# Observation of elastic photon-photon scattering events using collider based on Compton gamma sources

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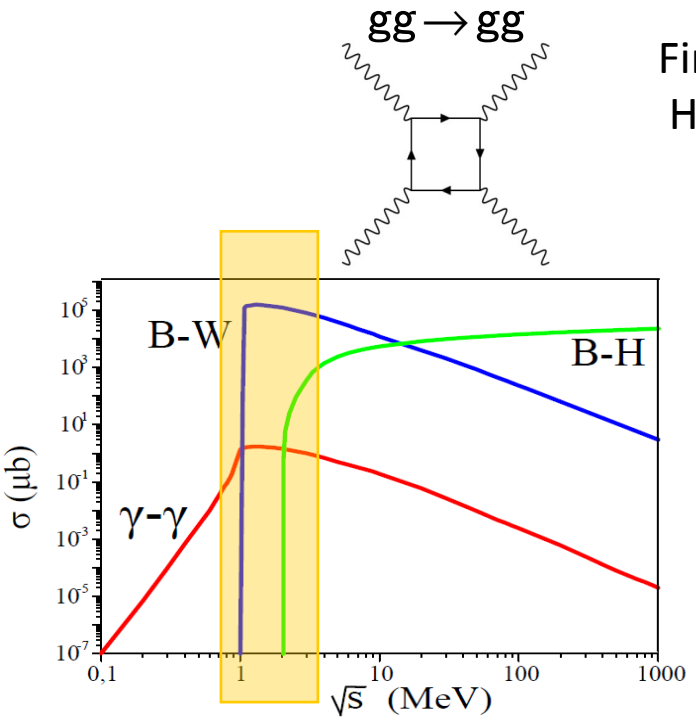
# Outline

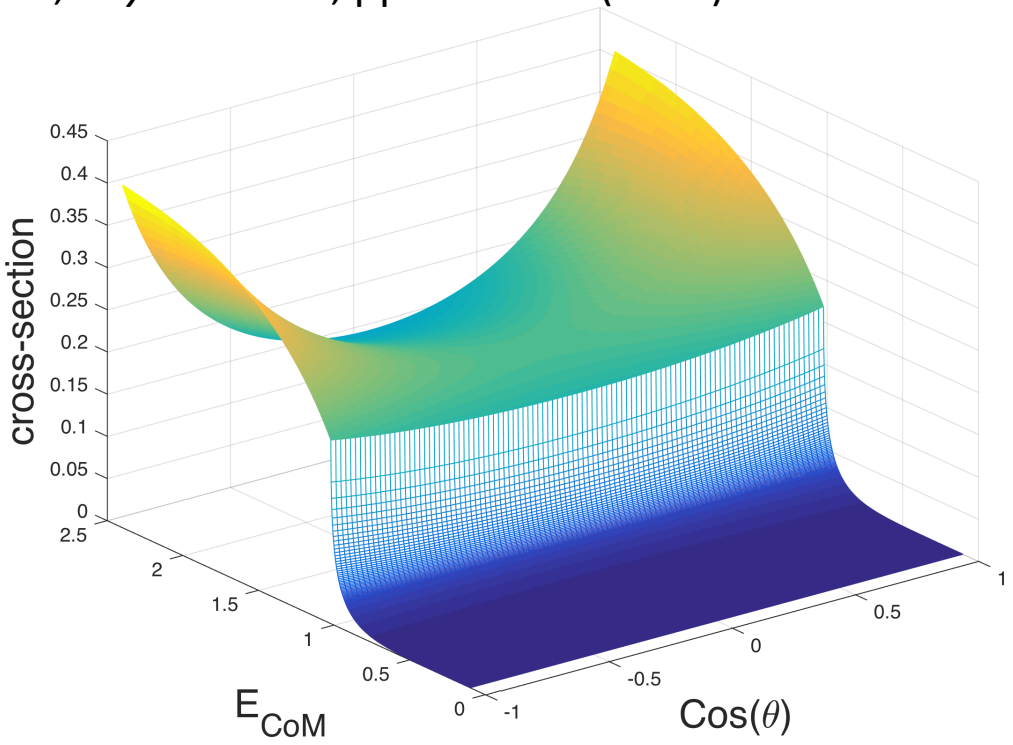
1. Kinematics and cross-section
2. Scheme and layout
3. Simulations ROSE code
4. Result

# Photon-photon elastic scattering




g–g: 1.5 mb @ 1.6 MeV

Firstly considered in 1933 by Halpern.
Halpern, *Phys. Rev.* **44**, pp. 855-856 (1933)

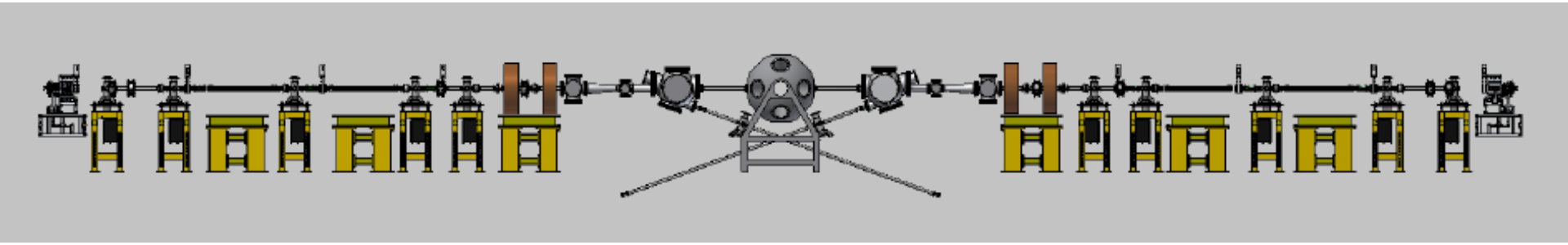



Comparison between g–g , Breit-Wheeler a
triplet pair production (TPP) cross sections
unpolarized photons.

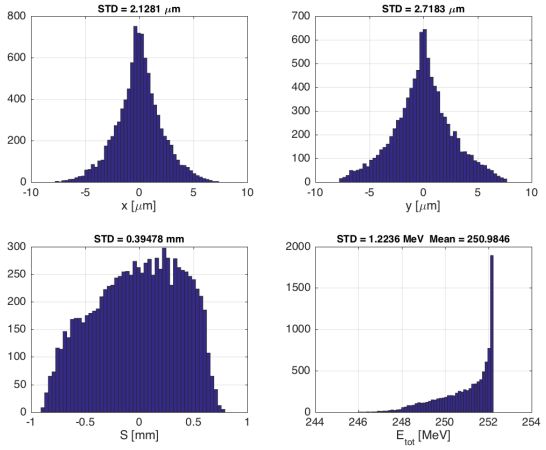
Differential cross section in the plane $E_{CoM}$, Cos($\theta$)

Acknowledgments to D. Micieli, E. Tassi

# Scheme and layout of collider g−g collider

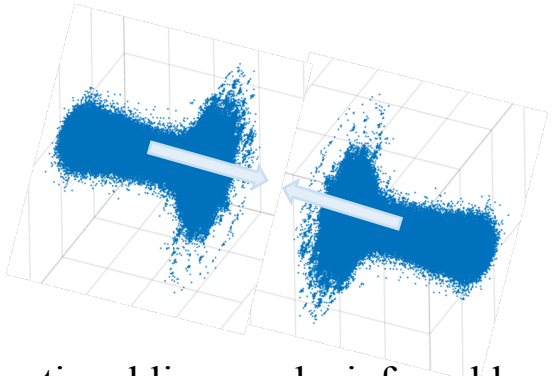


Electron bunch profile

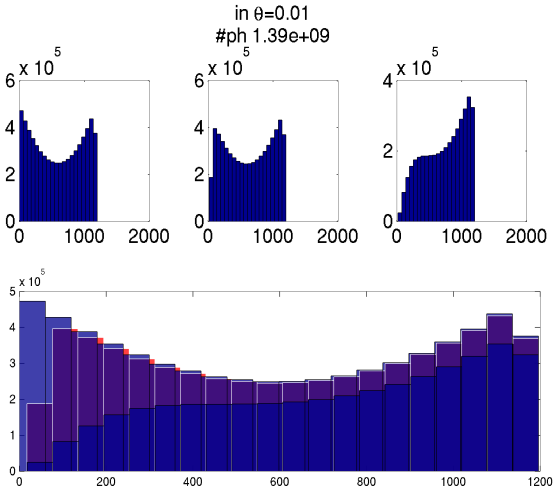



**Parameter of the Compton sources**

Total energy of the g−g system: 2 MeV
Electron energy: 250 MeV
Electron emittance: 0.4 mm mrad
Electron energy spread: 0.7 $10^{-4}$
Charge: 250 pC
Transverse electron width: 2.5 mm
Laser wavelength: 1000 nm
Laser waist: 10 micron
Laser Energy: 1 J
Photon energy: 1 MeV
Transverse photon beam dimension: 1 mm
Transverse photon beam dimension at IP: 10 mm
Repetition rate *f*: 100 Hz

