

Электророждение пионов на протоне (детектор CLAS12)

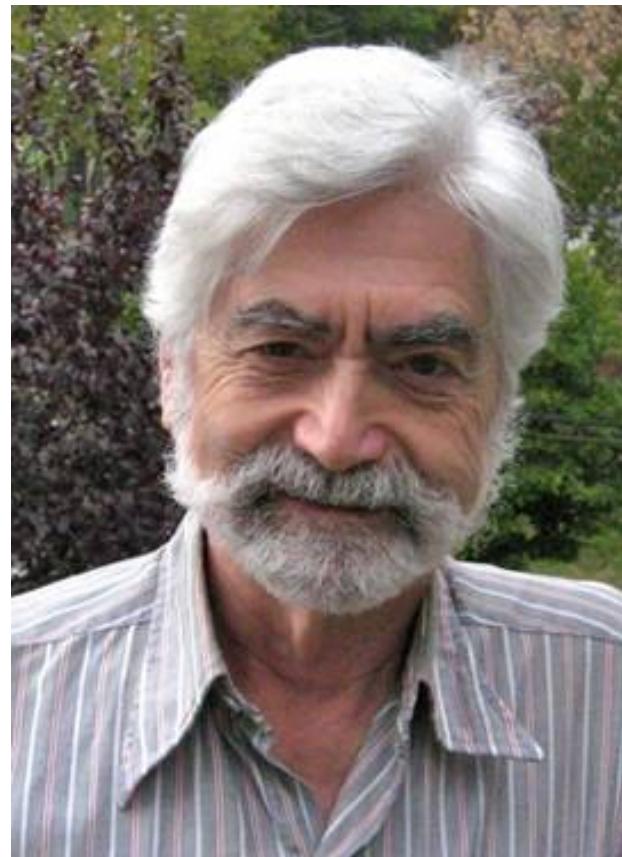
вед.инженер
Голубенко Анна Александровна



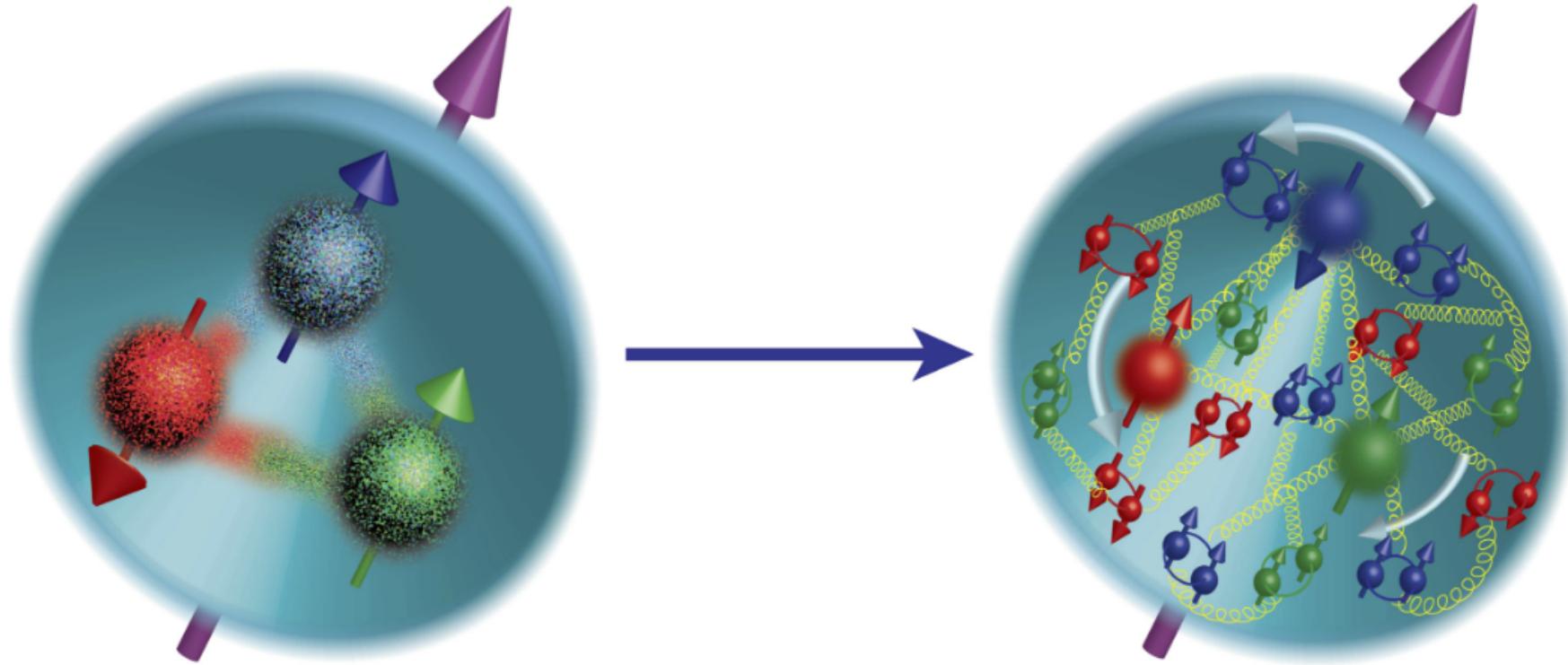
Кварковая структура нуклонов (1964)



Мюррей Гелл-Ман

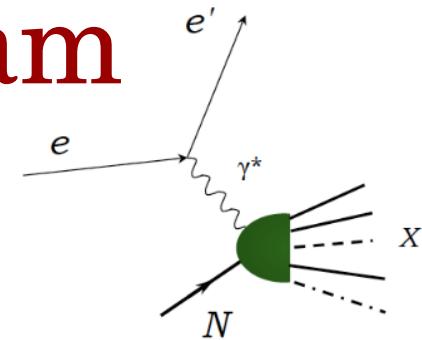
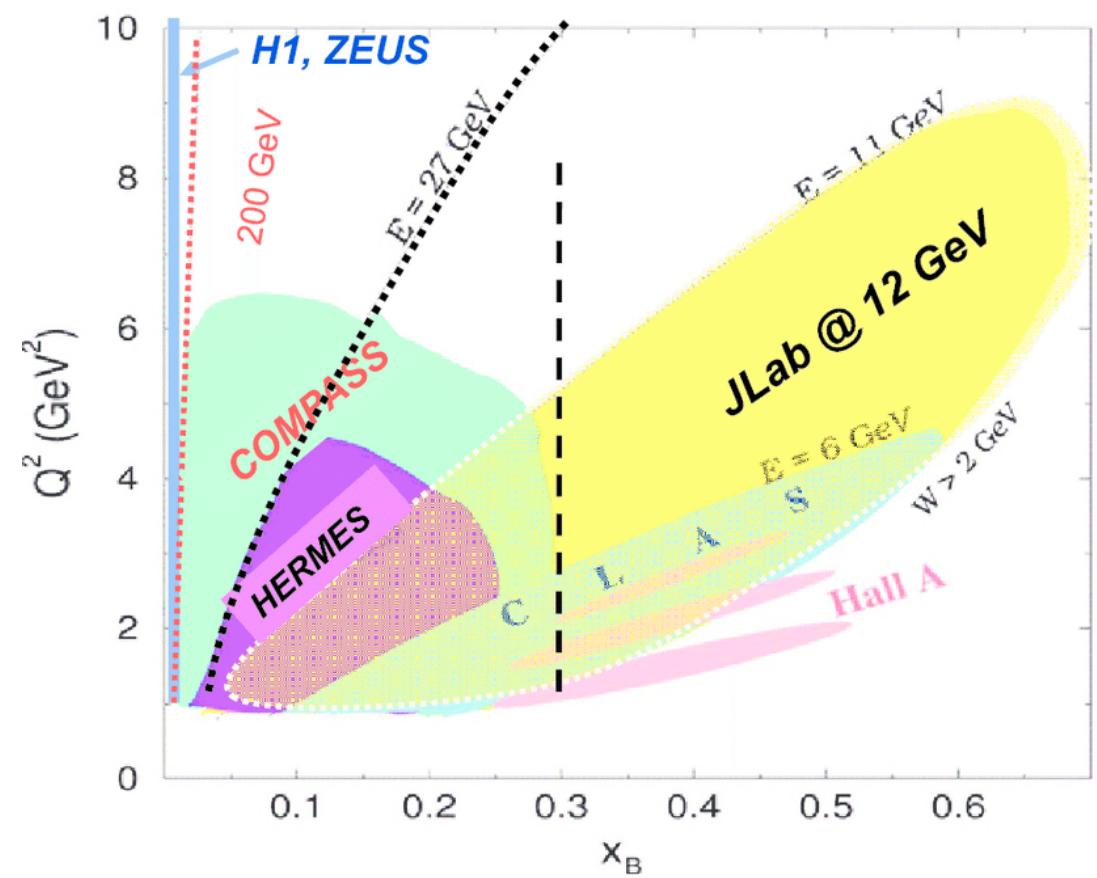
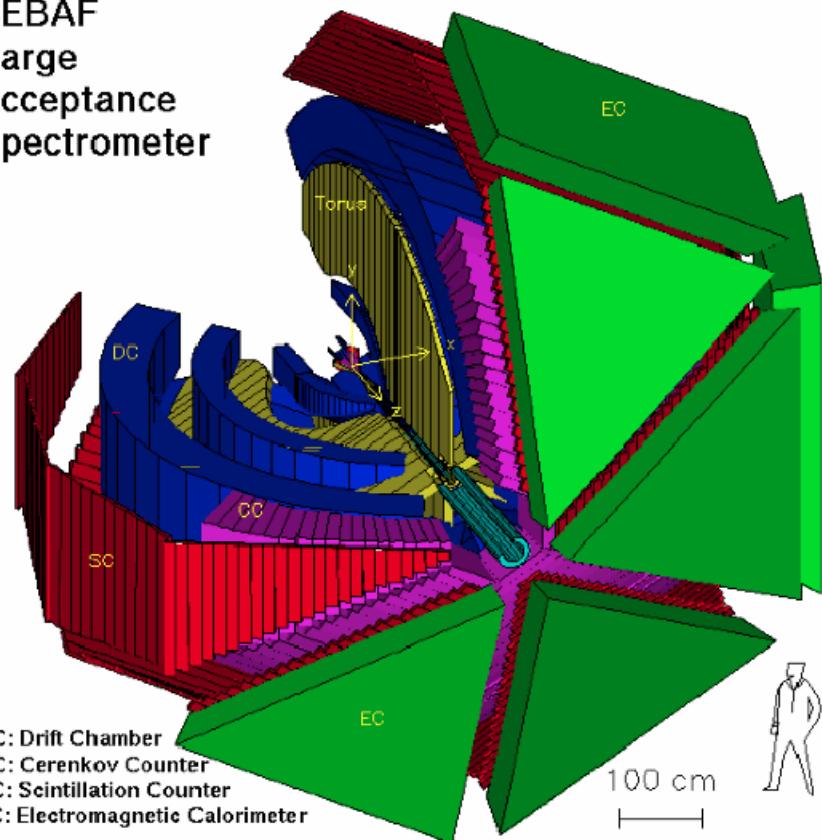


Джордж Цвейг

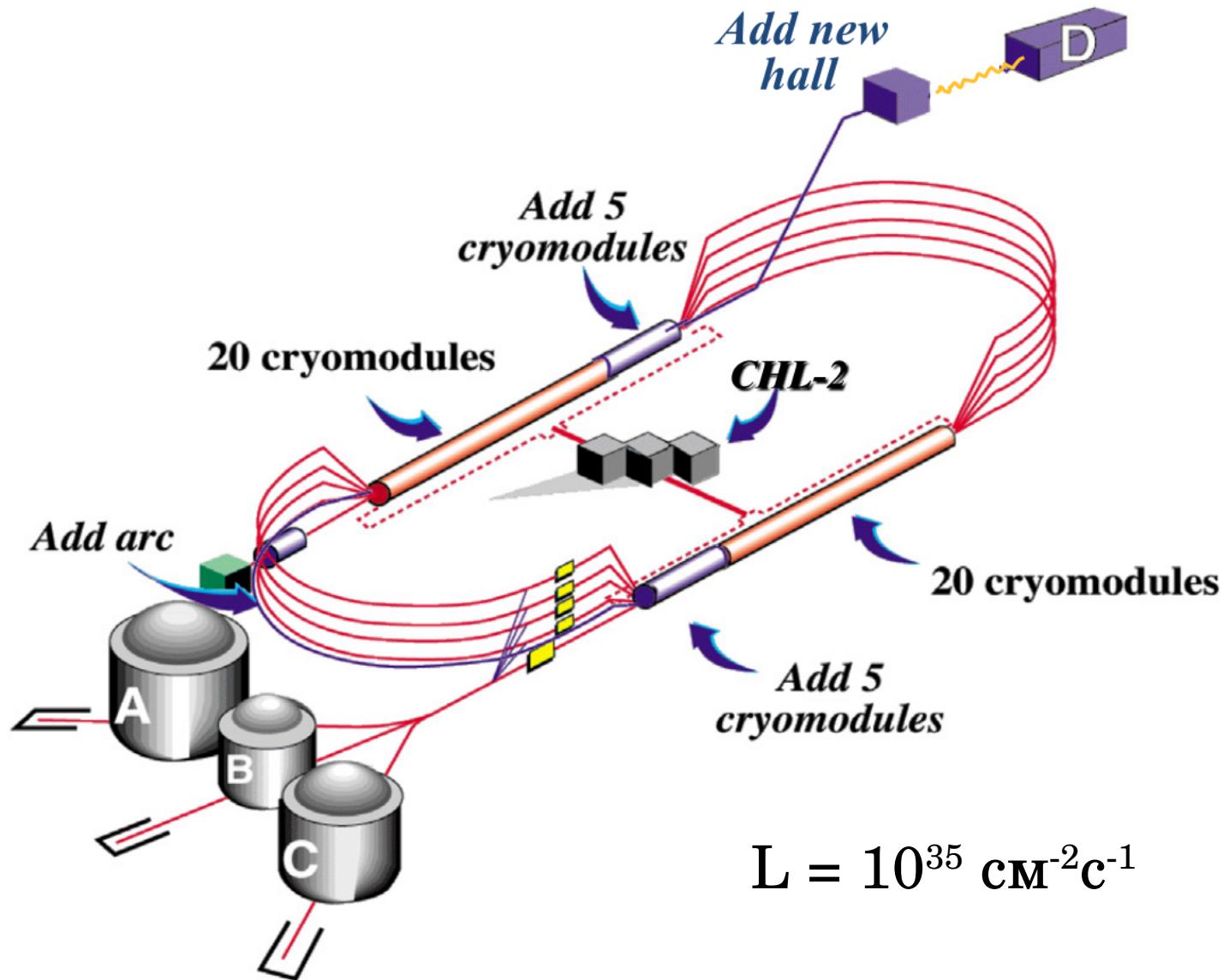


CLAS: The 6 GeV Program

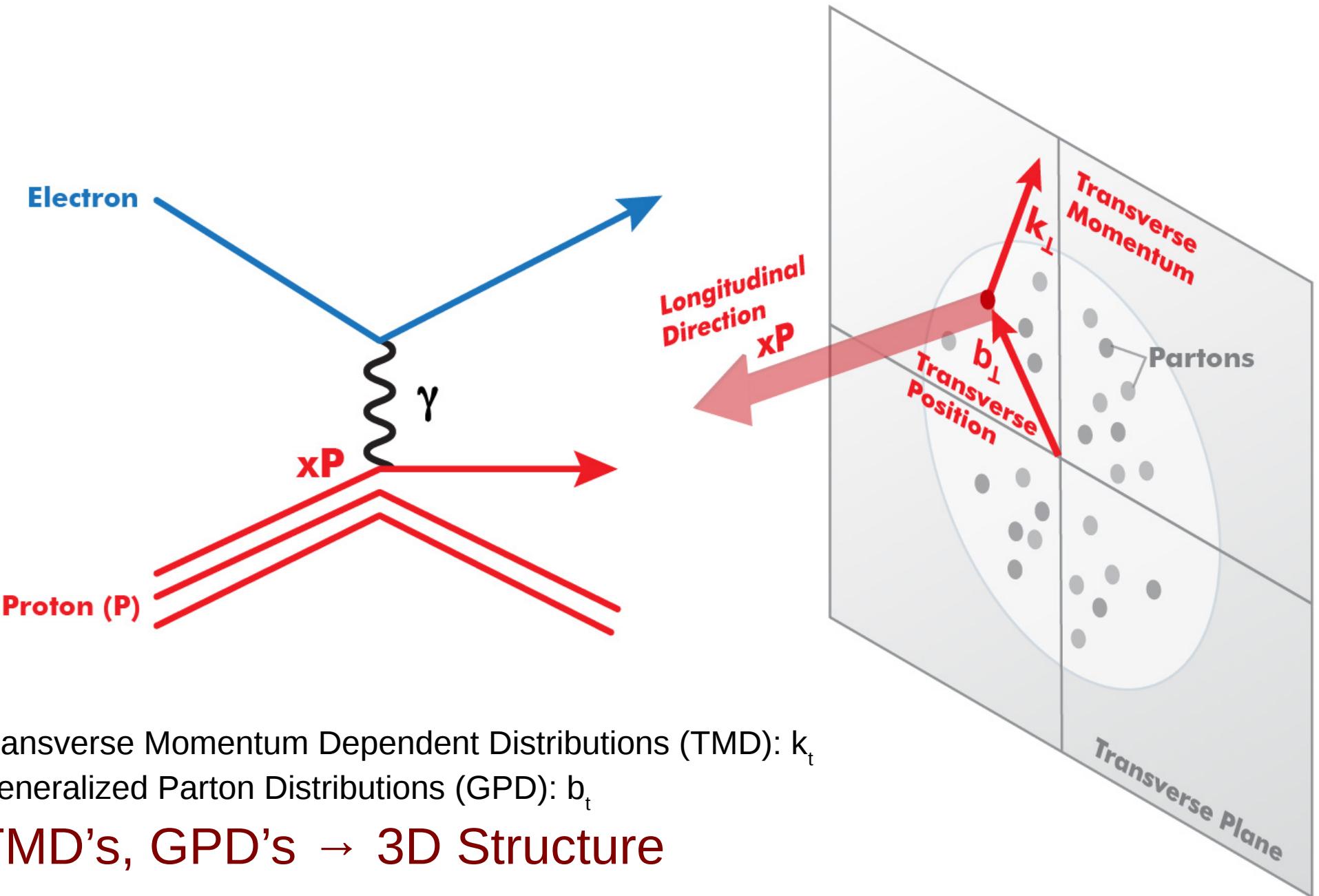
CEBAF
Large
Acceptance
Spectrometer



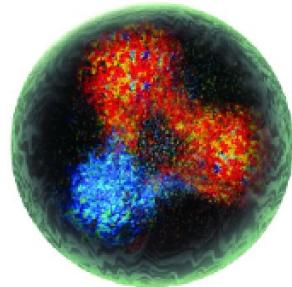
Continuous Electron Beam Accelerator Facility (CEBAF)



3D структура протона



Изучение обобщенных партонных распределений

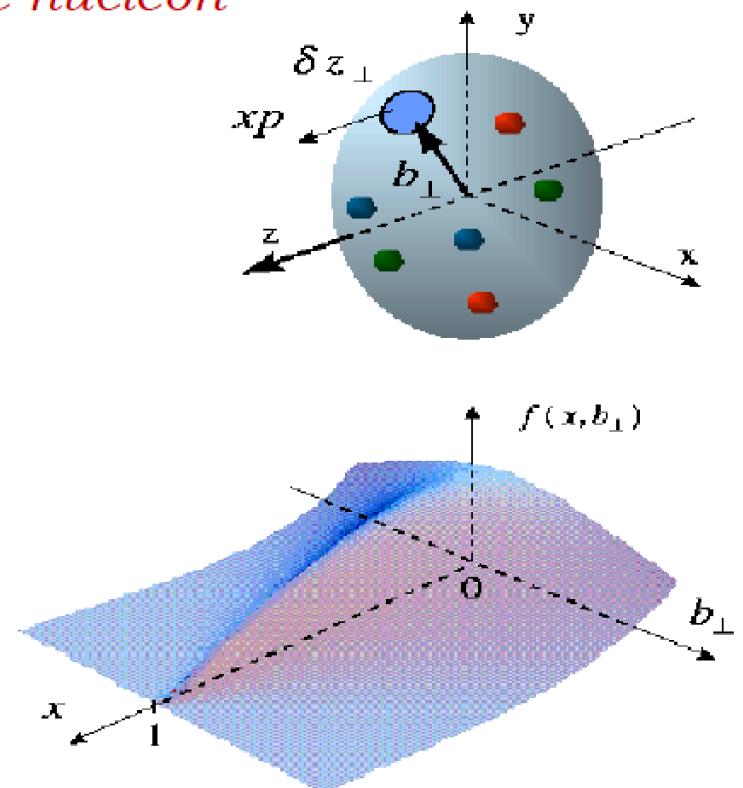


*Wigner function:
full phase space parton
distribution of the nucleon*

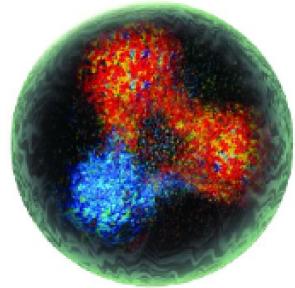
$$\int d^2 k_T$$

Generalised Parton
Distributions (GPDs)

- relate, in the infinite momentum frame, transverse position of partons (b_\perp) to longitudinal momentum (x).
- * Deep exclusive reactions, e.g.: Deeply Virtual Compton Scattering, Deeply Virtual Meson production, ...



