# BGC Tests on HEL Test Stand

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With thanks to

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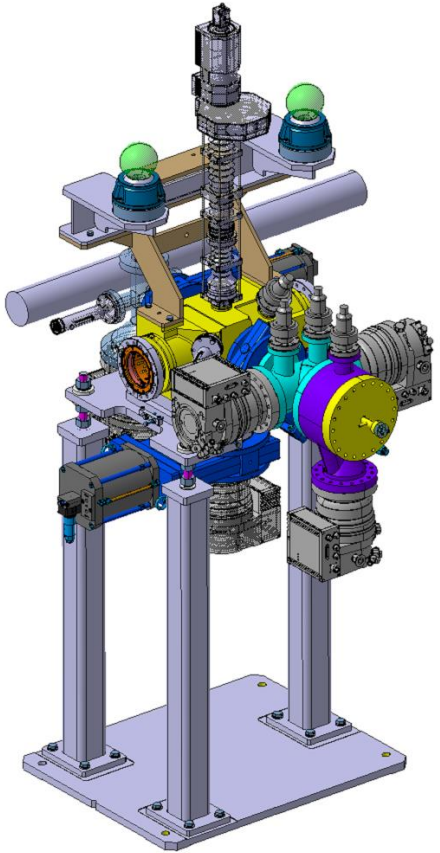
# Introduction and Status

- Gas jet diagnostic R&D funded by HL-LHC as part of UK-HL collaboration
  - 2 instrument deliverables with tests and personnel
  - First deliverable (called v2) is built and being tested at Cockcroft Institute (CI) with a 0.65 mW/5 keV CW electron gun
  - Second instrument (v3), designed for LHC installation, will be delivered early 2020, with Phase 1 integrated directly in LHC
    - This is the instrument we will install on the HEL test stand
    - Latest details from BGC collaboration meeting [*] held 2 weeks ago at CI
  - CI have submitted proposal for phase II production in-kind
- Background gas experiment in the LHC
  - An optical system, observing the existing BGI  background gas injection system in the LHC was approved and installed in the LHC in YETS 17/18
  - This took data for protons and heavy ions at injection and top energy during the 2018 run
  - Very interesting preliminary data – will request an upgraded system for run 3, using the v3 interaction chamber

