Rare Neutrino Interaction and π^0 Production Cross Sections with MicroBooNE

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MANCHESTER 1824
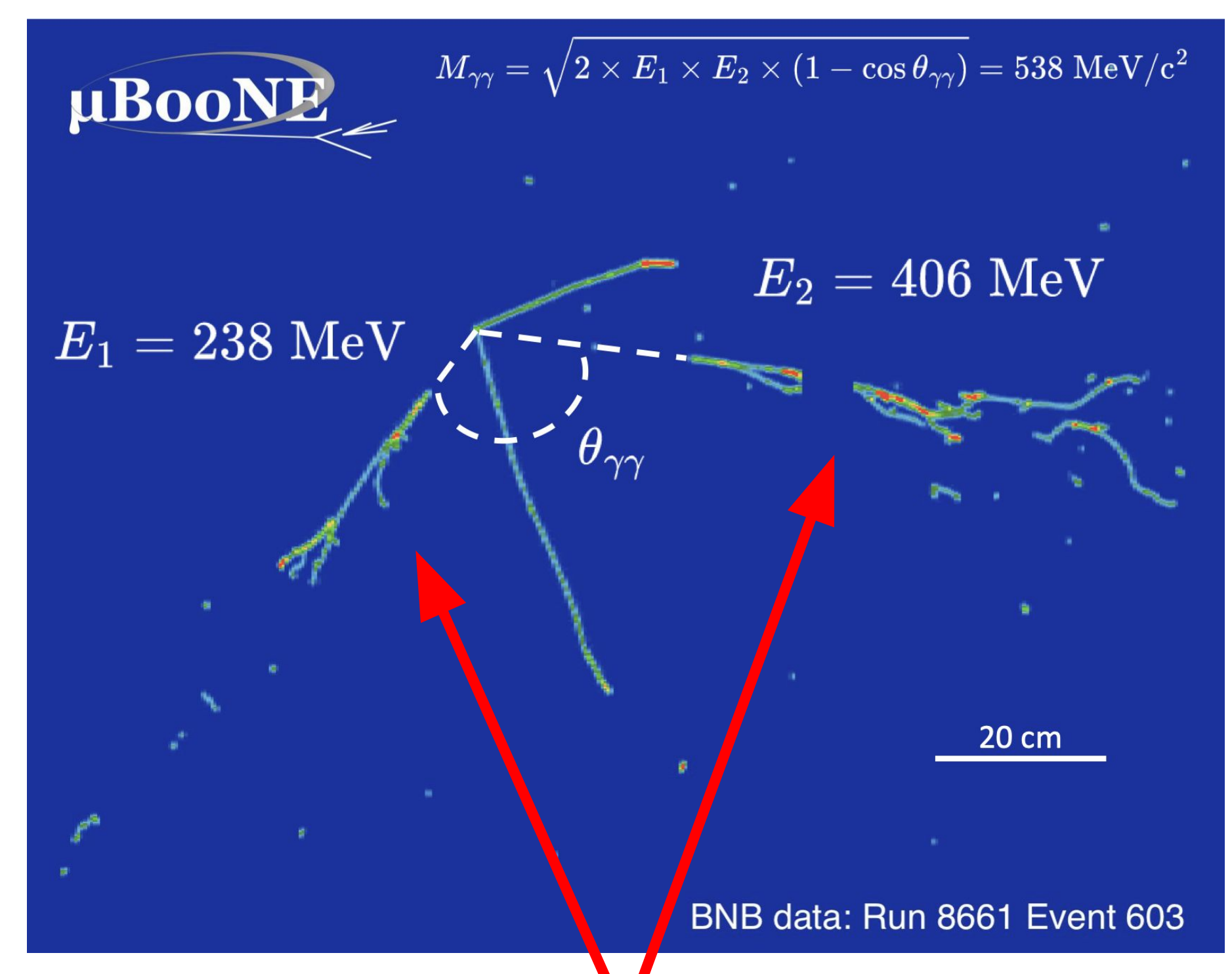The University of Manchester

η Mesons

Search for interactions of the type:

$$\nu + \mathrm{Ar} \rightarrow \eta + 0\pi^0 + X$$

X denotes any other final state hadrons or leptons.

These interactions are a **background to proton decay** measurements [1] and a valuable **probe of resonances** above the Δ (1232).

$$M_{\gamma\gamma} = \sqrt{2 \times E_1 \times E_2 \times (1 - \cos\theta_{\gamma\gamma})} = 538 \text{ MeV/c}^2$$

