

# COMPASS Polarized Target

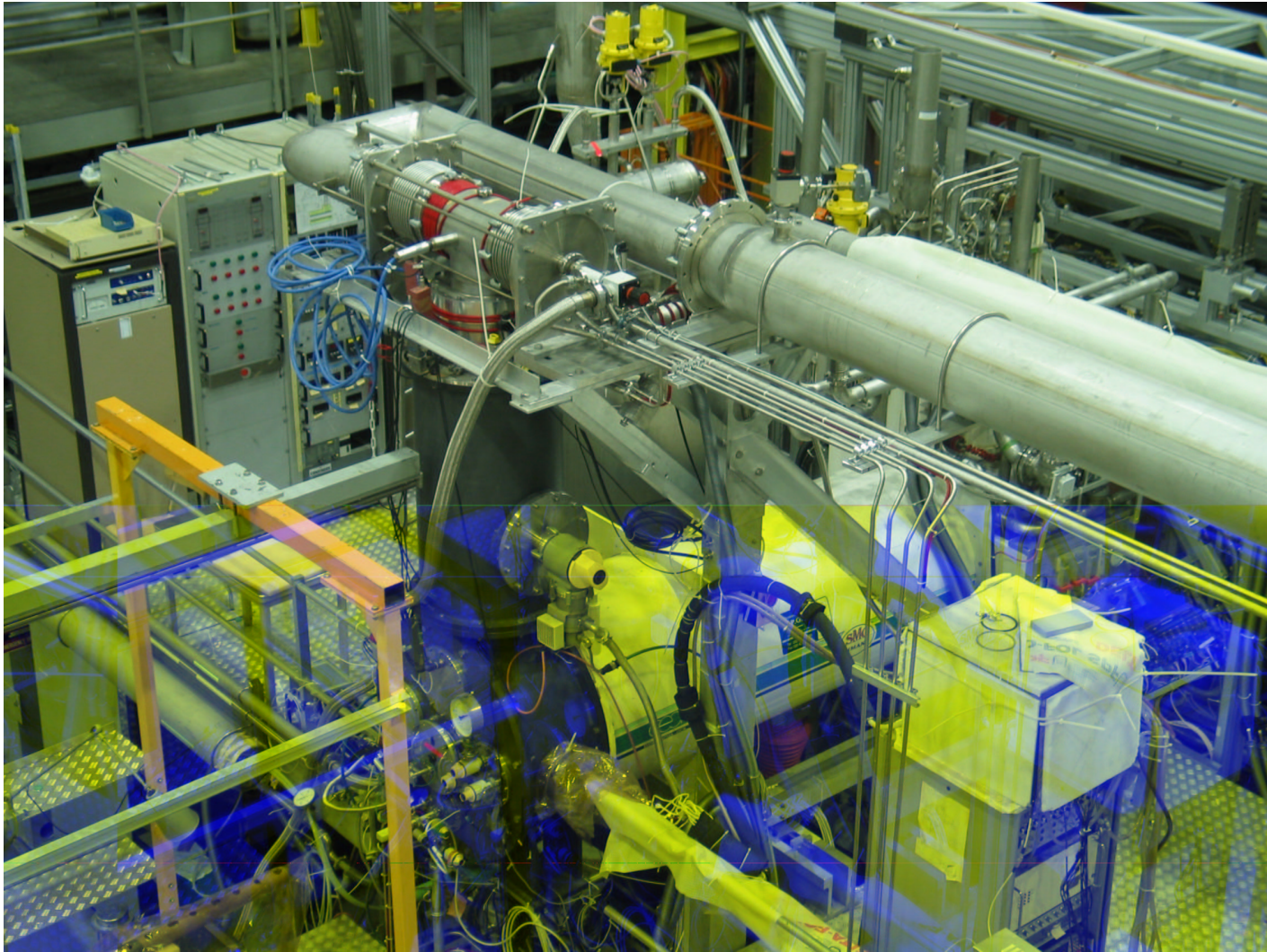
Polarization build up in the large COMPASS  $^6\text{LiD}$  target

Jaakko Koivuniemi

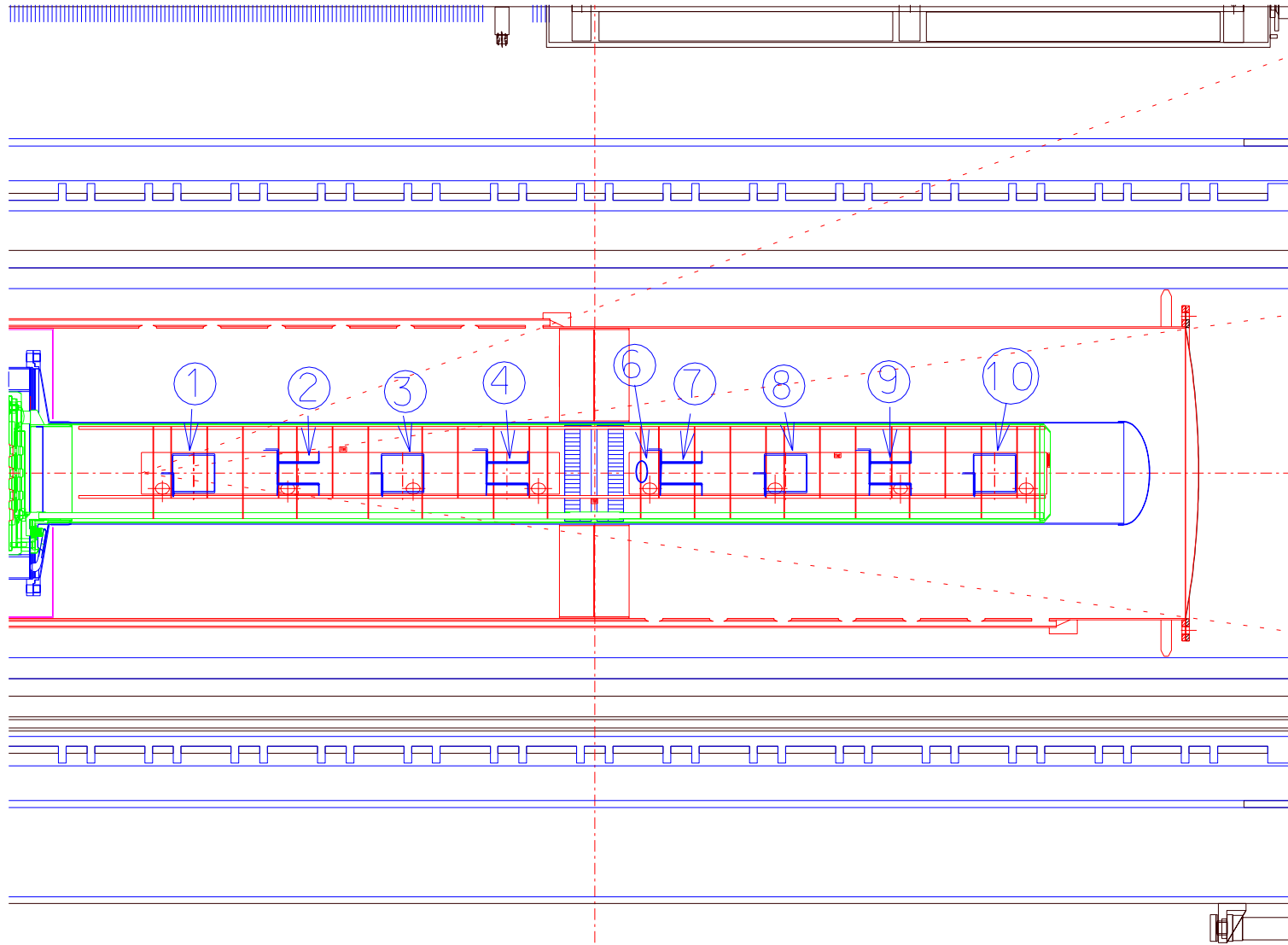
1. Deuterium polarization in muon run 2001 - 2004
2. Spin temperature and spin 1 level populations
3. Thermodynamics of dynamic nuclear polarization



