# Event generation of coherent Deeply Virtual Compton Scattering off $^4$He: status report

Exclusive Reactions Working Group

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## OUR MODEL

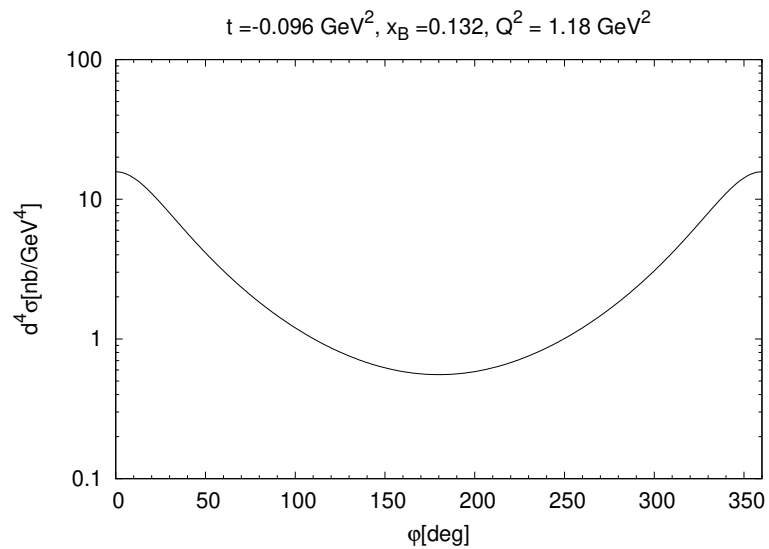
- Leading twist study
- Impulse approximation to the handbag approximation
  - Only nucleonic degrees of freedom
  - No final state interactions
- $^4$He $\longrightarrow$ one chiral even GPD
  - Convolution between nuclear ingredients ( realistic potential) and nucleonic GPD (GK11)
  - Recover of the proper forward limit
- The following results come from **S. Fucini, S.Scopetta, M. Viviani, PRC 98 (2018) 015203**

# Remarks of our model

$$\frac{d^{4\lambda}\sigma}{dx_A dt dQ^2 d\phi} = \frac{\alpha^3 x_A y^2}{8\pi Q^4 \sqrt{1+\epsilon^2}} \frac{|\mathcal{A}|^2}{e^6}$$

$$x_A = \frac{Q^2}{2M_A\nu}; \qquad \epsilon = \frac{2M_A x_A}{Q};$$

$$T^2_{BH} \propto F^2_A(t)$$
$$T^2_{DVCS} \propto \Im m\mathcal{H}^2 \text{ and } \Re e\mathcal{H}^2$$
$$I^{\lambda}_{BH-DVCS} \propto F_A(t)\Im m\mathcal{H}$$



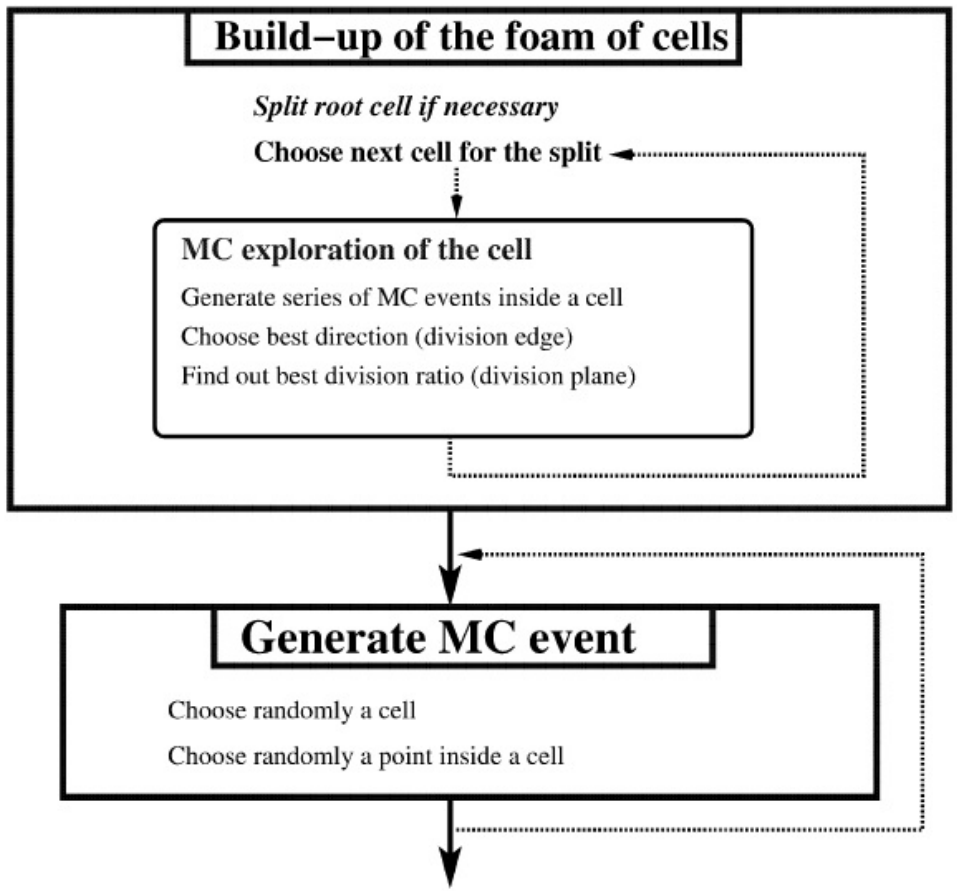
# Monte Carlo event generator (S.F., S. Scopetta, R. Dupré): TOPEG

