Model of magnetic monopole production in heavy-ion ultraperipheral collisions at the LHC

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Magnetic monopoles couple strongly to photons, making their production highly favored when ultrarelativistic heavy ions collide. Ultraperipheral collisions (UPC), where the ion-ion impact parameter exceeds the ion's diameter, act as an appreciable source of electromagnetic radiation. In the absence of dedicated searches to date in heavy-ion collisions at the LHC, a Monte Carlo model has been implemented to compute the monopole kinematics and production cross sections at the LHC's design collision energy.

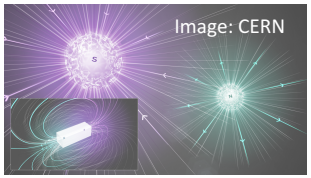
I. Magnetic Monopoles

• Magnetically charged point particles that restore the symmetry of Maxwell's Equations

$$\vec{\nabla}\cdot\vec{E}=\rho_E \qquad \vec{\nabla}\cdot\vec{B}=\rho_M$$

$$\vec{\nabla}\times\vec{E}=-\frac{\partial\vec{B}}{\partial t}-\vec{j}_M \qquad \vec{\nabla}\times\vec{B}=\frac{\partial\vec{E}}{\partial t}+\vec{j}_E$$

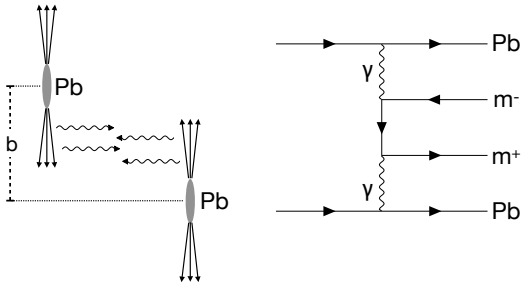
• A North (N) magnetic monopole is a source of a radial magnetic field.



II. Monopoles in Ultraperipheral Collisions

• Strong electromagnetic fields from ultrarelativistic high-charge ions (e.g. lead) as a flux of photons

• Monopole pair production via photon fusion



• Uncertainty principle suppresses photon energies at impact parameter b > $2R_A$ (nuclear radius)

III. UPC Parameters

• Four collision systems in comparison to proton-proton collisions at design energy of 7 TeV per beam

	$\sqrt{s_{NN}}$ [TeV]	Maximal $\sqrt{s_{\gamma\gamma}}$ [GeV]	Years
p	14	4.2×10^3	2010 -
$^{16}_{8}O$	7.0	490	2022 - 2024
$^{129}_{54}Xe$	5.9	204	2017
$^{208}_{82}Pb$	5.5	164	2010 -

• $\sqrt{s_{NN}}$: sum of beam energies carried by protons

• Photon-photon effective collision energy $\sqrt{s_{\gamma\gamma}}$ restricts monopole masses in ion collisions

IV. Photon Distribution

• Fourier transform of the ion's electromagnetic field into a flux of virtual photons [1]

• Photon probability scales quadratically as nuclear charge and inversely as its energy [2]

• Geometric cut-off to exclude photons less than R_A from the ion

• Needed to correctly model monopole cross sections and kinematics

References

[1] C. F. von Weizsäcker, 1934: *Z. Physik* **88**, 612; E. J. Williams, 1934: *Phys. Rev.* **45**, 729.

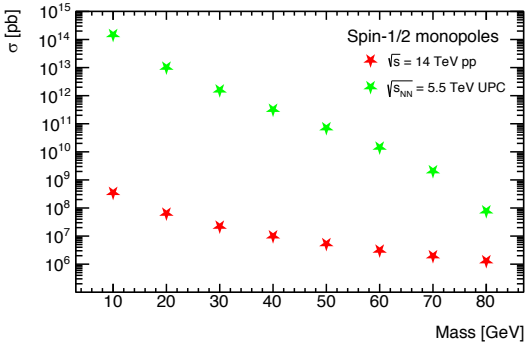
[2] J. D. Jackson, 1975: *Classical Electrodynamics* 2nd Ed., John Wiley & Sons, New York

[3] J. Alwall el al., 2007: *JHEP* **0709**, 028.

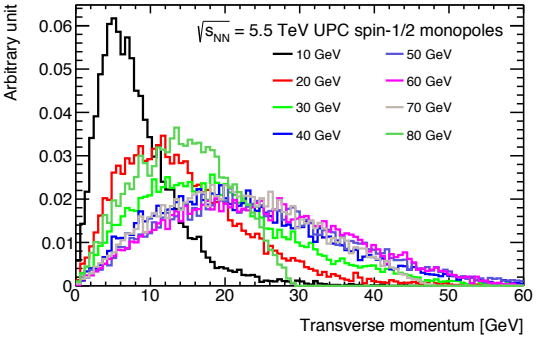
V. Results and Outlook

• Complete model in MADGRAPH5_aMC@NLO [3]

• Production in lead-lead ultraperipheral collisions dominant over proton-proton collisions for monopole masses up to 80 GeV



• $\sqrt{s_{NN}}$ restricts monopole kinematics



• Future prospect: increased sensitivity to higher masses with higher $\sqrt{s_{NN}}$ in light-ion collisions