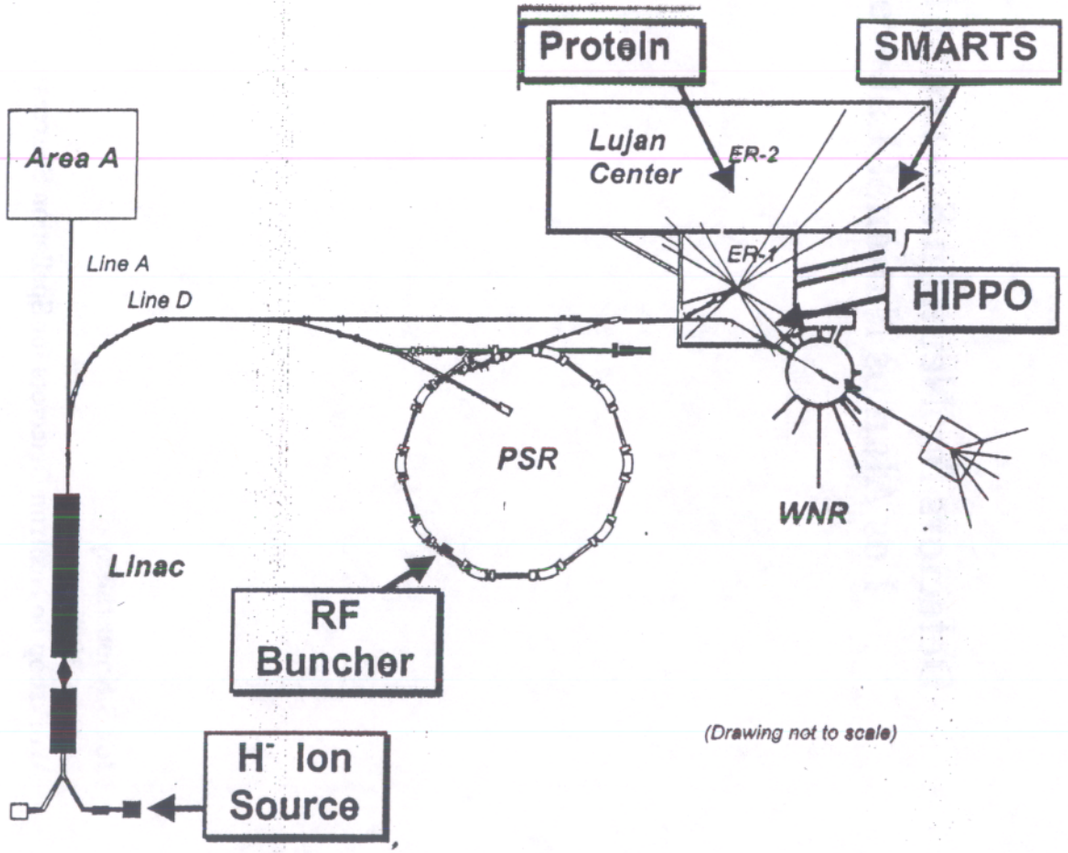
Detectors for Neutron Science at LANSCE
Los Alamos National Laboratory

Jon S Kapustinsky
24-Sept-1998
Workshop on Neutron Detectors for Spallation Sources

CLEAR TOPPER

SPSS Major Elements



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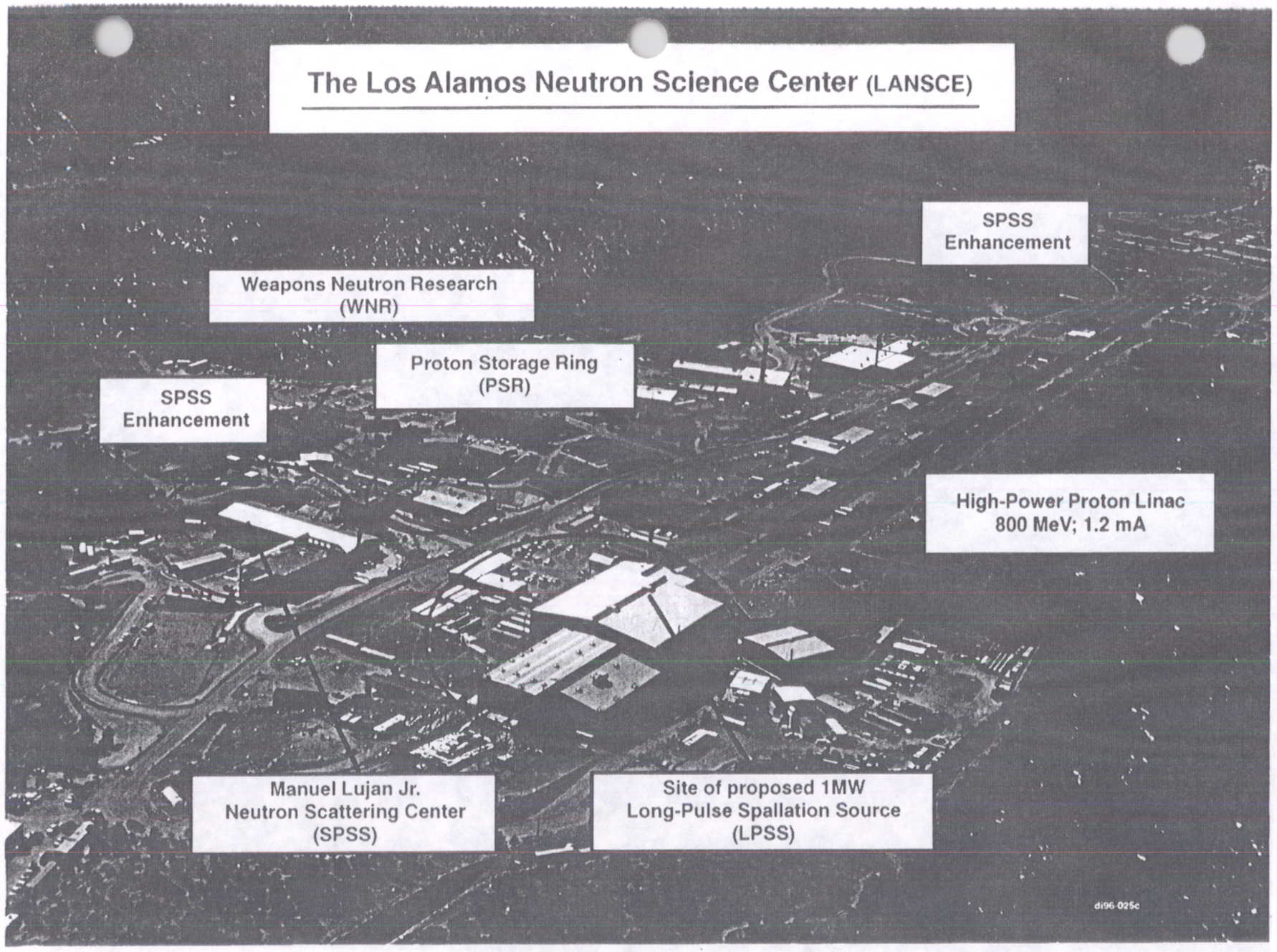
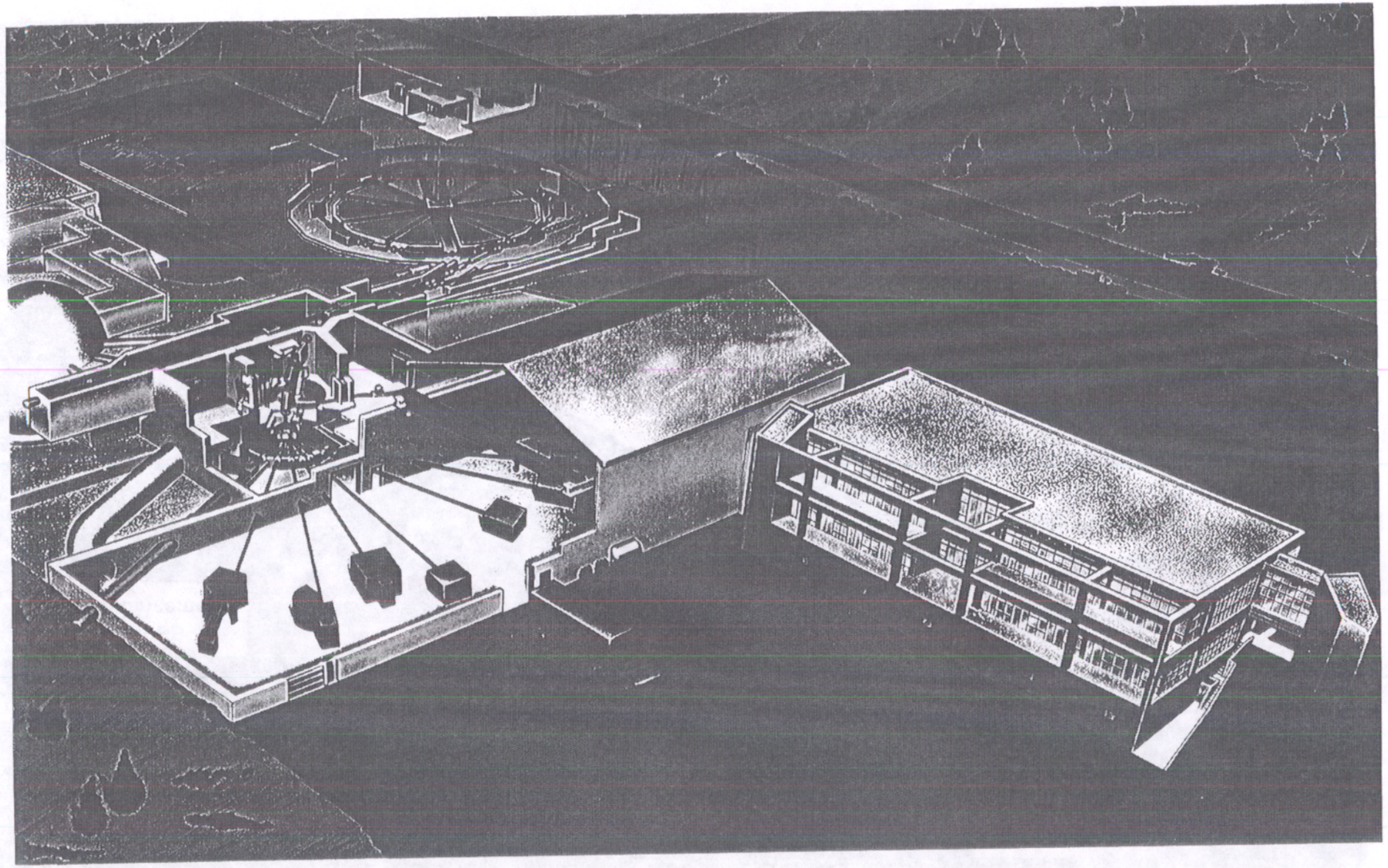
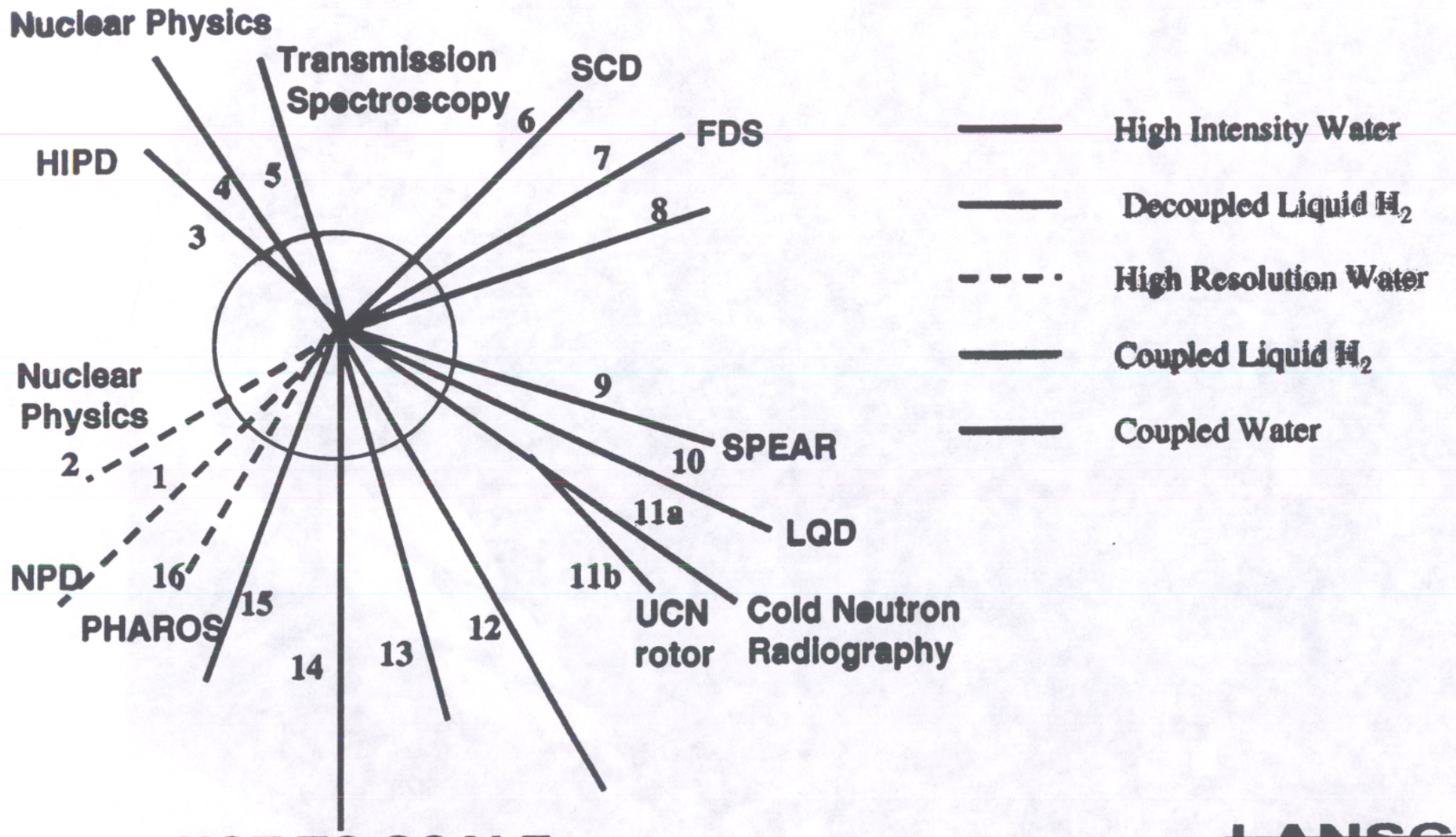