*State of art in May 2020*

- We are using **FOAM** library well integrated in ROOT
- We correctly generate events using the simple parametrization for the DVCS cross section off the $^4$He nucleus used by CLAS collaboration in the EG6 experiment analysis
- Our original Fortran program is quite slow $\longrightarrow$ link C++ and Fortran;
  optimize the integrations in order to reduce the execution time (one kinematic point $\approx$ 50 seconds with my PC).
  **Now, (one kinematic point $\approx$ 2-3 seconds with my PC)**

# FOAM: some remarks

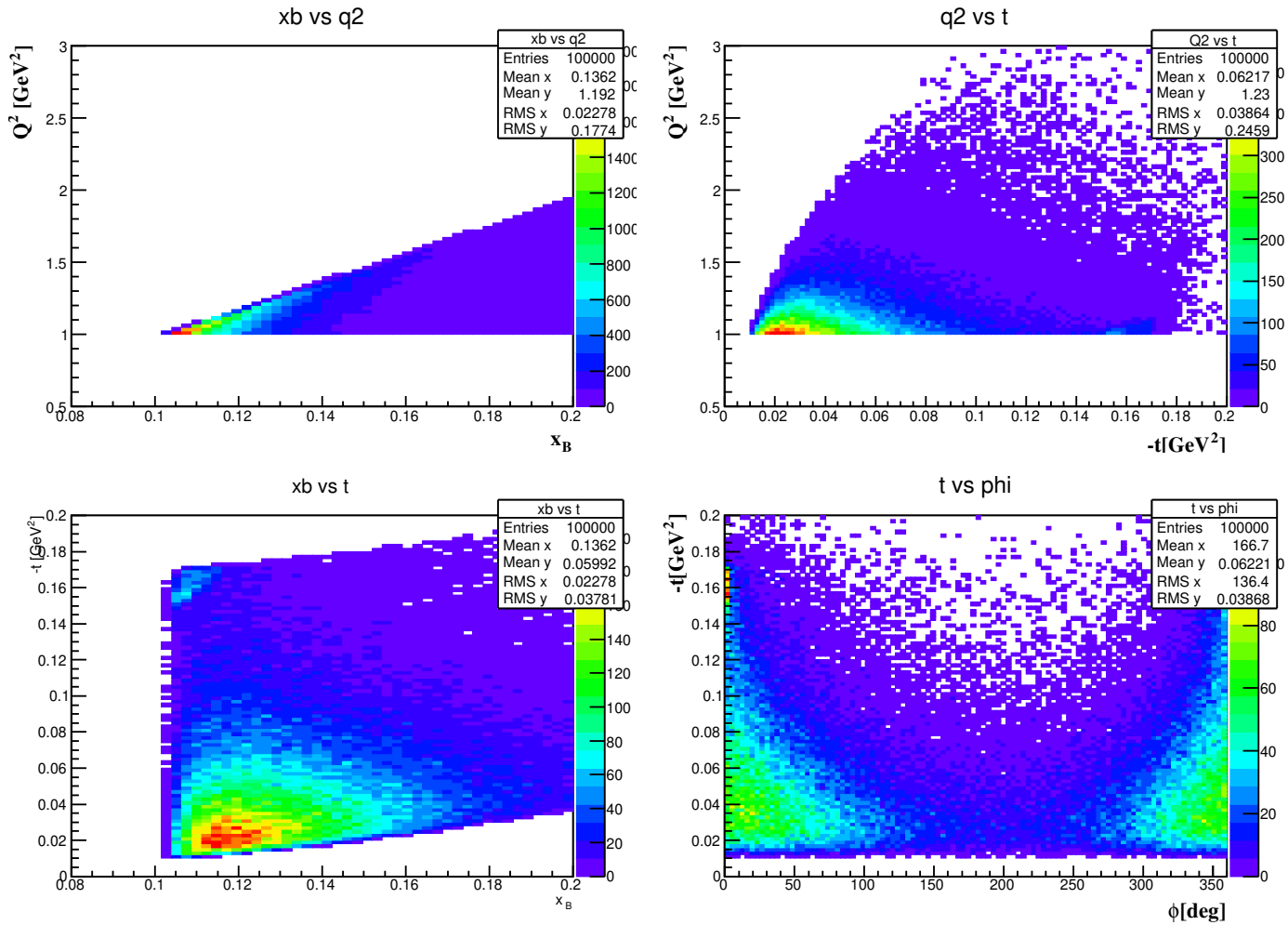
Two stages in the cellular algorithm of FOAM. Figure from **S. Jadach, Computer Physics Communications 152 (2003).**



