HKS TARGET

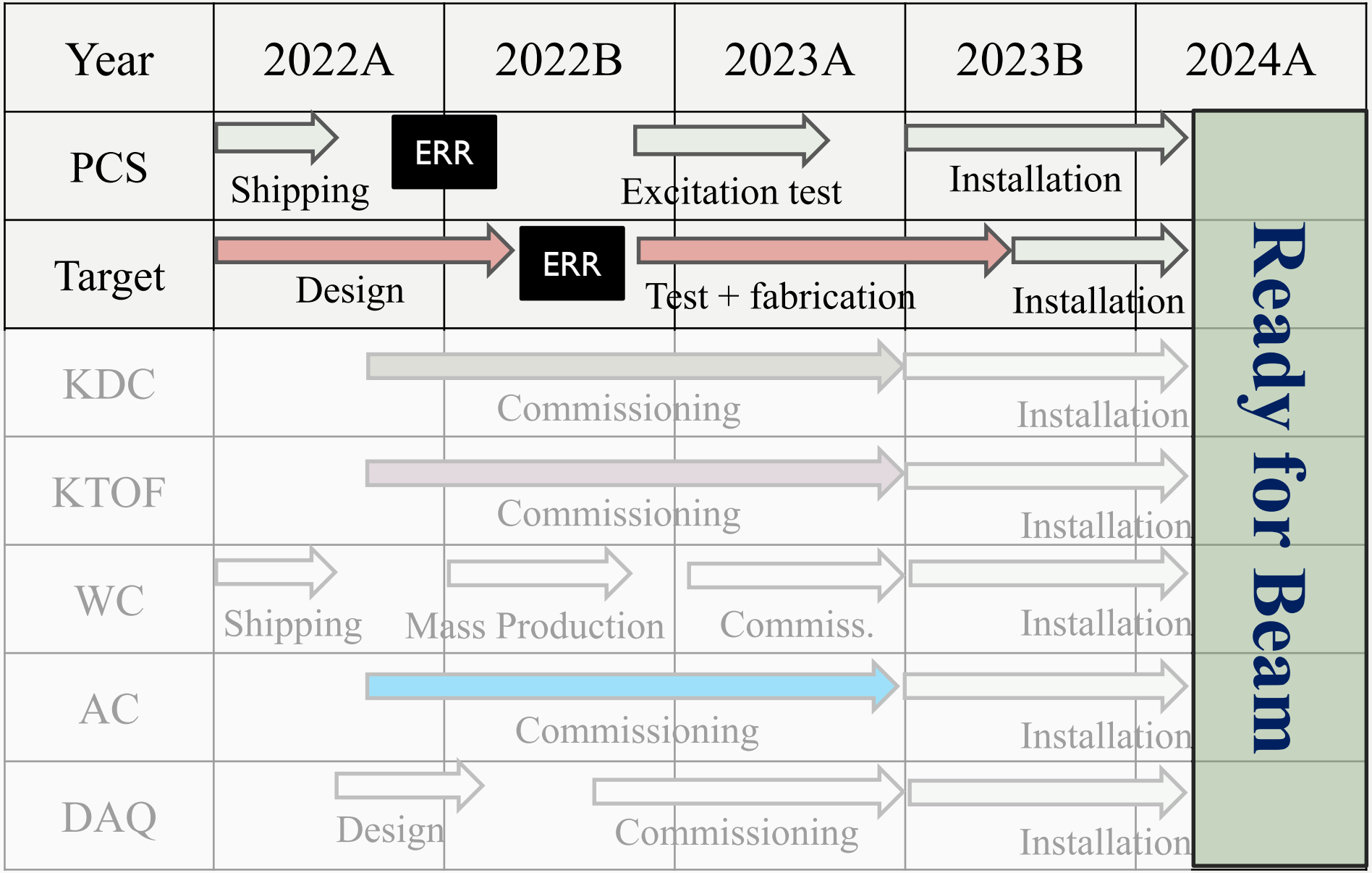
T. GOGAMI (KYOTO UNIV.), D. MEEKINS(JLAB)

2021/12/7

科研費 KAKENHI
SPIRITS
SUPPORTING PROGRAM FOR INTERACTION-BASED INITIATIVE TEAM STUDIES

POSSIBLE SCHEDULE

A = Jan—June
B = July—Dec



HKS target meeting

- Jan 10, 2022
- Dec 06, 2021
- Oct 22, 2021
- Oct 13, 2021
- Apr 27, 2021
- Jan 14, 2021 (TargetMeeting_20210114_gogami.pdf)
- Jan 08, 2021 (TargetMeeting_20210108_gogami.pdf)
- Dec 01, 2020 (TargetMeeting_20201201_gogami.pdf)

TARGET FOR HYPERNUCLEAR MEASUREMENTS

① C12-20-003 (^{3}H)

② C12-19-002 (^{3,4}He)

③ E12-15-008 (^{40,48}Ca + ^{6}Li, ^{11}B, ^{12}C …)

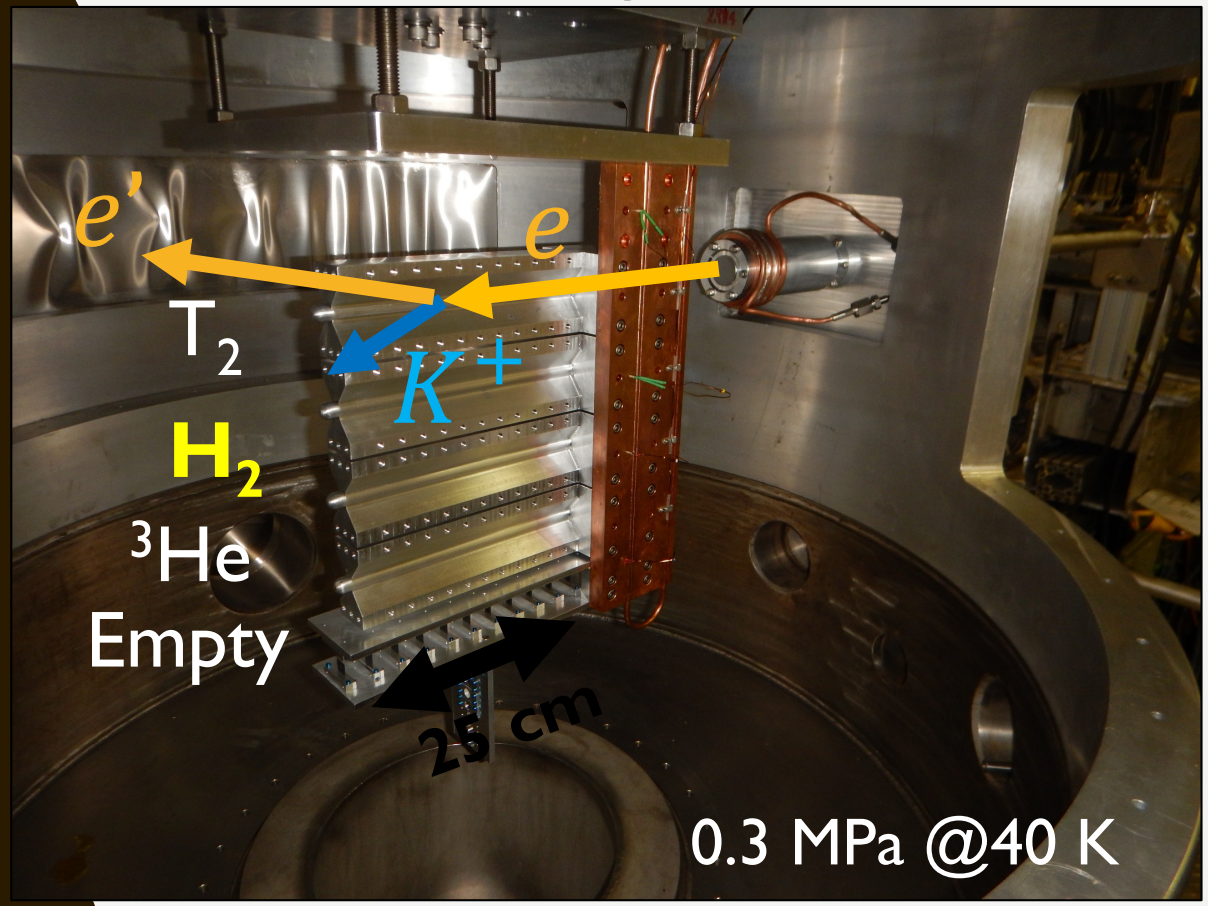
④ E12-20-013 (^{208}Pb)

