Future of neutrino interactions

Laura Munteanu (CERN)

XXXII International Conference on Neutrino Physics and Astrophysics

University of California, Irvine

26 June 2026

CERN

~~Future of neutrino interactions~~
Future neutrino interaction measurements in the GeV regime

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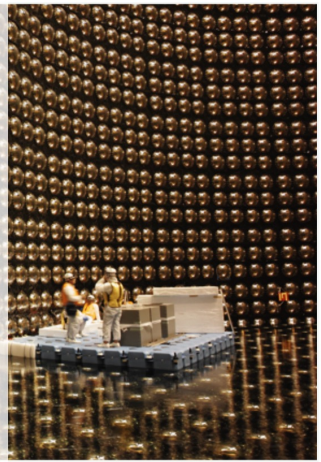
Reasons to measure neutrino cross sections

- ✓ One of the dominant **systematic uncertainty** at LBL programs
- ✓ Mismodeling nuclear effects can **bias** oscillation analysis
- ✓ Understand Standard Model effects (nuclear effects) to assess sensitivity to **BSM** signals
- ✓ Unique probe to learn about **nuclear structure**



From J. Sobczyk's talk on Wednesday

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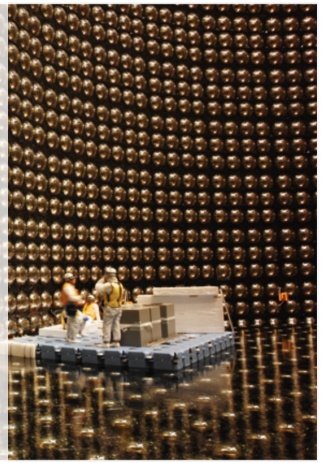

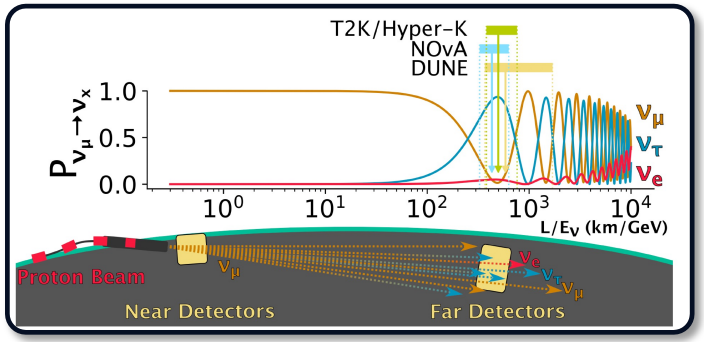

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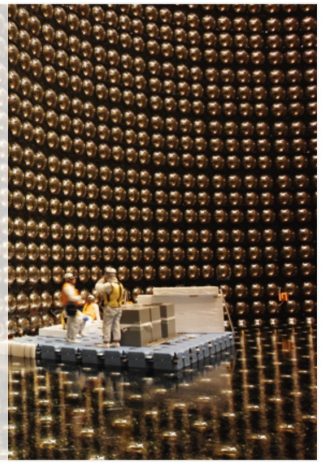

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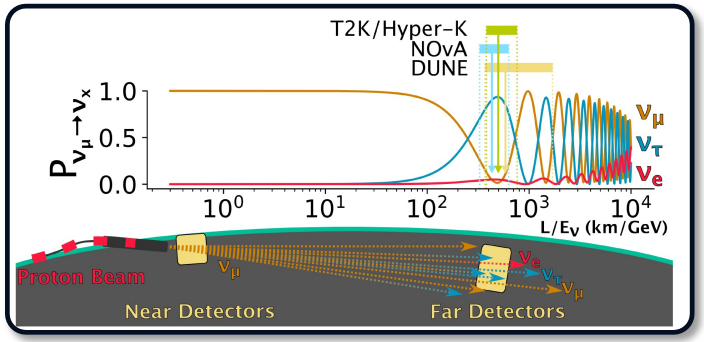

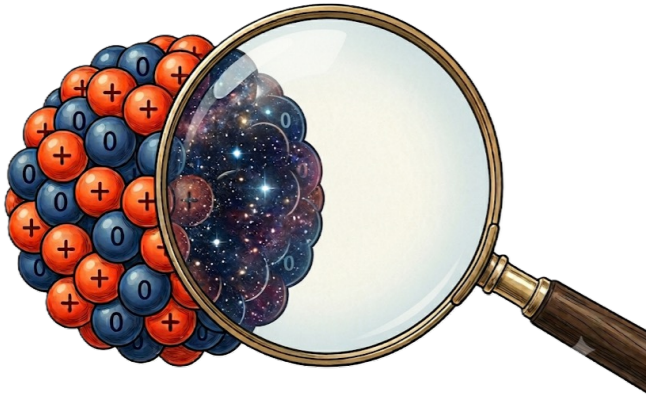

What do we need to know about ν interactions?

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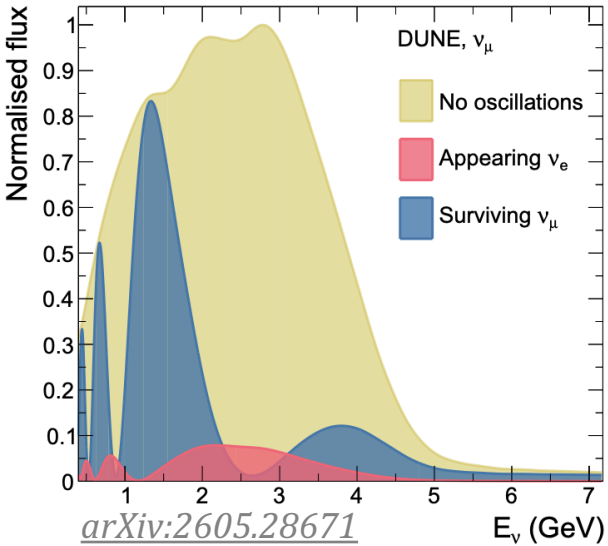

arXiv:2605.28671

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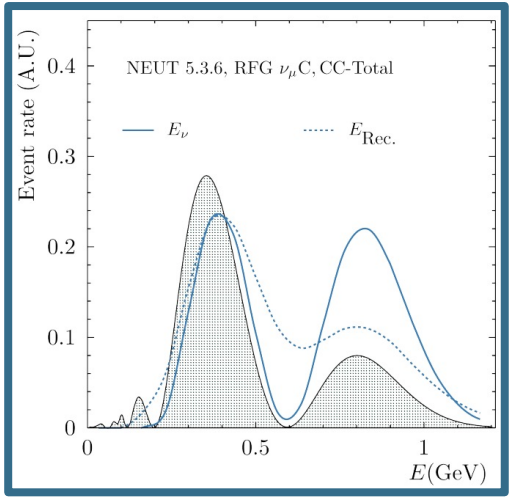

$$N_{\nu_\beta}(E_\nu^{reco}) = P_{\nu_\mu \to \nu_\beta}(E_\nu^{true})\Phi(E_\nu^{true})\sigma(E_\nu^{true})\epsilon(E_\nu^{true})S(E_\nu^{true}, E_\nu^{reco}) \qquad \beta = e, \mu$$

Energy smearing matrix

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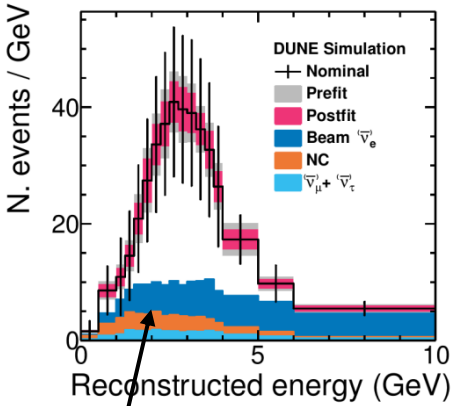

Backgrounds to oscillation searches

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For a very complete discussion of the impact of neutrino interactions uncertainties on oscillation experiments see *arXiv:2605.28671*

How well do we know these things *(in 2026)*?

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How well do we know these things *(in 2026)*?

Model differences up to ~20%

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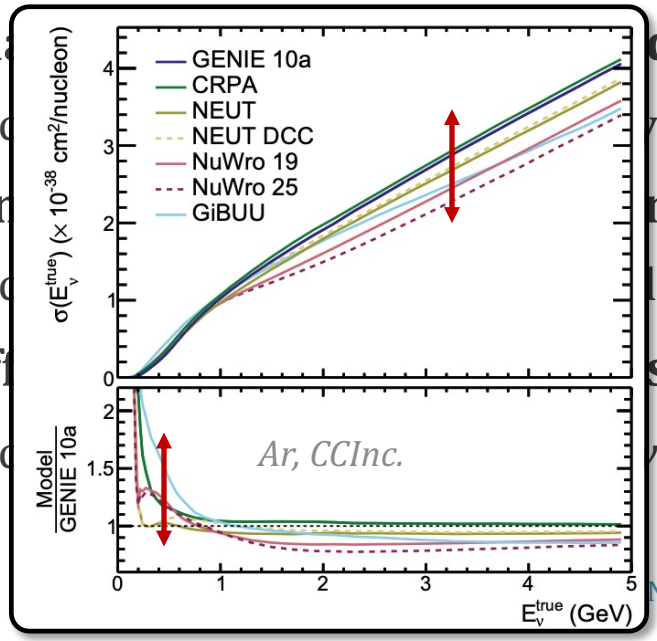
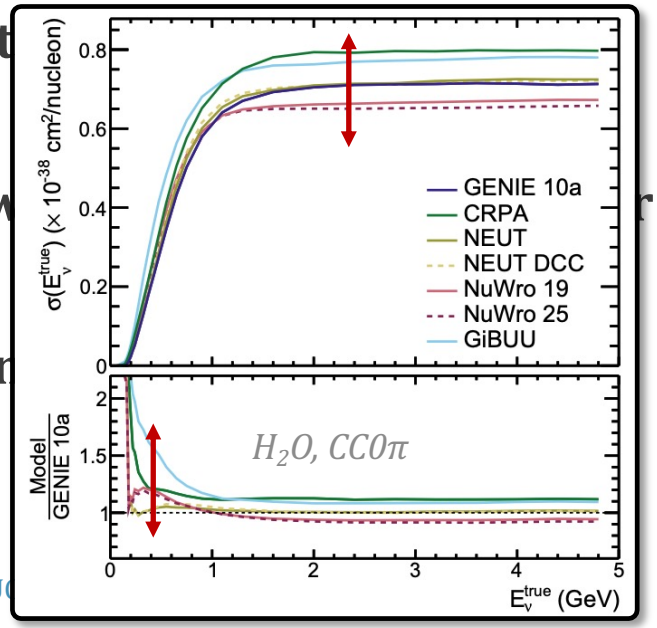
- **The rela… d reconst…**
  - So we c… reliably
- **The con… nt (NC), w… r νs**
  - So we c… lations
- **The diff… ss section…**
  - So we c… ν_e samples





How well do we know these things *(in 2026)*?

Model differences due to different physics processes range from ~20% to ~50%

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- **Th… …ue and recon**
  - S… …bability reliably
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  - S… …or oscillations
- **Th… ν_μ cross secti…**
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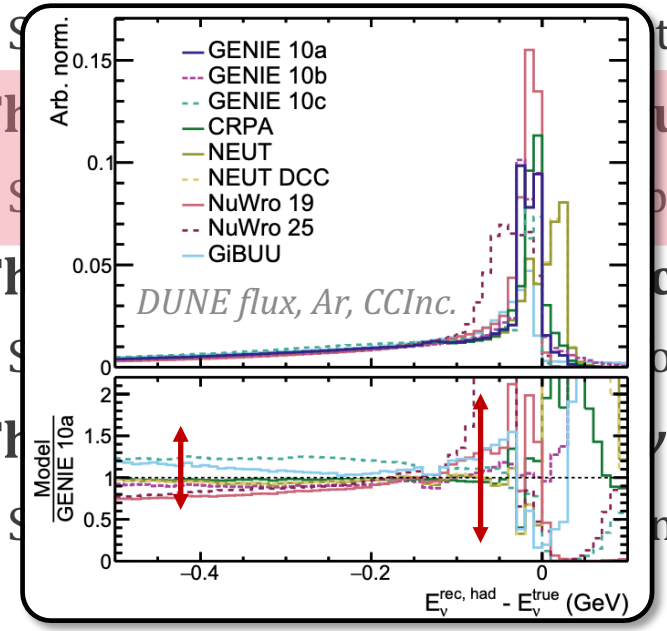

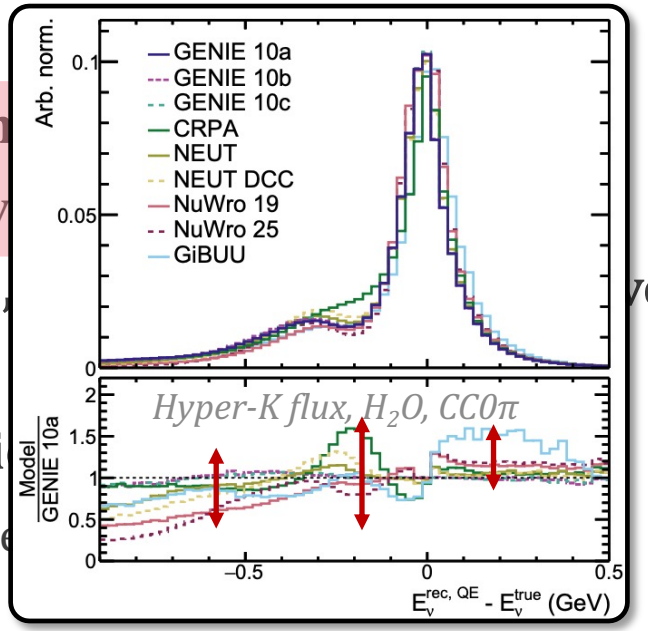

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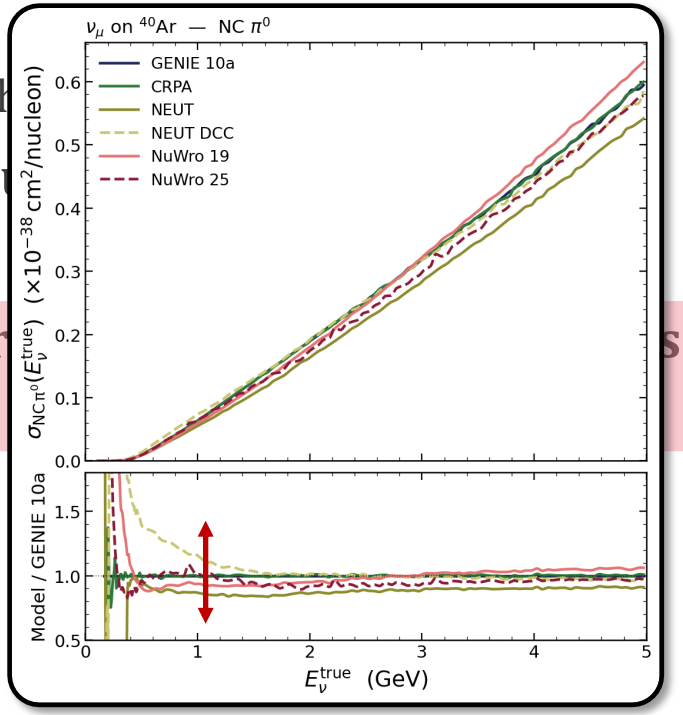

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Differences of ~5% in region where e/μ mass ratio is impactful

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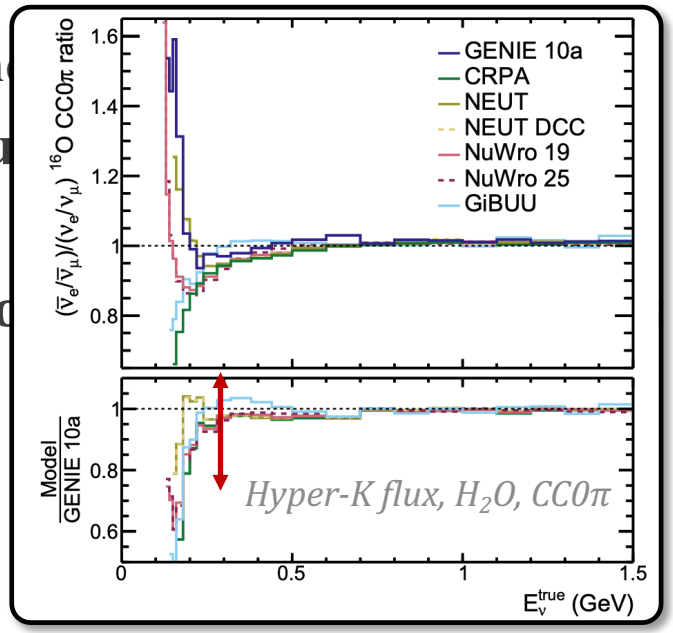

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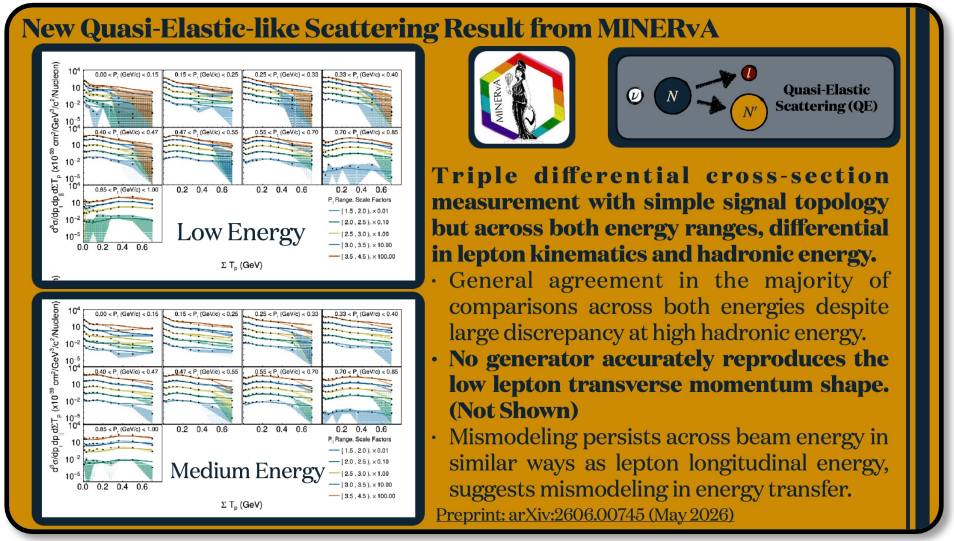
Current cross-section measurements

From B. Ramson's talk on Wednesday



Increasingly differential measurements

Current cross-section measurements

From P. Green's talk on Wednesday

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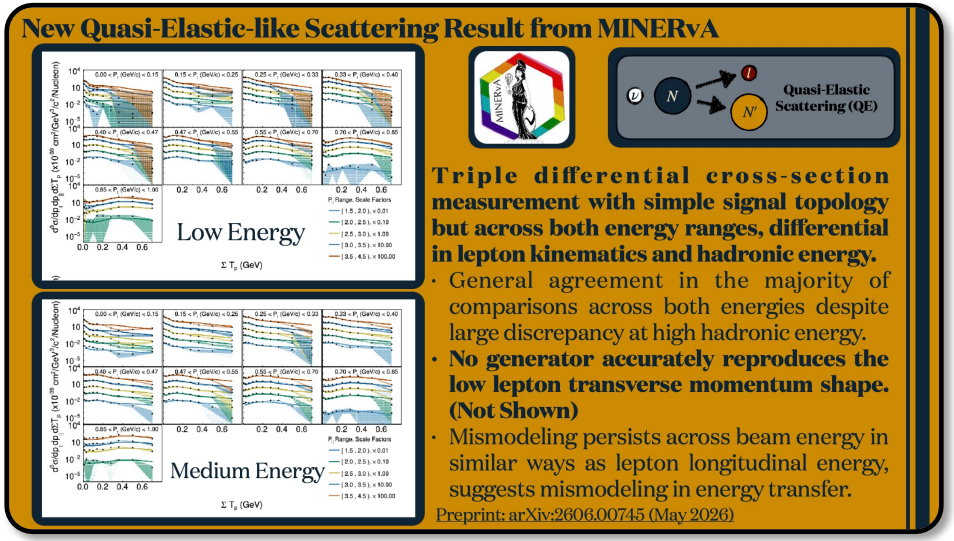

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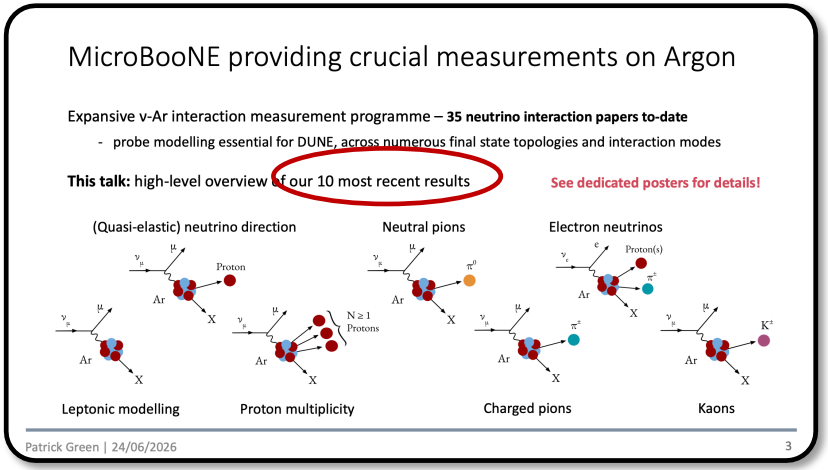

Trailblazing measurements

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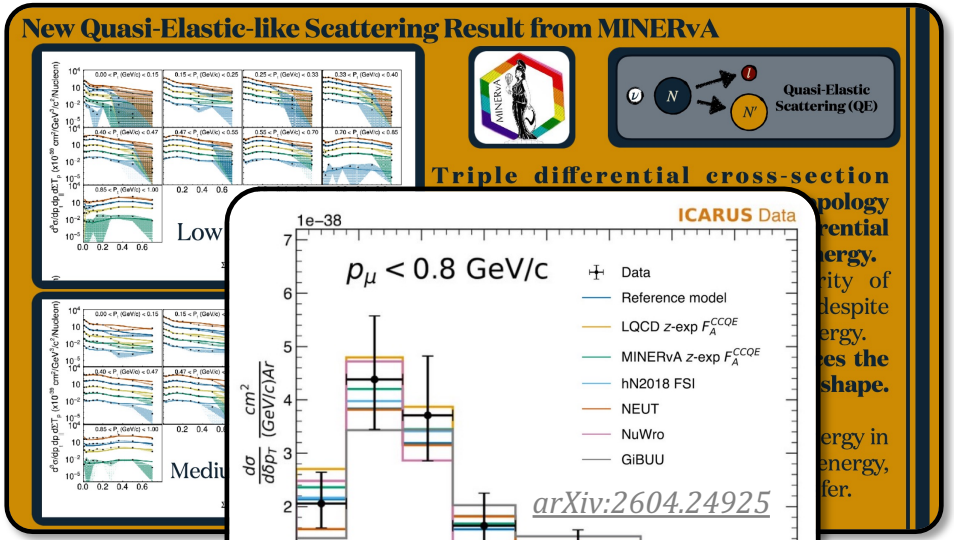
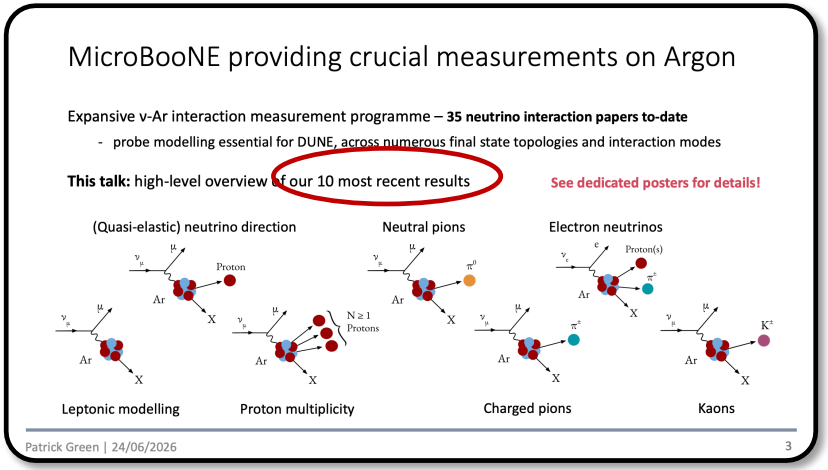


Increasi

arXiv:2604.24925

From M. Mooney's talk on Monday

Higher energies on Ar



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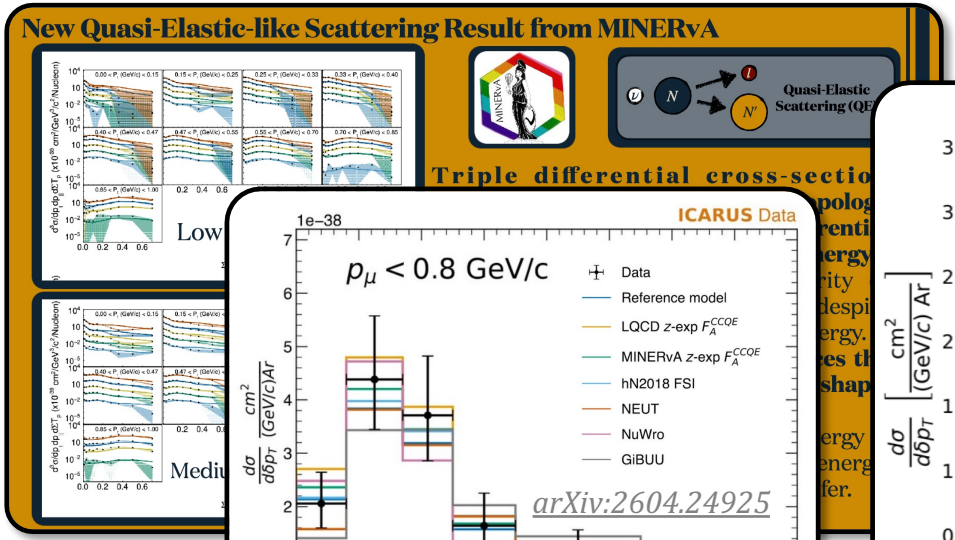

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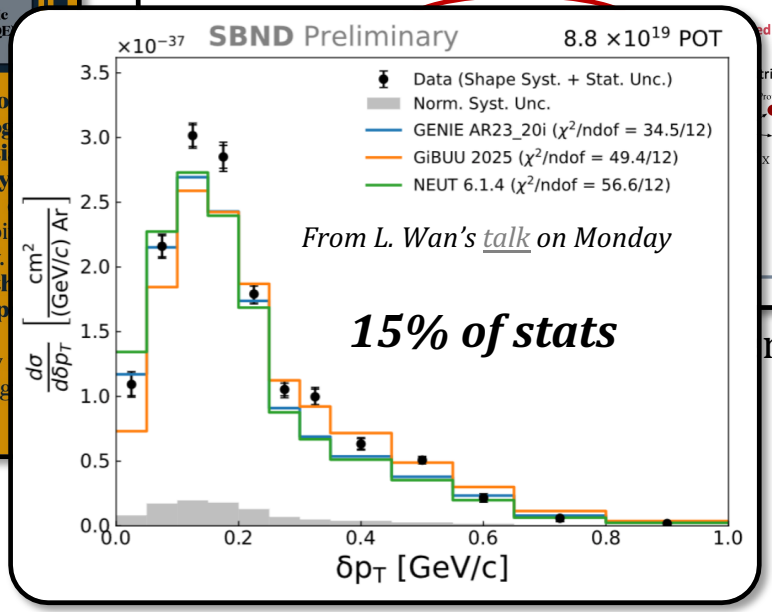


From L. Wan's talk on Monday

15% of stats

More statistics than ever before!

