Kobayashi-Maskawa Institute
for the Origin of Particles and the Universe

NAGOYA
UNIVERSITY

EcoTopia
Science Institute
NAGOYA UNIVERSITY

Development of fast neutron and proton detector in high gamma ray field and its applications

Kunihiro Morishima and collaborators

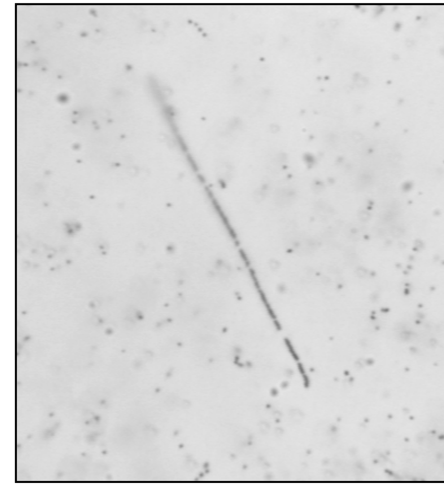
Flab, Department of Physics
Kobayashi-Masukawa Institute for the Origin of Particle and the Universe
EcoTopia Science Institute
Nagoya University

Contents

- application in normal condition
- application in high gamma ray field
    - sensitivity control of nuclear emulsion
    - inertial fusion diagnostics
    - laser fusion diagnostics
    - laser ion acceleration measurement

proton

neutron



		Particle	
		Proton	Fast neutron
Environment	normal	Proton measurement Radiography	Neutron measurement Radiography
	High gamma ray fields	Laser ion acceleration	Fusion plasma diagnostics

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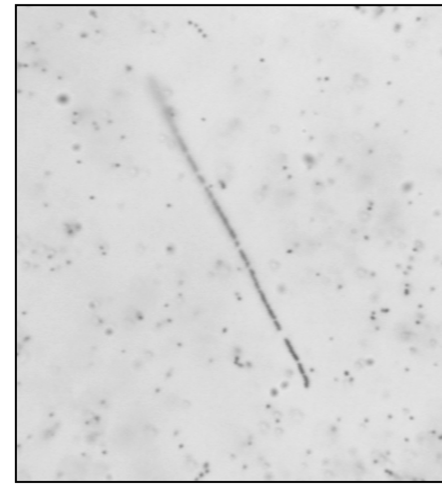

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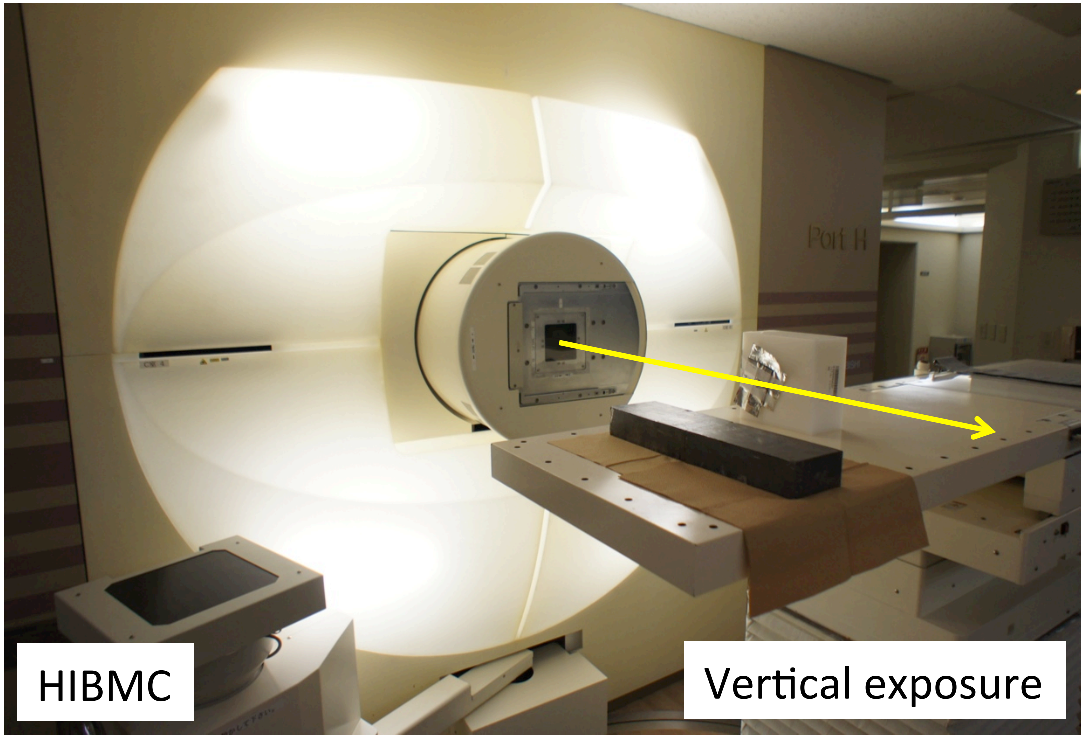
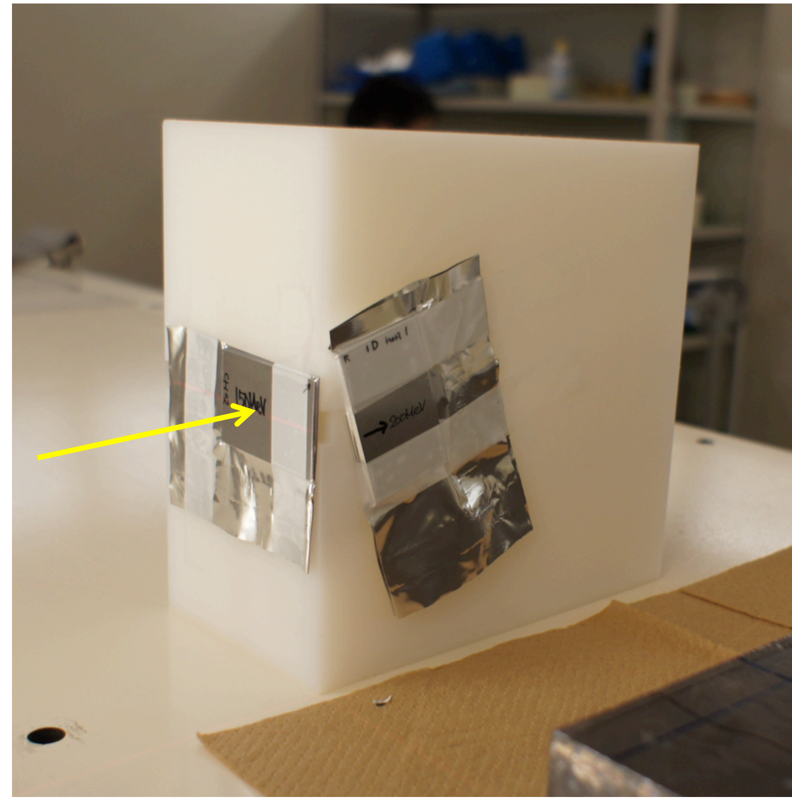
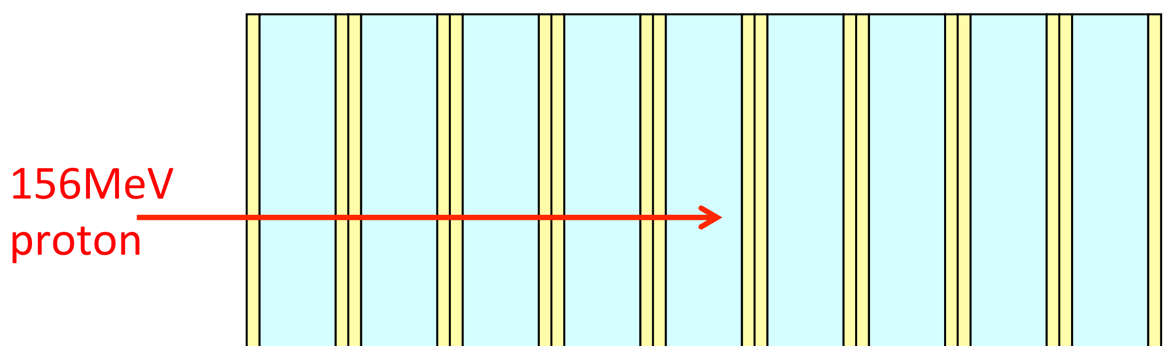
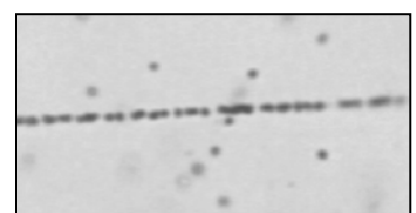
Proton beam exposure
@ HIBMC / HIMAC, NIRS



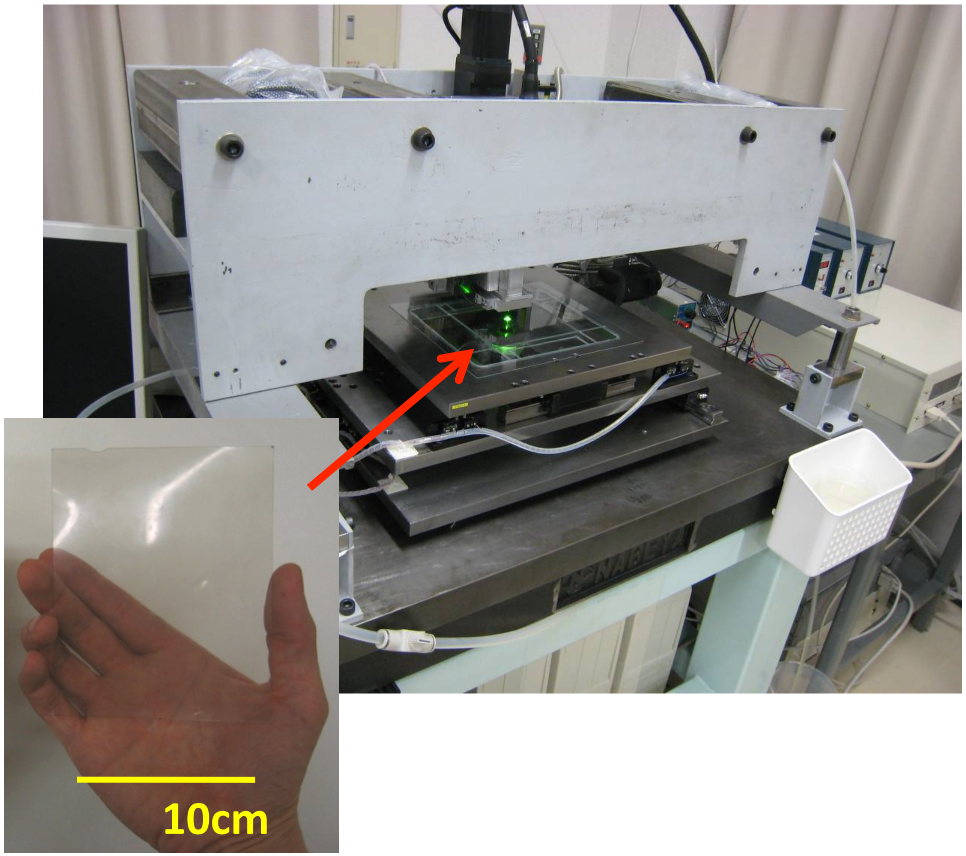


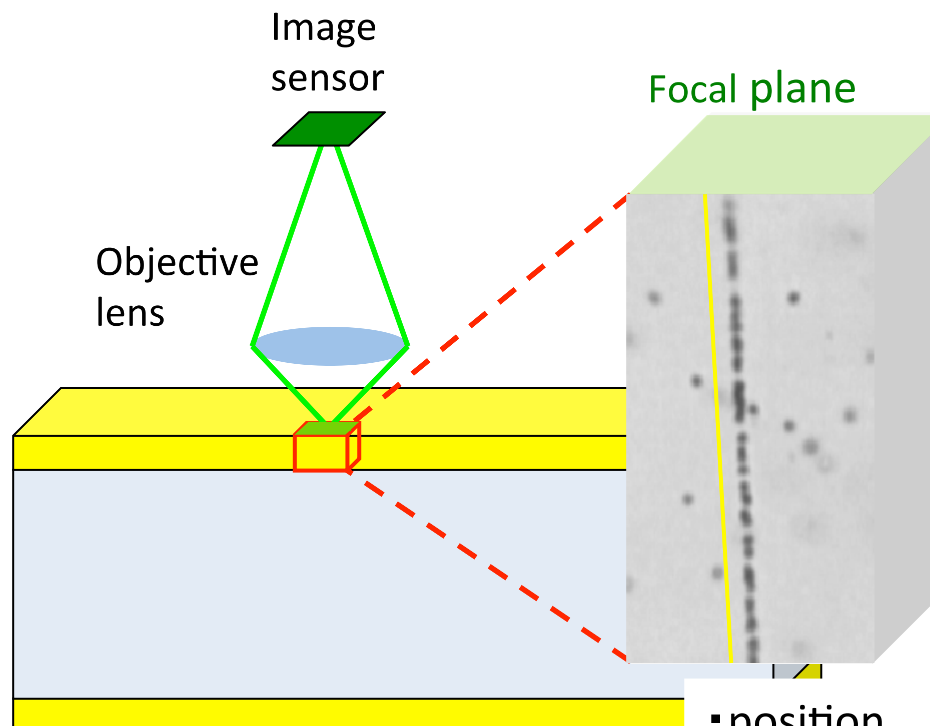




Japanese Emulsion Scanning System : Track Selector

S-UTS (Super-Ultra Track Selector)

