Cryostats & Dilution Refrigerators Across the Market

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This is an overview of the commercial cryostat and dilution-refrigerator (DR) landscape, organized first by geography, then by physical footprint and more. It also includes some key comparisons for comprehension as well as some non-dilution cryogenic vessels.

All headline releases are included—the sub-0.8 m² **Bluefors Ultra-Compact LD** laboratory system, the 1.6 m² **Bluefors KIDE** "cryo-house" platform, Oxford Instruments' modular **Proteox** S/MX/LX/QX family capped by the new QX tier, FormFactor-HPD's wafer-prober-ready JDry/LF lines and the 508 mm-plate **XLF-600**, plus China's mass-produced **EZ-Q** refrigerators for domestic quantum-fab roll-outs.

Europe continues to ship the broadest catalog of Stock-Keeping Units (SKUs), an internal, seller-defined alphanumeric label, spanning both DRs and high-vacuum Dewars. North America leads in probe-station and production-test variants. East-Asia is scaling indigenous volume for >2,000-qubit stacks. Footprint classes now span **< 0.5 m²** table-top inserts (e.g., *attoDRY-800*) through compact **0.6–1 m²** floor units to **> 1.5 m²** data-centre platforms such as *KIDE*. The following tables pair each DR line with its logical Dewar or bulk-cryogen counterpart, giving a lab-ready bill-of-materials perspective.

- **Dewar**: an *eponym*—named for Scottish chemist Sir James Dewar, who also liquefied hydrogen.
- **Cryostat**: a portmanteau of Greek **κρύος** (*kryos*, "frost") + *-stat* ("to make stand, hold"), literally "cold-keeper."
- **Thermos™**: commercial trademark (1904) for consumer Dewars (vacuum insulated flask); illustrates the generalization of the scientific invention.
- **Dilution** *(as in "dilution refrigerator")*: from Latin **diluere** "to wash away/thin out," via the French term "dilution". In a dilution refrigerator the *thinning* of a **³He**-rich phase into a **⁴He**-rich phase at ≈ 0.87 K absorbs heat (enthalpy of mixing), allowing continuous cooling to **<10 mK**. The idea was proposed by Heinz London (1951) and first realized experimentally by the Cambridge–Oxford collaboration in the early 1960s; the term "dilution refrigerator" cemented itself as the technology matured through the 1970s.

Note: A cryostat is any vacuum-insulated vessel or assembly that maintains cryogenic temperatures by *any* cooling method—stored liquid nitrogen or helium, a mechanical Gifford-McMahon or pulse-tube cryocooler, a charcoal-pumped **³He** pot, an adiabatic demagnetization refrigerator (ADR) "salt-pill" stage, or a continuous **³He/⁴He** dilution loop. This inclusive definition embraces a standalone liquid-helium Dewar as the simplest cryostat, while every dilution refrigerator is a cryostat that incorporates the **³He/⁴He** mixing loop required for continuous operation below ≈ 100 mK. Intermediate temperature regimes (≈ 300 mK – 1 K) are spanned by plug-in **³He** sorption coolers, ADRs, pumped-**⁴He** variable-temperature inserts (VTIs), and low-vibration 1 K stages, each selected to balance vibration, duty-cycle, and capital or operating cost for a given quantum-hardware or precision-metrology experiment.

CRYOGENIC VESSELS
- Passive Vessels (no active temperature control)
  - Dewar Flasks [L] ← vacuum-insulated storage
    - Static/ Storage Dewar
    - Transport Dewar (road/ air)
    - Open "bucket" Dewar (bench-top dip)
- Cryostats (instrumented cryogenic vessels, with active temperature control)
  - Liquid-Filled Platforms [L]
    - Bath Cryostat
      - LN_2 bath (~77 K)
      - LHe bath (4.2 K; pumped 1 K pot)
    - Continuous-Flow Cryostat (4 K – 300 K; fed from external Dewar)
  - Closed-Cycle Platforms "Dry" [D]
    - Gifford–McMahon (GM) head (≈ 2 – 4 K)
    - Pulse-Tube (PT) head (≈ 2 – 4 K; low vibration)
  - Ultra-Low-T Inserts (mount on any 2–4 K stage)
    - Dilution Refrigerator (DR) < 10 mK [D‡]
    - ADR/ PDR 50 – 100 mK [L/D]
    - ^{3}He Sorption Cooler 250 – 400 mK [L/D]
    - Pumped-^{4}He 1 K Stage/ VTI [L/D]

