Experimental methods in high energy particle physics.

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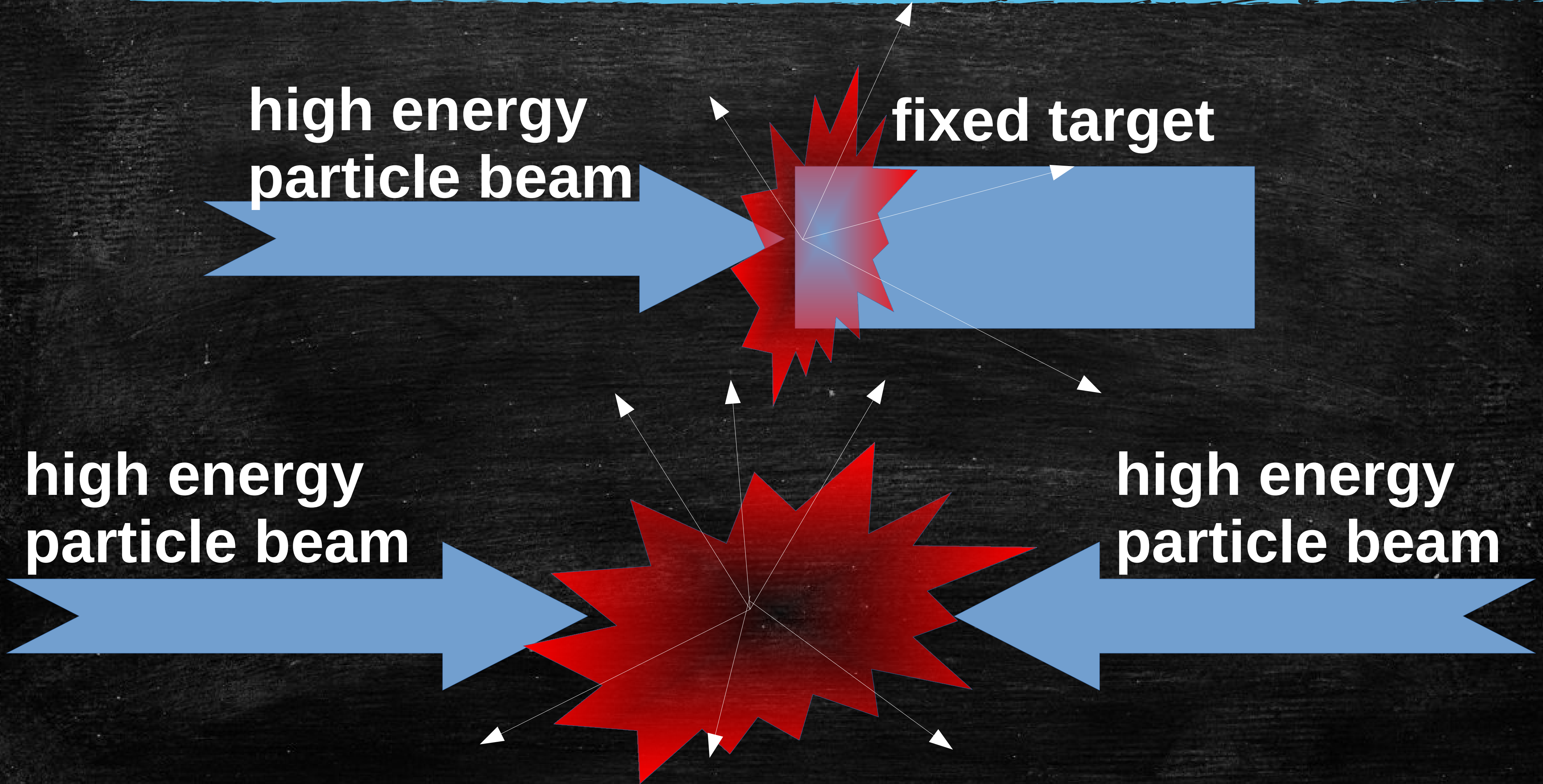
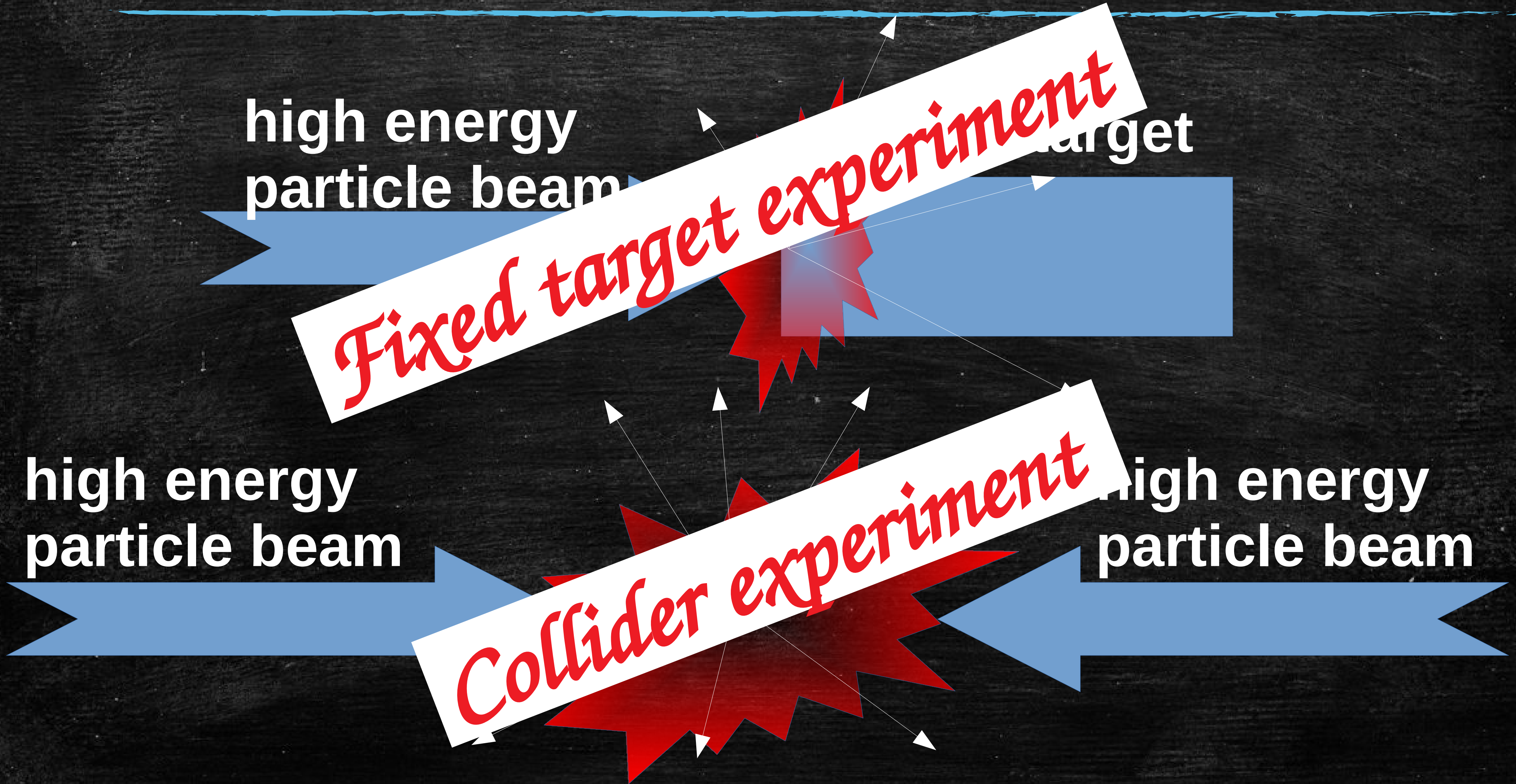
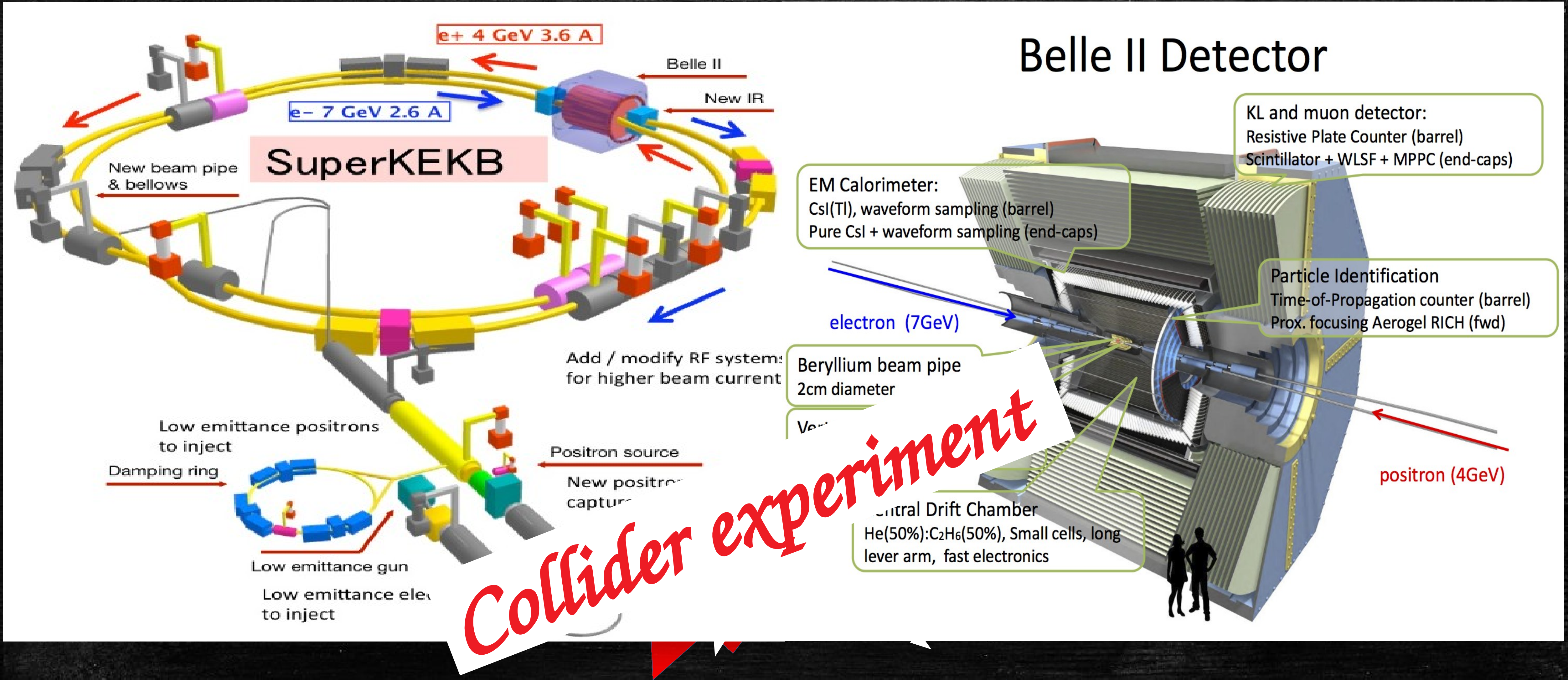
Experiments in high-energy particle physics



