Polarized 3He Target Analysis for GEn-II

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Hall A Collaboration Meeting 2024

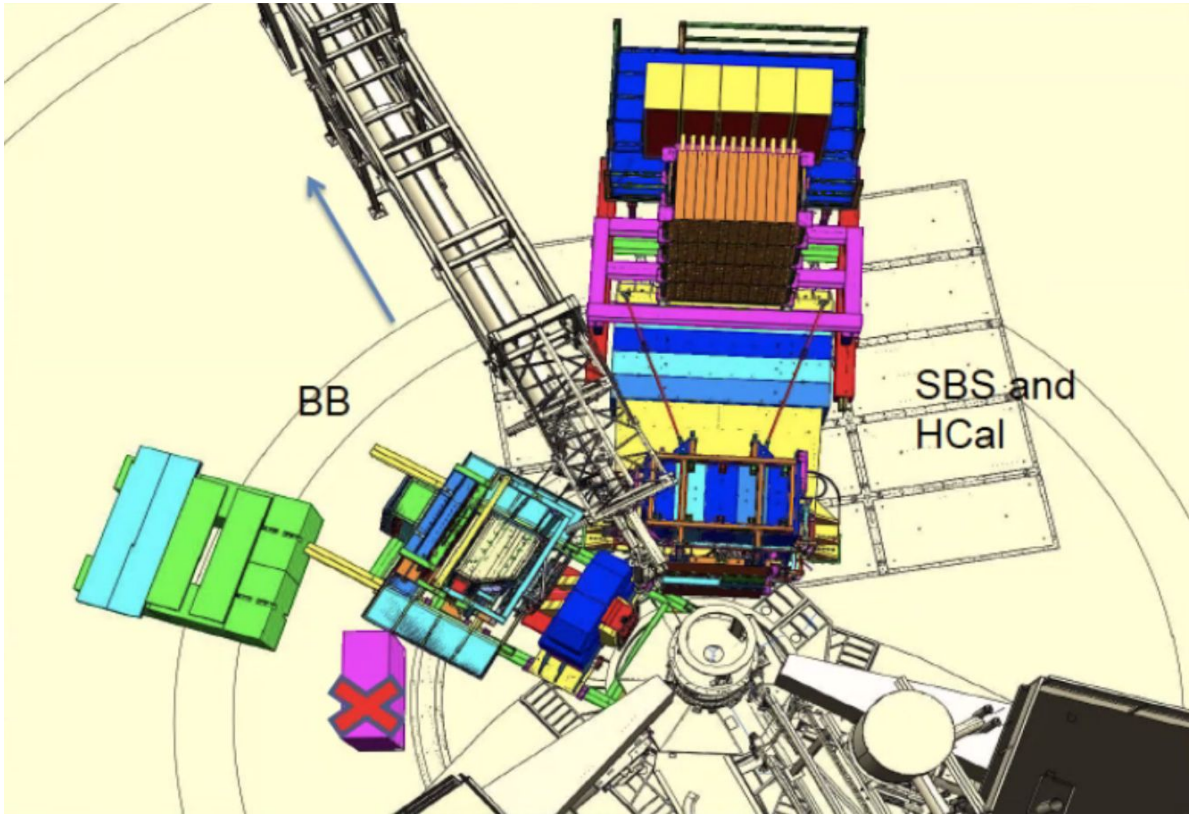
“Experimental nuclear physicists”

“Make them look cool”

“The coolest nuclear physicists possible”

