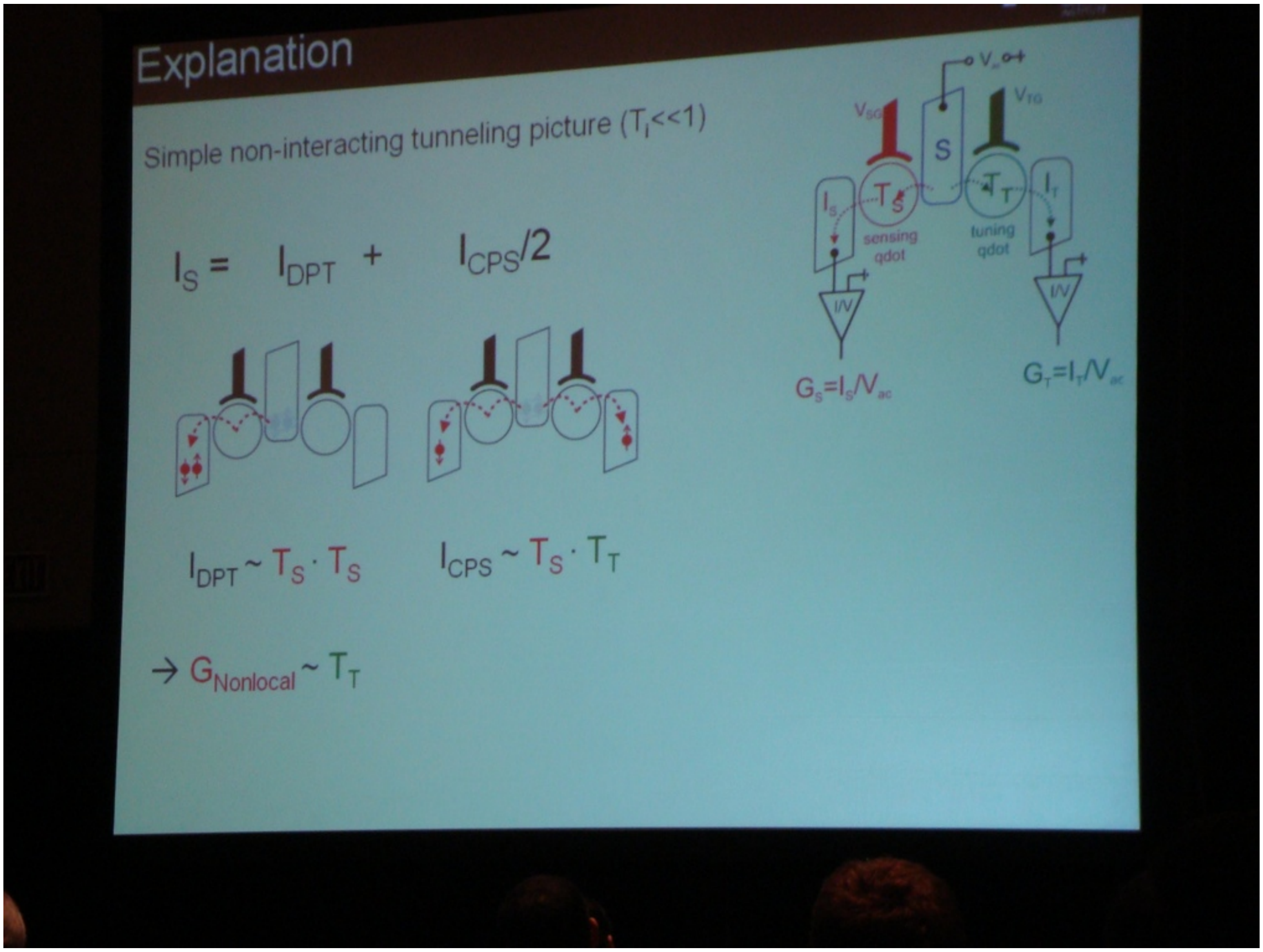
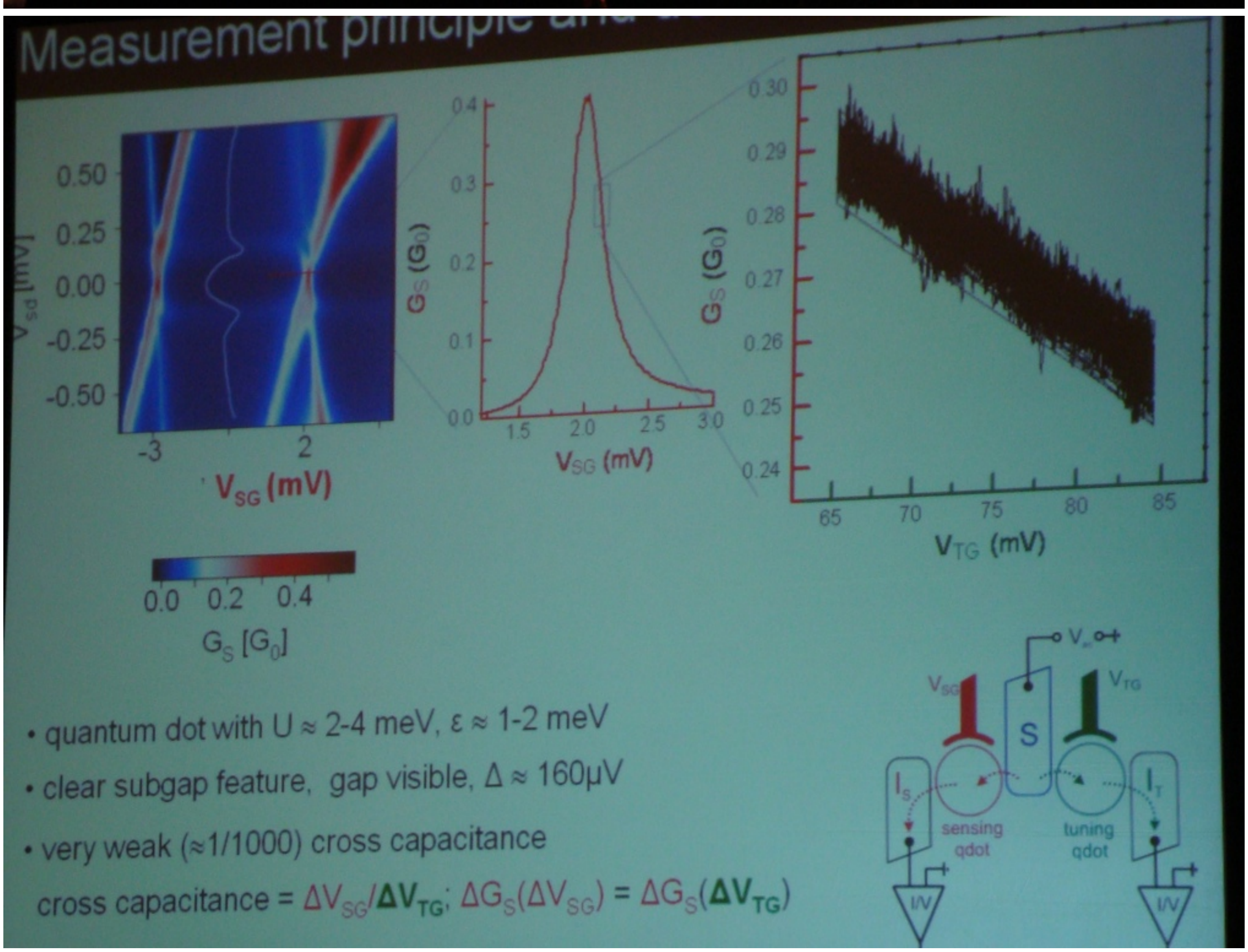