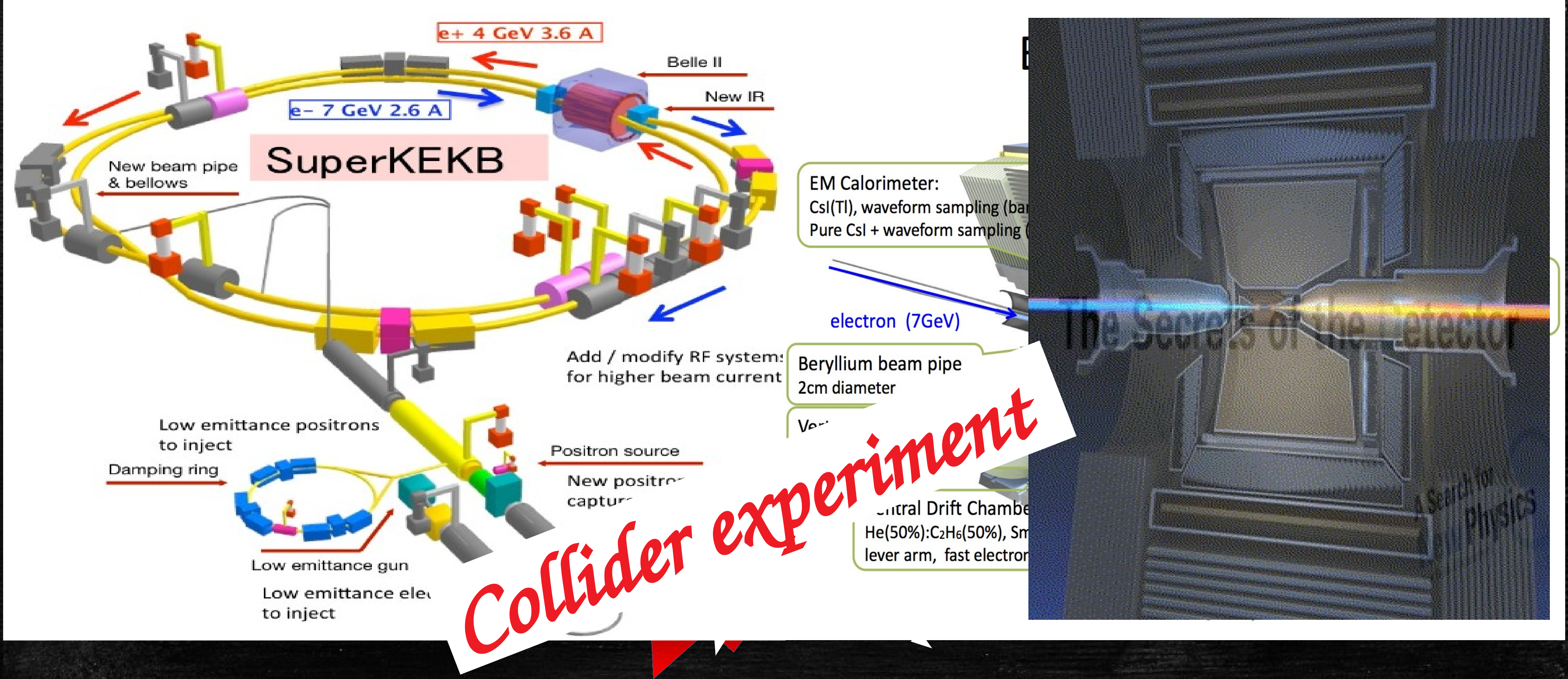
Experiments in high-energy particle physics



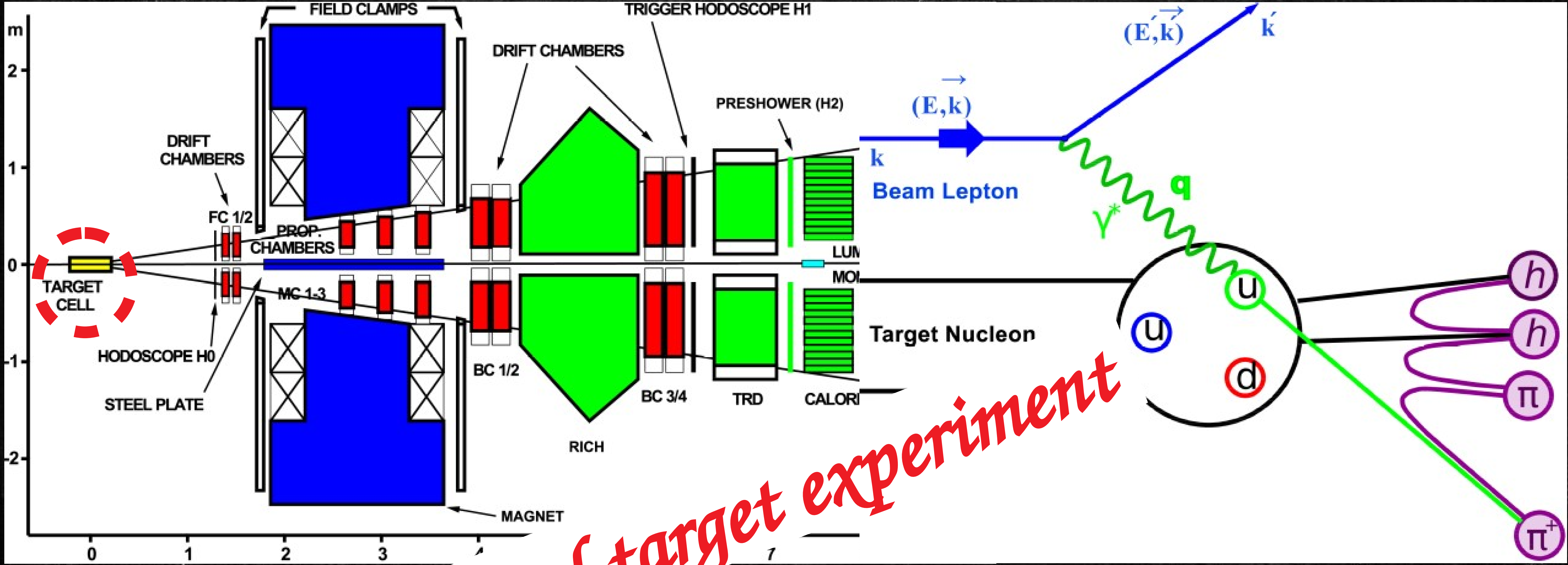
Experiments in high-energy particle physics



