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ZnWO₄

for the direction-sensitive dark matter search

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大阪暗黒懇談会

ADAMO's report

On the potentiality of the ZnWO_4 anisotropic detectors to measure the directionality of Dark Matter

F. Cappella¹, R. Bernabei^{2,3,a}, P. Belli³, V. Caracciolo⁴, R. Cerulli⁴, F.A. Danevich⁵, A. d'Angelo^{1,6}, A. Di Marco^{2,3}, A. Incicchitti⁶, D.V. Poda⁵, V.I. Tretyak⁵

Directional response with MeV alpha particles

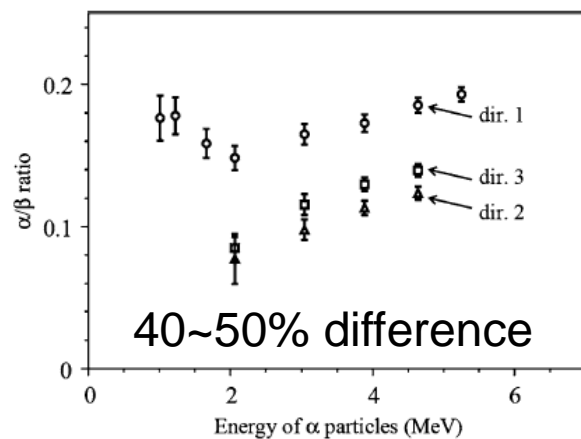


Fig. 3 Dependence of the α/β ratio on energy of α particles measured with ZnWO_4 scintillator. The crystal was irradiated in the directions perpendicular to (010), (001) and (100) crystal planes (directions 1, 2 and 3, respectively). The anisotropic behaviour of the crystal is evident [99]

“Estimated” quenching factor @ 5keV

Table 2 Quenching factors for O, Zn and W ions with energy 5 keV for different directions in ZnWO_4 crystal. Systematic uncertainties are estimated on the level of 20 % using data of [90]

Ion	Quenching factor		
	dir. 1	dir. 2	dir. 3
O	0.235	0.159	0.176
Zn	0.084	0.054	0.060
W	0.058	0.037	0.041

In case of stilbene crystal

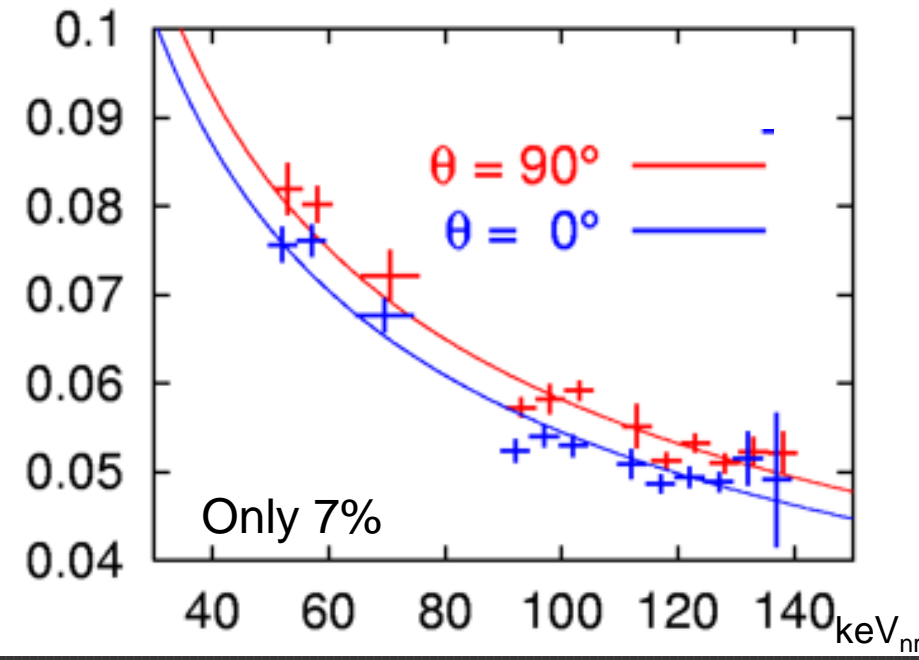
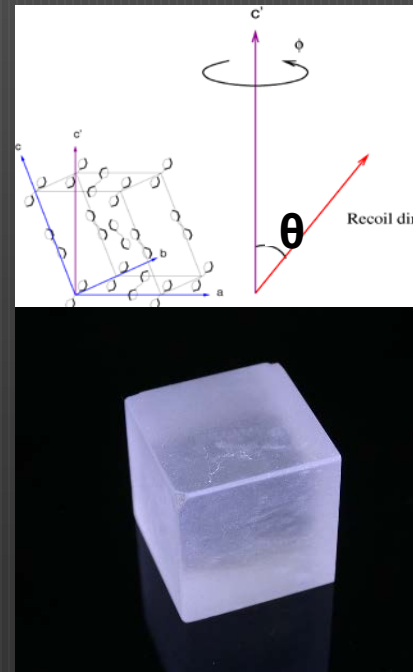
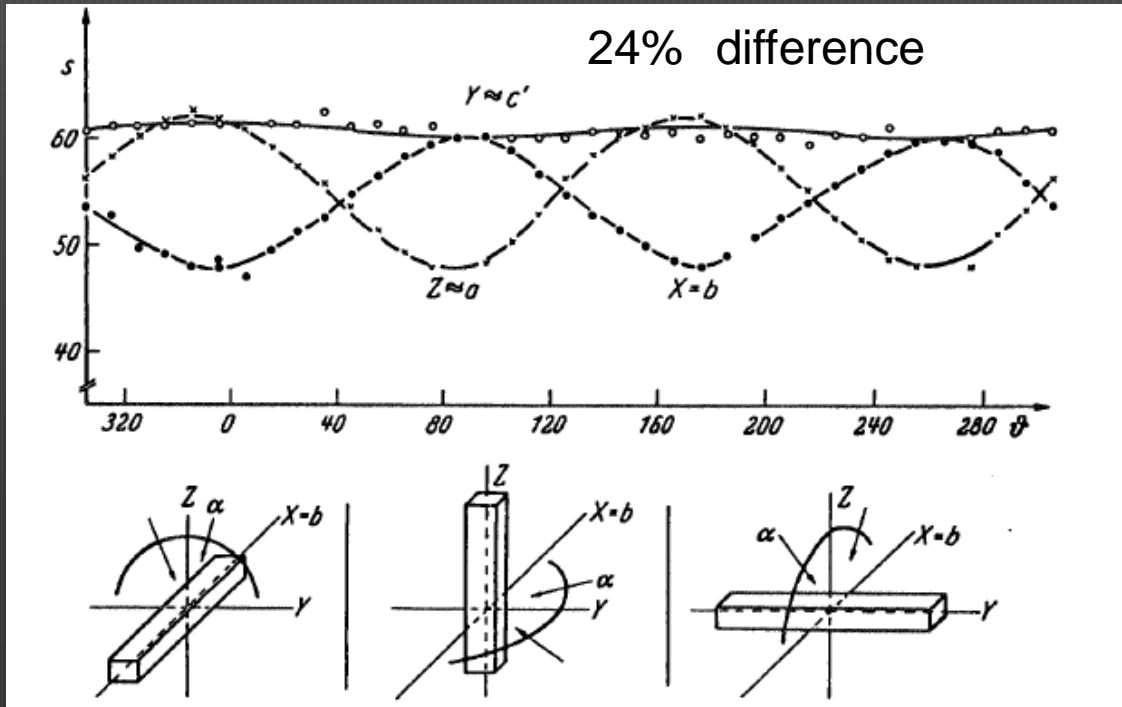
P.H. Heckmann et al., Z. Phys. 162 (1961) 122

