# First results from LiF bolometer at Kamioka

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Department of physics , School of Science, University of Tokyo

**Kentaro Miuchi**

**Group Members**

**M. Minowa**

**Y. Inoue[A], W. Ootani[A], Y. Ootuka[B], Y. Shimizu,**

**H. Sekiya, A. Takeda, K. Miuchi**

**University of Tokyo, ICEPP[A], Tsukuba University[B]**

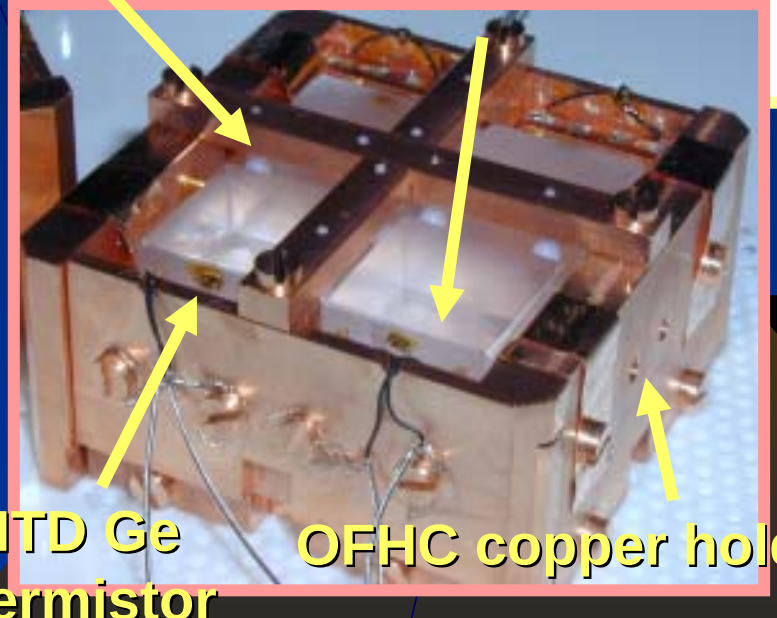
# 1 Detector

## 1-1 LiF Bolometer array

- For SD WIMPs
- 8pcs×21g LiF crystals ($2\times2\times2cm^3$)

delrin balls

LiF crystal

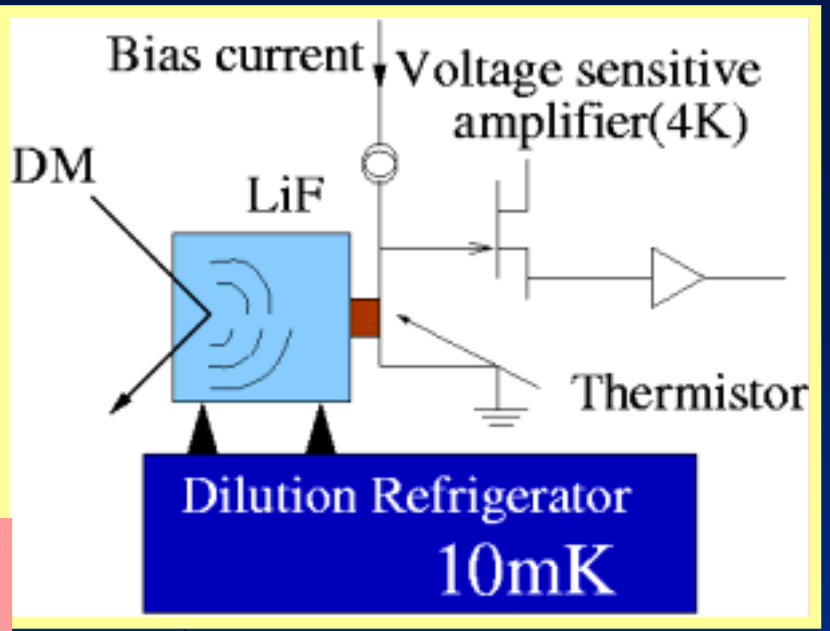


NTD Ge thermistor

OFHC copper holder

LiF bolometer array (1 of 2 stages )