Experiments in high-energy particle physics

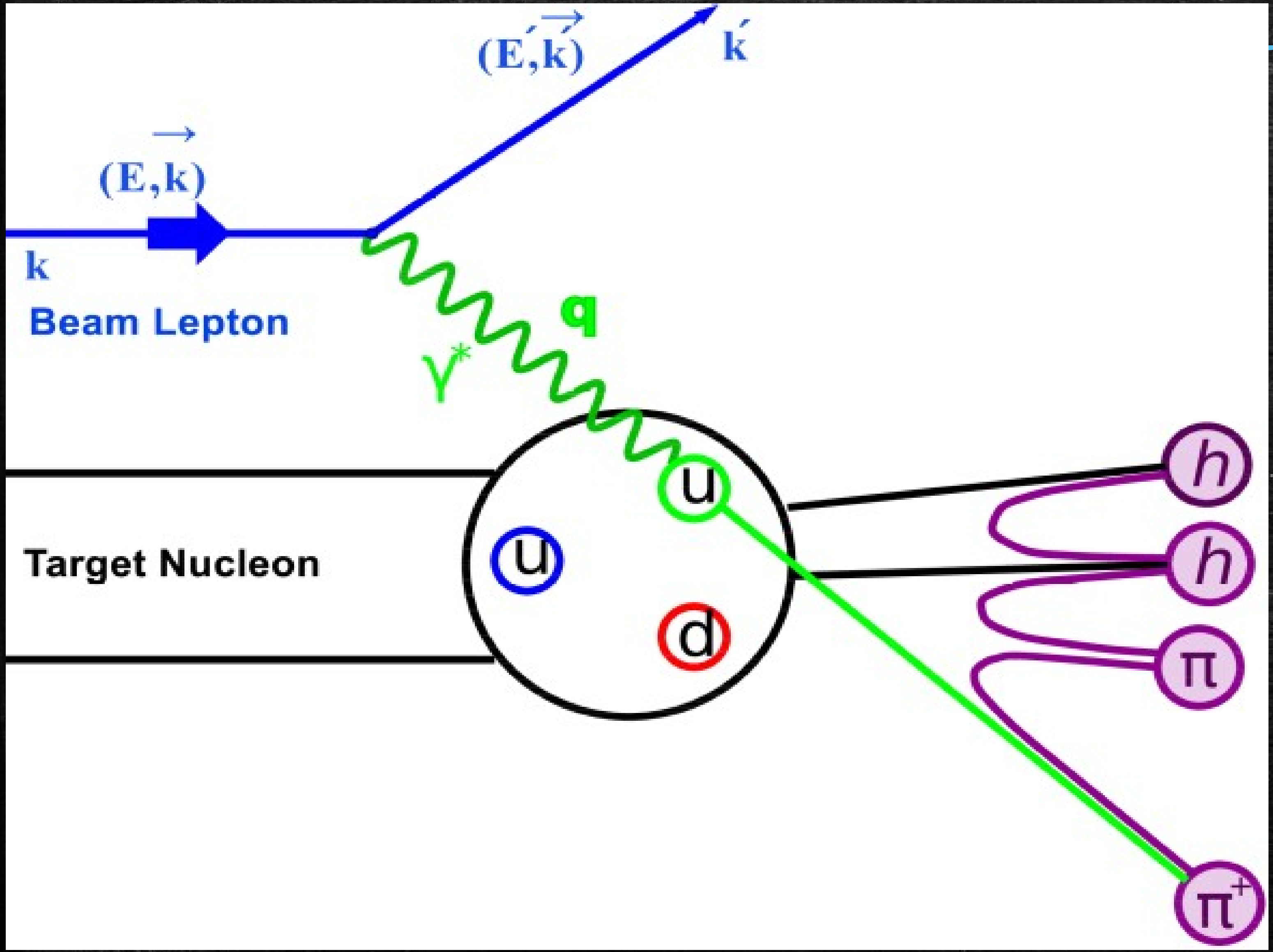


Experiments in high-energy particle physics



Fixed target experiment

Fixed target experiment



virtual photon energy

$$\nu = E - E'$$

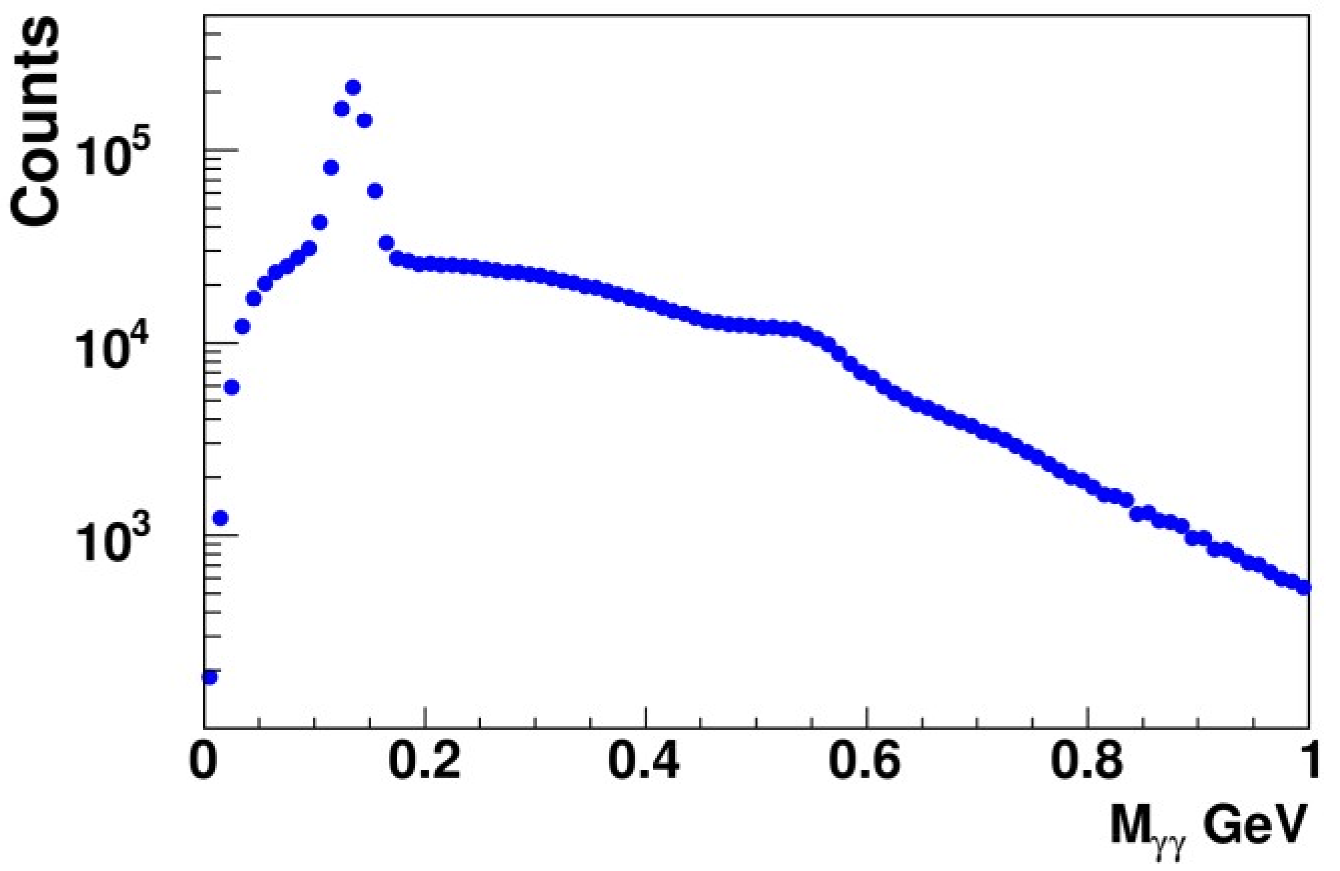
hadron fractional energy

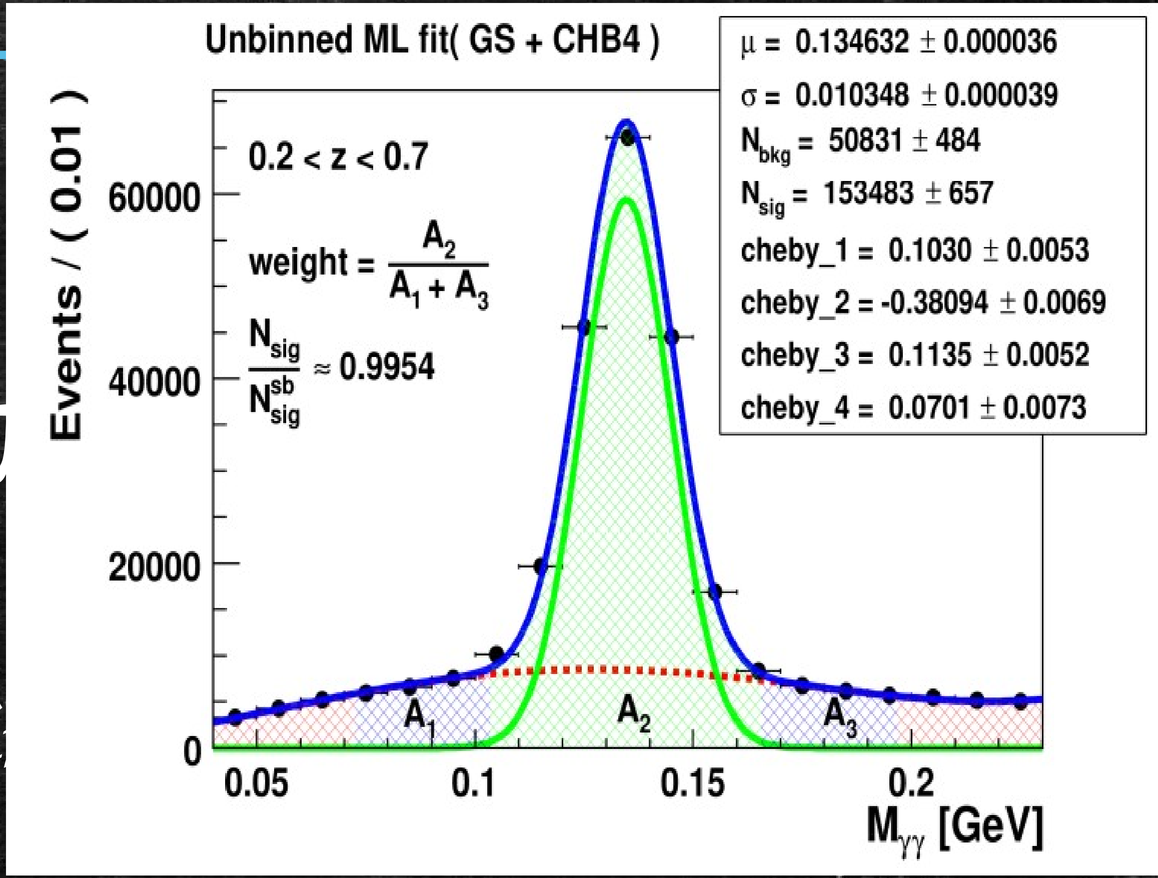
$$z = E_h / \nu$$

