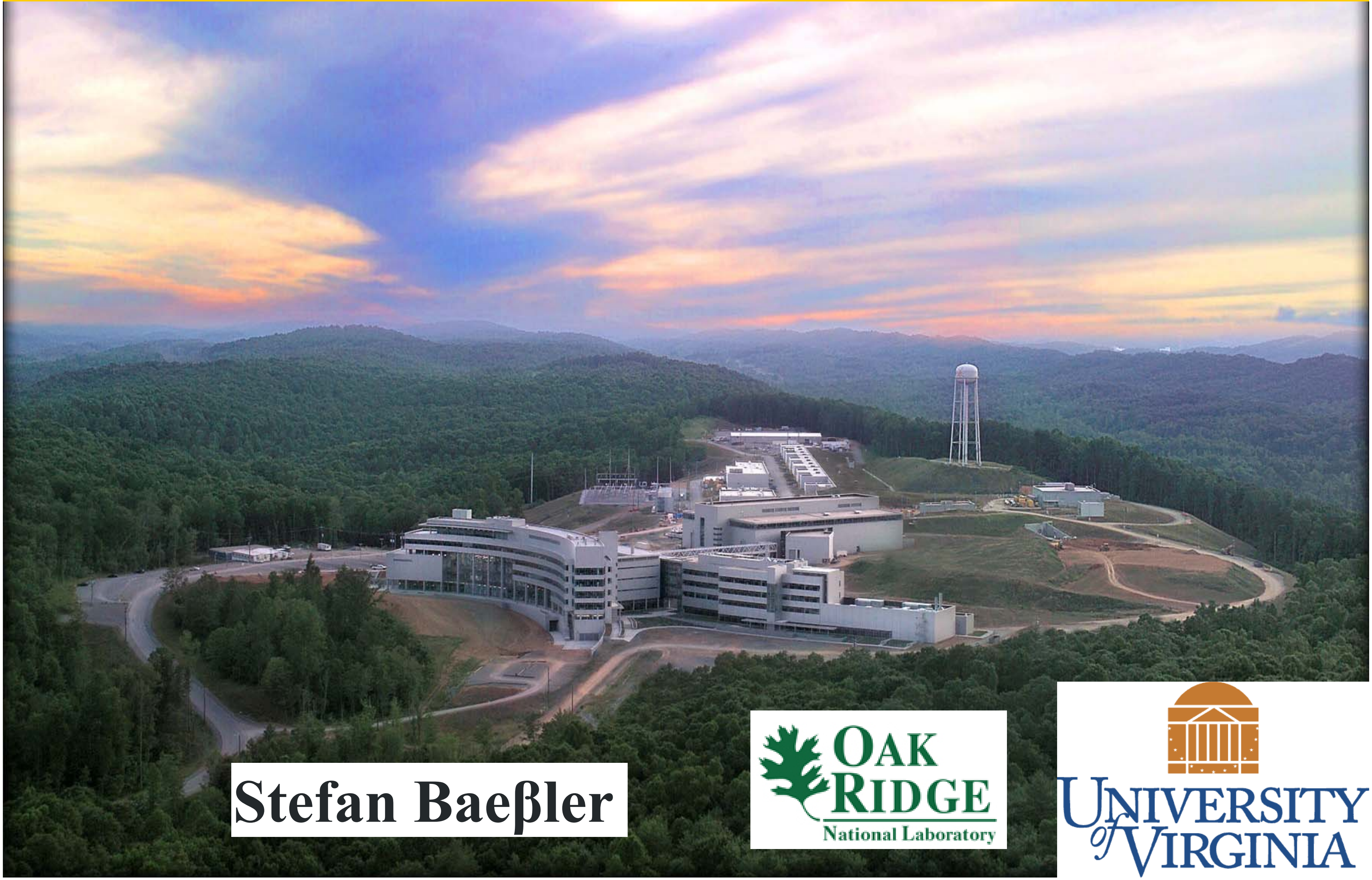
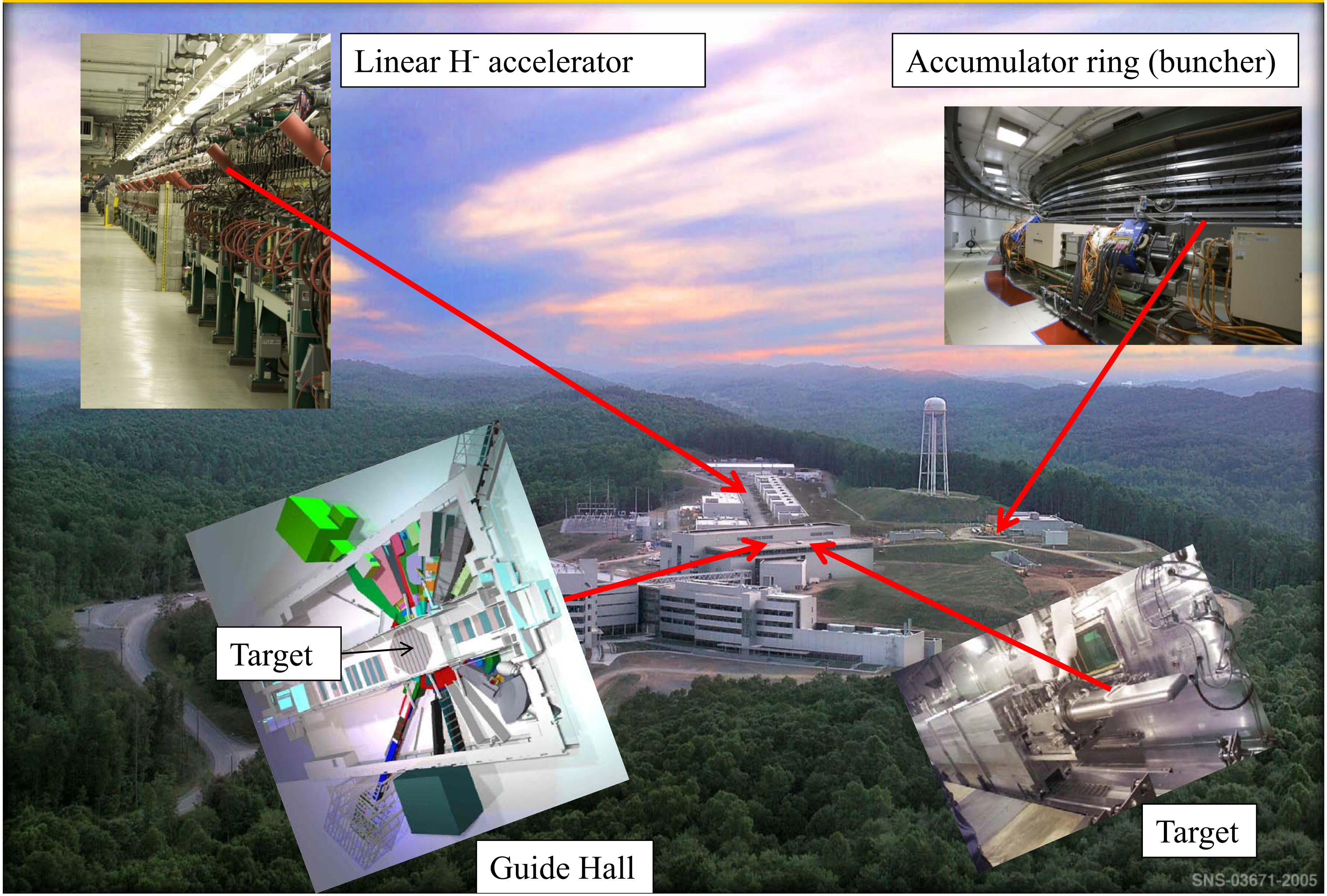
The planned Nab/abBA/PANDA spectrometer



Stefan Baeßler

The Spallation Neutron Source SNS in Oak Ridge, TN



Linear H^- accelerator

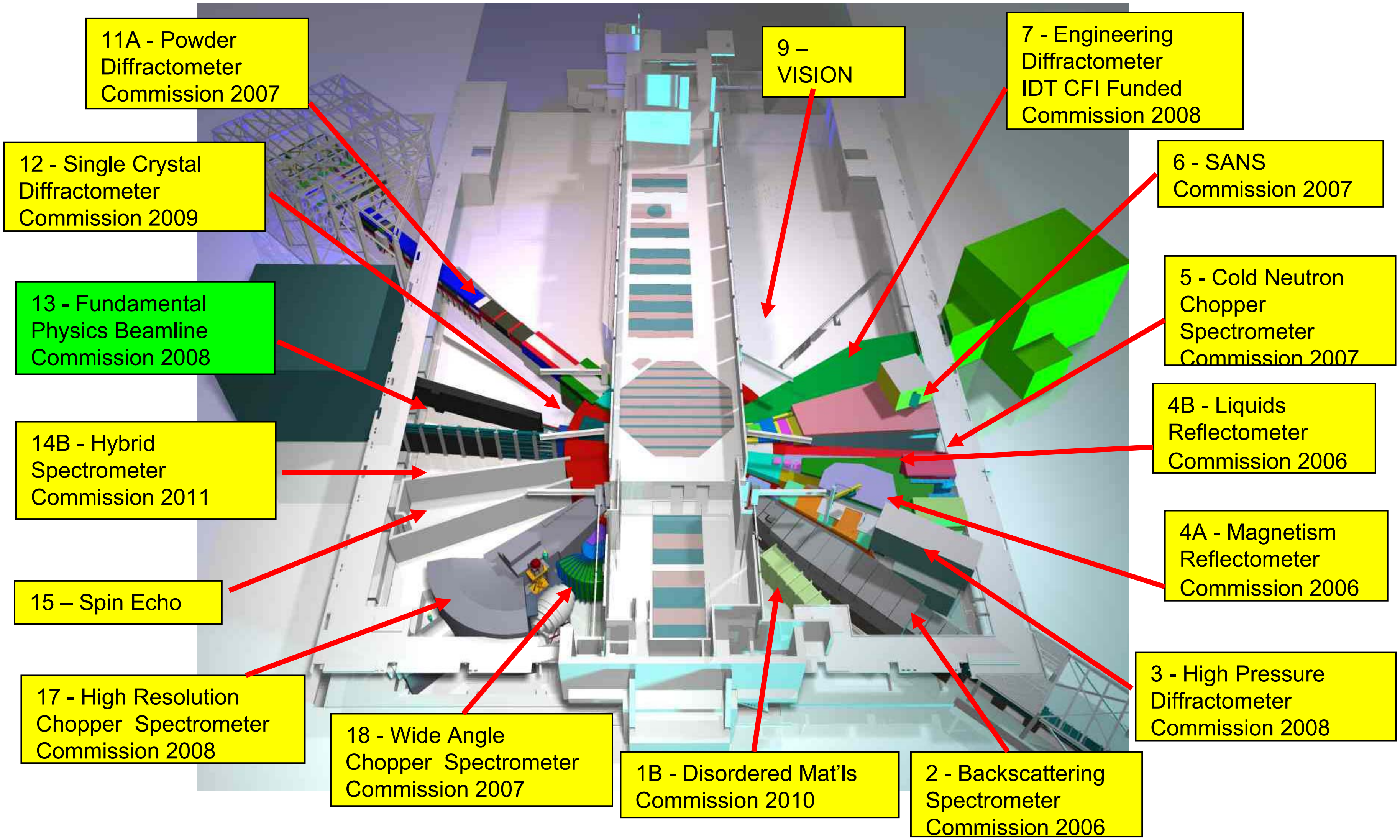
Accumulator ring (buncher)

Target

Guide Hall

Target

Usage of neutrons @ SNS



11A - Powder
Diffractometer
Commission 2007

12 - Single Crystal
Diffractometer
Commission 2009

13 - Fundamental
Physics Beamline
Commission 2008

14B - Hybrid
Spectrometer
Commission 2011

15 – Spin Echo

17 - High Resolution
Chopper Spectrometer
Commission 2008

18 - Wide Angle
Chopper Spectrometer
Commission 2007

1B - Disordered Mat'ls
Commission 2010

2 - Backscattering
Spectrometer
Commission 2006

3 - High Pressure
Diffractometer
Commission 2008

4A - Magnetism
Reflectometer
Commission 2006

4B - Liquids
Reflectometer
Commission 2006

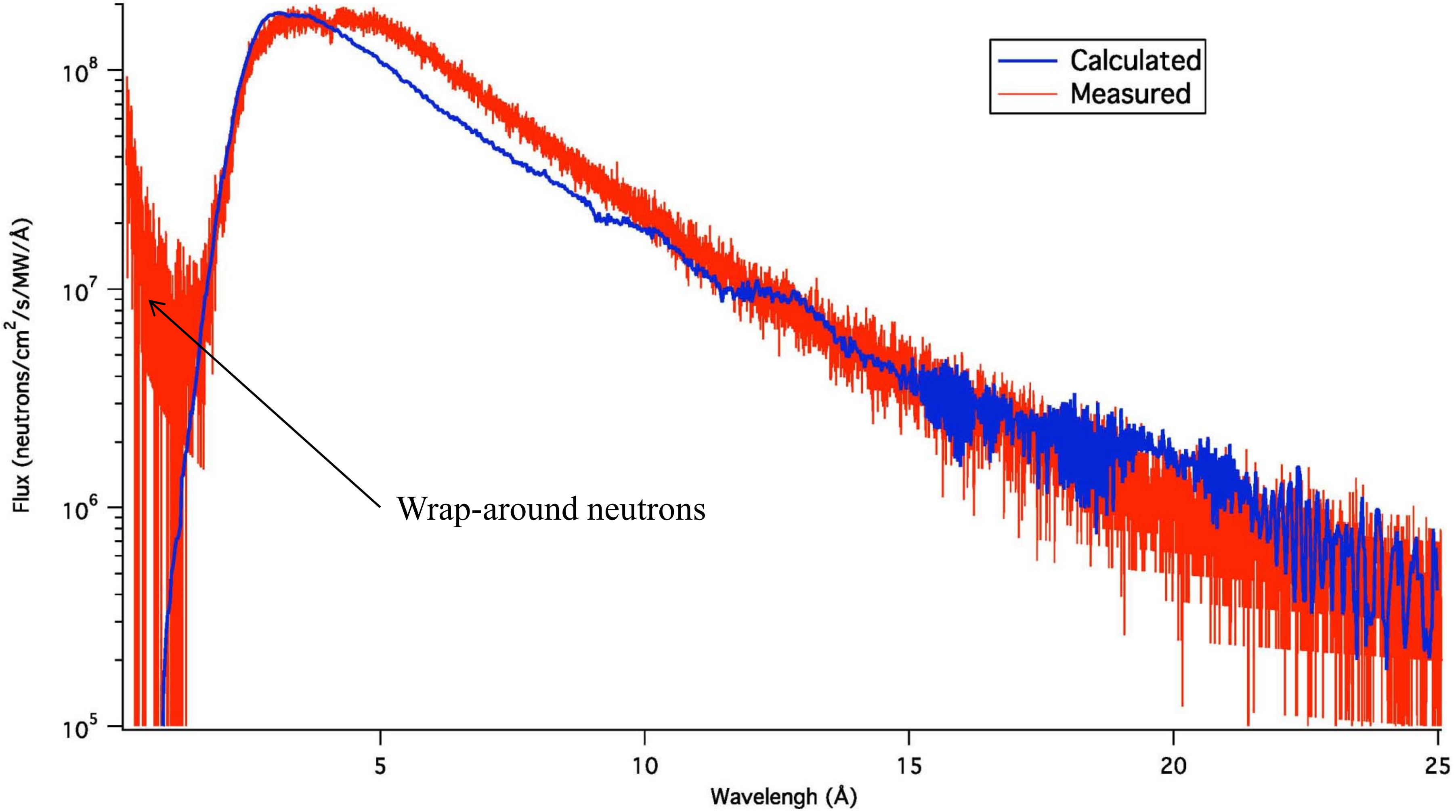
5 - Cold Neutron
Chopper
Spectrometer
Commission 2007

6 - SANS
Commission 2007

7 - Engineering
Diffractometer
IDT CFI Funded
Commission 2008

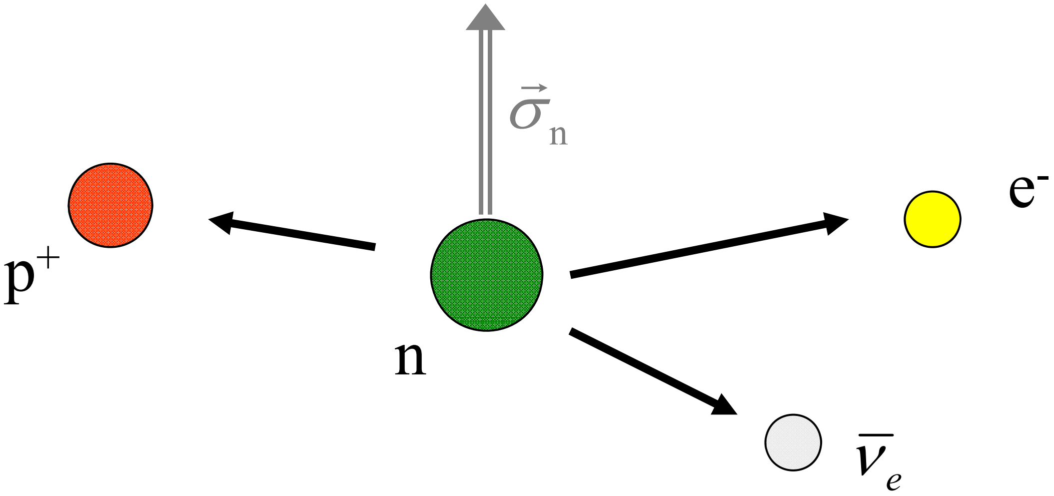
9 –
VISION

Performance of FNPB beamline



Measured (@1 MW) neutron capture flux at FNPB beam exit: $\Phi_c = 4\times10^9 \cdot \frac{1}{\mathrm{cm}^2\mathrm{s}}$ @ 1.4 MW

Neutron beta decay

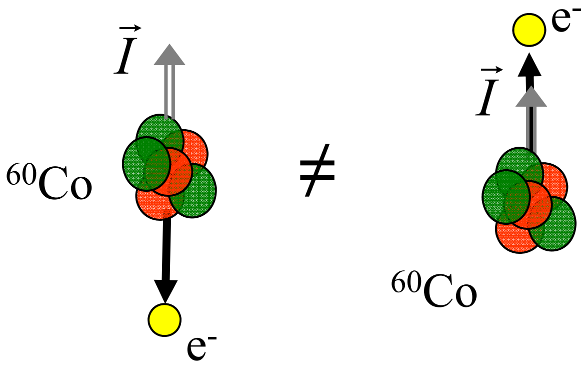


Beta Decay in the Standard Model

Fermi's golden rule:

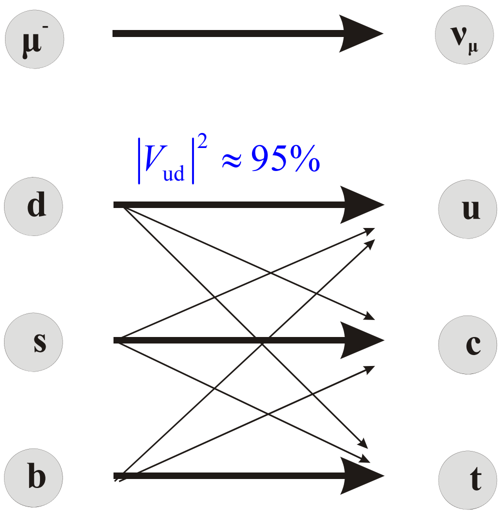
decay probability $\Gamma_{i\rightarrow f} = \frac{2\pi}{\hbar}\left|\left\langle f\left|H_{\text{weak}}\right|i\right\rangle\right|^2 \rho$

Parity Violation found by Wu et al, 1956



$$H_{\text{weak}} = \frac{G_F V_{ud}}{\sqrt{2}}\left\langle p\left|1\cdot\gamma^\mu + \lambda\gamma^\mu\gamma^5\right|n\right\rangle\left\langle e^-\left|\gamma_\mu - \gamma_\mu\gamma_5\right|\nu_e\right\rangle + \text{h.c.}$$

1. Quark mixing



2. Nucleon structure effects

$g_V = G_F \cdot V_{ud} \cdot 1$

$g_A = G_F \cdot V_{ud} \cdot \lambda$

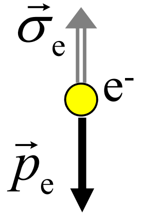
No nuclear structure effects

(for neutrons)

