Fermilab | U.S. DEPARTMENT OF ENERGY | Office of Science

Introduction of LAr Detector Engineering at FNAL

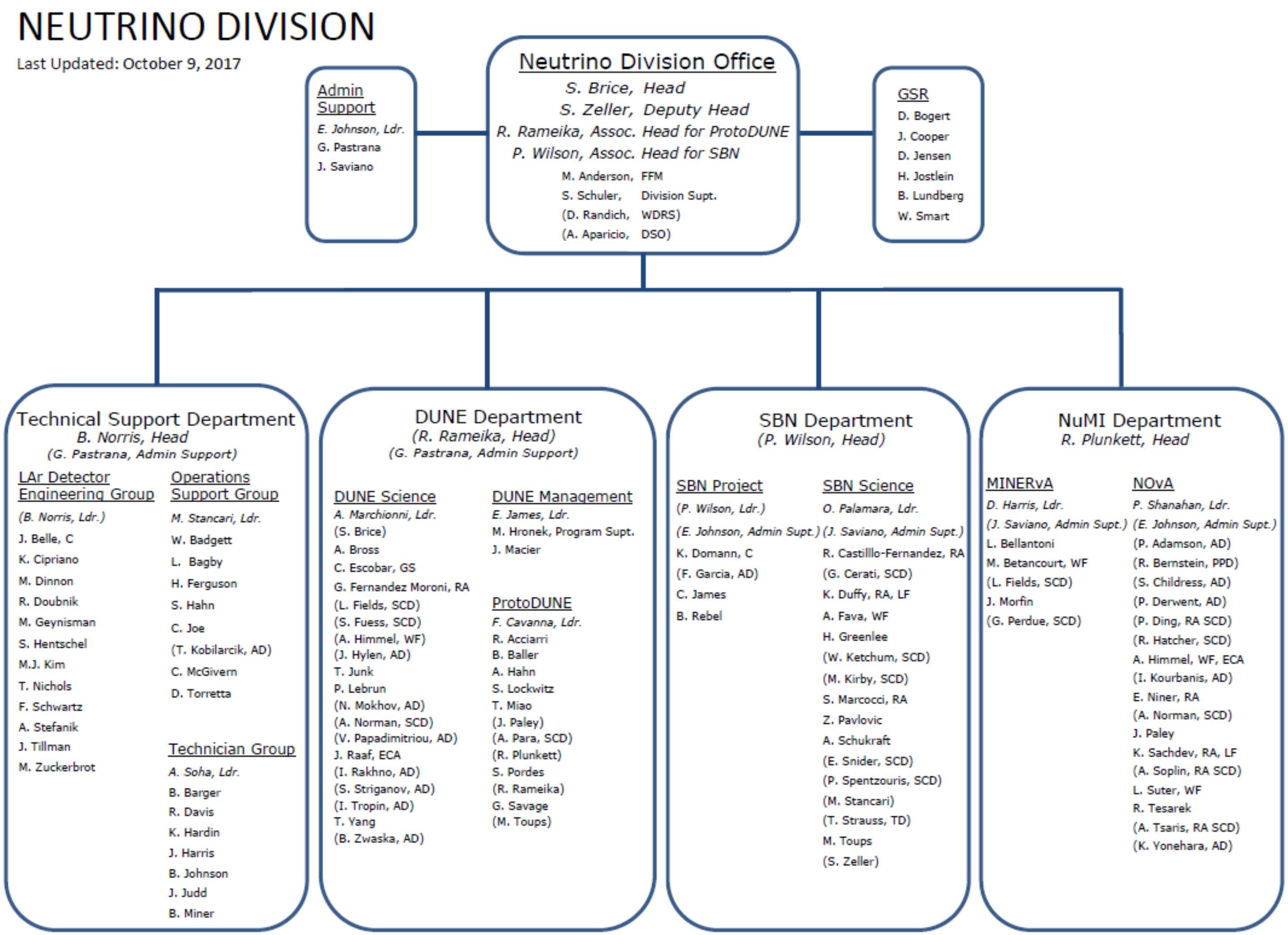
Barry Norris

ArgonCube Collaboration Meeting

17 October 2017

What is my role at FNAL?

