Summary of the Kaon Physics Session

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Project-X Physics Workshop

Nov 17th , 2007

Discussion Today, Standing Room only!

- Q&A with Pier Oddone.
- Discussion on Experimental probes of a Minimal Flavor Violating World. Joe Lykken (Fermilab) and Ikaros Bigi (Notre Dame) and will lead, 20 minutes.
- Cookbook for a high statistics K + -> pi+ nu,nubar: Challenges and tools for getting to 1000 events.
  Augusto Ceccucci, (CERN), 20+10 minutes.
- Cookbook for a high statistics K0 -> pi0 nu,nubar: Challenges and tools for getting to 1000 events.
  Doug Bryman, (Triumf/UBC), 20+10 minutes.
- Study of kaon and neutron yields from a high intensity 8 GeV proton source. Sergei Striganov, Fermilab. 15+5 minutes.
- Summary, next steps, 10 minutes.

Questions from the Community

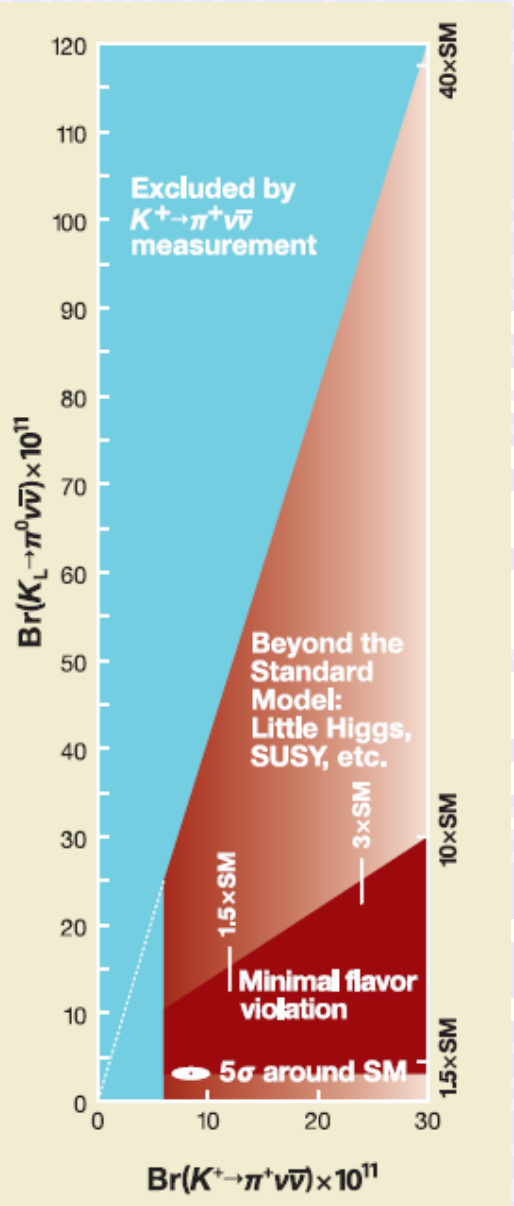
- What is the status of non-Fermilab experiments?
- More is better, but what is the beam power threshold or What is the threshold sensitivity?
- Studies are needed to better understand the roles of the two K --> pi nu nu modes in probing non-standard model physics. In particular, it would be helpful to quantify their relative sensitivities and the extent to which they are complementary to one another. Moreover, comparisons to analogous studies using rare B decays are also needed.
- On the experimental side, the projected sensitivities go well beyond what has been achieved thus far and a considerable amount of work is needed to establish that the detectors can accommodate the rates, and that backgrounds can be reduced to levels commensurate with the anticipated statistical sensitivities.
- What can we expect in various cases as opposed to how well we will mesure?
- What are theory errors?
- For a model comparison, what happens if we assume supersymmetry but with minimal flavor violation, which seems to be gaining popularity given the lack of new physics showing up at the B factories?

