

HYSPEC: Our Instrument at the Spallation Neutron Source.

Igor Zaliznyak

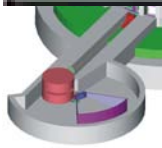
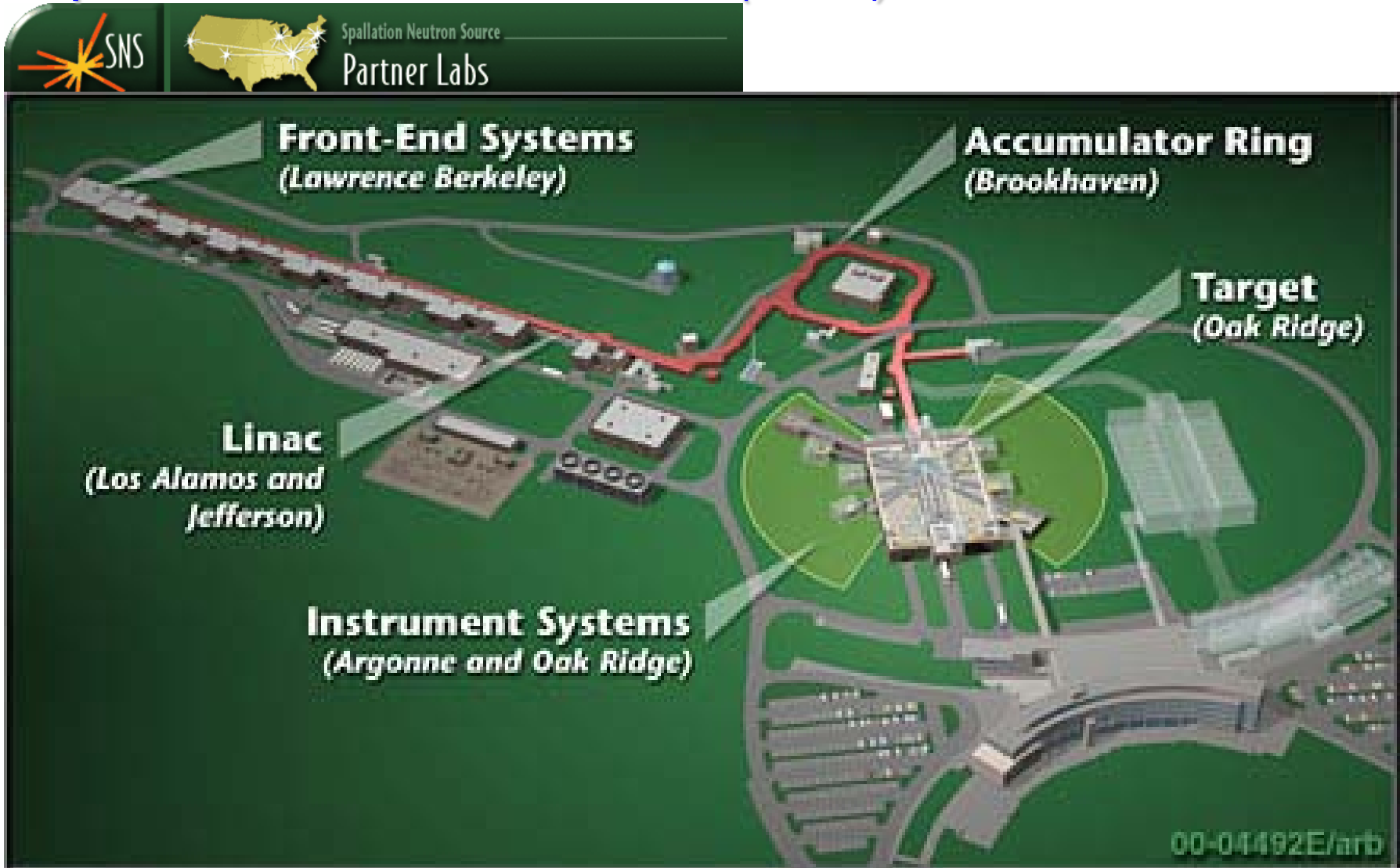
Neutron Scattering Group, Brookhaven National Laboratory

Outline

- Spallation Neutron Source (SNS) and the BNL
- Overview of the SNS instrument suite
- General features of a design and an operation of a spectrometer at a pulsed neutron source
- HYSPEC layout, principal features design and important design choices
- Instrument specific features and components
- Summary, work in progress and open questions



