

# NA62 spectrometer: a low mass straw tracker

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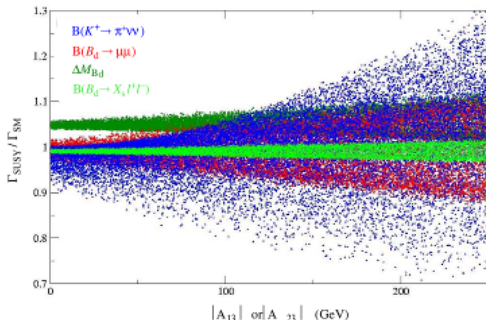
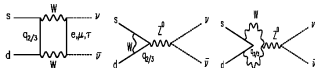
11 June 2011



# NA62 Goal: $K \rightarrow \pi \nu \bar{\nu}$

## Ultra rare decay

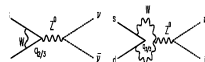
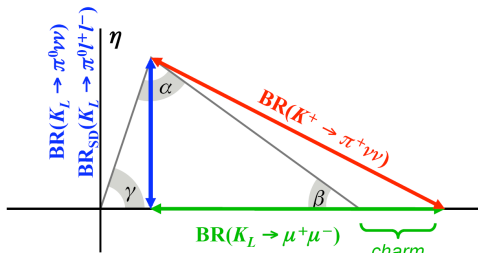
- FCNC process forbidden at tree-level
- Very clean theoretical prediction:  
hadronic matrix element extracted from  $BR(K \rightarrow \pi e \nu)$
- $BR_{SM} = (8.5 \pm 0.7) 10^{-11}$  @ NLO
- Current existing measurements based on 7 events (E787/949):  
 $(1.73^{+1.15}_{-1.05}) 10^{-10}$
- Measurement of  $V_{td} \approx 7\%$
- Example of SUSY scenario:



# NA62 Goal: $K \rightarrow \pi \nu \bar{\nu}$

Ultra rare decays

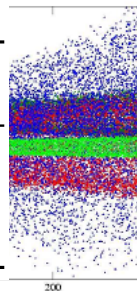
- FCNC processes
- Very clean hadronic
- $BR_{SM} =$
- Current estimate (1.73<sup>+1.14</sup><sub>-1.01</sub>)
- Measurement of  $V_{td} \approx 7\%$
- Example of SUSY scenario



$\rightarrow \pi e \nu$

E787/949):

	$\Gamma_{SD}/\Gamma$	Irreducible theory err. (amp)	SM BR
$K_L \rightarrow \pi^0 \nu \nu$	>99%	1%	$3 \times 10^{-11}$
$K^+ \rightarrow \pi^+ \nu \nu$	88%	3%	$8 \times 10^{-11}$
$K_L \rightarrow \pi^0 e^+ e^-$	38%	15%	$3.5 \times 10^{-11}$
$K_L \rightarrow \pi^0 \mu^+ \mu^-$	28%	30%	$1.5 \times 10^{-11}$



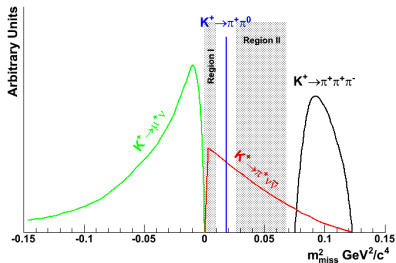
$v_{td}$

$|A_{13}| \text{ or } |A_{23}| \text{ (GeV)}$

# Measurement of $BR(K \rightarrow \pi\nu\bar{\nu})$

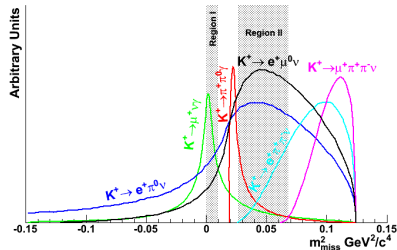
Measurement at 10% (100 SM events in 2 years)