transverse momentum of the produced hadron

$$p_\perp$$

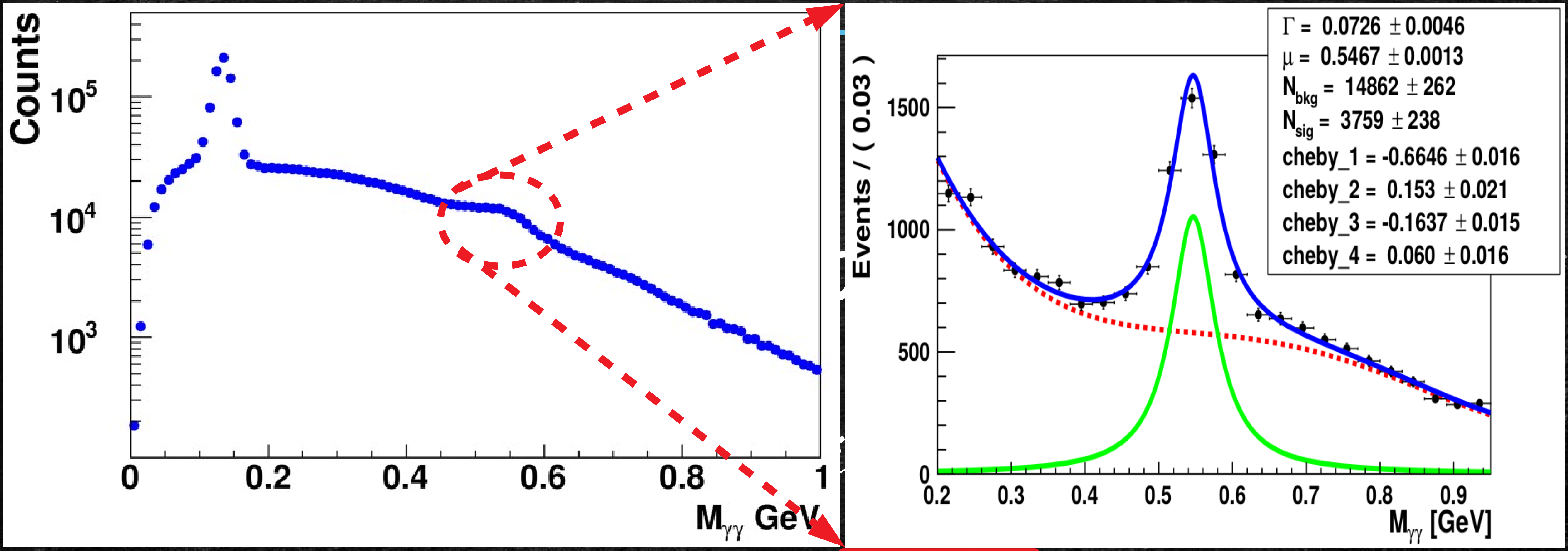
Invariant mass spectrum





$$M^2_{\gamma\gamma} = (p_\mu^{\gamma_1} + p_\mu^{\gamma_2})^2 \Rightarrow \boxed{m^2_{\pi^0}}$$

Invariant mass spectrum



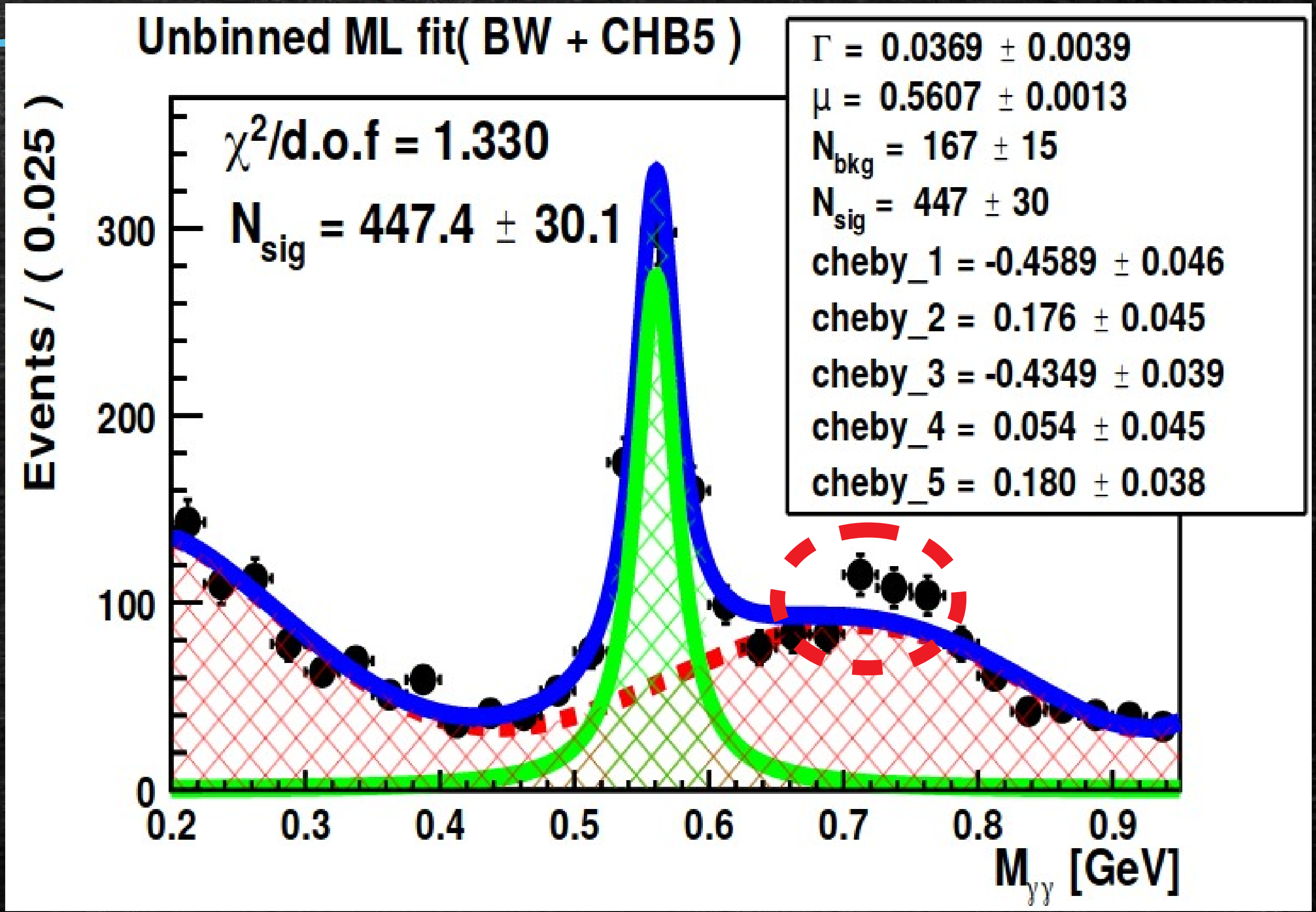
$$M^2_{\gamma\gamma} = (p_\mu^{\gamma_1} + p_\mu^{\gamma_2})^2 \Rightarrow m_\eta^2$$

