Direction-sensitive dark matter detection with gaseous tracking detectors (new proposal)

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(KOBE University)

Co-PI:Daniel Santos (LPSC/IN2P3)

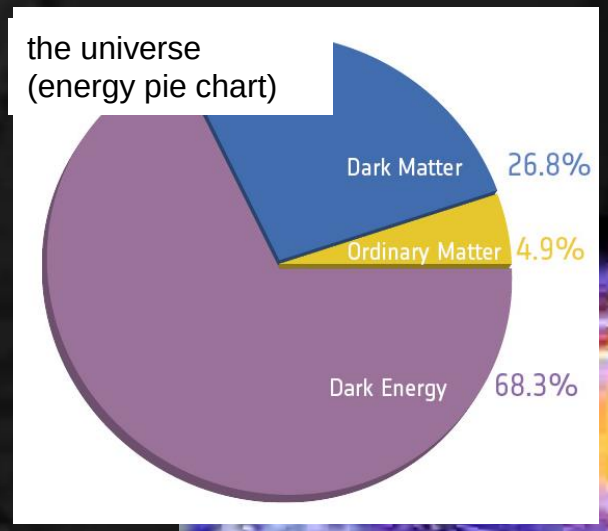
@ 2019 Joint workshop of FKPPL and TYL/FJPPL

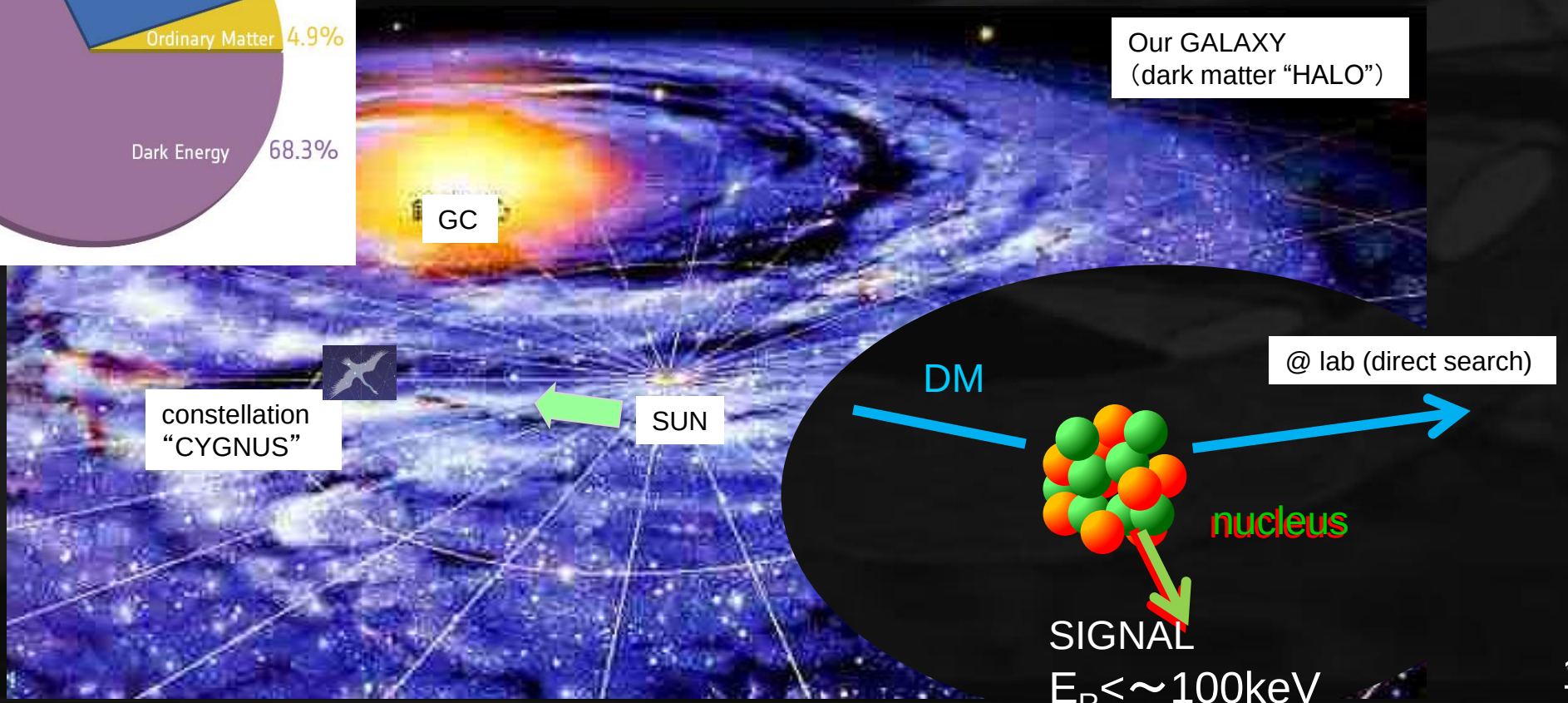
Physics case : dark matter

～1/4 of the universe

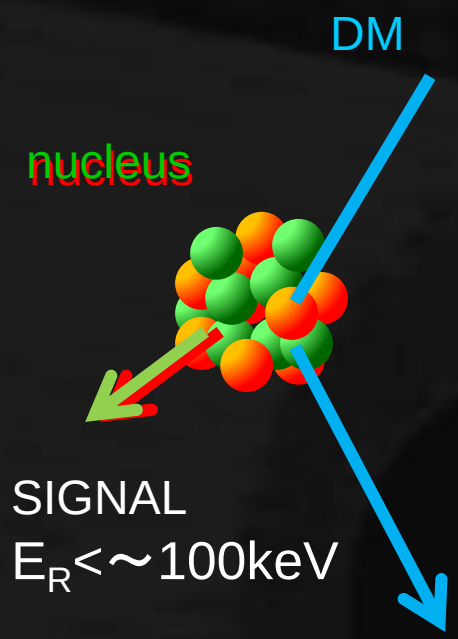
(can be) unknown particle beyond standard