Spallation Neutron Source (SNS) at ORNL



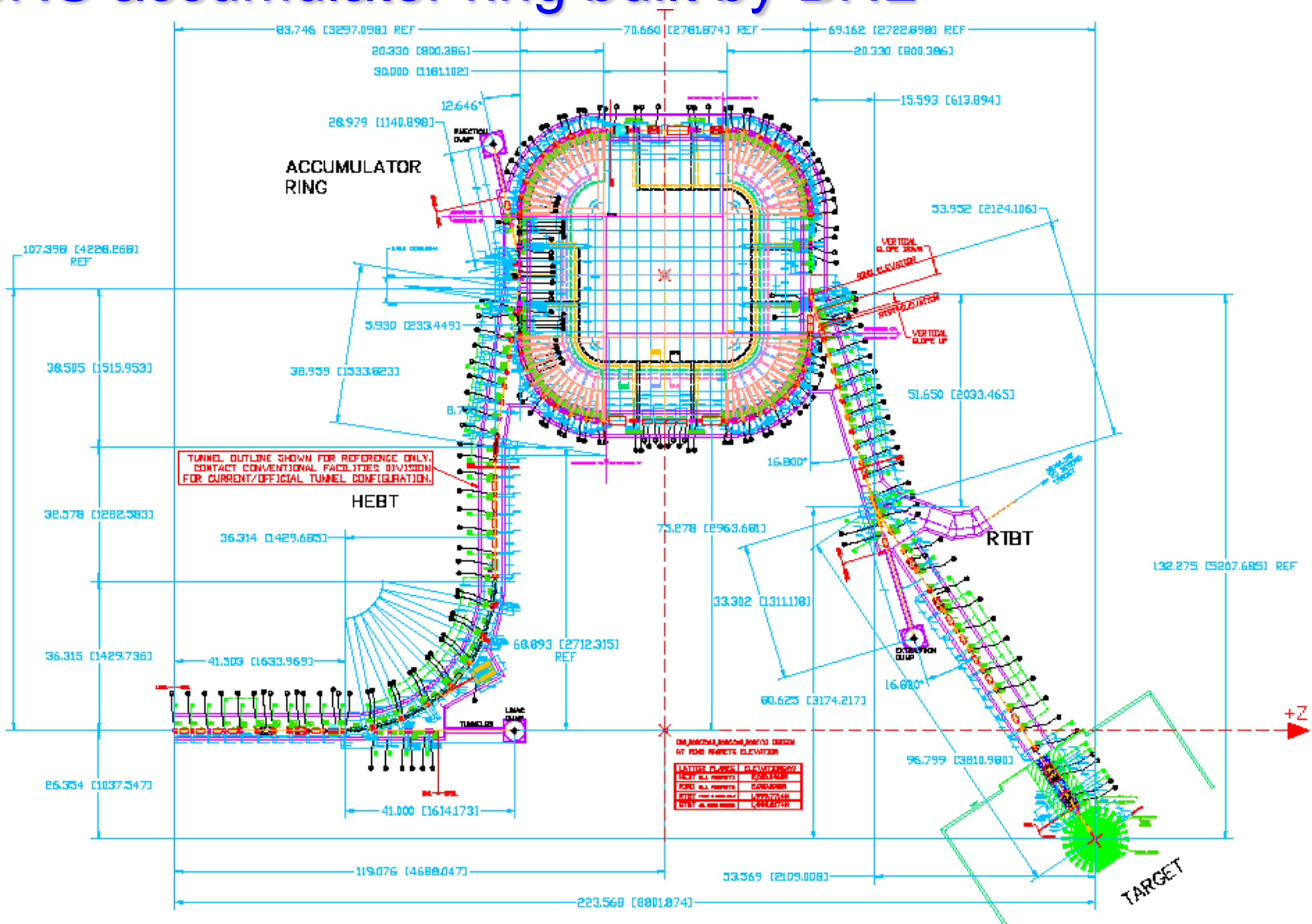
HYSPEC
IDT

<http://www.sns.gov/>

<http://www.sns.gov/partnerlabs/partners.htm>

BROOKHAVEN
NATIONAL LABORATORY

SNS accumulator ring built by BNL



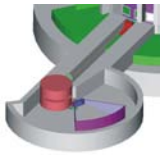
<http://sns.bnl.gov/>
http://sns.bnl.gov/ap_group/ring.html



Recent view of the SNS construction site



SNS target station: getting closer!



