

# Pulsed Polarized Neutron Instrumentation/Technology for Reflectometry at SNS

ORNL Users Week 2007

*Reflectometry Tutorial*



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DAS & Controls Group



# Using Spallation Pulsed Polarized Neutrons (in Reflectometry)

Shielding

Polarizer

Detector

Sample

Analyzer

Target,  
Reflector,  
Moderator,  
Guides and  
Choppers

**Cross  
Section  
measured:  
++**

Counting  
TOF

Extraction

DAS

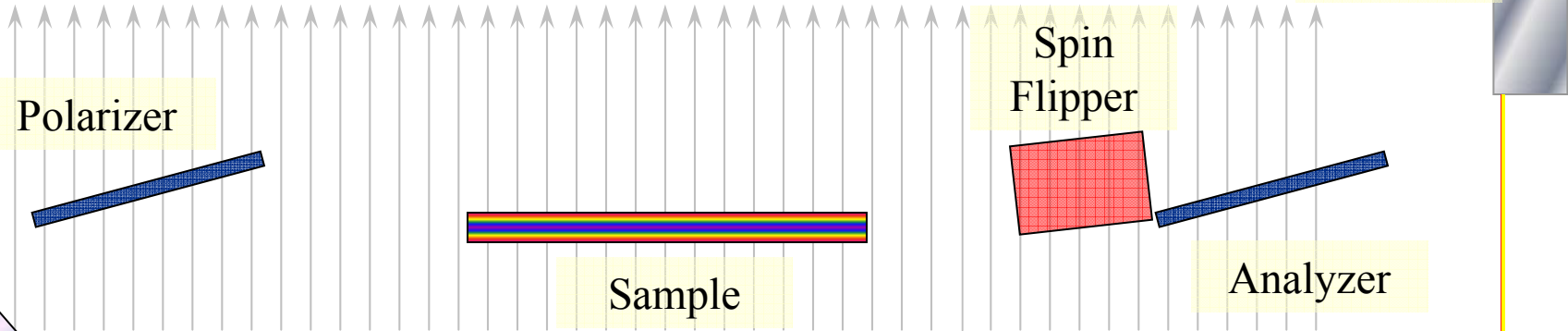


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Shielding



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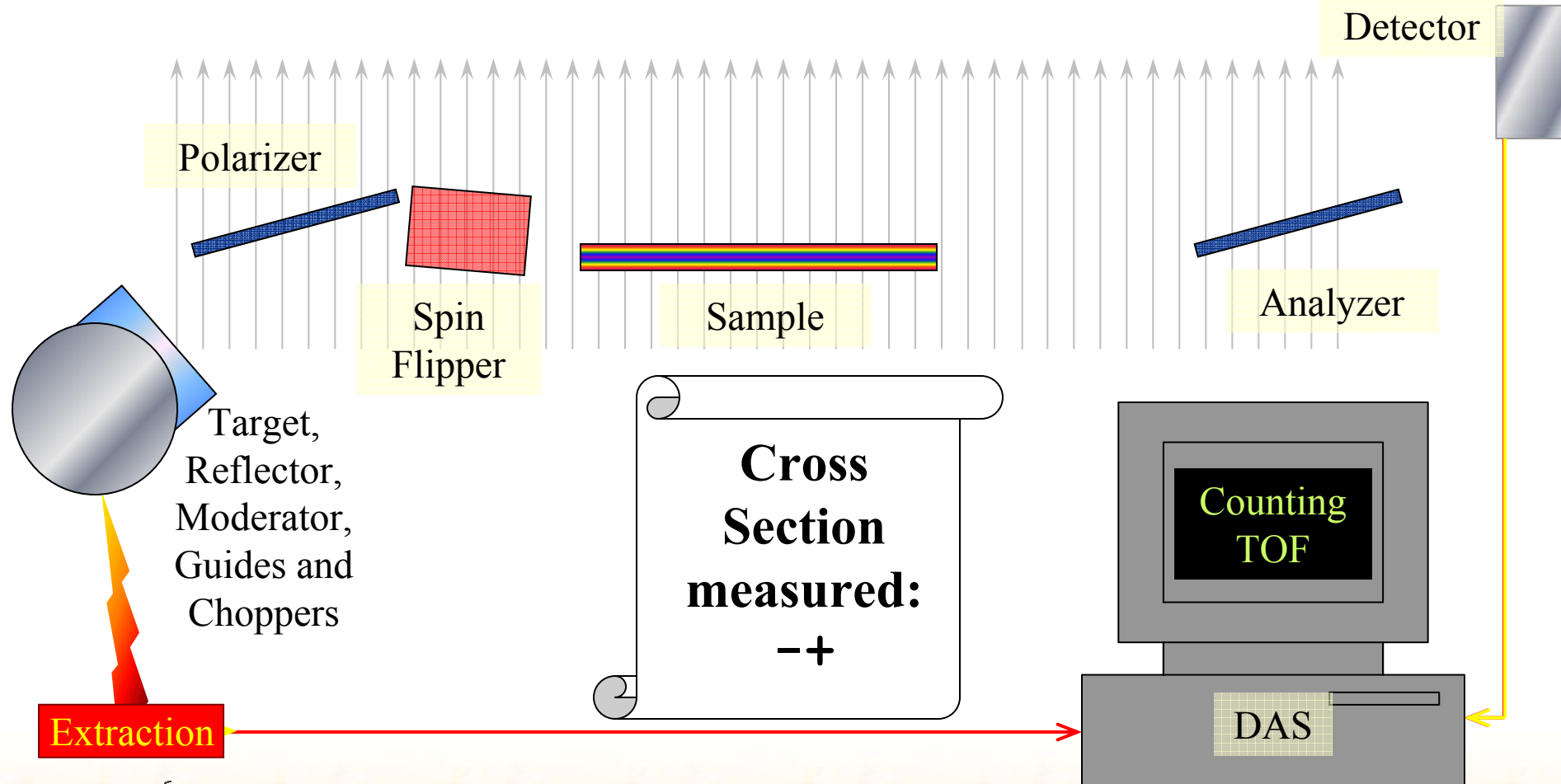


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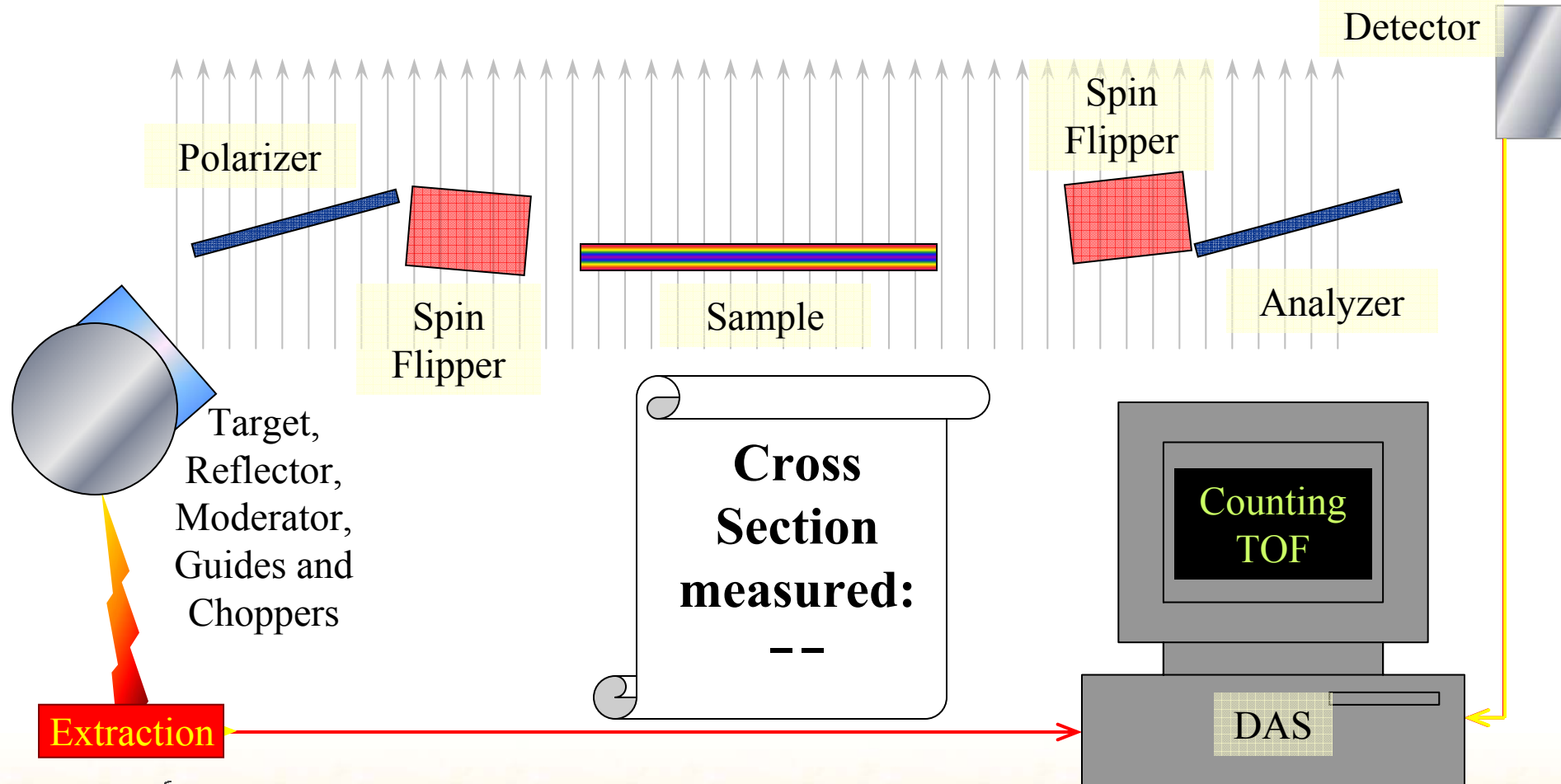
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Shielding