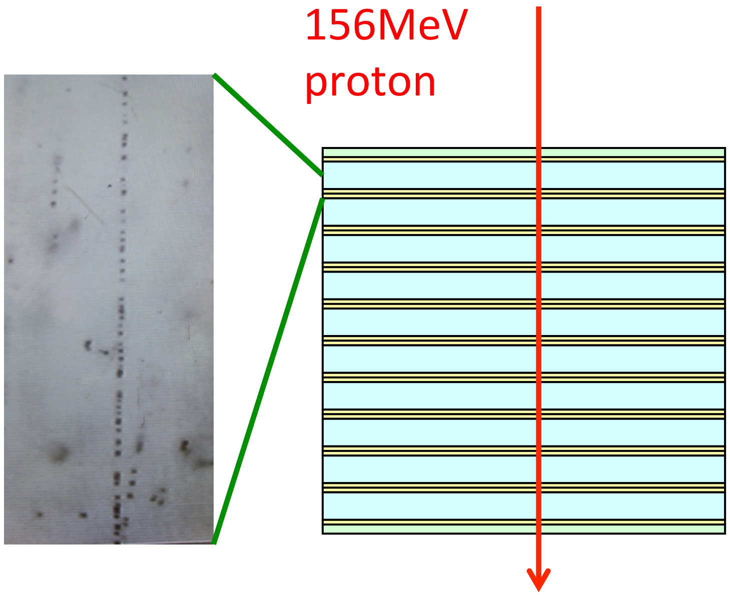




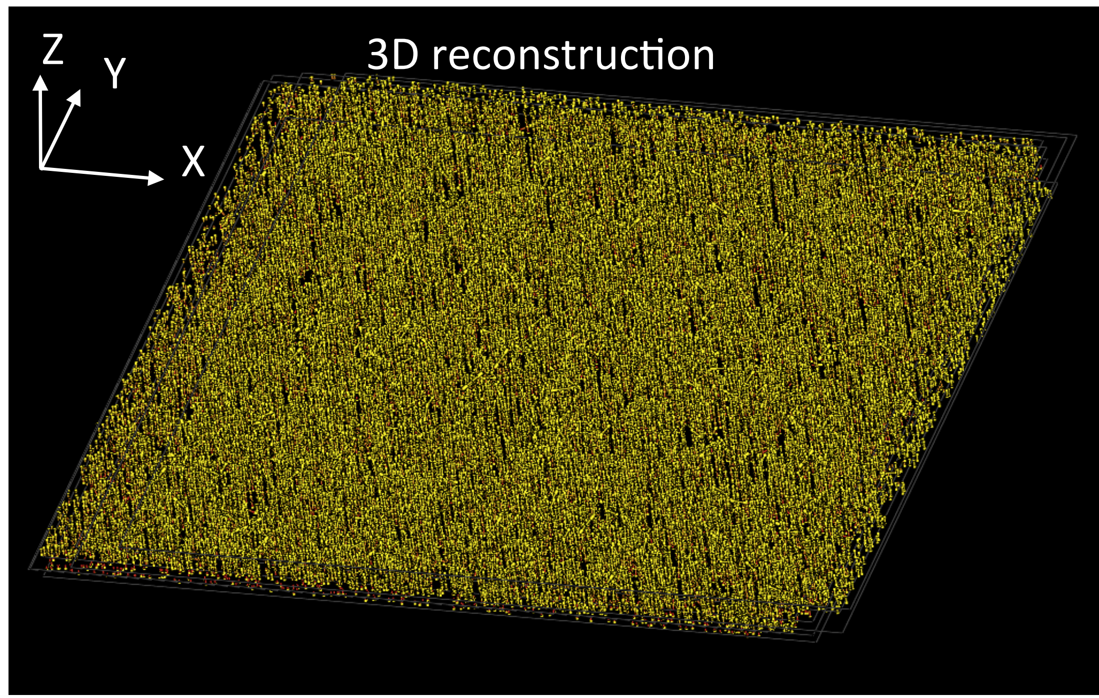
- position
- angle
- density

K.Morishima and T.Nakano, "Development of a new automatic nuclear emulsion scanning system, S-UTS, with continuous 3D tomographic image read-out", Journal of Instrumentation 5 P04011, 2010

Reconstruction of 156 MeV Proton Track



HIMAC @NIRS
proton density : $10^4/cm^2$



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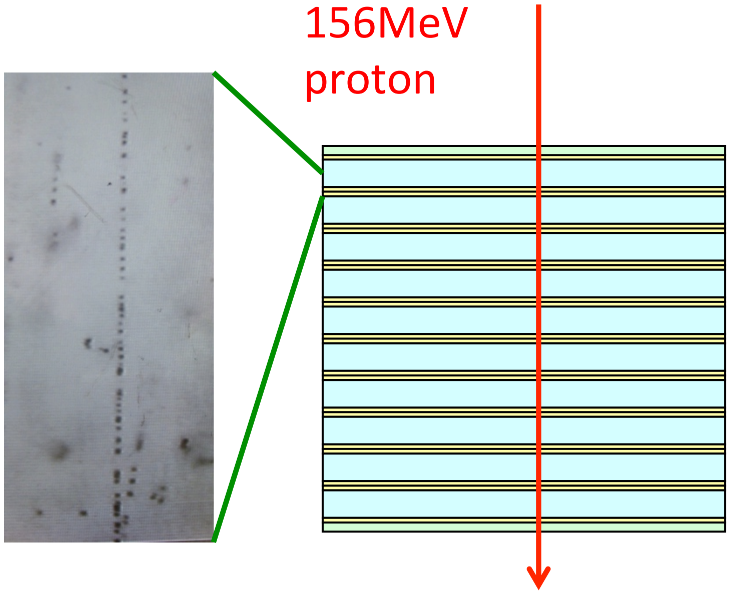

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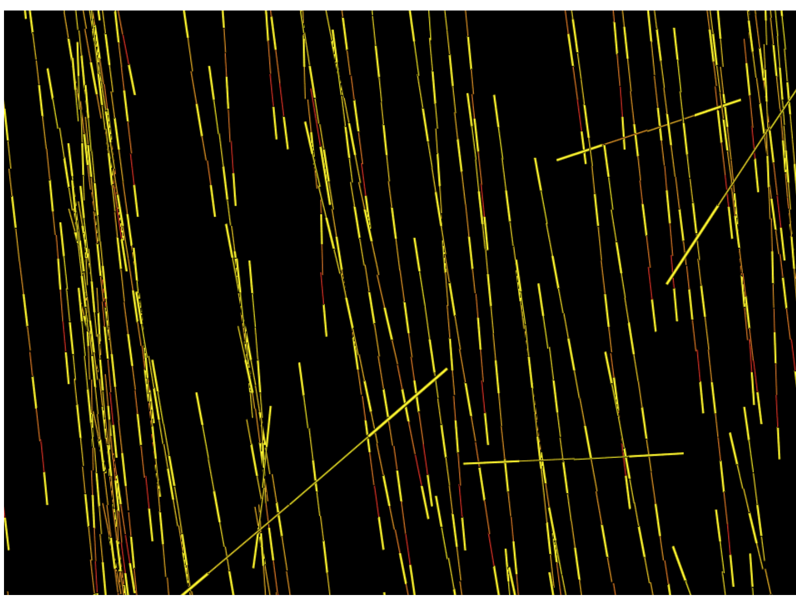

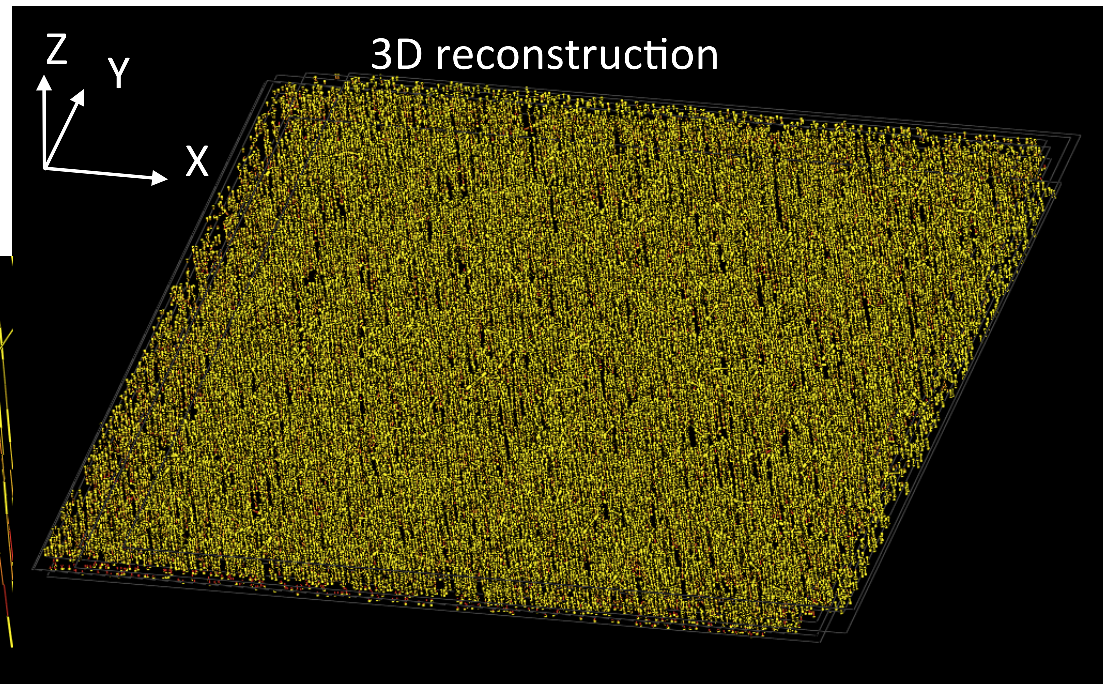

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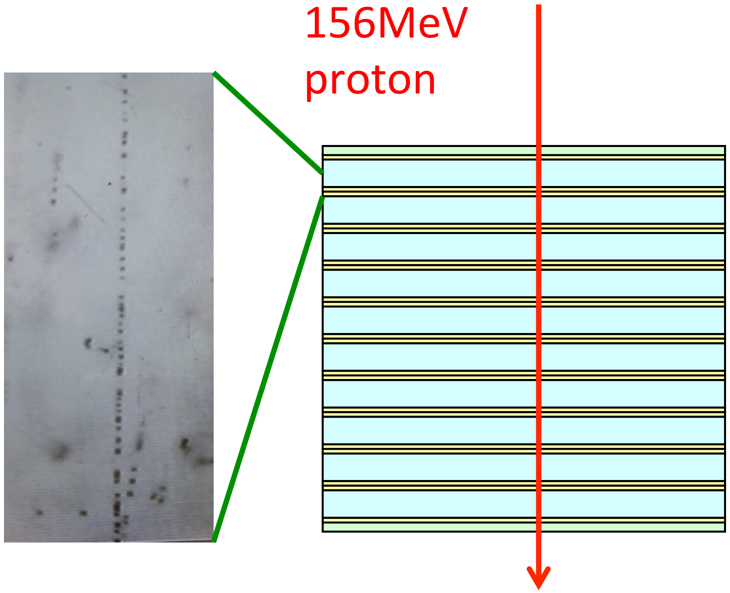
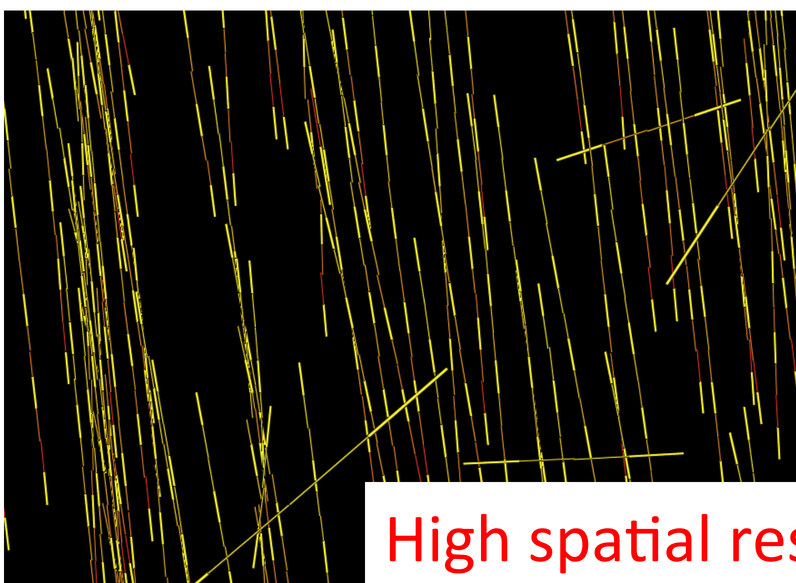
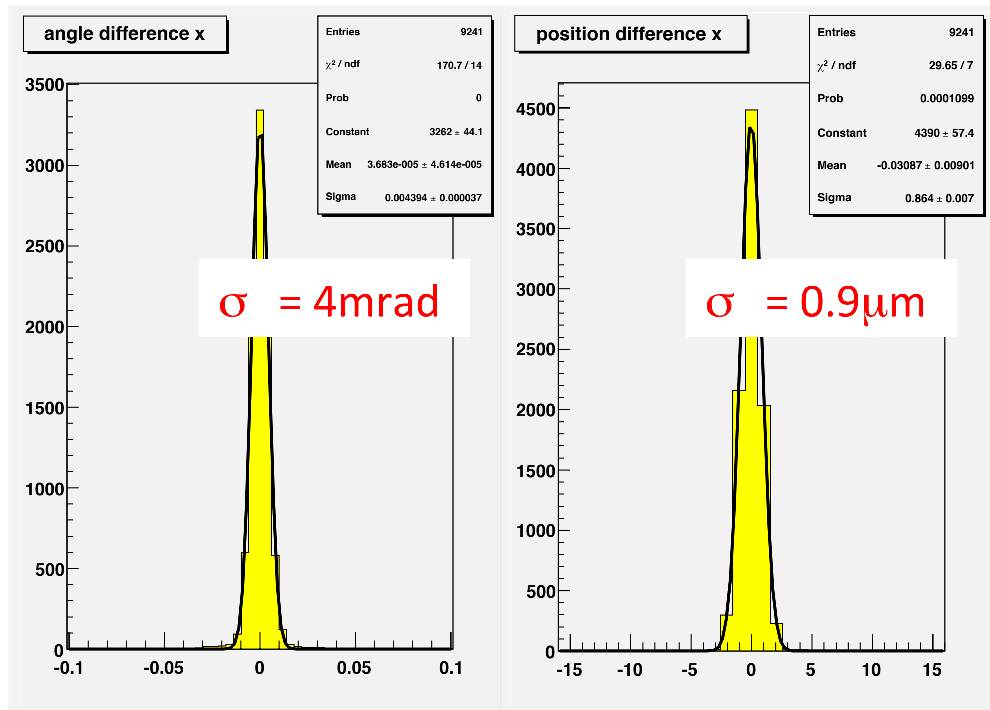




