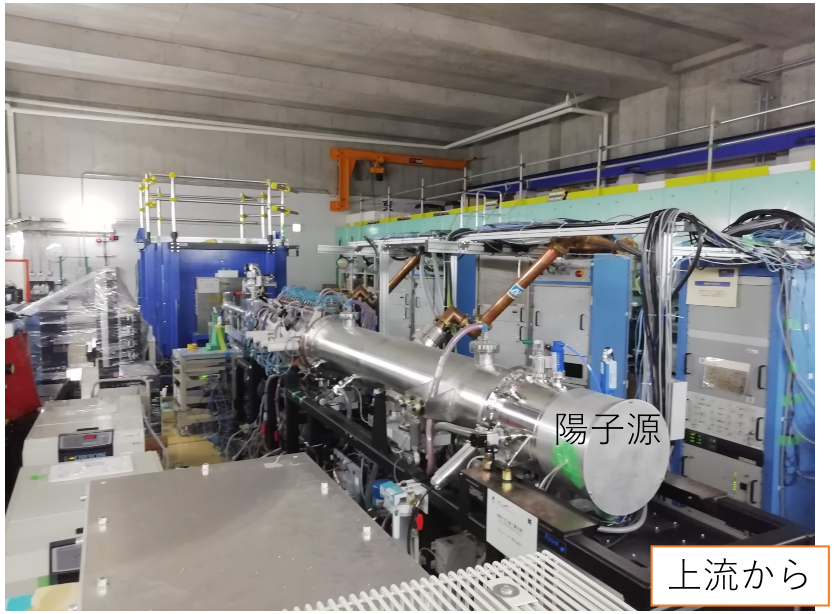
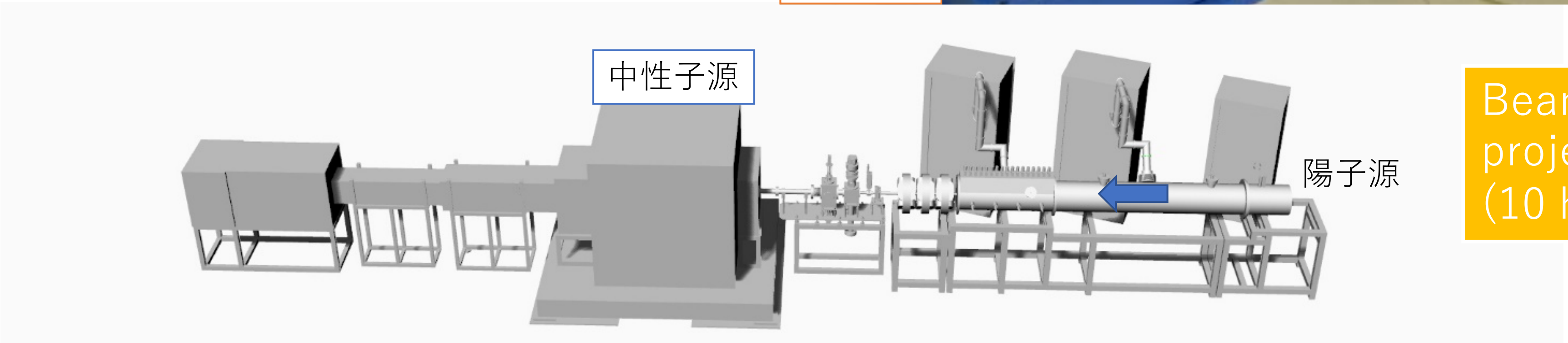
Radiation Hardness Test of μ-Coax cable at RANS

RIKEN/RBRC

Itaru Nakagawa

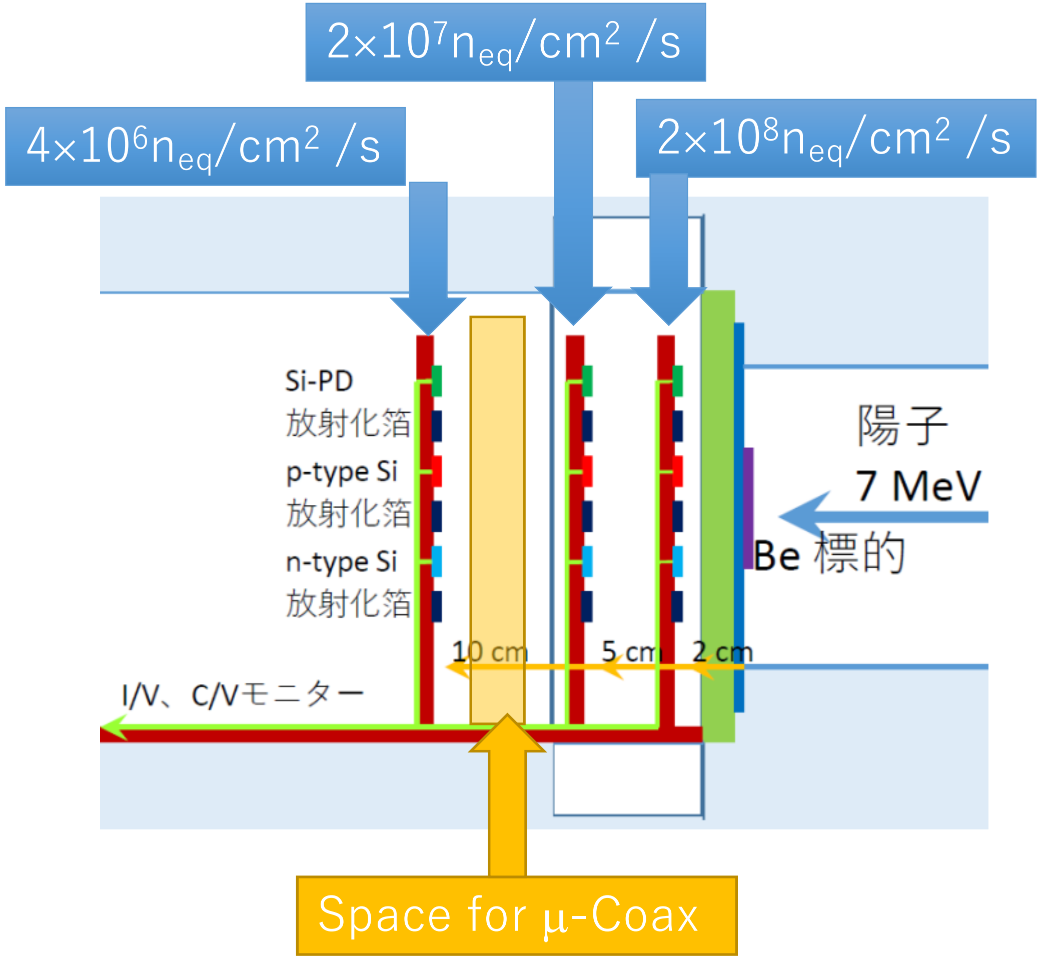
小型中性子源：RANS
(RIKEN Accelerator-driven compact Neutron Source)



