NFRI 국가핵융합연구소
National Fusion Research Institute

KSTAR 고속중성자의 산업활용

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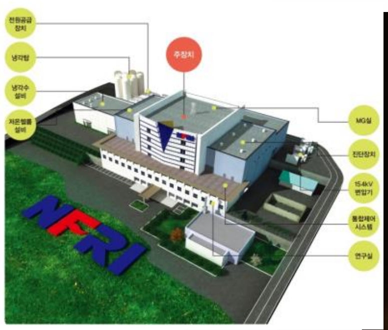
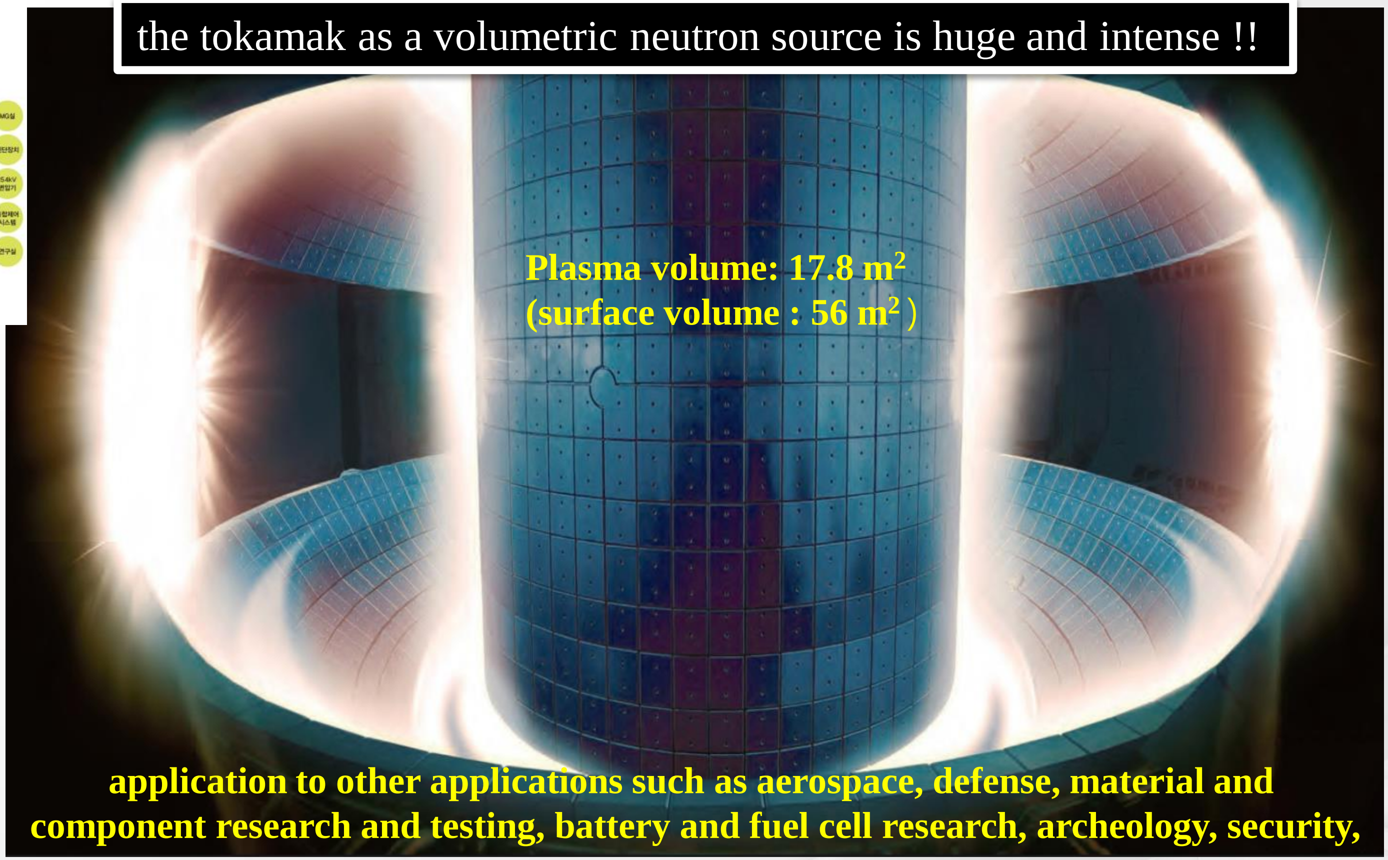
국가핵융합연구소 이 영 석

