QFEL

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Model equations

$$i\frac{\partial\Psi}{\partial\bar{z}} = -\frac{1}{2\bar{\rho}^{3/2}}\frac{\partial^2\Psi}{\partial\theta^2} - i(Ae^{i\theta} - A^*e^{-i\theta})\Psi$$ +transverse terms

$$\frac{\partial A}{\partial\bar{z}} + \frac{\partial A}{\partial z_1} = \int_0^{2\pi}\frac{d\theta}{2\pi}|\Psi|^2e^{-i\theta} + i\delta A$$ +transverse terms

Bonifacio, Piovella & Robb, NIMA 543 (2005),645
and Proceedings FEL Conference 2005

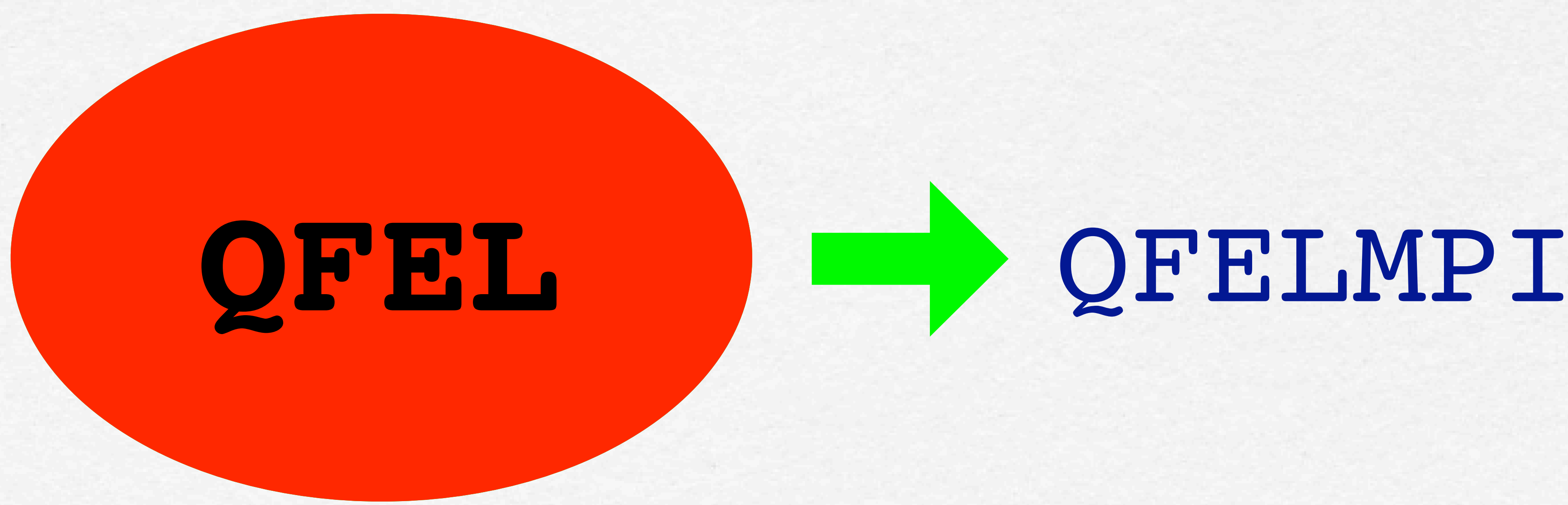
Expansion in discrete momentum states

$$\Psi(\theta, z_1, \bar{z}) = \frac{1}{\sqrt{2\pi}} \sum_{n=-\infty}^{\infty} c_n(z_1, \bar{z}) e^{in\theta}$$

