Prospects for $K^+ \to \pi^+ \nu\bar{\nu}$ at Fermilab

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Tevatron Stretcher

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- Tevatron can be use as a stretcher for providing 120 GeV beams to the existing Fermilab switch yard.
- MI: 120 GeV, 1.33 s cycle time, 2 pulses->Tevatron
- 100 Tp could be stored in the Tevatron for slow extraction using resonant extraction.
- 10% of the available beam would produce 70 kW with a **duty factor of 95%** over a 27.6 s cycle time.

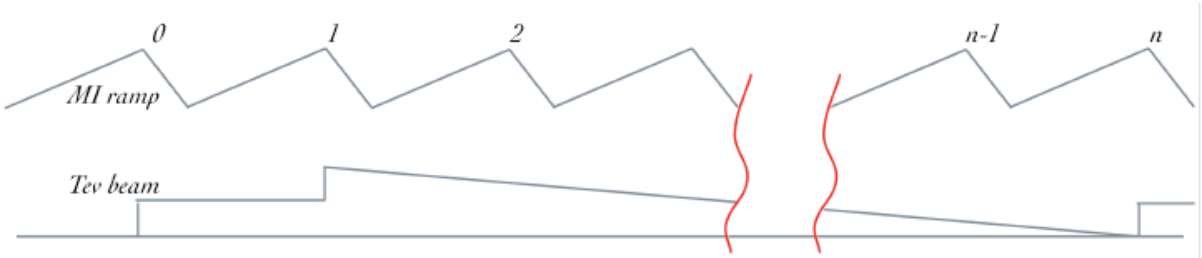

Figure 2. Main Injector energy ramps (top curve) and Tevatron beam intensity (bottom curve). Out of n, beam is injected over two cycles, and spilled for n-1.

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Stopped K^+ technique using the [MI+Tevatron Stretcher]

Opportunities:

- Use high intensity, high duty factor K production
- Build a new short, low energy K+ beam
- Develop a new stopped K+ experiment a la E949 at relatively low cost
  - Exploit advances in instrumentation to build a better detector than E949
- Use an existing solenoid at higher field and re-use other valuable equipment (e.g. vlpc) after collider stops

Goal:

>1000 events in 3-5 years

→ 3% precision -- comparable to SM theory
Discover new physics!

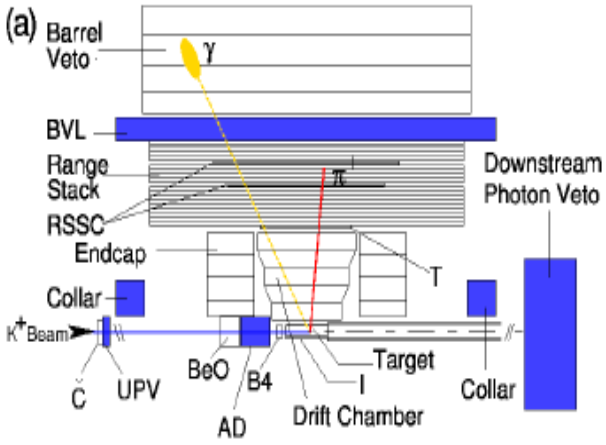
***New opportunity*:** $K^+ \to \pi^+ \nu\bar{\nu}$ at Fermilab/Tevatron Strecher:

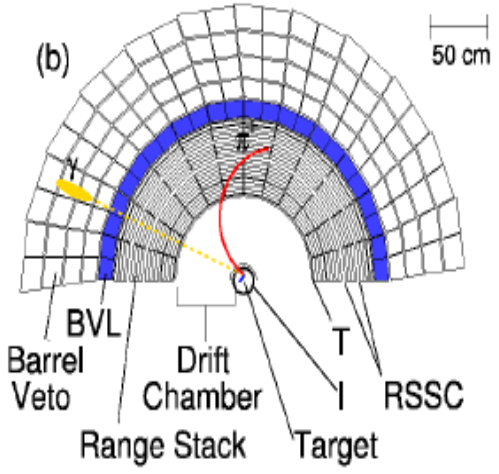
Stopped K technique $\rightarrow$ 1000 events!

Principal Improvement: Lower P_k ~450-550 MeV/c

Modest but significant upgrades to the methods of E949.

π / μ Particle I.D. largest single factor in acceptance loss.





- **3-4 x higher stop efficiency at low momentum**
- **Improved Acceptance (x10)**
- **Reduced randoms and accidental spoiling of events (photon veto) due to low momentum.**

Assumptions and Issues for a new $K^+ \to \pi^+ \nu\bar{\nu}$ Measurement at Fermilab

- **New high acceptance short Kaon beam** (E949) designed by Jaap Dornbos: **14.6** (19) **m**; **130** (50) **msr-%ΔP**; **450-550** (710) **MeV/c**

  3 x total acceptance relative to LESB3 at the AGS;
  3-4 **x efficiency for stopping kaons**
  Same survival rate

- ***10 x acceptance of E949 2002 run.*** **Detector/beam Improvements.**
  - Finer segmentation of RS (4-10x) for suppression of μ background
  - RS tracking using extruded scintillator and wls readout
  - Higher field, better momentum resolution, larger solid angle
  - Improved photon veto efficiency e.g. 24 L0 Shashlyk (18/15 L0)
  - Improved target
  - Improved photo-sensors (vlpc), electronics, and trigger, macro-efficiency
  - DAQ improvements

- **Reduced Accidental losses** from photon veto hits due to low momentum;
  90% (40%) duty factor

Net gain: (100 x E949) or >200 SM events/yr. *Proven technique.*

$K^+ \to \pi^+ \nu\bar{\nu}$	FNAL "Booster" (20 kW)	FNAL Tevatron Stretcher 10%MI	FNAL Project-X
Events/yr*	40	220	325
Events/5yr	200	1168	1600
Precision**	**8**	**3.4**	**3**

Estimates based on extrapolation of BNL E949.

*** Includes separate estimates of backgrounds in Regions I (10%) and 2 (75%)*.

Experiment/Proposal Issues

Incomplete List…

- Details of scheme for delivering ~100% duty factor
- Site and production target
- Uncertainties in low energy K production cross sections at 120 GeV
- Possible additional backgrounds from high energy n and μ
- Quantifying detector acceptance improvements, sensitivity
- Further development of CKM parameters (from theory and B physics) needed for 3% measurements
- Capital cost (estimated: Detector $20M, Beams $10M)
- Operations cost