Neutrino related data from Mainz

Miha Mihovilovič for A1-Collaboration

Motivation - Neutrino experiments

- The properties of neutrinos determined through the measurement of probability of flavor oscillation:
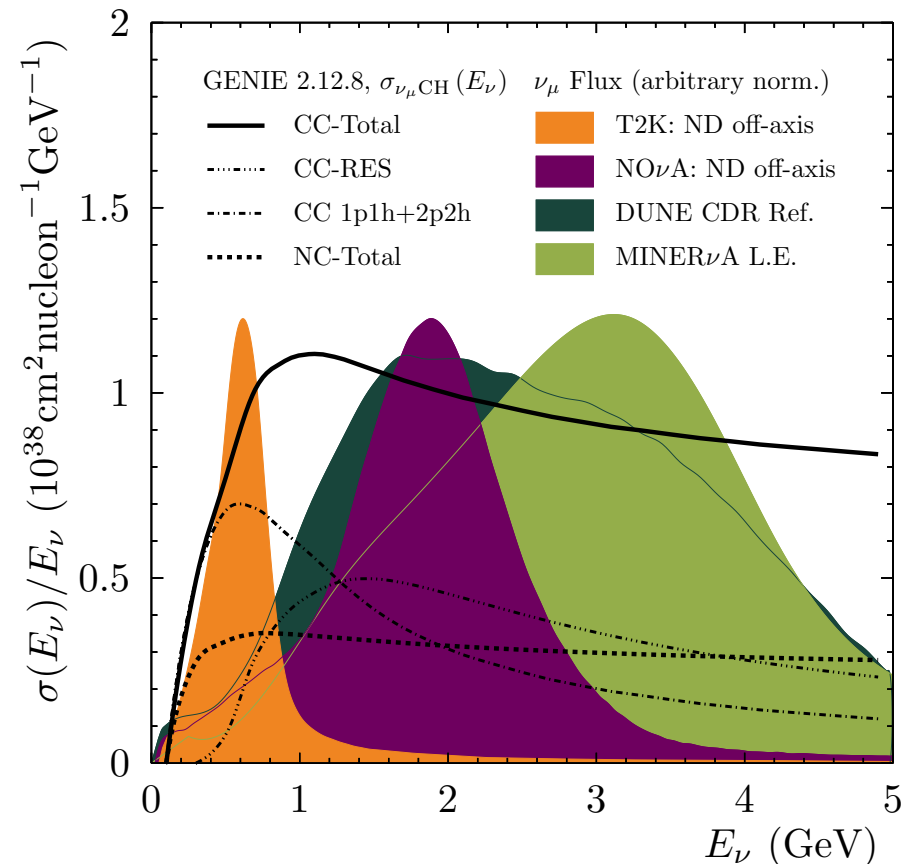
$$P(\nu_\alpha \to \nu_\beta) \simeq \sin^2 2\theta \, \sin^2 \left(\frac{\Delta m^2 L}{4E} \right)$$

- The probability is maximized, when:

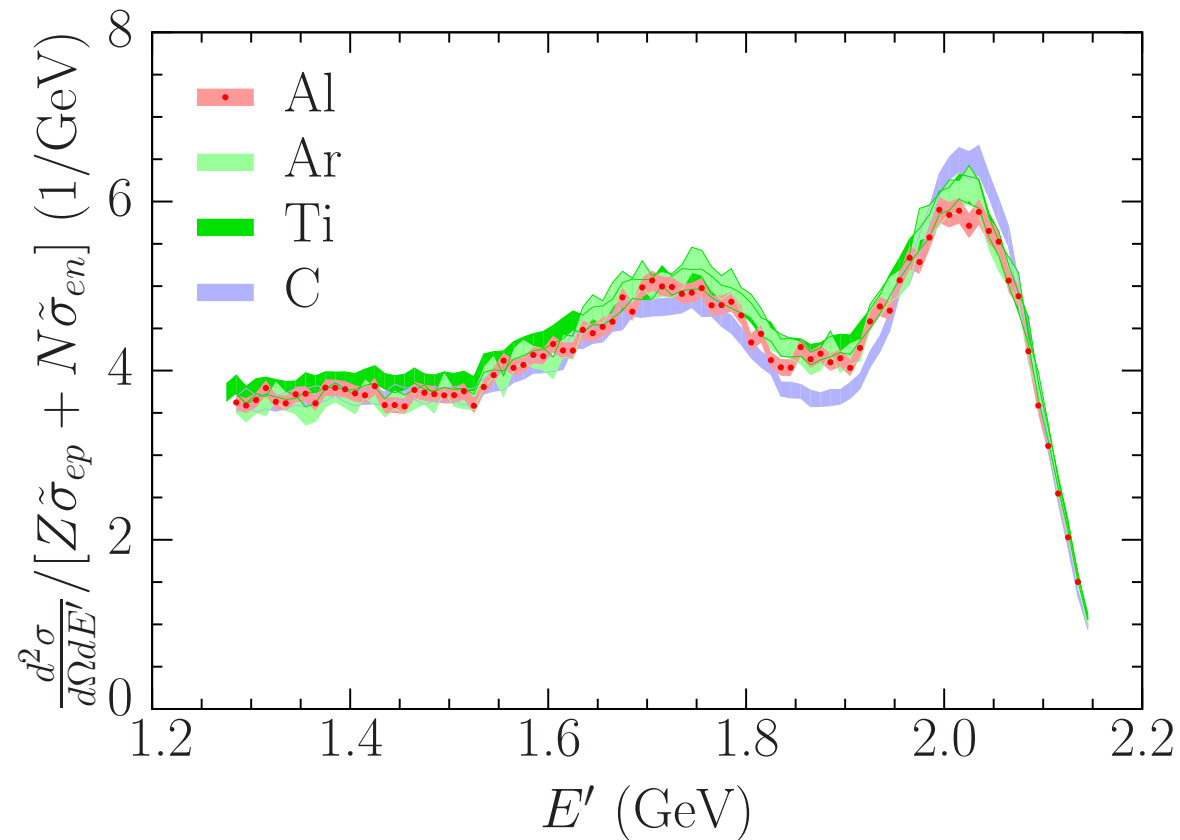$$E \approx \frac{\Delta m^2 L}{(4n+2)\pi}$$

