Introduction to DMunit:

International Research Unit
for
Innovative Dark Matter Research

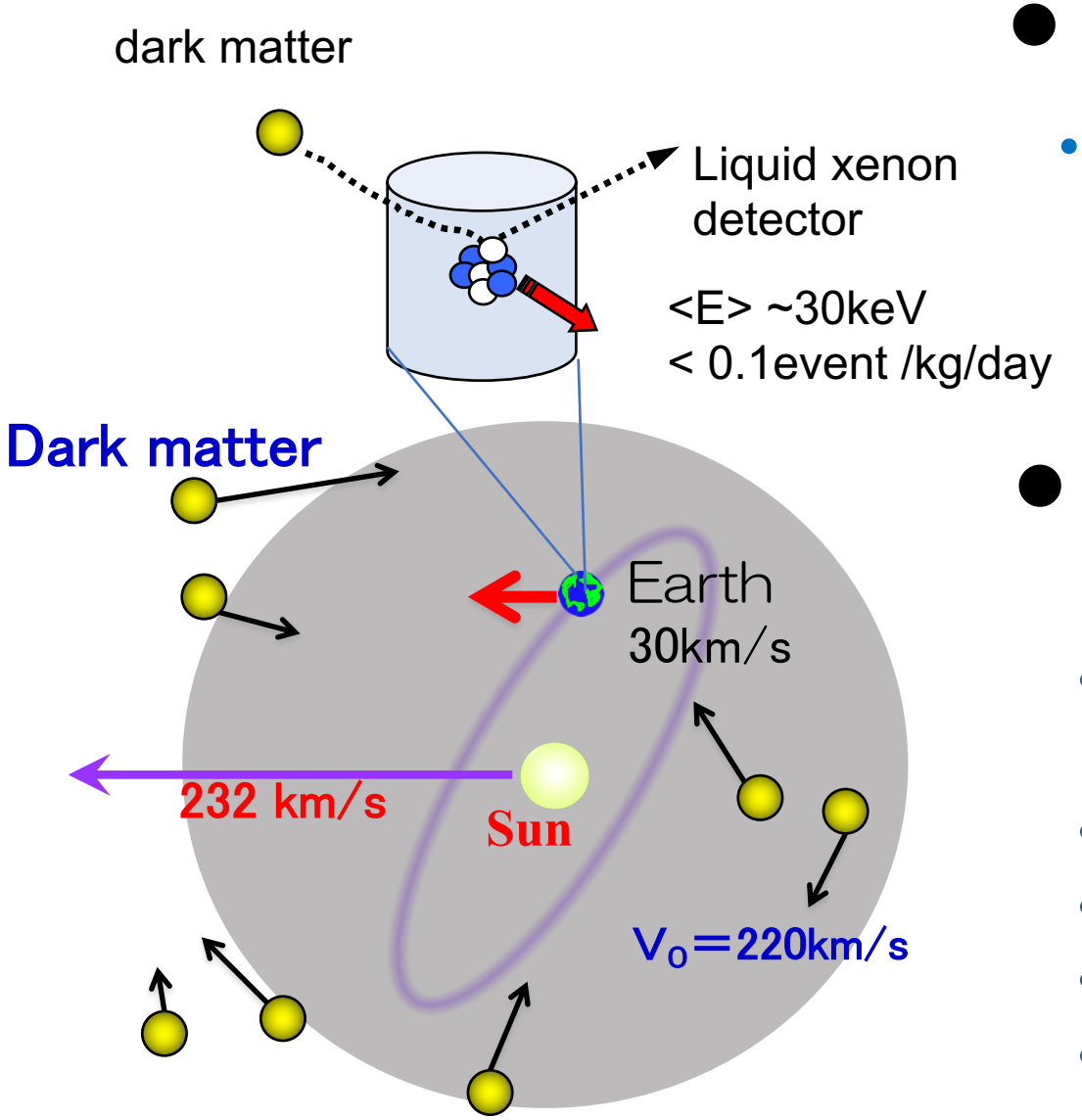
29 March 2023

Joint Nagoya B-1 symposium

ISEE/KMI Nagoya University

Yoshitaka Itow for “DMunit”