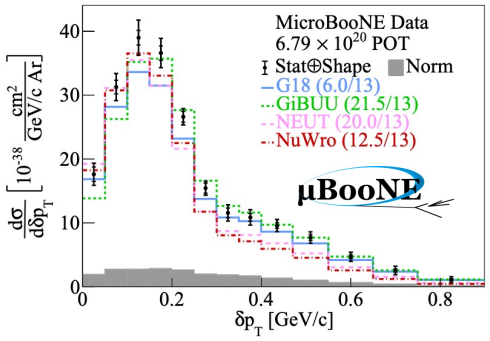
nts

And yet…

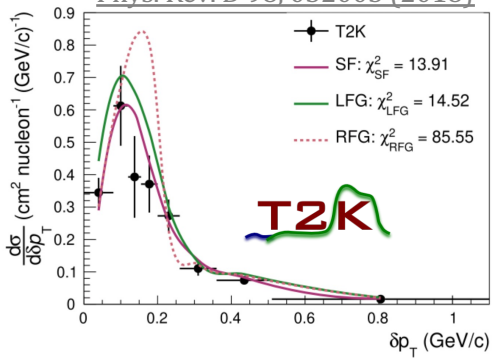
Atomic number

Energy

arXiv:2301.03700



Phys. Rev. D 98, 032003 (2018)



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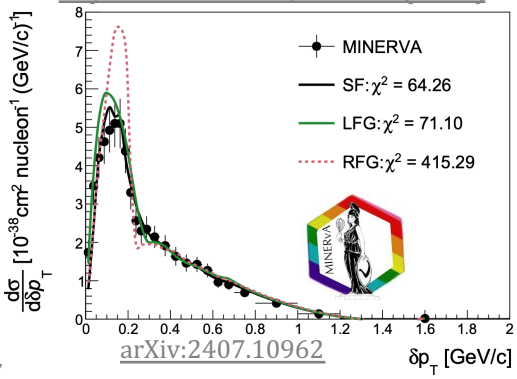

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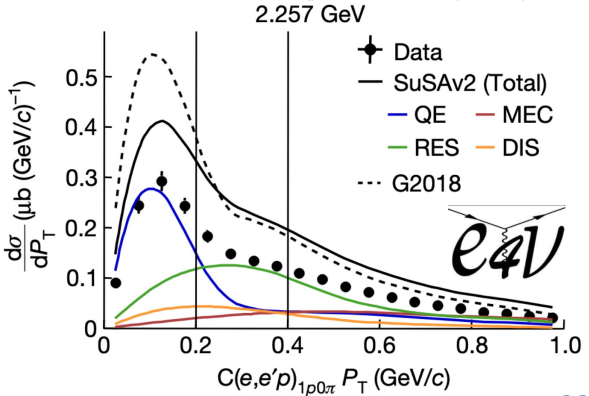

And yet…

No model is able to describe <u>global</u> neutrino scattering measurements

See *Phys.Rev.D 111 (2025) 3,3* for a quantitative analysis

Our ν measurements tell us that all the models are wrong ***but not how to fix them***

Atomic number

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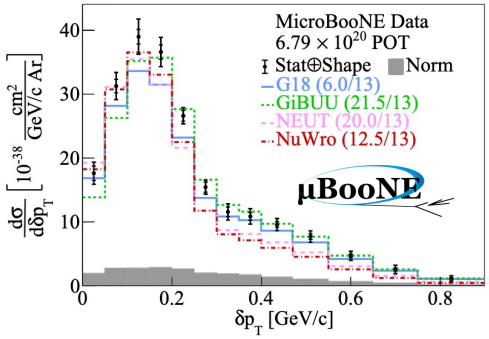

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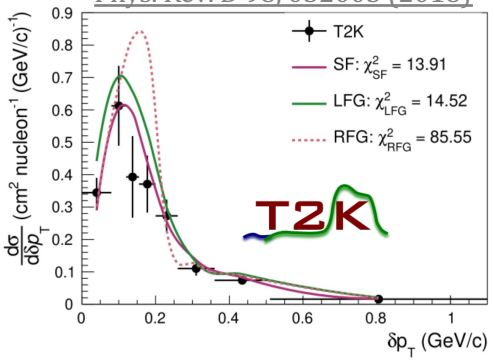

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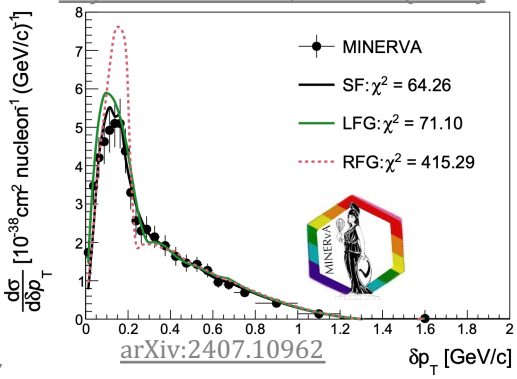

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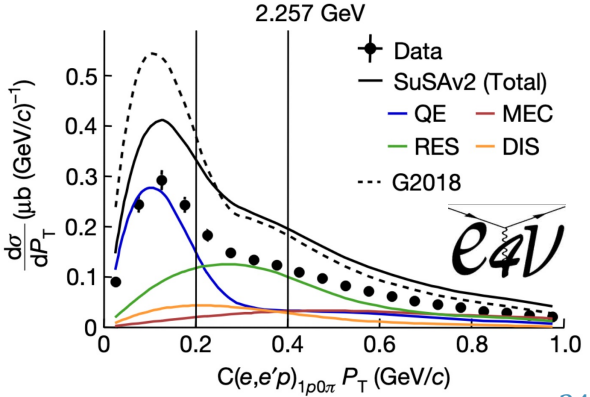

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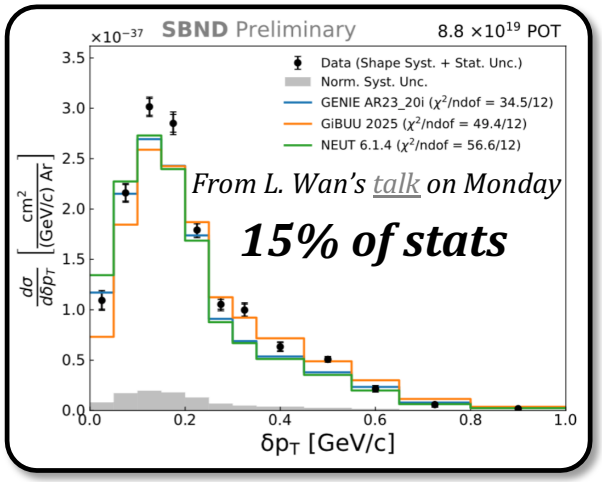
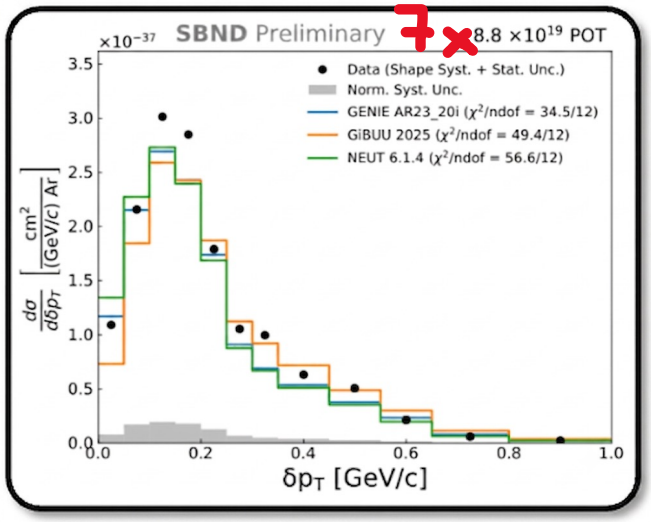
- **More stats**
  - Useful for quantitative constraints down the line





Artist's rendition of high stats SBND measurement

The (near) future of cross-section measurements

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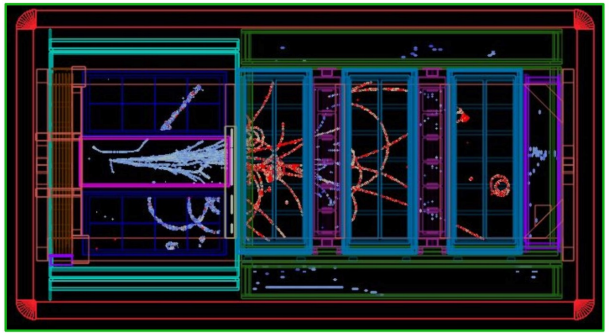
  - Open up new regions of phase space

From S. King's talk on Tuesday



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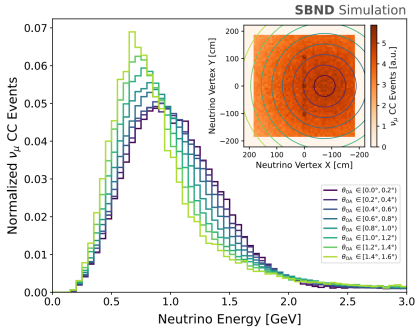

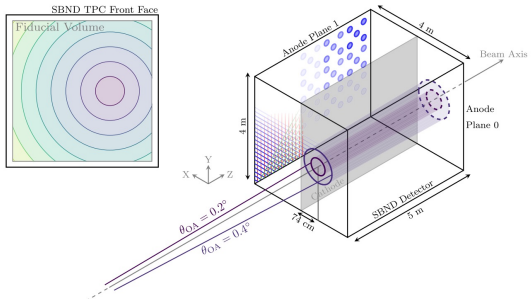

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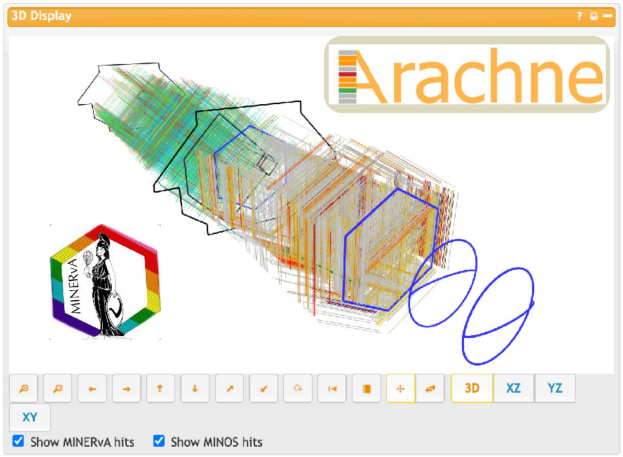
- **Continued analysis of existing data**
  - MicroBooNE, MINERvA and others
  - Make your own cross-section measurement with the MINERvA open data product! *https://minerva.fnal.gov/opendata/*



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Will these help us answer *everything* we need to know?
Probably not…

Why is it so difficult?

Fundamental issue: We do not know the neutrino energy or the neutrino flux

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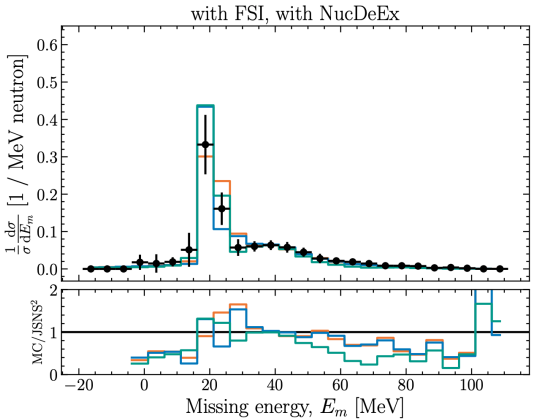


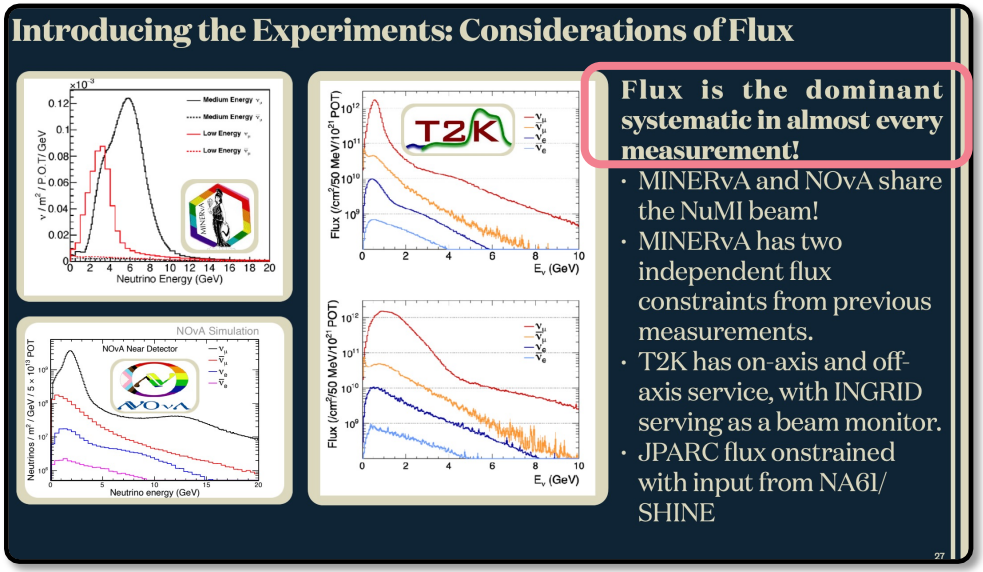
Phys. Rev. Lett. 134, 081801
arXiv:2601.14831
arXiv:2603.03210

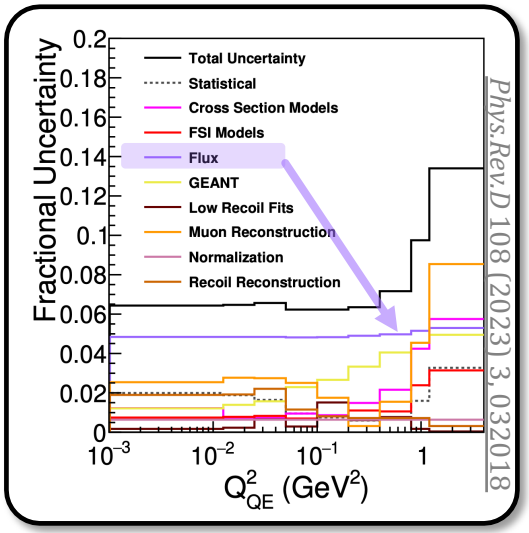
*with few exceptions such as pion and kaon decay at rest

Why is it so difficult?

Fundamental issue: We do not know the neutrino energy or the neutrino flux

- Introduces large systematic uncertainties





From B. Ramson's talk on Wednesday

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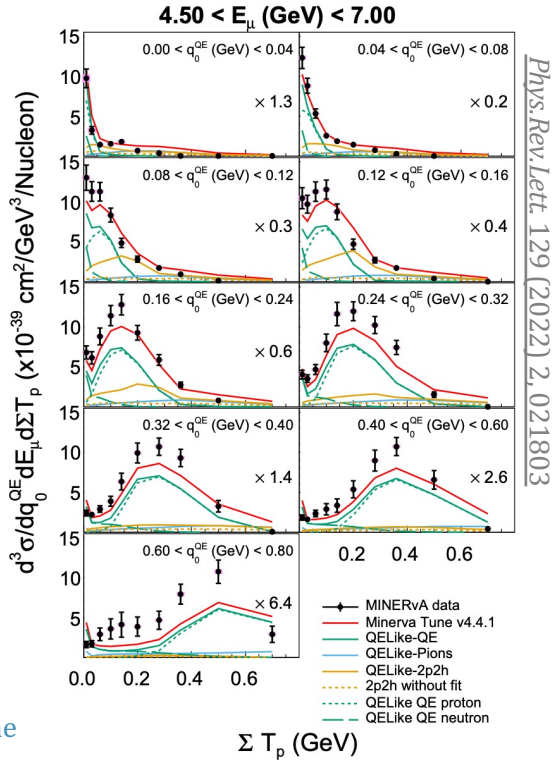
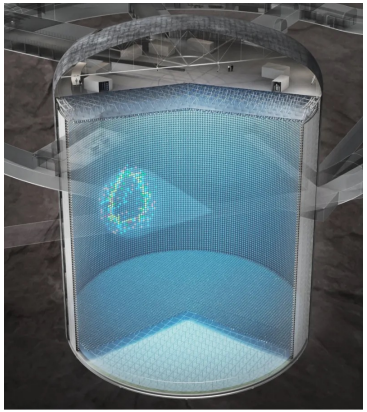
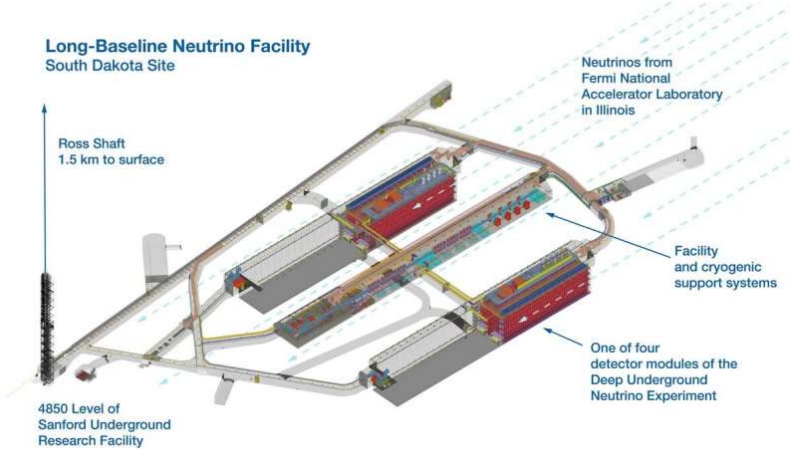
- Introduces large systematic uncertainties
- Cross-section features become degenerate



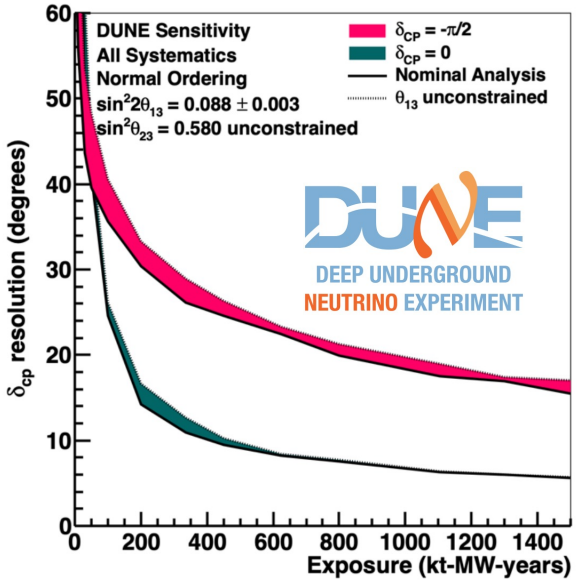
What will neutrino cross-section measurements look like in the Hyper-K and DUNE era?



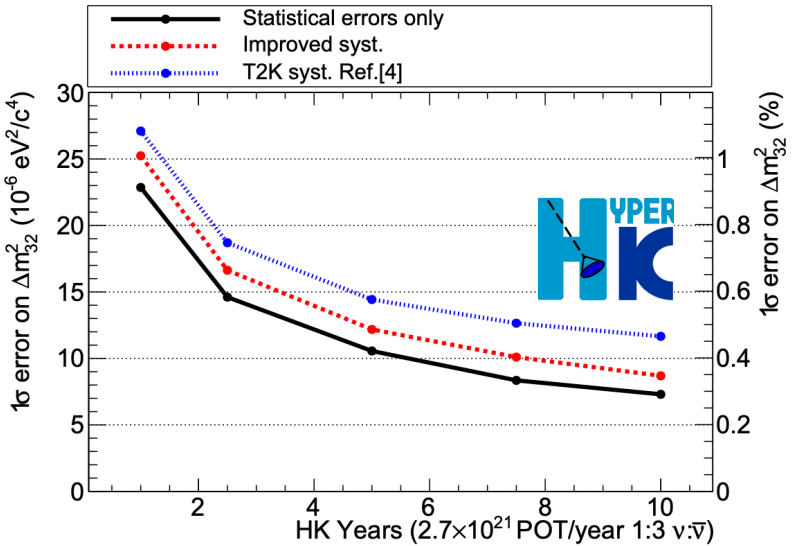


How precise is "precise"?

Possible definition: to reach precision measurement goals

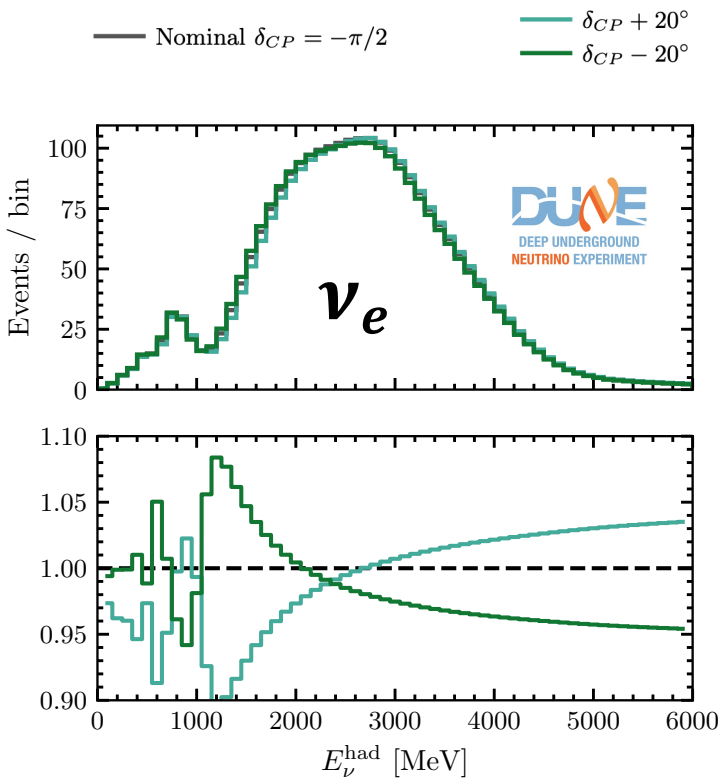


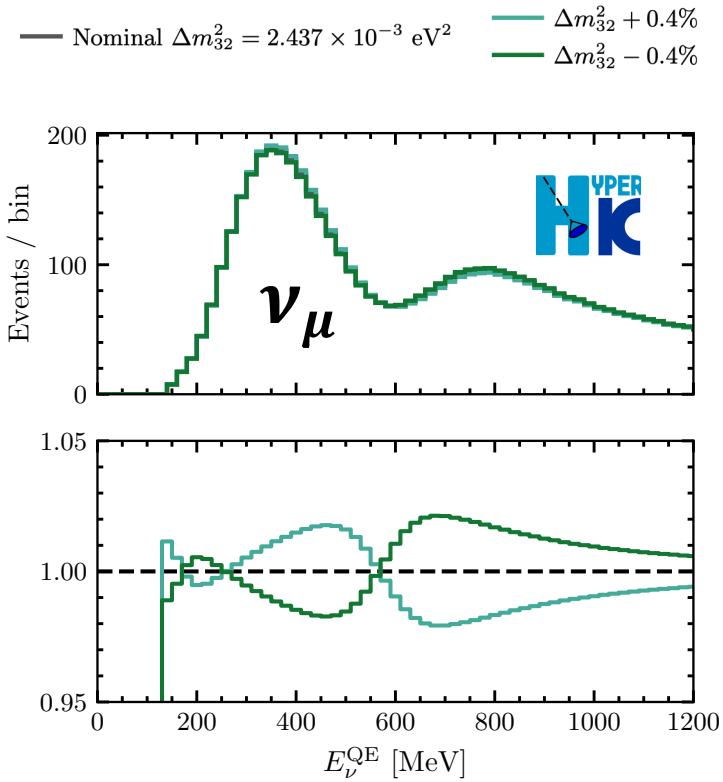
$\sim 20^{o}$ if $\delta_{CP} = -\pi/2$



$\sim 0.5\%$ on Δm^2_{32}

How precise is “precise”?





