２００６年日本物理学会秋季大会、奈良女子大学、20pSD-9

J-PARCでの ニュートリノ弾性散乱によるΔs測定

東工大理，KEK[A]，RCNP[B]
宮地義之，小六泰輔，齊藤直人[A]，坂下耕一，
酒見泰寛[B]，柴田利明，武居秀行

NeuSpin study group

- Proton Spin Problem and Δs
  - SU(3) flavor symmetry
- Neutrino Scattering and Δs
  - E734
  - Experiment at J-PARC
- Summary

Proton spin problem and Δs

- EMC results -

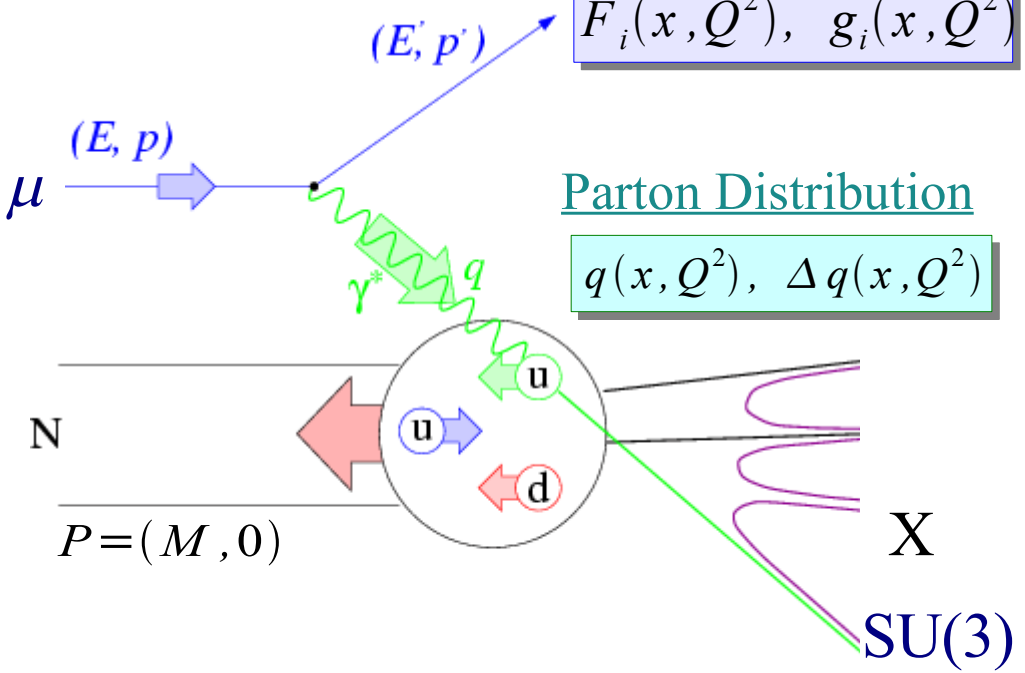
Nucl. Phys. B328 (1989) 1, Phys. Lett. B206 (1988) 364

Polarized DIS:

