# Cryogenic Neutron Detector by InSb Semiconductor Detector with High-Density Helium-3 Gas Converter

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# Motive

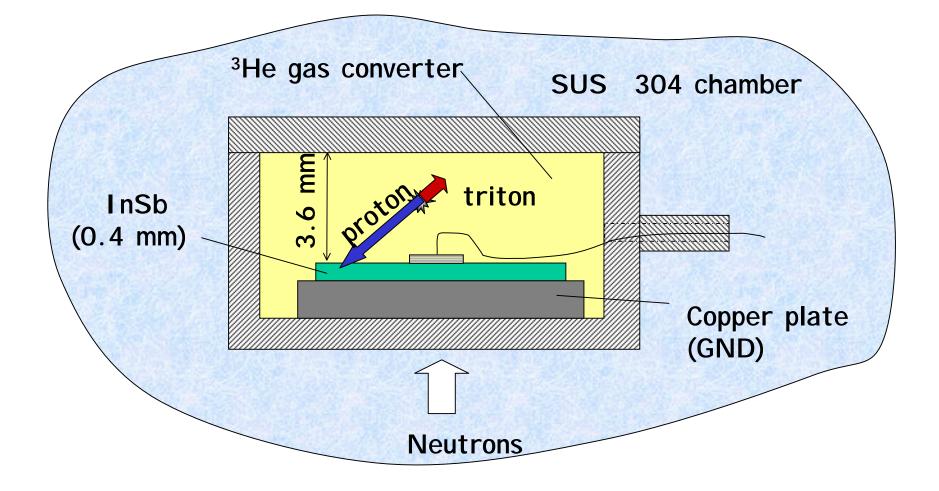


We proposed a cryogenic neutron detector that is comprised of an InSb semiconductor detector and a helium-3 gas converter. In this detector, neutrons are absorbed at helium-3 by the nuclear reaction,  ${}^{3}\text{He} + \text{n} \rightarrow \text{p} + \text{T} + \text{m}$ 765 keV ( <sup>3</sup>He (n,p) T ), and either a proton or a triton is detected at the InSb semiconductor detector. The important key of this detector is usage of cryogenic environment. This enables easy access to high-density of helium-3 nucleus. Under such condition, a range of a proton becomes very short, hence, **high position resolution** of a few tenth µm will be obtained. density helium-3 increases capture rate of neutrons and, moreover, a gas converter ensures very uniform detection efficiency at each incident position. It would be greatly advantageous when the arrayed detectors are used to obtain neutron images. The use of InSb semiconductor is advantageous at low temperature operation because its carrier, electrons and holes, mobility is about 40 and 20 times larger than that of silicon semiconductor, respectively.



