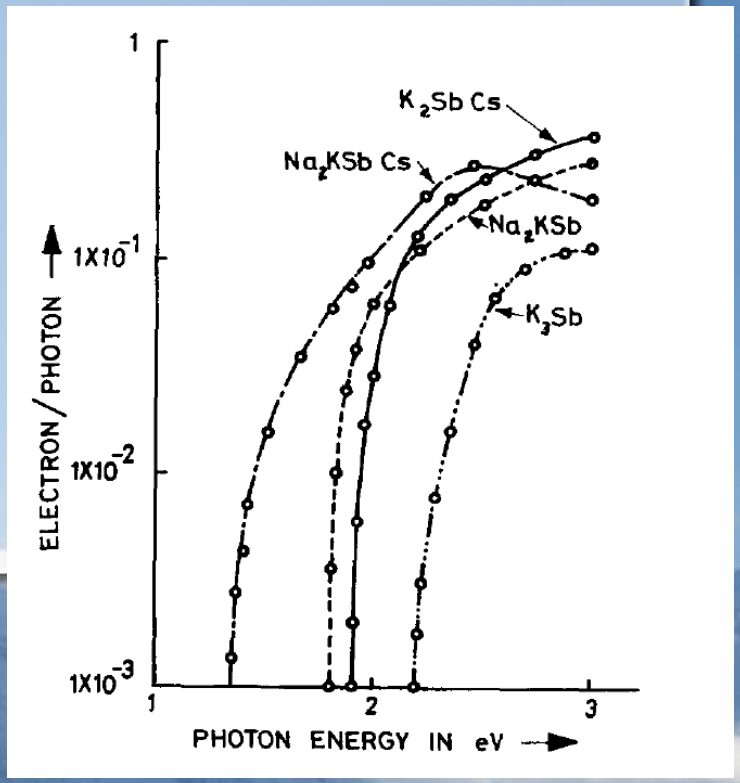
Status of Multi-Alkali Cathode R&D

Masao KURIKI
AdSM, Hiroshima University

Multi-Alkali Cathode

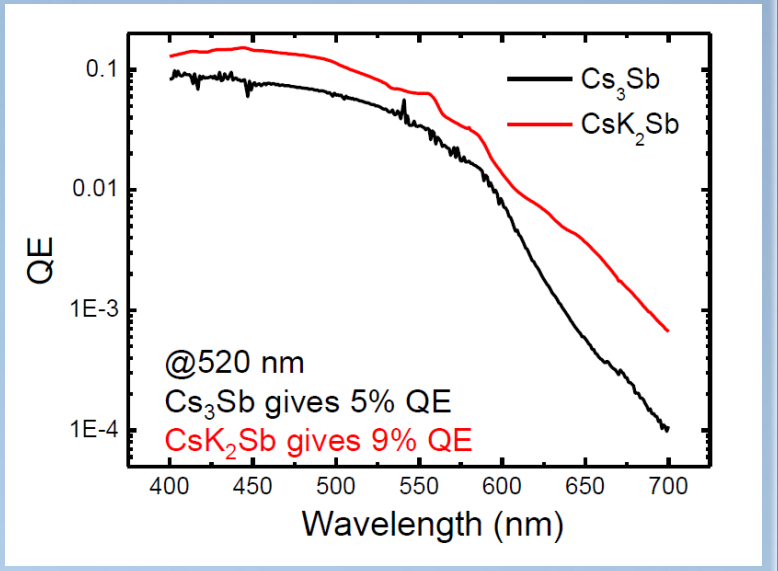
- 複数のアルカリ金属からなるカソード物質。
- 通常、薄膜カソードとして生成。
- PMT 陰極としての実績。
- 固体レーザーの二倍波で励起可能。



C. Ghosh and B. P. Varma , J. Appl. Phys. 49, 4549 (1978)

CsK_2Sb

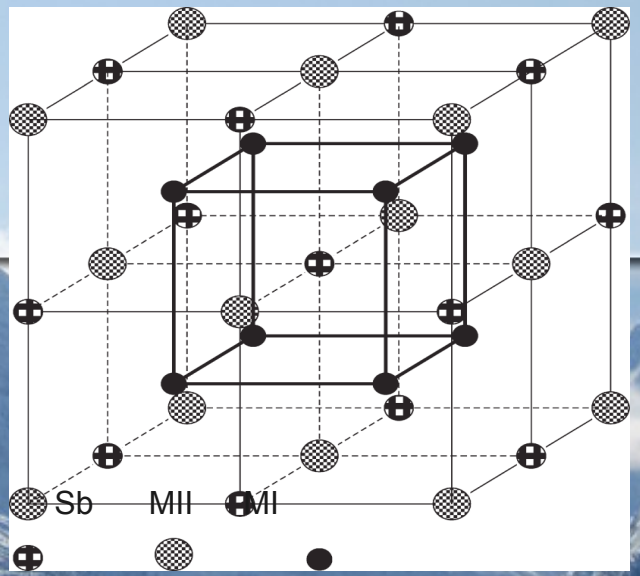
- DO_3 crystal structure.
- 量子效率 @532nm – 8%.
- Band-gap 1.2eV, PEA 0.7eV



ERL 2011

C. Ghosh and B. P. Varma
J. Appl. Phys. 49, 4549 (1978)

Photocathode	Band gap	Threshold energy	n	Electron affinity
K_3Sb	1.8	2.2	1.28	0.4
K_2CsSb	1.2	1.9	1.08	0.7
Na_2KSb	1.1	1.8	1.35	0.7
$Na_2KSb(Cs)$	1.1	1.34	0.94	0.24

