Status and discussion for underground lab. and Nagoya's activity

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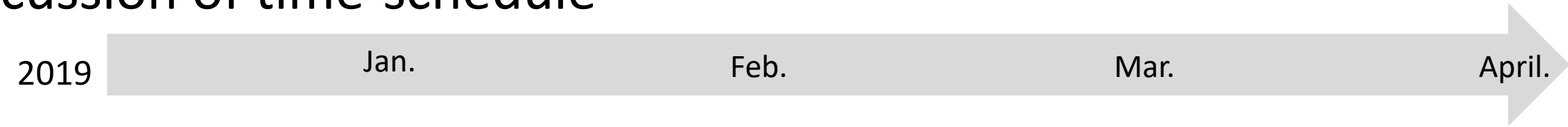
(move to the Toho University from April)

1. Feb., 2019 NEWSdm meeting @ Napoli University

Discussion of time-schedule



Surface lab.

Test for scanning and analysis with small device

- Surface run with equatorial telescope
- ~ 1 g scale data analysis
- Construction Phase-contrast imaging system
- Development of BDT analysis method

Now on here

Data analysis and surface run result as dark matter sensitivity

March , 2019

Data analysis for underground run and evaluation of dark matter sensitivity

Underground lab.

Production machine commissioning

operation

Emulsion gel handling environment and system

Infrastructure

Now on here

Underground Run

Current activities in LNGS

End od Nov. : Installed the production machine at LNGS
MOU was agreed in NEWSdm collaboration

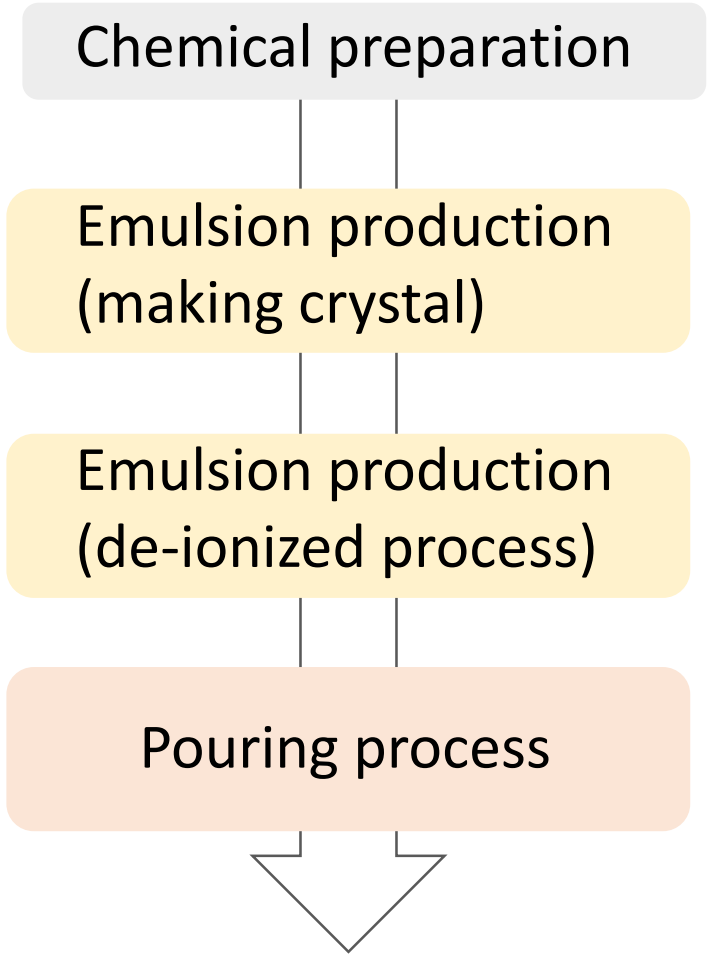
28 Jan. 2019 - : Started the commissioning of the machine

- Machine is working well
- There is one problem about air leakage
  ⇒ in this week, it become better, but not stable yet.
- As next step, first test of emulsion gel production
  ⇒ check the crystal size and sensitivity

