INSTRUMENT SYSTEMS TIMING: Desires and Requirements

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Overview

- General Inputs to Instrument Data Acquisition System

- Neutron Choppers
  - Instrument overview
  - Time-of-Flight Diagram - T0, Bandwidth, E0 choppers
  - Desired characteristics
  - Current activities

- Other timing concerns
  - Flexibility for novel data collection schemes

Inputs to DAS

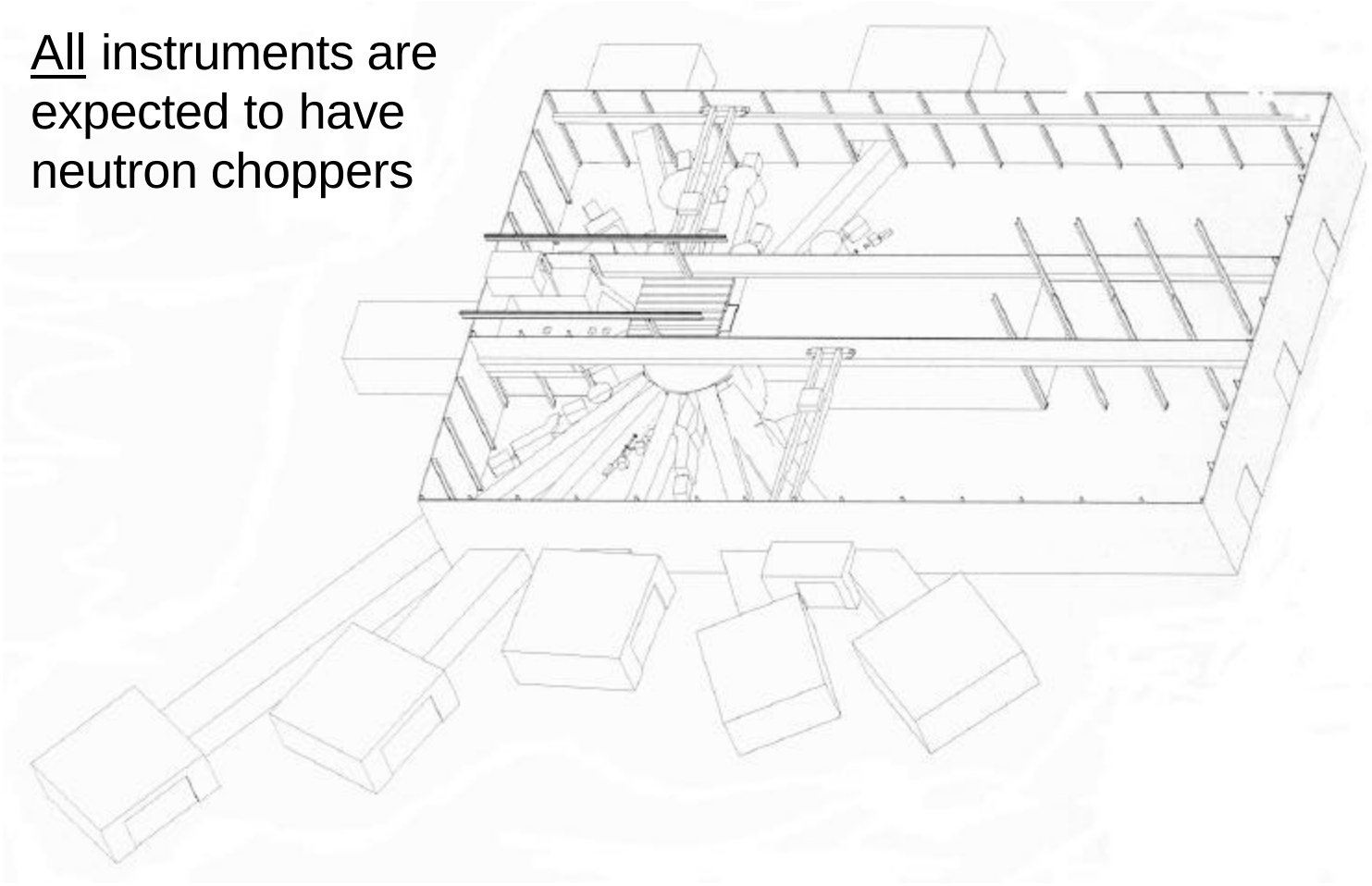
Instrument Systems is developing the data acquisition system for SNS. Some of the desired inputs from the global timing system are:

