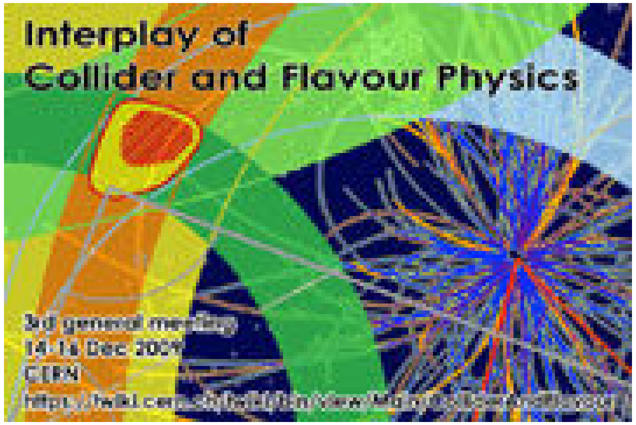
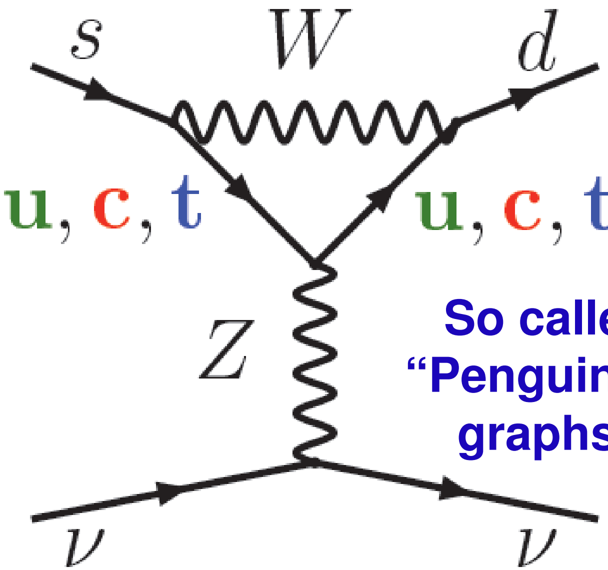
Present Status and Future Prospects in K Physics



Augusto Ceccucci/CERN

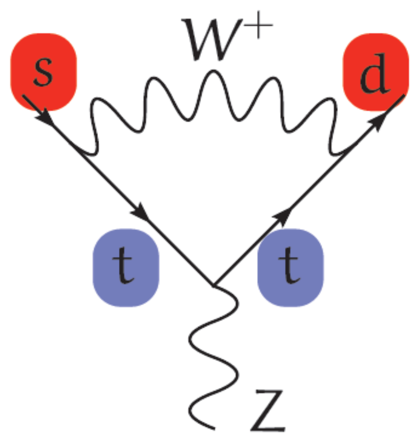
Ultra-rare K Decays

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

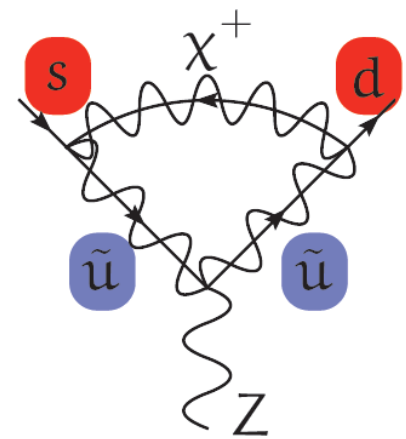


So called "Penguin" graphs

- The contribution to these processes due to the Standard Theory is strongly suppressed ($<10^{-10}$) and calculable with excellent precision (~%)
- They are very sensitive to possible contributions from New Physics



"Standard" Penguin



Possible "Super-Symmetric" Penguin

$K \to \pi \nu \bar{\nu}$: Current Status

Decay	Branching Ratio $(\times 10^{10})$	
	Theory (SM)	Experiment
$K^+ \to \pi^+ \nu \bar{\nu} (\gamma)$	0.85 ± 0.07[1]	$1.73^{+1.15}_{-1.05}$[2]
$K_L^0 \to \pi^0 \nu \bar{\nu}$	0.26 ± 0.04[3]	< 260 (90% CL)[4]

[1] J.Brod, M.Gorbahn, PRD78, arXiv:0805.4119
[2] AGS-E787/E949 PRL101, arXiv:0808.2459
[3] M. Gorbahn
[4] KEK-E391a arXiv:0911.4789v1

Neutral Beams for $K^0_L \to \pi^0 \nu\bar{\nu}$

"Pencil"

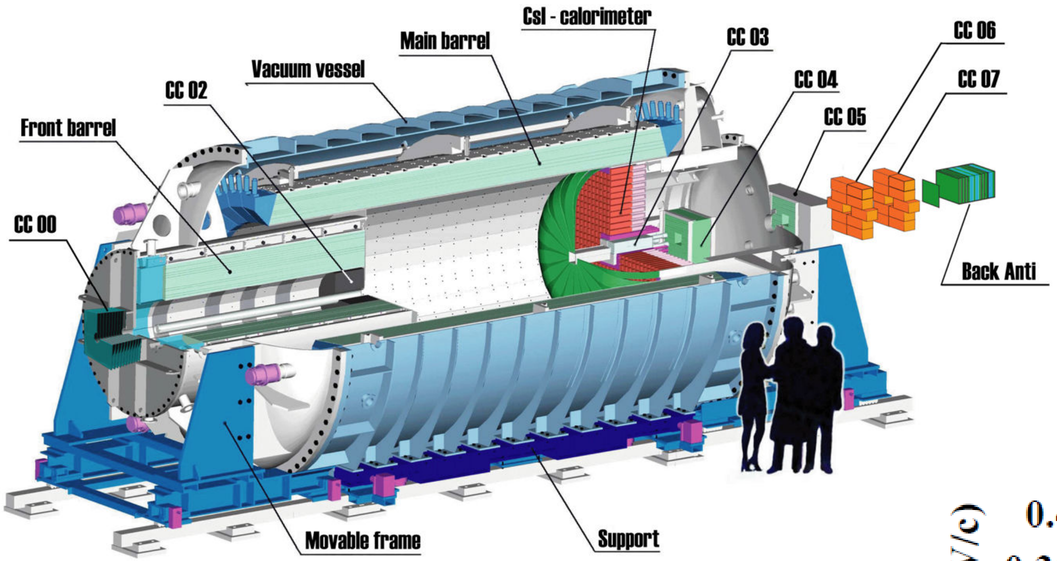
- π^0 + "nothing"
- P_T cut for $\Lambda \to n\pi^0$ & $K^0_L \to 2\pi^0$ suppression
- hermetic calorimetry

"Microbunched"

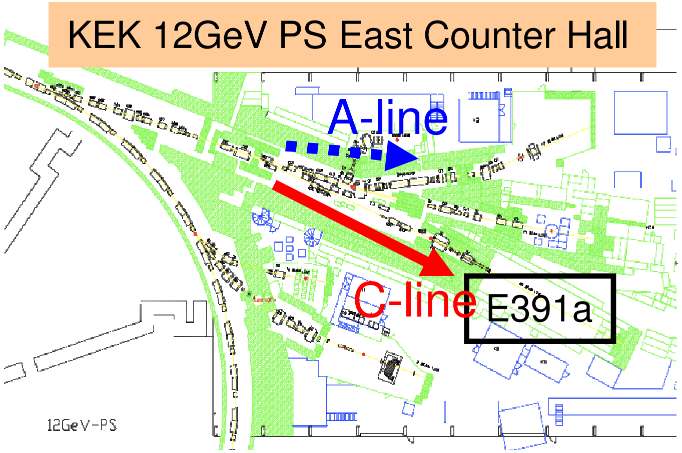
- E_K from TOF
- Low(er) Kaon Energy
- KOPIO BNL Concept further elaborated for FNAL (Bryman@KAON09)

Exp	Machine	UL 90% CL	Notes
KTeV	Tevatron	$< 5.7 \times 10^{-7}$ ($\pi^0 \to ee\gamma$)	
E391a	KEK-PS	$<2.6 \times 10^{-8}$	
KOTO	J-PARC		Aim at 2.7 SM evts / 3 y
KOPIO			Opportunity at Project X (IC2) ?

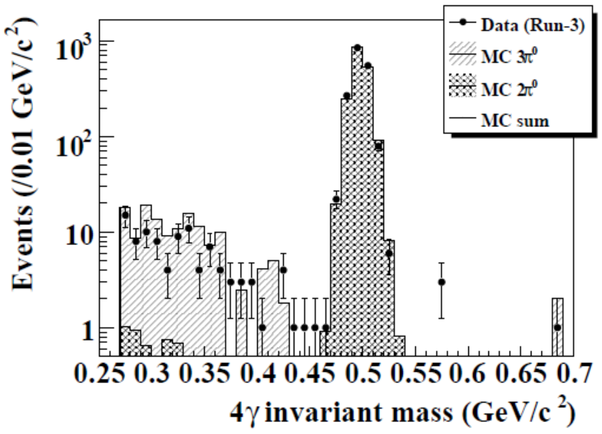
E391a @ KEK PS



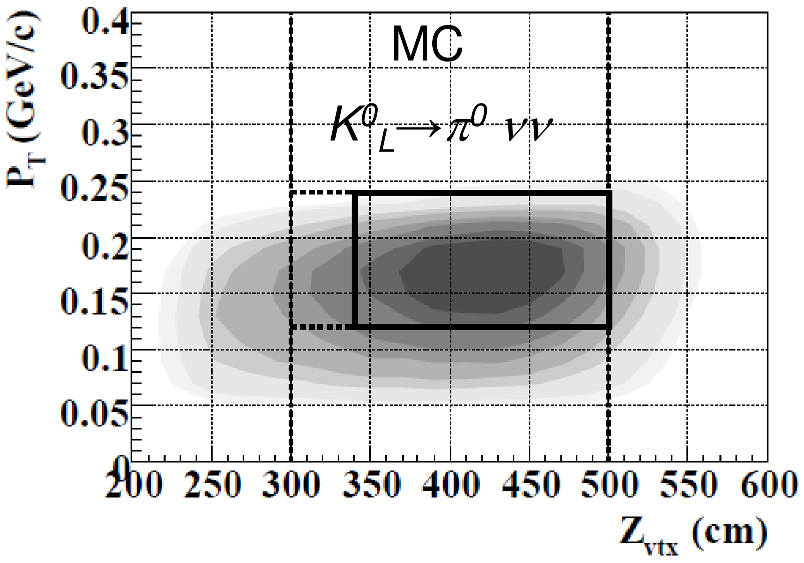
CsI - calorimeter
Main barrel
Vacuum vessel
CC 02
Front barrel
CC 00
CC 03
CC 04
CC 05
CC 06
CC 07
Back Anti
Movable frame
Support



KEK 12GeV PS East Counter Hall
A-line
C-line
E391a
12GeV-PS



Data (Run-3)
MC $3\pi^0$
MC $2\pi^0$
MC sum
Events (/0.01 GeV/c^2)
4γ invariant mass (GeV/c^2)

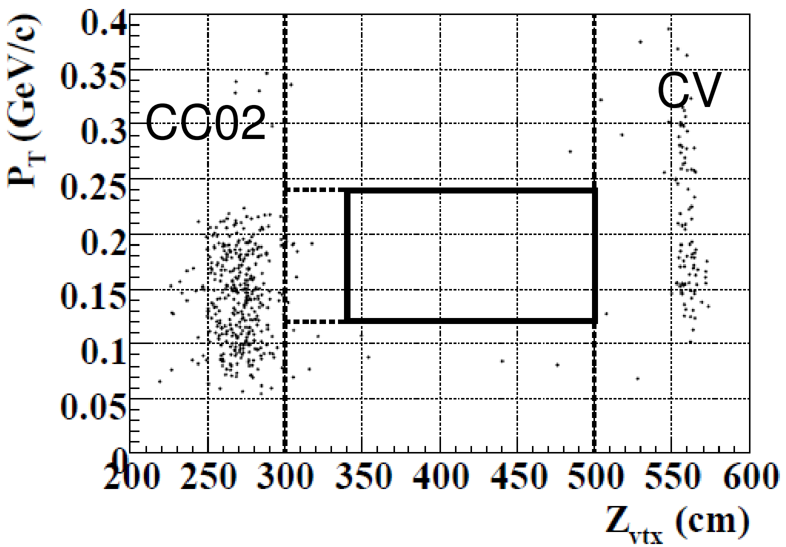


MC
$K^0_L \to \pi^0 \nu\nu$
P_T (GeV/c)
Z_{vtx} (cm)

E391a Final Result

- arXiv:0911.4789v1
- Based all full statistics (2004-2005) including reanalysis of already published data
- At these sensitivities backgrounds from kaon decays are negligible w.r.t. neutron induced ones

Signal Acceptance ~1%
Flux 8.7 x 10^9 K^0_L



Background		Estimated # evt
Beam Halo neutron	CC02-π^0 CV-π^0 CV-η	0.66 ± 0.39 <0.39 0.19 ± 0.13
$K^0_L \to \pi^0\pi^0$		$(2.4 \pm 1.8) \times 10^{-2}$
Other	Backward π^0	<0.05
Total		**0.87 ± 0.41**

$B(K^0_L \to \pi^0 \nu\nu) < 2.6 \times 10^{-8}$ 90% CL

Factor of x3 improvement

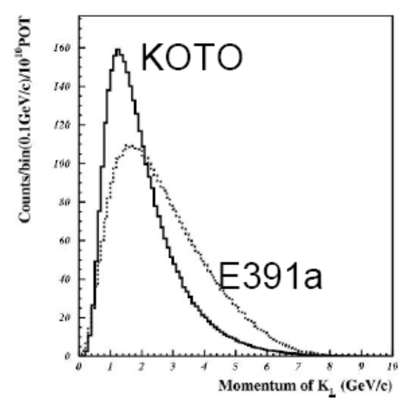
KOTO (E14) @ JPARC

Aim for **Flux x Run Time x Acceptance = 3000 x E391a**

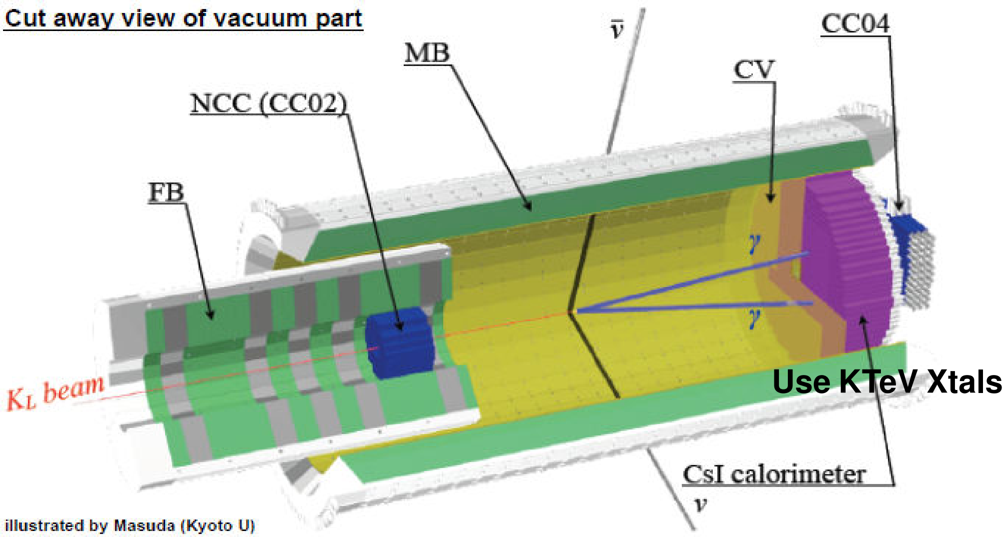
	KOTO	E391a (Run2)	
Proton energy	30 GeV	12 GeV	
Proton intensity	2e14	2.5e12	
Spill/cycle	0.7/3.3sec	2/4sec	
Extraction Angle	16 deg	4 deg	
Solid Angle	9μStr	12.6μStr	
KL yield/spill	7.8e6	3.3e5	x30 /sec
Run Time	3 Snowmass years =12 months.	1 month	x10
Decay Prob.	4%	2%	x 2
Acceptance	3.6%* *without Back splash loss	0.67%	x5

