



*Institut
Ruđer
Bošković*



hrzz
Croatian Science
Foundation

 **NINJA**
Neutrino Interaction research with
Nuclear Emulsion and J-PARC Accelerator



**Swiss National
Science Foundation**

The T114 Experiment

Bruno Kovač

1st Annual MAPS Meeting

2 July 2026, Zagreb

Outline

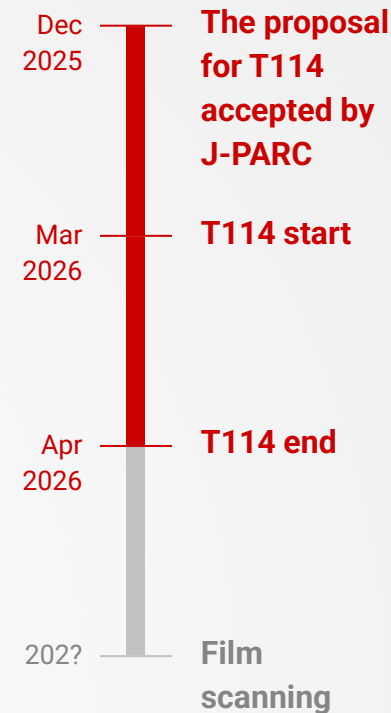
1. The T114 surface test experiment
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1. The T114 test experiment

The NINJA collaboration plans a very off-axis measurement at ground floor (ND280). Increasing the off-axis angle lowers the energy peak, resulting in a narrower flux.

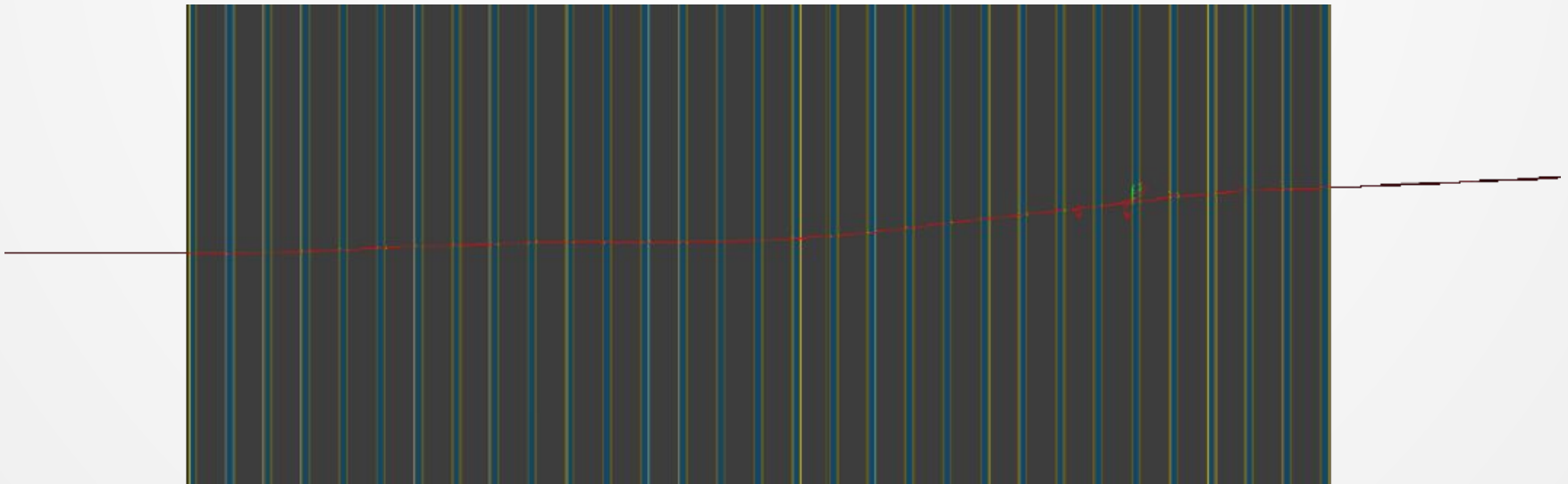
To prepare, the IRB's neutrino group proposed and conducted a test experiment to **characterize backgrounds** to our neutrino signal (μ , γ , sky-shine).

