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10TH CONFERENCE ON HOPPING AND RELATED PHENOMENA

(1 - 4 September 2003)

"Electrical Transport of Spin Polarized Carriers in Disordered Ultrathin Films"

presented by:

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Electrical Transport of Disordered Ultrathin Films: Glacial Space-Charge in a Parallel Magnetic Field

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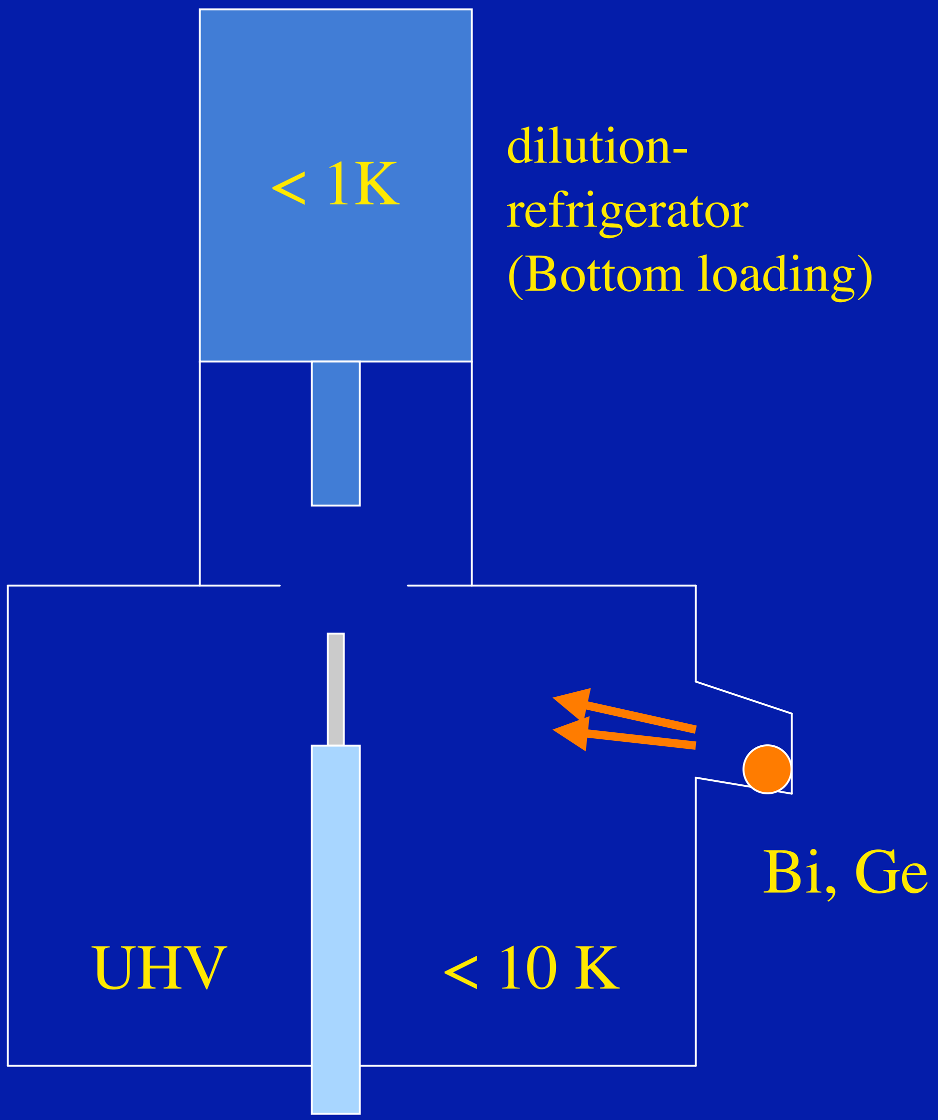
Allen M. Goldman

University of Minnesota

Phys. Rev. Letters (in press)

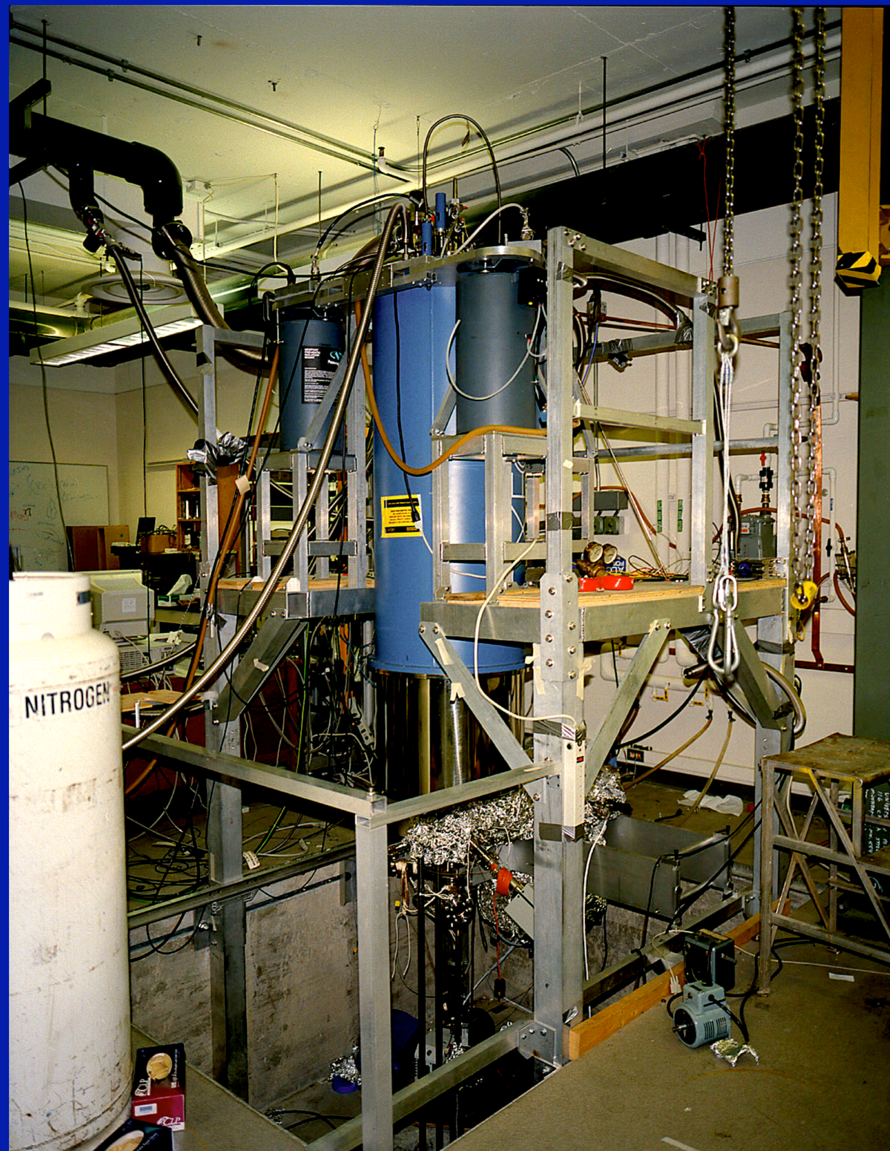
NSF Condensed Matter Physics Program DMR-0138209