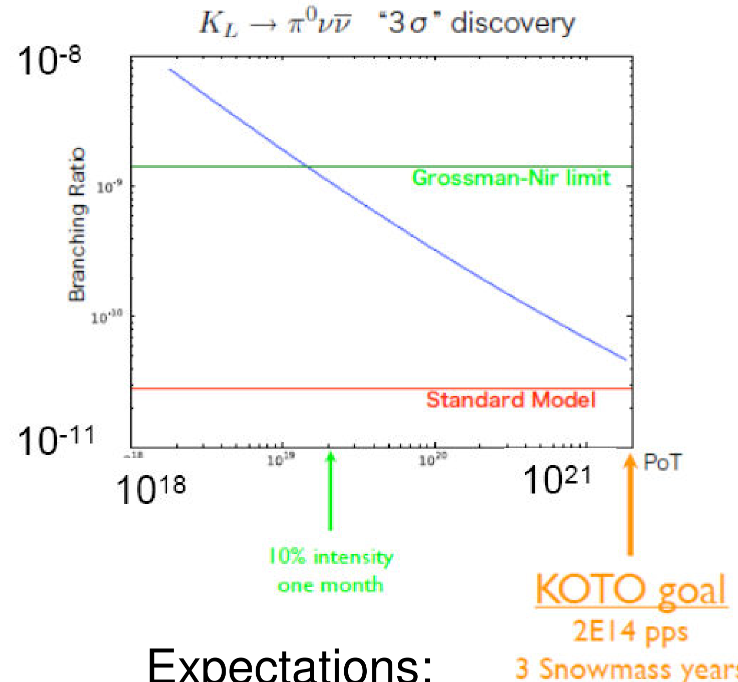
Main Ring Parameters:
L=1.6 Km
30 GeV
2×10^{14} ppp
0.3 MW
0.7 s spill / 3.3 s

Details in H. Nanjo KAON'09



KOTO @ JPARC





Schedule (H. Nanjo, KAON2009)

2009

- Beamline construction
- Beam Survey

2010

- CsI Calorimeter Construction
- Engineering run with CsI calorimeter

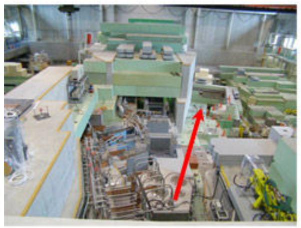
2011

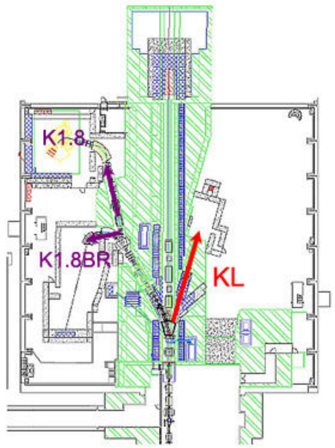
- Physics Run start

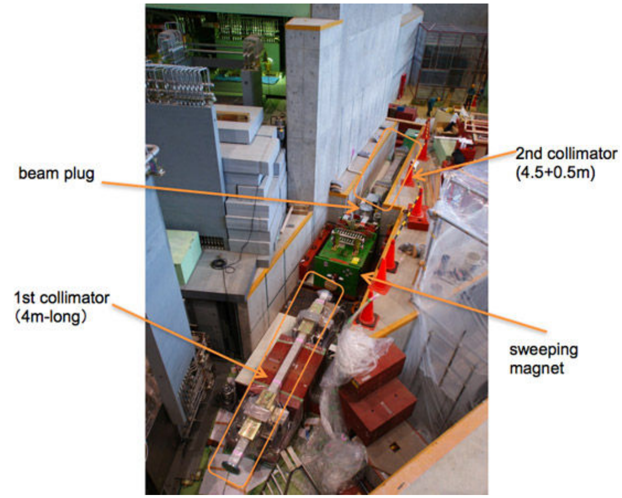
Expectations:

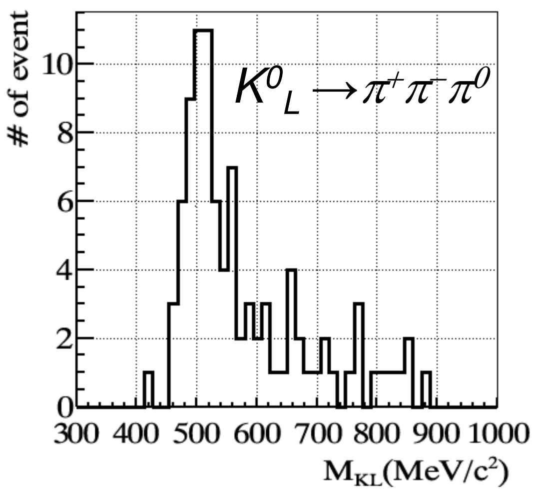
Signal	$K^0_L \to \pi^0 \nu\nu$	2.7
K^0_L Background	$\pi^0\pi^0$	1.7
	$\pi^+\pi^-\pi^0$	0.08
	$e^+\pi^- \nu$	0.02
Halo Neutrons		0.38

“Confirmation of neutral kaons in the KL beam line at Hadron Hall, J-PARC” Dec 7, 2009



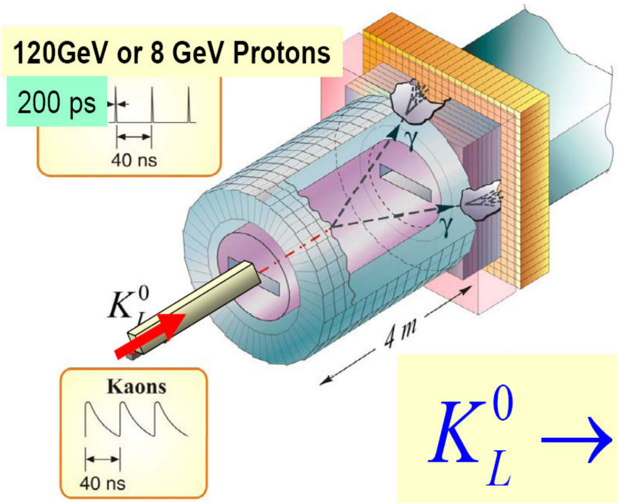




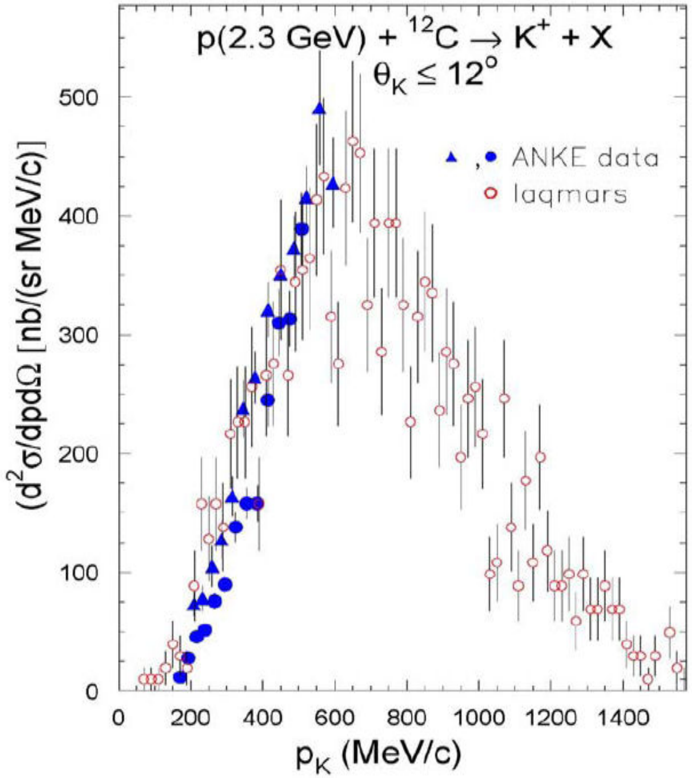


Beam Survey

K^0_L @ FNAL Project X ?



$$K_L^0 \rightarrow \pi^0 \nu \bar{\nu}$$



- KOPIO-like: TOF to determine Kaon Energy
- Knowledge of E_K allows rejection of two body decays
- Pointing Calorimeter
- 4 π veto for neutral and charged particles
- Small Beam instead of flat beam

- Project X (IC2): CW p LINAC ≥2 GeV
- Excellent bunch timing
- High flux of low energy K^0_L

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

"Stopped"

- Work in Kaon frame
- High Kaon purity (Electro-Magneto-static Separators)
- Compact Detectors

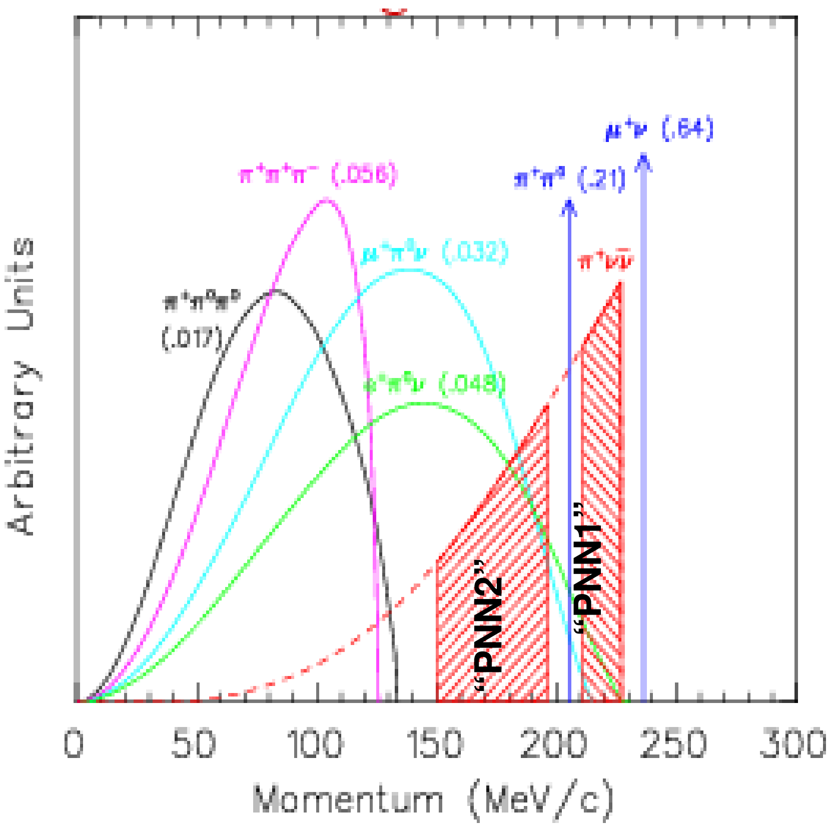
"In-Flight"

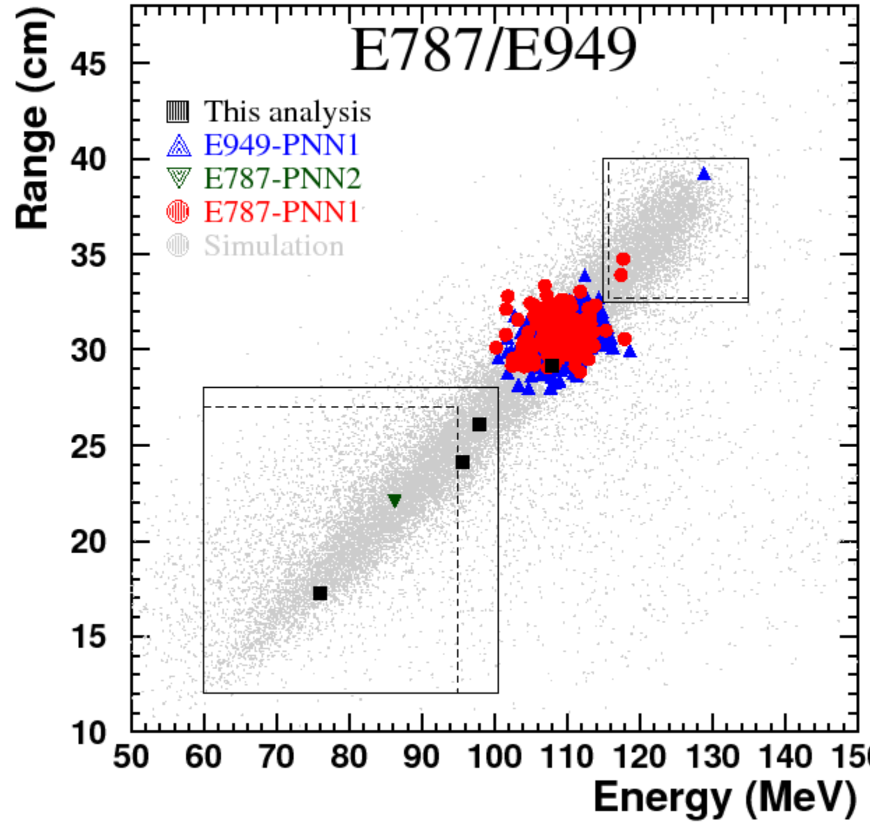
- Decays in vacuum (no scattering, no interactions)
- RF separated or Unseparated beams
- Extended decay regions

Exp	Machine	Meas. or UL 90% CL	Notes
	Argonne	$< 5.7 \times 10^{-5}$	Stopped; HL Bubble Chamber
	Bevatron	$< 5.6 \times 10^{-7}$	Stopped; Spark Chambers
	KEK	$<1.4 \times 10^{-7}$	Stopped; $\pi^+ \to \mu^+ \to e^+$
E787	AGS	$(1.57^{+1.75}_{-0.82}) \times 10^{-10}$	Stopped
E949	**AGS**	$(1.73^{+1.15}_{-1.05}) \times 10^{-10}$	**Stopped; PPN1+PPN2**
NA62	**SPS**		**In-Flight; Unseparated**
P996	FNAL		Stopped; Tevatron as stretcher ring?

E787/E949: Final Result

arXiv:0903.0030v1 PRD79:092004,2009





$$B(K^+ \rightarrow \pi^+ \nu\bar{\nu}) = (1.73^{+1.15}_{-1.05}) \times 10^{-10}$$

Stopped Kaon Redux?

Can one improve significantly over the E949 PNN1 efficiency figures?

Selection	α	Notes
$K\mu 2$	0.38	Beam,T, RS rec.
$K\pi 2$	0.88	E, range, selection
Pscat	**0.62**	Rej. of beam scat.
$\pi \rightarrow \mu \rightarrow e$	**0.35**	Decay chain
Trig	**0.18**	Trigger eff.
PS	**0.36**	Phase Space
nucl.	**0.50**	Pion interaction
T2	0.94	topology
fs	**0.77**	Stopping Fraction
"Standard"	1.7×10^{-3}	Total efficiency

- "Only" ~22% (.77 x .28) of kaons stopped in target
- The product of the red factors (1.5×10^{-2}) Is a high price to pay: $1/(1.5 \times 10^{-2})$ ~ **66x**

Possible Improvements (Bryman@KAON09):

1. Lower Kaon Momentum to increase the stopped kaon fraction
2. Larger Beam acceptance

→ **4-5x**

3. Detector Improvement: finer RS segmentation; LXe γ veto

→ **> 5x**

Stopped Kaon @ FNAL?

