National Physical Laboratory

Modules metrology

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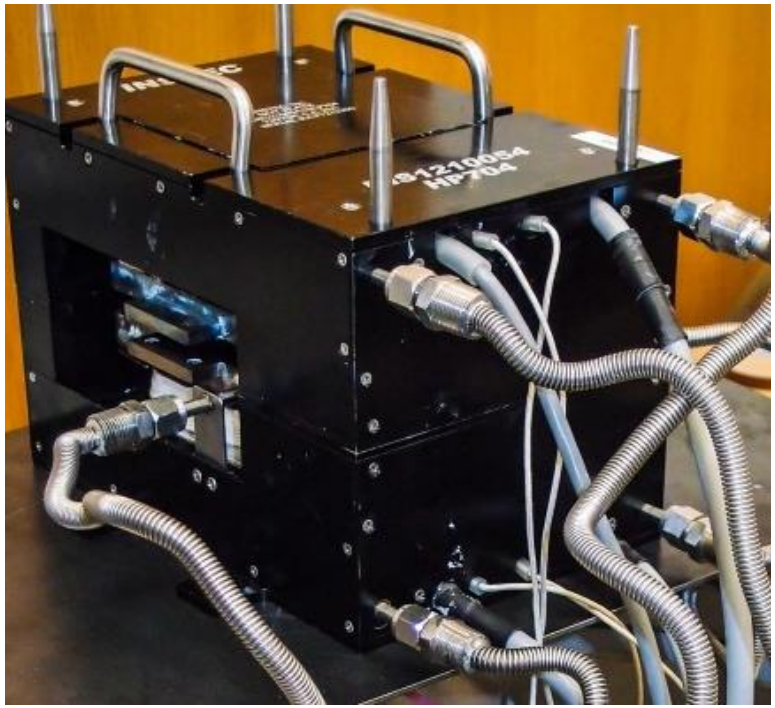
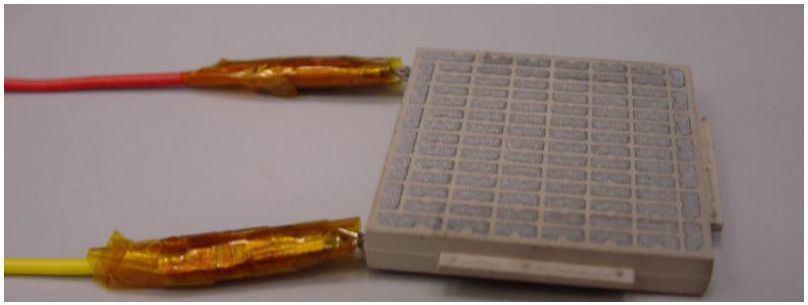
Motivation for HELboi facility

- High Power output for operating conditions
- Our partners in industry wants low uncertainty
- Everything else is a means to an end