It was important to collect emulsion data at ground level to develop our MC and improve understanding of backgrounds for a potential future NINJA site.



2. Test goals

1. **measure cosmic-ray flux** at ND280 ground level using an emulsion–lead detector
2. **determine muon momentum** as a function of zenith angle
3. **validate μ counting efficiency** with a scintillator counter

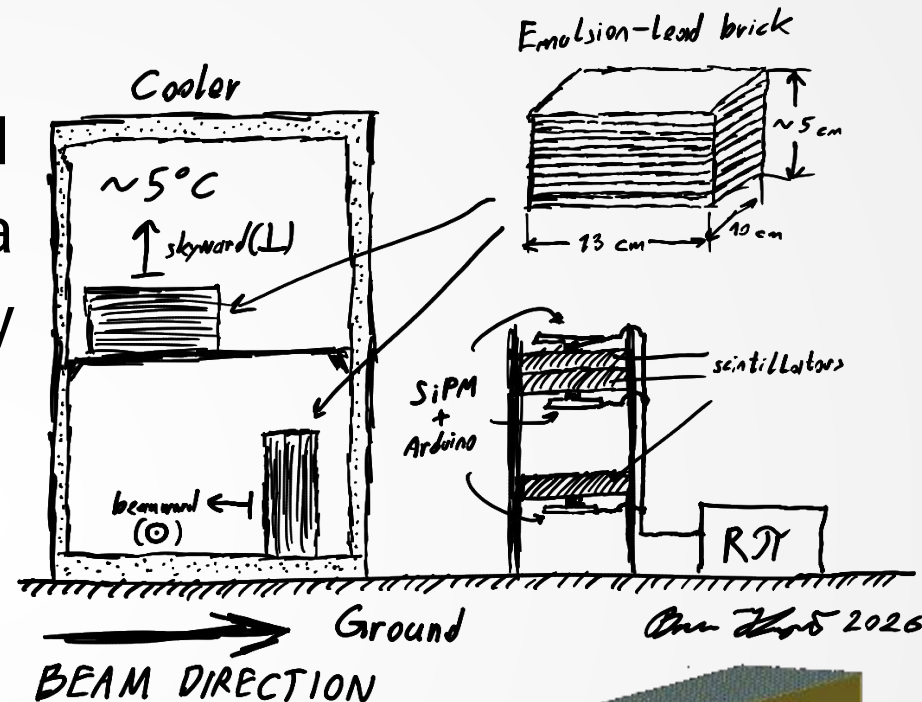


3. Experimental setup

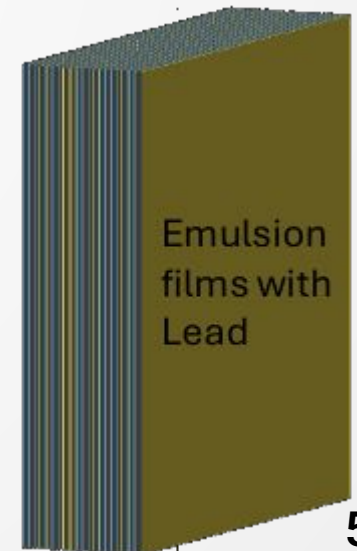
The setup for each run included **two emulsion bricks** placed in a cooler, one oriented horizontally and the other vertically.

Each brick consisted of 30 lead plates (1 mm thick) and 31 emulsion films ($13 \times 10 \text{ cm}^2$).

Bricks were **exposed for two weeks** in two separate runs: once during the T2K neutrino **beam-on** period and once during the **beam-off** period.



Alternating
lead plates and
emulsion films
form the brick.



3. Experimental setup

Each film had an ID with brick letter and emulsion number.