D. Bryman @ KAON09

$K^+ \to \pi^+ \nu \bar{\nu}$	FNAL "Booster" (20 kW)	FNAL Tevatron Stretcher 12%MI	FNAL Project-X
Events/yr*	40	200	325
Events/5yr	200	1000	1600
Precision**	**8**	**3.6**	**3**

**Estimates based on extrapolation of BNL E949.*

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

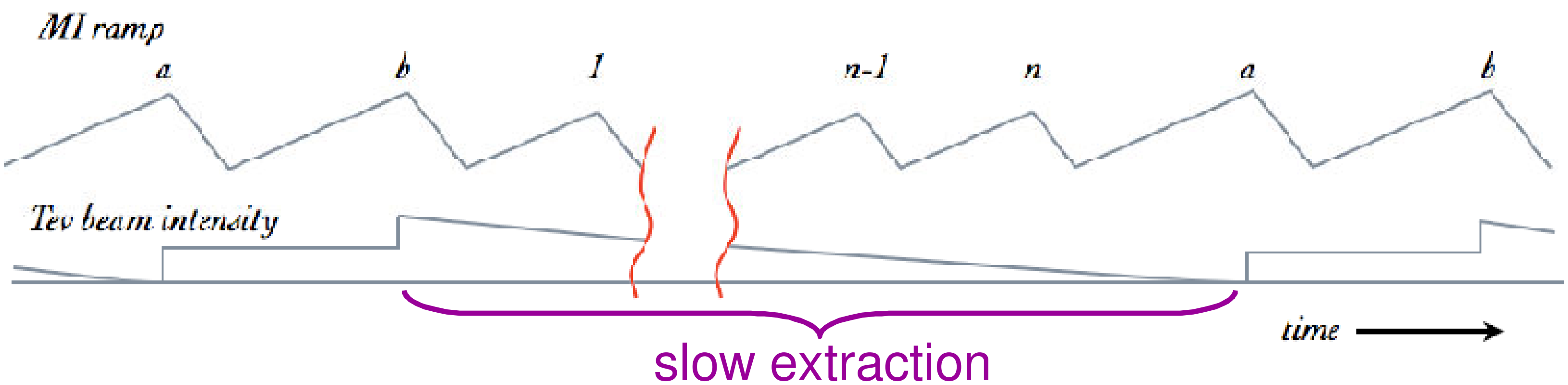
Tevatron in Stretcher Mode

Jack Ritchie @ Fermilab PAC

Stretcher operating scenario

- With NOvA, n pulses to NuMI beam (1.33 s ramp to 120 GeV) + 2 pulses to Tevatron (1.67 s ramp to 150 GeV); n ≈ 18

  10% hit in protons to NOvA; no effect on μBooNE, mu2e, g-2, …



- 96 Tp (1 TP = 10^{12} p) with 27.3 s cycle; duty factor = 94% (high duty factor is key to P996)
- Extraction hardware exists; 150 GeV is the normal Tevatron injection energy; 150 GeV extraction has been done before.
- If NOvA is off, higher intensity to P996 is possible.

Why here, why now?

- Existing Fermilab facilities (MI and Tevatron) provide an opportunity to make a decisive measurement.
  - Either New Physics will manifest, or severe constraints result.
- To be timely, this should compete head-to-head with CERN's NA-62 experiment.
- Tevatron stretcher operation is only viable if done soon after collider running ends.
- This measurement can provide important input for planning the Project-X Intensity Frontier program.
- This experiment will be a nucleation site for rebuilding the U.S. kaon-physics community, which is needed for Project-X.

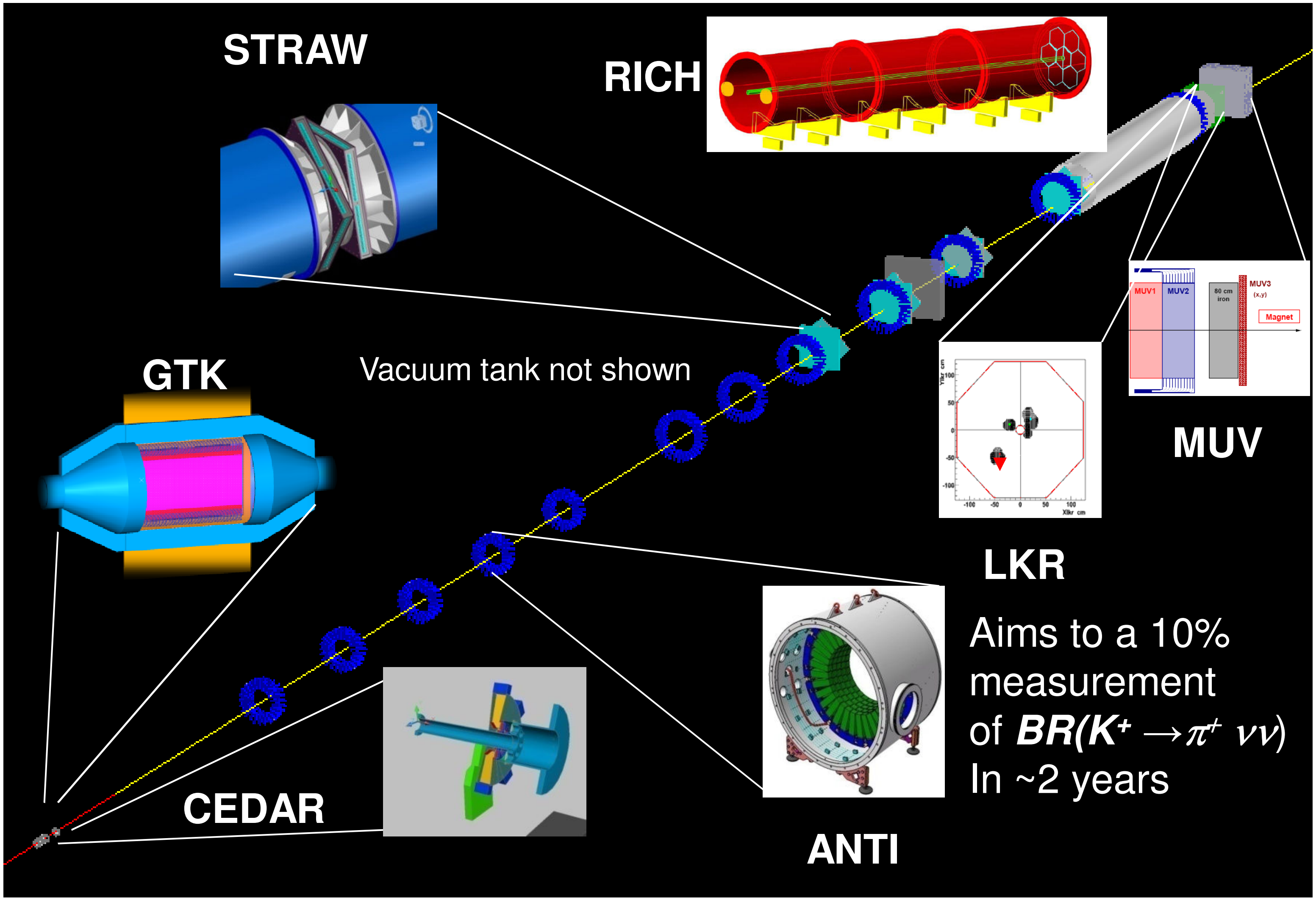
D. Jaffe @ Fermilab PAC

Projected Timescale

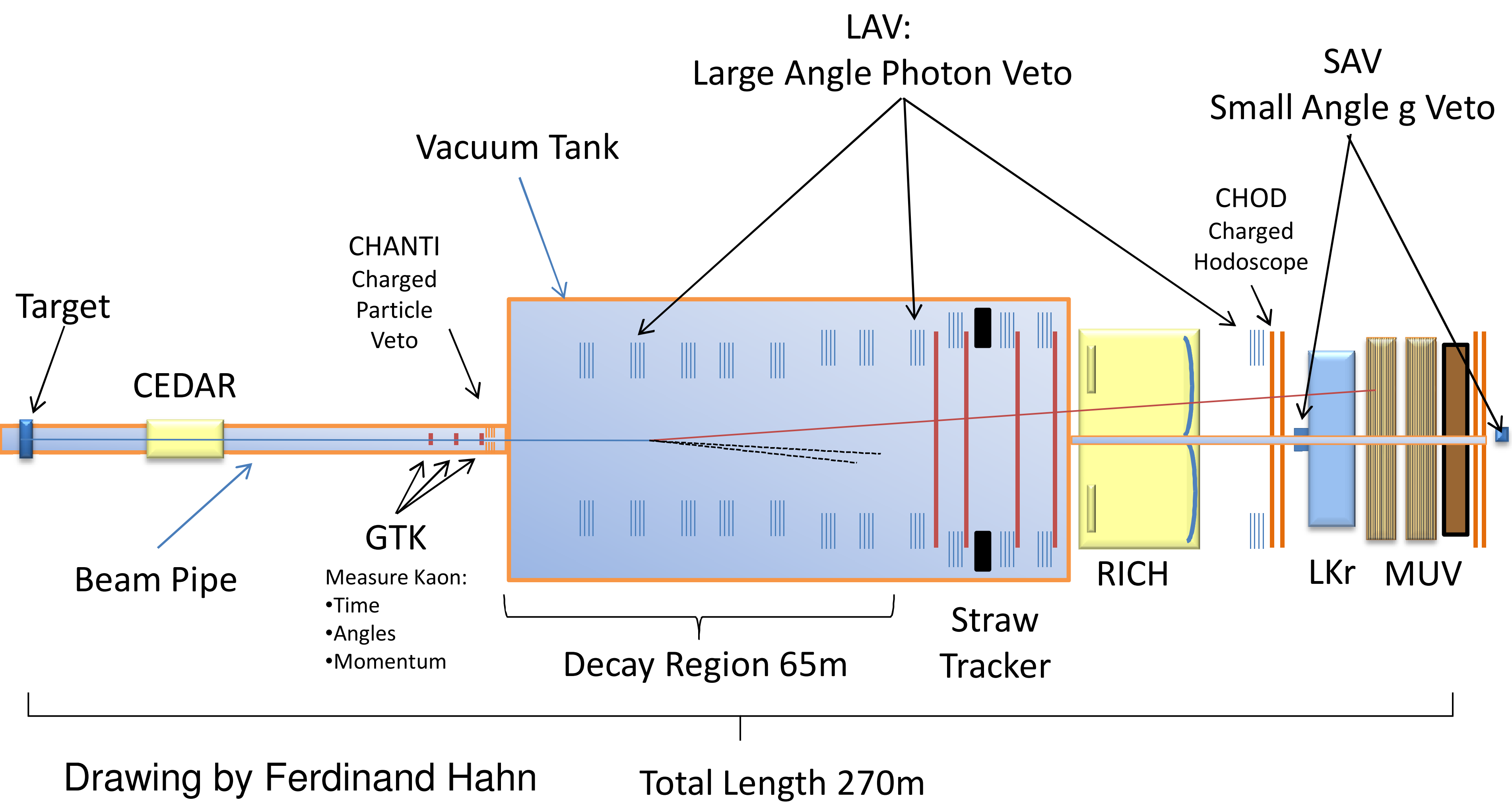
Milestone/Activity	Time Period
Stage One Approval	Fall 2009
DOE Approval of Mission Need (CD-0)	Spring 2010
Approve Alt. Selection/Cost Range (CD-1)	Fall 2010
Baseline Review (CD-2)	End of 2011
Start Construction (CD-3)	Spring 2012
Begin Installation	Mid-2013
First Beam/Beam Tests	End of 2013
Complete Installation	Mid-2014
First Data (CD-4)	End of 2014

Stage-1 approval is necessary to build a strong collaboration, make progress on the design, compete with NA62 (run start mid-2012) and use the Tevatron in stretcher mode.

NA62 @ CERN-SPS



NA62 Detectors



Drawing by Ferdinand Hahn

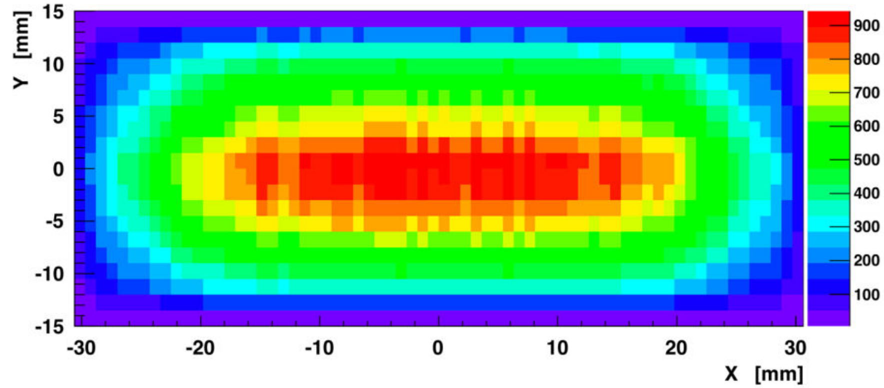
NA62 Sensitivity

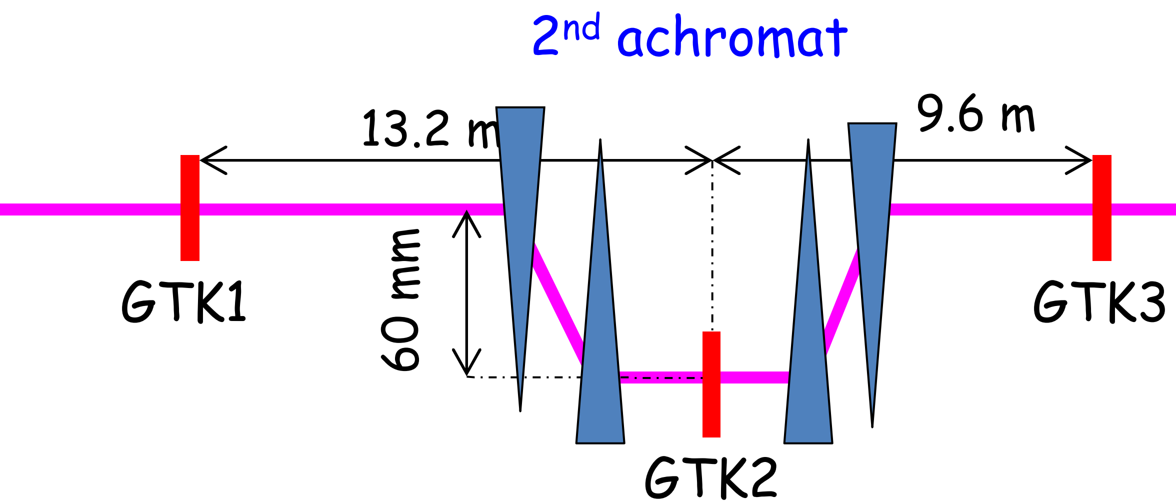
Decay Mode	Events
Signal: $K^+ \to \pi^+ \nu \bar{\nu}$ SM [*flux = 4.8×10^12 decay/year*]	55 *evt/year*
$K^+ \to \pi^+ \pi^0$ [$\eta_{\pi 0} = 2\times10^{-8}$ (3.5×10^{-8})]	4.3% (7.5%)
$K^+ \to \mu^+ \nu$	2.2%
$K^+ \to e^+ \pi^+ \pi^- \nu$	≤3%
Other 3 – track decays	≤1.5%
$K^+ \to \pi^+ \pi^0 \gamma$	~2%
$K^+ \to \mu^+ \nu \gamma$	~0.7%
$K^+ \to e^+ (\mu^+) \pi^0 \nu$, others	negligible
Expected background	≤13.5% (≤17%)

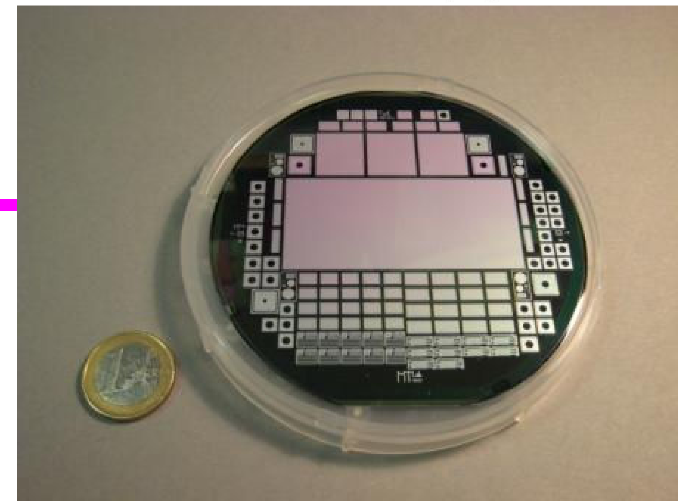
Definition of "year" and running efficiencies based on NA48 experience: ~100 days/year; 60% overall efficiency

NA62 Beam & GTK

SPS primary p: 400 GeV/c
Unsepared beam:
- **75 GeV/c**
- **750 MHz**
- **π/K/p (~6% K^+)**







