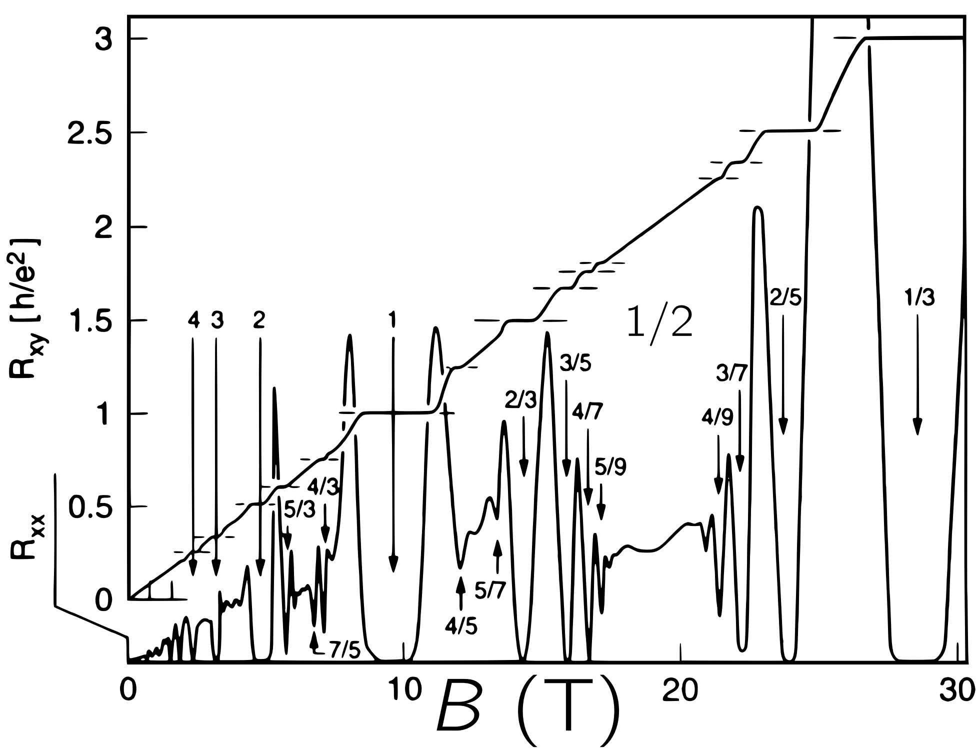
measurement of the hole-conjugate edge state structure

מכון ויצמן למדע
WEIZMANN INSTITUTE OF SCIENCE

GDR physique mésoscopique, Aussois

Amir Rosenblatt - **Fabien Lafont** - Itamar Gurman - Ron Sabo
Diana Mahalu - Vladimir Umansky - Moty Heiblum

FQHE hole-conjugate states



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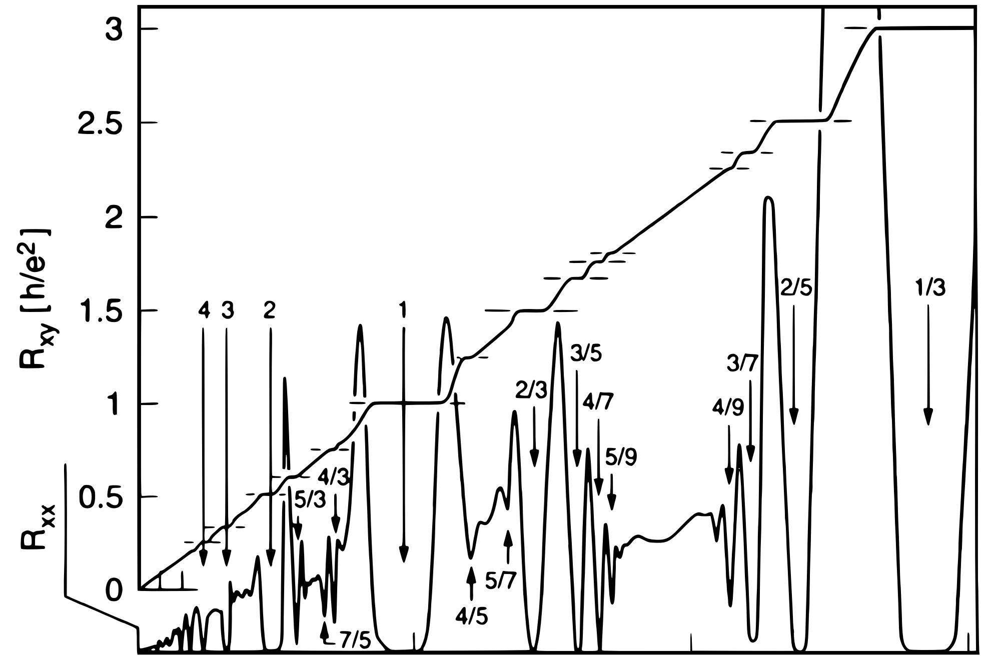

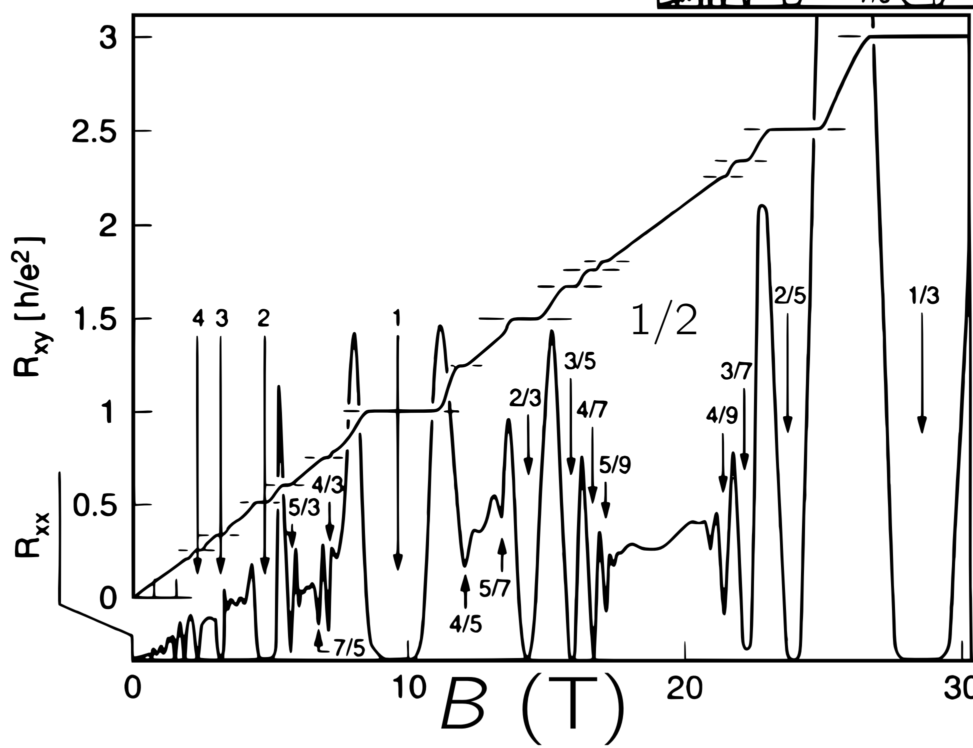

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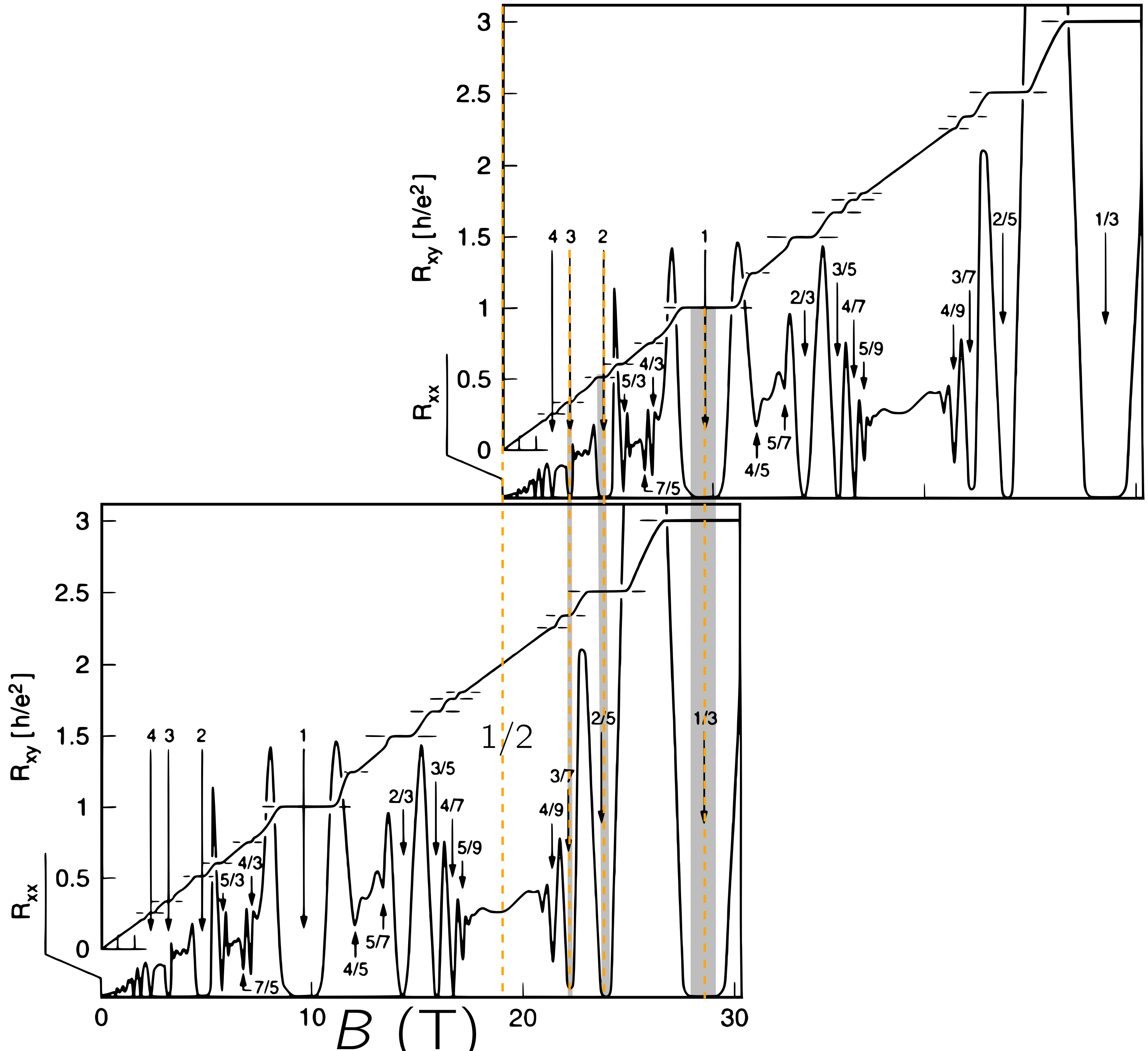

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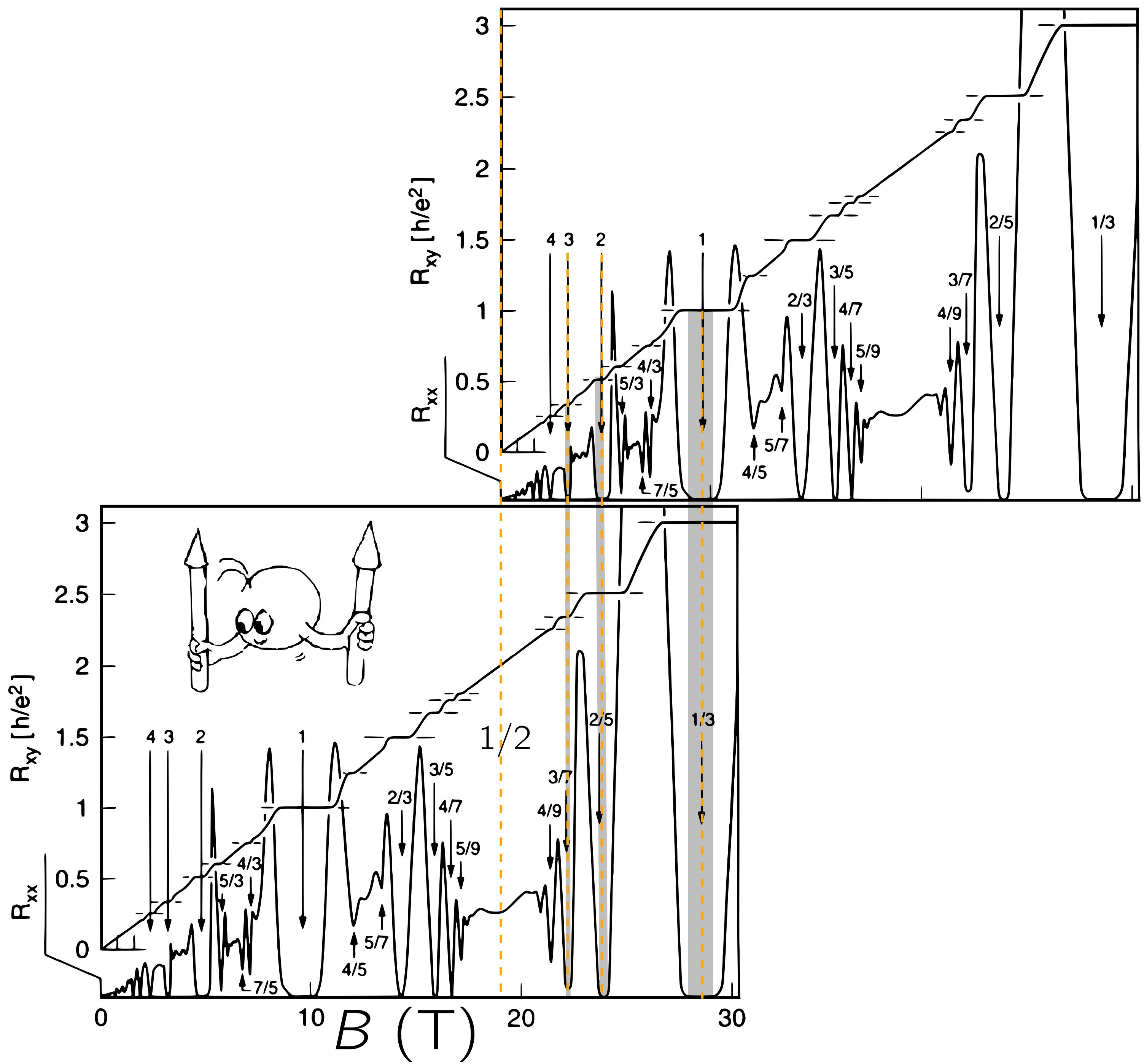

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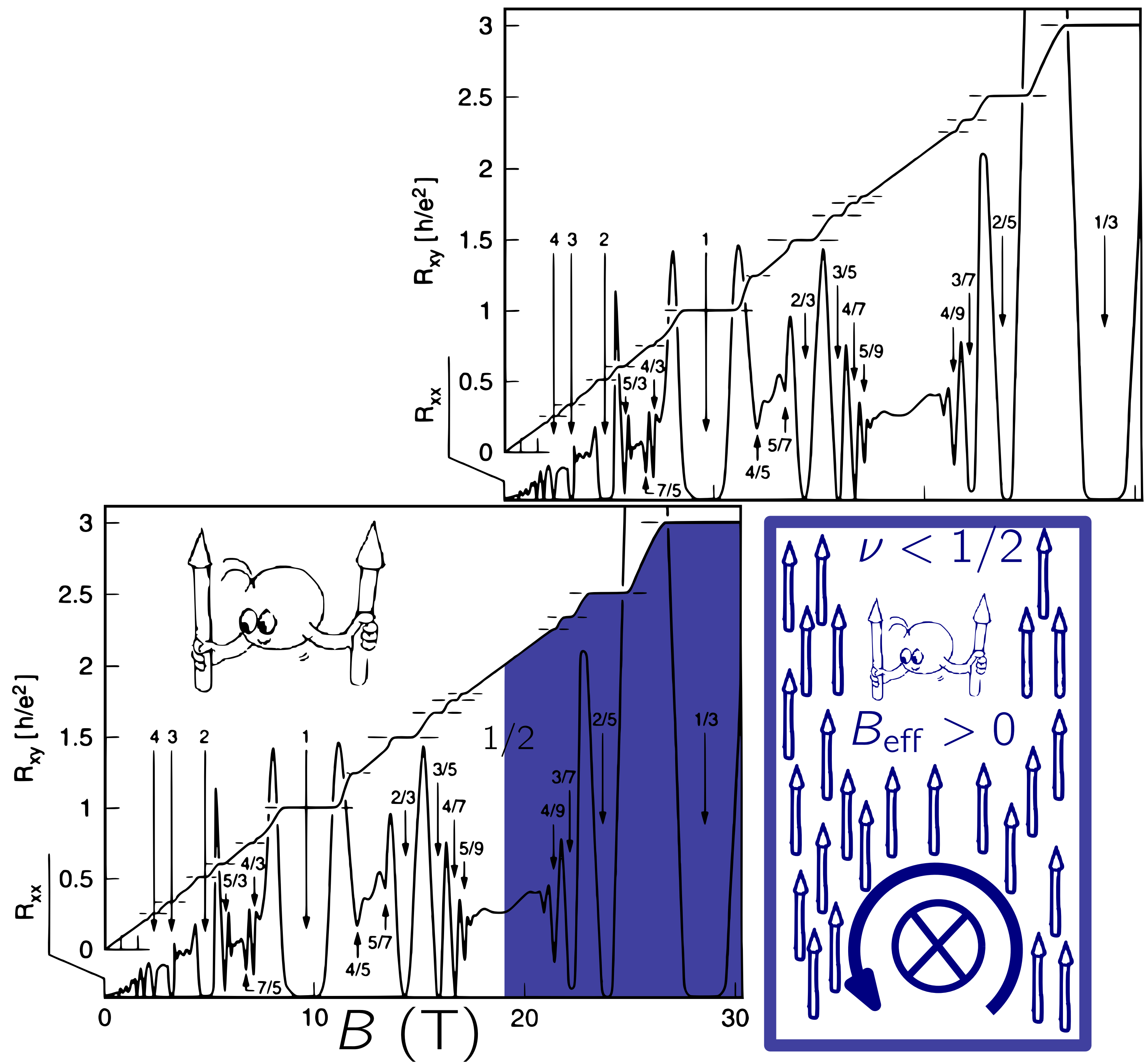

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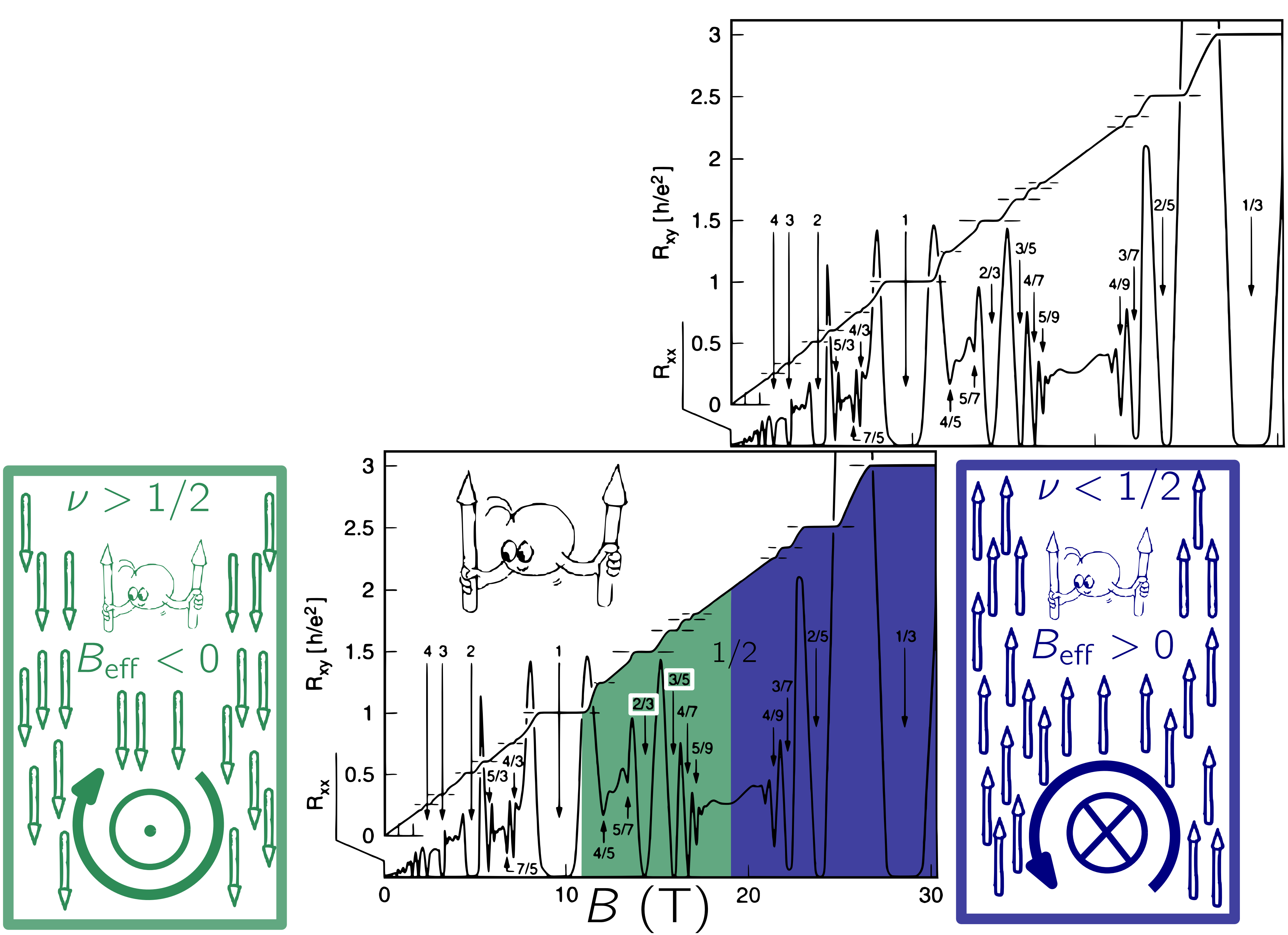
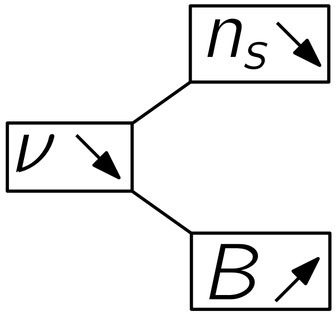
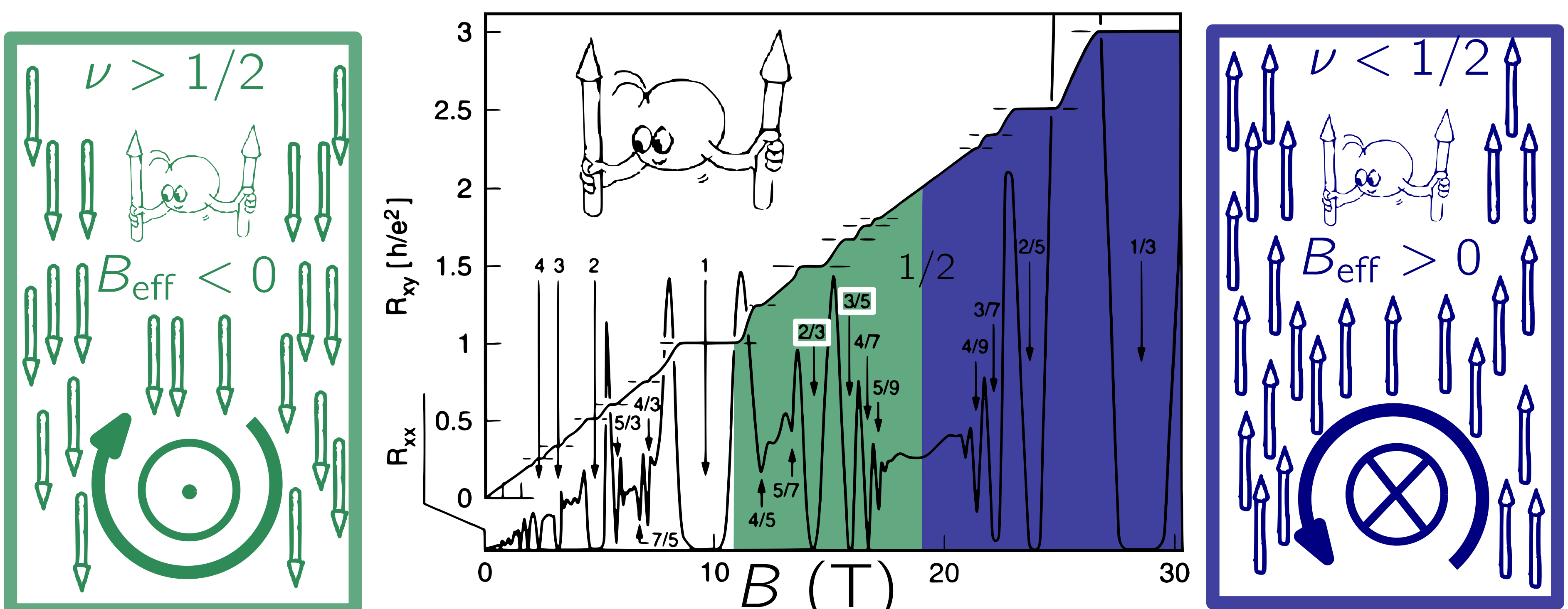


FQHE hole-conjugate states

$$\nu = \frac{n_s h}{eB}$$





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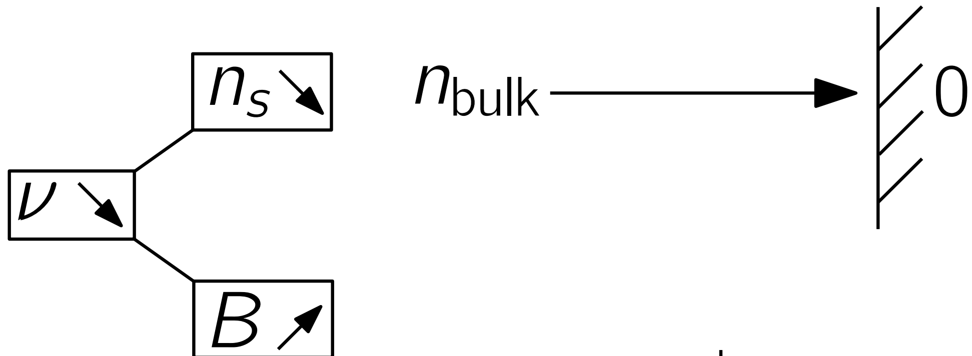
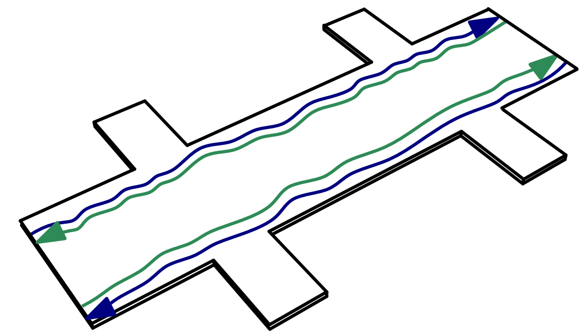
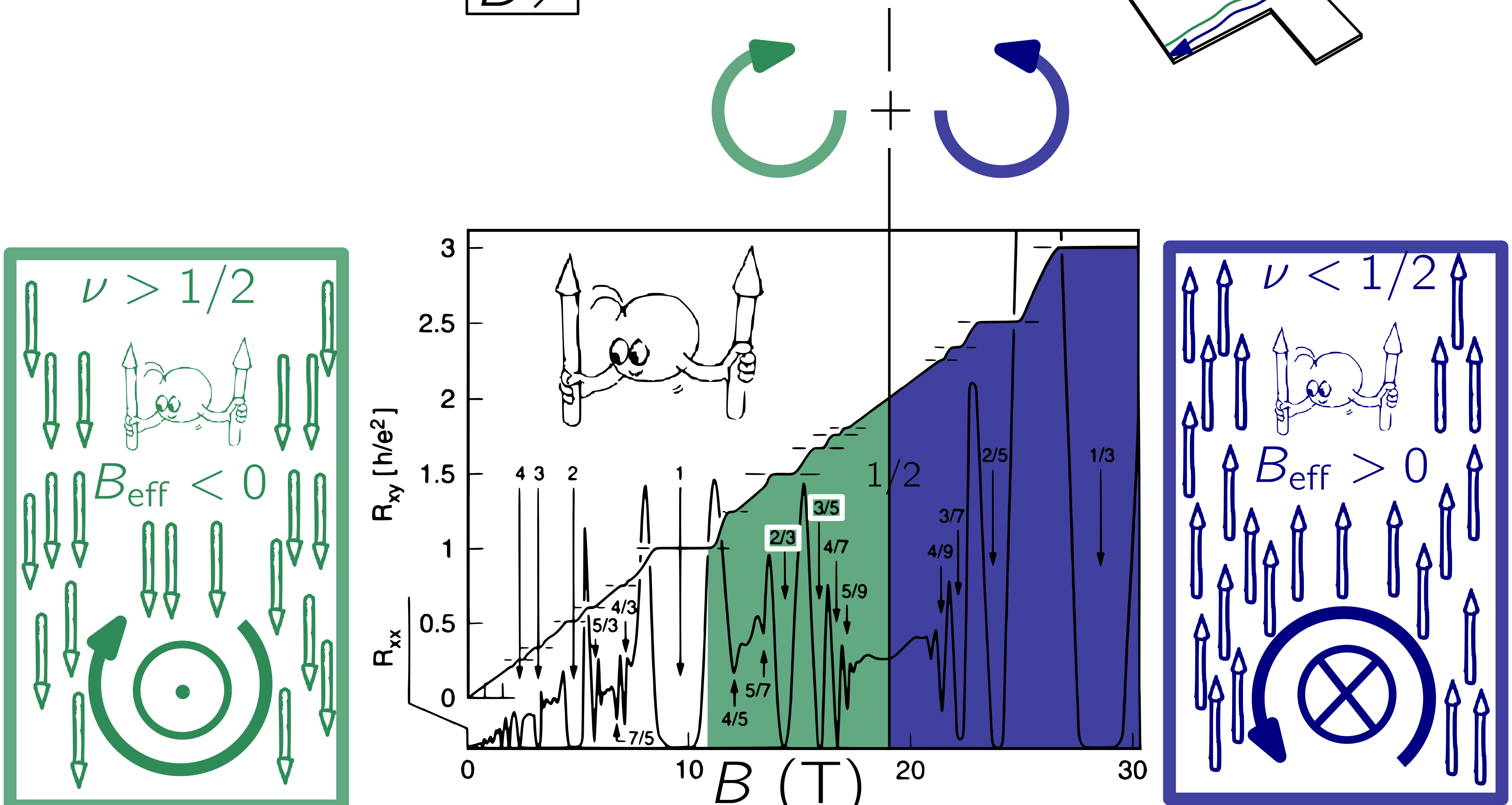
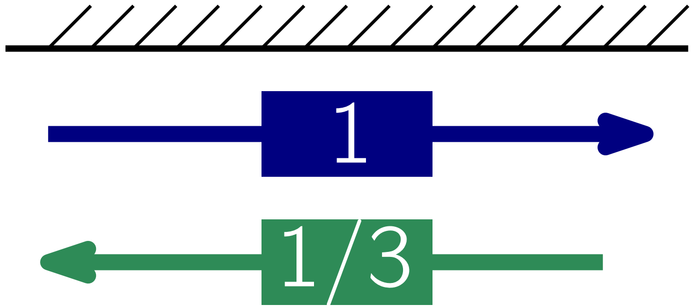






Theoretical models for $\nu = 2/3$



MacDonald and Girvin PRL, 64, 1990

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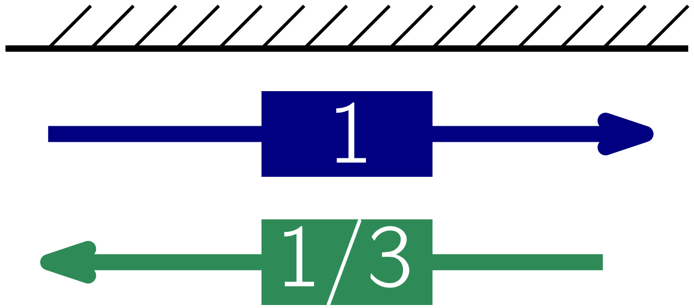

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Upstream charge modes have never been observed experimentally

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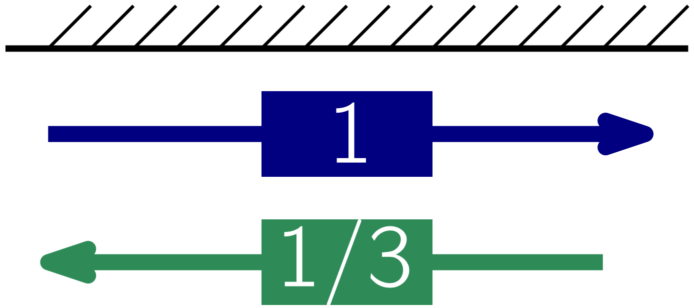

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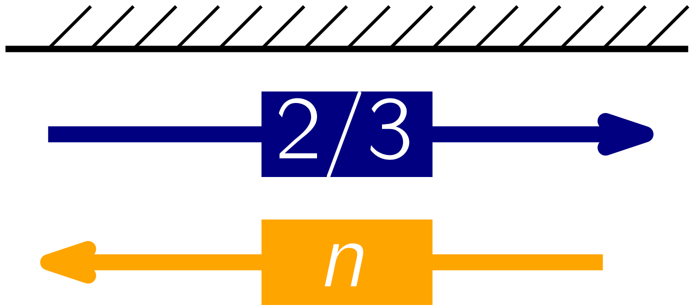