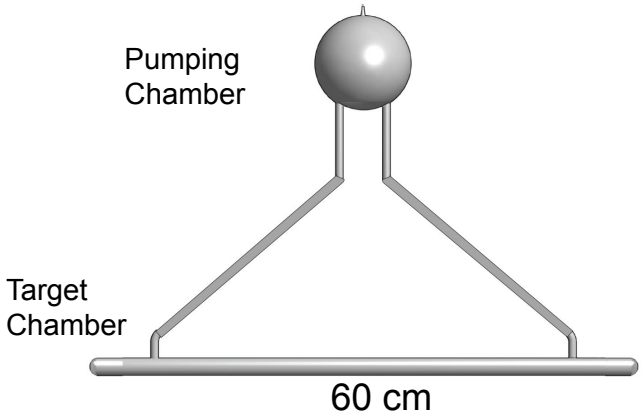
GEn-II Experimental Setup

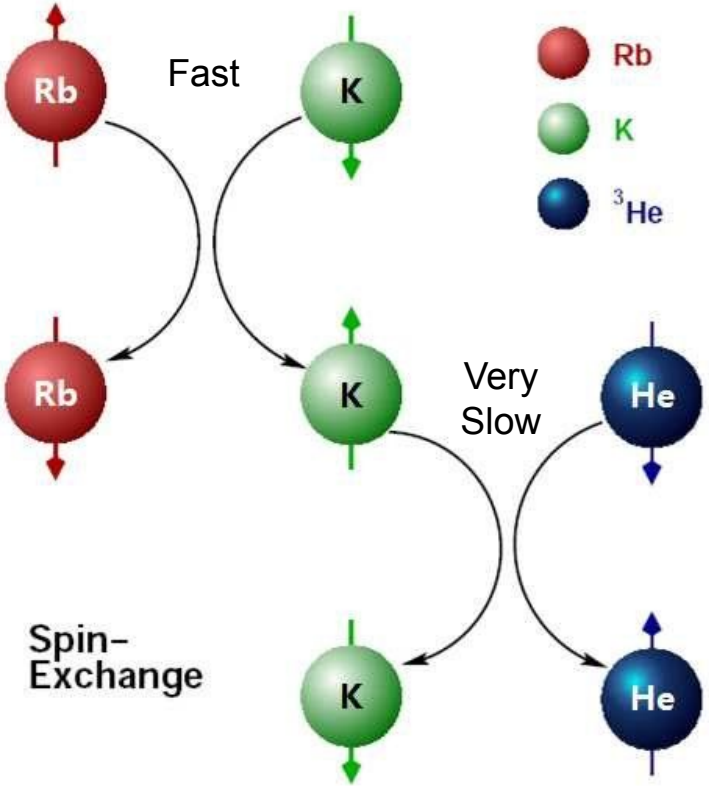
- **Extract ratio of GEn/GMn at high Q^2**
- Polarized electron beam
- Polarized 3He target
- Detect scattered electron and neutron in coincidence