schematics of the bolometer

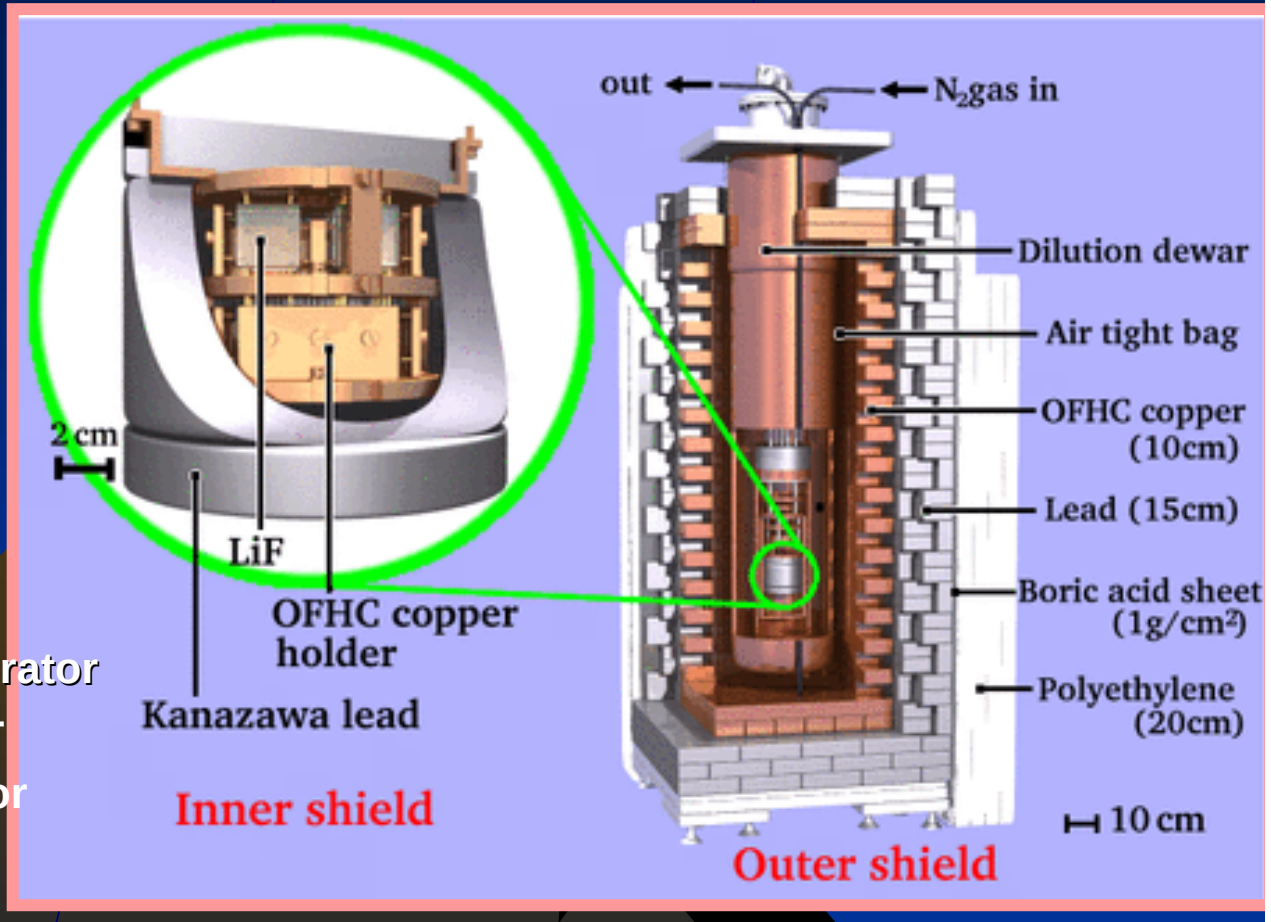



Spin factors of the materials used for DM search

| Isotope | abundance | $\lambda^2 J(J+1)$ |
|---|---|---|
| $^{7}$Li | 92.5% | 0.411 |
| $^{19}$F | 100% | 0.647 |
| $^{23}$Na | 100% | 0.041 |
| $^{73}$Ge | 7.8% | 0.065 |
| $^{127}$I | 100% | 0.023 |
| $^{129}$Xe | 26.4% | 0.124 |