$E_1 = 238$ MeV $\quad$ $E_2 = 406$ MeV $\quad$ $\theta_{\gamma\gamma}$ $\quad$ 20 cm
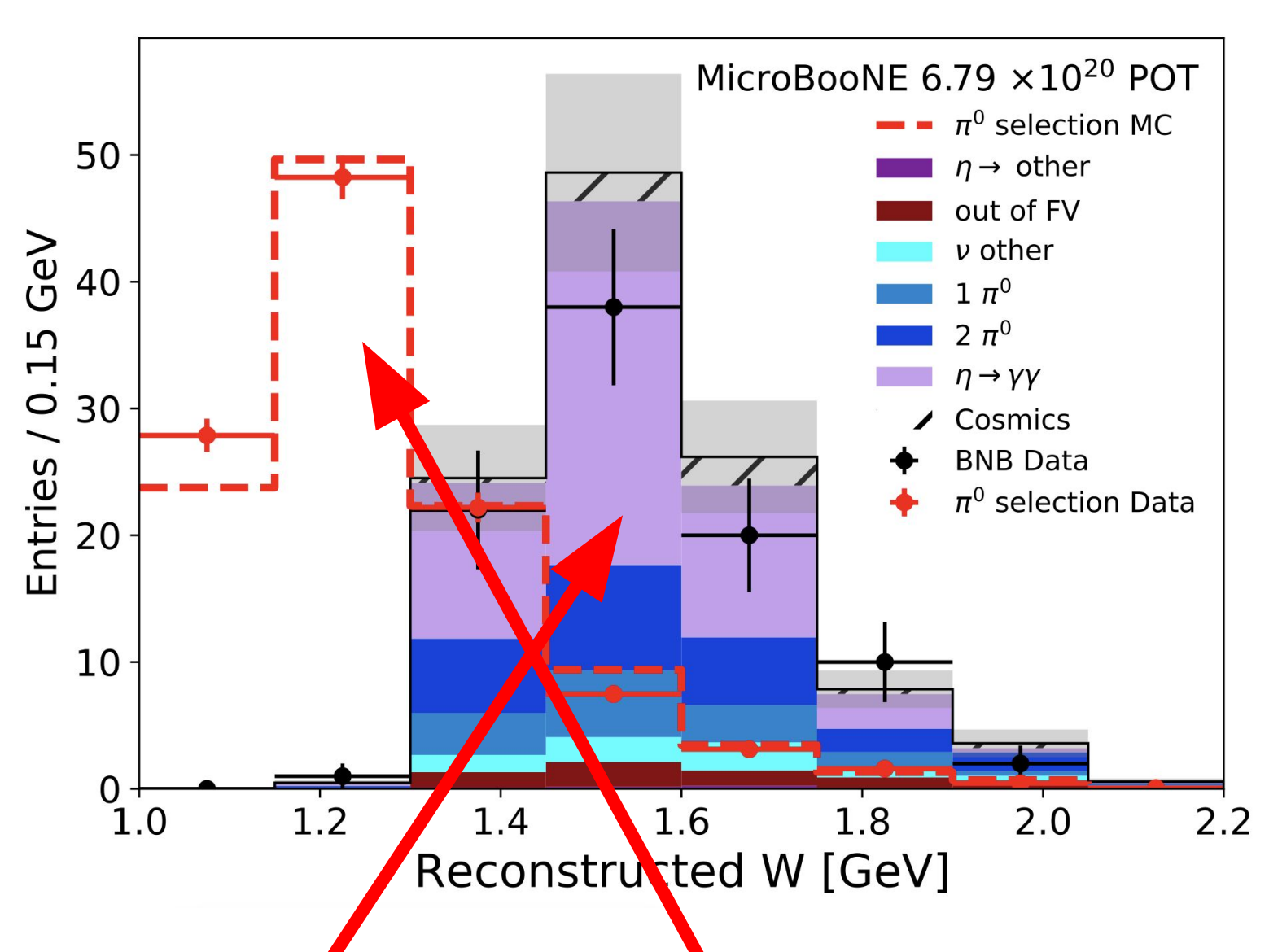
BNB data: Run 8661 Event 603