During my stay

- Complete the infrastructure (e.g., ventilation, ‘(demineralized) water supply, waste water treatment)
- Construction of chemical preparation and preparation of various equipment for the emulsion production
- Confirmation of all process for emulsion production (next slide)
- Efficiently evaluation system of the device

Process of emulsion production



Task

- ✓ Confirmation of process to buy chemicals
- ✓ various tools have to be prepared (currently not enough)
- ✓ Gelatin filtering process (filter tools were arrived from Nagoya)

- ✓ To solve air leakage problem
- ✓ Test using real chemical [crystal size, Ag ion conductivity]

- ✓ More efficiently method have to be developed
- ✓ Refrigerator is required

- ✓ More efficiently pouring process
- ✓ Drying process (e.g., climatic chamber)

Efficient pouring process study

Current process

24 hours

48 hours

54 hours

66 hours

One side pouring (e.g., 10 x 12 cm^2)

Dry

One more side pouring (e.g., 10 x 12 cm^2)

Dry

Protection coating by gelatin

Dry

Dry

New idea

3 hours

15 hours

Add the HA sensitization chemical in emulsion gel before pouring

One side poring on new stage

15 min (just wait setting)

One more side poring on new stage

~ 1 hours ??

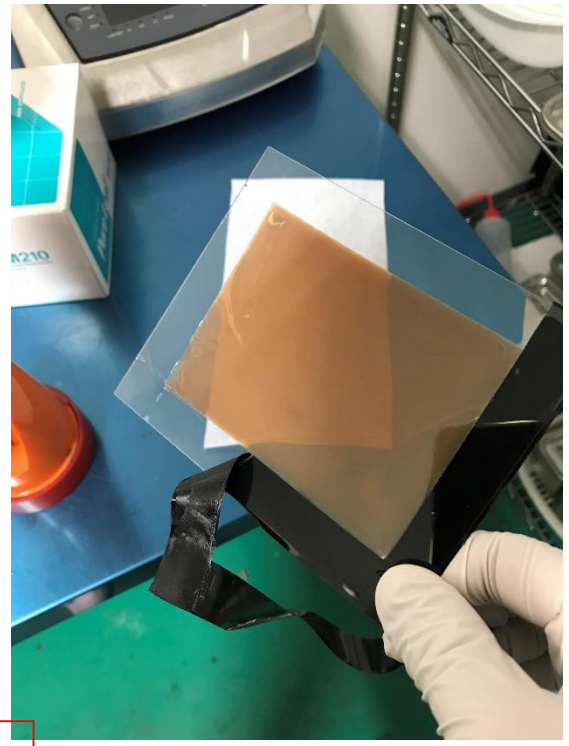
Protection coating by gelatin (not confirmed yet)

Dry

> 4 times improved for pouring speed !!

