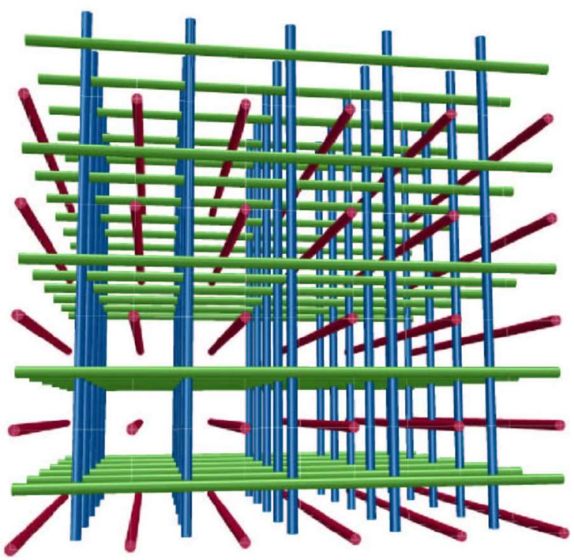
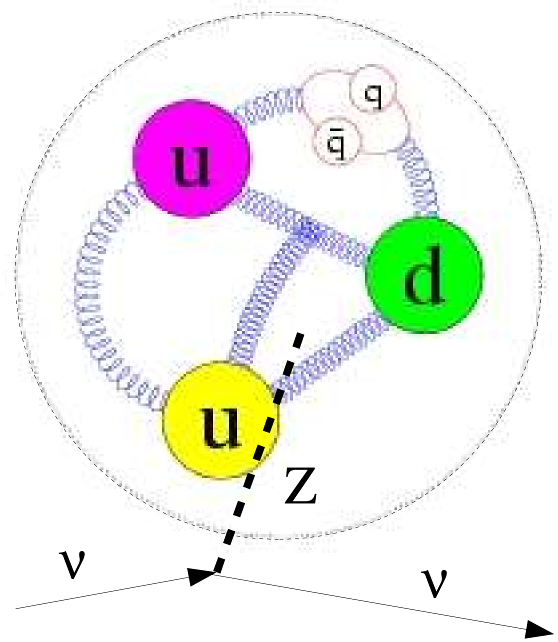
Probing Nucleon (strange) Spin Structure with Neutrino Scattering

Outline:
- Nucleon structure - strange quarks, spin
- Neutrinos as probes of strange spin - Δs
- The FINeSSE Experiment





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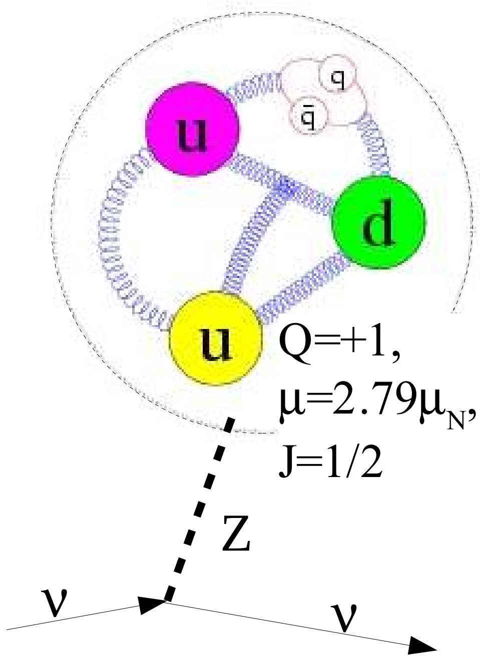
Nucleon Structure



- Can we describe the structure of the proton in terms of a fundamental theory?

  This is still an open question and an area of intensive effort at many labs around the world.

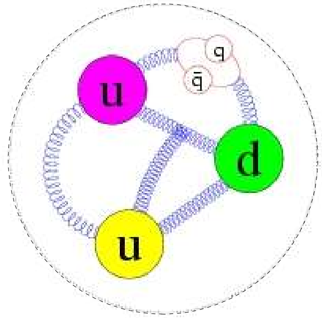
- In particular, What carries the nucleon spin! valence quarks, sea quarks, gluons?

- The neutrino, because of its unique properties, is an excellent way to investigate the spin of (strange) sea quarks.

- Current (and near future) intense neutrino sources offer the opportunity to make these measurements.

- We are proposing an experiment to do this!

Nucleon Structure: strange quarks



Net strangeness of the nucleon is zero. However, QCD: valence ud quarks + sea of qqbar pairs.

mass:

π-N scattering data -> strange quarks contribute to nucleon mass.

momentum:

DIS ν scattering (e.g. NuTeV), The strange sea carries a non-zero fraction of the proton momentum.

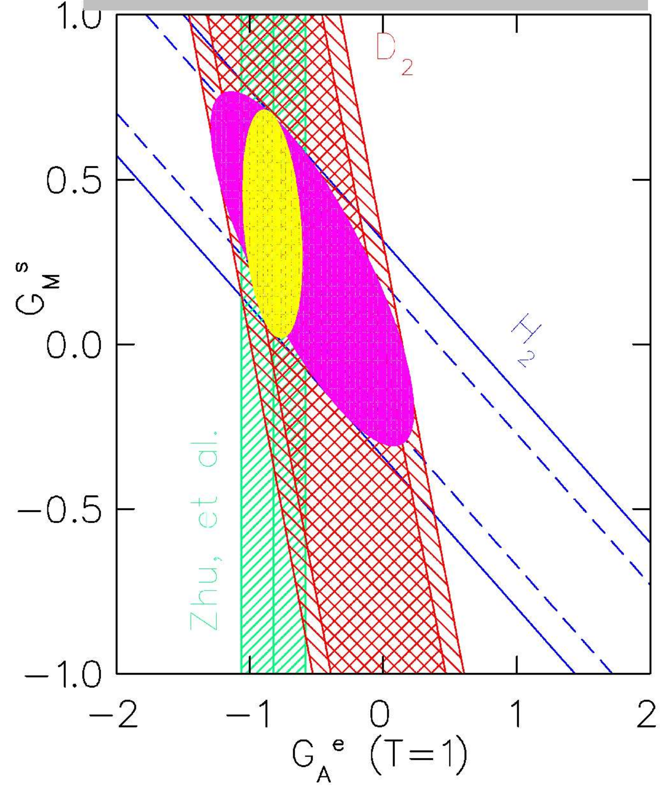
spatial distributions:

PV e^- scattering (e.g. SAMPLE, HAPPEX, G0, PVA4) looks for strange-quark contributions to the proton magnetic moment (μ_s) and radius (r_s).

SAMPLE: Looks like strange quarks are not showing up in proton magnetic moment.

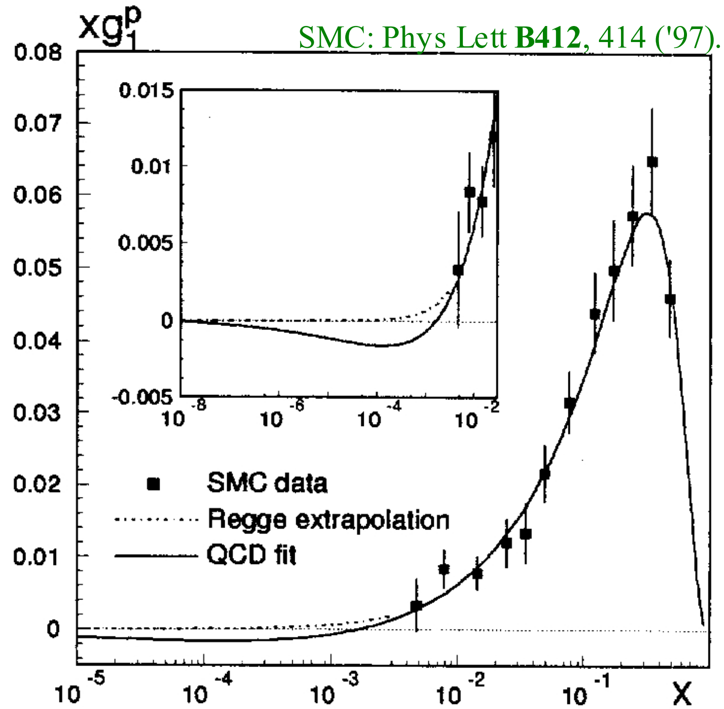
spin: ....

from SAMPLE(PLB 583, 79, '04):



Nucleon Structure: strange quark spin Δs

- Polarized Lepton Deep Inelastic Scattering (DIS) experiments; e.g. SLAC (ESA), CERN(EMC,SMC); have extracted the quark contributions to the spin (Δq) of the nucleon via the axial structure function: $g_1^{p,n}(x,Q^2)$.



Requires:

- integration over x $\left(\Gamma_1^{p(n)} \equiv \int_0^1 g_1^{p(n)}(x)\,dx\right)$
- use of nucleon/hyperon decay data (assumes $SU(3)_f$ symmetry)

$\Rightarrow$

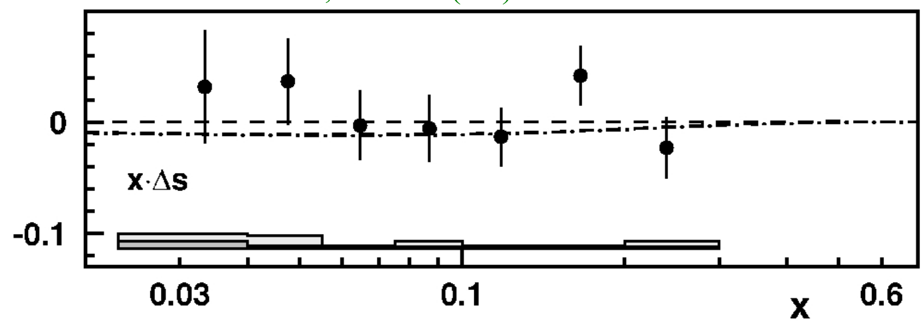
	"Regge"	QCD fit
Δu	0.84 ± 0.06	0.80 ± 0.06
Δd	-0.42 ± 0.06	-0.46 ± 0.06
Δs	-0.08 ± 0.06	-0.12 ± 0.06

$$\boxed{\begin{array}{c}\Delta\Sigma = \Delta u + \Delta d + \Delta s \\ \Delta q = q\uparrow - q\downarrow + \bar{q}\uparrow - \bar{q}\downarrow\end{array}}$$

Nucleon Structure: strange quark spin Δs...

- In addition, recent results from HERMES in semi-inclusive scattering of polarized positrons from polarized deuterium allow for the extraction of sea-quark helicities:

HERMES: PRL **92**, 012005 ('04).



$\Longrightarrow$ "Δs" = 0.03±0.03±0.01   (0.023<x<0.30)

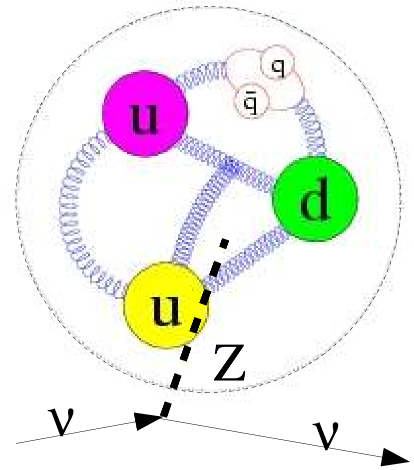
Note:
- Limited x range
- Is the factorization robust?

- A measurement of neutrino-nucleon elastic-scattering can determine Δs <u>directly</u> via a measurement of the neutral-current axial form factor. This method requires:
    - no extrapolation to x=0
    - no assumptions of SU(3) symmetry

$\Longrightarrow$ A theoretically robust measurement of Δs

$\nu N \rightarrow \nu N$ scattering and Δs

- Axial part of Nucleon Neutral Weak Current:



$$\langle N|A_\mu^Z|N\rangle = -\left[\frac{G_F}{\sqrt{2}}\right]^{1/2} \langle N|\frac{1}{2}\{\underbrace{\bar{u}\gamma_\mu\gamma_5 u}_{\Delta u} - \underbrace{\bar{d}\gamma_\mu\gamma_5 d}_{\Delta d} - \underbrace{\bar{s}\gamma_\mu\gamma_5 s}_{\Delta s}\}|N\rangle$$

$$= -\left[\frac{G_F}{\sqrt{2}}\right]^{1/2} \langle N|\frac{1}{2}\{-G_A(Q^2)\gamma_\mu\gamma_5\tau_z + G_A^s(Q^2)\gamma_\mu\gamma_5\}|N\rangle$$

- G_A (non-strange, Δu-Δd) known (from n β-decay)

- $G_A^s(Q^2 = 0) = \Delta s$

- At low Q^2, (NC elastic) cross section in most-sensitive to axial part (unique to neutrino scattering):

$$\frac{d\sigma}{dQ^2}(\nu p \rightarrow \nu p) \propto (-G_A + G_A^s)^2$$

- Therefore, a measurement of νN NC scattering (at low Q^2) yields Δs

A ratio method to extract Δs

A measurement of νN NC cross section is sensitive to Δs...
but a cross-section ratio measurement is better!

A measurement of R_ν(NC/CC) reduces

- experimental systematics (e.g. flux, efficiencies, etc.)