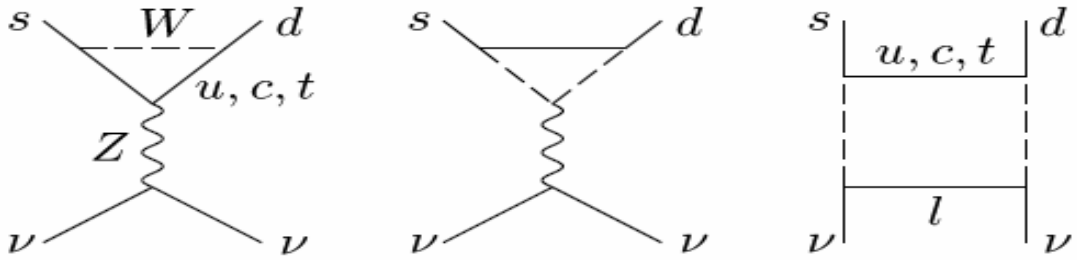
Q&A with Pier

- Physics case looks great, not enough.
- It is incumbent on the community to step up out-reach and communicate the case, this workshop is a good start.
- Successful rare-decay experiments are the result of campaigns, e.g. CERN, JPARC,KTeV. Can a campaign start at Fermilab before project-X?
- With the Booster?
- With the Main Injector?
- With the Tevatron/Stretcher?

- How does one advanced a staged program in a projectized world?

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





Standard Model (*Buras*): $\mathrm{Im}\,\lambda_t = \mathrm{Im} V_{ts}^* V_{td} = \eta A^2 \lambda^5$

$$B(K_L^0 \to \pi^0 \nu\bar{\nu}) = 1.8 \times 10^{-10} \left(\frac{\mathrm{Im}\,\lambda_t}{\lambda^5} X(x_t) \right)^2$$

$$\approx 4.1 \times 10^{-10} A^4 \eta^2 = 3.0 \pm 0.6 \times 10^{-11}$$

$$B(K^+ \to \pi^+ \nu\bar{\nu}) \approx 1.0 \times 10^{-10} A^4 \left[\eta^2 + (\rho_0 - \rho)^2 \right] = 7.8 \pm 1.2 \times 10^{-11}$$

Theoretical error <2% for neutral, <4% charged modes which motivates 1000-event experiments---conceivable with Project-X!

So we are in a Minimum Flavor Violating World…(?)

- What theory work is required to reduce the $K \to \pi\nu\nu$ SM theory error to the few-percent floor….Vcb, (ρ,η), what hidden error could blow up?

- What measurements in the B system work best with $K \to \pi\nu\nu$ to mimimize theory error and have the best BSM reach?

- Which $K \to \pi\nu\nu$ mode is more sensitive to BSM? Is it significant that the neutral mode is purely CP violating amplitude?

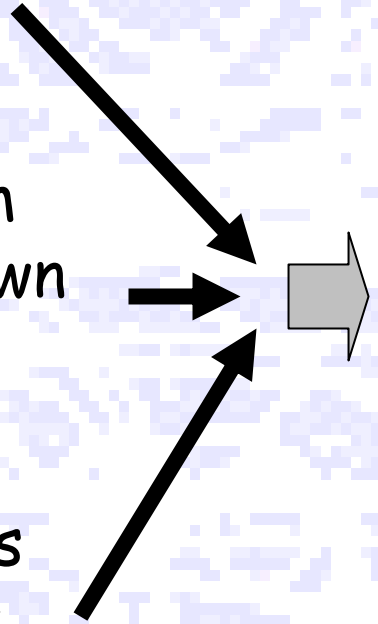
- What Does MFV mean? Is it a tautology?

Charged Mode, Where we are at Today

BNL program has established the process!

The CERN NA48 program evolves **step-by-step** down the sensitivity ladder.

Next generation concepts and designs developed by R&D for the Fermilab CKM experiment.