$$\vec{\mu} + \vec{N} \rightarrow \mu' + X$$

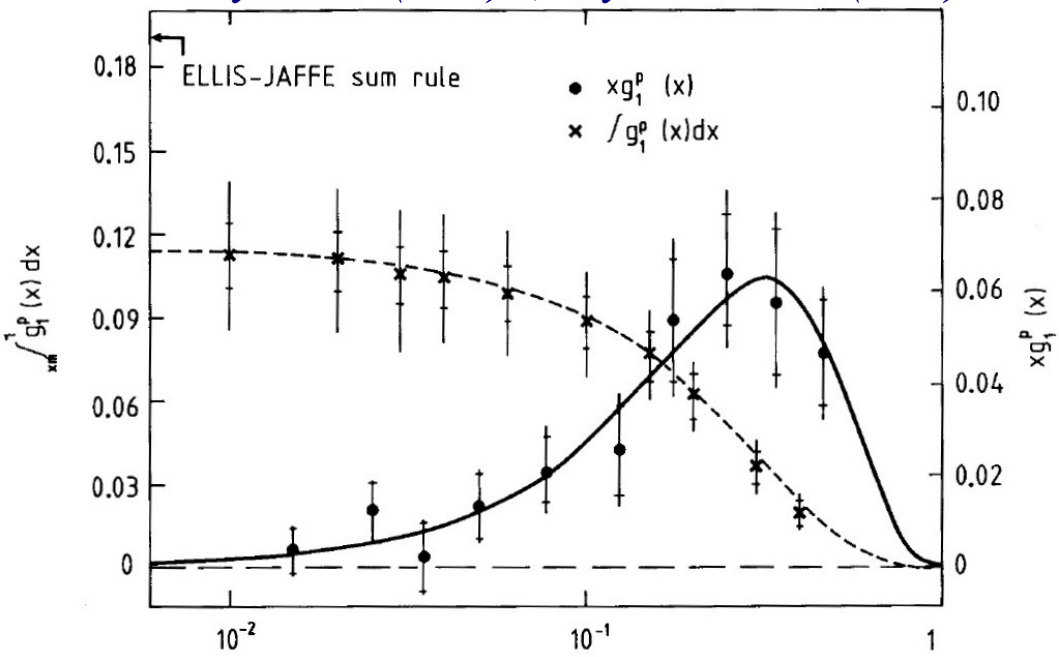
Structure Function

$$F_i(x, Q^2),\ \ g_i(x, Q^2)$$



Parton Distribution

$$q(x, Q^2),\ \ \Delta q(x, Q^2)$$



$$\int_0^1 dx\, g_1^p(x) = \frac{1}{9} a_0 + \frac{1}{12} a_3 + \frac{1}{36} a_8$$

$$= 0.126 \pm 0.01 \pm 0.015$$

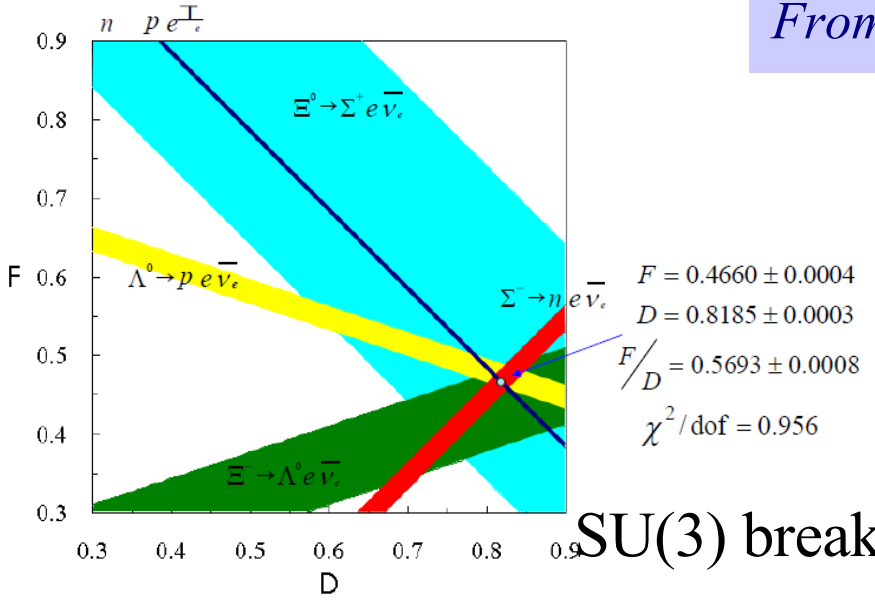
SU(3) flavor symmetry

$$a_3 = 1.26,\ a_8 = 0.58$$

$$a_0 \sim 0.1 \longrightarrow \Delta s \sim -0.19$$

SU(3) violation and impact on Δs

From Yamanishi's talk @ JPS meeting (March 28, 2006)

