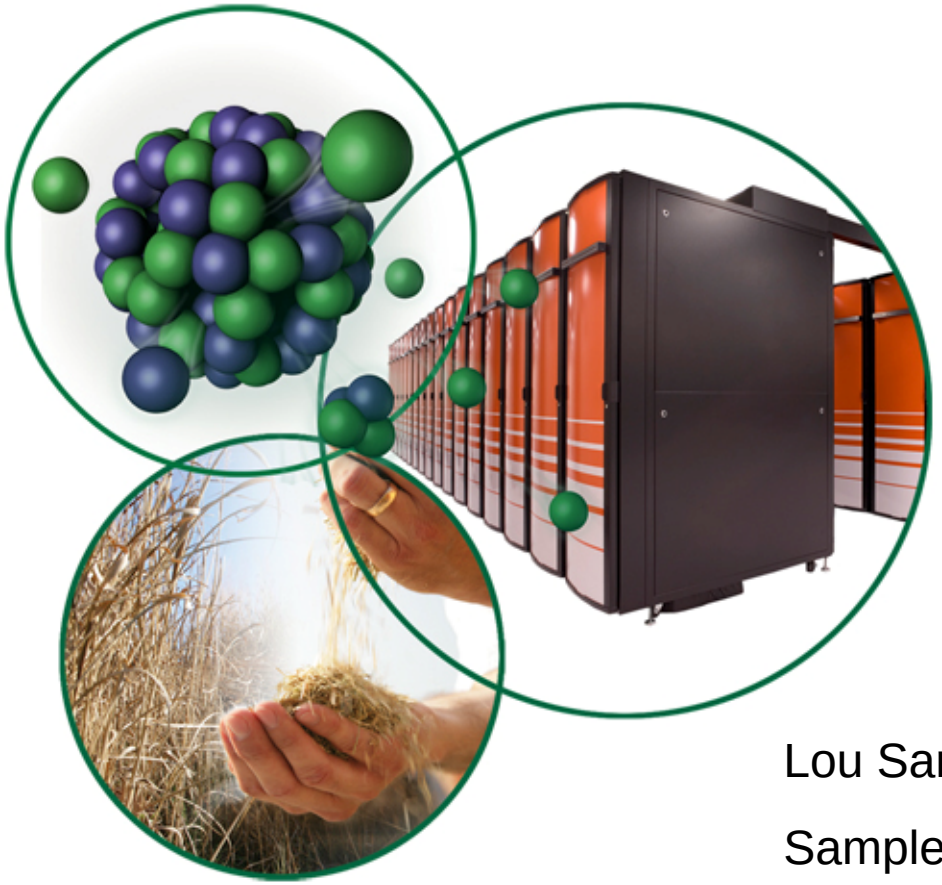
Experience with Cryofurnaces at ORNL



5th International Workshop on Sample Environment at Neutron Scattering Facilities

May 26-28, 2008

Grenoble, France

Lou Santodonato

Sample Environment Group Leader

NSSD, Oak Ridge National Lab

ORNL Neutron Scattering Facilities SNS and HFIR

- **SNS construction completed May 2006, user ops December 2007**
- **SNS achieved ~ 400 kWatt sustained beam power – most powerful pulsed spallation source**
- **3 SNS operational instruments**
- **3 SNS commissioning instruments**
- **HFIR cold source operational May 2007 (one of the brightest in the world)**
- **6 HFIR operational instruments**

Oak Ridge Sample Environment Group

Sample Environment Group

HFIR Team

Support user experiments & develop new capabilities

Shared R&D Team

Unified effort

SNS Team

Support user experiments & develop new capabilities

People

Oak Ridge Sample Environment Group

L. Santodonato – Group Leader

B. Hill – Facility Interface

HFIR Team

C. Redmon – Team Leader

D. Reass
J. Smith
New Tech

Shared R&D

L. Walker
J. Wenzel
L. Solomon

SNS Team

A. Church – Team Leader

R. McPherson
S. Elorfi
R. Mills
M. Collins

Cryofurnaces at Oak Ridge

A.S. Sci.

ILL/Orange

Hot VTI

JANIS

Hot Stick

Cold VTI

SNS

Hot VTI

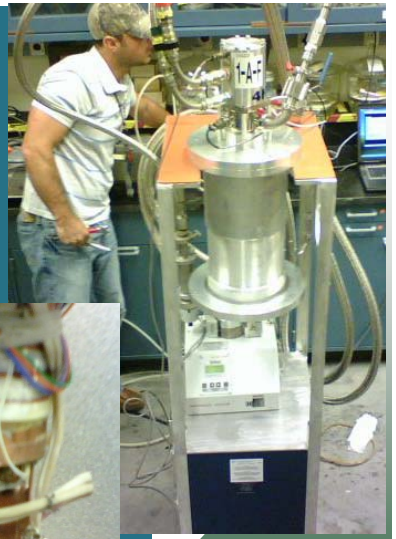
Do-it-yourself

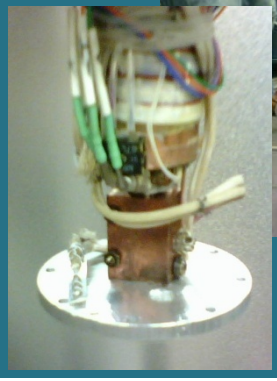
prototype

ARS

Hot stage

Displex



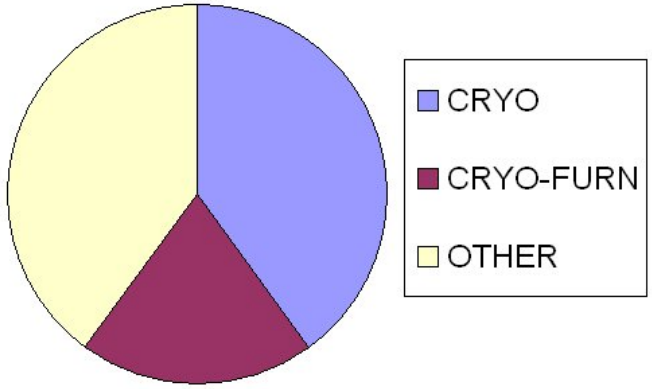


Cryofurnace Outline

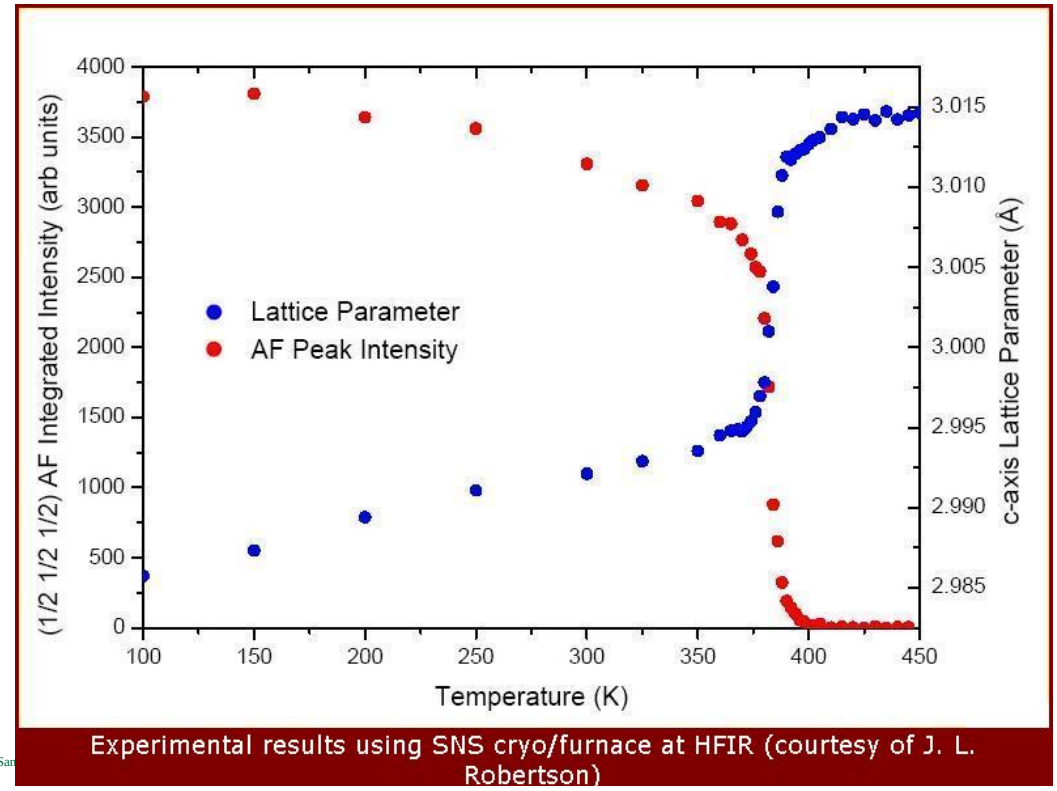
- **General considerations**
- **Four different designs**
- **Test data**
- **Summary**

