Electron scattering for neutrino physics at MAMI

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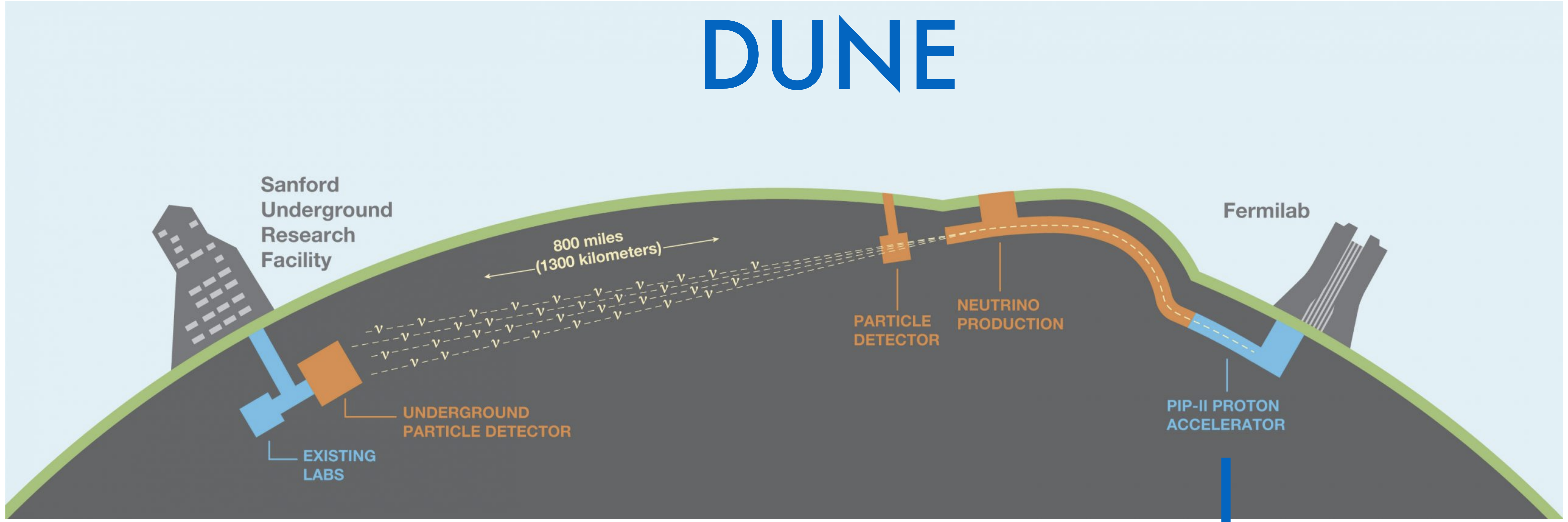
Introduction

* Long base-line Neutrino Experiments
* Relevance of Electron-Scattering for Neutrino Physics
* Experiments at MAMI
* Future Directions

Long Base-Line Experiments



Near Detector

$$N_{ND}(\nu_\alpha, E_R) = \int dE_\nu \Phi_{\nu_\alpha}(E_\nu) \times \sigma(E_\nu) \times R_{\nu_\alpha}(E_\nu, E_R)$$

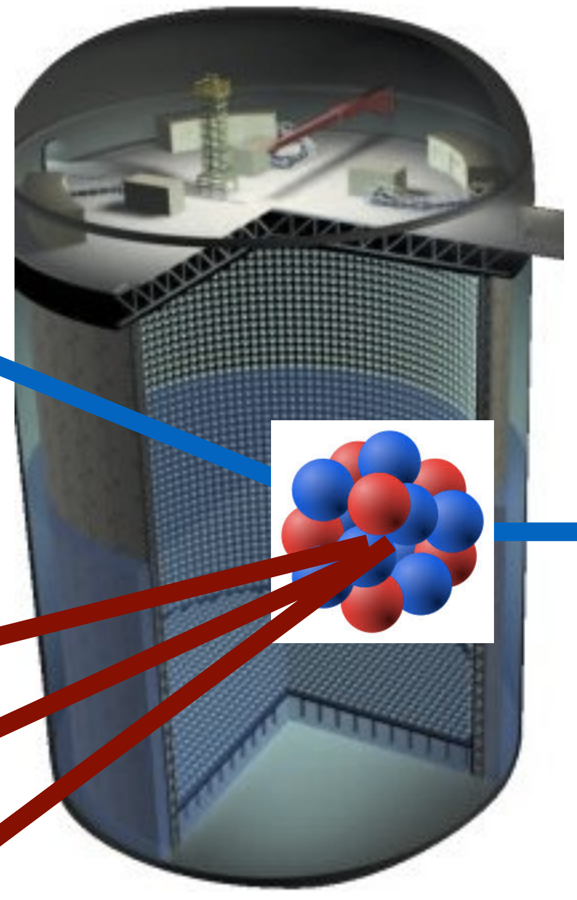
Far Detector

$$N_{FD}(\nu_\alpha \to \nu_\beta, E_R) = \int dE_\nu \Phi_{\nu_\alpha}(E_\nu) \times \sigma(E_\nu) \times R_{\nu_\alpha}(E_\nu, E_R) \times P(\nu_\alpha \to \nu_\beta, E_\nu)$$

Why nuclei are relevant for neutrino physics ?