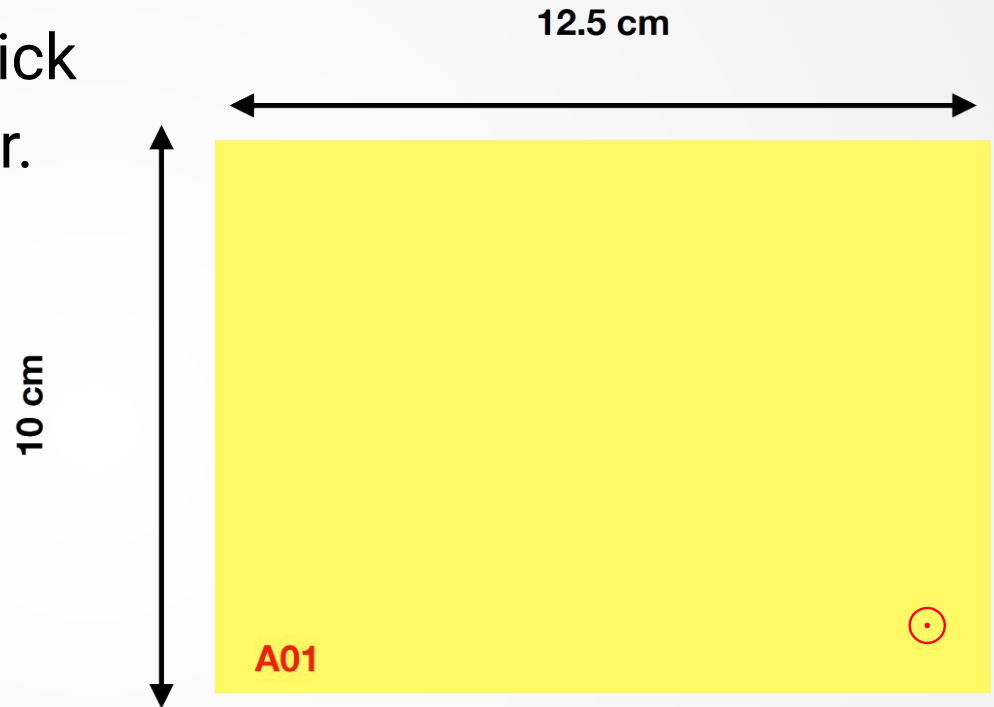


Table 2: Plate ID in each brick

Run number	Brick name	Brick orientation		Plates in the brick
1	A	⊙	Vertical brick	A01 - A31
1	B	⊥	Horizontal brick	B01 - B31
2	C	⊙	Vertical brick	C01 - C31
2	D	⊥	Horizontal brick	D01 - D31

