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2005 ICFA Workshop - Erice

Model equations

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

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

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



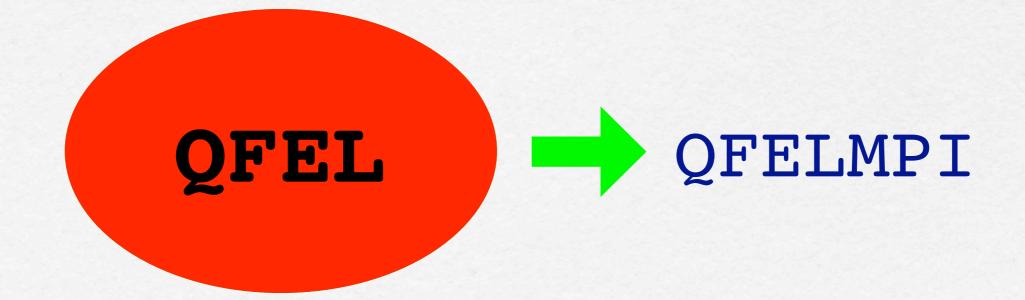
Expansion in discrete momentum states

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

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

Code scheme

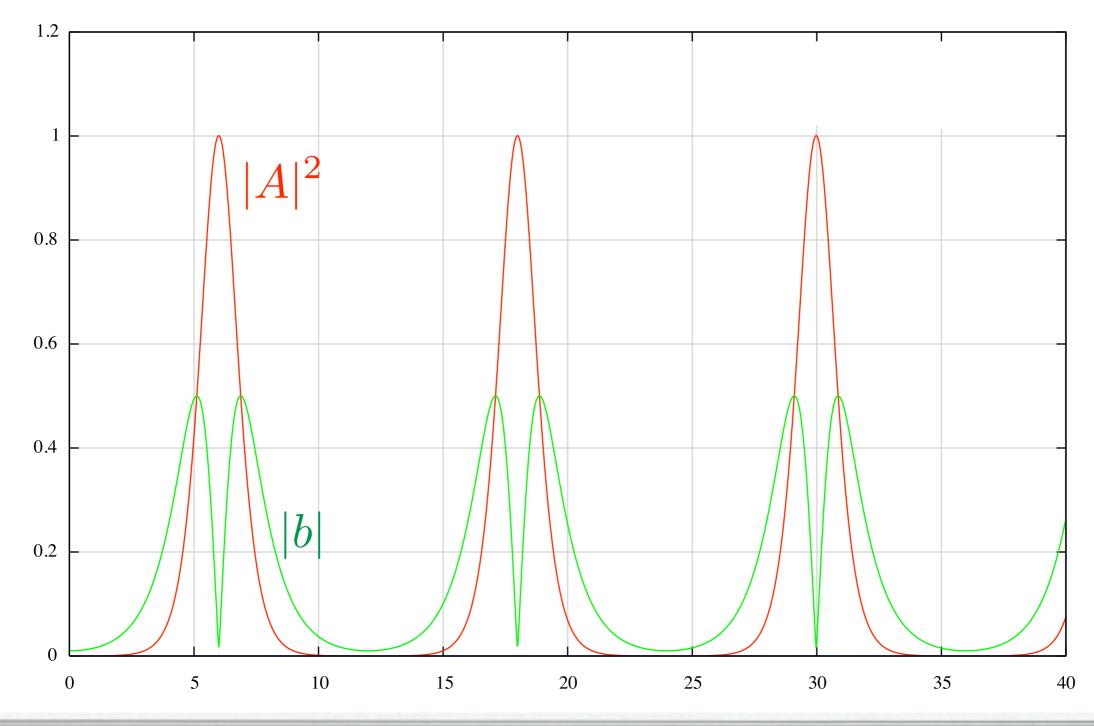
FD explicit scheme in space
 Runge-Kutta method in time