Kane Fisher and Polchinski, PRL 72, 1994

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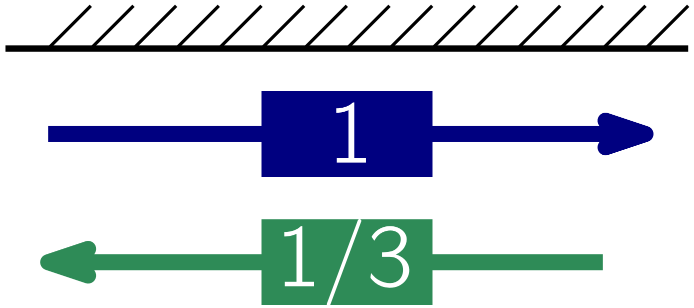

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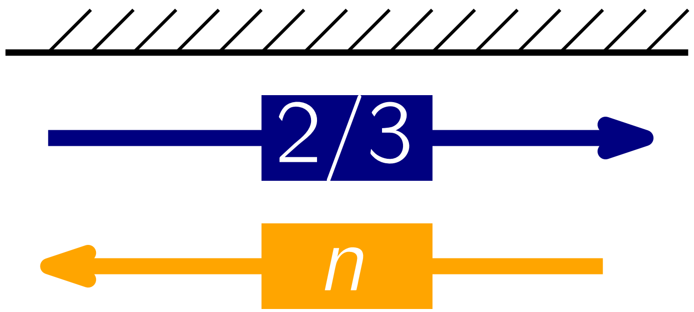

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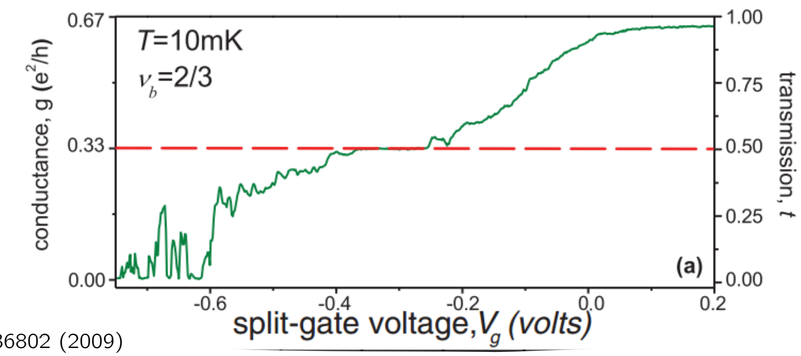
Plateau at $t = 1/2$



Bid et at PRL 103, 236802 (2009)

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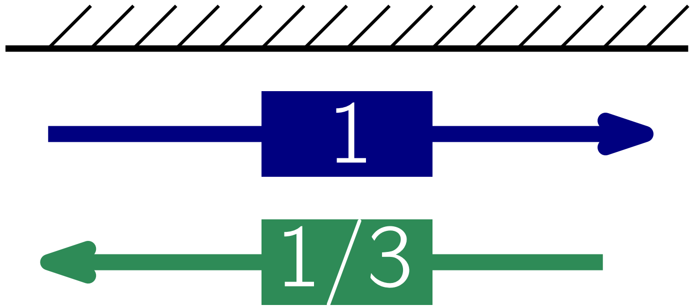

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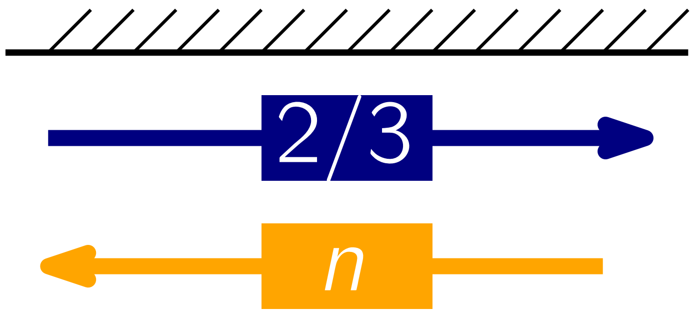

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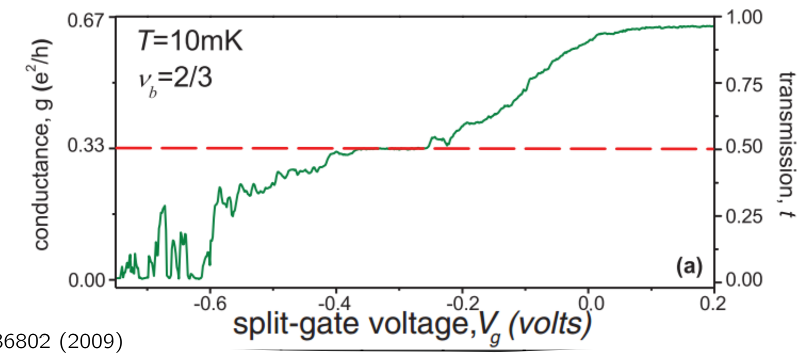

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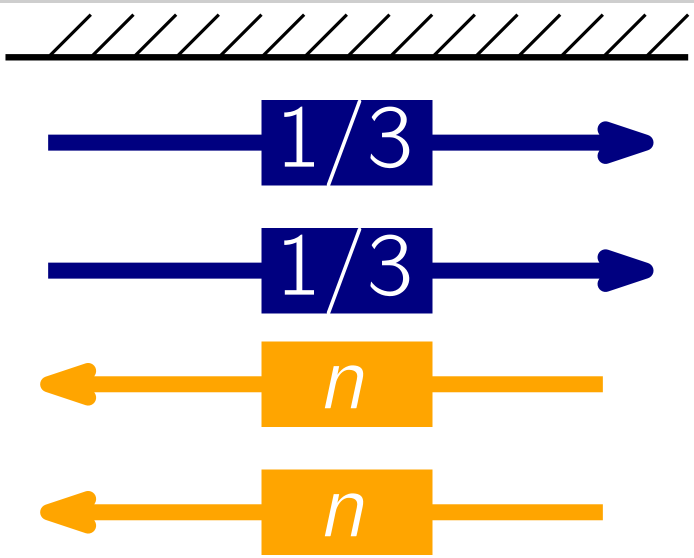

Wang, Meir and Gefen, PRL 111, 2013

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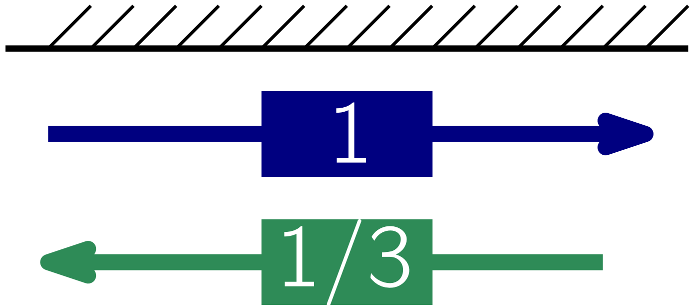

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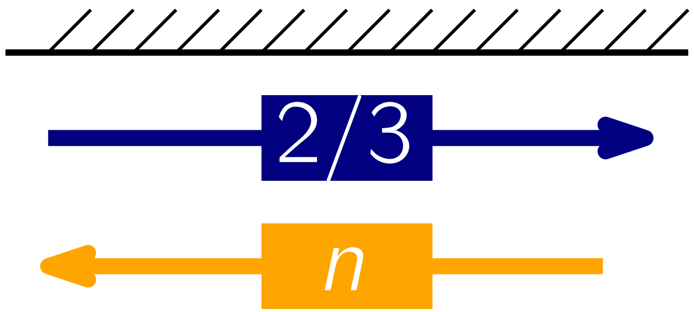

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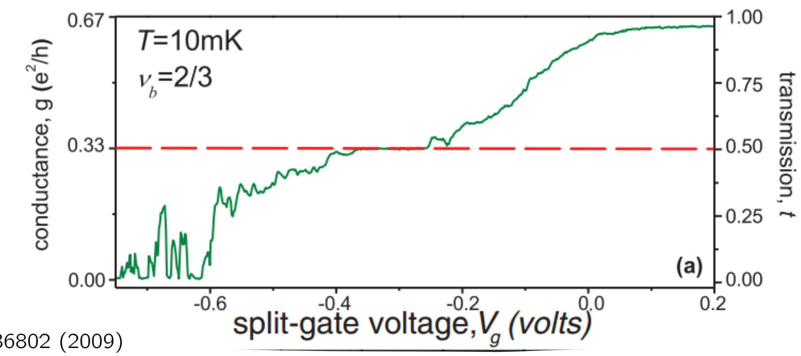

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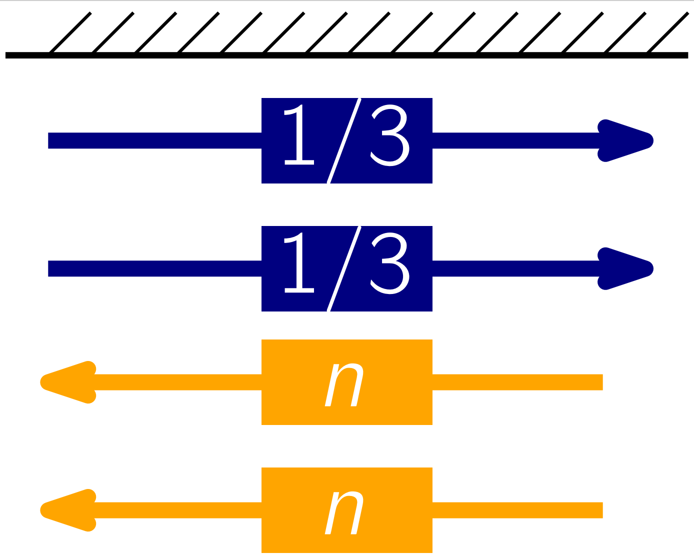

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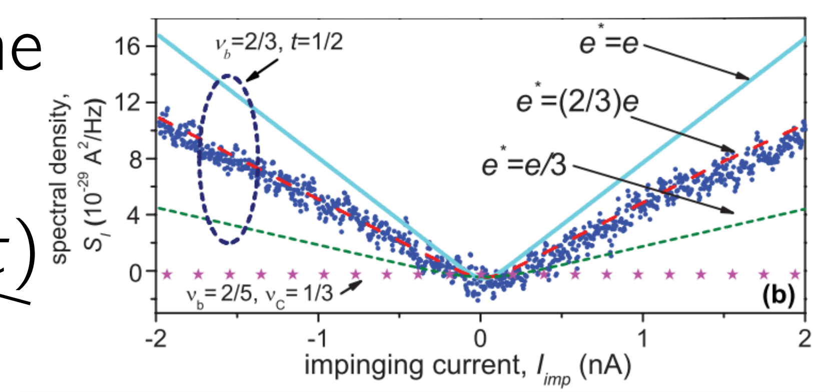
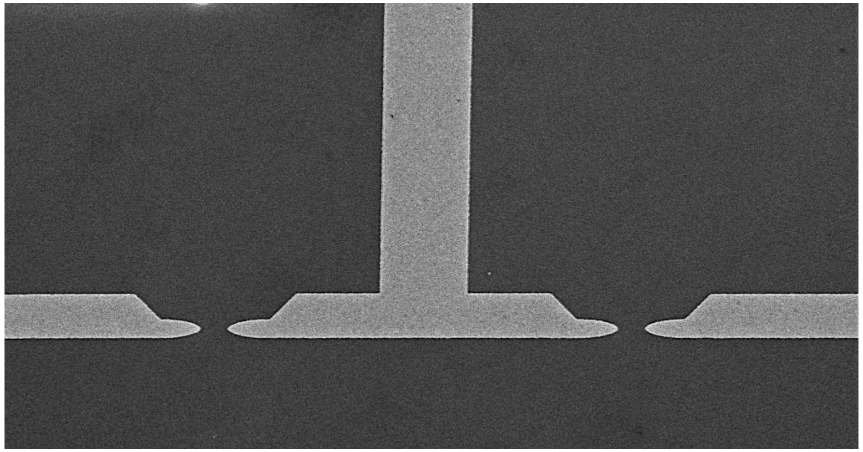
Noise on the plateau

~~$S \propto t(1-t)$~~



Triggered our work

Edge structure



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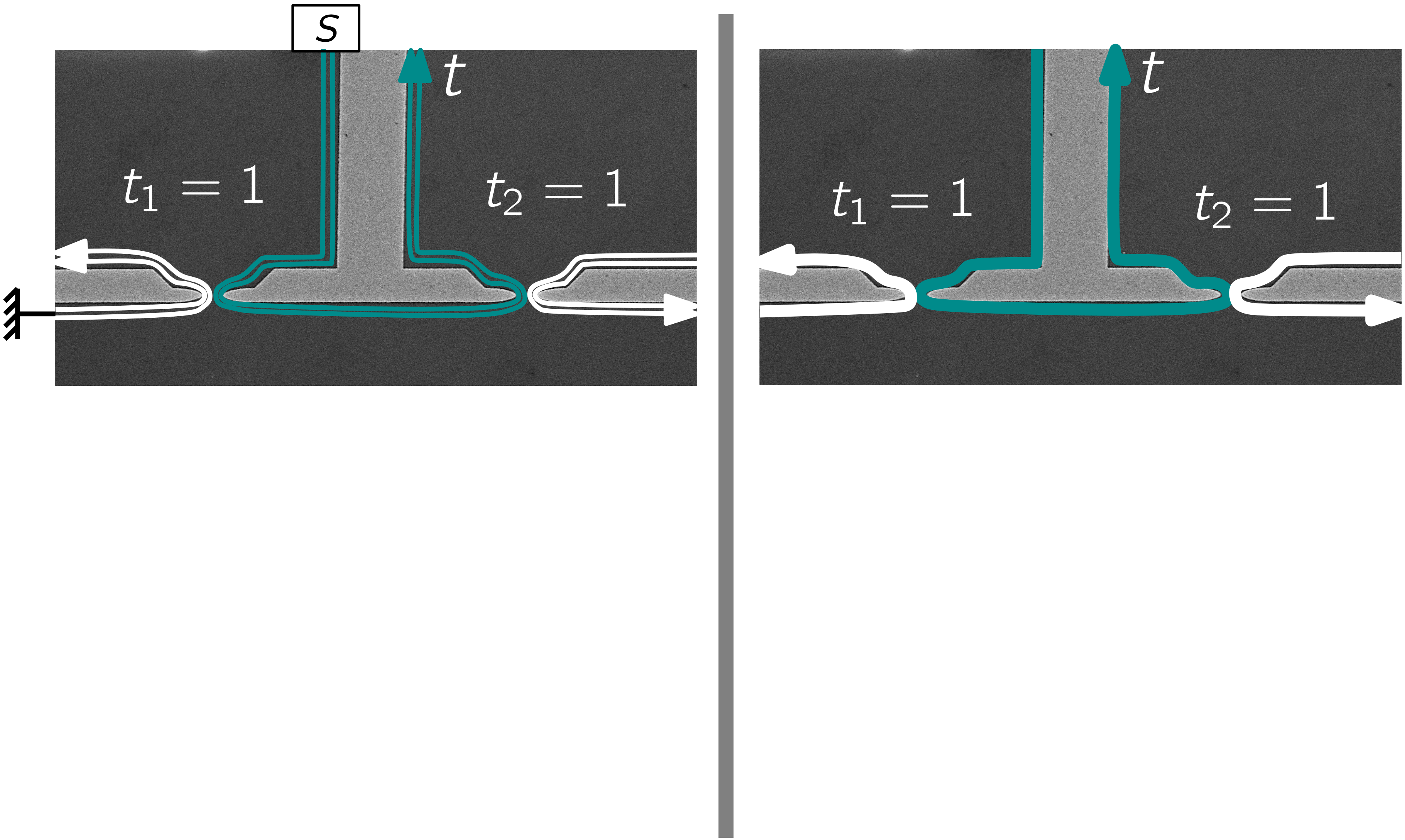

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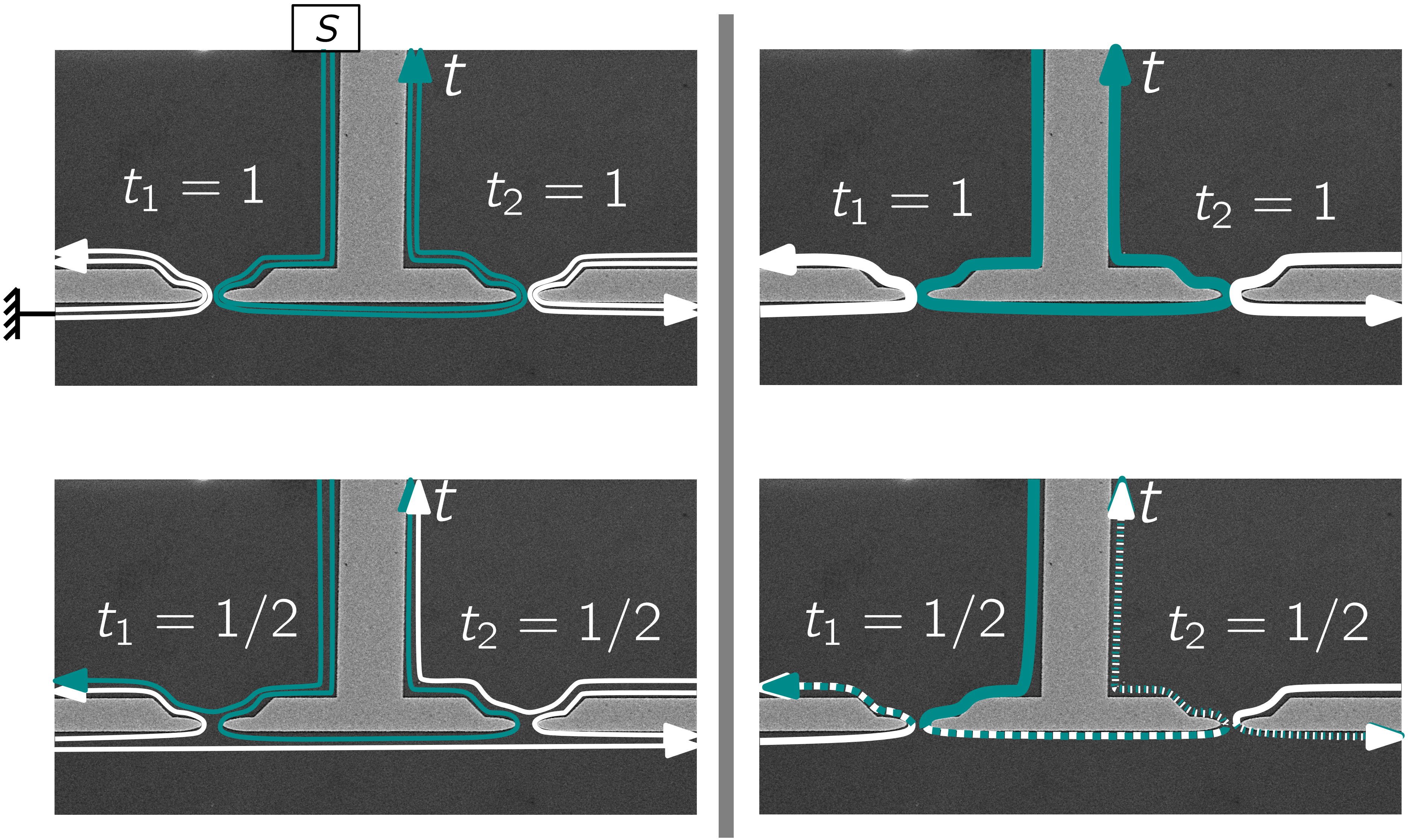

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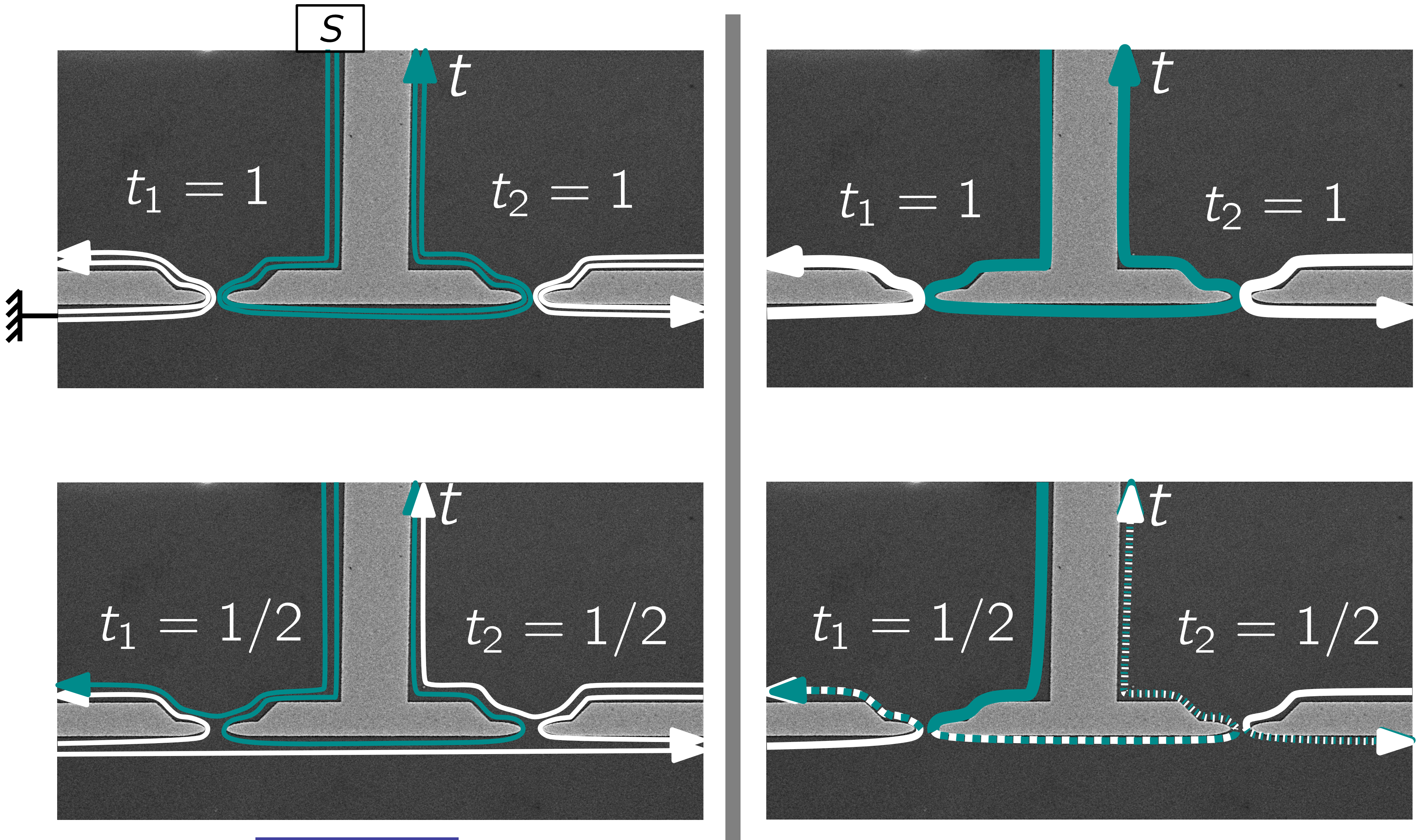

$t = 1/2$

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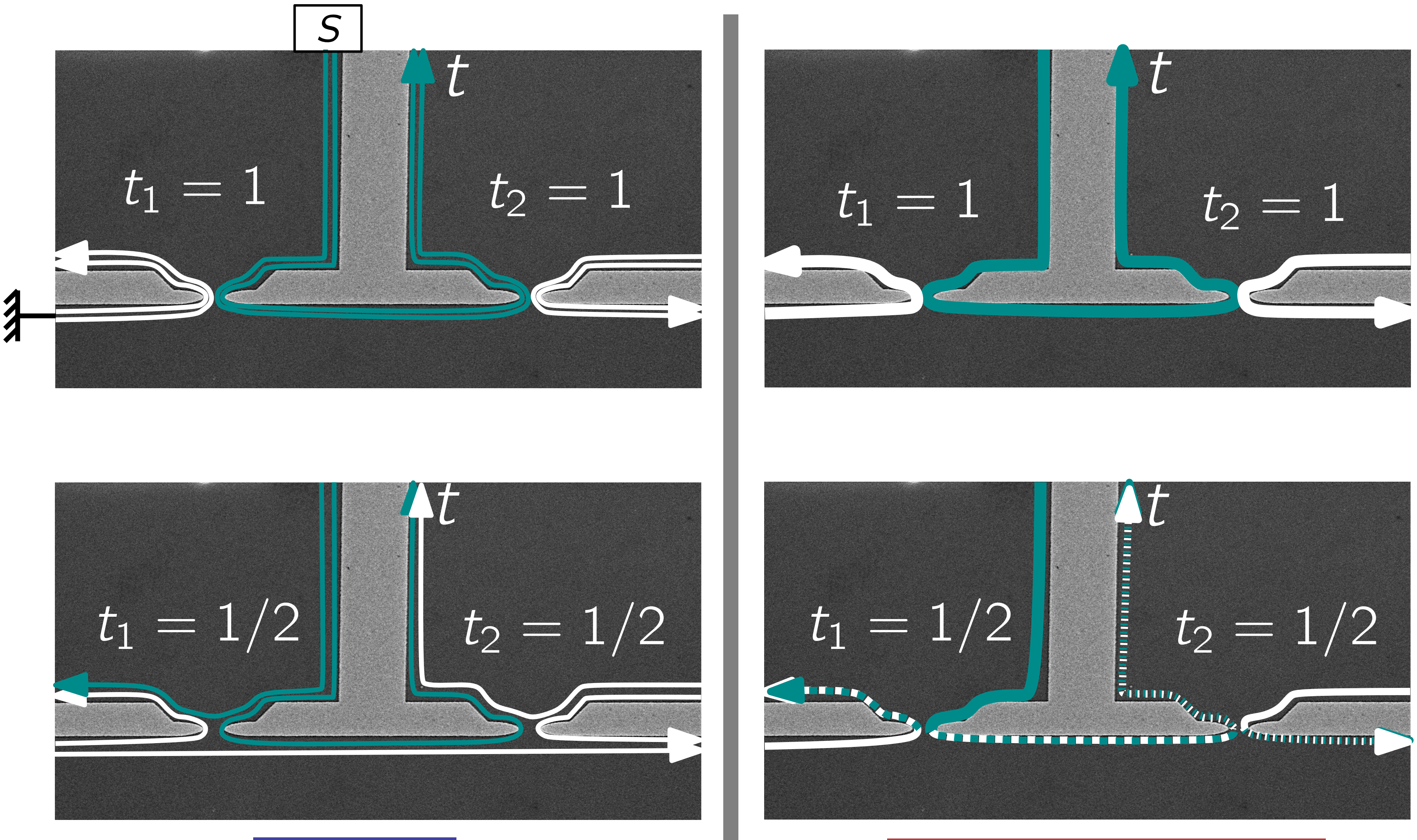
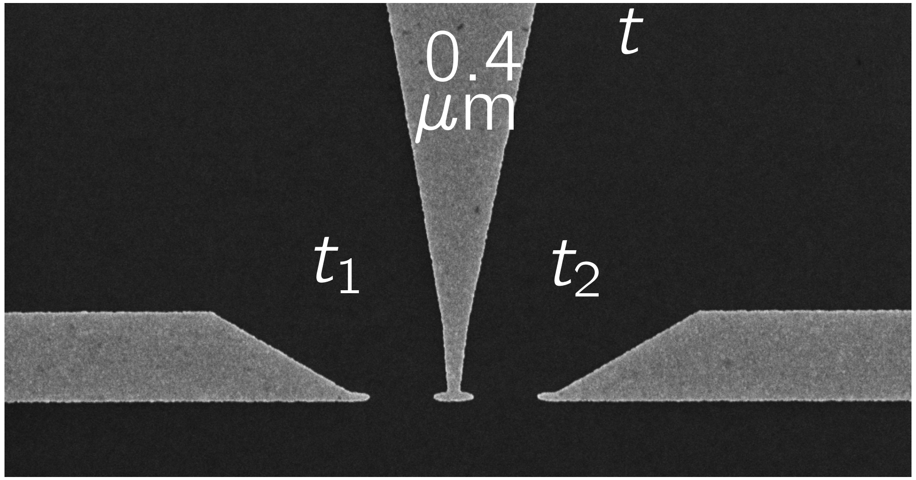


$t = 1/2$

$t = t_1 \times t_2 = 1/4$

Allow to distinguish the number of edge channels

Transmission through 2 QPCs



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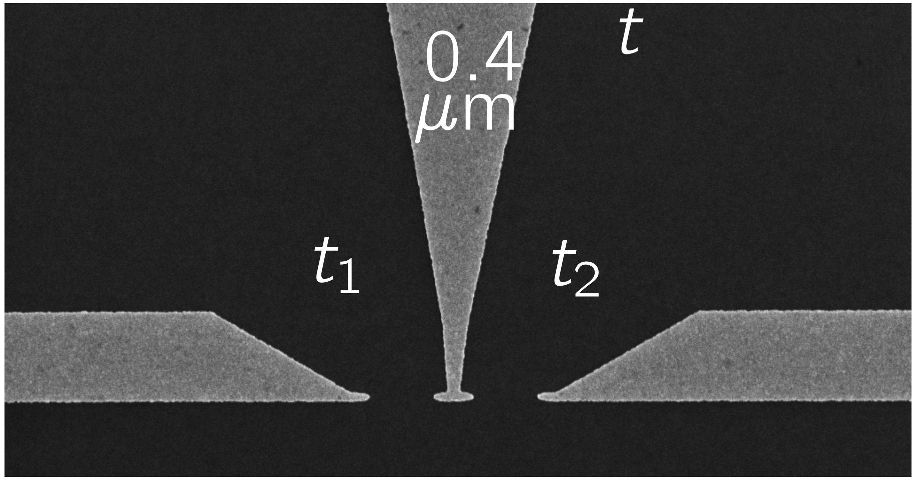

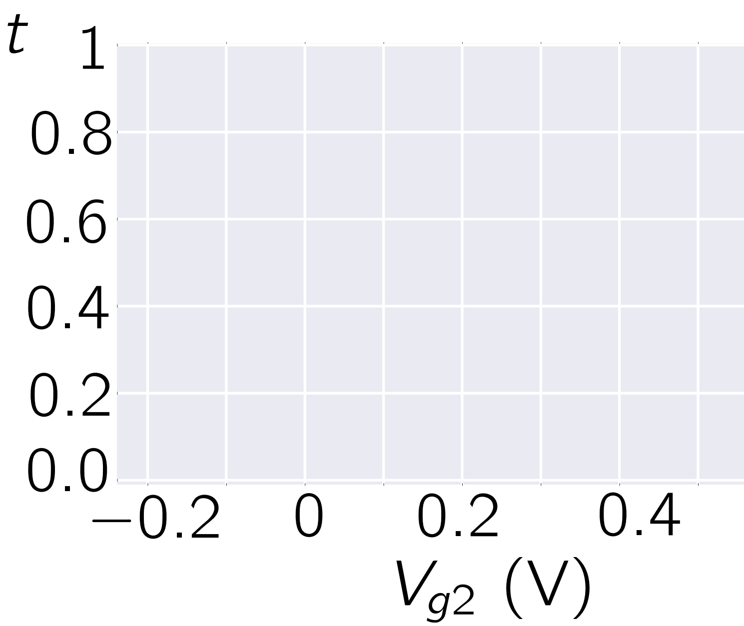

$\nu = 2/3$

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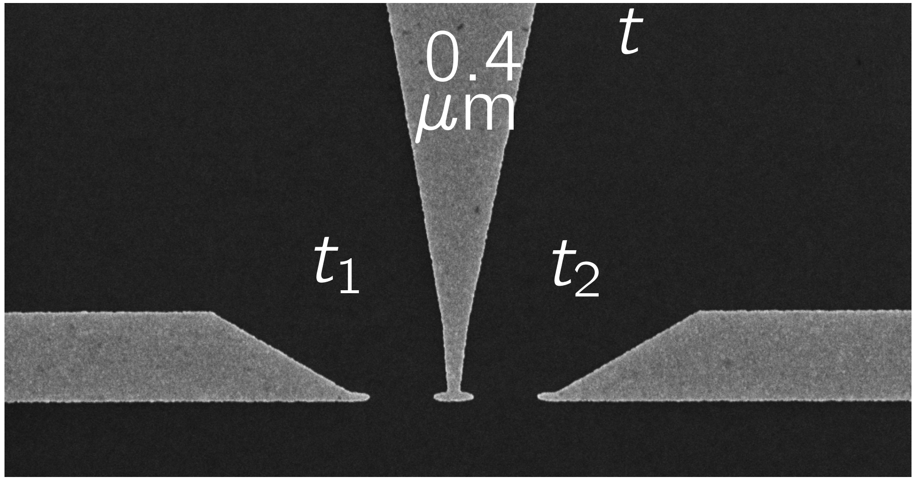