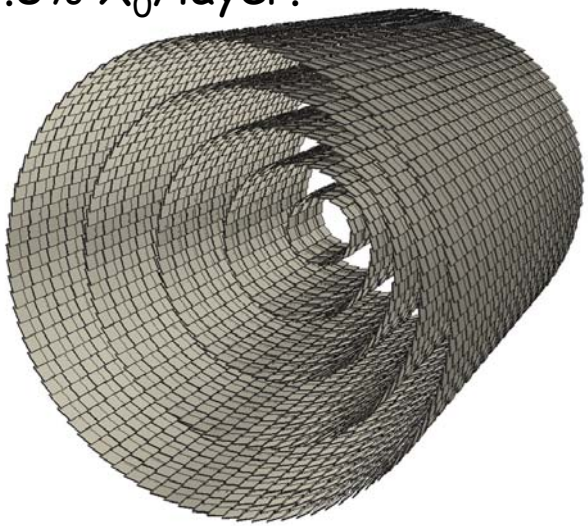


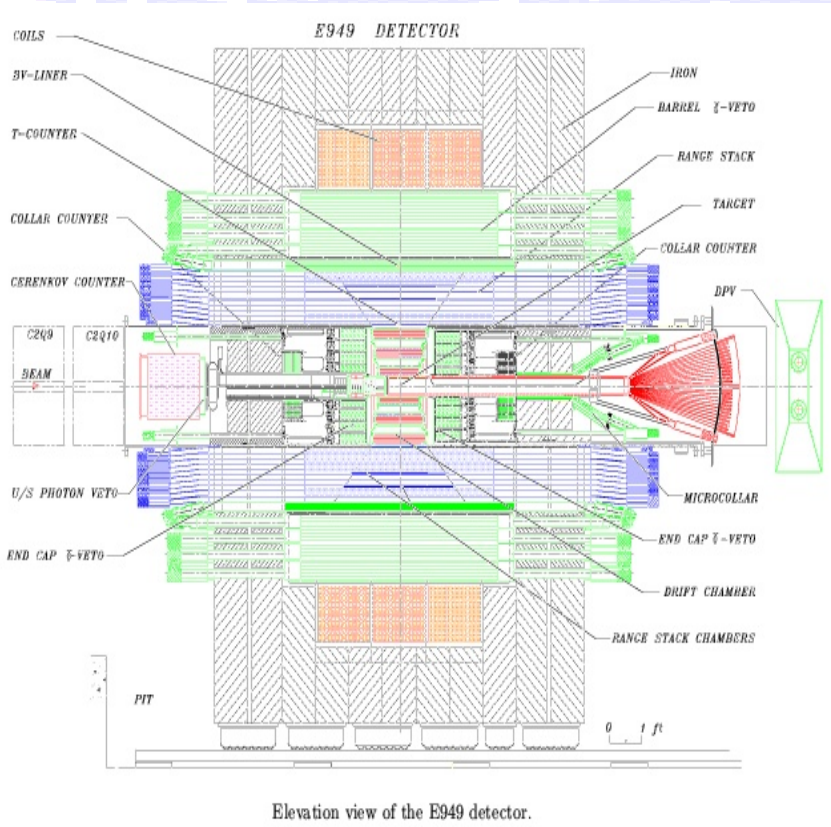
The now approved CERN NA62 experiment marches toward a 100 event measurement early next decade

New Charged Mode Ideas Discussed at this Workshop

•Exploit Project-X proton intensities to develop a next-generation stopped K+ experiment built from modern detector technology. Examples include low-mass ILC trackers and liquid xenon calorimeters and vetos.

SiD silicon tracker,
0.8% X_0/layer.





Elevation view of the E949 detector.

1000 events conceivable with next generation stopped expt.

Charged Mode, Where Project-X could go…

Evolution of CERN NA62 techniques based on a pure separated K+ beam enabled with ILC crab cavities.

SNuMI can deliver 100-200 events/year.

Project-X could deliver 300-600 events/year.

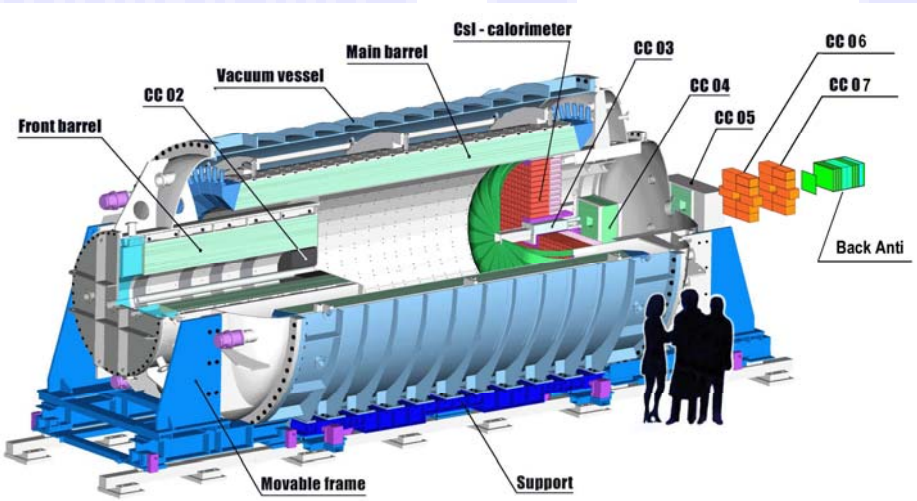
Should support and stage with respect with CERN NA62 experiment.

