# Measurement of the Pulsed Cold Neutron Flux at LANSCE

April 29, 2001

# Measurement of the Parity-Violating Gamma Asymmetry $A_\gamma$ in the Capture of Polarized Cold Neutrons by Para-Hydrogen, $\vec{n} + p \rightarrow d + \gamma$

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**http://p23.lanl.gov/len/npdg/**

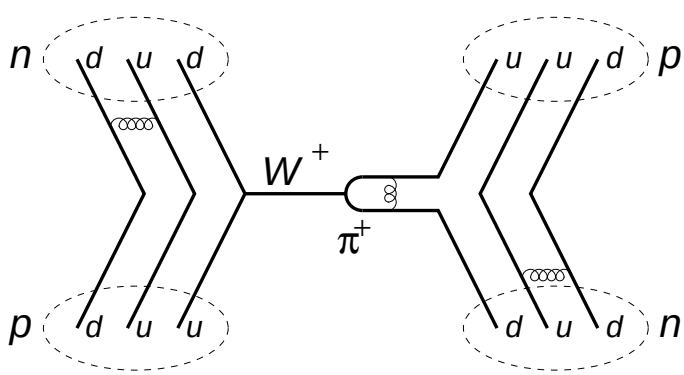
NPDGamma: $\vec{n} + p \rightarrow d + \gamma$

Measure parity-violating asymmetry $A_\gamma$ in capture of polarized cold $n$ by para-$H_2$

Expected asymmetry $\approx 5 \times 10^{-8}$

Target experimental error: $0.5 \times 10^{-8}$

$A_\gamma$ is a clean measurement of $H_\pi^1$,
the largest weak nucleon-nucleon coupling,
a fundamental quantity in low-energy QCD
and weak interaction physics



## NPDGamma Requirements

Target total stat. error: $0.5 \times 10^{-8}$ ...

need $4 \times 10^{16}$ $\gamma$-capture events $\approx$ 1 year

$\longrightarrow$ is this run time estimate correct?

Measure neutron flux to benchmark Monte Carlo

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Stat. error / 20 Hz $n$ pulse: $1 \times 10^{-4}$ ...

NPDGamma is sensitive to fluctuations in beam intensity & position

$\longrightarrow$ are pulse-to-pulse fluctuations $\sigma^2 < 10^{-4}$?

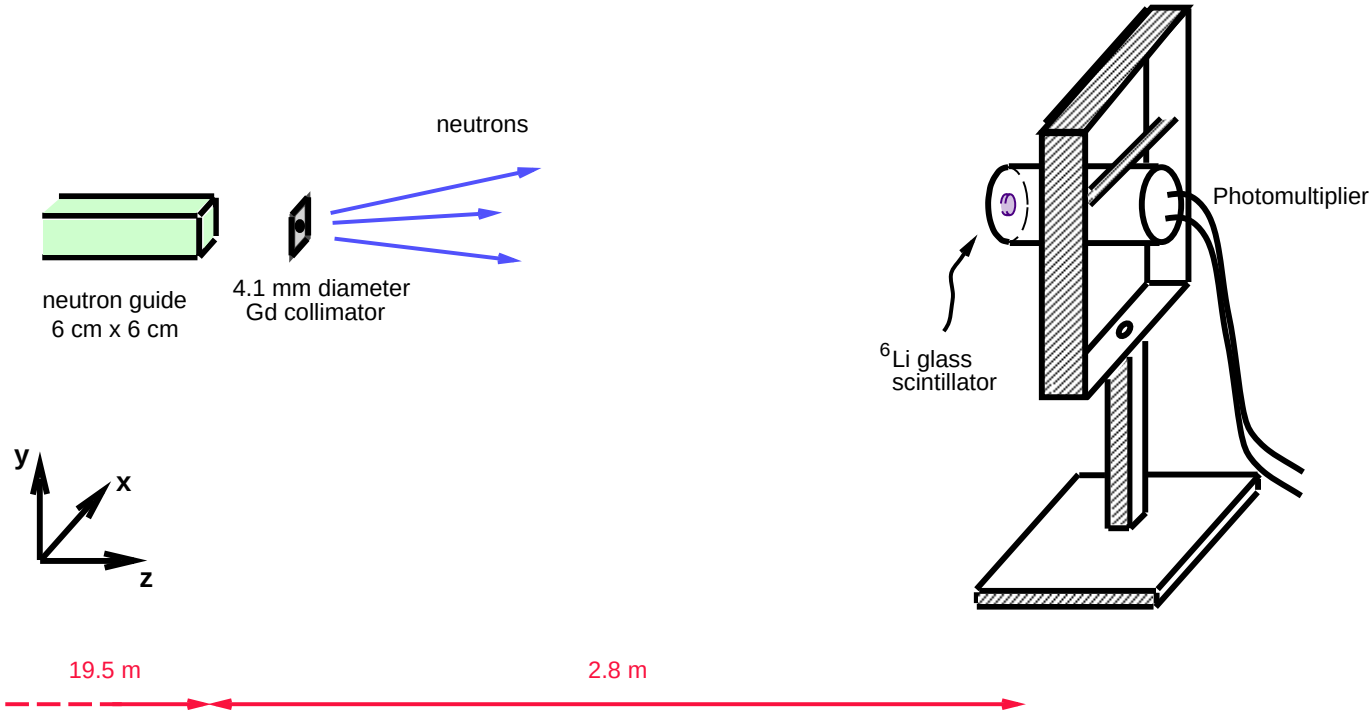
(criterion on variance based on simulation relating fluctuations in moderator density to fluctuations in neutron beam position)