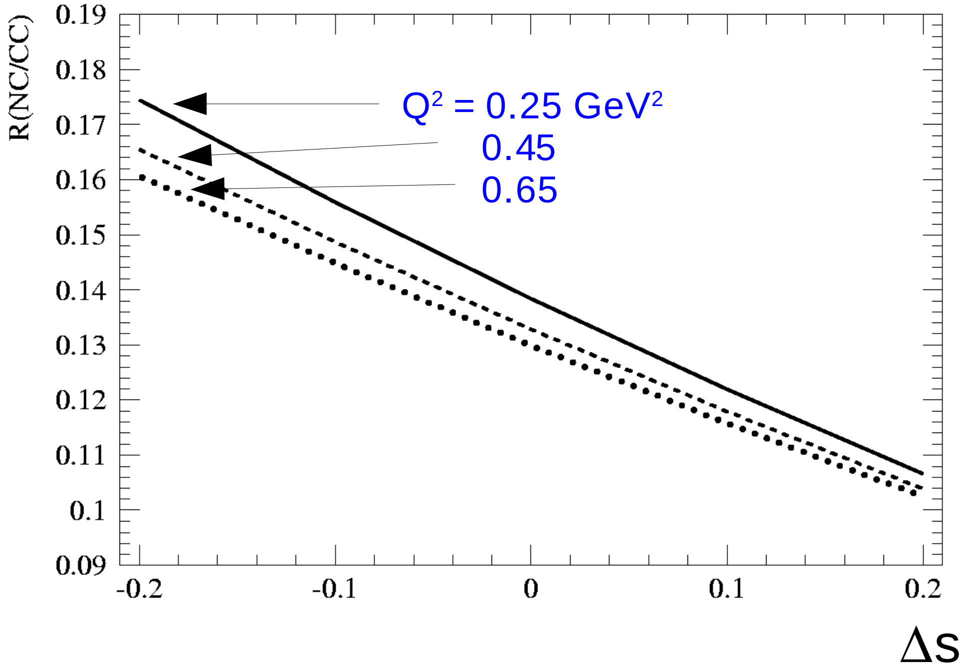
- nuclear effects

- other form factor uncertainties (e.g. M_A)

$$R_\nu(NC/CC) = \frac{\sigma(\nu_\mu p \rightarrow \nu_\mu p)}{\sigma(\nu_\mu n \rightarrow \mu p)}$$

$$\overline{R_\nu}(NC/CC) = \frac{\sigma(\overline{\nu_\mu} p \rightarrow \overline{\nu_\mu} p)}{\sigma(\overline{\nu_\mu} p \rightarrow \mu n)}$$

sensitivity of R(NC/CC) to Δs



Aside: a “rigorous sum rule” for NC nu scattering

From A. Thomas (hep-ex/0311029):

- measured in DIS:

$$\int_0^1 dx\, g_1^p(x,Q^2) = \left(\frac{1}{12} g_A^{(3)} + \frac{1}{36} g_A^{(8)}\right) C_{NS}(Q^2) + \frac{1}{9} g_A^{(0)}|_{\mathrm{inv}} C_S(Q^2) + \mathcal{O}\left(\frac{1}{Q^2}\right).$$

- measured in n-decay: $g_A^{(3)}$
- measured in hyperon-decay: $g_A^{(8)}$
- measured in nu NC scattering:

$$\begin{aligned} 2g_A^{(Z)} &= (\Delta u - \Delta d - \Delta s)_{\mathrm{inv}} + \mathscr{P}\,(\Delta u + \Delta d + \Delta s)_{\mathrm{inv}} \\ &+ O(m_{t,b,c}^{-1}), \end{aligned}$$

small

calculated
(Phys.Rev. D66 (2002) 031901)
correction (= -0.02)

- then the relation of quark to axial charges

$$(\Delta u - \Delta d - \Delta s)_{\mathrm{inv}} = g_A^{(3)} + \frac{1}{3} g_A^{(8)} - \frac{1}{3} g_A^{(0)}|_{\mathrm{inv}}.$$

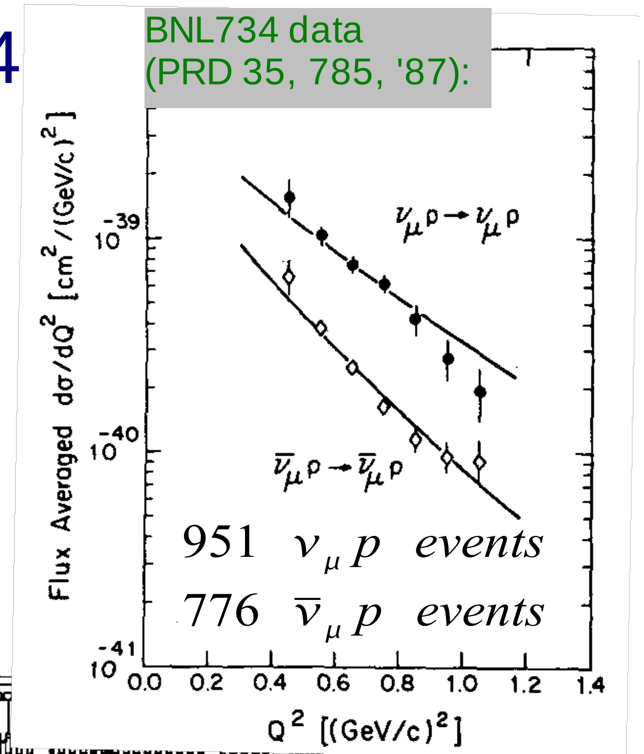
- becomes a “rigorous sum rule” relating DIS to 3 low-energy observables

- need nu NC measurement of NC axial charge, $g_A^{(Z)}$, to test this...

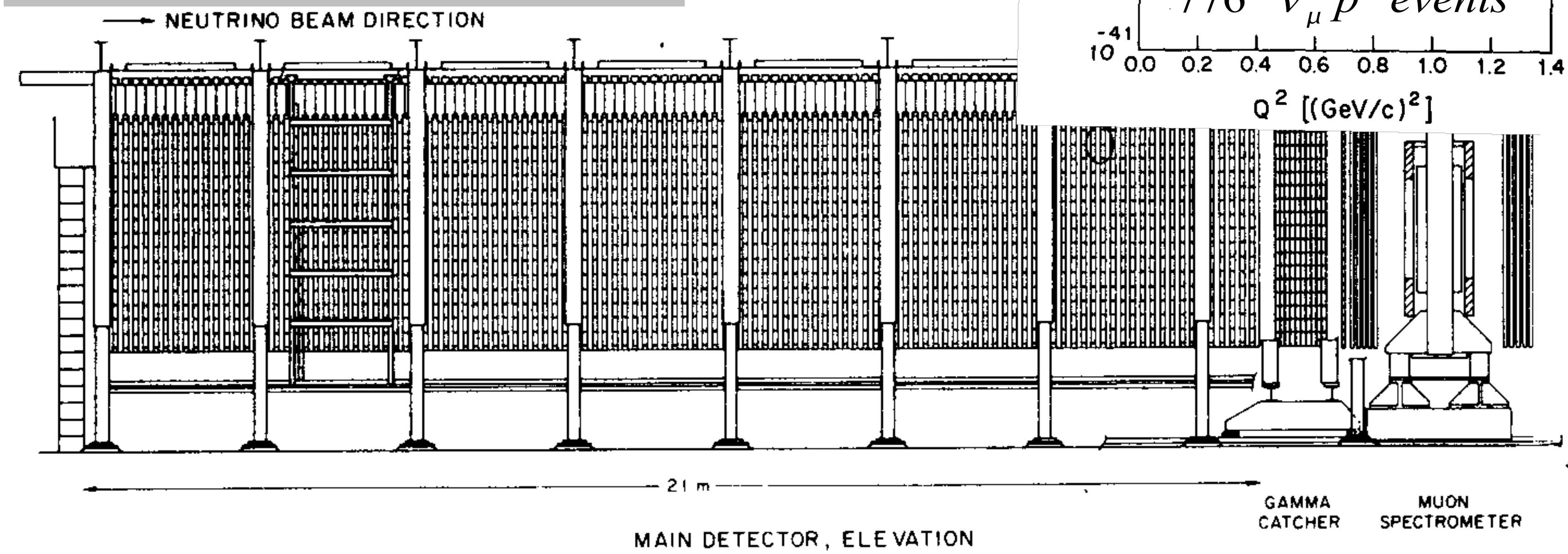
NC neutrino scattering: BNL E734

BNL E734: νp, $\bar{\nu} p$ elastic scattering
170 ton segmented detector
@E_ν~1.2 GeV , (Q^2=0.4 $\rightarrow$ 1.1 GeV^2)
(Ahrens et al.,PRD 35, 785, '87.)

BNL734 data
(PRD 35, 785, '87):

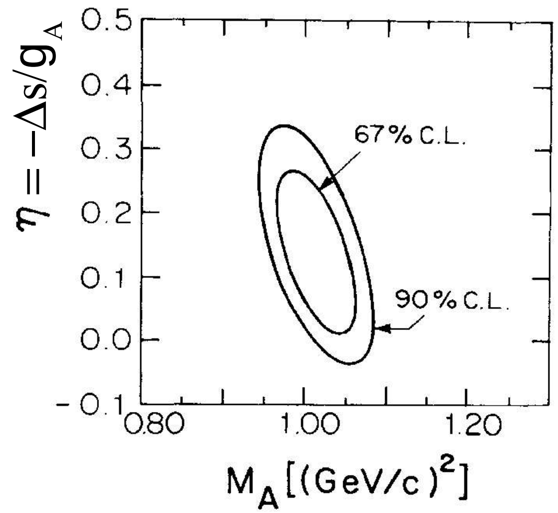


BNL734 detector



NC neutrino scattering: BNL E734

- A fit to the νp, $\bar{\nu}$p elastic scattering diff xsection yielded: Δs = -0.15±0.09 (Ahrens et al., PRD 35, 785, '87.)



- This data has generated much interest... and several reanalyses:
  - (Garvey et al., PRC48, 761, 1993): more realistic values for vector form factors, Q^2 evolution → Δs = -0.21±0.10±0.10
  - (Alberico et al., Nucl. Phys. A651, 277, 1999), considered ratios of NC,CC cross sections → Δs consistent with above
  - (Pate, PRL 92, 082002, '04): combines E734 data with eN data from HAPPEX, yields $G_A^s(Q^2=0.5\ GeV^2)$, but data not close enough to $Q^2=0$ → no Δs extraction.

- The BNL734 data is not accurate enough for an extraction of Δs with sufficiently small errors (i.e. to be competitive with DIS measurements)

- This data set may be improved in a new experiment...
  - with more events (~10k NCp events, ~x10 E734)
  - with lower background
  - at lower Q^2 (down to 0.2 GeV^2)
  - with a ratio method : R(NC/CC)

FINeSSE experiment

Physics Motivation:

- A measurement of Δs
- Intermediate-energy cross sections

Experiment:

- at a near (~100m) location on an intense ν source
- 2 part detector:
  - 10 ton liquid-scintillator/fiber vertex detector
  - muon rangestack

Possible locations:

- FNAL: 8GeV booster ν source
- BNL: AGS ν source
- JPARC: T2K beam

FINeSSE
Fine-grained
Intense
Neutrino
Scattering
Scintillator
Experiment

FINeSSE collaboration

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Booster Neutrino Beamline at FNAL

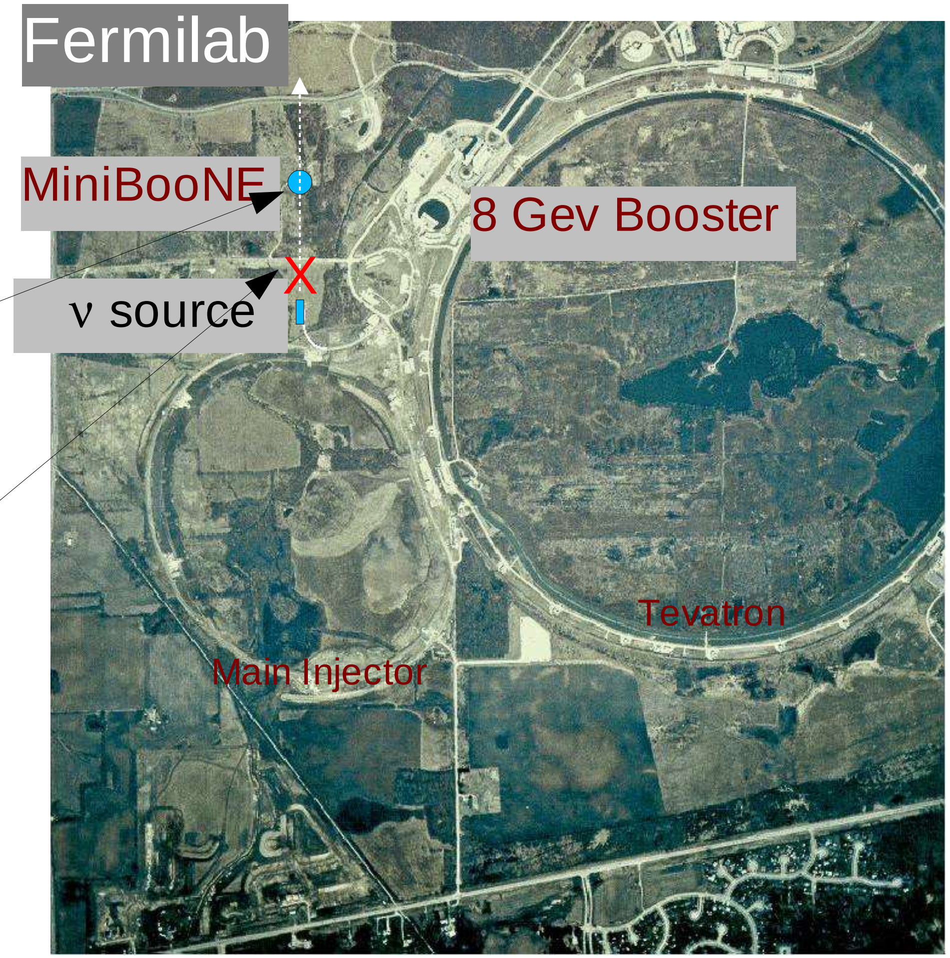
- currently delivering beam to MiniBooNE experiment (since Sept '02)

- 500m from ν target:

MiniBooNE...

- 100m from ν target:

open space!...

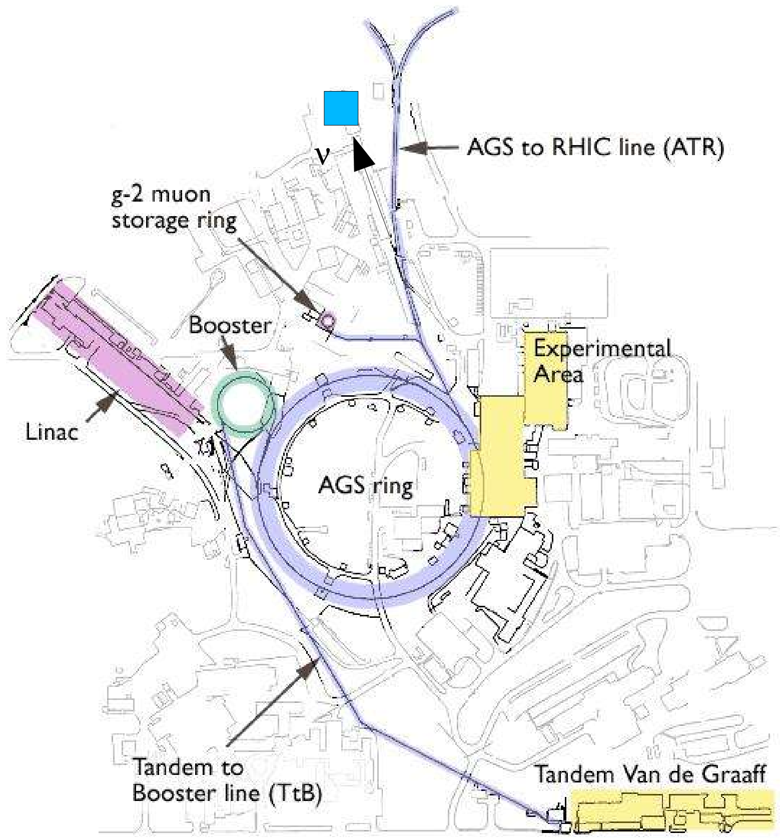


Neutrino Beamline at BNL

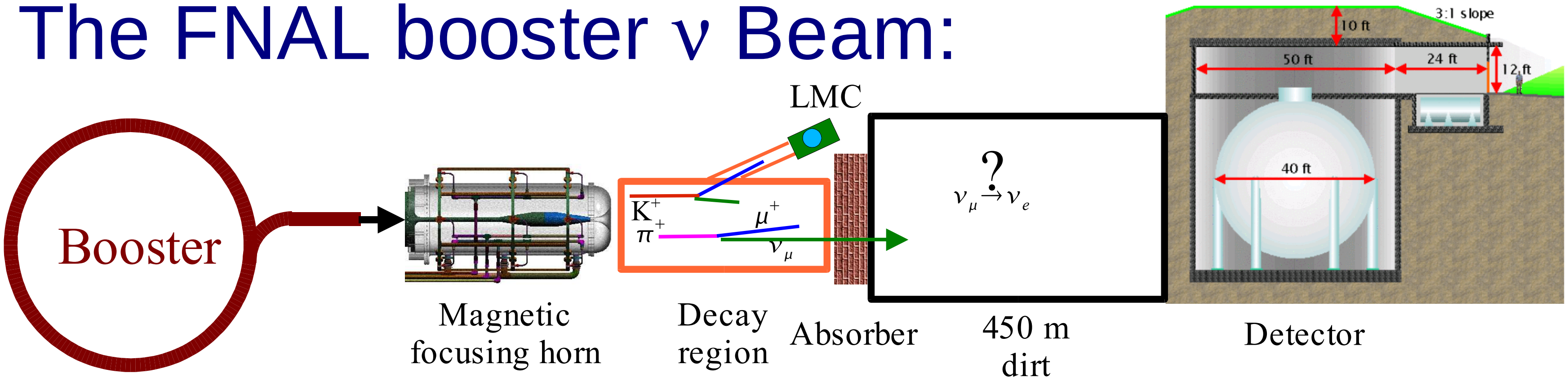
- (U-line) used to deliver beam to E734 (et al)