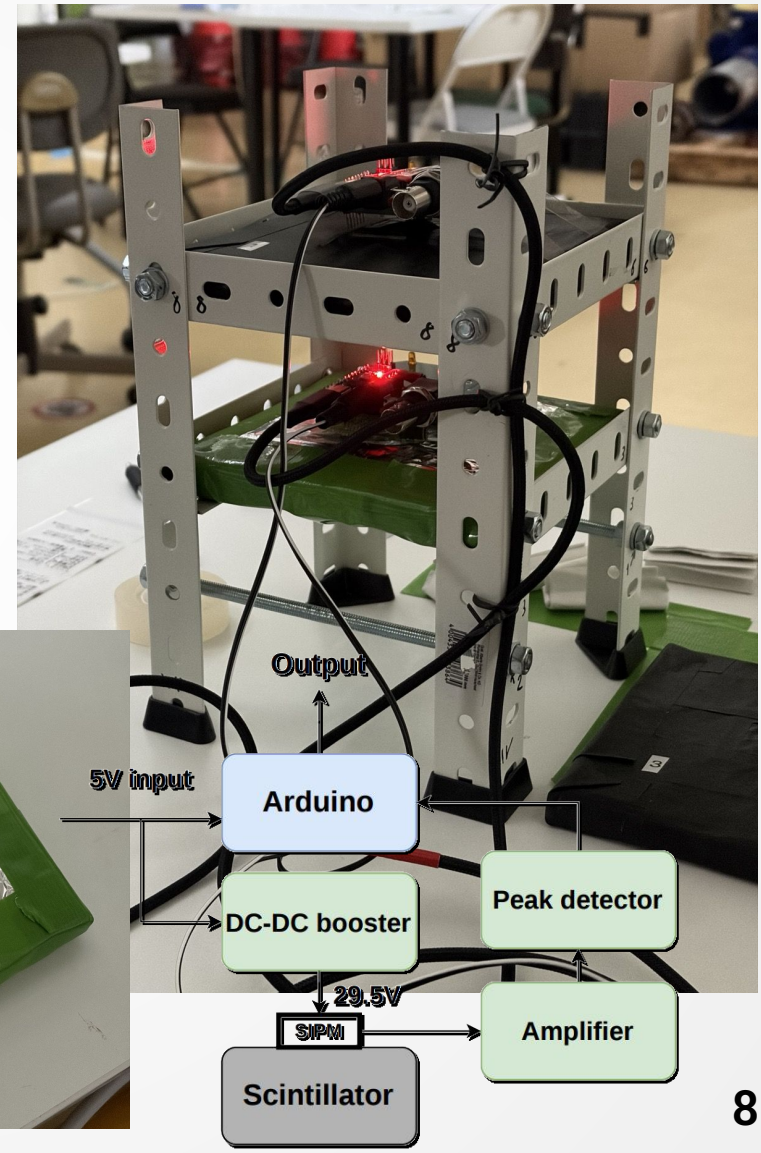
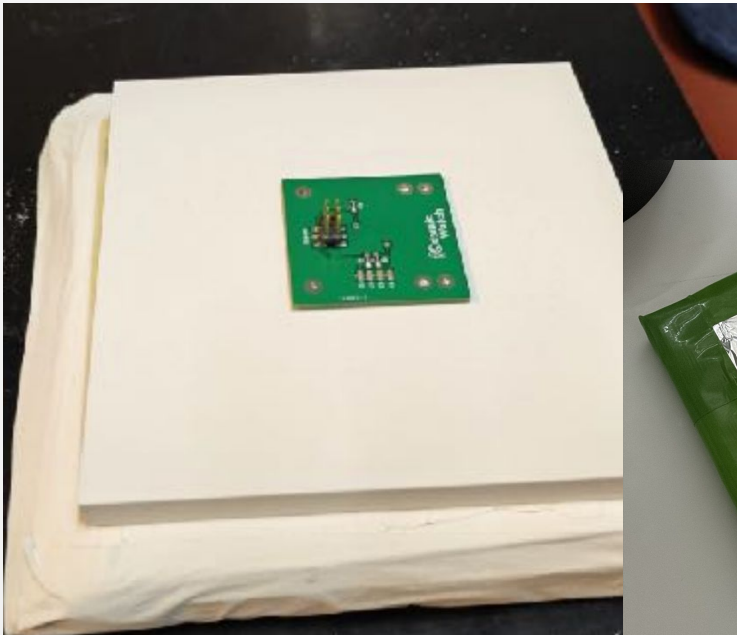
3. Experimental setup

A realized setup inside a J-PARC's Neutrino Assembly building.



3. Experimental setup

A **muon counter** made of 13×13 cm² acrylic scintillator plates with SiPM glued onto them was used to cross-check the tracks recorded in the emulsion bricks.



4. Film development

Emulsion films were developed in a dark room by immersing them in a series of chemical solutions:

1. developer (30 min)
2. stopper (10 min)
3. fixer (90 min),

followed by washing under running tap water for at least 60 minutes.



