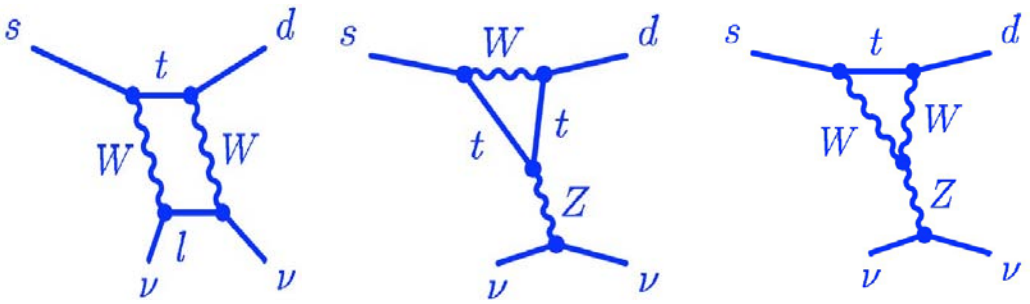
NA62 for IPP meeting

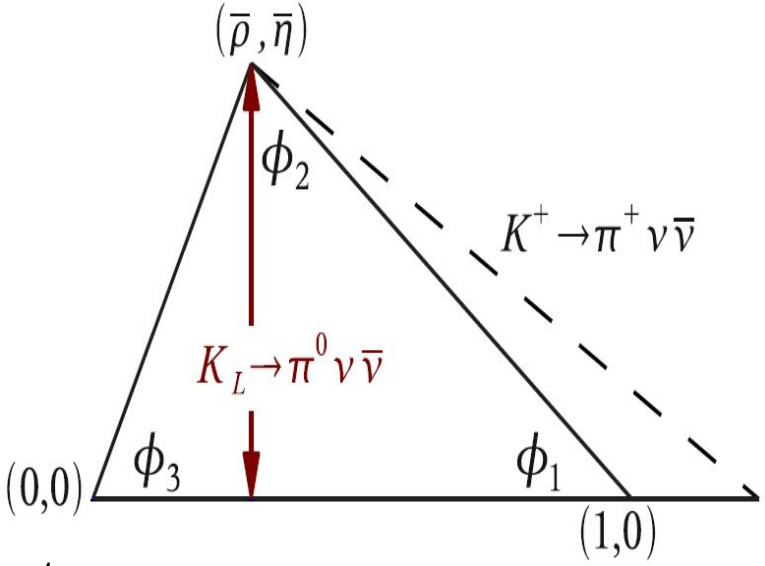
June 14, 2015

Toshio Numao

K→πνν̄ decays

u,d

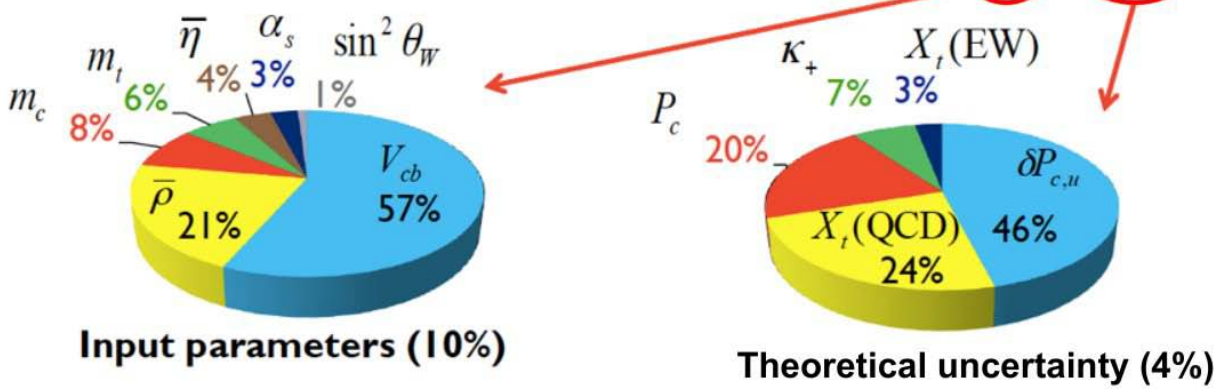




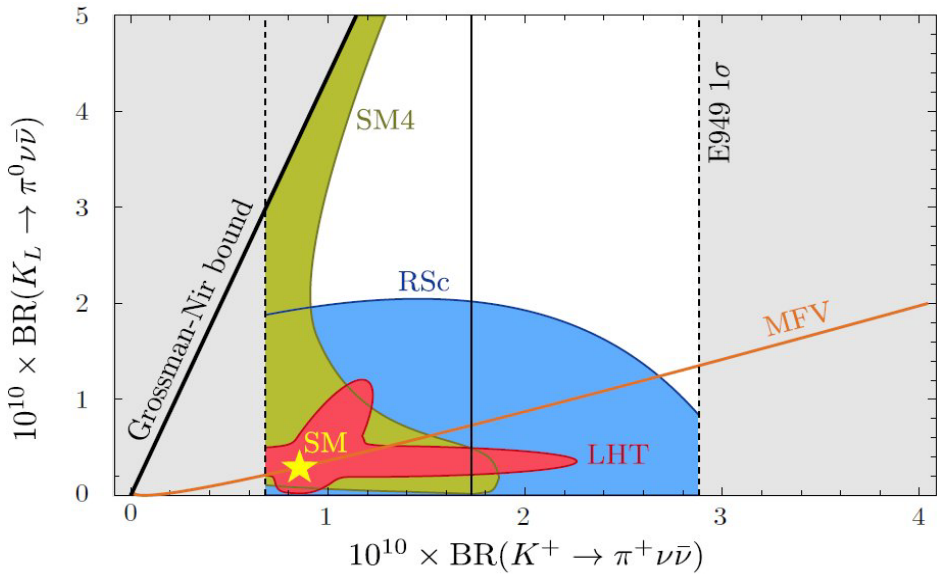
-K-πeν decay provides hadronic form factors.
-Calculated including the full 2-loop EW corrections.
-Uncertainties come from that of the CKM matrix.
-Uncertainty in the charm contribution in K^+ decay is 5 %.