Apparatus

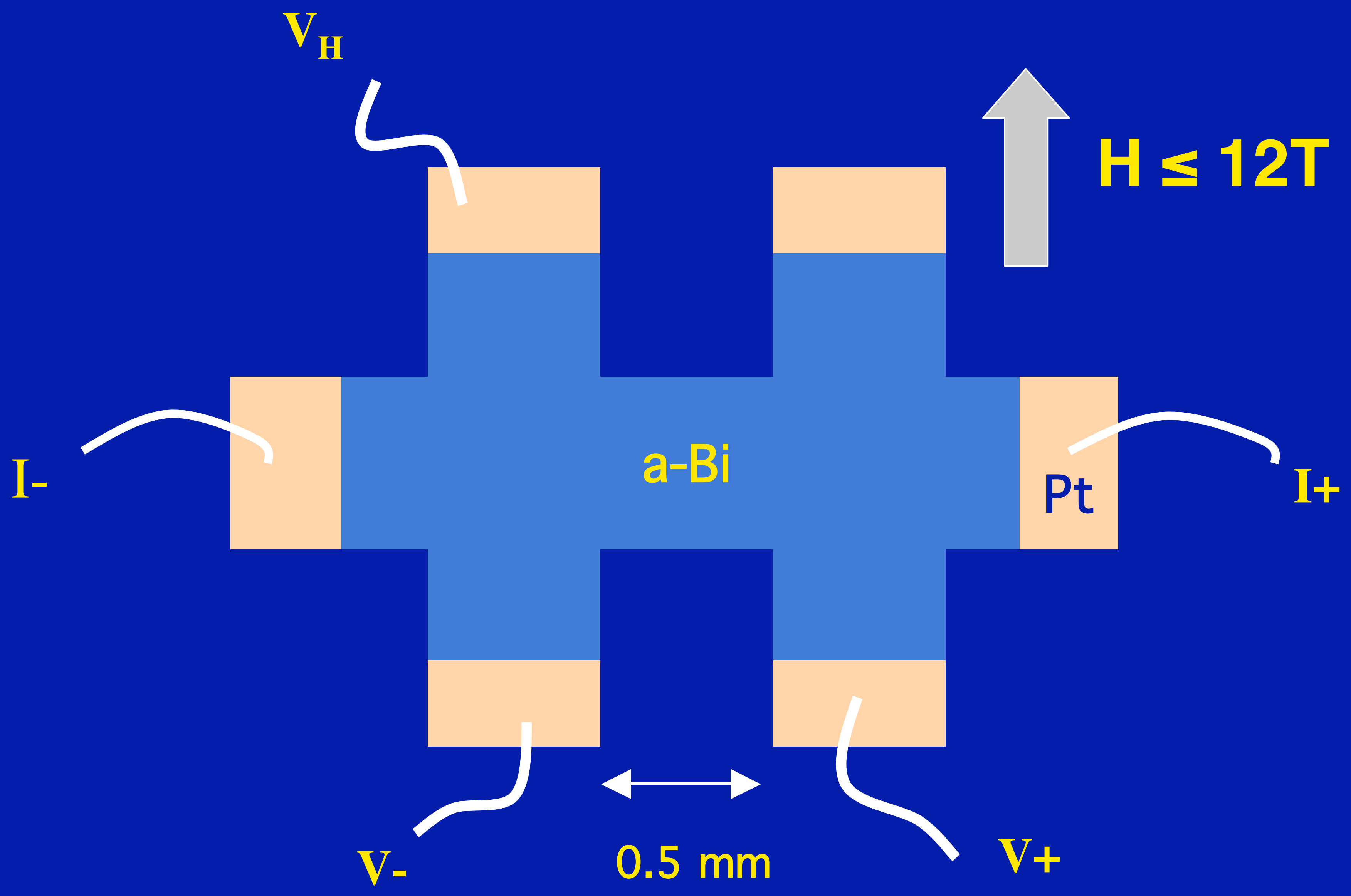


- *a*-Ge underlayer of 6Å deposited *in-situ*.
- 0.05-0.1Å increments.

