First measurement of near threshold J/ψ photoproduction*

(GlueX Collaboration)

(Dated: October 5, 2017)

We report on the first measurement of the J/ψ photoproduction that extends down to the thrshold.

I. GENERAL REMARKS

The paper describes the anlysis of the data from the spring 2016 GlueX run and low intensity part from the 2017 data (so far). We look at the exclusive reaction:

$$\gamma p \to p e^+ e^- \tag{1}$$

in the region of the e^+e^- invariant masses above 0.9 GeV, that includes ϕ, J/ψ, as well as Bethe-Heitler (BH) process as a continuum.

The idea of the presented analyses is to use the ϕ photoproduction and, possibly, BH cross-section to normalize the J/ψ cross-section, thus eliminating uncertainties from factors like luminosity and common detector efficiencies. To make sure that the relative detector efficiency in the invariant mass region between 1 and 3 GeV is under control we aim to match the data and simulations over the whole region. While for the ϕ and J/ψ peaks we can estimate the signal and the background (by fiting them separately), the problem is that we cannot do the same for the BH continuum. The main background comes from the pions that are suppressed by applying $\frac{E}{p}$ cuts, energy measured in the calorimeteris over the momentum recosntructed from the tracking. By making the cuts more restrictive we compare the yealds for BH with those of ϕ and J/ψ and thus decide about the cut values at which the BH signal dominates the background.

II. EVENT SELECTION

A. Initial cuts

The exclusive reaction 1 is identified using DReaction factory (from DAnalysis library) using the following initial loose cuts:

1. Missing mass squared, M_{miss}: $abs(M_{miss}) < 0.25 GeV^2$ (cut applied before forming particle combinations).

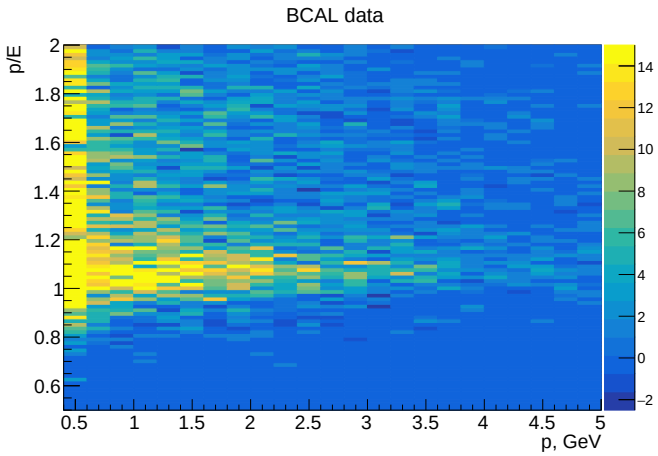
2. Missing transverse momentum, Pt_{miss}: $abs(Pt_{miss}) < 0.5 GeV$ (cut applied before forming particle combinations).

3. Timing cuts: on the three final state particle the time from BCAL and FCAL to be within $2.5ns$ from the RF-time, and in case of electron/positron from TOF, $1ns$ from the RF-time.
4. Energy (from calorimeter) over momentum (from tracking), E/p: $E/p > 0.6$ for electrons and positrons.

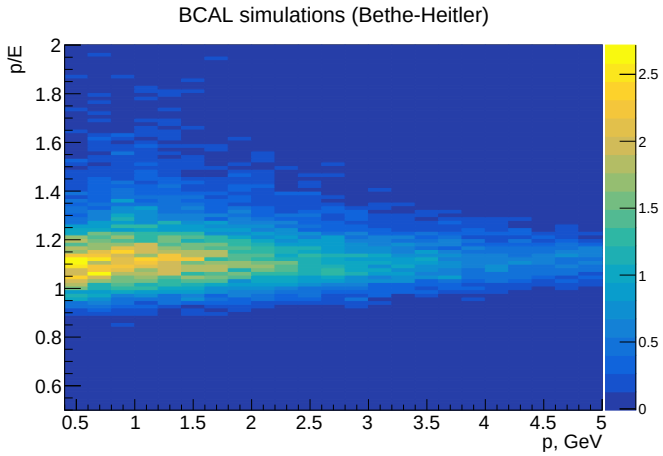
B. Electron/positron identification

The elctrons and positrons are identified using E/p cuts from the enrgy measured in BCAL and/or FCAL. The widths and mean values of the E/p distributions have been estimated from the experimental data (Fig. **??** and **??**). for events in the J/ψ peak by applying all other cuts (described later) except E/p for the corresponding particle and calorimeter. In case of BCAL additional cut is applied using pre-shower energy $E_{pre-shower}$