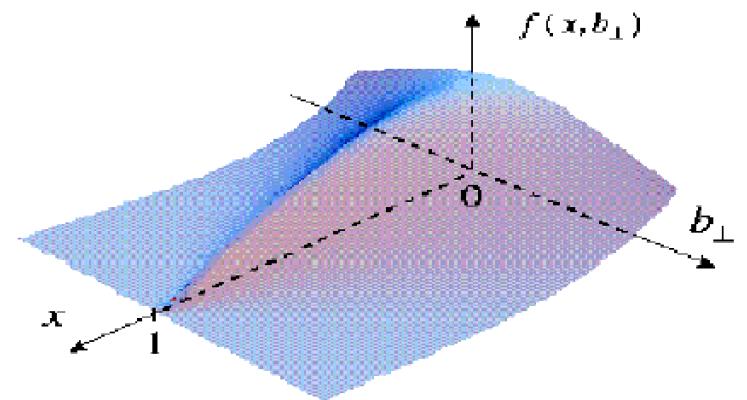
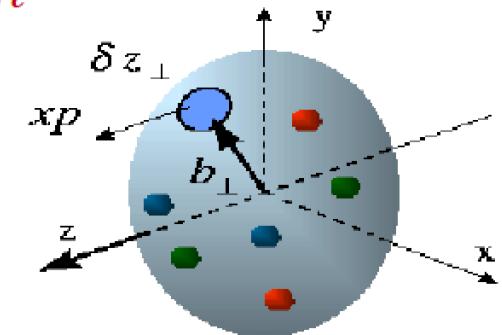
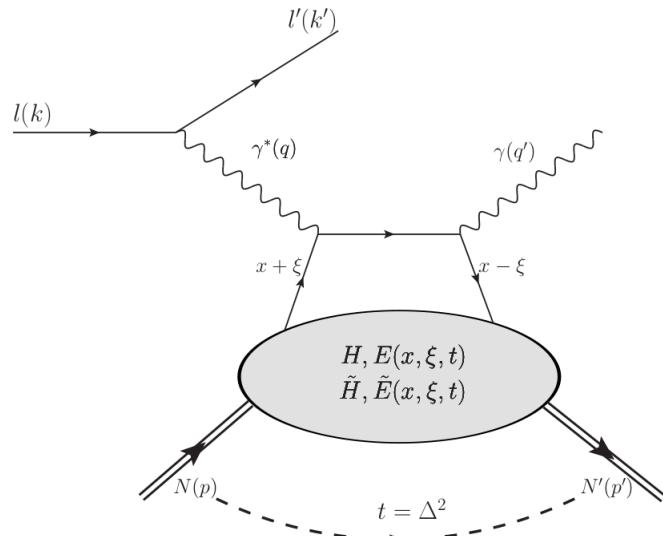
Изучение обобщенных партонных распределений



*Wigner function:
full phase space parton
distribution of the nucleon*

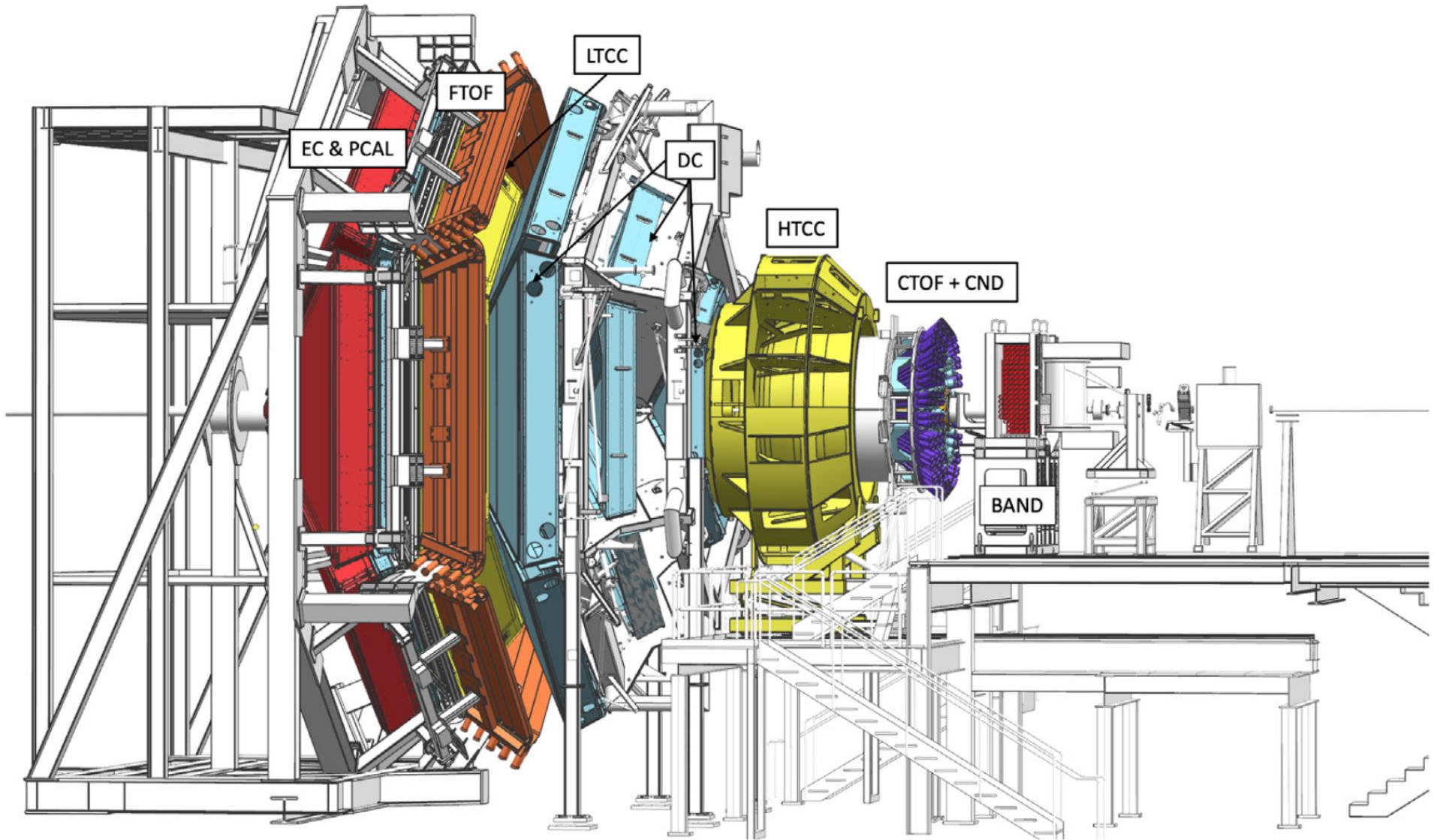
$$\int d^2 k_T$$

Generalised Parton
Distributions (GPDs)

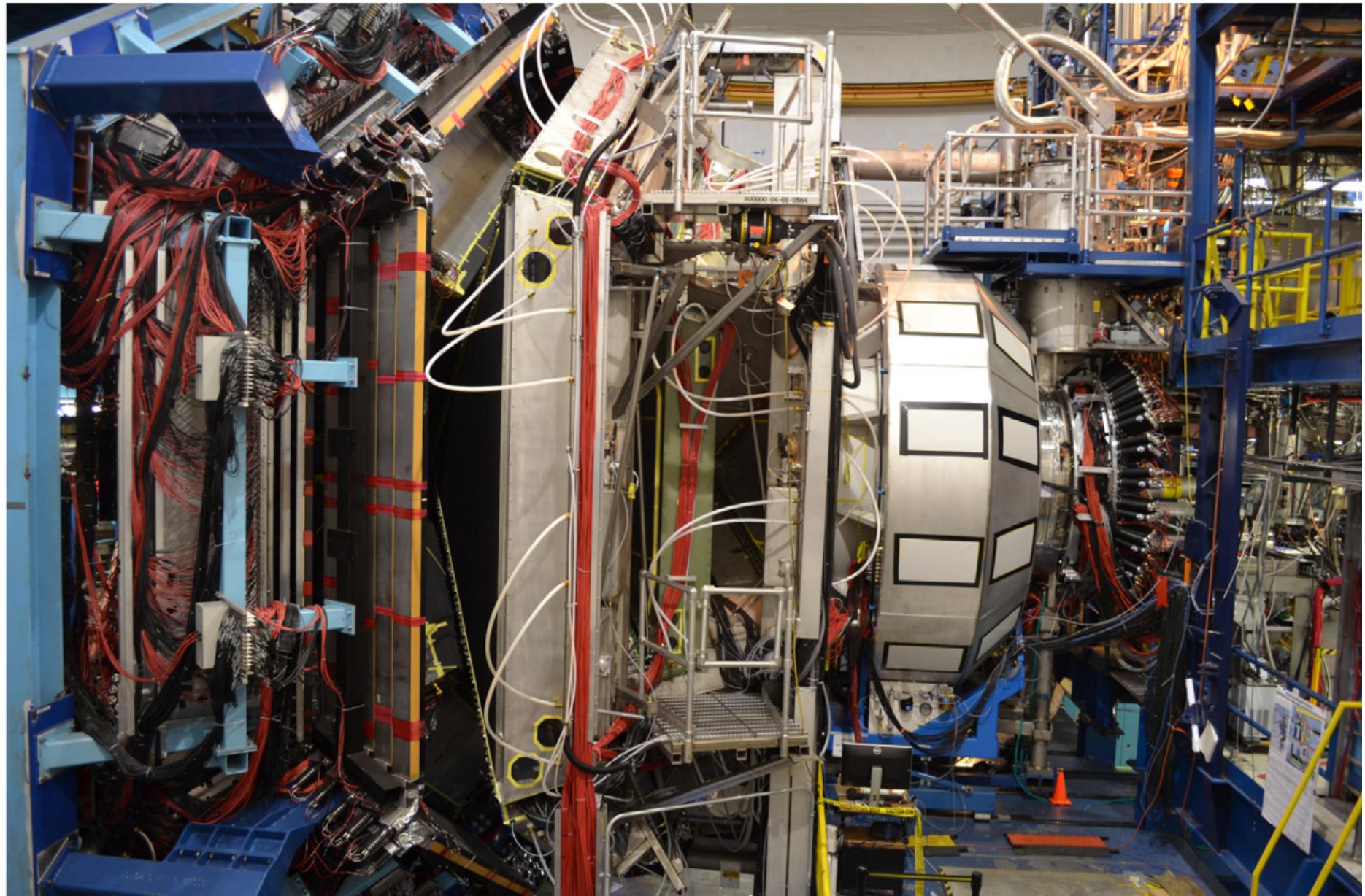


Deeply Virtual Compton Scattering,

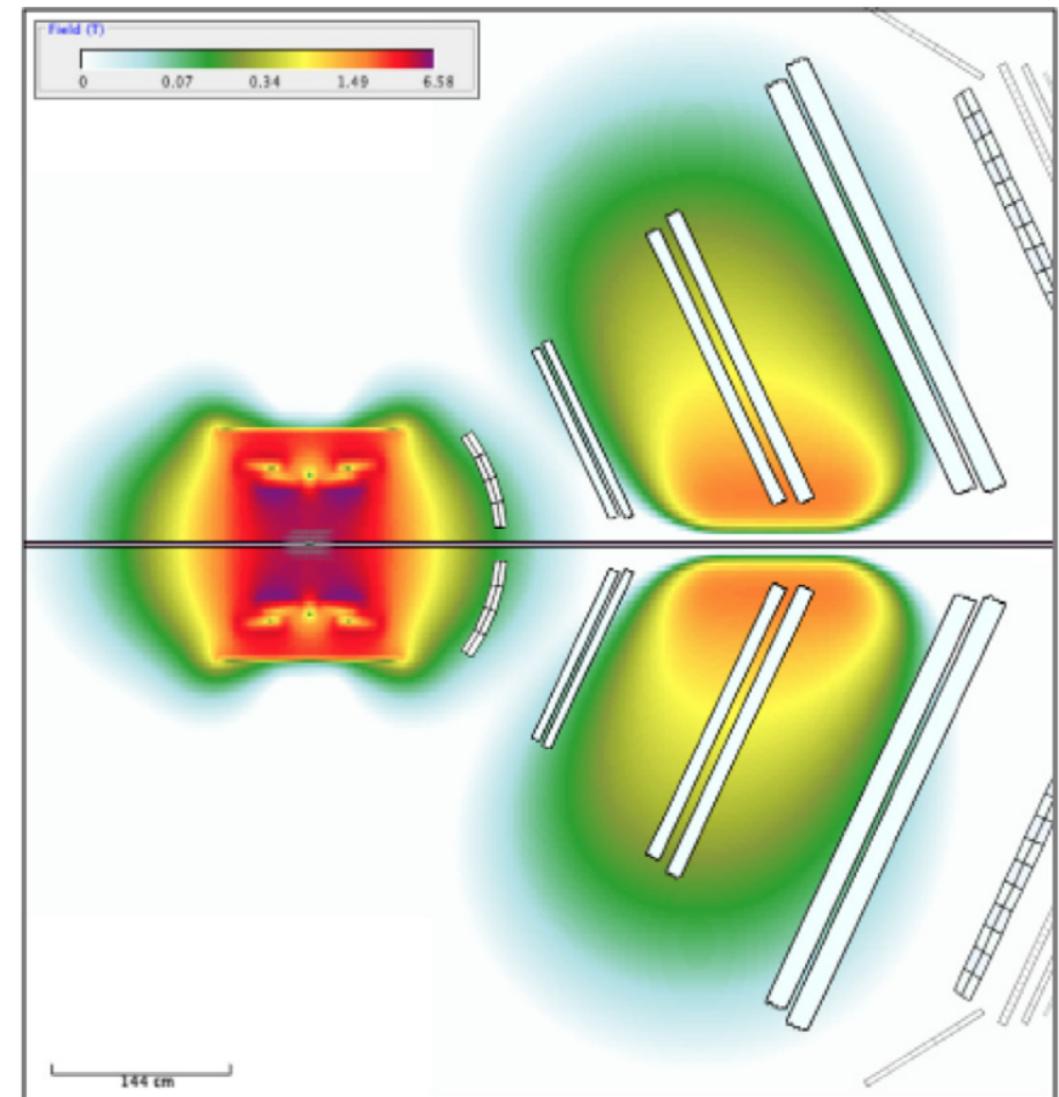
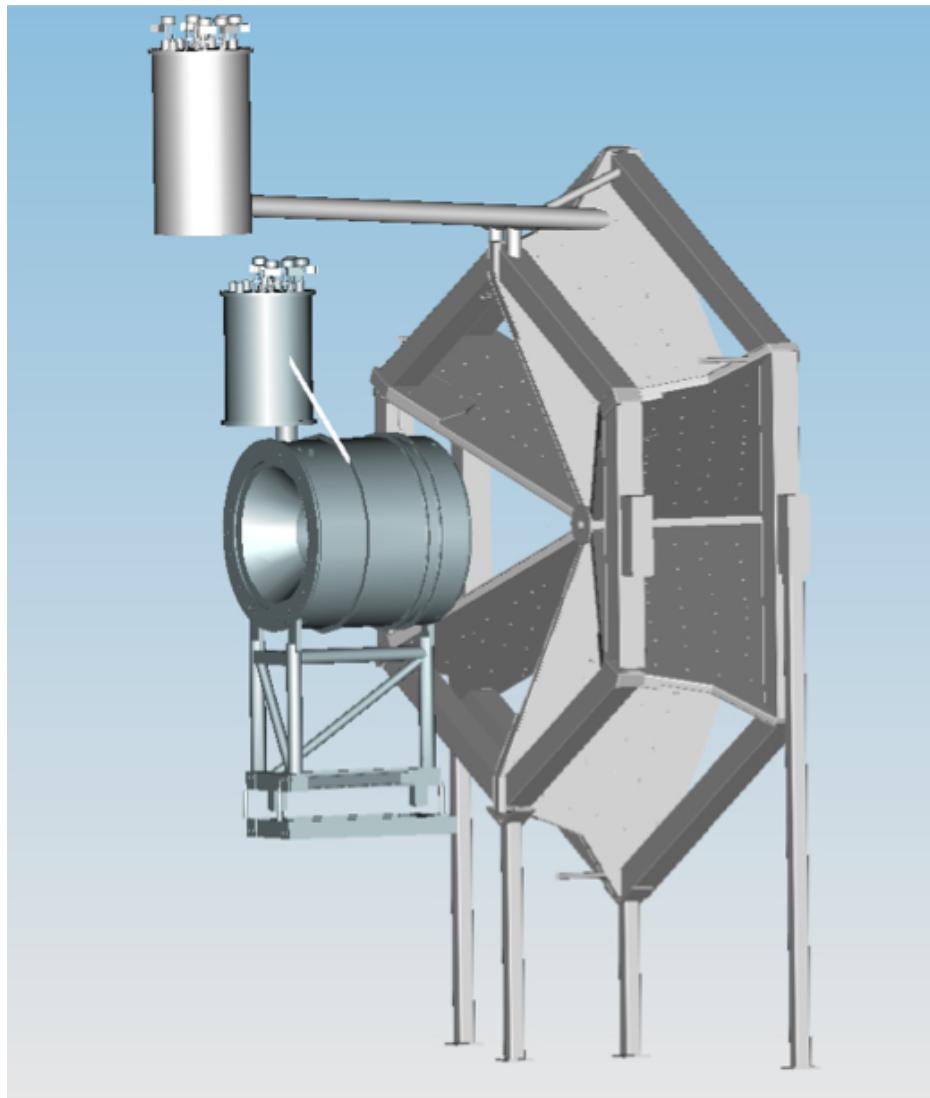
Детектор CLAS12



Детектор CLAS12

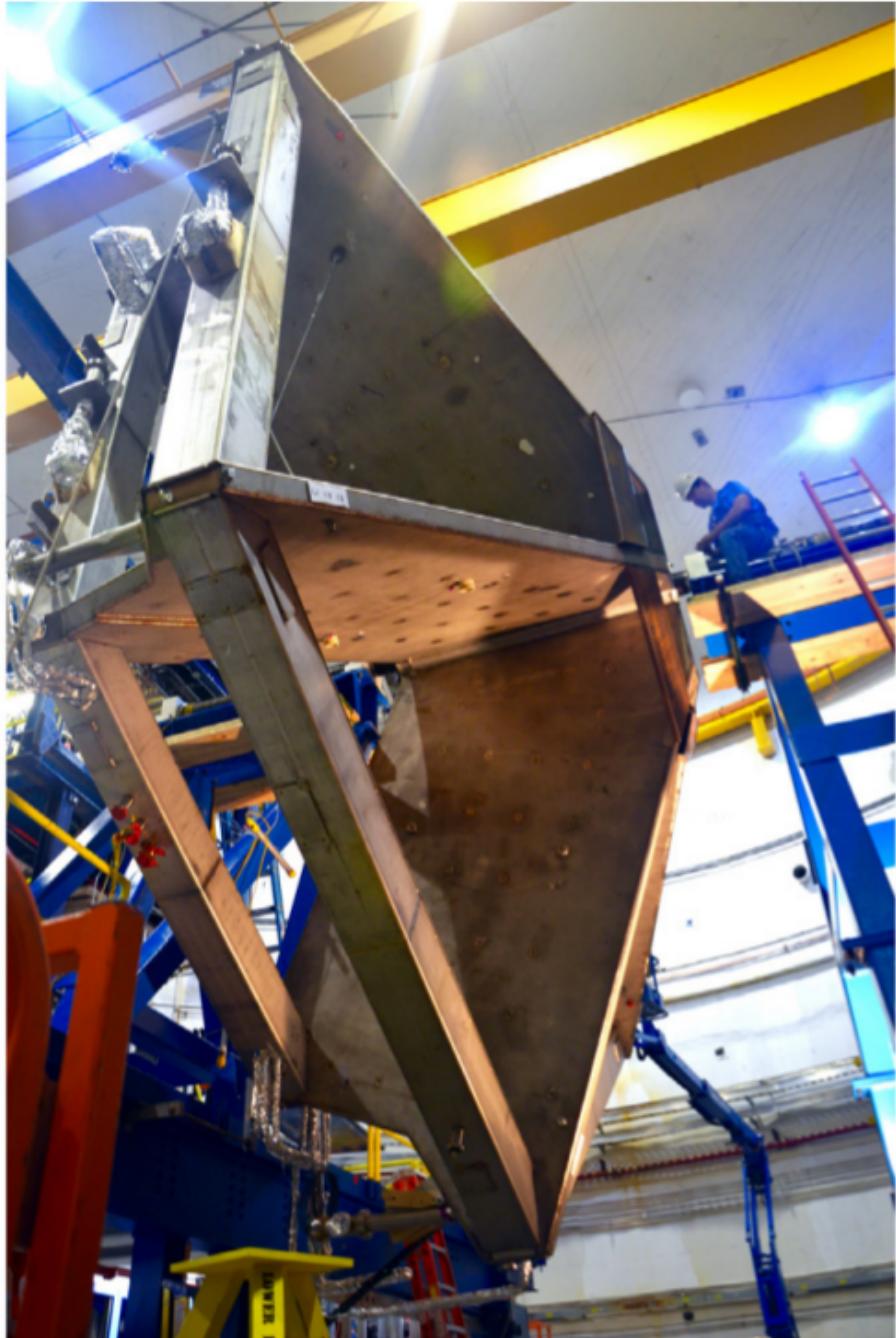


Магнитное поле CLAS12



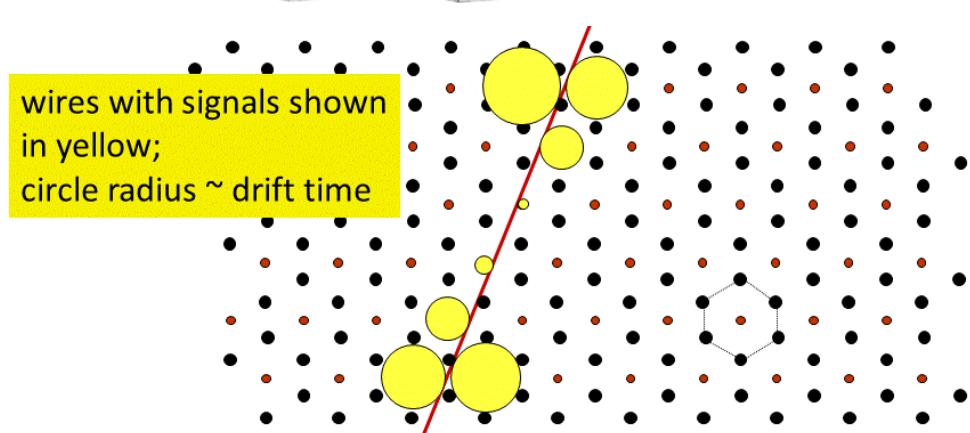
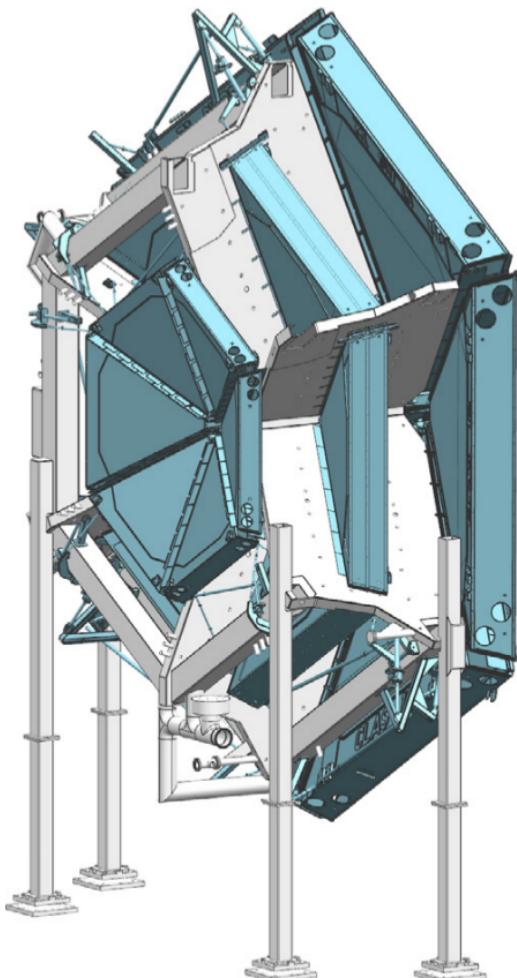