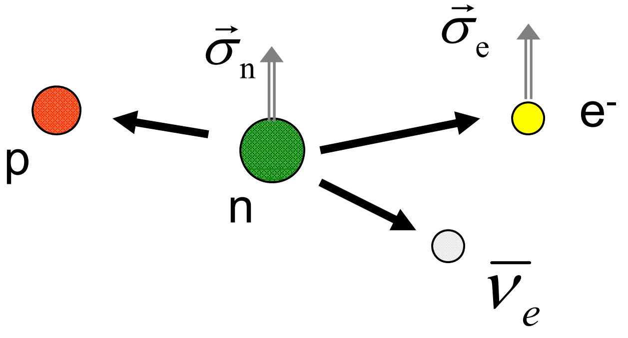
3. Helicity

… of elementary fermions: $-p/E$,

… of elementary anti-fermions: $+p/E$



Observables in Neutron Beta Decay



Jackson et al., PR 106, 517 (1957):

Observables in Neutron beta decay, as a function of generally possible coupling constants (assuming only Lorentz-Invariance)

$$dw \propto \rho(E_{\mathrm{e}}) \cdot \left(1+3|\lambda|^2\right) \cdot \left\{1 + a\frac{\vec{p}_{\mathrm{e}} \cdot \vec{p}_{\nu}}{E_{\mathrm{e}} E_{\nu}} + b\frac{m_{\mathrm{e}}}{E_{\mathrm{e}}} + \vec{\sigma}_{\mathrm{n}} \cdot \left(A\frac{\vec{p}_{\mathrm{e}}}{E_{\mathrm{e}}} + B\frac{\vec{p}_{\nu}}{E_{\nu}} + D\frac{\vec{p}_{\mathrm{e}} \times \vec{p}_{\nu}}{E_{\mathrm{e}} E_{\nu}} \right) \right\}$$

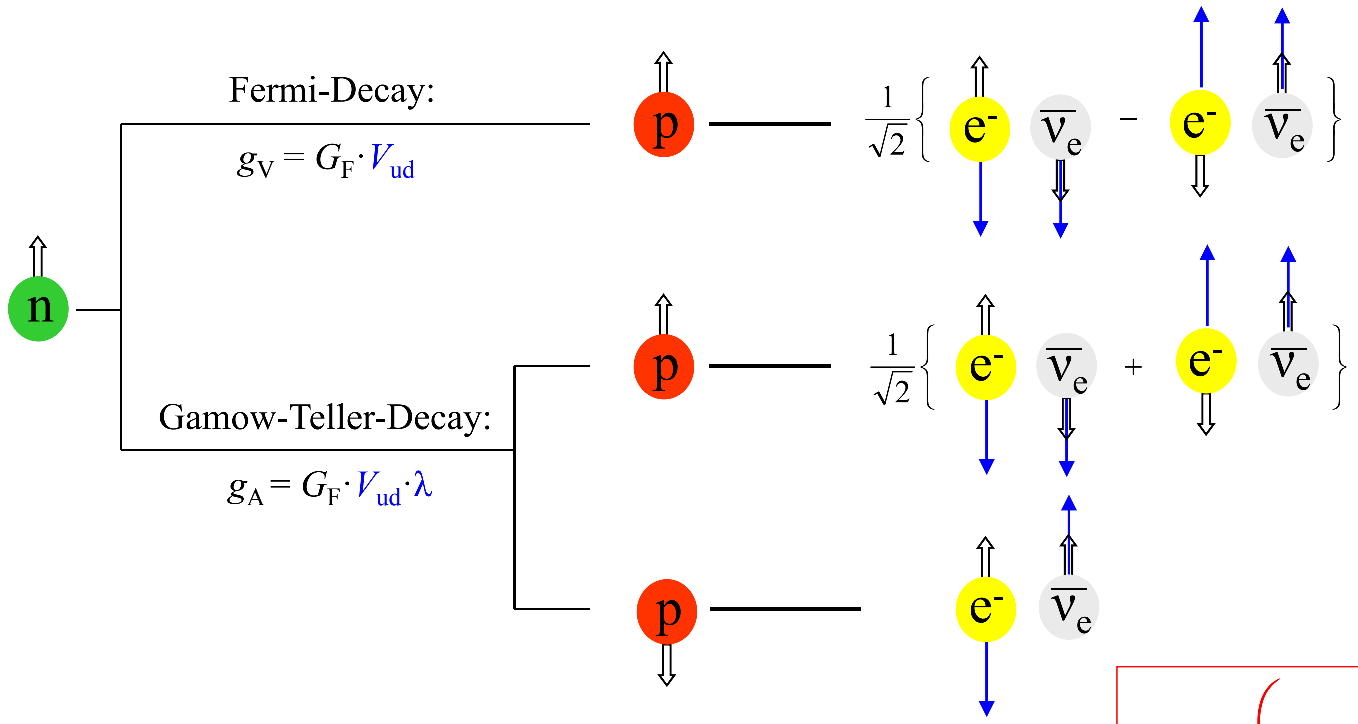
Fierz interference term $b = 0$

Beta-Asymmetry $A = -2\frac{|\lambda|^2 + \mathrm{Re}\,\lambda}{1+3|\lambda|^2}$

Neutrino-Electron-Correlation $a = \frac{1-|\lambda|^2}{1+3|\lambda|^2}$

Neutron lifetime $\tau_{\mathrm{n}}^{-1} = \frac{2\pi}{\hbar} G_F^2 V_{\mathrm{ud}}^{2} \left(1+3|\lambda|^2\right) \int \rho(E_{\mathrm{e}})$

The Standard Model Parameters V_{ud} and λ



Fermi-Decay:

$g_V = G_F \cdot V_{\text{ud}}$

Gamow-Teller-Decay:

$g_A = G_F \cdot V_{\text{ud}} \cdot \lambda$

$S = 0, m_S = 0$ $A = 0$

$S = 1, m_S = 0$ $A = 0$

$S = 1, m_S = 1$ $A = -1$

(after D. Dubbers, Prog. Part. Nucl. Phys. 26, 173 (1991))

$$\boxed{dw \propto \left(1 + A\frac{p_e}{E_e}\cos\left(p_e, \sigma_n\right)\right)}$$

Two unknown parameters, g_A and g_V, need to be determined in 2 experiments

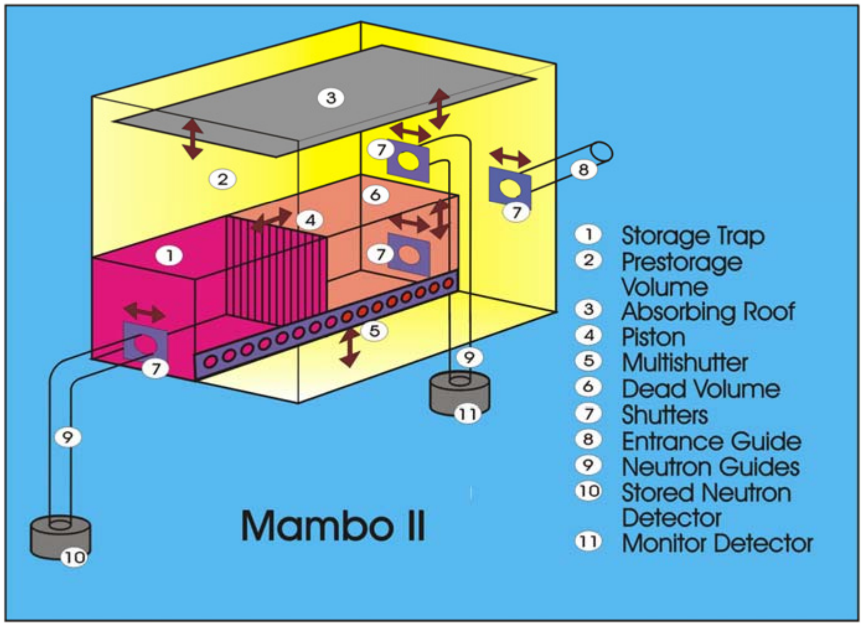
1. Neutron-Lifetime: $\tau_n^{-1} \propto \left(g_V^2 + 3g_A^2\right)$ $\tau_n \approx 885\ \text{s}$

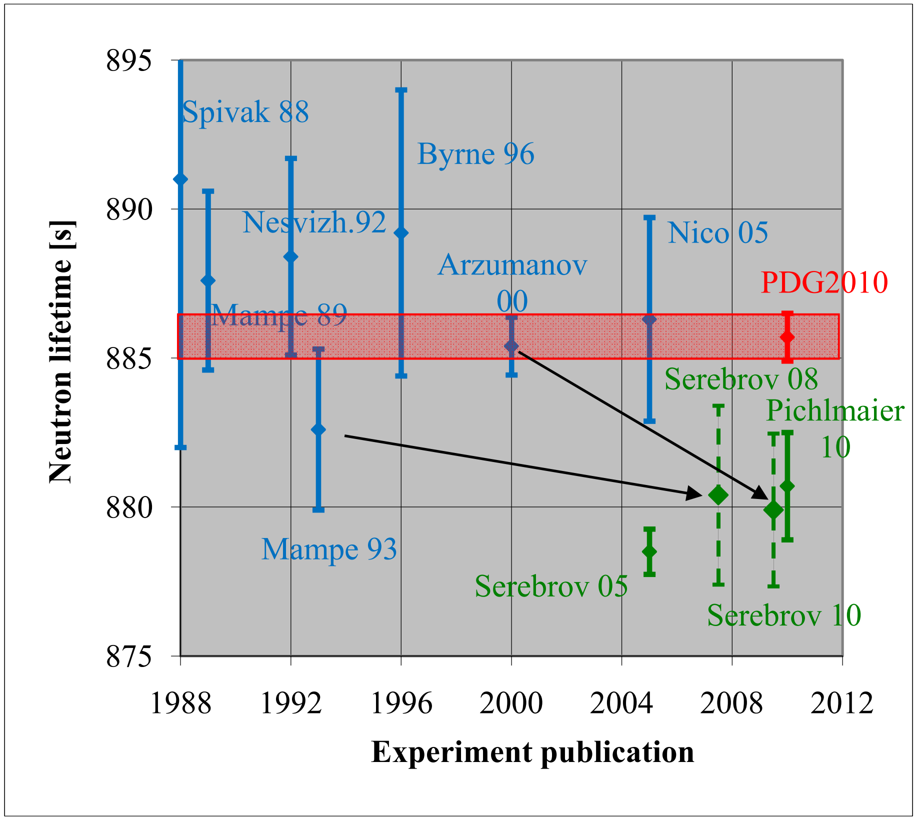
2. Beta-Asymmetry: $A = -2\dfrac{\lambda^2 + \lambda}{1 + 3\lambda^2} \approx -0.1$ $\lambda = \dfrac{g_A}{g_V}$

Neutron Lifetime Measurements

Decrease of Neutron Counts N with storage time t: $N(t) = N(0)\exp\{-t/\tau_{\mathrm{eff}}\}$

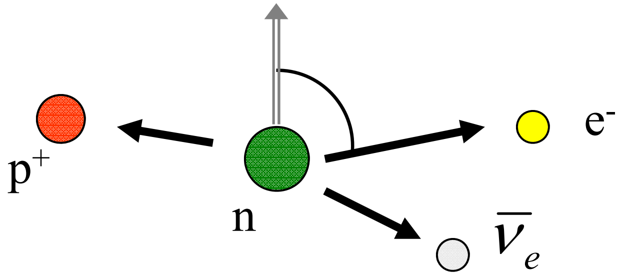
$1/\tau_{\mathrm{eff}} = 1/\tau_{\beta} + 1/\tau_{\mathrm{wall\ losses}}$

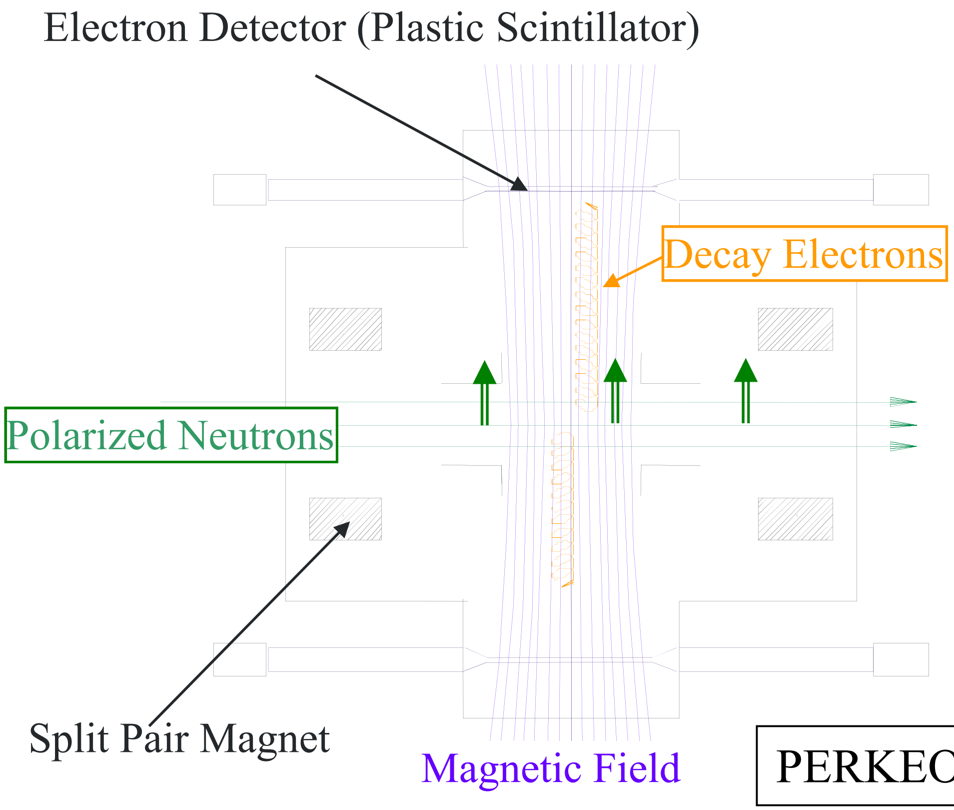




Many new attempts, mostly with UCN in magnetic bottles: Ezhov et al. (ILL, PNPI Gatchina), Arzumanov et al. (Kurchatov Inst., ILL), Liu et al. (Indiana), Paul et al. (TUM), Huffman et al. (NIST, NCSU), Nico et al. (NIST), Zimmer et al., (ILL) are (at least) under construction.

The Beta Asymmetry




Electron Detector (Plastic Scintillator)

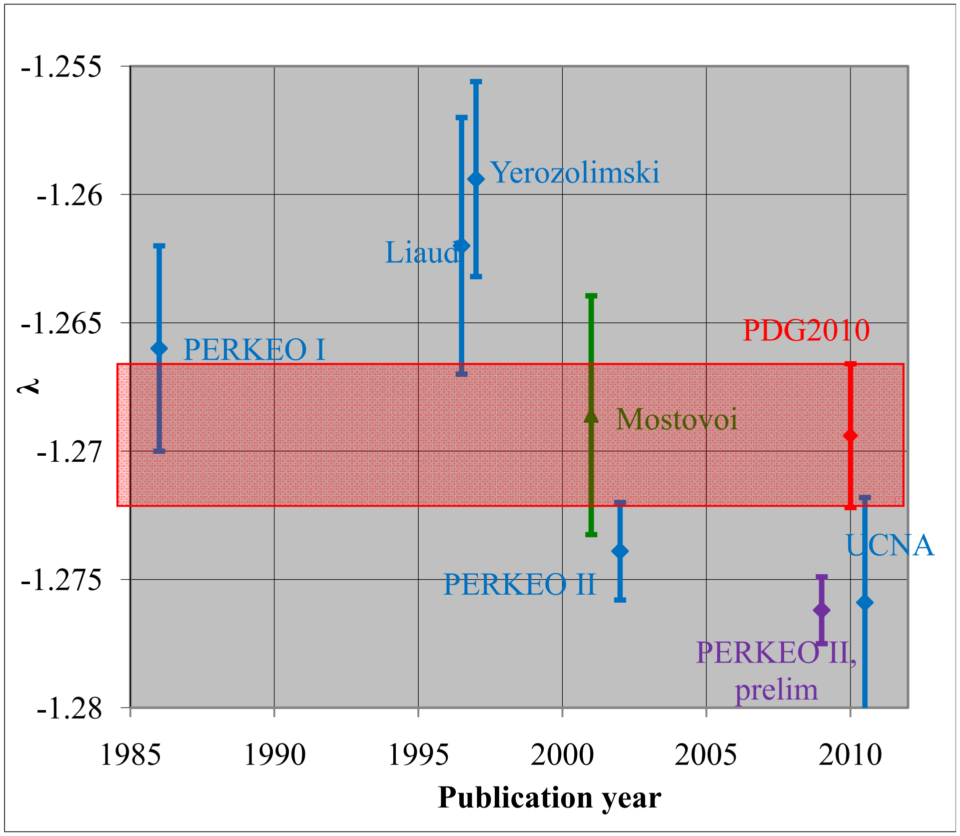
Decay Electrons

Polarized Neutrons

Split Pair Magnet

Magnetic Field

PERKEO II

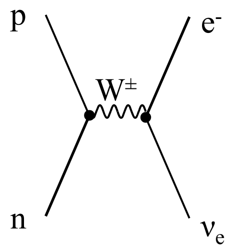


Ongoing funded experiments:
UCNA (NCSU, LANL), PERKEO III (Heidelberg), PERC (Europe)

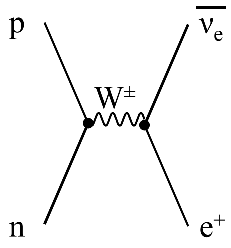
Use of coupling constants in Primordial Nucleosynthesis

Before Phase Transition:

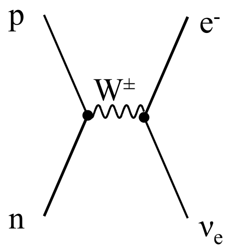
Equilibrium



$n + \nu_e \leftrightarrow p + e^-$



$n + e^+ \leftrightarrow p + \bar{\nu}_e$



$n \leftrightarrow p + e^- + \bar{\nu}_e$

After Phase Transition (some minutes after Big Bang):

$n + p \rightarrow d + \gamma$ $\qquad$ $d + d \rightarrow {}^3He + n \rightarrow t + p$

$d + {}^3He \rightarrow {}^4He + p$ $\qquad$ …..

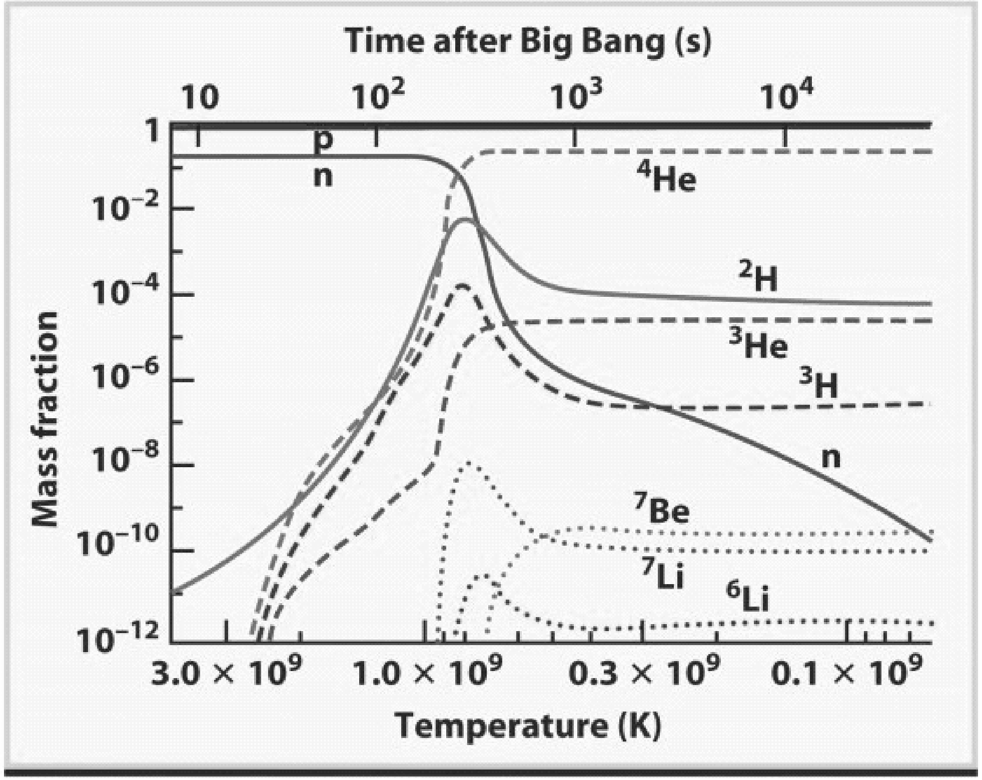
Then the Primordial Nucleosynthesis stops, as there are no stable nuclei with A = 5, 8, and as the free neutrons die out.