General Considerations

- **How much demand?**
  - **Roughly 20% cryofurnace**
  - **Based upon limited web survey**

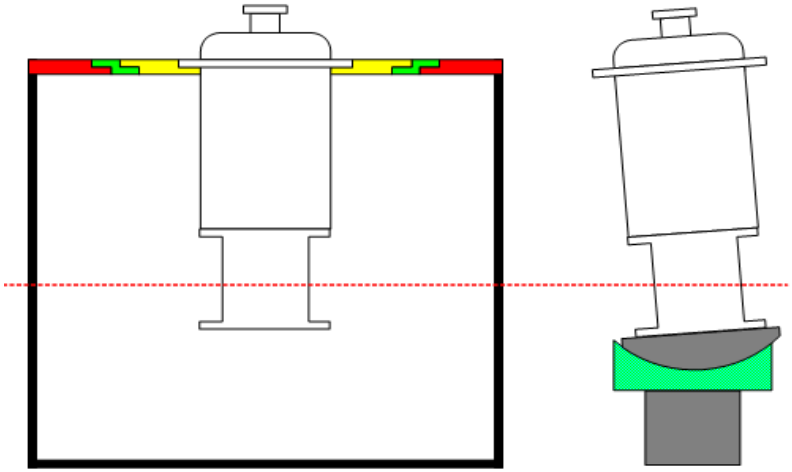


- **What temperature range?**
  - **Moderate range serves many**
  - **Others want great base temp**
  - **Can one device do it all?**



Experimental results using SNS cryo/furnace at HFIR (courtesy of J. L. Robertson)

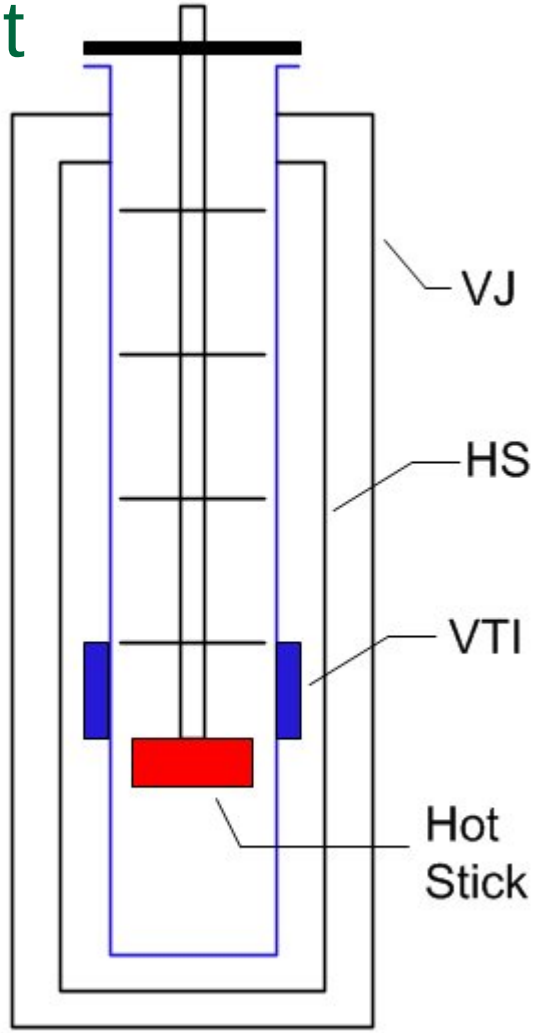
General Considerations



- **Instrument geometry**
  - **Tanks and tables**
- **Facility logistics**
  - **Changing SE equipment much harder than changing sample only**
- **Do-It-Yourself vs. Vendor-Supplied**

Design 1 – Hot Stick Cryostat

- **Operate as exchange gas cryostat 300K to base**
- **Evacuate VTI and heat stick for high temperature**
- **Pros**
  - **Adapt any top loading cryostat**
  - **Easy sample change**
- **Cons**
  - **Two operating modes**
  - **Potential for gradients**
  - **It's cheating!**



Vacuum jacket – VJ

Heat Shield - HS

Cryogenic variable temperature insert (VTI)

Janis Hot Stick Cryostat

Manufacturer:	JANIS Research
Range:	1.7 K to 600 K
Thermometry:	Cernox resistor on VTI
	type-E T/C on hot stick
Sample Space:	60 mm well

ORNL Experience

2004 Debug & commission at HFIR
Useful, but difficult to operate

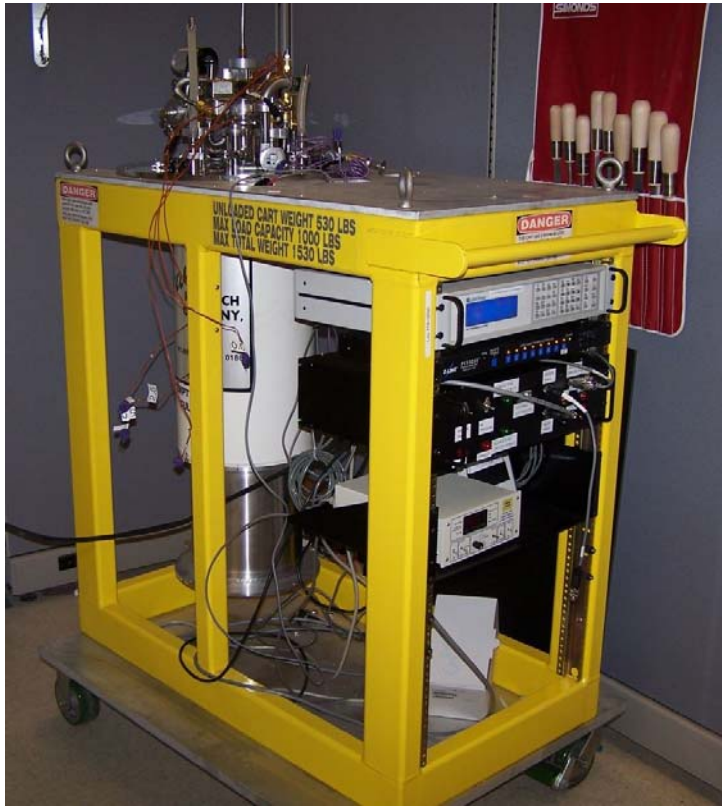
Early testing

Janis Hot Stick Cryostat

Manufacturer:	JANIS Research
Range:	1.7 K to 600 K
Thermometry:	Cernox resistor on VTI
	type-E T/C on hot stick
Sample Space:	60 mm well

