Kaon Rare Decays and the SM

CP-Violation

$K_L \to \pi^0 \nu\bar{\nu}$ (holy grail)

$K_L \to \pi^0 e^+ e^-$ { $K_S \to \pi^0 e^+ e^-$, $K_L \to \pi^0 \gamma\gamma$, $K_L \to ee\gamma\gamma$ }

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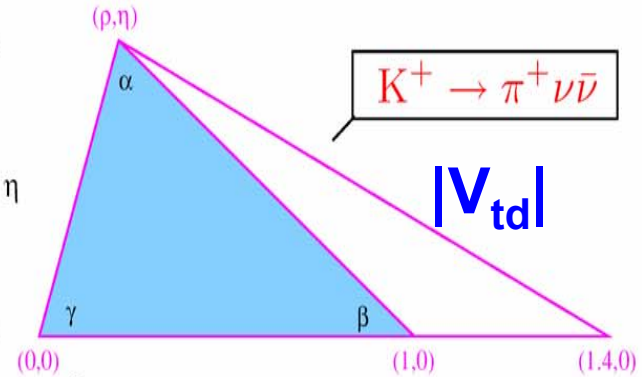


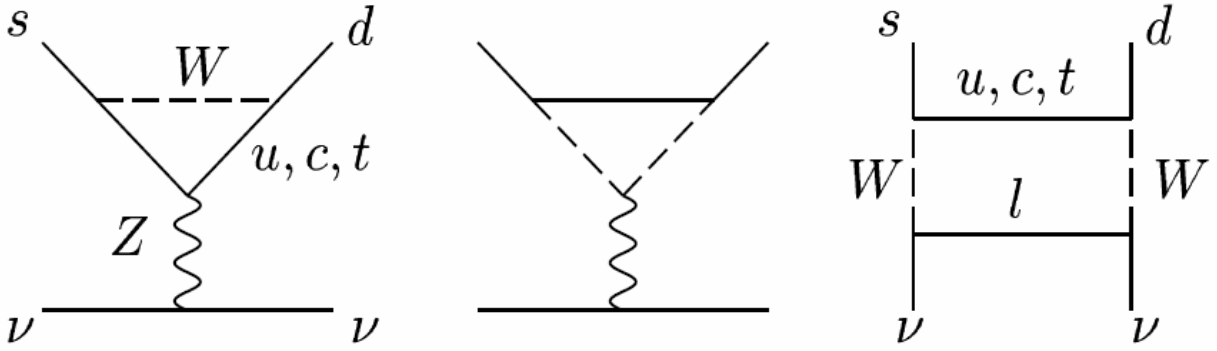
$K^+ \to \pi^+ \nu\bar{\nu}$

$|V_{td}|$

CP-Conservation

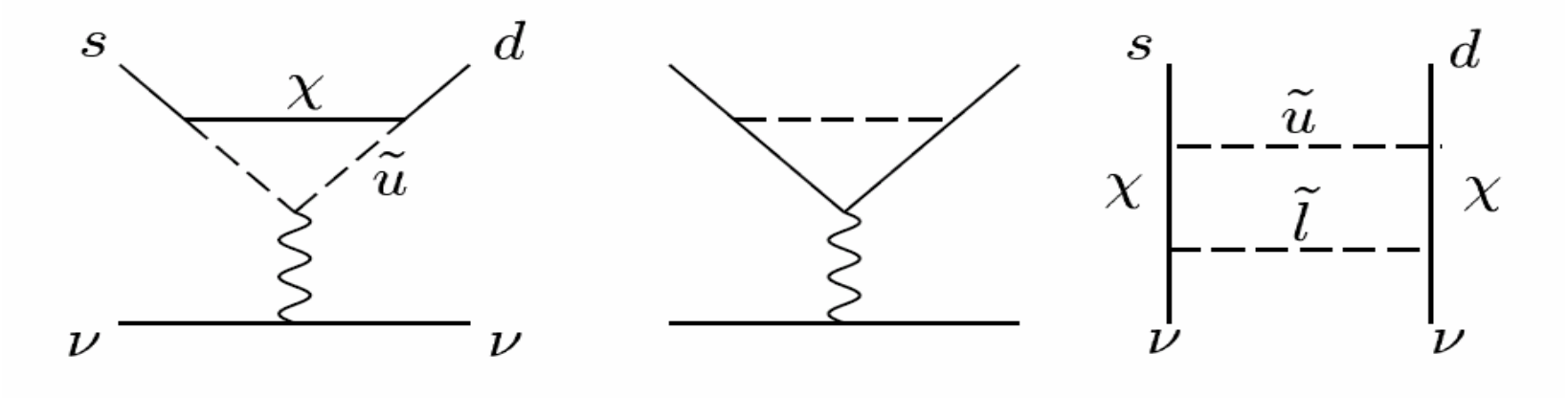
$K_L \to \mu^+\mu^-$ { $K_L \to \gamma\gamma$, $K_L \to e^+e^-\gamma$, $K_L \to e^+e^-e^+e^-$, $e^+e^-\mu^+\mu^-$ }