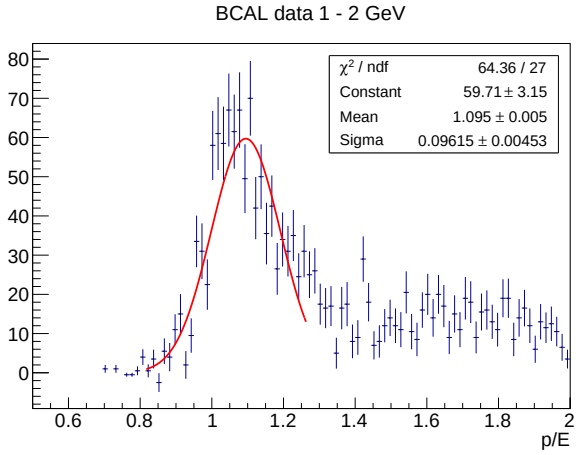
* Thanks to everybody who contributed to this work



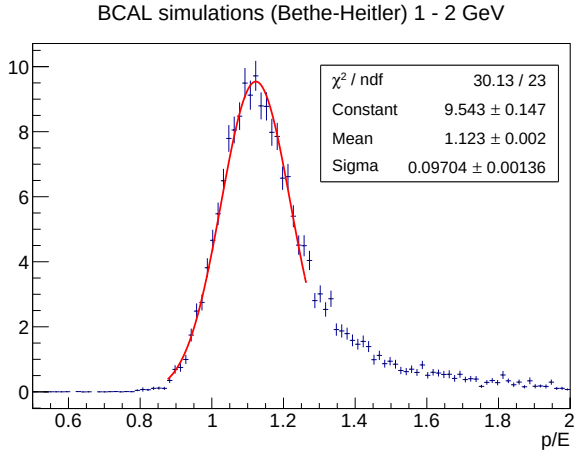
(a) p/E vs p distribution for BCAL from the data



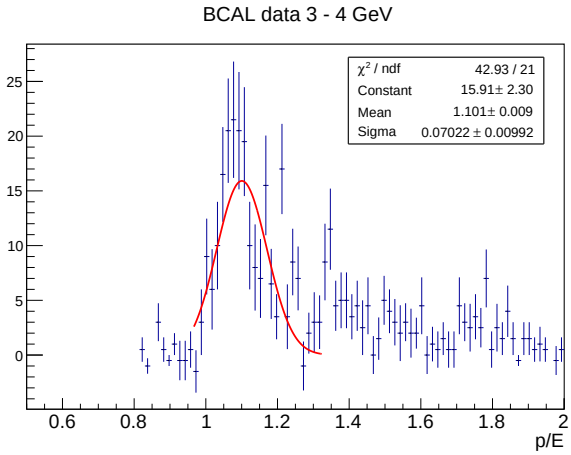
(b) p/E vs p distribution for BCAL from MC



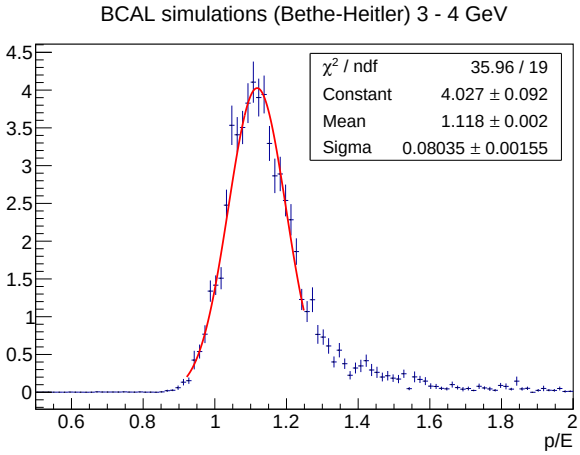
(a) p/E distribution for BCAL from the data in $1-2$ GeV momentum range.



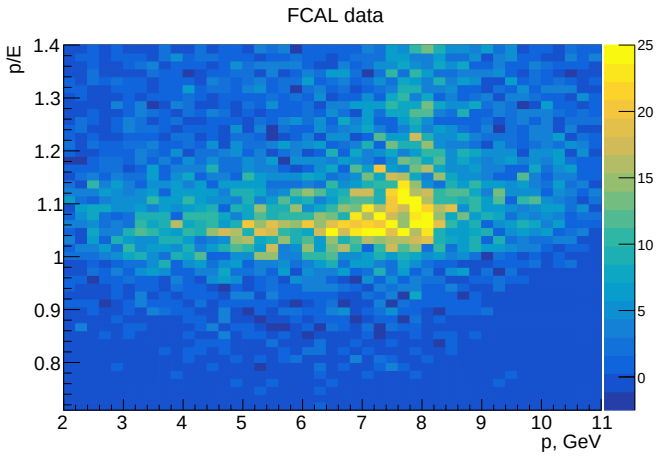
(b) p/E distribution for BCAL from MC in $1-2$ GeV momentum range.