Stronger coupling constants in n ↔ p reactions

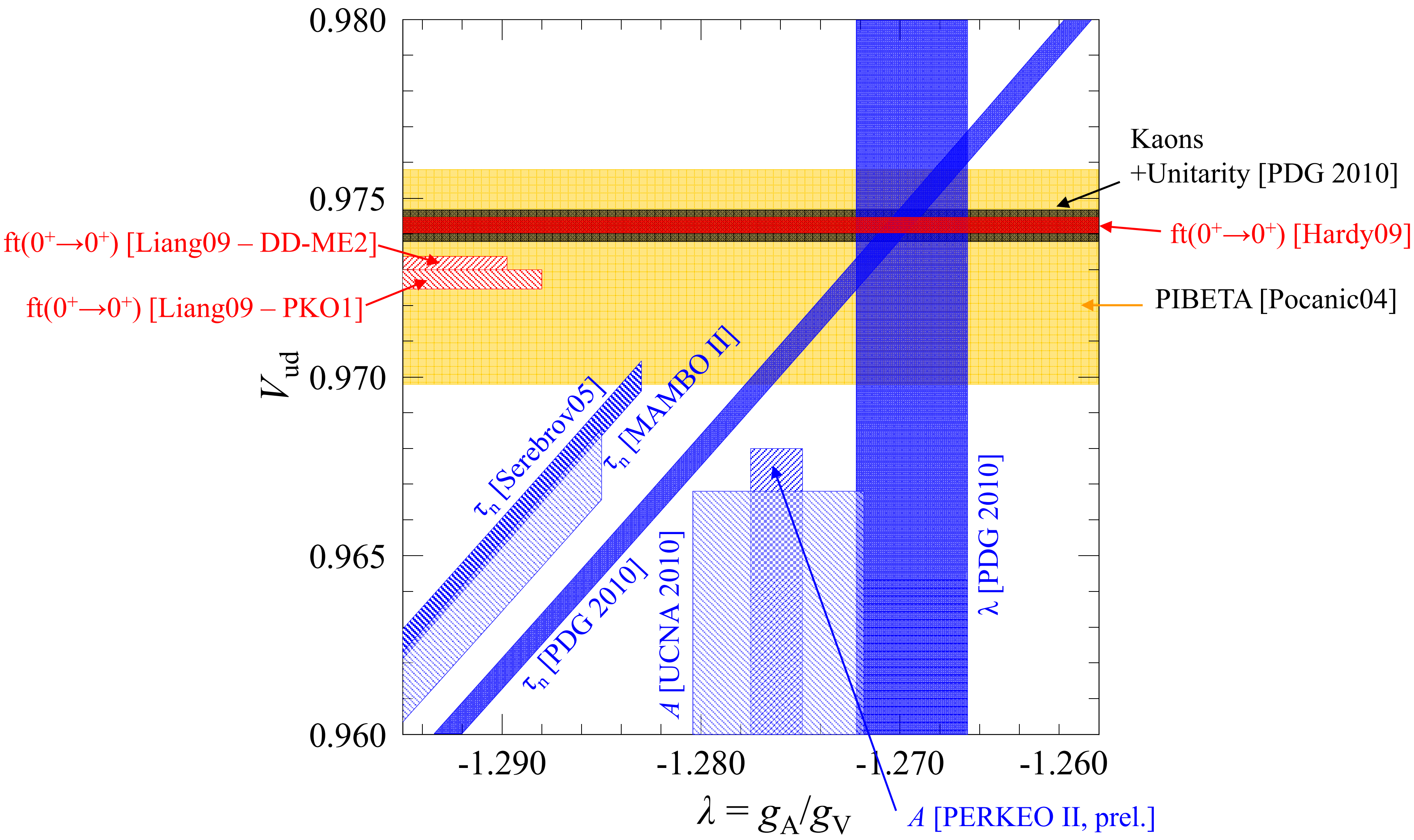
⇒ Phase transition later

⇒ nucleon density lower after phase transition

⇒ less ^4He, more d



Search for Standard Model Parameters



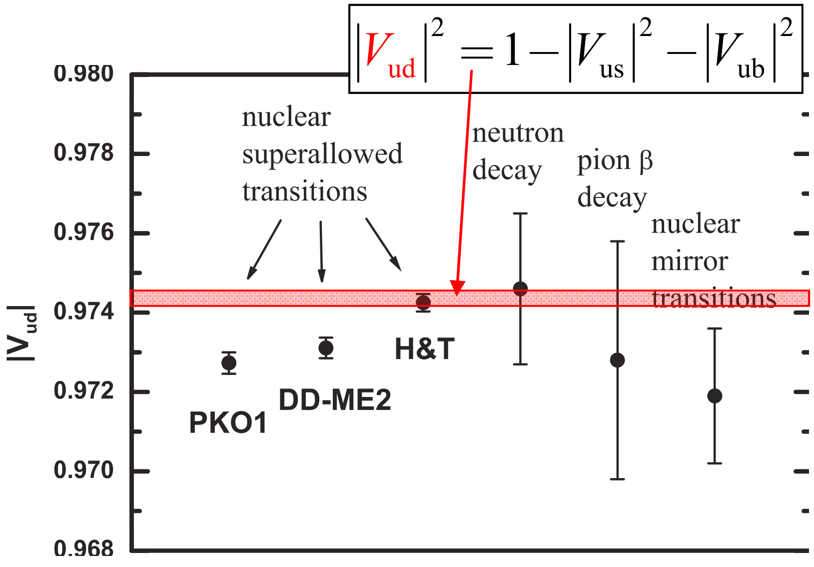
Unitarity and superallowed nuclear decays

V. Telegdi, 1977:

I would like to say that the theory of β-decay is the theory of the decay of the neutron. I have always thought that nuclear β-decay experiments were only done *faute de mieux*: … If you do not know how to do the one experiment, you take the average of twenty.

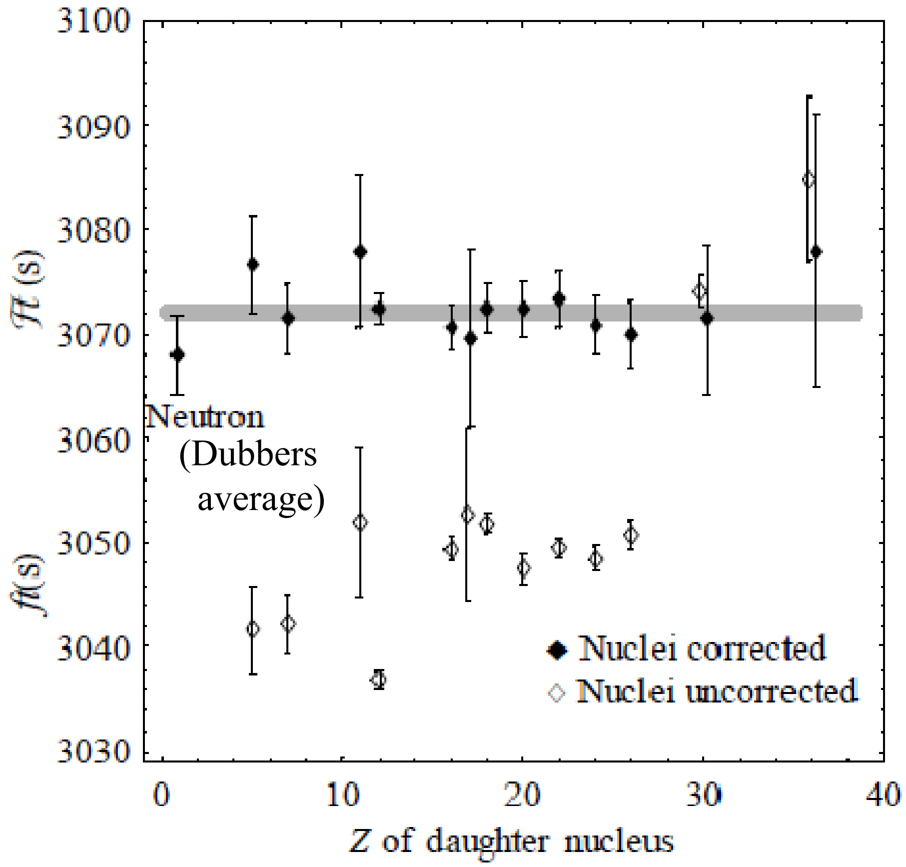
$$\overline{Ft} \propto g_V{}^2 = G_F{}^2 \left|V_{ud}\right|^2$$

$$\left|V_{ud}\right|^2 \propto \frac{1}{2G_F{}^2\left(1+\Delta_R^V\right)\overline{Ft}}$$



$$\left|V_{ud}\right|^2 = 1 - \left|V_{us}\right|^2 - \left|V_{ub}\right|^2$$

Liang et al., PRC 79, 064316 (2009)



Dubbers, Schmidt, RMP (2011), in press

Possible Tests of the Standard Model

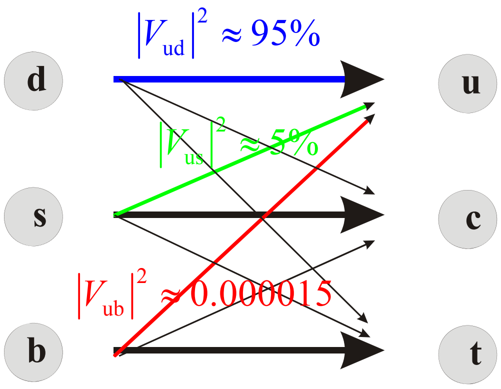
Multiple determinations (nuclear physics, other correlation coefficients) overconstrain problem, enable:

1. Search for Right-handed Currents (leptons are righthanded): W_R?
2. Search for Scalar and Tensor interactions (neutrinos have opposite handedness to electrons – 4 new coupling constants possible):

   Leptoquarks? Charged Higgs Bosons? Supersymmetry?

3. Test of the Unitarity of the Cabbibo-Kobayashi-Maskawa-Matrix:

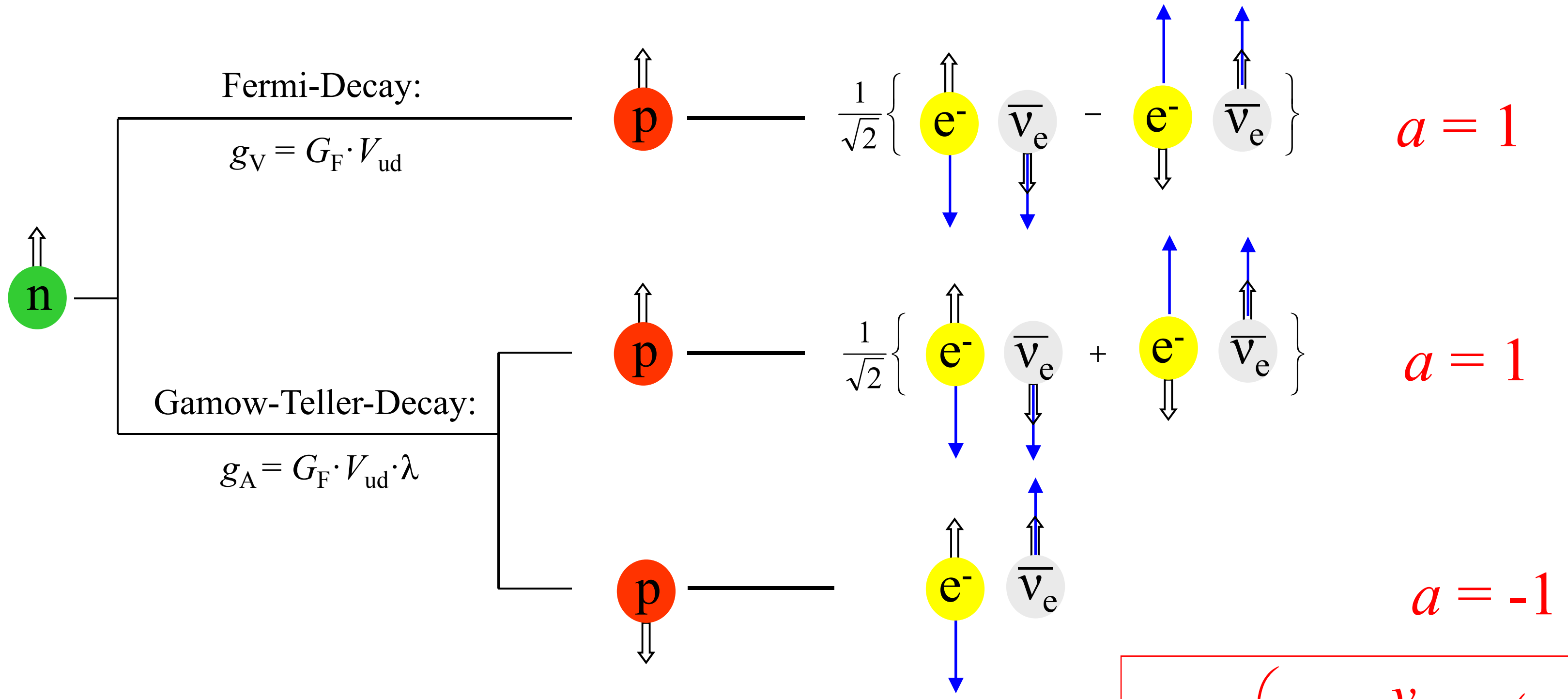
   Extra Z bosons? Supersymmetry? 4th quark generation?



$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{td} & V_{tb} \end{pmatrix} \cdot \begin{pmatrix} d \\ s \\ b \end{pmatrix}$$

$$|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 = 1 + ?$$

Determination of the Coupling Constants



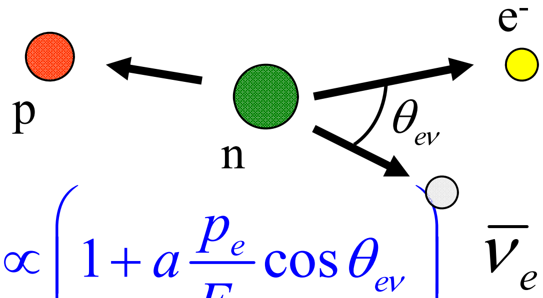
$$\boxed{dw \propto \left(1 + a\frac{v}{c}\cos\left(p_e, p_{\bar{\upsilon}_e}\right)\right)}$$

Two unknown parameters, g_A and g_V, need to be determined in 2 experiments

1. Neutron-Lifetime: $\tau_n^{-1} \propto \left(g_V^2 + 3g_A^2\right)$ $\tau_n \approx 885\ \mathrm{s}$

2b. Neutrino-Electron-Correlation *a*: $a = \frac{1-\lambda^2}{1+3\lambda^2} \sim -0.1$ $\lambda = \frac{g_A}{g_V}$

Idea of the cos $\theta_{e\nu}$ spectrometer Nab @ SNS

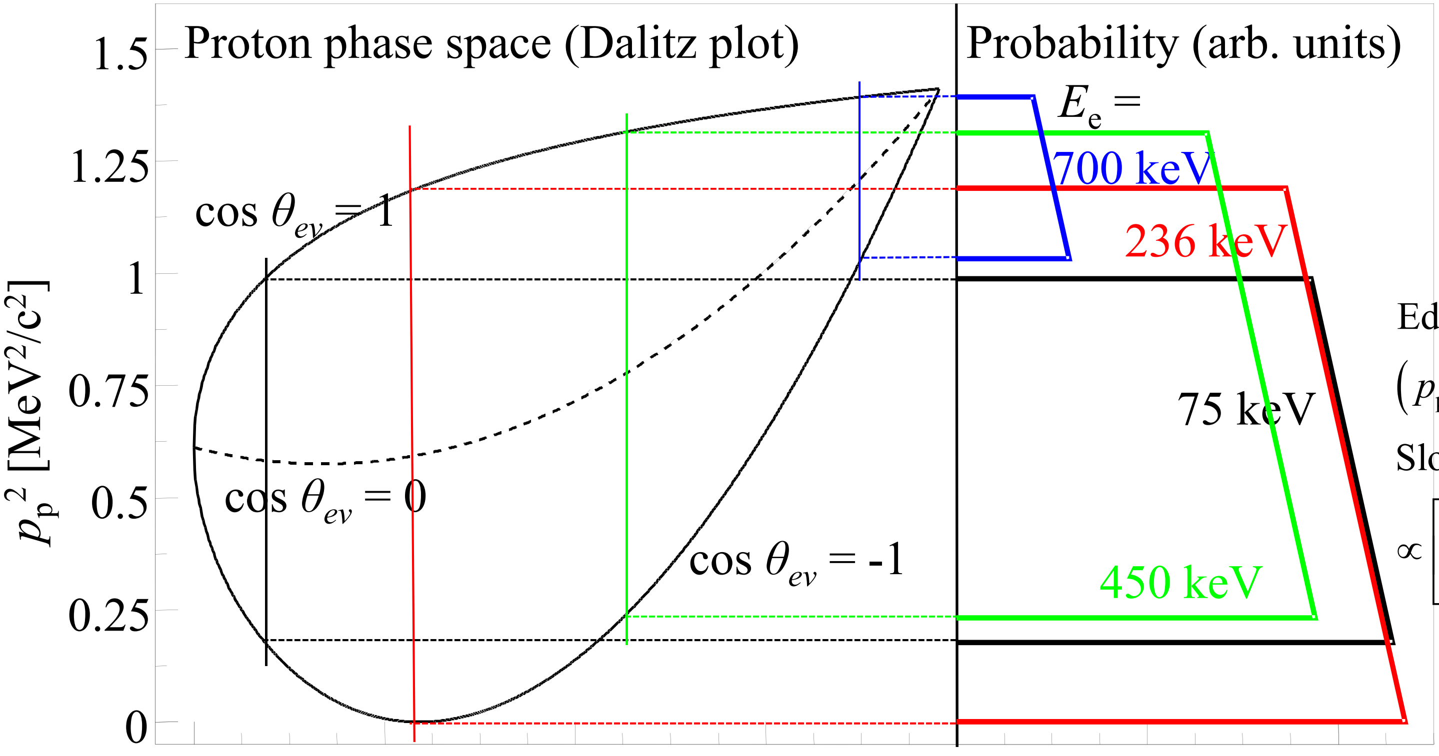


$$dw \propto \left(1 + a\frac{p_e}{E_e}\cos\theta_{e\nu}\right)$$

Kinematics:

- Energy Conservation: $E_\nu = E_{\mathrm{e,max}} - E_{\mathrm{e}}$
- Momentum Conservation

$$p_{\mathrm{p}}{}^2 = p_{\mathrm{e}}{}^2 + p_\nu{}^2 + 2p_{\mathrm{e}}p_\nu\cos\theta_{e\nu}$$



Proton phase space (Dalitz plot)

Probability (arb. units)

Edges:

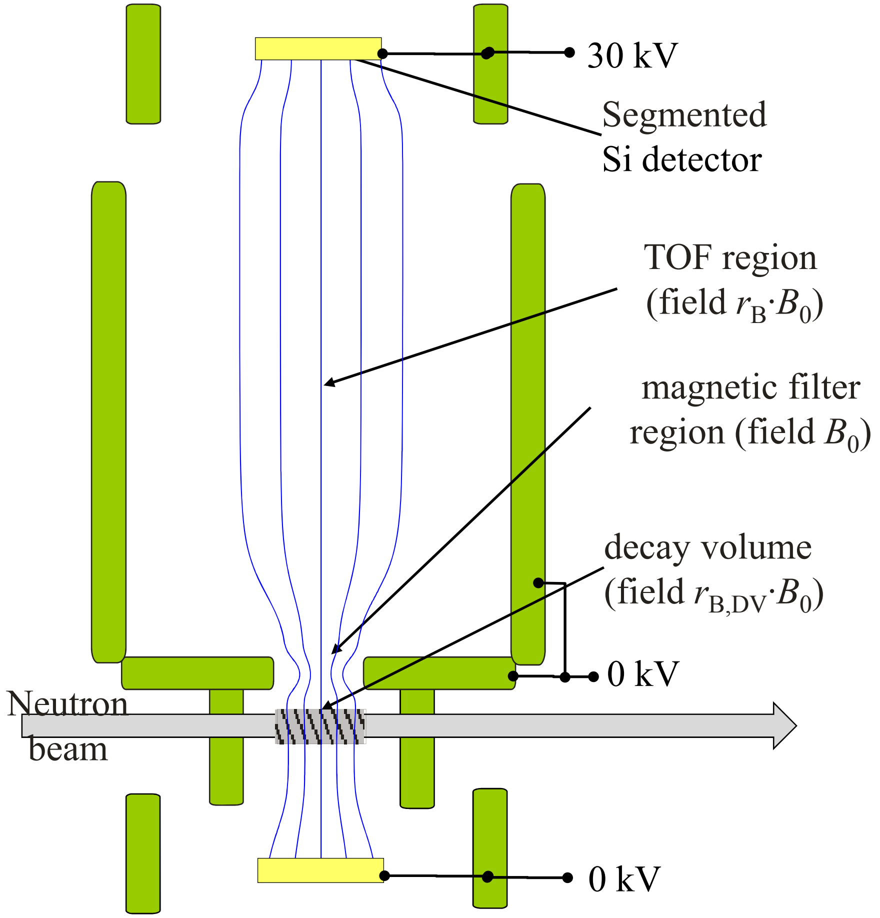
$$\left(p_{\mathrm{p}}{}^2\right)_{\text{min, max}} = \left(p_{\mathrm{e}} \pm p_\nu\right)^2$$

