# A lab-scale experiment for keV sterile neutrino search from tritium beta decay spectrum

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# Overview

- <sup>3</sup>H embedded in LiF crystal
- Calorimetric measurement
- Experimental bounds on keV mass sterile neutrino together with the expected sensitivity of this experiment
- Result of first test experiment

# Trace of Sterile $\nu$ on <sup>3</sup>H $\beta$ decay spectrum



From  $\beta$  decay spectrums, we can investigate the presence of sterile neutrinos



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## **Experimental bound**



# **Cosmological bound**

- X-ray bound : assumes the present DM is all sterile v's, regardless of its generation mechanism relevant with the mixing angle and possible history of early universe
- There are cosmological models(e.g. low reheating temperature model of MeV) that suppresses the generation of relic sterile neutrino, and bounds on mixing amplitude can be relaxed by 1e+3 [ Phys. Rev. Lett. 93, 081302 ]



# <sup>3</sup>H generation in LiF crystals



Mean free path : 2.3mm in LiF (7.6% <sup>6</sup>Li)



- Irradiation time : 7days
- Event rate : ~ 22 Hz



## <sup>3</sup>H distribution in LiF

<sup>3</sup>H location in 1x1x1 cm<sup>3</sup> LiF (MC result)



#### **Energy loss at the surface**

#### MC Simulation on energy escape in LiF crystal



- Using the <sup>3</sup>H distribution, the MC shows a negligible effect (< 0.06%) would result in a deposit energy spectrum for 10<sup>6</sup> counts.
- The MC result should be compared with m easured for high statistic data
- Extra energy catcher?

## Low Temperature test setup

## $LiF(^{3}H)$



dc-SQUID

**MMC** 

# **Measurement and Analysis**

#### Measurement

• Spectra were measured 3 times for 10 hours at a base temperature of 40mK in ADR

#### **Signal calculation**

• Signal amplitude was calculated by time-domain least square fit with the template of around 6keV

#### Fitting the measured spectrum

- Energy calibration function was assumed to be 2<sup>nd</sup> polynomial passing through the origin.
- Unresolved pile-up spectrum was assumed to be convolution of expected beta and Fe-55 X-ray spectrum with itself.
- An energy independent term was added as the rest of the background.
- Tried fitting the entire measured spectrum from 2 to 40keV with the function of <sup>3</sup>H + Fe-55 + Unresolved pile-up spectrum + Const-bkg (next page)

### **Measured spectrum**



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### **Measured spectrum**



## Results





- Energy resolution in FWHM
  = 791eV±24eV
- Unresolved pileup fraction =  $0.40\% \pm 0.05\%$
- $\chi^2/dof = 0.9989$

# Systematics on keV sterile $\nu$ study

• Surface effect:

 $\rightarrow$  Comparison between the measured and MC.

• Calibration:

 $\rightarrow$  Investigation of possible sources in the structure of refrigerator

• Long term stability:

 $\rightarrow$  Drift correction + Stable refrigerator condition

• Unresolved pileup:

 $\rightarrow$  Setup for fast rise-time + MC studies

• Possible backgrounds:

 $\rightarrow$  Measurement with no <sup>3</sup>H source

# Summary

- <sup>3</sup>H was embedded in a LiF crystal with reasonable activity.
- Simple calorimetric measurement of  ${}^{3}H\beta$  spectrum was done for 10 hour
- We plan a long term (several months) with multi-channel setups.

# Thank you!