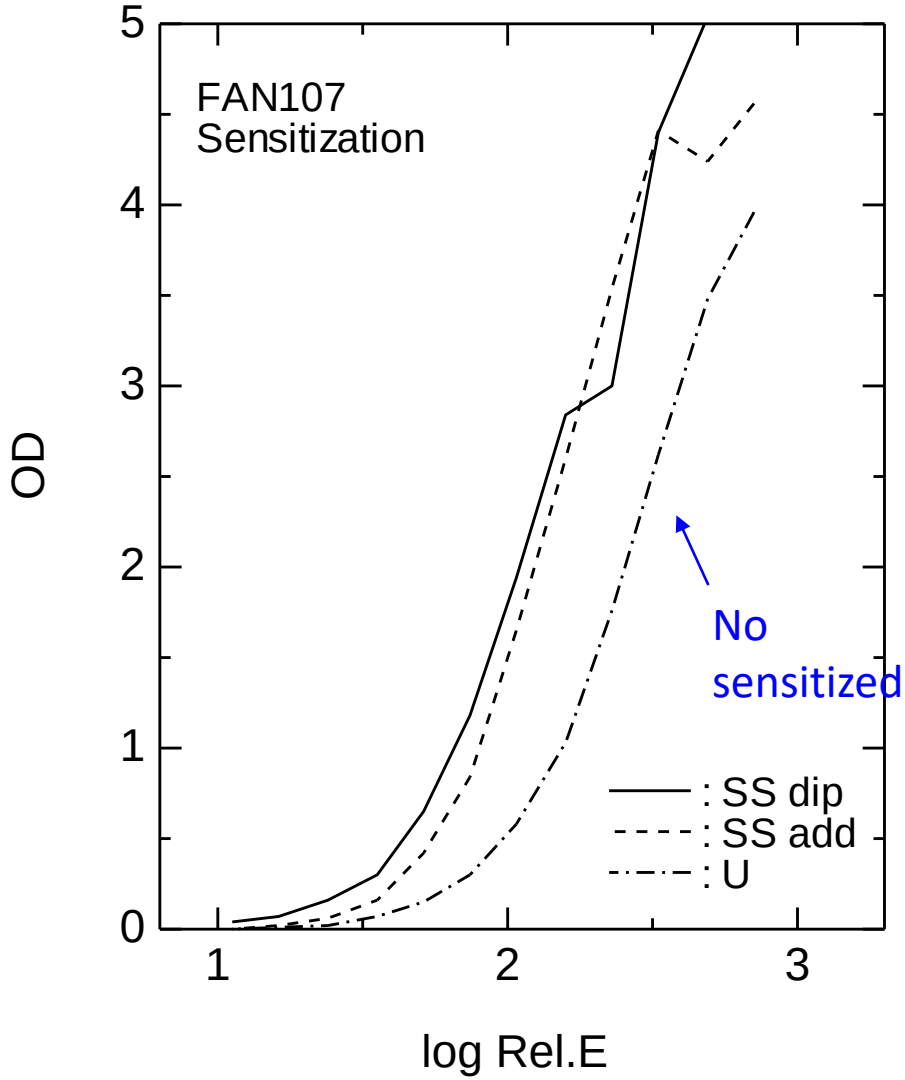
Pouring update

New pouring stage [produced by Todoroki]



Base type :
PMMA : 10 x 12 x 0.1 cm³
Glass : 10 x 12 x 0.1 cm³ (new)

Light sensitivity check between HA sensitization of current(dip) method and new (addition) method



Data analysis activity toward dark matter analysis

- Quality evaluation of emulsion device
- Preparation of test run and scanning toward > 1 g scale analysis
- Data analysis study

Detail will be discussed in Umemoto’s report

Quality evaluation of emulsion device

Update : larger-crystal size device [70 nm]

[Advantage]

- ✓ **higher brightness**
  ⇒ to obtain enough information of signal
  ⇒ improvement of accuracy for signal selection
  ⇒ signal and background discrimination using brightness information
  (current NIT of 40nm could not use that)

- ✓ **Improve ellipiticity – range correlation**
  ⇒ to estimate recoil energy spectrum
  ⇒ dark matter sensitivity estimation

- ✓ **Improve the readout efficiency**

[Disadvantage]

