QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Magnetic field for "PANDA*"

*Proton Asymmetry in Neutron DecAy

For the SNS-FnPB Magnet meeting

Prepared by Tim Chupp

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TIFF (Uncompressed) decompressor
are needed to see this picture.

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The proton Asymmetry

Asymmetry: $\dfrac{N_+ - N_-}{N_+ + N_-} = \mathbf{C}\, P_n\, \mathsf{A}\, \mathsf{F}\, (1\text{-}f) + A_{false}$

- f: background
- F: spin flip efficacy
- A: analyzing power
- P_n: neutron polarization

$$C = k(A+B) = 4k \frac{|\lambda|}{1+3|\,\lambda\,|^2} \qquad \lambda = \frac{g_A}{g_V} \qquad k=0.27484$$

Standard Model

$$\frac{dW}{dE_e d\Omega_e d\Omega_\nu} = S(E_e)\,[1 + a\,\frac{\mathbf{p}_e\cdot\mathbf{p}_n}{E_e E_n} + b\,\frac{m_e}{E_e} + \frac{\mathbf{J}}{J}\cdot\Big(A\frac{\mathbf{p}_e}{E_e} + B\frac{\mathbf{p}_\nu}{E_\nu} + D\,\frac{\mathbf{p}_e x \mathbf{p}_\nu}{E_e E_\nu}\,\Big)]$$

JTW-57

C and λ

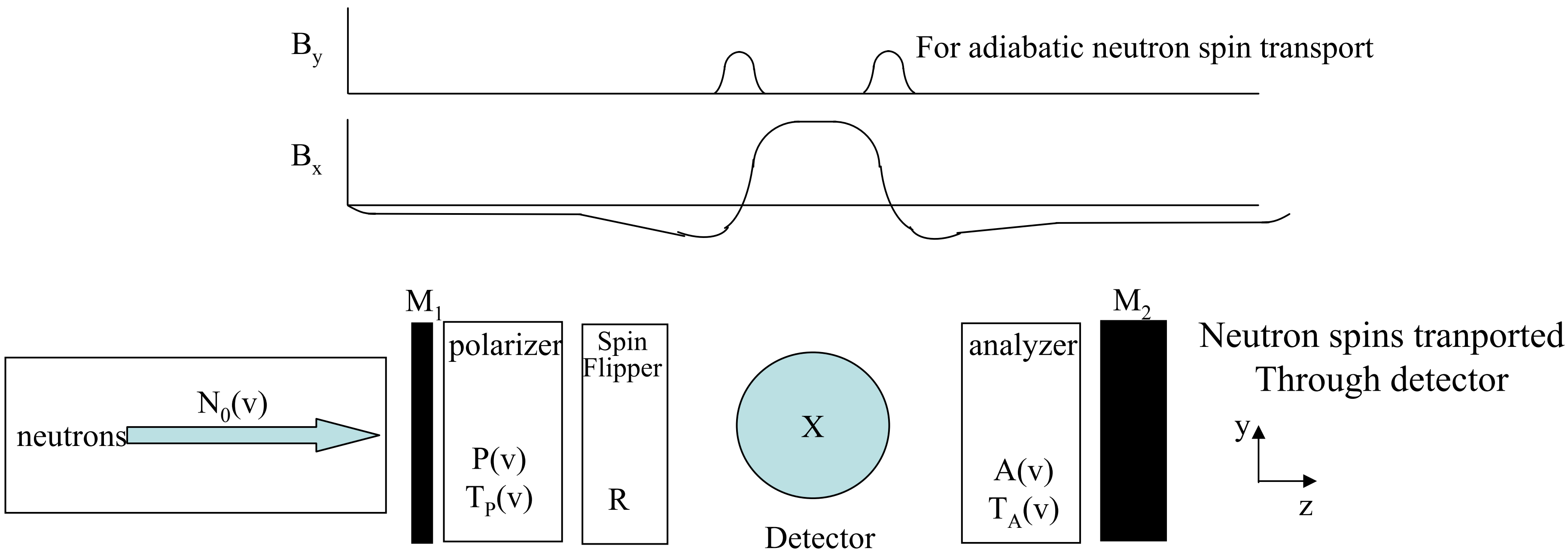
$$C = k(A+B) = 4k\frac{|\lambda|}{1+3|\lambda|^2}$$

