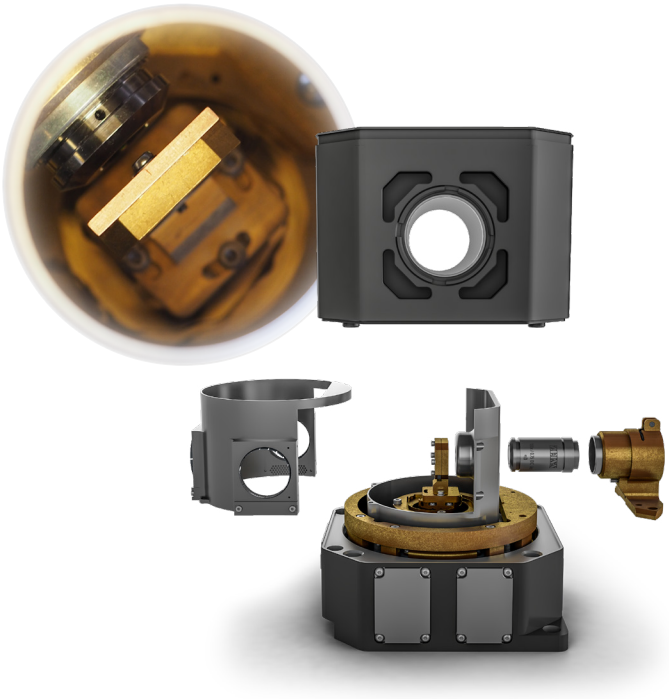
SPARK Integration

MONTANA INSTRUMENTS®
COLD SCIENCE MADE SIMPLE

Single-Photon Application Research Kit

Sparrow Quantum

A complete, integrated single-photon source to enable quantum research



KEY FEATURES:

- User friendly, commercially available single-photon source
- Reduce laboratory start-up time to experiment, no fabrication required
- Pure single-photon emission (>90%)
- Integrated Cryo-Optic® solution improves single-photon collection efficiency and chip performance
- Optimized output coupling with high NA optics
- Robust operation in wide temperature range (<15 K)

The world's first commercial single photon chip meets the industry leading closed-cycle optical cryostat.

The new SPARROW single-photon source is based on self-assembled InAs quantum dots coupled to a slow-light photonic-crystal waveguide made using a unique processing technology. The proven performance of the Cryostation provides the ideal environment for the chip to operate.

Single-Photon Chip

Each end of the single-photon source structure is coupled to precisely engineered suspended nano-beam waveguides and out-coupling gratings. The increased coupling efficiency from the quantum dot to the waveguide relies on the strong suppression of radiation modes together with an enhanced coupling into the waveguide mode. This makes it very robust to spatial and spectral dispersity meaning that the quantum dots are efficiently coupled.

Cryostation® + Cryo-Optic®

The Cryostation s100 provides an automated and controlled cryogenic envirnment for quantum research applications. The robust and compact tabletop design integrates into any lab, ensuring a simple and flexible setup.

The Cryo-Optic add-on provides an integrated high NA (0.75) objective for undetectable optical drift. The horizontal design simplifies experimental setup.

Applications

- Multi-photon generation
- Single-photon nonlinear optics and quantum gates
- Chiral quantum optics
- Fundamental quantum optics
- Photonic quantum networks

Focus on your core research. Access state-of-the art single photon source develpments with Sparrow Quantum.