For fixed proton current

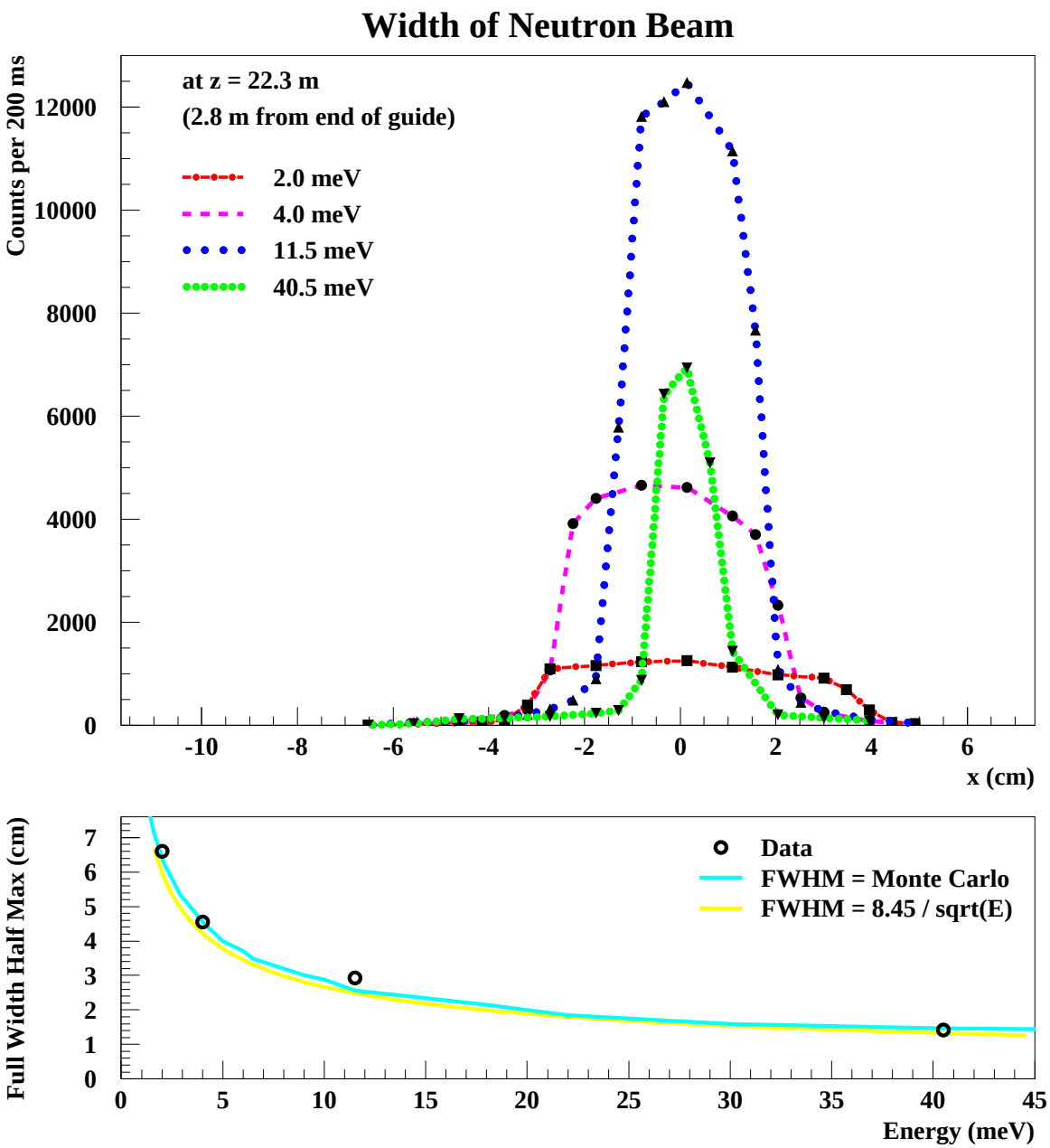
measure intensity fluctuations in neutron beam