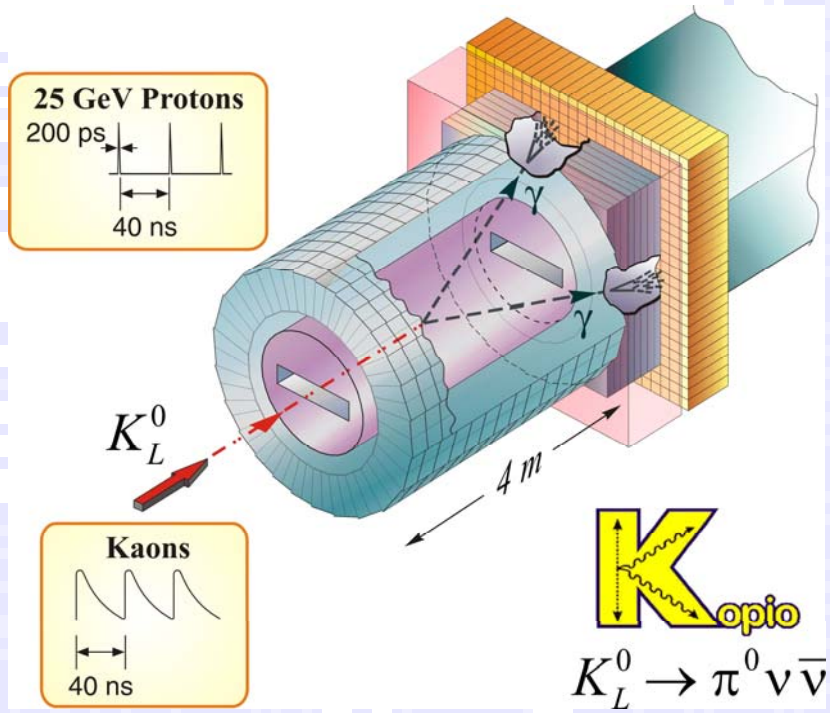
Neutral Mode, "Nothing-in nothing out"

•JPARC approach emphasizes high acceptance for the two decay photons while vetoing everything else:

A hermetic "bottle" approach.

•The original KOPIO concept measures the kaon momentum and photon direction…Good! But costs detector acceptance and requires a large beam to compensate.





High acceptance and vetoing all decay particles is the only way!

Kinematic handles is the only way!

Project-X proton flux can give us both!