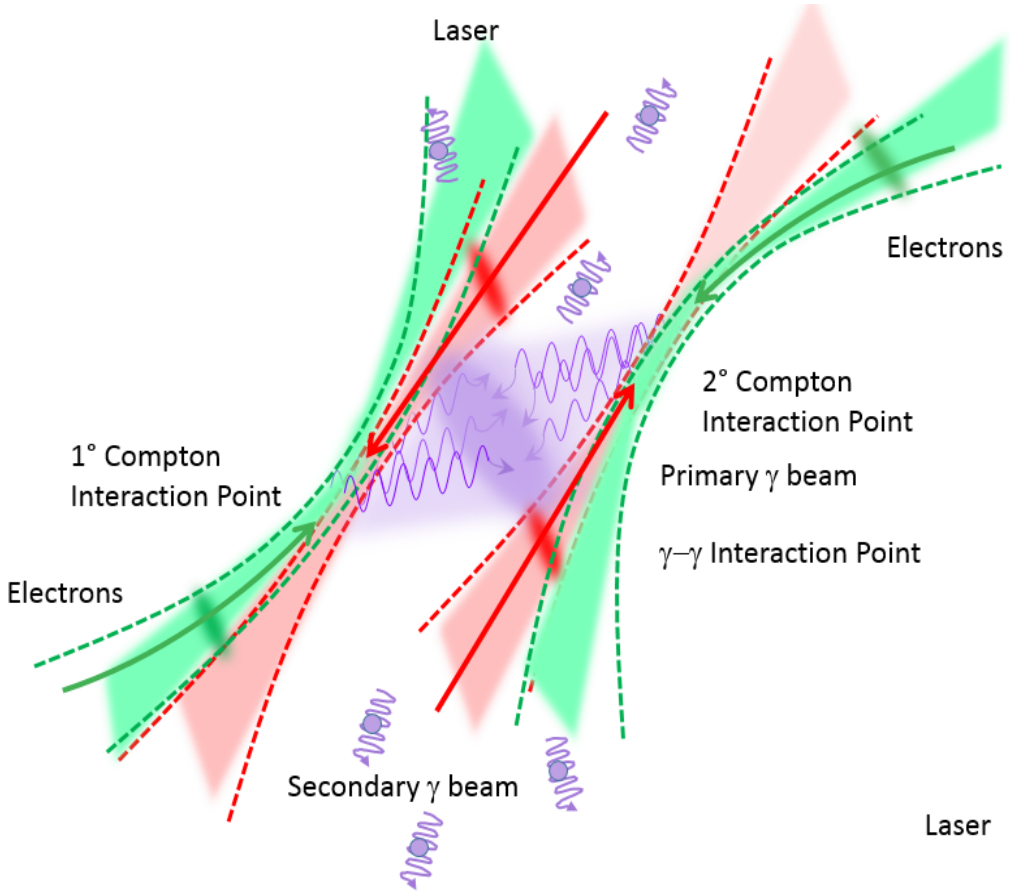


Energy spectrum of Compton back scattered Photons



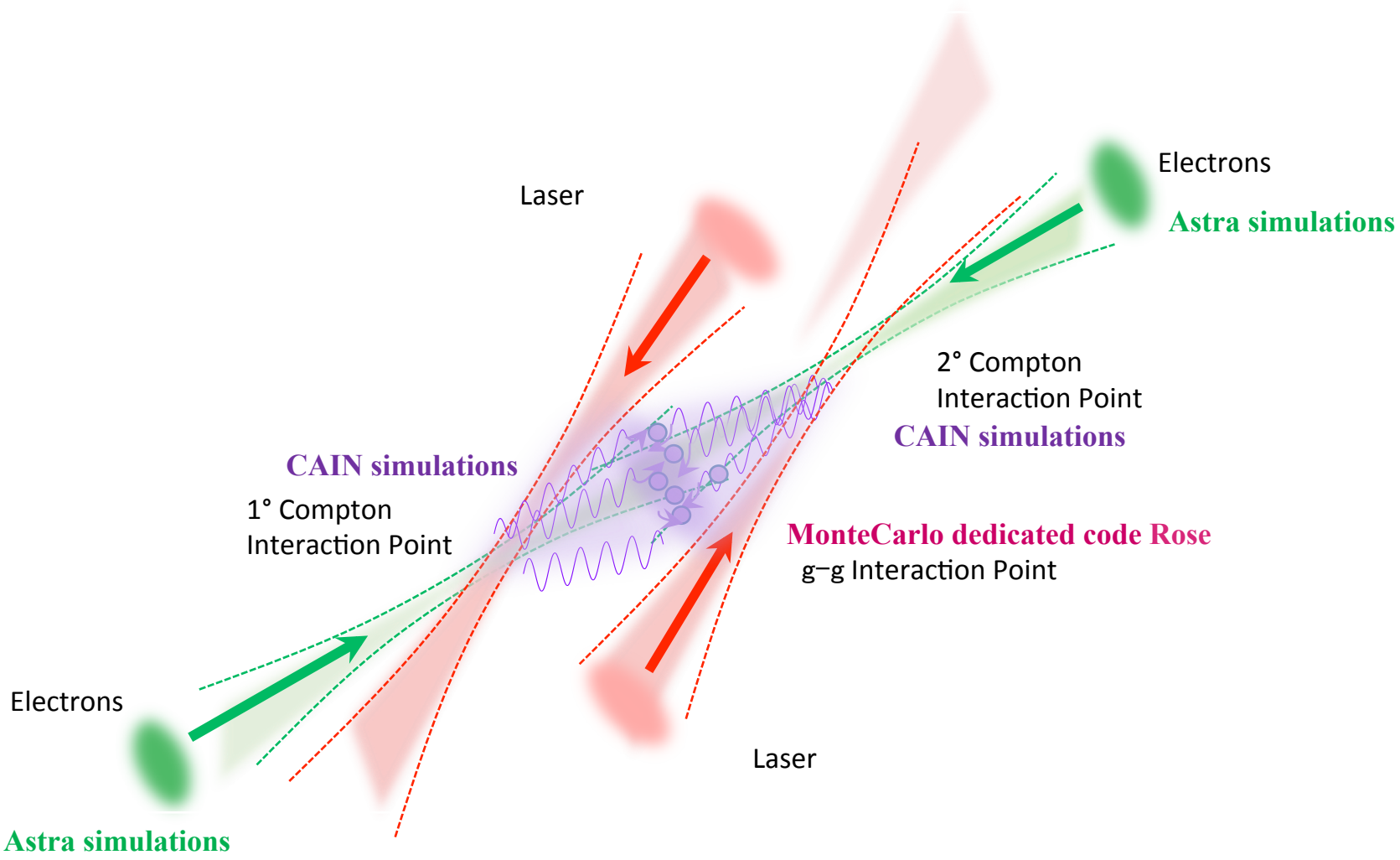

The setup chosen is based on conventional linac and a infrared laser, as those of the ELI_NP project.

# Gamma-gamma collider for the study of g−g events generation



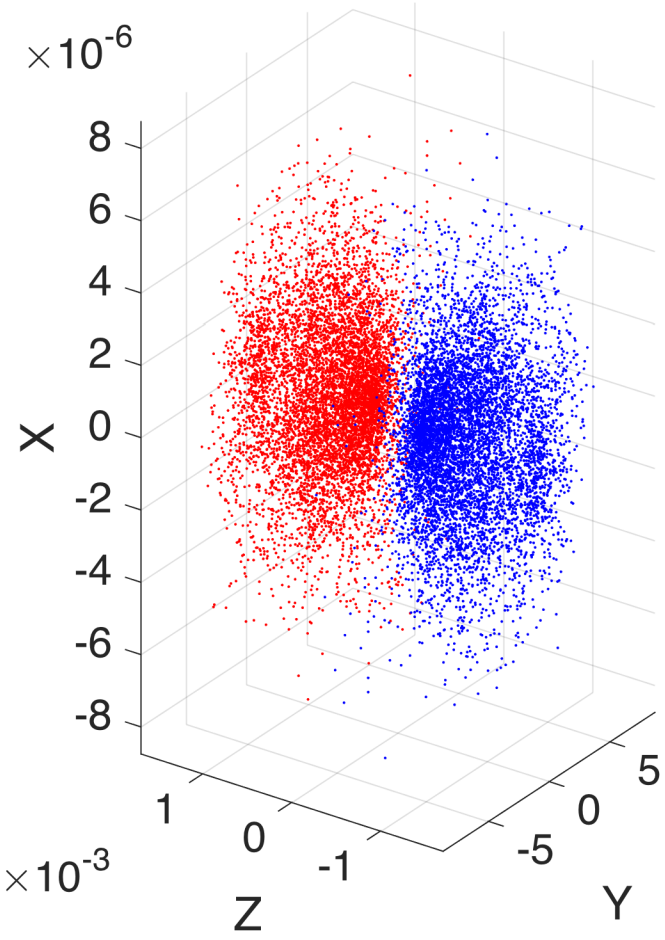

Scheme of the g−g interaction. Two lasers (in red) impinge on two electron beams (in green) in two interaction points (Compton IP), generating primary gamma rays (in violet). The primary gamma rays interact in the gg IP, generating secondary gammas.

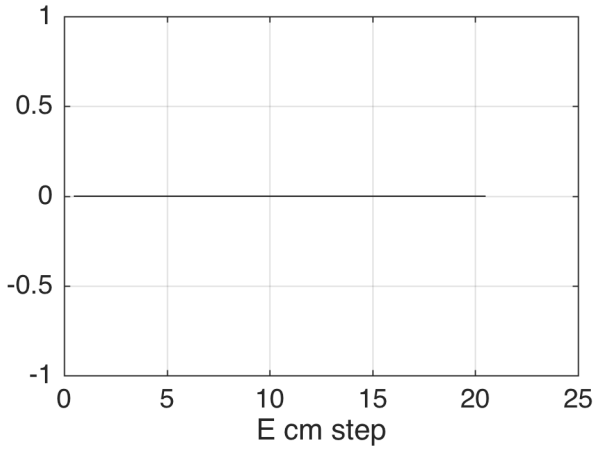
# Gamma-gamma collider for the study of g−g events generation

