Search for NC single photon (NC1γ) production in ND280

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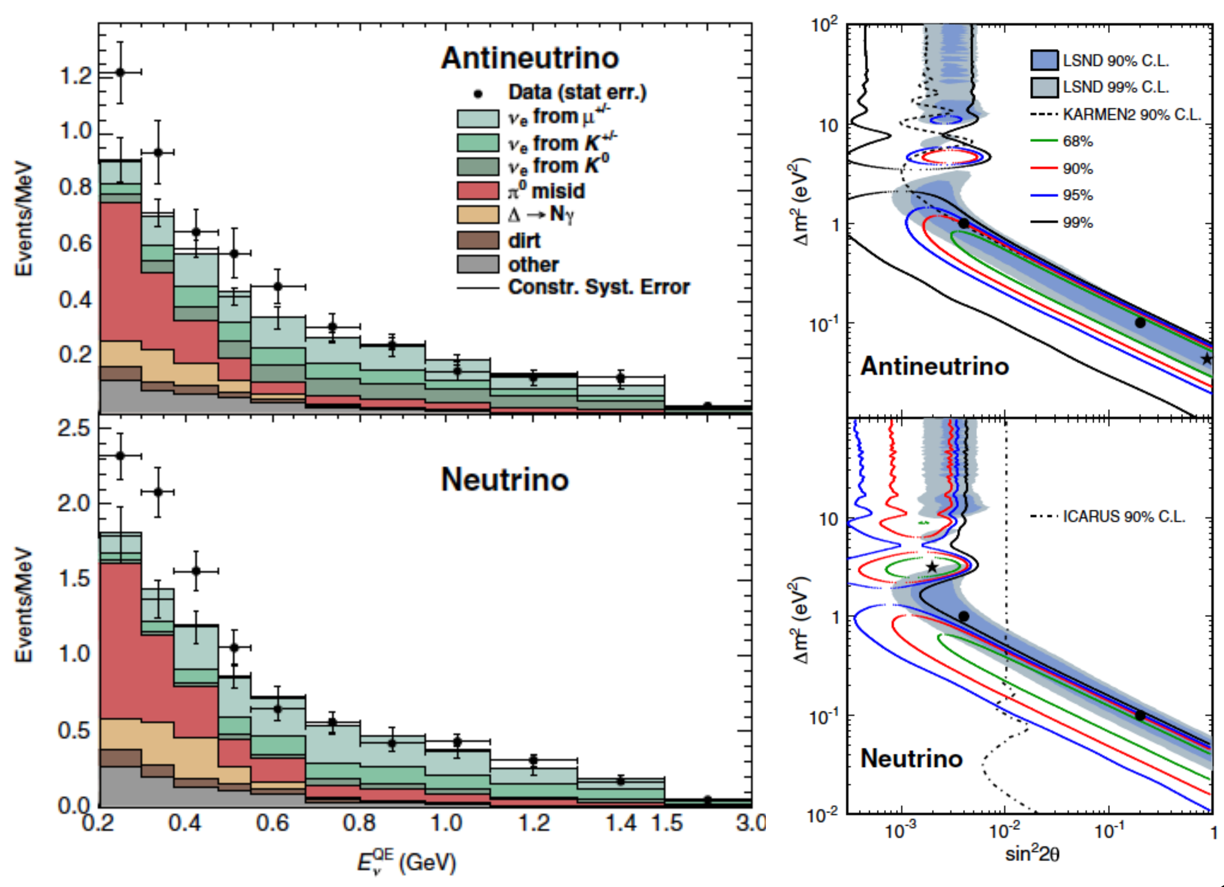
Introduction