Organizational Structure



Fermilab

Skill Set of Engineering Group

<u>Growing Skill Set and Group Size</u>
Cryogenic Engineers (5)
Mechanical Engineers (2)
Electrical Engineer (1)
Engineering Physicist (1)
Mechanical Designers (2)
Program Manager (1)

Technical Support Department
B. Norris, Head
(G. Pastrana, Admin Support)

<u>LAr Detector Engineering Group</u>
(B. Norris, Ldr.)
J. Belle, C
K. Cipriano
M. Dinnon
R. Doubnik
M. Geynisman
S. Hentschel
M.J. Kim
T. Nichols
F. Schwartz
A. Stefanik
J. Tillman
M. Zuckerbrot

<u>Operations Support Group</u>
M. Stancari, Ldr.
W. Badgett
L. Bagby
H. Ferguson
S. Hahn
C. Joe
(T. Kobilarcik, AD)
C. McGivern
D. Torretta

<u>Technician Group</u>
A. Soha, Ldr.
B. Barger
R. Davis
K. Hardin
J. Harris
B. Johnson
J. Judd
B. Miner

Fermilab

Ongoing Work for LAr Detector Engineering

*Category: Design and Construct**

<u>SBND and SBN-FD Cryogenics</u>

- FNAL Supplying design, procure and construct for all argon and nitrogen Cryogenic Infrastructure
- FNAL is collaborating with CERN (Johan Bremer) on design and integration of argon cryogenics which is CERN deliverable
  - FNAL providing design documentation (P&ID), valve lists, safety docs while supporting CERN deliverable for LAr cryogenic vessels and transfer lines
  - CERN outsourcing final design and build of equipment to DeMaCo in Holland
- FNAL has safety oversight of cryogenics to meet FNAL standards
  - Involves acceptance of European standards into our US safety culture
- FNAL has responsibility for all Cryogenic process controls (hardware and software)