# JLab 6: 2D distributions

**100k** events without the real part of the CFFs

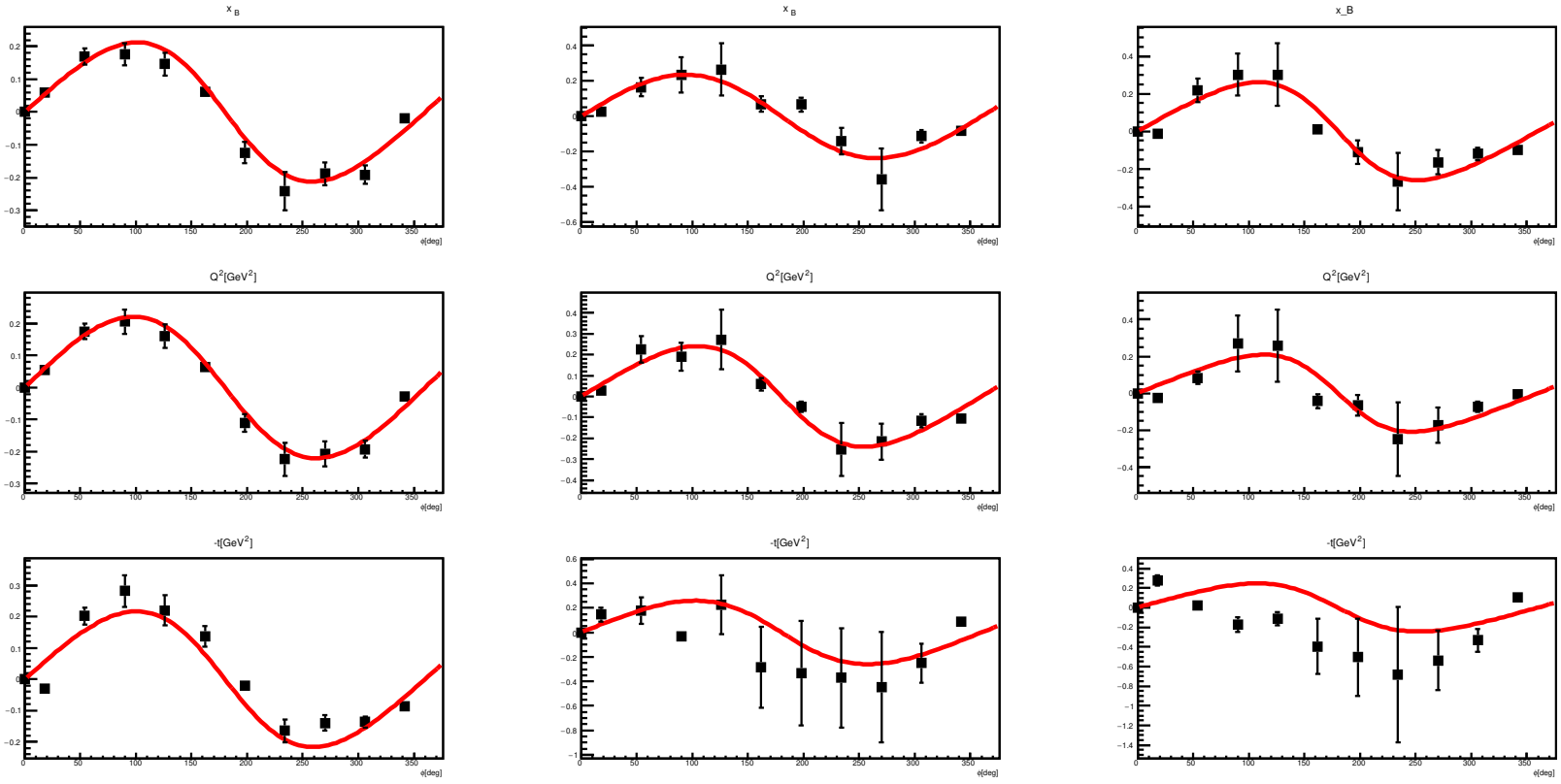
$Q^2 \in [1:4] GeV^2; y \in [0.15:0.85]; |t|_{range} = 0.16 Gev^2;$



# JLab 6: validation

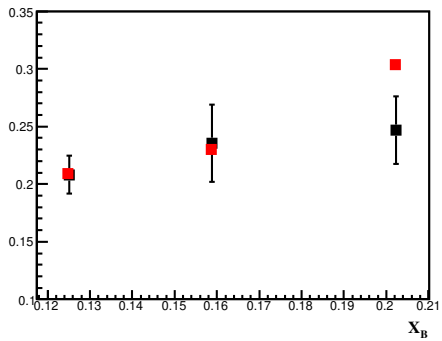
$N^{\pm}$ obtained with TOPEG (10k points)

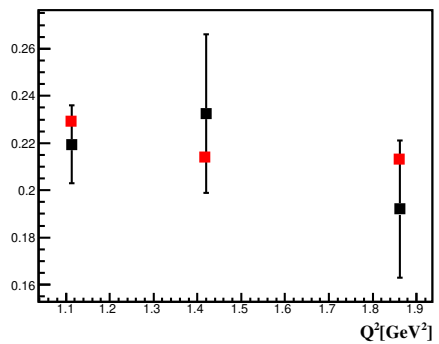
$$A_{LU} = \frac{N^+ - N^-}{N^+ + N^-} \longrightarrow \text{Fitting function} : A_{LU}(\phi) = \frac{\alpha \sin\phi}{1 + \beta \cos(\phi)}$$

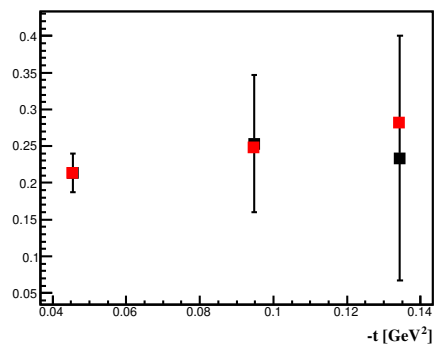


# JLab 6; validation of the BSA

$$A_{LU}(\phi) = \frac{\alpha \sin\phi}{1 + \beta \cos(\phi)} \longrightarrow A_{LU}(90^o) \equiv \alpha$$