Direct detection of particle dark matter

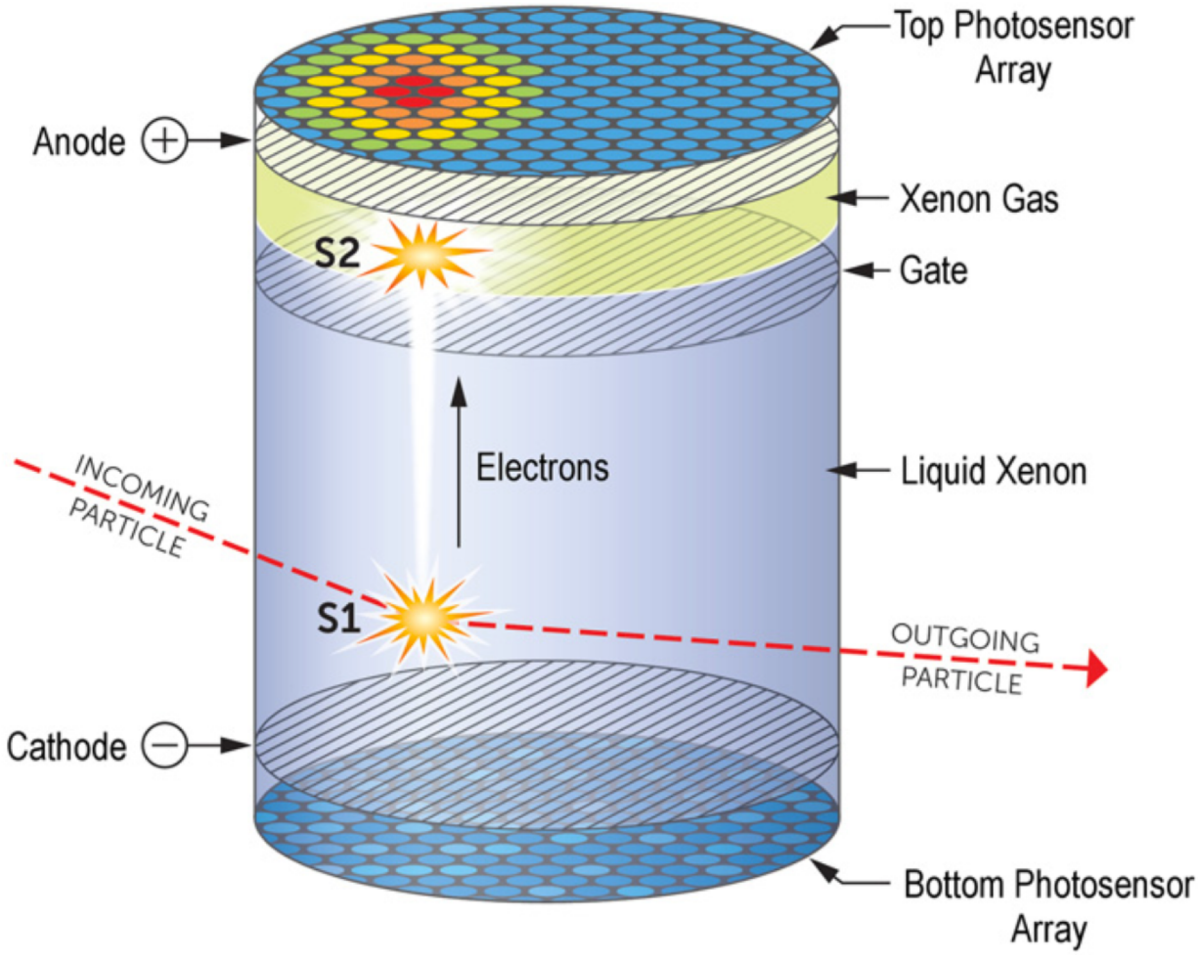


- Dark matter must be a new physics
  - *Break-through both in particle physics and astronomy*

- Direct detection of dark matter by collisions with a Xe-atom
  - *Gxe/LXe 2-phase Time Projection Chamber*
  - *On-going : XENONnT 8.5t LXe*
  - *Future : DARWIN ~50t LXe*
  - *Challenge for ultimate low RI detector*
  - *A new idea / a new material*