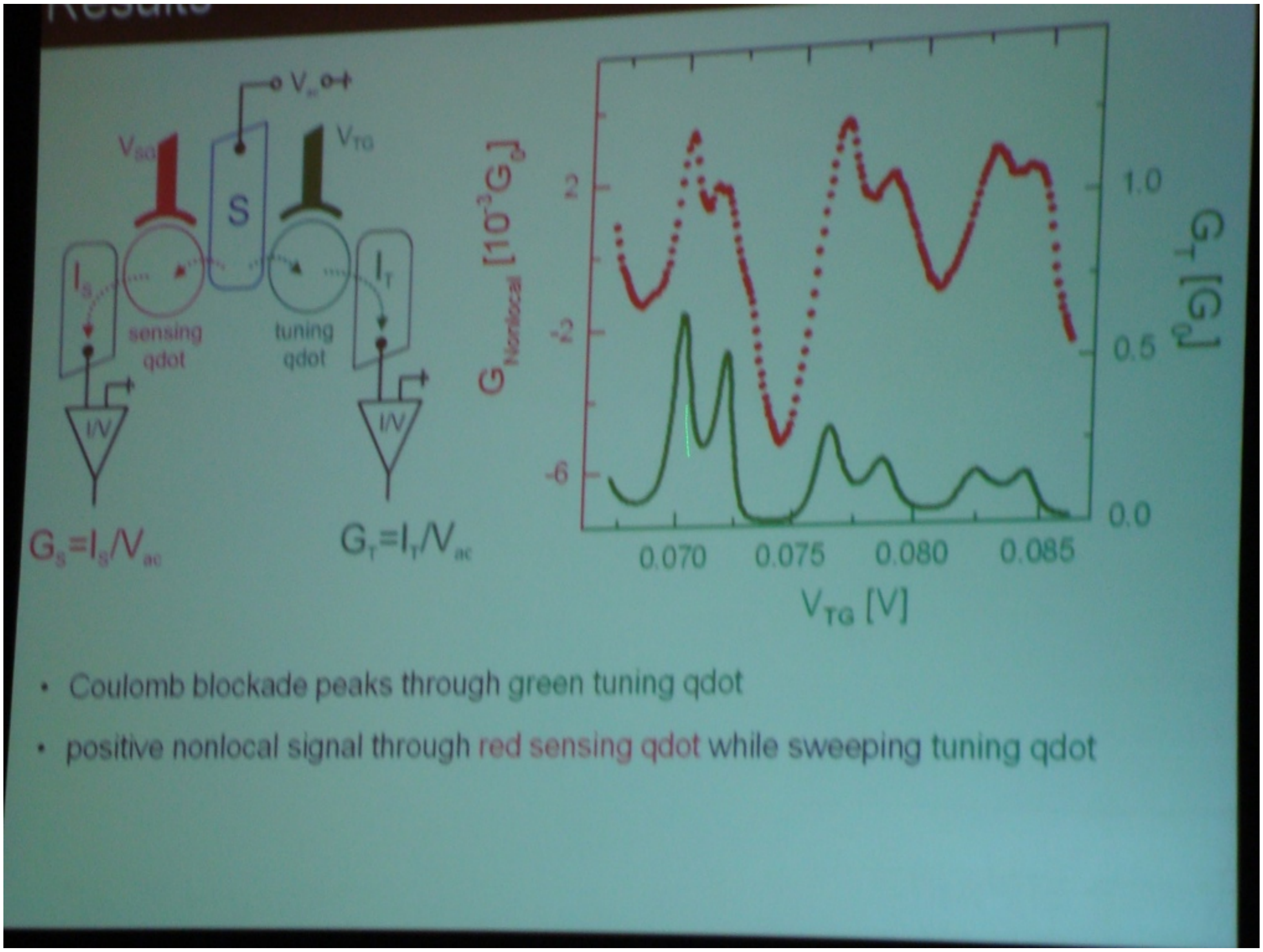