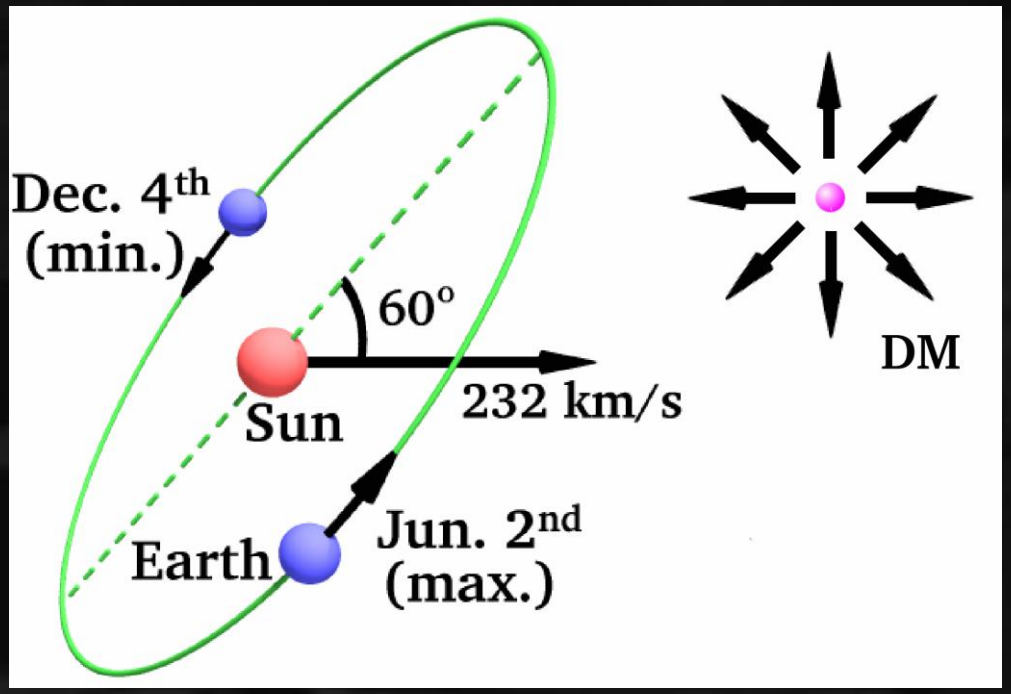
direct search: DM-nucleus interaction

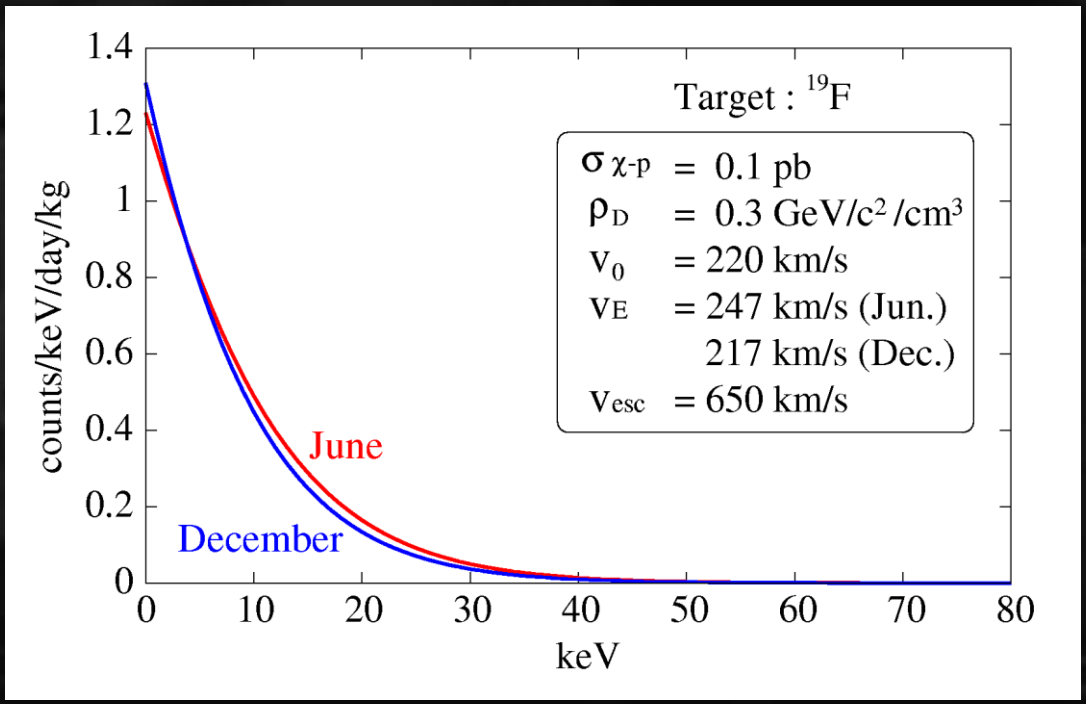




DM direct search



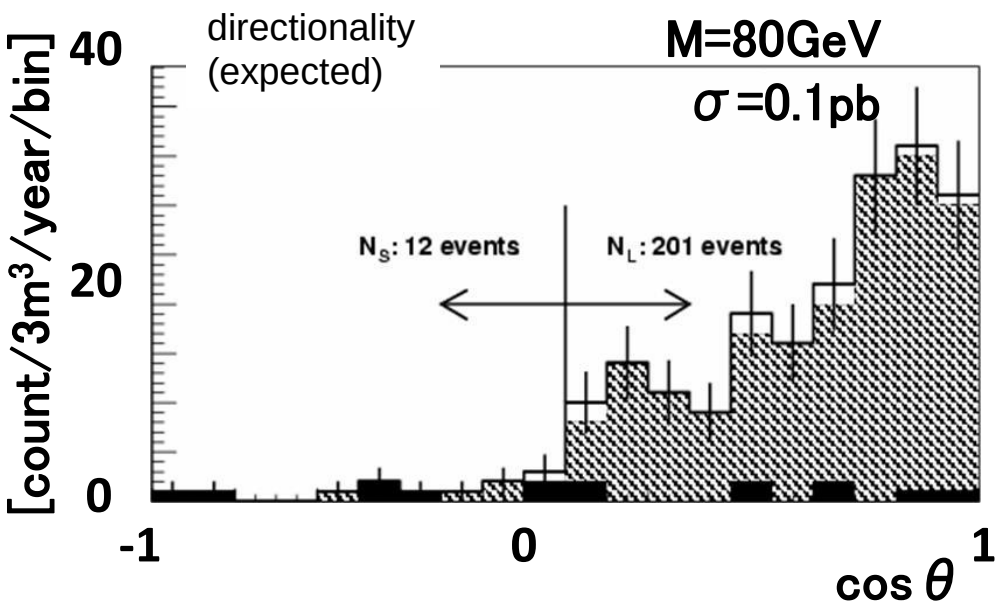




expected direct DM signals

- ① observed * events
- ② energy spectrum
- ③ seasonal modulation
- ④ material dependence
- ⑤ direction-sensitive

“direction-sensitive” dark matter direct search
detect the direction of the recoil nuclei



forward recoil would be a “smoking-gun” evidence

proposal overview

