PROCEEDINGS OF SCIENCE

Development of high-contrast developing for nuclear emulsion film for GRAINE experiment

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The GRAINE experiment is the balloon flight experiment with emulsion chamber telescope for observing of gamma rays that have energy range of 10 MeV to 100 GeV. We launched the emulsion chamber telescope in Australia in the April, 2023 (GRAINE2023). GRAINE2023 have the larger aperture area than previous experiments, and the aperture area increase from 0.38 square meters to 2.5 square meters. The nuclear emulsion film is the kind of photographic film, and we can observe emulsion films on the microscope after the development. The scale of experiments with the nuclear emulsion film increases, the Hyper Track Selector (THS) was developed for convert track in the nuclear emulsion film into data at high speed, and have been producing success. Additionally, the HTS2 was developed for improvement of the scanning speed over THS, by lowering the magnification and widening the field of view of the captured image. On the other hand, the THS2 is concerns about the deterioration of the detection performance of developed silver. As one way, to improve the detection performance of developed silver, we changed the developer, which makes enlarge developed silver grains. So far, we have used OPERA ' s development, but we made development possible to adjust the size of developed silver grains by mixing chemicals with ourselves. We study and develop of high-contrast developing for the nuclear emulsion film and report the result of developed emulsion films of GRAINE2023.

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1. Introduction

Gamma-ray astronomical observations in the GeV region have made great progress with the Fermi-LAT launched by NASA in 2008, and the angular resolution has improved year by year by observing and collecting statistics for several years. Fermi gamma-ray observations over eight years have reported 5064 gamma-ray objects in the range from 50 MeV to 1 TeV. On the other hand, it is also reported that 26% of these observed gamma-ray objects are unidentified objects[1].

Observations in this energy band lag behind observations in other wavelengths of electro-magnetic waves, and recent advances in observational techniques are expected to lead to further understanding of gamma-ray high-energy astronomical phenomena. One of the lagging observation technologies is the improvement of angular resolution.

1.1 GRAINE experimet

The GRAINE(Gamma-Ray Astro-Imager with Nuclear Emulsion film) experiment is the joint experiment by using the balloon-borne gamma-ray telescope with high spatial resolution emulsion films. The purpose of the GRAINE experiment is to analyze the gamma-ray imaging of high energy astronomical objects of 10 MeV to 100 GeV band in high detail. We are expected that the nuclear emulsion film telescope used in this study will adavance the obsevation of gamma-ray astronomical objects in high angular resolution.

The main detector consists of converter, time stamper, and three star cameras, and it has 2.5 m^2 aperture area. The converter part consist of twenty blocks that the one block is ninety stacked emulsion films, and the one emulsion film has 250 mm $\times$ 500 mm area. The role of the converter part convert gamma-rays into electron-positron pairs, and measures the energy of particles. The time stamper part consist of the multistage shifters, and the three star cameras for evaluates the attitude of telescope by registers the stellar objects.

In April 2023, the emulsion telescope was launched form Alice Springs, Australia (GRAINE2023). —

1.2 Nuclear emulsion film

The nuclear emulsion film is a track detector type of the photographic film coated nuclear emulsion gel, which is mixed AgBr in gelatin, on a plastic sheet base or on a glass base. The Ag^+ in nuclear emulsion film is sensitized when charged particles pass through the nuclear emulsion film, and is recorded as developed silver via develop the sensitized emulsion film. The developed silver can be observed using a microscope. By taking micrographs, we can analyze the track of charged particles. Track detectors include fog chambers and bubble chambers in addition to the nuclear emulsion film. A feature of the nuclear emulsion film is that it has a high spatial resolution of less than 0.1 μm. The nuclear emulsion film used in this study and GRAINE2023 is a plastic sheet base coated with nuclear emulsion gel on both sides to a thickness of 70 μm to 75 μm.

After developed, we can get track data for analyze using Track Selector via swelling. Track Selector was developed for convert track in the nuclear emulsion film into data. The scale of experiments with the nuclear emulsion film increases, Track Selector was developed with increased speed, Hyper Track Selector (HTS) and HTS2. The HTS2 was developed for improvement of the scanning speed over HTS, by lowering the magnification and widening the field of view of the captured image. On the other hand, as a result of lowering the magnification, the HTS2 is concerns about the deterioration of the detection performance of developed silver. To improve the detection performance of developed silver, we changed the developer, witch makes enlarge developed silver grains.