Measurement Accuracy

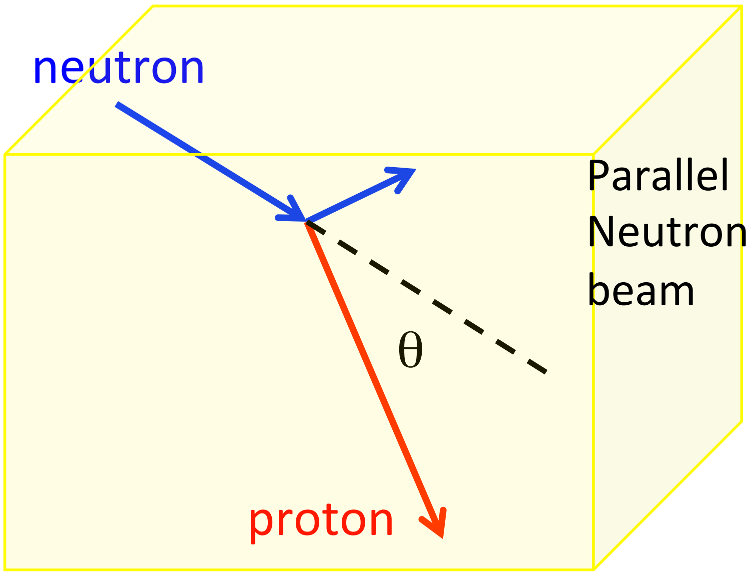


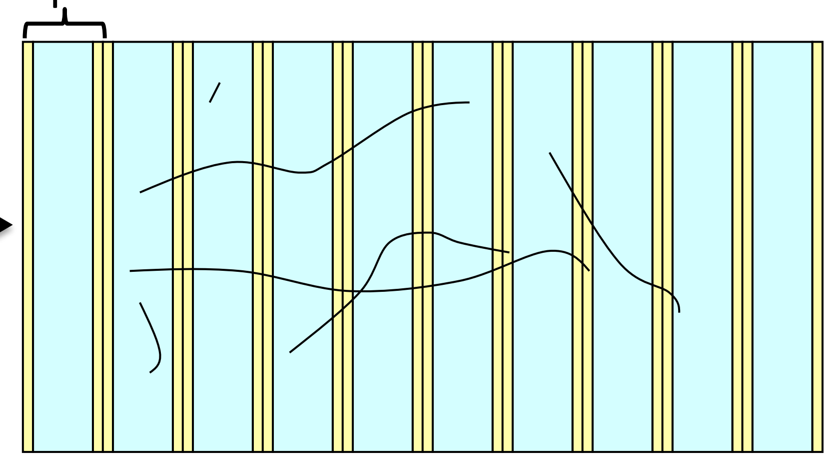
Detection Efficiency

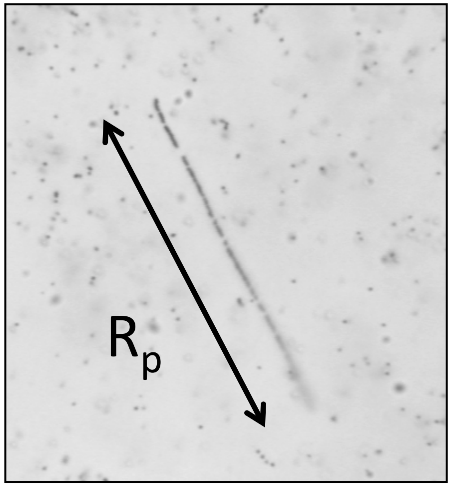
1 nuclear emulsion layer ~ 99%

High spatial resolution and High efficiency

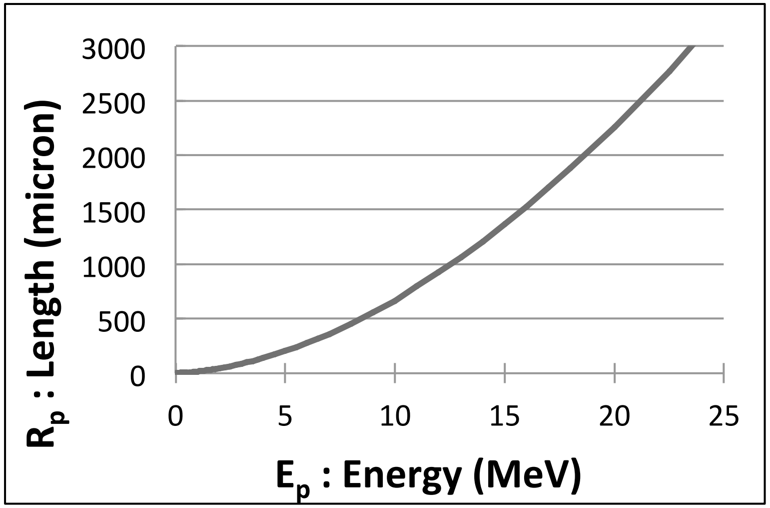
Fast neutron measurement



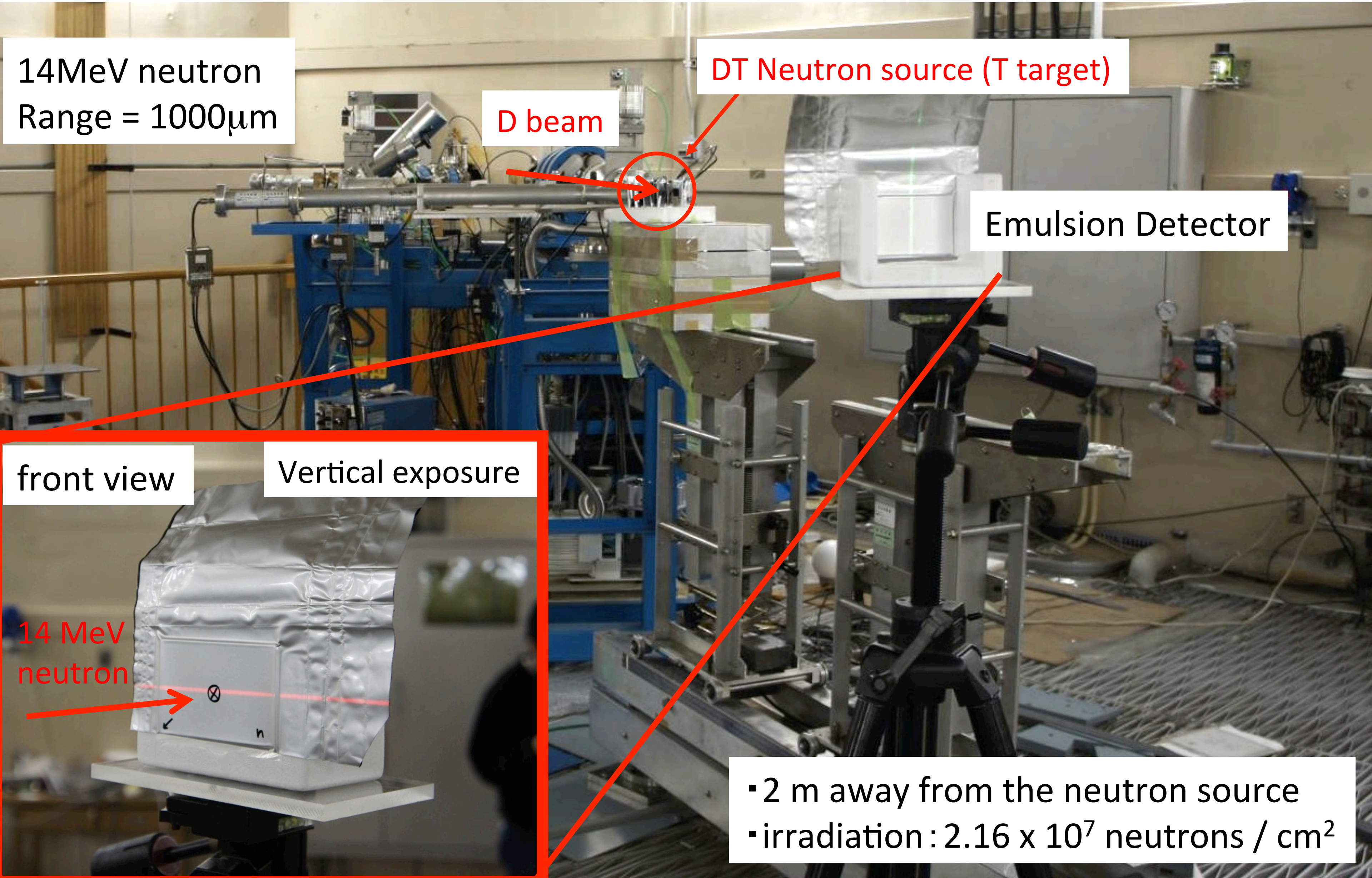




Fusion neutron DD(2.4MeV), DT(14MeV)



DT neutron measurement
@ 14.8MeV Neutron facility (AIST)



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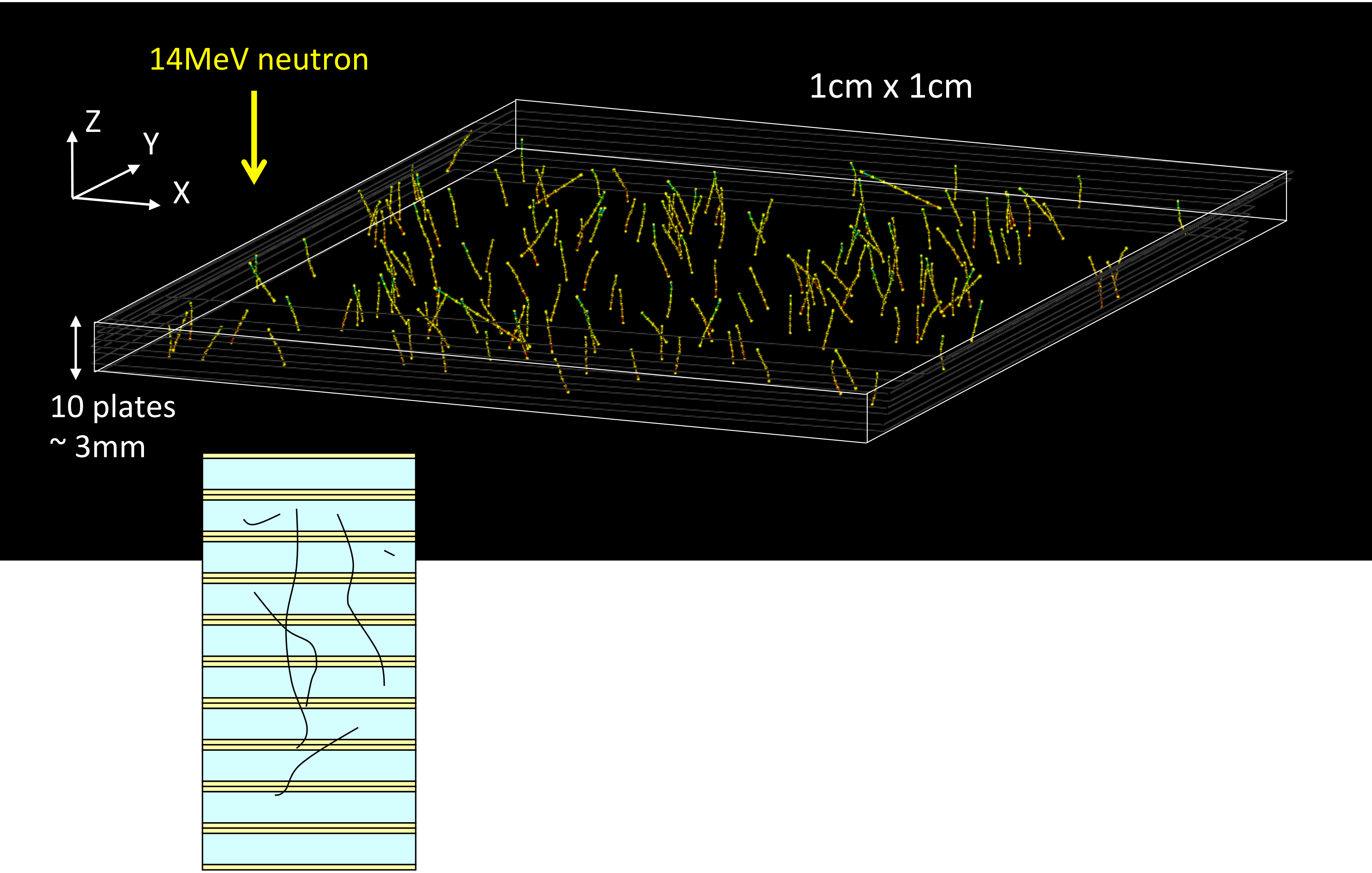

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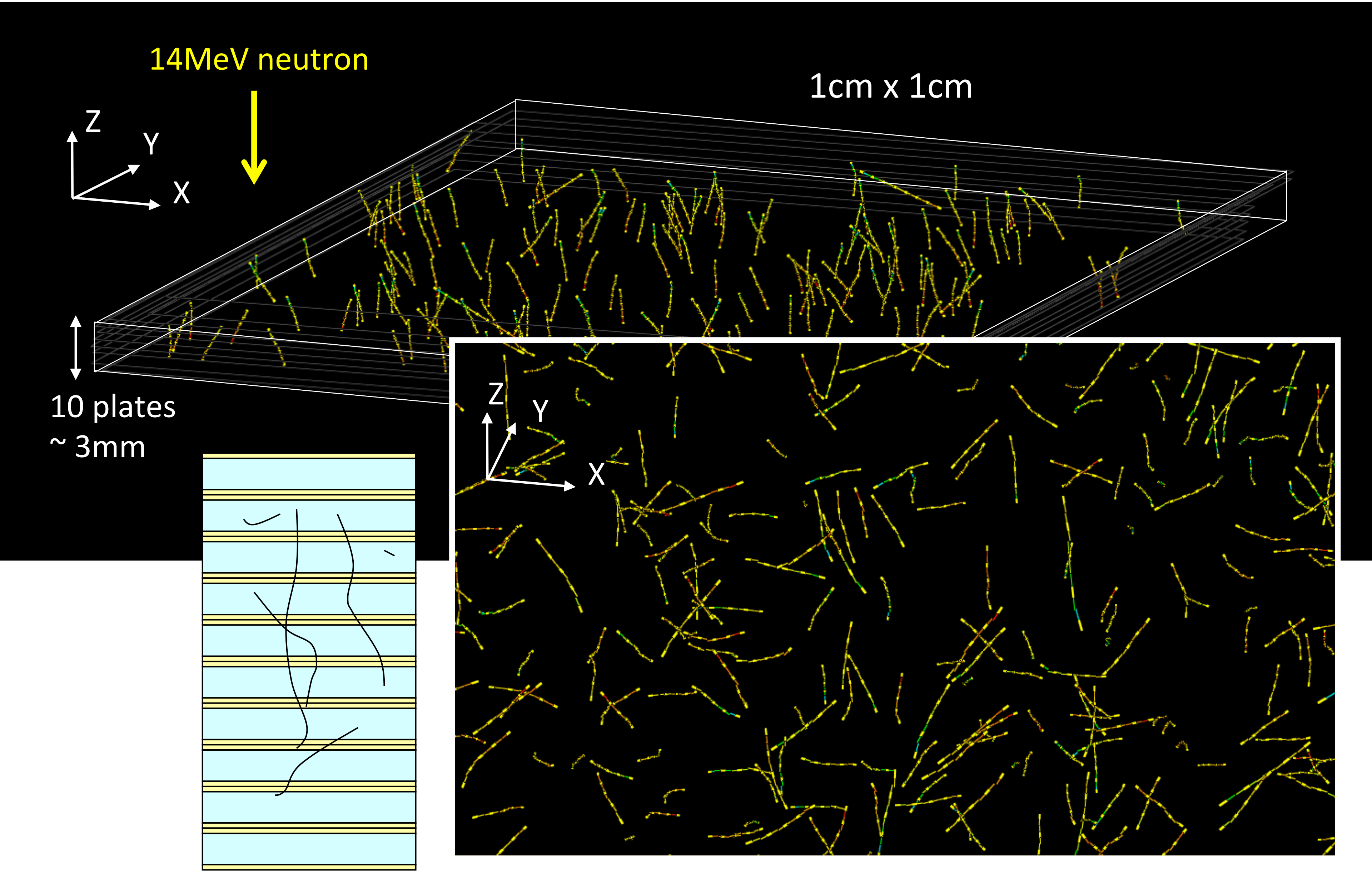
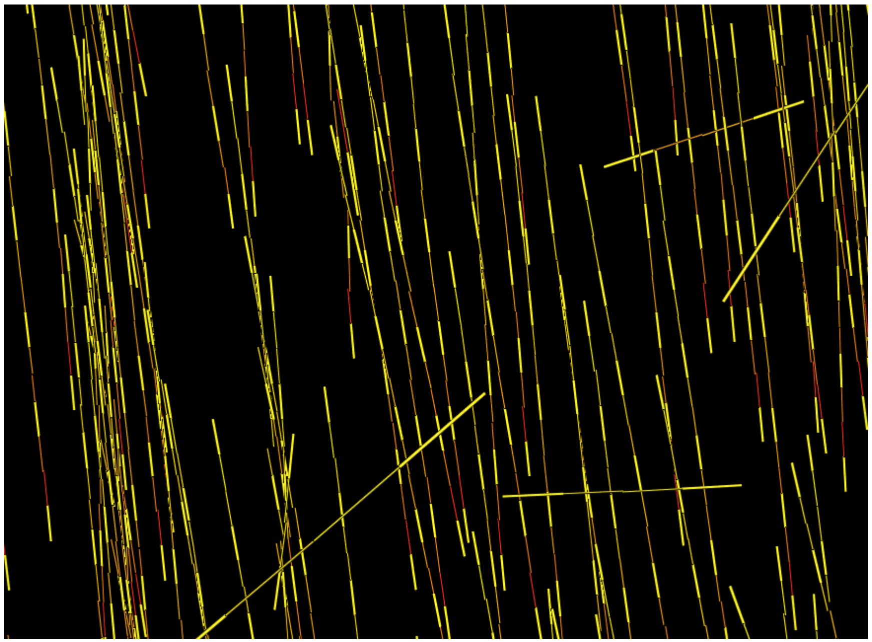