- no neutrino source currently in place

- could use MB nu source design relatively inexpensively



The FNAL booster ν Beam:

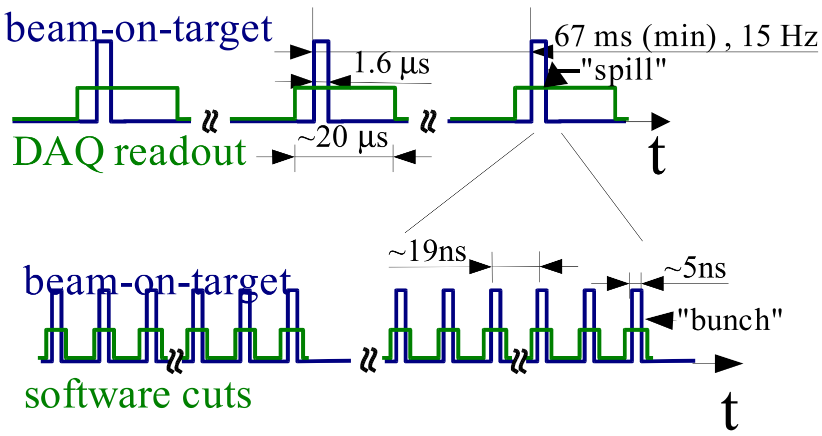


- 8 GeV protons from the FNAL booster...
- on a Be target, produce π^+ ...
- π^+ are focused via the neutrino "horn"...
- π^+ decay ($\pi^+ \rightarrow \mu\nu_\mu$) in 50m pipe...
- yielding intense source of ν_μ

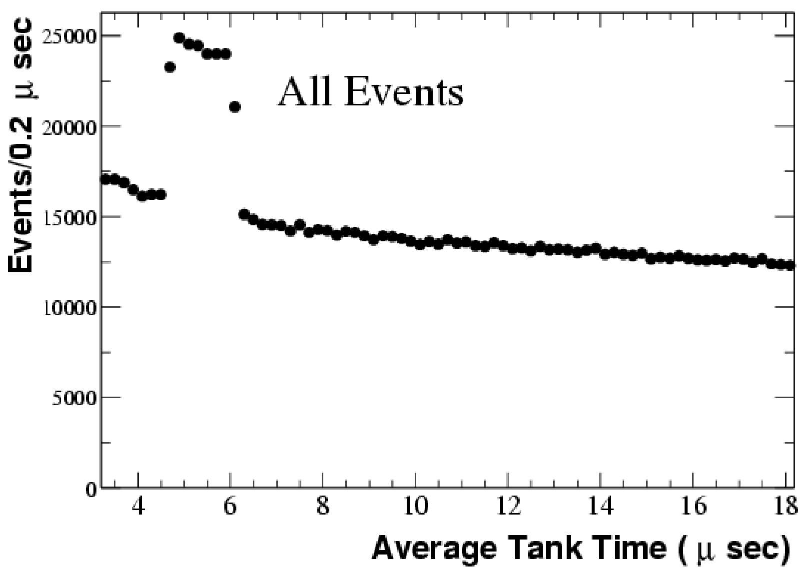
FNAL booster ν beam, timing:

- The beam is incident on the target in 1.6 μs "spills" (macro structure)

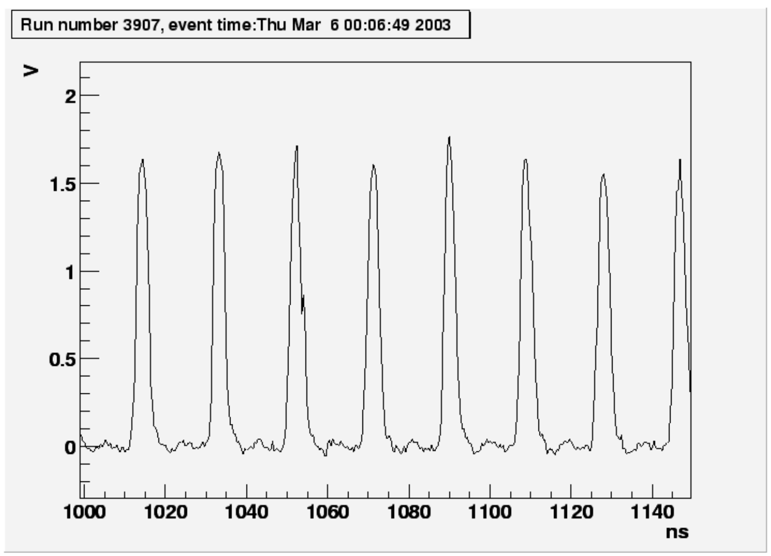
... nice feature for a neutrino experiment as beam-unrelated backgrounds are neglible in this beam



MiniBooNE nu candidates, no cuts



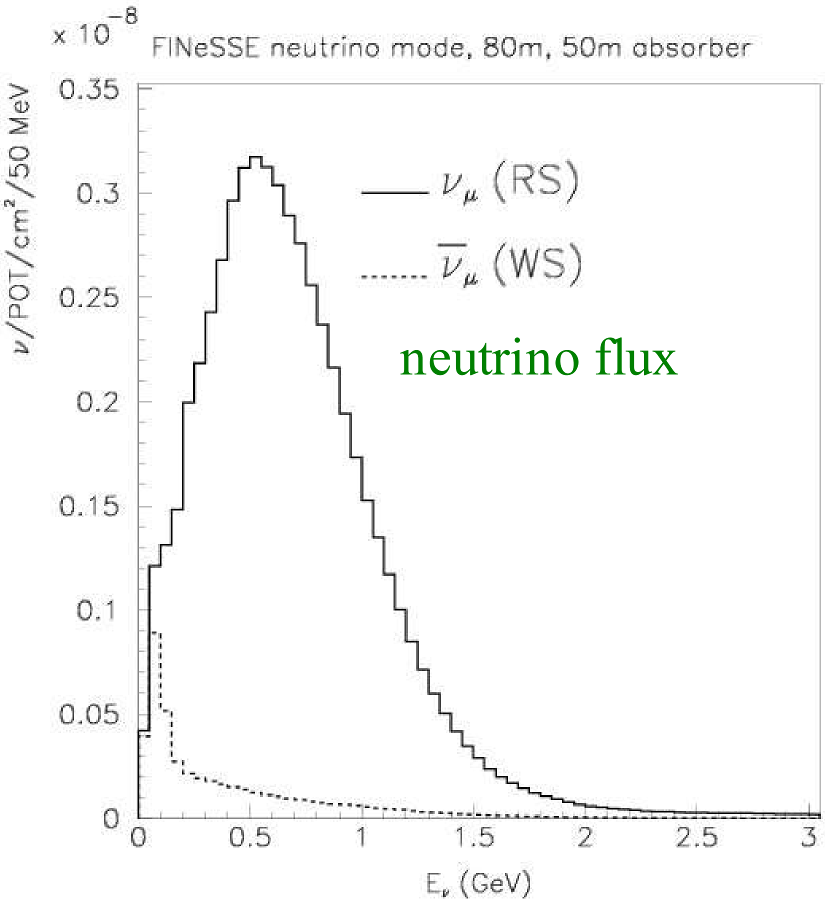
Booster nu beam, microstructure

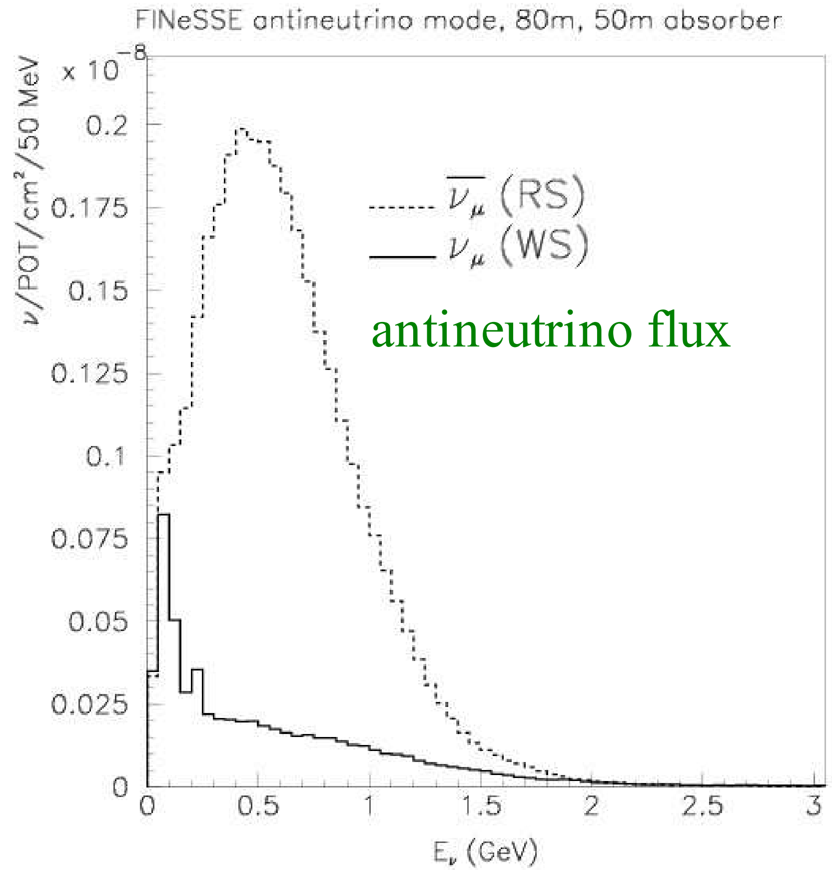


- there is also a 19ns microstructure...

Neutrino Flux

- nu/antinu flux at 80m location on FNAL (8 GeV) booster nu beamline
- nu: <E> ~ 700MeV, nubar frac = 7%
- nubar: flux ~ 60%(nu flux), <E> ~ 600MeV, nu frac = 16%
- similar fluxes may be obtained from AGS





Event Rates:

- with these nu/antinu fluxes, a first-rate physics program may be carried out with 1 yr nu running and 2 yr antinu and a 9 ton (fiducial) detector...

neutrino event rates

Reaction	ν_μ (RS) 10^{20} POT 1 ton	$\overline{\nu_\mu}$ (WS) 10^{20} POT 1 ton	ν_μ (RS) 2×10^{20} POT 9 ton (1 yr @FNAL)
CC quasi-elastic	10,107	181	$\boxed{181,930}$
NC elastic	4,126	78	$\boxed{74,275}$
CC resonant $1\pi^+$	4,990	0	89,827
CC resonant $1\pi^-$	0	42	0
CC resonant $1\pi^0$	928	13	16,704
NC resonant $1\pi^0$	1,301	19	23,414
NC resonant $1\pi^+$	458	8	8,237
NC resonant $1\pi^-$	357	5	6,422
CC DIS	253	2	4,550
NC DIS	91	0	1,642
NC coherent $1\pi^0$	365	14	6,566
CC coherent $1\pi^+$	603	0	10,858
CC coherent $1\pi^-$	0	24	0
other (multi-π, etc.)	621	18	11,174
total	24,200	403	435,600

antineutrino event rates

Reaction	$\overline{\nu_\mu}$ (RS) 10^{20} POT 1 ton	ν_μ (WS) 10^{20} POT 1 ton	$\overline{\nu_\mu}$ (RS) 4×10^{20} POT 9 ton (2 yr @FNAL)
CC quasi-elastic	2,219	787	$\boxed{79,892}$
NC elastic	922	323	$\boxed{33,179}$
CC resonant $1\pi^+$	0	470	0
CC resonant $1\pi^-$	419	0	15,092
CC resonant $1\pi^0$	130	93	4,666
NC resonant $1\pi^0$	230	118	8,294
NC resonant $1\pi^+$	83	43	2,996
NC resonant $1\pi^-$	59	35	2,132
CC DIS	3	30	116
NC DIS	2	11	58
NC coherent $1\pi^0$	184	30	6,624
CC coherent $1\pi^+$	0	51	0
CC coherent $1\pi^-$	298	0	10,714
other (multi-π, etc.)	157	93	5,644
total	4,706	2,086	169,402

(More) $\nu N \to \nu N$ scattering and Δs

- Differential xsection for νN, $\underline{\nu}N$ CC and NC (quasi-) elastic scattering:

$$\frac{d\sigma}{dQ^2} = \frac{G_F^2}{2\pi}\frac{Q^2}{E_\nu^2}[A \pm B\,W + C\,W^2],\ W = 4E_\nu^2/m_p - Q^2/m_p^2,\ \tau = Q^2/4m_p^2$$

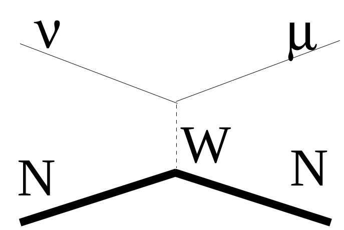
$$A = \frac{1}{4}[G_1^2(1+\tau) - (F_1^2 - \tau F_2^2)(1-\tau) + 4\tau F_1 F_2]$$

$$B = -\frac{1}{4}G_1(F_1 + F_2)$$

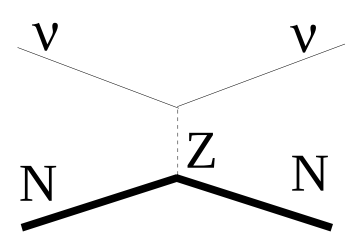
$$C = \frac{1}{16}\frac{m_p^2}{Q^2}[G_1^2 + F_1^2 + \tau F_2^2]$$

$$\nu NC: \nu_\mu p \to \nu_\mu p,\ \nu_\mu n \to \nu_\mu n$$
$$\nu CC: \nu_\mu n \to \mu^- p$$
$$\bar{\nu} NC: \bar{\nu}_\mu p \to \bar{\nu}_\mu p,\ \bar{\nu}_\mu n \to \bar{\nu}_\mu n$$
$$\bar{\nu} CC: \bar{\nu}_\mu p \to \mu^+ n$$

"CC": charged-current



"NC": neutral-current



- For CC, form factors are:

$$G_1 = -G_A$$
$$F_{1,2} = \pm F_{1,2}^p \mp F_{1,2}^n$$

- For NC, form factors are:

$$G_1 = \frac{-G_A}{2}\tau_z + \frac{G_A^s}{2};\ \tau_z = \pm 1$$

$$F_{1,2} = [\frac{1}{2} - \sin^2\theta_W][F_{1,2}^p - F_{1,2}^n]\tau_z - \sin^2\theta_W[F_{1,2}^p + F_{1,2}^n] - \frac{1}{2}F_{1,2}^s$$

