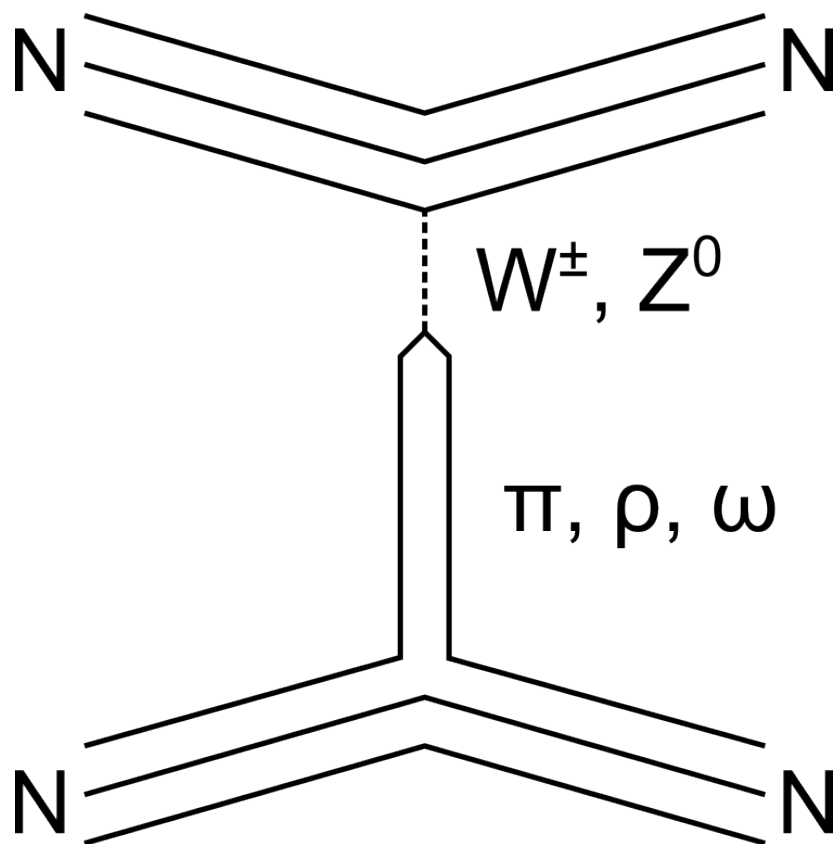


The NPDGamma Experiment: Parity Violation in Neutron-Proton Capture

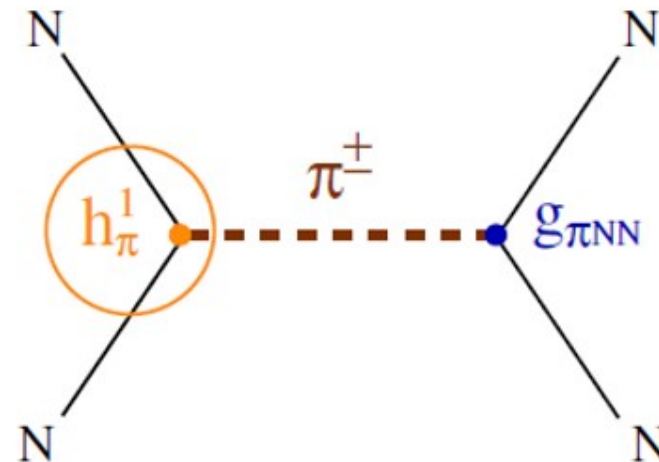
Matthew Musgrave
University of Sussex
For the NPDGamma Collaboration

Hadronic Parity Violation

- Weak nucleon-nucleon couplings are largely unknown
- Natural scale of 10^{-7} set by relative strength of the weak and strong forces



The meson exchange model* interprets the NN interactions via the exchange of light mesons.

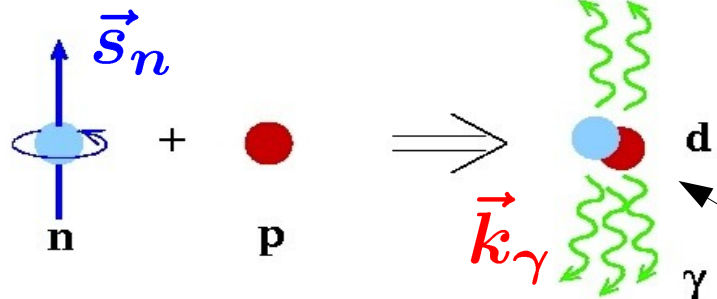


*Desplanques, Donoghue, Holstein, Annals of Physics 124, 449 (1980)

The NPDGamma Observable

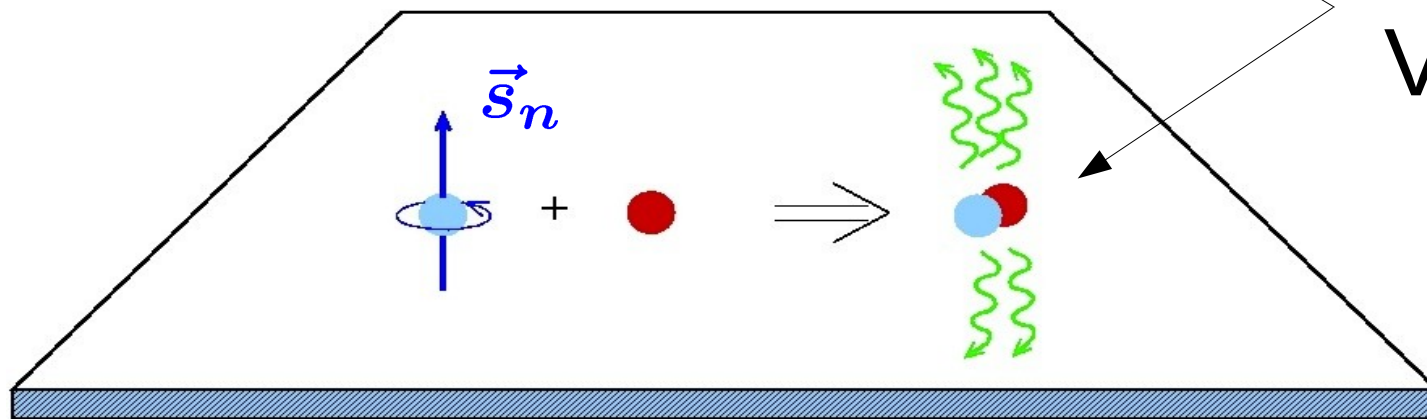
$$A_\gamma \approx \vec{s}_n \cdot \vec{k}_\gamma$$