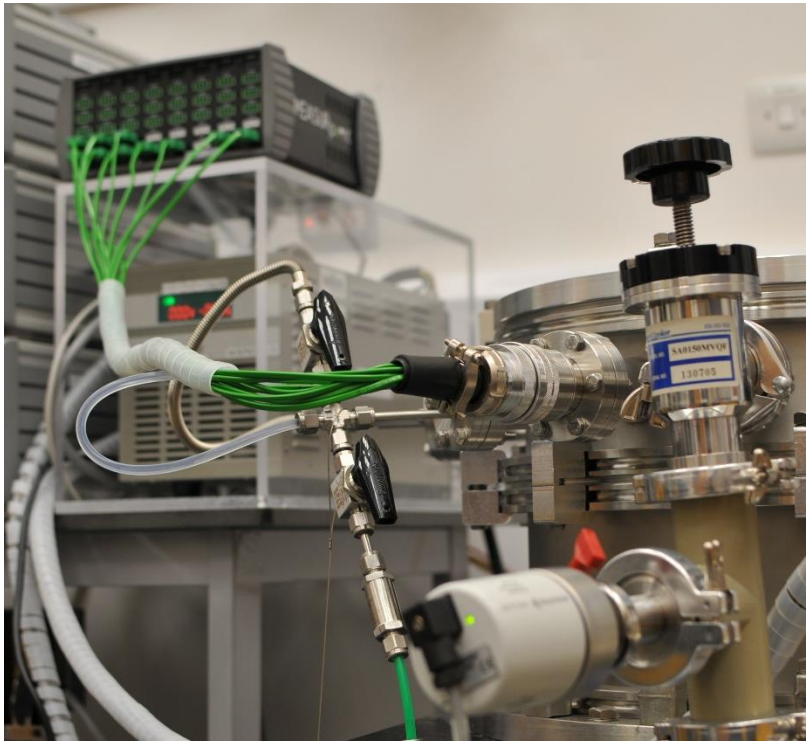
Modules



- Size
- Temperature range
  - Heating & cooling
- Environment
- Electrical leads
- Electrical isolation of top and bottom surface
- Soldering material
  - When it breaks off, use the same solder

Connections

- Thermocouples
  - K type
  - Quantity
  - Position
- Gas/Vacuum/liquid lines
  - Training
  - H&S volume of the room
  - Corrosion

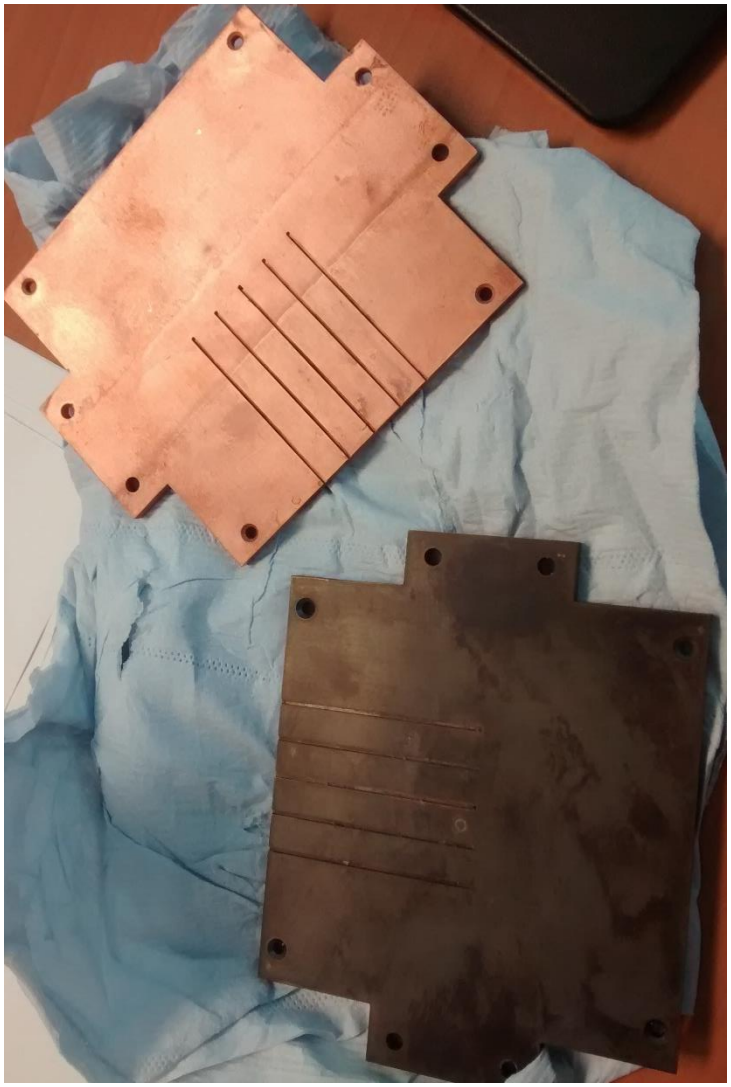


Connections

- How long are the cables
- Resistance compensation
- Feedthroughs
  - Sealed
- 16 A is a lot of current!

