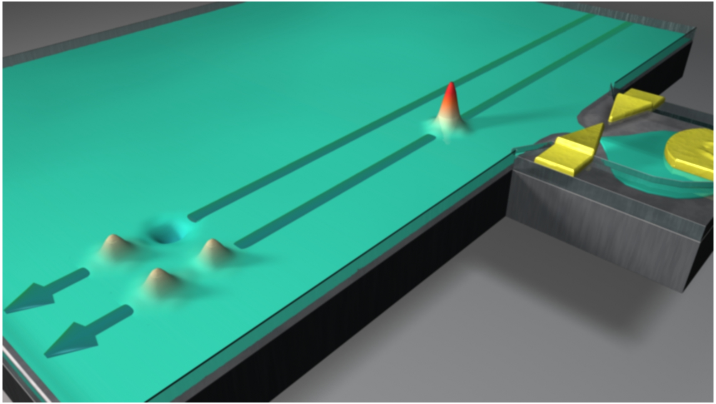
Electron quantum optics
The waveguides
Single electron sources
Comparison with quantum optics
Some example of Wigner functions

Electron quantum optics



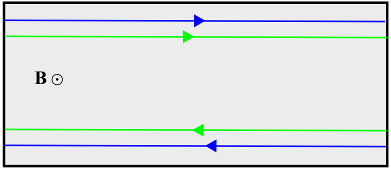
Reviews:

E. Bocquillon *et al*, Ann. Phys.-Berlin **526**, 1 (2014)

A. Marguerite *et al*, Phys. Status Solidi B **254**, 1600618 (2017)

Propagation and manipulation of electron

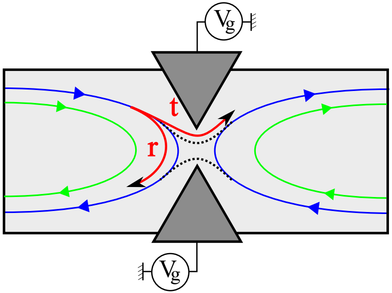
- 2D electron gas (AsGa/AsGaAl junction) with high free mean path (up to 20 μm at low temperature)
- High intensity magnetic field + low temperature: quantum Hall effect and edge channels.



K. von Klitzing *et al*, Phys. Rev. Lett. **45**, 494 (1980)
B. Halperin, Phys. Rev. B **25**, 2185-2190 (1982)

Propagation and manipulation of electron

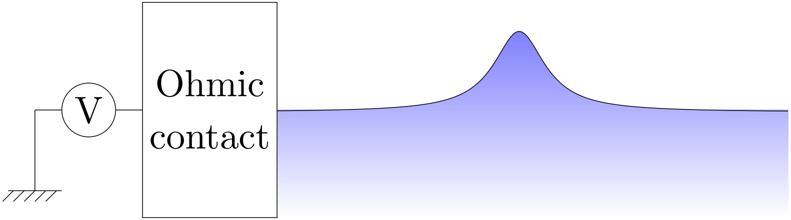
- 2D electron gas (AsGa/AsGaAl junction)
  with high free mean path (up to 20 µm at low temperature)
- High intensity magnetic field + low temperature:
  quantum Hall effect and edge channels.
- Metallic gates on top of the gas: Quantum Point Contact (QPC)



B. J. van Wees *et al*, Phys. Rev. Lett. **60**, 848850 (1988)

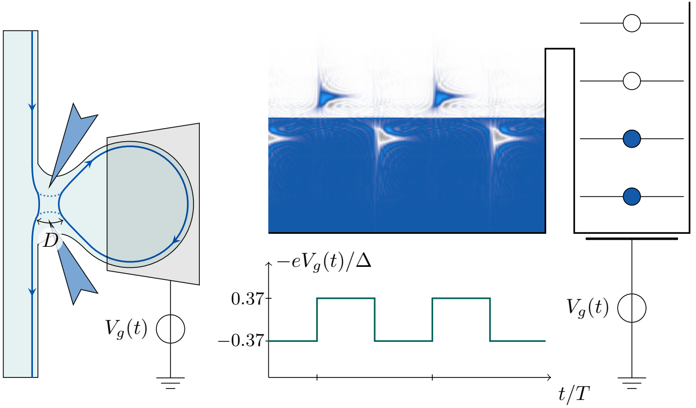
Single electron sources: time resolved

Time-resolved source, with a Lorentzian voltage pulse (Leviton)



