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https://indico.jlab.org/event/985/

Thermal simulation for HKS target by ANSYS

Graduate School of Science, Kyoto University

Kei Ishido

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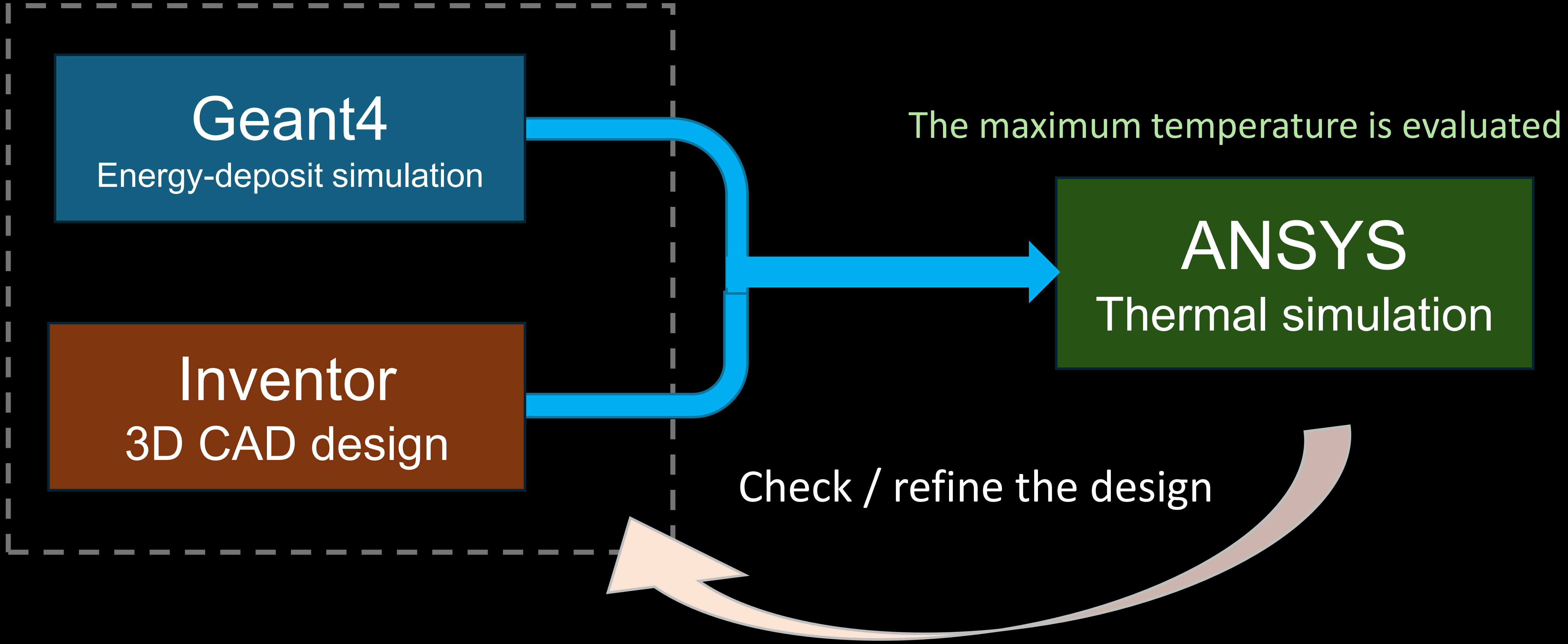
Target list

Material	Thickness (mg/cm²)	Density (mg/cm³)	Beam current (μA)
$^{6}\mathrm{Li}$	100	0.534	50
$^{9}\mathrm{Be}$	100	1.848	50
$^{11}\mathrm{B}$	100	2.340	50
$^{27}\mathrm{Al}$	150	2.70	50
$^{40}\mathrm{Ca}$	150	1.55	50
$^{48}\mathrm{Ca}$	150	1.55	50
$^{208}\mathrm{Pb}$	150	11.342	25
$^{12}\mathrm{C}$	150	1.750	50
$^{12}\mathrm{C}$ hall	150	1.750	50
LiH	450/150/100	0.820	50
H_2O	-	1.00	-
CH_2	450	0.930	2

Experiment target ($^{6}\mathrm{Li}$ – $^{208}\mathrm{Pb}$)

Calibration target ($^{12}\mathrm{C}$ – CH_2)