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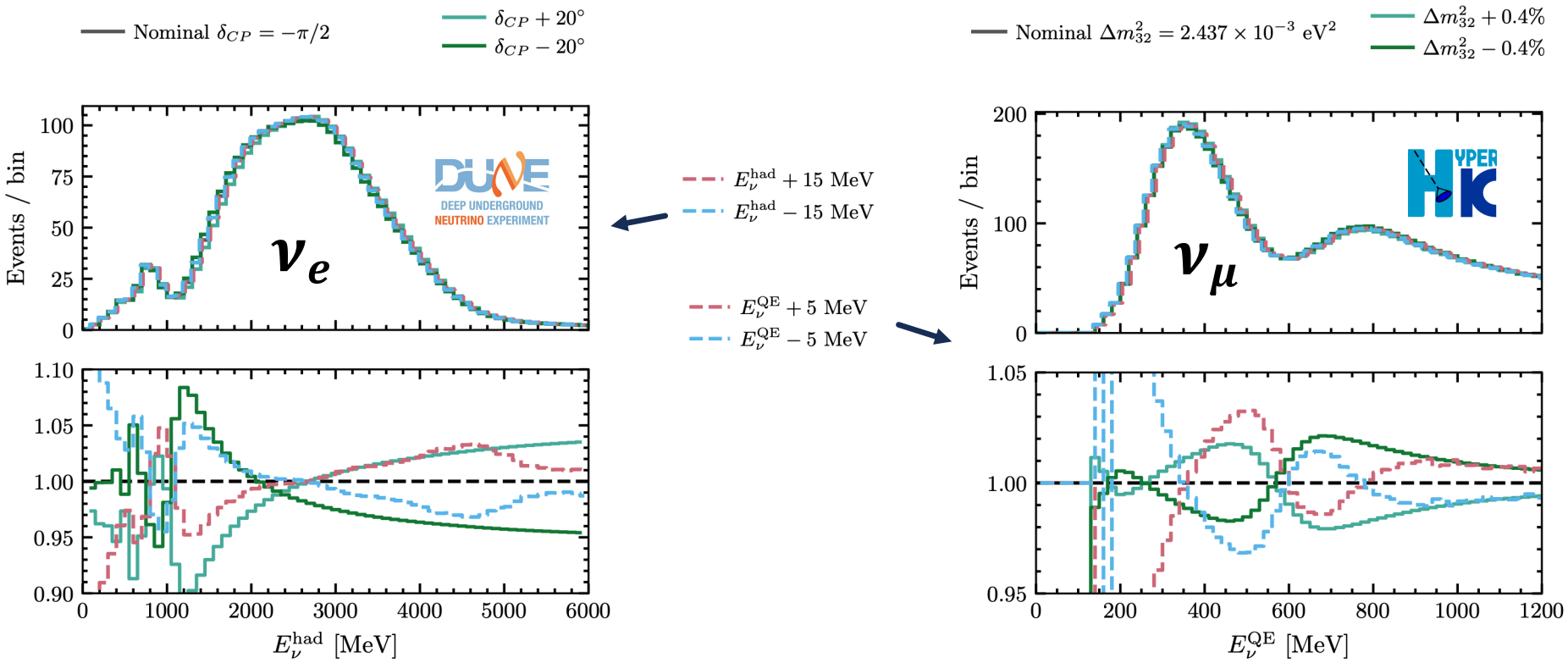

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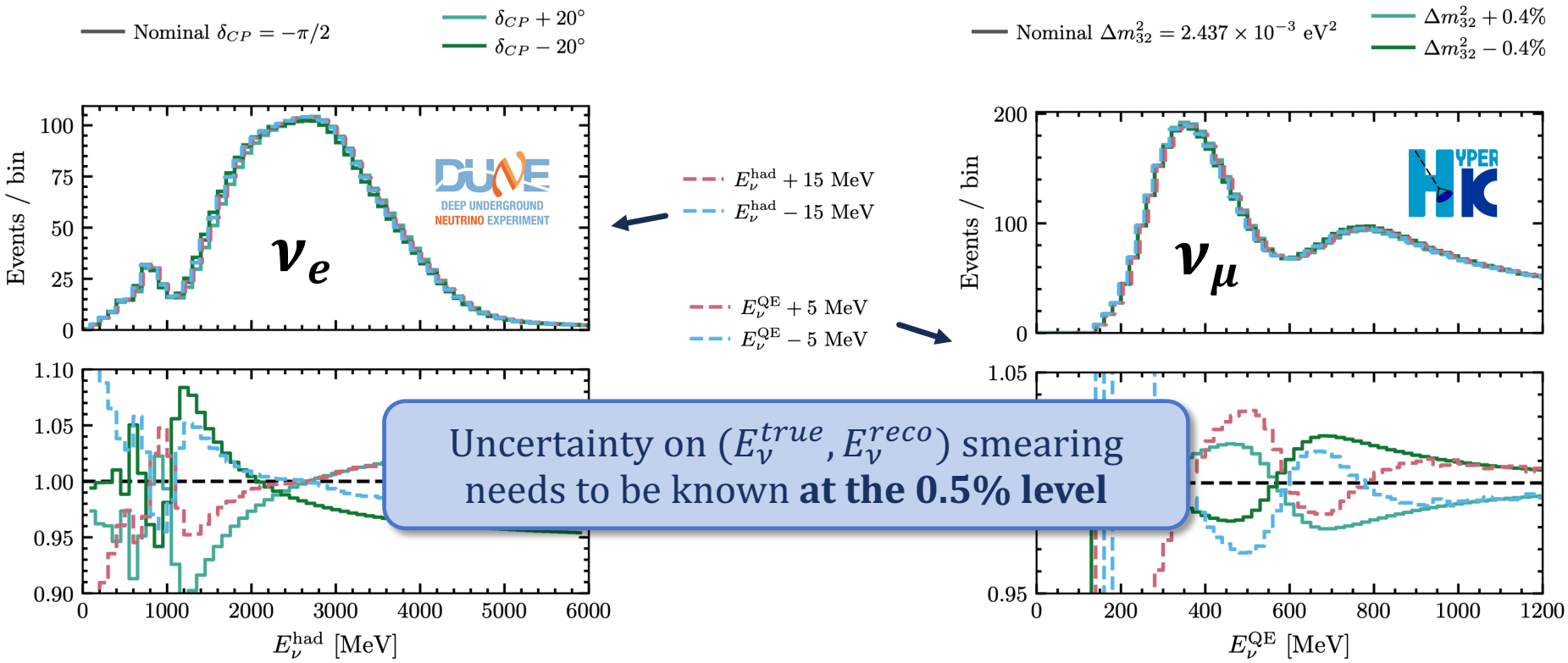
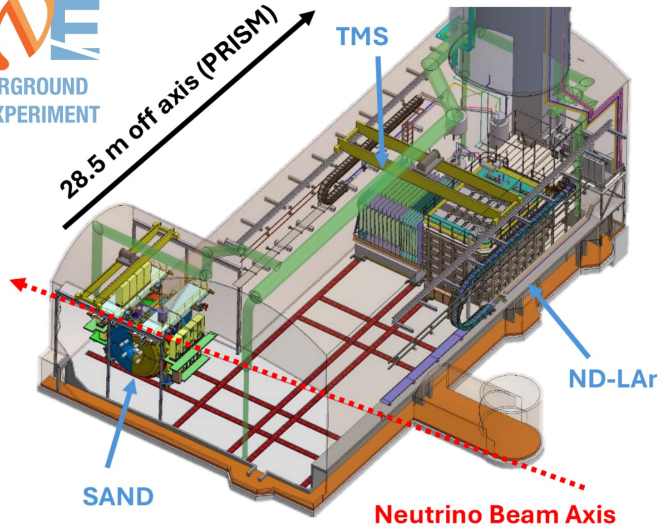
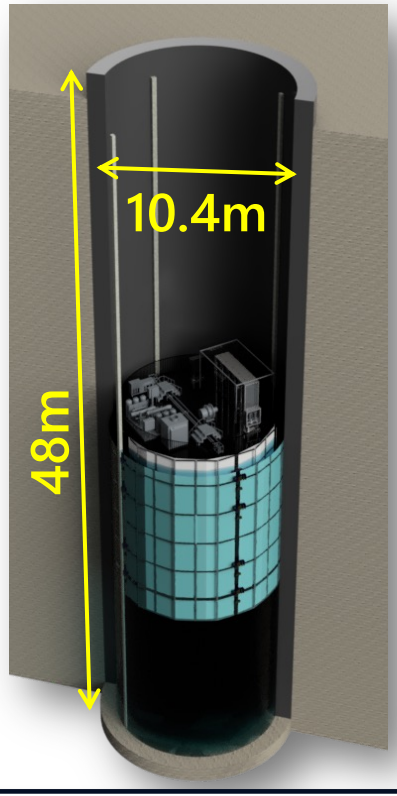


Uncertainty on $(E_\nu^{true}, E_\nu^{reco})$ smearing needs to be known **at the 0.5% level**

In-situ measurements with near detectors

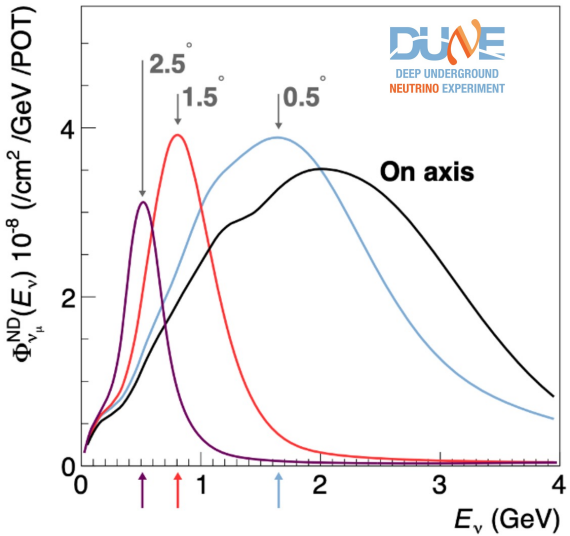


~150 t LAr + 1.3-2.4 MW beam



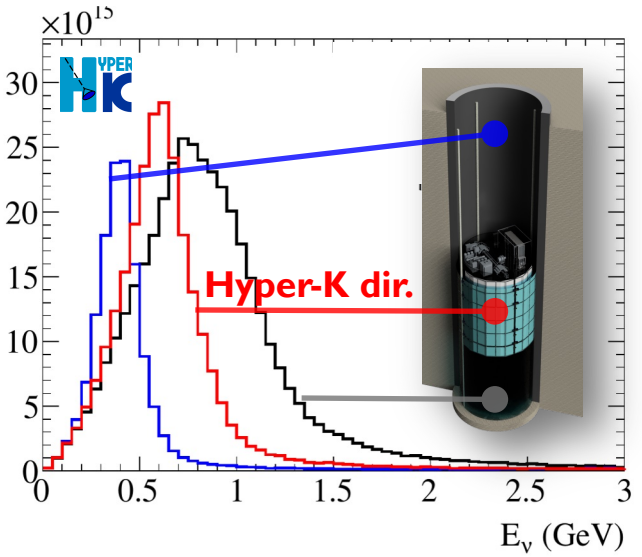
~110 t water + 1.3 MW beam

Interactions through the PRISM



Large interaction rates at different fluxes in the same beam

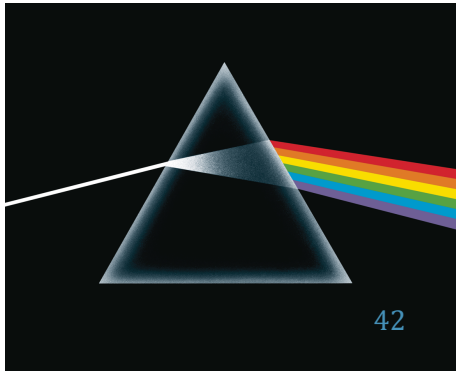
Adds in information about true neutrino energy



Off-axis fluxes can be combined to produce arbitrary shapes:

$$\mathbf{\Phi}\vec{c} \approx \vec{\phi}$$

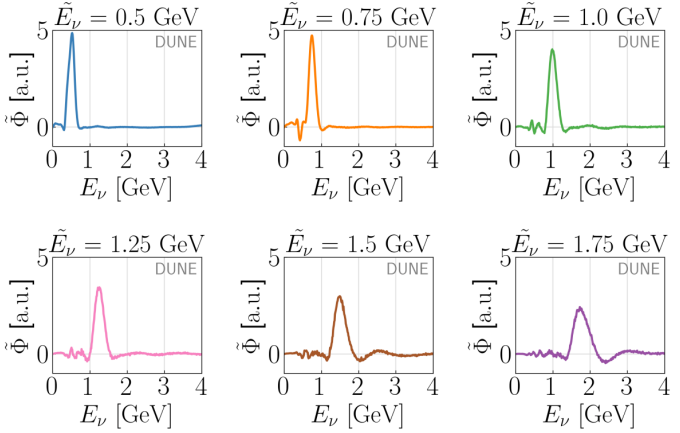
Real fluxes — Coefficients — Virtual flux



Interactions through the PRISM

arXiv:2509.07664

Can be used to obtain **quasi-monoenergetic** neutrino fluxes!



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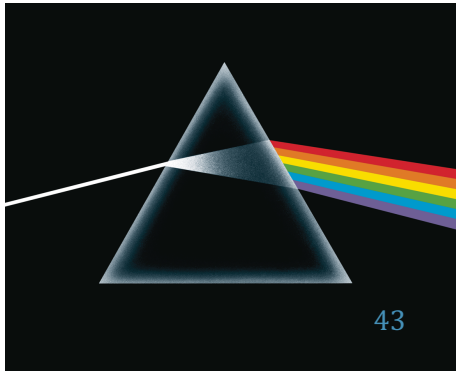

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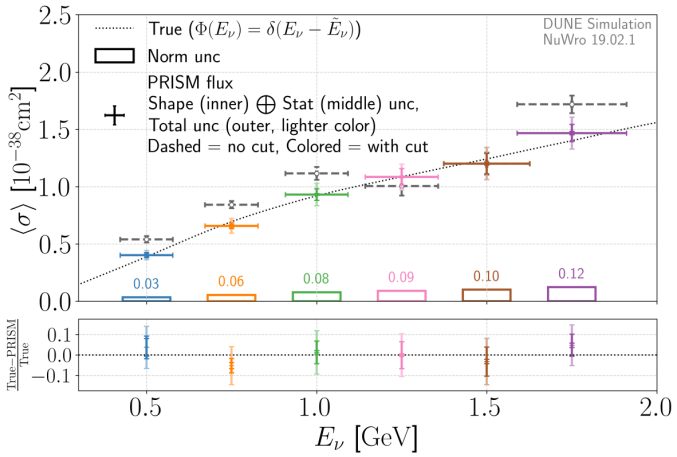
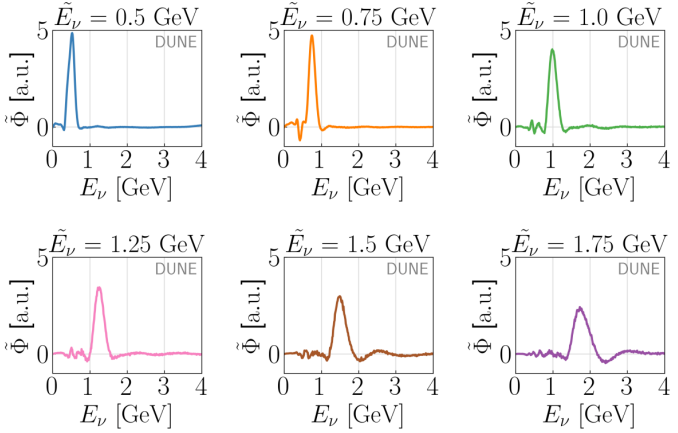
With ~2.5 years of DUNE ND data $\boldsymbol{\sigma_{tot}^{CC}}$ **known at ~10%**





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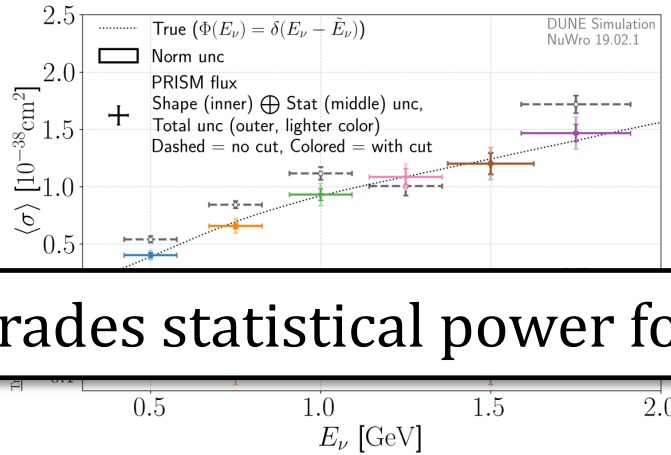

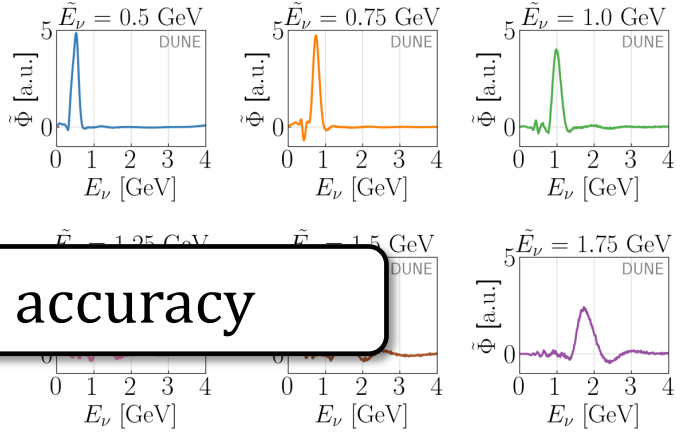

With ~2.5 yea
DUNE ND da
σ_{tot}^{CC} **known at ~10%**

Trades statistical power for accuracy

Off-axis fluxes can be combined to produce arbitrary shapes:

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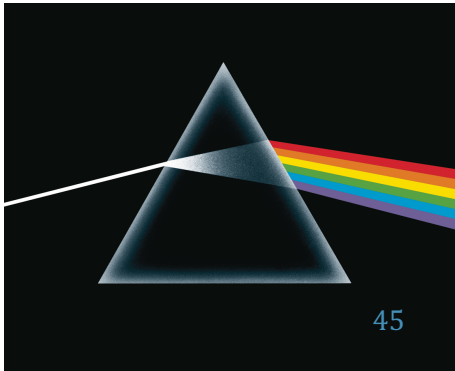
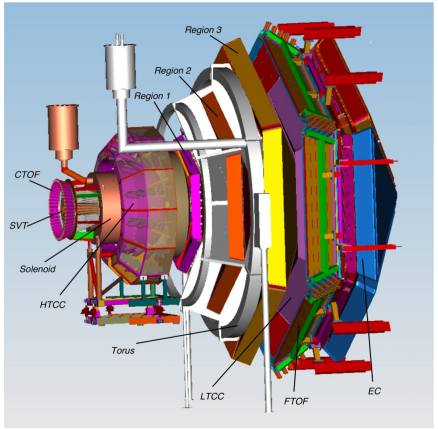
Real fluxes — Coefficients — Virtual flux



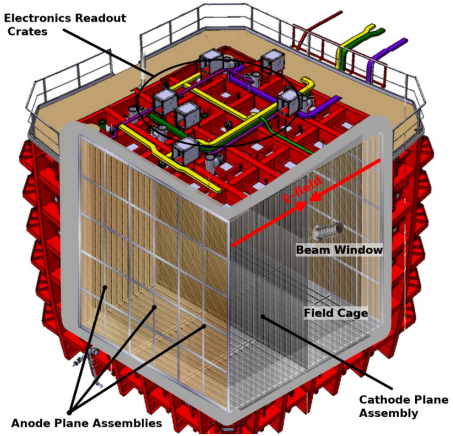
Getting a little help from our friends

Electron and hadron scattering experiments will provide us with useful constraints to constrain nuclear effects

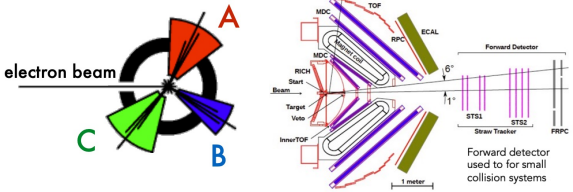
Major advantages: known probe energies, high statistics



Preparing new measurements with CLAS6 and CLAS12 data



Proton- and pion-Ar scattering measurements from protoDUNE



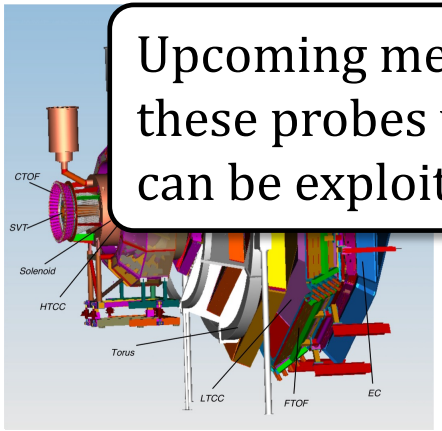
+ other facilities such as MAMI/MESA, HADES@FAIR(GSI)...

Getting a little help from our friends

Electron and hadron scattering experiments will provide us with useful constraints to constrain nuclear effects

Major advantages: known probe energies, high statistics

Upcoming measurements *(especially differential ones)* with these probes will be crucial to build better models which can be exploited by DUNE and HK near detectors



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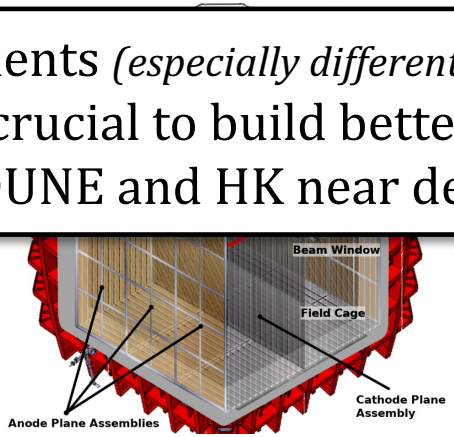

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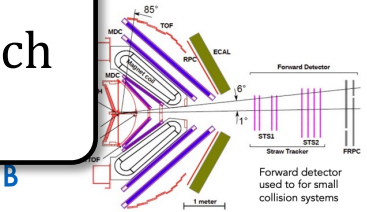


+ other facilities such as MAMI/MESA, HADES@FAIR(GSI)...

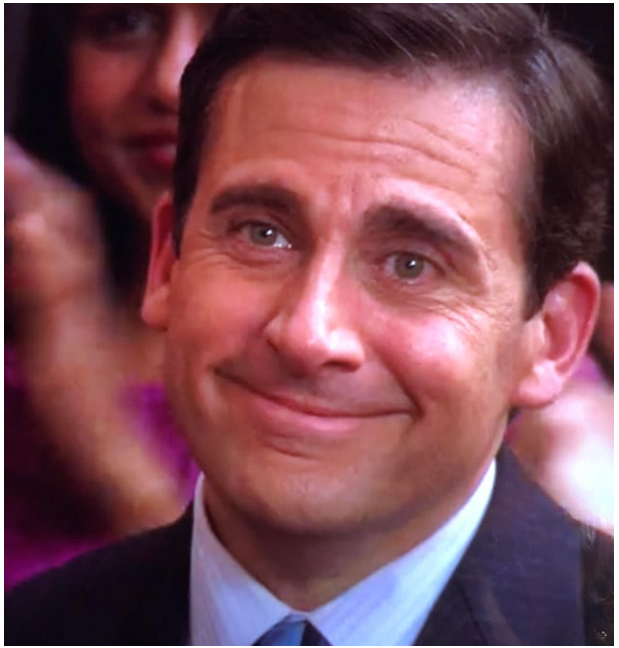
What we have to look forward to

Measurements from SBND + precise measurements from T2K ND280 + continued analysis of MicroBooNE, ICARUS, MINERvA, NOvA, ANNIE data

VERY high statistics near detectors
(notably NDLAr)

Usage of PRISM techniques

Electron and hadron scattering measurements



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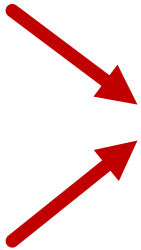

High statistics but we *still* do not know the neutrino energy

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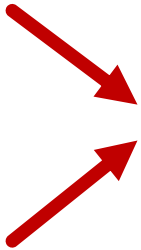

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Accuracy at the cost of statistical power

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VERY high statistics near detectors
(notably NDLAr)

→ High statistics but we *still* do not know the neutrino energy

Usage of PRISM techniques → Accuracy at the cost of statistical power

Electron and hadron scattering measurements → No axial information

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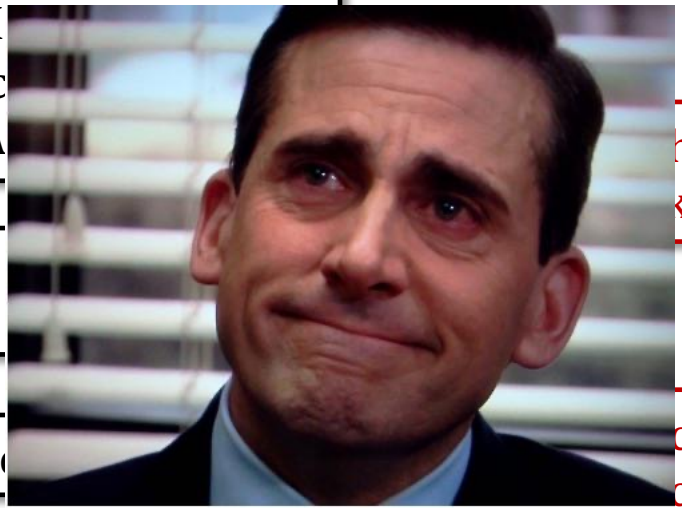
Measurements from SBND + precise measurements from T2K continued analysis of Mic ICARUS, MINERvA, NOvA



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→ No axial information

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Measurements from SBND + precise measurements from T2K ND280 + continued analysis of MicroBooNE, ICARUS, MINERvA, NOvA, ANNIE data

High statistics but we *still* do

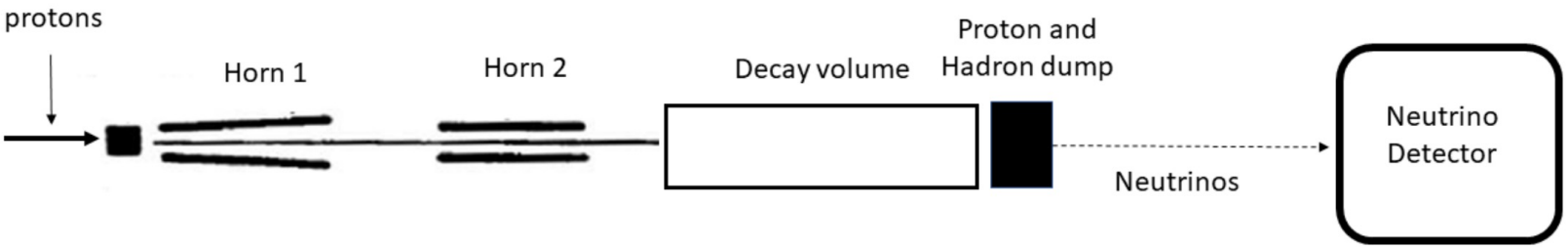
This *might* be enough but requires a **truly collective effort** + significant **theoretical developments**

Usage of PRISM techniques → Accuracy at the cost of statistical power

Electron and hadron scattering measurements → No axial information

A new frame of thought

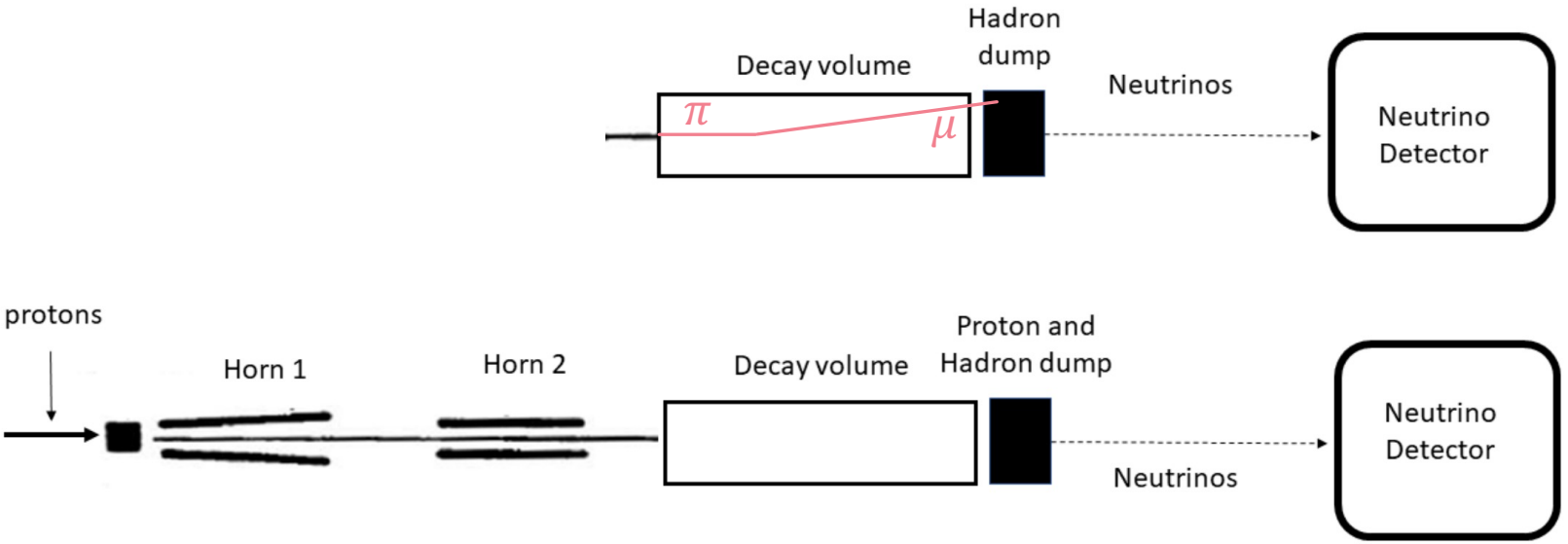
Rethinking how to make a neutrino beam



Appl. Sci. **2021**, *11*(4), 1644

Rethinking how to make a neutrino beam

What if we could *see* what we produce?



