Liverpool's Cryostat + Magnet: Current Status and Plans & Liverpool–IISc Programme

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The system at a glance

- **Magnet:** American Magnetics 8 T split-pair NbTi, built 2006, persistent switch
- **Cryostat:** custom three-vessel design
  - 1st vessel: outer vacuum chamber (OVC)
  - 2nd vessel: LN_2 shield (annular)
  - 3rd vessel: LHe bath with the split-pair NbTi coils
- **Manufacturer:** PRESS-MAG-O; **Origin:** INFN Laboratori Nazionali di Frascati
- **History:** no documented cool-down since 2012; arrived in Liverpool in June 2026
- **Current Operational Location:** B53 (in Chemistry)

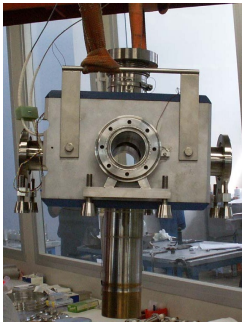
Key numbers and Planning

8 T peak field · ∼100 L LHe per run · monthly runs, ∼3 days each

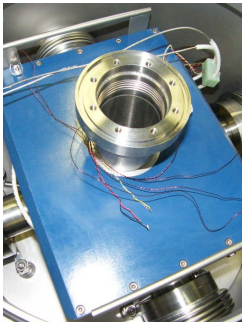
The system (disassembly at LNF)



AMI 8 T split-pair magnet
As delivered by American Magnetics



Magnet on its cross mount
On the handling tool used for insertion



Magnet inside the LHe vessel
Cross flanges closed with indium seals



LHe vessel wrapped in MLI
Lowered into the LN_2 vessel

What the magnet will be used for

SQUIDs and JPAs in magnetic fields

In-field characterisation of superconducting devices made at IISc, under the Liverpool–IISc Joint Seed Fund.

Quantum amplifiers for FLASH

SQUID, HEMT and TWPA amplifiers, and SQUID shielding in field, for the FLASH ALPs, DP and HFGW haloscope.

Towards new experiments

A facility for the group's quantum-sensing programme, including future LFM (dark-matter and gravity test at short distance) and VE experiment.

Progress since arrival (June – November 2026)



June

System delivered from INFN-LNF to Liverpool, then located in B53. (David Sim)

July – August

Inventory checked against the as-built record; missing parts identified.

Plan for construction and cool-down. (INFN-LNF)

September

LHe plan drafted: buy from BOC, through the School account, enough LHe for **two cold runs** (∼300 L).

Aim: study the cryostat's performance (boil-off rate) before regular use.

Purchase after assembly.

October

Geometry re-measured: additional 1.2 m bellows (not in LNF drawings).

B53 survey: ceiling, door, volume, ODH.

Helium recovery and liquefier options (Quantum Design).

First two fills re-planned from the corridor.

Now

B53 confirmed as the location.

LHe use in B53 approved.

Legs cut by 300 mm: stand now 550 mm.

Gantry crane purchased: Sealey SG1000KIT, BigDug. (D. Sim)

Months approximate.

Main challenges

Hardware gaps
Missing bracket, nuts, screws, O-rings and flanges; level sensors no longer present; all replacements non-magnetic.

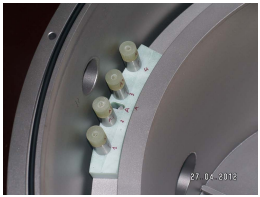
Helium supply
Physics liquefier out of service; BOC takes no new customers, so LHe comes through the School account. Boil-off is not recovered or returned to BOC (Konstantin Luzyanin).

Room geometry (B53)
2.74 m ceiling and a fixed 1.2 m bellows. Legs cut by 300 mm (stand 550 mm). The dewar needs ≈ 2.9 m, considering also the rigid stinger of the transfer line; the first fills are done from the corridor.

Safety in the small room and corridor
LHe use approved, but a $\sim$100 L quench releases $\sim$75 m^3 of helium, close to the room volume (75–85 m^3): monitors and alarms first. Corridor filling be agreed with H&S (Rob Valentine).

Cross-cutting: the work spans Physics, Chemistry, Health and Safety, NP (vacuum) and LNF (parts); one agreed sequence keeps it moving.