the 'real' world

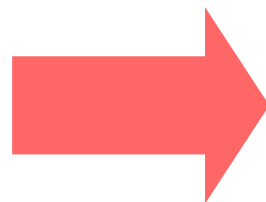


$$A_\gamma \approx 0.11 h^1_\pi$$

Parity Violation

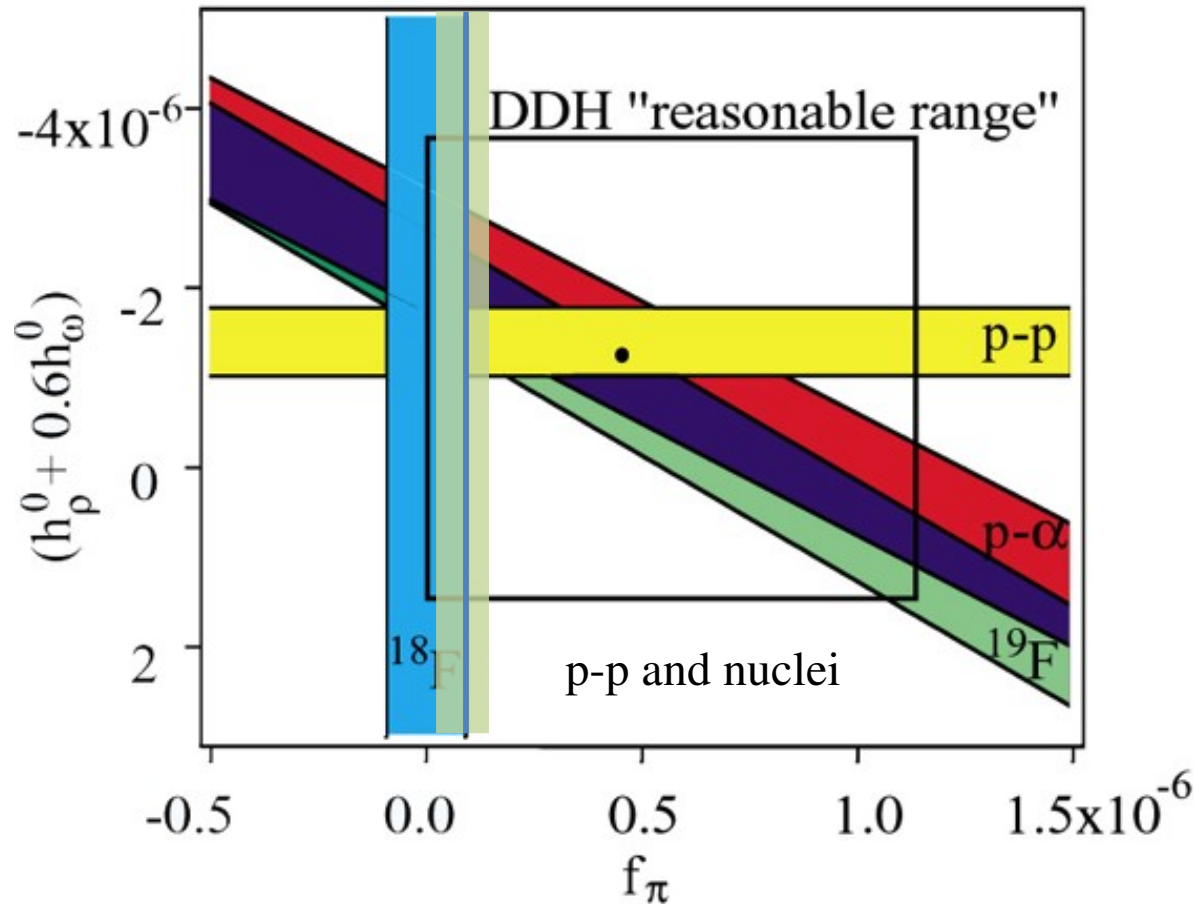


Hadronic weak interaction



Parity violating gamma ray asymmetry

Theoretical Predictions

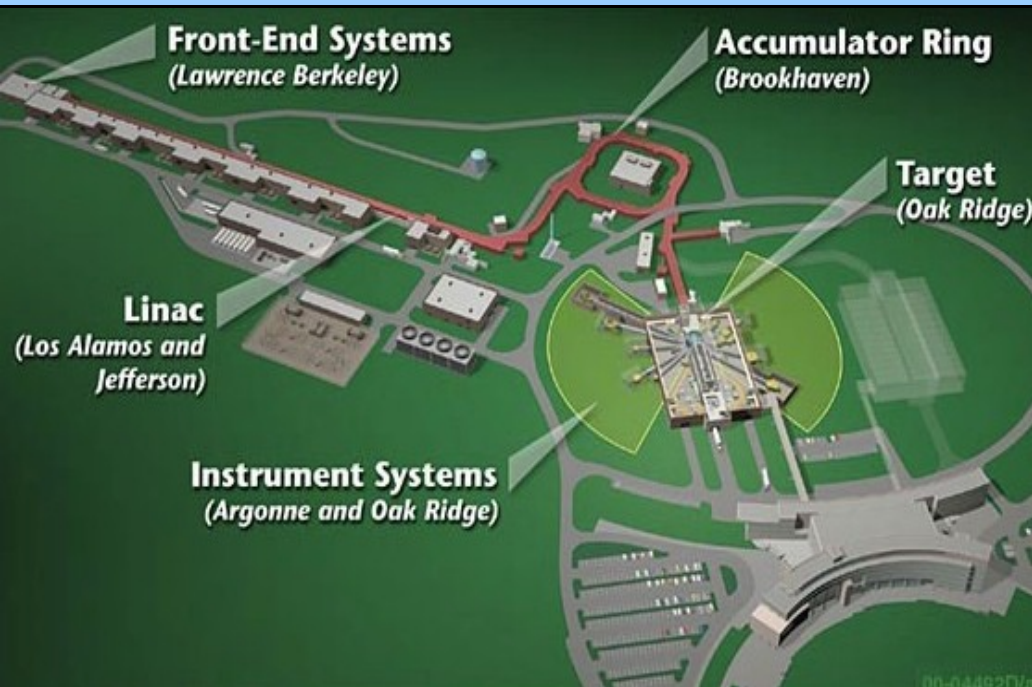


Meson-Exchange Model: $h_{\pi}^1 \approx 4.5 \times 10^{-7}$ $A_{\gamma} \approx 0.11 h_{\pi}^1 = 5 \times 10^{-8}$

Lattice QCD*: $h_{\pi}^1 = (1.099 \pm 0.505^{+0.058}_{-0.064}) \times 10^{-7}$ $A_{\gamma} \approx 1 \times 10^{-8}$