<u>SBND Cryostat and TPC</u>

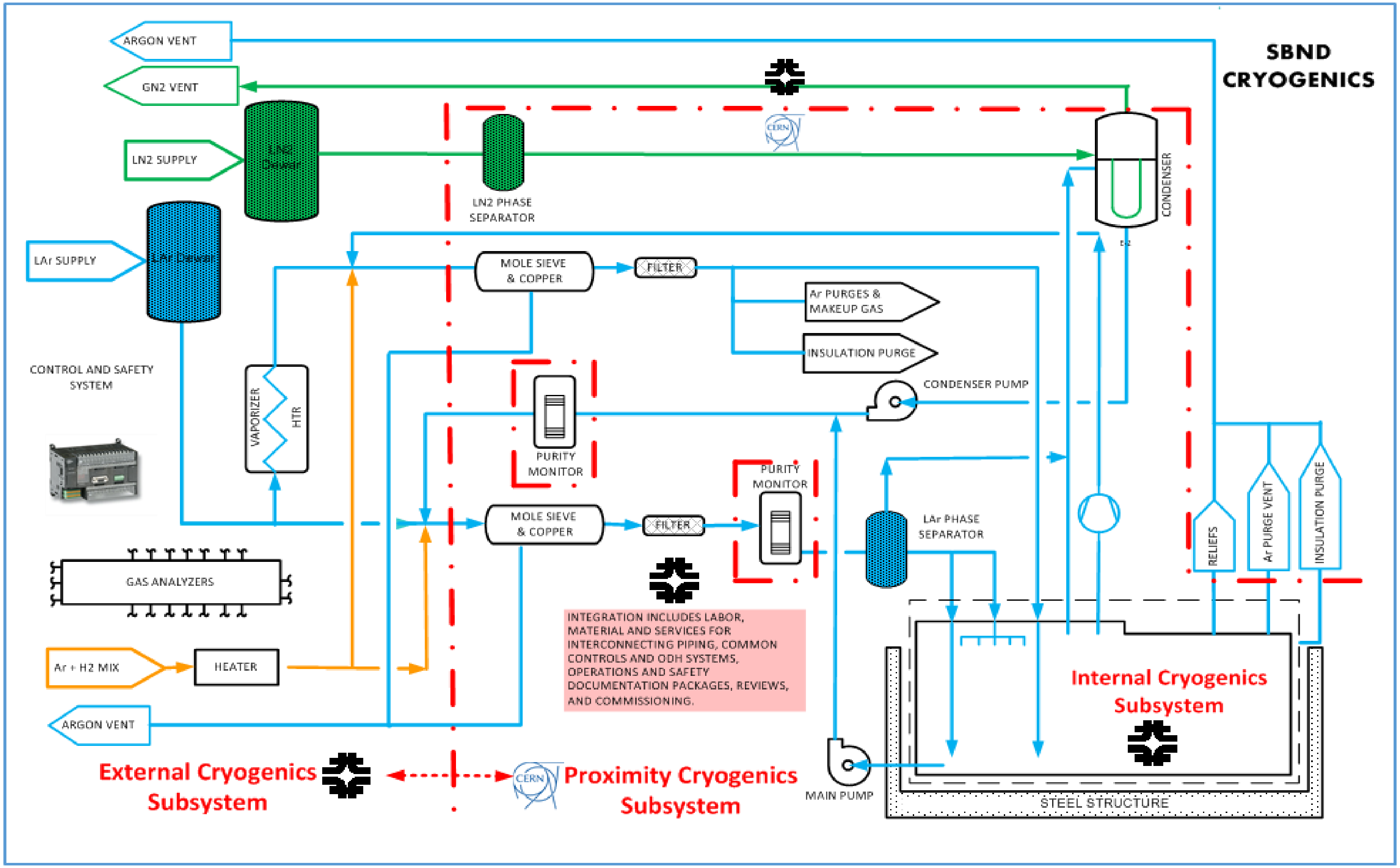
- Supporting Membrane Cryostat design including interfaces
- Working with Collaborators in TPC support systems and integration to cryostat

<u>SBND and SBN-FD CRT Mechanical Support</u>

- Working with CRT collaborators for supporting structures of SBND and SBN-FD

* Note that this is not including DUNE FD. LBNF has a small set of FNAL engineers dedicated are working on the cryogenics for LBNF. We however share technical expertise and for five years I was assigned Cryogenic Manager for LBNE/LBNF (now David Montanari of FNAL).

Example of Our Design Philosophy (SBND)



LAr Engineering Tasks (Cont'd)

Category: Operations and Interface to Experiments

Large LAr Ops

- MicroBooNE Cryogenics (170 tons) and Cryogenic Process Controls
- Future SBN Program (Near and Far Detectors; ~ 250 and ~ 700 tons)

Medium LAr Ops

FNAL Facility PC4 R&D

- 35 ton Membrane Cryostat*
- LAPD (Liquid Argon Purity Demonstrator)

Small LAr Ops

- LArIAT
- PAB support of small test vessels for R&D

* We (FNAL) have experience building first membrane cryostat to support LAr. 35 ton cryostat support structure used reinforced concrete rather than structural steel in nominal CERN design

Category: Design and Construct (cont'd)

And very recently we have begun to support …

<u>Gas Argon TPC</u>

- Support work of Jenn Raaf and testing of Gas TPC ideas
- Repurposing of existing FNAL cryostat as well as development of process piping et al for required infrastructure.
- Begun discussing with Alan Bross features of DUNE ND relative to 'low density' cryostat as well as vessel for Gas TPC

A Question Was Asked to Me About Cryostat Design

Question: What information would be needed to think about DUNE ND Cryostat design?