Experiment

l



π

p

n

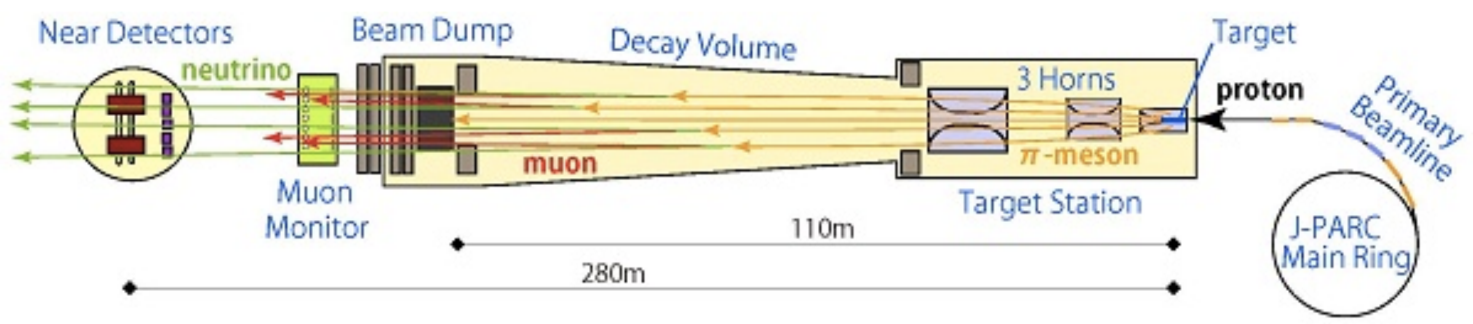
Detection

Oscillation

$$\begin{pmatrix}\nu_e\\ \nu_\mu\\ \nu_\tau\end{pmatrix}=\begin{pmatrix}c_{12} & s_{12} & 0\\ -s_{12} & c_{12} & 0\\ 0 & 0 & 1\end{pmatrix}\begin{pmatrix}c_{13} & 0 & s_{13}e^{-i\delta}\\ 0 & 1 & 0\\ -s_{13}e^{-i\delta} & 0 & c_{13}\end{pmatrix}\begin{pmatrix}1 & 0 & 0\\ 0 & c_{23} & s_{23}\\ 0 & -s_{23} & c_{23}\end{pmatrix}\begin{pmatrix}1 & 0 & 0\\ 0 & e^{i\alpha_1/2} & 0\\ 0 & 0 & e^{i\alpha_2/2}\end{pmatrix}\cdot\begin{pmatrix}\nu_1\\ \nu_2\\ \nu_3\end{pmatrix}$$

ν_l

Production



E_ν

Analysis

Cross section model

$\sigma(E_\nu)$

Reconstruct

E_ν

Oscillation Parameters $\theta_e, \theta_\mu, \theta_\tau \quad \delta_{CP}$

$\Delta m_e^2, \Delta m_\mu^2, \Delta m_\tau^2$

Electron Scattering vs Neutrino Scattering

Neutrino-Nucleus scattering

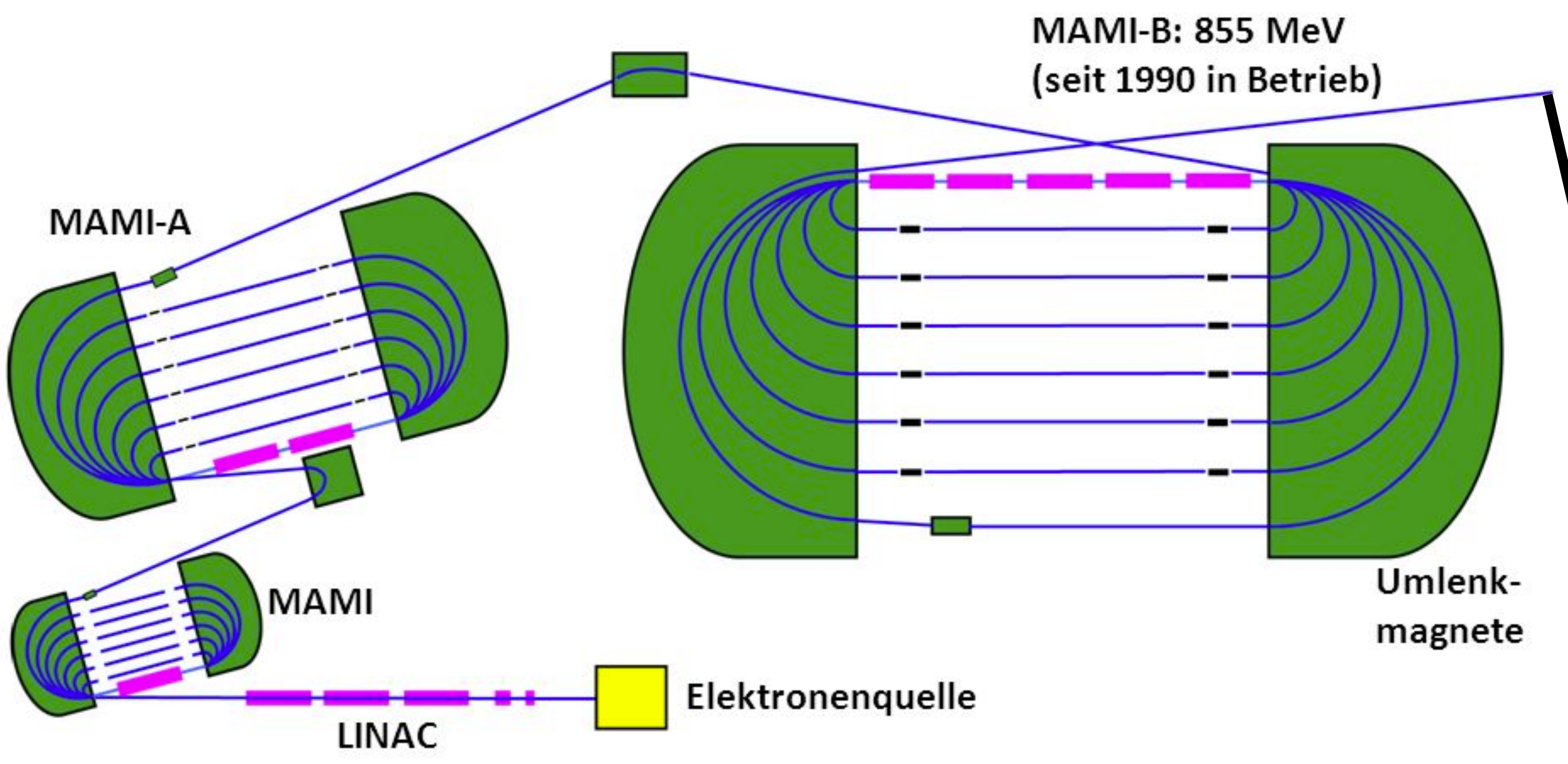
$$\frac{d^2\sigma}{d\Omega_{k'}d\omega} = \sigma_0 \left[L_{CC}R_{CC} + L_{CL}R_{CL} + L_{LL}R_{LL} + L_T R_T \pm L_{T'}R_{T'}\right]$$