- The amplitude of the oscillation:

$$P_{\max} \propto \sin^2 2\theta$$
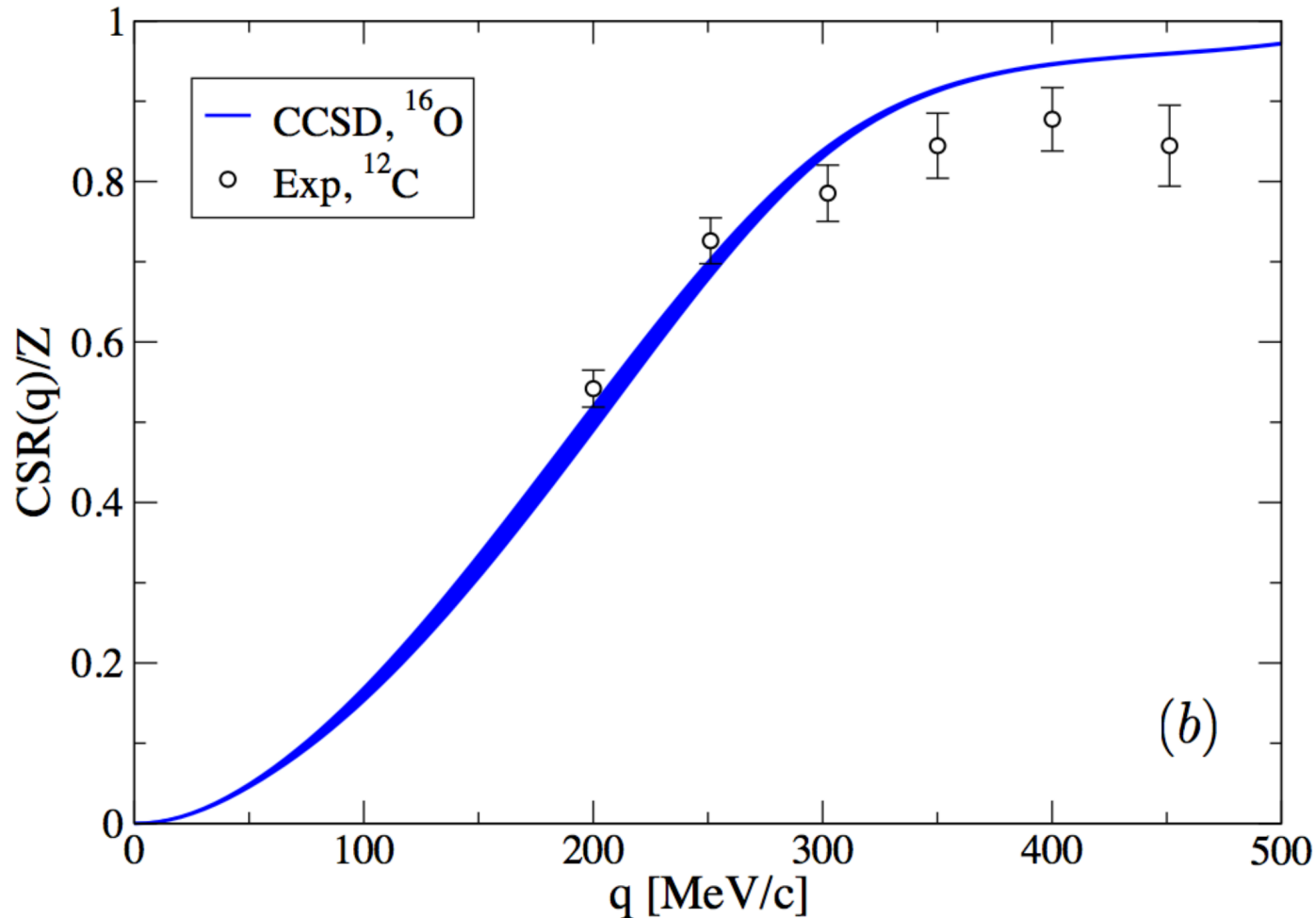
Motivation – E12-14-012

- Successful experiment performed at Jefferson Lab.

- Inclusive (and exclusive) data collected for C, Al, Ar, Ti targets at 2.2 GeV and 15.5°.

- Experiment confirmed approximate scaling.

Coulomb Sum Rule – ^{16}O

- Coulomb sum rule for Oxygen using coupled cluster theory (S. Bacca) .

- Theory extendable to ab-initio studies of neutrino-nucleus cross-sections.

- **No data exist!**

The Mainz Timeline

- **2017** – Letter-of-intent for an inclusive + exclusive measurement on Argon approved by PAC.

- **2019** – First test measurements on ^{12}C.

- **2020** – Full proposal for inclusive experiment on ^{16}O approved by PAC.

- **2020** – Full experimental agenda on ^{12}C.

- **2021** – Full experiment on ^{40}Ar with Jet target.

- **2022** – First (parasitic) measurements on ^{40}Ca.

––––––––––––––––––––––– Today –––––––––––––––––––––––
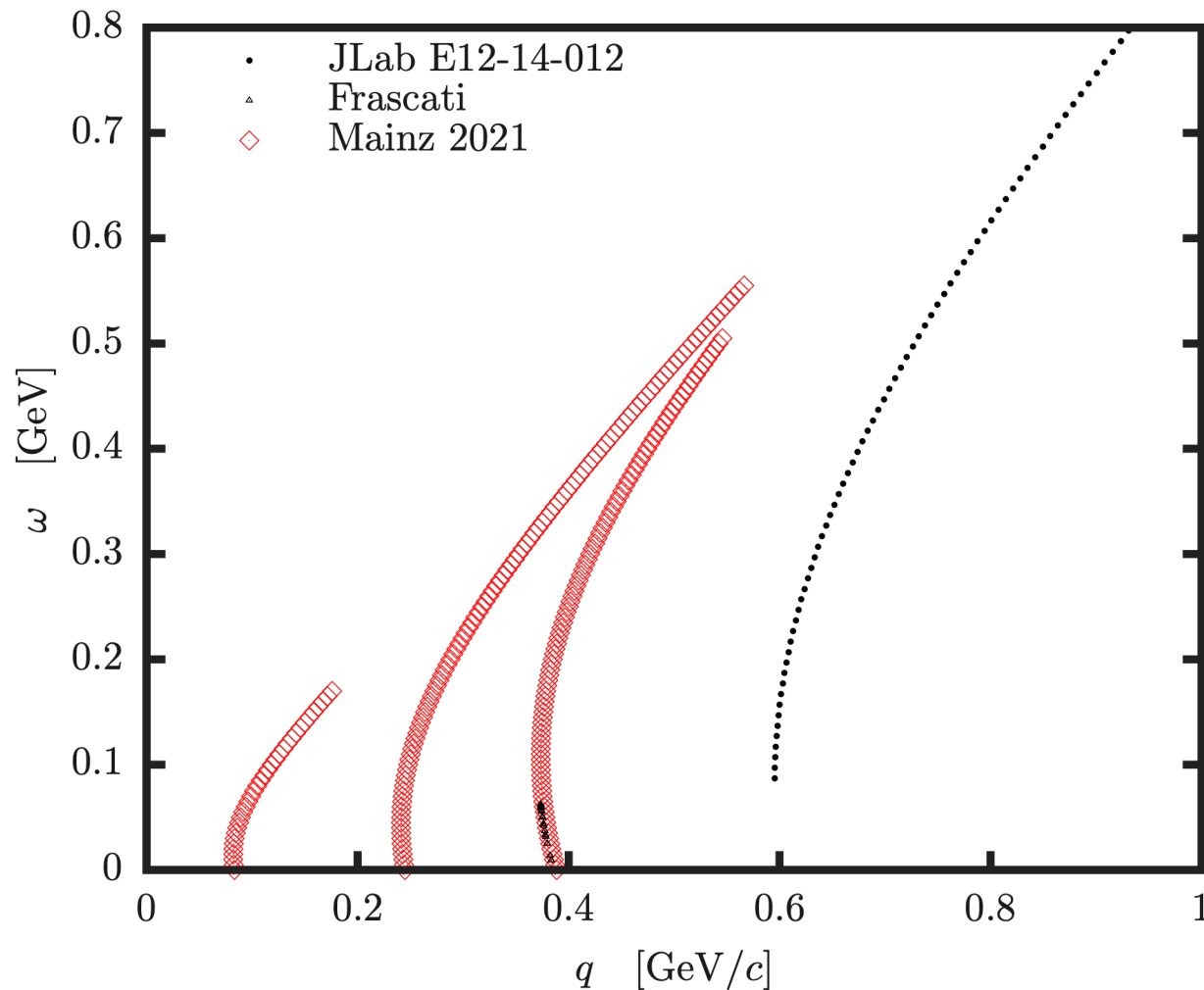
- **2025** – Experiment on ^{16}O?