Соленоид

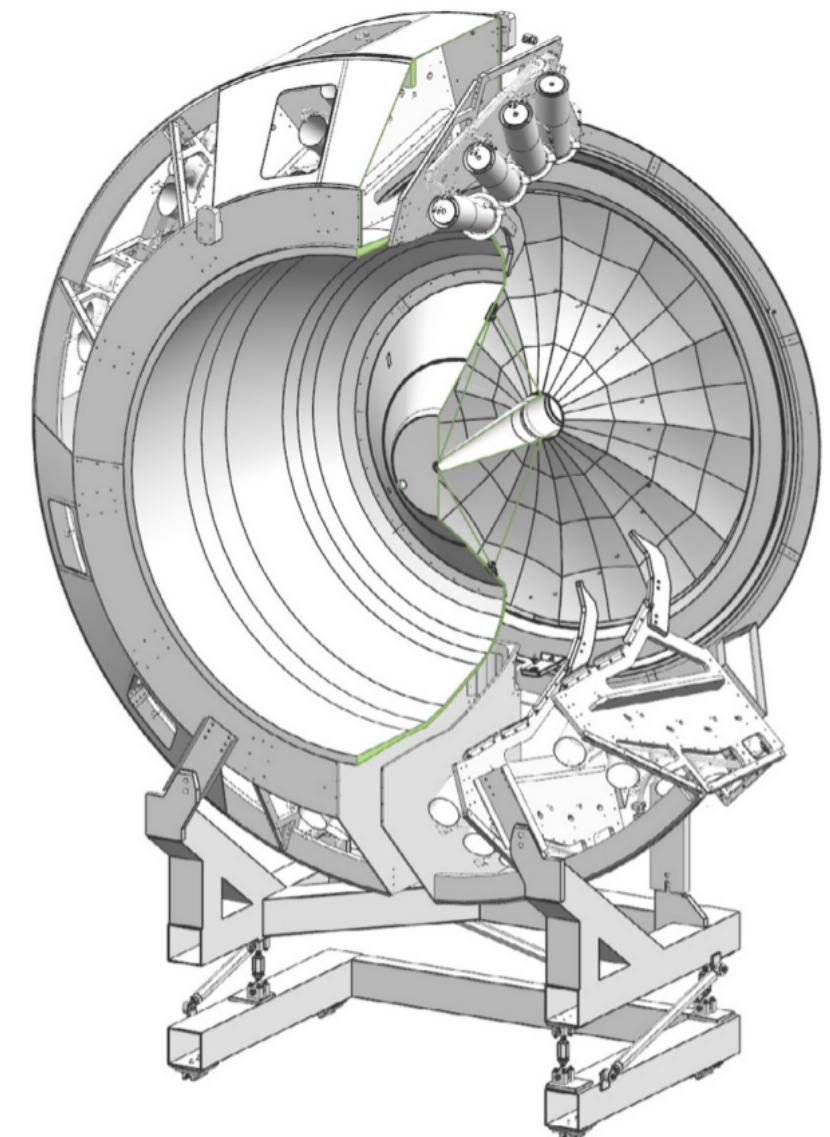
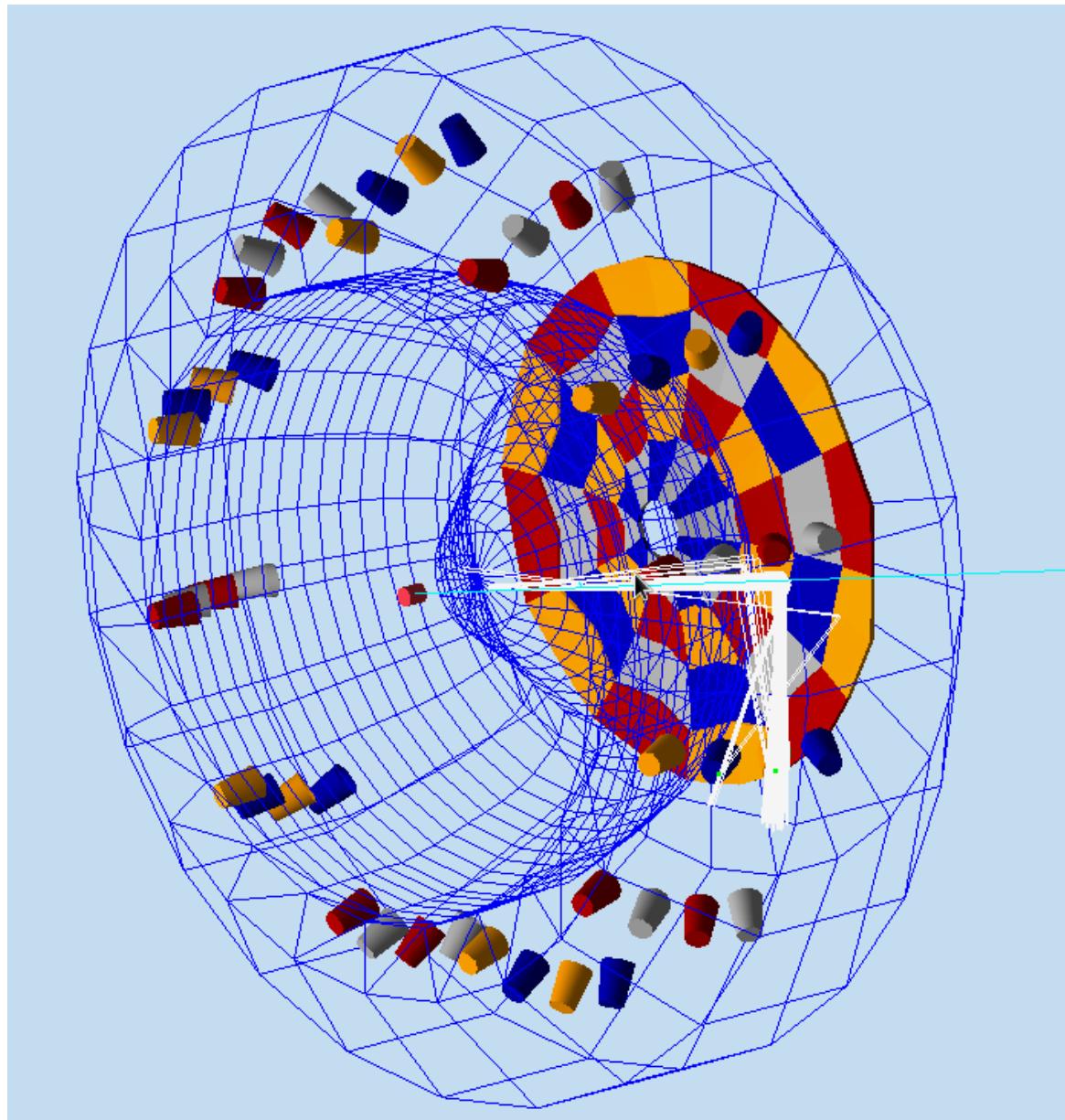


Тороидальный магнит

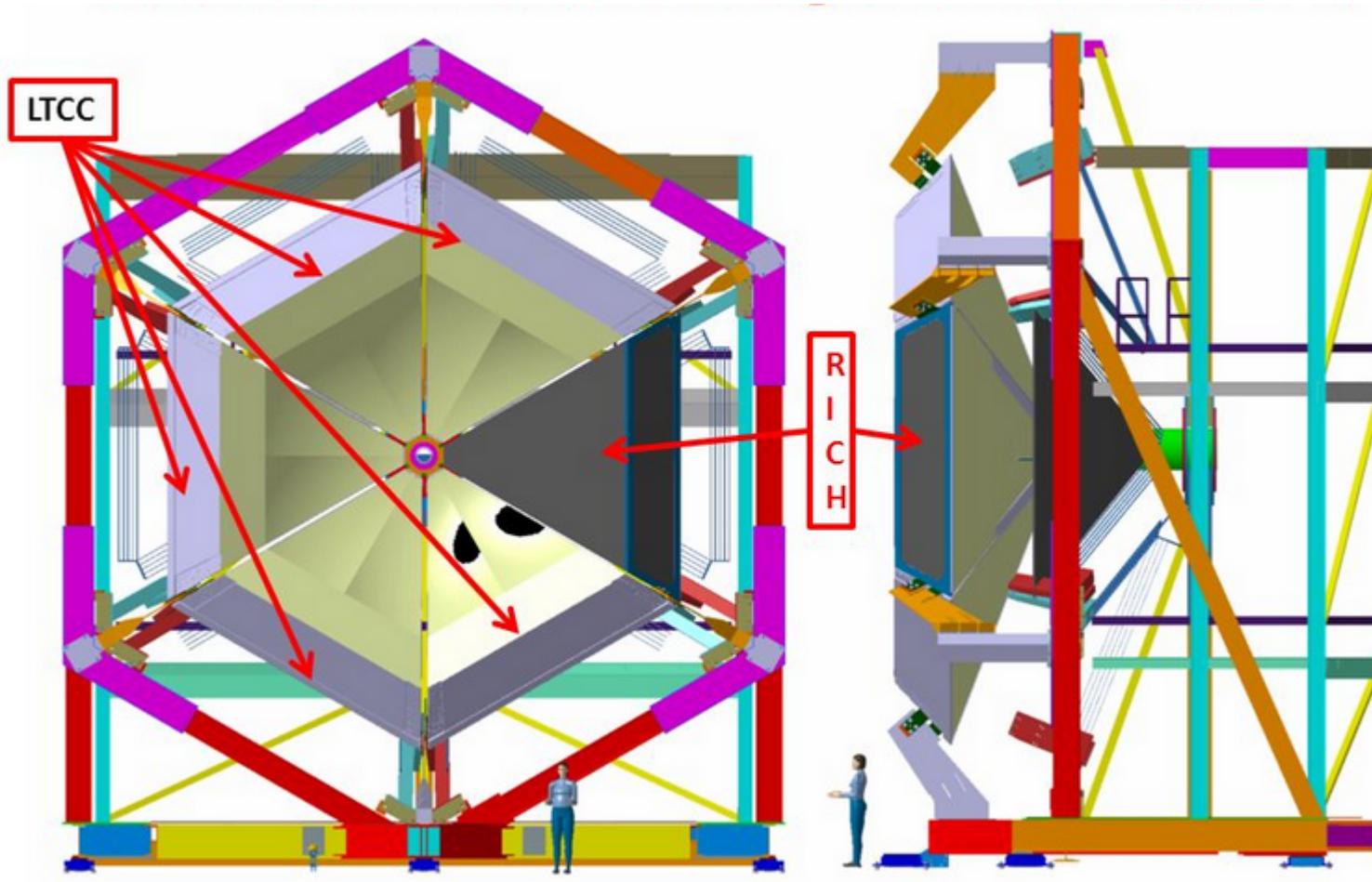
Дрейфовая камера



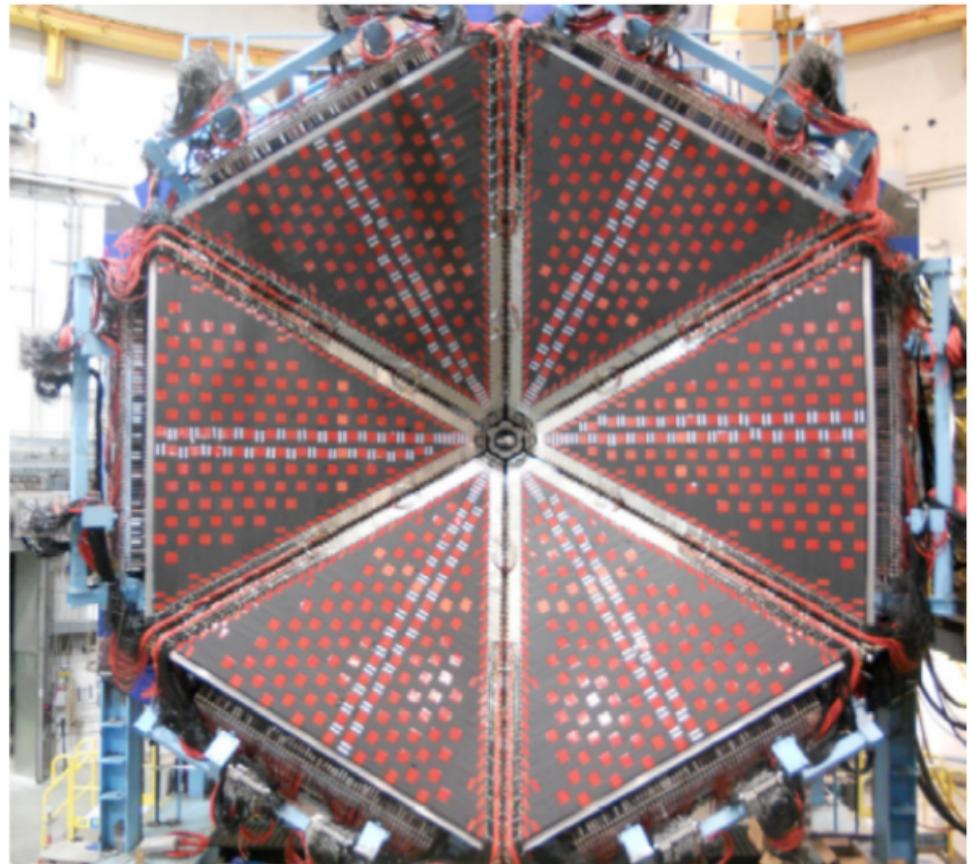
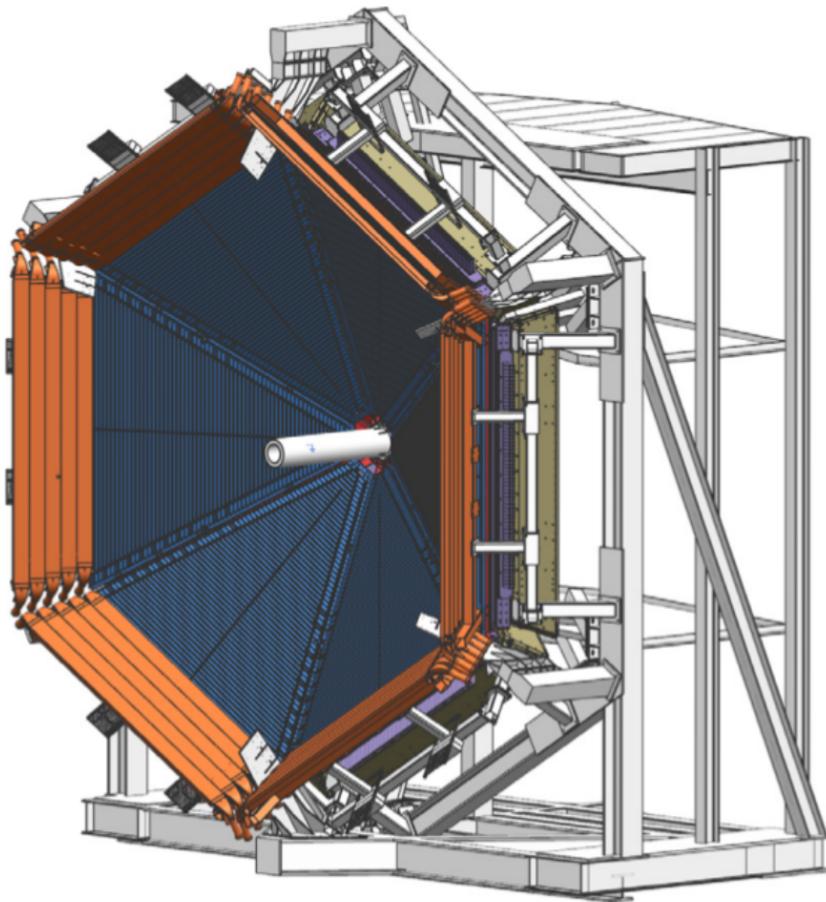
High threshold Cherenkov counter (HTCC)



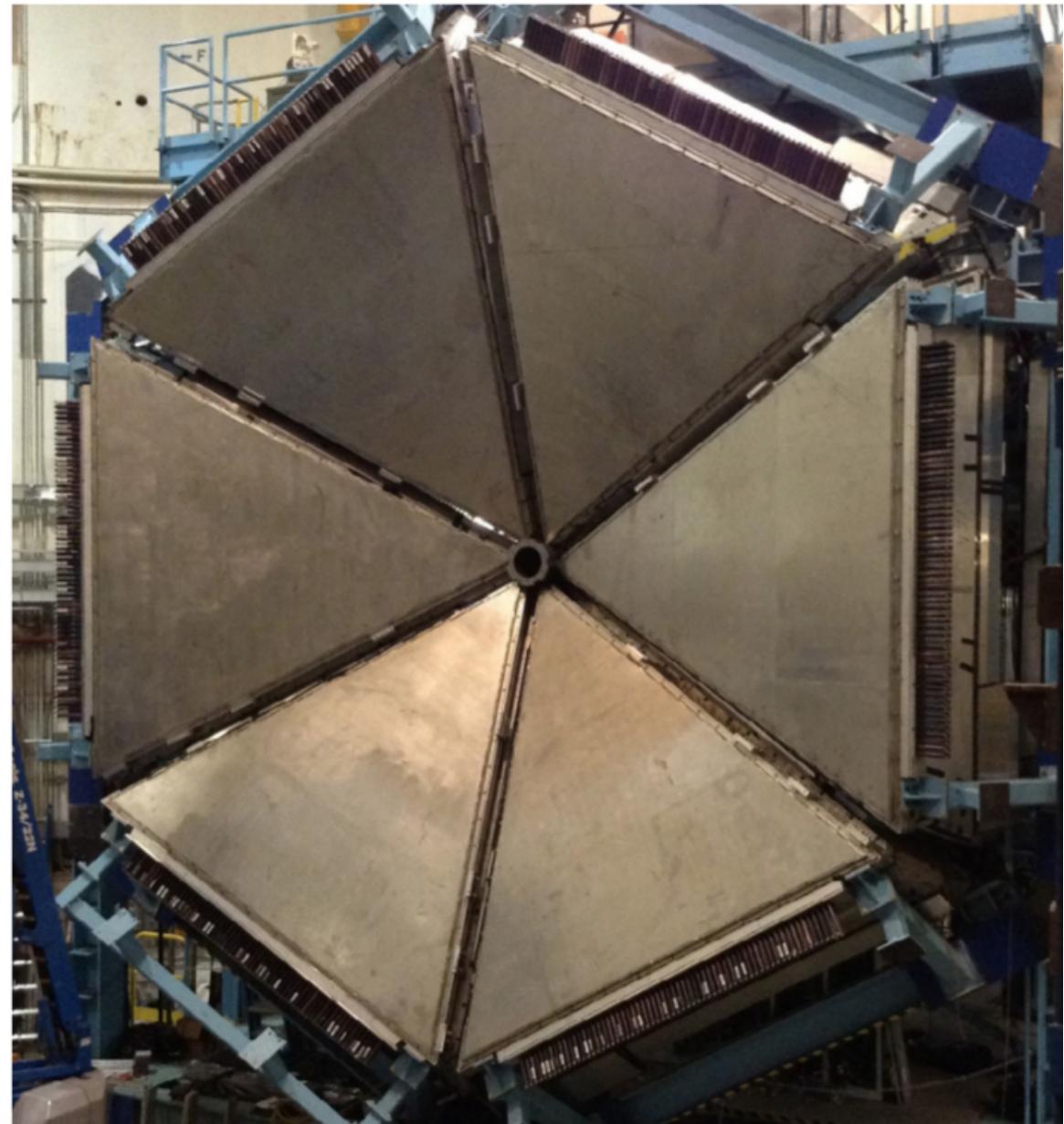
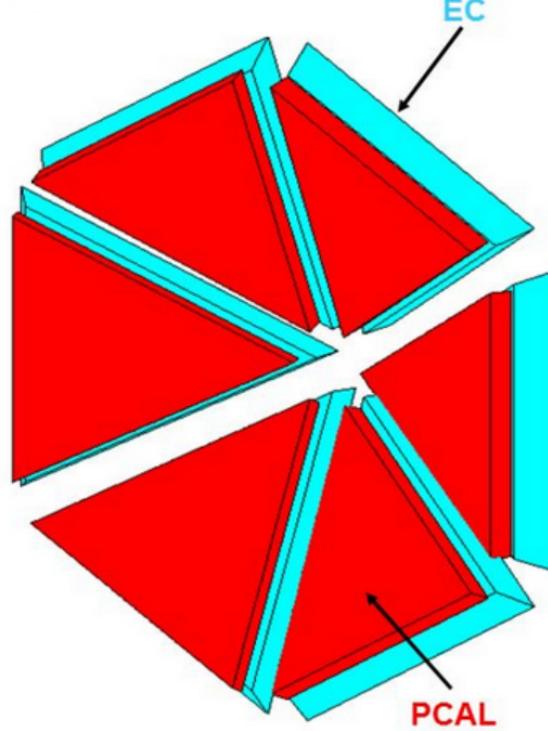
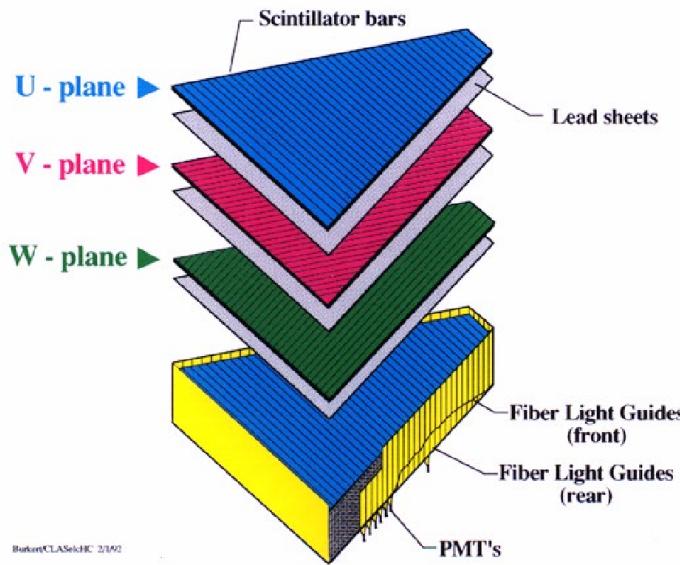
LTCC и RICH