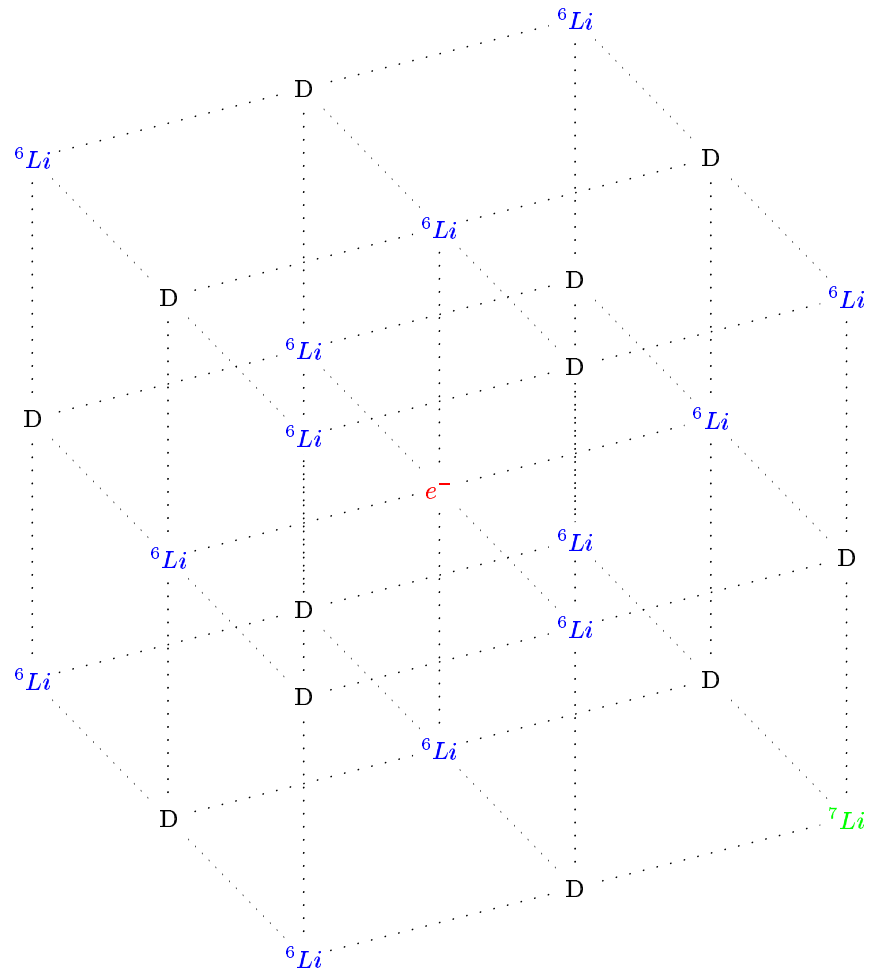
# COMPASS polarized target



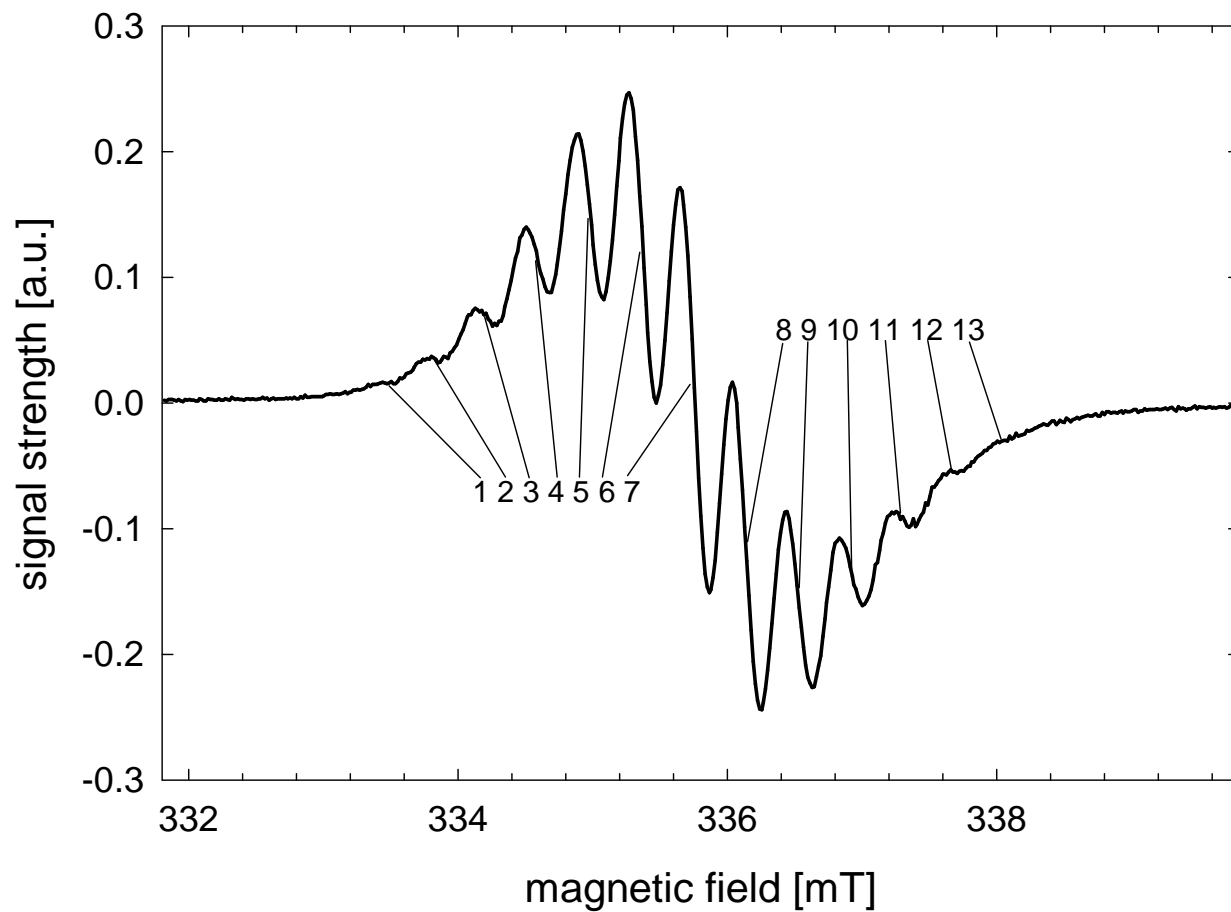
# Target cells $2 \times 60 \text{ cm } \varnothing 3 \text{ cm}$



