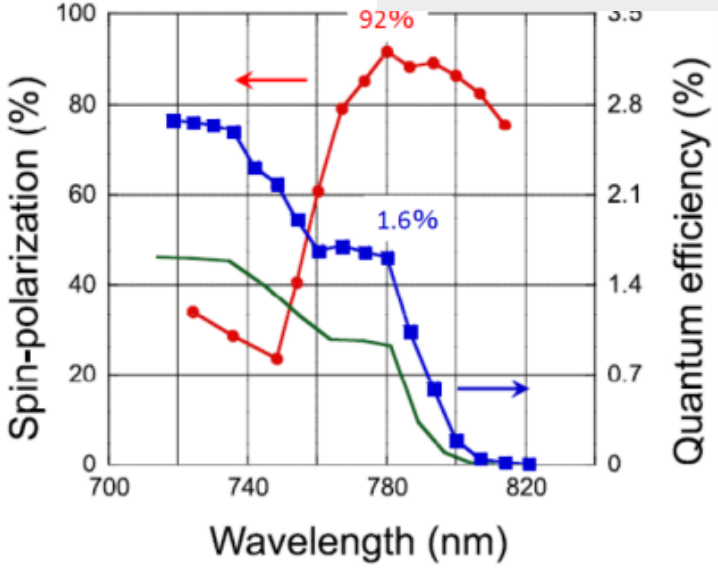
Polarized Cathode Development Update

Zachary J. Liptak

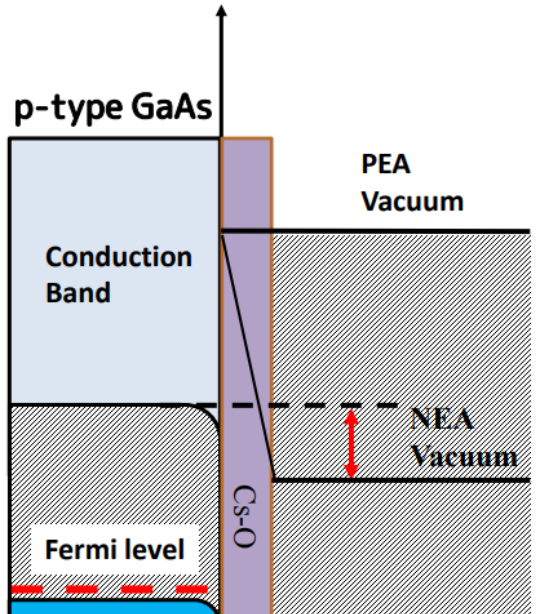
Polarized Source Development

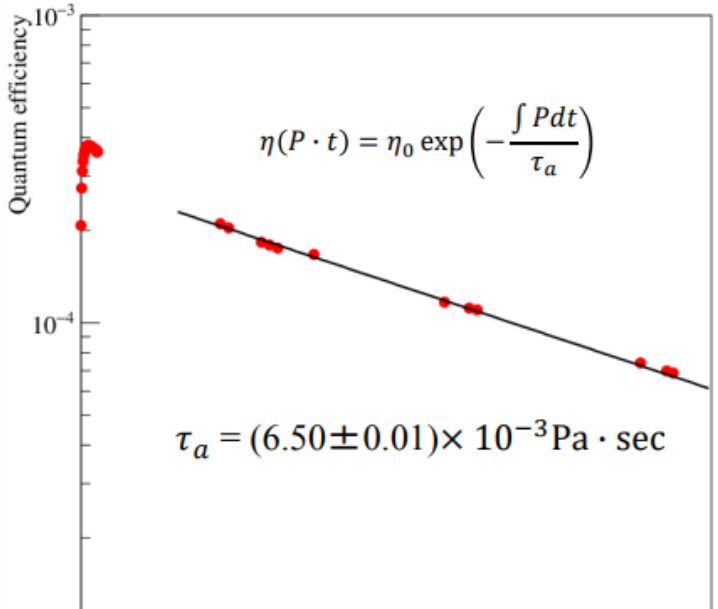


GaAs cathodes can produce beams with >90% polarization and ~1.6% QE, but due to a wide band gap accelerating electrons is difficult