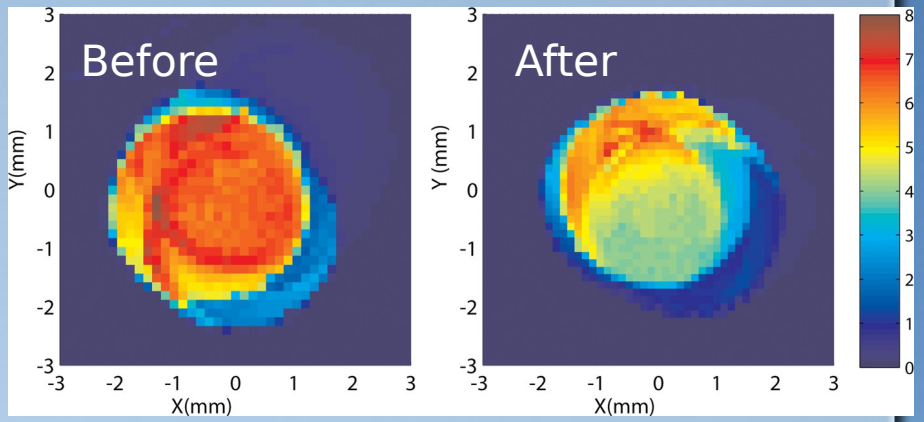


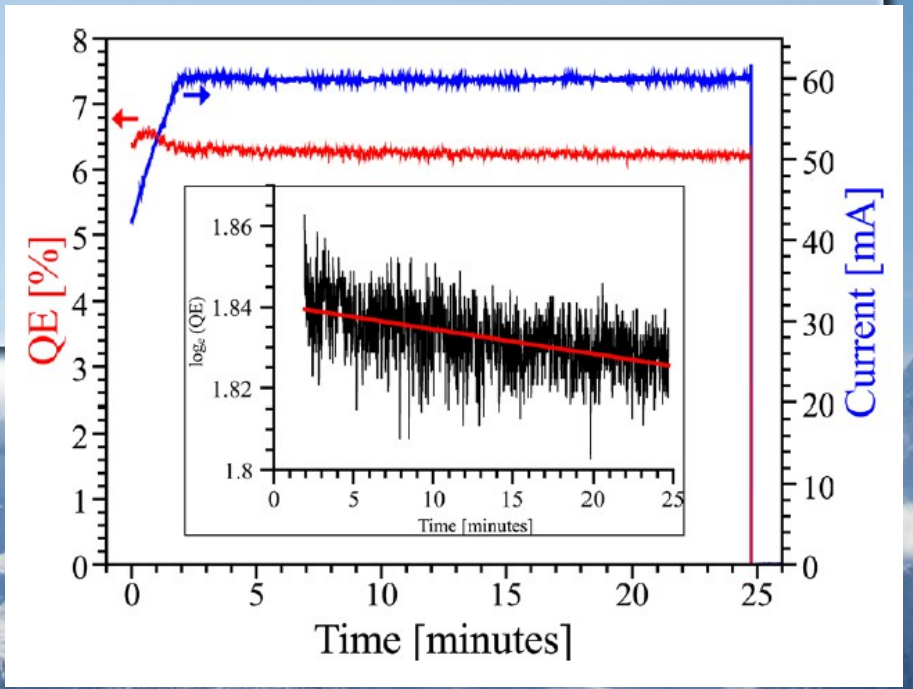
L. Kalarasse,B.Bennecer , F.Kalarasse
J. of Phys. and Chemi. of Solids 71 (2010) 314–322

CsK_2Sb in Cornell

- CsK_2Sb is evaporated on Si substrate.
- QE ~ 10% after activation, 5-7% in operation.
- 60mA, 30h 1/e life. (6480C).
- Roughly, 10 times more robust than GaAs.

Diameter 2.5 mm.

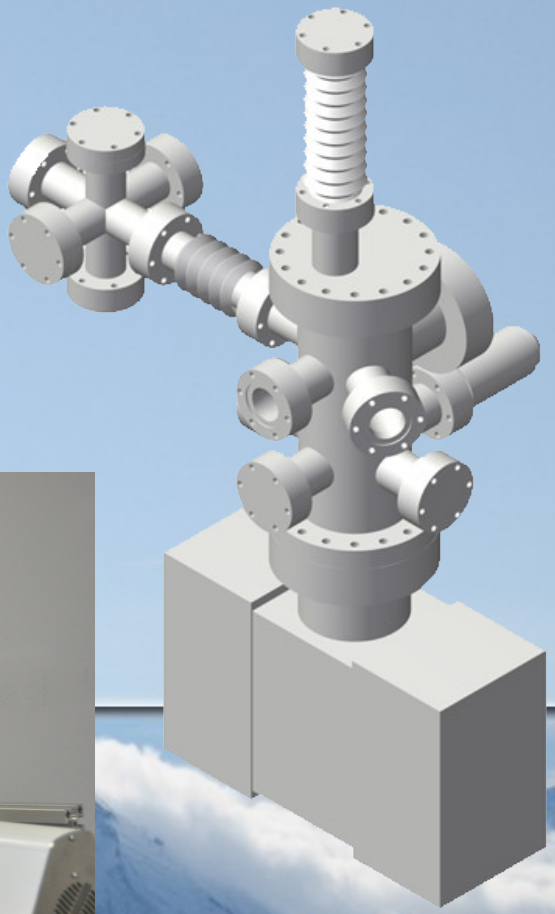


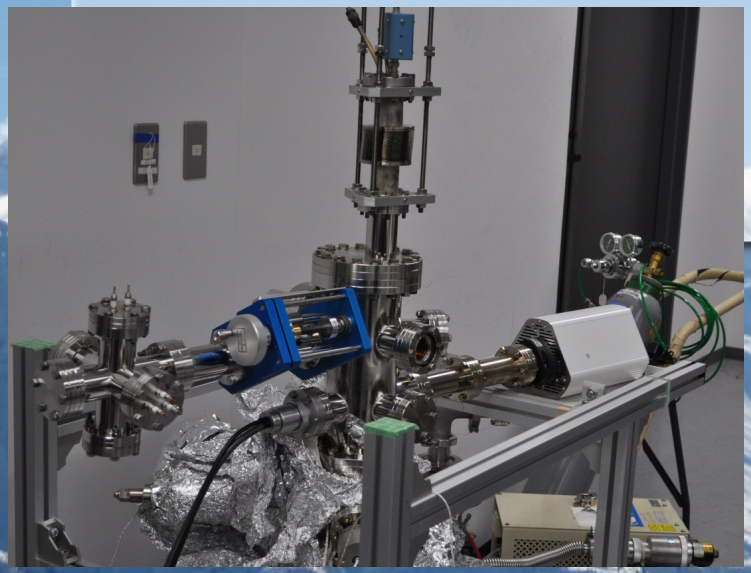


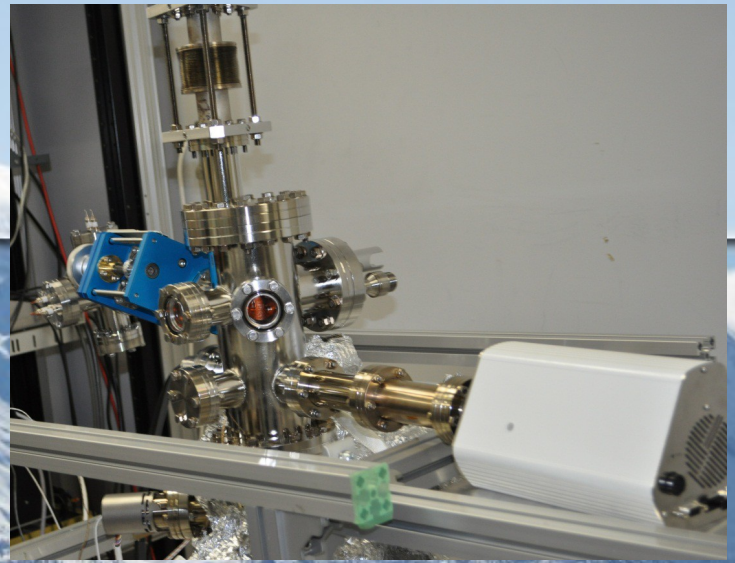
B. Dunham, APL 102,034105(2013)