2. Developer changes and improvements of developed silver

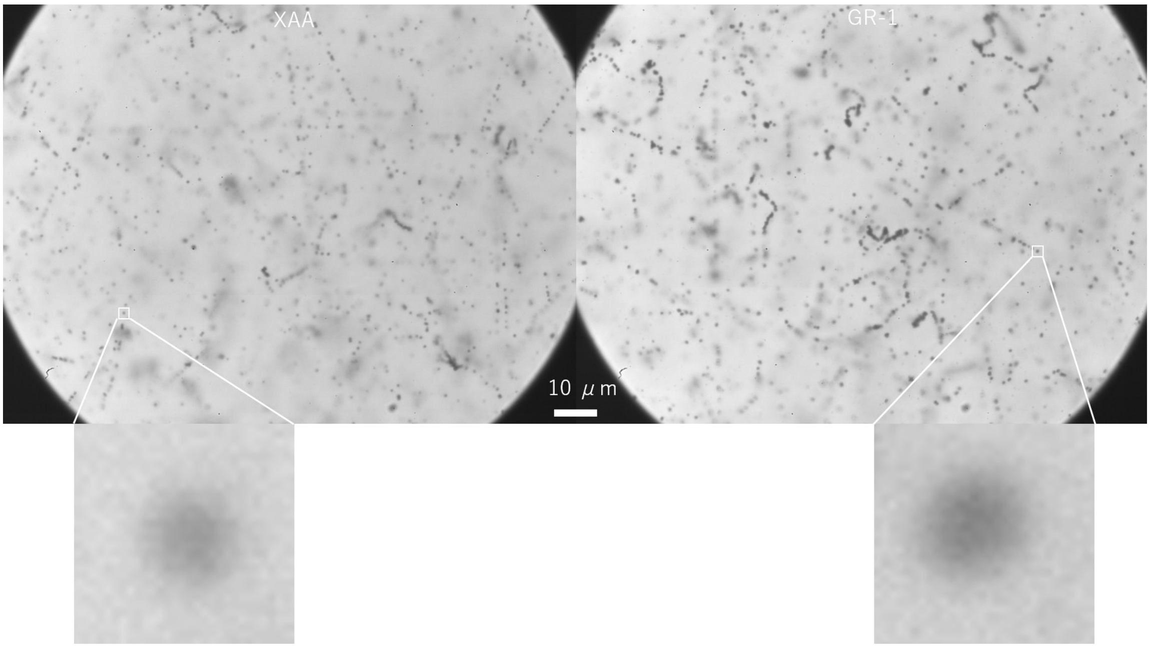

Figure 1: The microscope image of different developer. Left picture is XAA developer, and right picture is reversal developer.

3. Development for large scale processing

3.1 Exhaust status of developer

We evaluated the performance of the new developer in large-scale development. develop three times

4. GRAINE2023 balloon flight film

After the experiment, B was returned to Japan and developed at Gifu University.

5. summary and discussion

References

[1] S. Abdollahi, et al., “Fermi Large Area Telescope Fourth Source Catalog”, ApJS, 247, 33, 2020, March

