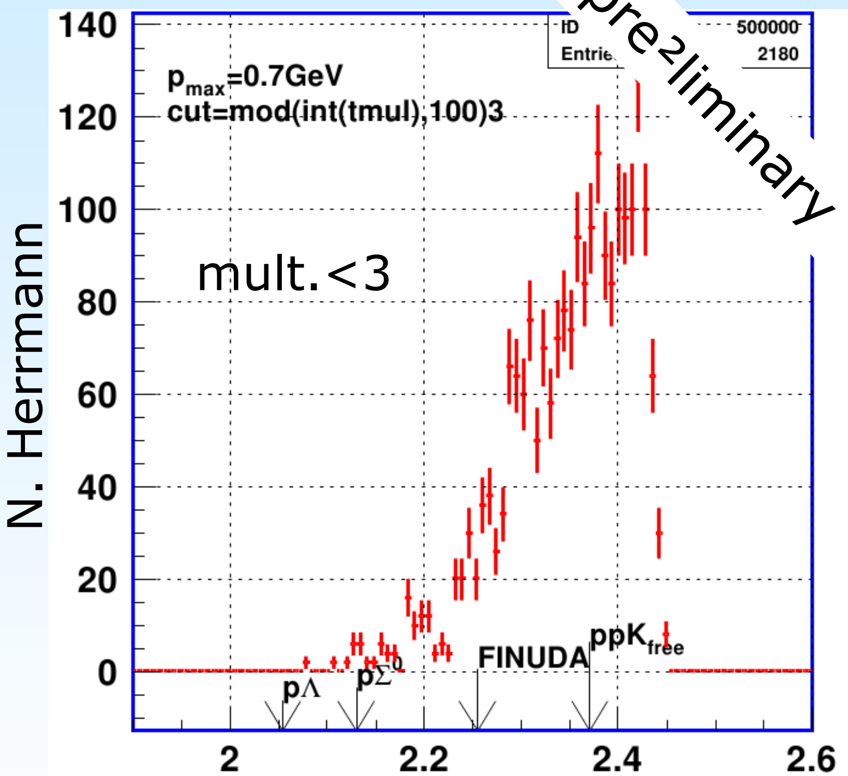
RPC/barrel region

K^+ mass distribution (after PID cuts)

~ ¼ of the statistics

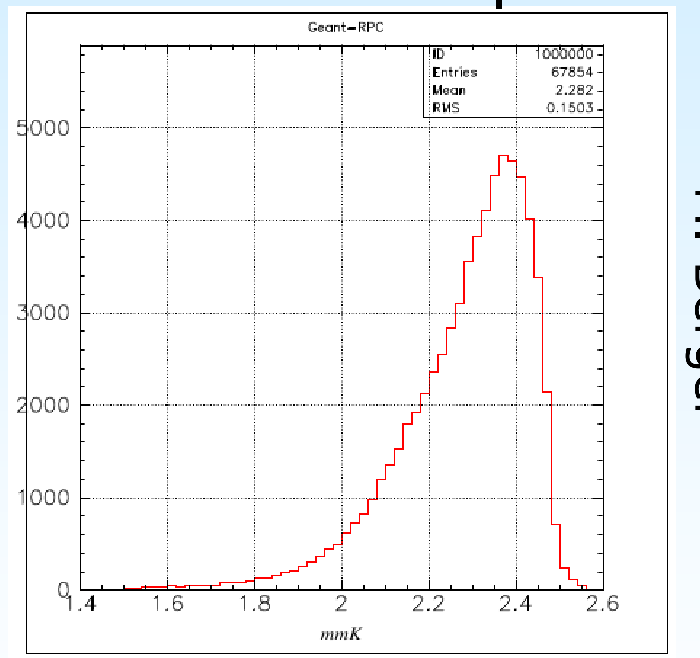
Data Analysis: K⁺ Missing Mass

S349 data



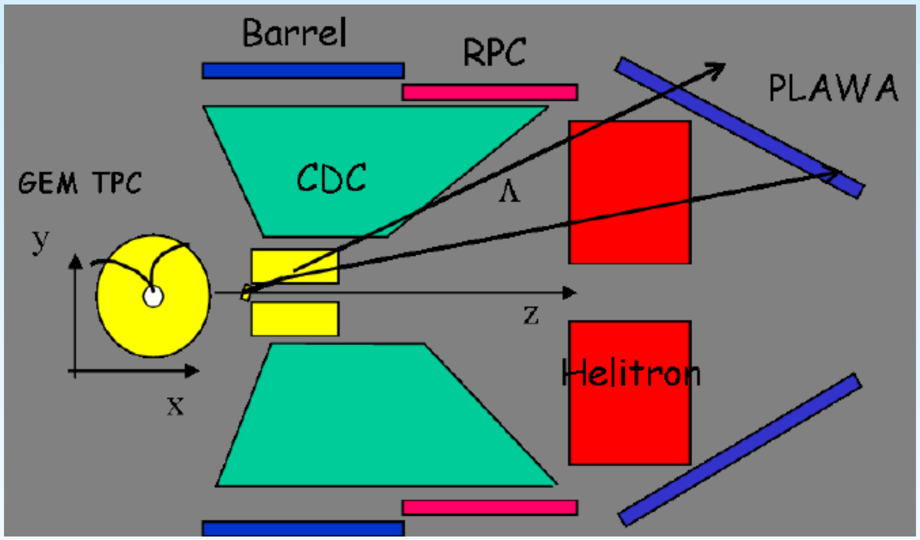
K⁺ missing mass [GeV/c²]