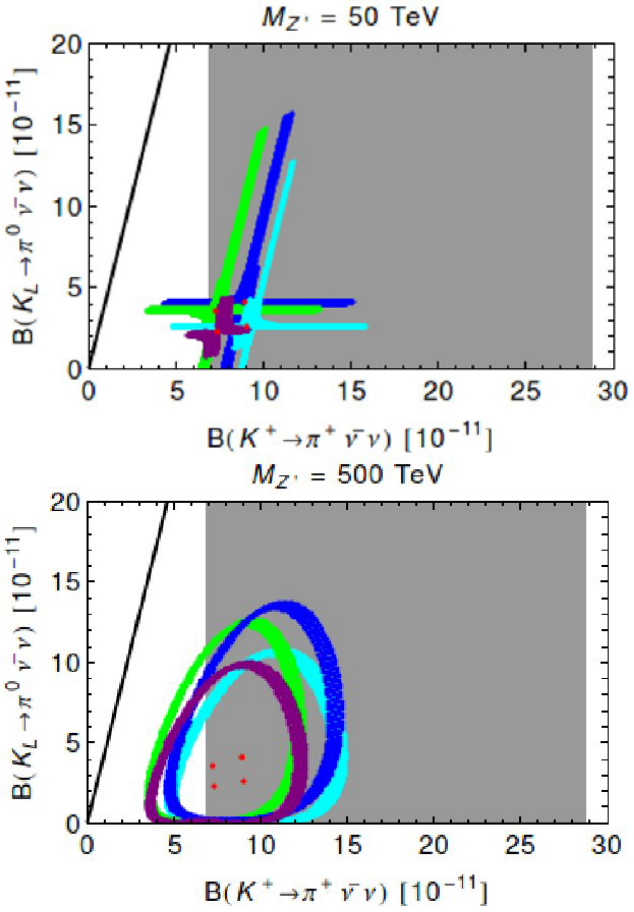
Current theoretical prediction [1] [2]

$$\mathrm{BR}(K^+\to\pi^+\nu\bar{\nu}) = (7.81^{+0.80}_{-0.71}\pm 0.29)\times 10^{-11}$$



K-πνν̄ beyond the Standard Model



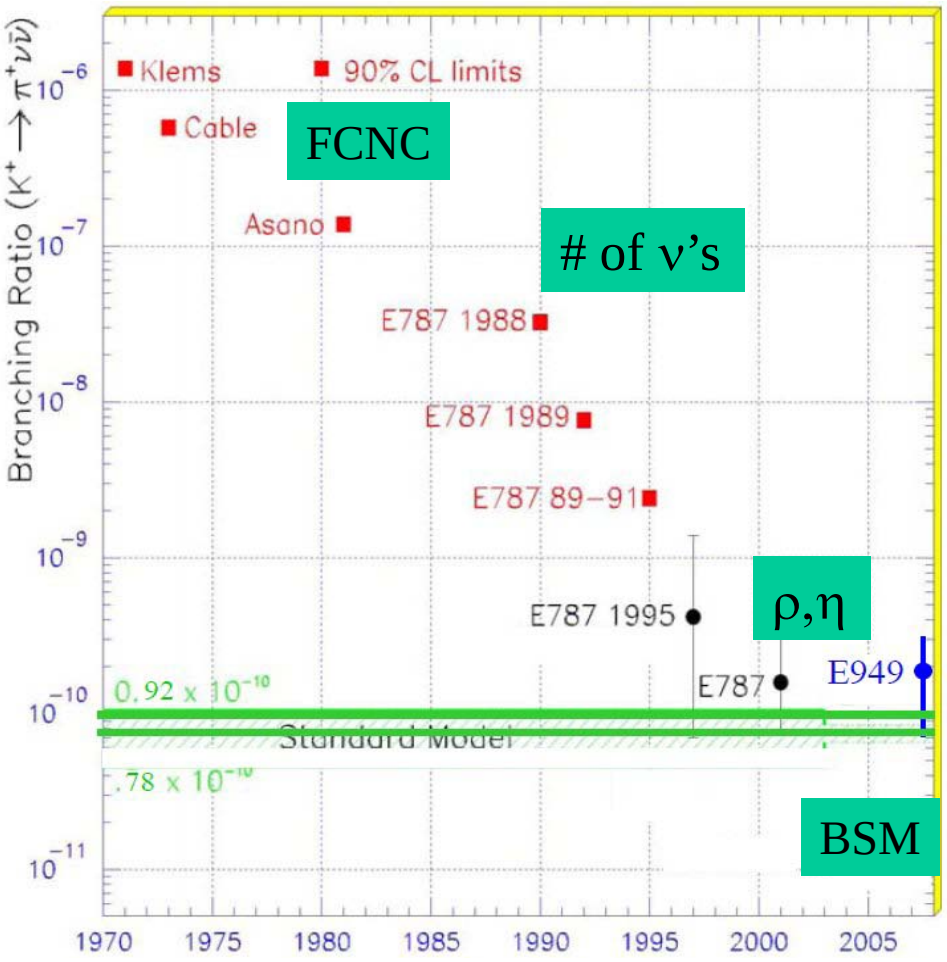


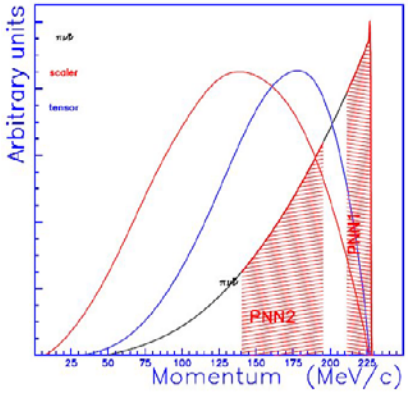
MFV: Minimal Flavor violation
LHT: Littlest Higgs with T-parity
SM4: SM with sequential 4th generation
RSc: Randall-Sundrum