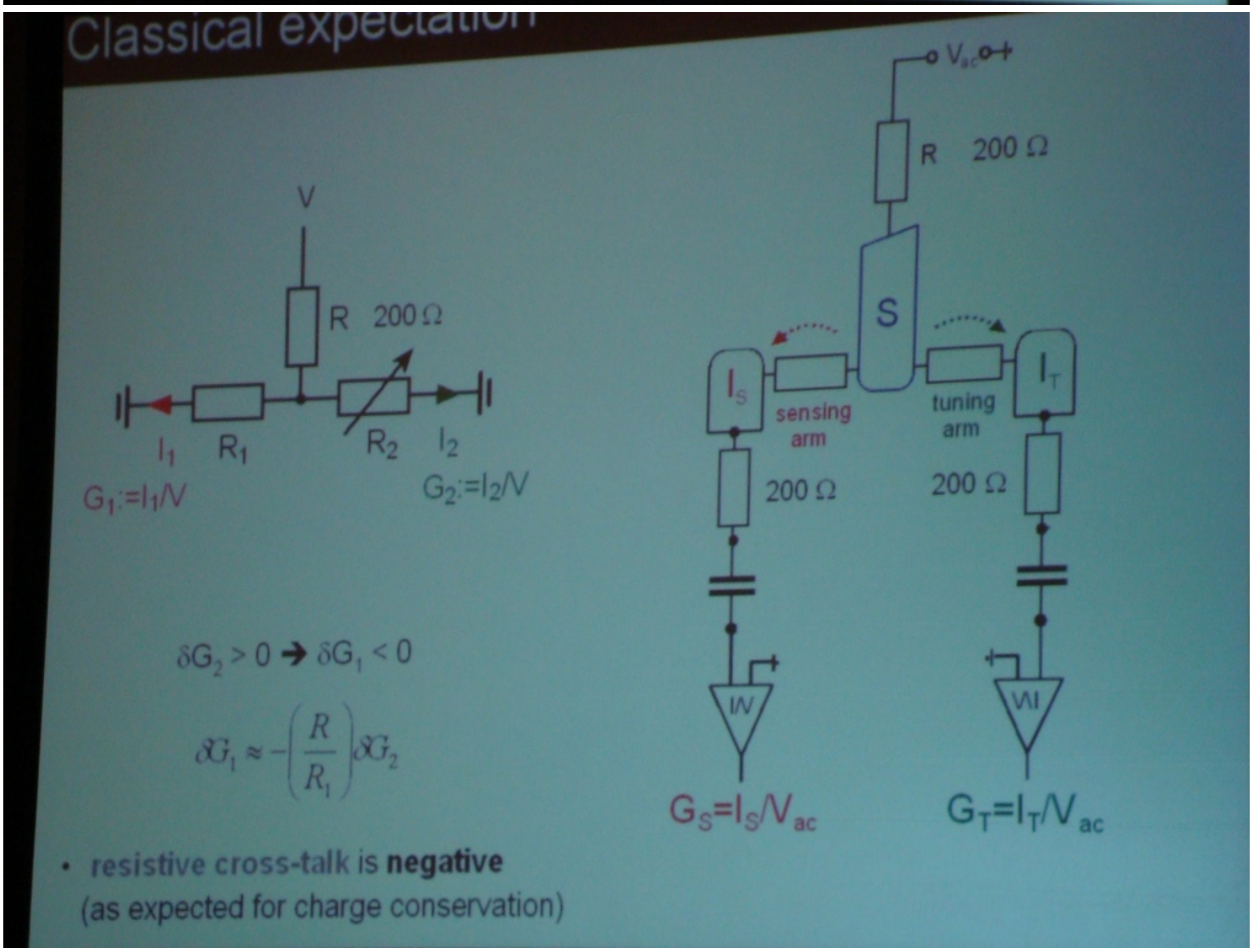
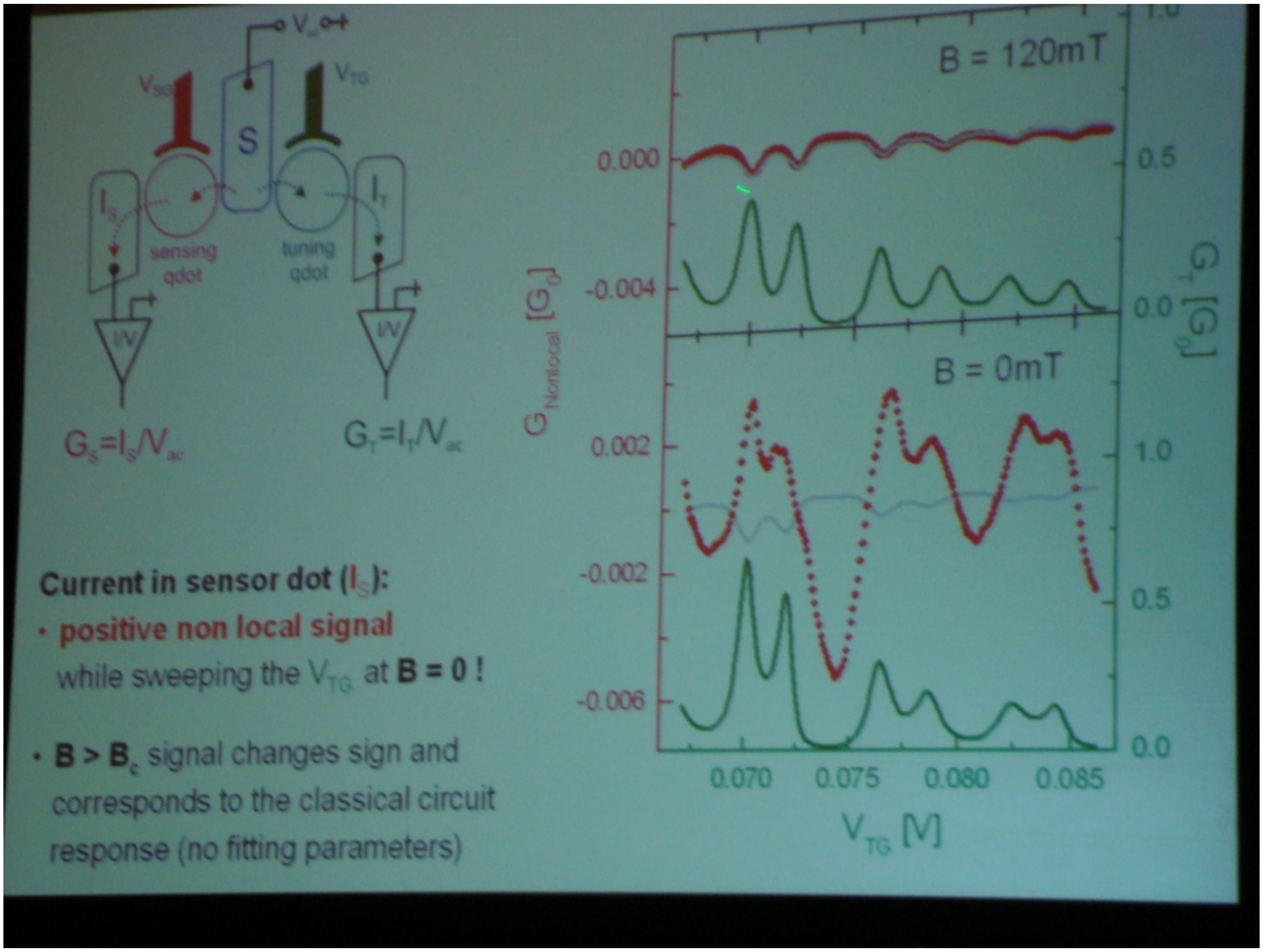