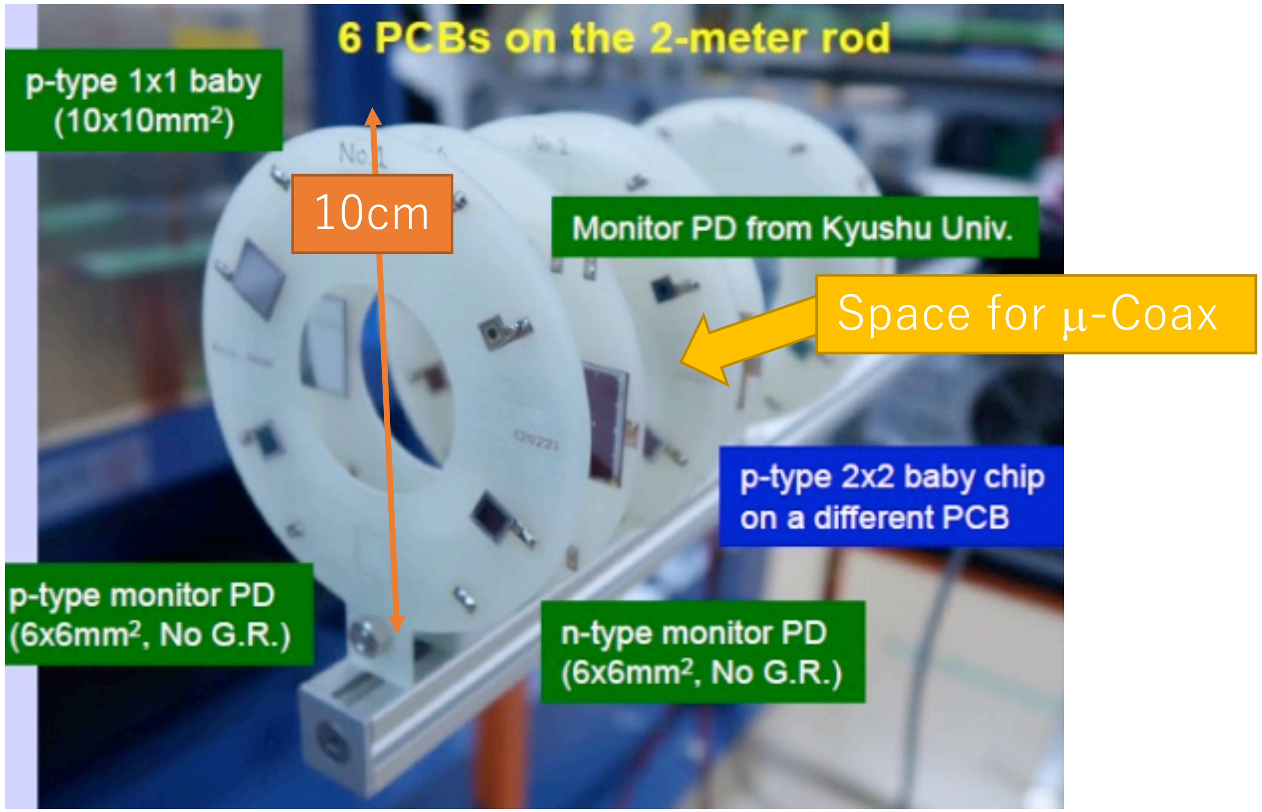


Beam Time for FoCAL@ALICE project in March 3-4, 2022. (10 hours)

Parasite to FoCAL@ALICE Experiment

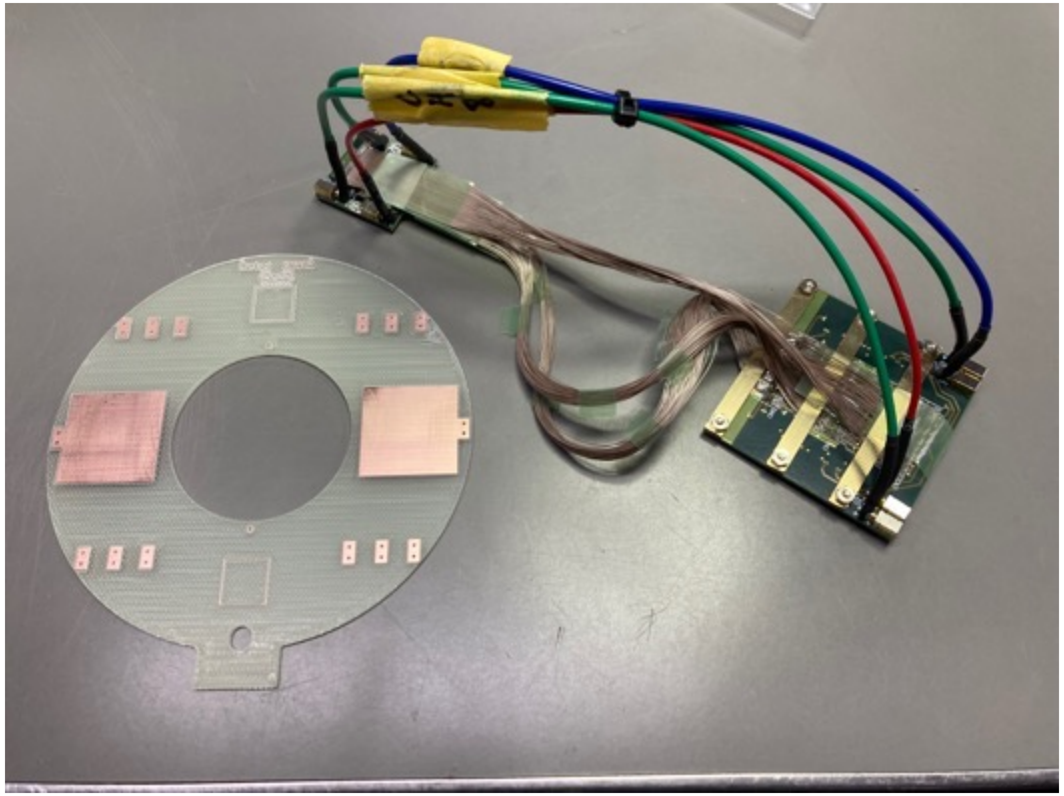


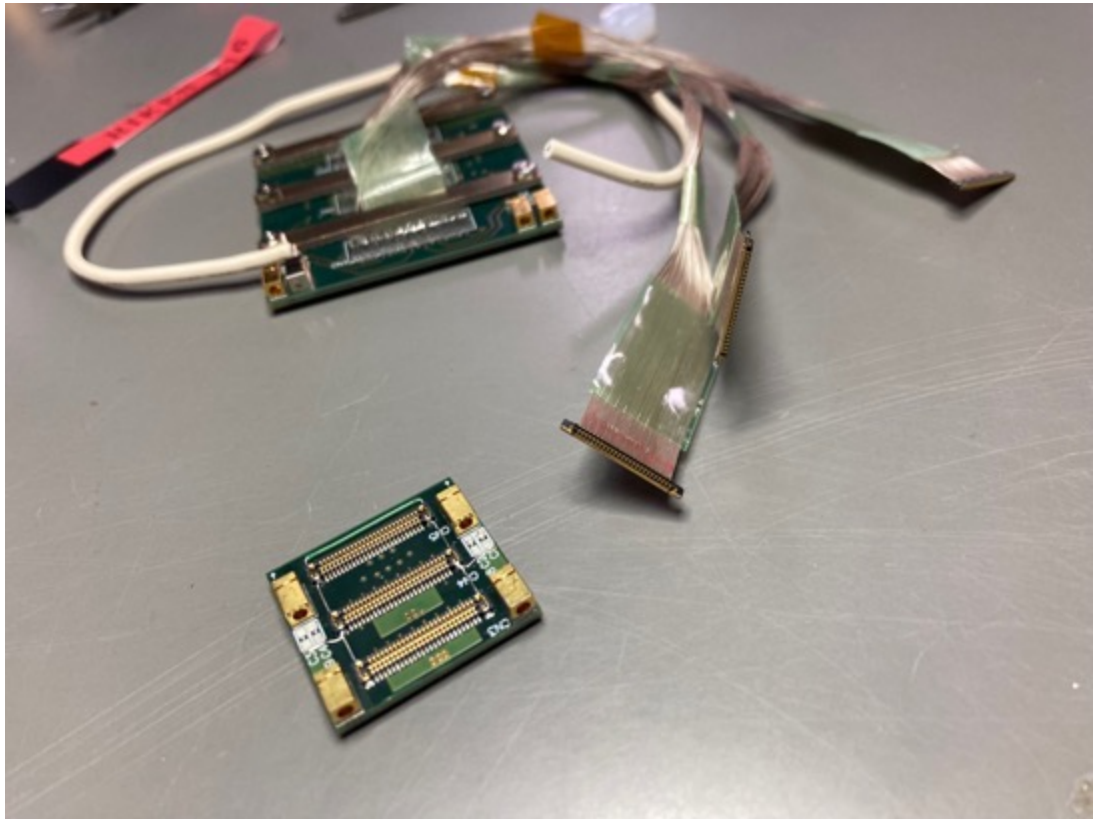
~ 1×10^7 n_{eq}/cm^2 /s ?