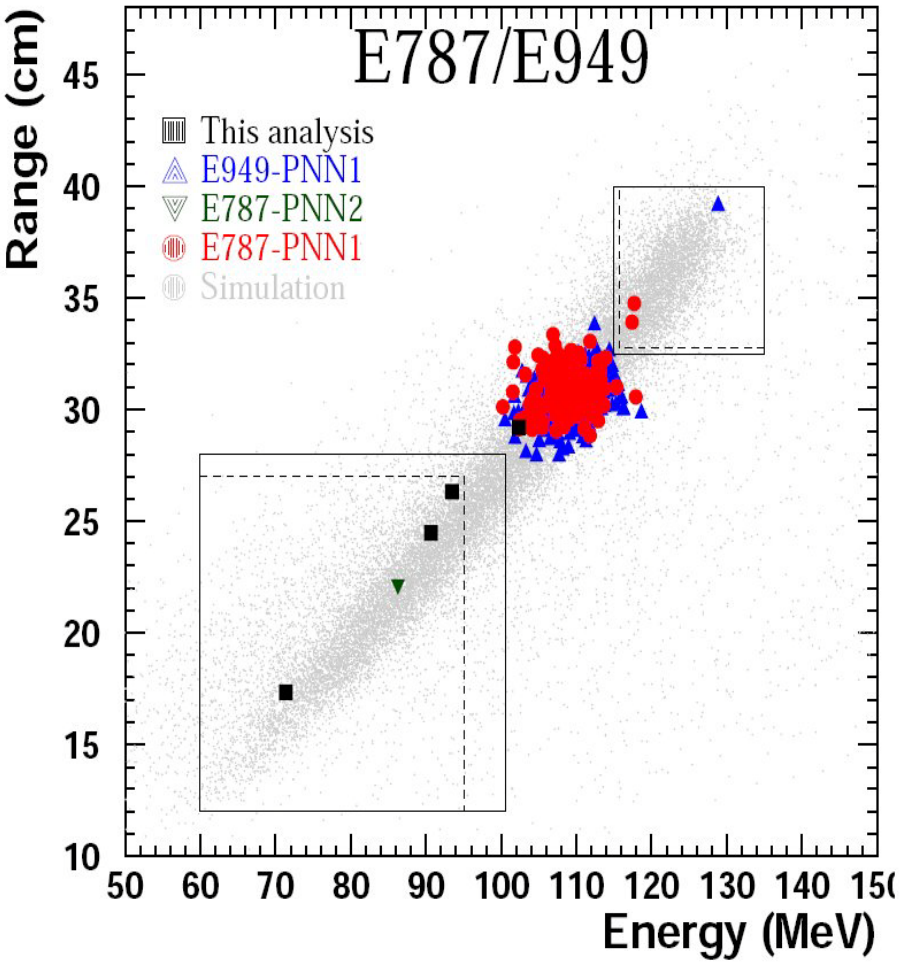
Straub, arXiv:1012.3893[hep-ph]

Heavy Z' Boson
Up: Left Handed Scenario
Down: L+R Scalar Scenario
Buras..., arXiv:1408.0728

K^+ decays





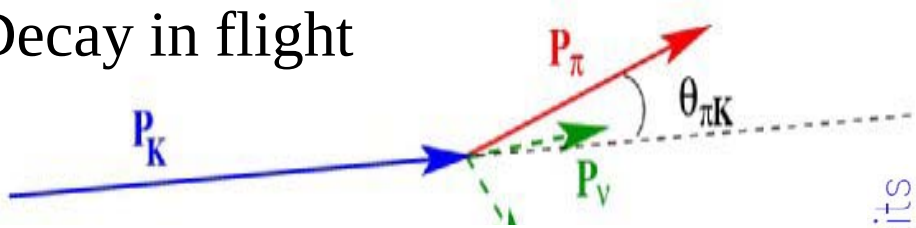


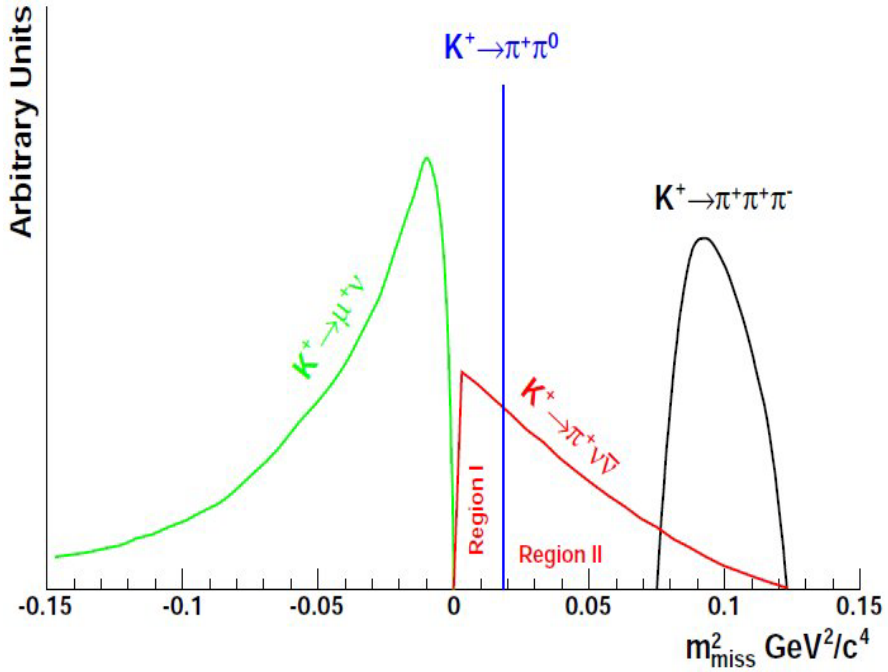
Present = $(1.73\ ^{+1.15}_{-1.05}) \times 10^{-10}$