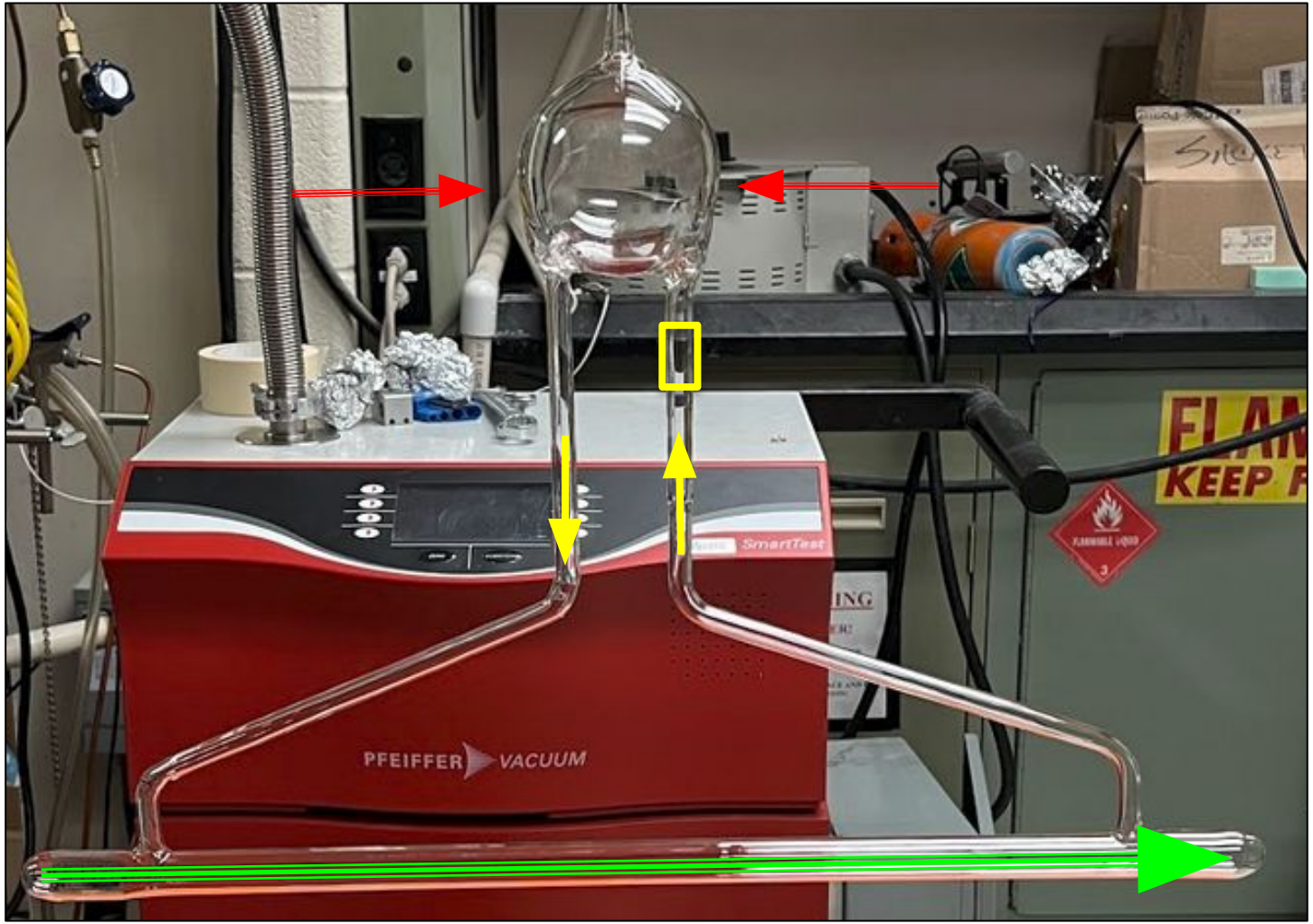
Spin-Exchange-Optical Pumping (SEOP)

- Optically pumped high density alkali vapor
- Both Rb and K used for increased pumping efficiency
- 3He nuclei polarized through hyperfine interactions during collisions
- Convection used for fast mixing



