Simulations of QMB Deposition Rates During Lithium Evaporation

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2010 NSTX Results & Theory Review

Lithium Research Topical Science Group

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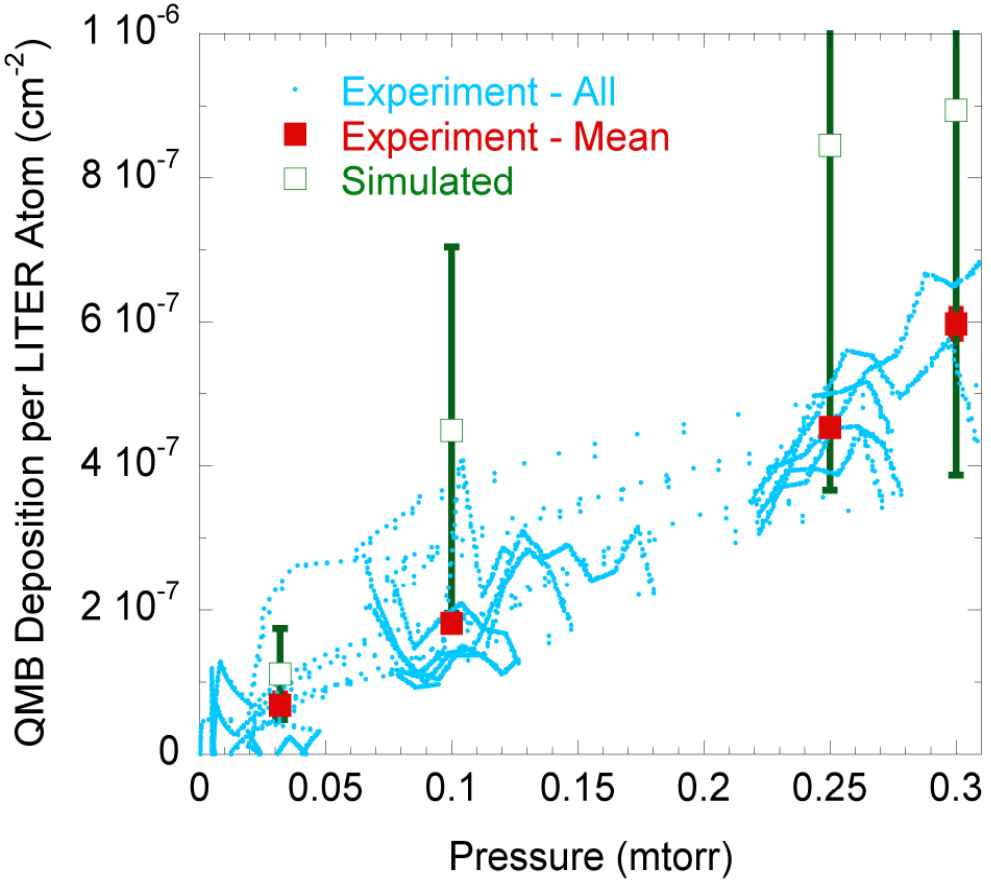
2009 XP 951 Investigated Diffusive Li Evaporation into Helium

- Coat larger fraction of graphite tiles to reduce impurity source due to sputtering.
- Optimized sequence of He pressures for XP 951 based on set of DEGAS 2 simulations.
- Resulting QMB data used to validate DEGAS 2 model,
  - 3-D vacuum vessel,
  - LITER velocity distribution & evaporation rate,
  - Li + He, Li + D_2 elastic scattering,
    - Cross sections uncertain, but similar $\Rightarrow$ treat as single background with Li mean free path $\propto 1 / P_{He}$
    - Need ~R to coat all surfaces.
  - PMI: Li sticks to surfaces.