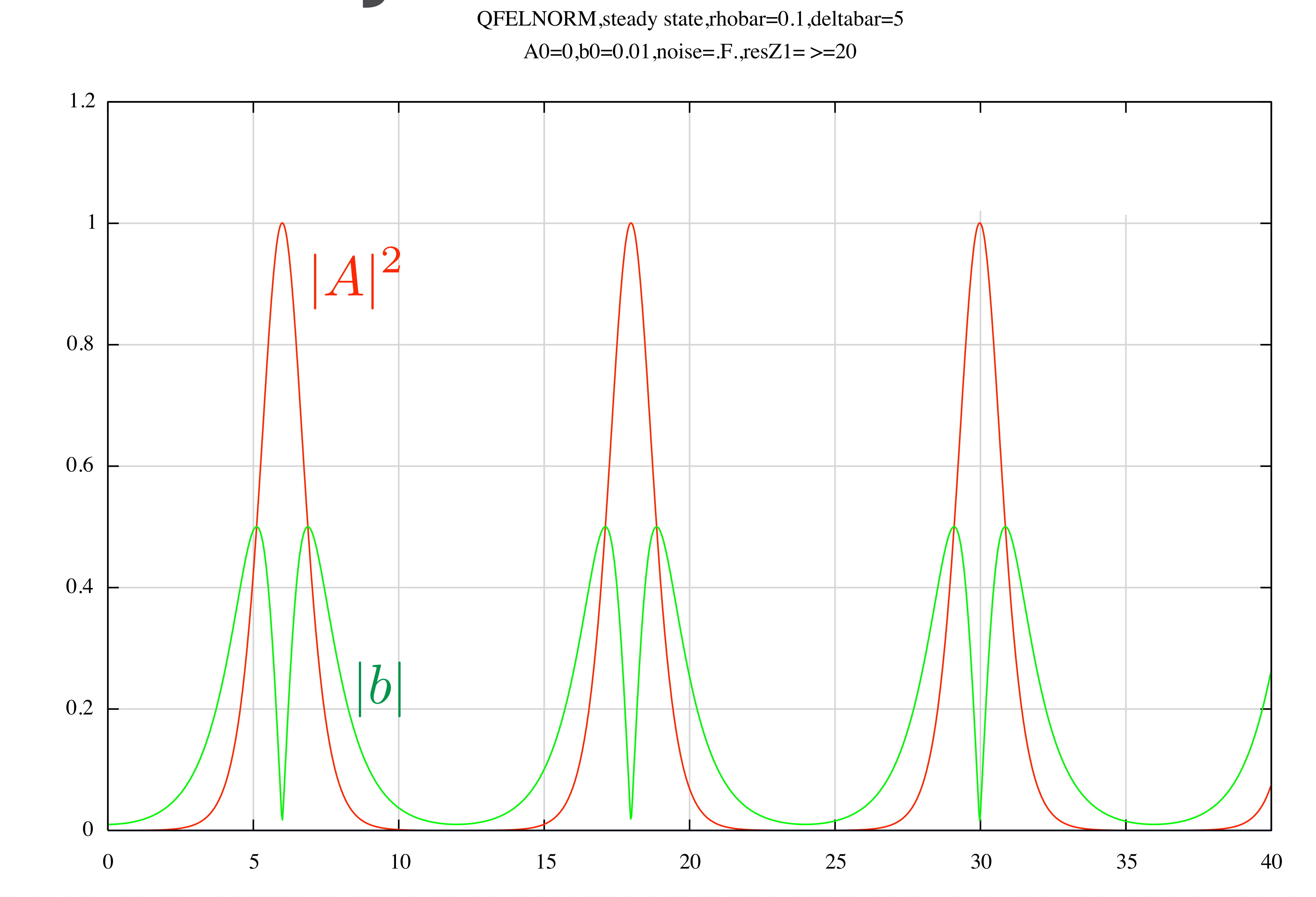
$$z_1 = \frac{z - vt}{L_c} \qquad \bar{z} = \frac{z}{L_g}$$