- 7 W (+12 W) for 100 mg/cm^{2} target (Al cell) @50μA

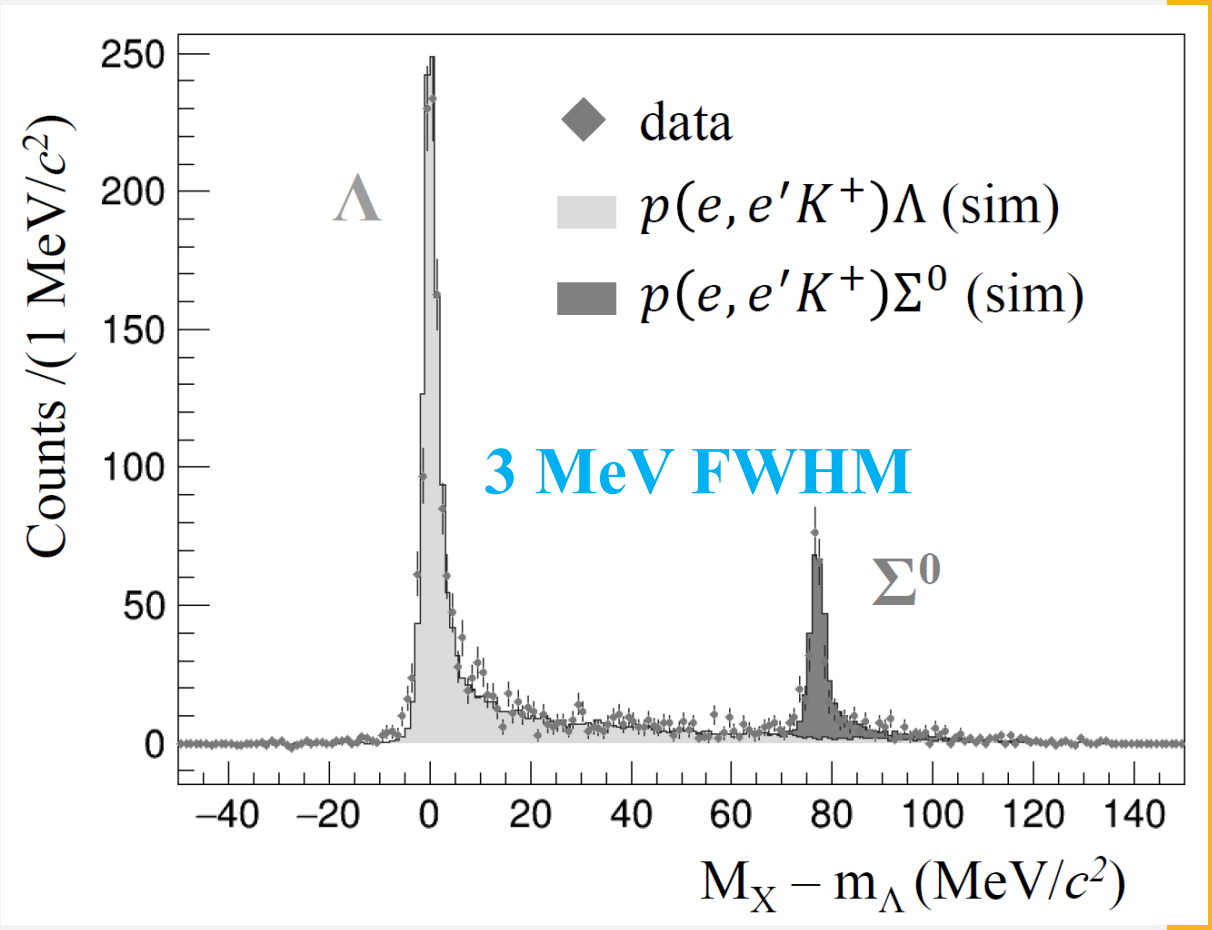
Study and conceptual design of multi-foil target
Yuki and Sho (Tohoku Univ.)

Energy calibration by Λ and Σ

Inside of scattering chamber

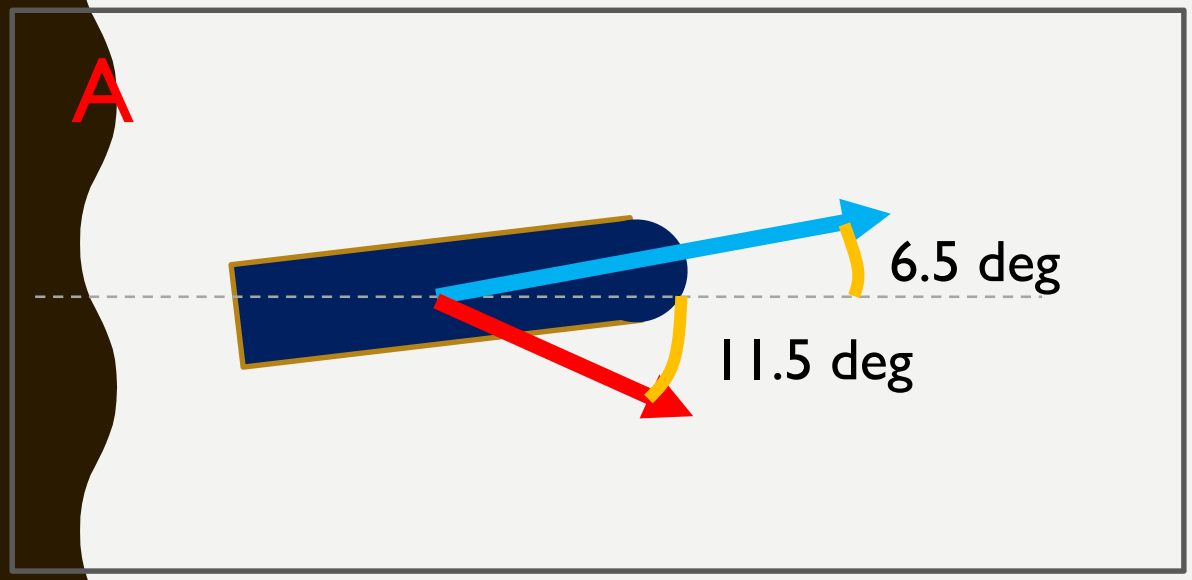


$H(e,e'K^+)\Lambda,\ \Sigma^0$

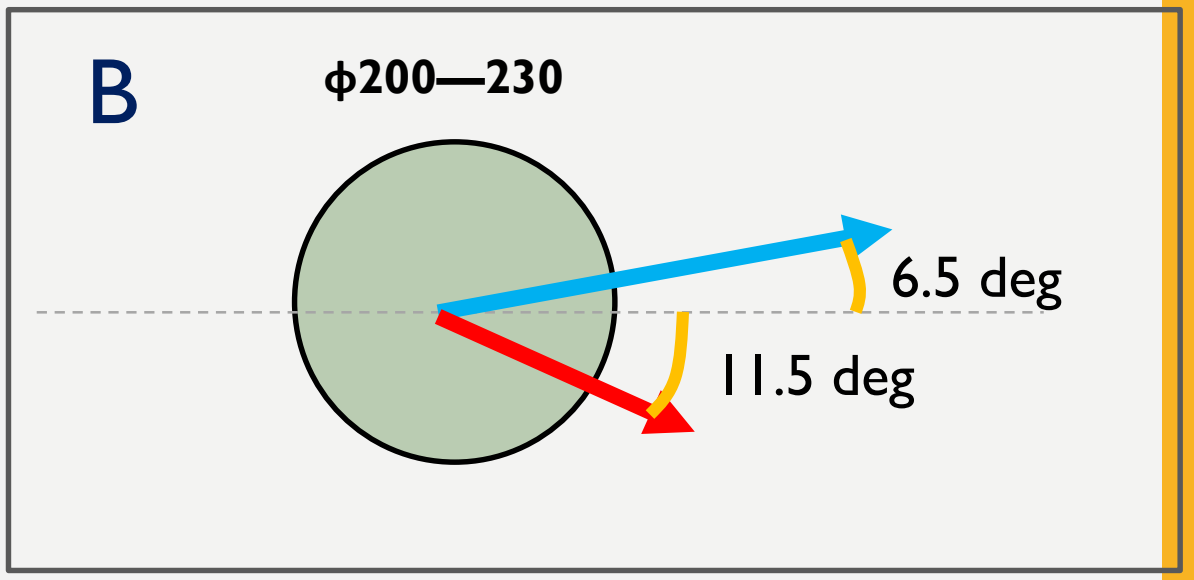


K.N. Suzuki et al., PTEP in Press (2021): https://academic.oup.com/ptep/advance-article/doi/10.1093/ptep/ptab158/6454035