Kaons provide quantitative tests of SM independent from B mesons



Further Enticement: New Physics?

- These rare kaon decays are second order weak interactions mediated by Z penguins that could be sensitive to NP
- A deviation from the predicted rates of SM would be a clear indication of new physics
- When/if new physics will appear at the LHC, the rare decays may help to understand the nature of it



Kaon Future: NA48/3

$K^+ \to \pi^+ \nu \nu$ at the CERN-SPS

SPSC-2004-029
SPSC-I229

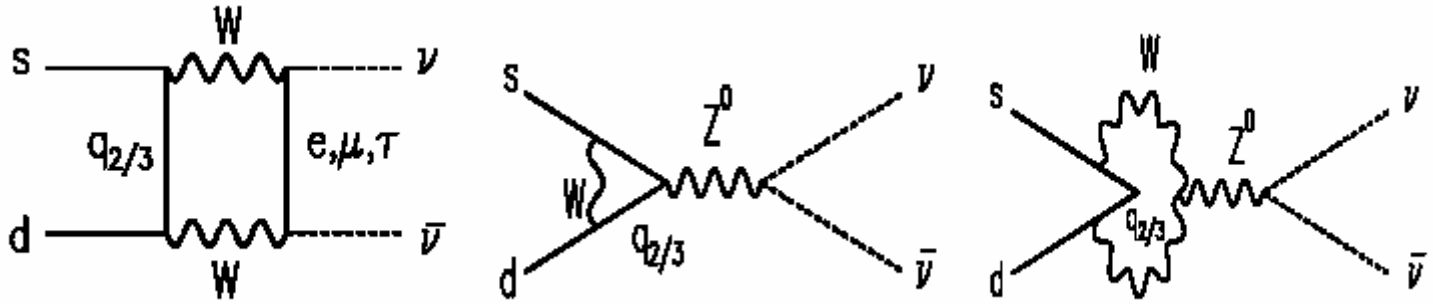
Cambridge, CERN, Dubna, Ferrara, Firenze, Mainz, UC Merced,
Perugia, Pisa, Saclay, Torino, + ??

Unique opportunity:

- SPS & NA48 Infrastructure
- High energy proton:
  - Larger *K* cross section
  - Less accidental background
- High energy kaons:
  - Better background rejection
  - Large acceptance
- Builds on the LHC detectors developments

$K^+ \to \pi^+ \nu\nu$: Theory

- The hadronic matrix element can be extracted from the well measured $K^+ \to \pi^0 e^+ \nu$
- No long distance contributions



$$B_{SD}(K^+ \to \pi^+ \nu\bar{\nu}) = \frac{\kappa_+ \alpha^2 B(K_{e3})}{2\pi^2 \sin^4\theta_W |V_{us}|^2} \sum_l |X_t \lambda_t + X_c \lambda_c|^2 =$$