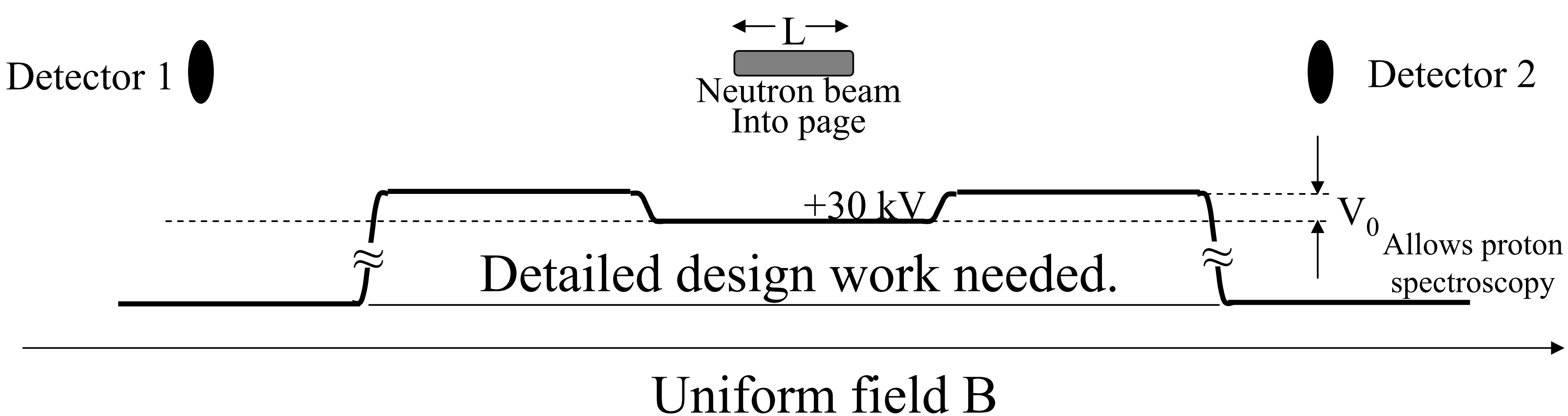
PDG 2005		$\frac{\sigma_\lambda}{\lambda} \Big/ \frac{\sigma_x}{x}$
λ	-1.2695±0.0029	
a	-0.103±0.004	0.2688
A	-0.1173±0.0013	0.2403
B	+0.983 ±0.004	1.385
C	+0.238 ±0.011*	1.430
D	-0.0004±0.0006	
ϕ	180.06±0.0029	

* Abele, 2005

$$\frac{dW}{dE_e d\Omega_e d\Omega_\nu} = S(E_e)\left[1 + a\frac{\mathbf{p}_e\cdot\mathbf{p}_n}{E_e E_n} + b\frac{m_e}{E_e} + \frac{\mathbf{J}}{J}\cdot\left(A\frac{\mathbf{p}_e}{E_e} + B\frac{\mathbf{p}_\nu}{E_\nu} + D\frac{\mathbf{p}_e x \mathbf{p}_\nu}{E_e E_\nu}\right)\right]$$