Code scheme

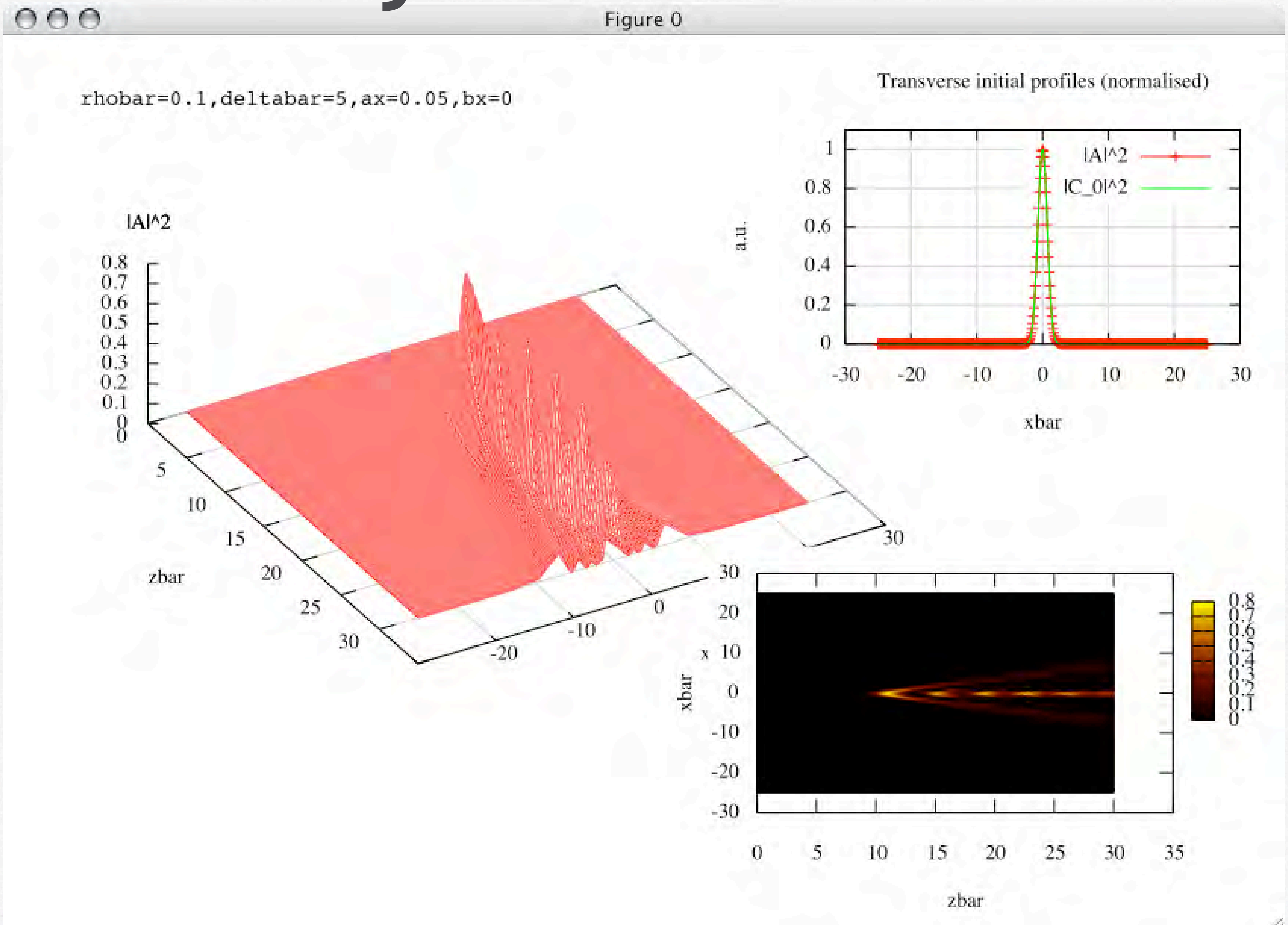
- FD explicit scheme in space
- Runge-Kutta method in time



