Proposal for a High Intensity Chopper Spectrometer at LANSCE

- Science requiring high sensitivity neutron spectroscopy
- Limitations of current instrumentation
- Optimizing for sensitivity
- Description of the HELIOS spectrometer
- Project Cost and Schedule

The HELIOS Team

Gabriel Aeppli	NEC Research Institute
Collin Broholm	Johns Hopkins University
Brent Fultz	Caltech
Bernhard Keimer	Princeton University
Sanford Kern	Colorado State University
Thom Mason	Oak Ridge National Lab.
Herb Mook	Oak Ridge National Lab.
Steve Nagler	Oak Ridge National Lab
Ray Osborn	Argonne National Lab.
Rob Robinson	Los Alamos National Lab.

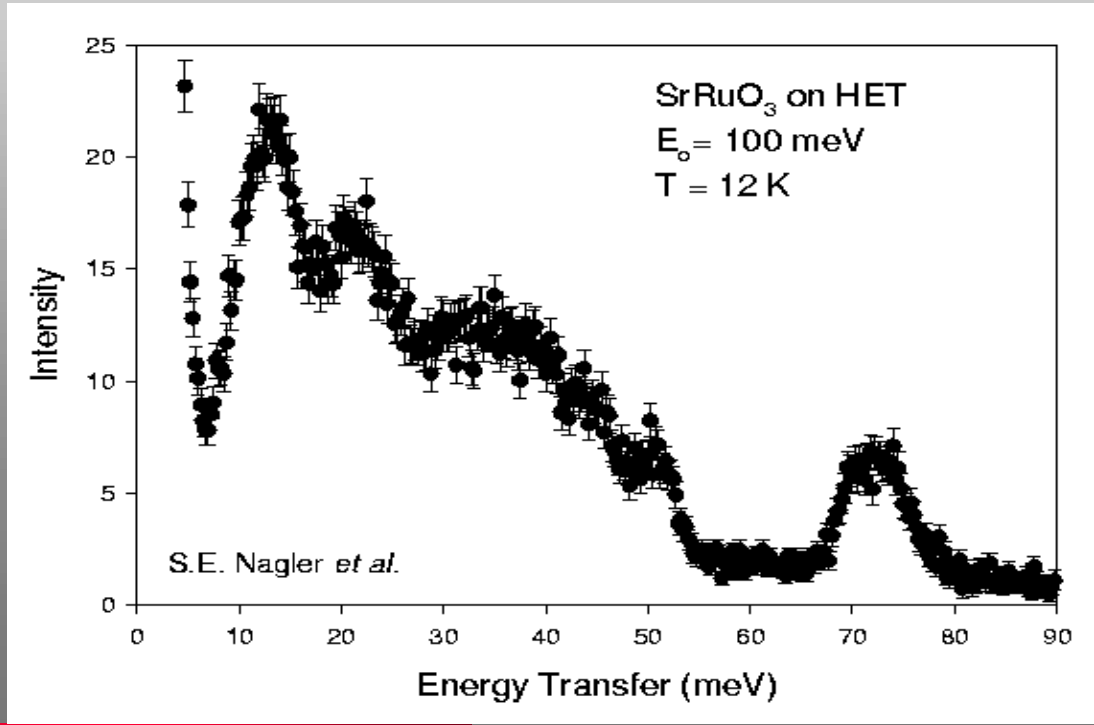
Science Requiring High Sensitivity Neutron Spectroscopy $5<h\omega<500$ meV

- **Materials with inherently broad spectra and weak scattering**
  - ***Phonon Density Of States (DOS) of small powder samples***
  - ***Magnetic excitations in correlated metals***
  - ***Impurity Dynamics***
  - ***Dynamics in disordered systems***
  - ***Multi-magnon modes in Quantum Magnets***

- **Parametric Studies of Dynamics versus P, T, H and composition**
  - ***Phonon DOS throughout structural phase diagram***
  - ***Spin dynamics throughout magnetic phase diagram***
  - ***Initial surveys of novel classes of materials***

