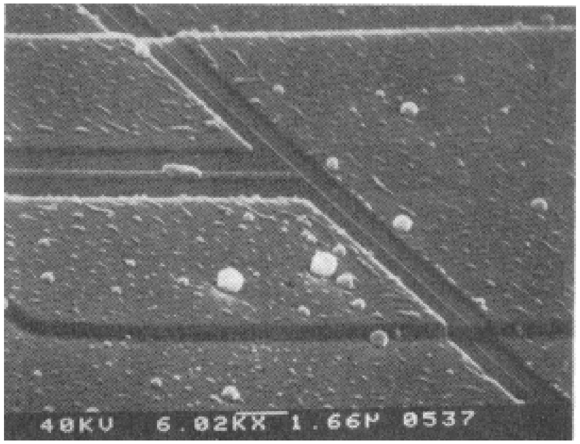
Nanostructures Research Group

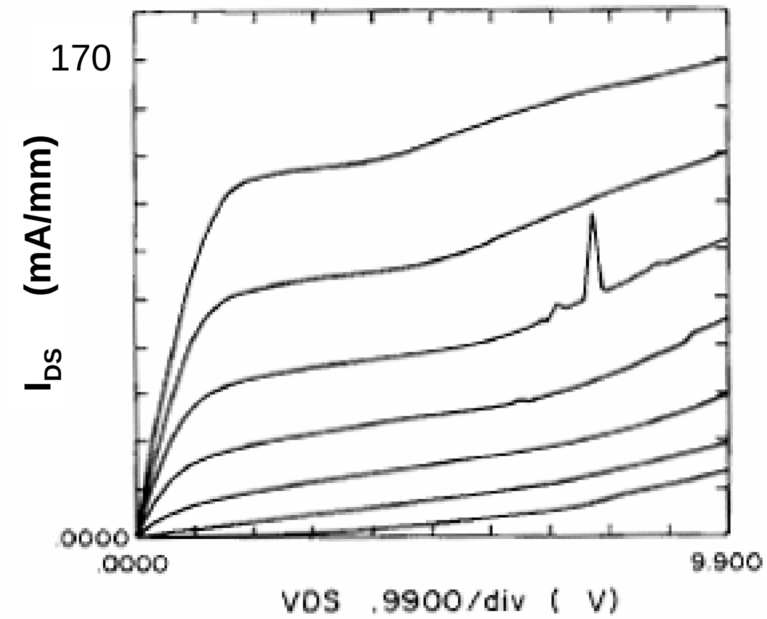
25years

1983-2008

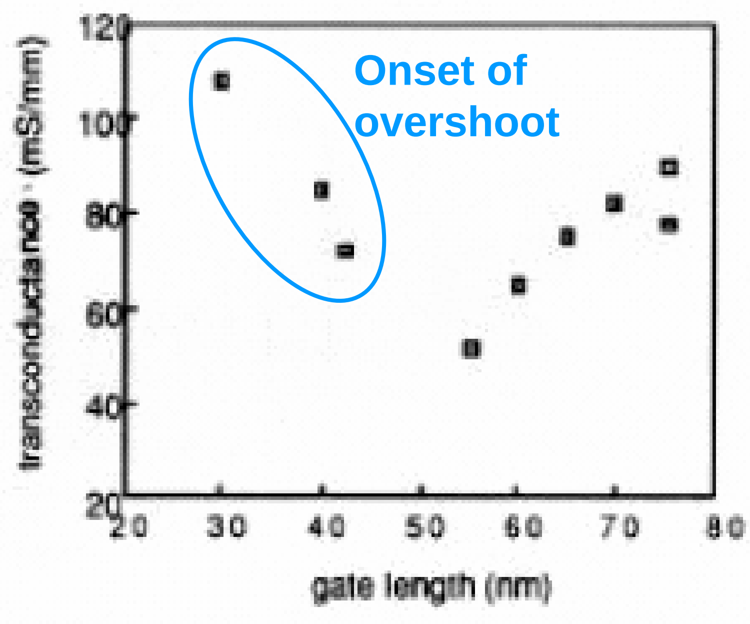
Ultra-Short Channel MESFETs & HEMTs

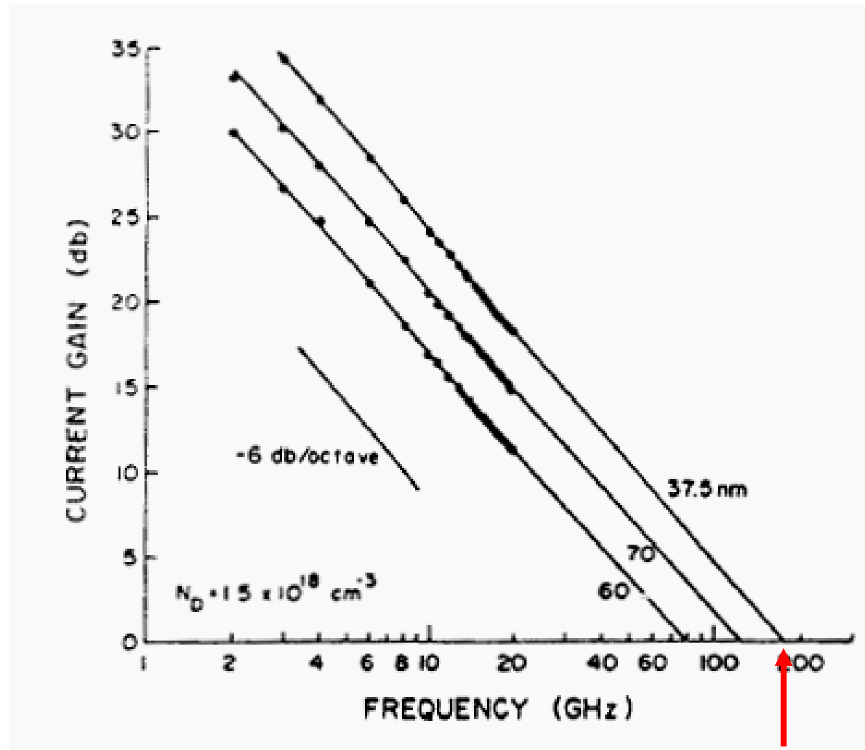