HS et al., Physics Letters B 571 (2003) 132+ IDM 2004

Directional response
with MeV alpha particles

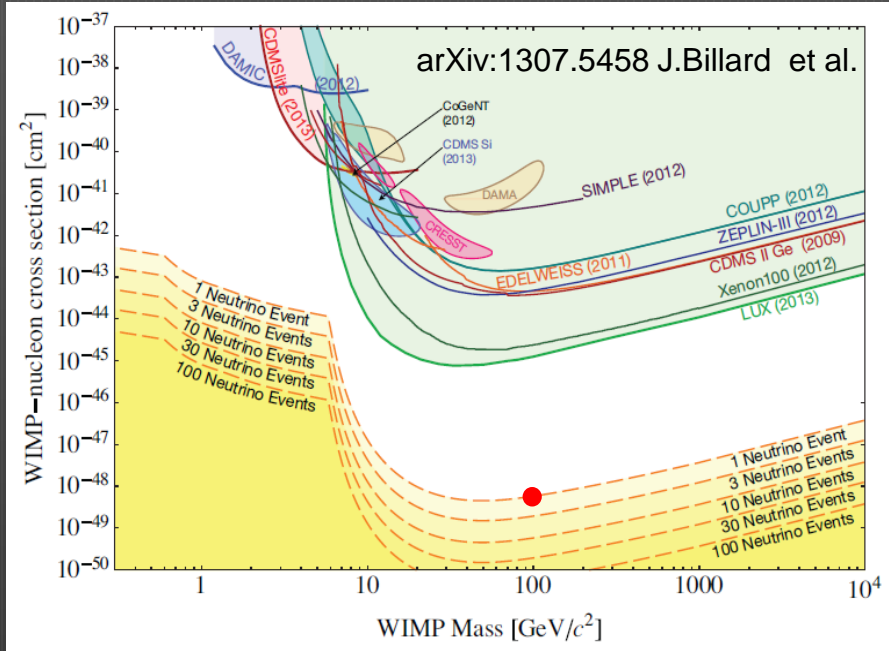
Measured quenching factor of C-recoils.

only 7 % difference

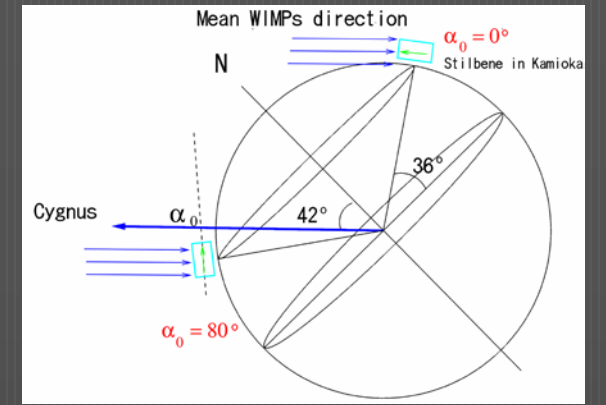


Requirement of exposure

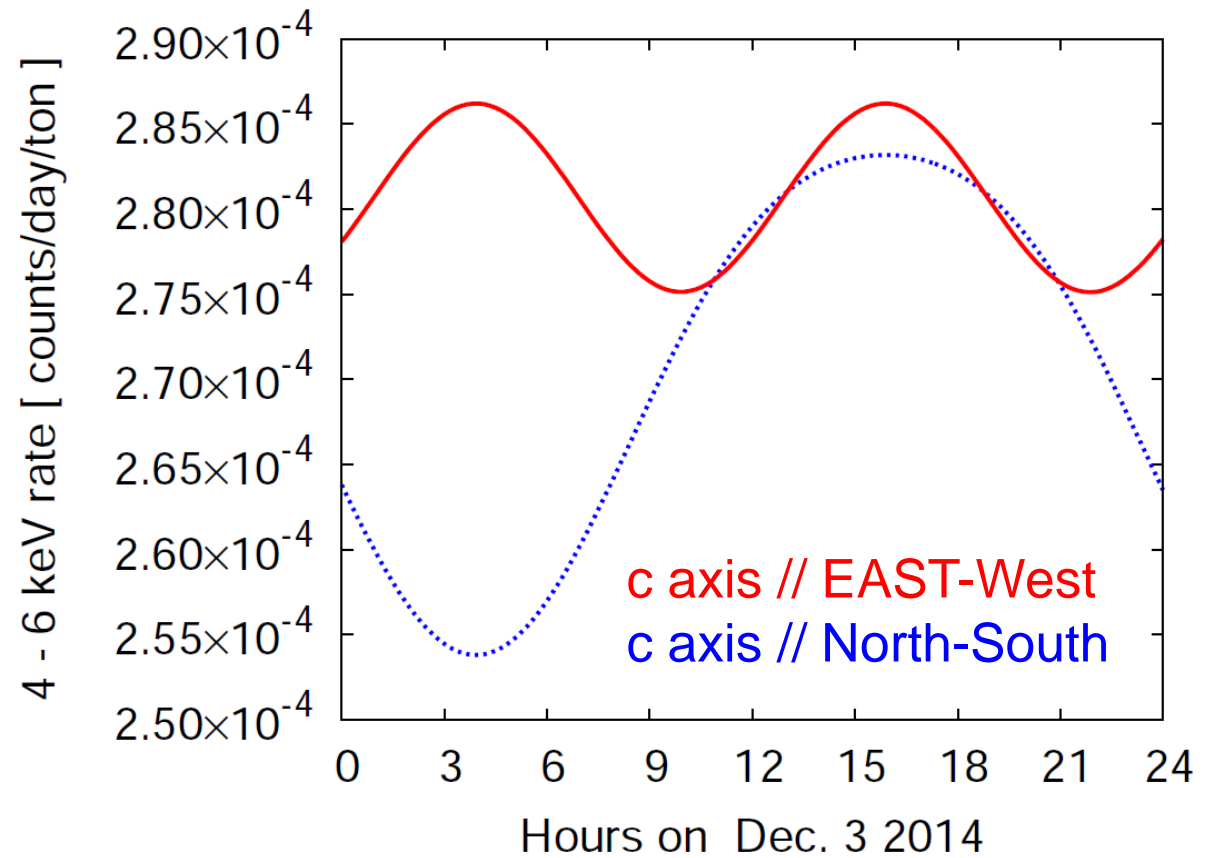
- Assuming 7% anisotropy @5keVnr in $ZnWO_4$
- 100GeV, 10^{-48}cm^2 signal + atmospheric ν (& DSNB) BG