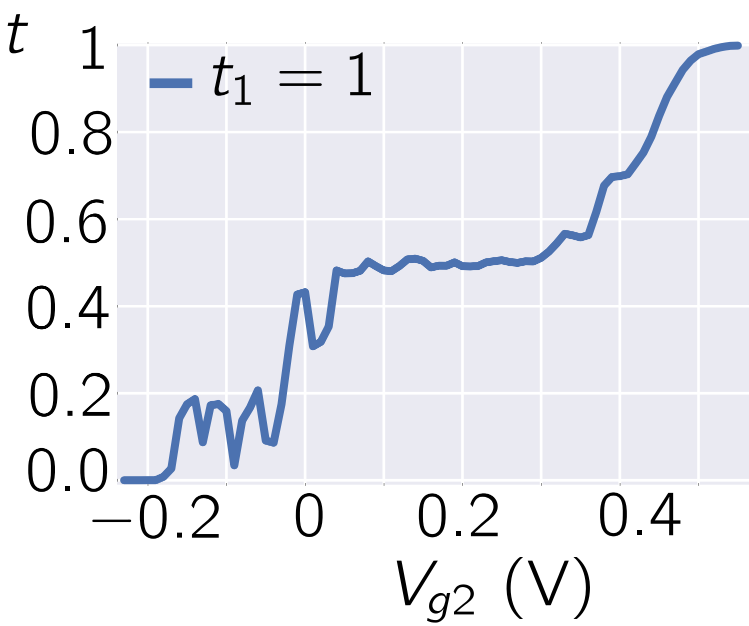

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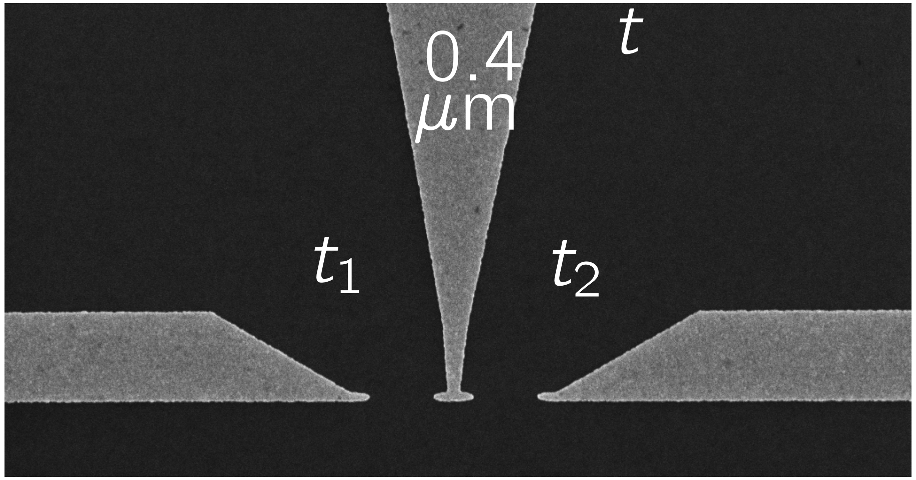

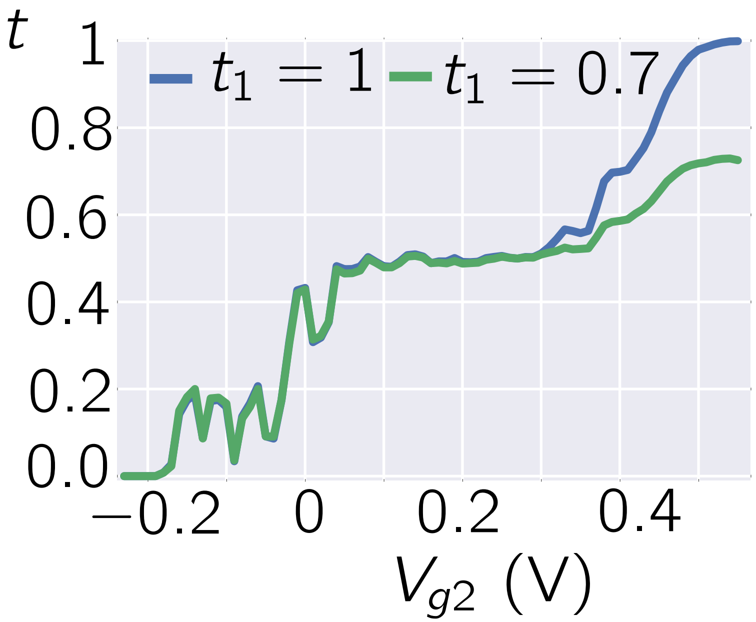

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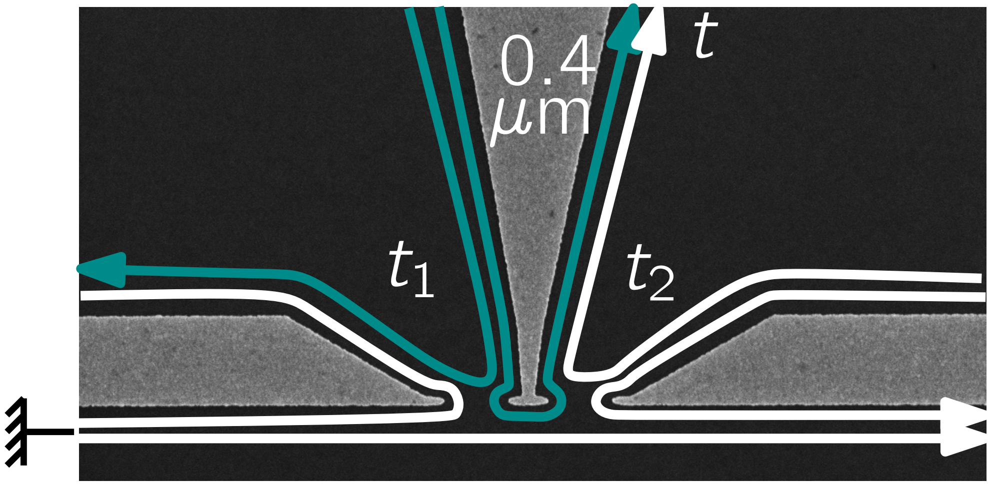

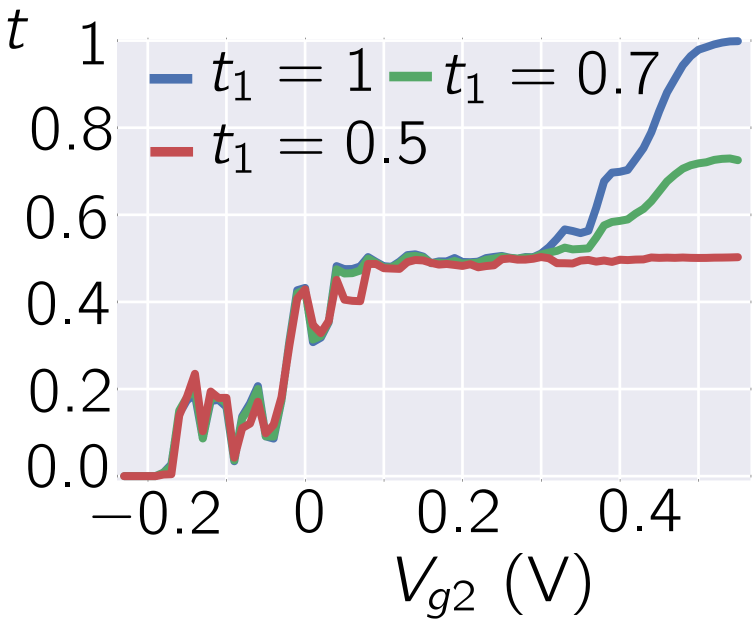

$$\nu = 2/3 \longrightarrow 1/3 + 1/3$$

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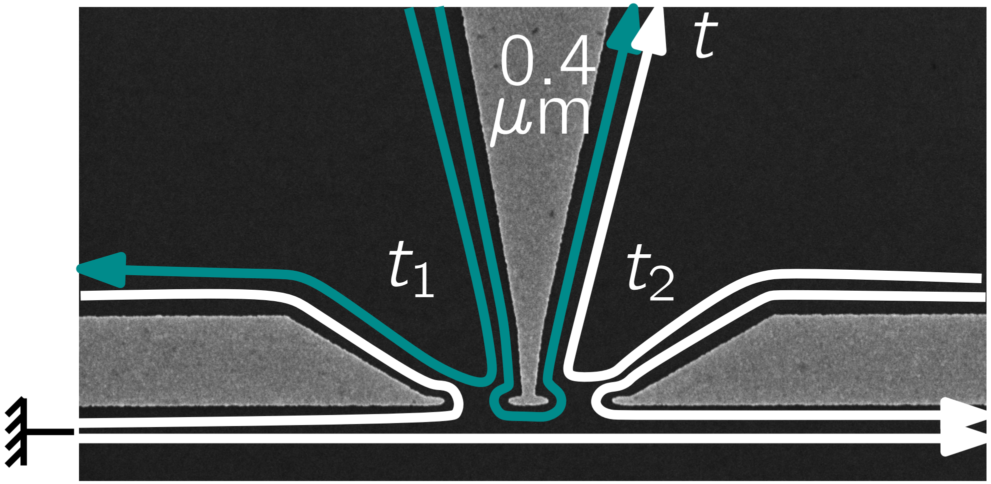

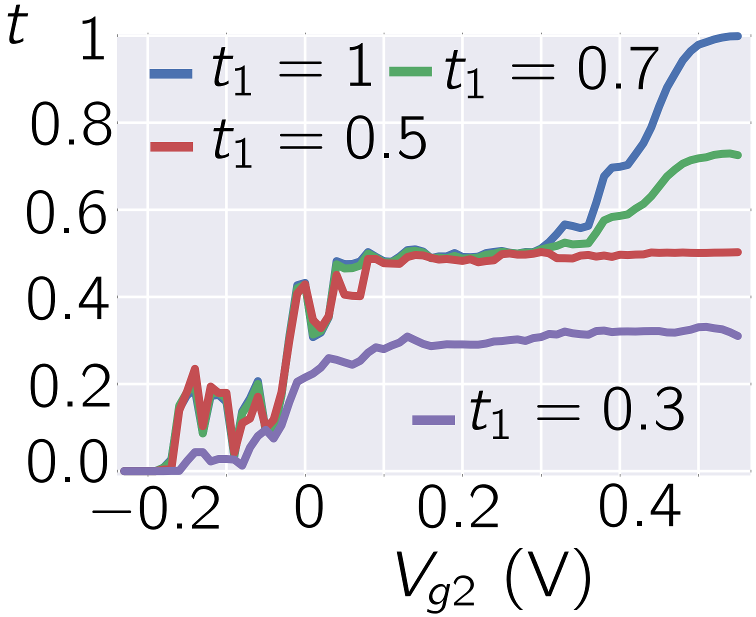

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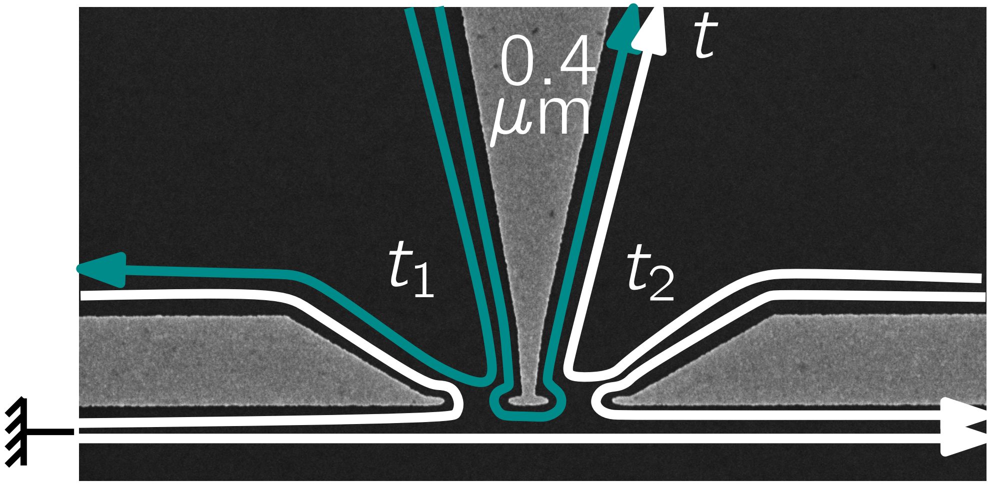

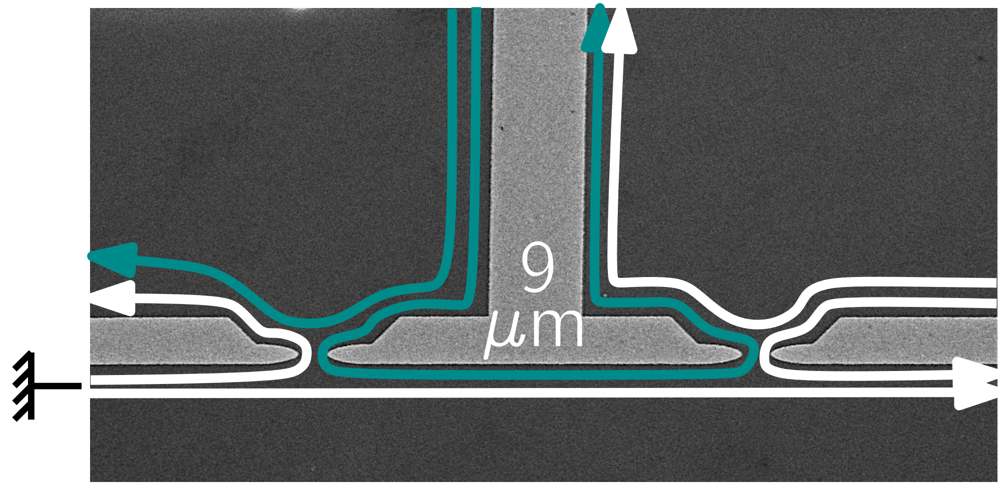

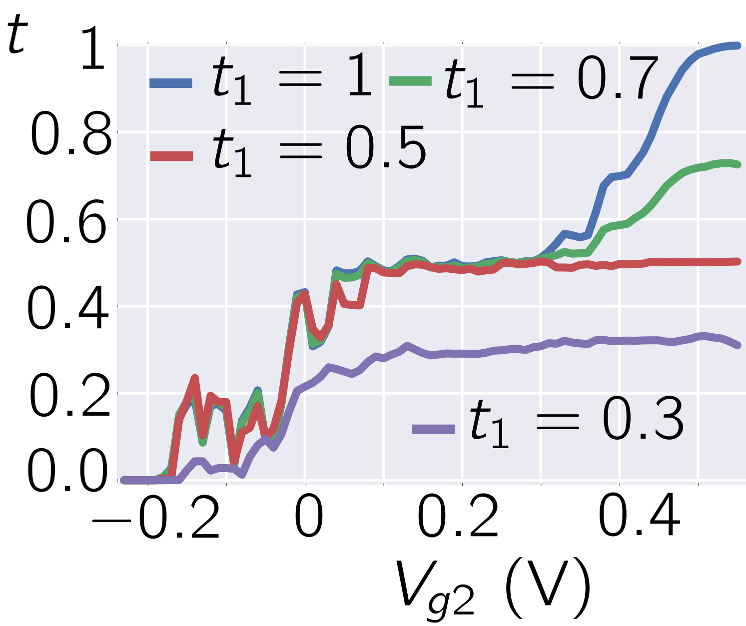

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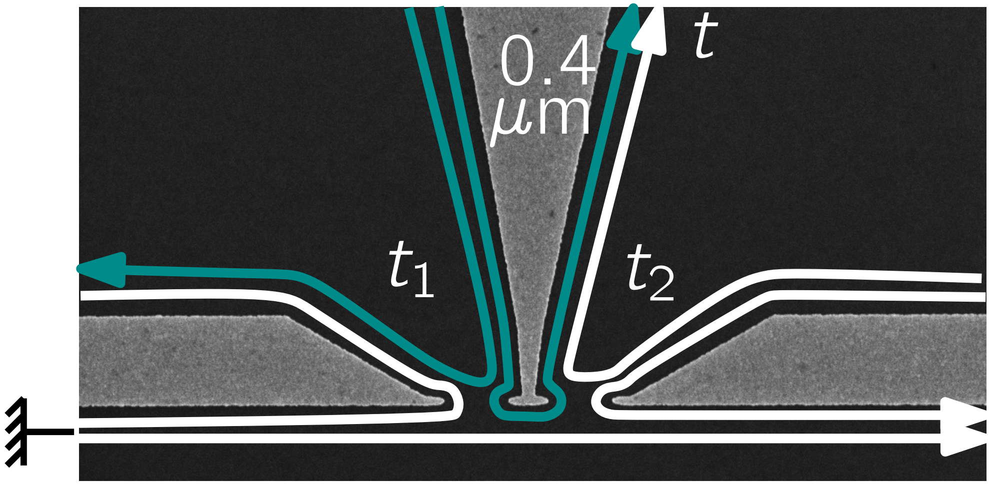

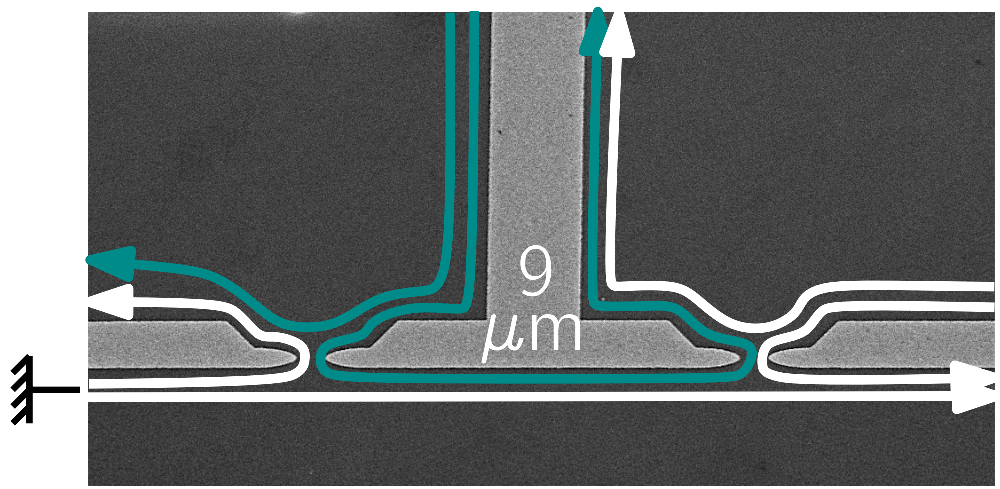

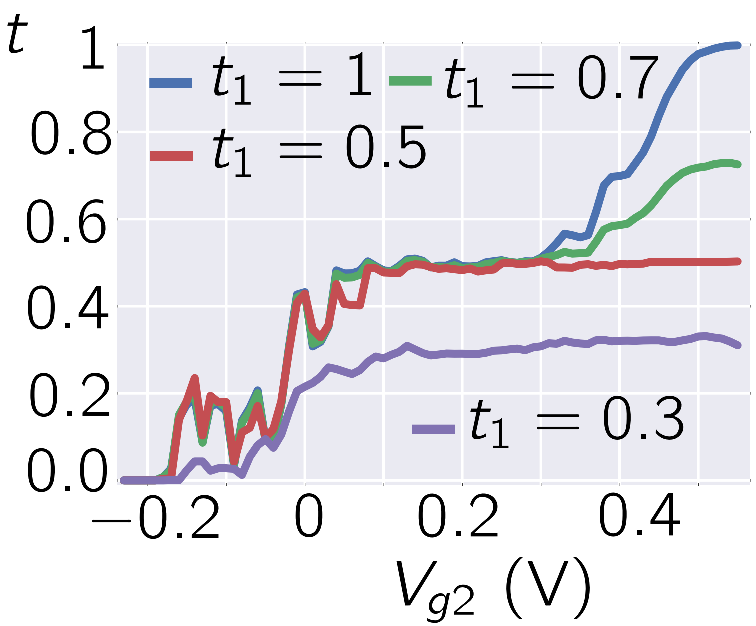

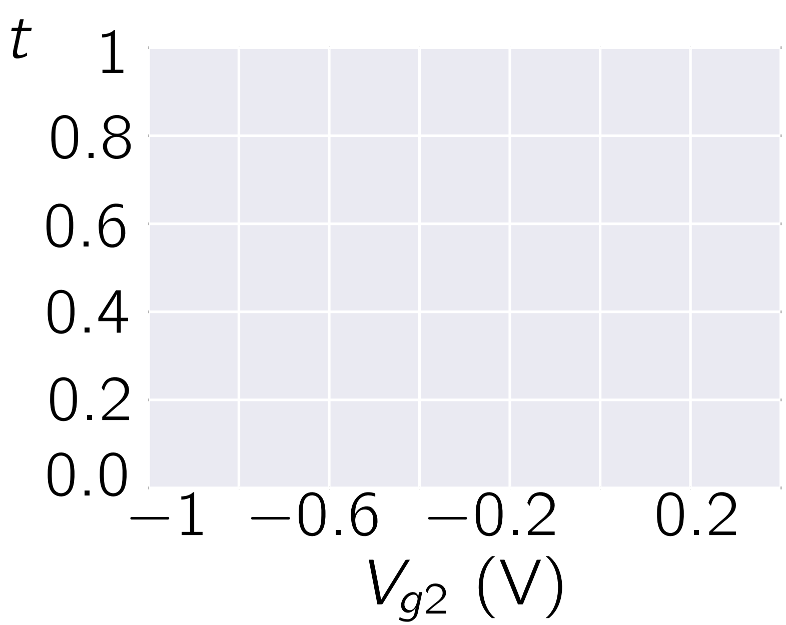

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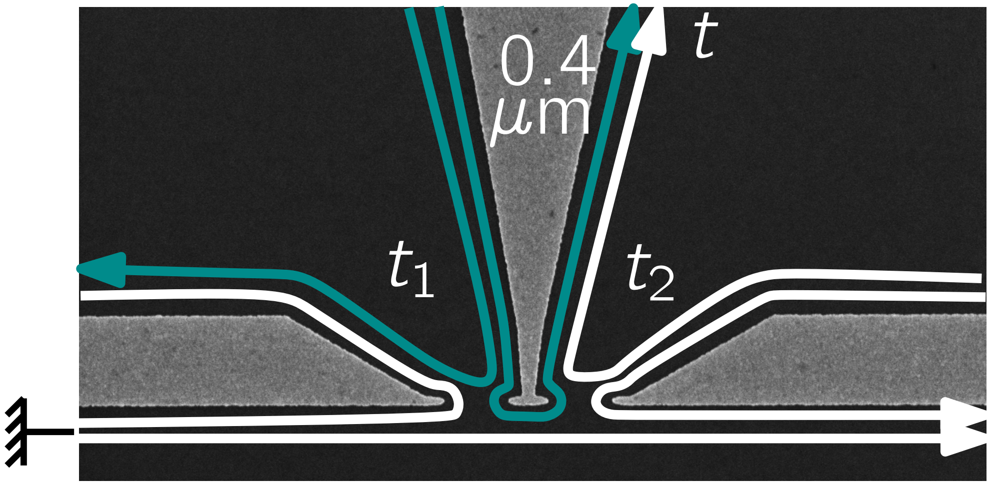

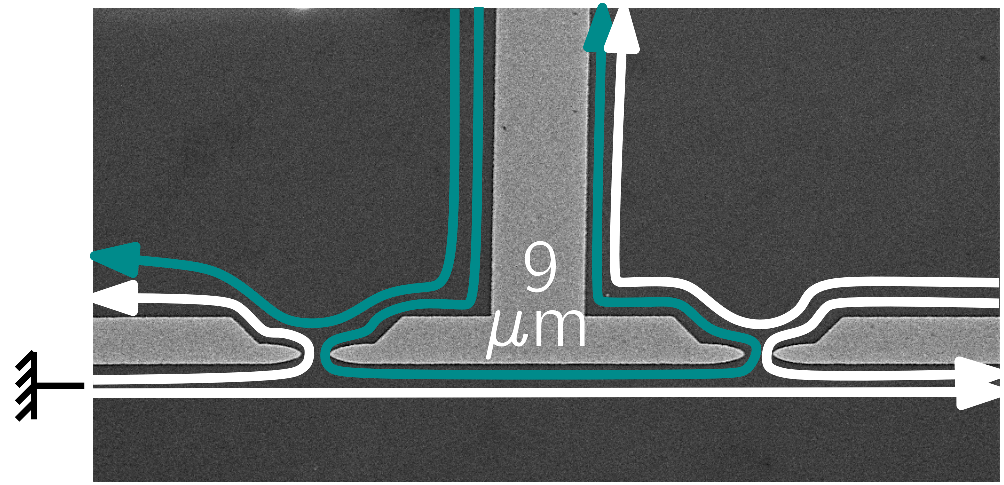

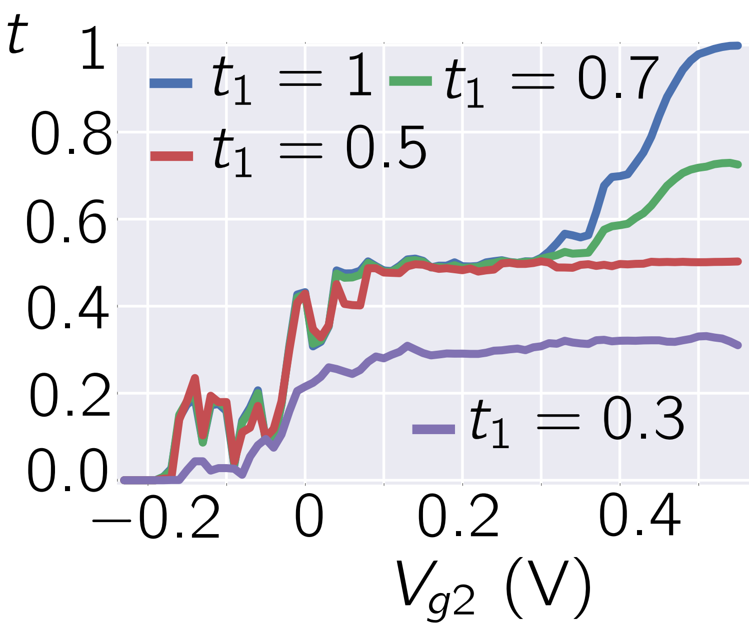

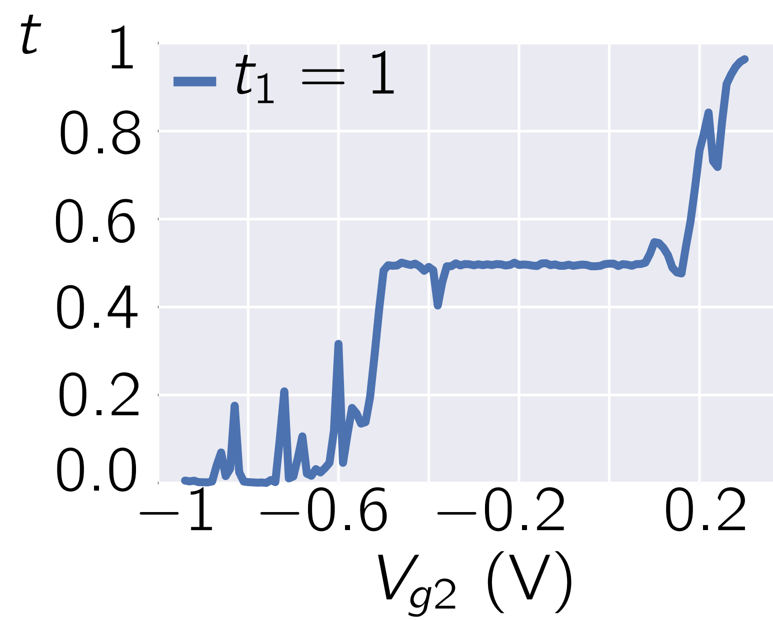

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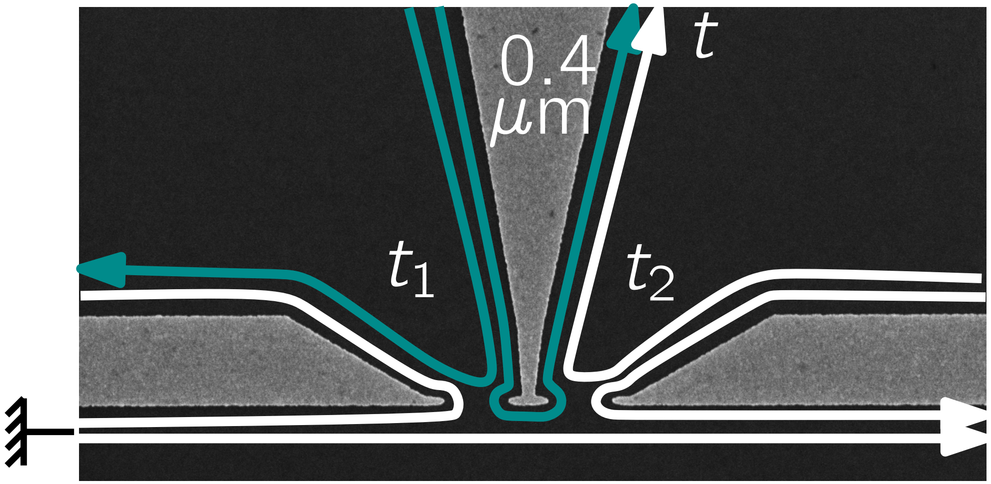

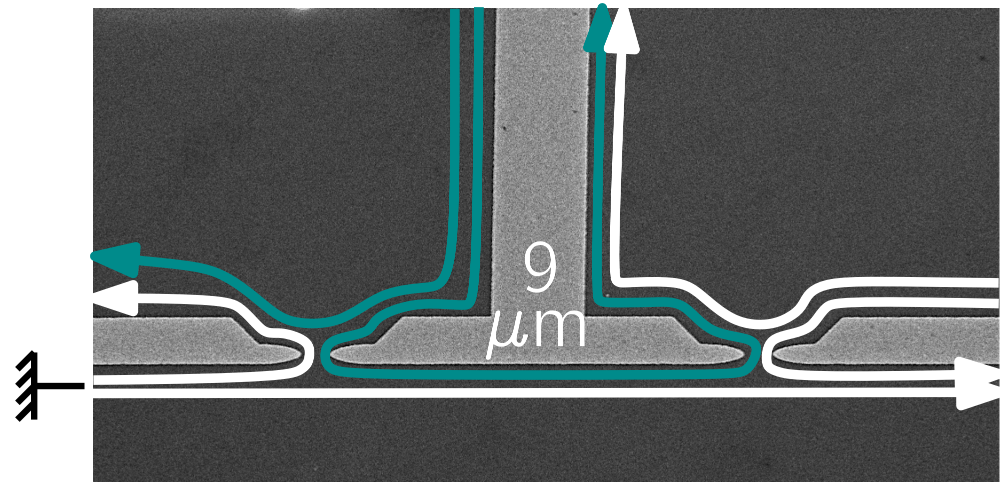

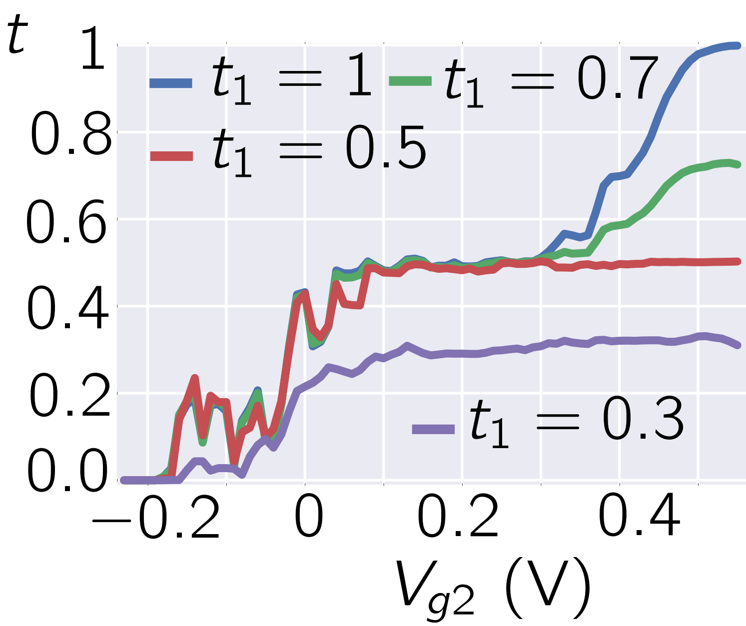

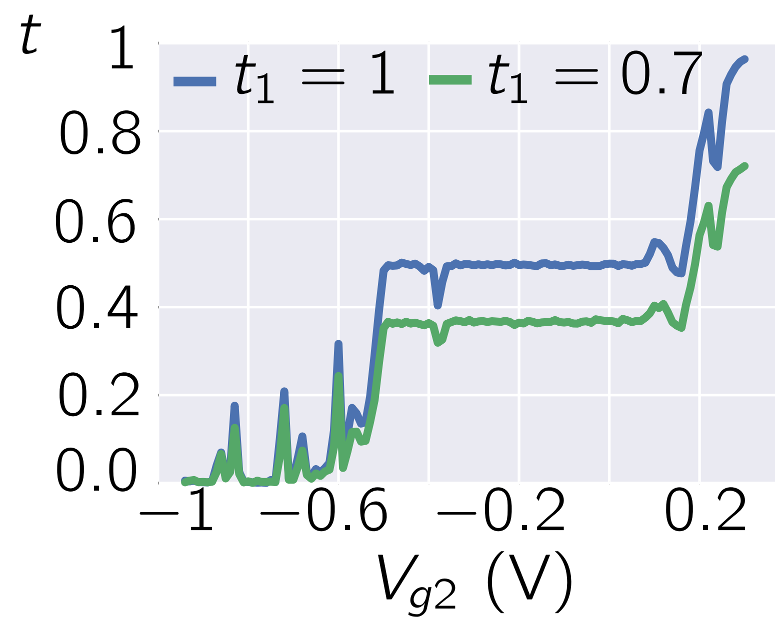

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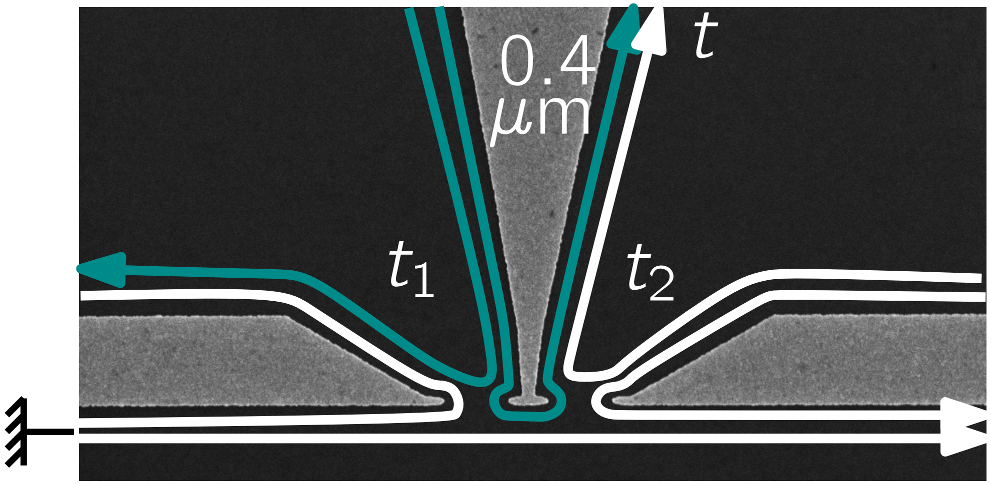