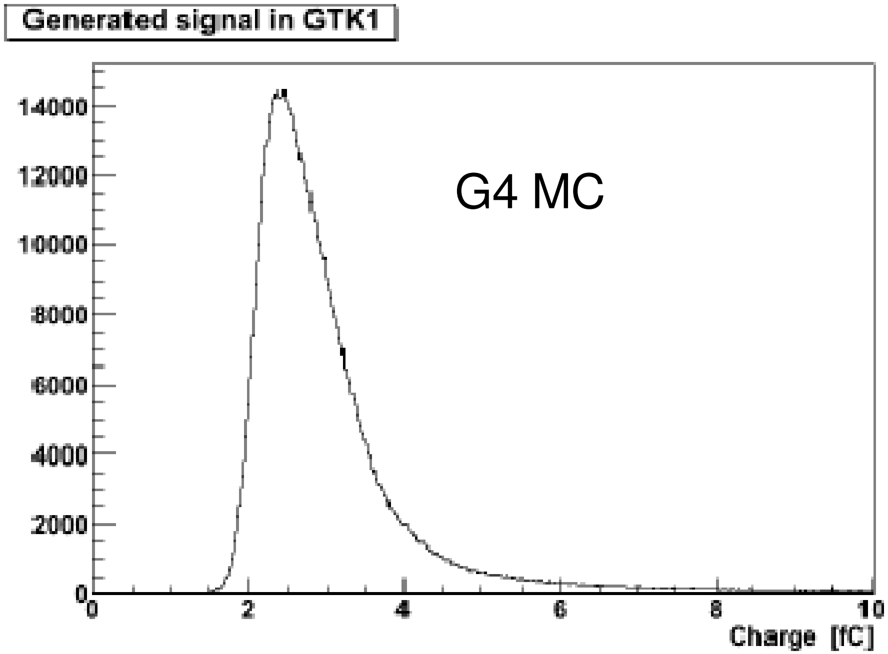
- **Sensitivity is NOT limited by protons flux but by beam (GigaTracKer (GTK))**
- **Similar amount of protons on target as NA48 (~5 10^{12} / pulse)**

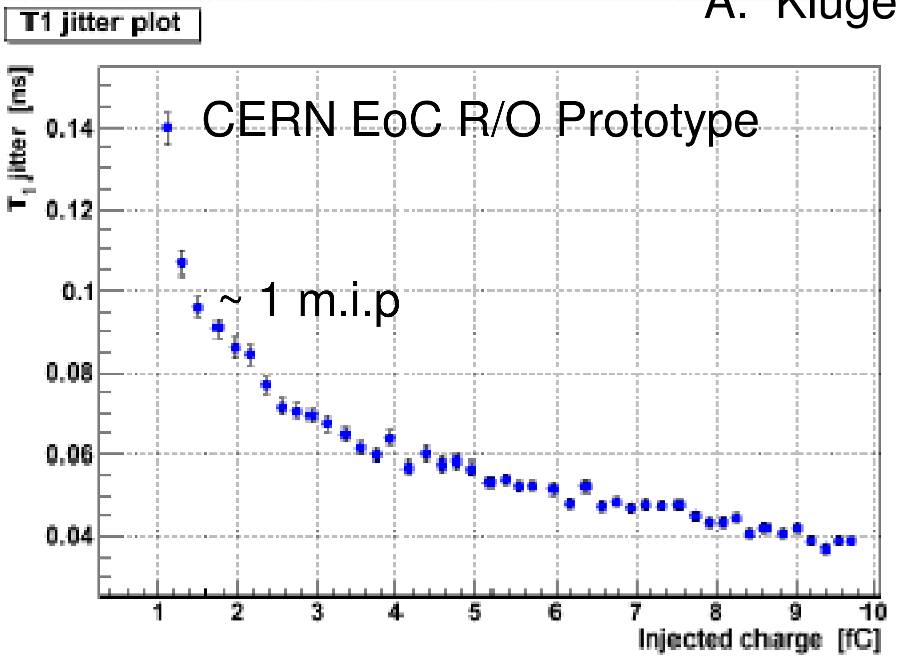
First Results from GTK Tests

M. Fiorini
M. Noy
A. Kluge

Preliminary

Charged weighted time jitter measured with test pulses





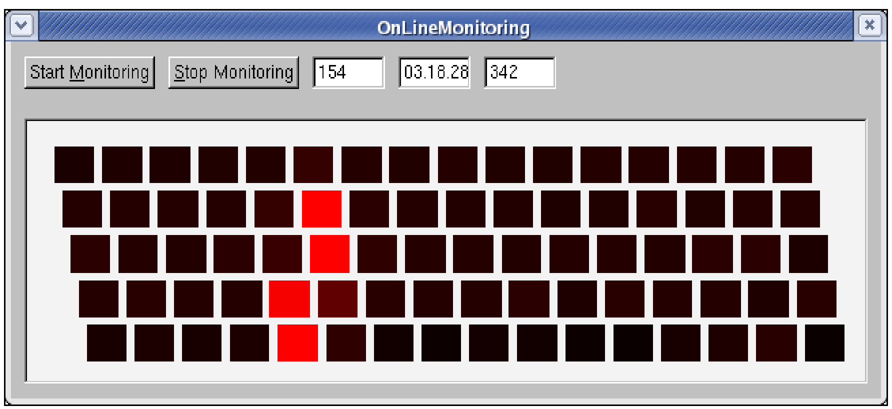
- taking into account the energy distribution of particle hits in the Gigatracker, one can extract a weighted average value for the jitter on T_1

"We come from Research to a working Prototype"

Flavio Marchetto

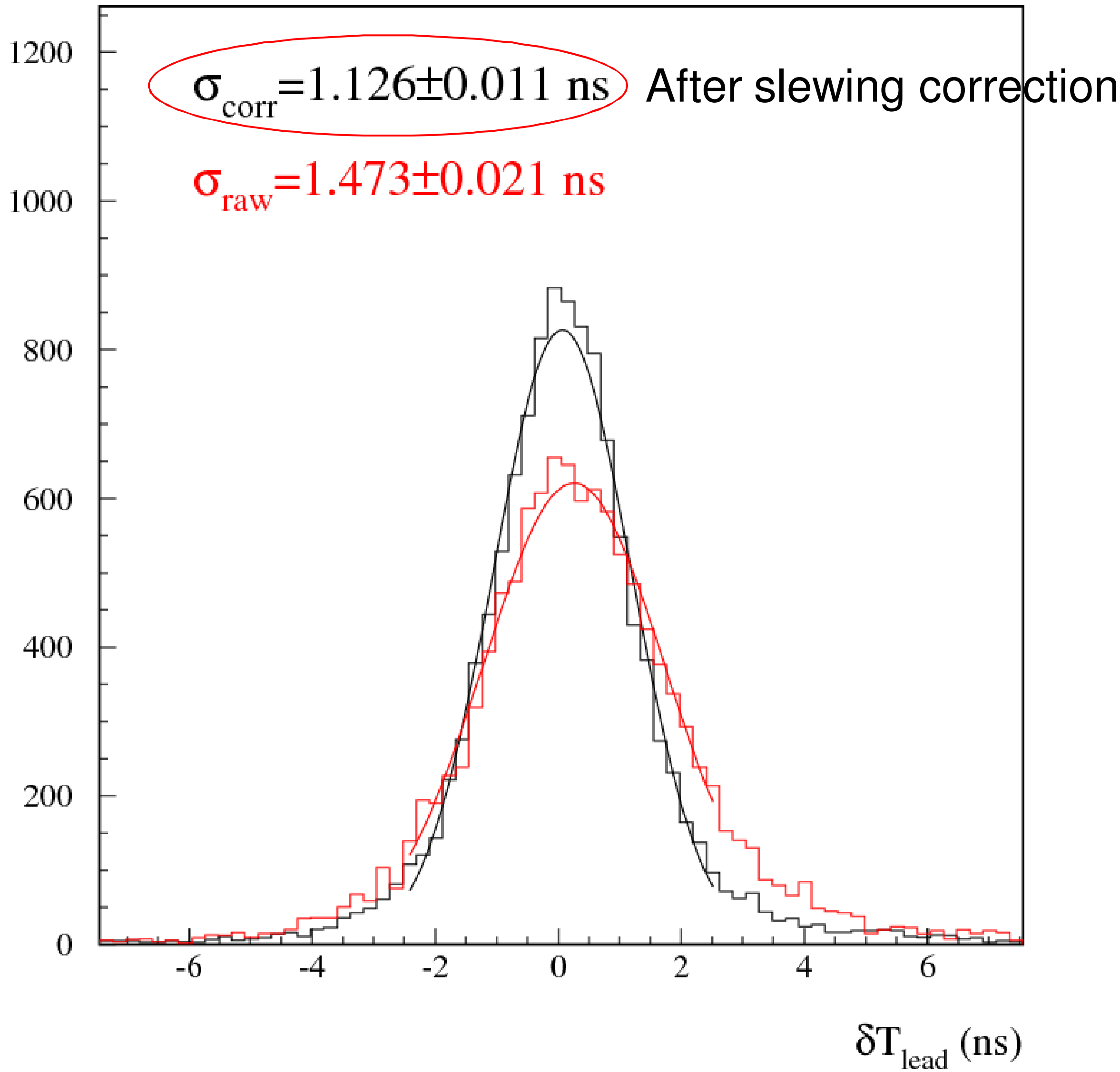
LAV ANTI-A1

- In summer 2009 the first station A1 was built at LNF and shipped to CERN. It is now mounted on the blue tube
- A test beam run with the complete system including prototype front-end electronics (FEE) was performed at the end of October 2009

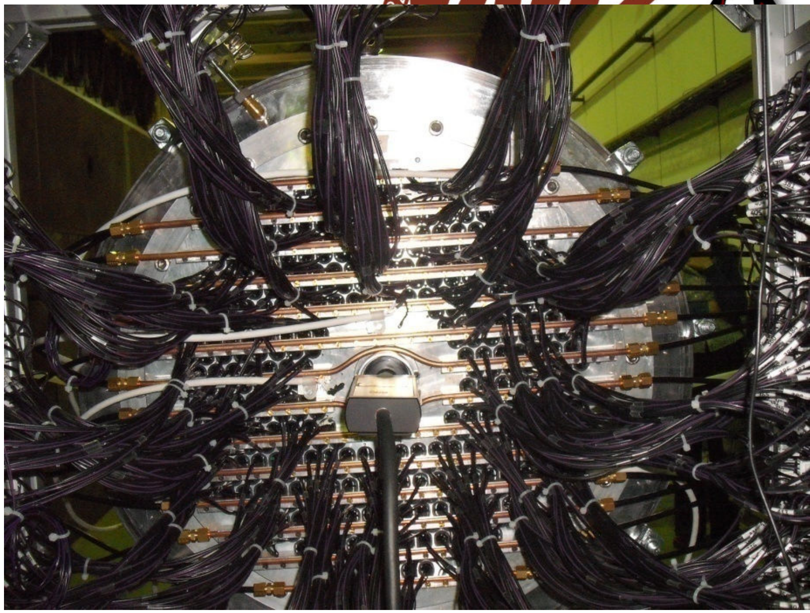


LAV Time resolution

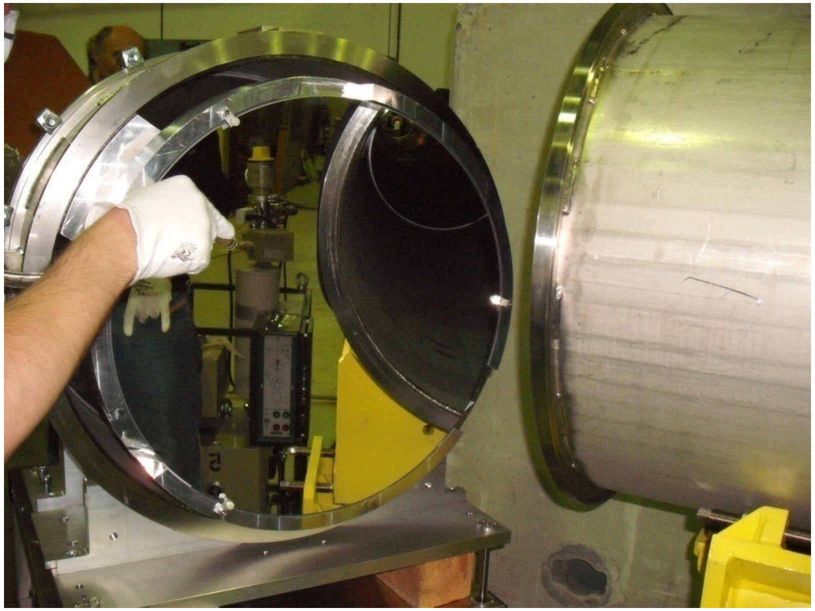
- 4 GeV electrons
- Time differences between two subsequent blocks
- Slewing correction
- Q obtained from time over threshold

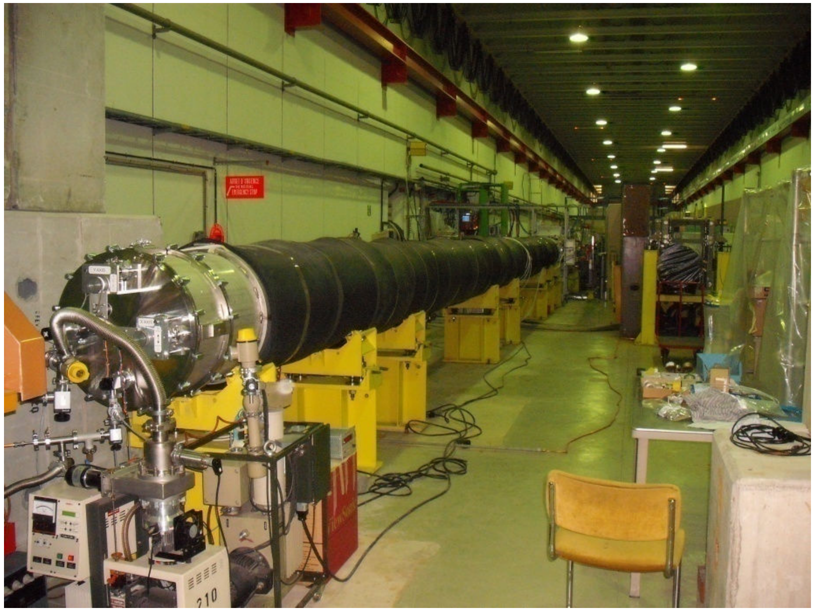


RICH 2009 prototype test beam



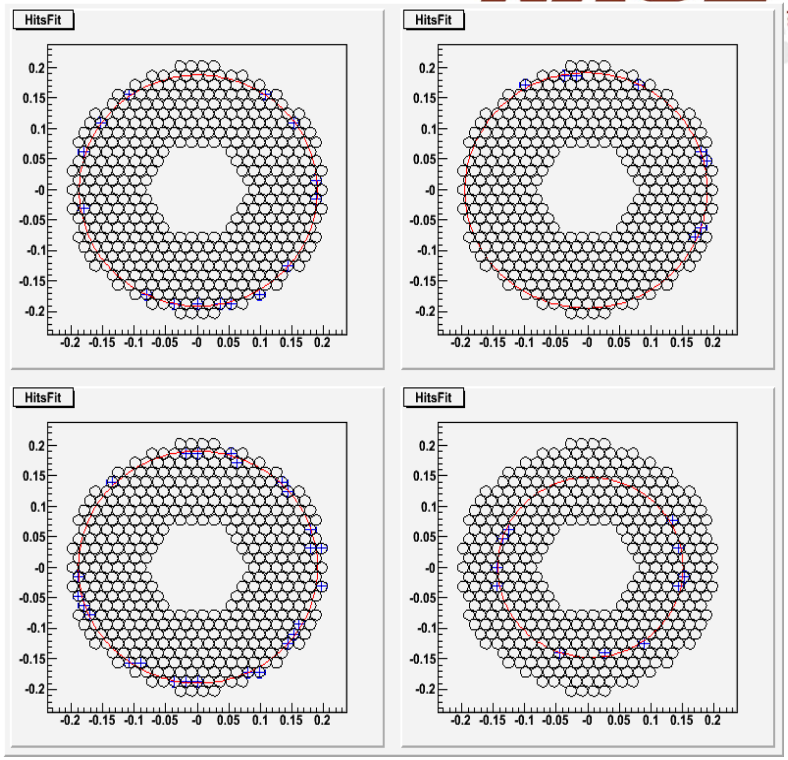
- 12.5.-27.6.2009: test beam
- 1 mirror with f=17m, 50 cm wide
- 414 PMT + full electronics chain