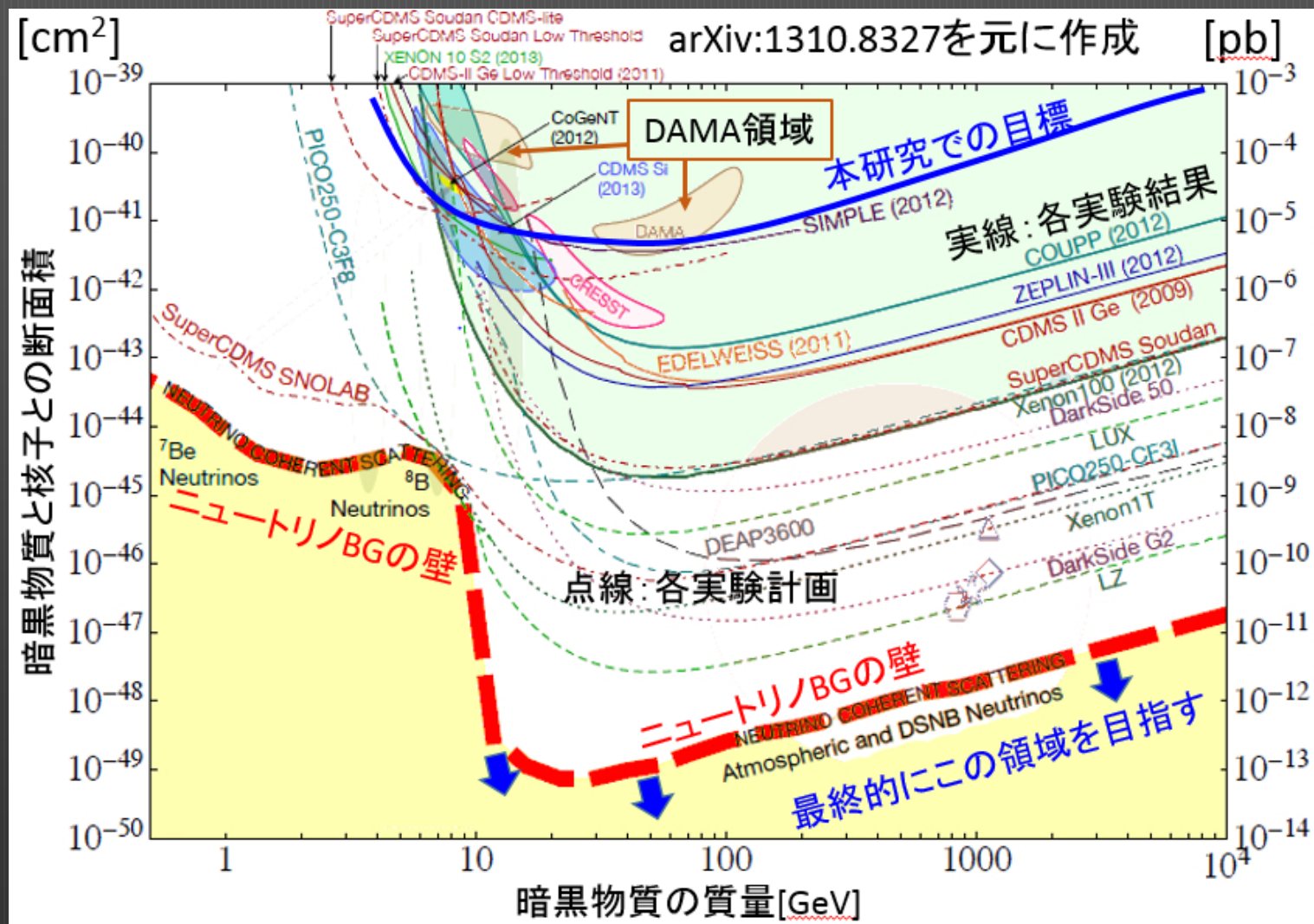
- **10^4 ton·days**
= 10 tons x 1000 days !
- **Needs 10t crystal**



Expected “diurnal modulation”