New Mainz Data – ^{12}C

- Experimental agendas during the commissioning of Jet target and other experiments.

- Data available at: **600 MeV** (25°, 28.8°, 36°, 60°), **315 MeV** (36°, 60°) and **855 MeV** (70°)
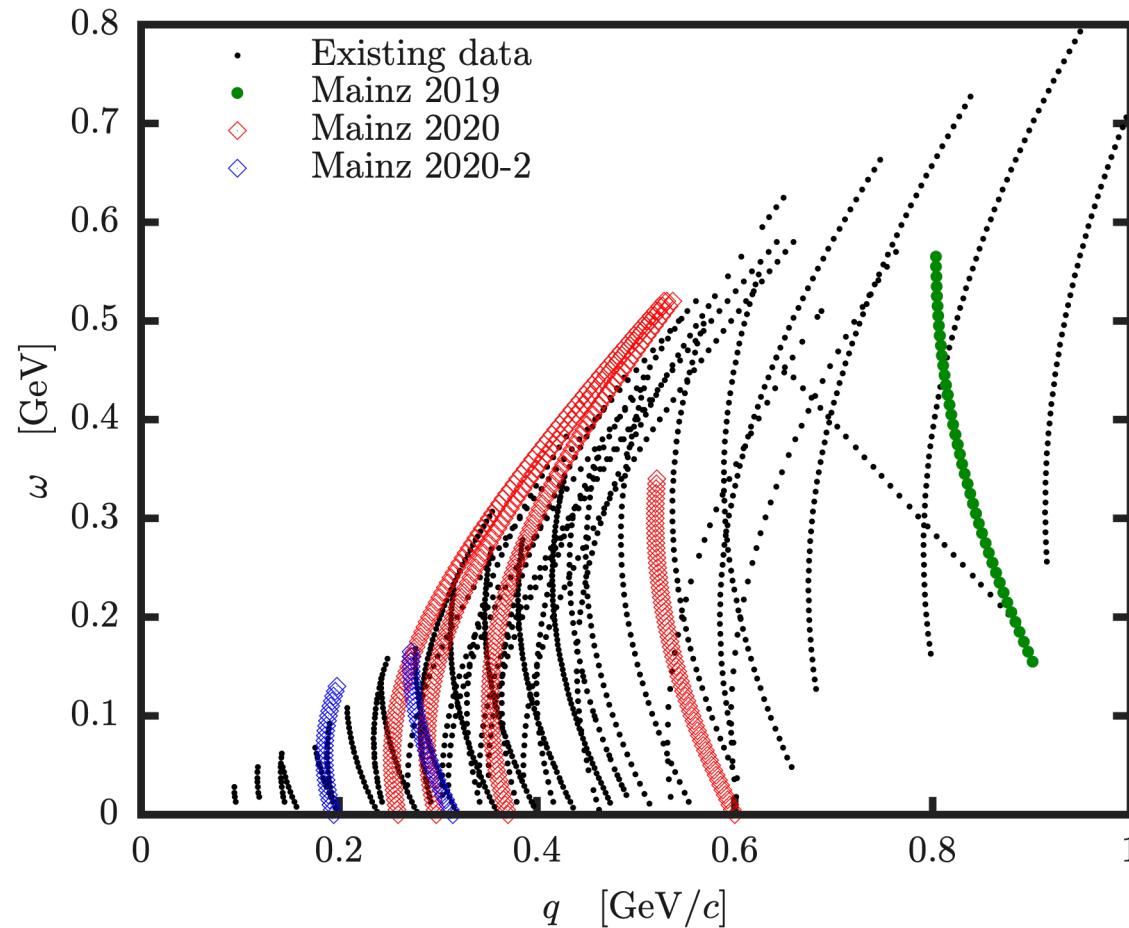
New Mainz Data – ^{40}Ar

- Data available at: **700 MeV** (20°, 32°), **240 MeV** (20°)

- Validation of Frascati results.

Challenging experiment

- Experiment performed with a windowless hypersonic gas-jet target developed for MAGIX

- No Luminosity of ~ **10^{35}/cm^{2}s** at T= 8K.

- Gas flow 800 l/min.

- Precise luminosity monitoring required.