25 nm HEMT
IEEE Electron. Dev. Lett. ***11****, 209 (1990)*



Ultra-Short Channel MESFETs & HEMTs





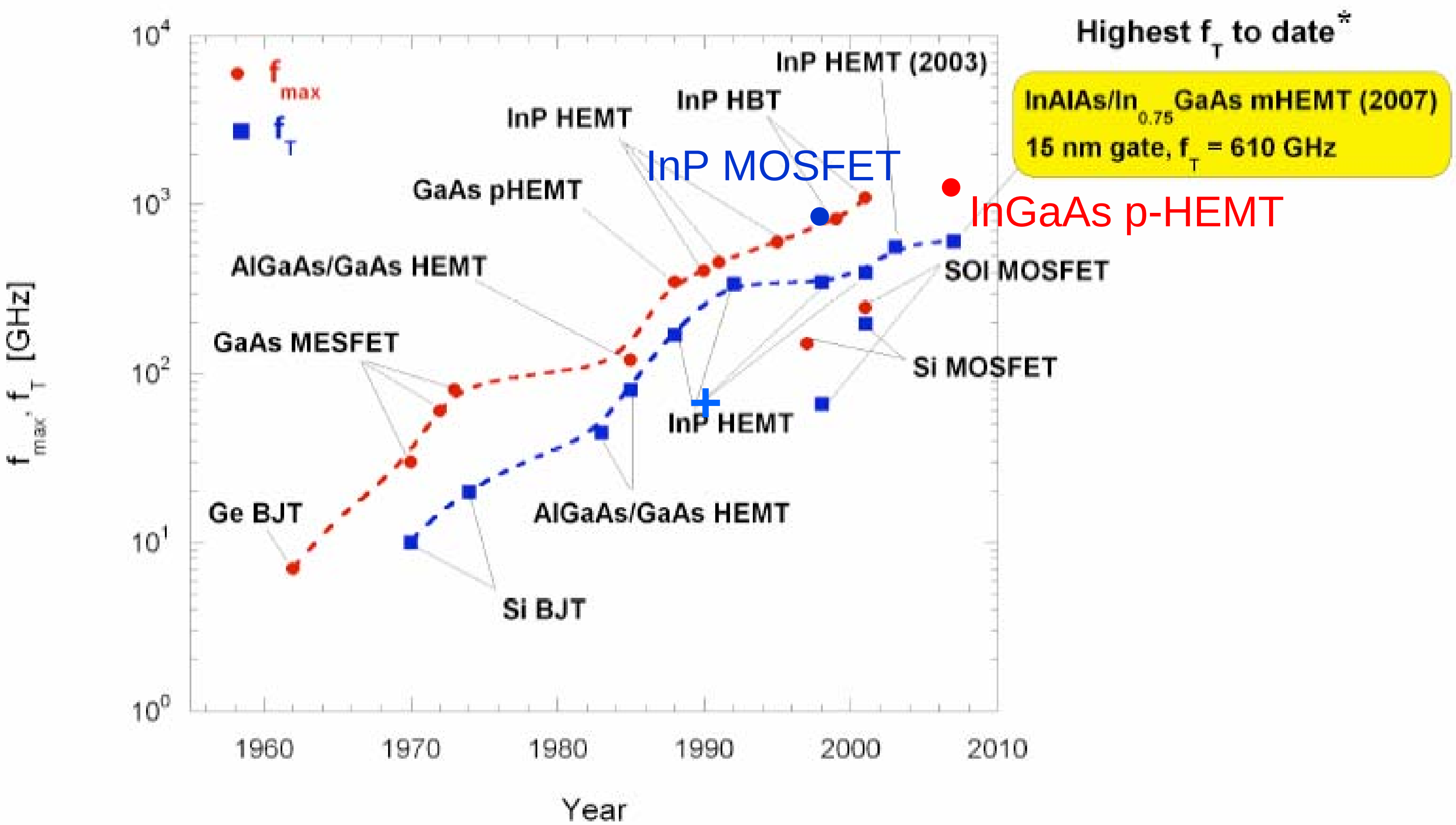
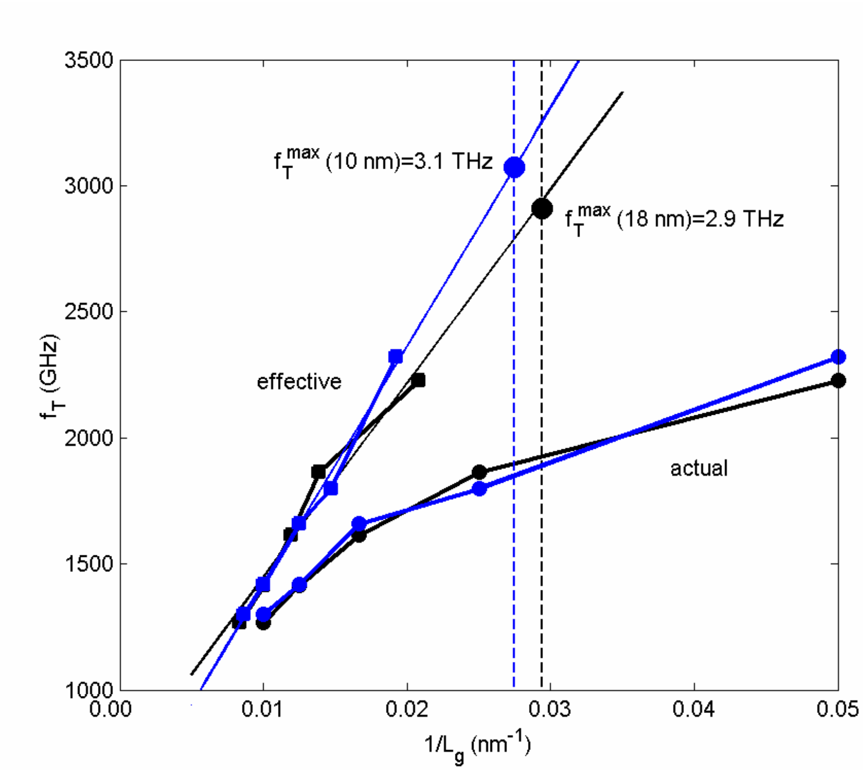
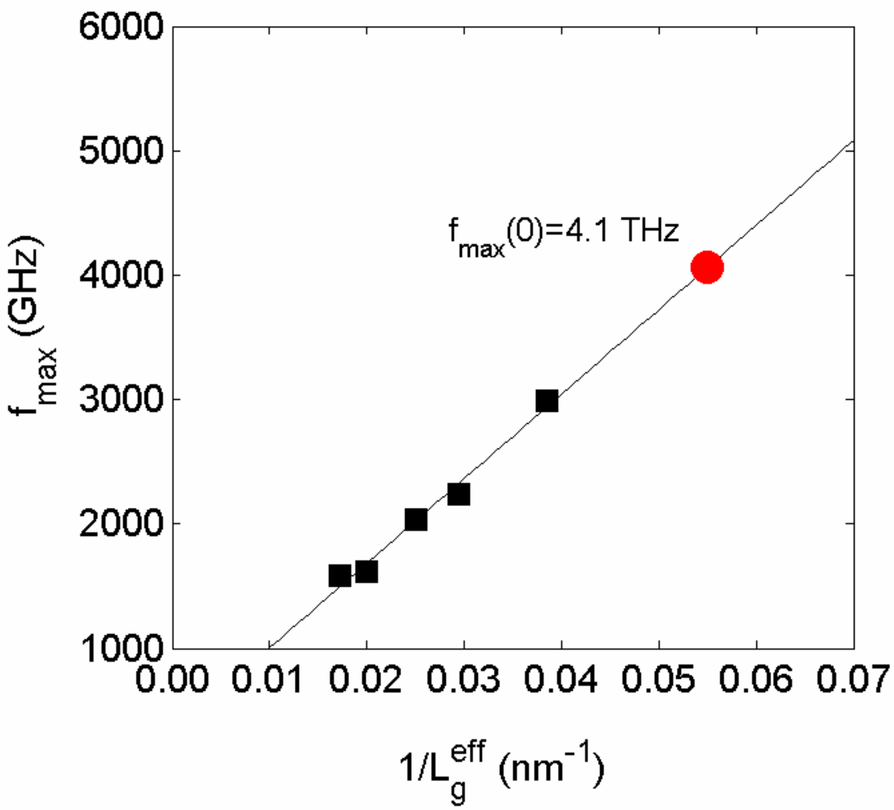