Invariant mass spectrum

Let's consider the spectrum in a specific kinematic range :

$0.8 < z < 1.1$

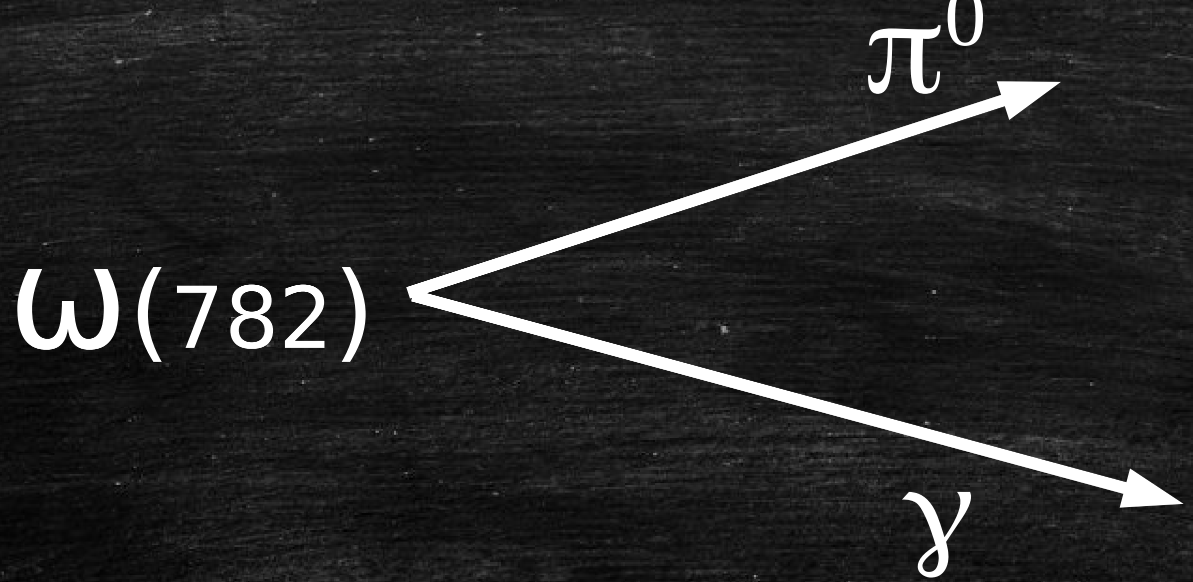
$p_\perp < 0.45$ [GeV]



Question. What makes a bump-like structure right after the signal ?

Experimental techniques

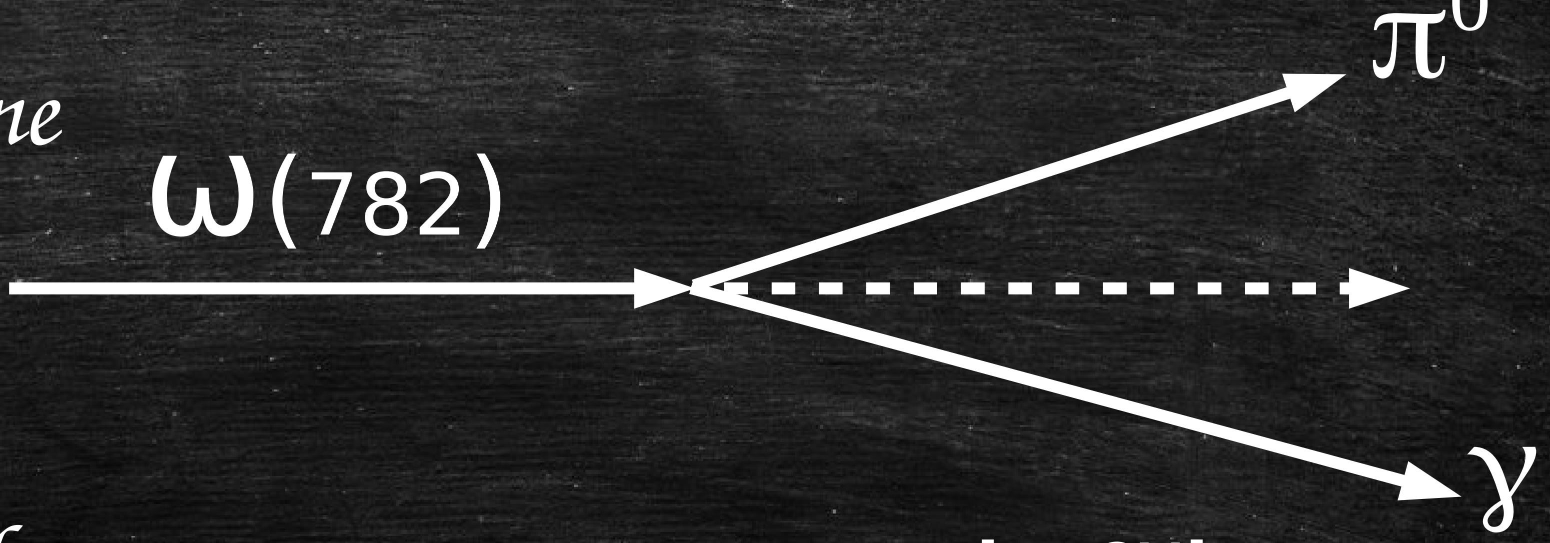
What if there is a contribution from other resonances.



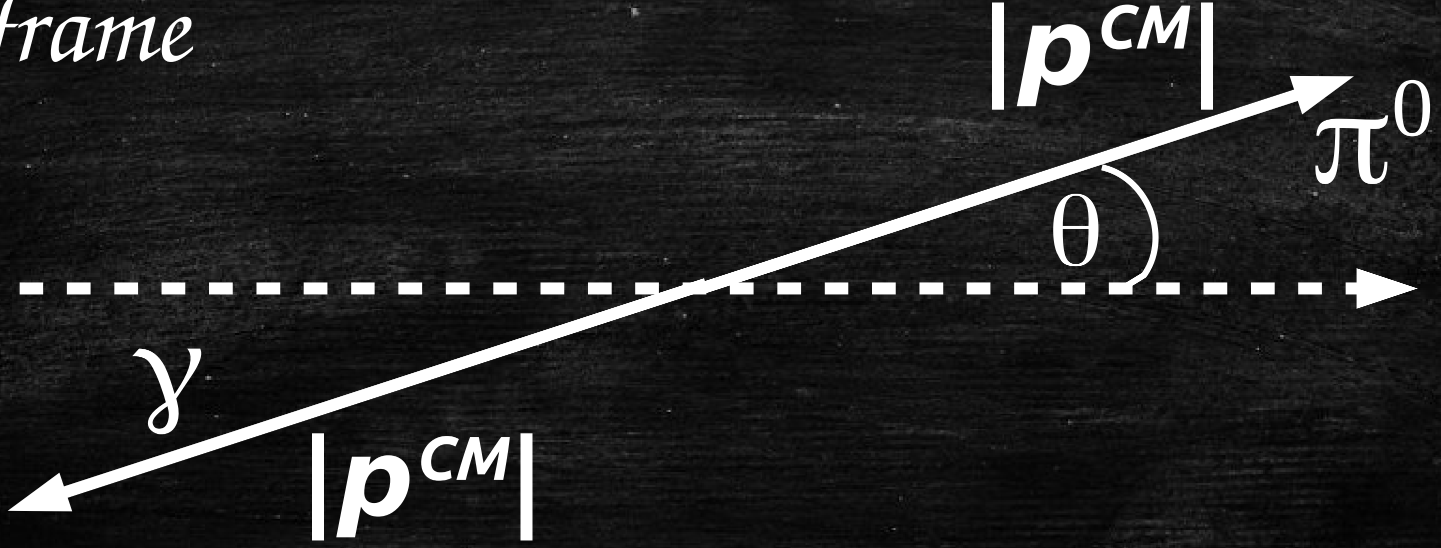
Question. How it contributes into two-photon invariant mass spectrum ?