Multi-alkali Test Chamber

- マルチアルカリ (CsK_2Sb) の蒸着試験用。
- NEG, IP による排気、 Q-mass 。
- 超高真空 (5.0E-9Pa), 膜厚測定、量子効率測定。

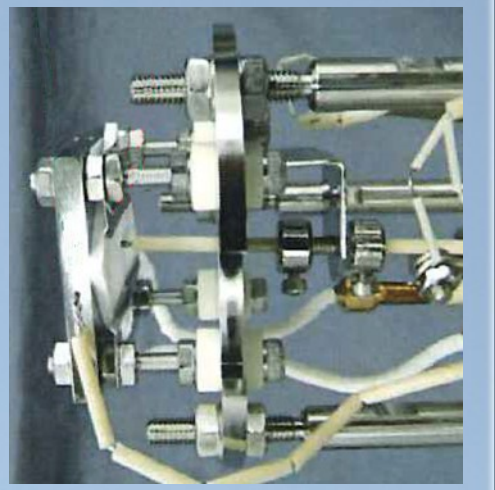


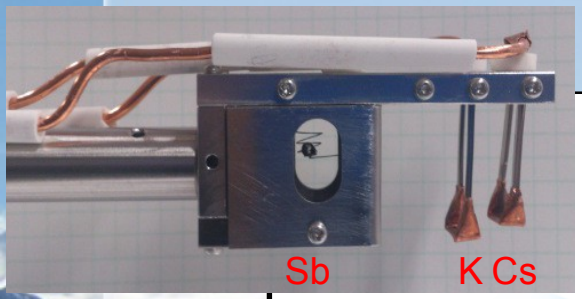


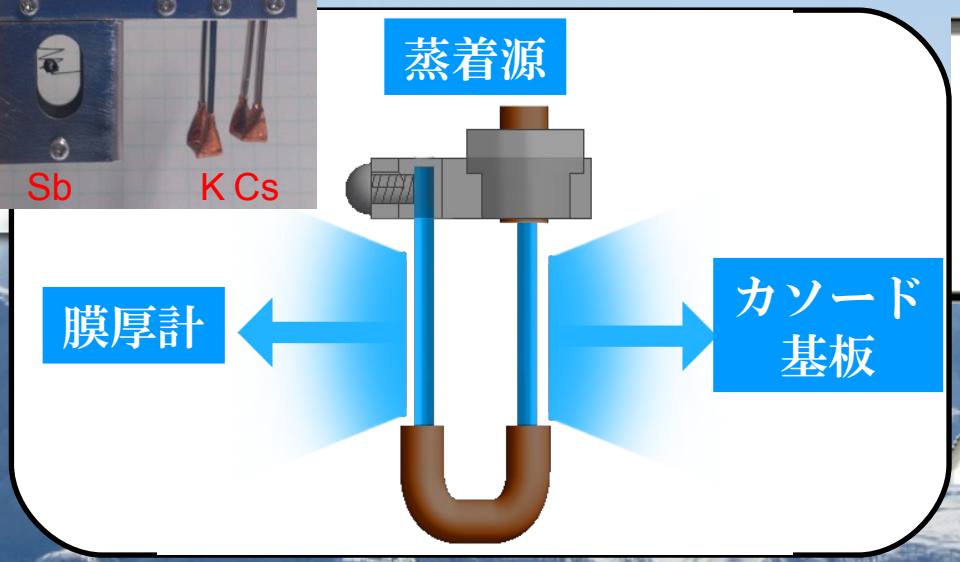


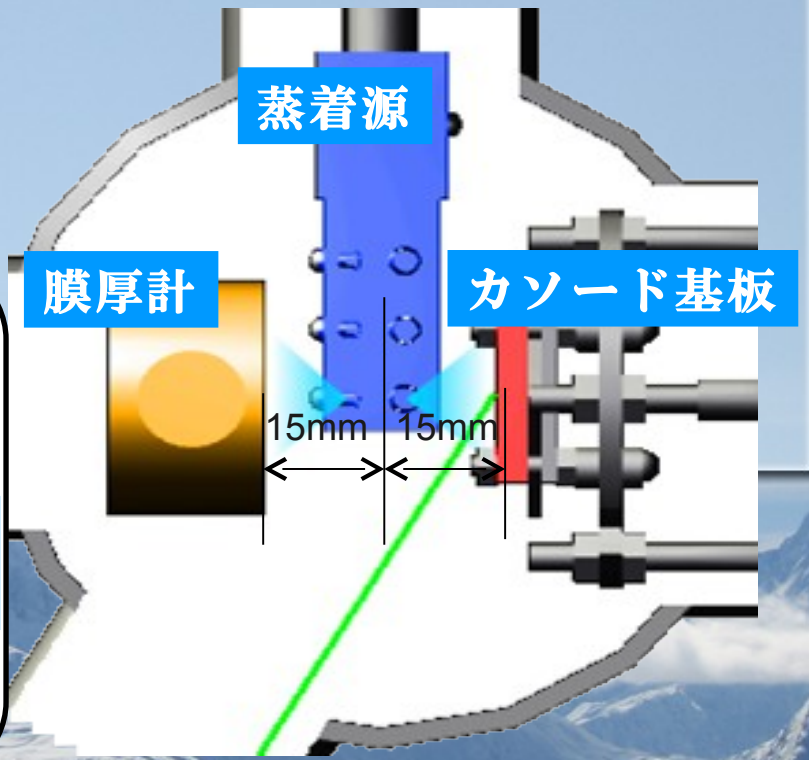
蒸着機構

- SUS 基板への蒸着。
- 加熱洗浄 (650℃) 、蒸着温度制御 (100-150℃) 。
- Bias voltage for QE measurement.
- Quartz thickness monitor.
- Symmety evaporation for simultaneous measuremnets of QE and thickness.