Legend

- **[L]** Requires stored liquid cryogen
- **[D]** Cryogen-free mechanical (GM or PT) cooler
- **[L/D]** Available in both wet-dipstick and dry bolt-on versions
- **[D‡]** > 90 % of new DRs ship cryogen-free; a few legacy wet dip-stick units still exist

Europe-Based Leaders

Company (HQ)	Flagship DR lines & plate Ø*	Distinctive attributes	Base-T
Bluefors (FI)	Ultra-Compact LD (≤ 300 mm), LD, **XLD/XLDsl/XL** (500 mm), **KIDE** (1.6 m²)	> 1,000 units shipped; KIDE has ≥ 4,000 RF lines	< 10 mK
Oxford Instruments – Proteox (UK)	Proteox S/MX (250–400 mm), Proteox LX/QX (≤ 450 mm)	Modular vector magnet, hot-swap inserts	< 7 mK
Leiden Cryogenics (NL)	CF-1100 · CF-CS-XXL (1 m) · MCK inserts	Four-PT option on 1 m plate	≈ 5 mK
ICE Oxford (UK)	DRY-ICE Eden (200 coax, 500 mm)	High 1 K power, low-vib HX	< 10 mK
Cryoconcept (FR)	HEXA-DRY (std) · **HEXA-DRY XXL** (Ø 800 mm)	Six-stage HX, remote diagnostics	< 8 mK
Cryogenic Ltd (UK)	STM DR inserts (UHV tubes)	Top-loading for high-field STM	< 20 mK
attocube (DE)	attoDRY-800 / -1100 inserts	Table-top nano-positioning	< 15 mK

EU Dewars & Cryogenic Vessels

Company	Core lines (capacity)	Notes
Wessington	PV/ TPV LN_2 tanks ≤ 2,000 L · ISO bulk	Large fixed storage
Statebourne	Helistor He 30–990 L · Cryolab LN_2 · CryoCycl micro-bulk	R&D + biobank
KGW-Isotherm	Bespoke glass-in-steel Dewars < 30 L	Optics & metrology
Cryo Diffusion	LO/ CDB / BIO 47–2 250 L (LHe & LN_2)	Pharma & space ISO
Thames Cryogenics	30–2,000 L LN_2 + vacuum flex hoses	Site plumbing

North-American Suppliers

Dilution Refrigerators

Company (HQ)	Key systems/ plate Ø	Extras	Base-T
Quantum Design (US)	**PPMS DynaCool + DR insert** (≈ 305 mm)	Pulse-tube, 50 mK, no external He	45–50 mK
FormFactor (HPD) (US)	JDry-400 · LF-400 · **XLF-600** (508 mm)	Wafer-prober integration	≤ 5 mK
Zero Point Cryogenics (CA)	Model I · Model L (250–340 mm)	“Continuous Cold” 1 K stage	< 10 mK
Cryomech (US)	PT 4 K/ 1 K stacks (OEM)	Pre-cool for many DRs	n/a

Measurement Platforms (≥ 2 K)

Company	System	Range	Notes
Quantum Design (US)	PPMS VersaLab	50 K–400 K	3 T mini-magnet
	MPMS-3 SQUID	2 K–400 K	≤ 10^{-8} emu

Dewars & Cryogenic Vessels

Company (HQ)	Core Dewar product lines & capacity	Notes/ differentiators
Cryofab (US)	**CMSH** liquid-helium Dewars 20 – 500 L; custom transfer lines	Turn-key LHe storage for magnet labs
Chart MVE (US)	**XC/ CryoShipper** LN_2 shuttles 3 – 60 L	Life-science cold-chain shippers & biobanks
Cryo Industries of America (US)	*D-Stat* direct-connect Dewars & closed-cycle hybrids	Drop-in dewar-plus-cryocooler kits for low-vib optics