Chart taken from S.-J. Yeon *et al.*, IEDM 2007, pp. 613-6, December 2007.

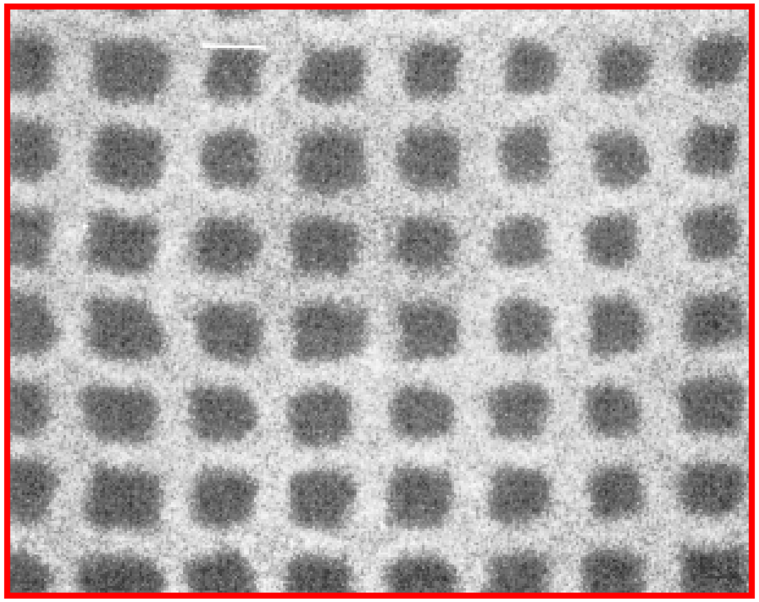
Nanostructures Research Group
CENTER FOR SOLID STATE ELECTRONICS RESEARCH