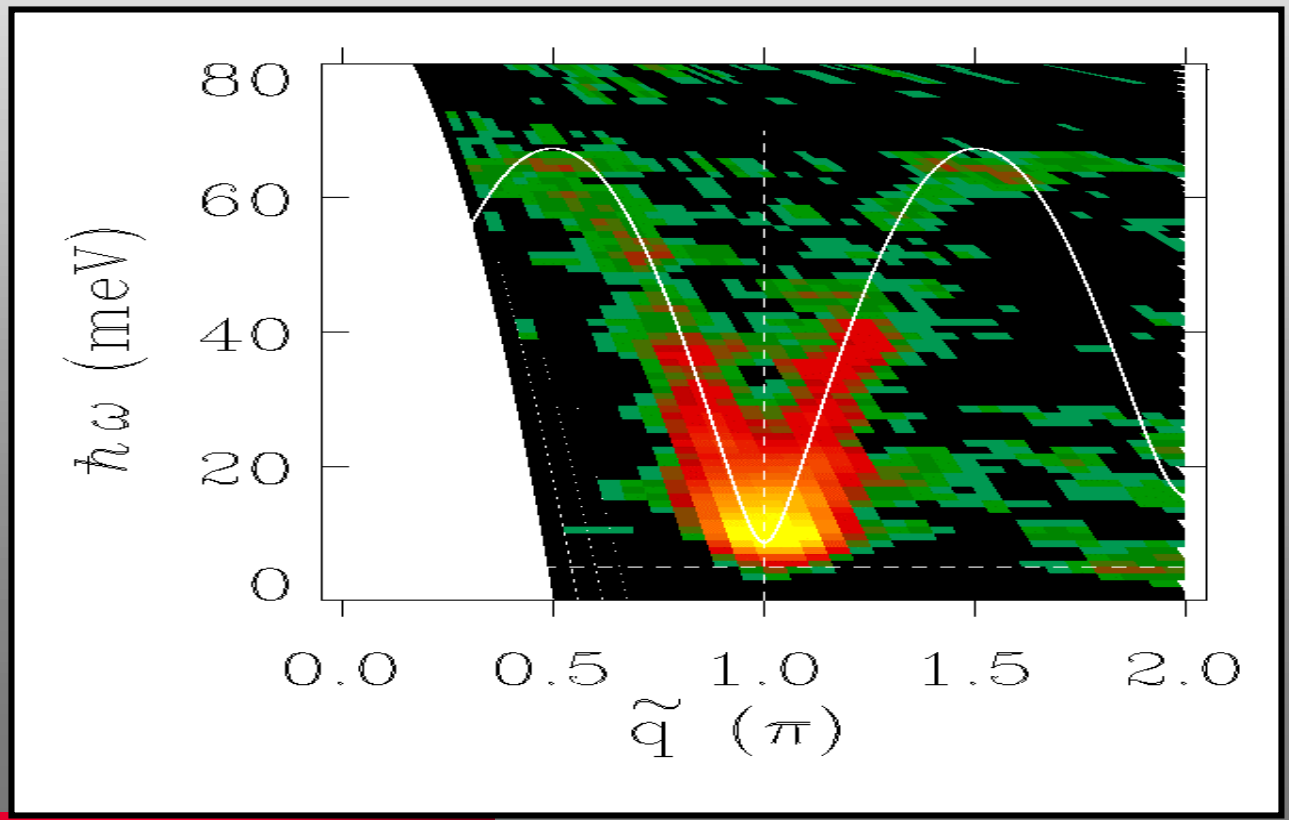
Coupled magnetic and phonon excitations in SrRuO3