ORNL Experience

2004	Debug & commission at HFIR Useful, but difficult to operate
2006	Auto exchange gas and cold valve commissioned at SNS
2008	Essential part of inventory – ever improving – also used with 3He insert



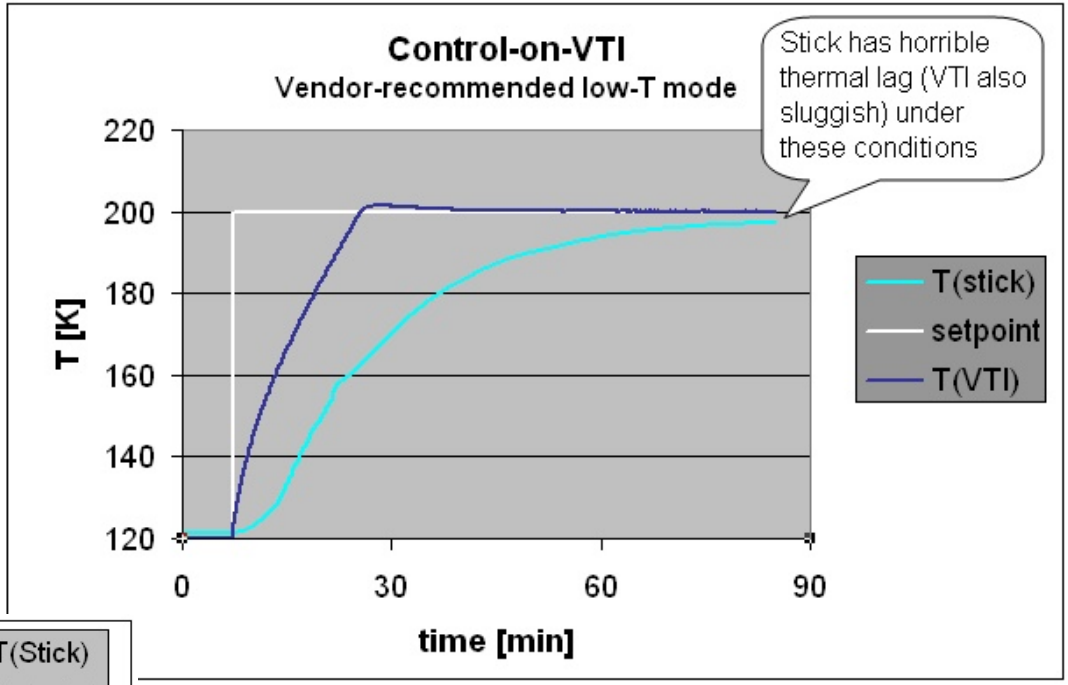
JANIS Cryo-cart

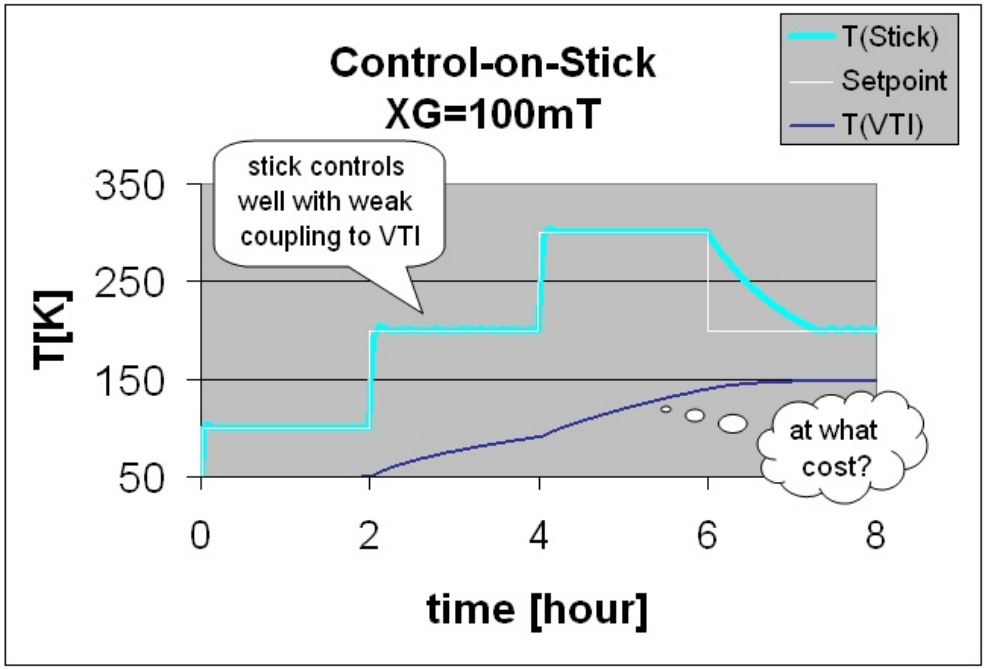
With off-the-shelf and do-it-yourself automation controls

Janis Hot Stick Cryostat: Test Data

Control-on-VTI is slow

Control-on-stick seems best for temperatures above 50 K





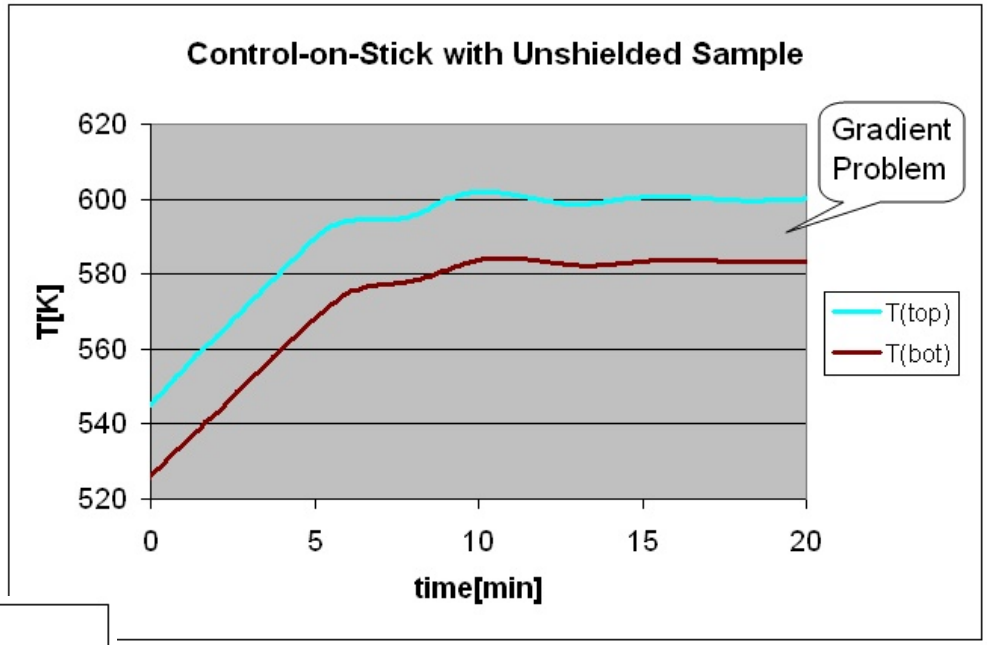
But we are concerned about temperature gradients