#### Principle of Cryogenic Neutron Detector

$$^{3}$$
He + n  $\rightarrow$  p + T + 765 keV

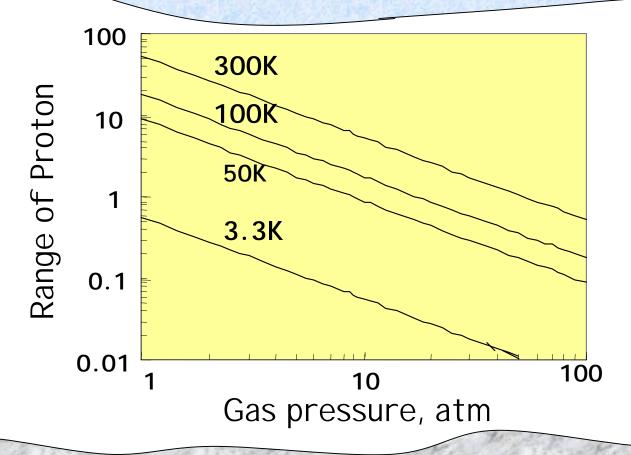


#### Dependence of proton range on temperature and gas pressure

Final purpose : High resolution neutron imaging

Short range of proton < 500mm

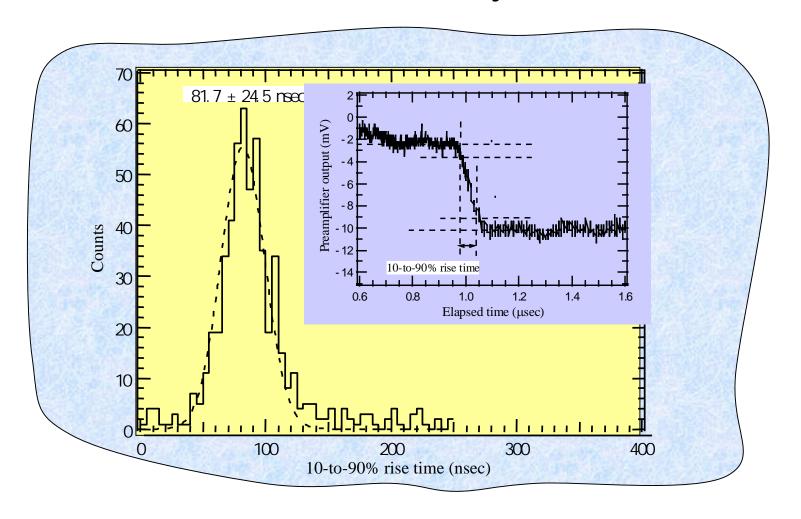
ad-10.90



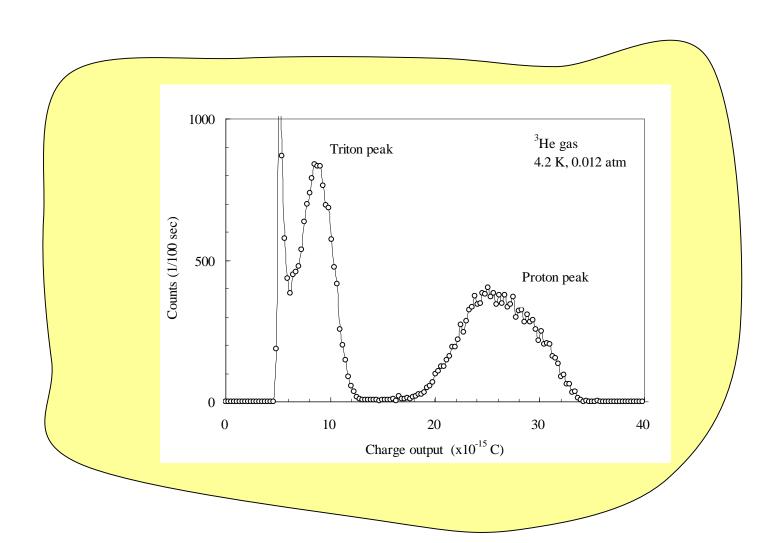
Gas pressure (3.3K, 10 atm) = Gas pressure (300K, ~900 atm)

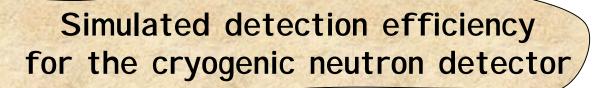
#### Pulse shape and rise time of preamplifier output signal

Rise time: 82ns 
Electron mobility: 78000cm<sup>2</sup>V<sup>-1</sup>s<sup>-1</sup>
Hole mobility: 750cm<sup>2</sup>V<sup>-1</sup>s<sup>-1</sup>

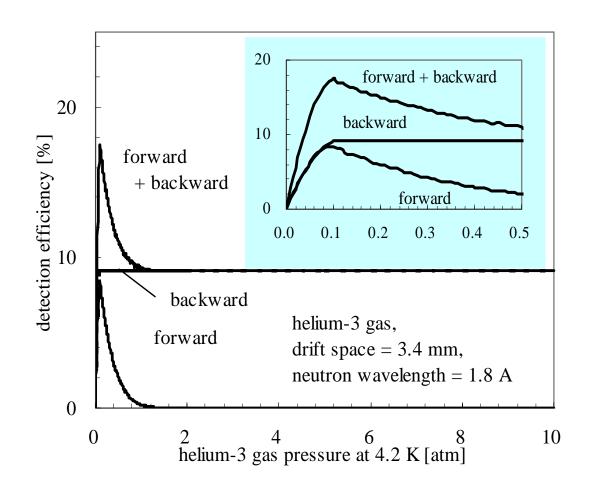


## Pulse height spectrum of <sup>3</sup>He + n → p + T + 765 keV

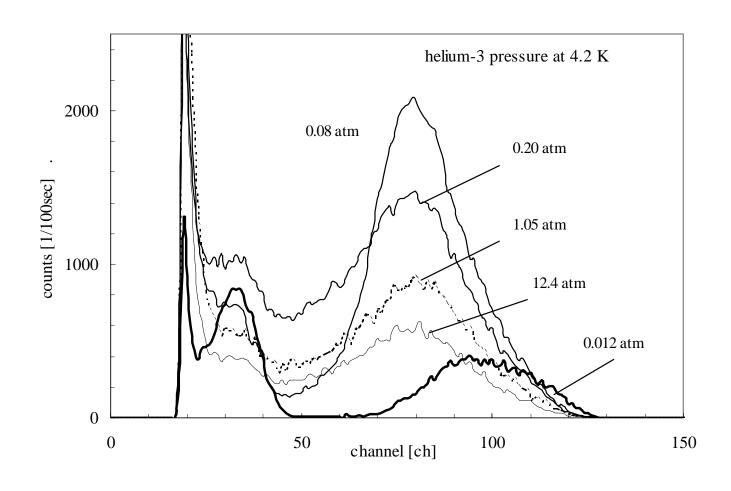






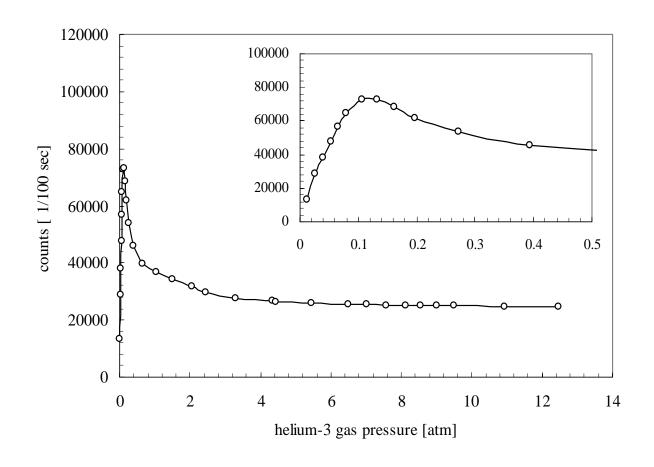


## Pulse height distribution of at the gas pressure from 0.1 to 12.5 atm at 4.2K





# Neutron counts as a function of Helium-3 gas pressure at 4.2K





### Conclusion

In conclusion, we confirmed that neutrons could be detected by a single InSb semiconductor detector at a gas pressure of 12.5 atm, where a spatial resolution of several tenth microns is expected.

We intend to develop an arrayed InSb semiconductor detector system in order to obtain neutron images.