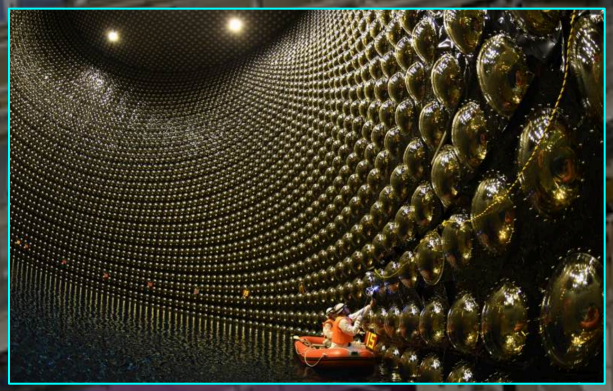
Studies of fast neutrons for design and characterization of neutrino experiments and spallation neutron sources



Teppei Katori
King's College London
EPAP PhD open day, Jan. 20, 2021

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Neutron physics is the future of neutrino physics!

Number of neutrons = “hadroness” of the shower
- PID to distinguish shower (multi-ring) topology

νeCC interaction	$\nu\tau$CC interaction	NC interaction
- Electromagnetic shower	- leptonic shower	- hadron shower
- not many neutrons	- some neutrons	- many neutrons

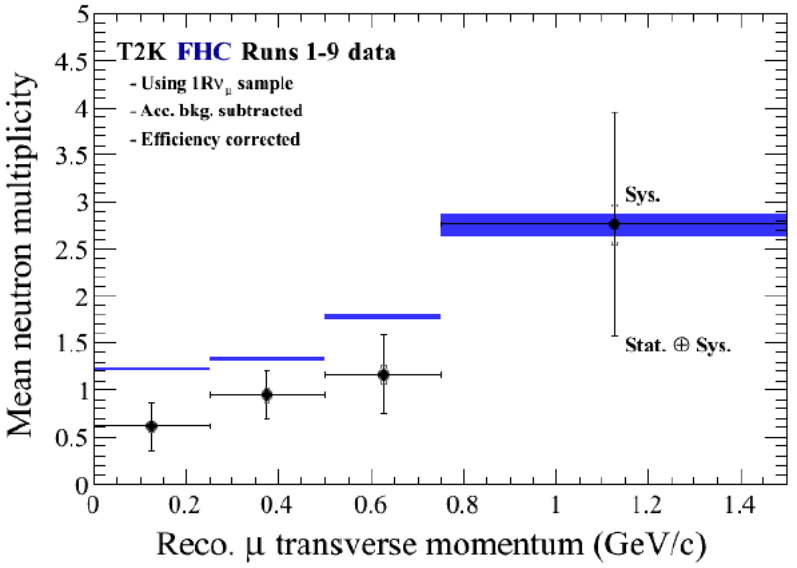
Neutron tagging ($n + p \rightarrow d + \gamma$, 2.2 MeV)
- SuperK: Captured neutron can be counted
- IceCube: Neutron capture gives late hits
- We need to predict neutron propagation in water or ice.

Akutsu (U. Tokyo), PhD thesis 20219
Steuer (Mainz), PhD thesis 2018

Neutron physics is the future of neutrino physics!

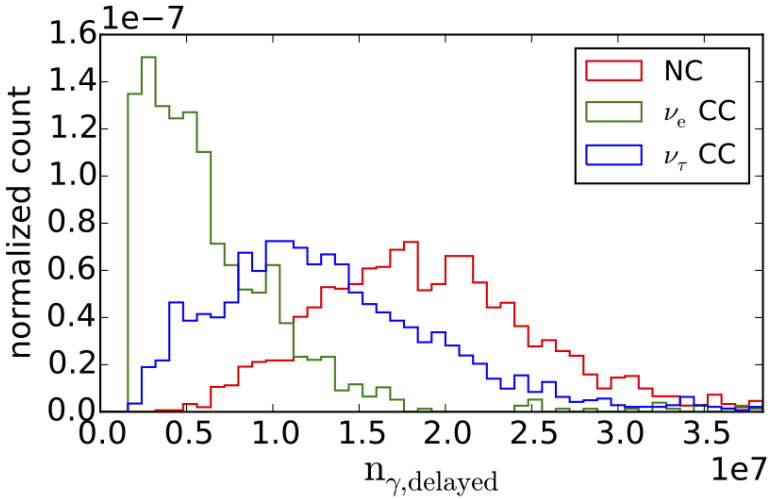
Beam neutrino-induced neutron measurement