IDEAS FOR TARGET CELL

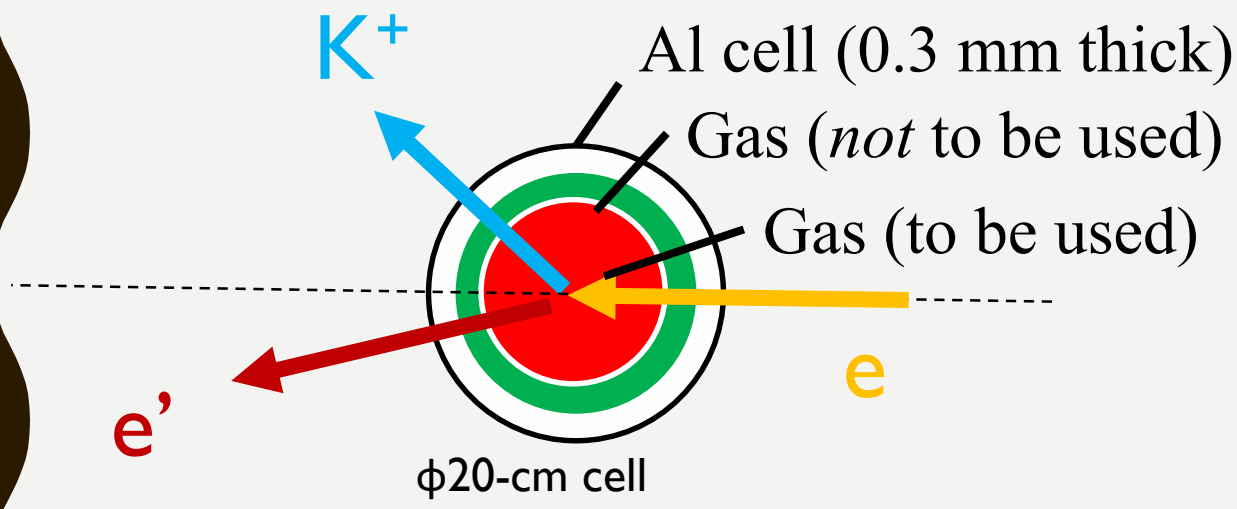


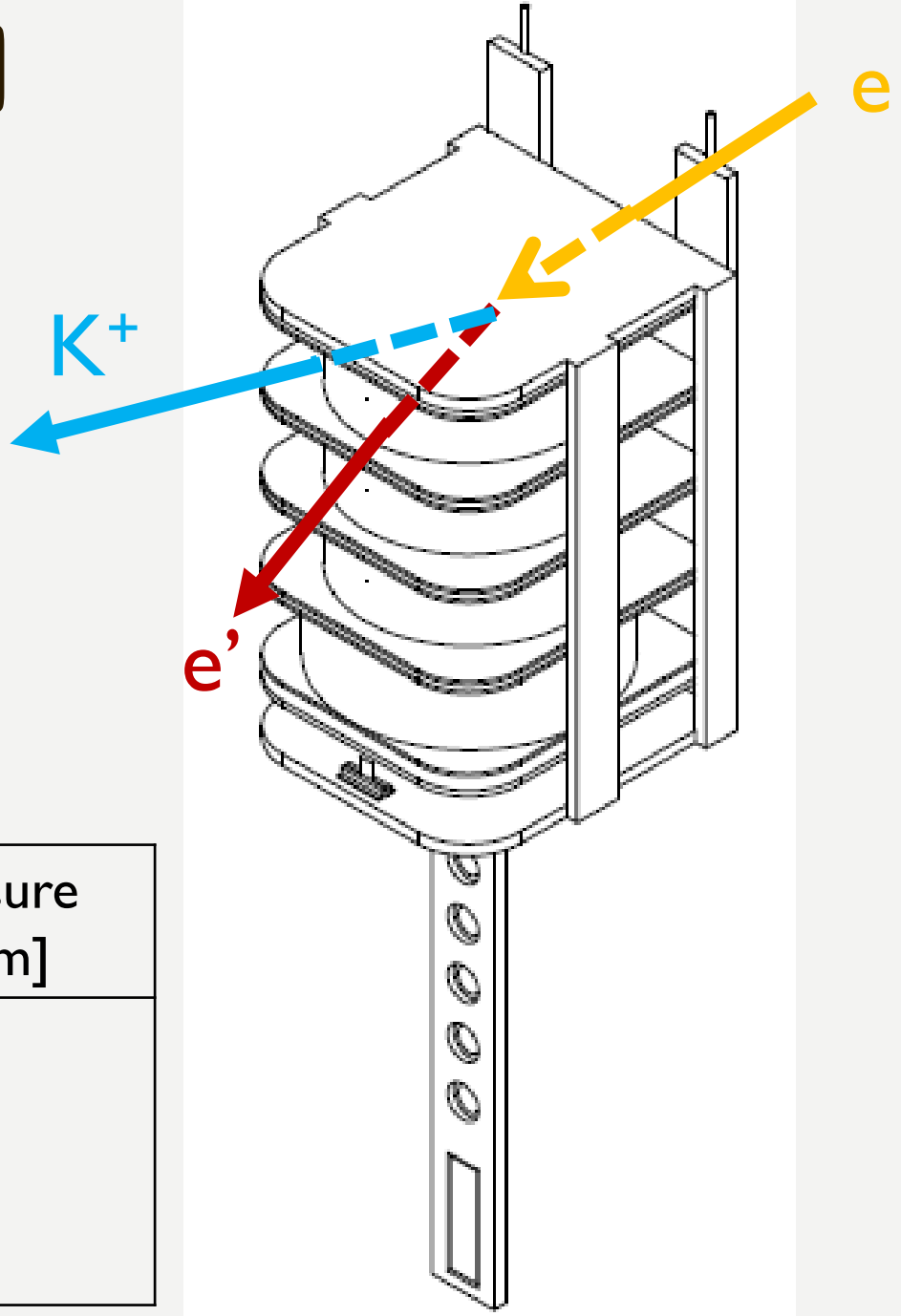
Large systematic error



We will use this cell

TARGET CELLS (TUNA CAN)





Target	Density [/(g/cm^3)]	Temperature [/K]	Pressure [/atm]
^{3}He	9.5	12	3
^{4}He	13.1		
$^1H_2$	2.8	30	

Calibrations and a systematic error on B_Λ

Calibration	Target + Sieve Slit	Reaction	z_t range (mm)	Beamtime (day)	Remarks
Mom. + z_t	H	$p(e,e'K^+)\Lambda,\Sigma^0$	$-110 < z_t < 110$	1	Λ: 3500, Σ^0: 1150
Mom. + z_t	^{12}C (multi foils)	$^{12}\mathrm{C}(e,e'K^+)^{12}_{\Lambda}\mathrm{B}$		1	$^{12}_{\Lambda}\mathrm{B}^{\mathrm{g.s.}}$: 300 × 5
Angle + z_t	^{12}C (multi foils) + SS	-		0.2	
z_t	Empty	-	$-100 < z_t < 100$	0.1	+ Background study
	Empty (or gas) + SS	-		0.2	+ Angle resolution check
Physics	^{3,4}He	$^{3,4}_{\Lambda}$H	$-100 < z_t < 100$	12	