Rudimentary Layout



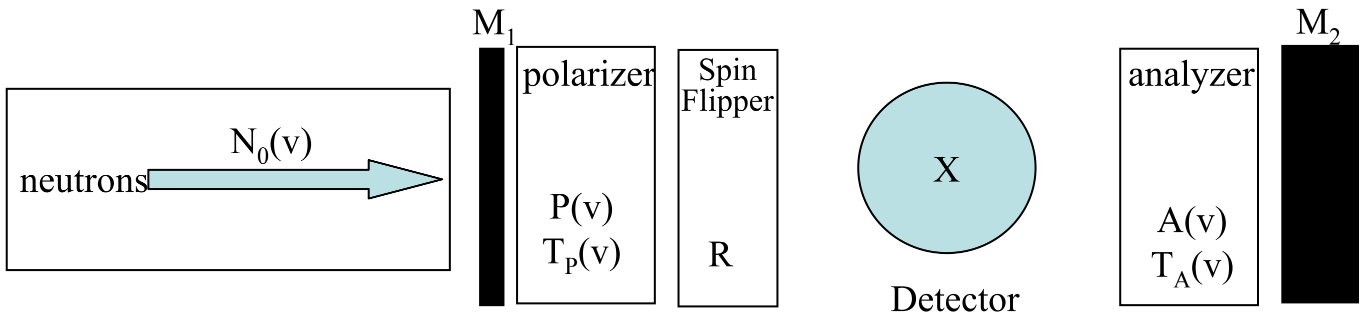


General Design Issues

Goal: $\sigma_x/x \sim 10^{-3}$ or better

- Neutron spin transported adiabatically from polarizer to analyzer (through detector)
- Uniform B in decay region: mitigates proton reflections from magnetic traps
- Proton orbit: d= 8 mm/B(T): 1-2T Needed (2 T for emiT proton segment
- Electrostatic proton energy resolution desired: requirements on B in proton drift region TBA
- Vacuum requirements: TBA

Neutron Polarization and Polarimetry



$\Gamma_{\pm} = \Sigma \pm \Delta \quad R_{Exp} = \Sigma(\uparrow + \downarrow) + \Delta(\uparrow - \downarrow) = N_0 T_1 T_2 T_P [\Gamma_0 + \Delta P R]$

$M_1 = N_0 \varepsilon_1 + B_1 \qquad M_2 = N_0 T_1 T_2 T_P T_A \varepsilon_3 [\, 1 + PAR \,] + B_2$

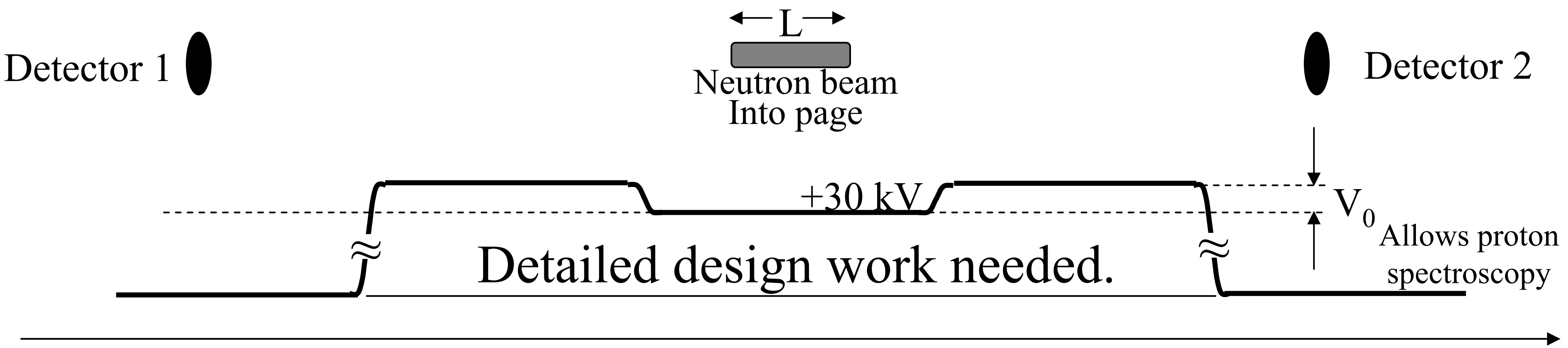
P/A	P_n (5Å)	T_n	P^2T	features
PSM	99.x%	10%	0.1	fixed; limited λ bite
^{3}He (60%)	80%	30%	0.2	flip P_3; P_3 varies

Flipper: $R^u = 1$ (unflipped); $R^f = F \approx -1$ (flipped) (-0.999 for AFP)

$$\frac{(M_2^u - M_2^f)}{(M_2^u + M_2^f)} \sim PA(1-F)\,(1-f_2)$$

(f_2:) BR (1% need to know to 0.1%)