The aim and end

- Utilization of KSTAR DD Fusion Neutrons





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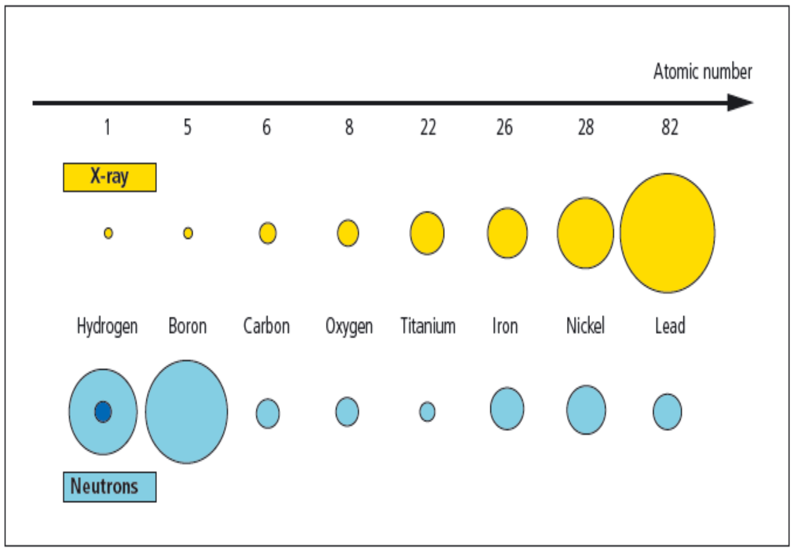
Introduction

- Characteristics of Fast neutron



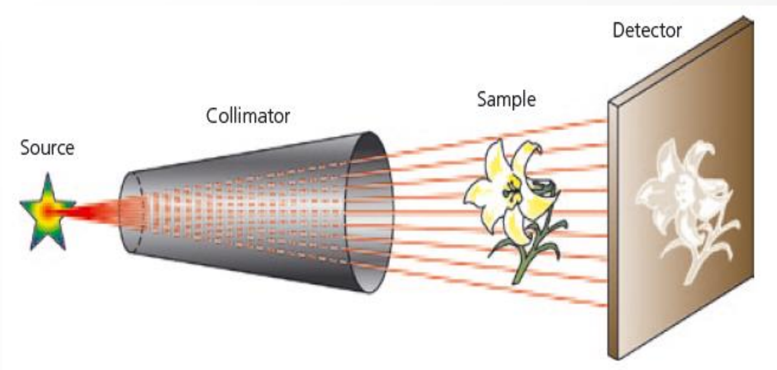
Transmission imaging with neutrons is a non-destructive testing method similar to the well-known X-ray transmission imaging technique.

The interaction cross sections and therefore transport properties for neutrons and X-rays in matter are very different. While for X-rays the interaction cross section in matter depends on the atomic number (~ Z^1 to Z^3) the cross section for neutrons depends on the specific nucleus and its nuclear structure and only very weakly on its atomic number.

For example, 1 cm of water will stop (scatter) thermal neutrons almost completely while about 97 % of fast 2.5 MeV neutrons are still transmitted through the sample. Therefore fast neutrons are the preferred choice for applications where thick samples of hydrogen rich matter are investigated.