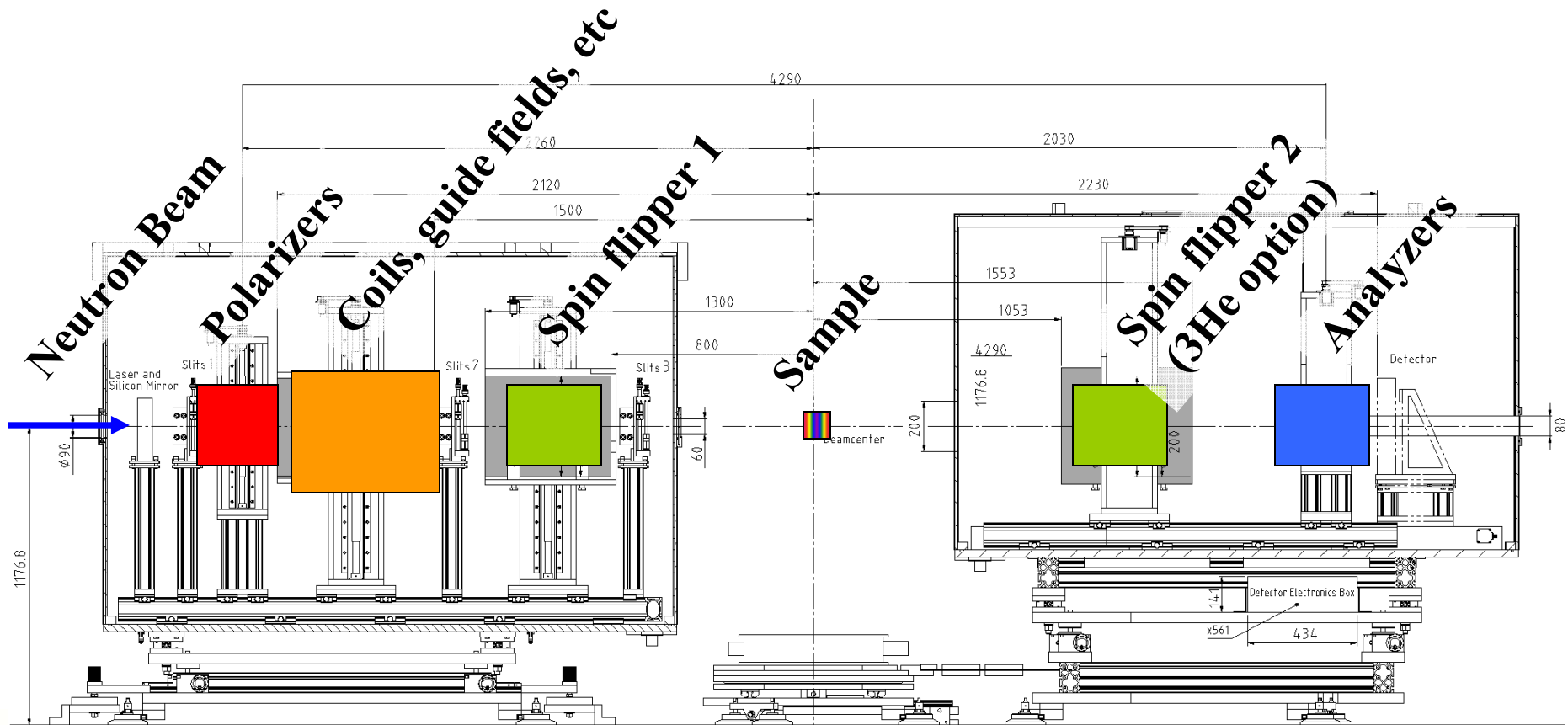
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Shielding

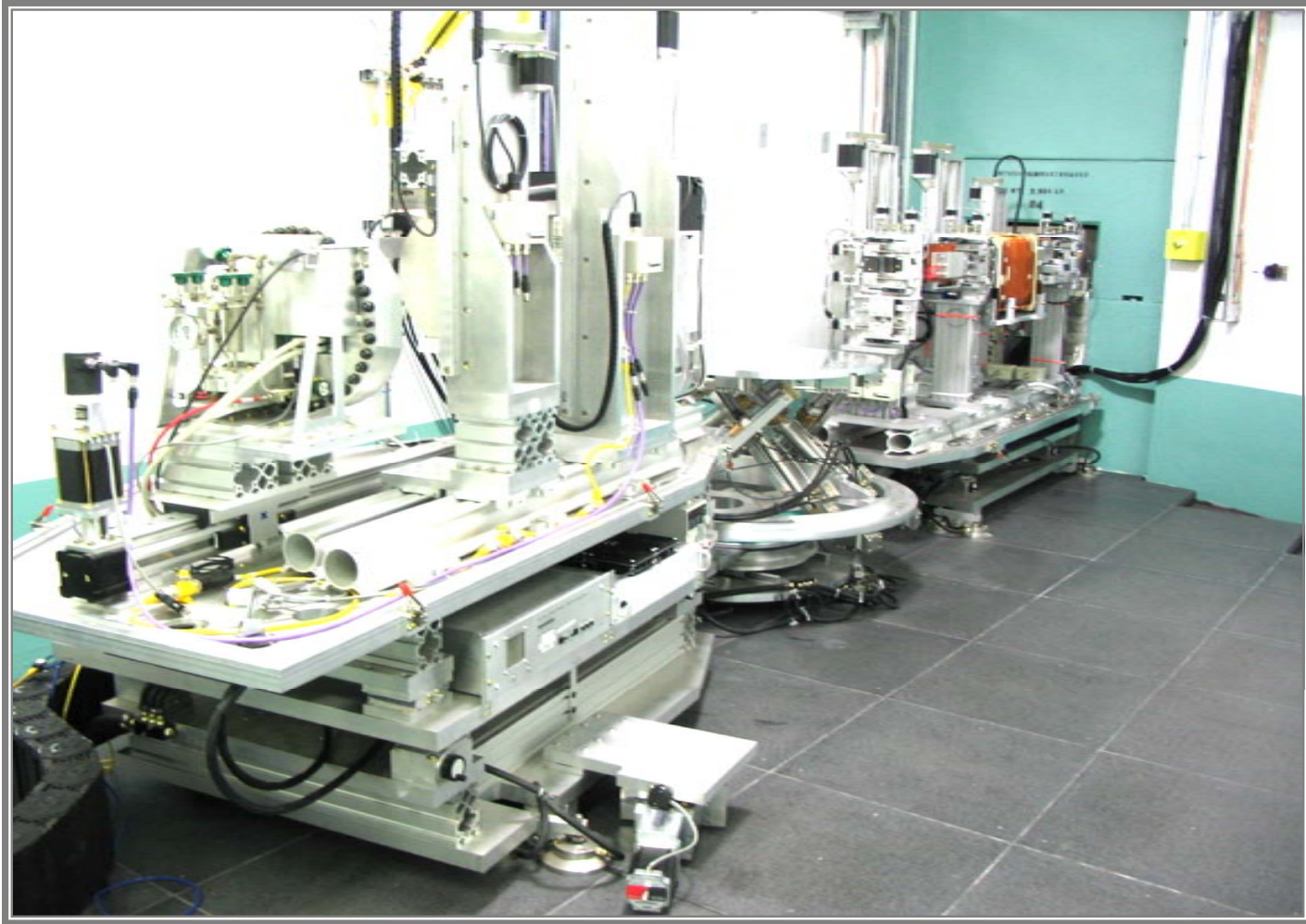




# Polarized Neutron Technology: The Magnetism Reflectometer at SNS



# Polarized Neutron Technology: The Magnetism Reflectometer at SNS



# Polarized Neutron Technology: Polarizers and Analyzers at the SNS Magnetism Reflectometer





# Polarized Neutron Technology: Polarizers and Analyzers

- **Select a particular neutron spin state (or, equivalently, a particular direction for the neutron magnetic moment)**
- Magnetic supermirrors (beam divergence and width limitation, but in general useful for reflectometry). Special configurations (polarizing guides, cavities, benders, etc) can overcome the beam size limitations.
- Magnetized crystals (generally not appropriate for pulsed sources)
- Spin filters

