Neutron beta decay observables (SM)

$$\frac{dw}{dE_e d\Omega_e d\Omega_\nu} \simeq p_e E_e (E_0 - E_e)^2$$

$$\times \left[1 + a \frac{\vec{p}_e \cdot \vec{p}_\nu}{E_e E_\nu} + b \frac{m}{E_e} + \langle \vec{\sigma}_n \rangle \cdot \left(A \frac{\vec{p}_e}{E_e} + B \frac{\vec{p}_\nu}{E_\nu} \right) + \dots \right]$$

where in SM:

$$a = \frac{1 - |\lambda|^2}{1 + 3|\lambda|^2} \qquad A = -2 \frac{|\lambda|^2 + Re(\lambda)}{1 + 3|\lambda|^2}$$

$$B = 2 \frac{|\lambda|^2 - Re(\lambda)}{1 + 3|\lambda|^2} \qquad \lambda = \frac{G_A}{G_V} \text{ (with } \tau_n \Rightarrow \text{CKM } V_{ud})$$

also proton asymmetry: $C = \kappa(A + B)$ where $\kappa \simeq 0.275$.

$\Rightarrow$ SM **overconstrains** a, A, B observables in n β decay!
Fierz interf. term b adds sensitivity to non-SM processes!

Goals of the Nab experiment (at SNS, ORNL)

- Measure the electron-neutrino parameter **a** in neutron decay

  with accuracy of $\boxed{\frac{\Delta a}{a} \simeq 10^{-3}}$ or $\sim 50\times$ better than:

  current results:

-0.1054 ± 0.0055	Byrne et al '02
-0.1017 ± 0.0051	Stratowa et al '78
-0.091 ± 0.039	Grigorev et al '68

- Measure the Fierz interference term **b** in neutron decay

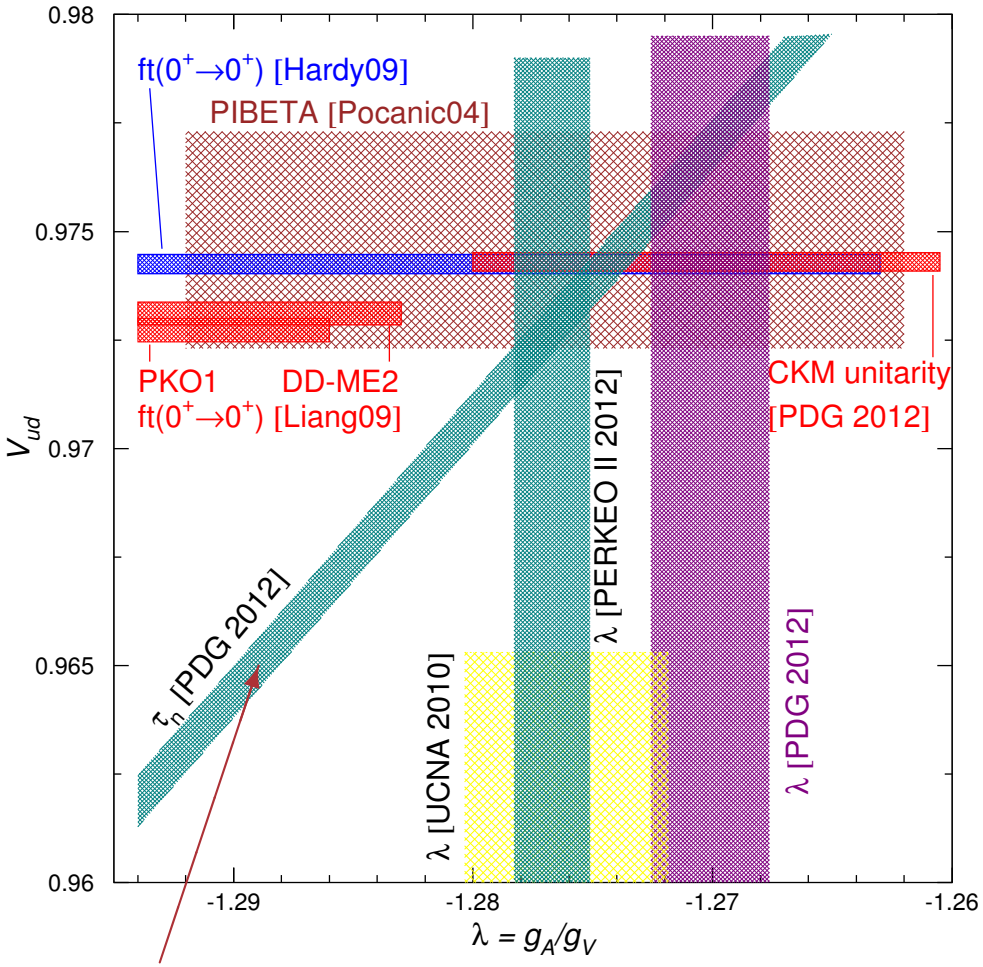
  with accuracy of $\boxed{\Delta b \simeq 3 \times 10^{-3}}$

