# DICER: A new Device for Indirect Capture Experiments on Radionuclides

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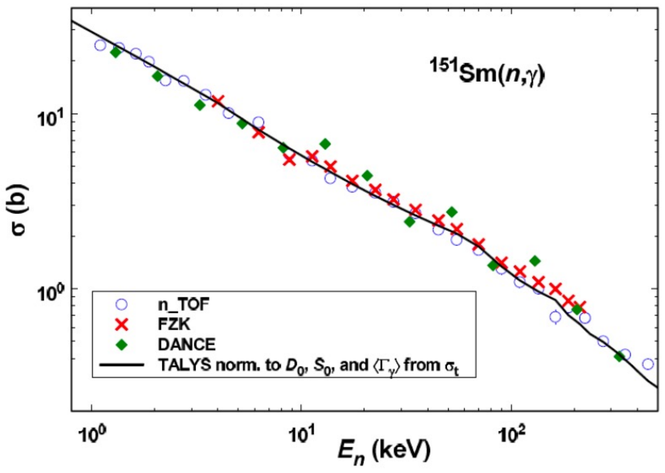
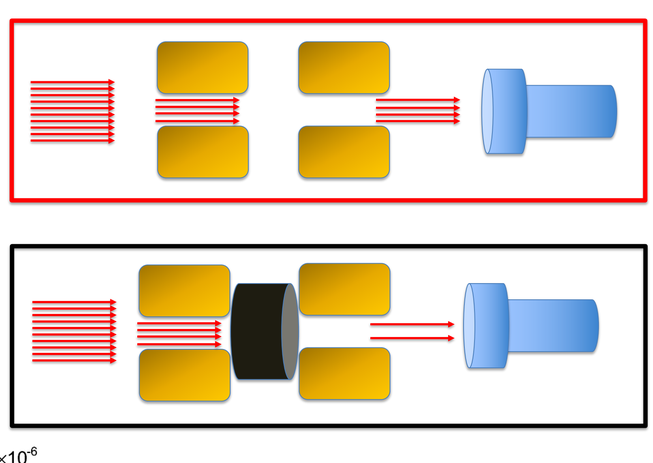
## Introduction

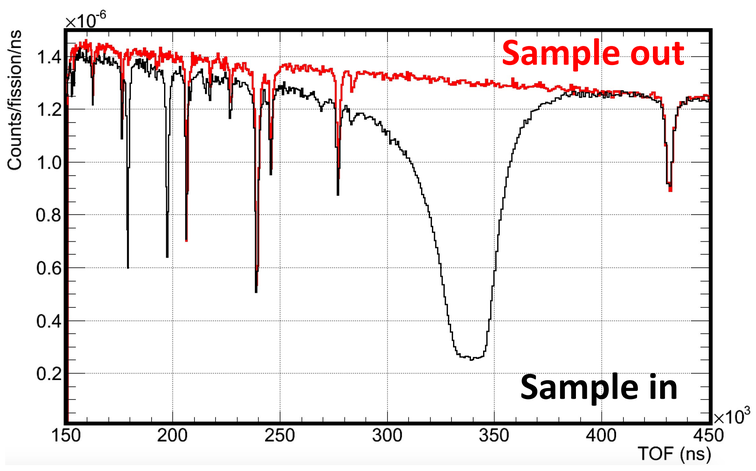
- **(n,γ) cross sections** on **radionuclides** are of high importance
  - Radiochemical diagnostics/technical nuclear forensics
  - Nuclear physics and astrophysics
  - Nuclear criticality safety and advanced reactors
  - Isotope production
- Challenging **direct measurements**: **big backgrounds** involved.
- **Indirect techniques** provide answers but heavily rely on theory, hence the **results** are **quite uncertain**
- A **new technique** is proposed, based on **3 steps**:
  - Neutron **transmission** experiments
  - **R-Matrix** analysis of the resonances seen in the transmission spectrum
  - Resonance properties to **calibrate Nuclear Statistical Models**.