- Only small samples are available
- Several Q and T must be probed



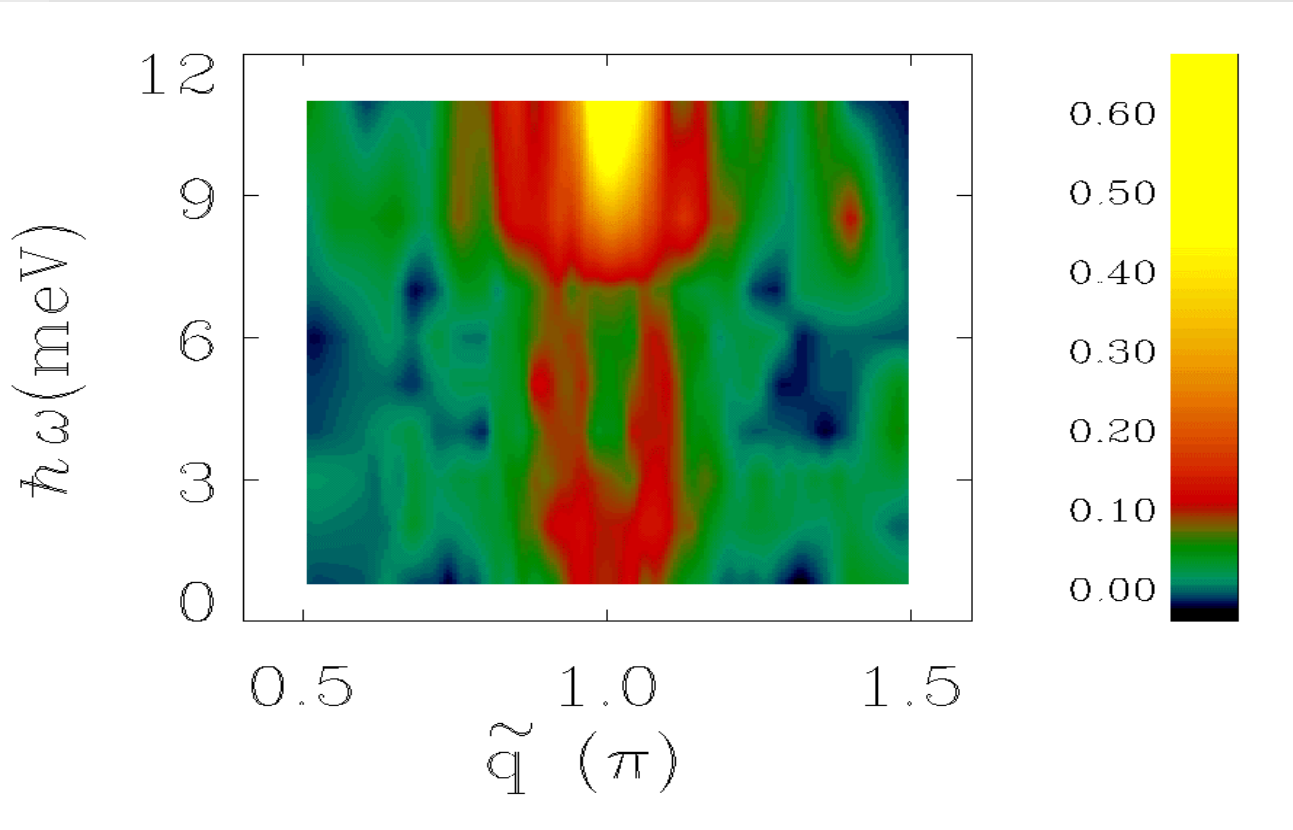
MARI data on pure Y_2BaNiO_5

Magnetic Scattering from a one dimensional S=1 Antiferromagnet
Large crystals were available and we used 20 g



Ca Doping of Y_2BaNiO_5 Yields Mobile Solitons

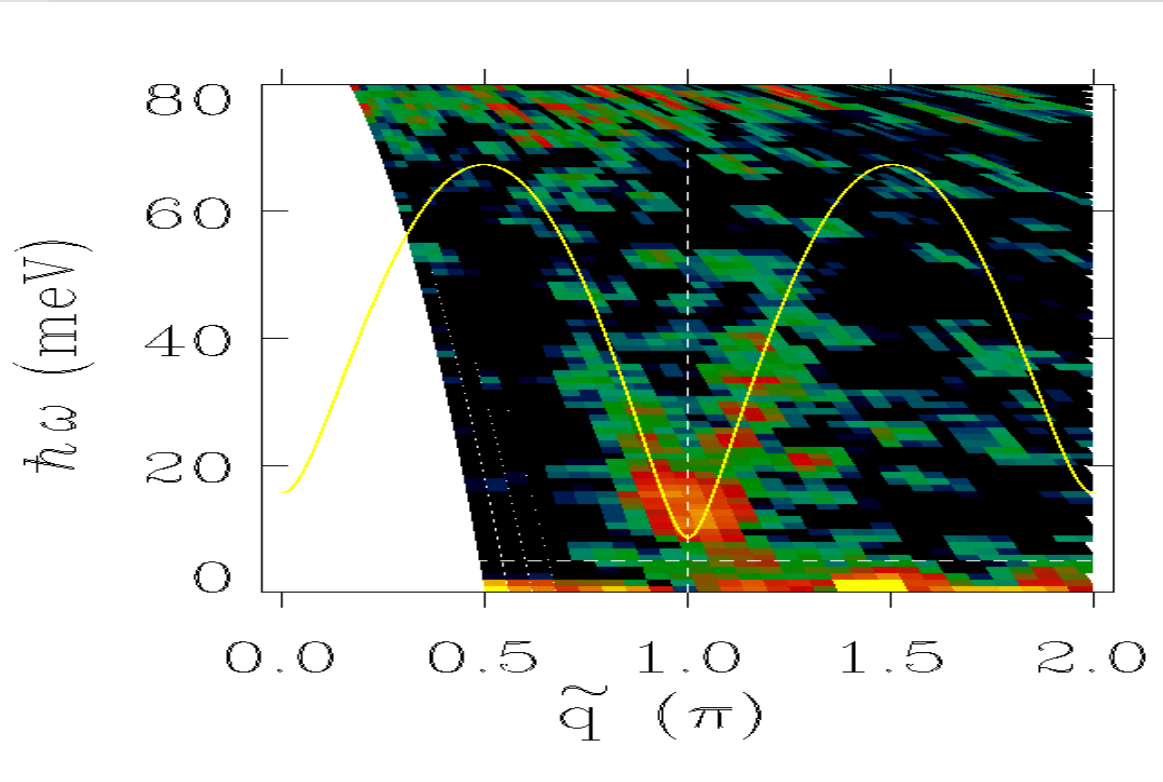
Double Ridge below 7 meV is structure factor of spin soliton



