The Brookhaven Project:
Programs, achievements, show-stoppers

K.R. Sreenivasan

Trieste, Italy

European Workshop on
Turbulence in Cryogenic Helium

CERN

24-25 April 2007

Rough Timeline of Highlights

~1990	Wrote to an US Admiral and to SSC
~1991-92	Presentation to SSC and informal approval
1993	Preparatory DOE grants to Oregon and Yale; the US Congress cancels SSC
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Dynamical similarity

Reynolds number, Re = VL/ν

Terrestrial applications: $O(10^9)$

Testing facilities: Huge in size (Langley: ~1 km long, ~3 m deep, ~6 m wide); expensive to operate; Re = $O(10^8)$

Extrapolation: Completely satisfactory answers for complex interactions can be obtained only by testing at full scale Reynolds numbers.

Astrophysics: $O(10^{13})$ and higher

Surface flow of ships and submarines

Dynamical similarity parameters: Re and the Froude number, Fr

$$Fr = V/(gL)^{1/2}$$

Matching Re and Fr simultaneously using water is impossible.

Possible, at least in principle, using helium II (Donnelly)

Thermal convection

The most important similarity parameter: Rayleigh number

$$Ra = \alpha g \Delta H^3 / \nu \kappa$$

For terrestrial flows up to $O(10^{20})$

Sun $O(10^{22})$

Flows available then (using helium): $O(10^{12})$, in Chicago

Why is all this interesting for Physics?

(Why SSC, Brookhaven and CERN?)

V.L. Ginzburg (2003 Nobel Prize in Physics)

(*Physics Today*, May 1990, page 9; also *Uspekhi* **42** (4), 353, 1999)

- Classified Physics into Microphysics, Astrophysics and Macrophysics (the small, the large and the complex)
- One of the 11 items of Macrophysics: “Strongly Nonlinear Phenomena: Turbulence”

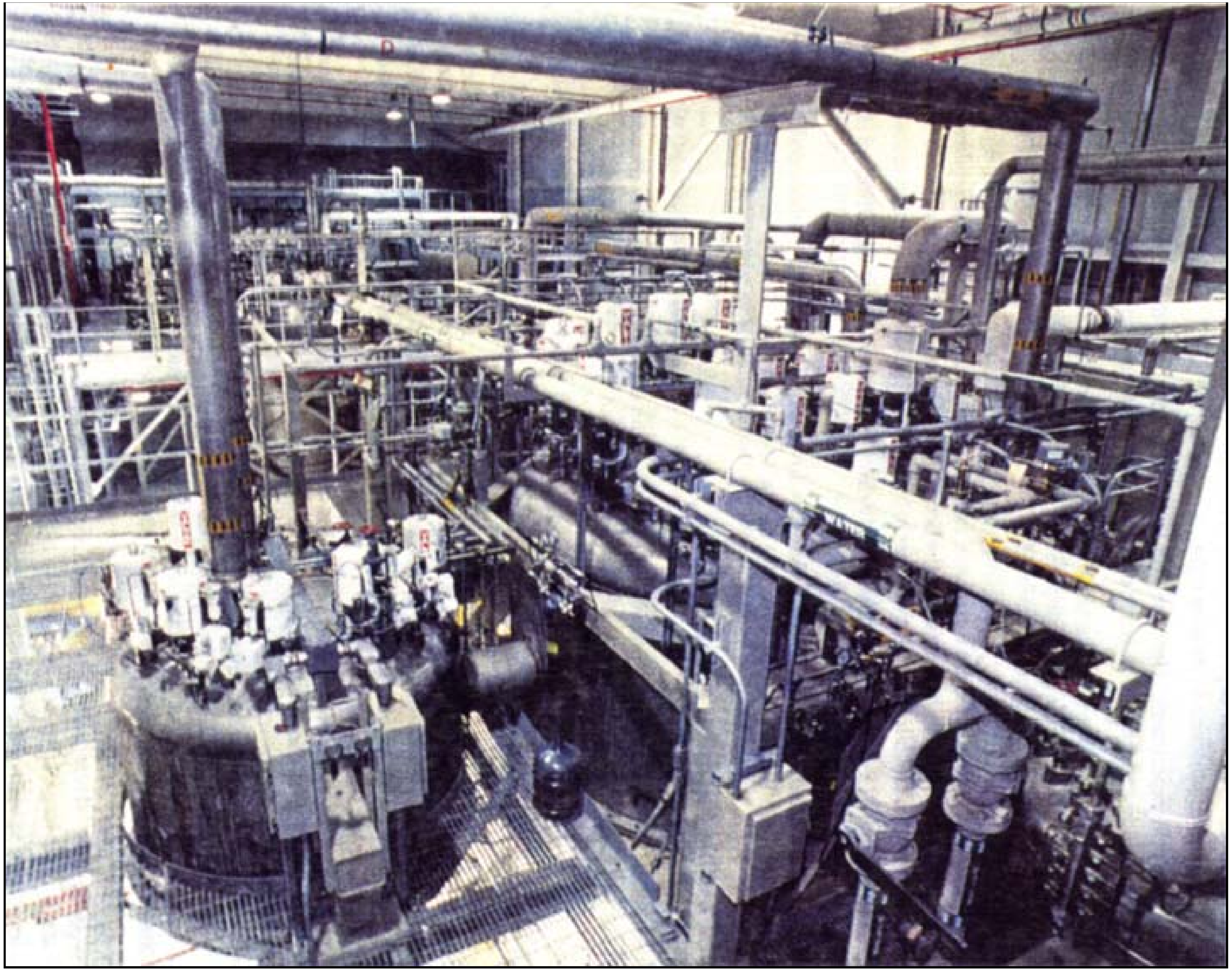
Scaling range, number of steps in the cascade, etc vary as $\log_2 Re$