FOCal Radiation Exposure Setup

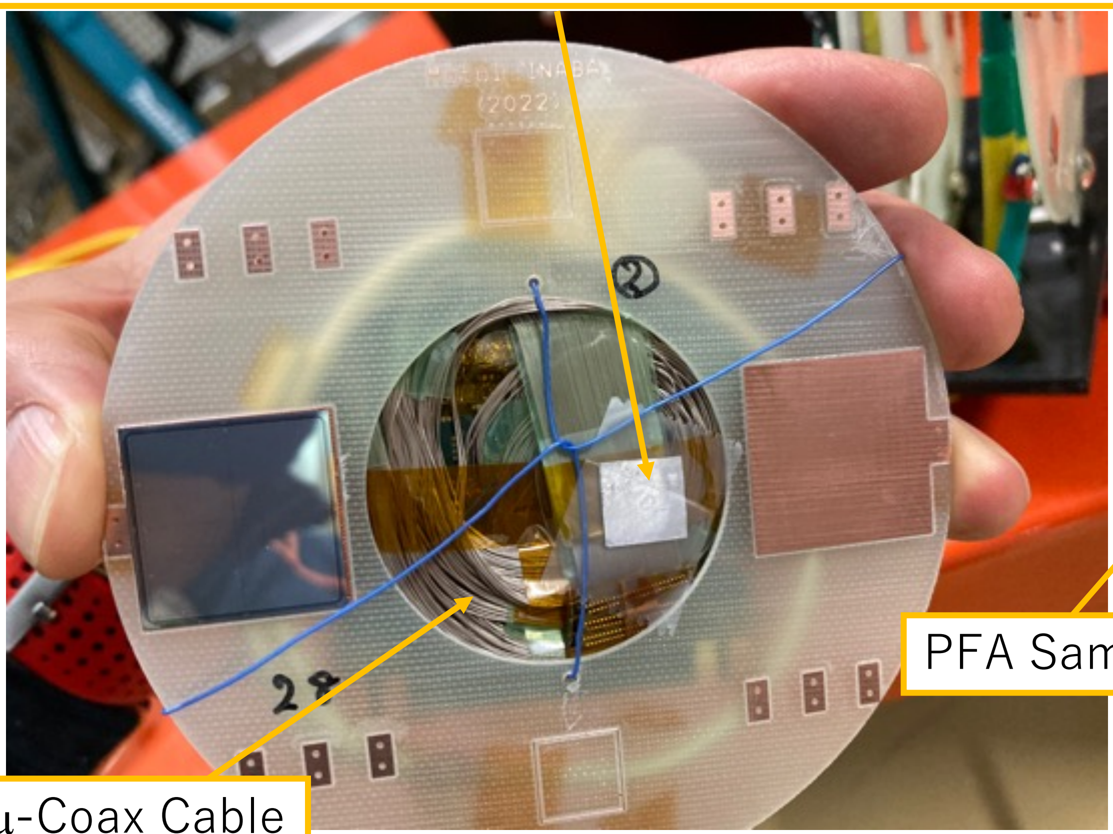
Prototype-I Cable Setup



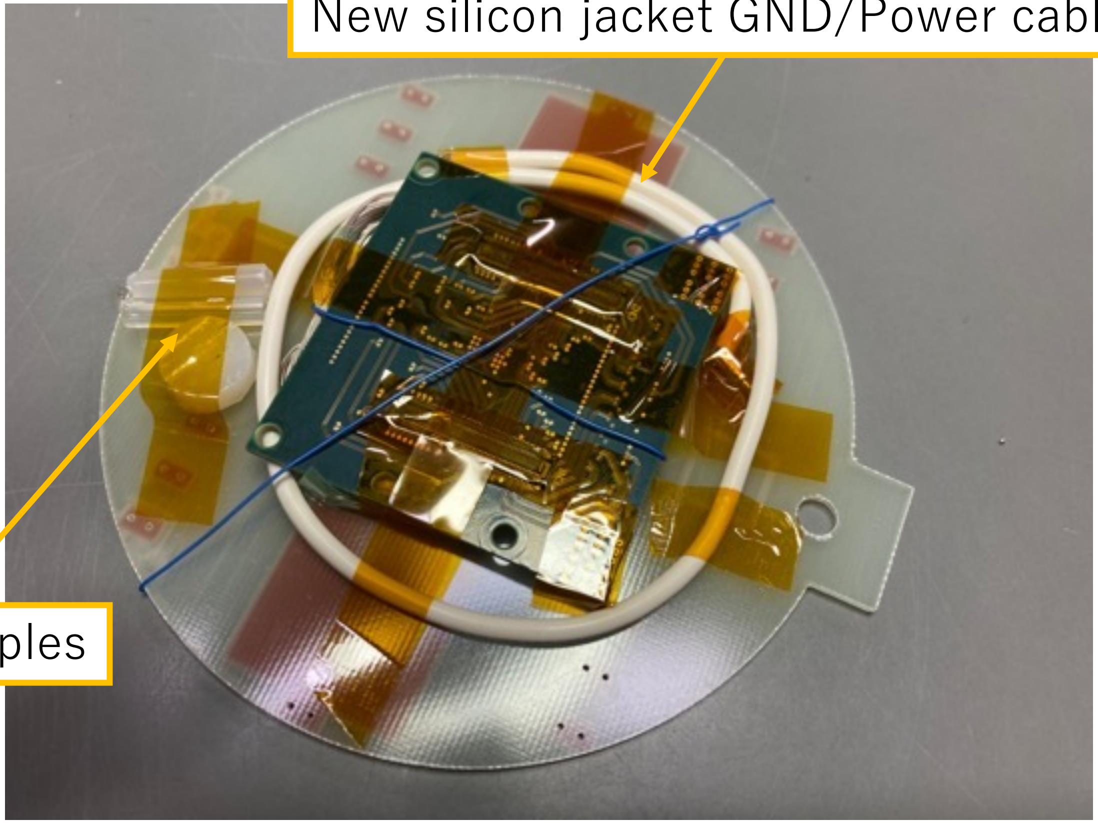


Dismounted GND/Power cables and ROC side connector