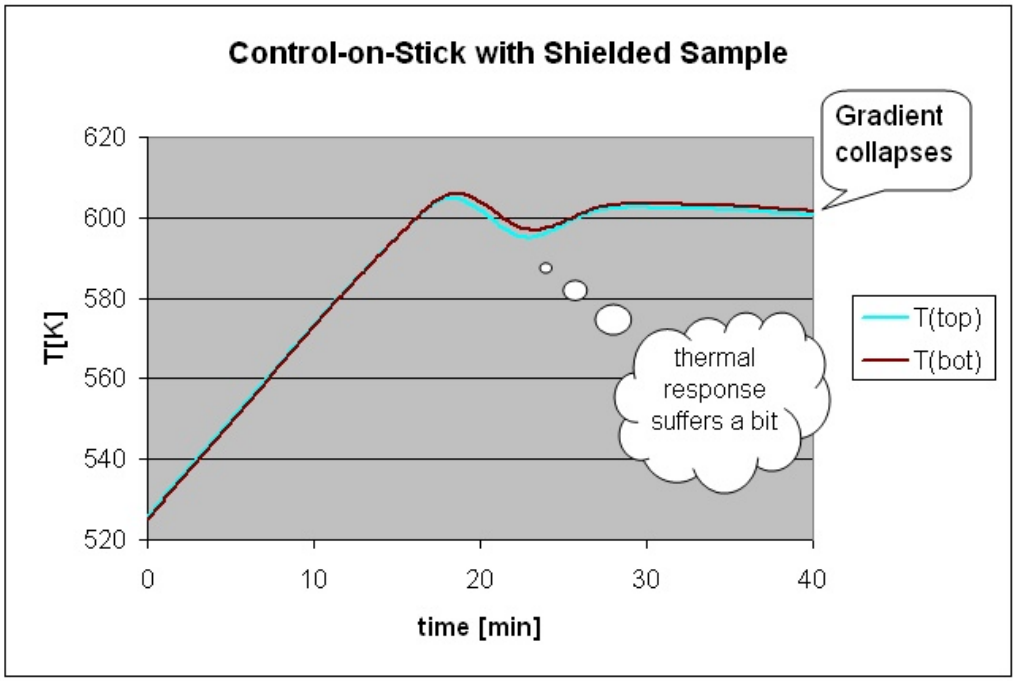
Environment

OAK RIDGE National Laboratory

Janis Hot Stick Cryostat: Test Data

- Measure top and bottom of sample
- Shielded versus un-shielded





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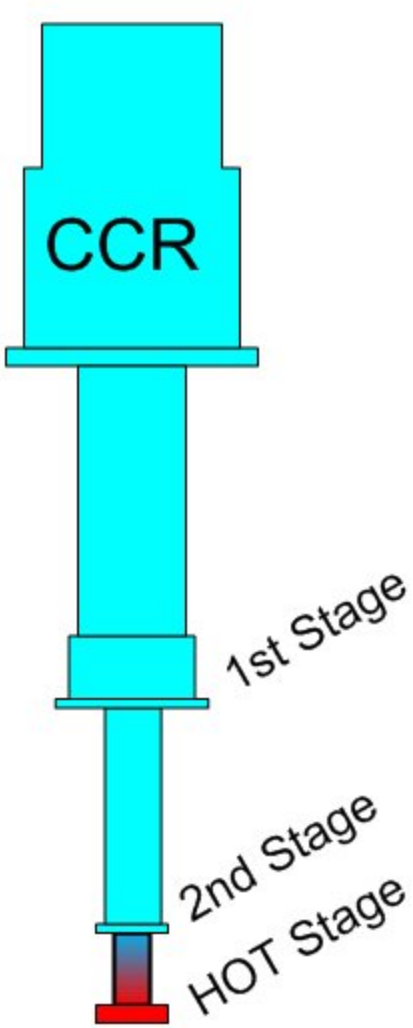
Design 2 – Hot Stage Displex

- **Heat switch**
- **Sample in vacuum**
- **Pros**
  - **Simple**
  - **Great range**
- **Cons**
  - **Delicate interface**



ARS Hot Stage Displex

Manufacturer:	Advanced Research Systems
Range:	5 K to 800 K *
	* see ORNL experience
Thermometry:	T/C's & Pt-RTD
	50 Ohm heater
Sample Space:	bottom load

ORNL Experience

Debug & commission at HFIR (2005)