Effect of crystal quality on performance of spin-polarized photocathode
Xiuguang Jin, Burak Ozdol, Masahiro Yamamoto, Atsushi Mano, Naoto Yamamoto, and Yoshikazu Takeda
Citation: Applied Physics Letters 105, 203509 (2014); doi: 10.1063/1.4902337

We can alleviate this problem by applying a thin Negative-Electron Affinity (NEA) film on the surface to shrink the band gap and impart some energy to the freed electrons.
Lifetimes of these cathodes are currently too short to be practically useful now and we are trying to improve them.





Cathodes	Lifetime τ_a [10^{-3}Pa · sec]
CsKTe/GaAs	6.50±0.01
Cs-O/GaAs	0.29±0.03 [1]
Cs-O/GaAs	0.40±0.02 [2]

[1]K. Miyoshi, M. Thesis, Hiroshima U. (2013)
[2]G. Lei, M. Thesis, Hiroshima U. (2014)

Reminder: Deposition Procedure and apparatus

Procedure has been to activate Te,Cs,K with Sb,Cs,K deposition.

The procedure went as follows:

(i)Te deposition followed by Cs [1]

(ii) Deposition of another layer of Te [2]

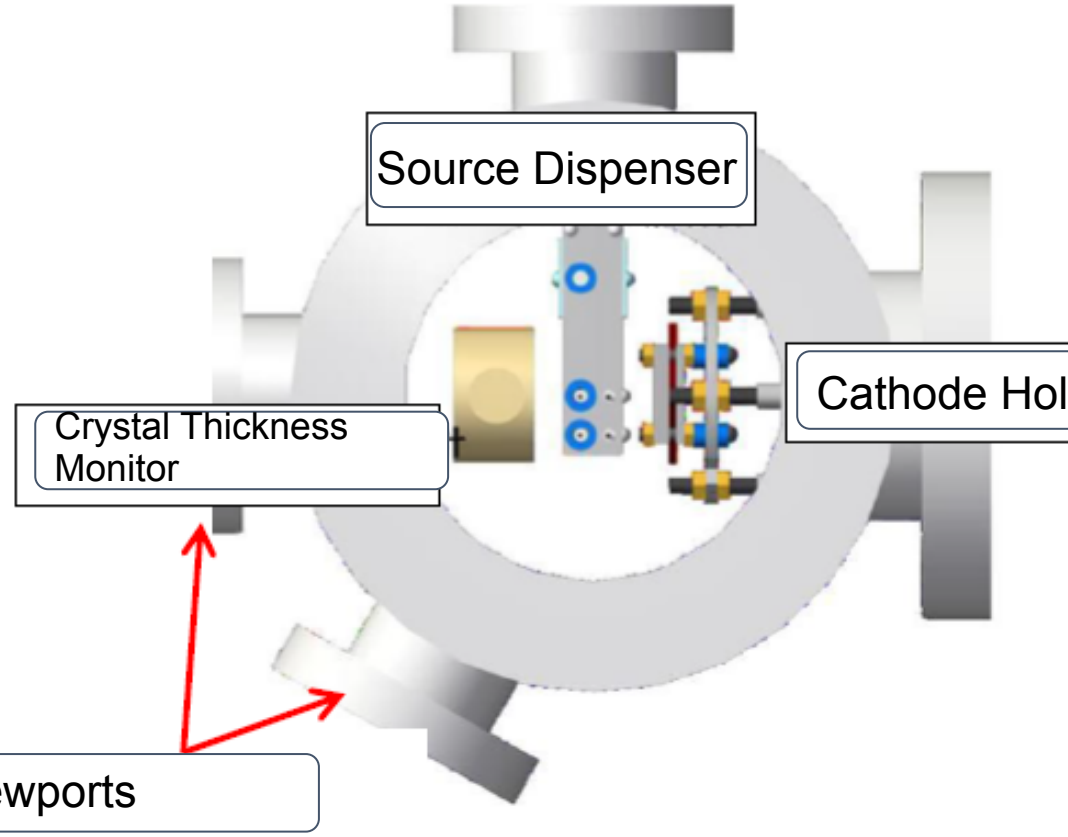
(iii) K,Cs deposited [3]