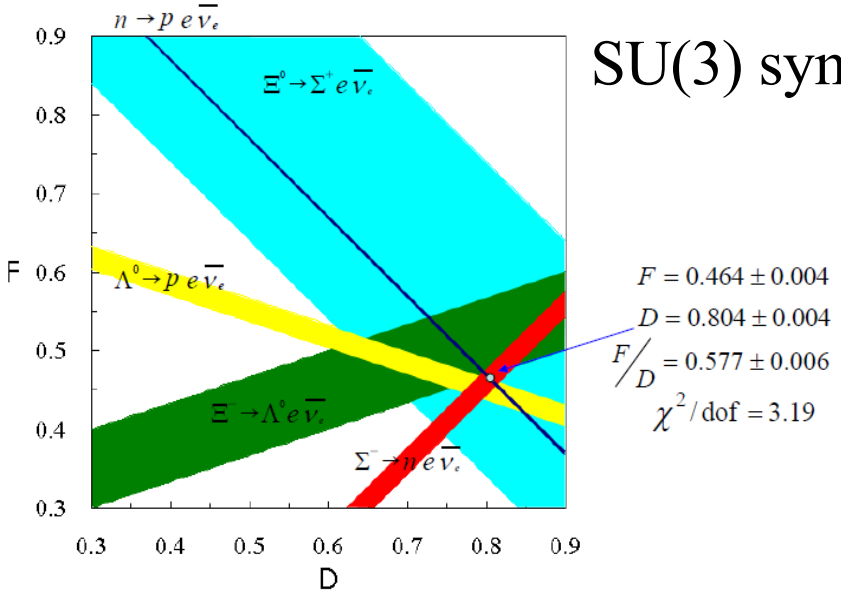


SU(3) breaking

$$\Delta s = 3\Gamma_1^p - \frac{3}{2}D\left(F/D + \frac{1}{9}\right)$$

$$\Gamma_1^p = 0.126 \pm 0.01 \pm 0.015$$

$$\Delta s = -0.185 \pm 0.054$$



SU(3) symmetry

$$\Delta s = -0.256 \pm 0.054$$

χQM calculation:

(*X. Song et. al., Phys. Rev. D55 (1997) 2624-2629*)

