Contribution ID: **8** Type: **Contribution type**

X-ray spectroscopy of kaonic atoms with TES-based microcalorimeters

Thursday, 10 June 2021 15:15 (20 minutes)

Kaon is the lightest meson containing a strange quark, and would play an important role to understand a high-density nuclear matter such as neutron stars. To extract the strong interaction between an anti-kaon and a nucleus at low energies, X-ray spectroacopy of kaonic atoms, Coulomb bound systems of a negatively-charged kaon, a nucleus, and electrons, are quite unique.
We performed a kaonic atom X-ray measurement at Japan Proton Accelerator Research Complex (J-PARC; Tokai, Japan) using a transition-edge-sensor(TES)-based X-ray spectrometer. The TES spectrometer has an excellent energy resolution, and is now a matured technology for various field of appplications. We used a 240-pixel TES array of about 23 mm^2 collecting area with 4 um thick Bi absorbers, developped by NIST in US. Our project was the first case to use the TES spectrometer in a hadron-physics experiment at a charged-particle beamline.
Following a demonstraion experiment in a pion beamline at PSI in 2014, and a commsioning experiment at J-PARC in 2016, we performed a scientific campaign to measure the 3d-2p X-ray lines of kaonic helium-3 and helium-4 (6.2 keV and 6.4 keV, respectively) in 2018. We successfully observed X-ray lines from kaonic atoms with a resolution of $\sim$6 eV in FWHM.
Here we will describe the details of our experimetal method and present an overview of the data analysis and the results. Especially, we will focus on how we dealed with challenges unique in our TES application at a charged-particle beamline.

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Session Classification: Session