Superfluid Turbulence

Helium II has a superfluid component, and produces tangles of quantized vortices.

This can coexist with classical turbulence.

Understanding the dynamics of superfluid turbulence for its own sake, and its interaction with classical turbulence are exciting problems.



The interior of the N-15 Service Building showing the cold boxes of two 4.5 kW helium temperature refrigerators. The top of one cold box with its attached turbine pod is seen in the foreground and the equipment of the second plant, N-15B, is seen in the background.

CRYOGENIC HELIUM GAS CONVECTION RESEARCH

A Discussion of Opportunities for Using the Cryogenic Facilities
of the SSC Laboratories for High Rayleigh Number and High Reynolds Number
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A Report to the Department of Energy under Grant No. DE-FG05-94ER40878
From the Department of Physics, University of Oregon
Eugene, Oregon 97403

Preparation of this report was supported also by the Department of Energy
through a grant to Yale University, DE-FG05-94ER40876 and to Duke University
through grant DE-FG05-94ER40877.

Authors of This Report

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Artwork
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Editor of Report
Russell J. Donnelly

October 1994

THE CRYOGENIC HELIUM GAS CONVECTION EXPERIMENT AT THE SUPERCONDUCTING SUPERCOLLIDER LABORATORY

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Appendix D: Plate Thermal Issues