SU(3) symmetry: Δs = -0.1

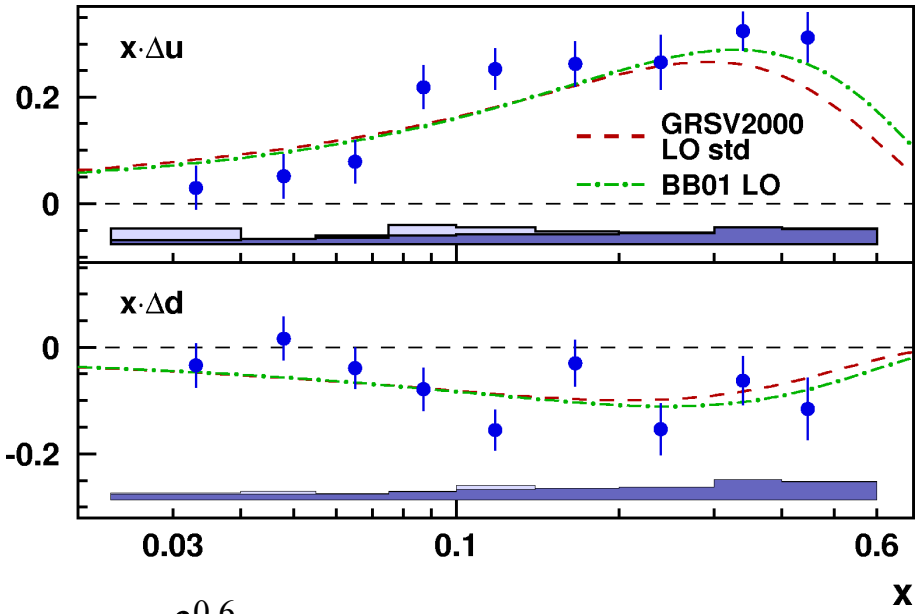
SU(3) breaking: Δs = -0.05

Strangeness spin inside proton

$\vec{e}+\vec{N}\rightarrow e'+h+X$

- HERMES results -

$\Delta\bar{s}(x)=0$ assumed



$$\Delta q=\int_{0.023}^{0.6} dx\,\Delta q(x) \qquad Q^2=2.5\,GeV^2$$

$\Delta u=0.601\pm0.039\pm0.049$

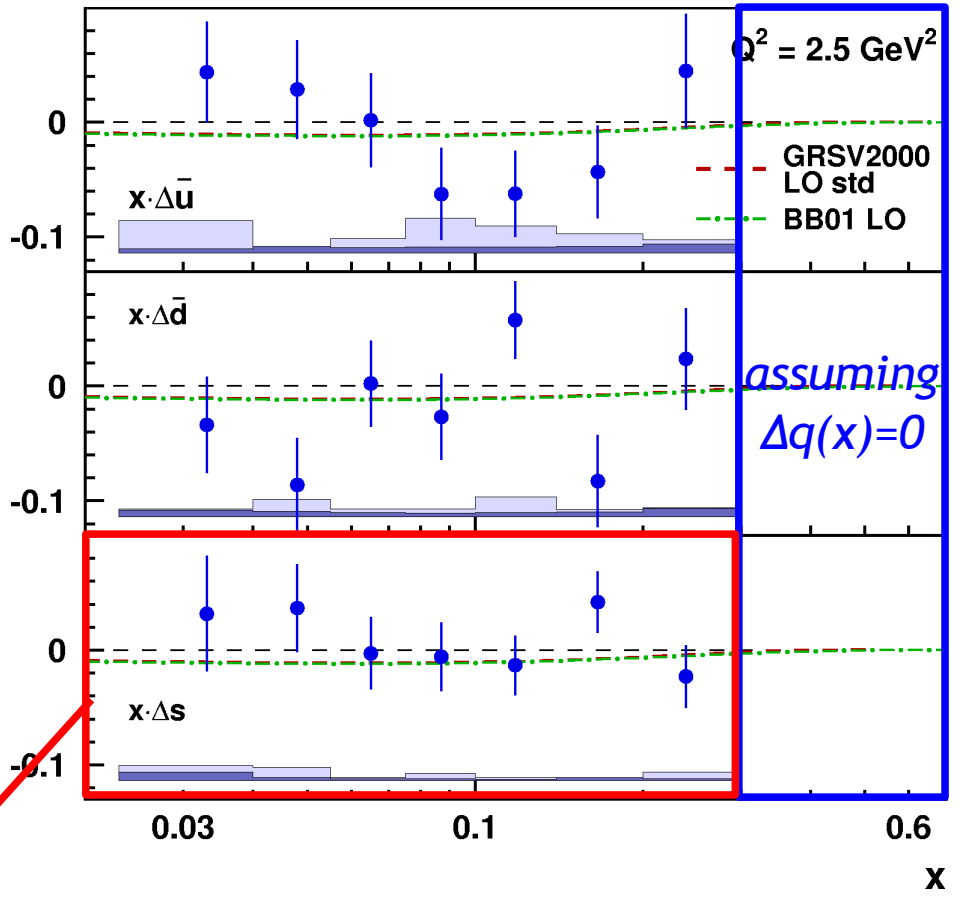
$\Delta d=-.226\pm0.039\pm0.050$

$\Delta\bar{u}=-.002\pm0.036\pm0.023$

$\Delta\bar{d}=-.054\pm0.033\pm0.011$

$\Delta s=0.028\pm0.033\pm0.009$

Phys. Rev D 71 (2005) 012003



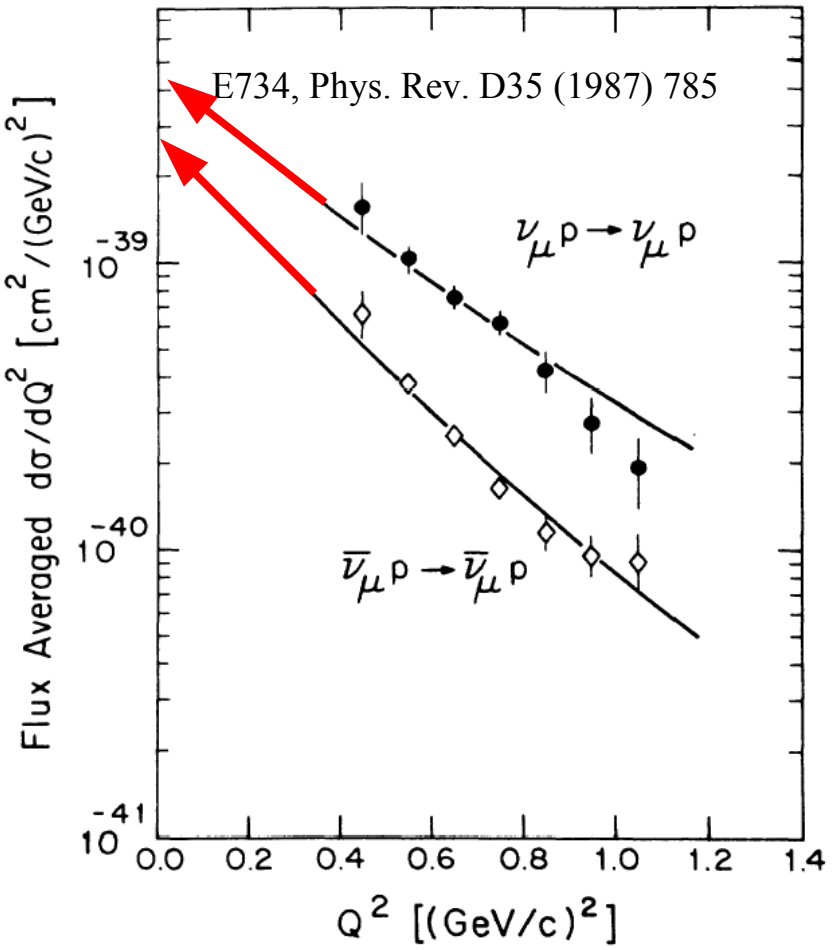
- without SU(3) symmetry assumption
- only partial moments are available