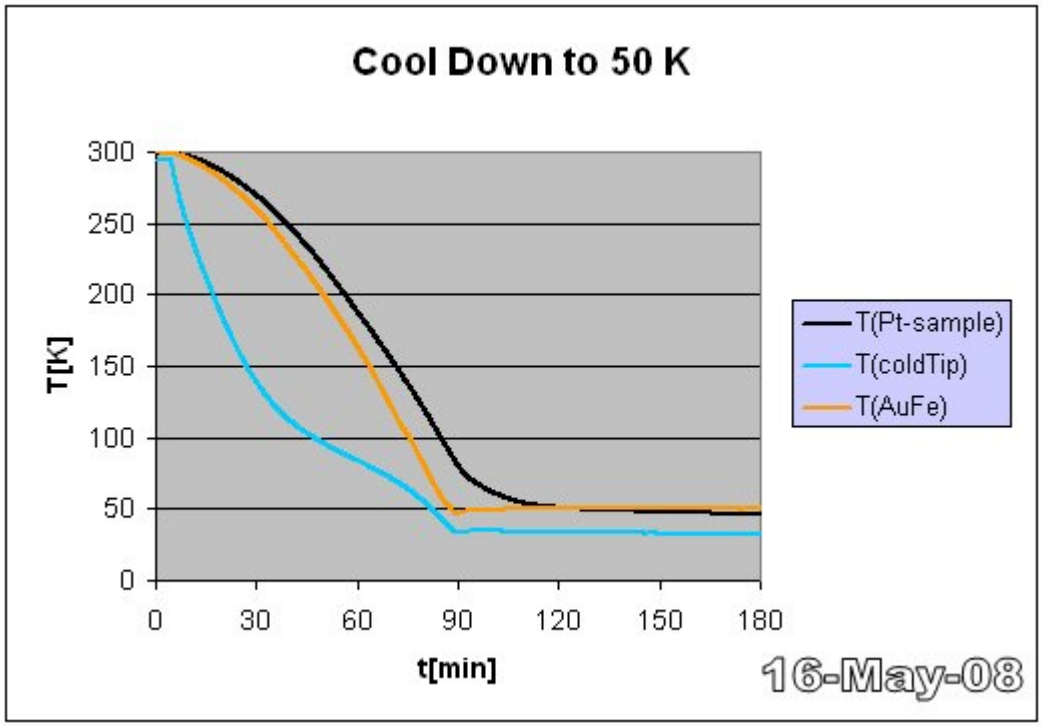
Good CF workhorse

Not used as all-in-one

5 k to 600 K with 50 W heater output

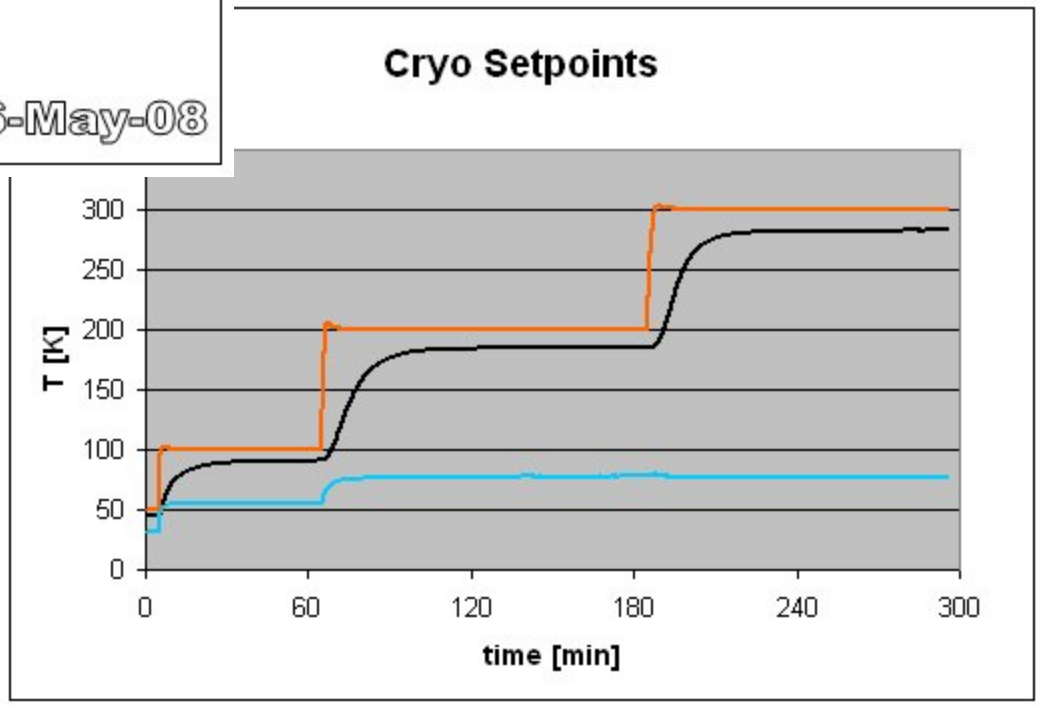
Needs thermometry upgrade

ARS Hot Stage Displex : Cryo-Data

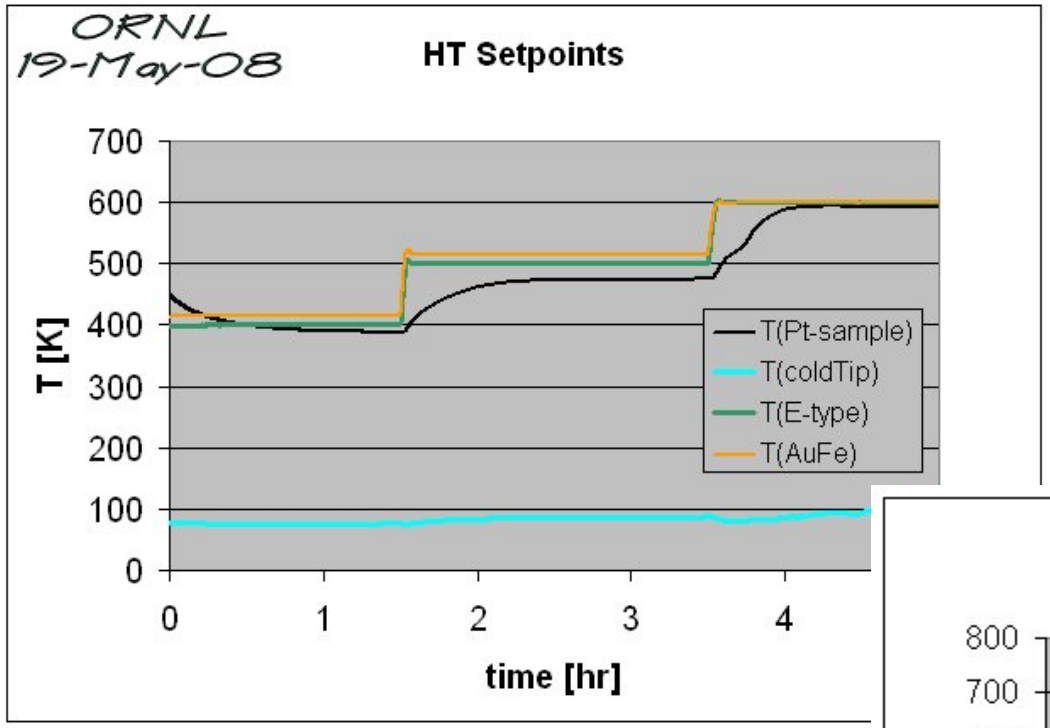


Good cool down and set point response

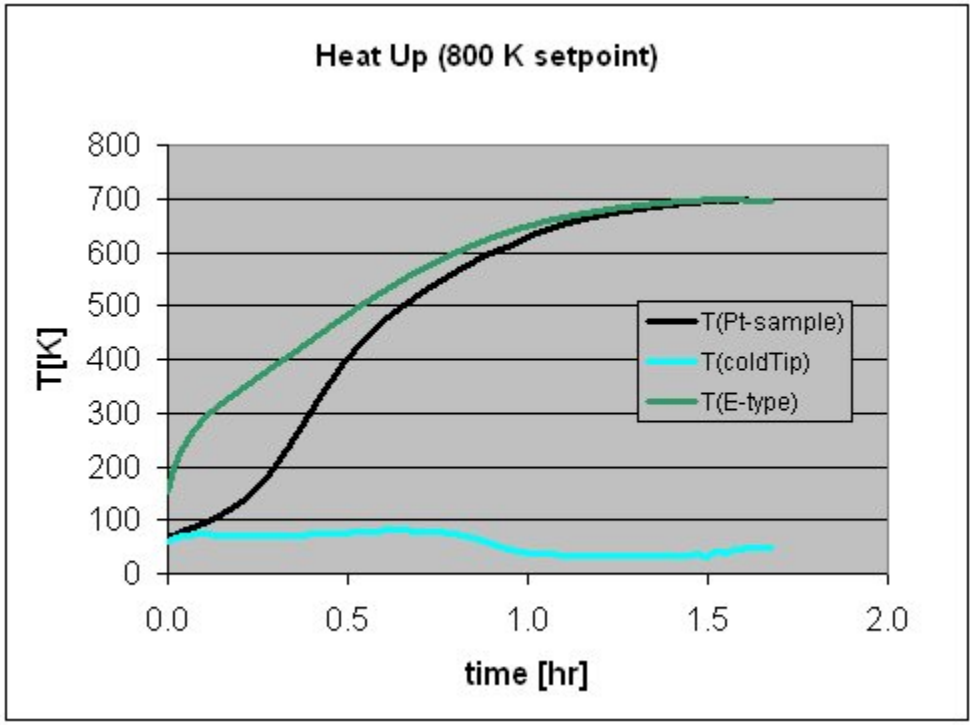
Sensor offset problem



ARS Hot Stage Displex : HT Data



Not bad, except for sensor offset

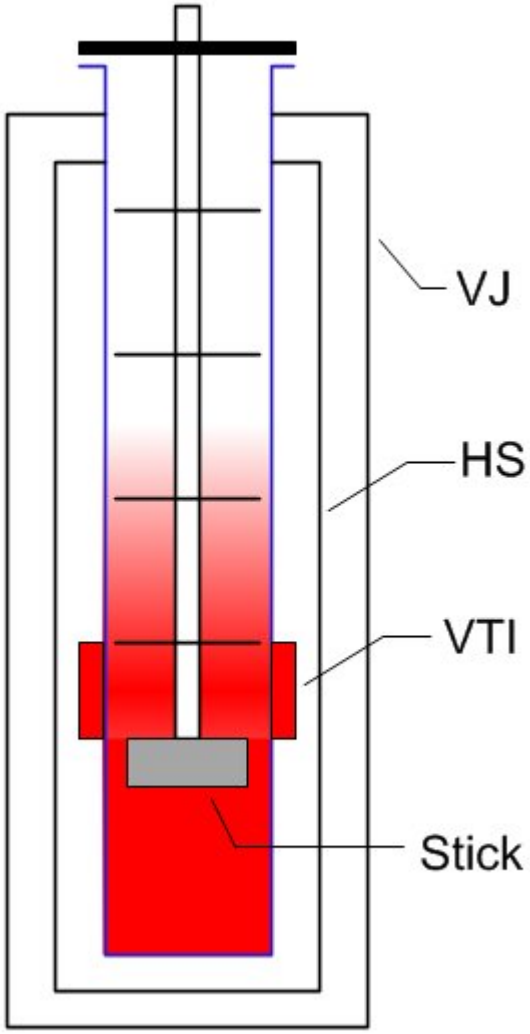


Not enough power to reach 800 K

Santodonat

Design 3 – Hot Exchange Gas - Dry

- **Pros**
  - **Sample in helium gas atmosphere**
    - **Better temperature uniformity?**
  - **Easy sample changes**
- **Cons**
  - **Hard to make it work as intended**