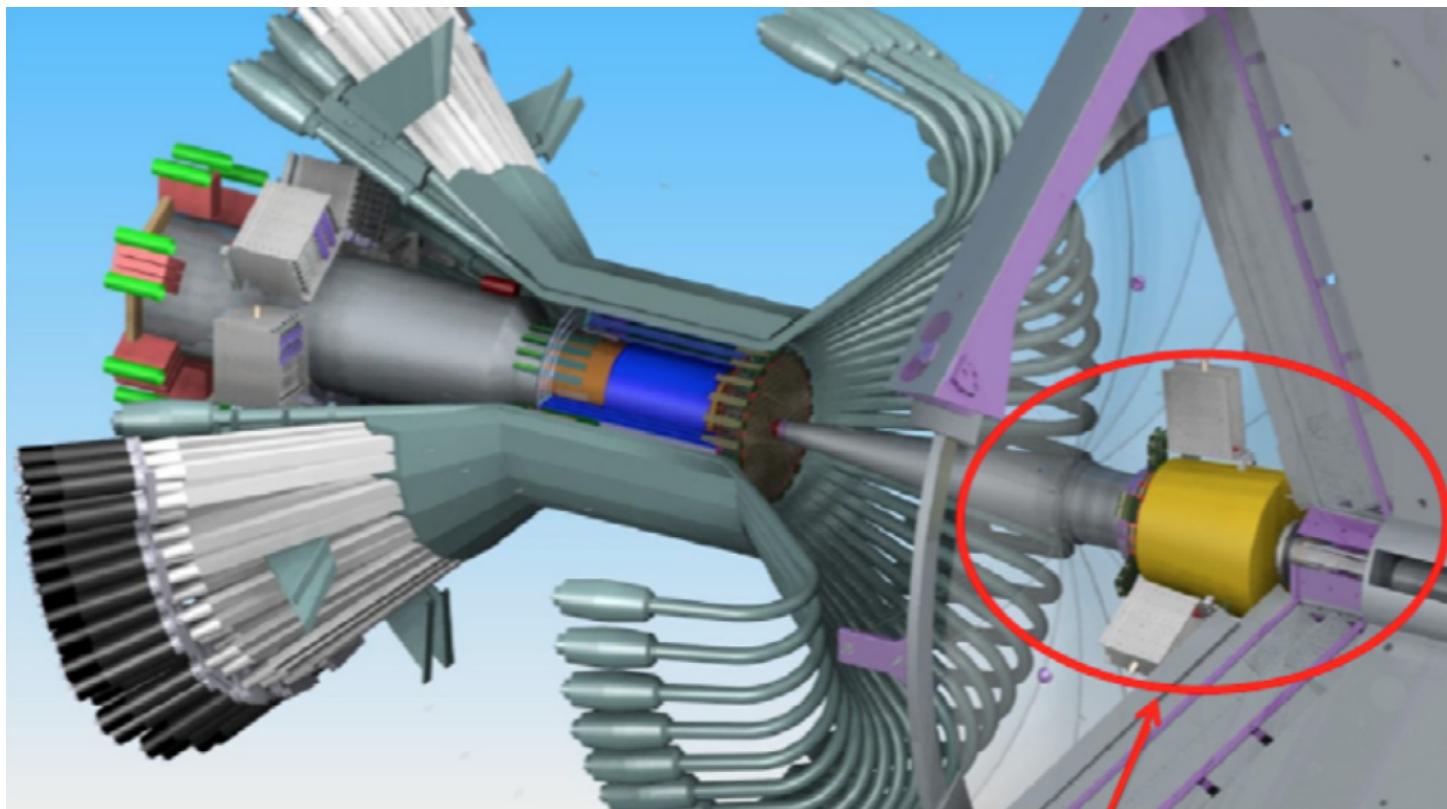
Времяпролетная камера



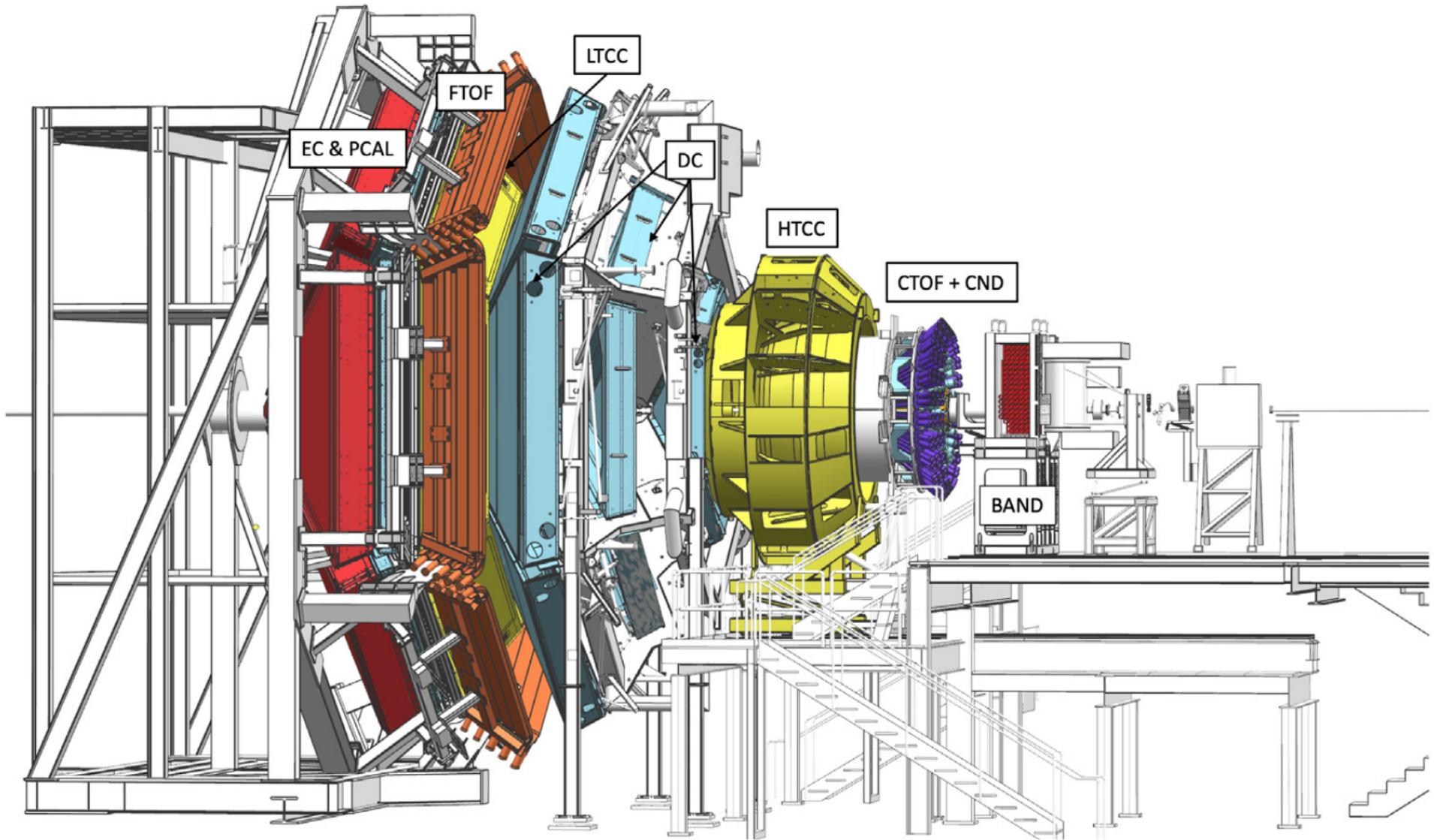
Электромагнитный калориметр



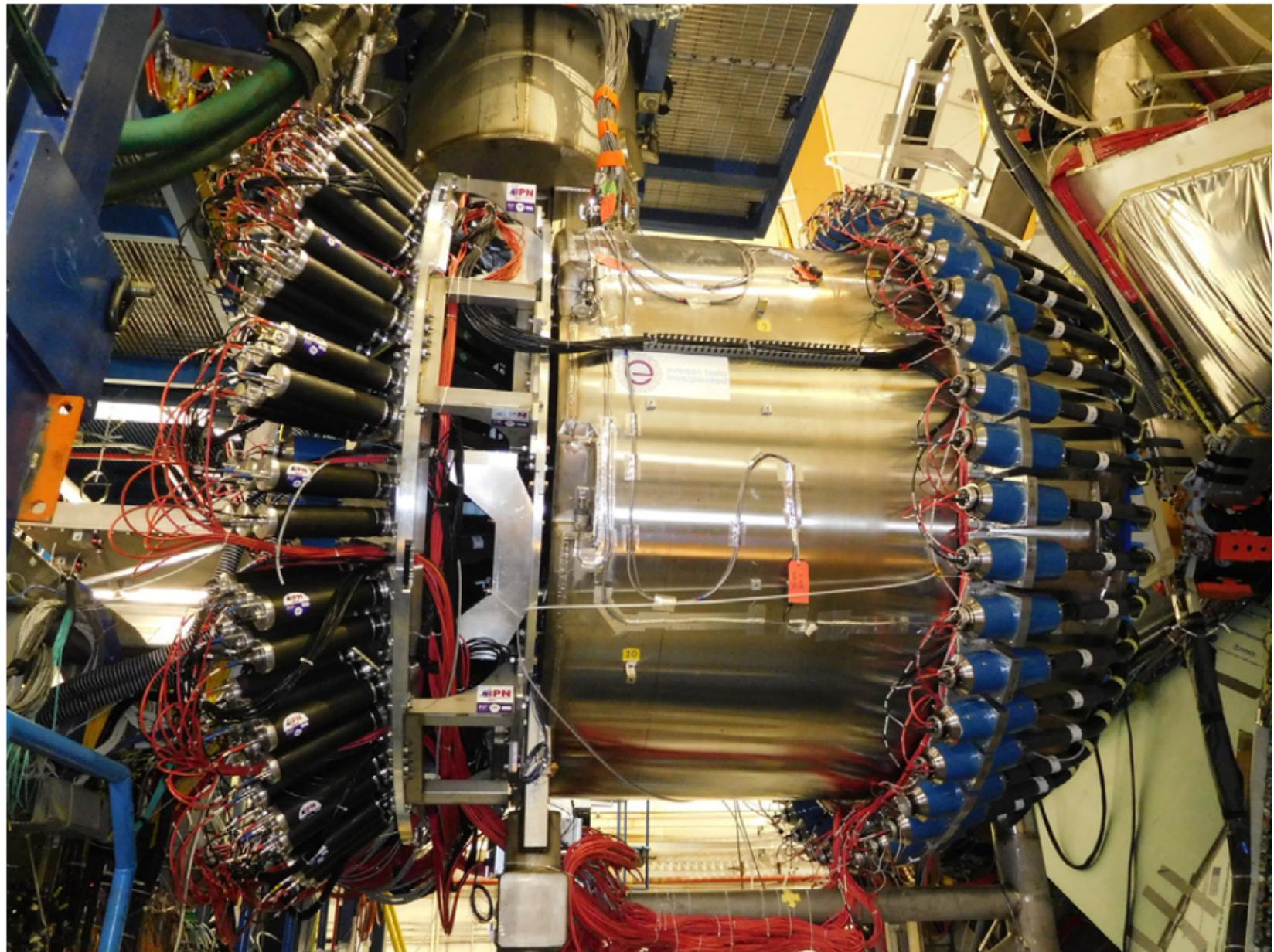
Forward Tagger



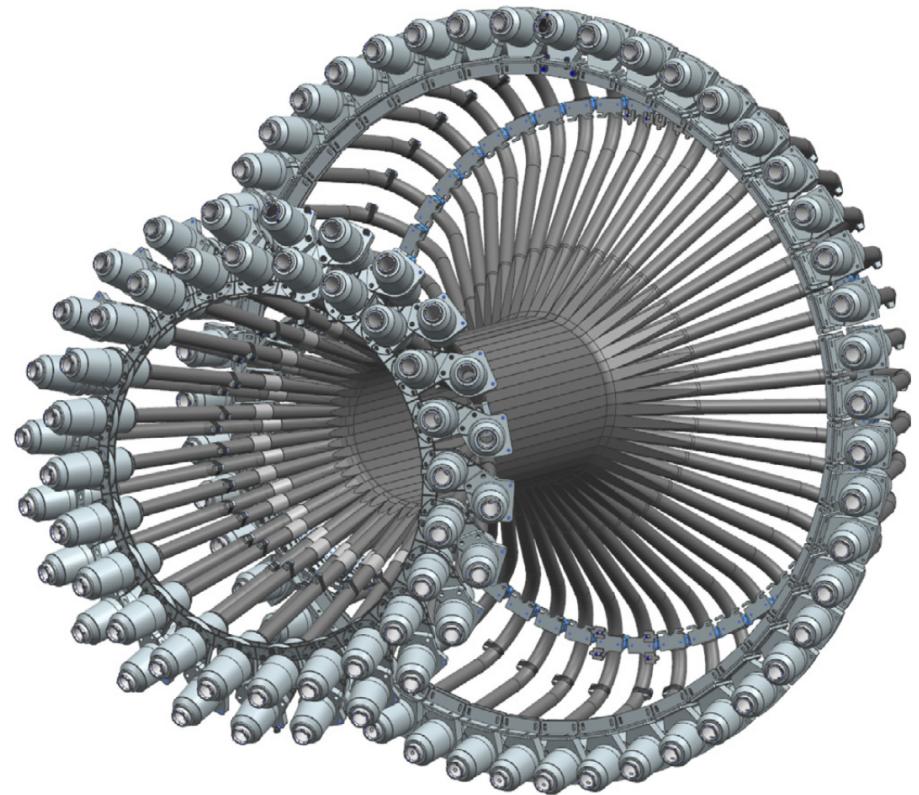
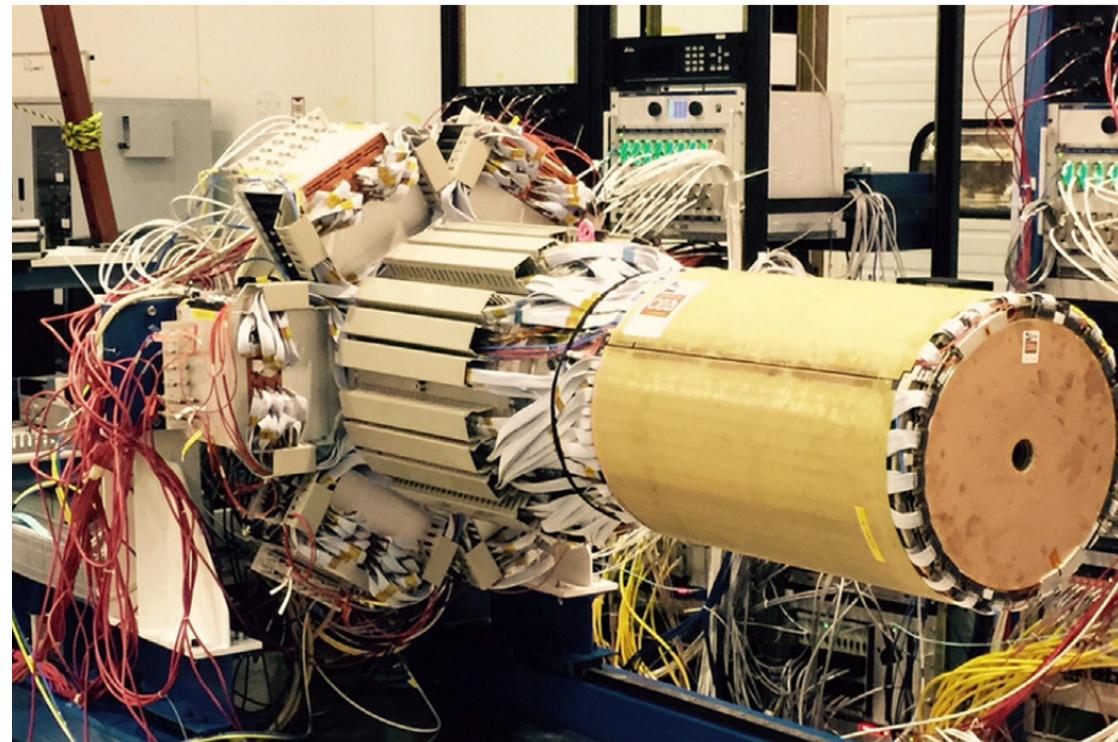
Детектор CLAS12



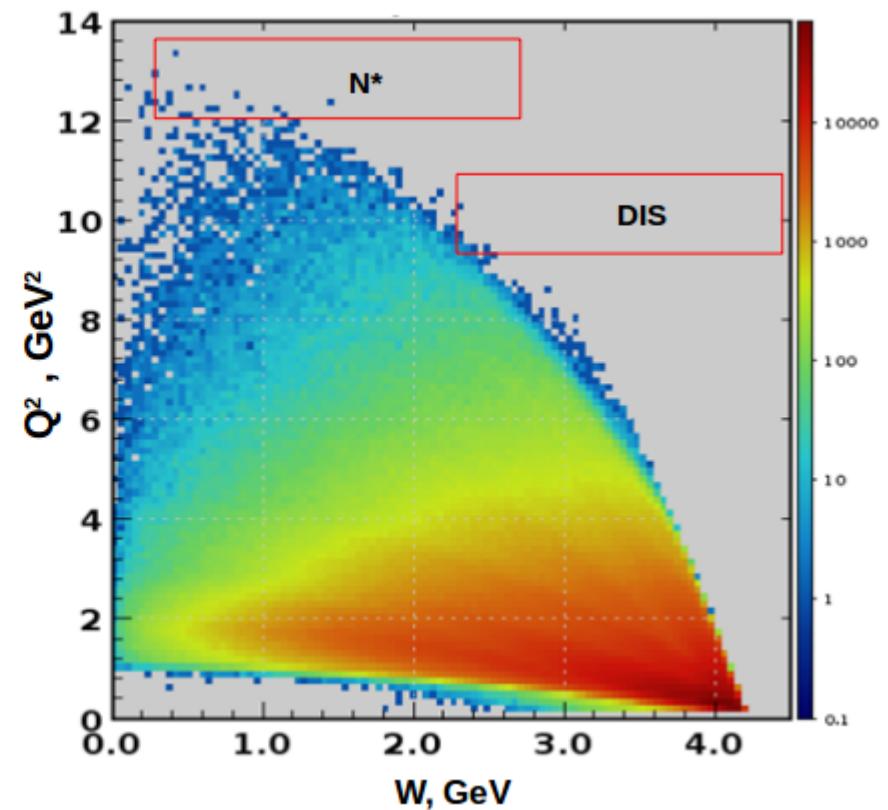
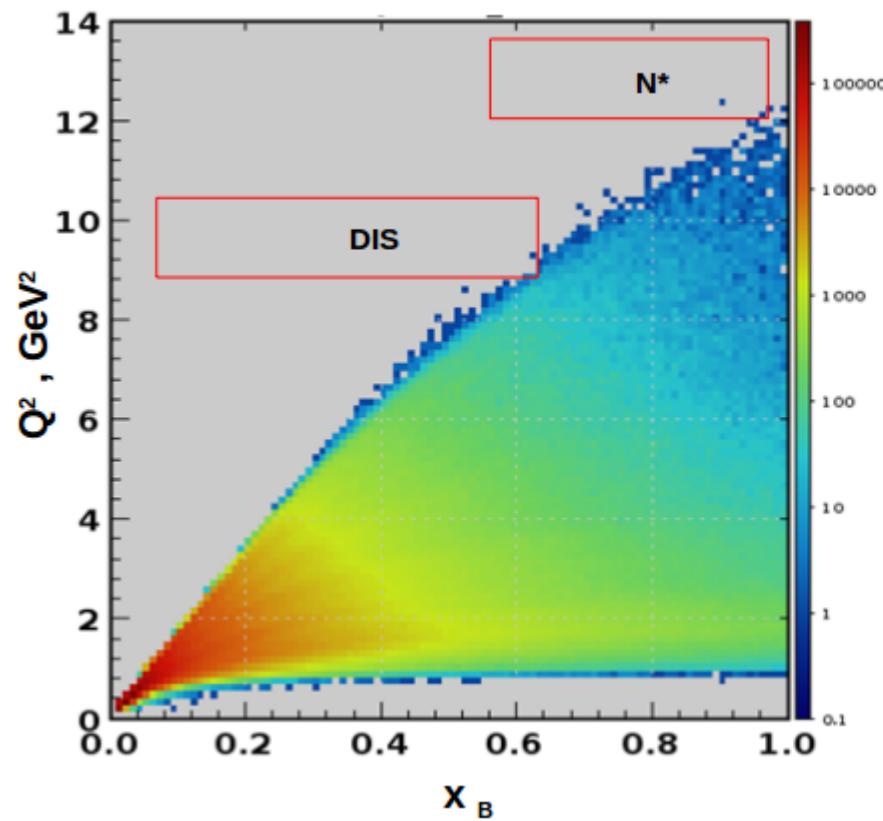
Центральный детектор