Introduction

- Principle of imaging



Thickness material of 1cm

Thickness material of 4cm

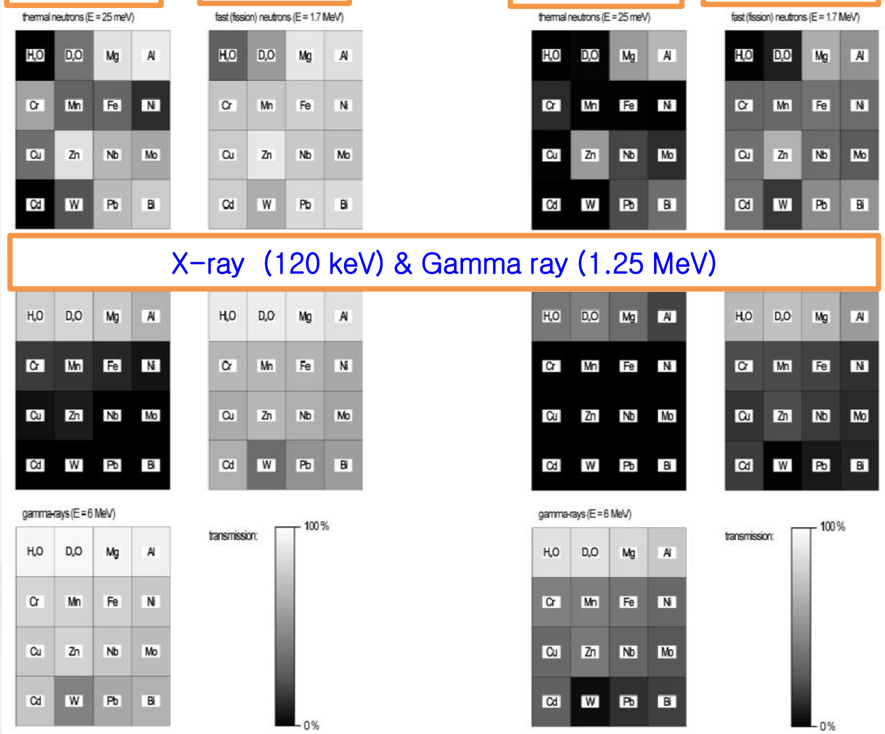
TN

FN

TN

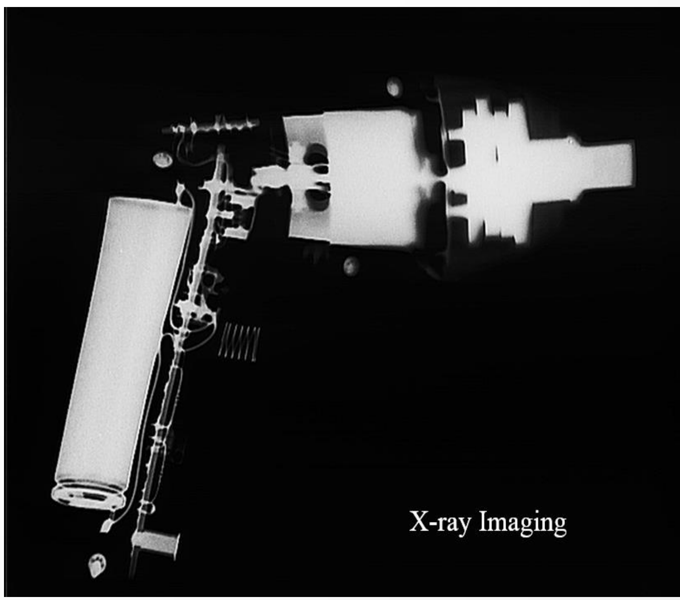
FN

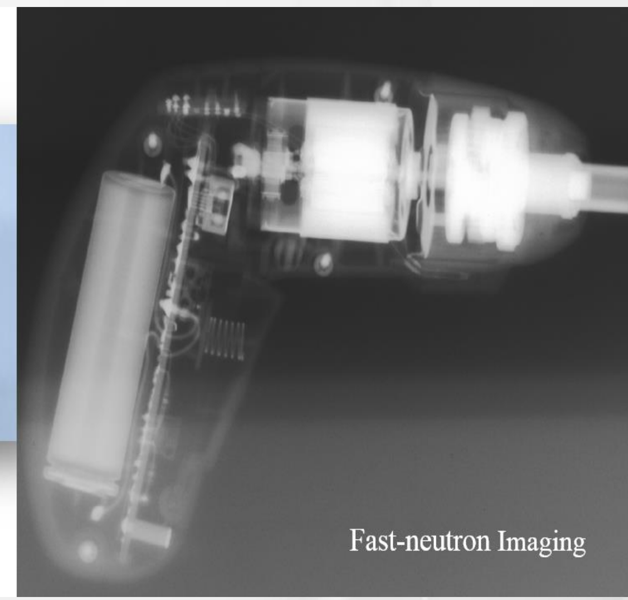
X-ray (120 keV) & Gamma ray (1.25 MeV)



Introduction

- Comparison of fast-neutron image and X-ray one (NFRI)