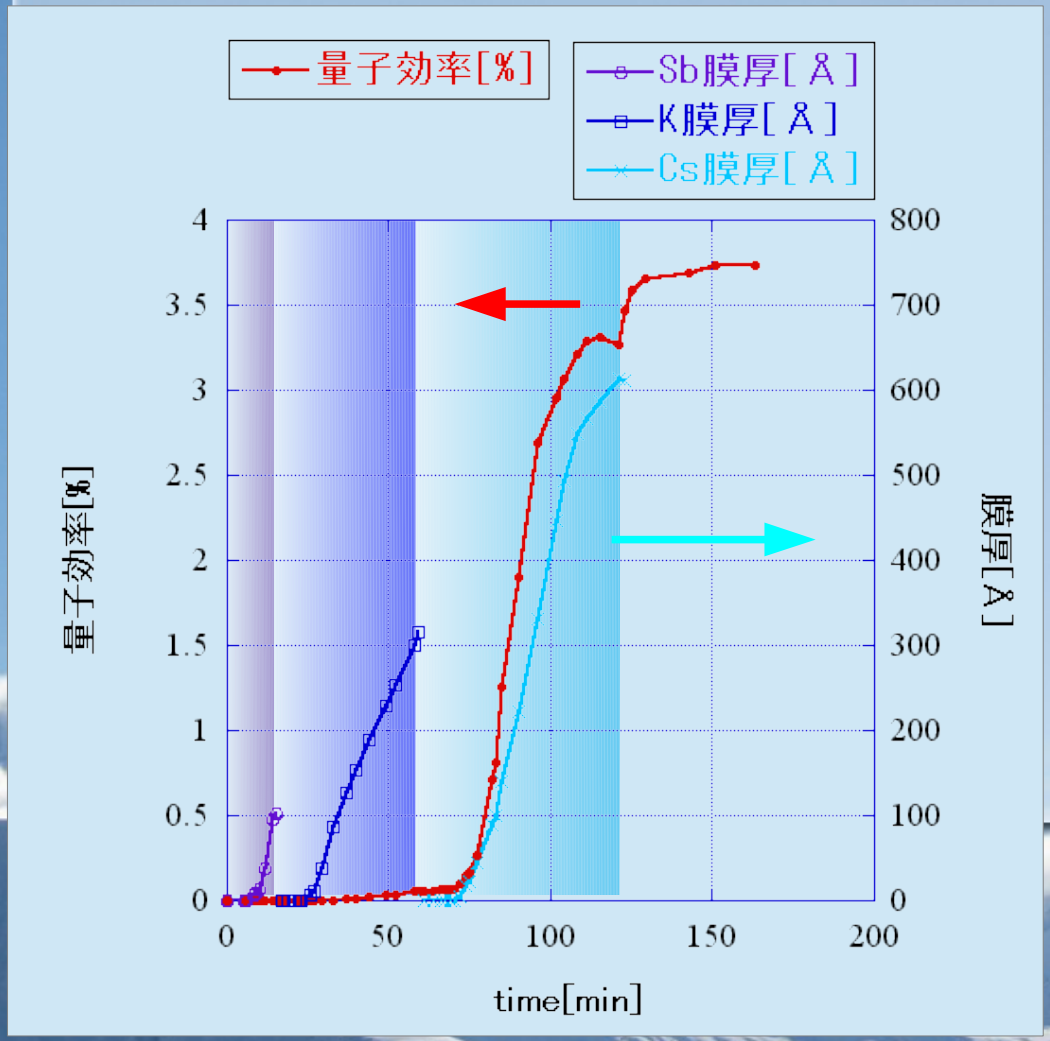








典型的な蒸着例



実験のパラメーター

基板温度	130℃
Sb 膜厚	103Å
K　膜厚	315Å
Cs 膜厚	612Å
光電流値	～50μA

最大量子効率
3.8%@532nm

Two lives

Dark life time

1/e life regarding to time.
Dimension is sec.

$$\eta = \eta_0 \exp\left(-\frac{t}{\tau}\right)$$

τ : dark life time

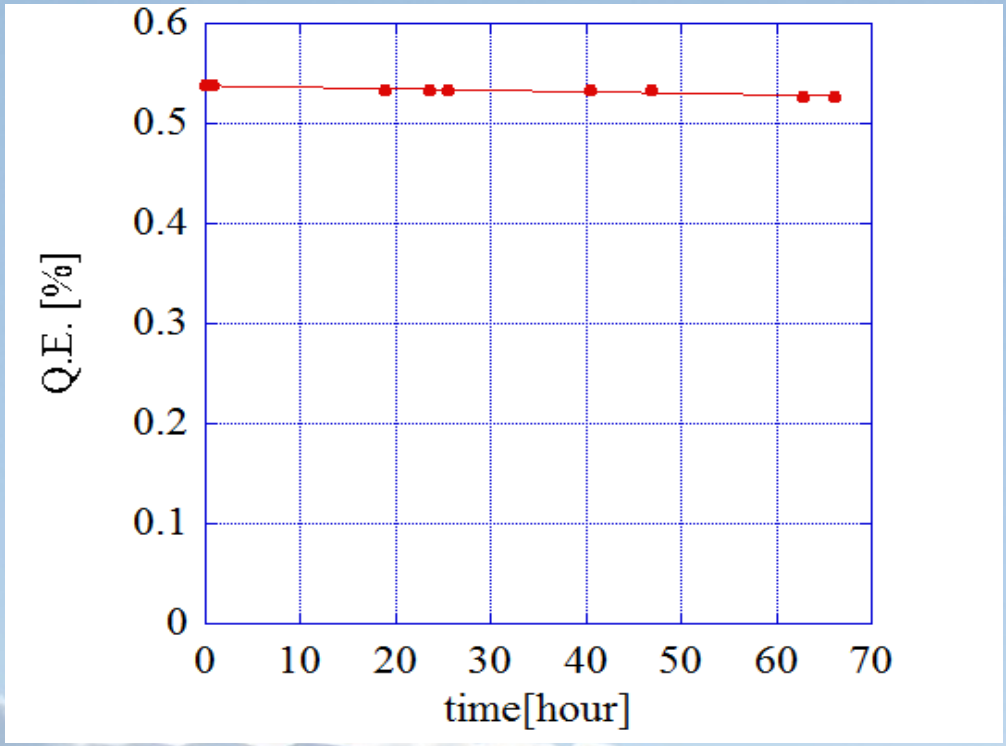
Charge life

1/e life regarding to charge density.
Dimension is C/m^2.