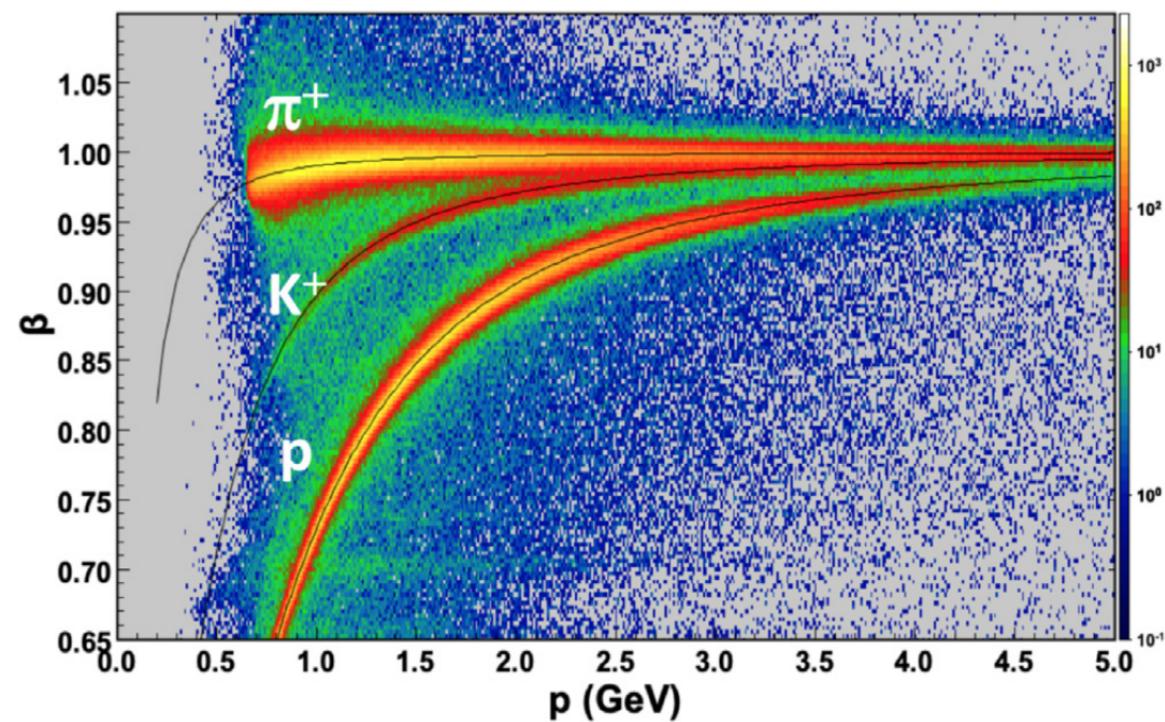
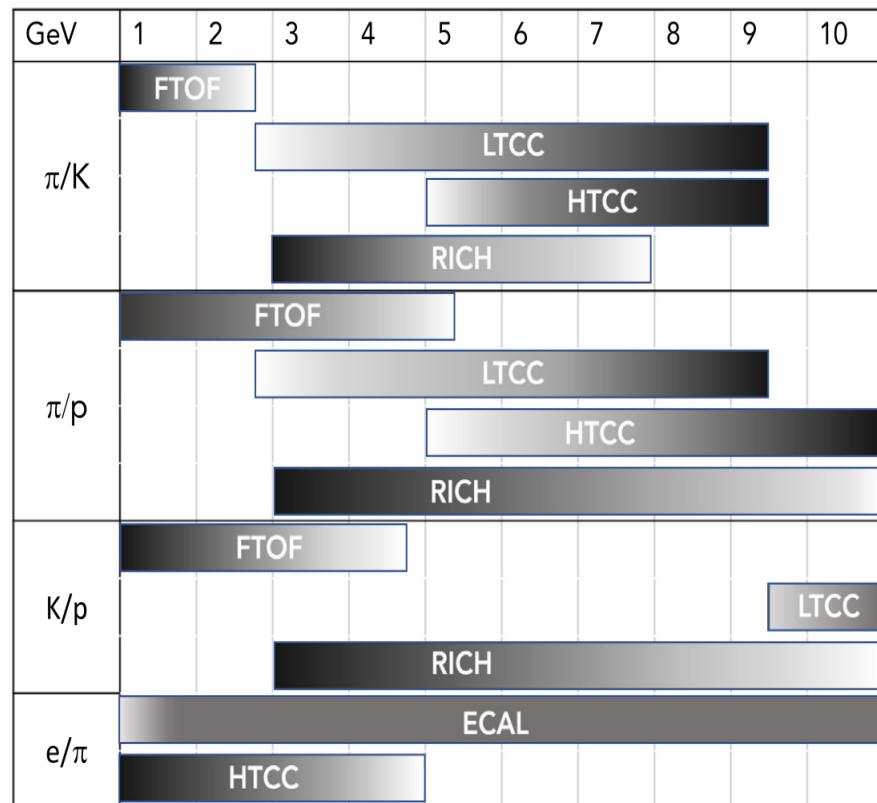
Центральный детектор



Кинематическое покрытие CLAS12

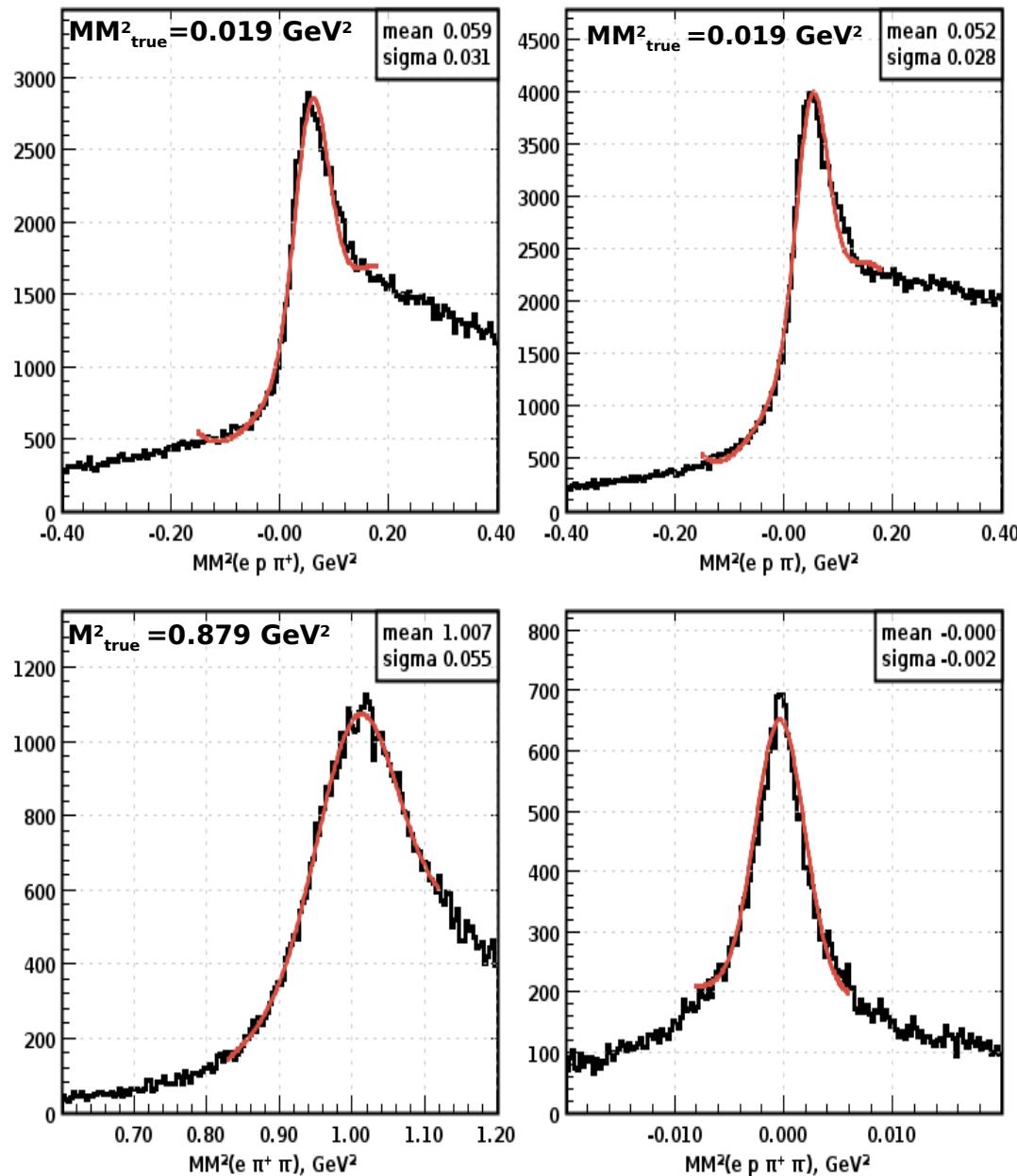


Идентификация частиц



Недостающая масса в реакции $e^- p \rightarrow e' p' \pi^+ \pi^-$

RGA 10.6 GeV. Outbending runs.



MM^2 -s and sigma-s are in GeV^2

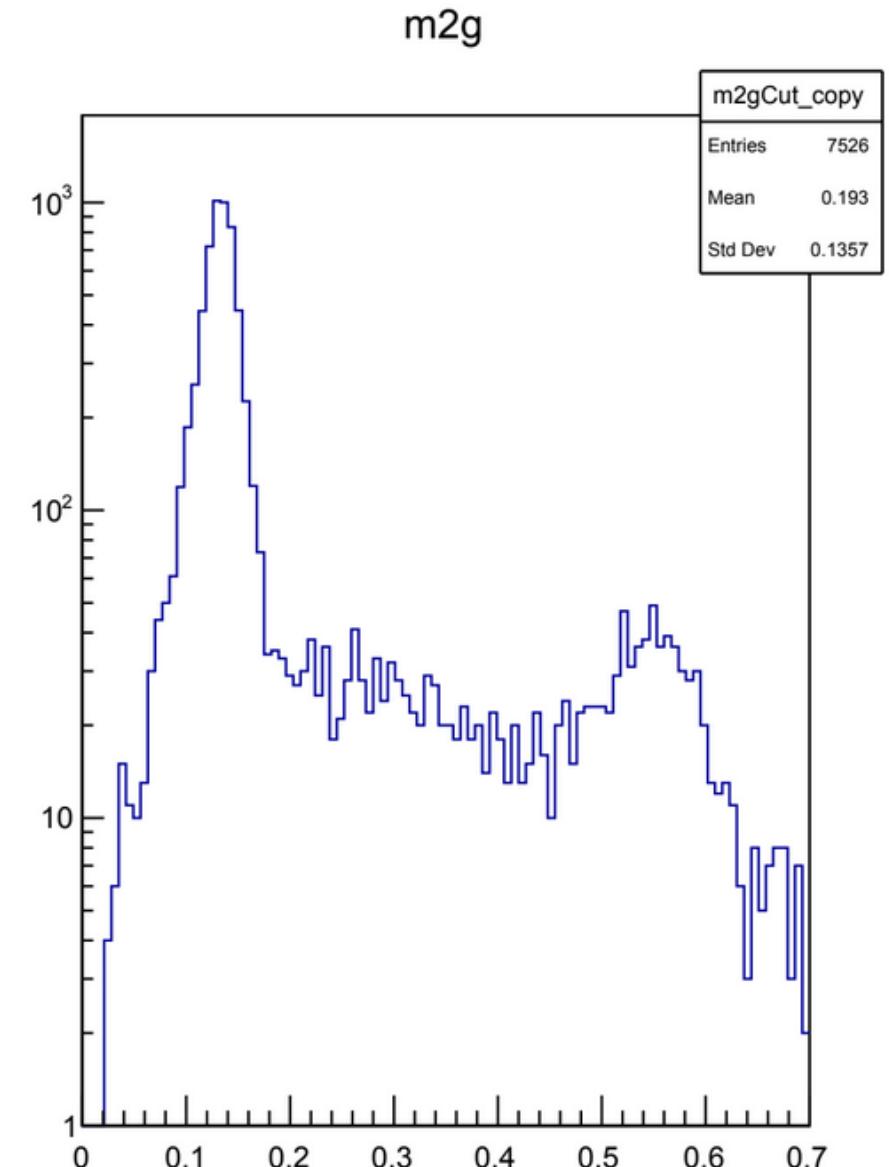
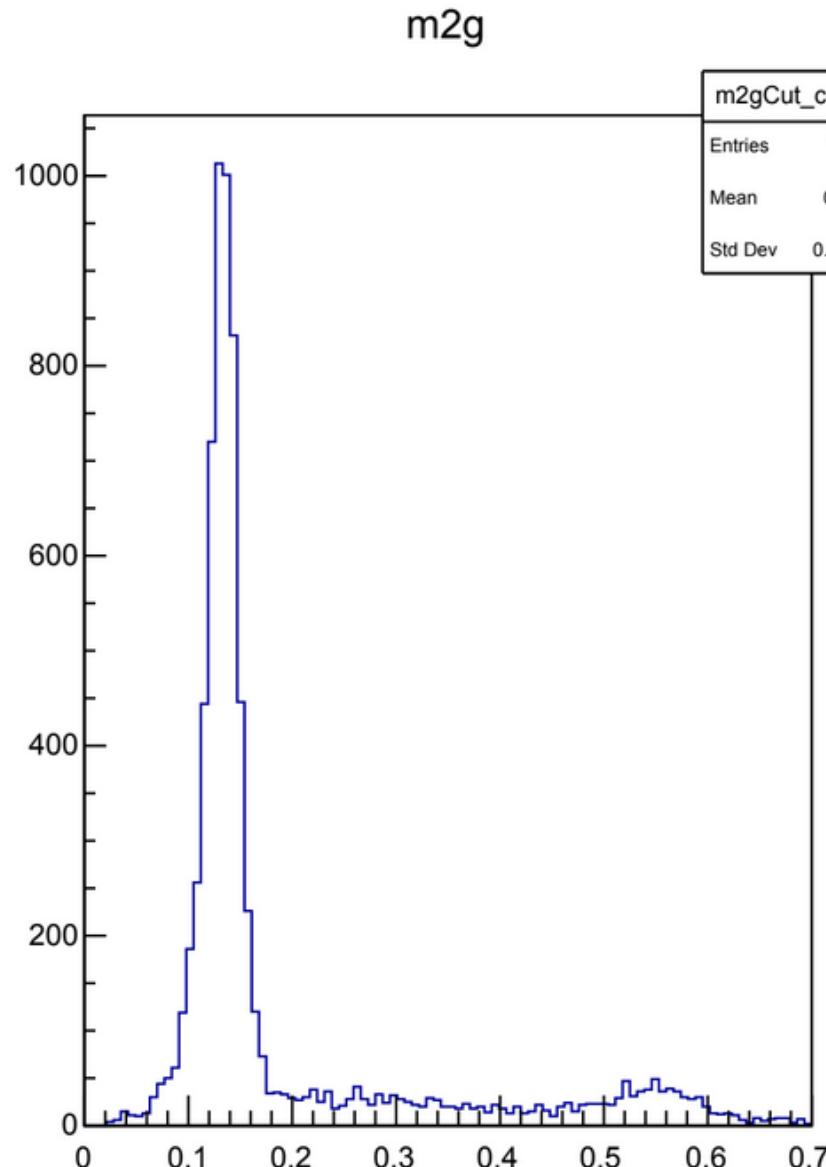
Run#	MM^2 (π^-)	σ	MM^2 (π^+)	σ	MM^2 (p)	σ
5424	0.060	0.032	0.052	0.028	1.003	0.051
5425	0.058	0.029	0.050	0.026	1.008	0.058
5428	0.054	0.025	0.048	0.024	1.011	0.053
5429	0.053	0.022	0.045	0.022	1.008	0.060
5730	0.055	0.027	0.045	0.022	1.007	0.061

Недостающая масса в реакции $e^- p \rightarrow e' p' \pi^+ \pi^-$

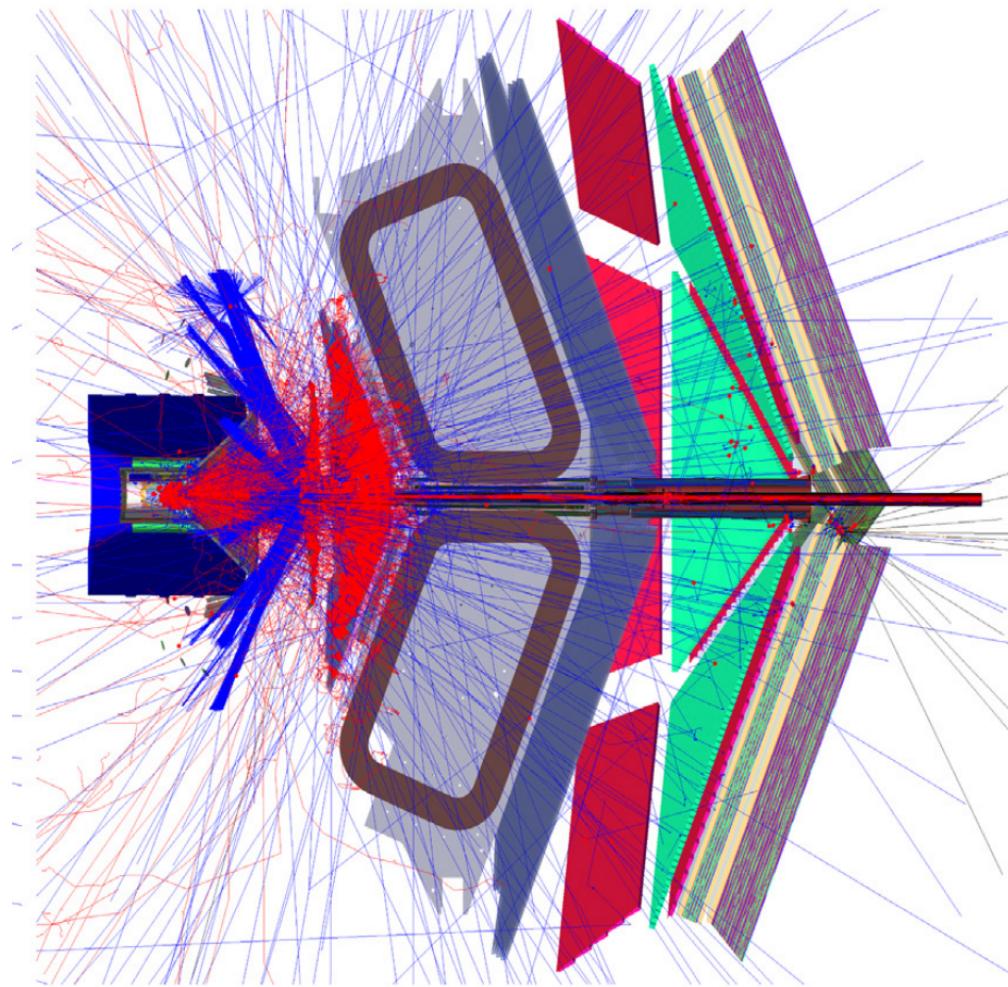
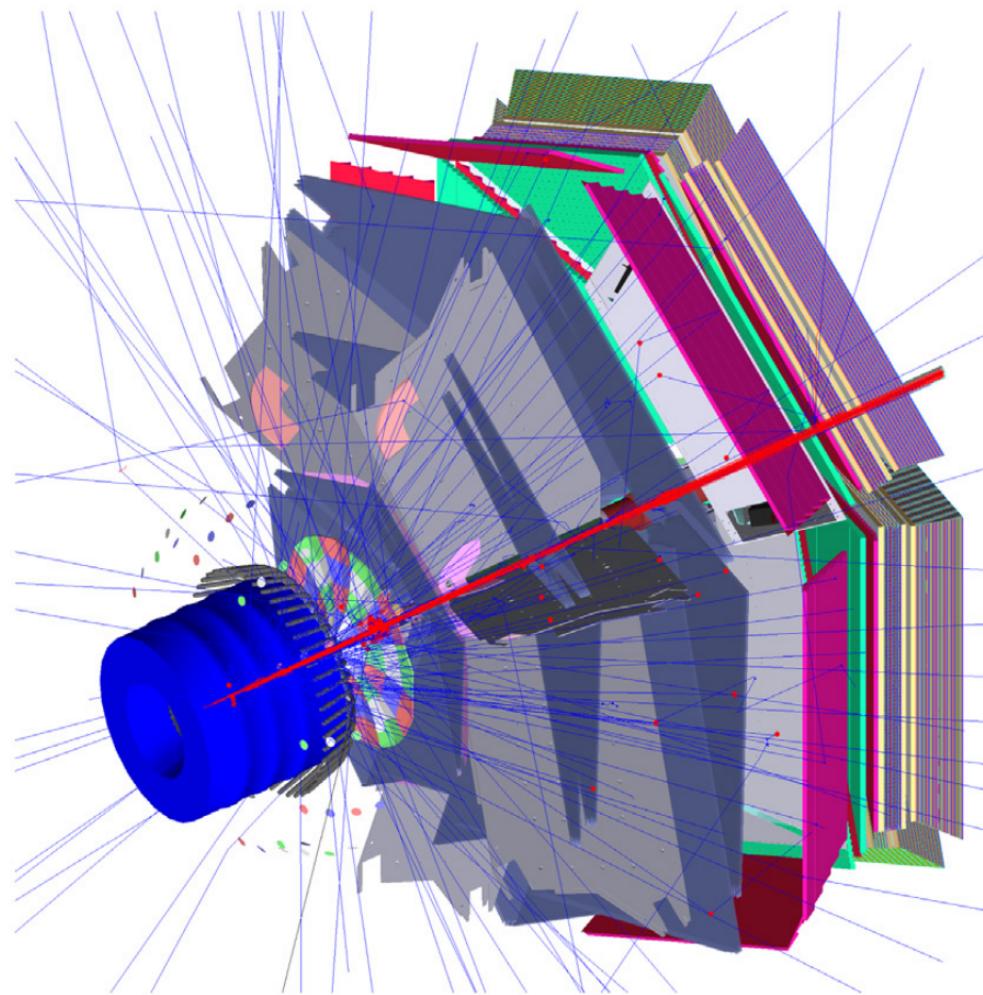
Run period	MM^2 (π^-)	σ	MM^2 (π^+)	σ	MM^2 (p)	σ	
RGA 10.6 GeV outbending	0.059	0.031	0.052	0.028	1.003	0.053	
RGA 10.6 GeV Inbending	0.017	0.024	0.019	0.016	0.878	0.056	5 runs
RGA 10.6 GeV Inbending	0.017	0.025	0.019	0.015	0.870	0.069	1 run (5038)
MM² true	0.019		0.019		0.879		