Major contributions to a systematic error on B_Λ

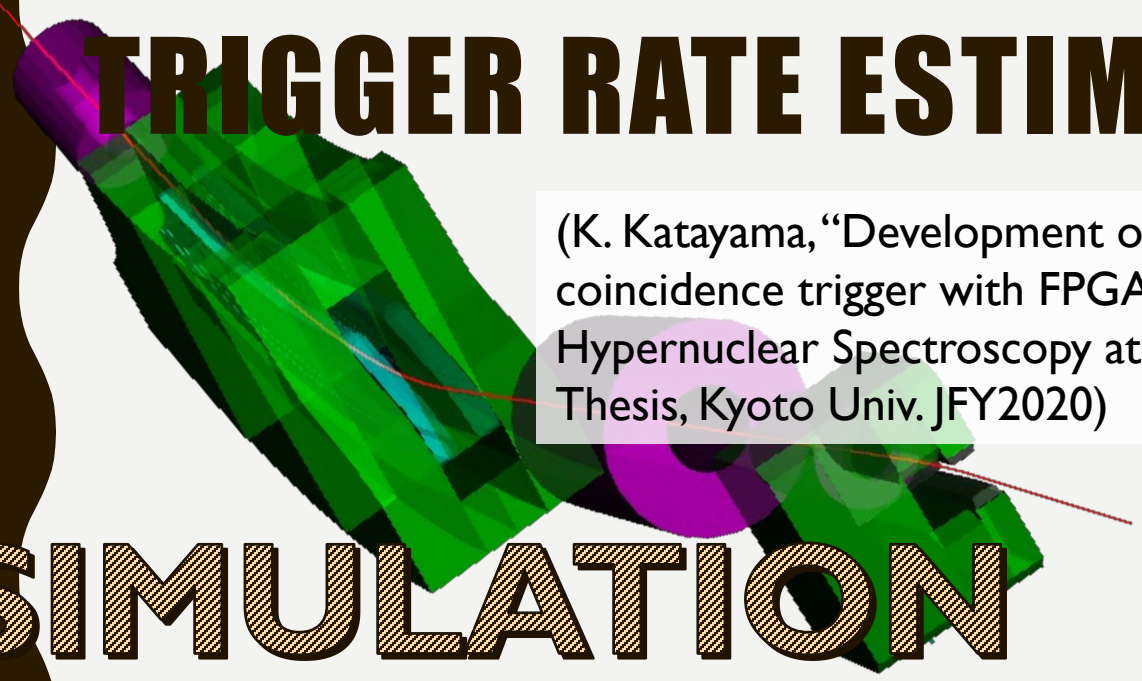
- Energy scale calibration(*) : ± 50 keV
- Energy loss correction: ± 23 keV
  - target density: $\pm 3\%$
  - **cell thickness uniformity: $\pm 25\mu m$**

(*) **NIMA 900 (2018) 69—83**

$$|\Delta B_\Lambda^{\mathrm{sys.}}| = 55 \text{ keV}$$

(T. Toyoda, "Basic design of gas targets for precise hypertriton mass measurement at JLab", Master's Thesis, Kyoto Univ. JFY2020)

TRIGGER RATE ESTIMATION



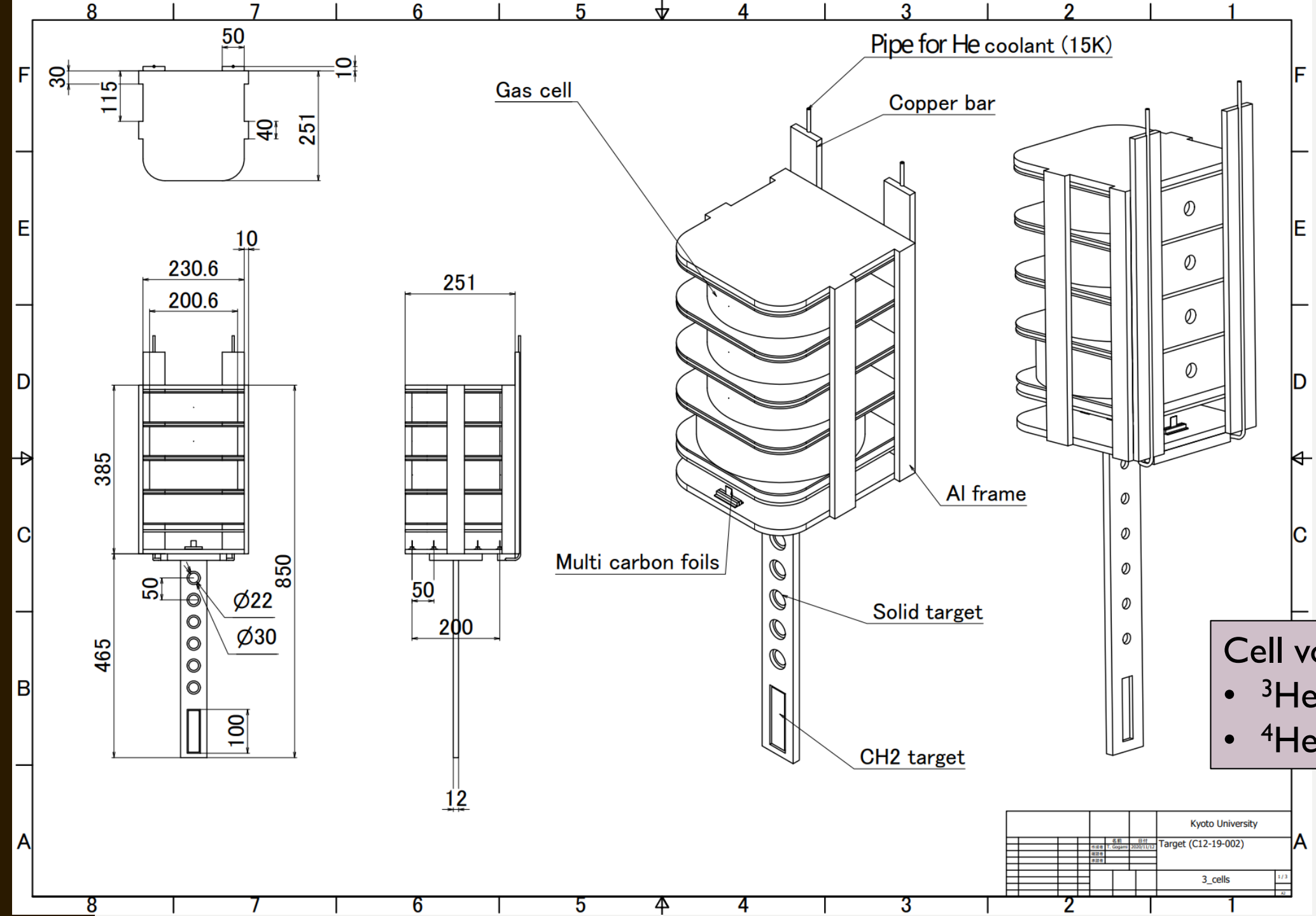
SIMULATION

(K. Katayama, "Development of HRS-HKS coincidence trigger with FPGA - Precise Hypernuclear Spectroscopy at JLab -", Master's Thesis, Kyoto Univ. JFY2020)

Geant4 (PCS+HRS+HKS) + Physics Event Generators

Target	Thickness (mg/cm^2)	Beam Current (μA)	e' (kHz)	p (kHz)	π (kHz)	Acc. rate (kHz)	Acc. rate w/ Chernkovs (kHz)
^{12}C	100	100	21.5	56	71	**0.4**	0.023
^{40}Ca	100	50	64.5	48	71	**1.2**	0.060
^{208}Pb	100	25	97.0	22	33	**0.8**	0.041
$^{3}He+^{27}Al$	190+162	50	90.8	163.2	252.5	**3.2**	**0.15**
$^{4}He+^{27}Al$	262+162	50	91.2	201.6	355.9	**4.9**	**0.23**

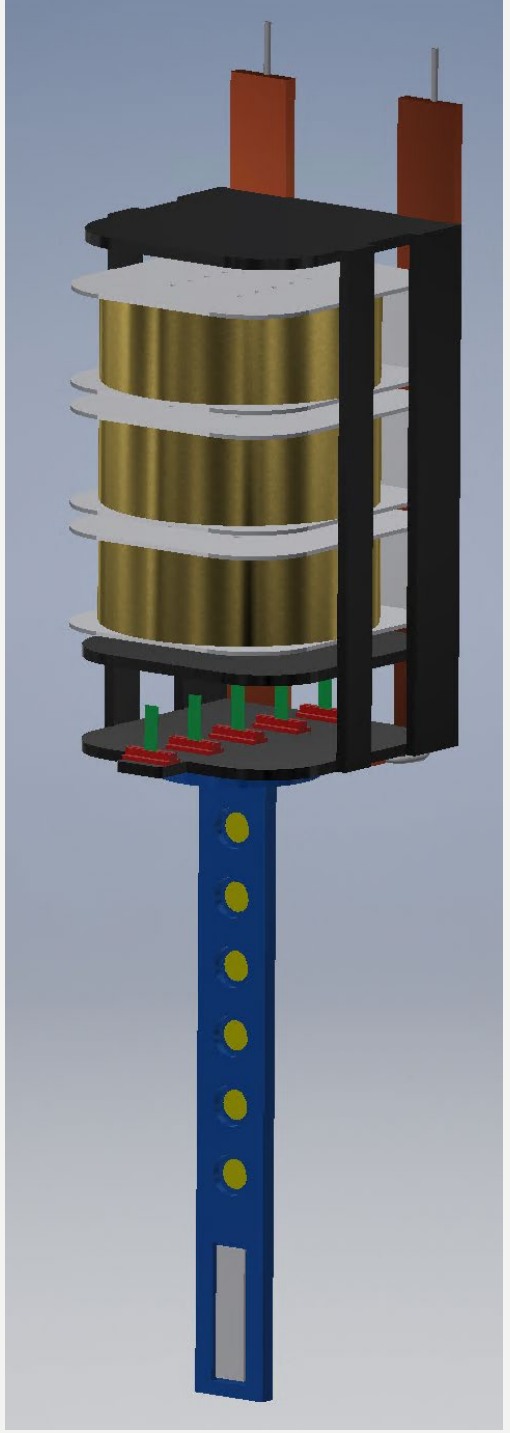
Particle identification by HKS: **NIMA 729, 816—824 (2013)**