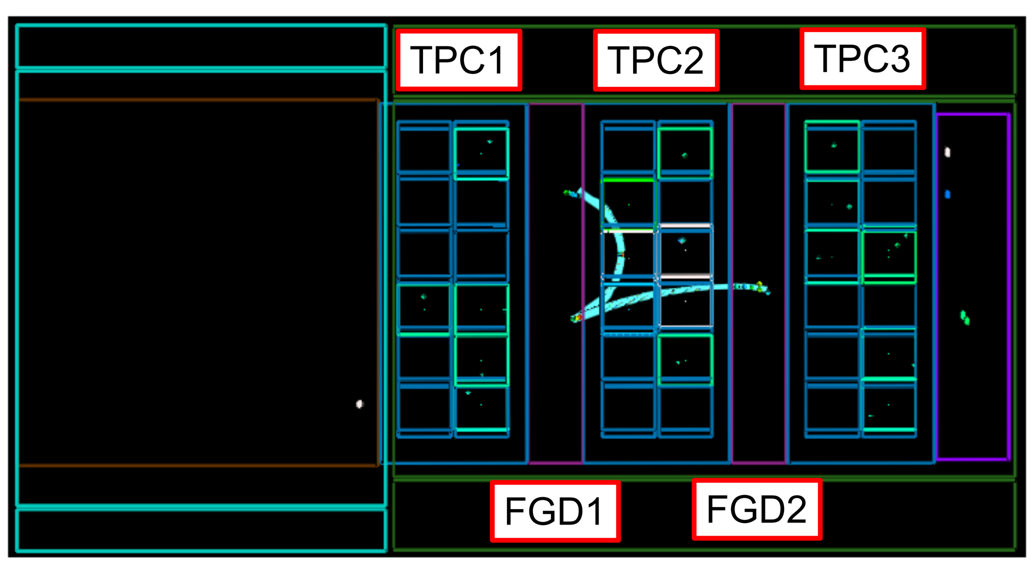
- MiniBooNE experiment observed ν_e candidate excess in ν_μ beam.
- Excess looks different from sterile neutrino hypothesis with LSND parameters.
- Excess could be due to unknown background. MiniBooNE,PRL110(2013)161801

There are 2 types of backgrounds
- Intrinsic
  - ν_e contamination in the beam
  - flat with energy
- misID
  - photon background
  - accumulate at low-energy region

There may be unknown photon production processes in NC?



NC1γ search in T2K ND280 fine-grained detector (FGD1)



Simple cuts make ~95% pure γ sample
- select electron-like tracks from dE/dx
- e^+ - e^- tracks < 10 cm
- W_{inv} < 50 MeV

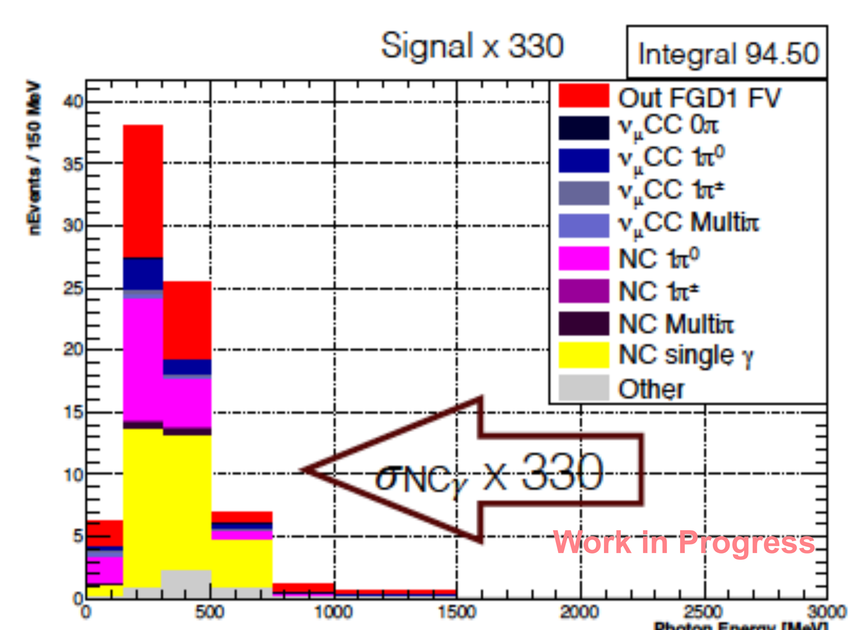
T2K, PRD87(2013)092003,NIMA637(2011)25;696(2012)1

vertex: FGD1 plastic scintillator
dE/dx: gas TPC with MicroMEGAS
Charge: 0.2 T refurbished UA1 magnet

However, majority of gamma rays are not NC1γ process… (signal fraction ~0.2%)