We want to know if solitons persists above the Haldane gap

MARI data on Ca doped Y_2BaNiO_5

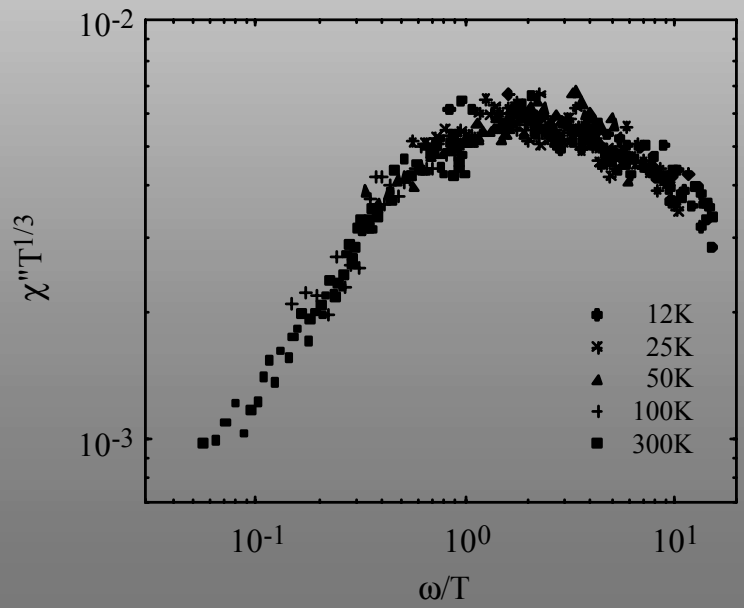
Single crystals of $Y_{2-x}Ca_xBaNiO_5$ are too small for detailed studies of hole doping in a quantum spin liquid using MARI



Universal Scaling of $\chi''(\omega)$ at Quantum Critical Point in UCu_4Pd

For $(1meV, 10K) < \omega, T < (30meV, 300K)$

$$\chi''(\omega,T)T^{1/3} = (T/\omega)^{1/3} Z(\omega/T)$$



Pros and cons of current Instrumentation for this type of experiments

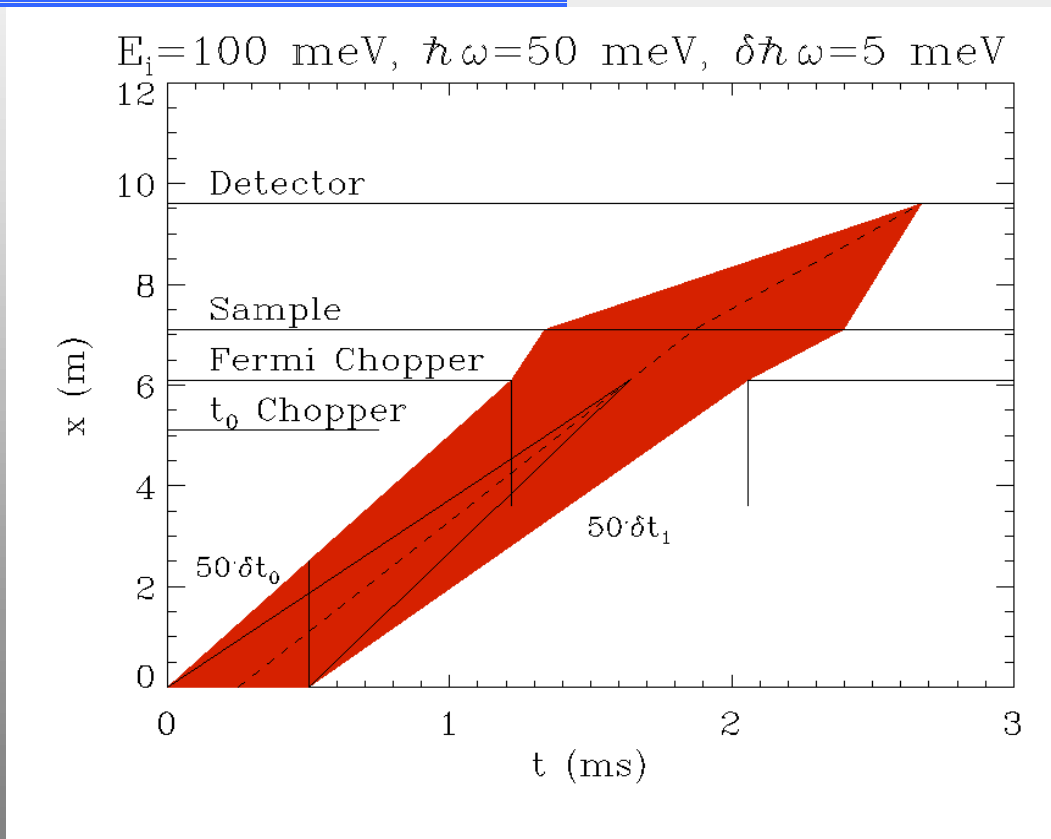
Thermal Neutron Triple Axis Spectrometers