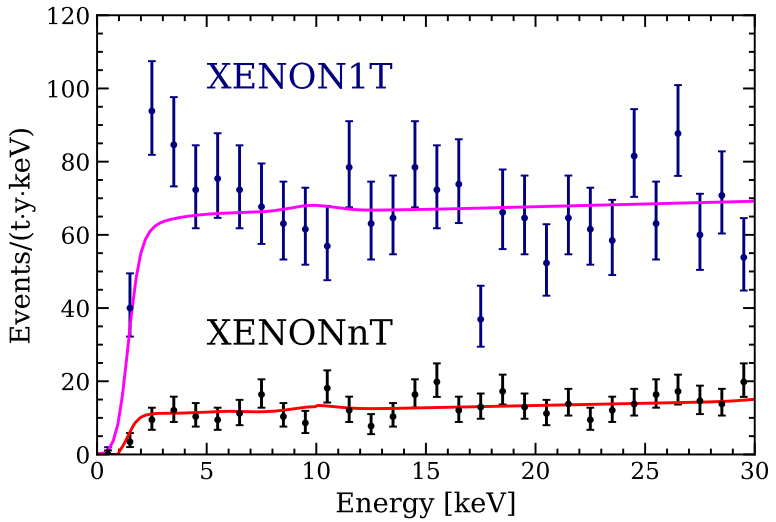
XENONnT: Direct DM detection by LXe 2-phase TPC

- DM-Xe scattering→ S1 and S2 lights in LXe and GXe, respectively



- XENONnT 8.5t LXe TPC (2021-)

  First LowER result (2022 Jun)



→ First WIMP result (2023 Mar)
→ Kazama-san's talk tomorrow

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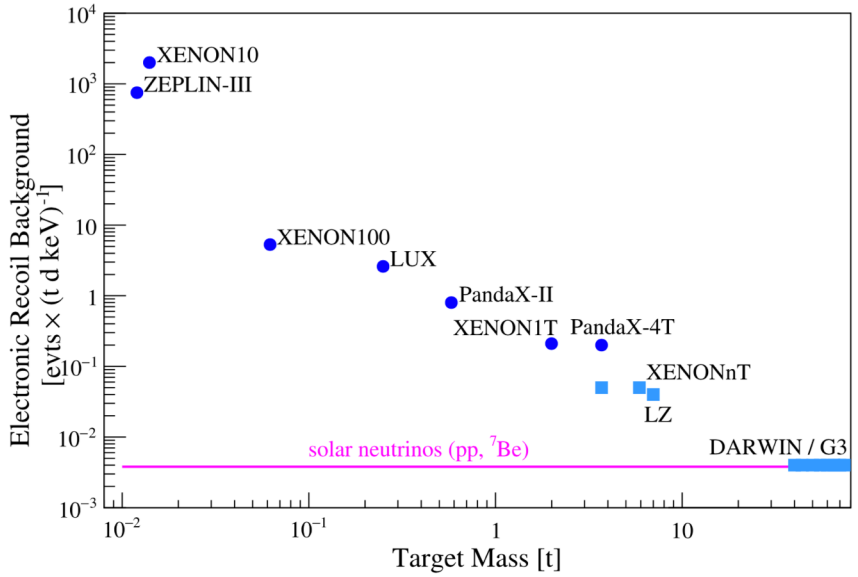
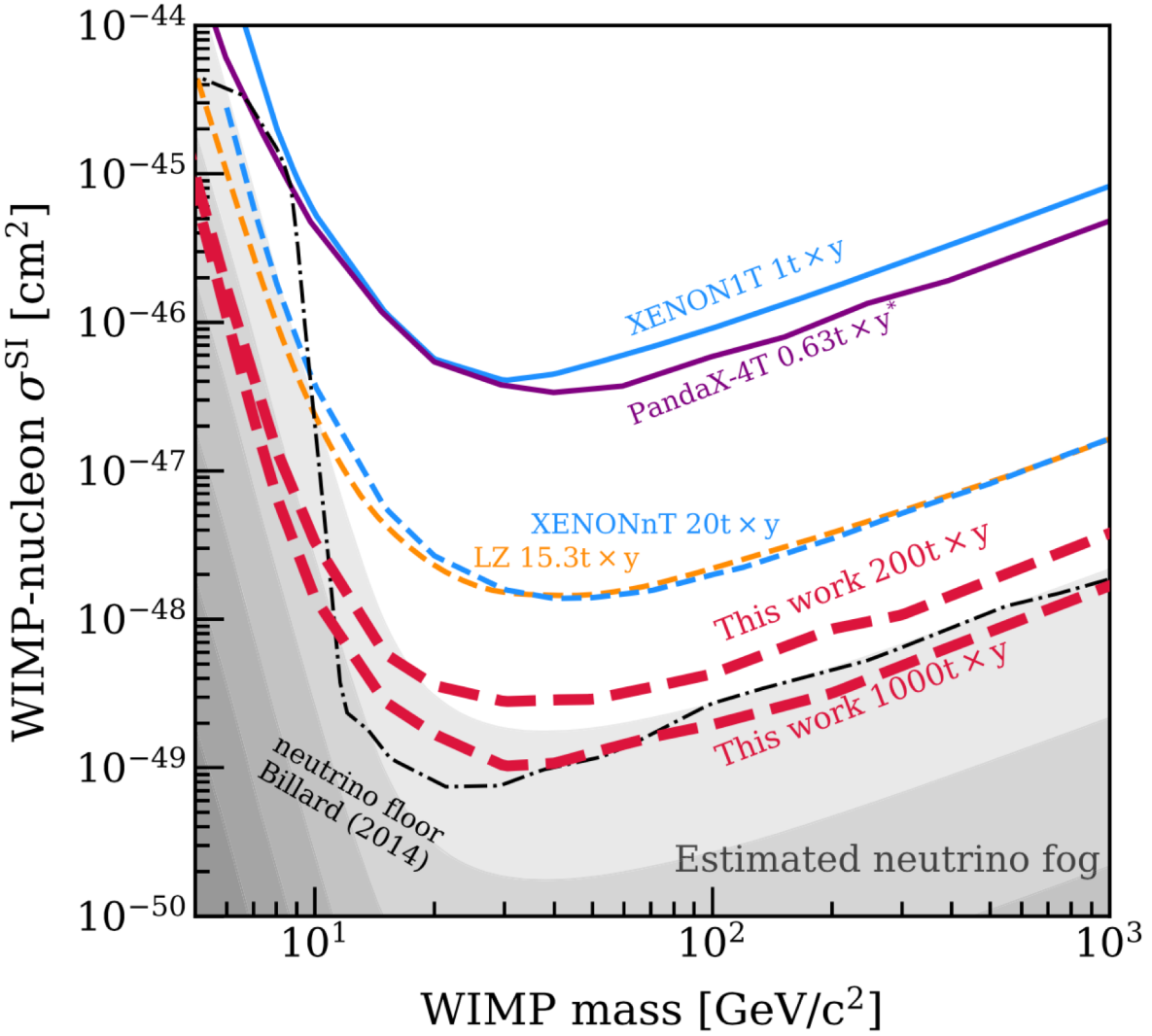
XENONnT (8.5t)~ DARWIN/XLZD (>50t)