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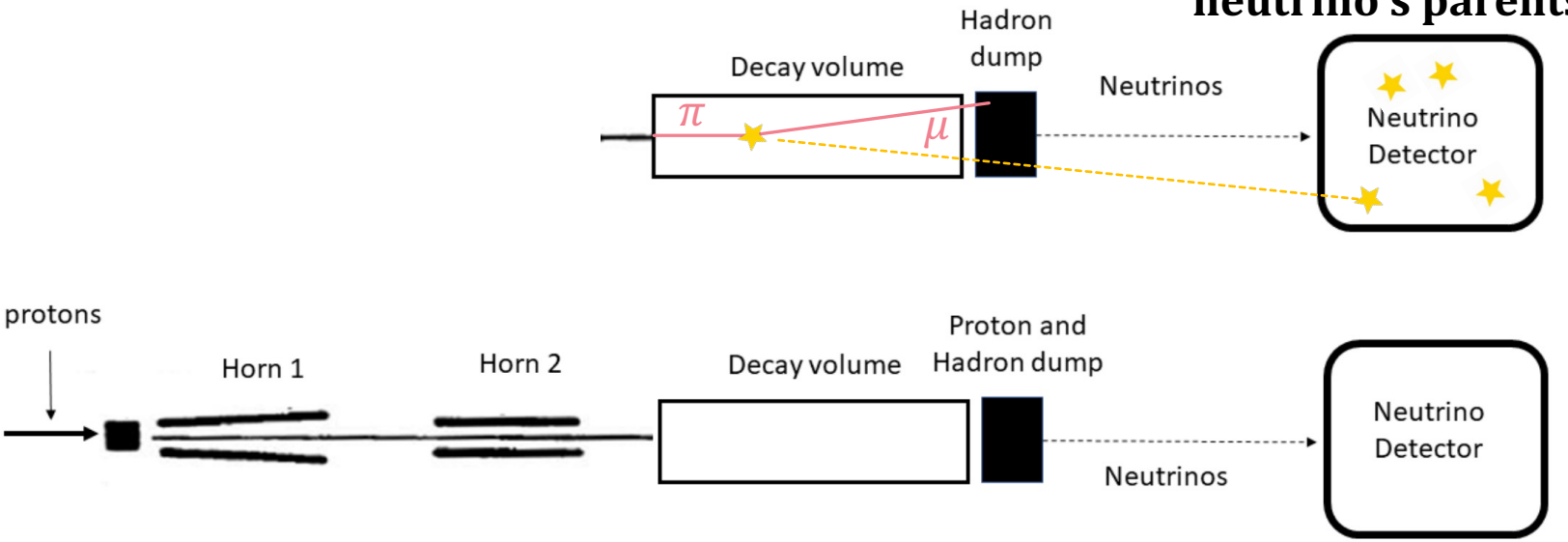
Rethinking how to make a neutrino beam

What if we could *see* what we produce?

And find each interacting neutrino's parents?



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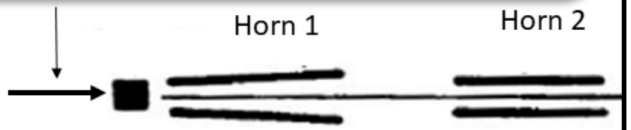

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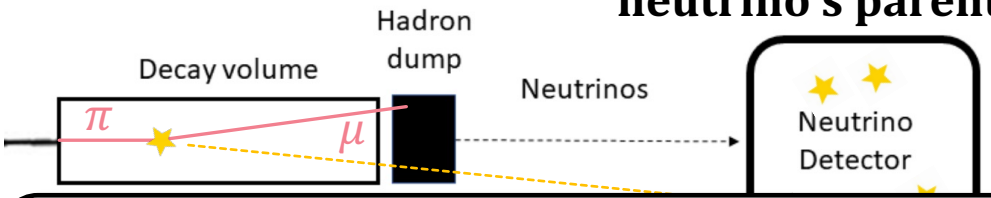

…Wait but neutrino interaction cross-sections are tiny…

To see 1 neutrino in 100 tons of material I would need

- ~10^{13} pions, each producing a neutrino
- To distinguish each pion!

Need a slowly beam which is extracted ***slowly***

Appl. Sci. **2021**, *11*(4), 1644

Rethinking how to make a neutrino beam

Use a less intense beam

What if we could *see* what we produce?

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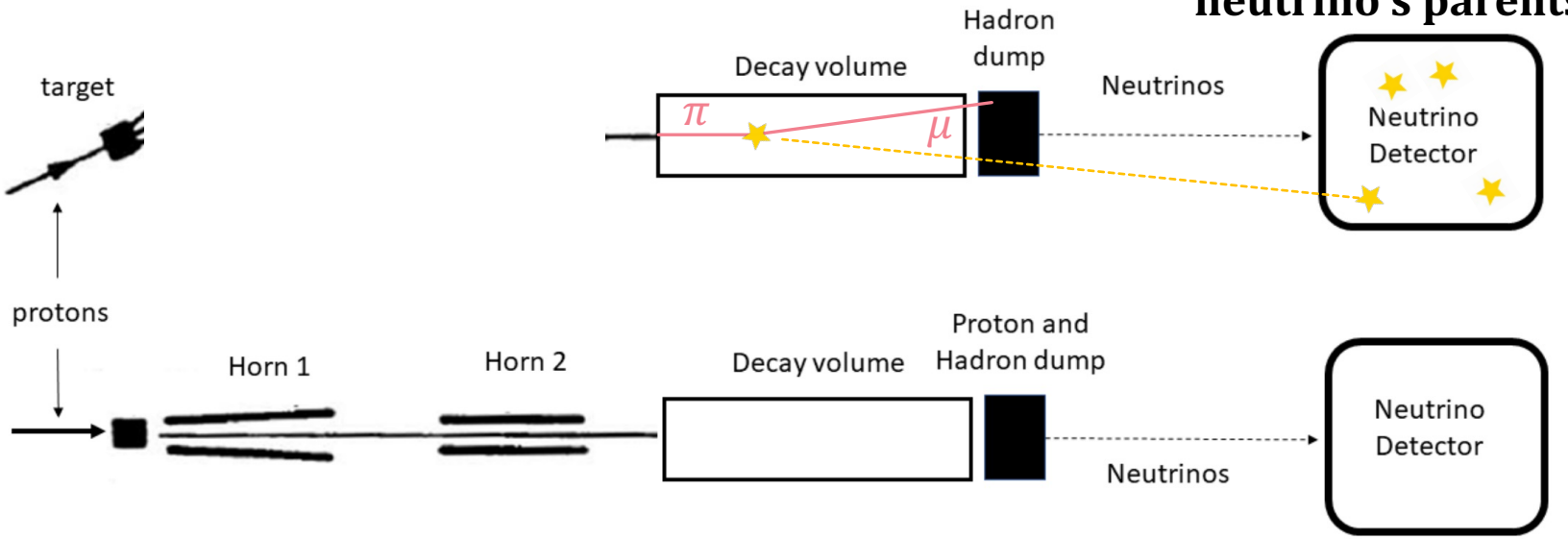

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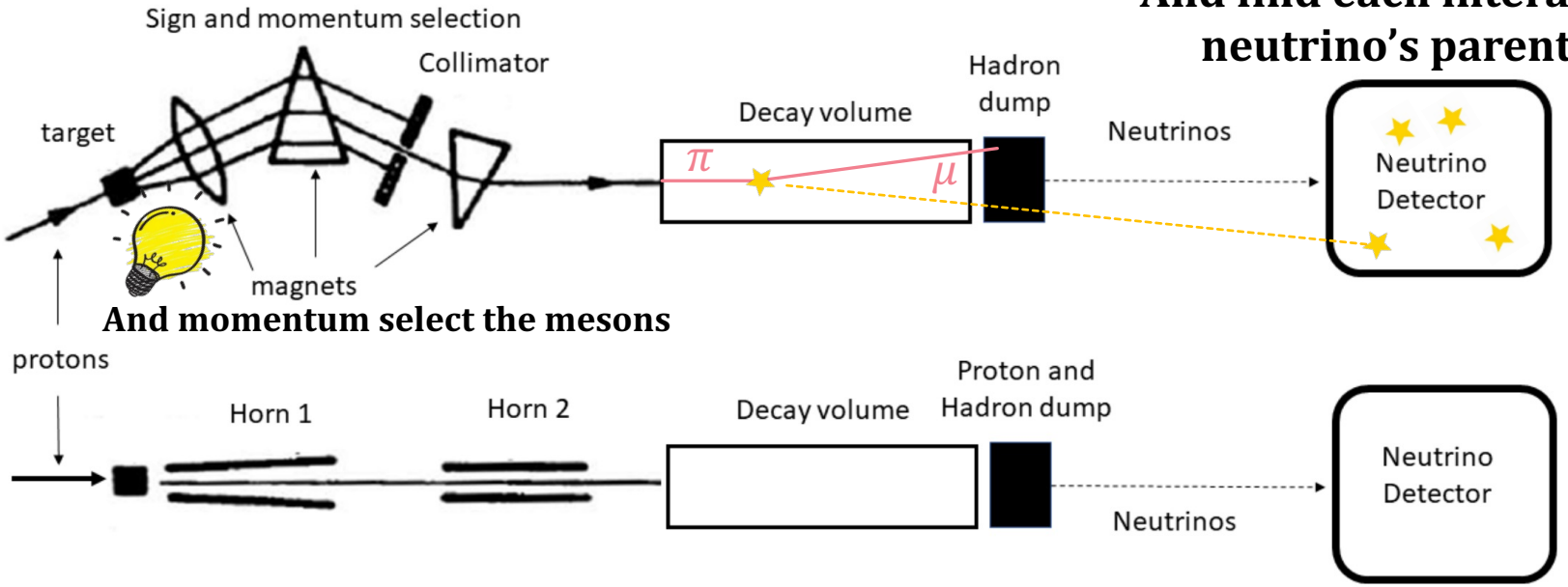

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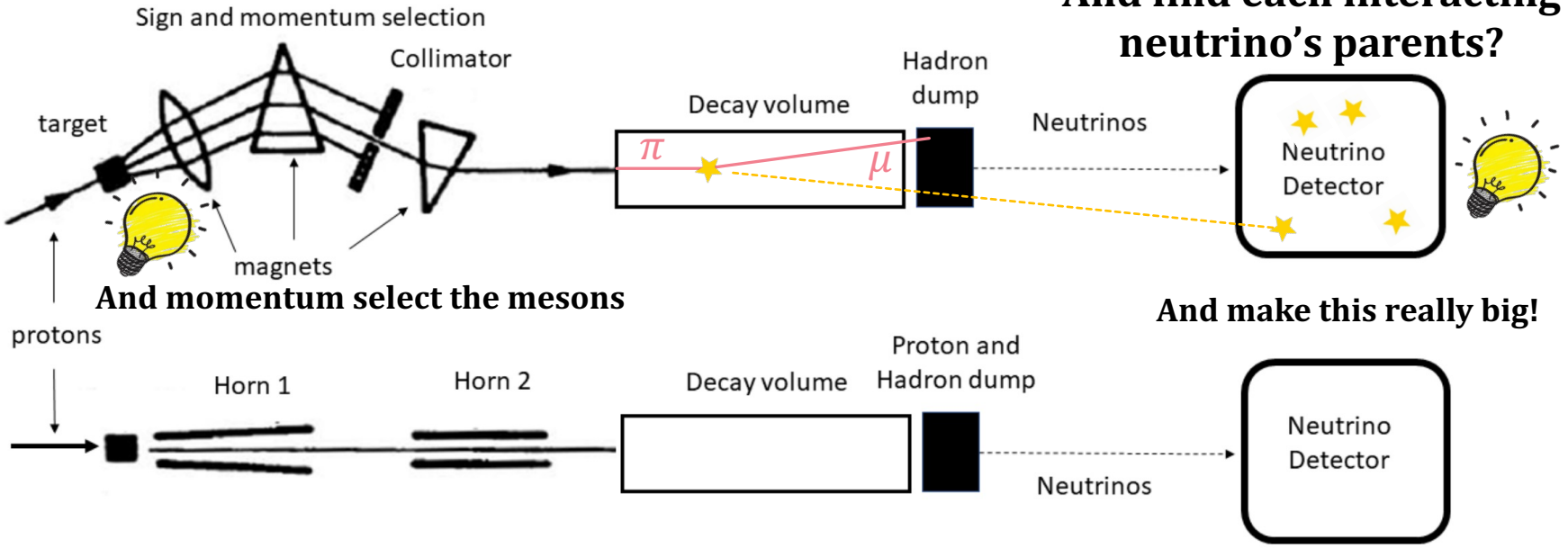


And momentum select the mesons

And make this really big!

Appl. Sci. **2021**, *11*(4), 1644

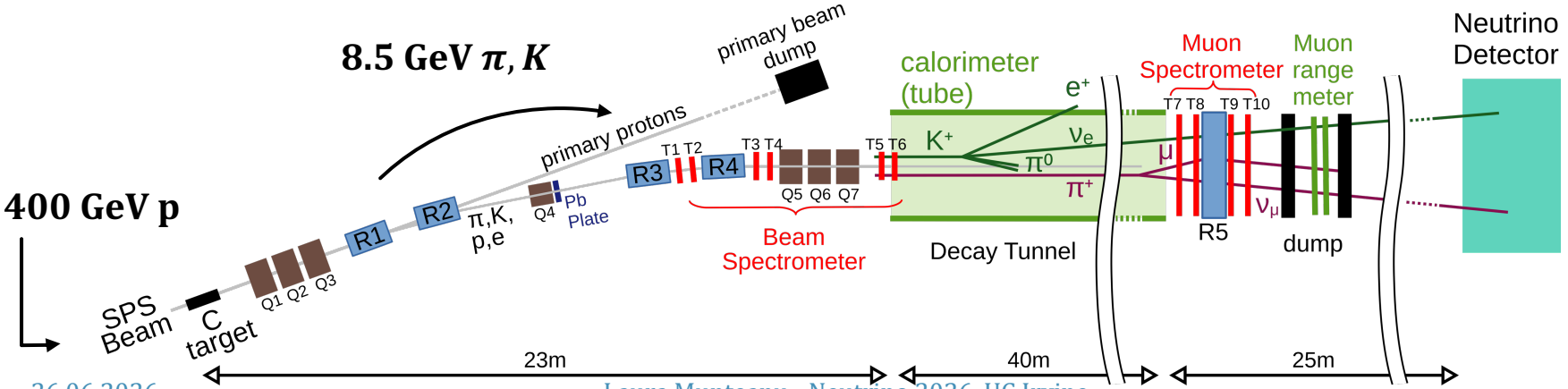
nuSCOPE (Neutrino SPS Complex for Precision Experiments)

Formed as a result of the merge of **ENUBET** and **NuTAG**

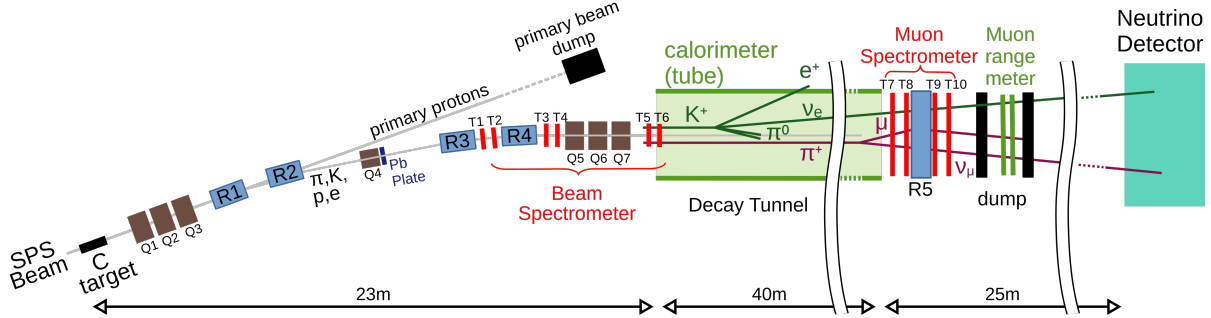
Proposal: use protons from SPS to create a **monitored and tagged neutrino beam at CERN** for short-baseline physics

- Key part of physics program: **neutrino cross-section measurements**

Input submitted to the European Strategy for Particle Physics Update 2026:
https://arxiv.org/abs/2503.21589



Not science fiction!



Monitoring *(ENUBET)*

Tagging *(NuTAG)*

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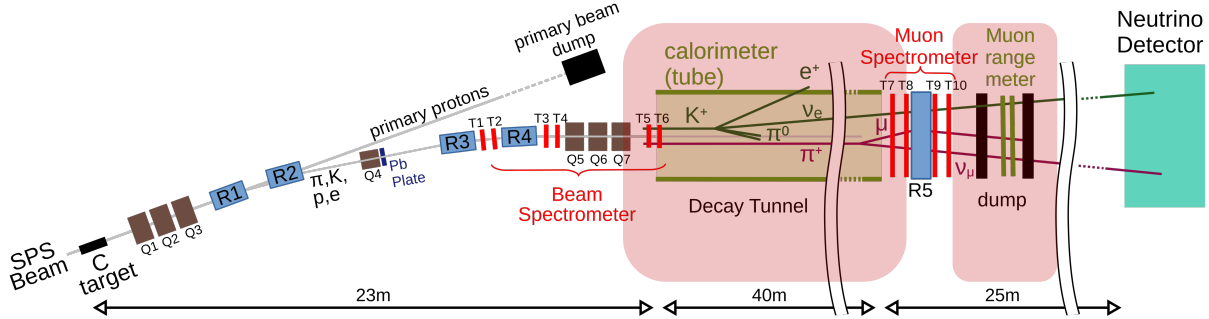

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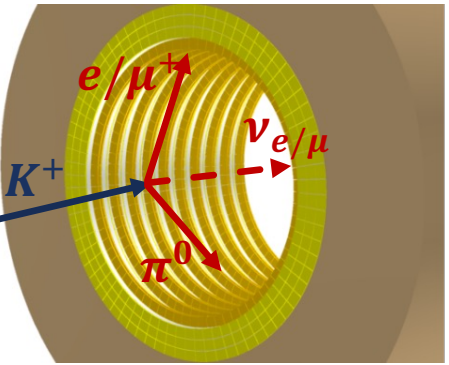

Performance of a section of the decay tunnel tested at CERN T9 Test Beam facility under NP06/ENUBET
Eur. Phys. J. C **83**, 964 (2023)

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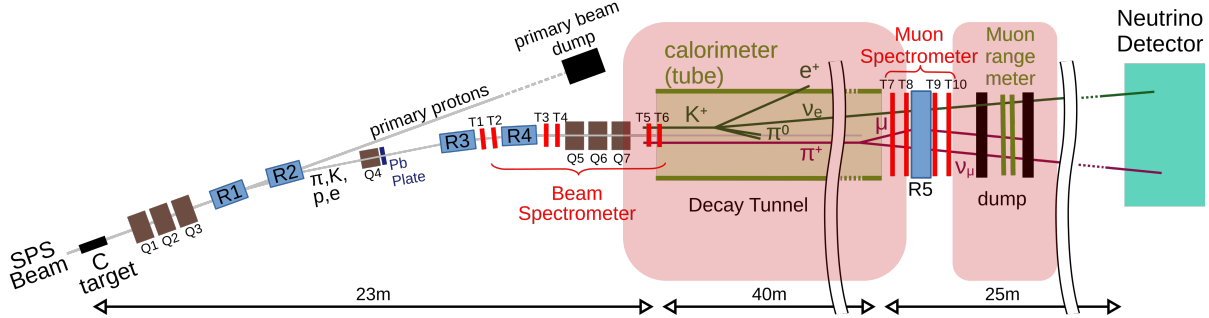

Monitoring *(ENUBET)*

Neutrino flux uncertainties <1%

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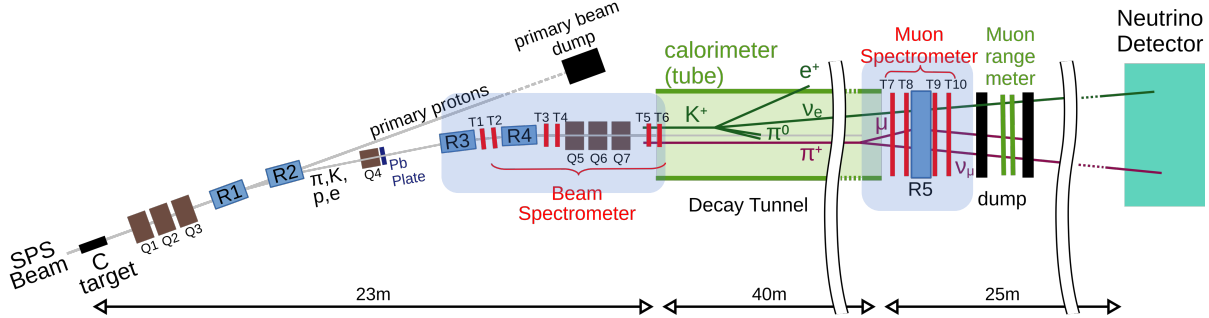

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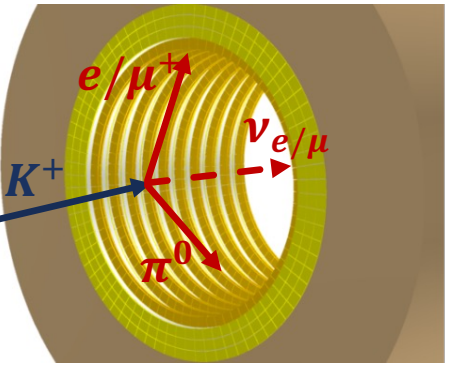

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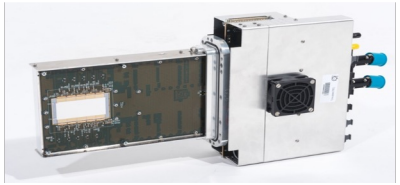
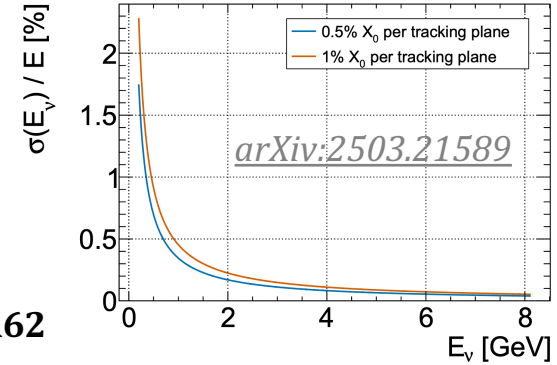
Tagging *(NuTAG)*

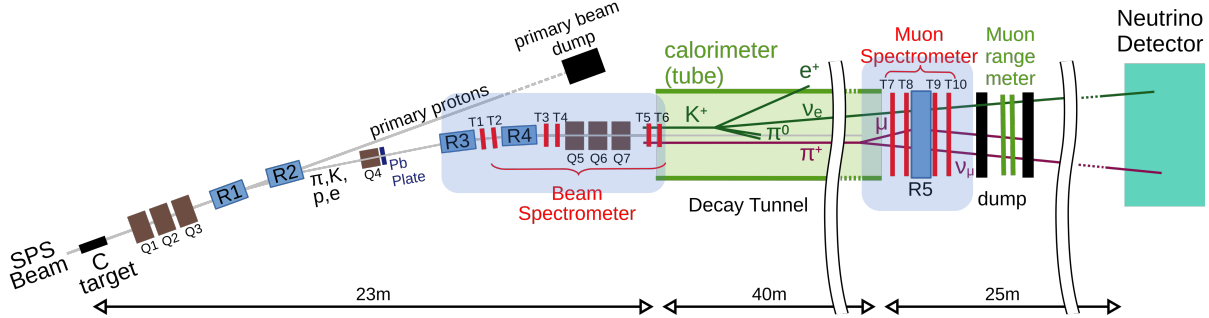


Phys.Lett.B 863 (2025) 139345

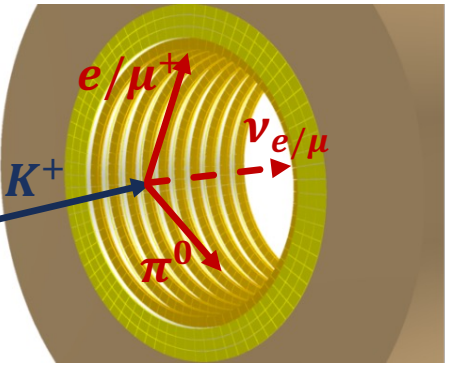
A first tagged neutrino candidate observed by NA62



Not science fiction!



Monitoring *(ENUBET)*



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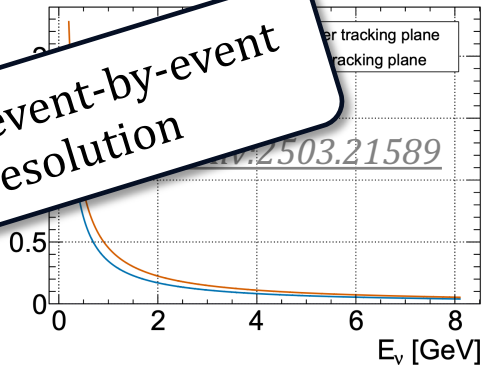
Phys. … *arXiv:2503.21589*

A firs… neutrino candidate observed by NA62

Neutrino energy event-by-event with <1% resolution



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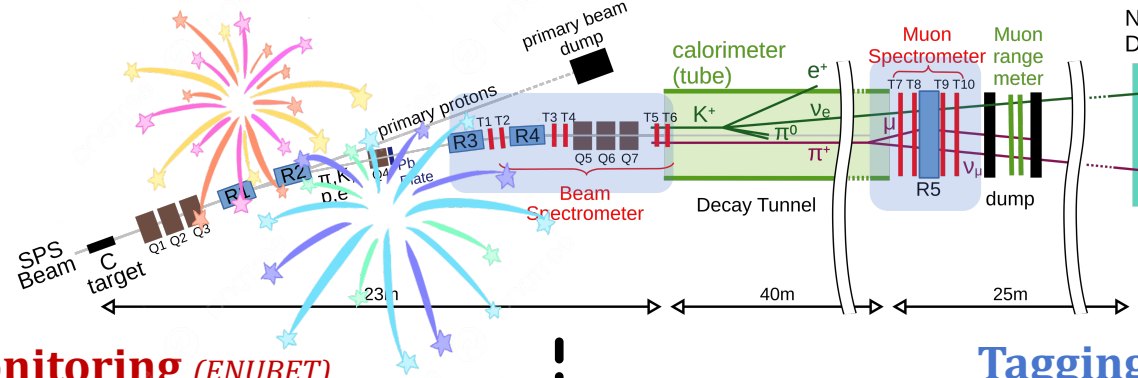

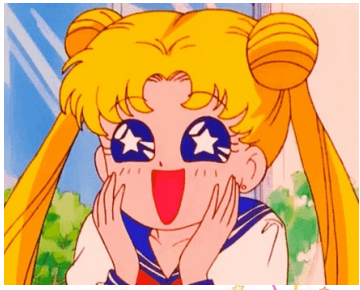

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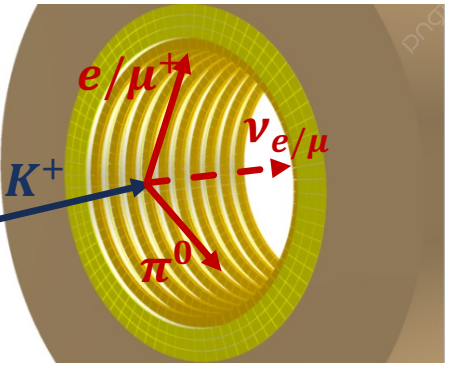

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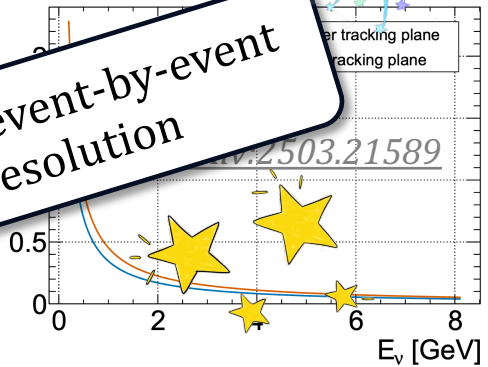

Fundamental issue: We do not know the neutrino energy or the neutrino flux

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~~**Fundamental issue**: We do not know the neutrino energy or the neutrino flux~~

What do we need to know about ν interactions?

