The Drift Chamber with a New Type of Straws for Operation in Vacuum

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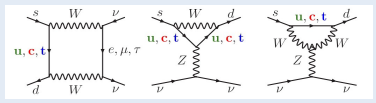
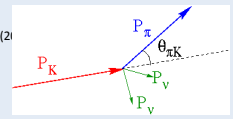
Measuring $K^+ \to \pi^+ \nu\bar{\nu}$

- FCNC loop process, short distance dominated
- hadronic matrix element from the (isospin rotated) semileptonic decay
- theoretically clean $|V_{td}|$ dependence



Perfect probe for New Physics, still complementary to LHC

Tree-level FCNC by Z': Buras et al, JHEP 1302 (2013) 116
Littlest Higgs with T parity: Blanke et al, Acta Phys. Polon. B41 (2010) 657
MSSM non-MFV: Isidori et al, JHEP 0608(2006) 064
Custodial Randall-Sundrum: Blanke et al, JHEP 0903 (2



BR x 10^{10}	SM prediction	Experiment
$K^+ \to \pi^+ \nu\bar{\nu}$	0.781 ± 0.075 ± 0.029	1.73 ± 1.10
$K_L \to \pi^0 \nu\bar{\nu}$	0.243 ± 0.039 ± 0.006	< 260

Brod, Gorbahn, Stamou: PRD83(2011) 034030, arXiv 1009.0947
BNL E787/E949: PRL101 (2008) 191802, arXiv 0808.2459
KEK E391a: PR D81 (2010) 072004, arXiv 0911.4789

Goal : measure BR with 10% accuracy

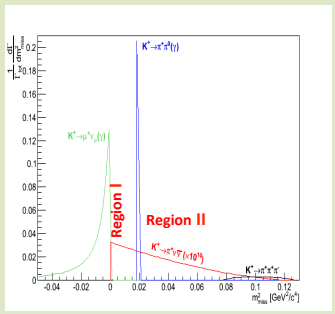
- signal signature : one K^+ track, one π^+ track
- kinematic variable : $m^2_{miss} = (P_K - P_\pi)^2$
- momentum measurement + particle identification + veto

Momentum measurement

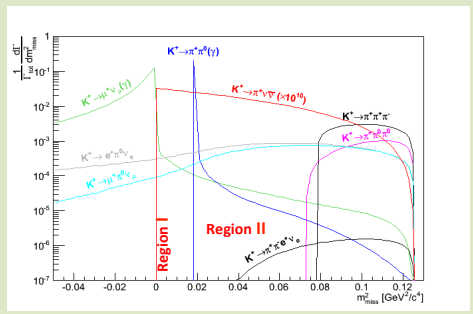
Kaon Tracker – GigaTracker (GTK)
Pion Tracker – Straw spectrometer (STRAW)

Background rejection

92% separated from signal by kinematic cuts



8% not separated by kinematic cuts



Region I: $0 < m^2_{miss} < 0.01$ GeV²/c⁴
Region II: $0.026 < m^2_{miss} < 0.068$ GeV²/c⁴

Expected background < 10

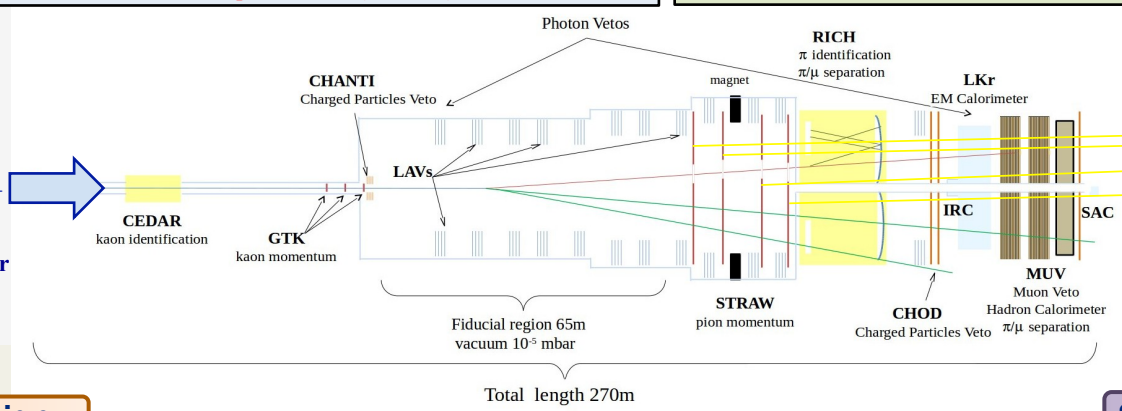
$\Delta P_\pi/P_\pi \leq 1\%$; $\Delta\theta_{K\pi} \leq 60$ μrad

