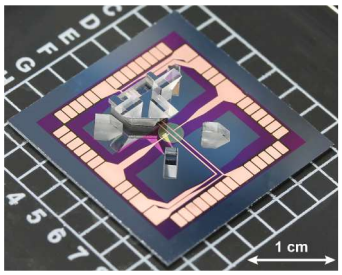
QuCAL

Quantum UltraCold Atom Laboratory



Optical lattice window chip

Product

Atom Chip enables rapid BEC production with high duty cycle and low power consumption

Complete System including power electronics, computer control system and all optics/vacuum required to create and image a BEC of Rb atoms.

Compact optical/magnetic setup with novel thru-breadboard beam delivery and alignment-free 2D(+) MOT stage.

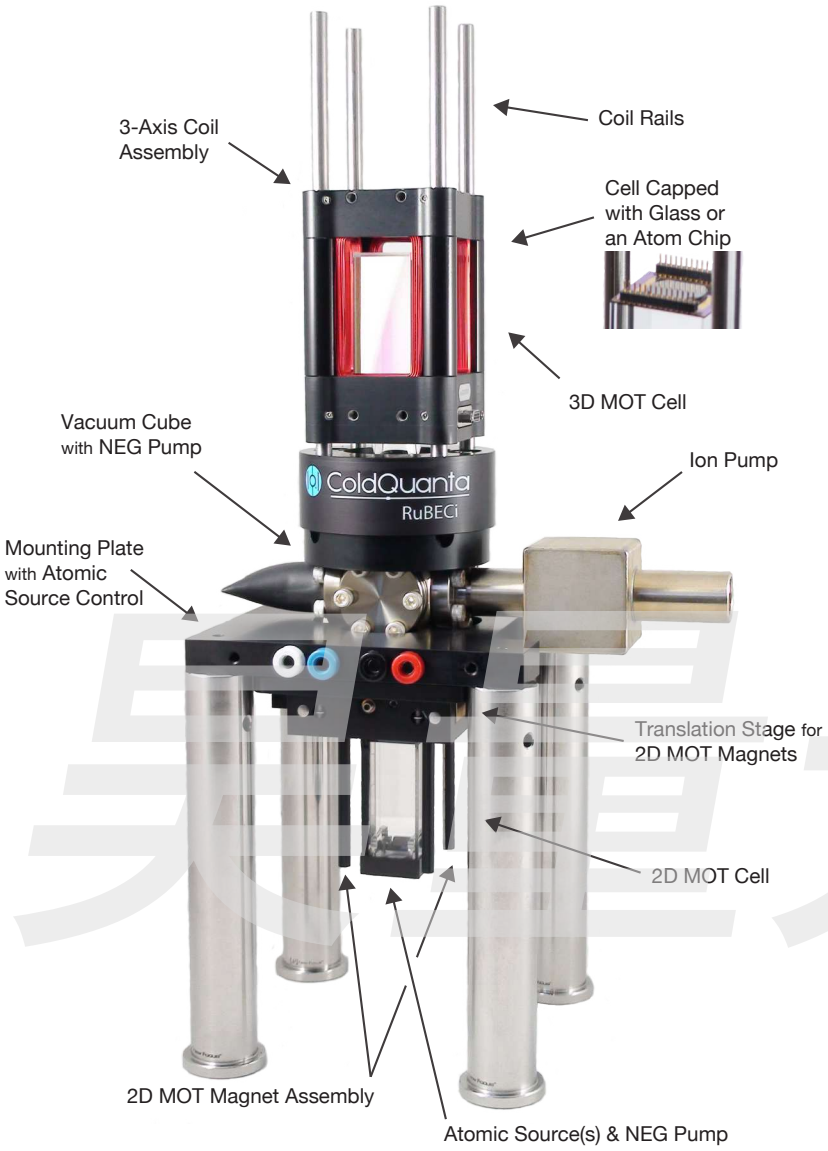
Beam Prep housed below, allowing broad user access to science region.

Custom-Designed suite of electronics ensures low noise and high stability.

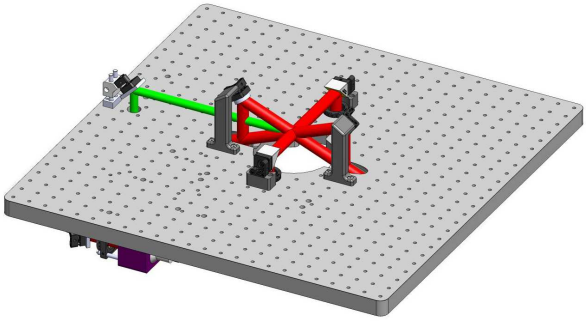
Turn-Key, two-stage MOT system also available for Cs or K.

QuCAL: Quantum UltraCold Atom Laboratory - Subsystems

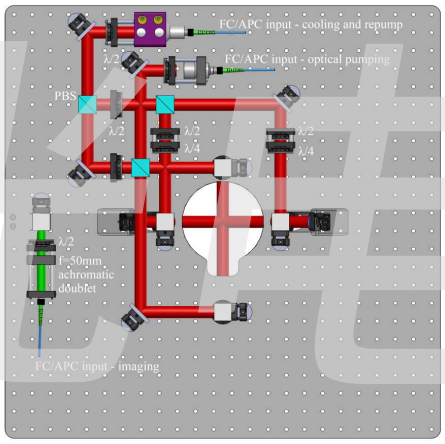
The ColdQuanta RuBECi® sits at the heart of the QuCAL, providing a 2D(+)MOT to 3D MOT chamber, topped by a ColdQuanta atom chip.



The ColdQuanta Physics Platform is a complete opto-mechanical package designed for BEC production. Its three-tiered configuration leaves ample space for user applications. ColdQuanta offer two different options for the 2D MOT optics: either a free-space, 2D-MOT setup or the PICAS, alignment-free package.

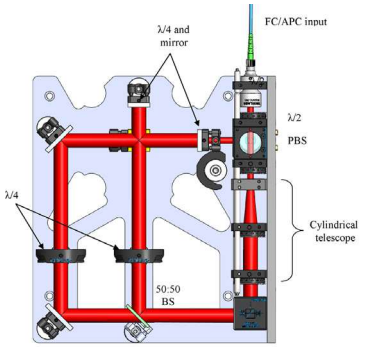


Level 3: 3D MOT, Optical Pumping & Imaging Beam Delivery
Housing all beam preparation on the underside leaves plenty of space around the 3D MOT cell to mount user applications.



Level 2: 3D MOT, Optical Pumping & Imaging Beam Staging
Well engineered, multi-level system utilizes both surfaces of a single breadboard: Preparing and delivering the 6-beam MOT light, optical pumping beam and imaging beam.

PICAS, Alignment-Free Level 1: 2D(+) MOT Beam Delivery
ColdQuanta's new PICAS is a compact, alignment-free package that fits over the source cell, and mounts to the 2D(+) MOT magnet assembly. The PICAS produces a high-flux beam of laser-cooled atoms, using fiber coupled light. The opto-mechanics unit can be removed during bake-out at up to 225 °C.

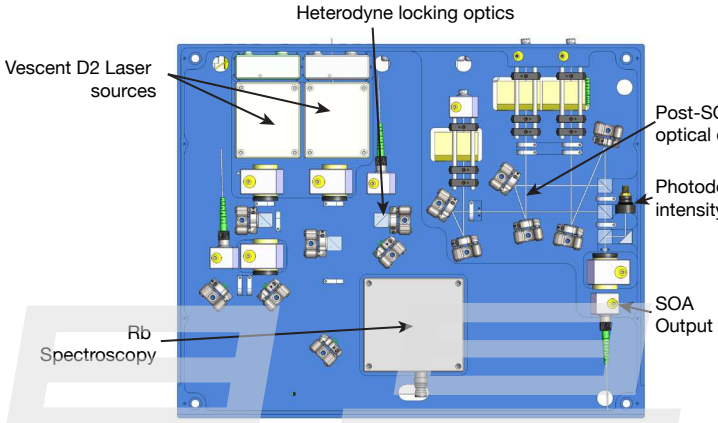


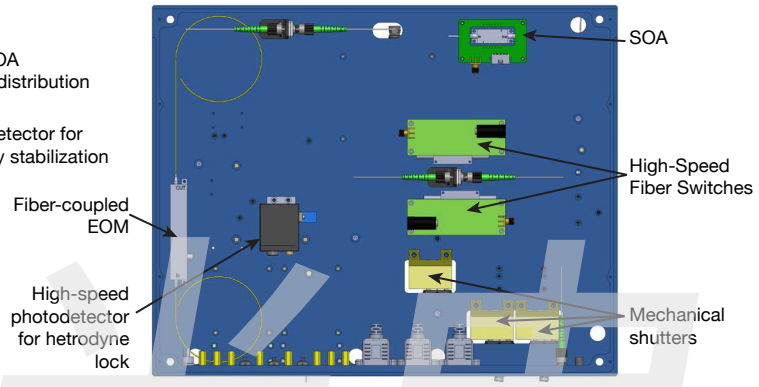
Traditional, Free-Space Level 1: 2D(+) MOT Beam Delivery
Includes delivery of 2D MOT and push beams.

The ColdQuanta Laser Solution

A compact, robust, and integrated laser system for laboratory laser cooling applications.

The system utilizes a two-laser source in a master-slave configuration. Repump light or sideband generation is achieved with a broadband (0 to 10 GHz) electro-optic modulator. Power amplification and active power stabilization are achieved via an on-board semiconductor optical amplifier (SOA). The entire system is controlled through a single Vescent Photonics Integrated Control Electronics (ICE) module, and a microwave source for sideband generation.





The ColdQuanta Ultracold Control Software

Cold atom experiments are controlled via a sequential timing scheme, built and saved by the user.

The GUI provides an array of on-off-controllable stages that define a variety of tasks by specifying a start time and a duration.

Global and stage variables allow the tasks to be parametrically programmed.

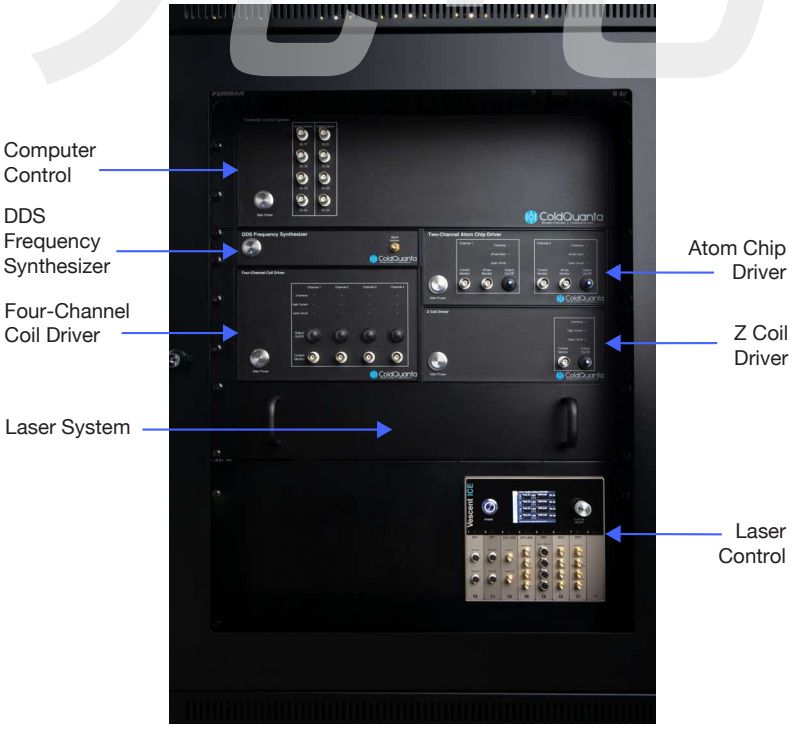
Operation modes include manual channel control, fixed-number loop, and loop-until-user-stopped.

Simple linear calibration and unit conversion is available.

A real-time error checker parses the recipe and highlights timing errors or conflicts.

A task-timing Gantt chart, and a full-experiment timing diagram provide easy visualization, where tasks are colored according to their type of action, eg. TTL-Out or Analog Ramp.

The ColdQuanta Ultracold Control Rack



QuCAL: Quantum UltraCold Atom Laboratory - Specifications

BEC:

Atom Number in BEC	20,000 - 40,000
Thermal Background Temp	200 - 1000 nK
Lifetime in Final Evap Trap	Typ 200 ms
Atomic Density	>1x10^{13} cm^{-3}
Production Time	<2 s
Production Technique	Forced RF in Atom Chip Trap

MOT:

Atom Number in MOT	>5x10^{8}
Atom Temp in MOT	≤300 µK
2D MOT Flux	1 x 10^{9} s^{-1}
1/e Loading Time	≤2 s
1/e MOT Lifetime	Typ 100 s
Cloud Diameter	>5 mm
Peak OD	Typ > 2

Imaging:

Image Resolution	3 µm
Imaging Pixel Depth	12 bit
Field of View	>3 mm

Facilities:

Electronics/Laser Rack	22"D x 24"W x 33"T (56 x 61 x 84 cm)
	70 kg
Physics Package[2]	24"D x 24"W x 17"T (61 x 61 x 43 cm)
	30 kg
Operating Voltage	110 / 220 VAC
Frequency	50 / 60 Hz
Power Consumption	1 kW
Warm-up Time	< 10 minutes
Environmental Requirements	10-30 °C Operating Temp
Cooling Requirements	None

Laser System:

Two Laser Sources in Master-Slave Configuration

Lasers - Vescent Photonics	2x D2-100-DBR-780 as Master/Slave
Control - Vescent Photonics	Integrated Control Electronics (ICE) Module
Phase Modulator - iXblue	NIR-MPX800-NL-10-P-P-FA-FA
Total Optical Output Power	80mW in 4 FC/APC optical fibers
2X High Power Outputs	0-50 mW w/ mechanical shutters
2X Low Power Outputs	0-10 mW w/ mechanical & fiber-optic shutters
Slave Tuning Range	> ± 9 GHz

Repump Light / Sideband Generation via 0 to 10 GHz electro-optic modulator

Power Amplification / Stabilization via Semiconductor Optical Amplifier (SOA)

Instrument Control System:

Control	FPGA for real-time programing/synch
Analog Outputs	16
Digital TTL outputs	24
Mechanical Shutter Control	3x 1394 TTL outputs

Software:

UI Employs Sequential Timing Scheme

Real-Time Error Checking

Global and Stage Variables Allow Parametric Task Programming

Channel Control Also Possible in Manual and Loop Modes

Gantt Chart of Task Timing for Easy Visualization

Coil Driver:

Bidirectional, voltage-controlled current sources for inductive loads.

Four independent channels, up to ± 3 A each.

Balanced, differential inputs: Isolated from Control Electronics.

[1]Listed specifications are for Rubidium-87. Contact ColdQuanta about other species.

[2]Footprint can be adjusted up or down to suit user's applications-space requirements. Available on English or Metric Breadboard.

QuCAL: Quantum UltraCold Atom Laboratory - Options

Species Options:
Rubidium (ultracold or cold)
Cesium (cold only)
Potassium (cold only)

Standard Configurations:
Utility Atom Chip BEC
Window Atom Chip BEC
for Thru-Chip Optical Access
Lattice Chip BEC
Window Atom Chip BEC
with High NA Imaging System
Custom Atom Chip BEC
Chipless, Cold Atom System
All-Optical Solution Coming Soon

Chip Transfer Options:
Z-Coil Transfer
Quadrupole Coil Transfer

Glass Cell Options:
Simple, Fire-Fused Cell
Optically Contacted Cells:
20 mm x 20 mm x 60 mm ID
10 mm x 13 mm x 60 mm ID
Imaging Cell(1)
Custom Cell

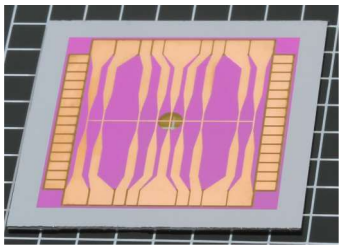
AR Coating Options:
Broadband AR Coating
Cs, Rb, K, 1064nm AR Coating
Custom AR Coating

Optical Package Options:
Physics Station: CPS-XXX
Physics Platform: CP1-XXX
Physics Platform + PICAS: CP3-XXX + PICAS

Intra-Vacuum Access Options:
Intra-Vacuum Mechanical Access - Optional
Bake-Out Station: Shroud and Turbo Pump System
Bake-Out Station: Shroud Only

Laser System Options:
Specified and tested with Vescent Lasers
Will provide requirements for user-provided lasers

Field Control Options:
Intra-Vacuum Field Plates Coming Soon


Window atom chip

[1]Imaging cell is matched to commercially-available objectives.

Screenshot of the QuCAL control software, showing the tasks, their respective channels, a timing Gantt chart and the Global and Local variables used to define the experiment.

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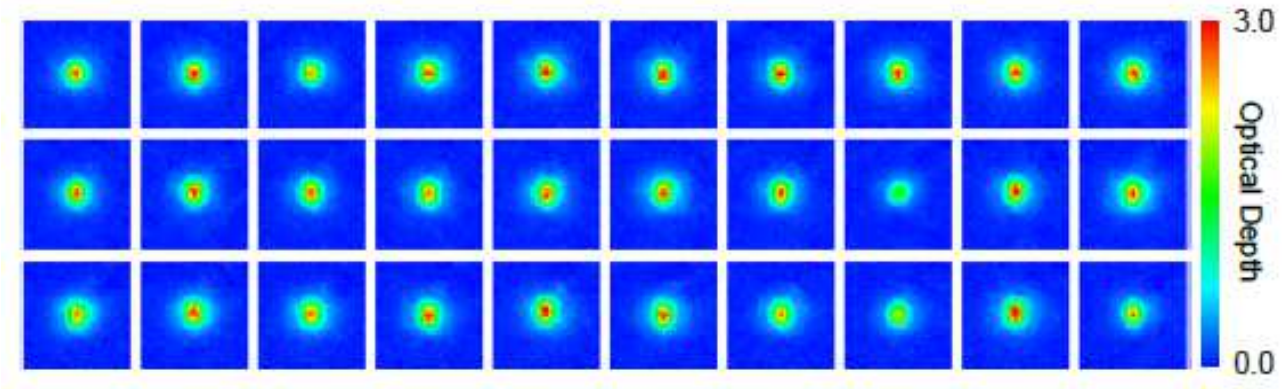
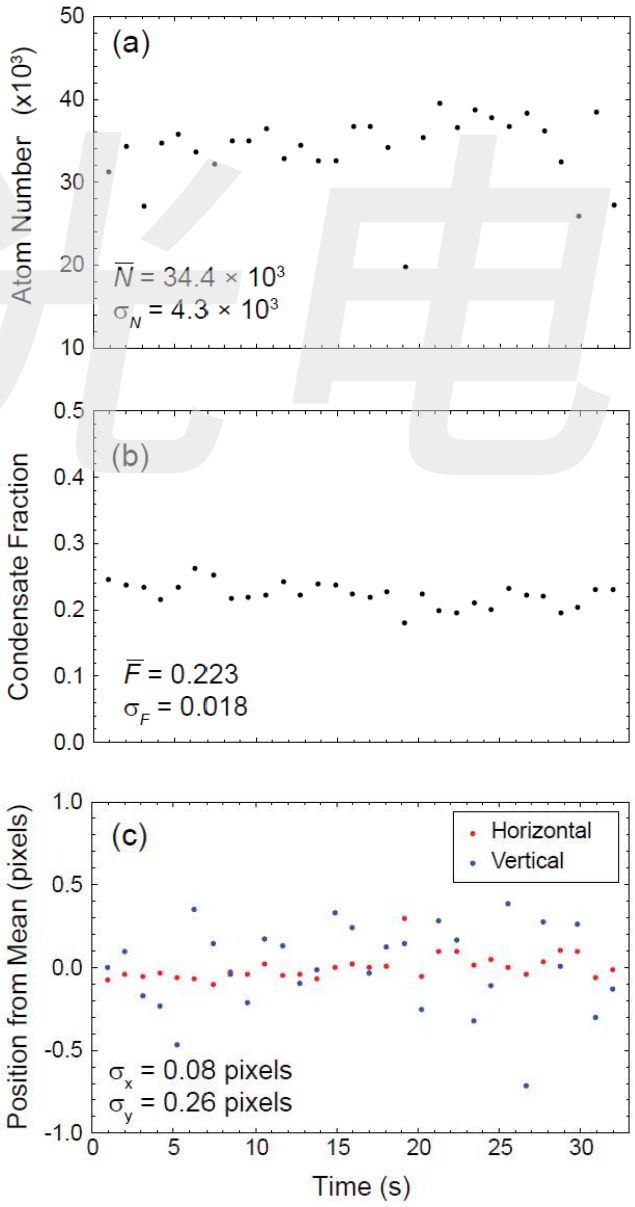


Above: Absorption images of 30 ^{87}Rb BECs produced and imaged in 32.1 s. Without imaging, a single BEC could be produced in 953 ms: A production rate exceeding 1 Hz. Each of these BECs is a data point in the plots on the right.

Right: Total atom numbers, condensate fractions, & cloud positions were obtained by fitting each filtered BEC image to a bimodal distribution.



Product Description

ColdQuanta's turn-key BEC system is a complete and transportable unit, providing researchers with a fast and cost effective platform for ultracold atom experiments. ColdQuanta's flagship RuBECi® ultracold matter cell serves as the heart of the system, housed in the Physics Platform and including a high-quality imaging system. The system includes the power electronics, computer control system, complete laser system, and optics required to create and image a Bose-Einstein Condensate of rubidium atoms.

The QuCAL ships with everything required to produce BEC in an atom chip trap. The system is installed at the user's facility by ColdQuanta scientists, and is guaranteed to produce a Bose-Einstein Condensate of rubidium. The system is highly configurable to meet specific experimental requirements.