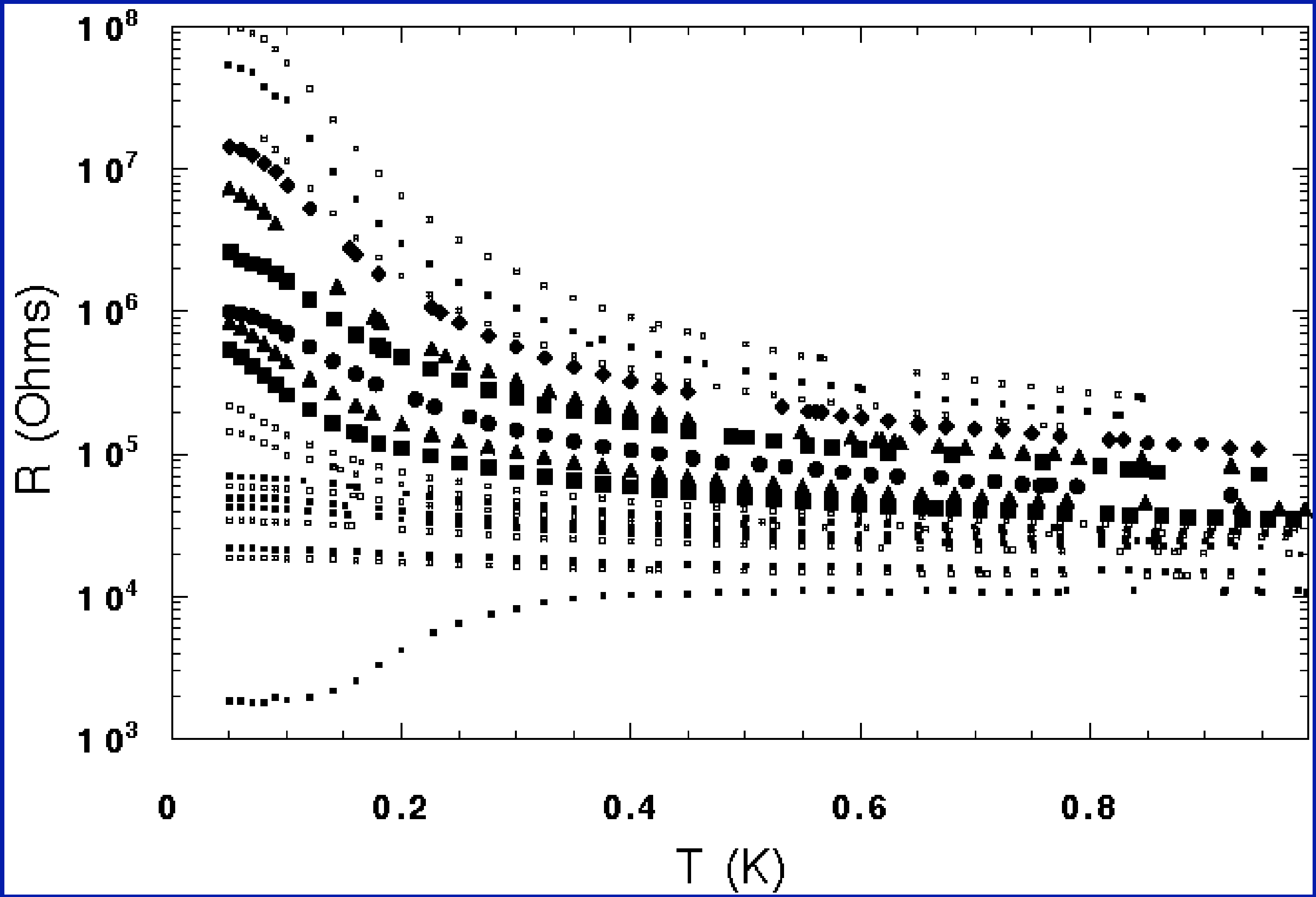
L.M. Hernandez and Allen M. Goldman, Rev. Sci. Instrum. **73**, 162 (2002)


NITROGEN

Measurement Geometry



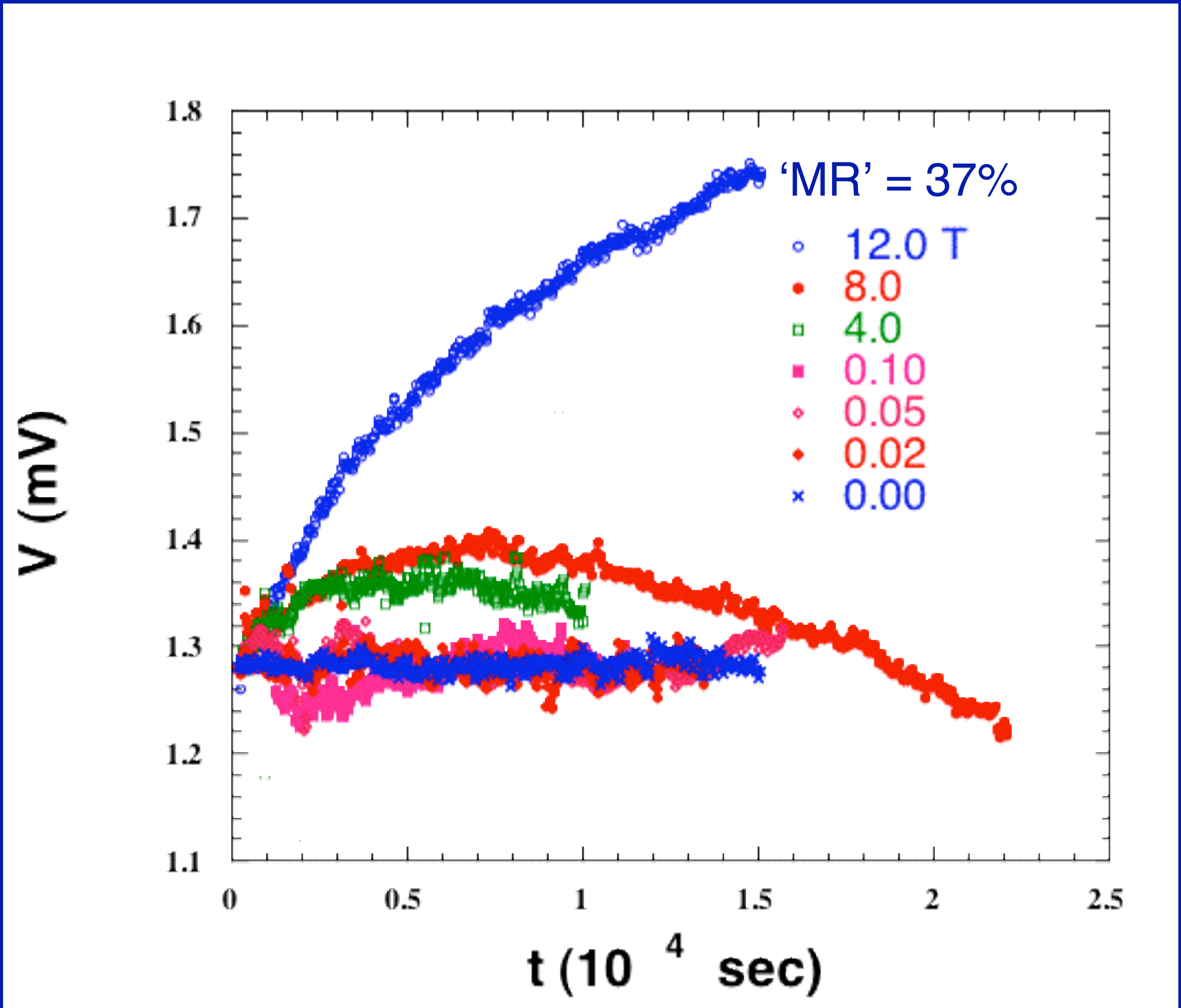
Evolution of R(T) with Thickness (on 6A *a*-Ge)