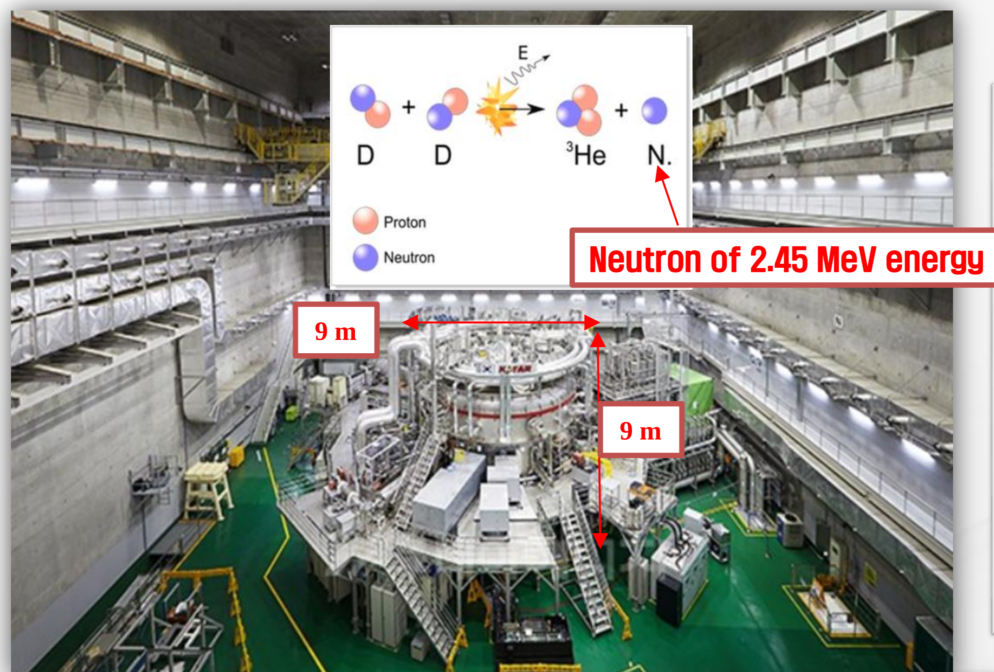


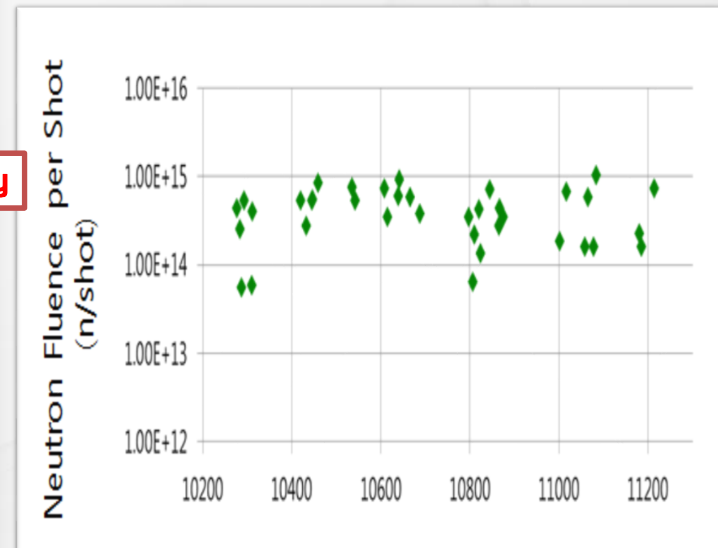
X-ray (58.2kV, 0.54mA)

fast-neutron image (2.45 MeV)

Experimental Setup

- KSTAR Tokamak & D-D Fusion Neutrons

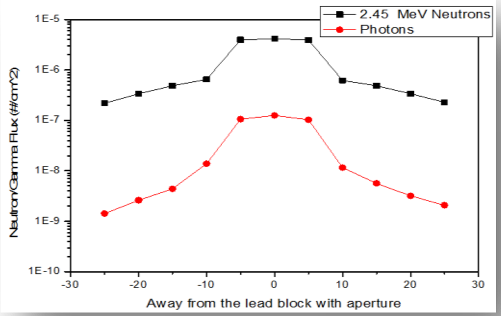


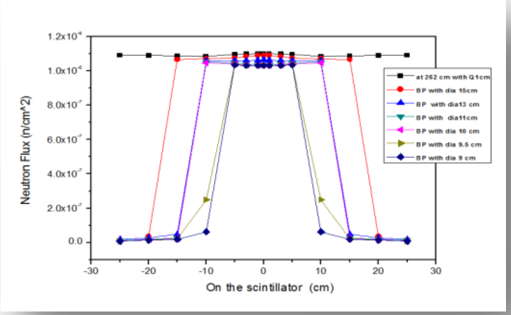


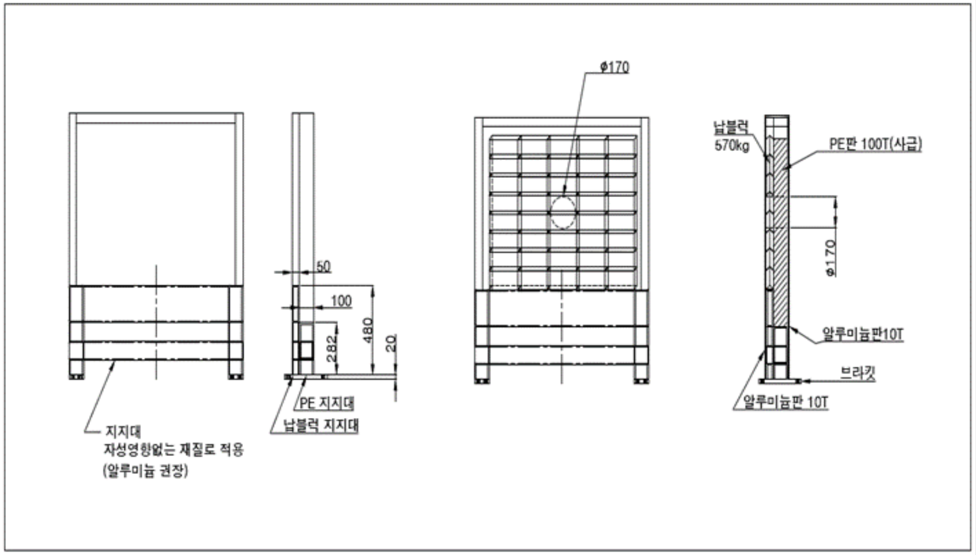
The total neutron yield during a fusion cycle in the 2015 campaign was estimated to be about 10^{13} s^{-1}