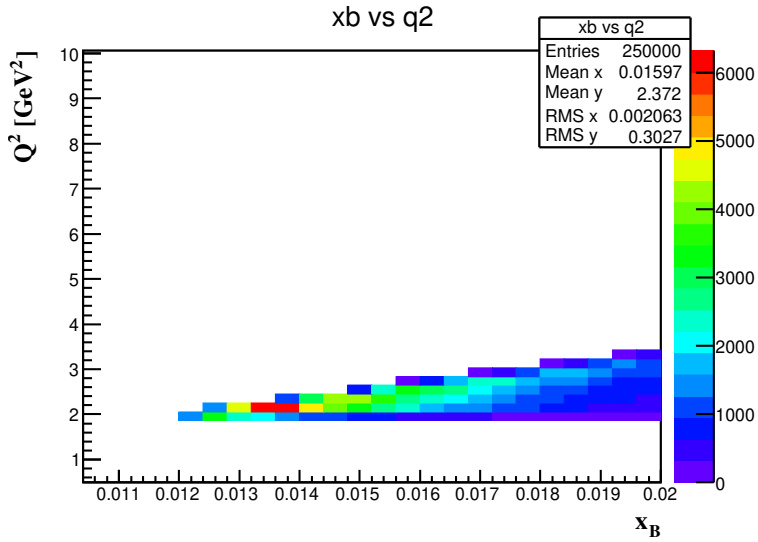



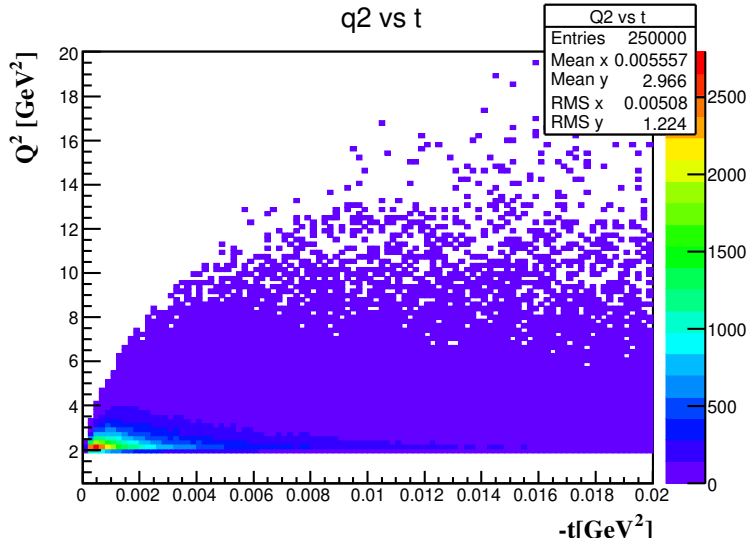

Differences between our theoretical results (red squares) and the results from TOPEG analysis (black squares) ranges between few percent up to 20 percent