4.1. Drying

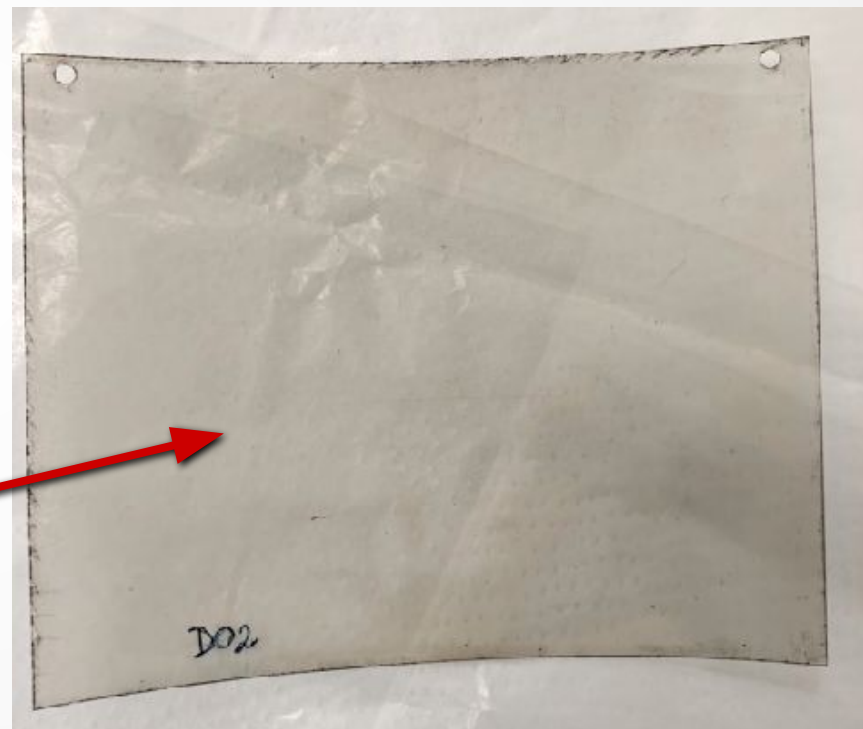
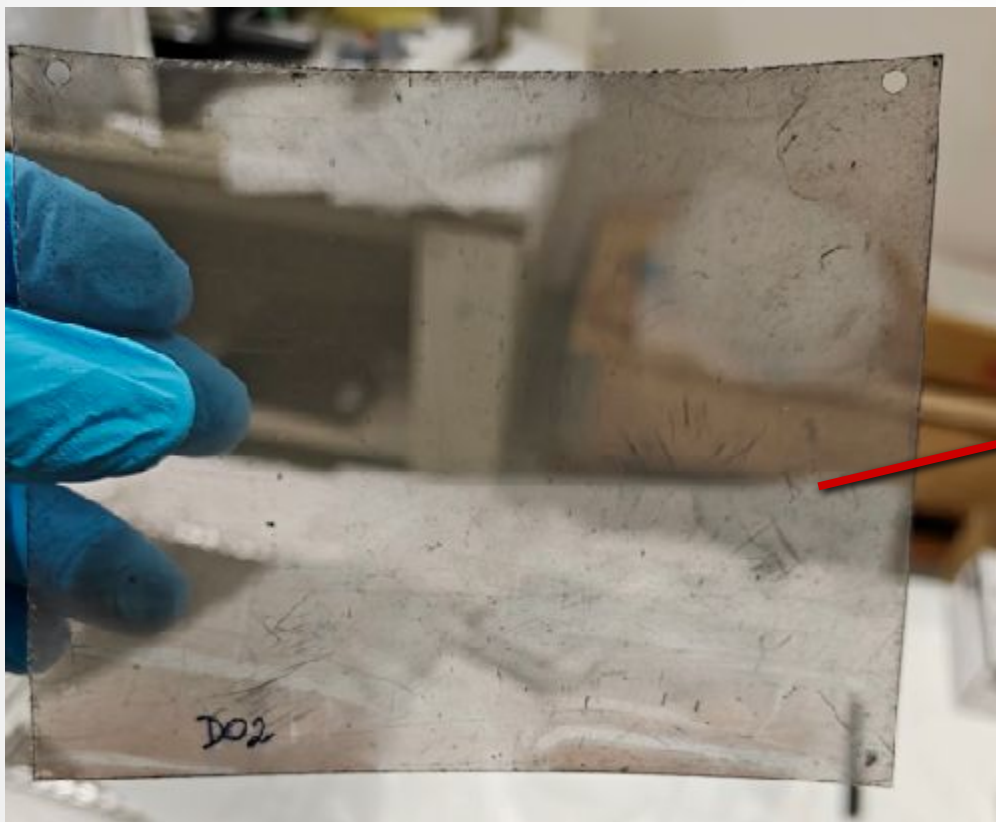
Films from the first batch were dried in the same rack used for development, resulting in uneven drying and edge damage.

Subsequently, the remaining films were dried by punching holes in the corners and hanging them to ensure uniform drying.



4.2. Silver removal

Worst part.