Predictions for Today's $In_{0.75}Ga_{0.25}As$ *p*-HEMTs





Lateral Surface Superlattices
Large Arrays of Quantum Dots

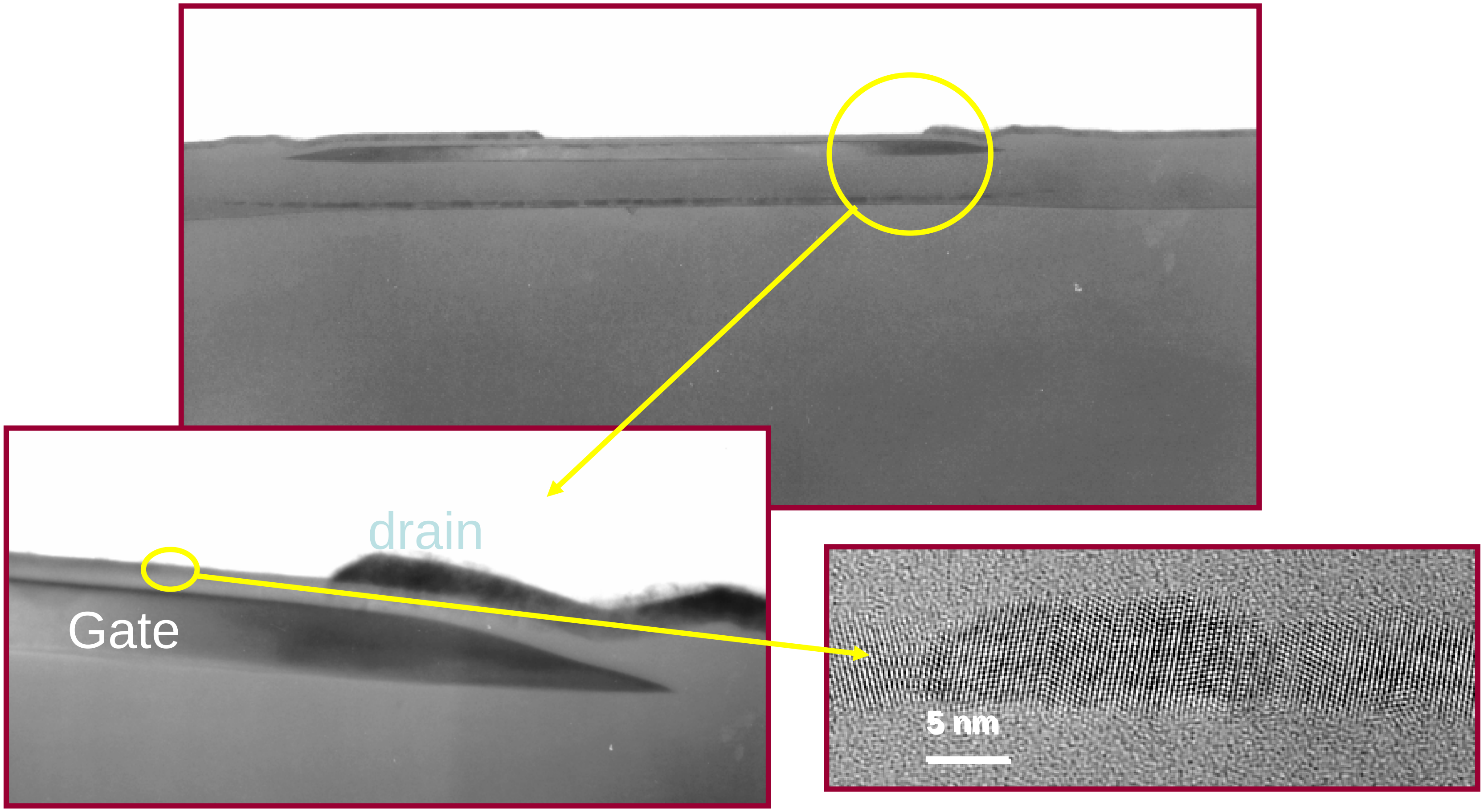


160 nm period lateral superlattice on AlGaAs/GaAs heterostructure

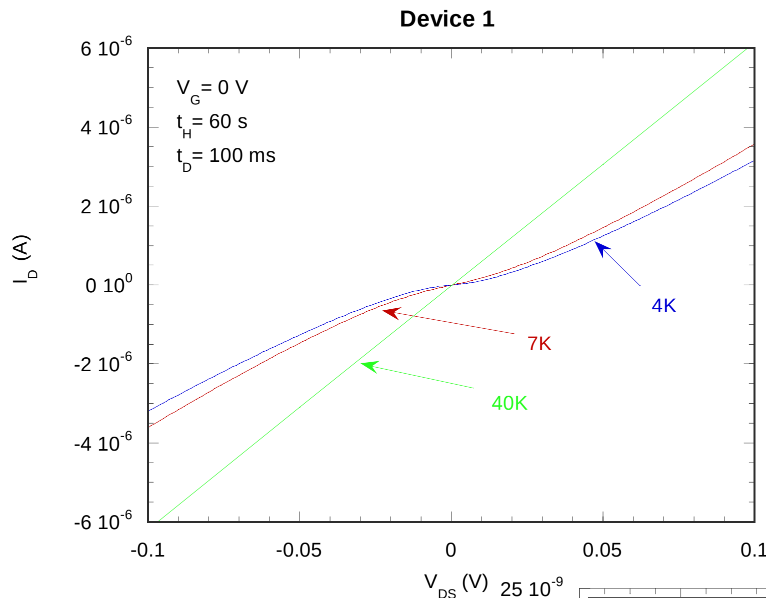
Prog. Quantum Electron. **16**, 251 (1992)
Superlatt. Microstruc. **2**, 373 (1986)

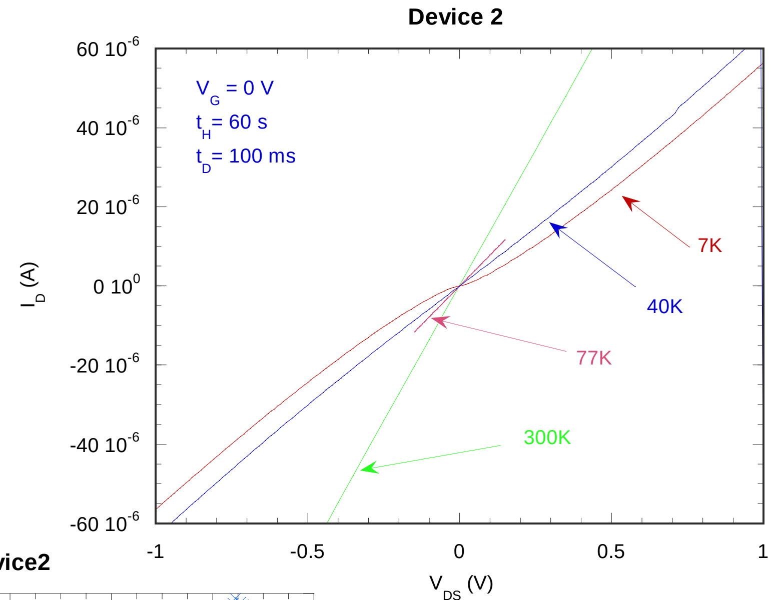
- **Established period band structure at both low and high magnetic fields**
- **Cooperative effects and shifts of energy in applied bias demonstrated**

