

Coherent scintillator

Adriano Lai¹ and Francesco Quochi^{1,2}

¹*INFN, Sez. di Cagliari*

S.P. Monserrato-Sestu Km 0.700, 09042 Monserrato (CA), Italy

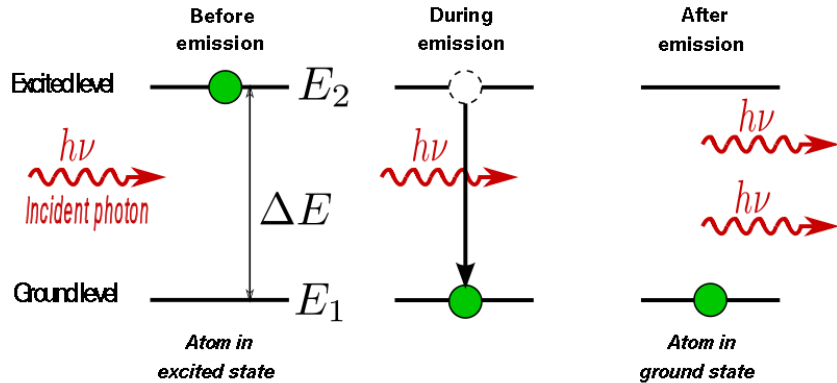
²*Dipartimento di Fisica, Università di Cagliari*

S.P. Monserrato-Sestu Km 0.700, 09042 Monserrato (CA), Italy

Email: adriano.lai@ca.infn.it
francesco.quochi@dsf.unica.it

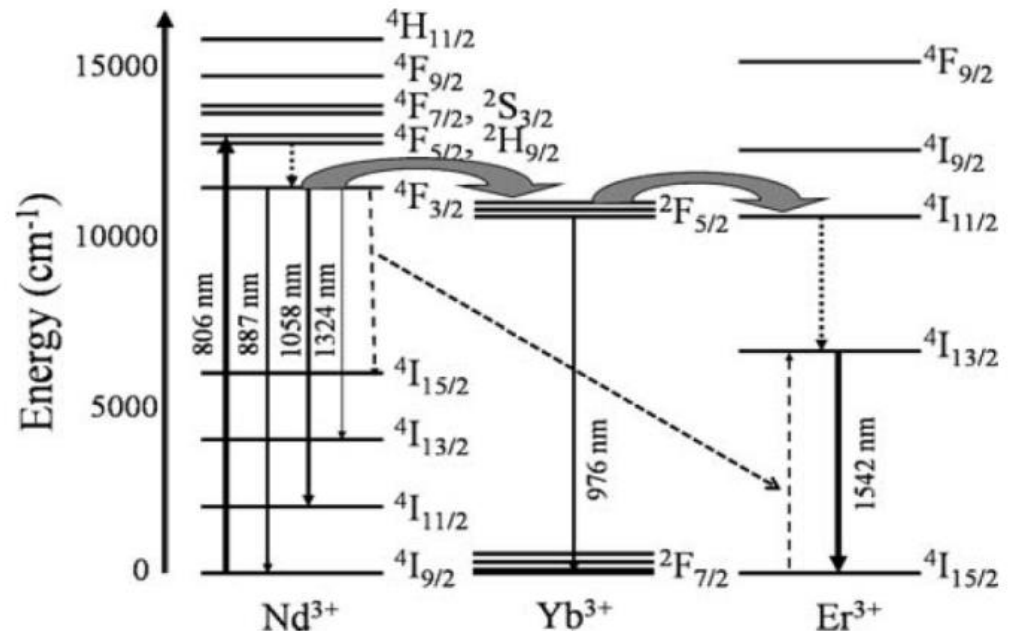
Inversion gain for coherent scintillator