full-scale GEANT simulation for pK⁺Λ



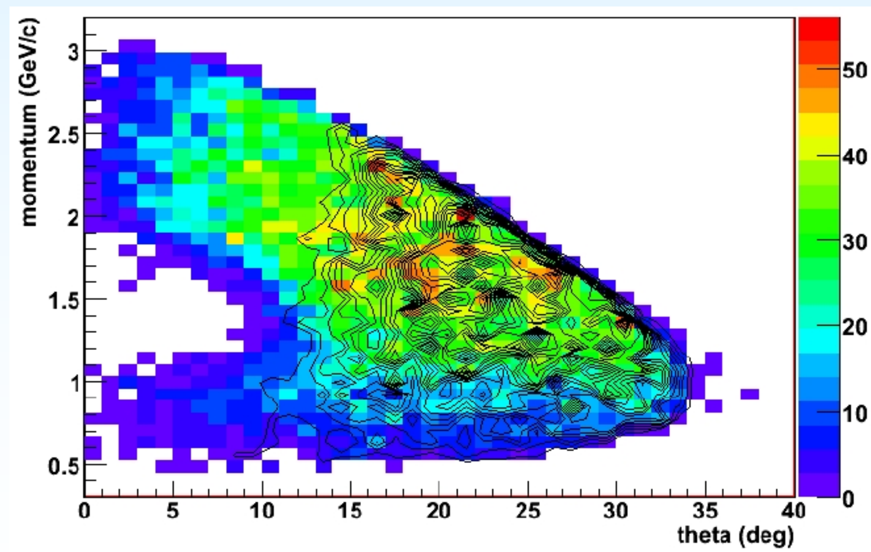
we are in the expected range

Outlook
GEM-TPC



further improvement of charged particle identification

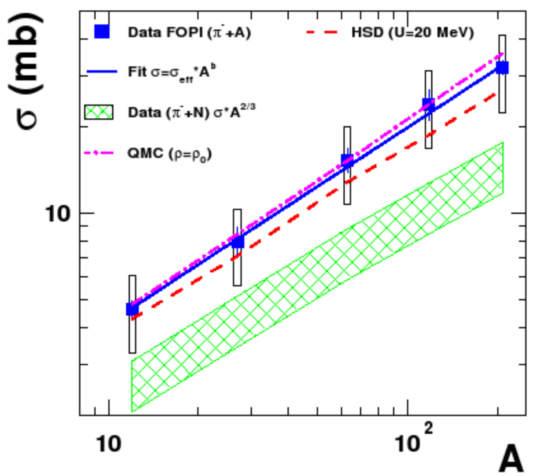
small prototype of the PANDA time projection chamber with GEM-readout

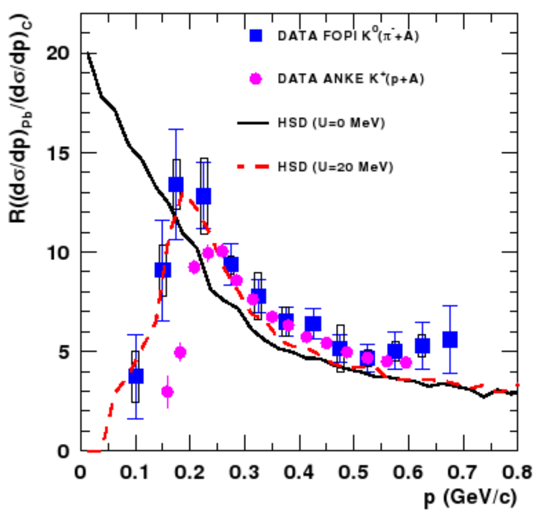


Outlook

Pion Beam Experiment

M.L.Benabderrahmane, PRL102(2009)

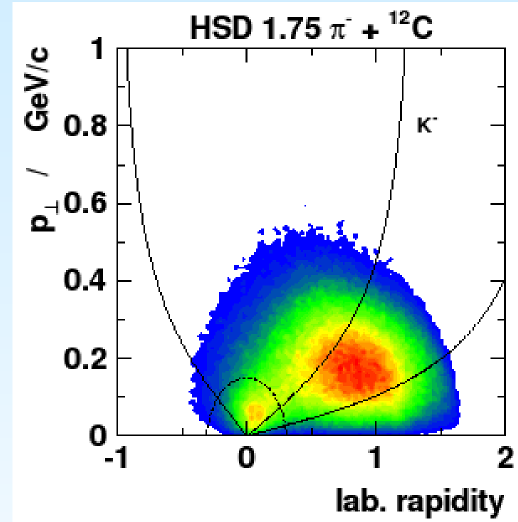




Experiment 2004
1.15 GeV/c π^-
+ C, Pb (Al, Cu, Sn)

in-medium K^0 production cross section

information on K^0N potential depth



2010:
1.75 GeV/c π^- +
H, C, Pb (,Cu)

K^+K^- co-production

Conclusions

- Deeply bound states of K^- predicted by Akaishi & Yamazaki 2002
  - p+p reaction at high energy proposed to form the fundamental cluster K^-pp
- Experimental Program started with FOPI at GSI-SIS
  - production run accomplished recently
- Complementary information from pion induced reactions envisaged