- ✓ **Higher energy threshold**

- ✓ **Deteriorate angular resolution in principle**

- ✓ **Gamma-ray sensitivity should be higher in principle**

NIT 40 nm device situation

Low-brightness situation make worse readout quality

⇒ currently we cannot utilize brightness information

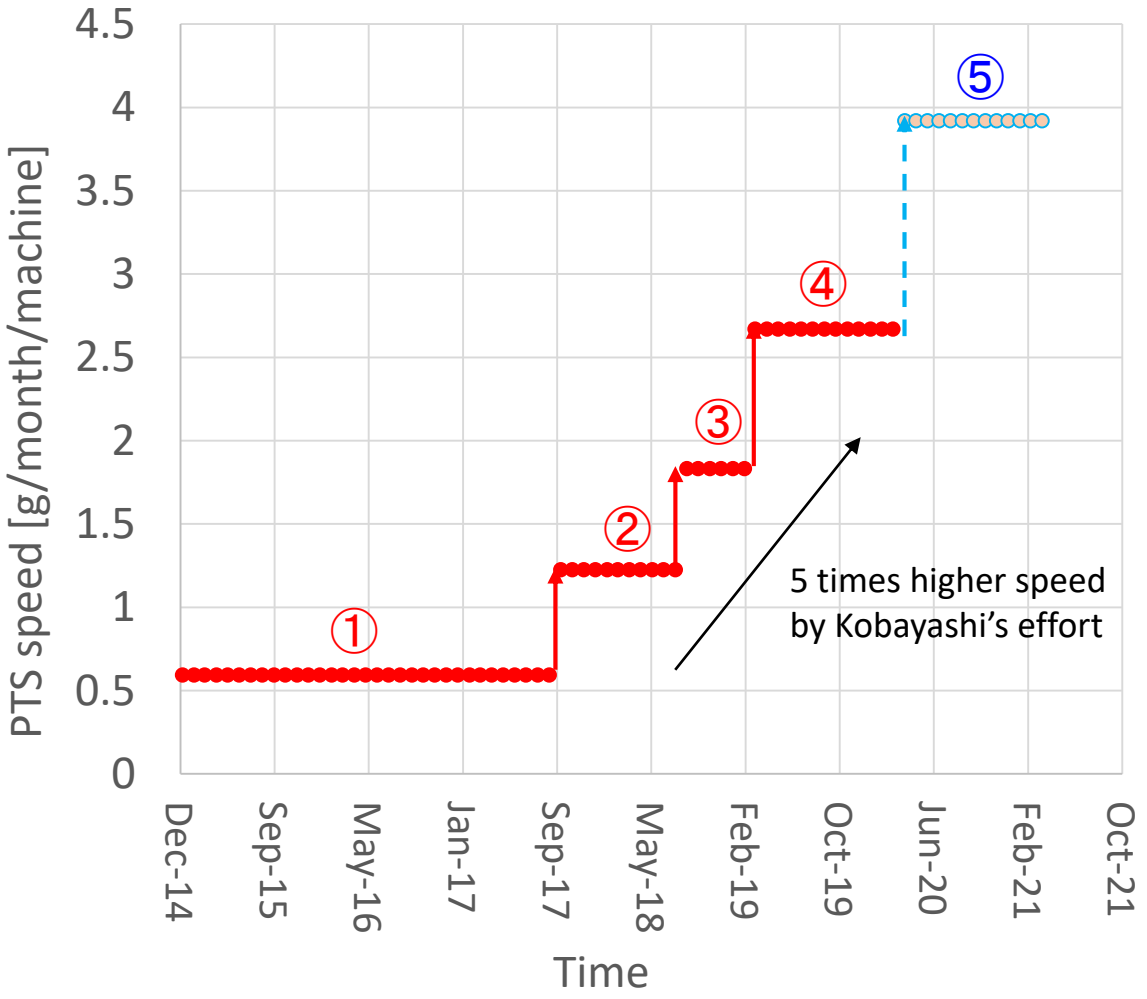
- Image processing improve
- Light source improve

Now on study

- Development treatment improve

Preparation of test run and scanning toward > 1 g scale analysis

➢ Scan speed of Nagoya's machine (PTS)