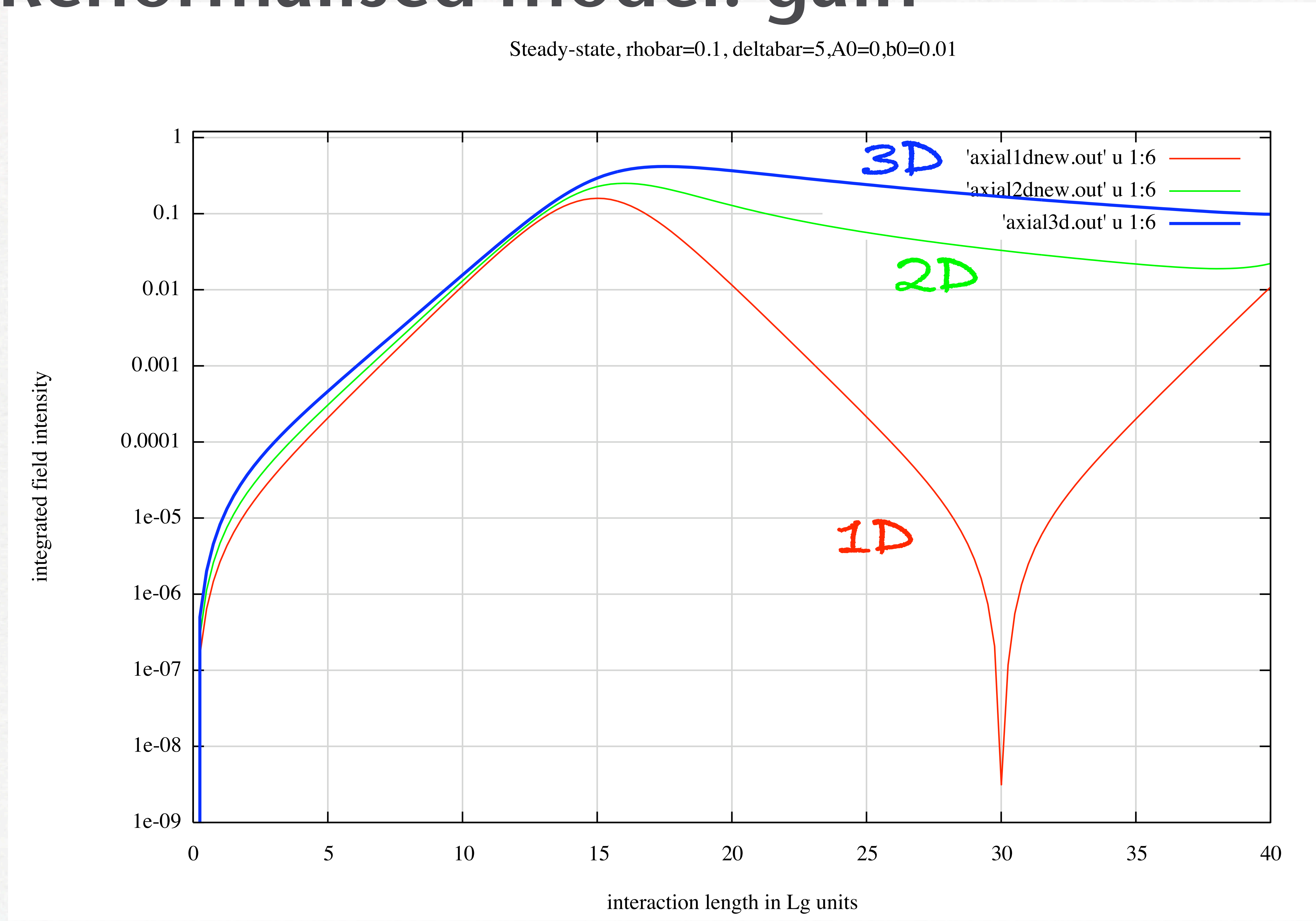
1D Steady state



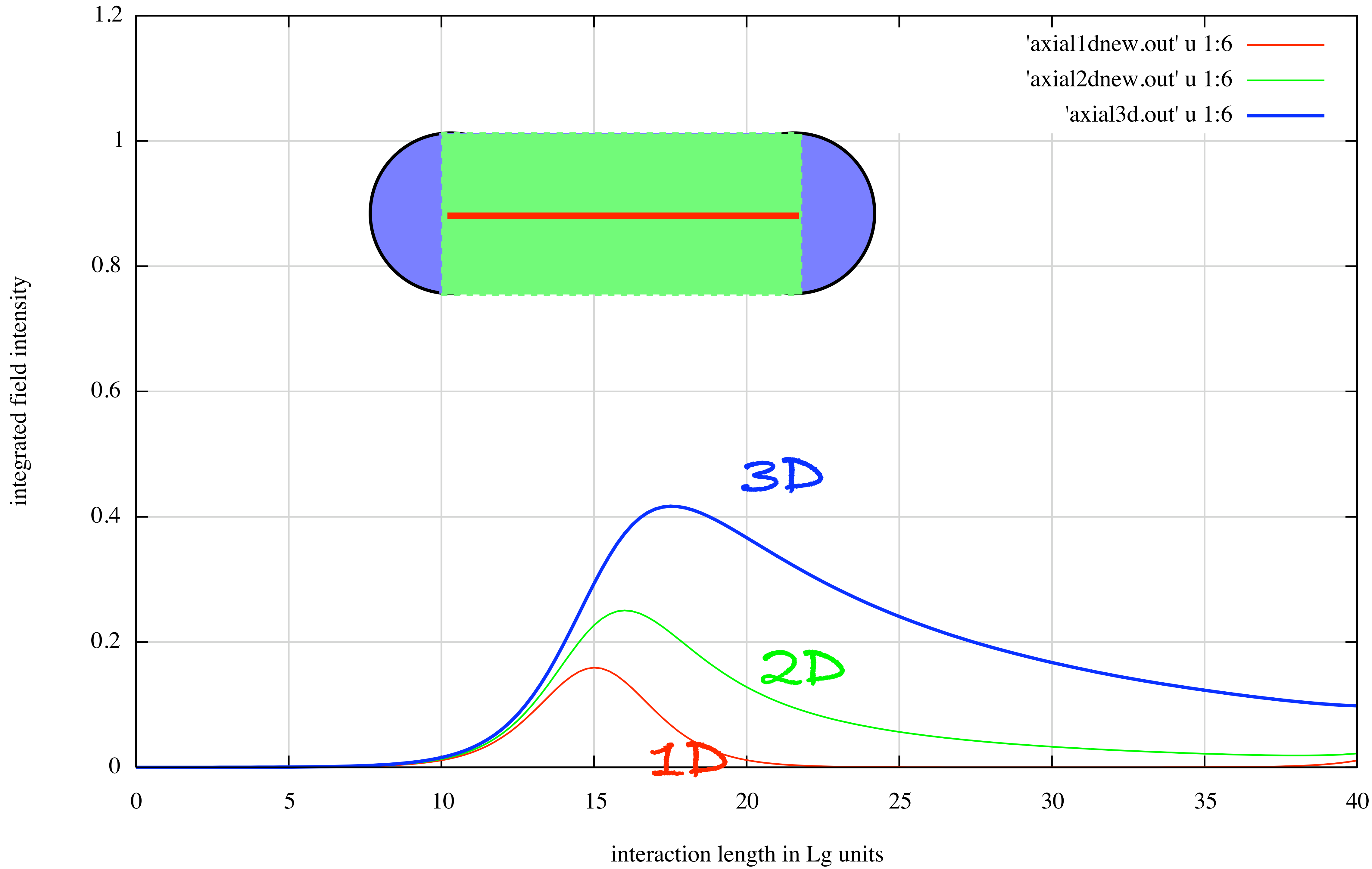
2D Steady state



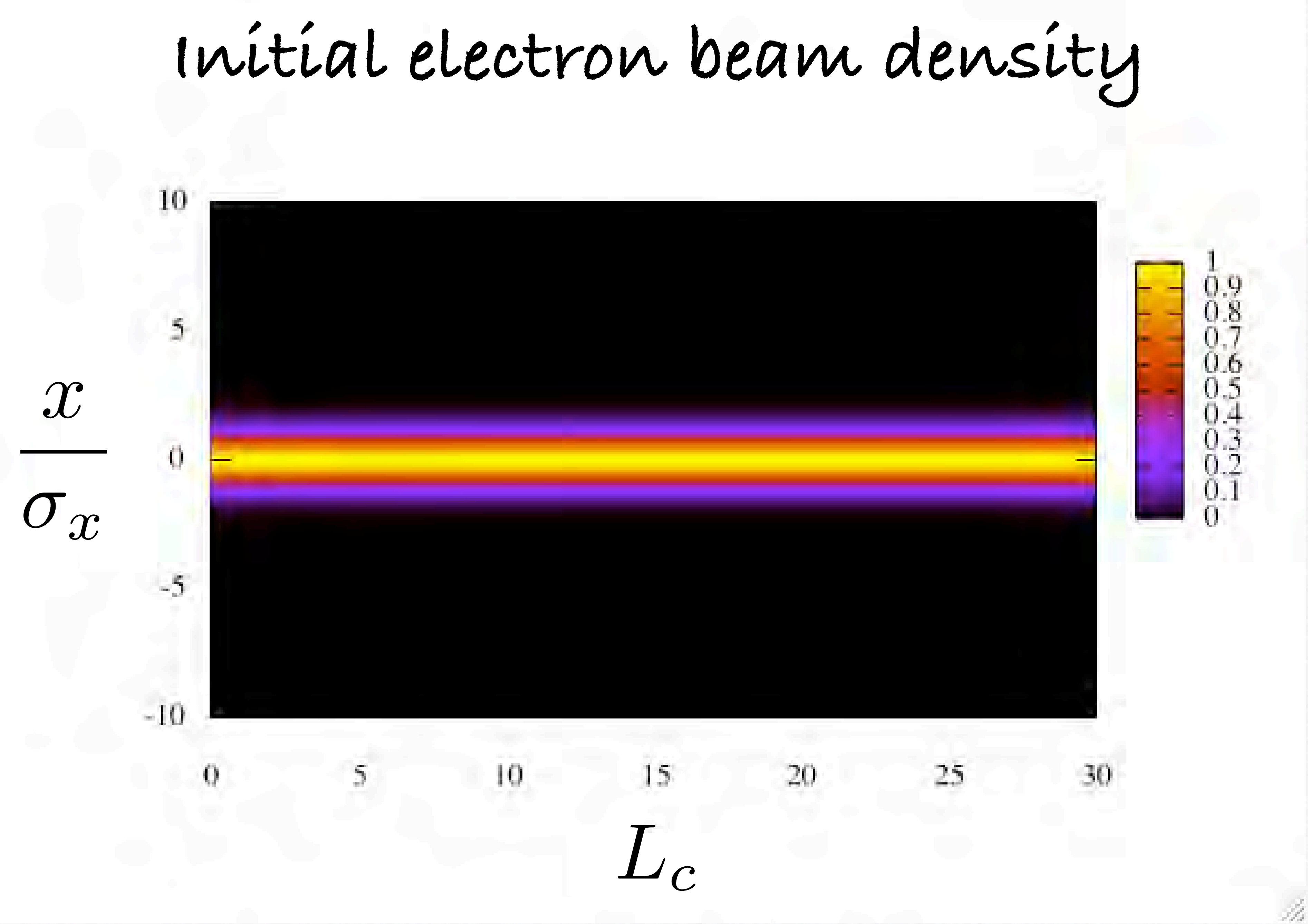
Renormalised model: gain



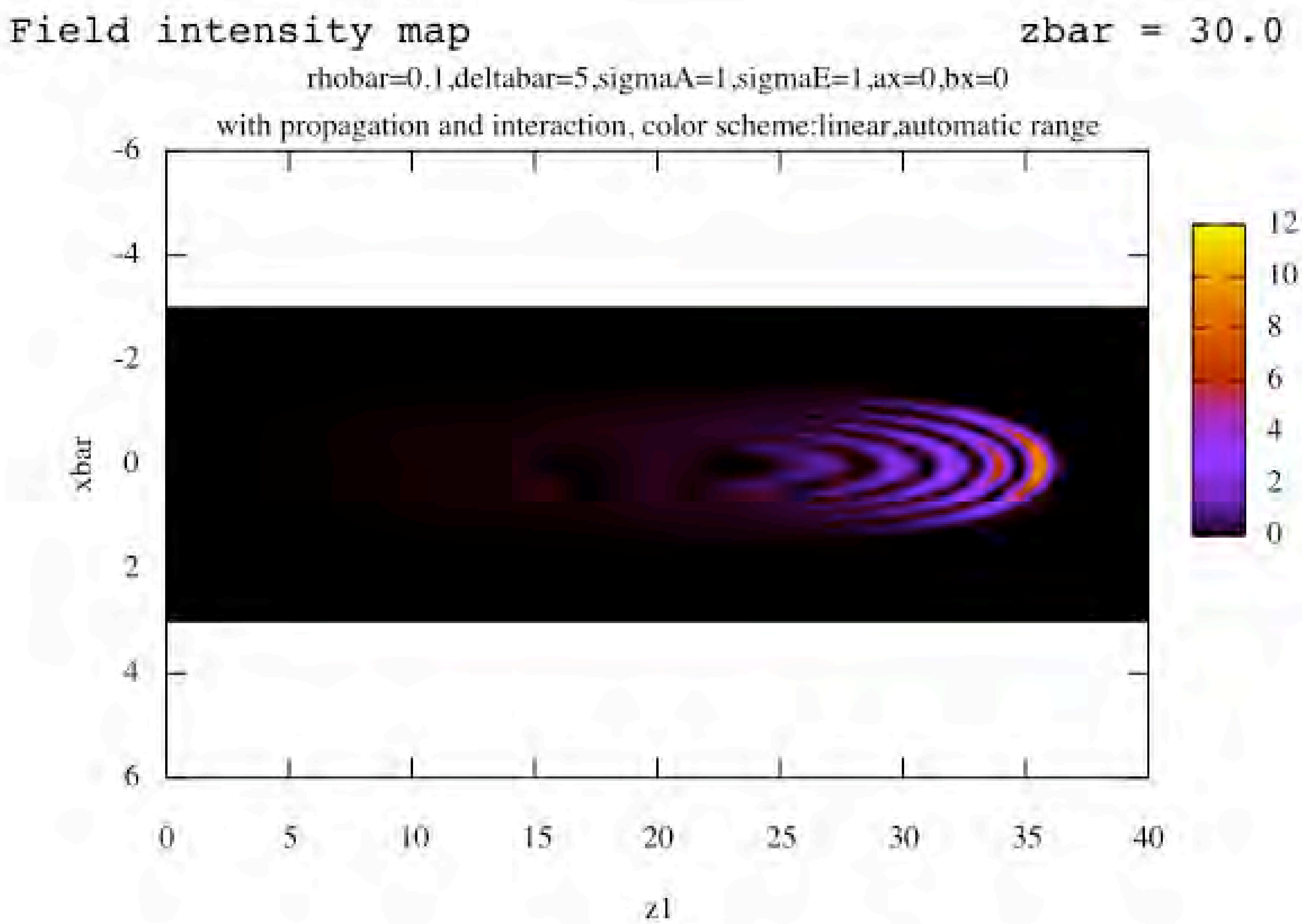
Renormalised model: saturation