Purpose and calculation flow



Geant4
Energy-deposit simulation

Inventor
3D CAD design

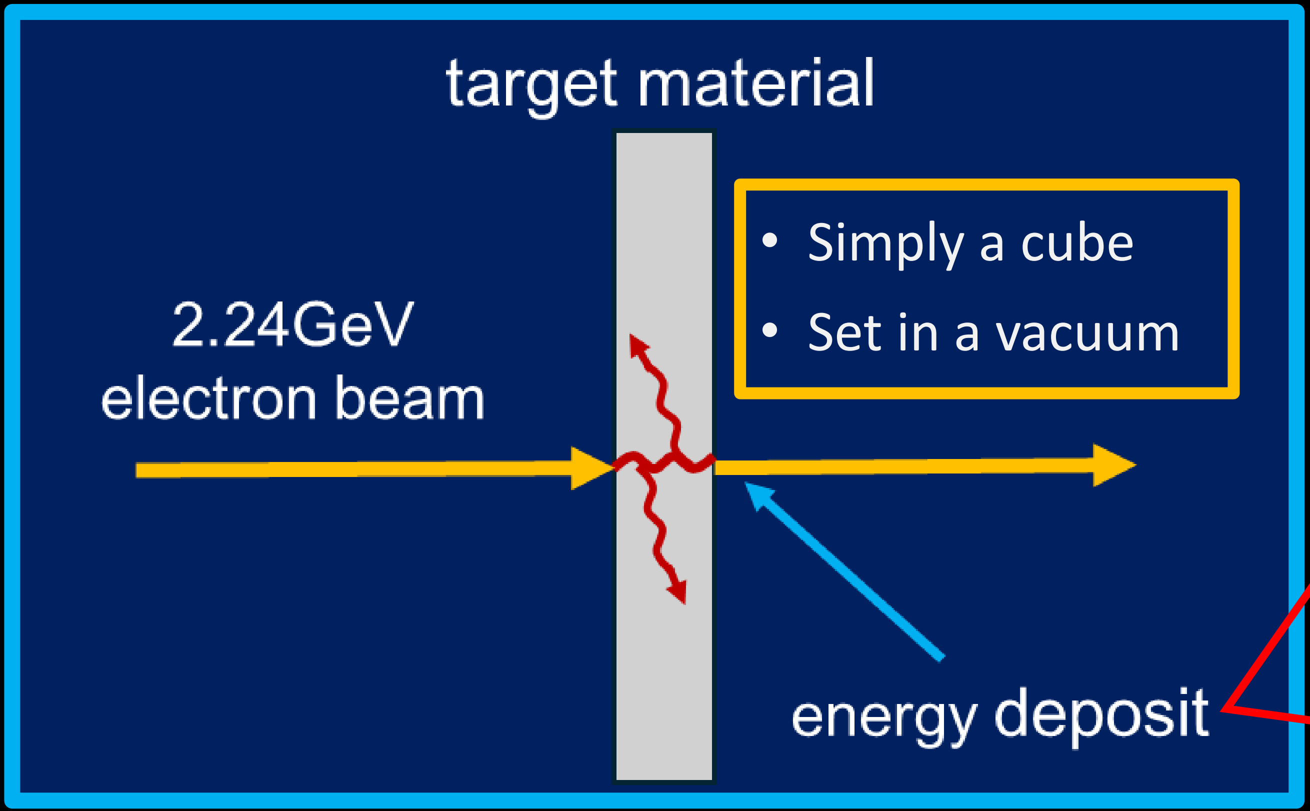
The maximum temperature is evaluated

ANSYS
Thermal simulation

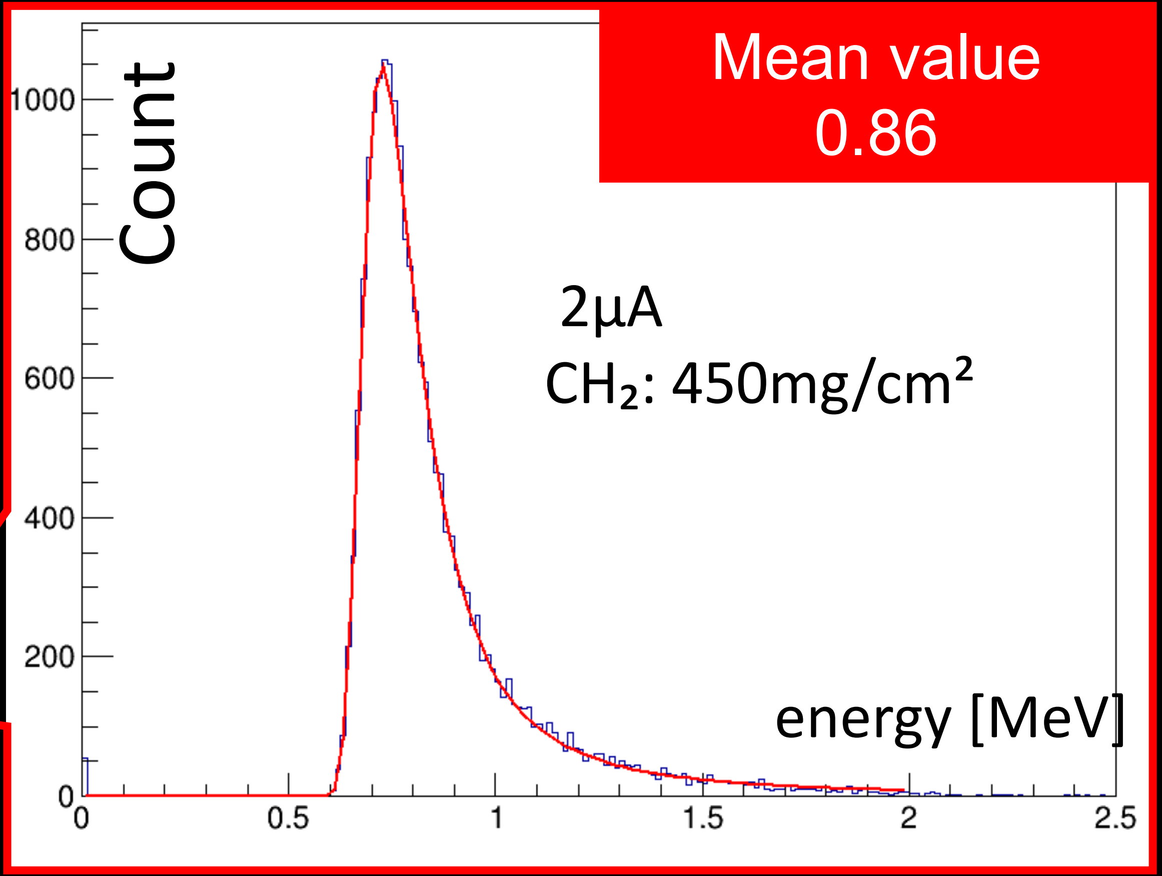
Check / refine the design

Energy deposit simulation by Geant4

Simulation set up


target material
2.24GeV electron beam
energy deposit

- Simply a cube
- Set in a vacuum

