Cryogenic detector for mass spectrometric identification of neutral molecules towards atomic and molecular collision experiments

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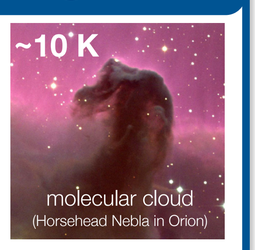
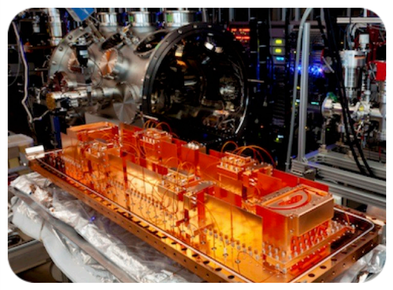
1. RICE — Cryogenic electrostatic ion storage ring

✓cold chemical reaction relevant to **universe evolution**
✓dynamics of **large complex molecules**
✓atom interaction with a ultra short-pulsed intense lasers

→ essential to be cooled down to 10 K

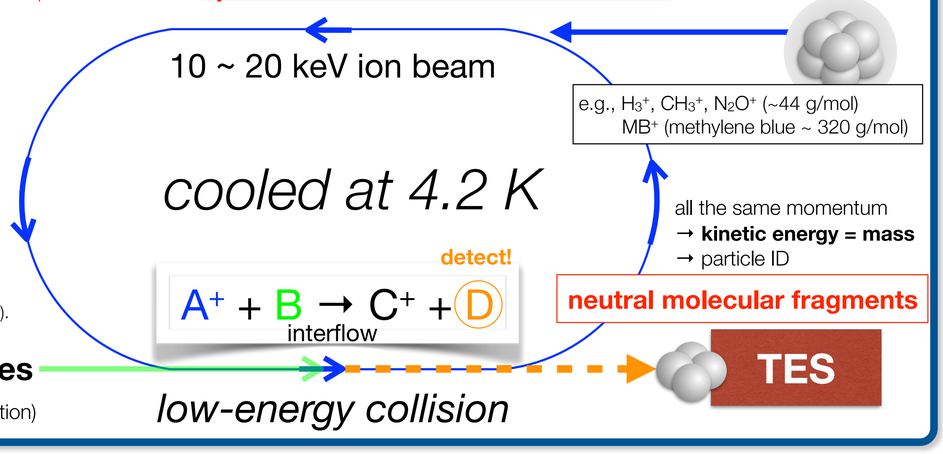


RICE
(RIken Cryogenic Electrostatic ion storage ring)



For details of this ring, refer the following paper :
Y. Nakano et al., Rev Sci. Instrum. 88, 033110 (2017).

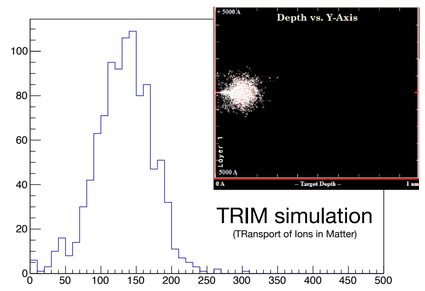
below 5 K → ground-state ions
experiment with **specific** vibrational and rotational states



2. Why cryogenic detector?

Why not Si detector ?

Range of 10 keV H on Silicon



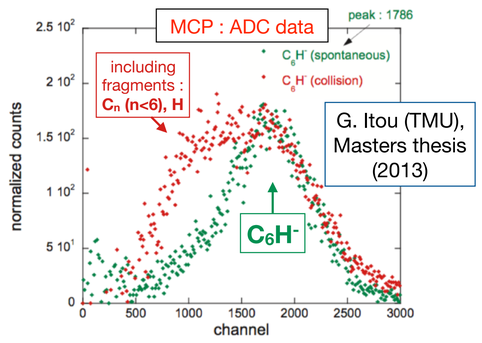
Range is only ~ 130 nm
even for 10 keV hydrogen

difficult to reach the depletion layer
-> insensitive for detection of molecular fragments (keV order energy)

Why not MCP ?