- Estimate of heat transport from known measurements
- Extrapolation by scaling
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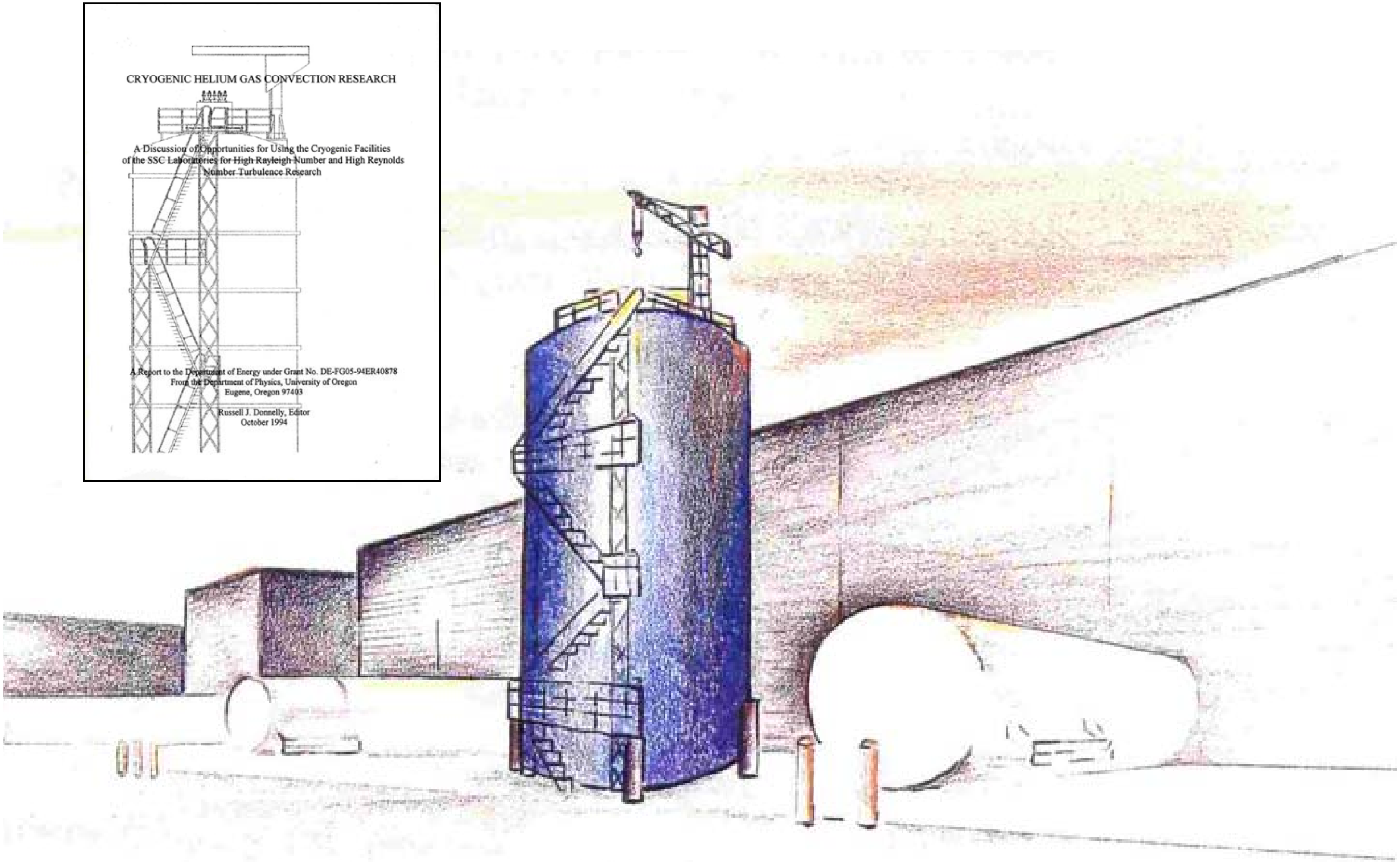