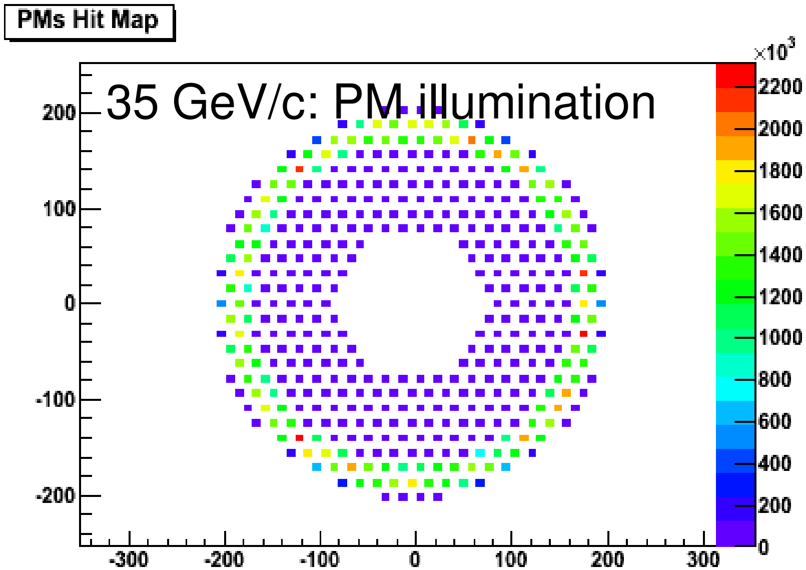


2009 test beam

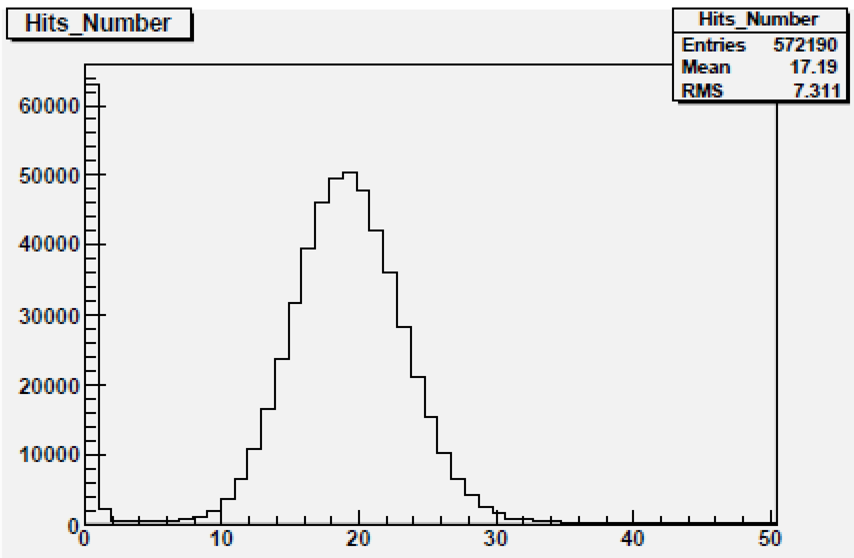
20 GeV/c: 3 positrons and 1 pion events



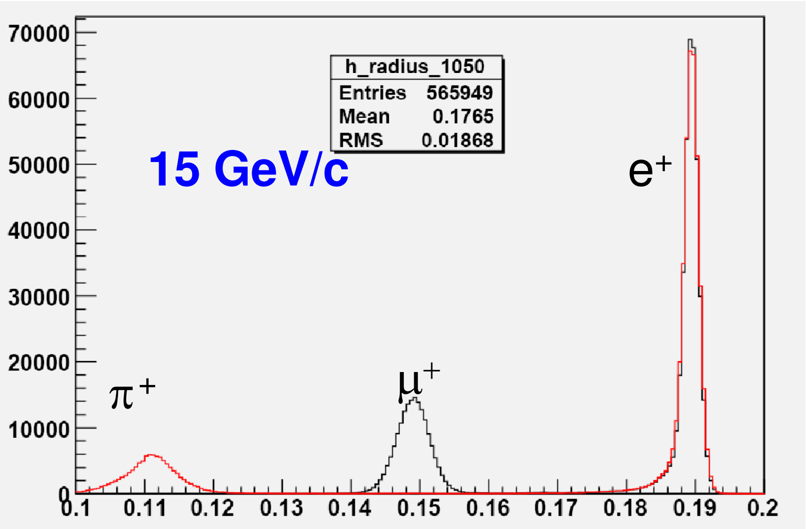
35 GeV/c: PM illumination

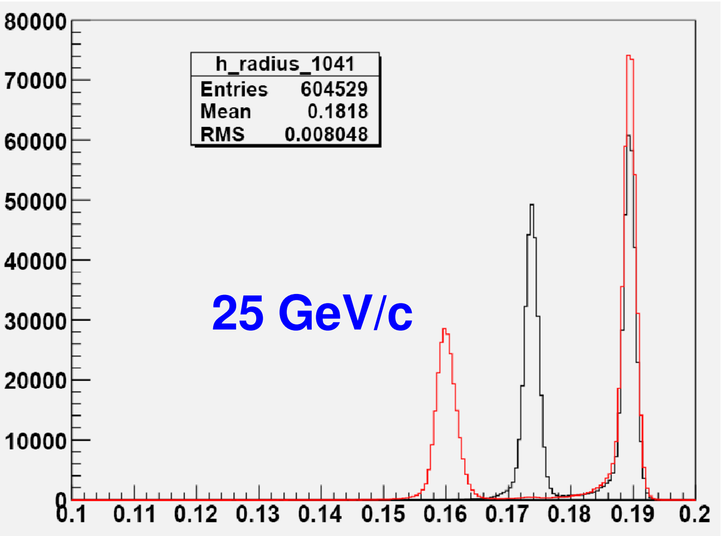


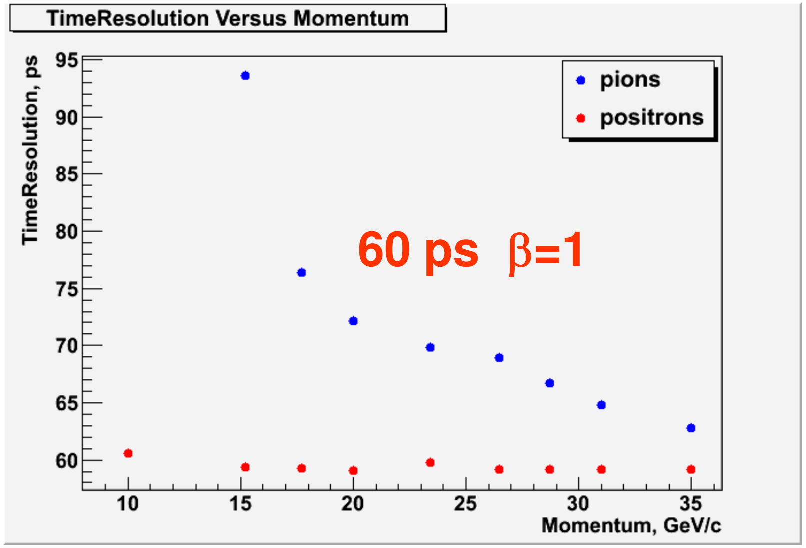
N. of hits per event at 35 GeV/c

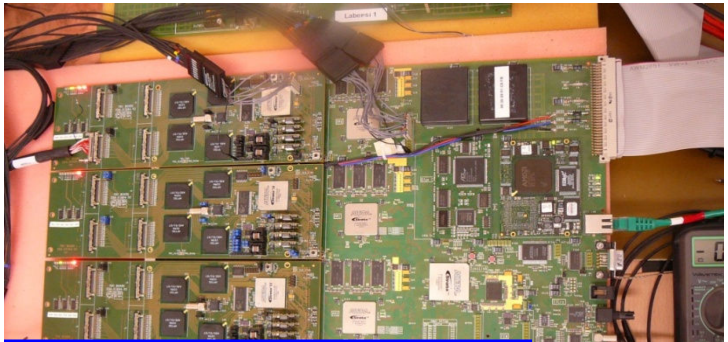


RICH Test, June 2009, Preliminary



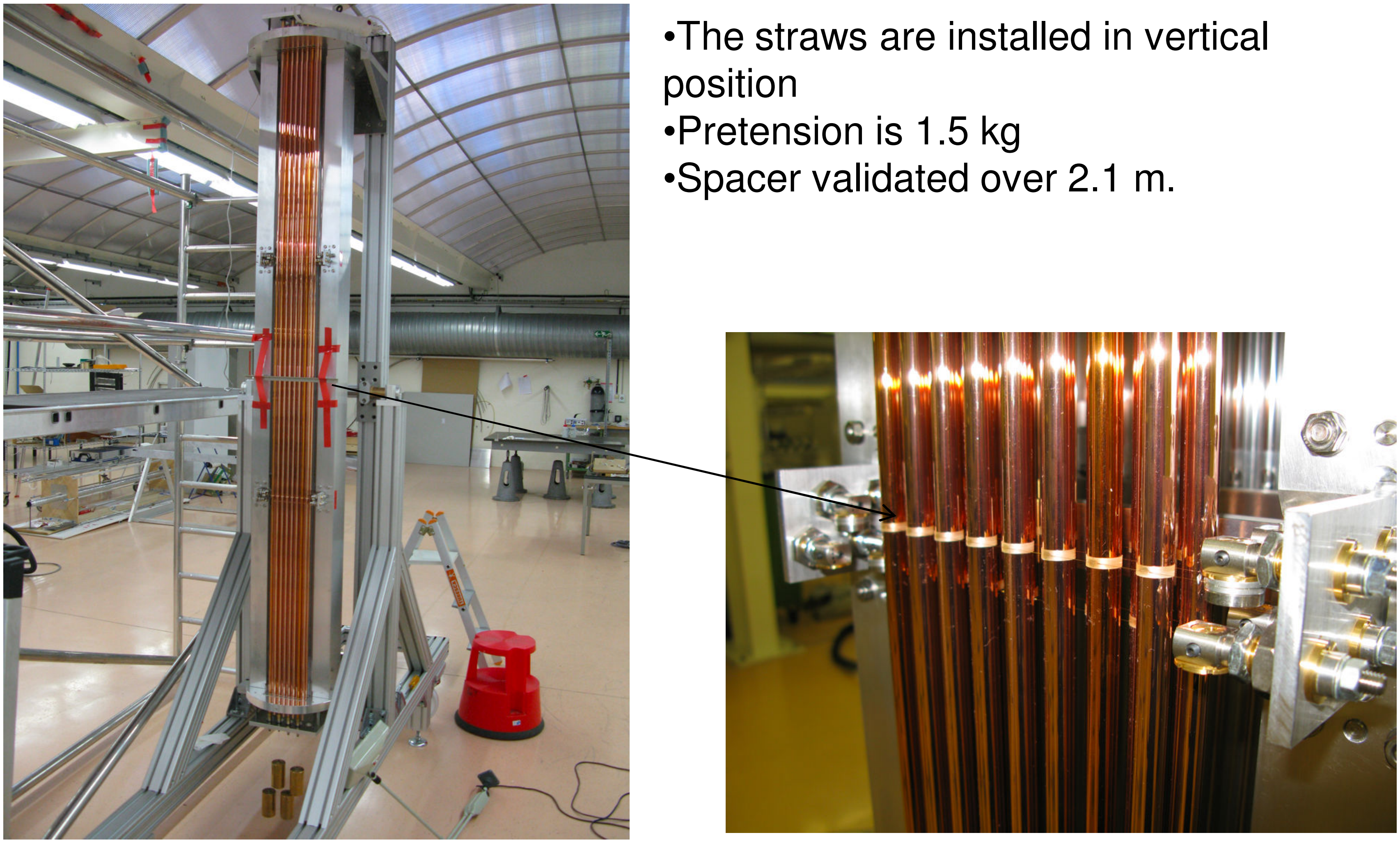






PM=Hamamtsu R7400-03
FE= preampl+Nino card
R/O=TELL1 fully equipped with HPTDCs (1 card = 512 channels)

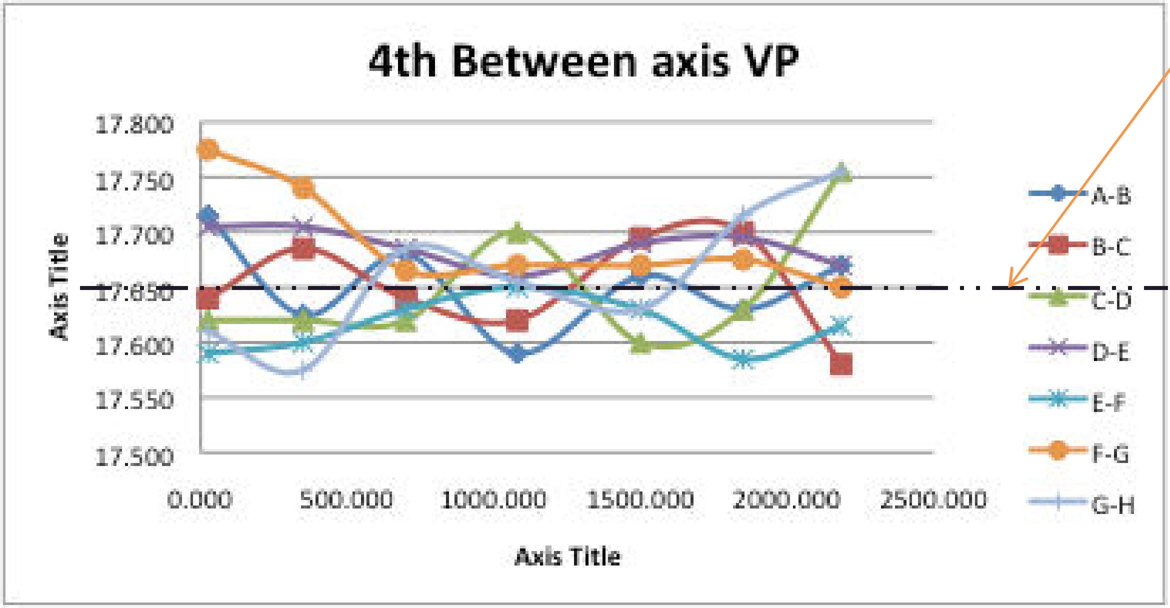
64 Straw technology Prototype

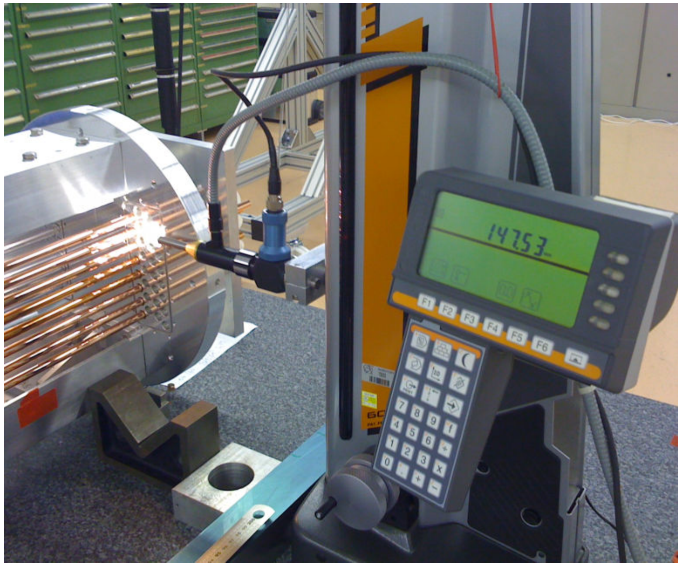


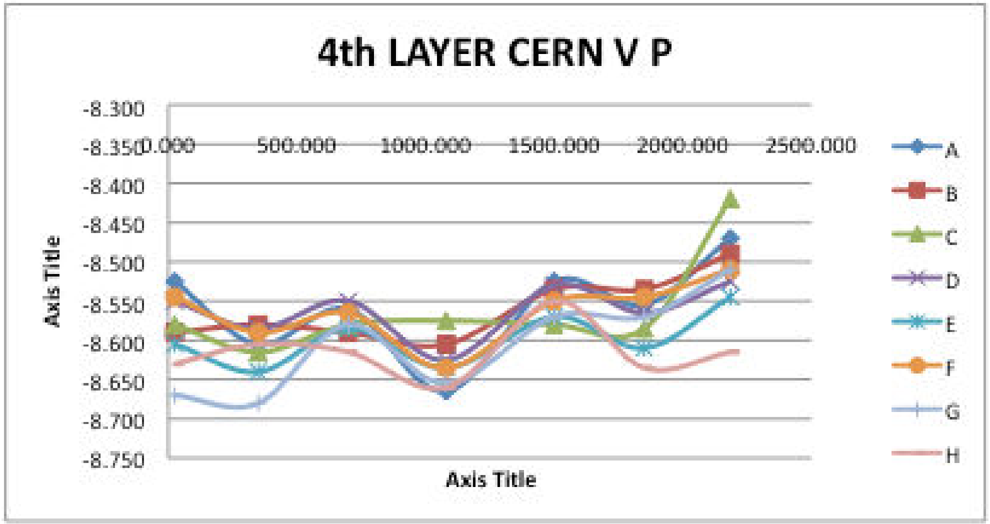
- The straws are installed in vertical position
- Pretension is 1.5 kg
- Spacer validated over 2.1 m.