Luminosity Monitor 705 MeV @ 20 deg

Nozzel

Laval-Nozzel

Gas-Jet

Catcher
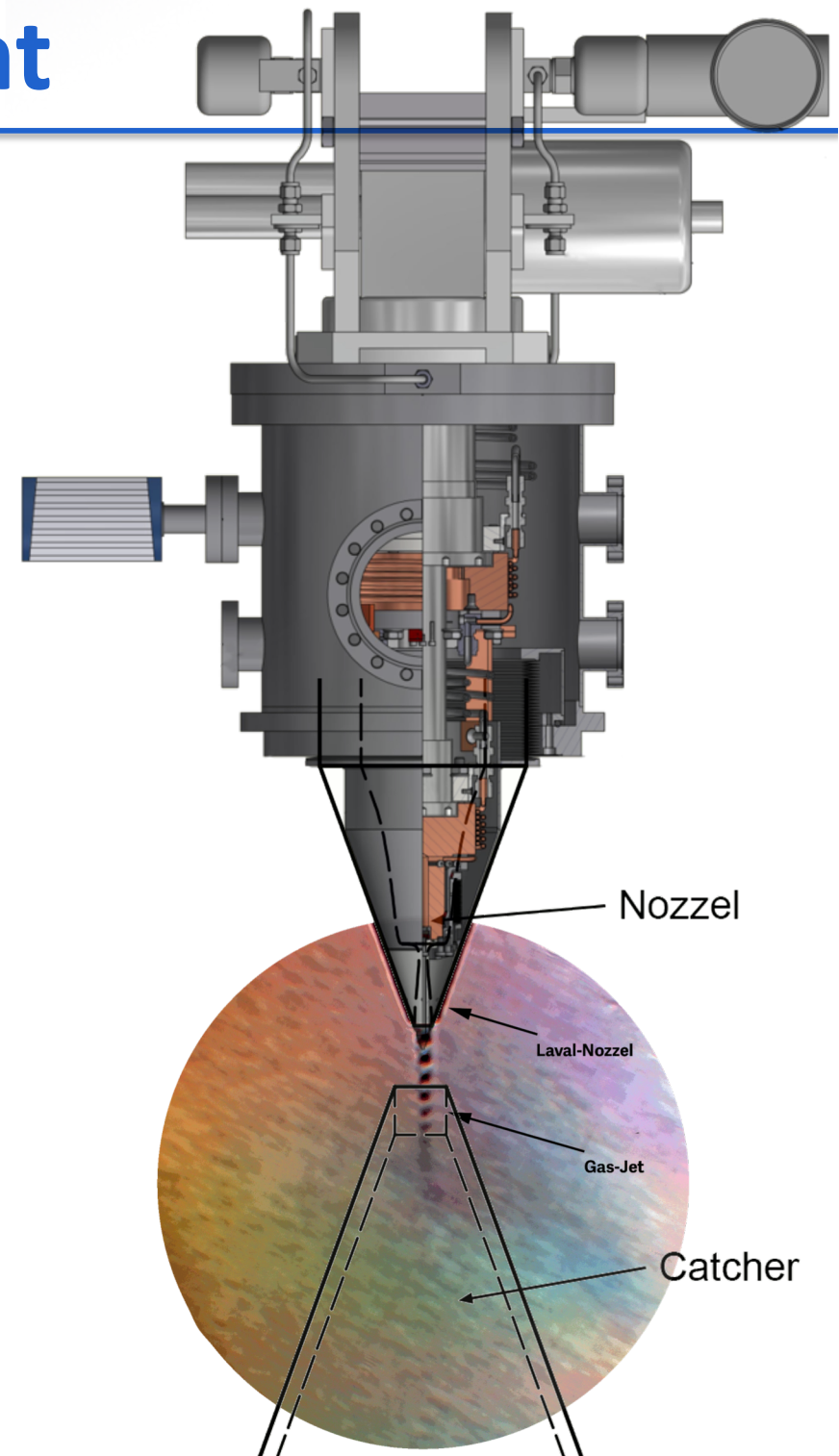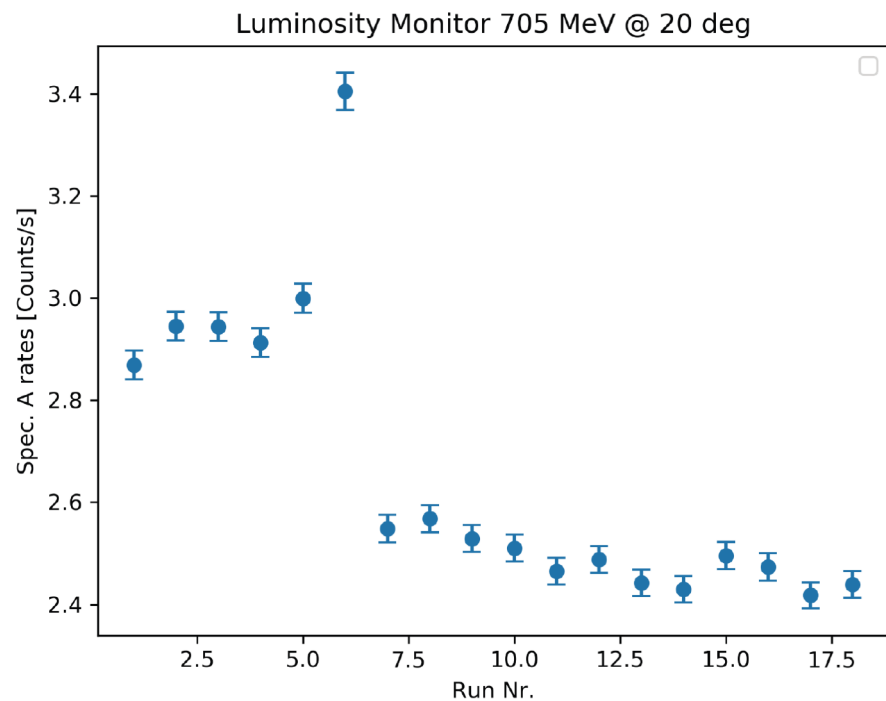
Argon analysis

- Experiment and analysis led by <u>Max Littich</u> and <u>Luca Doria</u>.

- Study of the luminosity and analysis of experimental cuts completed.
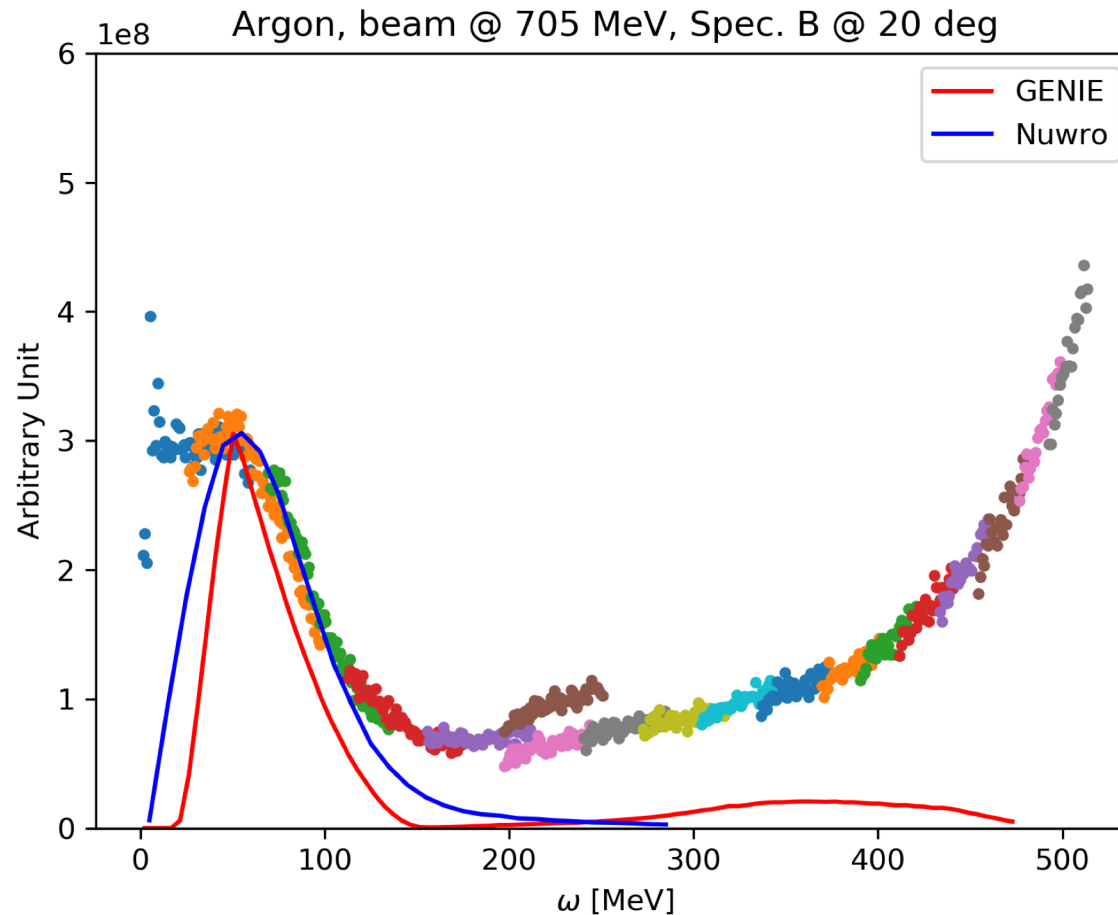
- <u>Next steps:</u> Comparison with the simulation, study of radiative corrections