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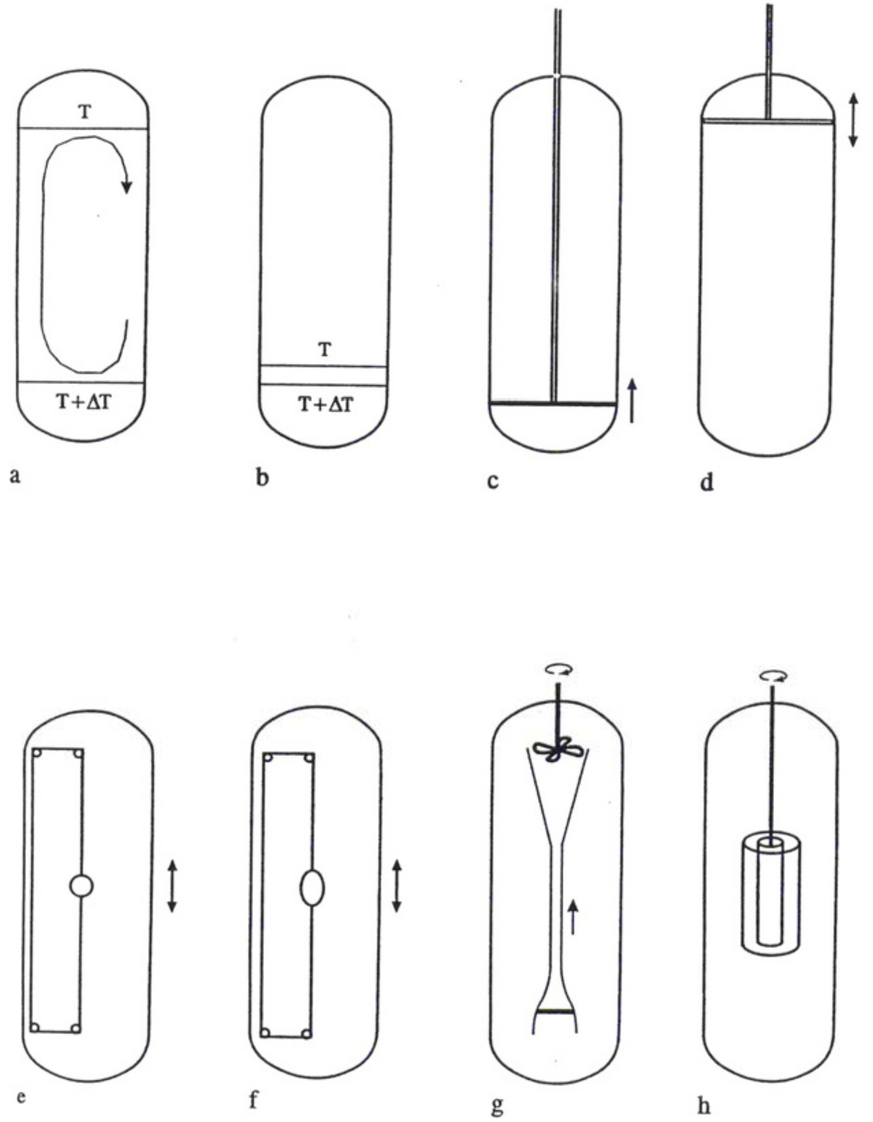

<u>The BNL cryostat and its potential uses</u>

(a) ultra-high-Rayleigh-number convection

(b) convection with variable aspect ratio

(c) towed grid

(d) oscillating grid

(e) towed sphere

(f) towed ellipsoid

(g) a tunnel insert