- Timing signal for proton beam-on-target distributed to each instrument (~0.1 μ s jitter)
- Integrated number of protons per pulse
- Access to other information from accelerator/ring system
  - Compatible time stamping for looking up pulse-by-pulse histories
  - Mode of operation (e.g. pulse stealing for 2nd target station)

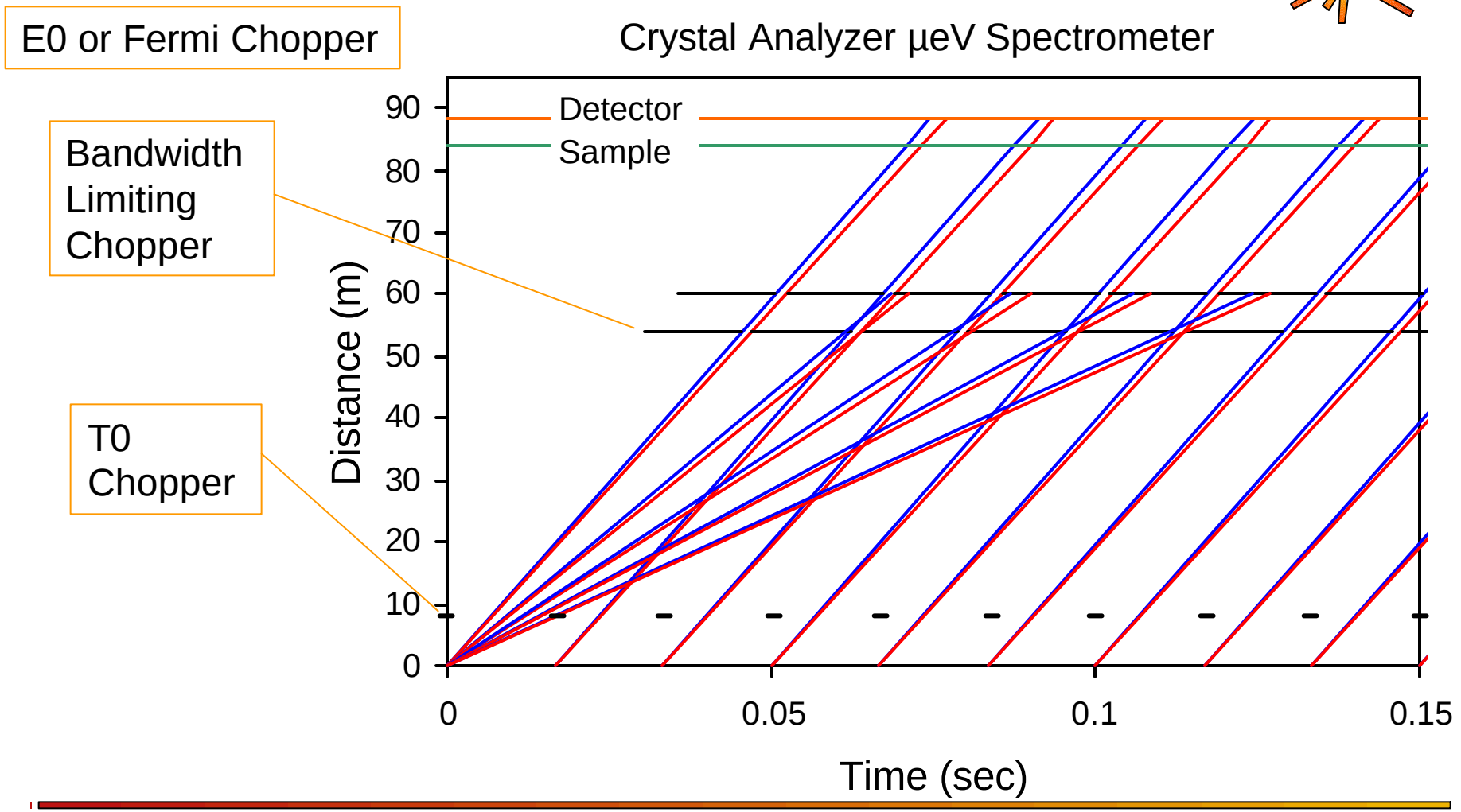
Specified in the (draft) Interface Control Document 1.7-1.9