Slope:

$$\propto \left[1 + a\frac{p_{\mathrm{e}}}{E_{\mathrm{e}}}\cos\theta_{e\nu}\left(p_{\mathrm{p}}{}^2\right)\right]$$

Alternative approaches: *a*SPECT (Mainz, ILL), aCORN (Tulane, NIST)

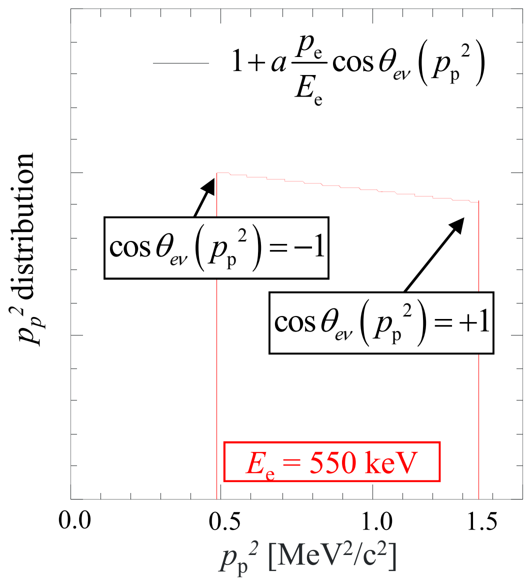
The asymmetric version of Nab @ SNS

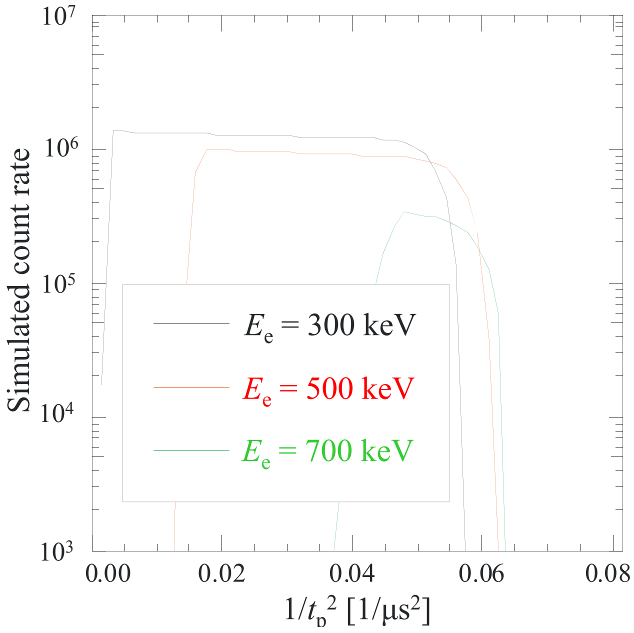


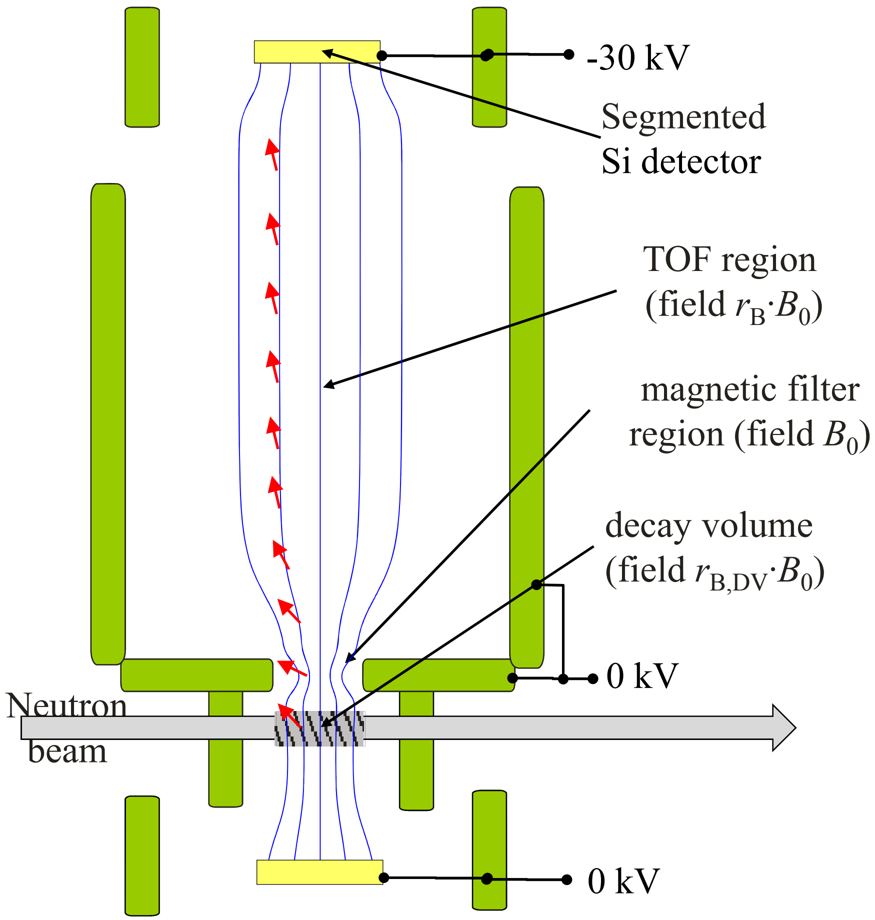
Advantages of asymmetric configuration:

- Detection function: Improved flight path length
- Reduced sensitivity to electrostatic and magnetic potential inhomogeneities
- Avoid deep Penning trap
- Statistical uncertainty: Bigger decay volume vs. angular acceptance
- Polarized experiment (abBA, PANDA) still possible

The $\cos\theta_{ev}$ spectrometer Nab @ SNS







-30 kV

Segmented Si detector

TOF region (field $r_B \cdot B_0$)

magnetic filter region (field B_0)

decay volume (field $r_{B,DV} \cdot B_0$)

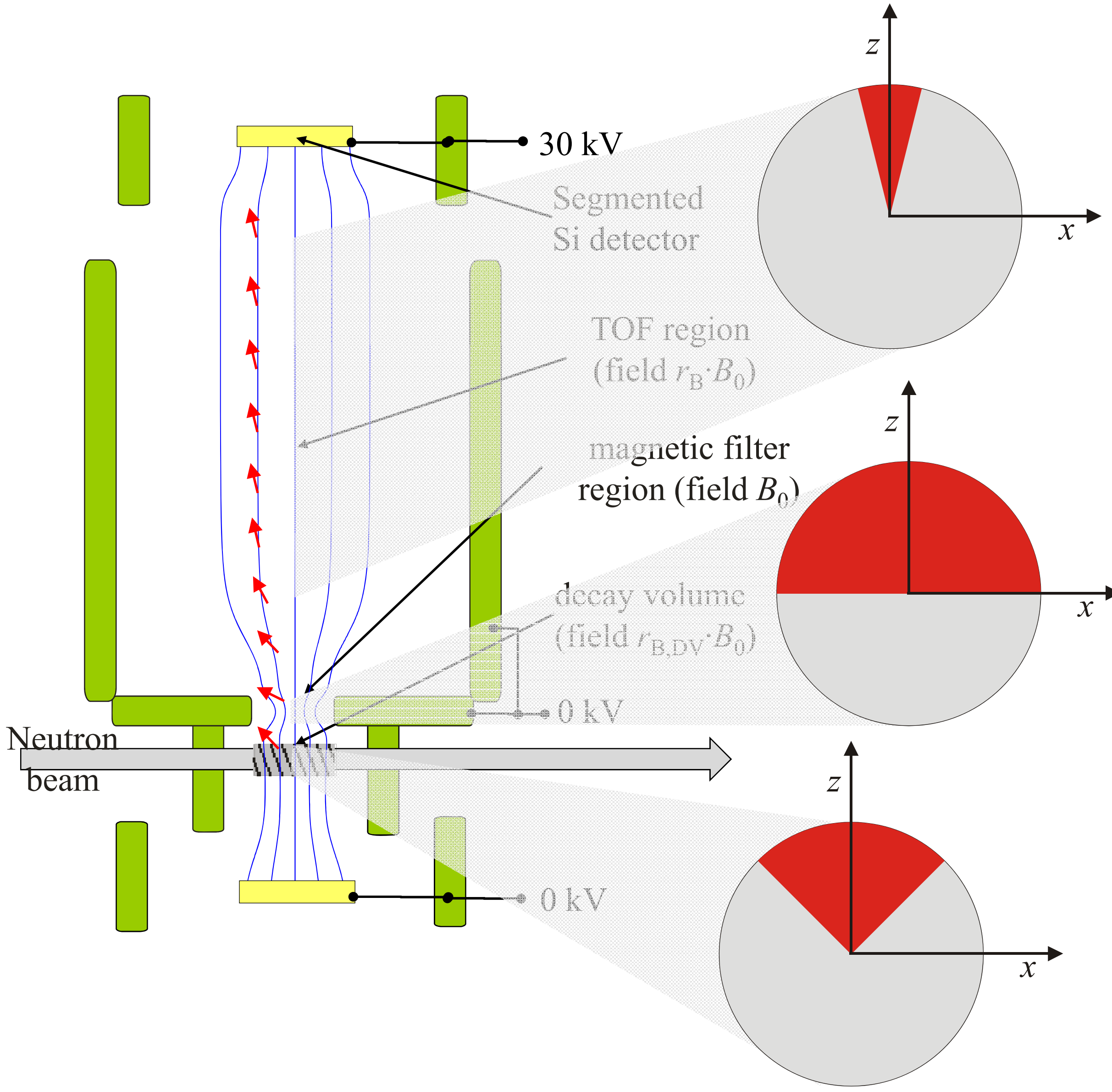
0 kV

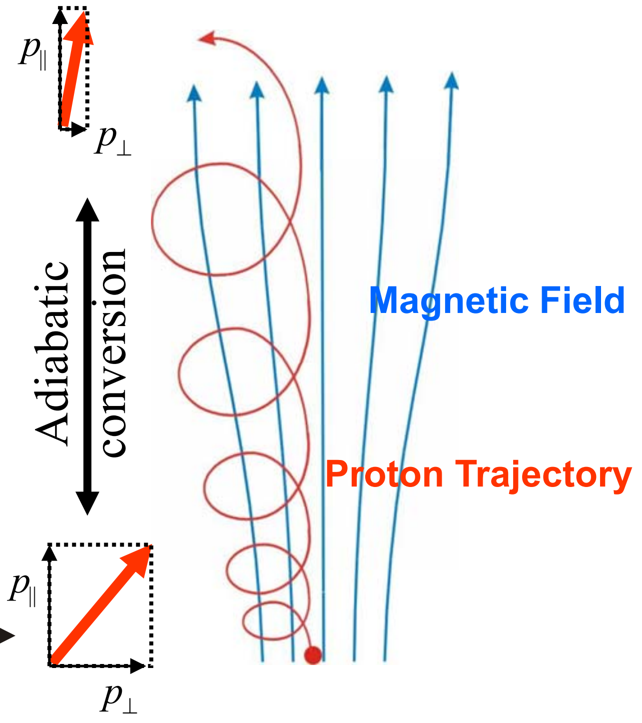
Neutron beam

0 kV

- Measurement of E_e and t_p for each event
- Background suppression through coincidences of electron and proton.
- Long flight path improves spectrometer

Determination of p_p through t_p: The magnetic field





- Measurement of E_e and t_p for each event
- Background suppression through coincidences of electron and proton.
- Long flight path improves spectrometer

Silicon detector for Nab / abBA / PANDA

Front side

Back side

Segmented ion-implanted silicon detector with fast readout electronics:

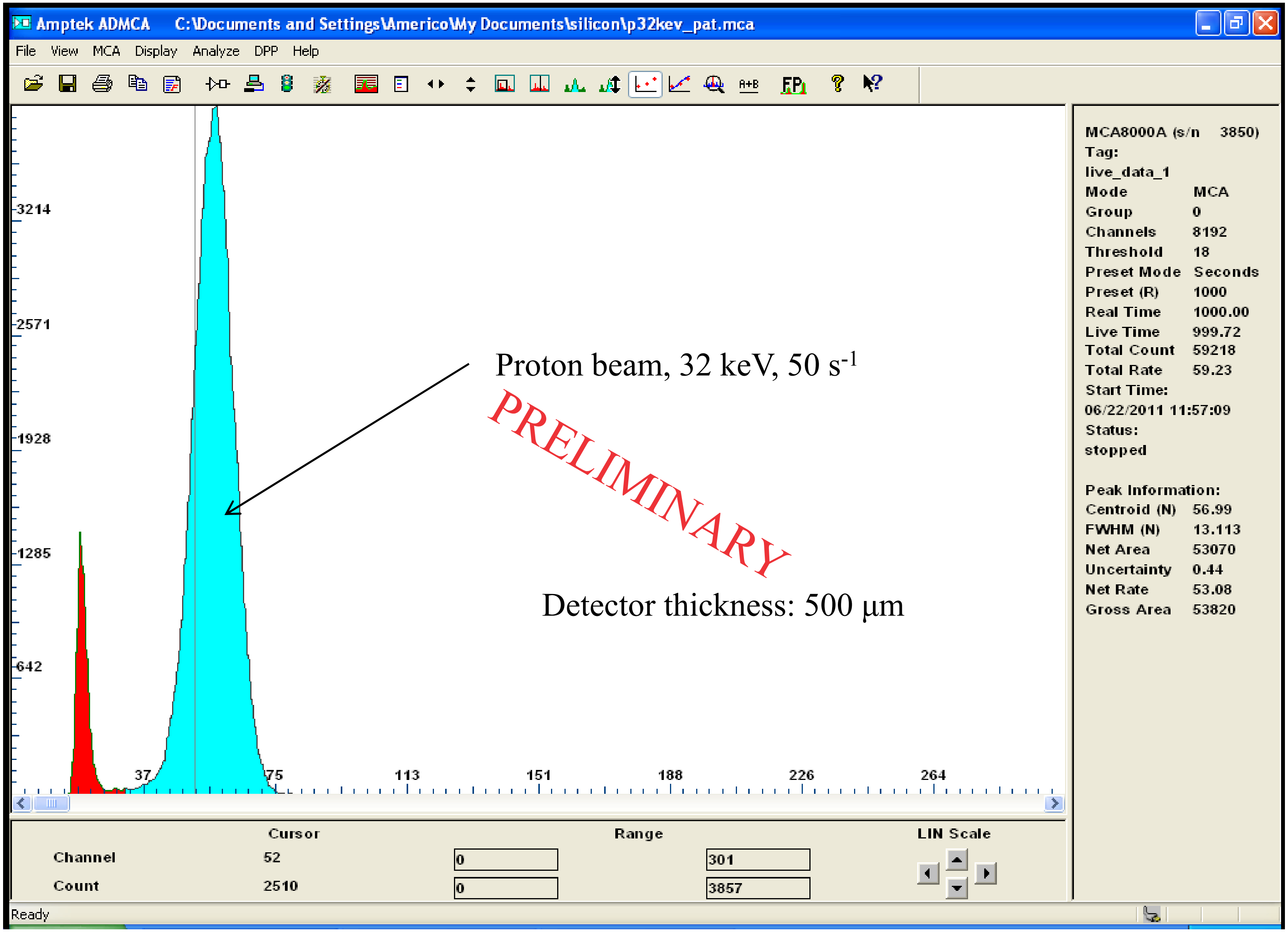
- Thickness 2 mm (less for testing)
- Thin dead layer of < 100 nm silicon (measured!):

  Energy loss for 30 keV protons: < 11 keV (measured!)
- 127 channels

  Sufficiently small count rate/pixel,

  Allows to find electron and correlated proton.

Detector properties: proton response



C:\Documents and Settings\Americo\My Documents\silicon\p32kev_pat.mca

Proton beam, 32 keV, 50 s^{-1}

PRELIMINARY

Detector thickness: 500 µm

MCA8000A (s/n 3850)
Tag:
live_data_1

Mode	MCA
Group	0
Channels	8192
Threshold	18
Preset Mode	Seconds
Preset (R)	1000
Real Time	1000.00
Live Time	999.72
Total Count	59218
Total Rate	59.23

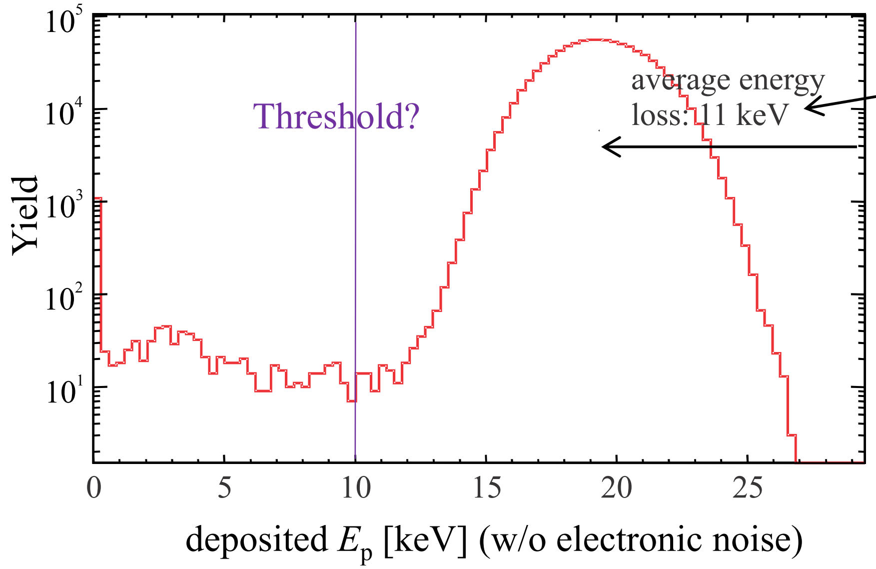
Start Time:
06/22/2011 11:57:09
Status:
stopped

Peak Information:

Centroid (N)	56.99
FWHM (N)	13.113
Net Area	53070
Uncertainty	0.44
Net Rate	53.08
Gross Area	53820

	Cursor	Range	
Channel	52	0	301
Count	2510	0	3857

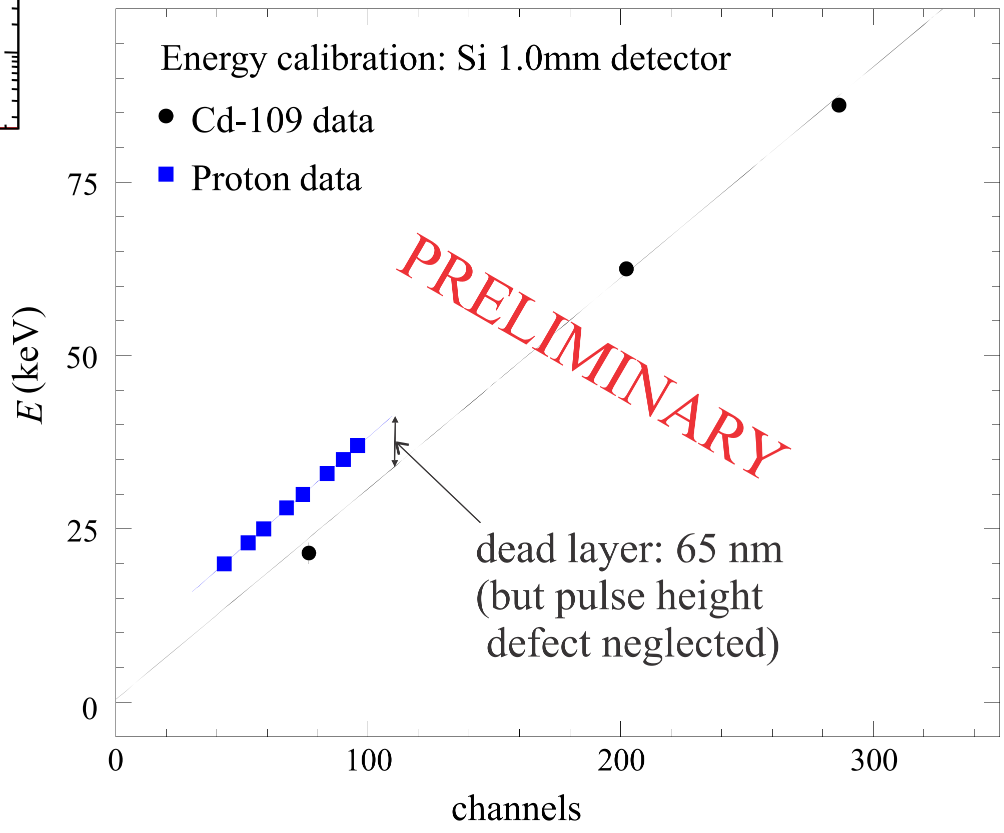
Detector properties: proton spectrum (II)