- Data and simulation don't agree
- Systematic error is underestimated



Neutron capture for astrophysical tau neutrino search

- Promising new PID idea



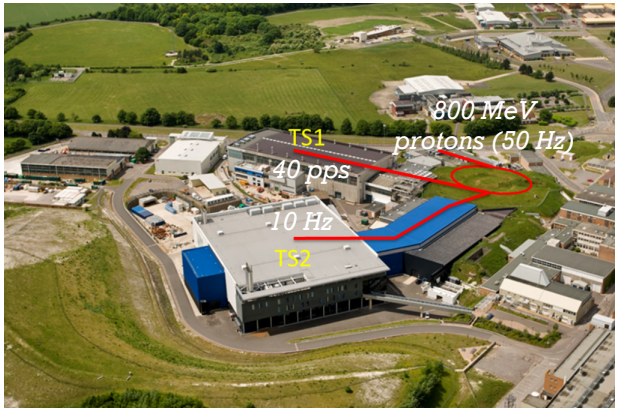
Physics of fast neutron (>10 MeV) is not well-understand. We perform fast neutron beam test at RAL ISIS ChipIr beamline to understand this.

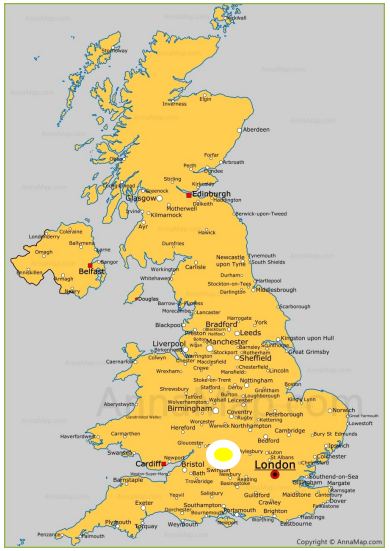
Such data will improve precision of neutron simulation in neutrino experiments, improving all science in both water and ice Cherenkov detectors.

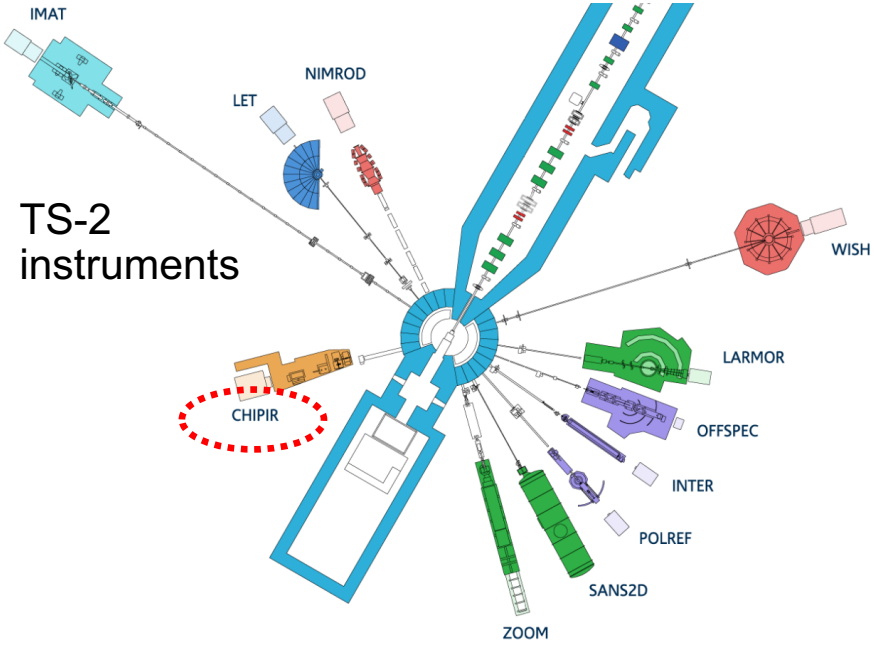
RAL ISIS neutron and muon sources

Rutherford Appleton Laboratory (RAL), Oxfordshire
https://www.isis.stfc.ac.uk/Pages/home.aspx
- ISIS target station 2 (TS2)
- ChipIr beamline (fast neutron beamline)
- Co-supervisor, Dr. Carlo Cazzaniga