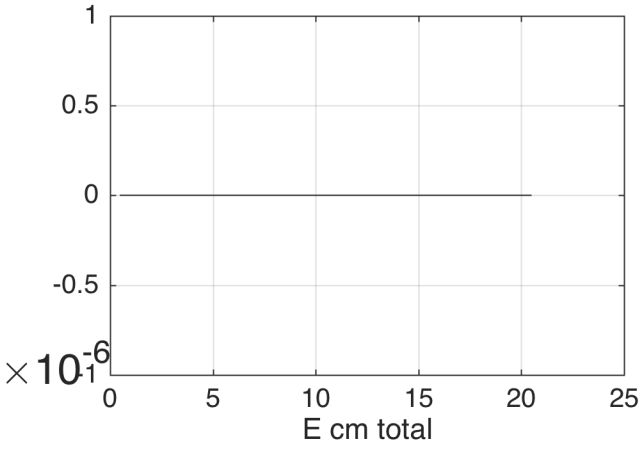


# Simulations of dynamics in the ROSE code

bin x 21 y 21 z 21 step 1

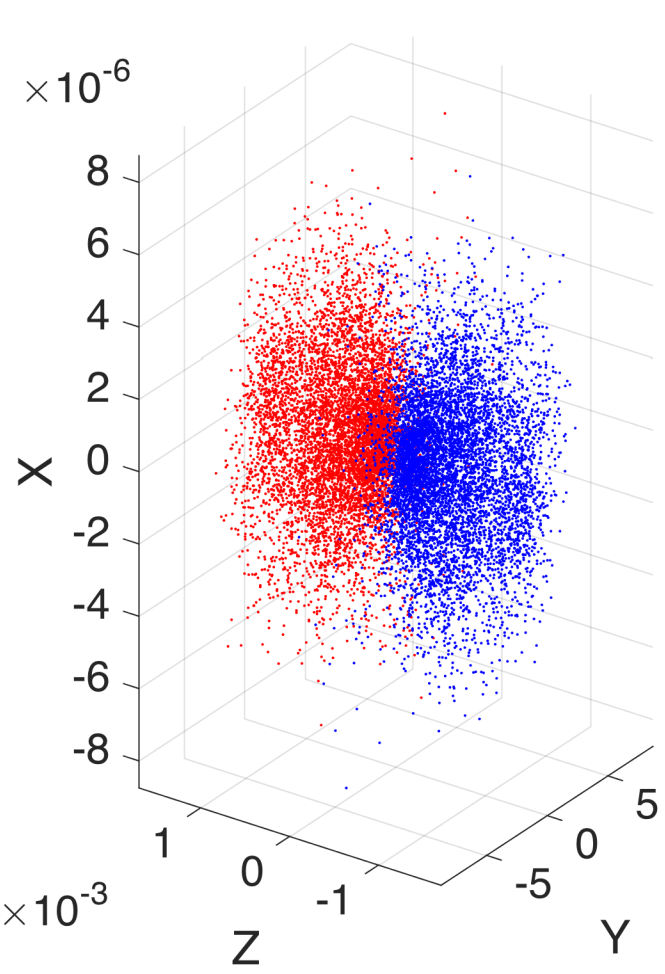


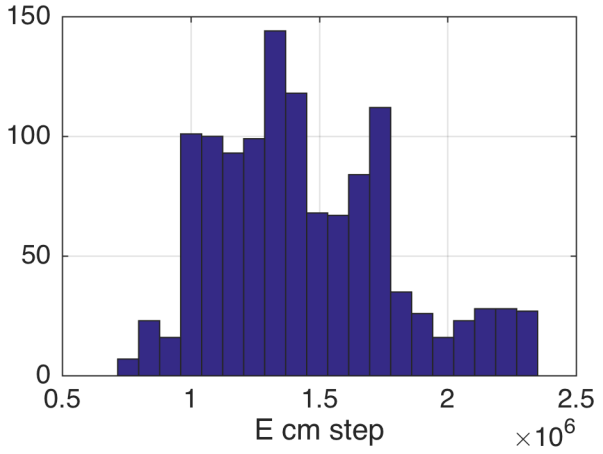



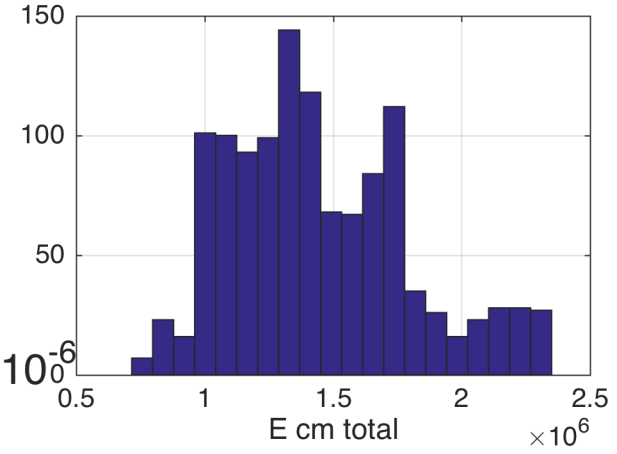



# Simulations of dynamics in the ROSE code

bin x 21 y 21 z 21 step 2



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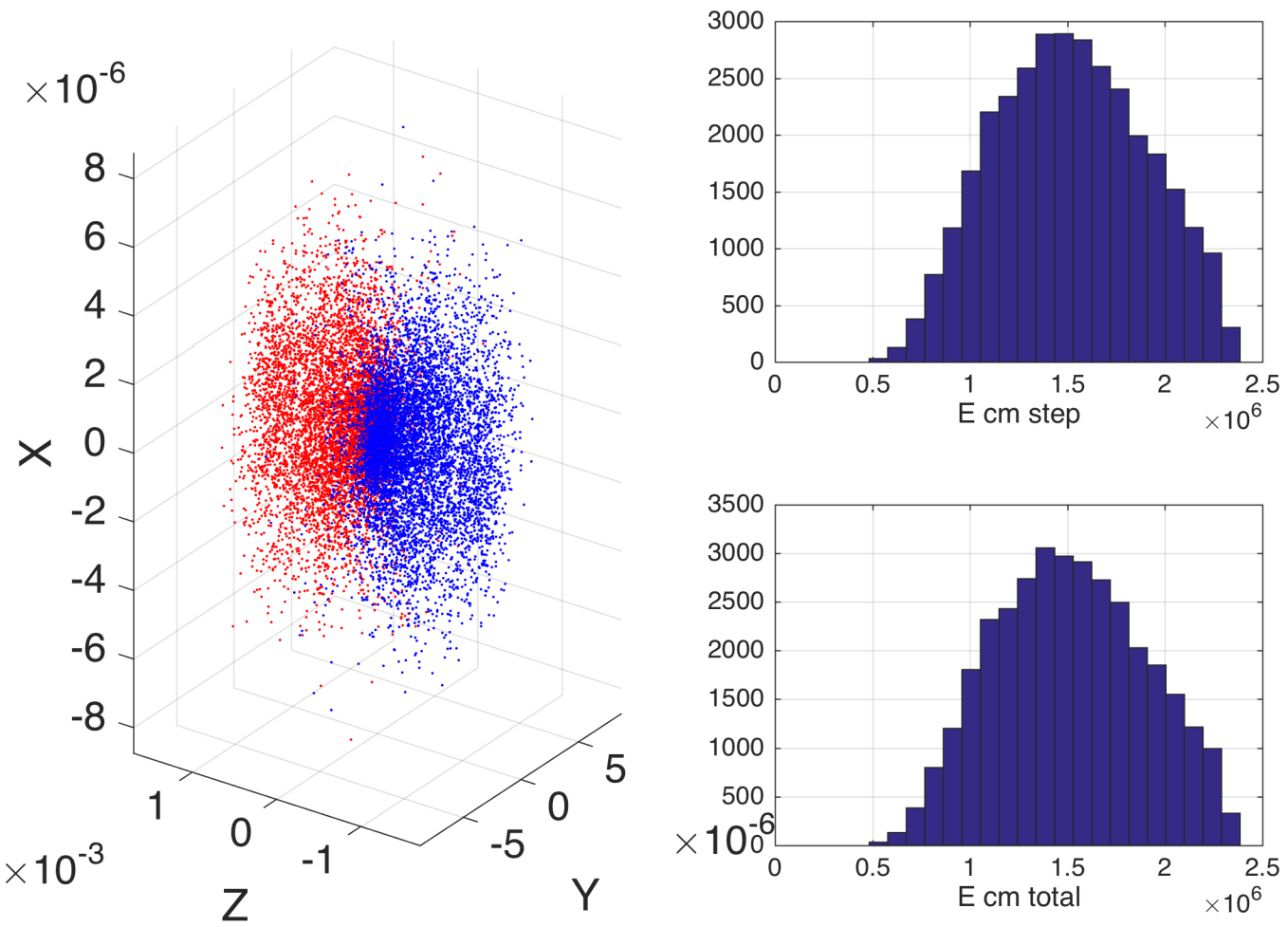
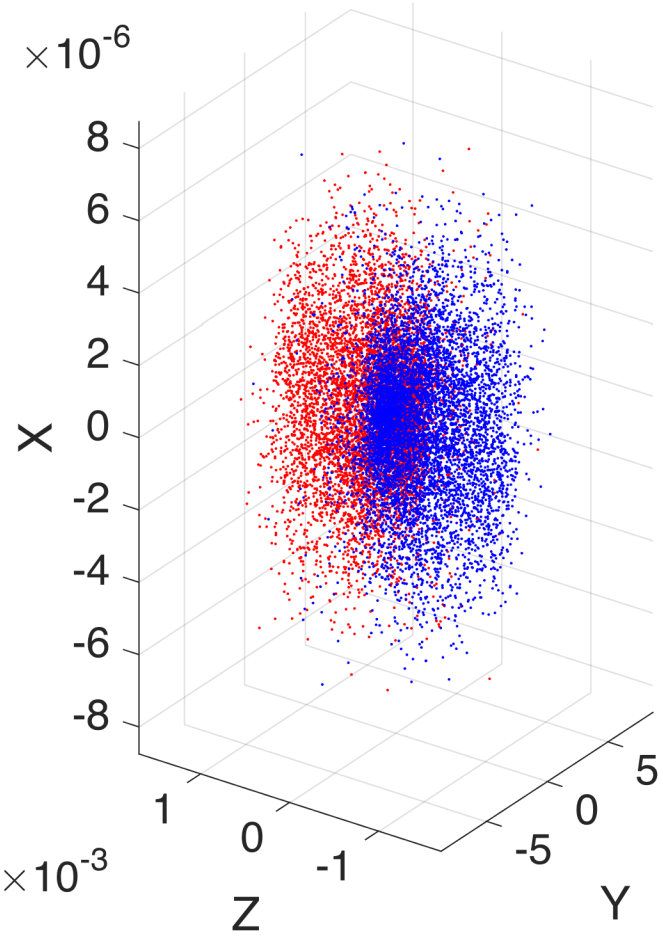
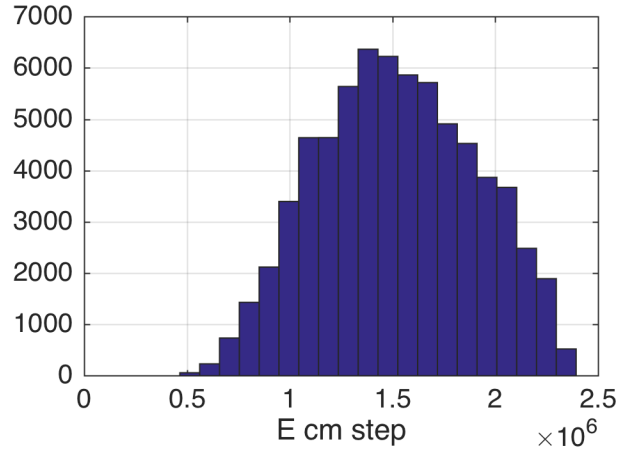
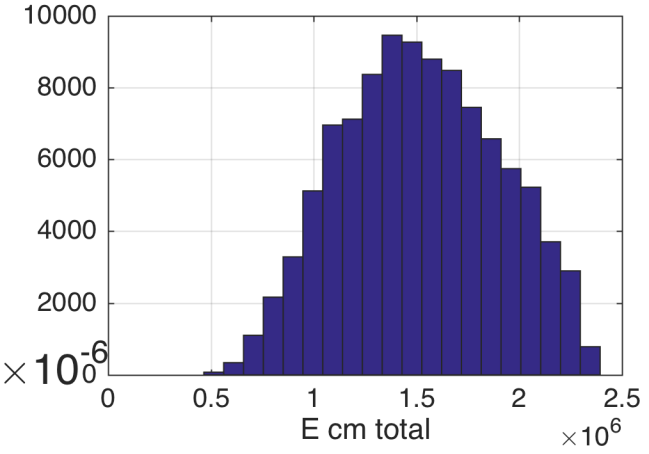