*Wasem, Phys. Rev. C 85 (2012) 022501

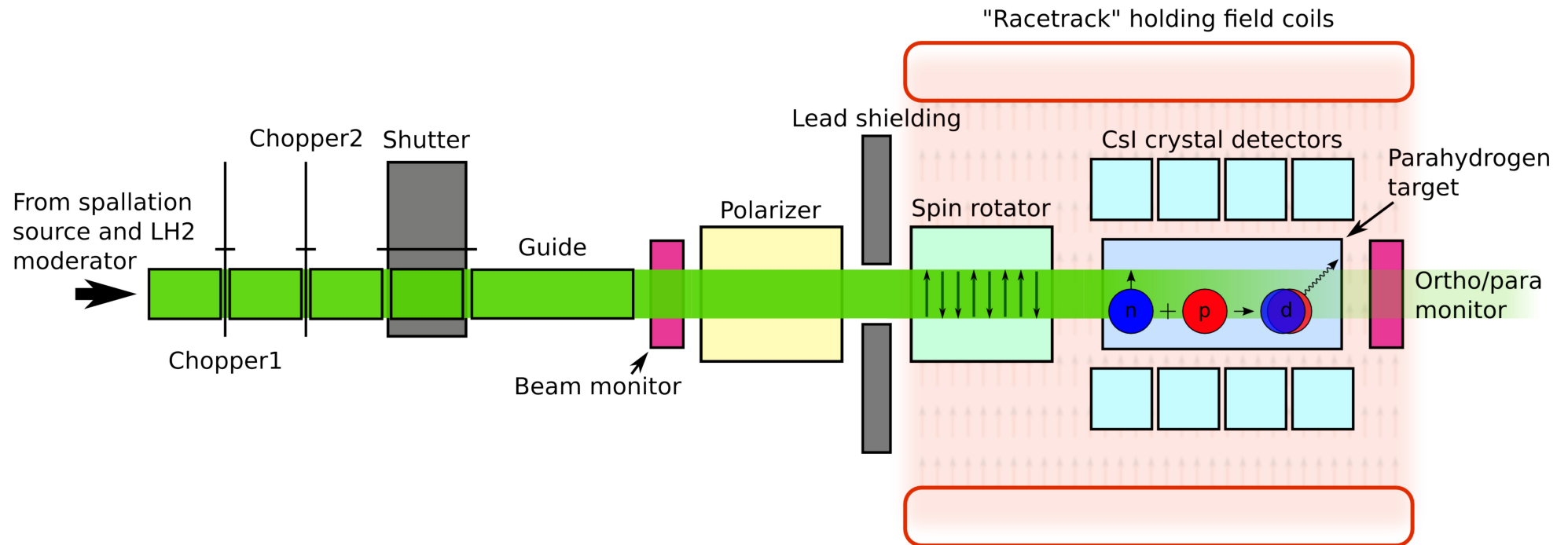
The Spallation Neutron Source



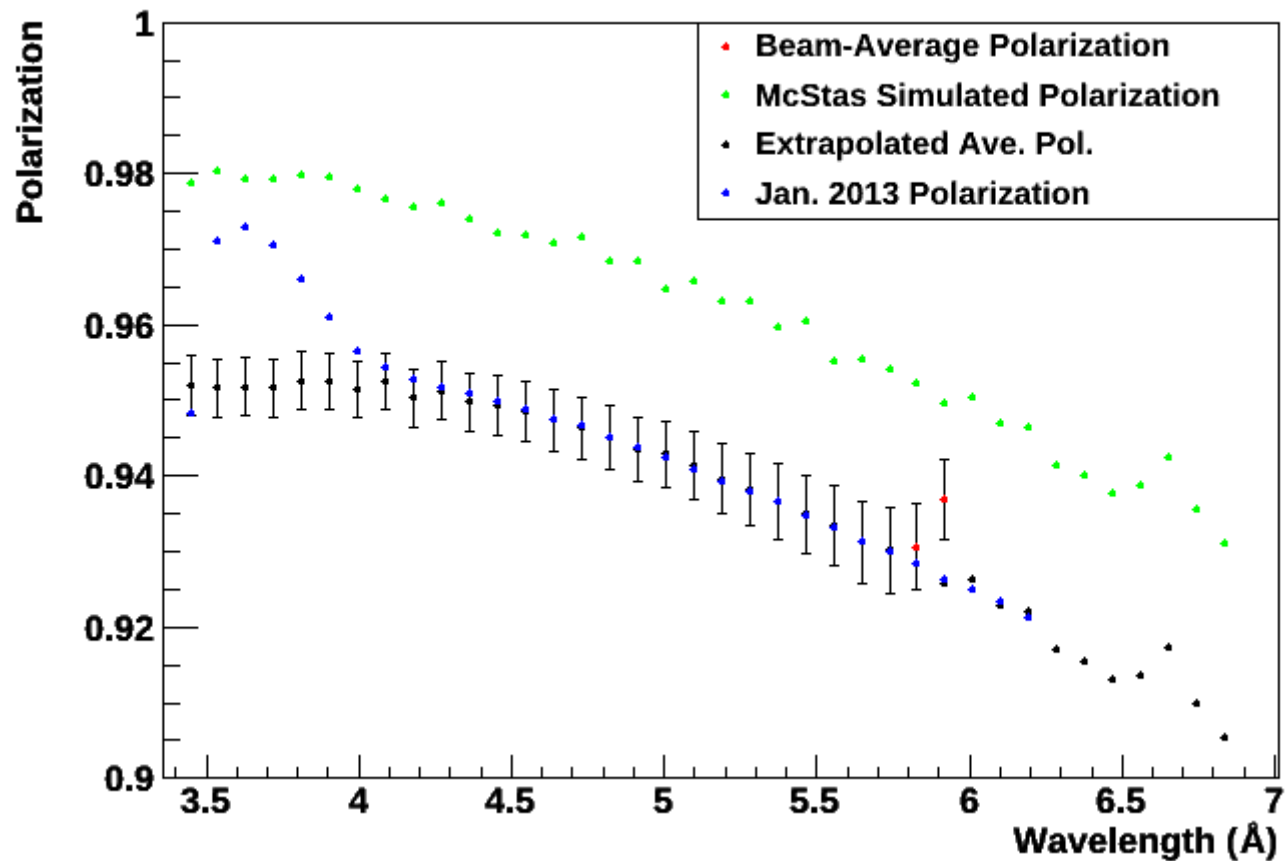
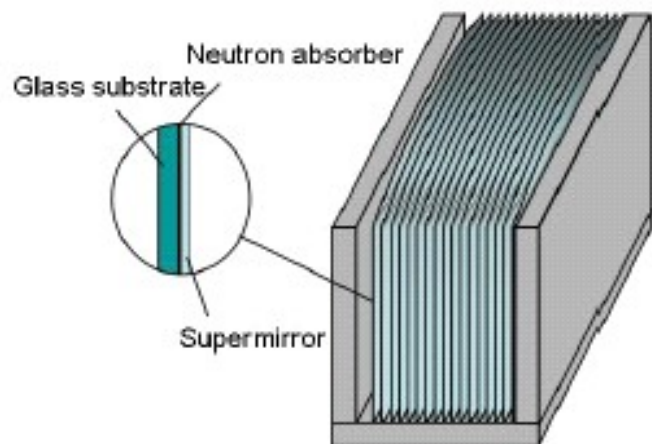
- Hg spallation target
- 60 Hz pulsed beam
- 850-1350 kW beam power