Title：Direction-sensitive dark matter detection with gaseous tracking detectors

Plan: 2019-2020 detector calibration @ Grenoble
2020- Dark matter search @ Kamioka

Member：Japan　Kentaro Miuchi（Kobe）（PI）

Kiseki Nakamura, Tomonori Ikeda, Hirohisa Ishiura, Takuma Nakamura, Takuya Shimada（Kobe）

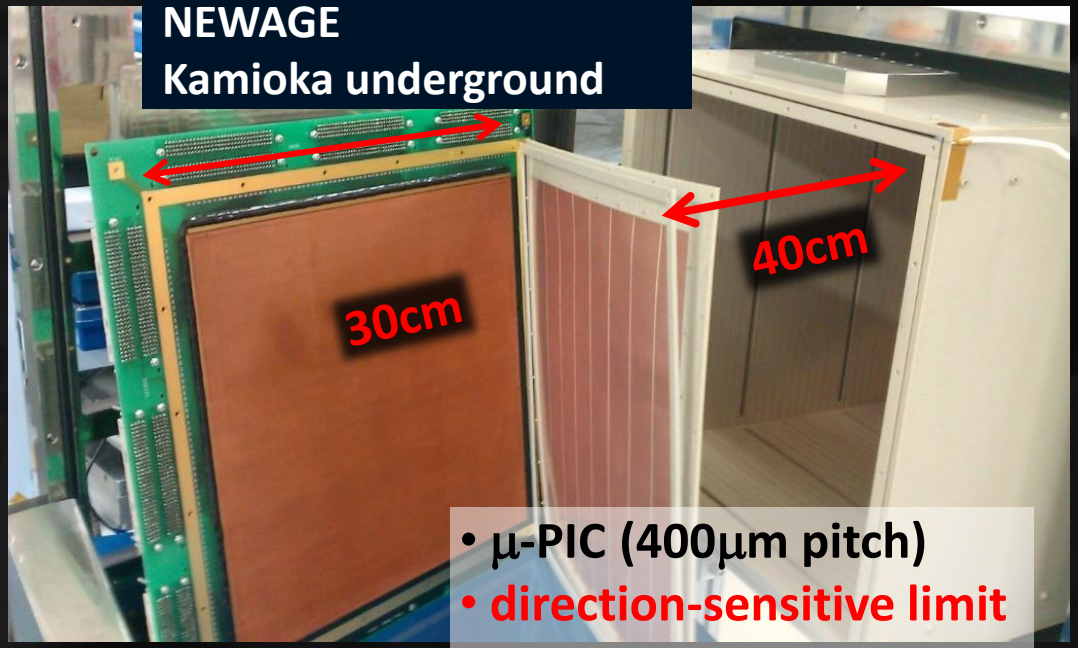
France　Daniel Santos (LPSC/IN2P3) (PI)

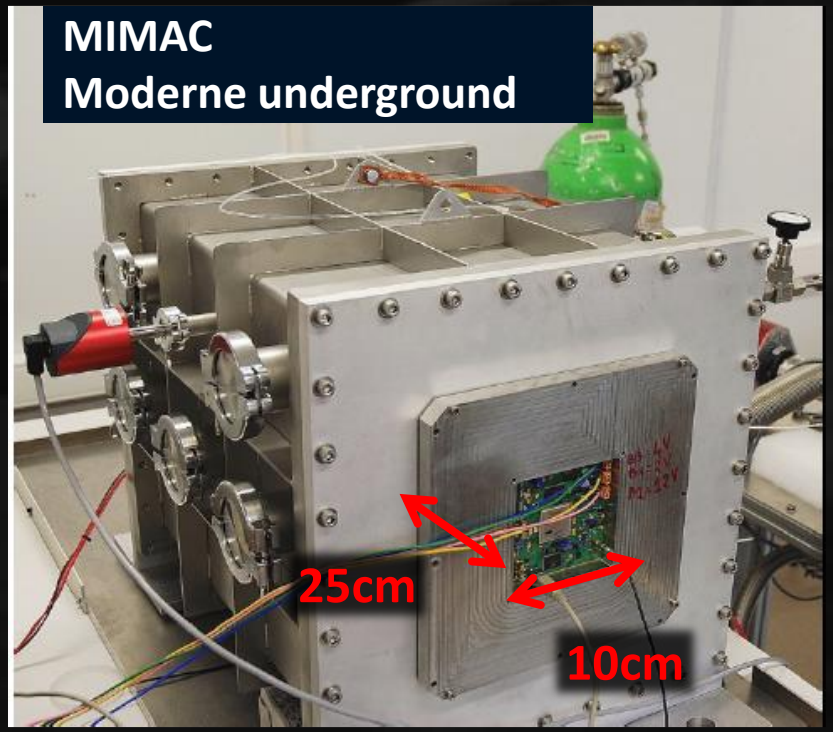
Charling Tao (CPPM/IN2P3), Fabrice Naraghi, Olivier Guillaudin, Jean-François Muraz (LPSC/IN2P3)