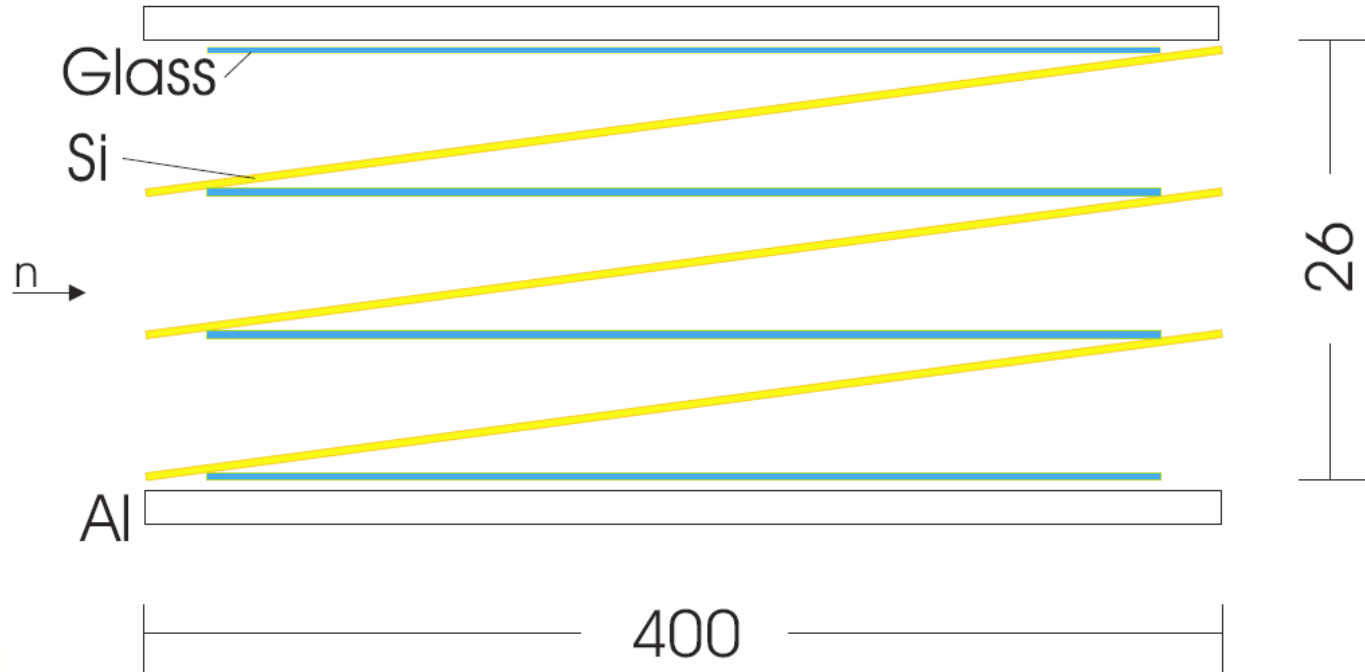


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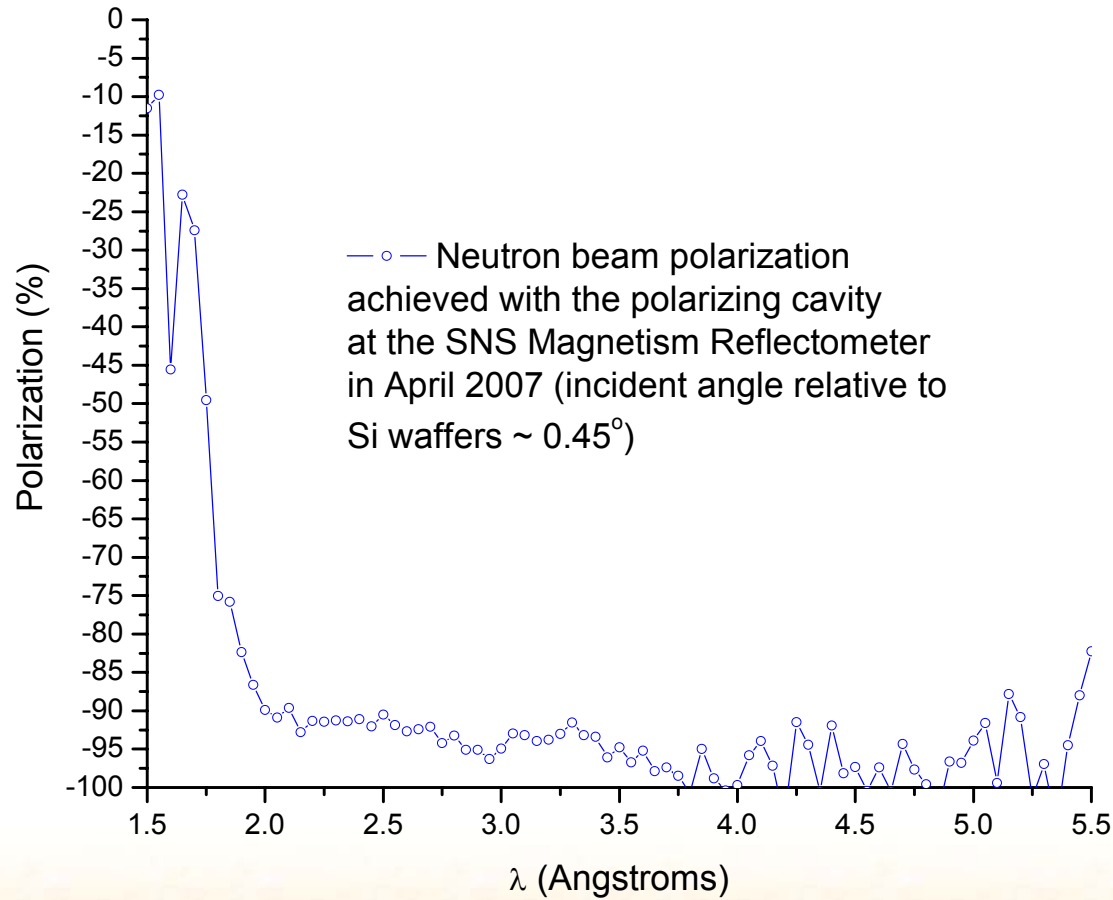
# Polarized Neutron Technology: Polarizers and Analyzers

- The polarizing cavity (for long  $\lambda > 4.85 \text{ \AA}$ )
- $m = 2.5$  coatings
- Works in transmission



# Polarized Neutron Technology: Polarizers and Analyzers

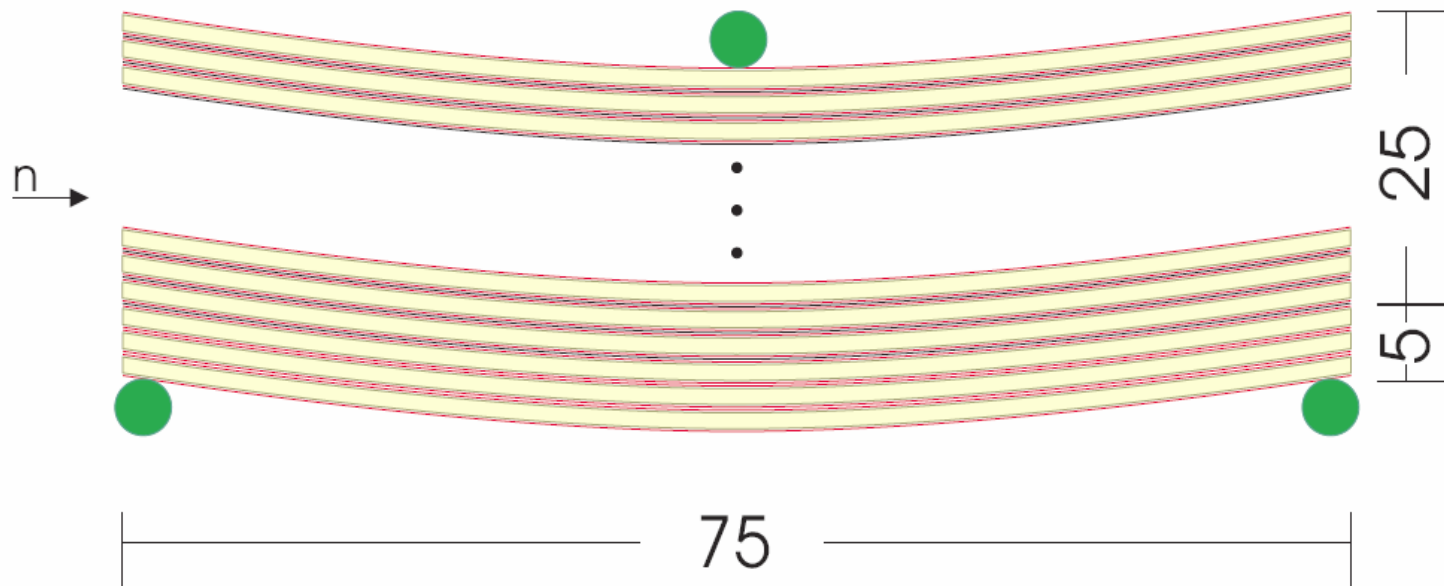
- The polarizing cavity (for long wavelength neutrons)