- **Rapid progress of direct detection using LXe**
- **XENON/DARWIN and LZ recently forms consortium**



	XENON1T	XENONnT	DARWIN
Start	2016	2020	~2030
Total Xe	3.2 t	8.5 t	~50 t
TPC size	~1.0 m	~1.3 m	2.6 m
Rn in LXe	13 μBq/kg	1.0 μBq/kg	0.1 μBq/kg
σ SI	10^{-46} cm^2	10^{-48} cm^2	10^{-49} cm^2

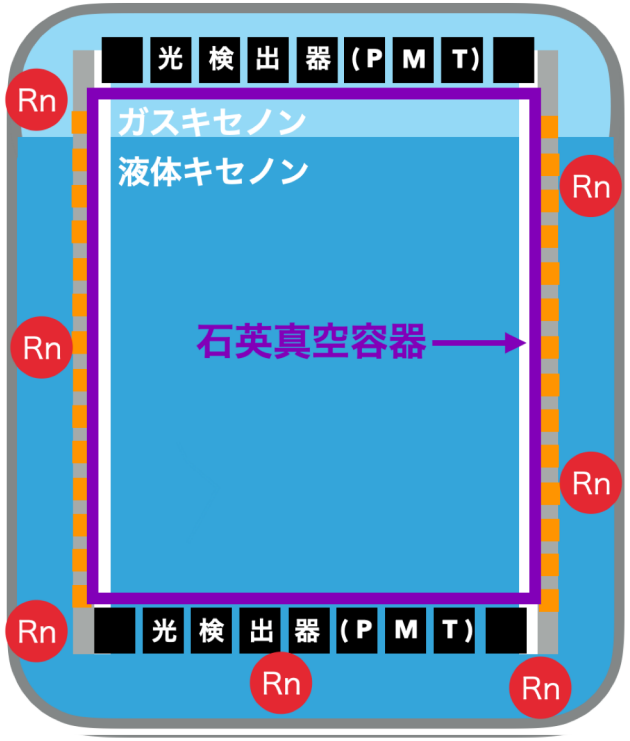


Toward future 50t LXe TPC (DARWIN/XLZD)