The Los Alamos Neutron Science Center (LANSCE)
SPSS Enhancement
Weapons Neutron Research (WNR)
Proton Storage Ring (PSR)
SPSS Enhancement
High-Power Proton Linac 800 MeV; 1.2 mA
Manuel Lujan Jr. Neutron Scattering Center (SPSS)
Site of proposed 1MW Long-Pulse Spallation Source (LPSS)
di96-025c



Present Flight Path Usage (last cycle)



NOT TO SCALE

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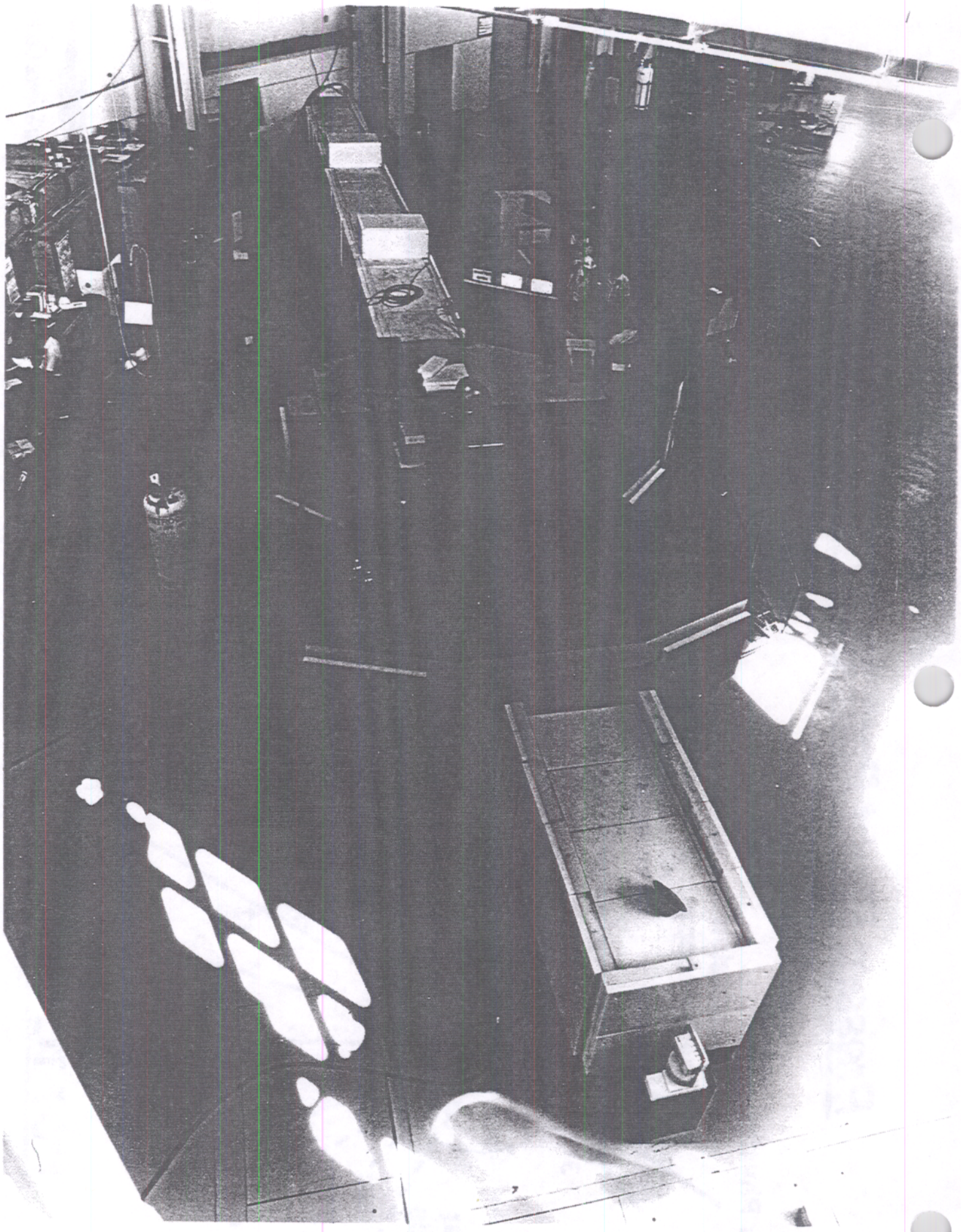
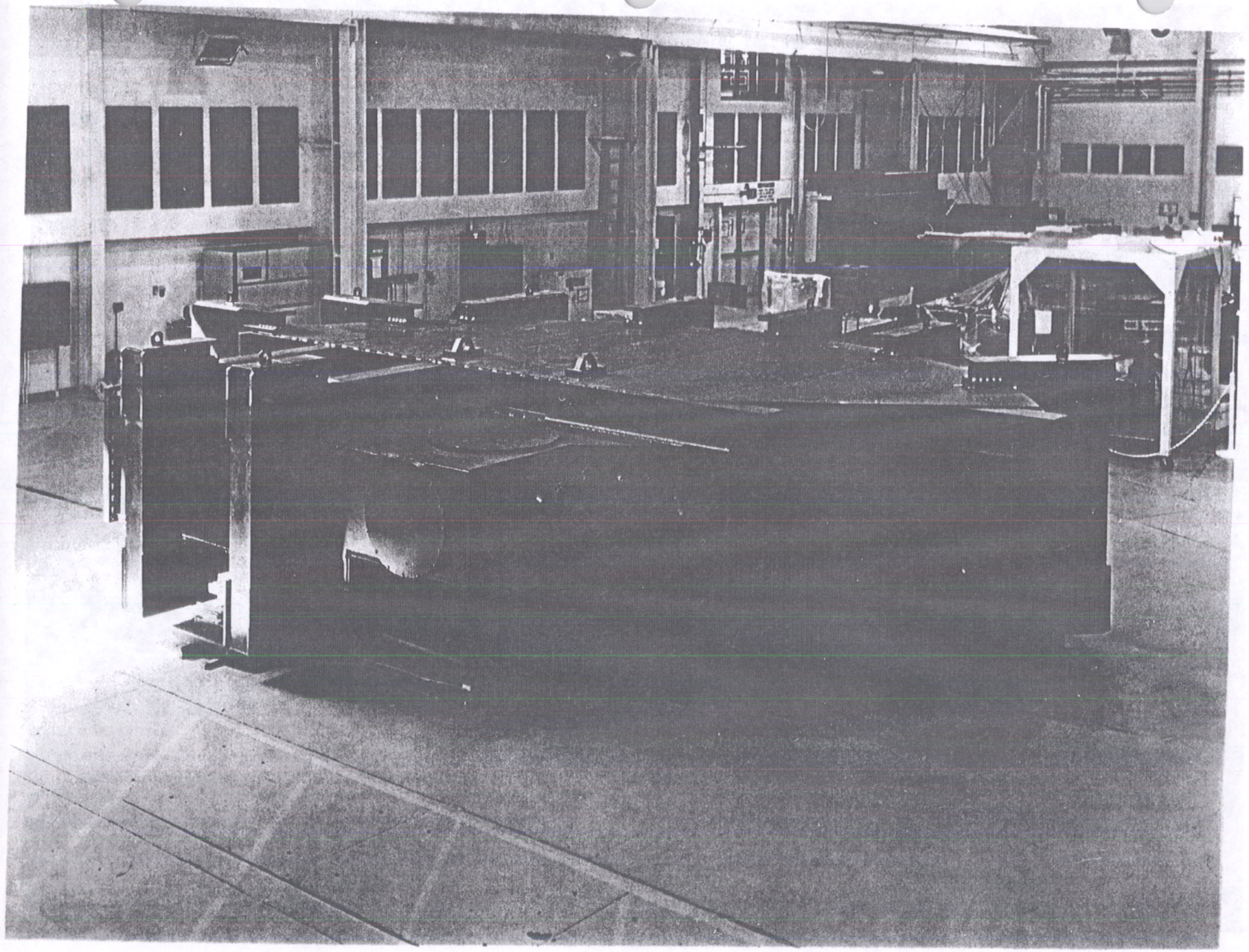
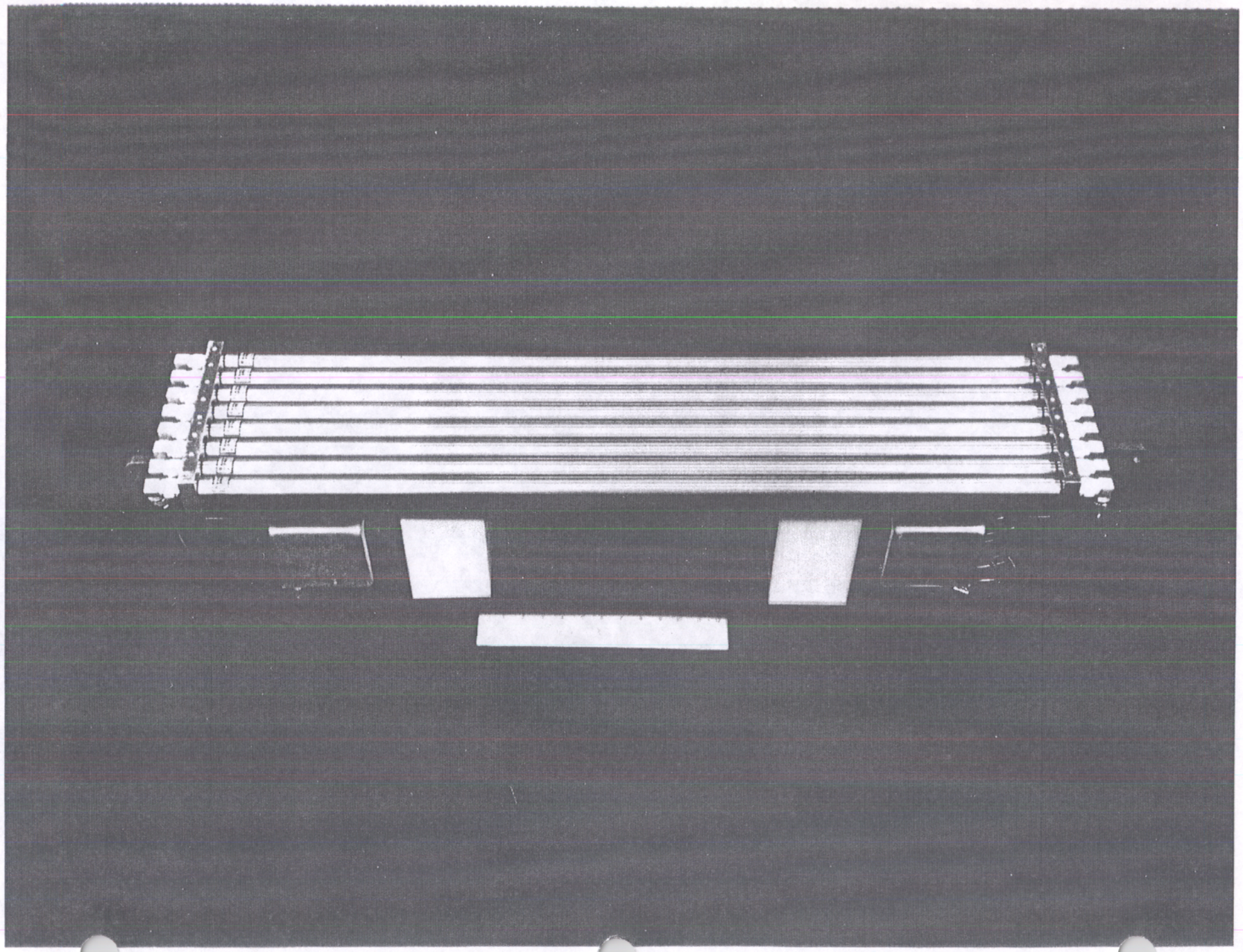