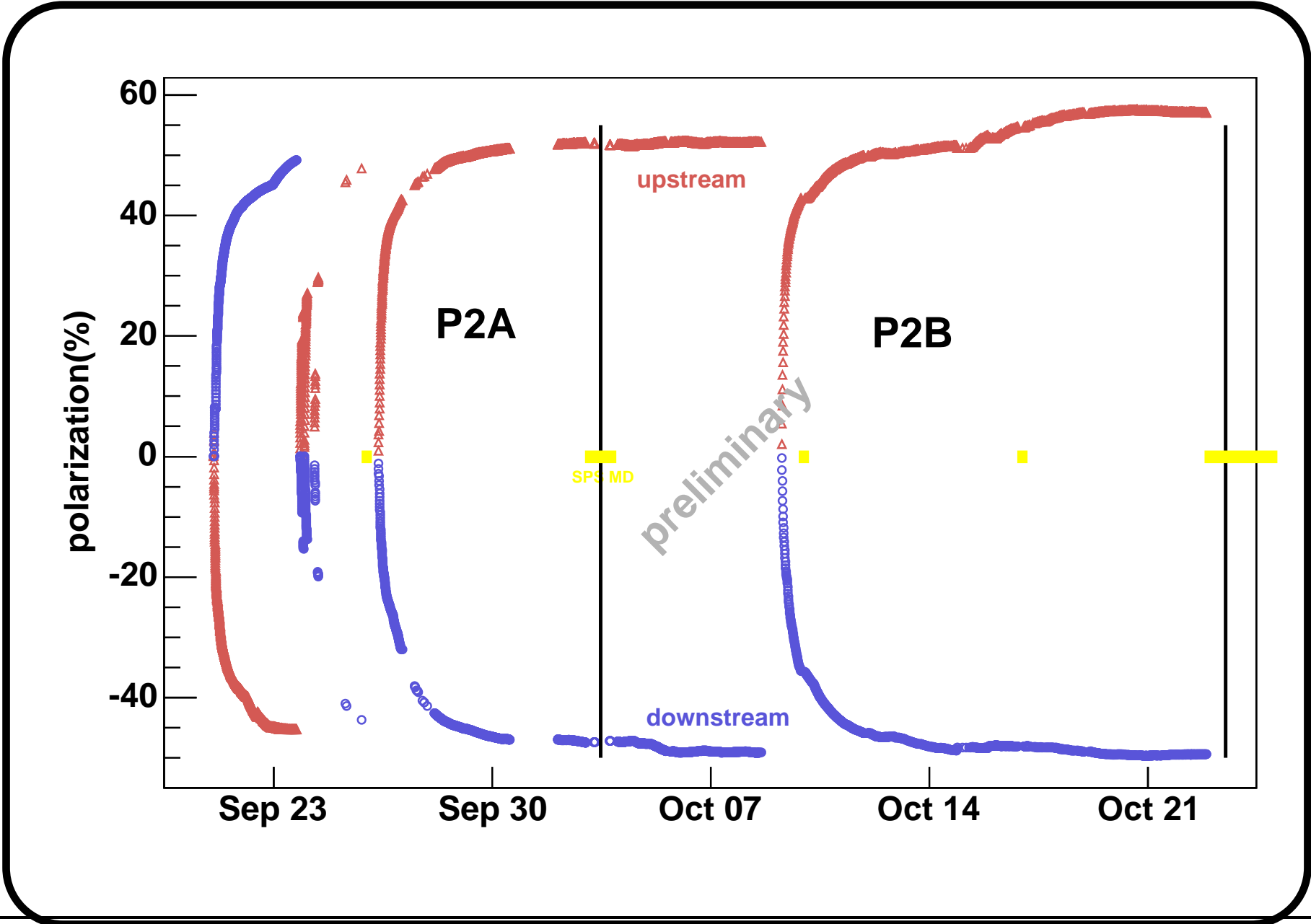
# ${}^6\text{LiD}$ target material



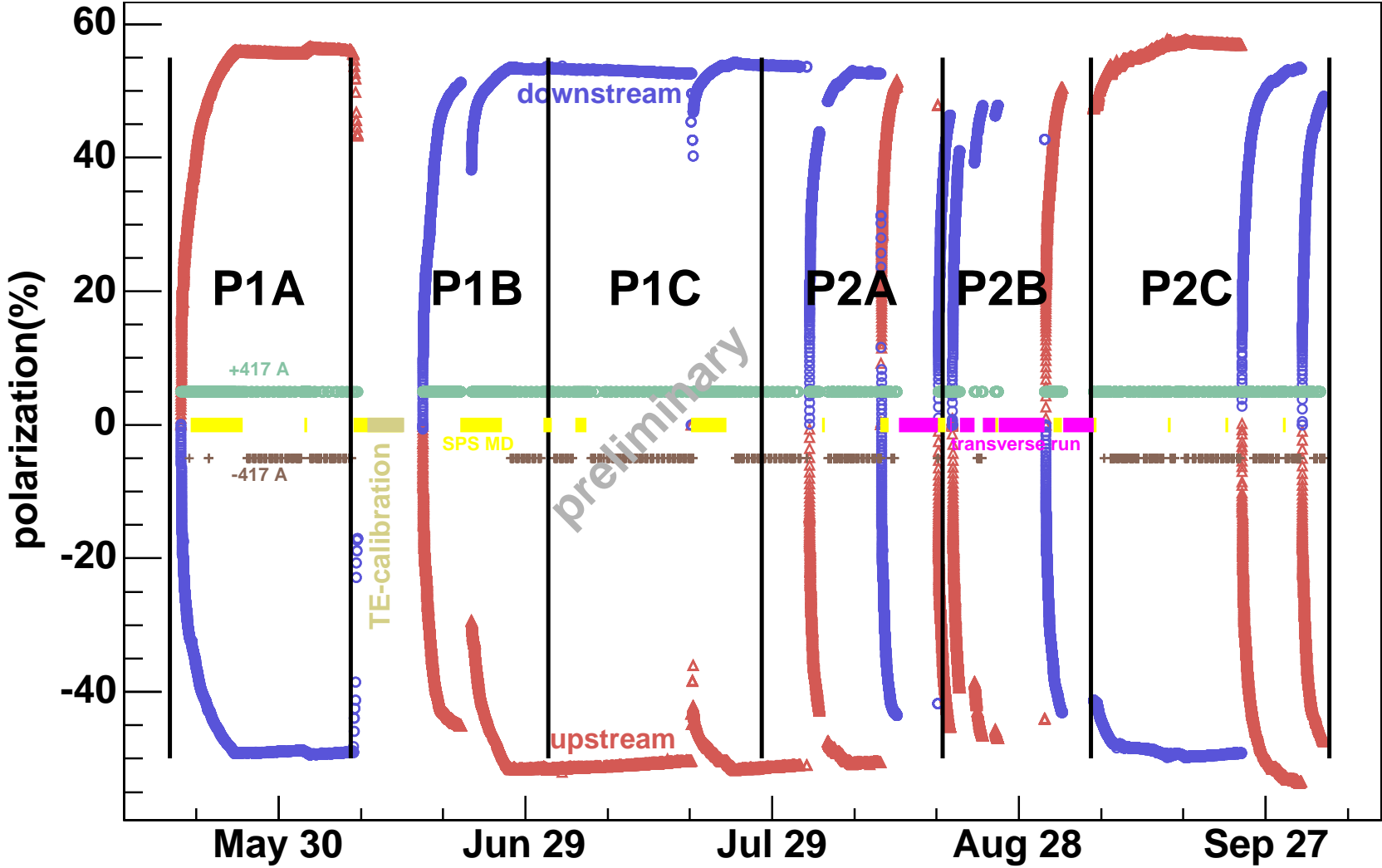
# Electron spin resonance



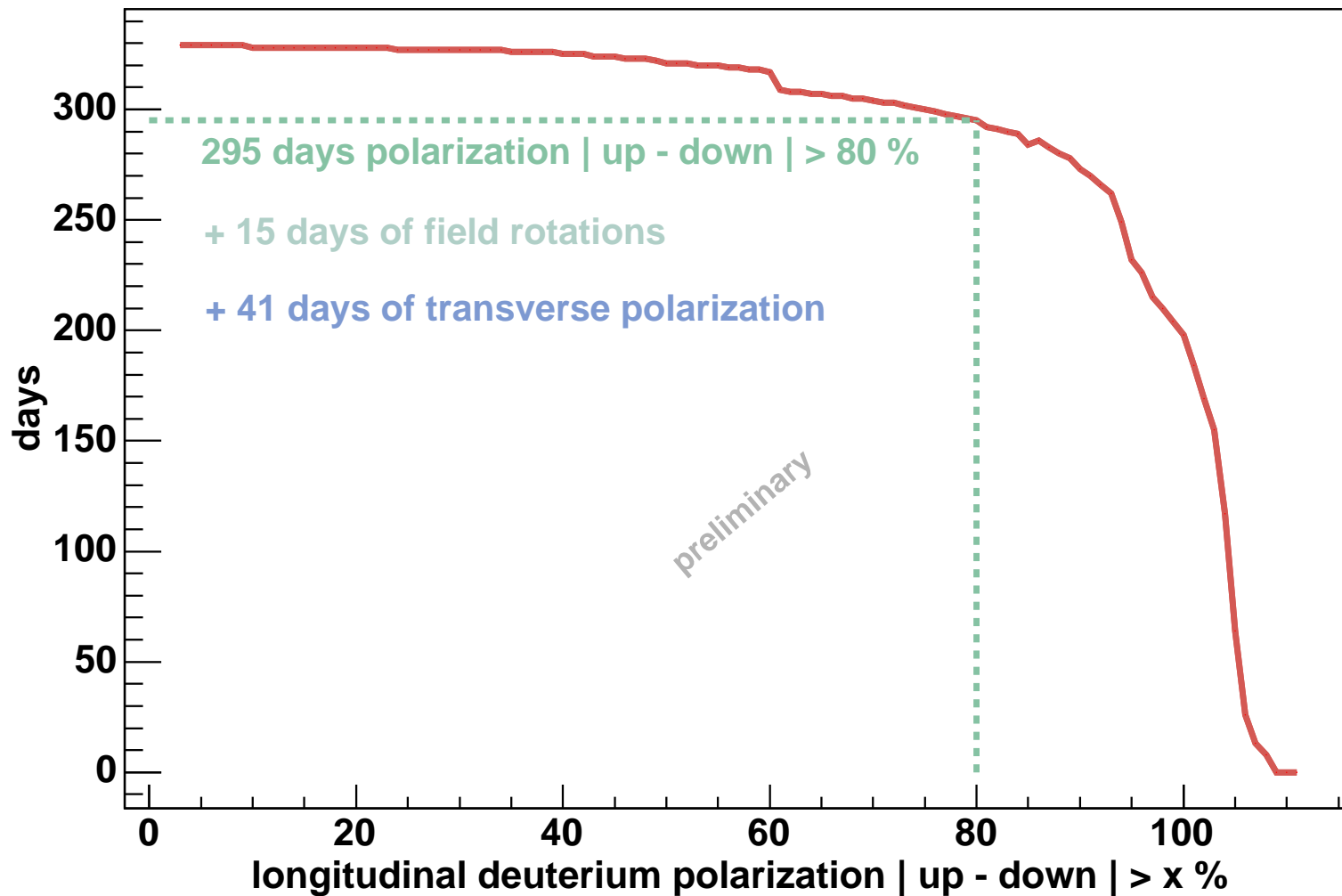