East-Asian Entrants & Emerging

Company (HQ)	System	Market position	Status
QuantumCTek (CN)	*EZ-Q Fridge*	Mass-production for domestic qubit fabs	Shipping since 2023
Origin Quantum (CN)	SL400/ SL1000	up to 1 mW @100 mK, ≥1,000 μW @10 mK	Shipping since 2024
Chinese state consortium	"EZ-Q" line	Govt-backed scale to 100s units/ yr	Ramp-up 2024
ULVAC Cryogenics (JP)	Next-gen DR (IBM co-design)	Target >2,000-qubit stacks	In dev., 2026 launch
Other domestic start-ups (CN, IN)	Lab-scale DRs	OEM PT modules	Market-watch reports

Dewars & Cryogenic Vessels

Company (HQ)	Flagship Dewar offerings	Market focus
Taiyo Nippon Sanso (TNSC) (JP)	LN_2 storage/ transport Dewars for 300 mm fabs	Semiconductor foundry bulk-gas logistics
Sumitomo — SHI Cryogenics (JP)	Stainless LHe/LN_2 Dewars 10 – 300 L paired to G-M coolers	OEM packages for GM-cooled optical cryostats

Size & Capability Spectrum (2025)

Tier	Representative systems	Footprint	P@100 mK	Typical users
Table-Top/ Insert	attoDRY-800/1100; Cryogenic STM; Leiden MCK	≤ 0.5 m²	≤ 50 µW	Nano-STM, academia
Ultra-Compact Floor	Bluefors Ultra-Compact LD	0.6–0.8 m²	~200 µW	Univ. qubit benches
Compact Floor (≈ 1 m²)	Bluefors LD / SD; Oxford Proteox S/MX; **QD DynaCool + DR insert**	0.8–1.1 m²	250–400 µW	Start-ups, mid-size labs
Large-Frame/ Multi-Qubit	Bluefors XLD/XL; ICE Eden; Leiden CF-CS-XXL; FormFactor XLF-600; Oxford Proteox LX/QX; ZP Model L	≥ 1 m²	0.6–1 mW	Scale-up R&D
Data-Center/ XXL	Bluefors KIDE; Cryoconcept XXL	> 1.4 m²	2–3 mW	IBM, Google, fabs
Mass-Production	QuantumCTek EZ-Q	auto gas-handling	0.3 mW	CN fabs
Next-Gen (road-map)	ULVAC 2,000-qubit DR	t.b.d.	t.b.d.	2026+

Footnote on DR “wet” outliers

Dilution Refrigerator (D-only) refers to > 90 % of new DRs, which are PT- or GM-pre-cooled. Legacy dip-stick DRs for wet helium baths (e.g., Oxford Heliox VL) still exist but are rarely purchased for new builds.