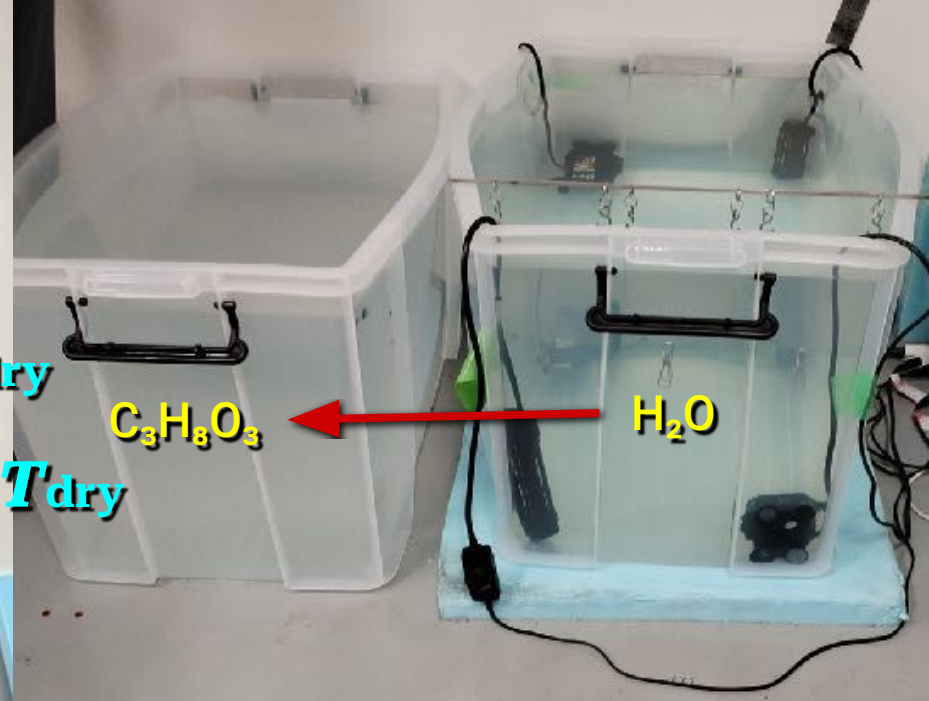


4.3. Swelling

$$T_{\text{aim}} = (T_{\text{gly}} - T_{\text{dry}}) \times 0.3 + T_{\text{dry}}$$

$$\Rightarrow T_{\text{gly}} = (T_{\text{aim}} - T_{\text{dry}}) / 0.3 + T_{\text{dry}}$$

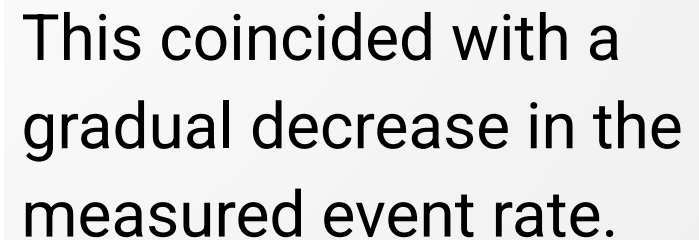
T_{aim} → thickness before development,
 T_{dry} → thickness after silver removal,
 $T_{\text{gly}} - 30$ → target thickness in water prior to glycerol dipping.



5. Test schedule

The test was originally planned for **Nov–Dec 2025**, but delays in obtaining onsite permissions pushed it to **Mar–Apr 2026**, when data-taking runs were successfully completed.