Good	Bad
5% < dE/E < 25% High Signal to Noise	0.1 meV < hω < 50 meV Probe small volume of Q-space

Conventional Spallation Source Chopper Spectrometers

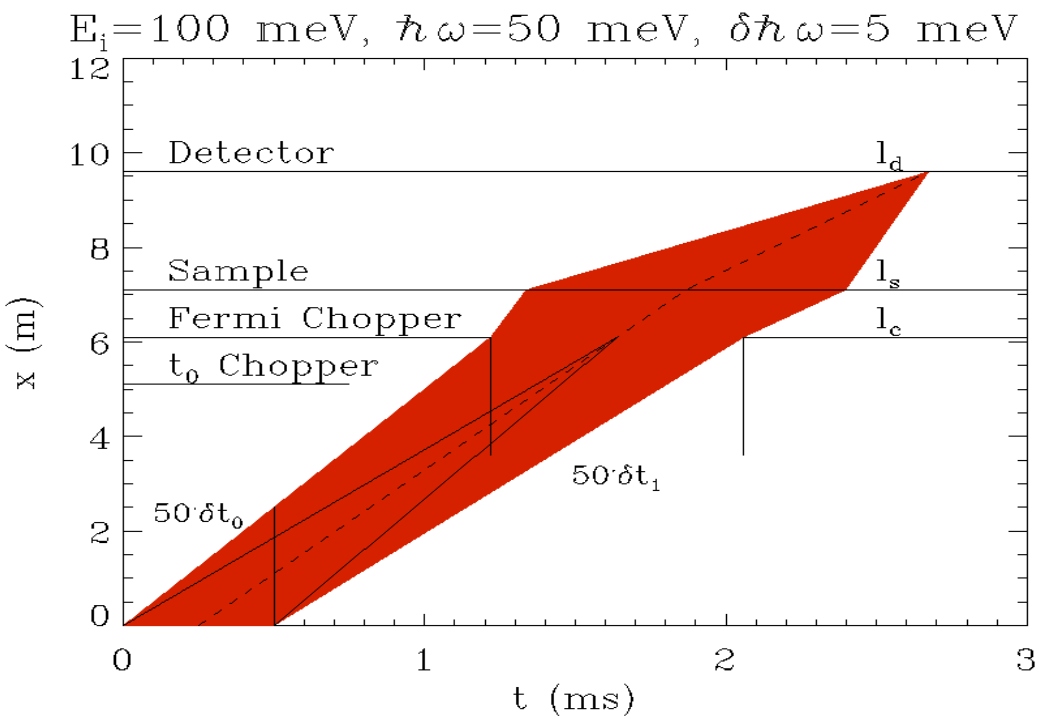
Good	Bad
1 meV < hω < 500 meV Probe Large volume of Q-space	0.5% < dE/E < 2%