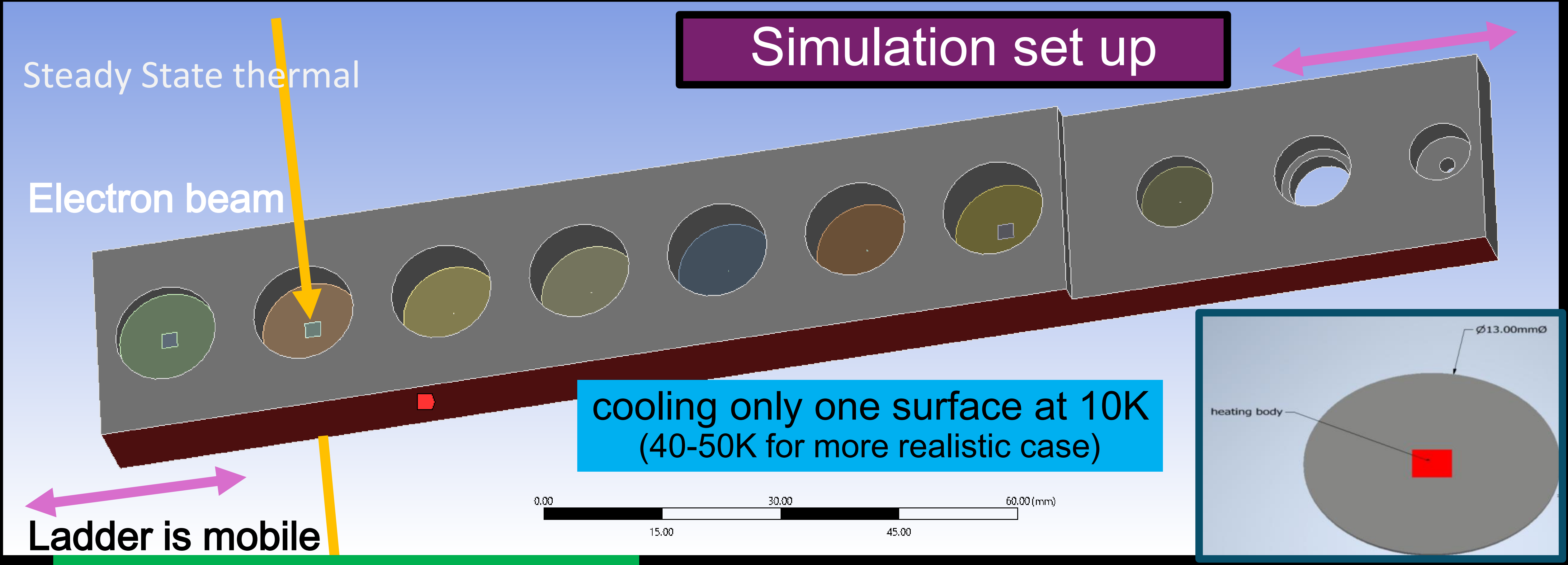


Energy deposit by Geant4 MC simulation

Material	CH_2	^{6}Li	^{9}Be	^{11}B	^{12}C	^{27}Al	^{40}Ca	^{48}Ca	^{208}Pb
Thickness (mg/cm²)	450	100	100		150				150
Energy deposit (mean value) (MeV)	0.86	0.16	0.14	0.14	0.24	0.22	0.24	0.20	0.18
Beam current (µA)	2	50	50						25
Energy deposit (W)	**1.7**	**8.3**	**7.1**	**7.2**	**12**	**11**	**12**	**10**	**4.5**