$\nu N \to \nu N$ scattering and Δs

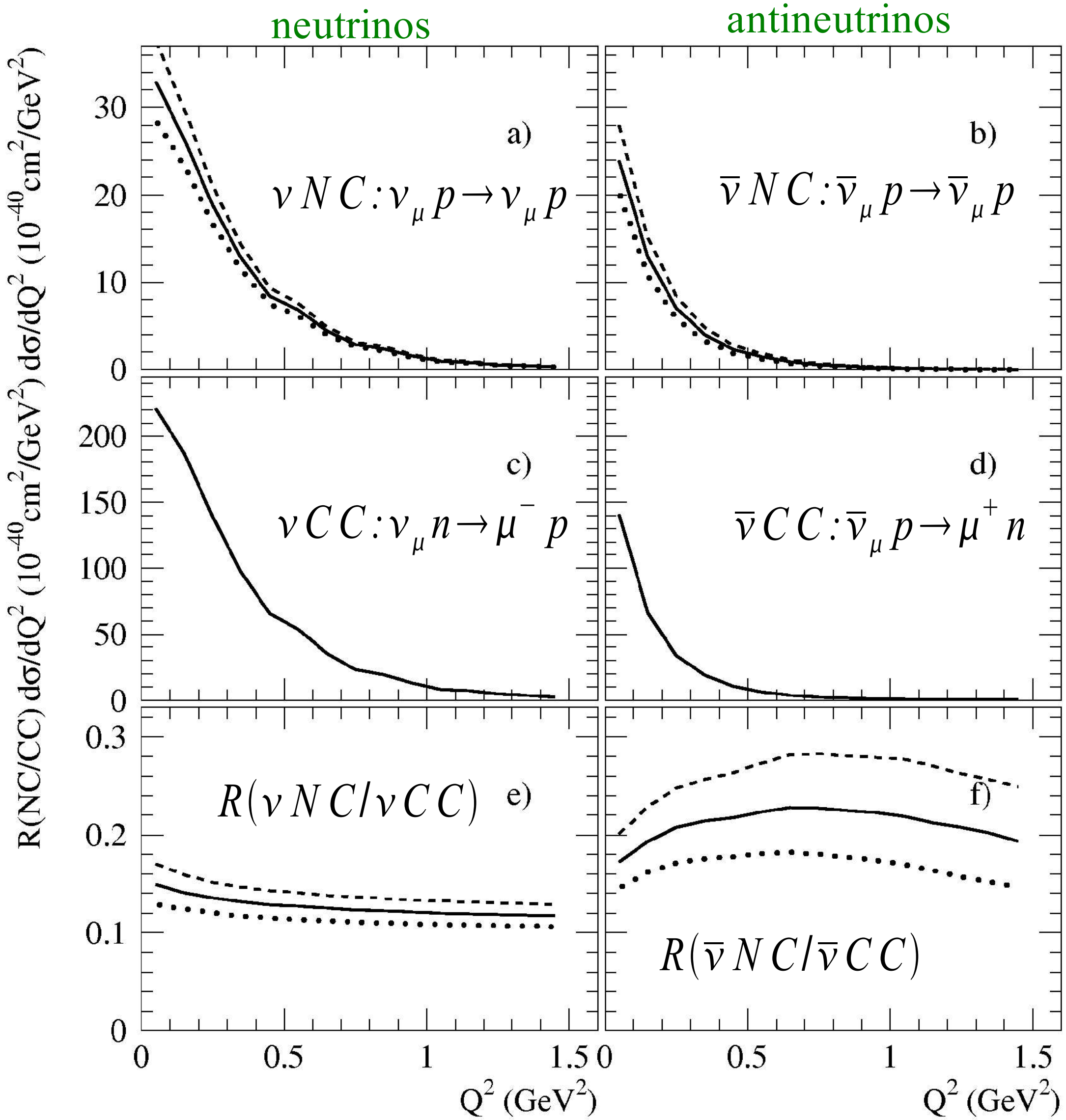
Differential xsections, ratios for νN, $\underline{\nu}$N CC and NC (quasi-) elastic scattering
- with different values of Δs

Δs=-0.1
Δs=0.0
Δs=+0.1

- flux-weighted (8 GeV flux)

- assuming dipole for Q^2 dep. of G_A, G_A^s:

$$G^s_A = \frac{\Delta s}{(1+Q^2/M^2_A)}$$

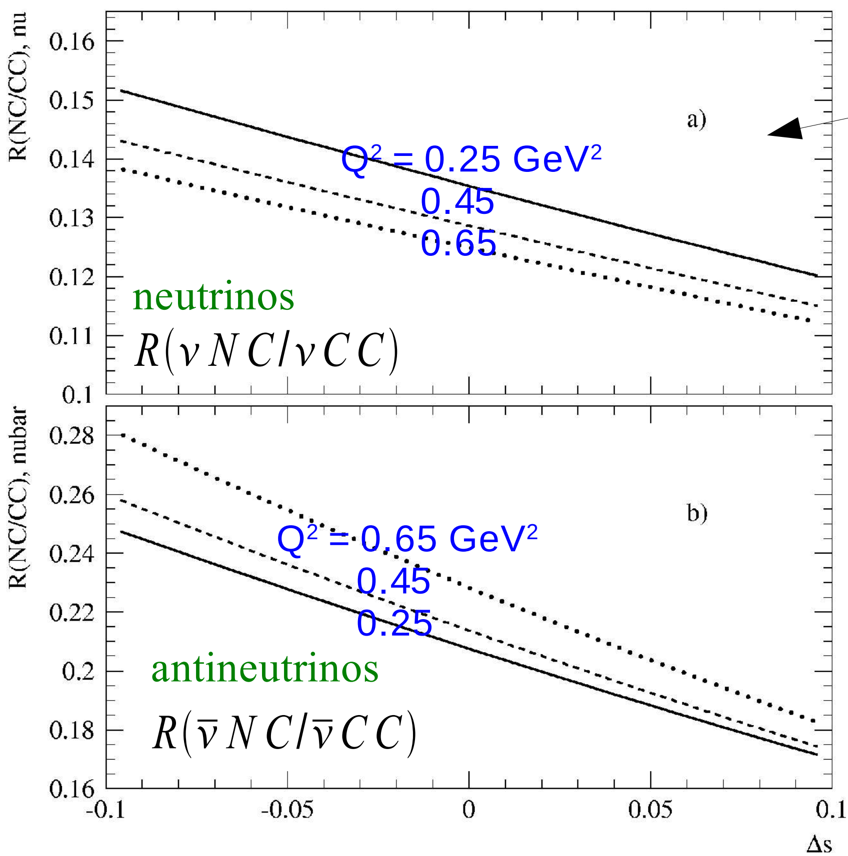


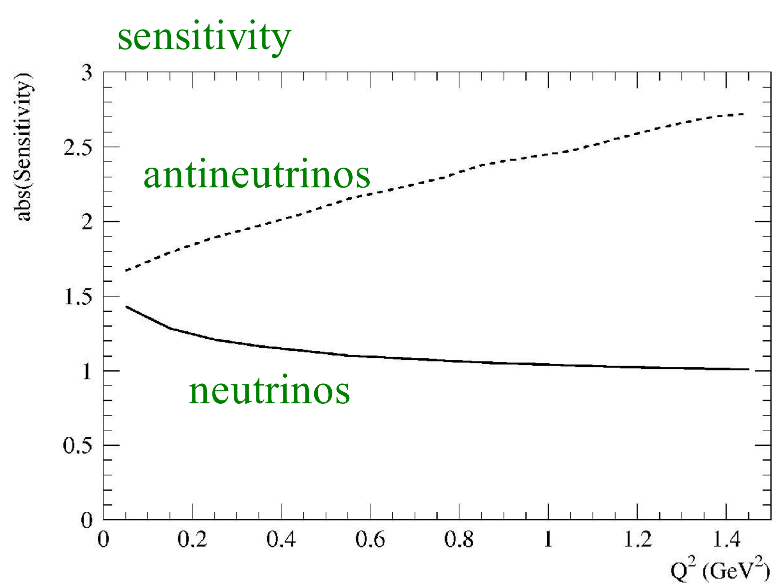
νN → νN scattering and Δs

- sensitivity of R(nu), R(nubar) to Δs is large
- actually larger for R(nubar)
- Q^2 dep of R(nu), R(nubar) is different => good systematic check...

$$R = \kappa(S\Delta s + 1)$$
$$\sigma(\Delta s) = \frac{1}{|S|}\frac{\sigma(R)}{R}$$

S is "sensitivity" of R to Δs
S = slope of this plot





NC neutrino scattering: some details

- A real-world neutrino experiment will use a nuclear target (e.g. CH_2) with *bound* nucleons.
  - This problem has been studied by many groups. While the correction is sizable for *absolute* cross sections, the uncertainty in a *ratio* is small. (PRC 54, 1954, hep-ph/0311053)

- The form factors depend on Q^2, most sensitive to G_1 (M_A) .
  - Will actually measure $G_A^s(Q^2)$ for $Q^2 = 0.2\text{-}0.9$ GeV^2
  - These uncertainties are reduced in ratio

- The NC/CC ratio depends upon other (unknown) strange form factors ($F_{1,2}^s$).
  - Sensitivity to $F_{1,2}^s$ is much smaller than to G_1
  - $F_{1,2}$ will be measured (G0, Happex at JLab)
  - measure nu and antinu ratios, combine with PVe data

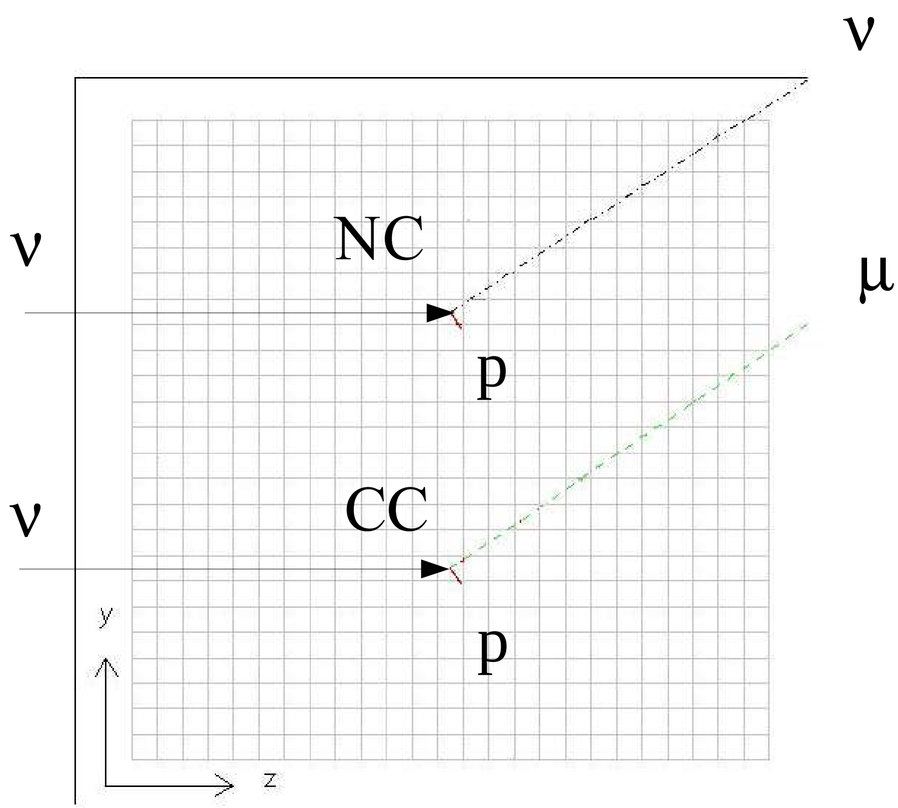
FINeSSE Detector Requirements

To precisely measure Δs, need a precise measurement of R(NC/CC) (to ~5%)

Also need to measure R(NC/CC) as function of Q^2($=2m_p T_p$) down to 0.2 GeV^2

Need:
- A ~10 ton (fiducial) detector capable of:
- proton energy measurement (independently of muon energy) down to T_p~100MeV (R~10cm)
- particle ID for NC/CC/background separation
- muon ID/tracking capability

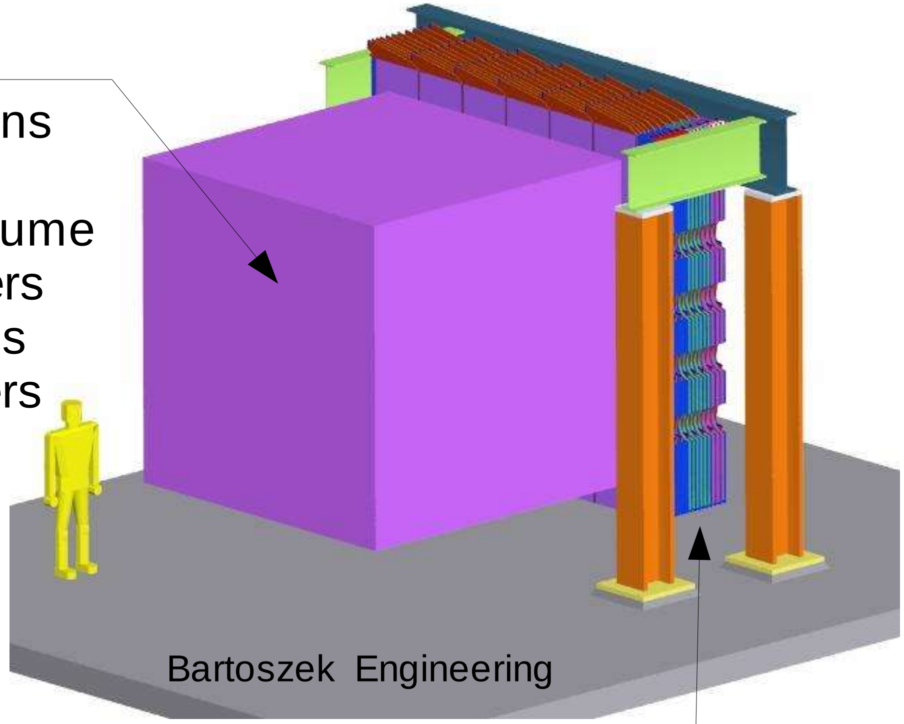
- Need a large, low-threshold, tracking "vertex" detector
- with a muon "rangestack"

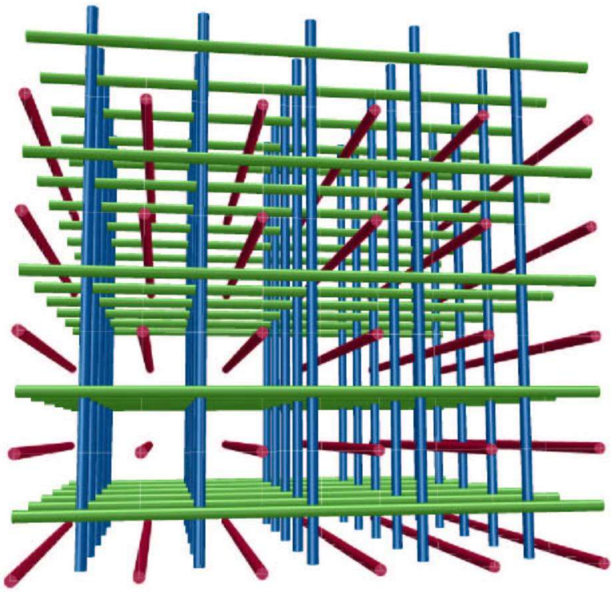


GEANT-generated events in scintillator:
$Q^2 = 0.2$ GeV^2, $E_\nu = 800$MeV
T_p~100 MeV, T_μ~600 MeV