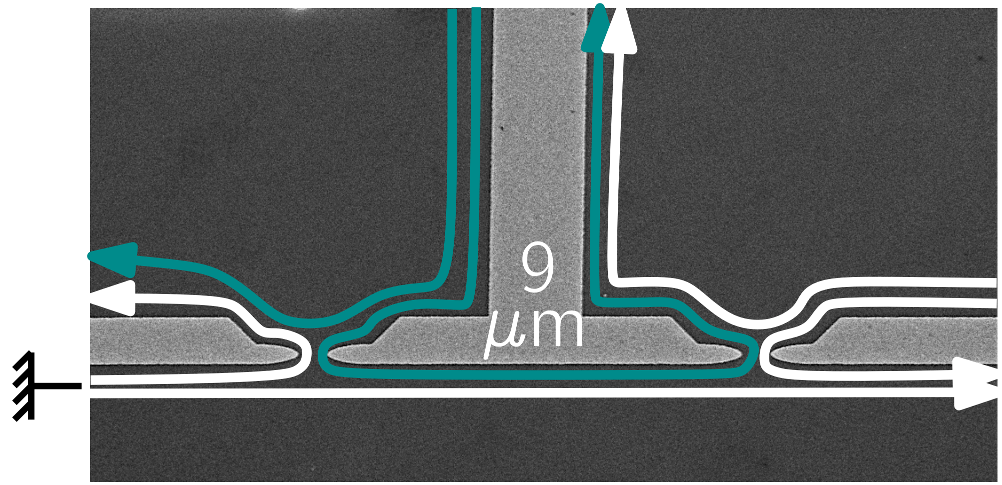

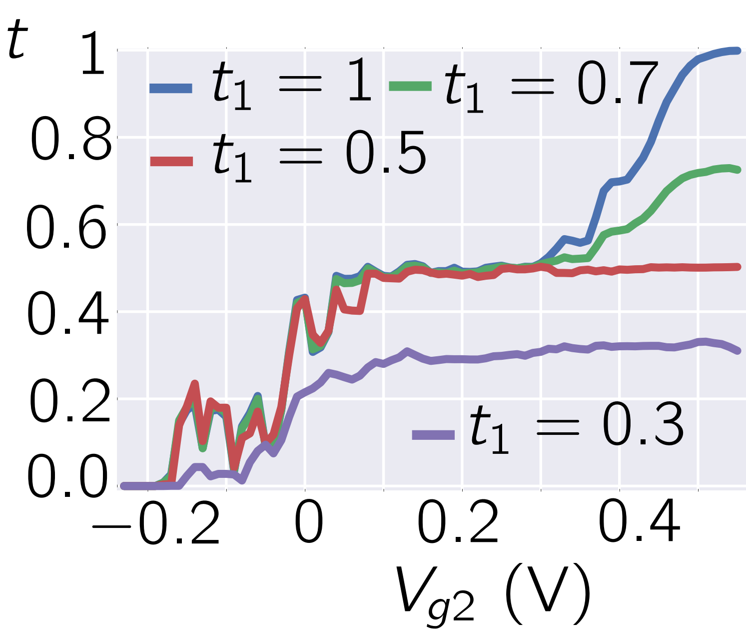

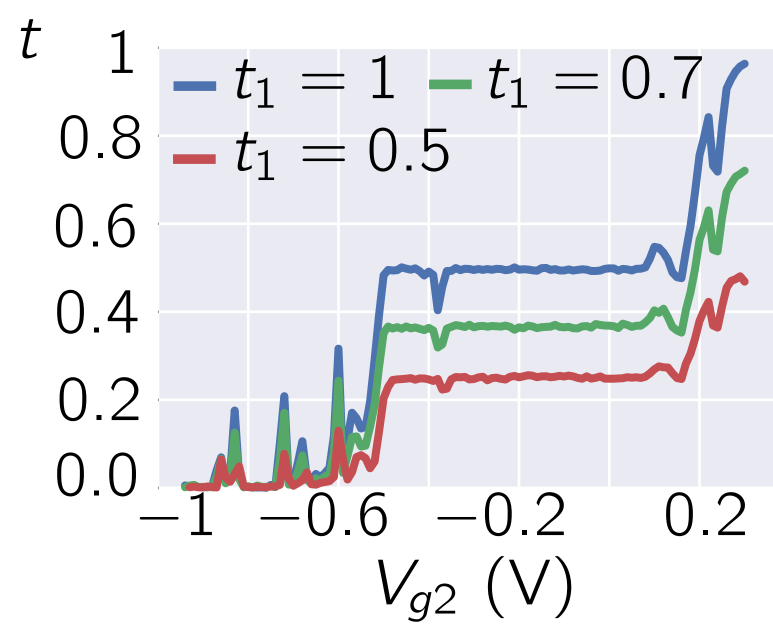

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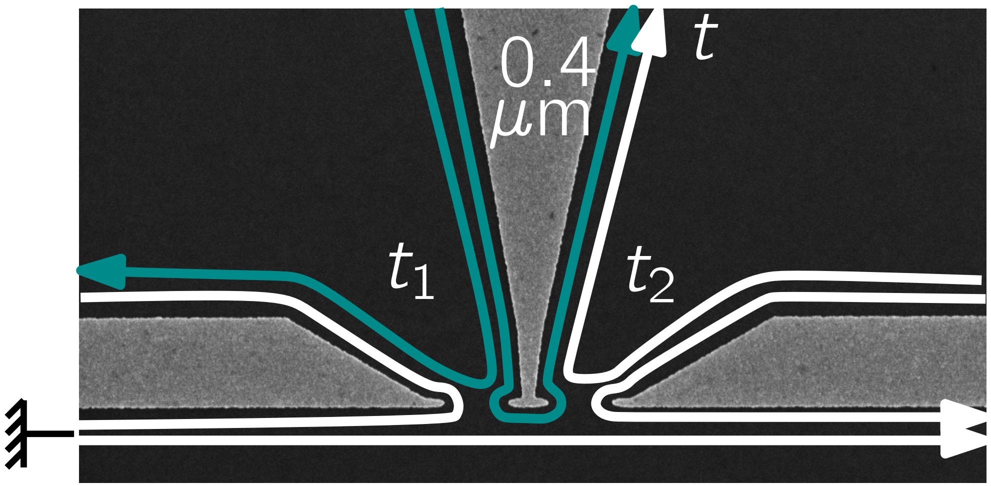
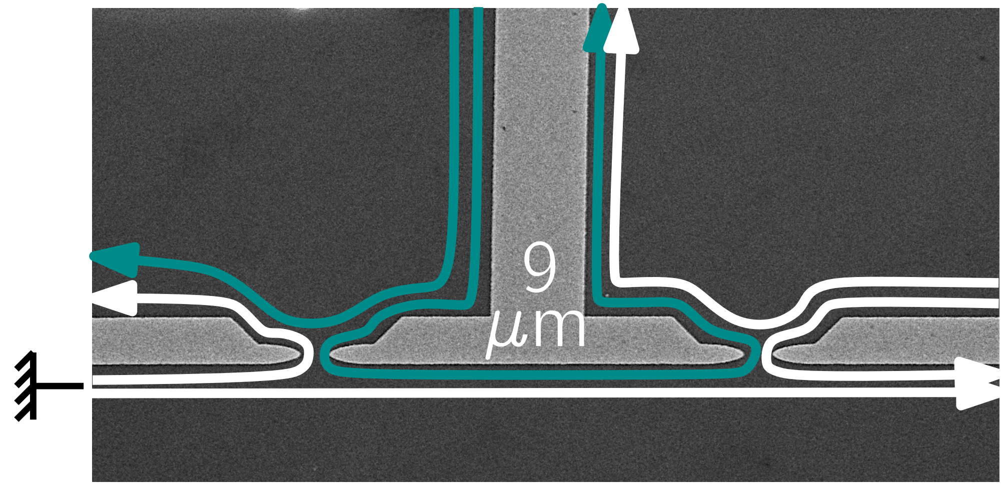
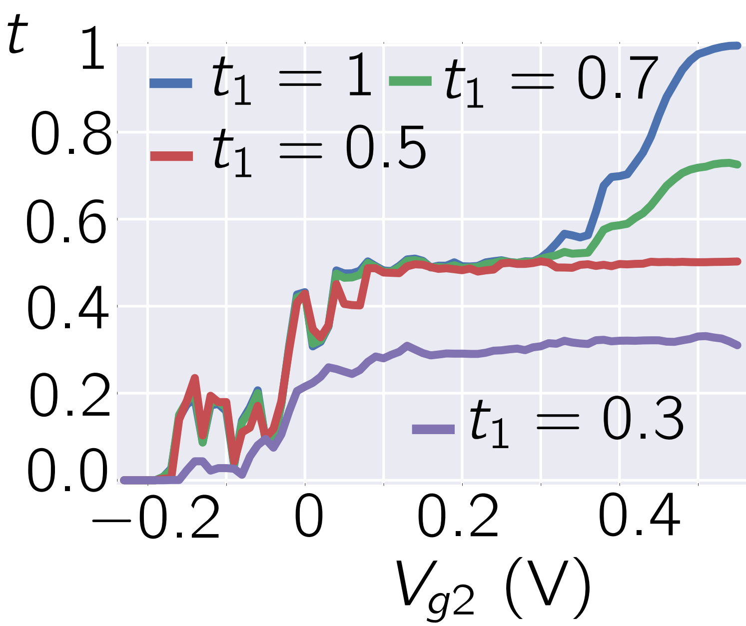
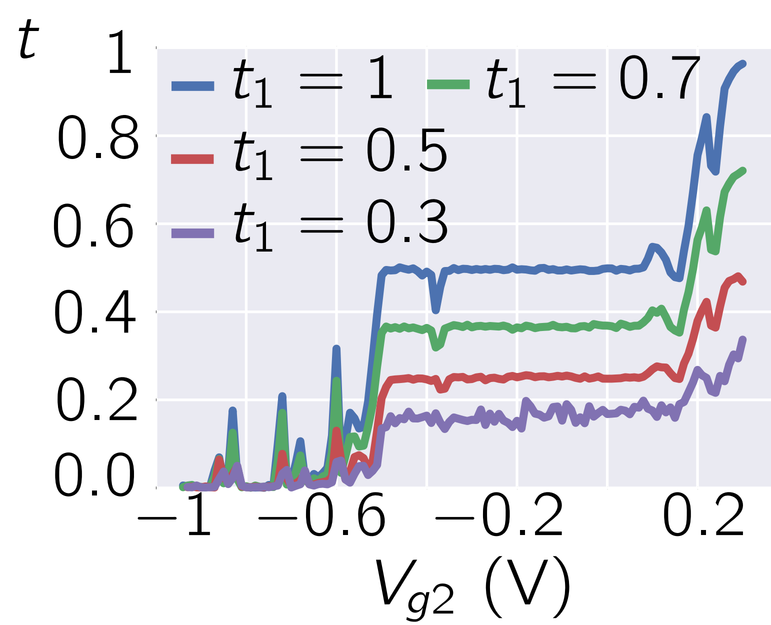




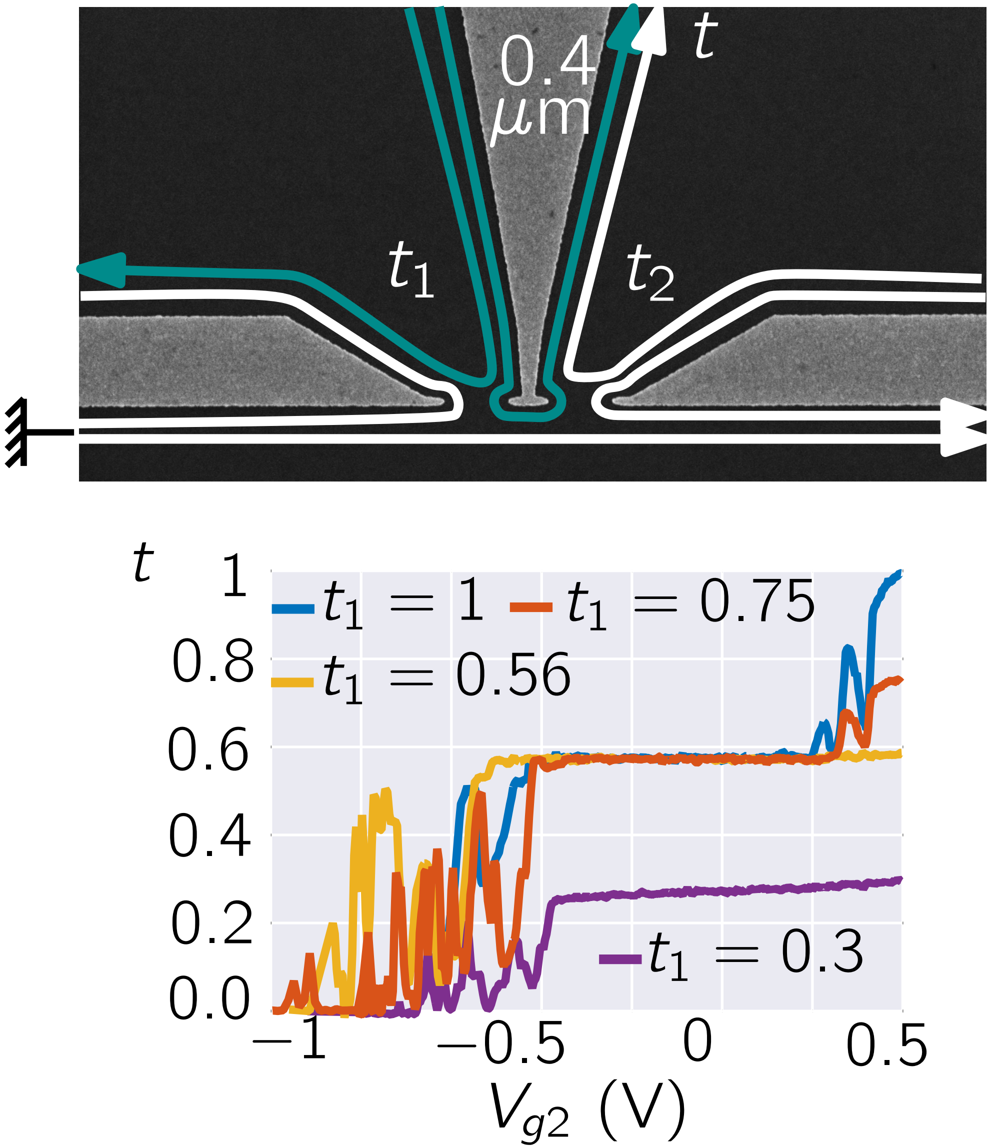


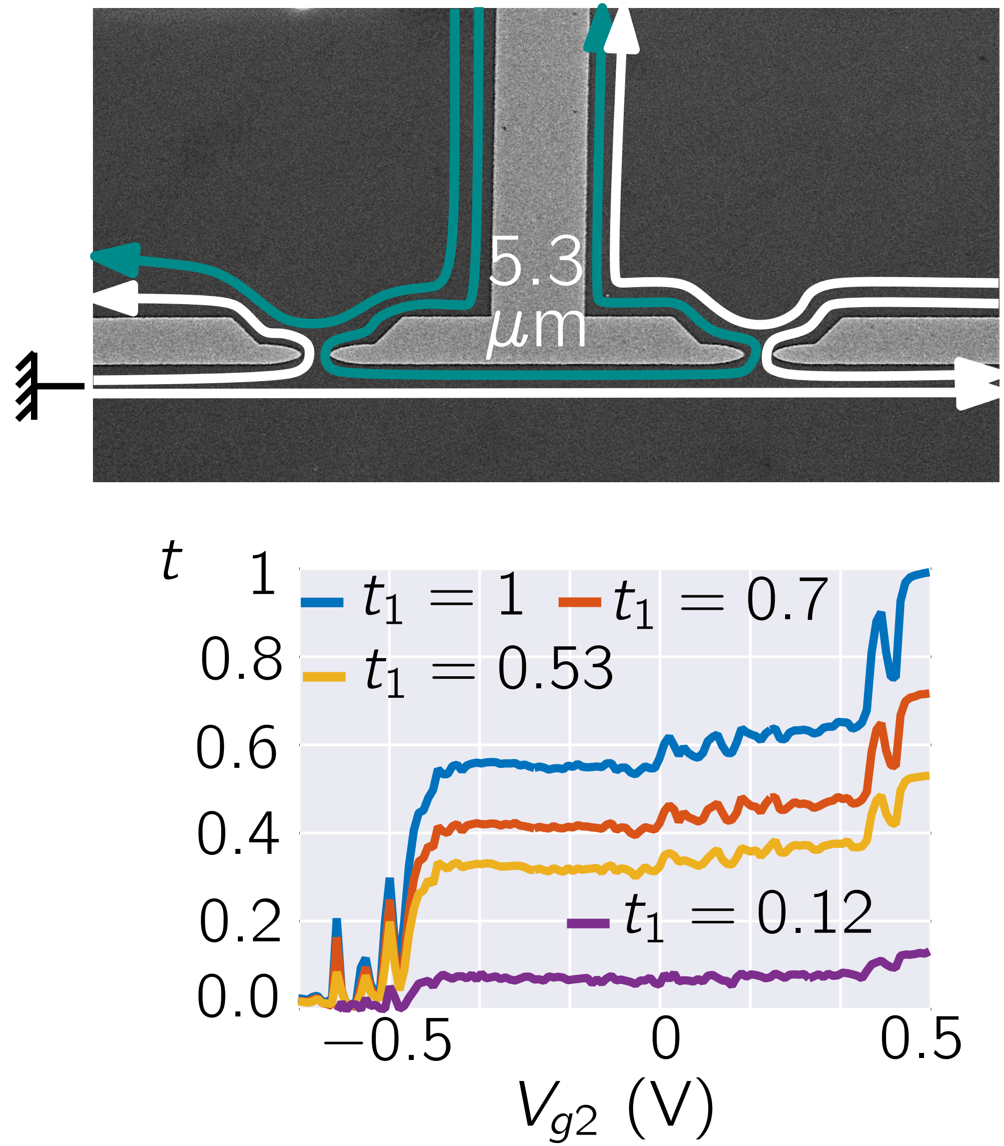


$\nu = 2/3 \longrightarrow 1/3 + 1/3$

Channels easily mix

Transmission through 2 QPCs





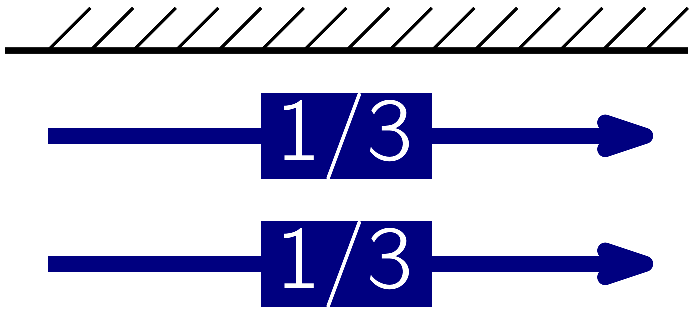
$\nu = 3/5 \longrightarrow 1/3 + 4/15$

Channels easily mix

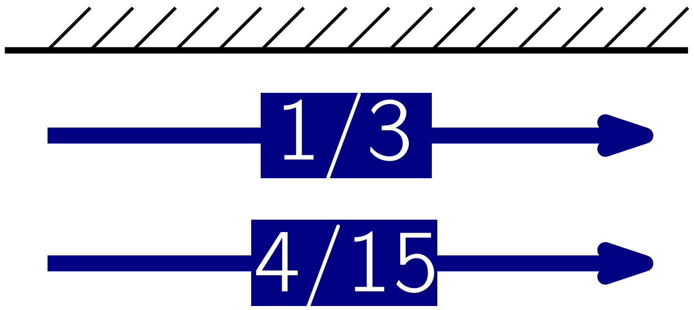
accepted in Nature Physics

Edge structure

$\nu = 2/3$



$\nu = 3/5$



Edge structure

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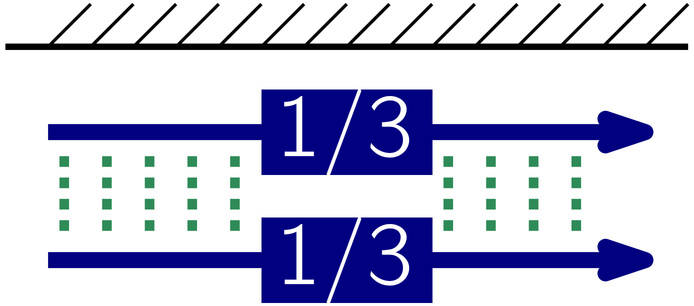
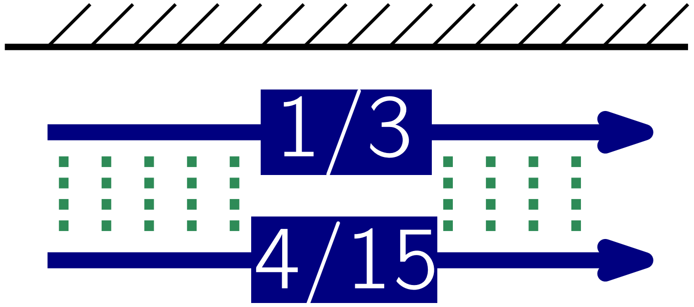
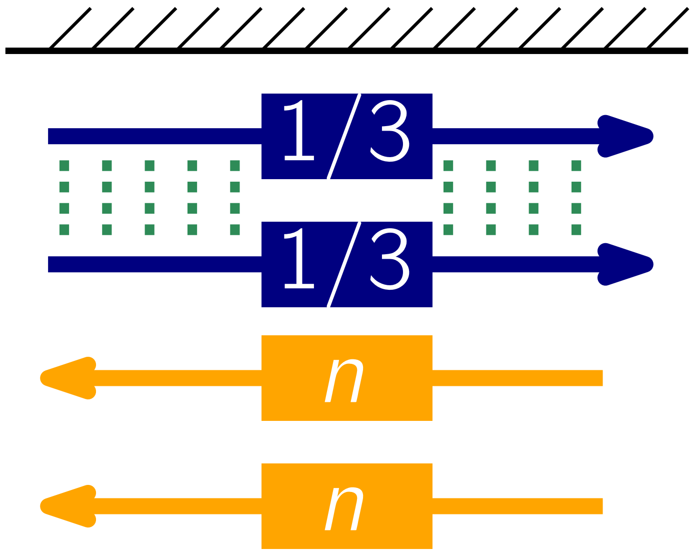


$\nu = 3/5$

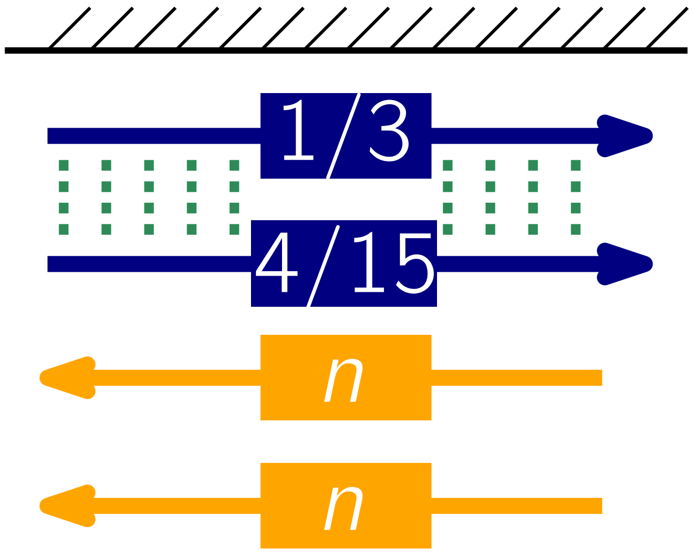


Edge structure

$\nu = 2/3$



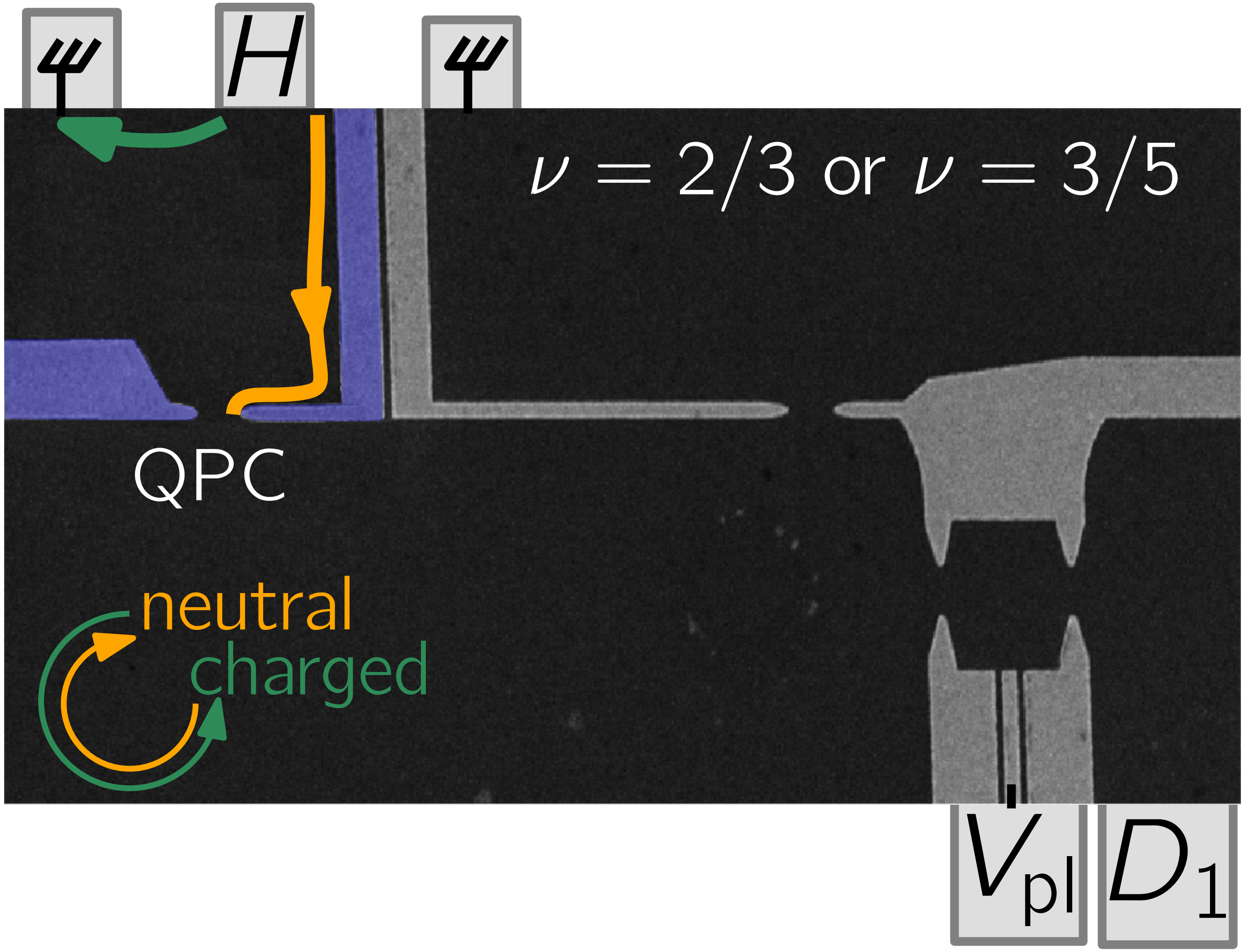
$\nu = 3/5$



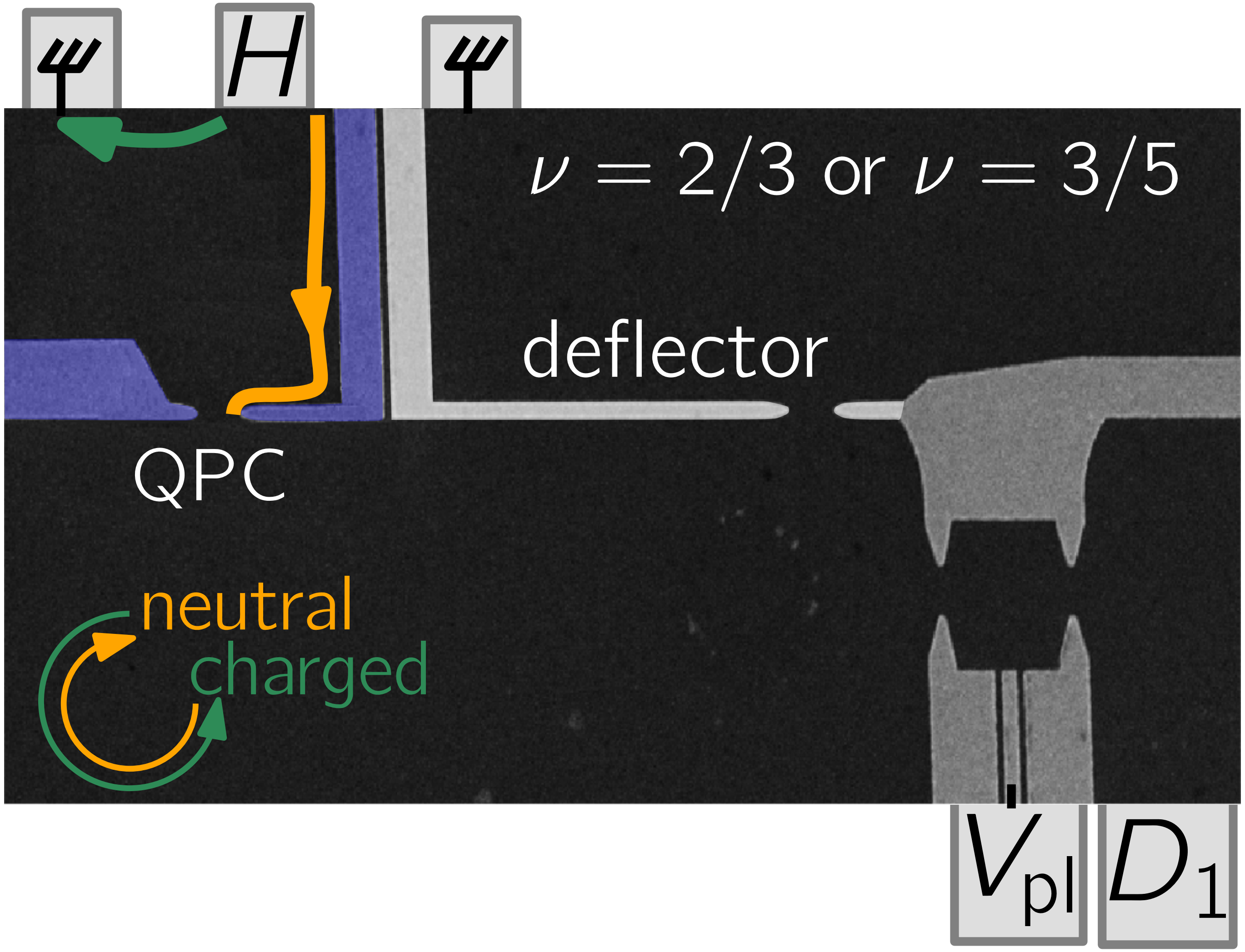
?

What about the neutral modes?