Raster ON

Thermal simulation by ANSYS


0.00
15.00
30.00
45.00
60.00 (mm)
Ø13.00mmØ
heating body

Simulation set up

Steady State thermal

Electron beam

Ladder is mobile

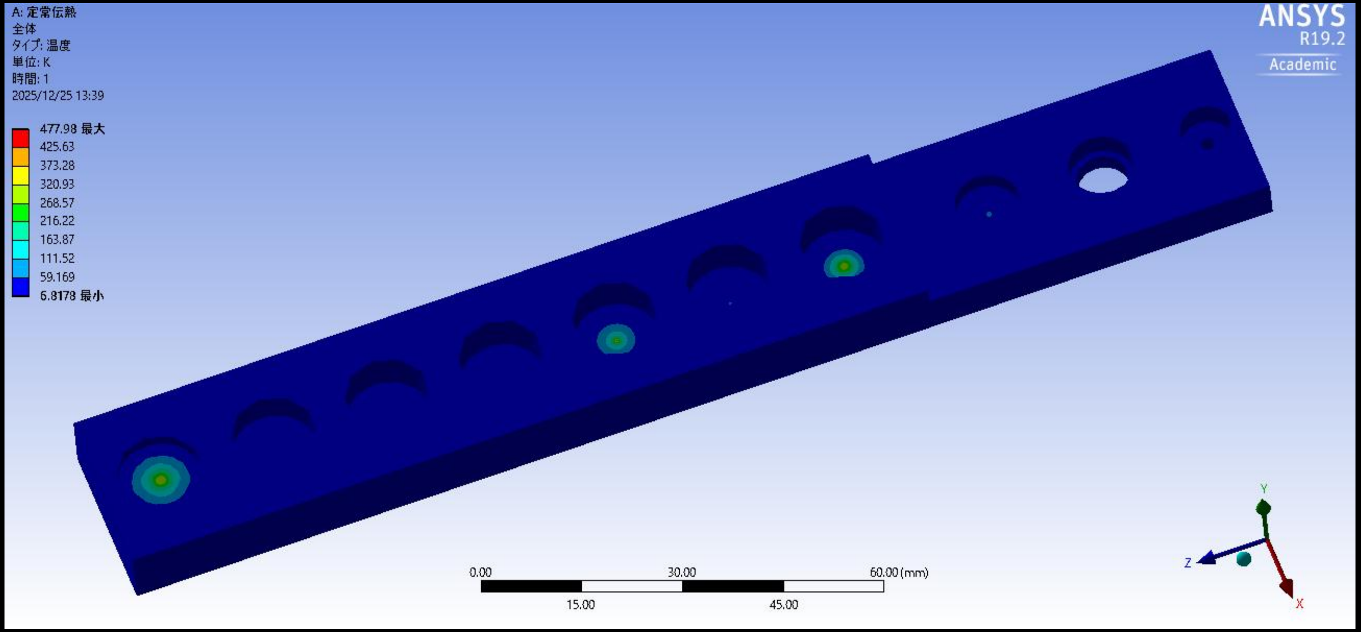
cooling only one surface at 10K
(40-50K for more realistic case)

Thermal conductivity between target and ladder frame: 100 W/(m・K)

Heating body($\phi = 100\mu$m / Raster=2 × 2mm²)

Thermal simulation results (ANSYS)