# Polarization 2001



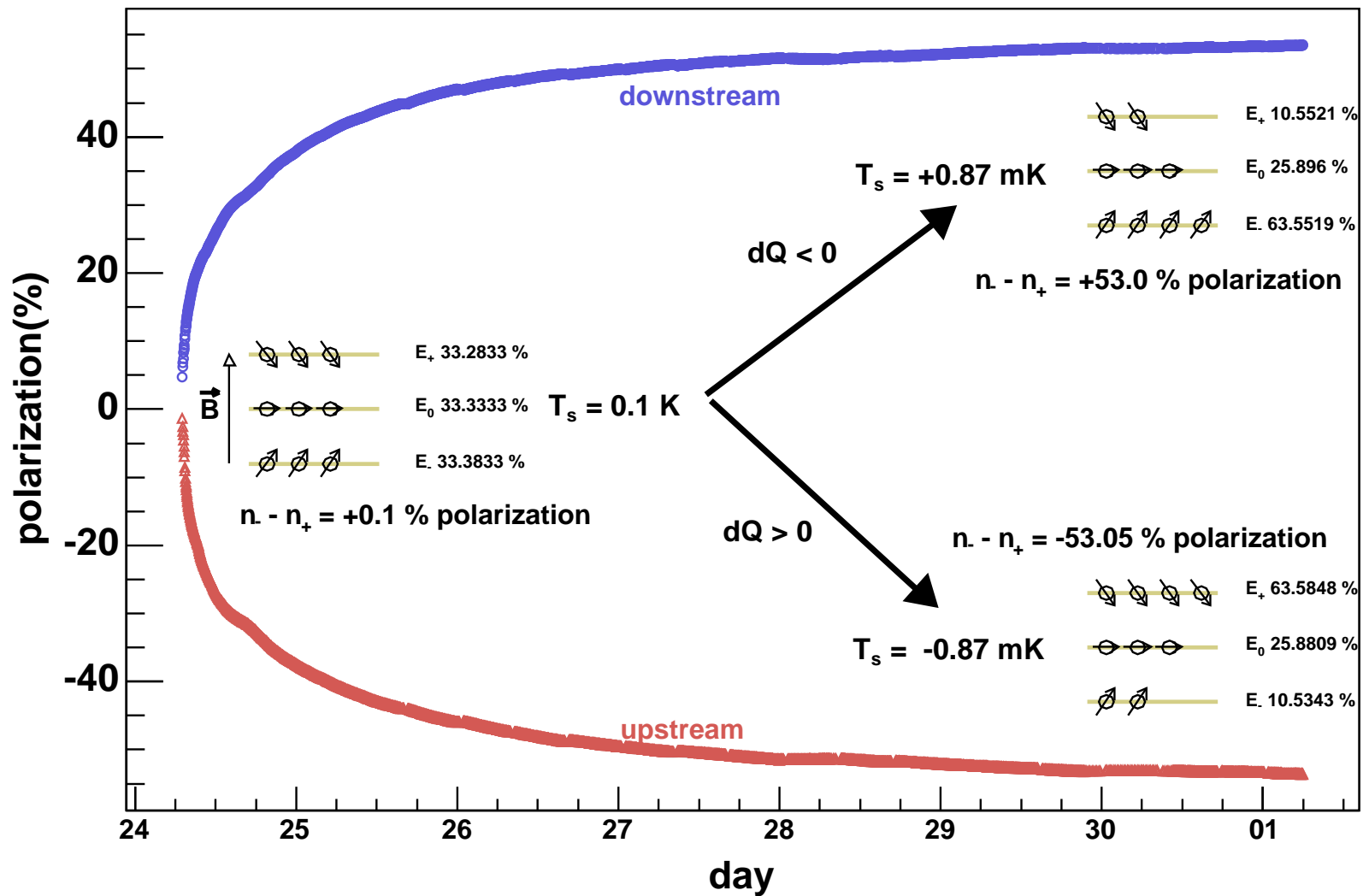
# Polarization 2004



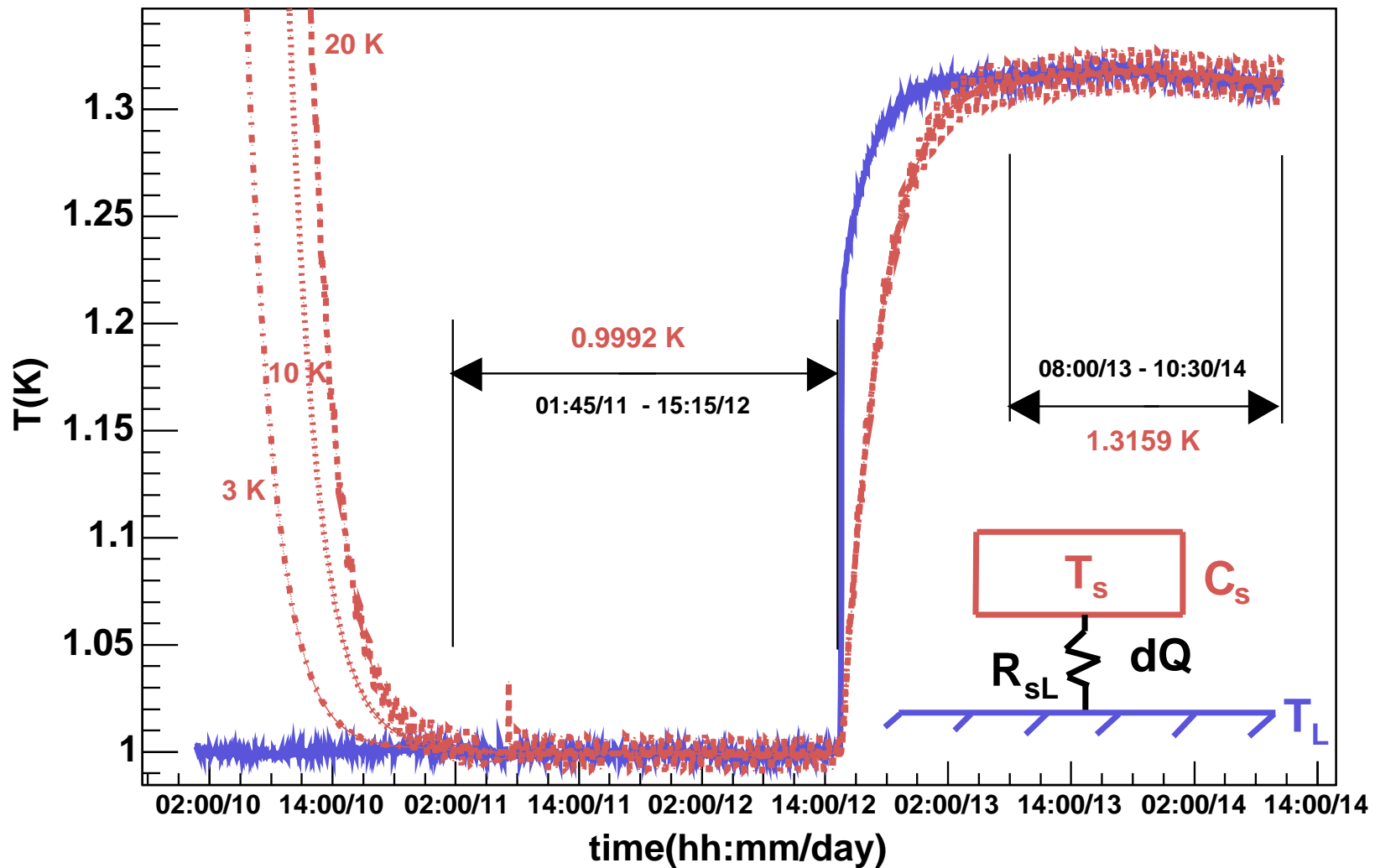
# <sup>6</sup>LiD target availability 2001 - 2004



