97 Dark Photon Search at A Circular e^+e^- Collider

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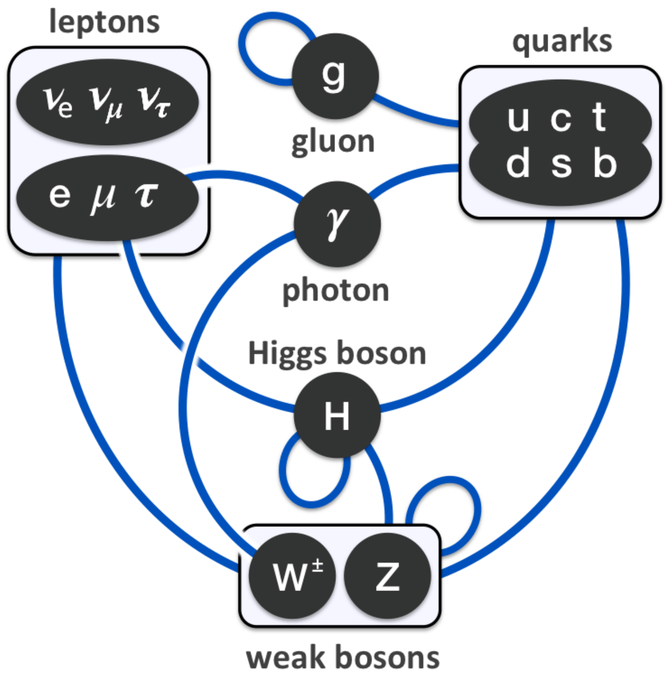
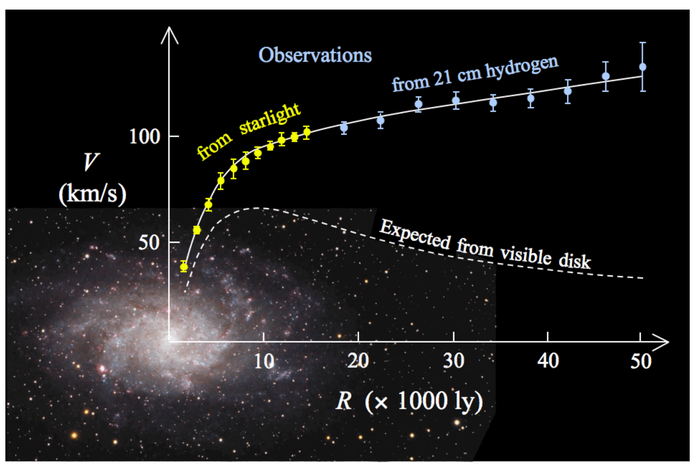
Introduction

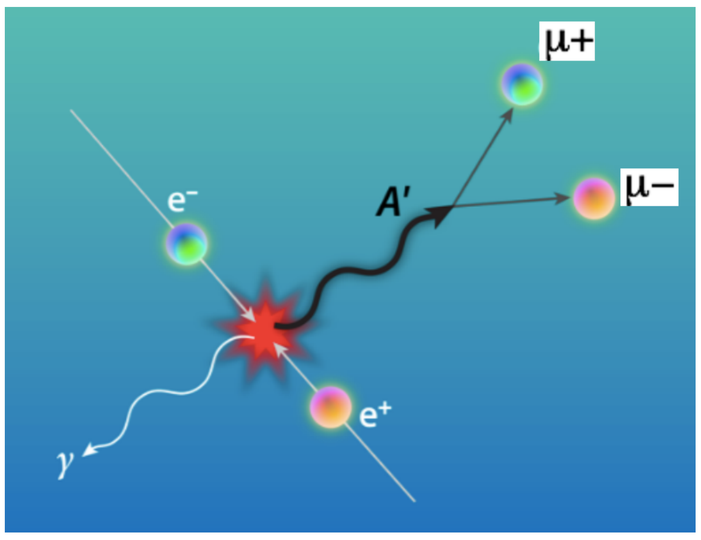
The Standard Model has demonstrated huge successes in providing experimental predictions!