# Simulations of dynamics in the ROSE code

bin x 21 y 21 z 21 step 4

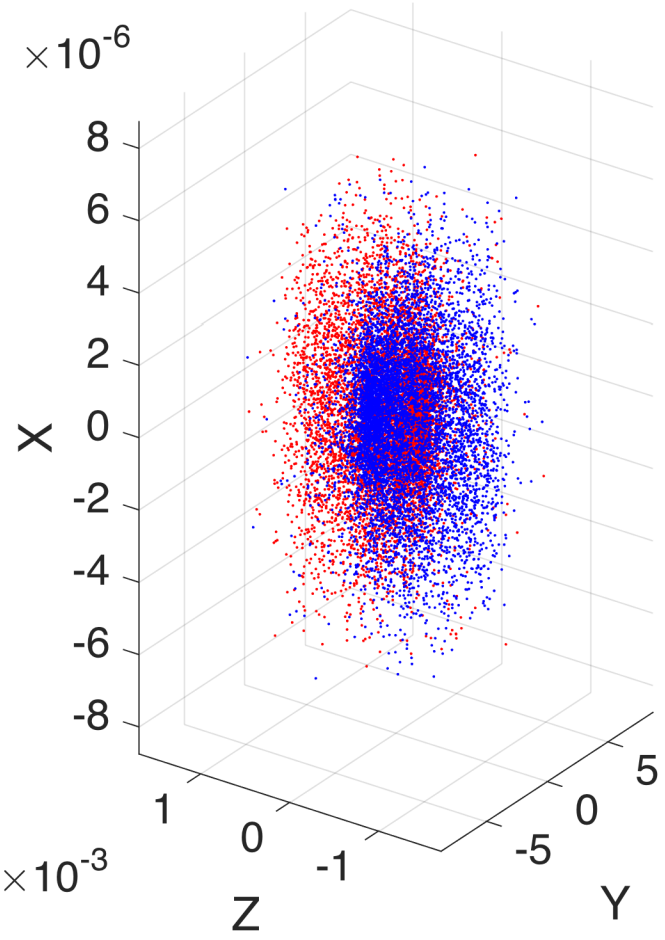


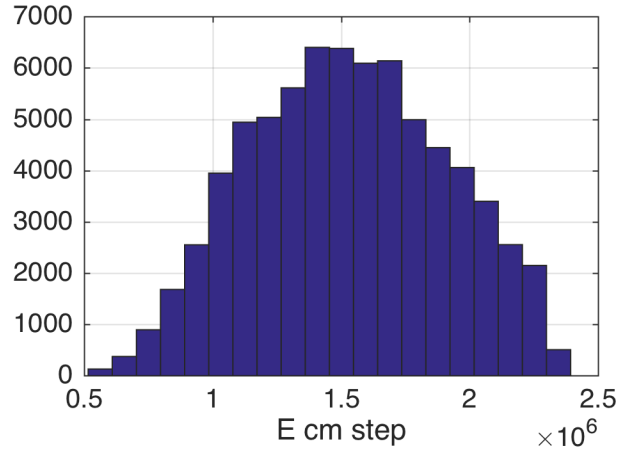



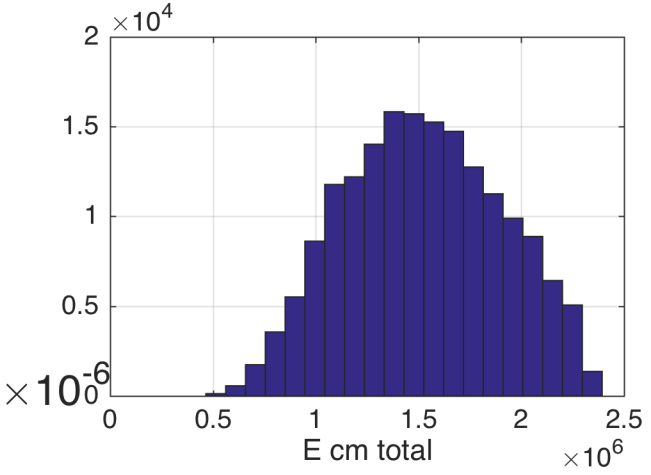



# Simulations of dynamics in the ROSE code

bin x 21 y 21 z 21 step 5

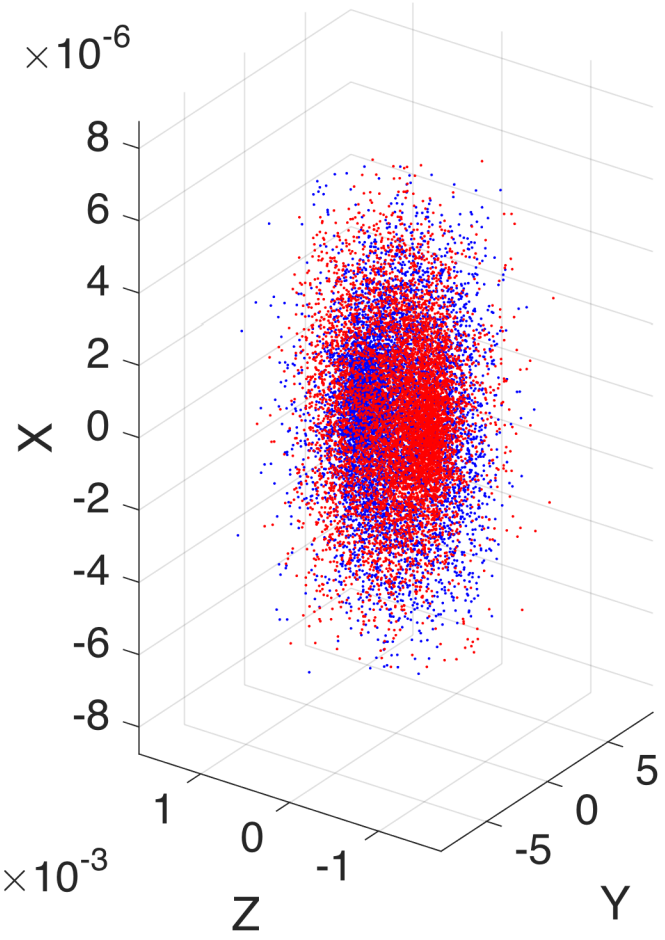


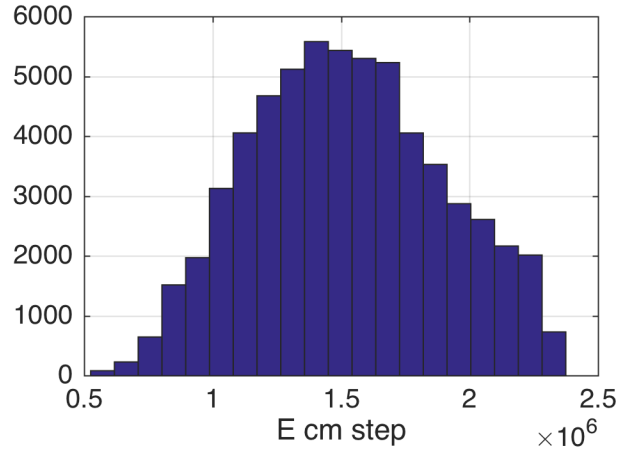



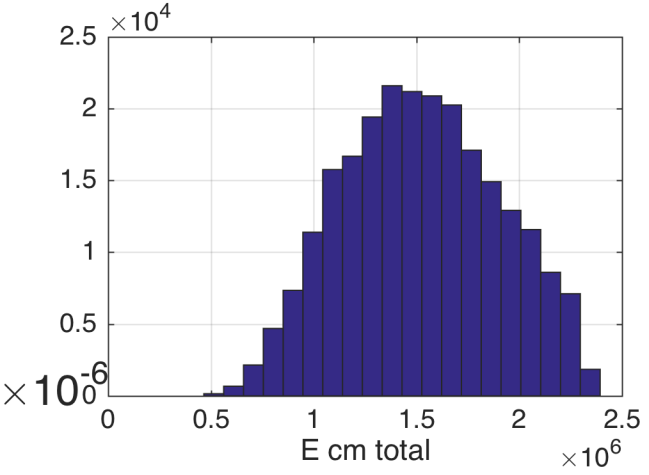



# Simulations of dynamics in the ROSE code

bin x 21 y 21 z 21 step 6

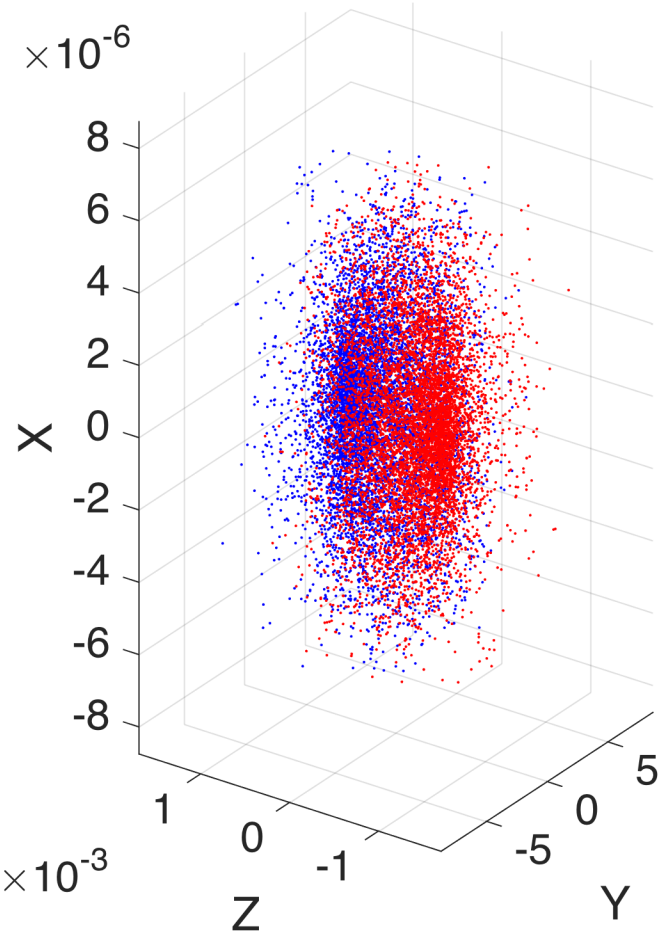


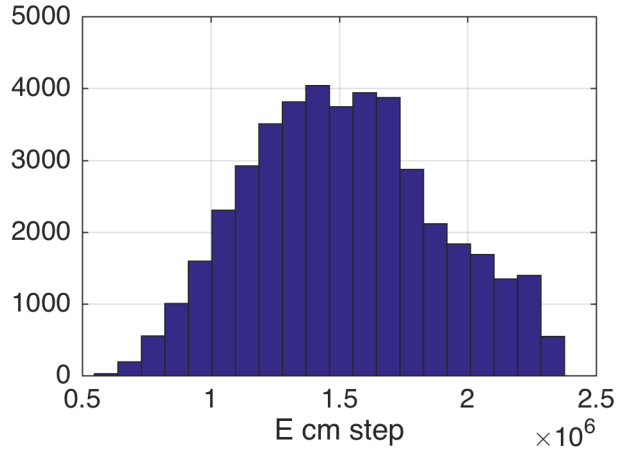



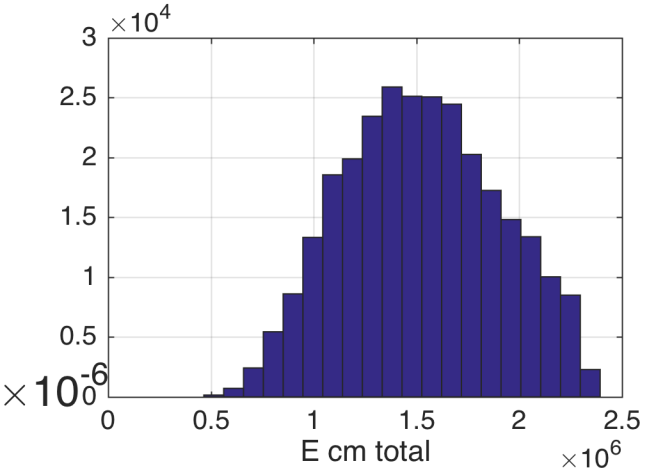