# Polarized Neutron Technology: Polarizers and Analyzers

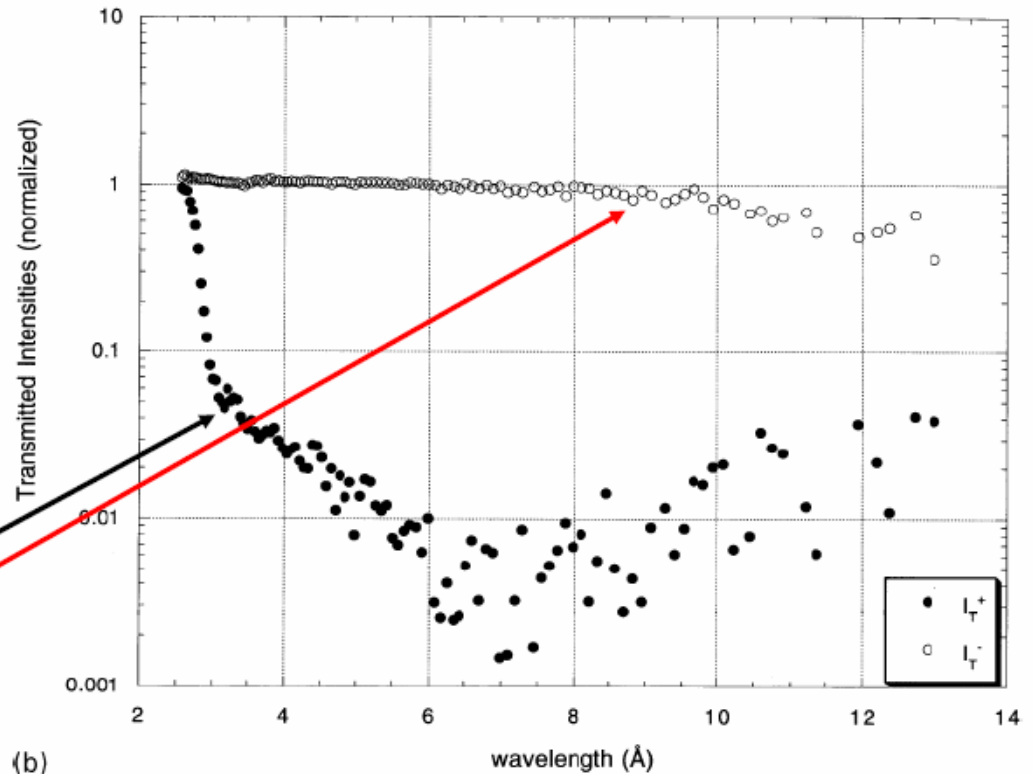
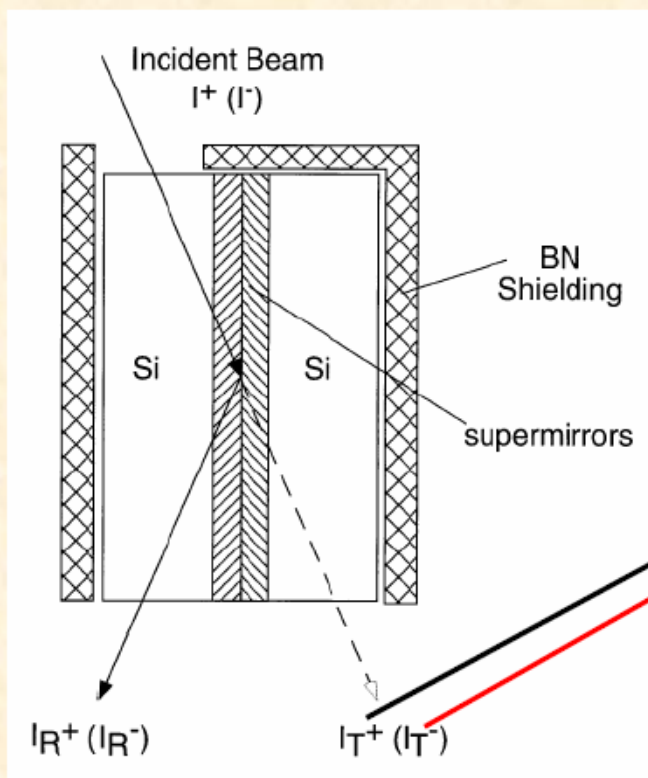
- The polarizing bender (for long wavelength neutrons)
- $M = 3$  supermirror coatings on both sides (+  $1 \mu\text{m}$  Gd on one side)

1. Bender (Short wavelength neutron spin analyser)





# Solid State Polarizer/Analyzer (Beam Splitter)

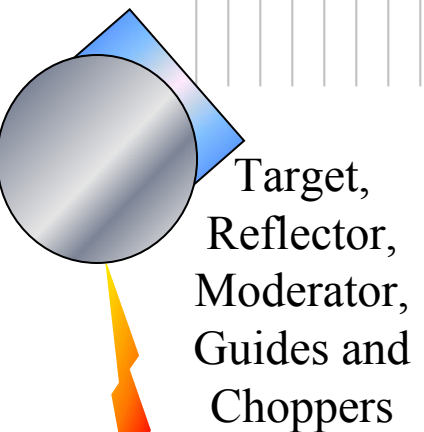
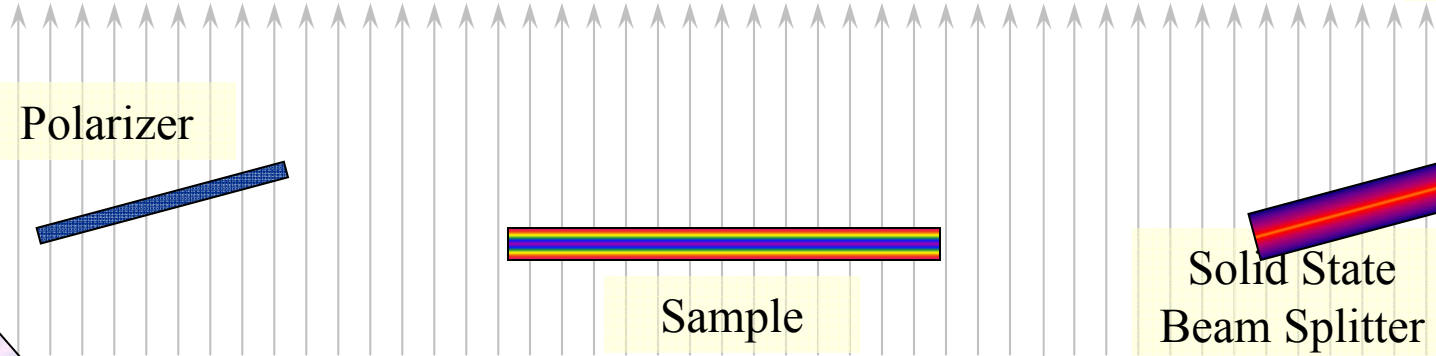


“Solid state”  $\text{Fe}_{0.89}\text{Co}_{0.11}/\text{Si}$  transmission polarizers work for arbitrary broad bandwidth (but are still limited in angular acceptance)

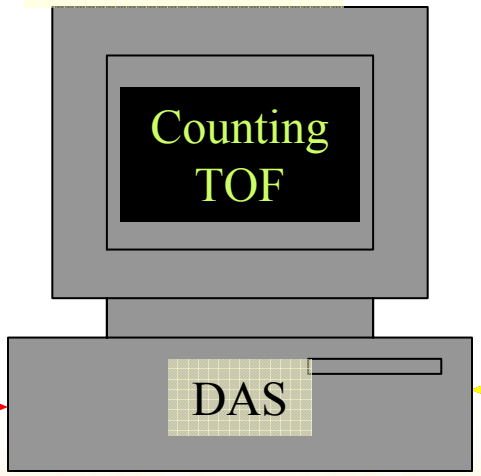
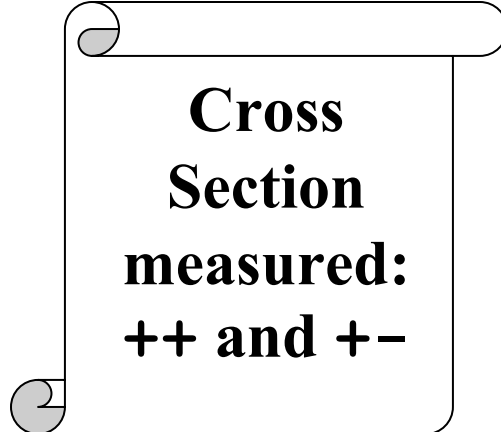
T. Krist, F. Klose, G.P. Felcher  
Physica B 248 (1998) 372-376

