What can we learn from correlated radio and X-ray variability?

Igor Gitelman & Ari Laor

What produces the core radio emission in Radio Quiet Quasars?

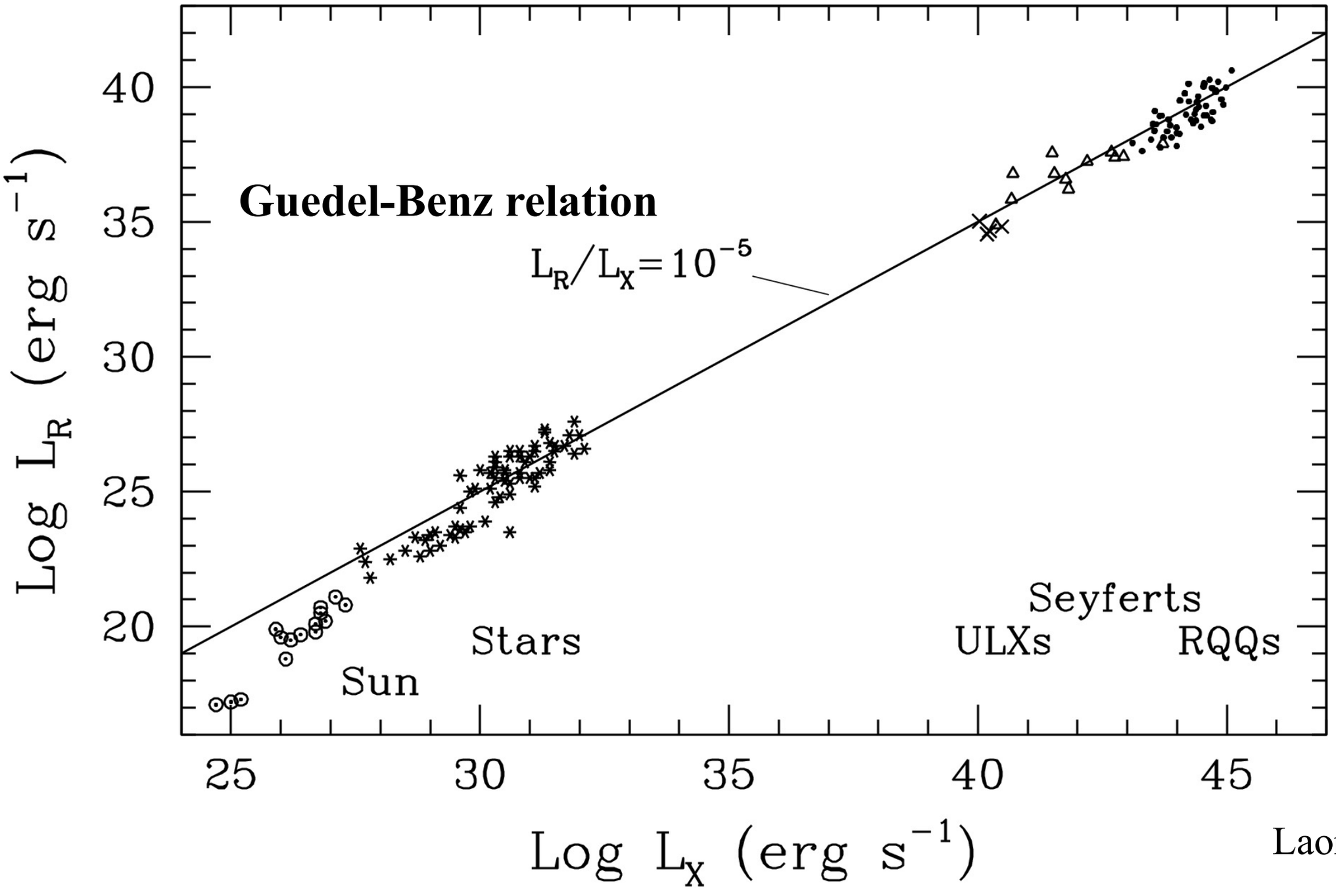
Evidence for coronal emission

If true, can we use the radio to study the coronal heating mechanism?

Yes.
Through simultaneous radio + X-ray monitoring.

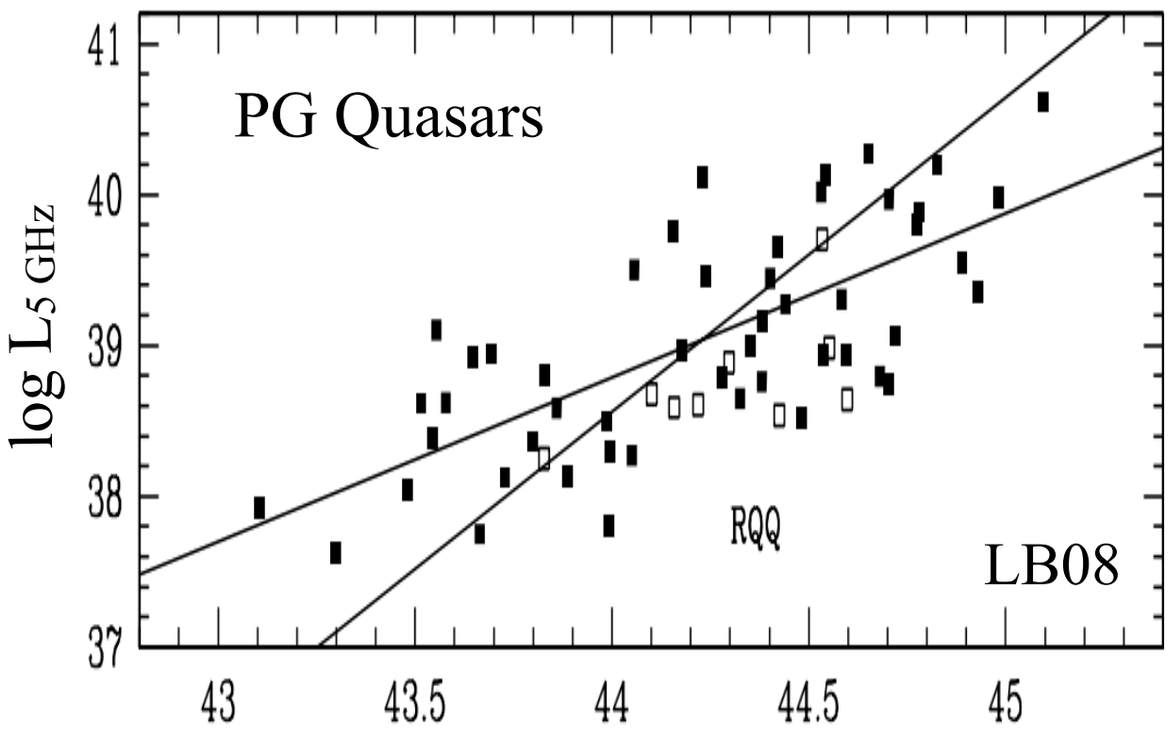
Evidence for Coronal Radio Emission

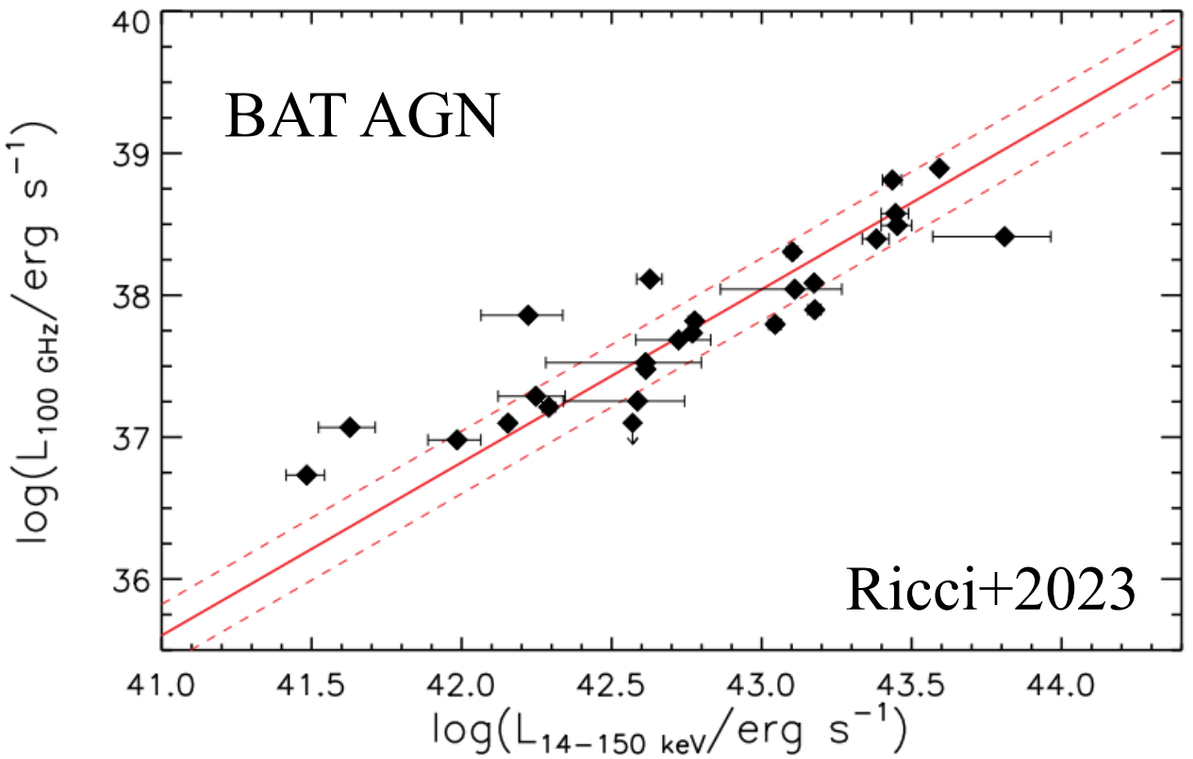
Coronally active stars vs. RQ AGN



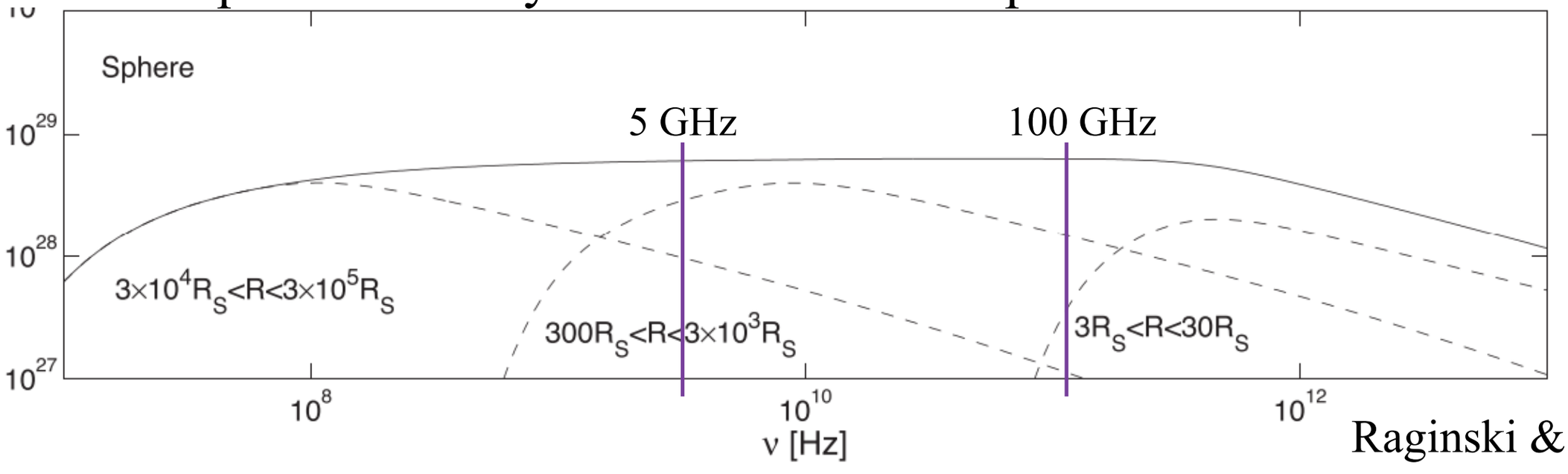
Laor & Behar (2008)