Stimulated emission

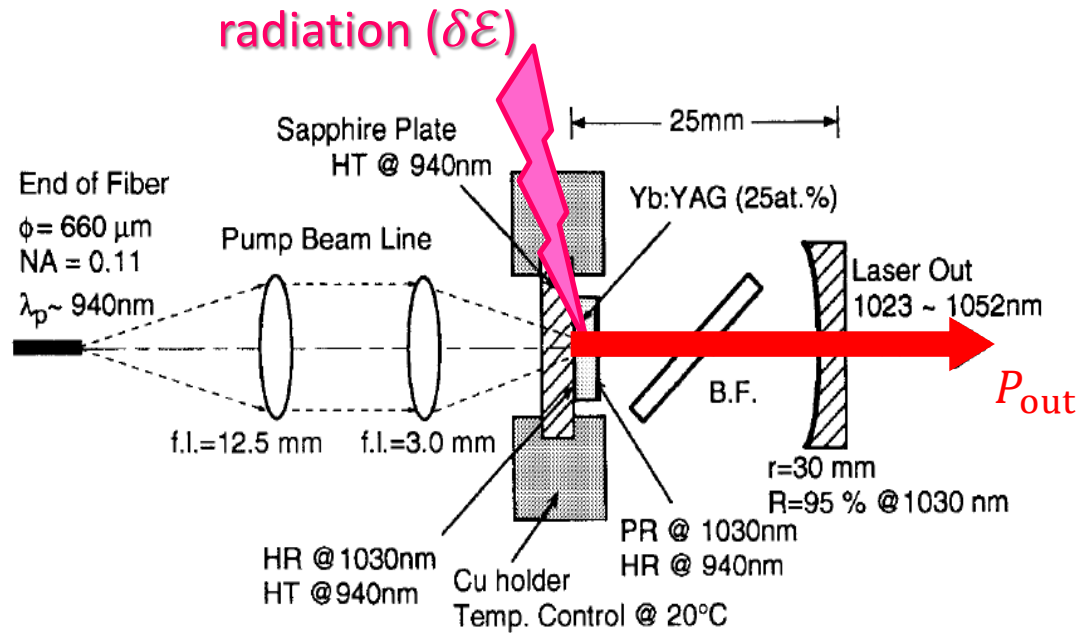


$$E_2 - E_1 = \Delta E = h\nu$$

Nd³⁺/Yb³⁺/Er³⁺-doped crystal



Lasing scintillator



Population inversion: $N_2 - N_1$

Gain coefficient: $G \propto N_2 - N_1$

Energy deposit: $\delta\mathcal{E}$

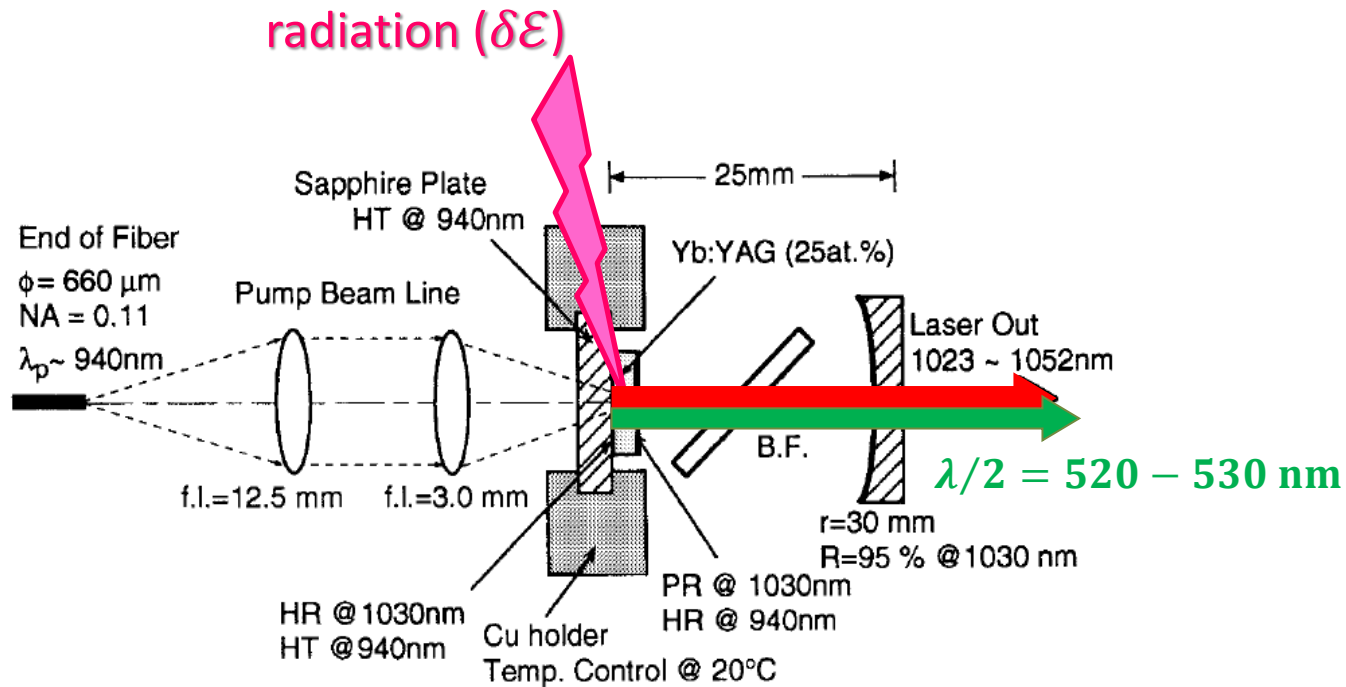
Detection:

$$\delta\mathcal{E} \rightarrow \delta(N_2 - N_1) \rightarrow \delta G \rightarrow \delta P_{\text{out}}$$

Laser on/off switching at threshold:

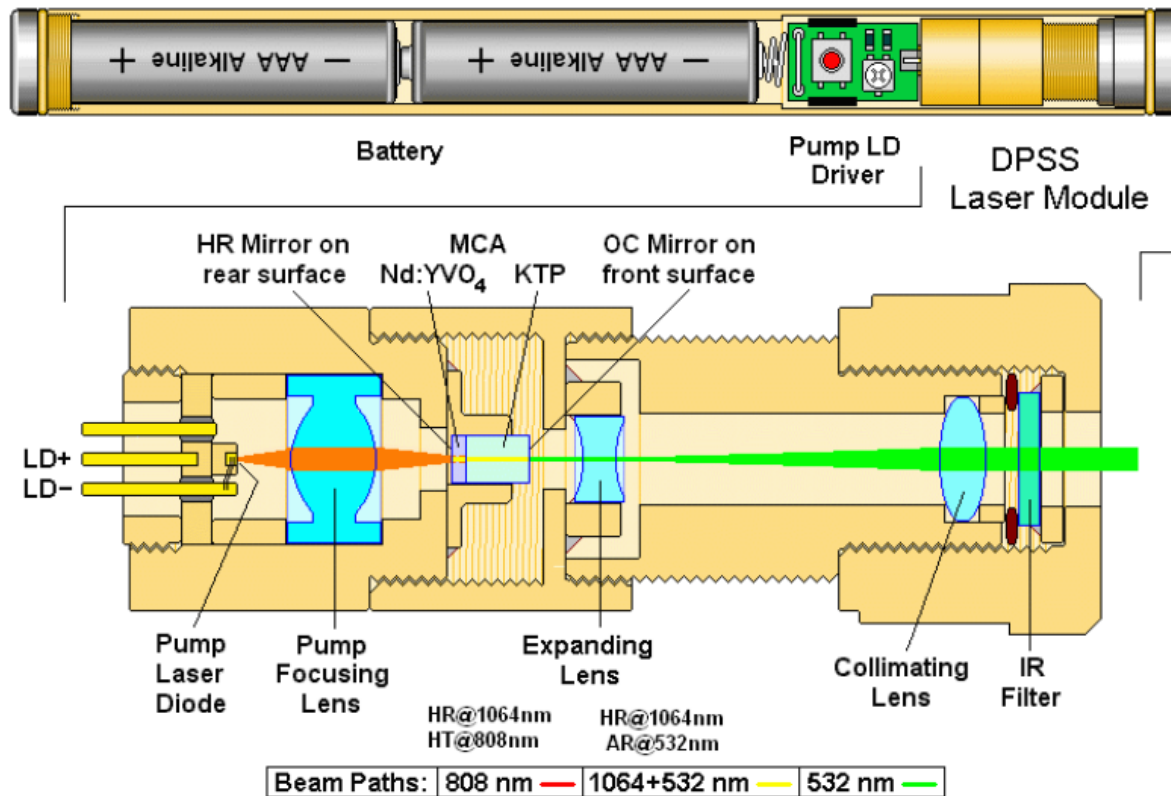
- High sensitivity*
- High detectivity*
- Fast response time*