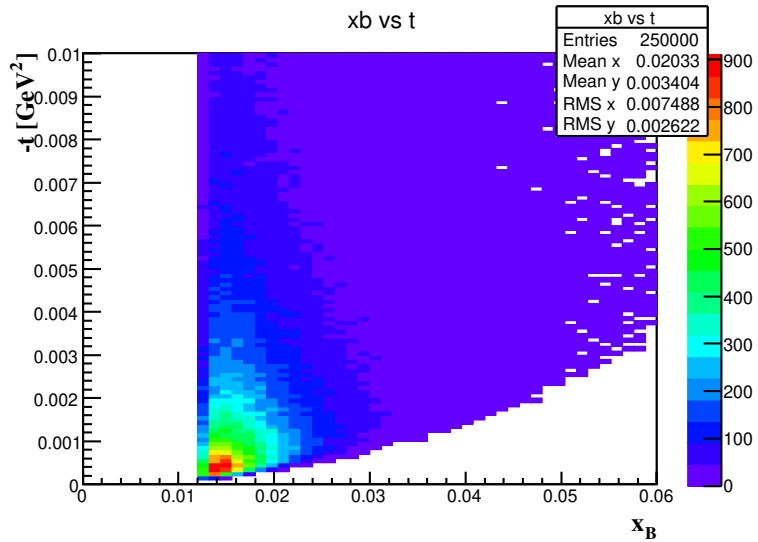
**WARNING: THE PLOTS SHOWN IN THE FOLLOWING ARE PRELIMINARY RESULTS!**

# EIC $^4$He -e: 41 GeV - 5GeV

**250k** events; $Q^2 \in [2 : 25] GeV^2$;
$y \in [0.1 : 0.8]$; $|t|_{range} = 0.22\, GeV^2$

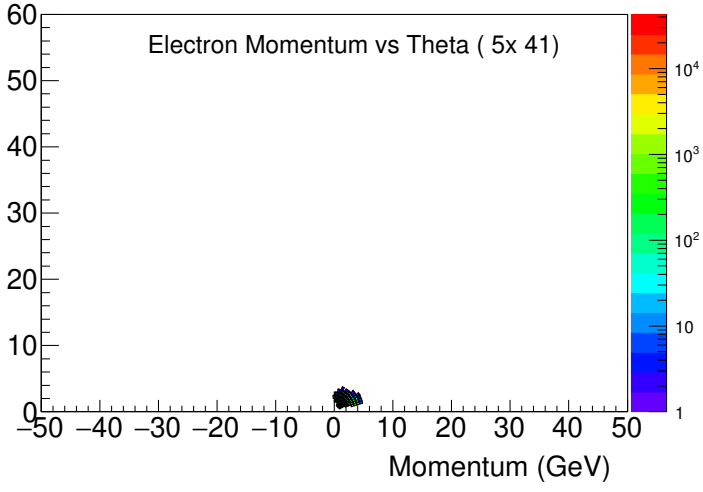


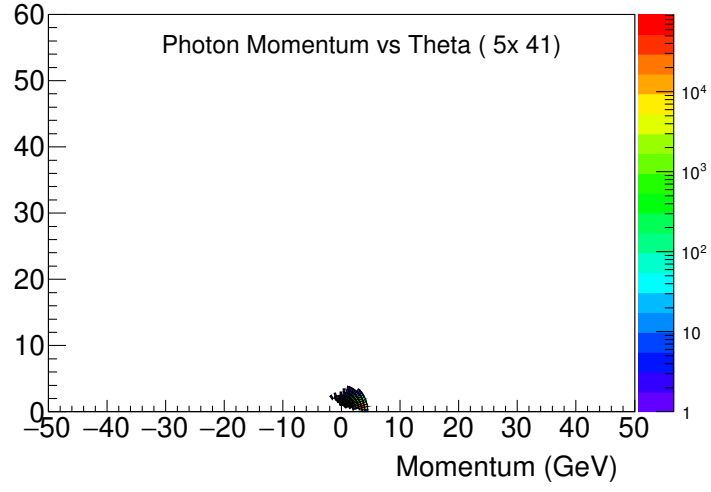



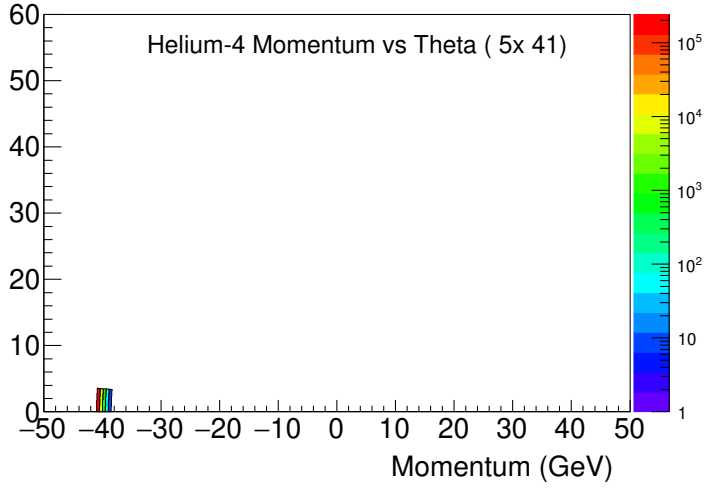



# **EIC $^4$He -e: 41 GeV - 5 GeV**: momentum vs angle

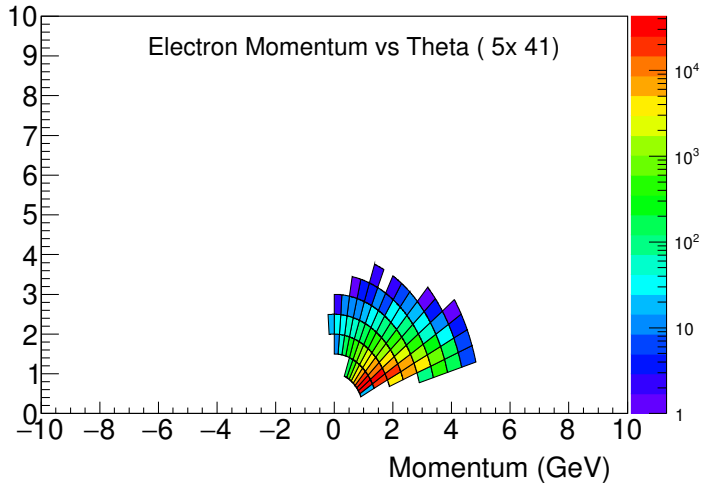
**250k** events $Q^2 \in [2 : 25] GeV^2$;
$y \in [0.1 : 0.8]$; $|t|_{range} = 0.22\, GeV^2$