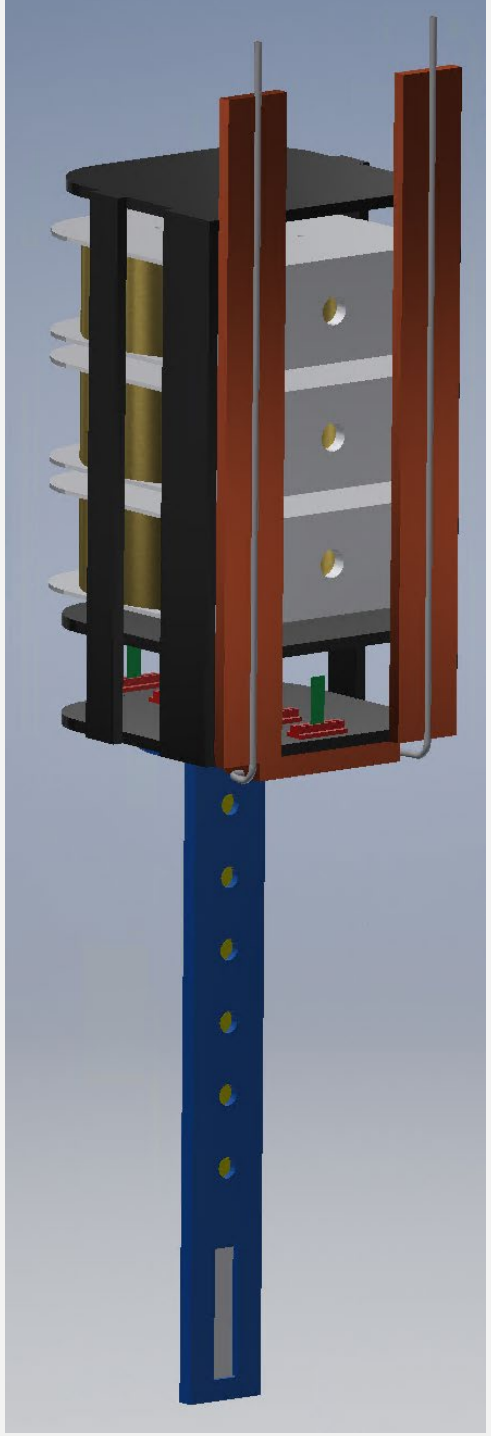


Cell volume → 1.57 l

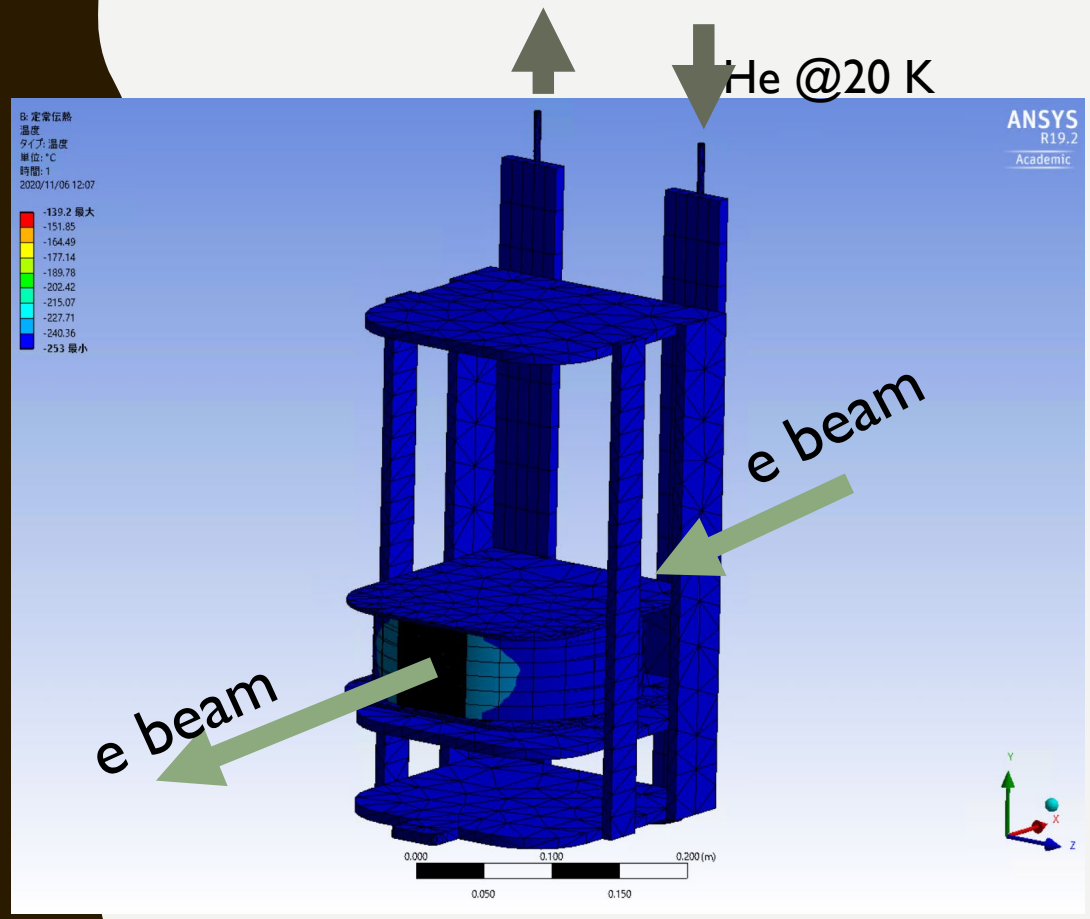
- ^{3}He 3.3 g
- ^{4}He 6.8 g

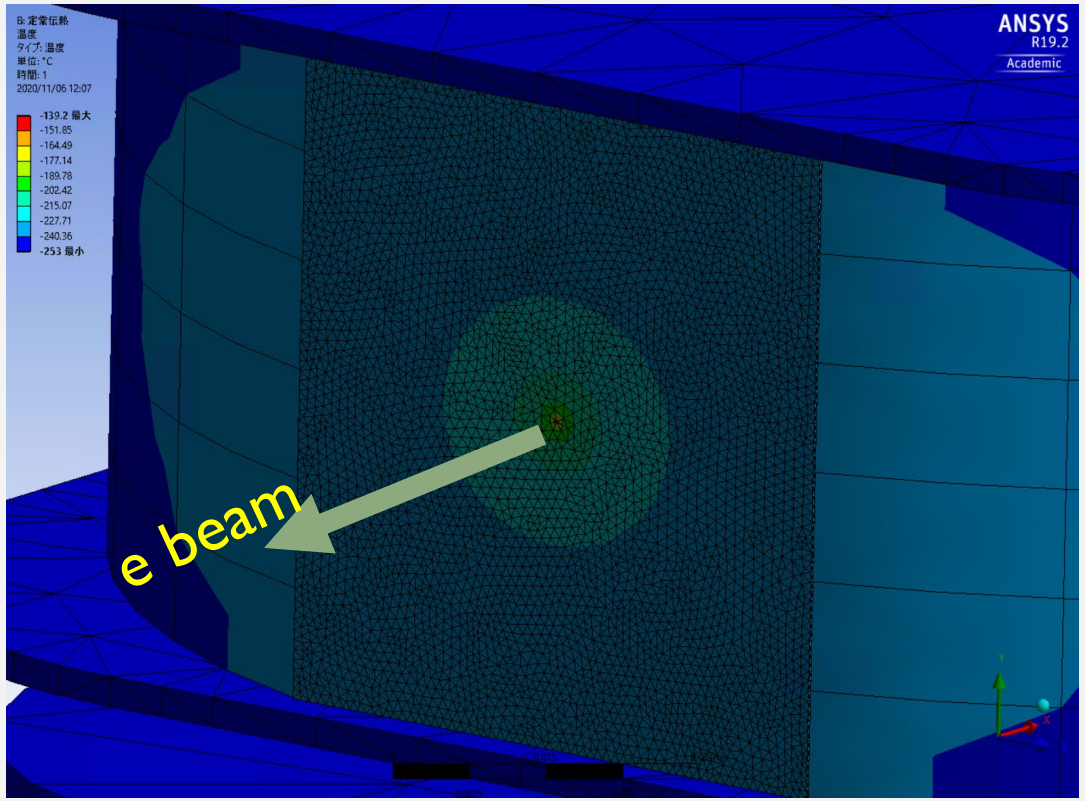
ANSYS





HEAT SIMULATION BY ANSYS (0.3 MM THICK AL)