Straw straightness

Nominal

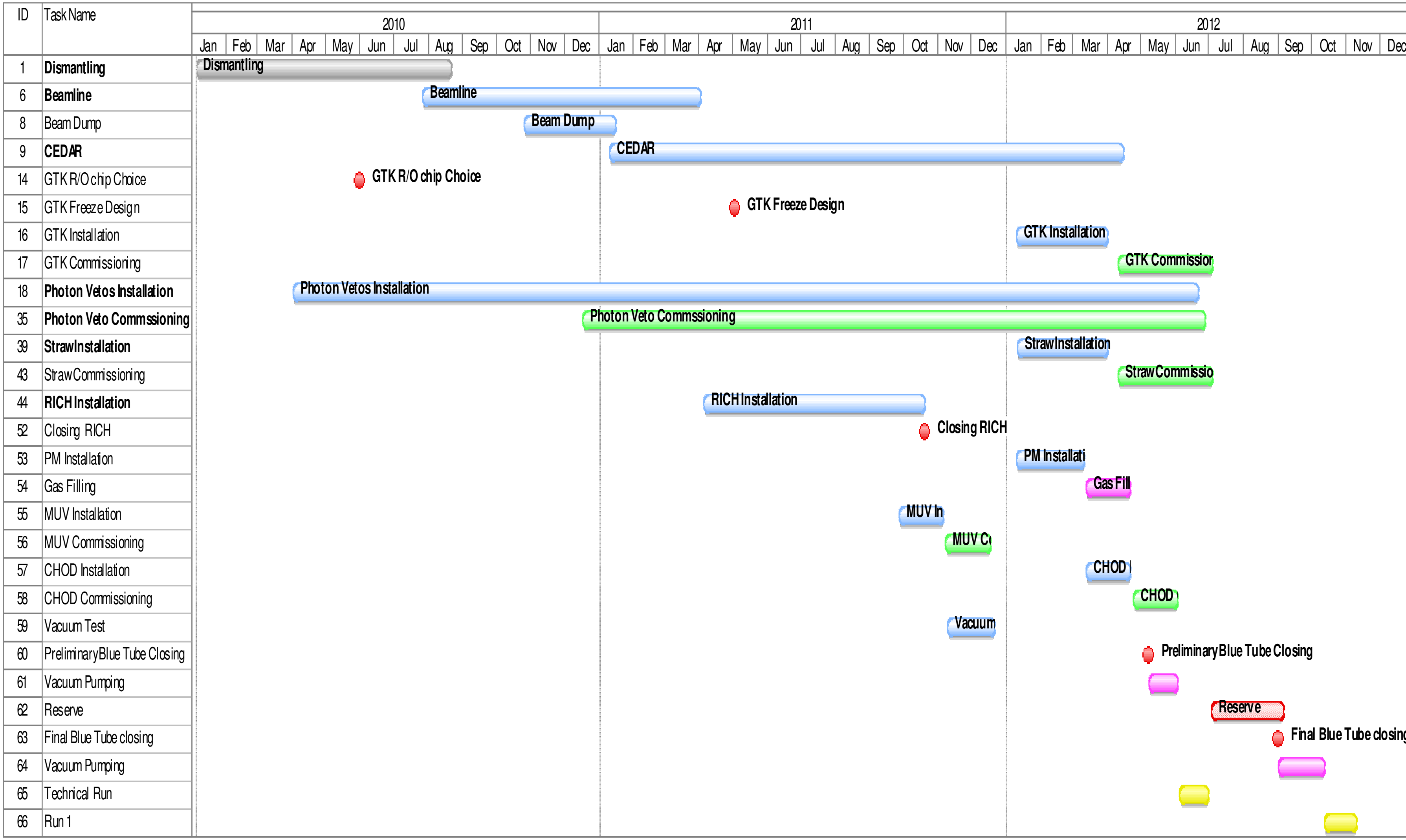






ECN3 Installation Planning

Preliminary (by Ferdinand Hahn)

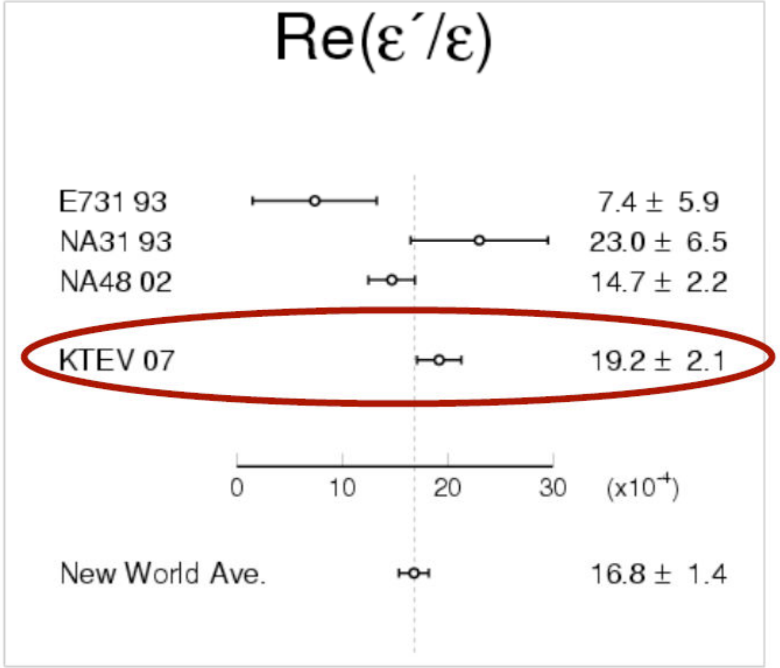


Some 2009 Experimental "Highlights" in Kaon Physics

- ε'/ε (KTeV, full sample) measurement
- Tests of Lepton Universality in leptonic decays
- Precise results of $\pi\pi$ S-wave Scattering Lengths from 3π and Ke4 decays (NA48/2)
- Updated determination of V_{us} from semi-leptonic decays

Ed Blucher @KAON09

KTeV Result: $\mathrm{Re}(\varepsilon'/\varepsilon) = [19.2 \pm 1.1(\mathrm{stat}) \pm 1.8(\mathrm{syst})] \times 10^{-4}$
$= (19.2 \pm 2.1) \times 10^{-4}$

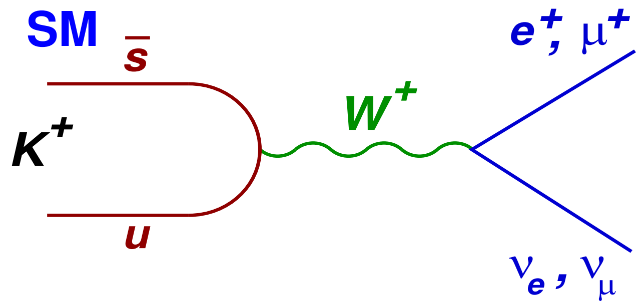


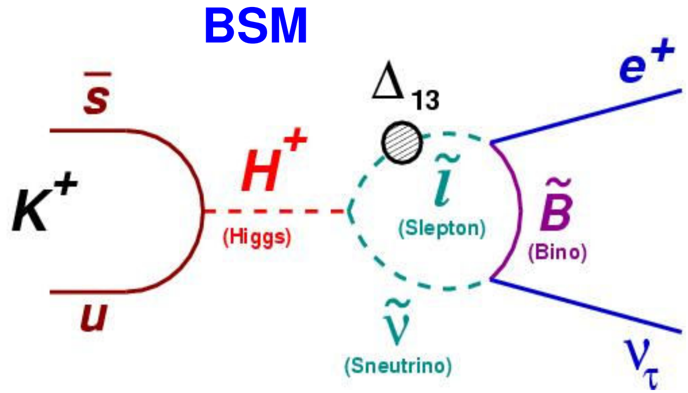
World average:
$\mathrm{Re}(\varepsilon'/\varepsilon) = (16.8 \pm 1.4) \times 10^{-4}$
(confidence level = 13%)

(KTeV 2003: $\mathrm{Re}(\varepsilon'/\varepsilon) = [20.7 \pm 1.5(\mathrm{stat}) \pm 2.4\ (\mathrm{syst})] \times 10^{-4}$)

R_K: Lepton Universality Test with $K^+ \to l^+ \nu$ Decays at CERN NA62 First NA62 Result*

New Result presented by Evgueni Goudzovski @ KAON09

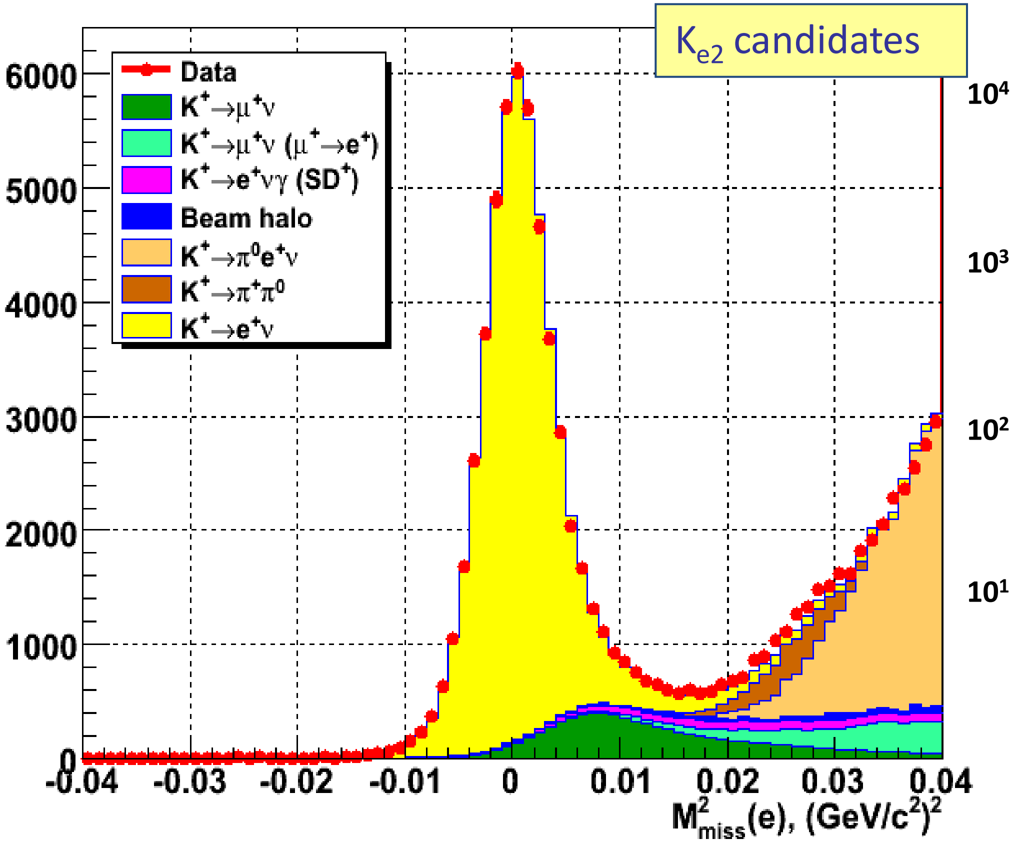




$$R_K = \frac{\Gamma(K^\pm \to e^\pm \nu)}{\Gamma(K^\pm \to \mu^\pm \nu)} = \frac{m_e^2}{m_\mu^2} \cdot \left(\frac{m_K^2 - m_e^2}{m_K^2 - m_\mu^2}\right)^2 \cdot (1 + \delta R_K^{rad.corr.})$$

* **New Collaboration practicing with single-track final states with old setup**

K_{e2}: 40% of data set



51,089 $K^+\to e^+\nu$ candidates,
99.2% electron ID efficiency,

Backgrounds:

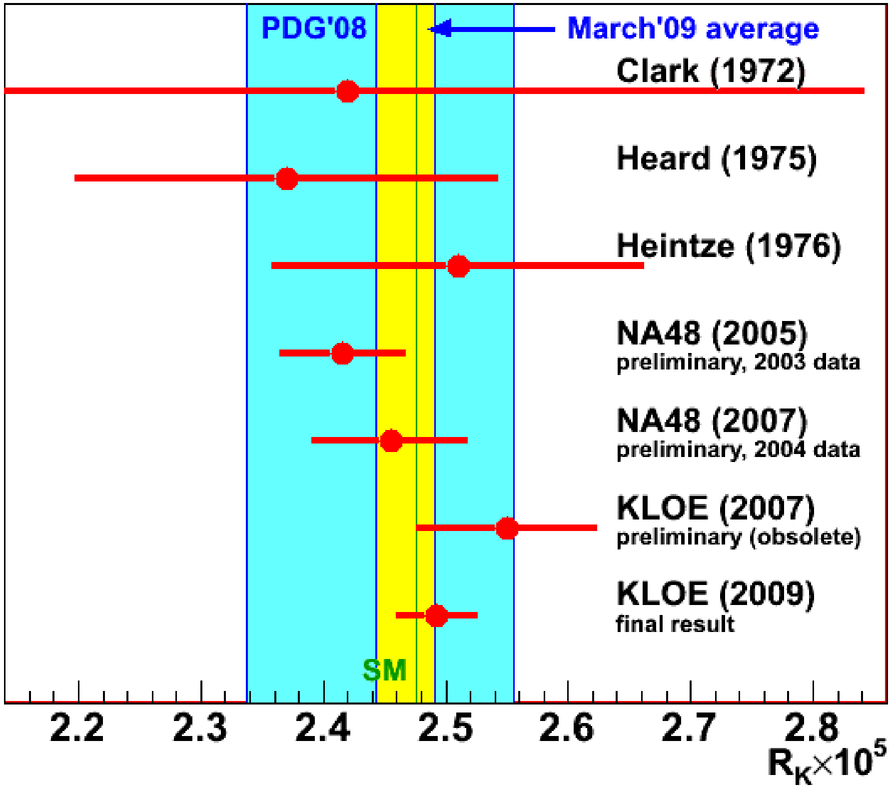
Source	B/(S+B)
$K_{\mu 2}$	$(6.28\pm0.17)\%$
$K_{\mu 2}$ ($\mu\to e$)	$(0.23\pm0.01)\%$
$K_{e2\gamma}$ (SD$^+$)	$(1.02\pm0.15)\%$
Beam halo	$(0.45\pm0.04)\%$
K_{e3}	0.03%
$K_{2\pi}$	0.03%
Total	$(8.03\pm0.23)\%$

$$R_K = (2.500 \pm 0.012_{stat} \pm 0.011_{syst}) \times 10^{-5}$$

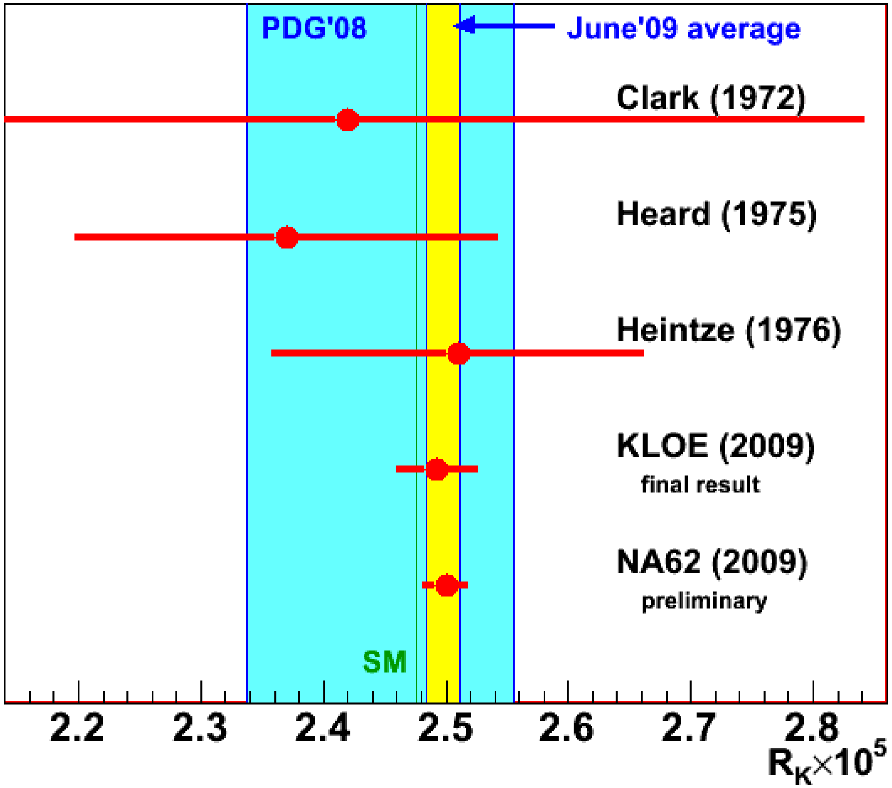
$$R_K = (2.500 \pm 0.016) \times 10^{-5}$$