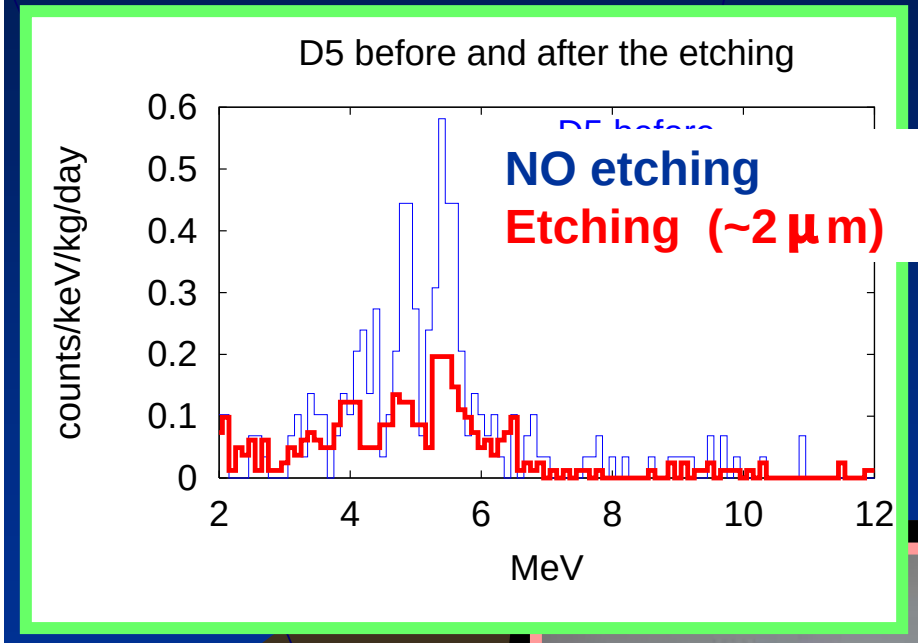
# 1-2 Detector set up

- Kamioka Mine (~2700m.w.e)
- Shielding
- Cryogenics
  - Dilution refrigerator
  - Helium liquefier
  - Liq. $N_2$ generator
- Bolometer array