FINeSSE Detector

The Vertex Detector...
- to precisely track low-energy protons (and muons, pions, electrons)
- $(2.5\text{m})^3$ active liquid scintillator volume
- 19200 (80x80x3) 1.5 mm WLS fibers on 3cm spacing with 3 orientations
- no optical separation between fibers ("scibath" method)

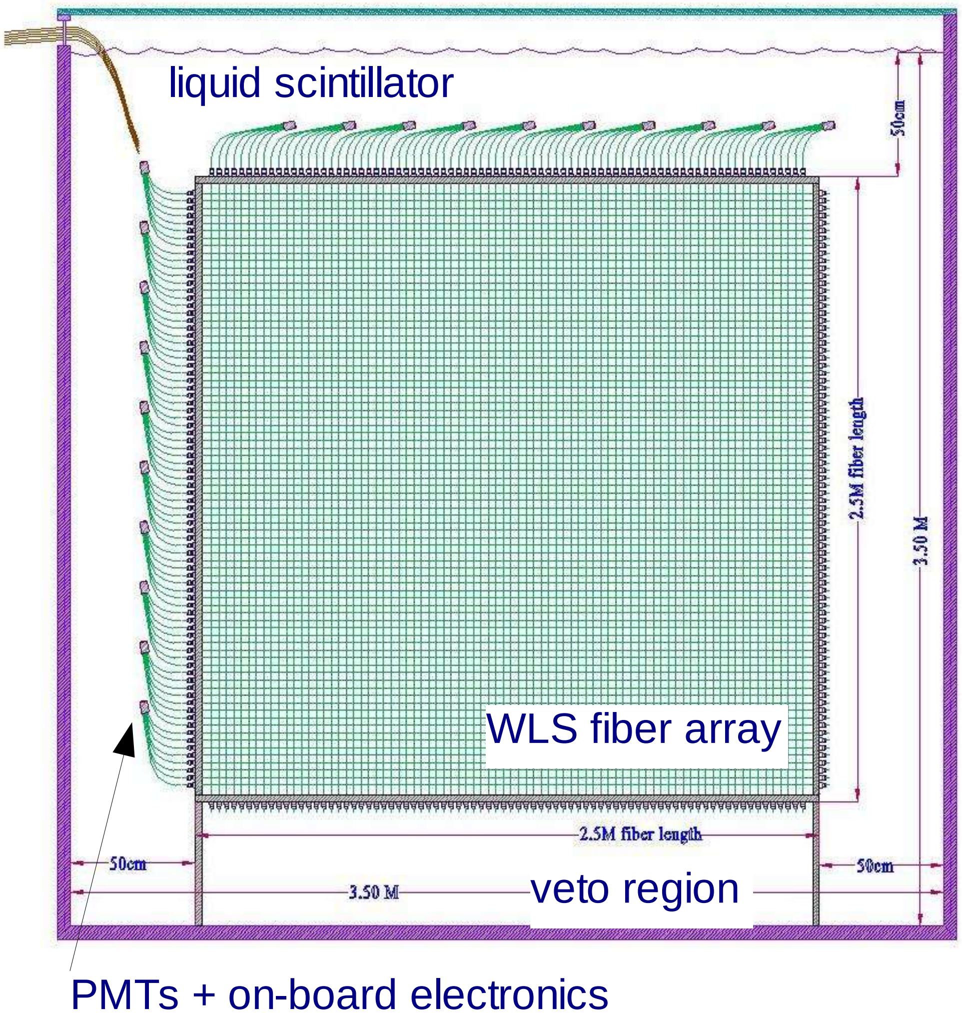



WLS fibers in vertex detector

The Muon Rangestack...
- to track and measure the energy of muons

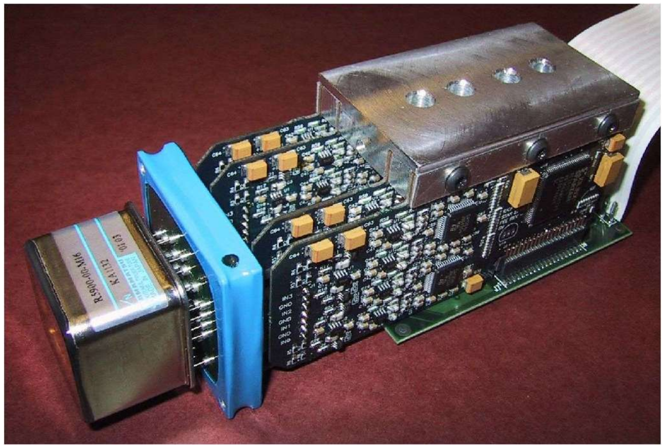
FINeSSE Vertex Detector...

Vertex Detector side view:



- read out with 64 anode PMTs and on-board electronics

STAR PMT w/front-end electronics

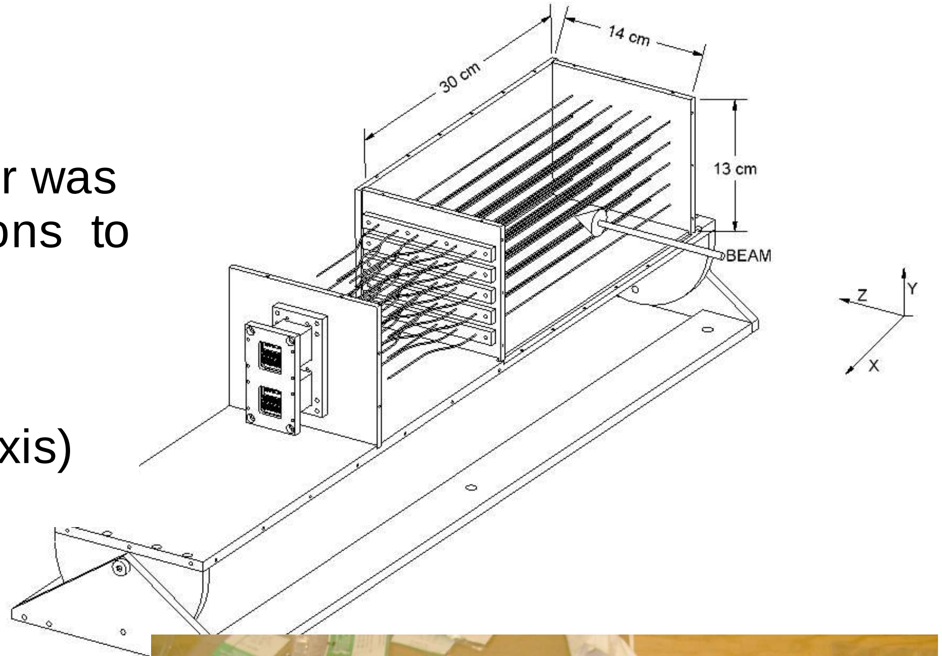


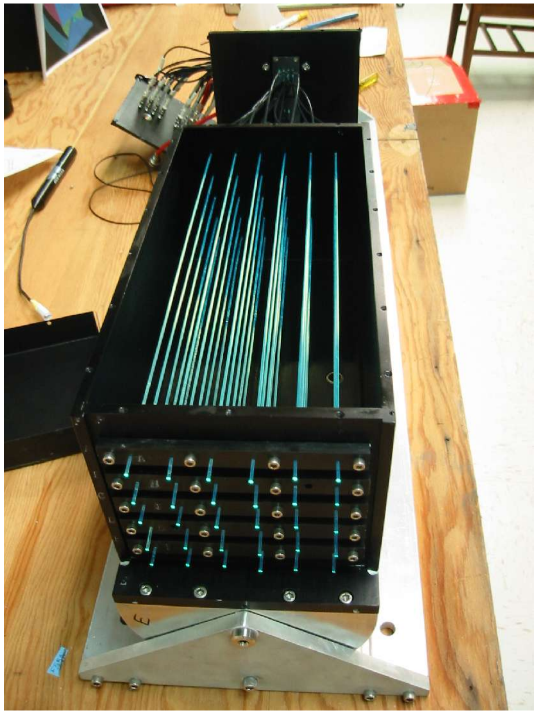
- similar scheme to that employed for STAR endcap calorimeter

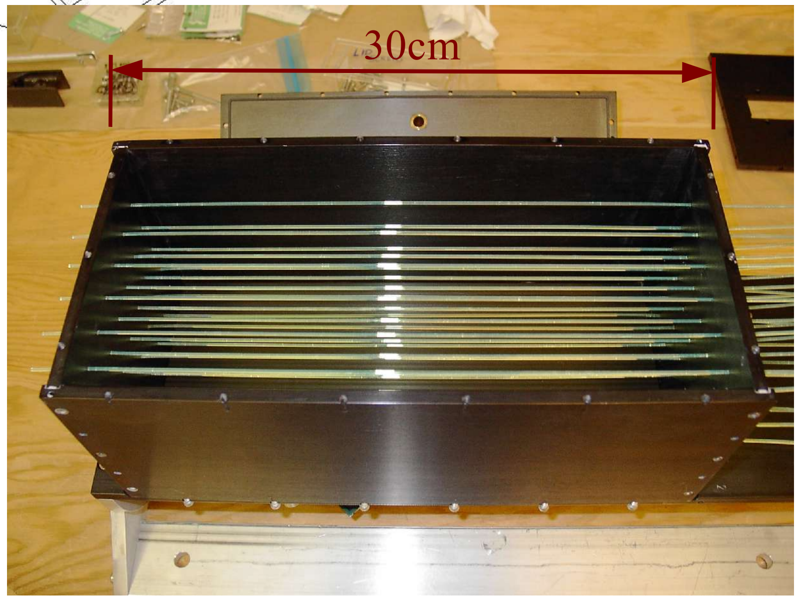
FINeSSE protoype tests

- A prototype “scibath” vertex detector was tested at the IUCF with 200MeV protons to determine suitability for FINeSSE

- 30 1.5mm WLS fibers immersed in liquid scintillator (all fibers along x-axis)





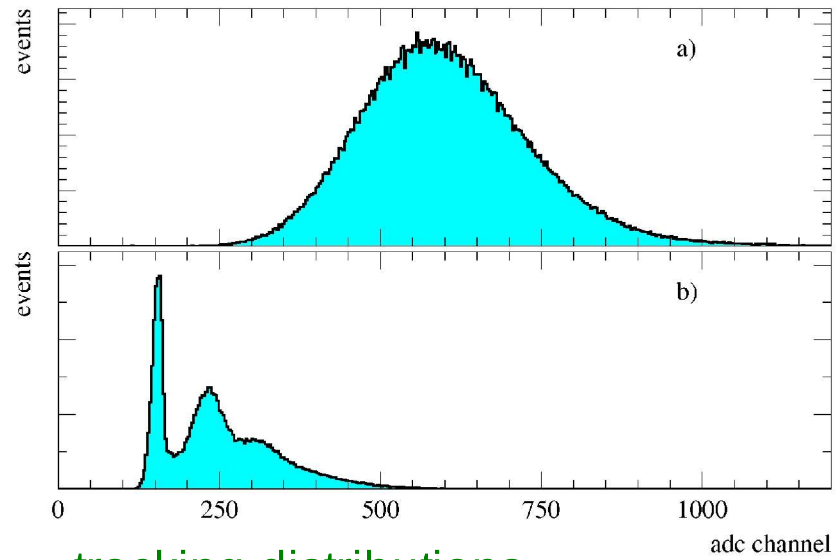


FINeSSE protoype tests...

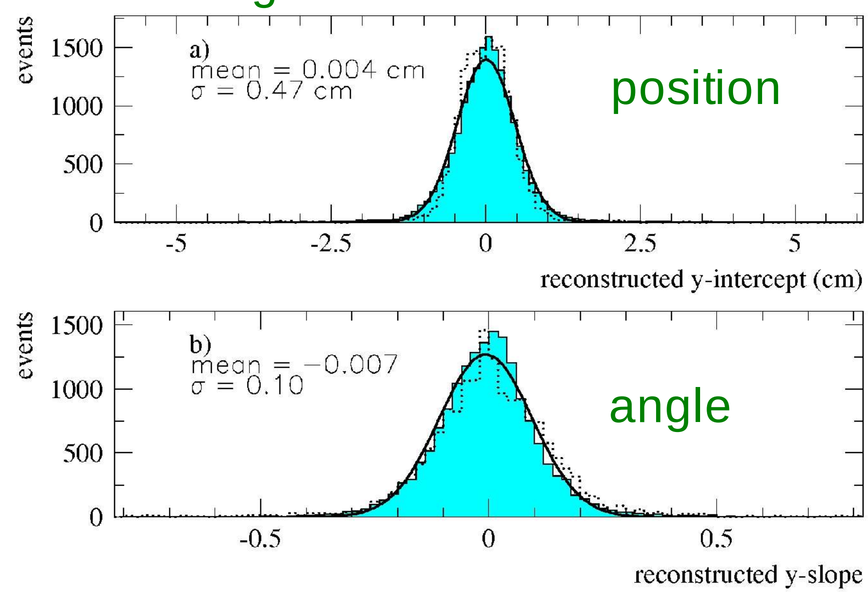
- Protons provide sufficient light in fibers:
  17±2 photoelectrons
  from proton tracks near fibers

- proton tracks were reconstructed with resolutions:
  position: 4.4 mm
  angle: 5.6°

typical ADC distributions



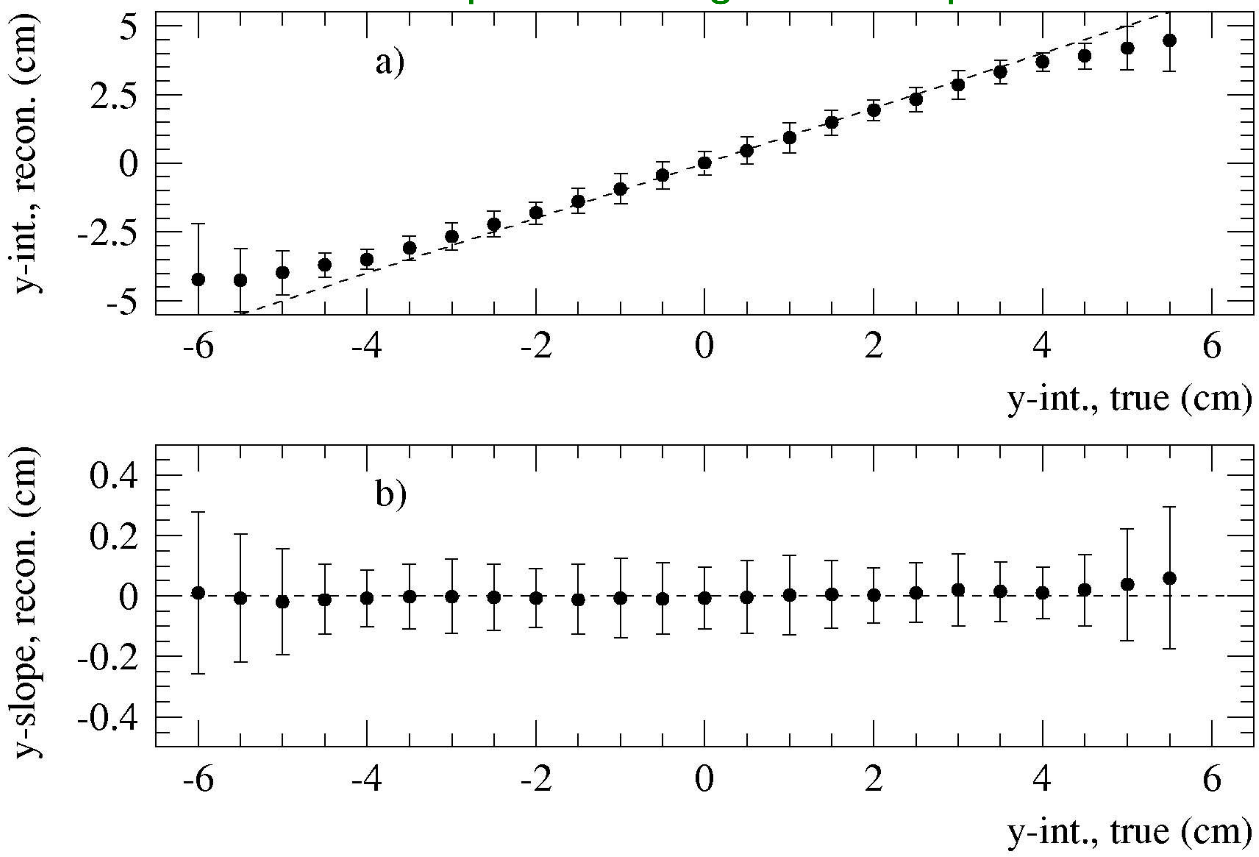
tracking distributions



FINeSSE protoype tests...