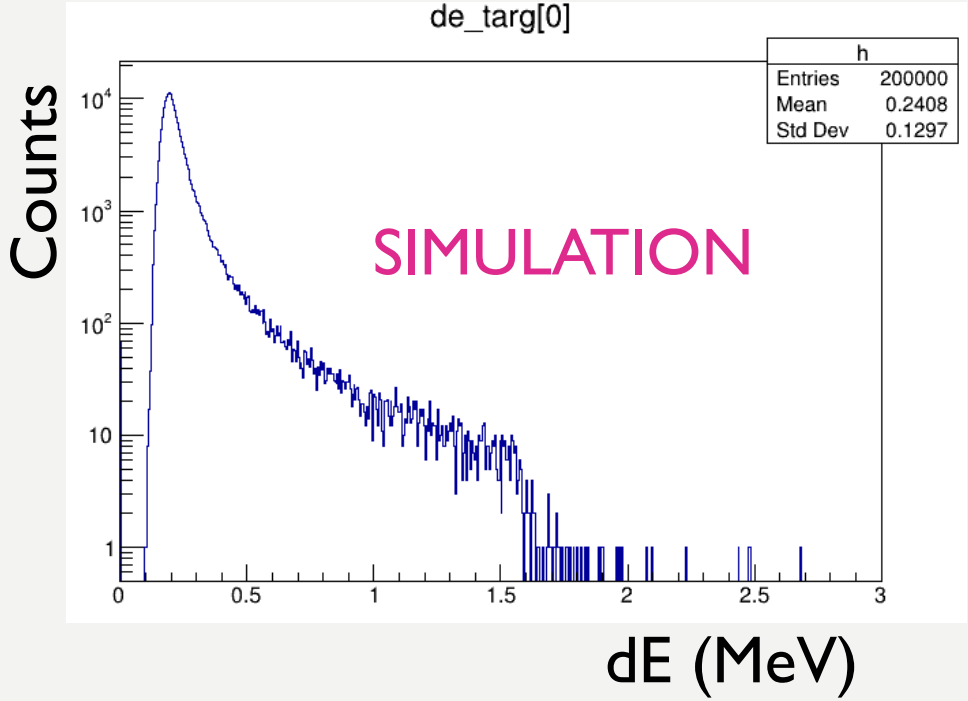
- 50μA electron beam
- 0.3 mm Al

➔ 6 W

Thermal contact coefficient h = 300 W/m²K

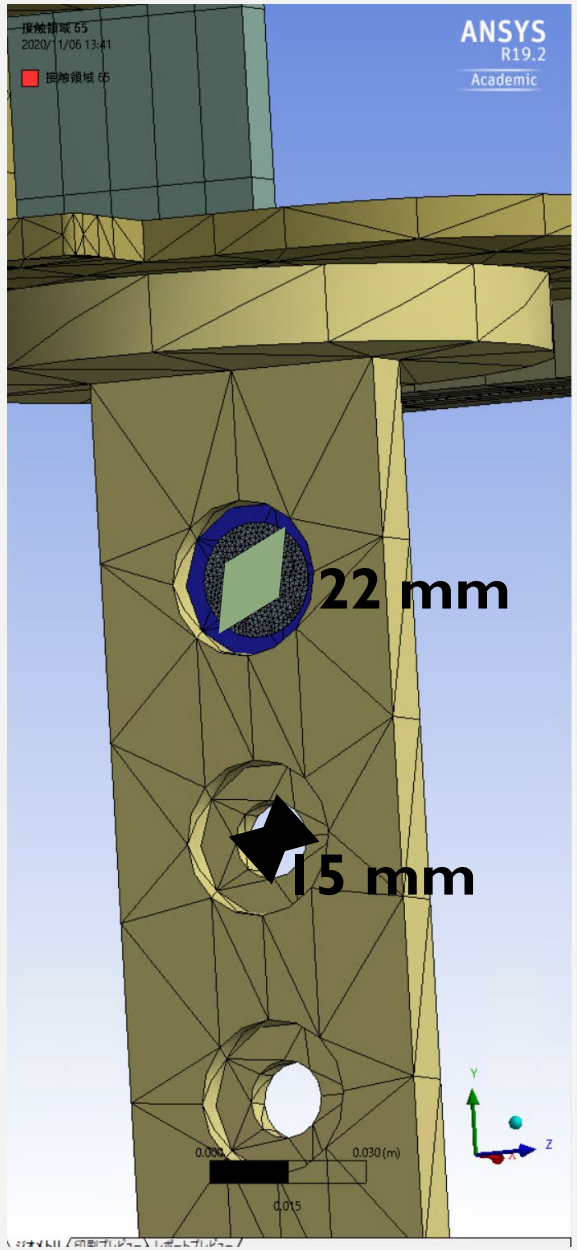
→ Max temp. = 130 K

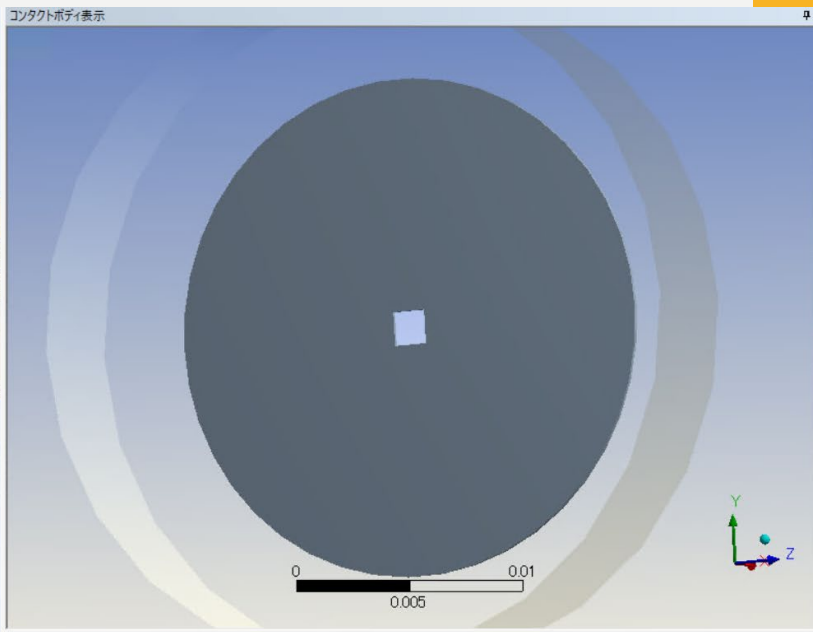
Test (Pb target)