- To reach sensitivity of 10^{-49}cm^2
- Need improve x 10 (1.0μ→0.1μBq/kg)

→ Kobayashi-san's and Marc's talks today

- Reduce internal Rn BG emanated from the detector material
  - Hermetic TPC → **Nagoya-Freiburg Collaboration**
  - low BG photo-sensor
  - LXe purification



Hermetic TPC design

Itow

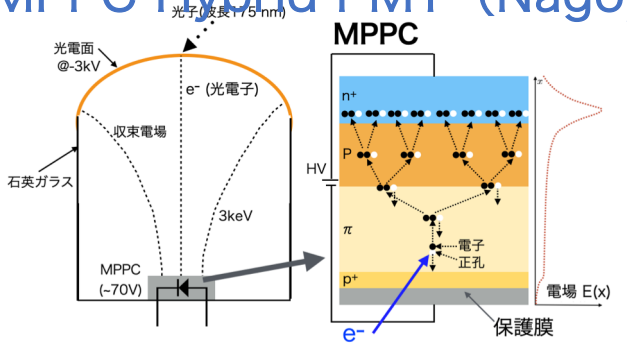
Kazama

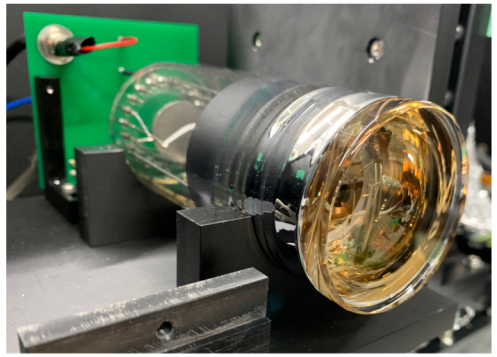
M.Schumann

Nagoya TPC

Freiburg TPC

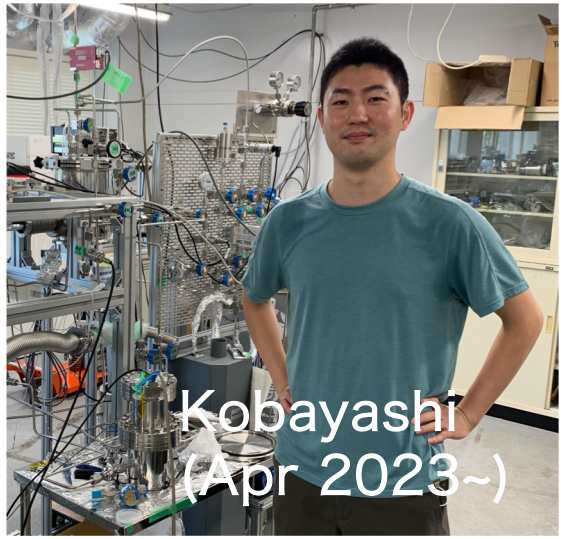
MPPC Hybrid PMT (Nagoya)