The NPDGamma Apparatus

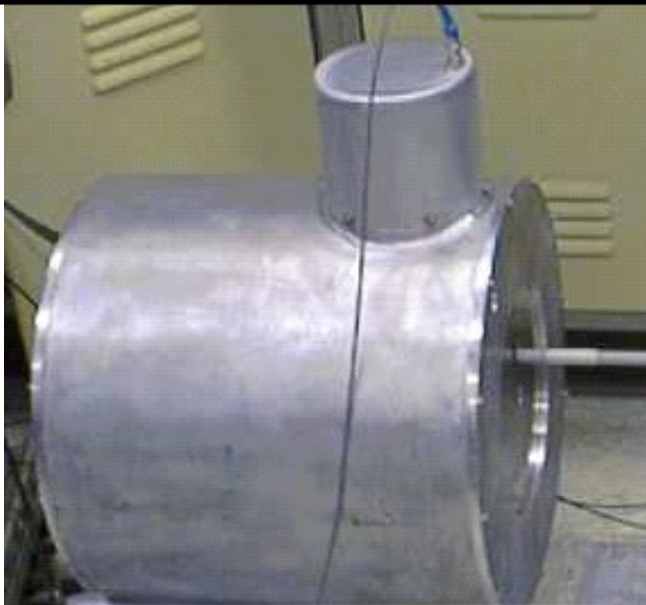


Supermirror Polarizer

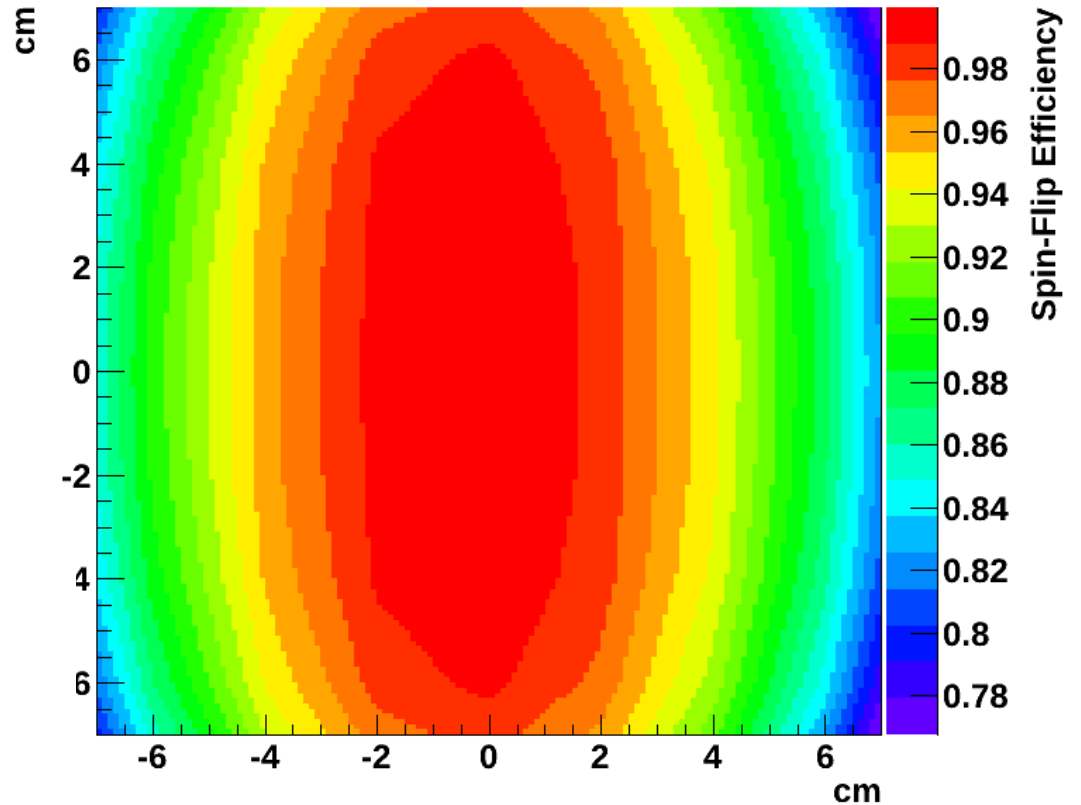
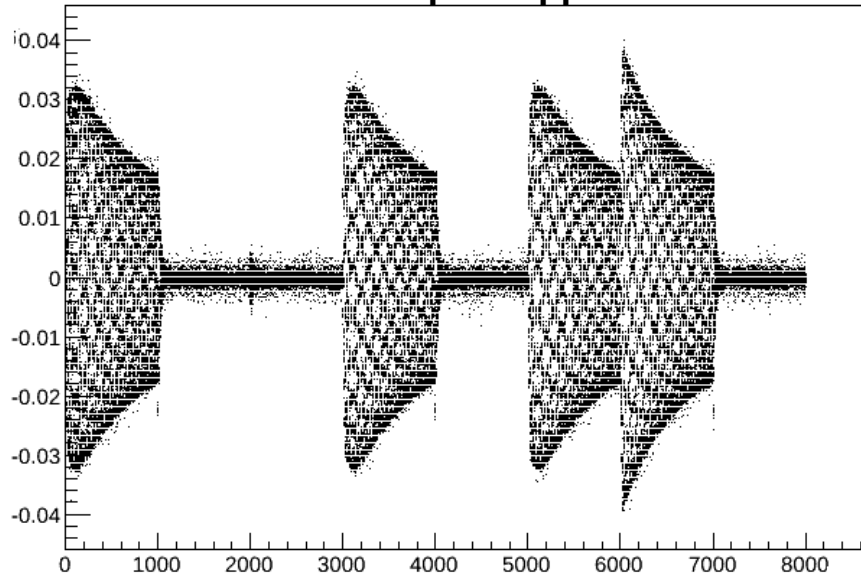