Worst case simulation
(dead layer: 100 nm Si)

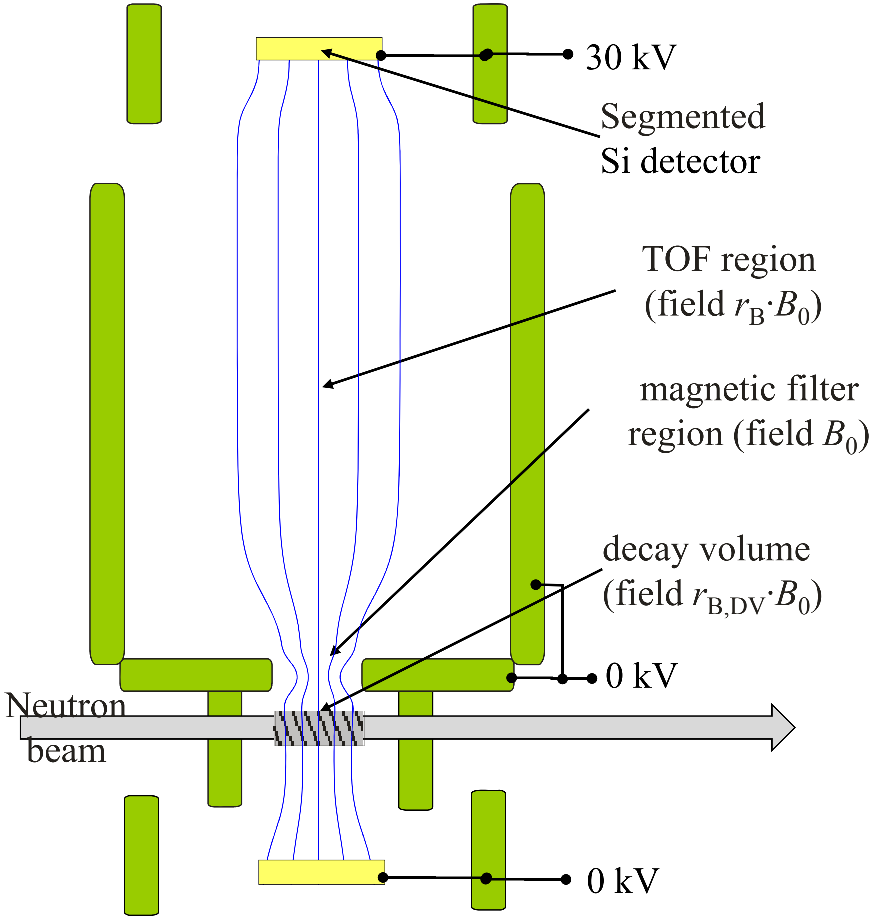
Threshold	lost protons	efficiency slope
8 keV	0.19%	110(30) ppm/keV
10 keV	0.20%	131(31) ppm/keV
12 keV	0.21%	165(32) ppm/keV
14 keV	0.28%	304(76) ppm/keV

For uncertainty in *a*, we assume a threshold of 10 keV and direct measurement of efficiency slope to 50%.



dead layer: 65 nm
(but pulse height
defect neglected)

Electron energy measurement with backscattering suppression



30 kV

Segmented
Si detector

TOF region
(field $r_B \cdot B_0$)

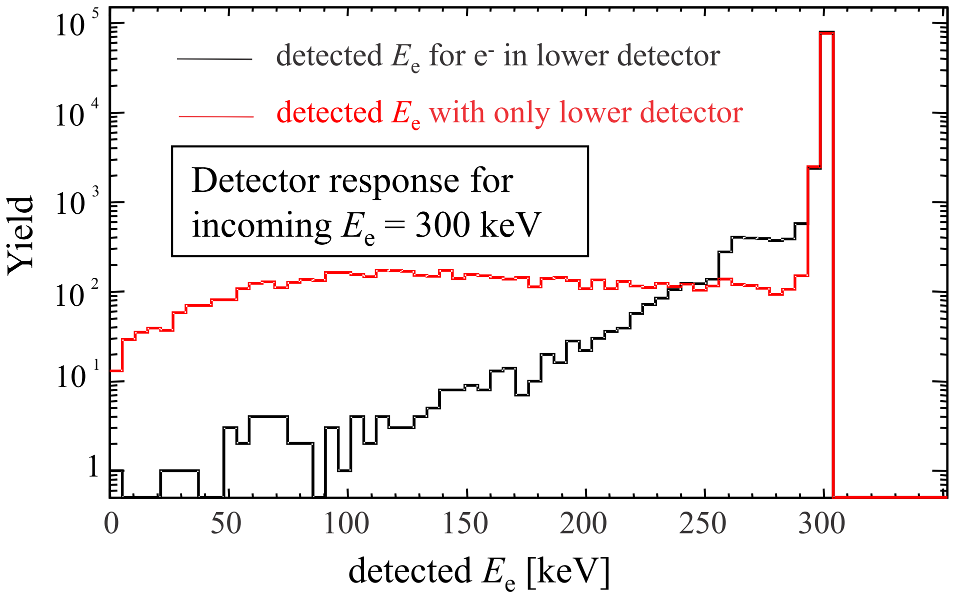
magnetic filter
region (field B_0)

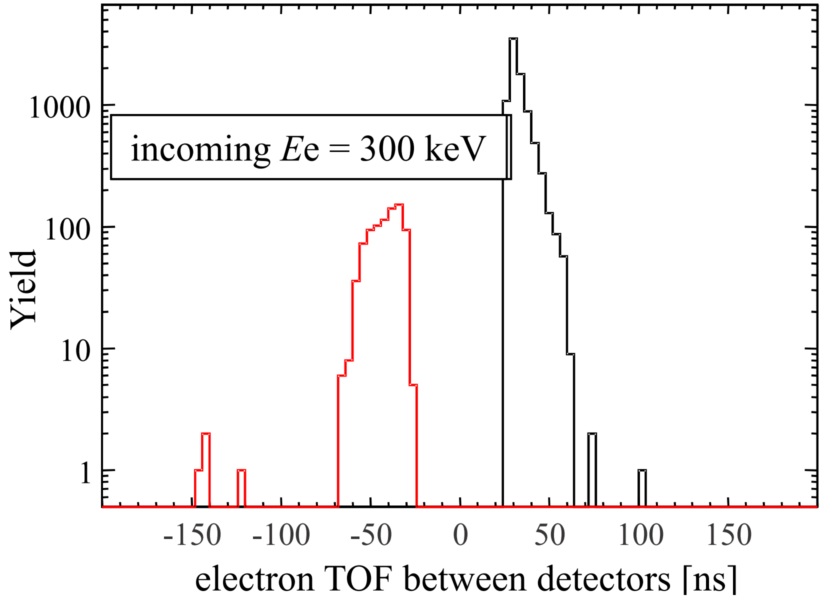
decay volume
(field $r_{B,DV} \cdot B_0$)

0 kV

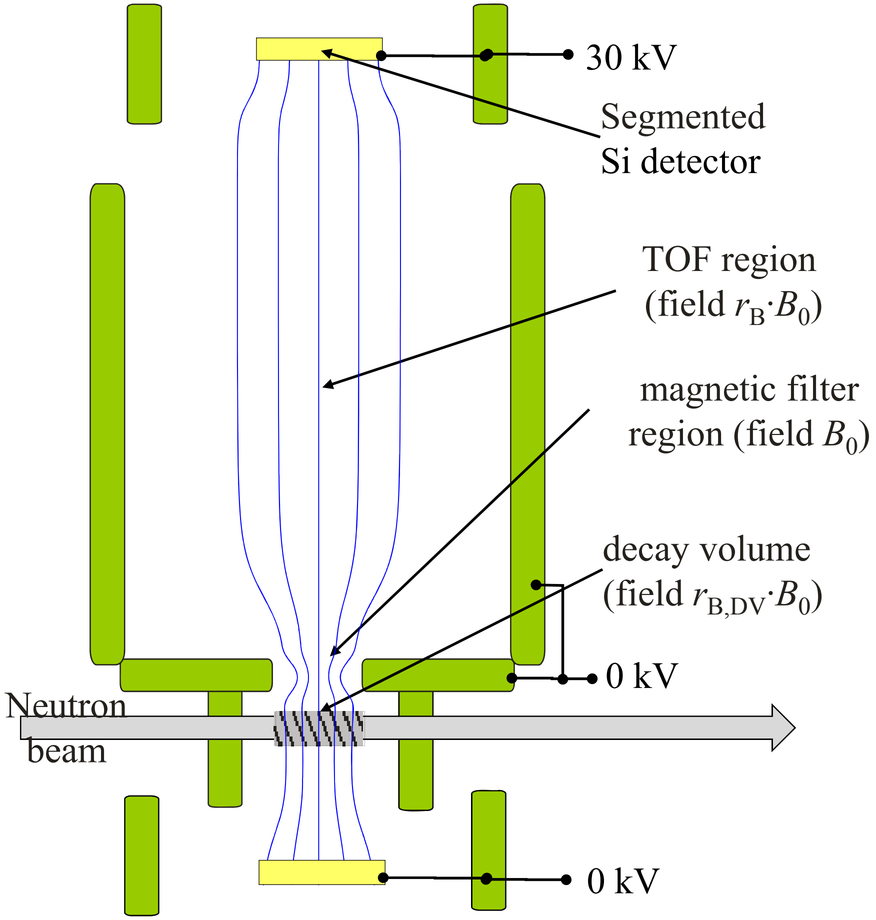
Neutron
beam

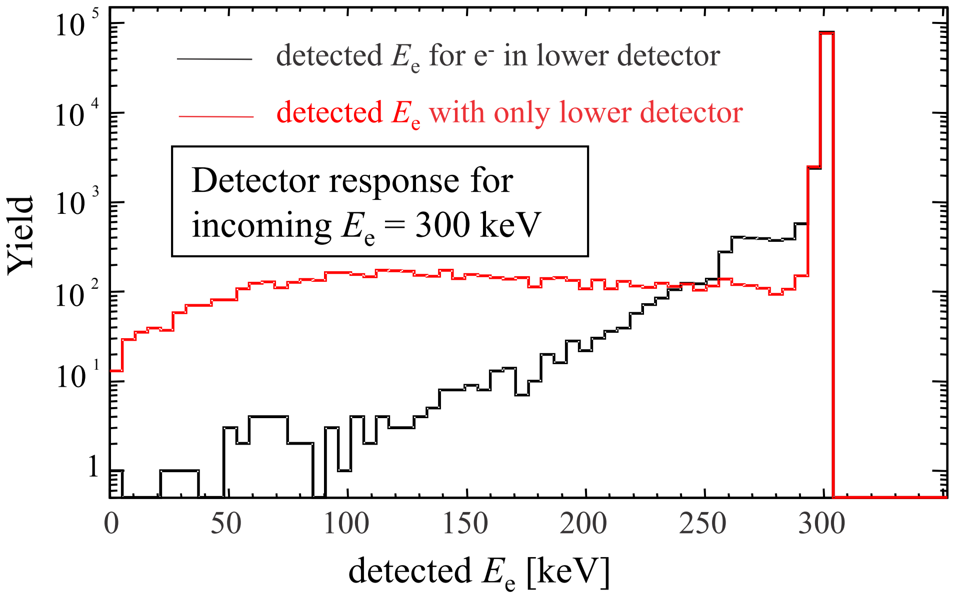
0 kV





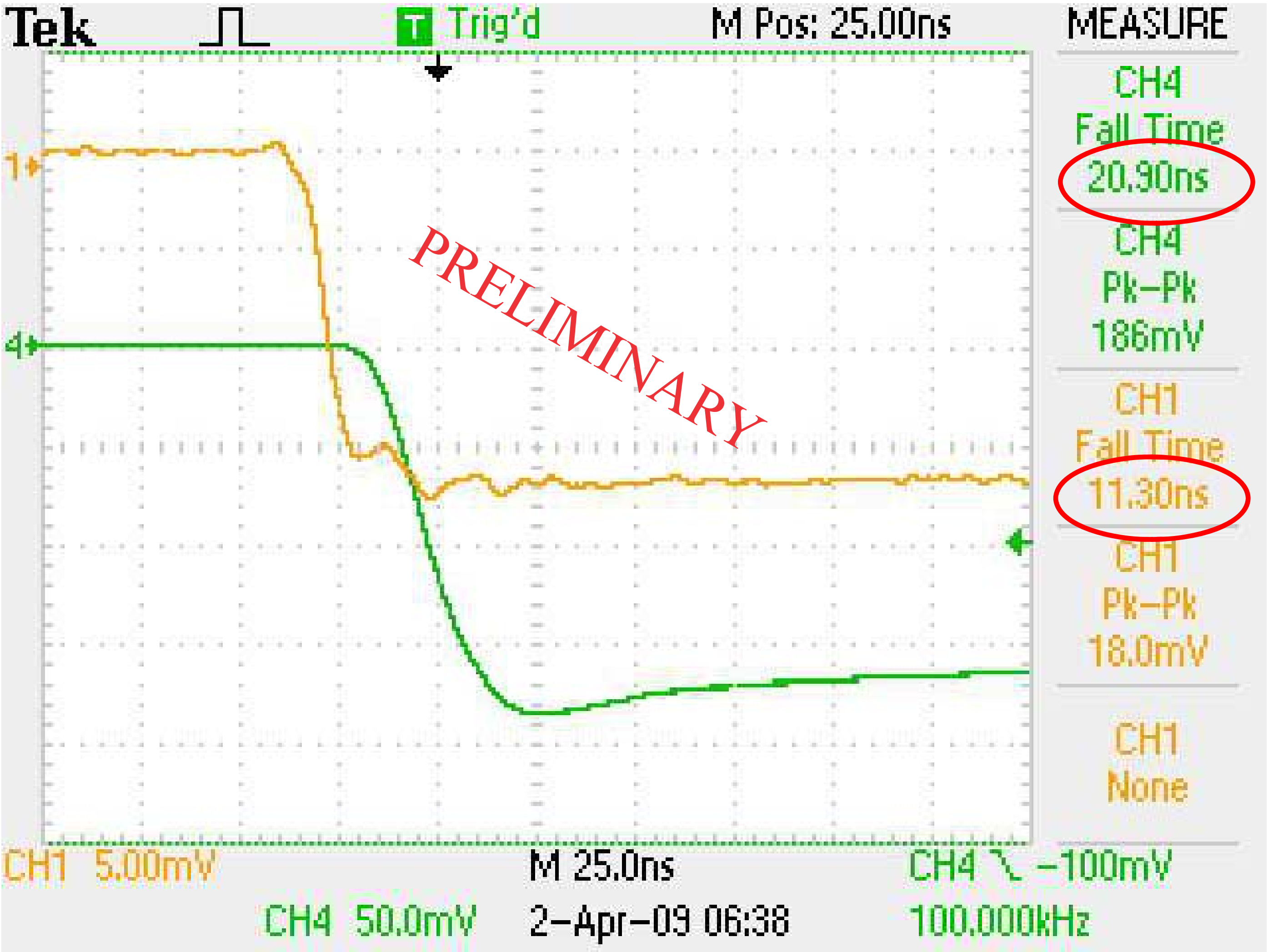
Electron energy measurement with backscattering suppression



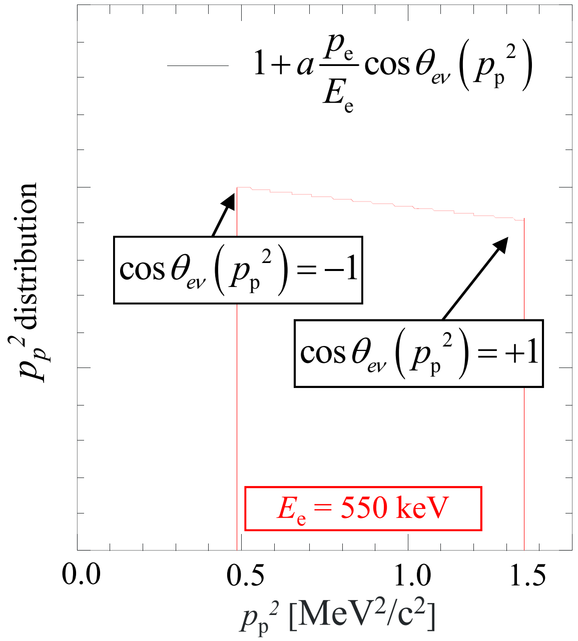


- Measurement of E_e (and t_p) for each event
- Backscattering suppression through adding energies of both detectors.
- Reconstructing of electron energy needs time resolution of < 20 ns

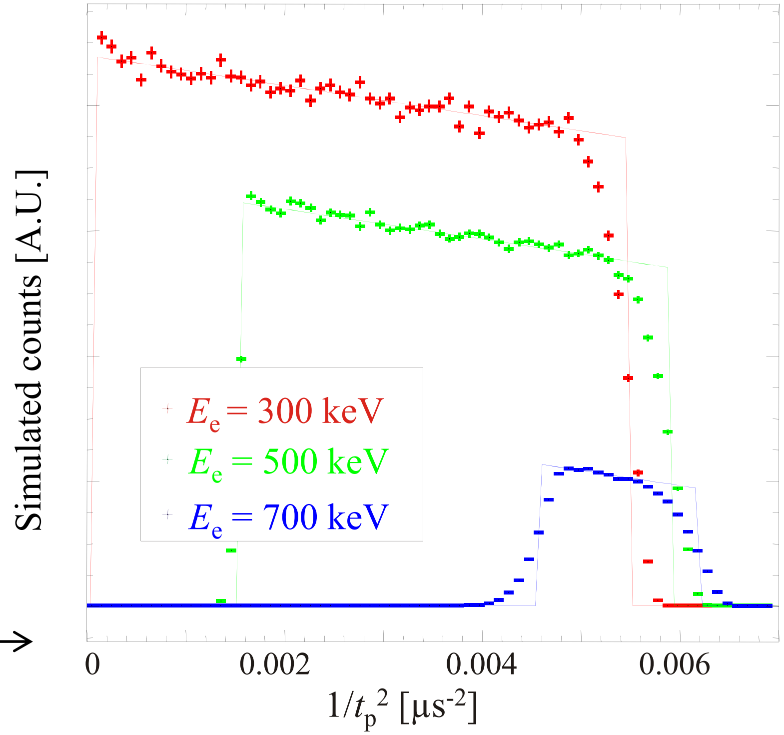
Detector properties: Speed



Extraction of *a* in Nab



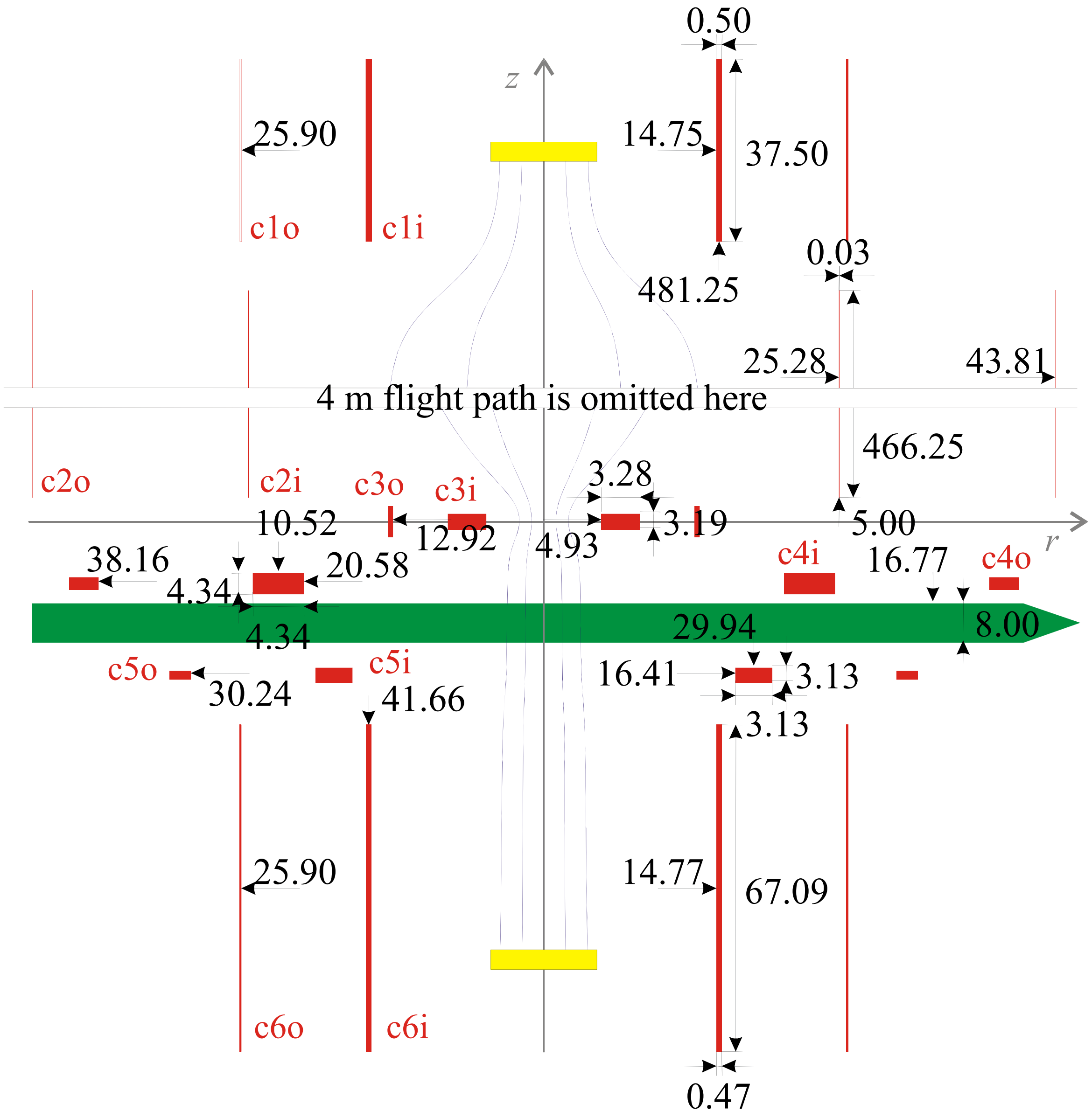
$$t_p = \frac{m_p}{p_p}\int \frac{dz}{\cos\theta_p(z)}$$