But it leaves some phenomena unexplained, such as the rotation curve of spiral galaxy M33.



Solution: Dark photon A' as an electromagnetic force carrier for dark matter.



Model

Lagrangian with kinetic mixing of $U(1)_Y$ and $U(1)_{A'}$

$$L = -\frac{1}{4}B_0^{\mu\nu}B_{0,\mu\nu} - \frac{1}{2}\sigma F'_{0,\mu\nu}B_0^{\mu\nu} - \frac{1}{4}F'_{0,\mu\nu}F_0^{\prime\mu\nu}$$

- $B_{0,\mu\nu} = \partial_\mu B_{0,\nu} - \partial_\nu B_{0,\mu}$,
- $B_0 = \cos\theta_W A_0 - \sin\theta_W Z_0$,
- $F'_{0,\mu\nu} = \partial_\mu A'_{0,\nu} - \partial_\nu A'_{0,\mu}$.

The effective Lagrangian concerning photon and dark photon interaction with SM currents is

$$L_{\rm int} = J^\mu_{em}A_\mu + J^\mu_Z Z_\mu + \epsilon J^\mu_{em}A'_\mu + \frac{m^2_{A'}\sin\theta_W\epsilon}{(m^2_Z - m^2_{A'})\cos\theta_W}J^\mu_Z A'_\mu \ ,$$

- $\epsilon = -\cos\theta_W\sigma$.

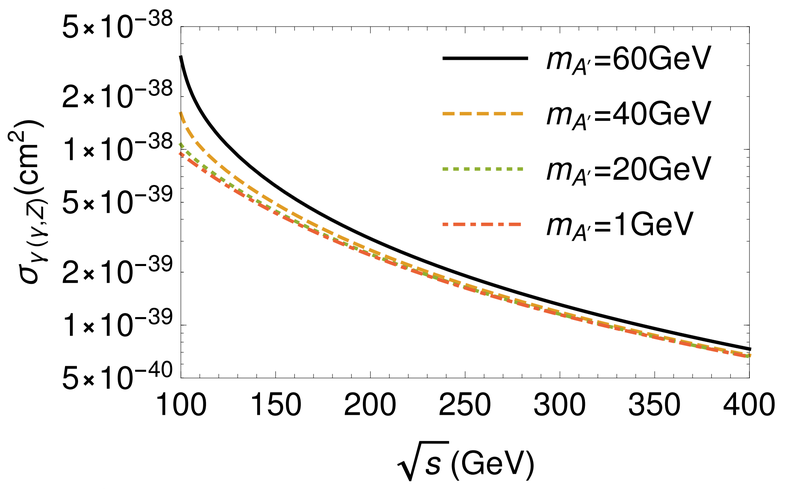
Sensitivities for CEPC and FCC-ee circular colliders

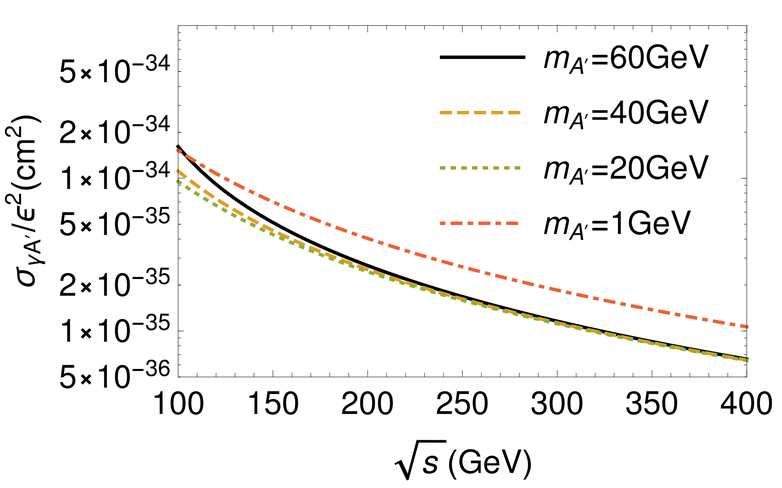
For process $e^+e^- \to \gamma(\gamma, Z, A') \to \gamma\mu^+\mu^-$, We define the cross section with the $\mu^+\mu^-$ invariant mass square $s_3 = (k_1 + k_2)^2$ close to $m^2_{A'}$. The $\sigma_{\mu\mu}$ is the dimuon mass resolution .