Engineering Run

# FP11A Flux Measurement Setup




- Countable rate from collimated beam
- Scan detector over the beam profile

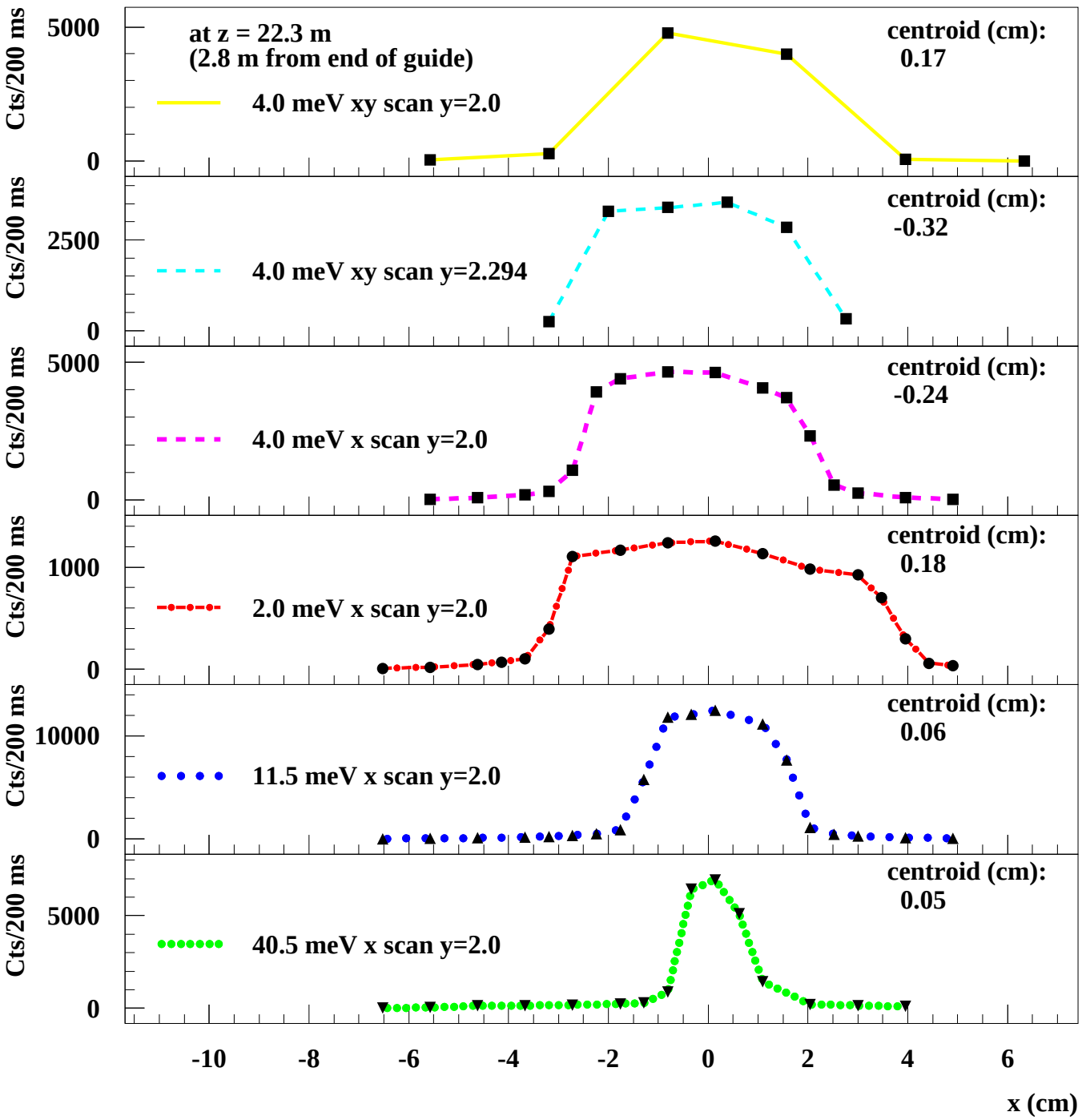



The collimated beam width at the detector follows the predicted energy dependence: by Monte Carlo simulation; or by assuming point source collimation (FWHM$=8.45/\sqrt{E}$)