Average Polarization: $\sim 0.95 \pm 0.005$

RF Spin Flipper



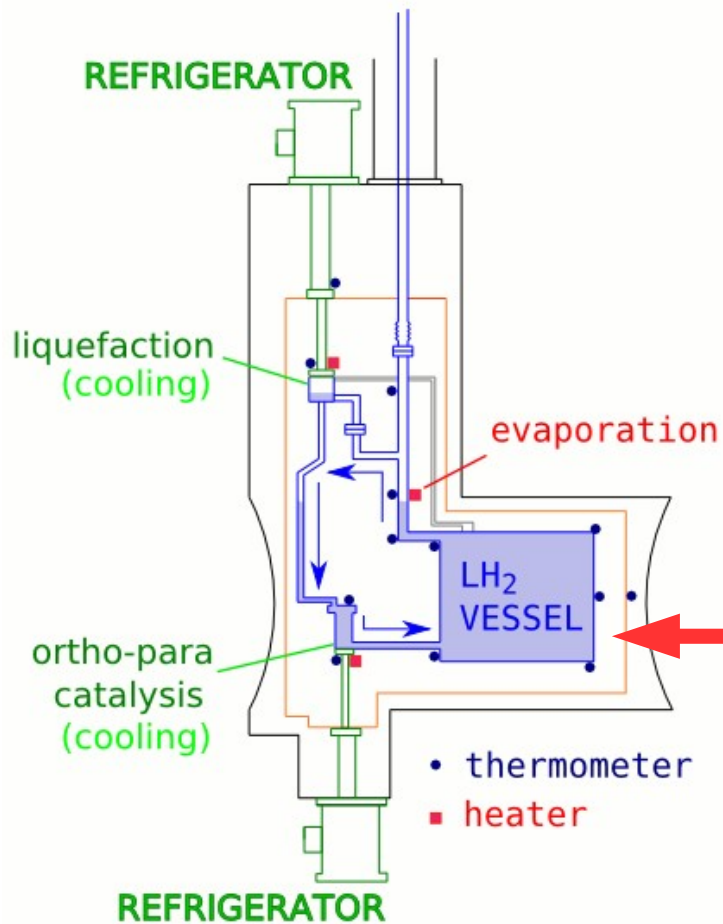
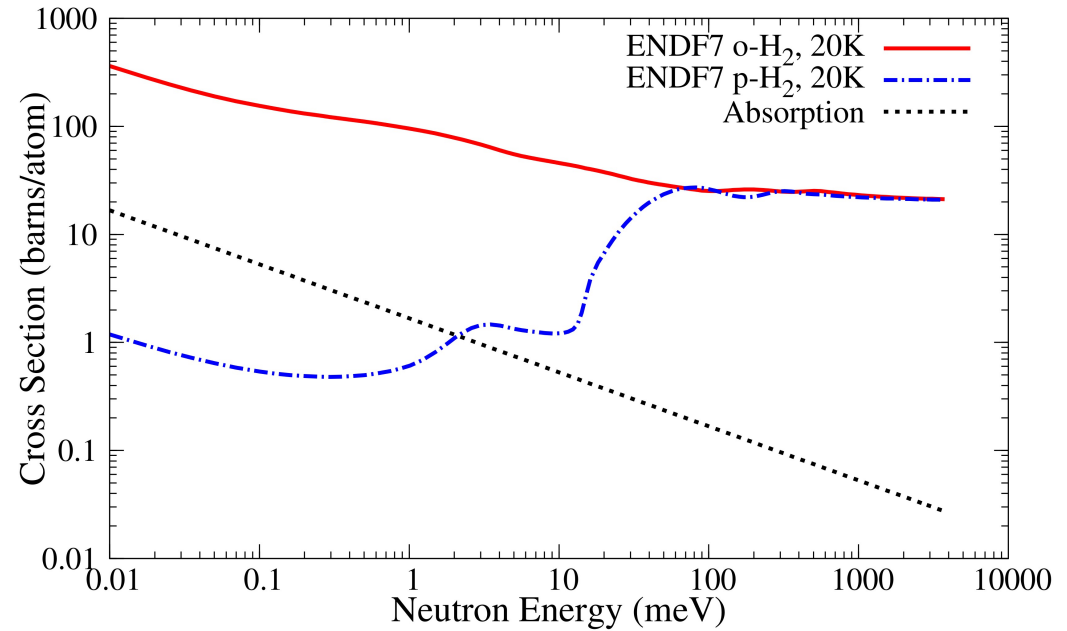
Current in the RF Spin Flipper



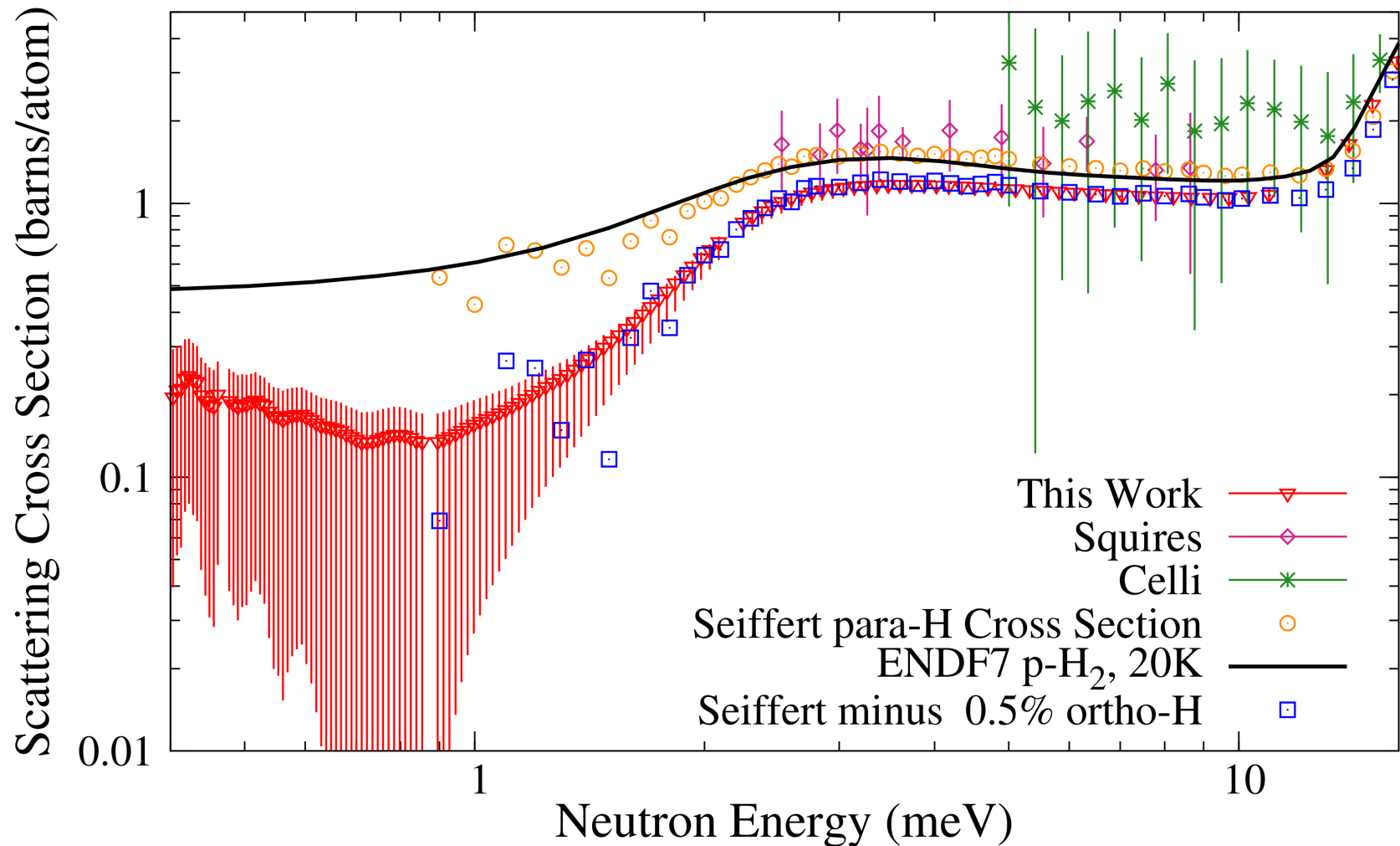
Average SF Efficiency:
 $\sim 0.98 \pm 0.002$