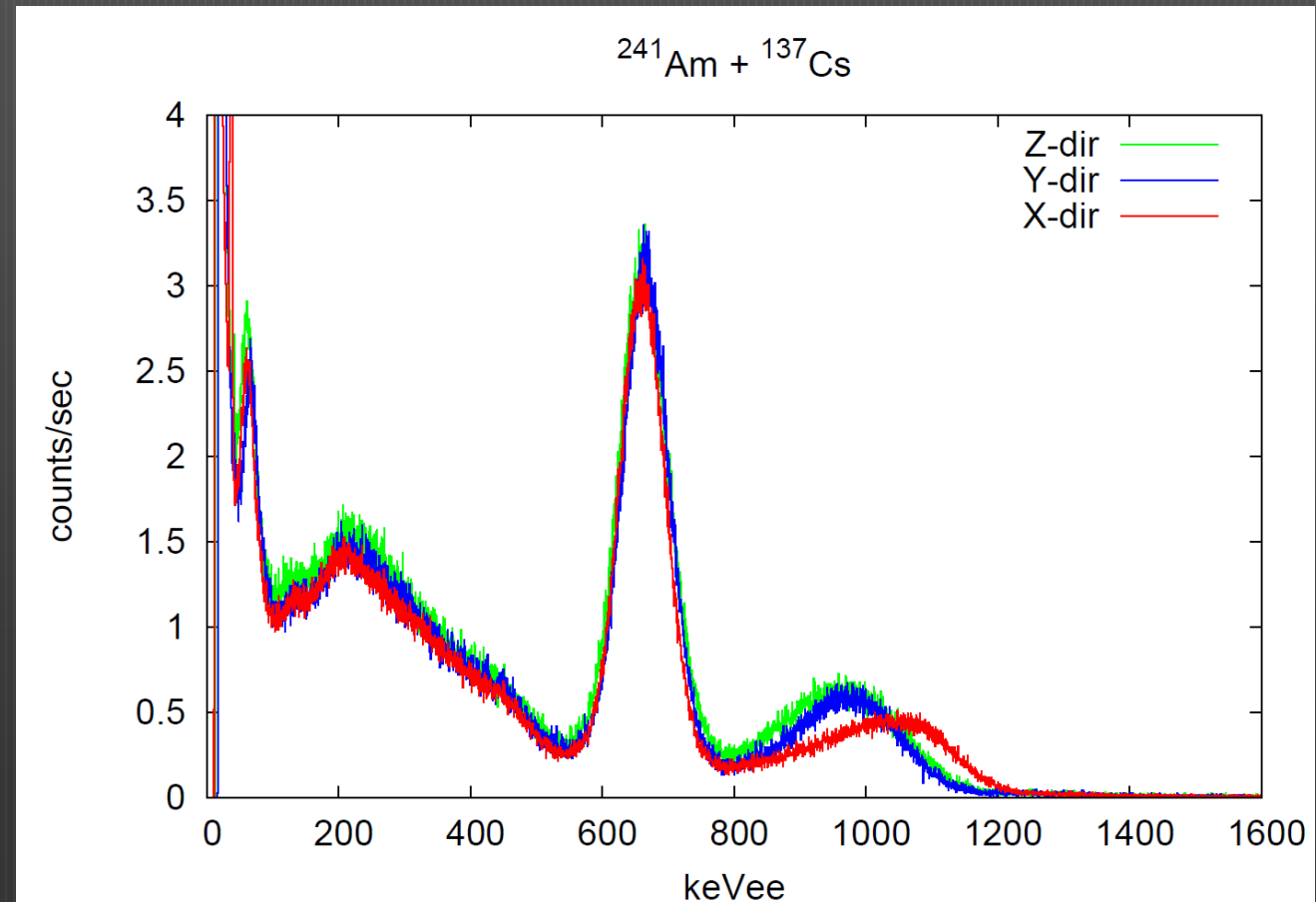


科研費申請書的な目標設定



現状

- ^{241}Am と ^{137}Cs 同時照射：アルファ線源で異方性の確認

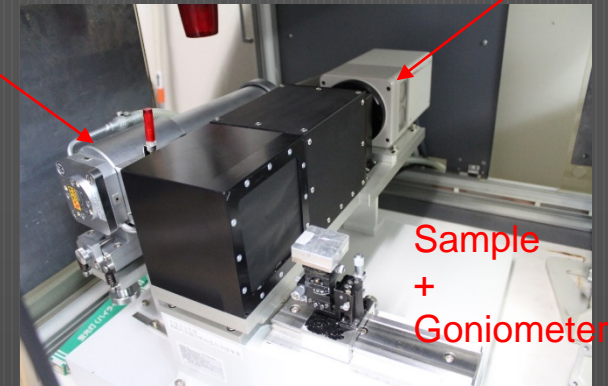


体制

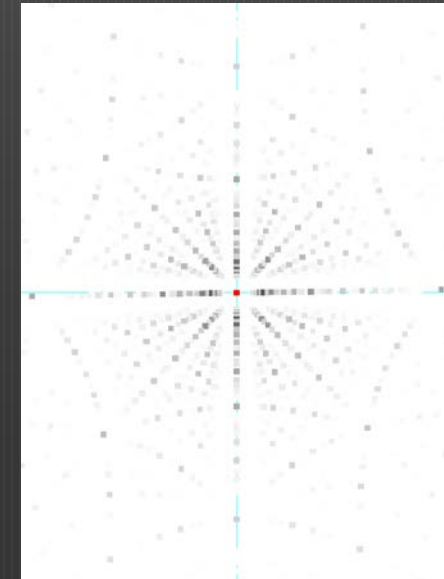
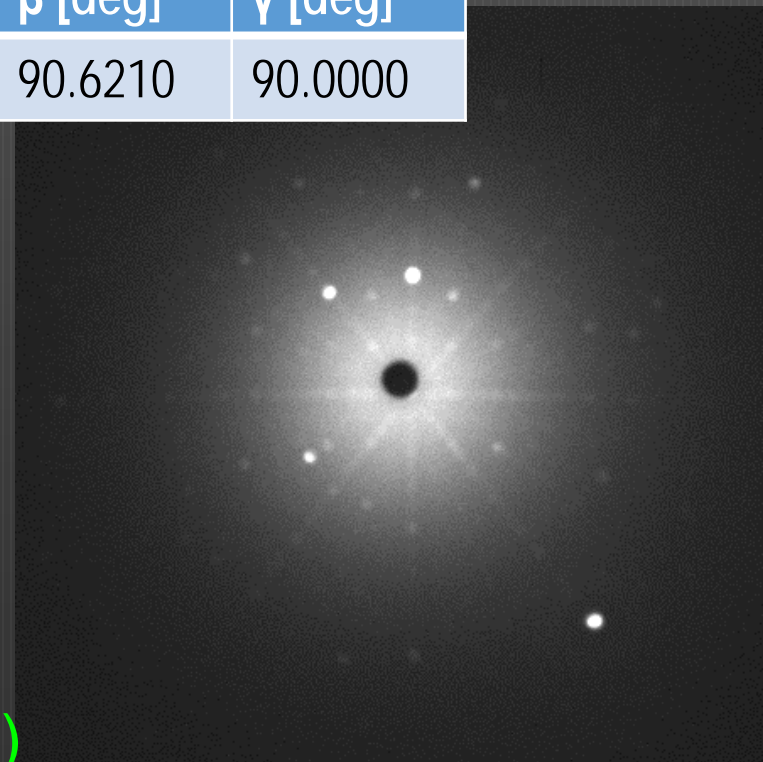
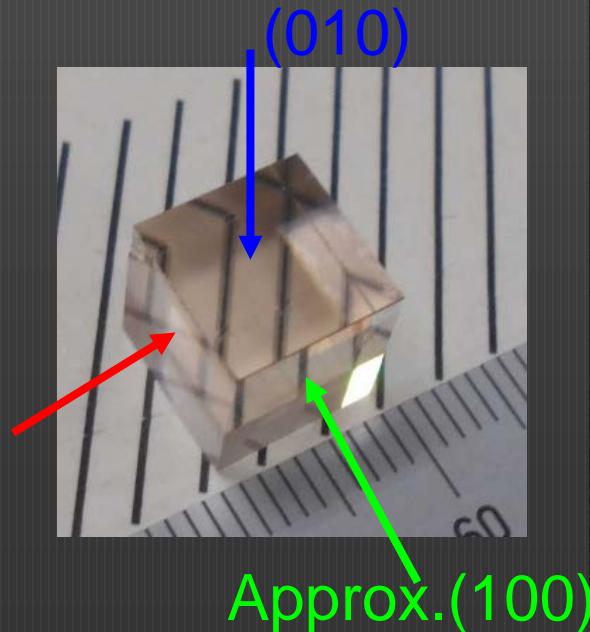
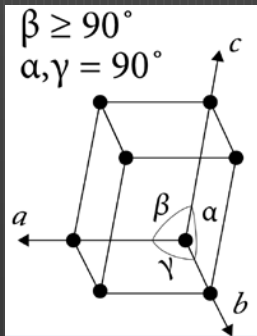
- すでに10人のコラボレーション！
- 各グループで予算獲得も含め主体的に進めてもらう
 - 東北大グループ
 - 韓国グループ
- 今後のやるべき体制づくり
 - 中性子ビーム試験(これをできる人を探す必要あり 飯田?)
 - 低BG結晶開発(新学術の恩恵で、伏見さん等から)
 - 大型低BG結晶製作(東北大、韓国チャンネルのロシア)

- 結晶のエキスパート集団

– スチルベンの中にはできなかったことが、簡単にできてしまう。

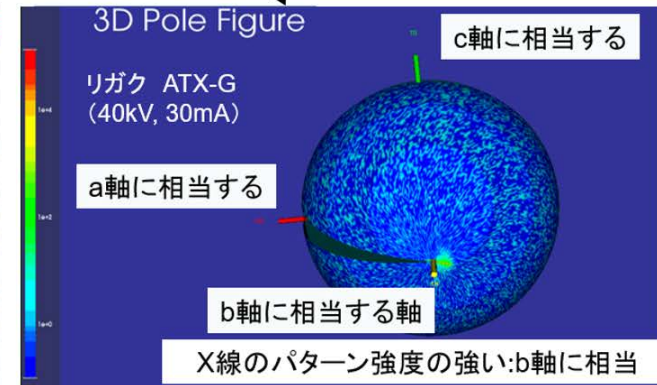
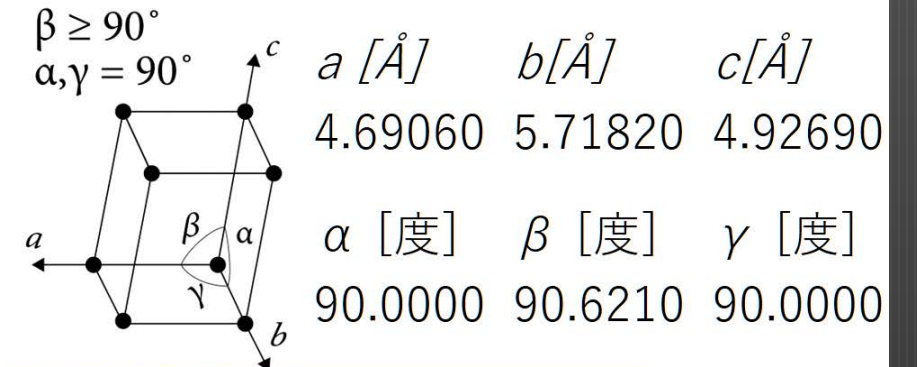
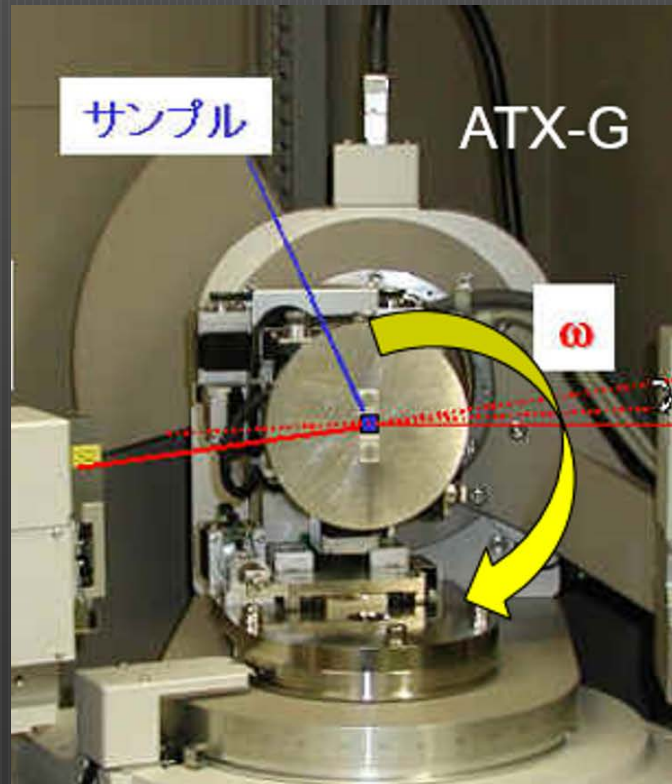