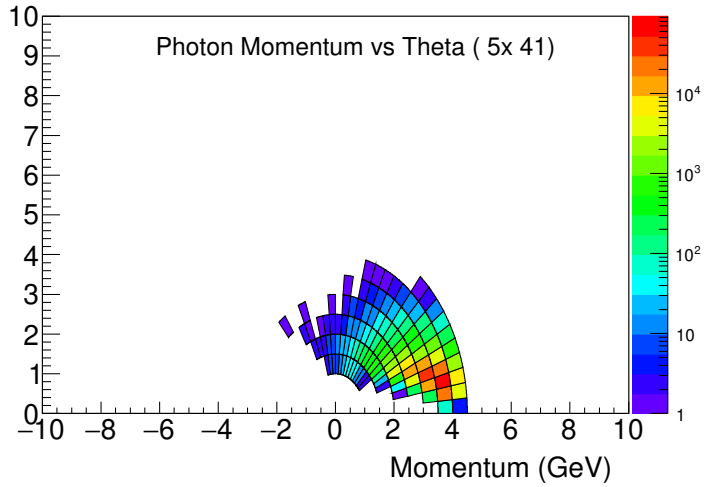


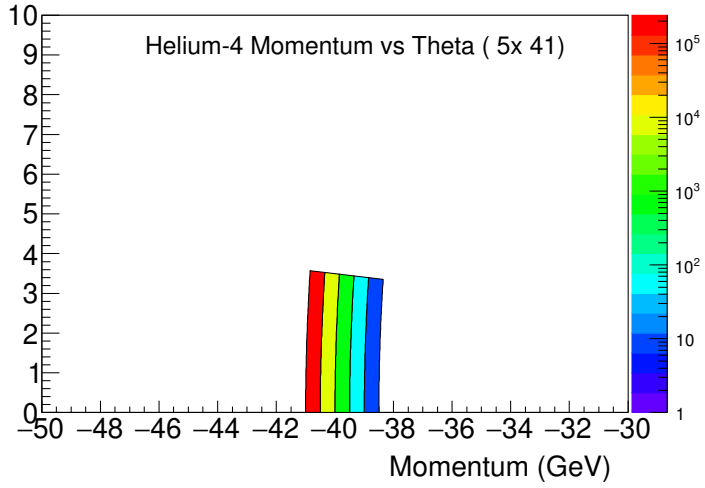



# **EIC $^4$He -e: 41 GeV - 5 GeV** :momentum vs angle



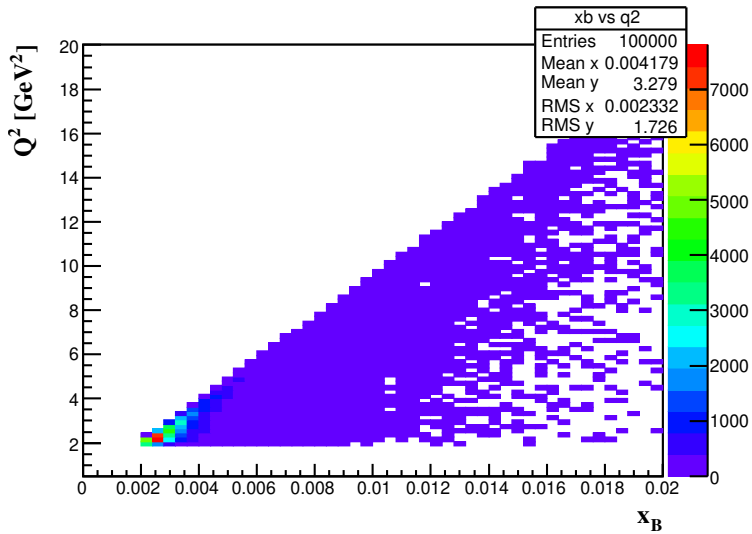



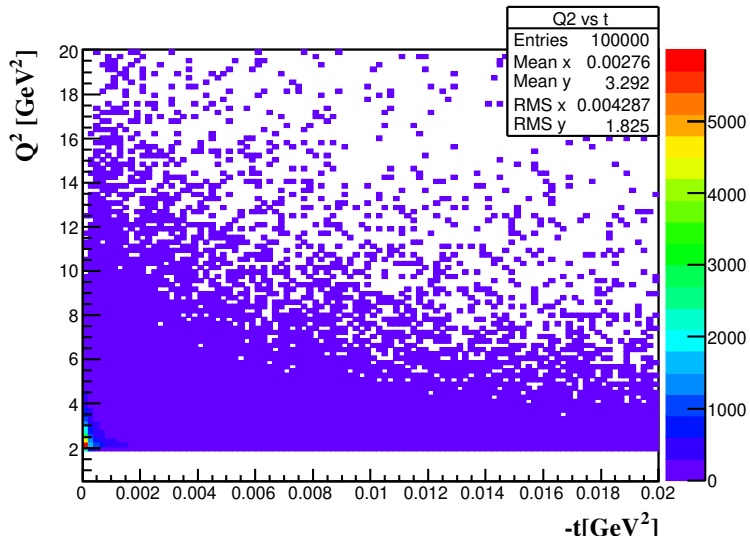



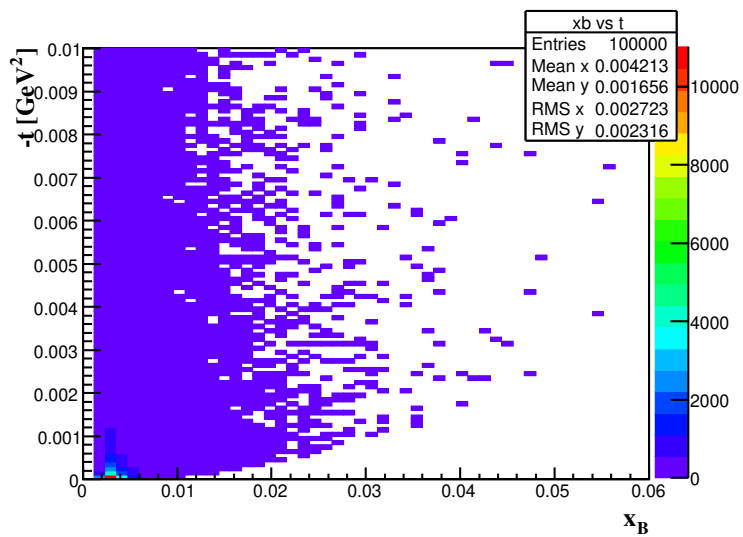

**250k** events $Q^2 \in [2:25] GeV^2; y \in [0.1:0.8]; |t|_{range} = 0.22 Gev^2$

# EIC $^4$He -e: 110 GeV - 10 GeV

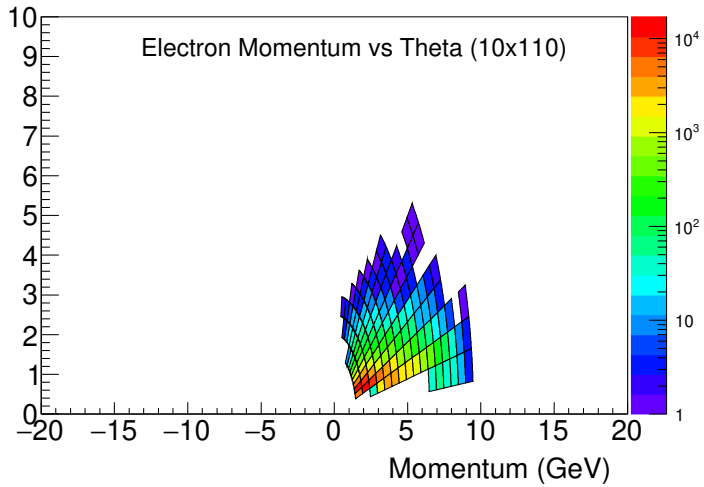
**100k** events $Q^2 \in [2 : 40] GeV^2$; $y \in [0.05 : 0.85]$;
$|t|_{range} = 0.20 GeV^2$