## Traditional vs DICER

### Traditional transmission measurements



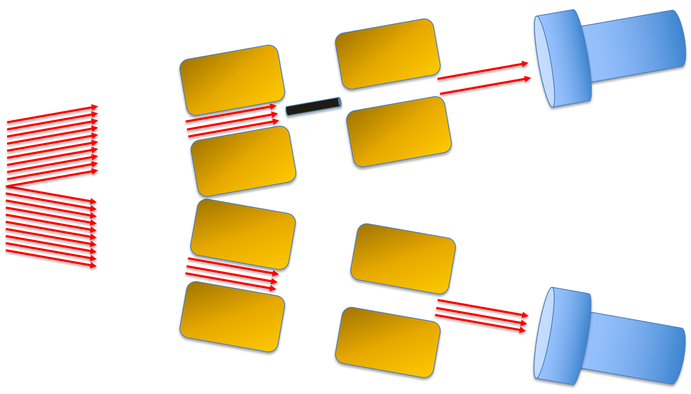




$$T_{exp} = \frac{C_{in} - B_{in}}{C_{out} - B_{out}}$$

C : counts
B : background

- **Sample cycling** is needed.
- Sample **positioning** has **finite accuracy**.
- Precise **repeatability** of the sample's **position**, relative to the collimation system, is **not ensured**.
- Treatment: **samples** are much **larger** than the neutron **beam**, defined by the collimation system.
- **Large samples** are sometimes **difficult to fabricate** when there are **dose rates** and **rarity** of the material considerations.

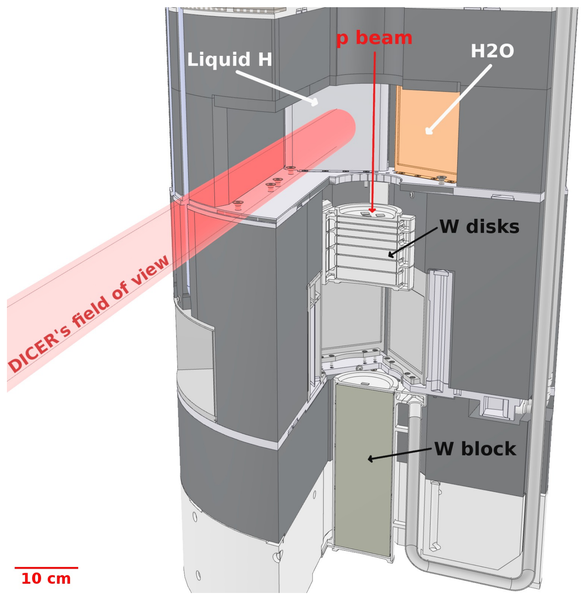
### DICER: Binocular approach



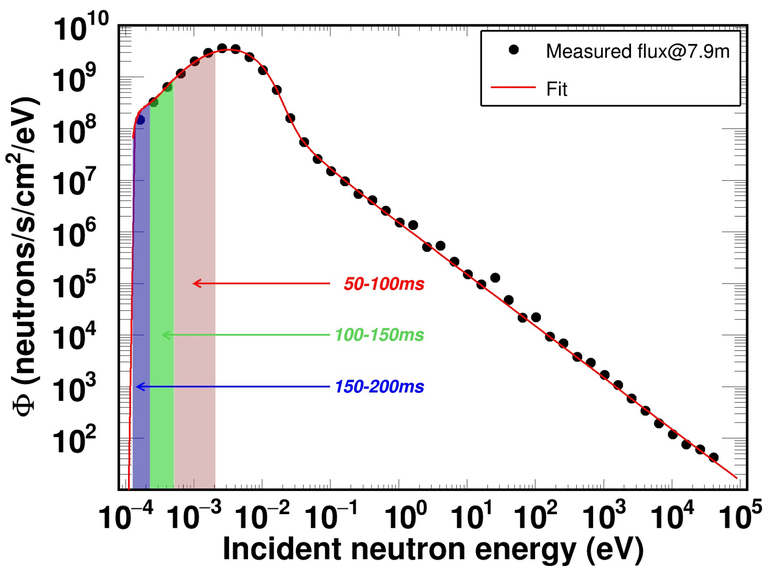
- **Binocular mode** of operation
- **Simultaneous** measurement of **sample in/out**
- **No** precise **repositioning concerns**
- Added **bonus**: measurements will be completed **50% faster**!