The L_X vs. L_R relation is tighter at 100 GHz





as expected from synchrotron self-absorption



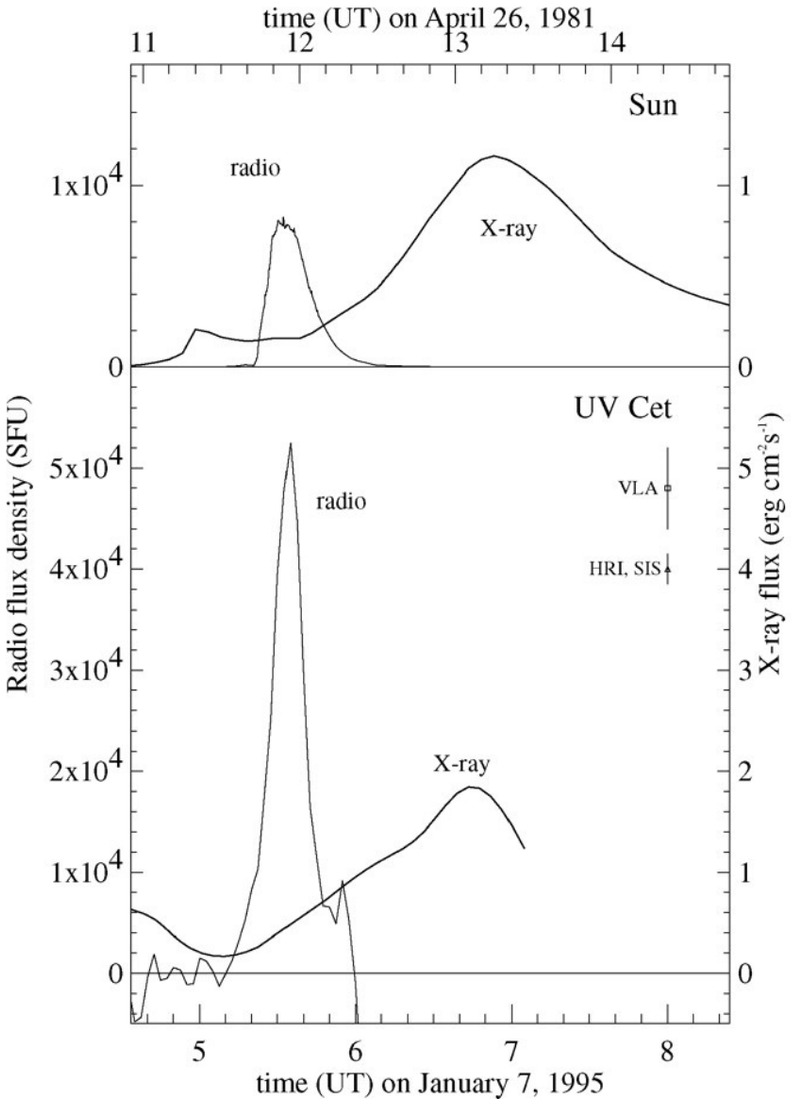
Raginski & Laor (2016)

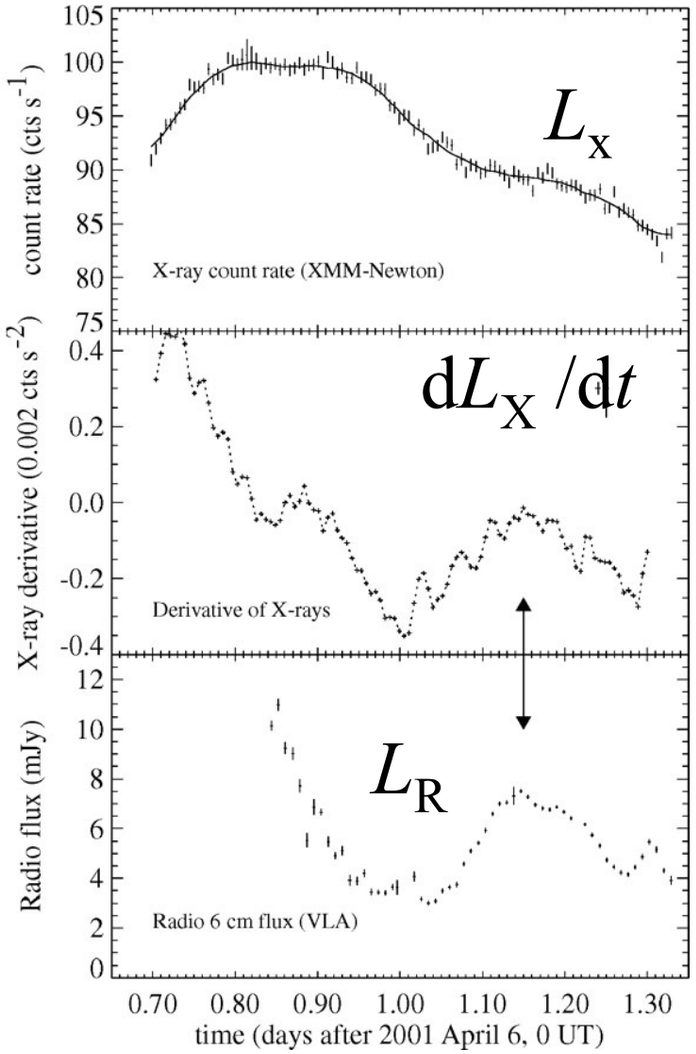
How can we test the coronal scenario?

The corona paradigm (stars)

$$B^2 \xrightarrow{\text{Reconnection}} \gamma^{-p} \xrightarrow[L_R]{\text{Heating}} kT \xrightarrow[L_x]{\text{Cooling}} \textbf{X-ray}$$

–> *Neupert Effect* $L_R \propto dL_X/dt$





Guedel (2002)

Does this apply also in RQ AGN?

Simulations

Monte Carlo scattering experiments which simulate:

1. Particle Fermi acceleration to $\gamma \gg 1$
2. Analytic solution for the synchrotron radiation
3. Scattering dissipation = Coronal gas heating
4. Photon scattering = Compton gas cooling

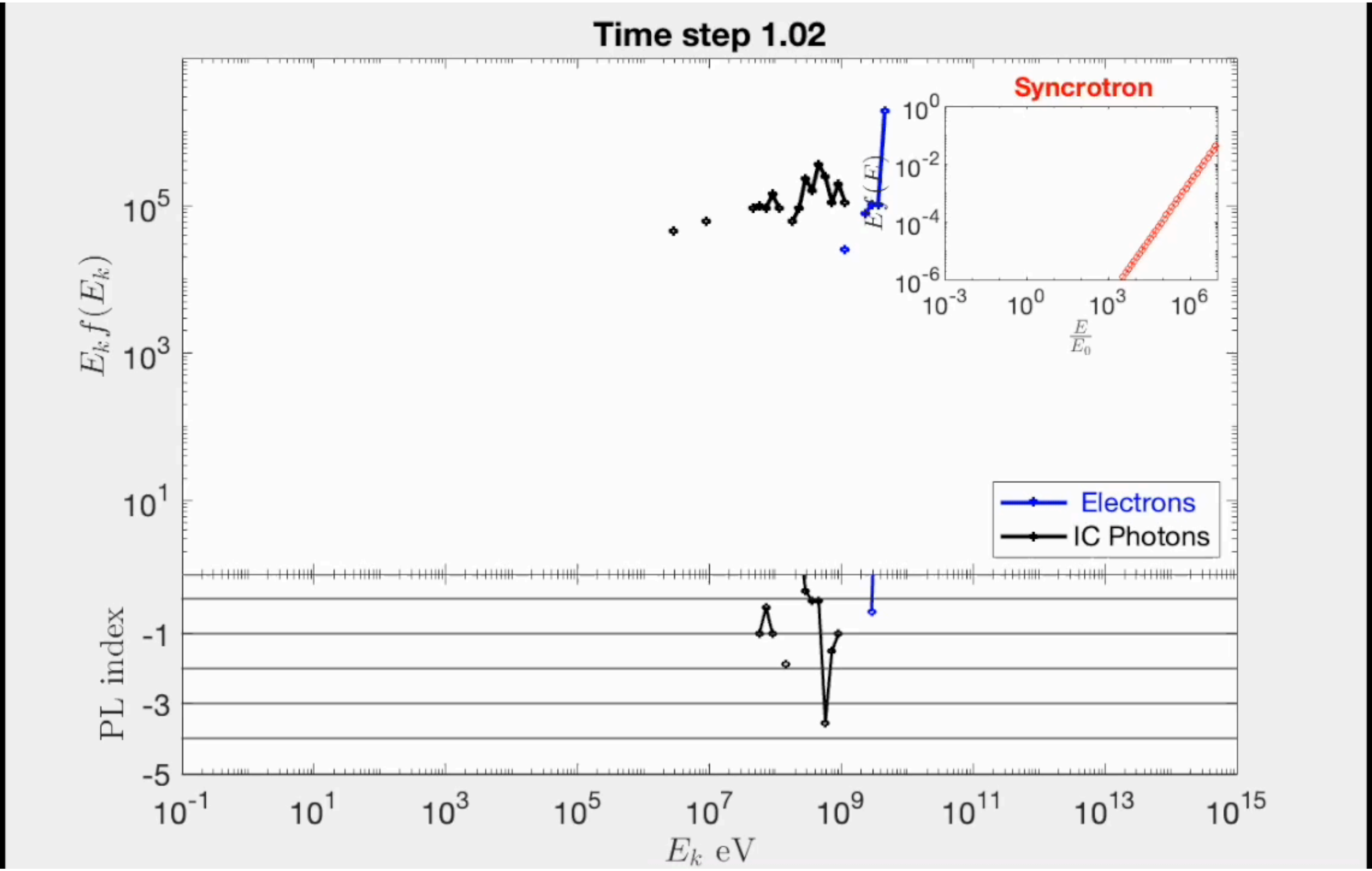
Simulation results for:

1. Steady state acceleration
2. Steady state dissipation
3. A time resolved acceleration event
4. A time resolved dissipation event
5. Dissipation + coronal heating = a Neupert effect

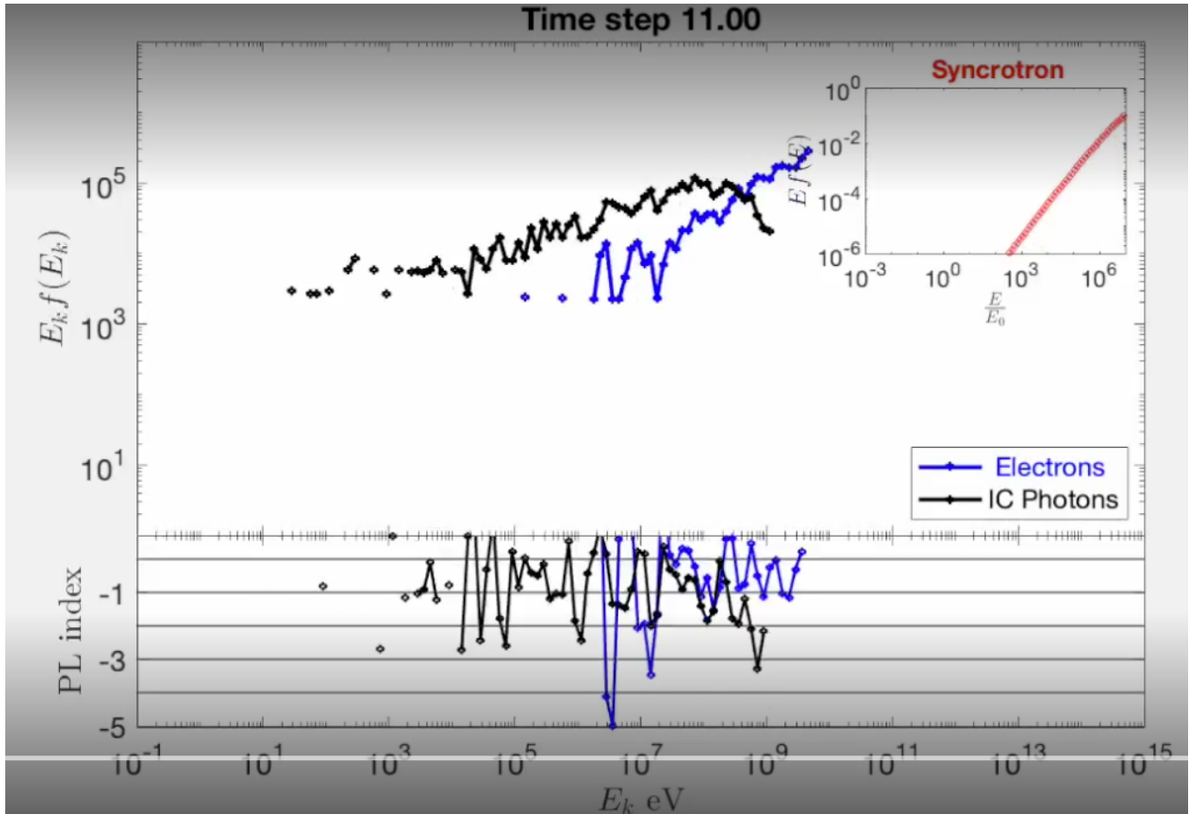
$\rightarrow$ Predicted light curves : $L_X(\nu, t),\ L_R(\nu, t)$

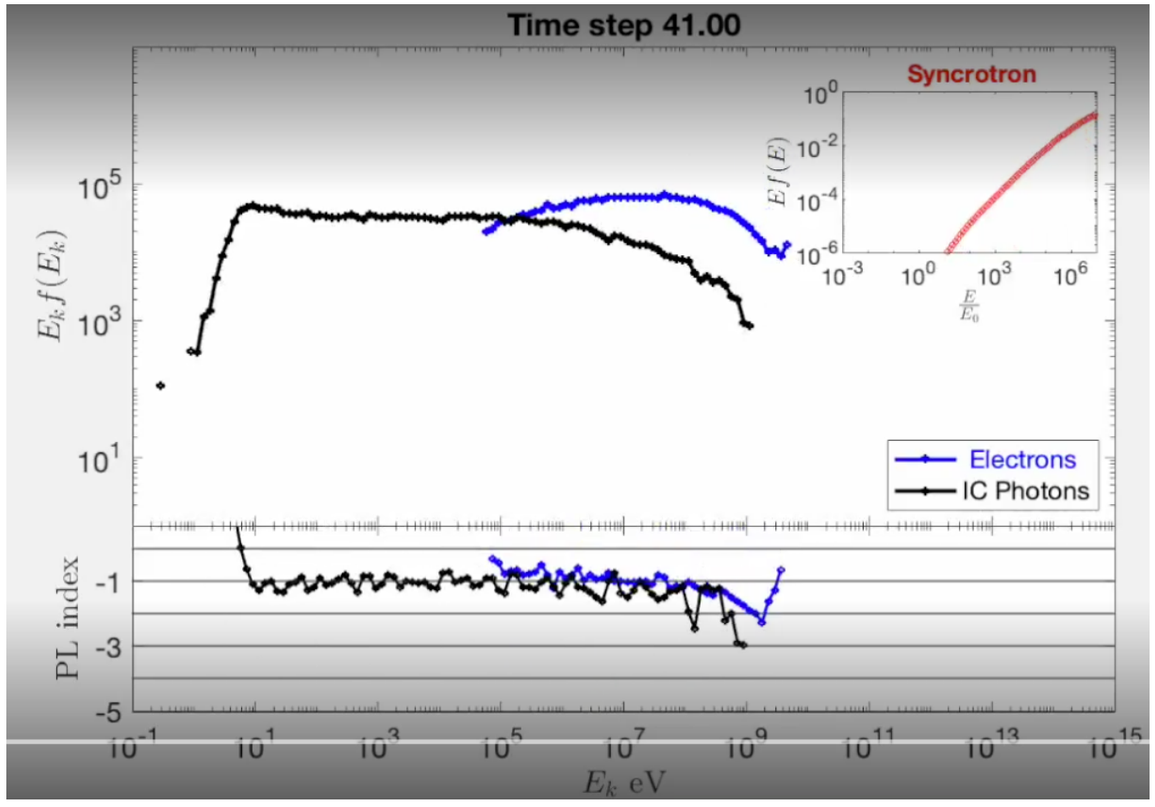
Energy cascade (shower formation) simulation