Constrained by kinematics



92% of K decays

Not constrained by kinematics



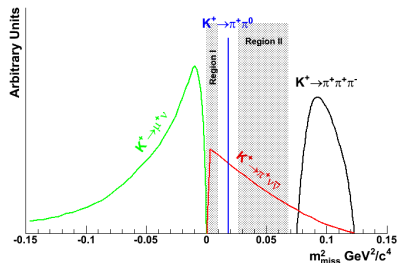
8% of K decays



# Measurement of $BR(K \rightarrow \pi\nu\bar{\nu})$

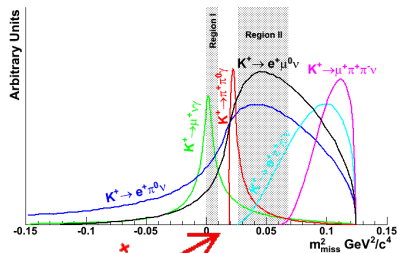
Measurement at 10% (100 SM events in 2 years)

Constrained by kinematics

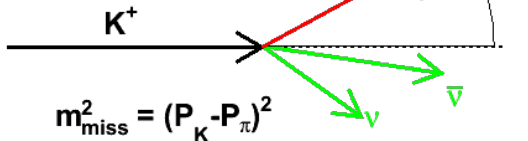


92% of K decays

Not constrained by kinematics



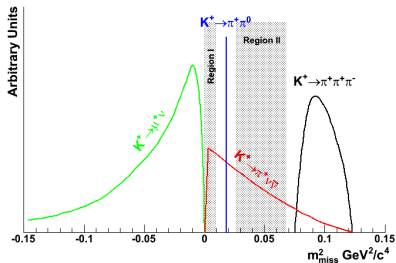
8% of K decays



# Measurement of $BR(K \rightarrow \pi\nu\bar{\nu})$

Measurement at 10% (100 SM events in 2 years)

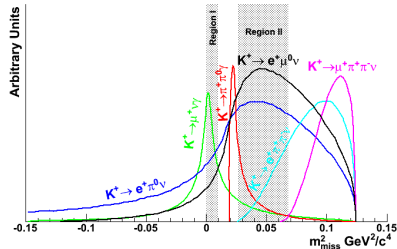
Constrained by kinematics



92% of K decays

- 2 signal regions
- Minimize multiple scattering

Not constrained by kinematics



8% of K decays

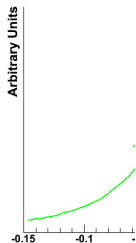
- Particle ID
- Photon vetoes

# Measurement of $BR(K \rightarrow \pi\nu\bar{\nu})$

Measurement at 10% (100 SM events in 2 years)

Constrained by kinematics

Not constrained by kinematics



## Background Rejection

- Main backgrounds:
  - $K^+ \rightarrow \mu^+ \nu_\mu$  ( $BR \approx 63\%$ )
  - $K^+ \rightarrow \pi^+ \pi^0$  ( $BR \approx 21\%$ )
- Rejection  $\approx 10^{-12}$ :
  - Kinematics  $\approx 10^{-5}$
  - Vetoes  $\approx 10^{-5}$
  - PID  $\approx 5 \cdot 10^{-3}$
- Time  $K - \pi$ :
  - Resolution  $\approx 100ps$