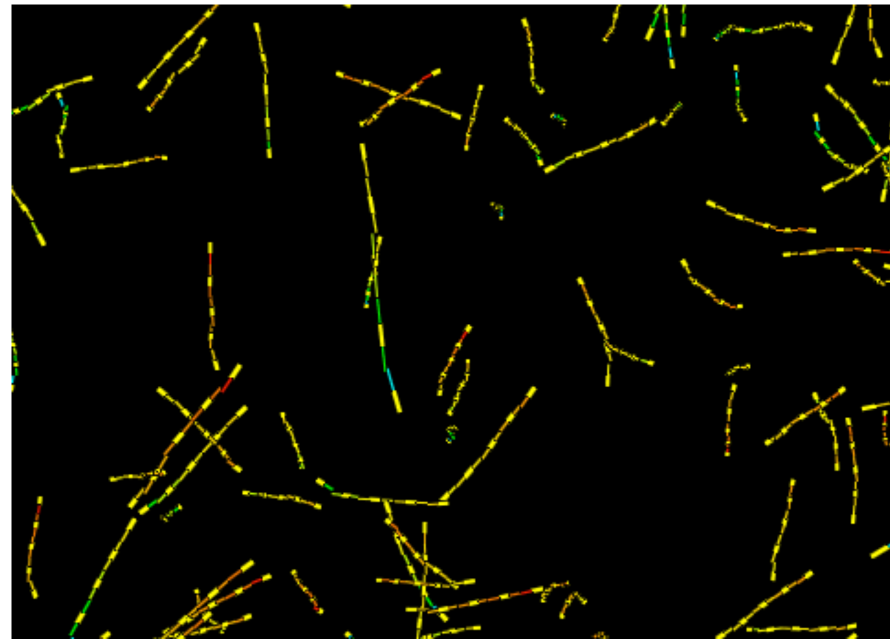
Comparison between proton and neutron

156MeV proton



Penetrating tracks
Straight tracks

14MeV neutron

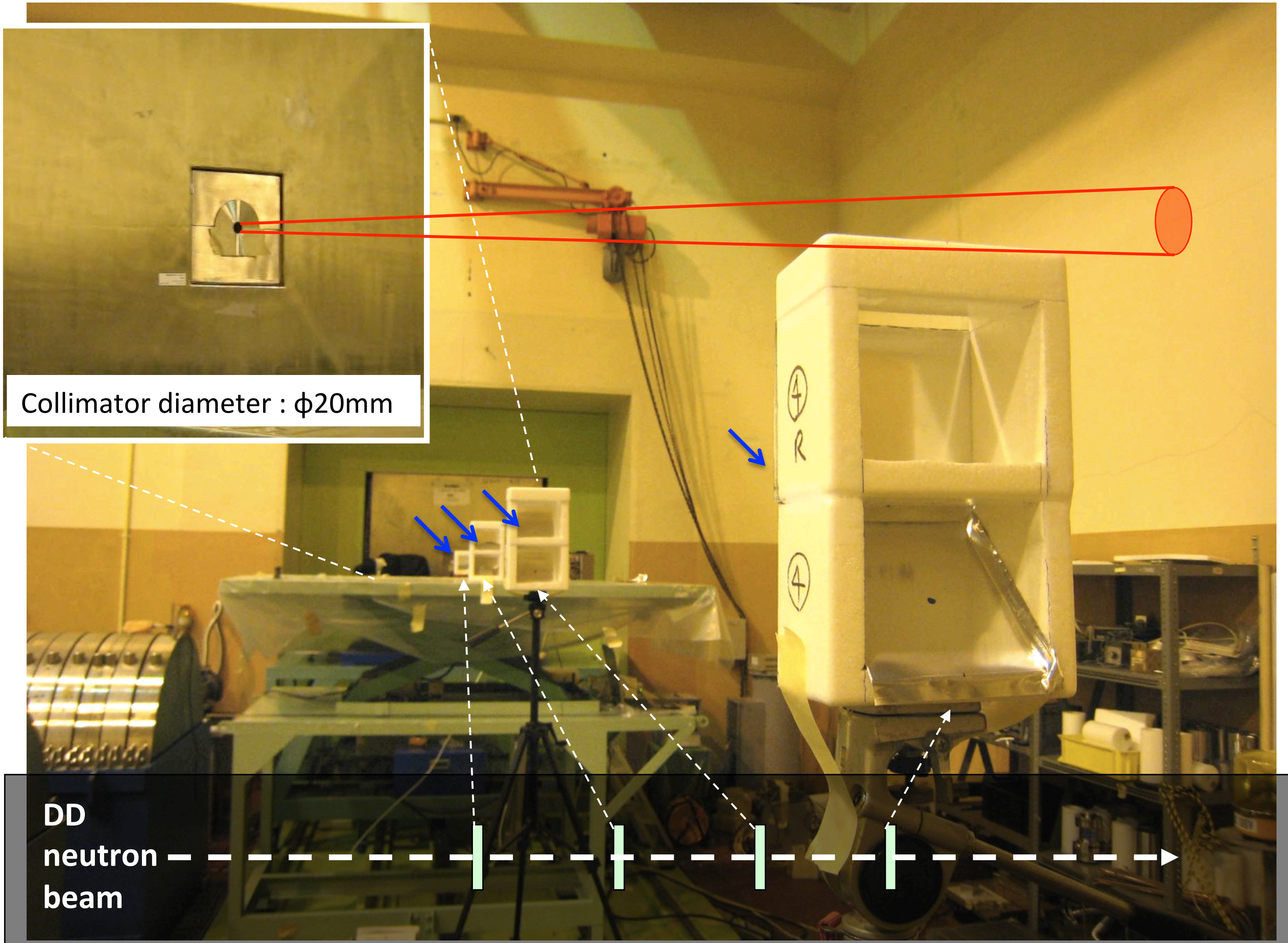


Generation and Stopped in emulsion
Bended tracks by coulomb scattering

It's possible to separate between proton and neutron by using these features

We are discussing about medical application with hadron therapist

DD neutron measurement @FNS JAEA, Japan



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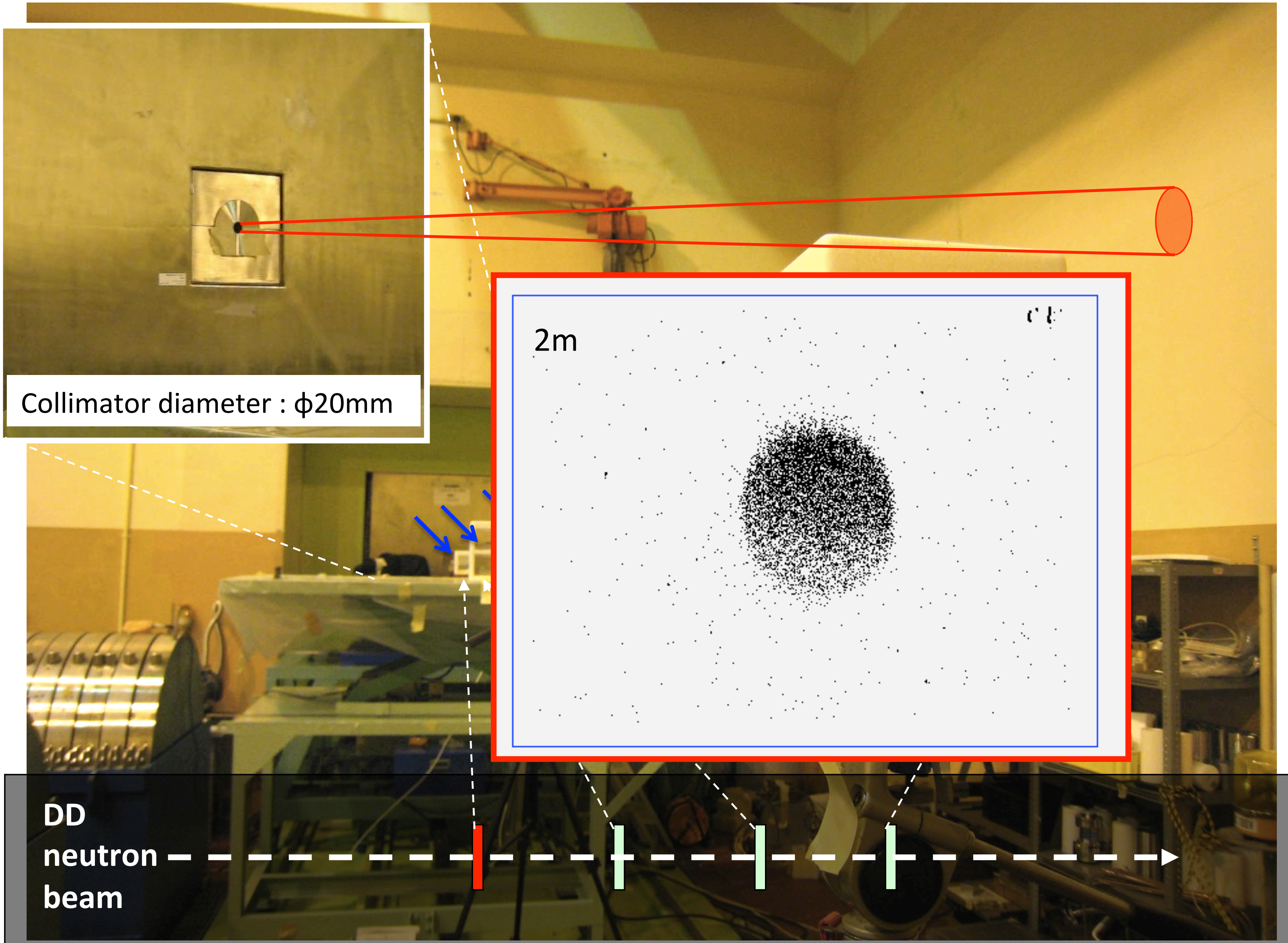

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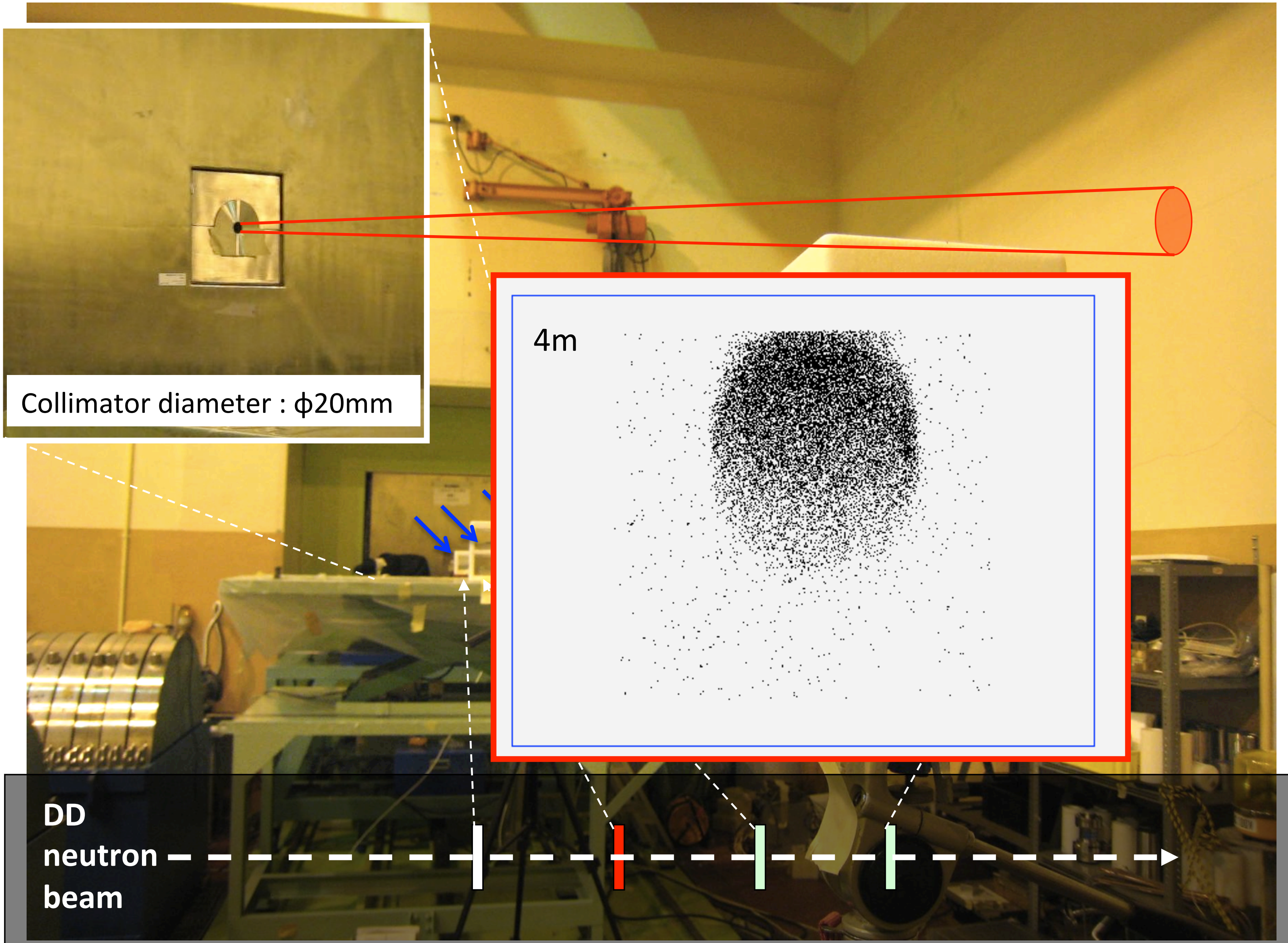