Para-Hydrogen Target

16 L liquid hydrogen target at 17 K



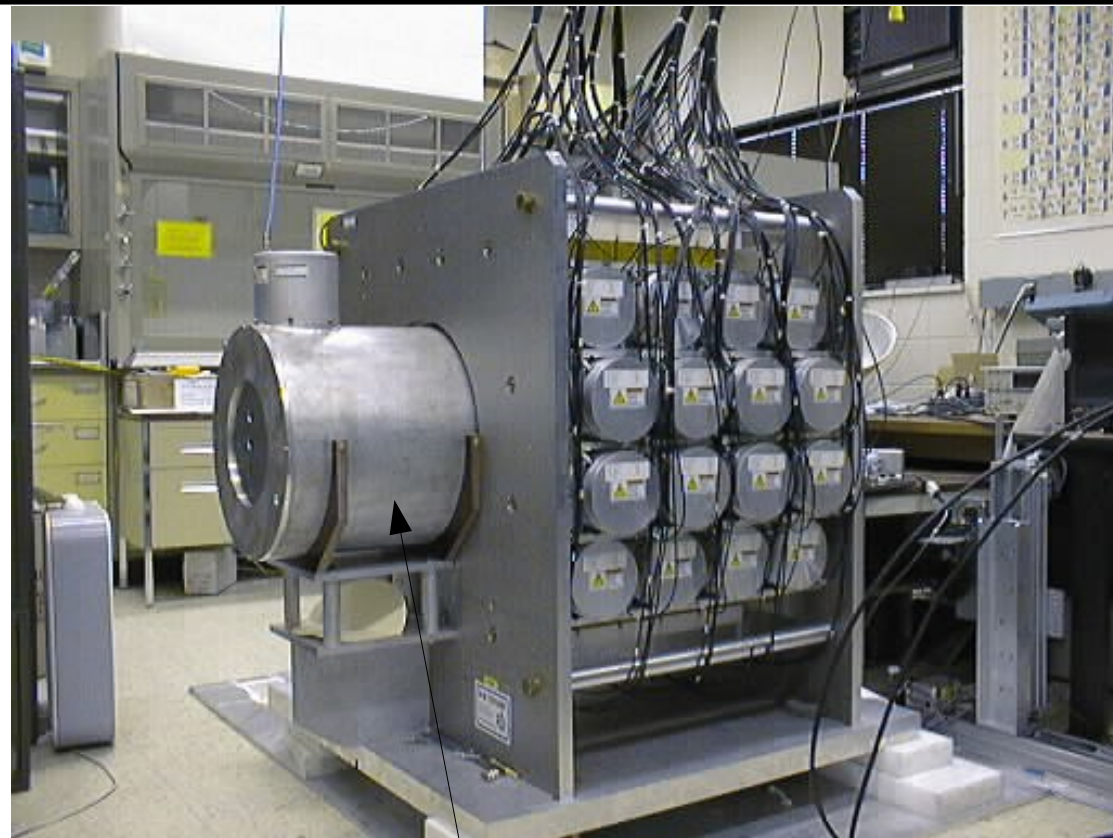
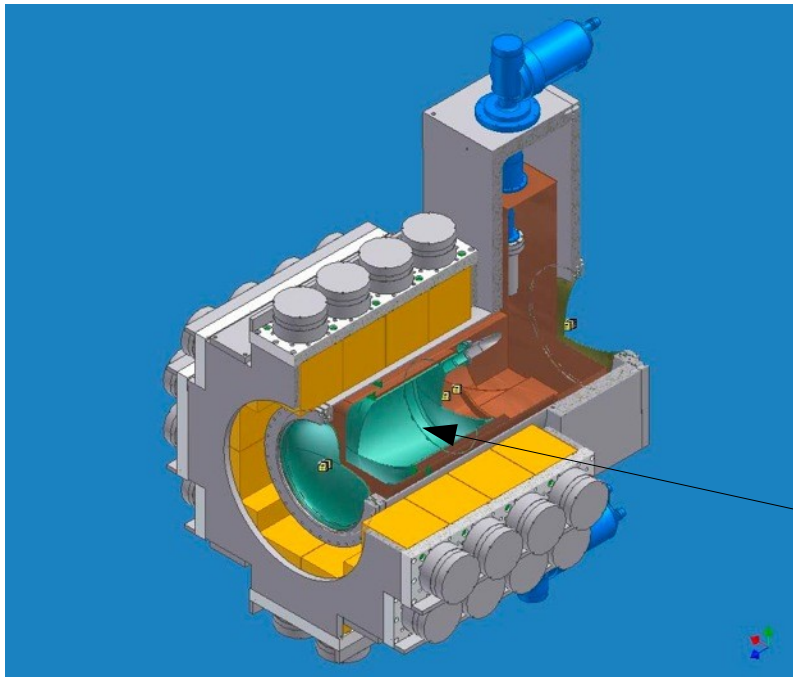
Para-Hydrogen Cross Section



Unintentionally made the world's best measurement of the para-hydrogen cross section!

CsI Gamma Ray Detectors

- 4 rings of 12 detectors
- 3π acceptance
- 95% detector efficiency
- Current mode detection
 5×10^7 gammas per pulse