[*] https://indico.cern.ch/event/817655/

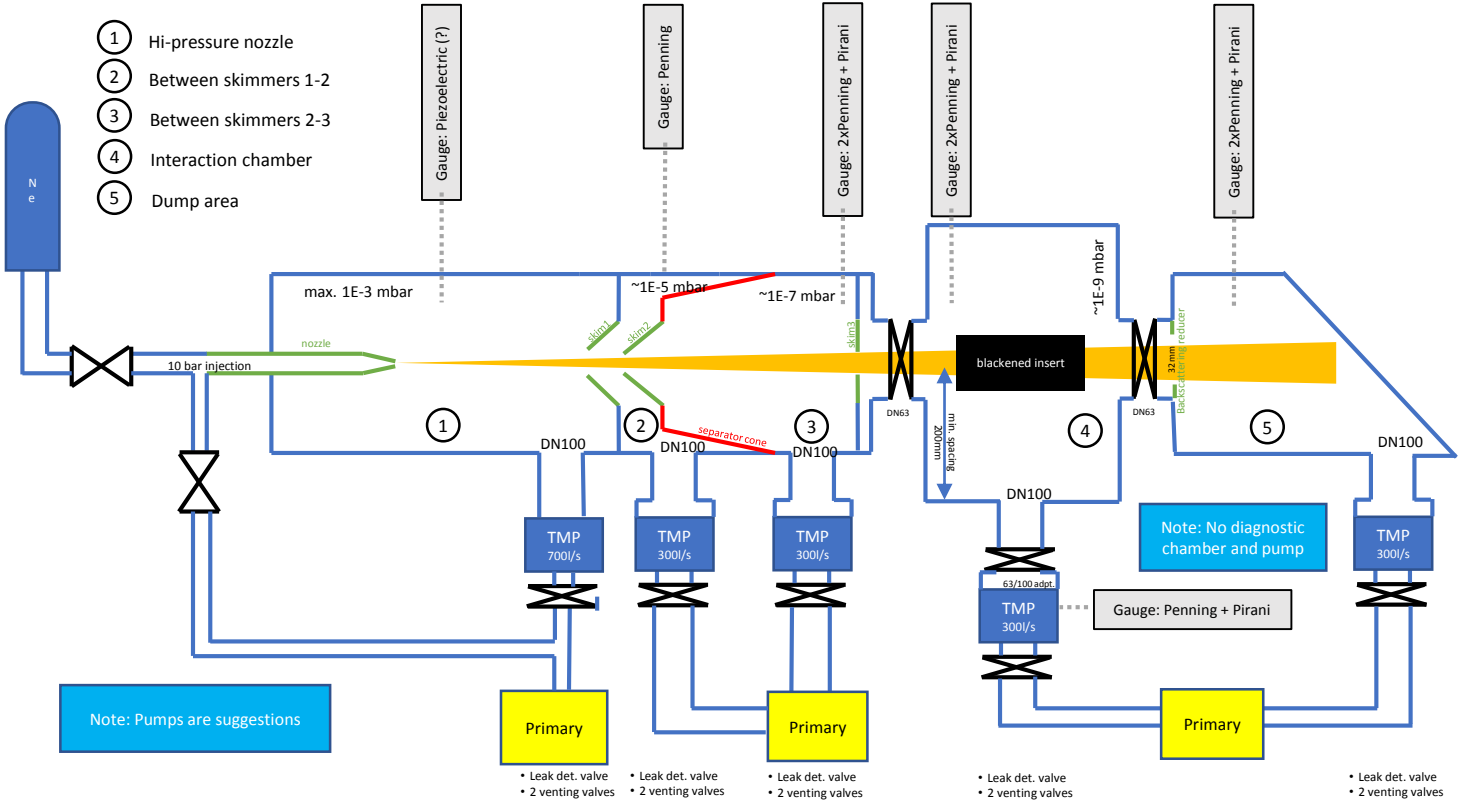
# BGC demonstrator v3 design

- Phase 1
  - Interaction chamber
  - BGC supports
  - Optical and geometer supports
  - Optical calibration target
- Phase 2
  - Gas injection
  - Dump
  - Pumping
  - Optics design