a [Å]	b [Å]	c [Å]	α [deg]	β [deg]	γ [deg]
4.69060	5.71820	4.92690	90.0000	90.6210	90.0000

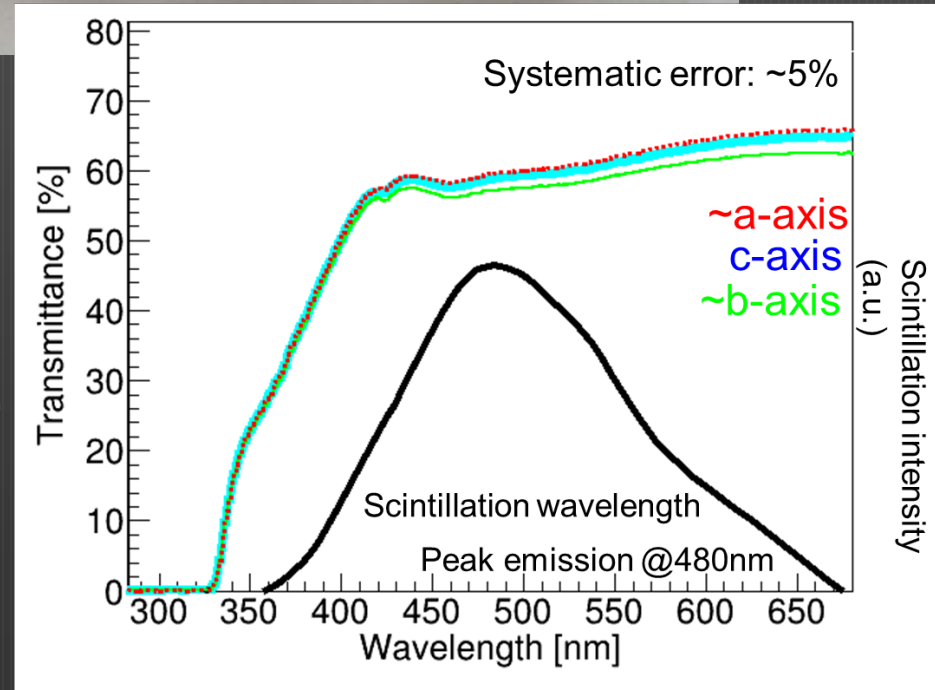
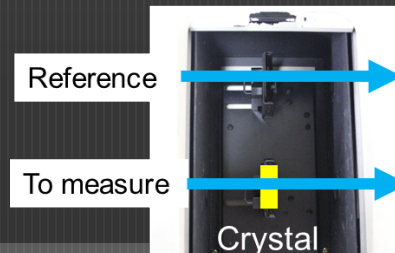
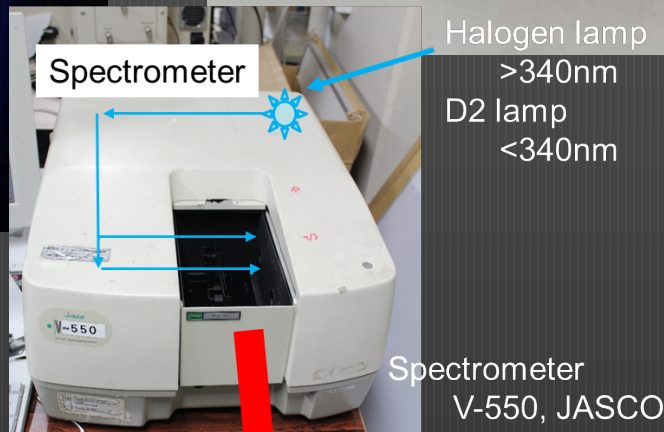
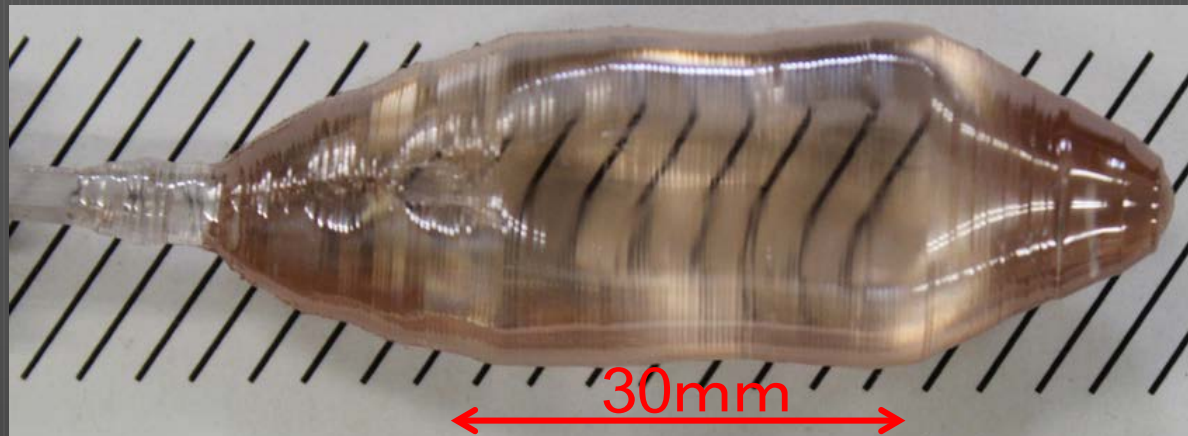
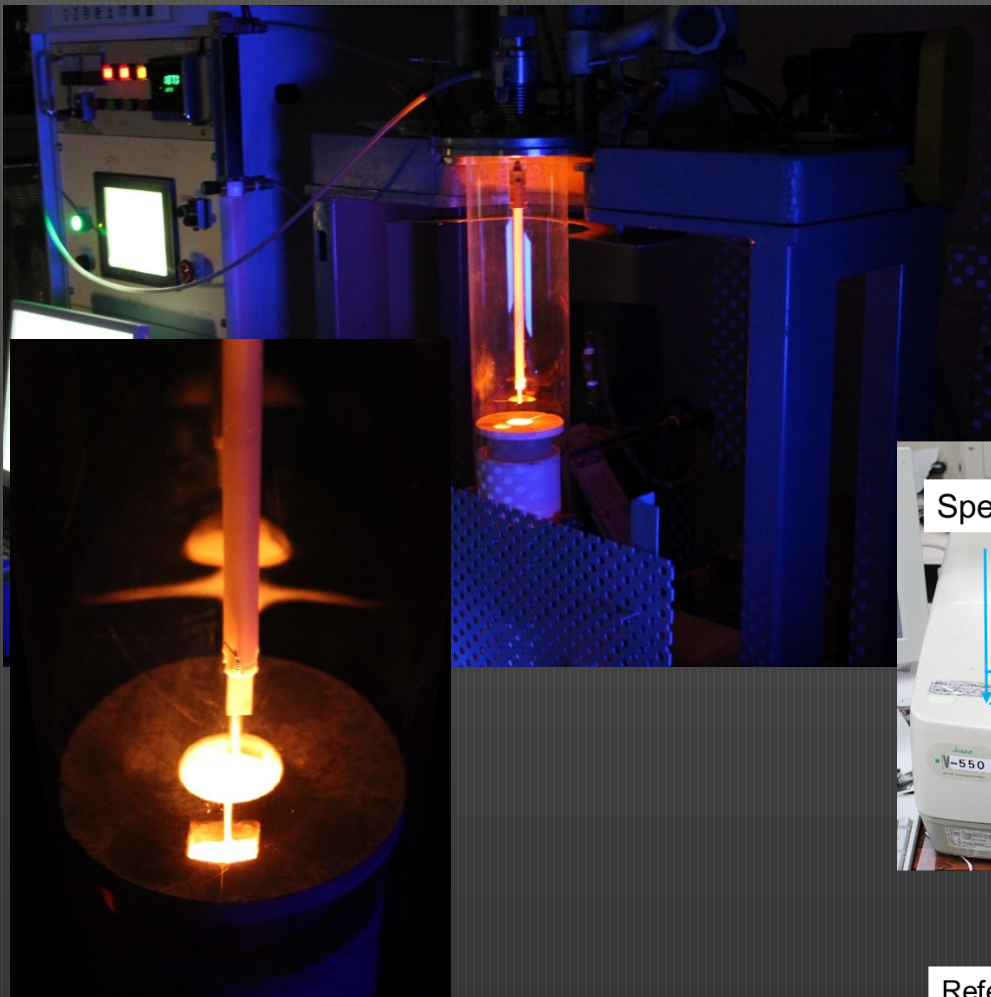