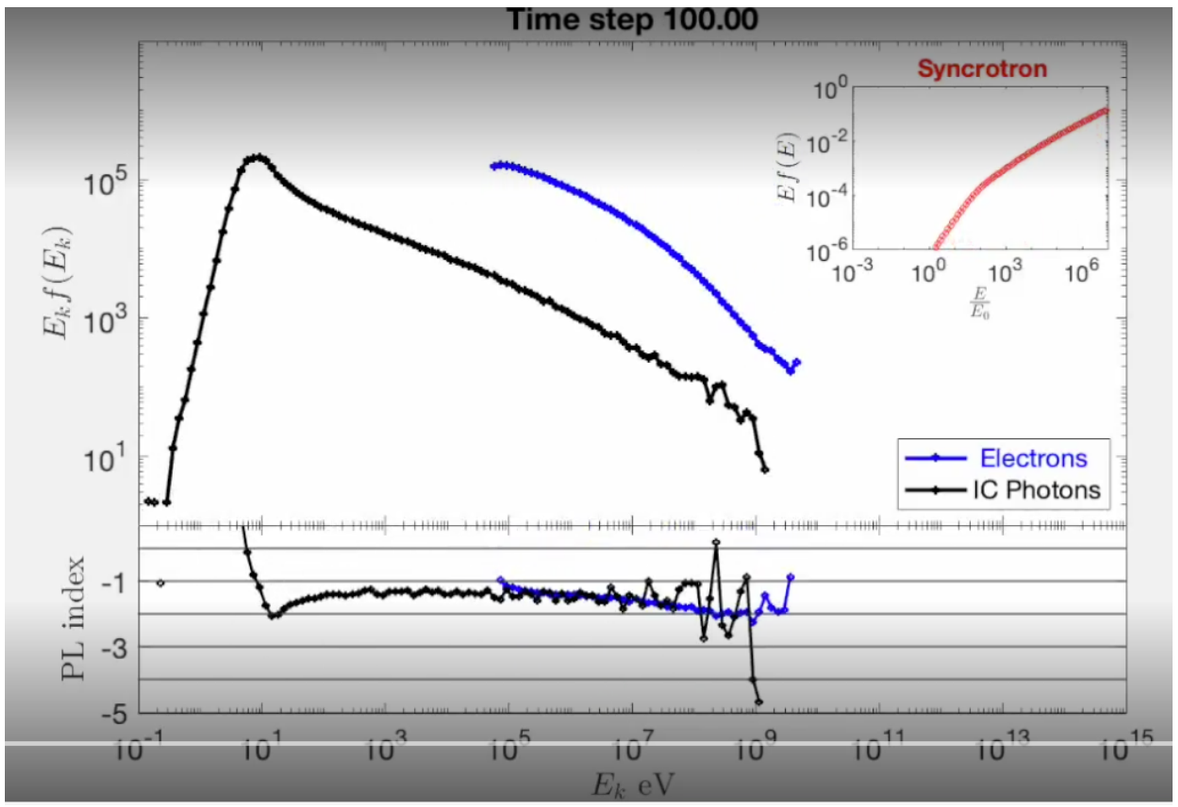
Constant injection rate of $\gamma\beta = 10^4$ background at $\gamma\beta = 0.2$

