PIENU at TRIUMF

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Summary:
* Aiming for precision $\mathbf{Br}(\pi \to e\upsilon) \sim \pm 0.0006 \times 10^{-4}$
* Searching for Sterile neutrinos (60-129 MeV) $|U_{ei}|^2 < 10^{-8}$
* Data taking completed at the end of 2012
        Analysis underway; first **Br** result expected in 2014
        Complete analysis in 2015
* Also measured direct muon capture to atomic states

IPP Meeting Sudbury June 2014

$\pi \rightarrow e\upsilon$ Branching Ratio

$$R_{e/\mu}^{th} = \frac{\Gamma(\pi \rightarrow e\nu + \pi \rightarrow e\nu\gamma)}{\Gamma(\pi \rightarrow \mu\nu + \pi \rightarrow \mu\nu\gamma)}$$

$$= 1.2352(1) \, x10^{-4} \quad \text{Cirigliano,Rosell 2007}$$

The most precise SM weak interaction observable involving quarks!

Experimental status:

R_{exp}= 1.2265 (34) (44) x 10^{-4} (TRIUMF, 1992)

1.2346 (35) (36) x 10^{-4} (PSI, 1993)

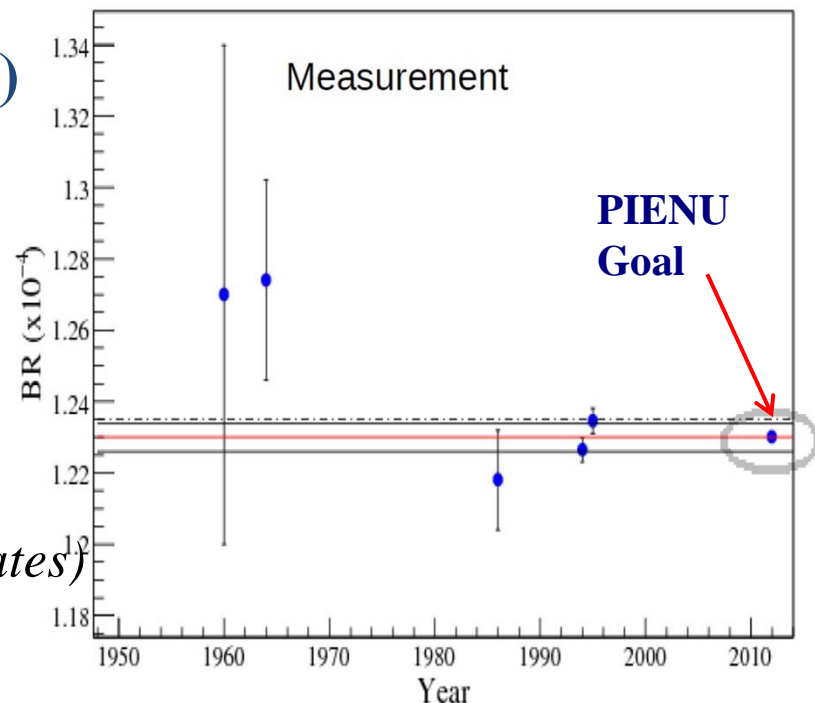**PIENU Precision goal:** **(0.0006 x 10^{-4})**

Search for BSM physics:

Mass scales up to 1000 TeV (Pseudoscalars)

…Charged Higgs,...