(iv)After Cs, add a layer of Sb [4]

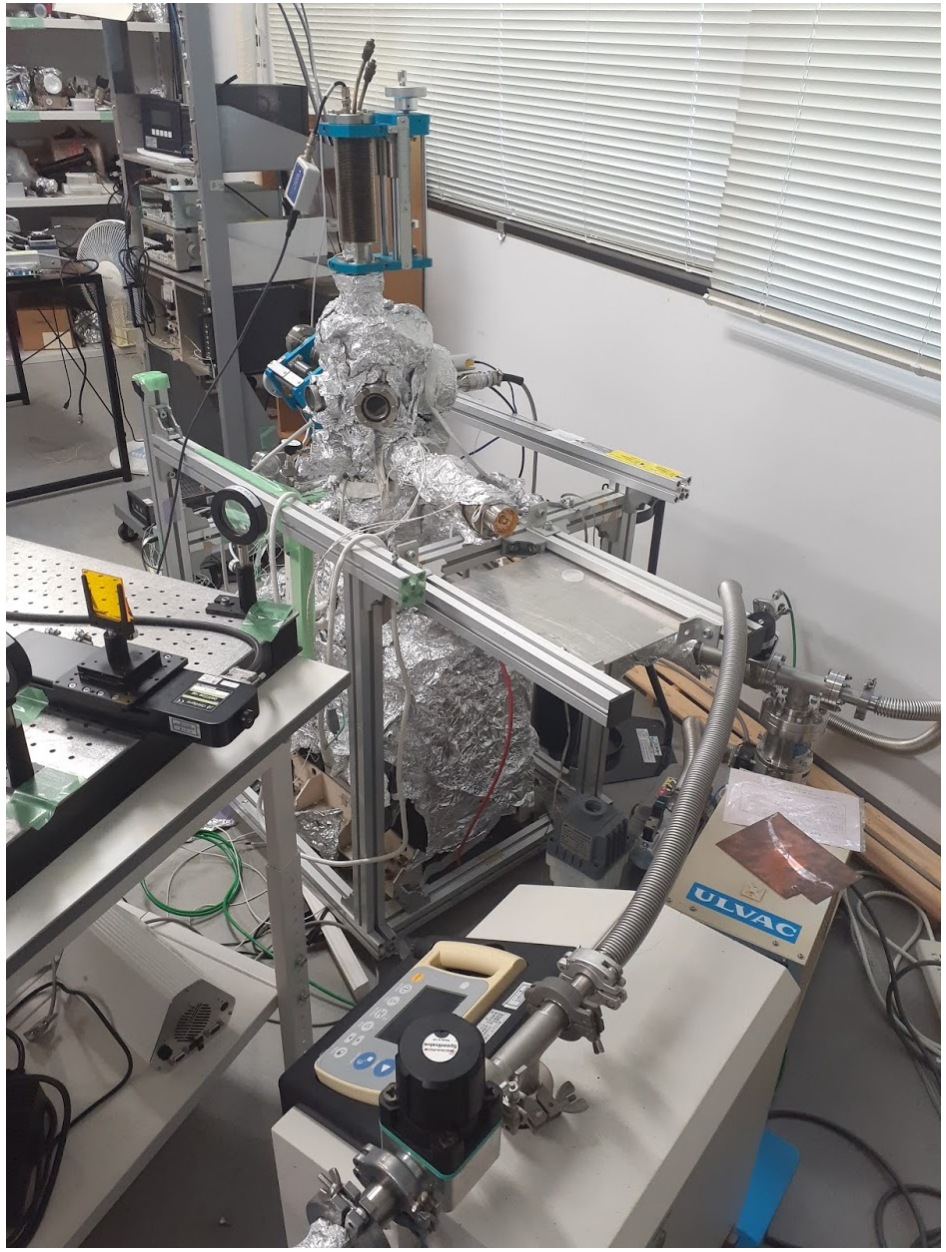
(v) Deposit a layer of Oxygen-exposed Cs、followed by Sb [4]