① : 1st PTS machine : no special techniques for high scanning speed

② : surface recognition improvement

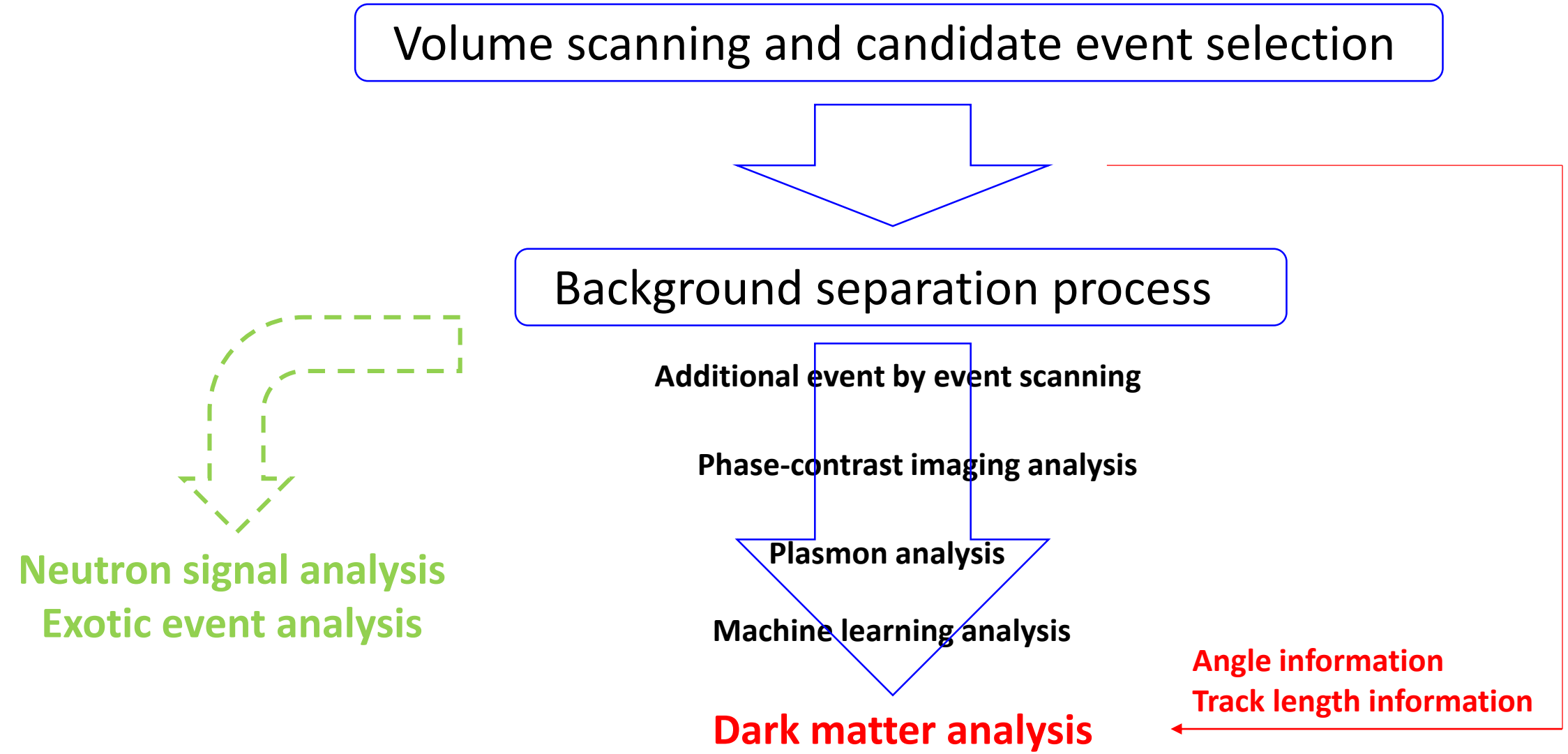
③ : image taking and processing speed improvement

④ : data taking without image data saving

Current achievement : 2.7 g/month/machine
5.4 g/month/2 PTS
> 10 g scanning will be done for > 2 month scan
* One more PTS machine construction at 2019
⇒ 8.1 g/month/3 PTS

⑤ : image processing and frame rate improvement (near future improvement)
11.7 g/month/3 PTS