Prototype-I Cable Setup

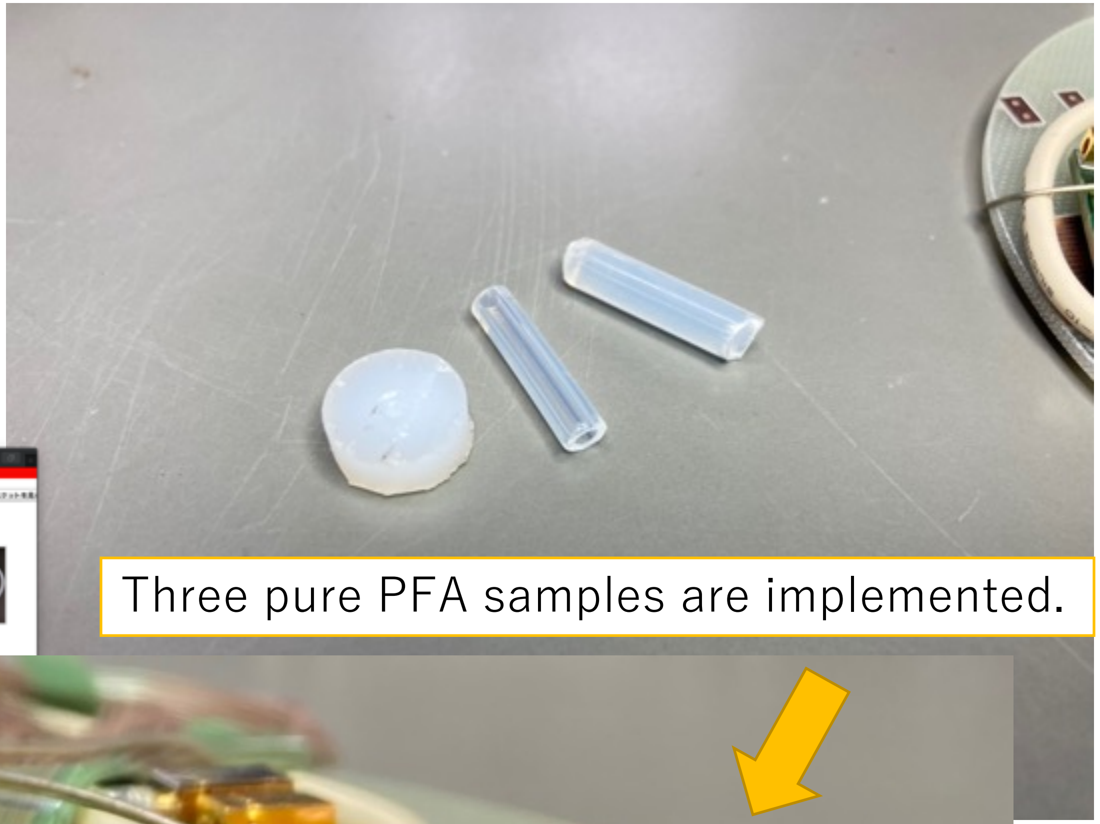


Attached to the disk (Front View)



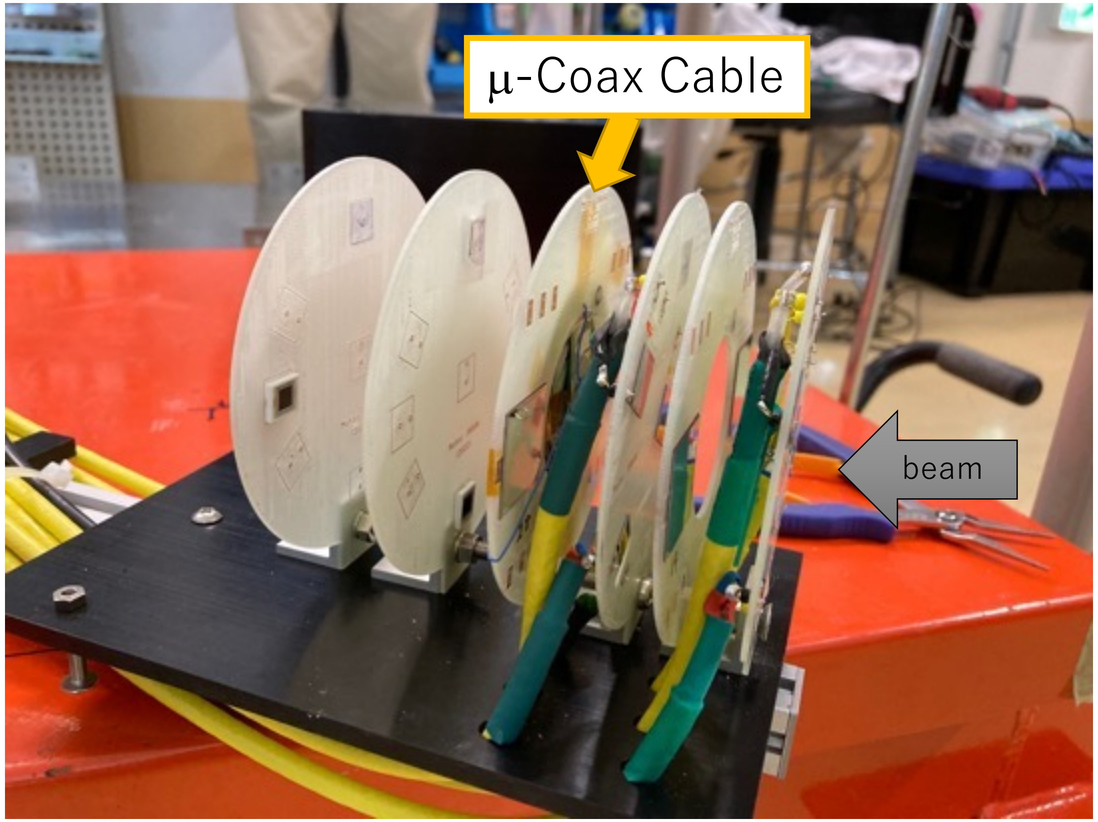
Attached to the disk (Back View)