Inversion gain + parametric process in ONE crystal: Self-Frequency Doubling (SFD)



$\text{Nd}^{3+}:\text{LiNbO}_3:\text{MgO}$, $\text{Nd}^{3+}:\text{YAl}_3(\text{BO}_3)_4 \dots$

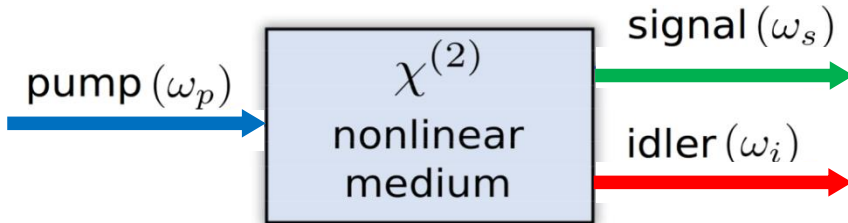
Intracavity Second-Harmonic Generation (SHG)



Nd³⁺ :YAG/YVO₄ + nonlinear crystal (KTP)

Parametric coherent scintillator

Parametric process



Optical parametric oscillator (OPO)

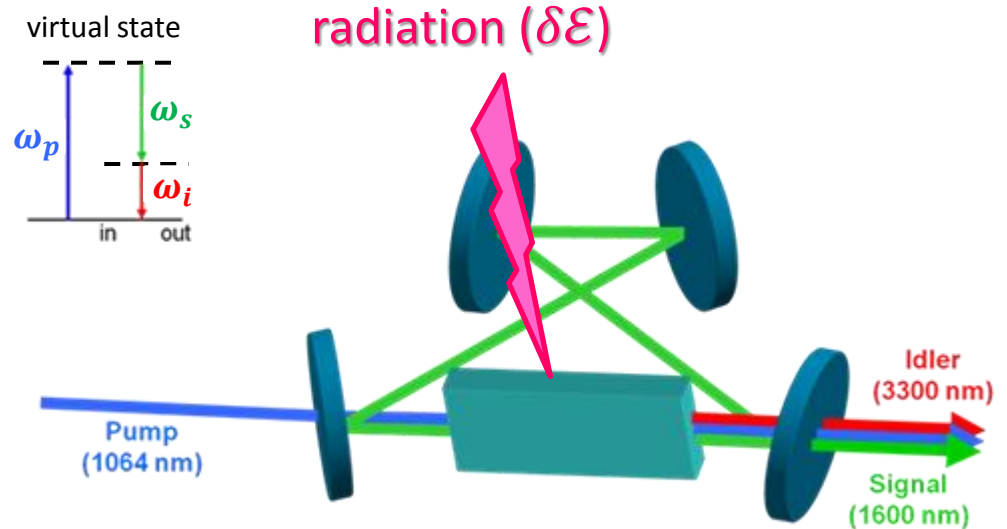
d : nonlinear coefficient
 Δk : momentum mismatch

$$k_s + k_i = k_p + \Delta k$$

$$P_p \propto \frac{P_s P_i}{n_p n_s n_i A} d^2 L^2 \text{sinc} \left(\frac{\Delta k L}{2} \right)$$

Detection:

$$\delta \mathcal{E} \rightarrow \delta n, \delta d, \delta(\Delta k) \rightarrow \delta G_{\text{par}} \rightarrow \delta P_{\text{out}}$$



Agenda 2016

- **Realization of an experimental set-up based on frequency-doubled Nd-doped crystal laser, pulsed RX irradiation and synchronous detection**
- **Measurement of coherent scintillator characteristics:**
 - **Sensitivity**
 - **Detectivity**
 - **Response time**
- **Direct comparison with characteristics of standard scintillator such as CsI(Tl) @540nm using the same photodetection set-up (light diffuser+light tube+Vis photomultiplier)**