Experimental Setup

- Design drawing of shielding system with a collimator





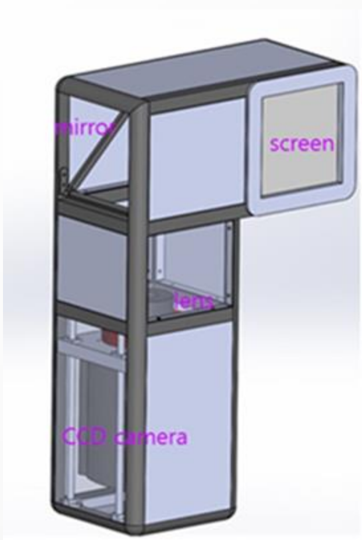


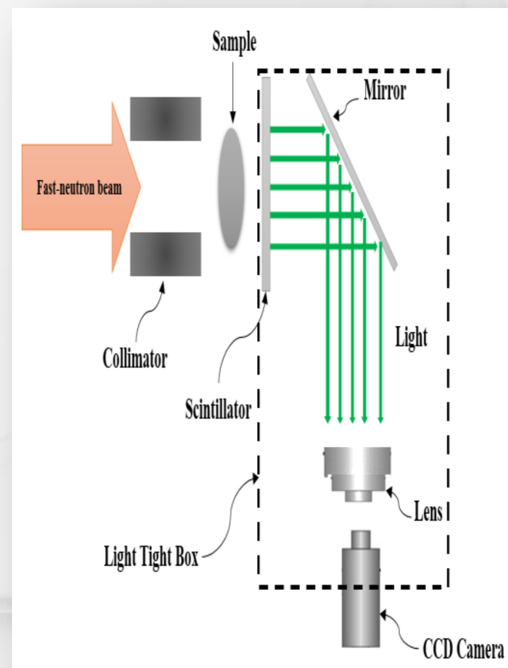
Consists of high-density polyethylene (HDPE), lead blocks and SUS304

Experimental Setup

- Light tight camera box and the fiber-optical scintillator

A design view of the L-shaped light tight camera box



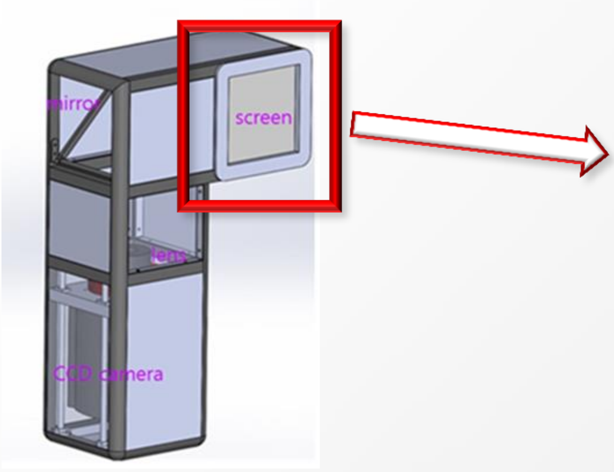


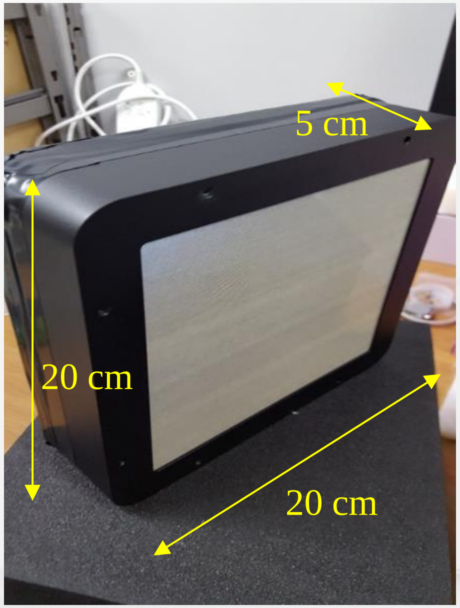
FOV of 150 x 150 mm in the scintillator plane