Cryogenic Vendors

Cryogenic Vendors
- Europe Tier-1
  - Dilution Refrigerators
    - Bluefors → Ultra-Compact LD, LD, XLD/XL, KIDE — 300 mm→1.6 m² plates (>4,000 RF) [D]
    - Oxford Instruments → Proteox S/MX, LX/QX — modular Triton successor [D]
    - Leiden Cryogenics → CF-1100, MCK — up to Ø 1 m, 4-PT option [D]
    - ICE Oxford → DRY-ICE Eden — 200-coax, <10 mK [D]
  - Dewars & Cryogenic Vessels
    - Wessington Cryogenics → PV/TPV LN_2 tanks (≤2,000 L), ISO bulk [L]
    - Statebourne → Helistor He (30–990 L), Cryolab LN_2, CryoCycl micro-bulk [L]
    - KGW-Isotherm → lab/transport Dewars (borosilicate & SS) [L]
    - Cryo Diffusion (Air Liquide) → LO/CDB/BIO LHe & LN_2 (47→2 250 L) [L]
    - Thames Cryogenics → LN_2 vessels 30–2,000 L + vacuum hoses [L]
- North America
  - Dilution Refrigerators
    - Quantum Design → PPMS DynaCool + DR insert — 50 mK, pulse-tube, cryogen-free [D]
    - FormFactor (HPD) → JDry, LF-400, XLF-600 — ≤5 mK, ≤270 coax [D]
    - Zero Point Cryogenics → Model I, Model L — “Continuous Cold” 1 K stage [D]
    - Cryomech → PT 1 K/4 K stacks for DR OEMs — OEM precoolers [D]
  - Non-Dilution Systems/ Measurement Platforms (cryogen-free, ≥2 K)
    - Quantum Design → PPMS DynaCool <u>without</u> DR insert — standard option (1.8K) [D]
    - Quantum Design → PPMS VersaLab (50 K–400 K, 3 T) [D]
    - Quantum Design → MPMS-3 SQUID (2 K–400 K, ≤10^{-8} emu) [D]
  - Dewars & Cryogenic Vessels
    - Cryofab → CMSH LHe dewars 20→500 L + transfer lines [L]
    - Chart MVE → XC/CryoShipper LN_2 biobanks 3–60 L [L]
    - Cryo Industries of America → “D-Stat” direct-connect dewars & hybrids [L]
- East Asia & Emerging
  - Dilution Refrigerators
    - QuantumCTek (CN) → EZ-Q Fridge [D]
    - CN State Consortium → EZ-Q scale-out platform [D]
    - ULVAC (JP) → next-gen DR (IBM co-design, ≥2026) [D]
  - Dewars & Cryogenic Vessels
    - Taiyo Nippon Sanso → LN_2 storage/transport tanks for fabs [L]
    - Sumitomo (SHI) → GM-pre-cooled LHe vessels 10→300 L [L]

Legend

- **[D]** cryogen-free (PT or GM pre-cooled), GM heads are rare in modern DRs; most large DRs are PT-cooled
- **[L]** requires stored liquid N_2/He

Key Trends (mid-2025)

- **KIDE ships & scales** – first 1.6 m² "cryo-house" fridges delivered to IBM & AIST Q-centres. (bluefors.com, bluefors.com)
- **Proteox replaces Triton** – Oxford's entire new-build catalog now lists Proteox S–LX; Triton lives on mainly in installed base. (nanoscience.oxinst.com)
- **FormFactor enters >500 mm club** – XLF-600 targets quantum-data-centre racks with 600 µW @ 100 mK. (formfactor.com)
- **Ultra-compact trend** – Bluefors shrinks LD footprint to <0.8 m² to fit power-lab closets. (bluefors.com)
- **China ramps EZ-Q** – domestic lines running since 2023; hundreds of units/year goal. (thequantuminsider.com, globaltimes.cn)
- **IBM–ULVAC collaboration** – next-gen DR co-designed for 2,000-qubit era, aimed at 2026 launch. (thequantuminsider.com)

All systems above are cryogen-free (pulse-tube-pre-cooled) unless explicitly labelled "wet" or "wet bath" (legacy Janis variants). Vendors continue to offer bespoke wiring looms, optical access, vector magnets and gas-handling automation, allowing the same base frames to serve superconducting-qubit stacks, SNSPD arrays, cavity optomechanics and nano-SQUID STM.

Mind-Map of DR/ Non-DR/ Dewar Sizes (Form-Factors)

Form-Factor Families — Dilution Refrigerators/ Non-Dilution Cryostats/ Paired Dewar Vessels