Select by identifying two showers with calorimetry consistent with two photons with large combined invariant mass.
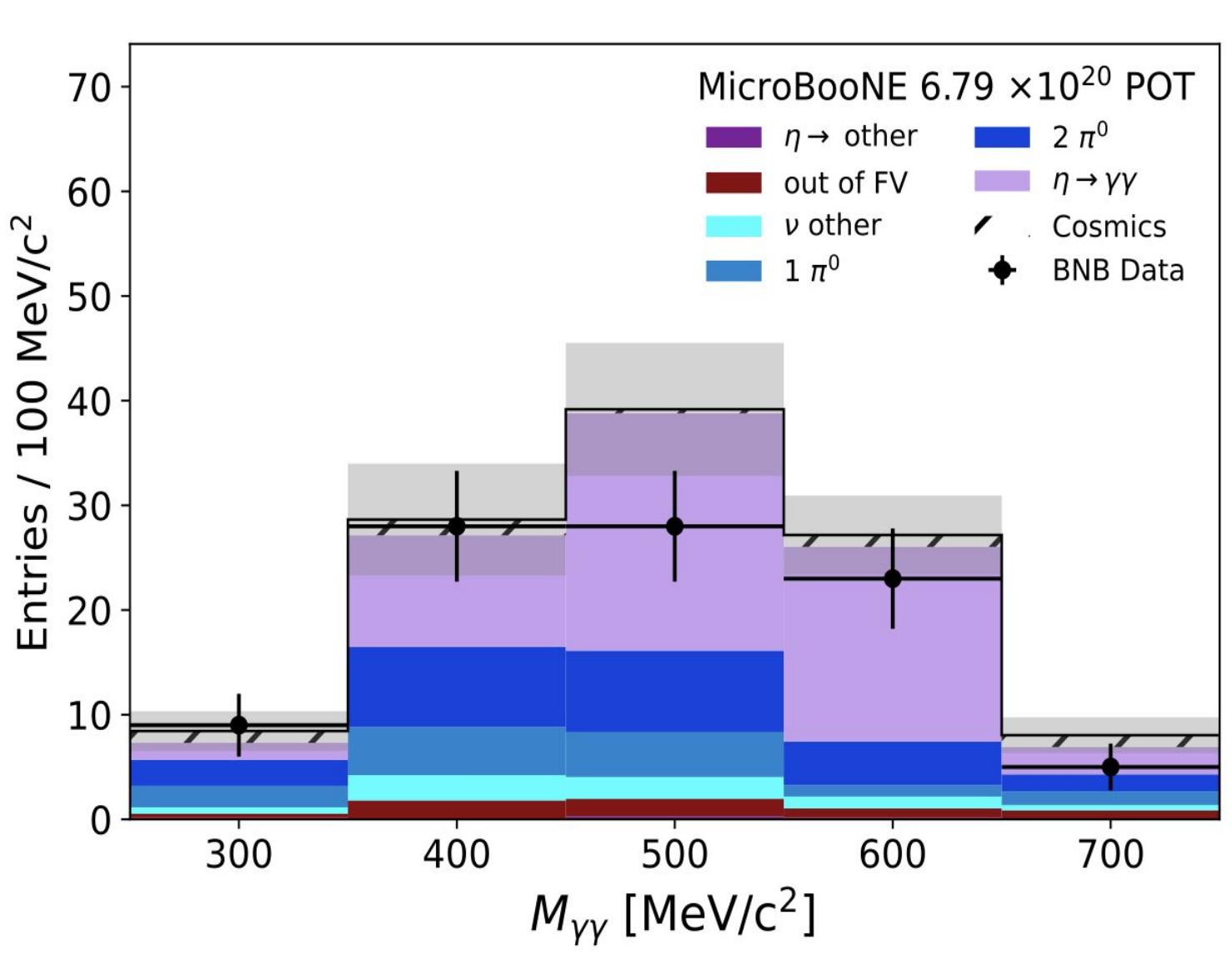
$\gamma\gamma$ invariant mass peak shape consistent with prediction.

Extracted cross section:

3.22 ± 1.20 x 10⁻⁴¹ cm²/nucleon

Hadronic invariant mass from **η selection** versus **π⁰ selection**. Separate Δ(1232) and N(1530) peaks - see resonance structure.

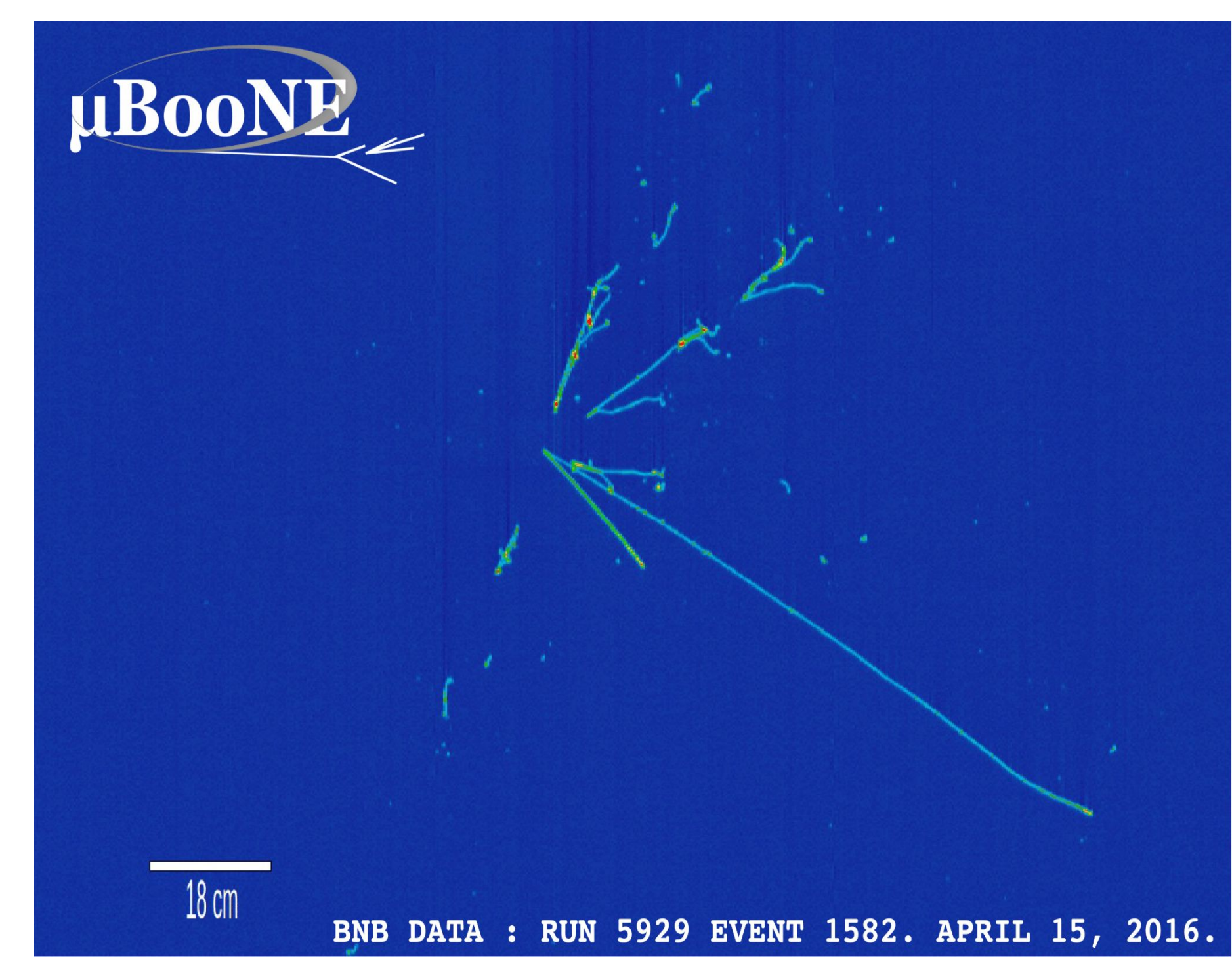See **Phys. Rev. Lett. 132 (2024) 15 151801** for more information!