MM²-s and sigma-s are in GeV²

Реакция рождения одиночного пиона

$$e p \rightarrow e' p' \pi^0$$


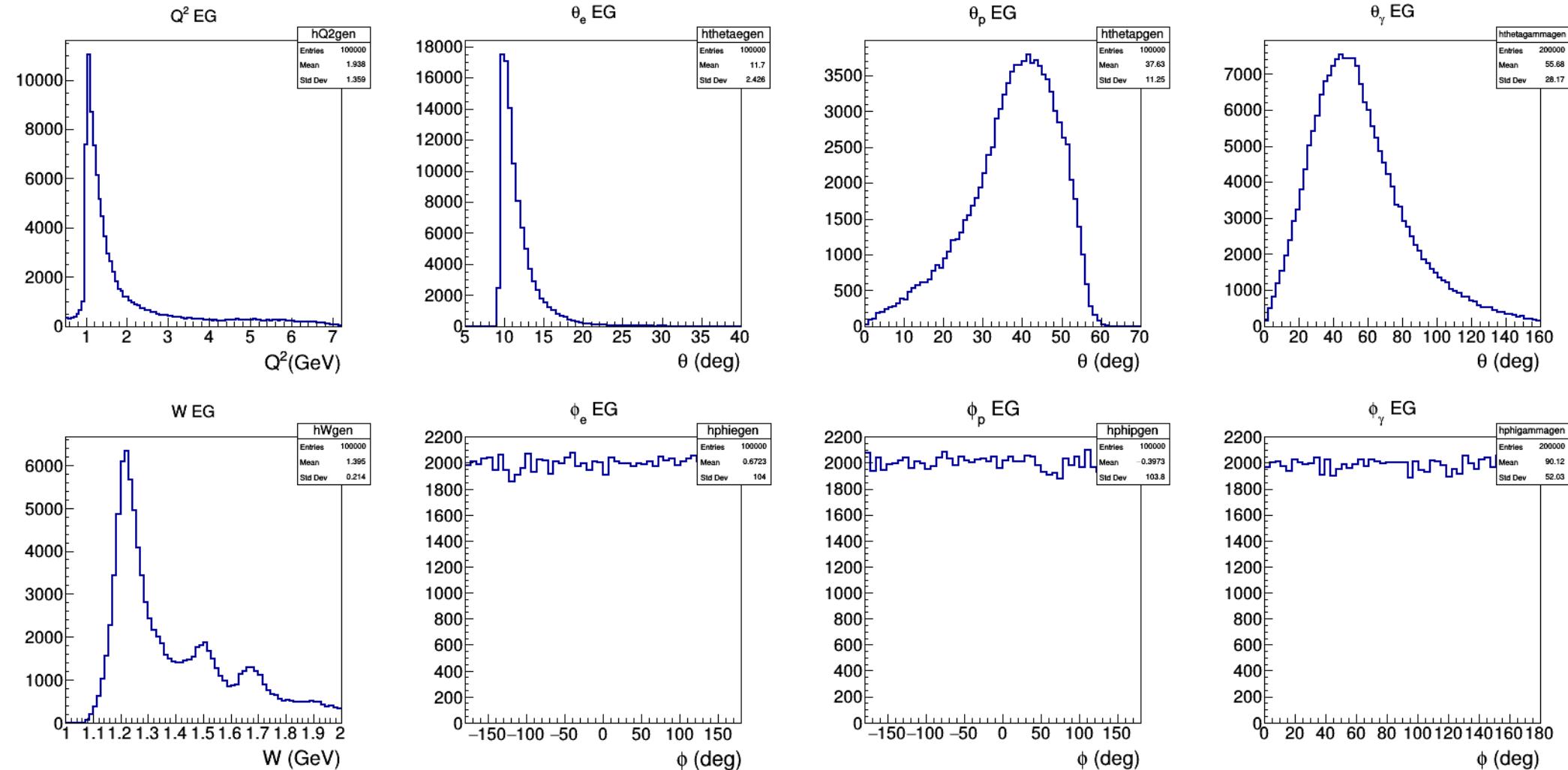
Моделирование детектора

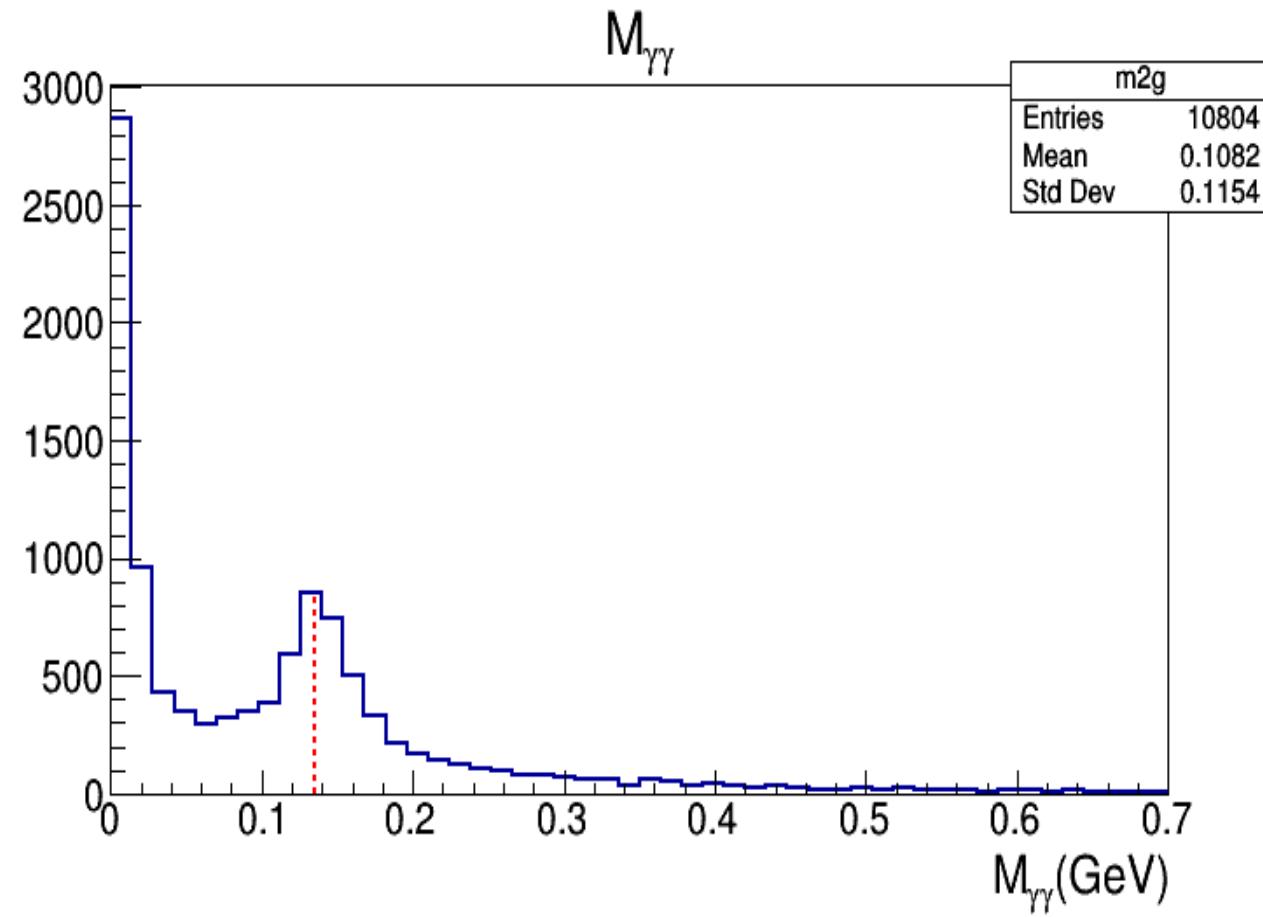


$E_{beam} = 6.535 \text{ GeV}$

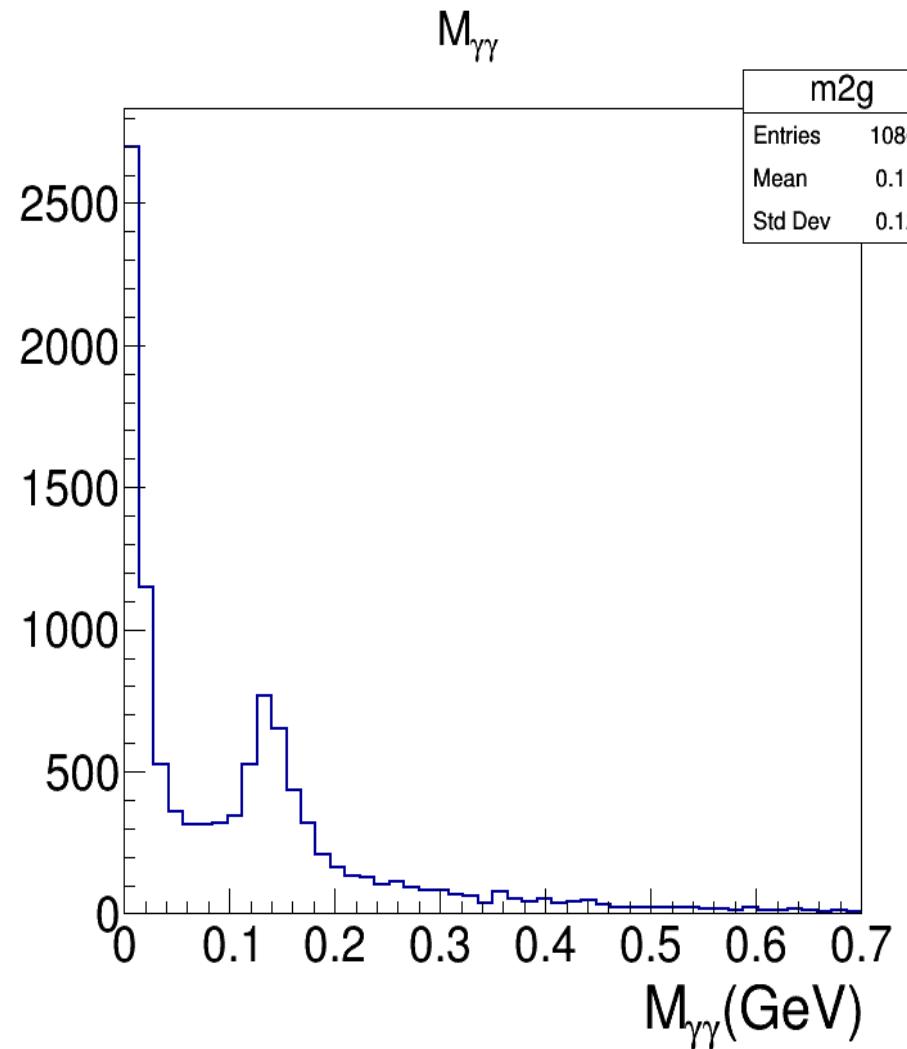
Data: Simulation (100000 events)

Reaction: $\text{ep} \rightarrow \text{ep}\pi_0^- \rightarrow \text{ep}\gamma\gamma$

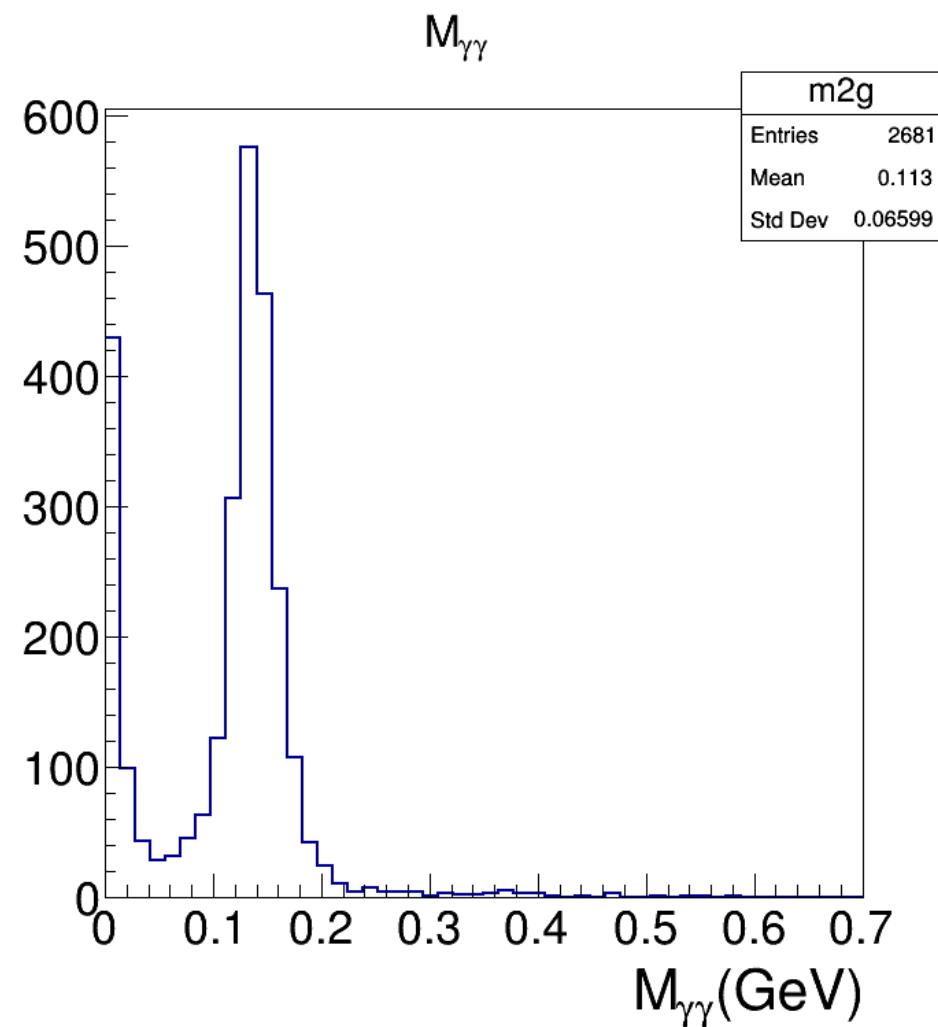




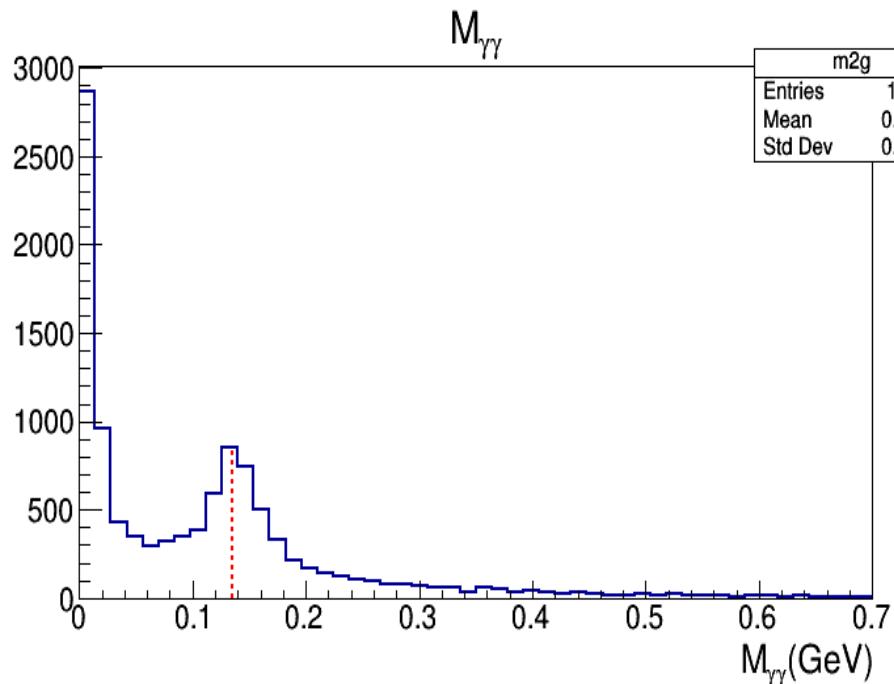
- $E_e > 1 \text{ GeV}$
- All gammas detected by FD



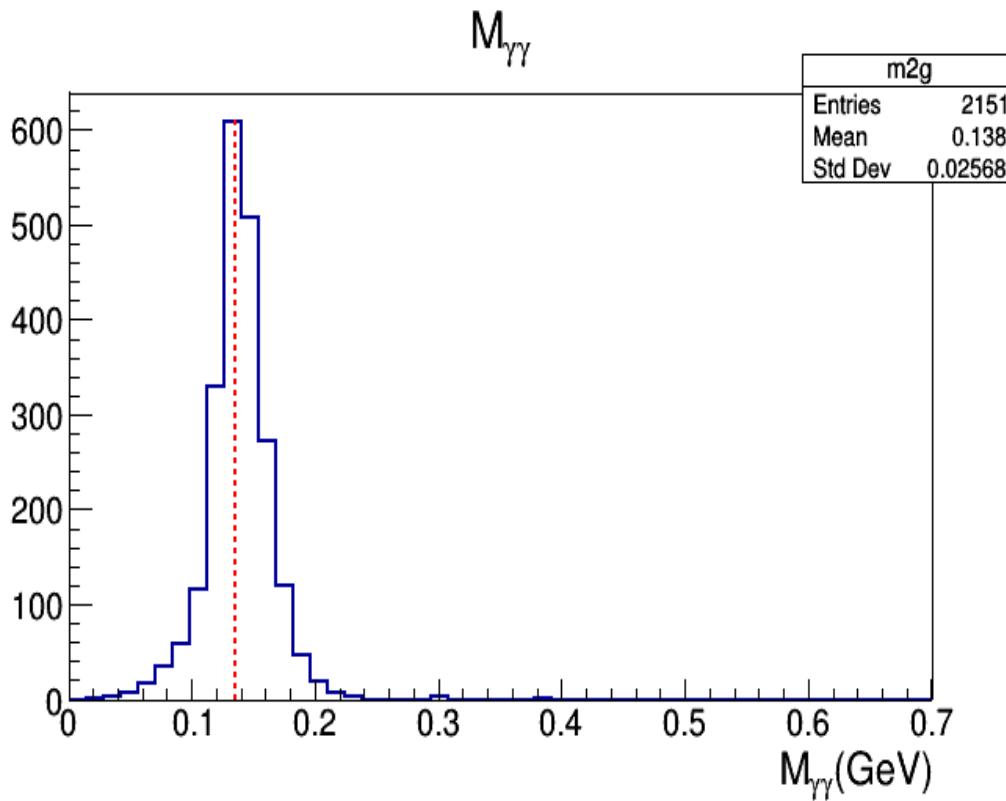
All gammas detected by FD

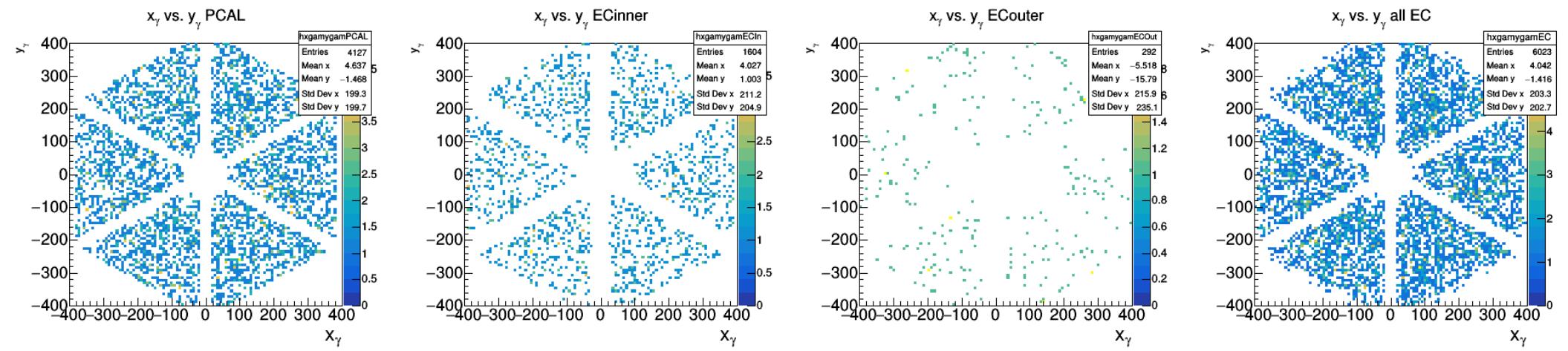
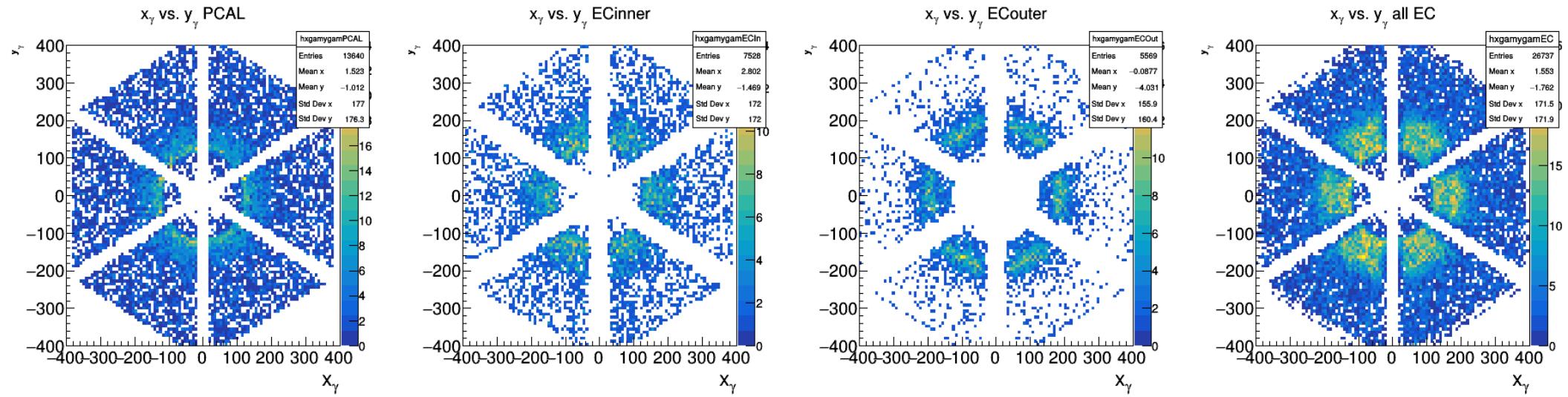