(Unpolarized) Electron-Nucleus scattering

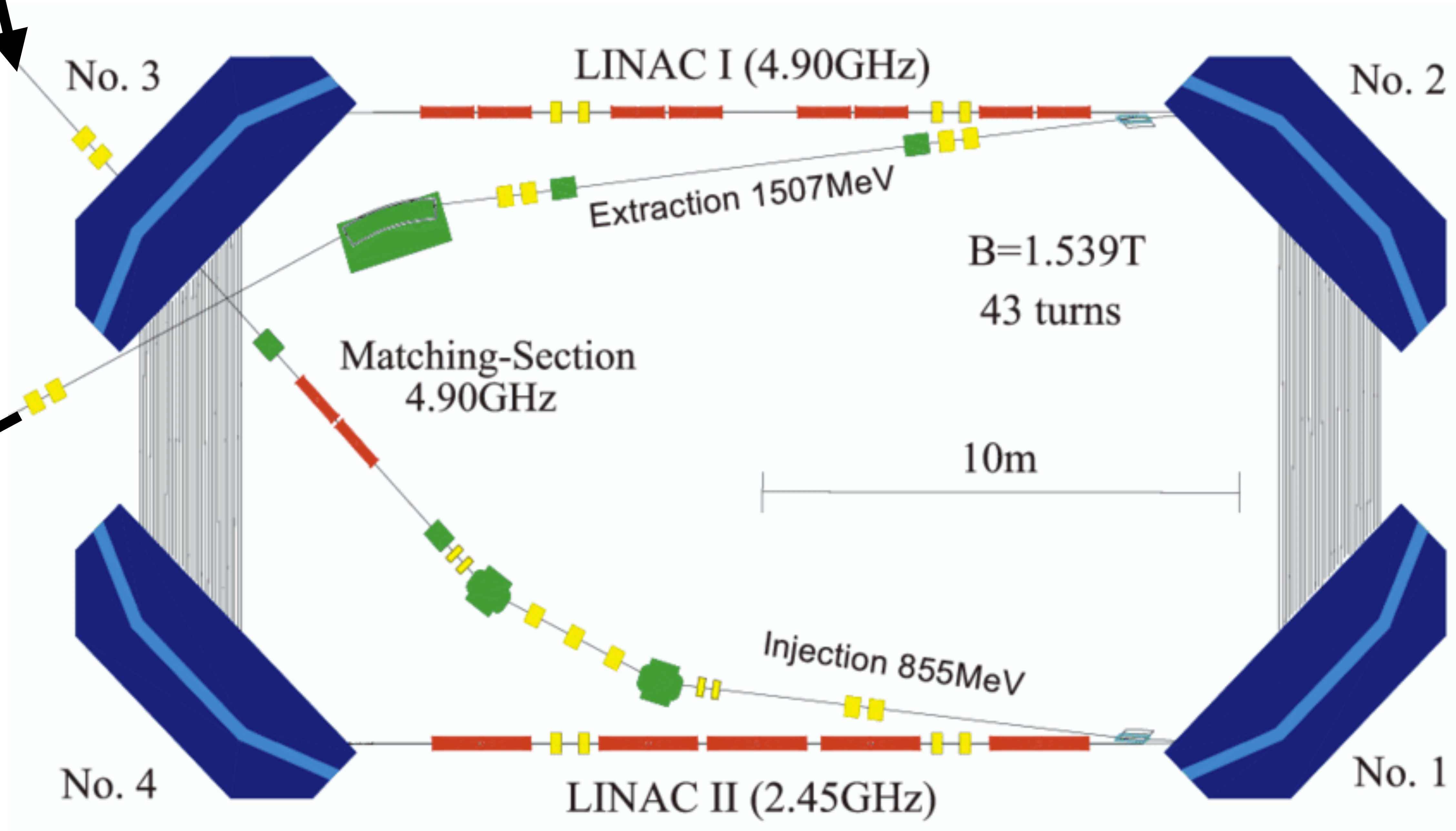
$$\frac{d^2\sigma}{d\Omega d\omega} = \left(\frac{d\sigma}{d\Omega}\right)_{Mott}\left[\frac{Q^4}{\vec{q}^4}R_L(q) + \left(\frac{1}{2}\frac{Q^2}{\vec{q}^2} + \tan^2\frac{\theta}{2}\right)R_T(q)\right] = \left(\frac{d\sigma}{d\Omega}\right)_{Mott}\left[\sigma_L + \sigma_T\right]$$

Use electrons for testing neutrino-nucleus interactions generators.

The Racetrack Microton
(Institute for Nuclear Physics, U. Mainz)