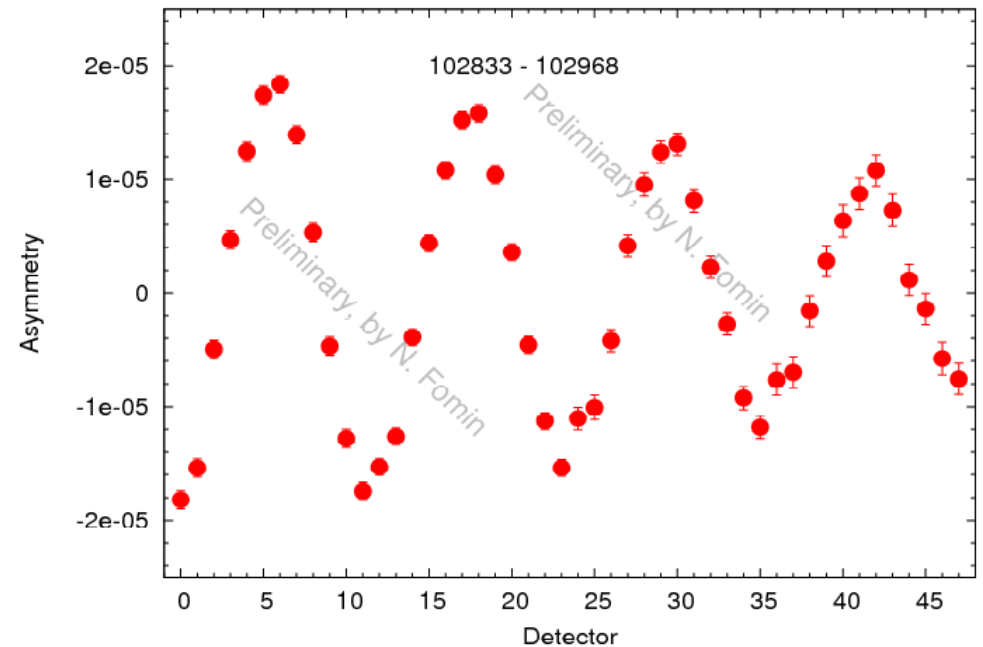


RF Spin Flipper

Para-H₂ Target

^{35}Cl Asymmetry

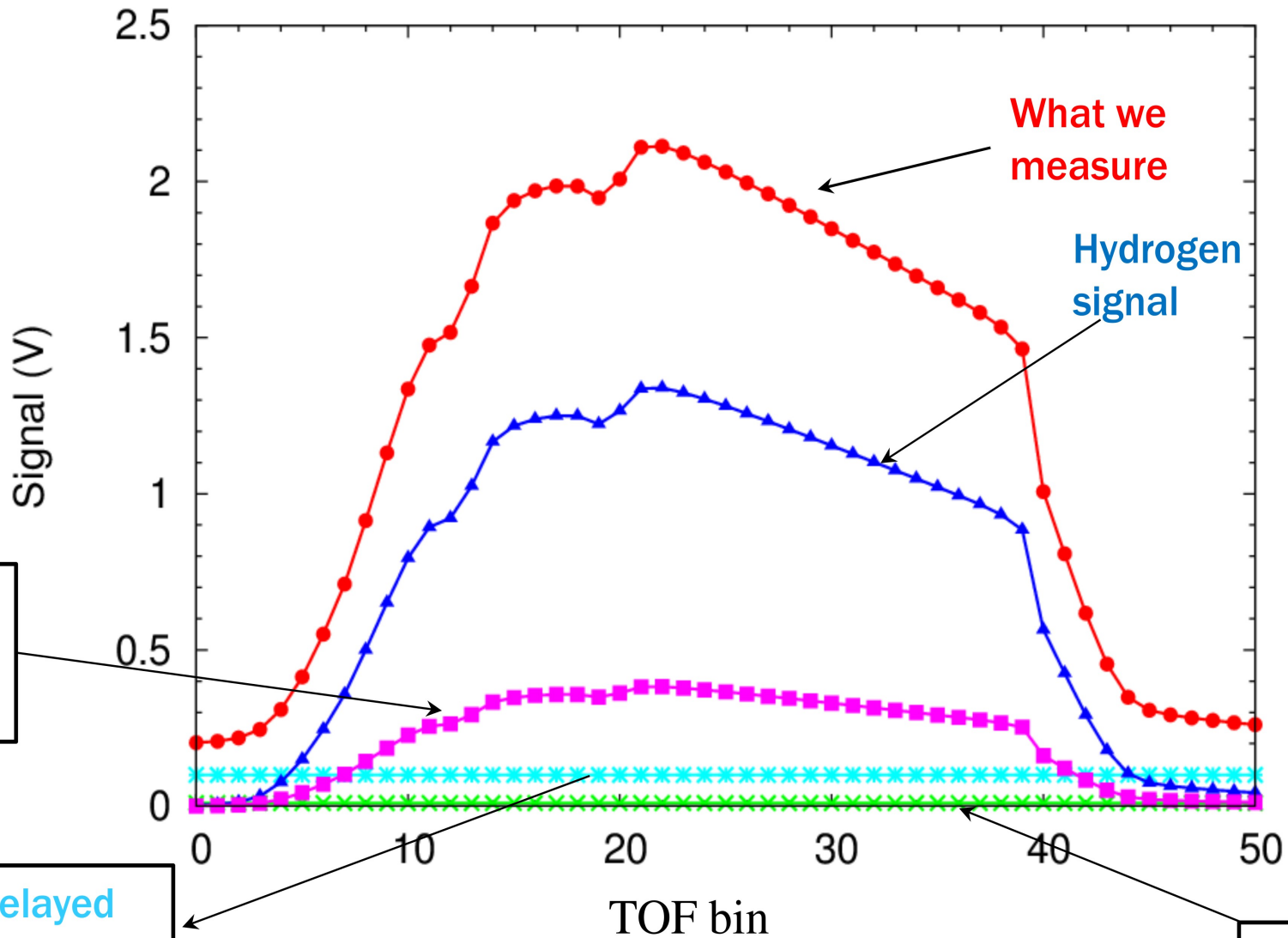
- ^{35}Cl has a large known PV asymmetry
- ^{35}Cl is used to calibrate the positions of the 48 CsI detectors
- Asymmetry result is in agreement with previous measurements
- More data is being analysed



Preliminary

Measurement	Asymmetry ($\times 10^{-6}$)
LANL	-29.1 ± 6.7
Leningrad	-27.8 ± 4.9
ILL	-21.2 ± 1.72
SNS (Current result)	-25.9 ± 0.6

Detector Signals



Prompt aluminum signal

β -delayed aluminum signal

What we measure

Hydrogen signal

Electronic pedestal

^{27}Al Asymmetry

- Dominate systematic effect
- ~20% of gamma signal
- Needs to be measured to 3×10^{-8}

Aluminium
Target



Preliminary

$$A_{\text{ud,PV}} = -18.0 \pm 7.1(\text{stat}) \pm 0.2(\text{sys}) \times 10^{-8}$$

$$A_{\text{lr,PC}} = -6.80 \pm 7.1(\text{stat}) \pm 0.2(\text{sys}) \times 10^{-8}$$