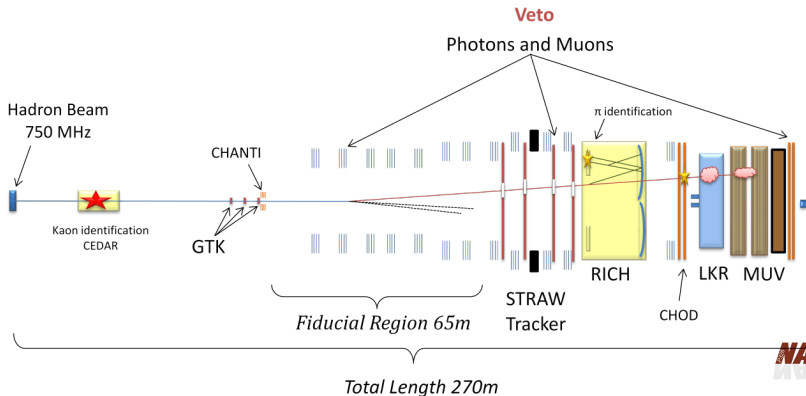


92% of K dec

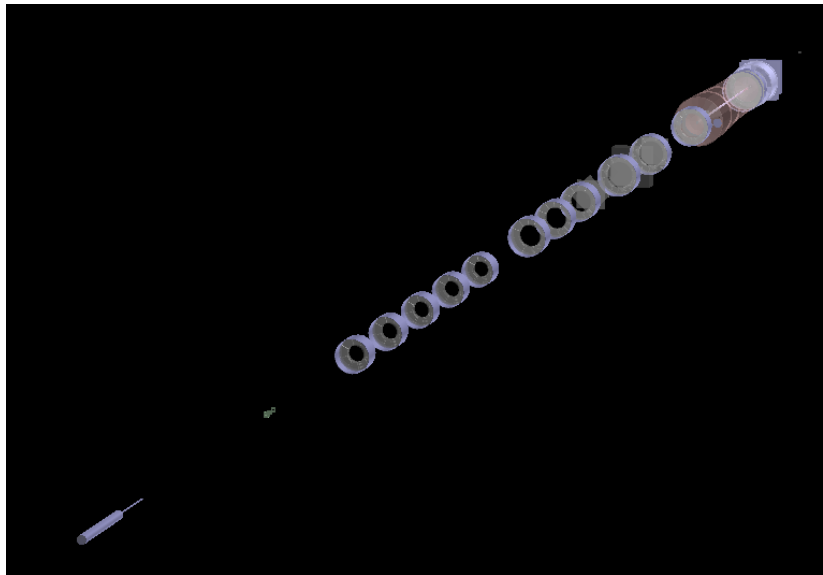
- 2 signal
- Minimiz

# Beam and Layout

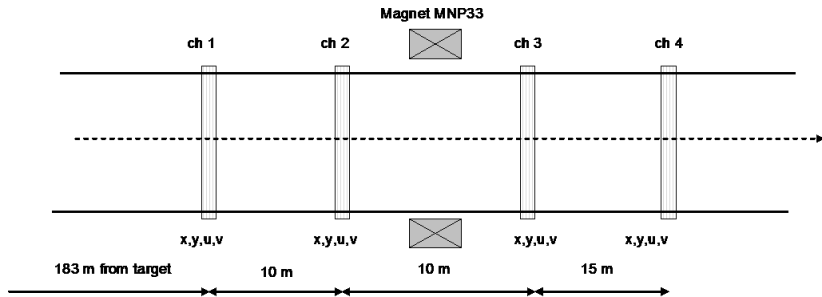
- SPS primary protons @ 400 GeV/c
- 75 GeV/c ( $\Delta P/P \approx 1\%$ )
- Area @ beam tracker 16 cm<sup>2</sup>
- Kaon decays/year  $4.8 \times 10^{12}$
- Unseparated secondary charged beam
- $p/\pi/K$  (positron free,  $K \approx 6\%$ ,  $p \approx 23\%$ )
- Integrated average rate @ beam tracker 750 MHz



# Beam and Layout



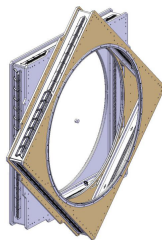
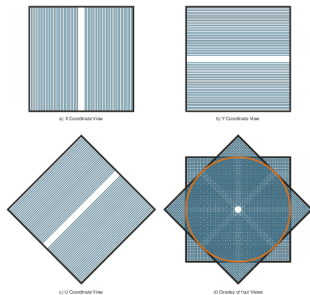
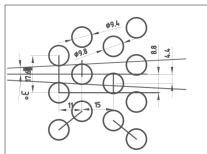
# STRAW Spectrometer



- Dipole magnet 0.36T ( $270\text{MeV}/c$   $p_T$  kick)
- In vacuum ( $< 10^{-6}\text{mbar}$ )
- 7168 mylar straws
- ArCO<sub>2</sub> 70%:30%
- $< 4 \times 0.5\% X_0$
- $\sigma_p/p = 0.32\% + 0.009\%p/(GeV/c)$
- $\sigma_\theta < 60\mu\text{rad}$
- $\geq 99\%$  hit efficiency
- leakrate  $< 10^{-1}\text{mbar l/s}$