[$n = 1$, $^{58}$Ni guide, allows $v_\perp < 7$ m/s]

Shifting centroid?

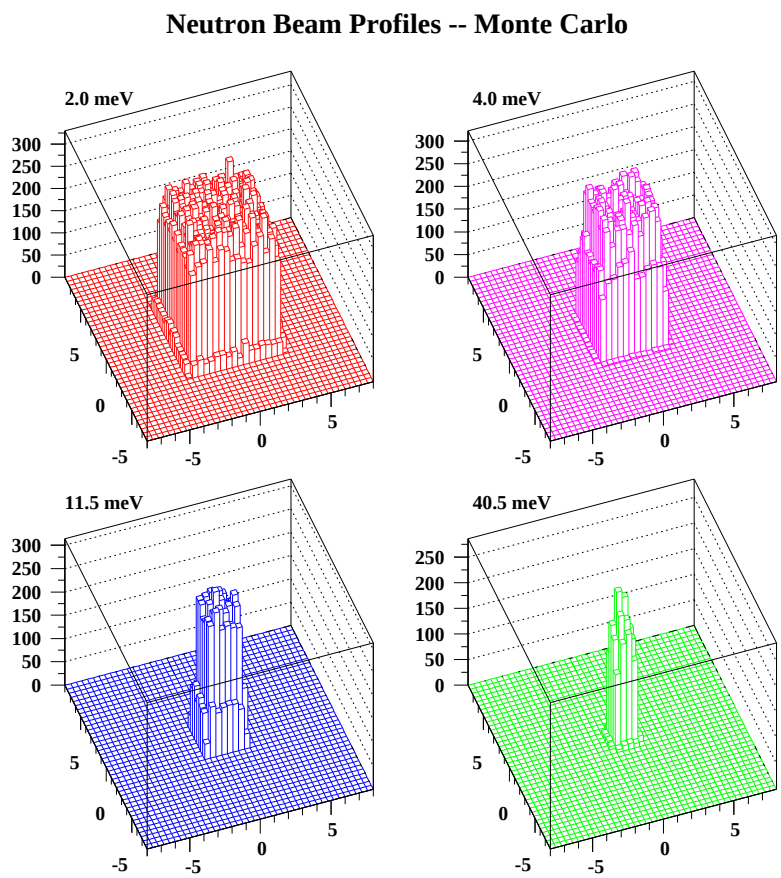
Explained by readback hysteresis.