Propagation in 2D

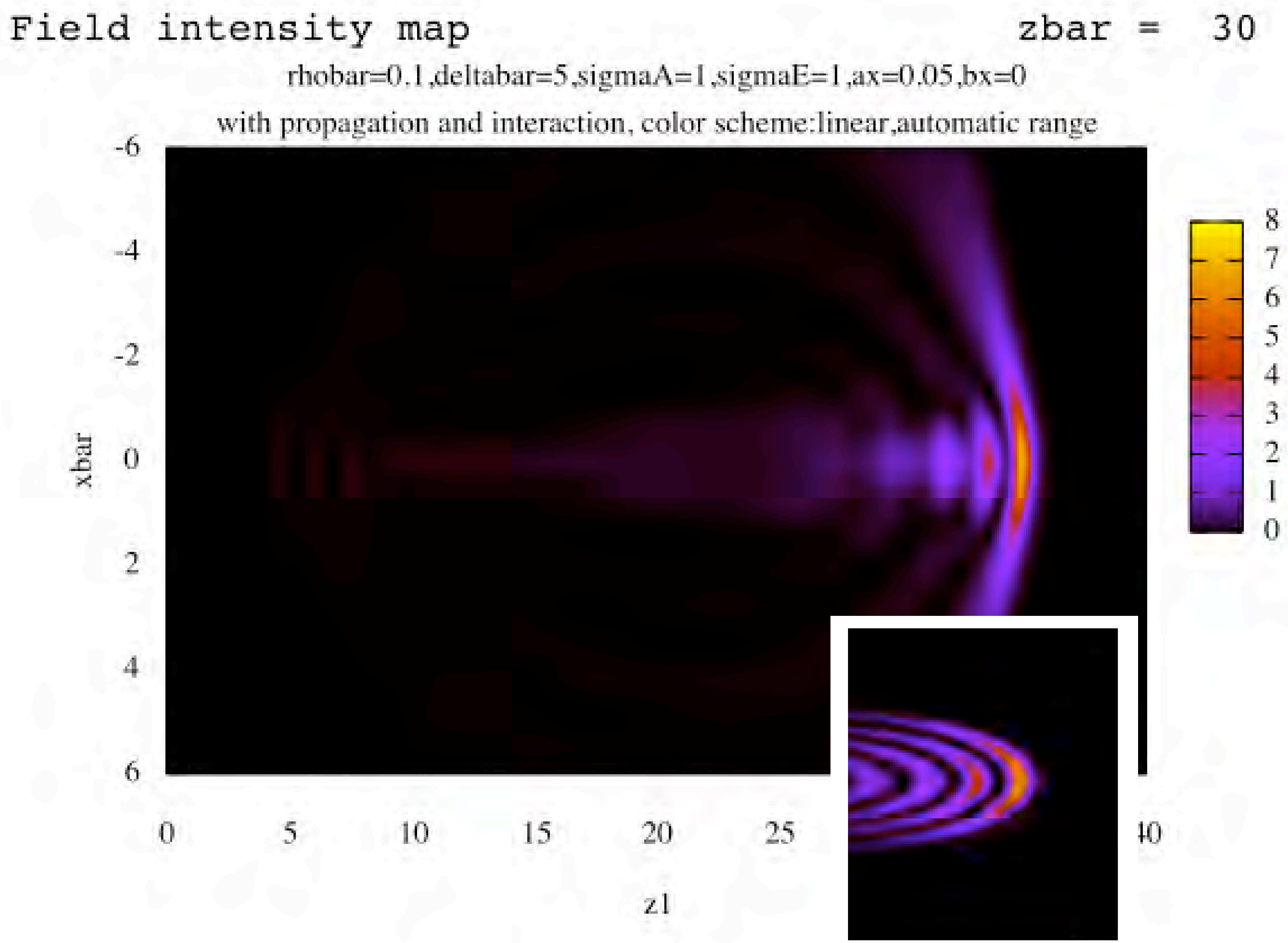


Seeded SRS

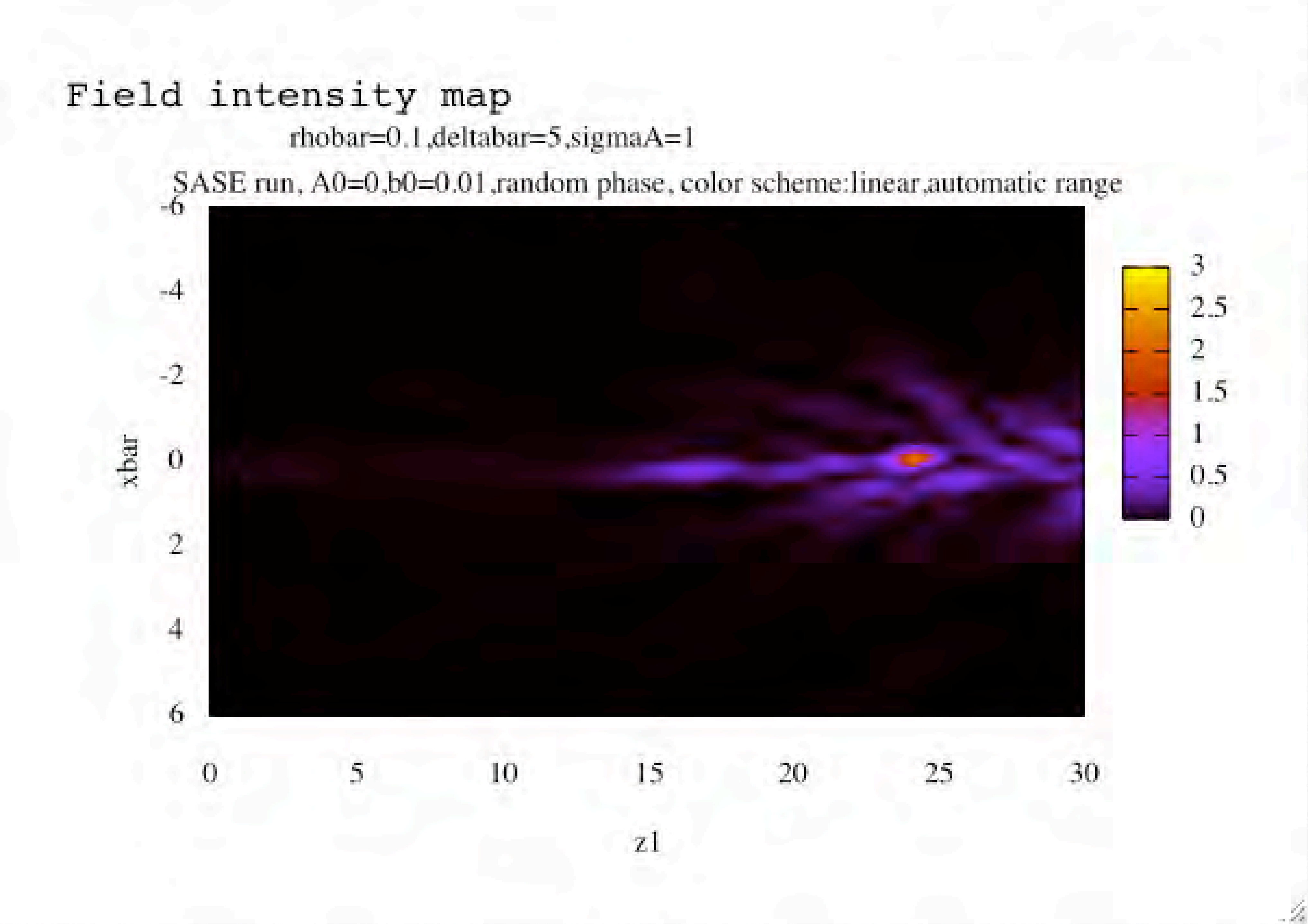


Field intensity map
zbar = 30.0
rhobar=0.1,deltabar=5,sigmaA=1,sigmaE=1,ax=0,bx=0
with propagation and interaction, color scheme:linear,automatic range
-6
-4
-2
0
2
4
6
xbar
0
5
10
15
20
25
30
35
40
z1
12
10
8
6
4
2
0

Seeded SRS + field diffraction



Towards QSASE



Computational resources for QSASE

- present 1D runs need 1000 points in z when propagation is switched on
- 400x400 points in the transverse plane
- total points $\sim 6 \cdot 10^8$ (5GB of memory)
- sustained power of <u>10 TFlops</u> for 1h run

Boundary condition issues

- differential operator not properly terminated at the boundary
- large number of mesh points in the transverse direction
- need for a perfectly absorbing recipe
- would reduce by a factor of 10 the resource requirements

Collaborators

- R. Bonifacio & N. Piovella, Uni. Milan and INFN
- G. Robb,Univ. of Strathclyde, Glasgow
- M.Ferrario +QFEL project @ LNF