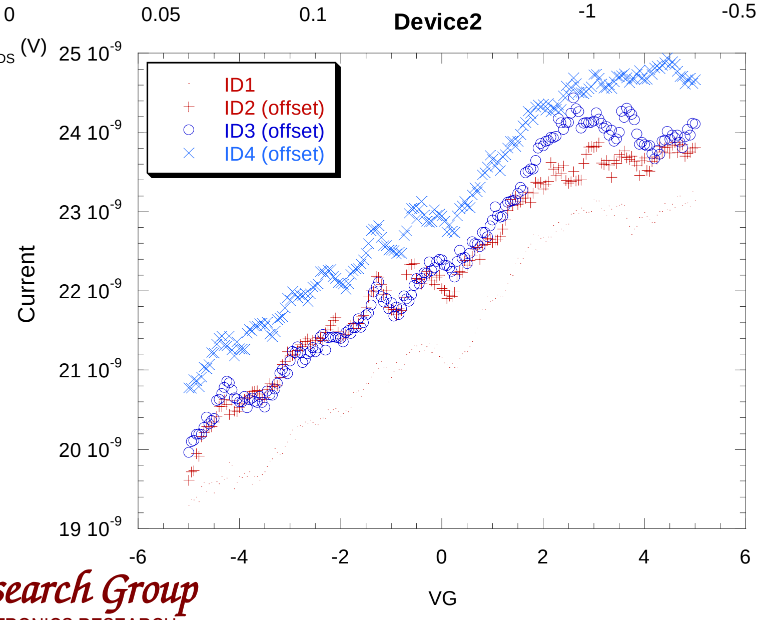
Poly-Si Based Single-Electron Devices



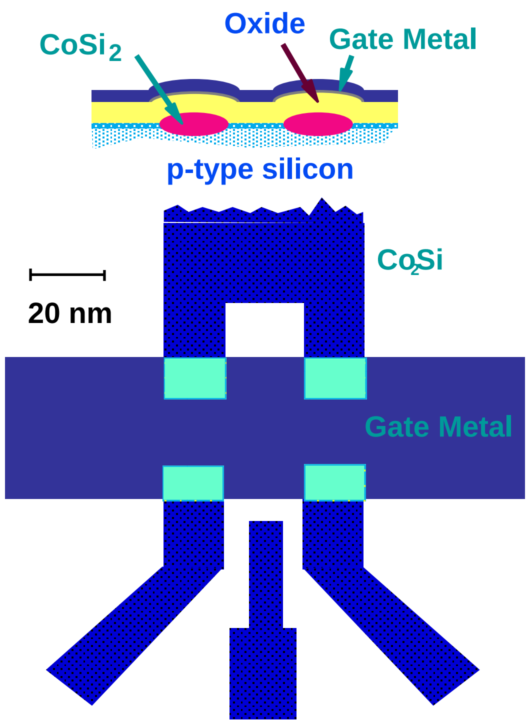
Poly-Si Based Single-Electron Devices

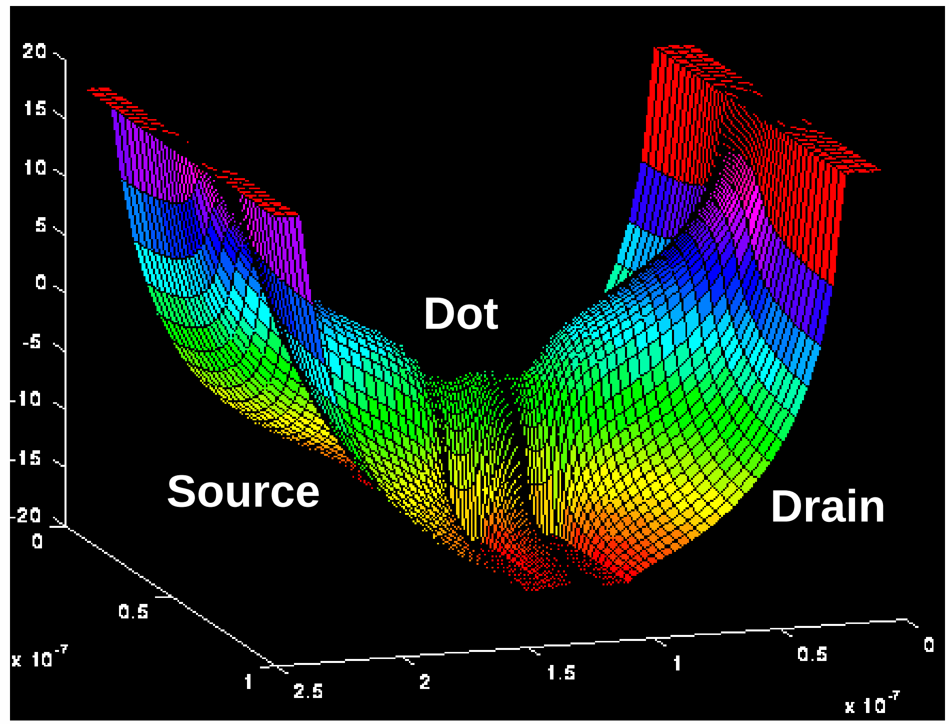