$$8.9 \times 10^{-11} A^4 \left[(\rho_0 - \bar{\rho})^2 + \bar{\eta}^2\right]$$

QCD NLO
Buchalla,
Buras 1999

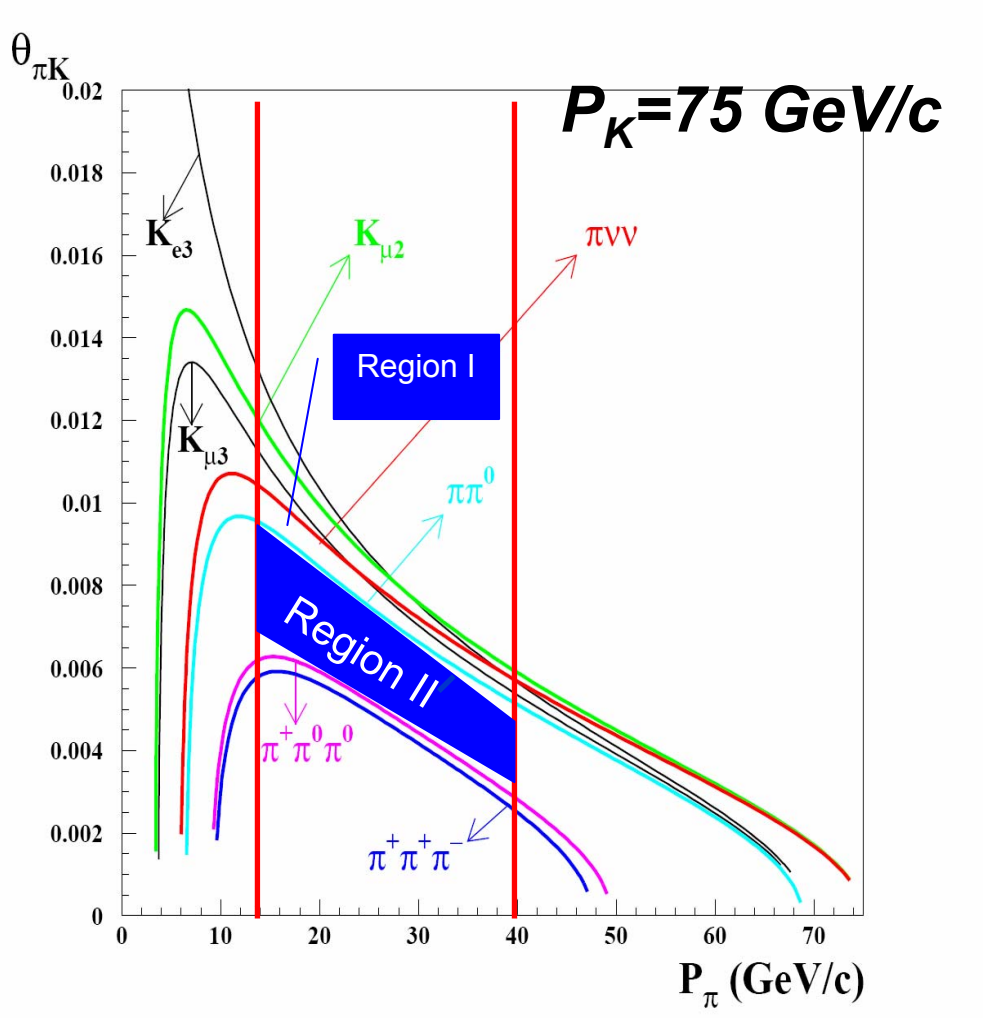
Prediction (CKM Workshop): $BR(K^+ \to \pi^+ \nu\nu) = 8.0 \pm 1.1 \times 10^{-11}$

Expect improvements NNLO calculation + reduction parametric uncertainty → 4 % error (Buras)