Results of Pilot Carbon Experiment

- Proof-of-principle measurement at **855 MeV** (70°)

- SUSAv2 model agrees well with the data

- Other calculations qualitatively agree with the data.
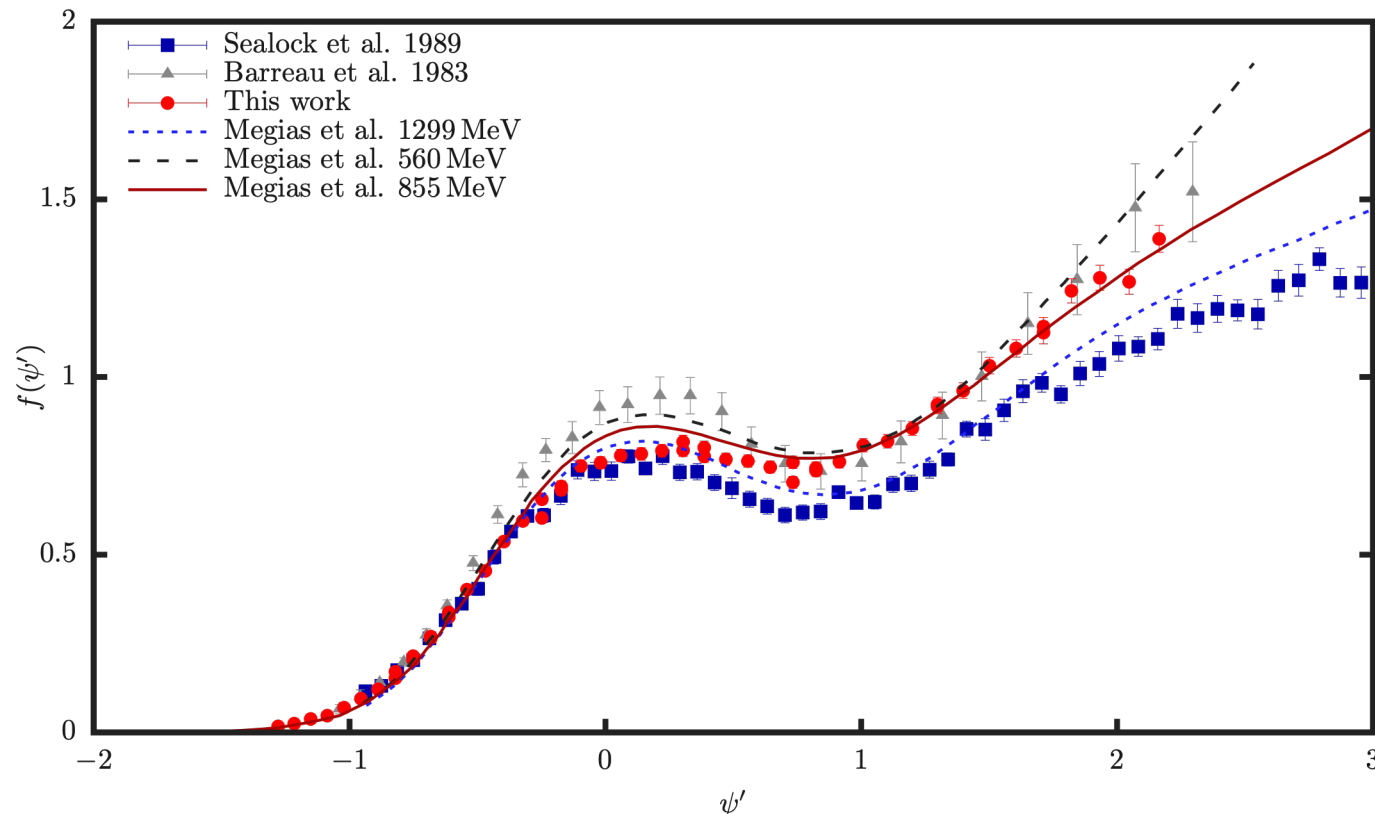
- Consistent QE calculations.
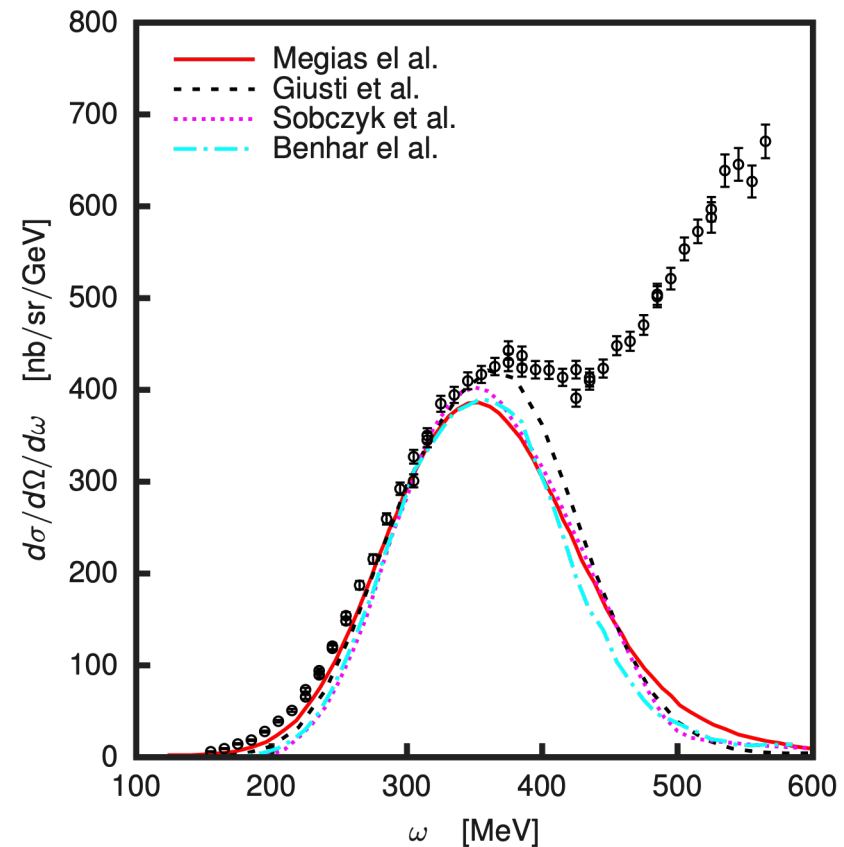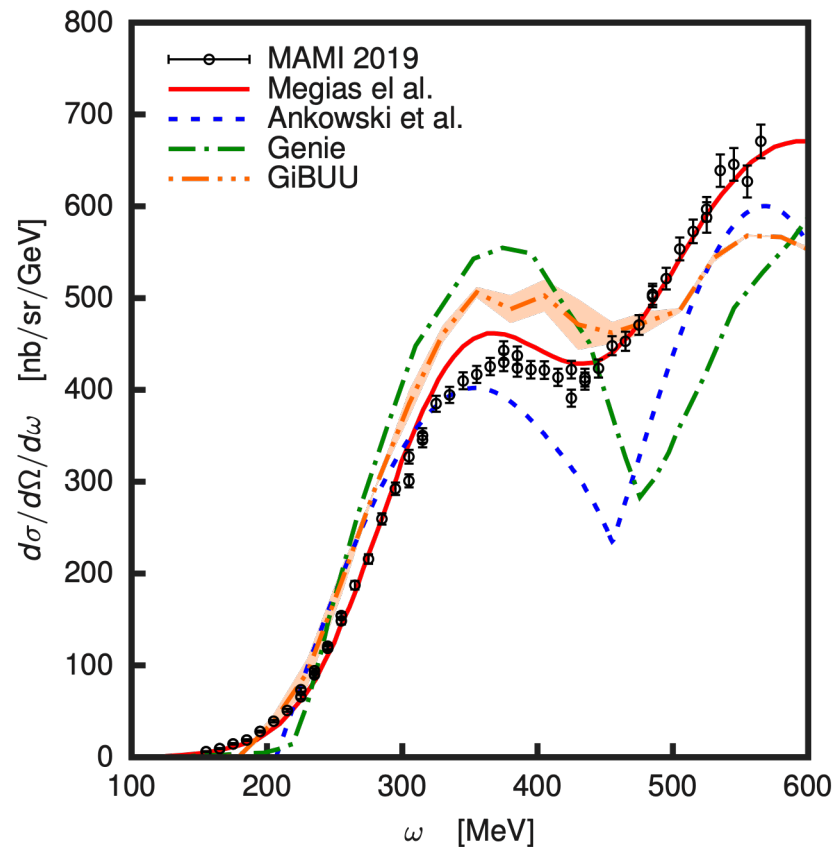
Scaling formalism at q = 0.8 GeV