- Spatial resolution 130 μm per coordinate, 80 μm per space point
- ≤ 0.5% of a radiation length (X_0) for each chamber
- Working in vacuum (P=10^{-5} mbar) with minimum gas load for the vacuum system 10^{-1} mbar l/s
- Operation in high rate environment (up to 500 kHz/channel) with a mean rate 60 kHz/channel

Beam

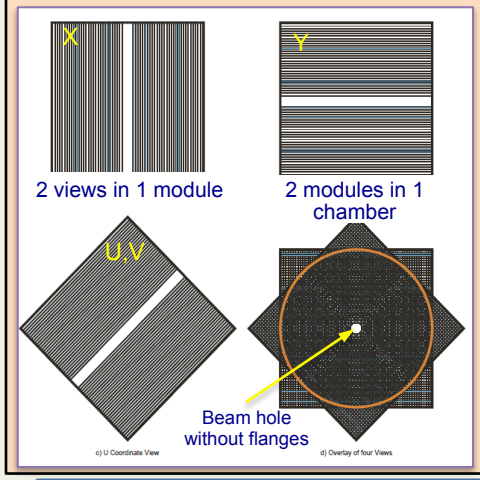
***Primary SPS Beam*:**
400 GeV/c protons
$3x10^{12}$ protons/pulse
4.8/16.8 s duty cycle

***Secondary Beam*: ~ 6% K^+**
p=75 GeV/c (Δp/p~1%)
beam acceptance: 12.7 mstr
total rate: 750 MHz
$4.5x10^{12}$ K^+ decays/year



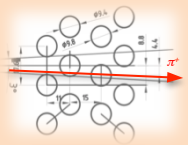
Straw detector design

4 views in 1 chamber

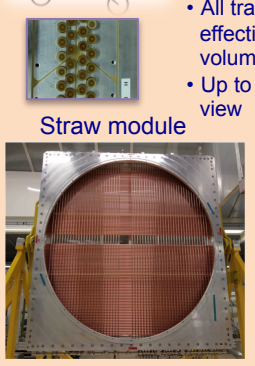


2 views in 1 module
2 modules in 1 chamber

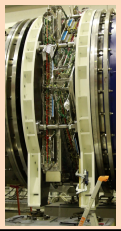
Straw view



Straw module



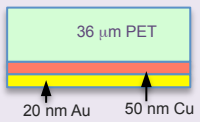
Straw chamber



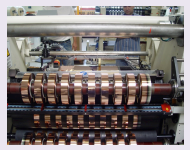
- 2 independent pairs of layers, each for registration of min 1 hit of particle with up to 3° angle;
- < 15% more material than in 2 closed layers (< 5% for straws with effective Ø= 9.4 mm);
- All tracks with 2 or more hits in effective (9.4 mm) straw volume;
- Up to 35% track with 3 hits in a view

Straw design, production and test

Film for straw production



Film slitting



Straw construction:
- 2.7 m long tube with a diameter of 9.8 mm
- The base material is Poly Ethylene Terephthalate (PET) or Mylar (Hostaphan) with thickness of 36 μm
- The film is coated on the inside with 50 nm of Cu and 20 nm of Au by sputtering

The electrical properties and operation:
- The anode wire is 30 μm in diameter and made from gold-plated tungsten
- Resistivity of anode: 50 Ohm, cathode: 65±5 Ohm, wave resistance: 350 Ohm
- Gas mixture: Ar (70%)+ CO_2 (30%) or CO_2 (90%) C_4H_{10} (5%) CF_4 (5 %)

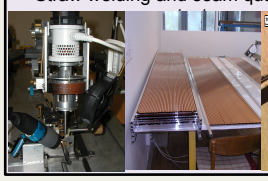
Over **8000** straws have been produced (more than **20 km** of ultrasonic welded tubes!)

Rejects:

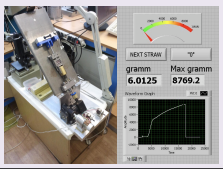
Diameter	0.78 %
Resistance	0.33 %
Tensile strength test	1.55 %
Seem width	0.04 %
Overpressure (3 bar)	0.08 %
Long term OP test (1.5 bar)	0.02 %
Total:	2.42 %