Target Building Layout with 24 Instruments

All instruments are expected to have neutron choppers



Neutron Time-of-Flight Diagram: Chopper types



Projected Chopper Population

Beamline	Moderator	Instrument Name/Description	T0	E0	BWL
18	BU	1% chopper spectrometer	1	1	0
16A	BU	Disordered materials	1	0	1
9	BU	Wide-angle chopper spectrometer	1	1	0
8	BU	Powder diffractometer	1	0	2
7	BU	Engineering diffractometer	1	0	2
6	TD	SANS	1	0	2
4	TD	Liquids reflectometer	0	0	3
4	TD	Polarized beam reflectometer	0	0	3
3	TU	100 microvolt spectrometer	1	0	3
2	TU	Crystal analyzer microvolt spectrometer	0	0	3
1	TU	Single crystal diffractometer	1	0	1
		Anticipated day-one total:	**8**	**2**	**20**
17	BU	Molecular spectrometer	1	0	0
16B	BU	Polarized diffractometer	1	0	2
15	BD	eV spectrometer	1	0	0
14	BD	Special environment	1	0	2
14	BD	Inelastic spectrometer	1	0	3
13	BD	High-intensity spectrometer	1	0	2
12	TU	Hi-res. Cold neutron single crystal	0	1	2
11	TU	Diffuse/critical scattering single crystal	1	0	2
11	TU	Advanced techniques reflectometer	0	0	3
10	TU	High intensity powder diffractometer	1	0	2
8	BU	Hi-Q, high intensity single crystal diff.	1	0	2
5	TD	Triple axis	1	0	0
1	TU	Special purpose SANS	1	0	2
		Totals:	**19**	**3**	**42**

Totals

30

64

T0 Neutron Chopper

Used to suppress high energy background from moderator.

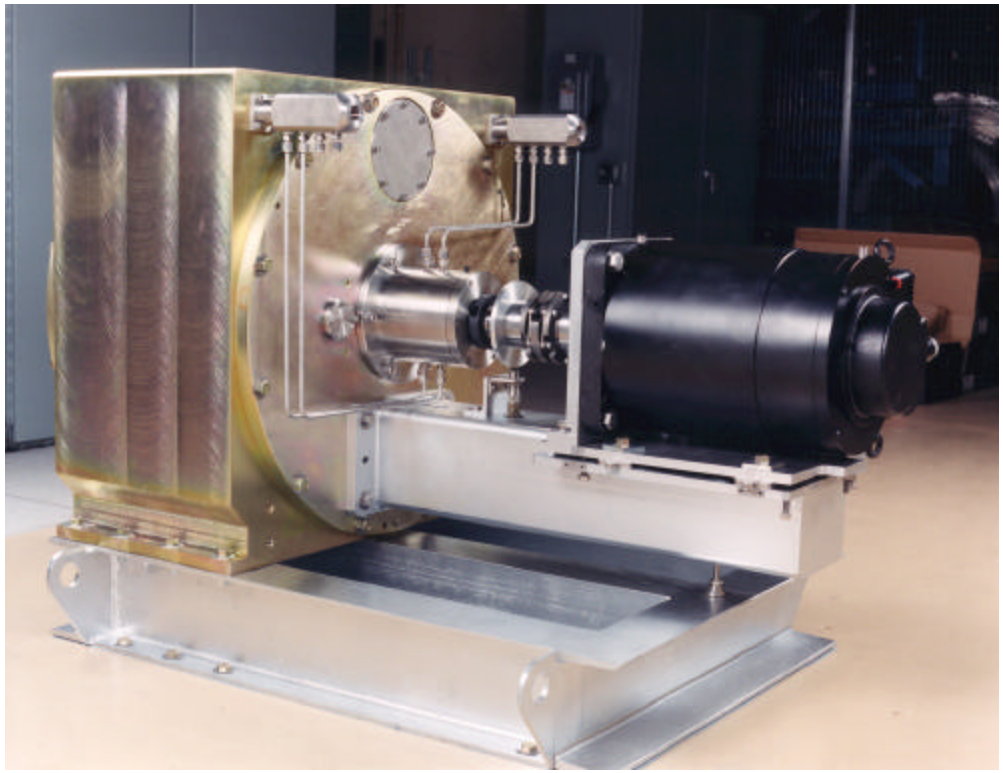
Massive absorber must be aligned with beamline for each pulse on target.