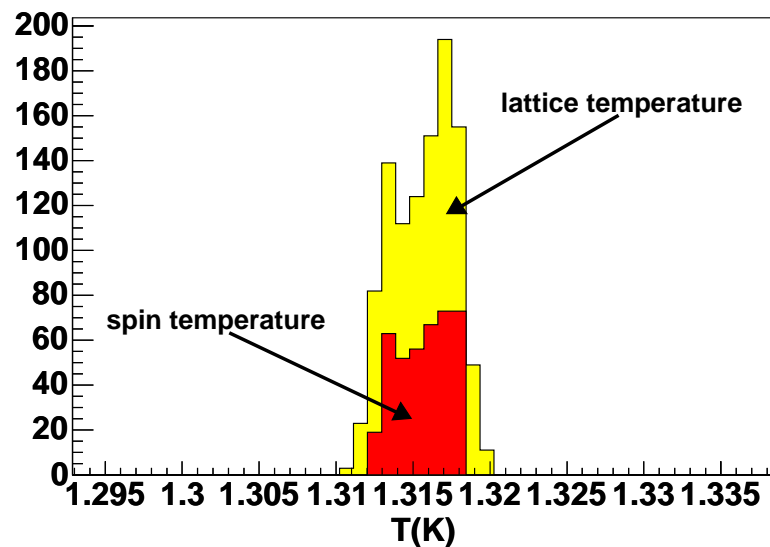
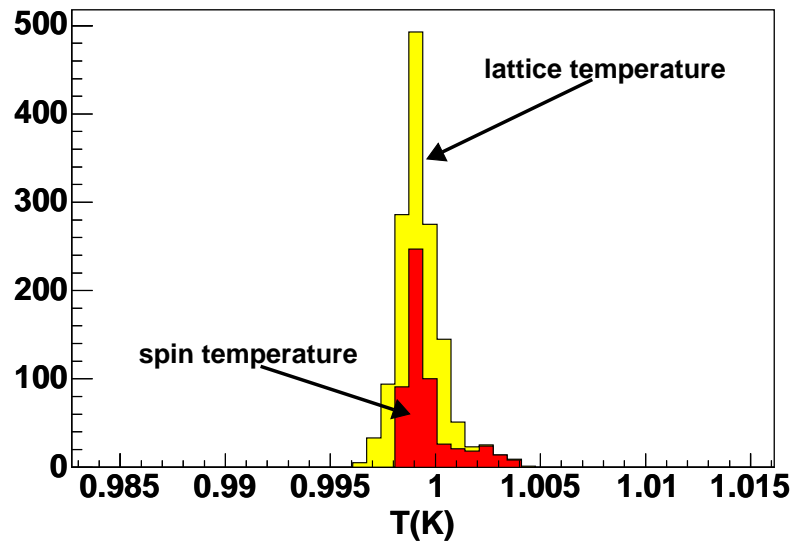
# Spin 1 level populations