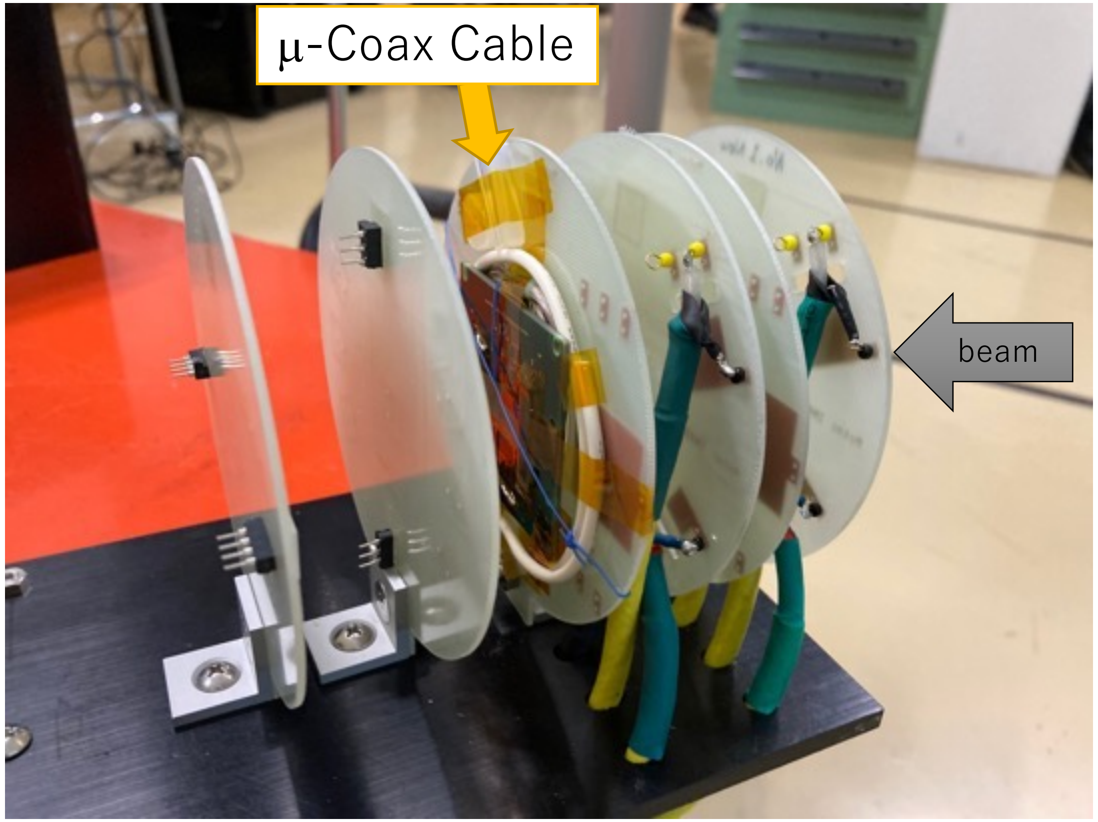
PFA Samples



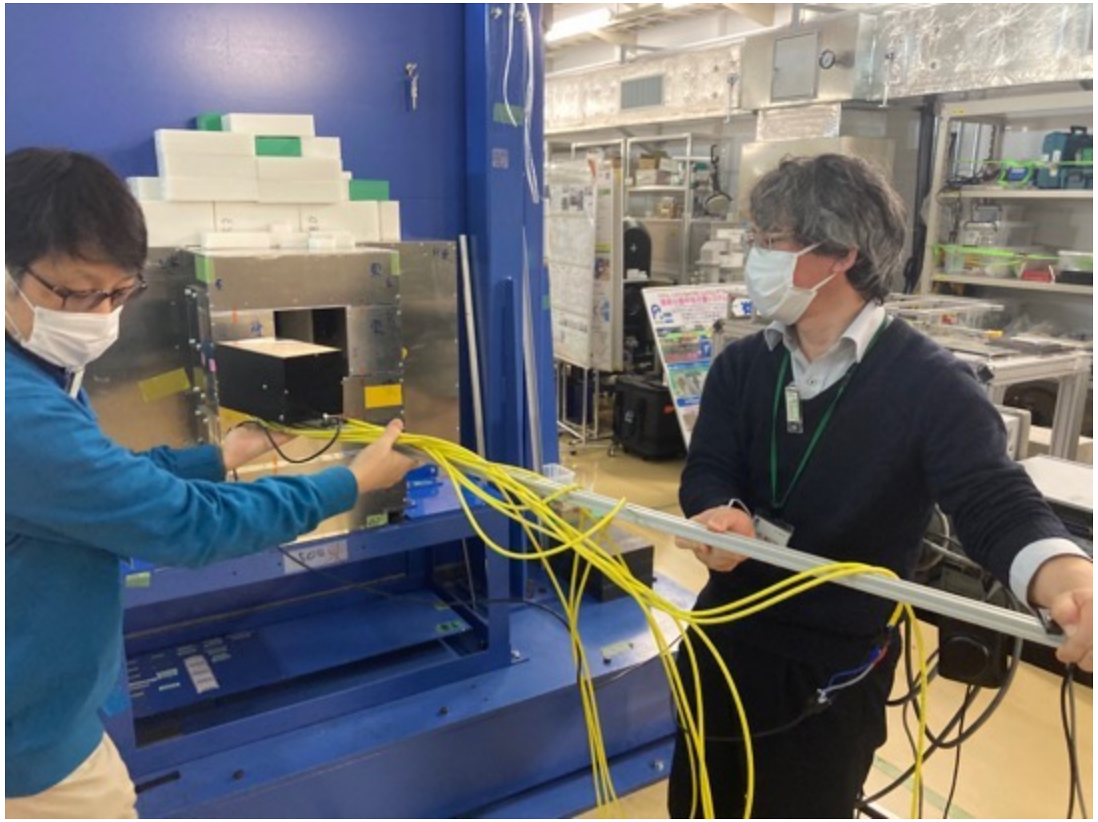
Three pure PFA samples are implemented.