- **Table-Top/ Insert (< 0.5 m²)**
  - DR attocube attoDRY-800/ -1100
  - DR Cryogenic Ltd STM-insert DRs (UHV tubes)
  - Dewar KGW-Isotherm lab borosilicate/ stainless hybrids (< 30 L)
- **Ultra-Compact Floor (≈ 0.6 – 0.8 m²)**
  - DR Bluefors Ultra-Compact LD (≤ 300 mm plate)
  - Dewar Statebourne Cryolab & CryoCycl LN_2 micro-bulk (30 – 60 L)
- **Compact Floor-Standing (≈ 1 m²)**
  - DR Bluefors LD/ SD
  - DR FormFactor-HPD JDry-400 · LF-400
  - DR Oxford Instruments Proteox S
  - DR Quantum Design PPMS DynaCool + DR insert
  - Non-DR Quantum Design PPMS DynaCool without DR insert (standard option)
  - Non-DR Quantum Design PPMS VersaLab
  - Non-DR Quantum Design MPMS-3 SQUID
  - Dewar Cryofab CMSH liquid-helium Dewars (20 – 500 L)
- **Large-Frame (≥ 1 m²)**
  - DR Bluefors XLD/ XL
  - DR FormFactor-HPD XLF-600
  - DR Oxford Instruments Proteox MX/ LX
  - DR ICE Oxford DRY-ICE Eden
  - DR Zero Point Cryogenics Model L
  - DR Leiden Cryogenics CF-CS-XXL/ 1 m plate
  - Dewar Wessington PV/ TPV tanks · Cryo Diffusion LO/ CDB series (> 1,000 L)
- **Data-Center/ XXL (> 1.4 m² · multi-PT stacks)**
  - DR Bluefors KIDE (1.6 m² flange)
  - DR Cryoconcept HEXA-DRY XXL (Ø 800 mm)
  - DR QuantumCTek EZ-Q (mass-production line)
  - DR ULVAC next-gen DR (IBM co-design, slated ≥ 2026)
  - Dewar Taiyo Nippon Sanso bulk LN_2 tanks · Sumitomo (SHI) GM-precooled LHe vessels

Mind-Map of Cryogenic Vessel Platforms

Cryogenic Platforms for Quantum/ Metrology
- **4–300 K Range**
  - Bath Dewar (He-4)
  - Continuous-flow He-4
  - Closed-cycle Pulse-tube (1.5 K)
- **1 K Class**
  - Pumped-^{4}He VTI
  - Dedicated 1 K PT Stage
- **0.3–1 K Sorption Family**
  - ^{3}He “pump-on” insert
  - He-7 (^{3}He/^{4}He) sorption fridge
- **50–100 mK Magnetic Cooling**
  - ADR (single-shot)
  - Continuous ADR (CADR)
- **<50 mK Dilution Line**
  - Standard DR (lab workhorse)
  - Large-Frame DR (Proteox LX, XLF-600)
  - Data-Center/ XXL DR (Bluefors KIDE)

Mind-Map of Cryogenic Vessels with Usage Tags

Cryogenic Platforms for Quantum/ Metrology
- **4–300 K Range**
  - Bath Dewar (Academic-dominant)
  - Continuous-flow He-4 (Academic-dominant)
  - Closed-cycle Pulse-tube (Mixed)
- **1 K Class**
  - Pumped-^{4}He VTI (Academic-dominant)
  - 1 K Pulse-tube Stage (Mixed → Industrial-leaning)
- **0.3–1 K Sorption Family**
  - ^{3}He “pump-on” insert (Academic-dominant)
  - He-7 sorption fridge (Academic-dominant)
- **50–100 mK Magnetic Cooling**
  - ADR (Academic-dominant)
  - Continuous ADR (CADR) (Government Space-science)
- **<50 mK Dilution Line**
  - Standard DR (Mixed/ Balanced)
  - Large-Frame DR (Industrial-leaning)
  - Data-Center/ XXL DR (Industrial-only)