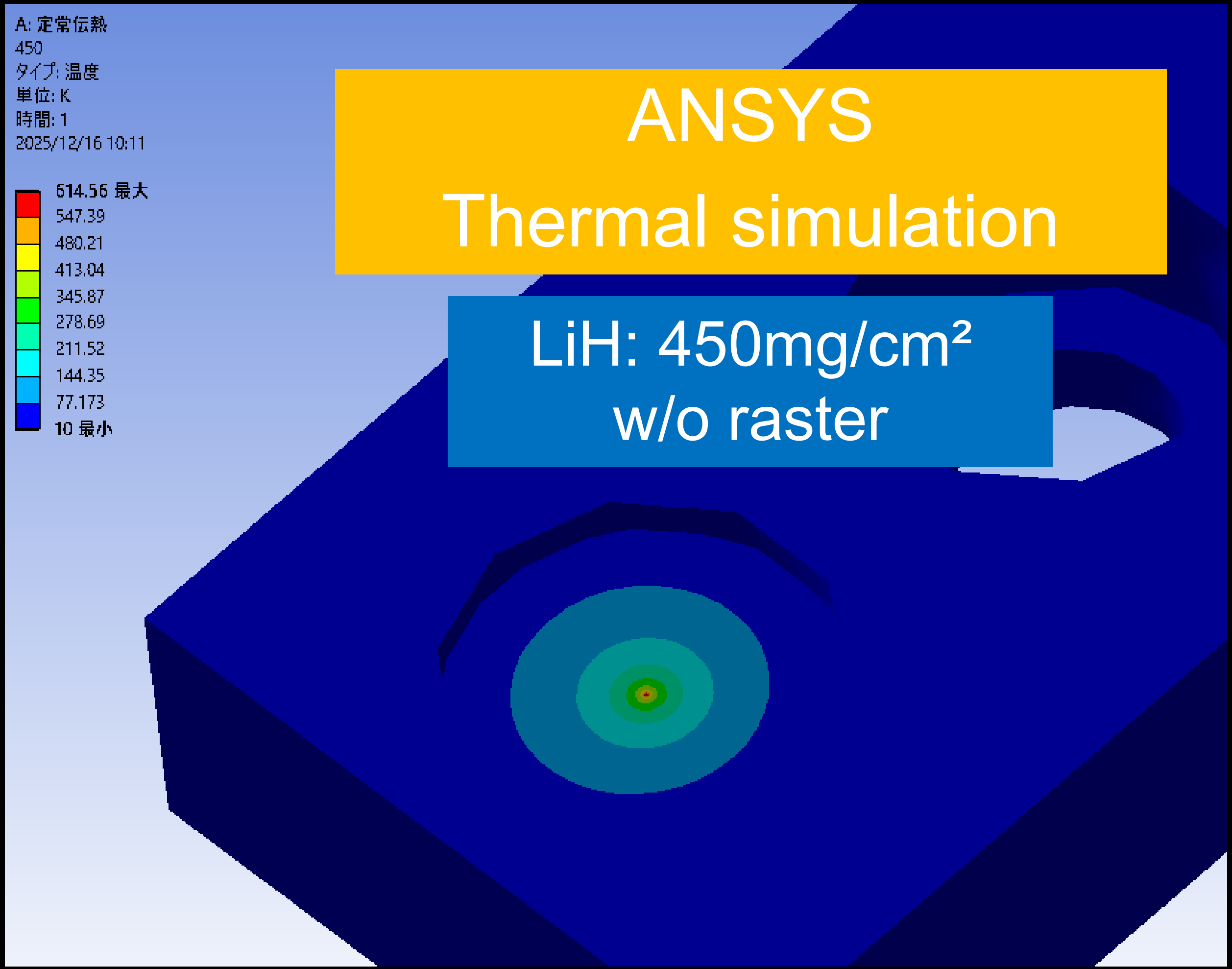
Material	CH_2	^{6}Li	^{9}Be	^{11}B	^{12}C	^{27}Al	^{40}Ca	^{48}Ca
Max Temp(K)	296	22.6	45.6	51.4	478	88.2	111	291
Melting point (K)	398	453	1560	2349	3823	933	1115	601


A: 定常伝熱
全体
タイプ: 温度
単位: K
時間: 1
2025/12/25 13:39
477.98 最大
425.63
373.28
320.93
268.57
216.22
163.87
111.52
59.169
6.8173 最小
ANSYS
R19.2
Academic
0.00
30.00
60.00 (mm)
15.00
45.00
Y
Z
X