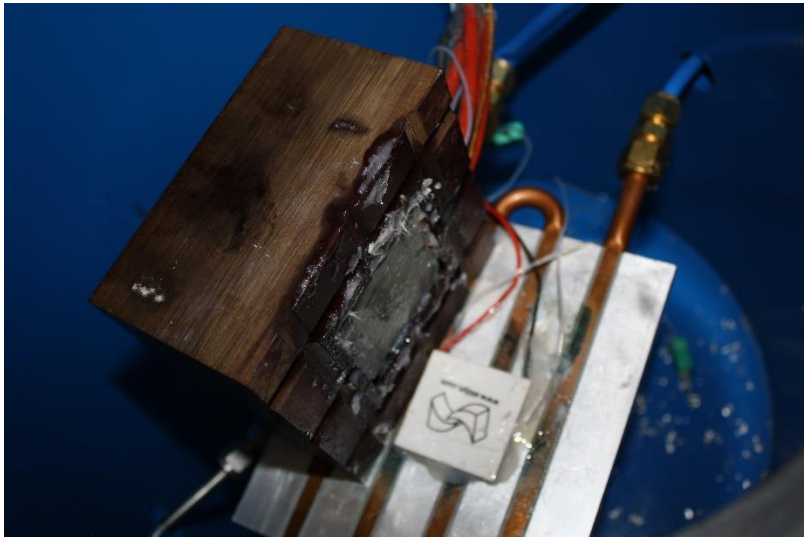
Heat spreaders

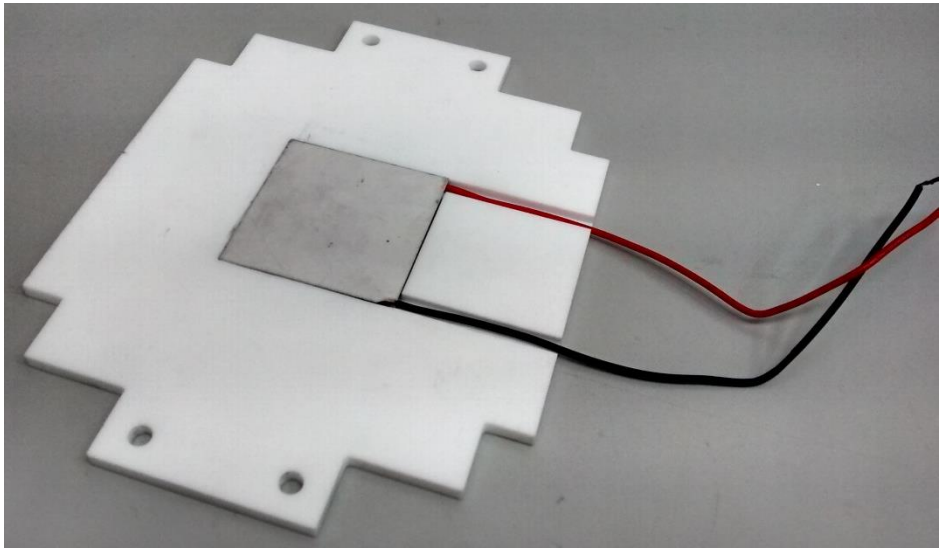
- Machining
  - Parallel surfaces
  - Surface roughness
  - Thermocouple feedthroughs
- Oxidation
  - Clean
  - Polish again
  - Zinc coating



Interface material & Isolation

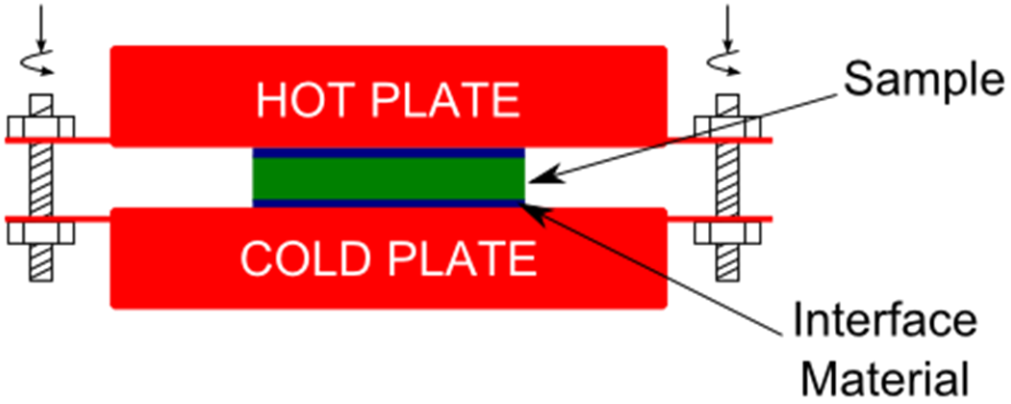
- Choice between using paste or graphite
- Shielding for lateral heat dissipation does not always help