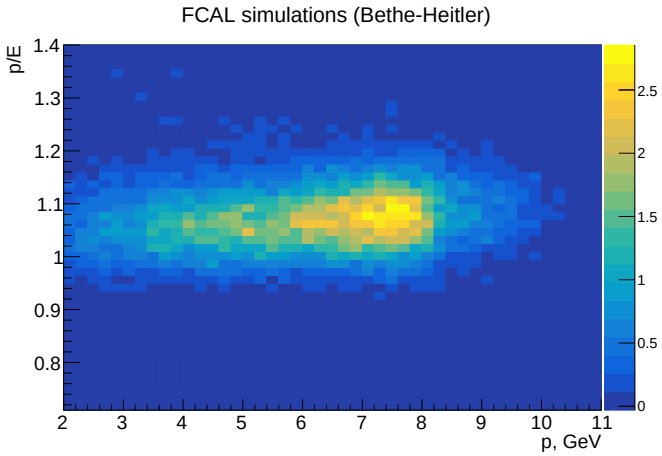
(a) p/E distribution for BCAL from the data in $3-4$ GeV momentum range.



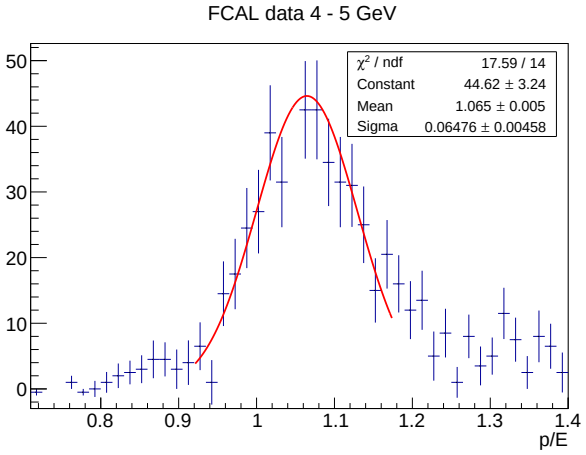
(b) p/E distribution for BCAL from MC in $3-4$ GeV momentum range.



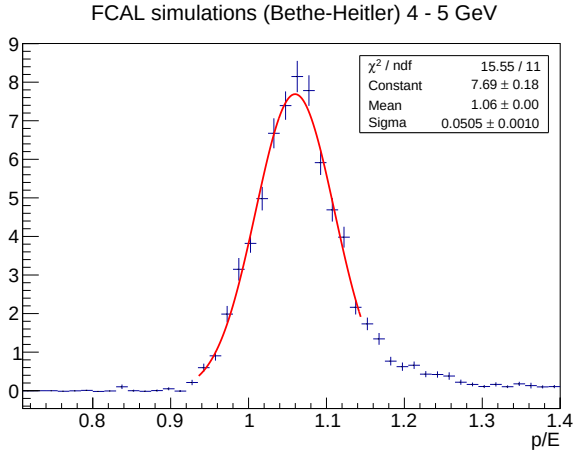
(a) p/E vs p distribution for FCAL from the data.



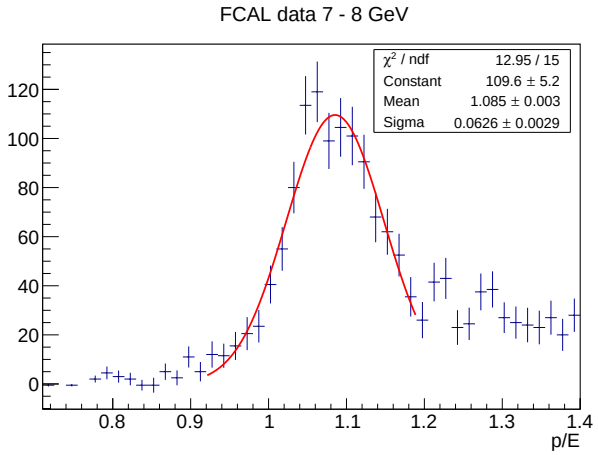
(b) p/E vs p distribution for FCAL from MC.