Funding request (2019-2020)：　Japan 1700k ¥
France 5k €

Background

- Miuchi and Santos are leading two major direction-sensitive experiments:
  NEWAGE and MIMAC
  - Both use MPGD (micro-patterned gaseous detectors)
  - No co-working before





PTEP (2015) 043F01s

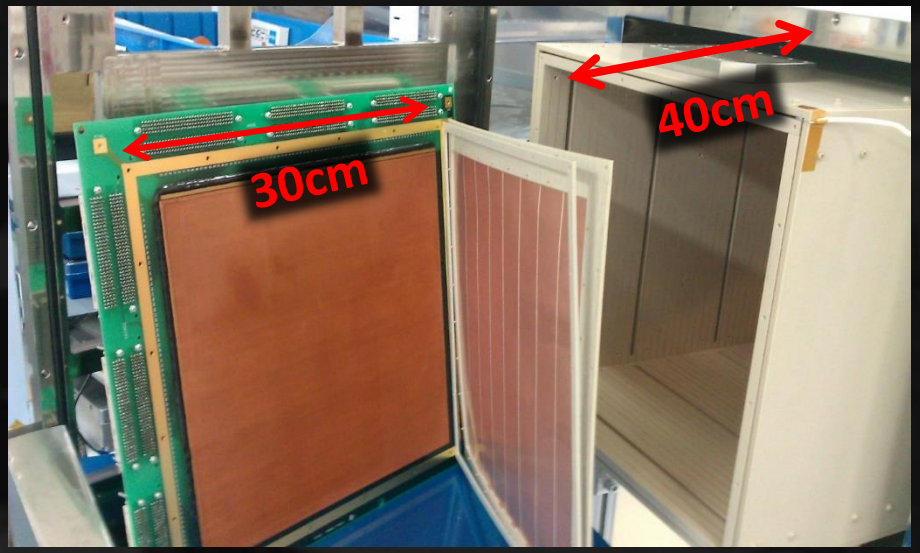
CYGNUS 2017- International Workshop
Xichang, Sichuan (CHINA) – June 13th- 15th 2017

We are in the same “CYGNUS” community.
This TYL/FJPPL would be a good kick-off for a important collaborative work.

NEWAGE: 3D-tracking

New general WIMP search with an Advanced Gaseous tracker Experiment

- μ-PIC(MPGD) based TPC
  - 3-D tracks SKYMAP
- CF_4 gas for SD search

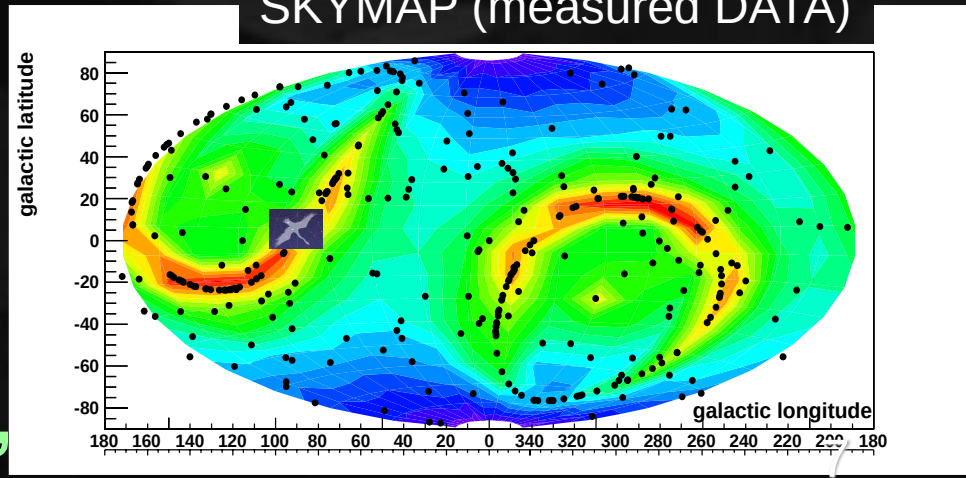


- Proposal PLB 578 (2004) 241
- First direction-sensitive limits

  PLB654 (2007) 58
- Underground results

  PLB686 (2010) 11, PTEP (2015) 043F01s
- Phase for “low BG detector”