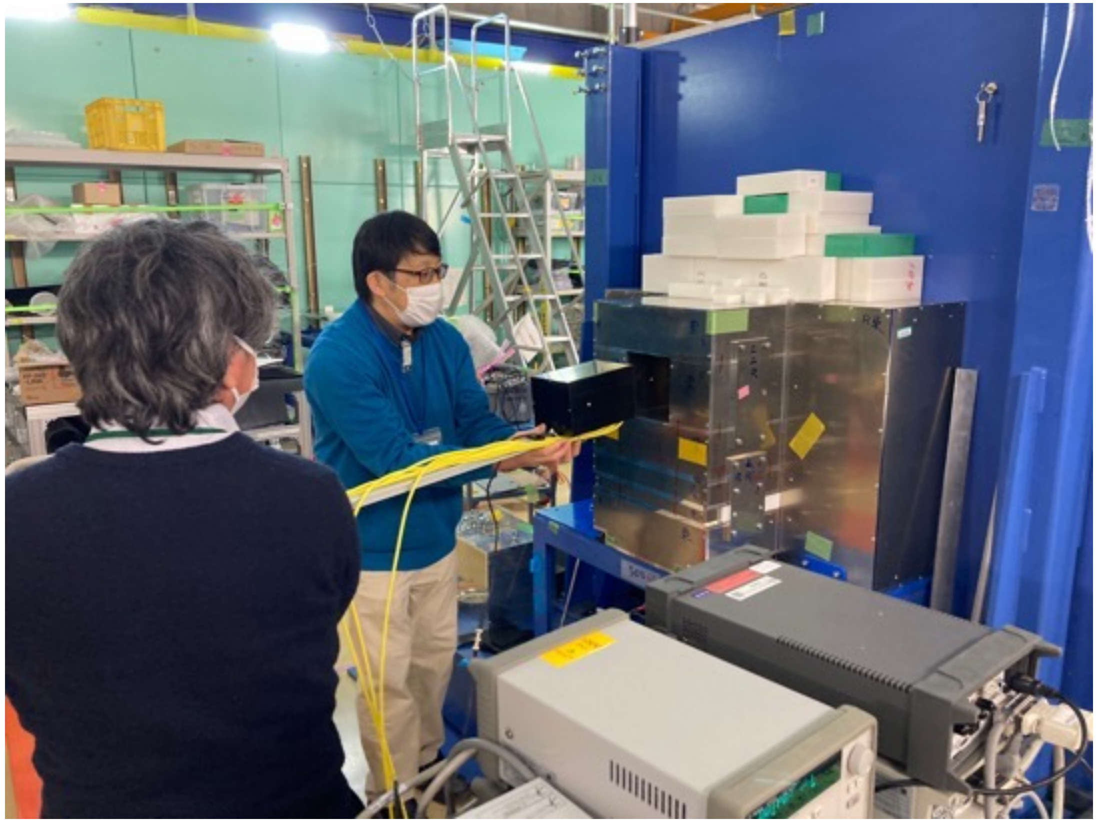
Disk Mount Setup with FoCAL Sensors





Installation to neutron source vessel



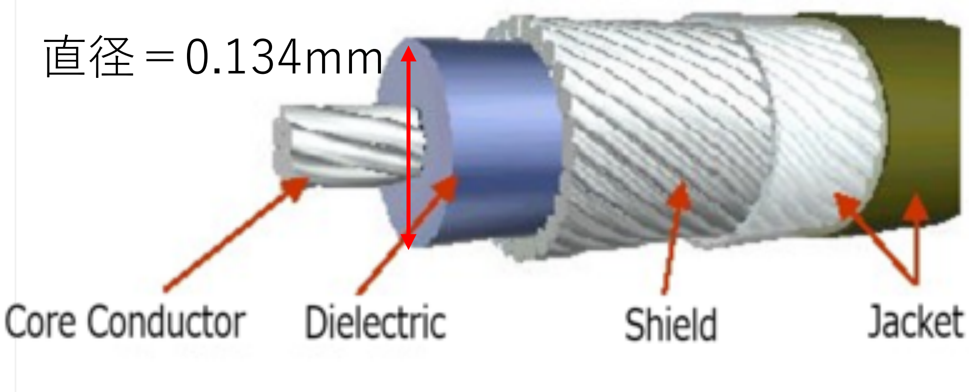


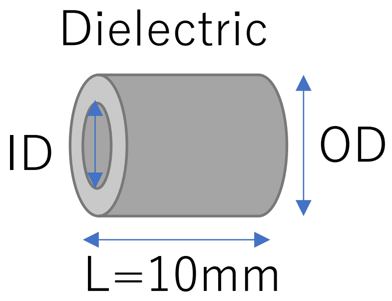
μ–Coax PFA Volume

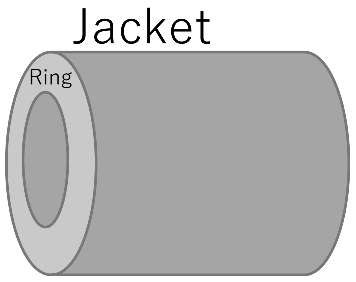
Material Breakdown of micro-Coax

2. Construction and material

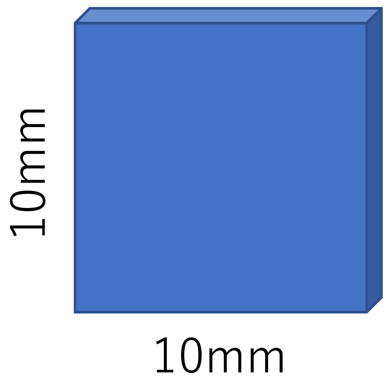
Item		Unit	Specified Value
Inner conductor	Material	-	Silver plated Copper Alloy wire
	AWG size	-	44
	Stranding	No./mm	7/0.02
	Dia.(approx.)	mm	0.06
Insulation	Material	-	PFA
	Thick.(nom.)	mm	0.037
	Dia. (approx.)	mm	0.134
	Color	-	Black
Outer Conductor	Material	-	Tinned copper alloy wire
	Type	-	Wrap(Right-hand lay)
	Strand Dia. (approx.)	mm	0.02
Jacket	Material	-	PFA
	Thick.(nom.)	mm	0.025
	Dia. (Max.)	mm	0.22(0.23)
	Color	-	Brown , Green







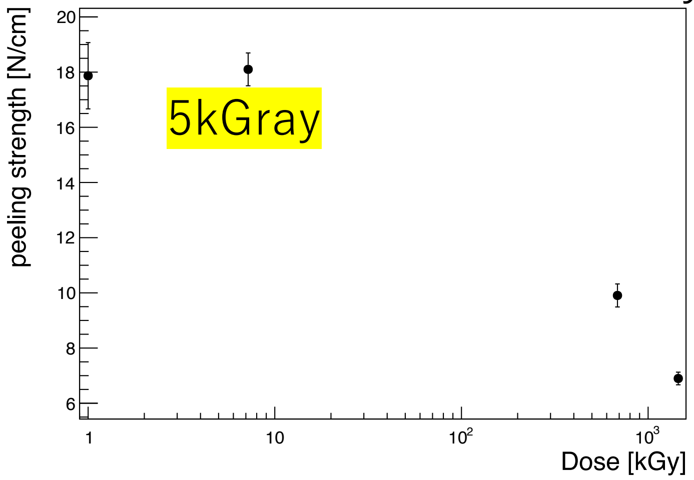
	OD [mm]	ID [mm]	Ring Area [mm²]	Tube Volume [mm³]
Dielectric	0.134	0.06	0.011	0.11
Jacket	0.22	0.17	0.015	0.15
Total				0.27

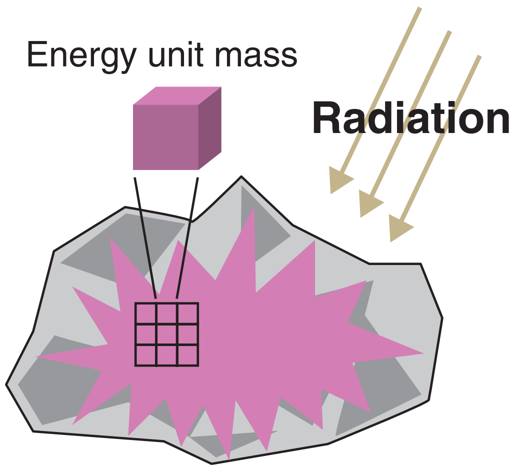


- The volume of PFA per 1 micro-Coax cable: 0.72 [mm^3]
- Shape transform for the simulation as a board. The thickness of 10mm x 10mm board is 0.0027mm=2.7μm equivalent.

Estimated Radiation Dose

Bus extender radiation hardness study





Gray (Gy)

This unit represents how much energy was received by an object or person hit by radiation.
A dose of 1 gray corresponds to 1 joule of energy absorbed by 1 kilogram of matter.

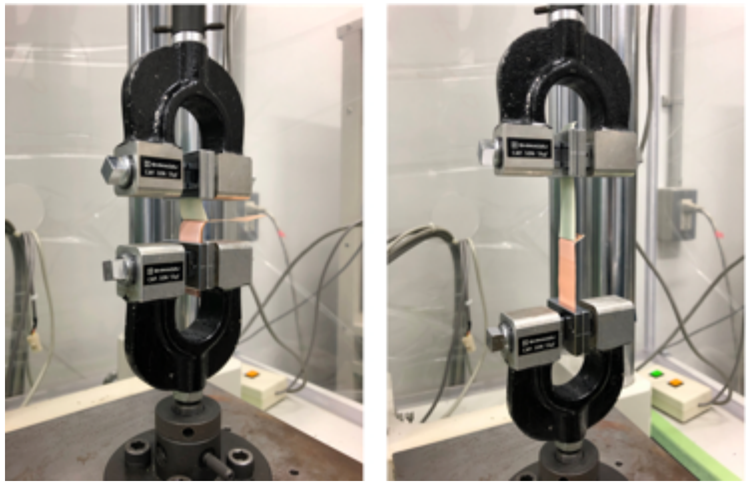
Weight of the Sample to be exposed [mg]	23
Neutron Flux [/cm^2/s]	1E+7
Energy loss per neutron [MeV]	2.7e-6*
Energy loss per neutron [Jule]	8.0E-19
Absorbed dose per neutron [J/Kgm^2=Gy/cm^2]	1.74E-4
Total dose in 10 hours of exposure /cable [Gy/cm^2]	0.6

*PHITS simulation by Genki.

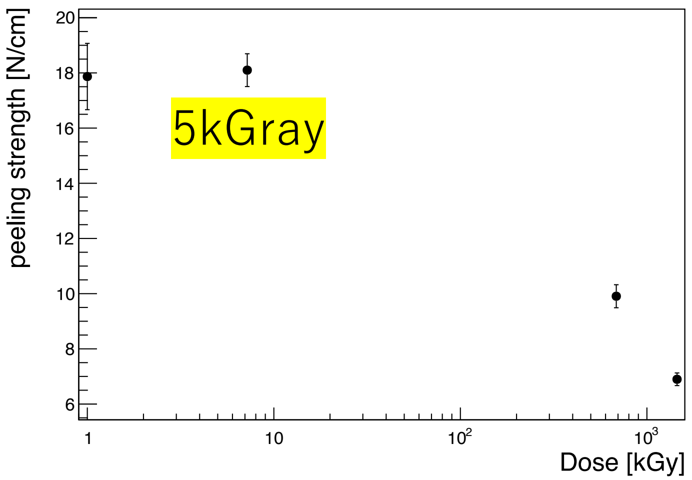
- The estimated radiation dose is predicted to be quite small due to its small volume.
- Presumably, neutron flux is rather important to prove radiation hardness of μ-coax.

Is 60kGray Sufficient?

