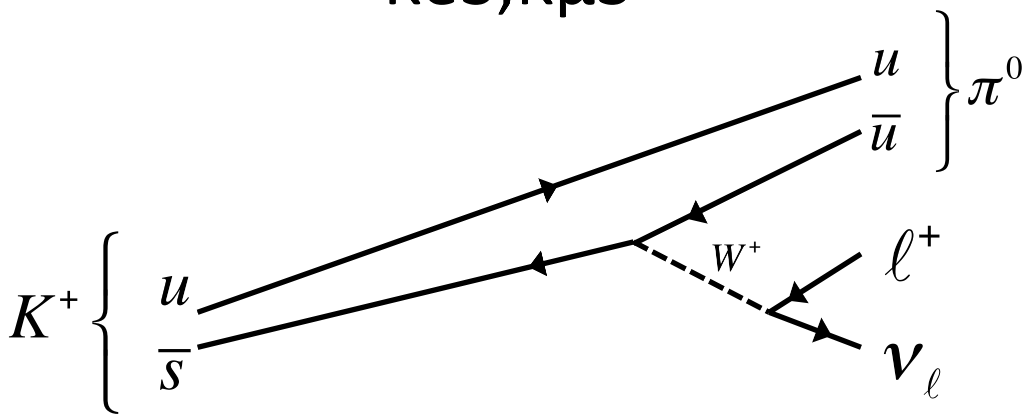
NA62 - Rare Kaon Decays

Measuring Semileptonic Kaon Decays
Ke3,Kμ3



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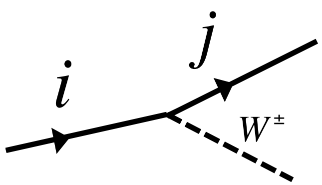
CKM Matrix

Wolfenstein parameterization:

$$V_{CKM} = \begin{bmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{bmatrix} = \begin{bmatrix} 1-\frac{1}{2}\lambda^2 & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\frac{1}{2}\lambda^2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{bmatrix} + O(\lambda^4)$$

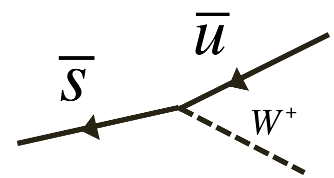
- Describes the probability amplitude of quark flavor transition in weak interactions.

In general:



$$M \propto V_{ij}$$

Semileptonic decay:



$$M \propto V_{us}$$

- The elements not known a priori – must be measured by experiments.
- Matrix should be unitary ($V_{CKM}V^{\dagger}_{CKM} = I$) – can form various relations from this:

Weak universality:

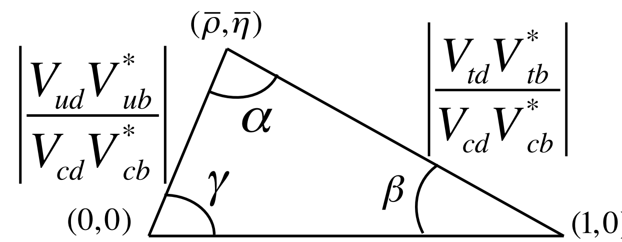
$$\sum_k |V_{ik}|^2 = \sum_i |V_{ik}|^2 = 1$$

Unitary triangles:

$$\sum_k V_{ik}V^*_{jk} = 0$$

Of which, the most common is:

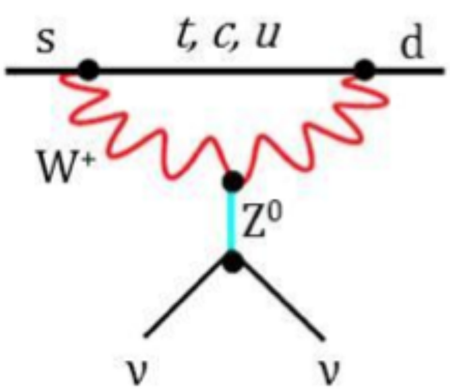
$$V_{ud}V^*_{ub} + V_{cd}V^*_{cb} + V_{td}V^*_{tb} = 0$$