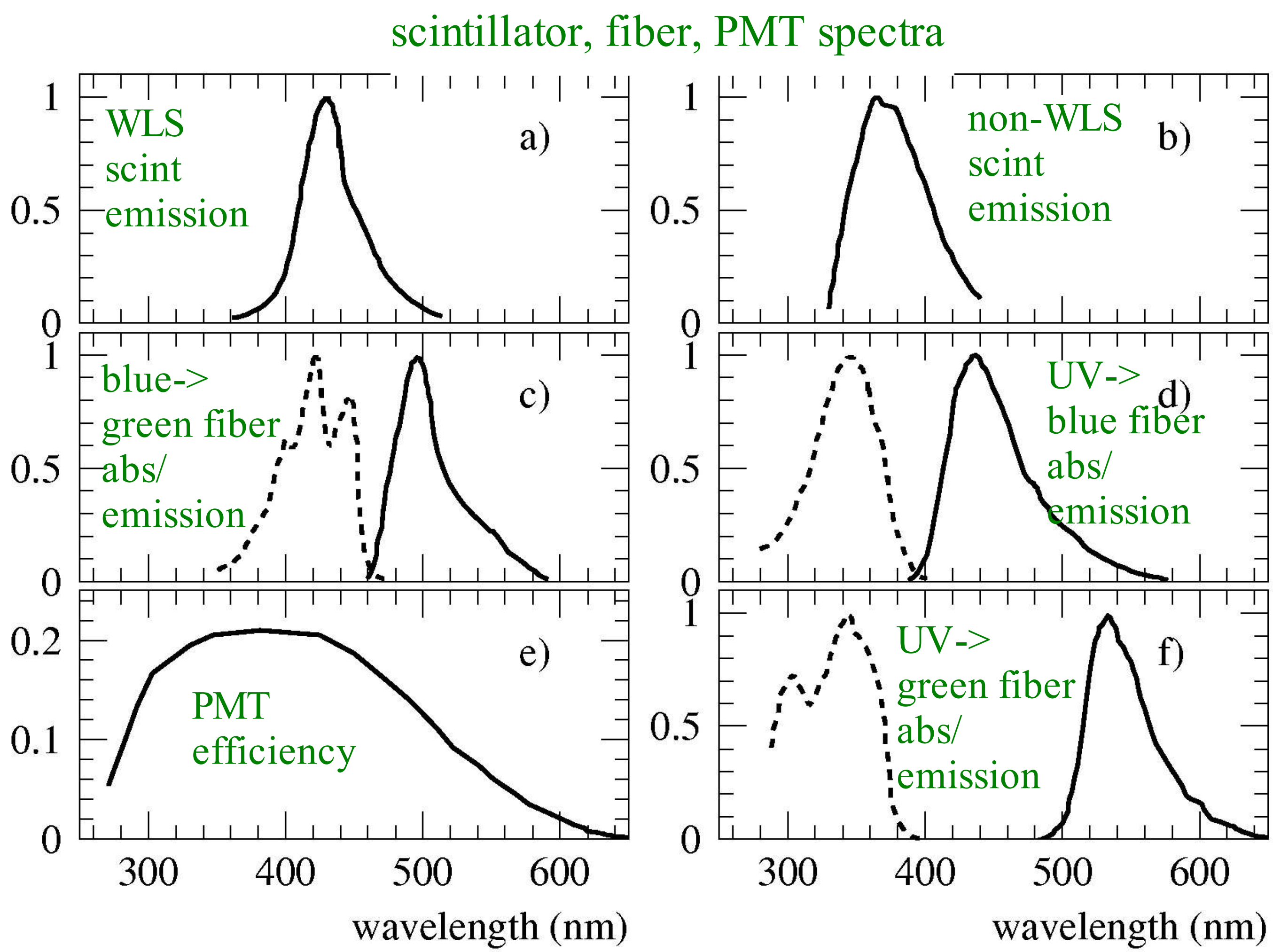
- position and angular resolution remains good out to edge of detector (~2cm)

reconstructed position/angle vs true position



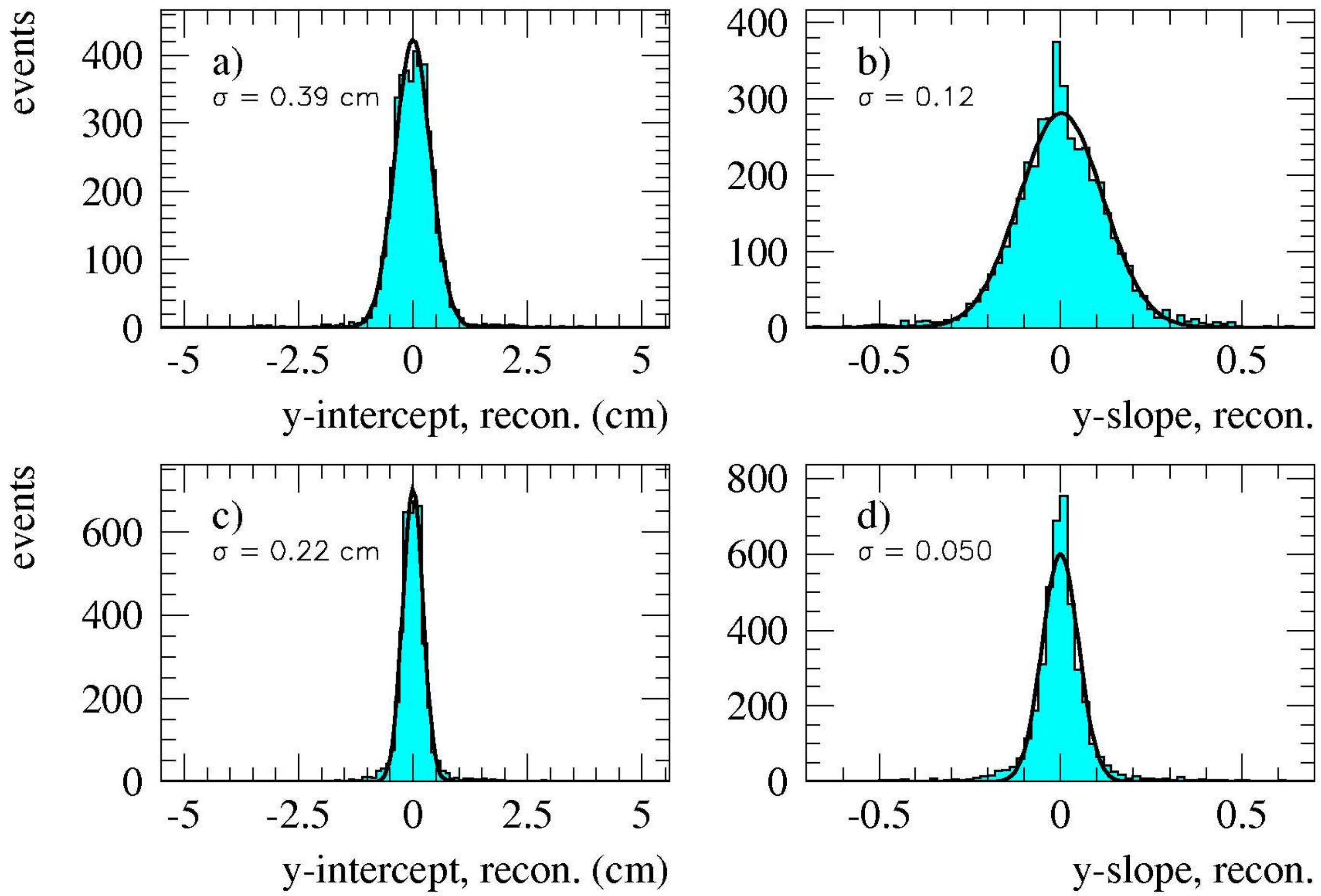
FINeSSE protoype tests...

Both “standard” wavelength-shifting (WLS) and non-WLS scintillator was tested with different combinations of fibers (blue->green, UV->blue, UV->green)



FINeSSE protoype tests...

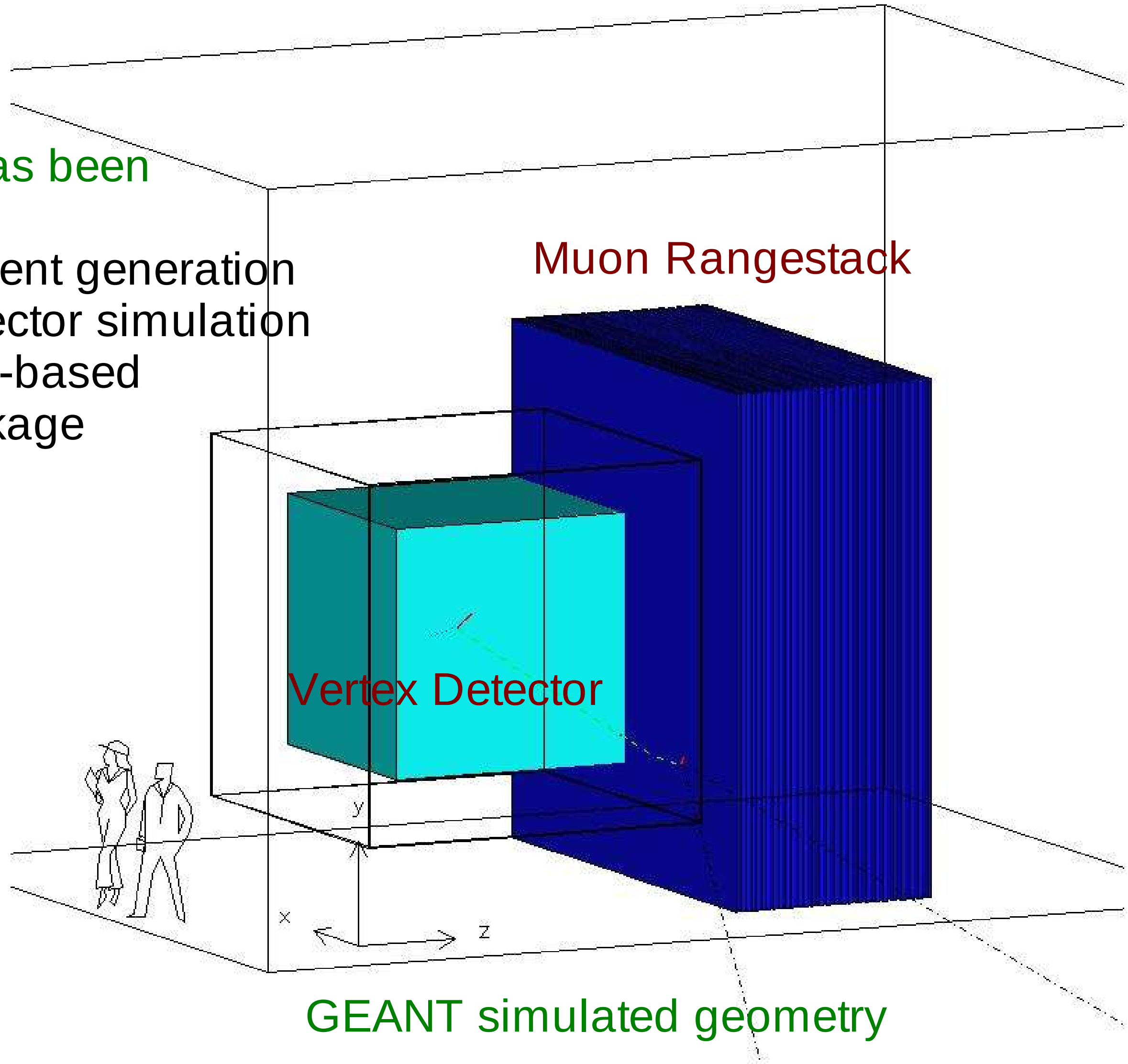
Best combination is non-WLS scint with UV-> blue fibers.
Position and angular resolution will be ~2mm, 3° in full-sized detector



FINeSSE Detector Simulation and Reconstruction

The FINeSSE detector has been simulated using:

- NUANCE for the event generation
- GEANT for the detector simulation
- A Hough-transform-based reconstruction package



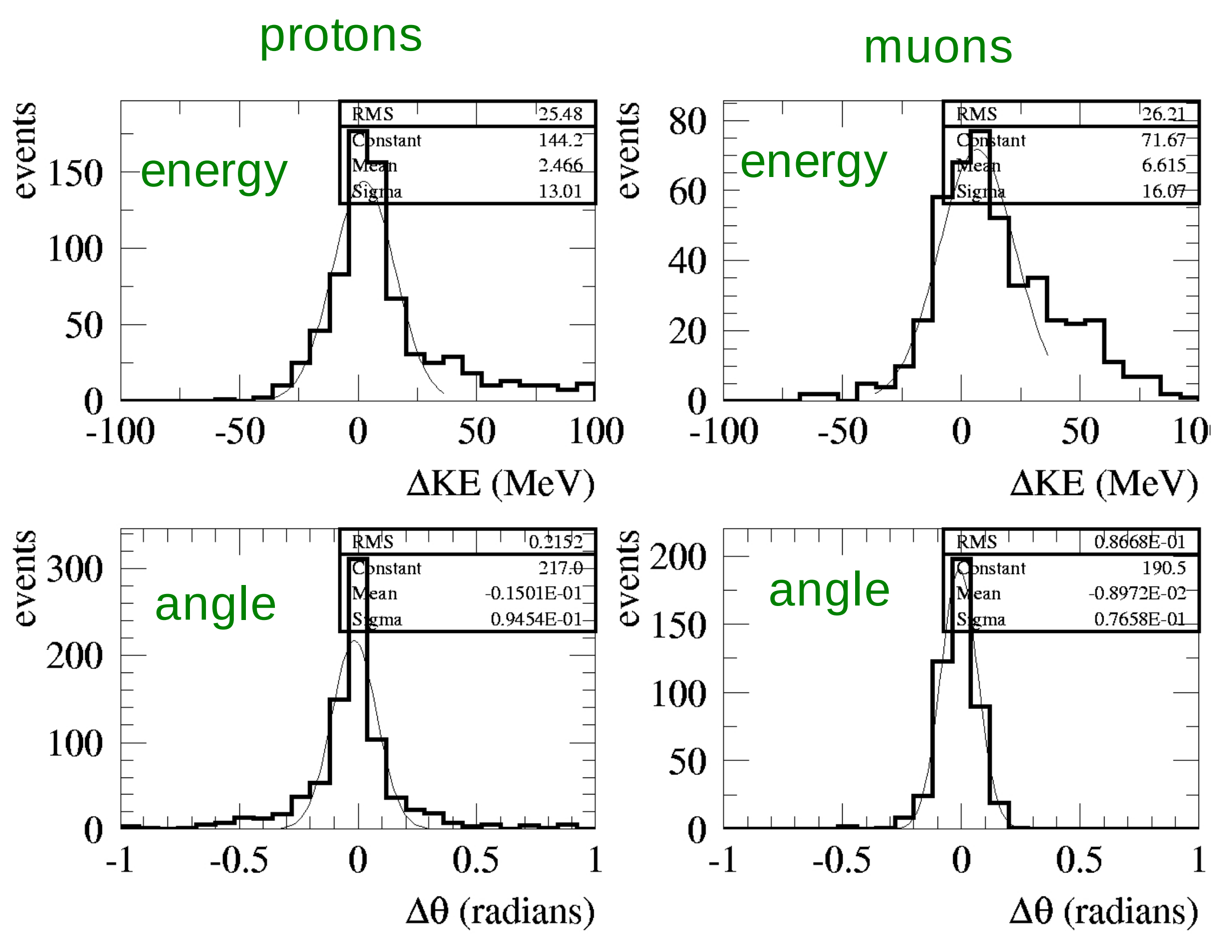
GEANT simulated geometry

FINeSSE Detector Simulation and Reconstruction...