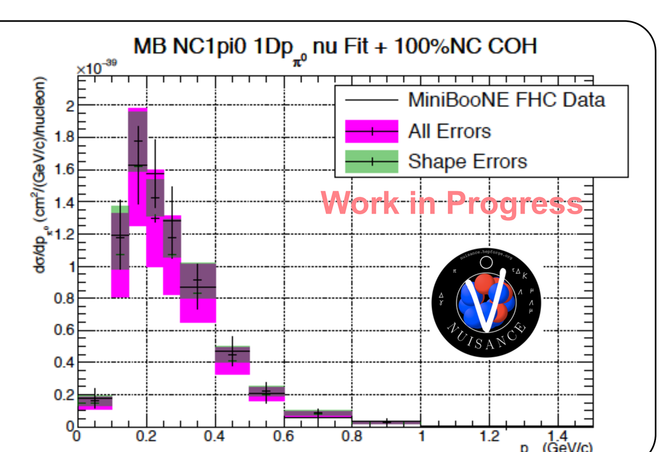
There are 2 types of backgrounds
- Internal background
- External background

We constrain backgrounds to set the upper limit of cross section of NC1γ process



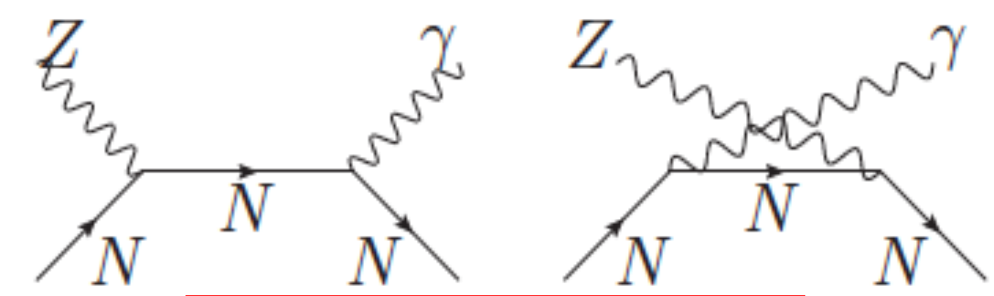
Internal background error estimation

- Single photon from π^o decay
- Use NUISANCE framework https://nuisance.hepforge.org/
- Use external data to constrain π^o production errors
- $\pm$15% error