Pion Production
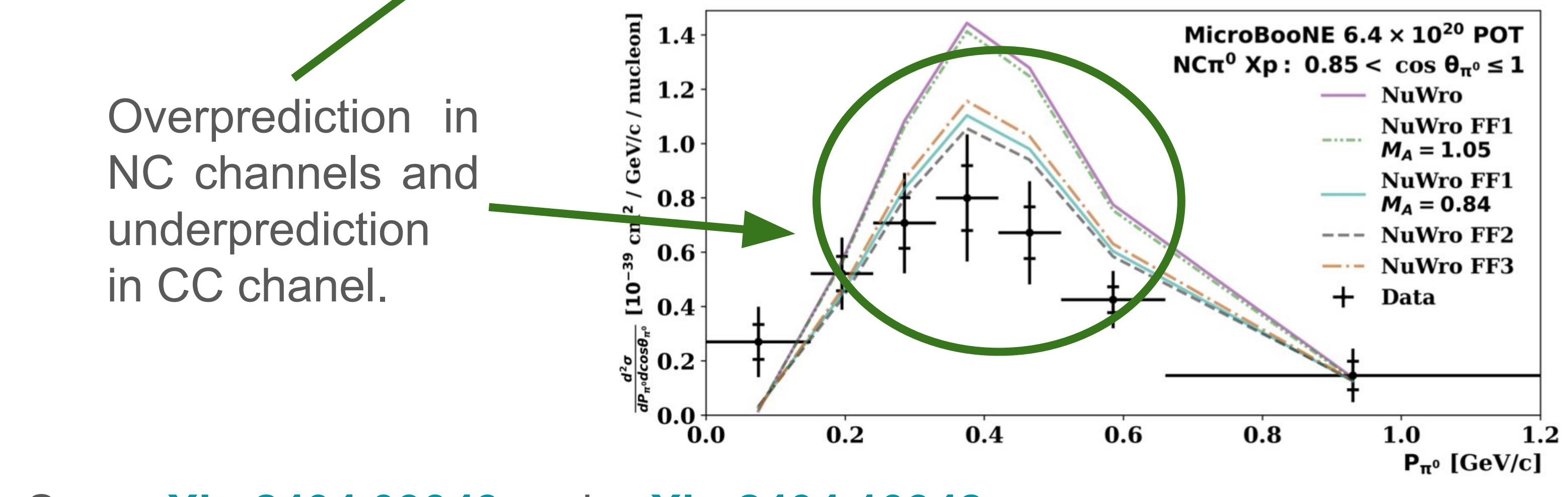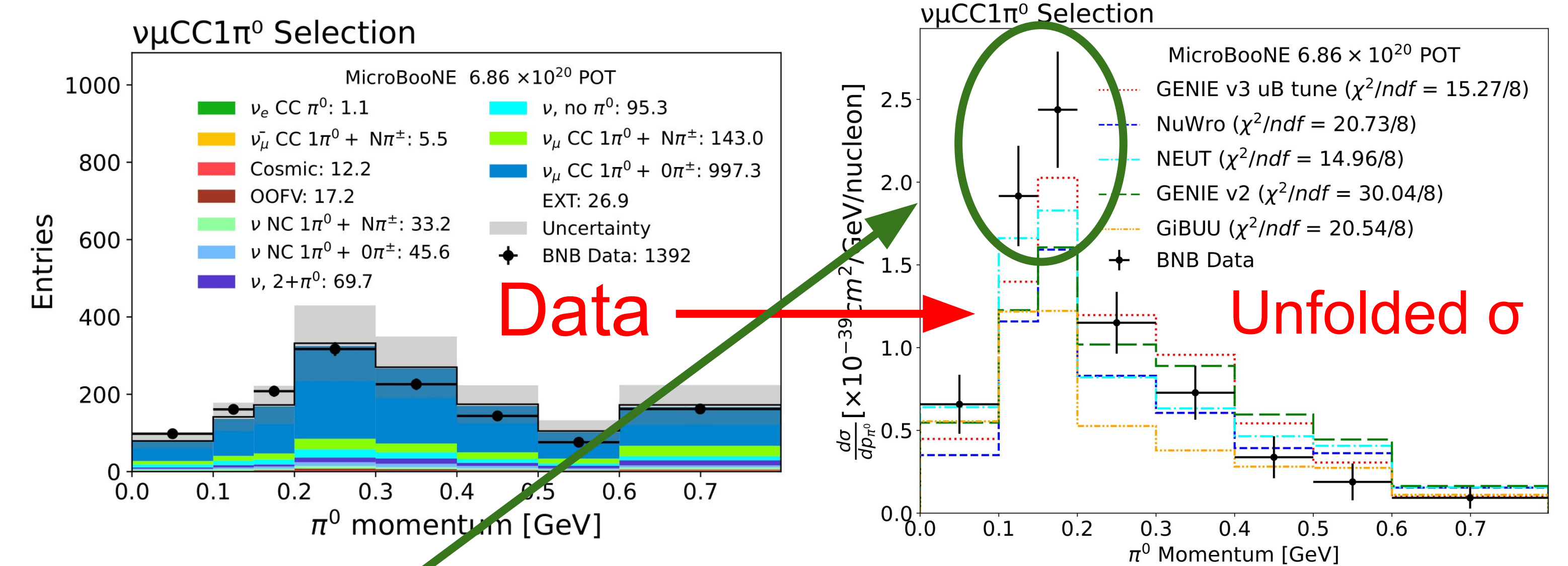
Search for interactions of the type:

$$\nu_\mu + \mathrm{Ar} \rightarrow \mu^- + \pi^0 + X$$
$$\nu_l + \mathrm{Ar} \rightarrow \nu_l + \pi^0 + X$$

Among the dominant sources of background in ν_e measurements, searches for BSM particles in neutrino detectors. Tool for studying resonance region.

BNB DATA : RUN 5929 EVENT 1582. APRIL 15, 2016.

Measure differential cross section as function of several variables. Obtain cross section through Wiener-SVD method [3], compare with generators.

Data $\quad$ Unfolded σ

Overprediction in NC channels and underprediction in CC chanel.

See **arXiv:2404.09949** and **arXiv:2404.10948**.
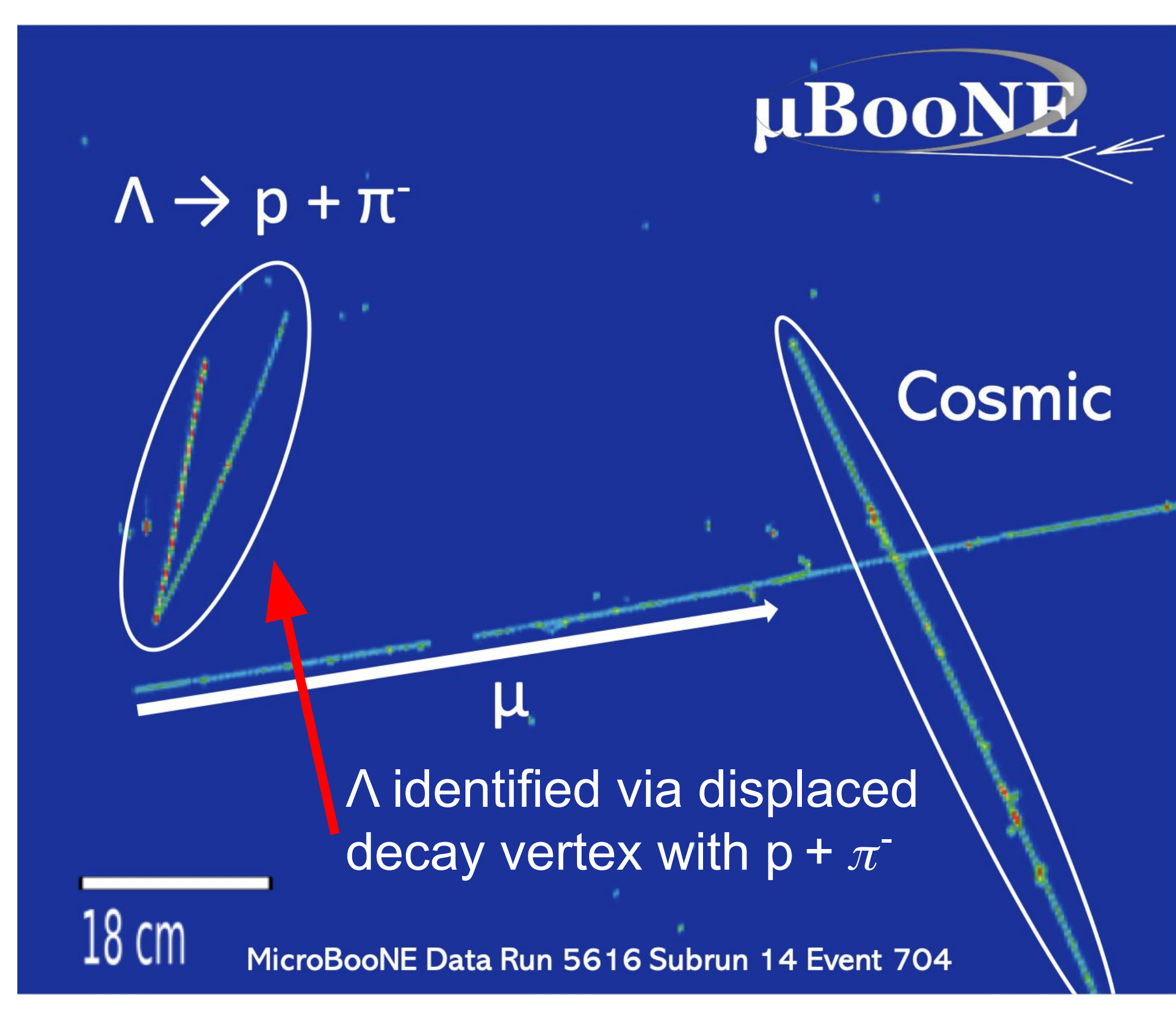
Λ Baryons