MCP = Micro Channel Plate

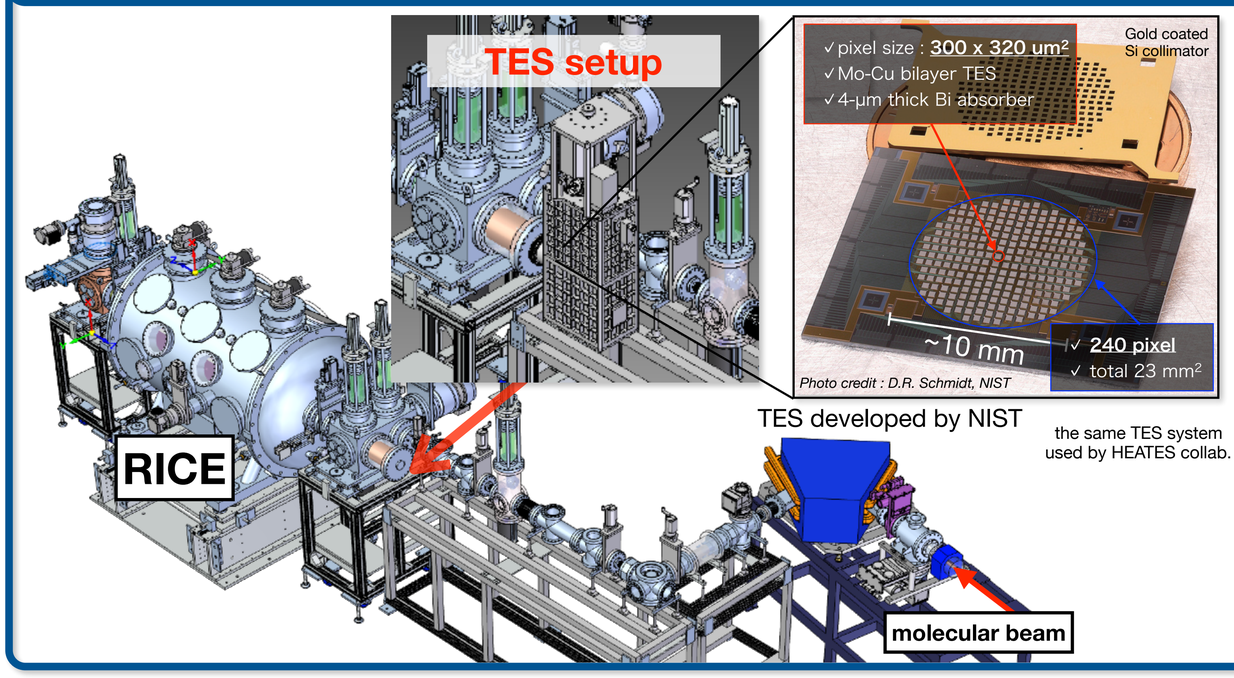
20 keV C_6H^- beam in a strage ring at TMU



Particle ID of C_6H^- and other fragments is difficult

Energy resolution is not enough

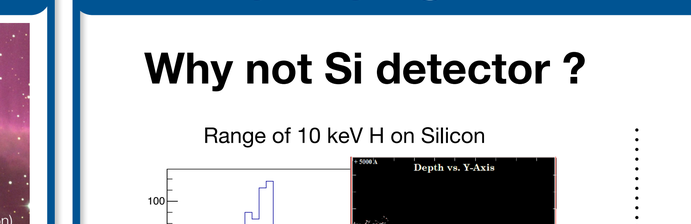
3. Setup with TES microcalorimeter



TES developed by NIST

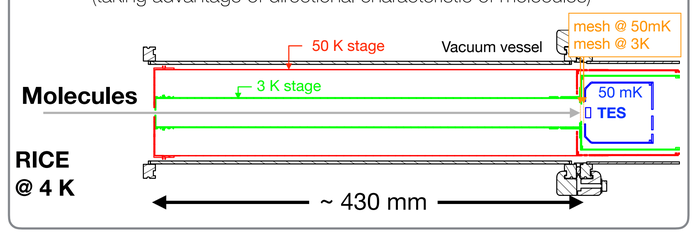
the same TES system used by HEATES collab.

4. Radiation shield — X-ray vs. molecule



IR affects not only cooling capacity but also TES energy resolution

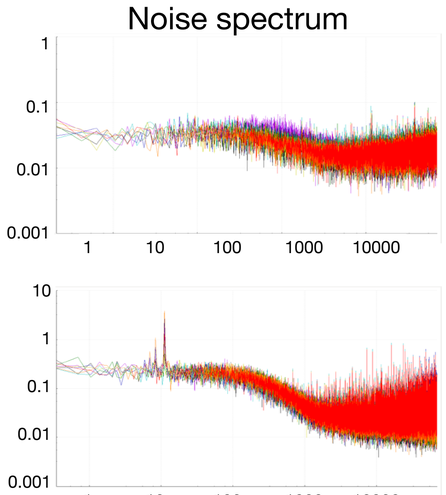
extend cylinder for radiation shield
(taking advantage of directional characteristic of molecules)