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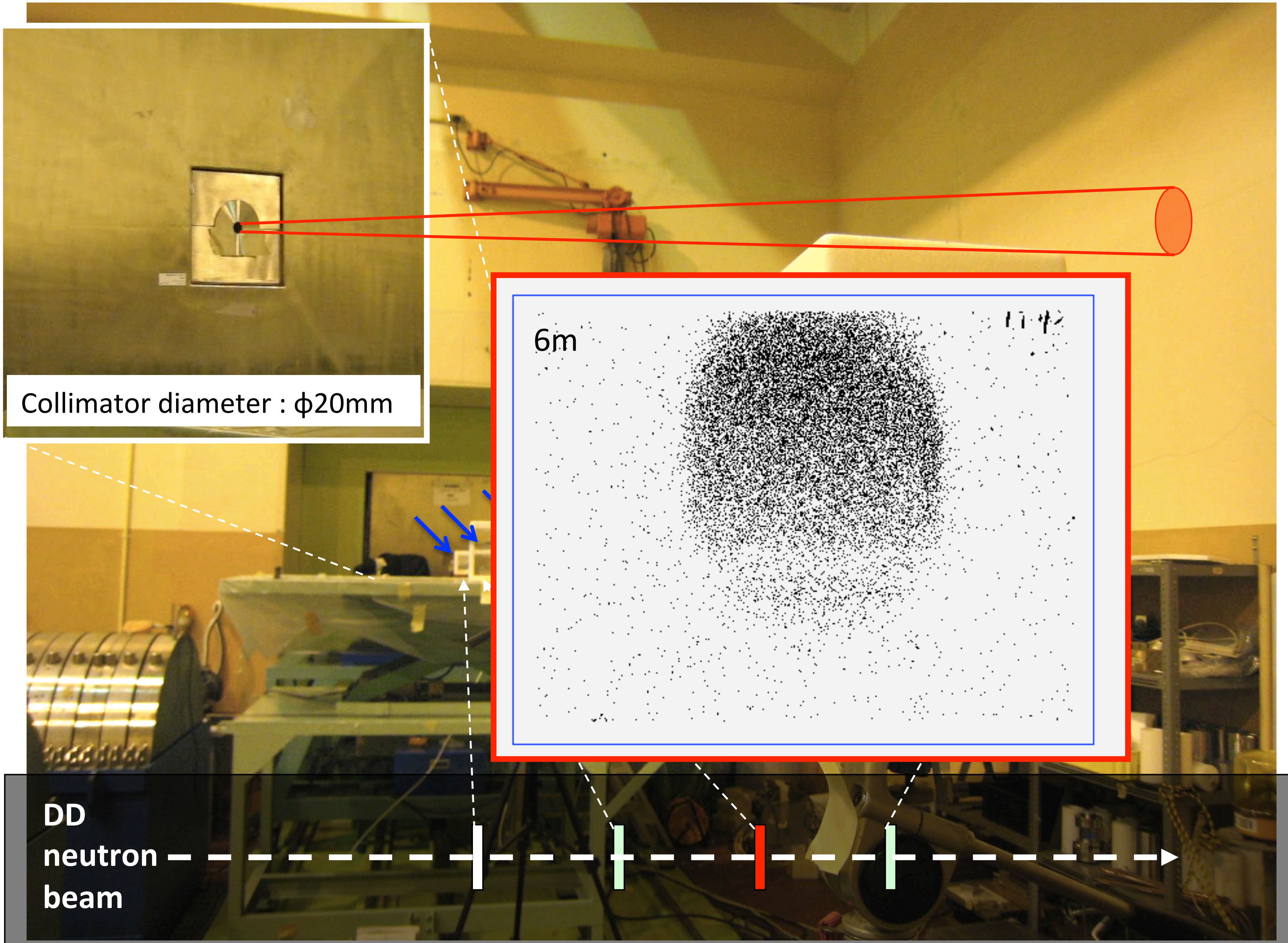

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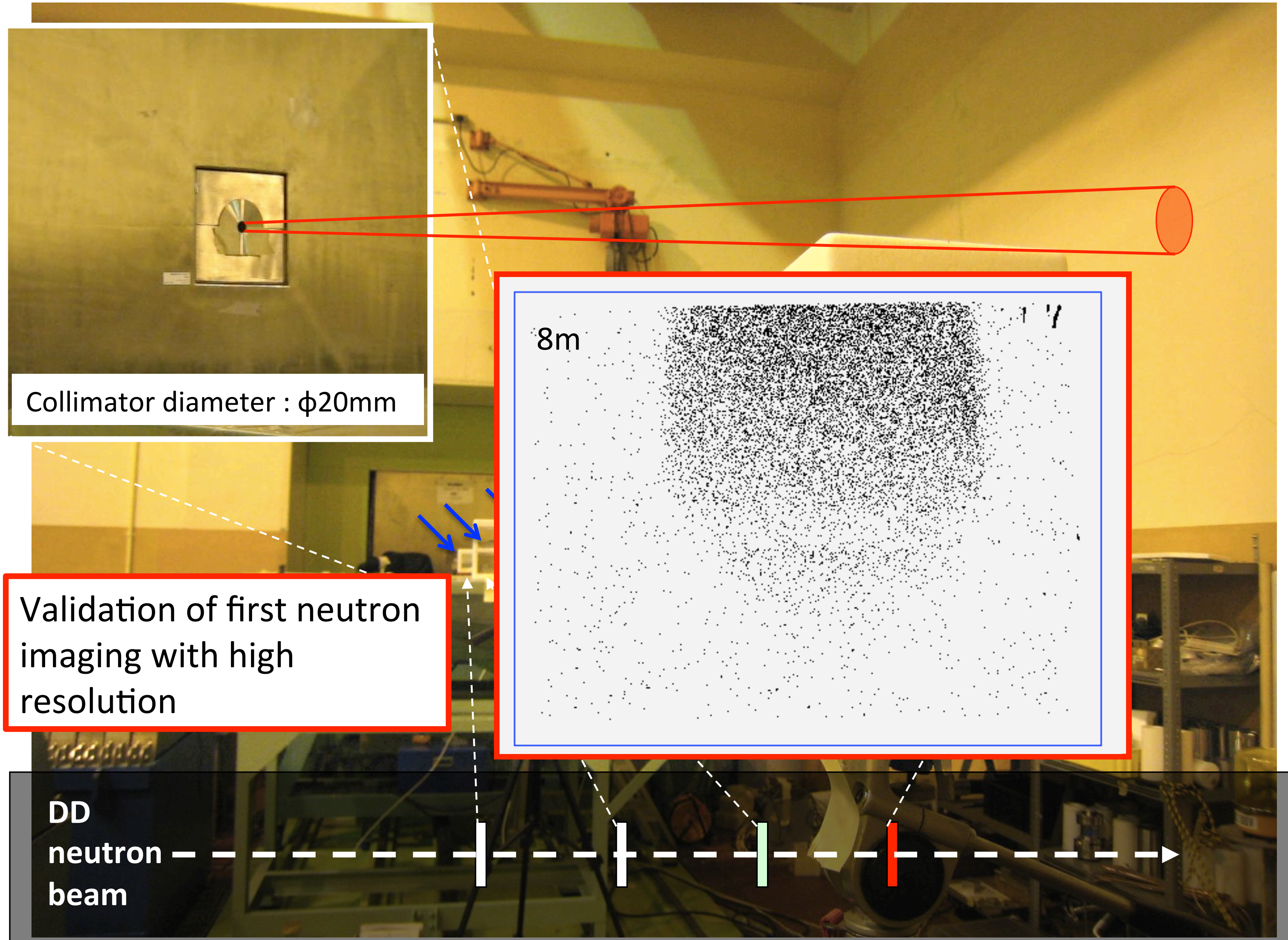
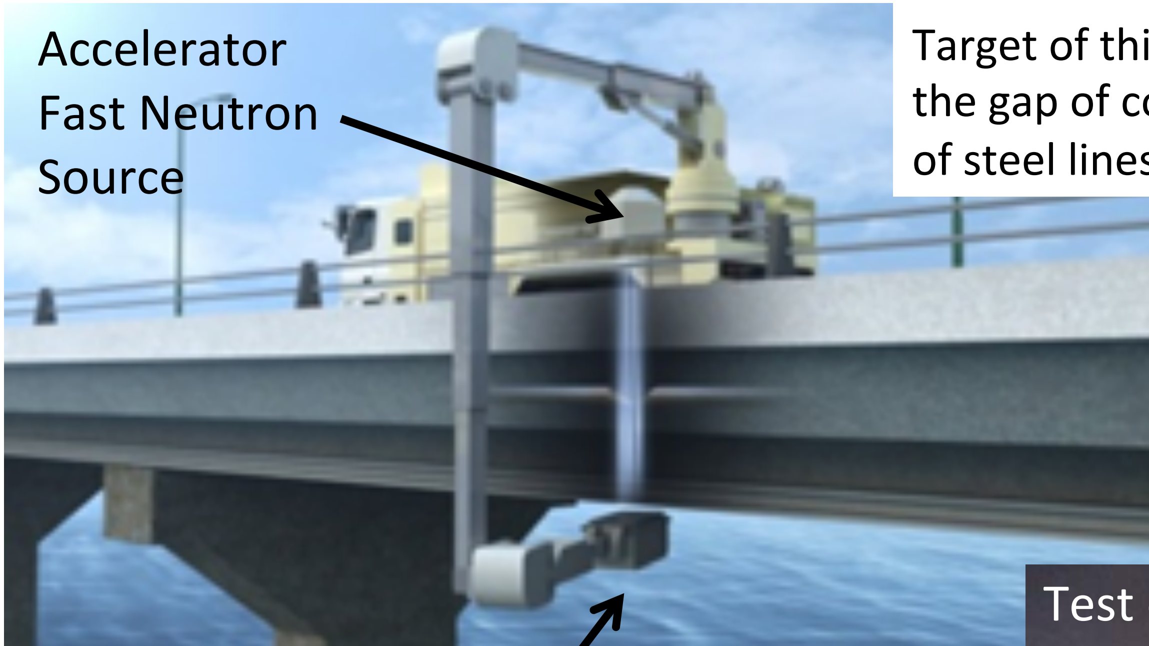


Validation of first neutron imaging with high resolution

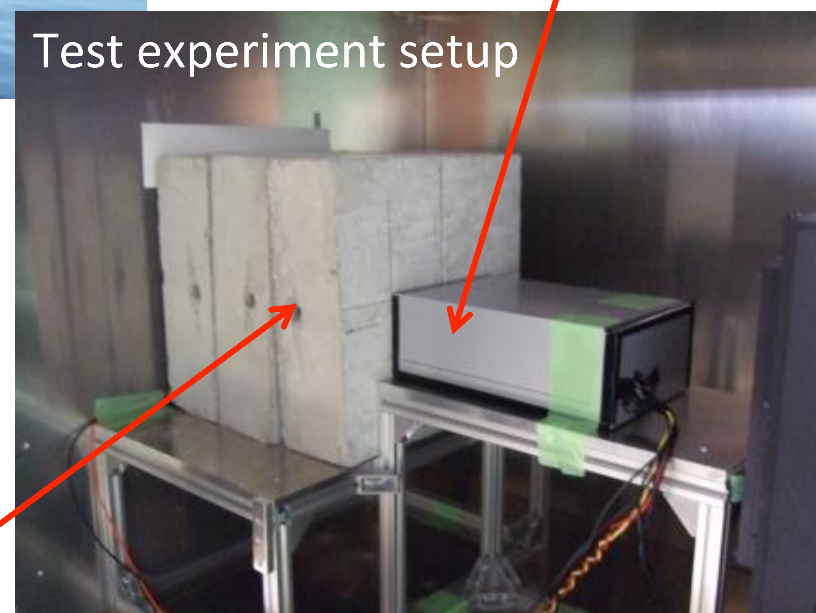
Plan : Fast Neutron Imaging for non-destructive inspection of large-scale concrete structure



Target of this measurement is the detection of the gap of concrete and breaking or thickness of steel lines.

Fast Neutron Detector

Emulsion Detector



We are planning to conduct test experiment on Nov. 2013 with RIKEN.

Concrete Sample
（100mm thickness）
With 16mm ϕ steel

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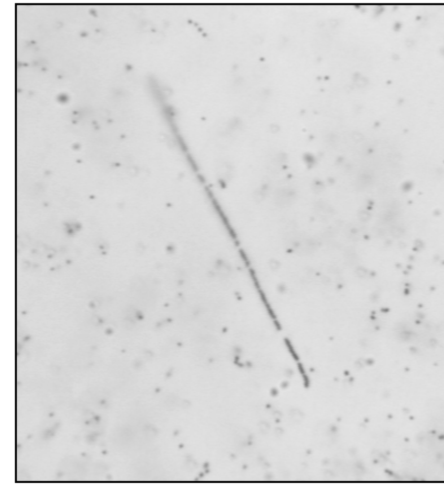

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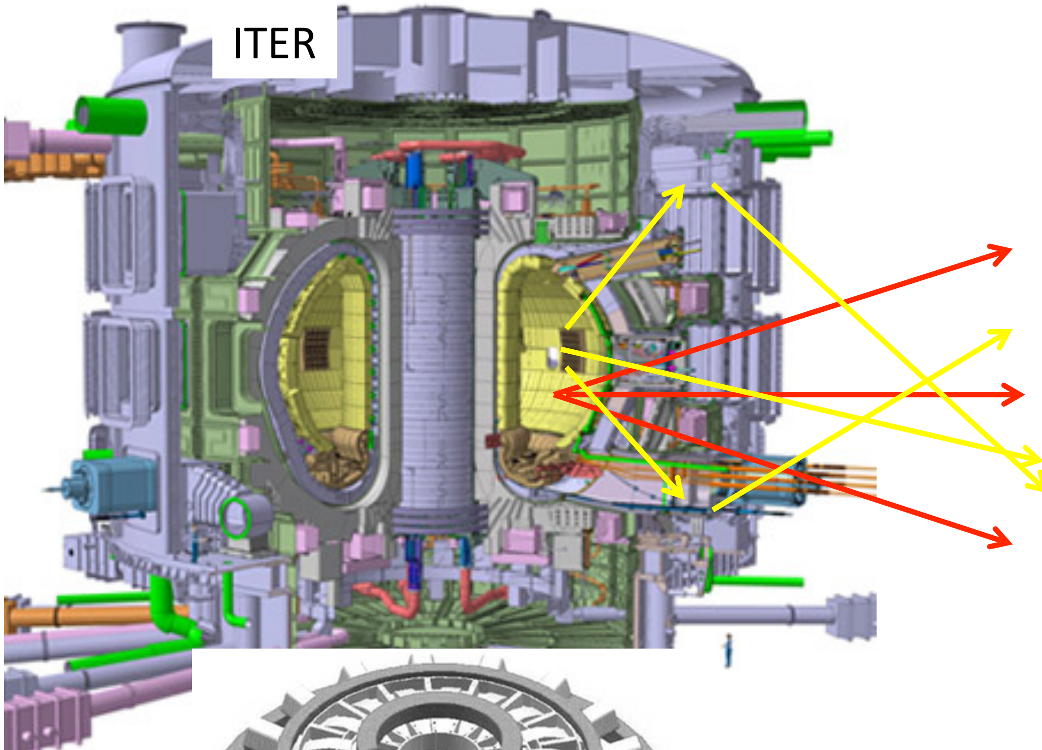
Nuclear Fusion Plasma Diagnostics
- neutron detection -