L. Levitov *et al*, J. Math. Phys. **37** (1996)
J. Dubois *et al*, Nature **502** (2013)

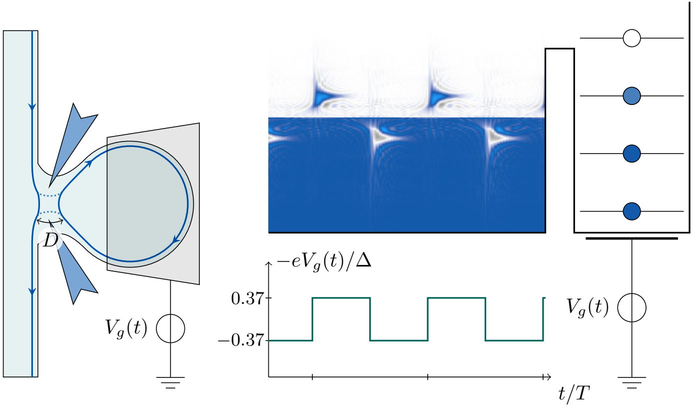
Energy-resolved source (Quantum dot)



G. Fève *et al*, Science **316** (2007)

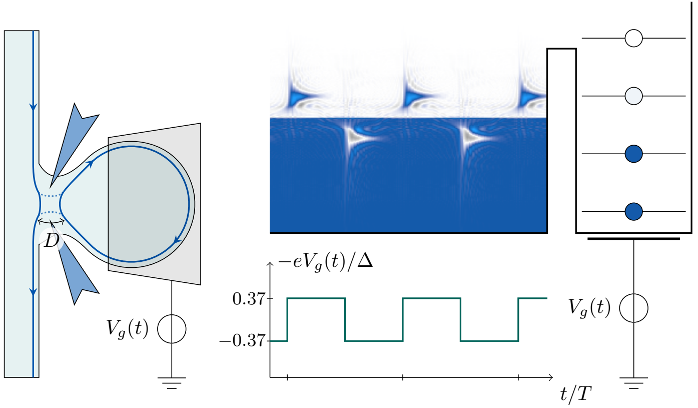
Single electron sources: energy resolved

Energy-resolved source (Quantum dot)



G. Fève *et al*, Science **316** (2007)

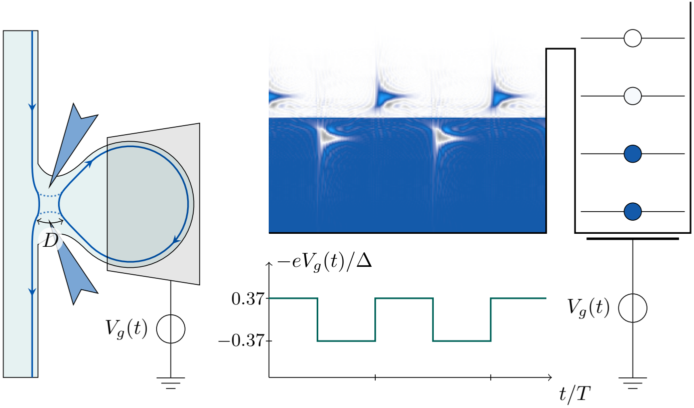
Energy-resolved source (Quantum dot)



G. Fève *et al*, Science **316** (2007)

Single electron sources: energy resolved

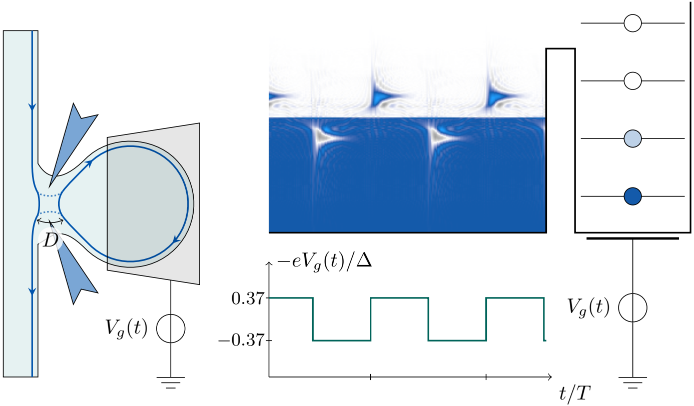
Energy-resolved source (Quantum dot)