Using this beamline, fast neutron scattering with water and other elements will be studied







TS-2 instruments

RAL ISIS neutron and muon sources

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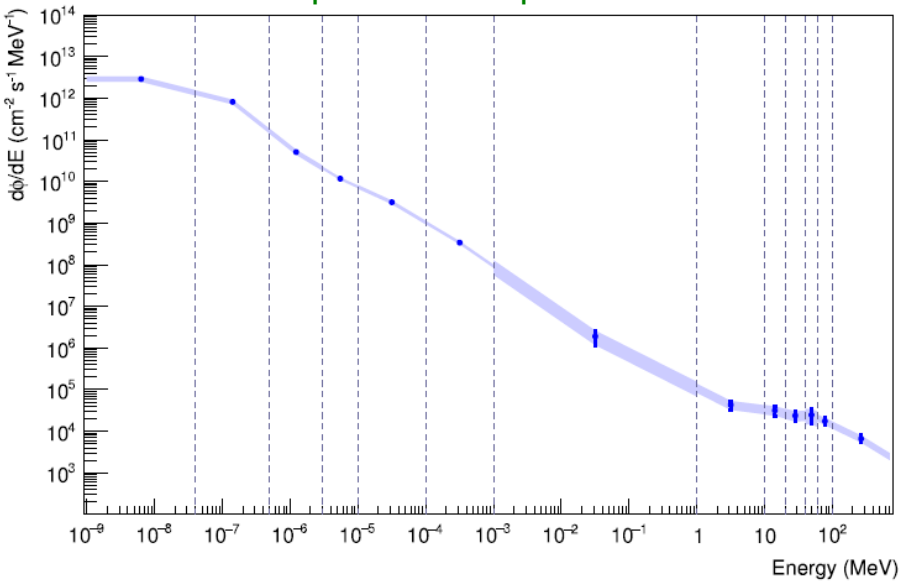
Using this beamline, fast neutron scattering with water and other elements will be studied

How to select fast neutrons? (activation foil?)
Can we measure multiplicity?
Cross-section function of energy?

→ You will design and perform the experiment. Then analyze the data and use results in Super-K/Hyper-K/IceCube.

ChipIr neutron spectrum



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Neutron radiation shielding with sintered lunar regolith

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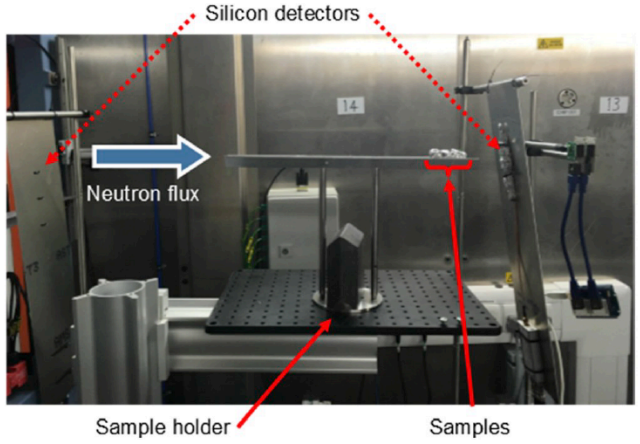

Fig. 2. Experimental setup inside the CHIP-IR facility.

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PhD and experiment timeline

3.5-yr PhD position, 1.5-yr at RAL, active member of Hyper-Kamiokande

Year 1: Stay London to learn particle physics and HyperK simulation
Year 2: Move to RAL, perform the experiment
Year 3: At some point the student comes back to London to write up paper(s) and thesis
Year 4: graduation