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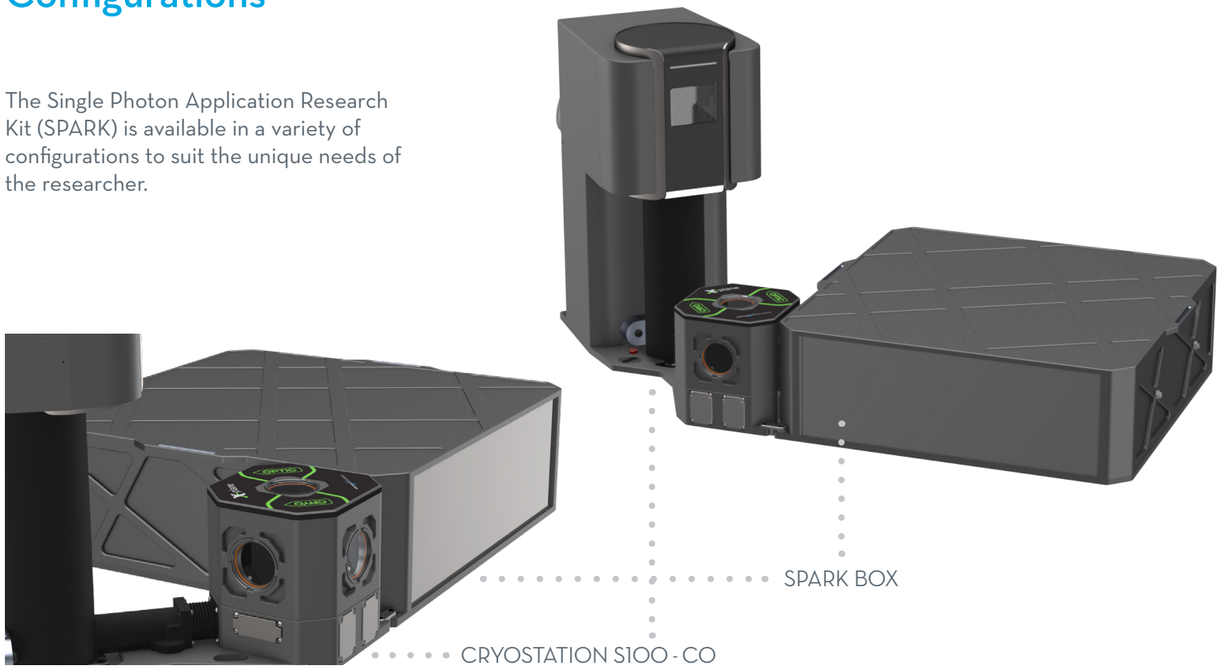
Configurations

The Single Photon Application Research Kit (SPARK) is available in a variety of configurations to suit the unique needs of the researcher.



	Basic	Source	Source + Analyzer
Cryostat w/ Objective	**Montana Instruments	Cryostation s100 Cryo-Optic** = Helium-free 3.7K – 350K optical cryostat system: cryostat with five optical ports; variable flow helium compressor; control unit with vacuum pump, power supplies, & temperature control electronics; user interface computer = Sample mount elements: integrated open loop XYZ nano-positioners and controller with modules, flex link, & sample mount for chip = Objective integration: internally mounted room temperature vacuum compatible Zeiss 100X, 0.75NA, 4mm working distance objective		
Single-Photon Chip	**Sparrow Quantum	Single-Photon Chip** = Advanced planar nanophotonic chip		
Enclosed Optical Breadboard	Optional (empty)	**Montana Instruments	SPARK Box** = 450mm x 450mm x 100mm optical breadboard with fully enclosed side housing & removable lid = Direct "light tight" interface to sample chamber. = Electrical control connectors (power, grating, & camera) & two fiber ports on side panels (excitation & output)	
Additional Components		**Camera + Lightsource** – for alignment & inspection **Optical Filter** [incl. control software] – for background suppression	
			Dual Detector Setup [incl. control software] – for HBT correlations with Si-APDs, basic spectroscopy & lifetime measurements
Options			**Excitation Laser** – above band ps diode **Resonant Excitation** – option utilizes modified optics, no laser **HOM** – for HOM indistinguishability measurement

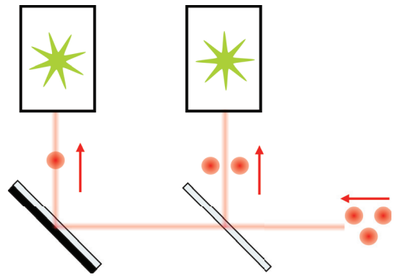
Specifications and other information subject to change without notice.