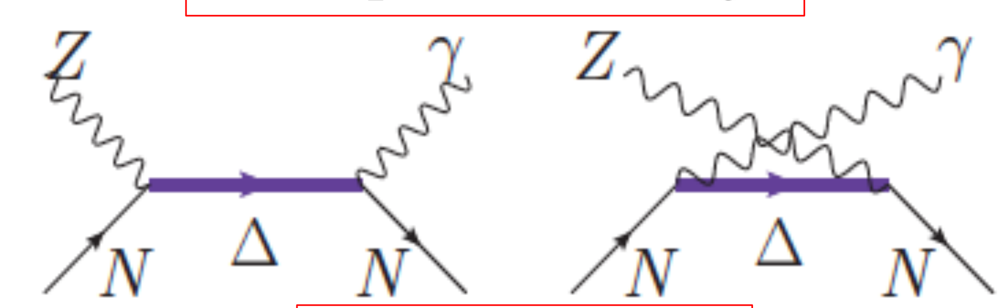


NC1γ with nuclear physics

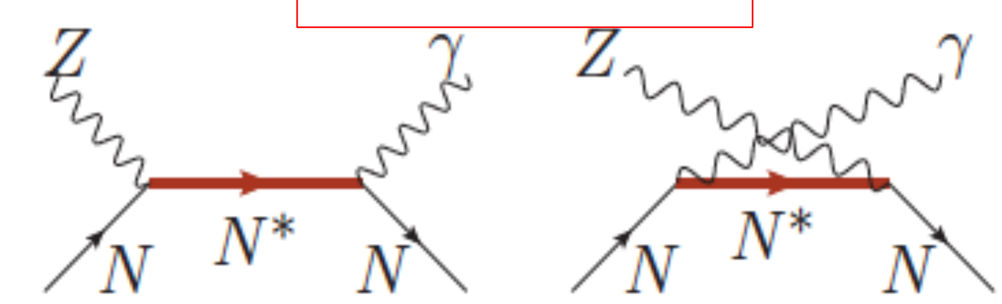
Wang et al,PRC89(2014)015503



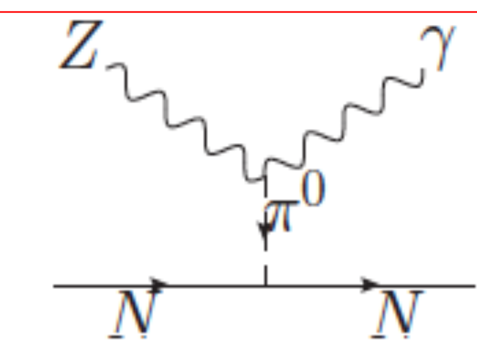
Compton scattering



Δ contribution

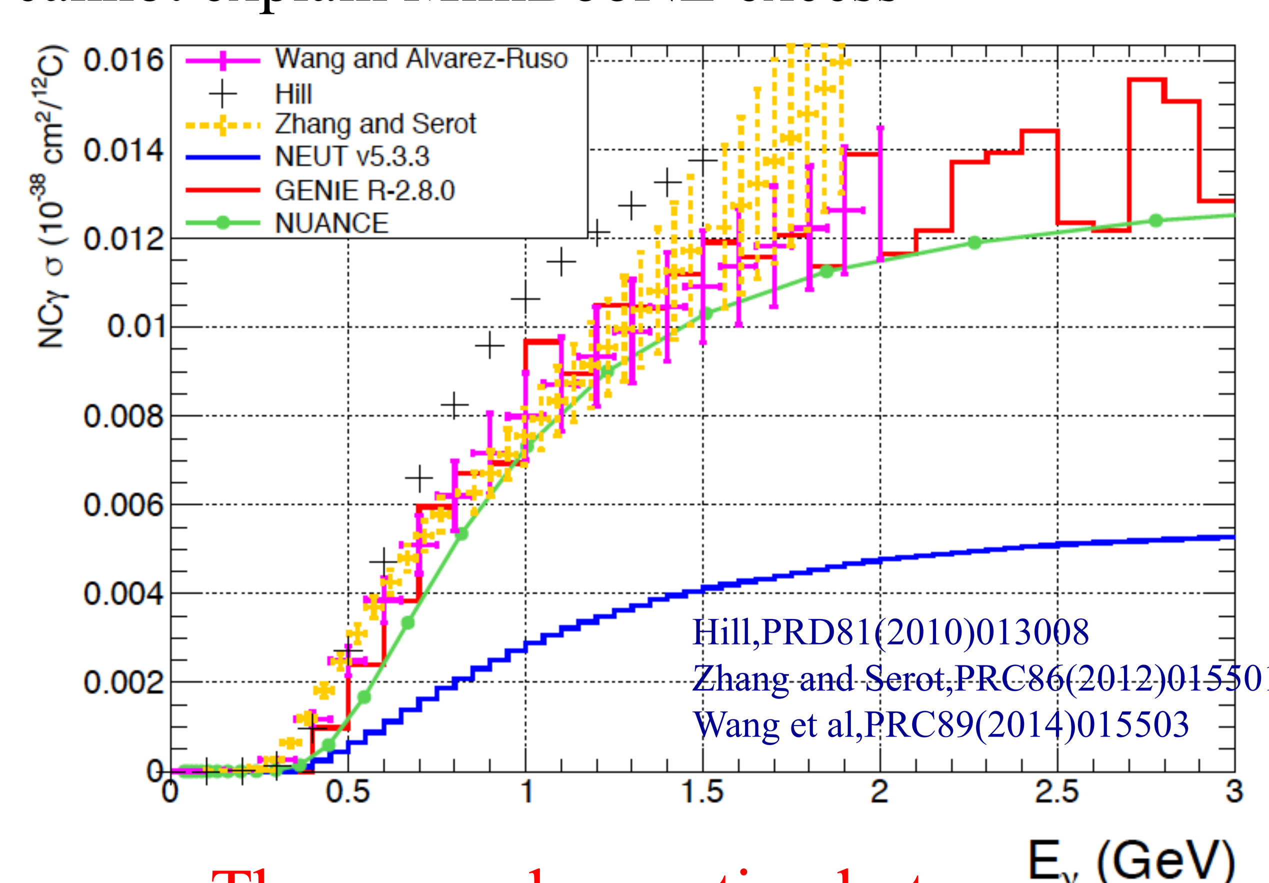


Higher resonance contribution



Anomaly-mediated process

Predictions more or less agree
→ Naïvely, Standard Model NC1γ process cannot explain MiniBooNE excess