# STRAW Chamber

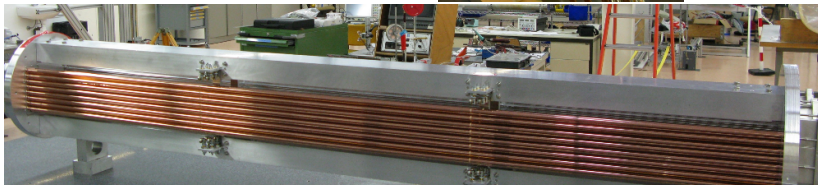
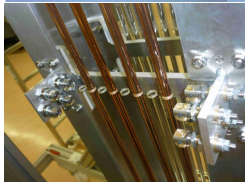
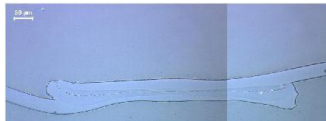
- 4 views (u,v,x,y)
- $\varnothing = 2.1\text{m}$  acceptance
- $\varnothing \approx 12\text{cm}$  beam hole
- Track angle coverage  $\pm 3^\circ$
- $30\mu\text{m}$  gold-plated W wire
- $100\mu\text{m}$  straw straightness
- $200\mu\text{m}$  wire position accuracy
- $\sigma < 130\mu\text{m}$  single view



# Straws

- 36 $\mu$ m thick mylar
- $\varnothing = (9.75 \pm 0.05)$ mm
- Cu-Au metalization (50-20nm)
- Ultrasonic welding
- To be operated in the vacuum tank with 1 bar overpressure
- 1.5Kg pretension
- > 500kHz capable (few straws closest to the beam passage)

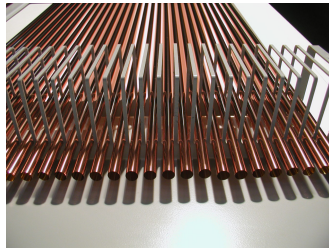
- Anode resistance 180 $\Omega$
- Cathode resistance 70 $\Omega$





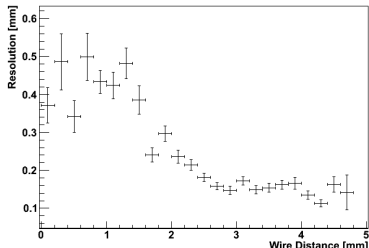
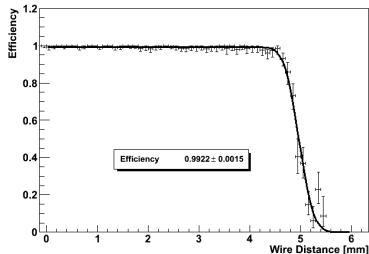
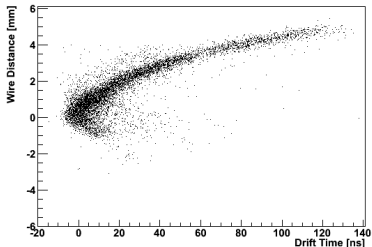
# First module construction

- u,v views of 1<sup>st</sup> chamber
- Straws production complete
- Frame vacuum tested
- Straws installation in progress

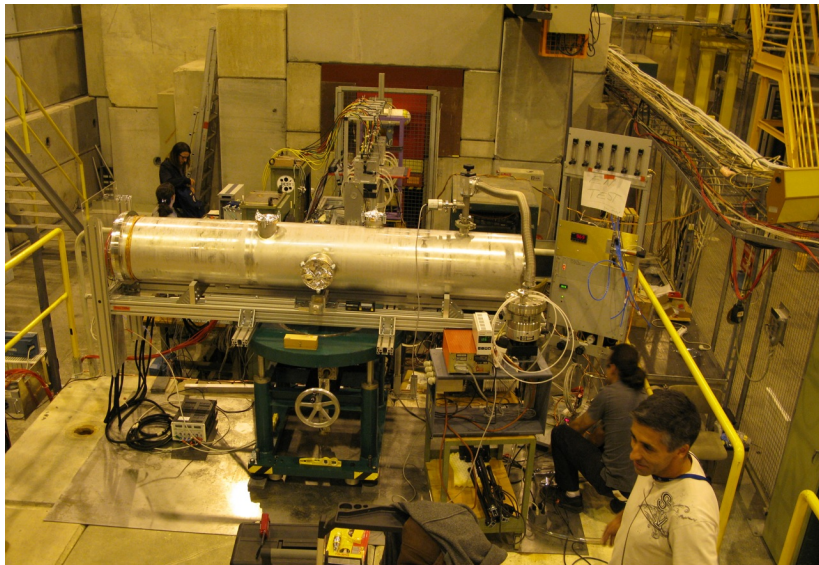


# Test Beam

- 64 straws prototype
- Final mechanics
- Vacuum proof vessel
- CARIOCA based FE
- 120GeV  $\pi$  beam