# 2 Recent improvements

## 2-1 Chemical etching of the LiF crystals



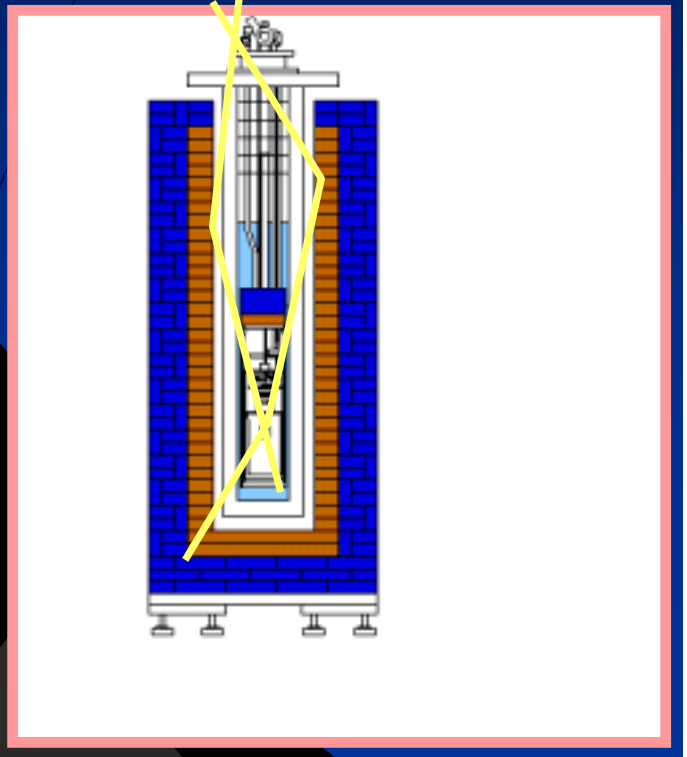

– **Results of the preliminary run at Kamioka**

– **α peaks are suppressed by etching the surface ( ~2μm) with perchloric acid**

– **20 μm etchings for this measurement.**

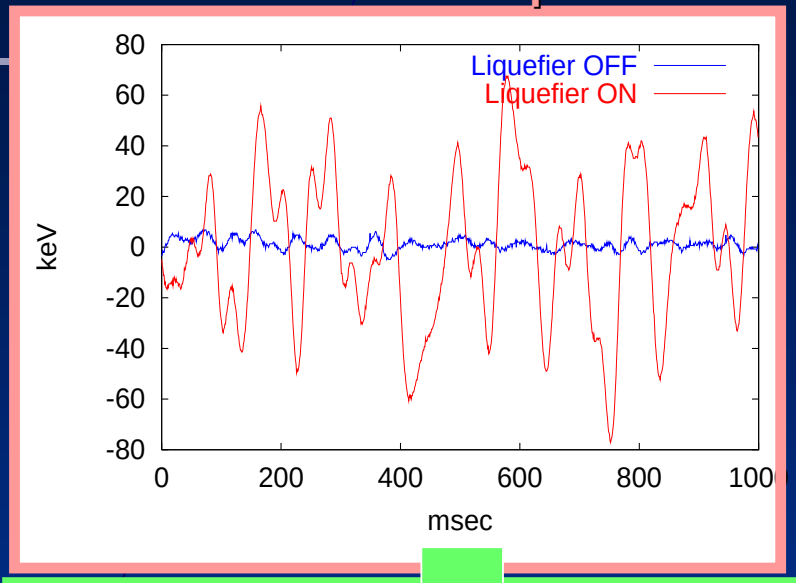
# 2-2Inner shield

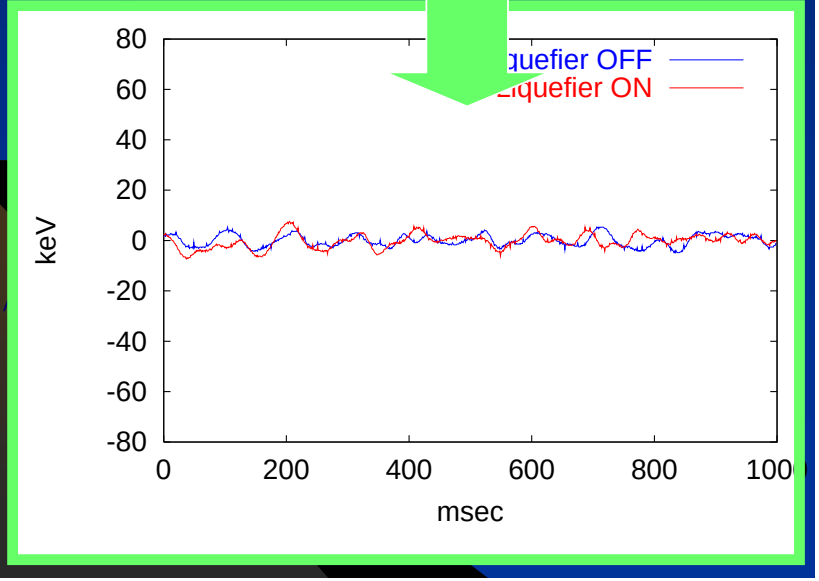
- Back-scattered γ-rays would be the serious BG source
  ⟶ install 2cm lead shield in the cold stage
- Problem: $^{210}$Pb ( half life=22.3 y )
  ⟶ old lead (>200 y) from Kanazawa castle