Performance Data

Detection Results

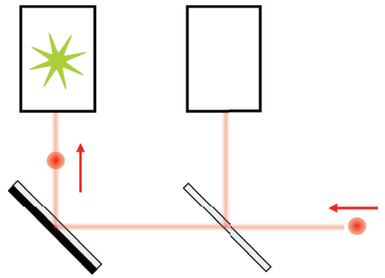
Case #1:
Multi-Photon Experiment

$g^{(2)}(0) = 1$

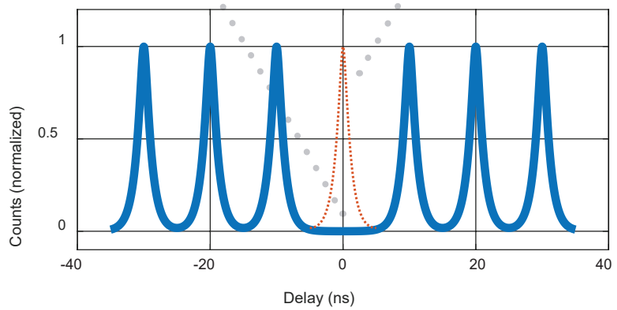


Case #2:
Single-Photon Experiment

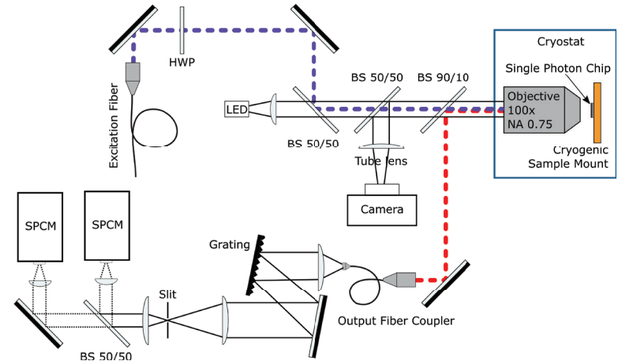
$g^{(2)}(0) = 0$

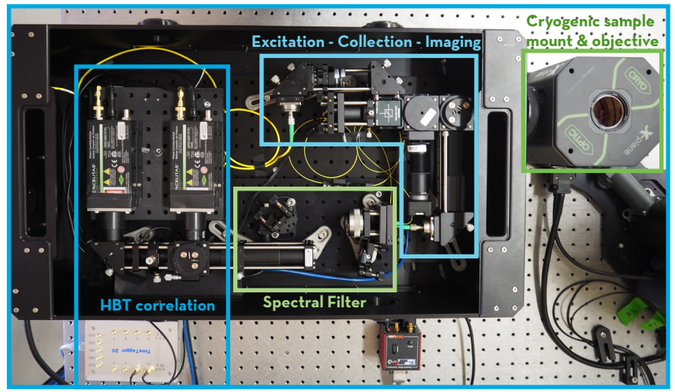


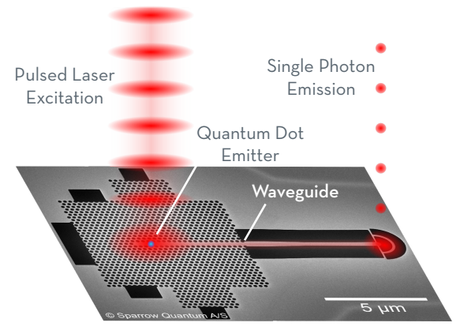
At $\Delta t = 0$, the peak disappears when single-photon emission is the dominant process.



SINGLE-PHOTON EXPERIMENT:
Coincidence Correlation







Specifications

Last Updated: July 27, 2017

Sparrow Quantum Single-Photon Chip	
Waveguide mode coupling efficiency (β factor)	90-98%
Single-photon purity (1-$g^{(2)}(0)$)	>95%
Second order coherence ($g^{(2)}(0)$)	< 0.1
Single-photon coherence (Indistinguishability) (1)	>60%
First-lens efficiency (2)	300 ks^{-1}
Emission wavelength (ground state) (3)	910 - 950 nm
Excitation wavelength (4)	800 - 960 nm
Excitation power (single photon regime) (4)	1 - 4000 nW
Excitation pulse length (4)	1 – 100 ps
Operating temperature (4)	< 15 K
Decay time (typical)	1 ns
Chip Dimensions (mm)	4 x 2 x 0.5 (w x d x h)

(1) Requires resonant excitation and low chip temperature
(2) 80 MHz excitation, in Gaussian mode
(3) Specific wavelength available on request
(4) Coherence dependent on excitation and temperature

Custom Nanophotonic Chip (no QDs)	
Wavelength range	700 – 1000 nm
Feature roughness	< 2 nm rms
Maximum structure size	300 µm
Minimum feature size	100 nm
Chip dimensions (mm)	4 x 2 x 0.5 (w x d x h)

Roadmap for Chip Improvement

- Improved fiber-coupling efficiency
  - 8 Mhz photon rate in fiber; see Optica Vol. 4, Issue 2, pp. 178-184 (2017)
- Improved single-photon indistinguishability
  - 62% visibility achieved by chip platform; see arXiv:1701.08131

Highlights

Sparrow Quantum single-photon chips are produced in a world-leading nanofab facility and feature advanced planar AlGaAs membrane photonic technology. The chips offer a flexible platform for nanophotonic experiments.

- Highest internal efficiency, future-proof roadmap based on planar photonic technology
- Excellent device quality
- Optimized output coupling
- Wide range of customization options in chip design
- Compatible with cryo-integrated turn-key single-photon source (SPARK)

Applications

The chips have applicability well beyond single-photon sources:

- Next-generation quantum cryptography
- Multi-photon generation
- Photonic quantum gates
- Fundamental quantum optics

About Sparrow Quantum

Sparrow Quantum A/S is a privately held company that develops and commercializes single-photon light sources and photonic technologies. Sparrow Quantum A/S is a spin-out from the Niels Bohr Institute in Copenhagen, Denmark.