Success of thermal calculations for simple models

➡ Next: more realistic simulations

Investigation of Lithium hydride(LiH) target

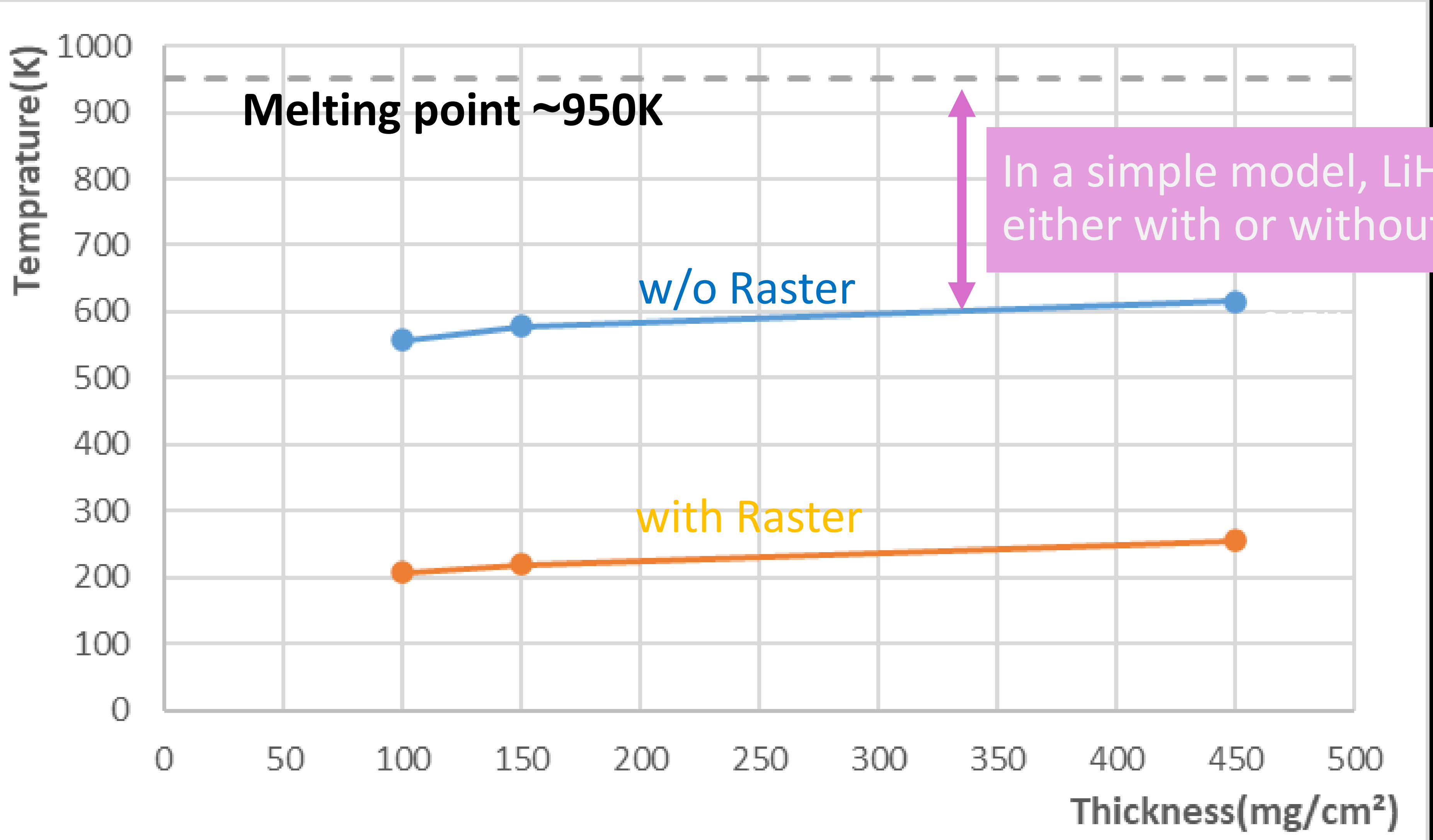

A: 定常伝熱
450
タイプ: 温度
単位: K
時間: 1
2025/12/16 10:11
614.56 最大
547.39
480.21
413.04
345.87
278.69
211.52
144.35
77.173
10 最小

ANSYS
Thermal simulation

LiH: 450mg/cm²
w/o raster

- density: 0.82g/cm³
- beam current: 50µA
- thermal conductivity: 10 W/(m·K)
- contact thermal conductivity: 100 W/(m ・ K)
- w/o raster or with raster
- melting point: 950K