Table 1. Design parameters for the LBNE 35 ton prototype

Design parameter	Value
Cryostat volume	29.16 m^3
Liquid argon total mass	38,600 kg
Inner dimensions of the cryostat	4.0 m (L) x 2.7 m (W) x 2.7 m (H) - flat plate to flat plate
Depth of the liquid argon	2.565 m (5% under plate A, total ullage 11%).
Insulation	0.4 m Polyurethane foam
Primary membrane	2.0 mm thick 304 corrugate stainless steel
Secondary barrier	0.1 mm fiberglass
Vapor barrier	1.2 mm thick carbon steel
Reinforced outer concrete layer	0.3 m thick
Liquid argon temperature	89 K +/- 1 K
Operating gas pressure	70 mBar (~1 psig)
Vacuum	No vacuum
Design pressure	207 mBar (~3 psig)
Leak tightness	1E-06 mBar*liter/sec
Heat leak	< 13 W/m^2
Duration	10 years

For DUNE ND, the idea of ‘low density’ LAr cryostat brings its own new requirement needs.

- Radiation length allowable?
- Total foot print allowable in the facility?
- How close must LAr TPC be relative to GAr TPC?

Fermilab

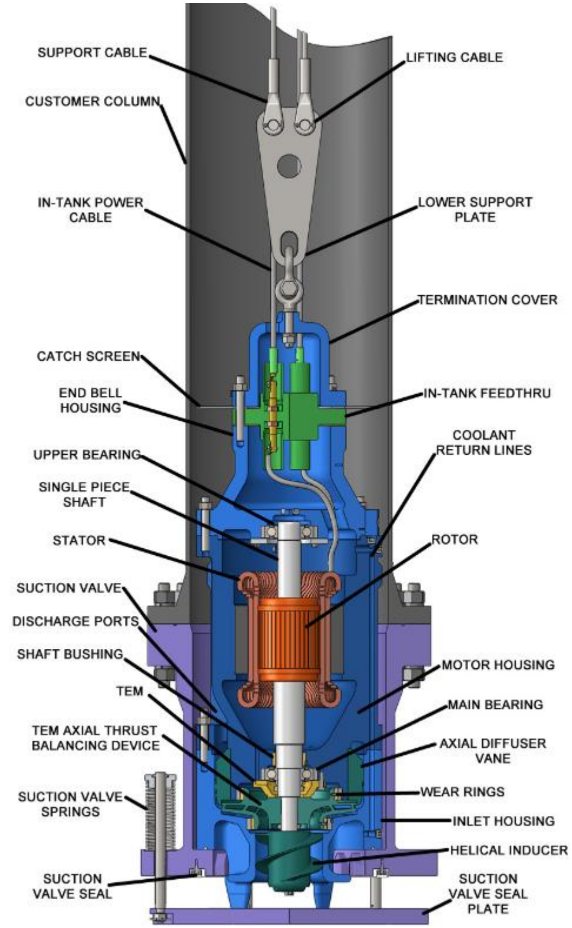
And just a couple thoughts of a technical nature….

A Thought on Argon Cube and DUNE ND

My opinion: A significant issue is when lowering the module into a LAr bath. This will cause gaseous boil-off that needs to be vented safely. One possible alternative is to insert the module into a ‘dry space’ and open the module to LAr when fully to bottom. See foot valve option used in LNG with pumps:

Here the key is pump is placed inside of pipe and lowered until it sits on ‘suction valve’.

You might be able use same concept of spring loaded fill valve to open just as you have module completely in place vertically.