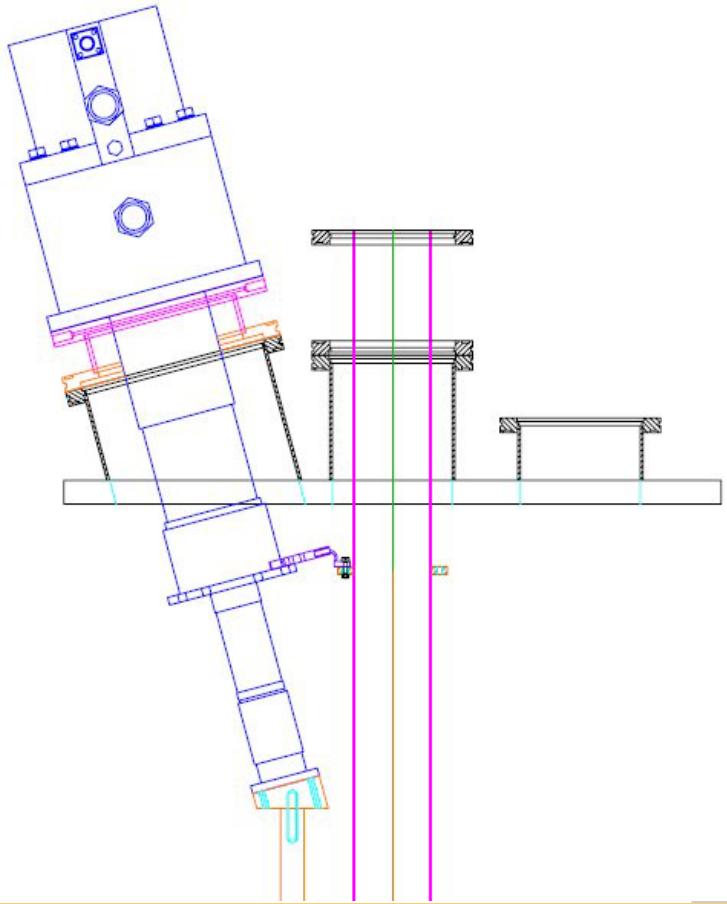


SNS Hot Exchange Gas CCR Prototype

SNS-designed interface

ARS DE-210 Cryocooler

Range:	20 K to 500 K	(rev 0)
	4 K to 400 K	(rev 1)
Thermometry:	Si diode (500 K chip)	
	50 Ohm heater	
Sample Space:	60 mm	



ORNL Experience

Motivated by needs on BASIS instrument

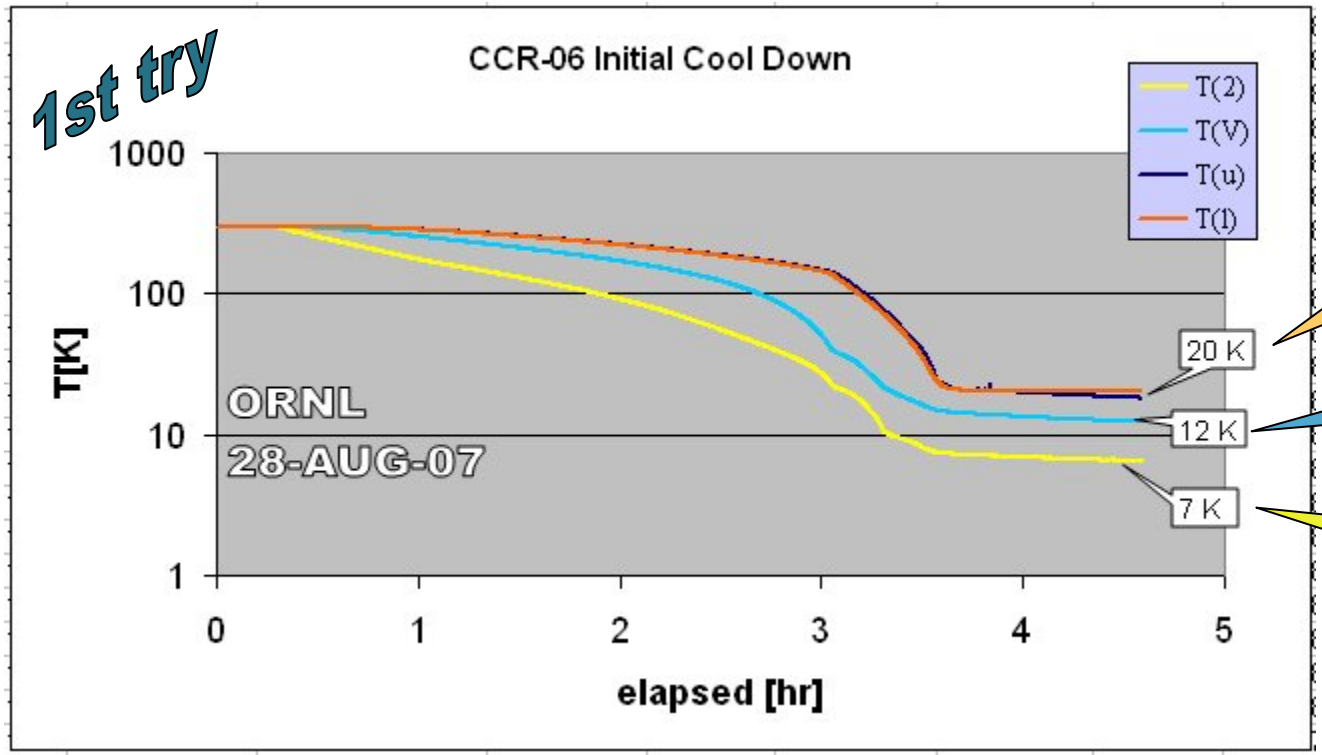
2007 Design, fabricate & test

2008 Many ups & downs

SNS Hot Exchange Gas CCR Prototype

ORNL Experience (cont.)

- Base temperature initially poor
- But VTI reaches 500 K
  - Long thermal link with large delta-T



Sample (upper & lower)