Neutrino scattering and Δs

- E734 results -

- **Neutral current elastic scattering cross section**
  - Liquid scintillator + Drift Tube 170 t
  - 0.5E19 POT for neutrino
  - 2.5E19 POT for anti-neutrino
- **From $G_A^s(Q^2)$ to Δs**
  - $G_A^s(Q^2 \to 0) = \Delta s = -0.21 \pm 0.10$
- **Further analysis based on E734**

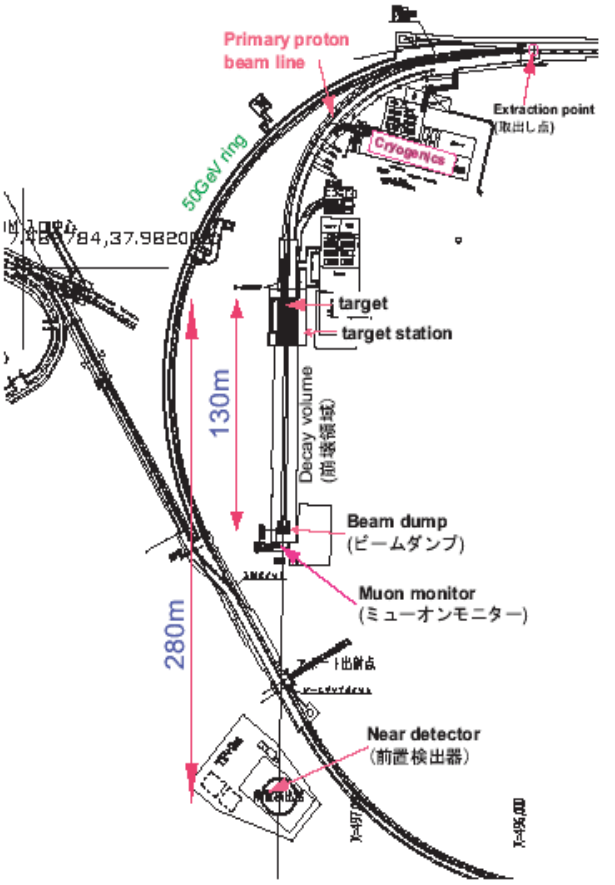
$$R^{\nu}_{NC/CC} = 0.152 \pm 0.007 \pm 0.017$$
$$R^{\bar{\nu}}_{NC/CC} = 0.218 \pm 0.012 \pm 0.023$$
$$R^{\nu/\bar{\nu}}_{NC} = 0.302 \pm 0.019 \pm 0.037 \qquad 0.5 < Q^2 < 1.0\ GeV^2$$



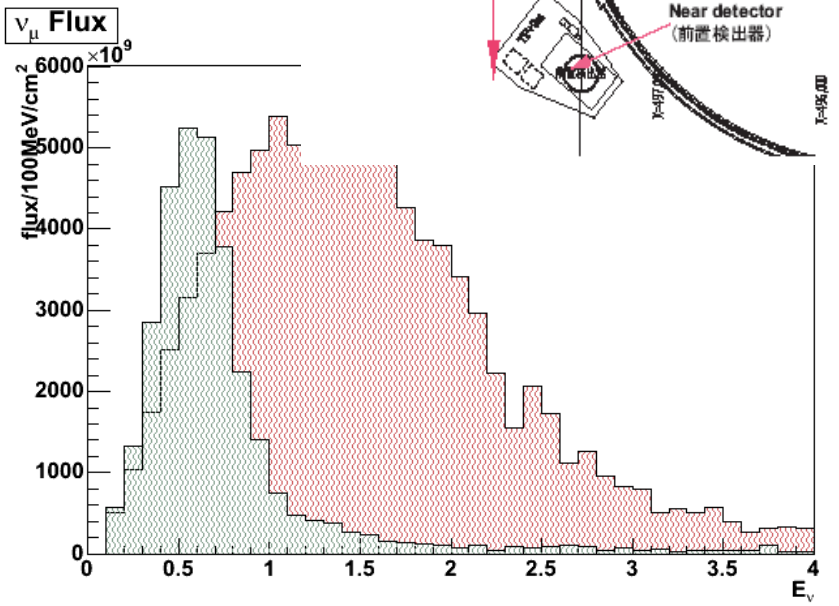
$-0.21 < \Delta s < 0$ strong correlation with the axial mass M_A