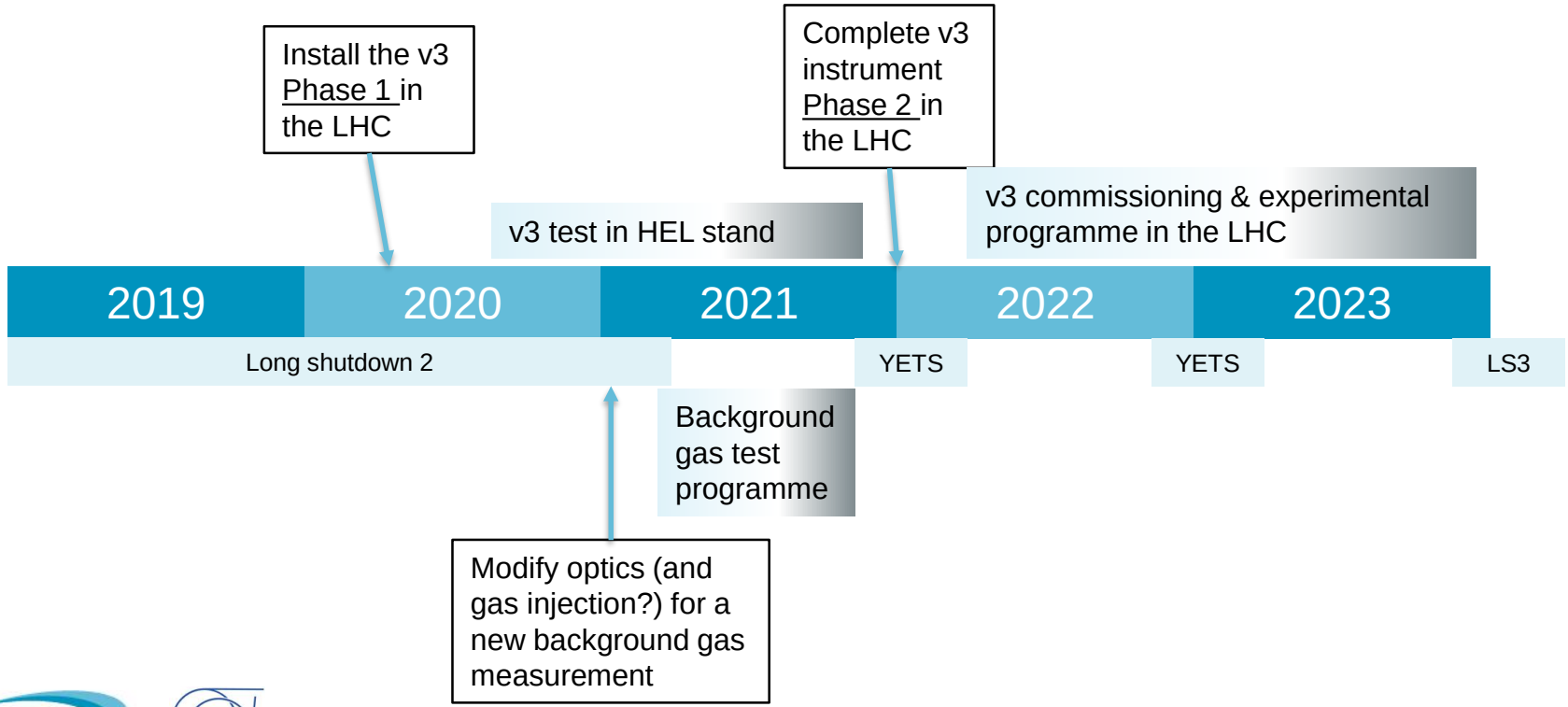


BGC tests on the HEL test stand

# BGC demonstrator (V3) Vacuum Layout



# BGC experimental roadmap

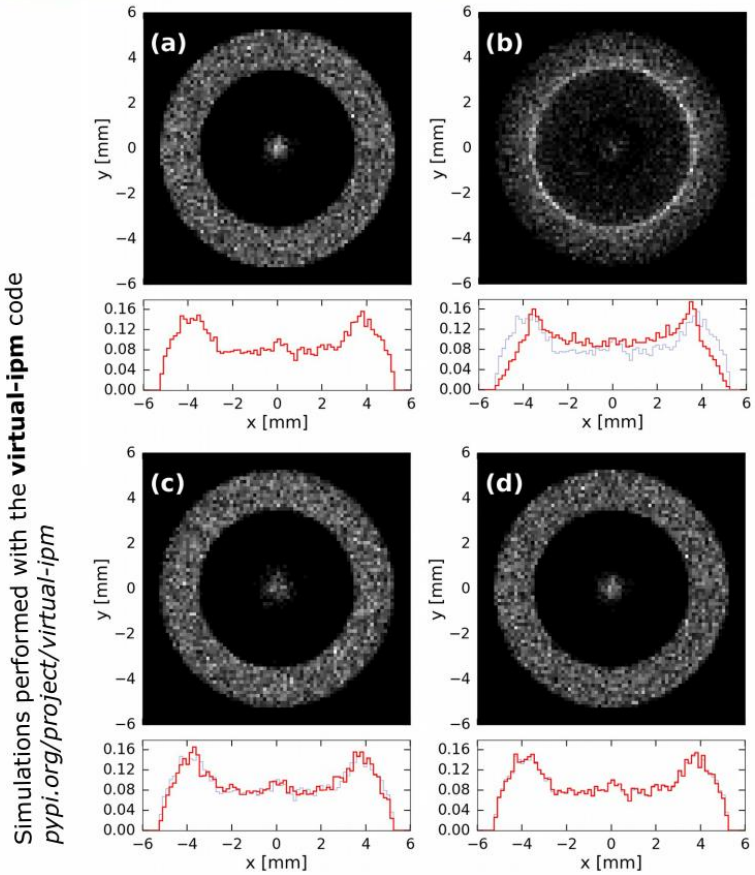


# Summary of experimental goals on HEL test-stand

- Validating the e- image for the instrument
  - Validating extrapolations from the Cockcroft test programme for higher intensity and signal/noise
  - Studying/mitigating photon noise background from the HEL e-gun
- Interactions with solenoid field
  - Exploring signal distortions from solenoid field (for N2 and Ar)
  - Potential electron trapping and remedies (clearing electrode)
- Validation of the full experimental and vacuum set-up at CERN before LHC installation
  - Operation with the full vacuum control system
  - Injection of background gas (Ne, N2, Ar) allows for benchmarking with CI results

➢ The ideal HEL test stand will duplicate the final HEL operating conditions as closely as possible

# Simulations of expected images for $N_2^+$, $Ne^+$ and $Ar^+$




Simulations performed with the **virtual-ipm** code *pypi.org/project/virtual-ipm*

2D and 1D histograms of the detected photons assuming **ideal gas curtain and optics with unit magnification**. The bin size is 0.15 mm. The 1D histograms are normalized.