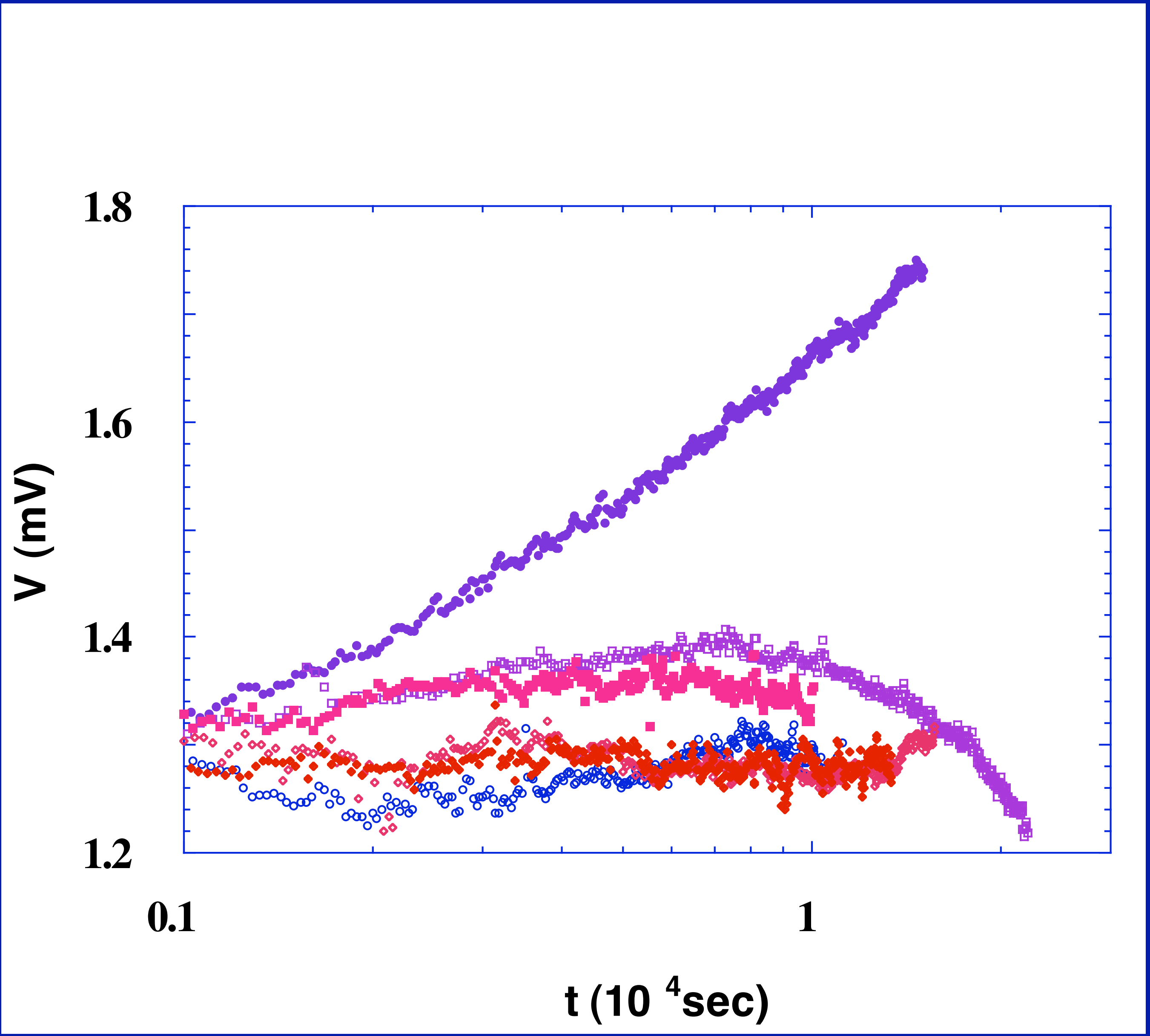
11.15Å
11.25
11.37
11.38
11.43
11.48
11.55
11.65
11.75
11.85
11.95
12.03
12.17
12.27
12.4
12.55
12.65
12.85
13.35