# Simulations of dynamics in the ROSE code

bin x 21 y 21 z 21 step 7

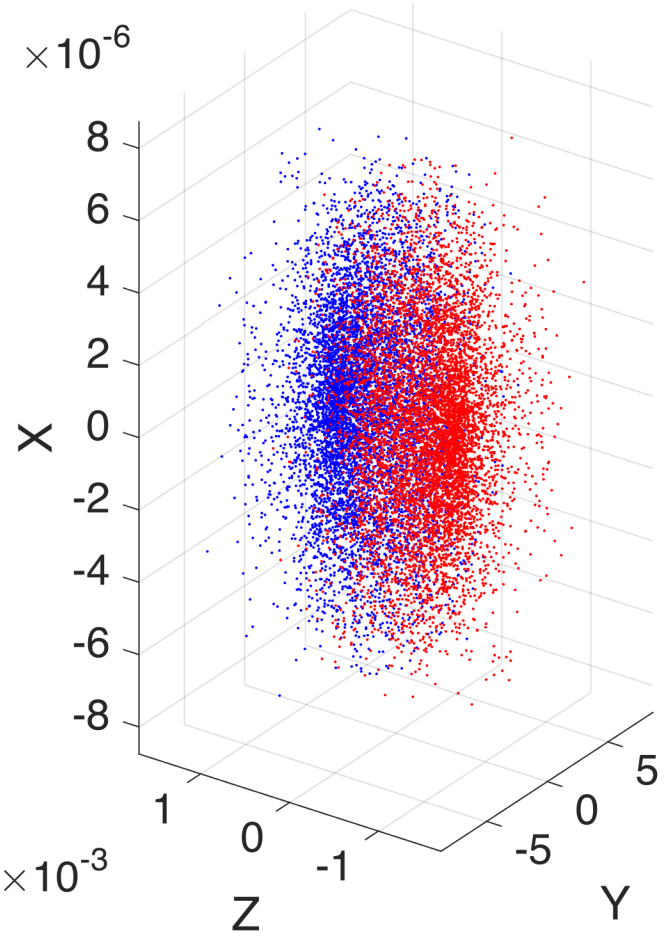


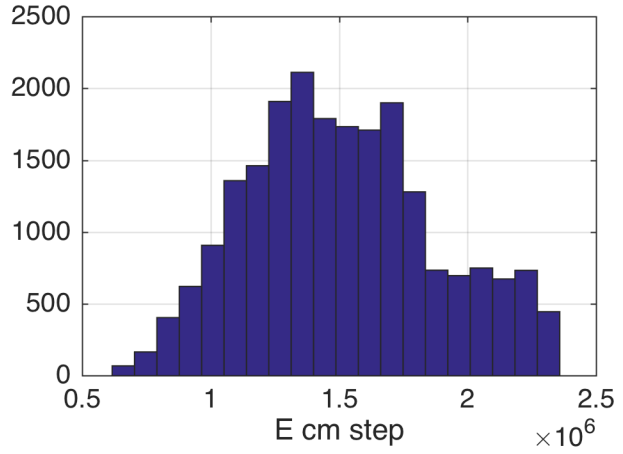



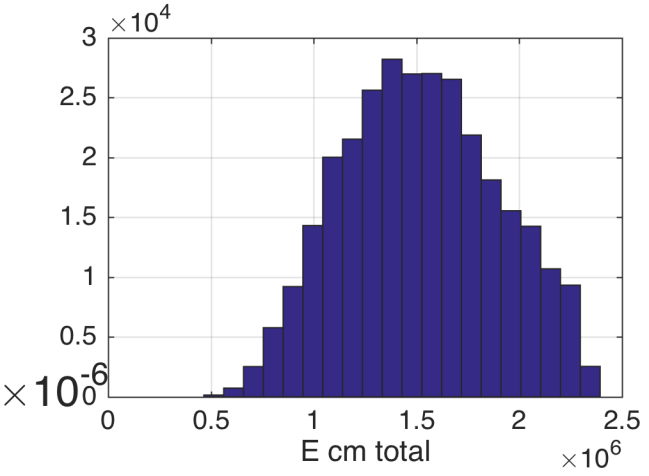



# Simulations of dynamics in the ROSE code

bin x 21 y 21 z 21 step 8

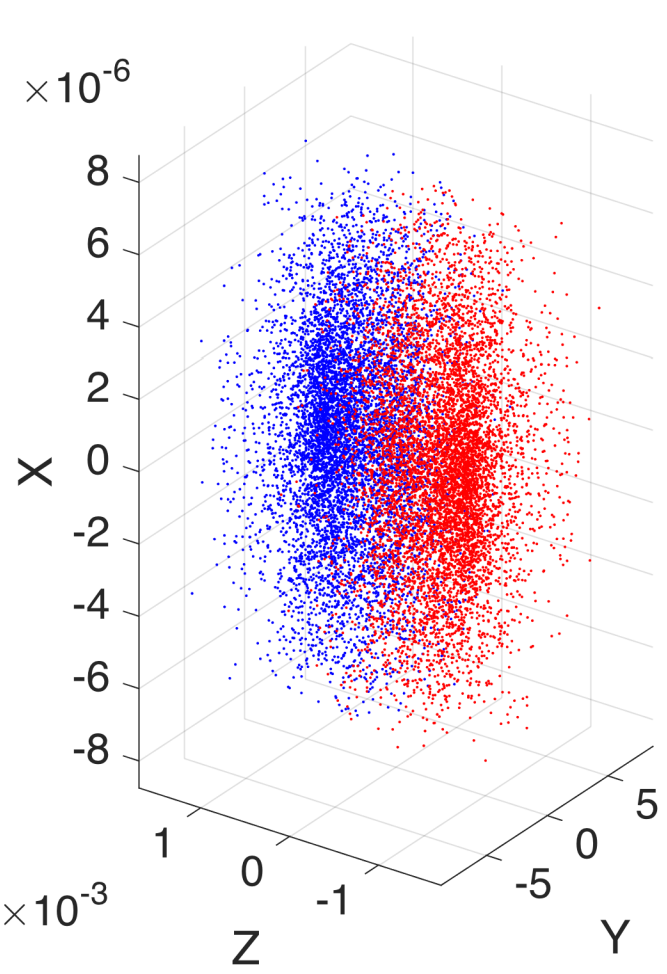


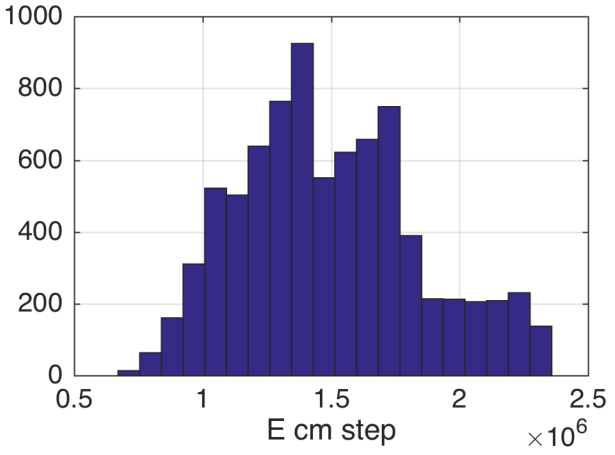



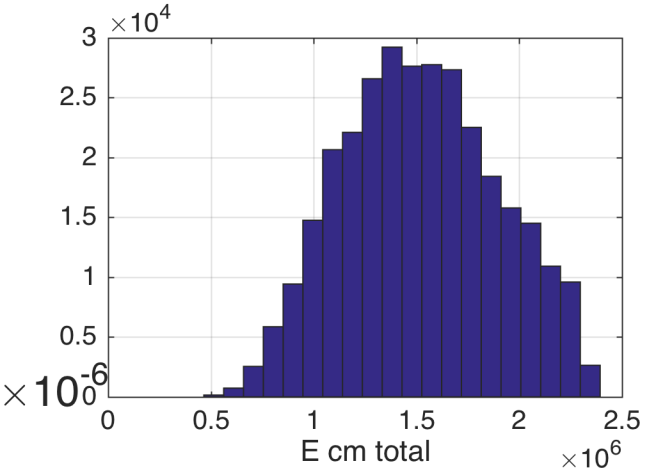



# Simulations of dynamics in the ROSE code

bin x 21 y 21 z 21 step 9

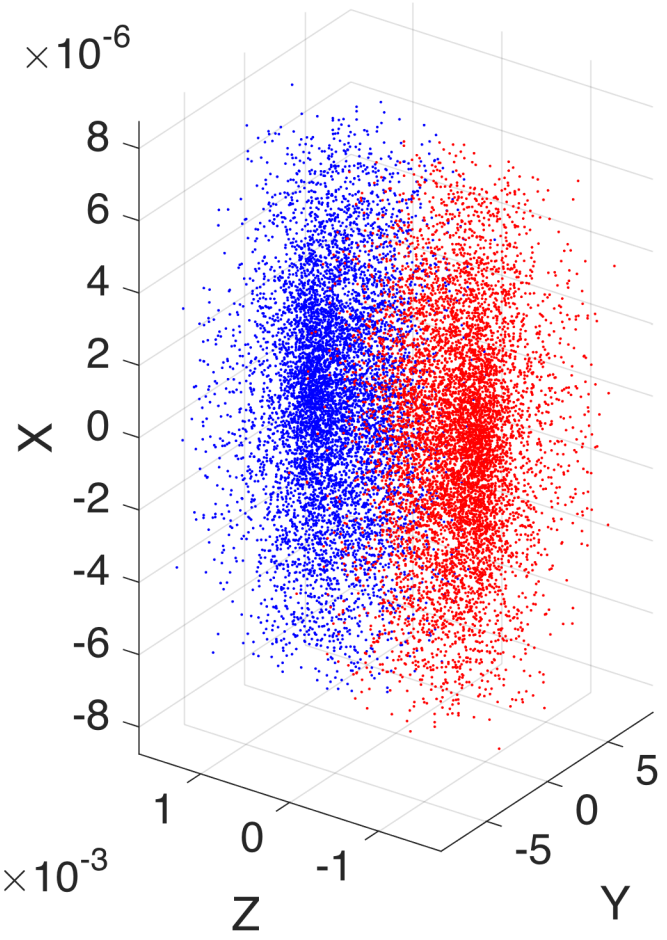


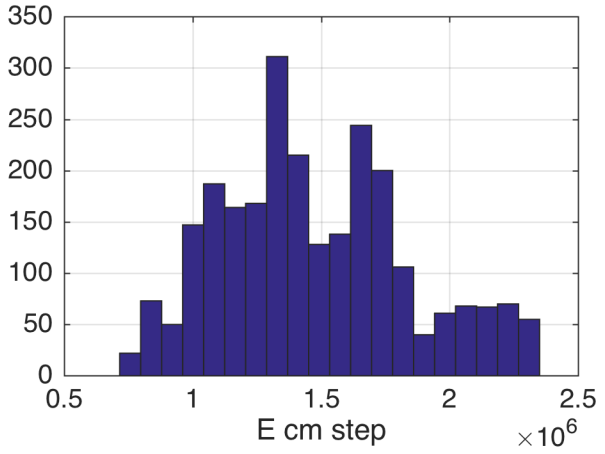