# 2-3 Eliminating the microphonic noise


He liquifier noise

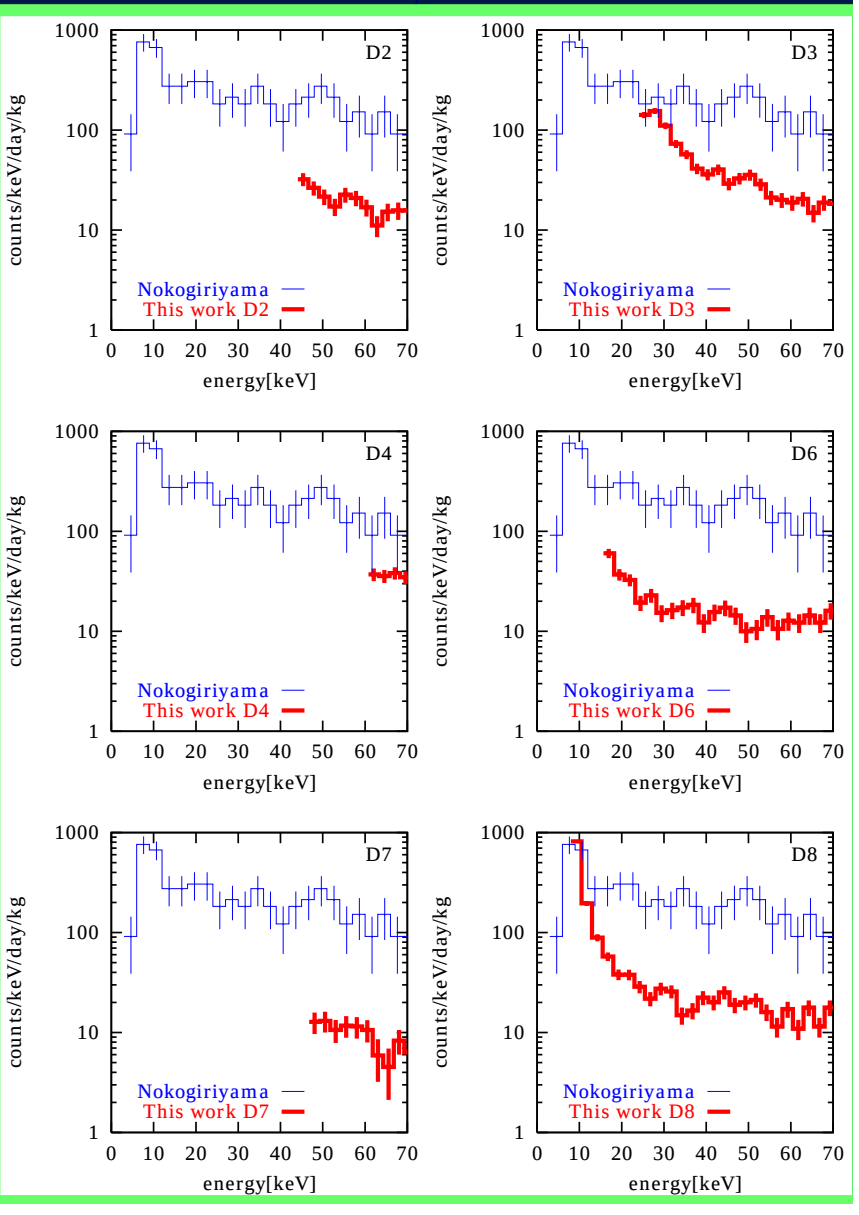


# 3 Measurement

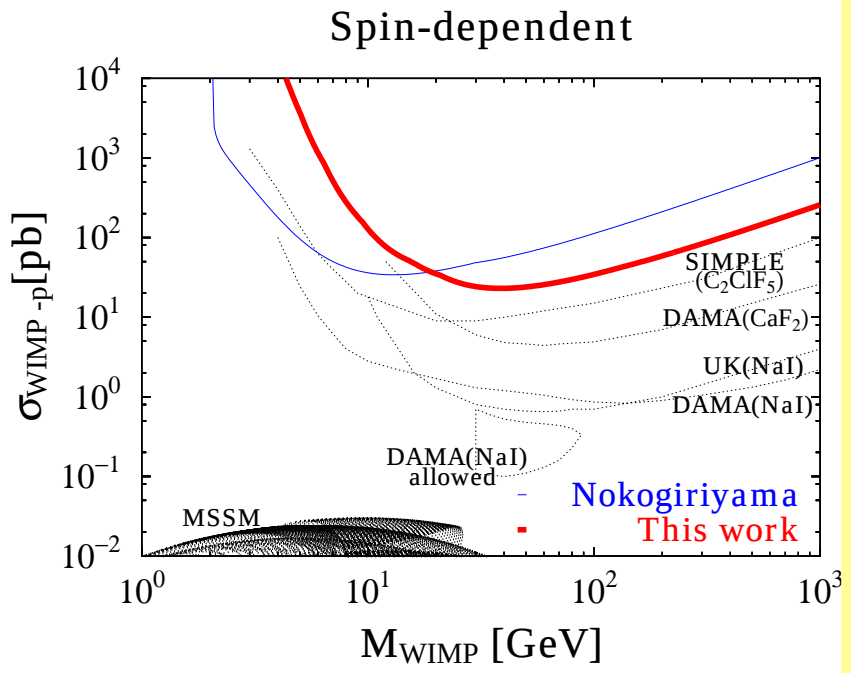
## 3-1 Run data

- Total exposure: **4.1 kg･days** ( 50 days )
- **6 of 8 detectors** was used for the analysis
- 10-30 counts/keV/kg/day
- BG rate : ✕1/10 from the pilot run



# 3-2 SD $\sigma_{WIMP-p}$ limits

– Assumtion : all events are WIMP- proton events.




| | |
|---|---|
| $\rho_{DM}$ | 0.3 GeV cm$^{-3}$ |
| $v_0$ | 220 km s$^{-1}$ |
| $v_{esc}$ | 650 km s$^{-1}$ |
| $v_{Earth}$ | 217 km s$^{-1}$ |

Astrophysical parameters

– Limits to $M_{WIMP}$ >30GeV : ×10 improved (from the pilot run)

– Best limits SD : 23 pb (for 40GeV)

# 3-3 SD limits in the $a_p$-$a_n$ plane

– **SD WIMP- N cross section**

$$\sigma^{SD}_{WIMP\text{-}N} = 4G_F^2 \mu^2_{WIMP-N} \left( a_p \left\langle S_{p(N)} \right\rangle + a_n \left\langle S_{n(N)} \right\rangle \right)^2 \frac{J+1}{J}$$

( D.R. Tovey et. al. Phys. Lett. B 488(2000)17)

(contributions of both proton and neutron are considered)

$a_p$, $a_n$: WIMP-nucleon couplings — To be measured

$\langle S_{p(N)} \rangle$: proton spin contribution in the nucleus

| Isotope | unpaired | $\langle S_{P(N)} \rangle$ | $\langle S_{n(N)} \rangle$ |
|---|---|---|---|
| $^{7}$Li | p | 0.497 | 0.004 |
| $^{19}$F | p | 0.441 | -0.109 |
| $^{23}$Na | p | 0.248 | 0.020 |
| $^{73}$Ge | n | 0.009 | 0.372 |
| $^{127}$I | p | 0.309 | 0.075 |
| $^{129}$Xe | n | 0.028 | 0.359 |