Slow Relaxation in $H_{||}$

T = 50mK thickness = 11.38Å 15 MΩ/sq

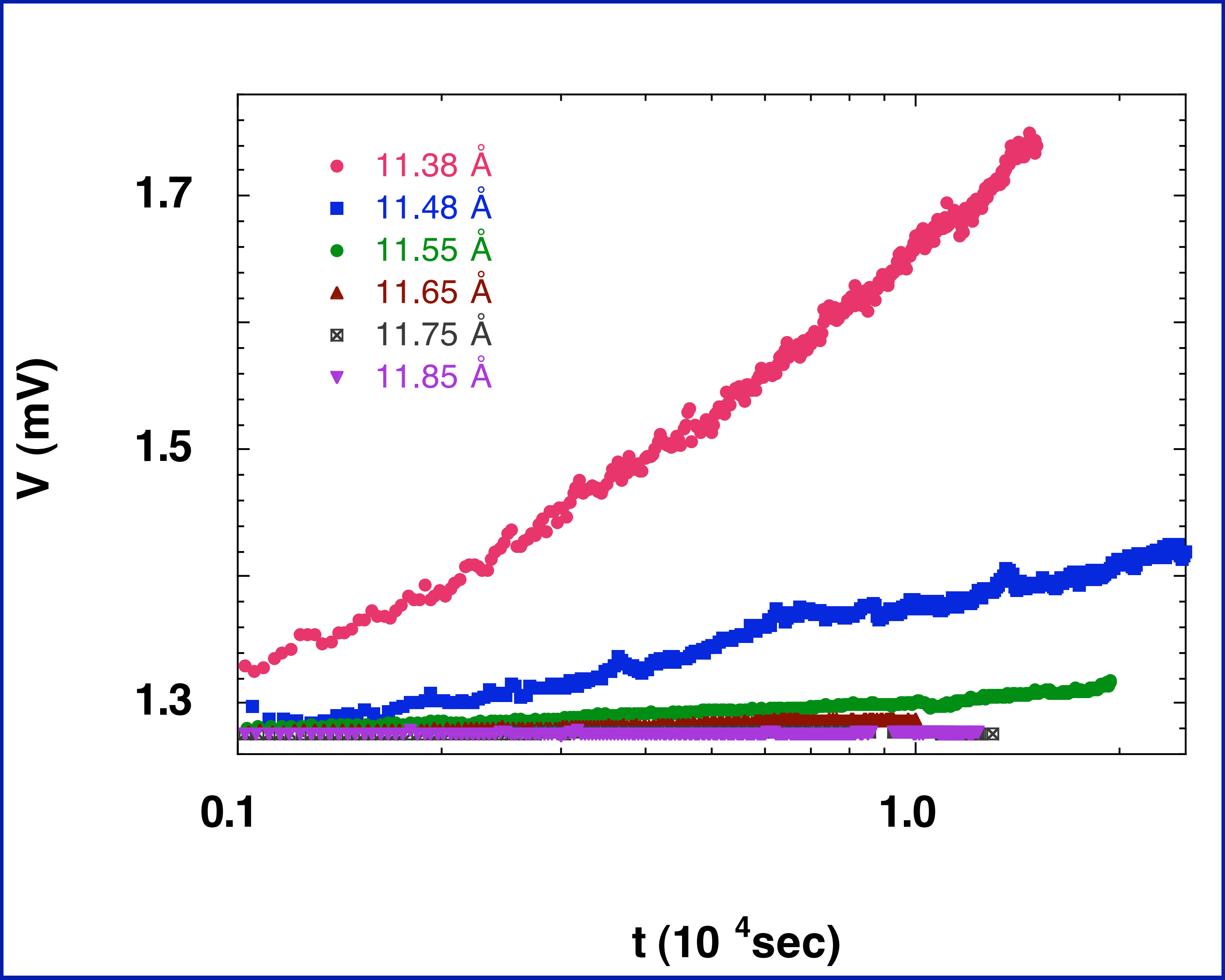


Slow Relaxation in $H_{||}$: log(t)