Comparison to world data

March 2009



June 2009



World average	$\delta R_K \times 10^5$	Precision
March 2009	2.467 ± 0.024	0.97%
June 2009	2.498 ± 0.014	0.56%

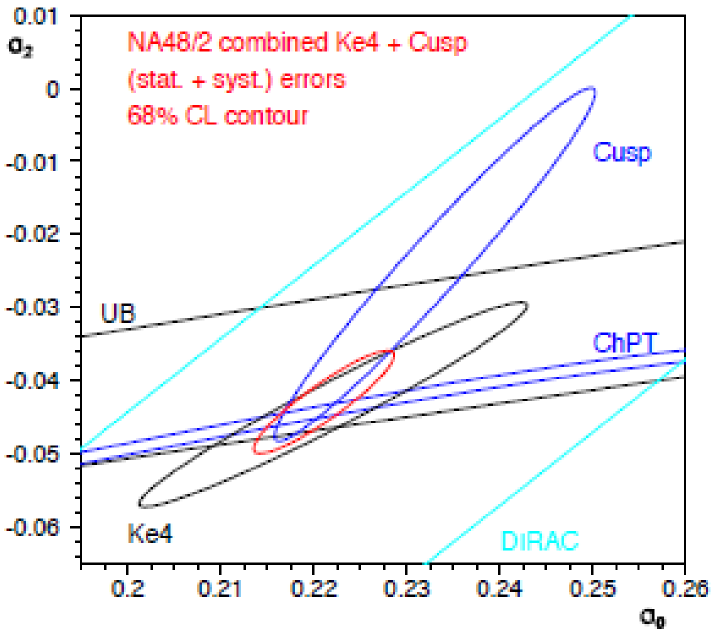
With the full NA62 data sample of 2007/08, the precision is expected to be improved to better than $\delta K_R/R_K = 0.5\%$.

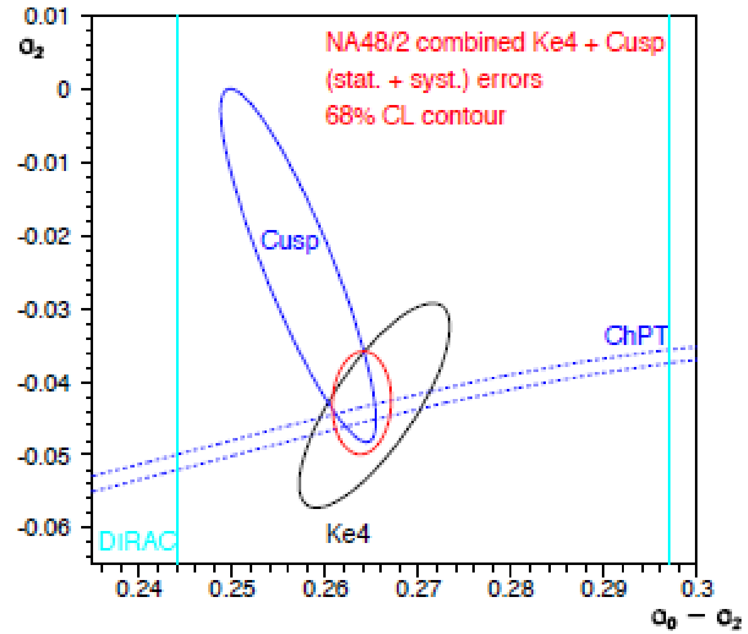
Full Sample NA48/2 Results on $\pi\pi$ scattering

- Completion of the cusp analyses:
  - arXiv 0912.2165 (DOI 10.1140/epjc/s10052-009-1171-3)
- Form factors and $\pi\pi$ scattering from Ke4 (KAON09)

ππ Scattering Lengths from Ke4 Decays

Combination of Ke4 and cusp measurements:





$a_0 = 0.2210\ (47)\ (15)$

$a_2 = -0.0429\ (44)\ (16)$

stat. syst.

$a_0 - a_2 = 0.2639\ (20)\ (4)$

$a_2 = -0.0429\ (44)\ (16)$

stat. syst.

With ChPT constraint:

$a_0 = 0.2196\ (27)\ (21)$

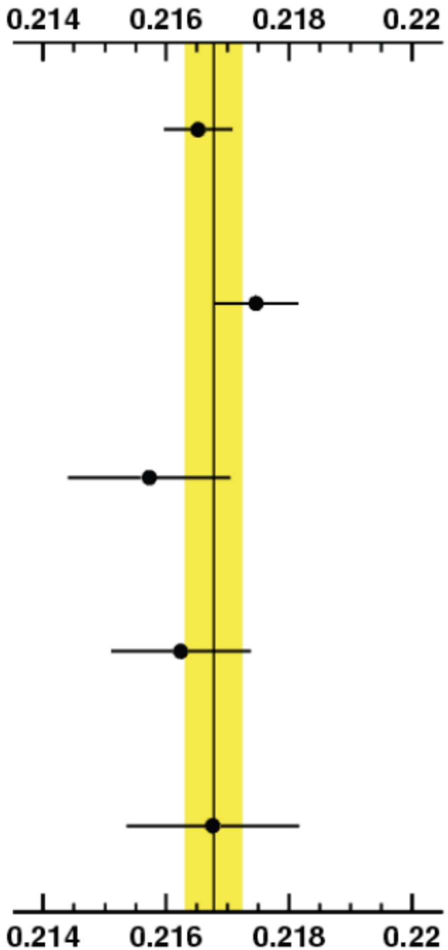
$a_2 = -0.0444\ (7)\ (5)$

ChPT prediction:

$a_0 = 0.220 \pm 0.005$

$a_2 = -0.0444 \pm 0.0010$

$|V_{us}|f_+(0)$ from K_{l3} data



M. Palutan @ KAON09

			Approx. contrib. to % err from:			
		% err	**BR**	**τ**	**Δ**	**Int**
K_Le3	**0.21652(56)**	**0.25**	0.11	**0.20**	0.11	0.10
$K_L\mu3$	**0.21746(69)**	**0.32**	0.17	**0.19**	0.11	0.15
K_Se3	**0.21572(132)**	**0.61**	**0.60**	0.03	0.11	0.10
$K^{\pm}e3$	**0.21624(113)**	**0.52**	**0.31**	0.06	**0.41**	0.09
$K^{\pm}\mu3$	**0.21676(141)**	**0.65**	**0.48**	0.06	**0.41**	0.15

Average: $|V_{us}|\,f_+(0)$ = 0.21660(47) **χ^2/ndf = 3.03/4 (55%)**

KLOE-2 at upgraded DAΦNE

Upgrade of DAΦNE in luminosity:

Crabbed waist scheme at DAΦNE (proposal by P. Raimondi)

- increase L by a factor *O*(5)
- requires minor modifications
- relatively low cost

- Successful experimental test at DAΦNE

KLOE-2 Plan:

- phase 0: KLOE restart taking data end 2009 with a minimal upgrade (L~5 fb^{-1})
- phase 1: full KLOE upgrade (KLOE-2) > 2011 (L>20 fb^{-1})

Physics issues:

- Neutral kaon interferometry, CPT symmetry & QM tests
- Kaon physics, CKM, LFV, rare K_S decays
- Dark matter
- η,η′ physics
- Light scalars, γγ physics
- Hadron cross section at low energy, muon anomaly

Detector upgrade issues:

- Inner tracker R&D
- γγ tagging system
- FEE maintenance and upgrade
- Computing and networking update
- etc.. (Trigger, software, ...)

Branchini @ KAON09

$|V_{us}|f_+(0)$: KLOE+Step0+WA

$$\Gamma(K_{l3(\gamma)}) = \frac{C_K^2 G_F^2 M_K^5}{192\pi^3} S_{EW} |V_{us}|^2 |f_+^{K^0\pi^-}(0)|^2 I_{K\ell}(\lambda_{+,0}) (1+\delta^K_{SU(2)}+\delta^{K\ell}_{em})^2$$

Approx. contr. to % err from:

		% err	BR	τ	δ	$I_{K\ell}$
K_Le3	0.2155(4)	0.21	0.09	0.13	0.11	0.09
$K_L\mu3$	0.2167(5)	0.25	0.10	0.13	0.11	0.15
K_Se3	0.2153(7)	0.33	0.30	0.03	0.11	0.09
$K^\pm e3$	0.2152(8)	0.38	0.25	0.12	0.25	0.09
$K^\pm\mu3$	0.2132(9)	0.42	0.27	0.12	0.25	0.15

Branchini @ KAON09

Fractional error on $|V_{us}|f_+(0)$ is 0.14%

World Average is 0.23%

Summary

- A World-Wide endeavor to corner the Standard Model in ultra-rare decays (CERN, J-PARC, possibly FNAL) is in place
- The Theory-Experiment interplay is pushing precision tests (e.g. V_{us}, Ke2) towards the ~0.1 % precision
- There is a stream of results coming from last round of experiments….
- ….and new data are expected from OKA (Protvino) and KLOE (Frascati) very soon
- The interplay between Collider and Flavor Physics is alive and kicking

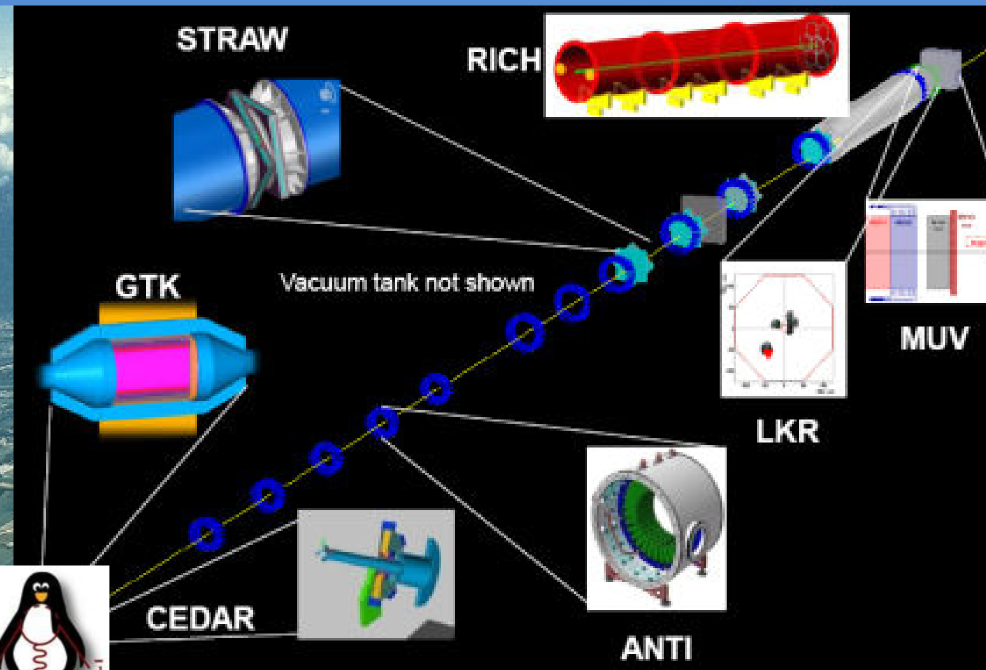
Spare Material

NA62 Physics Handbook

CERN, December 10-11, 2009

Advisory Committee:

Gerhard Buchalla
Andrzej Buras
Nicola Cabibbo
Vincenzo Cirigliano
Gerhard Ecker
Jonathan R. Ellis
Jean-Marc Gérard
Gino Isidori
Marc Knecht
Heinrich Leutwyler
Bill Marciano
Helmut Neufeld
Antonio Pich
Jorge Portoles
Eduardo de Rafael
Chris Sachrajda
Lalit Sehgal



Kaons @ CERN SPS, Topics:

- Rare Decays
- Radiative Decays
- Forbidden Decays & LFV tests
- (Semi)-Leptonic Decays
- Hadronic decays, $\pi\pi$ phases

Program Committee:

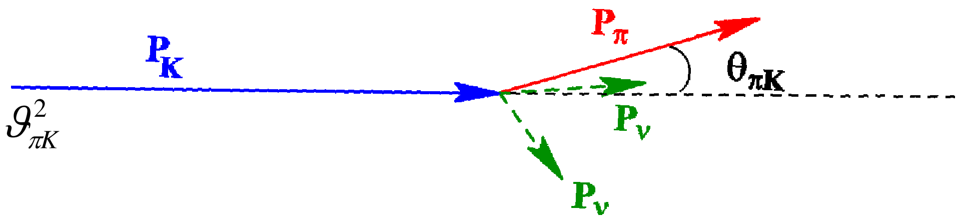
Johan Bijnens
Augusto Ceccucci
Patrizia Cenci
Gilberto Colangelo
Giancarlo D'Ambrosio
Martin Gorbahn
Ulrich Haisch
Federico Mescia
Matthew Moulson
Paride Paradisi
Christopher Smith

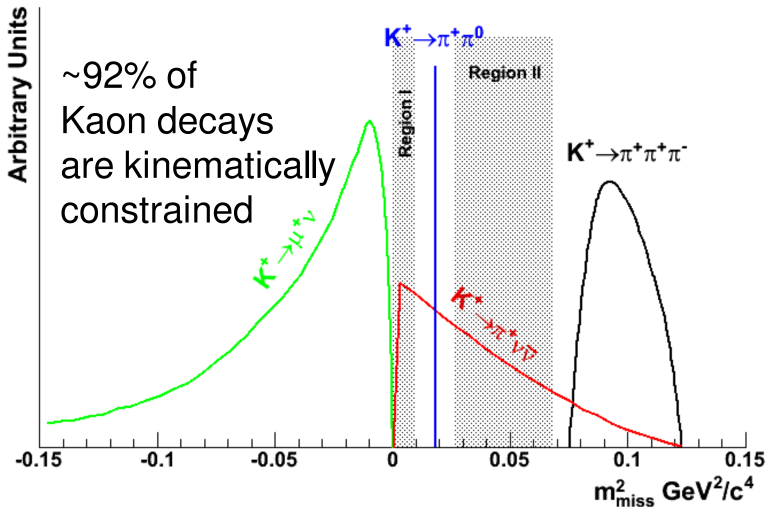
Secretariat: veronique.wedlake@cern.ch

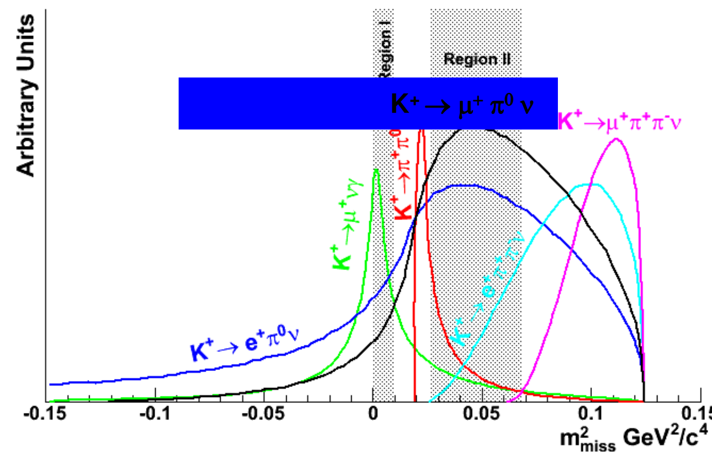
http://na62pb.ph.tum.de/

NA62 Experimental Method

$$m^2_{miss} \approx m^2_K\left(1-\frac{|P_\pi|}{|P_K|}\right)+m^2_\pi\left(1-\frac{|P_K|}{|P_\pi|}\right)-|P_K||P_\pi|\vartheta^2_{\pi K}$$