# Polarized Neutron Technology: Polarizers and Analyzers

Shielding



Extraction

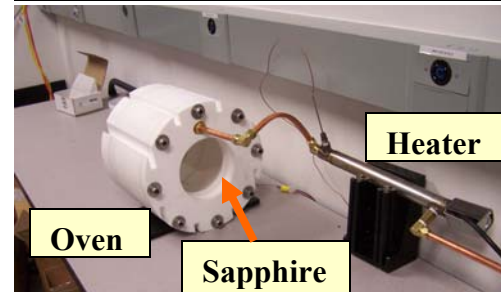
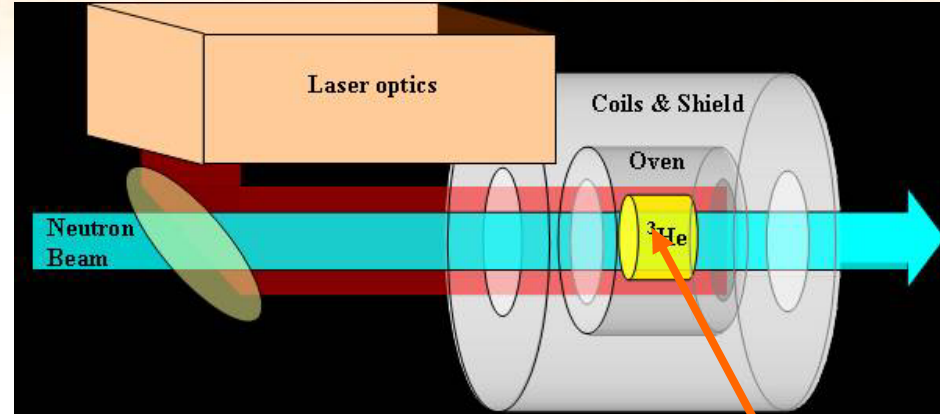


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# Wide-Angle $^3\text{He}$ Analyzer System (Hal Lee)

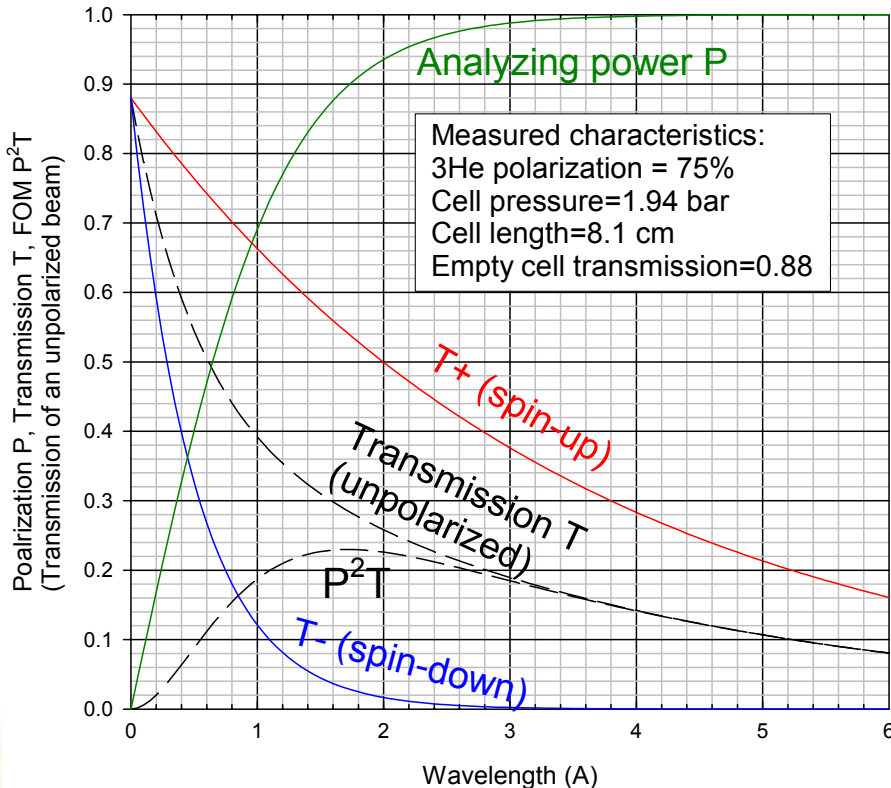
$^3\text{He}$  cell system will be continuously operated, i.e. no polarization decay



actual cell



Magnetic holding field and shielding

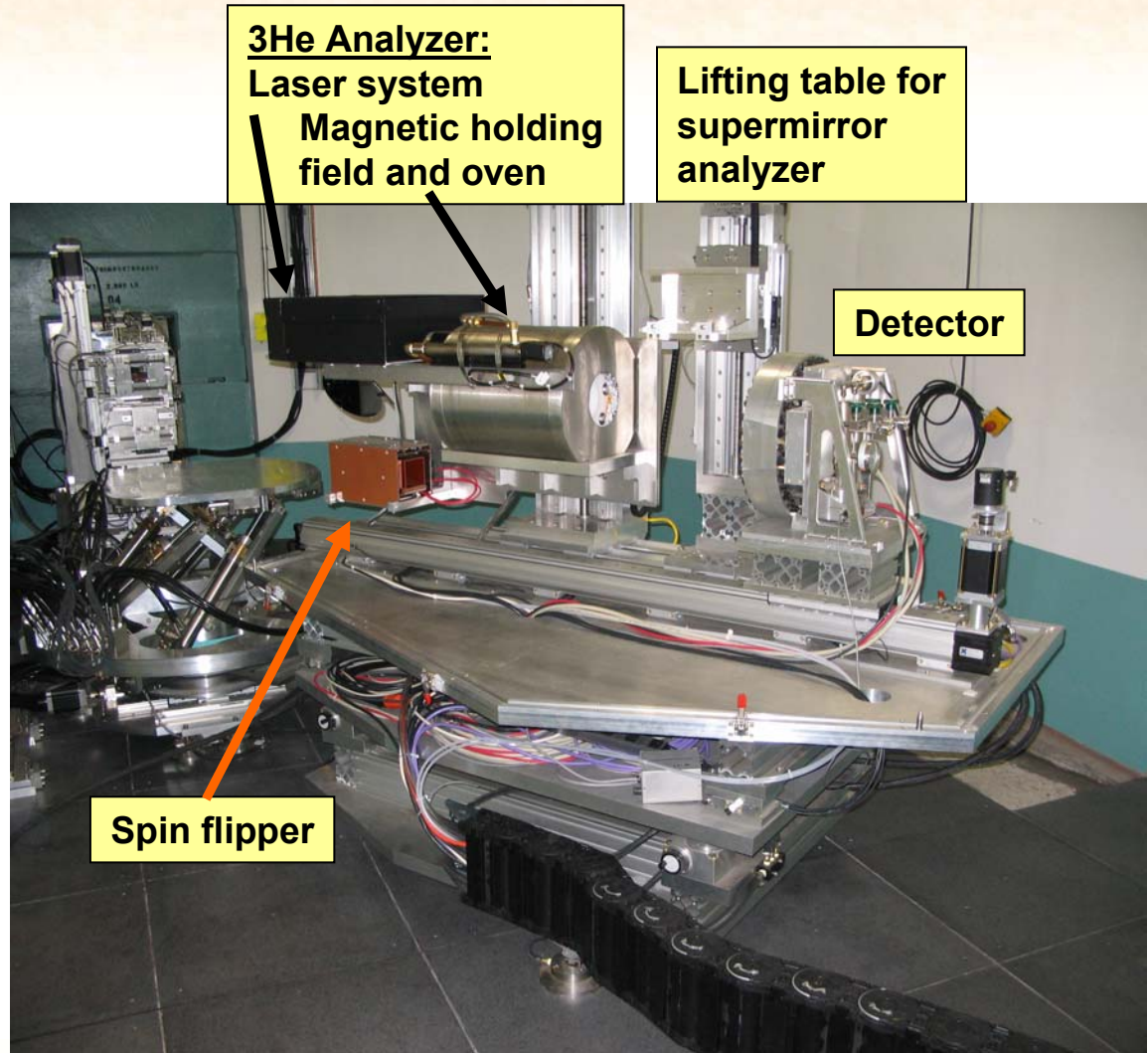
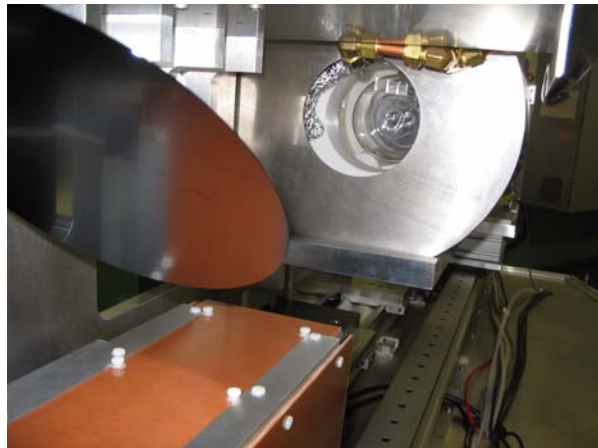