高価な武器が自由に使える

- 高出力・高精度複数軸X線回折計(リガク ATX-G)
- ATXを使えば短時間で3次元に回転させながら自動で結晶軸を同定できる。



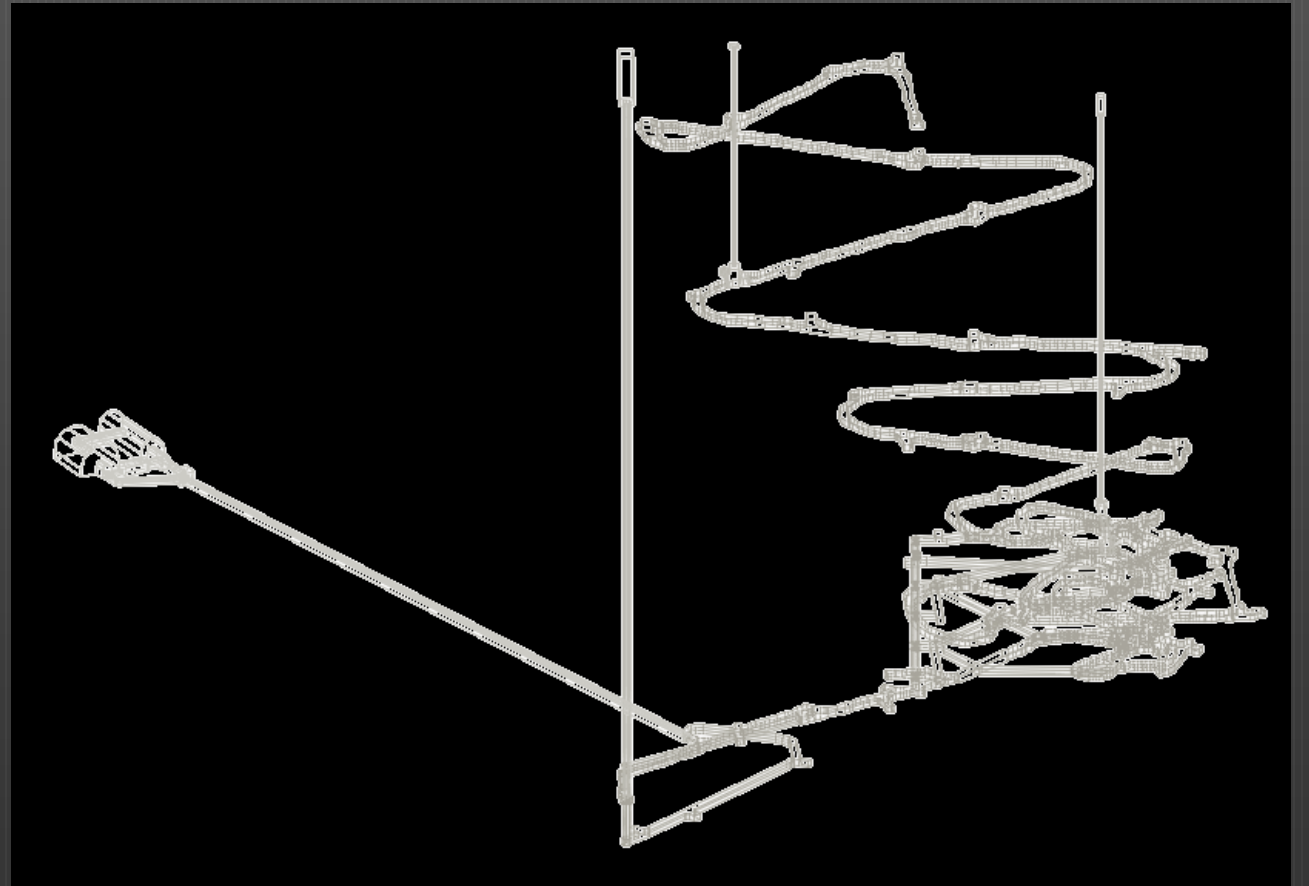
Low BG化へ向けて自前で結晶製造できる



- 少なくとも、人の作った結晶でも評価できる術は入手

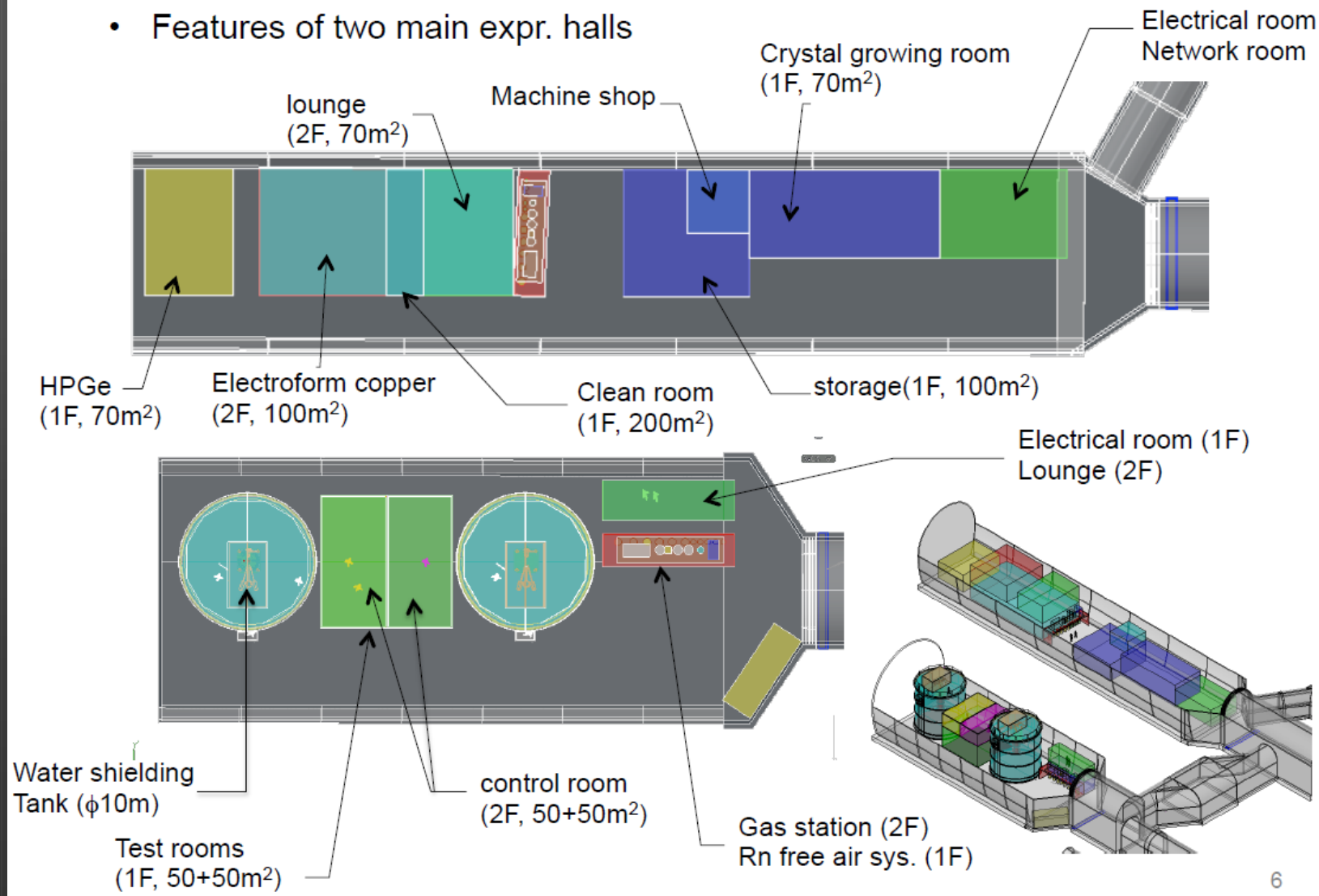
IBS Astro-particle Research Facility(ARF)

- Handuk mine



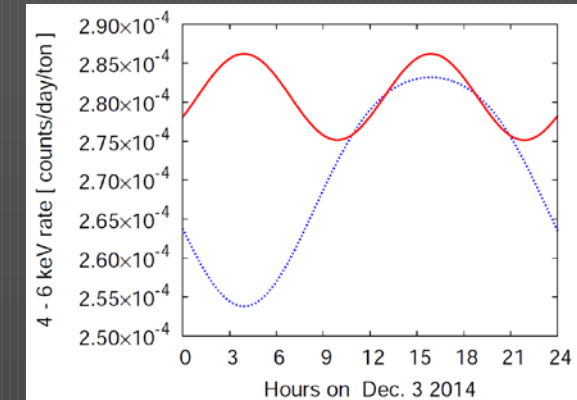
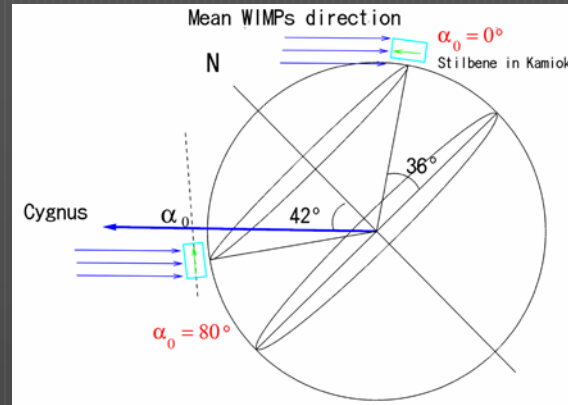
AMoRE + KIMS(not COSINE?)