**(a)** No distorsions
**(b)** $N_2^+$, $\tau_{BIF}$ = 60 ns
**(c)** $Ne^+$, $\tau_{BIF}$ = 11 ns
**(d)** $Ar^+$, $\tau_{BIF}$ = 9 ns

The 1D histogram from (a) is reproduced in grey in all the others.

**Simulation parameters**

$B_{sol}$ = 1 T
$I_e$ = 5 A
$D_e$ = 10.5 mm
$d_e$ = 7 mm
$\langle I_p \rangle$ = 1 A
$\sigma_{tp}$ = 0.3 mm
$4 \cdot \sigma_{lp}$ = 1.01 ns
$N_y^e \approx 12500$
$N_y^p \approx 250$

Such simulations should be performed with a realistic gas curtain too for a better reproduction of the image to be expected.

# HEL test stand constraints

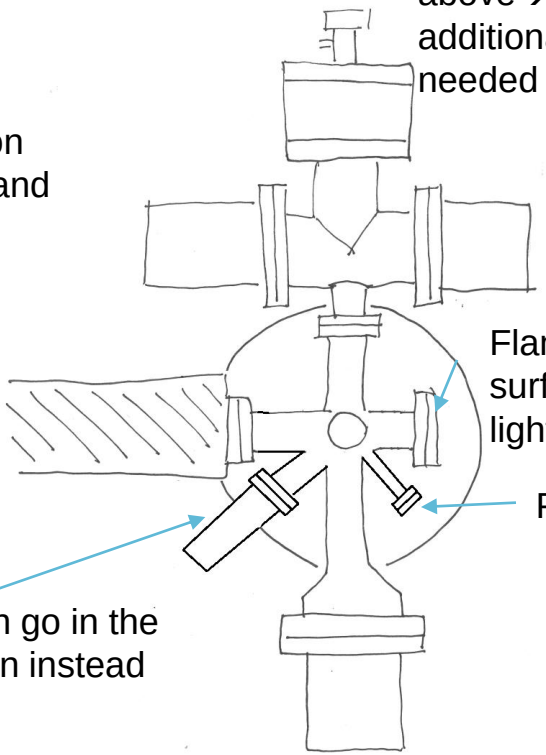
- 5 A intensity, but initially limited to 2x10e-4 duty cycle (limited by collector/YAG screen)
  - Camera (and even gas) can be gated, so signal/noise will be an improvement on the CI test stand
  - However, integrated intensity is 1 mA cf. 0.65 mA at CI, so data integration times will not significantly improve
  - Would like to push duty cacle as close as possible to HL operating conditions
- Geometry of gun and solenoids is different from the final design
  - Can make some tests for photon background and mitigation (masking/blackening of surfaces)
  - Would be interesting to move the HEL to a distance from the gun that is close to the final design
  - We could make preliminary tests for electron trapping, but would need simulations too

# BGC On HEL test design (Preliminary!)

Gas injection from above→ no additional support needed here

Support?
→ Maybe change the position for calibration target port or/and port for clearing electrode