(non-exhaustive list focused on LBL experiments)

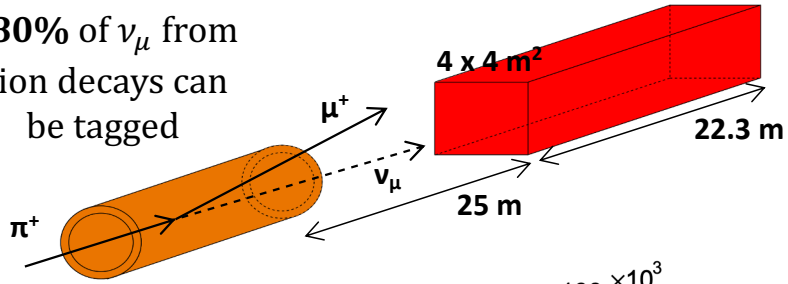
- **The energy dependence of the cross section**
  - So we can extrapolate constraints from the ND to the FD
- **The relationship between true and reconstructed E_ν**
  - So we can measure the osc. probability reliably
- **The contribution of neutral current (NC), wrong-sign or wrong-flavor νs**
  - So we can model backgrounds for oscillations
- **The difference between ν_e/ν_μ cross section**
  - So we can apply our ν_μ constraints to ν_e samples

How can nuSCOPE answer these?

Reference setup

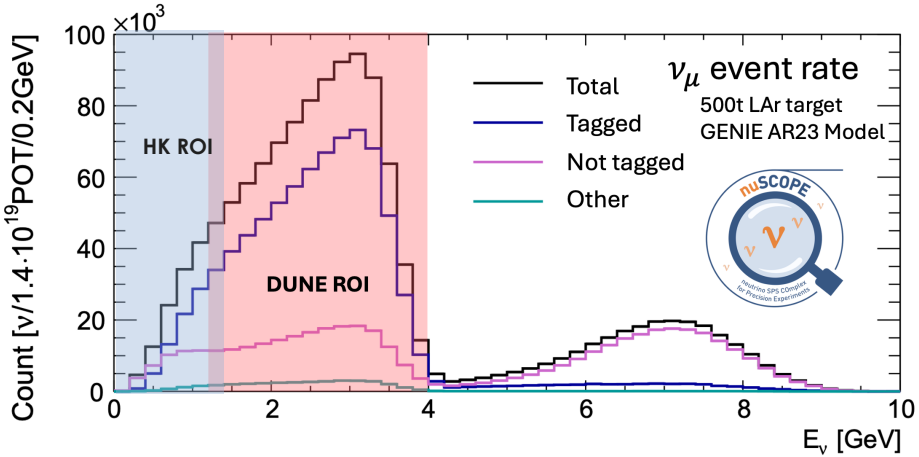
500t of LAr/100t of water

~80% of ν_μ from pion decays can be tagged



With 1.4×10^{19} POT in 5 years expect:

- **Monitored events**: 1M ν_μ CC
  12k ν_e CC /500t Ar
- **Tagged events**: ~760,000 tagged ν_μ CC/500t Ar
  ~140,000 tagged ν_μ CC/100t H_2O



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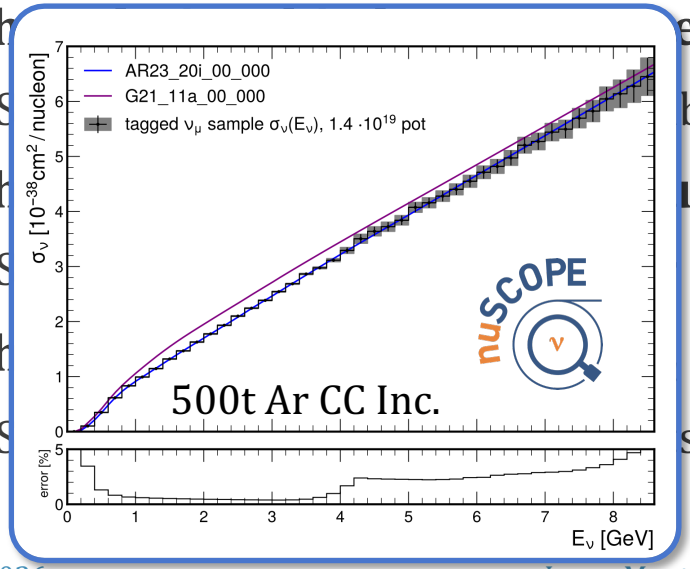
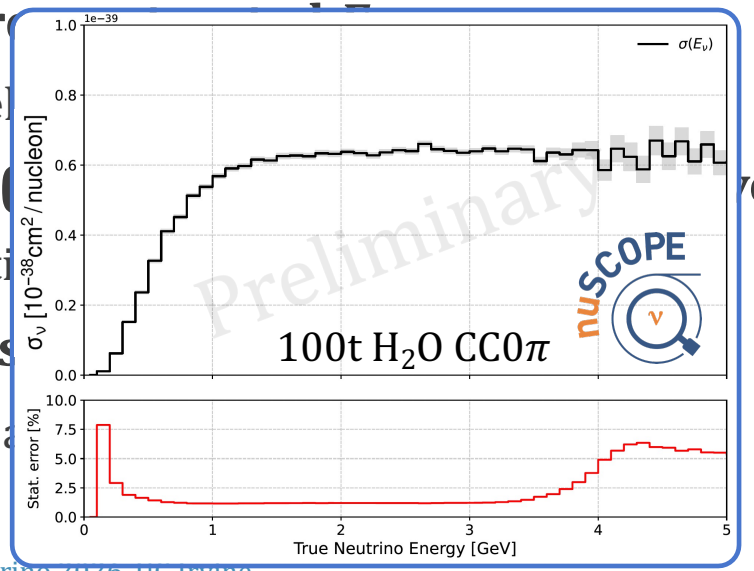
- **Th** … **cross s** …
  - S … s to ν_e s …





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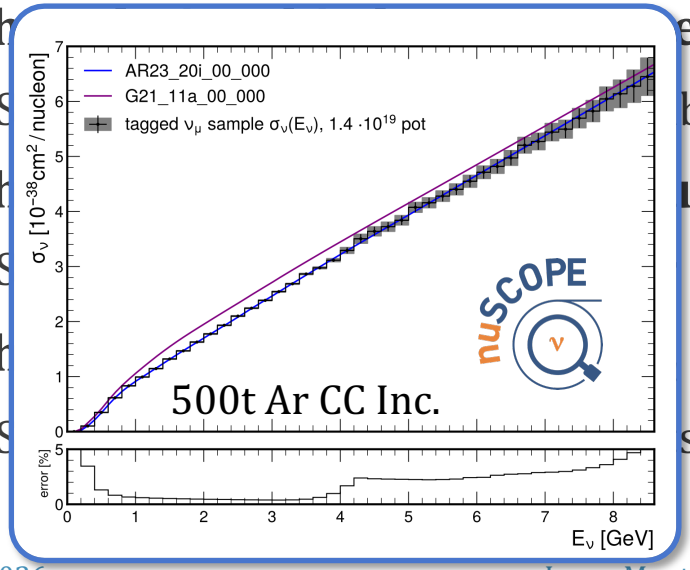

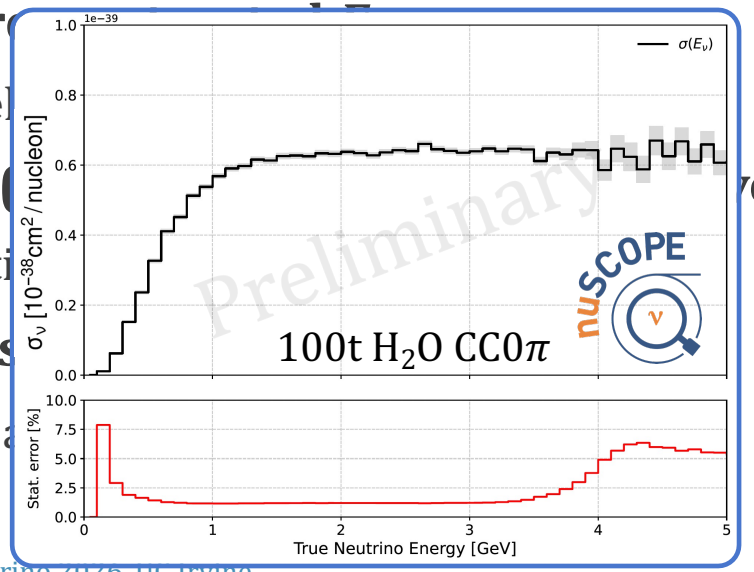

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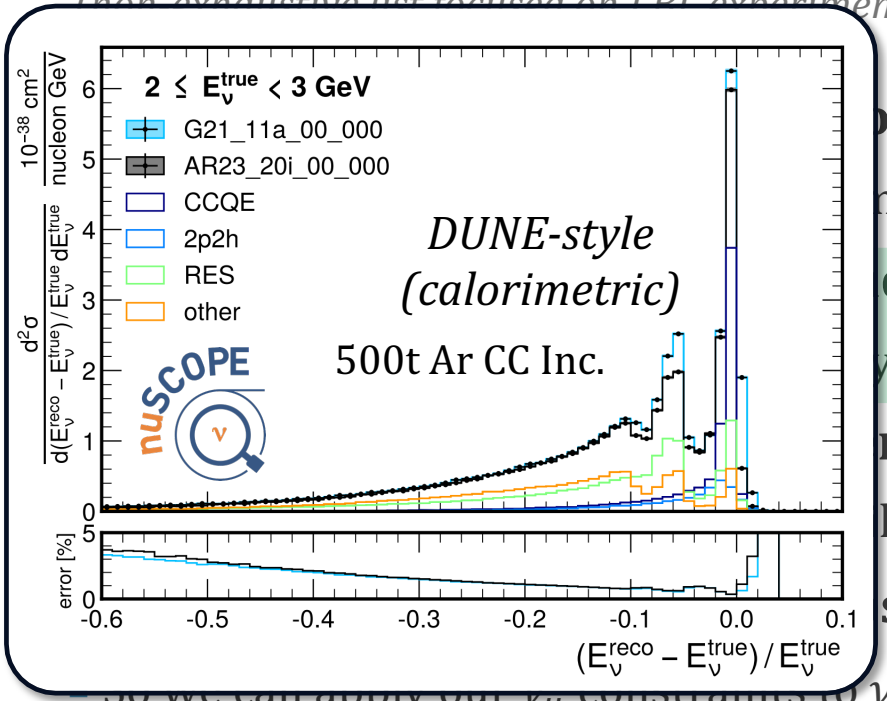

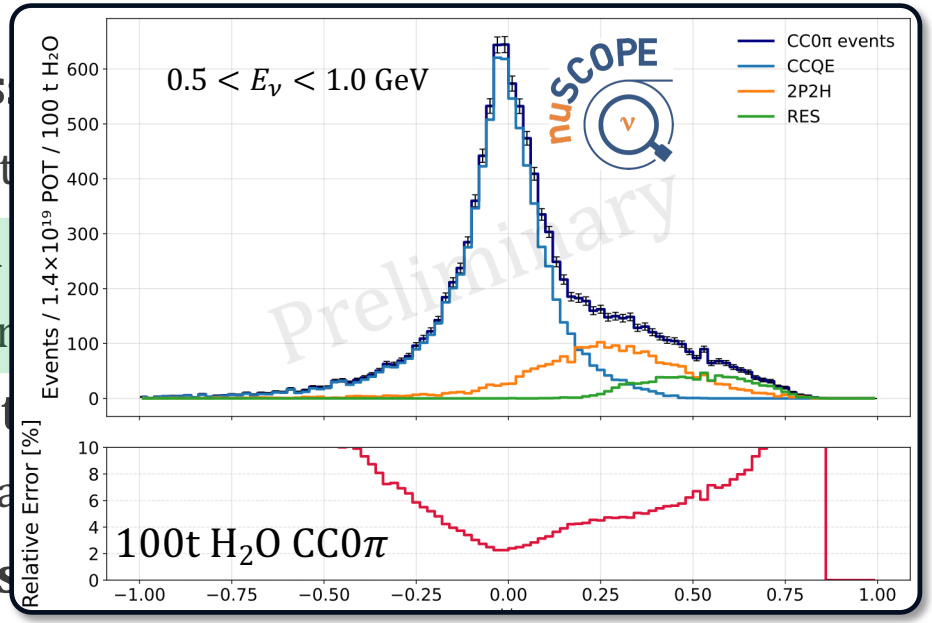

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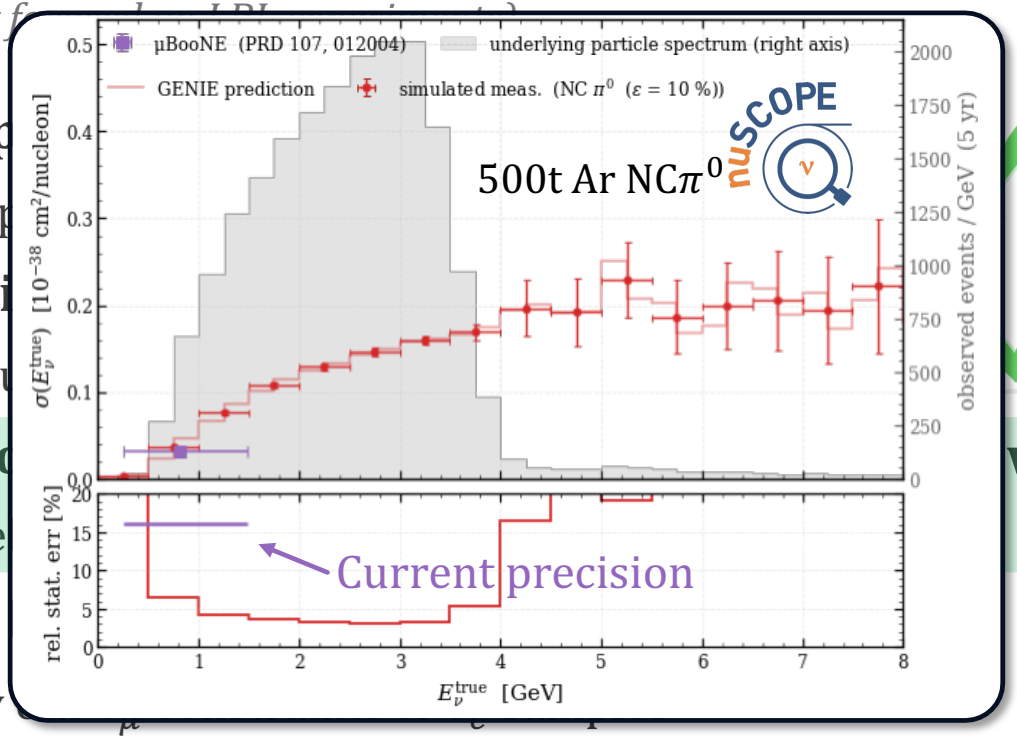

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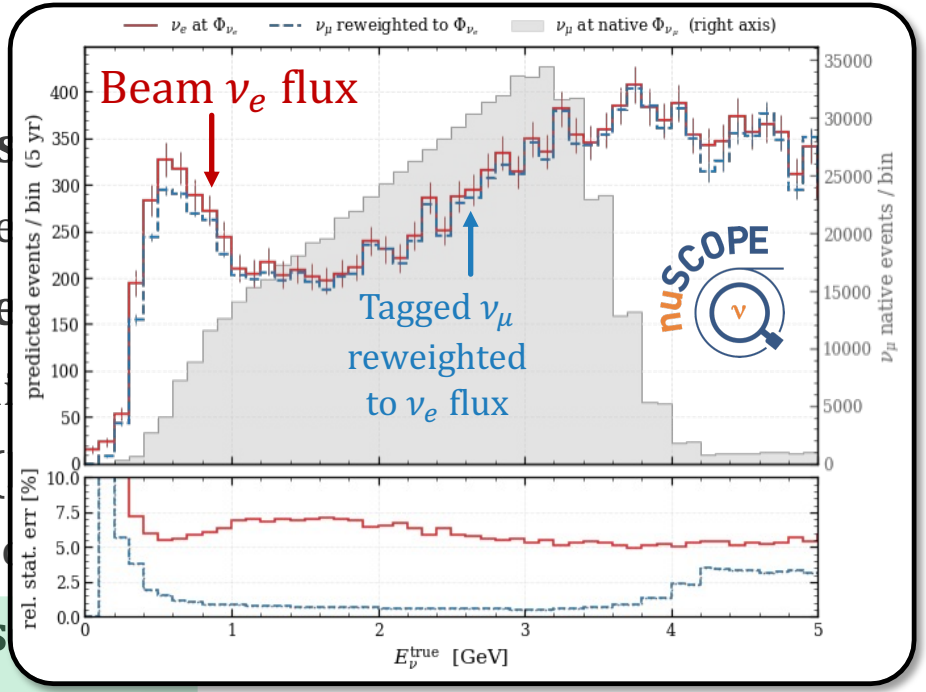

$$\frac{\sigma_{\nu_\mu}}{\sigma_{\nu_e}} = 0.971 \pm 0.0078 \quad (\mathbf{0.801}\ \%)$$

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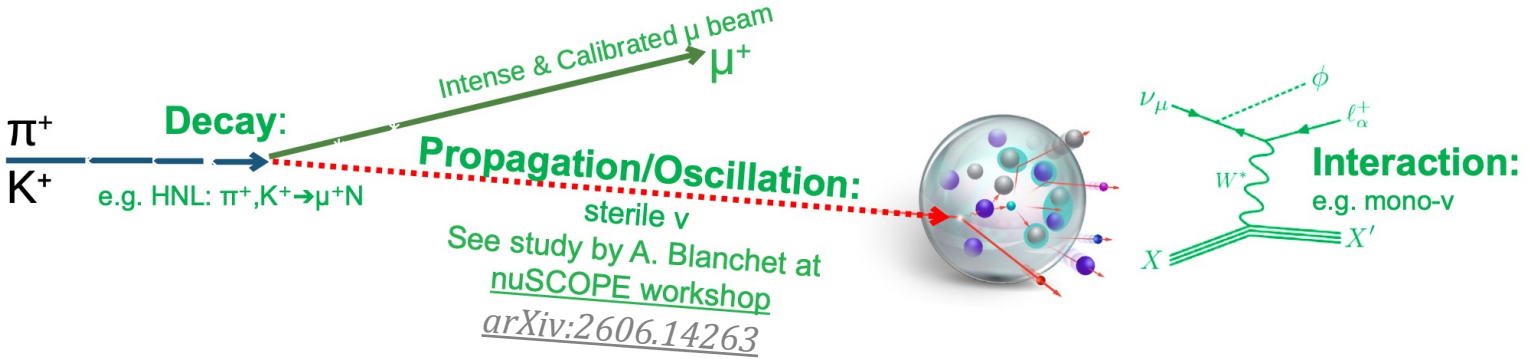
A very broad physics program

Neutrino Interactions

large ν interaction samples.
flux knowledge, energy resolution

Beyond Standard Model



Kaon Physics

ultra rare decay exploiting large stats

Nuclear Physics/QCD

repeat electron scattering exp. but with ν as probe
access axial structure...

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nuSCOPE
neutrino SPS COmplex for Precision Experiments
https://nuscope.web.cern.ch/

Recent feature article in CERN Courier

CERNCOURIER | Reporting on international high-energy physics

Summary

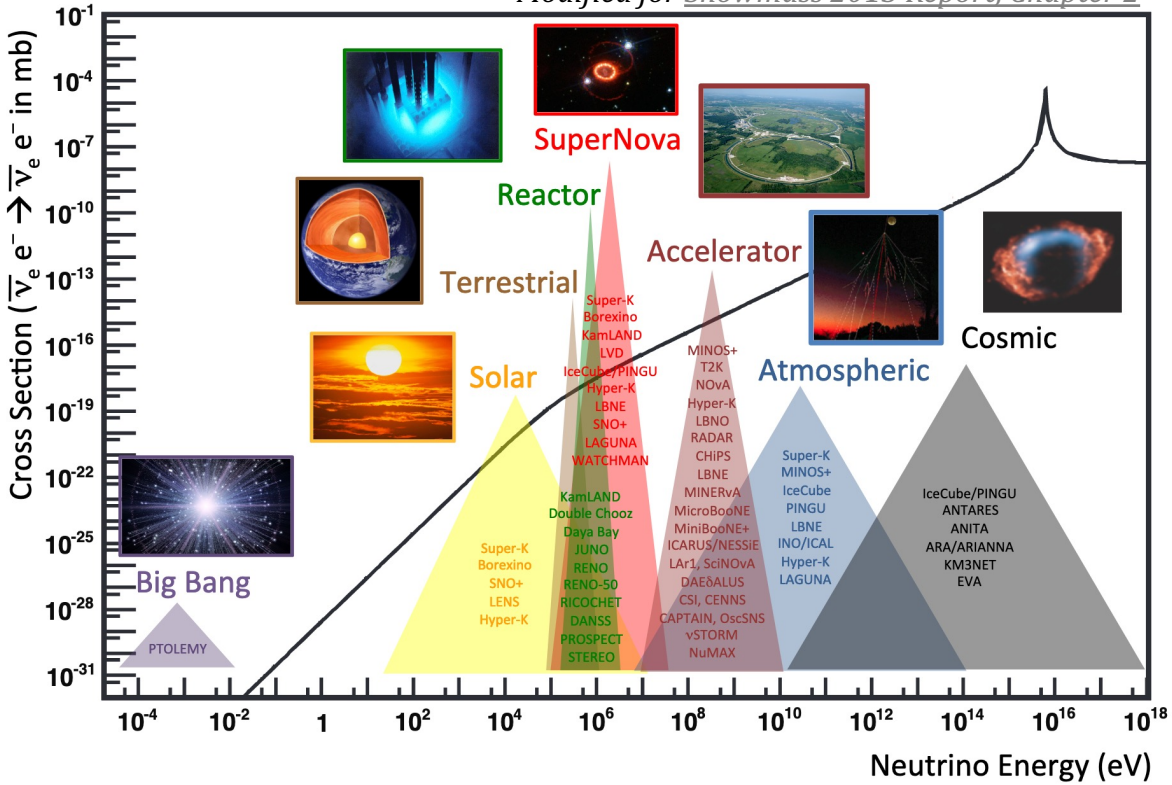
- Next-generation neutrino oscillation experiments require precise descriptions of neutrino-nucleus interactions
- Current model disagreement is large and no single model can describe all the measurements
- Next-generation experiments rely on a variety of approaches to reach required precision – requires a concerted effort from different communities
- nuSCOPE – a change of paradigm in neutrino beam creation may help bring neutrino-nucleus interactions into sharper focus

Thank you for your attention!

Supplementary material

What I will not talk about (but is still very important!!)