Test setup at RIKEN

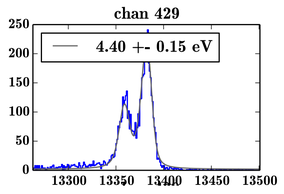
5. Shield effect @ 50 mK

Noise spectrum

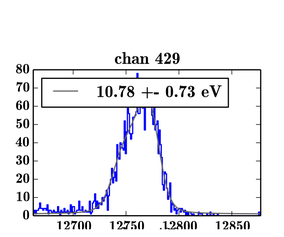


50 mK stage

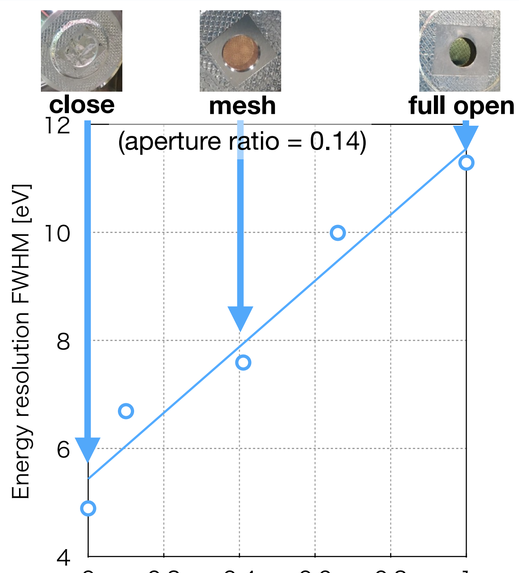
ΔE ~ 4 eV (FWHM)
for 6 keV X-ray

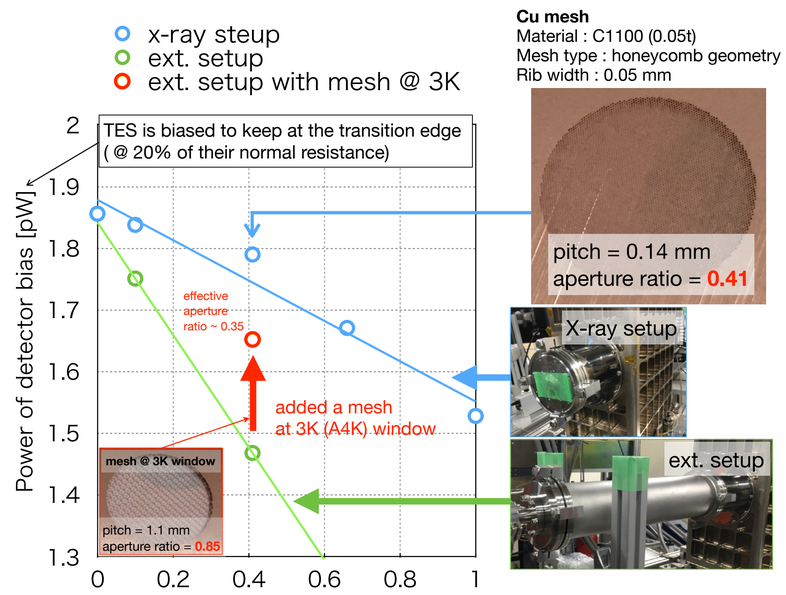


ΔE ~ 11 eV (FWHM)
for 6 keV X-ray



6. Mesh at 50 mK (and 3 K) window

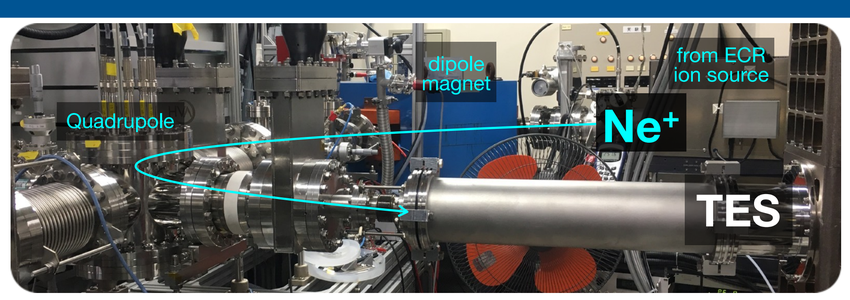


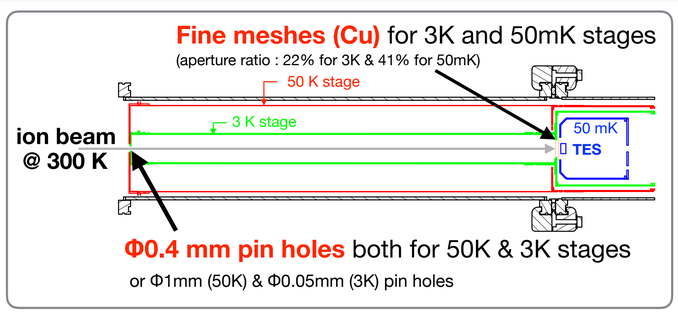


Cu mesh
Material : C1100 (0.05t)
Mesh type : honeycomb geometry
Rib width : 0.05 mm

The sweep voltage goes down to 0.16 if 3K front-edge cap has a Φ1mm hole.

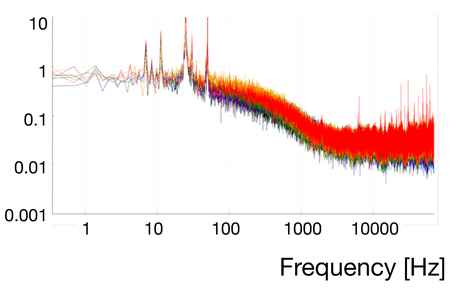
7. Test with ion beam from ECR





→ working with this condition

Noise spectrum



Power of detector bias
~ 1.27 [pW]

Online plots
pulses (ion beam ON)