- Features of two main expr. halls



Get more information of WIMP direction

- So far, 10 tons are needed

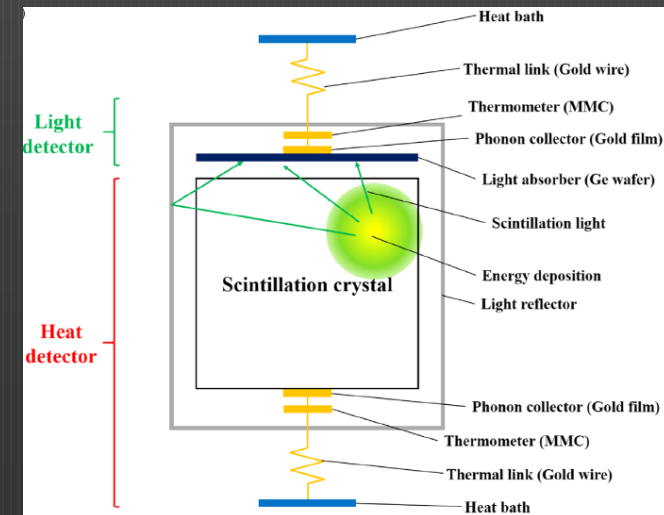


- Phonon channel?

- Total energy deposit vs direction-dependent light output makes the sensitivity better
- Started collaboration with AMoRE

Yong-Hamb Kim

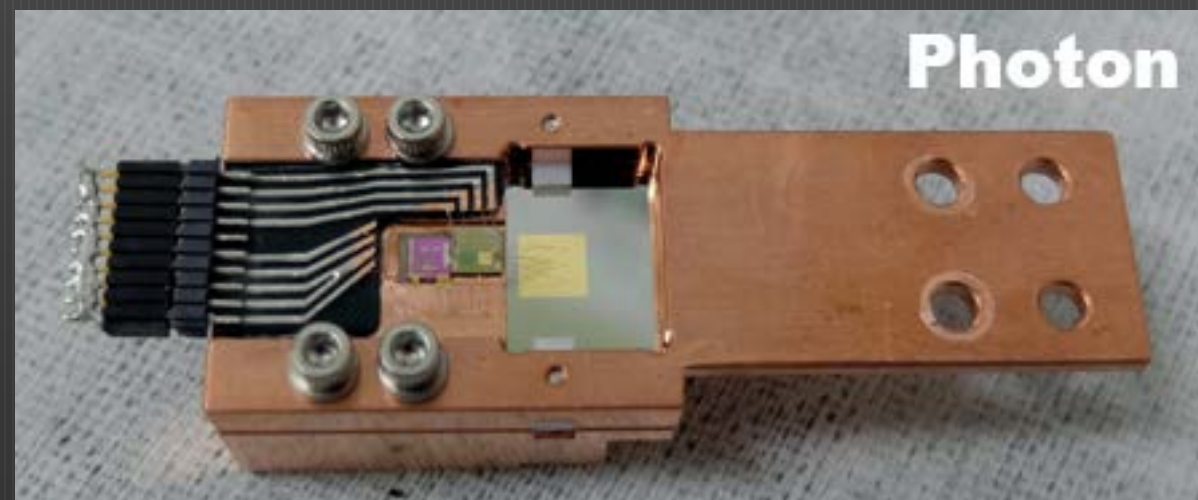
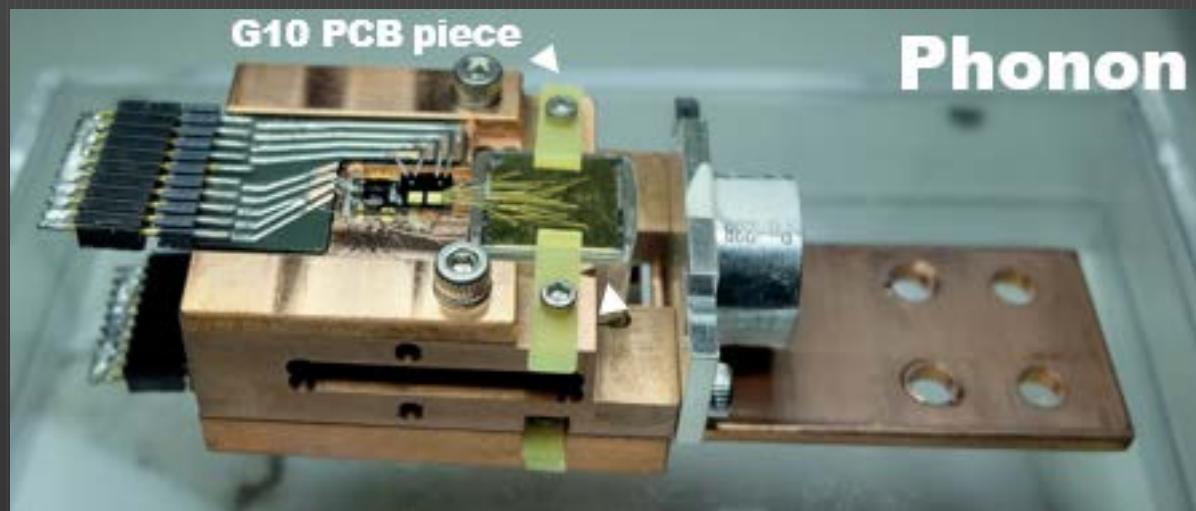
ZnWO₄ or Stilbene ←