e-µ Universality

Sterile neutrinos
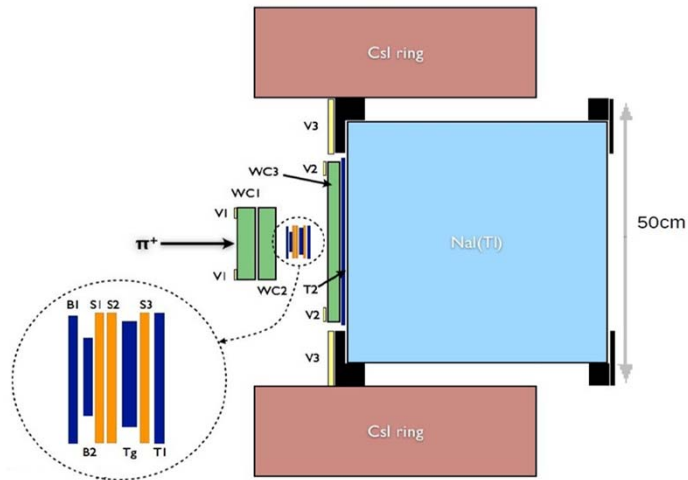
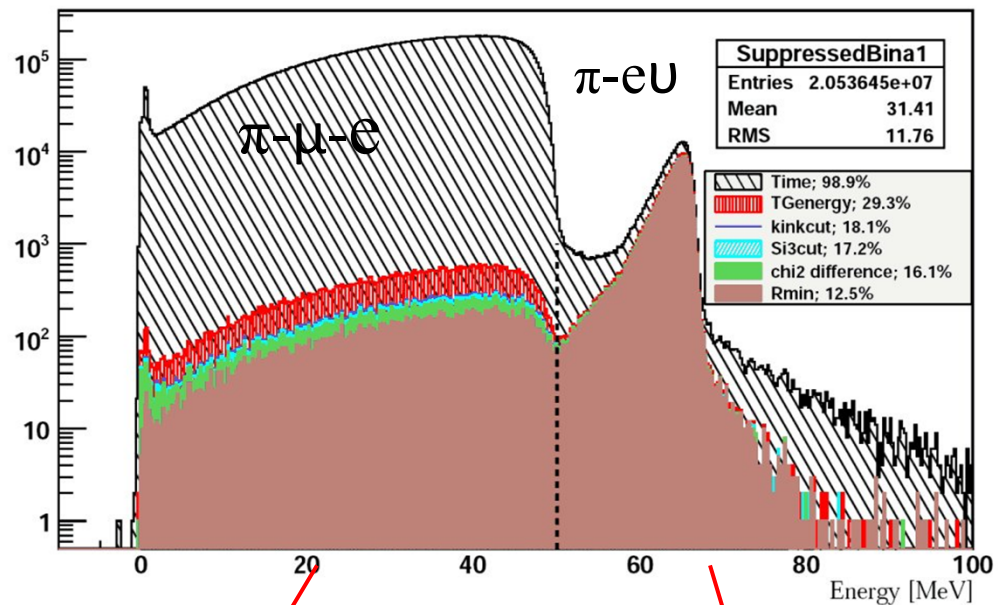*(Another topic: Direct muon capture to atomic states)*

eμ Universality Tests

Mode	g_e/g_μ		
π→eυ/ π→μυ	0.9979 ± 0.0016	⟹	±0.0003 PIENU/PEN
K→ eυ/K →μυ	1.0022 ± 0.0018	⟹	±0.0010 NA62/TREK
τ →eυυ/ τ →μυυ	0.9980 ± 0.0015	⟹	Belle II
υe/υμ scattering	1.10 ± 0.05		
W decays	0.999 ± 0.011		

TRIUMF PIENU

Measure Energy and time in a precision crystal spectrometer

Energy Spectrum

π-eυ

π-μ-e

SuppressedBina1	
Entries	2.053645e+07
Mean	31.41
RMS	11.76

Time; 98.9%
TGenergy; 29.3%
kinkcut; 18.1%
Si3cut; 17.2%
chi2 difference; 16.1%
Rmin; 12.5%

Energy [MeV]

Fit time spectra simultaneously
- π-eυ, π-μ-e, πDIF, old μ
- radiative π decays
- π + old μ
- (μDIF)

Time Spectra

Low Energy π-μ-e

High Energy π-eυ

Suppress Backgrounds,
Make small systematic corrections for
NaI lineshape and other tiny effects.