Modified for Snowmass 2013 Report, Chapter 2



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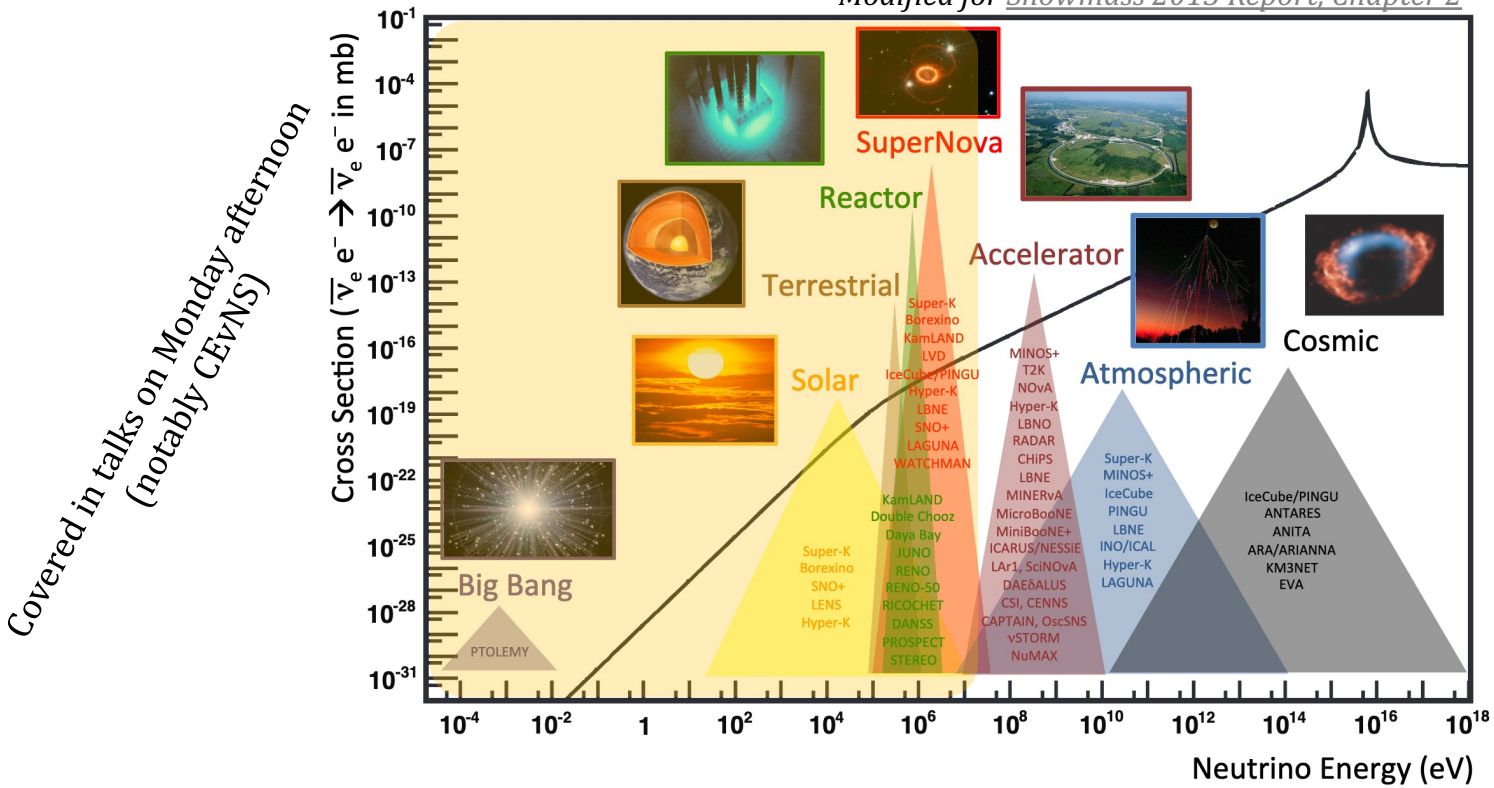

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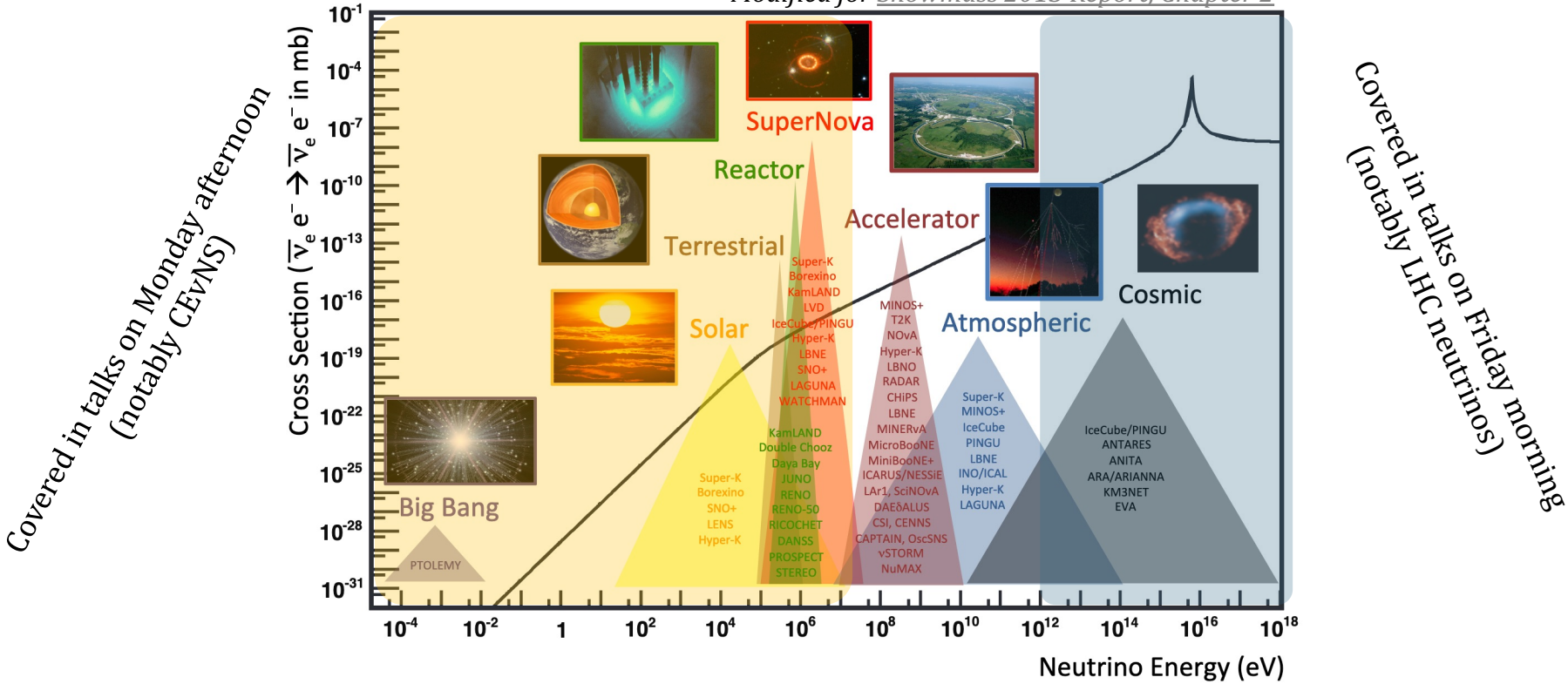
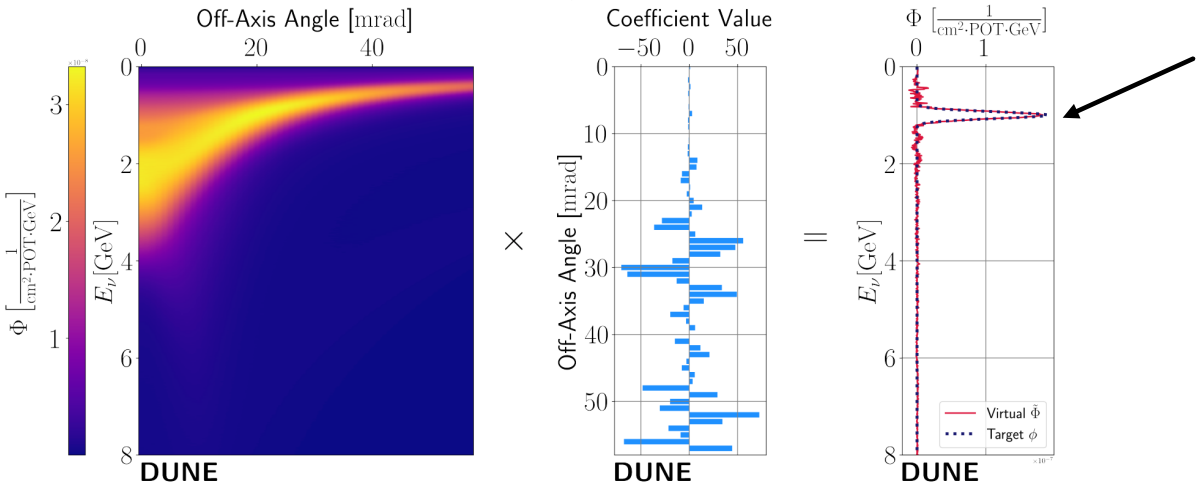


Interactions through the PRISM

arXiv:2509.07664

$$\mathbf{\Phi}\vec{c} \approx \vec{\phi}$$



Monoenergetic virtual neutrino flux

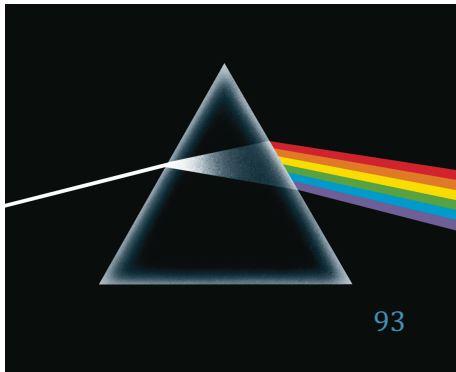
Off-axis fluxes can be combined to produce arbitrary shapes:

$$\mathbf{\Phi}\vec{c} \approx \vec{\phi}$$

Real fluxes

Coefficients

Virtual flux



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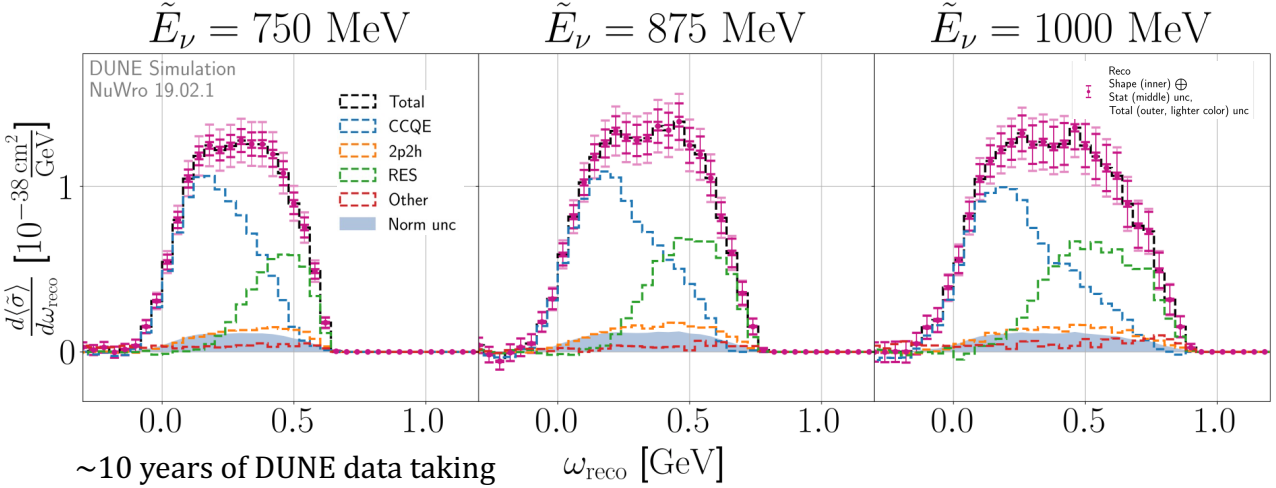
With ~2.5 years of DUNE ND data
σ_{tot}^{CC} **known at ~10%**

But becomes **statistically limited** for differential measurements



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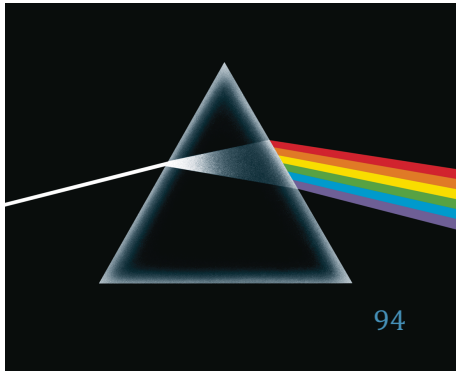
Real fluxes — Coefficients — Virtual flux



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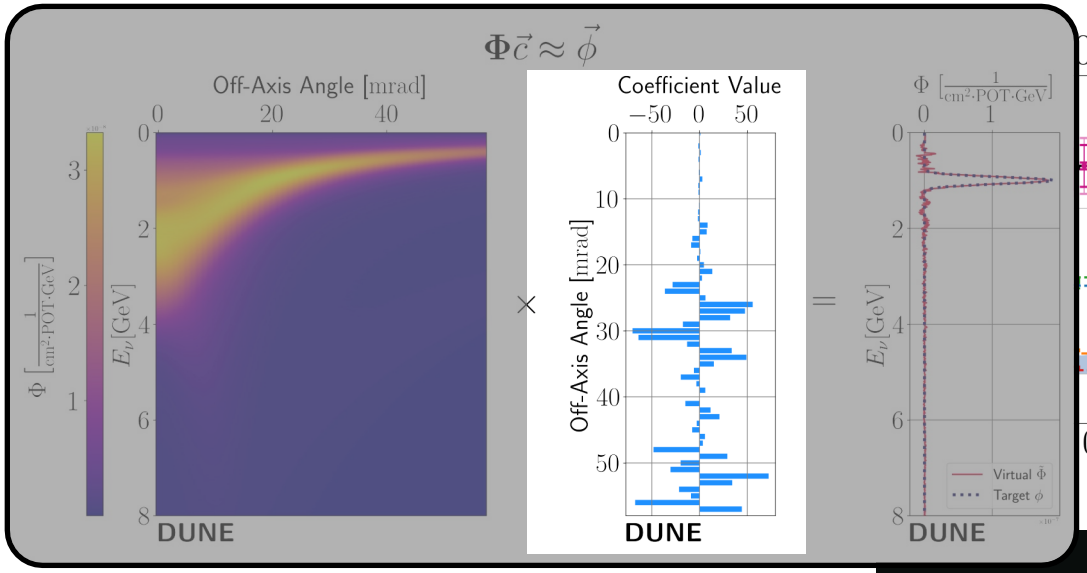
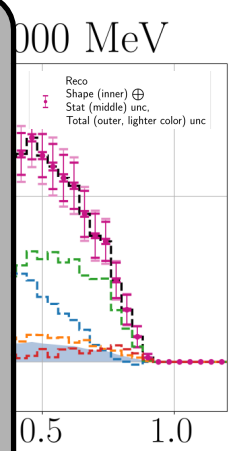




Off-axis fluxes can be combined to produce arbitrary shapes:

$$\Phi\vec{c} \approx \vec{\phi}$$

Real fluxes — Coefficients — Virtual flux

What do we (not) know about neutrino interactions?

Unknown unknowns

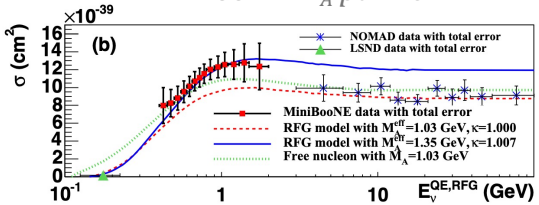
Known unknowns
(non-exhaustive)

Hadron transport inside the nucleus
$\nu/\bar{\nu}$ differences
Impact of nuclear potential
C/O/Ar/Fe/etc. differences
Relative contributions of different channels
Hadronization
…
…
…

What do we (not) know about neutrino interactions?

Unknown unknowns

MiniBooNE M_A puzzle



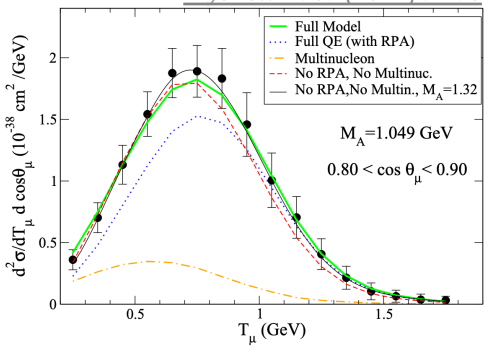
Phys.Rev.D 81 (2010) 092005

Multinucleon interactions (2p2h)

+

nuclear screening (RPA)

Phys.Lett.B 707 (2012) 72-75



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Relative contributions of different channels

Hadronization

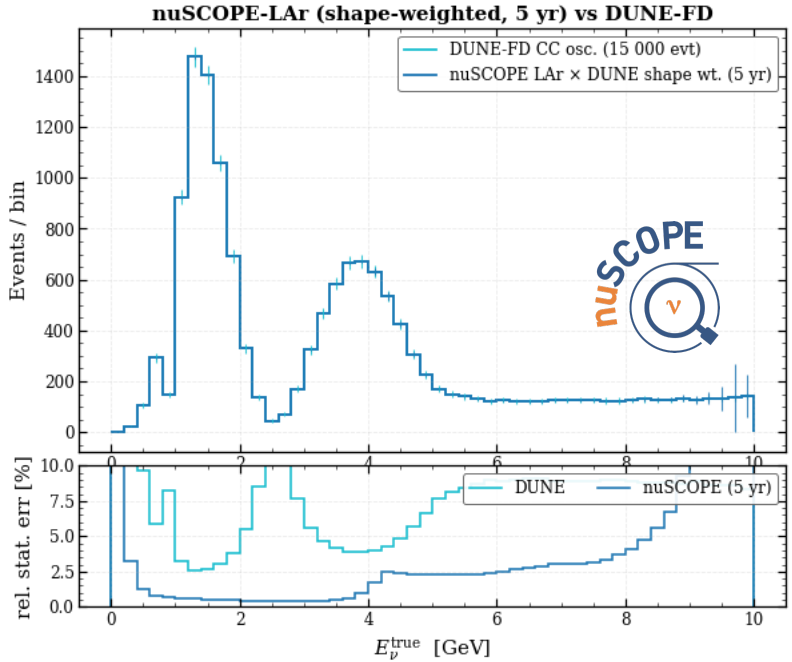
…

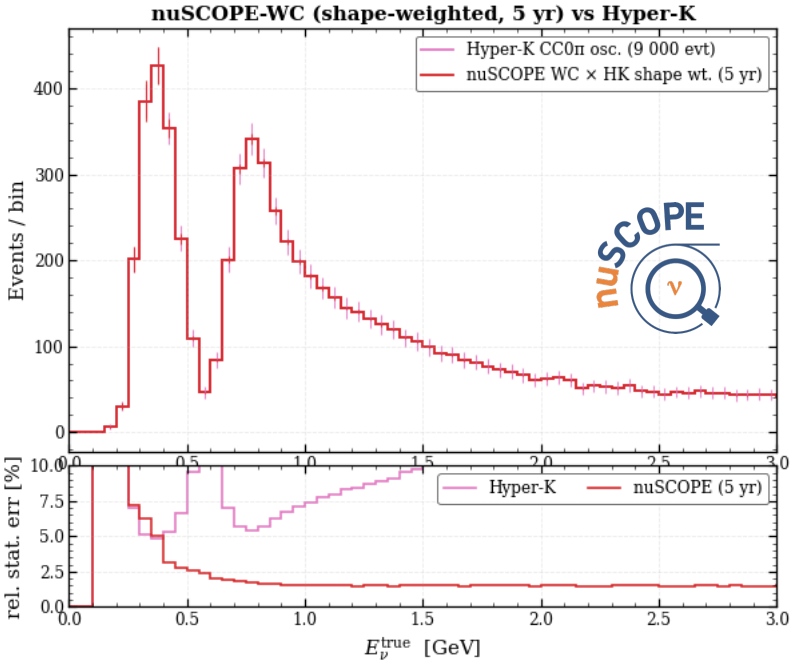
…

…

Previous unknown unknowns become known unknowns!

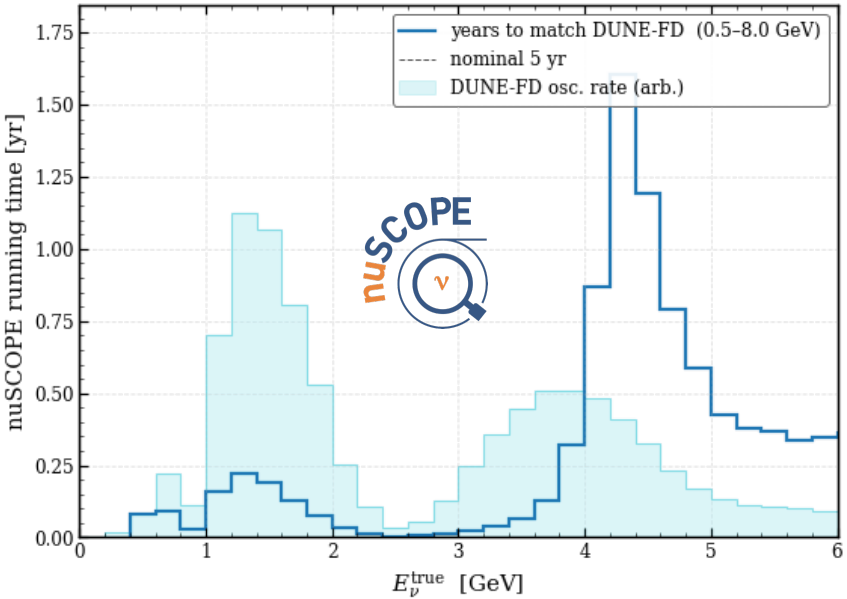
When can nuSCOPE make these constraints?



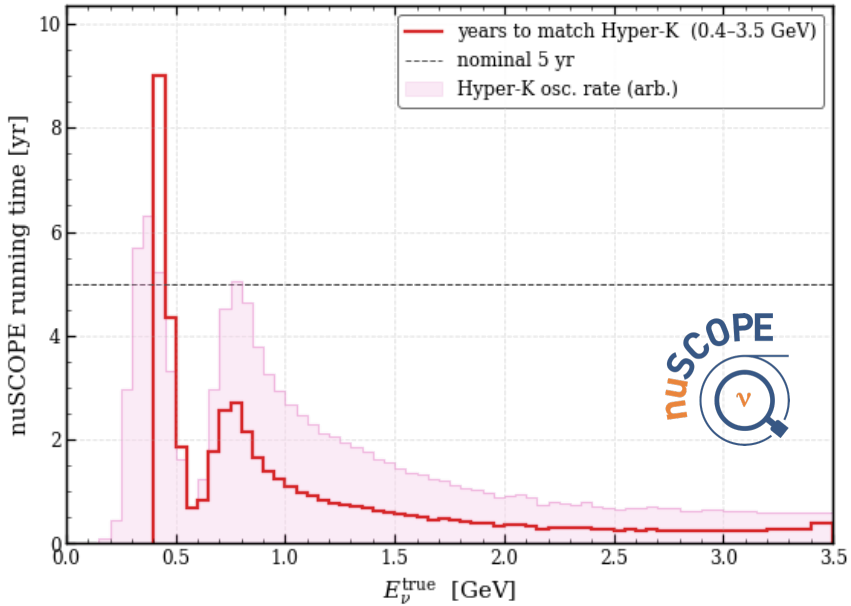


Statistical power of nuSCOPE 5 years (1.4×10^{19} POT) data taking reweighted to DUNE and Hyper-K predicted oscillated event rates after ~10 years

When can nuSCOPE make these constraints?



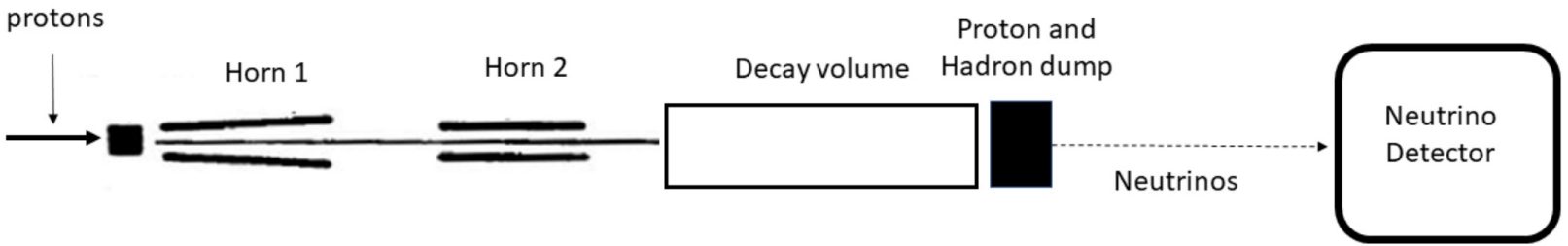
Can provide informative constraints in the region of the oscillation maxima of DUNE **almost immediately** once operation starts



Can provide informative constraints in the region of the oscillation maximum of Hyper-K **within ~1 year** once operation starts

Rethinking how to make a neutrino beam

Conventional neutrino beams



Appl. Sci. **2021**, *11*(4), 1644

Rethinking how to make a neutrino beam

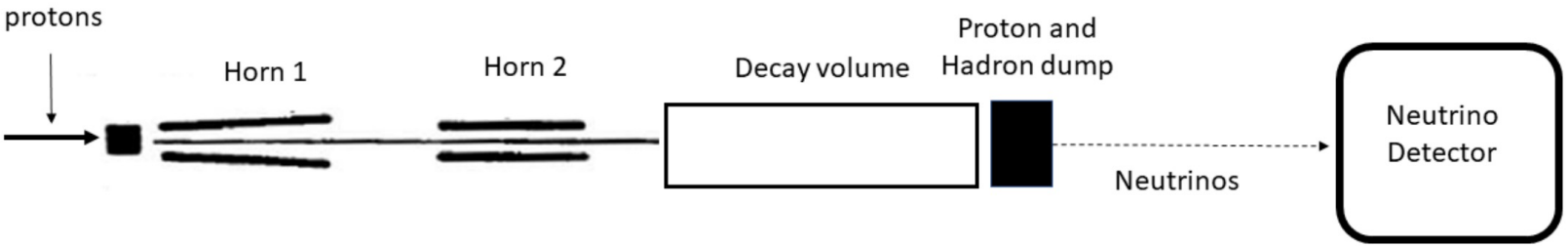
Conventional neutrino beams

"Employ the most intense proton accelerator at your disposal"

"Focus as many pions/kaons as possible"

Pros: Large yield of pions per proton-on-target (pot)

Drawbacks: Lack of control on neutrino energy



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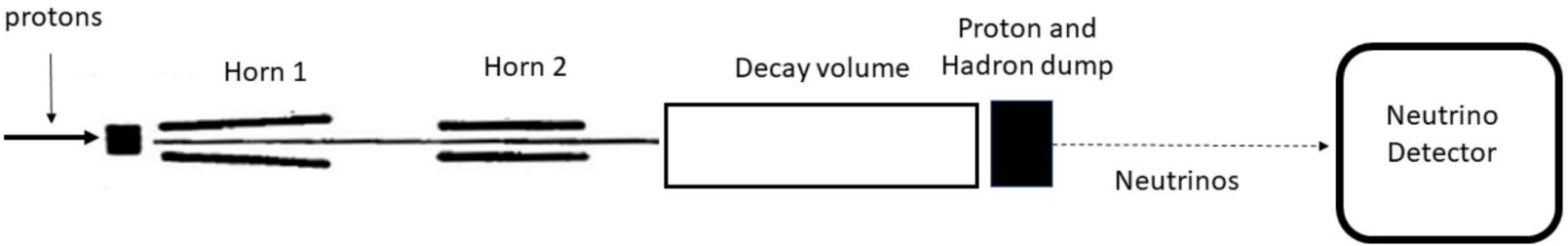
Rethinking how to make a neutrino beam

Conventional neutrino beams

"Employ the most intense proton accelerator at your disposal"	"Focus as many pions/kaons as possible"	"Eliminate any material along the beamline in the decay tunnel"
Pros:	Large yield of pions per proton-on-target (pot)	Large number of neutrinos from pion decay
Drawbacks:	Lack of control on neutrino energy	Coarse beam diagnostics