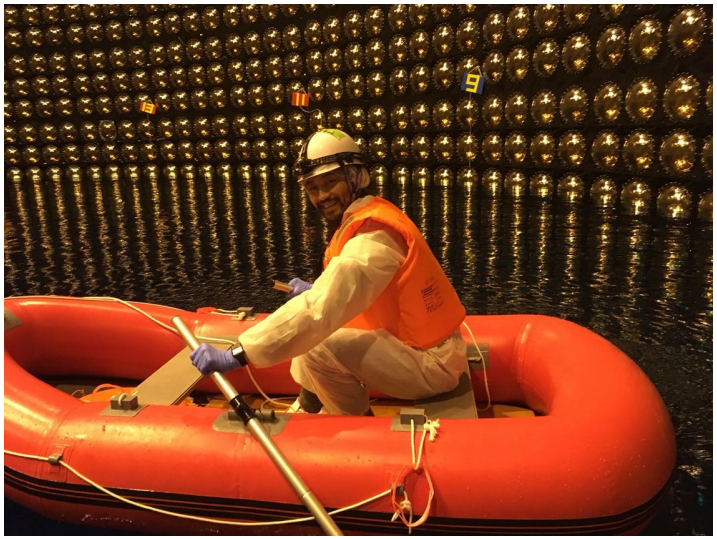
The project is hardware oriented. Prior experience in neutron physics (simulation, hardware) is desirable.

Year	0.5	1.0	1.5	2.0	2.5	3.0	3.5
Taking University of London HEP courses							
Learning HyperK simulation, and implement and test experimental results in simulation							
Setting up fast neutron measurement at ISIS, and construct simulation							
Test of material of interest for target station components							
Writing peer-reviewed papers and thesis							

Red = high% of time, Yellow = moderate% of time, Green = low% of time

Why join us? Because it's fun!

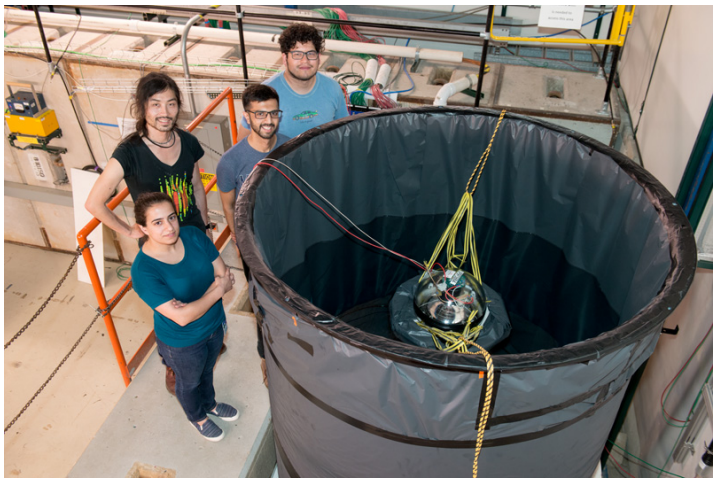
The dream boat for neutrino physicists!
(Inside of the Super-Kamiokande detector)



Group photo
(before pandemic)

Group photo
(after pandemic)

Beam test
at Fermilab



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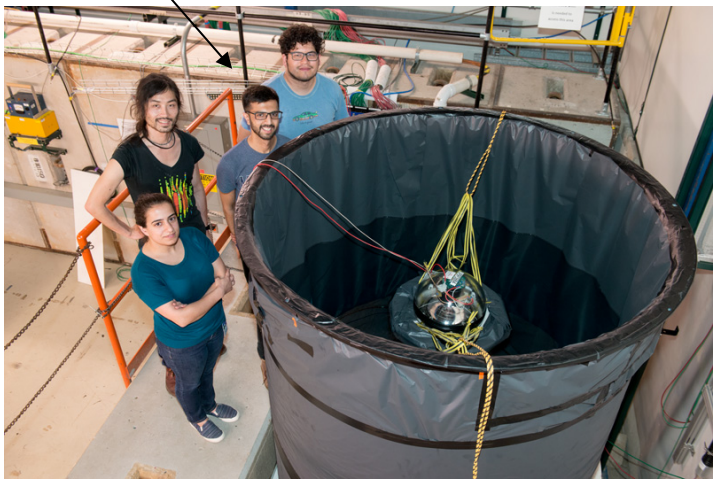
Teppei's recent publications
https://nms.kcl.ac.uk/teppei.katori/#papers

Fermilab beam test (2017)

"Pulse shape particle identification by a single large hemispherical photomultiplier tube"
https://iopscience.iop.org/article/10.1088/1748-0221/15/05/T05002

Shivesh

Beam test at Fermilab



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TECHNICAL REPORT

Pulse shape particle identification by a single large hemispherical photomultiplier tube

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Teppei and DOM (21/01/15)