  current results: **none** (not yet measured in n decay)

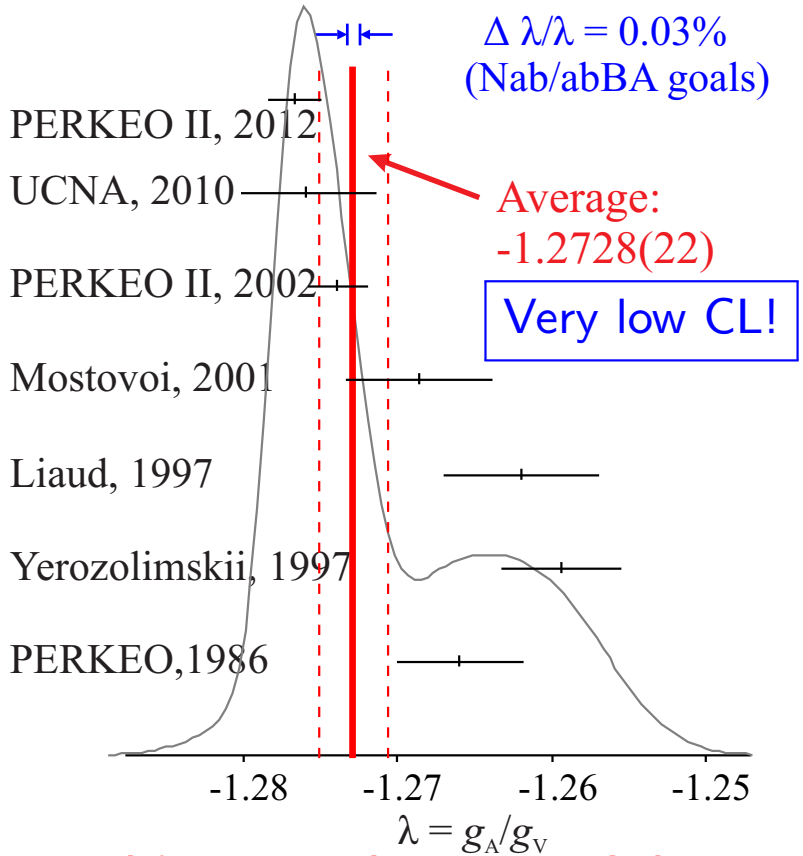
- **Nab** will be followed by the **abBA/PANDA** polarized program to measure **A**, electron, and **B/C**, neutrino/proton, asymmetries with $\simeq 10^{-3}$ relative precision, an independent measurement of λ.

Current status of V_{ud} and λ, from n decay

. . . remains an unresolved mess:



$$\tau_n^{-1} \propto |V_{ud}|^2 |g_V|^2 (1 + 3|\lambda|^2)$$



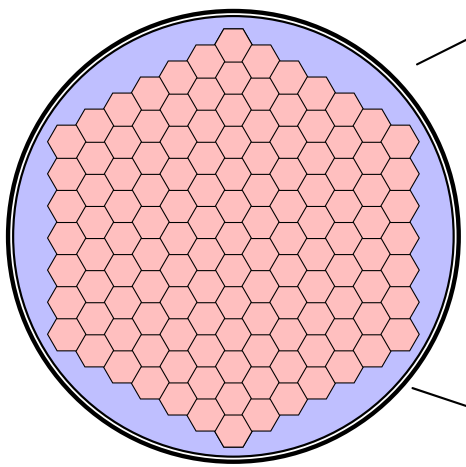
$$\frac{\Delta\lambda}{\lambda} \simeq 0.27\frac{\Delta a}{a} \simeq 0.24\frac{\Delta A}{A}$$