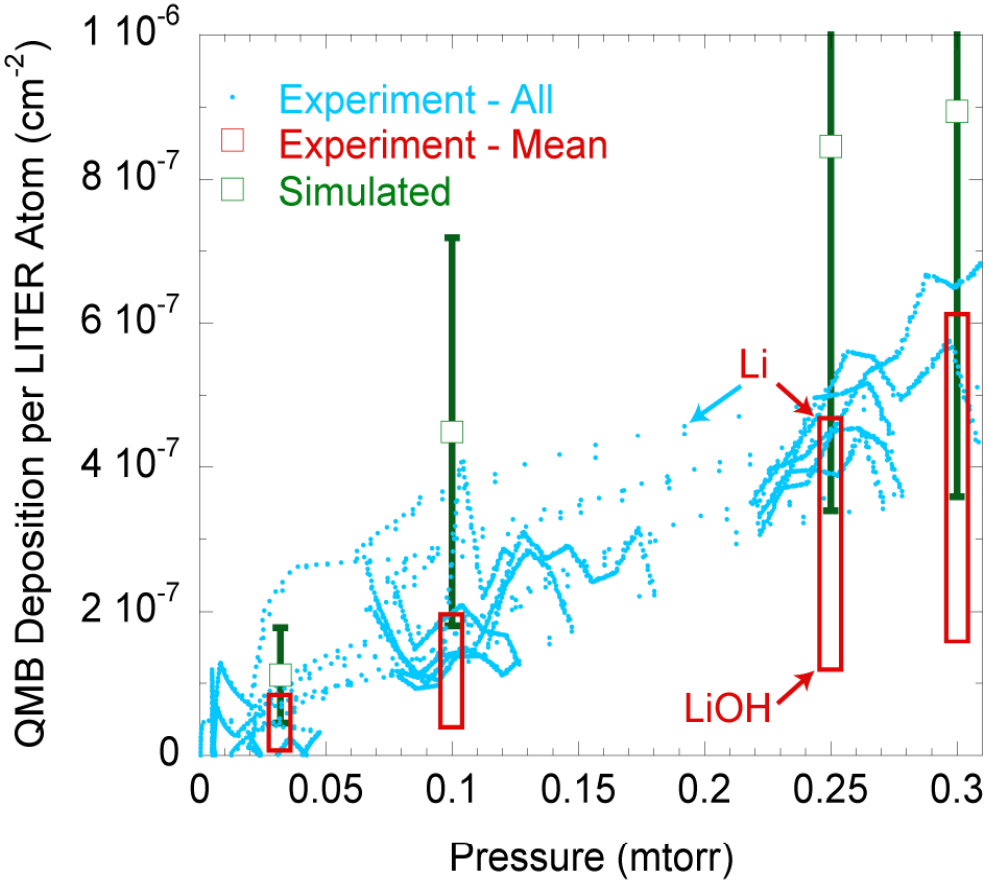
Experimental Rates Are Within the Large Simulation Uncertainties

- Analyze data from XP 951:
  - Compute QMB mass deposition rate & divide by Li mass ⇒ rate of Li atom deposition,
  - Normalize by LITER evaporation rate ⇒ probability for evaporated Li atom to be deposited on QMB.
- Simulation uncertainty due to:
  - Scattering cross section,
  - Pressure unfolded from ionization gauge data,
  - LITER position,
  - QMB position & angle.
- Deviation of LITER evaporation rate from formula not accounted for,
  - Likely for T > 600 °C ⇒ no longer in molecular flow regime,
  - Could affect angular distribution.



It's More Complicated Than That…

- Are deposits pure Li?
  - XP 951 RGA shows > 10^{-6} torr H_2O during evaporation,
  - Associated H_2O flux > 10 x Li flux ⇒ is deposit LiOH?
  - Assume deposited mass between Li & LiOH.
  - What happens to Li on C?
- Is Li reflection coefficient really 0?
  - Equivalent: reflection coefficient same on QMB & tiles.
  - Relaxing further complicates problem enormously.
- How do stresses & non-uniformities in deposited layers affect QMB response?