- Measured cross-sections compared to the existing data via scaling variables and functions:

$$\psi' \equiv \frac{1}{\sqrt{\xi_F}} \frac{\lambda' - \tau'}{\sqrt{(1+\lambda')\tau' + \kappa\sqrt{\tau'(\tau'+1)}}} \qquad f = k_F \frac{d^2\sigma/d\Omega_e d\omega}{\sigma_M \left[v_L G_L(\kappa,\lambda) + v_T G_T(\kappa,\lambda)\right]}$$
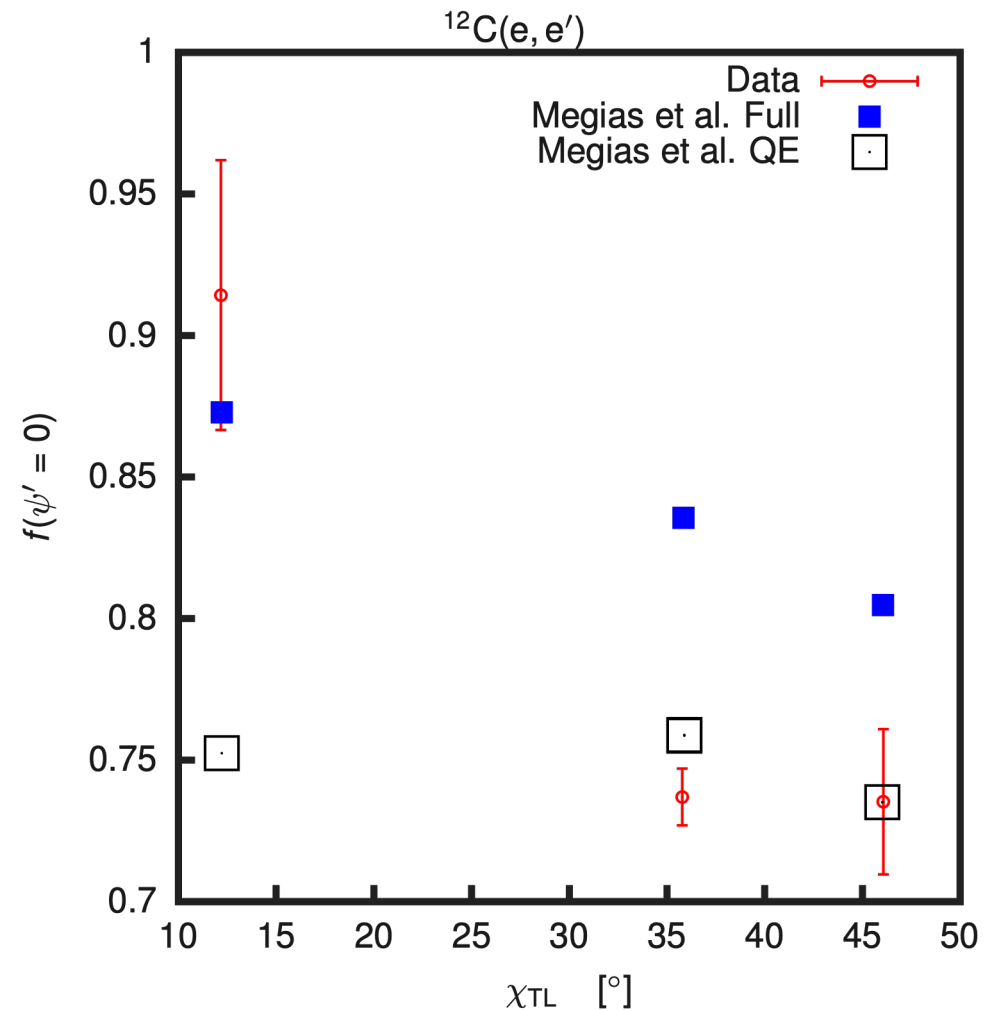
- Scaling is preserved for Ψ' < 0.