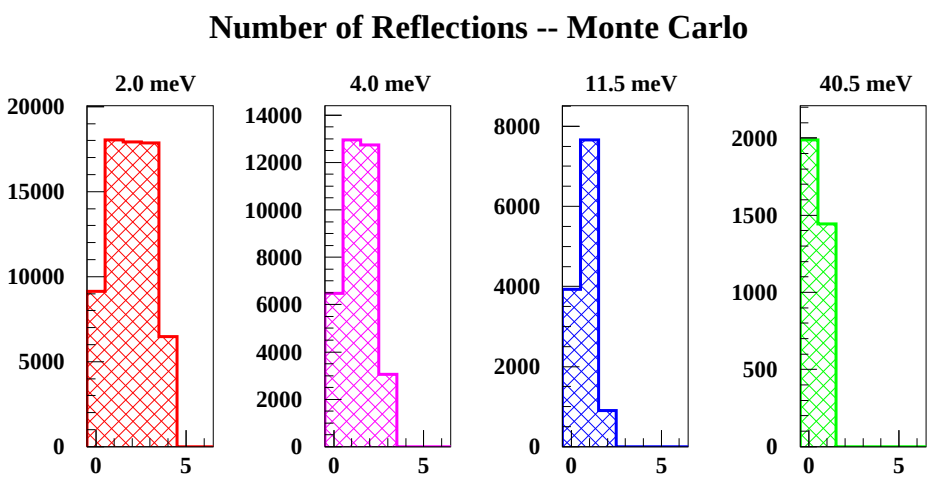


# Monte Carlo

Simulation of FP11A flux measurement collimation

Profiles are at detector $z$, $x/y$ axis units in cm



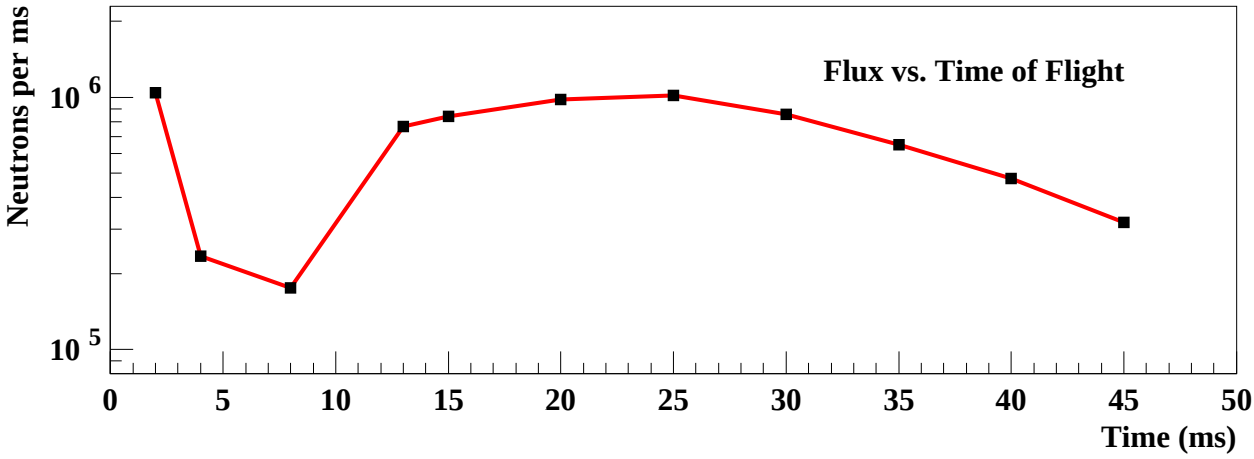
# Measurements of neutron spectrum

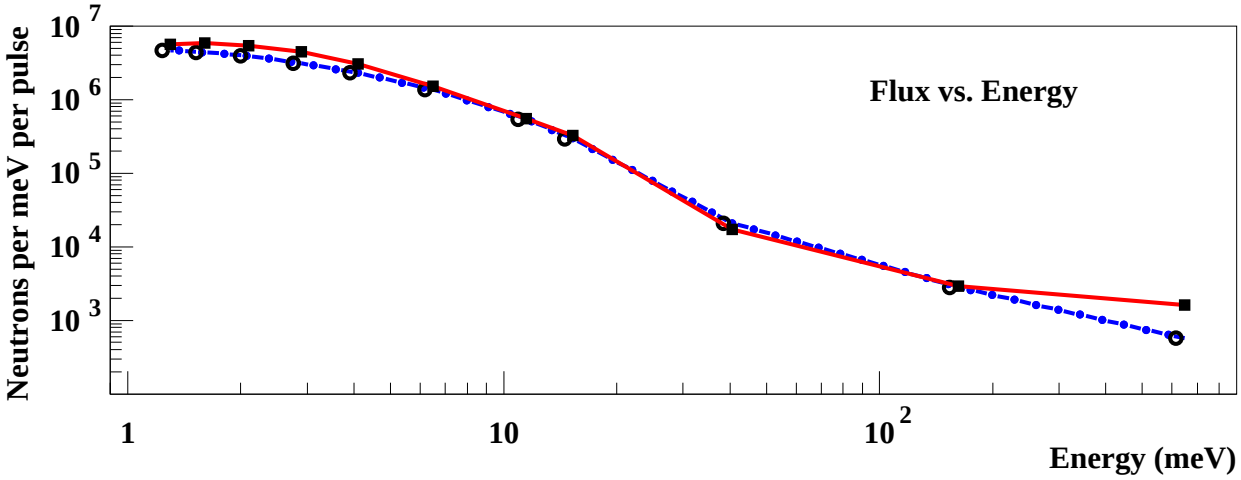
## neutrons/ms and neutrons/meV/pulse are flux out of the end of the FP11A guide