(h) a Taylor-Couette insert

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N. Goldenfeld (U. Illinois)
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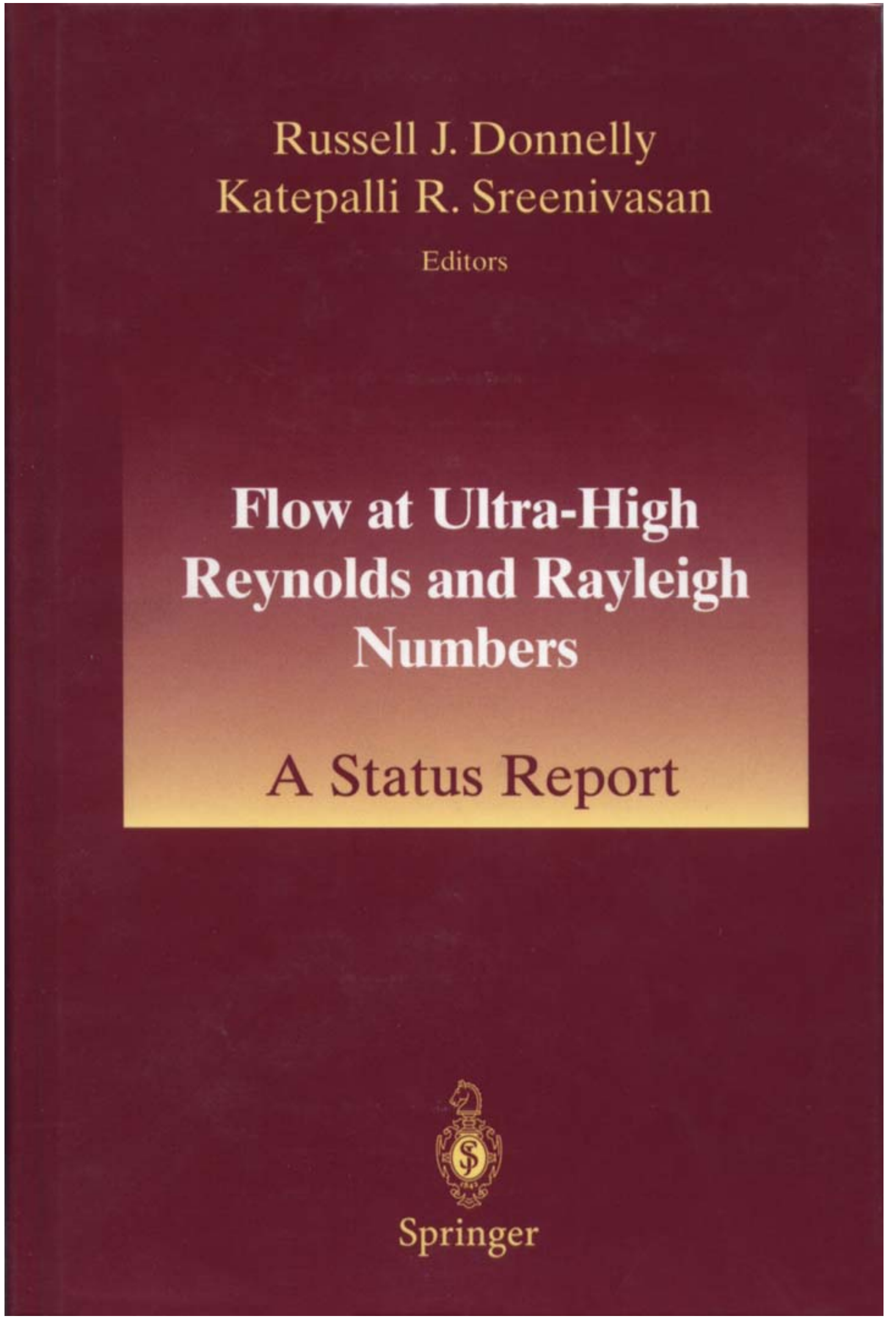
Russell J. Donnelly
Katepalli R. Sreenivasan
Editors
Flow at Ultra-High Reynolds and Rayleigh Numbers
A Status Report
Springer