Typical timing requirement:

11cm absorber for 10cm beam at R=35cm, 60 Hz $\Rightarrow$ $\pm$ 38 μ s

But, for high energy neutrons need absorber out of beam with

~ $\pm$ 10 μ s error at 120 Hz



SNS prototype under testing at ANL

Bandwidth Limiting Choppers

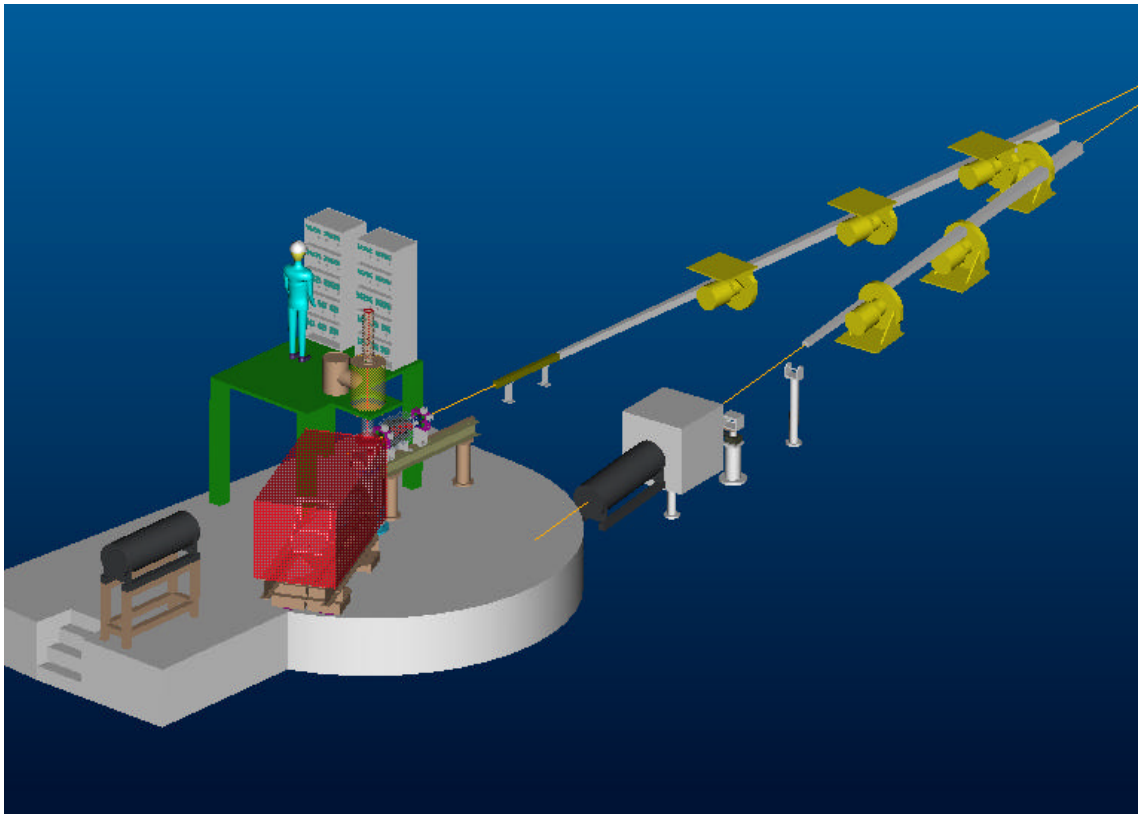
Used to select energy range for the instrument, and eliminate “frame overlap” contamination.

Relatively light weight absorbing discs.