More data is being analysed

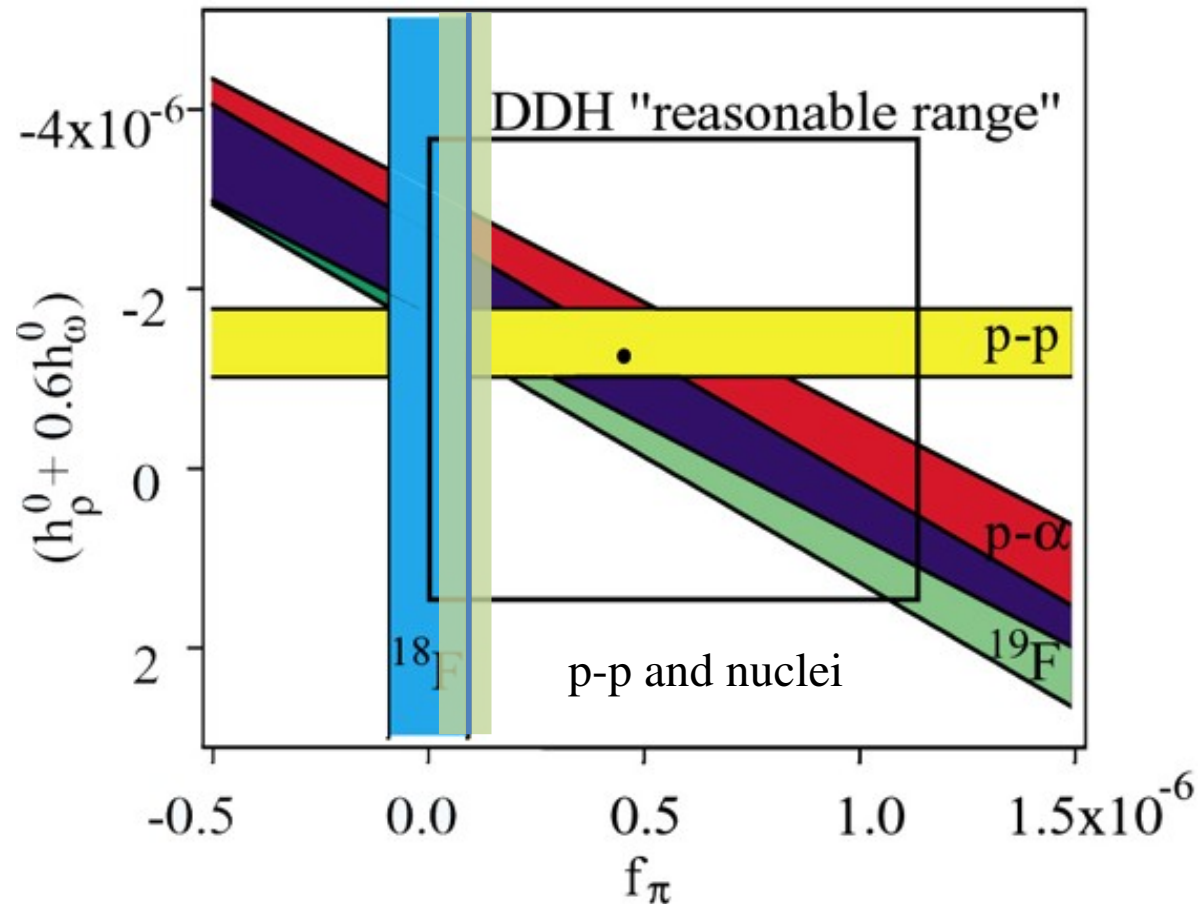
H₂ Asymmetry Uncertainties

Systematic Effects which may cause false Asym	Size
Additive Asymmetry (instrumental)	< 1x10 ⁻⁹
Multiplicative Asymmetry (instrumental)	< 1x10 ⁻⁹
Stern-Gerlach (steering of the beam)	< 1x10 ⁻¹⁰
γ - ray circular polarization	< 1x10 ⁻¹²
β - decay in flight	< 1x10 ⁻¹¹
Capture on ⁶ Li	< 1x10 ⁻¹¹
Radiative β -decay	< 1x10 ⁻¹²
β - delayed Al gammas (internal + external)	< 1x10 ⁻⁹
Uncertainties in applied corrections	
Neutron beam polarization uncertainty	< 2%
RFSF efficiency uncertainty	~ 0.5%
Depolarization of the neutron beam	< 0.5% (target-dependent)
Uncertainty in geometric factors	1%
Polarization of overlap neutrons	0.1%
Target Position	0.03%

Statistical Uncertainty (H₂ & Al)

~1.3x10⁻⁸

Para- H_2 Asymmetry



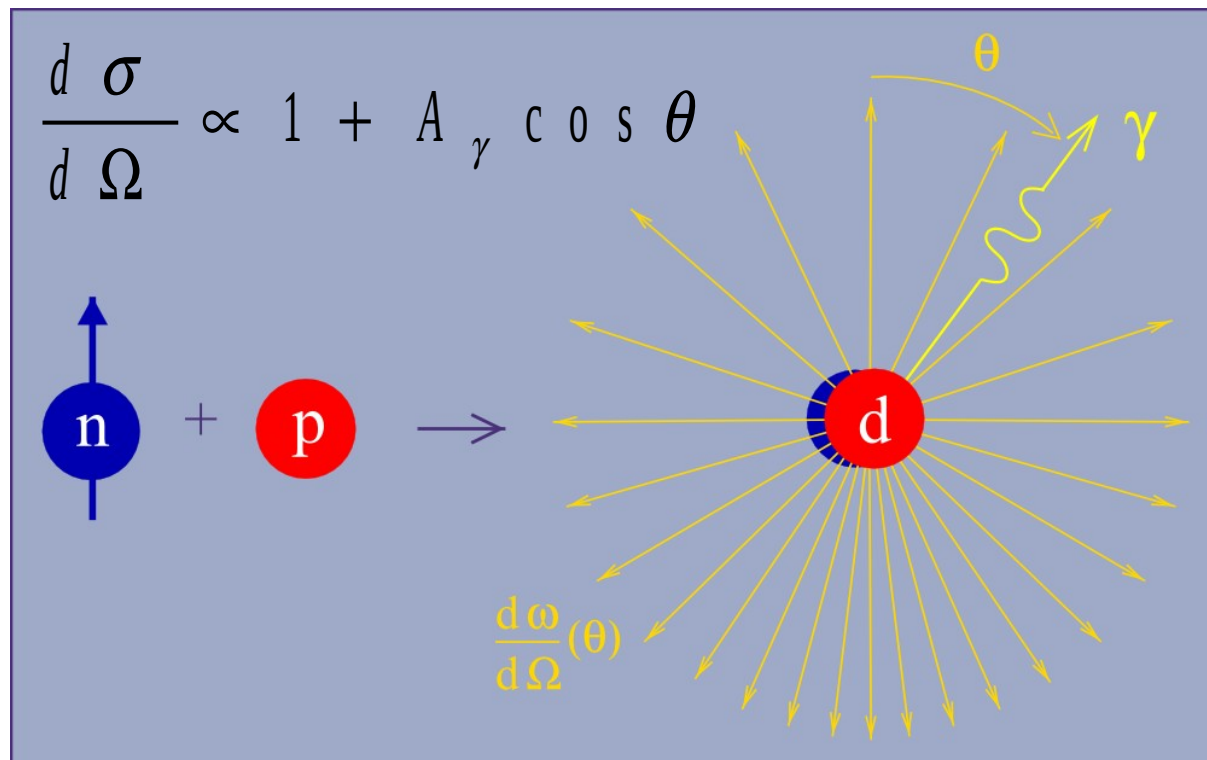
Official statement from Collaboration regarding A_y :

“The preliminary result for the parity-violating asymmetry A_y is that it is small with a statistical error of about 13 ppb.”

Thank you for your Attention



The NPDGamma Observable



$$h_{\pi}^1 \approx 4.5 \times 10^{-7}$$

$$A_{\gamma} \approx 0.11 h_{\pi}^1 = 5 \times 10^{-8}$$