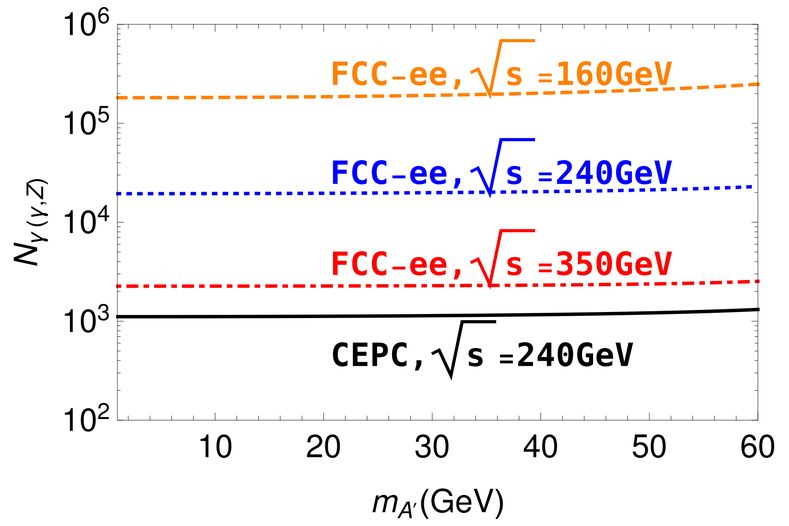
$$\sigma_{\gamma A'} = \int_{(m_{A'}-\sigma_{\mu\mu})^2}^{(m_{A'}+\sigma_{\mu\mu})^2} \frac{d\sigma_{\gamma A'}}{ds_3}ds_3,$$

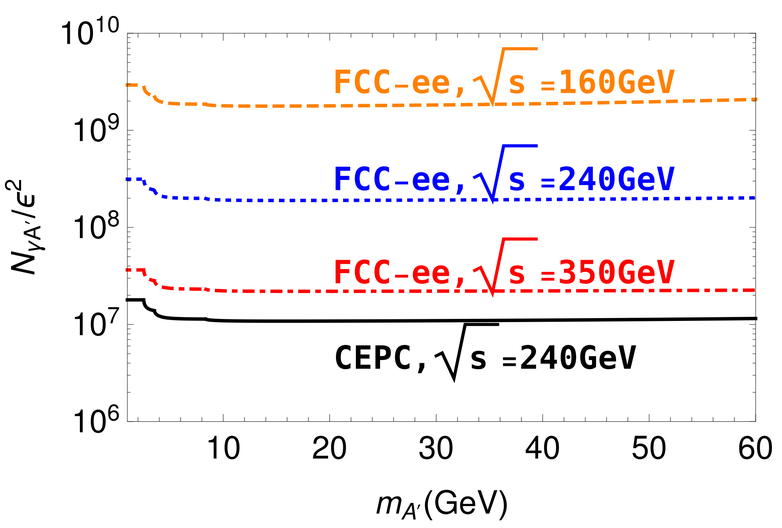
$$\sigma_{\gamma(\gamma,Z)} = \int_{(m_{A'}-\sigma_{\mu\mu})^2}^{(m_{A'}+\sigma_{\mu\mu})^2} \frac{d\sigma_{\gamma(\gamma,Z)}}{ds_3}ds_3 \ .$$

Cross section and one-year running number of events at CEPC and FCC-ee colliders.









We define $\chi = N_{\gamma A'}/\sqrt{N_{\gamma(\gamma,Z)}}$. We have the sensitivity plots for different colliders. arXiv:1701.08614