Simulation and reconstruction of
50-500MeV protons and muons:

- ΔE ~15MeV

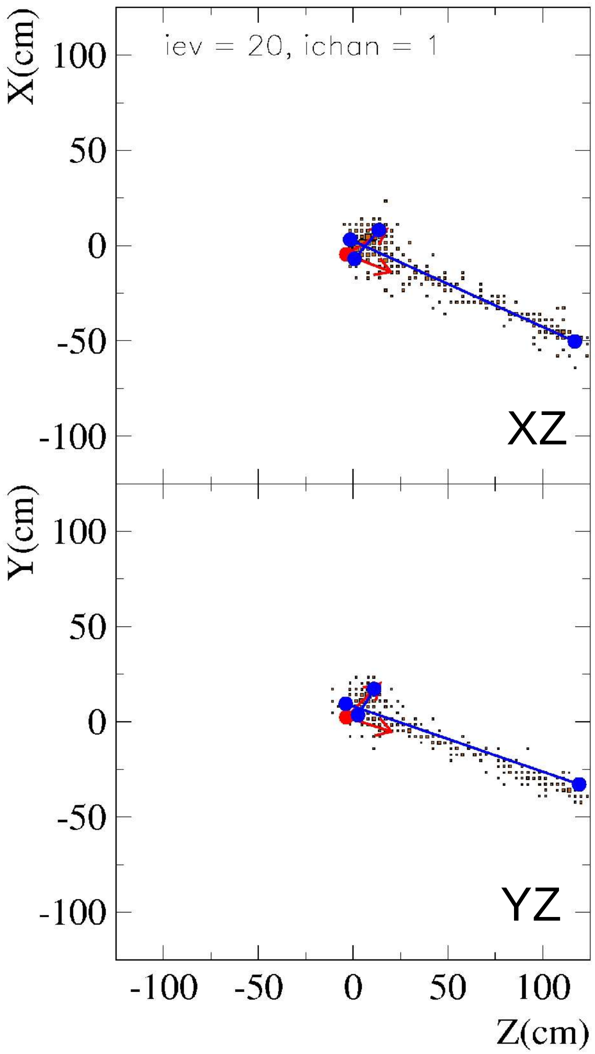
- $\Delta\Theta$ ~6°
  (in agreement with
  prototype tests)



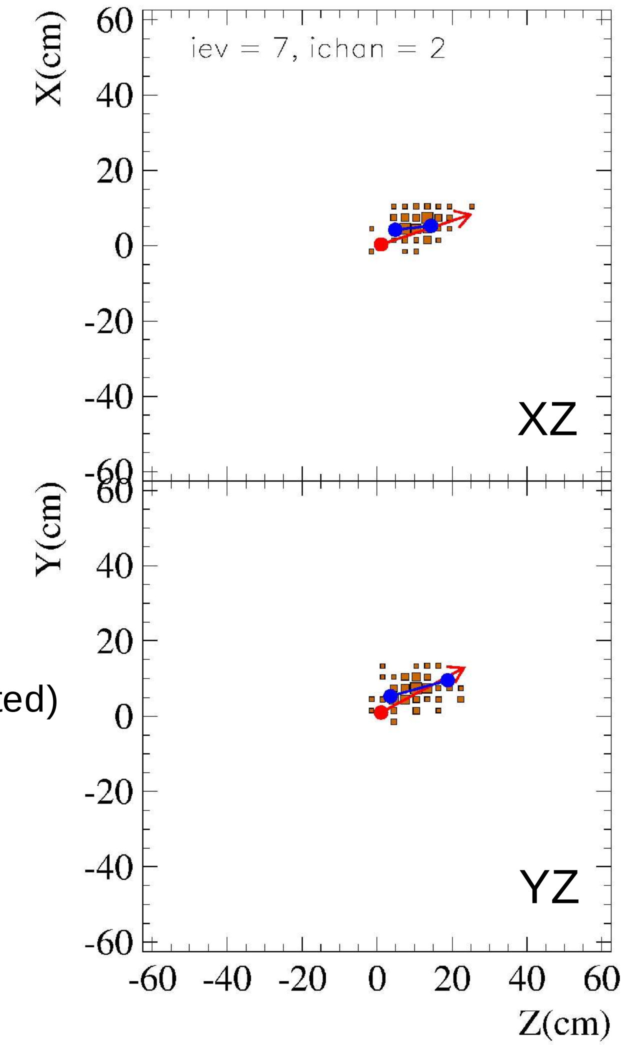
FINeSSE Detector Simulation and Reconstruction...

simulated hits and reconstructed tracks in the Vertex Detector

CCQE event



NCp event



fiber hits,
(size ∝ # γ collected)

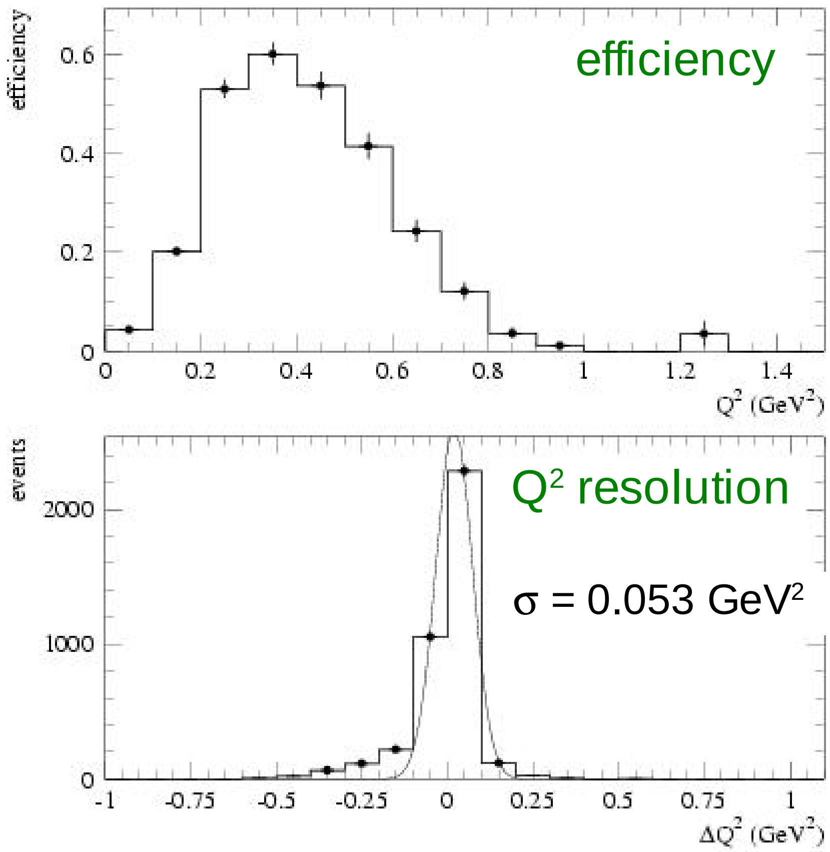
generated

reconstructed

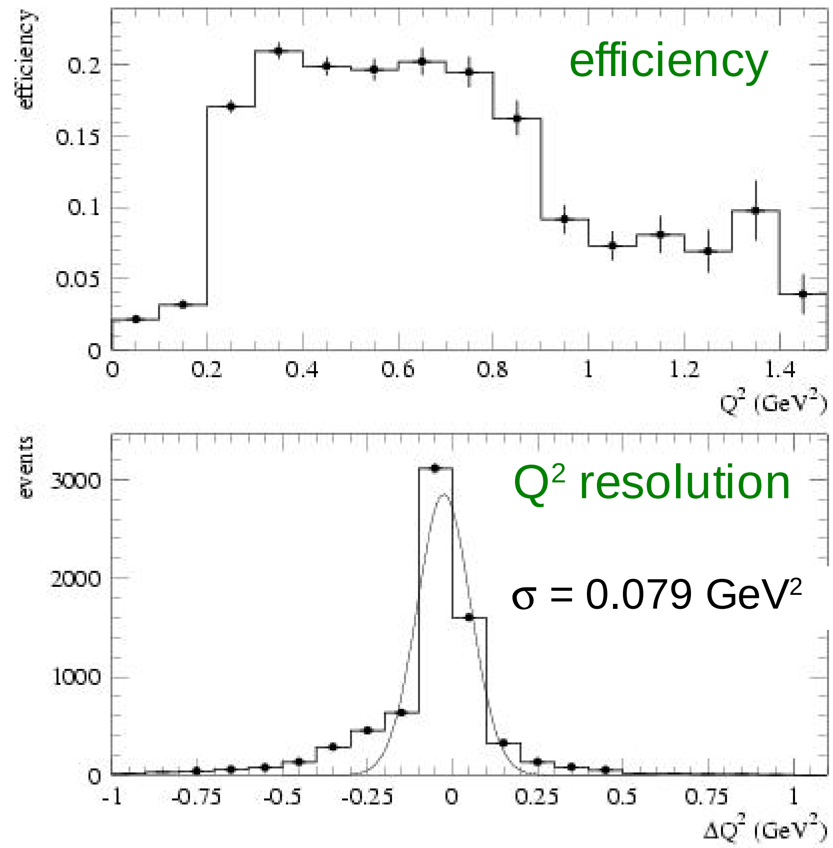
Simulation of R(NC/CC) measurement

Good efficiency, Q^2 resolution, background rejection has been demonstrated...

NCp events:



CCQE events:

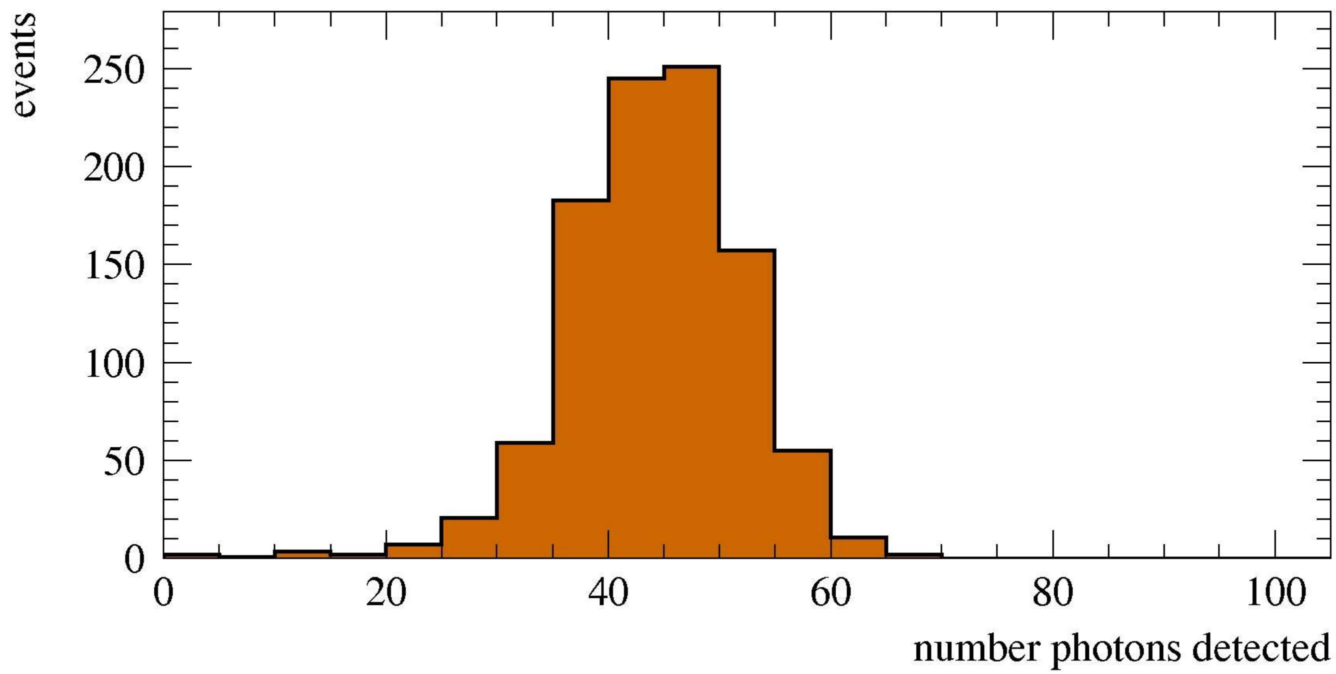


Simulation of R(NC/CC) measurement

- Rejection of NCn background is crucial as it has "opposite signed" sensitivity to Δs $\quad (NCn: \nu_\mu n \rightarrow \nu_\mu n)$

- This is achieved by detecting 2.2 MeV n-capture photon $\quad (n\,p \rightarrow d\,\gamma(2.2\,MeV))$

vertex detector response to 2.2 MeV photon



Simulation of R(NC/CC) measurement..