K^+-$\pi^+\nu\bar{\nu}$ experiments

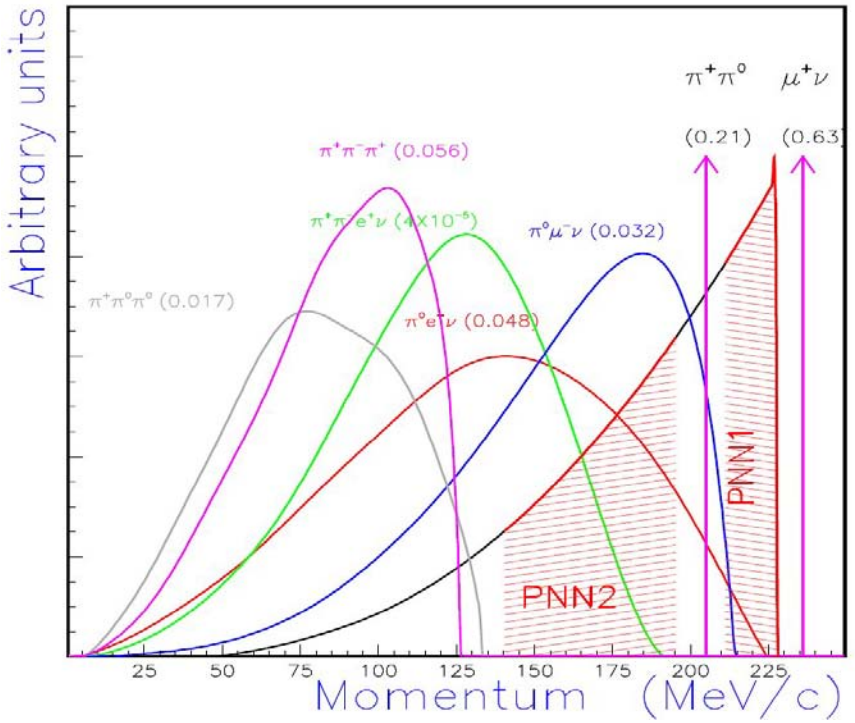
Signature: a single π^+

NA62
-Decay in flight



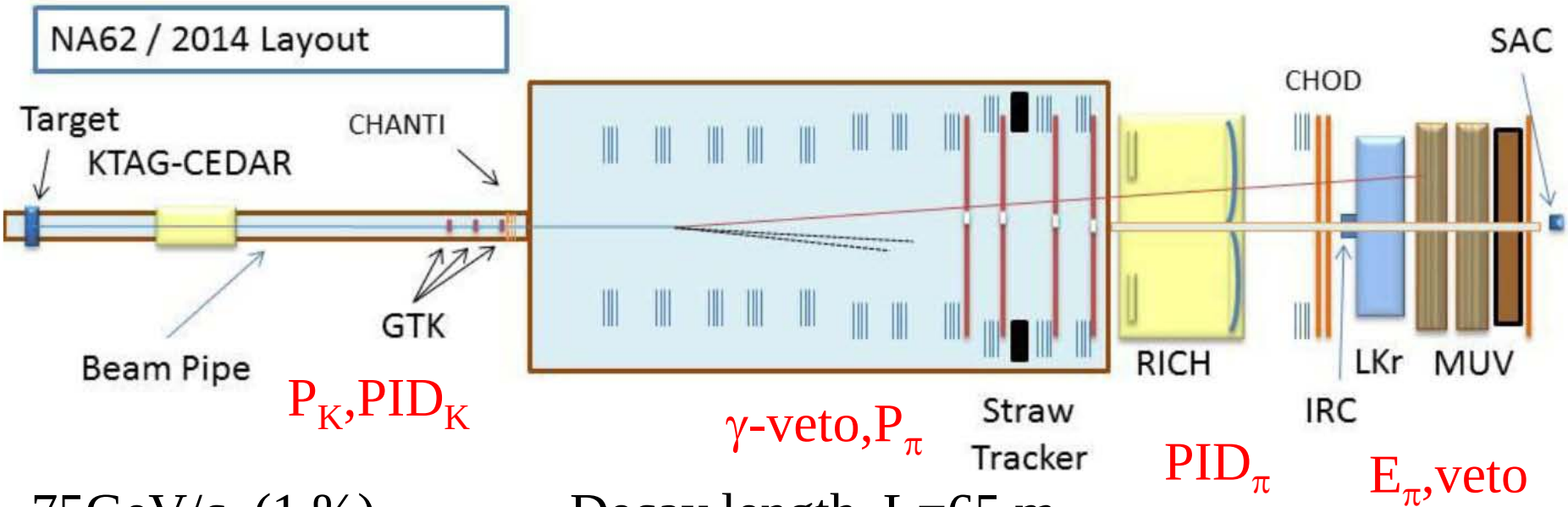


E787/949
-Decay at rest



Kinematics, particle ID, Photon veto

NA62@CERN



75GeV/c, (1 %)
(50MHz K's)

Decay length L=65 m
(6 MHz decays)

Kin. Rejection: 2×10^{-4} ($K_{\pi2}$), 7×10^{-5} ($K_{\mu2}$)
PID: 10^{-7} (μ/π)
PV: 10^{-8} for $\pi^0\rightarrow\gamma\gamma$

NA62

Decay	evt/year
$K^+ \to \pi^+ \nu\nu$ [SM] (flux 4.5×10^{12})	45
$K^+ \to \pi^+ \pi^0$	5
$K^+ \to \mu^+ \nu$	1
$K^+ \to \pi^+ \pi^+ \pi^-$	< 1
$K^+ \to \pi^+ \pi^- e^+ \nu$ + other 3 tracks decays	< 1
$K^+ \to \pi^+ \pi^0 \gamma$(IB)	1.5
$K^+ \to \mu^+ \nu \gamma$(IB)	0.5
$K^+ \to \pi^0 e^+(\mu^+) \nu$, others	negligible
Total background	< 10

Further NA62 K Physics Program

Decay	Physics	Present limit (90% C.L.) / Result	NA62
$\pi^+\mu^+e^-$	LFV	1.3×10^{-11}	0.7×10^{-12}
$\pi^+\mu^-e^+$	LFV	5.2×10^{-10}	0.7×10^{-12}
$\pi^-\mu^+e^+$	LNV	5.0×10^{-10}	0.7×10^{-12}
$\pi^-e^+e^+$	LNV	6.4×10^{-10}	2×10^{-12}
$\pi^-\mu^+\mu^+$	LNV	1.1×10^{-9}	0.4×10^{-12}
$\mu^-\nu e^+e^+$	LNV/LFV	2.0×10^{-8}	4×10^{-12}
$e^-\nu\mu^+\mu^+$	LNV	No data	10^{-12}
π^+X^0	New Particle	5.9×10^{-11} $m_{X^0} = 0$	10^{-12}
$\pi^+\chi\chi$	New Particle	–	10^{-12}
$\pi^+\pi^+e^-\nu$	$\Delta S \neq \Delta Q$	1.2×10^{-8}	10^{-11}
$\pi^+\pi^+\mu^-\nu$	$\Delta S \neq \Delta Q$	3.0×10^{-6}	10^{-11}
$\pi^+\gamma$	Angular Mom.	2.3×10^{-9}	10^{-12}
$\mu^+\nu_h, \nu_h \to \nu\gamma$	Heavy neutrino	Limits up to $m_{\nu_h} = 350\ MeV$	
R_K	LU	$(2.488 \pm 0.010) \times 10^{-5}$	>×2 better
$\pi^+\gamma\gamma$	χPT	< 500 events	10^5 events
$\pi^0\pi^0e^+\nu$	χPT	66000 events	O(10^6)
$\pi^0\pi^0\mu^+\nu$	χPT	-	O(10^5)

PIENU Experiment

Test μ-e universality at 0.05 % level, sensitive at 1000Tev mass scale.
Data taking in 2009 – 2012: recorded >5x10^6 π^+-$e^+\nu$ decays

Status:

Completed analysis of 2010 data:
R=(1.2344+-0.0023+-0.0019)x10-4. g_e/g_μ=0.9996±0.0012.
to be published.