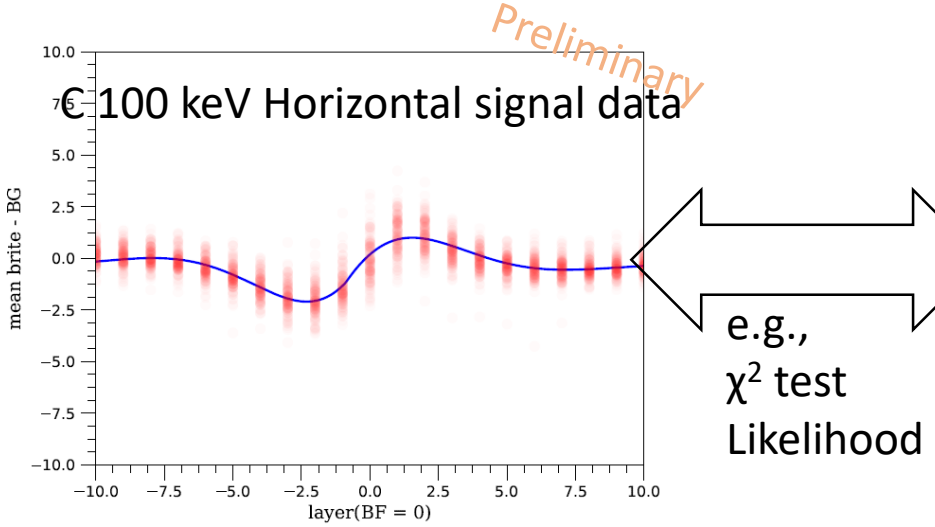
Dark Matter analysis flow



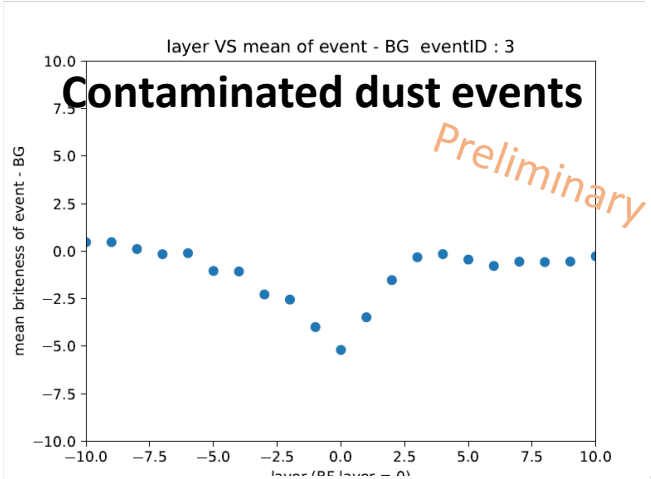
Study for background discrimination

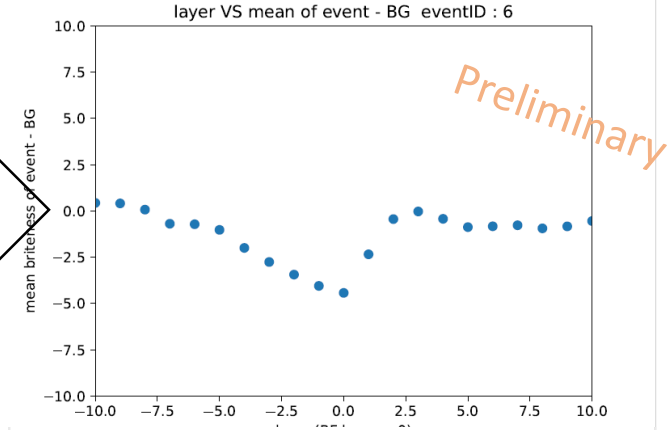
Phase contrast imaging [Kobayashi, Hamano]

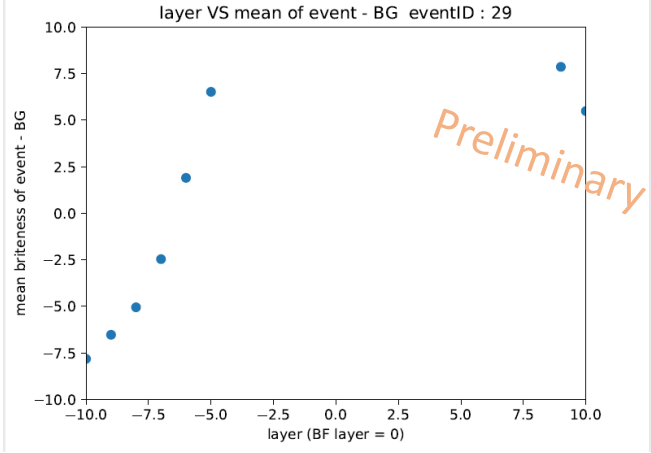
- New information which was not output in usual optical image
- Event by event analysis selected by elliptical selection
- Behavior of contrast with moving focus (Z direction) may be utilizes signal-background discrimination



e.g.,
χ^2 test
Likelihood







Current status

- Phase-contrast optics have been installed on PTS-3
- Started to make output parameter
- Calibration using signal and noise dominant samples