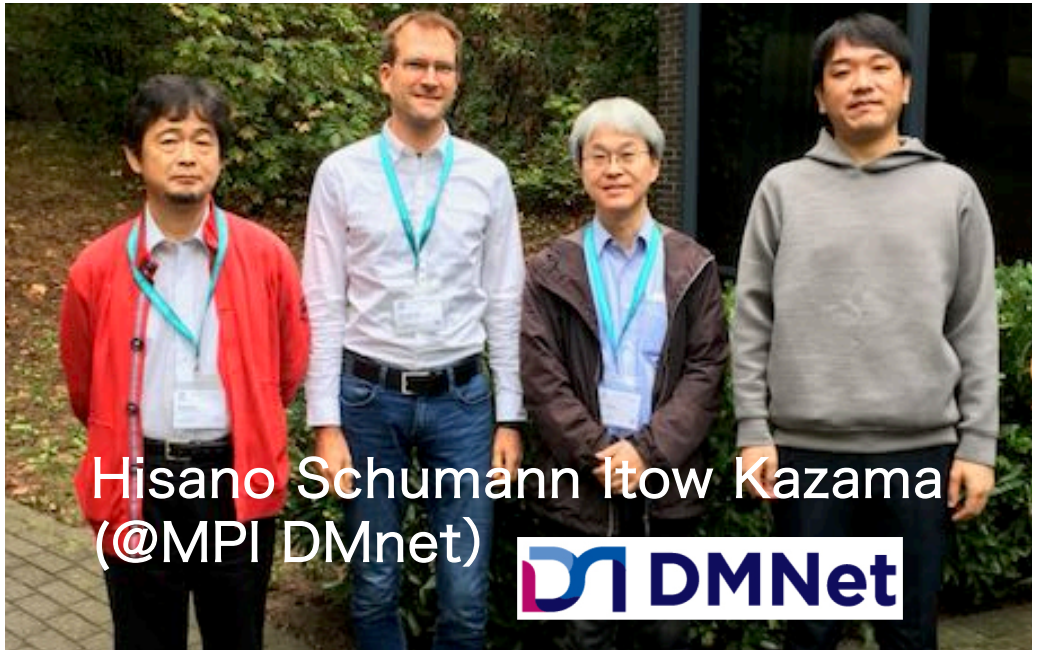




Collaborate with Hamamatsu

Sep 2022, DMunit kicked off





DARWIN-size TPC prototype
@Freiburg

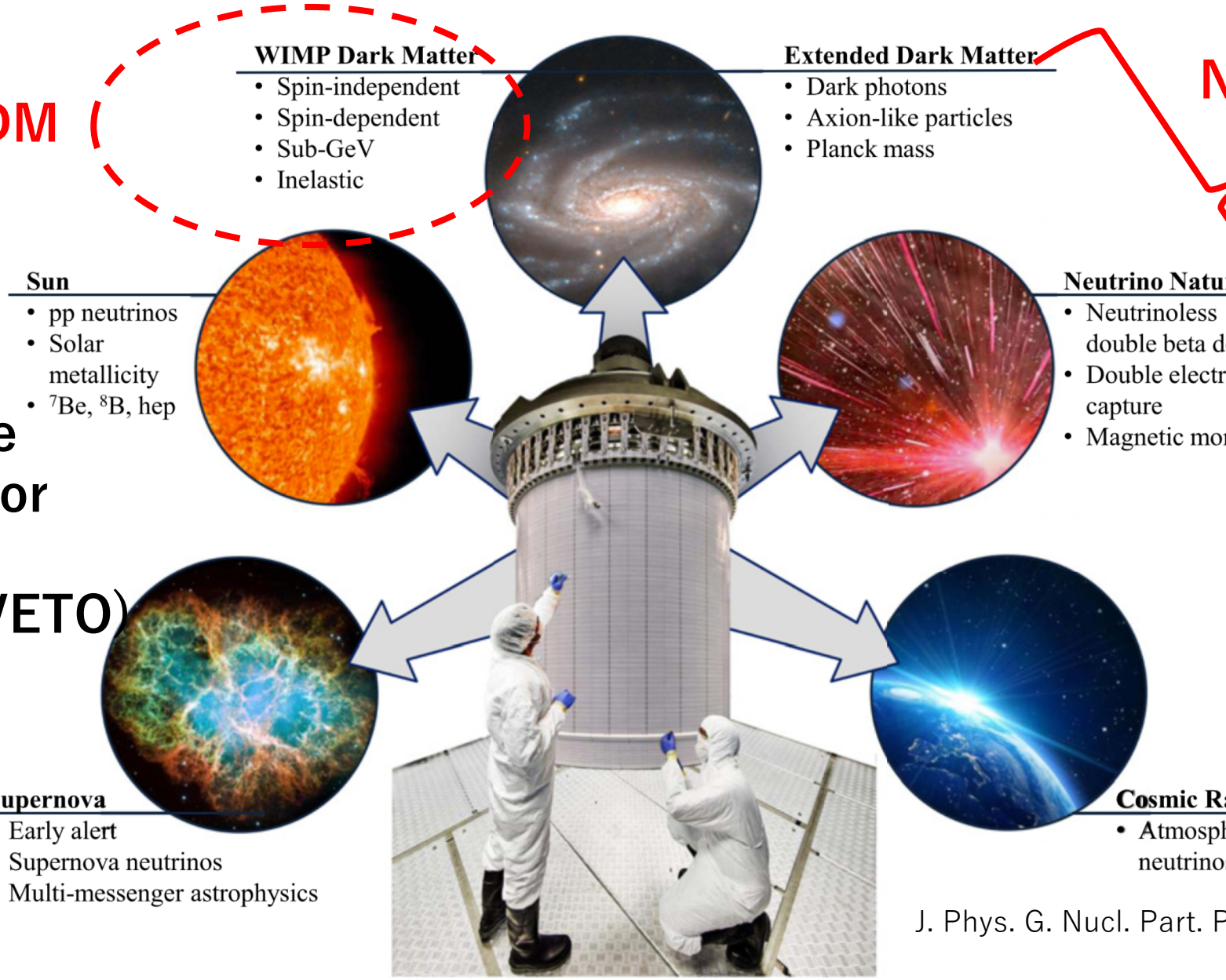
- A new “B-1 research unit” supported by Nagoya U.(Sep2022-Mar2025)
- Dark matter searches and related physics using XENONnT
- Tight collaboration between theory and the experiment.
- Joint R&D for future DARWN/XLZD focusing on Hermetic TPC design
- International research hub in cooperation with DMNet
- Interdisciplinary activity between DM search and other researches