1D Steady state

QFELNORM, steady state, rhobar=0.1, deltabar=5

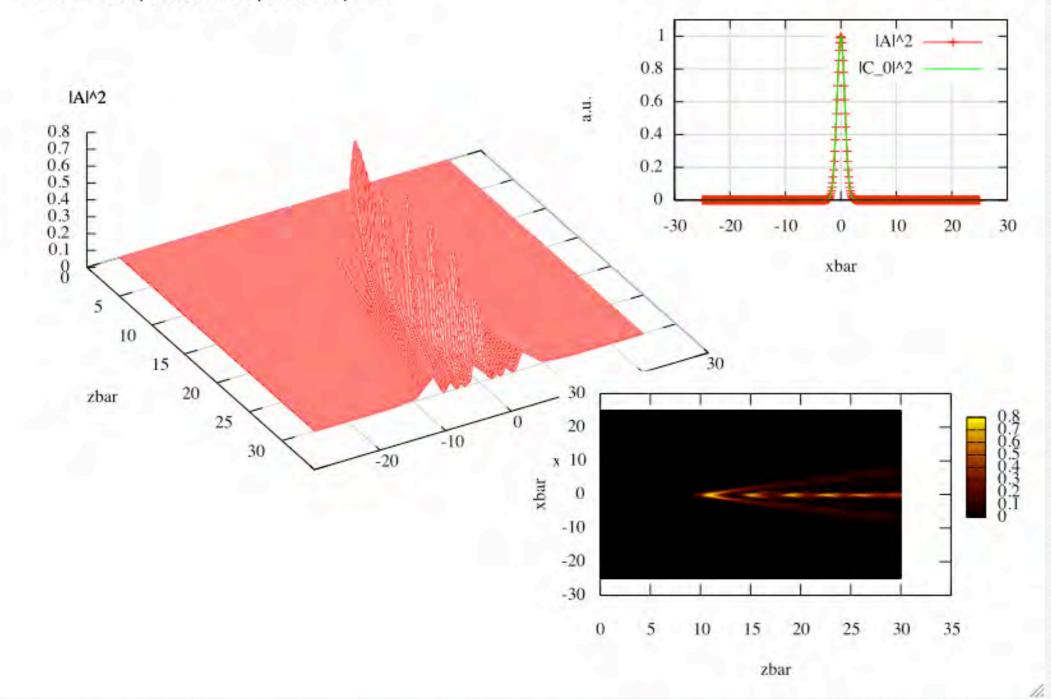
A0=0,b0=0.01,noise=.F.,resZ1=>=20



2D Steady state

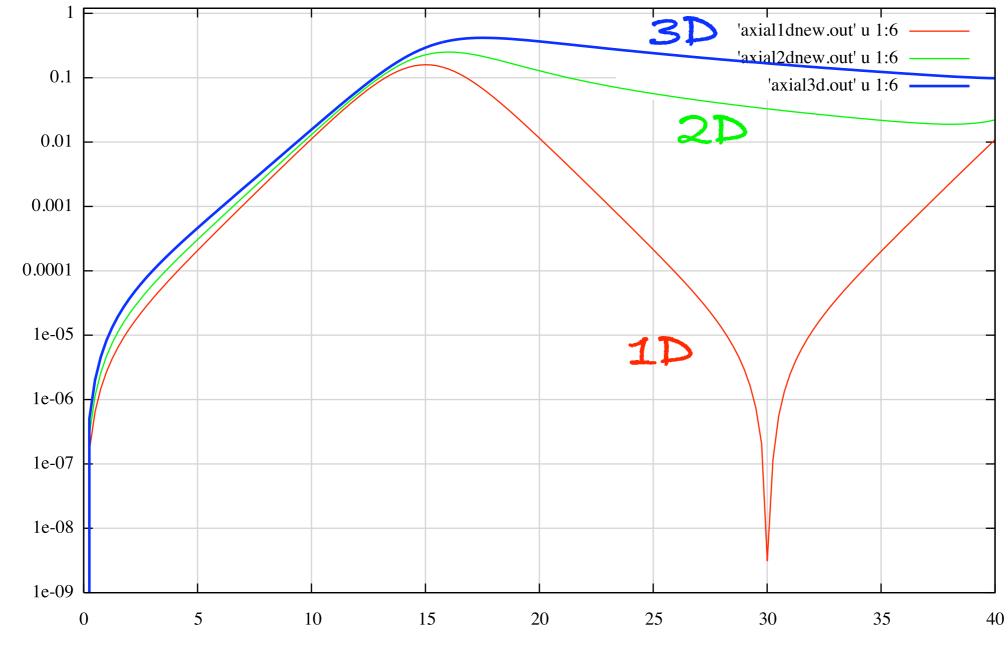
rhobar=0.1, deltabar=5, ax=0.05, bx=0

Transverse initial profiles (normalised)