| tof | counts | velocity | energy | counts/ms | counts/meV | FWHM | areas ratio | 6Li | neutrons | neutrons |
|---|---|---|---|---|---|---|---|---|---|---|
| t (ms) | N, per 200 ms | v = z/t (m/s) | E (meV) | dN/dt | dN/dE | (cm) | | efficiency | /ms | /meV/pulse |
| 2 | 57130 | 11150 | 647.7 | 285.6 | 0.44 | 0.88 | 1676 | 0.46 | +1.04E+06 | +1.60E+03 |
| 4 | 20897 | 5575 | 161.9 | 104.5 | 1.29 | 0.86 | 1601 | 0.71 | +2.35E+05 | +2.90E+03 |
| 8 | 6845 | 2788 | 40.5 | 34.2 | 3.38 | 1.47 | 4677 | 0.92 | +1.75E+05 | +1.73E+04 |
| 13 | 12793 | 1715 | 15.3 | 64.0 | 27.12 | 2.33 | 11751 | 0.98 | +7.65E+05 | +3.24E+05 |
| 15 | 11732 | 1487 | 11.5 | 58.7 | 38.21 | 2.56 | 14185 | 0.99 | +8.40E+05 | +5.47E+05 |
| 20 | 7413 | 1115 | 6.5 | 37.1 | 57.22 | 3.49 | 26364 | 1.00 | +9.79E+05 | +1.51E+06 |
| 25 | 4642 | 892 | 4.1 | 23.2 | 69.99 | 4.50 | 43831 | 1.00 | +1.02E+06 | +3.07E+06 |
| 30 | 2769 | 743 | 2.9 | 13.8 | 72.14 | 5.35 | 61953 | 1.00 | +8.58E+05 | +4.47E+06 |
| 35 | 1522 | 637 | 2.1 | 7.6 | 62.97 | 6.27 | 85093 | 1.00 | +6.48E+05 | +5.36E+06 |
| 40 | 867 | 558 | 1.6 | 4.3 | 53.54 | 7.14 | 110345 | 1.00 | +4.78E+05 | +5.91E+06 |
| 45 | 469 | 496 | 1.3 | 2.3 | 41.24 | 7.94 | 136458 | 1.00 | +3.20E+05 | +5.63E+06 |

# Neutron Flux at LANSCE Lujan Center FP11A

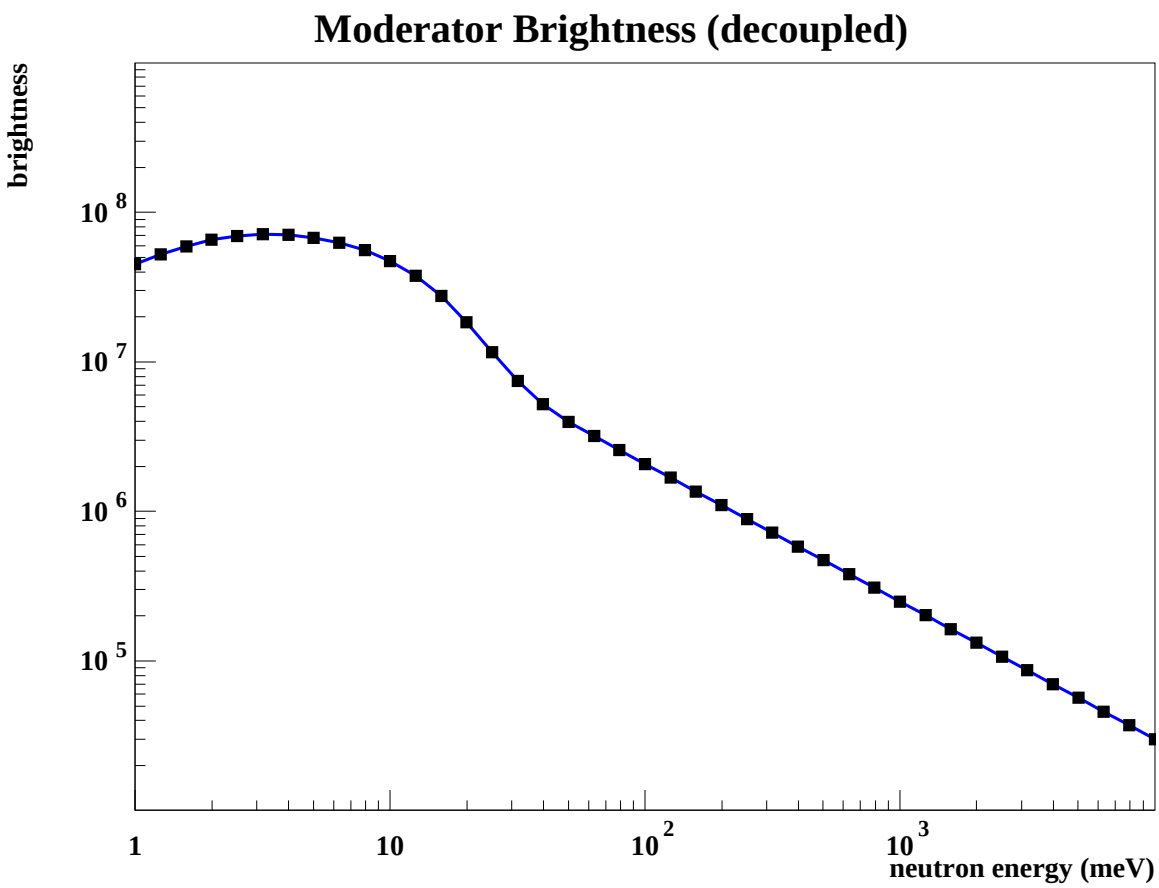
Red curves measurement, blue Monte Carlo (adjusted for attenuation in air, Al windows)