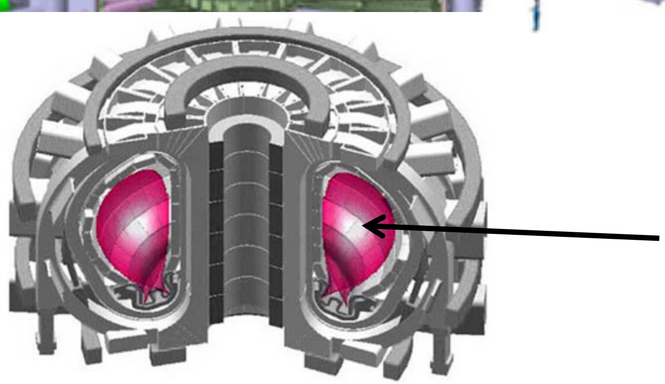
DD or DT neutrons have direct information of fusion plasma



neutron

gamma ray (photon) from high dens plasma

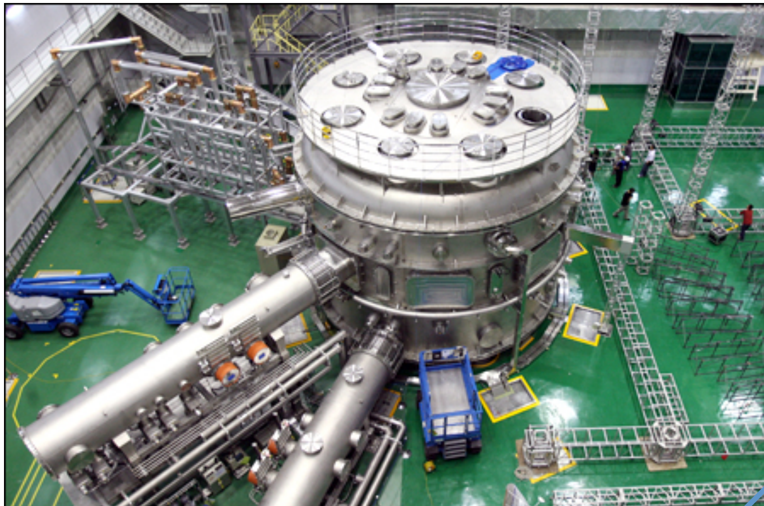
Measurement condition :
Neutron and gamma ray
Combined field



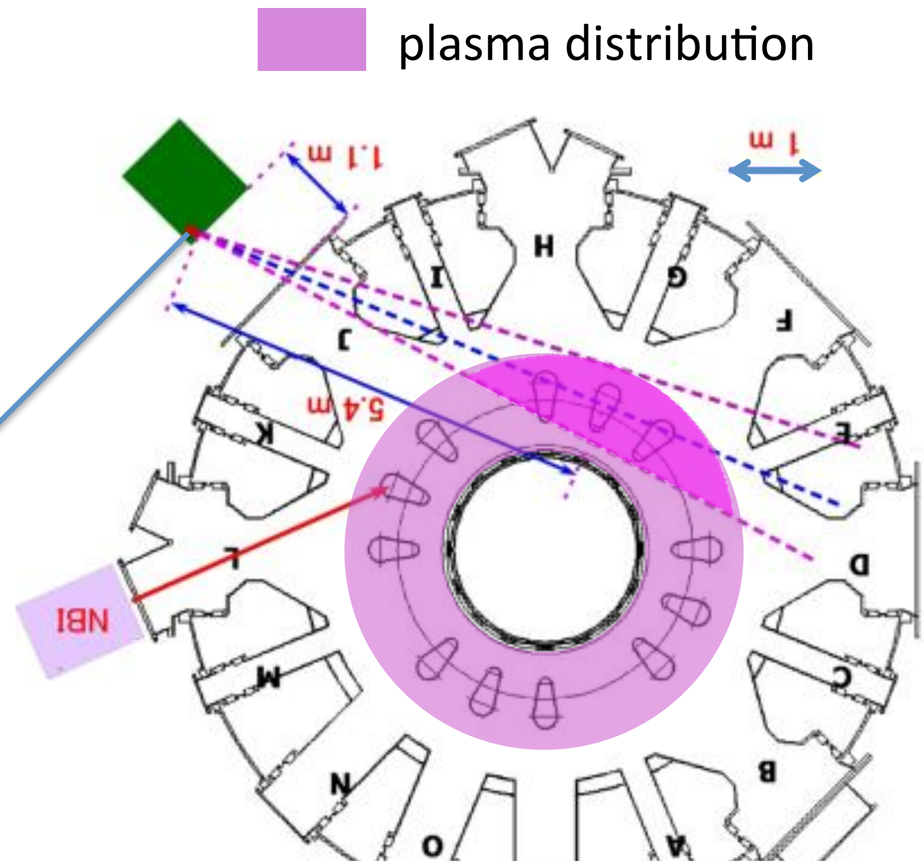
DD or DT Plasma was confined by magnetic fields in order to keep high plasma density for fusion ignition.

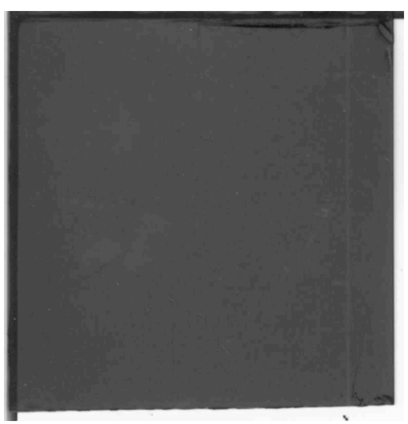
Test experiment @KSTAR, KOREA

DD neutron fusion plasma



TOP view



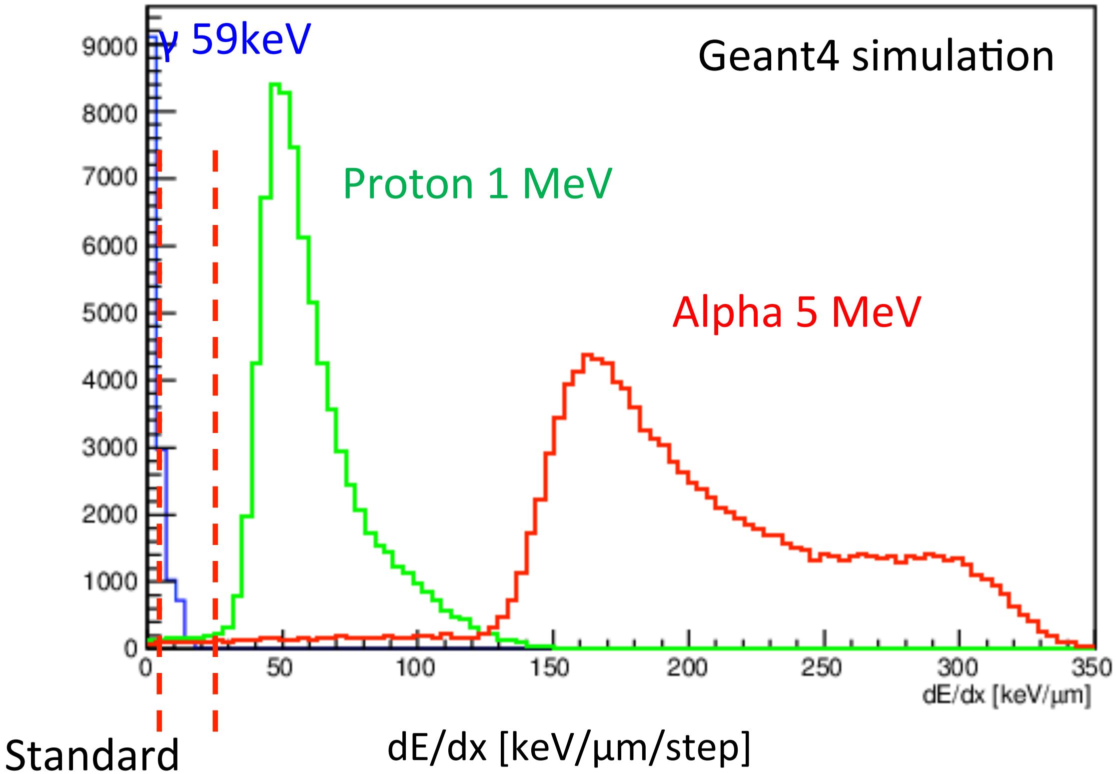


Too high background electron tracks to analyze

⇩

Need to control sensitivity in order to discriminate gamma ray

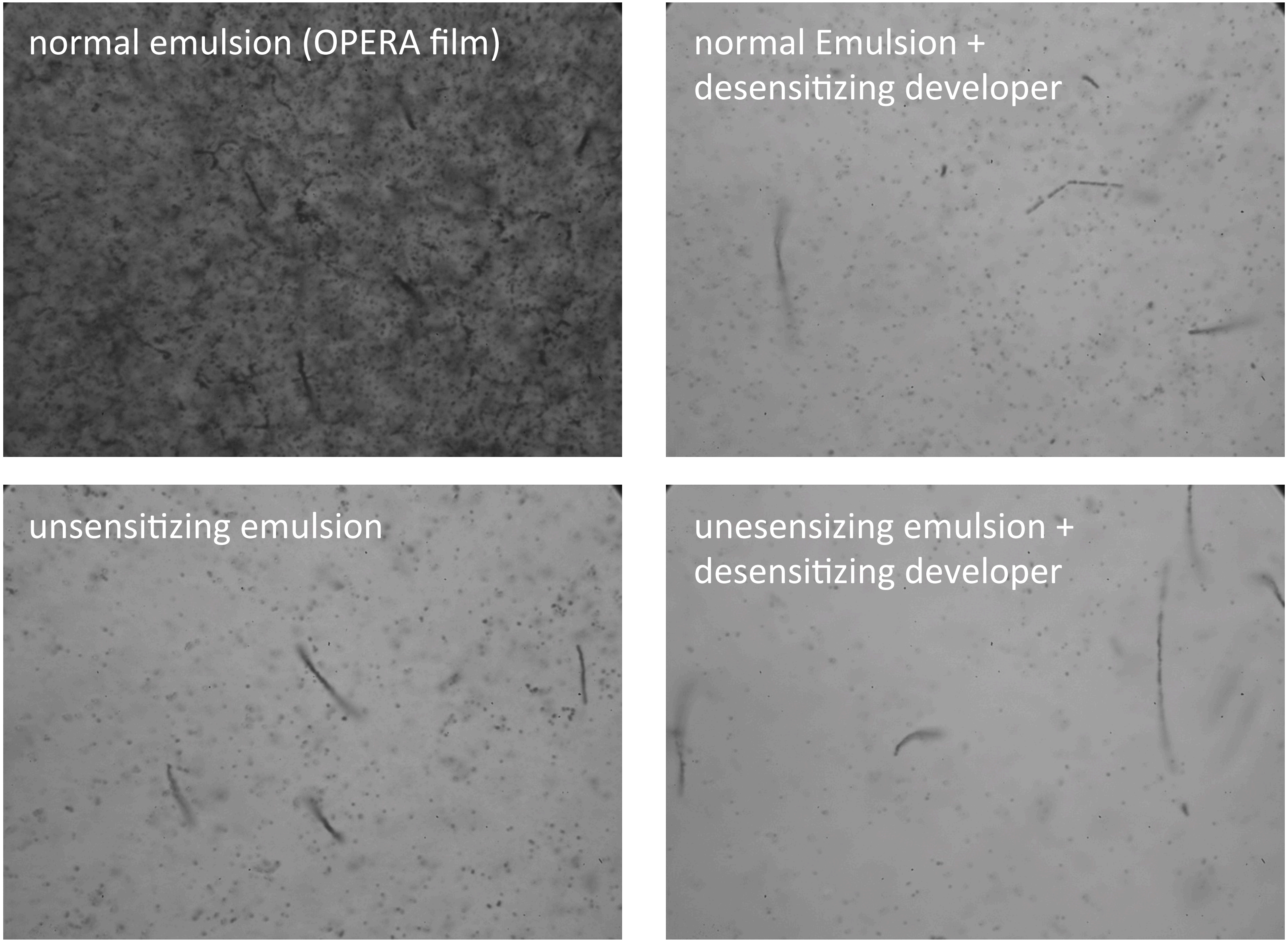
Sensitivity Control Study



- Desensitizing developer
- Desensitizing AgBr crystal

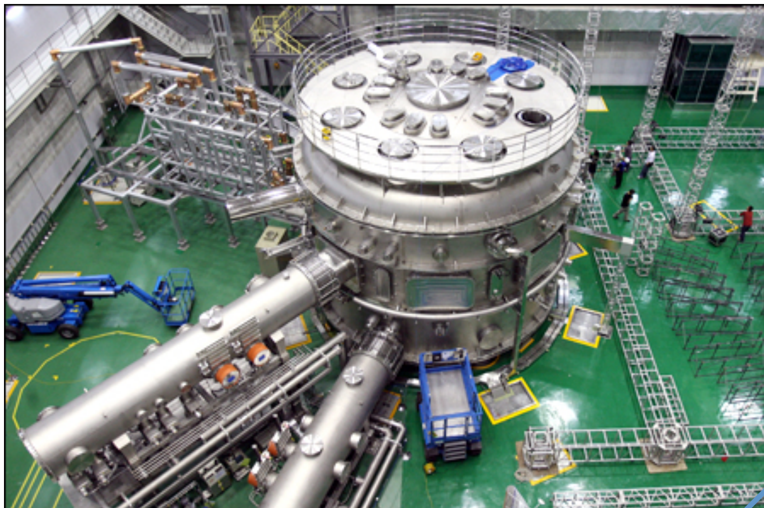
Test neutron and gamma ray source is Cf252.