Renormalised model: gain

Steady-state, rhobar=0.1, deltabar=5,A0=0,b0=0.01

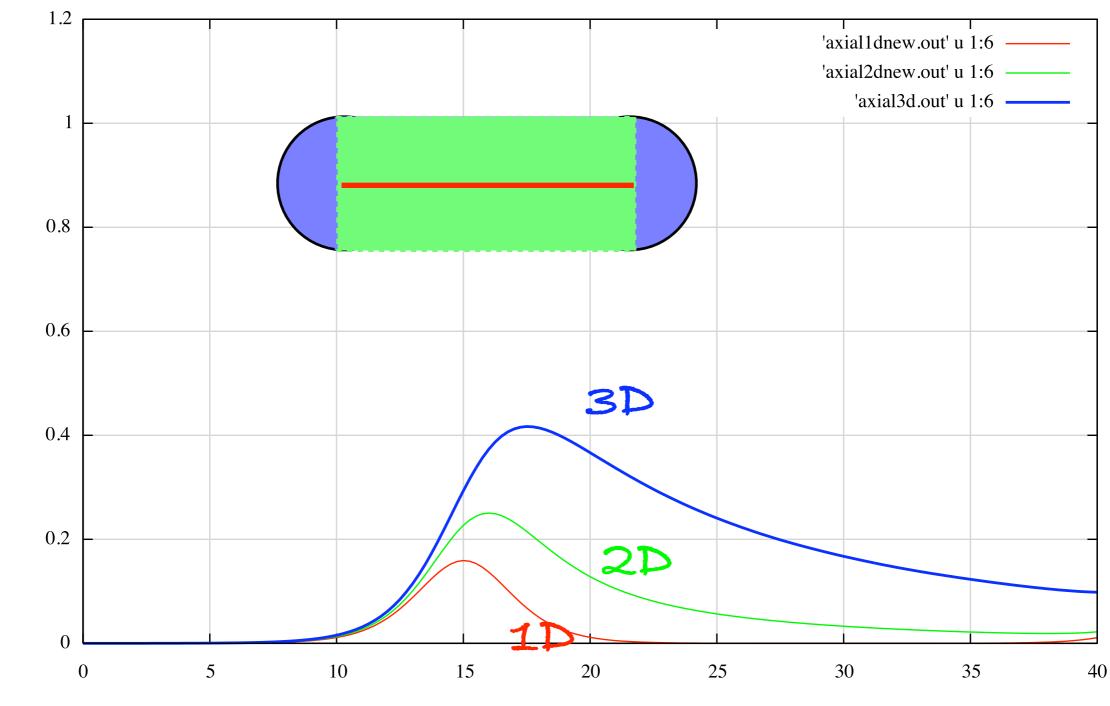


interaction length in Lg units

integrated field intensity

Renormalised model: saturation

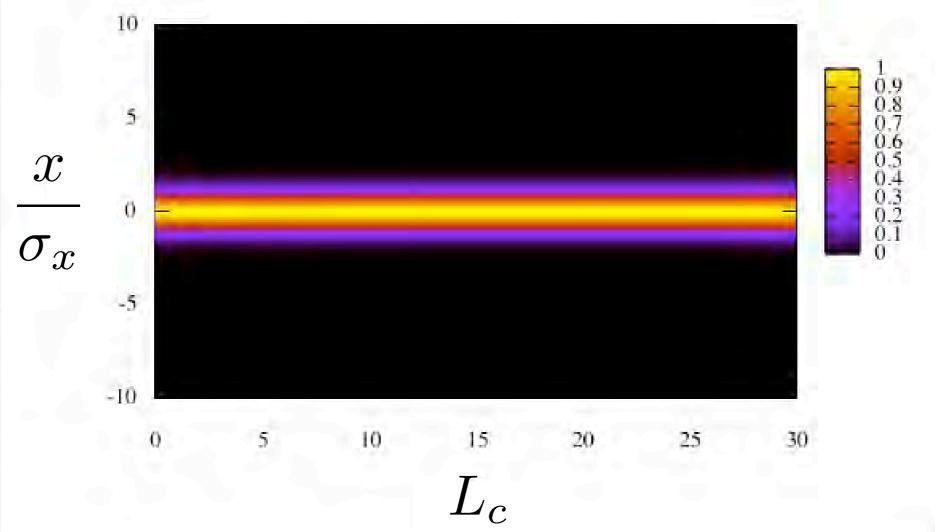
integrated field intensity



interaction length in Lg units

Propagation in 2D

Initial electron beam density



Th.