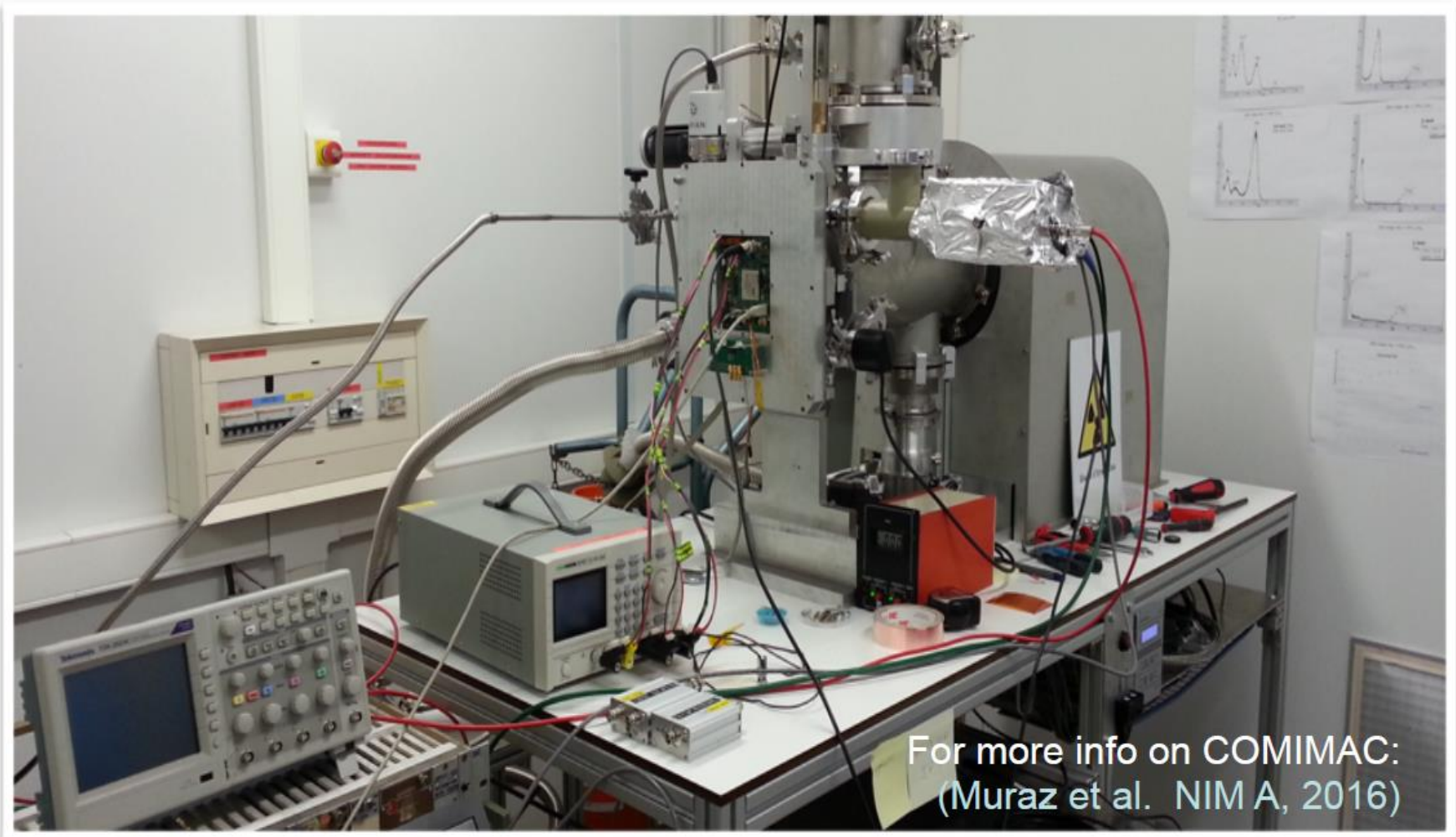
SKYMAP (measured DATA)



Expertise of MIMAC: COMIMAC

J.F. Muraz, J. Médard, D. Santos et al., NIMA 832 (2016), 214

First controlled Fluorine tracks, using COMIMAC



LTPC – Conference, Paris- December 13th 2018

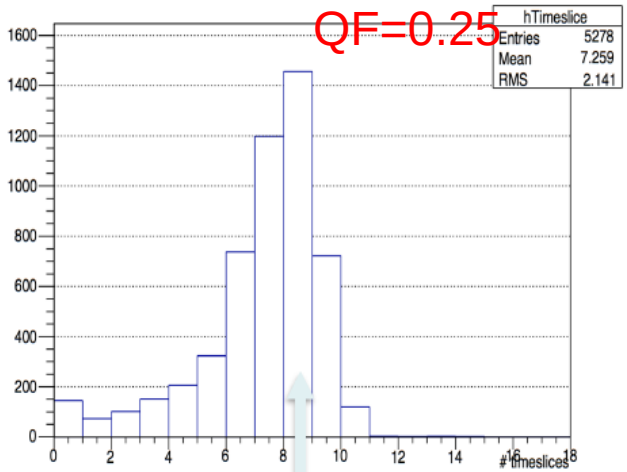
D. Santos (LPSC Grenoble)

- **COMIMAC measures Quenching Factor (nuclear tracks ionize less effectively than electron tracks)**
  ⇒important as a "calibration" for a DM detector