Scaling function at QE peak

- Scaling broken at QE peak.

- Influence of the transverse response.
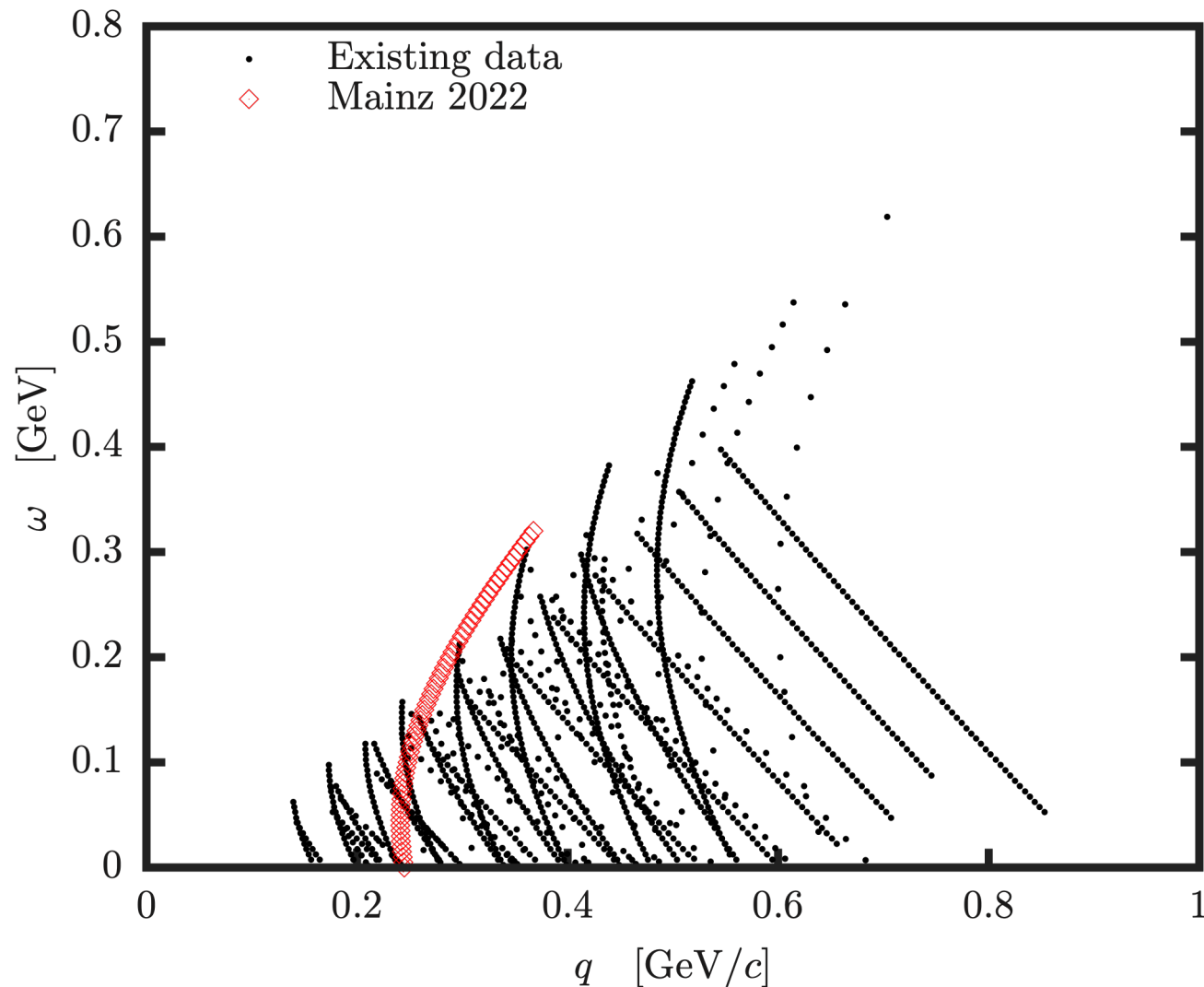
- Ratio of R_L and R_T contributions:

$$\tan^2 \chi_{TL} = \frac{v_L \; G_L}{v_T \; G_T}$$

- Theory overestimates the non-QE contributions.

