Ellipticity of nonlinear Compton spectrum in linearly polarised background

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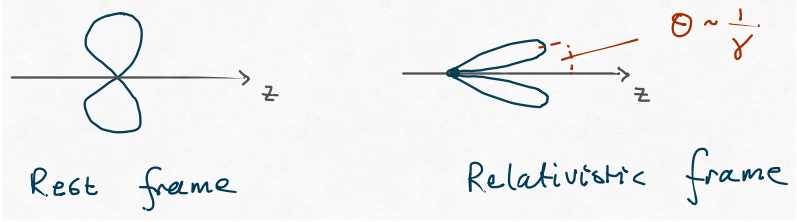
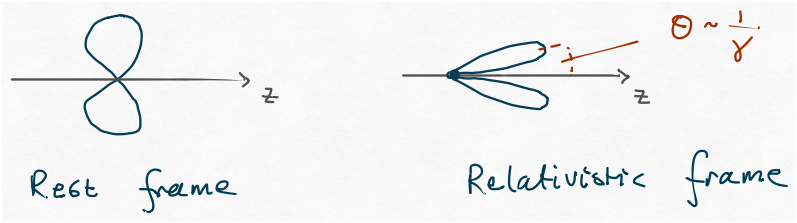
LUXE simulation meeting

31-8-21



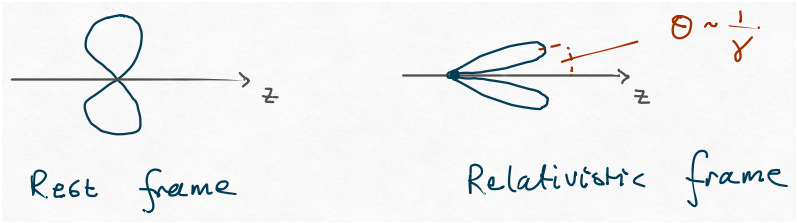
- For relativistic charges, '$1/\gamma$' emission cone



- For relativistic charges, '$1/\gamma$' emission cone

- Electron's classical momentum in a plane wave:

$$\pi^{\mu}_{\text{cl.}} = \underbrace{p^{\mu}}_{\text{initial}} - \underbrace{a^{\mu}}_{\text{field}} + \underbrace{\varkappa^{\mu}\left(\frac{p\cdot a}{\varkappa\cdot p} - \frac{a^2}{2\,\varkappa\cdot p}\right)}_{\text{longitudinal (to field)}}$$



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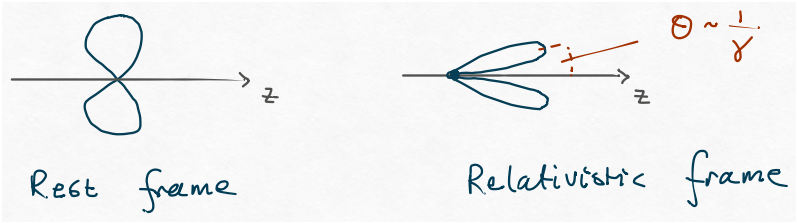
- If a^{μ} linearly polarised in e.g. x-direction, $\pi^{x}/\pi^{\parallel} \sim \xi/\gamma$



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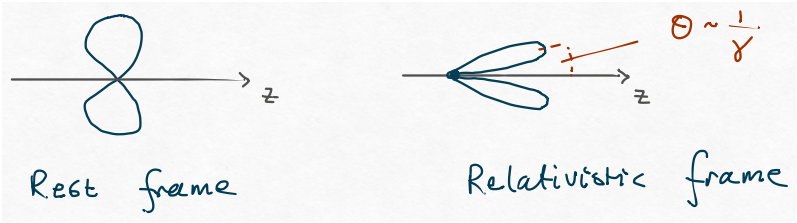
$\Rightarrow$ For photon spectrum:

$$\frac{k_x}{k_y} \sim \xi$$



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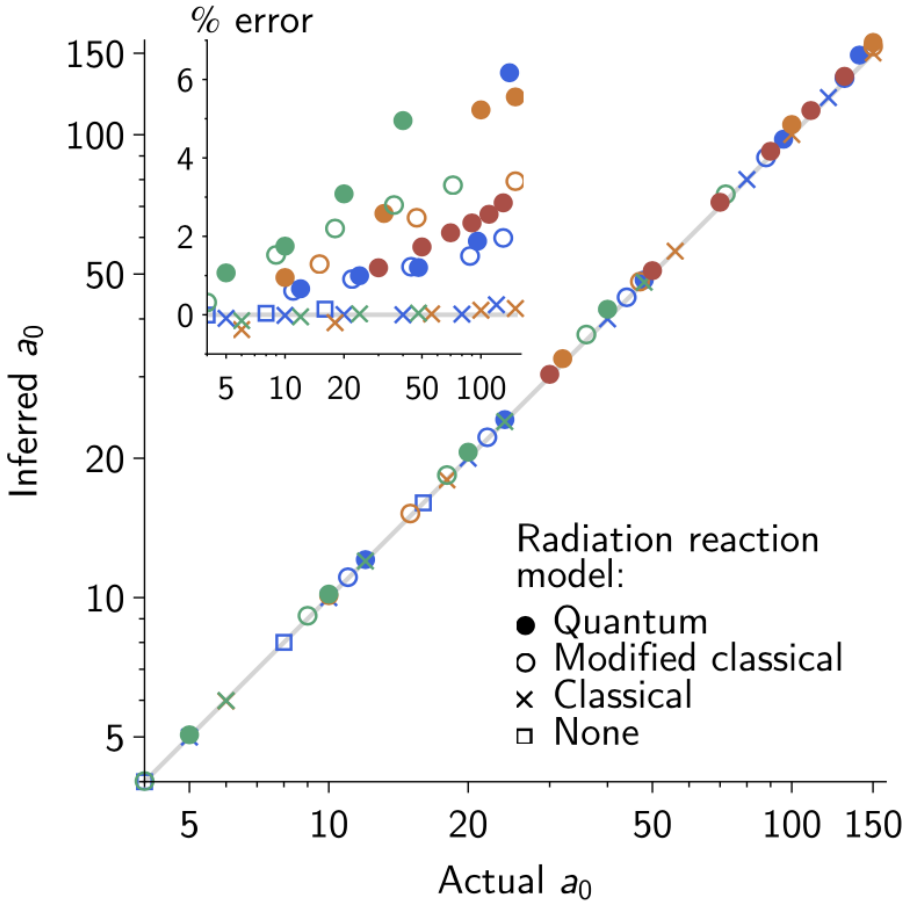
$\Rightarrow$ For photon spectrum:

$$\frac{k_x}{k_y} \sim \xi$$

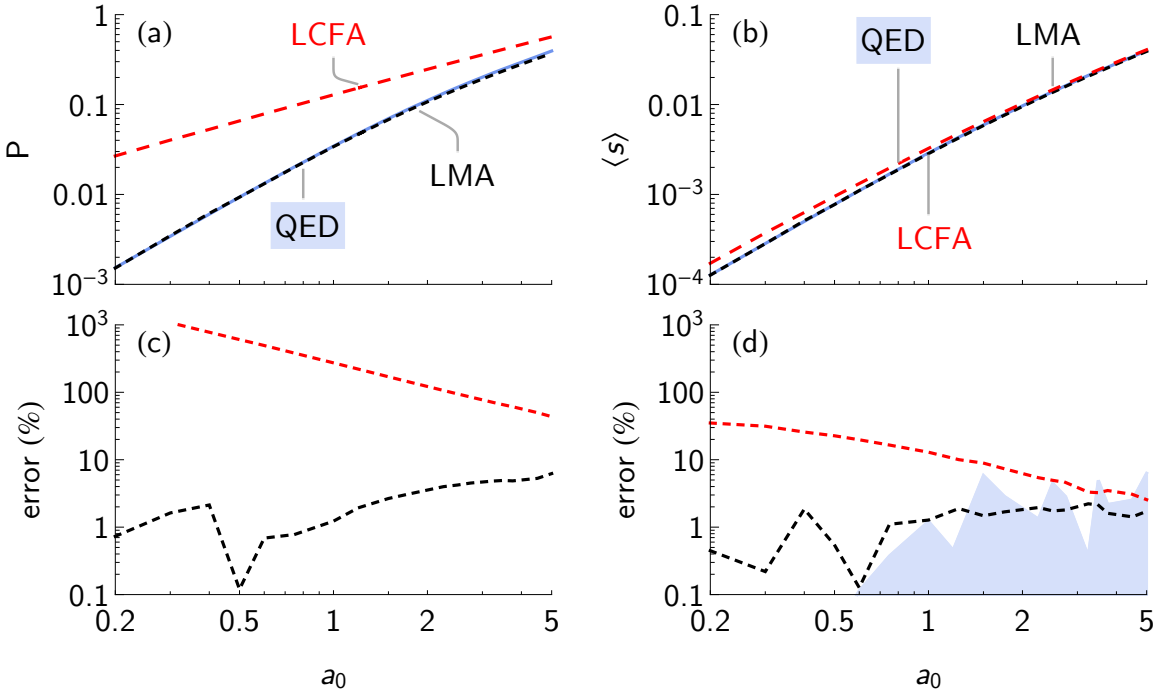
- Can add radiation reaction ($\alpha\eta\xi^2\Phi \not\ll 1$)