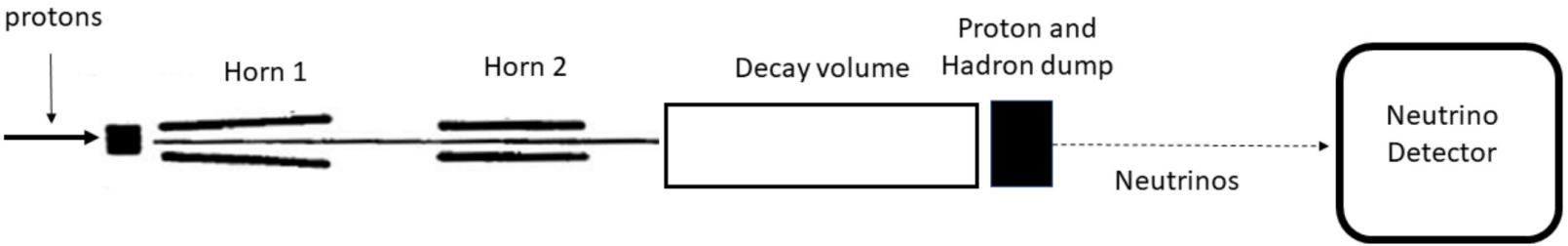


Appl. Sci. **2021**, *11*(4), 1644

Rethinking how to make a neutrino beam

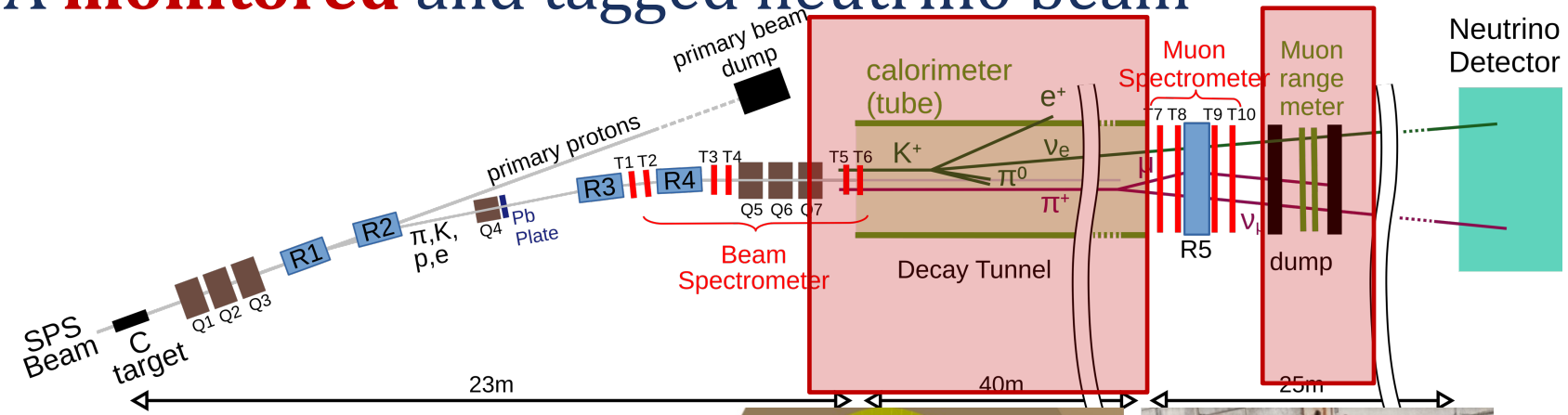
Conventional neutrino beams

"Employ the most intense proton accelerator at your disposal"	"Focus as many pions/kaons as possible"	"Eliminate any material along the beamline in the decay tunnel"	"Build the largest possible neutrino detector"
Pros:	Large yield of pions per proton-on-target (pot)	Large number of neutrinos from pion decay	Large statistics of neutrino interaction events (CC and NC)
Drawbacks:	Lack of control on neutrino energy	Coarse beam diagnostics	Limited precision in the final state reconstruction

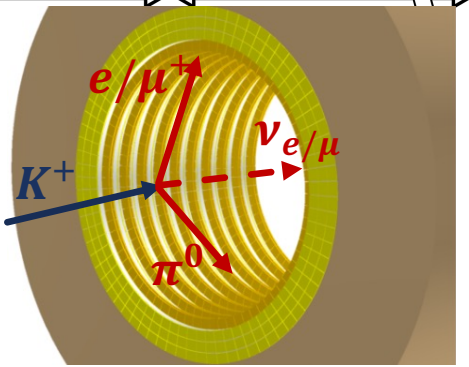


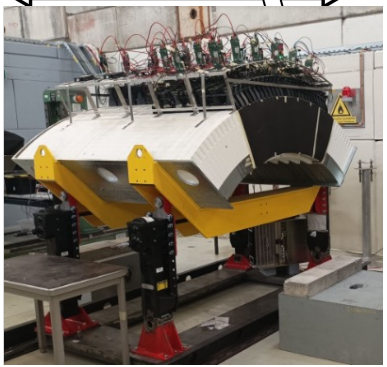
Appl. Sci. **2021**, *11*(4), 1644

A **monitored** and tagged neutrino beam



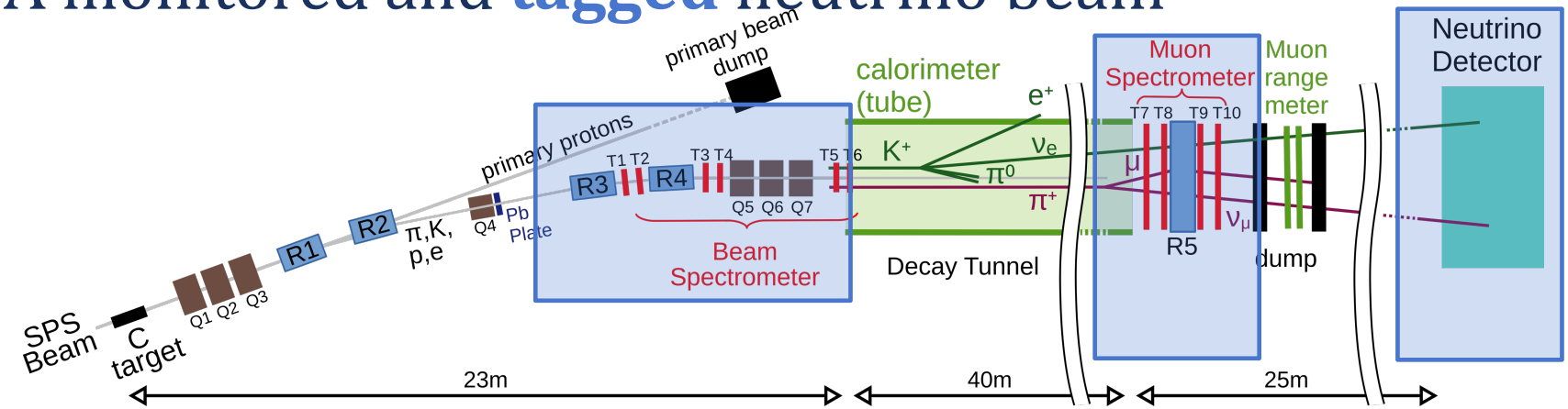
- Instrumented calorimeter decay tunnel & hadron dump
- Identifies the decay products of mesons producing neutrinos



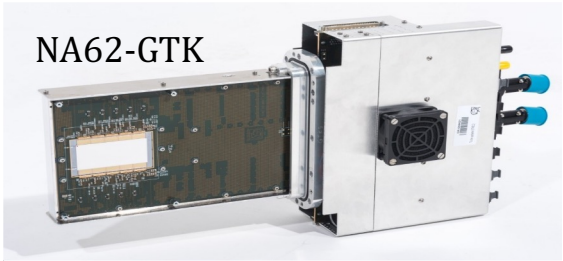


Performance of a section of the decay tunnel tested at CERN T9 Test Beam facility under NP06/ENUBET Eur. Phys. J. C **83**, 964 (2023)

A monitored and **tagged** neutrino beam



- State-of-the-art **silicon detectors** to track incoming mesons and outgoing muons
- **Unique association** between each neutrino interacting in the detector with its parents



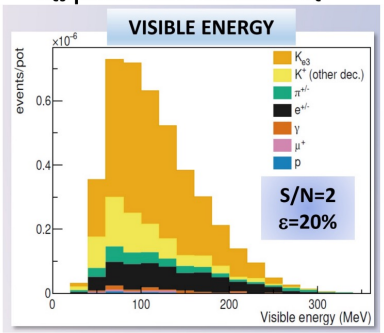
Phys.Lett.B 863 (2025) 139345

A first tagged neutrino candidate observed by NA62

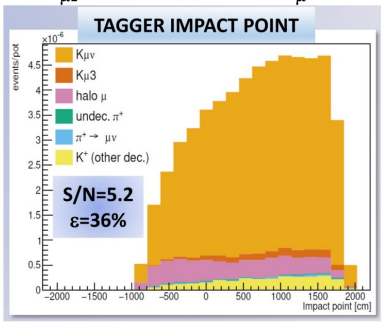
What does nuSCOPE bring to the table?

Monitored beam: ~1% flux uncertainties

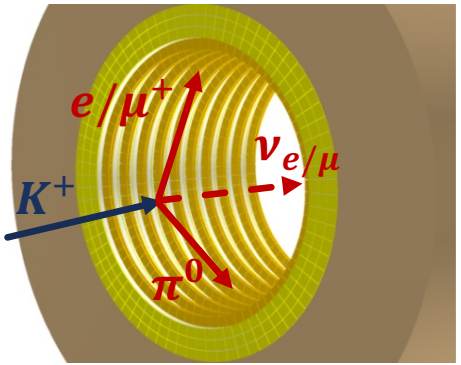
K_{e3} positrons: constrain ν_e

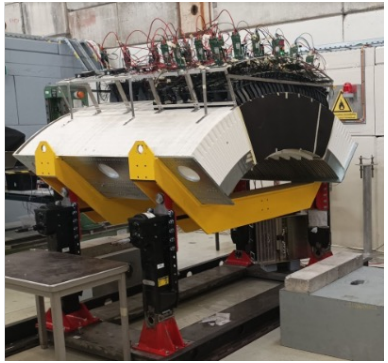


$K_{\mu 2}$ muons: constrain ν_μ



Lepton distributions from calorimeter and tagger
(see slides from A. Longhin)





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Eur. Phys. J. C **83**, 964 (2023)

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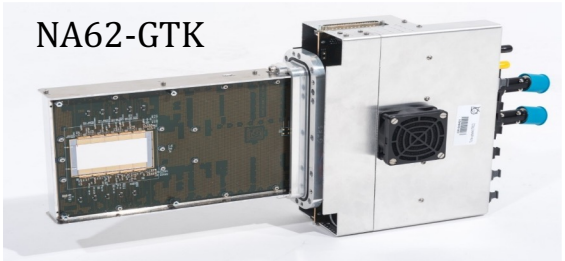
Neutrino tagging: measure neutrino energy event-by-event



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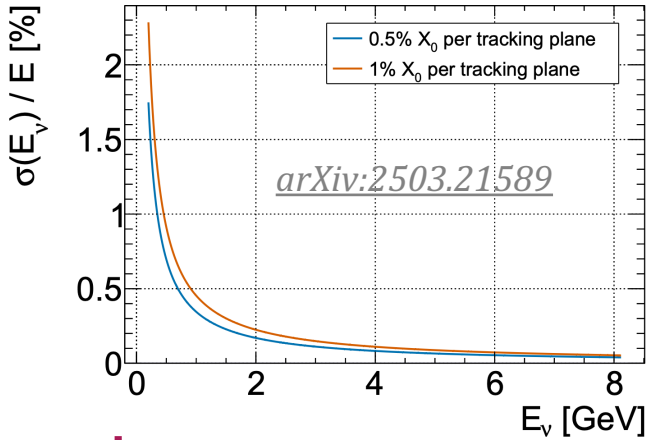

It is possible to measure neutrino energy event-by-event with <1% resolution

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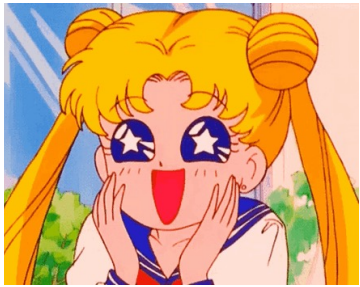

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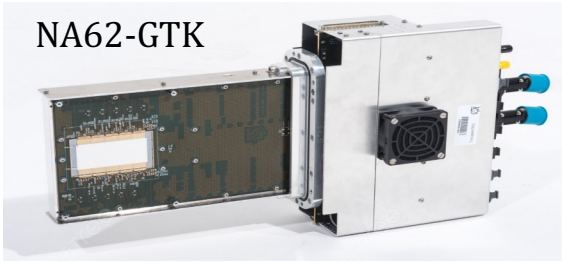
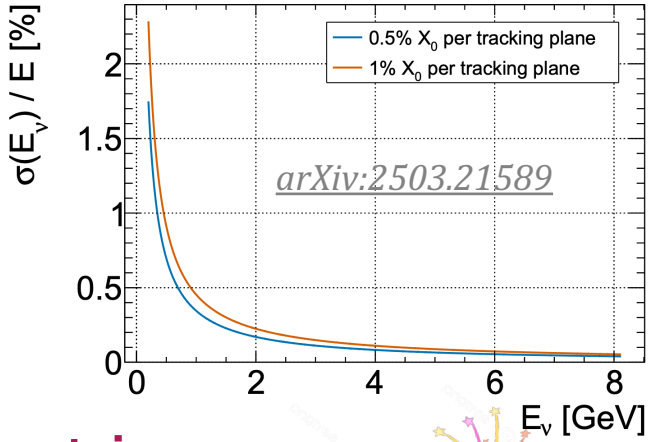


Phys.Lett.B 863 (2025) 139345



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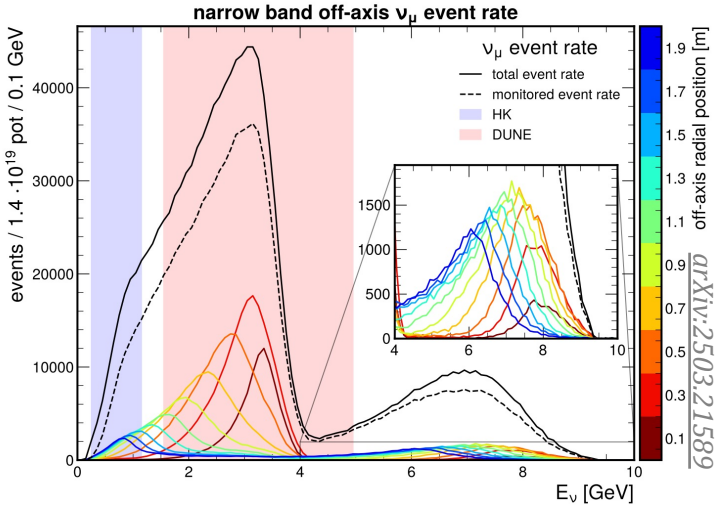
What does nuSCOPE bring to the table?

Monitored beam: ~1% flux uncertainties

Neutrino tagging: measure neutrino energy event-by-event

Wide range of energies: covers both DUNE and HK regions of interest



What does nuSCOPE bring to the table?

Monitored beam: ~1% flux uncertainties

Neutrino tagging: measure neutrino energy event-by-event

Wide range of energies: covers both DUNE and HK regions of interest

This relies on:

- Slow extraction beam, low intensity (10^{13}protons/9.6s spill)
- Large detectors – $O(1kt)$ – close to decay tunnel
- Excellent beamline ($O(10-100)$ps) and detector ($O(1)$ns) timing resolution

Examples of measurements nuSCOPE can make

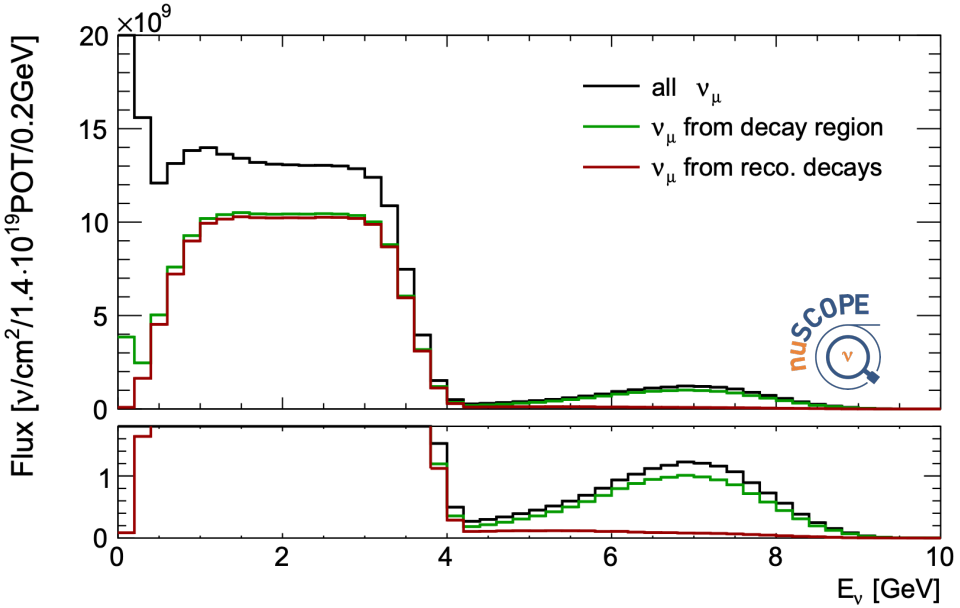
See arXiv:2503.21589 for more details

Studies done assuming 1.4×10^{19} *POT*

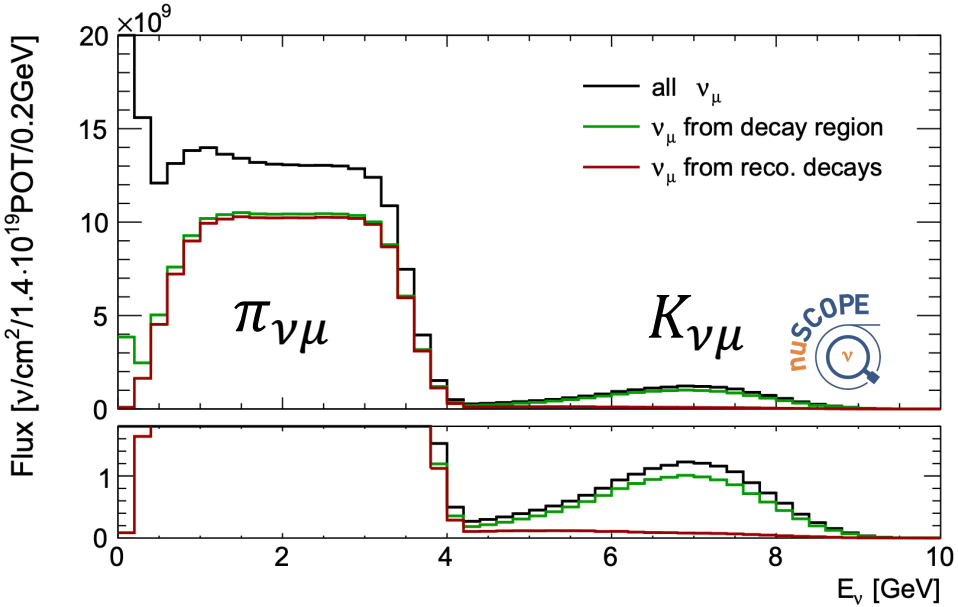
(5 years of running, POT to ensure compatibility with fixed target experiments e.g. SHiP)

Sensitivity studies led by **Filippo Bramati** (LAr), **Mara Pripon** (water)

Neutrino flux

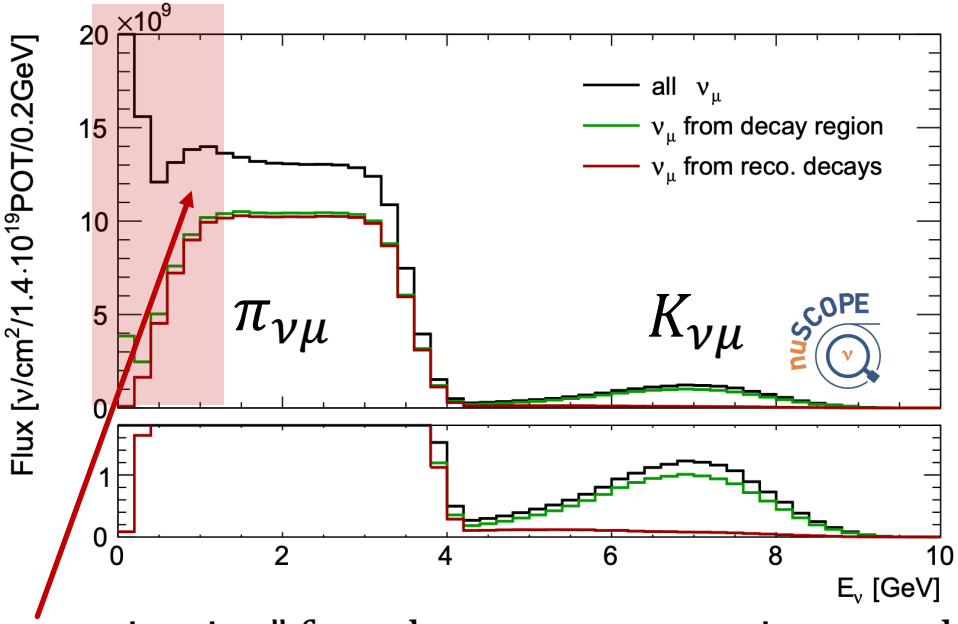


Neutrino flux



Kinematics of π and K decays with ~monoenergetic beam allow for a clear separation of the two contributions

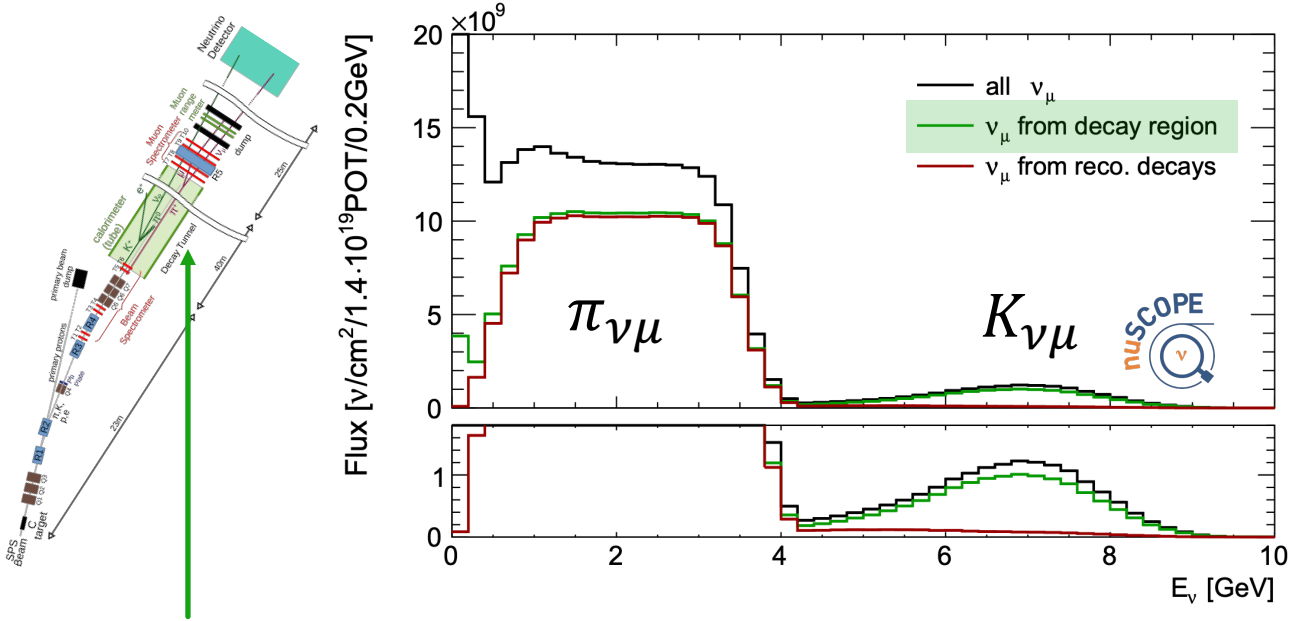
Neutrino flux



"Contamination" from low energy neutrinos produced from target region and proton dump

In practice it is heavily suppressed by the low cross-section

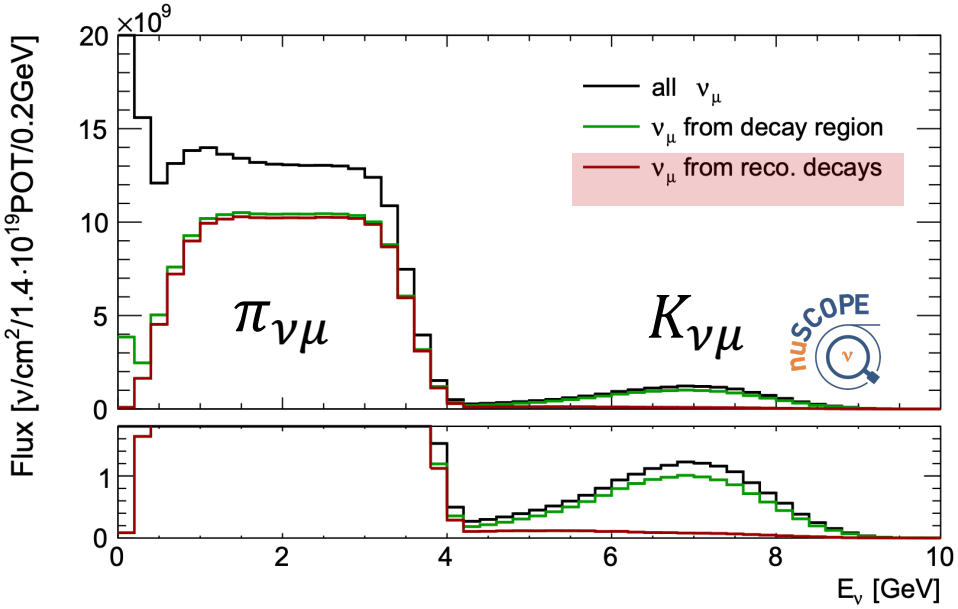
Neutrino flux

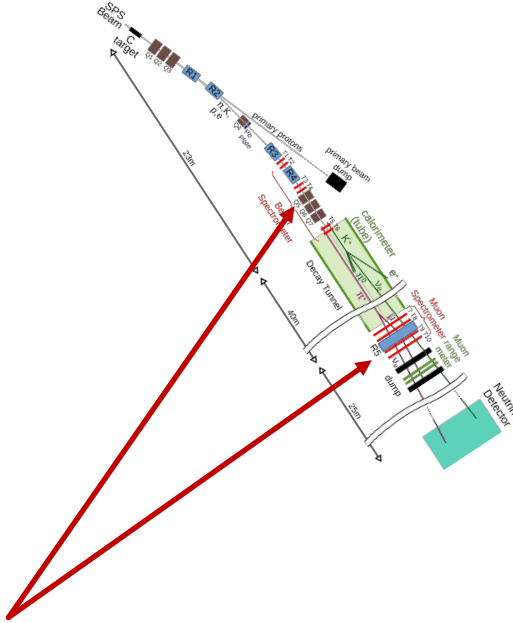


Monitored neutrinos (inside decay tunnel)

<1% flux uncertainties

Neutrino flux

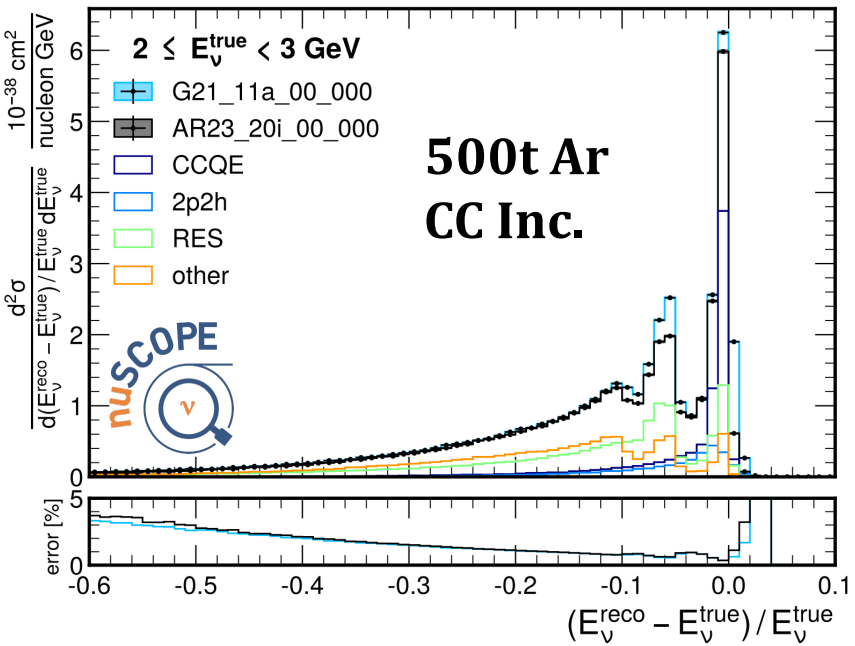




Monitored neutrinos (inside decay tunnel)
<1% flux uncertainties

Tagged neutrinos (inside decay tunnel)
<1% resolution on neutrino energy event-by-event