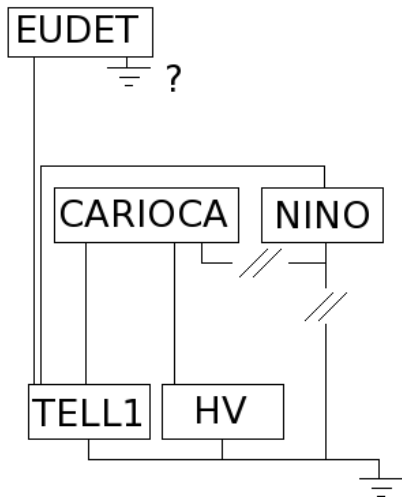


# Setup

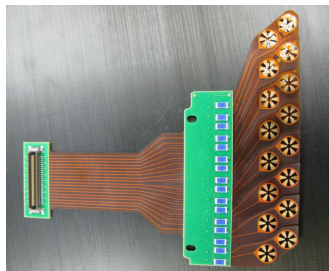


# Setup (2)

## Block Diagram

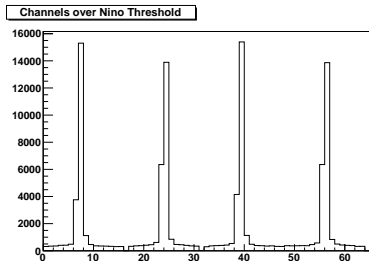


## Front-End



# Detector status

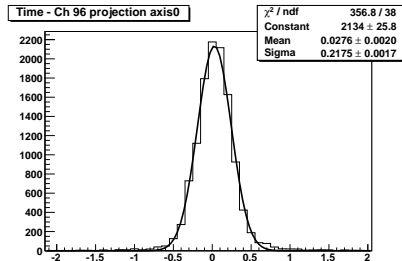
## Channels



## Channel occupancy

- 1 broken channel
- Small cross talk

## Time reference

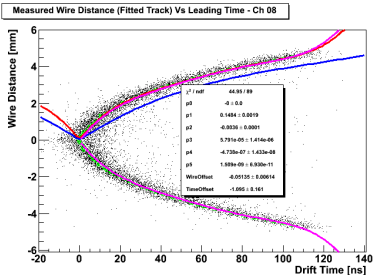


## Time resolution of 1 of the PMs

- 4 PMs  $\rightarrow \approx 200\text{ps}$
- $\approx 1 \times 1 \text{ cm}^2$  (coincidence of 4)

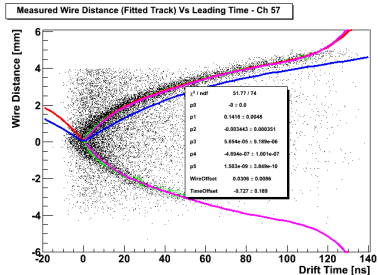
# R-T Dependence

Ar:CO<sub>2</sub> 70:30 (MC)



- Red = Used
- Magenta = Fitted

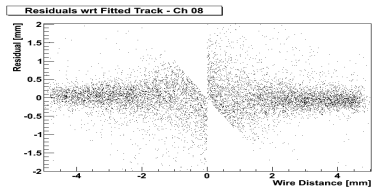
Ar:CO<sub>2</sub> 70:30 (Data)



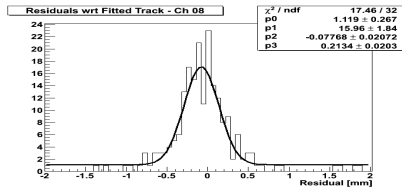
- Blue = MagBoltz @ 760Torr
- Accidentals (subtracted)

# Residuals

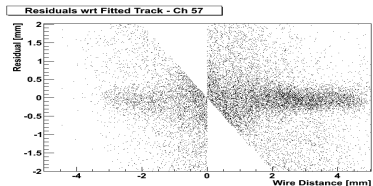
## Ar:CO<sub>2</sub> 70:30 (MC)