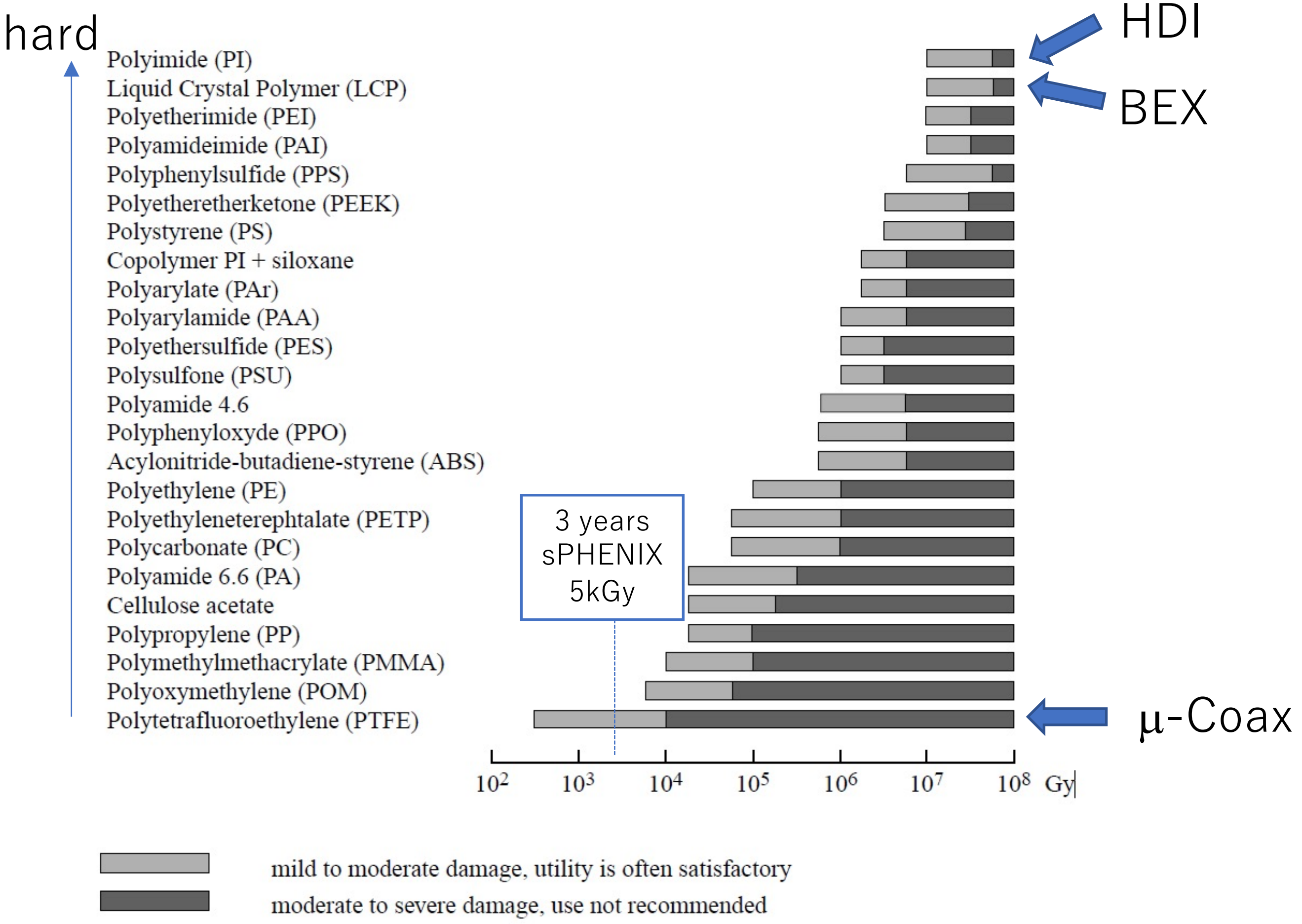
Hikaru Imai, Deploma Thesis (2021)



Peel Strength Test



Bus Extender Radiation Hardness Study

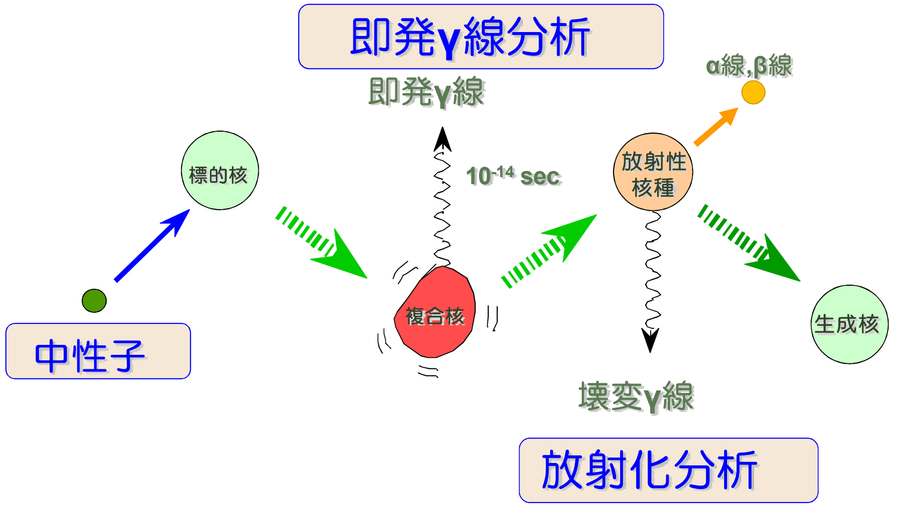


Given the distance of the conversion cable from IP, 60kGray seems sufficient.

Backup

Absolute Radiation Dose Measurement

Indium sample will be implemented right next to the coax-cable.



https://www.htc.co.jp/12cyuseishi/kaisetsu/No3_Ref.pdf

The gamma emission will be measured right after the neutron exposure.

μ–Coax Cable Structure and Material

2. Construction and material Material Breakdown of micro-Coax

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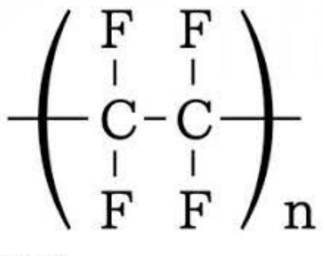
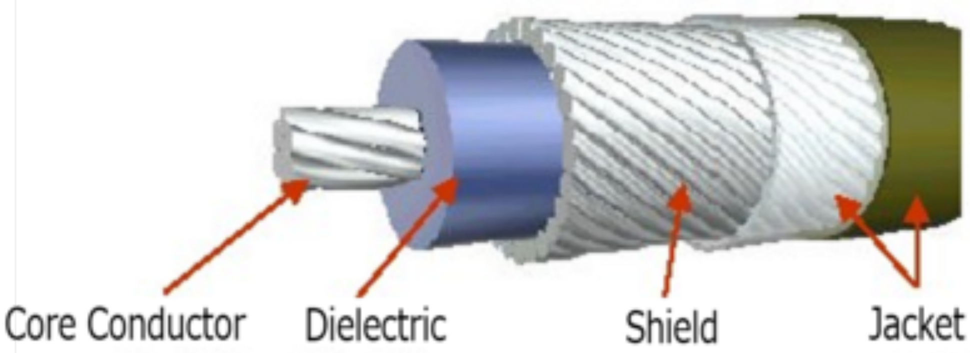


PTFE 化学式



PFA（フッ素樹脂）=**パーフルオロアルコキシアルカン**
四フッ化エチレン・パーフルオロアルコキシエチレン共重合樹脂

http://www.diced.jp/~KAZU/syousya.txt.htm

Fleoropolymer Types

https://www.yumoto.jp/material-onepoint/plastic-ptfe-pfa-pvdf

http://www.differencebetween.net/science/chemistry-science/difference-between-pfa-and-ptfe/