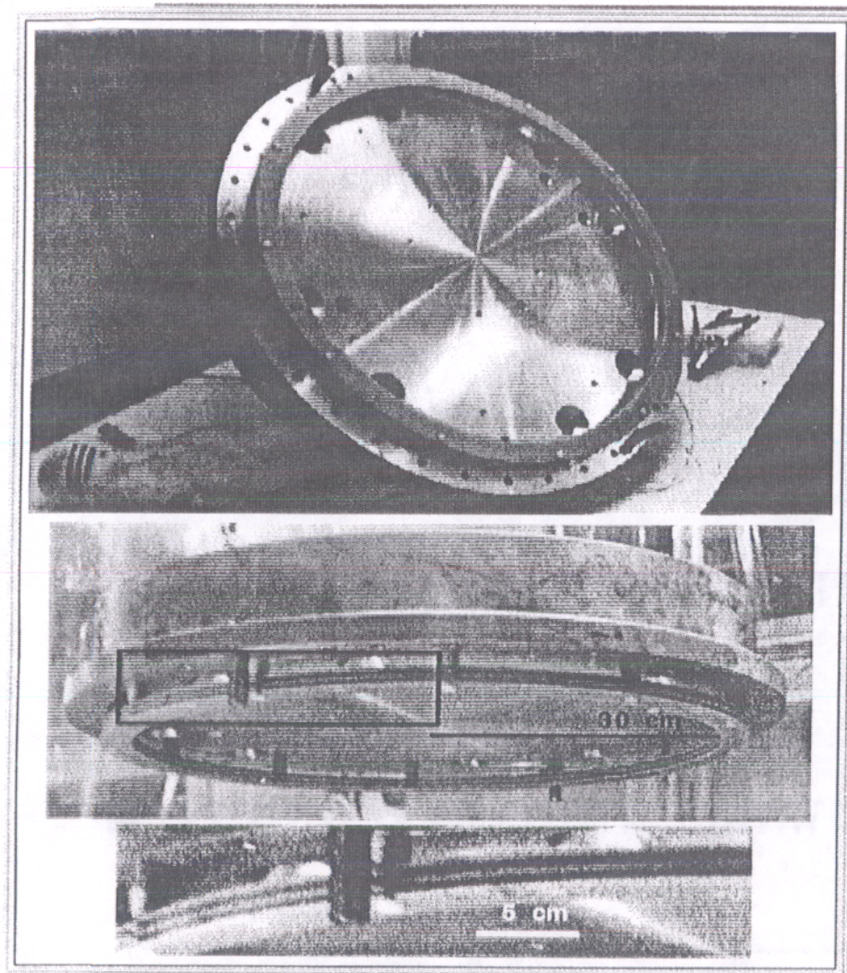
CN88 3856





CN 93 440

Detecting Neutrons: The 2-D Area Detector



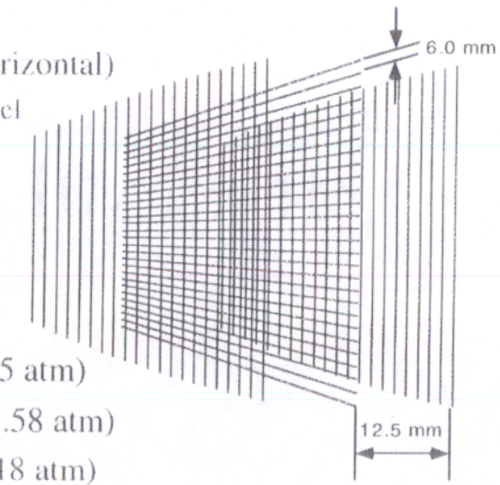
Long Length Scales

R.P. Hjelm

Characteristics of the area sensitive, Proportional counter:

Three 100 wire planes:

- Two cathode planes (vertical)
  - 100 μ phosphorous bronze
  - 1.7 kV
- One anode plane (horizontal)
  - 20 μ stainless steel
  - 3.4 kV



Gas amplification:

- Active gas: ^3He (1.75 atm)
- Amplification: Ar (1.58 atm)
- Quenching: CH_4 (0.18 atm)

Read out:

- Delay line principle
- Position encoded by signal timing at wire ends and coincidence

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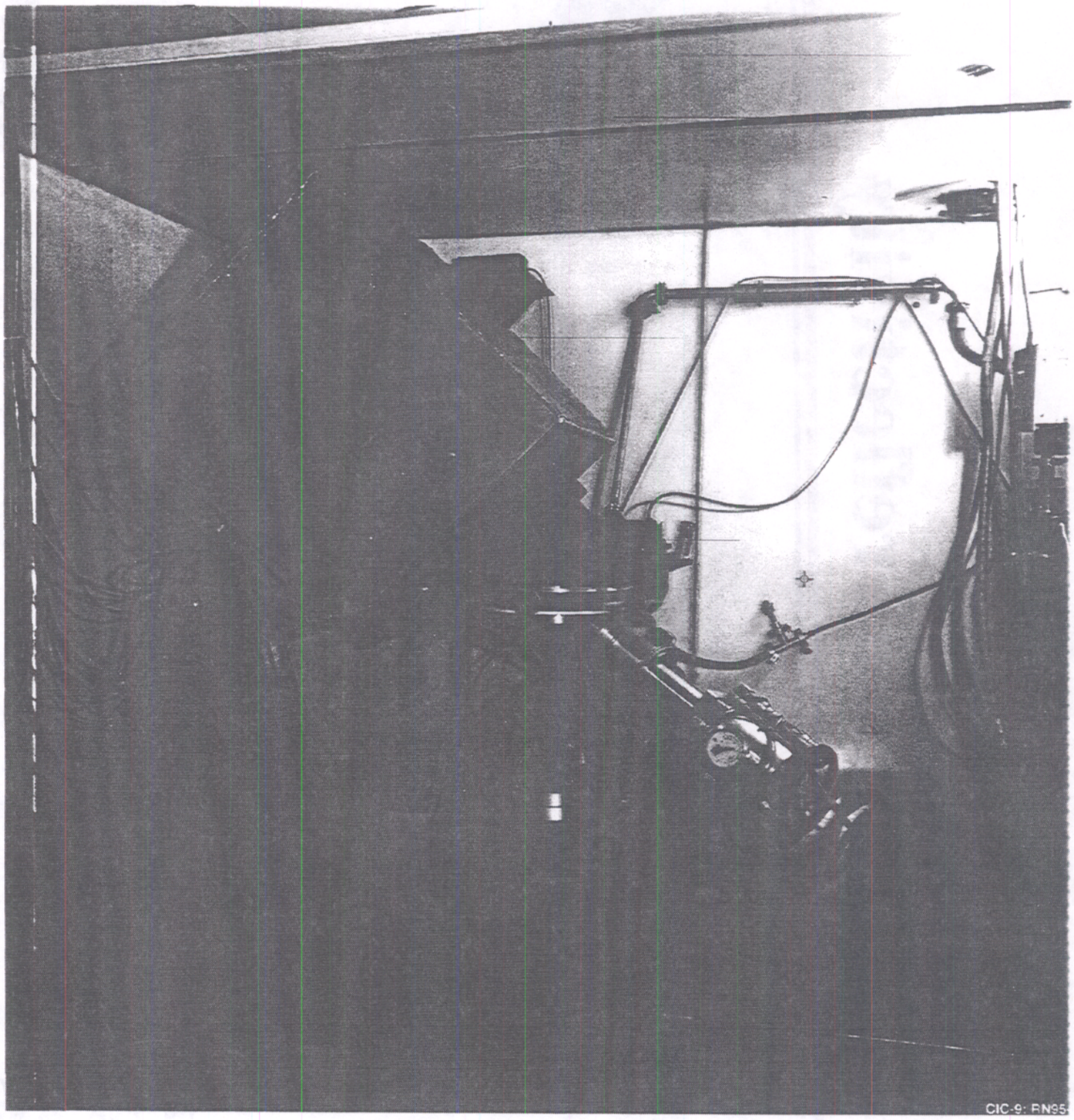
The Future Challenge: Higher Count Rates

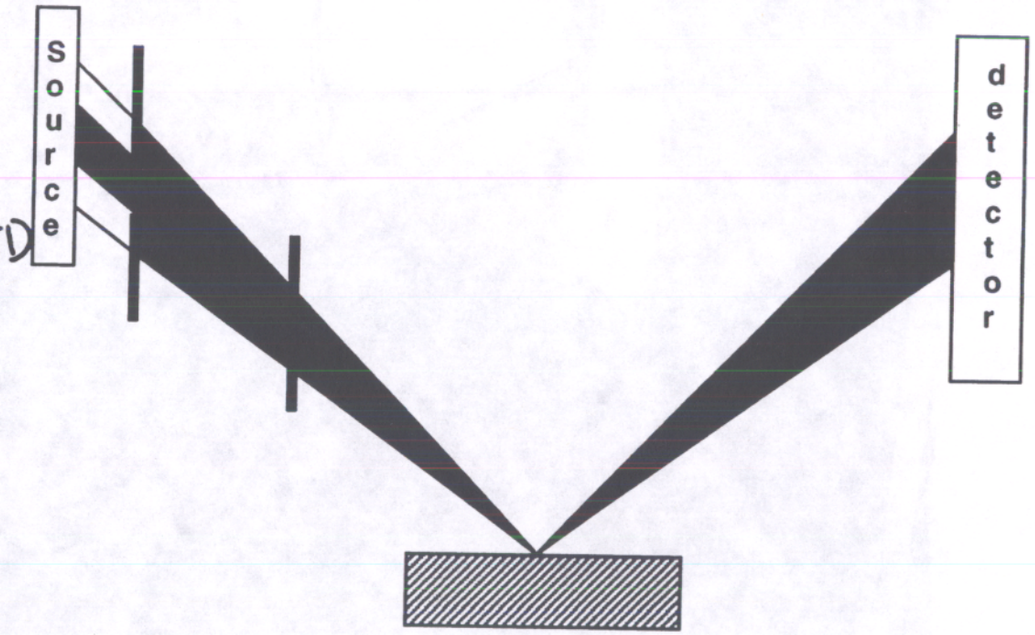
- Science driving toward higher count rates
- Brighter sources
- More efficient instrument design
- Typical instantaneous count rates: 10^3-10^6 Hz at 1 MW
- Multichannel readout ^{3}He position-sensitive detectors: $\approx$ 1 MHz
- Better solutions needed


CIC-9: RN95

Specular reflectivity

low reflectivity - S.E. ^{3}He

off-specular- linear ^{3}He PSD



- θ incidence equals θ reflection
- Angular resolution determined by
  - -psd
  - -slits

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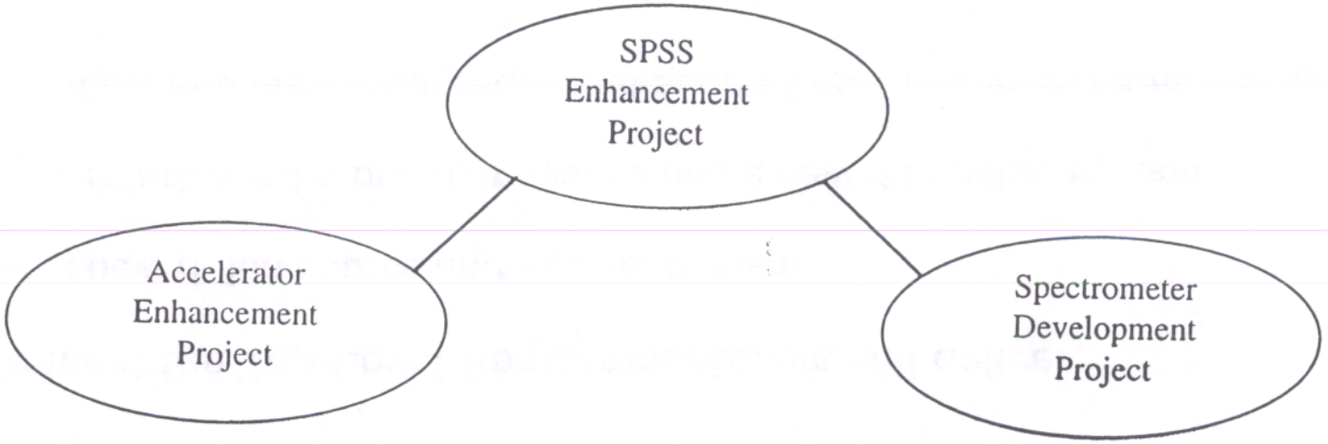
SPSS Enhancement Project Components & Objectives



Objective:

increase beam power delivered to spallation target to 160 kW, thereby increasing neutron flux available for experimental purposes

Defense Programs - $16.7M

Objective:

increase diversity and number of neutron scattering investigations performed at LANSCE by deploying additional spectrometers

Energy Research - $24.8M

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Technical Baseline - Accelerator Enhancement Project

- Top-Level Requirements
  - 200 μA @ 30 Hz (resulting in 160 kW beam power to target)
  - ≥ 85% Availability (with respect to schedule)
  - capability for 8 months per year operation
  - beam losses in PSR ≤ 0.3 μA
- To meet the Top-Level Requirements, we will deliver:
  - a new H- ion source and injector system
  - a refurbished rf buncher system and a new rf buncher system
  - utility and facility upgrades that support the enhanced rf buncher systems

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Spectrometer Development Components

Instruments incorporated to date:

- **protein crystallography spectrometer**
  LANL, BNL MOU
  BER funded, selected 12/96, technical review 11/96, baseline established 5/98
- **HIPPO - high pressure preferred orientation spectrometer** (formerly UCMRD)
  UC, LANL MOU
  BES funded, selected 11/97, technical review 5/98, baseline established 5/98
- **SMARTS spectrometer for materials research at temperature & stress**
  LANL, CalTech, Northwestern MOU
  BES funded, selected 11/97, technical review 5/98, baseline established 5/98

Common project elements

- **project management and planning**
- **common technical**
  data acquisition & control architecture, detector systems, configuration management, ES&H

Additional instruments recommended by the PEC - 3/98

- **Hermes - high resolution crystal backscattering spectrometer** - *BNL, ISIS, ANL, LANL*
- **Helios - high intensity chopper spectrometer** - *ORNL, ANL, JHU, CalTech, LANL*
-
-