LiH : Thermal simulation result



In a simple model, LiH does not melt, either with or without raster

Summary & outlook

Thermal simulation of the targets

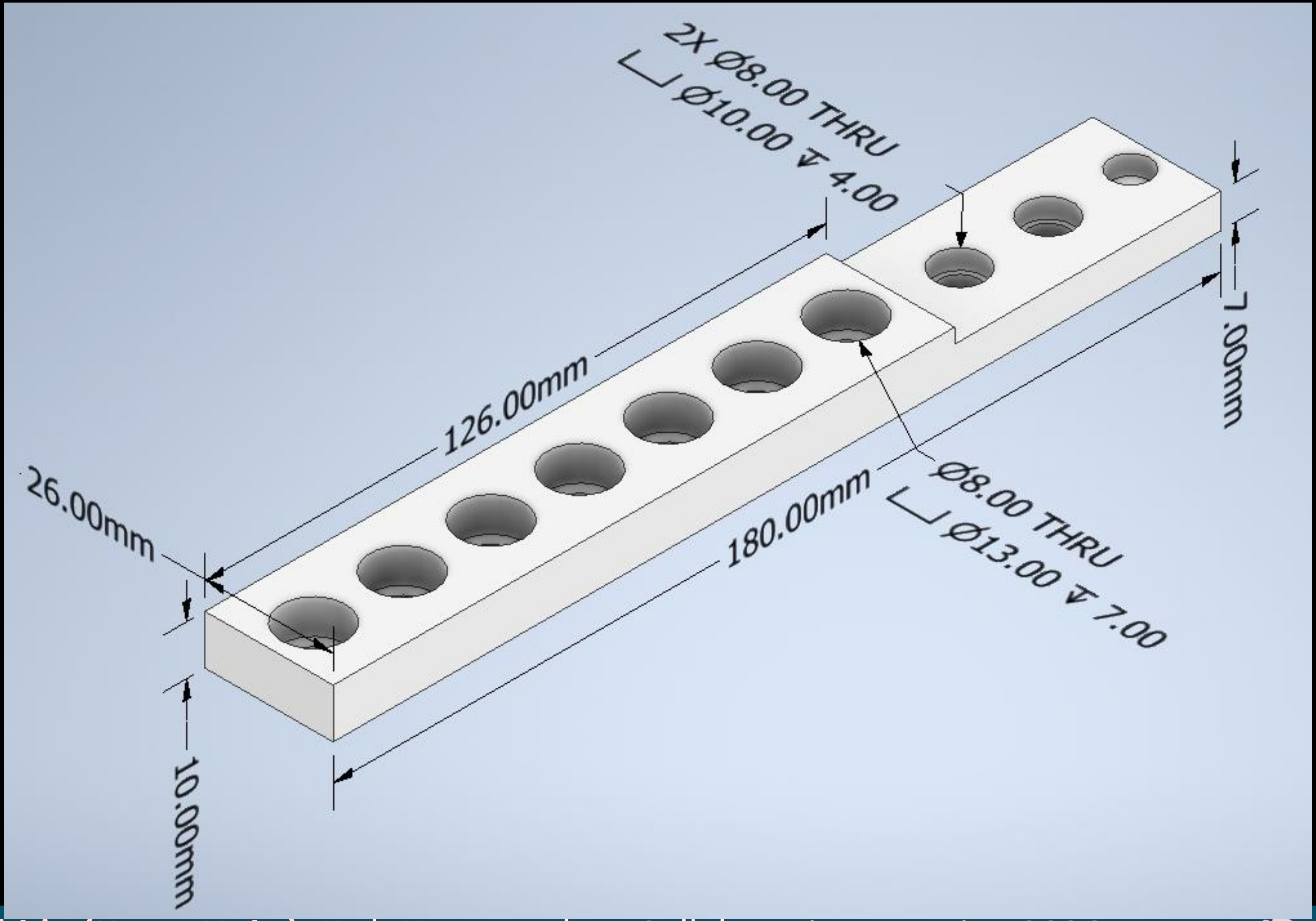
- Three tools
  - Geant4 (Energy deposit)
  - 3D-CAD software (design)
  - ANSYS (temperature)
- I have successfully gone through entire simulation flow

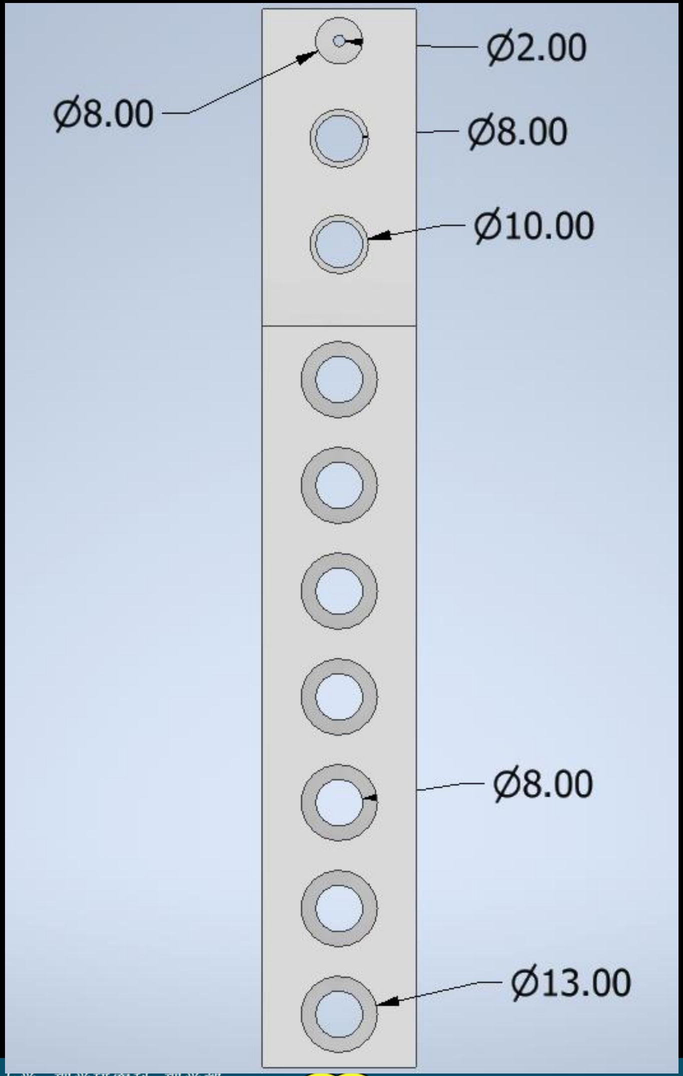
Outlook

- More realistic design will be incorporated in the simulation, cooperating with the target (David Meekins+) and designer teams
- Monte Carlo simulations for evaluating the effect on missing mass measurement from target design (thickness uncertainty / uniformity etc.) (in progress)