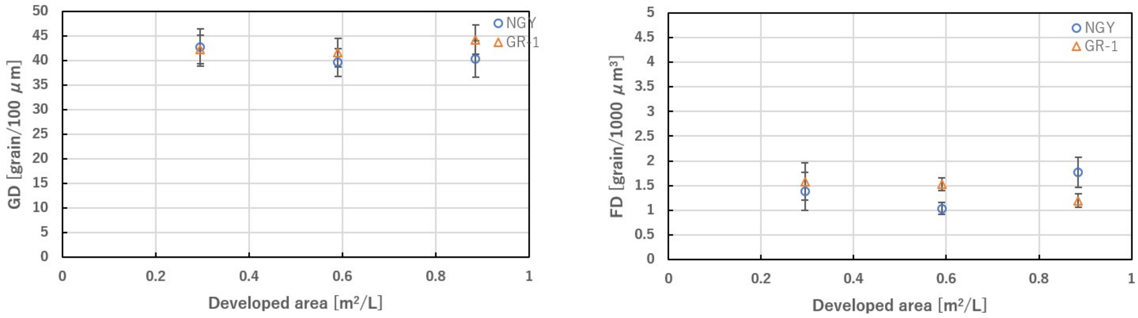

Figure 2: GDFD

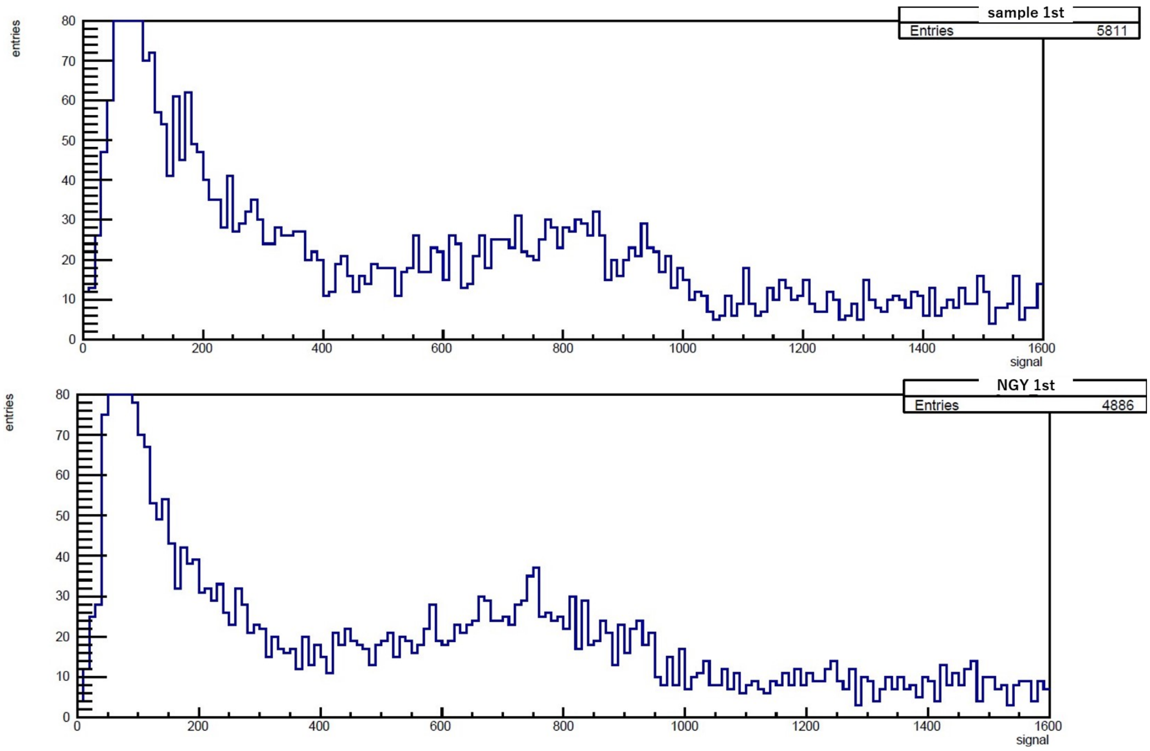

Figure 3: signal first

[2] ....