What did we do right?

Pretty much everything until the last step

What could we have done better?

1. Emphasis could have been solely on physics
2. Didn’t involve sufficient number of physicists outside of nonlinear physics; astrophysicists, geophysicists
3. Instrumentation didn’t make as much progress as hoped
4. Dynamics of the community
5. Didn’t pursue the resubmission for personal reasons

What thoughts for this enterprise?

- Build on what has happened already
- Get the long-term commitment of the CERN management
- Commit an articulate and respected leader, and build an international team
- Build a genuine community with a broad base and high standards (core + second rung)
- Prepare a proposal for instrumentation first and make it succeed (~a few M Euro)
- Prepare the final proposal after many discussions

THE END

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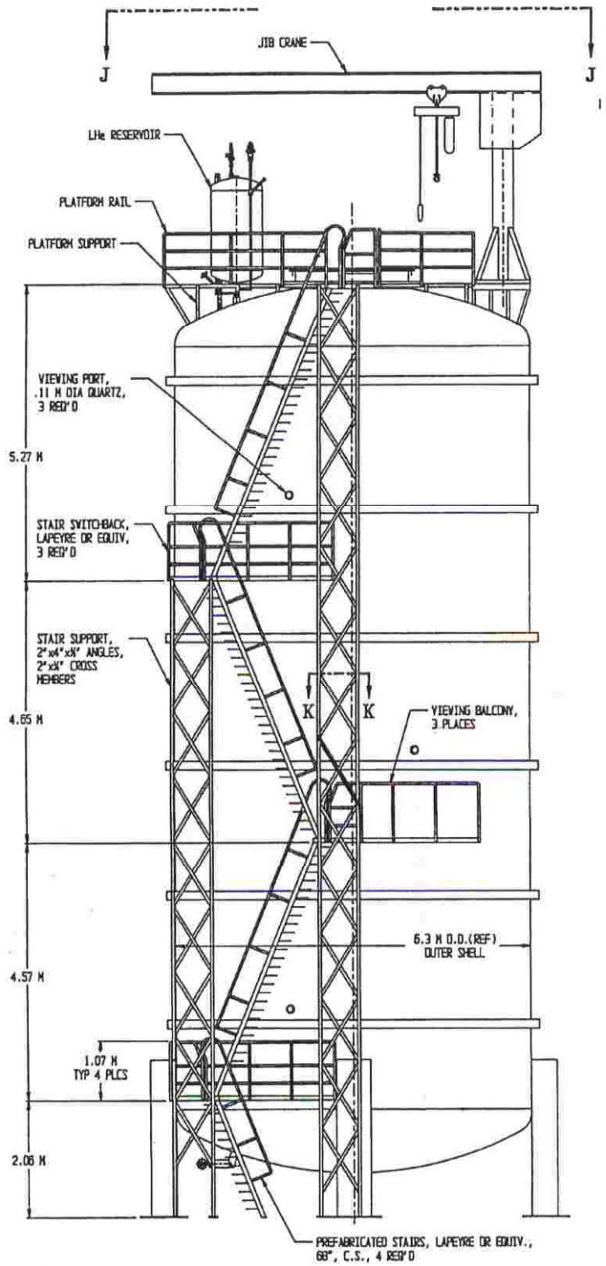
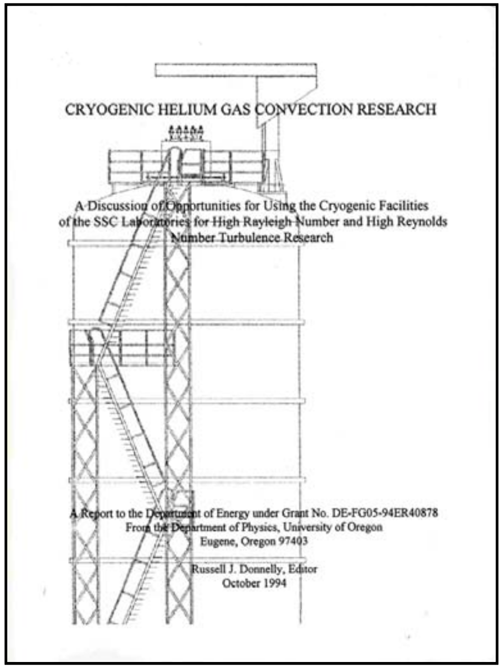


PLATFORM AND STAIR SYSTEM DETAIL

SCALE: 1/48 = 1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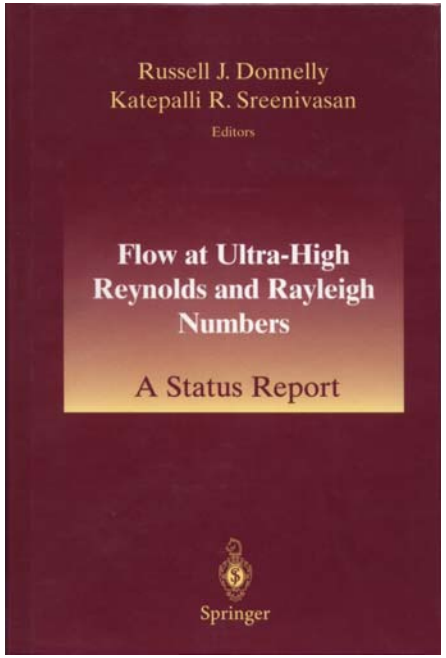

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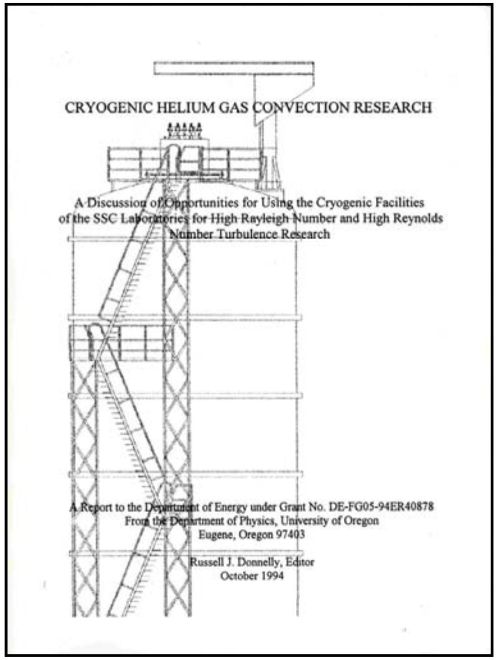

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