Seeded SRS

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

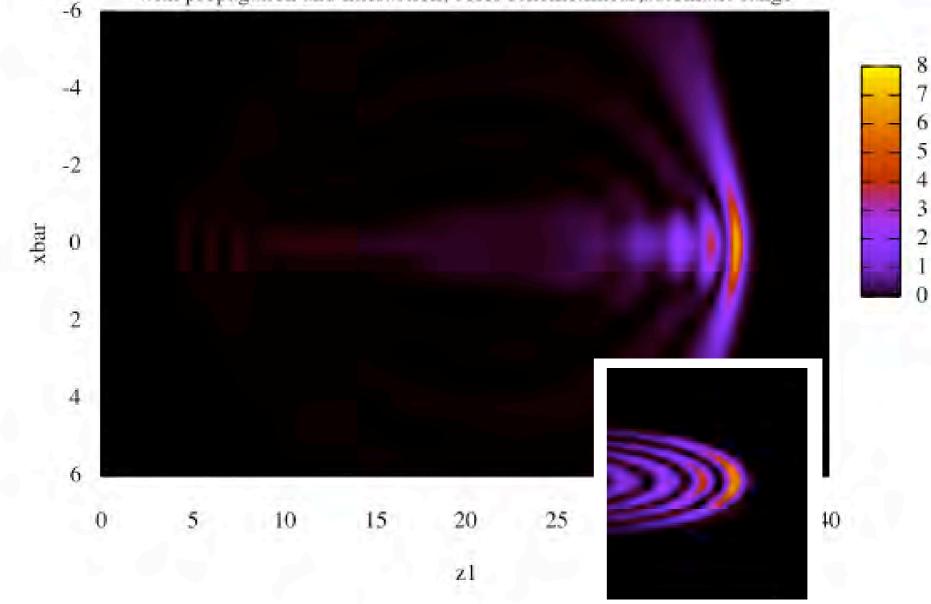
seeded SRS + field diffraction

Field intensity map

zbar = 30

rhobar=0.1,deltabar=5,sigmaA=1,sigmaE=1,ax=0.05,bx=0

with propagation and interaction, color scheme:linear,automatic range

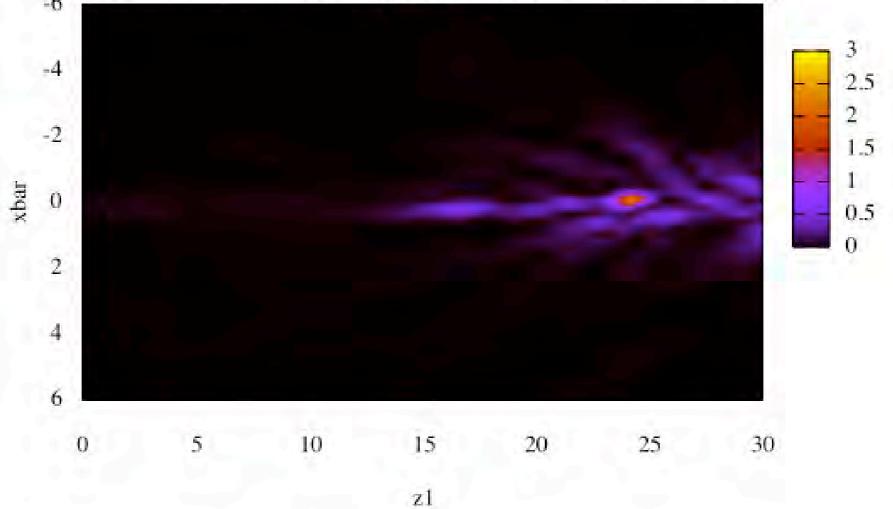


Towards Q.S.A.S.E

Field intensity map

rhobar=0.1,deltabar=5,sigmaA=1

SASE run, A0=0,b0=0.01,random phase, color scheme:linear,automatic range



./e

Computational resources for QSASE

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

Boundary condition

- dífferential 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

- α
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 and INFN
- O G. Robb, univ. of Strathclyde, Glasgow
- D M. Ferrario + QFEL project @ LNF