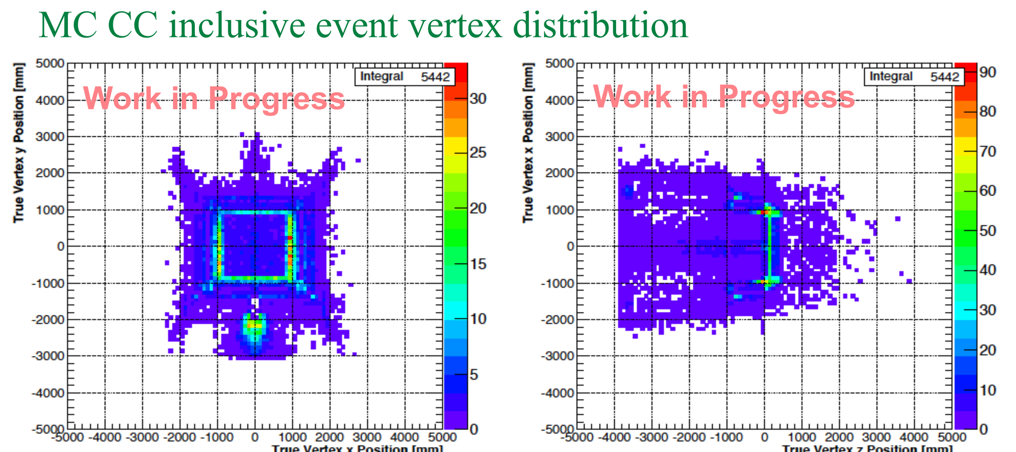
There may be exotic photon production processes in NC?

"Large axial anomaly contribution", PRL99(2007)261601
"Heavy neutrino decay", PRL103(2009)241802
"Dark photon conversion", PLB689(2010)149

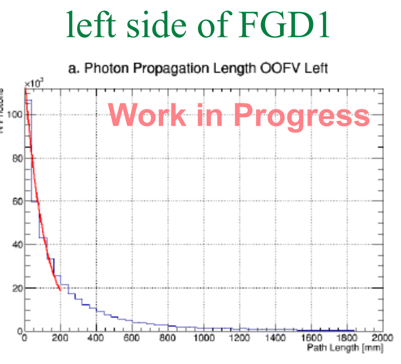
External background error estimation

- Photon produced in dead materials
- CC inclusive data to understand dead material distribution
- MC to estimate photon propagation errors
- +23/-16% error (large asymmetry)

MC CC inclusive event vertex distribution



effective mean free path for photons from left side of FGD1



Preliminary sensitivity study

NOMAD, PLB706(2012)268

From given total errors (+27/-22%) and signal fraction (0.2%), we estimate our sensitivity on NC1γ production cross section at FGD1 is order 10^{-39}cm^2/nucleon with 90%CL at <600 MeV>. This is roughly factor 500 larger than the expected signal.

NOMAD set a limit on this channel as a cross-section ratio, i.e., $\sigma_{NC\gamma}/\sigma_{CCincl}<1.6\times10^{-4}$. From measured CC inclusive cross section, NOMAD limit is translated to 6×10^{-41}cm^2/nucleon with 90%CL at <25 GeV>.

Although our limit may be worse than NOMAD, this analysis will set the first limit of this channel below 1 GeV.

Conclusions and Discussion

- To constrain internal background, π^o production rate should be measured internally → need 4π acceptance detector
- To constrain external background, incoming background needs to be internally measured → need large active veto and less dead materials

Current and future experiments (MINERvA, MicroBooNE, SBND) may have better chance to nail down this exotic process.