Neutrons per pulse at sample



$$N = \phi\ \delta t_1\ dE_i/dt_0\ \delta t_0\ \Omega_i$$

Energy Transfer Resolution



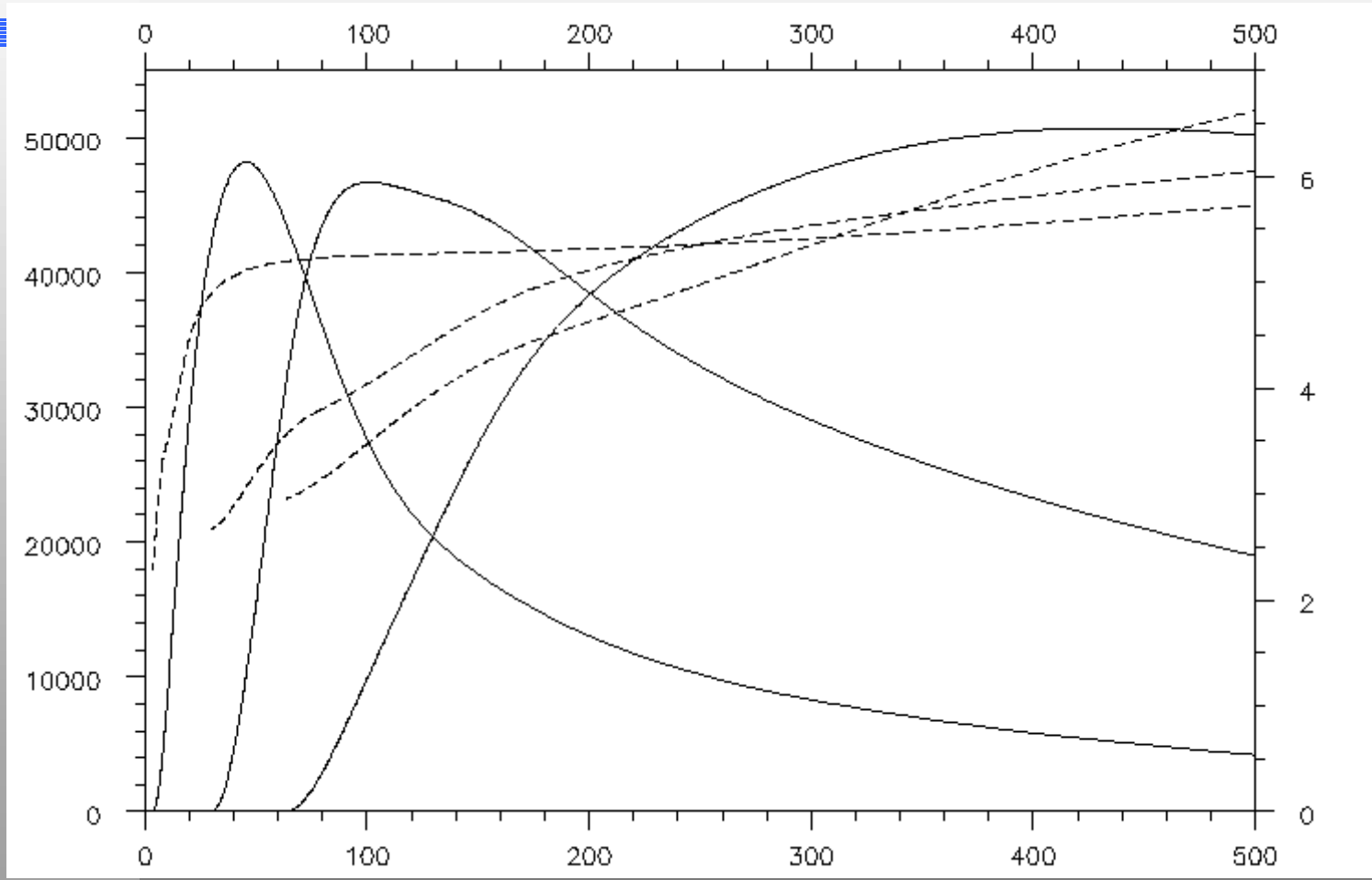
$$\delta\hbar\omega = 2E_i\sqrt{(1+\frac{l_s-l_c}{l_d-l_c}(\frac{E_f}{E_i})^{3/2})^2(\frac{\delta t_0}{t_1})^2+(1+\frac{l_s}{l_d-l_s}(\frac{E_f}{E_i})^{3/2})^2(\frac{\delta t_1}{t_1})^2}$$

Constrained Optimization

- ***Given:*** **E_i, $h\omega$, $\delta h\omega$, and secondary spectrometer**
- ***Optimize:*** **Incident Flight path and pulse width δt_0**
- ***Assume:*** **Peak flux ϕ and δt_0 are independent and N=4 guide starting 4 m from source**

$$N = \hat{\phi} \cdot \delta\hbar\omega \cdot \delta t_0 \cdot \Omega_i \frac{\sqrt{1 - \left(\frac{2E_i}{\delta\hbar\omega}\frac{\delta t_0}{t_1}\left(1 + \frac{l_s - l_c}{l_d - l_s}\left(\frac{E_f}{E_i}\right)^{3/2}\right)\right)^2}}{1 + \left(\frac{E_f}{E_i}\right)^{3/2}\frac{l_s}{l_d - l_s}}$$