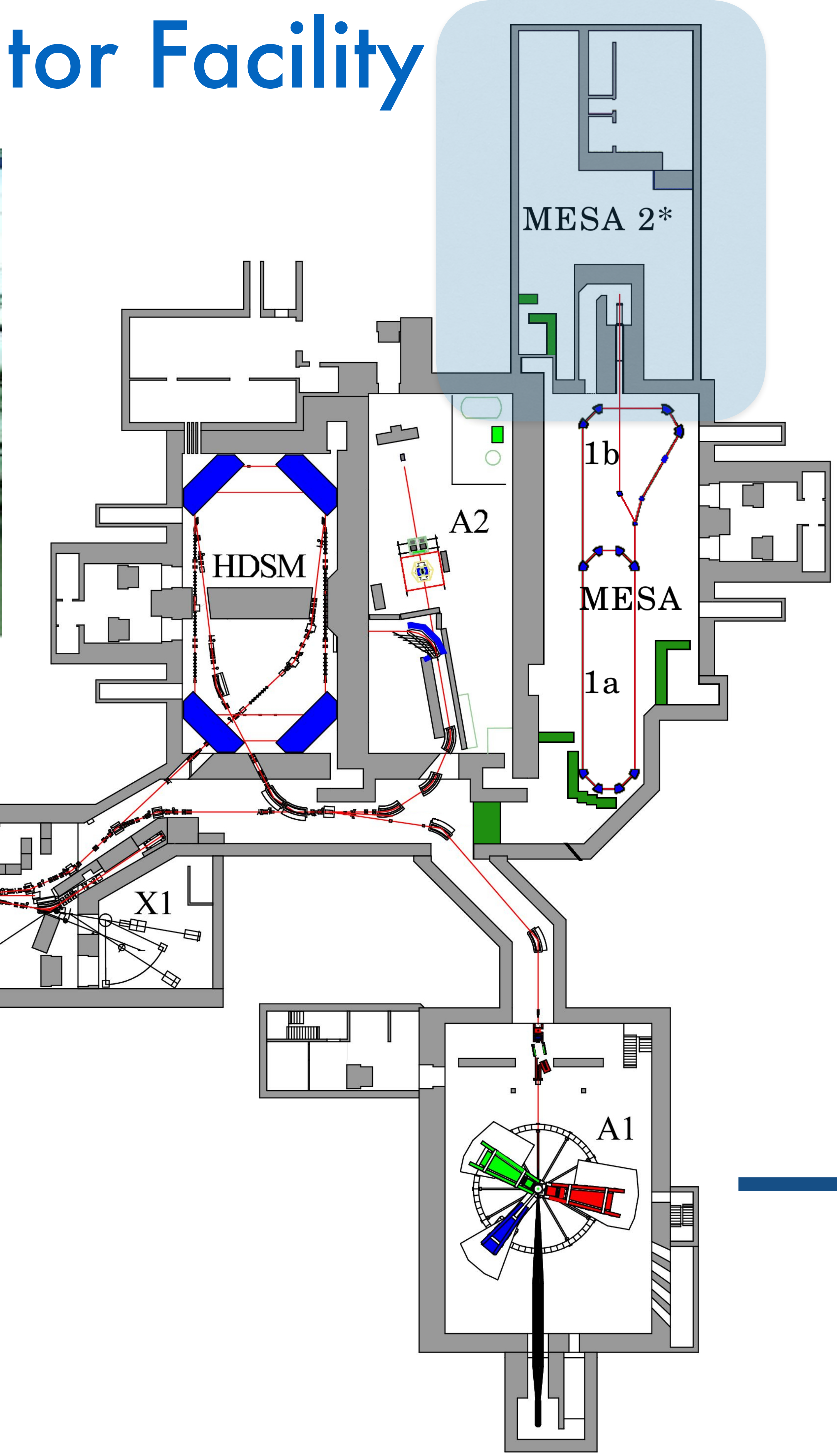
up to 855 MeV



up to 1.6 GeV

CW electron beam
Up to 100 uA current
80% polarization
dE <13 keV

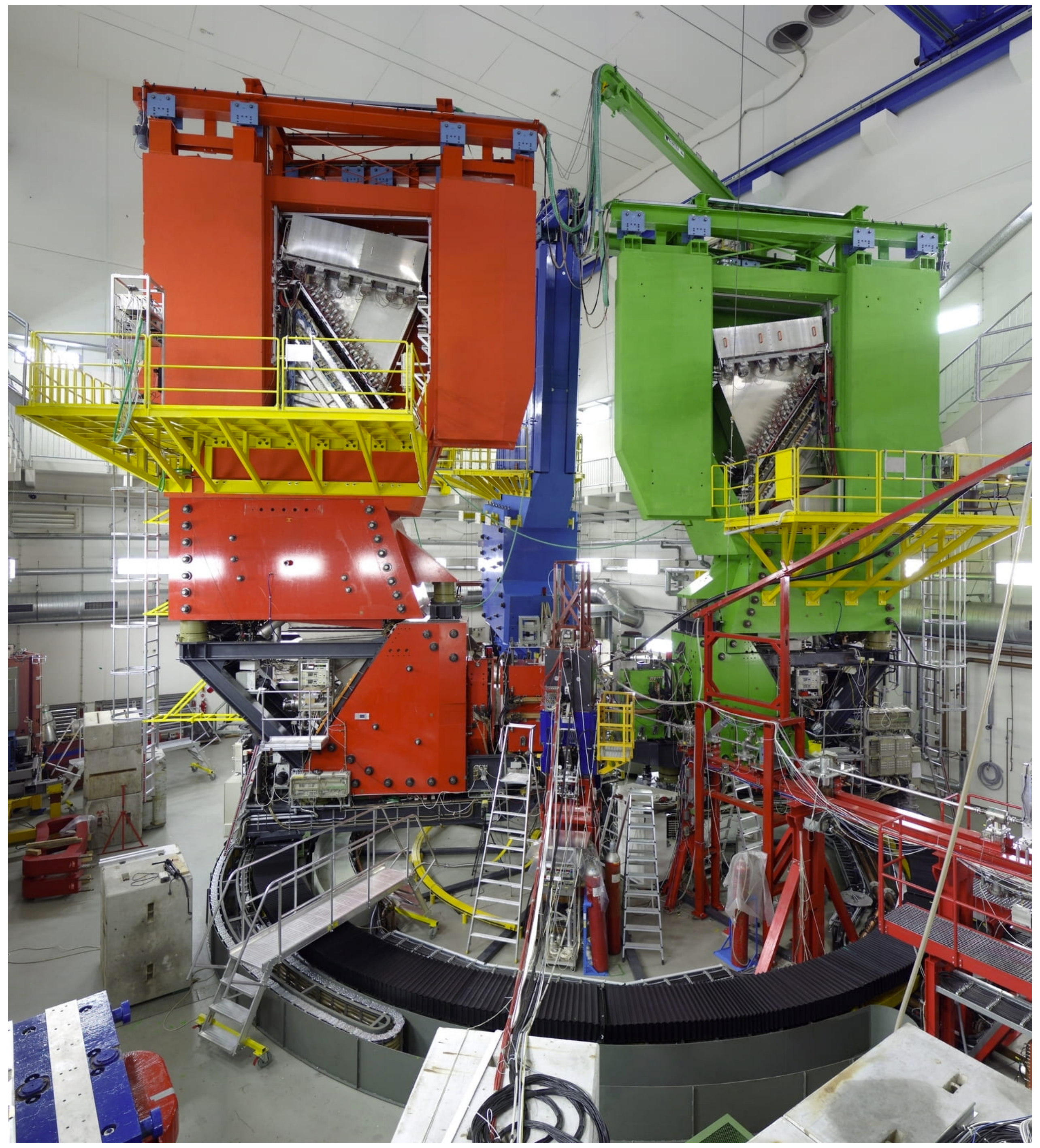
The MAMI Accelerator Facility