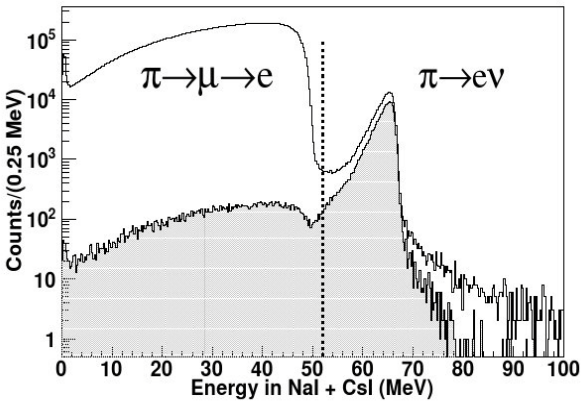


FIG. 2: Energy spectra of positrons in the early time region without (open) and with (shaded) background-suppression cuts (see the text). The vertical line at 52 MeV indicates the E_{cut} position.

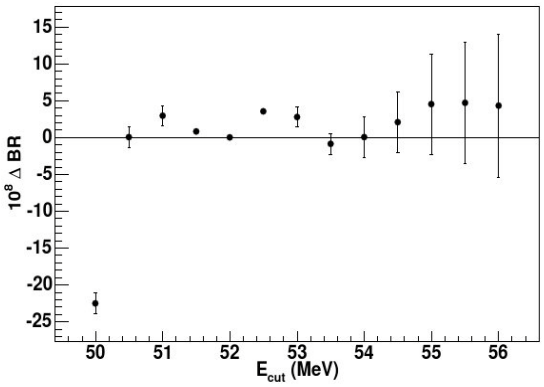


FIG. 4: Dependence of the branching ratio on E_{cut} with respect to the value at 52 MeV. The error bars indicate additional statistical and systematic uncertainties. Note the statistical uncertainty at $E_{cut} = 52$ MeV is 23×10^{-8}.

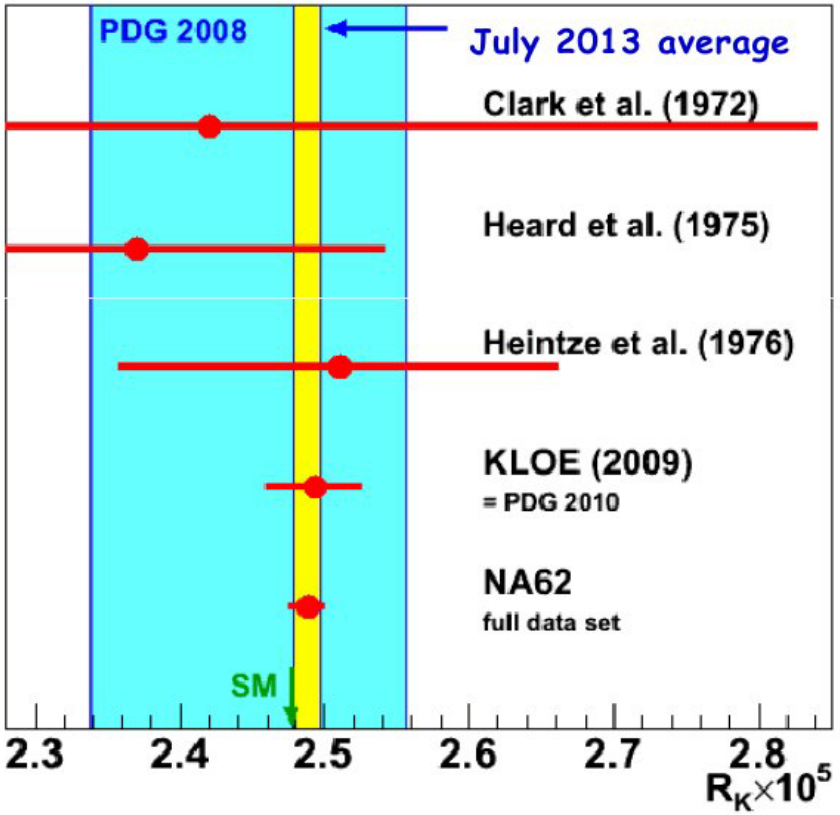
Final Analysis:
Expected statistical uncertainty 0.05%; systematic uncertainty <0.1 % by careful studies of the data and intensive Monte Carlo simulation.
Final result 2017.