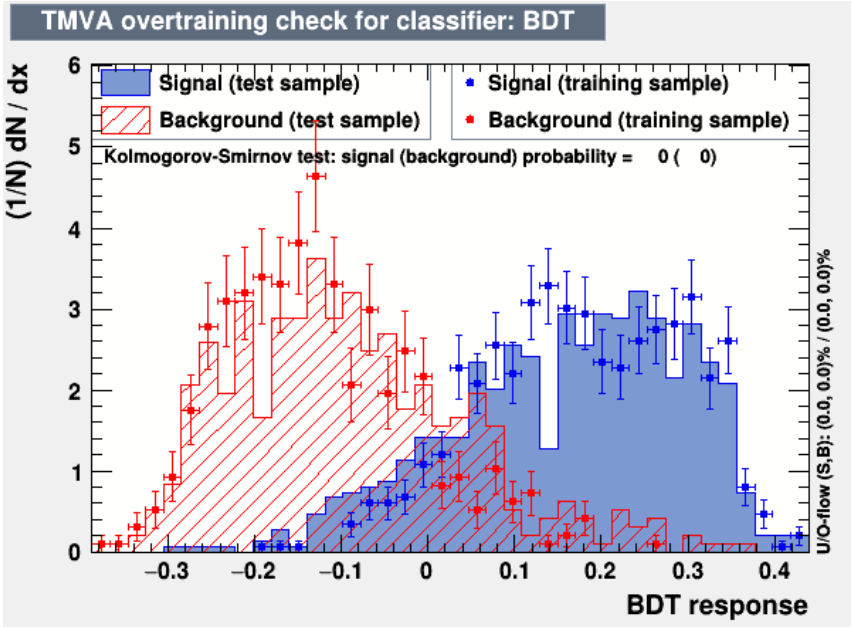
Study for background discrimination

BDT analysis using Plasmon information[Fukuzawa, Shiraishi]

- Feasibility study for BDT analysis of NIT emulsion
- Out parameter ⇒ plasmonic information (spectrum information)
- Training sample

⇒ singal = C ion

⇒ background = dust and developed grain leaked signal cut region



Current status

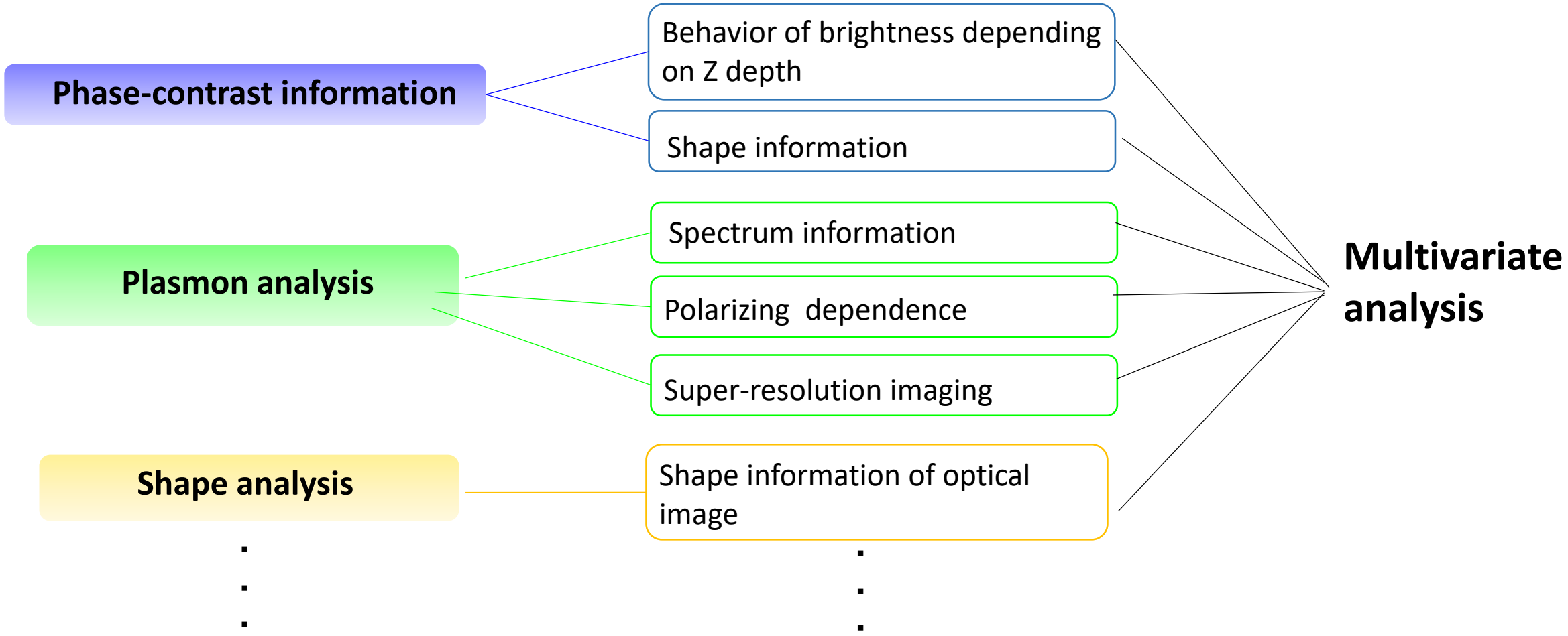
- We could see difference between signal and background for NIT of 40 nm crystal
- Now on study for possibility for C-ion and electron separation