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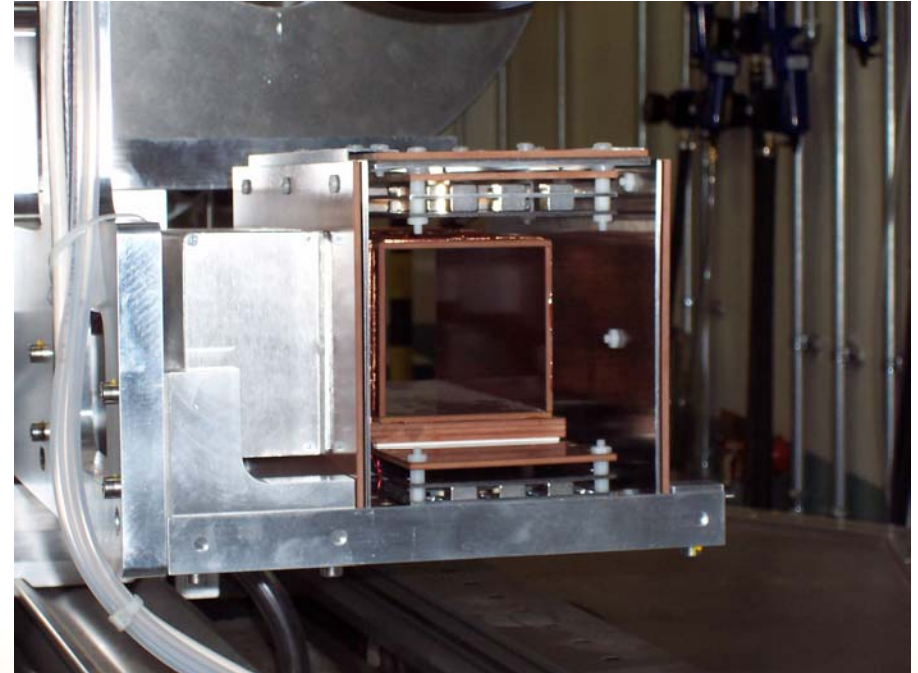
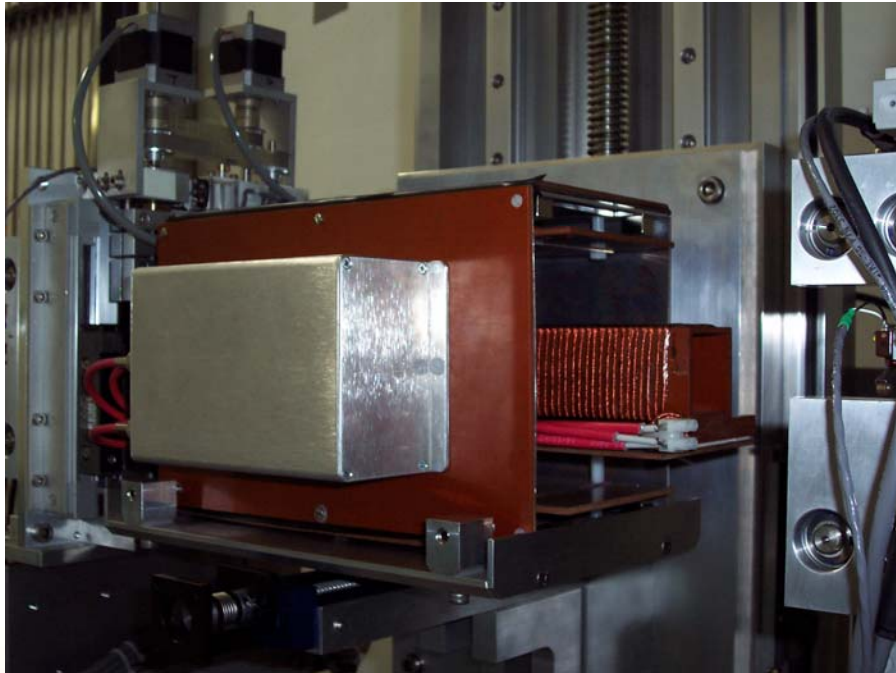
# Wide-Angle $^3\text{He}$ Analyzer System (Hal Lee)





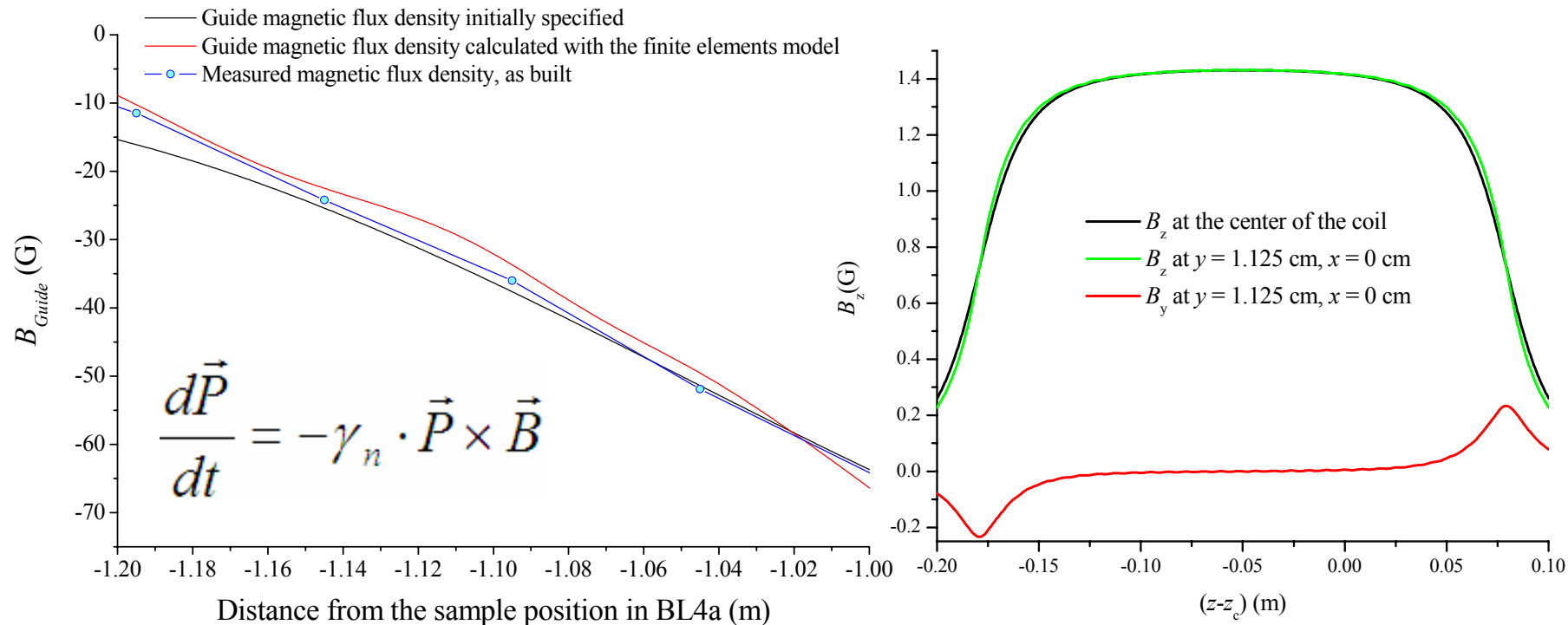
# Polarized Neutron Technology: Spin-Flippers

- In general, the adiabatic RF-gradient neutron spin flippers seem to be the most adequate to be used in pulsed sources
- The SNS-MR is equipped with RF-gradient neutron spin flippers
- Operation @ 150 kHz