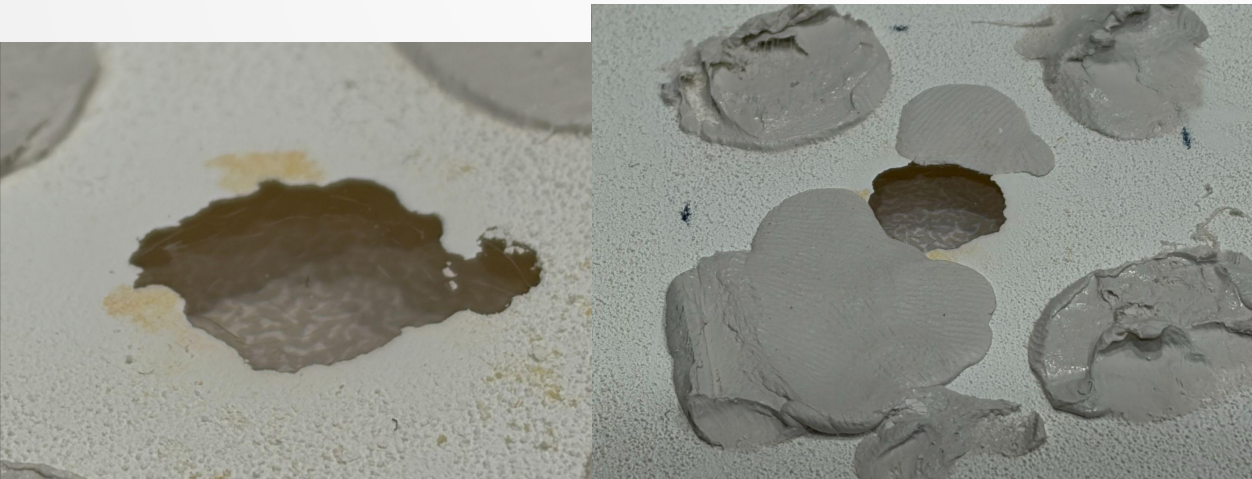
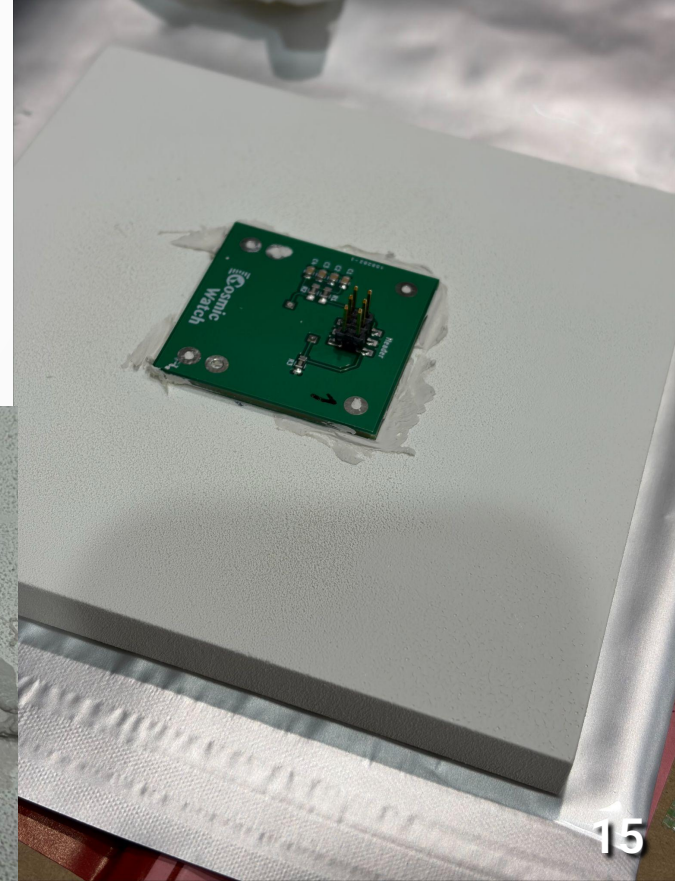
The next stage of the experiment will involve **film scanning**. This will be followed by **data analysis**, with a focus on **cosmic muons, gamma rays, and beam-induced neutrino backgrounds**.



Muon counter troubles

With EJ-500 optical cement provided by NINJA's Kyoto group, the SiPM was reattached for the second run.

The scintillator was flipped so the SiPM sat on top, reducing coincidence due to increased separation, which can be corrected via angular acceptance.



6. Summary

The T114 test experiment successfully completed two emulsion film exposure runs at J-PARC's NA building.

Development, silver removal, and swelling of 124 films have been finished, while scanning parameters are set and the full scanning schedule is still pending.

The muon counter operated near the bricks throughout both runs; although the SiPM detached midway during the first run, it was repaired in time for the second.

This marks **the first Croatian experiment** to be proposed and successfully carried out **at J-PARC**.