O Har-Shemesh, A Di Piazza, Optics Lett. **37**, 1352-1354 (2012)
T. G. Blackburn et al. PRAB **23**, 064001 (2020)



T. G. Blackburn et al. PRAB **23**, 064001 (2020)

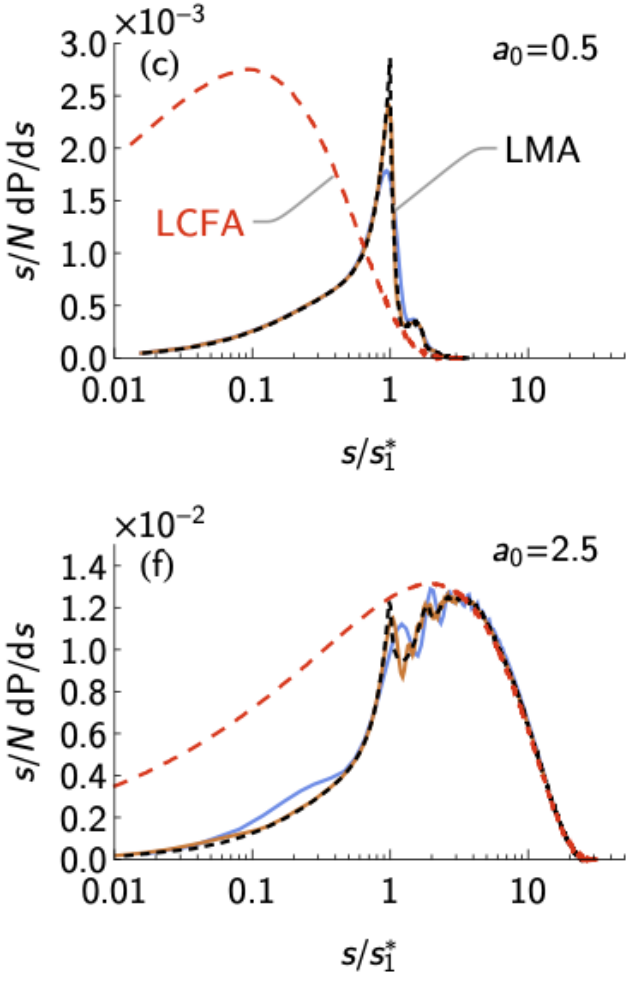
What about $\xi < 5$ region?



T. G. Blackburn, A. J. Macleod, B. King, 2103.06673 [hep-ph]

- QED and LMA exist to benchmark with (but slow)
- Simulation with LMA will take several months to implement
- LCFA can be provided in simulation

$\Rightarrow$ Use LCFA in regions where a good approximation.