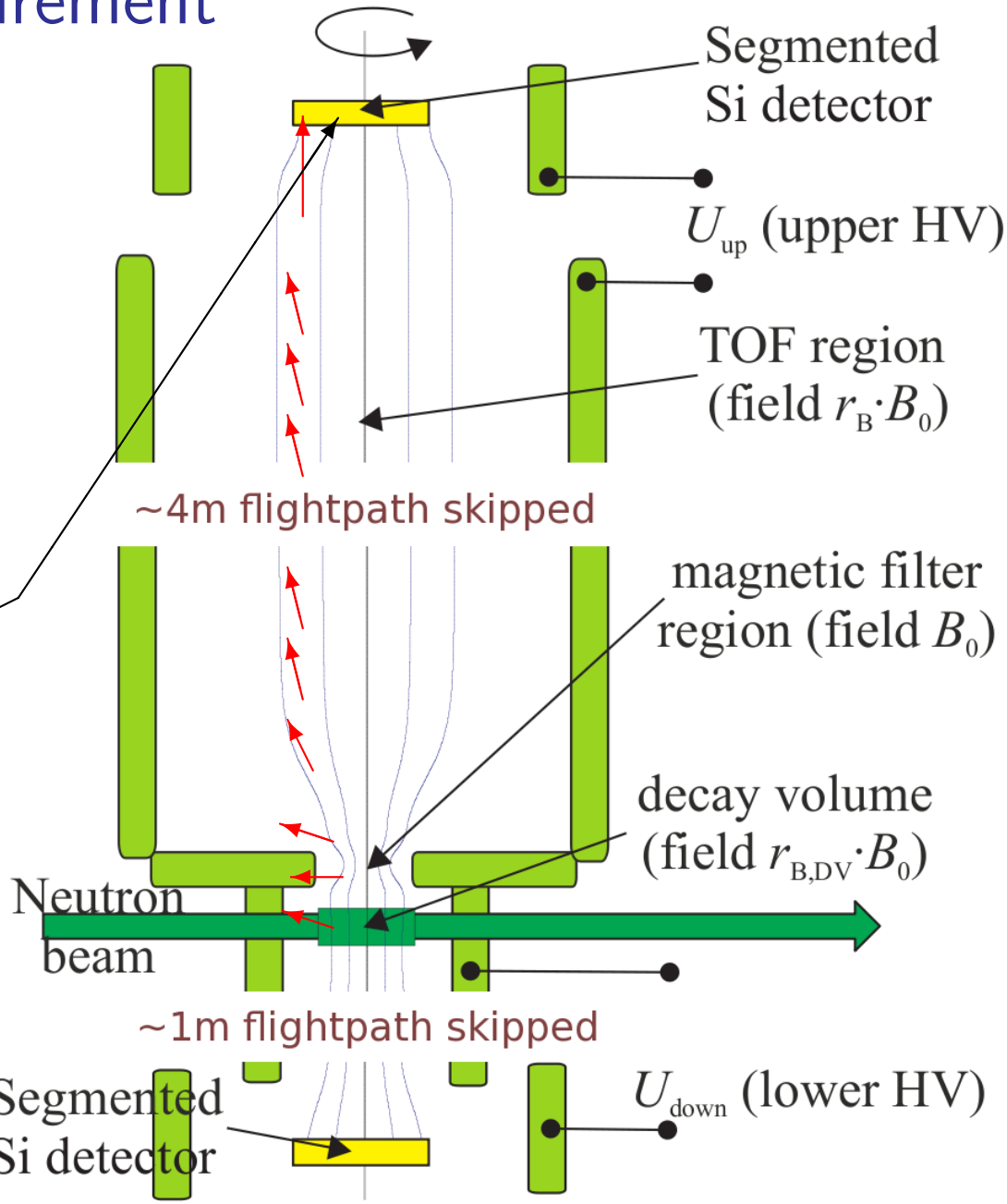
λ sensitivity to a, A is **similar**.

- Nab+abBA $\Rightarrow$ several independent $\sim 0.03\%$ determinations of λ,
- Combined with b $\Rightarrow$ new limits on non-SM terms, esp. RH Tensor.