Search for interactions of the type:

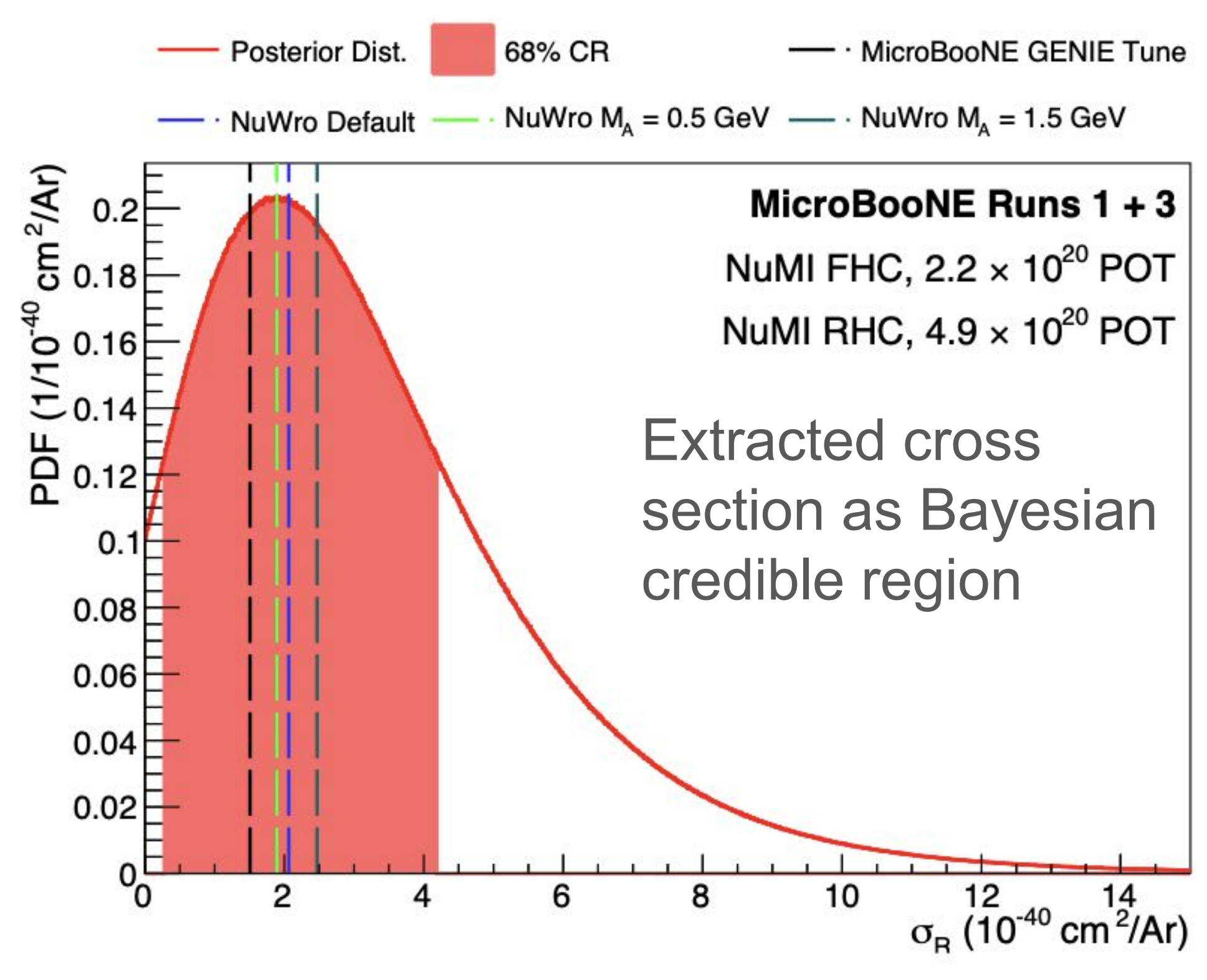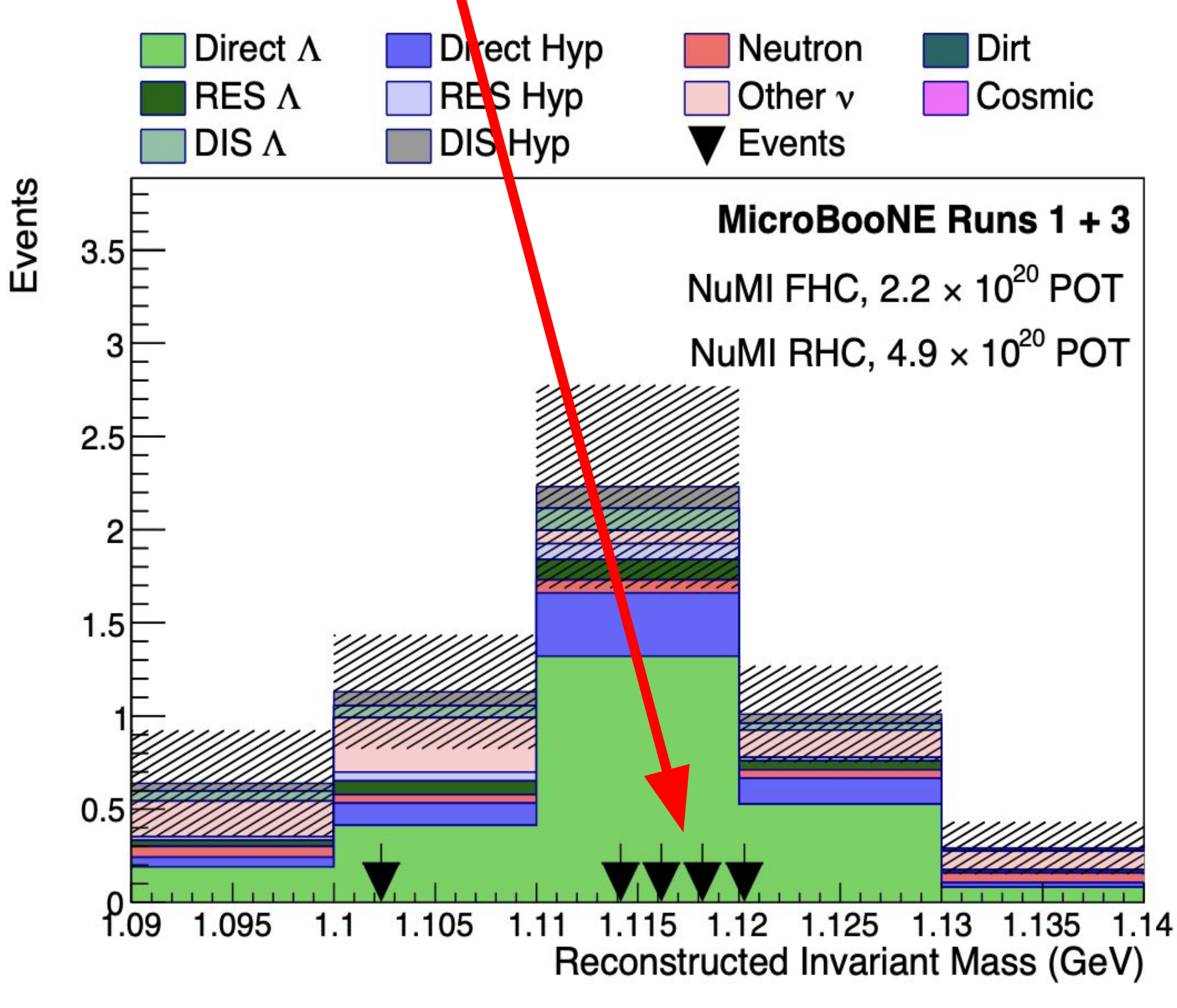$$\bar{\nu}_\mu + \mathrm{Ar} \rightarrow \mu^+ + \Lambda + 0K + X$$

Hyperon production is one of the **least understood neutrino interactions**.

Measurements of Λ and Σ production channels can **disentangle final state interactions from other effects** [2].

Simulation predicts 34 candidates prior to selection against ~10⁶ background events. Selection reduces background to O(1) event. After selection, find 5 Λ candidates in data.

