Low Temperature Operation Discsussion

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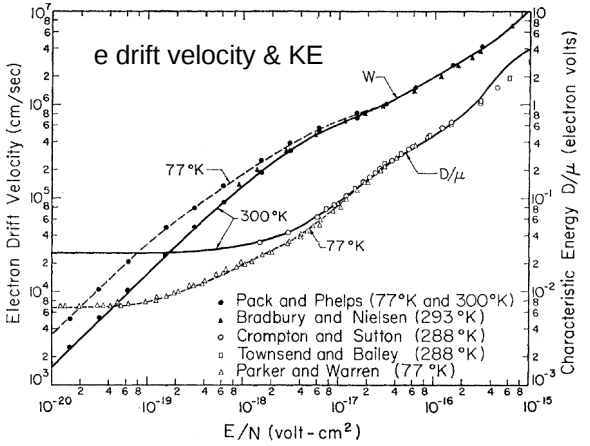
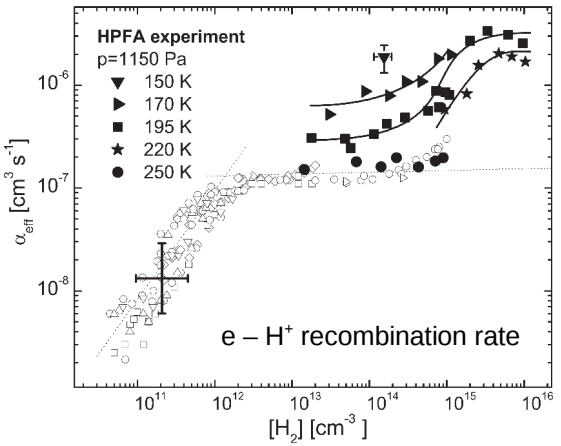
Foreword

- I have not investigated this matter with any depth
  - There will be very few numbers in these slides
- My goal is to stimulate conversation and ideas about how the operating temperature affects both the vacuum and helical channels
  - What is unique?
  - What is common?
  - What needs to be addressed?

Of Interest to the HCC

- Colder operation improves virtually every aspect of plasma dynamics associated with an HPRF cavity
- Keep in mind we have RF, not DC: beneficial processes accelerate when E → 0





- Larger H^+ clusters form & recombination with e^- faster (left)
- e^- attachment rate to O_2 higher / lifetime smaller (bellow)

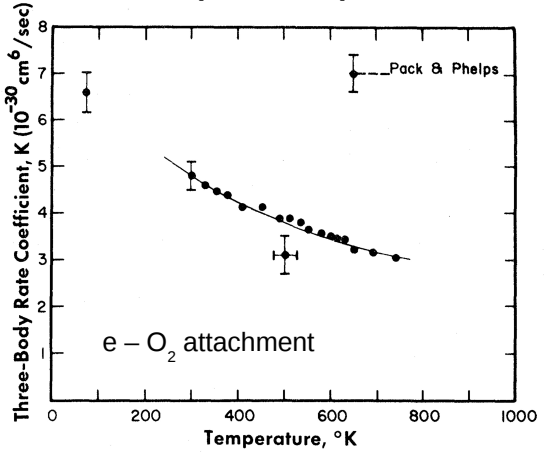
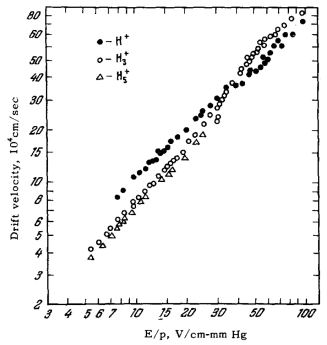
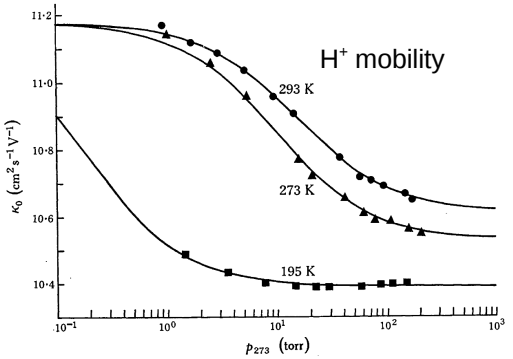


FIG. 6. Temperature dependence of the peak at 0.09 eV in the rate constant K for production of O_2^- in pure O_2, in comparison with the experiment of Pack and Phelps. The present data are normalized to those of Pack and Phelps at 300°K.





- e^- drift velocity and KE smaller (top left)
- Ion mobility smaller, i.e. less plasma loading (left)

Considerations for Both

- Power consumption:
  - Resistivity of copper decreases with temperature → higher Q
- Windows:
  - Thermal conductivity of both copper and beryllium increases with decreasing temperature → better cooling of RF windows / less thermal expansion → less frequency detuning
- Cavity length / Number of cavities:
  - This does not intrinsically depend on operating temperature
  - However, there is a trade-off game one can play with cavity length vs # of cavities vs E gradient that can be alleviated somewhat through operating temperature

Of Interest to the VCC

- I scratched my head, but could not come up with any issues related to temperature that would be a challenge only for the VCC
  - Unless the HCC ends up not using RF windows
- Perhaps some ideas from the experts...?

Engineering / Cost Considerations

- Is it feasible to operate both channels at LN_2 temperature?
  - There is not a lot of room in the HCC, perhaps more in VCC (but not by much?)
  - Where would the cryostat go?
  - Where would ports for LN_2 feedthroughs fit?
- Would the cryo system cost outweigh the power consumption saved?

Discussion

- Have I missed anything?
- Is there any feeling about how big an impact the previously mentioned would make?
- Who is currently putting in actual numbers?
  - And what have been the results?
- Collaboration between groups should cut the required effort in half