# LAHET Calculation of Moderator Brightness

decoupled liquid $H_2$ moderator, calculation by LANL LANSCE-12




Peak brightness is at 4 meV:

$$7 \times 10^7 \text{ neutrons/cm}^2\text{/s/sr/meV/}\mu\text{A}$$

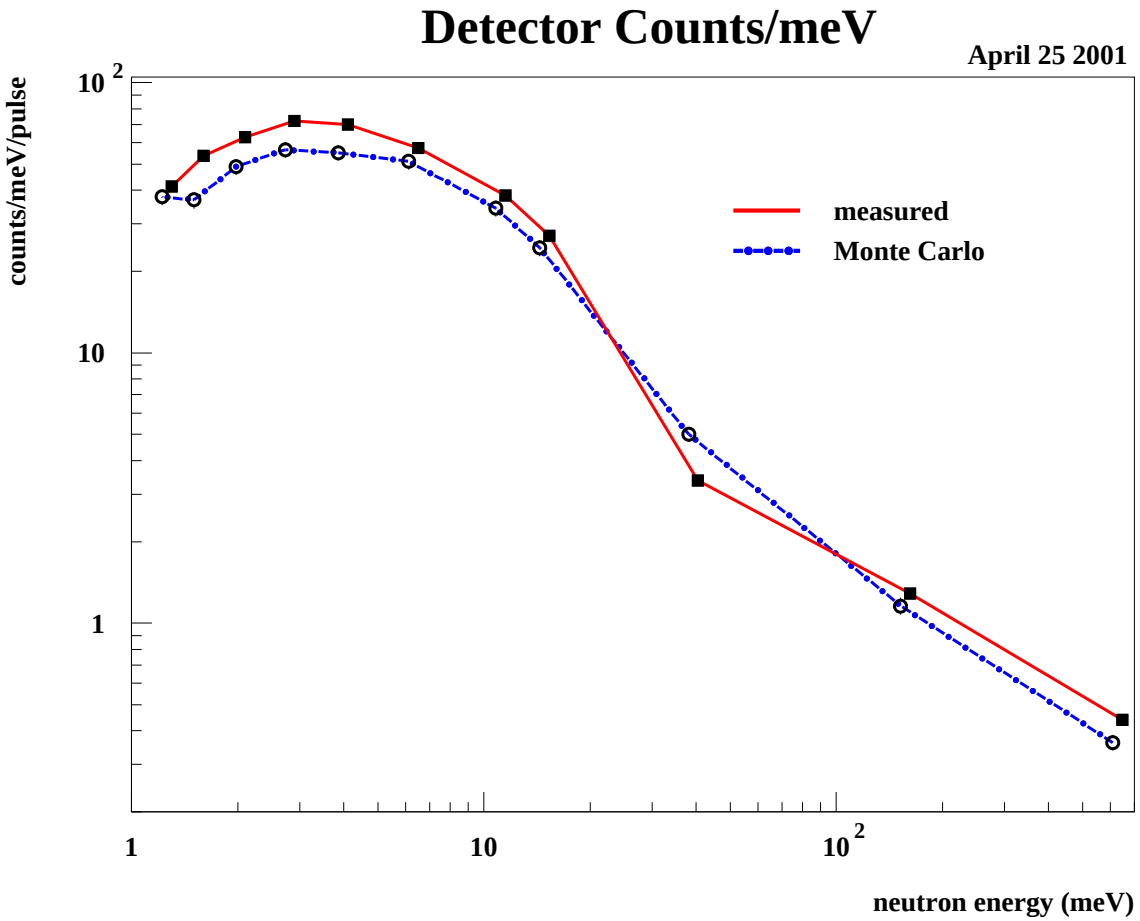
## Comparison to Monte Carlo

Excellent agreement $\sim$ 20%

MC results adjusted for attenuation due to:
air (2.8 m) and aluminum windows (1 cm total)

MC underestimates the measured flux, but FP11A views a partially coupled $LH_2$ moderator . . .
(should produce more low energy neutron flux than a decoupled one)

New LANSCE Lujan Center FP12 flux will be as assumed for NPDGamma, and this counting method can easily measure it

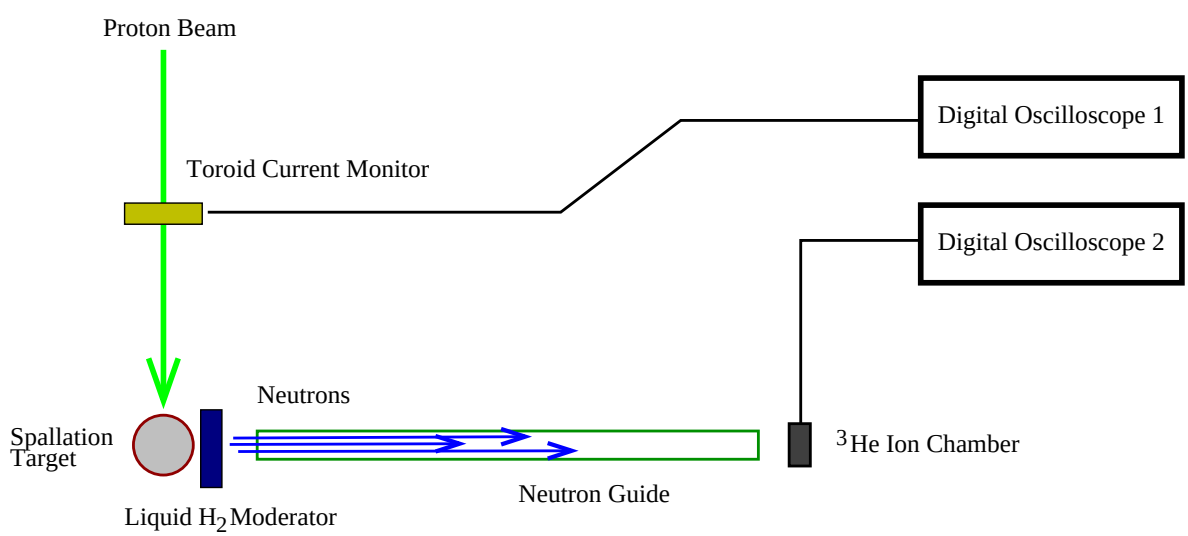


# Fluctuations

Density fluctuations in the moderator & corresponding position fluctuations of the neutron beam are dangerous

$\longrightarrow$may produce pulse-to-pulse fluctuations large compared to counting statistics

Setup for measuring fluctuations:




Three sets of measurements of fluctuations each yielded: $\sigma^2(\text{neutron/proton}) \approx 1 \times 10^{-5}$

- position fluctuations are washed out by the guide
- density fluctuations are negligible for NPDGamma

# Conclusions

• Fluctuations of the neutron beam position and intensity are insignificant for NPDGamma.

• FP11A flux measurement data agree with Monte Carlo.

Including a 9.5 cm $\times$ 9.5 cm guide, $n$=3, 200 $\mu$A proton current, 30 cm dia. target located 2.65 m from the end of the guide, the MC predicted FP12 NPDGamma flux integrated from 1.5 meV $\rightarrow$ 15 meV:

$$6\times10^{8}/\text{pulse}.$$

Accounting for 65% capture in $LH_2$ target, this is sufficient rate for the required $10^{-4}$ asymmetry measurement per pulse.