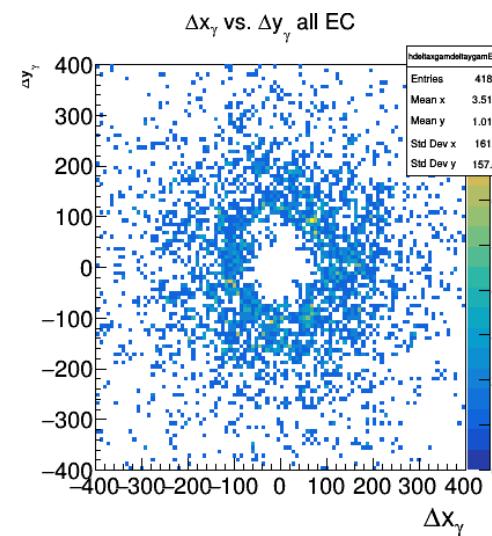
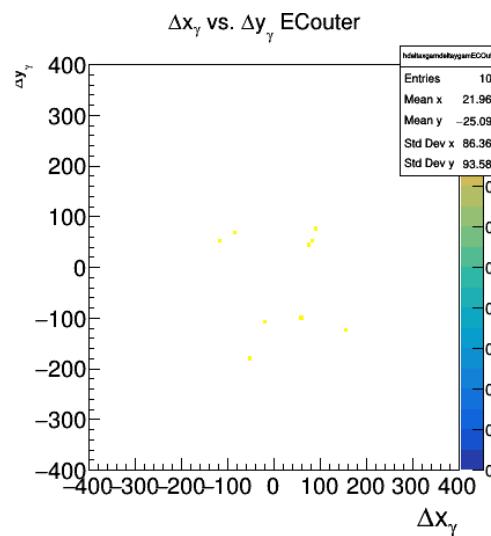
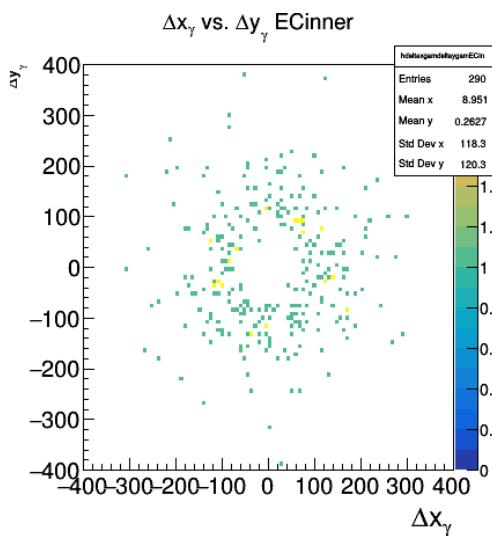
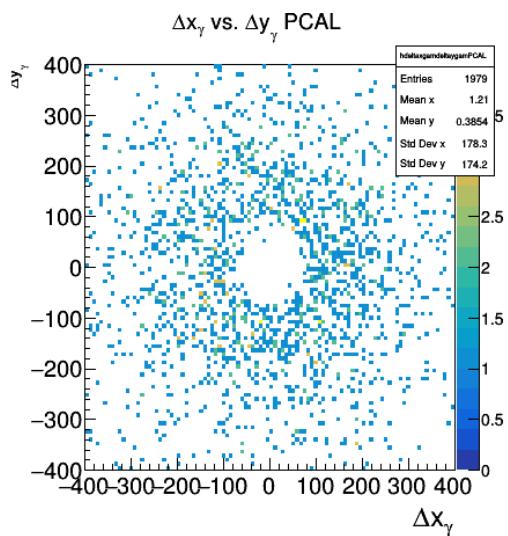
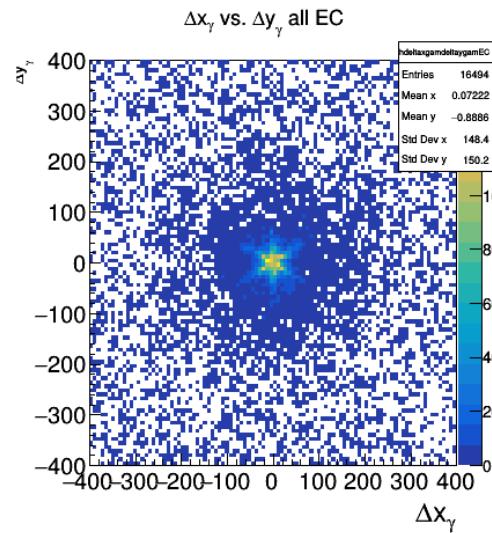
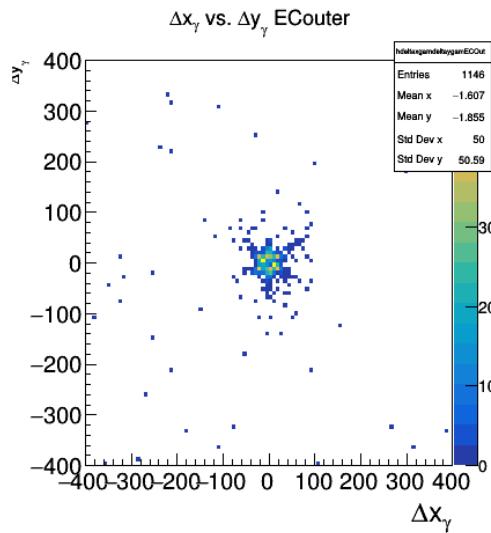
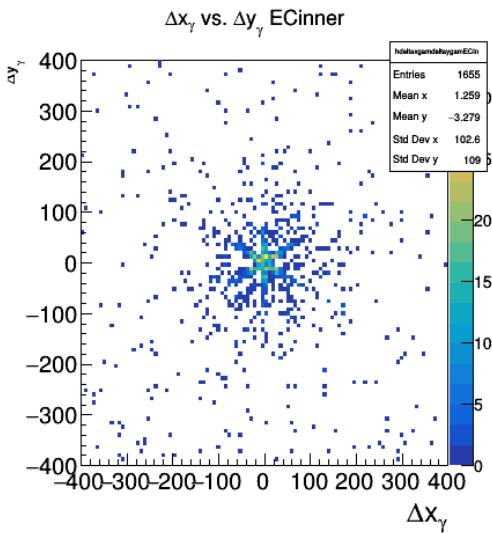
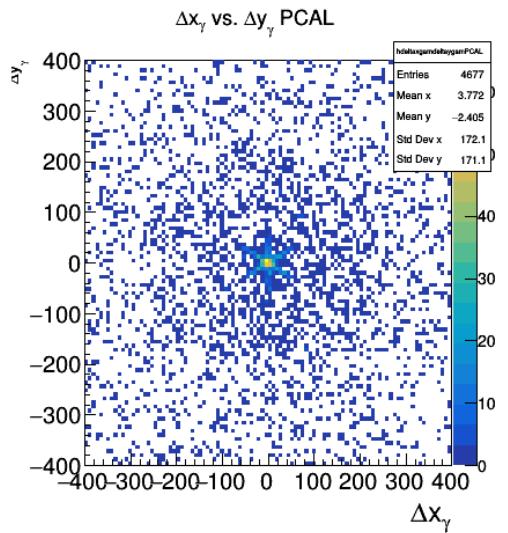
All gammas detected by FD +
Two photons from π^0 and
scattered e^- are measured in
different sectors



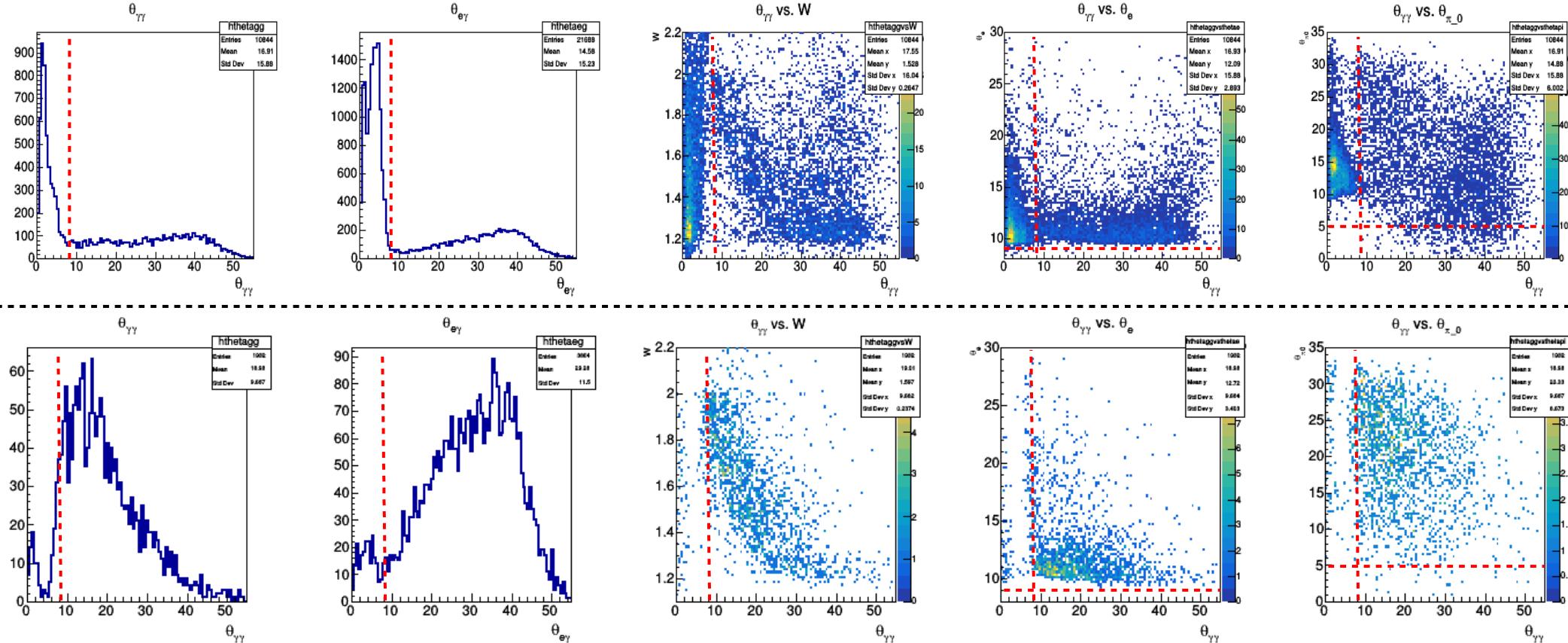
- $E_e > 1$ GeV
- All gammas detected by FD





$\Delta X = X_{\gamma 1} - X_{\gamma 2}$ $\Delta Y = Y_{\gamma 1} - Y_{\gamma 2}$ 

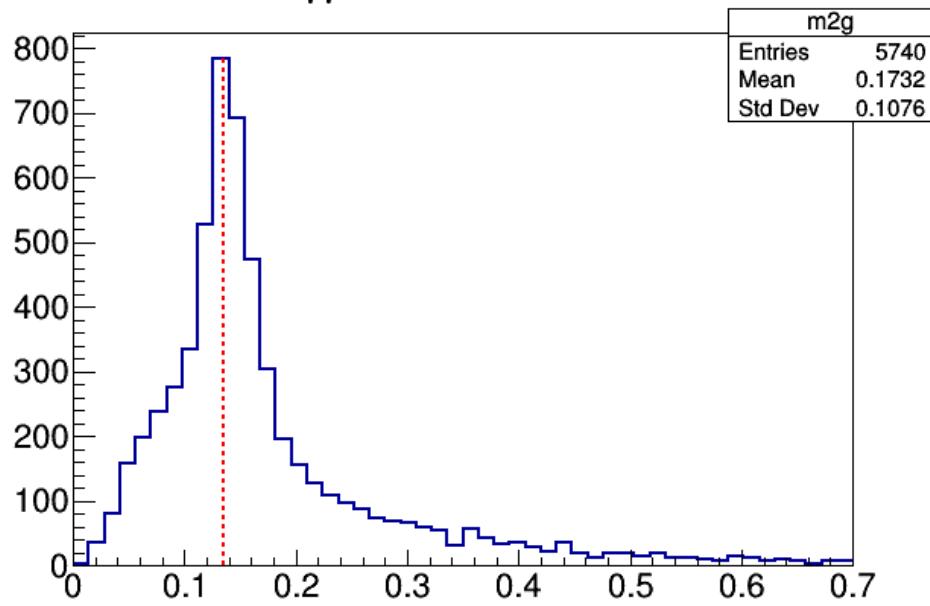
- $E_e > 1 \text{ GeV}$
- All gammas detected by FD



- Matched events

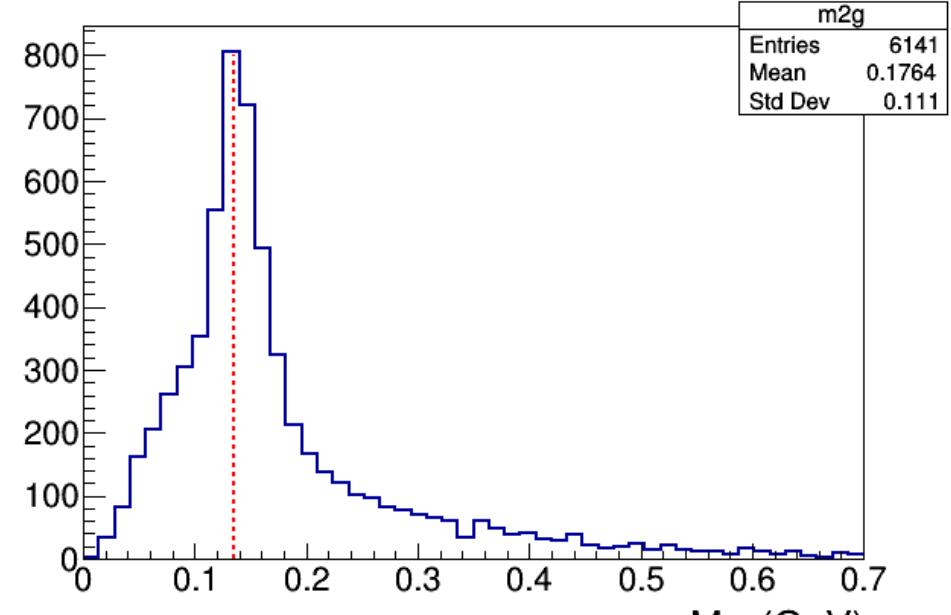
$$\Rightarrow \theta_{e\gamma} > 8^\circ, \theta_{\gamma\gamma} > 8^\circ, \theta_{\pi_0} > 5^\circ$$

$\gamma\gamma$ invariant mass

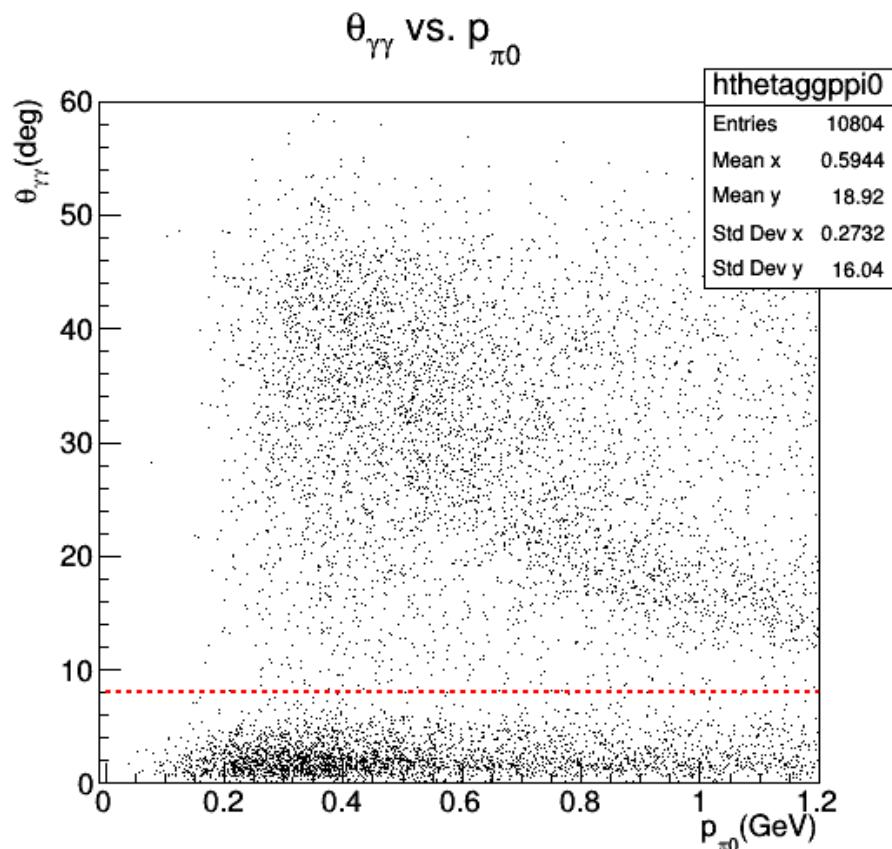


- $E_e > 1 \text{ GeV}$
- All gammas detected by FD
- $\theta_{\pi^0} > 5^\circ, \theta_e > 8^\circ, \angle(\gamma_1, \gamma_2) > 8^\circ$

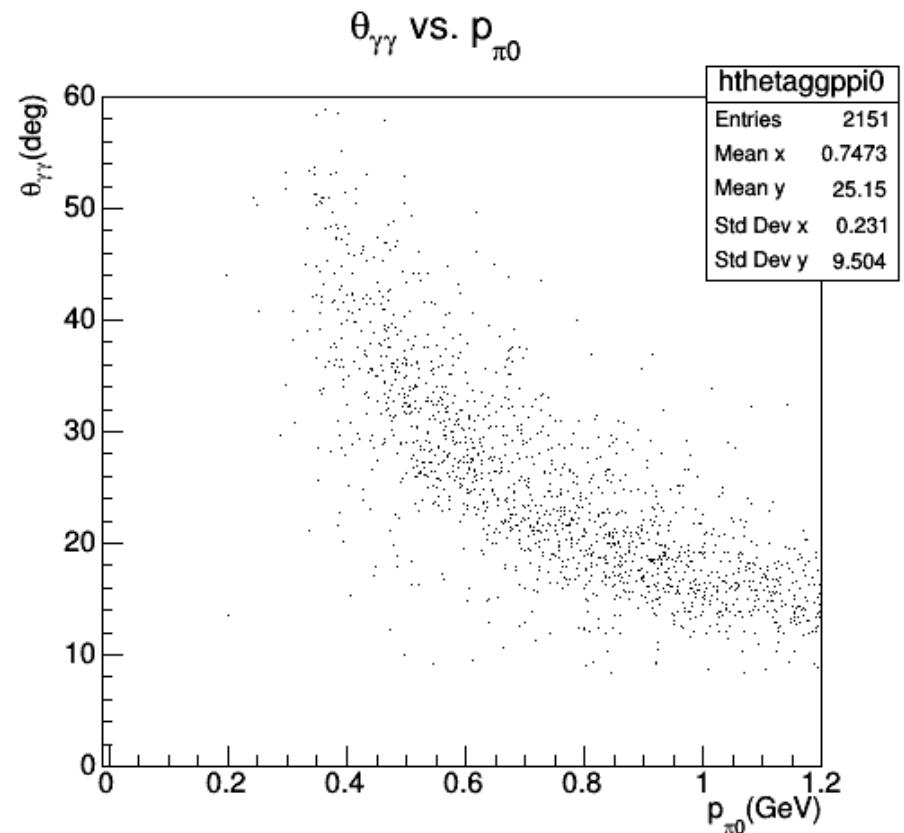
$\gamma\gamma$ invariant mass



- $E_e > 1 \text{ GeV}$
- All gammas detected by FD
- $\angle(\gamma_1, \gamma_2) > 8^\circ$