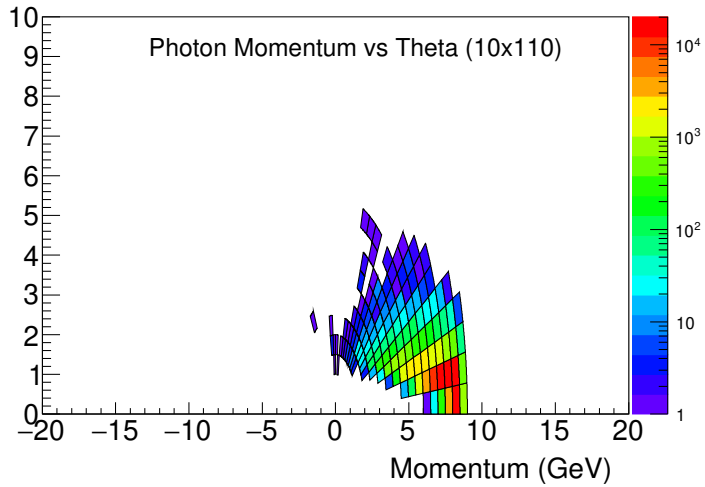


# **EIC $^4$He -e: 110 GeV - 10 GeV**: momentum vs angle

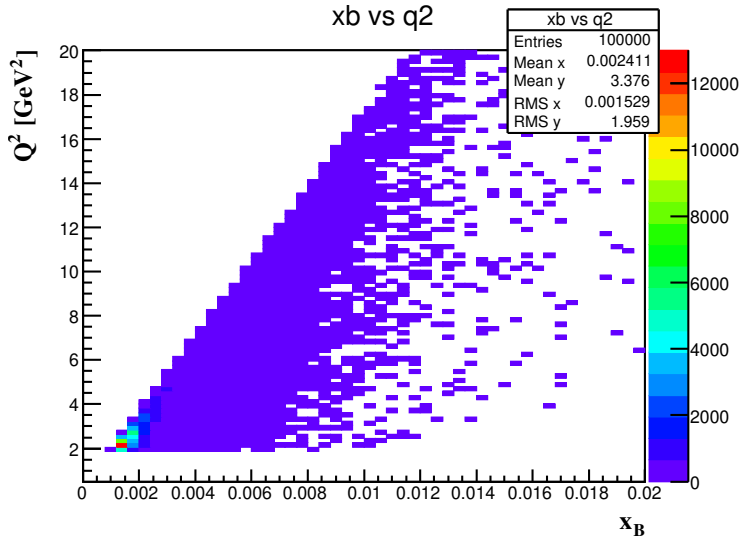


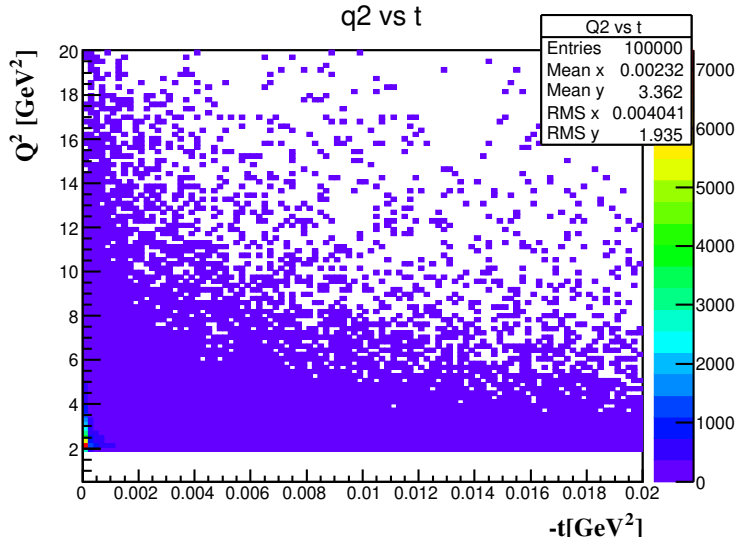



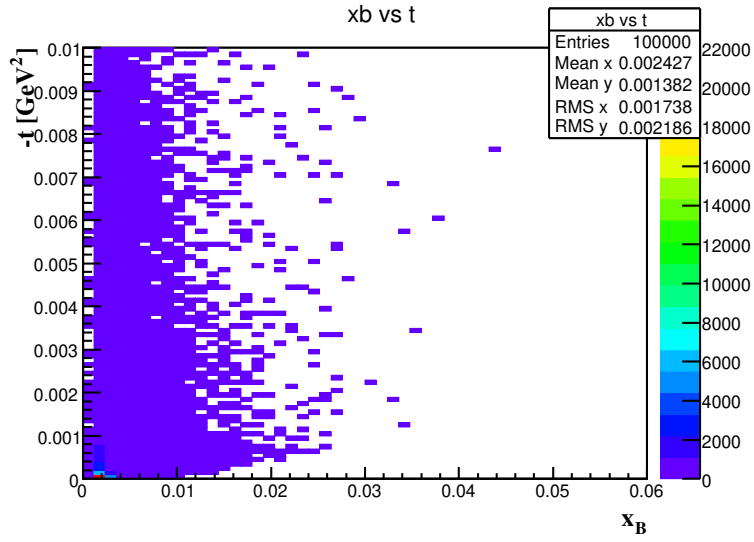

**100k** events $Q^2 \in [2 : 40] GeV^2$;

$y \in [0.05 : 0.85]; |t|_{range} = 0.20 GeV^2$

# EIC $^4$He -e: 110 GeV - 18 GeV

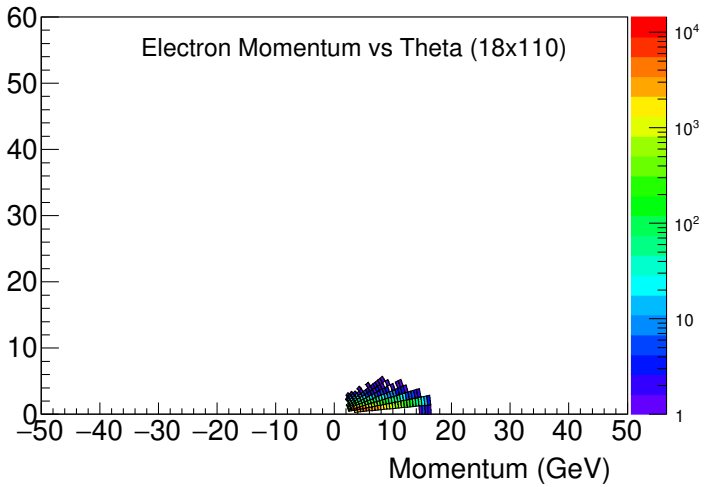


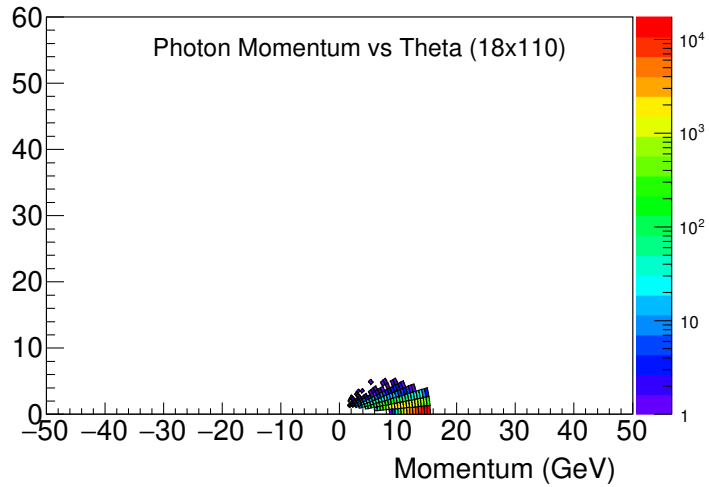




**100k** events $Q^2 \in [2:50] GeV^2; y \in [0.1:0.85]; |t|_{range} = 0.20$ GeV$^2$;

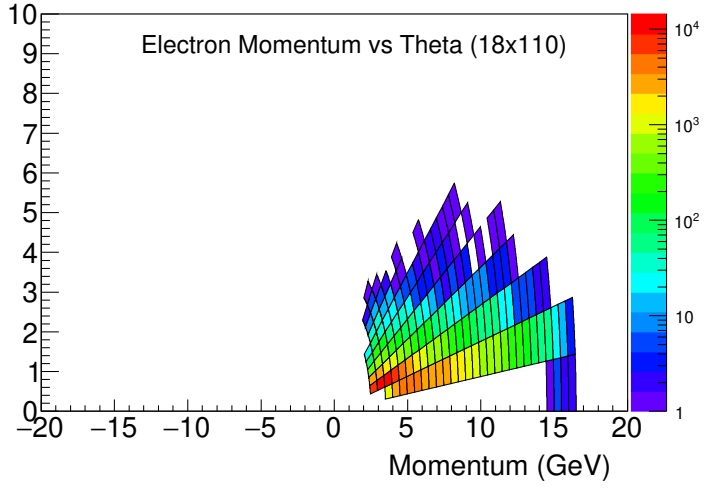
# EIC $^4$He -e: 110 GeV - 18 GeV

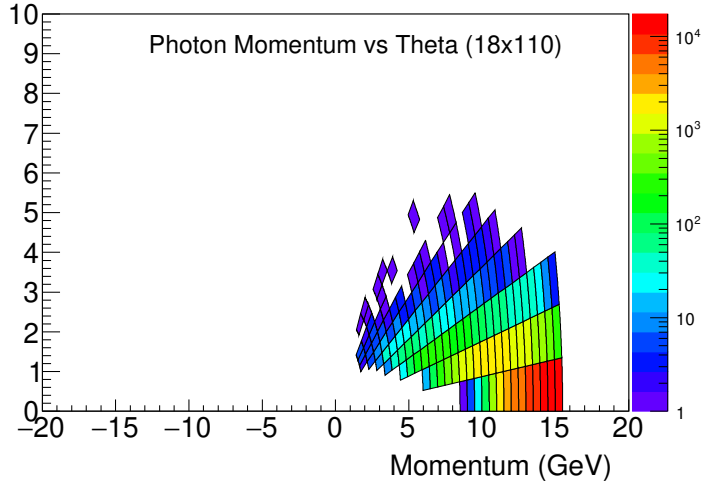



**100k** events $Q^2 \in [2 : 25] GeV^2$;
$y \in [0.1 : 0.8]; |t|_{range} = 0.22 GeV^2$

# **EIC $^4$He -e: 110 GeV - 18 GeV**: momentum vs angle




**100k** events $Q^2 \in [2 : 25] GeV^2$; $y \in [0.1 : 0.8]$;
$|t|_{range} = 0.22 GeV^2$

# Conclusions

A new event generator, based on the FOAM library, that is:

- flexible; different **light nuclei** like d, $^3$He, $^4$He, **different setups** (fixed target, collider)
- **open** (different available models to be implemented)
- validation within the JLab 6 configuration $\longrightarrow$ Fixed target kinematics!

- **We are close tag the 1$^o$ version!**

# What's next?

- Complete simulation of the EIC detectors taking into account all the experimental environment (collaboration with M. Hattawy $\longrightarrow$ Tomography ? )
- Tune the number of events to match the requested value of the integrated luminosity
- Other checks for the $t_{range}$
- Introduce the incoherent channel for the DVCS off $^4$He and the DVCS off free proton ; implement the coherent DVCS off $^3$He