$\Lambda \rightarrow p + \pi^-$

Cosmic

μ

Λ identified via displaced decay vertex with p + π^-

MicroBooNE Data Run 5616 Subrun 14 Event 704

See **Phys. Rev. Lett. 130 (2023) 23 231802**.

In Development

K⁺ Production: $\nu_\mu + \mathrm{Ar} \rightarrow \mu^- + K^+ + X$

Candidate μ $\quad$ Cosmic

Select K⁺ by searching for "bent" track

Candidate K $\quad$ Candidate μ $\quad$ e Candidate

BNB Data Run 5204 Subrun 155 Event 7788

K⁰-Short Production: $\nu_\mu + \mathrm{Ar} \rightarrow \mu + K^0_S + X$

K^0 identified through decay to $\pi^+ + \pi^-$

μ $\quad$ π $\quad$ π $\quad$ π $\quad$ p

Simulation
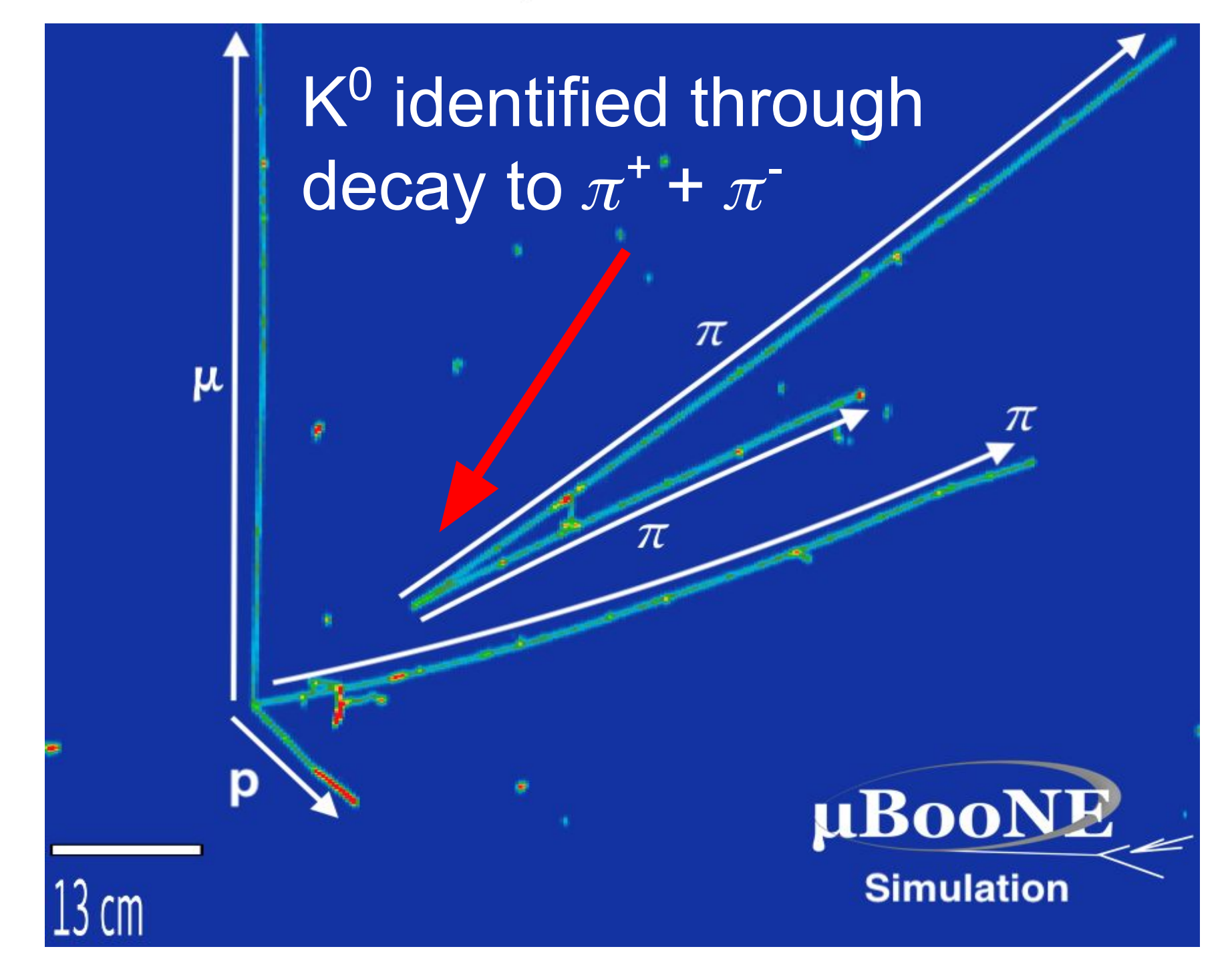
Both dangerous sources of background in proton decay measurements.

[1] arXiv:1705.07221.
[2] Phys. Rev. C **104 (2021)**, 035502.
[3] JINST, 12, P10002 (2017).