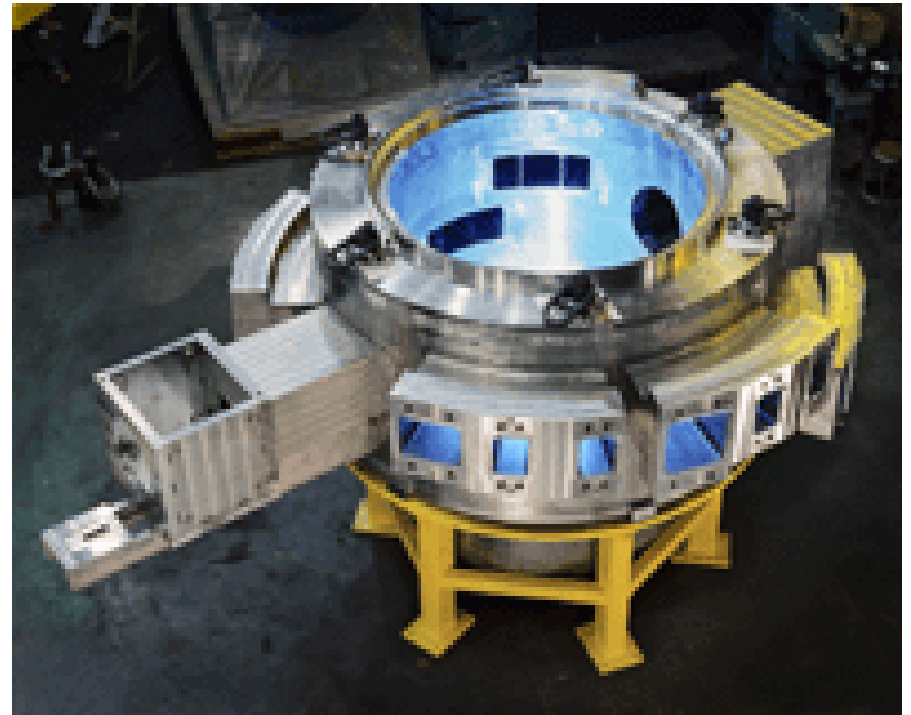
HYSPEC
IDT

BROOKHAVEN
NATIONAL LABORATORY

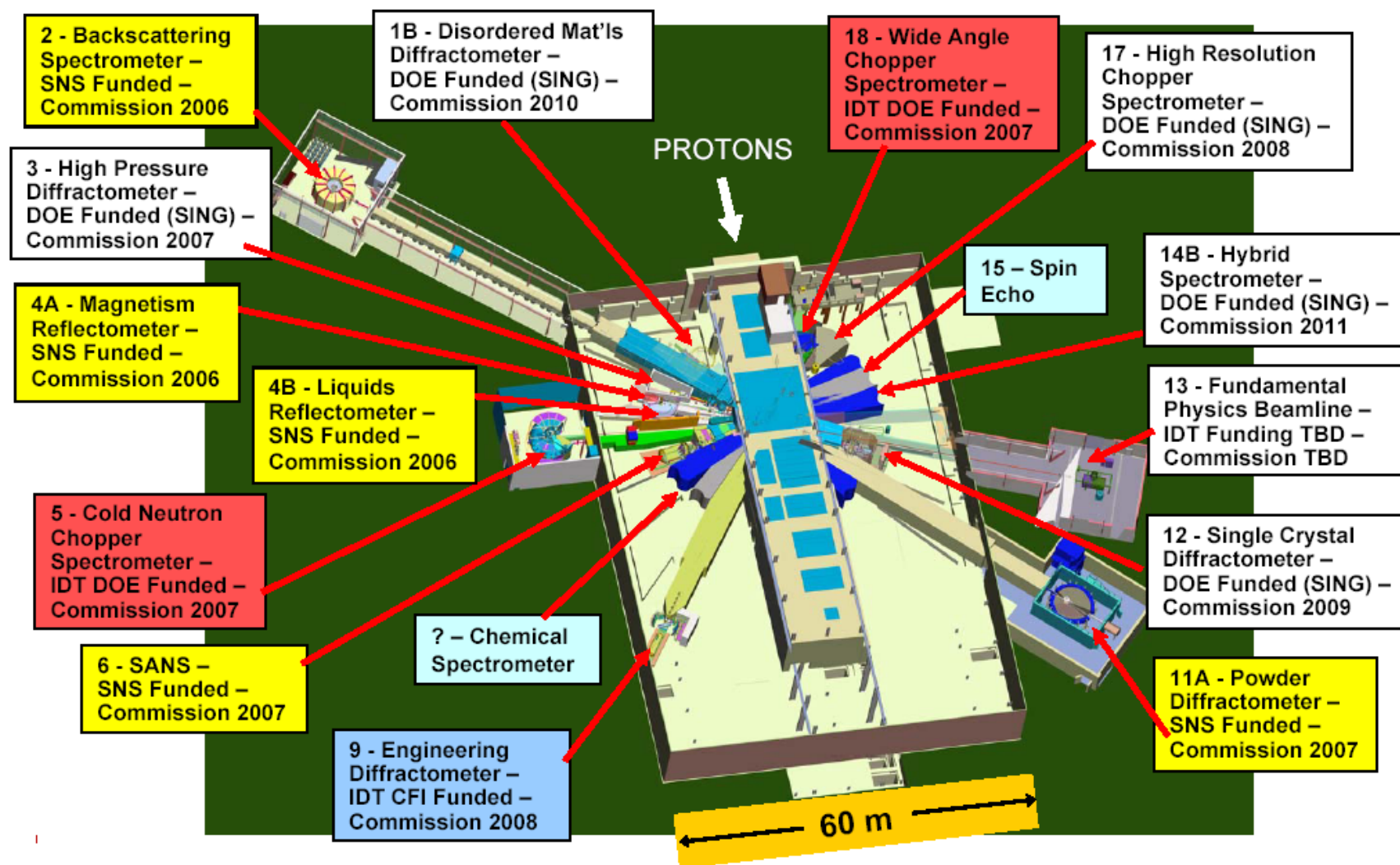
SNS construction: the middle of the way is passed (and the funding ramps down).



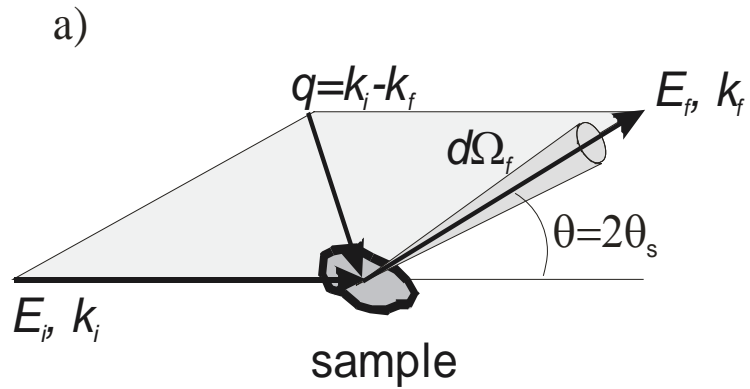
The heaviest lift in the construction:
the core vessel is installed!