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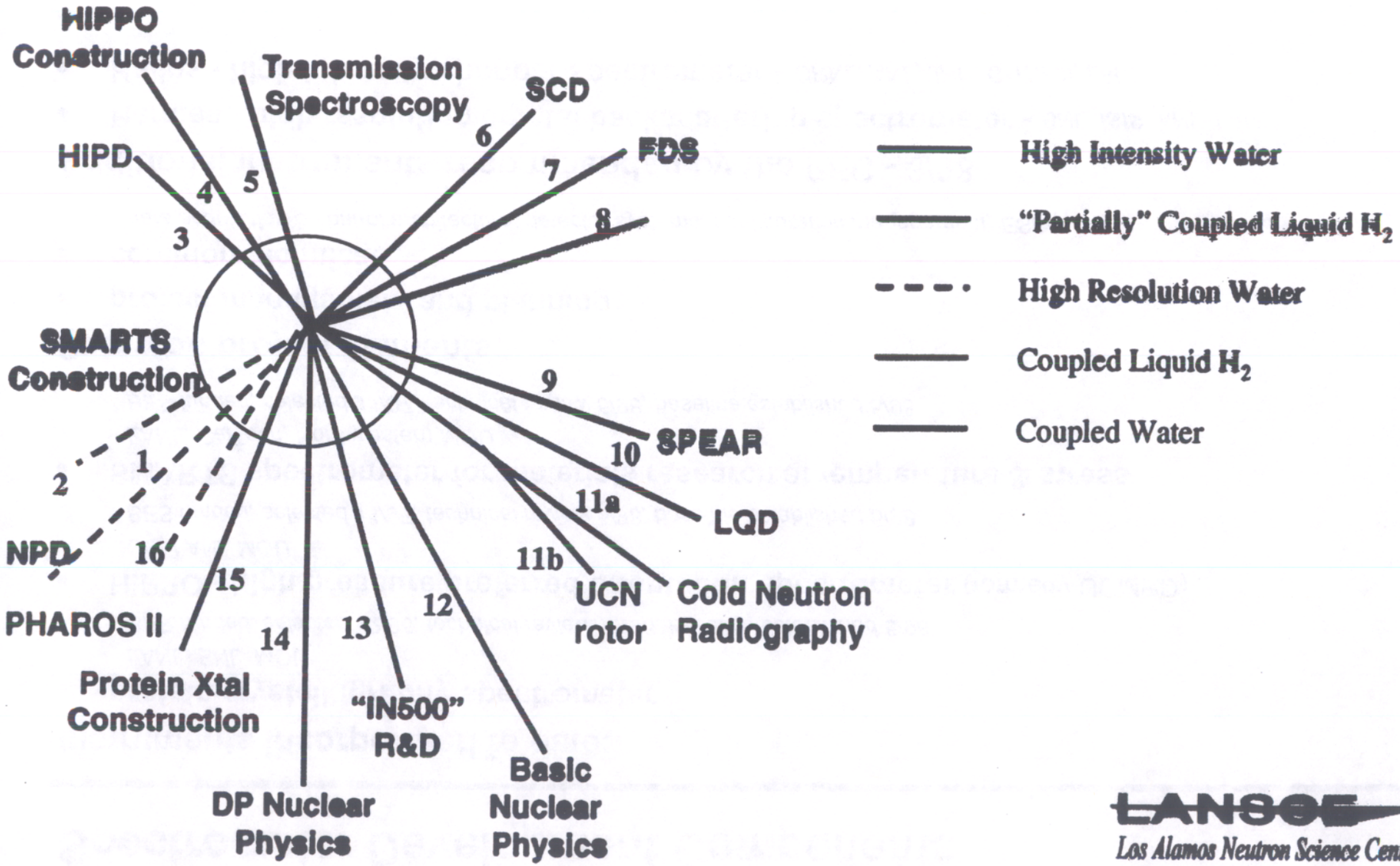
Near Term Flight Path Usage (present~2 years)



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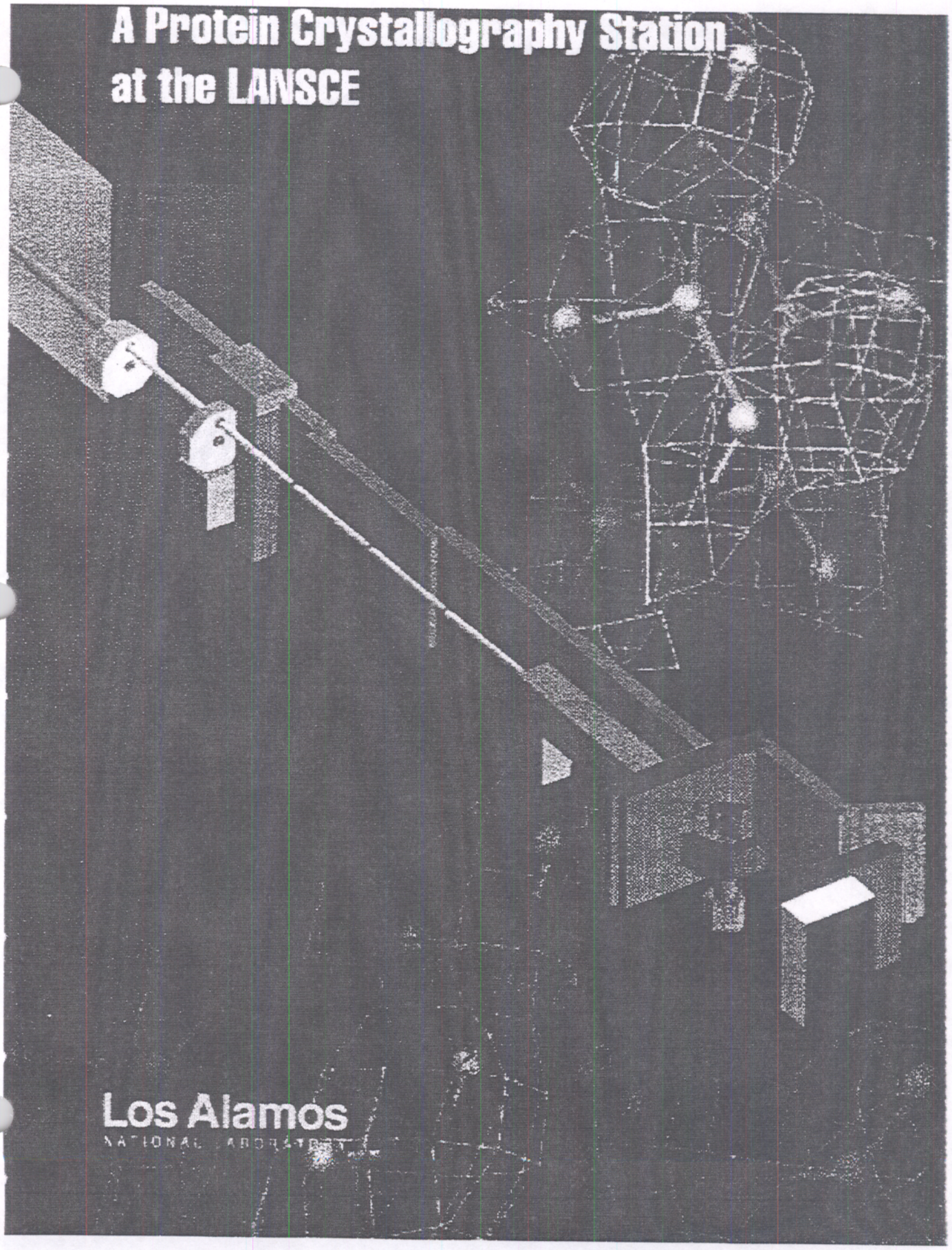
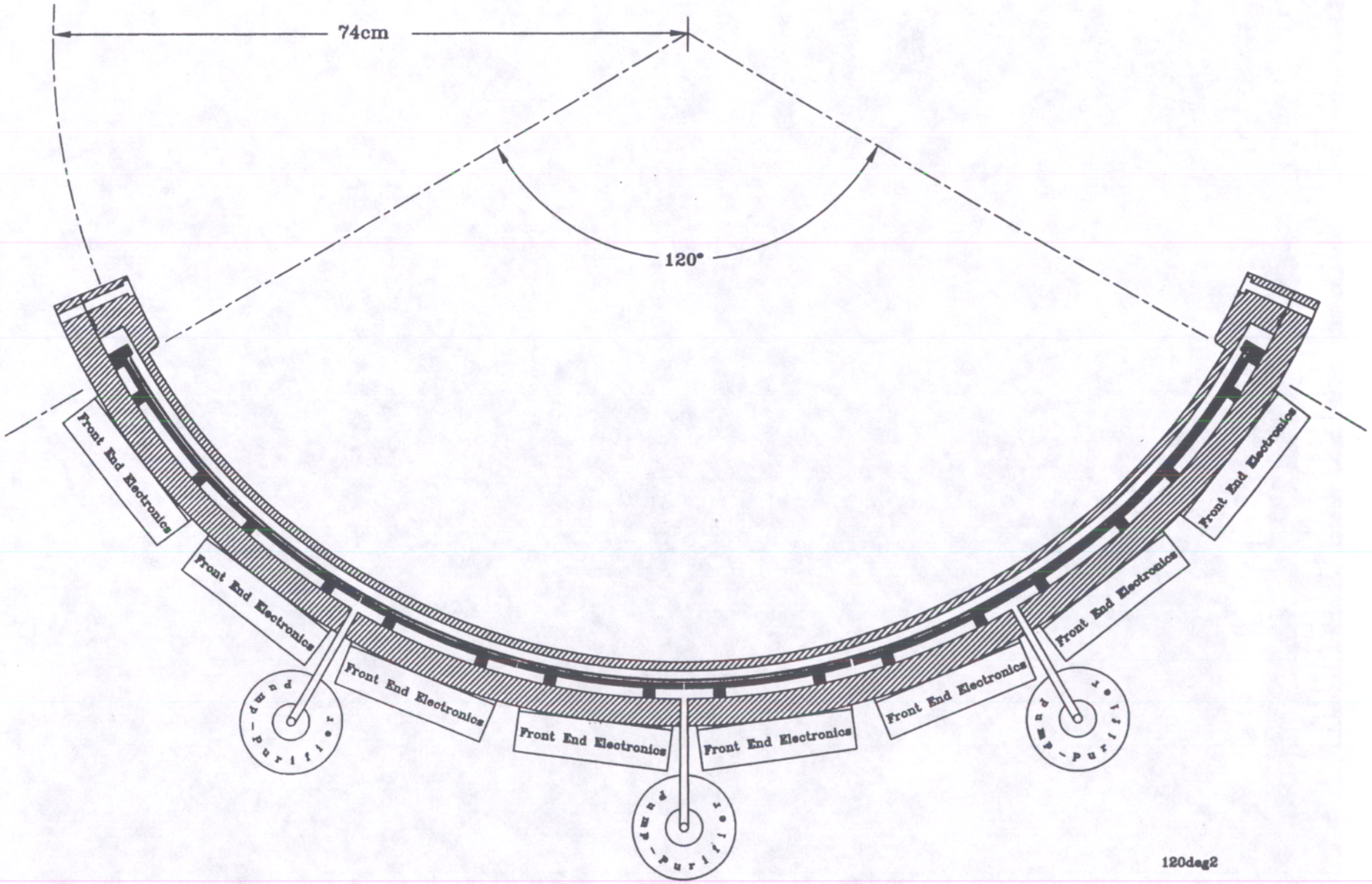
A Protein Crystallography Station at the LANSCE



Los Alamos
NATIONAL LABORATORY

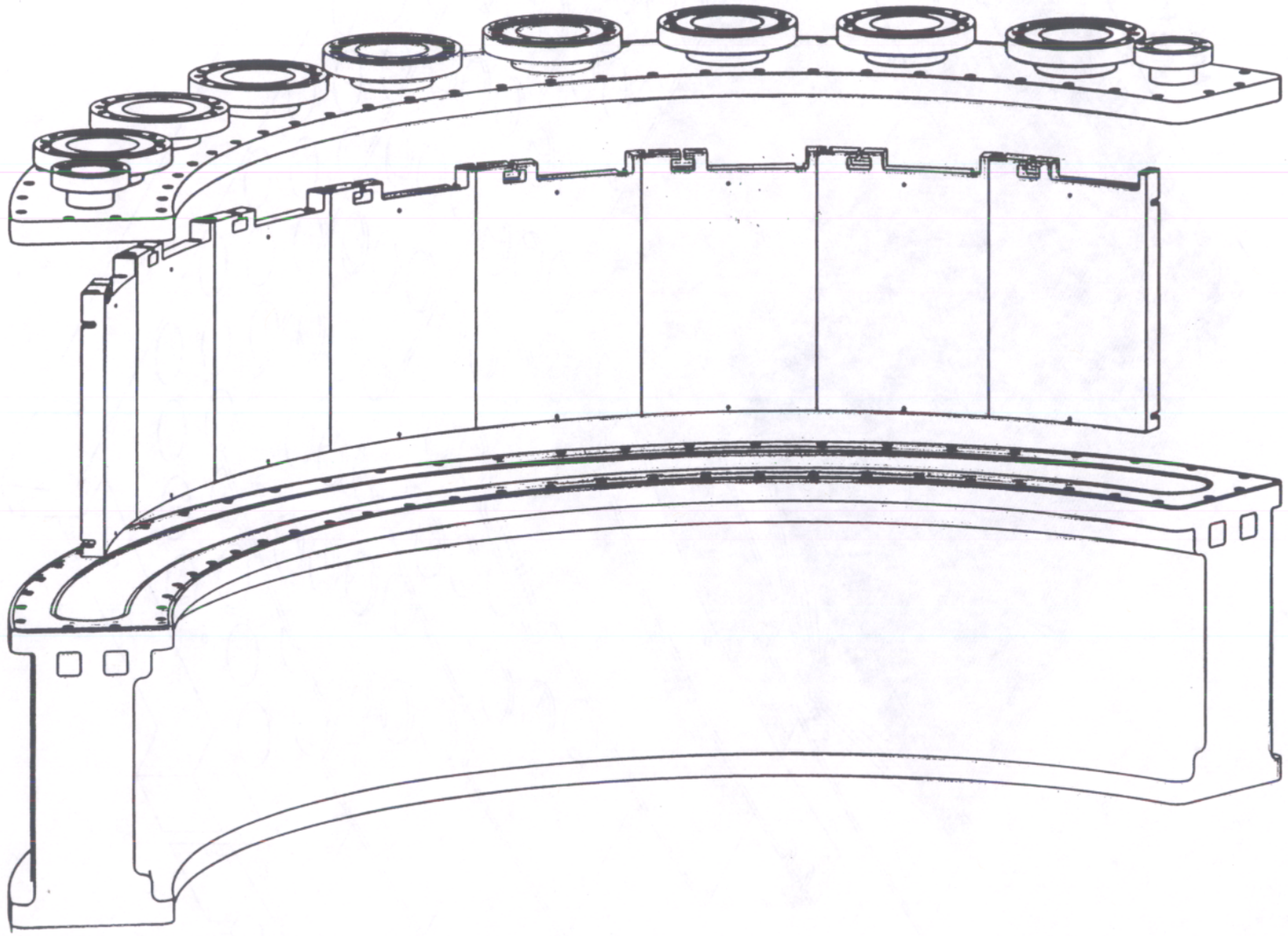
LANSCE 120 DEGREE THERMAL NEUTRON DETECTOR