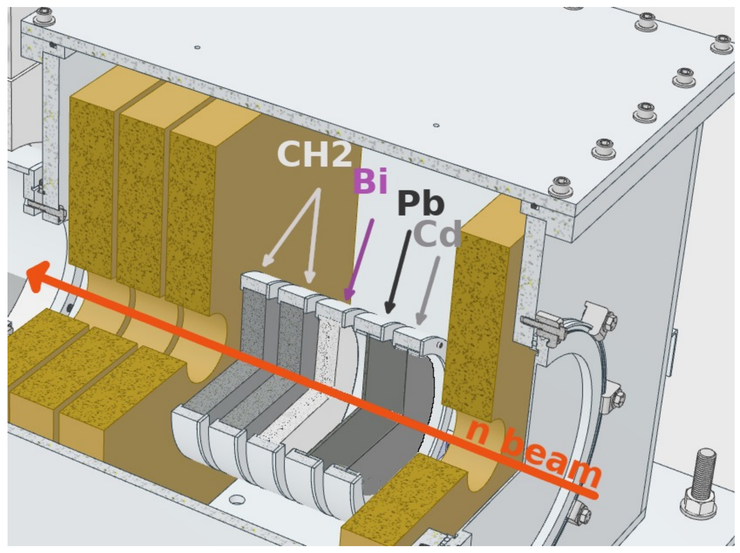
## Technical details

### Neutron source and spectrum



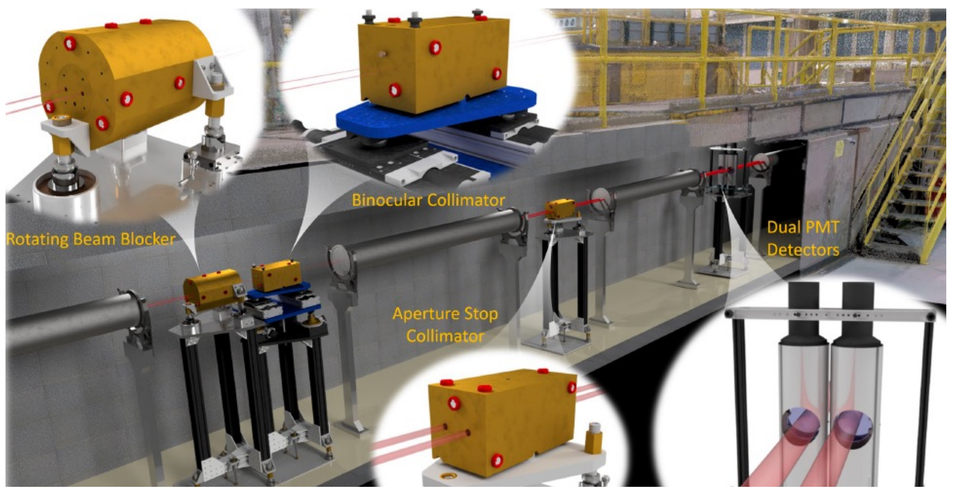

- **Neutrons** are **spallation** products
- **800MeV protons from** LANL's LANSCE impinge on a split **W target** at a **20 Hz** duty cycle.
- DICER points to the **liquid hydrogen moderator**
- Neutron spectrum spans **~0.2 meV – 100 keV**
- The neutron spectrum can be filtered using a set of paddles



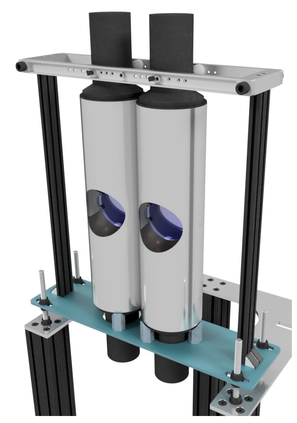

### Collimation system

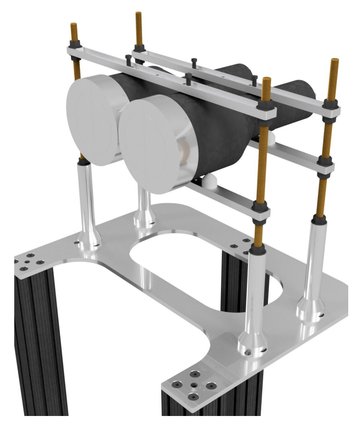
- The collimation system consists of **3 components**
  - **Rotating beam blocker**: Allows the **passage/blocking** of **neutrons** on each mini beam line (14.35 m)
  - **Binocular collimator**: Collimates the beam down to **1 mm** diameter and serves as a **sample holder** (14.85 m)
  - **Aperture stop collimator**: Provides the last collimation stage, **shaping** the beam at the proper diameter to intercept with the detectors (18.5 m).