VTI

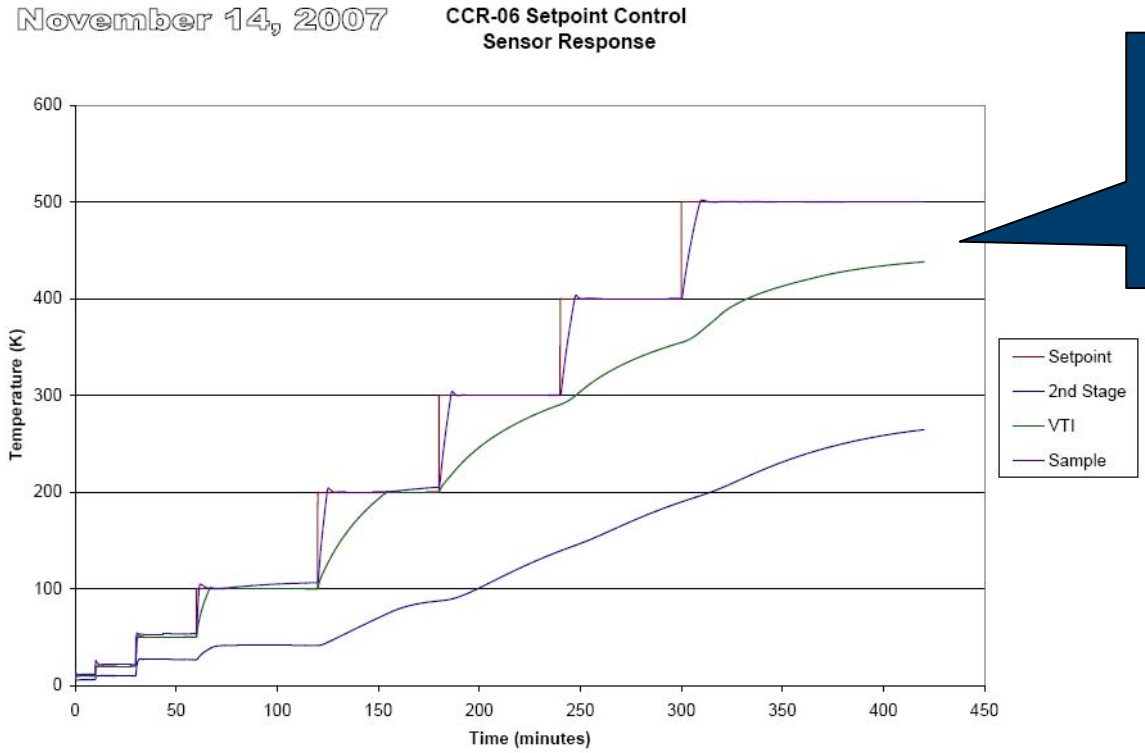
Cold tip

OAK RIDGE National Laboratory

SNS Hot Exchange Gas CCR Prototype

ORNL Experience (cont.)

- Control on VTI slow, but does reach 500K
- Dual control helps

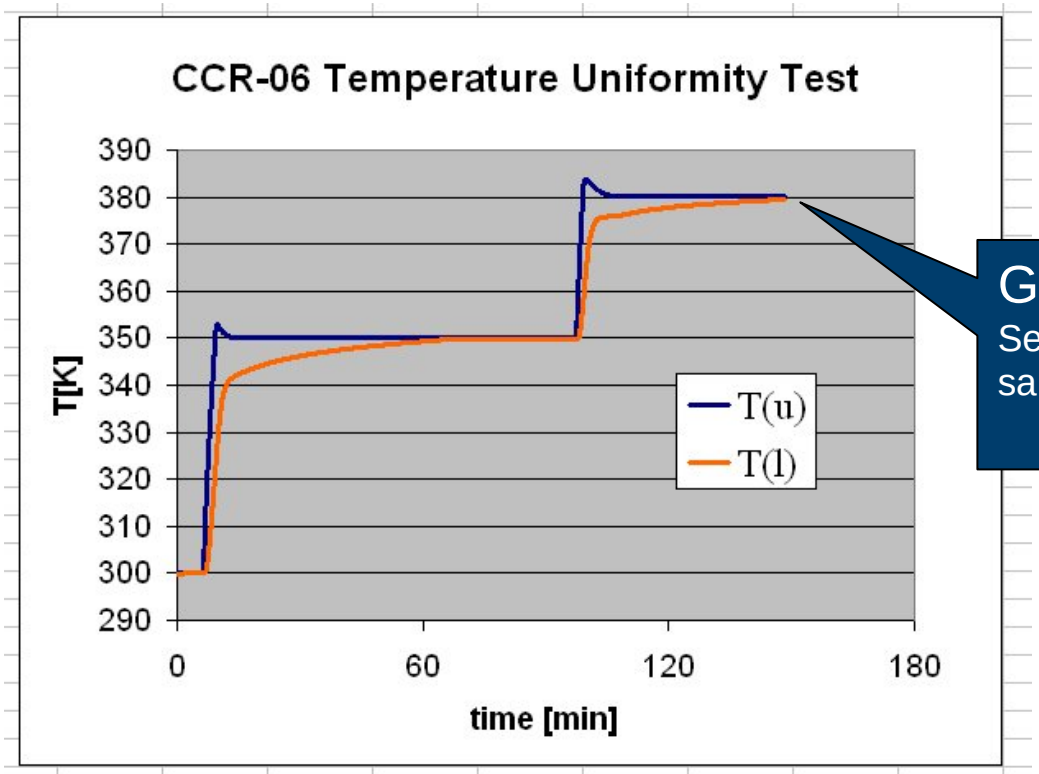


Dual control test to 500K
Sample stick controls quickly
VTI sluggish at high-T

SNS Hot Exchange Gas CCR Prototype

ORNL Experience (cont.)

- Gradients evaluated

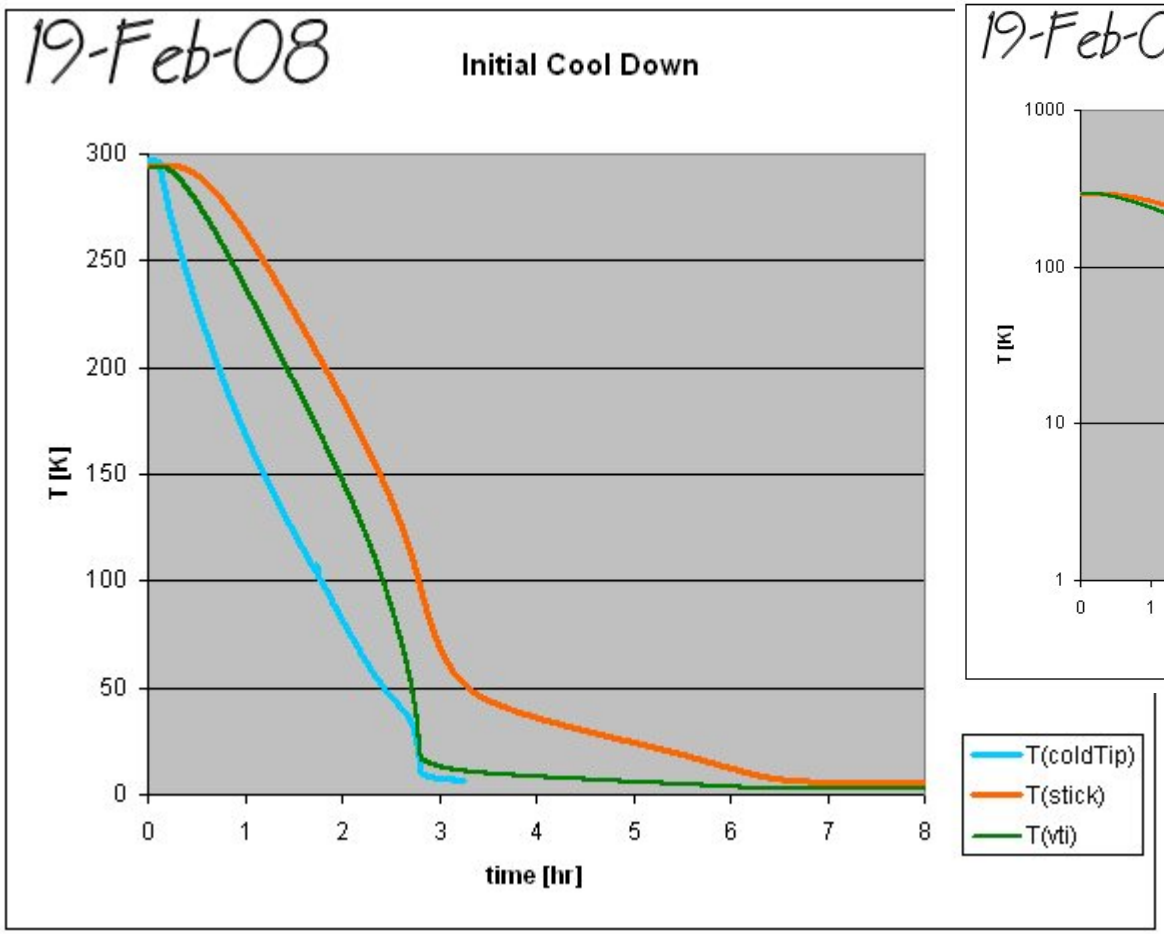


Gradient Test
Sensors on top and bottom of sample agree (eventually)

SNS Hot Exchange Gas CCR Prototype

ORNL Experience (cont.)