# Thermal equilibrium temperature

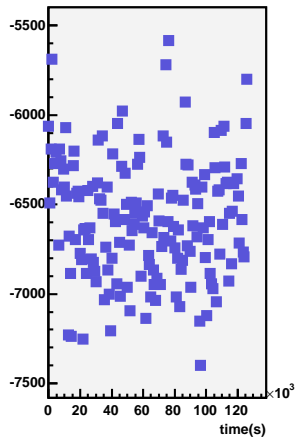


# Thermal equilibrium temperature

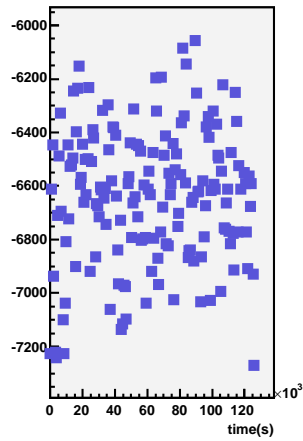


# Thermal equilibrium areas

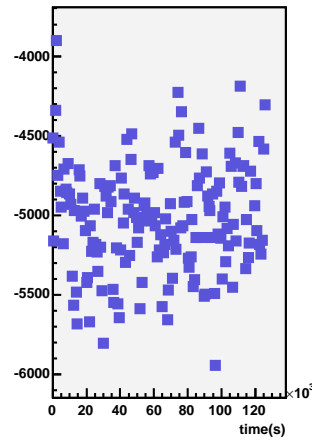
Graph



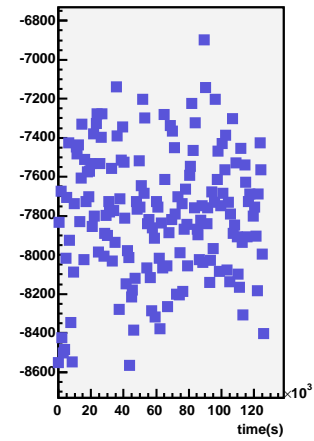
Graph



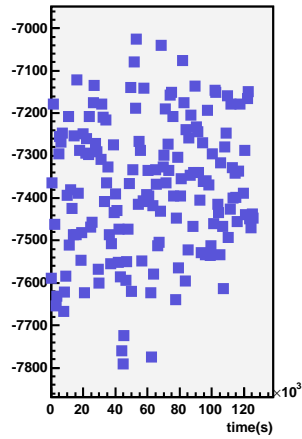
Graph



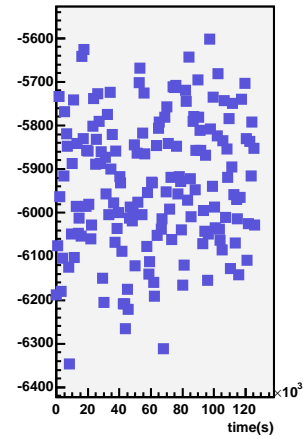
Graph



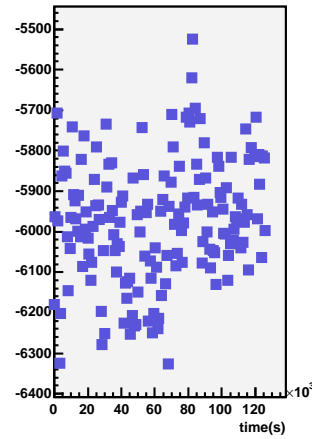
Graph



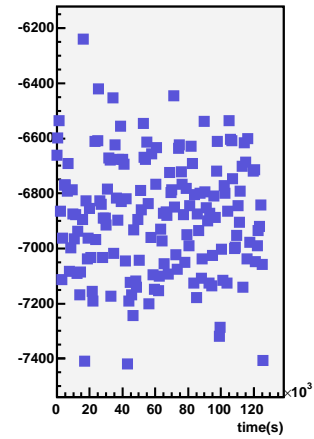
Graph



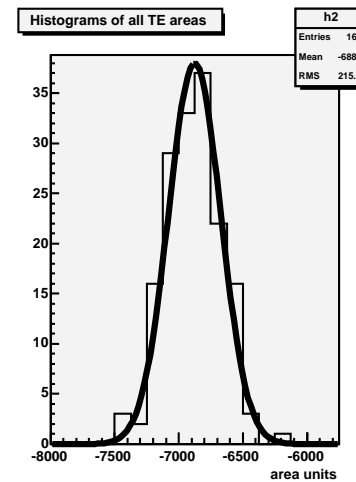
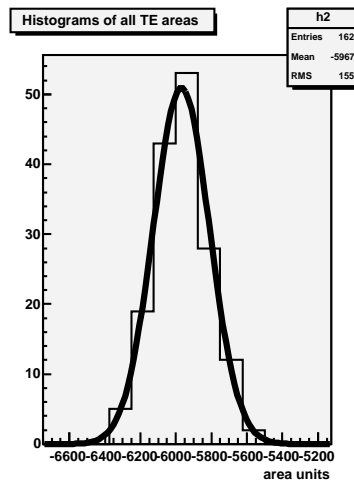
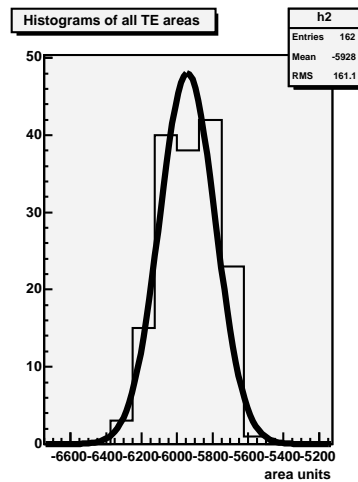
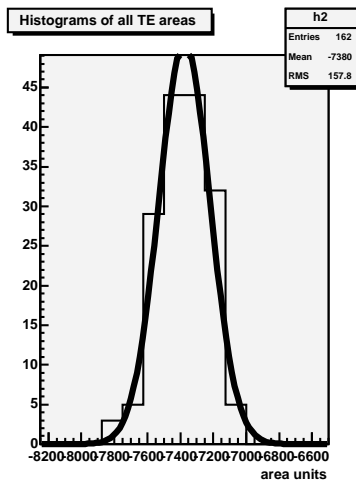
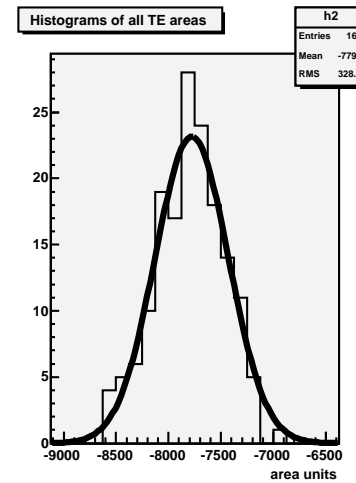
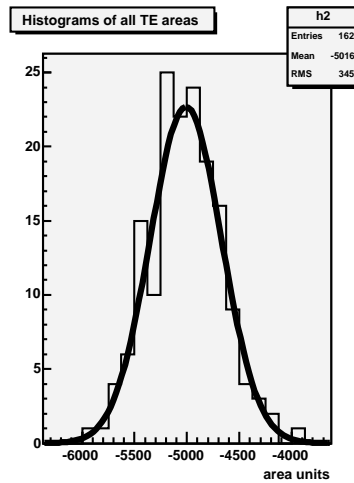
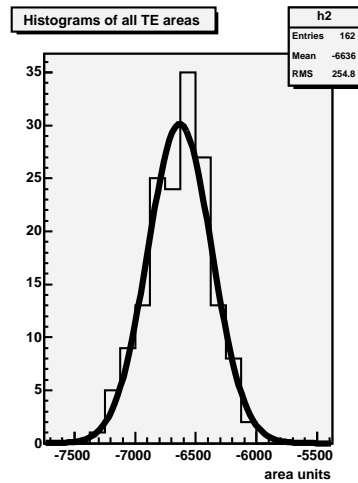
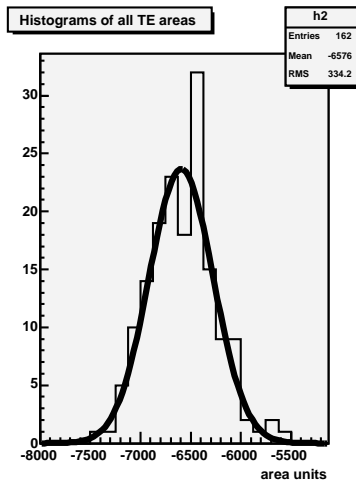
Graph