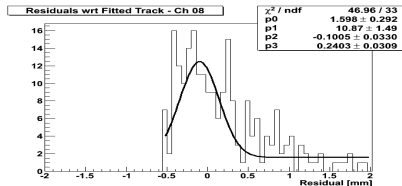
## Ar:CO<sub>2</sub> 70:30 (MC Good Point)



## Ar:CO<sub>2</sub> 70:30 (Data)

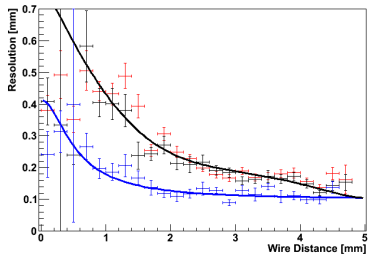


## Ar:CO<sub>2</sub> 70:30 (MC Biased Point)



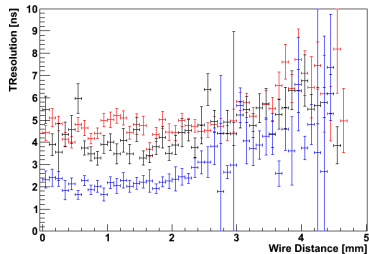
# Resolution

## Space (Data/MC)



- Red = Data
- Black = MC

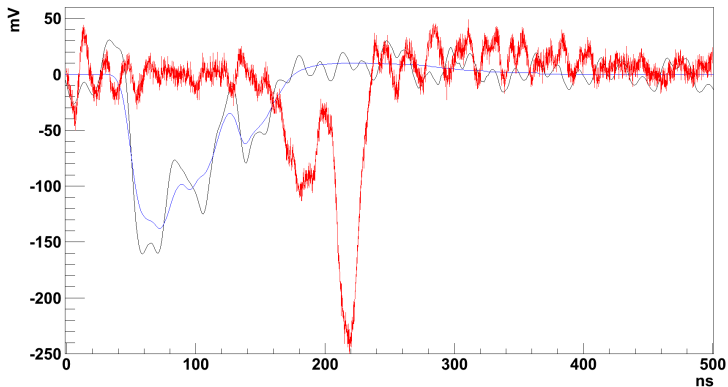
## Time (Leading Edge)



- Blue = MC no noise
- Lines = Expected

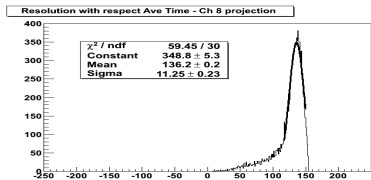


After adding the noise using FFT + true sample signal

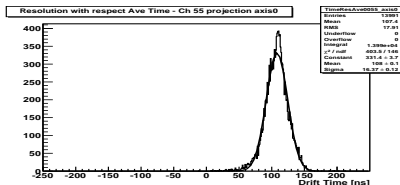


# Time Resolution Trailing Edge and NHits (@ 2fC)

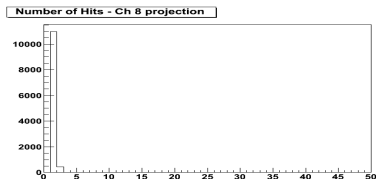
Ar:CO<sub>2</sub> 70:30 MC



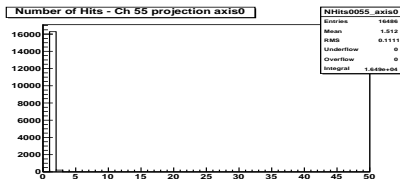
Ar:CO<sub>2</sub> 70:30 Cosmics



Ar:CO<sub>2</sub> 70:30 MC



Ar:CO<sub>2</sub> 70:30 Cosmics



## Test Beam and simulation:

- Ar:CO<sub>2</sub> 70:30 was 15% faster than expected (consistent with  $\approx 0.5\%$  H<sub>2</sub>O pollution)
- Space resolution is dominated by time resolution
- Intrinsic noise cannot account for 4 ns time resolution  $\Rightarrow$  margin for improvement (both for leading and trailing edge)
- Efficiency is  $\approx 99\%$

## Full detector:

- Production of straws in progress
- First module ready before September
- Using results from the test beam the estimated performance is as expected