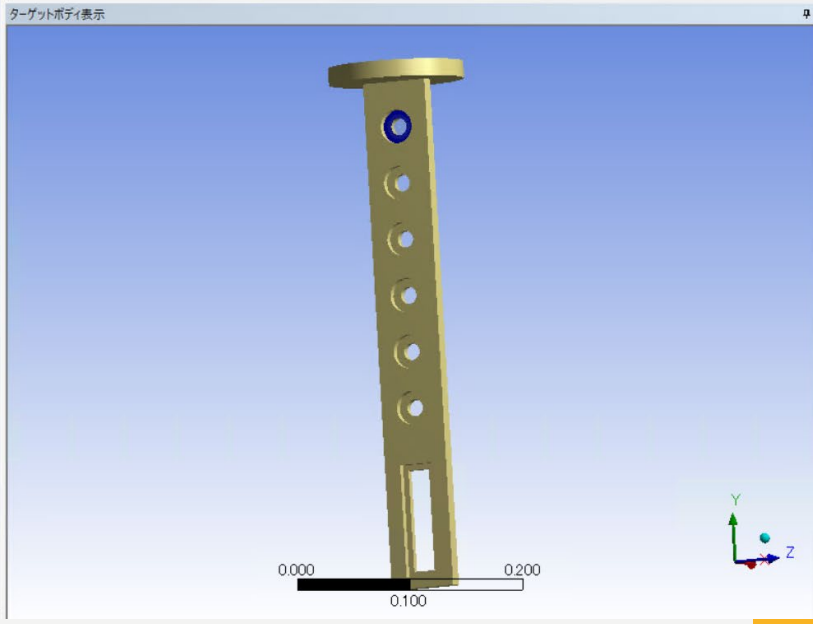


Gean4 with a 0.2 g/cm^2 of Pb
→ Mean dE = 240 keV
→ **6 W @25 µA**

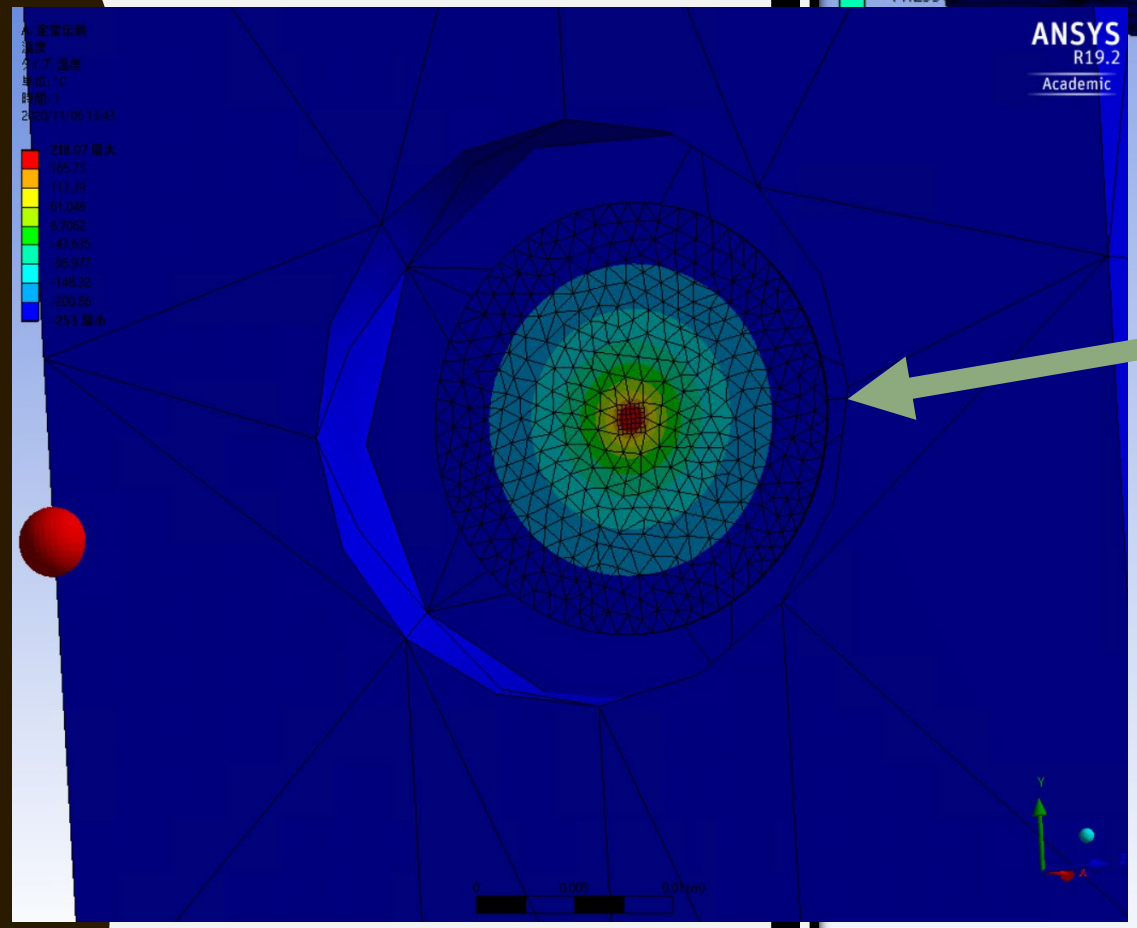
Thermal contact coefficient
→ h = 300 W/m^{2}K (and 1000 W/m^{2}K was also tested)