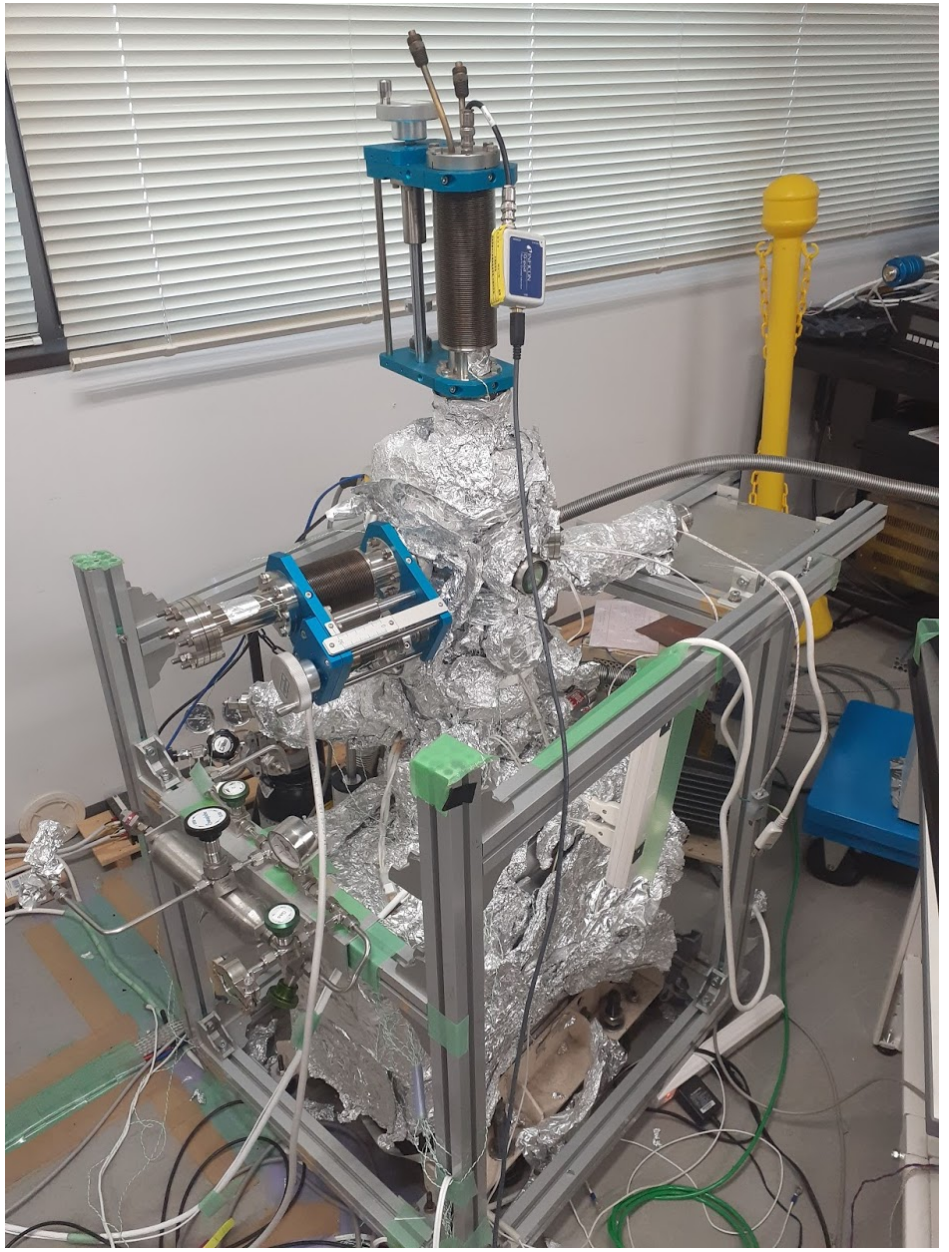
(vi) K,Cs [5]

for comparision, (x) another layer of O-exposed Cs
etc.



