

Bound-free pair production in heavy-ion collisions at high energies

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Secondary ion beams by electromagnetic interactions

Bound-free pair production

Double bound-free pair production

A trigger on electromagnetic processes

The bound-free pair constrained photon-photon luminosity

Physics interest

Secondary Pb-beams at hadron colliders

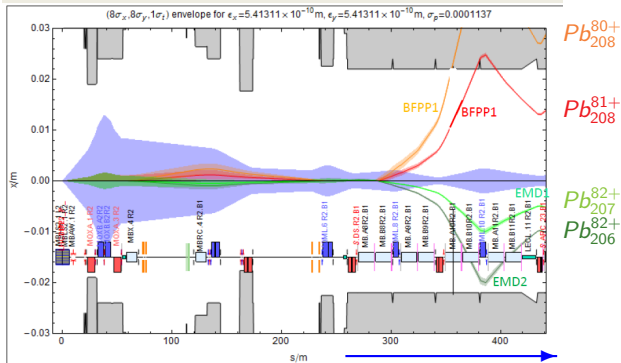
- magn. rigidity:

$$B\rho = \frac{Z}{A} \frac{p}{q}$$

- sec. Pb-beams:

$$\frac{Z}{A} \neq \frac{82}{208}$$

Secondary beams from Beam 1 in IR2 (horizontal plane)



J.M. Jowett, Workshop on photon-induced collisions at the LHC, 4 June 2014

cold section: dipoles

John Jowett, Workshop on
photon-induced collisions at the LHC,
CERN, June 2-4, 2014

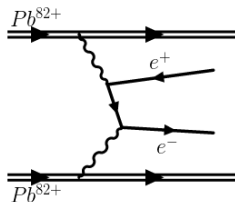
Active collimators - detectors ?

- active collimators:

- ▶ at LHC: not possible (no space)
- ▶ at FCC: up for discussion

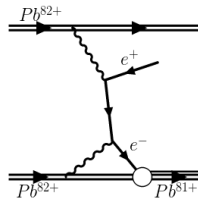
Single and multiple pair production

single pair production: free e^+e^-



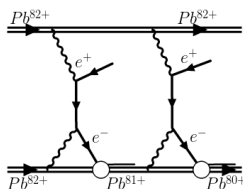
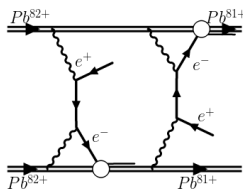
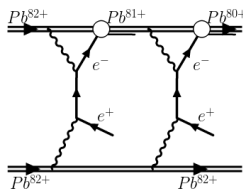
$$\sigma_{\text{Born}}(e^+e^-, \text{PbPb, LHC}) \sim 200 \text{ kb}$$

bound-free e^+e^-



$$\sigma_{\text{BFPP}}(\text{PbPb, LHC}) \sim 270 \text{ b per beam}$$

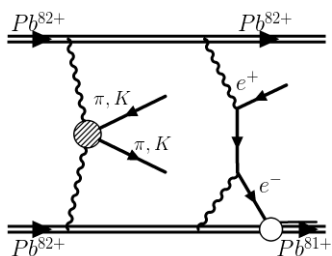
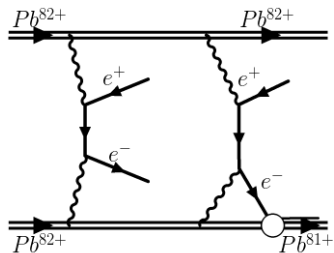
double bound-free pair production