Hardware gaps flagged in the as-built record



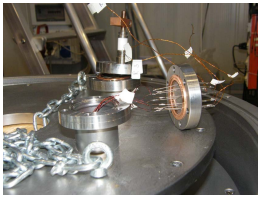
3rd-vessel support bracket



Insert-flange closure nuts
Missing; replace with non-magnetic hardware



Insert-tube retaining screws
In one arm of the cross; to be found or replaced

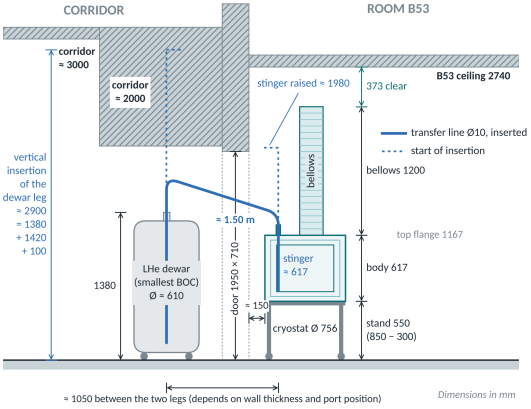


CGR level sensors
No longer present; replace with new thermometry

Also outstanding: O-rings and flanges (iterating with LNF), fresh indium for every seal, and new bellows-compression brackets.

Photos: PRESS-MAG-O cryostat as-built record, INFN-LNF. CGR: carbon-glass resistor.

First two fills: LHe from the corridor



Dimensions in mm, from the B53 height check;

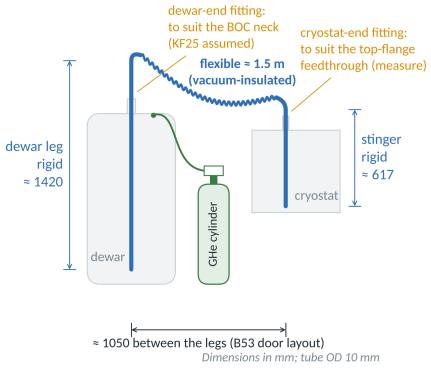
dewar total height (∼1420), for 120 L of LHe − BOC.

Until the liquefier is available

1. Stand at 550 mm (legs cut by 300 mm); roll the cryostat to the B53 door, fill port facing the door.
2. LHe dewar stays in the corridor, pressurised with GHe from a cylinder; insert the dewar leg there (≈ 2.9 m needed).
3. Pass the line through the door (≈ 1.5 m high), raise the stinger (≈ 2.0 m) and insert it into the cryostat.

Corridor heights ≈ 3 m and ≈ 2 m; wall thickness and port position (line span); use of the corridor agreed with H&S.

Key procurement: the LHe transfer line



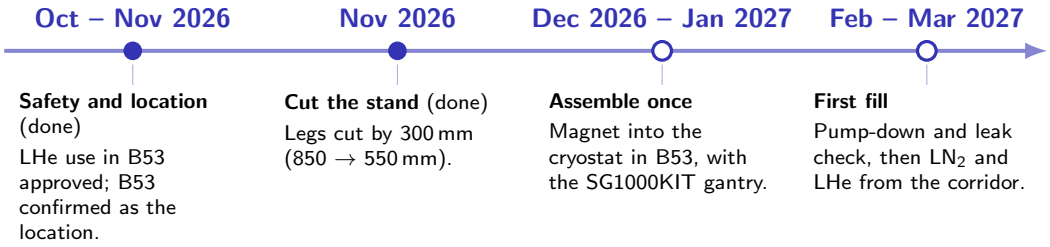
Next: BOC for the leg length and neck fitting; request quotes now (custom item). A two-piece dewar leg would also allow fills inside B53 later.

Why it matters: we have to buy one; it is needed for every LHe fill, so it is on the critical path to the first fill (Feb – Mar 2027). A different transfer line for the Quantum dilution system?

Specification

- **Tube:** vacuum-insulated, 10 mm OD
- **Dewar leg:** rigid, ≈ 1420 mm, inserted in the corridor
- **Flexible section:** ≈ 1.5 m, through the door at ≈ 1.5 m
- **Stinger:** rigid, ≈ 617 mm, into the top-flange feedthrough
- **Ends:** BOC dewar neck (KF25); cryostat feedthrough (measure)
- **GHe:** cylinder and regulator to pressurise the dewar during the transfer. (In contact with Chemistry)

Path to the first cool-down (first milestone)



In parallel

- Missing parts with INFN-LNF
- Vacuum pumping station (NP)
- LHe transfer line: quotes and order
- New thermometry and level probe
- Risk assessment and B-field monitoring

Filled markers: done · open markers: planned.

Liverpool–IISc programme

SQUIDs and JPAs in magnetic fields

Liverpool–IISc programme: SQUIDs and JPAs

Joint Seed Fund 2026–27 · PIs **Gianluigi Casse** (Liverpool), **Vibhor Singh** (IISc) · started 15 October 2026

IISc: devices and specifications
Provides the SQUIDs and JPAs; specifies the DC and RF wiring and the measurement approach.

Liverpool: sample board and coordination
Coordinates the campaign; designs and makes the sample PCB (Ashley Greenall); brings the board and the SQUID to Lancaster.