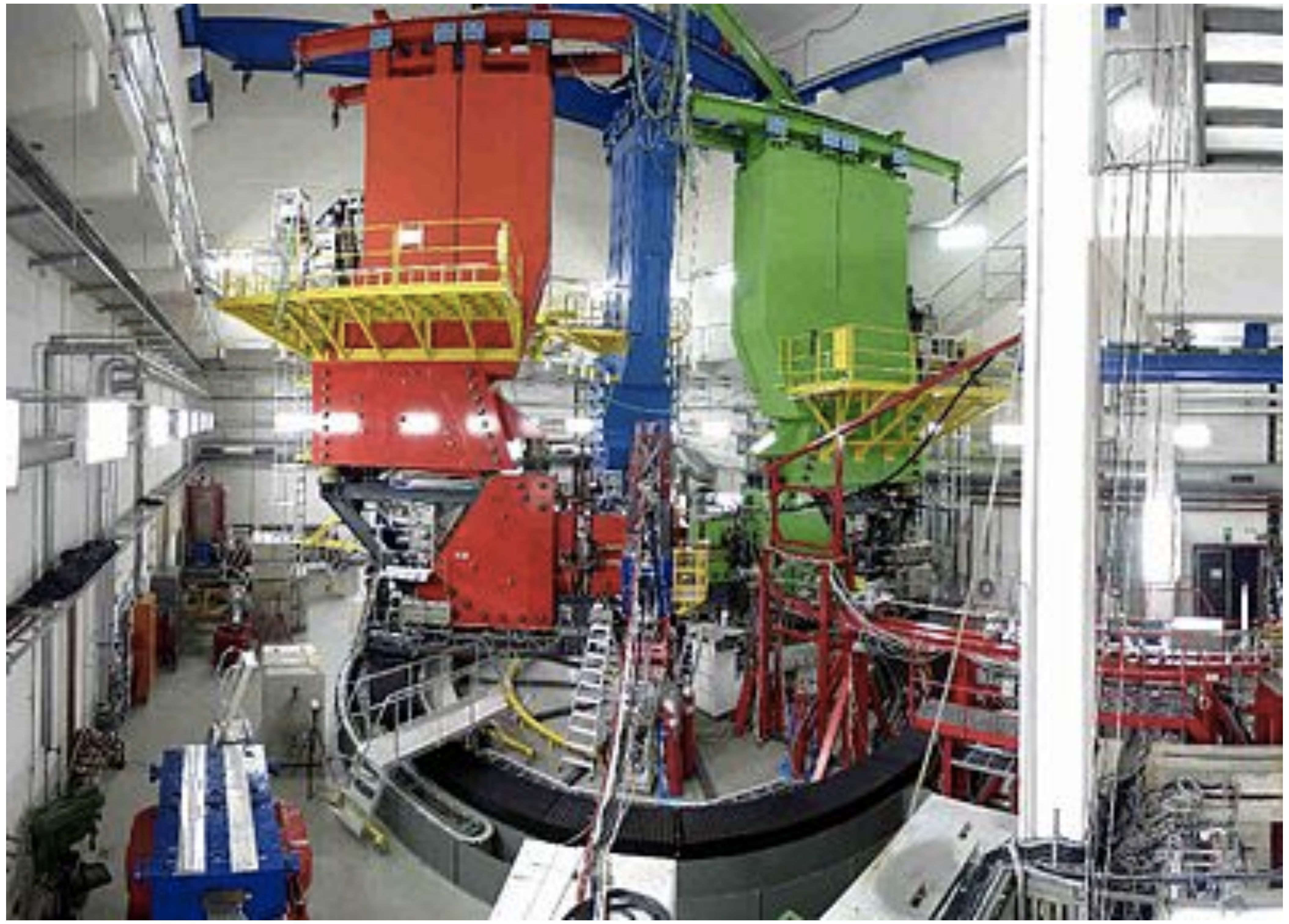
MESA

Mainz
Energy-recovery
Superconducting
Accelerator

A1 Collaboration
3-Spectrometers Setup

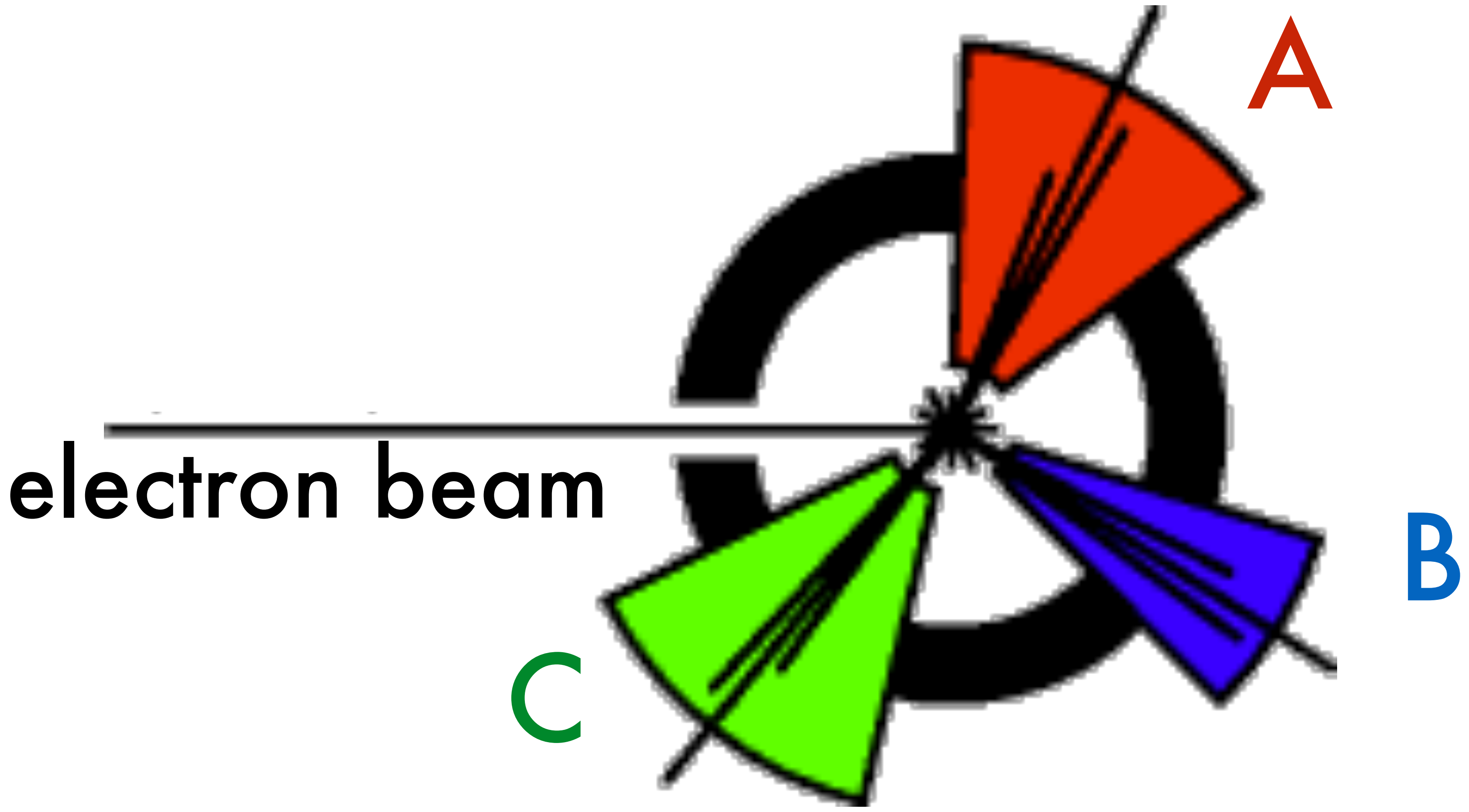


A1 Collaboration