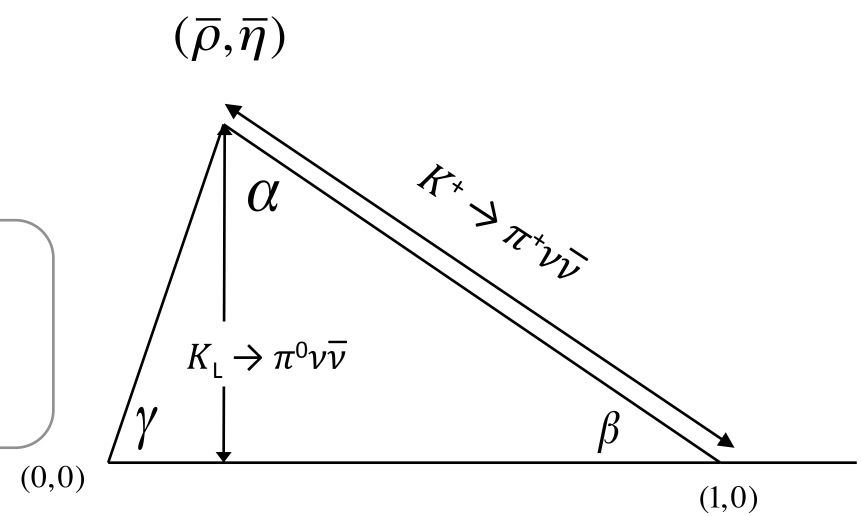
- Deviations from unitarity Δ_{CKM} limit energy scale of NP: Λ

NA62

- Latest experiment at CERN looking at Kaon decays. Data taking to start 2014.
- Aims to measure BR($K^{+} \rightarrow \pi^{+}\nu\bar{\nu}$ & $K_{L} \rightarrow \pi^{0}\nu\bar{\nu}$).
- Aims to measure 80 decays over two years with 10% uncertainty.
- Theoretically clean Decay; QCD calculations may be substituted by the BR of semileptonic decay Ke3.
- Offers unique opportunity to test SM and deepen knowledge of the CKM matrix.
- Should be sensitive to new physics.

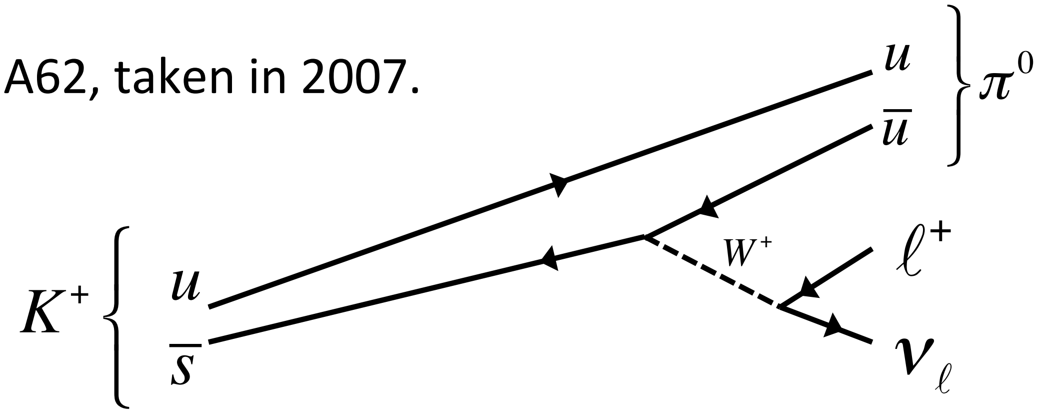


$$M_q \propto \frac{m_q^2}{m_W^2} V_{qs}^{*} V_{qd}$$



Semileptonic Kaon Decays

Using data from 1st phase of NA62, taken in 2007.