$^{19}$F has opposite sign of $\langle S_{p(N)} \rangle / \langle S_{n(N)} \rangle$ compared to $^{23}$Na, $^{73}$Ge, $^{127}$I

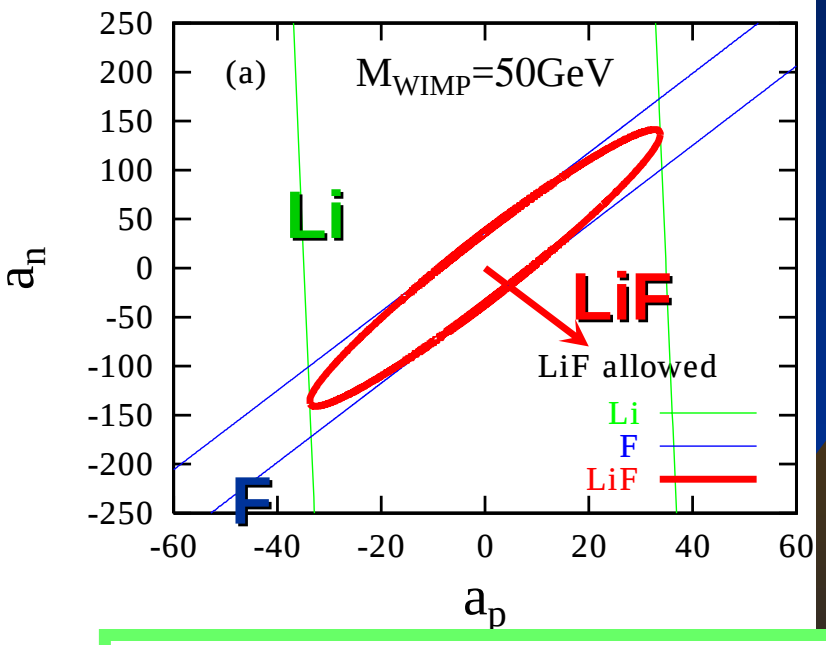
→ COMPLEMENTARY for $a_p$, $a_n$ determination

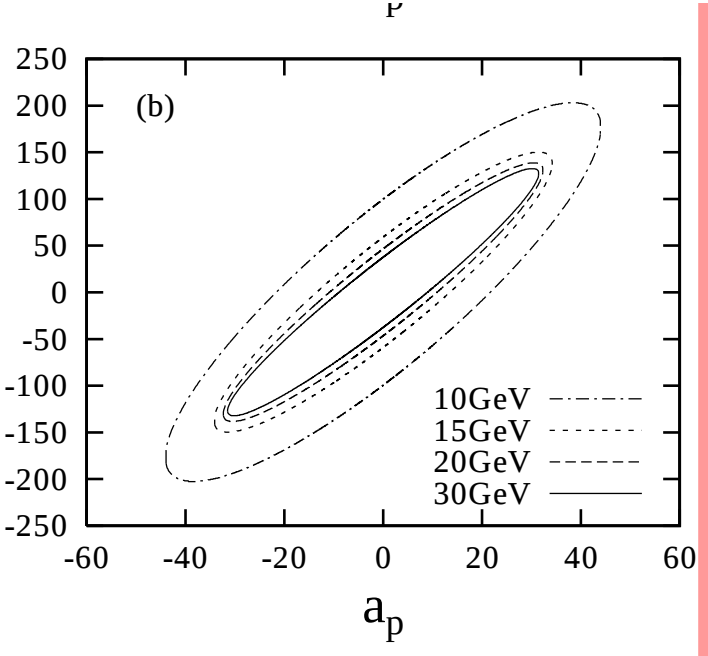
$\langle S_{p(N)} \rangle$ and $\langle S_{n(N)} \rangle$ values ( calculated by shell models )