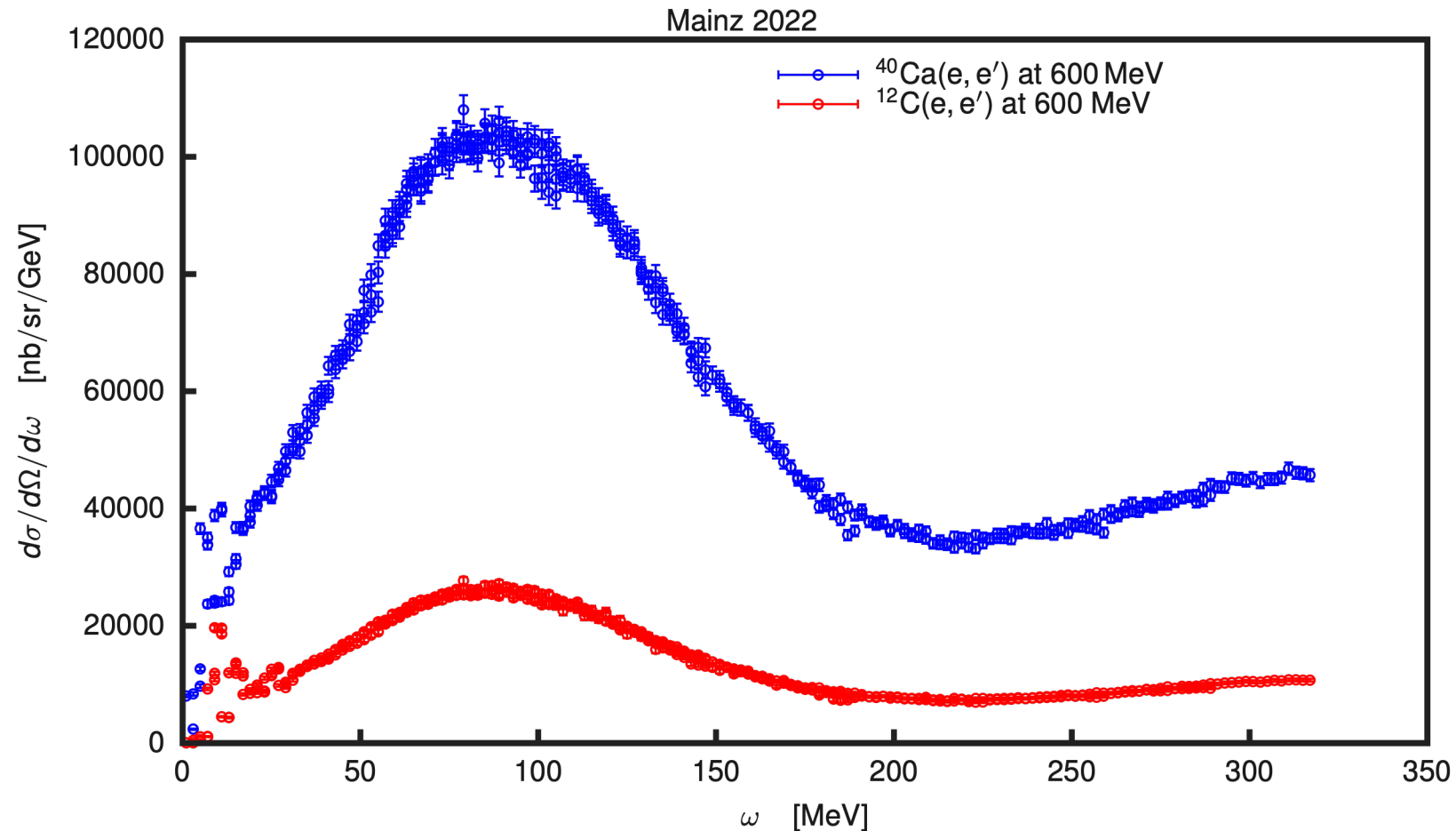# New Mainz Data – ^{40}Ca

- Parasitic measurement during $^{40}Ca(\vec{e}, e')\vec{p}$ experiment led by Tel Aviv group.

- Data at **600 MeV** (38°) comparable with Frascati kinematics.

# Online results of the ^{40}Ca experiment

- Simultaneous measurement with ^{40}Ca and ^{12}C target.

- Overlapping kinematics for control over systematic uncertainty.

- Elastic data for validation of absolute normalization.

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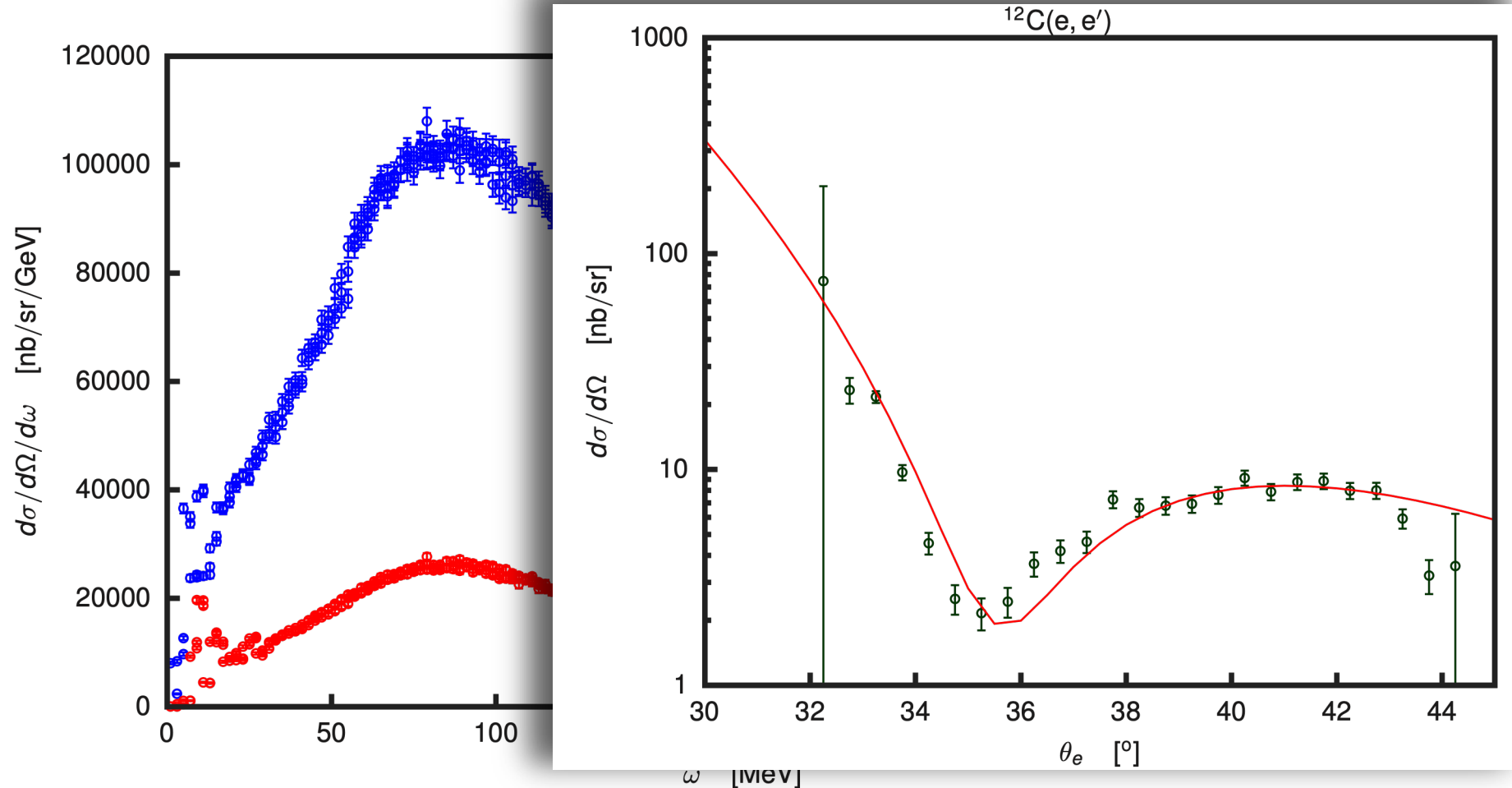
Conclusions

- MAMI perfect setup for nuclear cross-section measurements at ~1GeV.

- **New data sets for 12C, 40Ar and 40Ca targets:**

    - Several "parasitic" measurements.

    - Two full experimental agendas.

- Experiments with jet target for background free measurements.

- New Argon measurements will validate Frascati data.

- Challenge of the analysis: reliable description of the radiative corrections.

- Theoretical support is very welcome.

- Approved experiment on ^{16}O is pending.

- **Investigation of exclusive channels and polarization degrees of freedom also possible.**

Thank you!