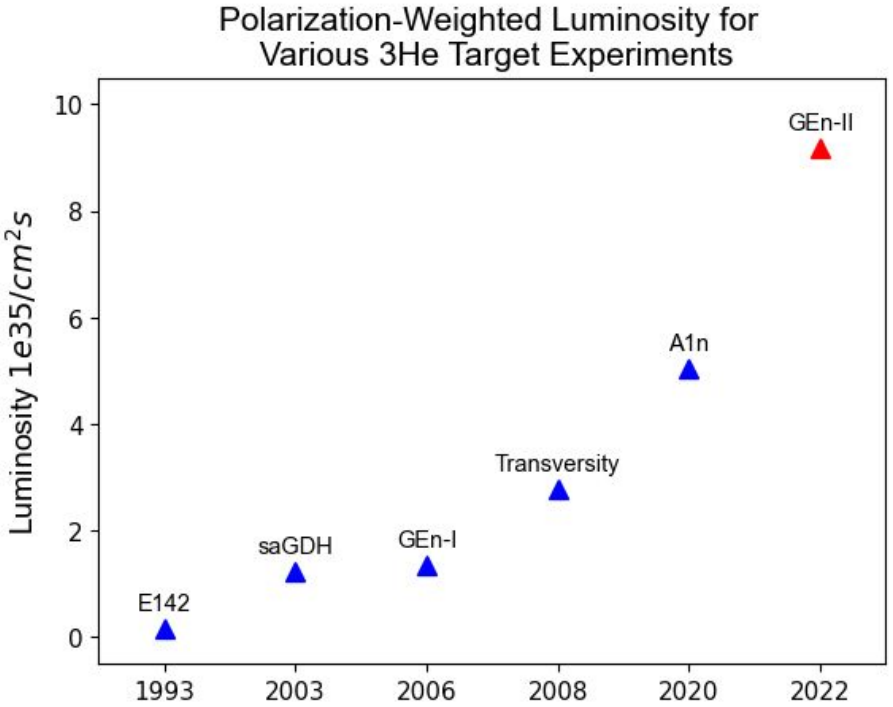


https://www.researchgate.net/figure/Hybrid-approach-of-Spin-Exchange-(


PFEIFFER VACUUM
SmartTest

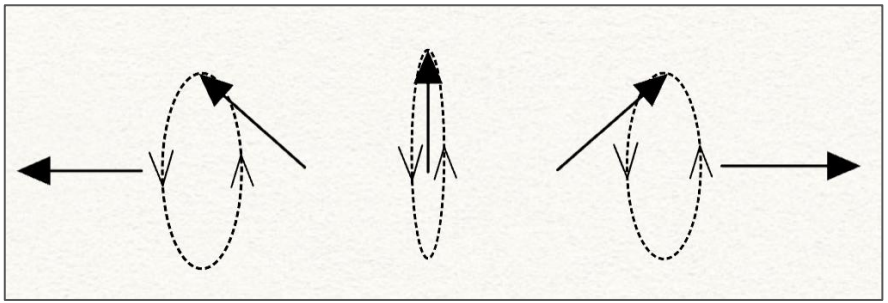
SBS GEn-II Goal: Record Breaking Target Performance

- Polarization-weighted luminosity of previous 3He targets
- Projected performance of GEn-II targets
  - Target chamber length increased to 60 cm
  - Target chamber volume increased by factor of 2
  - Bigger cell -> higher current
    - Limits depolarization effects
  - **Projected goal: 45% at 45uA**



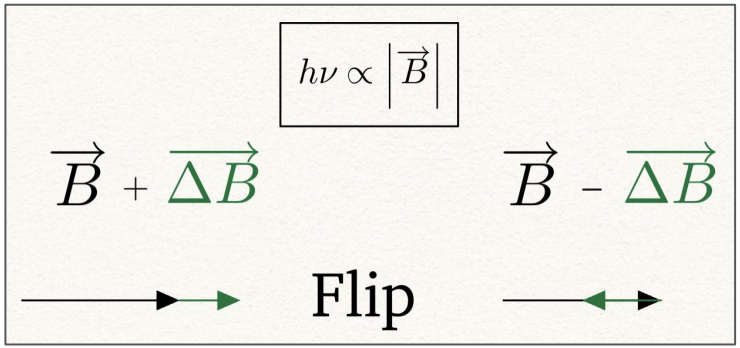
NMR

- Cell in magnetic holding field
- Apply RF (91KHz) field and sweep holding field
- Measure voltage of coils placed near the cell to track polarization signal during sweep
- **Yields signal in mV**



EPR

- Use feedback system to find the frequency at which unpaired electrons in the alkali atoms resonate
- Flip the spins of the 3He
- Find new resonance frequency
- The difference in the frequency is proportional to the 3He polarization
- **Yields percentage of polarization**