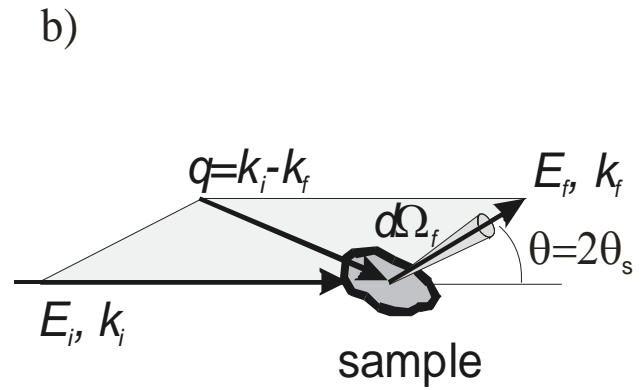
Current status of the SNS instrument suite



Setup of a scattering experiment

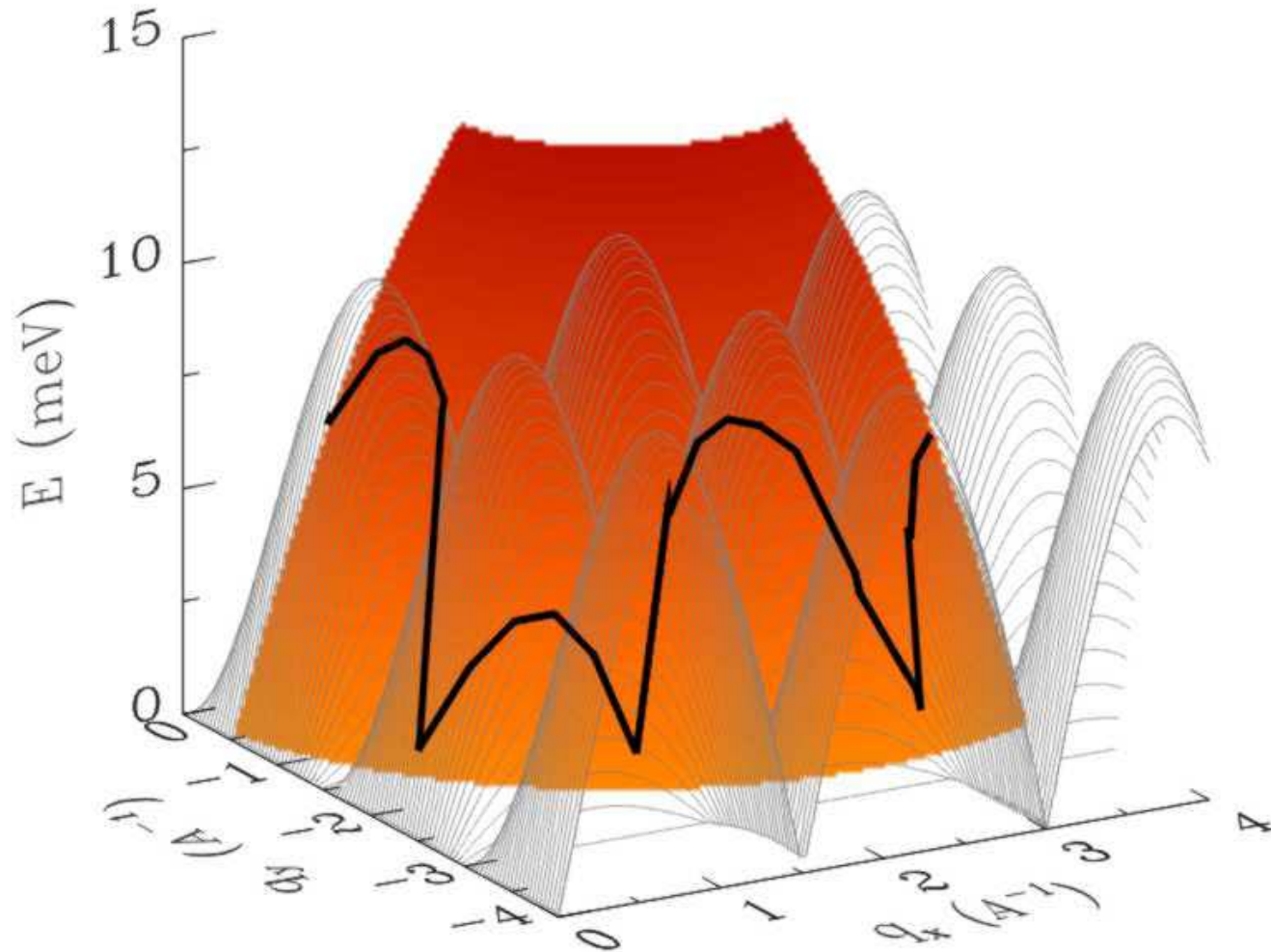


Elastic.
The scattered neutron's
wave vector is large



Inelastic.
The scattered neutron's
wave vector is large