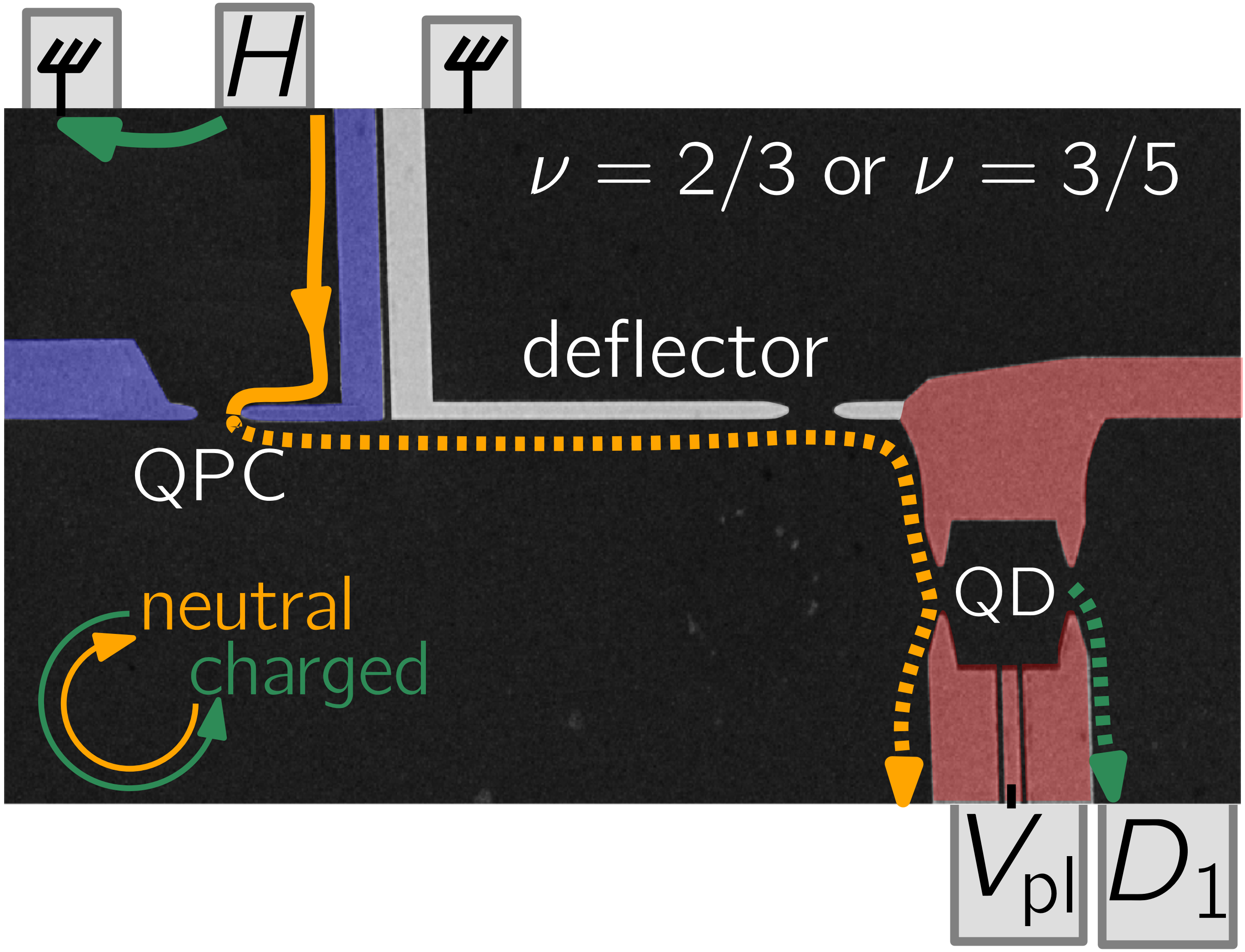
Sample



Sample

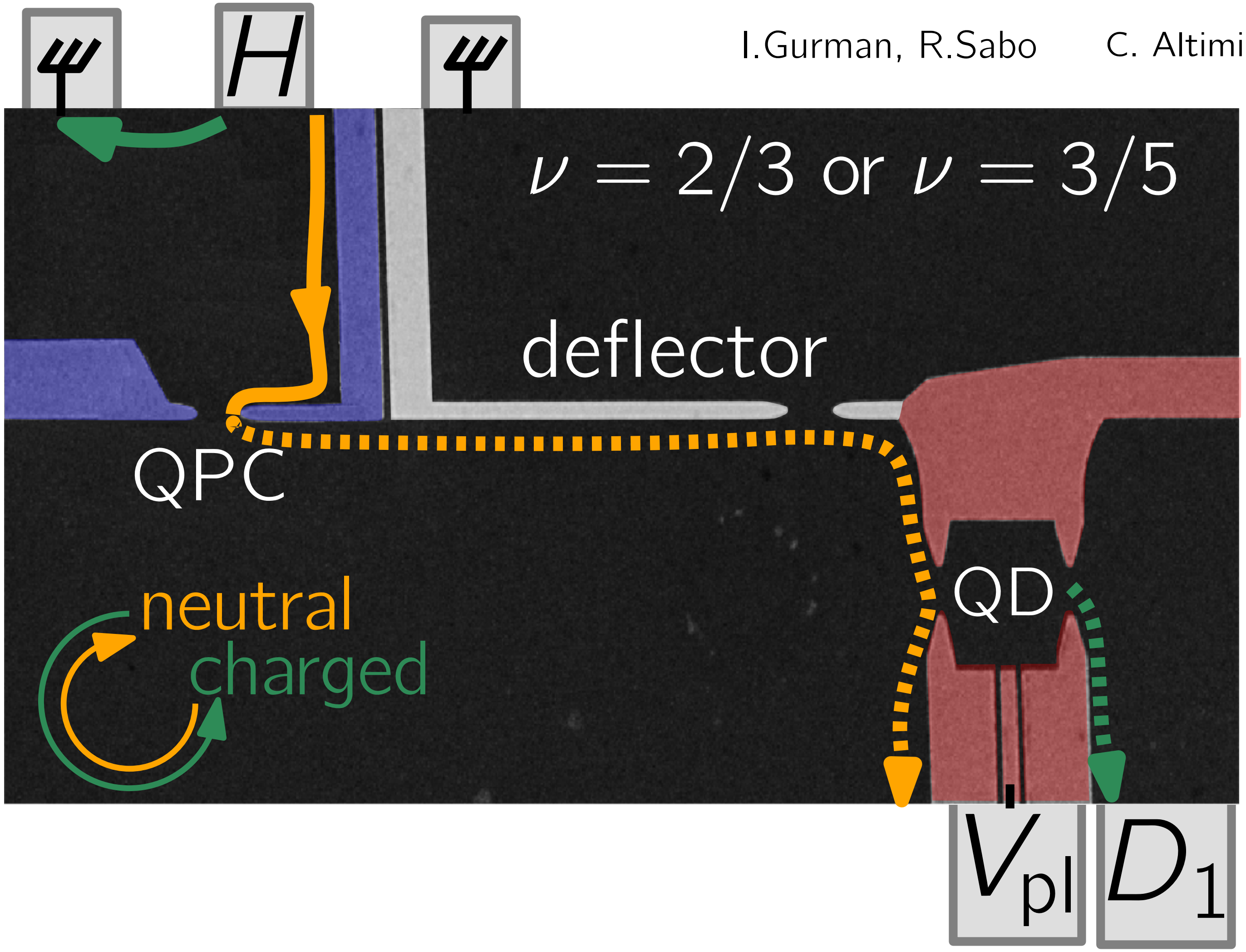


Sample



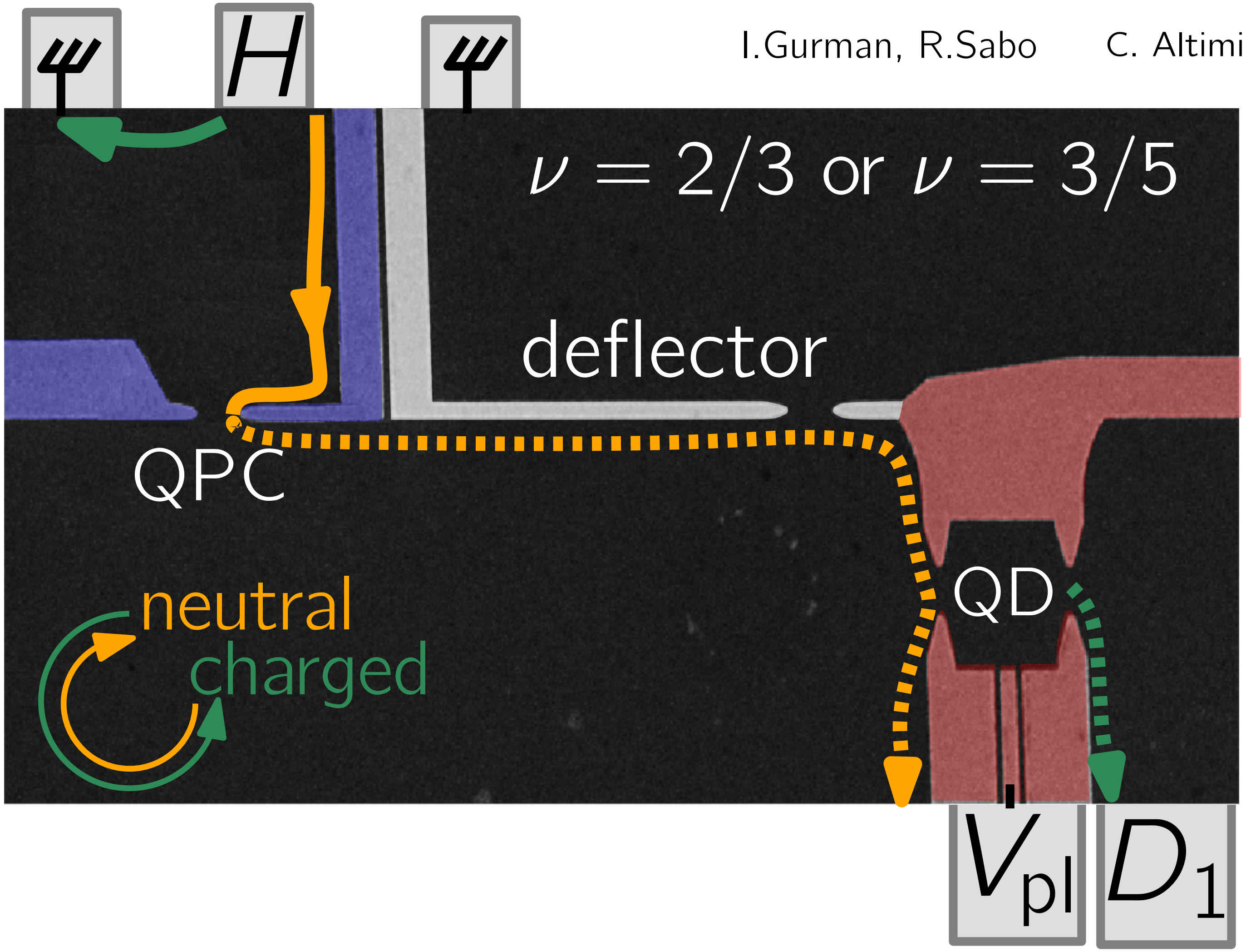
Sample

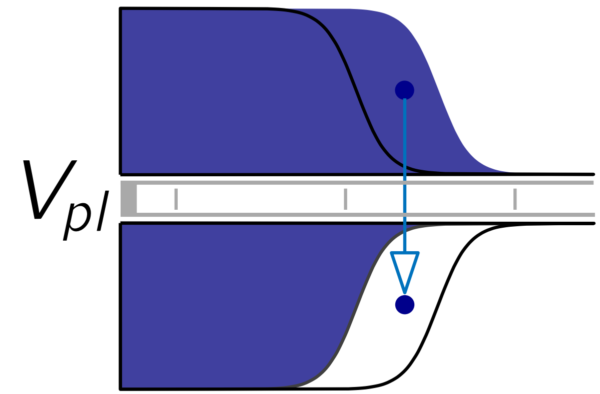
I.Gurman, R.Sabo   C. Altimiras, F. Pierre   A. Yacoby