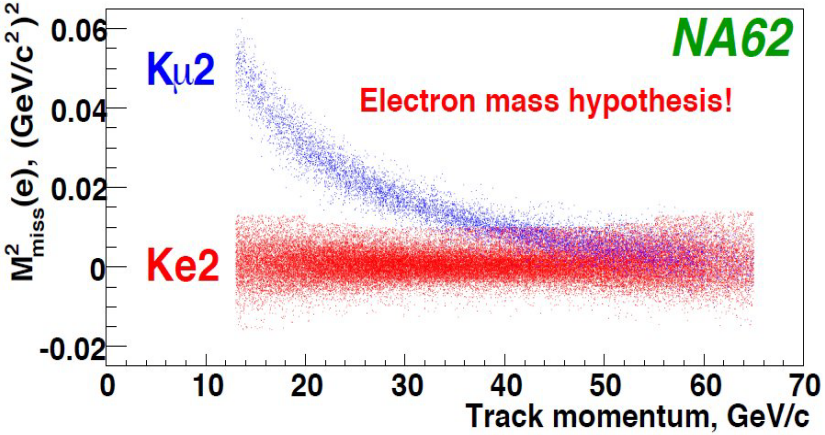
K-eν/K-μν

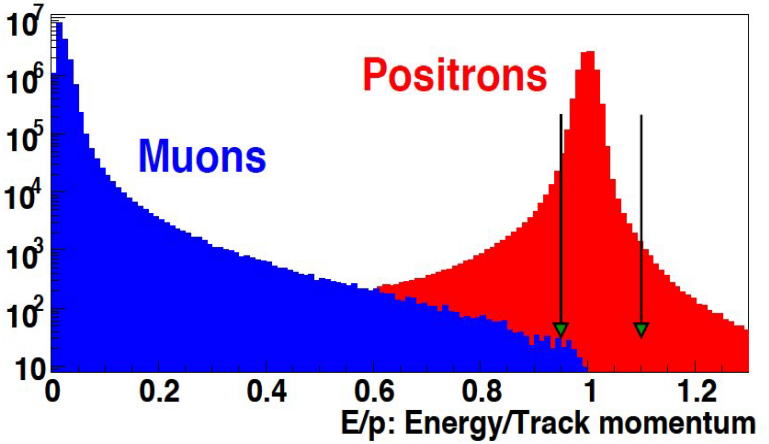
$$R_K = \frac{\Gamma(K\to e\nu)}{\Gamma(K\to \mu\nu)}$$

$$= \frac{g_e^2\, m_e^2\, (m_K^2-m_e^2)^2}{g_\mu^2\, m_\mu^2\, (m_K^2-m_\mu^2)^2}\,(1+\delta)$$

$$= (2.477 \pm 0.001)\times 10^{-5}$$







NA62:
Less background with RICH.

Present Activity of TRIUMF Group:

Data taking

Analysis

-Photon veto efficiency (correlation)

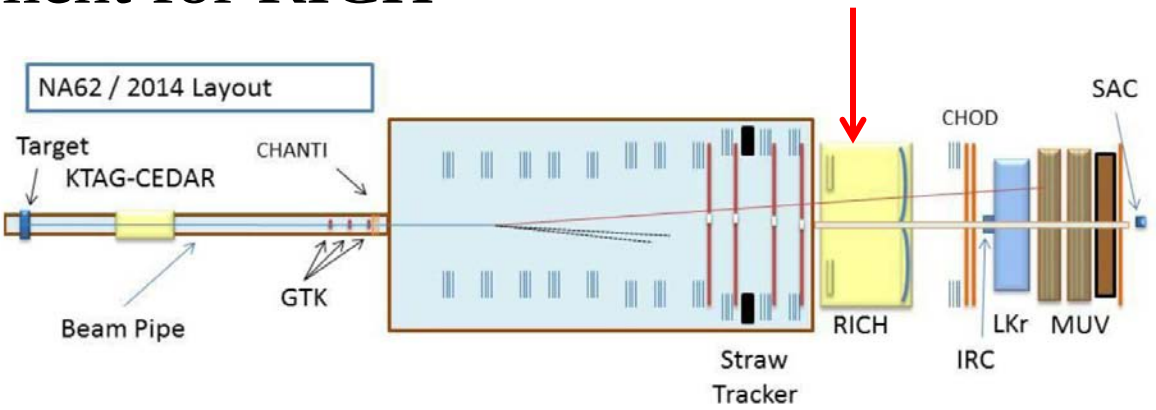
-MC study for correlations in BG suppression

-Particle ID (correlation between P/E and P/RICH)