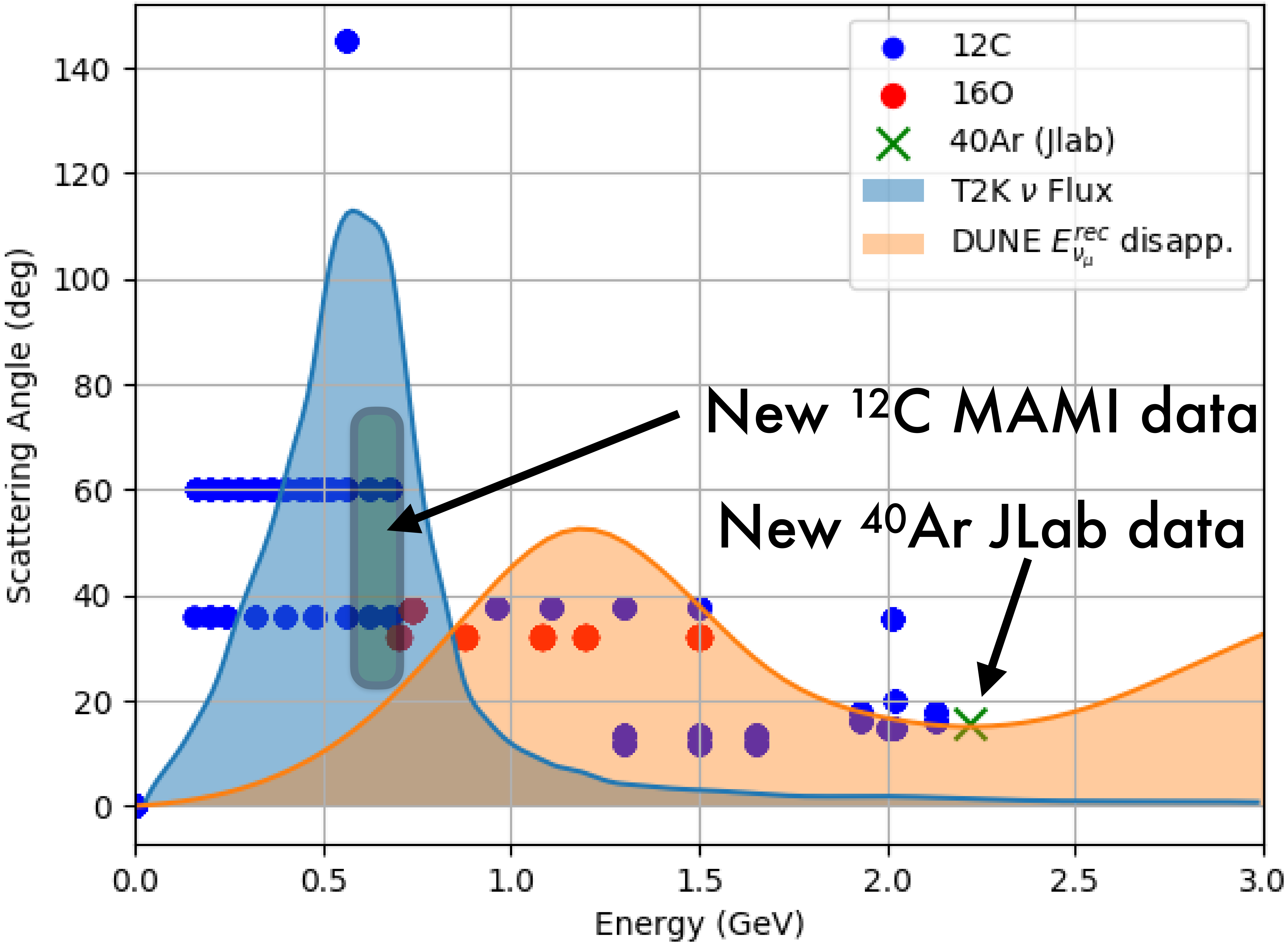


Spectrometers

	A	B	C
Configuration	QSDD	D	QSDD
Max.Momentum (MeV)	735	870	551
Solid Angle (msr)	28	5,6	28
Mom. Resolution	10^{-4}	10^{-4}	10^{-4}
Pos. Res at Target (mm)	3-5	1	3-5