G. Fève *et al*, Science **316** (2007)

Single electron sources: energy resolved

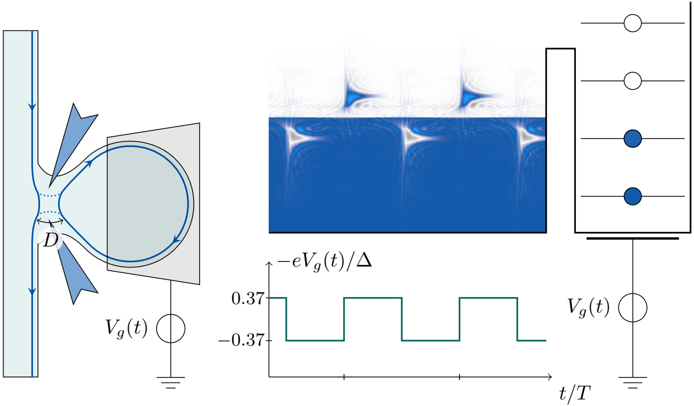
Energy-resolved source (Quantum dot)



G. Fève *et al*, Science **316** (2007)

Single electron sources: energy resolved

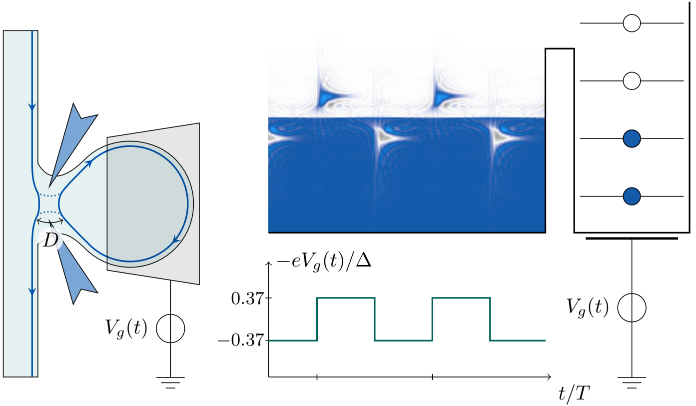
Energy-resolved source (Quantum dot)



G. Fève *et al*, Science **316** (2007)

Single electron sources: energy resolved

Energy-resolved source (Quantum dot)



G. Fève *et al*, Science **316** (2007)

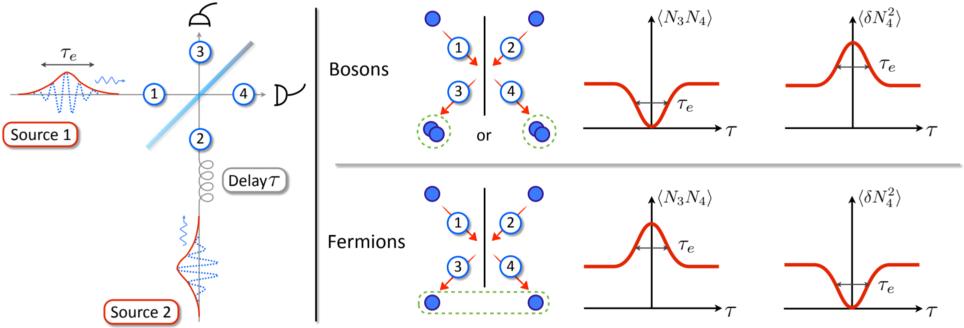
Similarities and differences

	Optics	**Electronics**
Similarities	Optical fiber	Quantum Hall edge channels
	Beamsplitter	Quantum point contact
	Photonic source	Single electron source
Differences	Bosons	Fermions
	True vacuum	Fermi sea
	No interaction	Coulomb interaction

Coulomb interaction will lead to decoherence and relaxation in electronic systems.