70 MeV e$^+$ at 0°.

Photo-nuclear Bumps

Deposited Energy (MeV)

*Response function measurements
showed up photo-nuclear n emission.*
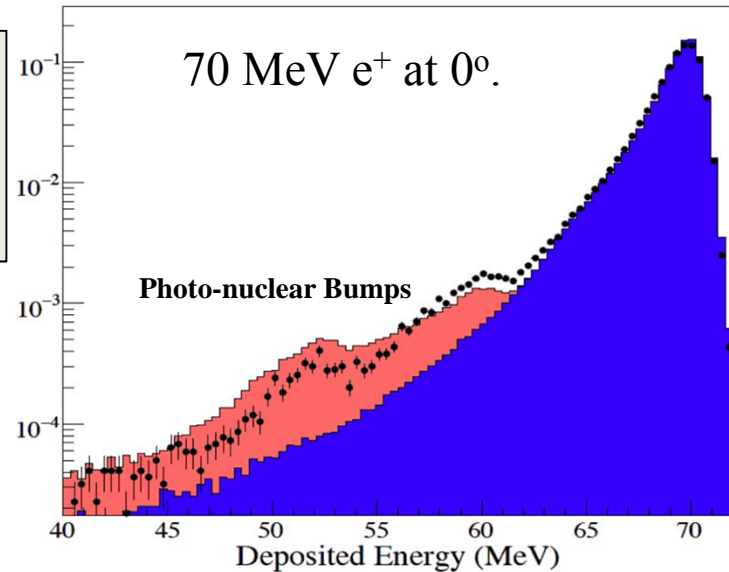
Background Suppression

-Suppress π-μ-e background with target energy
-Remove πDIF background with track angles
-Correct for selection bias

Target Energy

Counts

π→eυ

π-μ-e

Total Energy (MeV)

Kink Angle

π$^+$ → e$^+$ ν

π$^+$ → μ$^+$ ν
Decays in Flight Events

Kink Angle (rad)
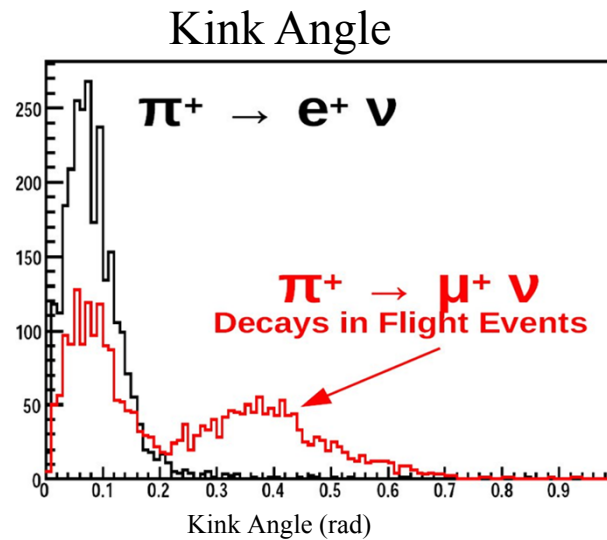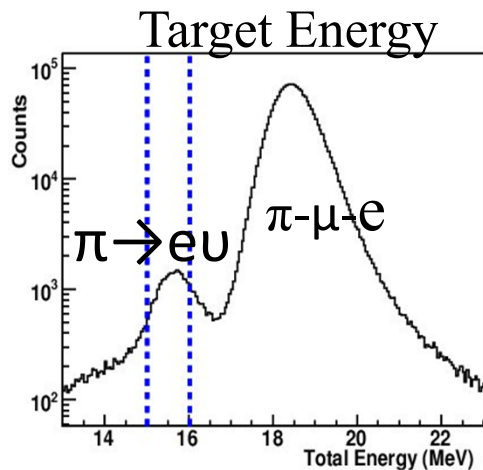
PIENU: Summary of Expected Uncertainties

Source	Old TRIUMF	PIENU Goals
Statistics	0.0028	0.0005
Low-energy tail	0.0025	0.0003
Acceptance corrections	0.0011	0.0003
Pion lifetime	0.0009	0.0002
Other	0.0011	0.0003
Total	0.0047	0.0006

Current PIENU
Result For Sterile
Neutrinos: