Quantum-Nano Fabrication & Characterization Facility (QNFCF)

Core Scientific Research Platform

Facility Usage Stats and Highlights

July 27, 2021

UNIVERSITY OF WATERLOO | QNFCF

https://qnfcf.uwaterloo.ca

Facility Overview

Distributed across 13 sites - Centrally managed under *Office of Research*

$63M in Capital Investments

QNC Building

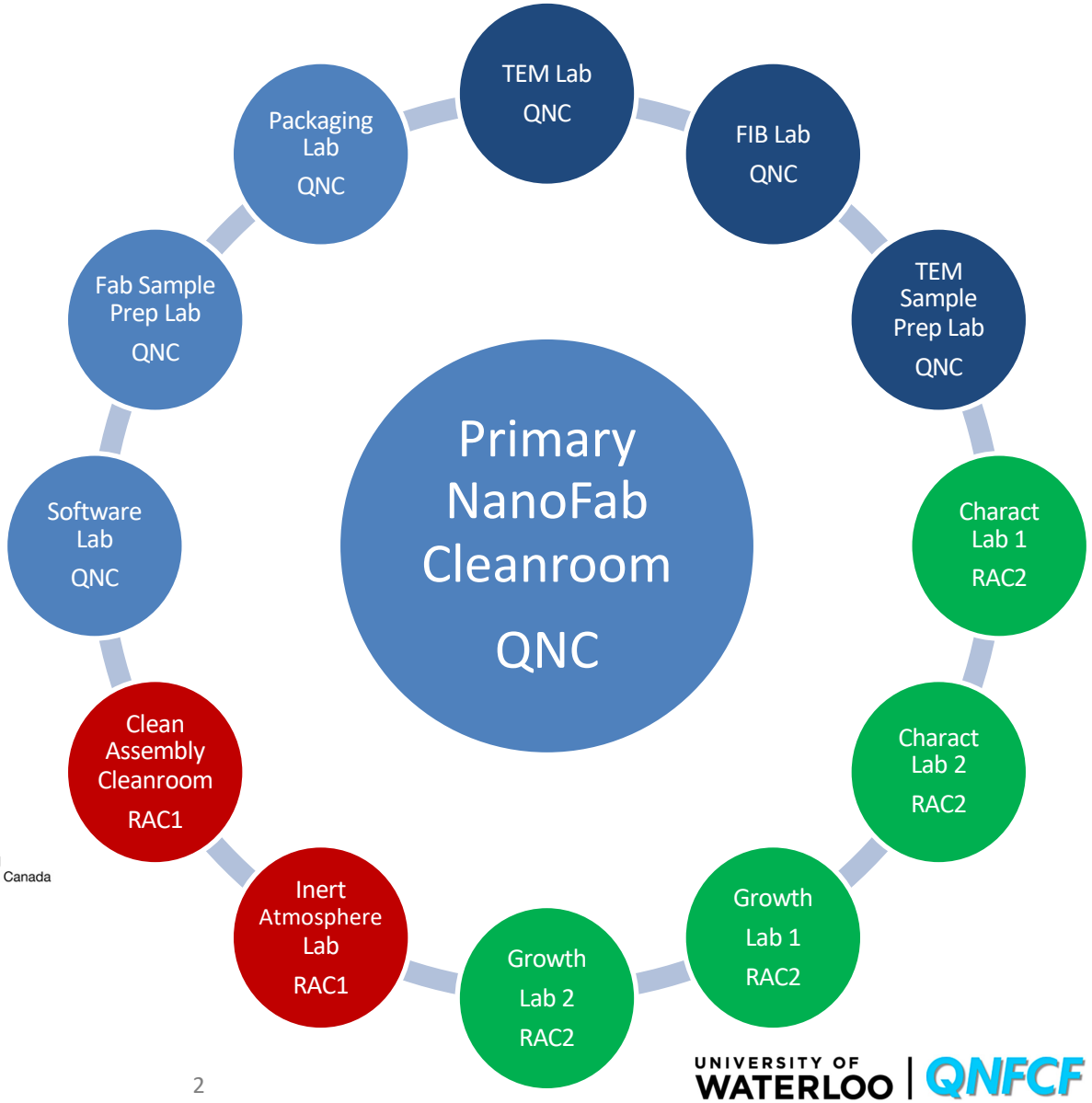
$25M	ISO 4 rated Cleanroom VC-G rated Metrology labs
$26M	Lab equipment

RAC1 Building

$1M	ISO 6 rated Cleanroom
$1M	Lab equipment

RAC2 Building

$10M	Lab equipment



INNOVATION.CA CANADA FOUNDATION FOR INNOVATION | FONDATION CANADIENNE POUR L'INNOVATION

Ontario

UNIVERSITY OF WATERLOO | IQC Institute for Quantum Computing

Innovation, Science and Economic Development Canada

CANADA FIRST RESEARCH EXCELLENCE FUND | APOGÉE CANADA FONDS D'EXCELLENCE EN RECHERCHE

TQT Transformative Quantum Technologies

Broad Range of Capabilities

Deposition

1. ALD / PECVD Cluster Deposition System
2. LPCVD Low Temperature Oxidation (LTO) Furnace
3. LPCVD Poly SIlicon and Silicon Carbide Furnace
4. LPCVD Silicon Nitride Furnace
5. Rapid Thermal Processor #1 (RTP)
6. Rapid Thermal Processor #2 (RTP)
7. PVD E-Beam & Resistive Heating Thermal Evaporator
8. PVD E-Beam Long Throw Evaporator
9. PVD Nb Superconducting Films Sputter System
10. PVD Twin Chamber Sputter System
11. PVD Al Superconducting Films Evaporator System
12. PVD Thermal Evaporator for P-Type Contacts
13. Thermal Oxidation Furnace

Lithography

1. E-Beam Lithography System (30kV)
2. E-Beam Lithography System (100kV)
3. Beamer/Tracer Software Suite
4. Front/Back Mask Aligner
5. Wafer Bonder
6. UV Direct Write Lithography System
7. Oven: Convection
8. Oven: HMDS & Image Reversal
9. Spin Coater: Dual General Purpose Hood
10. Spin Coater: E-Beam Resists
11. Spin Coater: UV Resists

Dry Etch

1. Ion Mill
2. Photoresist Strip
3. RIE: Deep Silicon Etch (DRIE)
4. RIE: Metal & III-V Materials

Wet Benches

1. Bulk Silicon Etch
2. Critical Point Dryer
3. Diffusion Pre-Clean (RCA Chemistries)
4. E-Beam Resist Develop
5. HF Acids Only
6. Non-HF Acids & Bases
7. Piranha Organics Clean & Resist Strip
8. Solvent Processing Station #1
9. Solvent Processing Station #2
10. UV Resist Develop

Characterization

1. Bruker Atomic Force Microscope
2. Scanning Electron Microscope
3. Manual Cleaving Tool
4. 4-Point Probe
5. Electrical Prober Station: **Generous donation from EVERBEING**
6. Electrical Probe Station
7. Ellipsometer
8. Microscope #1
9. Microscope #2
10. Reflectometer: Thin Film Mapping
11. Reflectometer: Thin Film Spot Measurement
12. Surface Profiler #1
13. Surface Profiler #2
14. Wafer Stress Measurement
15. SEM Sample Coater

Packaging Lab

1. Convection Cure Oven
2. Dicing Saw
3. Die Bonder
4. H2 Plasma Cleaner
5. Measurement Microscope
6. Wirebonder: Manual Wedge/Ball
7. Wirebonder: Semi-automatic Wedge
8. Wire Pull Tester
9. Epoxy dispenser

QNC Metrology Labs

1. SEM/FIB System
2. S/TEM System
3. Dry Sample Prep Lab

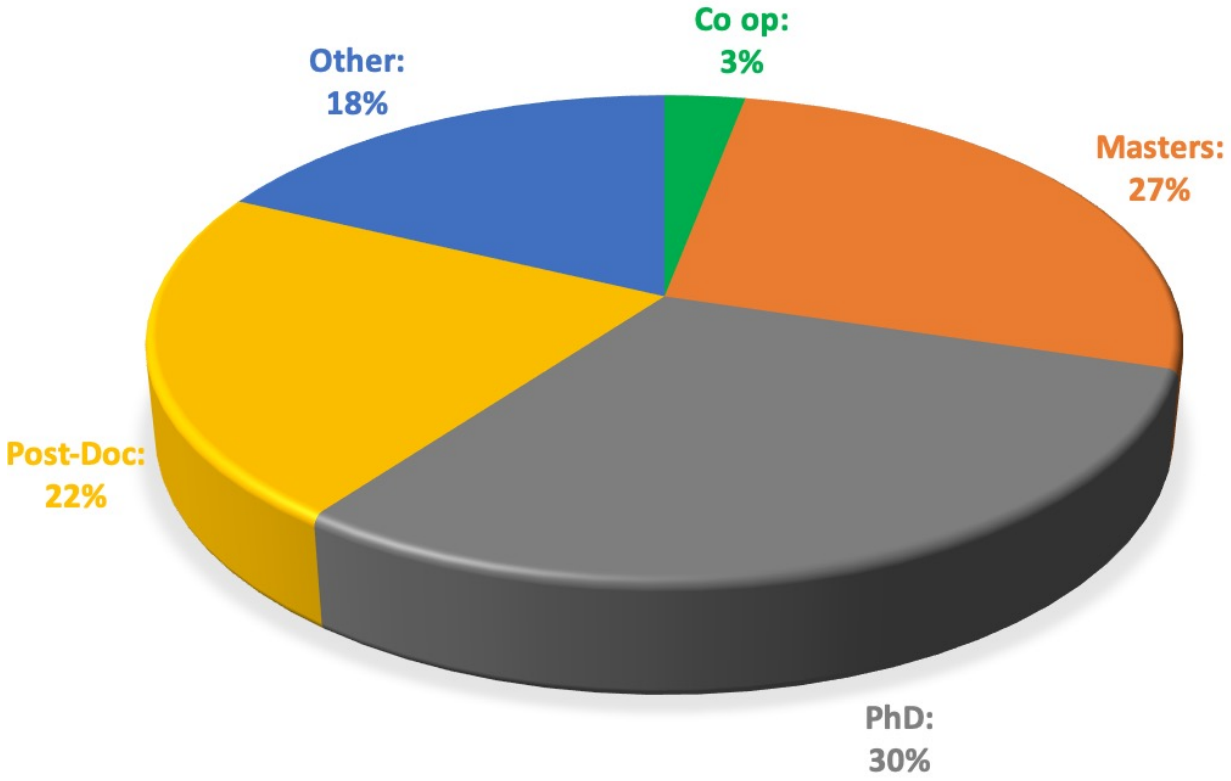
RAC1 Labs

1. Assembly Station #1
2. Assembly Station #2
3. Environmental Chamber
4. Laser Welder
5. Sample Polisher
6. Sample Cutter
7. Sample Lapper
8. Wire Saw
9. Microscope #1
10. Microscope #2
11. Microscope #3
12. O2/Ar Plasma Cleaner
13. Wet Bench: Non-HF Acids & Bases
14. Wet Bench: HF Acids
15. Wet Bench: Solvent Processing
16. Wire Bonder
17. 3D Optical Surface Profiler

RAC2 Labs

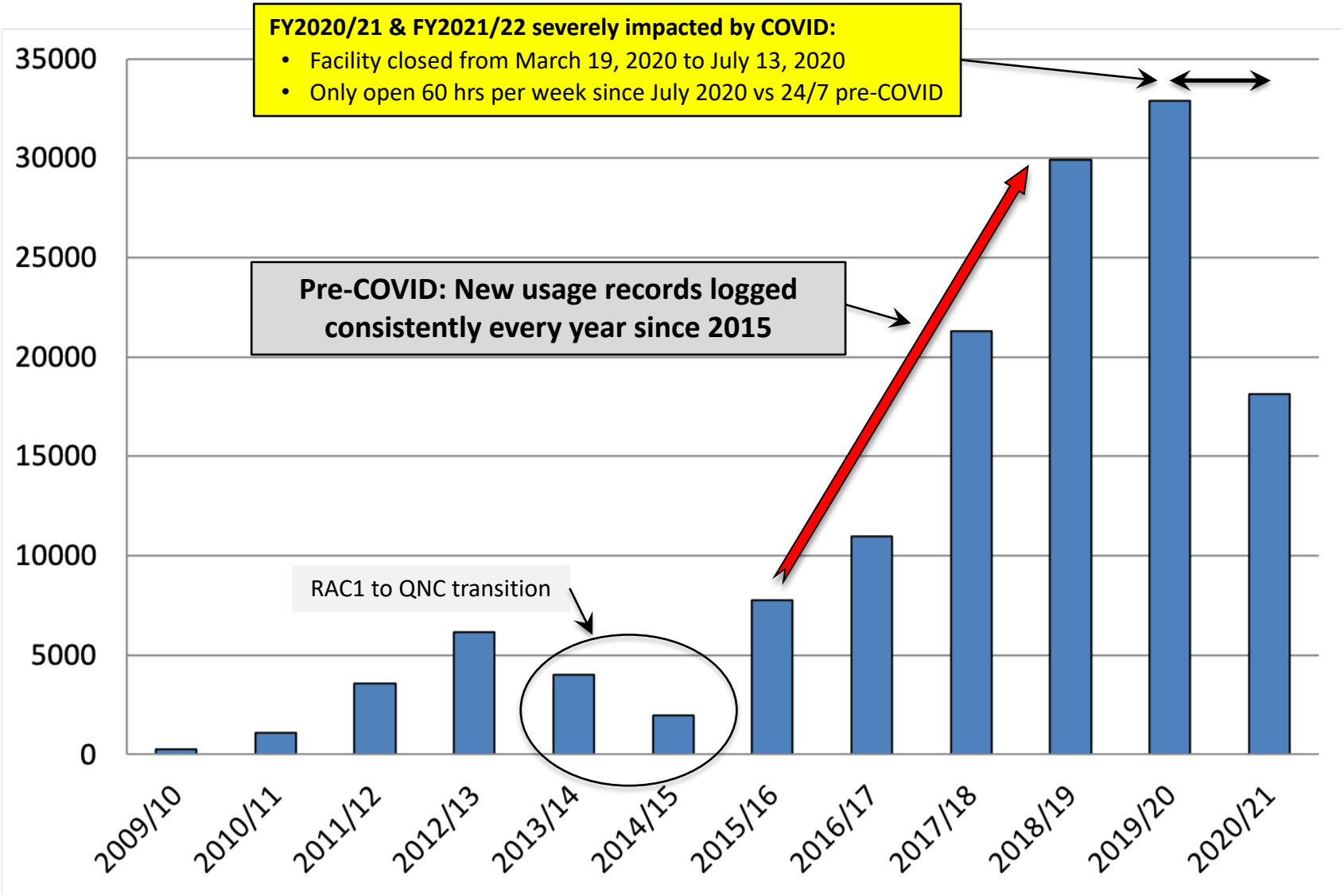
1. Fiber Splicer
2. Microscope #2
3. Veeco Atomic Force Microscope
4. LPCVD for Carbon Nanotube Growth
5. Pulsed Laser Deposition System

Well used by broad range of Lab Members (Users)



Hours of equipment use invoiced per fiscal year*

** Fiscal years ending April 30 - graph does not include user training & support hours logged by QNFCF staff*



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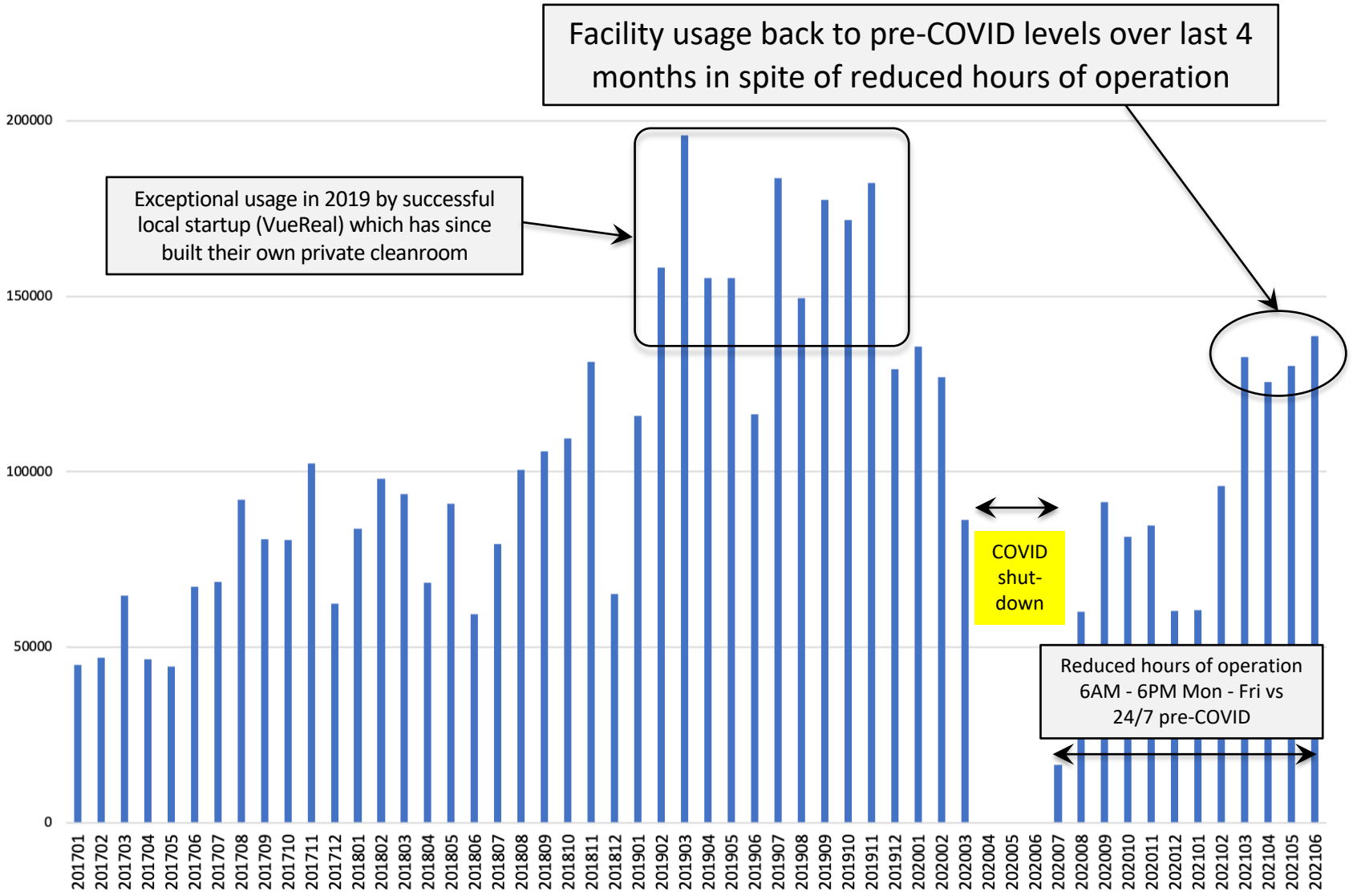
Monthly invoicing trends: Jan 2017 to June 2021



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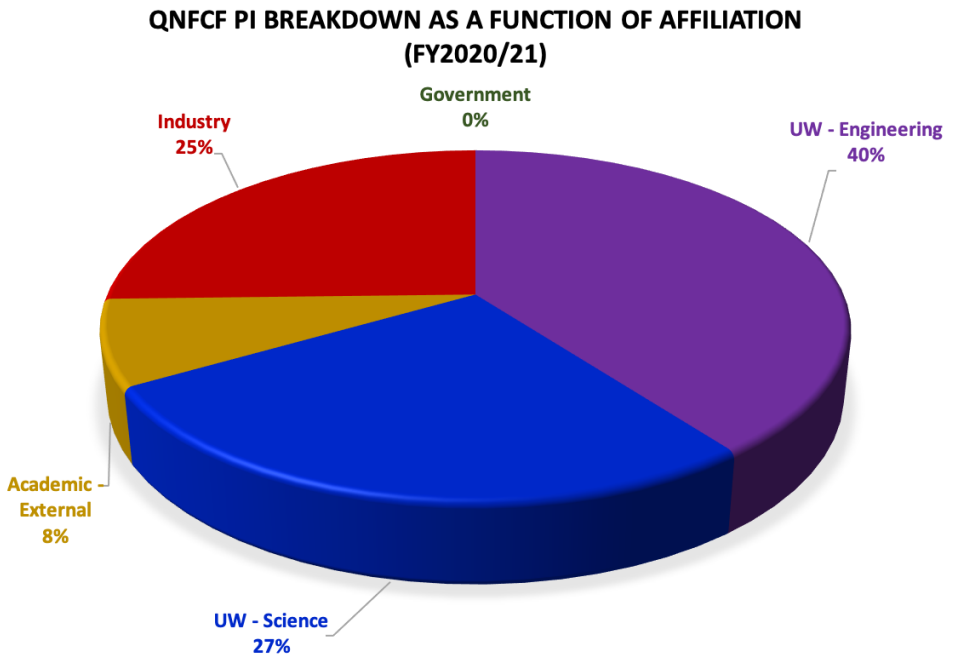
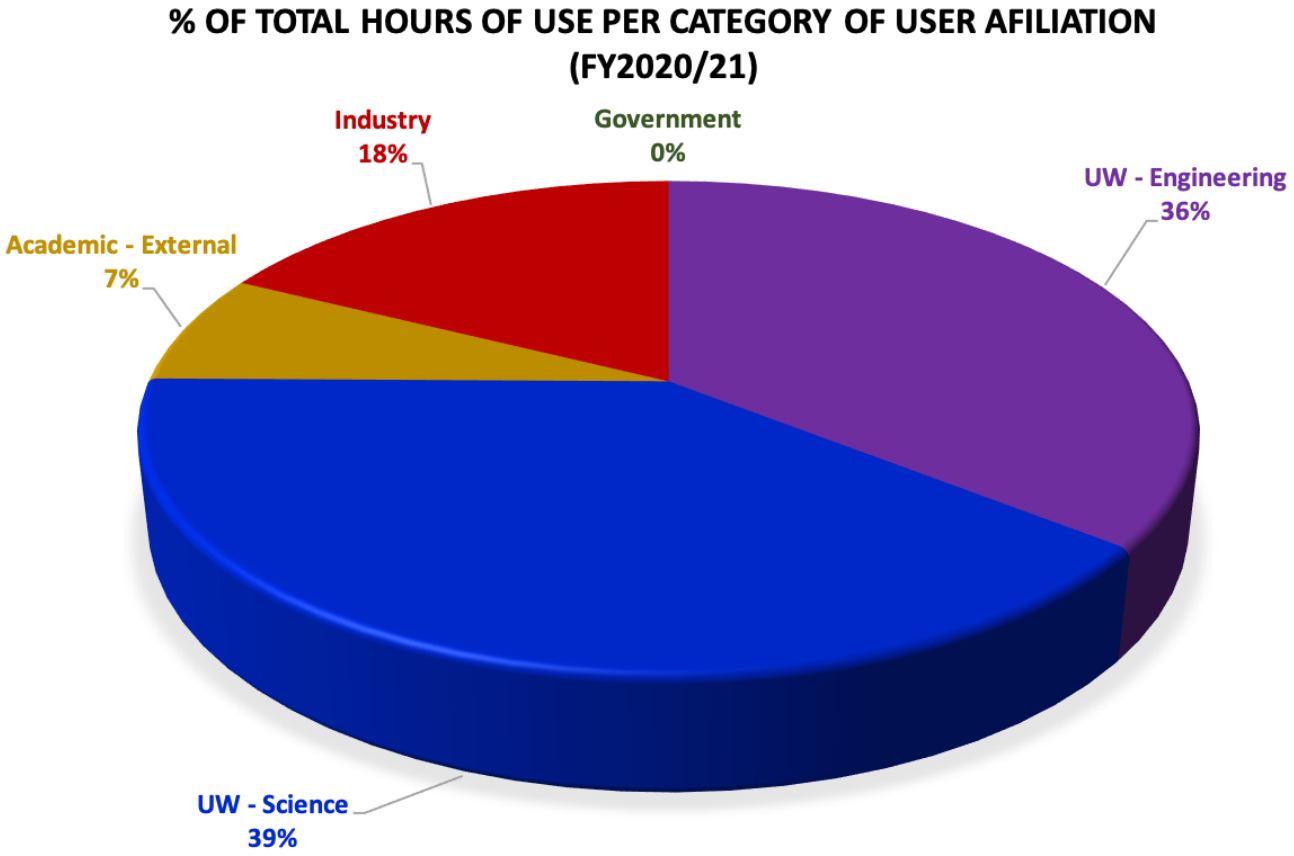
FY2020/21: 164 Users under 63 distinct research groups

Principal Investigator	Hours of Equip Use Logged	Category: Academic, Industry, Govt, Other	Institution / Company Name	Faculty	Department
Abdel-Rahman, Eihab	24	Academic	UW	Engineering	Sys Design Eng
Alfano, Marco	1	Academic	UW	Engineering	MME
Bajcsy, Michal	81	Academic	UW	Engineering	ECE
Cui, Bo	1928	Academic	UW	Engineering	ECE
Daun, Kyle	2	Academic	UW	Engineering	MME
Goldthorpe, Irene	245	Academic	UW	Engineering	ECE
Karim, Karim	60	Academic	UW	Engineering	ECE
KIM, Na Young	67	Academic	UW	Engineering	ECE
Mansour, Raafat	660	Academic	UW	Engineering	ECE
Mayer, Michael	11	Academic	UW	Engineering	MME
Miao, Guo-Xing	125	Academic	UW	Engineering	ECE
Mitra, Sushanta	5	Academic	UW	Engineering	MME
Musselman, Kevin	142	Academic	UW	Engineering	MME
Nieva, Patricia	2	Academic	UW	Engineering	MME
Reimer, Michael	431	Academic	UW	Engineering	ECE
Safavi-Naeini, Safieddin	41	Academic	UW	Engineering	ECE
Sivoththaman, Siva	19	Academic	UW	Engineering	ECE
Wasilewski, Zbigniew	81	Academic	UW	Engineering	ECE
Wei, Lan	5	Academic	UW	Engineering	ECE
Wilson, Christopher	1792	Academic	UW	Engineering	ECE
Wong, William	160	Academic	UW	Engineering	ECE
Yavuz, Mustafa	112	Academic	UW	Engineering	MME
Yeow, John	251	Academic	UW	Engineering	Sys Design Eng
Yim, Evelyn	190	Academic	UW	Engineering	Chem Eng
Yu, Alfred	45	Academic	UW	Engineering	ECE
Baugh, Jonathan	2526	Academic	UW	Science	Chemistry
Budakian, Raffi	96	Academic	UW	Science	Physics
Choi, Kyung Soo	1	Academic	UW	Science	Physics
Cory, David	1912	Academic	UW	Science	Chemistry
Forrest, James	29	Academic	UW	Science	Physics
Islam, Rajibul	29	Academic	UW	Science	Physics
Jennewein, Thomas	9	Academic	UW	Science	Physics
Kycia, Jan	9	Academic	UW	Science	Physics
Lupascu, Adrian	767	Academic	UW	Science	Physics
Mariantoni, Matteo	197	Academic	UW	Science	Physics
Resch, Kevin	2	Academic	UW	Science	Physics
Schipper, Derek	12	Academic	UW	Science	Chemistry
Sciaini, German	421	Academic	UW	Science	Chemistry
Senko, Crystal	442	Academic	UW	Science	Physics
Slavcev, Roderick	34	Academic	UW	Science	Pharmacy
Tsen, Adam Wei	671	Academic	UW	Science	Chemistry
Maheshwari, Vivek	4	Academic	UW	Science	Other

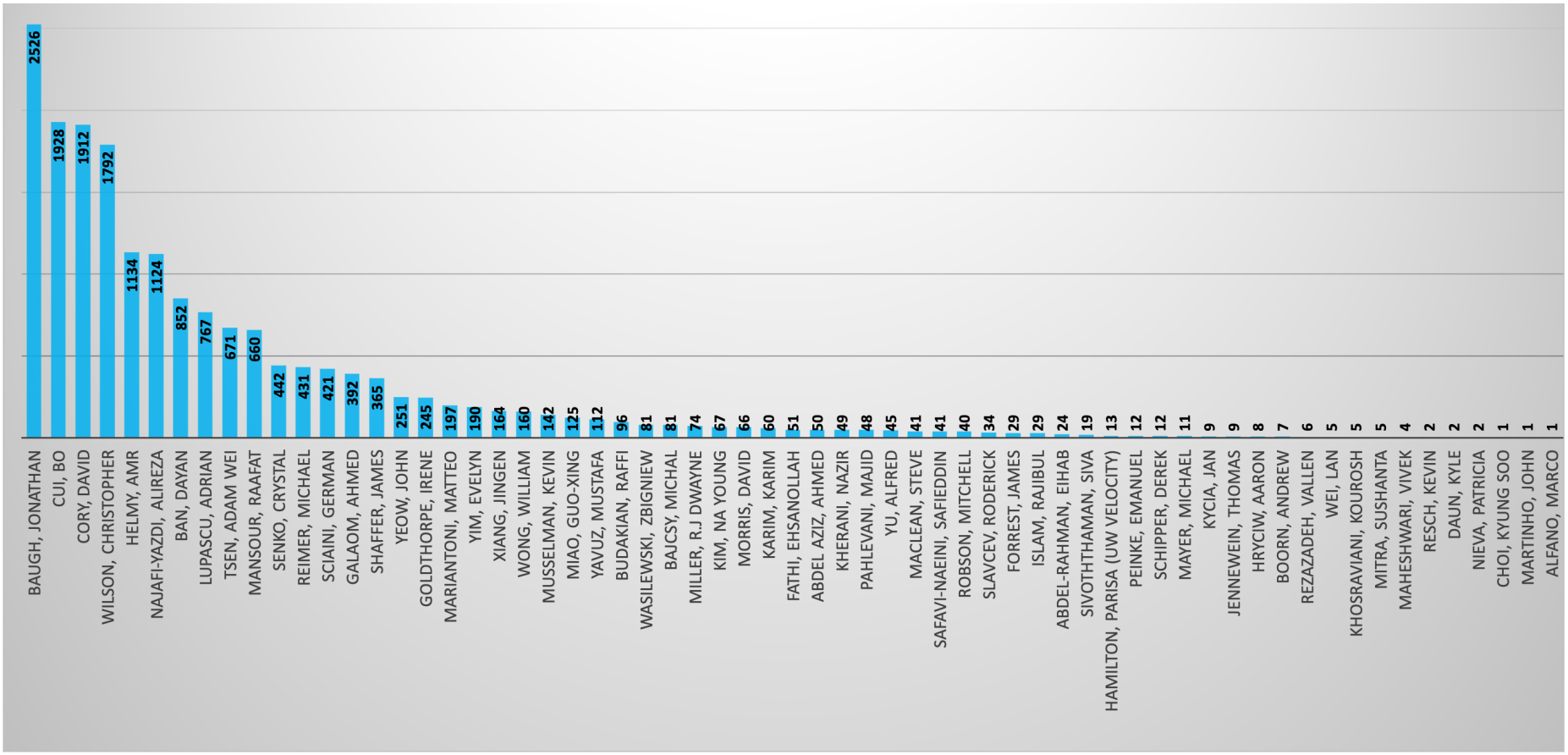
Principal Investigator	Hours of Equip Use Logged	Category: Academic, Industry, Govt, Other	Institution / Company Name	Faculty	Department
Helmy, Amr	1134	Academic - External	University of Toronto	N/A	N/A
Hryciw, Aaron	8	Academic - External	University of Alberta	N/A	N/A
Kherani, Nazir	49	Academic - External	University of Toronto	N/A	N/A
Miller, R.J Dwayne	74	Academic - External	University of Toronto	N/A	N/A
Pahlevani, Majid	48	Academic - External	University of Queens	N/A	N/A
Ban, Dayan (VueReal)	852	Industry	UW	Engineering	ECE
Abdel Aziz, Ahmed	50	Industry	Simwi Tech Corp	N/A	N/A
Boorn, Andrew	7	Industry	High Q Technologies, LP	N/A	N/A
Fathi, Ehsanollah	51	Industry	VueReal Inc	N/A	N/A
Galaom, Ahmed	392	Industry	Sheba Microsystems	N/A	N/A
Hamilton, Parisa (UW Velocity)	13	Industry	LSK Technologies	N/A	N/A
Khosraviani, Kourosh	5	Industry	Adhawk Microsystems	N/A	N/A
MacLean, Steve	41	Industry	Infinite Potential Laboratories	N/A	N/A
Martinho, John	1	Industry	RANOVUS	N/A	N/A
Morris, David	66	Industry	ICSPI Corp.	N/A	N/A
Najafi-Yazdi, Alireza	1124	Industry	Anyon Systems Inc	N/A	N/A
Peinke, Emanuel	12	Industry	TandemLaunch, Inc.	N/A	N/A
Rezazadeh, Vallen	6	Industry	TransEON Inc.	N/A	N/A
Robson, Mitchell	40	Industry	Ambature Inc.	N/A	N/A
Shaffer, James	365	Industry	Quantum Valley Ideas Lab	N/A	N/A
Xiang, Jingen	164	Industry	SpinQ Technologies	N/A	N/A



FY2020/21: % of total hours of use per category of affiliation



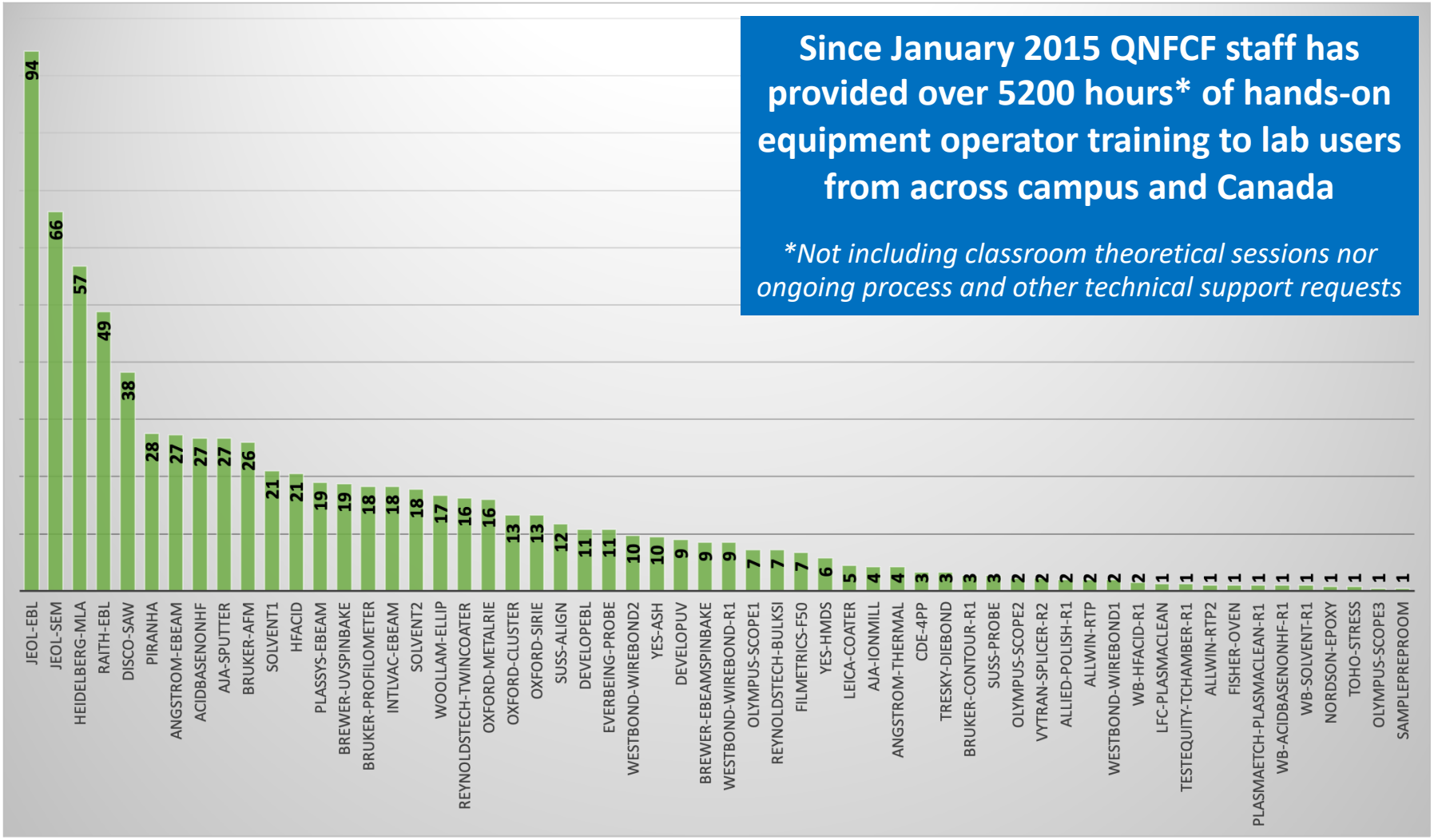
FY2020/21: Hours of use logged per PI



Top 3 QNFCF users in FY 2020/21 (most active research groups):

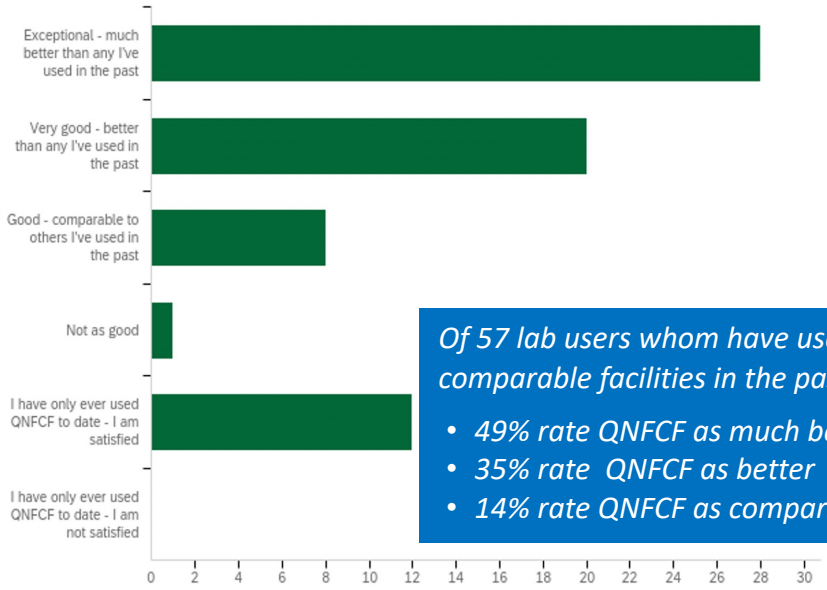
1. Jonathan Baugh
2. Bo Cui
3. David Cory

FY2020/21: Logged 800 Hours of hands-on training



Highlight from July 2021 Lab Member survey

Q13 - Rate the overall caliber of the QNFCF compared to other academic facilities you have used in the past (in terms of staff support, training, infrastructure, management).

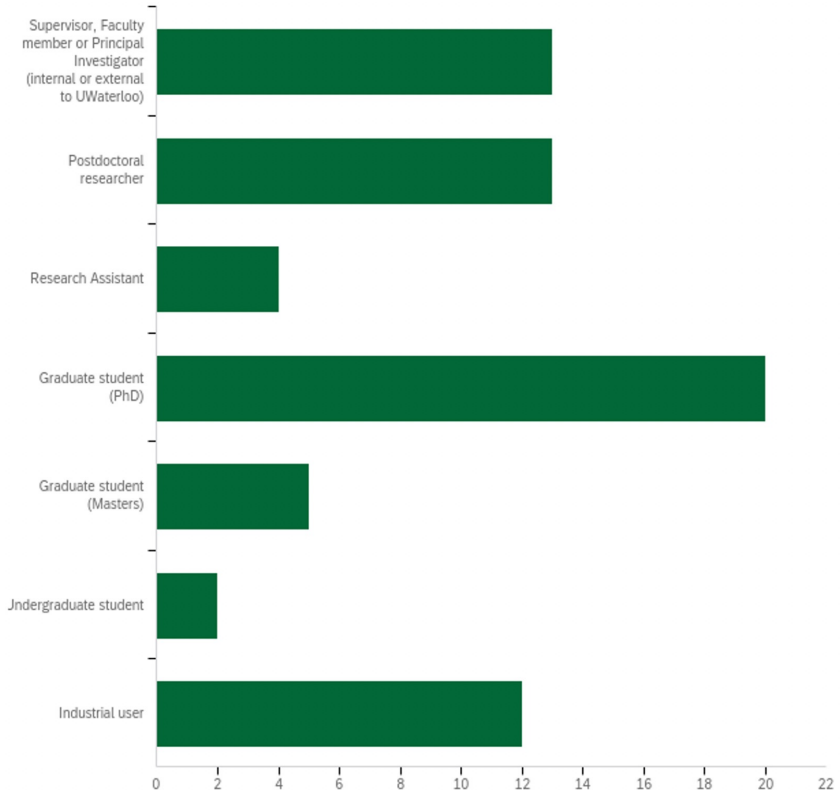


Of 57 lab users whom have used comparable facilities in the past:

- *49% rate QNFCF as much better*
- *35% rate QNFCF as better*
- *14% rate QNFCF as comparable*

#	Answer	%	Count
1	Exceptional - much better than any I've used in the past	41%	28
2	Very good - better than any I've used in the past	29%	20
3	Good - comparable to others I've used in the past	12%	8
4	Not as good	1%	1
5	I have only ever used QNFCF to date - I am satisfied	17%	12
6	I have only ever used QNFCF to date - I am not satisfied	0%	0
	Total	**100%**	**69**

Q20 - Please describe your current position:



#	Answer	%	Count
1	Supervisor, Faculty member or Principal Investigator (internal or external to UWaterloo)	19%	13
2	Postdoctoral researcher	19%	13
3	Research Assistant	6%	4
4	Graduate student (PhD)	29%	20
5	Graduate student (Masters)	7%	5
6	Undergraduate student	3%	2
7	Industrial user	17%	12
	Total	**100%**	**69**

Annual O&M expenses and User fees trends*

** Fiscal years ending April 30*

EXPENSES	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Average Last 3 Years
SALARIES & BENEFITS Sub-Total:	$222,645	$274,113	$290,309	$365,712	$460,623	$613,184	$819,592	$1,535,502	$1,701,655	$1,778,492	$1,671,883
SUPPLIES, MAINTENANCE & REPAIRS Sub-Total:	$101,393	$122,271	$506,975	$405,379	$589,031	$802,204	$1,163,558	$1,380,003	$1,400,137	$1,071,837	$1,283,992
TOTAL:	$324,038	$396,384	$797,285	$771,091	$1,049,653	$1,415,388	$1,983,150	$2,915,505	$3,101,791	$2,850,329	$2,955,875
USER FEES COLLECTED	$86,583	$157,915	$111,333	$80,860	$348,371	$539,638	$994,730	$1,376,704	$1,763,769	$877,024	$1,339,166
% EXPENSES COVERED BY USER FEES	27%	40%	14%	10%	33%	38%	50%	47%	57%	31%	45%

In addition to several million dollars contributed towards multiple lab renovations and equipment acquisitions & upgrades, IQC and CFREF-TQT have also made substantial contributions towards the QNFCF's routine operating expenses over the past 10 years:

- IQC: $3,551,105
- CFREF-TQT: $1,915,520

Summary of key QNFCF success factors

1. Outstanding multi-year financial support from IQC and CFREF-TQT
2. Rare ensemble of lab equipment backed by solid expertise
3. QNFCF Team with extensive technical & operations experience
4. Strong focus on customer service
5. Revision-tracked SOPs / well-characterized recipes / process support
6. Extensive mandatory training
7. Stable, professionally-maintained lab equipment & infrastructure
8. Clearly defined, communicated & enforced policies (fair access to all)
9. UWaterloo's "creator owned" IP policy