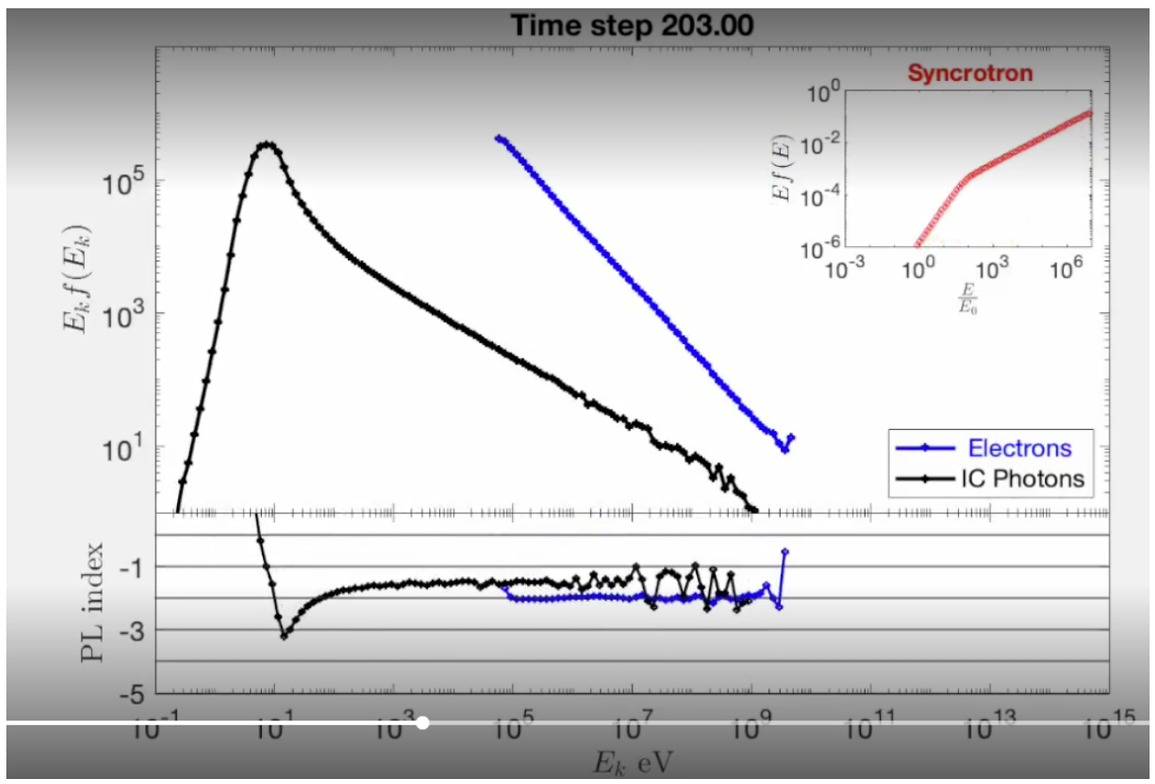


Energy cascade (shower formation) simulation



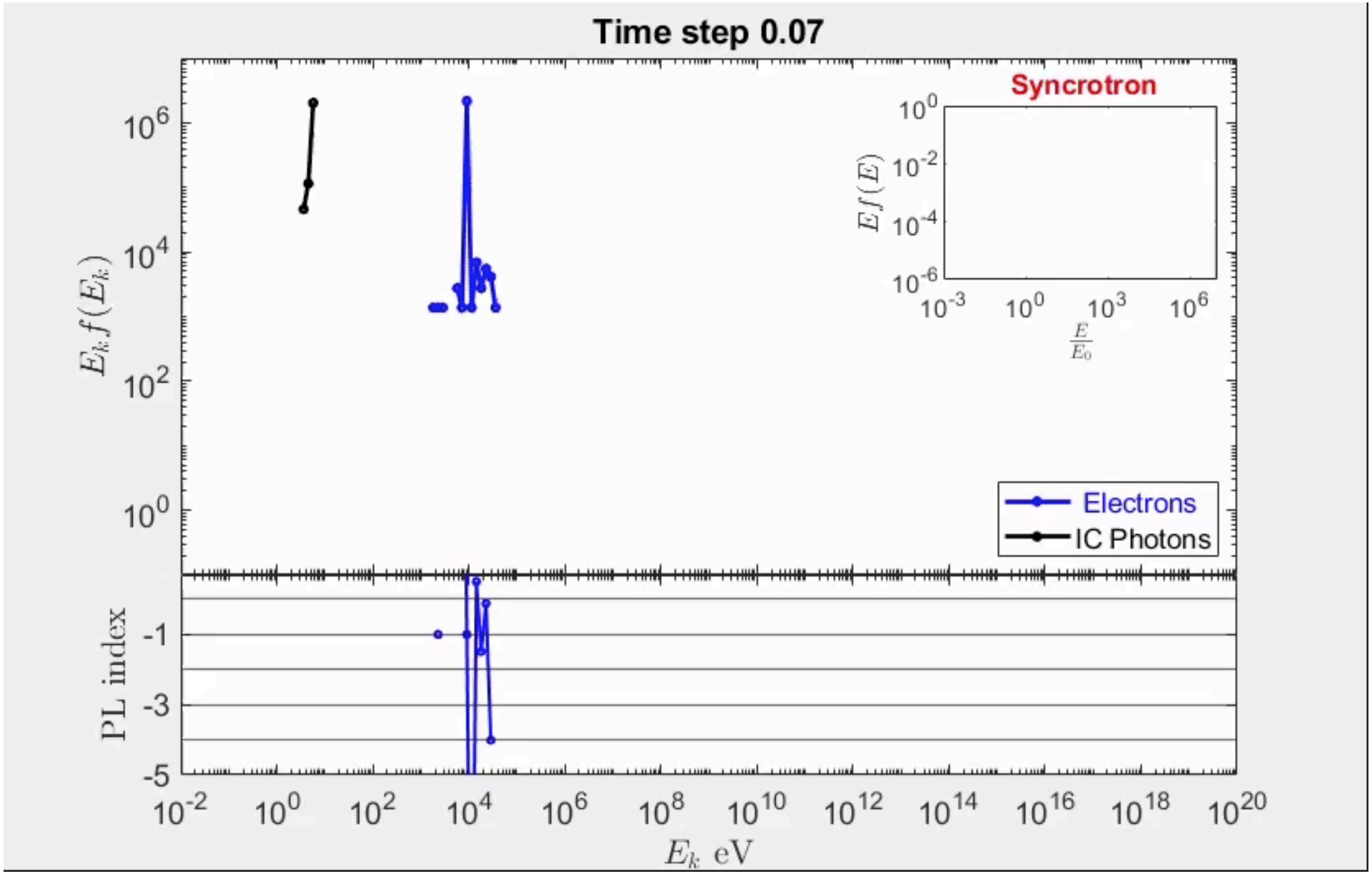




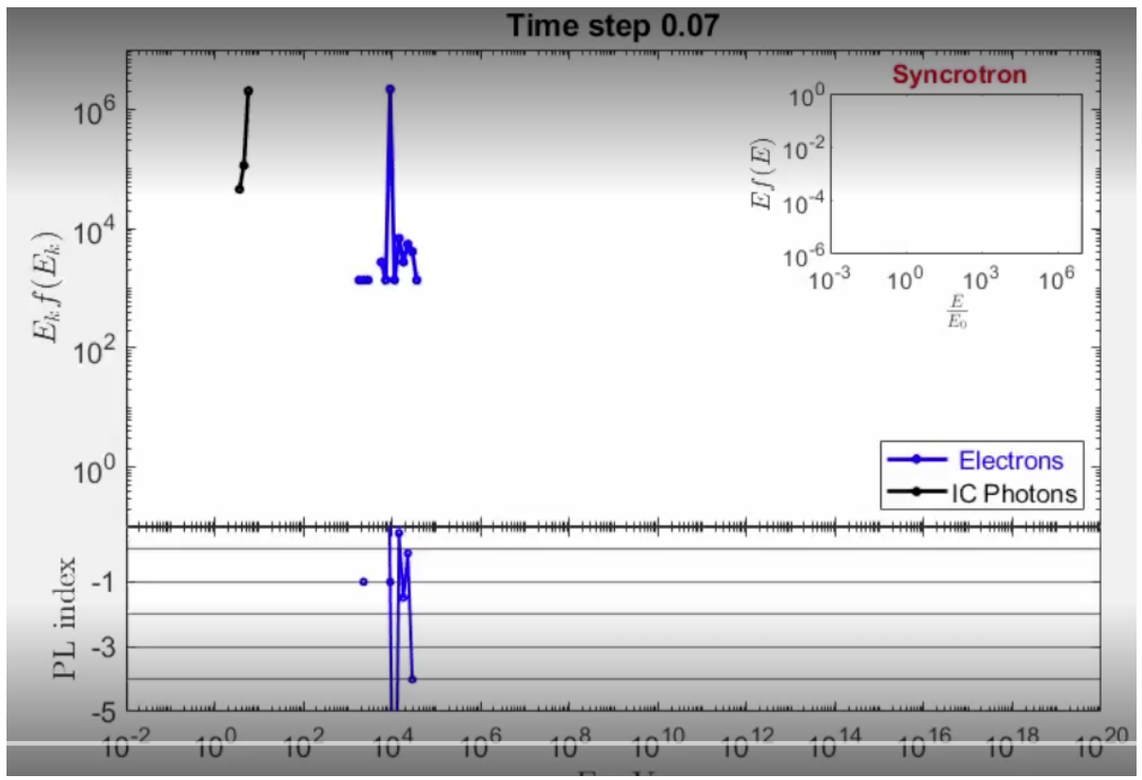


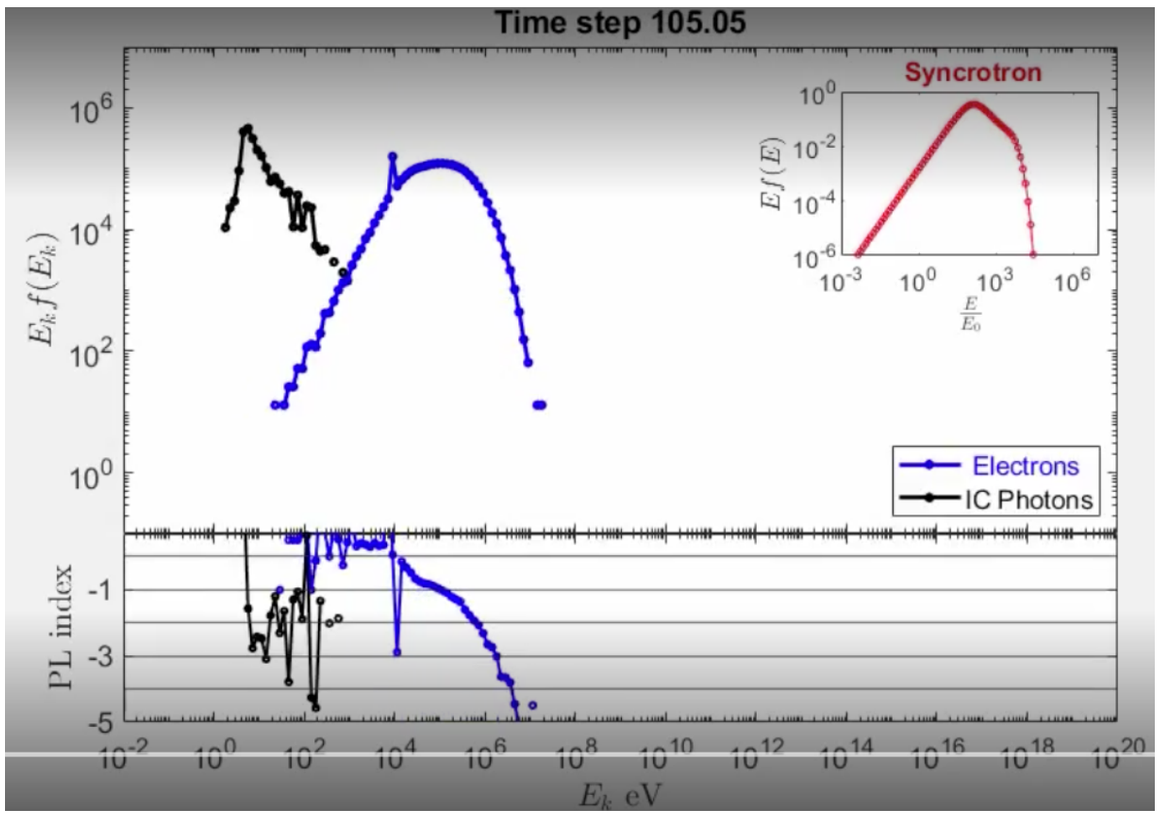
Fermi acceleration sim' - evolution to steady state

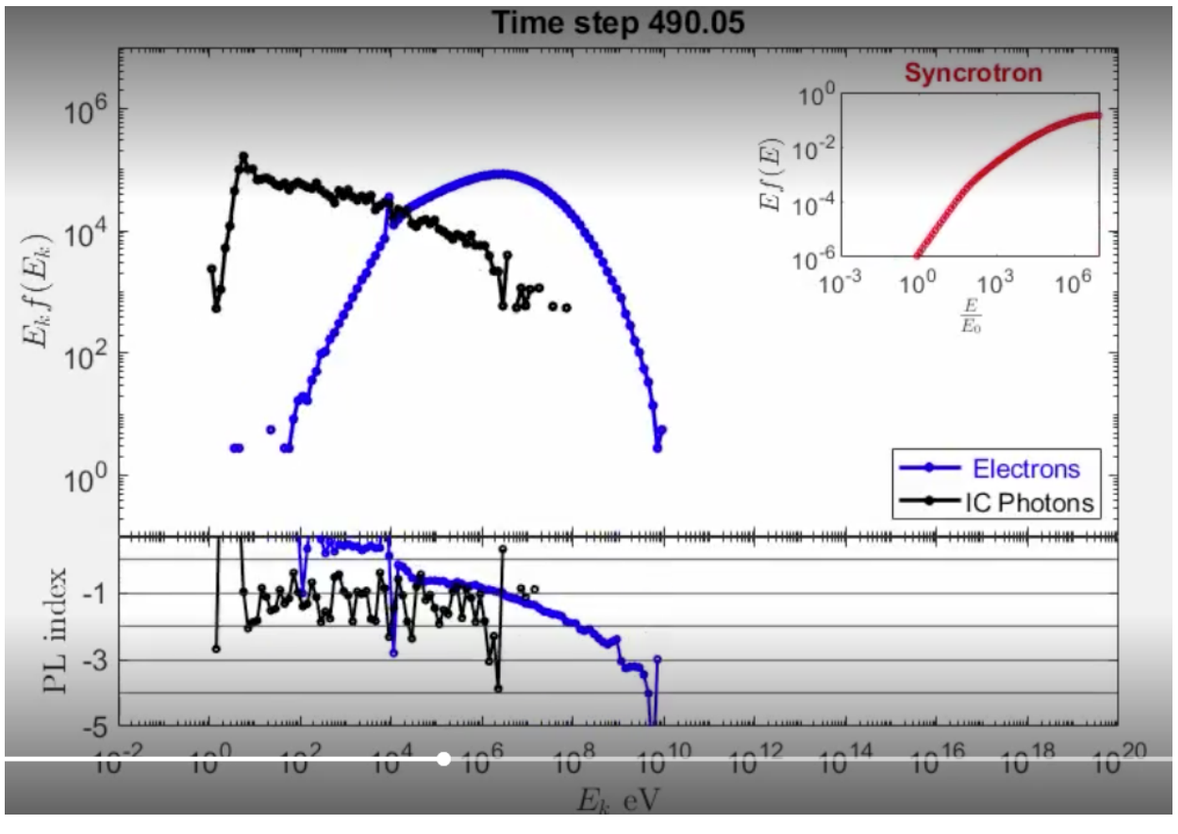
Constant injection rate of 10 keV electrons