$$\eta = \eta_0 \exp\left(-\frac{Q/S}{\rho}\right)$$

Q/S beam charge density
ρ : charge life

Dark Life of CsK_2Sb

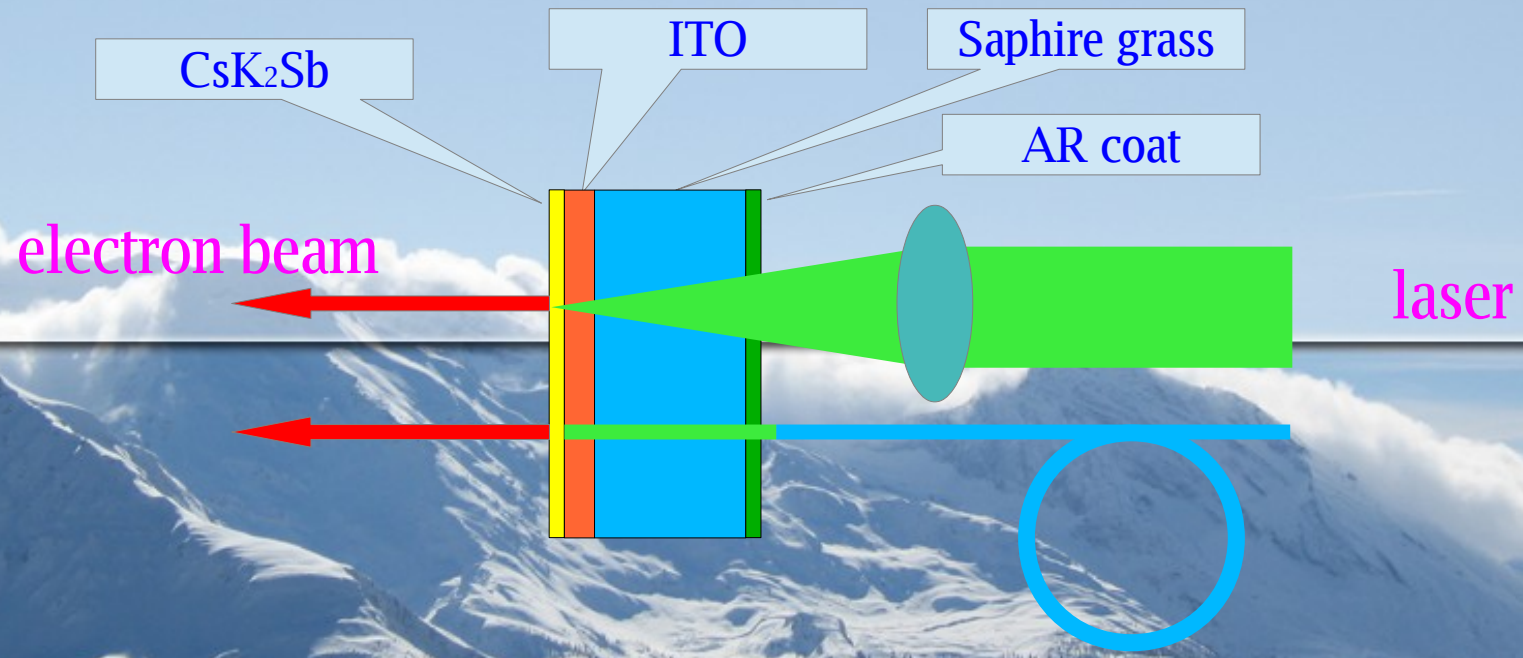


- The darklife time is > 3500 h.
- This is not dominant comparing to the operation period.

$$\eta = \eta_0 \exp\left(-\frac{t}{\tau}\right)$$

透過型カソード

- 緑色励起可能なマルチアルカリ薄膜カソードを可視光領域で透過性のある導体上に成膜することで、背面照射が可能。
- レーザー導入の簡略化、スポット操作性の向上（例　短焦点極小径、ファイバー結合）.
- 分子研が主となり開発。広島大学は蒸着条件を提供。



Surface Analysis

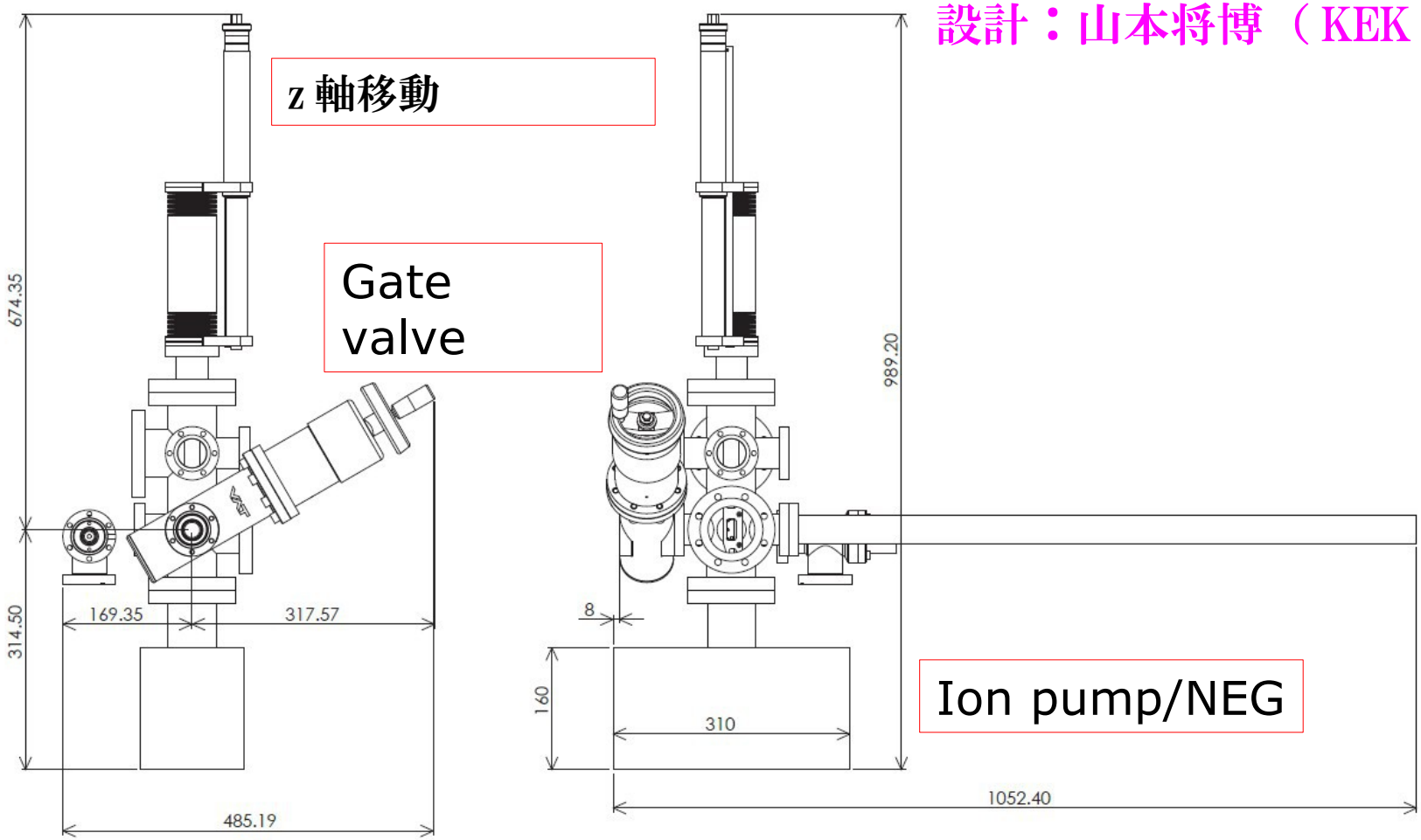
- To optimize the cathode evaporation condition, good diagnostics to evaluate the cathode is desirable.
- Parasite experiments at UVSOR beamline is an ideal place to carry out the experiment.
  - XPS: material fruction,
  - UPS: band structure,
  - LEED : crystallinity.
- Collaboration between UVSOR and Hiroshima university has been started in Oct. 2013.
- Evaporation chamber is developped in 2013 JFY.
- Experimetns will be carried out in 2014 JFY.