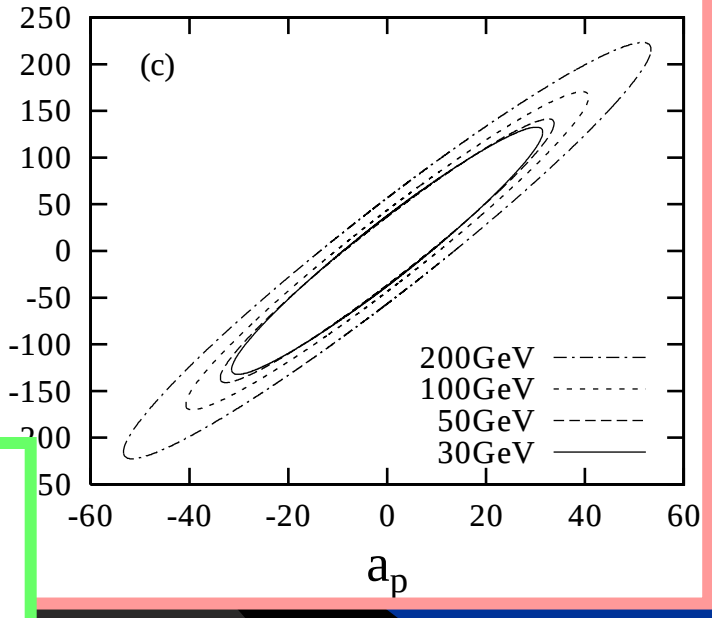
## SD limits in the $a_p$-$a_n$ plane

– Derived the $a_p$-$a_n$ limits from the cross section limits.

$$\sigma^{SD}_{WIMP\text{-}N} \propto \left(a_p \left\langle S_{p(N)} \right\rangle + a_n \left\langle S_{n(N)} \right\rangle\right)^2 \frac{J+1}{J}$$




**$|a_p| < 32$ , $|a_n| < 133$**

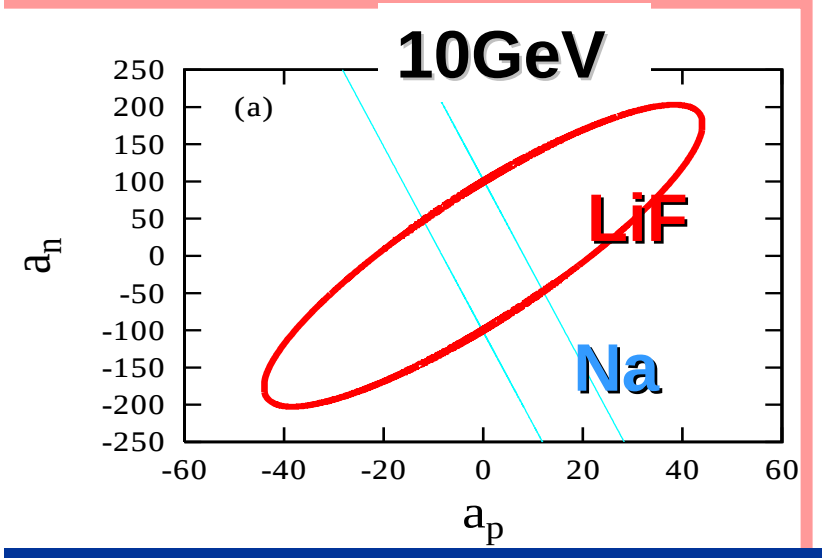
**for 30GeV WIMP**

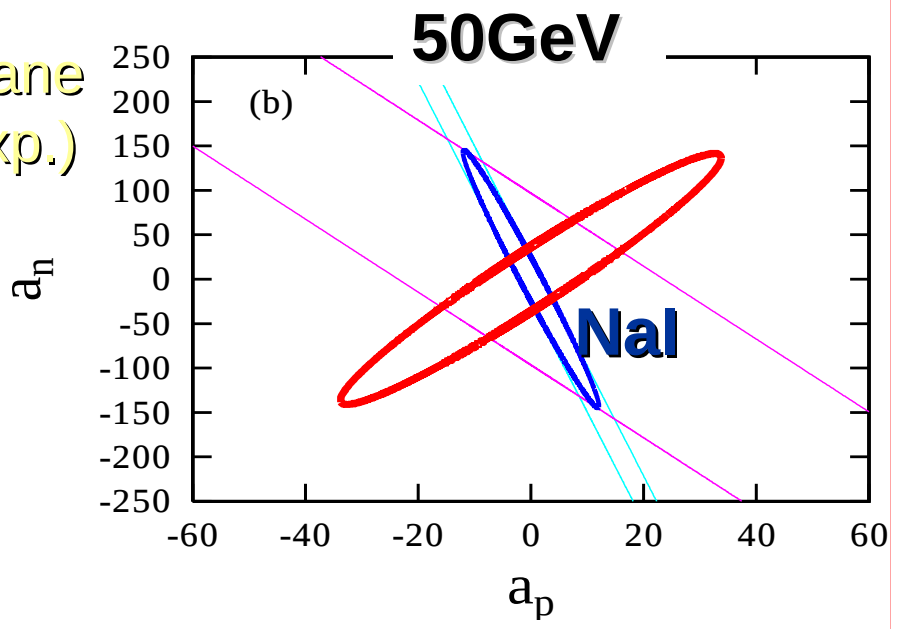
## SD limits in the $a_p$-$a_n$ plane (comparison with other exp.)