COMIMAC: first controlled tracks of ^{19}F

8 keV kinetic → 2 keVee

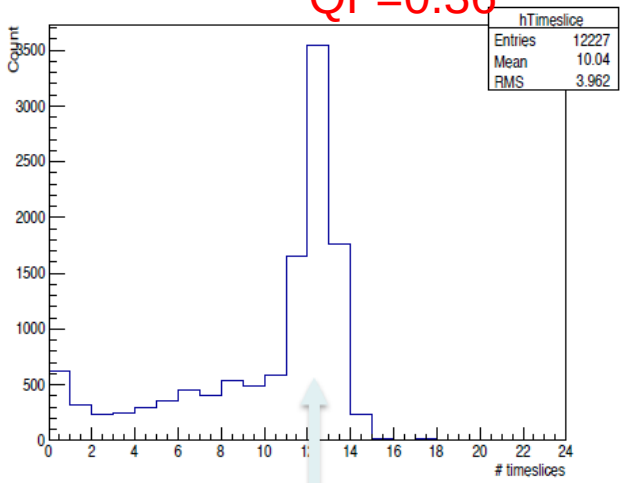
QF=0.25



8 timeslices
* 20 ns/timeslices
* 23.5 µm/ns
= 3.8 mm

25 keV kinetic → 9 keVee

QF=0.36



12 timeslices
* 20 ns/timeslice
* 23.5 µm/ns
= 5.8 mm

C. Couturier, I. Moric, Y. Tao et al. (in preparation)

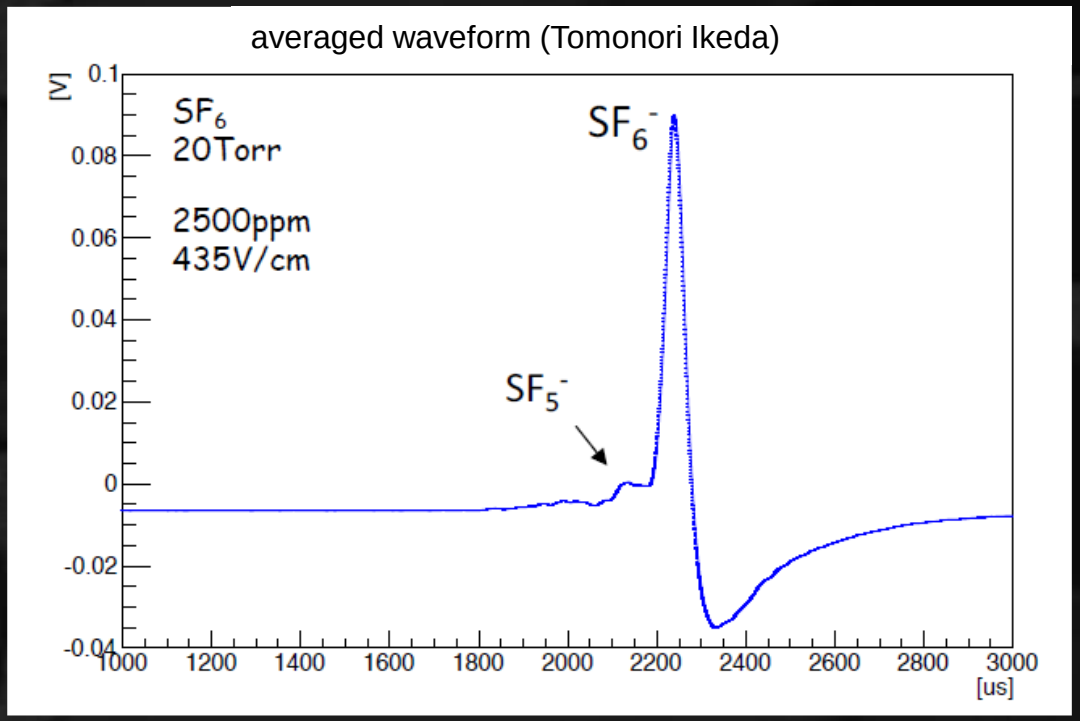
Expertise of NEWAGE: Negative-Ion TPC

- **original study by New Mexico group** 2017 JINST 12 P02012
- **readout electronics development by NEWAGE**

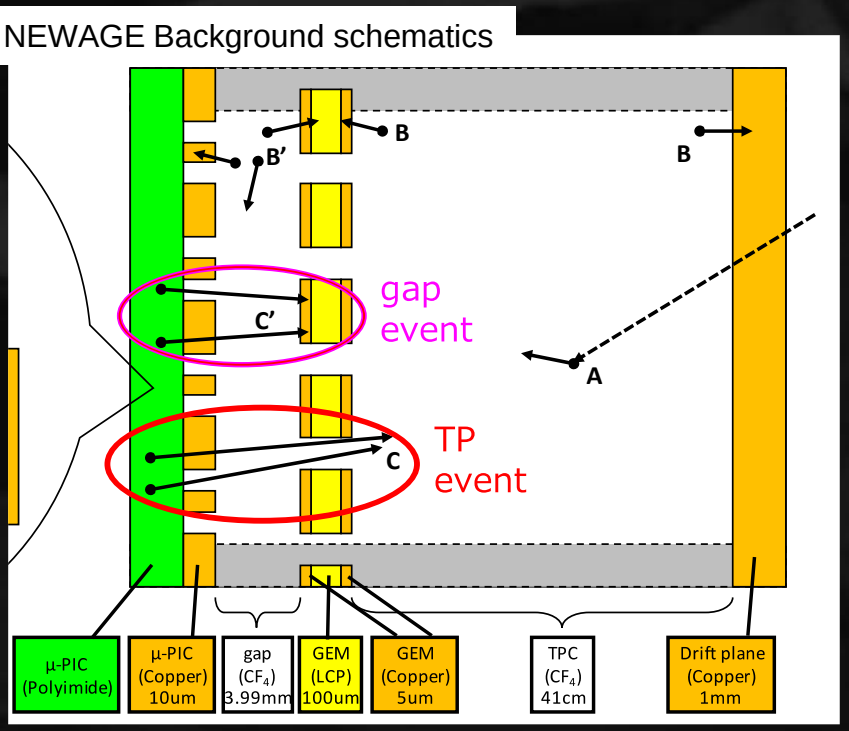
several species of ions with different velocities

$$z = (t_a - t_b)\frac{v_a v_b}{(v_b - v_a)}$$

averaged waveform (Tomonori Ikeda)