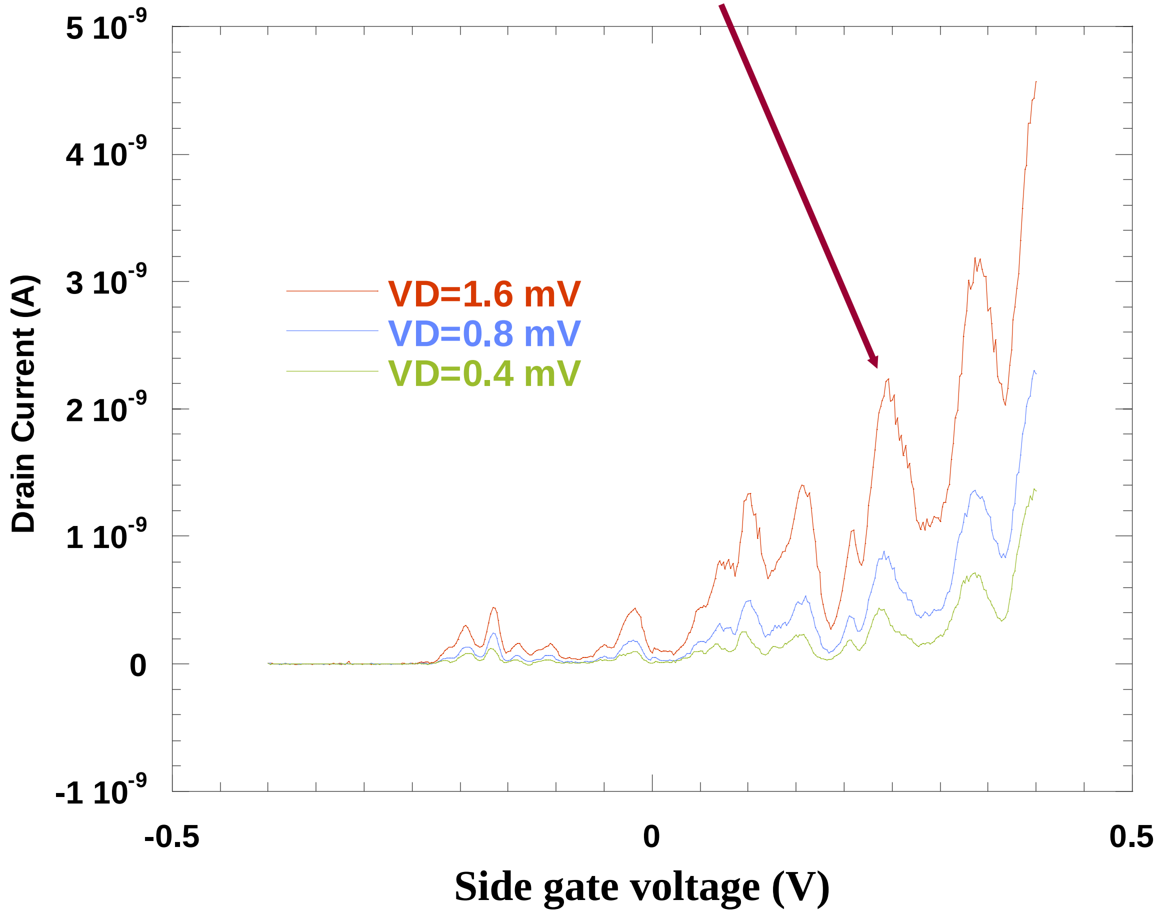
MOS-based Nanodevice



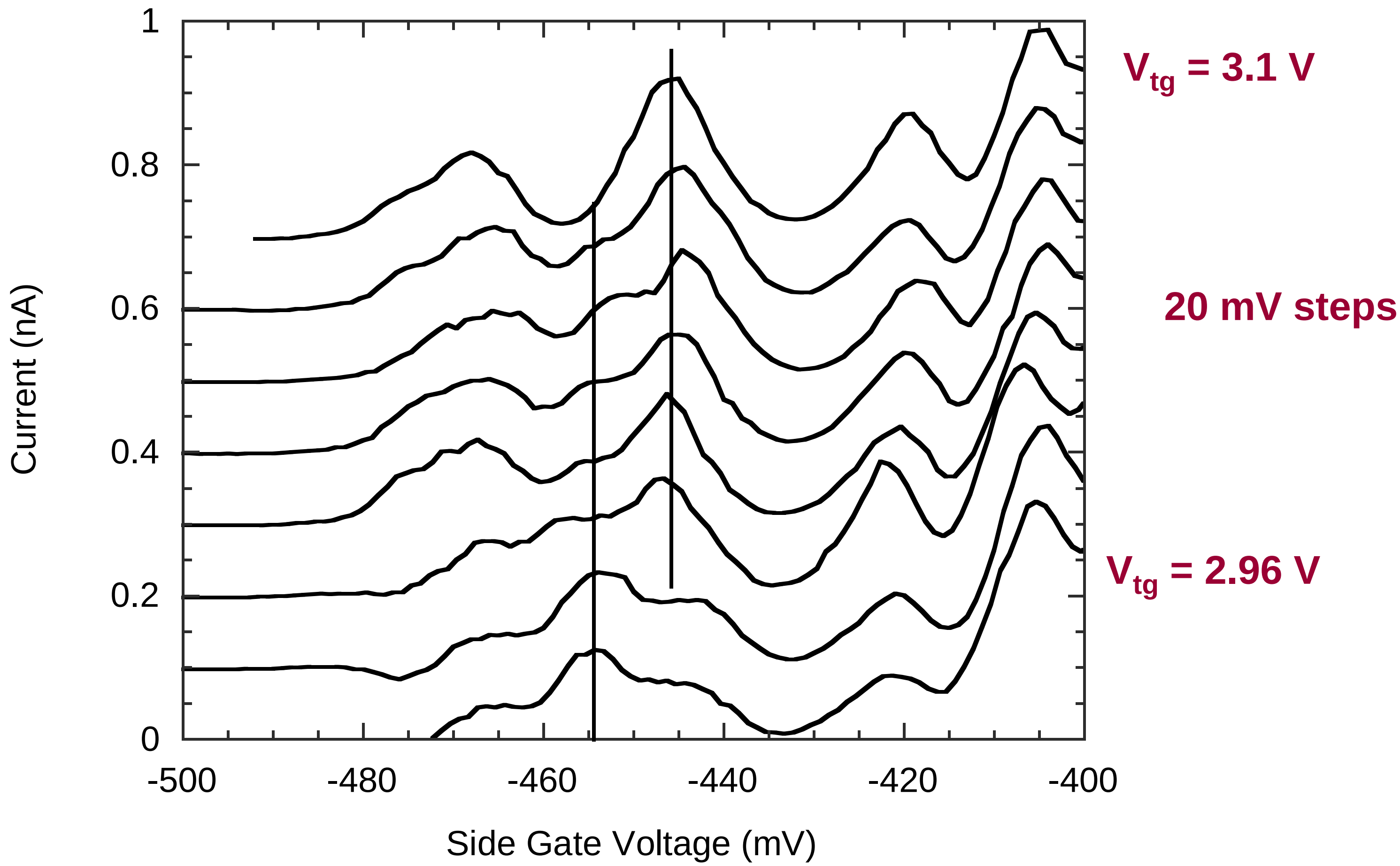


Dot 1

Position of peaks does not change with the drain bias--this indicates role of single electron charging