Experimental Setup

- Light tight camera box and the fiber-optical scintillator

A photo of the fiber-optical scintillator (FOS) which is mounted inside the adapter box

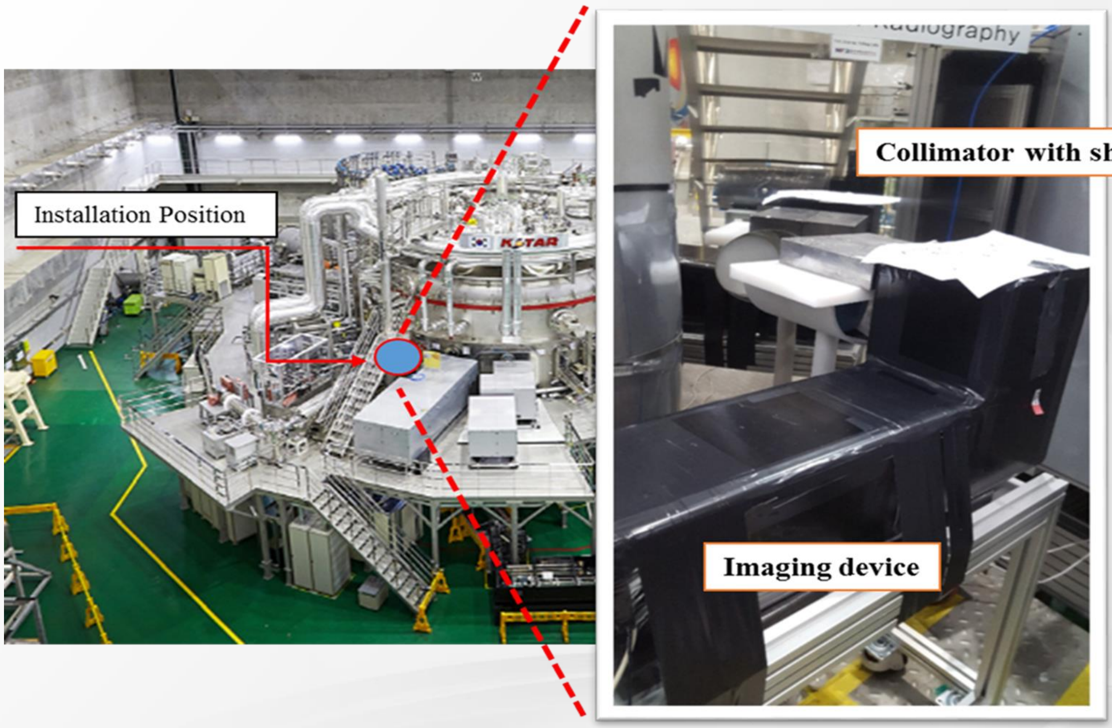




5 cm long and 0.7 mm in diameter fibers of BCF-12 plastic scintillator

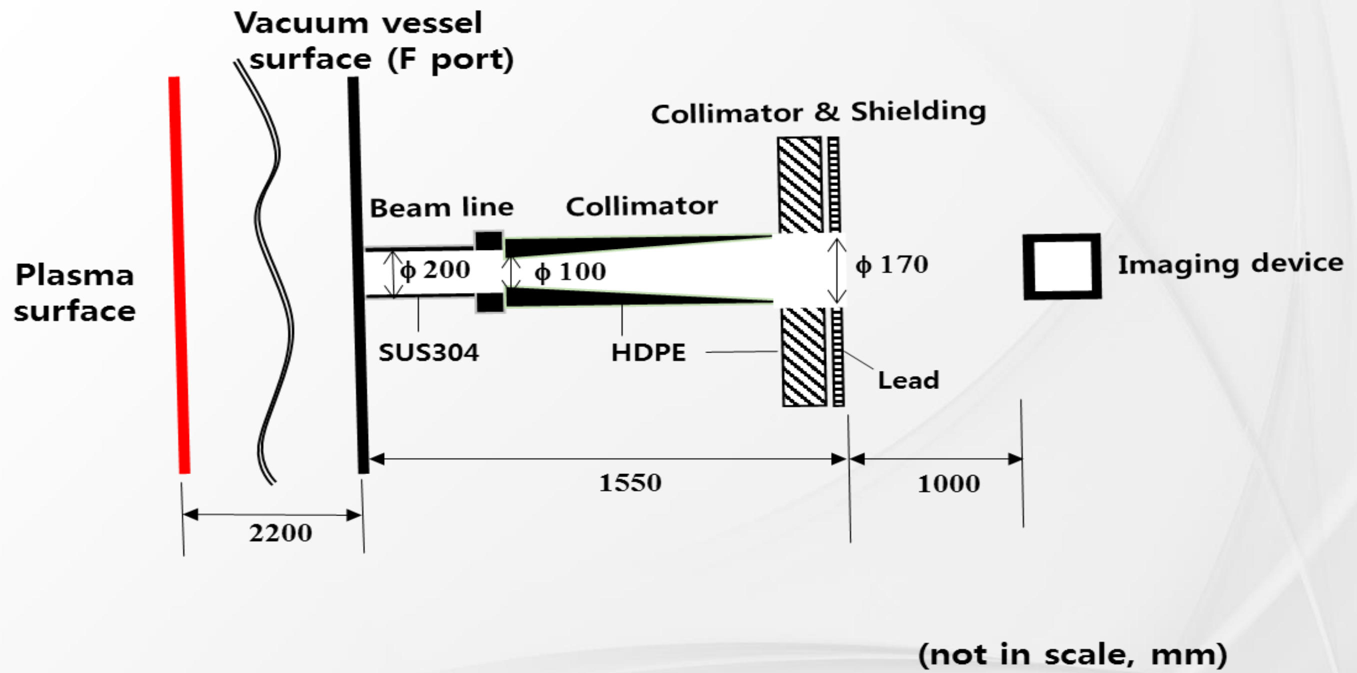
Experimental Setup

- Installation of fast-neutron imaging device at the KSTAR tokamak



Experimental Setup

- Experimental arrangement for fast-neutron imaging at the KSTAR tokamak