Phase space overview of a TOF experiment



Two-spinon continuum in SrCuO₂: direct measurement

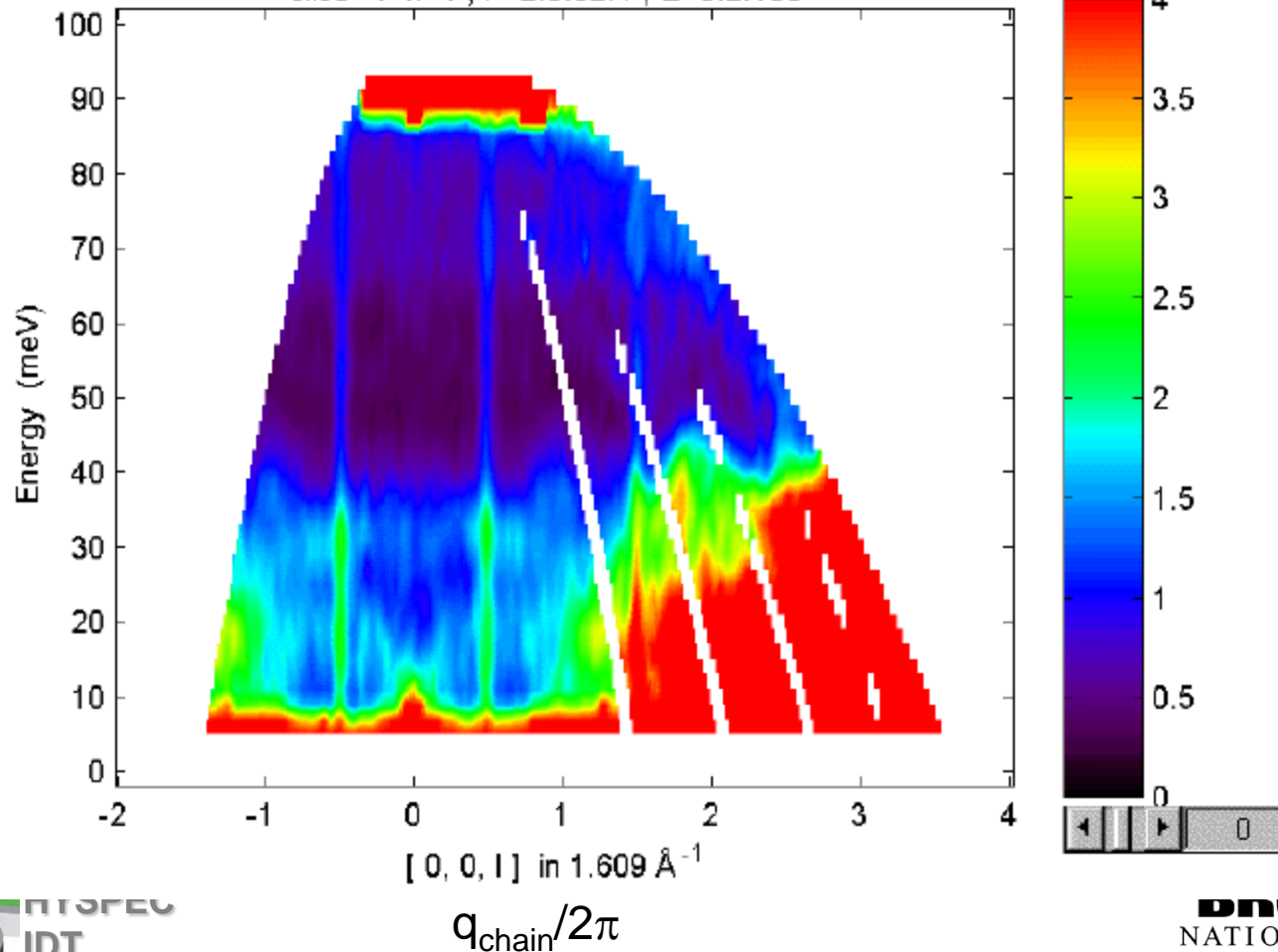
MAPS@ISIS, $E_i = 98$ meV.

Color contour map of the scattering intensity. White lines are gaps in the detector array. Vertical lines at $l = n/2$ are spinons.