Our Setup: Vacuum Chamber

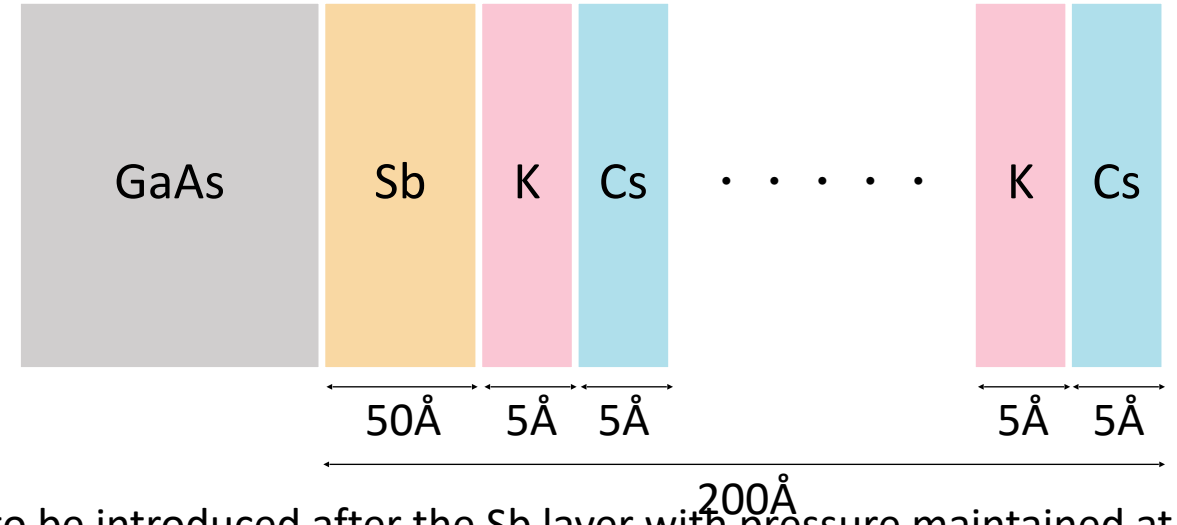




Experiment in Progress

Starting in the Fall, we've had a student (Misato Kishi) working with cathode development for her thesis. After various mechanical troubles, baking and prep began at the beginning of the year.

Following the procedure on the previous slide, currently preparing a cathode as shown below (not to scale):