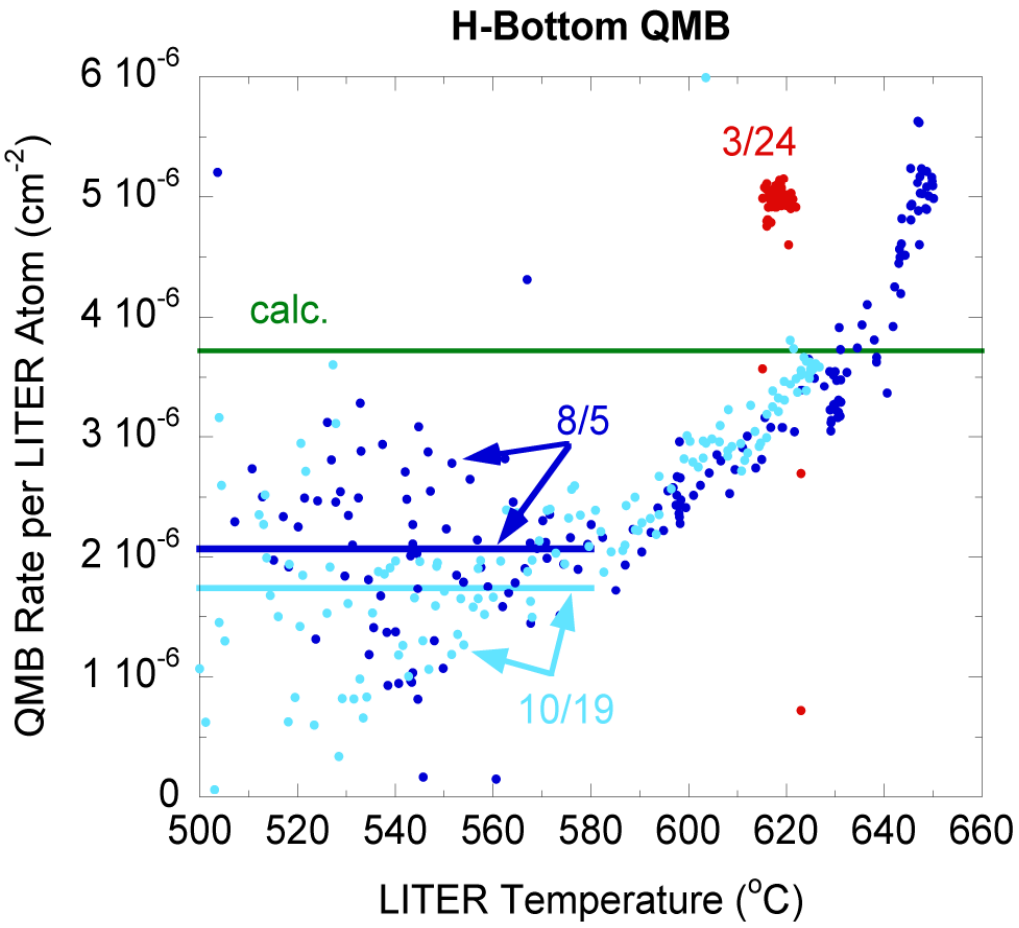


End Result: Ideas for More Discriminating Experiments

- Operate LITERs separately,
- Use other QMBs,
- Run LITERs at lower temperatures,
- Evaporate with pumps on,
  - Maintain P_{He} via leak valve.
- Reduce uncertainties with more in-vessel measurements.
- Post-mortem ex-vessel analysis of QMB:
  - Quantify hydration,
  - Identify other anomalies.
- Monitor pressure with baratron & RGA.

2010 Vacuum Evaporation QMB Measurements Utilize First Four Techniques

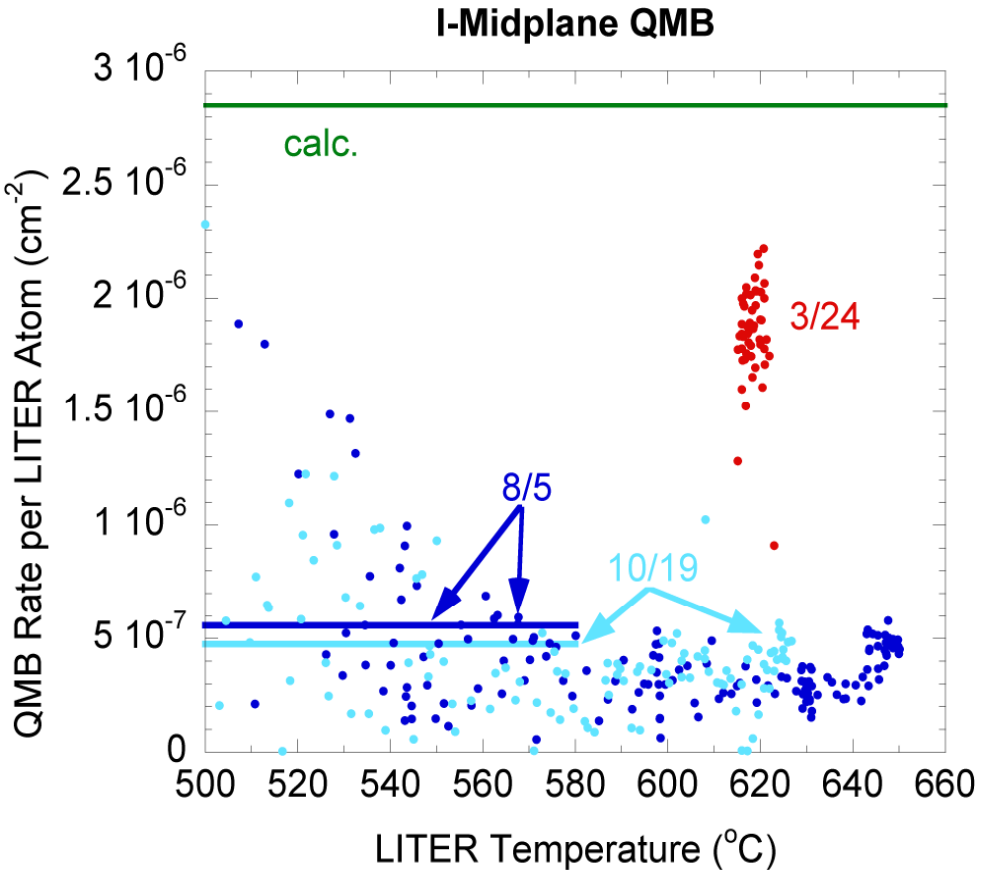
- LITERs operated separately on 3/24,
- Scan temperature of Bay K LITER on 8/5 and 10/19.
- QMB rate normalized by LITER rate from Schneider & plotted vs. LITER temperature.
- No trend over 500 – 580 °C ⇒ Schneider rate OK,
- Average over this range ~1/2 of calculated value.
- Use data above 580 °C to get non-molecular flow rate correction?
  - What about discrepancy with 3/24 data?