Academic vs Industrial Usage Table

Branch in the family tree	Typical users today	Representative evidence
Bath Dewar (He-4)	**Academic-dominant** — low-budget superconductivity, Hall-bar labs	University lab manuals & cryogenics texts list bath Dewars as "entry-level" cryostats. (research.physics.illinois.edu)
Continuous-flow He-4 cryostat	**Academic-dominant** — fast magnetotransport, microscopy	Oxford-type CF cryostats reported in research papers on magnetic microscopy. (pubs.aip.org)
Closed-cycle PT (1.5 K)	**Mixed** — academic spin qubit benches *and* industrial device screening	Pulse-tube coolers marketed for both lab R&D and industrial cryopumps. (thequantuminsider.com)
Pumped ^{4}He VTI (1 K pot)	**Academic-dominant** — custom magnet systems (MagLab, Neutron sources)	National MagLab lists 1 K VTI sample environments for users. (nationalmaglab.org)
Dedicated 1 K PT stage	**Mixed → industrial-leaning** — pre-cooling dense coax in qubit fabs	Bluefors XLD-He^{1}K systems pitched at spin-qubit foundries. (bluefors.com)
^{3}He "pump-on" insert (0.3 K)	**Academic-dominant** — graphene transport, thermometry courses	Cryogenic Ltd 300 mK insert for CFMS research suites. (cryogenic.co.uk)
He-7 (^{3}He/^{4}He) sorption fridge	**Academic-dominant** — CMB cameras, balloon telescopes	He-7 fridges specified in STRIP/LSPE CMB instrument papers. (researchgate.net)
ADR (single-shot 35–80 mK)	**Academic-dominant** — millikelvin STM, μ-SQUID probes	UHV STM platform cooled by single-shot ADR. (pubs.aip.org)
Continuous ADR (CADR)	**Government space-science** — NASA far-IR missions (industrial contractors build, but science-driven)	NASA's multistage CADR cited for space telescopes. (nrao.edu)

Standard dilution refrigerator (lab workhorse, ≤20 mK)	**Balanced** — every superconducting-qubit university *and* most start-ups own one	Bluefors & ICEoxford market DRs simultaneously to universities and start-ups.(bluefors.com)
Large-Frame DR (Oxford Proteox LX/QX, FormFactor XLF-600)	**Industrial-leaning** — multi-hundred-qubit prototypes at Rigetti, IQM, etc.	Oxford Proteox LX in Rigetti partner program;(oxinst.com) FormFactor XLF-600 positioned for "quantum data centers."(formfactor.com, formfactor.com)
Data-Center/ XXL DR (Bluefors KIDE, Cryoconcept XXL)	**Industrial-only** — IBM Quantum System Two, Google, national QC centers	First KIDE delivered to IBM; IBM blog confirms use for System Two.(bluefors.com, ibm.com)

Legend – "Academic-dominant" = >70 % of installed base in universities/public labs; "Industrial-leaning" = roughly even but trending commercial; "Industrial-only" = found almost exclusively in corporate fabs or government megaprojects.

Choosing the Right Variant

- **≥1 K work** – pumped-^{4}He or cryogen-free pulse-tube cryostats are cheapest and least complex.
- **0.3–1 K niche** – ^{3}He inserts or He-7 sorption coolers shine when you need vibration-free sub-kelvin temperatures for hours, not weeks.
- **50–100 mK stable "science-grade" base** – ADRs give motion-free cooling for space instruments; continuous ADRs are now hitting 50 mK nonstop.
- **Sub-50 mK, high wiring density (HDW), continuous uptime** – dilution refrigerators (and their KIDE-class big-siblings) are the *de facto* standard for quantum processors, SNSPD arrays, and precision Johnson-noise thermometry.

Comparison Between Familiar Compact vs. Large-Frame PT-Cooled Dilution Refrigerators

The **Quantum Design PPMS DynaCool** becomes a *compact* dilution refrigerator (≈ 1 m² footprint) when its 50 mK insert (aka DR insert) is installed. A single two-stage PT furnishes the 4 K stage, and a sealed ^{3}He/^{4}He loop cools from 300 K to ≈ 45 mK with no external dewars.

The **Bluefors XLDsl** is a *large-frame* PT-cooled refrigerator with the dilution circuit factory-integrated. Its 500 mm mixing-chamber flange, dual-PT stack and ≥ 1,000 μW cooling power at 100 mK support up to 1,008 coax/twisted-pair/FPC/optical lines delivered by hot-swappable High-Density Wiring “chandeliers.”

Thus both systems are cryogen-free dilution refrigerators, but they differ sharply in flange size, cooling power, wiring density and upgrade path rather than in the basic refrigeration principle.