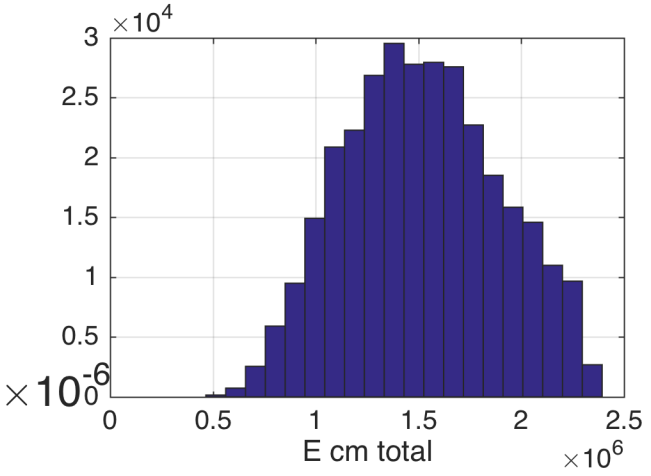



# Simulations of dynamics in the ROSE code

bin x 21 y 21 z 21 step 10



# Simulations of dynamics in the ROSE code

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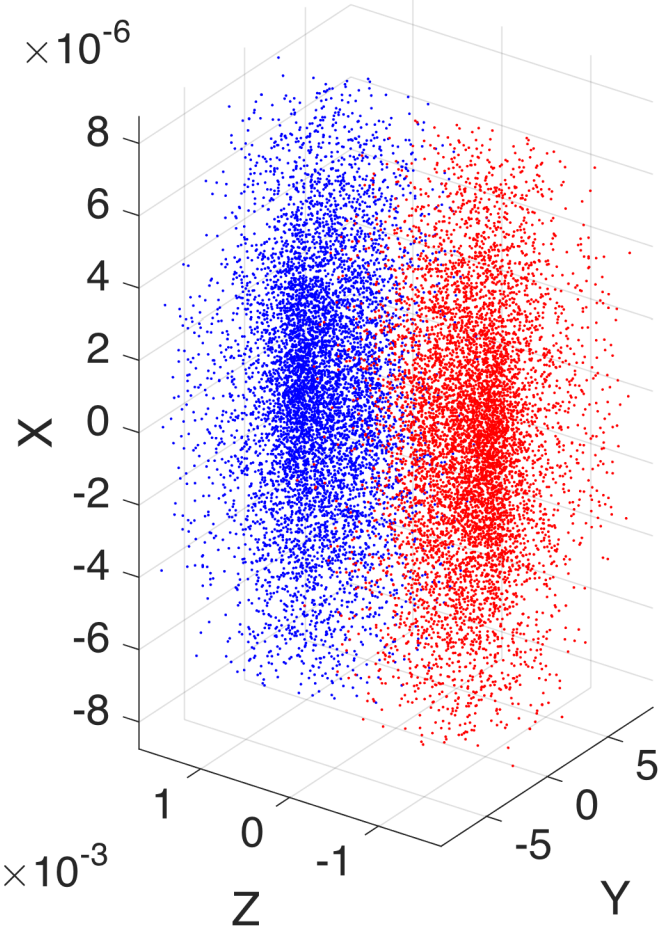
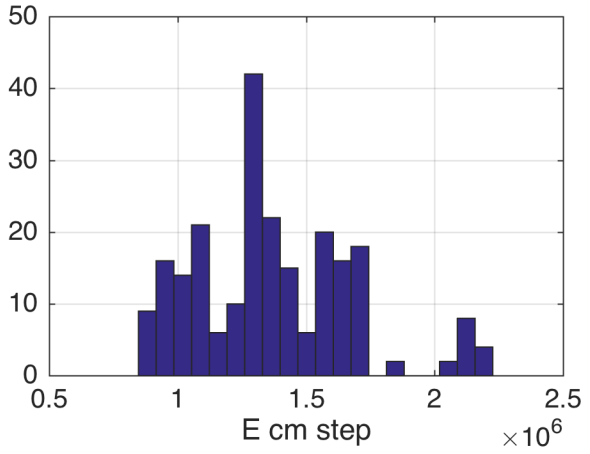
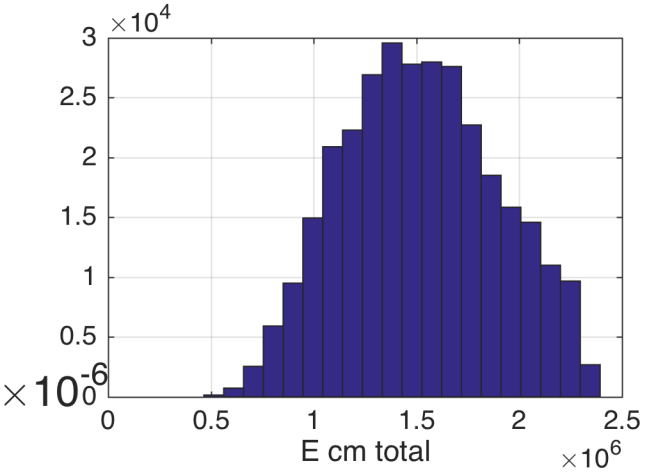
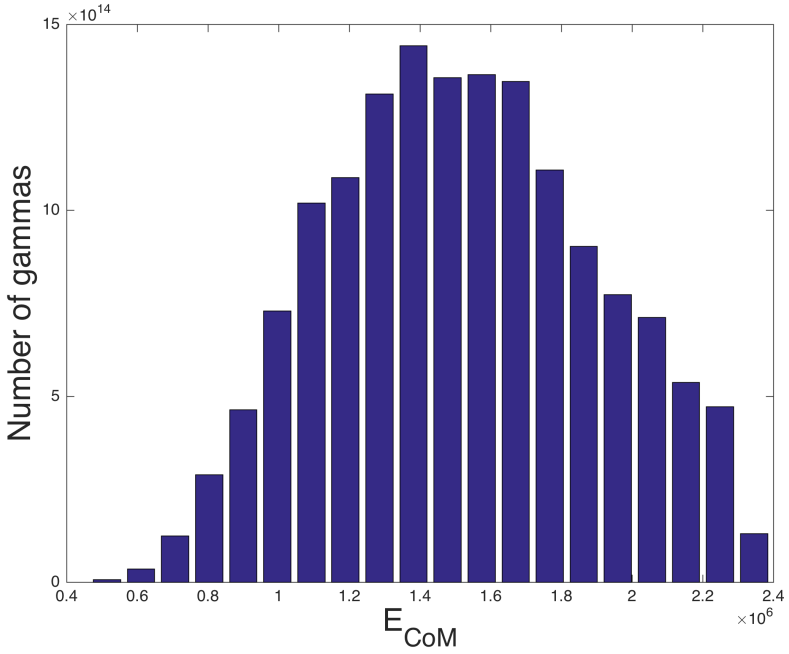


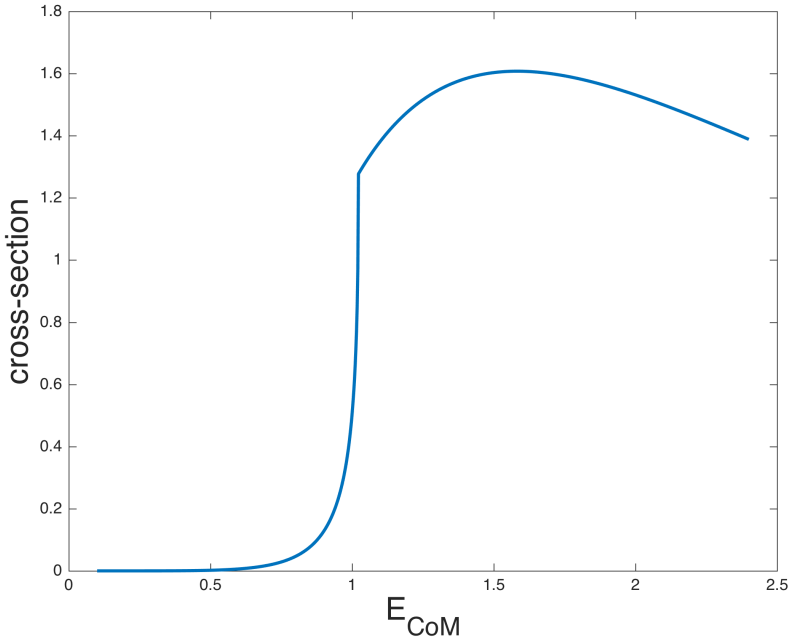



# Simulations of dynamics in the ROSE code

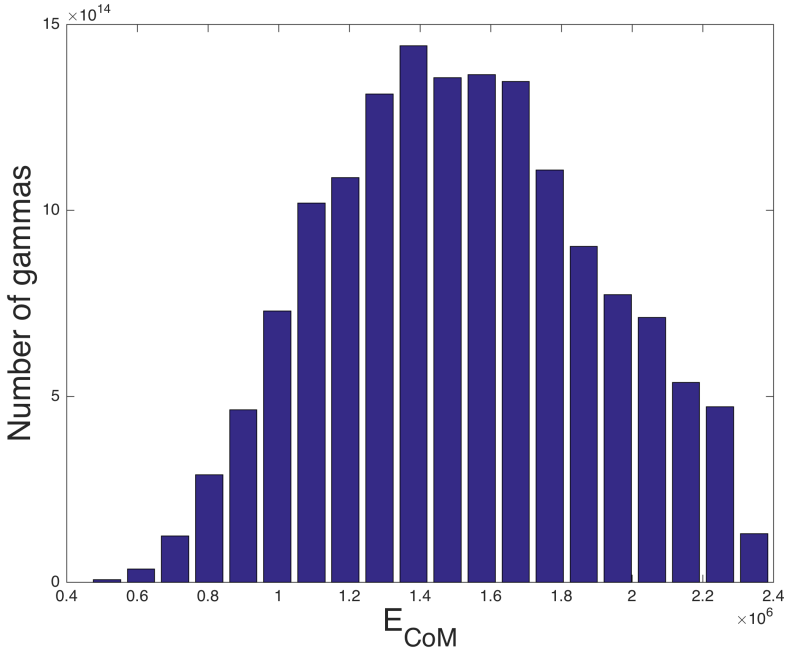



Build a histogram of the energy of center of mass (CoM) for the all possible pair.