Aim:

- To make a measurement of BR($K^+ \to \pi^0 e^+ \nu$) and BR($K^+ \to \pi^0 \mu^+ \nu_\mu$)

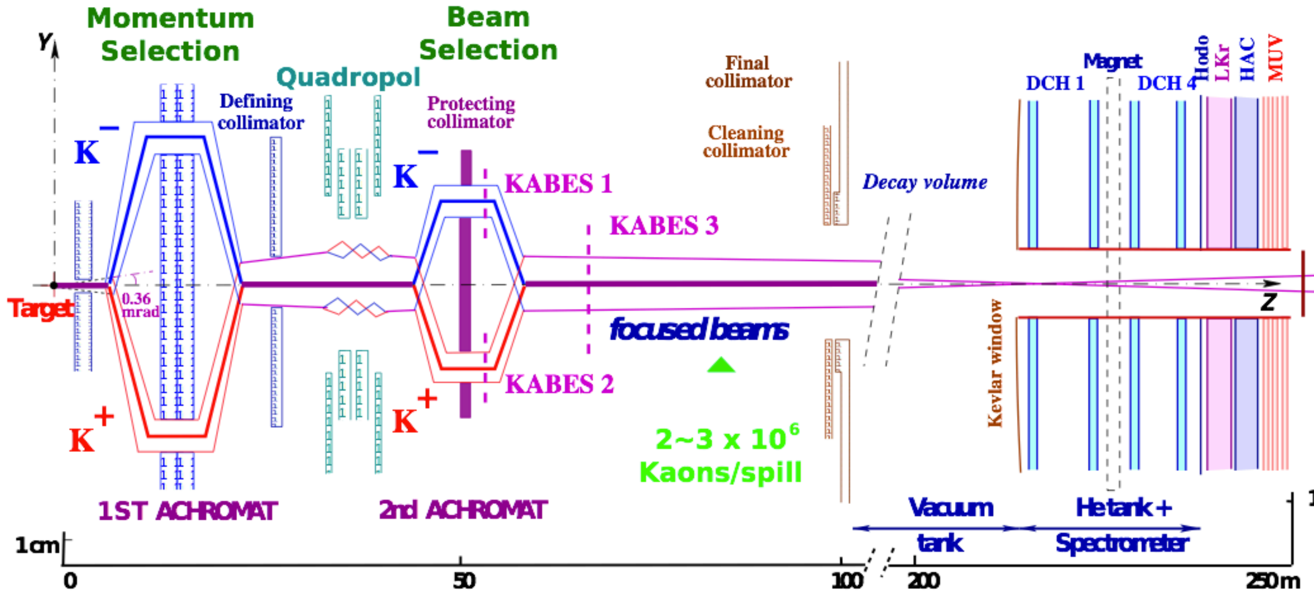
  Using the data from 1st phase of NA62, taken in 2007.

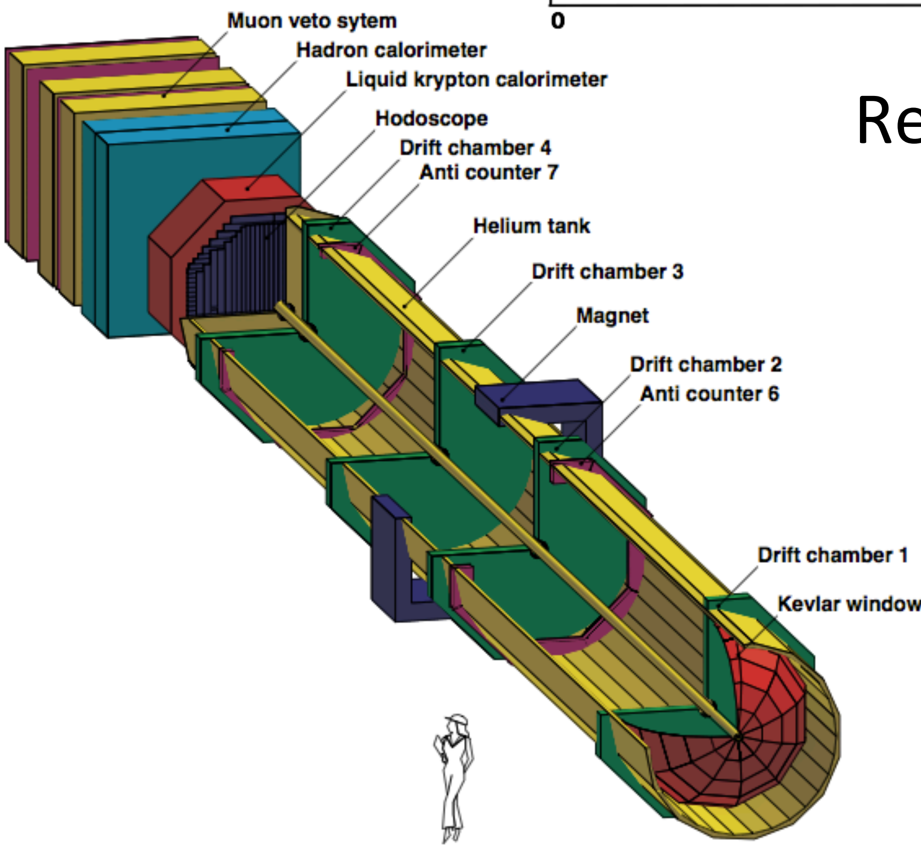
  Current values: 5.078(31)% 3.359(32)% - FlaviaNet20