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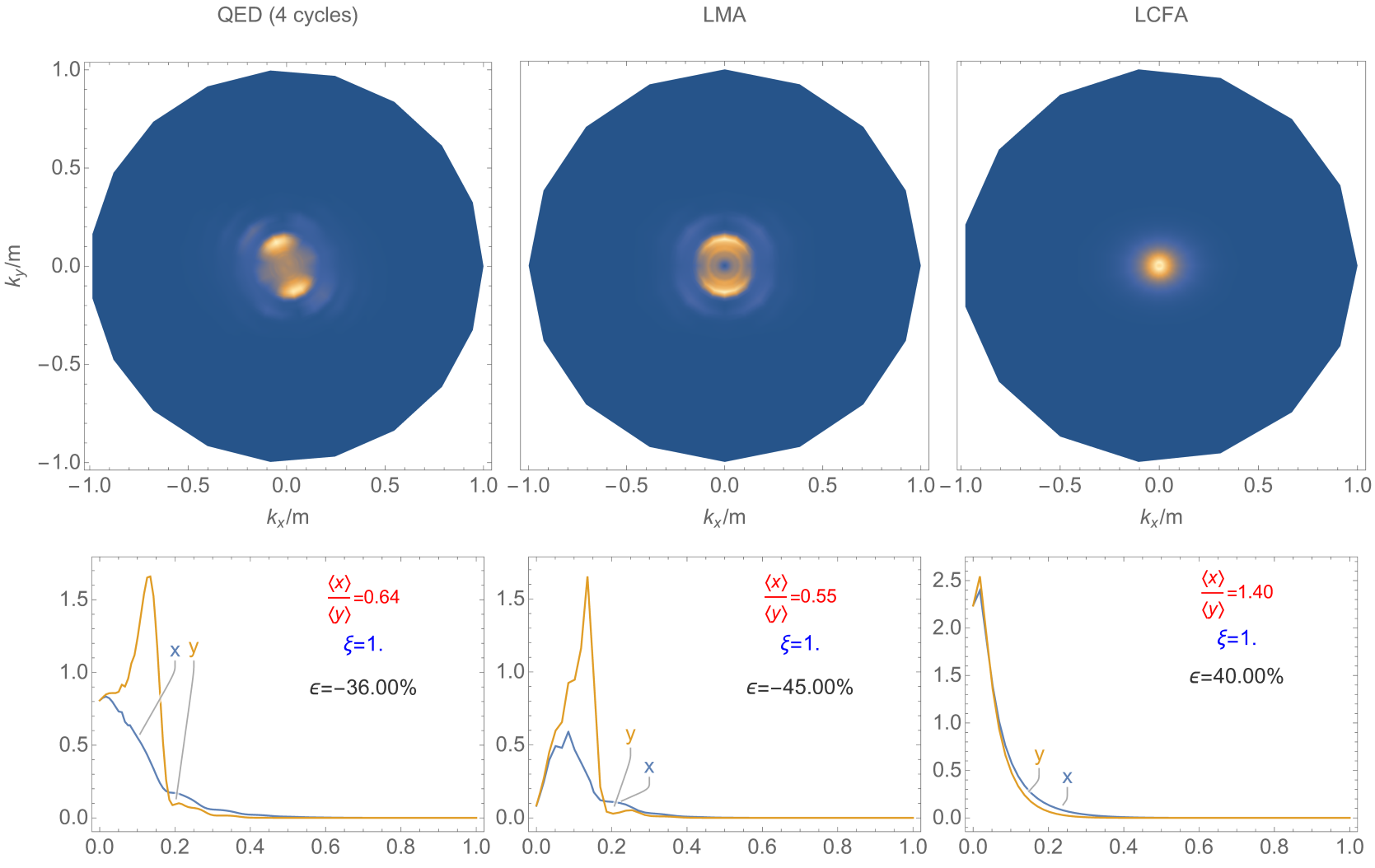