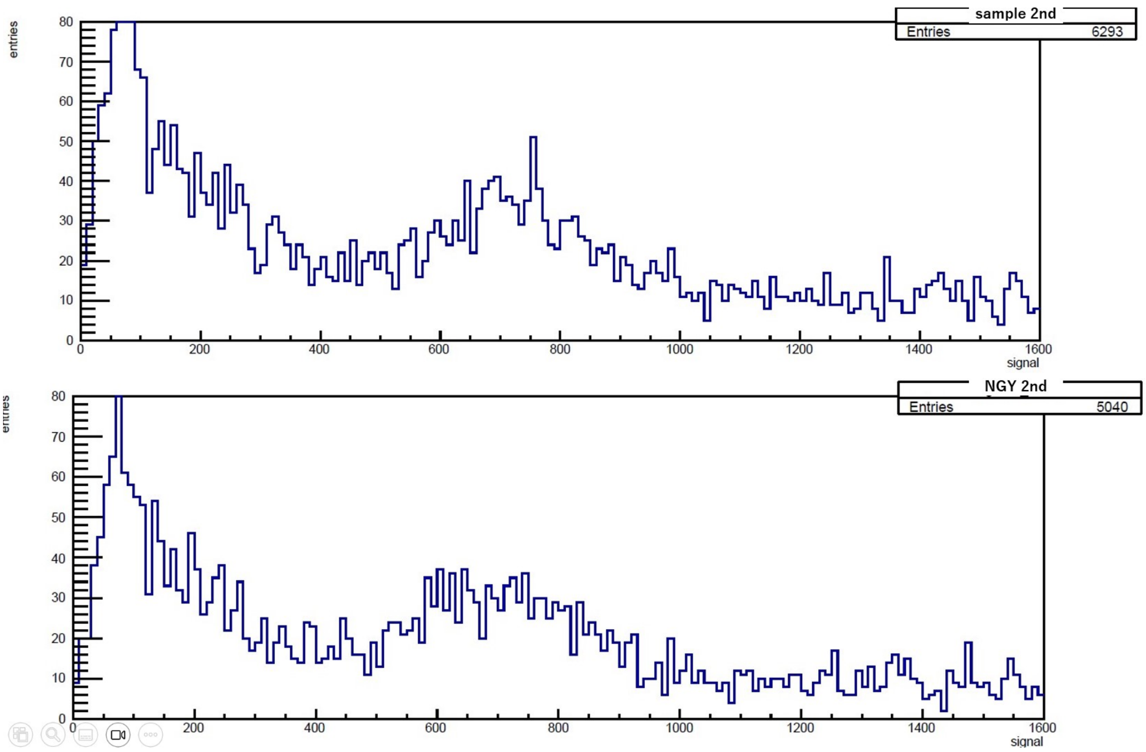

Figure 4: signal second

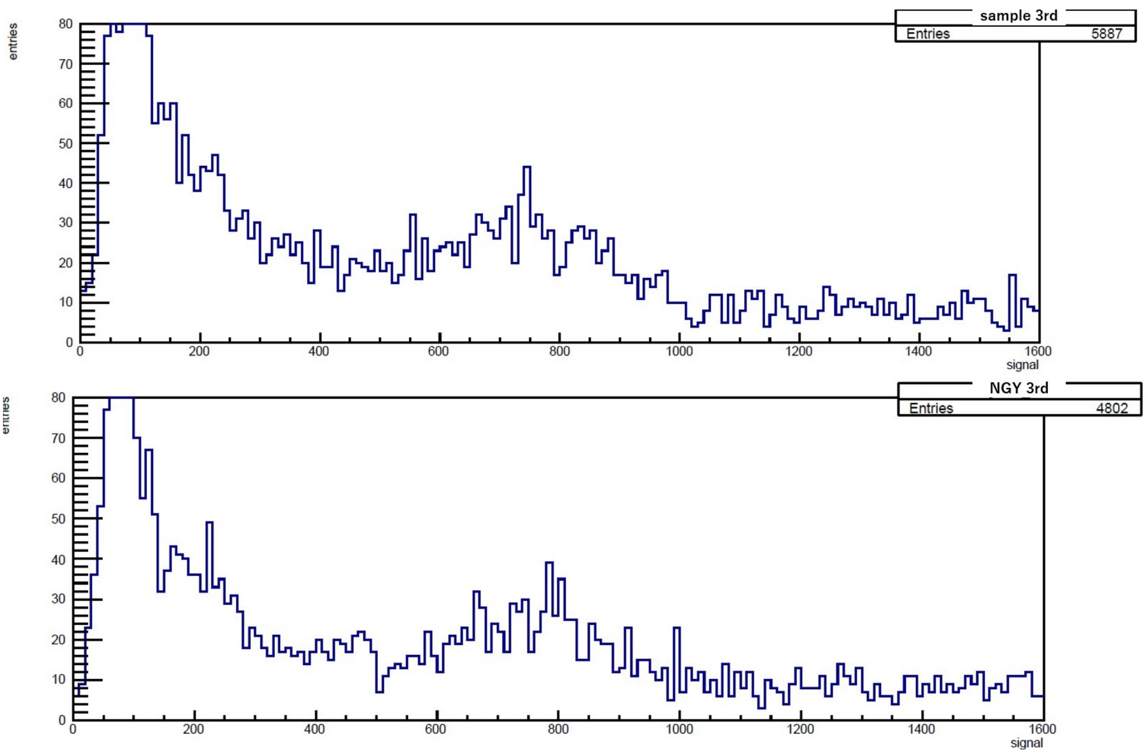

Figure 5: signal third

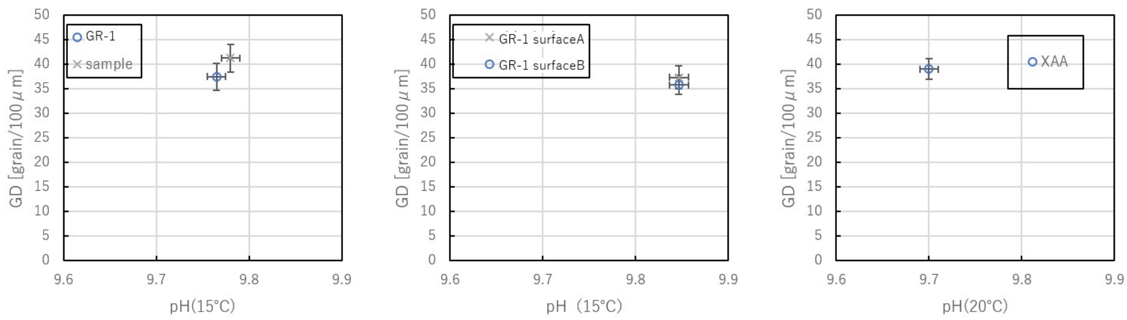

Figure 6: GD.