Metric	PPMS DynaCool + DR Insert	Bluefors XLDsl
Footprint	≈ 1 m² floor unit	≥ 1 m² large frame
PT stages	1 two-stage PT	2 two-stage PTs
Mixing-chamber flange	305 mm	500 mm
Cooling power @ 100 mK	≈ 400 μW	≥ 1,000 μW
Base temperature	45–50 mK	< 10 mK
Wiring capacity	≤ 360 RF/DC lines	1,008 HD lines

What the Bluefors XLD “Chandelier” Really Is

Term	OEM language	Function
XLDsl Dilution Refrigerator Measurement System	Marketed as a *cryogen-free DR measurement system* with large experimental space.	The entire fridge—including still, heat-exchangers, mixing chamber—is already inside the vacuum can.
High-Density Wiring (side-load or top-load)	Bluefors calls the modular wiring loom “High-Density Wiring,” compatible with XLD.	Provides hundreds of coax/twisted-pair lines; resembles a metallic “chandelier.”
Colloquial “chandelier”	Community photos and forum threads show the gold-plated wiring tree hanging from the mixing chamber.	Visual nickname, not a refrigeration stage.

Key idea: the chandelier is **part of the wiring infrastructure**, not the refrigeration insert. You can call it a **high-density wiring chassis**, a modular loom that brings hundreds of coax, twisted-pair, optical fiber, or ribbon lines down to the mixing-chamber plate. In Bluefors systems the dilution unit is permanently integrated; users add or swap chandeliers (wiring modules, attenuators, filters) to suit qubit count, signal bandwidth, or device technology.

How to Tell an Insert from a Wiring Tree/ Chassis

Indicator	Dilution Refrigerator Insert	Wiring “Chandelier”
Contains still, heat-exchangers, mixing chamber	**Yes**	No
Circulates ^{3}He/^{4}He mixture	**Yes**	No
Must connect to gas-handling system	**Yes**	No
Bolts to 50 mK plate; routes cables & attenuators	Optional plate on bottom	**Primary purpose**
Delivered as stand-alone module for a pre-existing 4 K cryostat	DynaCool DR insert (dry)	N/A—comes with chassis

Glossary of Acronyms

Acronym	Full term / meaning	One-line context / why it matters
ADR	*Adiabatic Demagnetization Refrigerator*	Single-shot magnetic-salt cooler that reaches 50–100 mK without circulation gas
CADR	*Continuous ADR* (multiple ADR stages run out-of-phase)	Provides 40–70 mK indefinitely for space telescopes and sub-mm detectors
CCR	*Closed-Cycle Refrigerator* (industry shorthand for a PT-based cryostat)	Two-stage PT inside a vacuum can; "1.7-4 K CCR" in your platform table
DR	*Dilution Refrigerator*	Continuous ^{3}He/^{4}He mixing loop for <10 mK physics; all large quantum stacks use one
FPC	*Flex-Printed-Circuit* cabling option in Bluefors High-Density Wiring	Brings hundreds of signal lines on ribbon-like copper traces
GM	*Gifford–McMahon* cryocooler head	Alternative to PT for 4 K precool; more moving parts
HDW	*High-Density Wiring* (Bluefors "chandelier")	Hot-swappable loom that carries up to 1,008 coax/twisted-pair/FPC/optical lines
He-7	^{3}He/^{4}He *triple-stage* sorption refrigerator	Reaches 200 mK with no mechanical pump; useful for balloon CMB cameras
KID	*Kinetic Inductance Detector*	Ultra-low-noise sub-K photon sensor for CMB astronomy; often mounted in sorption or DR stages
LN_2/ LHe	*Liquid-Nitrogen* / *Liquid-Helium* baths	Classic 77 K and 4.2 K cryogens for "wet" platforms
PDR	*Paramagnetic (or Praseodymium) Demagnetization Refrigerator* – a rare-earth variant of ADR	Shown as "ADR / PDR 50–100 mK" in the tree; same physics, different salt choice
PT	*Pulse-Tube* cryocooler	Vibration-isolated 50 K / 4 K stages that make modern DRs "dry"
RF/ SMA	*Radio-Frequency* signals and the **SMA** coax connector standard	Large DR flanges quote "128 SMA" or ">4,000 RF lines" for qubit wiring