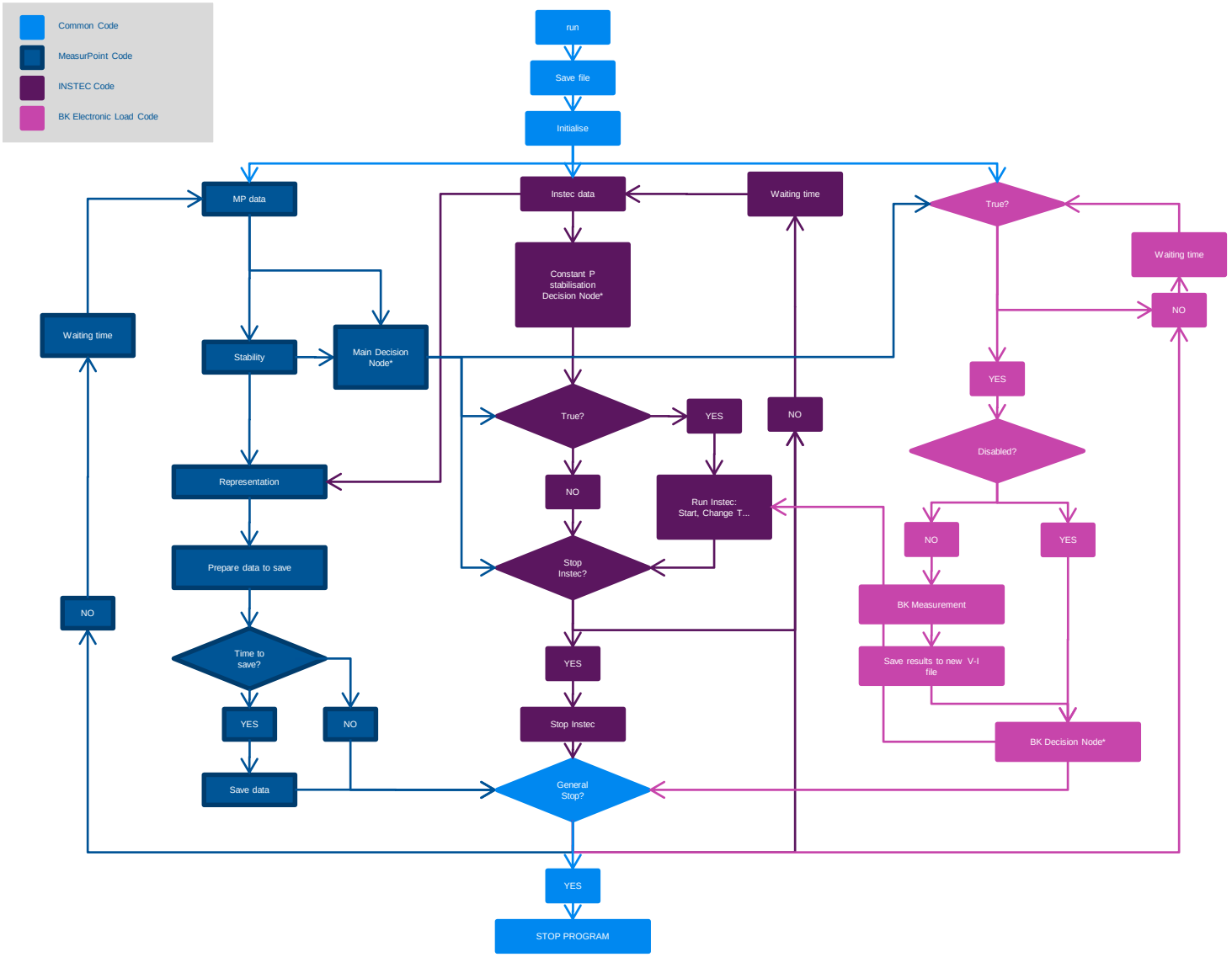




Pressure and procedures

- Order to tighten the bolts
- Does everybody use the torque wrench the same way?