J-PARC ν-beam line

- **Beam flux**
  - 1 GeV for "on-axis"
  - < 1GeV for "off-axis"
- **10^{21} POT/year (130 days)**
  - 30 times BNL-E734
- **anti-neutrino beam**
  - neutrino anti-neutrino asymmetry measurement



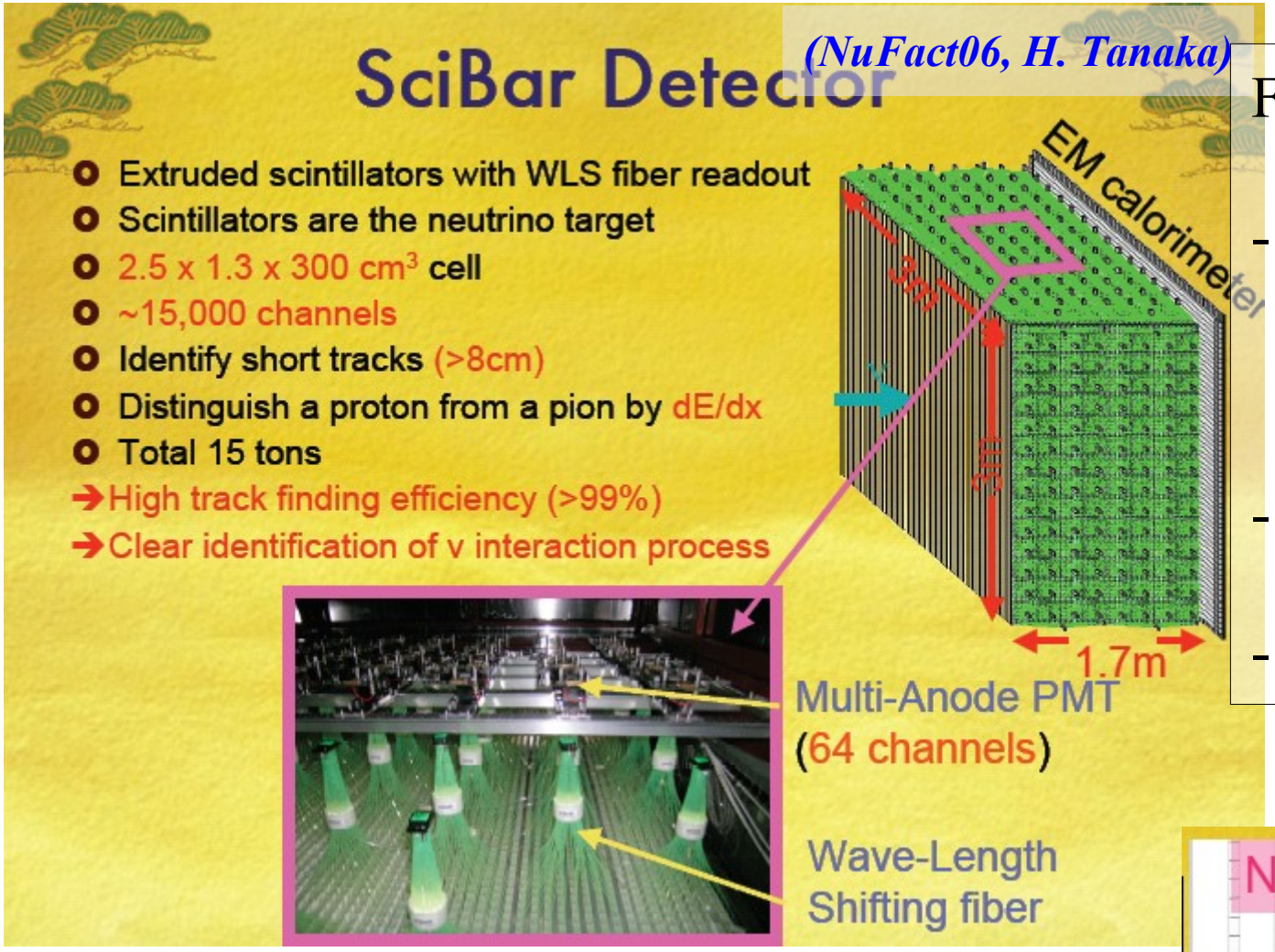
Expected ν flux (MC data)



Nuclear Effect on Δs extraction

- **Nuclear effect (ex. C target):**
  - Nuclear model uncertainty on Δs extraction
- **R(NC/CC) measurements:**
  - Neutrino flux should be canceled. It also suppresses the nuclear effect.
  - Is there any model dependence uncertainty?
- **ν-H scattering extraction:**
  - Using two targets with different mixture of H and C
    - Separation of ν-H and ν-C scattering becomes possible
  - Neutrino flux information is needed to extract the cross section.