Motivation:

- Currently largest Kl3 data sample in the world, should be of O**(20 million)**
- BR($K^+ \to \pi^0 e^+ \nu$) is input to the $K^+ \to \pi^+ \nu \bar{\nu}$ calculation.
- Most accurate and theoretically clean way to extract $|V_{us}|$.

  Current value: $V_{us} = 0.2252 \pm 0.0009$
- Test CKM unitarity: $|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 = 0.9999(4)(4)$ -PDG 2012
- Current Δ_{CKM} sets $\Lambda > 11$TeV





Relevant Sub Detectors:

Magnetic spectrometer

- Measures position and momentum of charged particles.

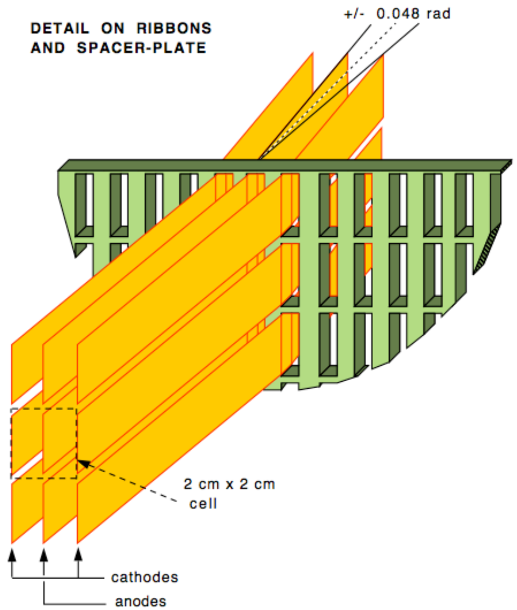
Hodoscope

- Timing measurements

Liquid Krypton Calorimeter

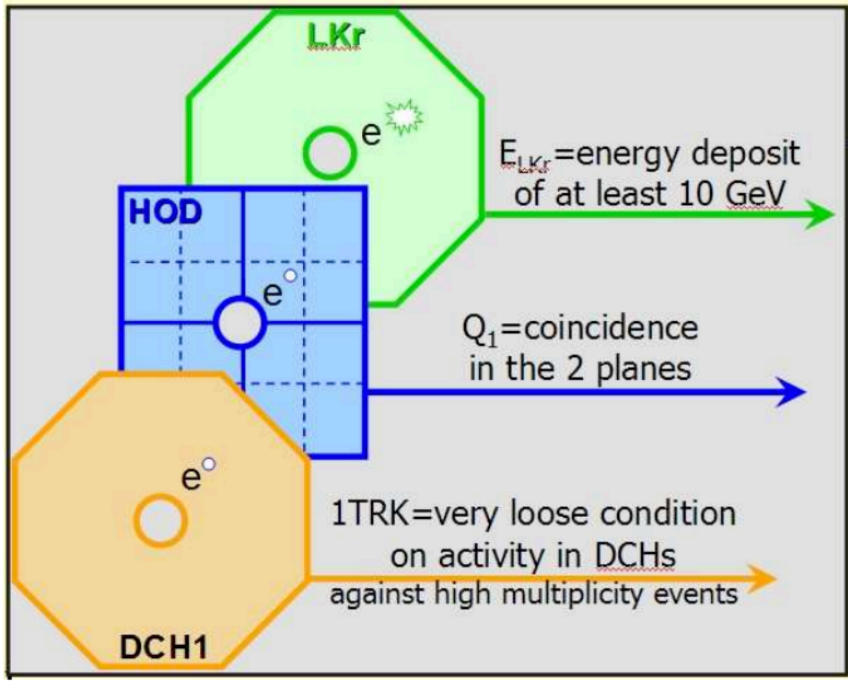
- Measures energy of particles (not muons)