Armenteros-Podolanski technique

Laboratory frame

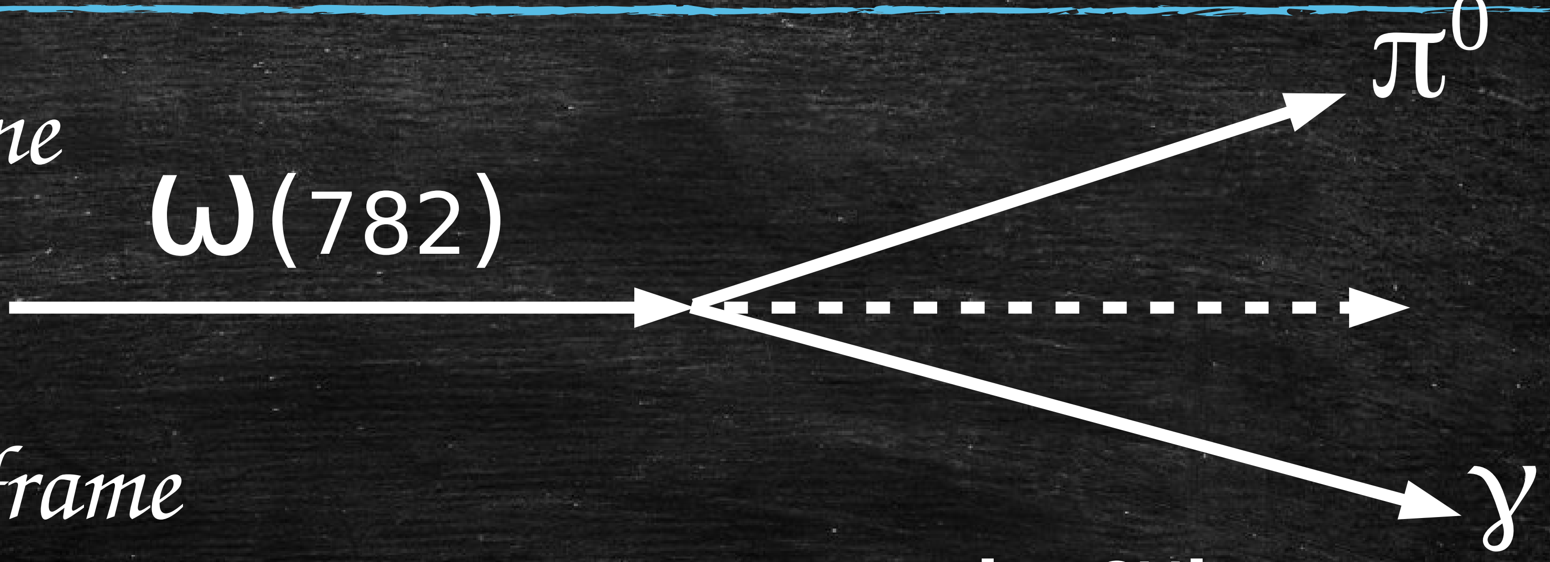


Center of mass frame



Armenteros-Podolanski technique

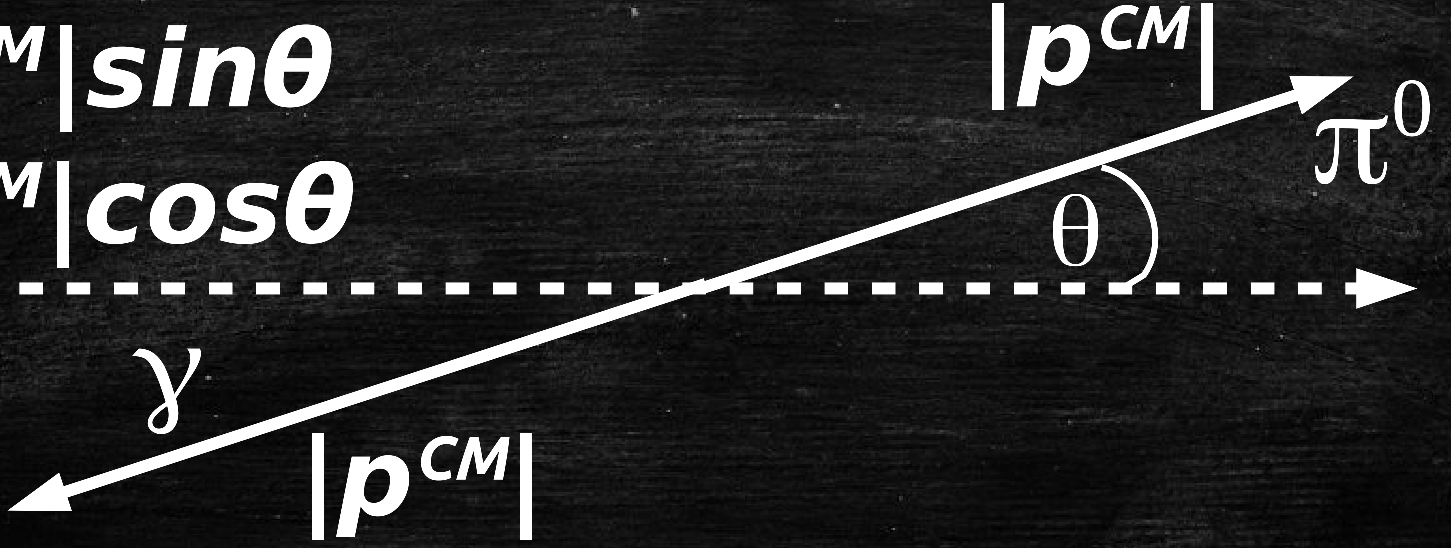
Laboratory frame



Center of mass frame

$$p^{CM}_{T} = |p^{CM}| \sin\theta$$

$$p^{CM}_{L} = |p^{CM}| \cos\theta$$

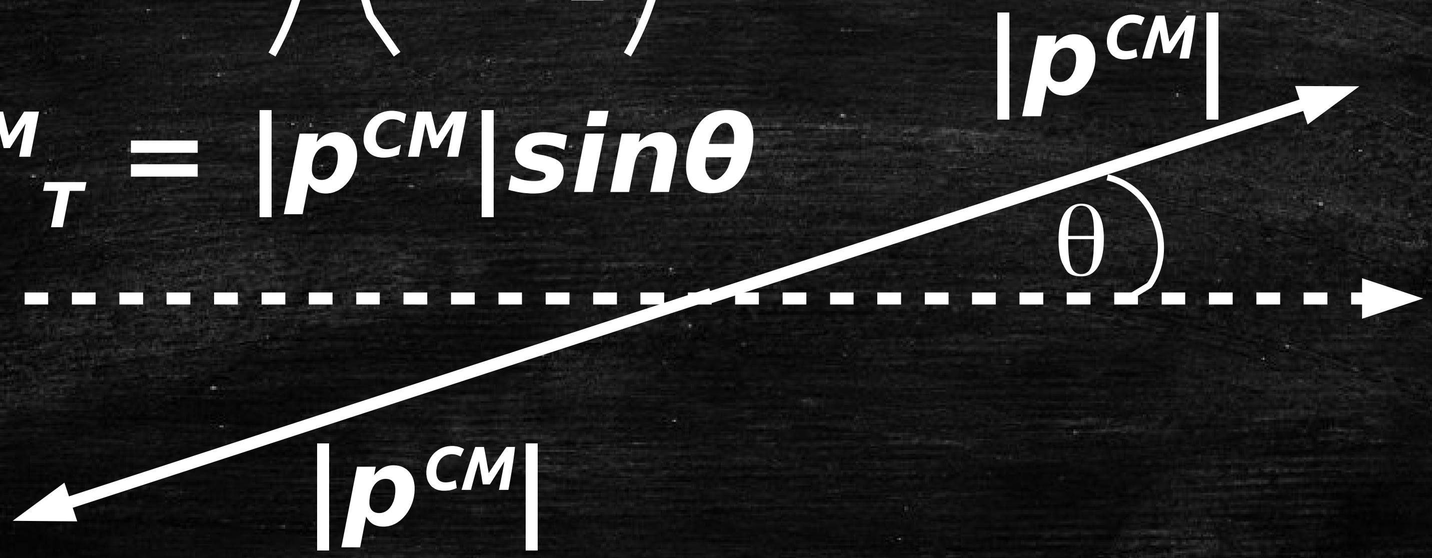


Armenteros-Podolanski technique

Use Lorentz transformation to go from CM frame to Lab frame.