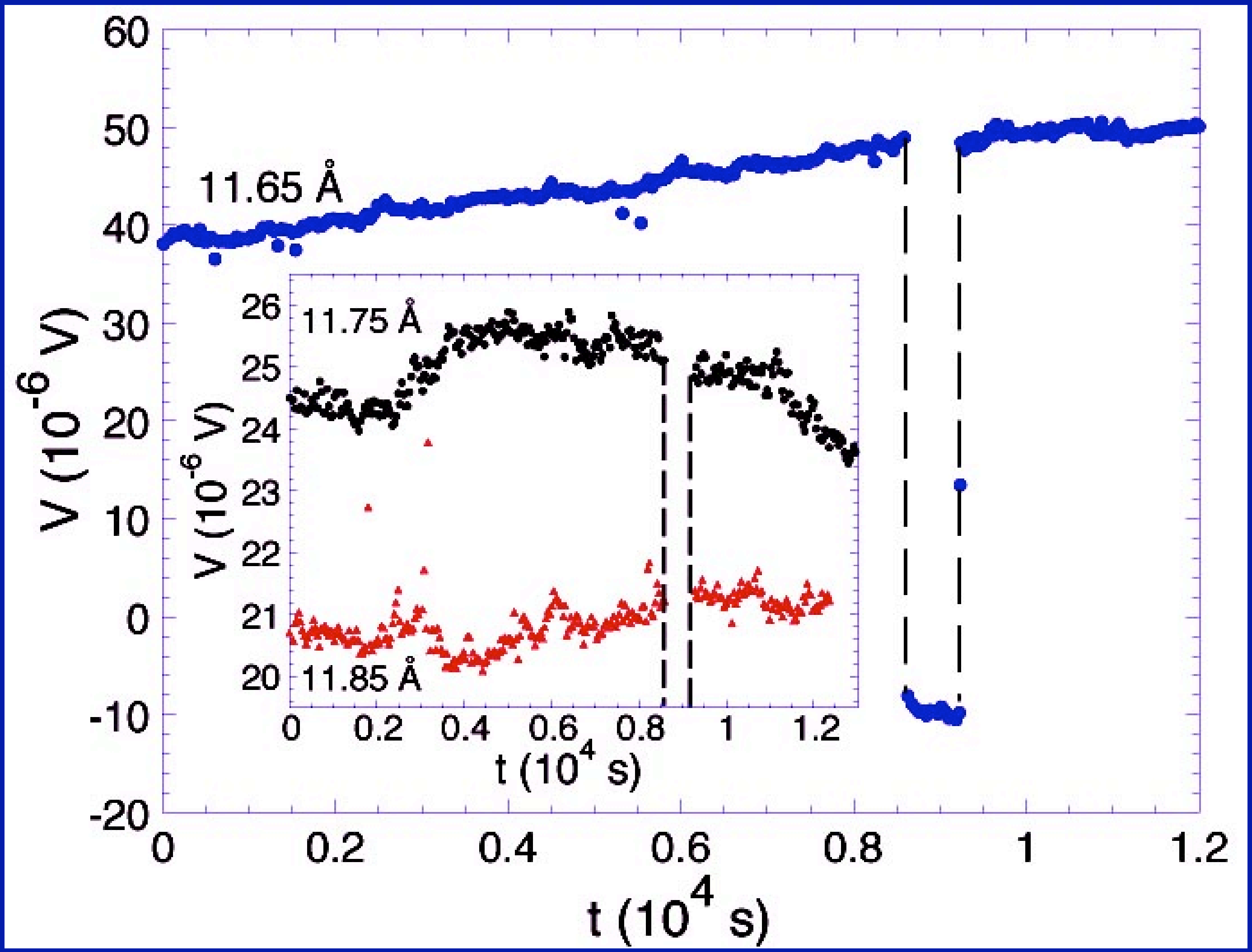


Evolution with Thickness

$H_{||}$ = 12T T = 50mK



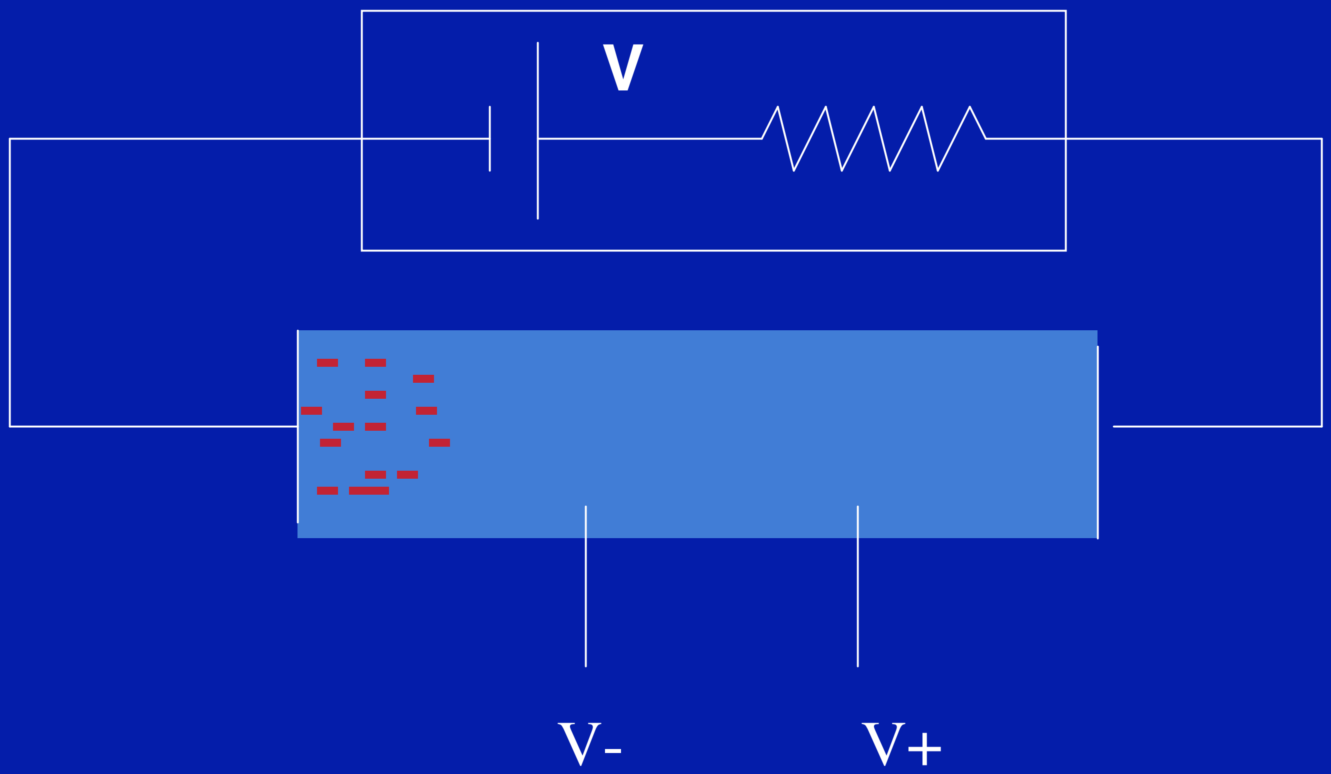
Memory Effect



Summary of Data

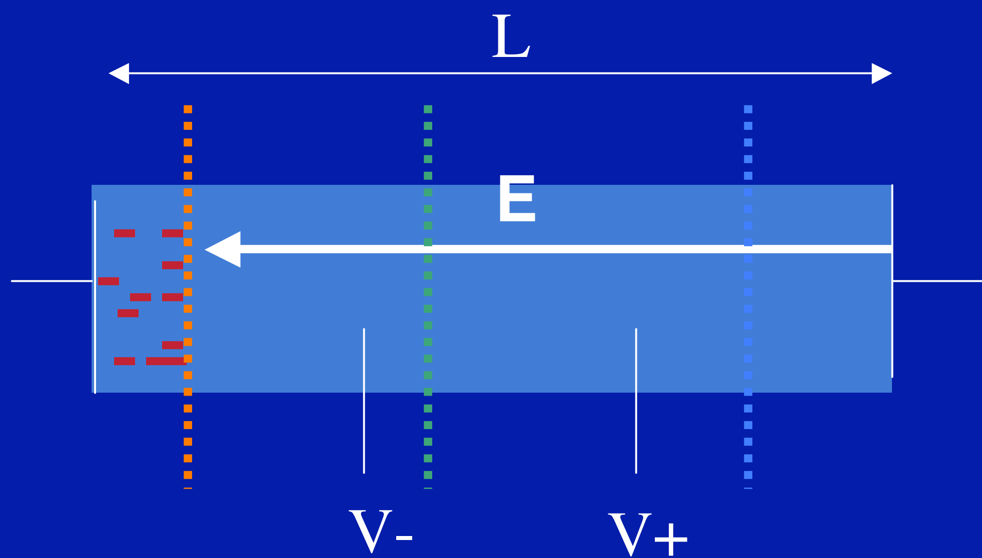
- Glacial charge dynamics at $H_{||} > 0.1$ T and $T < 200$mK.
- Transient behavior in $H_{||}$ - V increasing and then decreasing.
- Response slows down with increasing magnetic field, with no sign of saturation, even for $\mu H >> kT$.
- Effect is stronger for films deeper in insulating regime.
- Memory effect.