Muon Counter


DETAIL ON RIBBONS
AND SPACER-PLATE
+/- 0.048 rad
2 cm x 2 cm
cell
cathodes
anodes

The Data Set

Trigger:

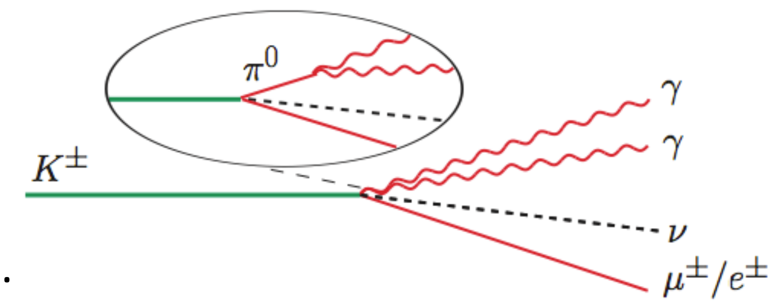


- Events which meet trigger criteria are saved.
- Saved data can be opened in analysis program (C code) .
- We must develop a piece of code which analyses data of each event and identifies what the decay was.
- Count the number of Kl3 events relative to another decay of known BR - $K^{+} \rightarrow \pi^{0}\pi^{\pm}$

Event Selection

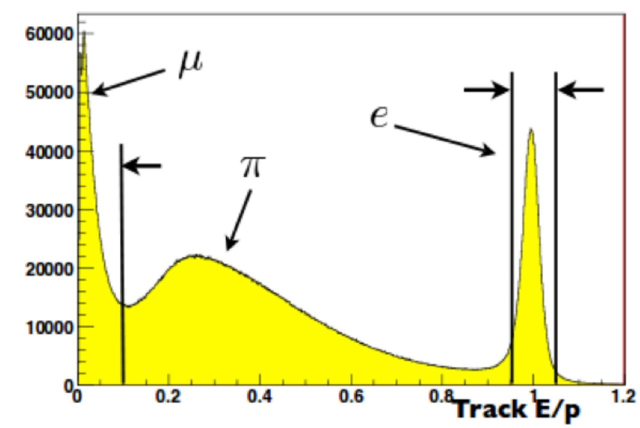
Ke3:

- 1 charged track with an associated LKr hit and $E/P \approx 1$.
- 2 LKr hits with no associated tracks with $|m_{\gamma\gamma}-m_{\pi 0}| \approx 0$.
- $|m^2_{missing}| = (P_K - P_e - P_\pi)^2 < 0.1$ GeV.



Kμ3:

- 1 charged track with an associated LKr hit and $E/P \approx 0$.
- 2 LKr hits with no associated tracks with $|m_{\gamma\gamma}-m_{\pi 0}| \approx 0$.
- $|m^2_{missing}| = (P_K - P_\mu - P_\pi)^2 > 0.1$ GeV.
- Associated MUV hit.



K2π:

- 1 charged track with an associated LKr hit.
- 2 LKr hits with no associated tracks with $|m_{\gamma\gamma}-m_{\pi 0}| \approx 0$.
- $|m^2_{missing}| = (P_K - P_\mu - P_\pi)^2 > 0.1$ GeV.
- No associated MUV hit.

But this is the easy bit..

To make accurate we must:

- Measure & correct for background.
- Measure trigger efficiencies.
- Apply radiative corrections.