Detector

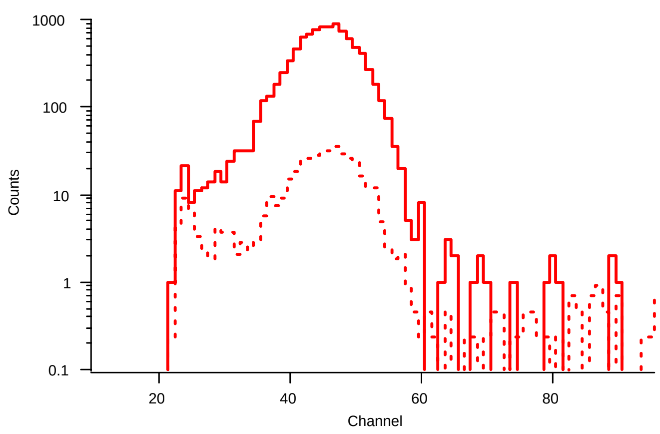


Uniform field B

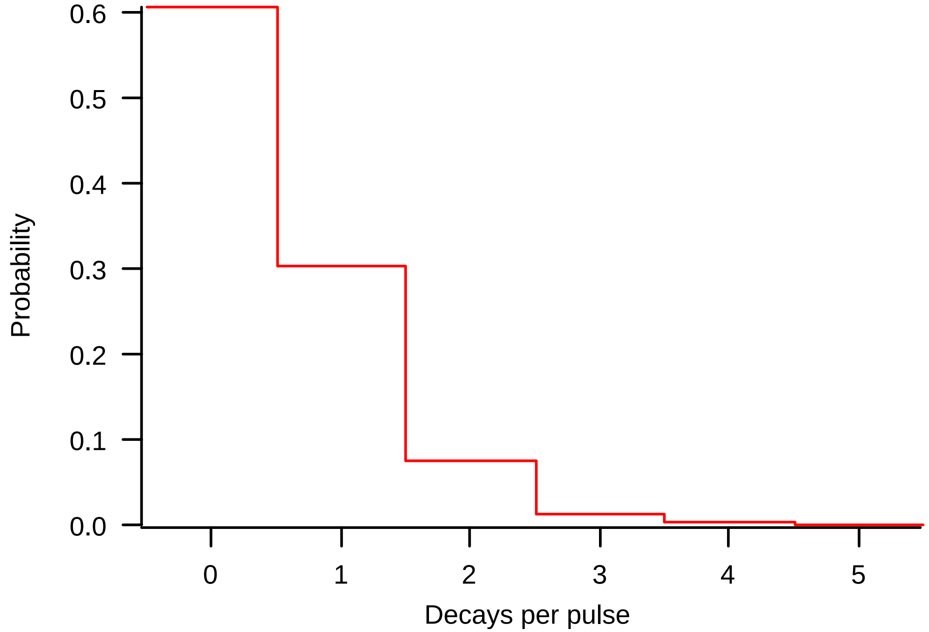
Ideal: $A_1=A_2=1$, $\varepsilon_1=\varepsilon_2=1$, $f_1=f_2=0$

- with adiabatic spin transport J||B
- with adiabatic proton orbits, A=1
  (scattering: resid. gas, baffles, etc.)

Proton detection: e.g. emiT2



Statistics



$\rho_n \sim 10^3/\text{cm}^3$

We expect about 0.5 decays per pulse: about 2.5 million events per day.
0.1% precision requires < a few days
NOT STATISTICS LIMITED
Focus on systematics…

Systematics

$$\frac{N_+ - N_-}{N_+ + N_-} = \mathbf{C}\, P_n\, A\, F\, (1-f) + A_{false}$$

Need to know: neutron polarization
analyzing power
spin flip efficiency
backgrounds
spin independent
spin dependent (false asymmetry)

e.g. False asymmetry from electrons emited from $\vec{n}$-decay (BR)
- study of proton energy dependence
Noise, gain shifts, etc.
- flip ^3He

C is INDEPENDENT of P_n, xy, L, tof, ^3He, B, BR, … statistical power