# Polarized Neutron Technology: Spin-Flippers

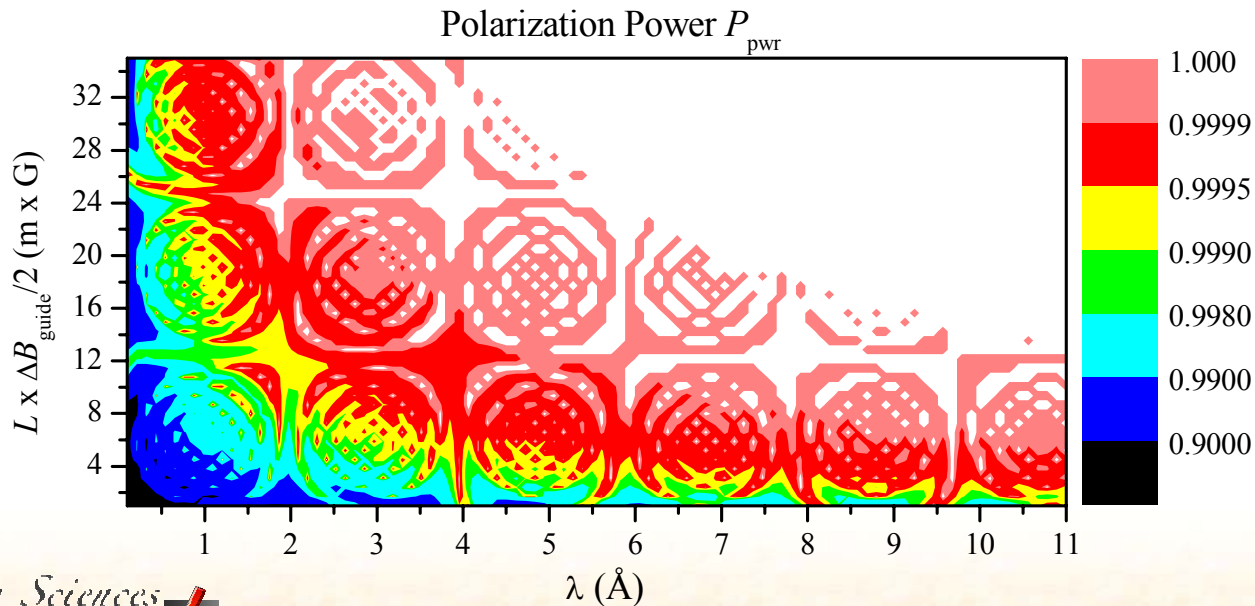
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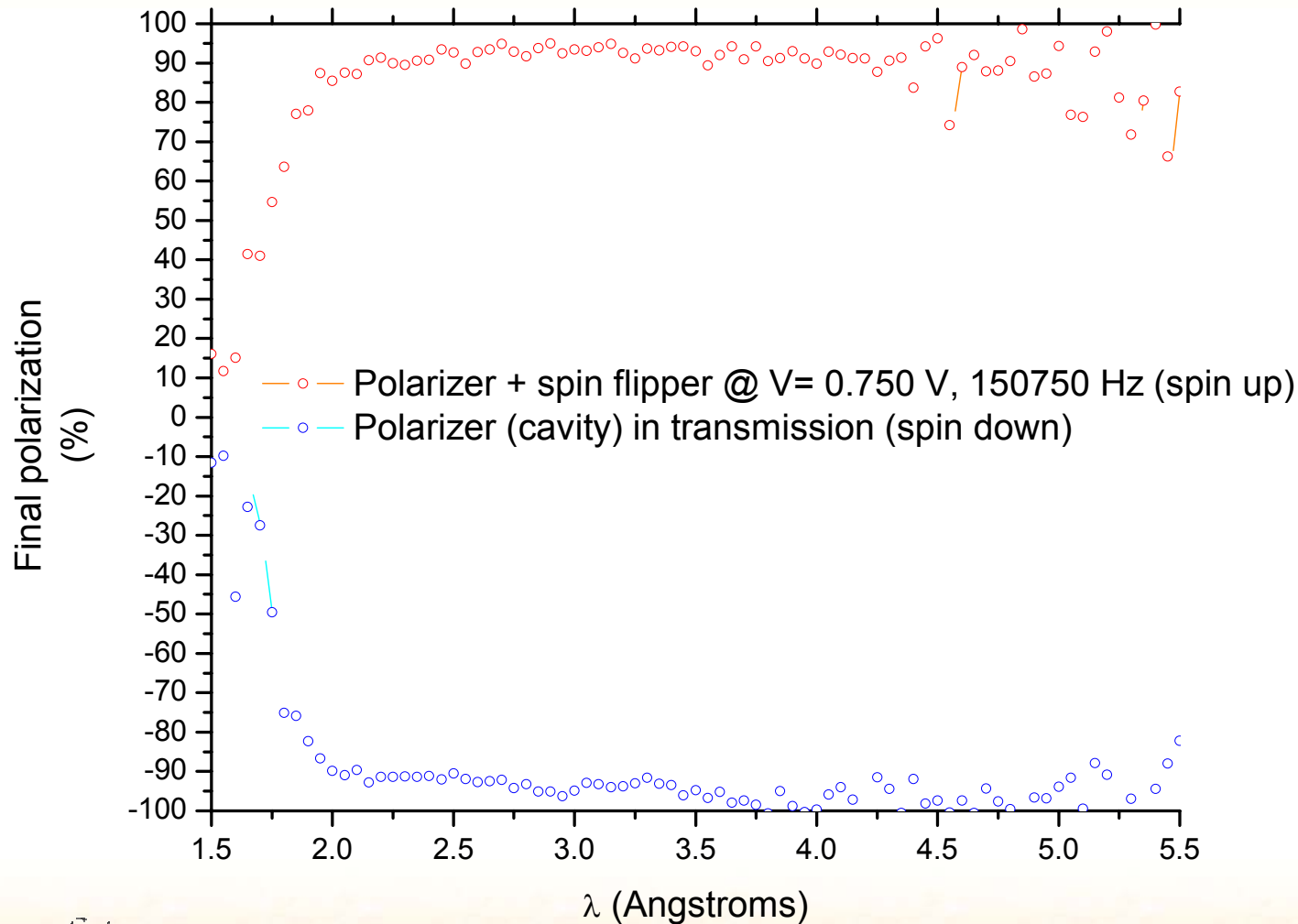
# Polarized Neutron Technology: RF-Gradient Spin-Flippers

- [1] A.N. Bazhenov et al., Nuc. Instr. and Meth. In Phys. Res. A 332 (1993) 534-536
- [2] S.V. Grigoriev et al., Nuc. Instr. and Meth. In Phys. Res. A 384 (1997) 451-456
- [3] T. Keller et al., Nuc. Instr. and Meth. In Phys. Res. A 451 (2000) 474-479

$$P_{prw} = 1 - \frac{\sin^2\left(\frac{\pi}{2} \cdot \sqrt{k^2 + 1}\right)}{k^2 + 1} \quad k \cong \gamma_n \cdot L \cdot \frac{\lambda \cdot m_n \cdot \Delta B_{guide}}{h \cdot 2 \cdot \pi}$$

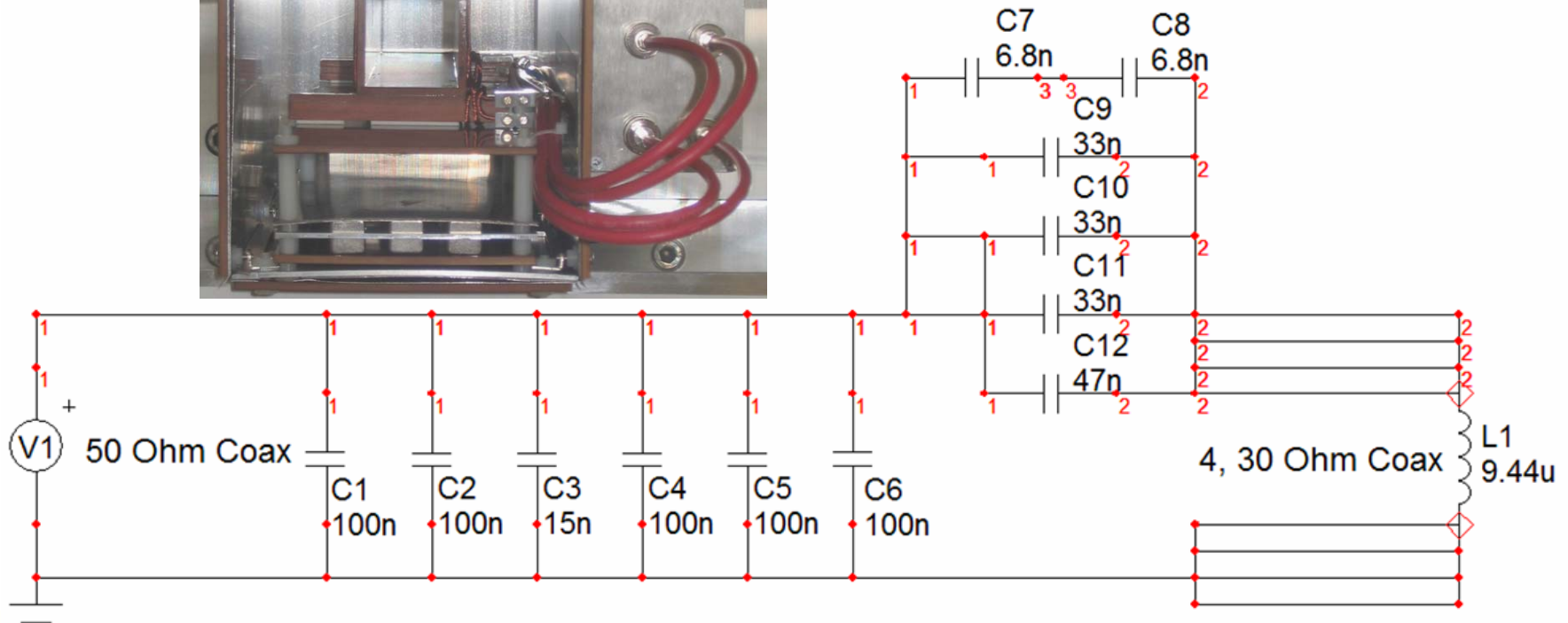
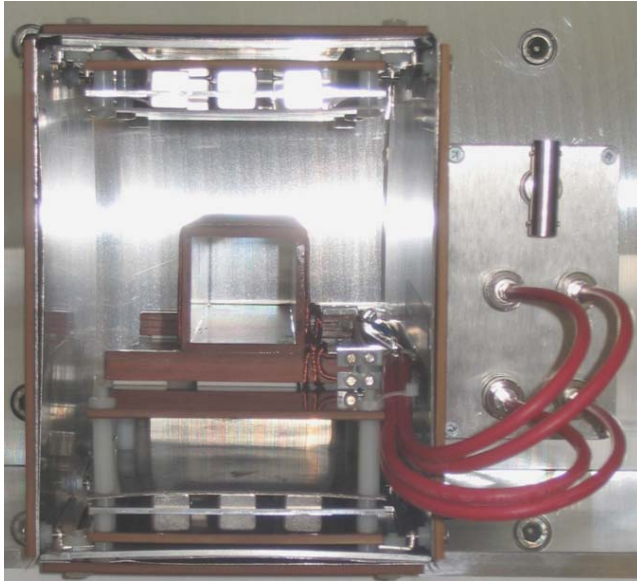