Polarimetry

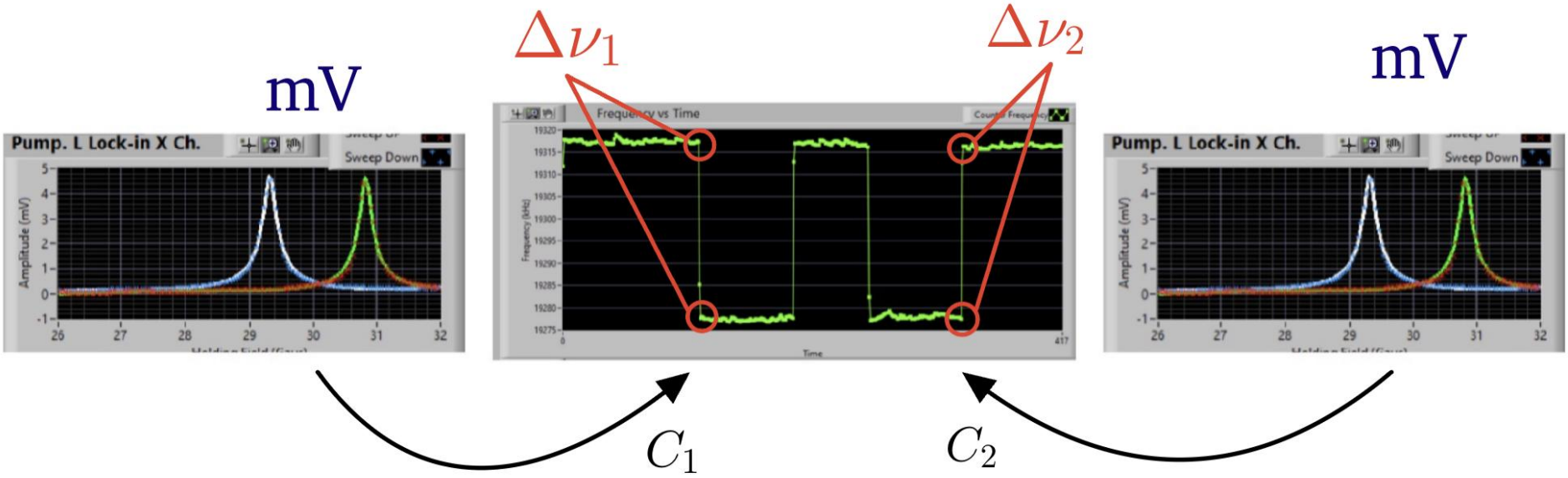
- NMR measurements taken every 3 hours
- Multiple EPR calibrations per cell
- Tasks
  - **Calculate** broad calibration constants for each cell %/mV
  - **Correct** for density fluctuations during calibrations
  - **Apply unique calibration** constant for each NMR
  - **Apply polarizations** for data-taking runs in GEn

Cell Information

	Cell Name	Average Polarization	Max Polarization	Number of Calibrations	Duration Installed
Kinematic 2	Hunter	40%	46.08%	23	20 days
Kinematic 3	Windmill	45%	49.80%	6	14 days
	Hunter	42%	46.32	11	24 days
Kinematic 4	Fringe	53%	55.92%	12	60 days
	Chicago	n/a	43.60%	6	12 days
	Donya	40%	44.49%	3	31 days
	Christin	40%	45.57%	7	20 days

Task 1: Broad Calibrations

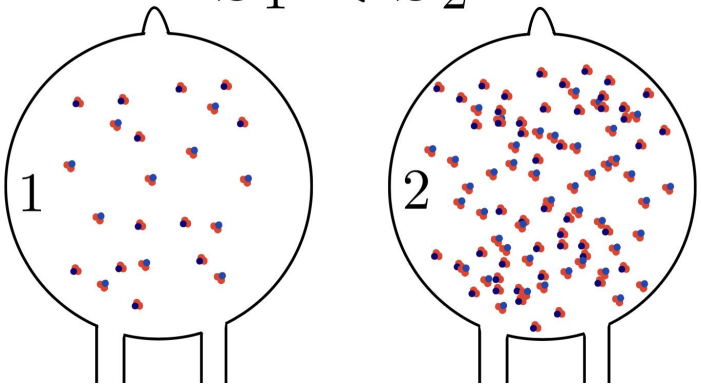
- Completed during the running of each cell
- Gives a generally accurate %/mV value to apply to NMR data in real time