Space Charge

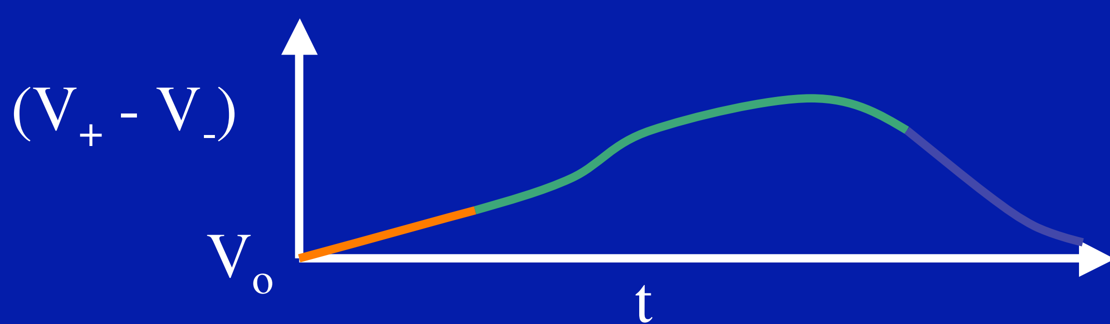


Space Charge : Spatially Inhomogeneous **E**

Evolution of Space Charge with Time

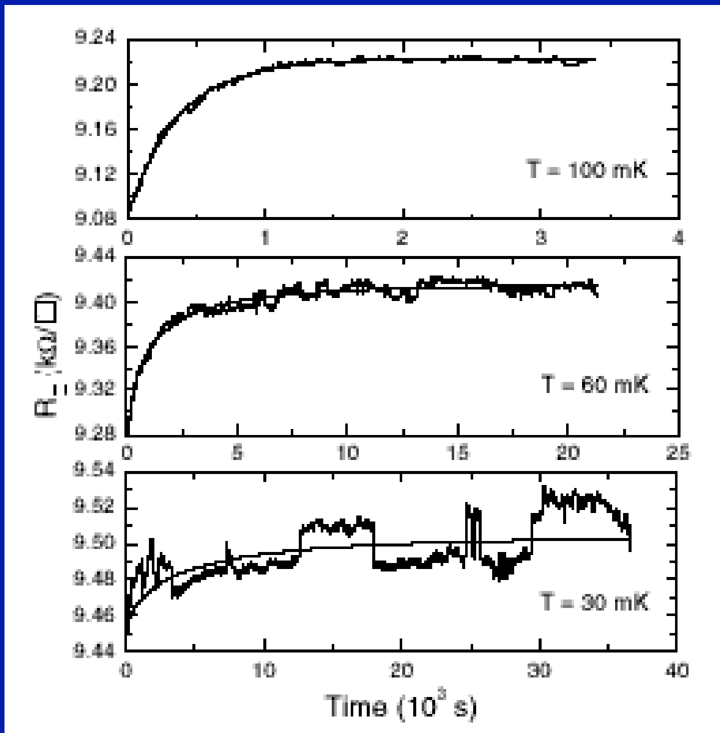


It is possible that E > V / L



Ref: Current Injection in Solids by Mark and Lampert

Other Work



- Weakly insulating granular Al films (10k□/).

- Superconductivity quenched with H, and glassy behavior observed in large $H_{\perp}$ and $H_{||}$.

- Glassy response < 2% of total R.

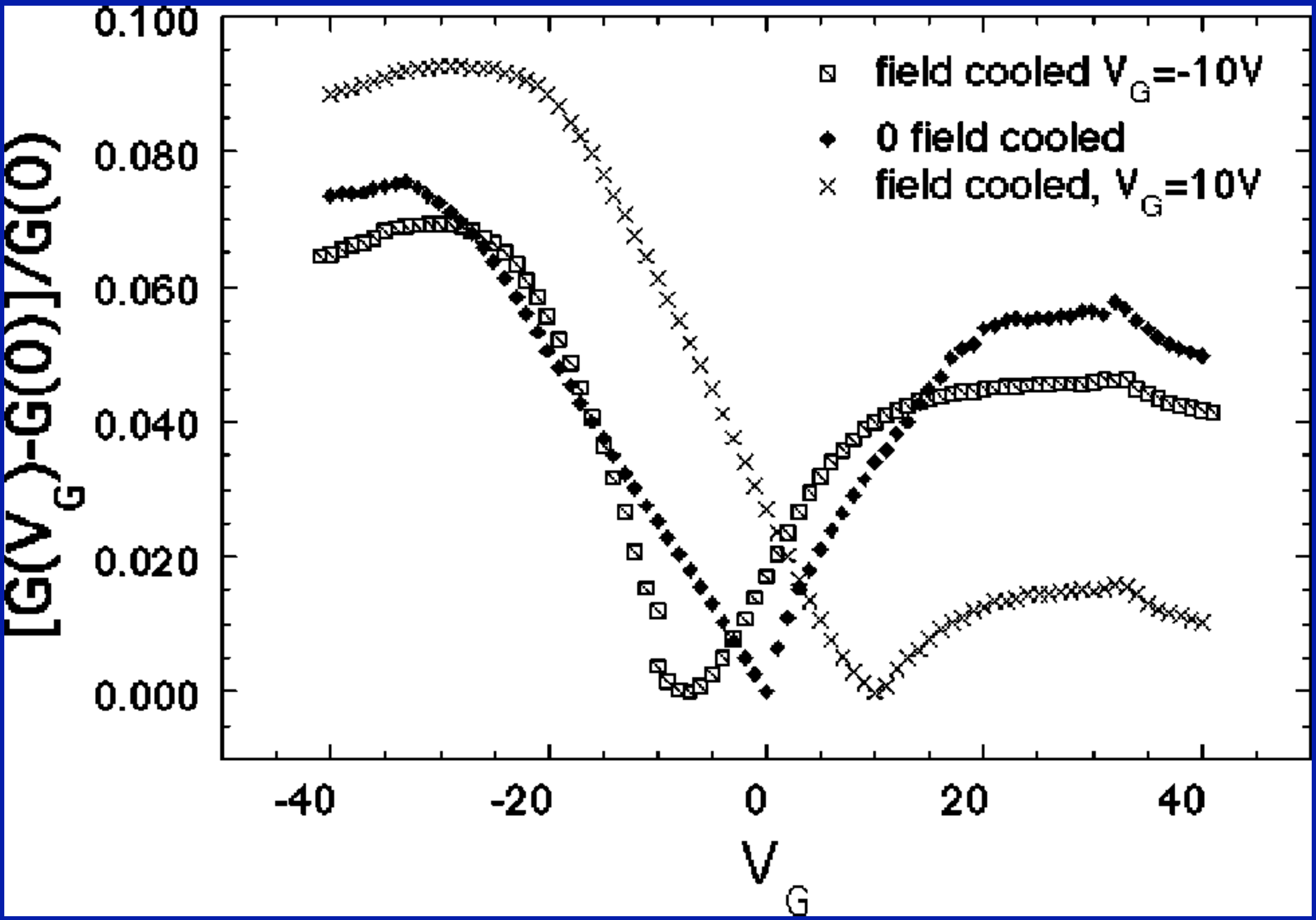
E. Bielejec and W. Wu, PRL **87**, 256601 (02).