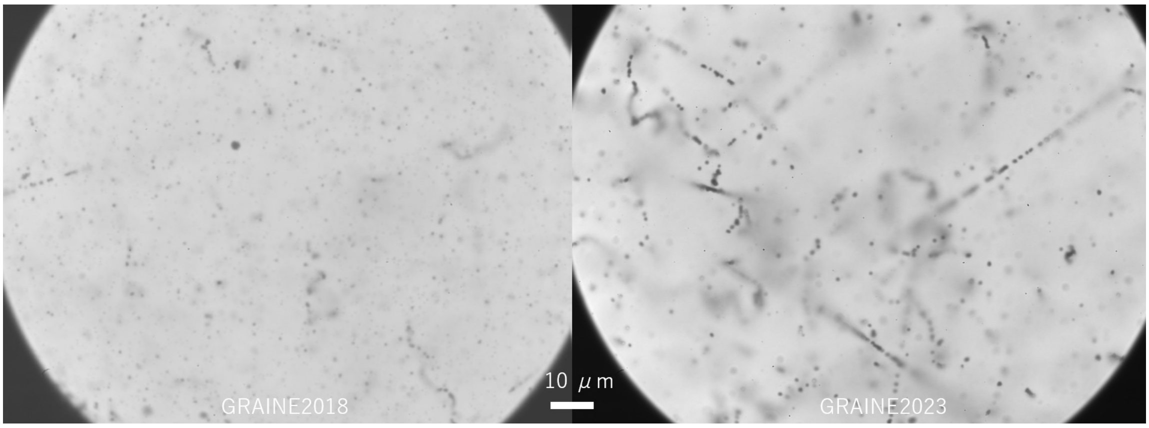

Figure 7: The microscope image of ballon flight film. Left picture is flight film in 2018, and right picture is flight film in 2023.