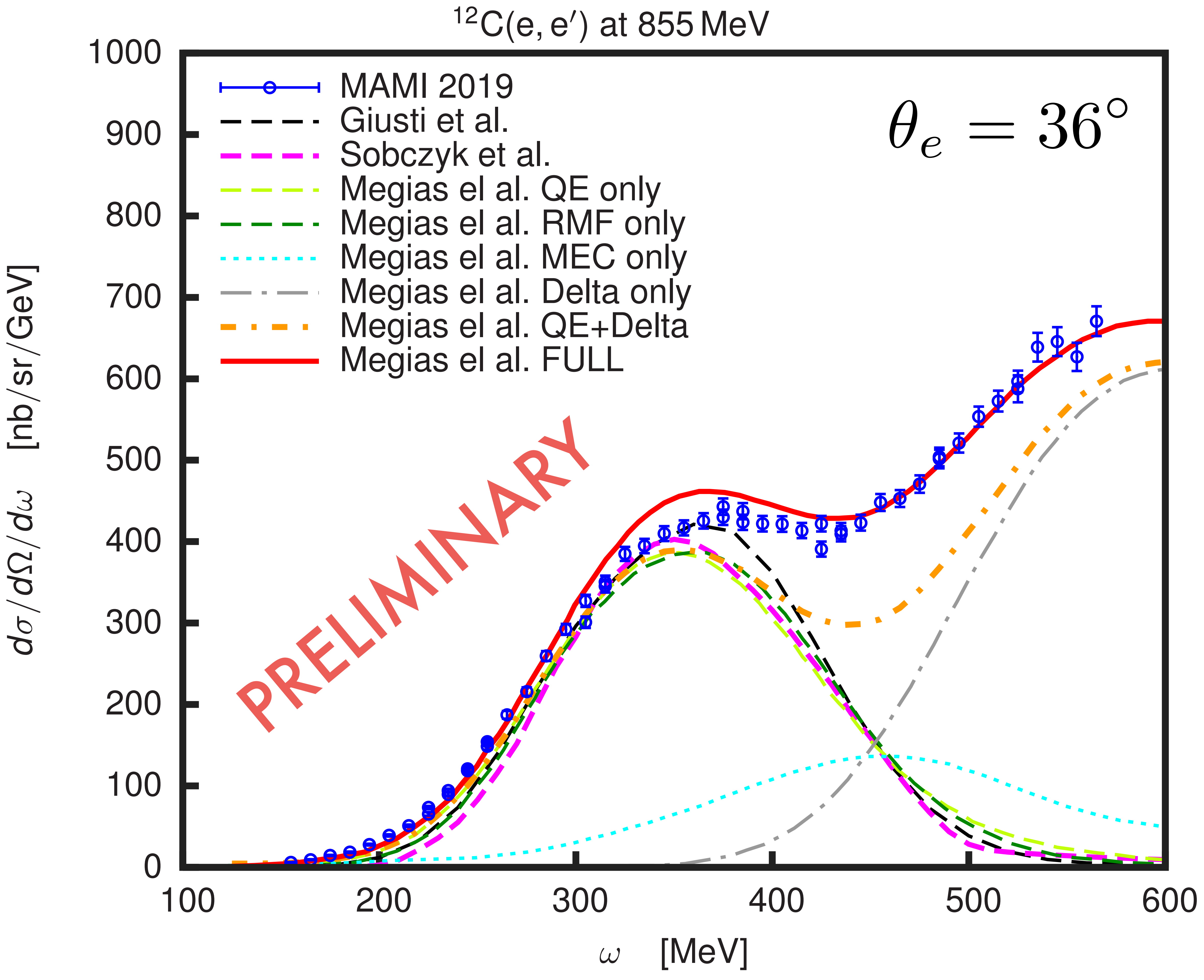


Electron Scattering: Existing Dataset

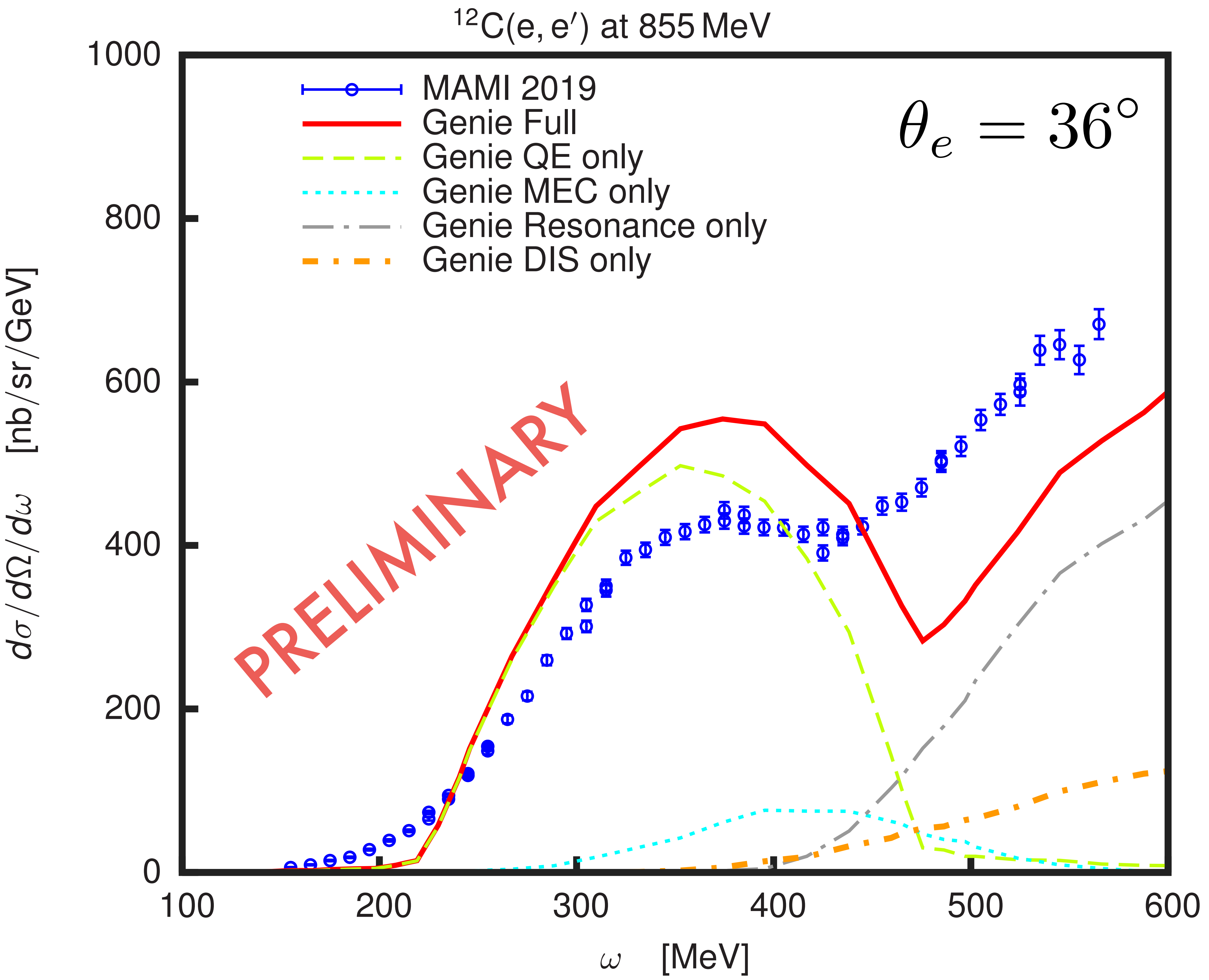


MAMI ^{12}C data

M. Mihovilovic (J.Stefan Inst.)

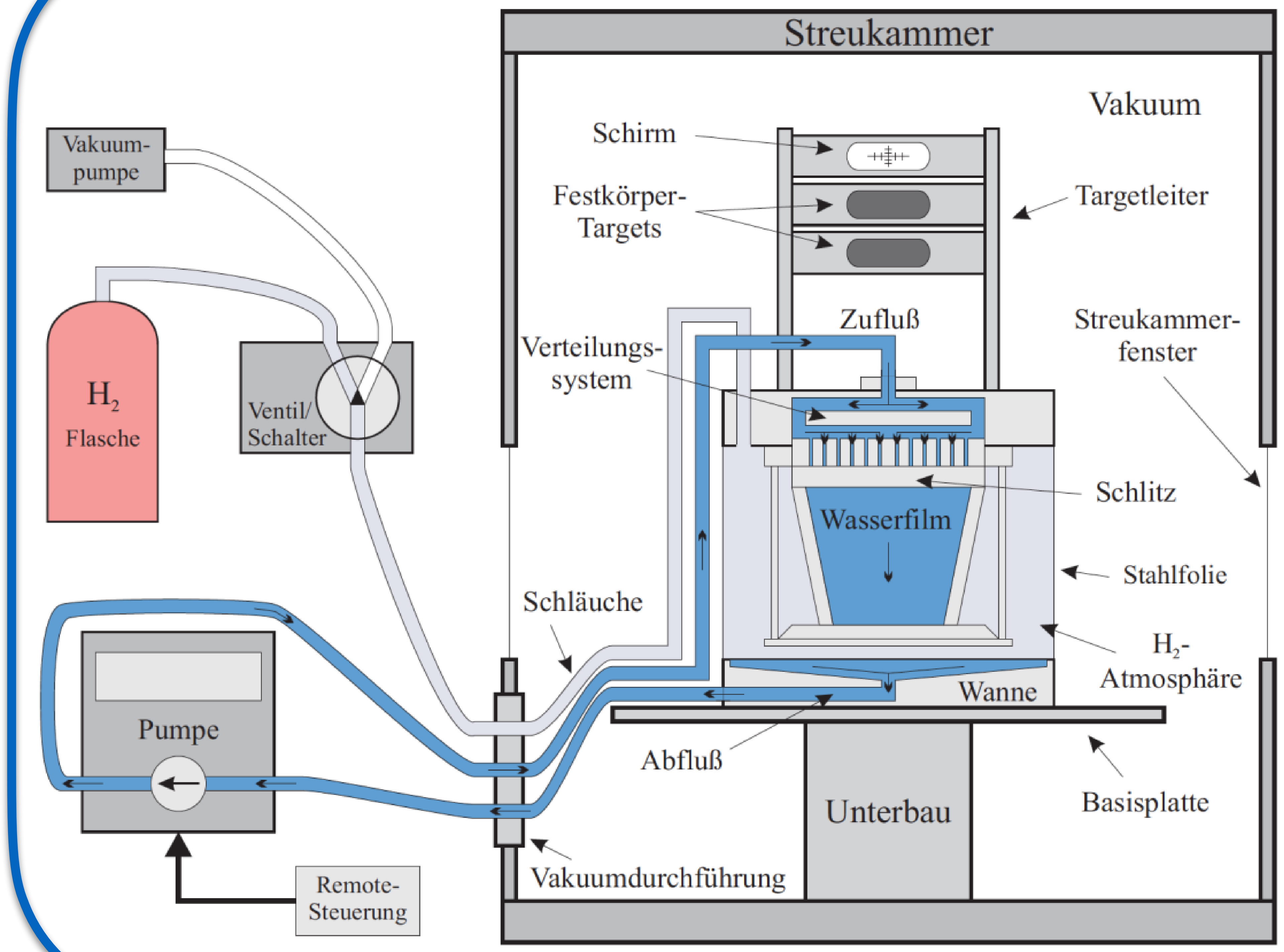


GENIE (2.x tune) calculation kindly from A.Ankowski



In the near future: Oxygen and Argon

Waterfall target



Cluster-jet Target

- Window-less targets: backgrounds reduction
- Exclusive measurements possible

Summary

Contribute to next generation LB neutrino physics program

* Neutrinos are a concrete case of new physics, top priority in particle/fundamental physics
* MAMI + A1 well suited for precision measurements of eN cross sections
* More ^{12}C data to analyze: L/T separation, Coulomb sum rule, ...

In the future

* Measurements on Argon and Oxygen with a Jet Target
* Exclusive measurements, pion production, ...
* MESA: precision low energy eN scattering (an opportunity for SN neutrinos?)
* Complementary to the JLab program