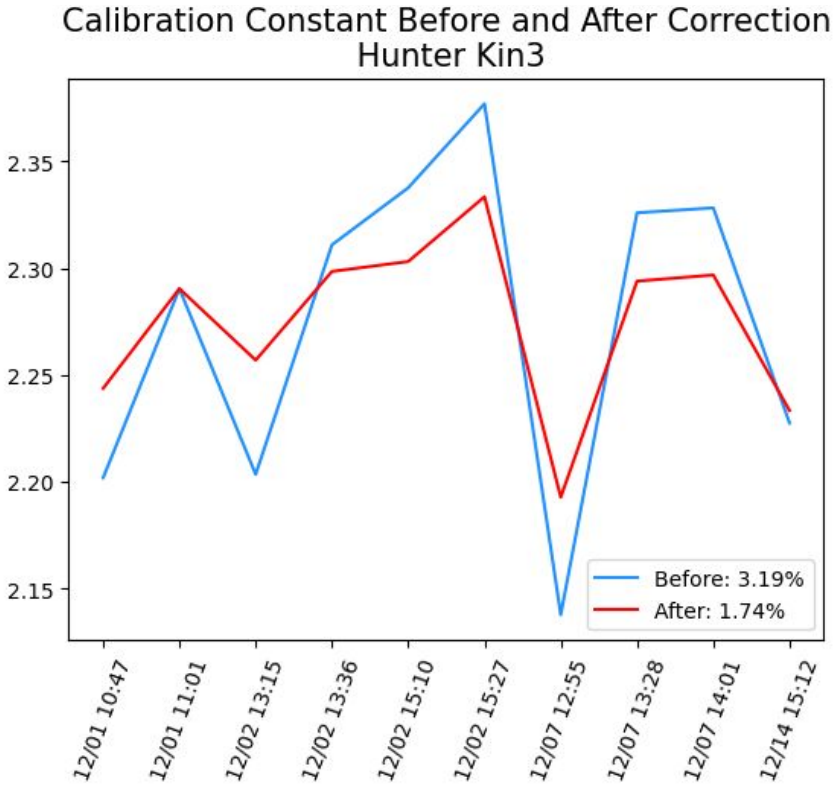


Task 2: Correct Calibrations

- Calibrations precise if temperatures are exactly the same
- Correct for different temperatures using volumes and signal ratios
- After eliminating systematic fluctuations in calibrations, average