Also: Capacitive Charging

Z. Ovadyahu and M. Pollak, PRL **79**, 459 (97).

G. Martinez-Arizala *et al.* PRB 57R (98).

Capacitive Charging



Inhibition of Hopping by $H_{||}$

Spin-Polarization Effects :

Hopping involving sites with double occupancy not allowed in presence of large magnetic field.
Mechanism saturates for $\mu B >> kT$. (Kurobe, Kamimura et al.)
No saturation is observed.

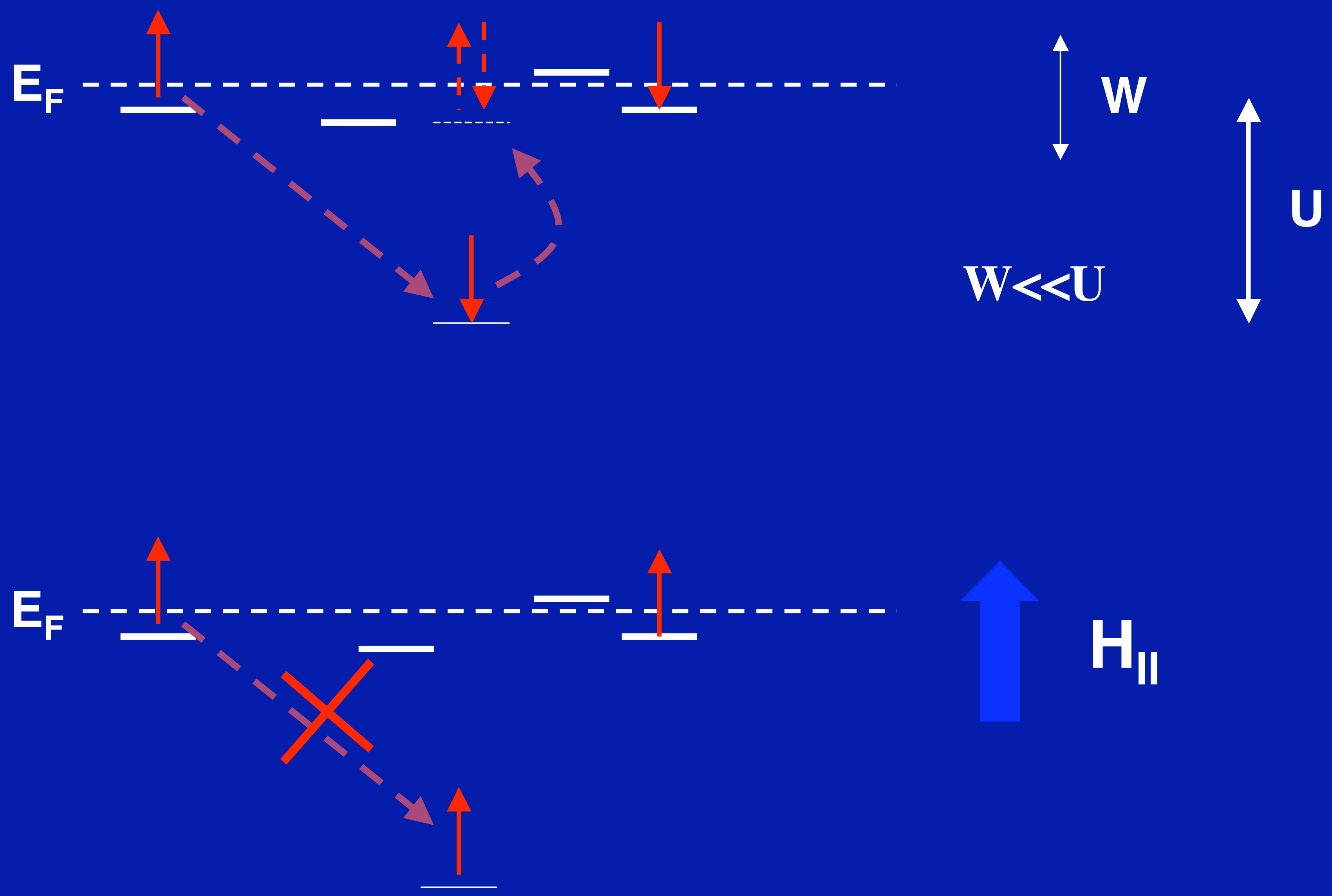
Wave function squeezing:

Magnetic length □ >> a_B at low fields at which the onset of the effect is seen (0.1T). Ref: Clare C. Yu, **PRL** 82, 4074 (99).

Superconductivity:

No evidence of superconductivity or superconducting fluctuations in any of the films exhibiting glass-like behavior.
Resistances were one to two orders of magnitude greater than those of Rochester group.

Inhibition of Hopping by $H_{||}$?



Other Physics needed to explain glassy behavior?

Wigner glass, spin liquid… Ref: Chakravarty, Kivelson et al., Phil. Mag. B **79**, 859 (99).

Conclusion

Application of a parallel magnetic field induces an electron glass in highly insulating disordered films. Systematics of relaxation seem to support the idea of space charge injection.

Future Work

- Spatial dependence of the space charge distribution and its relaxation.

- Anisotropy in magnetic field - systematically vary angle of applied field, both in plane and out of plane.