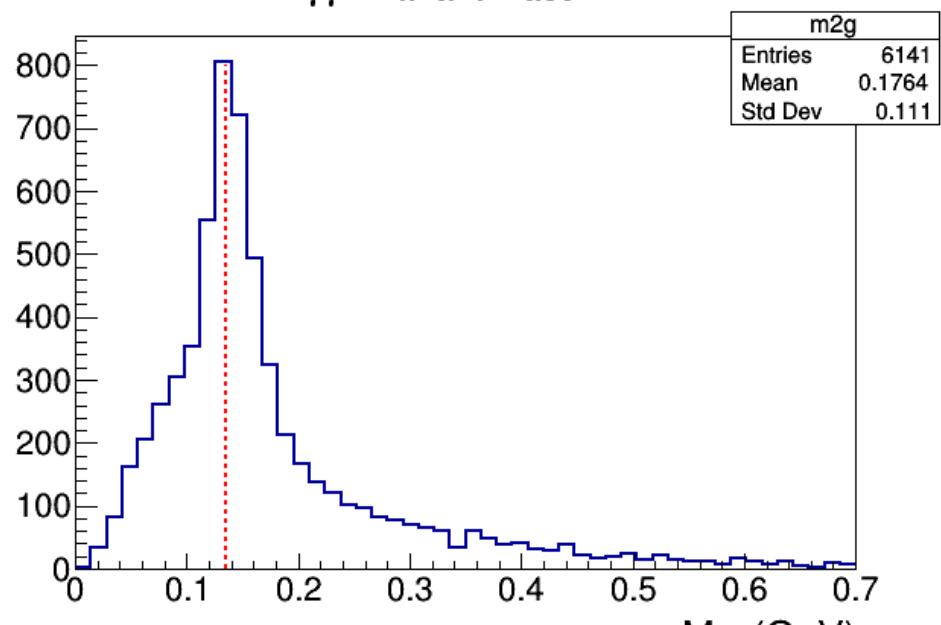


- $E_e > 1$ GeV
- All gammas detected by FD



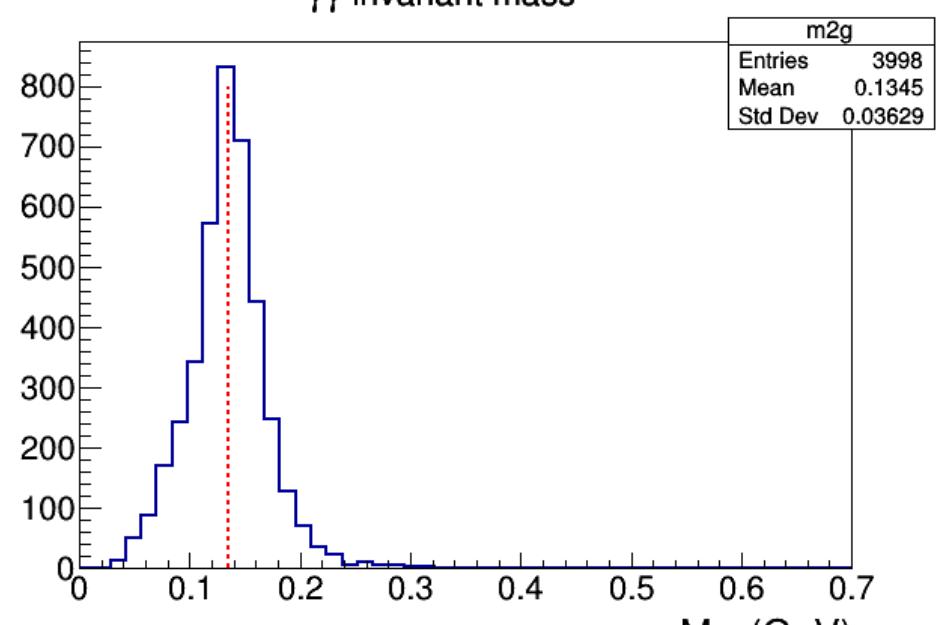
- Matched events

$\gamma\gamma$ invariant mass



- $E_e > 1$ GeV
- All gammas detected by FD
- $\angle(\gamma_1, \gamma_2) > 8^\circ$

$\gamma\gamma$ invariant mass



- $E_e > 1$ GeV
- All gammas detected by FD
- Momentum depended cut for $\angle(\gamma_1, \gamma_2)$

База данных CLAS и CLAS12

CLAS Physics Database

[JLab](#) | [Search](#) | [Overview](#) | [Login](#) | [Edit](#) | [Register](#)

Search form for the data related to the CLAS physics

You are not logged in. [Login](#).

Select reaction:

Beam:	Target:	Final state:
<input type="button" value="any"/>	<input type="button" value="any"/>	<input type="button" value="any"/>
polarization:	polarization:	polarization:
<input type="button" value="any"/>	<input type="button" value="any"/>	<input type="button" value="any"/>

Select kinematics range:

Search for average values

$Q^2_{\min}, [\text{GeV}]^2:$	<input type="text"/>	$Q^2_{\max}, [\text{GeV}]^2:$	<input type="text"/>
$W_{\min}, [\text{GeV}]:$	<input type="text"/>	$W_{\max}, [\text{GeV}]:$	<input type="text"/>
$x_{\min}:$	<input type="text"/>	$x_{\max}:$	<input type="text"/>
$EY_{\min}, [\text{GeV}]:$	<input type="text"/>	$EY_{\max}, [\text{GeV}]:$	<input type="text"/>

Select observables:

Quantity measured:	<input type="button" value="any"/>
	<input type="button" value="σ"/>
	<input type="button" value="dσ/dΩ"/>
	<input type="button" value="σ_L"/>
	<input type="button" value="σ_T"/>
	<input type="button" value="σ_L/σ_T"/>

База данных CLAS и CLAS12

Experiment comment: Release 1 - Data replay: recsis prod-1-9. RC and acceptance: aao_rad+MAID98

Publication:

- K. Joo, L. C. Smith, V. D. Burkert, R. Minehart, I. G. Aznauryan, L. Elouadrhiri, S. Stepanyan, and CLAS Collaboration [Q² Dependence of Quadrupole Strength in the γ* p → Δ^{+\(1232\)}](#)
→ π⁰ Transition // Phys. Rev. Lett. 88, 122001 (2002)

Quantity measured: $d\sigma/d\Omega$, mcbn/srad

Differential cross section.

Beam: e, **polarization:** none

Target: p (Z=1, A=1), **polarization:** none

Final state: π⁰p, **polarization:** none

Q² : 0.35 – 0.45 GeV²

W : 1.1 GeV

ε : 0.877

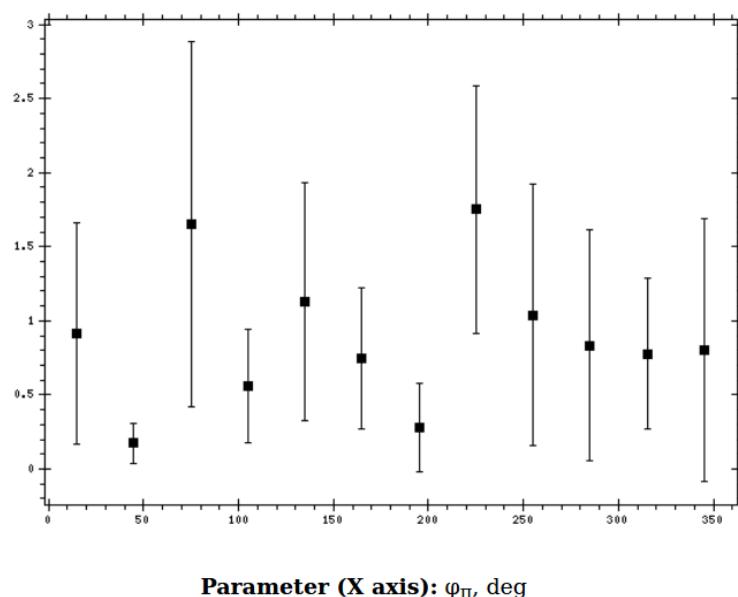
Select data slice:

$\cos(\theta_\Pi) =$ dimensionless

Fit φ dependence:

- $A + B \cdot \cos(2\varphi) + C \cdot \cos(\varphi)$
- $A + B \cdot \cos(2\varphi) + C \cdot \cos(\varphi) + D \cdot \cos(3\varphi)$
- $\frac{1}{\varphi_{max} - \varphi_{min}} \int_{\varphi_{min}}^{\varphi_{max}} \frac{d\sigma}{d\Omega} d\varphi$

Observable quantity measured (Y axis): $d\sigma/d\Omega$, mcbn/srad



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Experiment comment: Release 1 - Data replay: recsis prod-1-9. RC and acceptance: aao_rad+MAID98

Publication:

- K. Joo, L. C. Smith, V. D. Burkert, R. Minehart, I. G. Aznauryan, L. Elouadrhiri, S. Stepanyan, and CLAS Collaboration [Q² Dependence of Quadrupole Strength in the \$\gamma^* p \rightarrow \Delta^+\(1232\) \rightarrow \pi^0 p\$ Transition](#) // Phys. Rev. Lett. 88, 122001 (2002)

Quantity measured: $d\sigma/d\Omega$, mcbn/srad

Differential cross section.

Beam: e, **polarization:** none

Target: p (Z=1, A=1), **polarization:** none

Final state: $\pi^0 p$, **polarization:** none

Q² : 0.35 — 0.45 GeV²

W : 1.1 GeV

ε : 0.877

Select data slice:

$\cos(\theta_\Pi) =$ dimensionless

Fit φ dependence:

$A + B \cdot \cos(2\varphi) + C \cdot \cos(\varphi)$

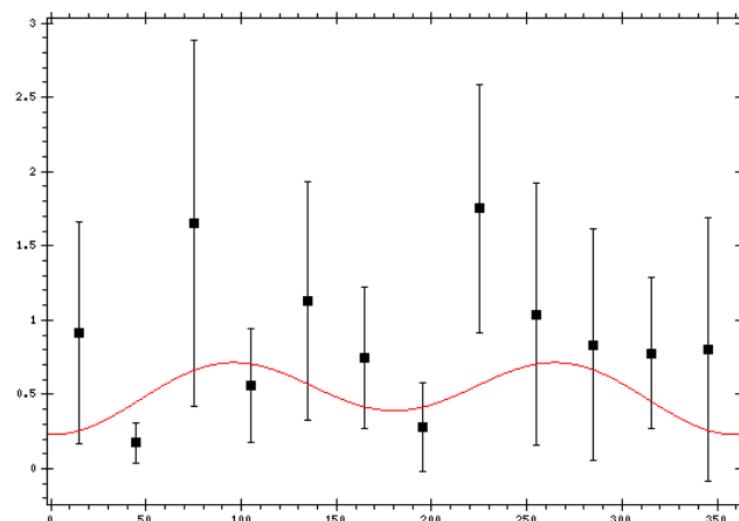
$\chi^2 = 0.2928$

Value	Uncert
A 0.5097	0.22459
B -0.20039	0.37712
C -0.080928	0.28832

$A + B \cdot \cos(2\varphi) + C \cdot \cos(\varphi) + D \cdot \cos(3\varphi)$

$\frac{1}{\varphi_{max} - \varphi_{min}} \int_{\varphi_{min}}^{\varphi_{max}} \frac{d\sigma}{d\Omega} d\varphi$

Observable quantity measured (Y axis): $d\sigma/d\Omega$, mcbn/srad



Parameter (X axis): φ_Π , deg

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Structure functions and cross-sections

Observable: F_1 F_2 σ $d\sigma/dWdQ^2$ Show W grid instead of x_B

Channels: inclusive π^+n π^0p $\pi^+\pi^-p$ $2\pi^0p + \pi^+\pi^0n$ $\pi^+n + \pi^0p + \pi^+\pi^-p$ $K^+\Lambda$ $K^+\Sigma^0$ ηp $\eta' p$

Abscissa	First	Step	Last
Q^2, GeV^2 :	0.5	0.1	0.5
x_B :	0.1	0.01	0.9

Data set: CLAS data only CLAS and world data Resonant contributions Difference Ratio

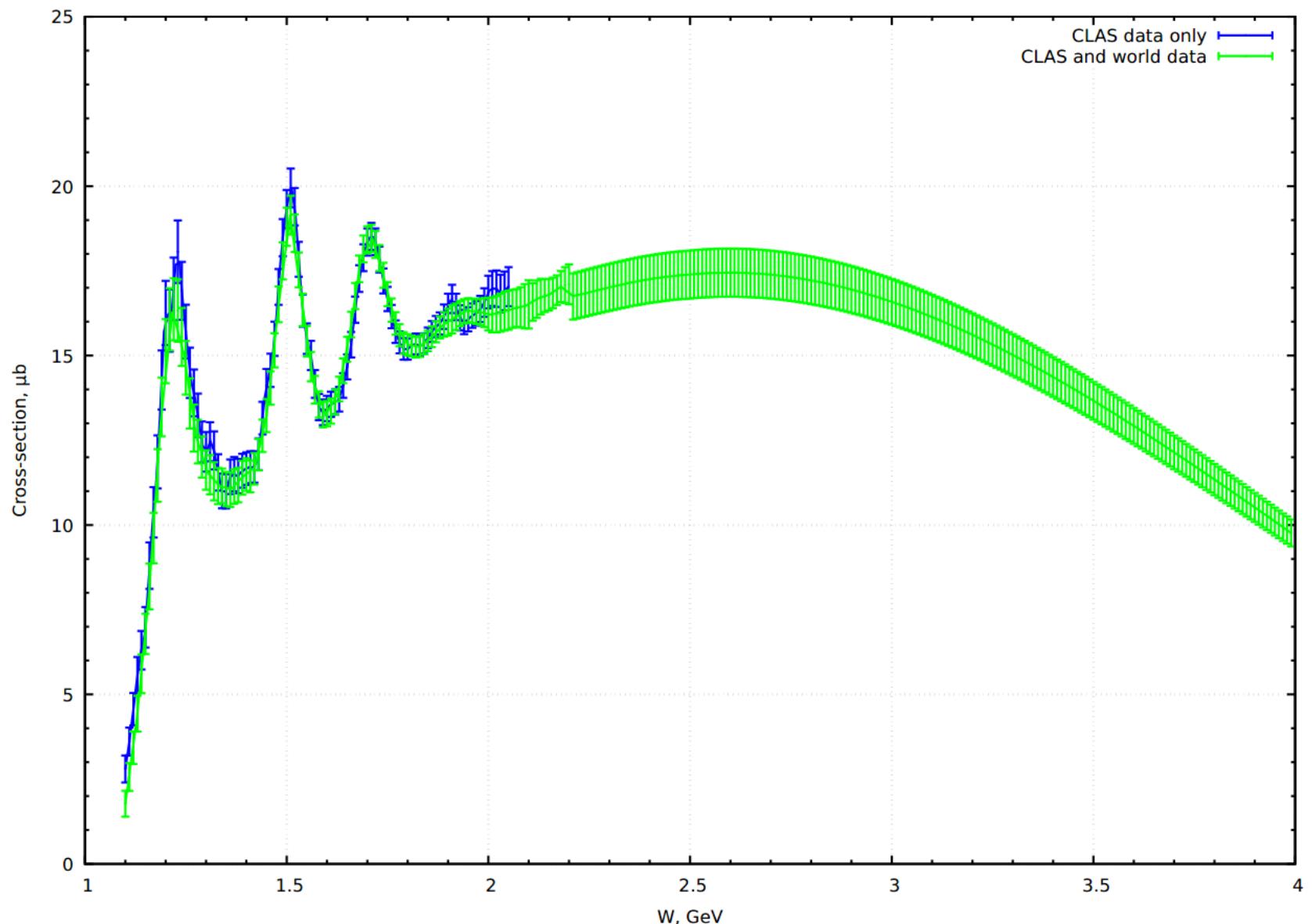
Results view: HTML Plot Plot-SVG Text Gnuplot PDF

Plot type: splines lines points

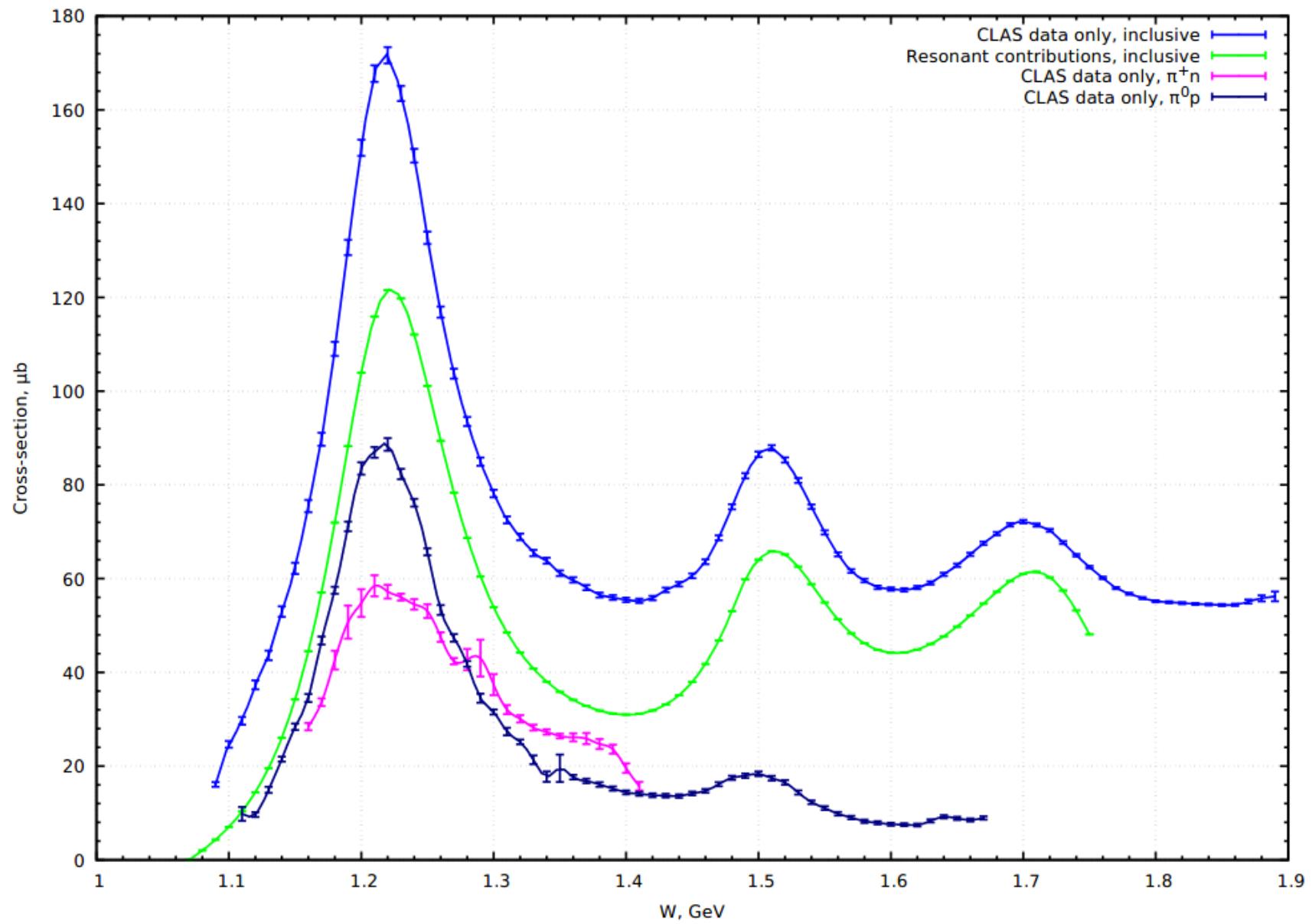
The interactive website evaluates the inclusive structure functions F_1 , F_2 , inclusive virtual photon σ and electron scattering cross sections $d\sigma/dWdQ^2$ as the function of (x, Q^2) or (W, Q^2) , where x is Bjorken variable. Choice of the variable set should be defined by a user by checking "Show W grid instead of x "-box. The ranges of variables should be defined by implementing their values into the boxes in Q^2 and x (W) form rows: "First" stands for the minimal value, "Last" stands for the maximal value of the variable with the grid step in the box "Step". In a case of the just single value of the variable, the boxes "First" and "Last" should contain the same number. For W values, GeV units should be used. The aforementioned observables can be presented as the function of Q^2 , or x , or W by checking the respective icons in column "Abscissa". Inclusive cross sections depend on the polarization parameter of the virtual photon which determines the weight of the longitudinal part of inclusive cross sections. For evaluation of the virtual photon polarization parameter user is required to specify the incoming electron beam energy in GeV in the box " E_{beam} ". The inclusive electron scattering observables can be computed from the CLAS data only [1] or from the CLAS and world data [1,2]. The inclusive electron scattering observables and their uncertainties are computed from the CLAS/world experimental data within the framework of the interpolation procedure described in [3]. The resonant contributions to the inclusive electron scattering observables are evaluated within the framework of the Breit-Wigner ansatz [4]. The experimental results from CLAS on γ_pN electroexcitation amplitudes [5,6] and momentum dependent resonance hadronic decay width [7] are used in the computations of the resonant contributions to the inclusive electron scattering observables. For the computation of the resonant contributions, the box "Resonant contribution" should be checked. The statistical uncertainties of the electron scattering observables can be evaluated from the total number of events collected in (W, Q^2) bins for integrated luminosity defined by a user. The box "Calculate σ uncertainties" should be checked and integrated luminosity should be inserted in the box " L, mcbn^{-1} " together with bin sizes over W in GeV and Q^2 in GeV^2 . The computed result can be presented in different formats by checking appropriate boxes in the two bottom form rows.

<https://clas.sinp.msu.ru/strfun/>

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Nucleon resonance contributions to unpolarized inclusive electron scattering

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The first CLAS12 experiments will provide high-precision data on inclusive electron scattering observables at a photon virtuality Q^2 ranging from 0.05 to 12 GeV² and center-of-mass energies W up to 4 GeV. In view of this endeavor, we present the modeling of the resonant contributions to the inclusive electron scattering observables. As input, we use the existing CLAS electrocoupling results obtained from exclusive meson electroproduction data off protons, and evaluate for the first time the resonant contributions based on the experimental results on the nucleon resonance electroexcitation. The uncertainties are given by the data and duly propagated through a Monte Carlo approach. In this way, we obtain estimates for the resonant contributions, important for insight into the nucleon parton distributions in the resonance region and for the studies of quark-hadron duality.

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→ Первая публикация CLAS12

Спасибо за внимание!