HORIZONTAL CROSS-SECTION

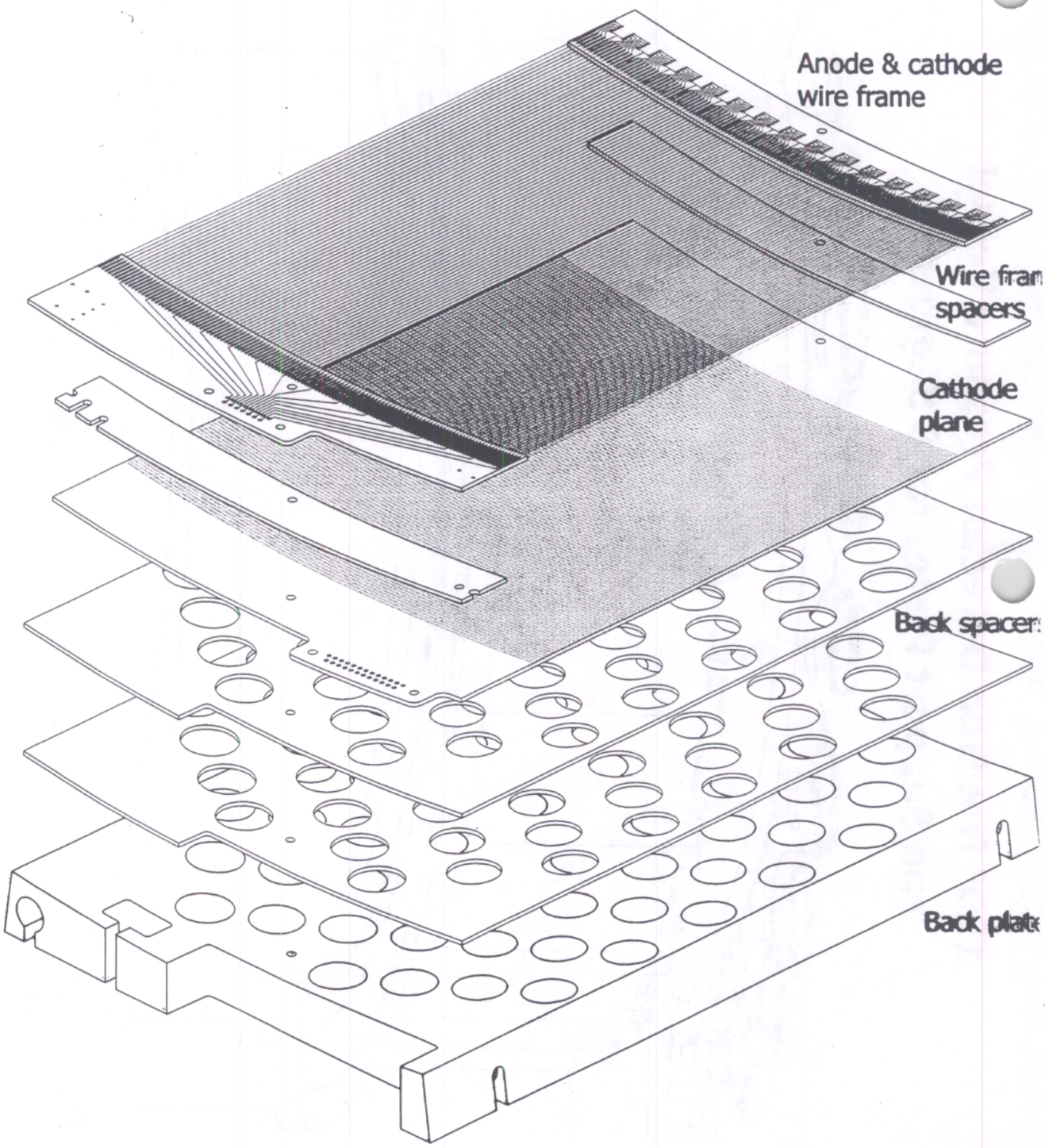


120deg2

120° Neutron Detector Pressure Vessel and Support Plates for 8 Segments



Segment Assembly



"SMARTS"

Spectrometer for MAterials Research at Temperate and Stress

- "Powder" (polycrystalline) diffractometer optimized for strain measurements
- Engineering related problems now use nearly 80% of time on the Neutron Powder Diffractometer (NPD)
- Will Address a variety of SBSS and basic materials research
- Represents ~x30 increase in count rate over NPD
  - x5 from neutron guides
  - x6 from increased detector solid angle
- Will allow improved spatial resolution, time evolution measurements
- Can accommodate a variety of samples and sample environments
- Optimized for efficient handling of many samples

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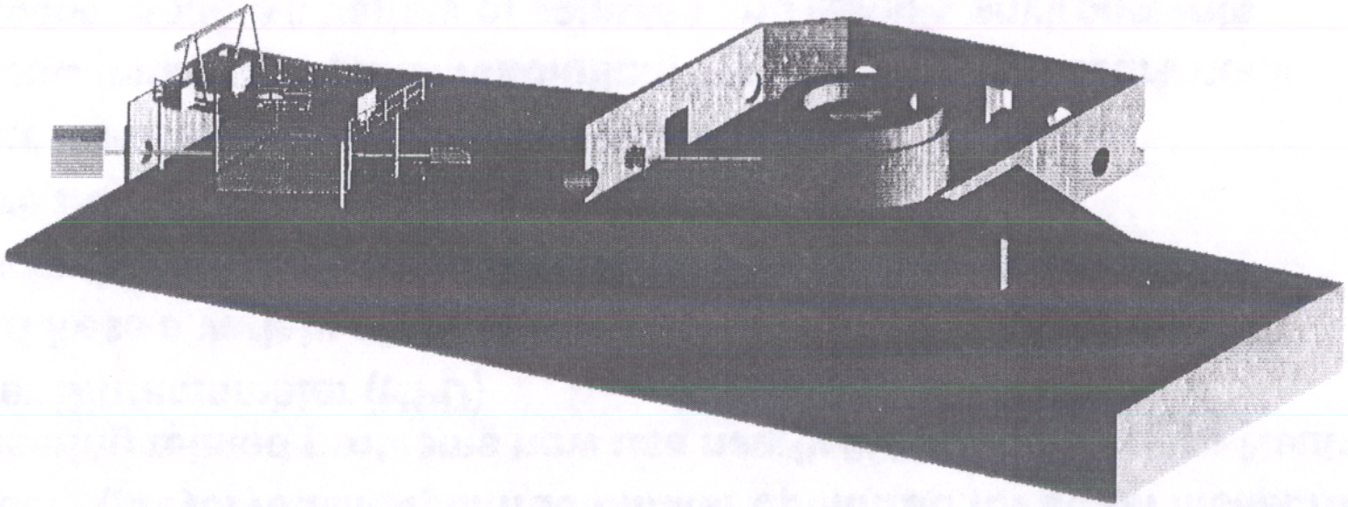
SMARTS Arrangement

Isometric View SMARTS in Building



ESA

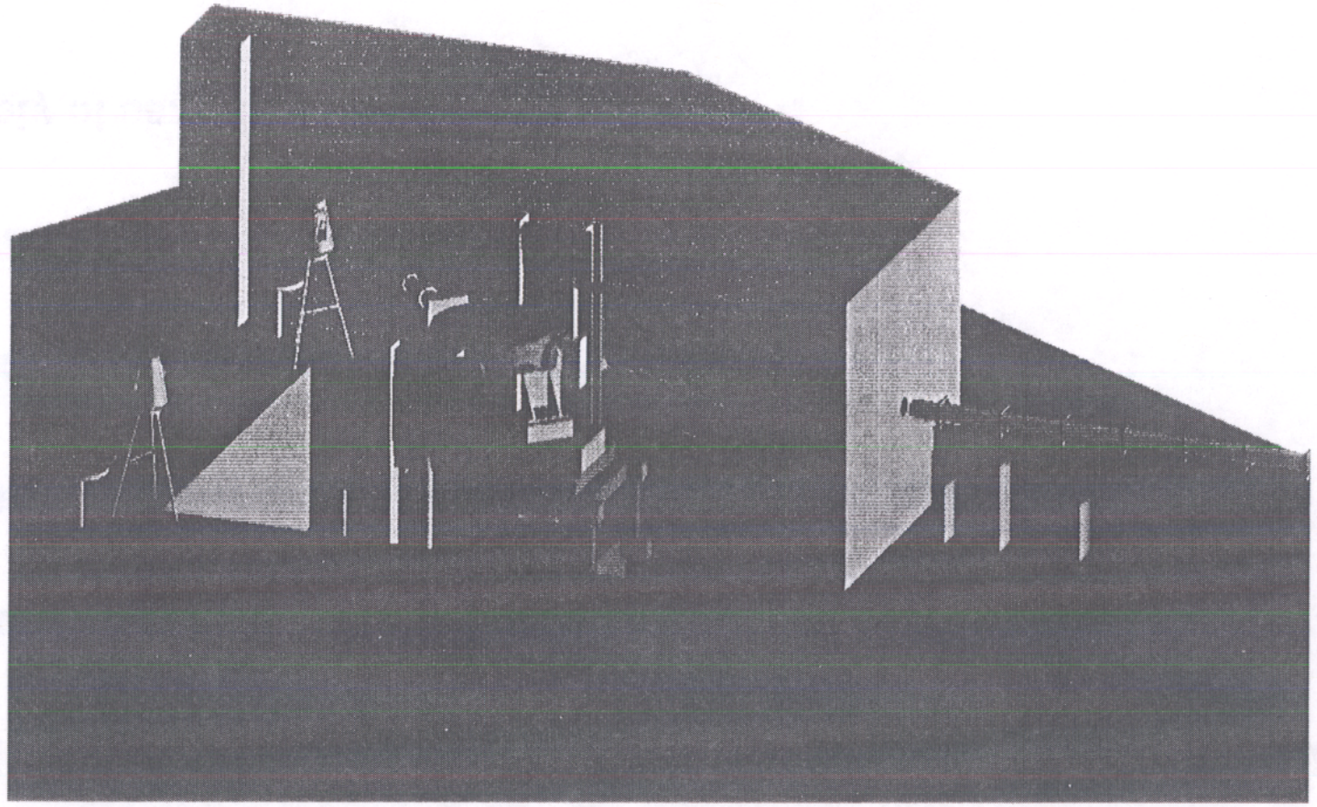
Design Engineering

Engineering Sciences and Applications Division

Los Alamos National Laboratory, Los Alamos, NM

SMARTS Arrangement

Isometric View SMARTS Cave Layout



UC Materials Research Diffractometer at LANSCE

- "Powder" (polycrystalline) diffractometer optimized for "Texture"
- High count rate (x20-x60 over current capability) due to large detector area
- Will address basic materials science, applied science (geophysics...) & SBSS
- Flexible to allow small ($1mm^3$) and large ($2cm^3$) sample volumes
- Spatial resolution and kinetic studies
- Rapid turnover in samples
- Variety of sample environments.