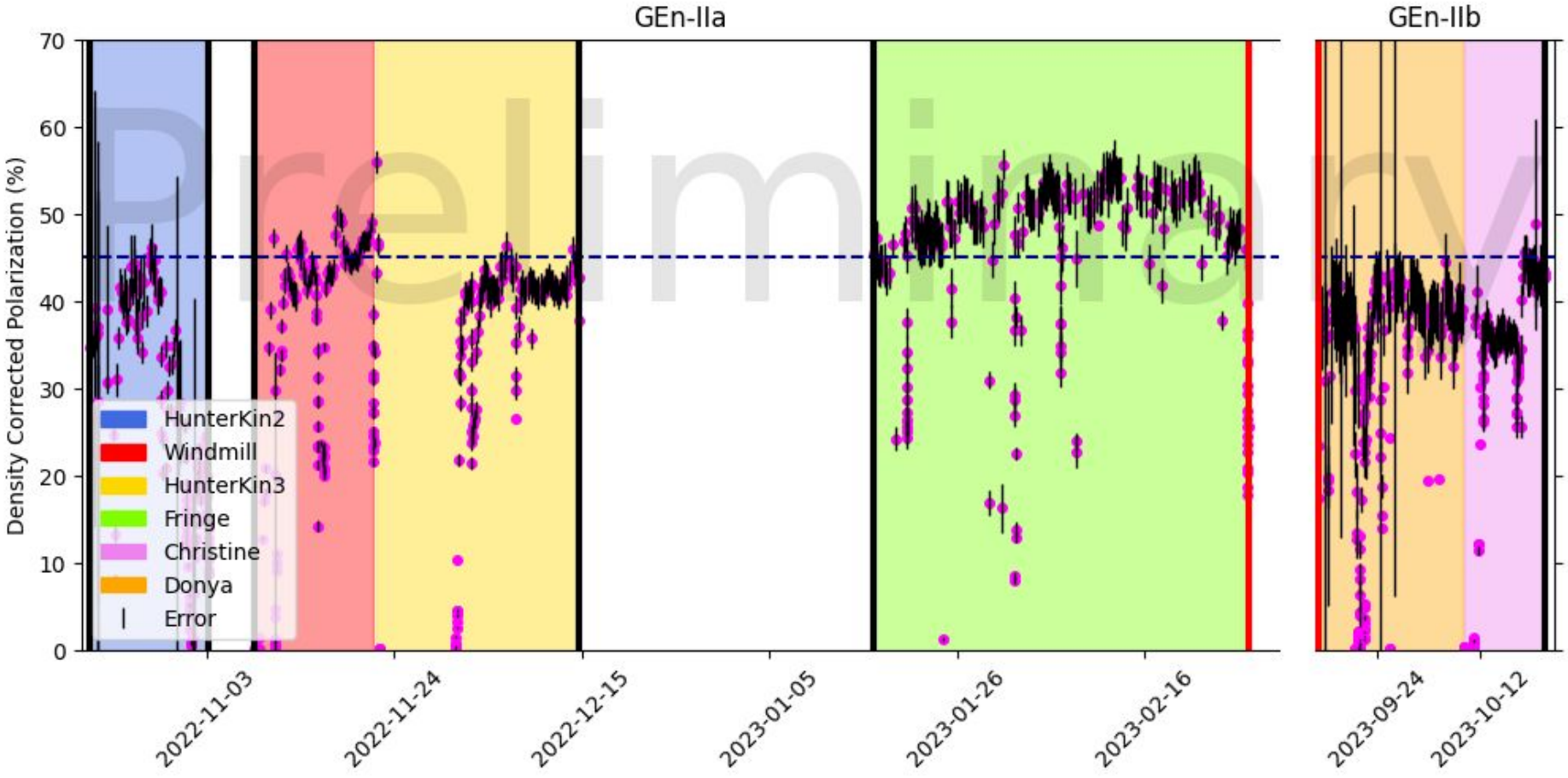
$$S_1 < S_2$$





Task 3: Apply Unique Calibration

- Take corrected averaged calibration constant
- Use comparison of ratio **during calibration** and the ratio of **each individual NMR** during the run to adjust the averaged calibration
- Corrected for density fluctuations across multiple calibrations in task 2
- Task 3 corrects for density fluctuations between the calibrations and the production NMR sweeps


GEn-IIa
GEn-IIb
Density Corrected Polarization (%)
70
60
50
40
30
20
10
0
HunterKin2
Windmill
HunterKin3
Fringe
Christine
Donya
Error
2022-11-03
2022-11-24
2022-12-15
2023-01-05
2023-01-26
2023-02-16
2023-09-24
2023-10-12
Preliminary

Summary and Future Steps

- GEn-II data taking is **complete (10/2022-11/2023)**
- **GEn-II Polarimetry** is well under way
- Preliminary results suggest target goal of **45% at 45uA** has been reached
- Polarization Interpolation (Task 4) in early stages of development