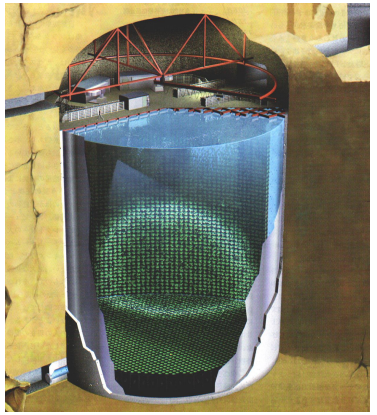
Synergy with other different fields (i.e. neutrino physics)

WIMP DM

Non-WIMP DM

Neutrinos





And technique

- **Photo-sensor**
- **Low RI**
- **(water C nVETO)**

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Summary

- Dark matter will be a door-way to next break through
  - Maybe a first indication of dark matter detection in several years.
  - Next step: ~50t LXe with ultimate low PI BG (decrease Rn)
- B-1 unit for innovative dark matter search kicked-off :
  - Direct detection in XENONnT and future DARWIN/XLZD
  - Strong collaboration between experiment and theory
  - LXe Hermetic TPC R&D by Freiburg and Nagoya
  - A new photo-sensors and low RI technique
  - Synergy to neutrino physics

Proposed Unit

韓国IBS
パドヴァ大
エジンバラ大
マックスプランク研
東大

JSPS core-to-core(2020-25)