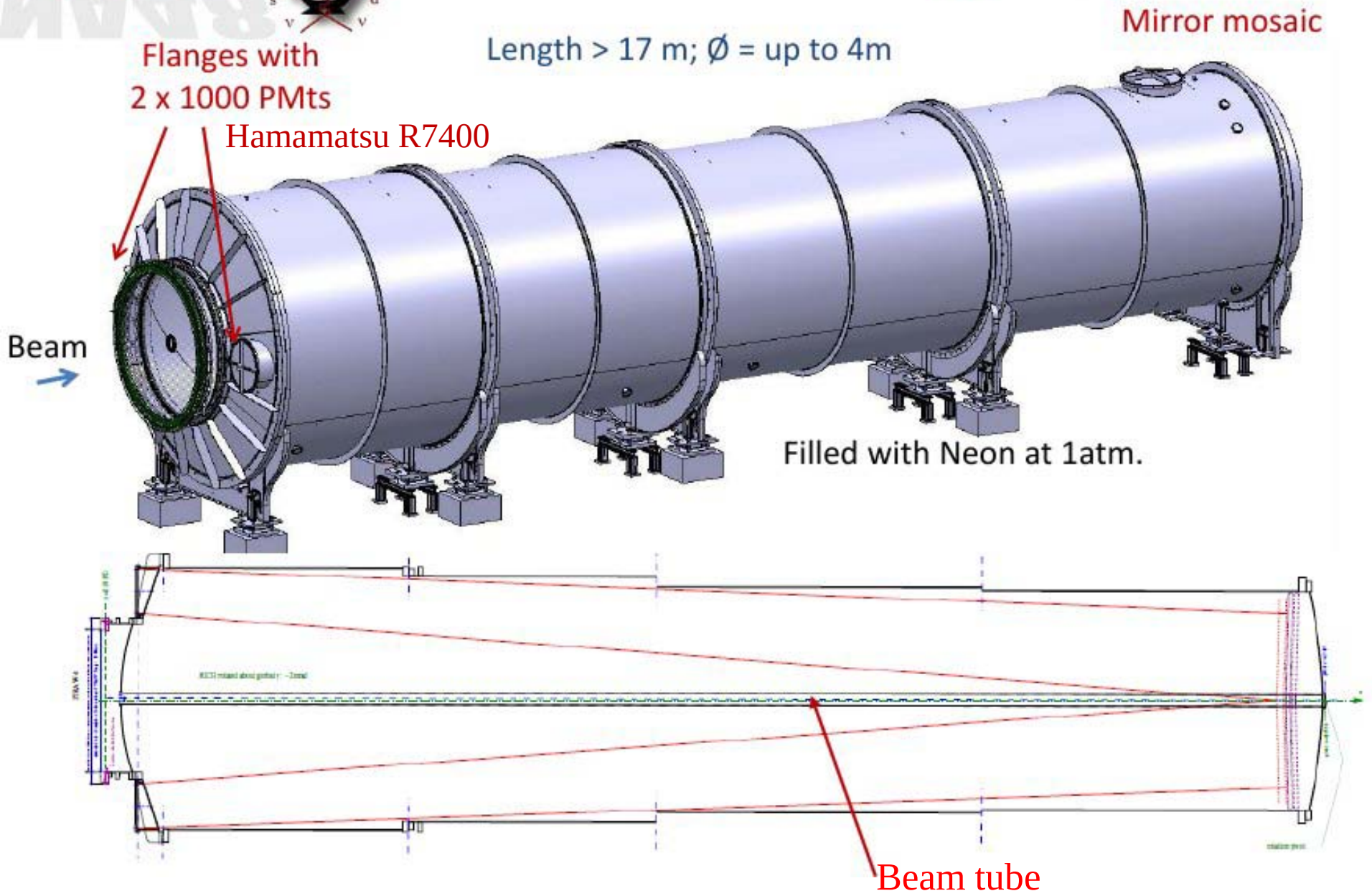
-Trigger for K-eν

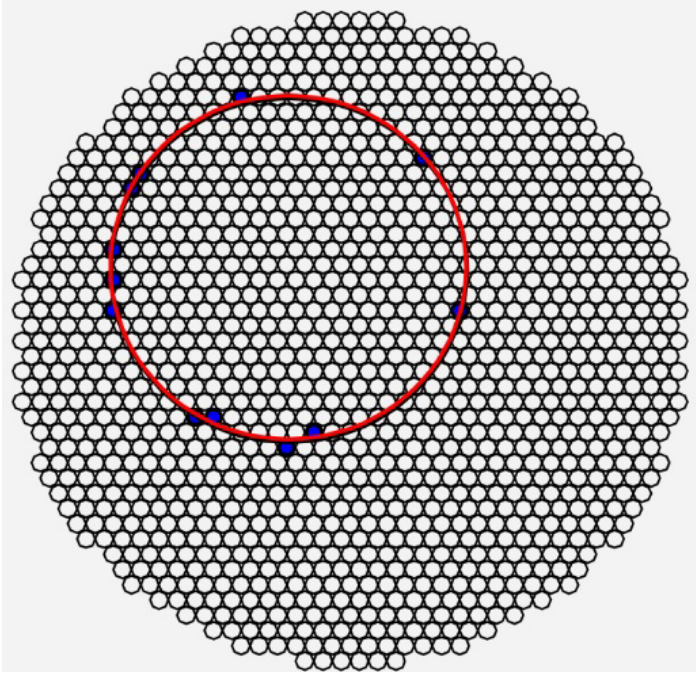
R&D

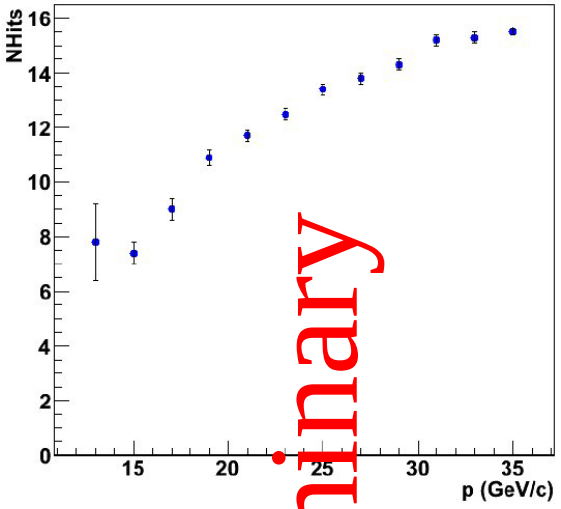
Improvement for RICH

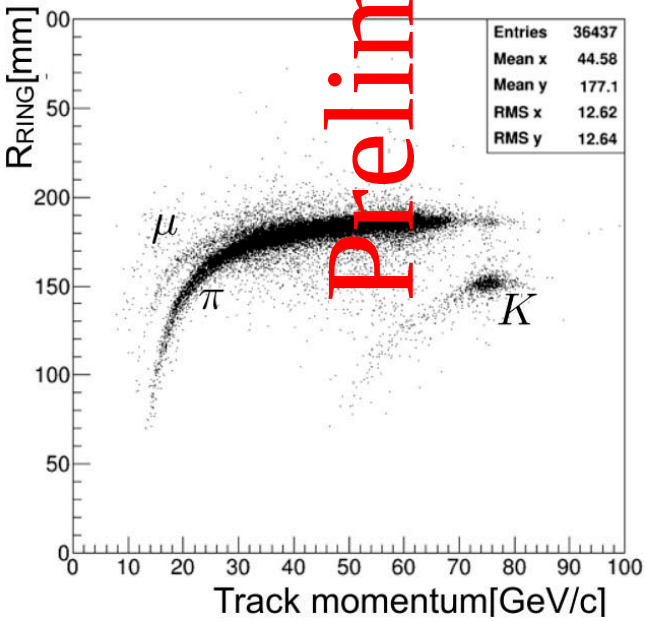


NA62 RICH Detector =>π/μ Separation









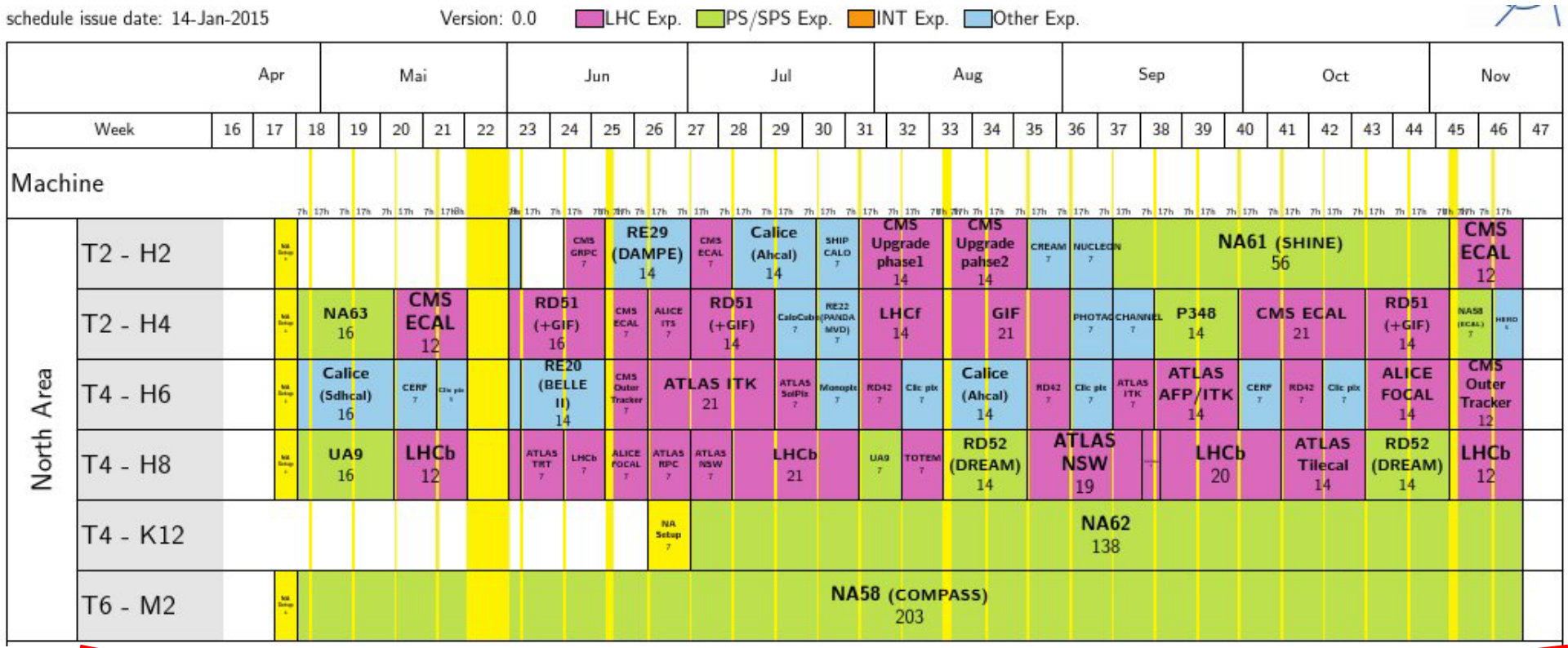
Preliminary

-Higher efficiency?

-More granularity?

SiPM, high efficiency PMT?

Schedule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LHC Exp.
PS/SPS Exp.
INT Exp.
Other Exp.
Apr
Mai
Jun
Jul
Aug
Sep
Oct
Nov
Week
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47
Machine
North Area
T2 - H2
CMS GRPC 7
RE29 (DAMPE) 14
CMS ECAL 7
Calice (Ahcal) 14
SHIP CALO 7
CMS Upgrade phase1 14
CMS Upgrade pahse2 14
CREAM 7
NUCLEON 7
NA61 (SHINE) 56
CMS ECAL 12
T2 - H4
NA63 16
CMS ECAL 12
RD51 (+GIF) 16
CMS ECAL 7
ALICE ITS 7
RD51 (+GIF) 14
CaloCub 7
RE22 (PANDA MVD) 7
LHCf 14
GIF 21
PHOTAG 7
CHANNEL 7
P348 14
CMS ECAL 21
RD51 (+GIF) 14
NA58 (ECAL) 7
HERD 5
T4 - H6
Calice (Sdhcal) 16
CERP 7
Clic pix 5
RE20 (BELLE II) 14
CMS Outer Tracker 7
ATLAS ITK 21
ATLAS SciPix 7
Monopix 7
RD42 7
Clic pix 7
Calice (Ahcal) 14
RD42 7
Clic pix 7
ATLAS ITK 7
ATLAS AFP/ITK 14
CERP 7
RD42 7
Clic pix 7
ALICE FOCAL 14
CMS Outer Tracker 12
T4 - H8