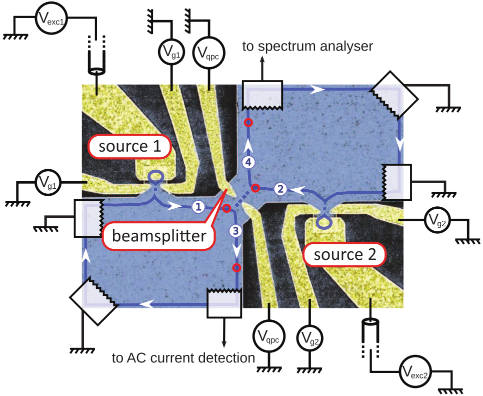
Hong-Ou-Mandel experiment

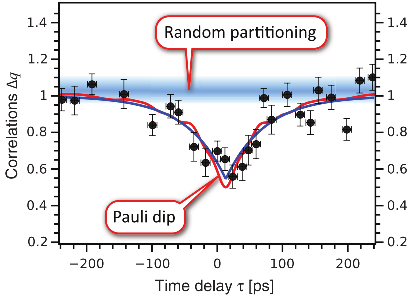
A good way to see the difference in statistics.



C. K. Hong, Z. Y. Ou & L. Mandel Phys. Rev. Lett. **59** 2044–2046 (1987)

HOM results



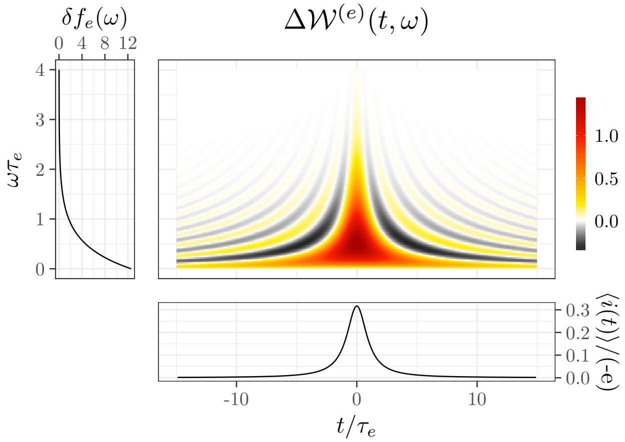


E. Bocquillon *et al*, Science **339** (2013)

Indirect proof of decoherence through contrast reduction.

Coherences produced by the sources: Leviton

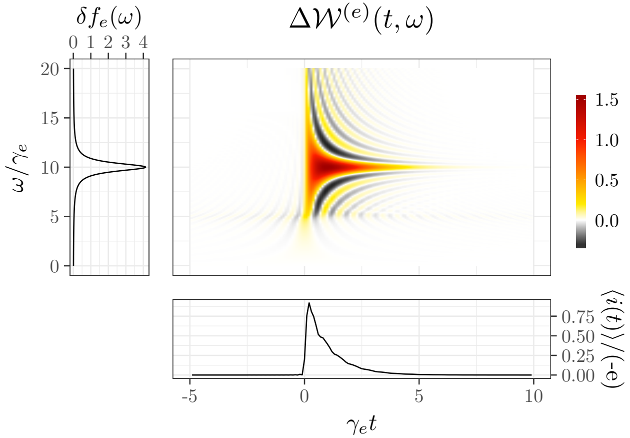
Lorentzian voltage pulse



J. Dubois *et al*, Nature **502** (2013).

Coherences produced by the sources: Quantum dot

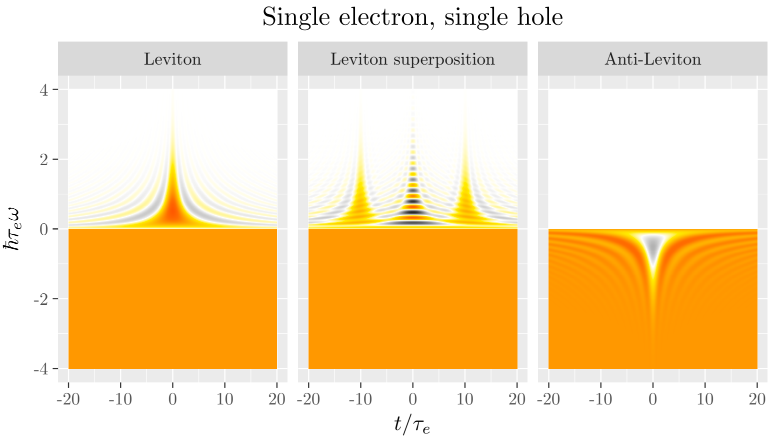
Using the quantum dot to create an energy resolved electron ($\omega_e\gamma_e = 10$)



G. Fève *et al*, Science **316** (2007)

Coherence from wavefunctions

Basic excitations: single electron or single hole



Basic excitations:
e/h pair and superposition of e/h pair and Fermi sea