Lancaster: fridge and magnet
Hosts the dilution refrigerator. DC wiring confirmed; RF set-up being finalised together. (Jonathan Prance, Michael Thompson)

Aims and deliverables

- In-field characterisation of IISc SQUIDs and JPAs
- Fabricate–measure–redesign loop between the sites
- Open-source `Python/QCoDeS` characterisation toolkit
- Reciprocal two-week exchanges (PhD students, postdocs)
- Dissemination workshop in project month 9
- Case for follow-on funding: UKRI FLF, EPSRC NQTP, ERC StG, STFC

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IISc programme: first test campaign at Lancaster

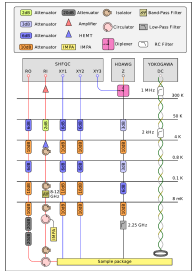
Requirement	SQUID	JPA
Test mode	DC	RF, around 6 GHz
Magnetic field	About 1 mT	About 1 mT
Wiring	DC lines, on-board RC and RF filters	RF lines, as in the figure
Geometry	Two Josephson junctions in a loop	To be specified by IISc
Sample board	New compact board (Liverpool)	New compact board (Liverpool)

Ongoing fine-tuning organisation with Lancaster

- Choosing the fridge: Bluefors (5 T solenoid) or Triton 400
- Matching RF lines, attenuation and HEMT to the JPA
- Fitting our board on the mixing-chamber plate
- Planning test slots around the cool-down cycle
- Applying $\sim$1 mT: solenoid at low current or a local coil

First measurement

- **Device:** an Al SQUID already tested at IISc
- **Measure:** critical current from the I–V curve
- **Where:** dilution fridge at Lancaster, most likely Bluefors (10 mK, 5 T solenoid)
- **Board:** copper PCB made at Liverpool from the IISc design, about 1 day to machine
- **Logistics:** about 4 weeks for shipment



Measurement RF lines set-up: R. Li *et al.*, PRX **14**, 041050 (2024), Fig. 6 (CC BY 4.0).

Lines to consider (IISc): RI and Z, without the 2.25 GHz low-pass filter.

IISc–Liverpool kick-off meeting (28 Sep 2026) and dilution-fridge planning with IISc and Lancaster.

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IISc programme: timeline



Start-up

Kick-off meeting, 28 Sep.

Grant starts, 15 Oct.

Wiring and board requirements gathered.

Preparation

Sample PCB made at Liverpool from the IISc design. (A. Greenall)

Devices shipped ($\sim$4 weeks).

Shared `QCoDeS` toolkit set up.

First tests

mK tests at **Lancaster: AI SQUID** critical current, then **JPA** at $\sim$6 GHz.

Higher-field mK tests (Feb – Mar).

First report, end of March.

High field and outreach

AMI 8 T magnet at field: high-field tests at 4.2 K.

Exchanges; workshop in month 9 ($\approx$ Jul).

Seed fund ends in Oct; follow-on bids.

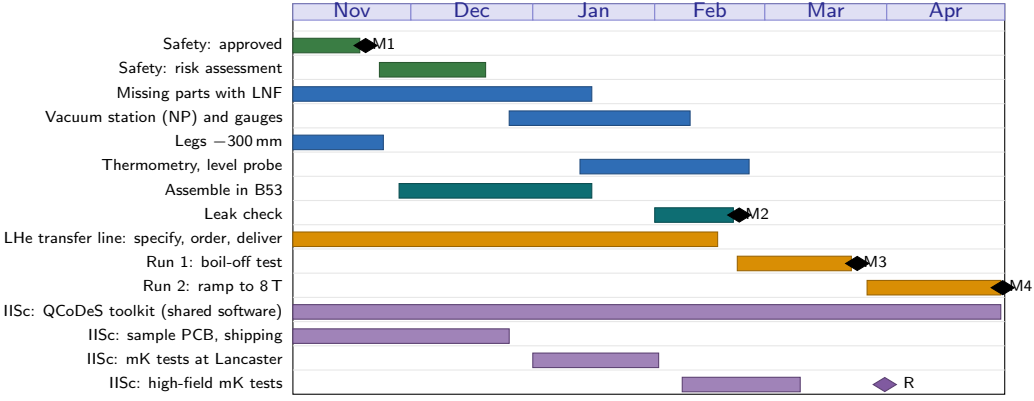
Milestones: kick-off (Sep 2026), first report (end Mar 2027), workshop ($\approx$ Jul 2027), end of the seed fund (Oct 2027).