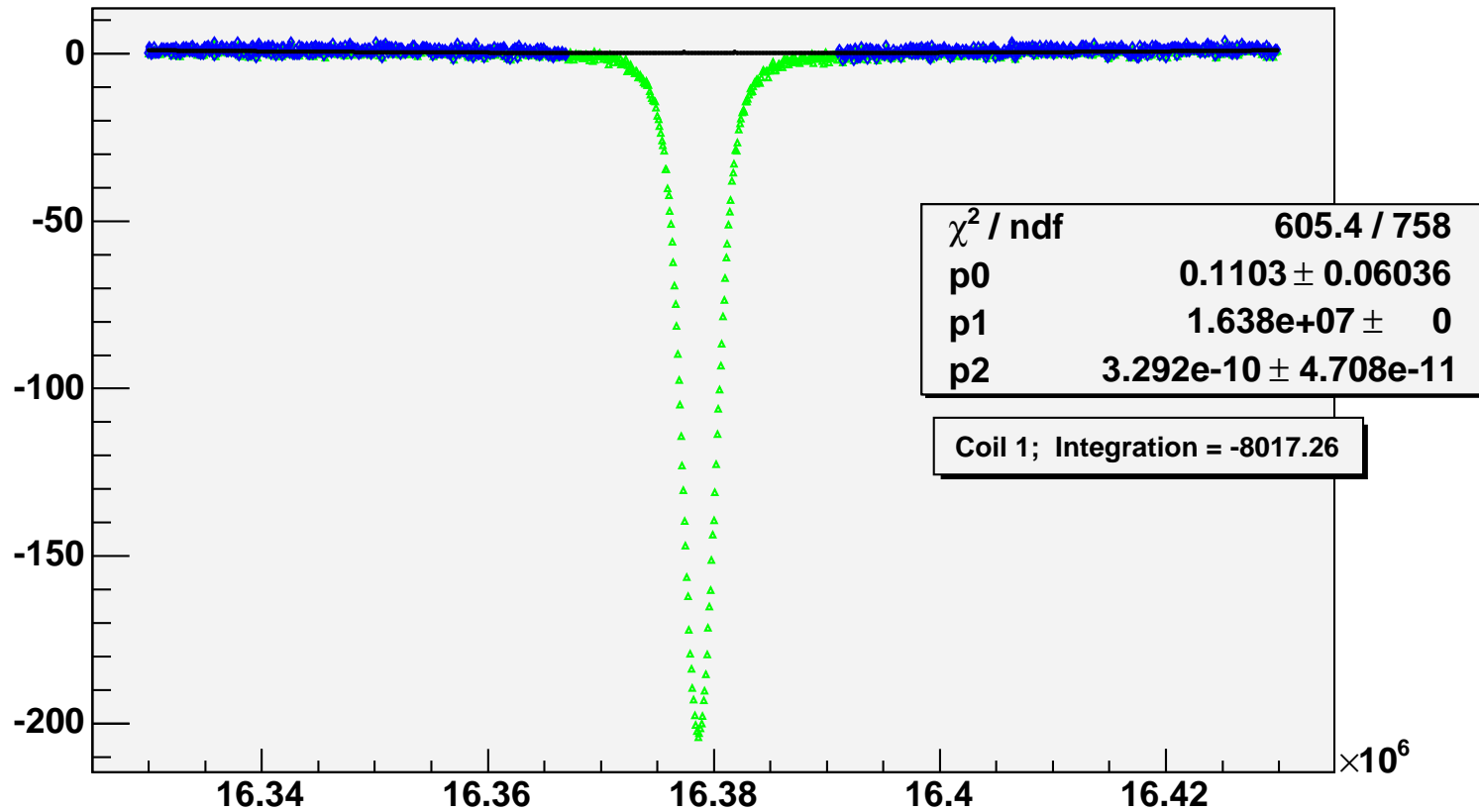
Graph



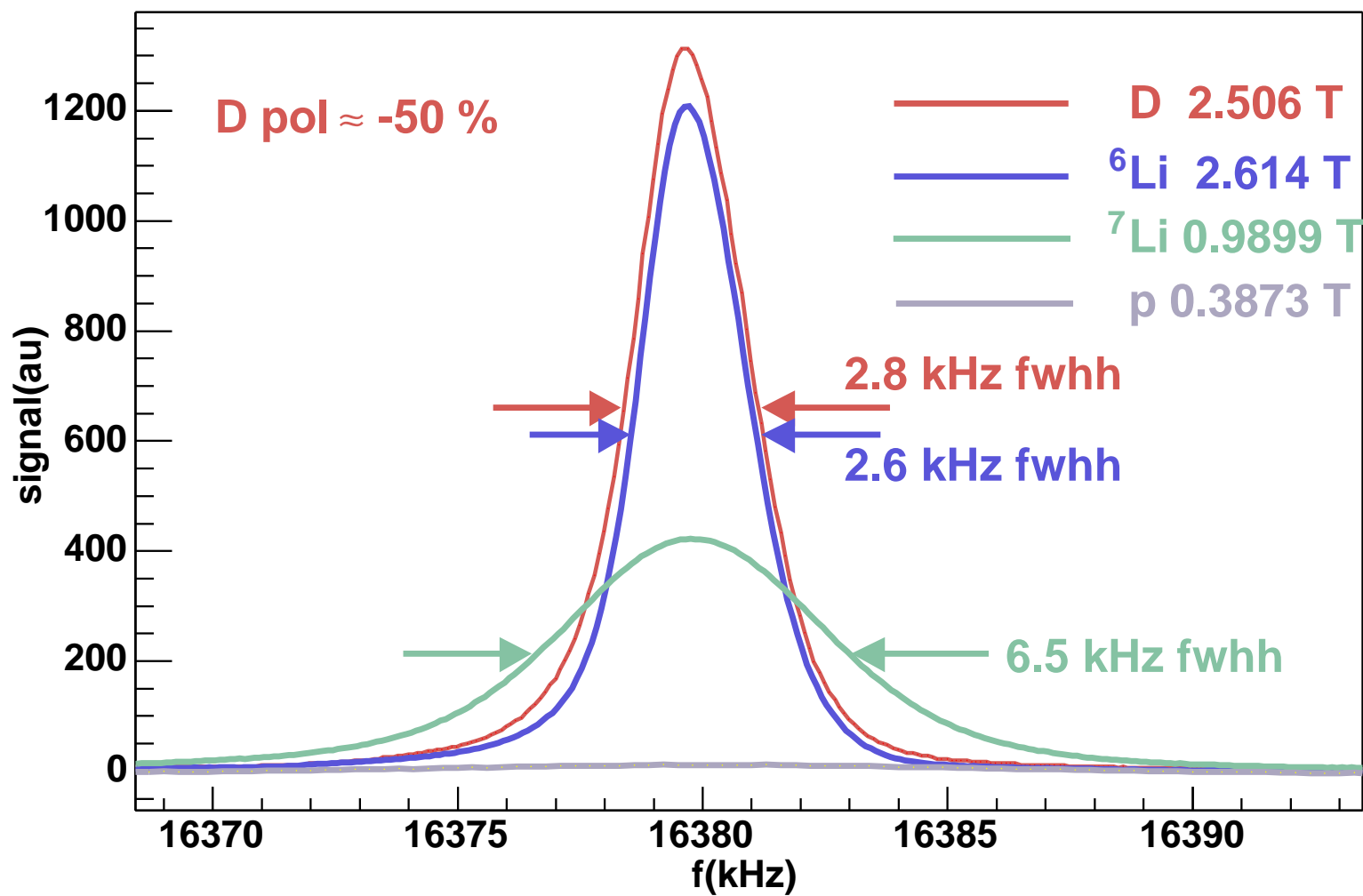
# Thermal equilibrium areas



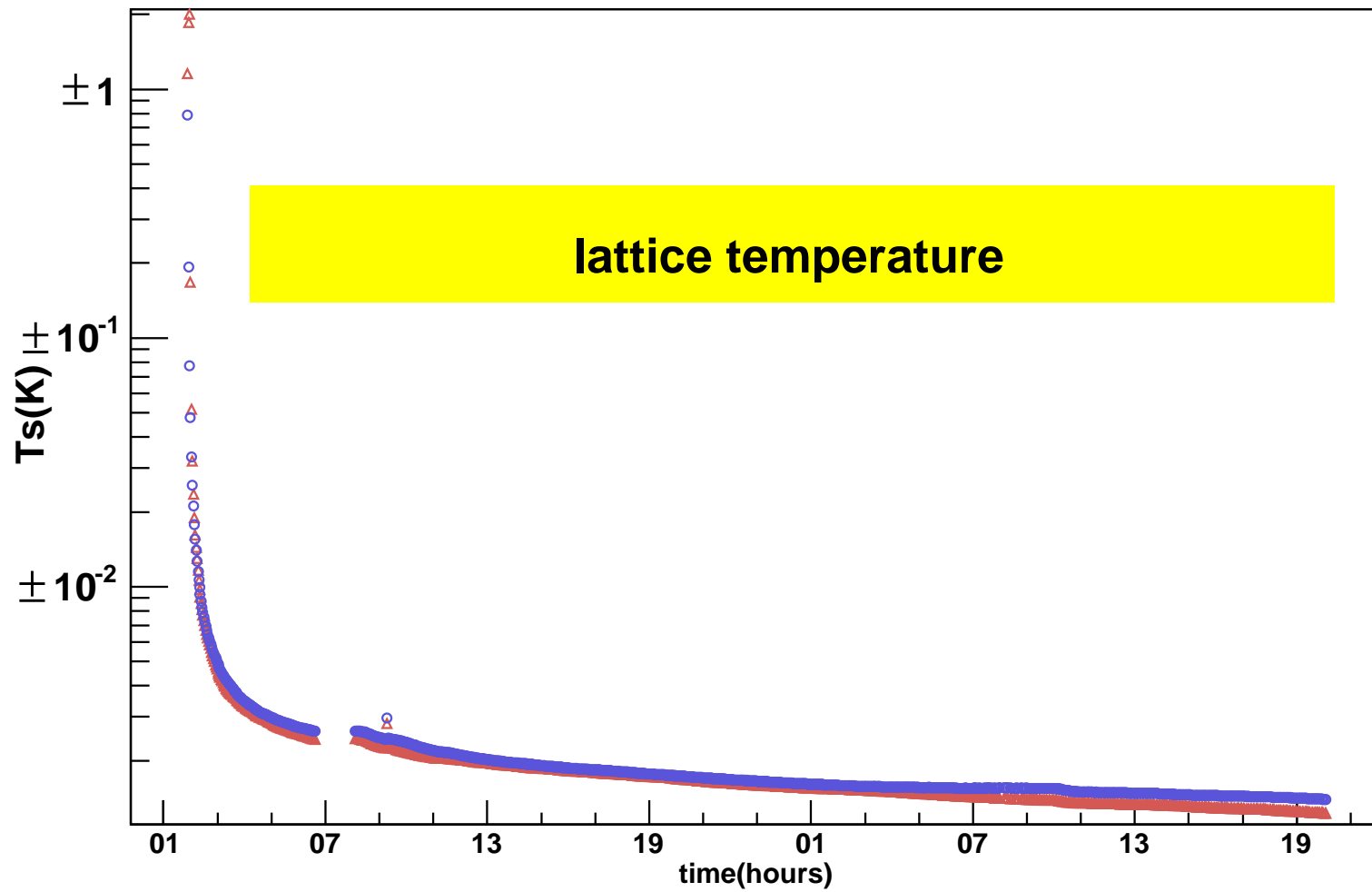
# Super TE-signal 2004



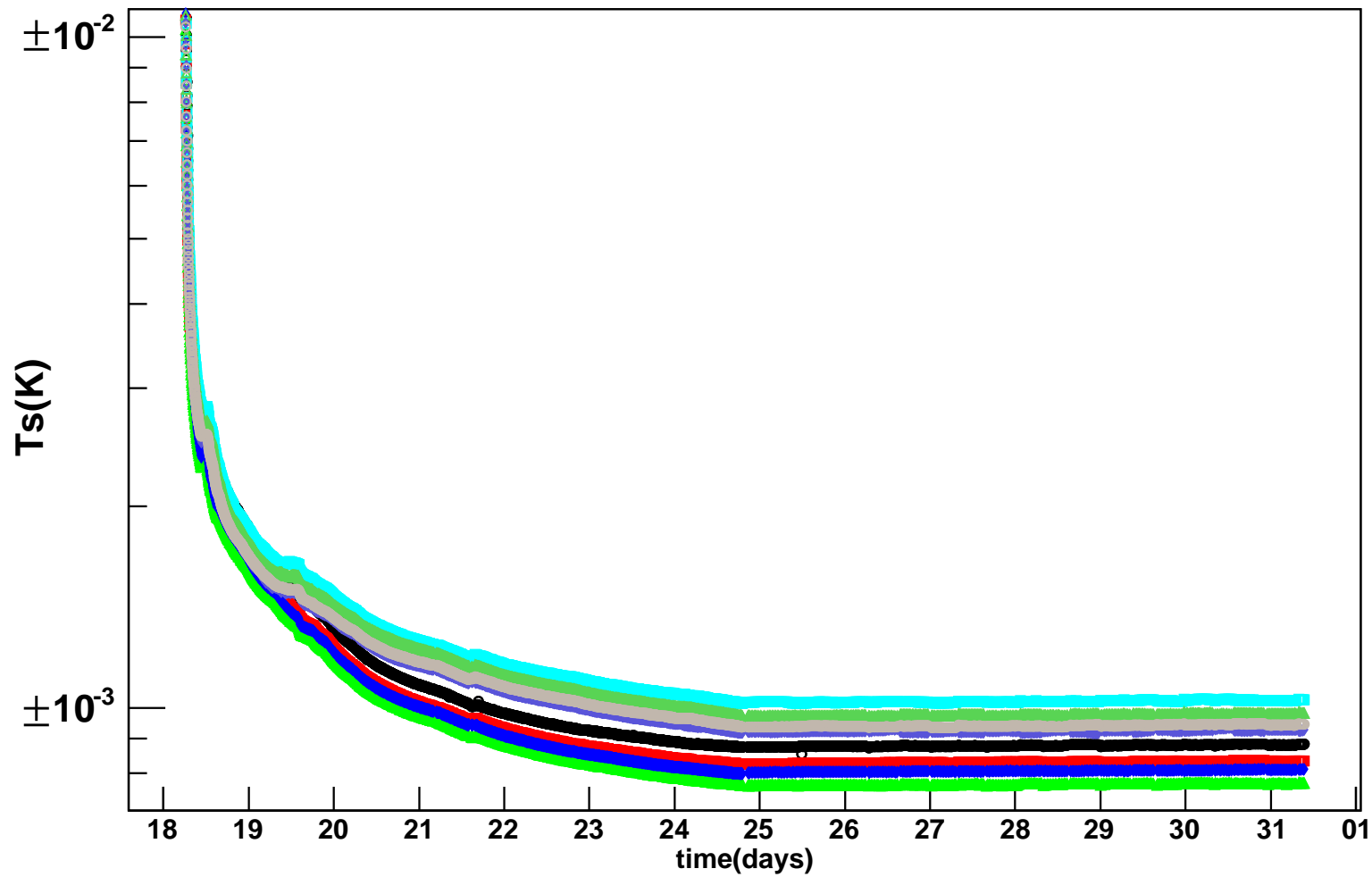
# Enhanced NMR signals 2003



# Average nuclear spin temperature



# Spin temperature seen by coils



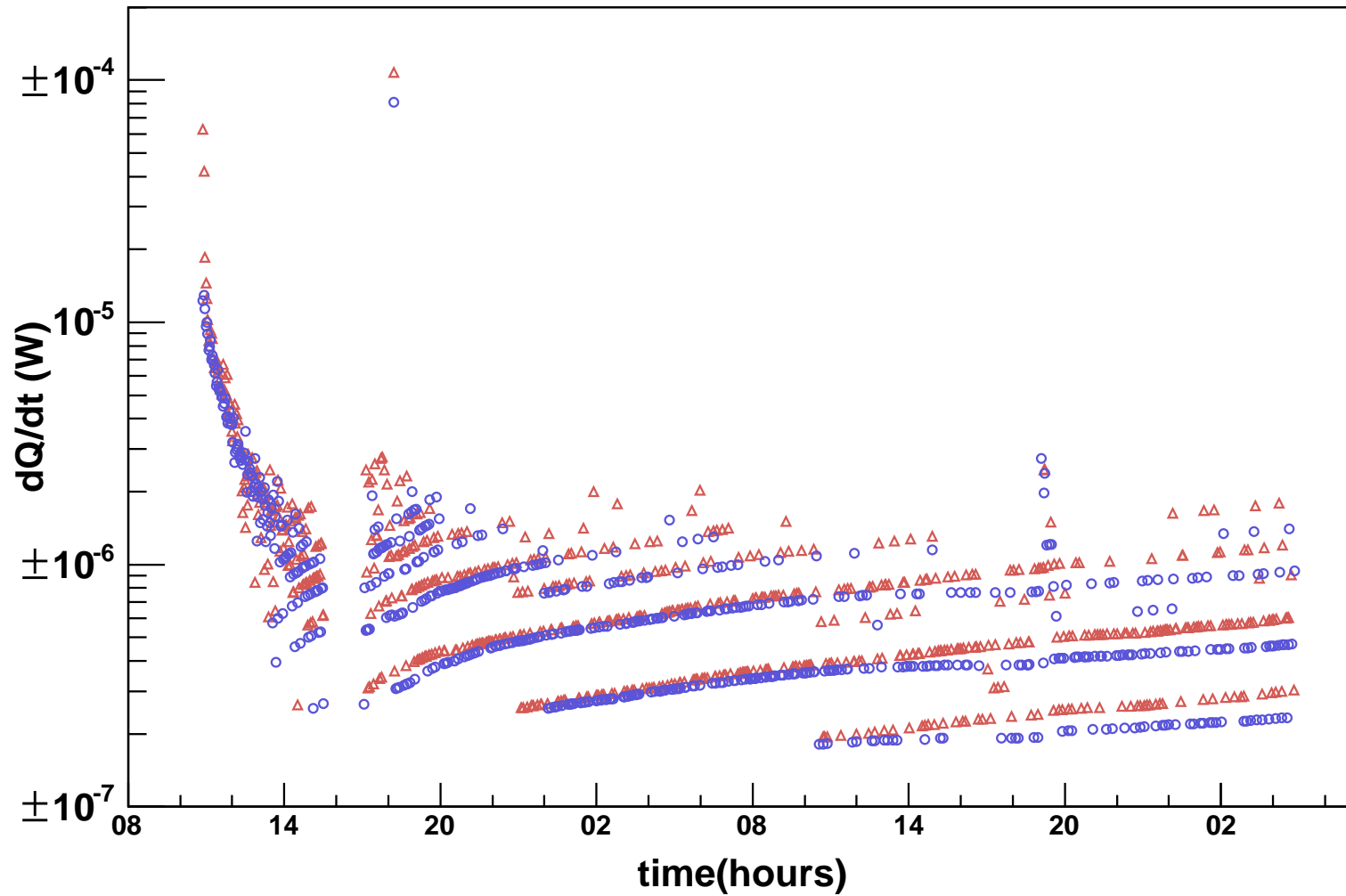
# Nuclear spin heat capacity

$$C_s = \frac{1}{3}k_B N_0 J(J+1) \left(\frac{hf}{k_B T_s}\right)^2 (\text{J/mol} \cdot \text{K})$$

when  $hf \ll k_B |T_s|$ , problems when  $|T_s| \lesssim 0.8 \text{ mK}$

For one small  $2 \text{ mm} \times 3 \text{ mm} \times 4 \text{ mm}$   ${}^6\text{LiD}$  crystal  $\sim 4 \cdot 10^{-19} \text{ J K}/T_s^2$