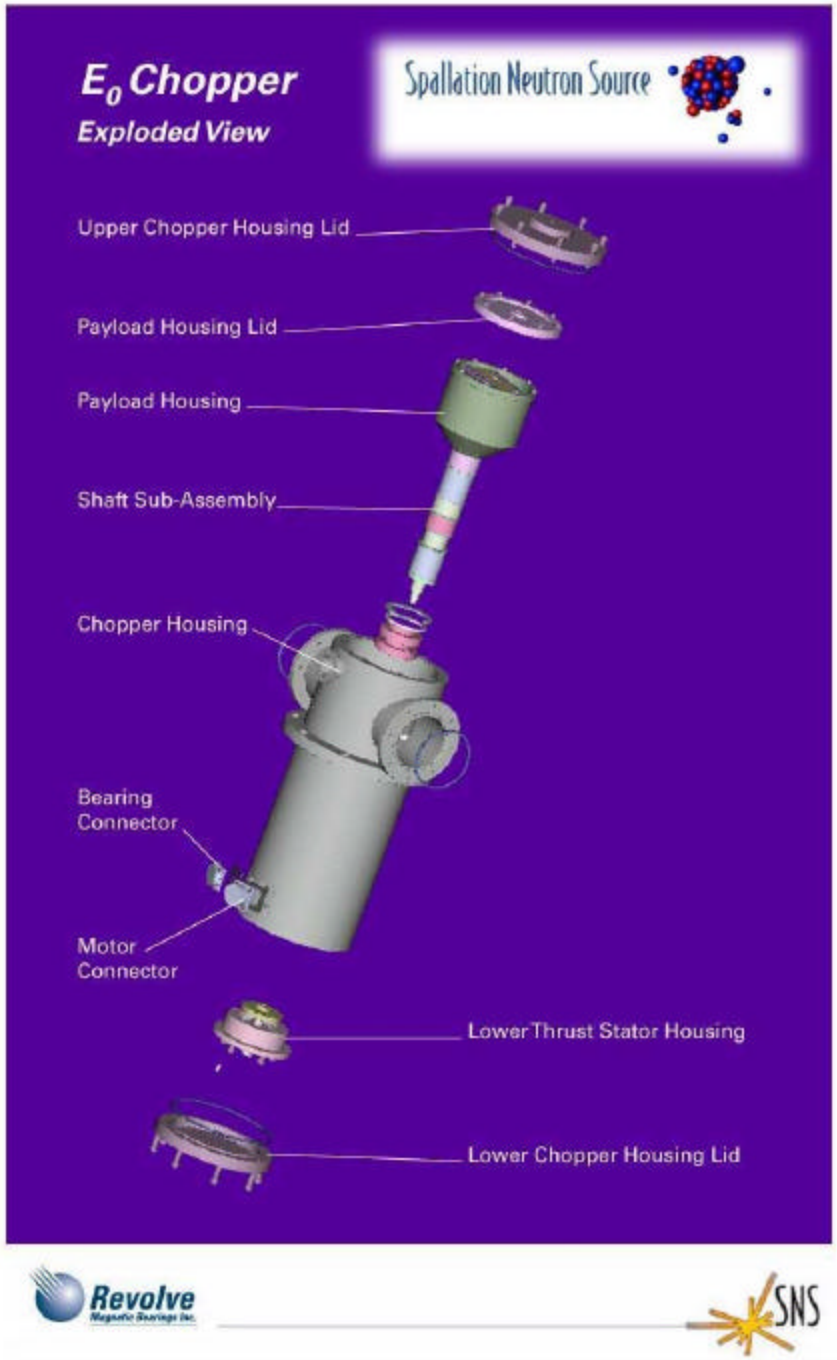
Typical timing requirement:

Depends on application, but can be similar to T0 chopper ~ ± 10 μ s error

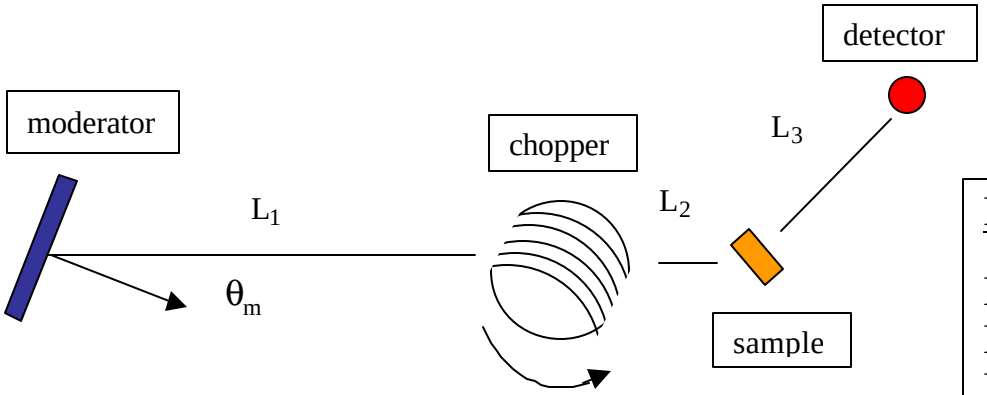
Reflectometers



E0 or Fermi Chopper



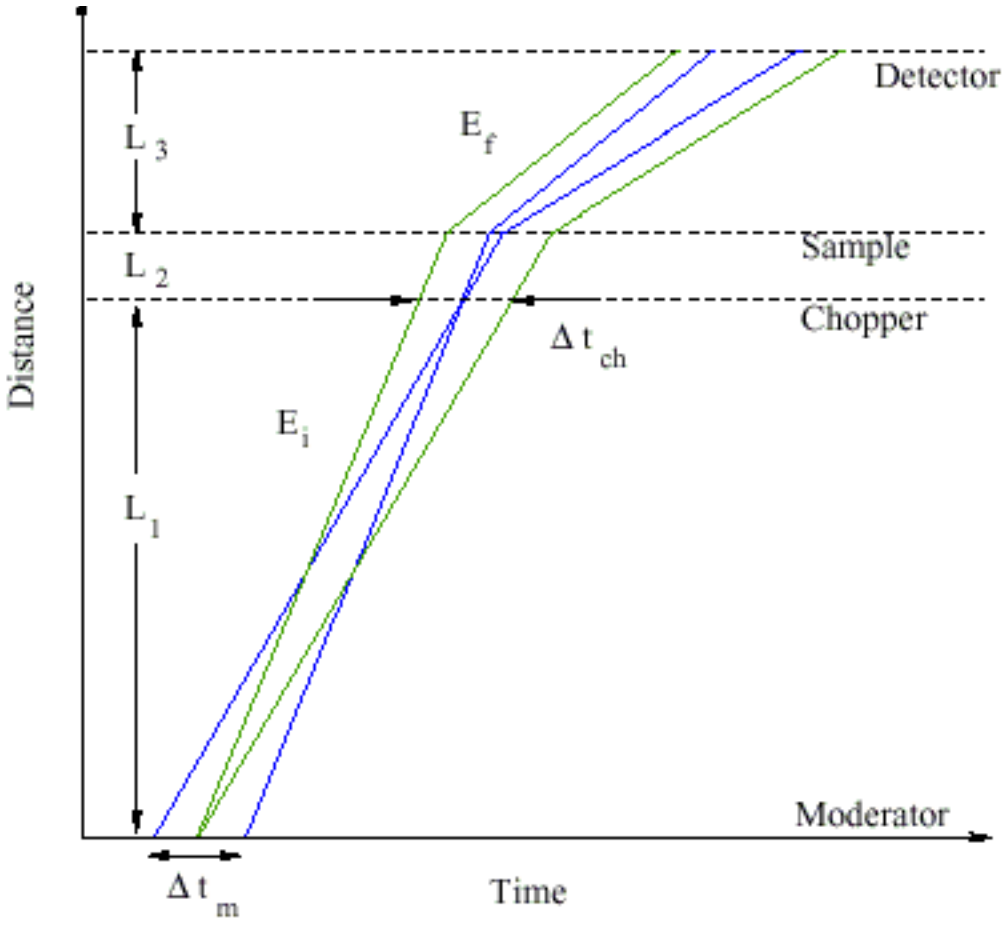
E0 or Fermi Chopper



Parameters

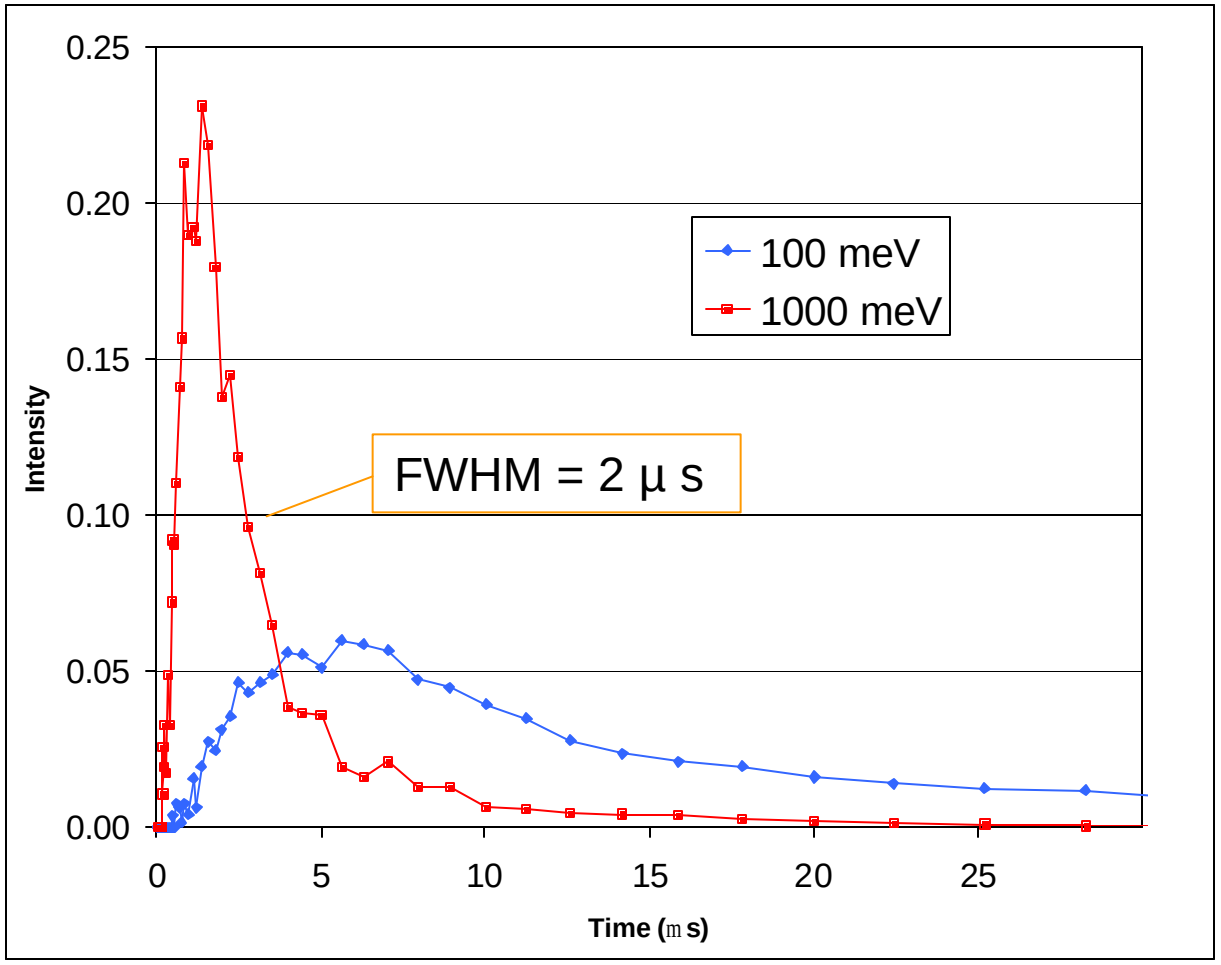
L_1	Moderator-Chopper distance
L_2	Chopper-Sample distance
L_3	Sample-Detector distance
Δt_m	Moderator pulse width (FWHM)
Δt_{ch}	Chopper pulse width (FWHM)
	Moderator-Chopper flight time

E0 or Fermi Chopper



Timing errors will combine with the moderator pulse width to contribute to the energy uncertainty of the experiment.

Moderator Pulse Shapes



E0 chopper timing requirement:

At highest energies, want negligible contribution from timing error ⇒

± 0.5 μ s

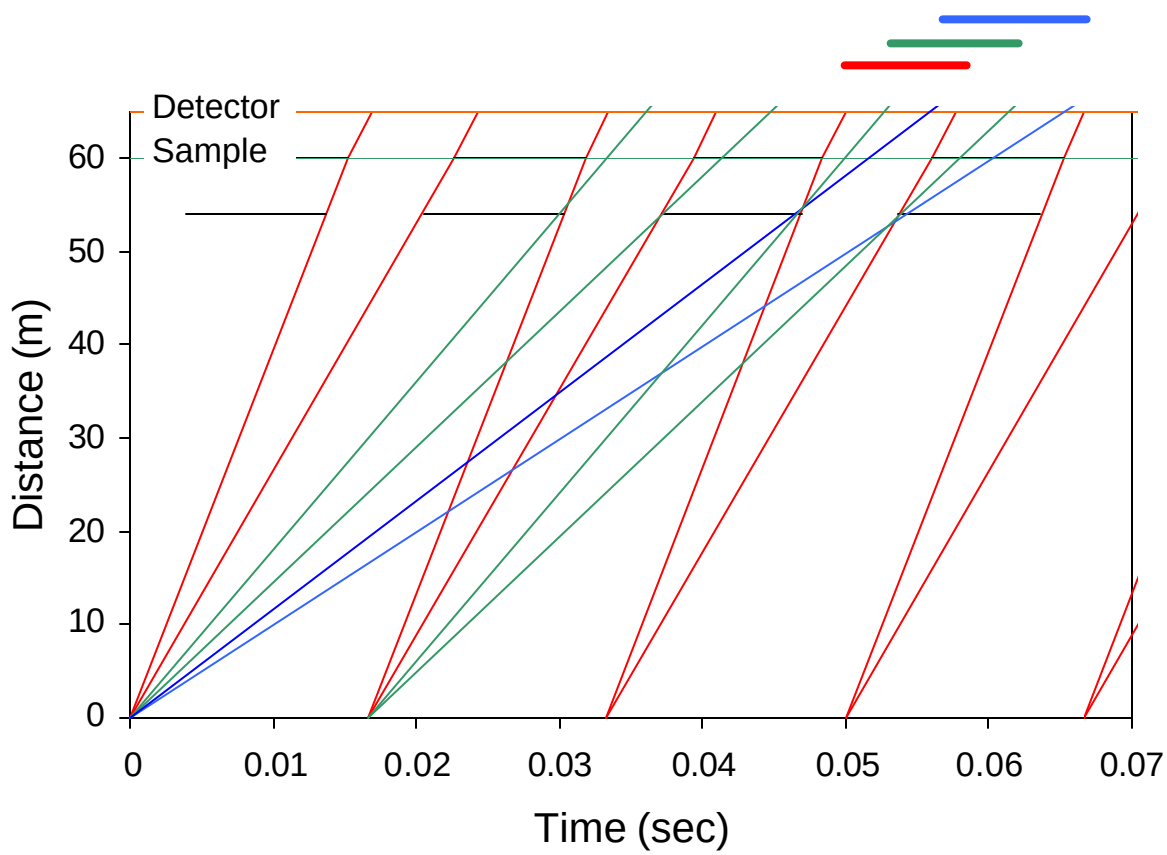
Neutron Chopper Control Goals

Chopper Type	Operating Frequency	Desired Timing Errors	Nominal Reference Frequency	Reference Frequency Drift
E0	600 Hz maximum	±0.5 μs	60 Hz	1 mHz /s
BWL	60 Hz (30,20,15,10)	±10 μs	60 Hz	1 mHz /s
T0	60 Hz (120 Hz)	±10 μs	60 Hz	1 mHz /s

Neutron Chopper Activities

- Chopper Test Facility set up and functioning at ANL.
- T0 chopper prototype fabricated and under test.
- Prototype chopper control system fabricated.
  - Chopper control will be tested with T0 chopper once initial chopper tests are completed.
  - Chopper control system is intended to operate with all types of choppers.
- Turnkey E0 chopper with dummy slit package now in-house. Timing tests to resume immediately.
- Bandwidth-limiting chopper prototype going out for commercial production.

Other Timing Concerns: Flexibility for Novel Data Collection



By intentionally allowing frame overlap, data could be collected more rapidly to study systems changing incrementally in time.

This constrains the pulse-to-pulse interval to not change drastically over several periods. Total error should be less than a few μ s.

Summary

- Timing requirements
  - Beam delivery to target and a large collection of different chopper systems must be synchronized. Tightest time tolerance is for the E0 choppers ~ 1 μ s. Multiple E0 choppers will run simultaneously.
  - Information needs to be given to the Instrument data acquisition systems, e.g. pulse arrival, intensity, mode.
- Timing desires
  - Flexible system that can be adapted as more is learned about actual chopper performance.
  - Allow for novel data collection modes.