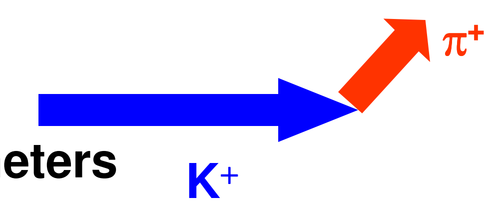






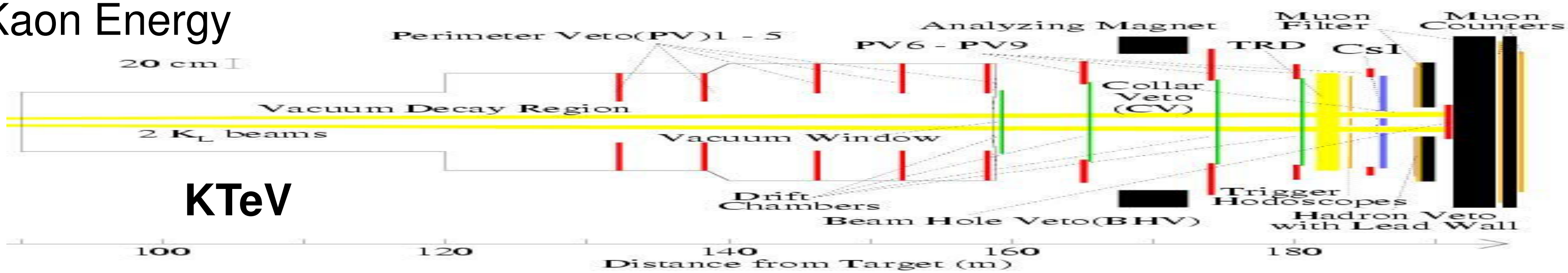
Signature:

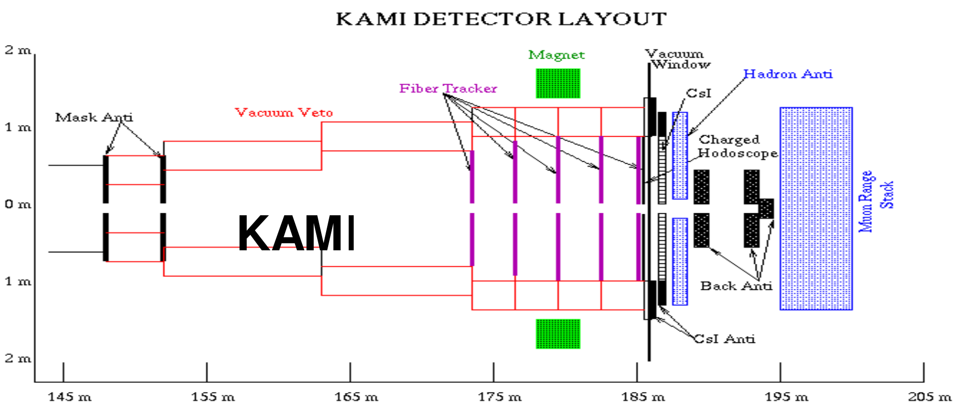
- **Incoming high momentum (75 GeV/c) K^+**
- **Outgoing low momentum (< 35 GeV/c) π^+**
- **For $K_{\pi 2}$ $P(\pi^0)$ > 40 GeV/c deposited in calorimeters**
- **PID: CEDAR (π/K), RICH (π/μ), MUV (μ), E/P (e/π)**

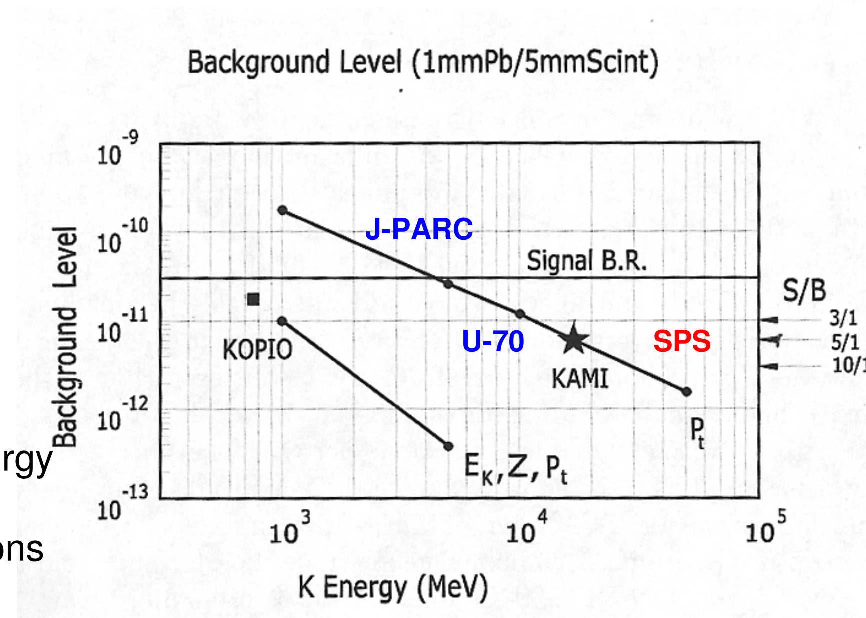


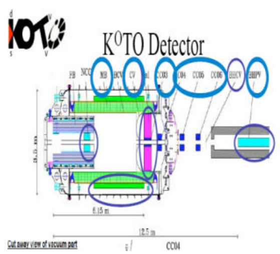
K^0_L Pencil: E_K vs Length

Increasing Kaon Energy









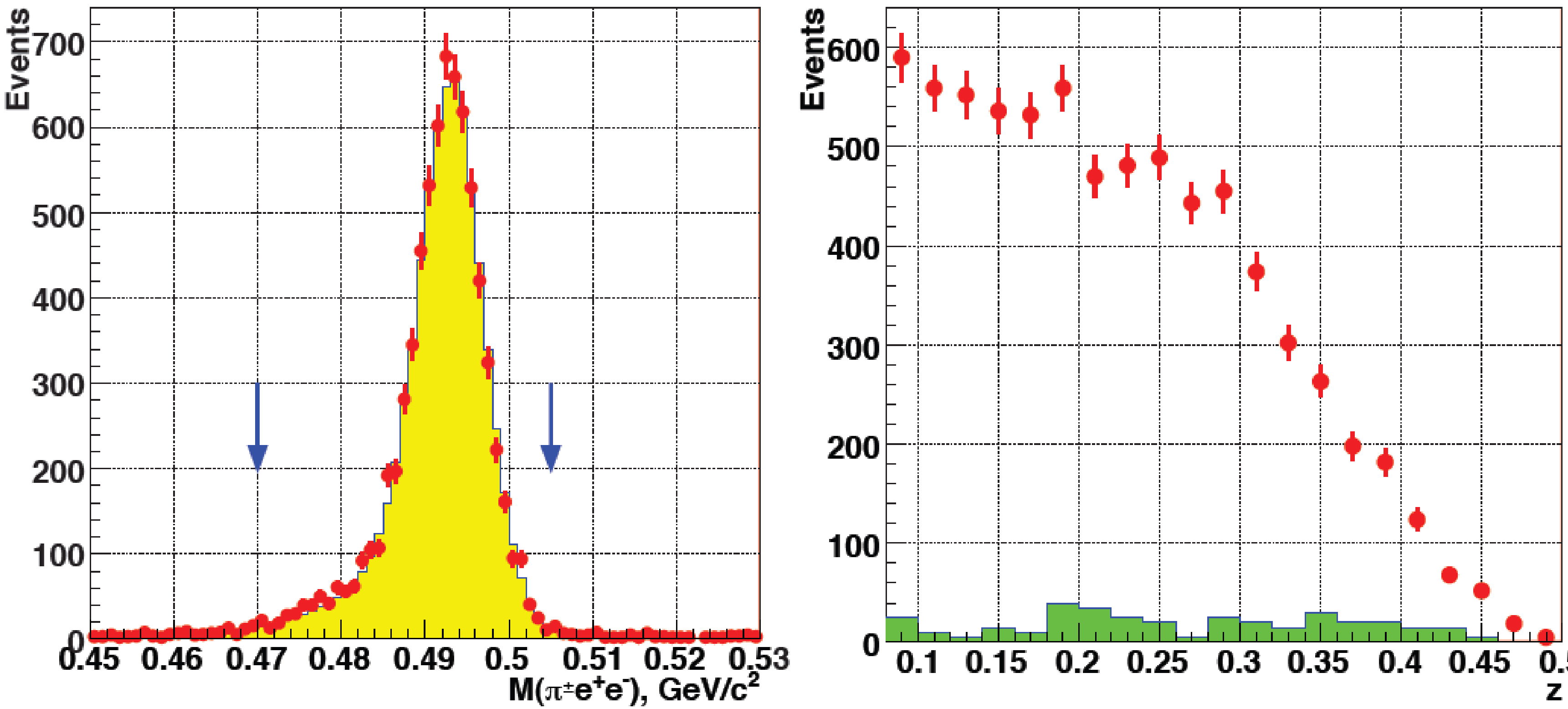
KOTO

Trade-off between higher Kaon Energy for better background suppression and (longitudinal) detector dimensions

(c.f. KAMI proposal)

Experiment Length

Precise Measurement of $K^{\pm} \to \pi^{\pm} e^{+} e^{-}$

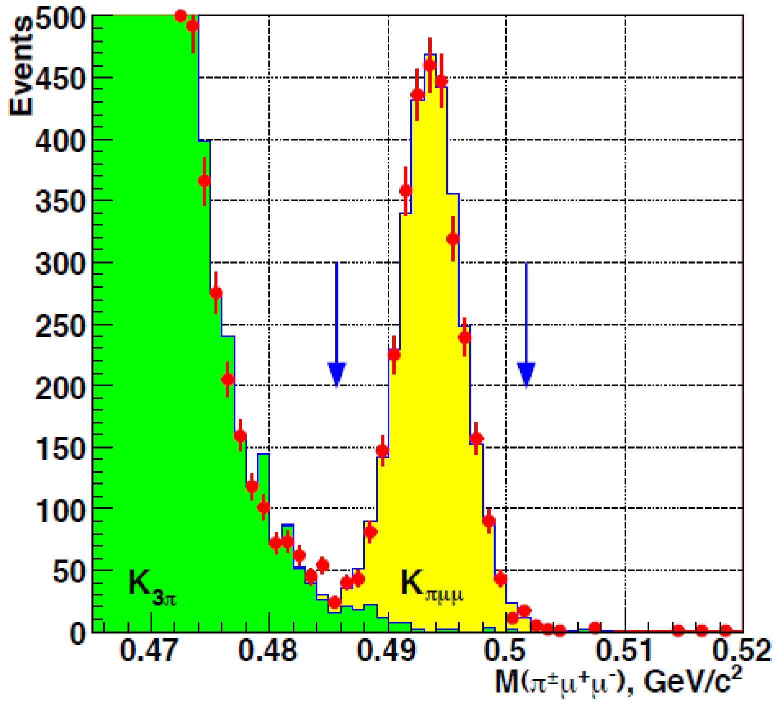


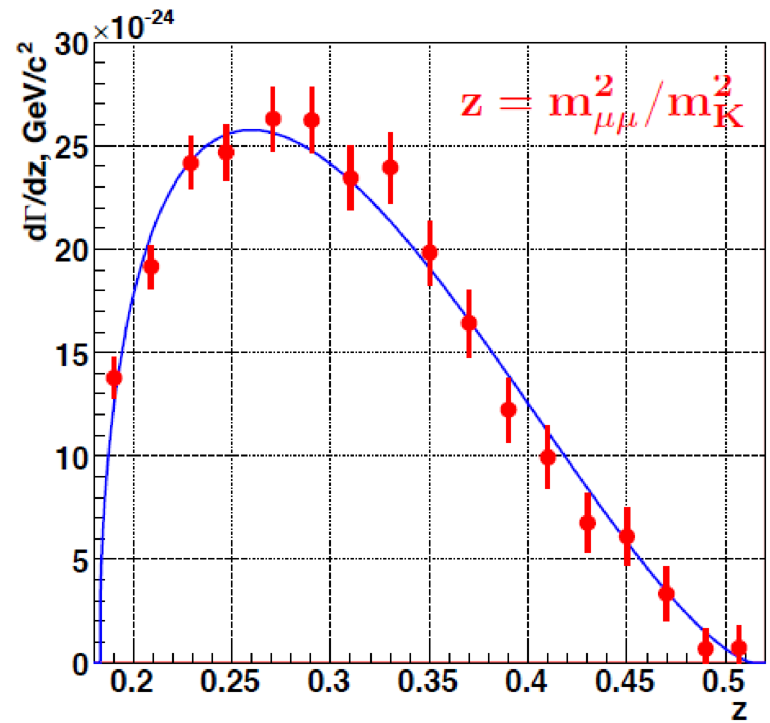
(PLB 677 (2009) 246)

$$\mathrm{Br}(K^{\pm} \to \pi^{\pm} e^{+} e^{-}) = 3.11\,(4)_{\mathrm{stat}}\,(5)_{\mathrm{syst}}\,(8)_{\mathrm{ext}}\,(7)_{\mathrm{model}} \times 10^{-7}$$

Also limit on direct CP violation: $\frac{\mathrm{Br}^{+} - \mathrm{Br}^{-}}{\mathrm{Br}^{+} + \mathrm{Br}^{-}} = (-2.1 \pm 1.5 \pm 0.6)\%$

Measurement of $K^{\pm}\rightarrow\pi^{\pm}\mu^{+}\mu^{-}$





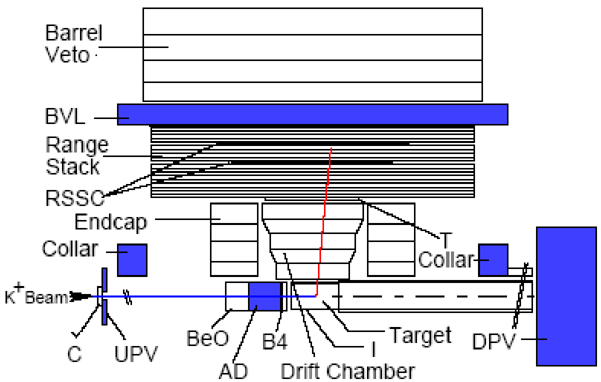
<u>Whole NA48/2 data set:</u> **3120 $K^{\pm}\rightarrow\pi^{\pm}\mu^{+}\mu^{-}$ candidates**

(World largest data sample)

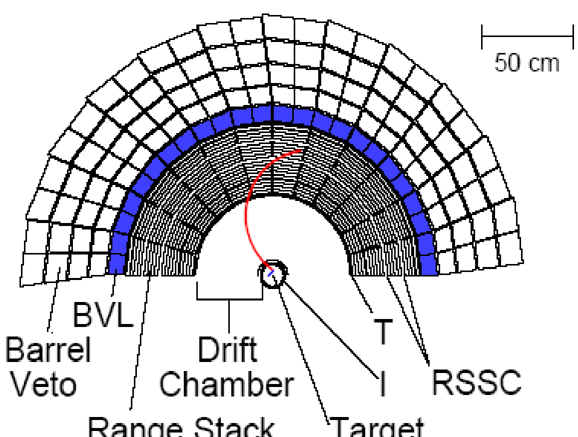
$Br(K^{\pm}\rightarrow\pi^{\pm}\mu^{+}\mu^{-}) = (9.6 \pm 0.2 \pm 0.1) \times 10^{-8}$

E787/E949: "Extreme Beam"

"The entire AGS beam of 65 x 10^{12} (Tp/ spill) at a momentum of 21.5 GeV/c was delivered to the E949 K^+ production target"



- Duty Factor: 2.2 s / 5.4 s ~ **40%**
- 1 int. length Pt target
- Before separators: 500 π : 500 p : 1 K
- After separators: Purity **K:π ~ 3-4 : 1**
- Incoming **710 MeV/c** K^+ identified by Č and slowed down by BeO and Active Degrader
- **~27%** K^+ stopped in the target (1.6 MHz)
- 1 T solenoid



K^+: Č x B4 x Target

π^+: Delayed Coincidence
Range
Energy
Momentum
$\pi^+ \rightarrow \mu^+ \rightarrow e^+$