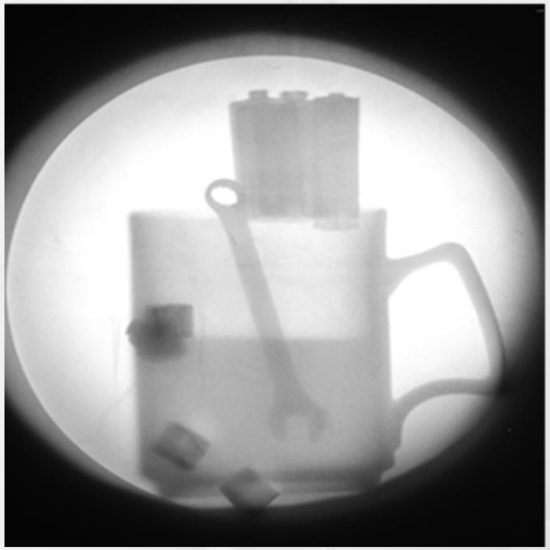
The L/D is ~21, and the available neutron fluence for a single exposure of an image (limited by a single discharge cycle of the KSTAR) was of the order of 10^{10} cm^{-2} in the detector plane

Fast-Neutron Imaging Results

- Fast-neutron image by the film method on KSTAR tokamak

Uncollimated

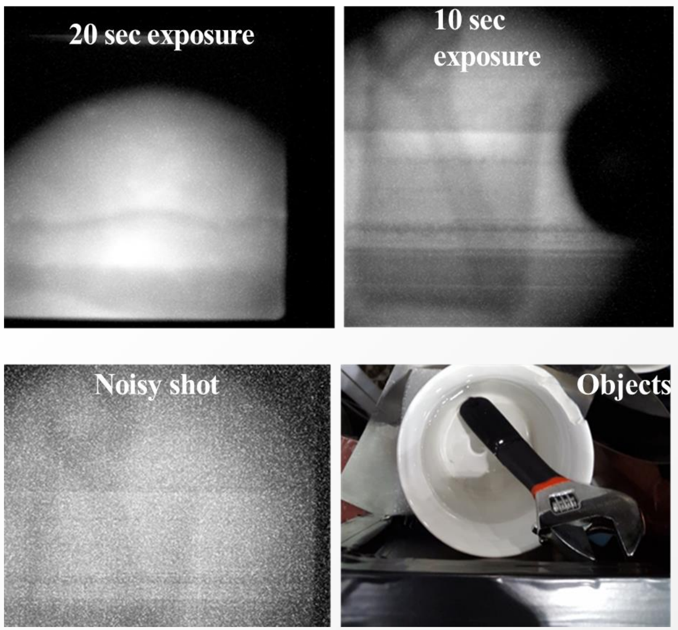
Collimated

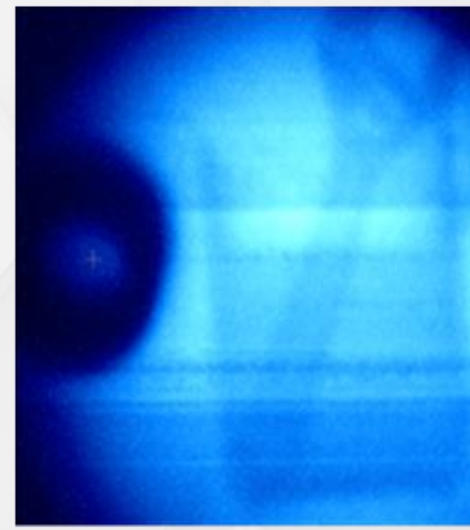


The use of only industrial X-ray film <u>without any converters such as Gd, Dy and In</u>