MAP03336_9CARDS_4_4TO1.SPE, c^* perp k_i , $E_i=98.13$ meV, $s=2$

$u=[1\ 0\ 0]$, $v=[0\ 0\ 1]$, $\Psi_i=(u, k_i)=0$

slice $-4 < k < 4$, $l=-2:0.02:4$, $E=0:2:100$



Two-spinon continuum in SrCuO₂: direct measurement

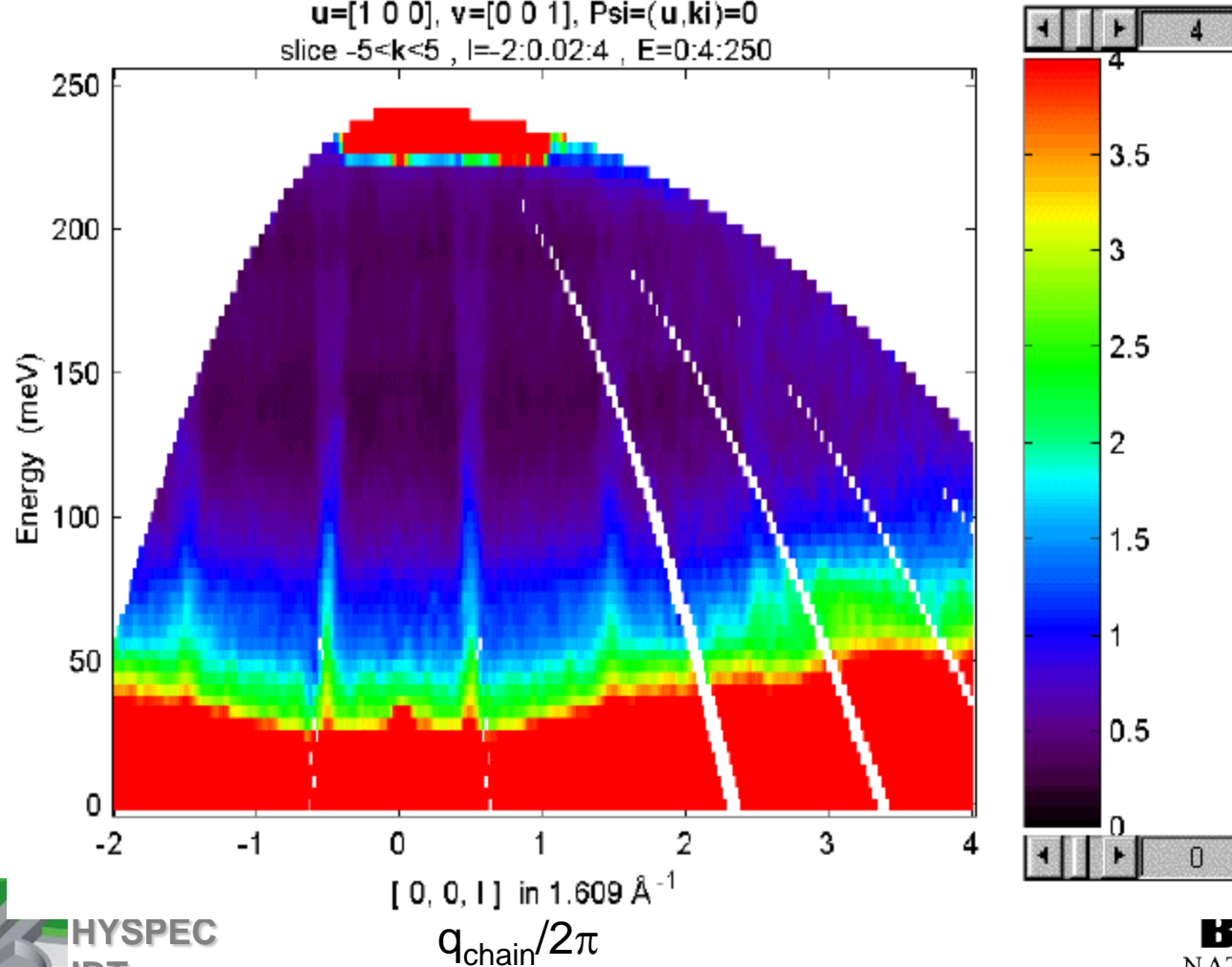
MAPS@ISIS, $E_i = 241$ meV.

Color contour map of the scattering intensity.

MAP03337_9CARDS_4_4TO1.SPE, c^* perp k_i , $E_i=240.6$ meV, $s=2$

$u=[1\ 0\ 0]$, $v=[0\ 0\ 1]$, $\Psi(u, k_i)=0$

slice $-5 < k < 5$, $l=-2:0.02:4$, $E=0:4:250$



Two-spinon continuum in SrCuO₂: direct measurement

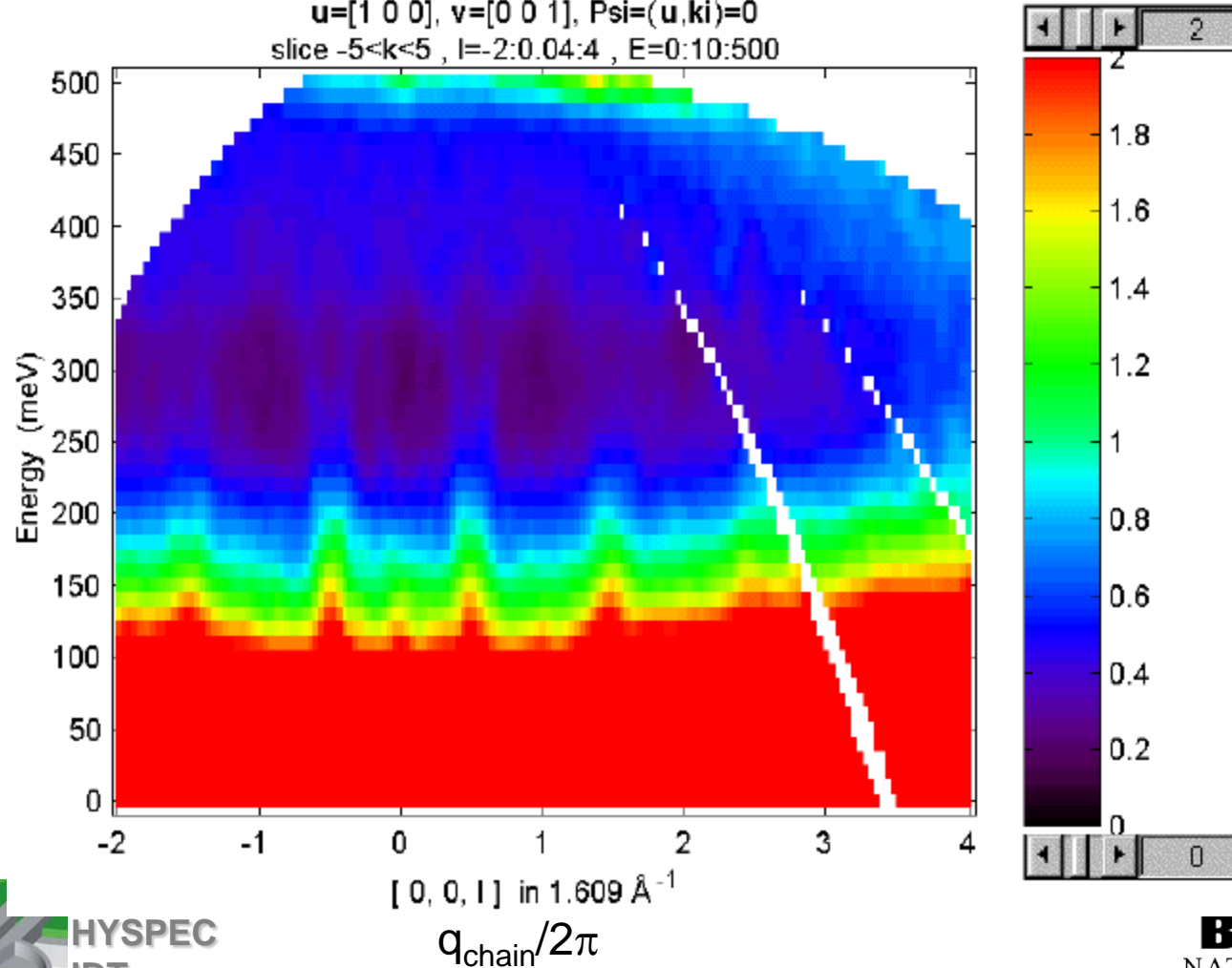
MAPS@ISIS, $E_i = 520$ meV.