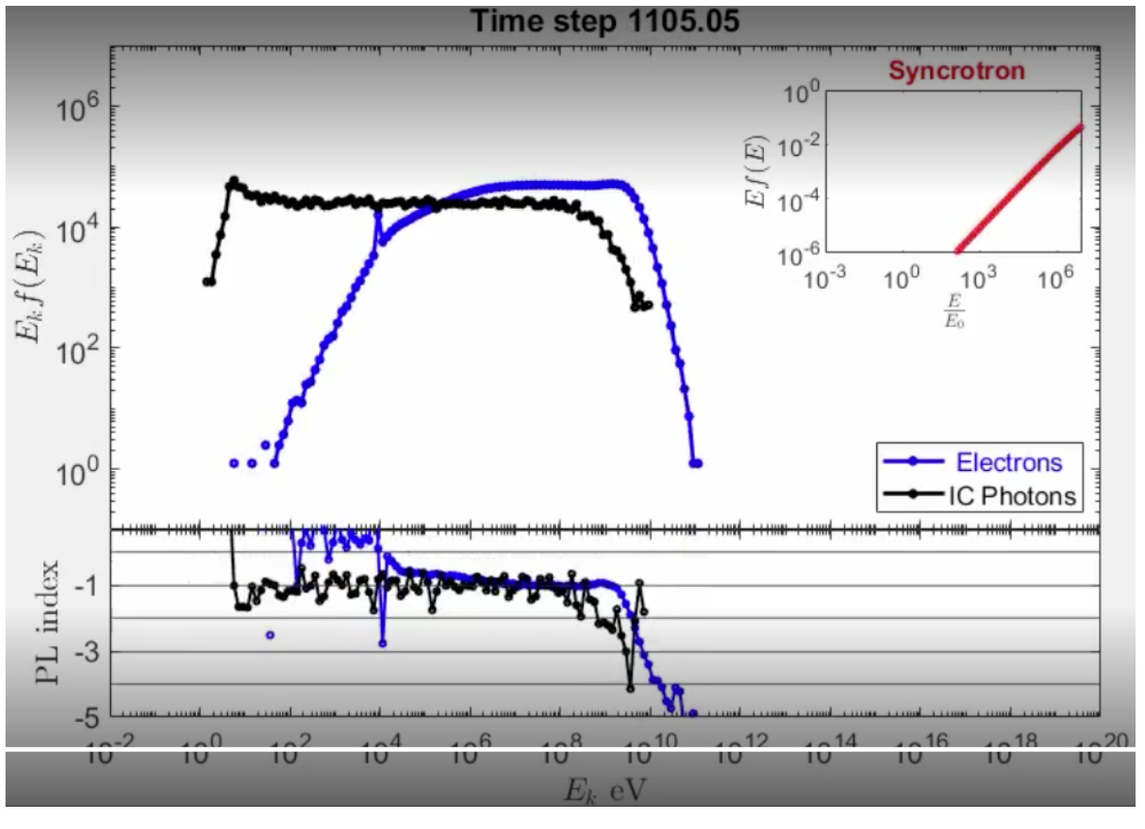


Fermi acceleration sim' - evolution to steady state



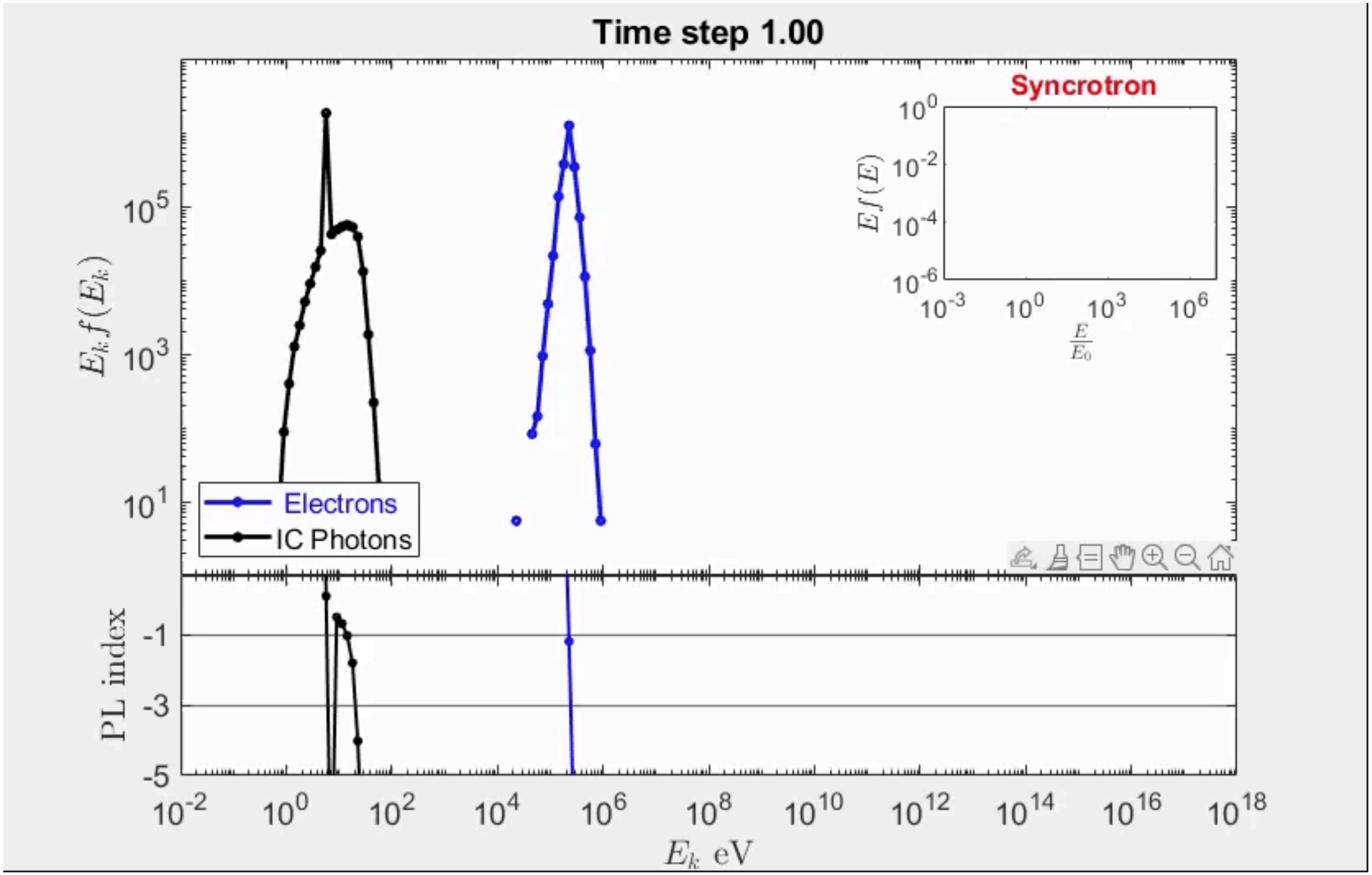




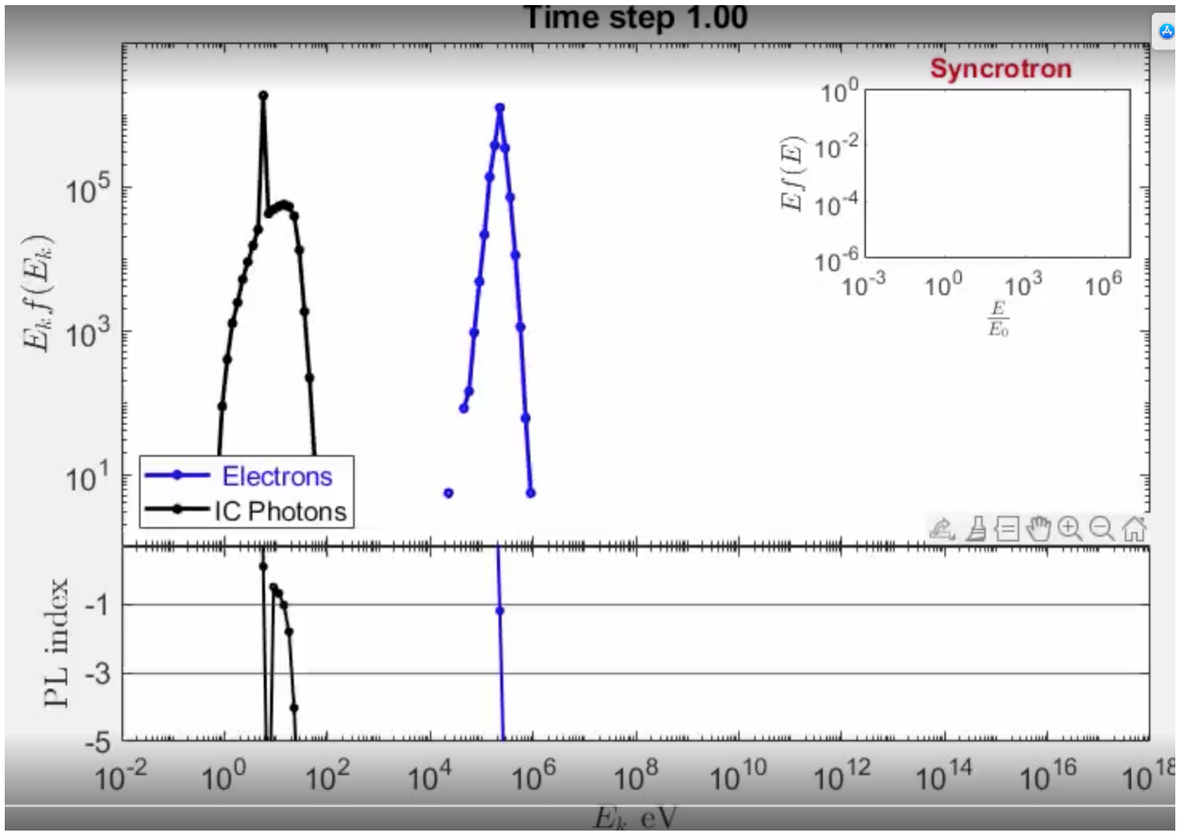


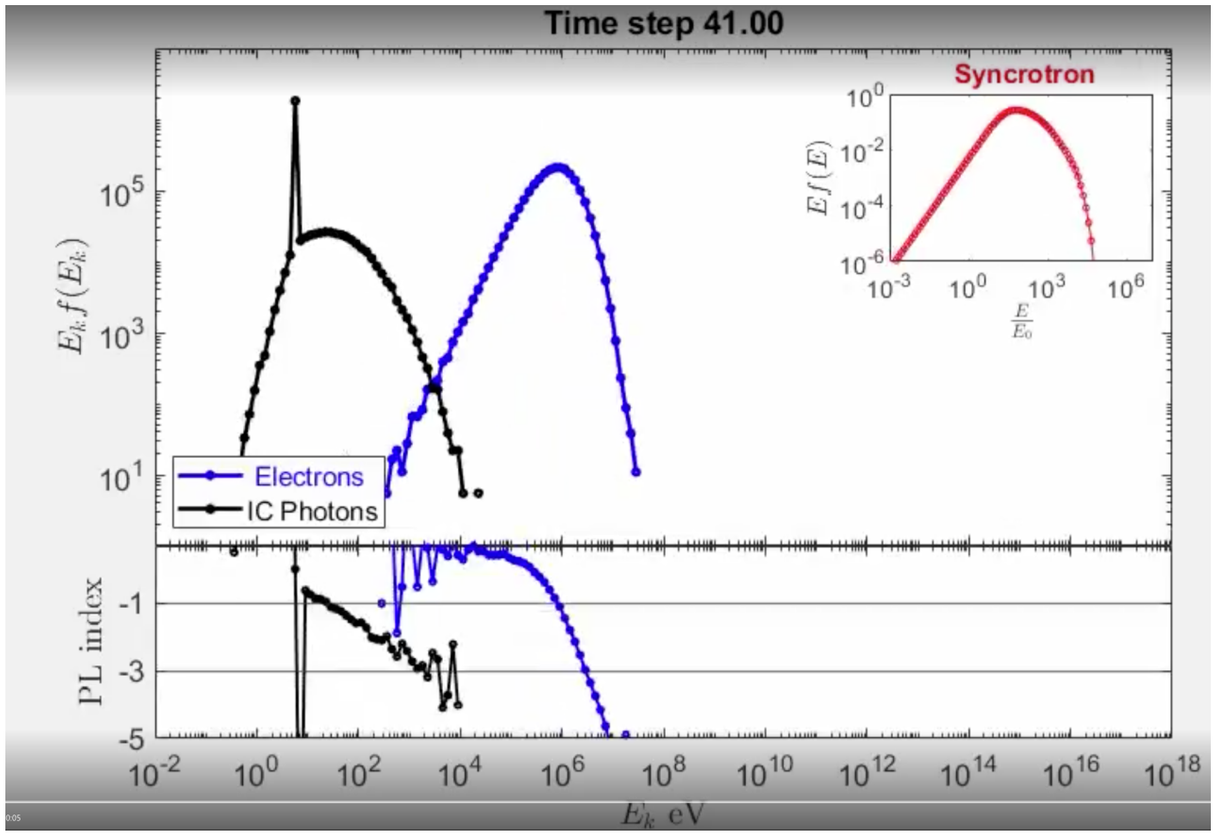
A time resolved acceleration event

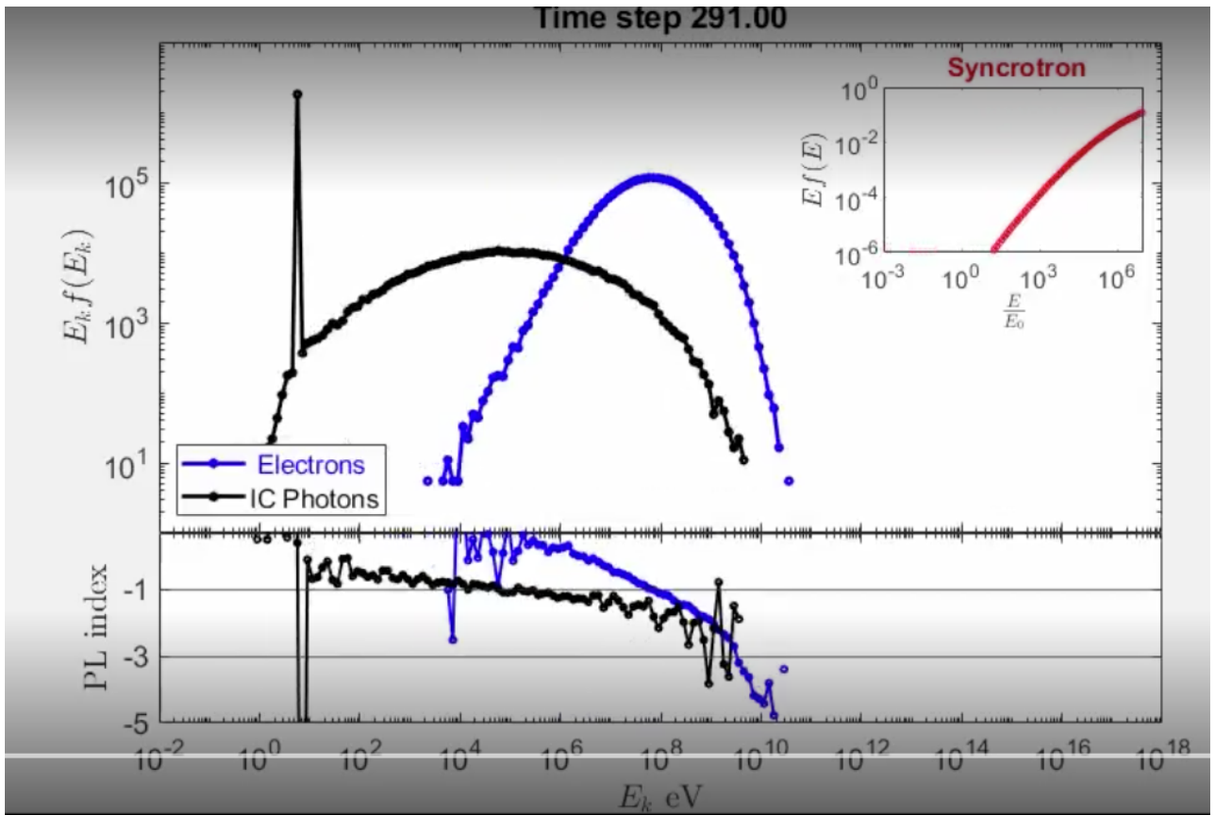
P (collisions)= 0.9

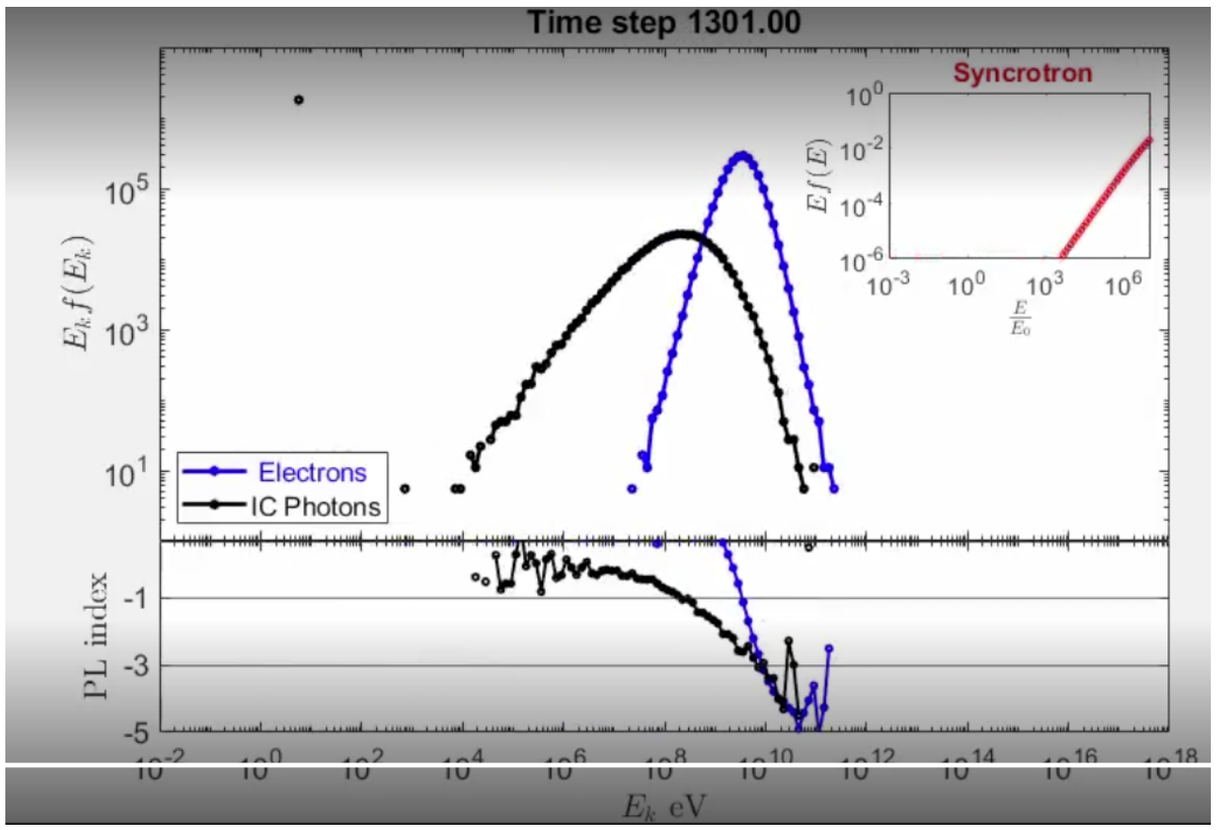


A time resolved acceleration event