# Polarized Neutron Technology: The RF-Gradient Spin-Flipper at the SNS-MR



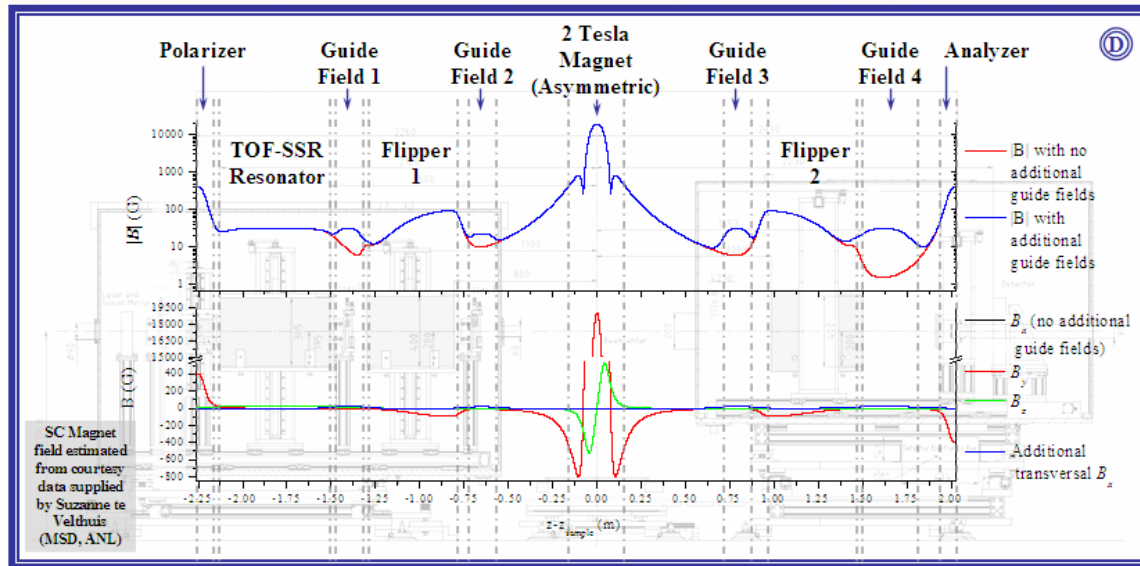


# Polarized Neutron Technology: SNS-MR RF-Gradient Spin-Flippers Unique Features

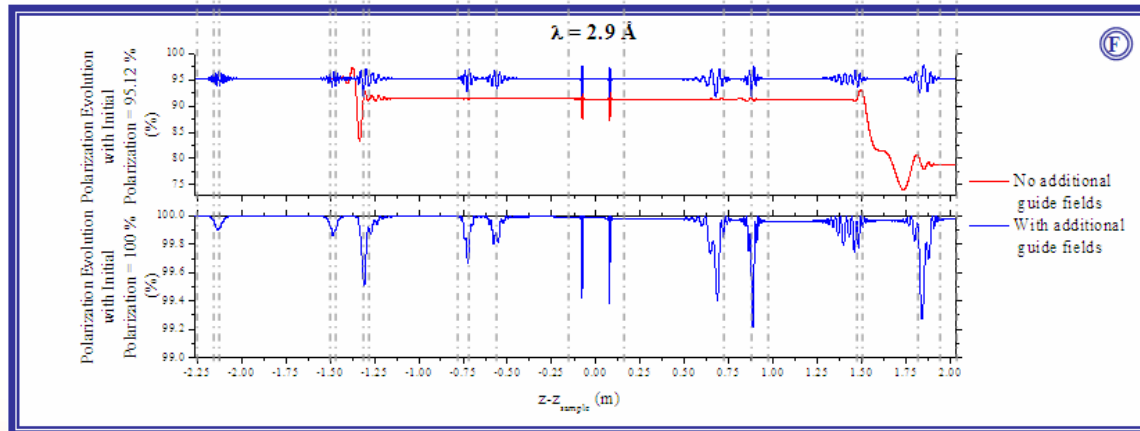


A23 – Matching network for spin flipper 1.

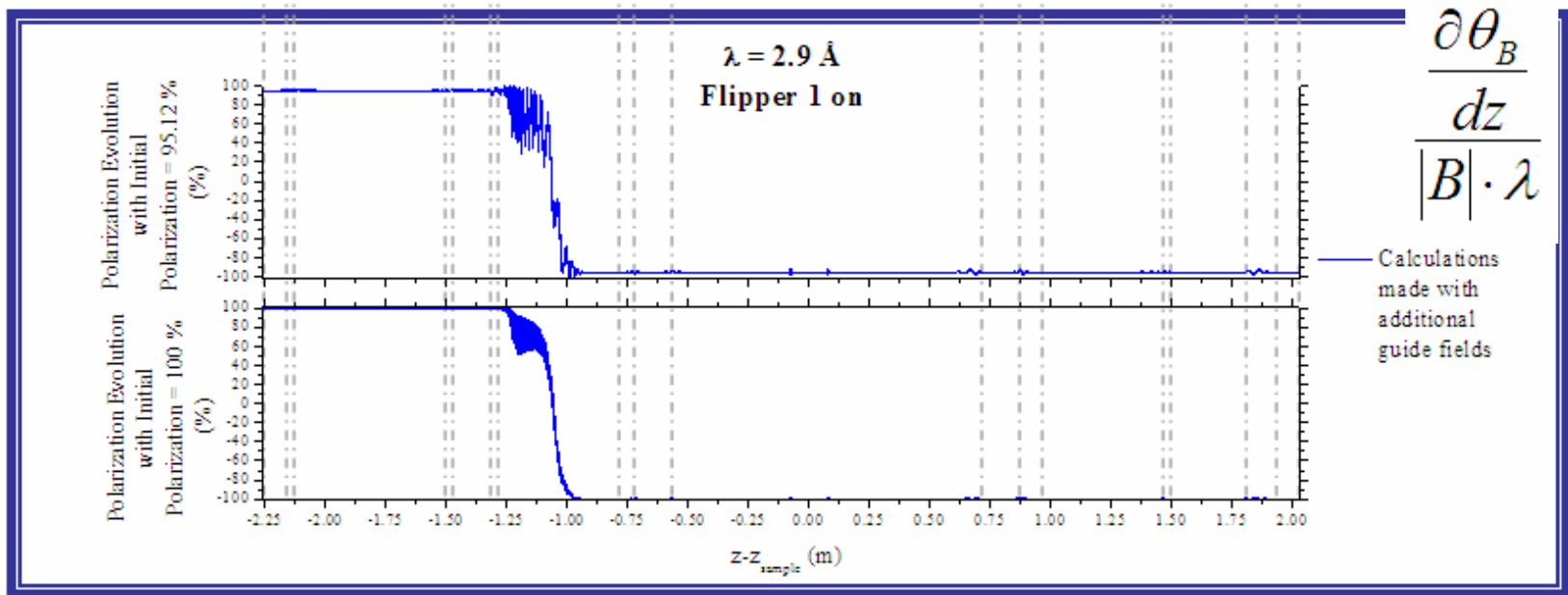
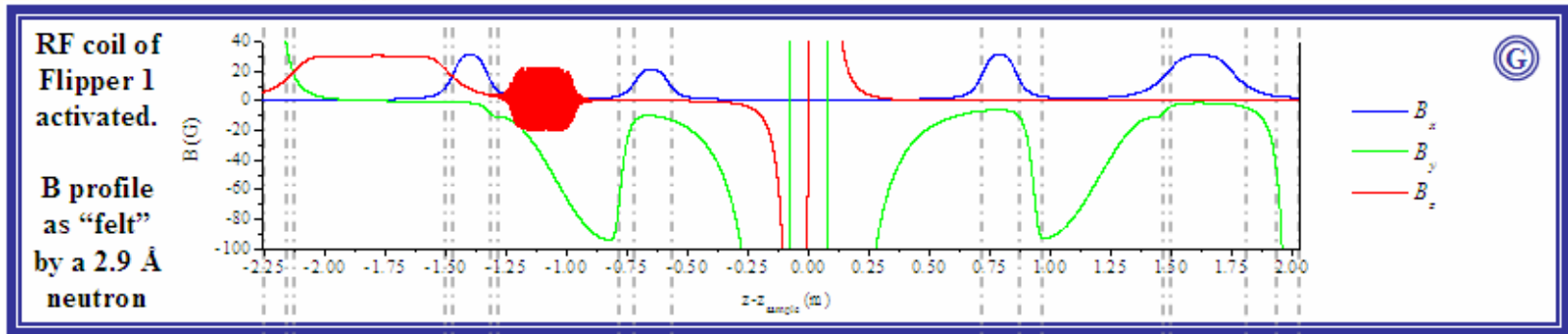
# Polarized Neutron Technology: The Magnetism Reflectometer at SNS



$$\frac{\partial \theta_B}{dz} \cdot \lambda$$



# Polarized Neutron Technology: The Magnetism Reflectometer at SNS



# Acknowledgements

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