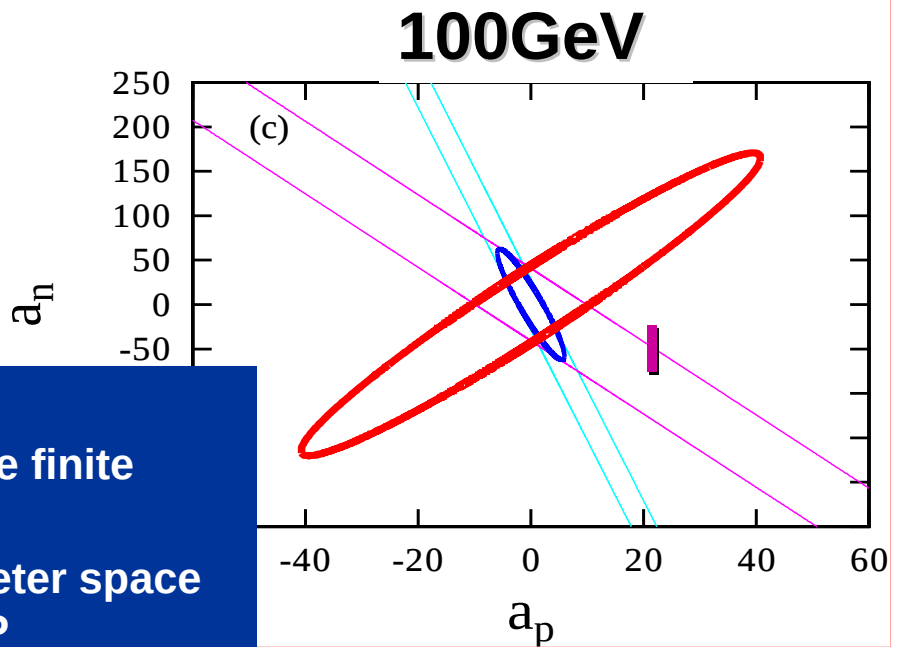
- Comparison with the UKDMC

**LiF sets the limits**

COMPLEMENTARY to NaI




- This is the **only experiment** to set the finite limits for 10 GeV WIMP
- **Killed more than 2 / 3** of the parameter space allowed by UKDMC for 50 GeV WIMP

# 4 Discussions, prospects

- **Main background**
  - $^{40}K$ contamination in LiF crystals
  - U, Th in the holder and Kanazawa lead
  - $^{3}H$ from neutron capture of $^{6}Li$
- **prospects**
  - Etching the crystals more deeply
  - Ta bolometer as an active shield
  - NaF bolometer
  - Directional detectors ( stilbene scintillator )

Y. Shimizu et. al. astro-ph/0207529

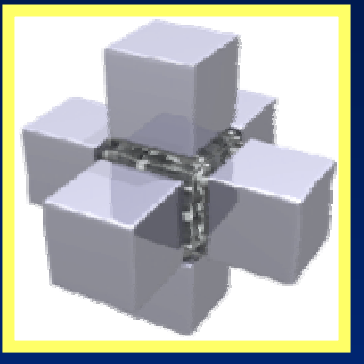
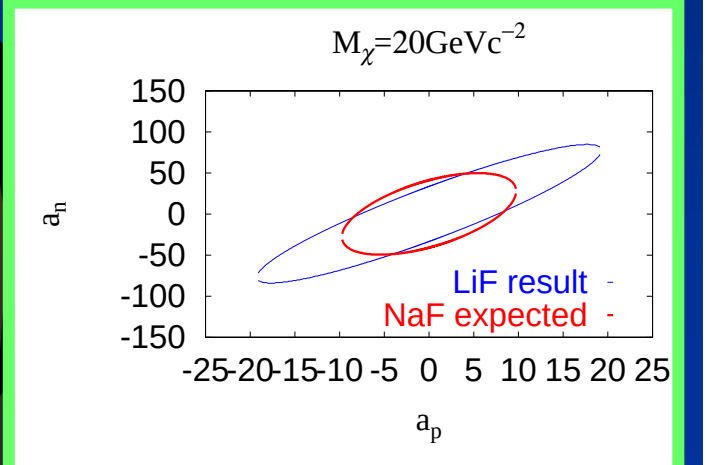


Image of Ta active shield

Expected limits with NaF



# 5 Conclusions

- LiF bolometers with special care for
  - low threshold
  - low background

  was used for the measurement.
- SD limits in the $a_p$-$a_n$ plane are shown.
- A large part of the parameter space in the $a_p$-$a_n$ plane for light WIMPs allowed by UKDMC experiment was excluded by this experiment.