### Detectors

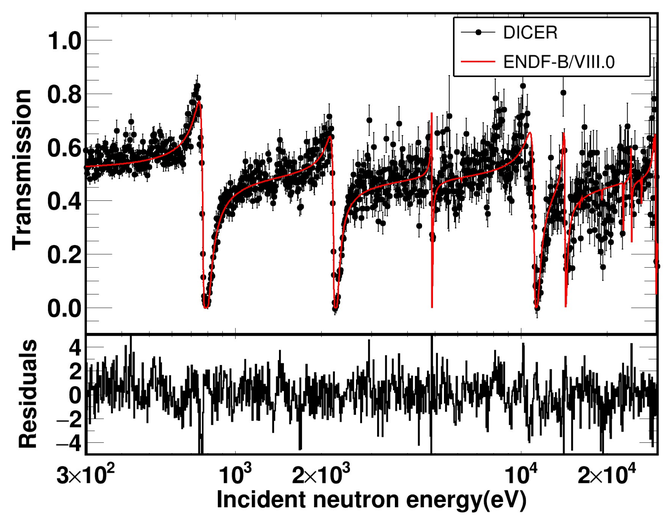
- A commercial $^{235}$U loaded fission chamber is installed at ~7.8 m to monitor the neutron flux.
- Two types of $^{6}$Li-glass neutron detectors are available at the 31.5 and 64m detector stations:
  - ORELA type: Dual PMT detector.
    Less material in beam: less background
    Poorer light collection
  - Chi-nu type: Single PMT detector.
    PMT in contact with the $^{6}$Li-glass
    More material in beam: more background



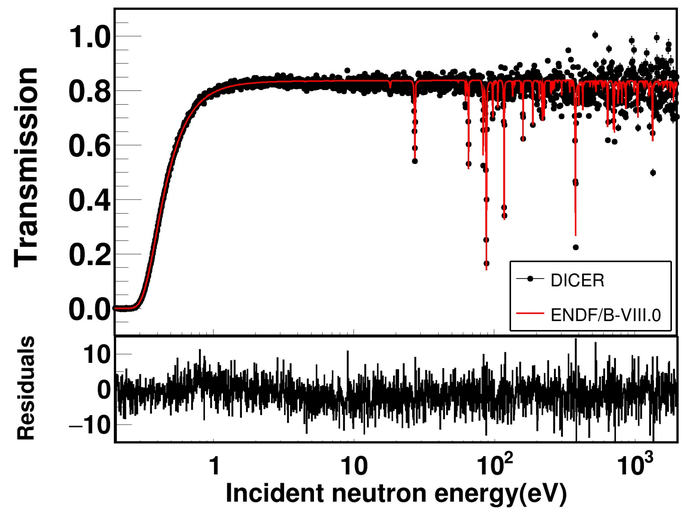


## First results

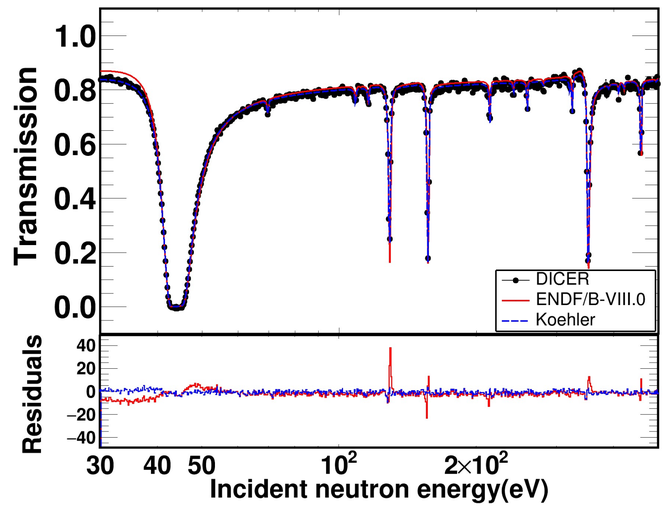
$^{209}$Bi




$^{nat}$Cd




$^{95}$Mo




## Perspectives

- First radionuclide measurement ($^{88}$**Zr**): to be **completed soon**
- Data already taken on several stable nuclei: $^{191,193}$**Ir**, $^{147,149}$**Sm**
- **Upgrade** of the **spallation** target during the LANSCE **2022** cycle break.
- Upgrade of the **sample collimator**: **0.1mm** diameter
- Upgrade of the detection system: a **pixelized detector array** (LAPPD) will replace the current dual/single PMT detector.

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