UA9 16
LHCb 12
ATLAS TRT 7
LHCb 7
ALICE FOCAL 7
ATLAS RPC 7
ATLAS NSW 7
LHCb 21
UA9 7
TOTEM 7
RD52 (DREAM) 14
ATLAS NSW 19
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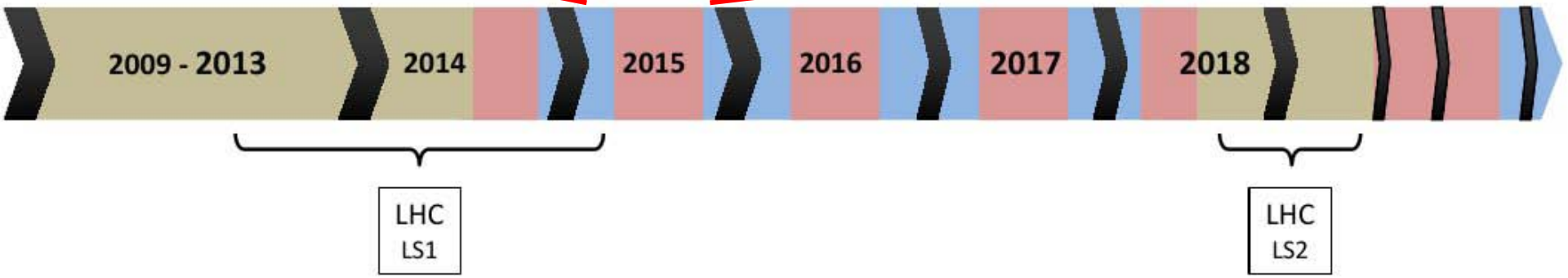
2009 - 2013
2014
2015
2016
2017
2018
LHC LS1
LHC LS2

TRIUMF-UBC NA62 Group:

D. Bryman	UBC	
T. Numao	TRIUMF	
L. Doria	TRIUMF	RA
A. Sher	TRIUMF	RA
J. Fu	UBC	M.Sc.

Three possible experimental scenarios

- Everything works so well.
  - Another 3 years of analysis.
  - Next experiment? K_L-->$\pi^0\nu\nu$?
    - π^0 tracking ?
    - Another option?

- Needs upgrade for better precision or to achieve original goal.
  - Another 2-3 years of analysis.
  - RICH improvement, or other improvement projects.

- No hope of improvements.
  - Still requires 2-3 years of analysis for other processes.

Future Activity:

- Data analysis and simulation
  - $-K^+-\pi^+\nu\nu$ branching ratio and its background
  - Precise measurement of $K-e\nu/K-\mu\nu$

- Minor contribution to the upgrade
  - RICH or other detector that requires upgrade.

Resource Requirements

Year/	2017	2018-
Financial:		
NSERC ($)	150k	200k
TRIUMF Personnel:		
(FTE/year)	0.5	$(0.5)_{2018}$
Computing:		
WestGrid (core*year)	50	50
Storage (TB)	50	50