Flux and Resolution Calculation



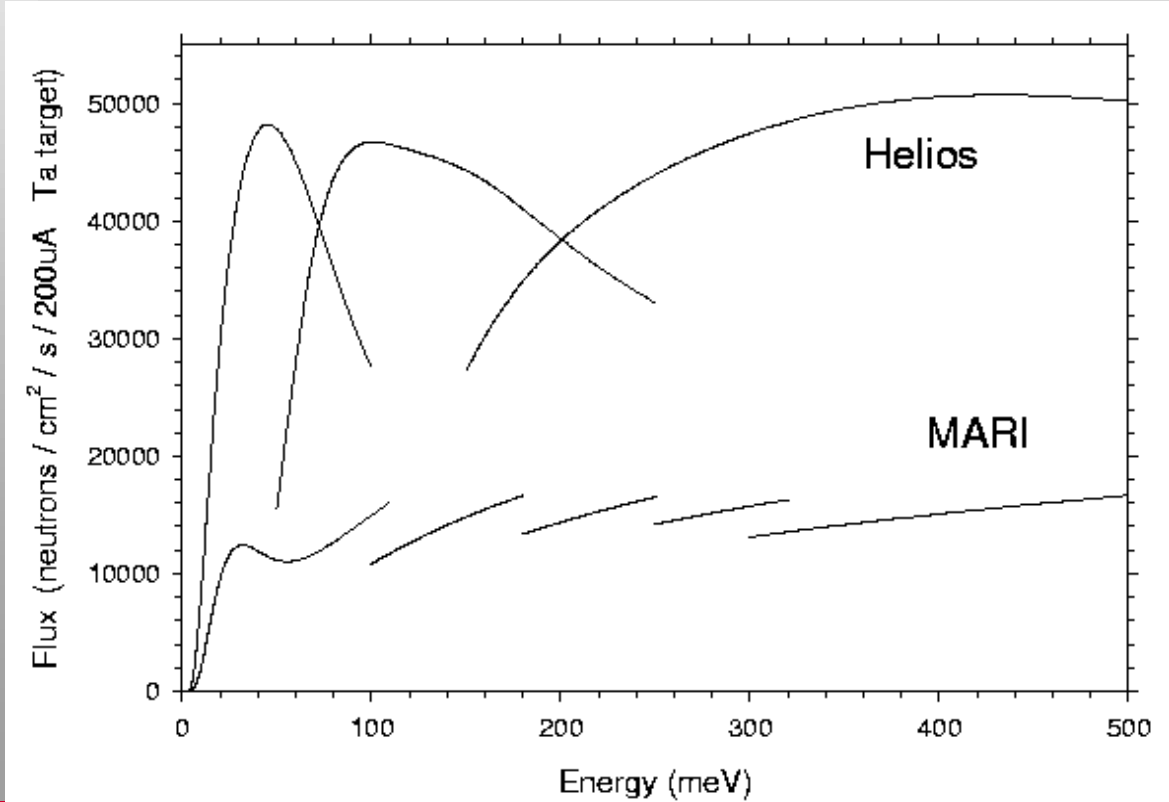
Flux (n/cm^2/sec)

dE$_i$ (meV)

E$_i$ (meV)