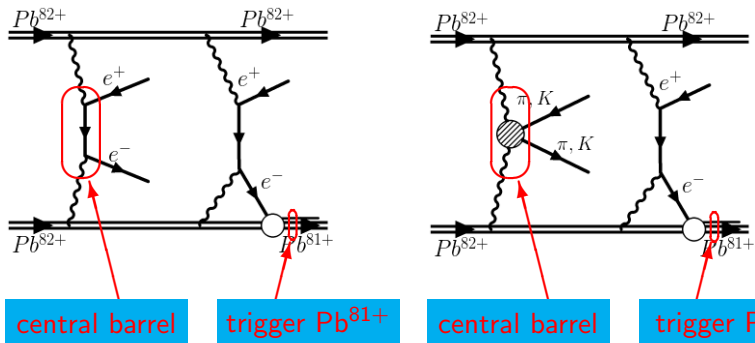
$$\sigma_{2 \times \text{BFPP}}(\text{PbPb, LHC}) > 6 \text{ mb (priv. comm. V.Serbo)}$$

Multiple pair production

production of bound-free pair with a free pair



Trigger on electromagnetic processes



Forward trigger on Pb^{81+} with measurement in central barrel

- free e^+e^- , $\mu^+\mu^-$, $\tau^+\tau^-$ - pairs
- $\pi^+\pi^-$ and K^+K^- - pairs
- $\gamma\gamma \rightarrow X$

→ Bound-free pair constrained photon-photon luminosity

Bound-free pair constrained photon-photon luminosity

■ Free muon pair production

$$\frac{d^2 L^{(st)}}{d\omega_1 d\omega_2} = \frac{d\sigma_{AA \rightarrow AA\mu\mu}}{d\omega_1 d\omega_2 \sigma_{\gamma\gamma \rightarrow \mu\mu}} = \frac{dn(\omega_1)}{d\omega_1} \frac{dn(\omega_2)}{d\omega_2} = \frac{4Z^4 \alpha^2}{\pi^2 \omega_1 \omega_2} \log \frac{\gamma}{R\omega_1} \log \frac{\gamma}{R\omega_2}$$

■ Free muon pair plus bound-free pair production

$$\frac{d^2 L^{bfree}}{d\omega_1 d\omega_2} = \frac{dP_{\mu\mu}(b)}{d\omega_1 d\omega_2 \sigma_{\gamma\gamma \rightarrow \mu\mu}} P_{ee}(b, Z_1, Z_2) d^2 b = \frac{Z^4 \alpha^2}{\pi^4 \omega_1 \omega_2} F(b) P_{ee}(b, Z_1, Z_2) d^2 b$$

$$\text{with } F(b) = \int_R^\infty \frac{d^2 b_1 d^2 b_2}{b_1^2 b_2^2} \delta(\mathbf{b}_1 - \mathbf{b}_2 - \mathbf{b}) \approx \frac{4\pi}{b^2} \log \frac{b}{2R}$$

integration over \mathbf{b} : main contribution from $2R < b < 1/m_e$, where

$$P_{ee}(b, Z_1, Z_2) \sim A = 1.65 \cdot 10^{-3} \text{ (Art. et al)*}$$

$$\frac{d^2 L^{bfree}}{d\omega_1 d\omega_2} = A \frac{4Z^4 \alpha^2}{\pi^2 \omega_1 \omega_2} \left[\log \frac{1}{2Rm_e} \right]^2, \quad \frac{d^2 L^{bfree}}{d\omega_1 d\omega_2} \sim \mathcal{O}(10^{-3}) \frac{d^2 L^{st}}{d\omega_1 d\omega_2}$$

(Art. et al)*: A.N. Artemyev, V.G. Serbo, A. Surzhykov, European Physical Journal C74 (2014), 2829.

Physics topics in tagging bound-free secondary beam

- cross section bound-free pair production
 - ▶ unitarity, Coulomb corrections ?
- cross section double bound-free pair production
 - ▶ $\sigma(\text{Pb}^{81+}\text{Pb}^{81+}) = 2 \times \sigma(\text{Pb}^{82+}\text{Pb}^{80+})$?
 - ▶ unitarity, Coulomb corrections ?
- Multiple lepton pair production
- Pion/Kaon pair photoproduction
- $\gamma\gamma \rightarrow$ low mass resonances
- Total $\gamma\gamma$ -hadronic cross section beyond resonance region
- $\gamma\gamma \rightarrow \gamma\gamma$: light-by-light scattering by lepton loops, quark loops or monopole loop.