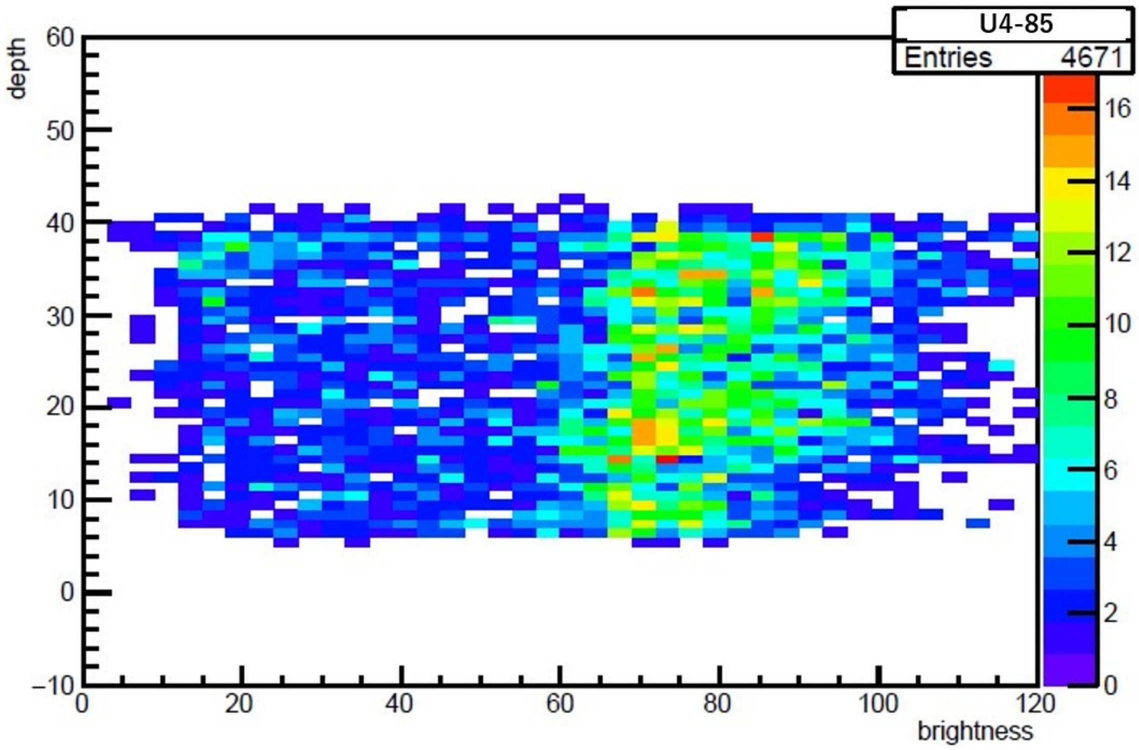

Figure 8: depth

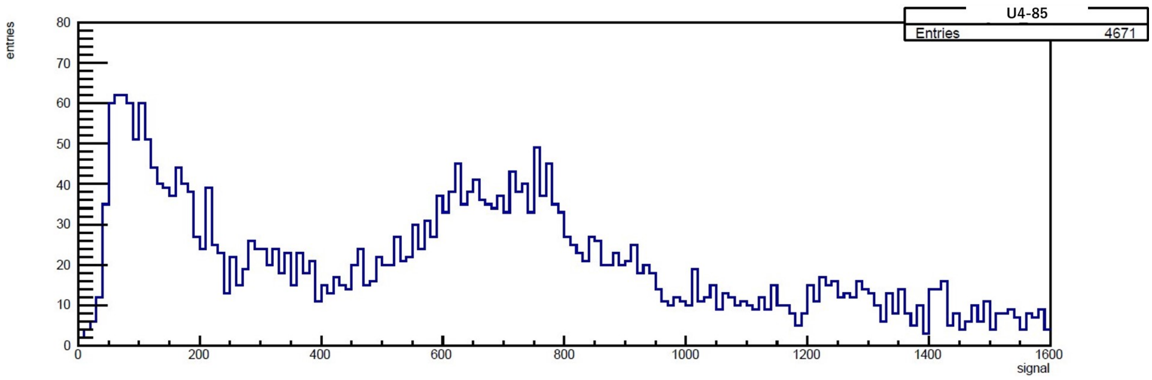

Figure 9: depth