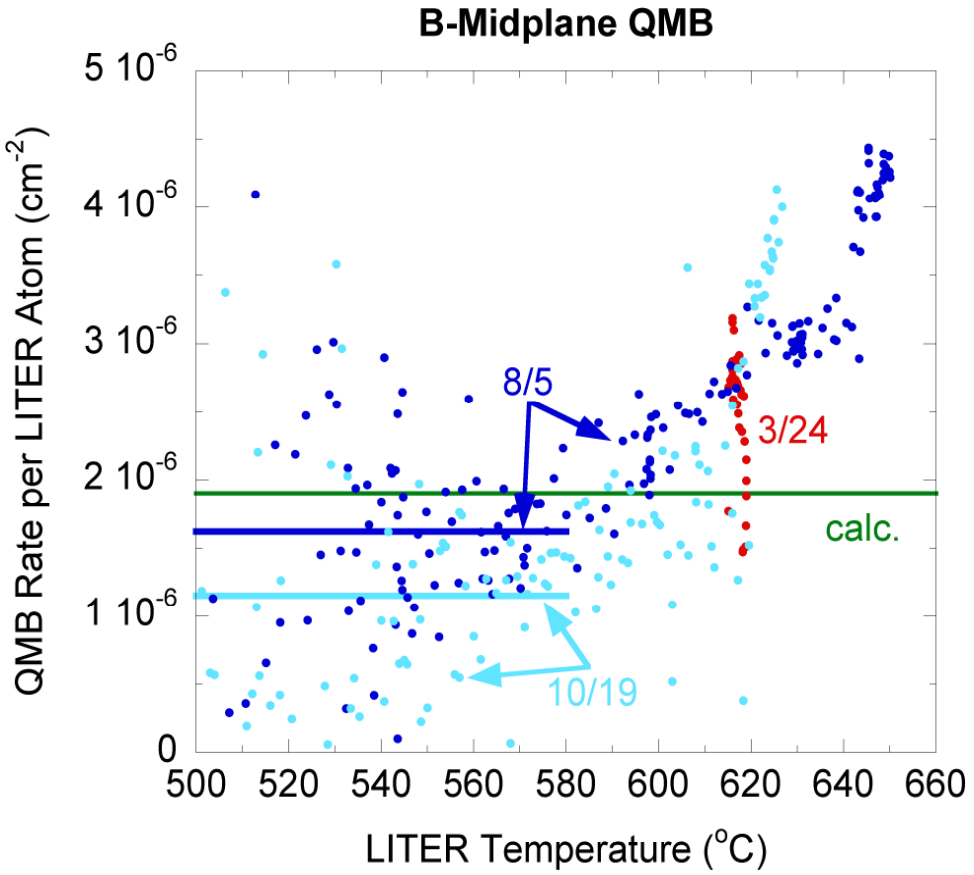
Bay K LITER only!

Data from Midplane QMBs Contradict These Trends

8/5 & 10/19 rates *drop* with increasing temperature?



Average rates much closer to calculation & 3/24 data:



- Effects of thick and / or non-uniform deposition?
- Variations in sticking coefficients between QMB & surrounding surfaces?
- To calibrate LITER and / or use QMBs for monitoring of Li evaporation, should do controlled off-line experiments.