No intersection with cooling devices for the magnets on the right



optics

Flange with blackened surface, in the shadow of egun light

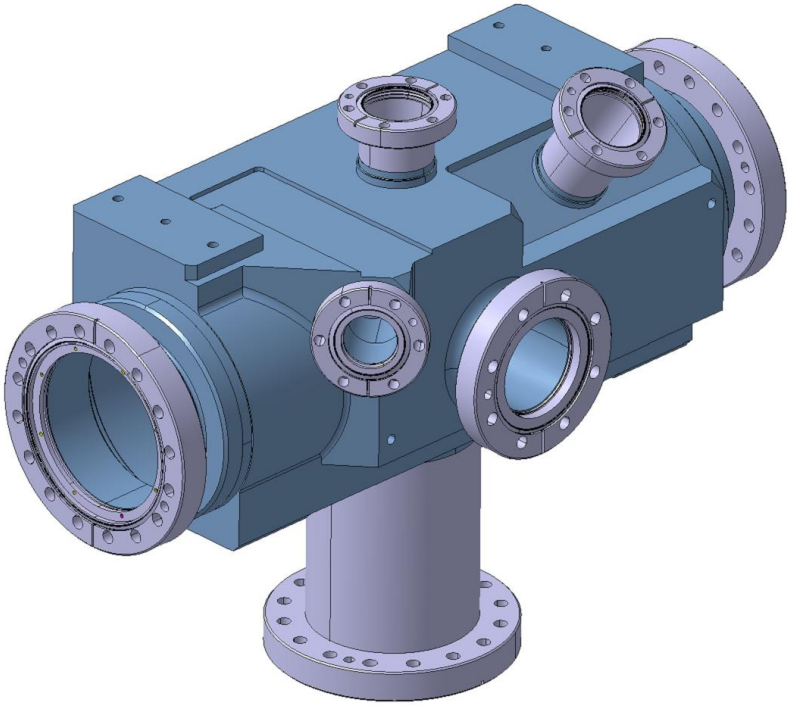
Port for clearing electrode

Calibration target can go in the precise beam position instead of above

Gas jet shoots at a pump

# HEL Test specific

- Complete re-design of Interaction chamber
- Support System
- Valves?



BGC V3 Interaction chamber to be redesigned for HEL

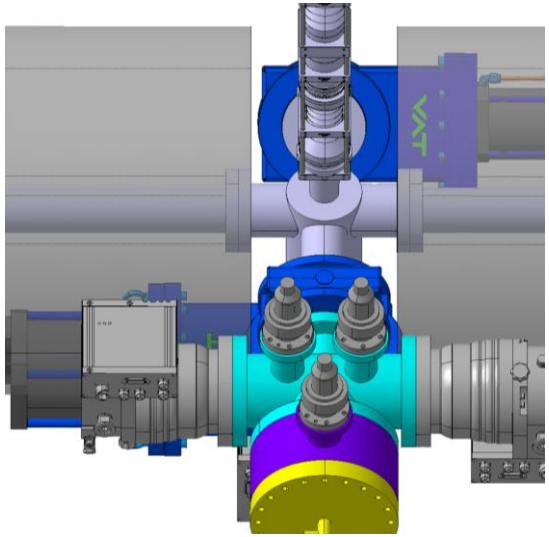
# Summary

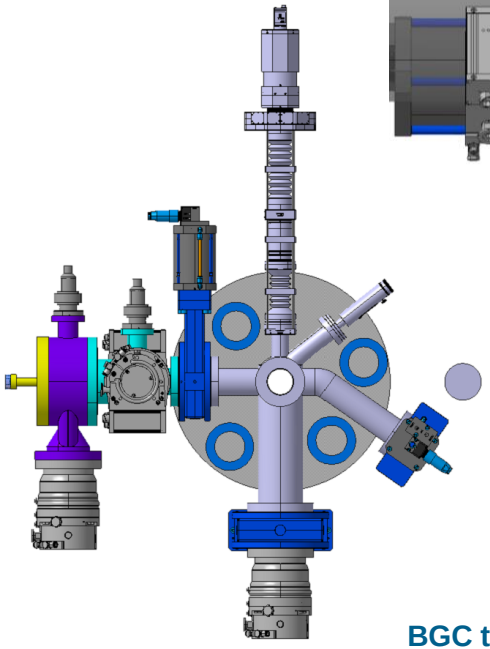
- BGC v3 is planned for installation on the HEL test stand in summer 2020, with test programme window upto end of 2021
  - Will need design/production of a dedicated interaction chamber
- Basic test objectives are identified
  - This is being iteratively developed between HEL and BGC
  - Personnel for testing would also be available with a successful UK-HL Phase II in-kind collaboration
- There are some limitations for the HEL test stand WRT final HEL
  - These need to be clearly identified (ultimate test stand vs. installed HEL) and mitigations put-in-place
  - Will there be testing on the final HEL before installation?
- This HEL test stand will be an important step for the qualification of the ‘High intensity hollow e-beam’ part of the BGC performance