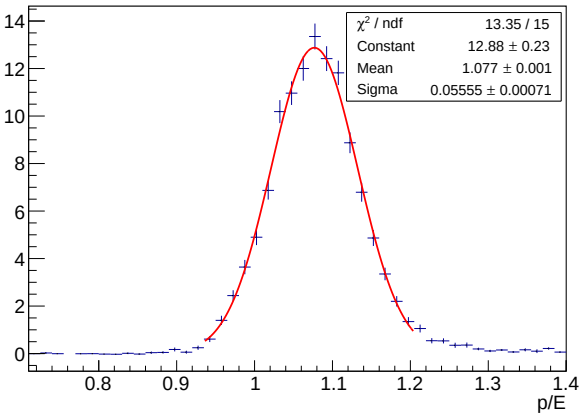
(a) p/E distribution for FCAL from the data in $4-5$ GeV momentum range.



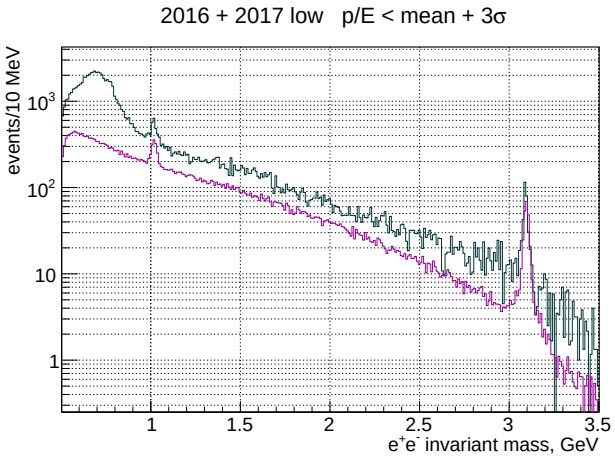
(b) p/E distribution for FCAL from MC in $4-5$ GeV momentum range.



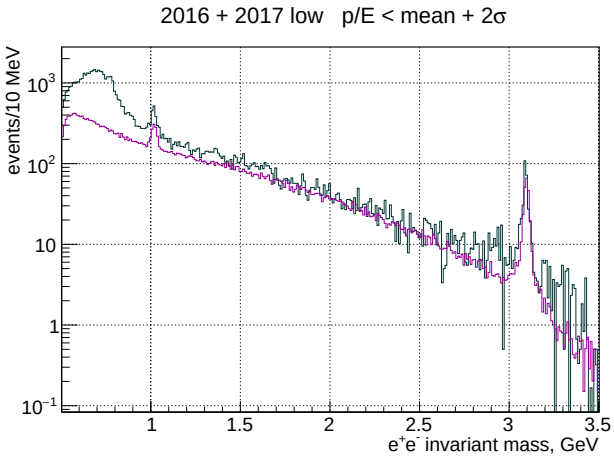
(a) p/E distribution for FCAL from the data in $7-8$ GeV momentum range.



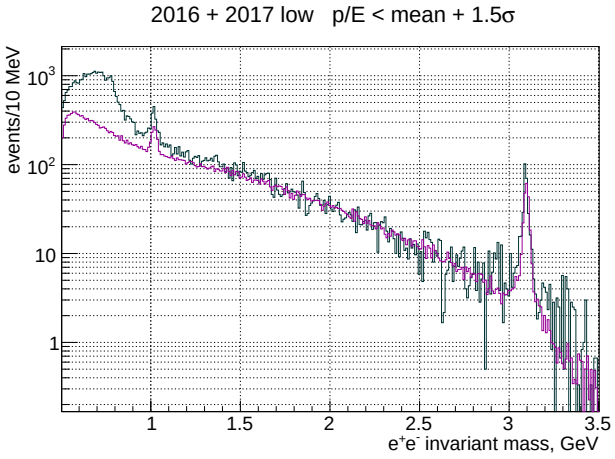
(b) p/E distribution for FCAL from MC in $7-8$ GeV momentum range.



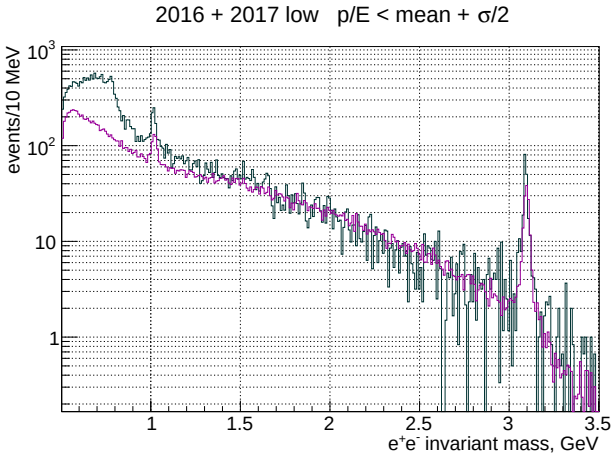
(a) Di-electron invariant mass distribution with 3σ p/E cuts on both calorimeters: green – data, magenta – simulations.