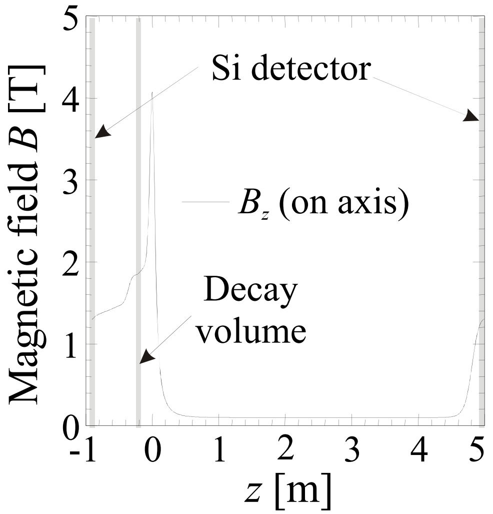


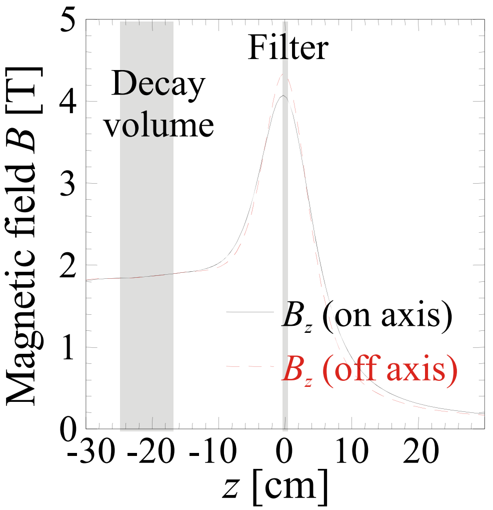
Data analysis: Use edge to determine or verify the shape of the detection function.

Then, use central part to determine slope and the correlation coefficient *a*.

Detailed spectrometer magnet design

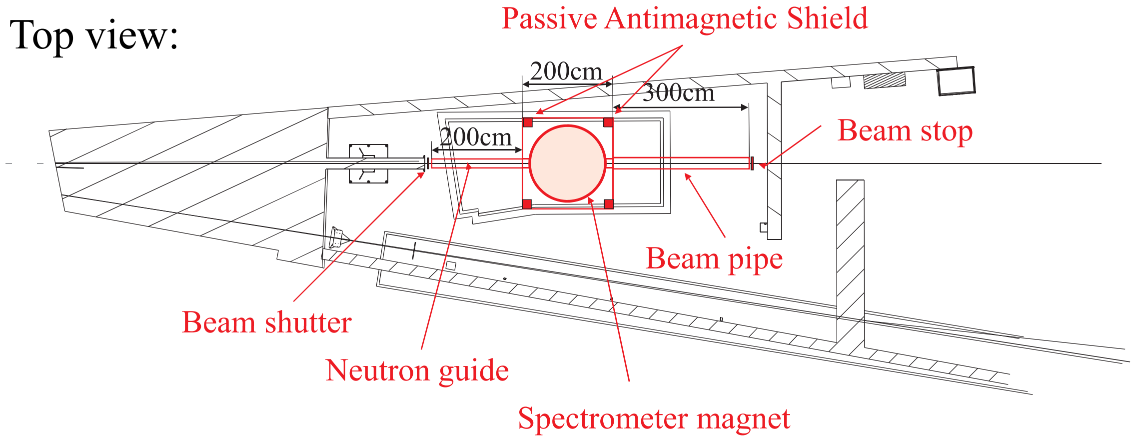




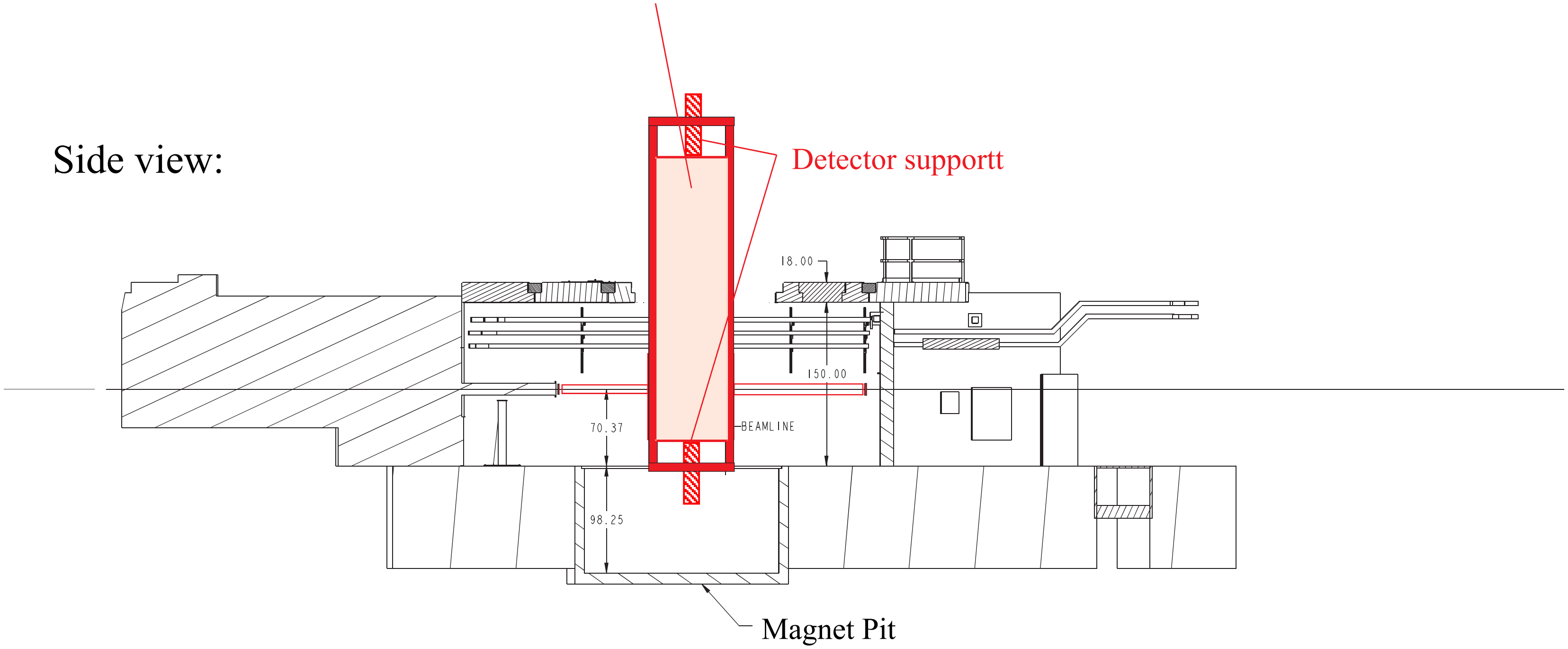


Nab setup, about to scale

Top view:

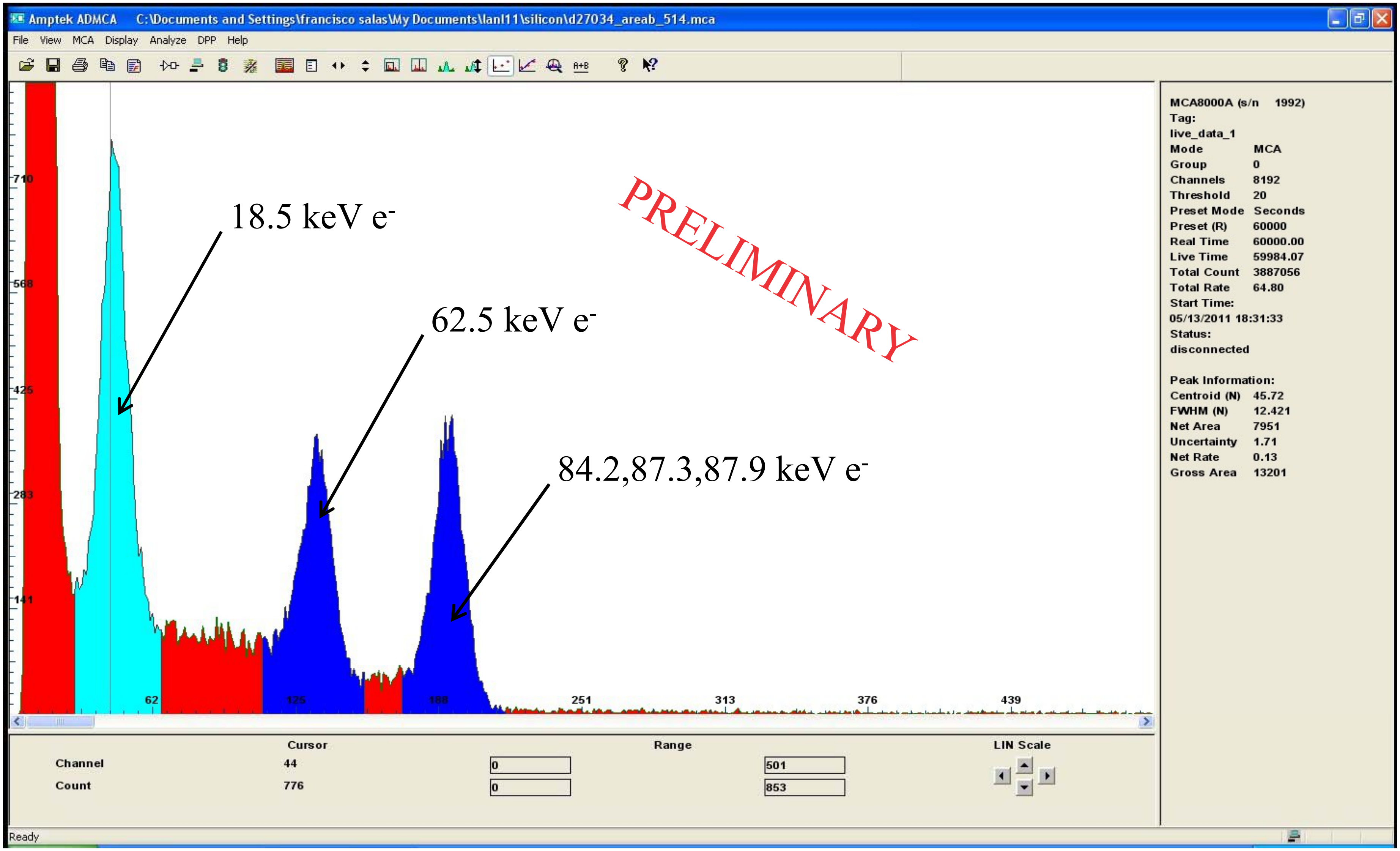


Side view:



Prototype detector spectra

Source: Cd 109. Preamp: LANL homemade. Micron detector, thickness: 1.5 mm



C:\Documents and Settings\francisco salas\My Documents\lanl11\silicon\d27034_areab_514.mca

18.5 keV e$^-$

62.5 keV e$^-$

84.2,87.3,87.9 keV e$^-$

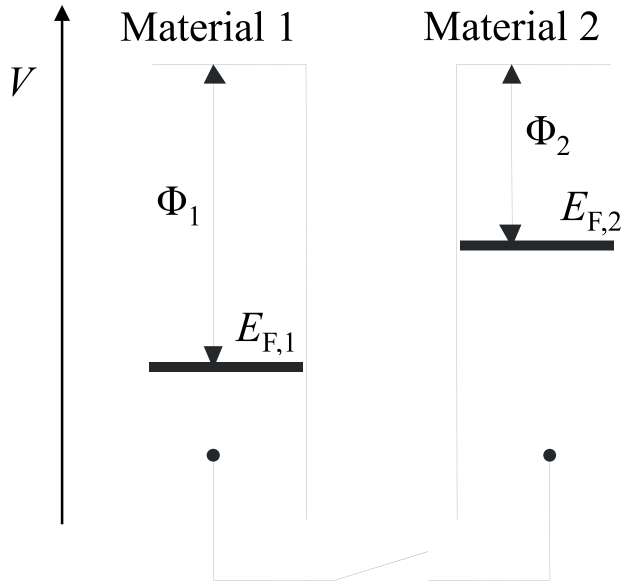
PRELIMINARY

```
MCA8000A (s/n    1992)
Tag:
live_data_1
Mode          MCA
Group         0
Channels      8192
Threshold     20
Preset Mode   Seconds
Preset (R)    60000
Real Time     60000.00
Live Time     59984.07
Total Count   3887056
Total Rate    64.80
Start Time:
05/13/2011 18:31:33
Status:
disconnected

Peak Information:
Centroid (N)  45.72
FWHM (N)      12.421
Net Area      7951
Uncertainty   1.71
Net Rate      0.13
Gross Area    13201
```

```
           Cursor              Range
Channel    44        0         501
Count      776       0         853
```

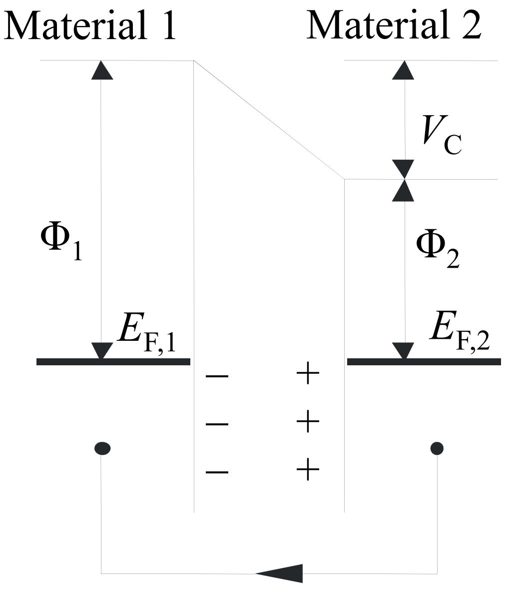
Kelvin Probe: Tool to measure Work Functions



2 Materials with different work functions, isolated

1st material: to be tested

2nd material: tip with known work function

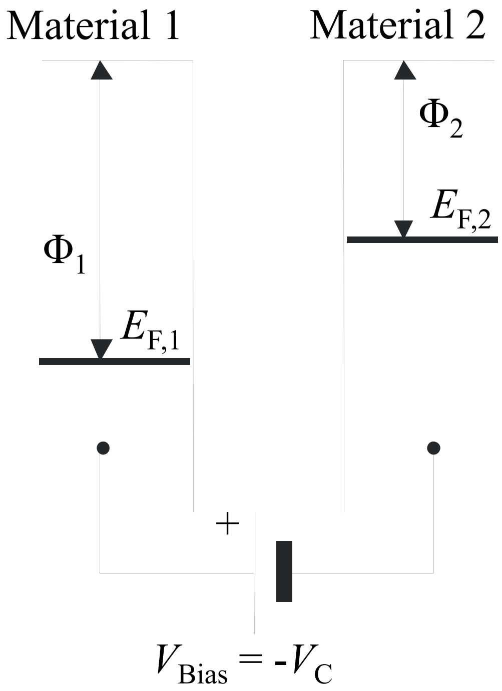


Electrical Connection:

→ Charging, until Fermi levels are equal

→ External electric field

→ If Material 2 is moved: Capacitance changes, voltage is constant, therefore charge has to change (current)

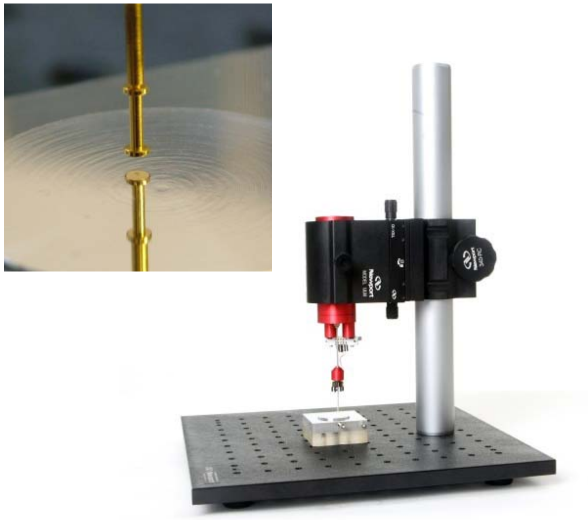


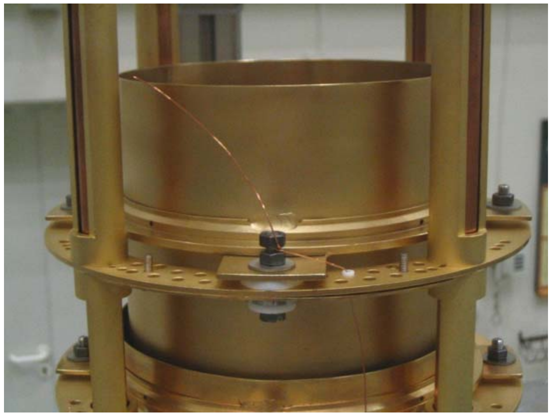
Bias Voltage

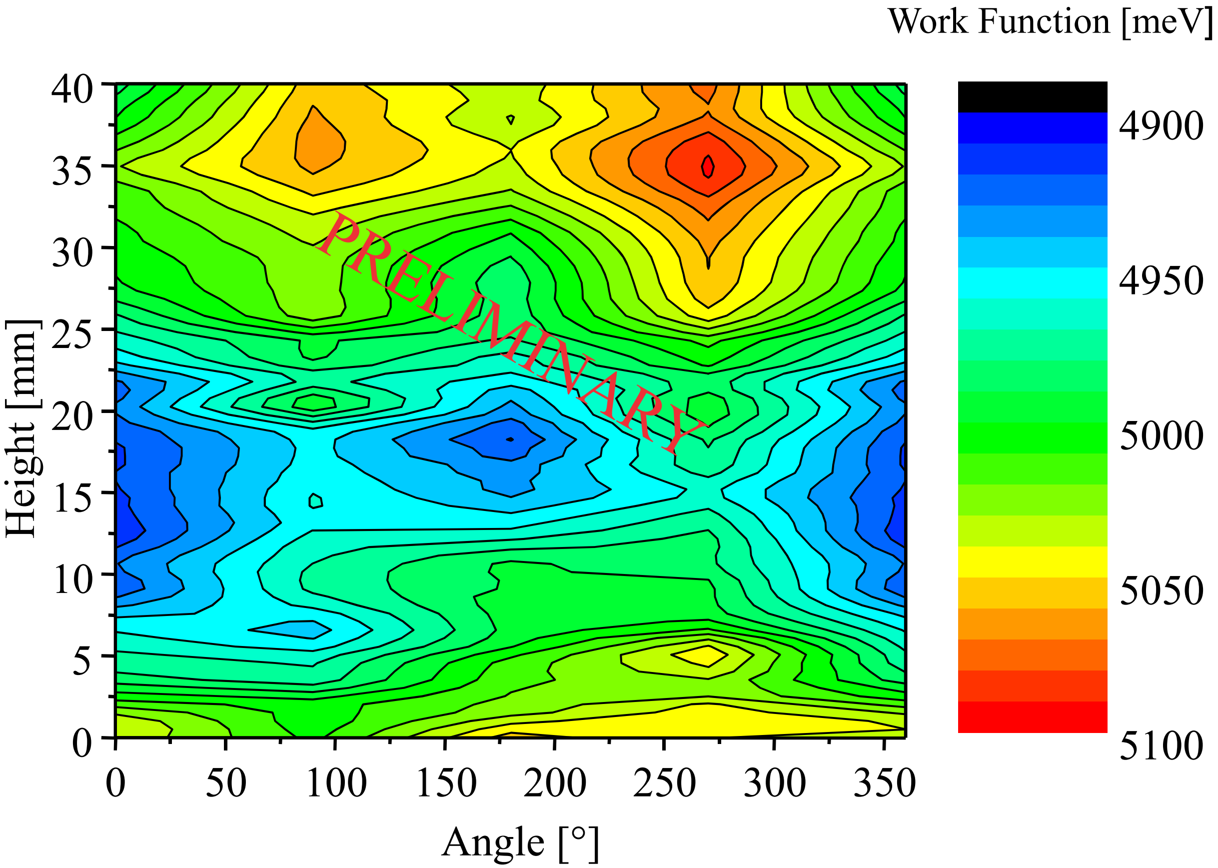
→ Charge disappears, no external electric field