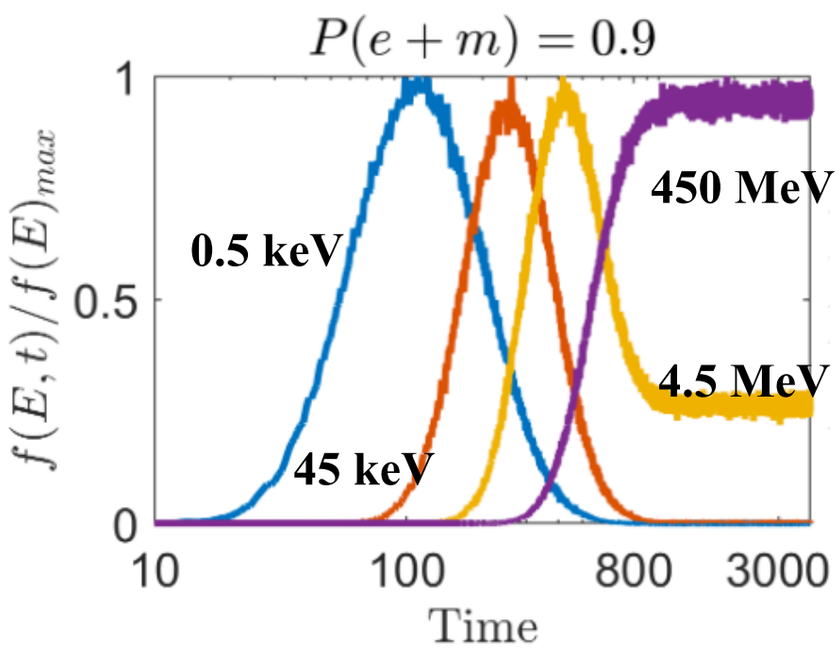


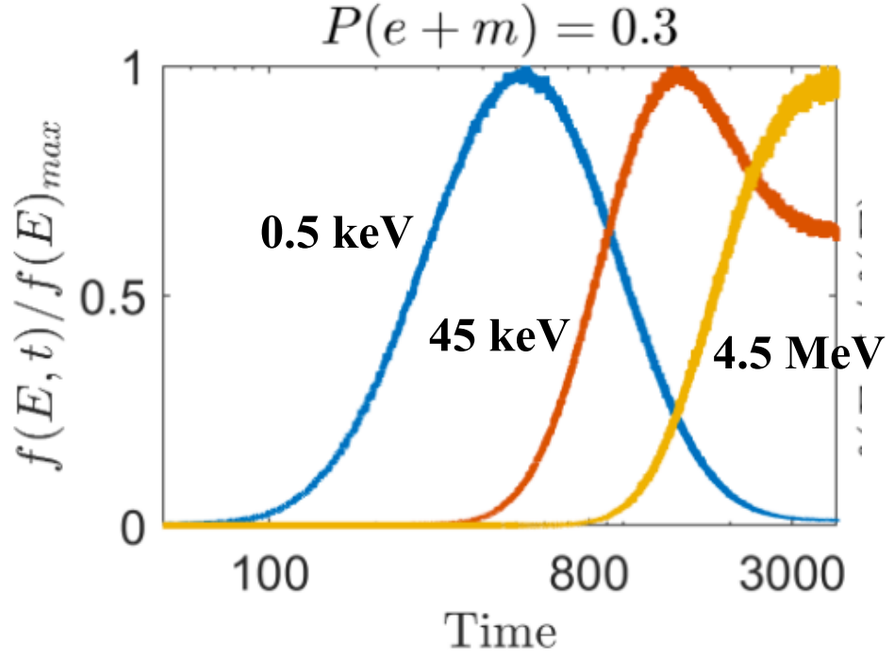




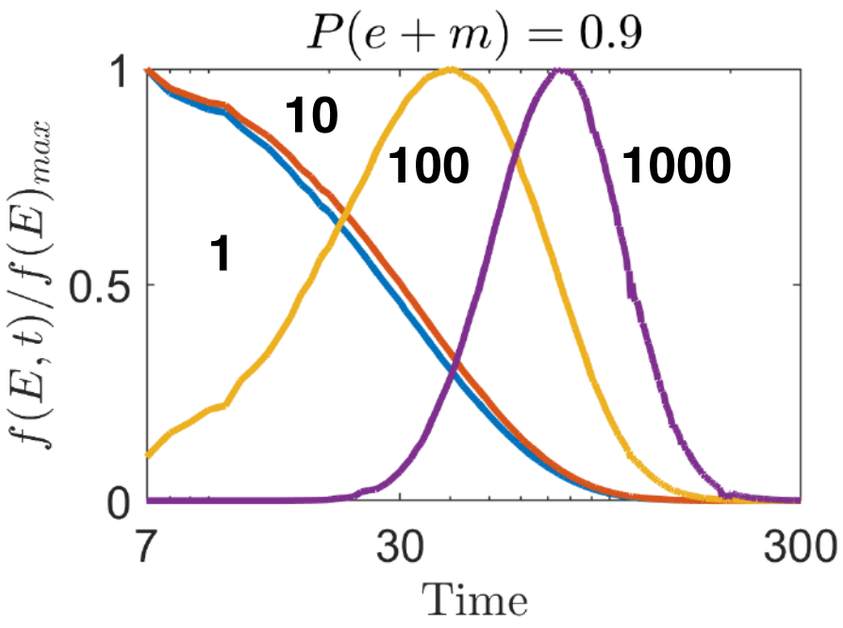


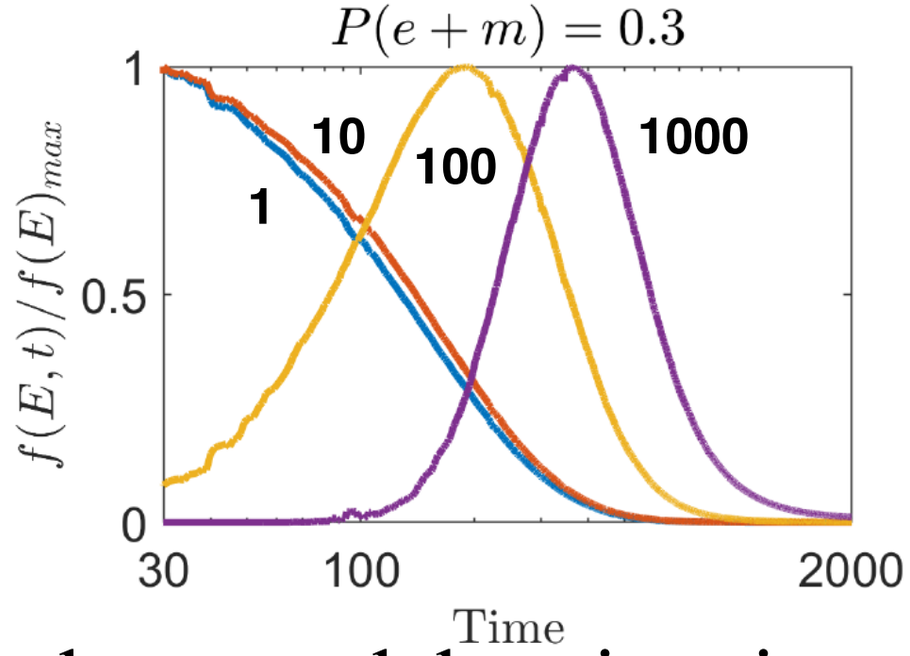
A time resolved acceleration event - light curves





X-ray IC delay time increases with energy - **hard delay**

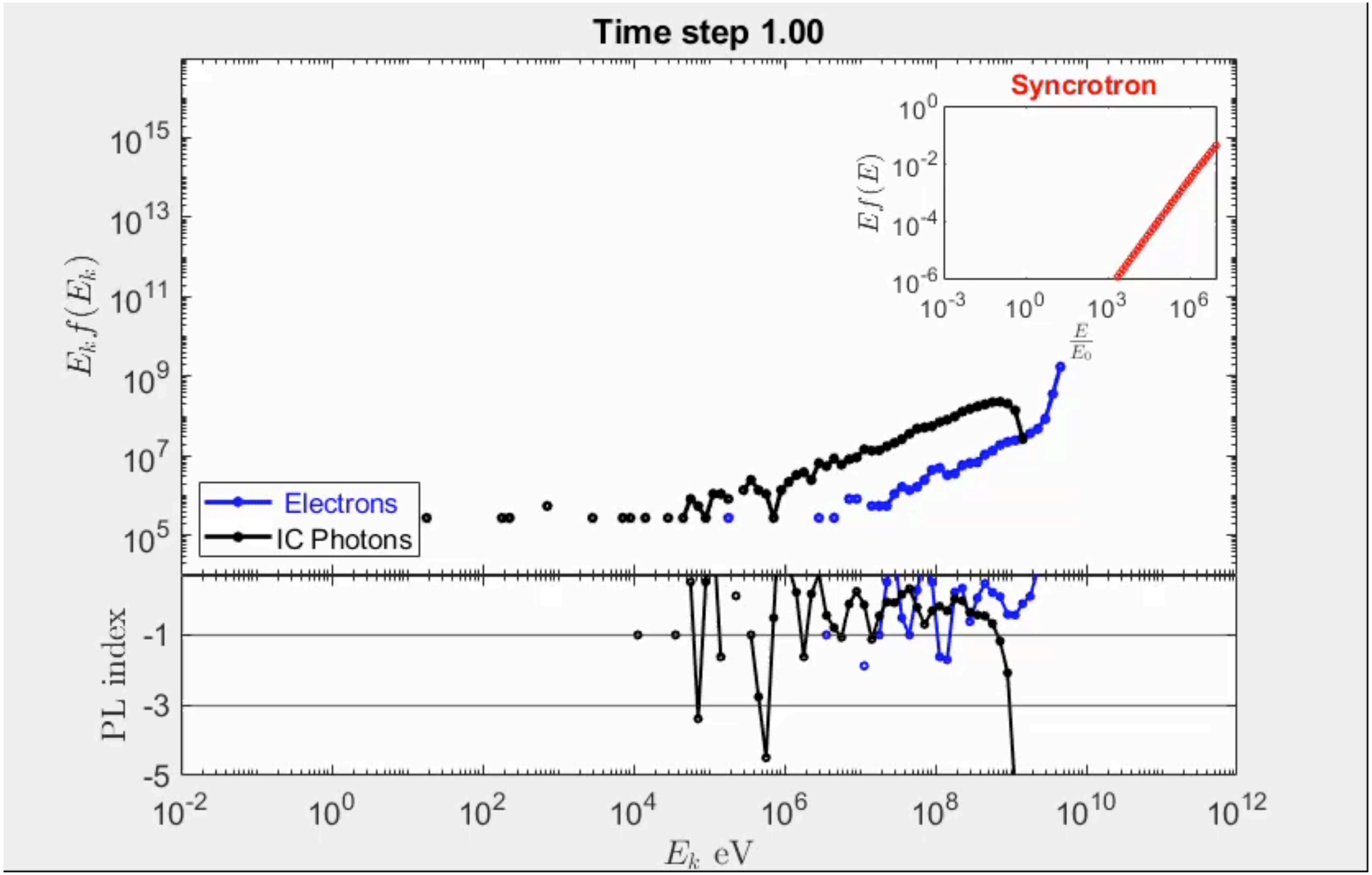




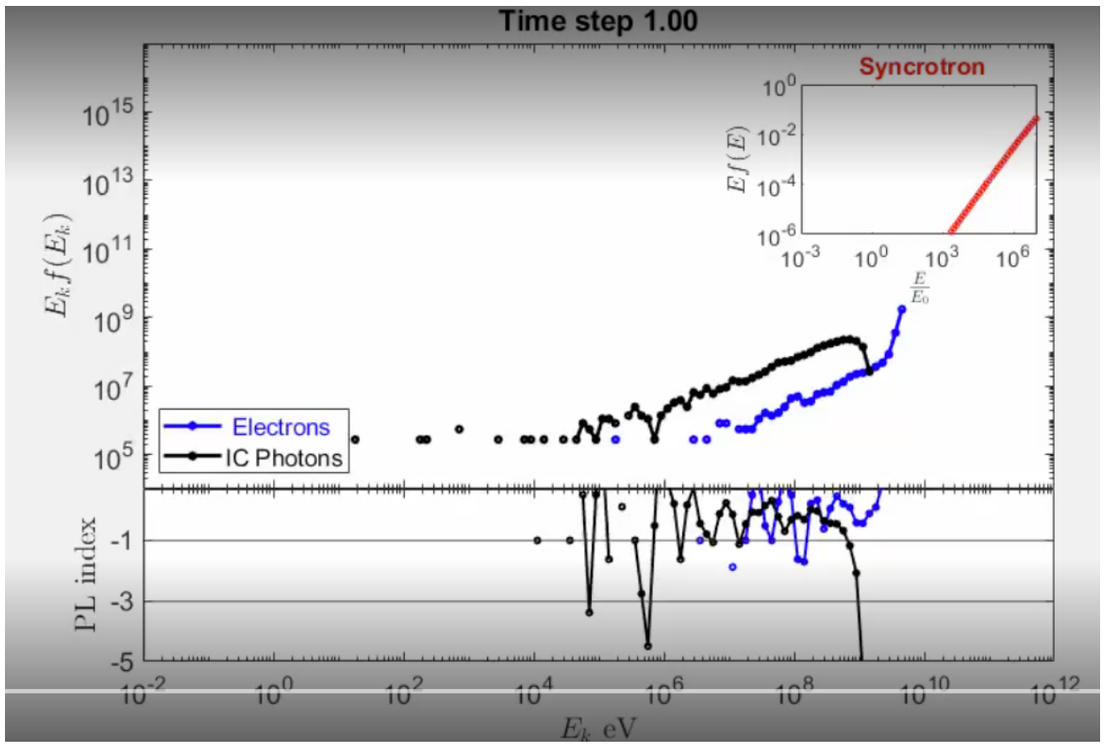
Radio Synchrotron delay time increases with energy