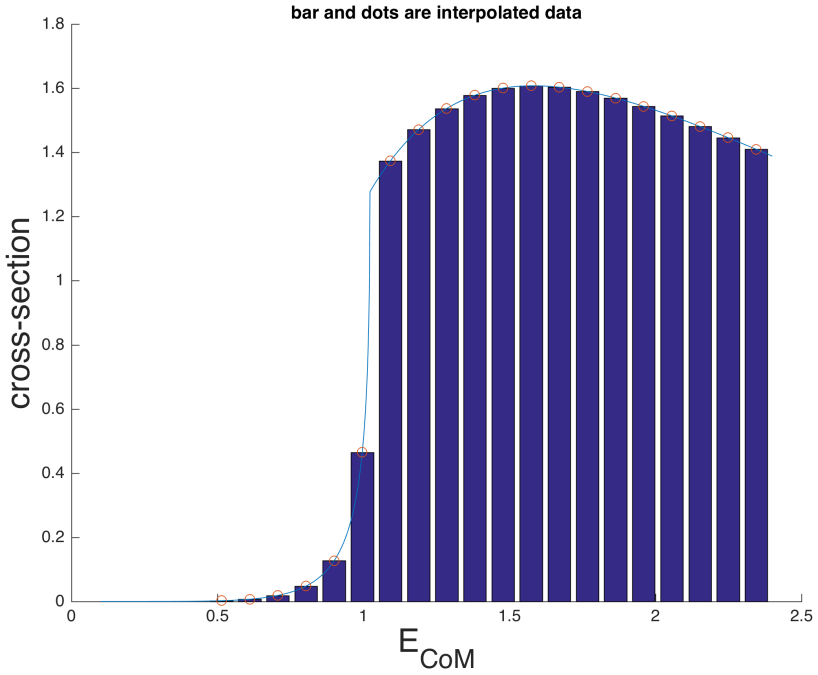



Differential cross section in the plane $E_{CoM}$ (integrated on $\theta$)

# Simulations of dynamics in the ROSE code

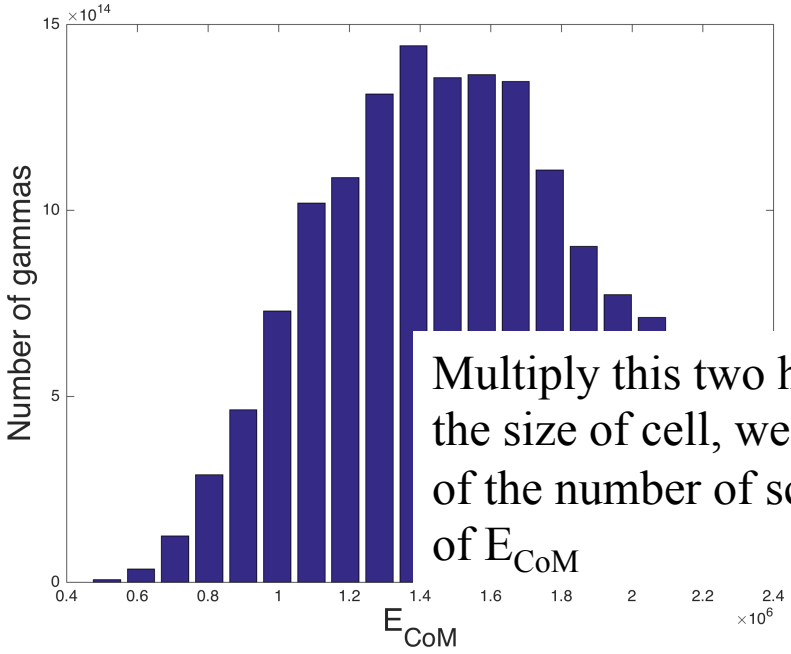


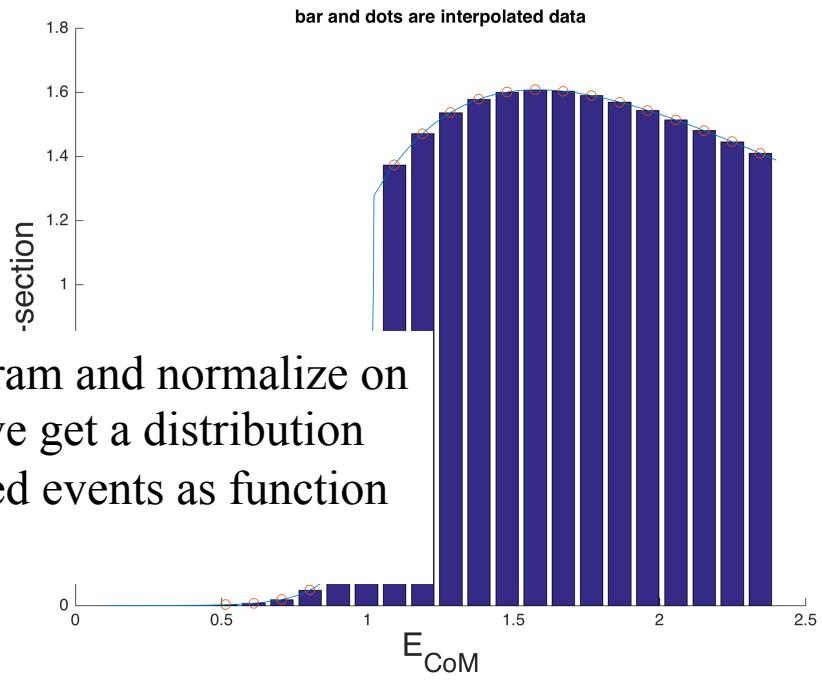

The histogram of the energy of center of mass (CoM) for the all possible pair.




Build a histogram for total cross-section with exactly the same width of bin that in the number of gammas

# Simulations of dynamics in the ROSE code



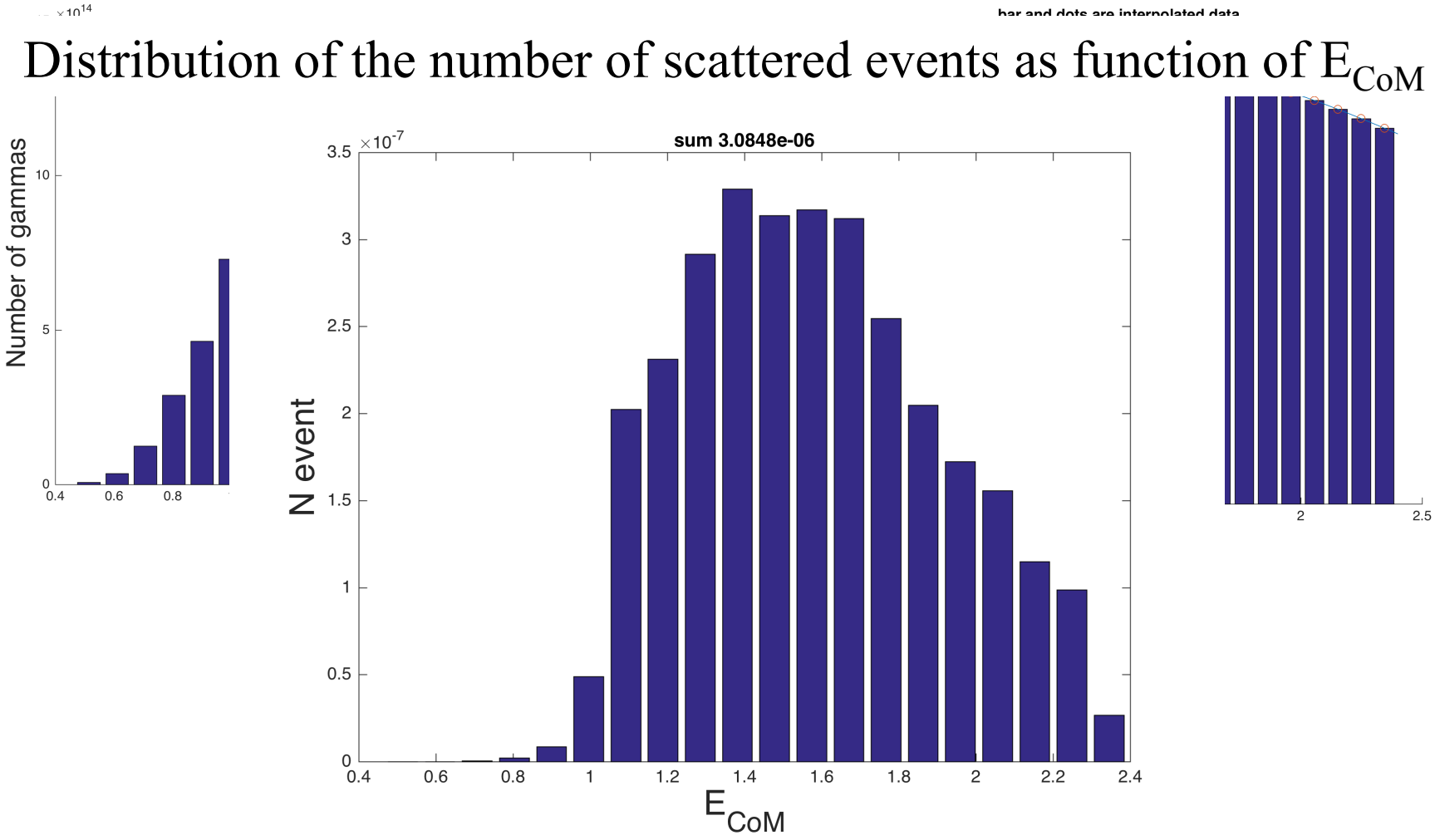

Multiply this two histogram and normalize on the size of cell, weight we get a distribution of the number of scattered events as function of $E_{CoM}$

The histogram of the energy of center of mass (CoM) for the all possible pair.