Link to the AMI magnet: the first tests need millikelvin temperatures, so they run at Lancaster; the 8 T magnet (4.2 K bath) adds high-field tests later. *Gaining experience*

Future projects: LFM for ultra-light DM search and GR at short distance; VE QED test experiments

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Next 6 months: November 2026 – April 2027



Milestones: M1 B53 decided (Nov) · M2 vacuum-tight (Feb) · M3 first cool-down (Mar) · M4 magnet at 8 T (Apr) · R Liverpool–IISc report (end Mar)

Additional slides

Status, reference set-up and safety details for questions

Status by subsystem

Subsystem	Status	Next step
Location	**Done:** B53 (Chemistry) confirmed	Position the cryostat by the door
Safety	**Done:** LHe use in B53 approved	Finalise risk assessment; install O_2/He monitors
Stand and lifting	**Done:** legs cut by 300 mm (850 $\rightarrow$ 550 mm); Sealey SG1000KIT gantry purchased (BigDug)	Lift plan for assembly (LOLER); gantry set $\leq$ 2.7 m
Magnet	**In progress:** inspected and stored; not yet installed	Insert into the LHe vessel
Cryostat vessels	**In progress:** missing 3rd-vessel bracket, closure nuts, insert screws, O-rings and flanges	Source or fabricate, with LNF
Vacuum	**In progress:** pumps, gauge and connections to secure	Pumping from NP; leak detector (loan or quote)
Transfer line	**In progress:** needed for every LHe fill; geometry set by the corridor fill	Confirm BOC neck and leg; quotes and order
Instrumentation	**On hold:** CGR level sensors no longer present; fasteners must be non-magnetic	New thermometry and LHe level probe
Cryogens	**On hold:** liquefier out of service; first two fills from BOC dewars in the corridor	Order $\sim$300 L LHe after assembly

Schedule: first cool-down now planned by March 2027.

Reference set-up: R. Li *et al.*, PRX **14**, 041050 (2024)

RIKEN–Toshiba, *high-fidelity CZ gate with a double-transmon coupler*: our reference for the JPA RF chain.

Key results

- CZ gate: $99.90 \pm 0.01\,\%$ (48 ns), stable over 12 h
- Single-qubit gates: $> 99.98\,\%$
- ZZ on/off ratio $\approx 1.3 \times 10^4$
- $T_1 > 200\,\mu$s (Ta on Si, Al junctions)
- Readout via an IMPA (impedance-matched JPA)
- Chip on a home-designed PCB, Cu package, flux-bias coil outside

Line	**Wiring, 50 K → 8 mK** (BlueFors LD400; Fig. 6)
Readout in	6, 10, 6, 10, then $10 + 20 + 20$ dB at 8 mK (≈ 82 dB)
Qubit drive	6, 10, 6, 10, 10 dB (42 dB)
Fast flux	3, 10, 3, 6, 10 dB (32 dB); 2.25 GHz low-pass
Readout out	circulator, IMPA, isolators, 8–12 GHz band-pass; HEMT at 4 K; amplifier at 300 K
DC flux bias	twisted pair; RC filters $\sim$1 MHz (300 K), $\sim$2 kHz (4 K)
Shielding	Al can and two-layer μ-metal at base

What it means for our JPA tests

- $\sim$80 dB input attenuation and isolators before the HEMT: compare with the Lancaster lines.
- Band-pass filter and isolators to be chosen around 6 GHz, not 8–12 GHz.
- They shield the field; we apply $\sim$1 mT with a coil outside the package, as for their flux bias.

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Safety: quench and oxygen depletion in B53

$\sim 75\ \mathrm{m}^3$

of helium gas from a quench of $\sim$100 L LHe (room temperature, 1 atm)

$75\text{–}85\ \mathrm{m}^3$

estimated volume of B53

Risk assessment in preparation

- LN_2 and LHe release
- Stray magnetic field
- Alarms and interlocks
- Liquid on the floor
- Magnet quench and venting
- O_2 monitors and He sensor
- Signage and access control
- Corridor transfer and escape route

LHe use in B53 has been approved. The risk assessment, O_2 and He monitors and alarms must be in place before the first fill.

Summary and discussion: what we need

What we need

1. Workshop time: bracket fabrication and fittings
2. Vacuum pumping (from NP) and a He leak detector (loan or quote)
3. An LHe transfer line, dewar to cryostat (specify and order now)
4. Cryogens for two initial runs, including a boil-off test before commissioning ($\sim$300 L LHe)
5. Student effort, with my own time, for commissioning and the IISc measurements

Bottom line

- Location and safety settled: B53, LHe use approved.
- The hardware is largely understood, the gaps are known, and the gantry crane is in place.
- First cool-down by March 2027, then FLASH measurements (SQUID shielding in field) from spring 2027.
- IISc: first mK SQUID tests at Lancaster; first report at the end of March 2027.