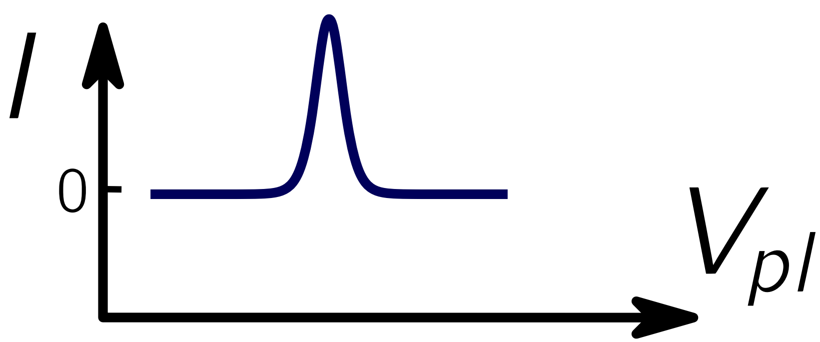


Sample

I.Gurman, R.Sabo C. Altimiras, F. Pierre A. Yacoby

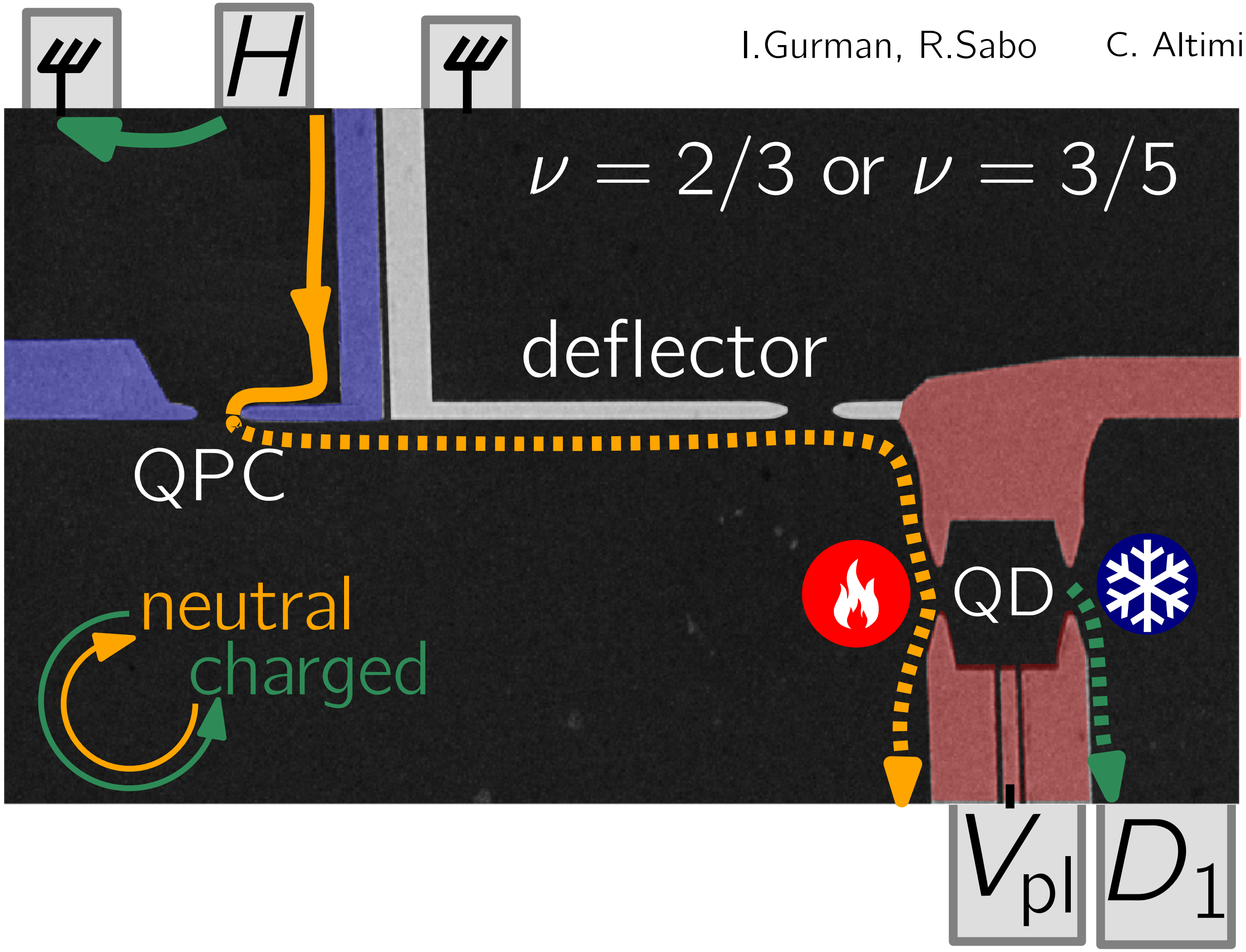


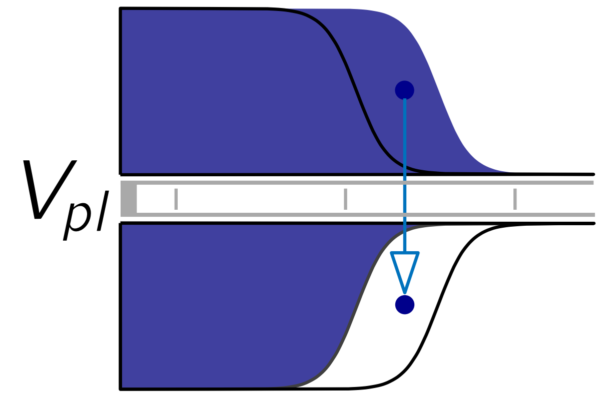


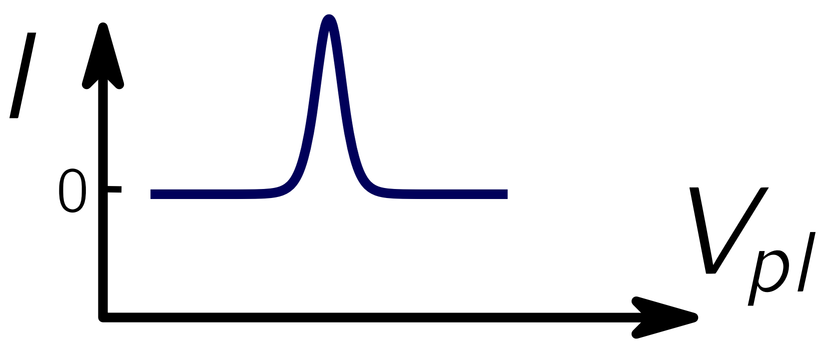


Sample

I.Gurman, R.Sabo   C. Altimiras, F. Pierre   A. Yacoby

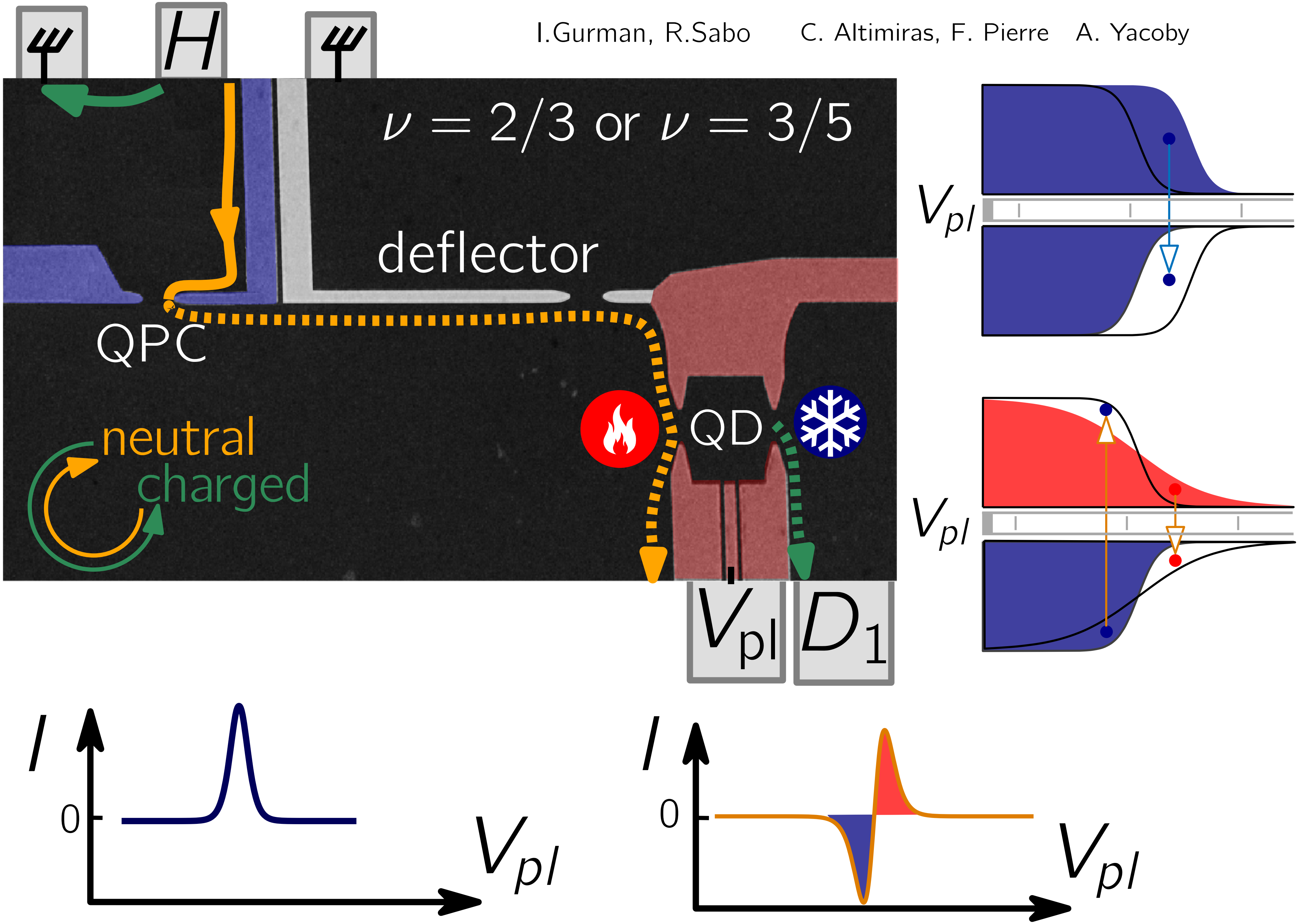






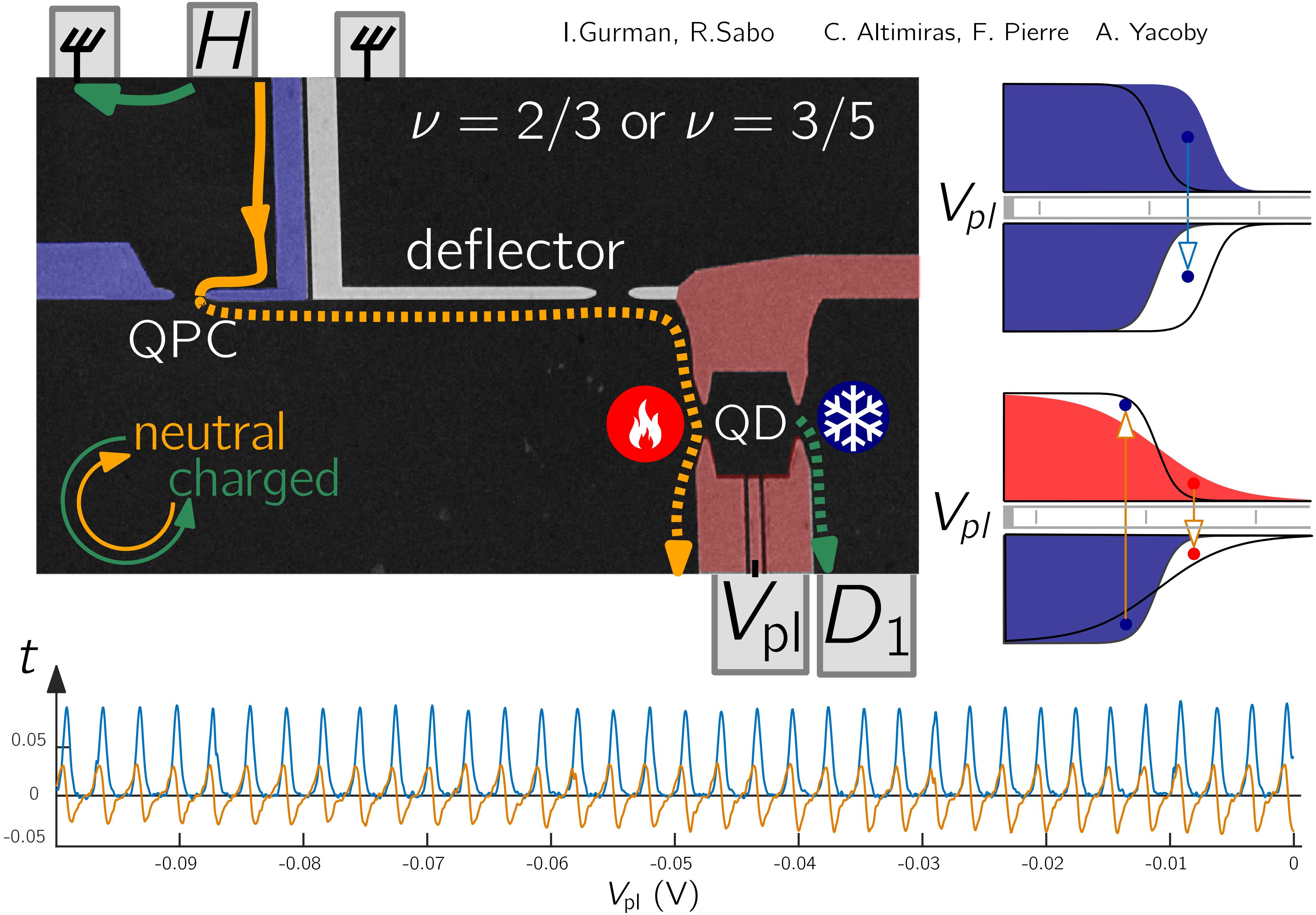
Sample

I.Gurman, R.Sabo C. Altimiras, F. Pierre A. Yacoby



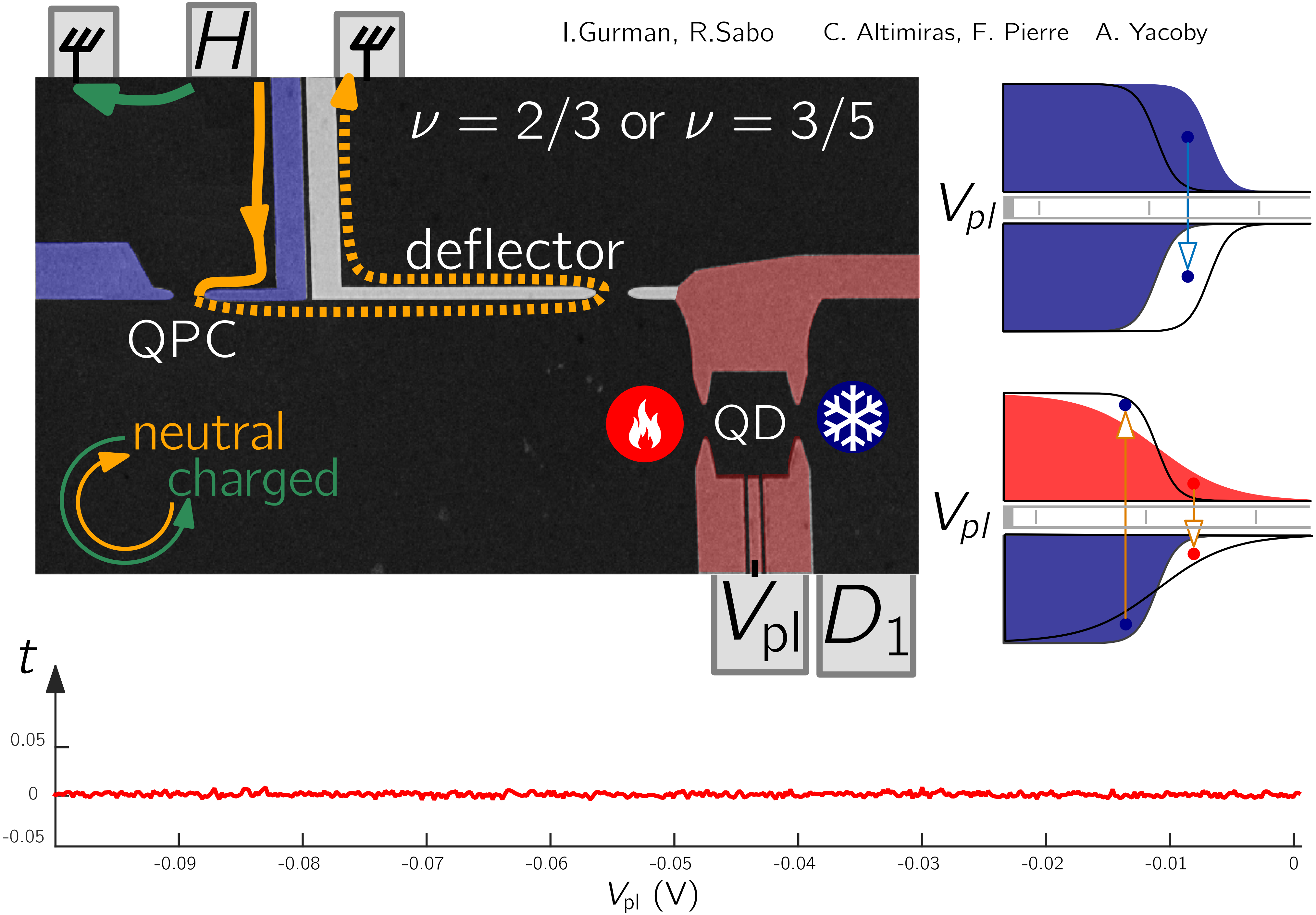
Sample

I.Gurman, R.Sabo   C. Altimiras, F. Pierre   A. Yacoby

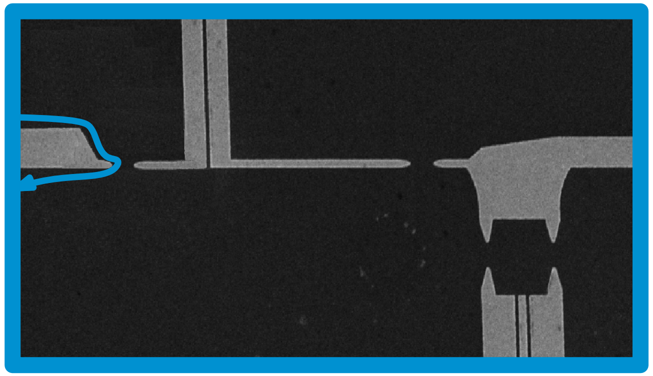


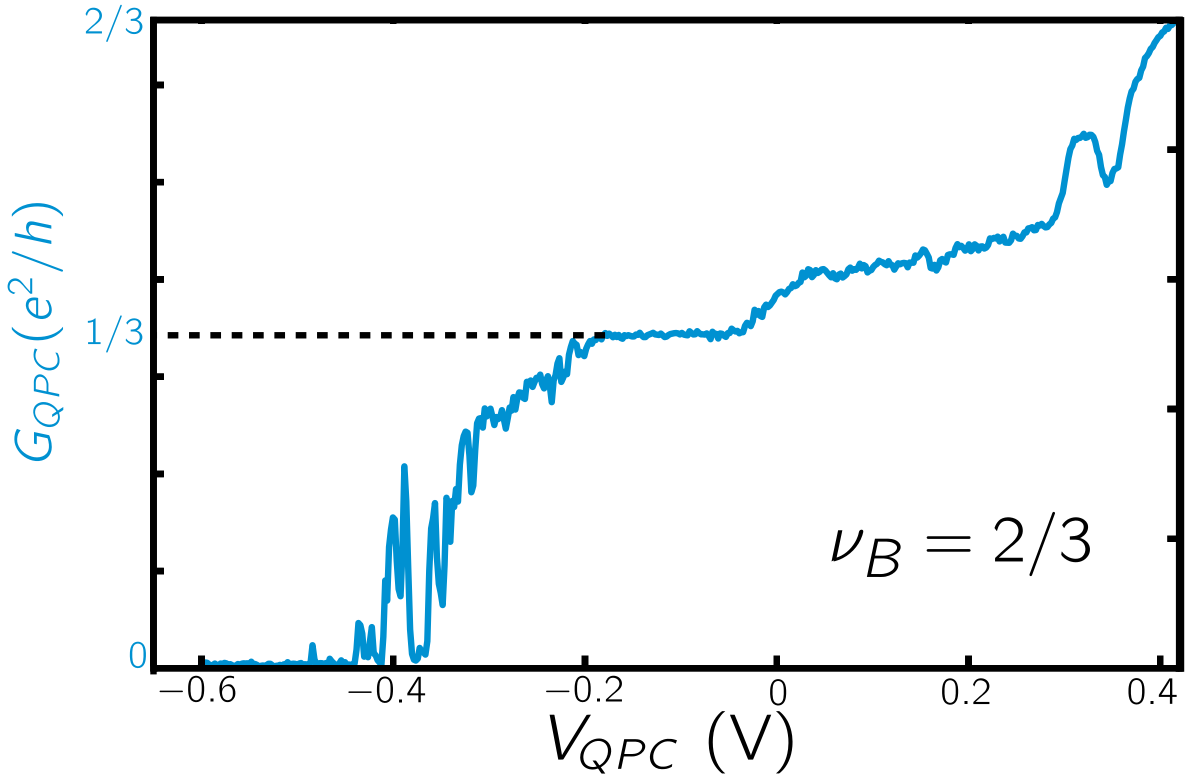
Sample

I.Gurman, R.Sabo C. Altimiras, F. Pierre A. Yacoby

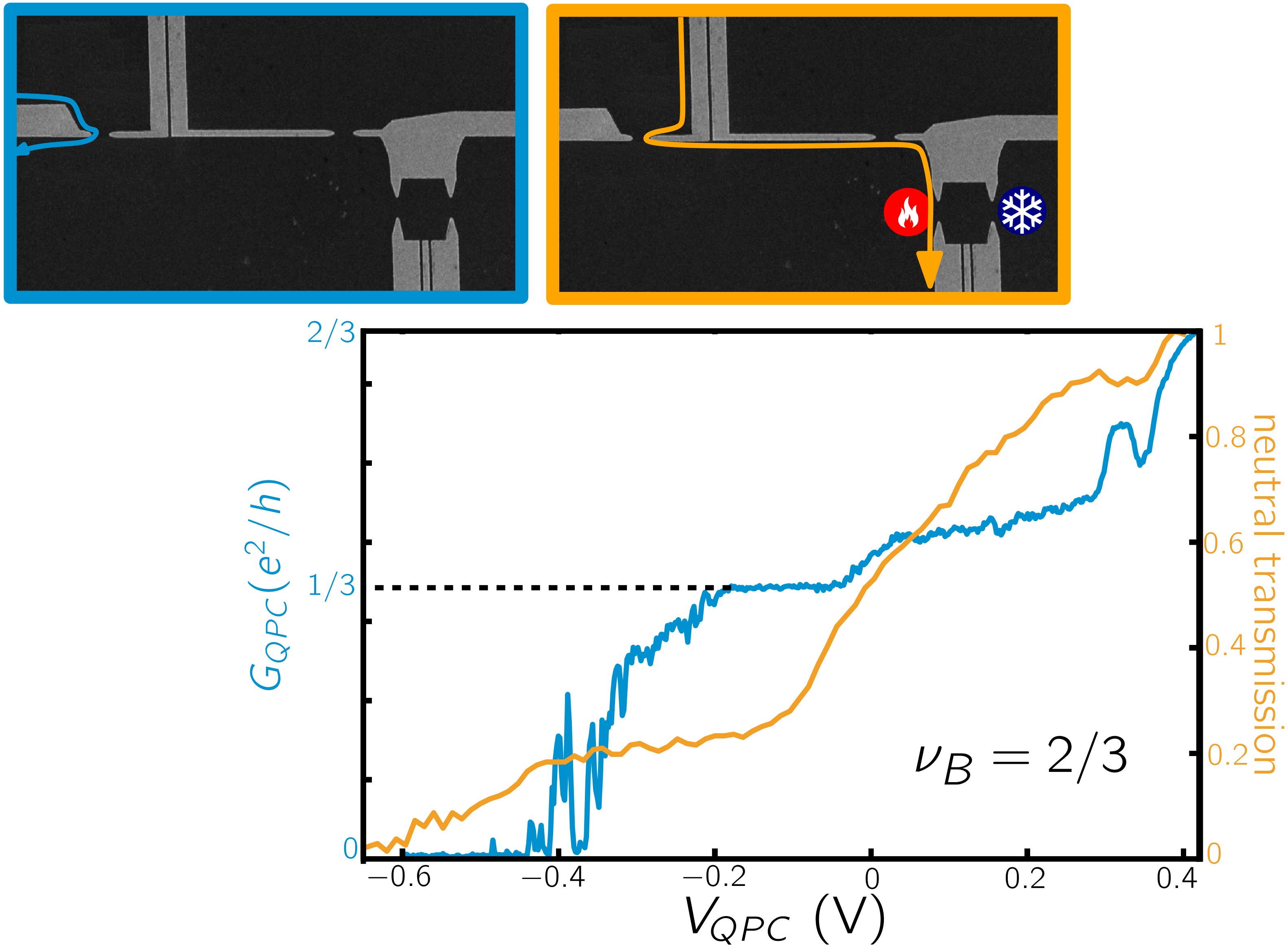


Neutral transmission $\nu = 2/3$

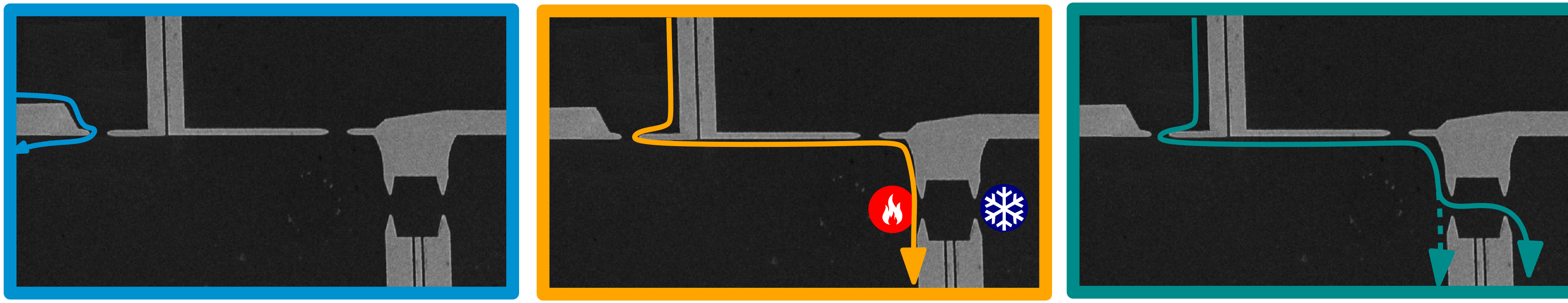


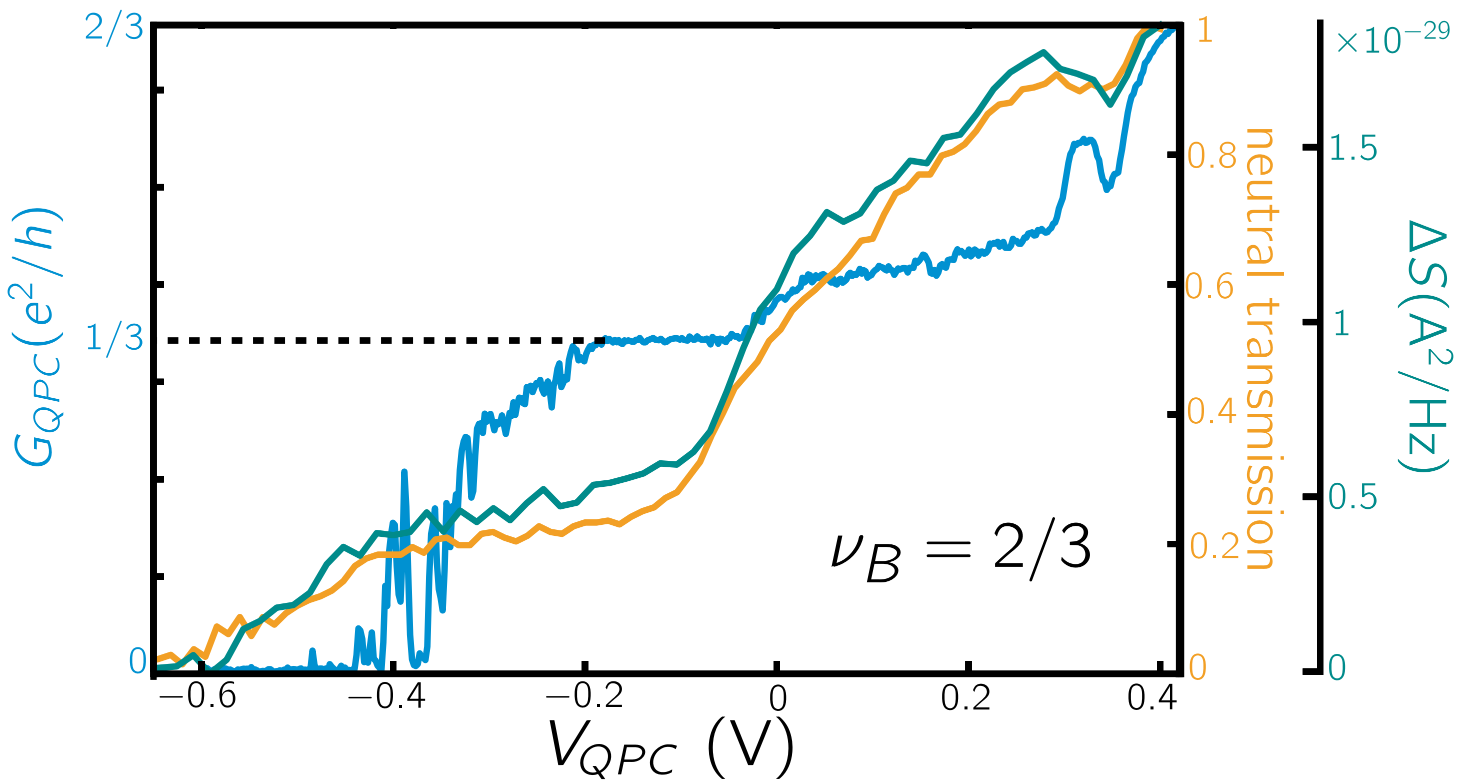


Neutral transmission $\nu = 2/3$

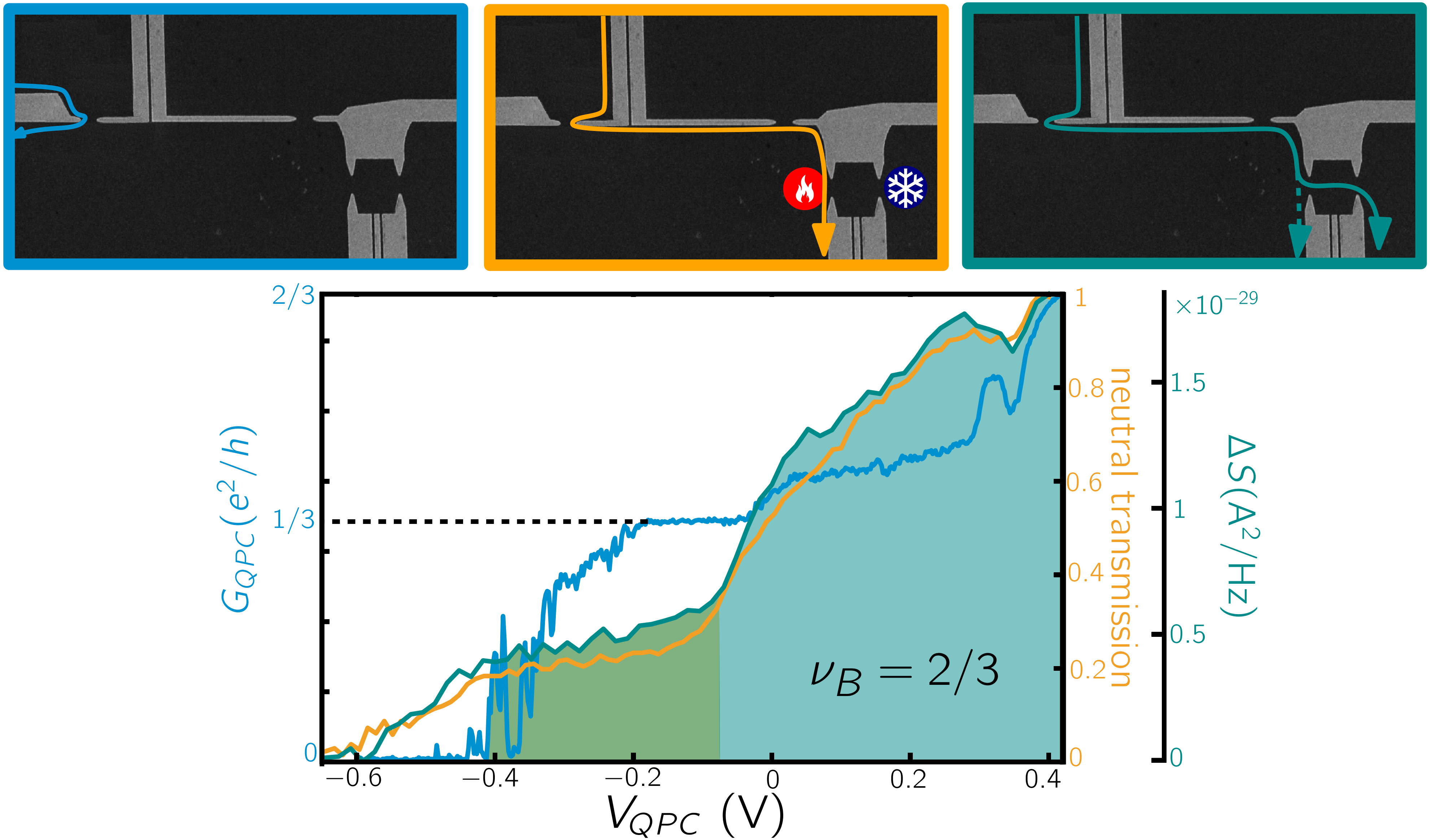


Neutral transmission $\nu = 2/3$



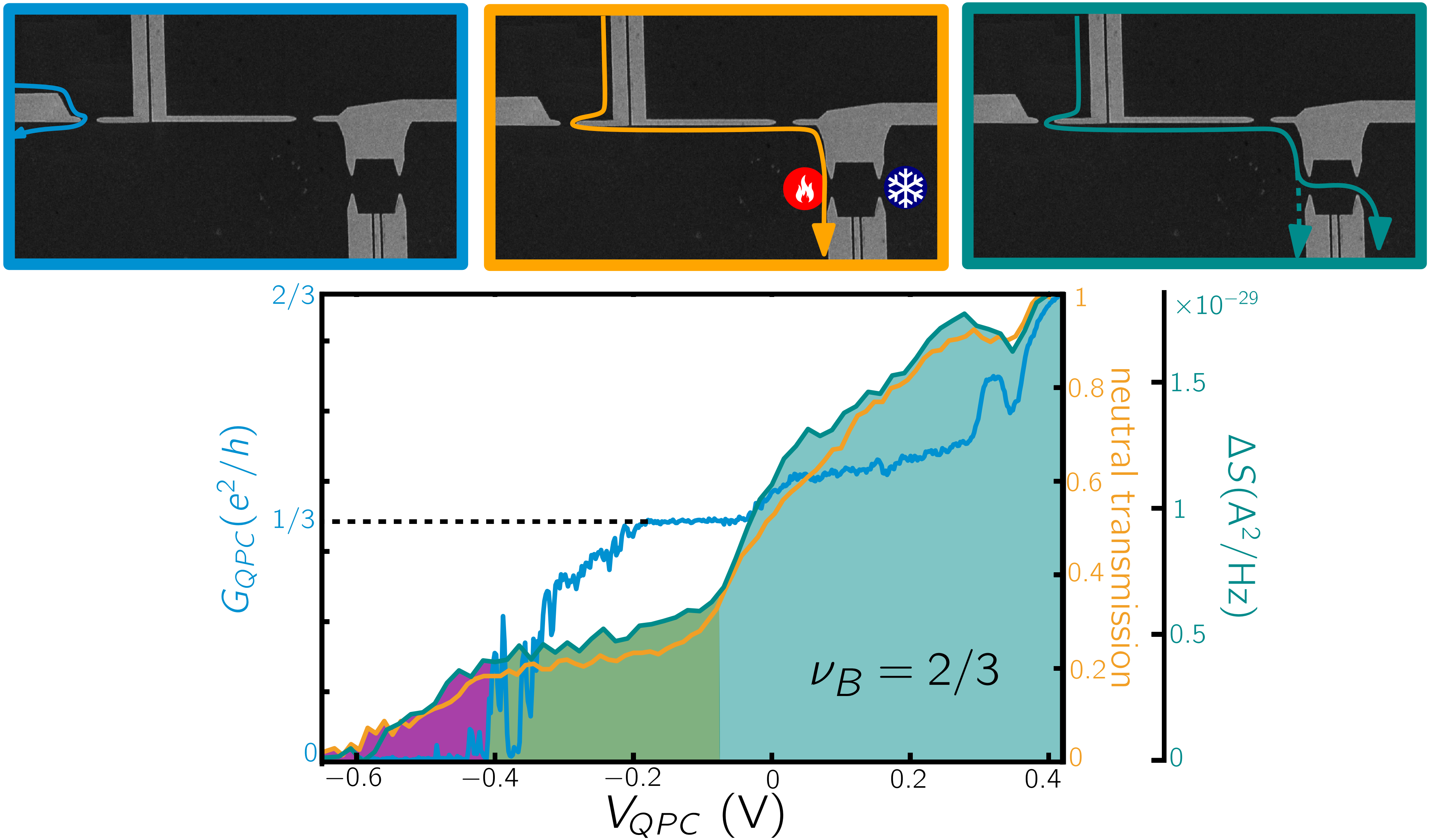


Neutral transmission $\nu = 2/3$



The neutral transmission drops on the plateau

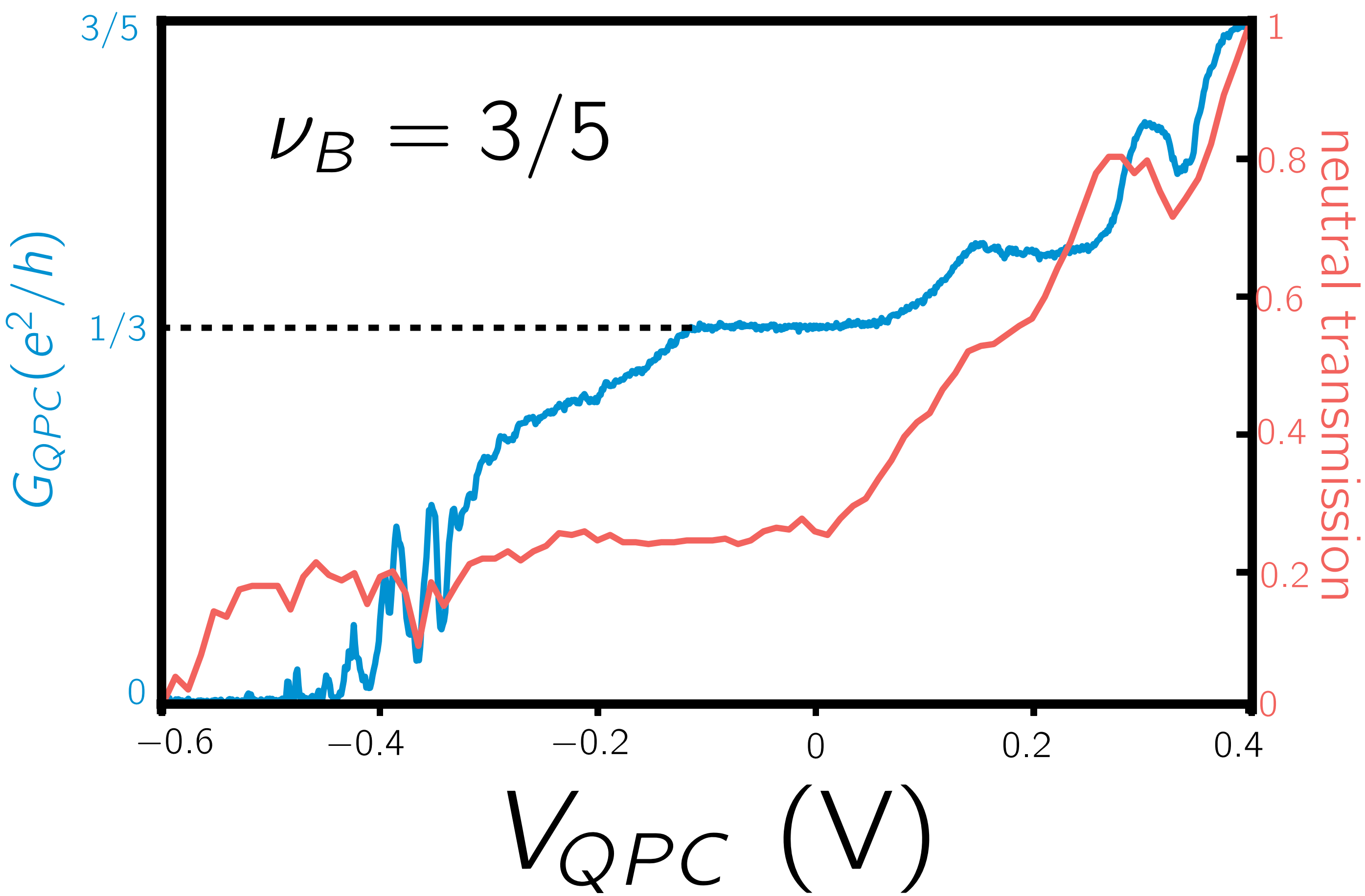
Neutral transmission $\nu = 2/3$



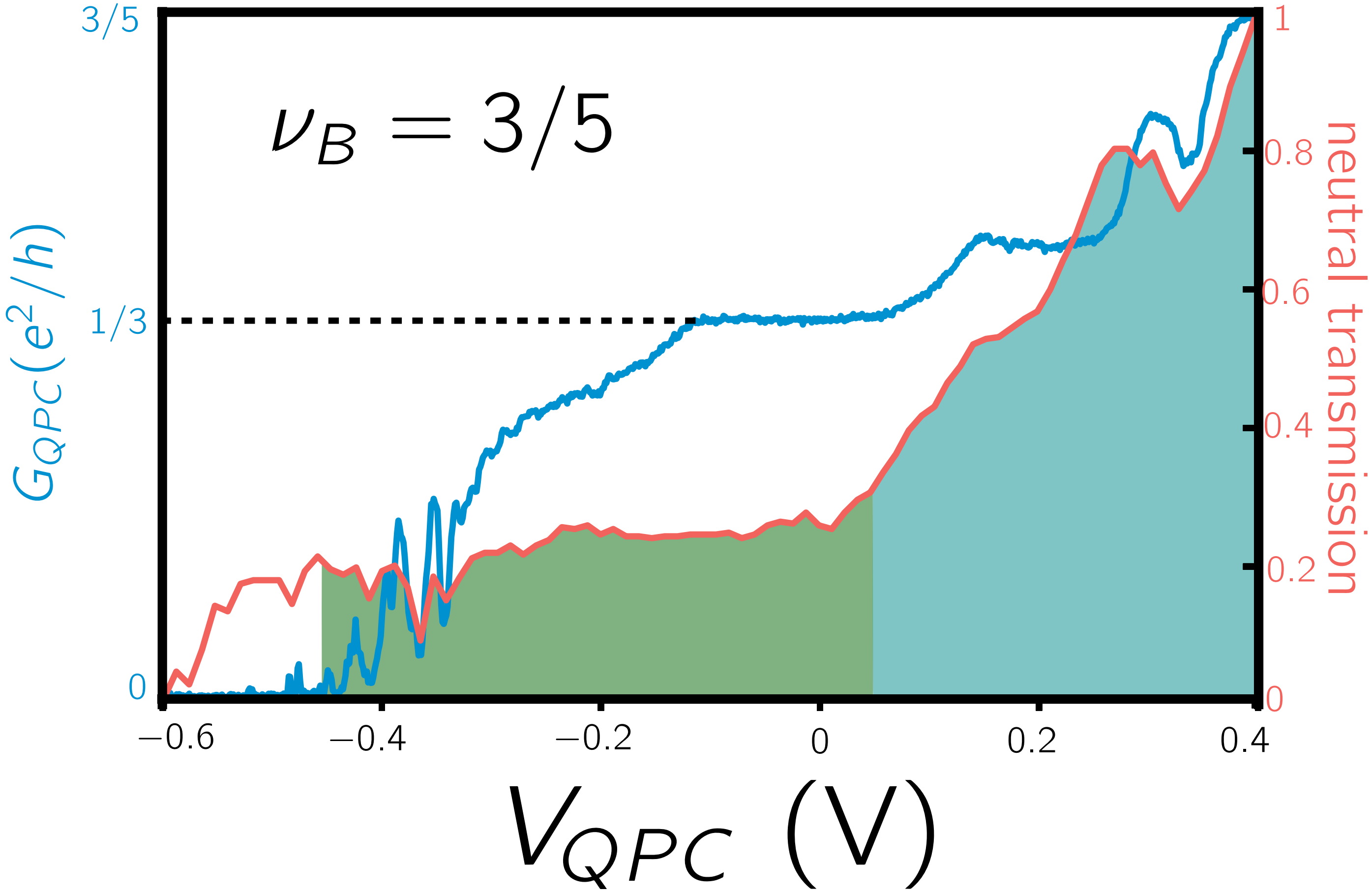
The neutral transmission drops on the plateau

A reminiscent signal is present after the QPC closing

Neutral transmission $\nu = 3/5$

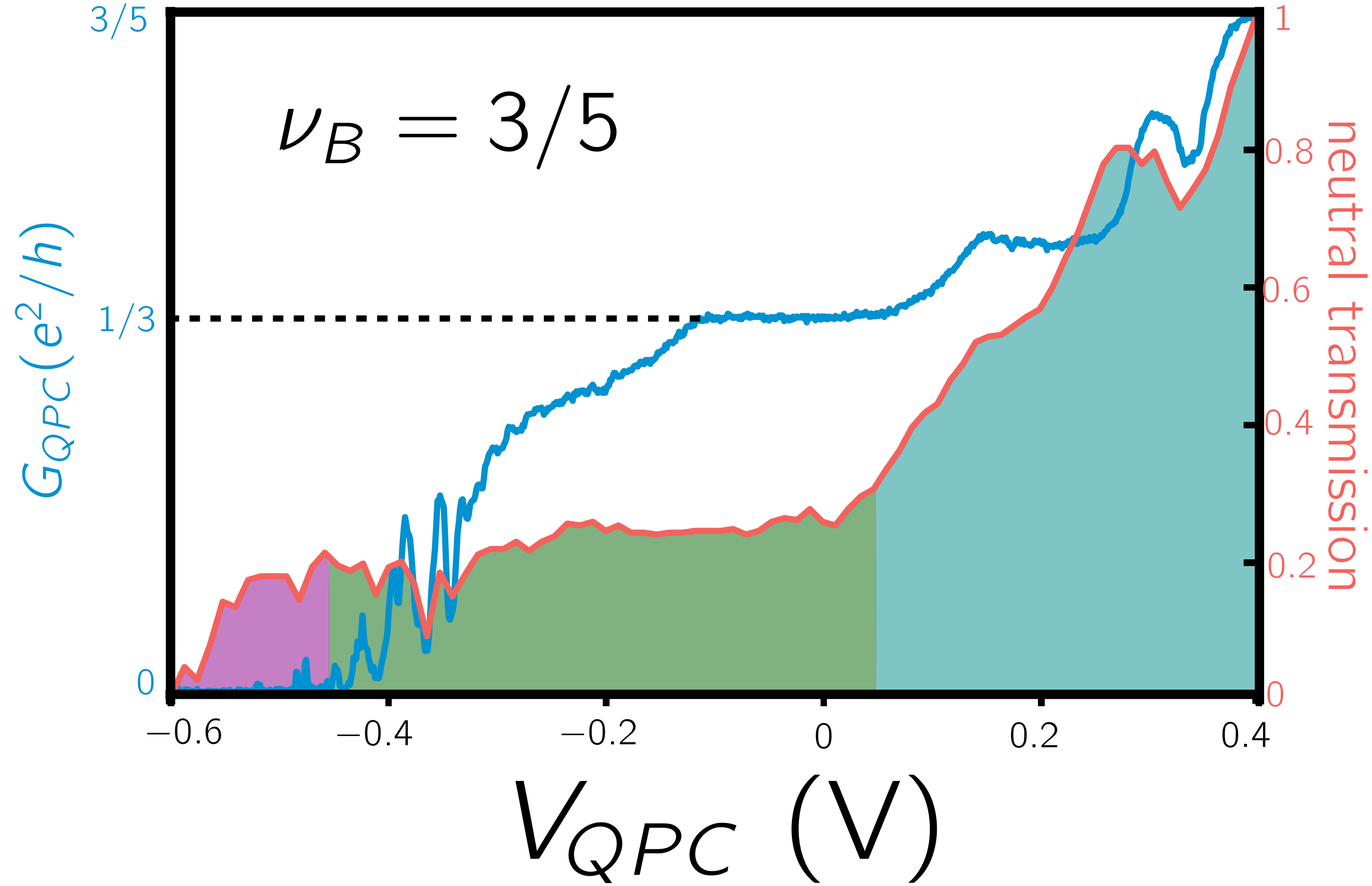


Neutral transmission $\nu = 3/5$



Most of the neutral signal is attached to the inner edge

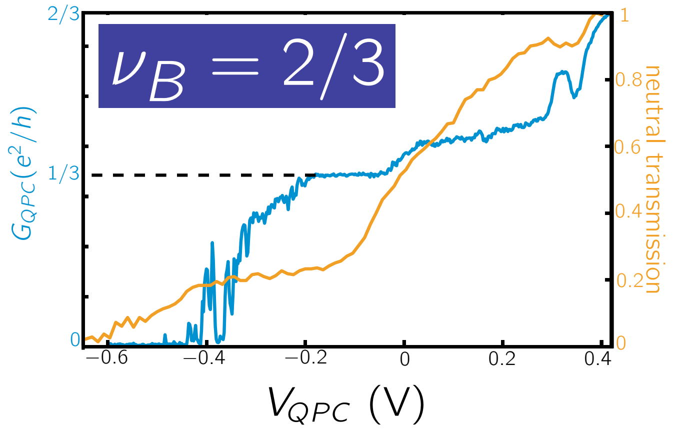
Neutral transmission $\nu = 3/5$

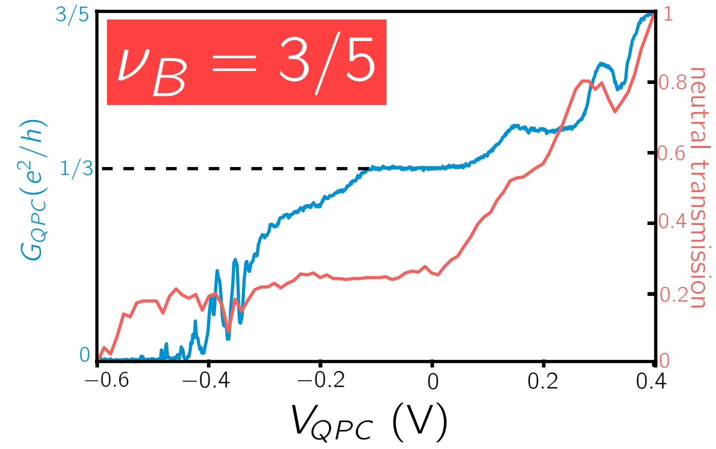


Most of the neutral signal is attached to the inner edge

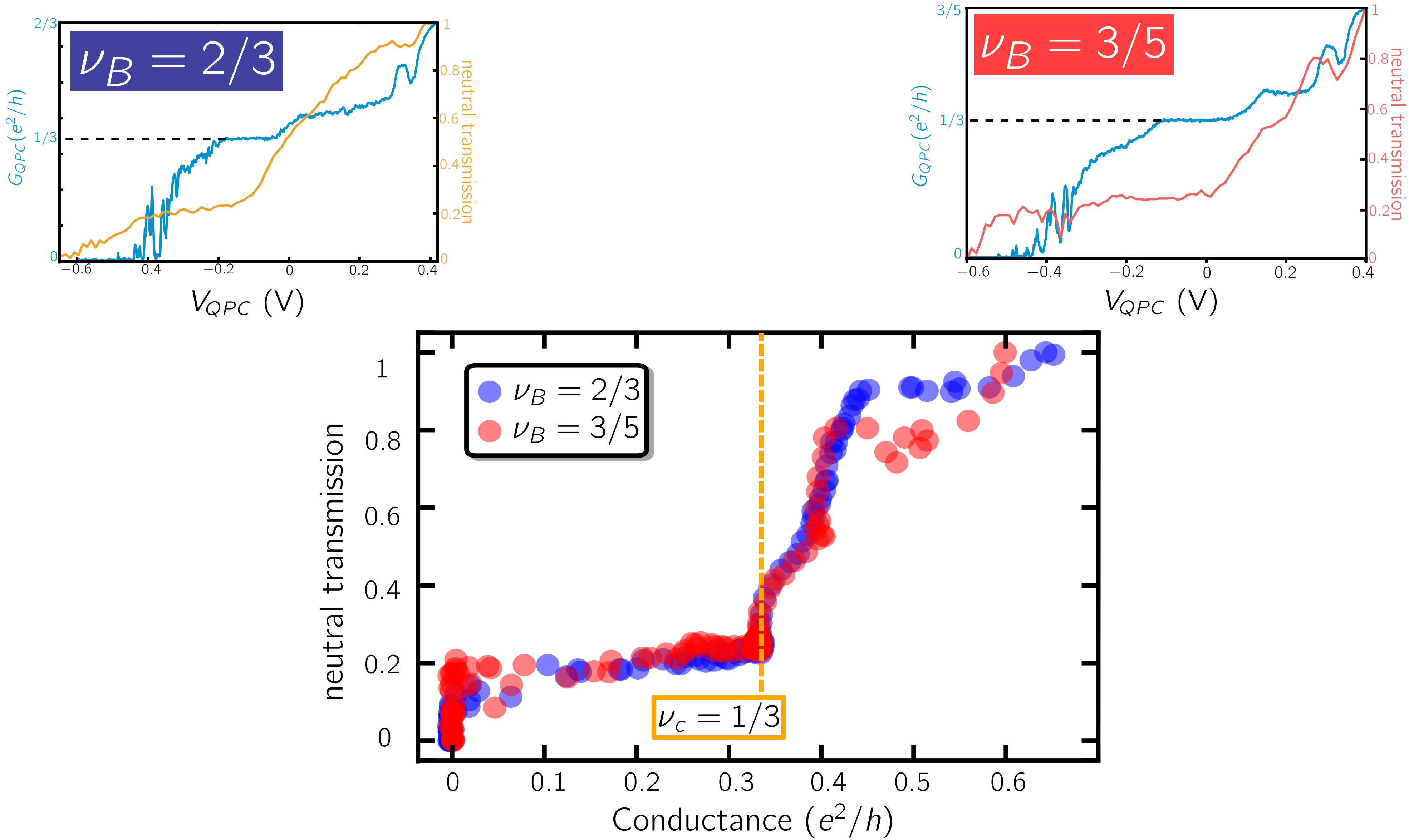
The reminiscent signal is still present for $\nu = 3/5$