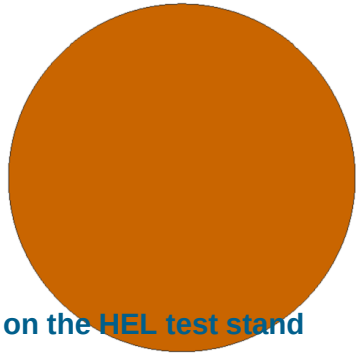
# *Backup slides*

# BGC HEL study inner beam line

- Significant space constraints
- Highly optimised design
- Challenging assembly







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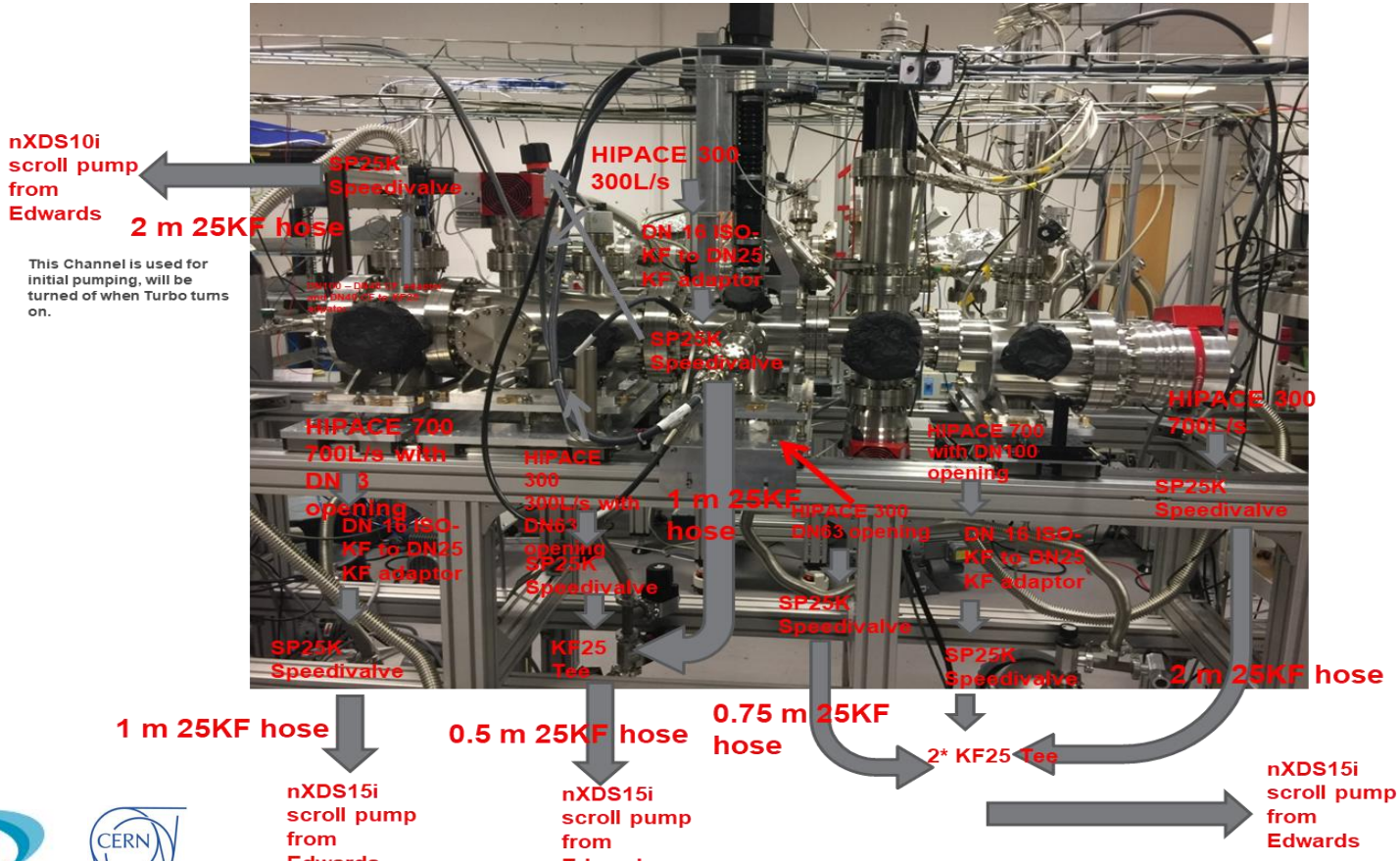
# BGC Laboratory Design use at Cockcroft




Courtesy: E. Page, H. Zhang