# Nuclear cooling power



# Kapitza resistance to LHe

$$R_K = \frac{15\hbar^3 \rho_s v_s^3}{2\pi^2 k_B^4 T_L^3 A \rho_{He} v_{He}}$$

For one small 2 mm × 3 mm × 4 mm <sup>6</sup>LiD crystal  $\sim 2 \cdot 10^3 \frac{\text{K}^4}{T_L^3 \text{W}}$

Cooling power for one crystal  $\sim 1 \mu\text{W} / 10^4 \sim 0.1 \text{ nW}$

$$\Delta T = R_K \cdot \frac{dQ}{dt} \sim 0.2 \text{ mK for } T_L \sim 100 \text{ mK}$$

# Electron-phonon thermalization

phonon-phonon scattering time

$$\tau = \frac{3\kappa V_m}{C_{ph} v_s^2}$$

$$\sim 2.4 \cdot 10^{-7} \frac{\text{s} \cdot \text{K}^3}{T_L^3} \sim 10^{-5} \text{s} - 3 \cdot 10^{-4} \text{s}$$

$$\text{electron spin flip rate} \sim \frac{dQ/dt}{hf_e N_e} \sim 3 \cdot 10^4 - 3 \cdot 10^5 \text{ 1/s}$$

# Spin lattice coupling model