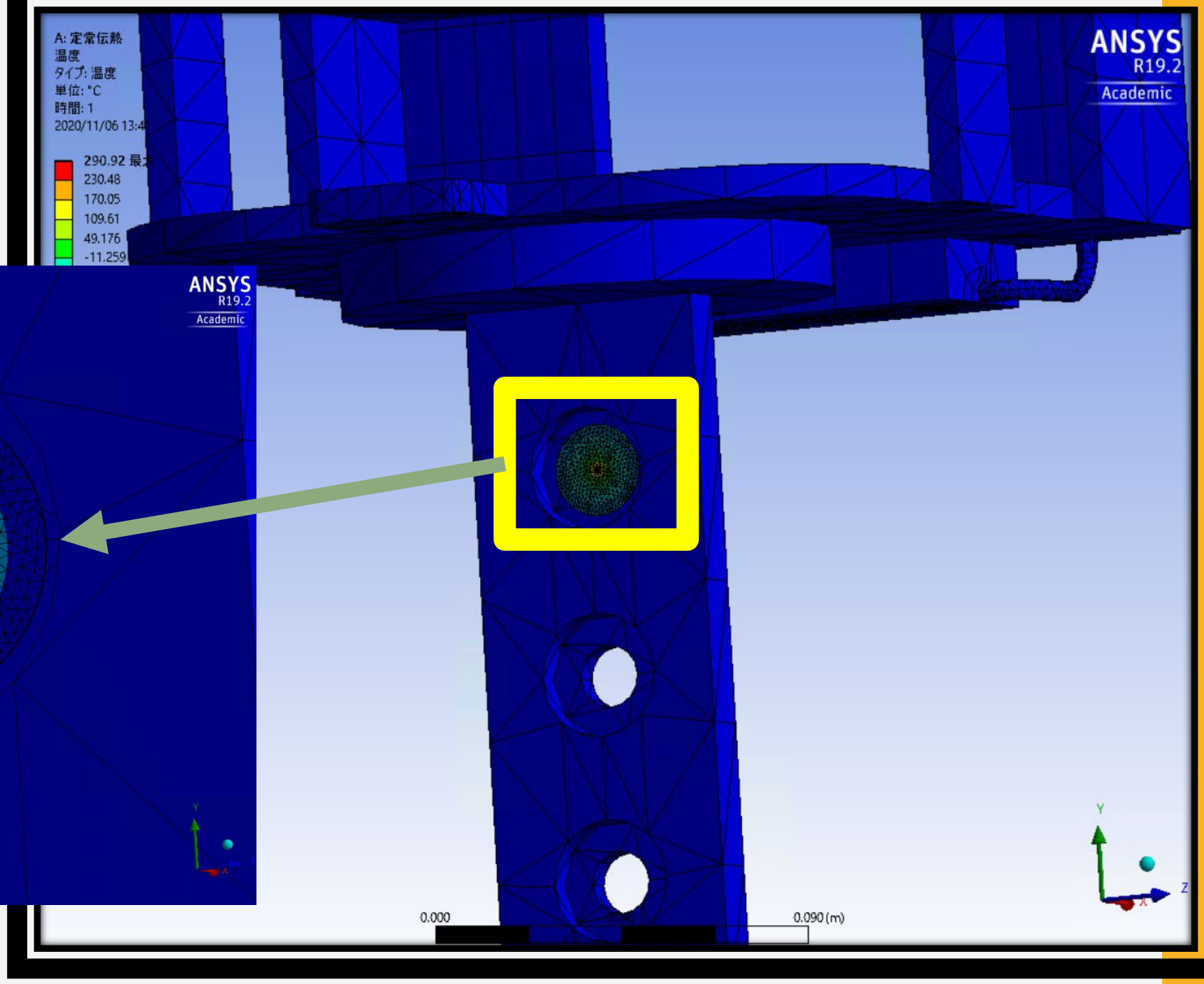




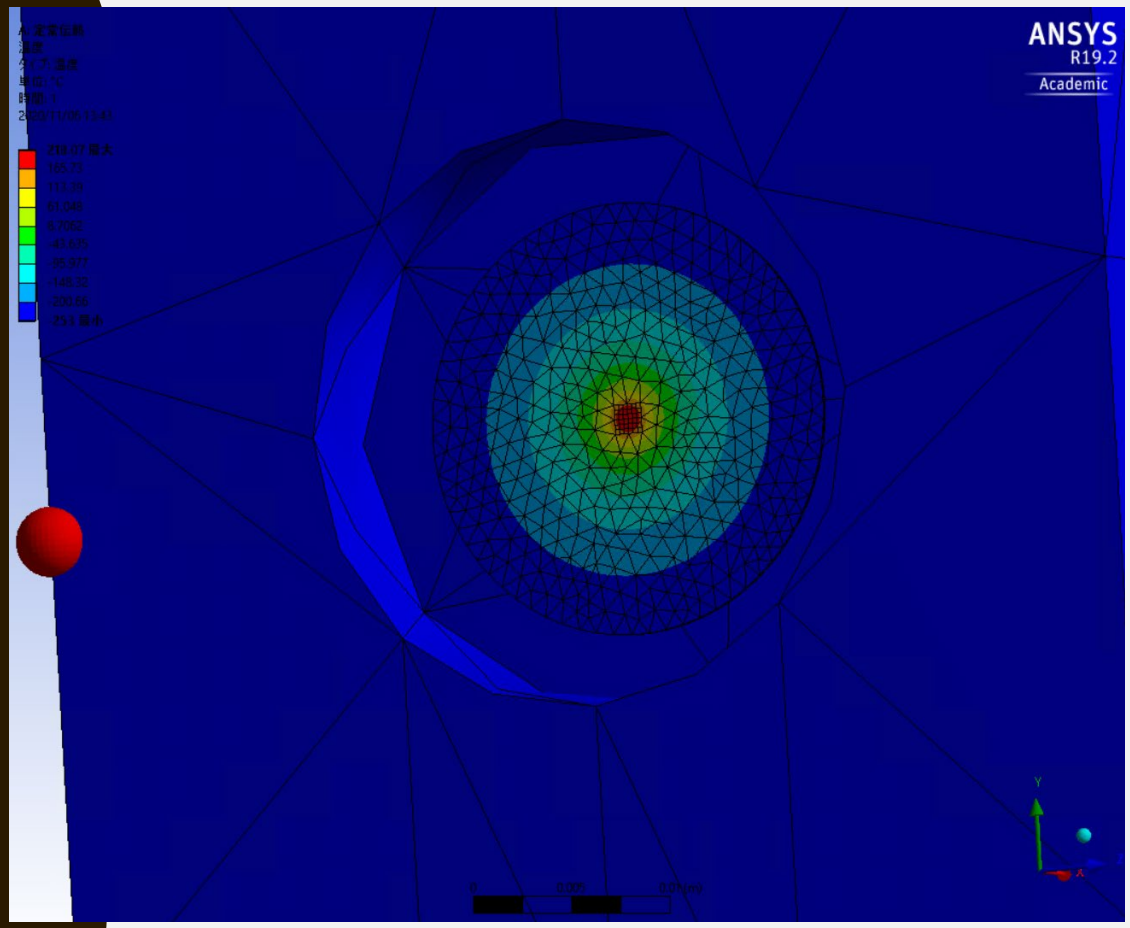


Test
(Pb target)





MAXIMUM TEMPERATURE (0.2 G/CM² PB, 25 MA)



- Raster size = 1.5 × 1.5 mm²
- Beam current = 25 μA
  → Heat deposit = 6 W

Max. temp.

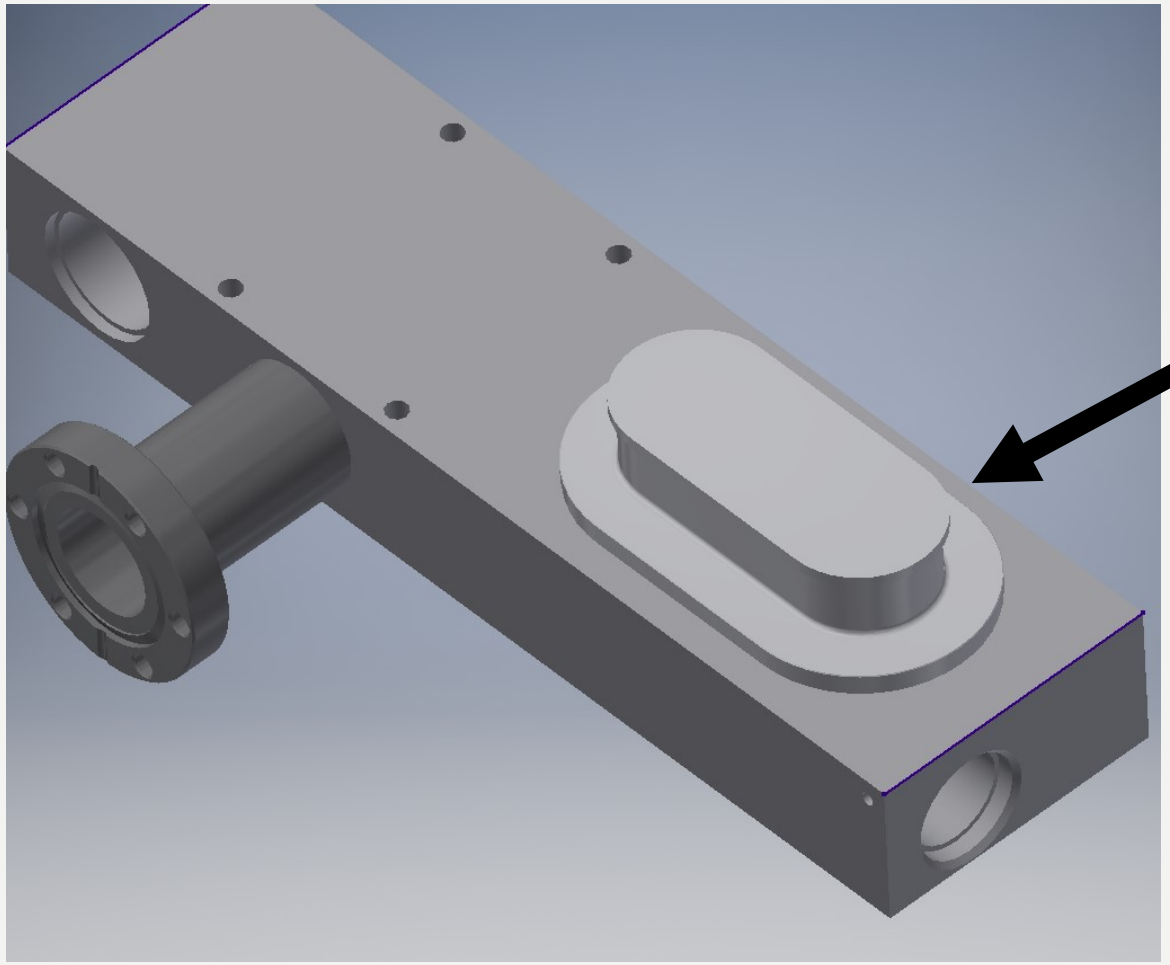
563 K @ h = 300 W/m²K

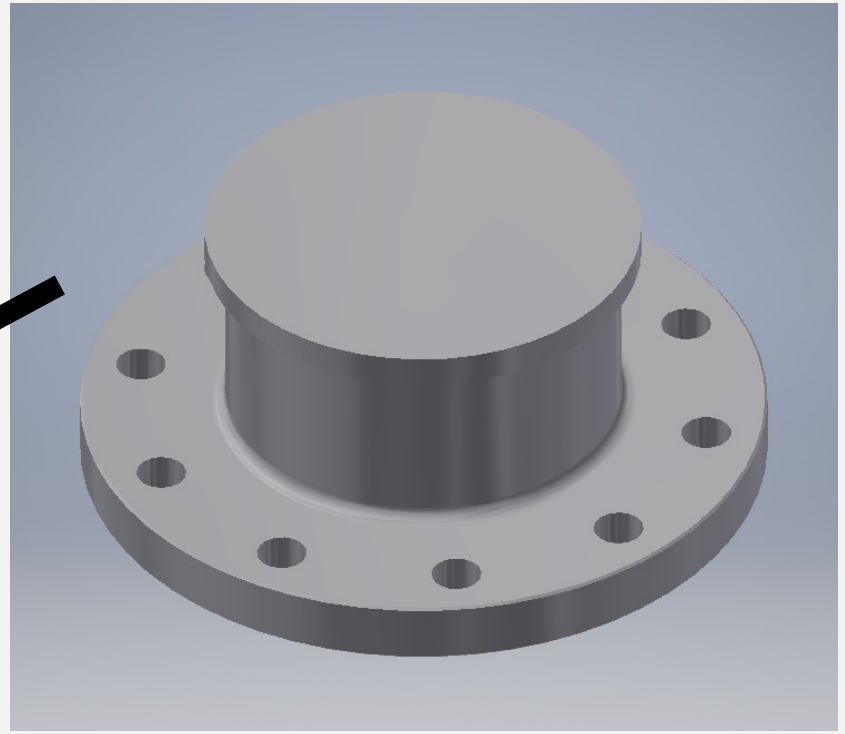
491 K @ h = 1000 W/m²K

(Melting pint = 600 K)

Very simple model does not hit the limit

CELL + BLOCK





300 μm thick Al alloy

SUMMARY

- Tuna can cell
- 300-μm thick Al alloy (Al7075)
- Detailed design started
- ERR for the target part in October 2022