M. Kishi

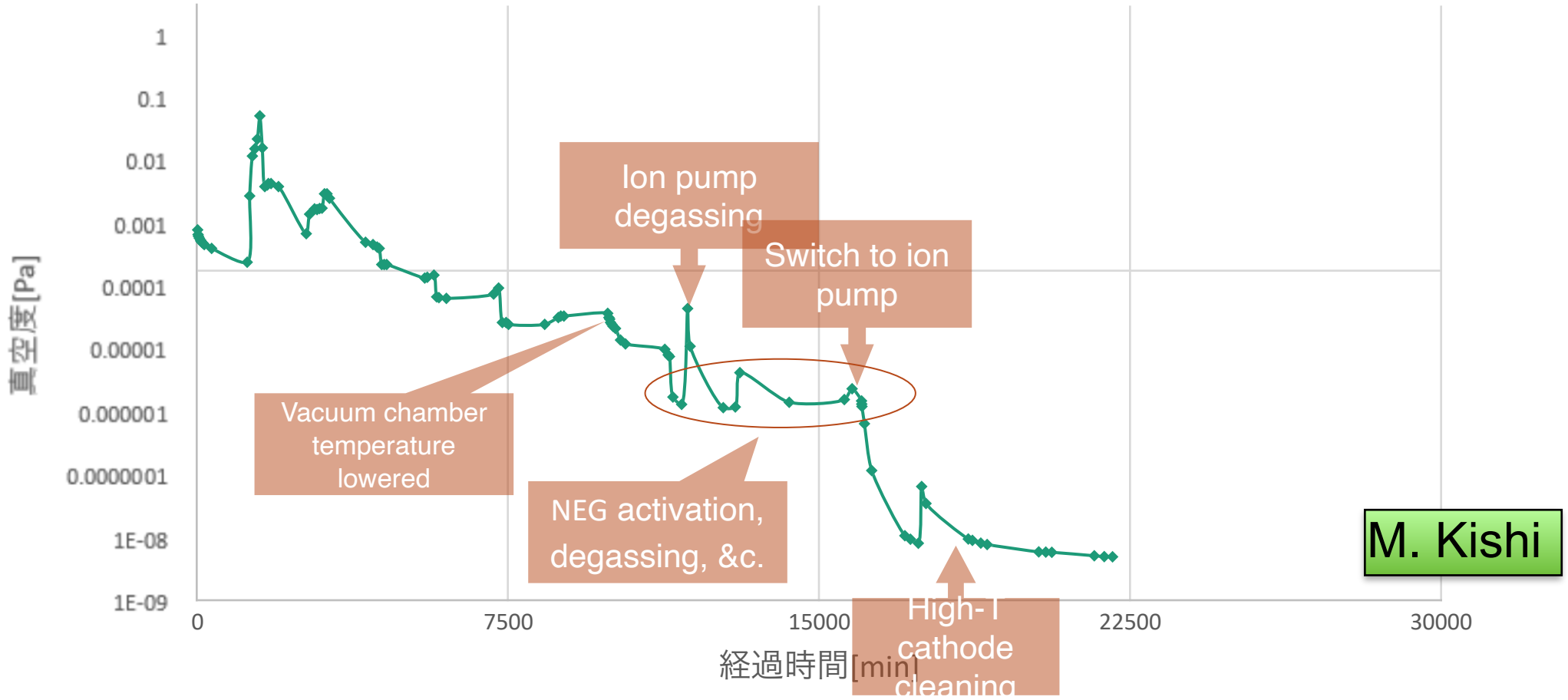
O_2 to be introduced after the Sb layer with pressure maintained at 6.6×10^{-7} Pa.