SNSPD	*Superconducting Nanowire Single-Photon Detector*	Cryogenic optical detector packed by the thousand in big DRs
SQUID	*Superconducting Quantum-Interference Device*	μ-SQUID microscopes often cooled by ADRs
STM	*Scanning-Tunnelling Microscope*	Millikelvin STMs ride in single-shot ADRs or DRs for ultra-low-vibration measurements
TES	*Transition-Edge Sensor*	Cryogenic calorimeter used with KID arrays in He-7 or DR stages
UHV	*Ultra-High Vacuum*	Vacuum environment ($<10^{-9}$ mbar) required by some millikelvin STMs and DR sample inserts
VTI	*Variable-Temperature Insert* (pumped-^{4}He "1 K pot")	0.8–1.2 K intercept for dense coax bundles before the mixing chamber

Glossary of Special-Purpose Cryogenic Platforms

Platform	What it is/ How it works	Operating window & duty-cycle	Where you meet it in practice
^{3}He "pump-on" insert (single-shot He-3 pot)	A sealed reservoir of ^{3}He gas is condensed onto a tiny pot by a charcoal sorption pump; once the pump is cooled and evacuated, evaporative cooling drives the pot to ≈ 300 mK. No moving parts after start-up.	**1.5 K → 300 mK** for **12–48 h**, then needs warm-up & recycle.	Graphene/mesoscopic transport, Johnson-noise thermometry, low-vibration optics.
He-7 sorption refrigerator (^{3}He/^{4}He triple-stage)	Cascaded charcoal pumps: first ^{4}He precools to ~1 K, then two ^{3}He stages reach 300 mK and 200 mK. Entire unit is bolt-on and vibration-free.	**1 K → 200 mK**, single-shot **24–72 h**.	KID/ TES detector cameras, balloon-borne CMB telescopes, portable sub-K test stands.

Adiabatic Demagnetization Refrigerator (ADR)	Magnetize a paramagnetic salt pill at 4 K, then demagnetize it adiabatically; magnetic entropy turns into cooling reaching **50–100 mK** (≈ 35 mK with modern salts). No circulation gas.	Single-shot **8–24 h** below 100 mK.	Ultra-low-vibration STM, μ-SQUID scanners, small space payload prototypes.
Continuous ADR (CADR)	Several ADR stages run out-of-phase; while one stage warms, another cools, so the cold tip stays at **≈ 50 mK indefinitely** (≈ 10 μW cooling power).	**Continuous 40–70 mK** operation, weeks to months.	Far-IR bolometers & X-ray micro-calorimeters on NASA space telescopes.
Pumped-^{4}He "1 K stage"	A mechanical pump lowers vapor-pressure of a small ^{4}He bath or JT loop, giving a **1 K plate** that intercepts heat from hundreds of coax lines before they enter a dilution unit.	**4 K → 0.8–1.2 K**, runs as long as the pump does.	Pre-cool wiring in big dilution fridges; basic magnetotransport below 2 K.
Pulse-tube cryostat (CCR 1.7–4 K)	Two-stage pulse-tube cooler inside a vacuum can; cryogen-free. Some models (QD OptiCool, DynaCool+DR) accept DR or sorption inserts down to 50 mK.	**300 K → 1.7 K** (OptiCool) or **→ 50 mK** with DR insert, fully continuous.	Cryo-CMOS & spin-qubit test rigs, optical spectroscopy with vector magnets.
Large-scale dilution refrigerator (≥ 1 m² plate)	Pulse-tube precooling plus continuous ^{3}He/^{4}He mixing. Examples: **Bluefors KIDE** (1.6 m², >4,000 RF) and **Oxford Proteox LX** (≤ 450 mm plate, 128 SMA).	**4 K → ≤ 5 mK**, continuous; **0.5–3 mW** at 100 mK depending on model.	100–1,000 qubit quantum-computer racks, large SNSPD arrays, cryo-data-centres.

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