Neutral transmission vs G_{QPC}

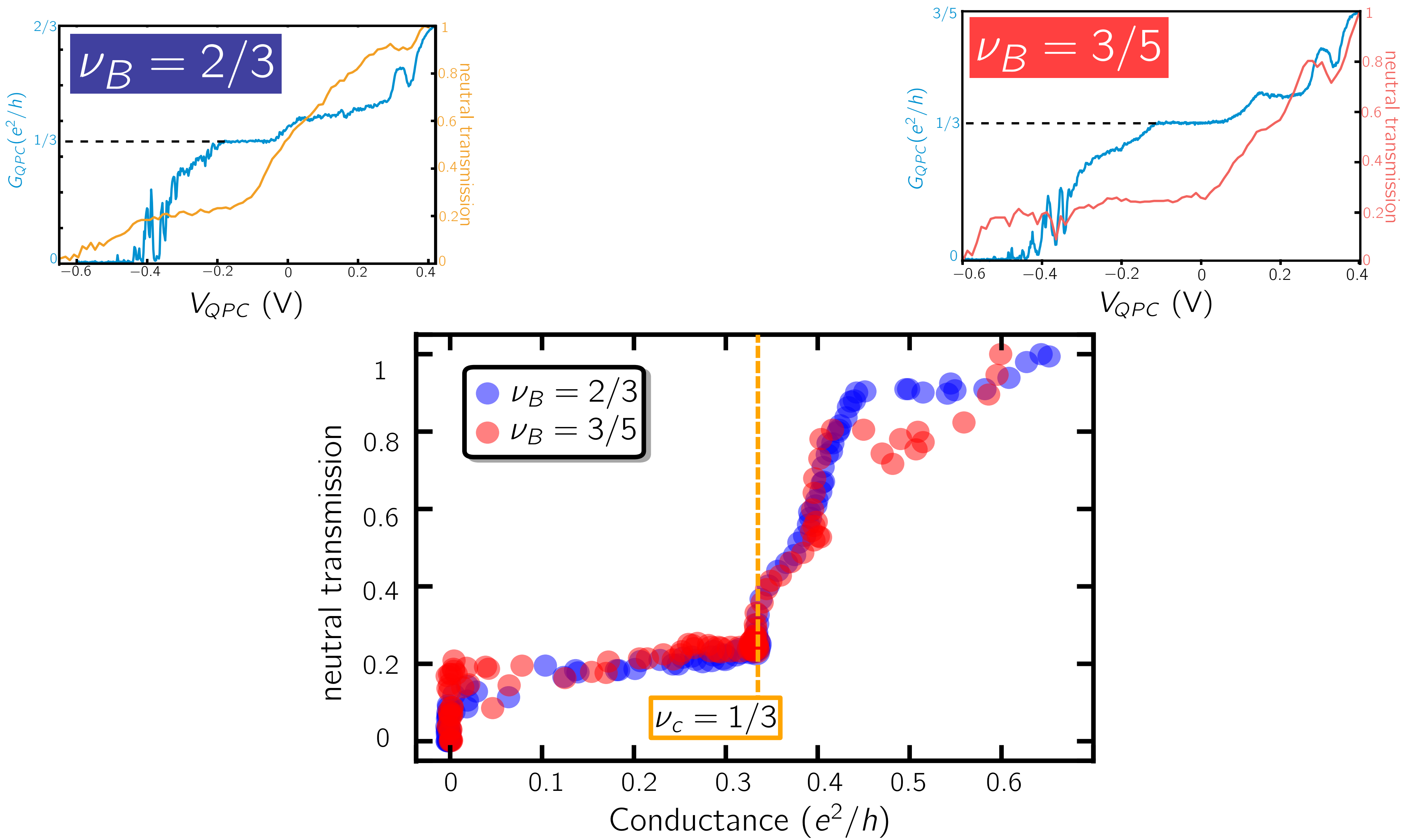




Neutral transmission vs G_{QPC}

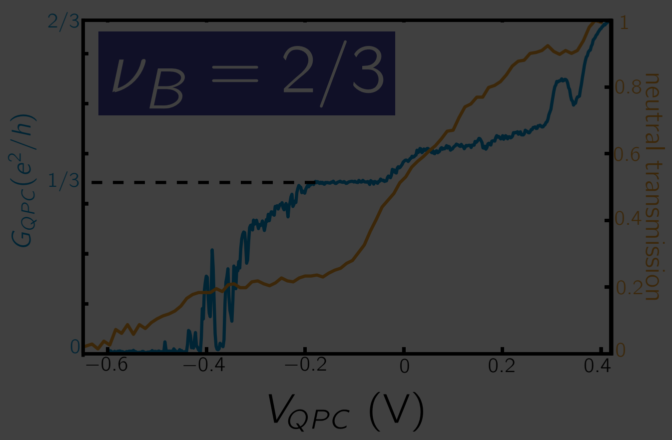


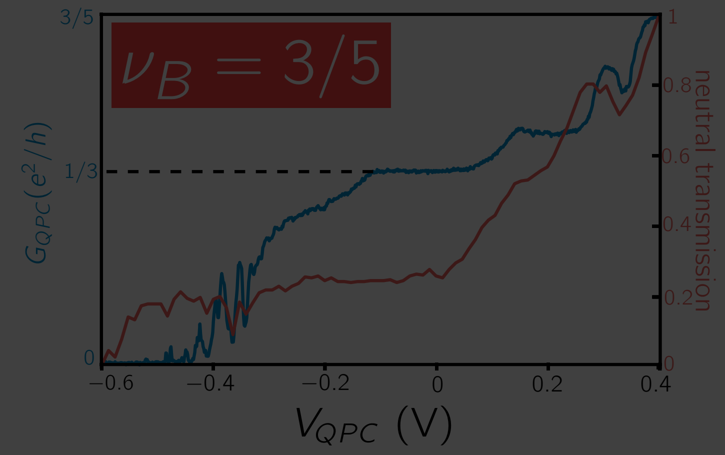
Neutral transmission vs G_{QPC}

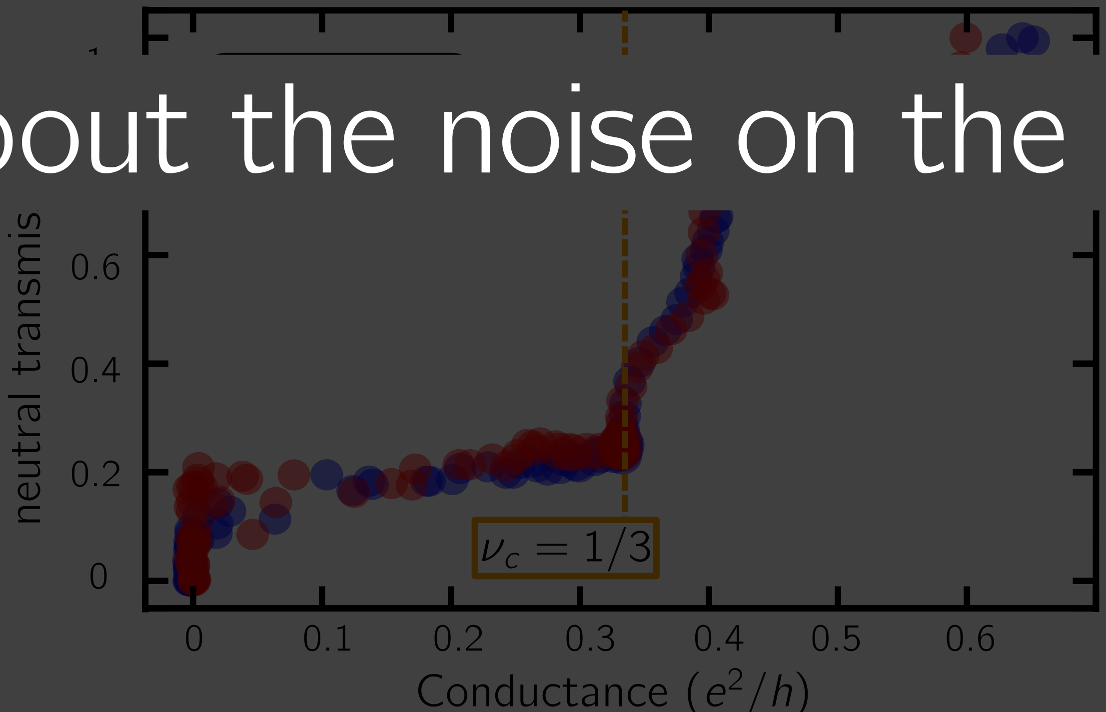


The neutral transmission is dictated by the conductance at the QPC constriction

Neutral transmission vs G_{QPC}



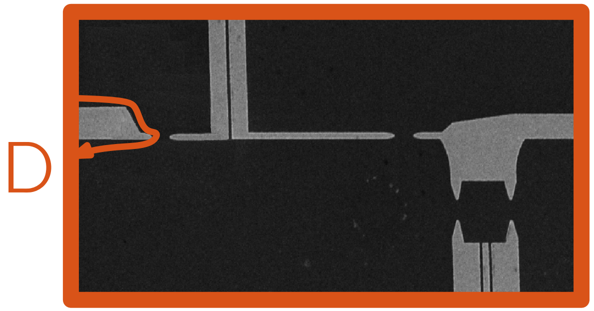


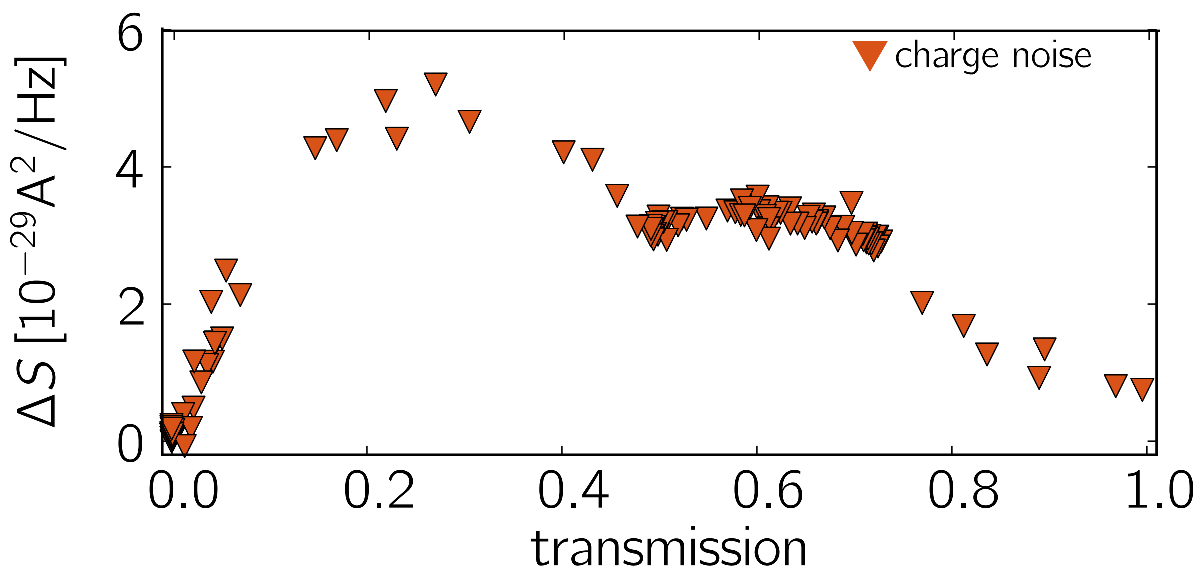


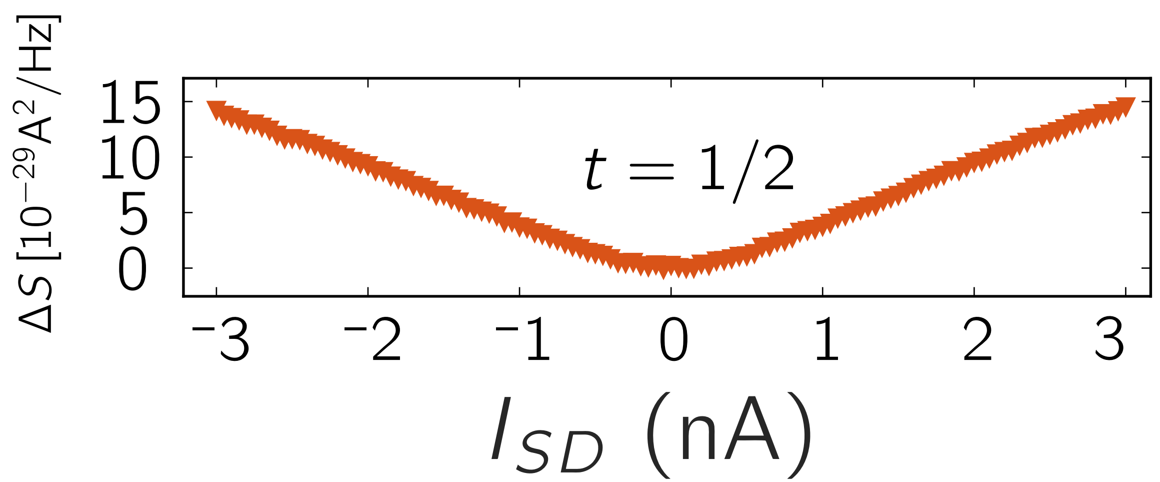
What about the noise on the plateau?

The neutral transmission is dictated by the conductance at the QPC constriction

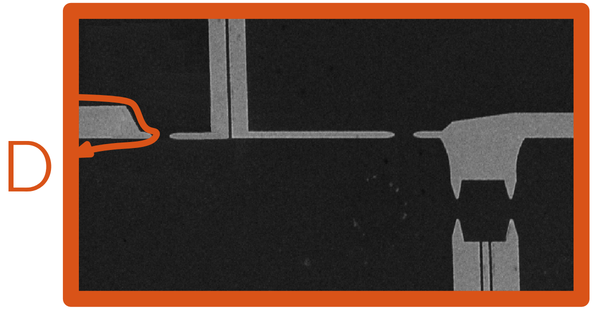
Noise measurements

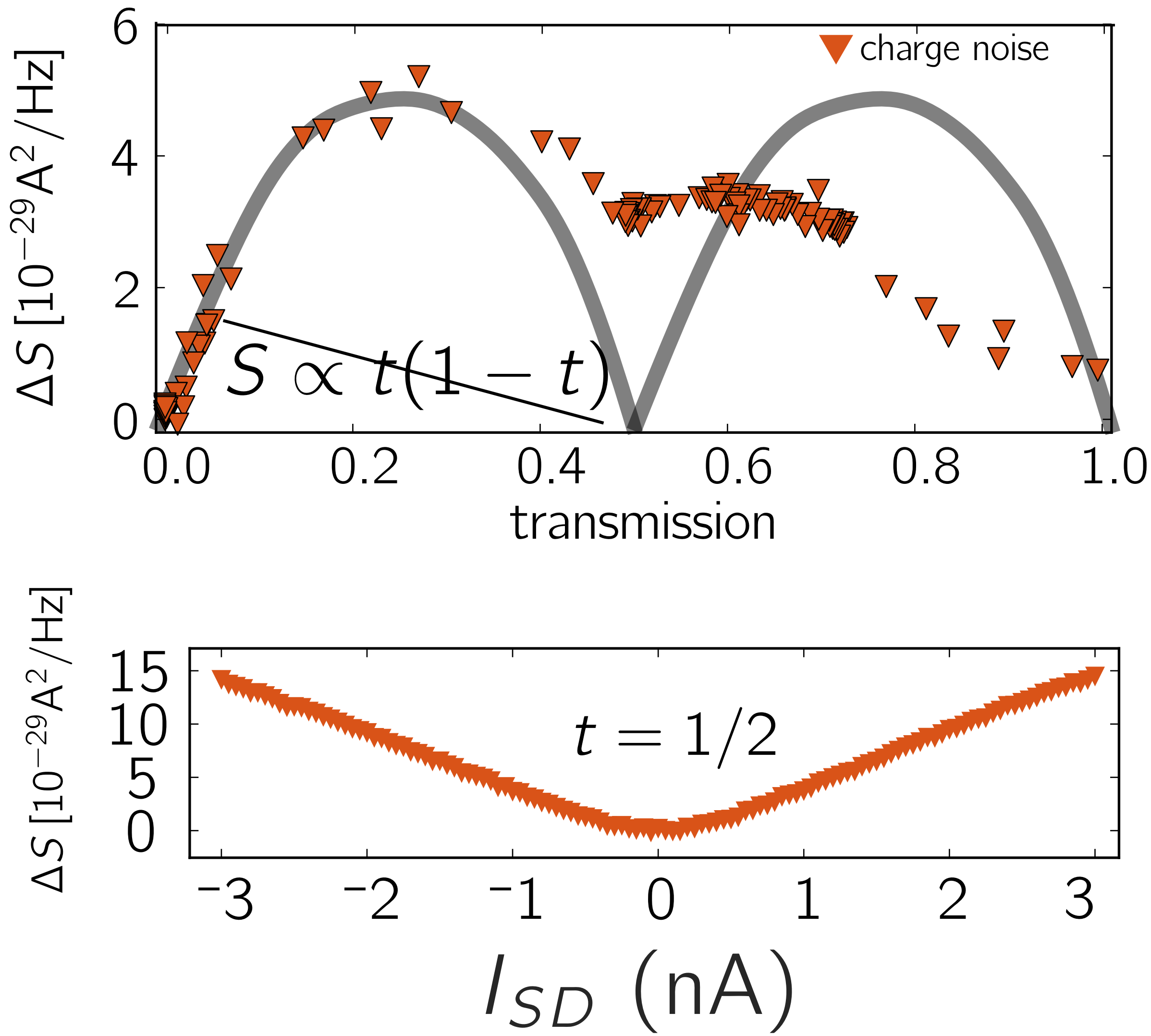




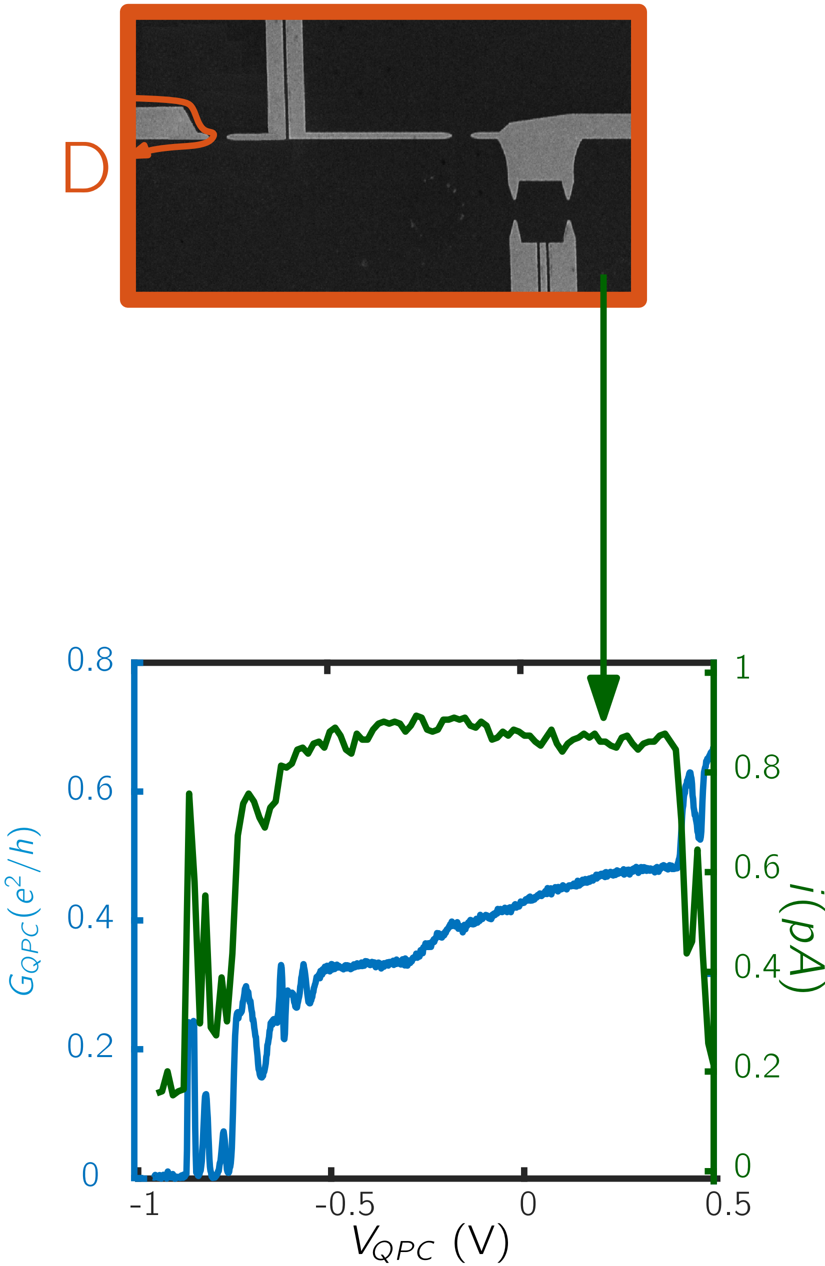


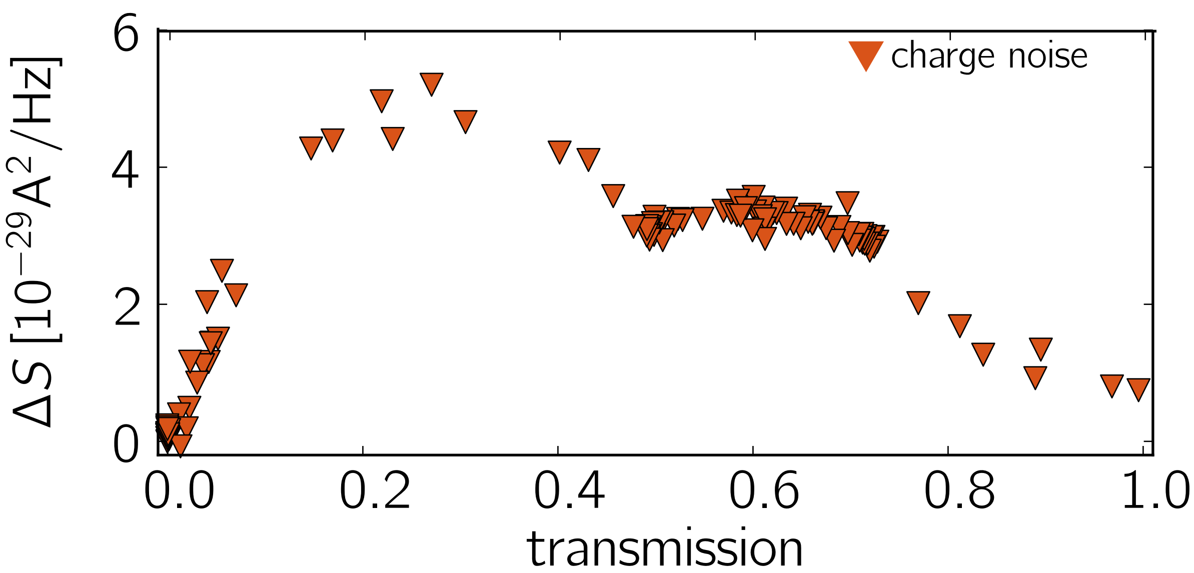
Noise measurements

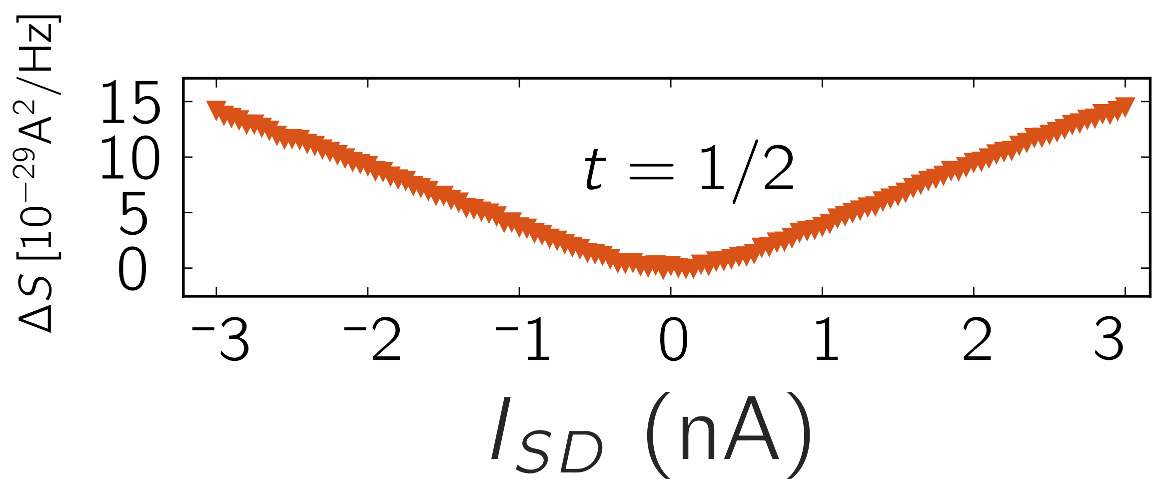




Noise measurements

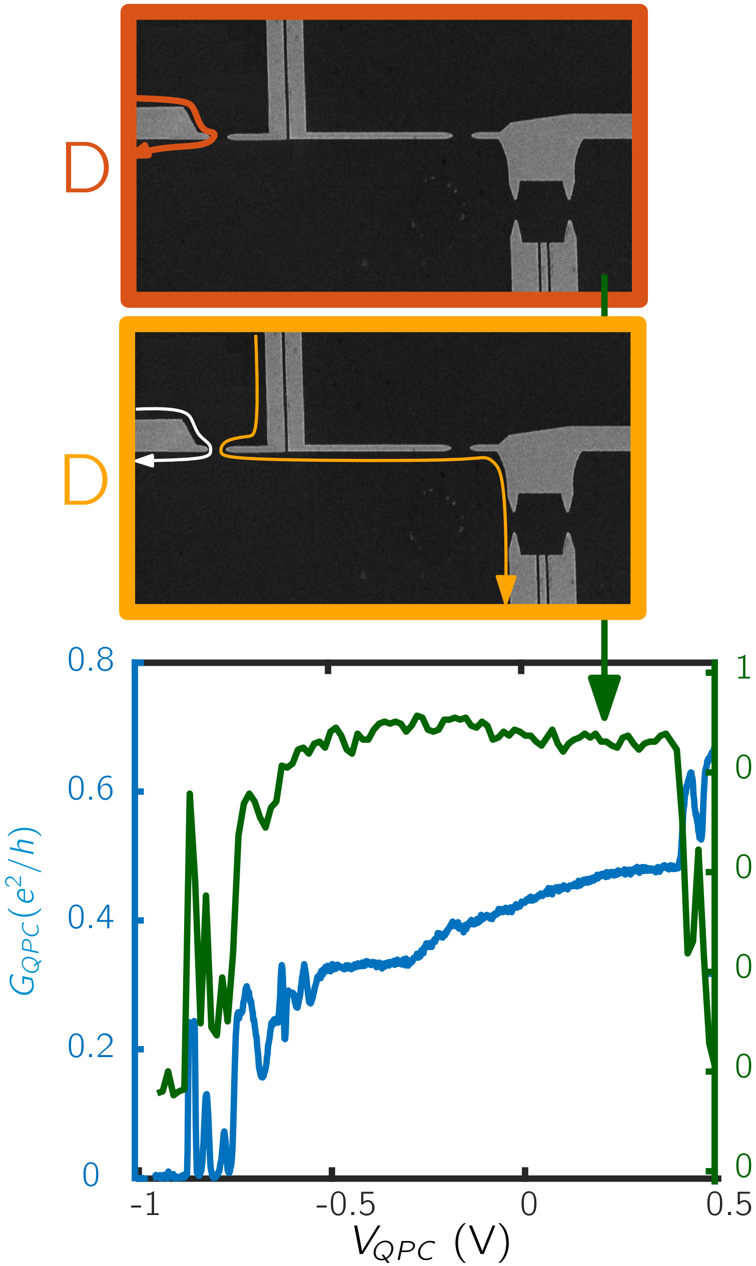


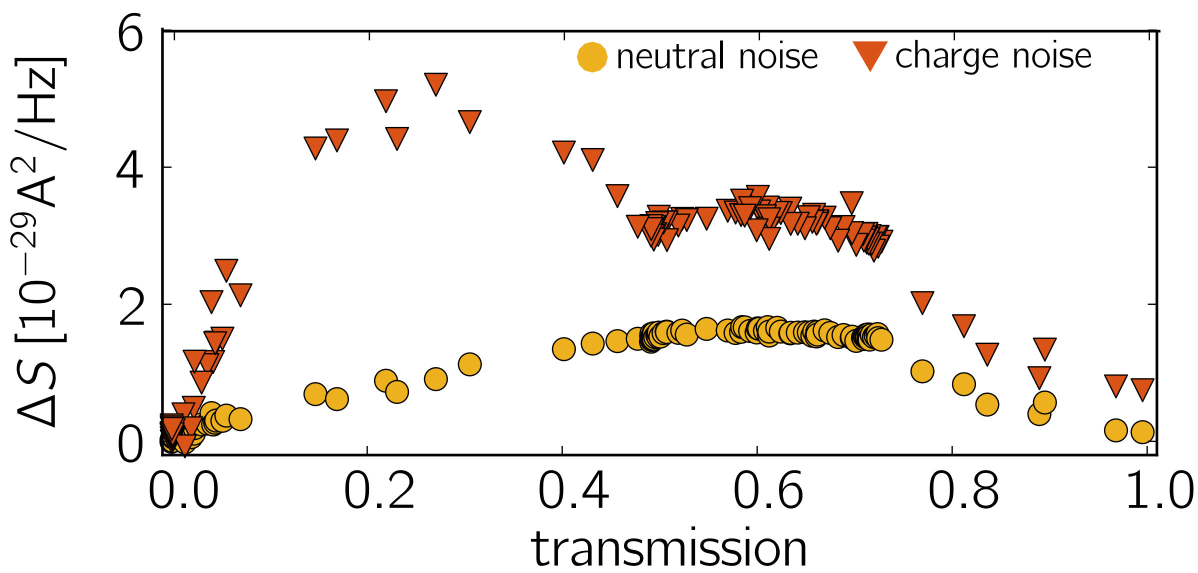


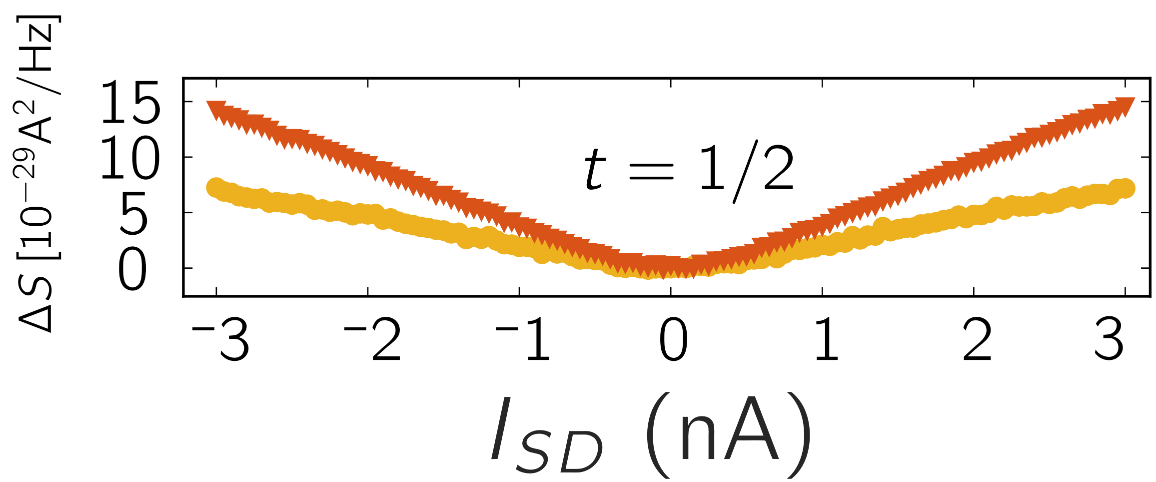


Current through the dot when sourcing from charge source

Noise measurements

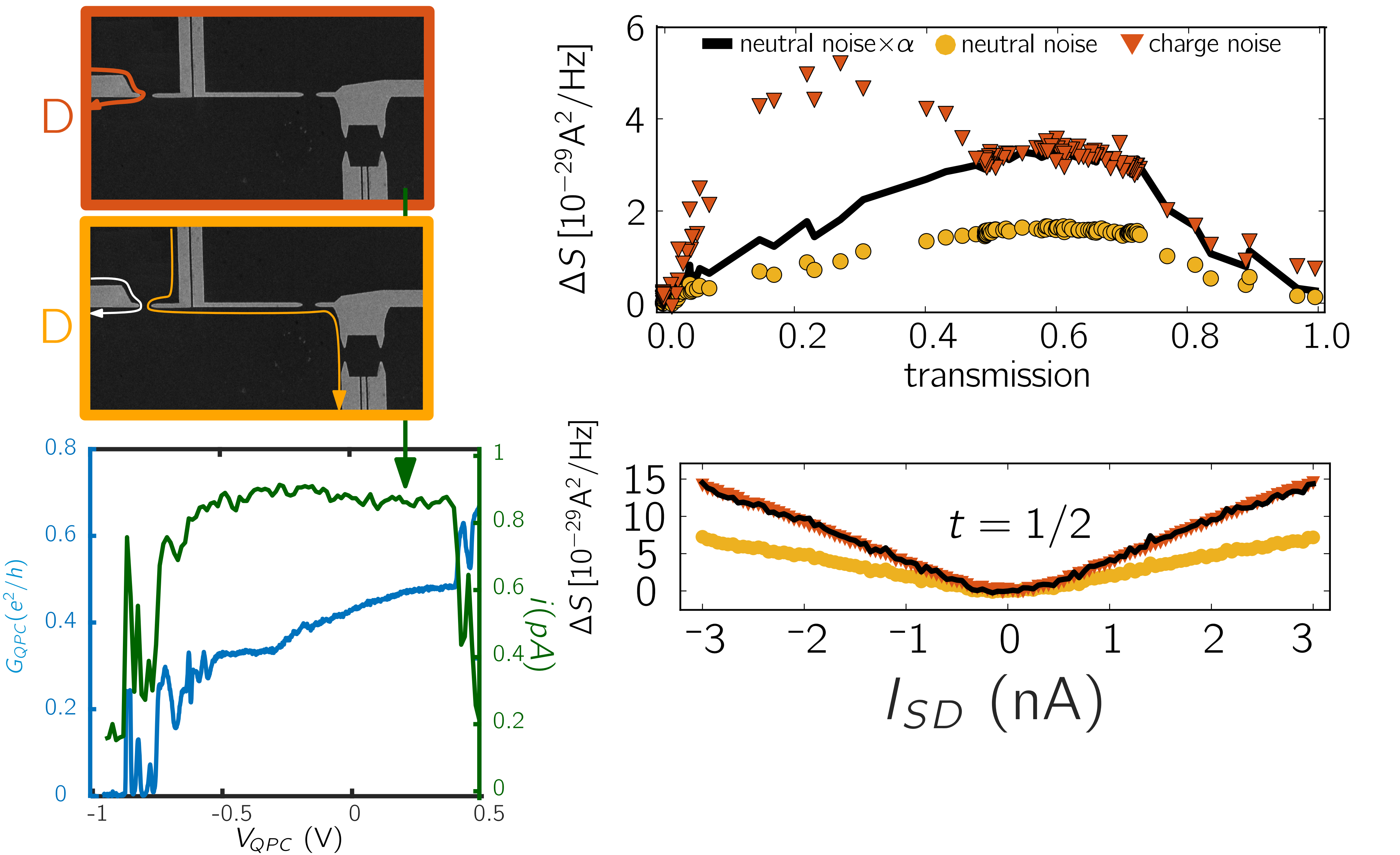






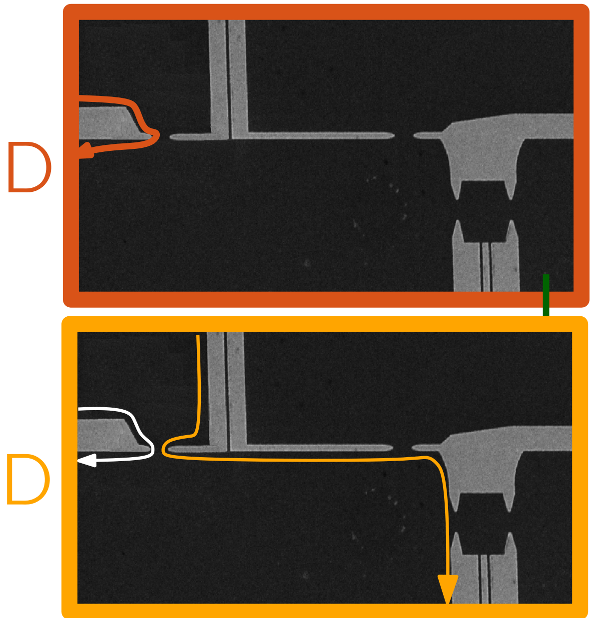
Current through the dot when sourcing from charge source