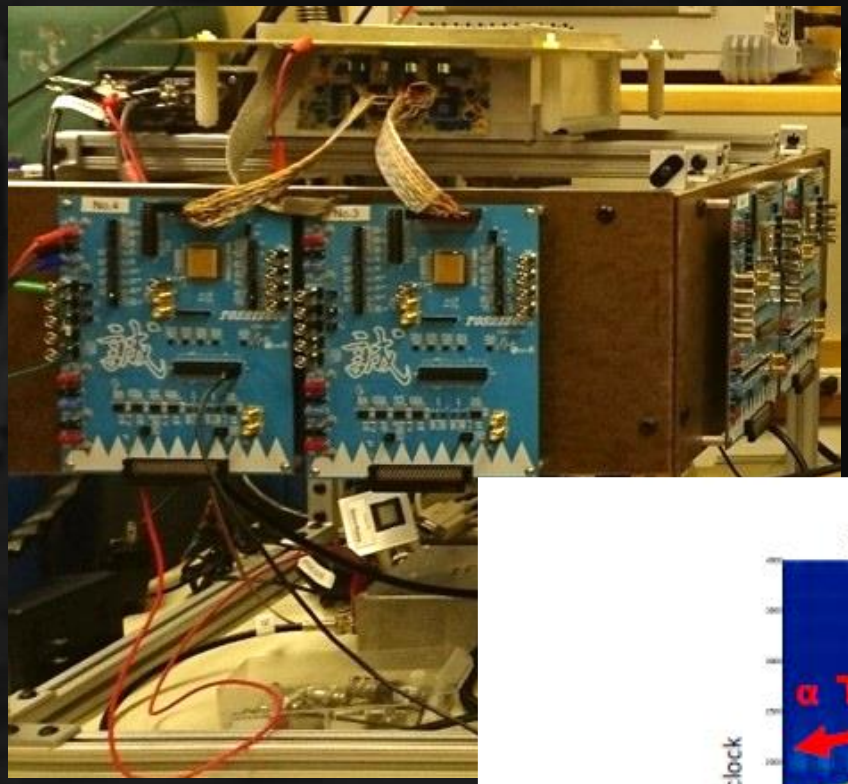
NEWAGE Background schematics



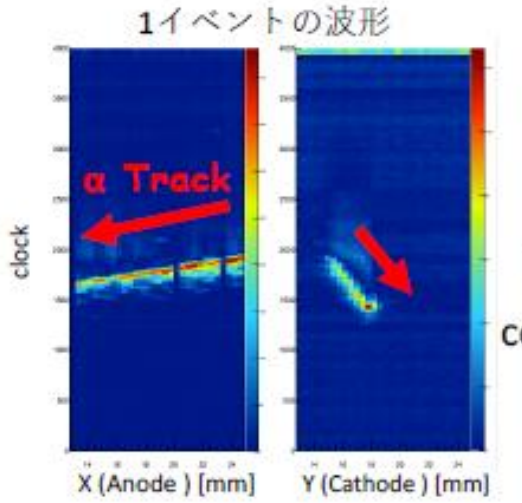
z-fidutialzation → Background killer!

NEWAGE electronics for SF_6

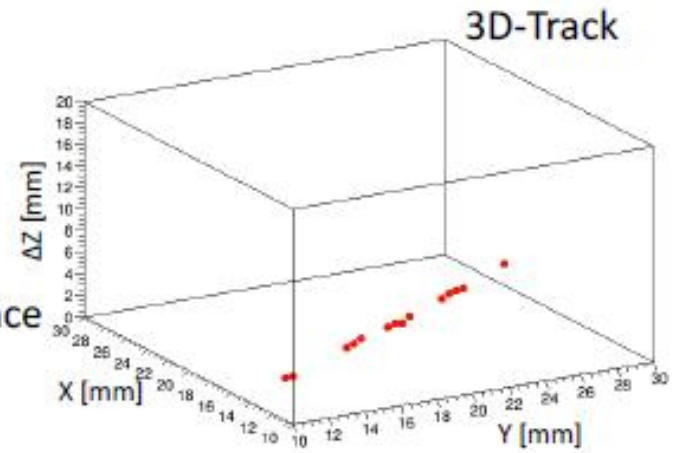
2019 J. Inst. 14 T01008

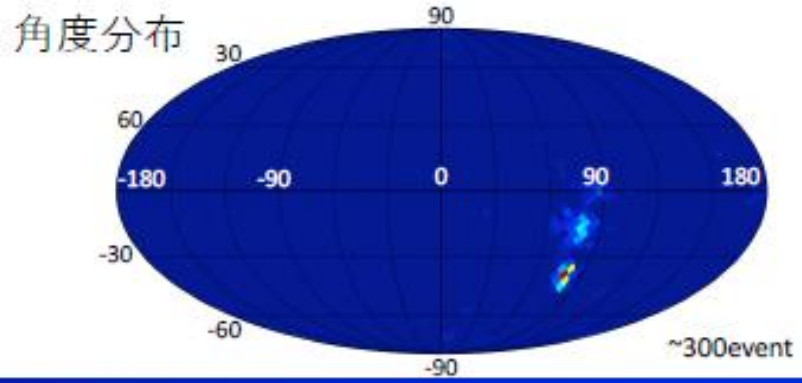


Kobe-KEK(Liq Ar group) ASIC development
first-ever detected 3D tracks in SF_6 gas