Build a histogram for total cross-section with exactly the same width of bin that in the number of gammas

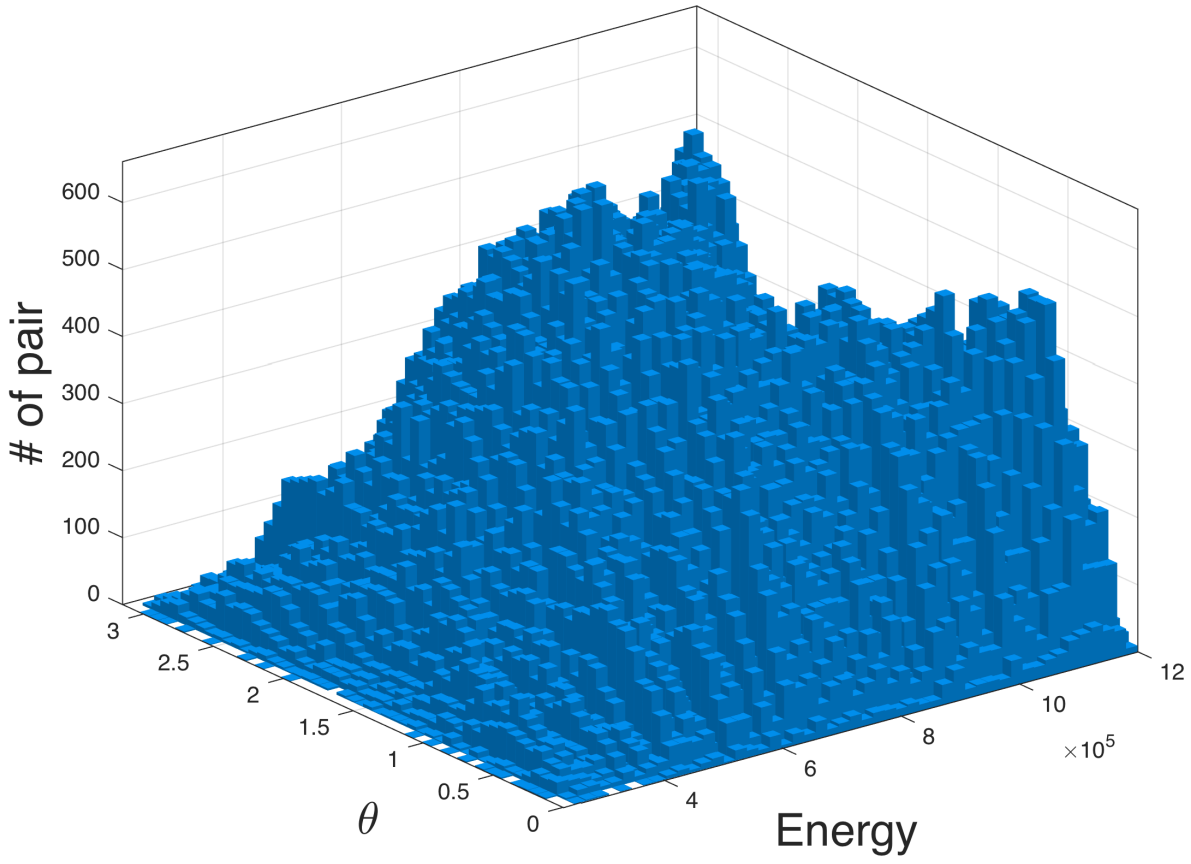
# Simulations of dynamics in the ROSE code

## Distribution of the number of scattered events as function of $E_{CoM}$

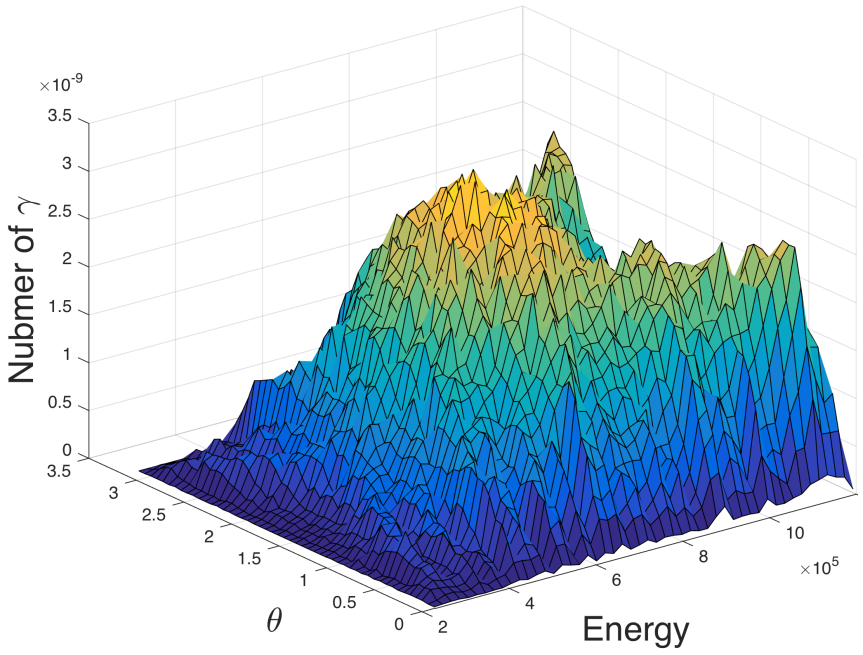


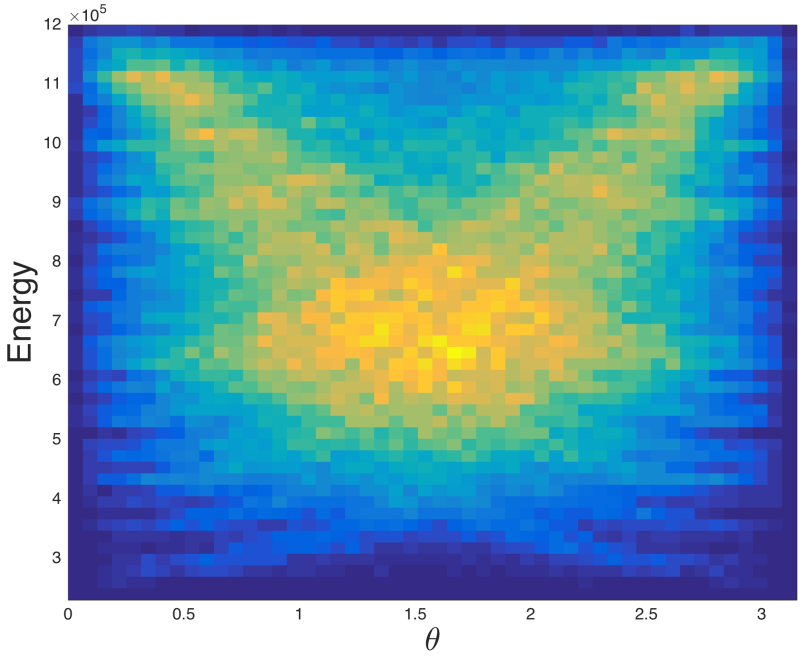

$3*10^{-6}$ per 1 shot * 100 Hz repetition rate => 1 event per hour

Distribution of the γ-γ events in the laboratory as a function of the energy of the secondary particles $E=E_{3,4}$ and of the zenith angle θ.

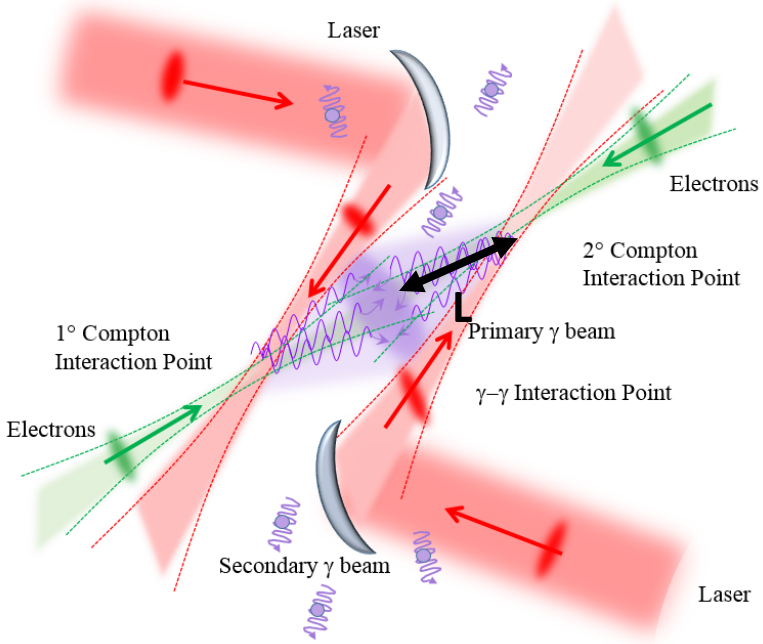


Distribution of the γ-γ events in the laboratory as a function of the energy of the secondary particles E=E3,4 and of the zenith angle θ.

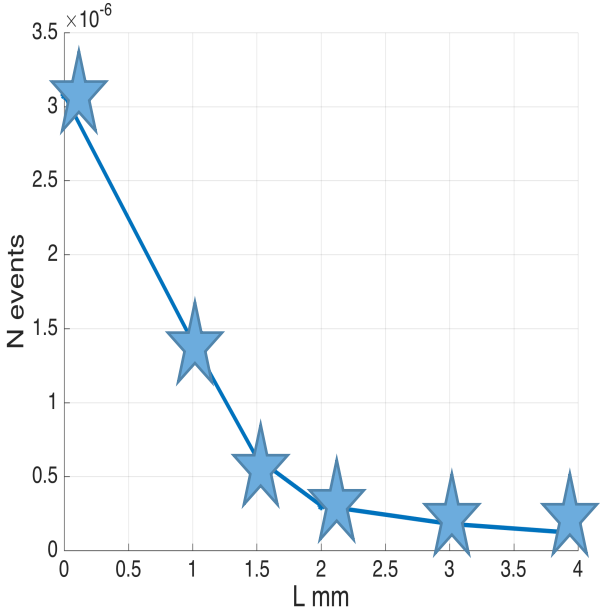


# Results of a Monte Carlo dedicated ROSE code




1 event/h



# Conclusions

- A design of a γ-γ collider based on conventional Compton gamma sources was presented for the first observation of the elusive *scattering of light by light*.

- Our code ROSE, developed *ad hoc*, allow a set of simulations of the γ-γ interactions and give evaluation of the event rate and energy-angular distributions of the scattered gammas.

- Tuning the nominal CoM energy to optimal, **1 event/hour** is achieved for ***L*= 1-2mm** and with a repetition rate ***f*=100Hz**

- An accurate treatment of the **background processes** such as **Breit-Wheeler process (**Never been observed**)** will be the object of future work.