CsK_2Sb implementation to accelerators

- From an operational point of the view, CsK_2Sb long life cathode is desireble as a backup for ERL.
- It is mandate that the implementation to the accelerator should not be conflict with the GaAs cathode.
- The ERL gun group established a policy that the cathode is introduced by a transfer system (vacuum suitcase) from an isolated evaporation system.
- Hiroshima university is in charge of developping the evaporation system.
- KEK is in charge of developping the vacuum suitcase and the interface to the ERL gun system.

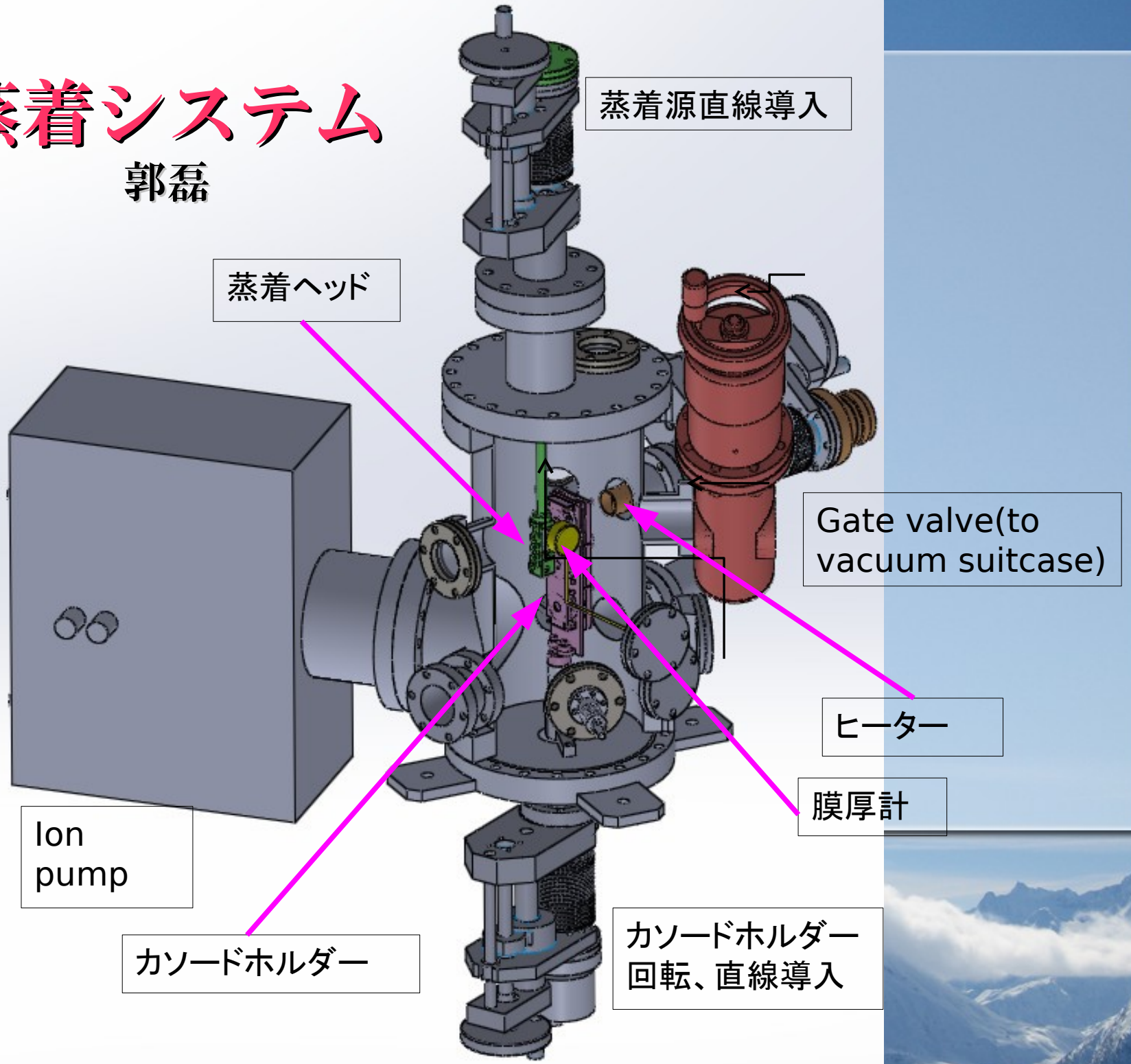
真空輸送システム
(vacuum suit case)