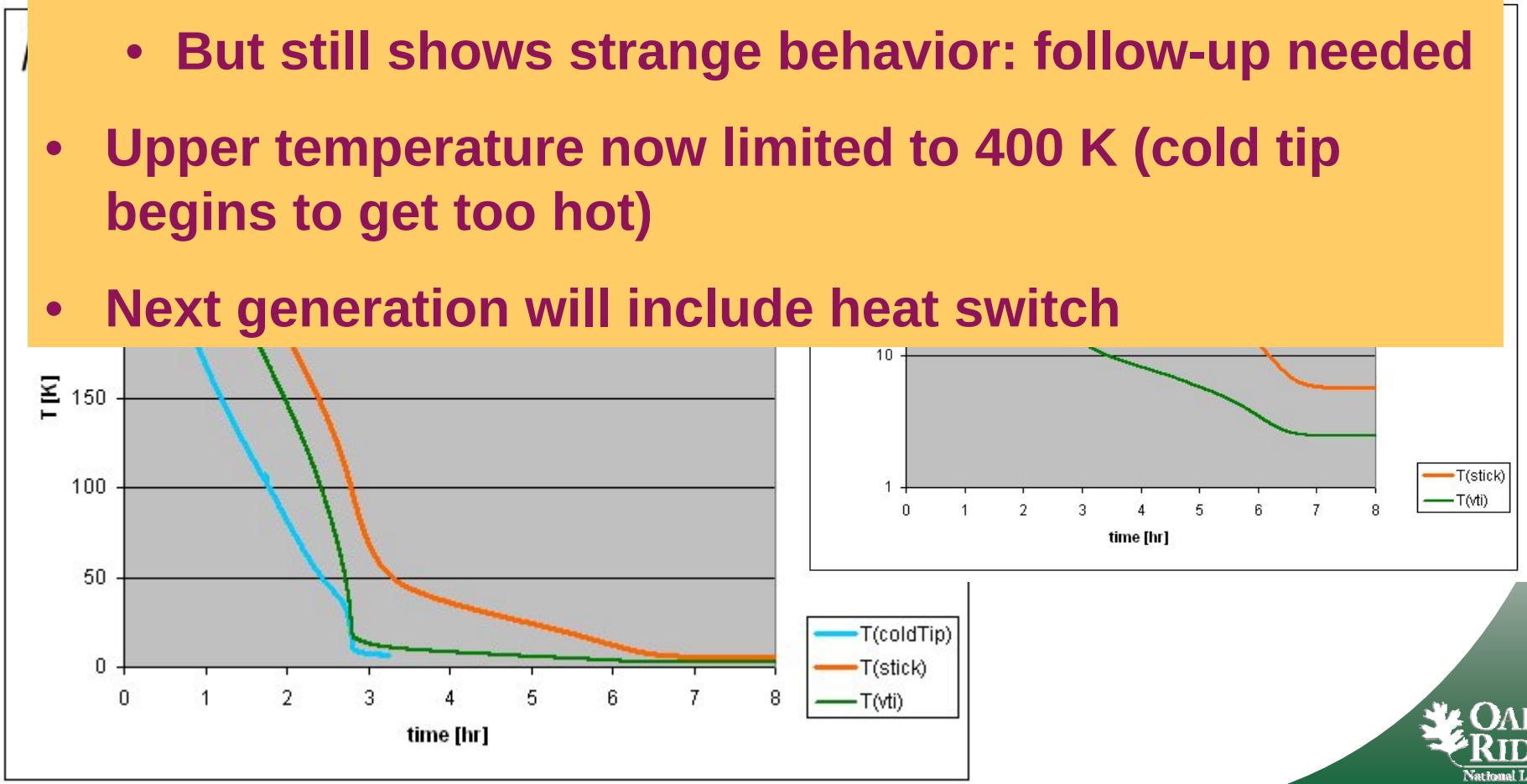
- Improved thermal contact and achieved better base temperature



SNS Hot Exchange Gas CCR Prototype

ORNL Experience (cont.)

- Improved thermal contact and achieved better base temperature
  - **But still shows strange behavior: follow-up needed**
- **Upper temperature now limited to 400 K (cold tip begins to get too hot)**
- **Next generation will include heat switch**

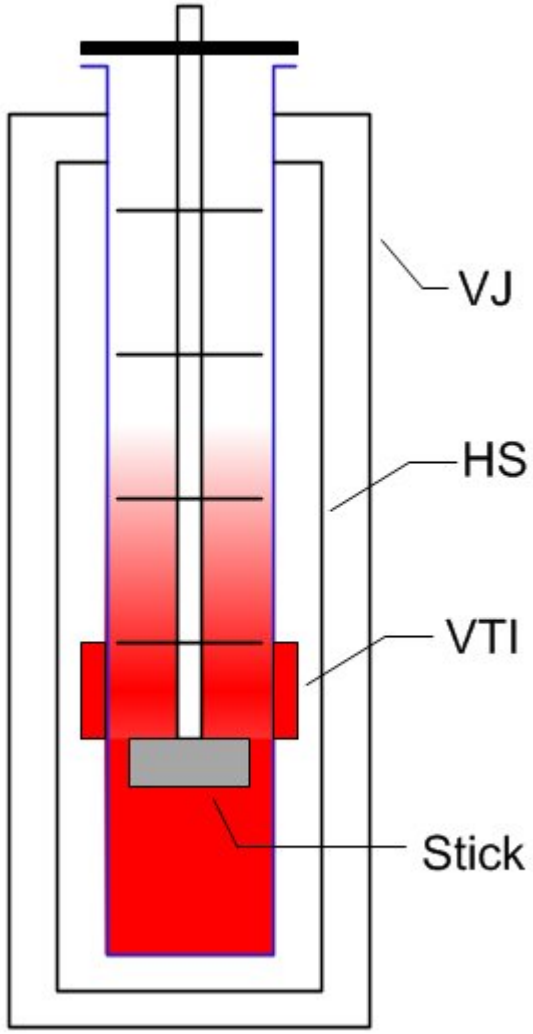


Design 4 – Hot Exchange Gas - Wet

- **Keep exchange gas in tube throughout entire experiment**
- **Pros**

Summer intern project

- **Cons**



Vacuum jacket – VJ

Heat Shield - HS

Cryogenic variable temperature insert (VTI)

ILL Orange Cryofurnace

Manufacturer:	A. S. Scientific Ltd.
Range:	2 K to 600 K
Thermometry:	RhFe
	8 Ohm heater?
Sample Space:	70 mm

Summer intern project

Acknowledgements

- **Ken Volin –** for years of help and advice, as he led IPNS sample environment efforts

- **SNS and HFIR Sample Environment Teams**
  - **John Wenzel:** R&D on JANIS automation and SNS hot exchange gas CCR design
  - **Andy Church:** Debugging equipment and optimizing the operating procedures

- **Jonathan Demko –** ORNL cryogenic engineer

Summary

- **We are making steady progress toward optimizing all of our cryofurnaces**
- **All should be treated as R&D projects**

- **Despite difficulties, prototype project is beneficial in the long run**