NA48/3 (I229): Decay In Flight

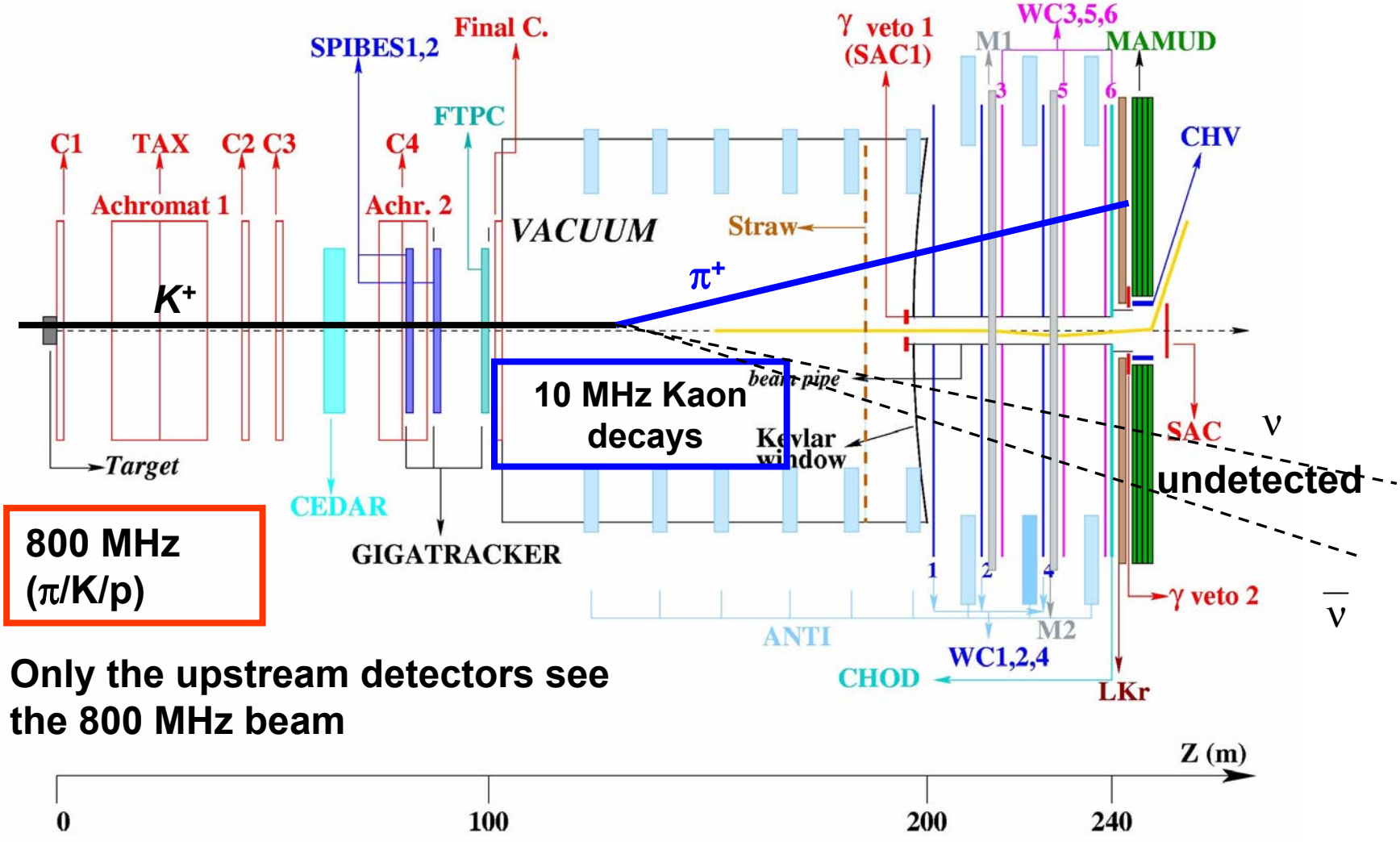
- Collect 80 $K^+ \to \pi^+ \nu\nu$ events in about two years of data taking for:
  - 4×10^{12} Kaon decays/SPS yea
  - BR($K^+ \to \pi^+ \nu\nu$)~10^{-10}
  - Acceptance ~ 10%
  - **Absolute advantage:**

    High energy kaon beam: >35 GeV of EM energy deposited in the vetoes Vey Difficult to miss the π^0 !!



ECN3

NA48/3 Detector Layout



New high-intensity K^+ beam for NA48/3

Already Available

Beam:	Present K12 (NA48/2)	New HI K^+ > 2006	Factor wrt 2004
SPS protons per pulse on T10	1×10^{12}	3×10^{12}	3.0
Duty cycle (s./s.)	4.8 / 16.8		1.0
Solid angle (μsterad)	≈ 0.40	≈ 16	40
Av. K^+momentum $\langle p_K \rangle$ (GeV/c)	60	75	Total : 1.35
Mom. band RMS: ($\Delta p/p$ in %)	≈ 4	≈ 1	~0.25
Area at Gigatracker (cm^2)	≈ 7.0	≈ 20	≈ 2.8
Total beam per pulse (x 10^7)	5.5	250	~45 (~27)
per Effective spill length MHz	18	800	~45 (~27)
MHz/cm^2 (gigatracker)	2.5	40	~16 (~10)
Eff. running time / yr (pulses)	3* x 10^5	3.1 * 10^5	1.0
K^+ decays per year	1.0×10^{11}	4.0×10^{12}	≈ 40

"CERN Director General Outlines Seven-point Strategy for European Laboratory"

18.6.2004 Official CERN Press Release

Geneva 18 June 2004. "At the 128th session of CERN Council, held today under the chairmanship of Professor Enzo Iarocci, CERN Director General, Robert Aymar, outlined a seven-point scientific strategy for the Organization. Top of the list was completion of the Large Hadron Collider (LHC) project with start-up on schedule in 2007. This was followed by consolidation of existing infrastructure at CERN to guarantee reliable operation of the LHC, with the third priority being an examination of a possible future experimental programme apart from the LHC."

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The possible Future Programme was reviewed by the SPSC in Villars (September 22-27, 2004)