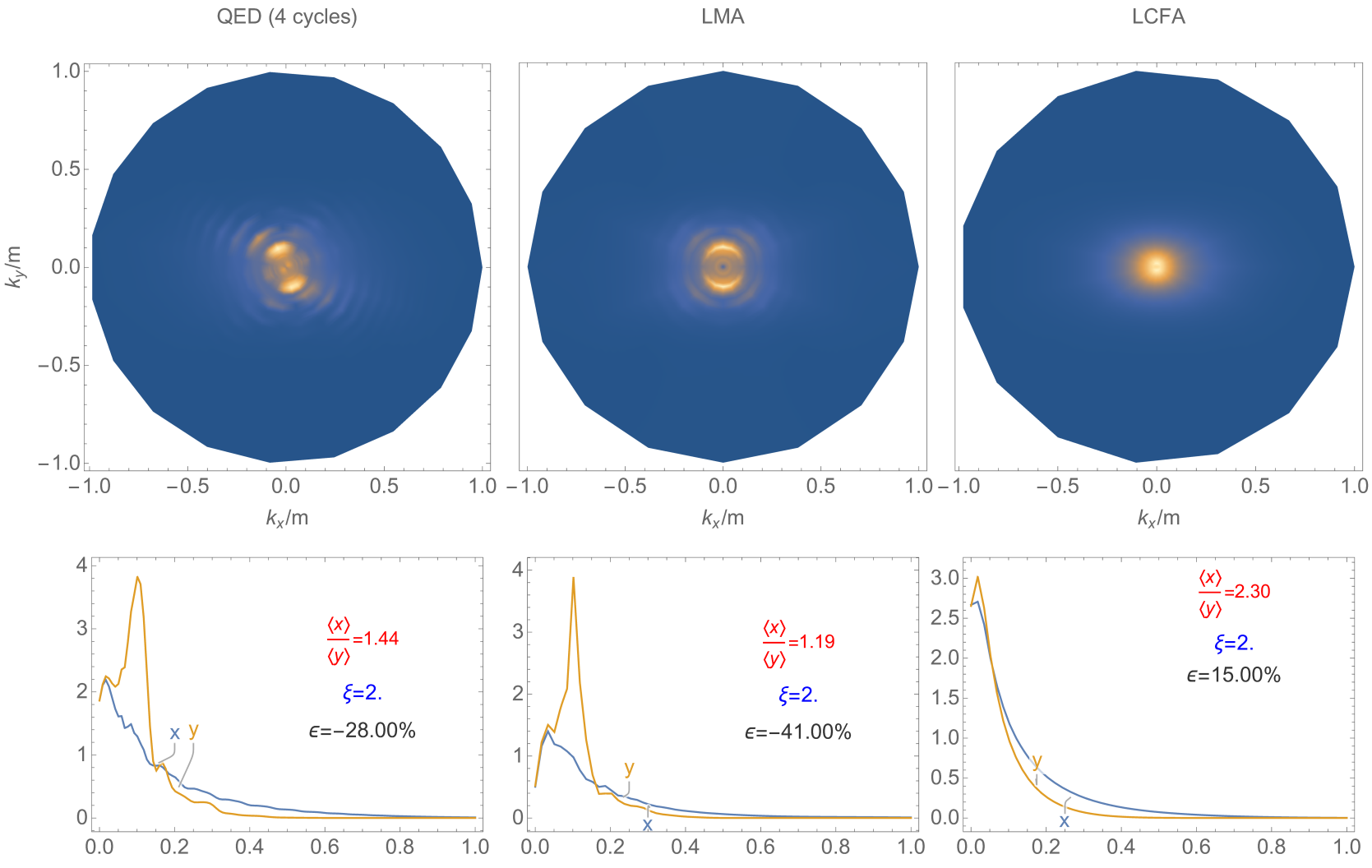
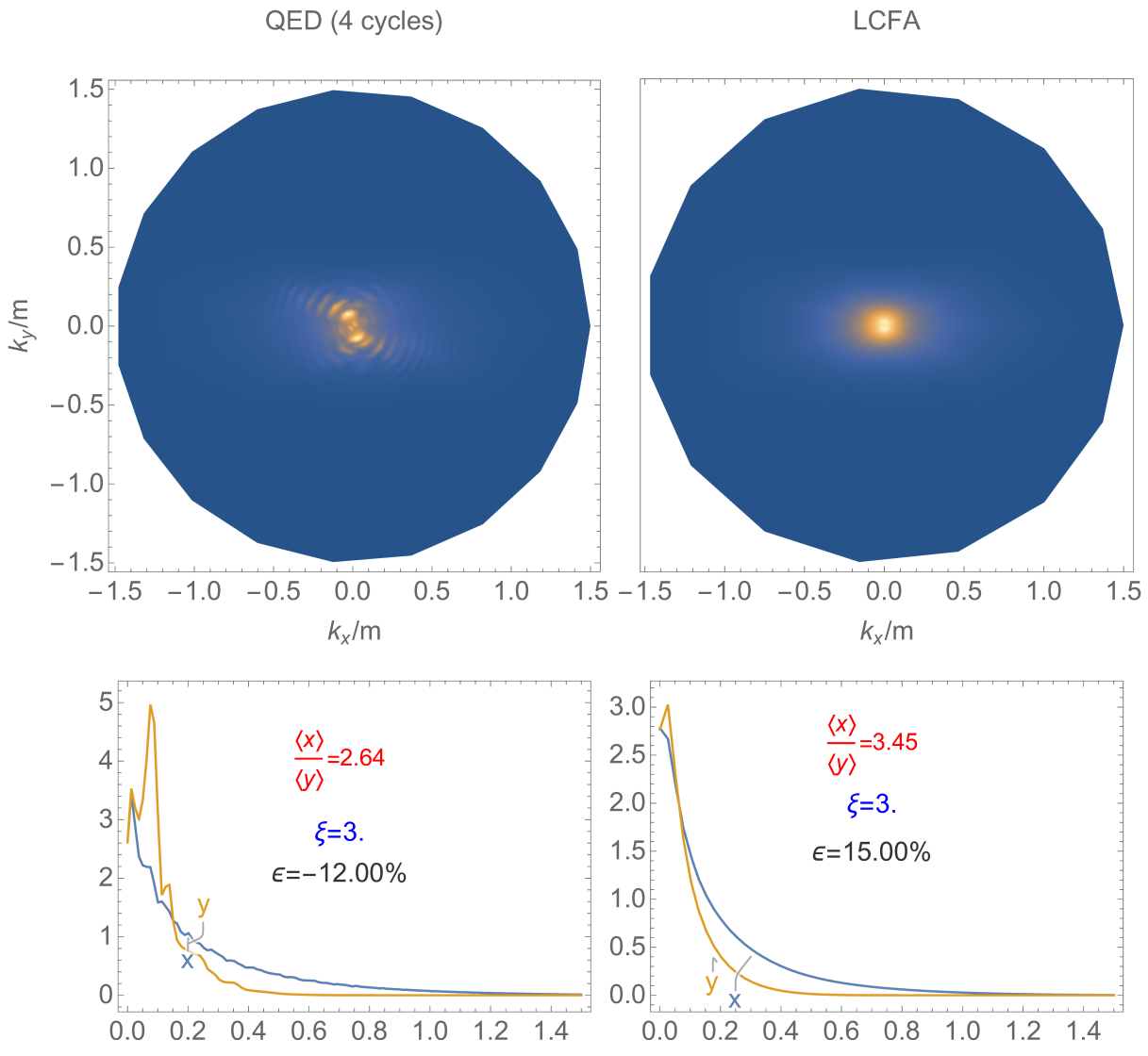
$\xi = 1$:


QED (4 cycles)
LMA
LCFA
k_y/m
k_x/m
$\frac{\langle x \rangle}{\langle y \rangle}$=0.64
ξ=1.
ϵ=−36.00%
$\frac{\langle x \rangle}{\langle y \rangle}$=0.55
ξ=1.
ϵ=−45.00%
$\frac{\langle x \rangle}{\langle y \rangle}$=1.40
ξ=1.
ϵ=40.00%
x
y

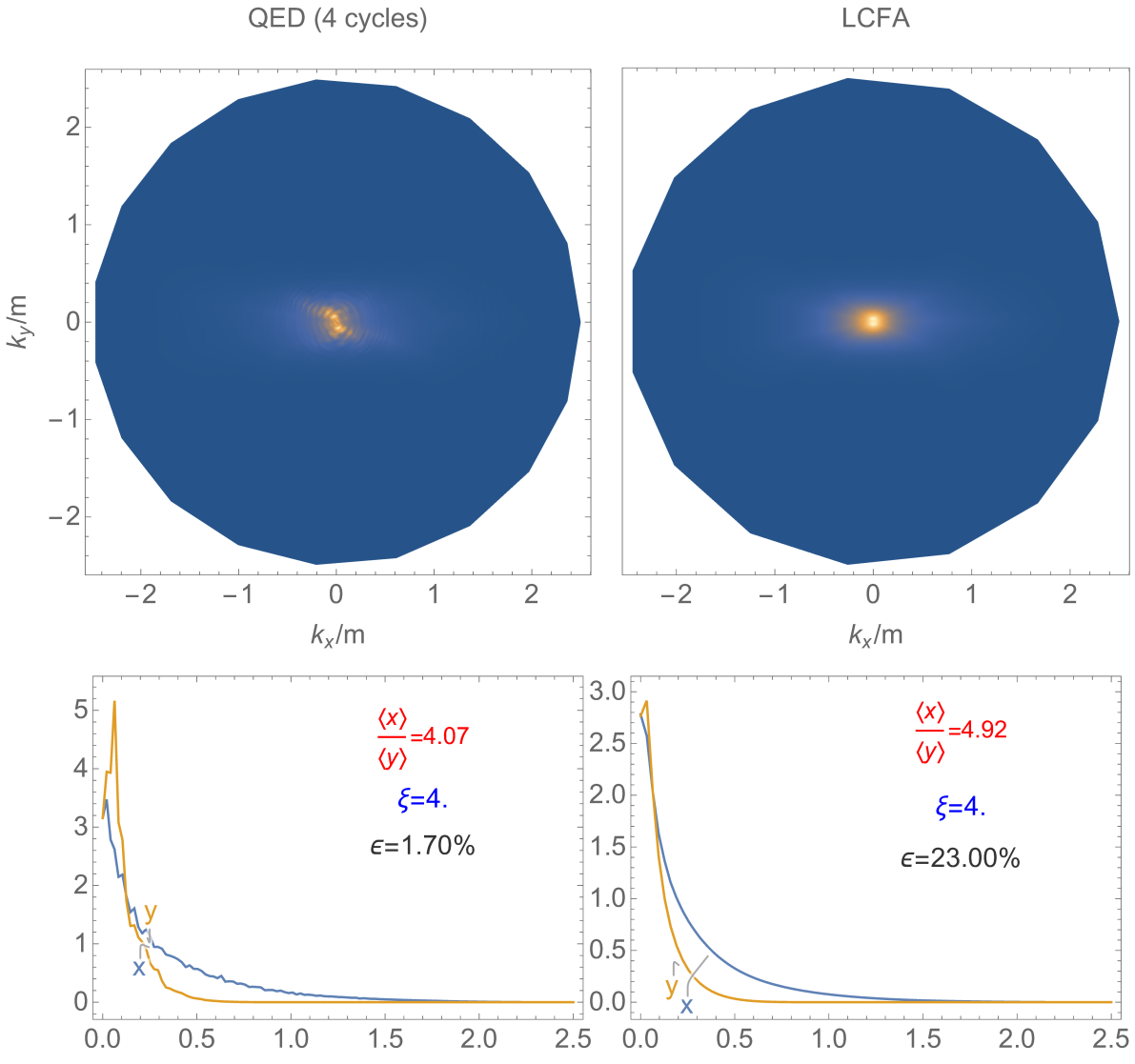
$\xi = 2$:


QED (4 cycles)
LMA
LCFA
k_y/m
k_x/m
$\frac{\langle x \rangle}{\langle y \rangle}$=1.44
ξ=2.
ϵ=−28.00%
$\frac{\langle x \rangle}{\langle y \rangle}$=1.19
ξ=2.
ϵ=−41.00%
$\frac{\langle x \rangle}{\langle y \rangle}$=2.30
ξ=2.
ϵ=15.00%
x
y

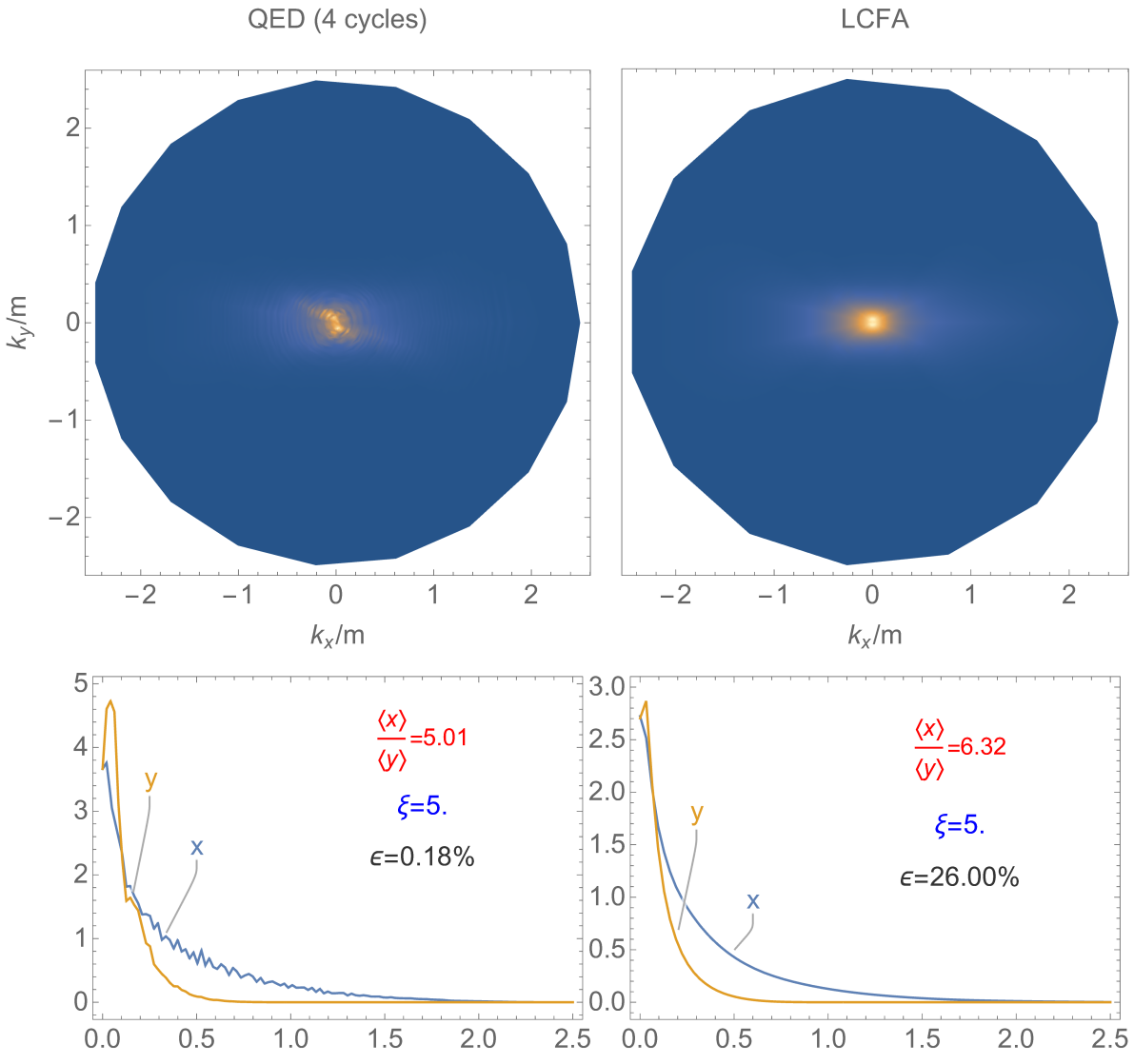
$\xi = 3$:

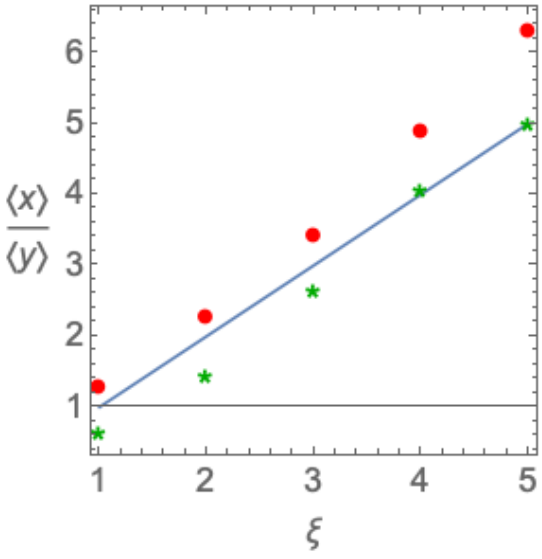

QED (4 cycles)
LCFA
k_y/m
k_x/m
k_x/m
$\frac{\langle x \rangle}{\langle y \rangle}$=2.64
ξ=3.
ϵ=−12.00%
y
x
$\frac{\langle x \rangle}{\langle y \rangle}$=3.45
ξ=3.
ϵ=15.00%
y
x

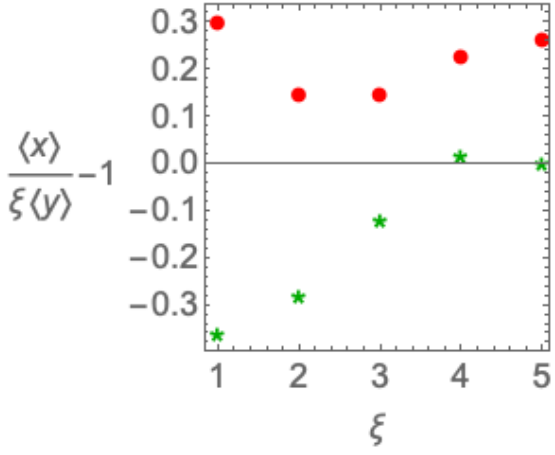
$\xi = 4$:


QED (4 cycles)
LCFA
k_y/m
k_x/m
k_x/m
$\frac{\langle x \rangle}{\langle y \rangle}$=4.07
ξ=4.
ϵ=1.70%
$\frac{\langle x \rangle}{\langle y \rangle}$=4.92
ξ=4.
ϵ=23.00%
y
x
y
x

$\xi = 5$:


QED (4 cycles)
LCFA
k_y/m
k_x/m
k_x/m
$\frac{\langle x \rangle}{\langle y \rangle}$=5.01
ξ=5.
ϵ=0.18%
y
x
$\frac{\langle x \rangle}{\langle y \rangle}$=6.32
ξ=5.
ϵ=26.00%
y
x


⟨x⟩/⟨y⟩
6
5
4
3
2
1
1
2
3
4
5
ξ


⟨x⟩/(ξ⟨y⟩) − 1
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
1
2
3
4
5
ξ

What about $\xi < 5$ region?

- QED and LMA exist to benchmark with (but slow)
- Through benchmarking QED and LCFA for $\xi < 5$, can probably answer the question:

  For an accuracy of x%, we require $\xi \gtrsim y$.... what are x and y?

$\Rightarrow$ Use LCFA in regions where a good approximation.