97.58% straws are good after all quality tests

Straw welding and seam quality visual

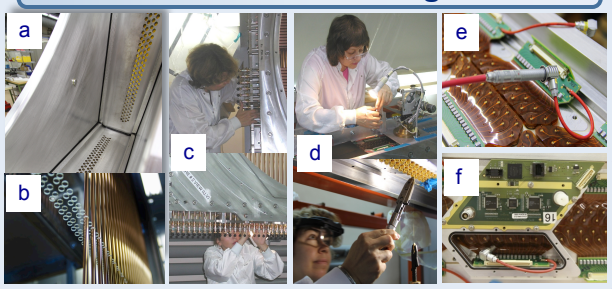


Tensile strength test

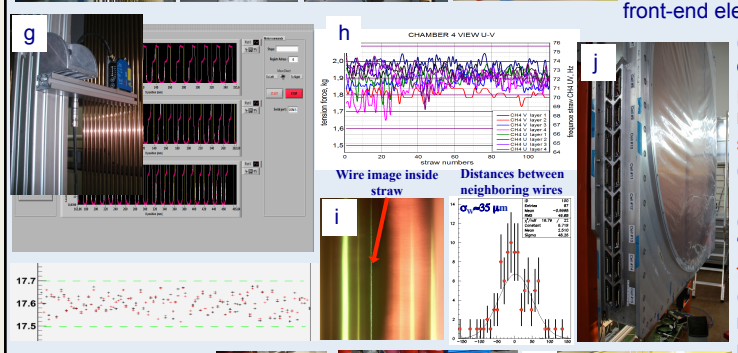


Long term gas leak test test

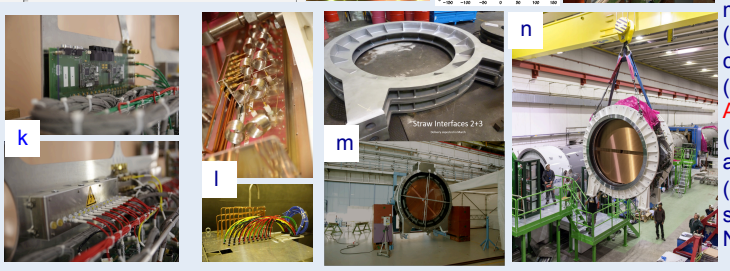
Straw module assembling and test



(a) - module sealing by epoxy sealant;
(b) - straw spacers;
(c) - straw insertion in horizontal position and gluing in vertical one with a pretension 1.8 kg;
(d) - wire insertion (vertically) with 90 g tension and crimping;
(e) - electrical connection (HV and signal, 16 straw granularity) by flexible circuit board (WEB) and HV tests;
(f) – gas manifold assembling with front-end electronics at covers;



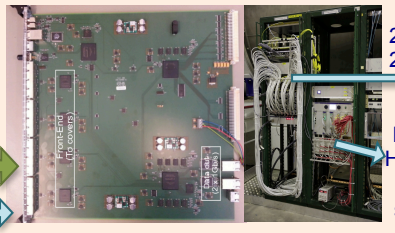
(g) – straw position test by optical rangefinder – ±100 μm from the nominal (17.6 mm) distance between straws;
(h) – straw pretension test - 1.6÷2.1 kg;
(i) - wire position test by "visible light" - ±35 μm from the nominal position;
(j) - vacuum test - < 0.8 mbar l/min CO_2 per one module;
(k) - HV, LV and signal connections;
(l) - gas connectors for Ar(70%) CO_2(30%);
(m) - straw chamber assembling;
(n) – integration of the straw chamber into the NA62 setup



RO electronics and data flow

30 front-end covers/ view:
2 CARIOCA + ALTERA as TDC (<1 ns intrinsic resolution), 16 channels

2 SRB/view (VME-9U) Serial link



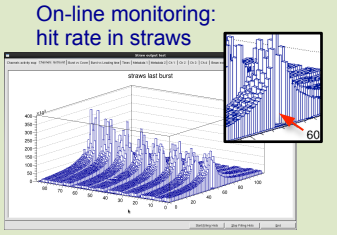
2 fibers 2 Gbit/s

PC-farm

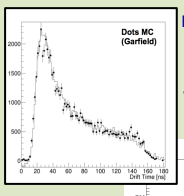
MPOD HV & LV power supply

First Results

On-line monitoring: hit rate in straws

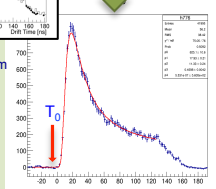


Hit time distribution



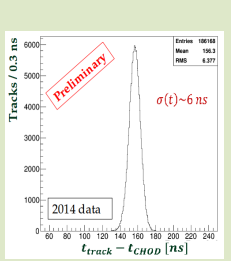
$F(t) = A + B \cdot \exp(-(t - t_{max})^2 / (2 \cdot \sigma(t)^2))$,

where $\sigma(t) = \sigma_0 + k \cdot t$



R-t dependence from MC

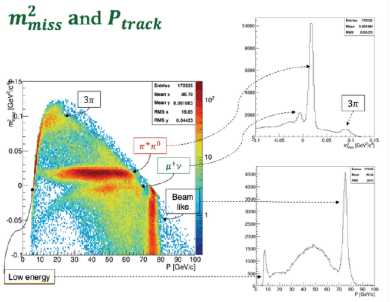
T_0 for each channel In progress



- Kaon selected in time with CHOD and Spectrometer track + geometrical acceptance;
- Vertex in fiducial region;
- 15 < P < 35 GeV/c.

Resolution of the $\pi^+\pi^0$ peak $5*10^{-3}$ GeV²/c⁴

m^2_{miss} and P_{track}



$3*10^{-3}$ GeV²/c⁴ in MC