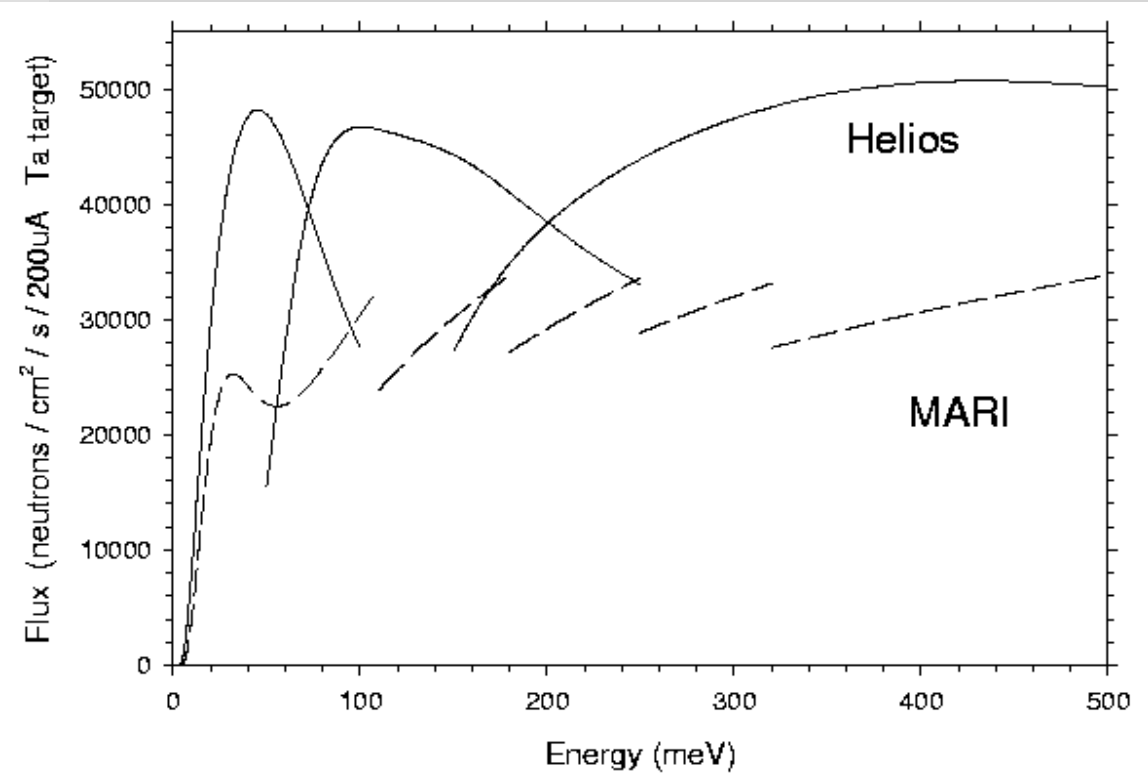
Comparing MARI and HELIOS

- HELIOS views 12.5x12.5 cm^2 moderator
- MARI views 10x10 cm^2 moderator (Actual case)

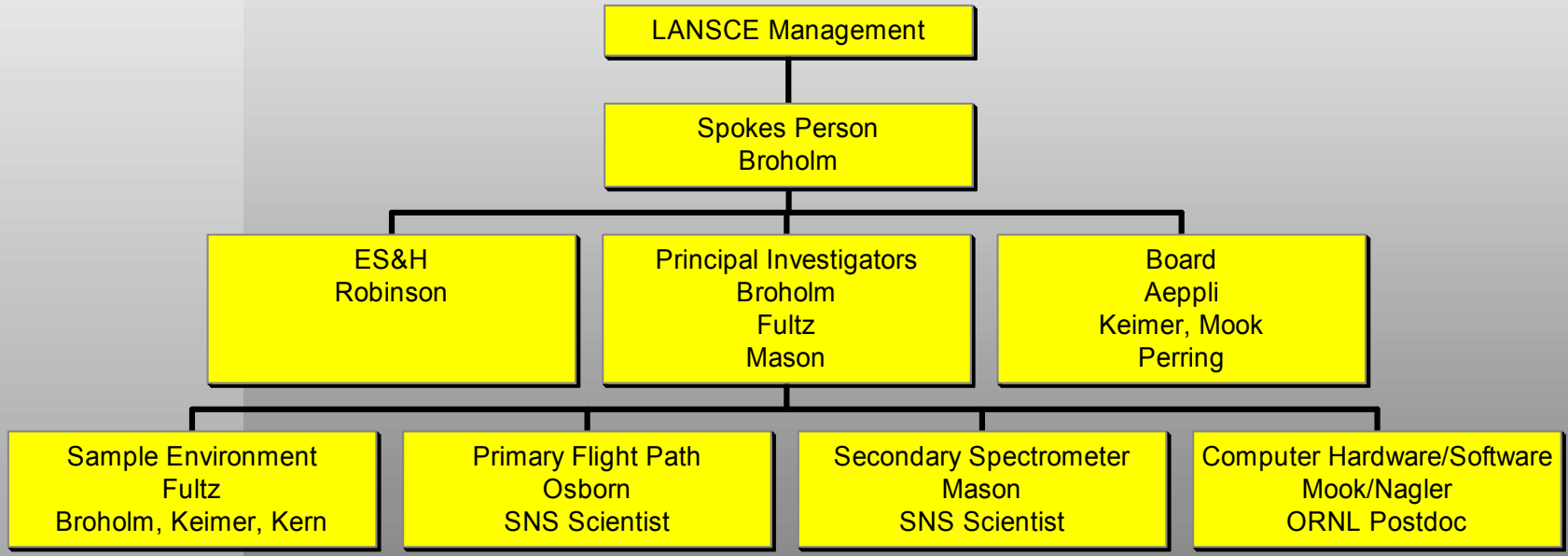


Comparing MARI and HELIOS

- HELIOS views 12.5x12.5 cm^2 moderator
- MARI views 12.5x12.5 cm^2 moderator (Optimistic case)



HELIOS Spectrometer Development Team



Summary of HELIOS Proposal

- **Important problems in Materials Science and Condensed Matter Physics require high sensitivity neutron spectroscopy with $5\ meV < h\omega < 500\ meV$ and $5\ meV < \delta h\omega < 10\ meV$.**
- **Current neutron spectrometers are not optimized for such experiments.**
- **HELIOS combines the broad phase sampling of chopper spectrometers with the relatively coarse energy resolution of triple axis spectrometers to address this need.**
- **HELIOS will be a unique resource at LANSCE and an important development project for the SNS.**