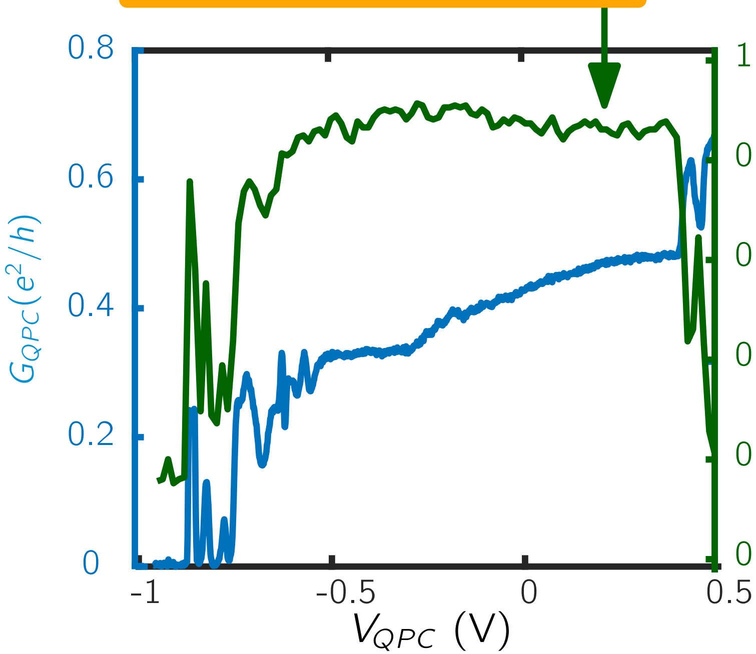
Noise measurements



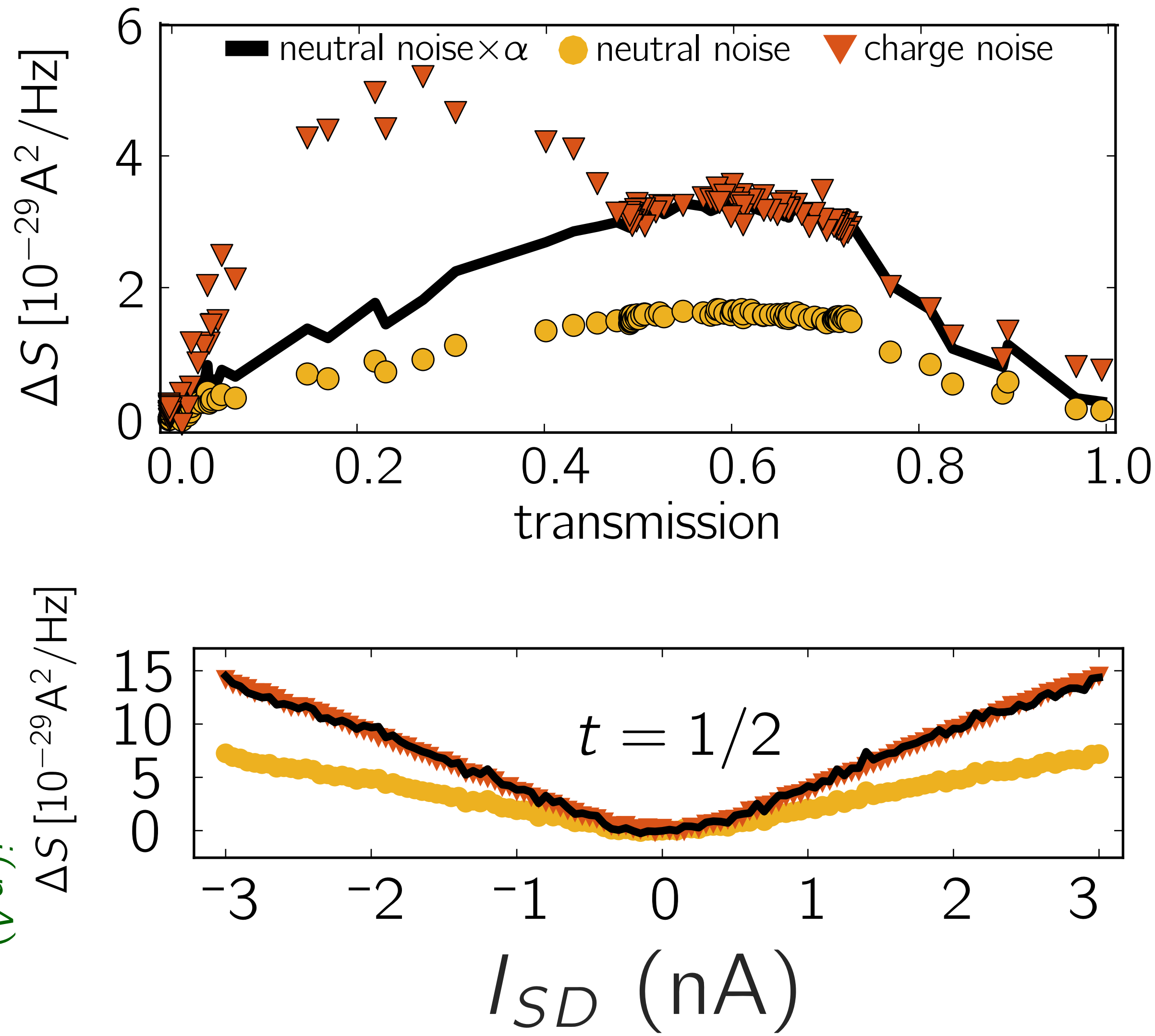
Current through the dot when sourcing from charge source

Noise measurements



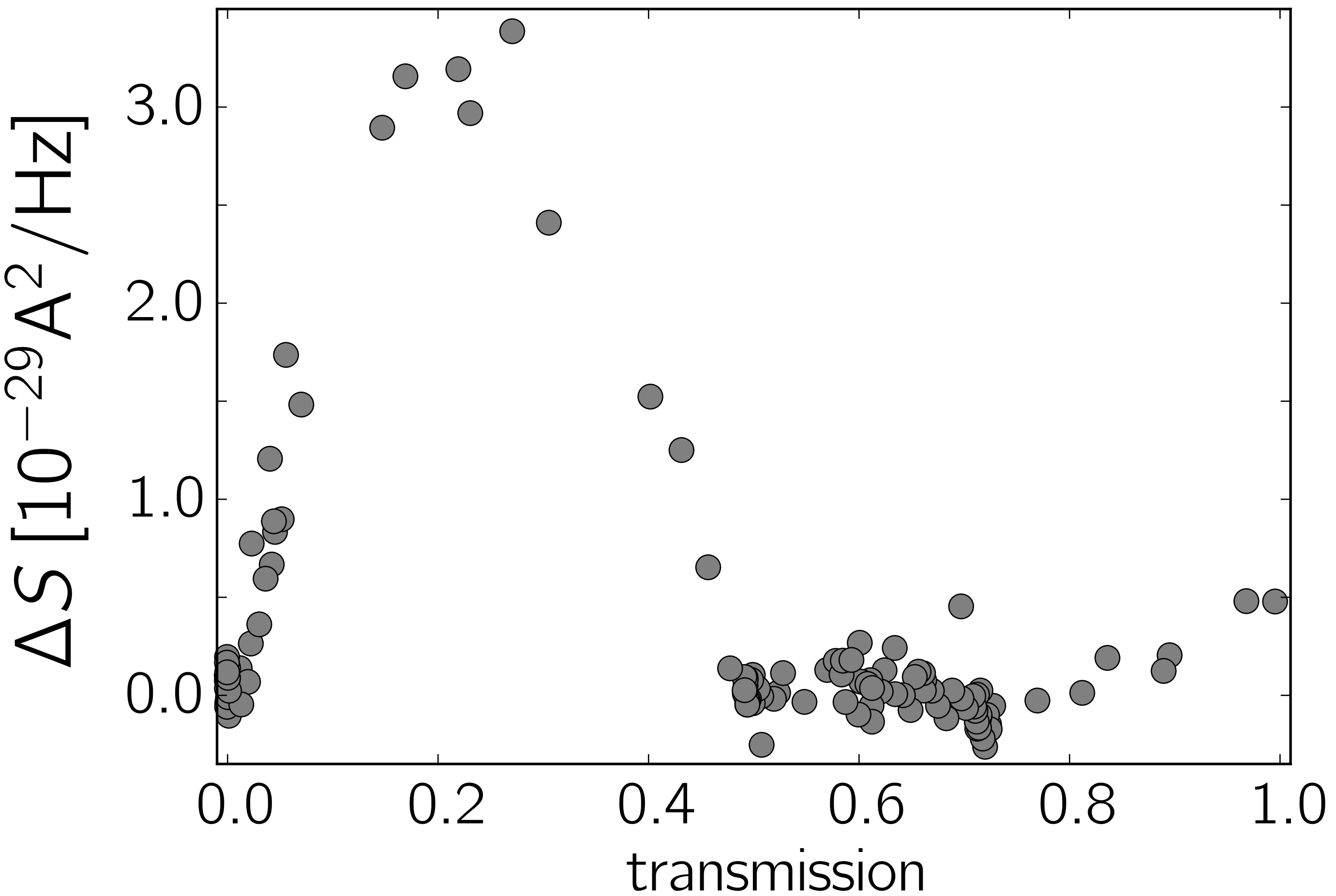


Current through the dot when sourcing from charge source



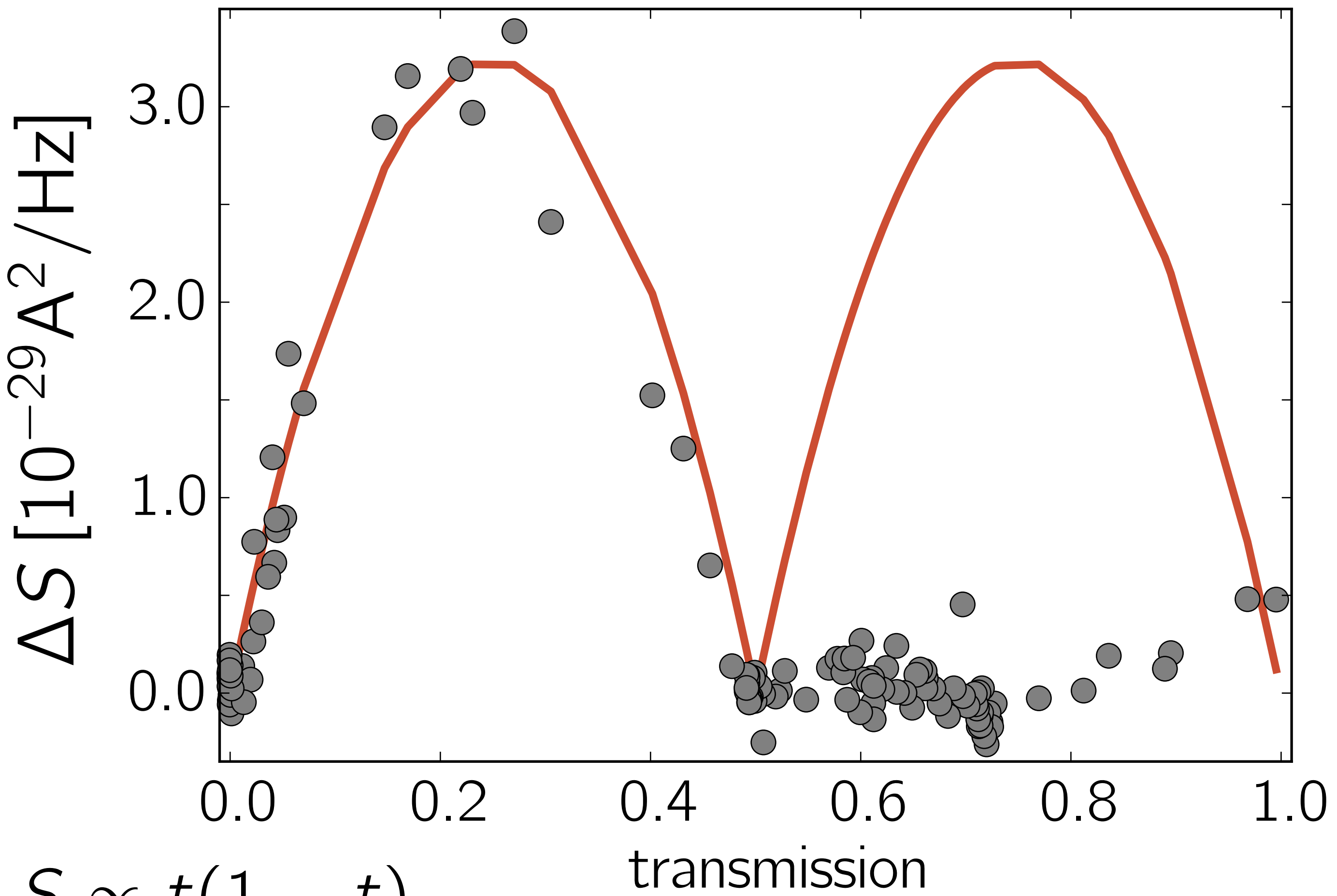
Substraction of this noise

Noise measurements



The outer channel follows the usual shot noise behavior

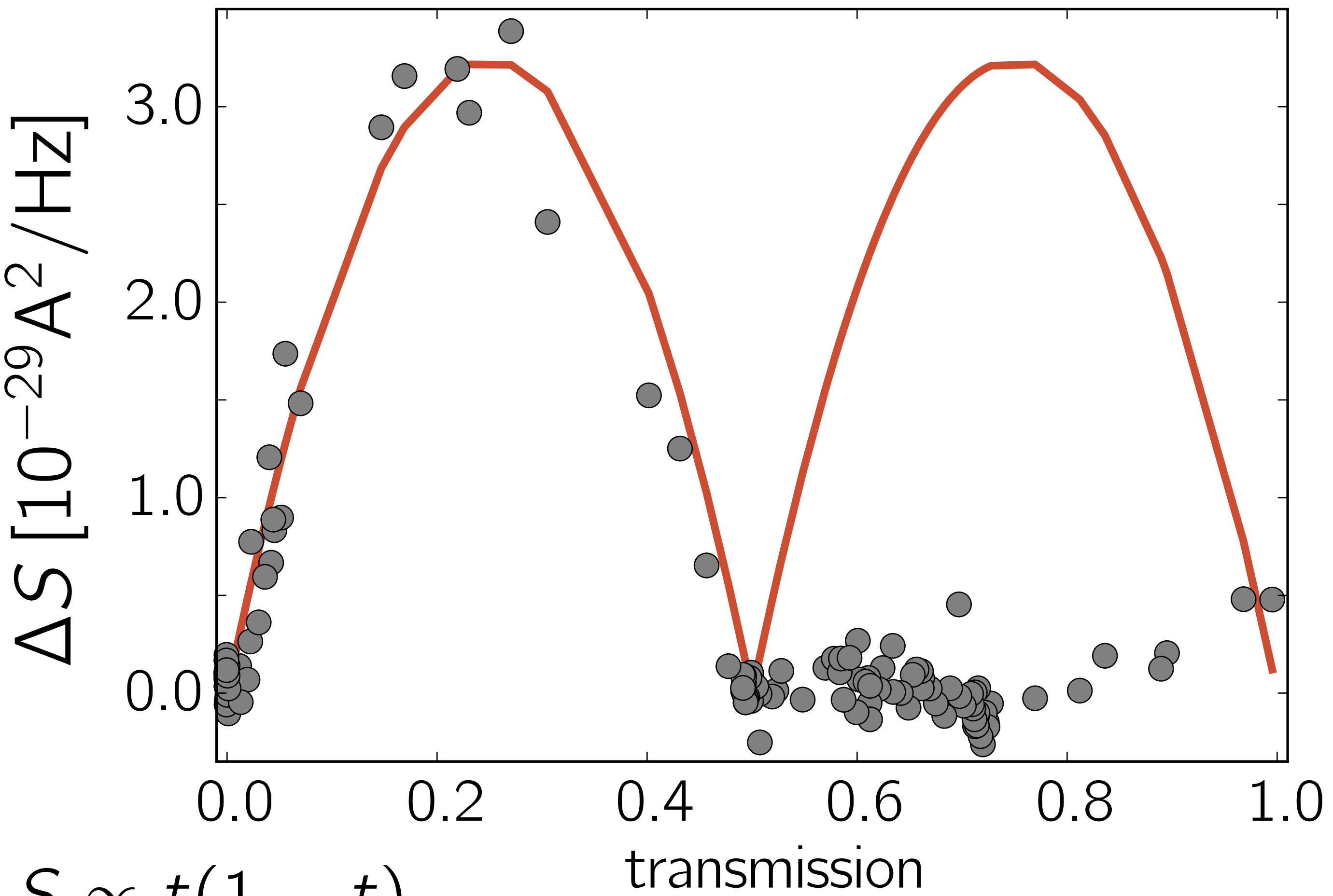
Noise measurements



$S \propto t(1-t)$

The outer channel follows the usual shot noise behavior

Noise measurements



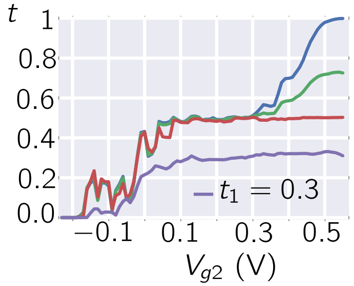
$S \propto t(1-t)$

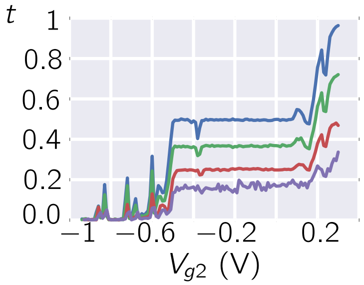
The outer channel follows the usual shot noise behavior

The inner channel appears shot noiseless...

Summary and perspectives

- $\nu = 2/3$ and $\nu = 3/5$ are composed of two independent charge channels





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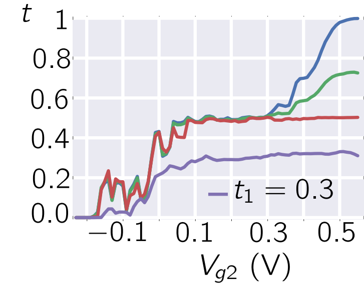
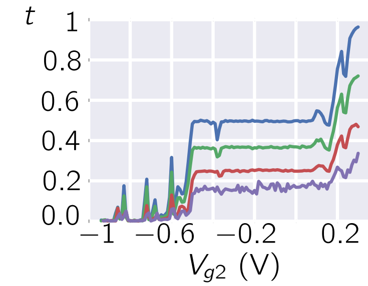
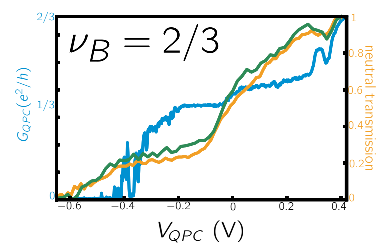
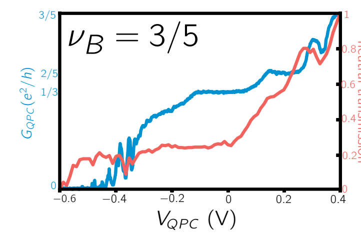




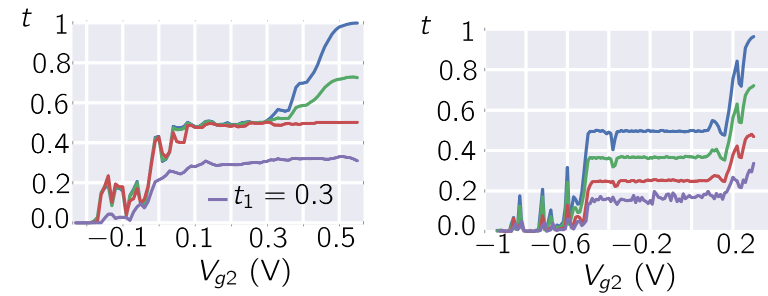
- Measurement of the transmission of neutral modes at $\nu = 2/3$ and $\nu = 3/5$



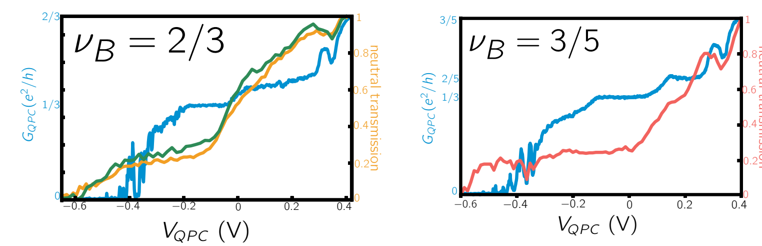


Summary and perspectives

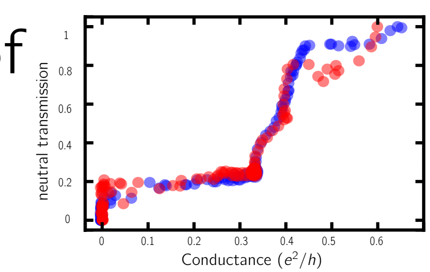
- $\nu = 2/3$ and $\nu = 3/5$ are composed of two independent charge channels



- Measurement of the transmission of neutral modes at $\nu = 2/3$ and $\nu = 3/5$

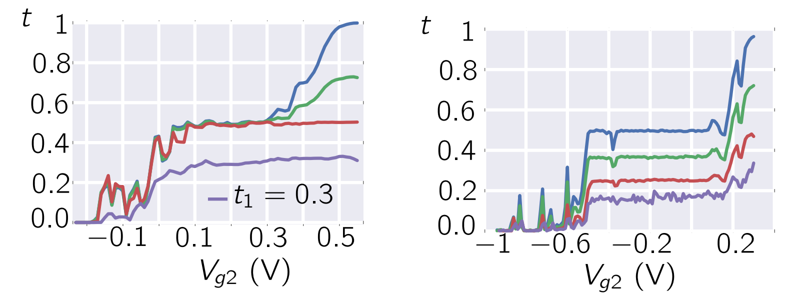


- The neutral mode transmission is governed by the FF of the QPC
  - Can help theoretical developments



Summary and perspectives

- $\nu = 2/3$ and $\nu = 3/5$ are composed of two independent charge channels



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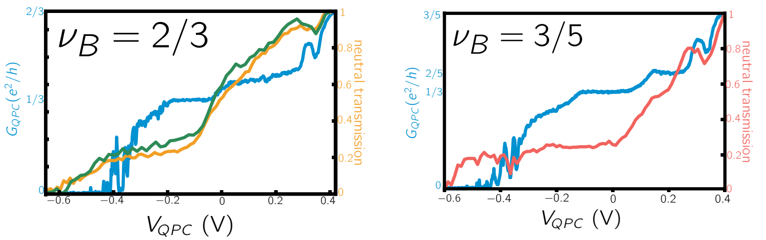

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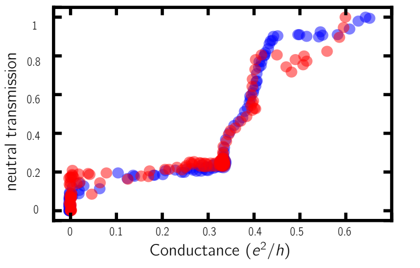
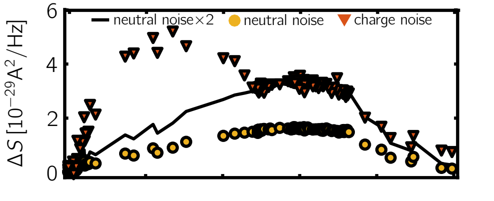


- Noise measurement reveals that the noise on the plateau at $\nu = 2/3$ can have thermal origin.



Thank you very much

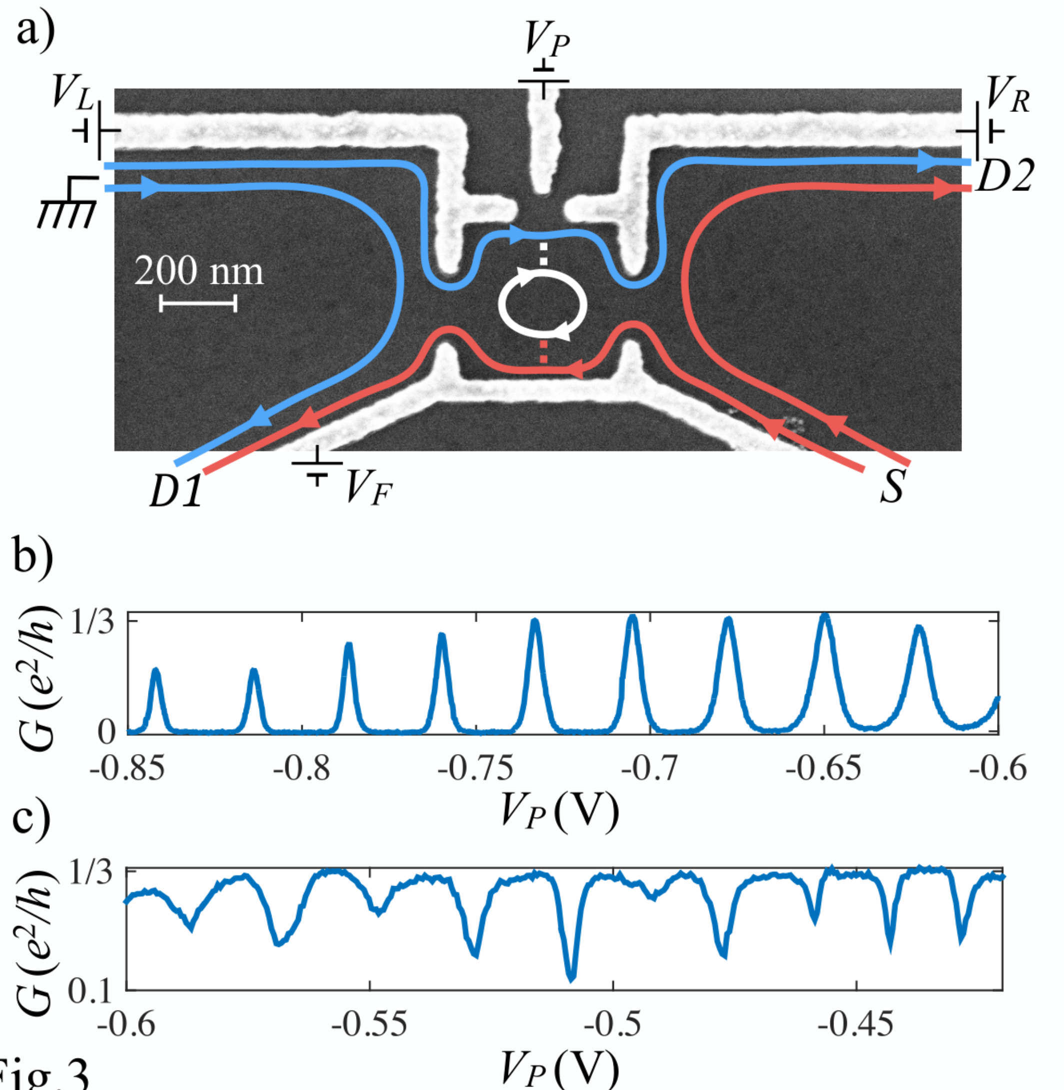
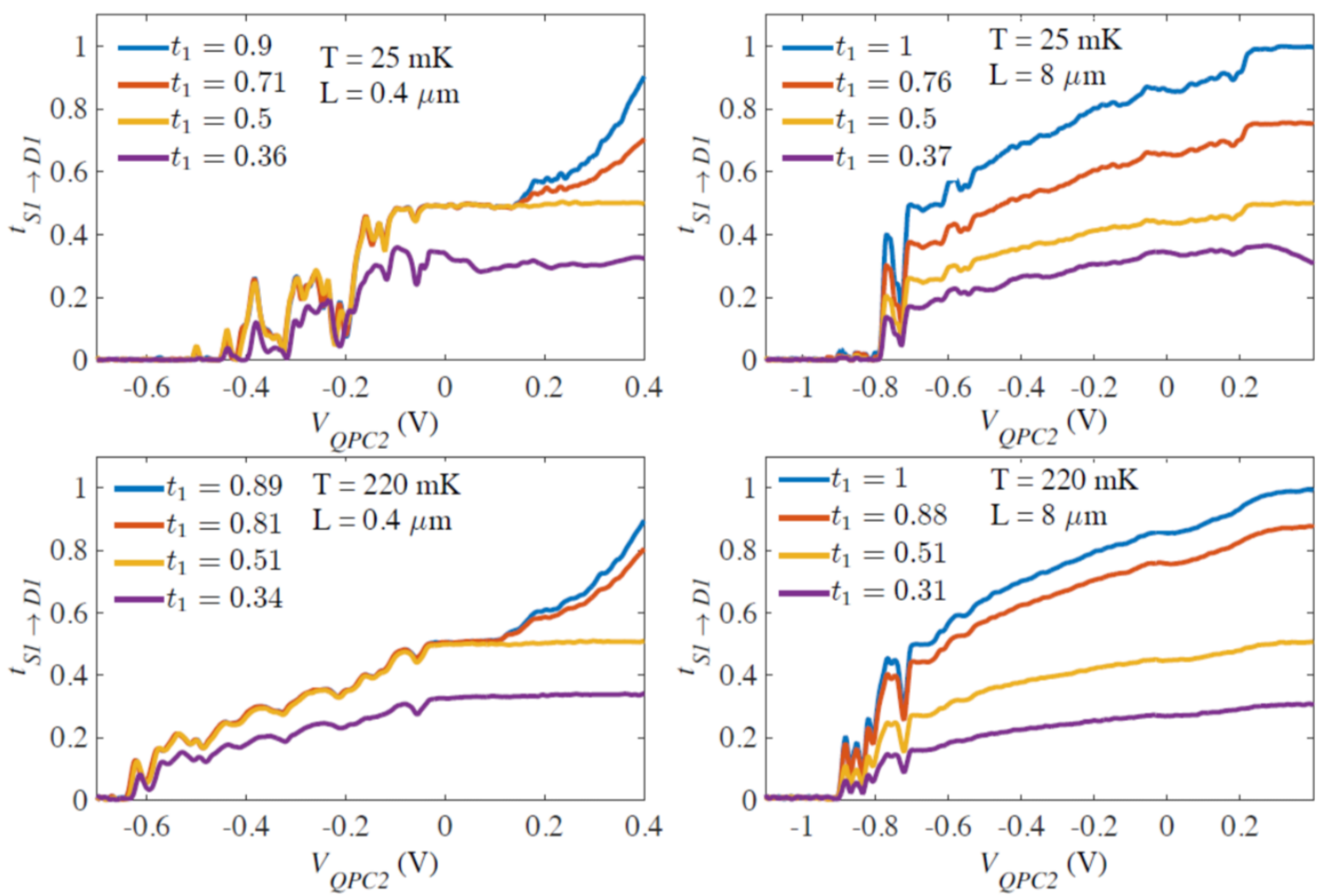

a)
V_P
V_L
V_R
D2
200 nm
D1
V_F
S
b)
$G\,(e^2/h)$
1/3
0
-0.85
-0.8
-0.75
-0.7
-0.65
-0.6
V_P (V)
c)
$G\,(e^2/h)$
1/3
0.1
-0.6
-0.55
-0.5
-0.45
V_P (V)

Fig.3



$t_1 = 0.9$
$t_1 = 0.71$
$t_1 = 0.5$
$t_1 = 0.36$
T = 25 mK
L = 0.4 μm
$t_{S1 \to D1}$
V_{QPC2} (V)
$t_1 = 1$
$t_1 = 0.76$
$t_1 = 0.5$
$t_1 = 0.37$
T = 25 mK
L = 8 μm
$t_1 = 0.89$
$t_1 = 0.81$
$t_1 = 0.51$
$t_1 = 0.34$
T = 220 mK
L = 0.4 μm
$t_1 = 1$
$t_1 = 0.88$
$t_1 = 0.51$
$t_1 = 0.31$
T = 220 mK
L = 8 μm