設計：山本将博（KEK）

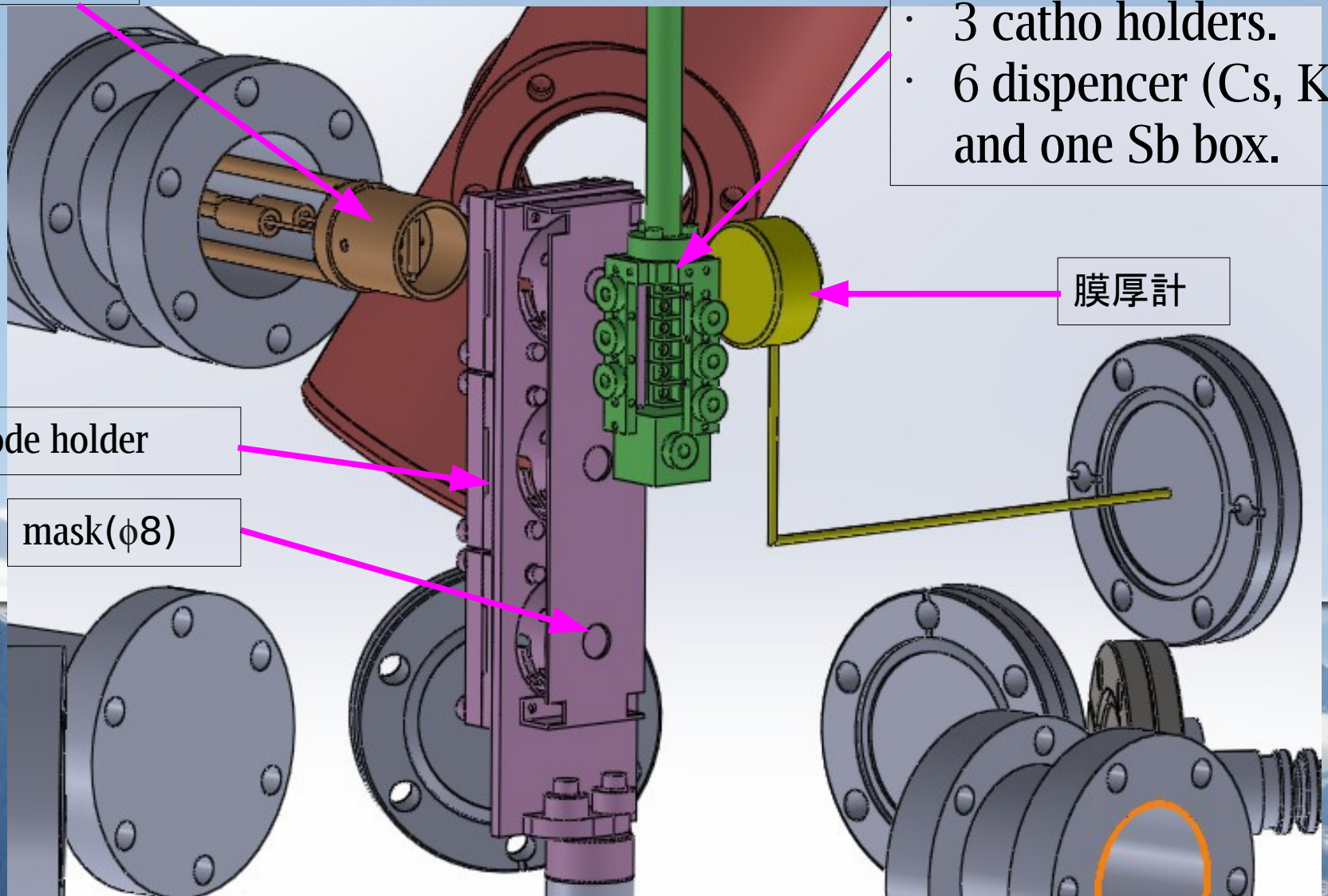


蒸着システム

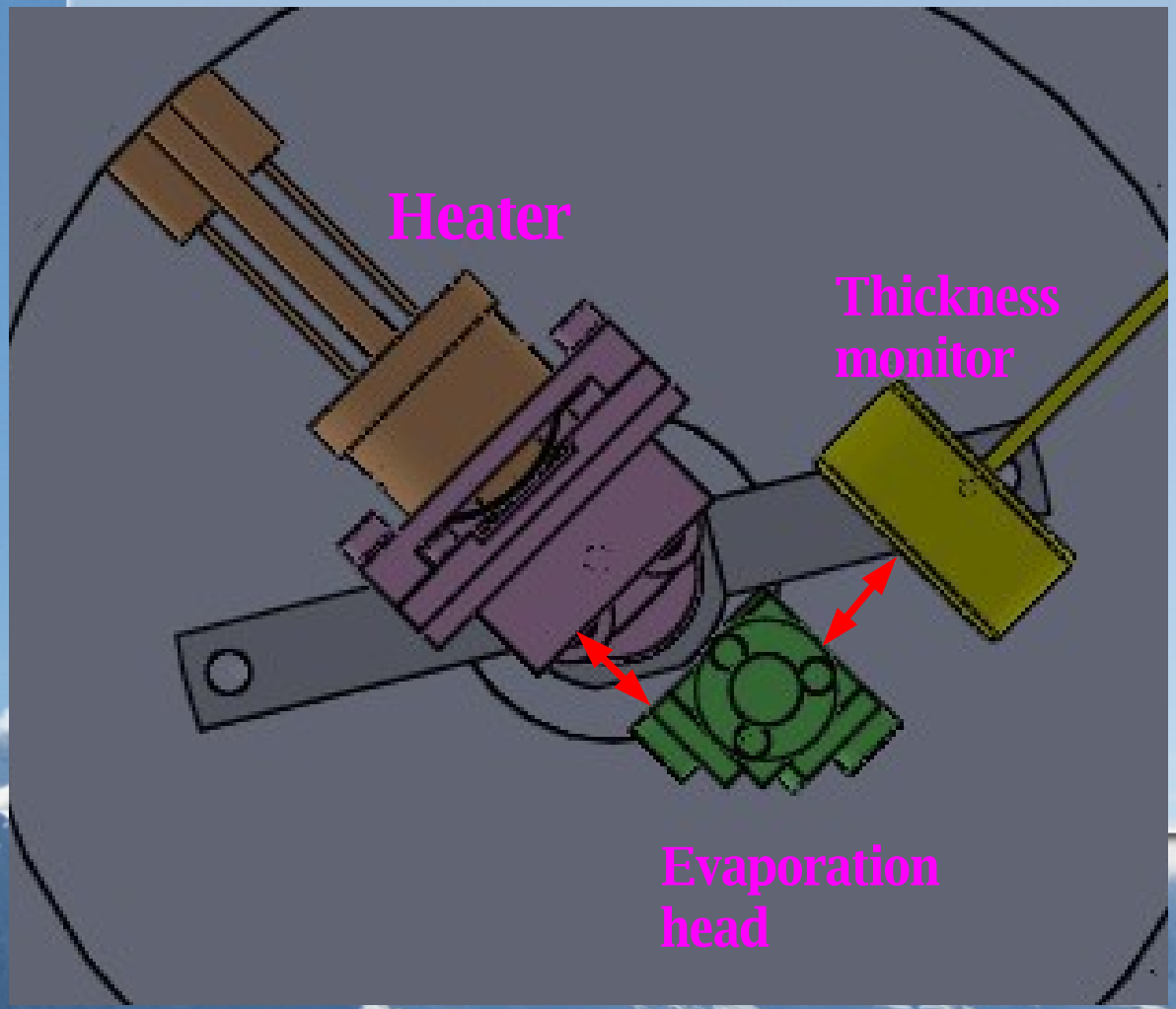
郭磊


蒸着源直線導入
蒸着ヘッド
Gate valve(to vacuum suitcase)
ヒーター
膜厚計
Ion pump
カソードホルダー
カソードホルダー回転、直線導入