Common Code
MeasurPoint Code
INSTEC Code
BK Electronic Load Code
run
Save file
Initialise
MP data
Instec data
Waiting time
True?
Waiting time
Constant P stabilisation Decision Node*
NO
Waiting time
Stability
Main Decision Node*
YES
True?
YES
NO
Disabled?
Representation
NO
Run Instec: Start, Change T...
NO
YES
Prepare data to save
Stop Instec?
BK Measurement
NO
Time to save?
YES
Save results to new V-I file
YES
NO
YES
Stop Instec
BK Decision Node*
Save data
General Stop?
YES
STOP PROGRAM

Measurements

- Do a screening exercise to find out the variables with the highest influence e.g.
  - Pressure of assembly
  - Interface Material
  - Controlled environment
  - Heat flow isolation
- Improve the repeatability of the exercise
- Do an uncertainty analysis to add traceability of the experiment

A	B	C	D	Power	Run
-1	+1	+1	+1	Very Low	1
+1	+1	+1	+1	Max	2
+1	-1	-1	+1	Max	3
+1	-1	-1	-1	Low	4

Combined Uncertainty

Measurement service: precision

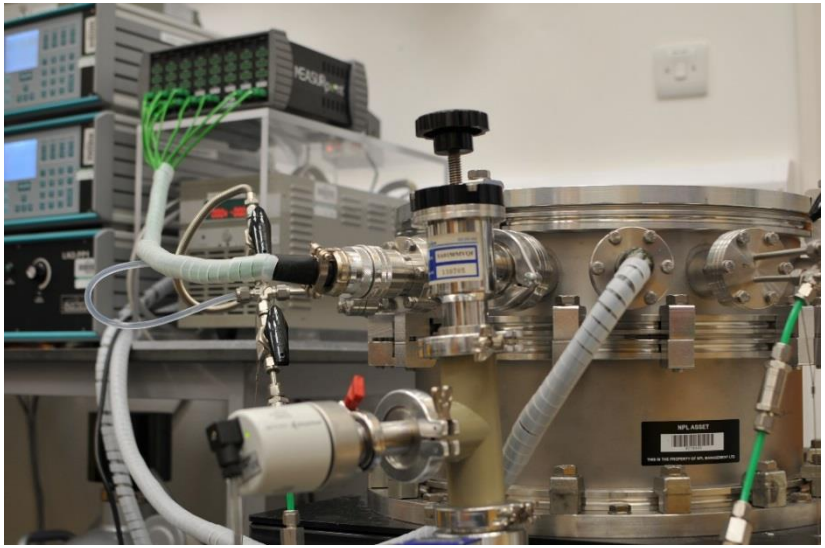
Repeatability	$u_c < 0.1\%$	Level of confidence: 1σ (68%)
Combined uncertainty:	$u_c = 2.9\ \%$	Level of confidence: 1σ (68%)
Extended uncertainty:	$U = 5.8\ \%$	Level of confidence: 2σ (95%)

Accuracy and validation:

- Use standards for calibration
- Round-robin among Institutions

Main sources of discrepancies:

- Interface material
- Clamping pressure
- Mean temperature (cold temperature)
- Constant ΔT during characterisation



Conclusions

- **Measurement service available at NPL with a repeatability < 0.1%**

- If you really want to go through all that trouble please contact us and we can tell you the Good Practice.
- NPL can provide certificate with known traceability from different NPL departments: Temperature or Electrical
- Departments are closely knitted: solder analysis, IR camera, SEMs & AFMs.
- NPL facility is ready for use: Special offer for Attendees 10% discount.