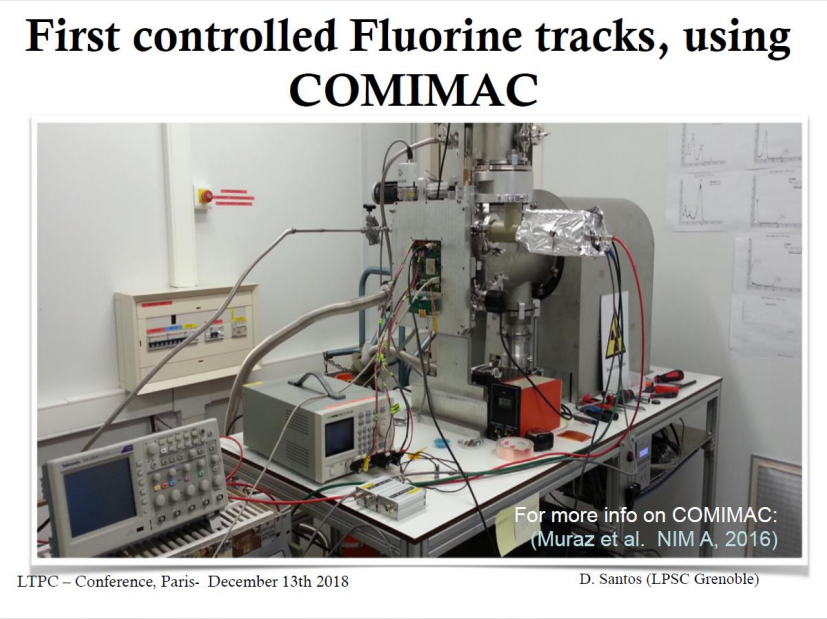


coincidence





This proposal ① (2019-2020):



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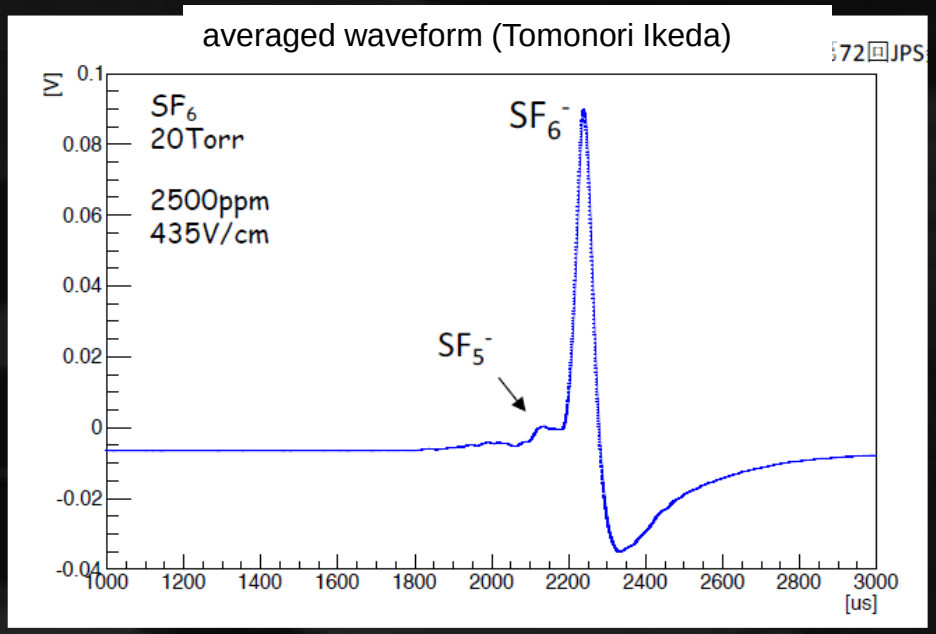
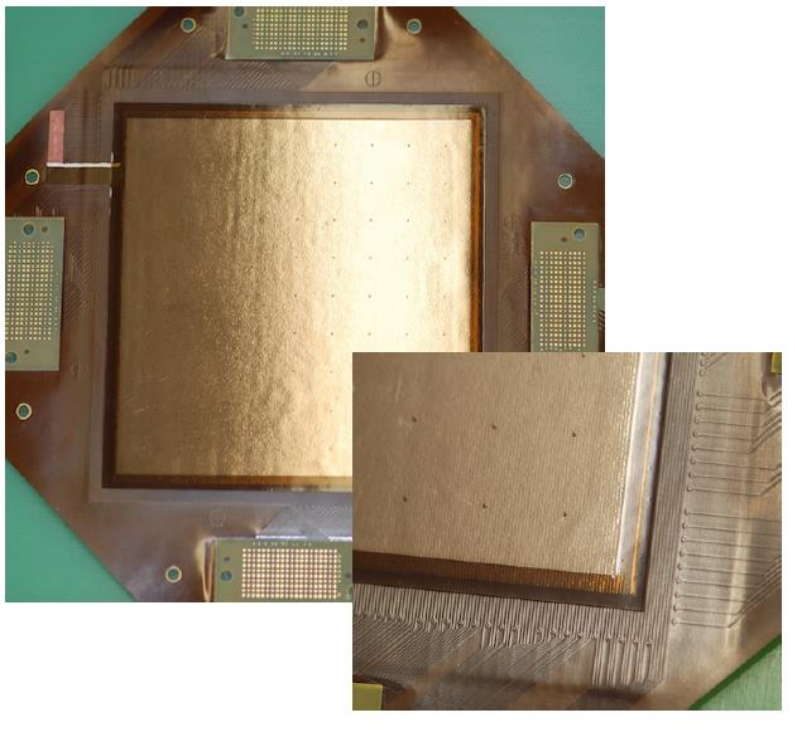


- SF_6 quenching factor measurement

This proposal ② (2020-) :

MIMAC low background MIcromegas



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CYGNUS/NEWAGE multi-window chamber

- **Dark Matter Search @ Kamioka**

Summary

- New Proposal:
  Direction-sensitive dark matter detection with gaseous tracking detectors

- By Miuchi (NEWAGE leader) and Santos (MIMAC leader)

- QF measurement (2019-2020)
- Dark Matter Search (2020-)