- high purity/low background for NC and CCQE events

400k reconstructed MC events

$\nu NC: \nu_\mu p \rightarrow \nu_\mu p$

	reaction channel				
NCp cuts	NCp	NCn	NCπ	CCQE	CCπ
raw events	39098	37544	35500	184032	100630
passed events	5668	483	131	203	24
efficiency (%)	14.5	1.3	0.4	0.1	0.0
fid. eff. (%)	21.3	1.9	0.5	0.2	0.0
purity (%)	87.1	7.4	2.0	3.1	0.4

$\nu CC: \nu_\mu n \rightarrow \mu^- p$

CCQE cuts	NCp	NCn	NCπ	CCQE	CCπ
raw events	39098	37544	35500	184032	100630
passed events	84	7	285	10090	1789
efficiency (%)	0.2	0.0	0.8	5.5	1.8
fid. eff. (%)	0.3	0.0	1.2	8.0	2.6
purity (%)	0.7	0.1	2.3	82.0	14.5

Simulation of R(NC/CC) measurement..

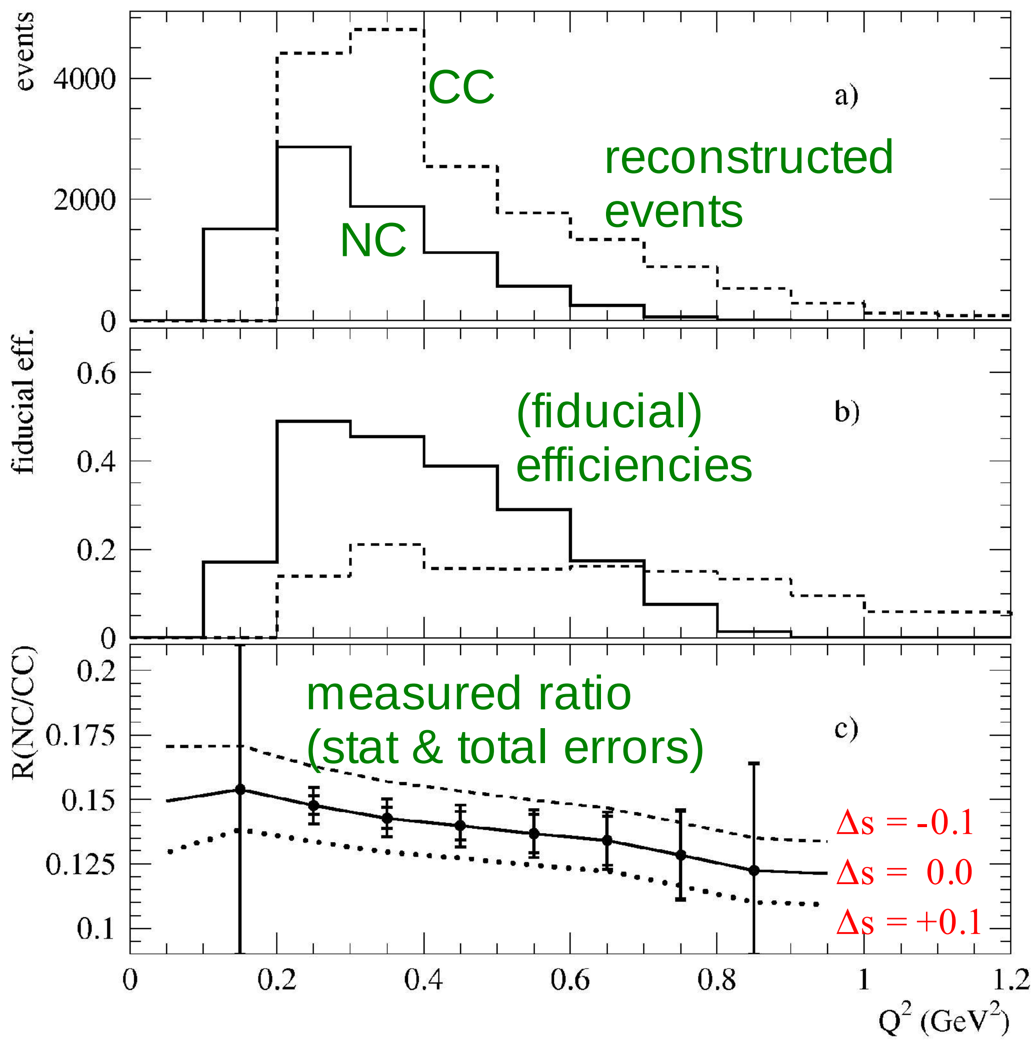
A fit to the simulated data was performed to estimate the precision of Δs extracted from a measurment of the neutrino NC/CC ratio (1 yr nu run):

$$R_\nu(NC/CC) = \frac{\sigma(\nu_\mu p \to \nu_\mu p)}{\sigma(\nu_\mu n \to \mu p)}$$

Included the effects of:
- statistical errors
- systematic errors due to...
- NCn ($\nu n \to \nu n$) scattering misid
- scattering from free protons
- uncertainties in efficiencies
- Q^2 reconstruction

experimental (stat + sys) error:

$\sigma(\Delta s) = \pm 0.025$



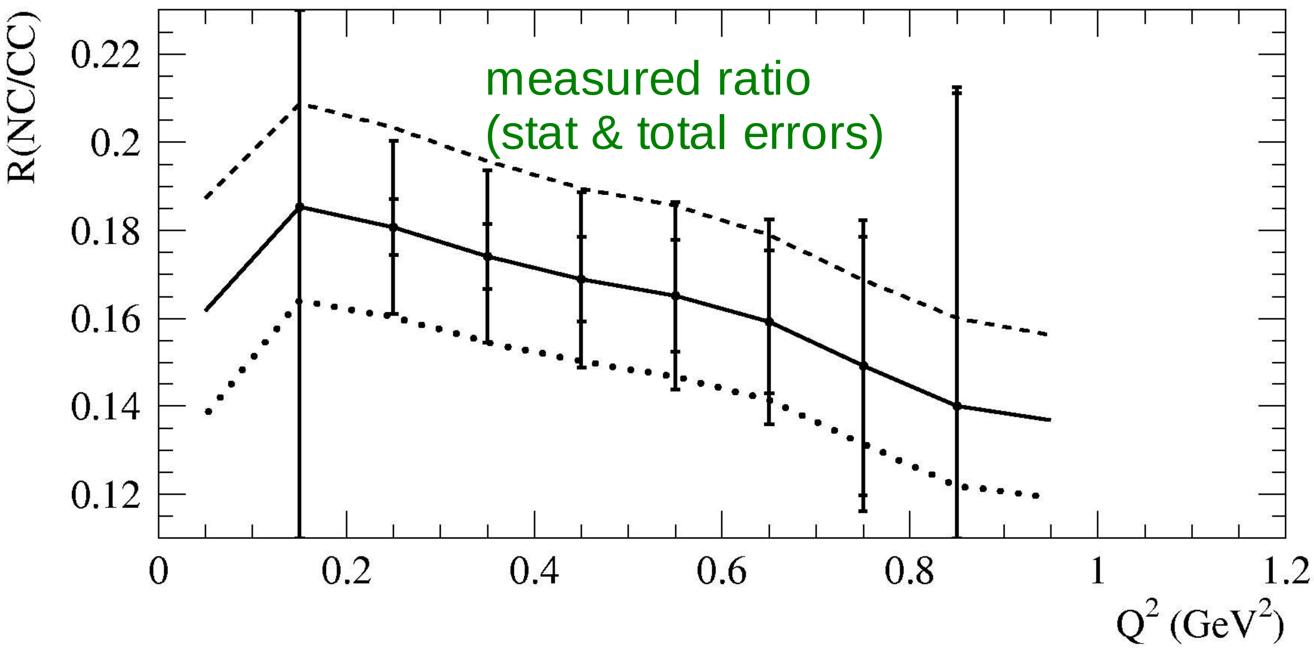
Simulation of R(NC/CC) measurement..

A similar exercise (albeit less rigorous, full simulations on antinu runs underway) was performed for a 2 yr antinu run:

$$\overline{R_{\nu}}(NC/CC) = \frac{\sigma(\overline{\nu_{\mu}}\, p \rightarrow \overline{\nu_{\mu}}\, p)}{\sigma(\overline{\nu_{\mu}}\, p \rightarrow \mu\, n)}$$

experimental (stat + error:

σ(Δs) = ±0.04

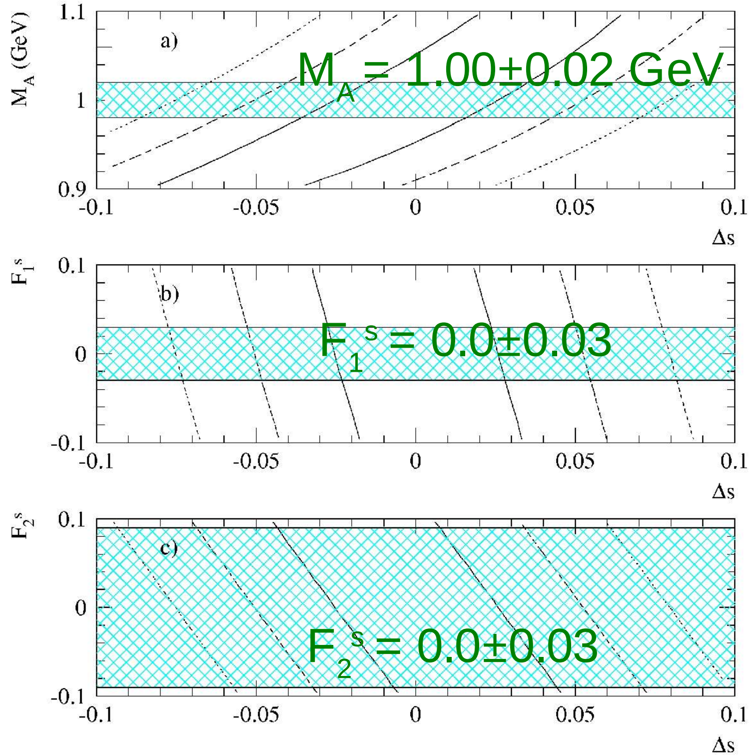


Simulation of R(NC/CC) measurement..

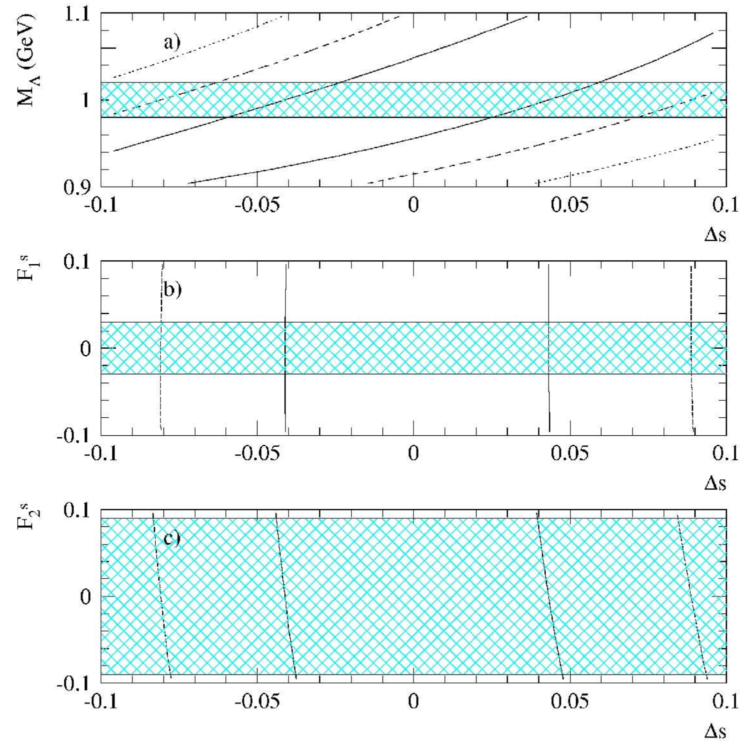
Form factor uncertainties:

The NC/CC ratios depend (somewhat) on F_1^s, F_2^s (and M_A) also:

neutrinos



antineutrinos



- form factor uncertainties: $\sigma(\Delta s) = \pm 0.02$ (both nus and antinus)
- actually a global fit with nu/antinu/PVe data may be done (ala Pate, PRL 92, 082002, '04) to reduce this error and/or constrain Δs, F_1^s, F_2^s

Expected errors on Δs

From neutrinos (1y run at FNAL):
$\sigma(\Delta s) = \pm\, 0.02$ (exp. stat. and sys.)
± 0.02 (f. f. systematic)

From antineutrinos (2y run at FNAL):
$\sigma(\Delta s) = \pm\, 0.04$ (exp. stat. and sys.)
± 0.02 (f. f. systematic)

Recall:
BNL E734:
$\Delta s = -0.15 \pm 0.09$ ($\pm$f.f. systematics)
polarized DIS:
$\Delta s = -0.12 \pm 0.06$
-0.08 ± 0.06

This experiment will provide a precise, theoretically robust, measurement of Δs via neutrino-scattering.

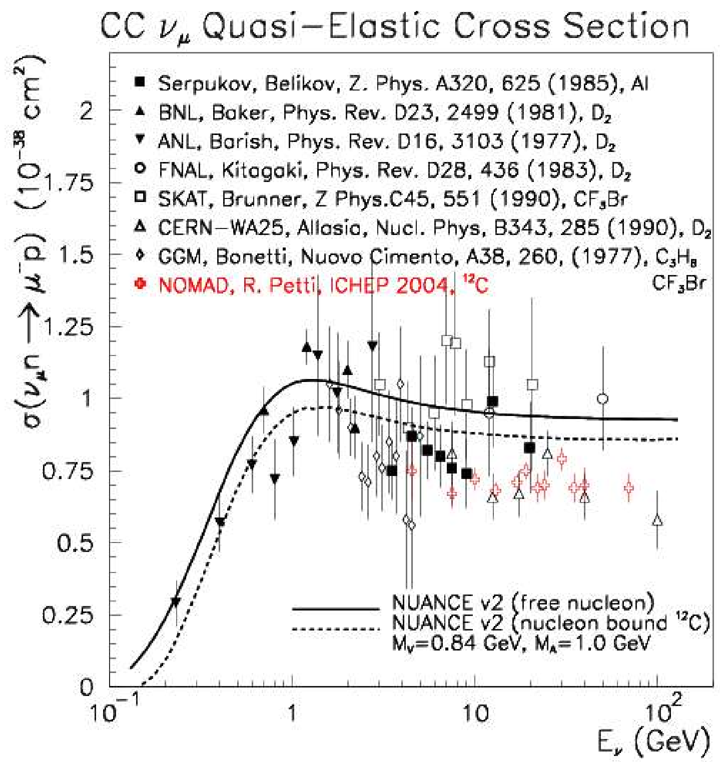
Cross section measurements with FINeSSE:

- Neutrino oscillation experiments experiments need good neutrino cross sections! (and.... they hold interesting physics as well)

- The “APS Multidisciplinary Neutrino Study” cites this as a high priority

- FINeSSE is well-suited to make these measurements

- For both neutrinos and antineutrinos, these channels are of interest:
  - CC quasielastic
  - NC and CC charged and neutral pi production
  - coherent pi production



FINeSSE status:

- LOI submitted to BNL, physics is “compelling” and proposal encouraged

- LOI submission to FNAL imminent (for April PAC)

Costs:
- $2.6M for detector
- at FNAL: ~$2M for building (on beam center)
- at BNL: ~$5M for nu beamline and source (needs to be rebuilt)
  + beam time

Summary

- A neutrino NC scattering experiment to measure Δs would yield important information on nucleon spin structure.

- In addition it would provide important (and needed) xsection measurements.

- Our collaboration continues to work to make it happen!

More info:
- http://www-finesse.fnal.gov