Color contour map of the scattering intensity.

MAP03339_9CARDS_4_4TO1.SPE, c^z perp kisym(2), Ei=518.3 meV, s=3

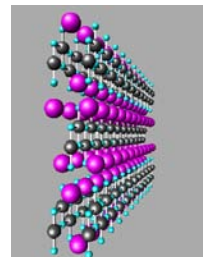
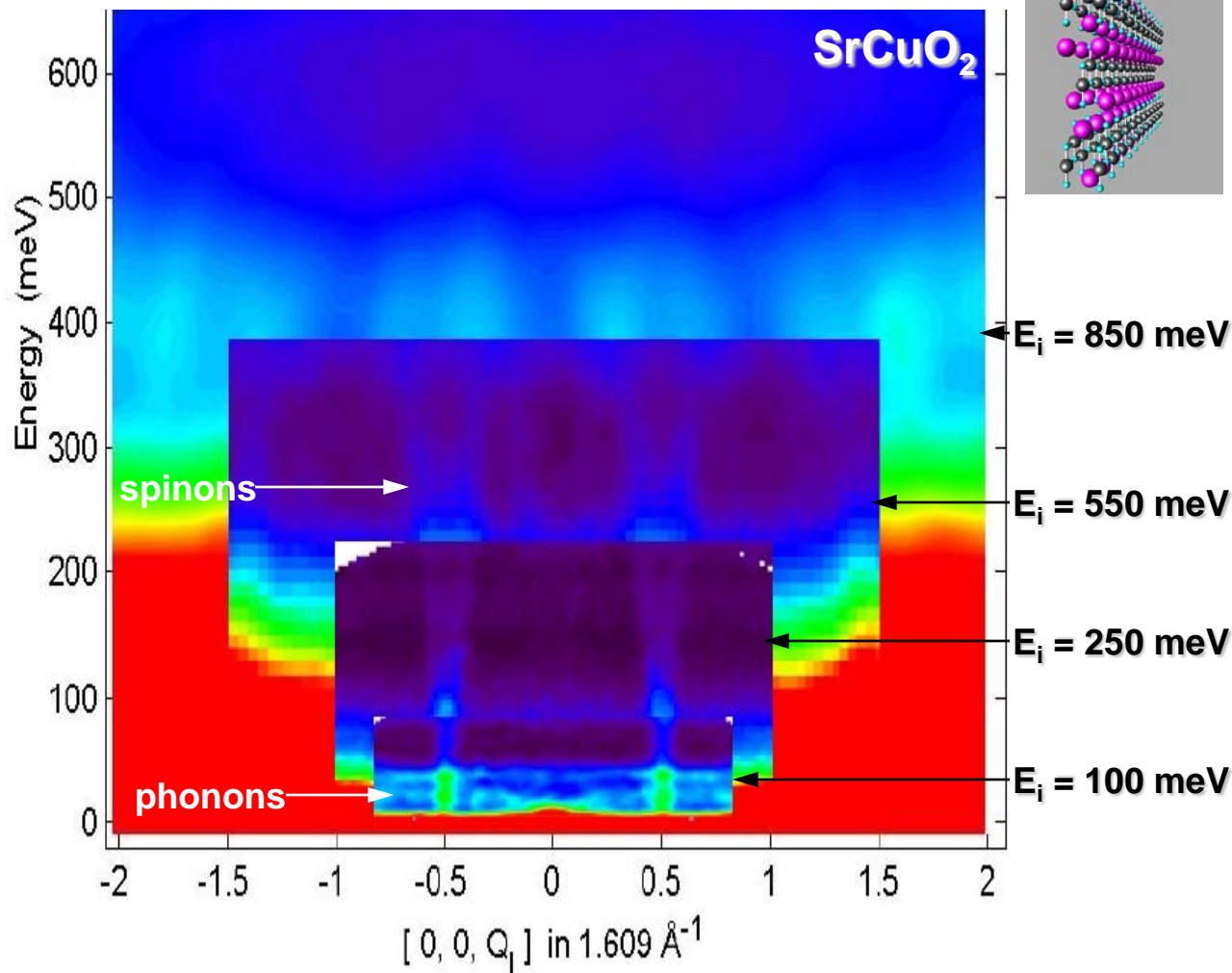
$\mathbf{u}=[1\ 0\ 0]$, $\mathbf{v}=[0\ 0\ 1]$, $\Psi(\mathbf{u}, \mathbf{k}_i)=0$