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SolCell

Metrology for MJSC

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Extras

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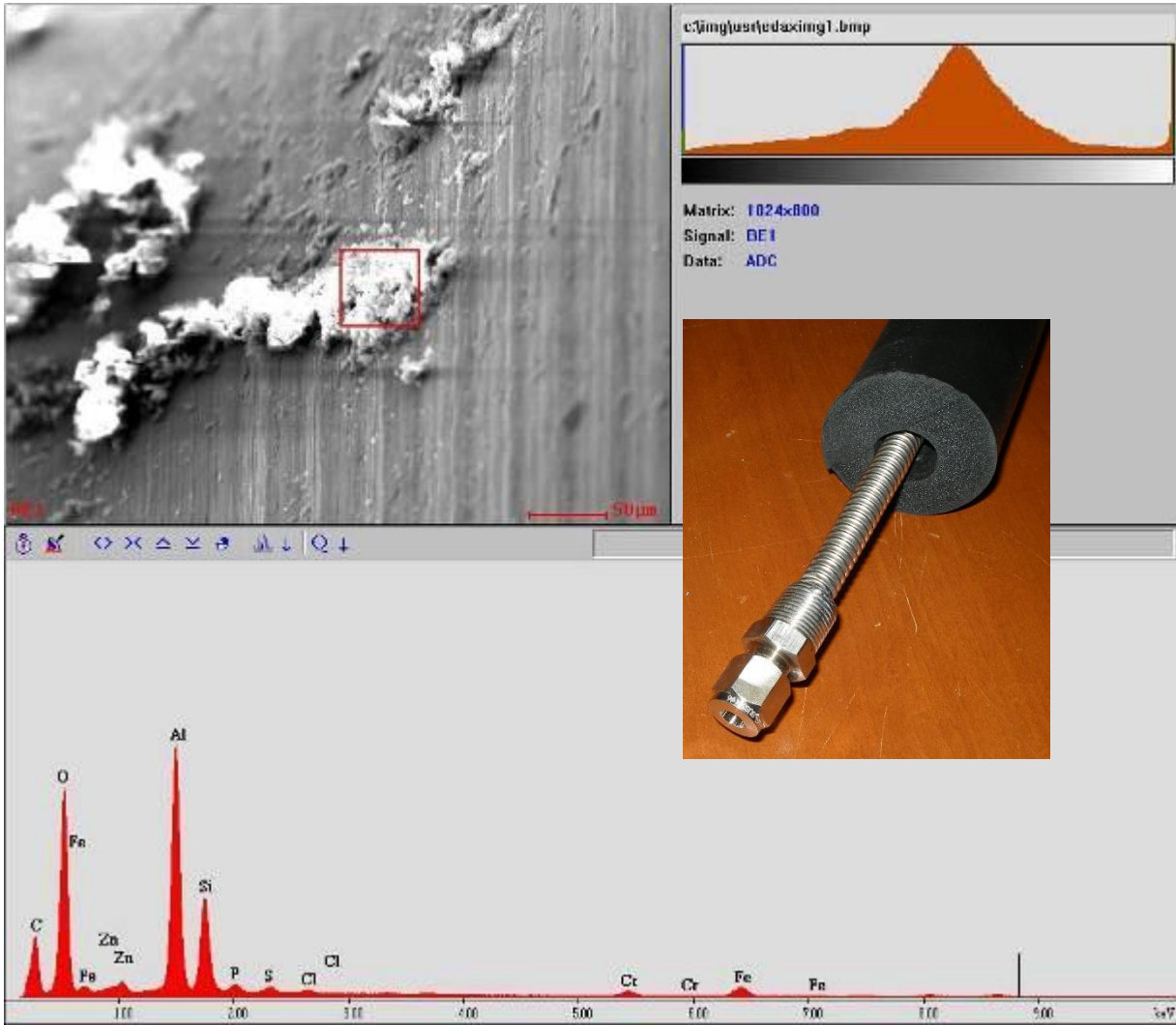
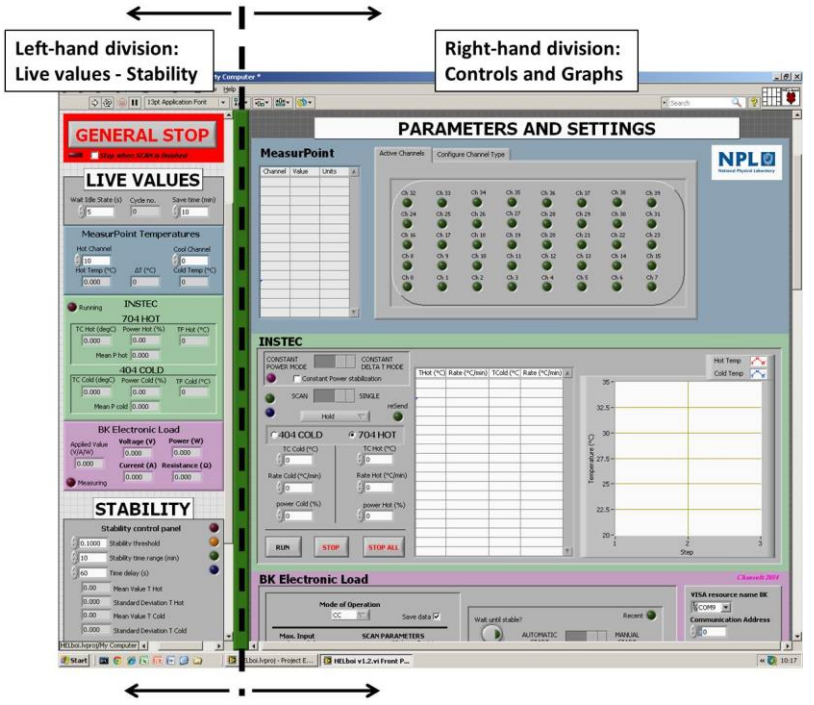
Connections