$$\begin{pmatrix} E^{LAB} \\ p^{LAB}{}_{L} \end{pmatrix} = \begin{pmatrix} \gamma & \gamma\beta \\ \gamma\beta & \gamma \end{pmatrix} \begin{pmatrix} E^{CM} \\ p^{CM}{}_{L} \end{pmatrix}$$

$$p^{LAB}{}_{T} = p^{CM}{}_{T} = |p^{CM}| \sin\theta$$



Armenteros-Podolanski technique

By introducing $\boldsymbol{\alpha}$, $\bar{\boldsymbol{\alpha}}$, $\boldsymbol{a}$ as :

$$\alpha = (p^{LAB(1)}{}_L - p^{LAB(2)}{}_L) / (p^{LAB(1)}{}_L + p^{LAB(2)}{}_L)$$

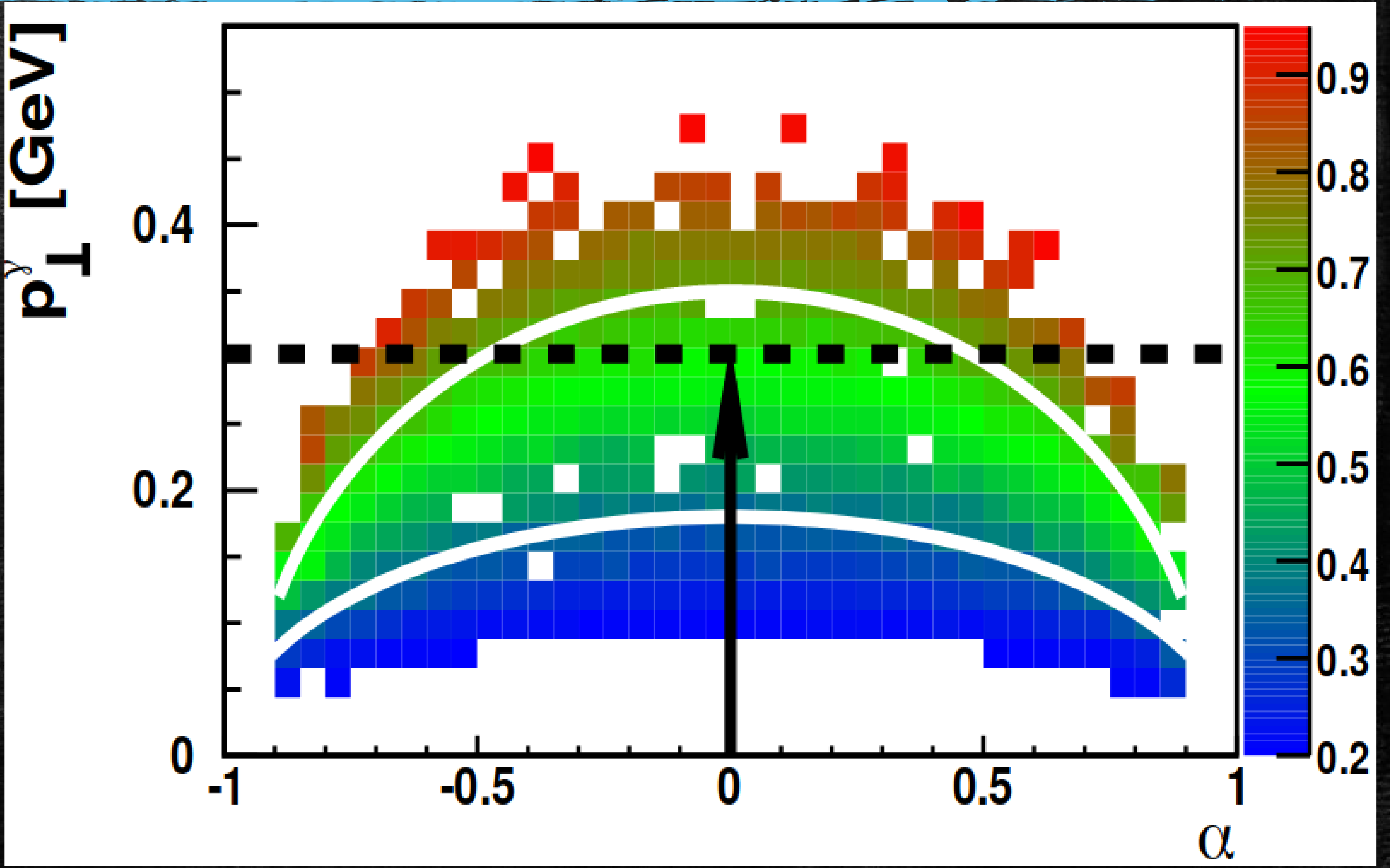
$$\bar{\alpha} = (E^{CM(1)} - E^{CM(2)}{}_L) / m_{(resonance)}$$

$$a = 2|p^{CM}| / m_{(resonance)}$$

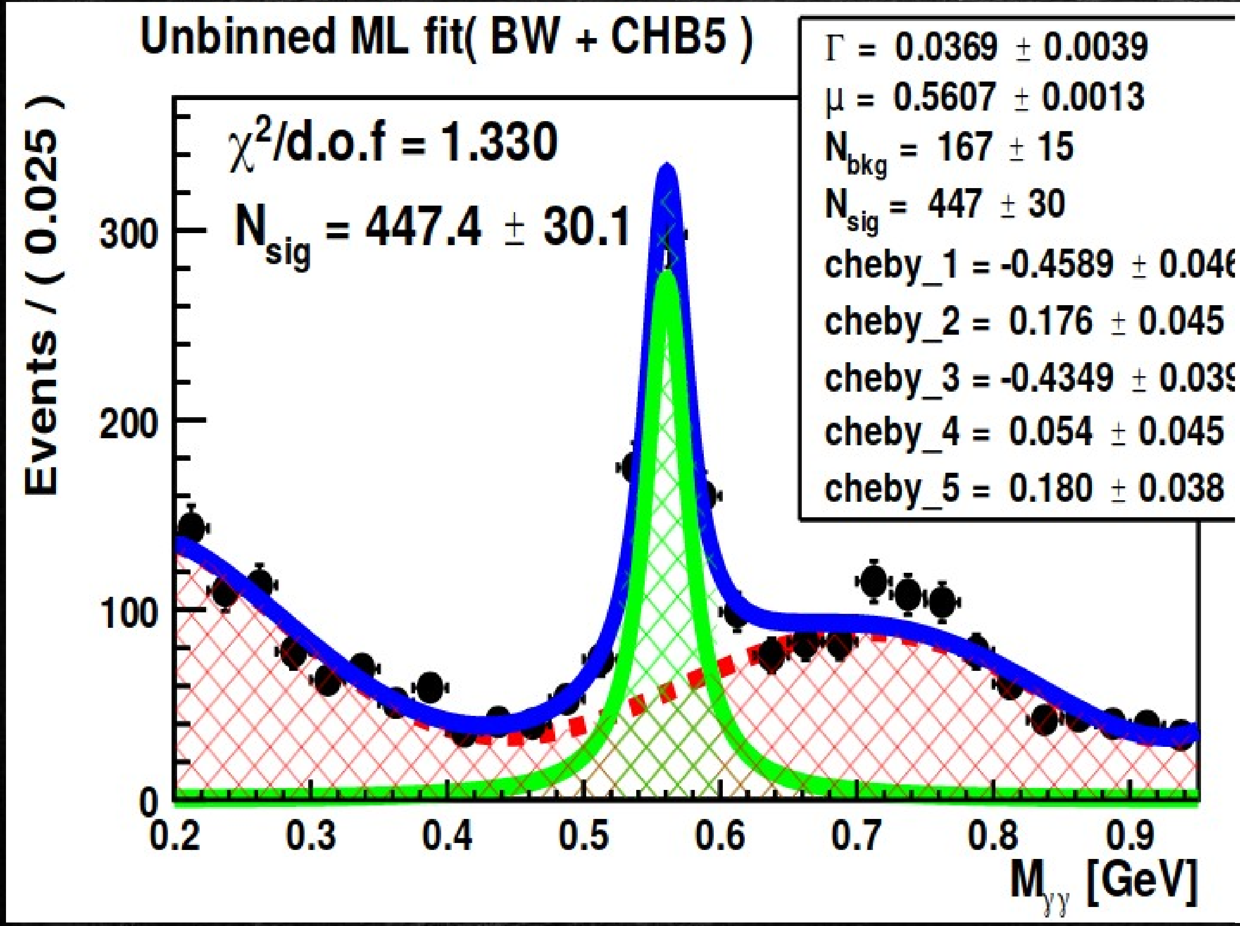
Prove : $((\alpha - \bar{\alpha})/a)^2 + (p^{CM}{}_T / |p^{CM}|)^2 = 1$