Calibration of detector energy response



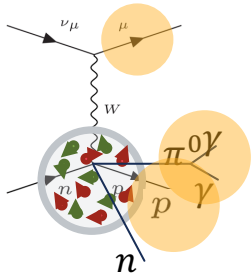
Can measure the **difference between true and reconstructed neutrino energy**

$$E_\nu^{\text{reco}} = E_\mu + \sum_{i=\pi^\pm,p} T_i + \sum_{i=\pi^0,\gamma} E_i$$

"visible" energy using calorimetric method (like DUNE, NOvA, MINERvA)

Measures the amount of invisble energy carried away by neutrons and neutrinos

Calibrate out nuclear effects



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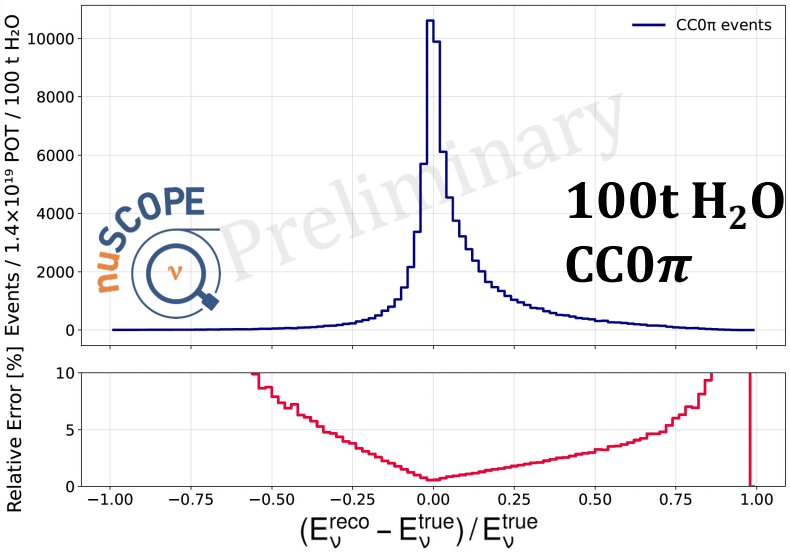


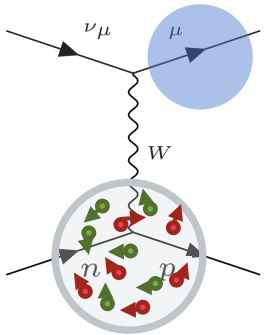
Can measure the **difference between true and reconstructed neutrino energy**

$$E_\nu^{QE} = \frac{1}{2}\frac{m_\ell^2 + (m_N^{eff})^2 - m_{N'}^2 - 2E_\mu m_N^{eff}}{E_\ell - |\vec{p_\ell}|\cos\theta_\ell - m_N^{eff}},$$

$$m_N^{eff} = m_N - E_b,$$

"QE" energy using kinematic reconstruction (T2K/SK/HK)

Measures the neutrino energy bias due to Fermi motion, npnh, FSI…



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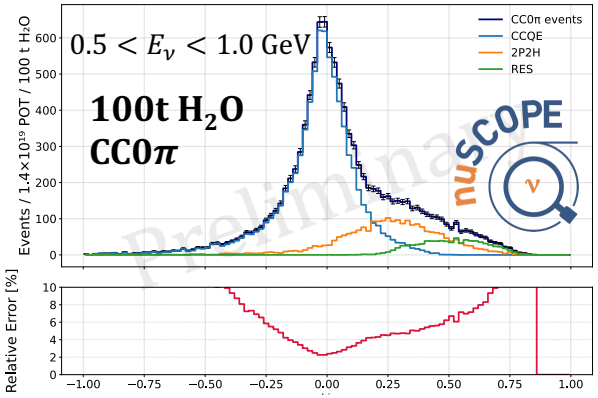

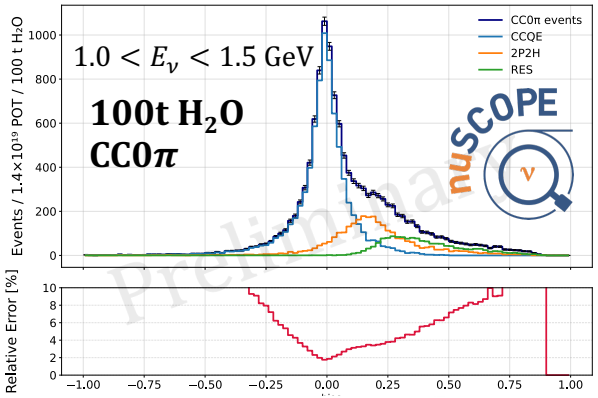

$(E_\nu^{true} - E_\nu^{reco})/E_\nu^{true}$

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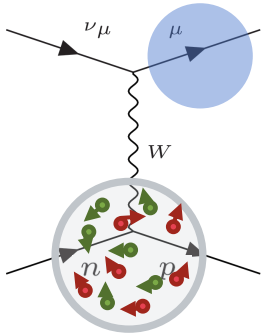
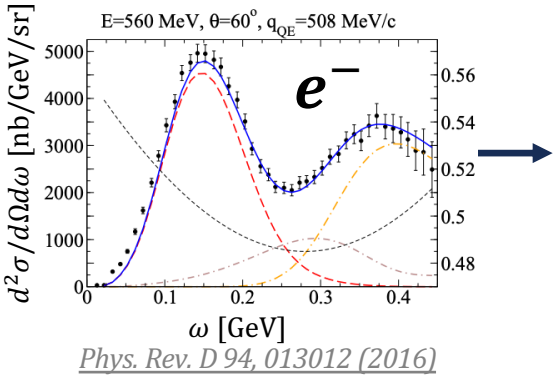
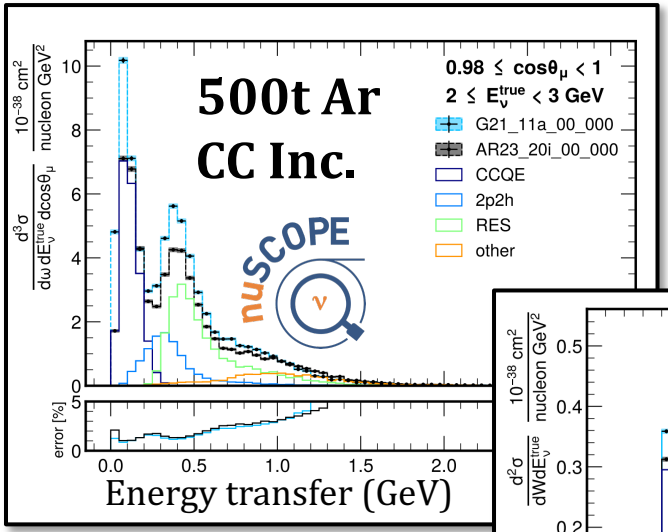


Calibrate out nuclear effects

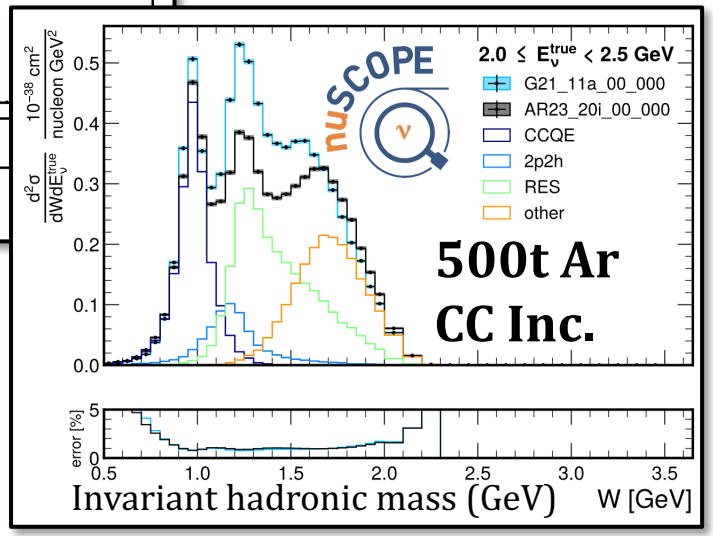
Electron scattering-like measurements with neutrinos



Phys. Rev. D 94, 013012 (2016)

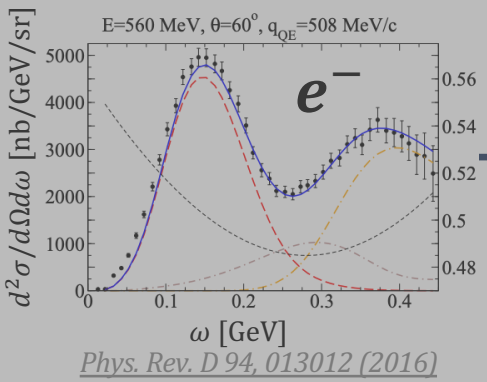


Now possible with **neutrinos!**



Gives access to fundamental nuclear physics processes

Electron scattering-like measurements with neutrinos



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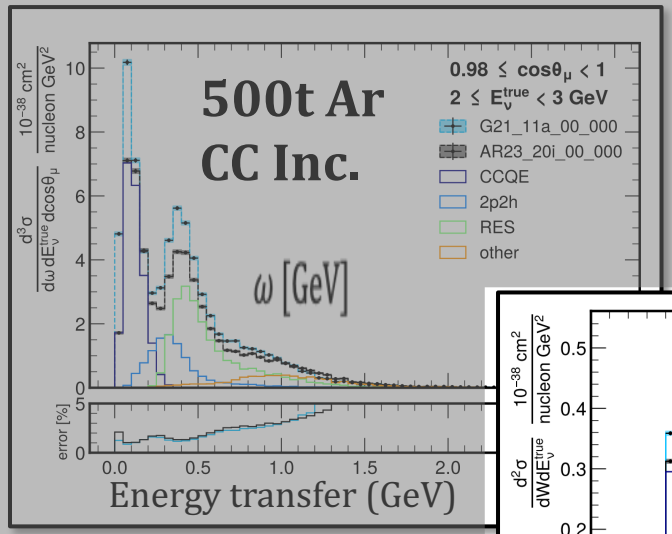

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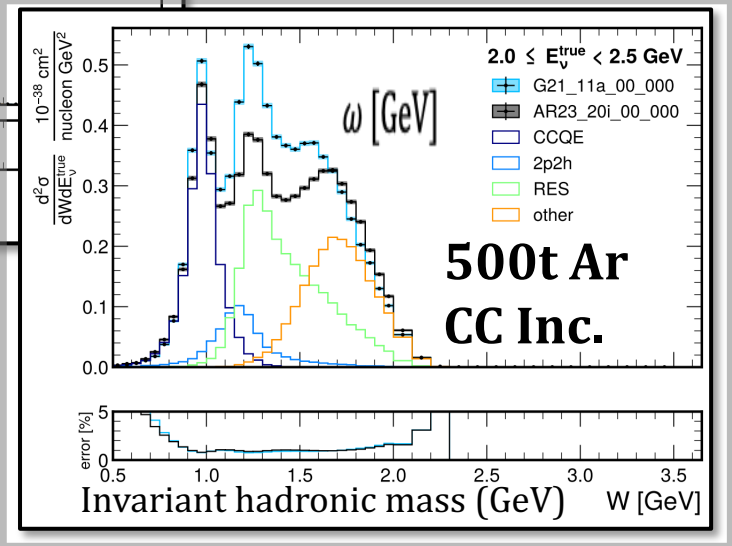

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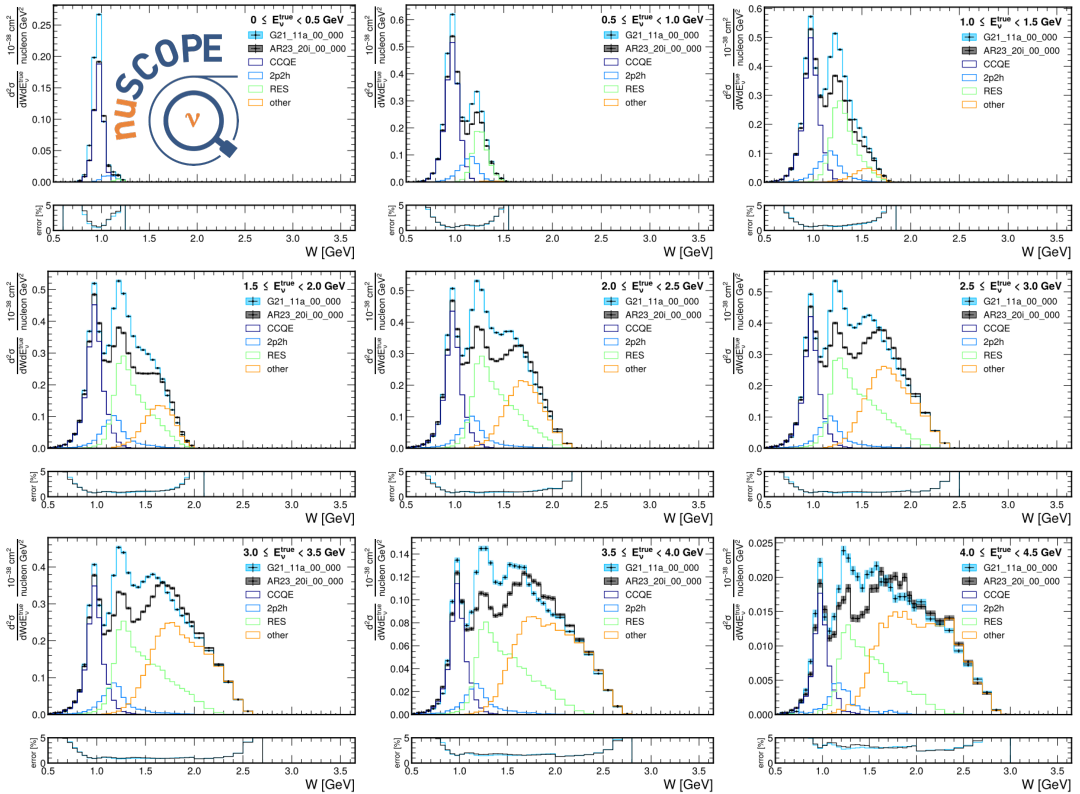
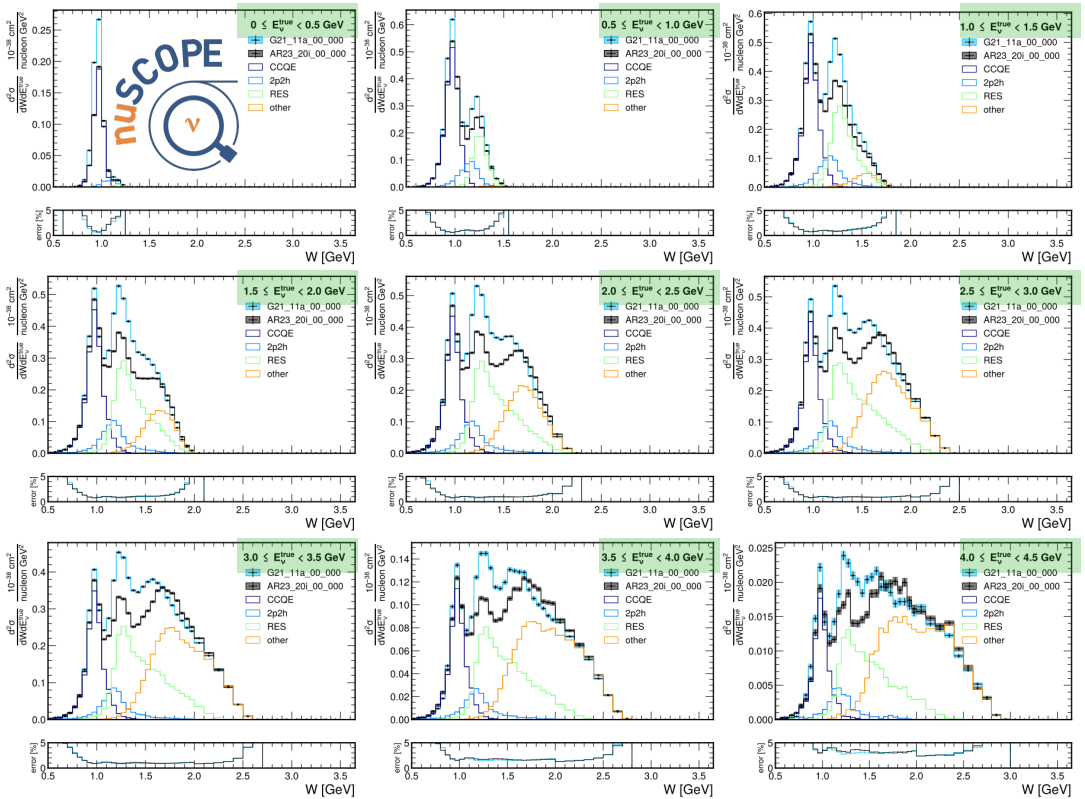


Electron scattering-like measurements with neutrinos

High statistics for **multi-differential measurements** (here as a function of E_ν)



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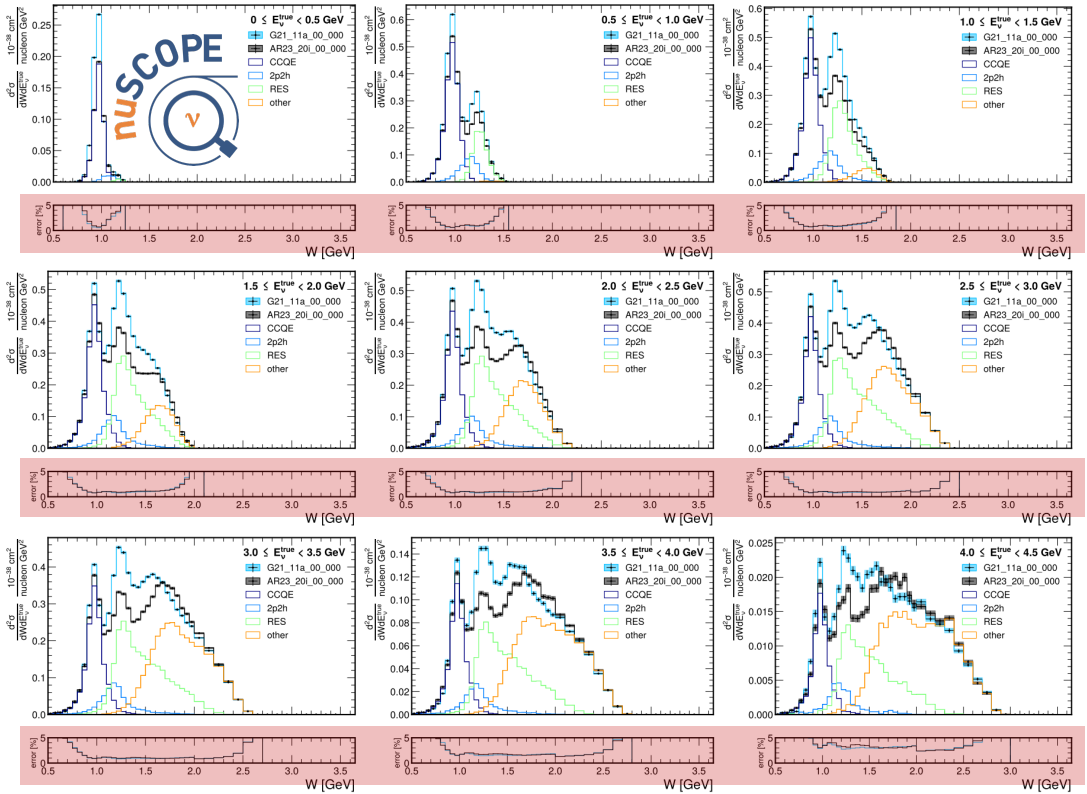
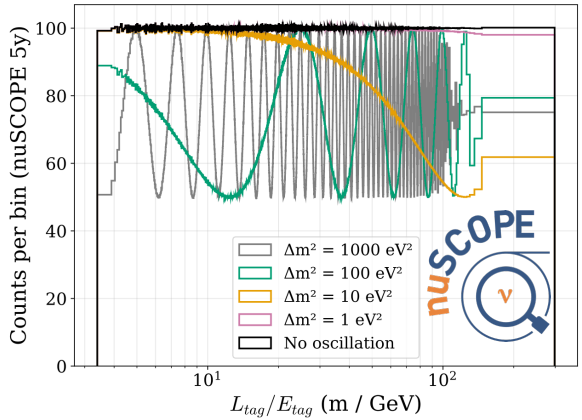


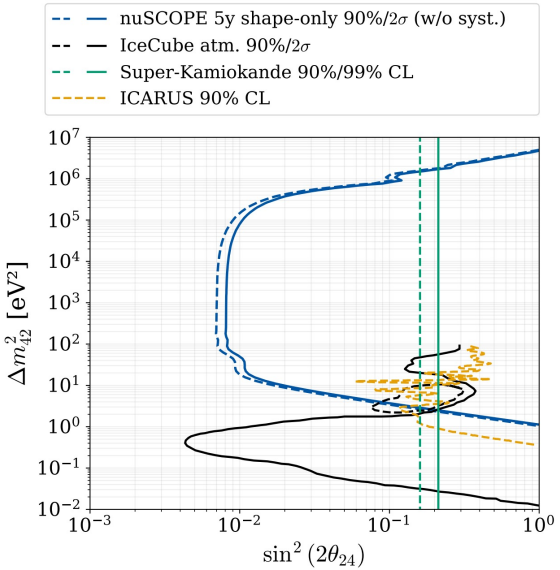
(<)1% level statistical uncertainties

Beyond cross-section measurements

Short-baseline oscillations

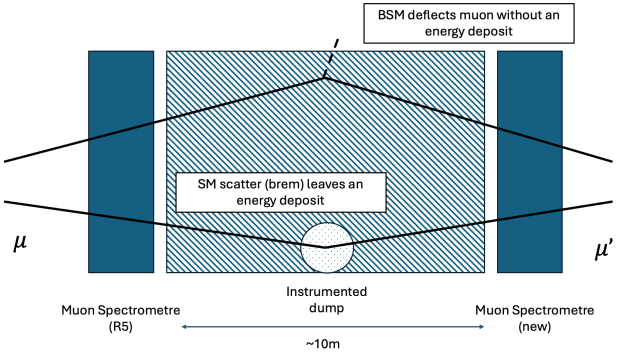
- ✓ **Neutrino energy** known with **<1%** uncertainty event-by-event
- ✓ **Precise** neutrino detector (~mm) to determine L
- ✓ Known neutrino **flavor**





arXiv:2606.14263

Muon/pion/kaon beam physics



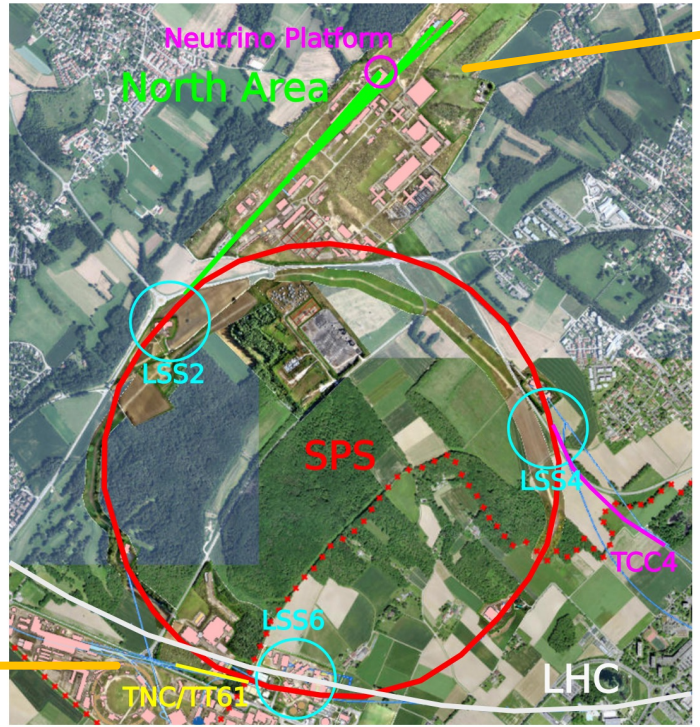
- ✓ Expect 10^{16} muons in 5 years
- ✓ Can enable searches for dark matter (e.g. via missing energy)

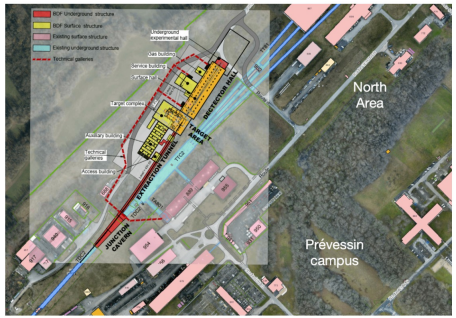
Paper in preparation (in collab. with R. Plestid and Y. Soreq)

Possible implementation at CERN

Feasibility studies conducted by CERN Accelerator & Technology Sector – **2 sites identified**

Proton sharing is compatible with other fixed target experiments (e.g. SHiP)

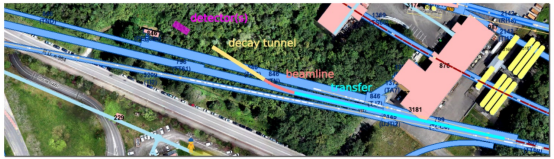




North Area (ECN4)

Feasibility studies ongoing under the umbrella of **Physics Beyond Colliders**

Meyrin (LSS6)



Status and next steps

- In 2024-2025 we submitted an input to the ESPPU process (and now feature in the Physics Briefing Book!)
  - Focused on beamline design and preliminary physics sensitivities, mainly cross-section measurements
- We held a successful workshop & kick-off collaboration meeting at CERN in Oct. 2025 and a proto-collaboration meeting in May 2026
  - Focused on neutrino detector design, physics studies & inputs for EoI
- We are preparing a more sophisticated simulation and reconstruction framework and exploring further physics studies
- Plan to submit a EoI to CERN SPSC before end of the year

Synergies: why should you care?

Comprehensive effort with **lots of opportunities**

- Accelerator studies
- Beamline detectors/instrumentation
  - E.g. **Silicon trackers** taking inspiration from LHCb-VELO & new R&D for HiLumi LHC
  - Need to cope with event rates of 20 GHz!
- Neutrino detector
  - We need a **fast** neutrino detector !
  - High coverage **photo-detection system**
  - **Containment** and design optimization
- Collaboration with **nuclear theory** community