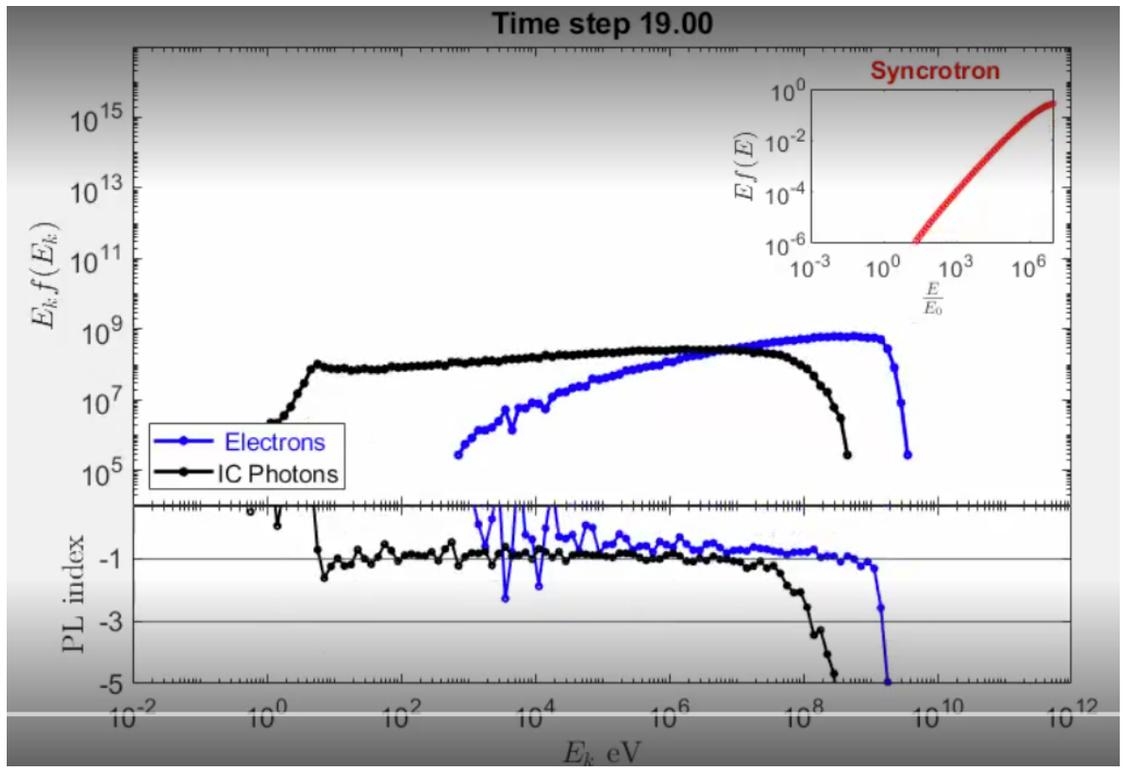
A time resolved cascade (reconnection) event