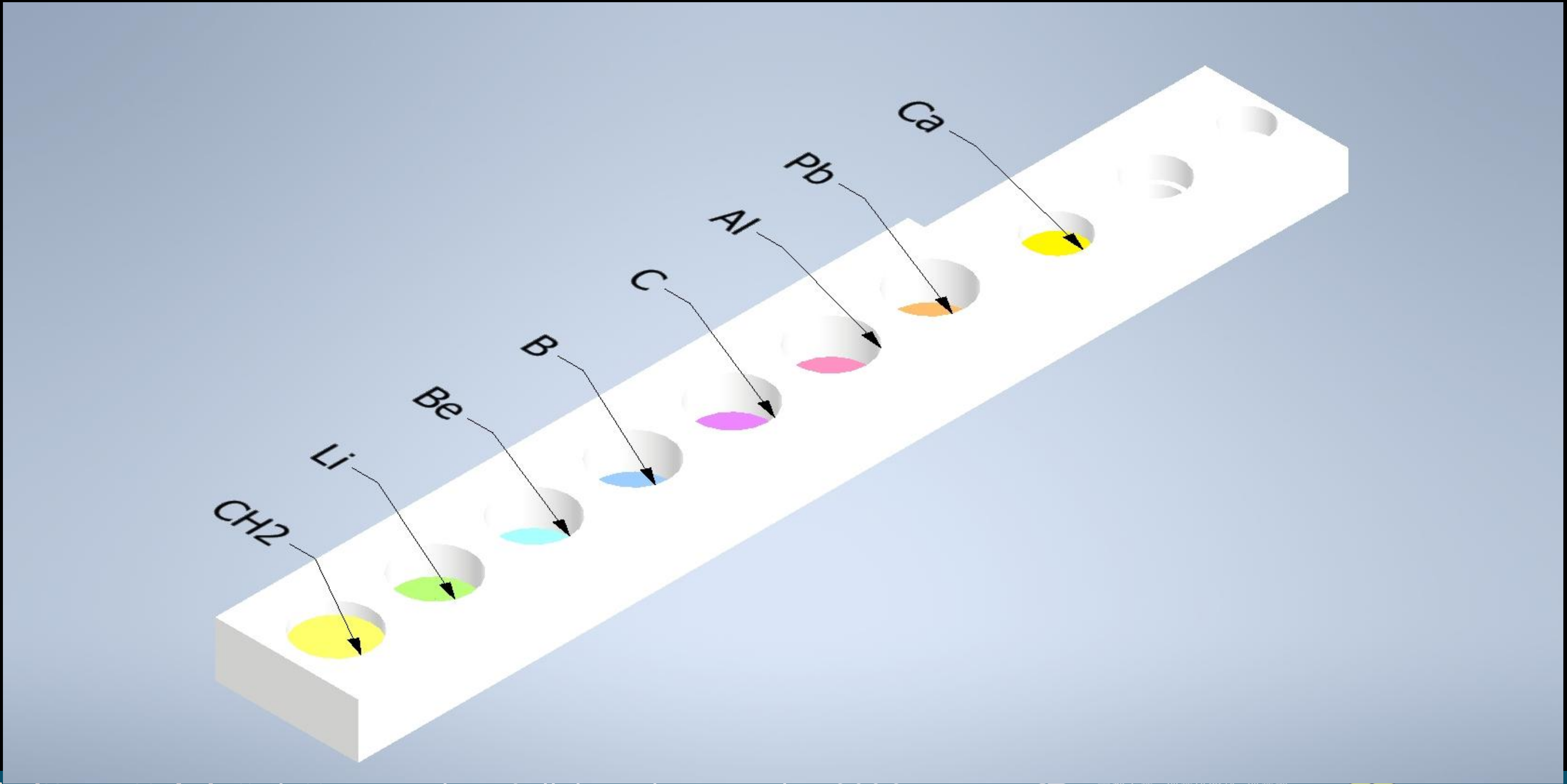
Back up

Ladder model for ANSYS simulation


2X Ø8.00 THRU
⌴ Ø10.00 ↧ 4.00
126.00mm
26.00mm
7.00mm
Ø8.00 THRU
⌴ Ø13.00 ↧ 7.00
180.00mm
10.00mm


Ø2.00
Ø8.00
Ø8.00
Ø10.00
Ø8.00
Ø13.00

Ladder model for ANSYS simulation


Ca
Pb
Al
C
B
Be
Li
CH2