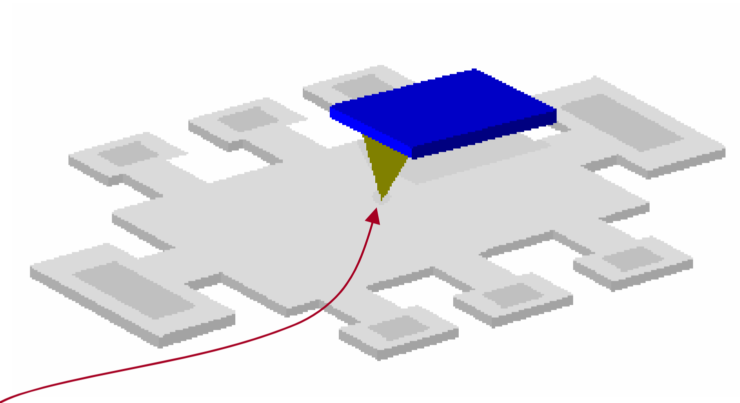


Charging characteristics:
Peak positions "crossover" possible



Introduction

Scanning gate microscopy (SGM)

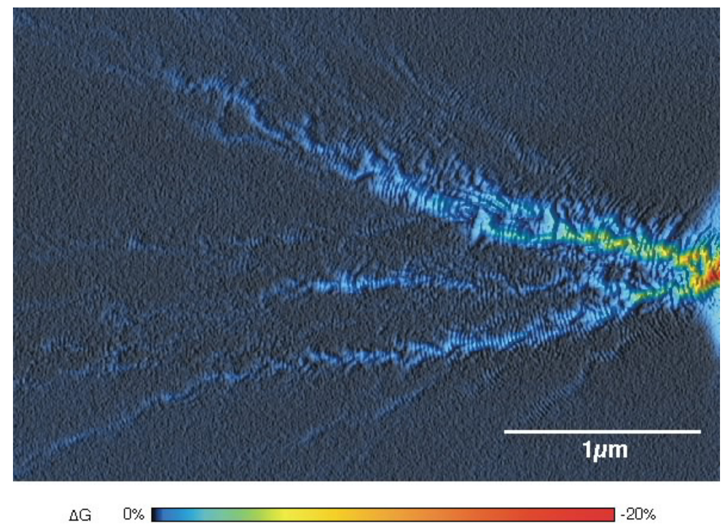


Metalized AFM tip with negative bias applied.

Detection of:

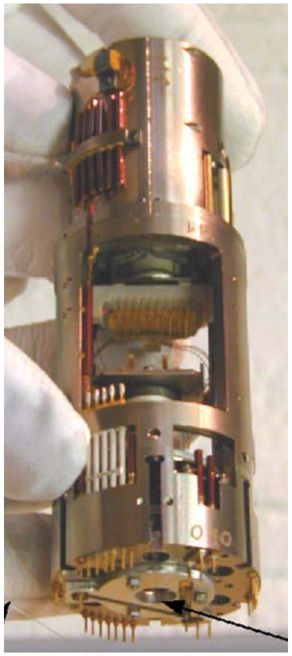
local potential
local charge
local current distribution

Imaging of Current flow from QPC



M.A. Topinka *et al*., Nature 410, 183 (2001)

Cryogenic SPM System

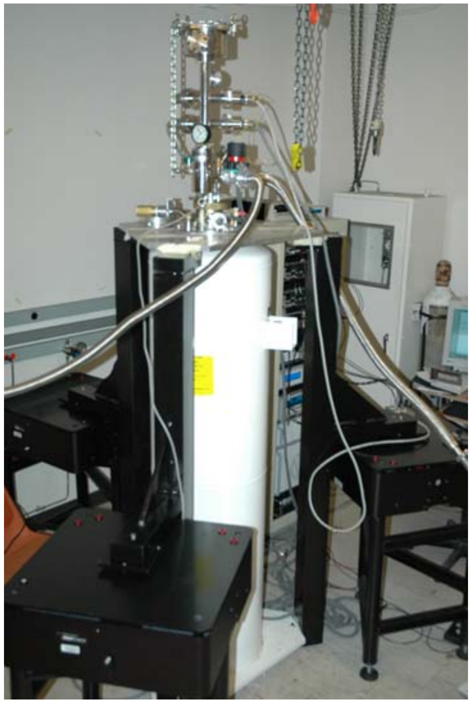


Cryogenic SFM head by Omicron

Scan window = 20 μm x 20 μm at RT,
decreasing 2.7 μm at 0.3 K

Piezo resistive cantilever
- PtIr coated tip
- Biased up to –3 V

Scan mode
- Contact mode for topography
- Lift mode for SGM



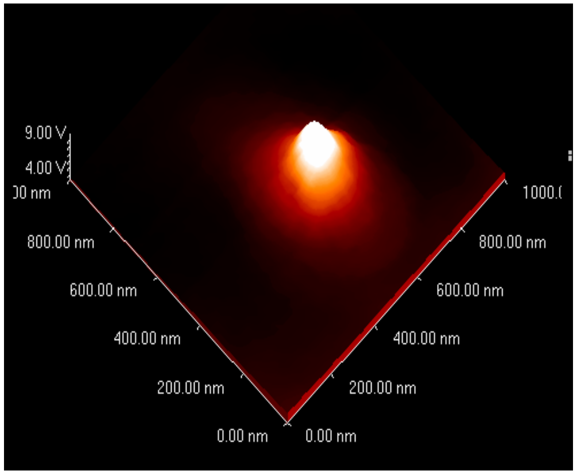
He^3 cryostat by Janis

Base temperature: 0.27 K

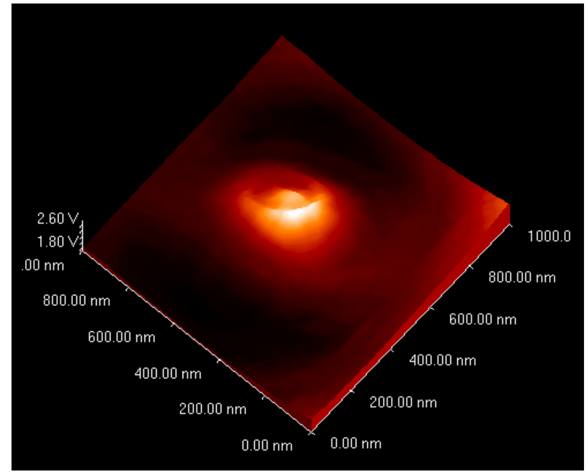
Isolators by Minus-K

< 0.5Hz resonant freq.