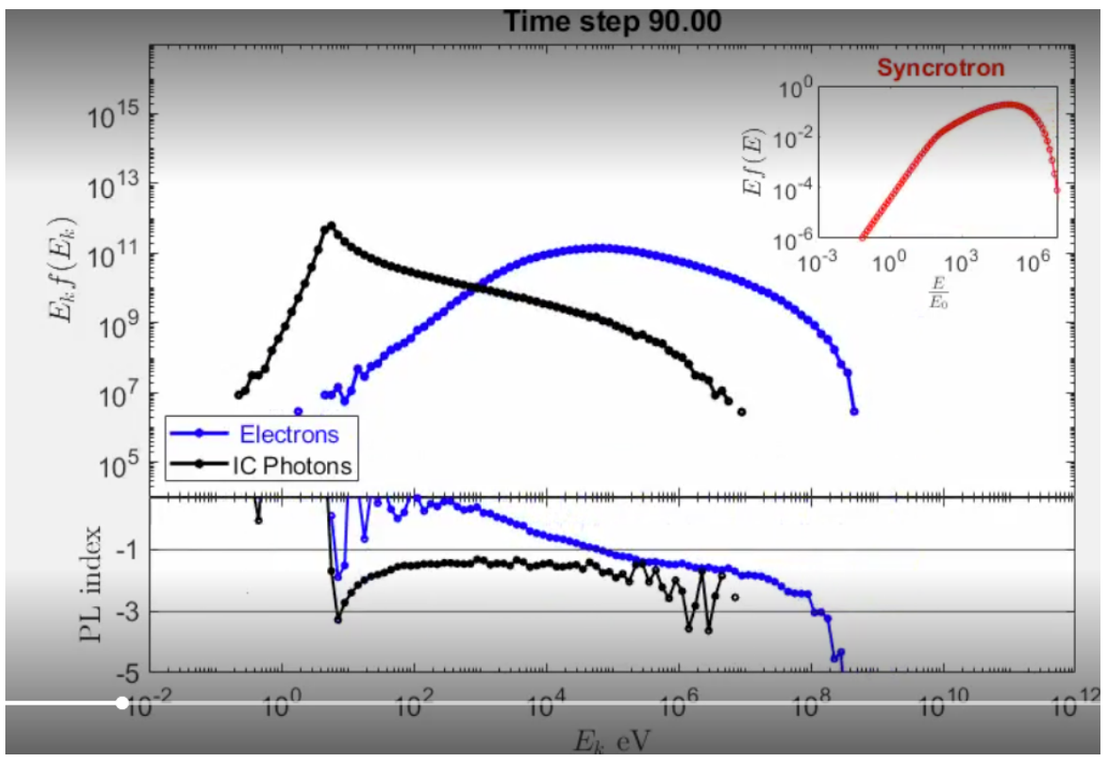
P (collisions)= 0.1

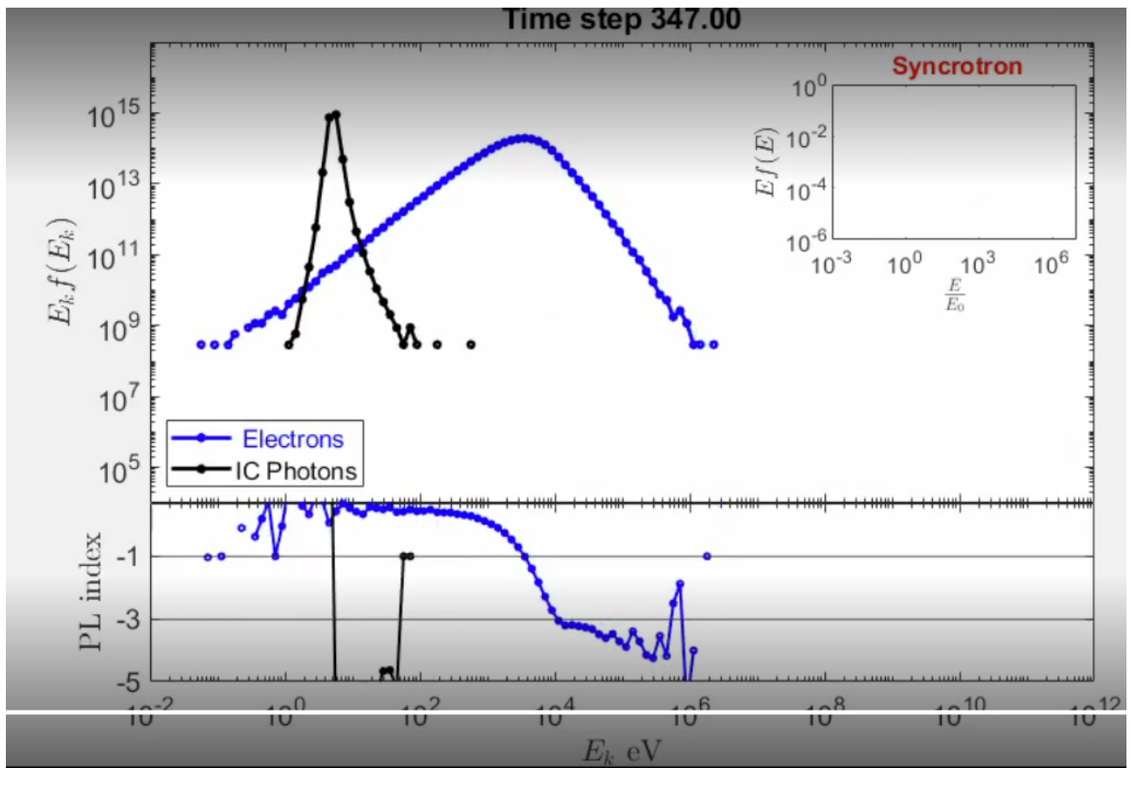


A time resolved cascade event

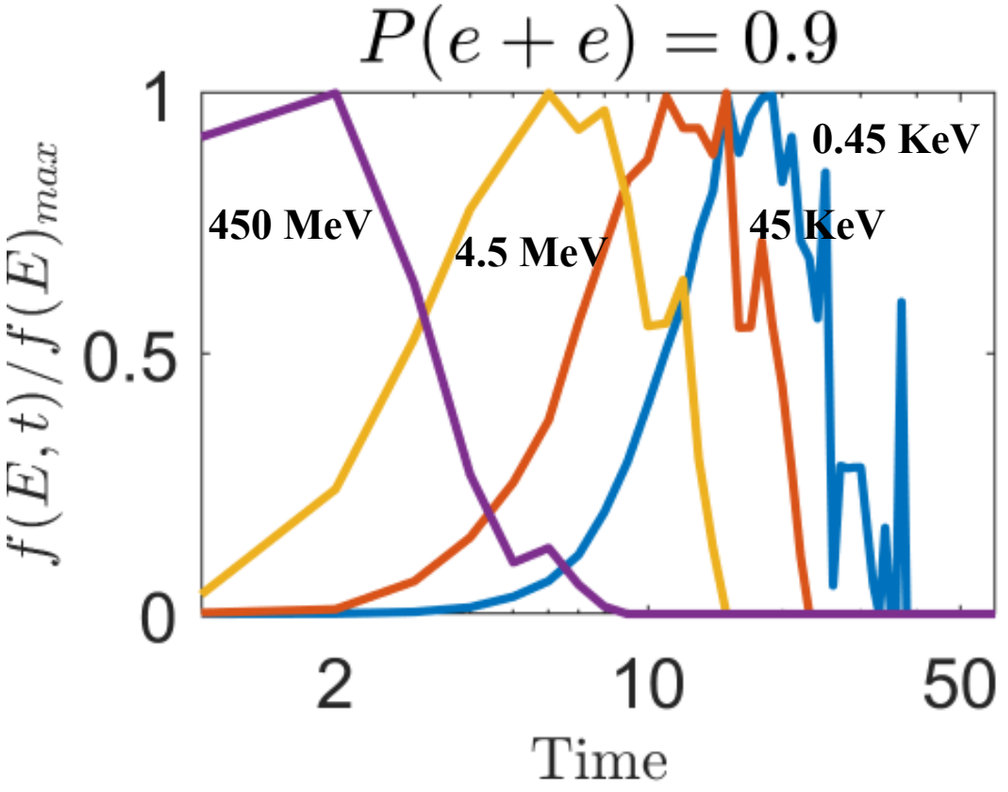


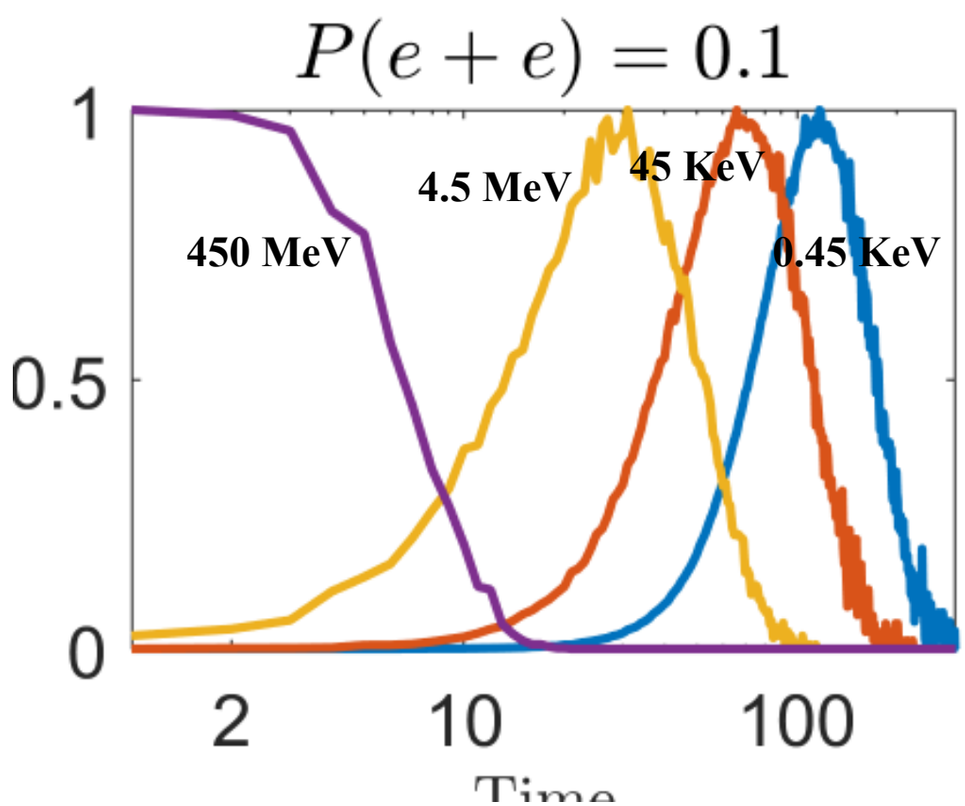




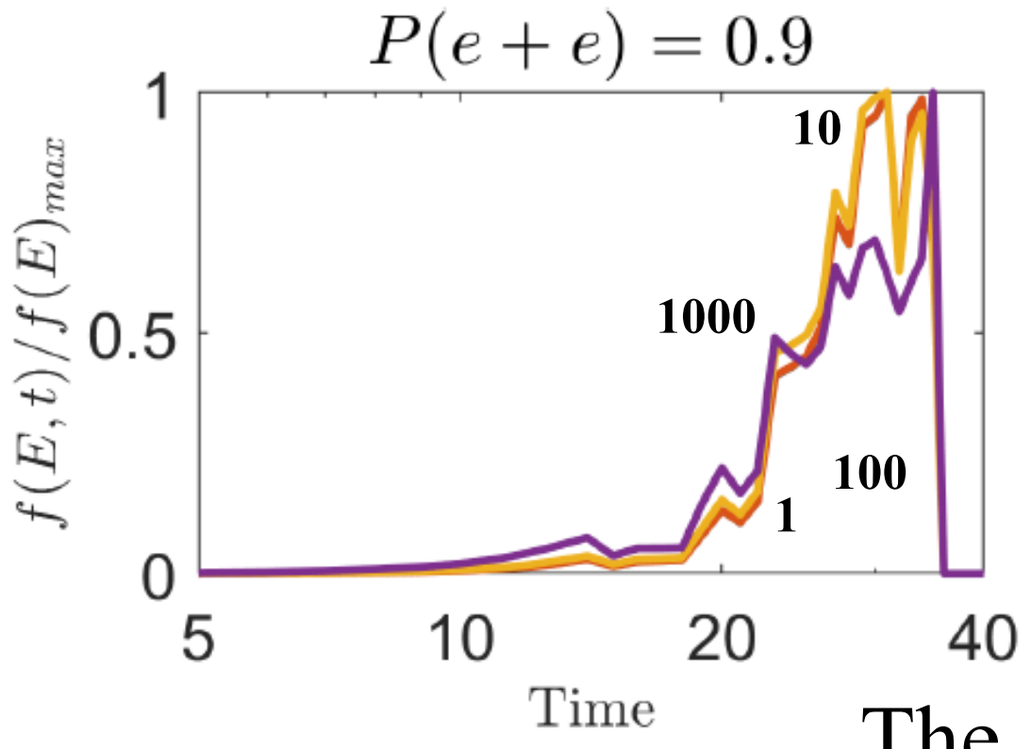


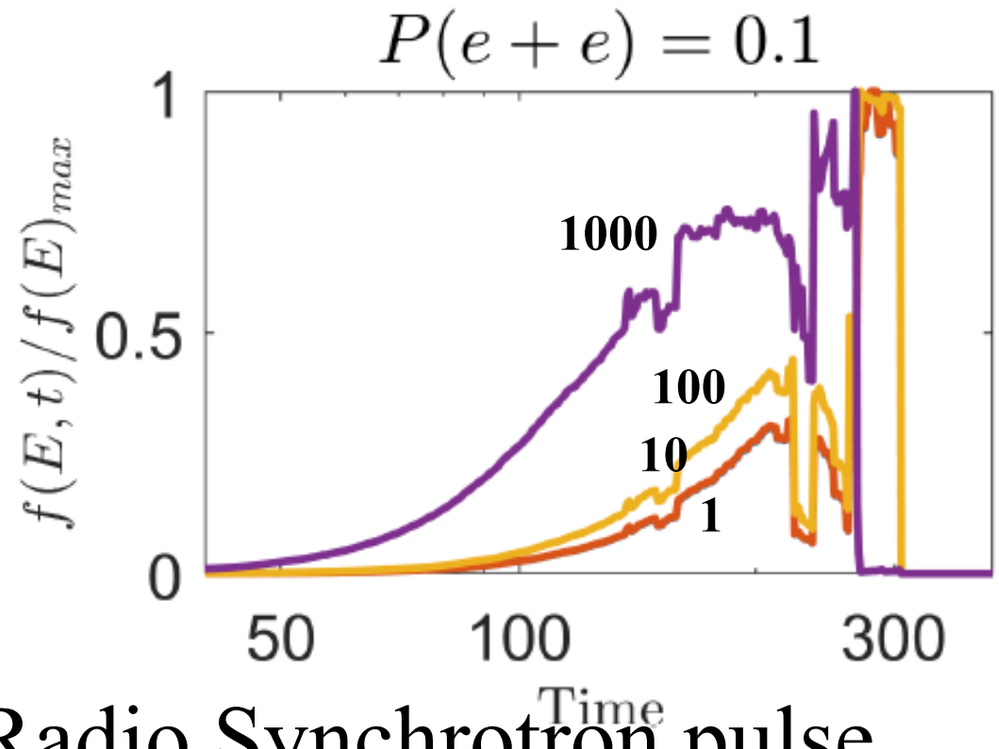
A time resolved cascade event - light curves





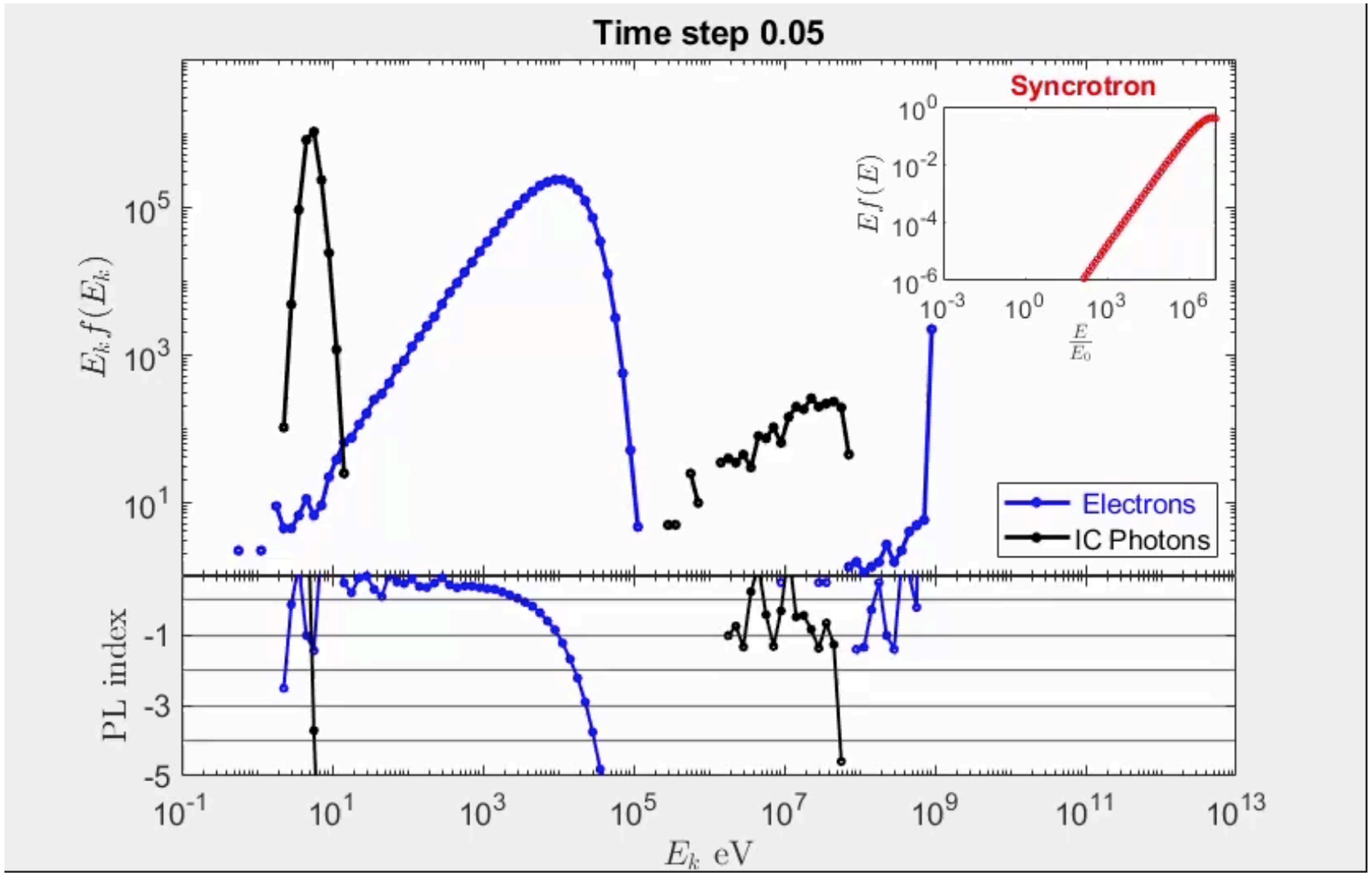
X-ray IC delay time decreases with energy - **soft delay**

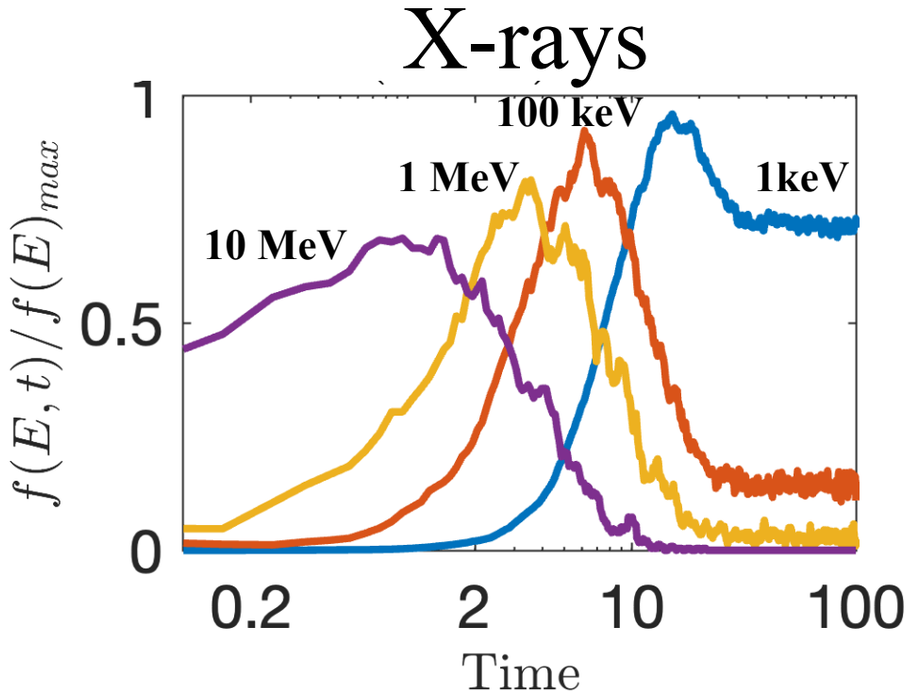




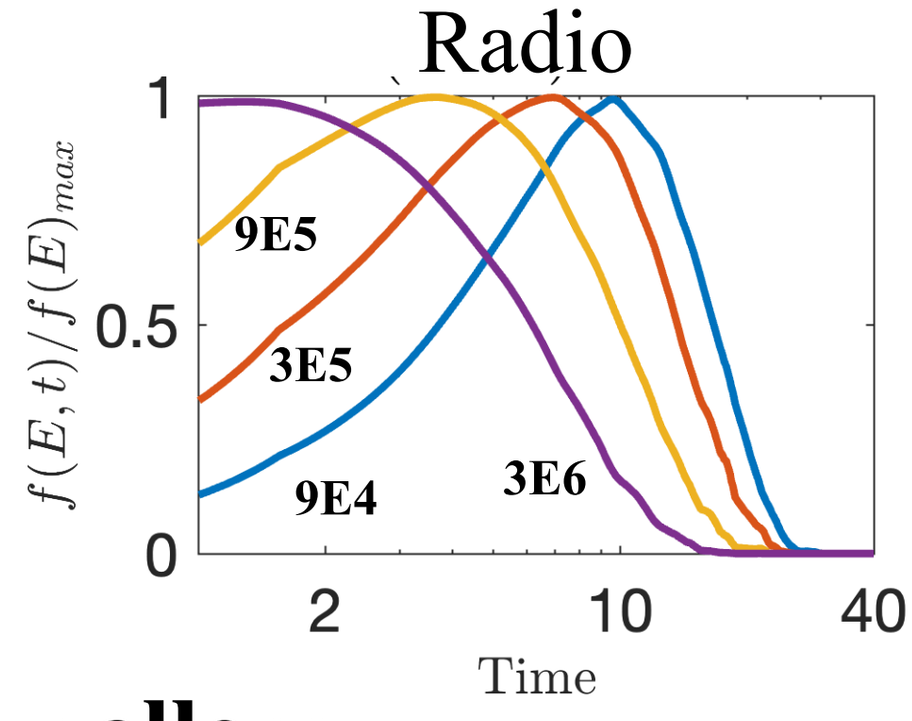
The Radio Synchrotron pulse

A coronal heating event





Is there a Neupert effect? $L_R = \frac{dLx}{dt}$



Radio (mm) + X-ray monitoring may allow to understand the physics of AGN coronae