Explanation
Simple non-interacting tunneling picture (T<<1)
I_S = I_DPT + I_CPS/2
I_DPT ~ T_S · T_S
I_CPS ~ T_S · T_T
→ G_Nonlocal ~ T_T
V_ac
V_SG
V_TG
S
I_S
T_S
T_T
I_T
sensing qdot
tuning qdot
I/V
G_S=I_S/V_ac
G_T=I_T/V_ac

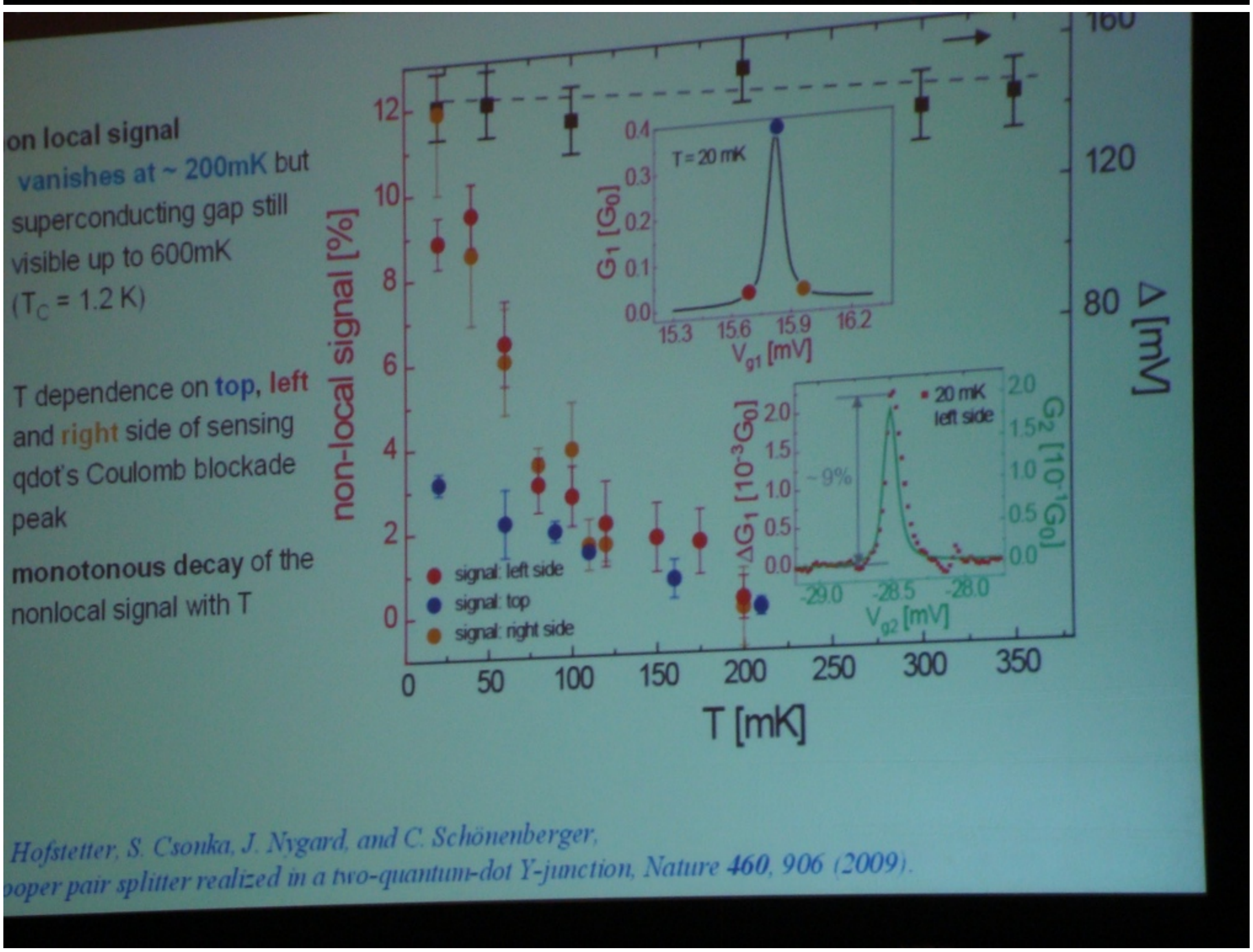

Measurement principle
V_sd [mV]
0.50
0.25
0.00
-0.25
-0.50
-3
2
V_SG (mV)
0.0
0.2
0.4
G_S [G_0]
G_S (G_0)
0.4
0.3
0.2
0.1
0.0
1.5
2.0
2.5
3.0
V_SG (mV)
0.30
0.29
0.28
0.27
0.26
0.25
0.24
65
70
75
80
85
V_TG (mV)
• quantum dot with U ≈ 2-4 meV, ε ≈ 1-2 meV
• clear subgap feature, gap visible, Δ ≈ 160μV
• very weak (≈1/1000) cross capacitance
cross capacitance = ΔV_SG/ΔV_TG; ΔG_S(ΔV_SG) = ΔG_S(ΔV_TG)
V_ac
V_SG
V_TG
S
I_S
I_T
sensing qdot
tuning qdot
I/V


V_ac
V_SG
V_TG
S
I_S
I_T
sensing qdot
tuning qdot
I/V
I/V
G_S=I_S/V_ac
G_T=I_T/V_ac
G_Nonlocal [10^-3 G_0]
G_T [G_0]
2
-2
-6
1.0
0.5
0.0
0.070
0.075
0.080
0.085
V_TG [V]
• Coulomb blockade peaks through green tuning qdot
• positive nonlocal signal through red sensing qdot while sweeping tuning qdot