Nab principles of measurement

- Collect and detect both electron and proton from neutron beta decay.
- Measure E_e and TOF_p and reconstruct decay kinematics
- Segmented Si det's:

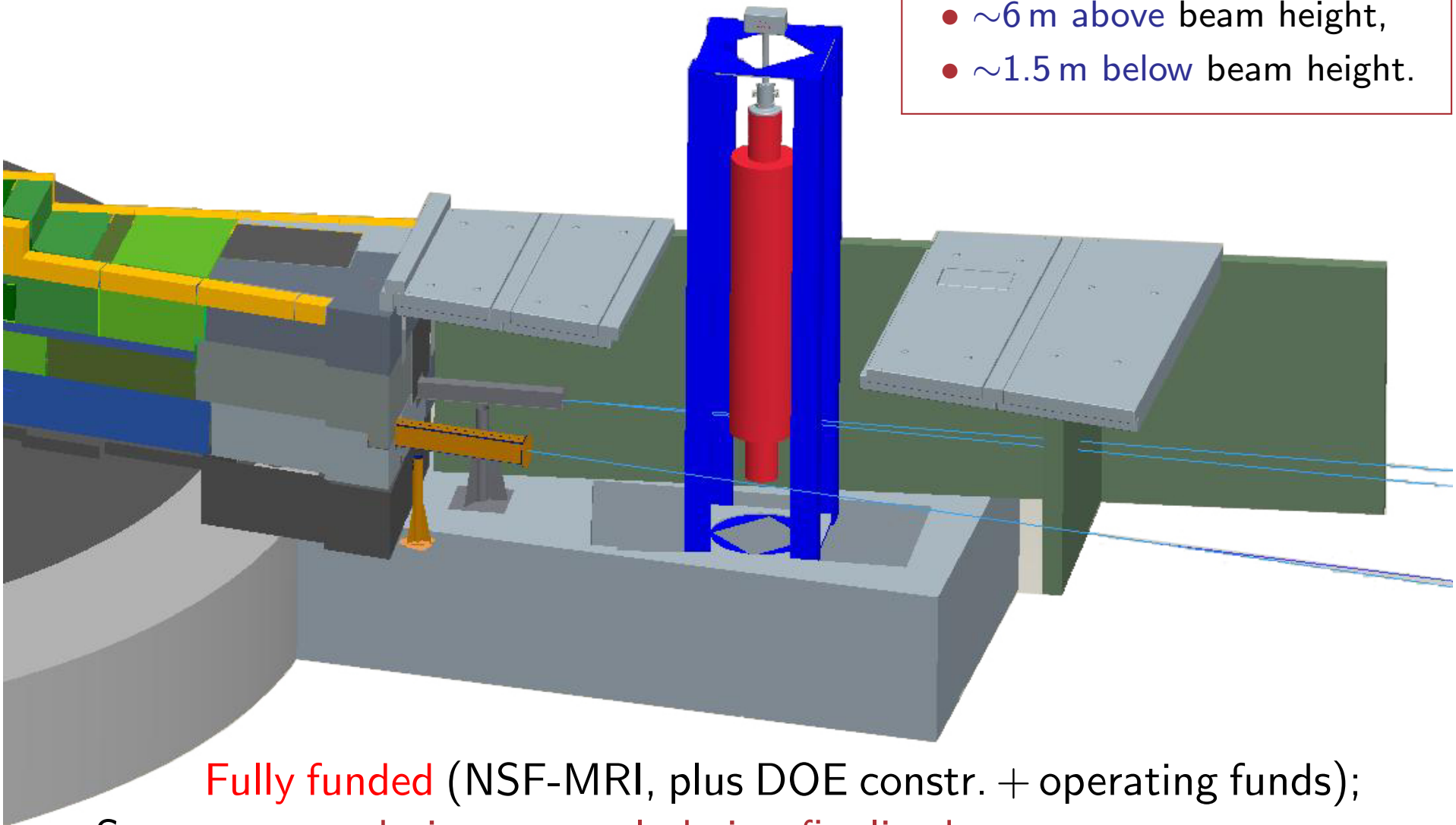




Nab apparatus in FnPB

Apparatus extends:

- ∼6 m above beam height,
- ∼1.5 m below beam height.



Fully funded (NSF-MRI, plus DOE constr. + operating funds);
Spectrometer design currently being finalized;
Experiment projected to be ready for beam sometime in 2015.