Fast-Neutron Imaging Results

- Fast-neutron image with the CCD camera on KSTAR tokamak

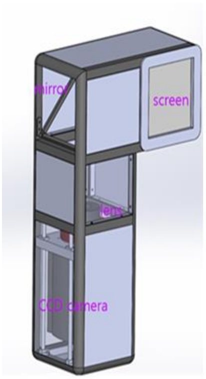


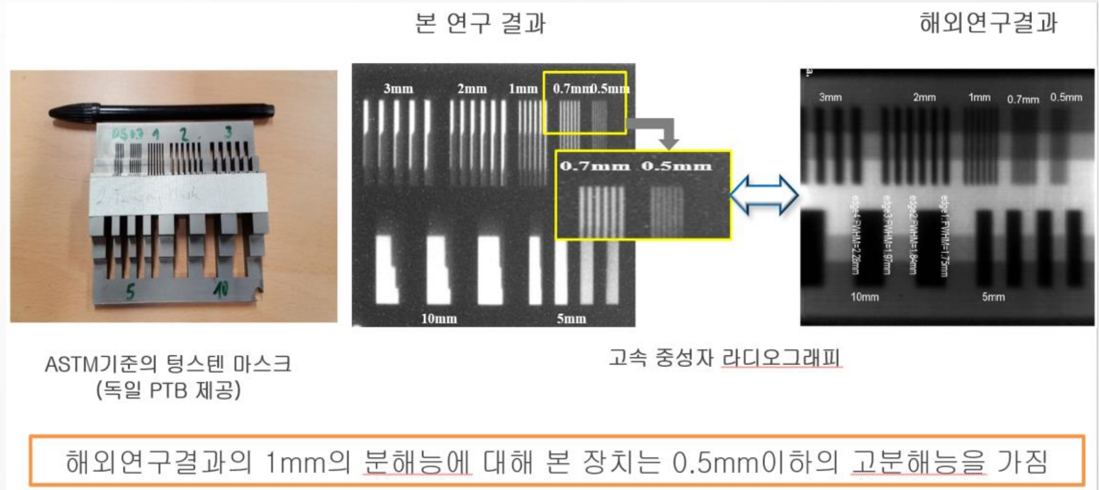


exposed to only one plasma shot less than about 8 sec

Due to the low L/D, the thick scintillator and the large neutron source !!

Summary





- **Nation’s first fast-neutron imaging technique in korea**
- **Demonstration of use possibility of KSTAR as large-scale research facility**
- **fast neutron imaging at the KSTAR tokamak can be used for industrial applications**
- **and also the development of fast neutron imaging techniques may open the door to many new applications**

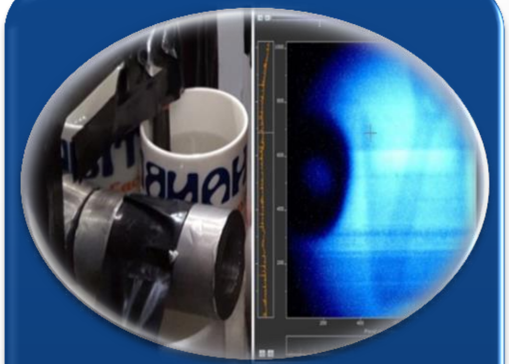
The developed digital imaging technique on the basis of CCD camera is

- Realization of world-class technology level,

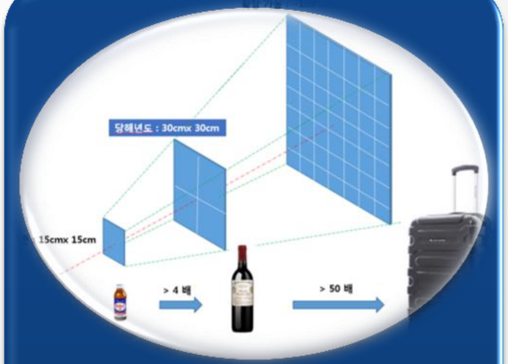
※ spatial resolution (<0.5mm) of our imaging system compared to that (~1mm) of PSI (Swiss) and PTB (Germany) where plays the world’s leading role in neutron imaging is much superior

Future Plan

On-site fast-neutron imaging technique



The nation's first fast-neutron imaging technique



Large-scale imaging technique

On-site imaging equipment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