Sensitivity Control (Developer, AgBr crystal)



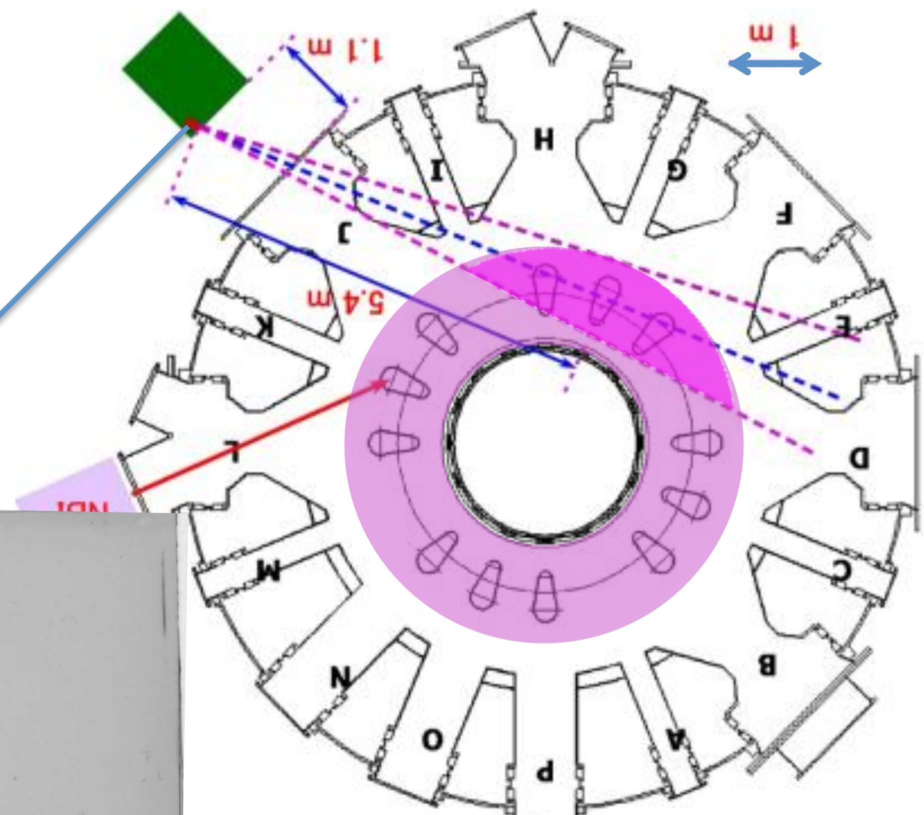
Test experiment @KSTAR, KOREA

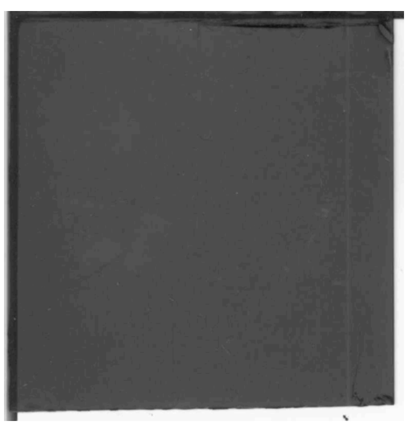
DD neutron fusion plasma



TOP view

plasma distribution



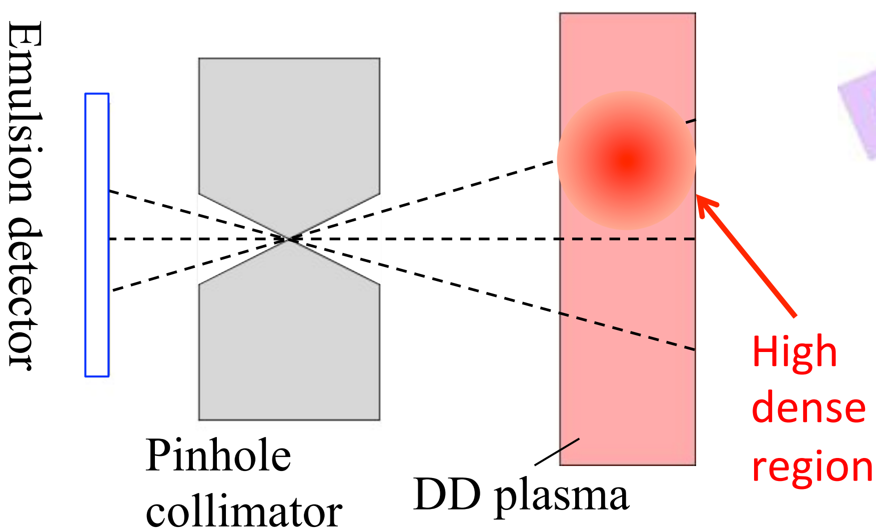


Desensitizing developer

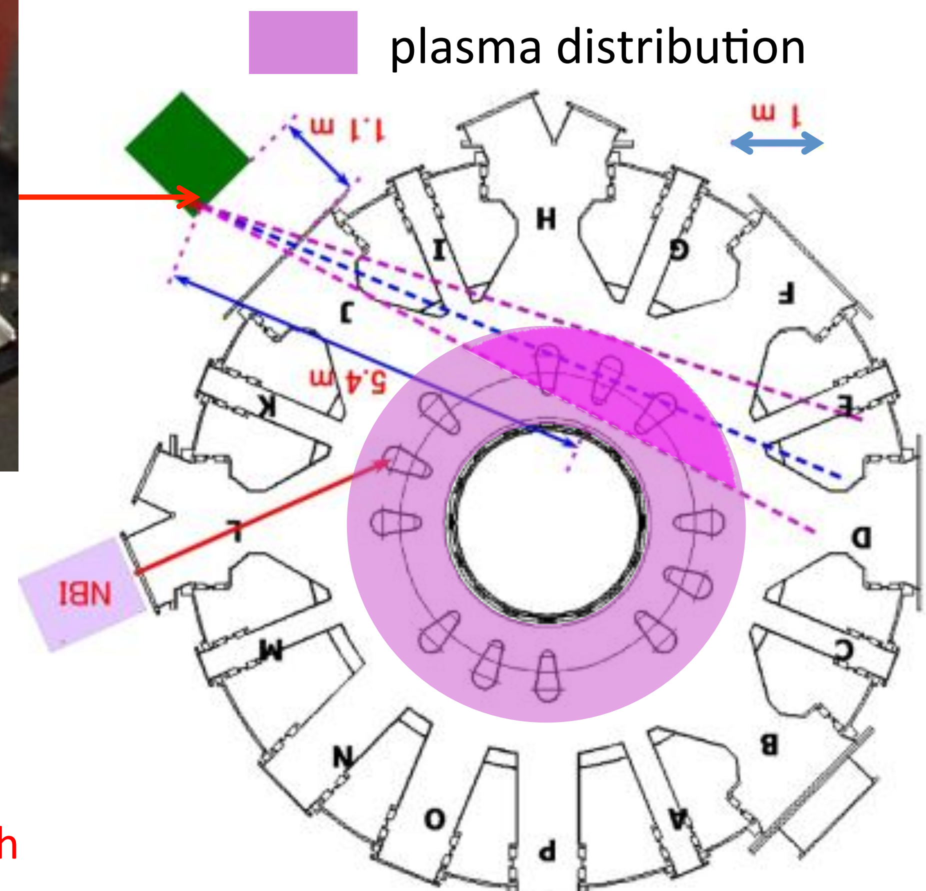
Test experiment @KSTAR, KOREA

DD neutron

Principle is same as light pinhole camera



TOP view



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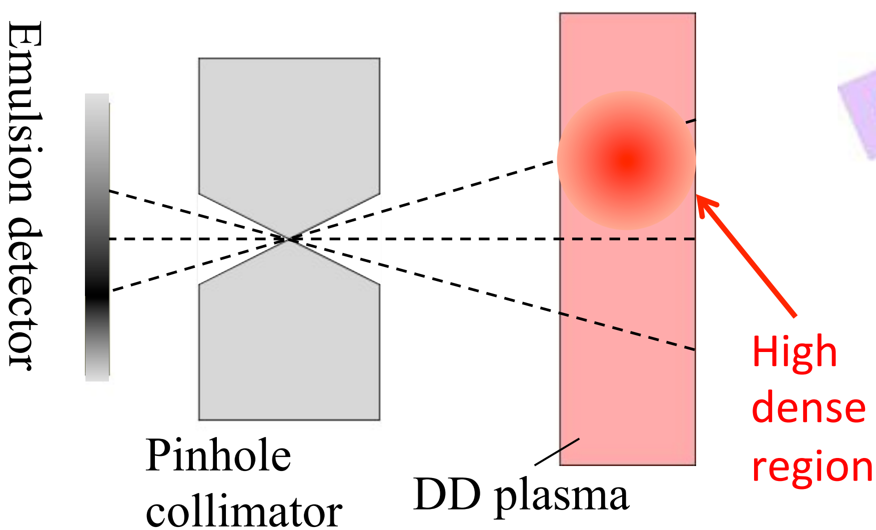

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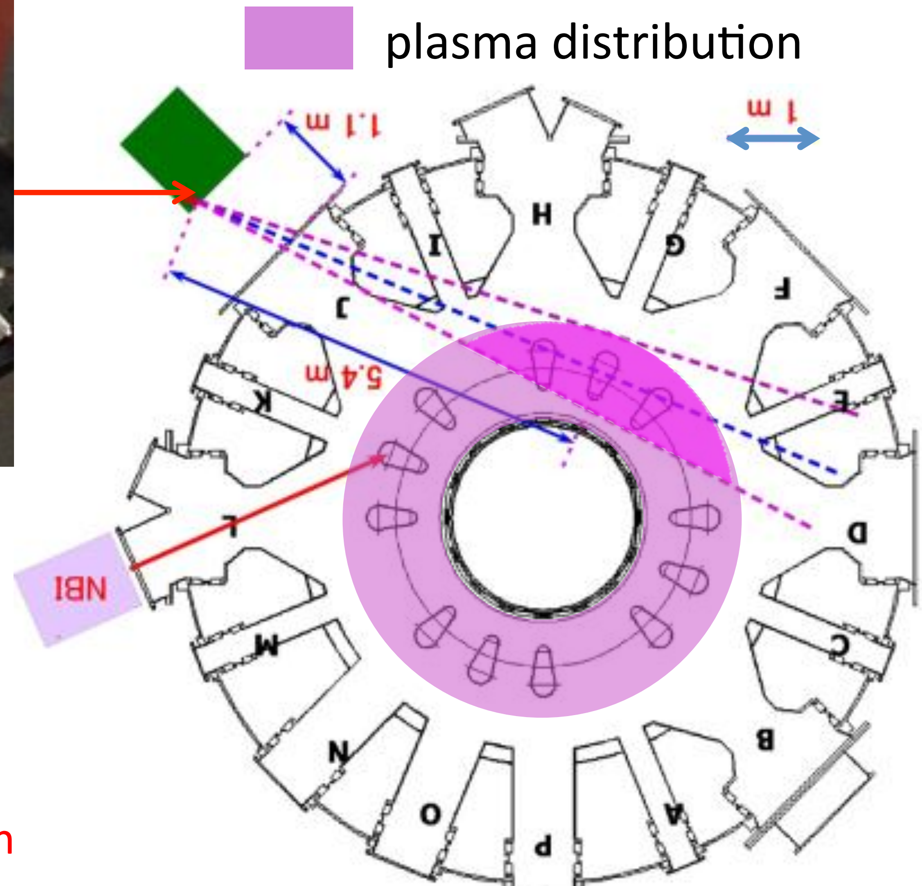

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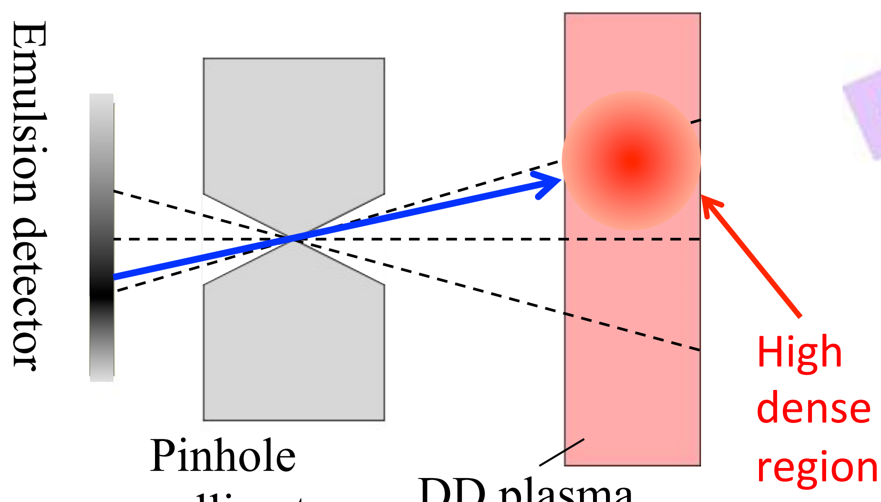
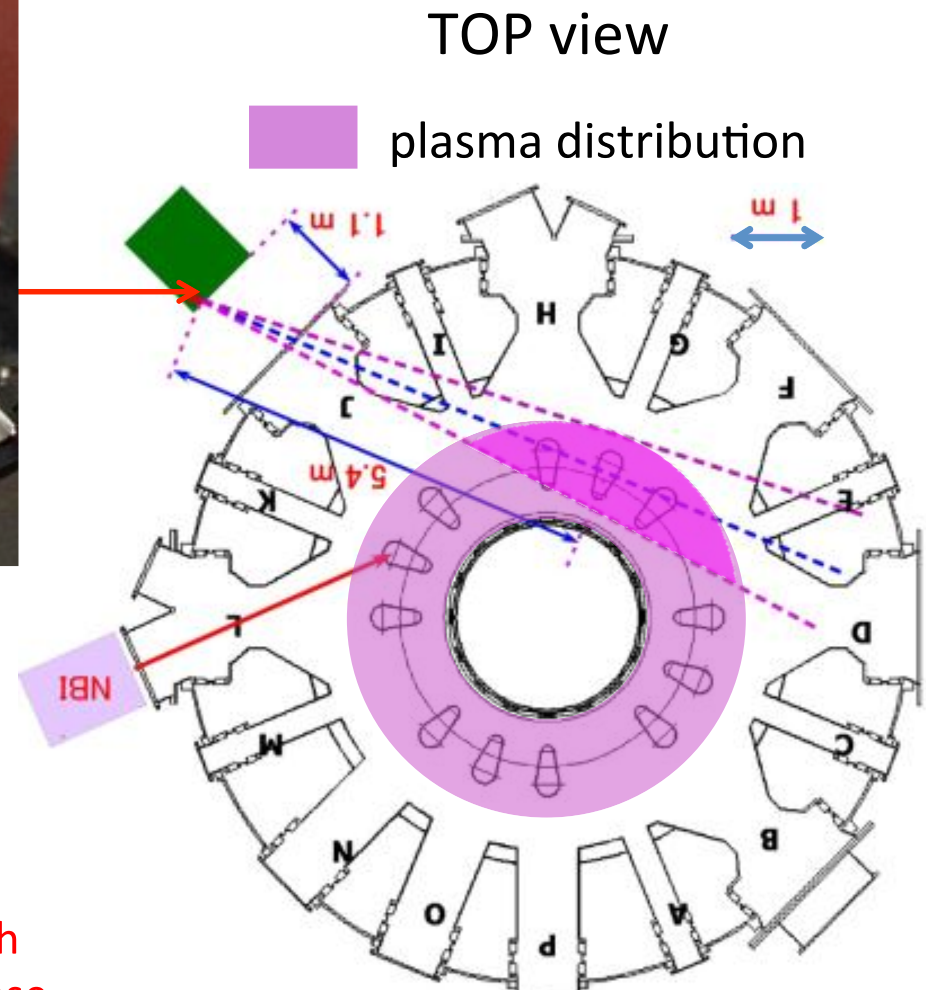