Task as next step

- Check for 70 nm crystal case
- Demonstration using neutron exposure sample
- More efficiently data taking (e.g., color camera information)

Potential of machine learning

mutivariate analysis is very interesting for our study



Performance calibration of the NIT device

Ion-implantation

- Uniform direction and energy
- Vacuum condition and only surface event

Neutron

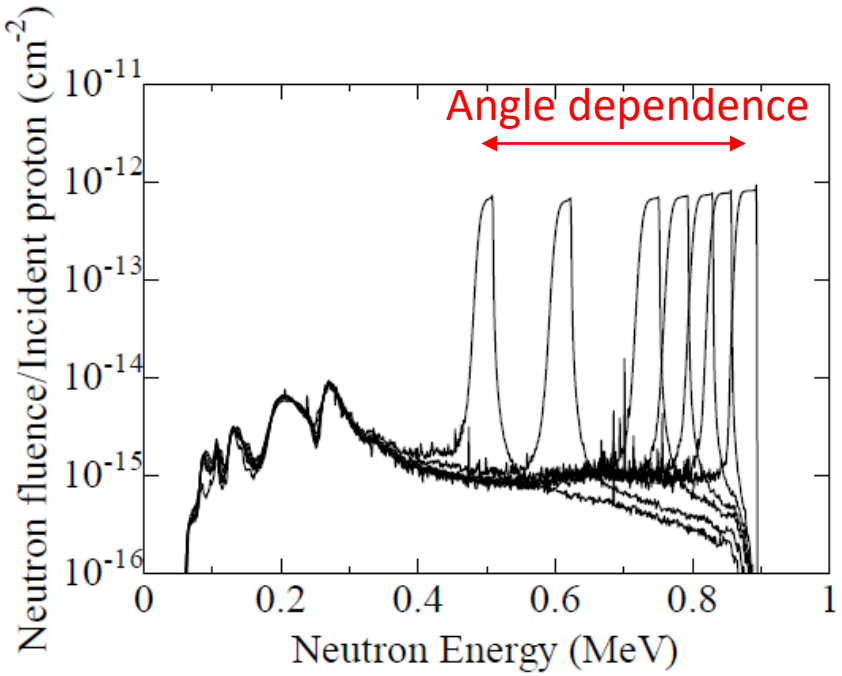
- Nuclear fission reaction

  500 – 800 keV neutron exposure (e.g., $^{7}Li(p,n)^{7}Be$, $T(p,n)^{3}He$
  ⇒CNO recoil energy : < ~ 250 keV

- Cf-252 source
  - around 1.5 MeV and broad spectrum
  - gamma emission simultaneously

Gamma-ray

- Am-241 source (and also higher energy source e.g., Cs-137, Co-60 etc.)
  - low-energy β sigal
  - demonstration for C-14 β
  - conversion of sensitivity from γ-ray to C14 β



Discussion point

- making the consensus about underground lab. schedule
- making the system for experiment from device production to development treatment
- making the flow for dark matter analysis include simulation study
- confirm the contribution sharing between collaborators