蒸着源周辺

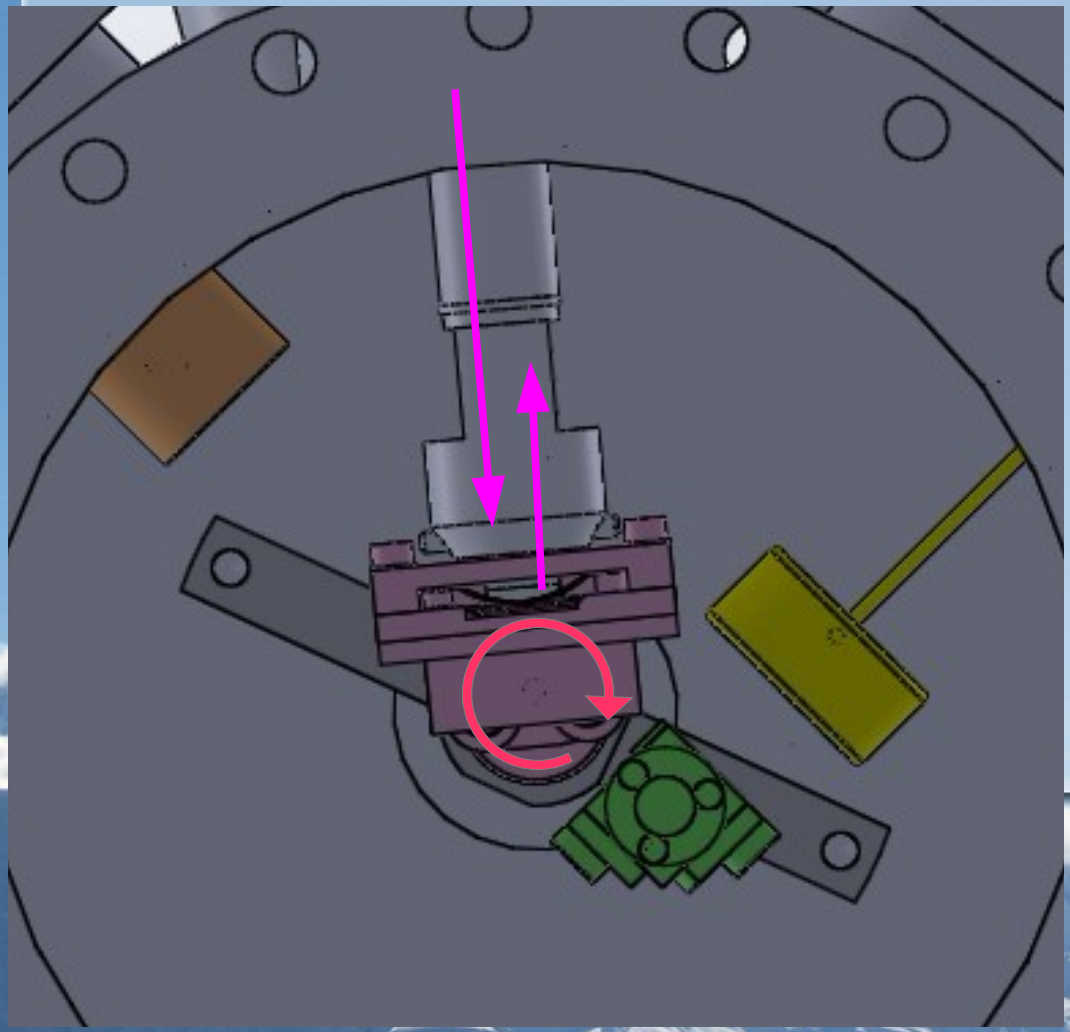

Heater
Evaporation head
· 3 catho holders.
· 6 dispencer (Cs, K, spares) and one Sb box.
膜厚計
Cathode holder
mask(ϕ8)

Arrange for evaporation



- Cathode puck temperature is controlled by a heater attached from the backp-side.
- Evaporation film thickness is measured by Quartz monitor.
- The system is designed symmteric so that eveporation amounts are same for them.

Arrange for Transfer



- Cathode puck holder is rotated to direction of the transfer rod.
- Heater retreats to avoid conflict.
- Thickness monitor and evaporation head are not moved.
- Puck is cathced by the rod from the backside.

R&D Schedule

2013

- Establish the CsK_2Sb evaporation recipe (catch up Cornell).
- Eveporation chamber development for cERL.
- Prepartion for the surface observation at UVSOR.

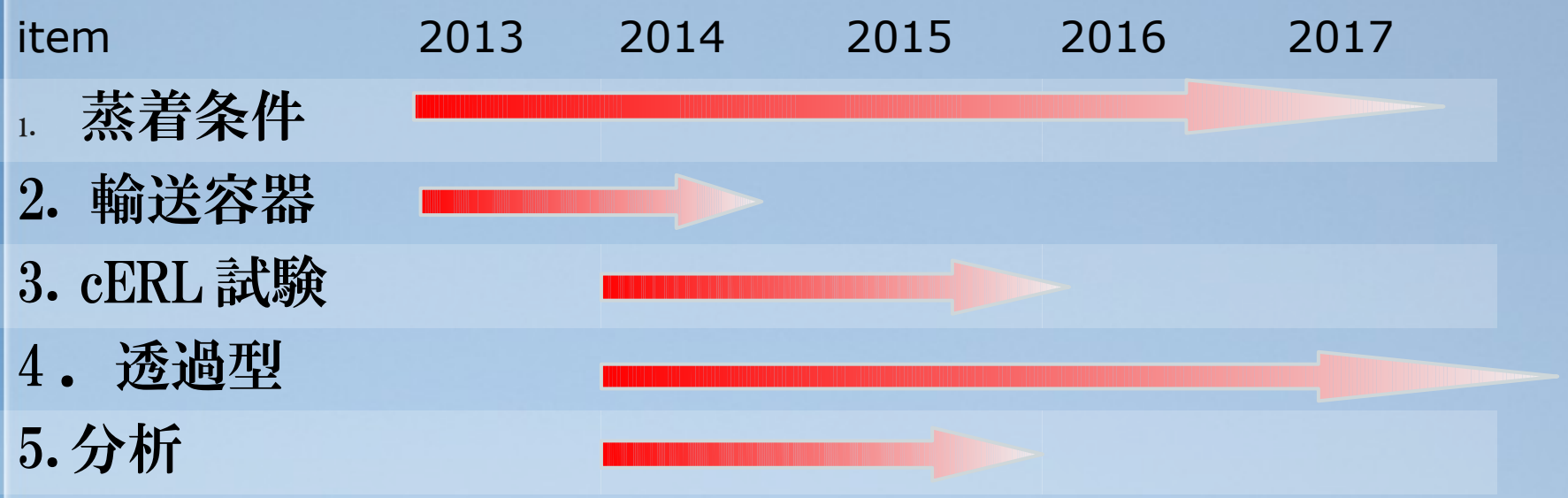
2014

- Demonstration at cERL(KEK).
- Surface observation (UVSOR).

2015

- Demonstration of high current operaiton at cERL.
- Transparent cathode R&D(UVSOR).

Timeline



Summary

- CsK_2Sb cathode R&D has been started in Hiroshima U.
- The experiment shows a good result, although the conditions are not ideally good.
- The performance is still a factor below that in Cornell. We need improve our technology and condition.
- Surface observation at UVSOR will give us rich informations and helpful to achieve better performance.
- The cathode will be ready at cERL in 2014.