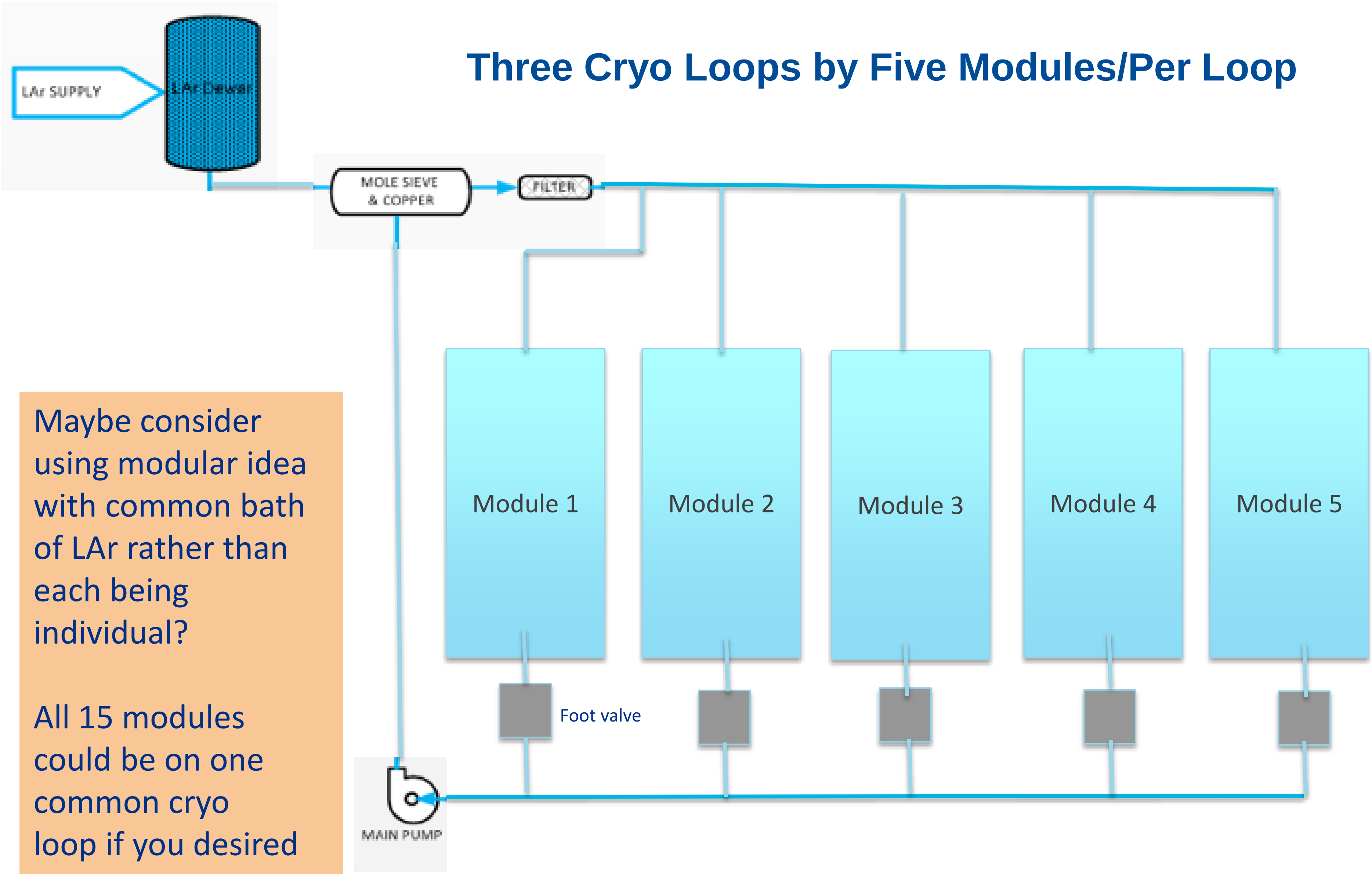


Just a thought …

Possibility: A hybrid approach to DUNE ND, meaning modularity for detector but reducing complexity of cryogenic pumping, filtering and re-condensing.

- Assume there are three (3) cryogenic ‘loops’ of five (5) modules total.
- Assume cryogenic condensers, filters, pump outside of cryostat as in LarIAT, 35 ton, MicroBooNE, future DUNE FD.
- Assume your module is placed inside its own secondary volume and not directly into the LAr bath.

Three Cryo Loops by Five Modules/Per Loop



Maybe consider using modular idea with common bath of LAr rather than each being individual?

All 15 modules could be on one common cryo loop if you desired