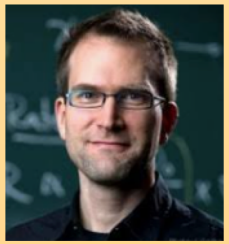
DMNet

R3: Direct DM search

R7: Future projects

KMI DM International Center

Future



M.Schuman

- DARWIN Co-PI
- DMnet partner PI
- Large test bench

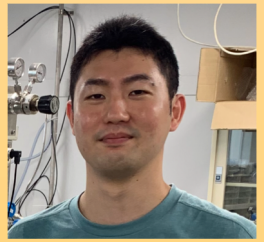
UNI FREIBURG

MoU

XENONnT
DARWIN

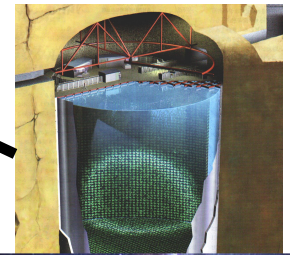
Hisano

Kazama



Kobayashi

Itow



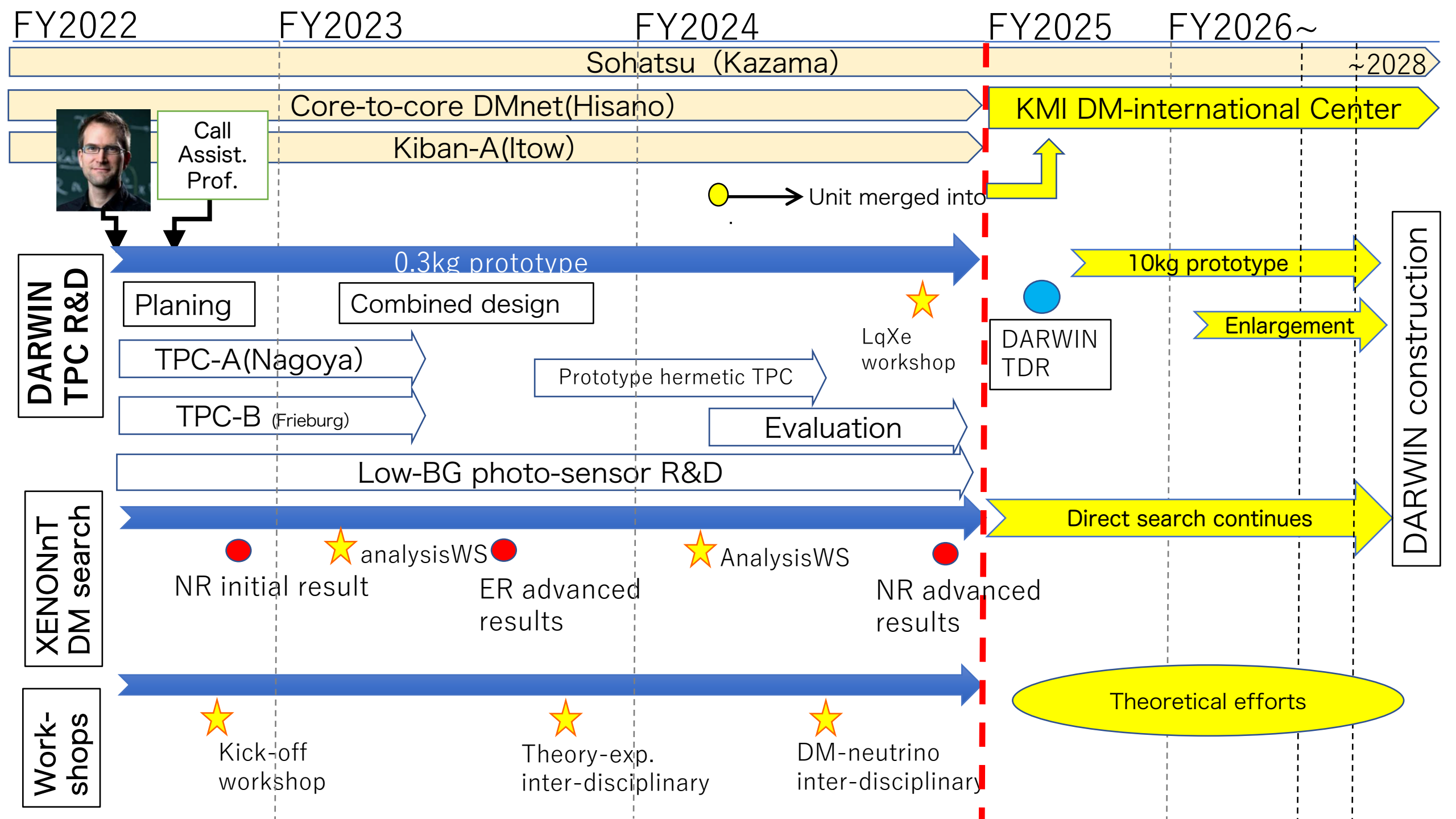
Synergy w/ Neutrino physics

DM international Research Unit

① LqXe technology R&D
- Hermetic TPC
- New photo-sensors
- Larger (50t LXe)

② Direct DM search
- XENONnT data analysis
- Data analysis center
- Various DM searches

③ Workshops
- Theory-experiment synergy
- DM-Neutrino synergy
- LXe technology


FY2022
FY2023
FY2024
FY2025
FY2026~
Sohatsu (Kazama)
~2028
Core-to-core DMnet(Hisano)
KMI DM-international Center
Kiban-A(Itow)
Call Assist. Prof.
Unit merged into
DARWIN TPC R&D
0.3kg prototype
10kg prototype
Planing
Combined design
LqXe workshop
DARWIN TDR
Enlargement
TPC-A(Nagoya)
Prototype hermetic TPC
TPC-B (Frieburg)
Evaluation
Low-BG photo-sensor R&D
DARWIN construction
XENONnT DM search
Direct search continues
analysisWS
AnalysisWS
NR initial result
ER advanced results
NR advanced results
Work-shops
Theoretical efforts
Kick-off workshop
Theory-exp. inter-disciplinary
DM-neutrino inter-disciplinary