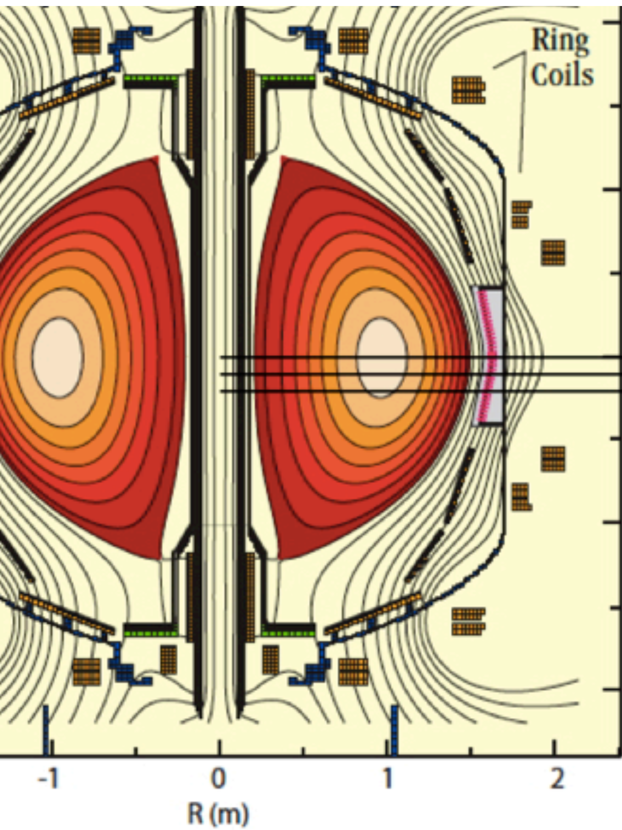


NSTX, Princeton University, USA

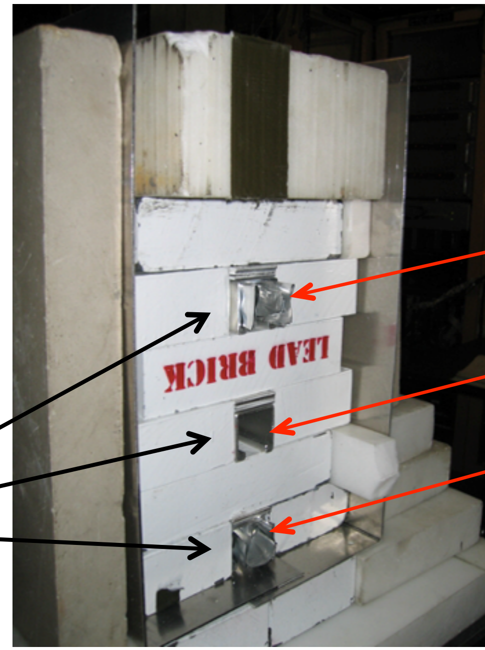
DD neutron

SIDE view

DD nuclear plasma density distribution
2-dimensional contour

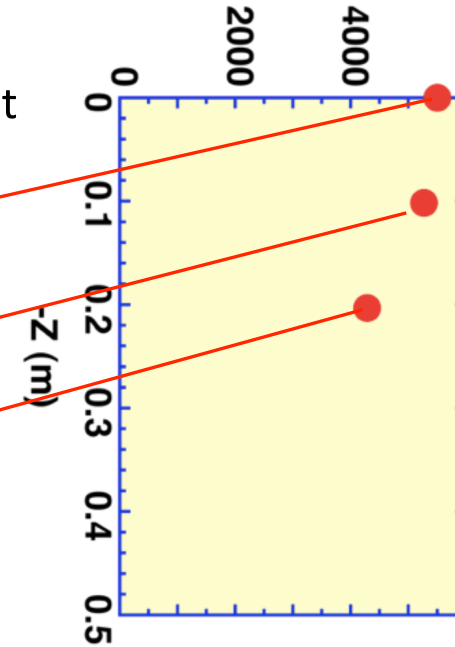


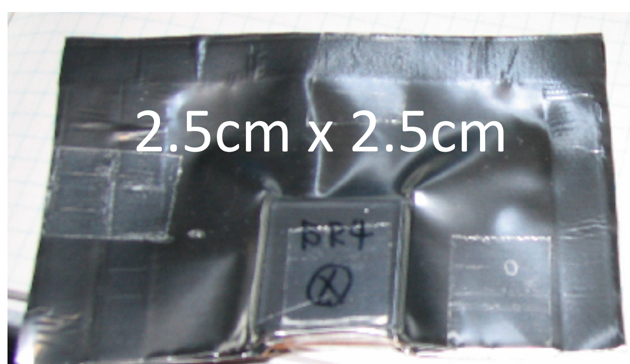
Poristilene and lead collimator



Result

Tracks of recoil proton



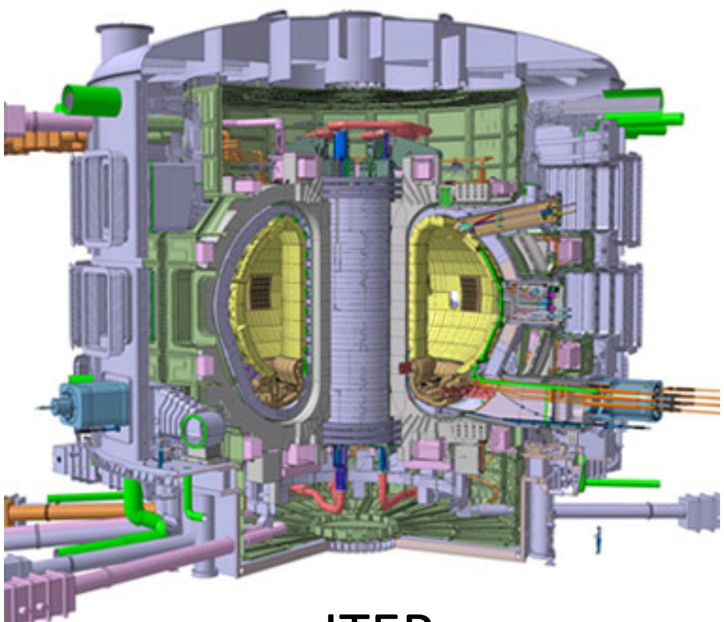


First result
neutron density was observed by automated scanning system

Proposal for ITER

Diagnostic of D-T burning plasma

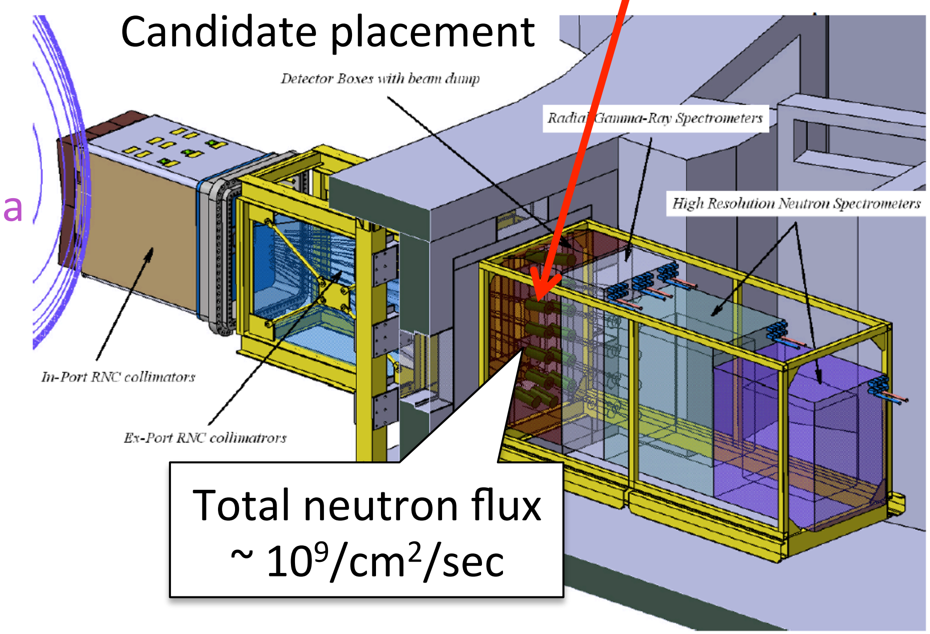
DT neutron plasma



ITER

DT plasma

Nuclear Emulsion



We are proposing nuclear emulsion method as new DT neutron measurement technology with NIFS (National Institution for Fusion Science)

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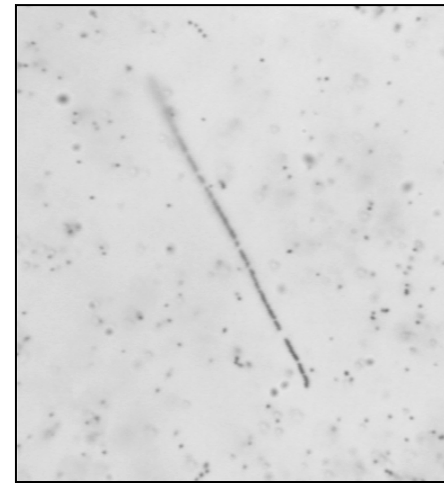

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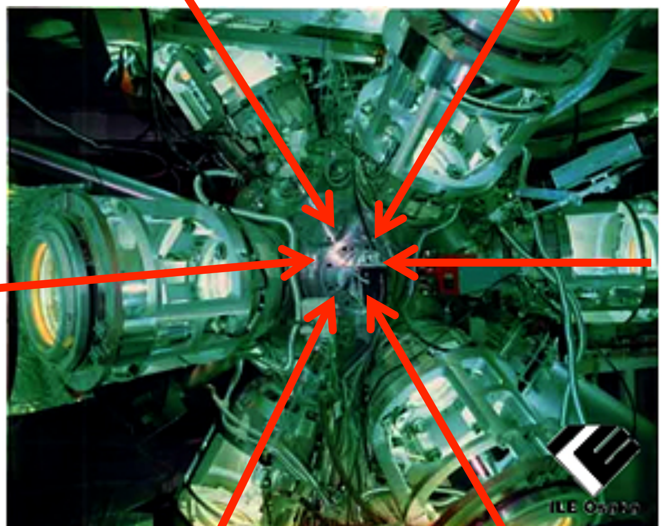
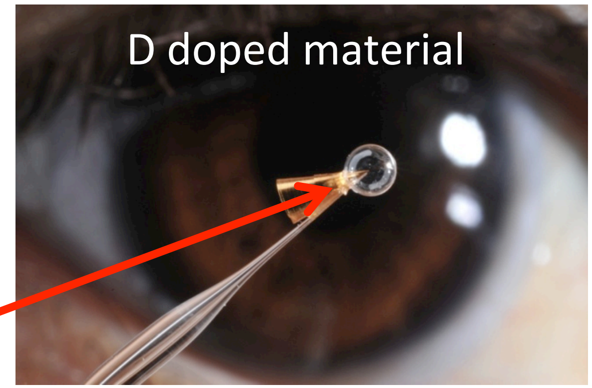
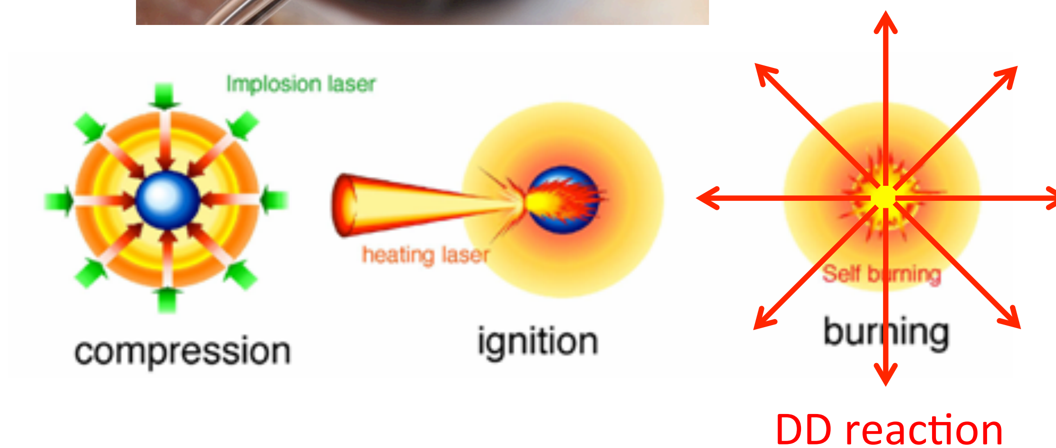
OSAKA University, JAPAN

ILE Osaka

Laser fusion (DD neutron)

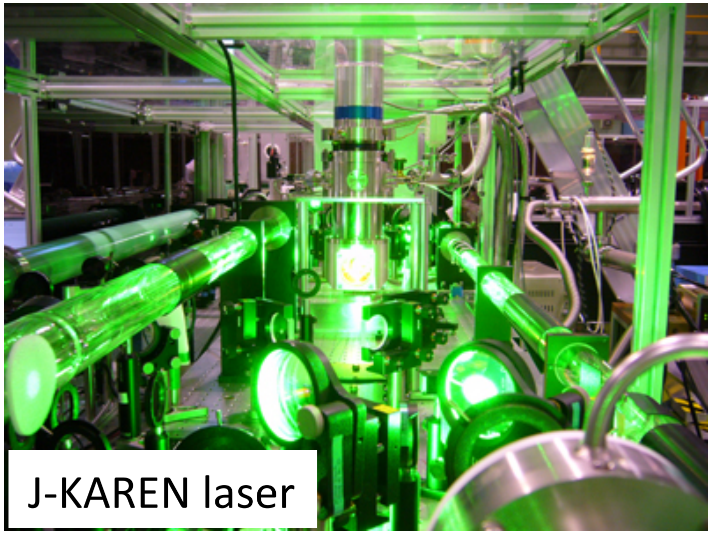


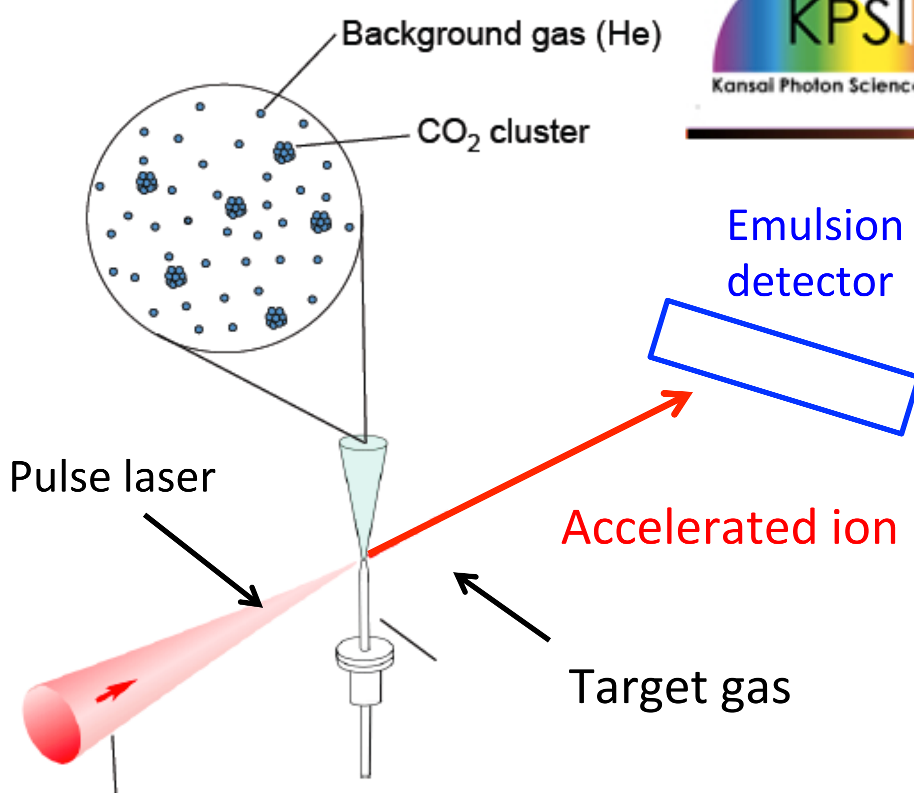




Estimation : 10^{13} gamma rays / laser shot

Laser acceleration @ KPSI, JAEA





Accelerate ion
A lot of gamma ray are generated

Exposed Oct 2013. Scanning and analyzing soon.

Conclusions

■We are developing proton/neutron detector and start applying to many fields with many institutions.

NIFS, JAEA, Osaka University ILE, RIKEN, NCC(Korea), and universities

■Sensitivity control is very important in high gamma ray fields.

We are developing its technologies and applied to fusion plasma diagnostics.

■We are planning to apply this technology to more heavy particle detection.

applications…

astroparticle physics, heavy ion therapy, space radiation measurement, …

More desensitizing crystal test Is on going