SciBar detector: K2K, SciBooNE, T2K



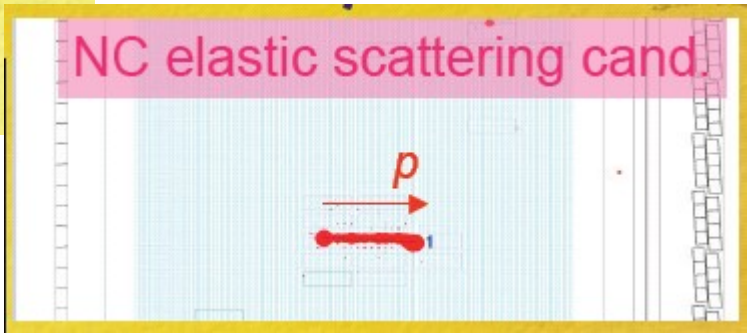
For Δs measurement:

- Difficult to realize dual targets with different H-C mixture.

- Non-isotropic detector

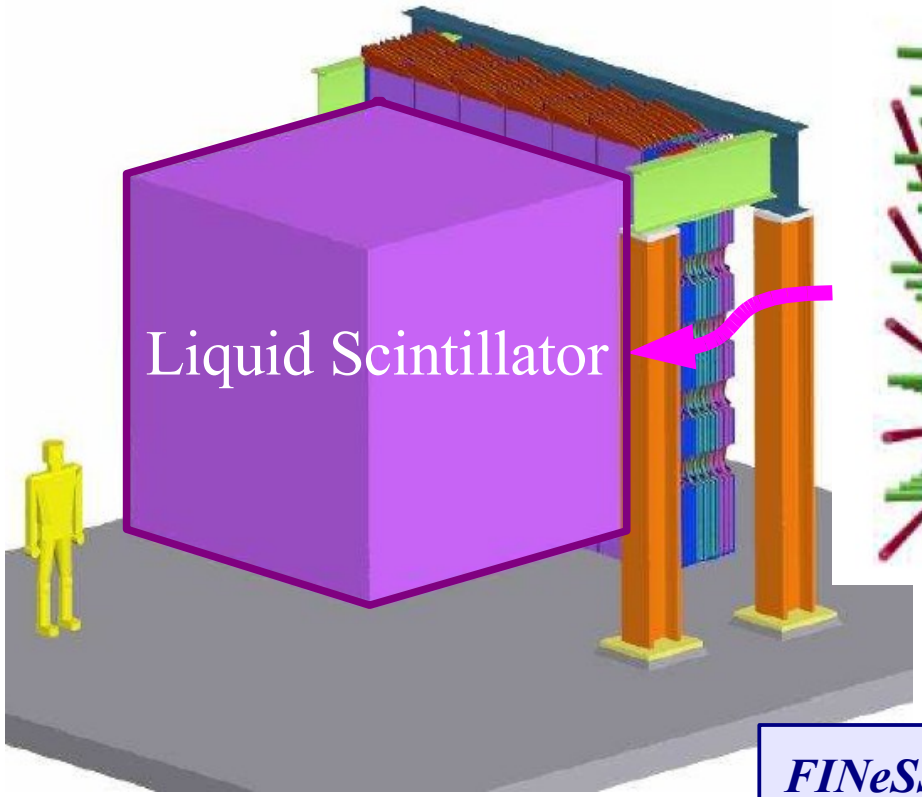
- R(CC/NC) measuremnet

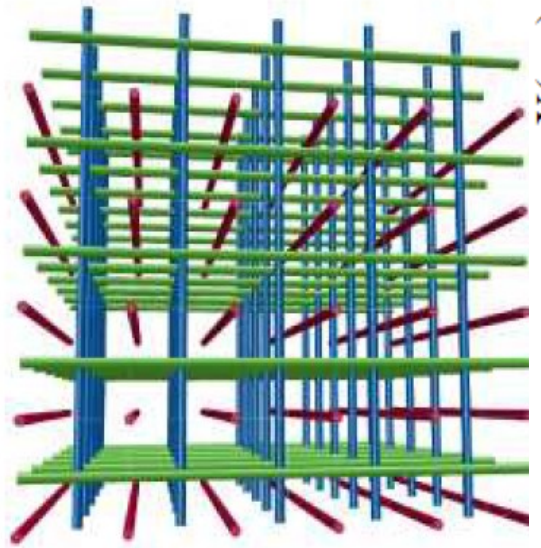
ex.) K2K Data



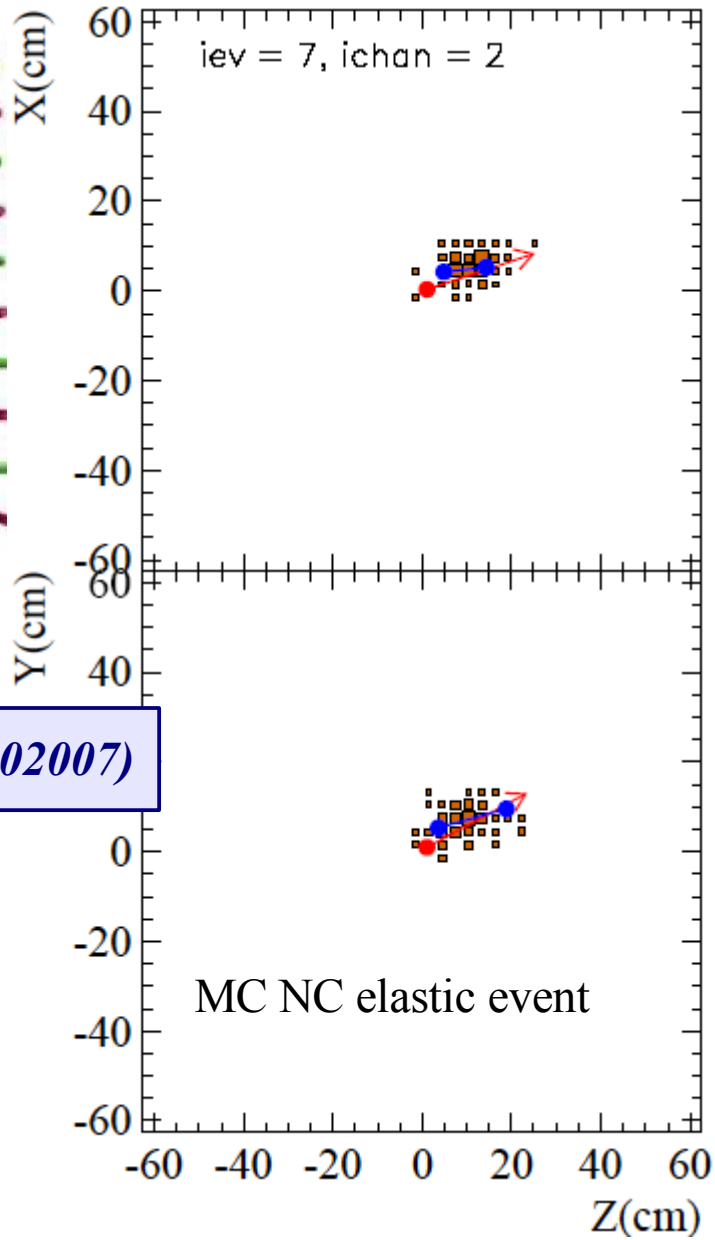
SciBooNE実験の紹介： 20pSD-10

SciBath Detector: FINeSSE





WLS readout



FINeSSE Proposal (hep-ex/0402007)

- Isotropic detector
- Different H:C mixture targets exist:
  BC501A(H/C~1), BC533(H/C~2)

Sensitivity at J-PARC

- **Beam: (using T2K neutrino beam MC data)**
  - 1E21 POT, off-axis (2.5°), 280m from the production target
- **Neutrino interaction generator:**
  - NEUGEN 3.0
- **Liquid scintillator dual target: WLS fiber readout**
  - Dual 2.5x2.5x2.5 m^3 (using BC501A and BC533)
  - Detection efficiency from FINeSSE proposal: hep-ex/0402007
  - Lower Q^2 cut-off : 0.1 GeV^2
- **Free from the nuclear effect**

$$\delta(\Delta s)=0.03 \quad \text{(J-PARC)}$$

Statistical error only. The normalization error is under investigation.

Summary

- **Proton spin problem**
  - Δs is a key for understanding of sea quark contribution
- **Neutrino scattering: NC elastic scattering**
  - Unique tool for studying Δs (direct access to the first moment)
  - Key points: nuclear effects, Q^2 extrapolation to $Q^2=0$, and normalization
  - Measurement at J-PARC:
    - Sensitivity study based on
      - 1E21POT neutrino beam at280m away from the production target
      - Dual SciBath detector (BC501A and BC533)
      - **$\delta(\Delta s) \sim 0.03$** expected (E734: $\delta(\Delta s) \sim 0.08$)
    - Feasibility of SciBar will be investigated at SciBooNE

End