- Can the tubbing withstand change of pressure (negative)?
- Are the fittings all of the same make?
- Corrosion?
- Heat loss?



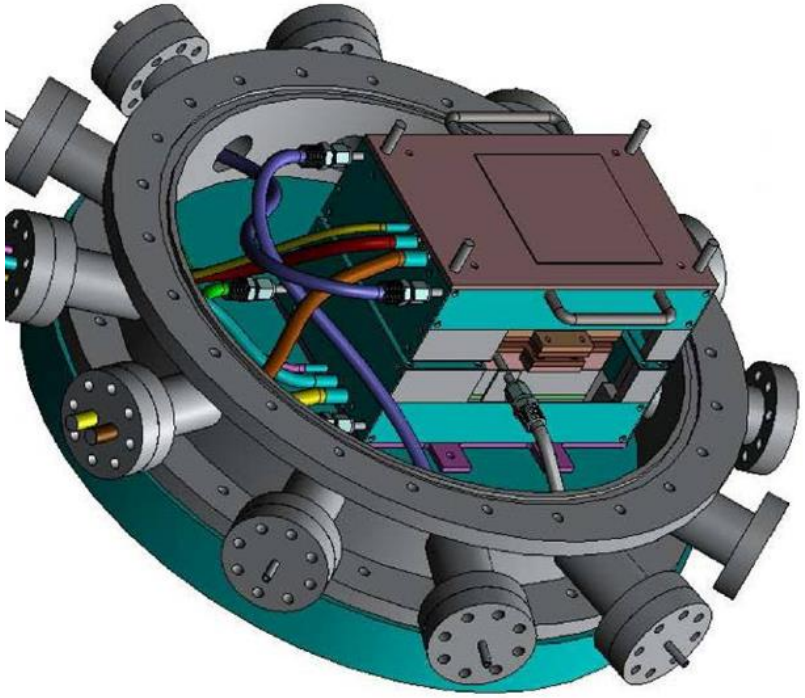
Software

- Timing the data acquisition
- V-I or Power reading?
- Analysis
  - Graph fitting
  - Uncertainty budget



Purchasing equipment

- Hot plate (top and bottom)
  - Choose the correct temperature range
  - Uniform heat
- Chiller
  - Processed chilled water
  - Liquid Nitrogen (H&S)
- Enclosure
  - Design
  - Vacuum chamber



Purchasing equipment

- Electronic Load
- Data acquisition systems
- Controllers such as PID
- Power supply