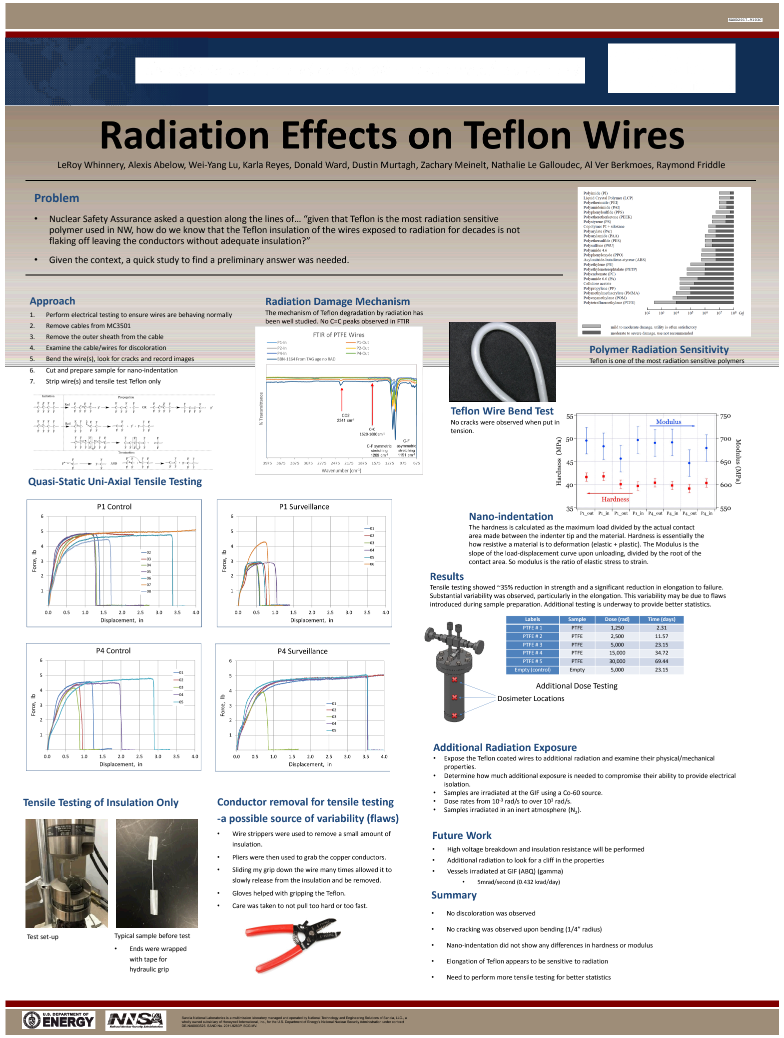
Summary:

1. Both PFA and PTFE are fluoropolymers.
2. PTFE is the more commonly used fluoropolymer, and it is popularly known as "Teflon."
3. PFA is melt processable and more versatile than PTFE, but PTFE is superior when it comes to being less water absorbent and resistant to weathering.
4. PFA is more often used in industrial applications, particularly with lab equipment and industrial tubing, but PTFE is more common and popular especially with cookware.

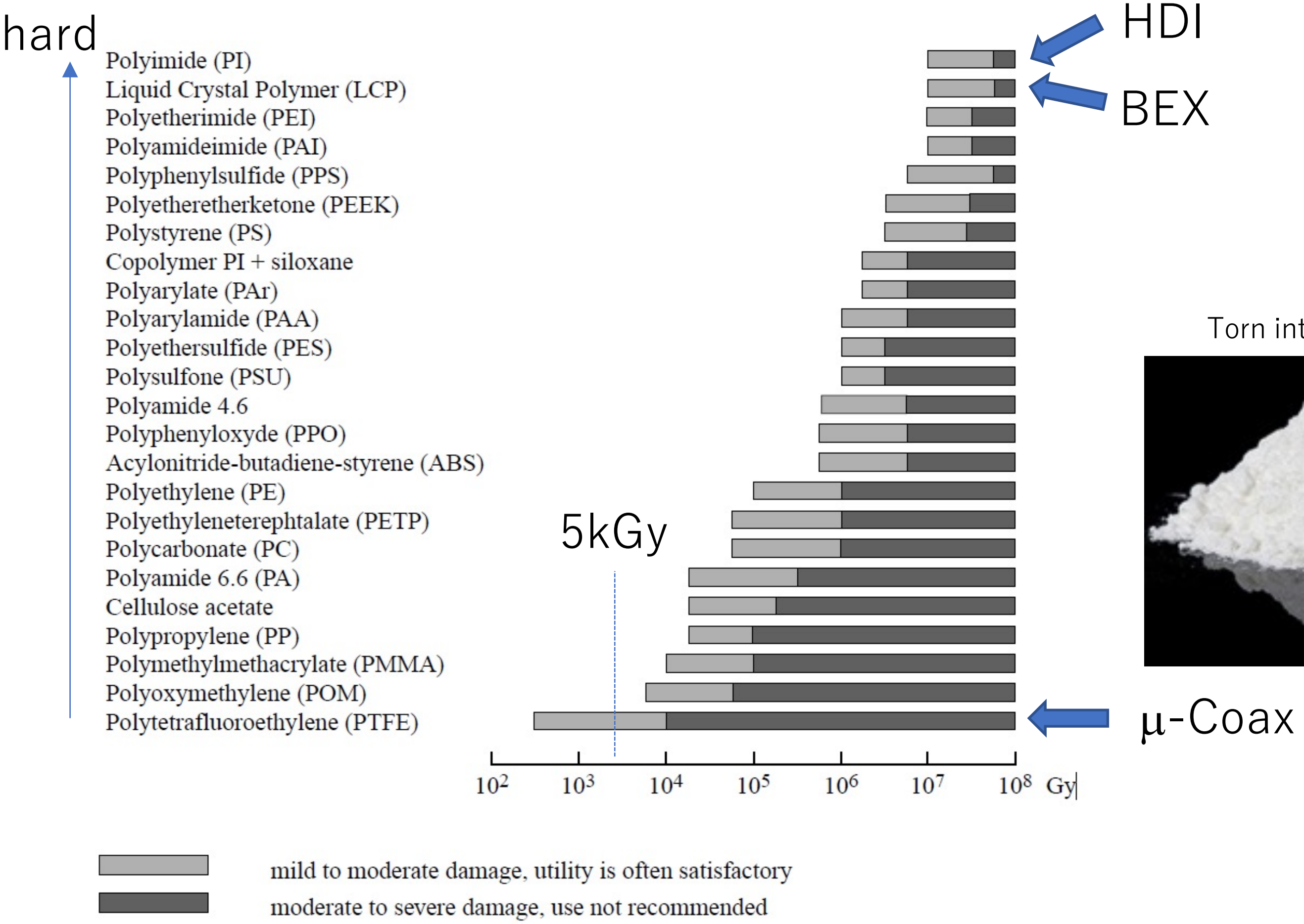
Let's assume PTFE and PFA are similar in terms of radiation hardness

Radiation Hardness of Fluoropolymer

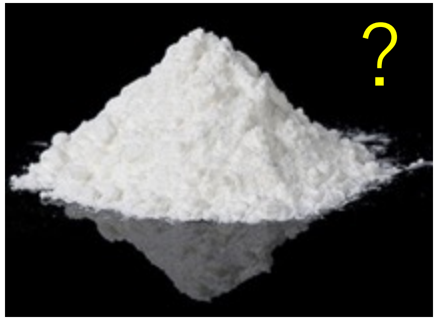
https://www.osti.gov/servlets/purl/1467983



Dielectric material



Torn into pieces?



In general, fluoropolymer is known to to be weak against the radiation