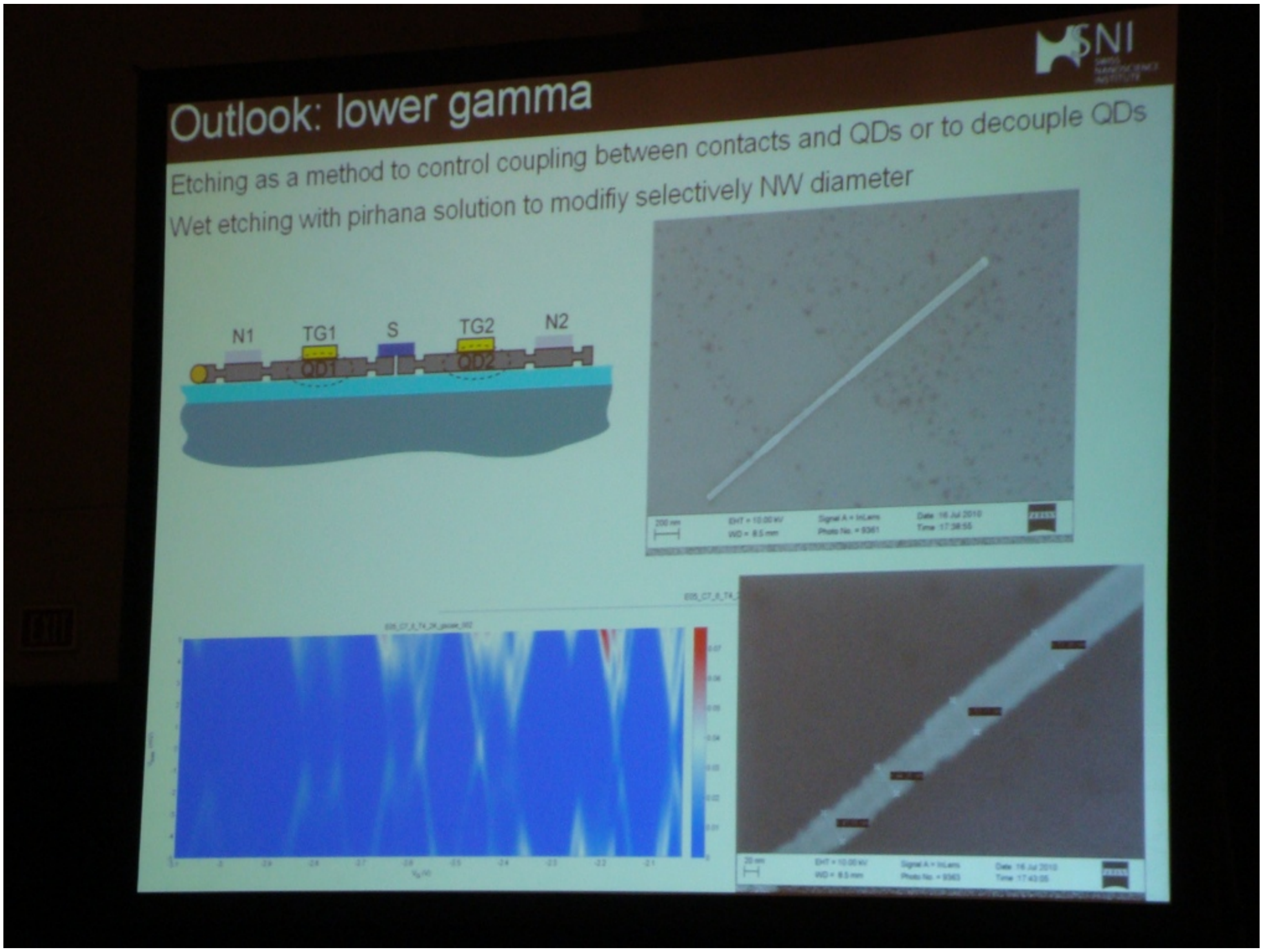

Classical expectation
V
R 200 Ω
I_1 R_1
R_2 I_2
G_1:=I_1/V
G_2:=I_2/V
δG_2 > 0 → δG_1 < 0
δG_1 ≈ −(R/R_1)δG_2
• resistive cross-talk is negative
(as expected for charge conservation)
V_ac
R 200 Ω
S
I_S
I_T
sensing arm
tuning arm
200 Ω
200 Ω
I/V
V/I
G_S=I_S/V_ac
G_T=I_T/V_ac