slice $-5 < k < 5$, $l = -2:0.04:4$, $E = 0:10:500$

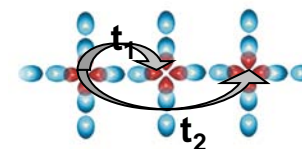


Spin part of one-dimensional electrons

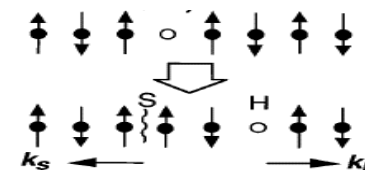
Triplet spectrum of two-spinon states, combined set of 4 measurements on MAPS at ISIS



- **Effective single-band Hubbard model at half-filling**



- **Spin-charge separation**



- **Holon gap**

$$m \approx 0.75 \text{ eV}$$

- **Optic gap**

$$\Delta = 2m \approx 1.5 \text{ eV}$$

- **Two-spinon band**

$$\pi J \approx 0.7 \text{ eV}$$



HYSPEC: place in the SNS inelastic instruments suite.

High energy transfer

10-1000 meV Fermi Chopper Spectrometer

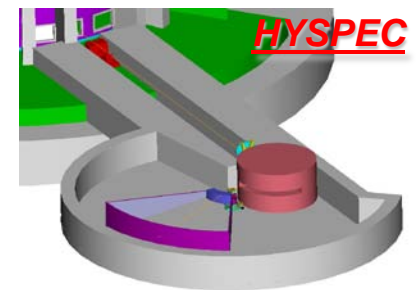
- $E = 10 - 1000 \text{ meV}$
- $Q = 0.1 - 22 \text{ \AA}^{-1}$



High intensity at moderate resolution and medium energy transfer + polarized beam

Crystal Monochromator Hybrid Spectrometer

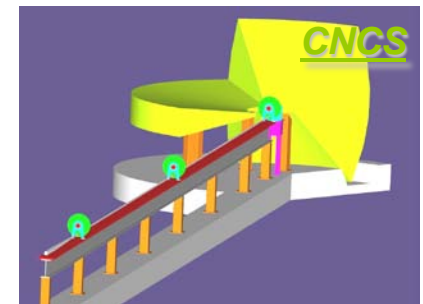
- $E = 2.5 - 90 \text{ meV}$
- $Q = 0.1 - 8 \text{ \AA}^{-1}$



High resolution and low energy transfer

10-100 μeV Multichopper Spectrometer

- $E = 2 - 20 \text{ meV}$
- $Q = 0.1 - 4 \text{ \AA}^{-1}$



HYSPEC timeline: history of the project.

- ❑ **May, 2003**
 - DOE CD0
- ❑ **December, 2002**
 - HYSPEC proposal submitted to DOE
- ❑ **January, 2002**
 - HYSPEC IDT filed Letter of Intent with SNS
- ❑ **Fall, 2001**
 - Instrument Development Team formed
 - Workshop on the Hybrid Spectrometer held at BNL
 - Refined HYSPEC concept presented to EFAC
- ❑ **March, 2001**
 - Draft proposal of a Direct Geometry Hybrid Spectrometer first presented to EFAC, received positive reply
- ❑ **December, 2000**
 - Completed review of the possible instrument designs
 - Concept of the Hybrid Spectrometer formulated and adopted
- ❑ **Fall, 1999**
 - Center for Neutron Science and Neutron Scattering Group at BNL initiate an effort to design a spectrometer for the SNS



HYSPEC Instrument Development Team and Design Workgroup.

IDT: Current Members and their Institutional Affiliations

<u>I. Zaliznyak</u> , co-PI	BNL
<u>S. M. Shapiro</u> , co-PI	BNL
G. Shirane	BNL
J. Tranquada	BNL
L. Passell	BNL
D. Abernathy	SNS
L. Daemon	Los Alamos
M. Greven	Stanford
B. Gaulin	McMaster
V. Kiryukhin	Rutgers
Y. Lee	MIT
S. Nagler	ORNL
R. Osborn	ANL
J. Rhyne	U. Missouri
C. Stassis	Ames/Iowa St.
A. Zheludev	ORNL

HYSPEC Instrument Design Workgroup

- *I. Zaliznyak (BNL)*
- *S. M. Shapiro (BNL)*
- *L. Passell (BNL)*
- *V. J. Ghosh (BNL),
Monte-Carlo simulations*
- *S. Doran
(SNS/ANL)*
- *Engineering design
concept*



HYSPEC Layout and principal features

Part 2. Conceptual design and Top Level Specifications