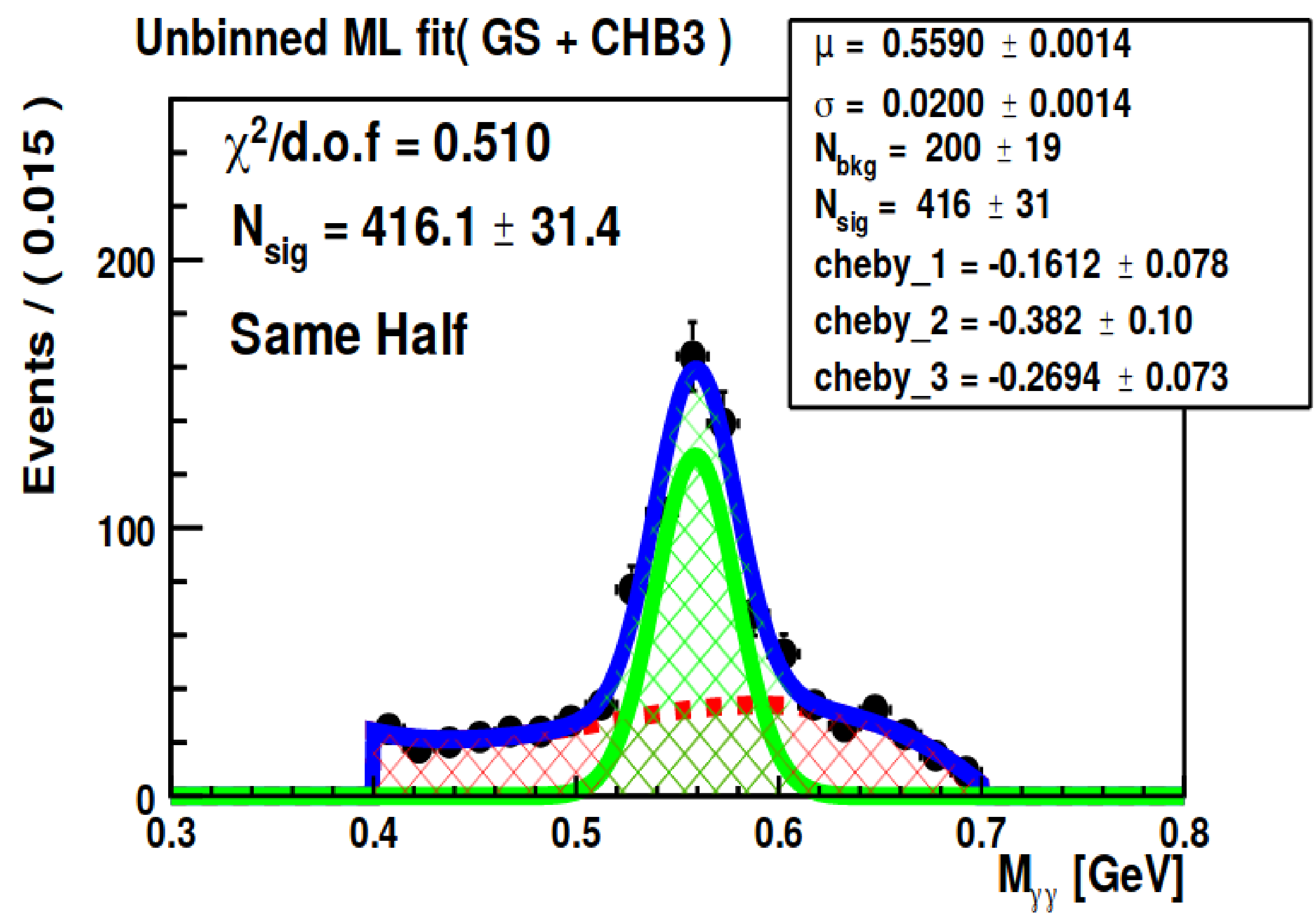
Armenteros-Podolanski plot

The color bar shows two-photon invariant mass distribution.

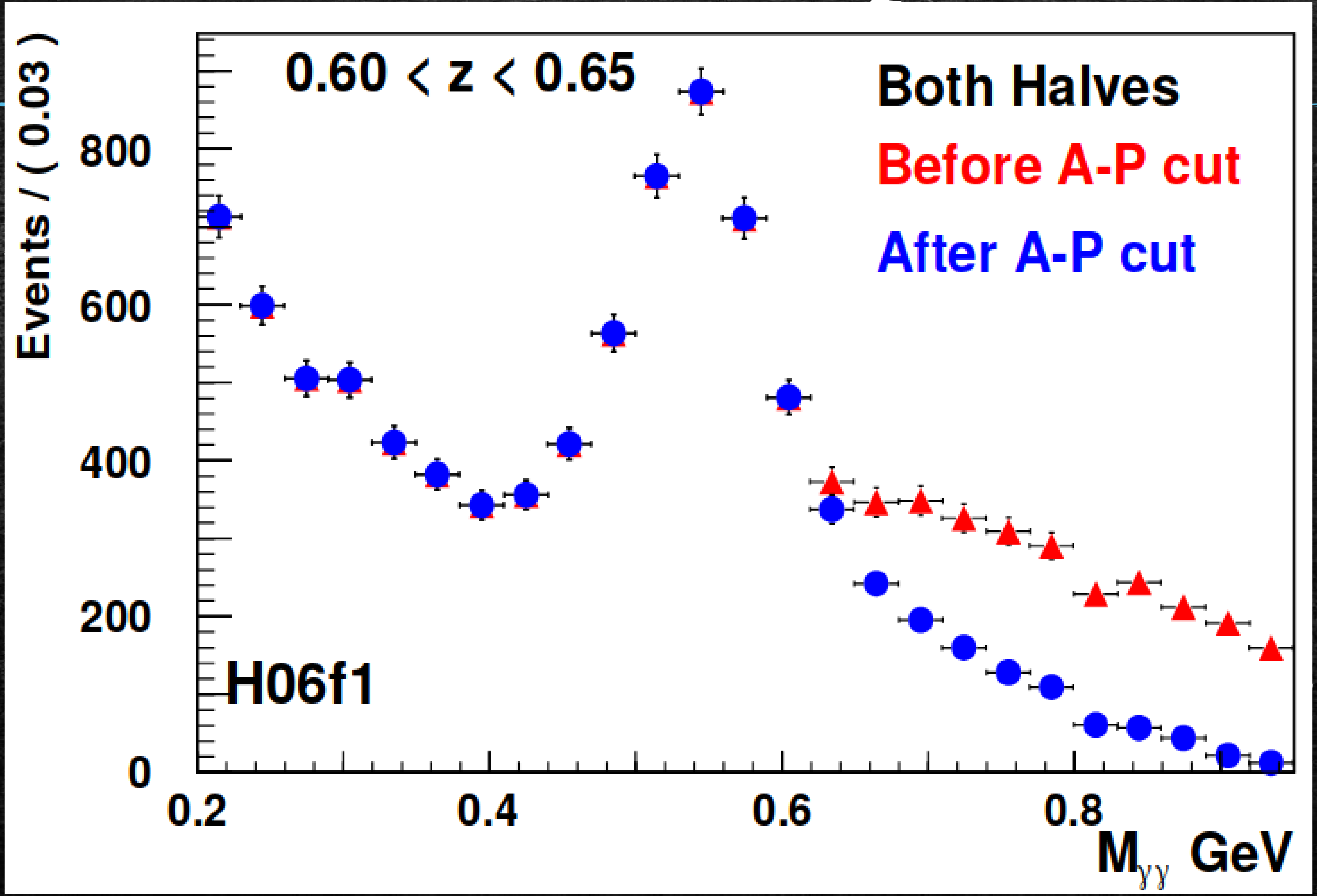


Armenteros-Podolanski technique





Armenteros-Podolanski technique



" Well, I must endure the presence of two or three caterpillars if I wish to become acquainted with the butterflies. It seems that they are very beautiful."

Antoine de Saint-Exupery

"The Little Prince"