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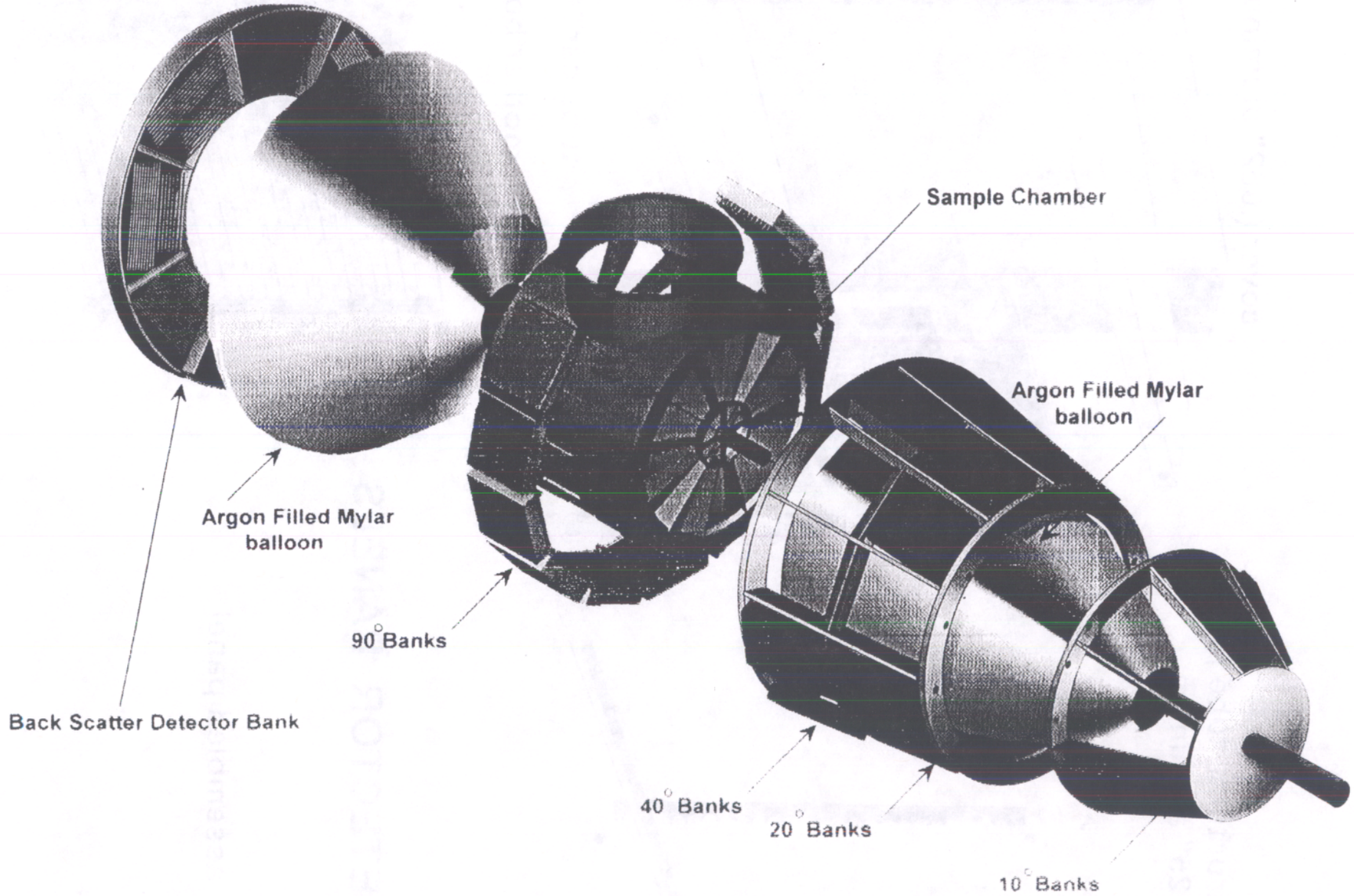
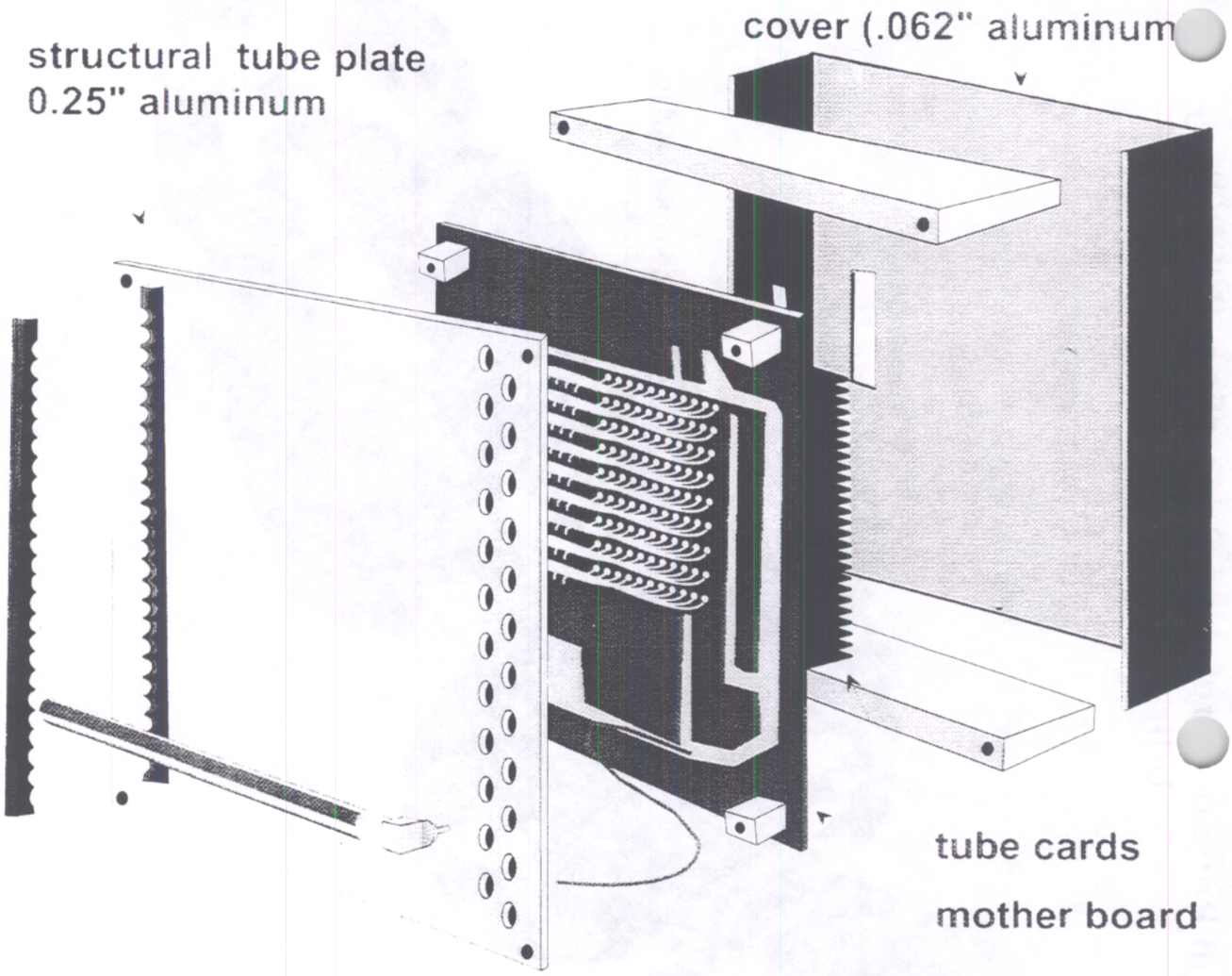
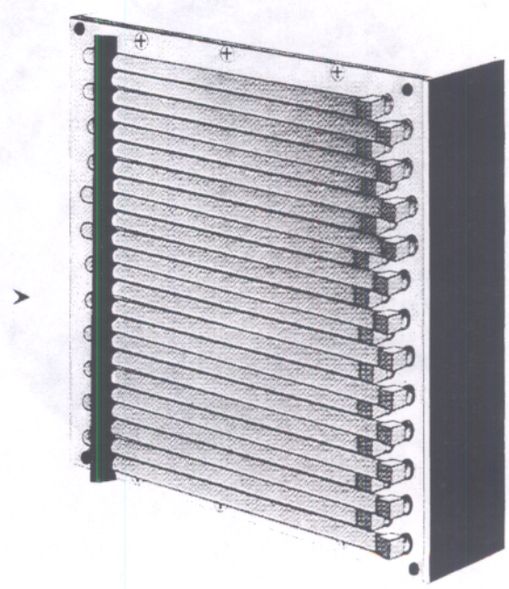
High Pressure Preferred Orientation (HIPPO) Diffractometer





DETECTOR PANELS

assembled panel



High Energy Resolution MachinES I

ΕΡΜΗΣ *Hermes*

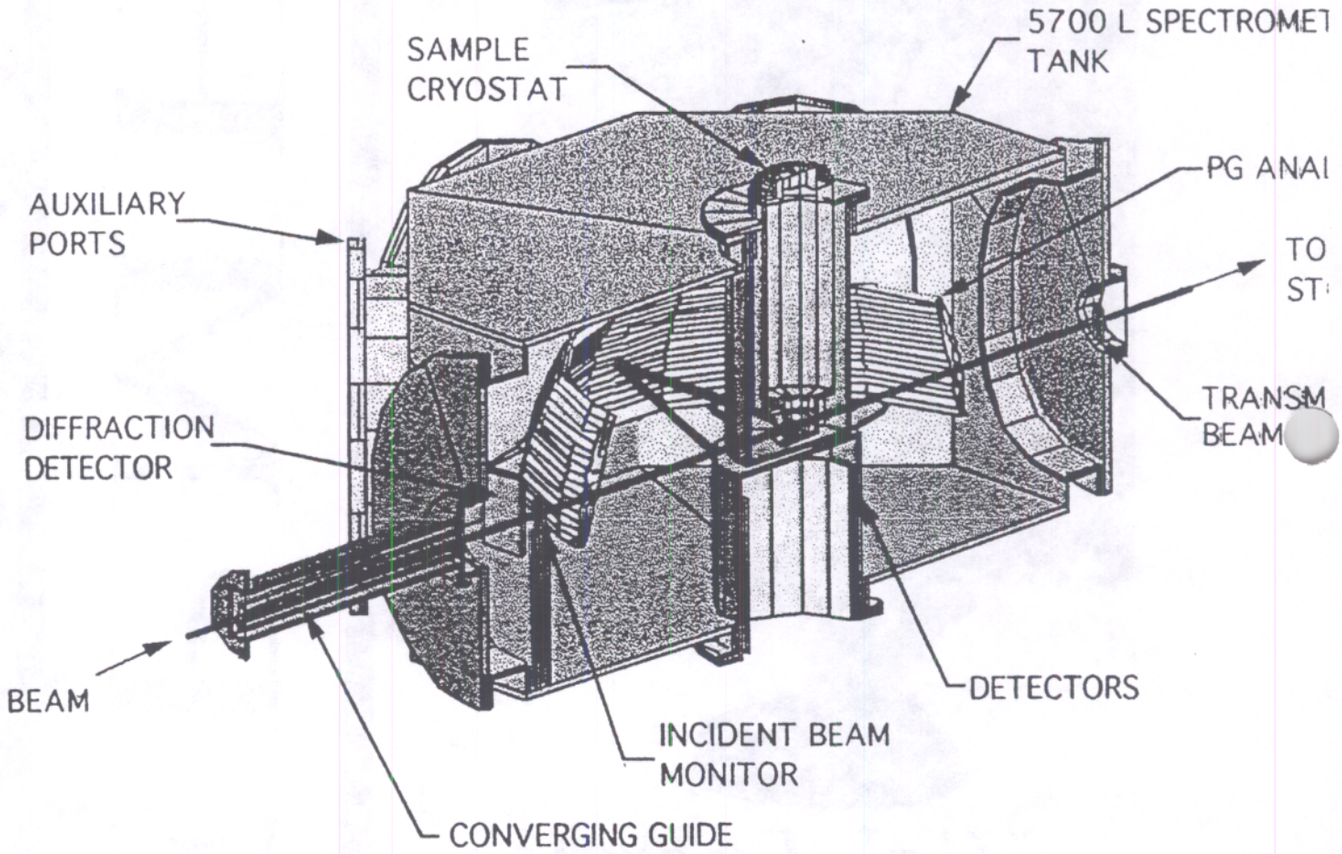
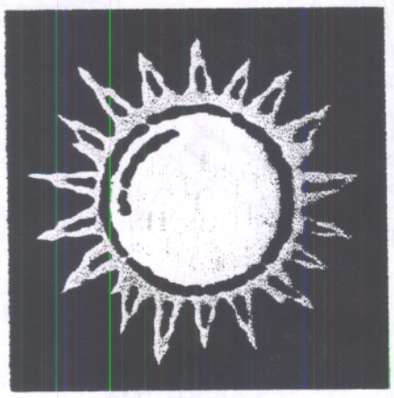


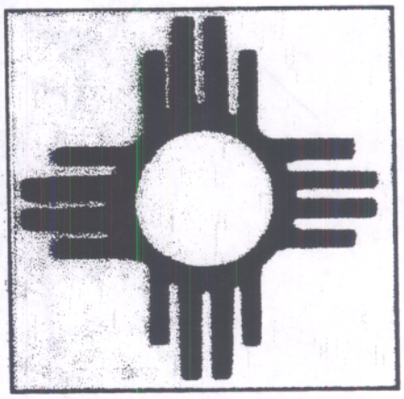
Figure 2 - The HERMES I Analyzer Tank

HELIOS: A High Intensity Chopper Spectrometry at LANSCE

Thom Mason, Spallation Neutron Source, Oak Ridge, TN
Collin Broholm, Johns Hopkins University
Brent Fultz, California Institute of Technology

HELIOS Proposal and Home Page





HELIOS will be the world's most sensitive instrument for measuring spectra of inelastically-scattered thermal neutrons. Such data can provide spectra of elementary excitations in materials. It is anticipated that HELIOS will be used for studies of phonons, magnetic excitations, and crystal field excitations. The funding for this instrument is being provided by the U.S. Dept. of Energy through its Office of Basic Energy Sciences. HELIOS be built at the Los Alamos Neutron Science Center (LANSCE), with engineering performed primarily at Argonne, Los Alamos, and Oak Ridge National Laboratories.