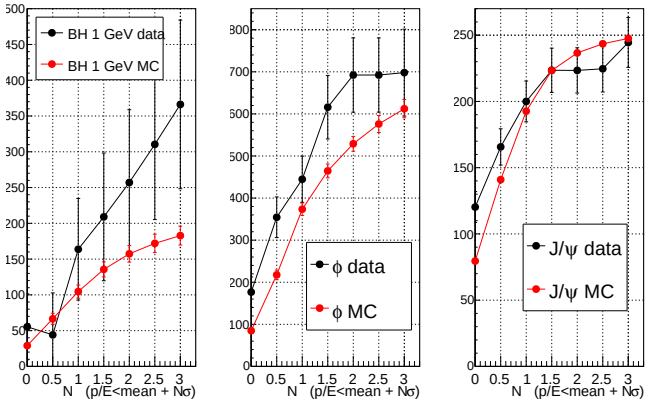
(b) Di-electron invariant mass distribution with 2σ p/E cuts on both calorimeters: green – data, magenta – simulations.



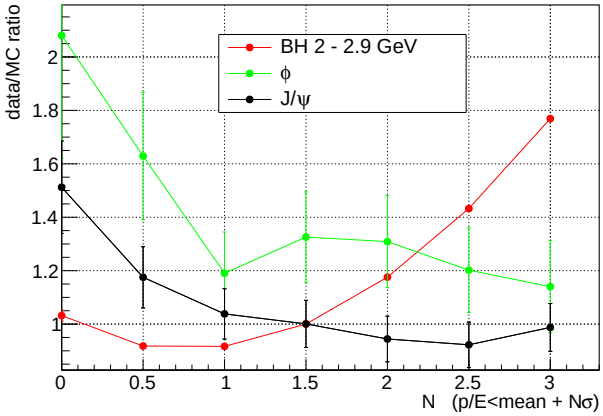
(a) Di-electron invariant mass distribution with 1.5σ p/E cuts on both calorimeters: green – data, magenta – simulations.



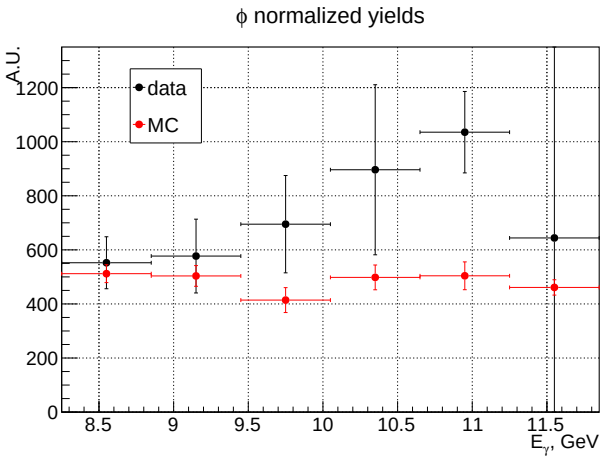
(b) Di-electron invariant mass distribution with 0.5σ p/E cuts on both calorimeters: green – data, magenta – simulations.



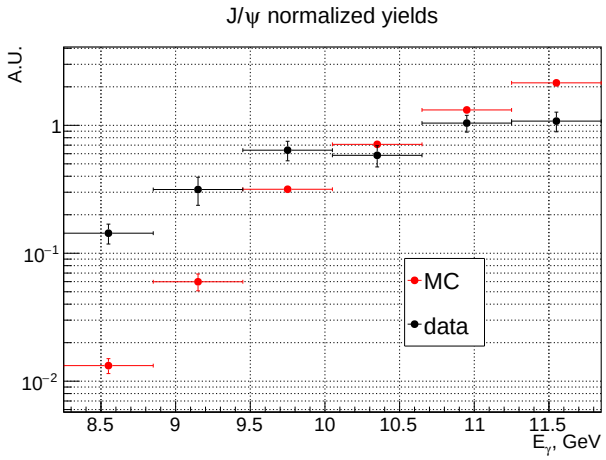
(a) Data (black) and MC (red) results for yields of BH at 1.02 GeV (left), ϕ (middle), and J/ψ (right) vs p/E cut values for both calorimeters.



(b) ratios



(a) Data (black) and MC (red) results for ϕ yields normalized to the flux and efficiency



(b) Data (black) and MC (red) results for J/ψ yields normalized to the flux and efficiency