→ No current if Material 2 is moved

Kelvin Probe: First results from early work on *a*SPECT

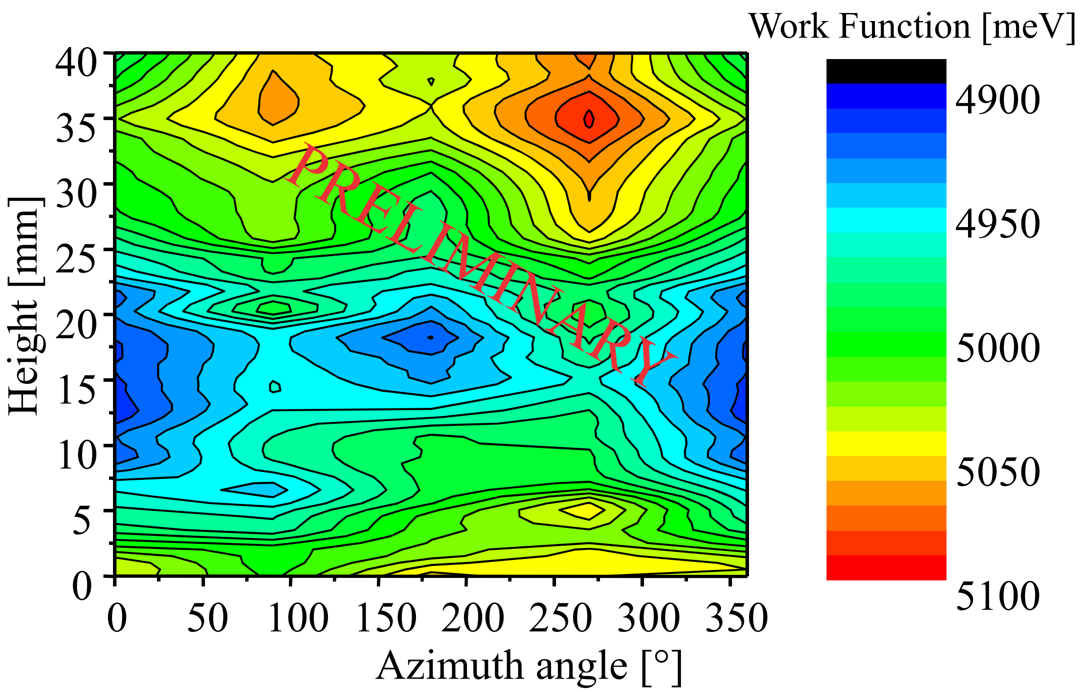






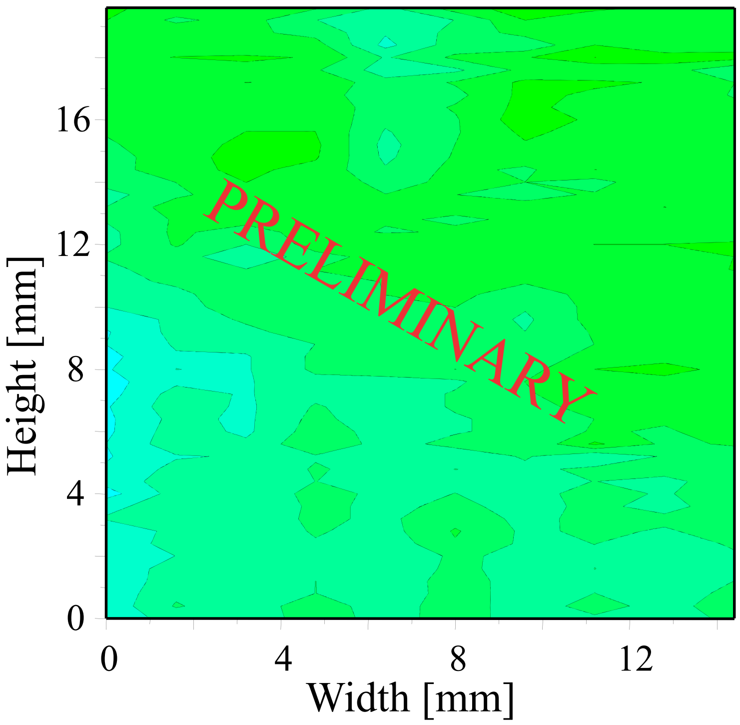
In collaboration with Prof. I. Baikie, KP Technologies

Now: Better coating



In collaboration with Prof. I. Baikie, KP Technologies

(arbitrary offset added)



Thanks to:
Rachel Hodges (undergraduate research prize), Gertrud Konrad, Sean McGovern (Masters), Henry Bonner

Uncertainty budget

PLANNED statistical uncertainty budget:

lower E_e cutoff	**none**	**100 keV**	**100 keV**	**300 keV**
upper t_p cutoff	**none**	**none**	**40 µs**	**40 µs**
Δ_a	$2.4/\sqrt{N}$	$2.5/\sqrt{N}$	$2.5/\sqrt{N}$	$2.6/\sqrt{N}$
Δ_a **(E_{cal}, l variable)**	$2.5/\sqrt{N}$	$2.6/\sqrt{N}$	$2.7/\sqrt{N}$	$2.7/\sqrt{N}$
Δ_a **(E_{cal}, l variable, inner 70% of data)**	$4.1/\sqrt{N}$	$4.1/\sqrt{N}$	**$4.1/\sqrt{N}$**	$4.1/\sqrt{N}$

About 2×10^9 events can be detected in 6 weeks (Decay volume $V = 246\ \text{cm}^3$, decay density $n_d = 20\ \text{cm}^{-3}$, 12.7 % of decay protons go to upper detector, 80% duty factor)

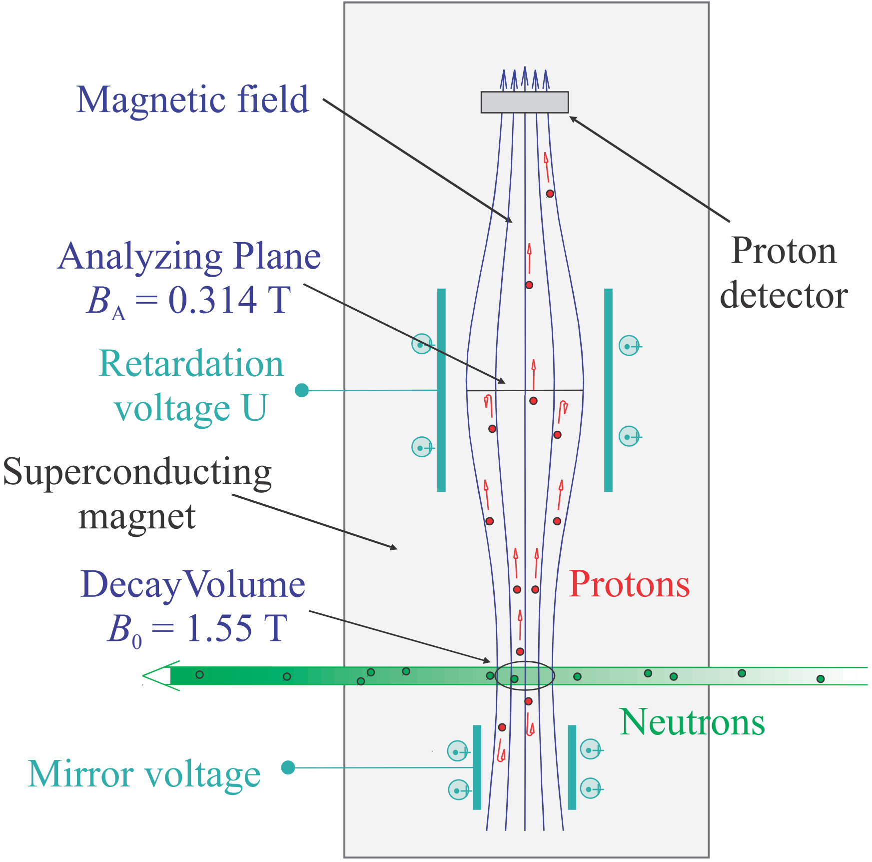
→ $(\Delta a/a)_{stat} < 1\times10^{-3}$ can be reached

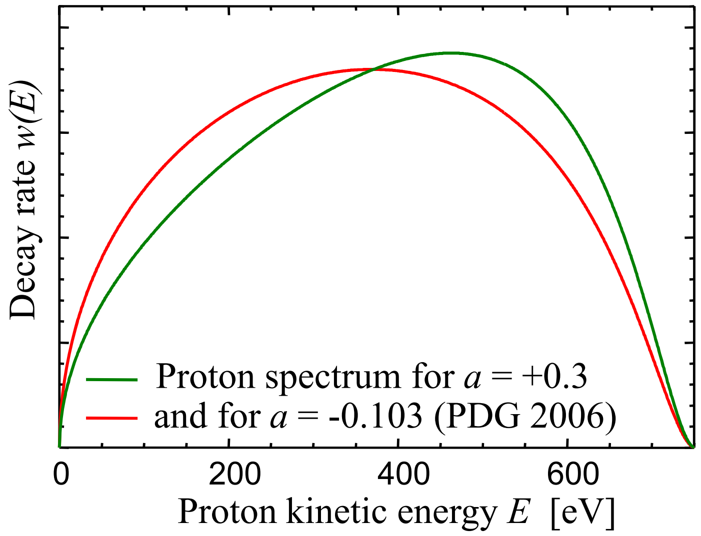
Compare to $\Delta a/a = 5\ \%$ of existing experimental results

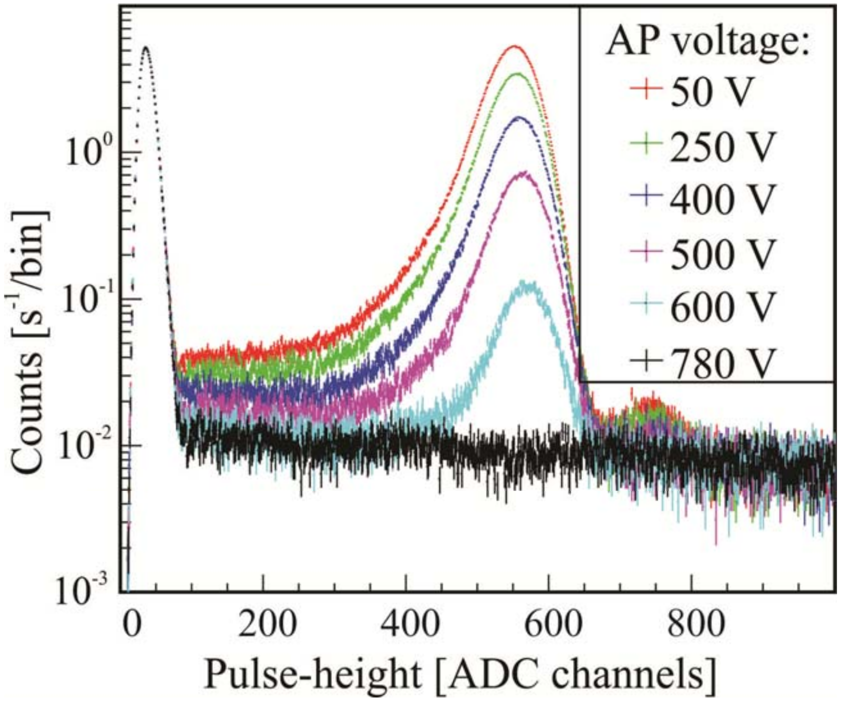
PLANNED systematic uncertainty budget:

Experimental parameter	**Systematic uncertainty Δa/a**
Magnetic field	
... curvature at pinch	$5\cdot10^{-4}$
… ratio $r_B = B_{TOF}/B_0$	$2.5\cdot10^{-4}$
… ratio $r_{B,DV} = B_{DV}/B_0$	$3\cdot10^{-4}$
Length of the TOF region	(*)
Electrical potential inhomogeneity:	
… in decay volume / filter region	$5\cdot10^{-4}$
… in TOF region	$1\cdot10^{-4}$
Neutron Beam:	
… position	$4\cdot10^{-4}$
… profile (including edge effect)	$2.5\cdot10^{-4}$
… Doppler effect	small
Unwanted beam polarization	can be made small
Adiabaticity of proton motion	$1\cdot10^{-4}$
Detector effects:	
… Electron energy calibration	(*)
… Electron energy resolution	$5\cdot10^{-4}$
… Proton trigger efficiency	$2.5\cdot10^{-4}$
Residual gas	small
Background	small
Accidental coincidences	small
Sum	**$1\cdot10^{-3}$**

Other ongoing experiments: *a*SPECT

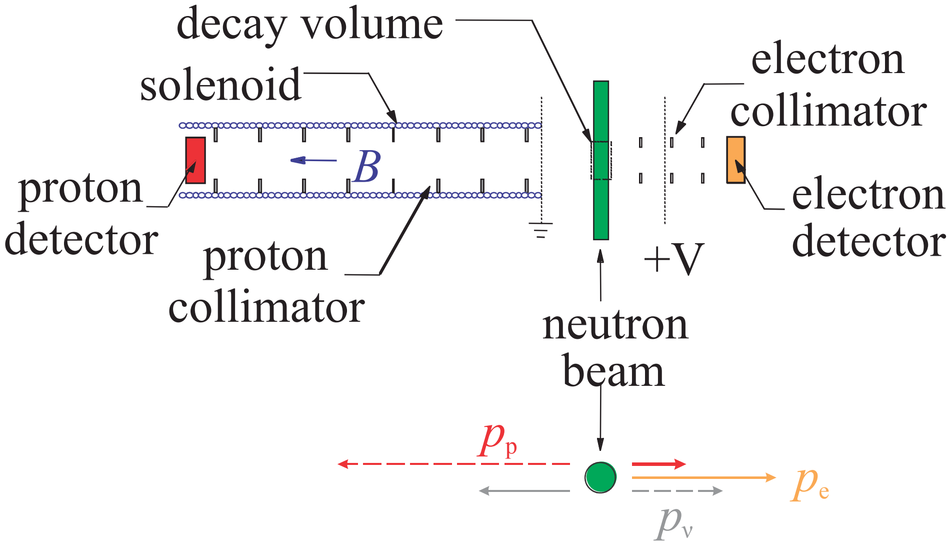


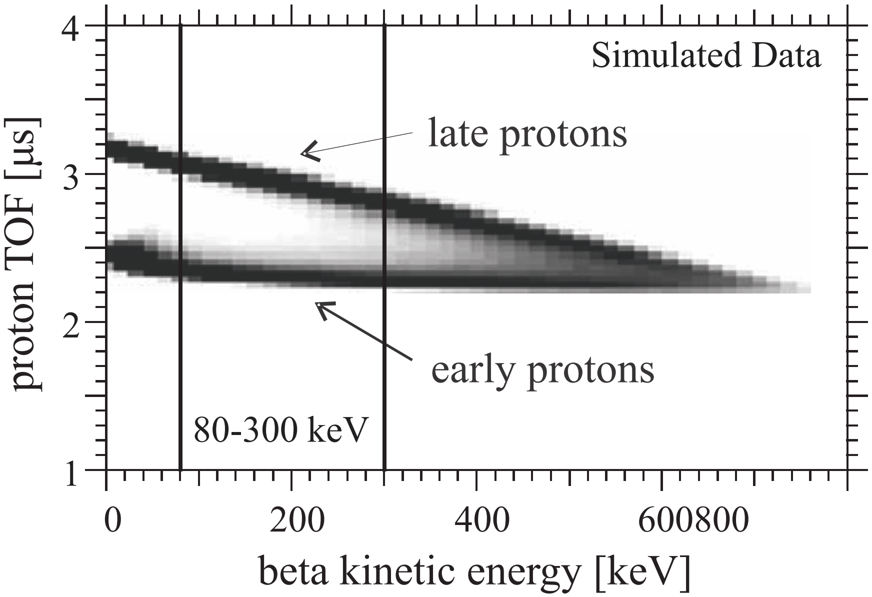




Leading uncertainty probably trapped particle background, $(\Delta a/a)_{\text{background}} = 0.61\%$

Other ongoing experiments: *a*CORN @ NIST





Expected total uncertainty of $\Delta a/a \sim 1$ %

(limited by systematics)

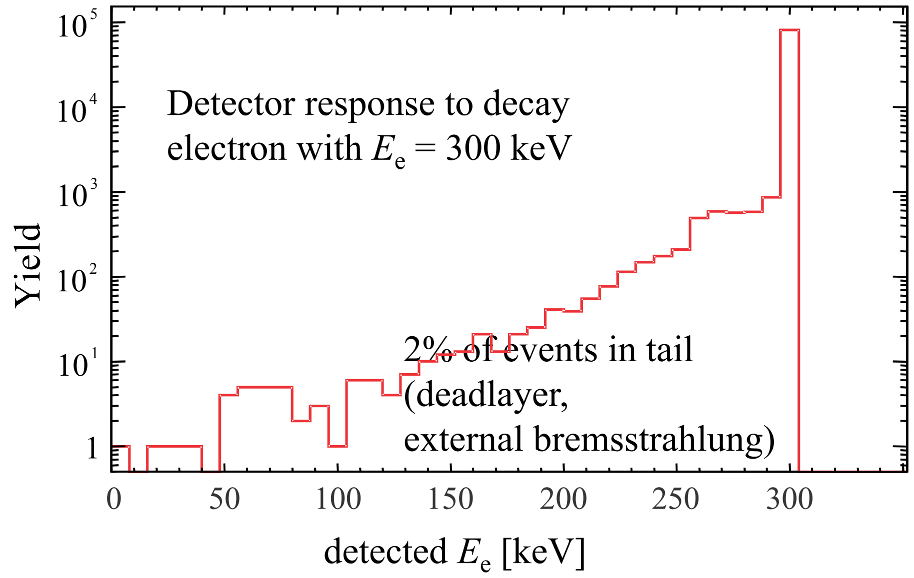
- only part of the available neutron decays used
- I find it hard to determine the acceptance precisely

The determination of the Fierz Interference term

$$dw \propto \rho(E_e)\cdot\left(1+3|\lambda|^2\right)\cdot\left\{1+b\frac{m_e}{E_e}\right\}$$

Systematic uncertainties:

1. Electron energy determination



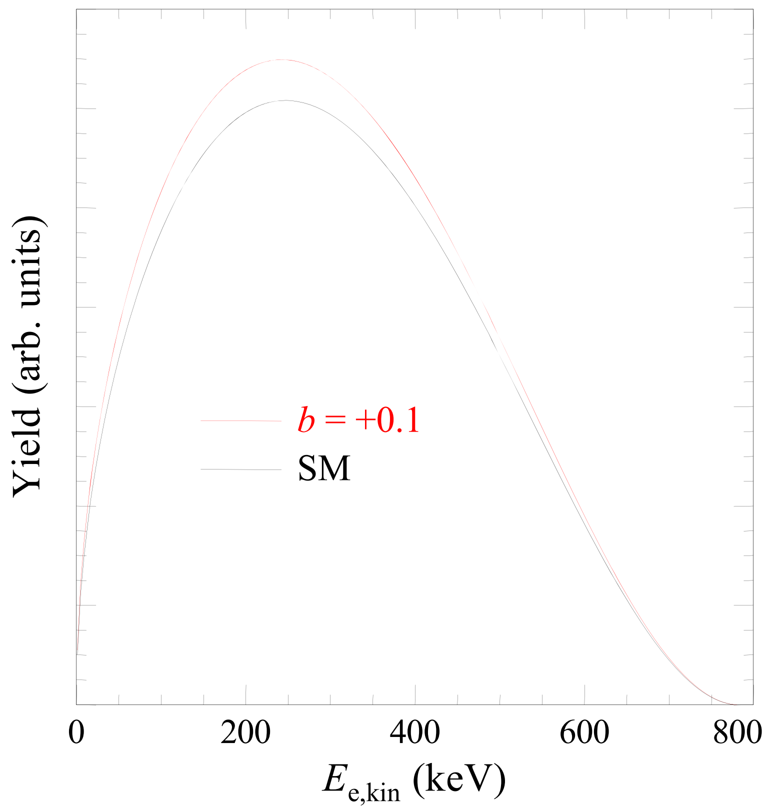
Detector response to decay electron with E_e = 300 keV

2% of events in tail (deadlayer, external bremsstrahlung)

2. Background

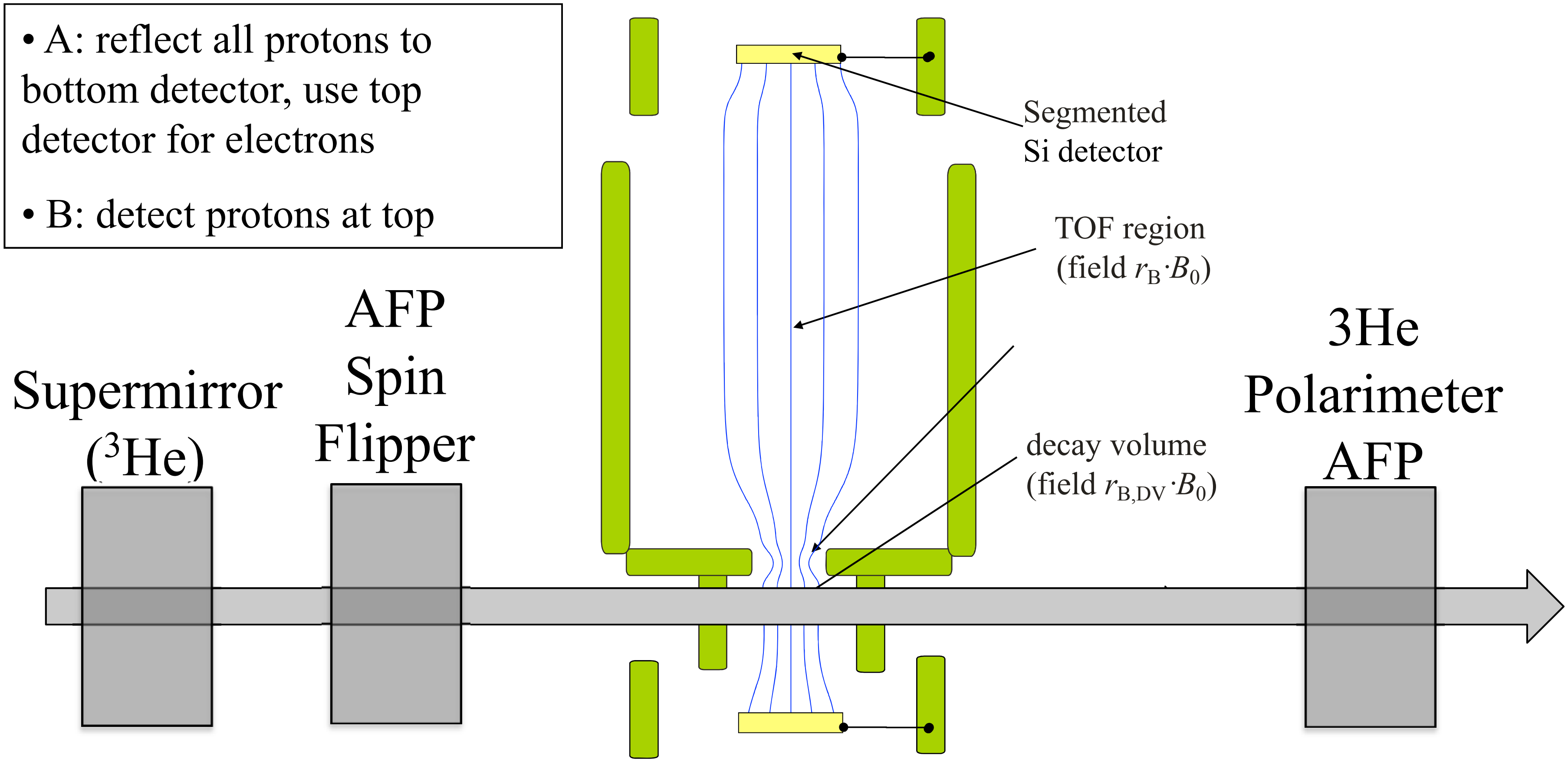
Δb ~ 3×10^{-3} can be reached (systematics limited)

Electron spectrum:



A/B at SNS or NIST: abBA / Nab / PANDA

- A: reflect all protons to bottom detector, use top detector for electrons
- B: detect protons at top



- Main uncertainties in PERKEO II: statistics, detector, polarization, background
- Superior detector energy resolution, good enough time resolution
- Keep coincidences to improve background
- Asymmetric detector: Filter improves on systematics; statistics @ SNS is an issue for A
- Polarization measurement seems manageable (XSM or He-3)

Uncertainty budget for A

PLANNED statistical uncertainty budget:

lower E_e cutoff	**none**	**100 keV**	**200 keV**	**250 keV**
$\boldsymbol{\Delta_A}$	$4.3/\sqrt{N}$	$\mathbf{4.8/\sqrt{N}}$	$7/8/\sqrt{N}$	$11.9/\sqrt{N}$

N_d is the number of decays. Only 13% are detected, due to asymmetric configuration.

$N_d = 2\times10^9$ decay events (40 live days at SNS)
→ **$(\Delta A/A)_{stat} = 1\times10^{-3}$ can be reached**

Possible improvements:
- He3?
- NIST NG-C?

PLANNED systematic uncertainty budget:

Experimental parameter	**Systematic uncertainty ΔA/A**
Electrical potential inhomogeneity:	Relevant only for *B*/C
Neutron Beam:	
… position	irrelevant
… profile (including edge effect)	small
… Doppler effect	small
… Beam polarization	$< 10^{-3}$
Detector effects:	
… Electron energy calibration	$2\cdot10^{-4}$
… Electron energy resolution	small
Residual gas	small
Background	small
Sum	**TBD**

Our goal is a total uncertainty of $\Delta A/A = 10^{-3}$ or better (same for B/C, not discussed)

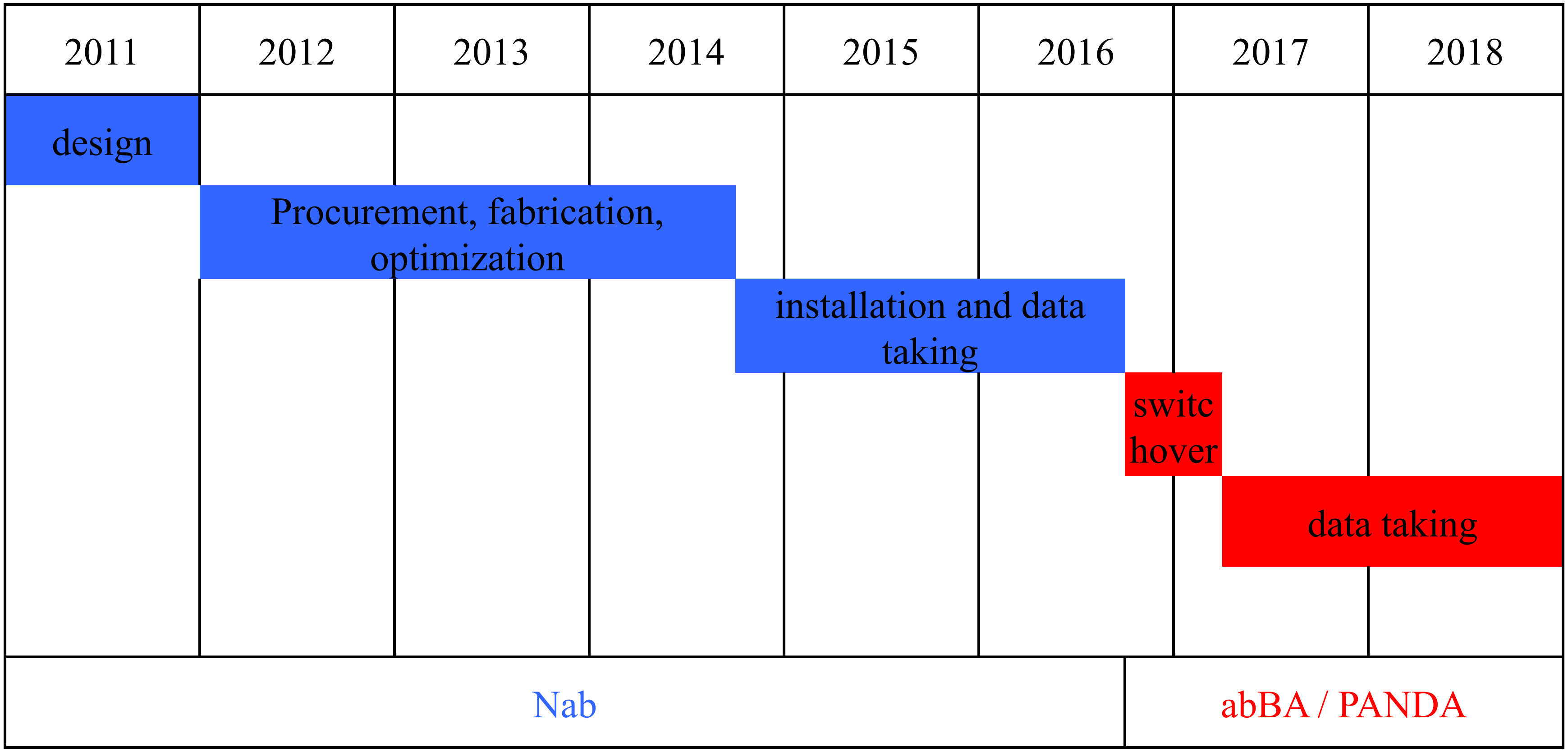
Competition:

- UCNA: Goal $\Delta A/A = 2\cdot10^{-3}$ (A. Young, NSAC), check of cold beam experiments
- UCNB: Goal $\Delta B/B = 10^{-3}$, but electric potential homogeneities have to be $\Delta U < 0.3$ mV
- PERC: Goal $\Delta A/A = 3\cdot10^{-4}$

Time schedule

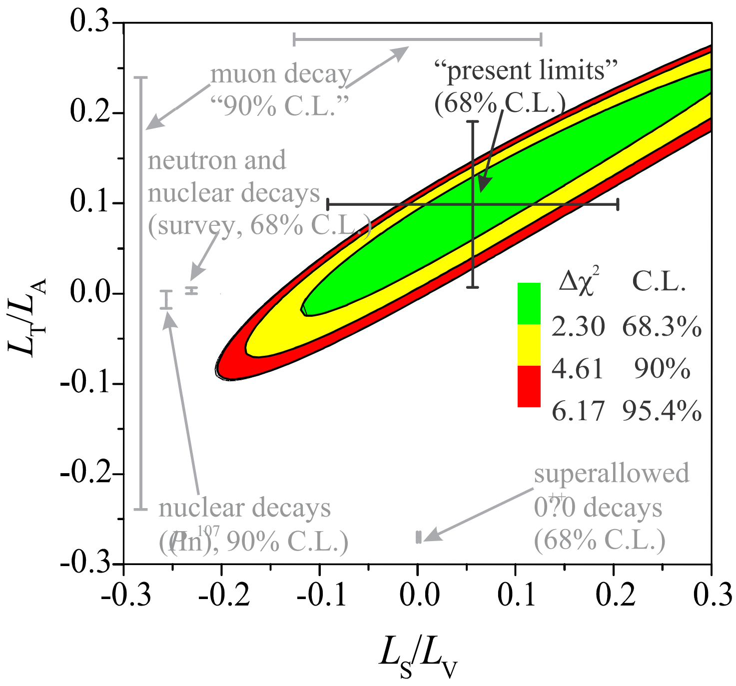
As presented at NSAC meeting,

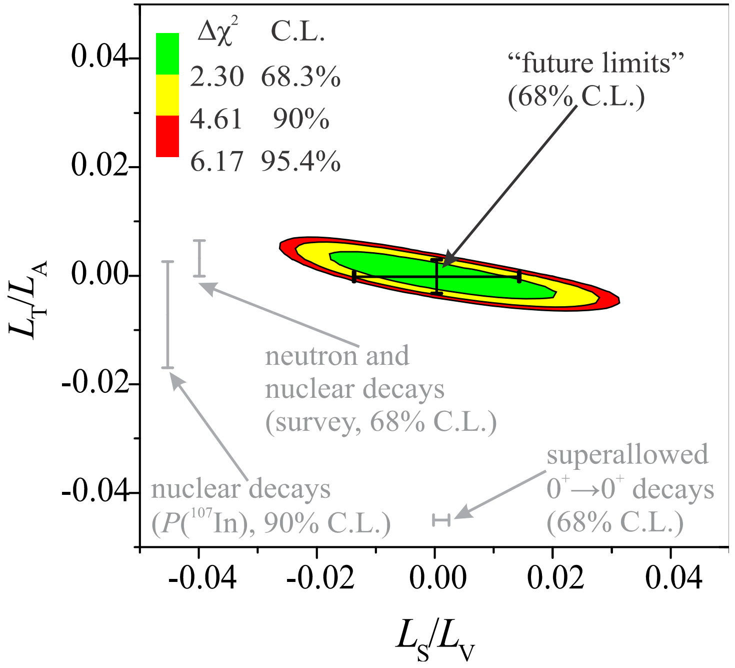
assuming **NO** major technical or funding delays



The experiment might move to NIST NG-C, probably for the polarized program.

Sensitivity to left-handed S-T couplings





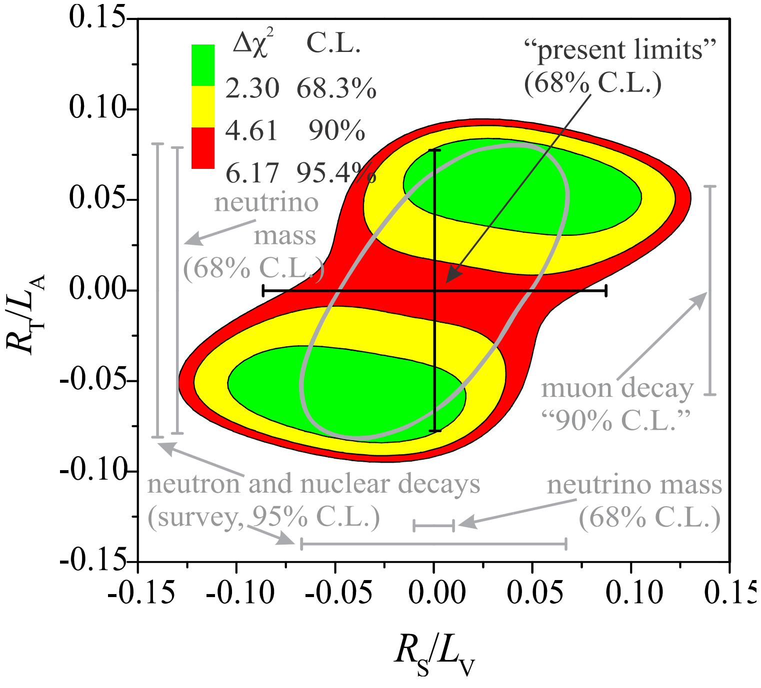
Present limits (n decay data)
SM is in the origin of this plot

Future limits,
assuming a = -0.1059(1), A = -0.1186(1) , B = 0.9807(30), C = -0.23785(24), τ_n = 882.2(13) s, b = 0±0.003

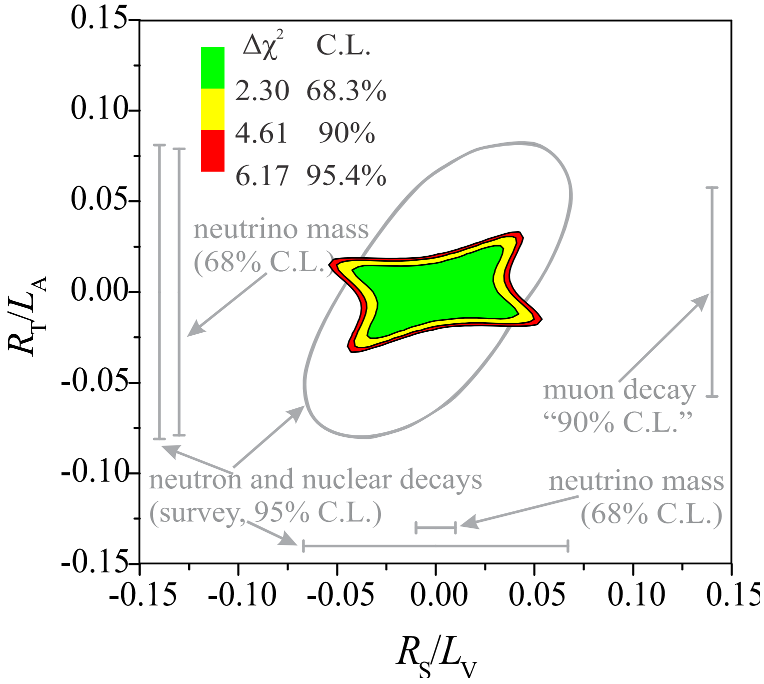
Model-dependent predictions: Supersymmetry, leptoquarks, …

Analysis similar to G. Konrad, S.B. et al., ArXiv:1007.3027

Sensitivity to right-handed S-T couplings



Present limits (n decay data)
SM is in the origin of this plot



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B = 0.9807(30), C = -0.23785(24), τ_n = 882.2(13) s

Analysis similar to G. Konrad, S.B. et al., ArXiv:1007.3027

The Nab collaboration

R. Alarcon[a], L.P. Alonzi[b] , S.B.[b] (Experiment Manager), S. Balascuta[a], J.D. Bowman[c] (Co-Spokesmen), M.A. Bychkov[b], J. Byrne[d], J.R. Calarco[e], T.V. Cianciolo[c], C. Crawford[f], E. Frlež[b], M.T. Gericke[g], F. Glück[h], G.L. Greene[i], R.K. Grzywacz[i], V. Gudkov[j], F.W. Hersman[e], A. Klein[k], J. Martin[l], S. McGovern[b], S. Page[g], A. Palladino[b], S.I. Penttilä[c] (On-site Manager), D. Počanić[c] (Co-Spokesmen), K.P. Rykaczewski[c], W.S. Wilburn[k], A.Young[m]

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[m] Department of Physics, North Carolina State University, Raleigh, NC 27695-8202

Tasks of UVa group: Spectrometer design, Superconducting magnet, Proton source

Summary

- Precise and reliable results from neutron physics are preferred to extract information about the Standard Model without nuclear structure uncertainties

- Main difference to European effort (PERKEO II/III, *a*SPECT, PERC): less count rate, e^--p coincidences

- Status of Nab spectrometer: Funding application at DOE to perform Nab at the FNPB beamline at the SNS. Second funding application to NSF (MRI)

- Experiment is received (preliminary) endorsement of NSAC last week (rank 4 out of 5 out of 15)

Thank you for your interest !!