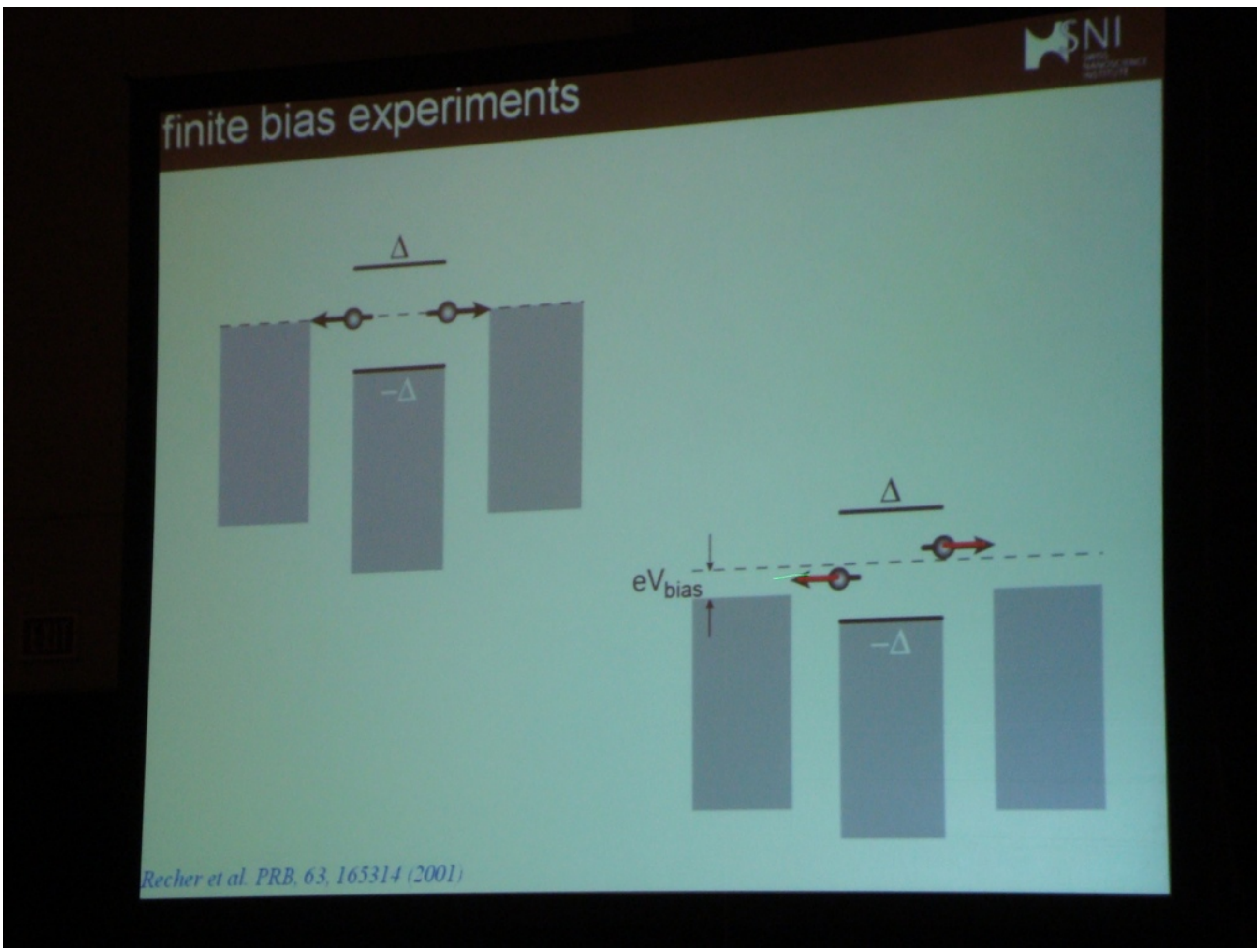


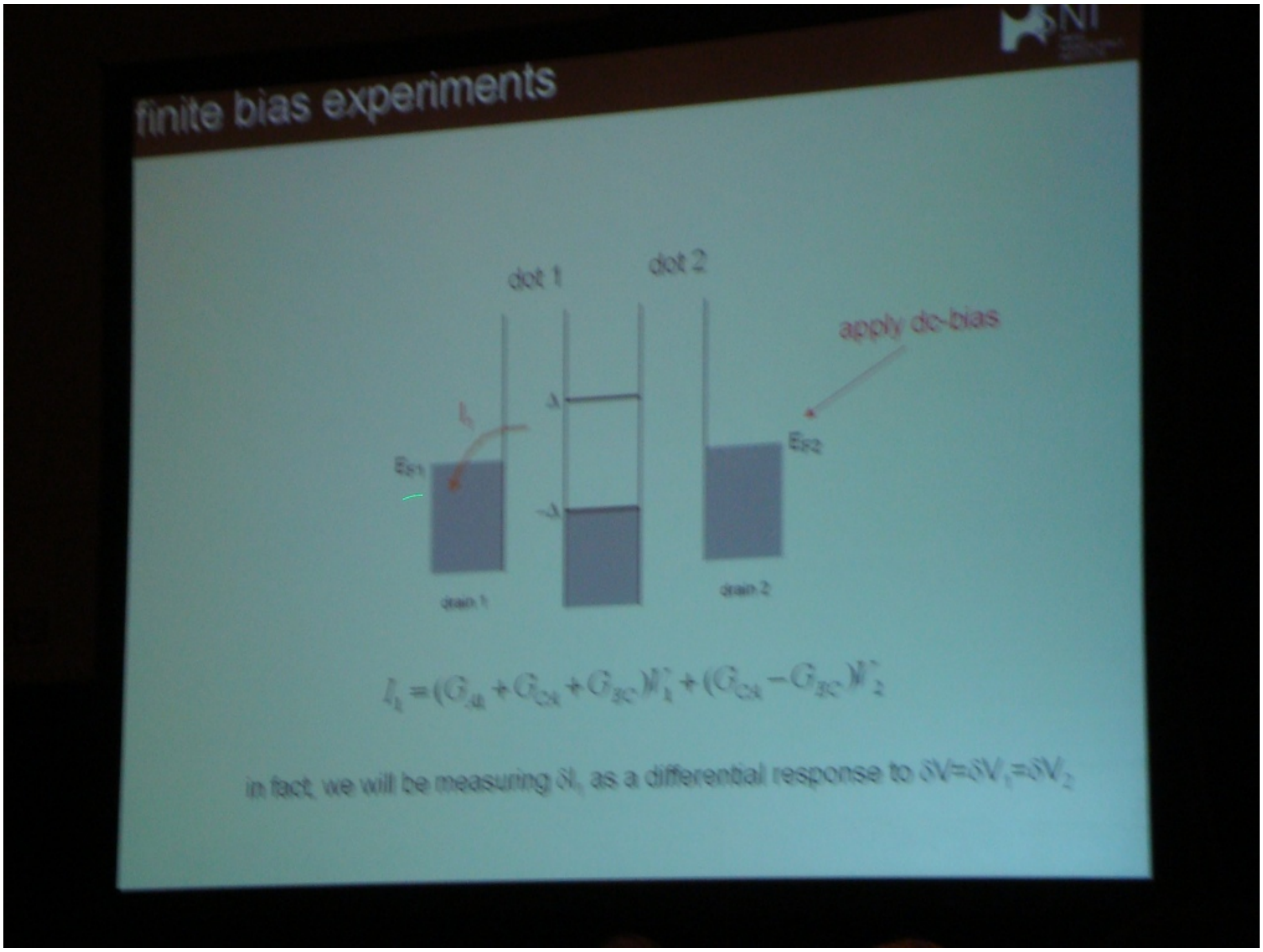
V_{ac}
V_{SG}
V_{TG}
S
I_S
I_T
sensing qdot
tuning qdot
I/V
I/V
$G_S=I_S/V_{ac}$
$G_T=I_T/V_{ac}$
Current in sensor dot (I_S):
• positive non local signal while sweeping the V_{TG} at B = 0 !
• B > B_c signal changes sign and corresponds to the classical circuit response (no fitting parameters)
B = 120mT
B = 0mT
$G_{Nonlocal}$ [G_0]
G_T [G_0]
V_{TG} [V]