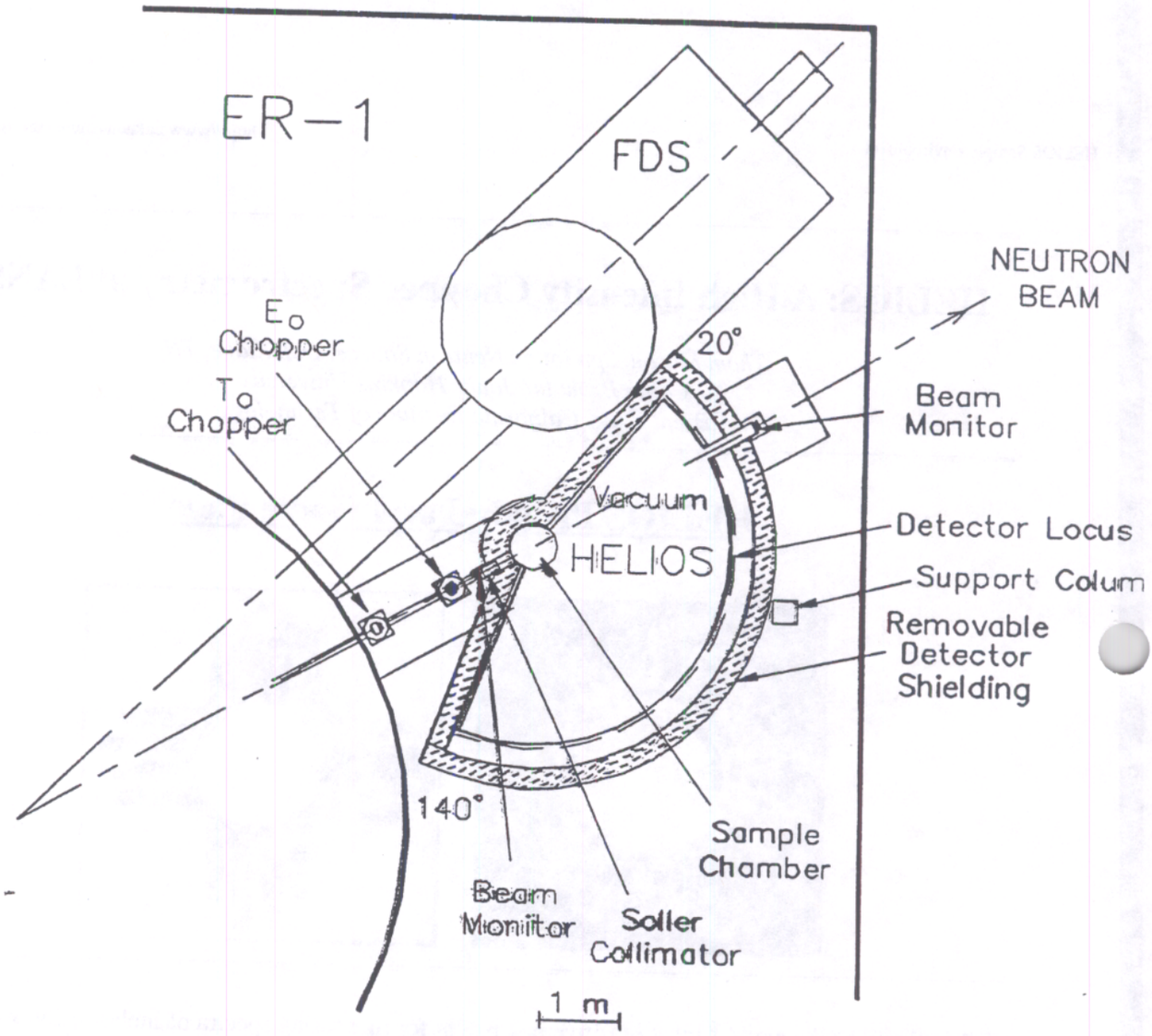
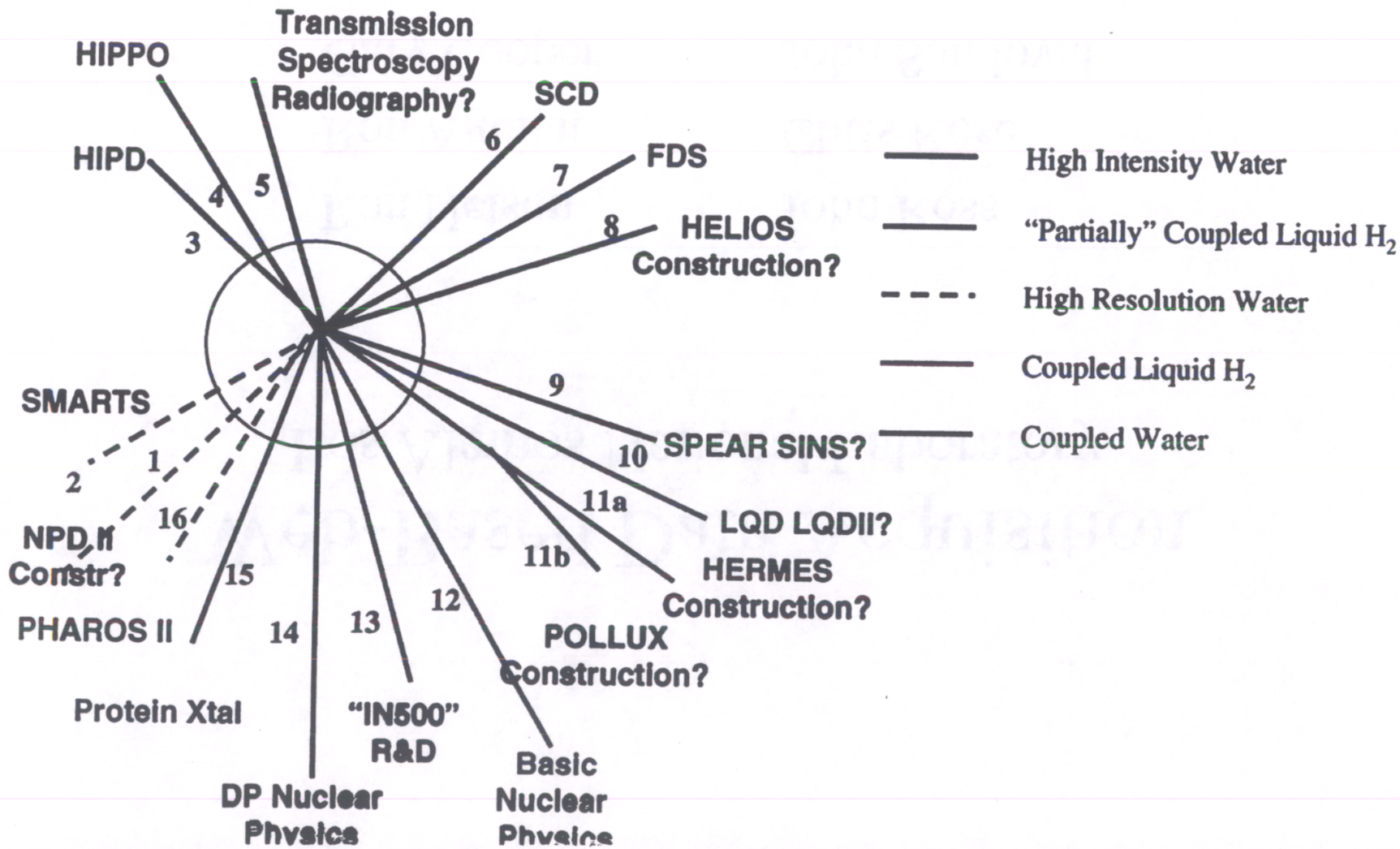


Figure 5: Layout of HELIOS on Flight Path 8 in ER-1.

Medium Term Flight Path Usage (~2-5 years)



Web-Based Data Acquisition

Los Alamos National Laboratory

Ron Nelson
Ron Aguilar
Gary Cooper
Tom Kluegel
Tom Kozlowski
Art Nichols
John Ross
Chris Rose
John Sandoval
John Seal
Bernice Williams

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Feasibility Issues
"Hard" Requirements

- Hardware performance
  - count rates - 10^6 events/s
  - histogram storage - 100 MB
  - histogram transfer rates - 100 MB in 15 s
- Software performance
  - simple interface for user
  - viability of EPICS for data acquisition

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Common Requirements

- collaborating with IPNS at Argonne
  - common hardware design with different firmware
  - EPICS-based software
- beneficiaries
  - user community - more consistency
  - SNS - software/hardware reuse

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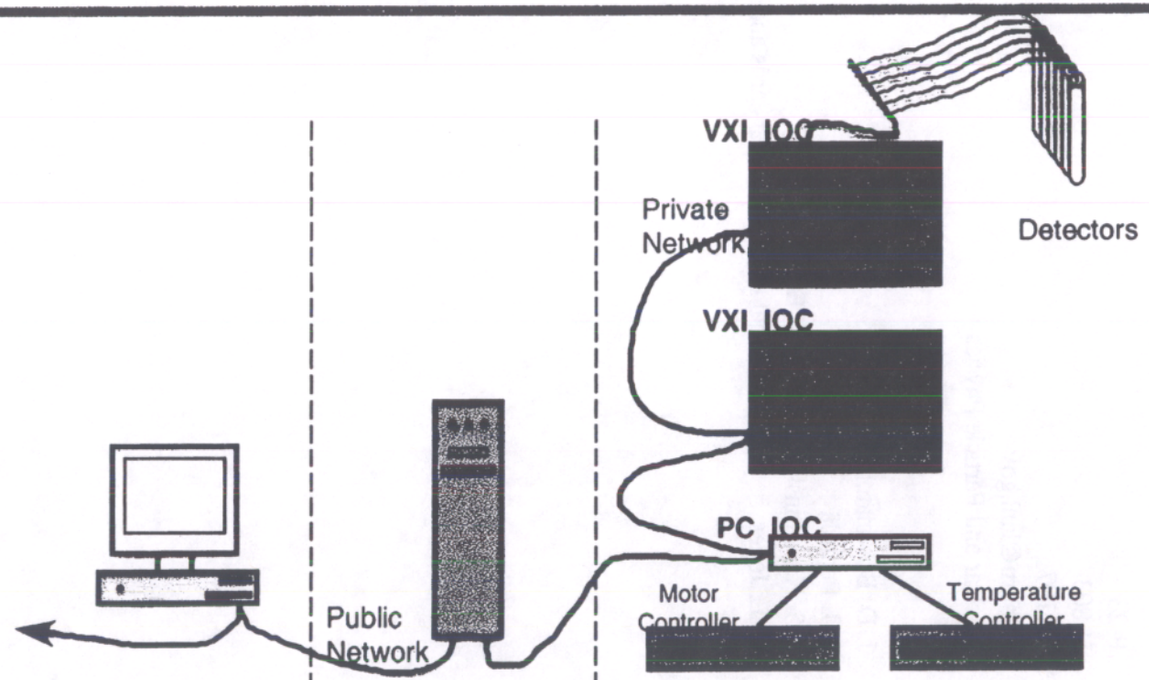
Sample Configuration



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Development of Detectors and Electronics for the Study of the Beta Decay of Polarized Neutrons at LANSCE

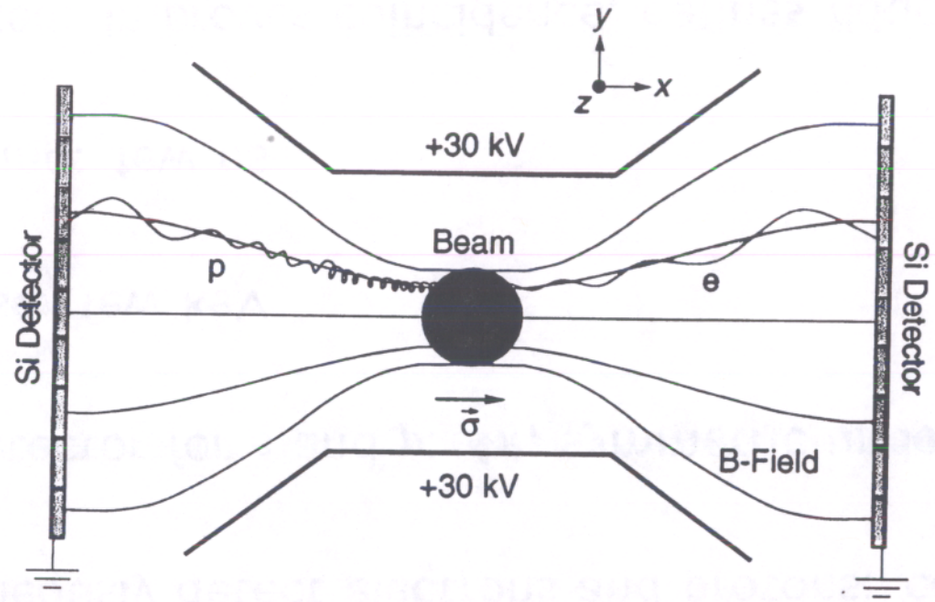
May 26, 1998

Principal Investigator: W. S. Wilburn

Group:	P-23
Mail Stop:	H-803
Phone:	7-2107
EMAIL:	wilburn@lanl.gov
Category:	Nuclear and Particle Physics

Collaborators:	J. D. Bowman,	P-23
	S. I. Penttilä	P-23
	J. S. Kapustinsky,	LANSCE-DO
	G. L. Jones	National Institute of Standards and Technology

Neutron β-Decay with Cold Neutrons at LANSCE



- Magnetic guide field
- No magnetic pinch effect
- $e - p$ coincidence
- No apertures or grids
- *In situ* P_n measurement
- Silicon detectors

Silicon Strip Detectors

- Thin dead layer: detect 4 keV protons
- Almost unity efficiency: very small corrections
- Simultaneously detect electrons and protons: coincidence
- Same detector for e and p: 4π, symmetric under P_n reversal
- Low-noise: few keV
- Fast timing: few ns
- Segmented: improves coincidence, defines fiducial volume

Neutron Detectors

C. L. Morris, J. M. Anaya, T. J. Bowles, J. J. Gomez, S. F. Hahn,
G. W. Hart, R. E. Hill, D. M. Lee, K. B. Morley, S. J. Seestrom,
T. N. Taddeucci, W. A. Teasdale and J. D. Zumbro
Los Alamos National Laboratory