Measurements in a Quantum Point Contact



$1.5\ G_0$

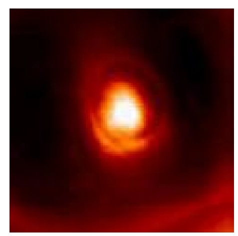


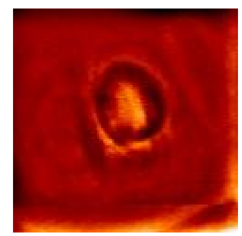
$0.4\ G_0$

(700 nm × 700 nm)

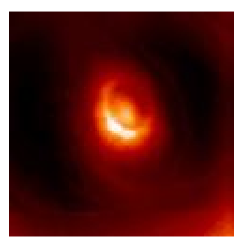
Resistance image — High pass filtered

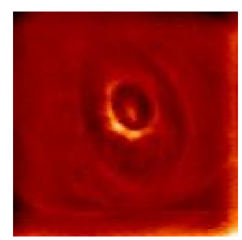
0 T



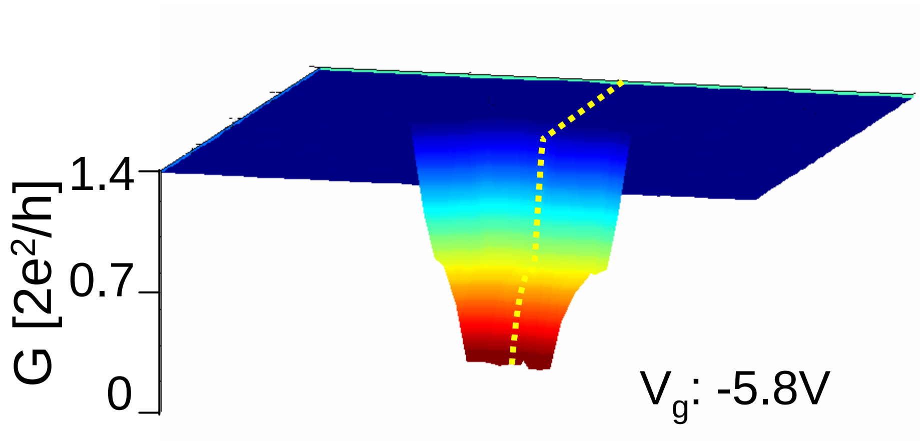


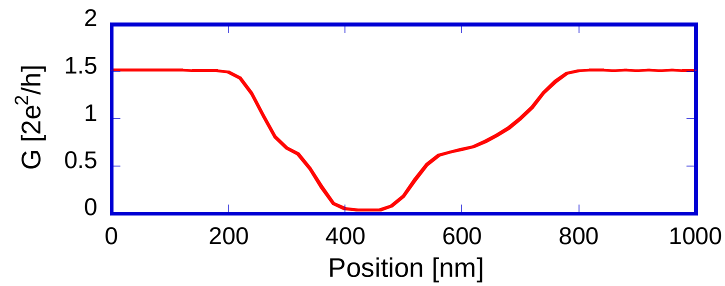
200 mT



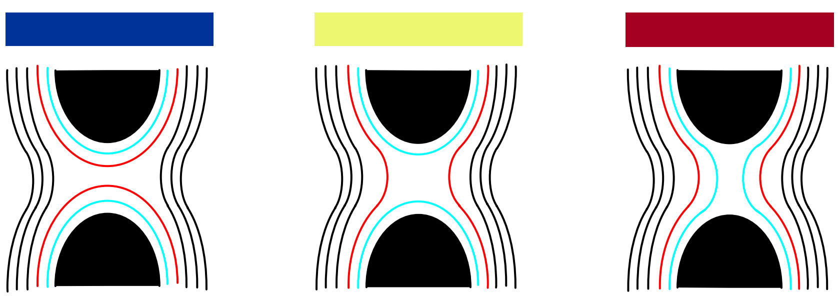


Imaging Incompressible States in QHE





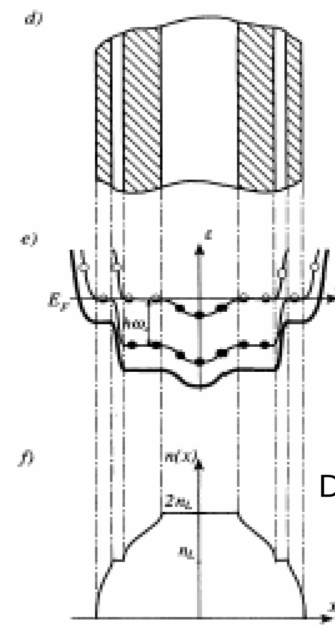
Cross section at the center of image



2 edge channel propagation

1 edge channel propagation

No edge channel propagation



D.B. Chklovskii *et al*., Phys. Rev. B, 47, 12605 (1993)

Self-consistent electrostatic picture of IQHE

Imaging of incompressible edge state?

And the future holds…

- Transition of NRG into a Center within AINE, designed to couple the nanoelectronics activities within EE to the nano-physics thrusts within the Physics Department
- Expand simulation activities to more devices as part of the Computational Science Center
- Transport in new materials (graphene, oxide heterojunctions, nanowires, …)
- Continue SGM studies of quantum coherence in quantum dots