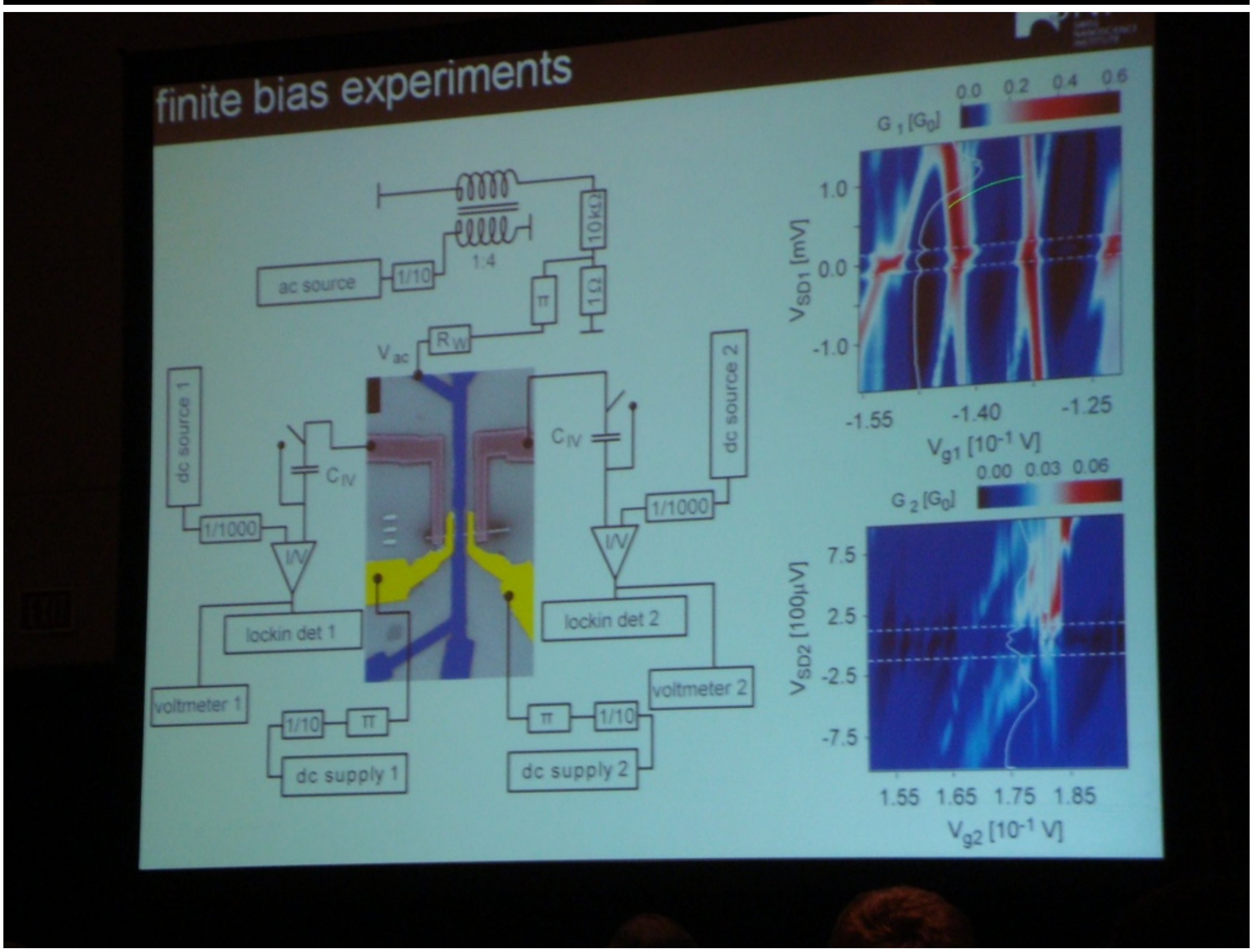


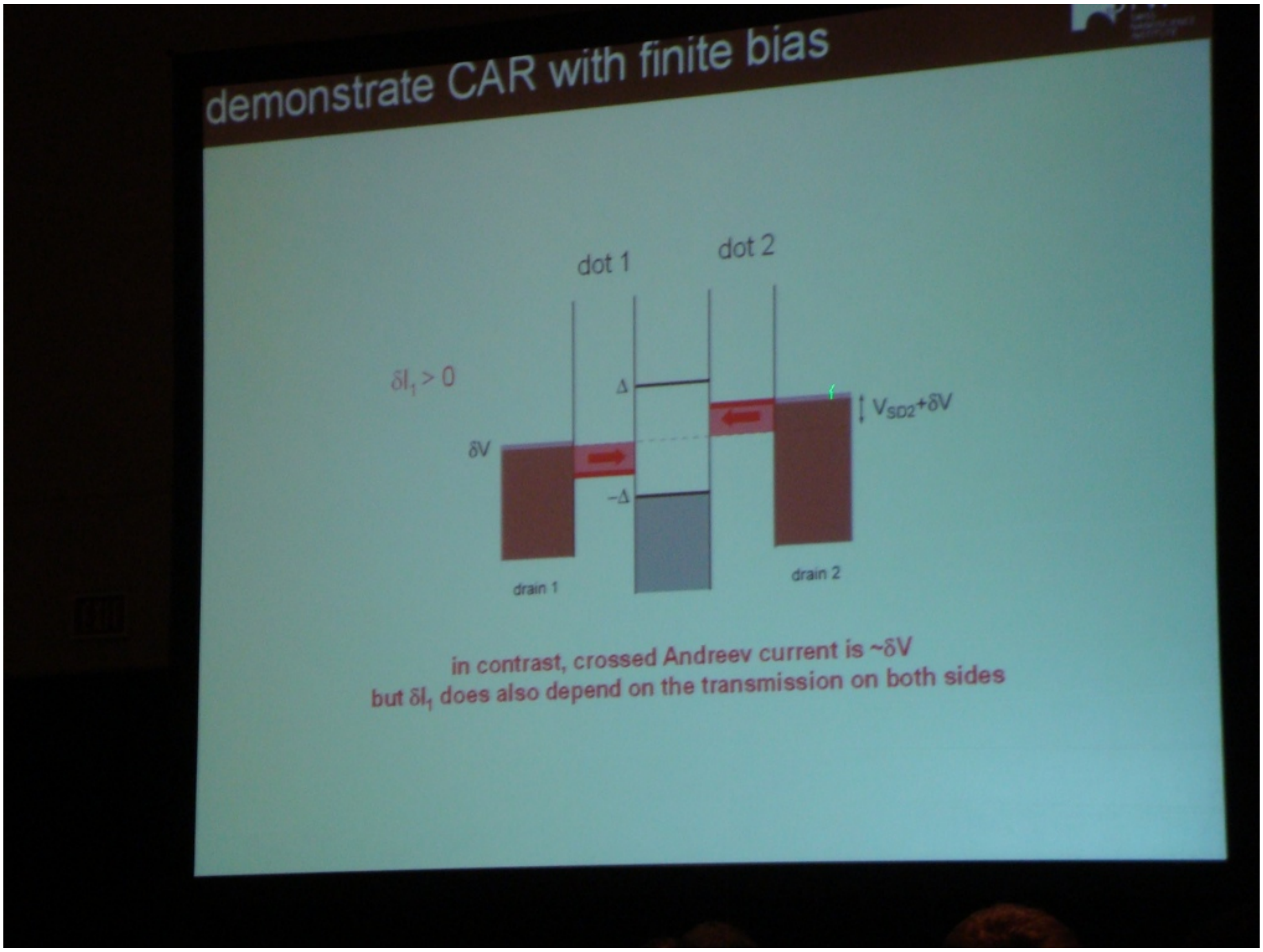
on local signal
vanishes at ~ 200mK but superconducting gap still visible up to 600mK
(T_C = 1.2 K)
T dependence on top, left and right side of sensing qdot's Coulomb blockade peak
monotonous decay of the nonlocal signal with T
non-local signal [%]
T [mK]
Δ [mV]
T = 20 mK
G_1 [G_0]
V_{g1} [mV]
ΔG_1 [$10^{-3}G_0$]
G_2 [$10^{-1}G_0$]
V_{g2} [mV]
20 mK left side
~9%
signal: left side
signal: top
signal: right side
Hofstetter, S. Csonka, J. Nygard, and C. Schönenberger,
ooper pair splitter realized in a two-quantum-dot Y-junction, Nature 460, 906 (2009).