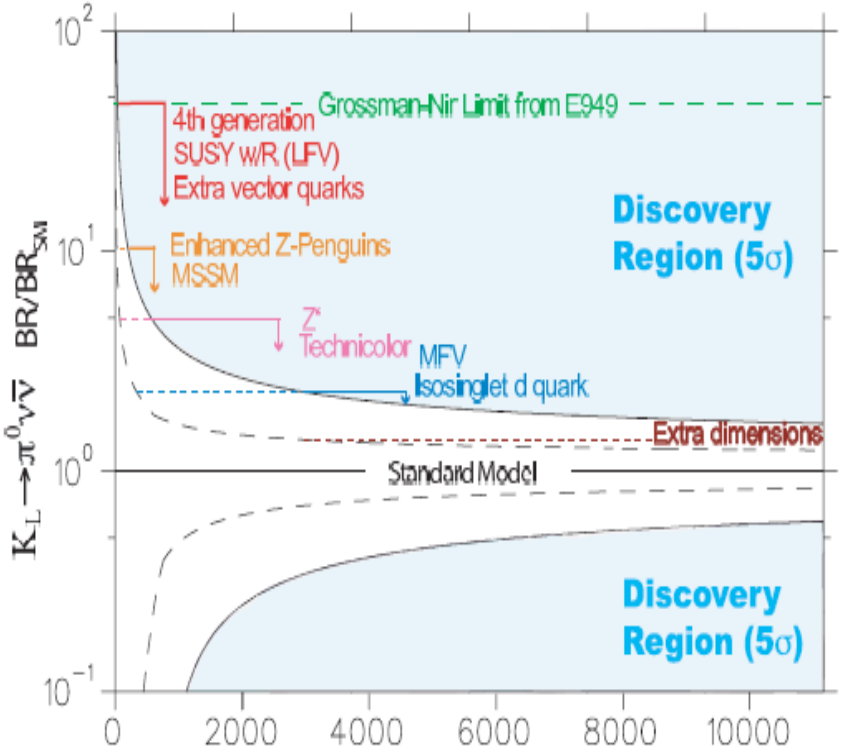
Project-X proton flux can give us both!

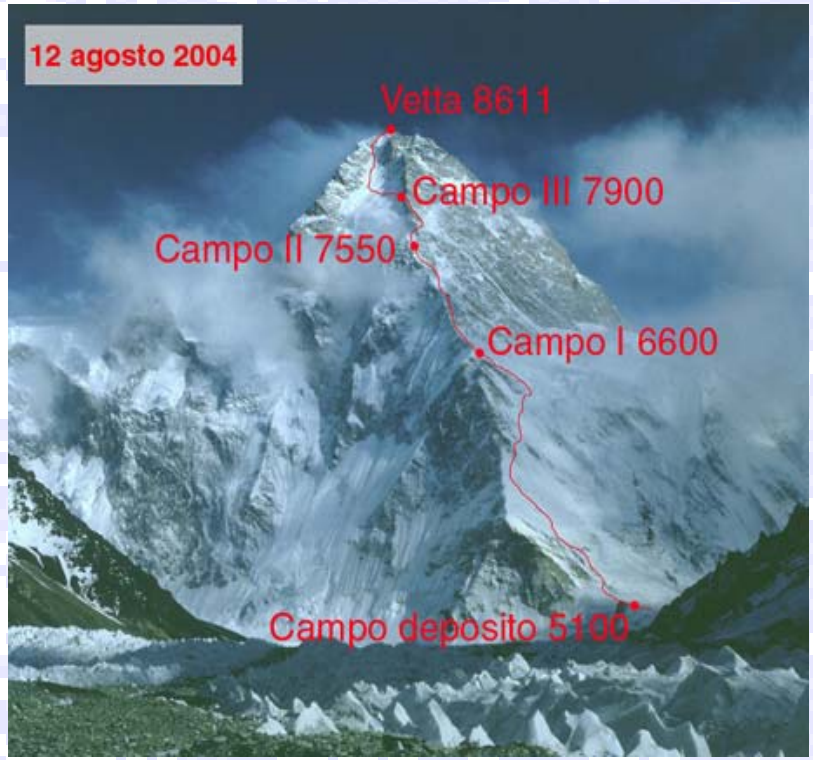
Neutral Mode, Where Project-X Could go…

- The very high 8-GeV proton flux from Project-X permits a redesign of the KOPIO detector concept with a very small solid angle "laser" neutral kaon beam which recovers the hermetic bottle veto coverage and increases the detector acceptance dramatically.

- An experiment can start at the Booster with sensitivity for about 50 Standard Model events per year. This detector can be designed with Project-X in mind, which would follow with a precision measurement of about 300 events/year.

$K \to \pi \nu \nu$, step by step…





Experiment Running Hours.

A famous K-peak, K2

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Summary

- Physics case is there. Outreach and communication must be improved!
- Programs are advancing in Japan and Europe in response to this physics case.
- Can't defend 1000-event experiments today in court, but there is sufficient promise to continue working toward this goal. We will form a joint working group of experimenters and theorists.
- In all cases success requires a staged approach. The existing accelerator complex can support the first steps which come to full fruition with Project-X. This staging means cooperation and collaboration with next generation experiments on the books.