Preparation

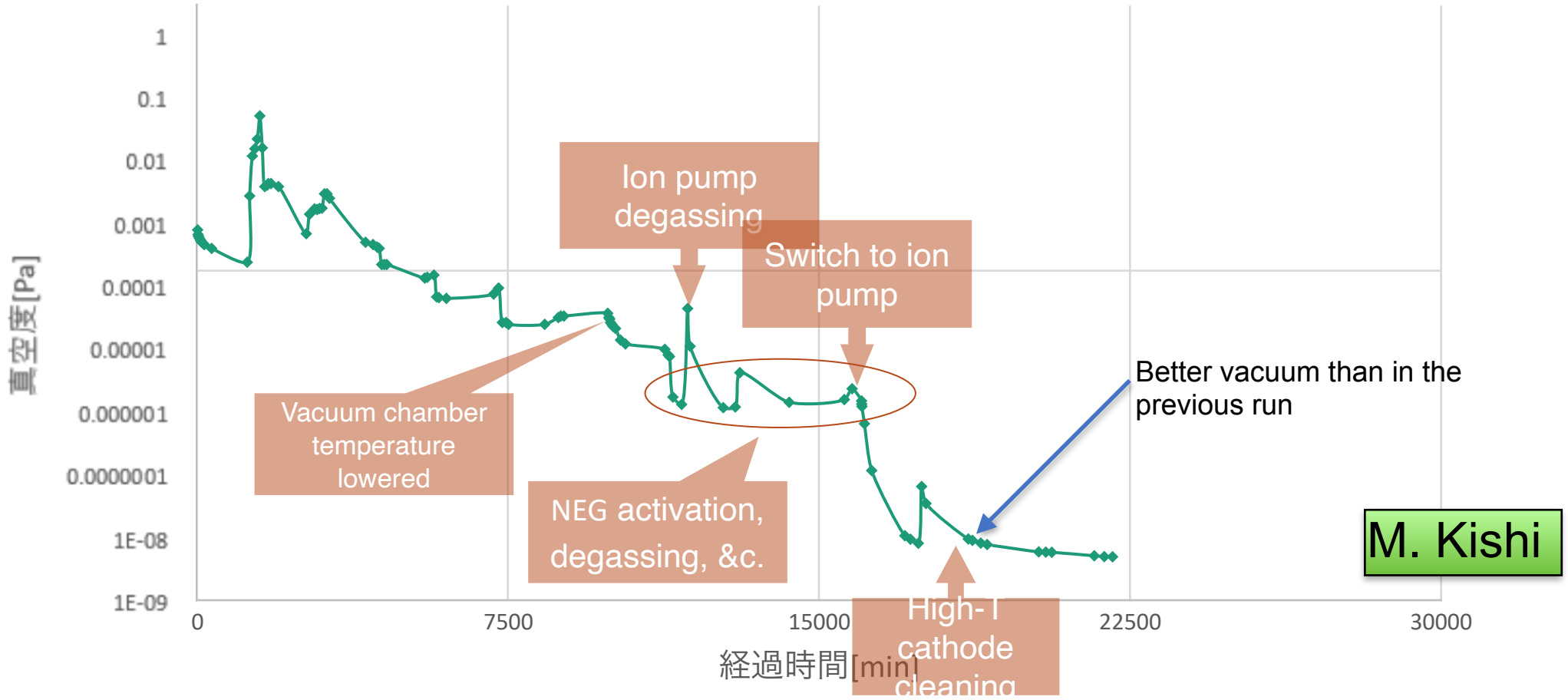
- NEA materials prepared and connected to the apparatus and checked for shorts
  - Sb comes in pellets, held in a W wire basket
  - Cs, K come in metal dispensers with slits for evaporation
- GaAs wafer face is washed in an oxygenated ammonium bath (semicoclean 23) and attached to the stage.
  - Washing procedure: 5’ semicoclean -> distilled water (3x) -> ethanol -> He gas
- NEA material and wafer holders introduced to the vacuum chamber
- Once vacuum reaches 10e-5 Pa, check for leaks using the Qmass flowmeter and He gas
- To improve vacuum bake at ~200 C for ~2 days and run pump to remove any outgassed H from the chamber walls.
    - Here we encountered some mechanical issues: NEG pump had trouble staying activated, and ion pump took much longer than expected to get to full working order
- At the level of 10e-6 Pa, close the angle valve and switch to ion pump -> 10e-9 Pa
- Bake GaAs cathode to remove any remaining surface contaminants before