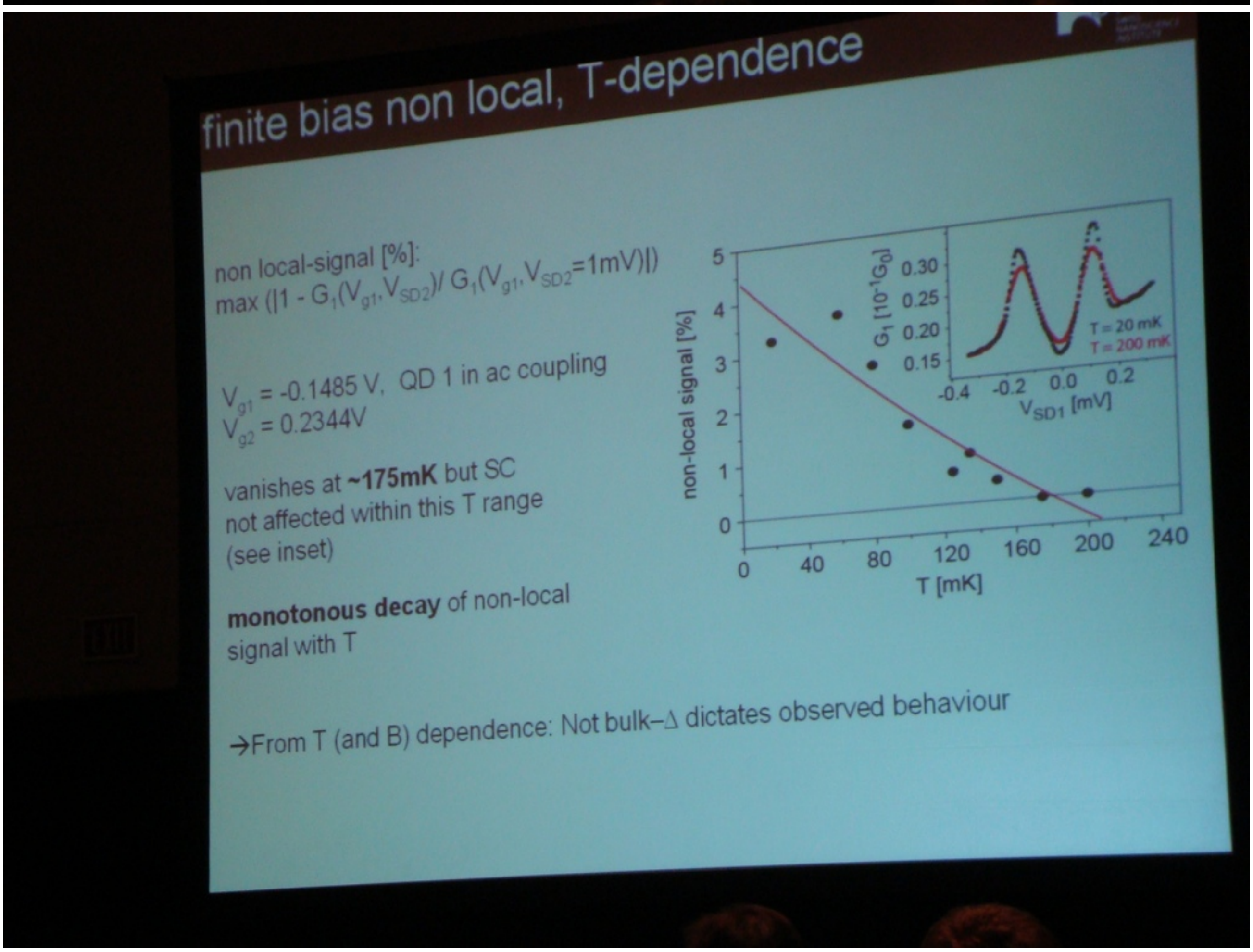

SNI
Outlook: lower gamma
Etching as a method to control coupling between contacts and QDs or to decouple QDs
Wet etching with pirhana solution to modifiy selectively NW diameter
N1
TG1
S
TG2
N2
QD1
QD2


SNI
finite bias experiments
Δ
−Δ
Δ
eV$_{bias}$
−Δ
Recher et al. PRB, 63, 165314 (2001)


finite bias experiments
dot 1
dot 2
apply dc-bias
I1
Δ
-Δ
ES1
ES2
drain 1
drain 2
$I_1 = (G_{AR} + G_{CA} + G_{EC})V_1 + (G_{CA} - G_{EC})V_2$
in fact, we will be measuring δI1 as a differential response to δV=δV1=δV2


finite bias experiments
ac source
1/10
1:4
10kΩ
1Ω
π
RW
Vac
dc source 1
dc source 2
CIV
1/1000
I/V
lockin det 1
lockin det 2
voltmeter 1
voltmeter 2
1/10
π
dc supply 1
dc supply 2
G1 [G0]
0.0 0.2 0.4 0.6
VSD1 [mV]
1.0
0.0
-1.0
-1.55 -1.40 -1.25
Vg1 [10-1 V]
G2 [G0]
0.00 0.03 0.06
VSD2 [100µV]
7.5
2.5
-2.5
-7.5
1.55 1.65 1.75 1.85
Vg2 [10-1 V]


demonstrate CAR with finite bias
dot 1
dot 2
δI₁ > 0
Δ
−Δ
δV
V_SD2+δV
drain 1
drain 2
in contrast, crossed Andreev current is ~δV
but δI₁ does also depend on the transmission on both sides


finite bias non local, T-dependence
non local-signal [%]:
max (|1 - G₁(V_g1,V_SD2)/ G₁(V_g1,V_SD2=1mV)|)
V_g1 = -0.1485 V, QD 1 in ac coupling
V_g2 = 0.2344V
vanishes at ~175mK but SC
not affected within this T range
(see inset)
monotonous decay of non-local
signal with T
→From T (and B) dependence: Not bulk–Δ dictates observed behaviour
non-local signal [%]
T [mK]
G₁ [10⁻¹G₀]
V_SD1 [mV]
T = 20 mK
T = 200 mK