Metallic magnetic calorimeter(MMC)

- 常磁性体の温度変化による磁化の変化をSQUIDを用いて読み出し
 - Yong-HambがBrown大時代に開発

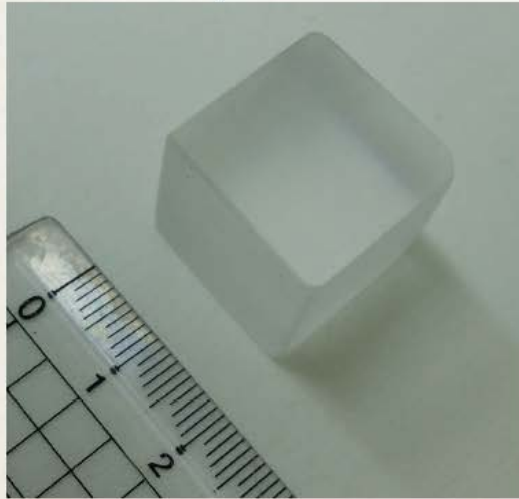
結晶に直接蒸着した金にMMCを取り付けるとphononセンサー
結晶から離れたGe基板を光吸収体として用い、そこへMMCを取り付けるとphotonセンサー



はじめはStilbeneでやりたいといわれて。。。。

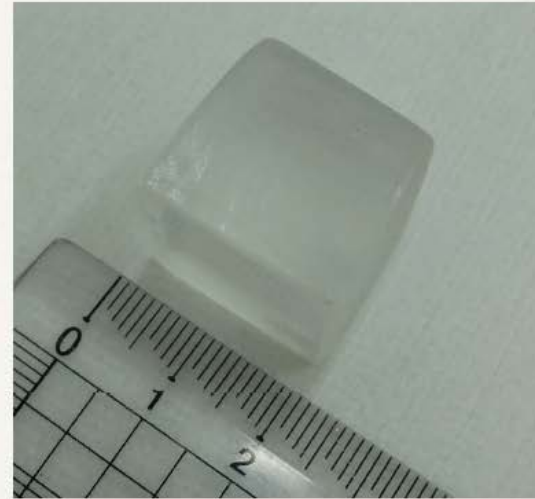
Present issue of the stilbene crystal

< When just arrived >



Almost regular hexahedron

< After immersed in ethanol >

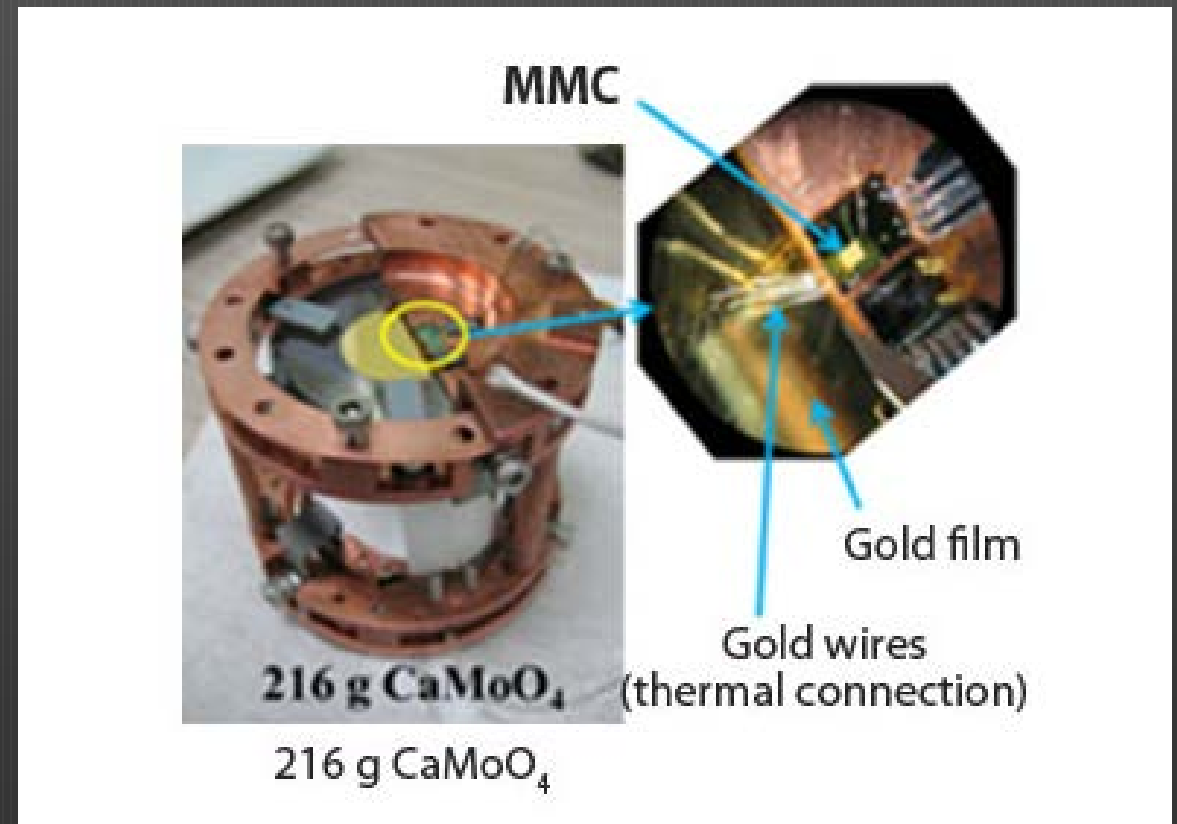


It dissolved a bit. (mass : 8442 mg)

- ❖ At least one side of the surface should be polished to evaporate a phonon collector film

KAISTの核断熱消磁冷凍機

- AMoREの結晶スクリーニング用だったものを利用



とりあえず、学生論文用

- ^{241}Am 線源を3面に取り付けられるホルダー設計完了