M. Kishi

Preparation: Vacuum Baking



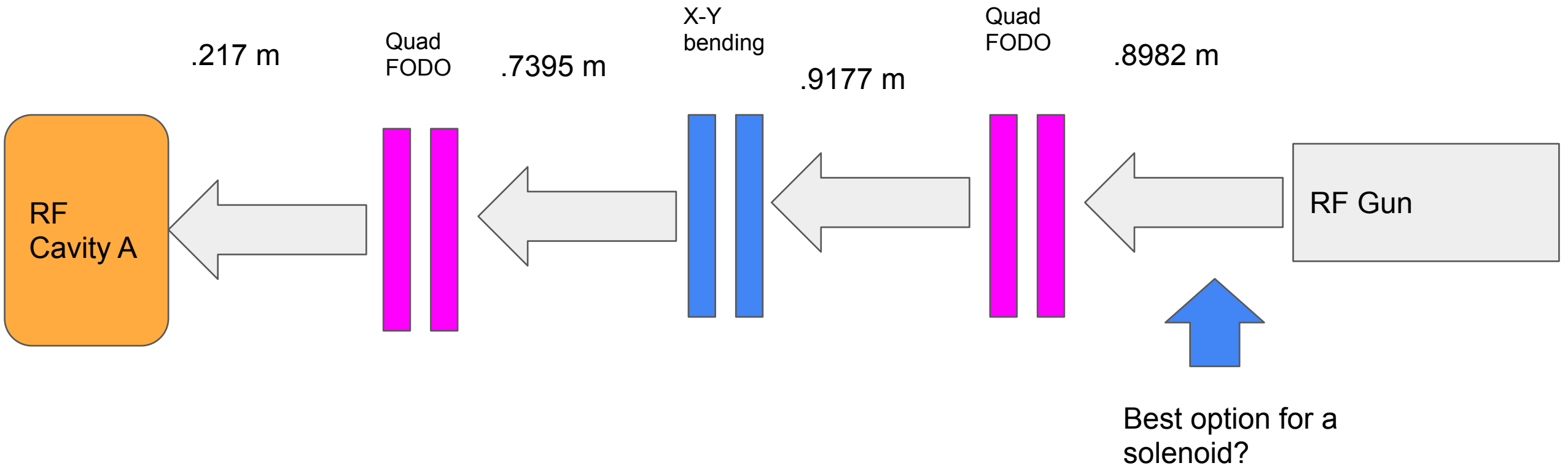
Preparation: Vacuum Baking



Linac model for transport

After production, we need to align spin polarization vectors to the vertical (presumably before entering the J-arc.

I looked into the current setup of the Linac from the RF gun to the first RF cavity to find potential places for placing a rotator solenoid. The setup as I understand it is shown in the cartoon below.
(This setup comes from the (maybe outdated) SAD model provided to me by Iida-san. Is it possible to place such a solenoid in the beamline? Or is there more space upstream of where the RF gun is placed in the SAD model?)



US-Japan Proposal

U.S.-Japan Common Contents (in English)

U.S.-Japan Science and Technology Cooperation Program in High Energy Physics
Proposal Application form

Date December 15, 2021

Title of Proposal	*R&D for a New Belle II Era of Polarization Physics at SuperKEKB*
Lead Japanese Principal Investigator	*Zachary Liptak, Assistant Professor, University of Hiroshima*
Lead U.S. Principal Investigator	*Brett Parker, Senior Scientist, BNL Superconducting Magnet Division*
	The SuperKEKB accelerator is currently in operation at KEK in Tsukuba, Japan, delivering electron-positron pairs to the Belle II experiment and increasing its delivered luminosity to become the first Super B Factory. In addition to the current physics plan, implementing a longitudinally-polarized electron beam at the interaction point (IP) would enable measurement of spin observables and open up a new future era of high energy physics studies at KEK. Measurement of spin asymmetries in B-B_{bar} pairs with Belle II's planned data set would provide a powerful new avenue to measure the weak mixing angle θ_W, in a

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We submitted the above proposal materials last month. HUGE thanks to Brett et al. for the hard work under time pressure!

US-Japan Proposal: Next Steps

Next up is an in-person hearing at KEK on Feb. 21st.

The format is 15 + 5’ presentation — Brett has provided me slides for magnet development, and I’ll be adding my own on cathode production.
Of course, any suggestions/input are welcome!

This will also be my first time appearing for a USJ hearing, so any helpful tips would also be appreciated…

Summary

- We’ve begun a new experimental run at HU to produce a GaAs+NEA cathode with oxygen introduced.
- Mechanical troubles have made the preparation and run time longer than expected.
- A cathode production run is ongoing now, with results expected in time for our student to graduate this semester.
- I looked into the linac model from the gun to the 1st RF cavity to investigate places to put a solenoid; it’s unclear to me where a solenoid could be placed for alignment.

Our Setup: Xenon lamp

Used for testing QE response from cathode with tunable wavelengths