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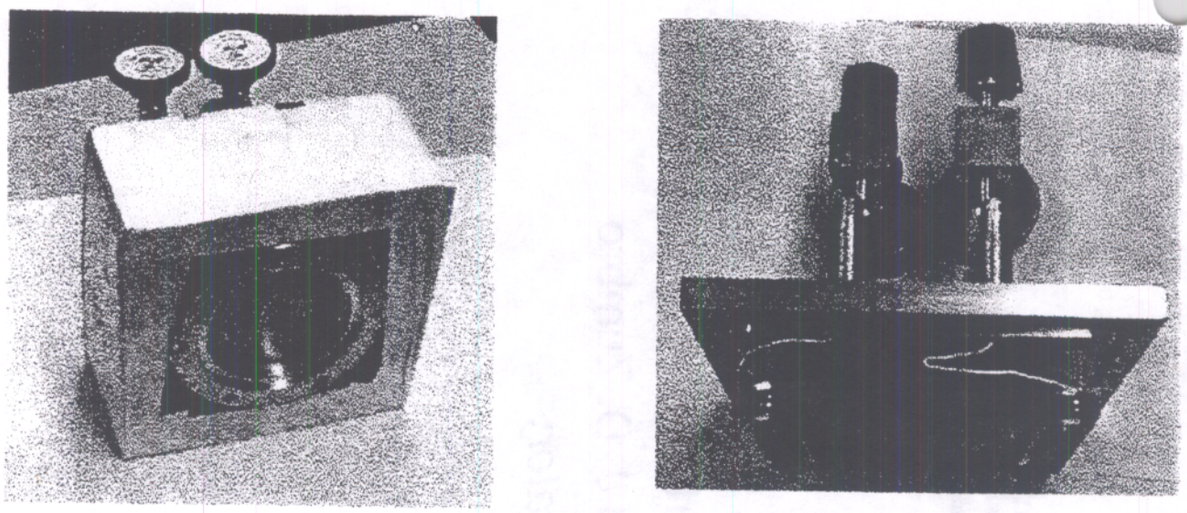


Figure 3: Photographs of the UCN detector

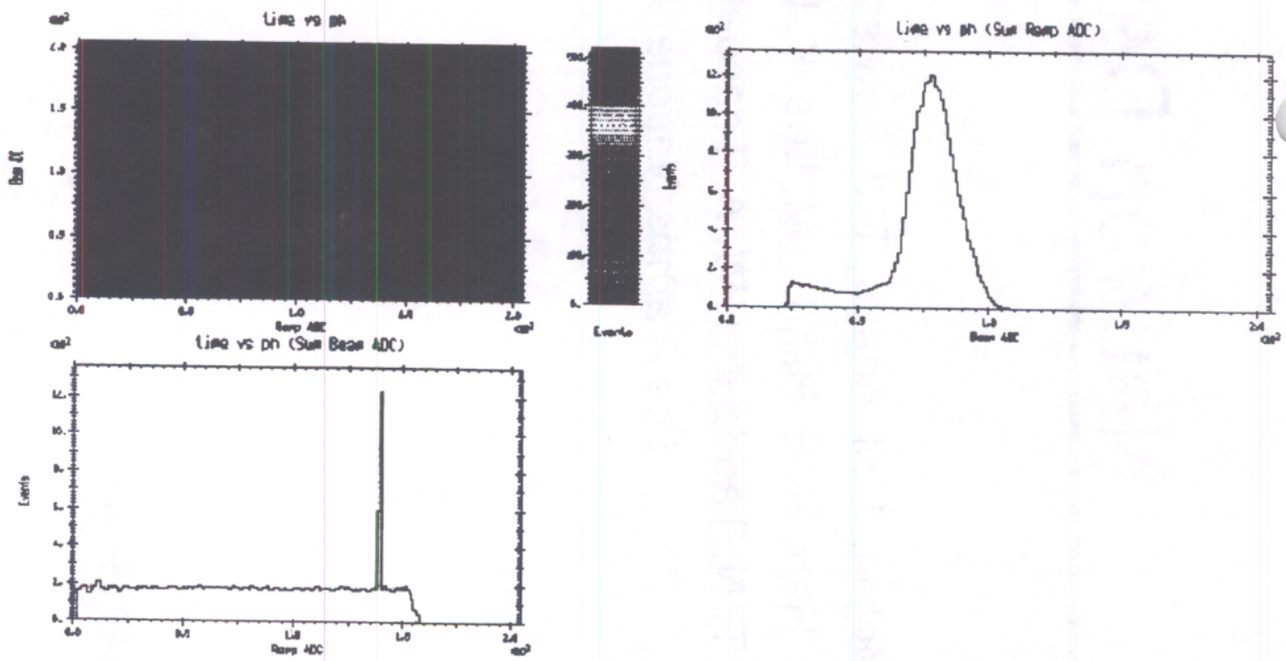


Figure 4: Two-dimensional histogram of time on the horizontal axis and pulse height on the vertical axis.

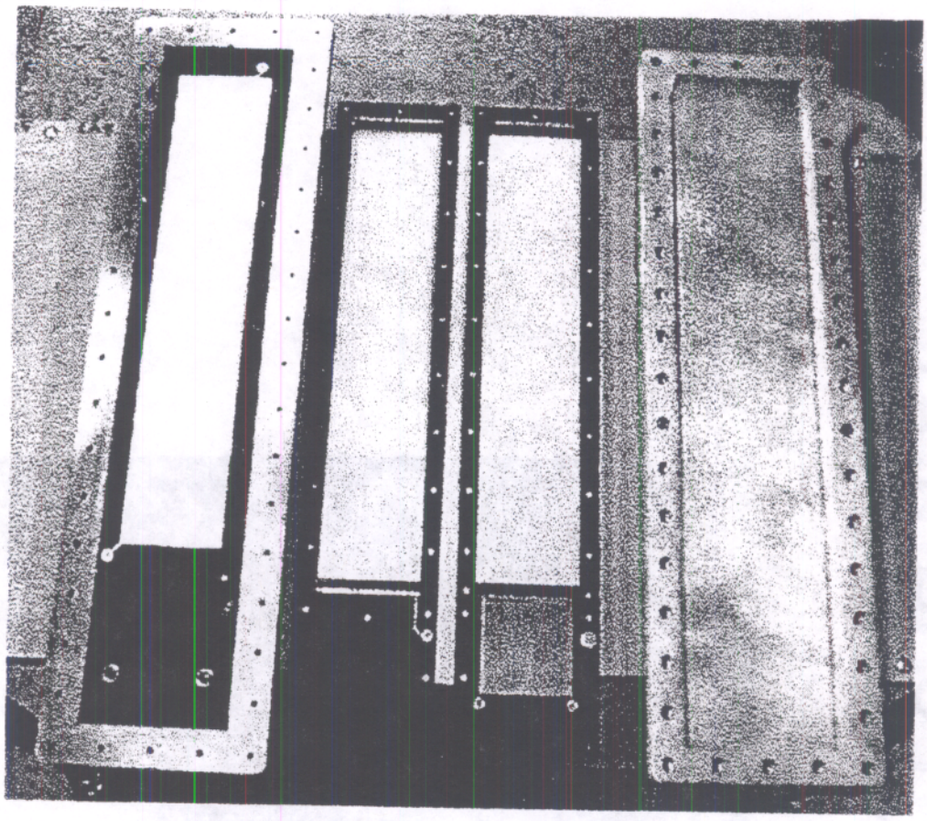


Figure 5: Photographs of the delay-line readout detector.

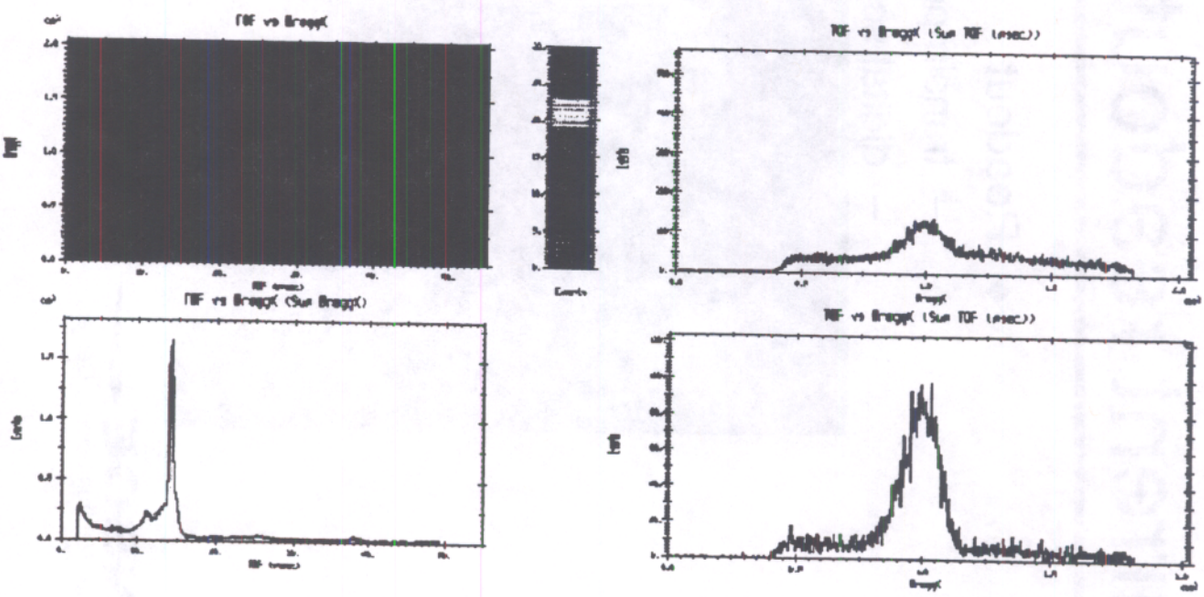
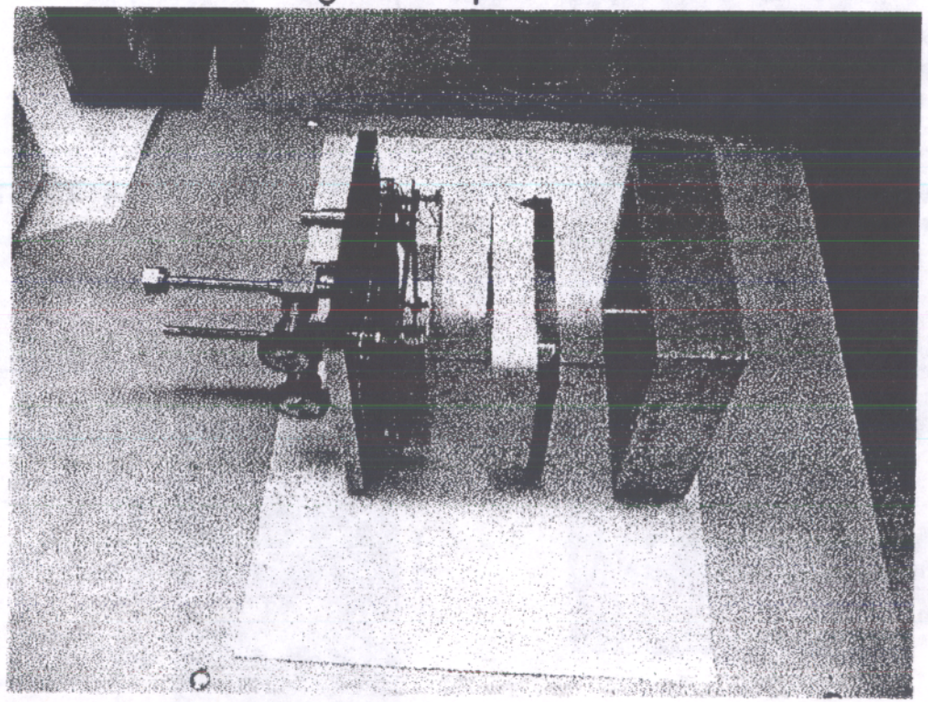


Figure 6: Two-dimensional histogram of Bragg spectrum from the moving rotor.

Current readout ion chamber

- Readout
  - transimpedence amplifier
  - digital scope



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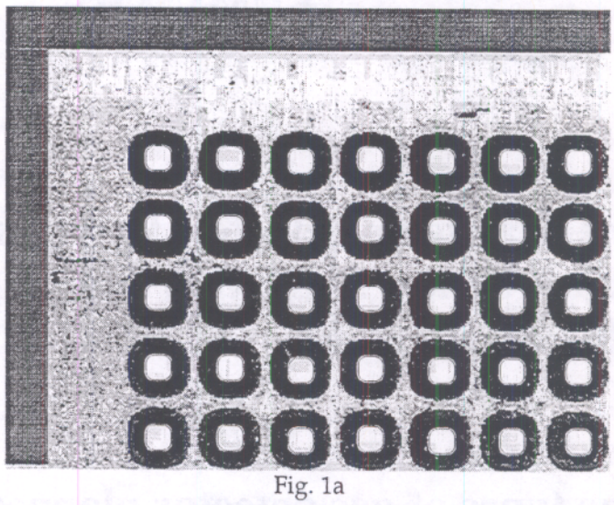

Fig. 1a

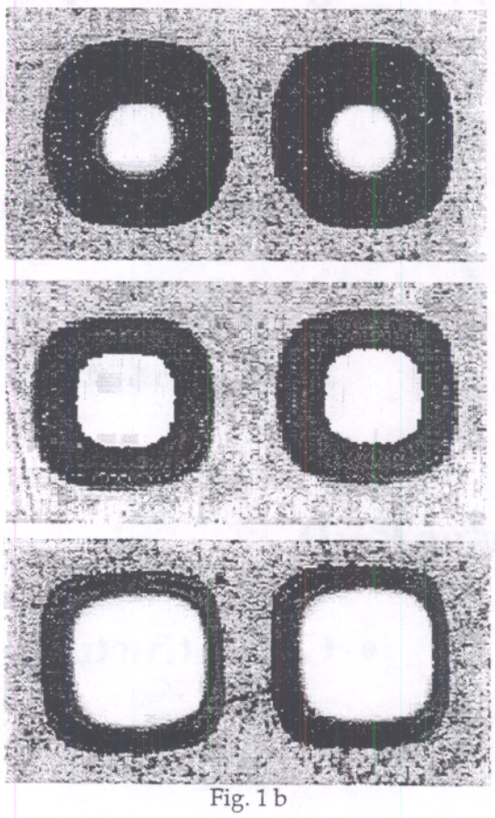

Fig. 1 b

SUMMARY

- The near term detector development at the Lujan Center Spallation Source is focused on ^{3}He gas detectors

- The types of gas detector planned or in use are
    - Commercial cylindrical tubes
    - Commercial area detector
    - Custom area detector (BNL Instrumentation)

- Detector R&D
    - GEM structures
    - Scintillators
    - Silicon strips or pads