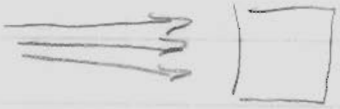
Angular acceptance:

input beam must be collimated.

divergent beam has a spread of input directions:



doesn't matter much in one direction

in other → conversion varies across beam

- see line go across beam.

to calculate:

plot $\text{sinc}^2(\Delta k(\Theta_{opt} + d\theta) L/2)$ vs $d\theta$

some crystals more forgiving

- Type III is best.

Require ~ several mrad, may restrict crystal length

PM bandwidth

- short pulses → range $\Delta\omega$
- plot $\text{sinc}^2(\Delta k(\omega_0 + \Delta\omega) L/2)$ vs $\Delta\omega$) — ($\omega_0 + \Delta\omega$ at input.)

want > 90% across input BW

- restricts length for short pulses.

Group velocity walk off.

- connected to PM bandwidth

group delay $\tau_g = L/v_g$

if $|\tau_g(\omega) - \tau_g(2\omega)| > \tau_p$

→ inefficient doubling.

Quasi-phase matching.

- use for non-birefringent materials

consider eqn for A_3:

$$A_3' = i \frac{2\omega_3 d_{eff}}{n_3 c} A_1 A_2 e^{i\Delta k z}$$

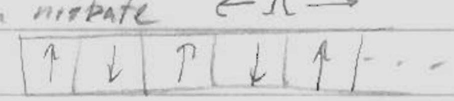
let $d_{eff} = d(z) = d_0 \cos Kz$

$$A_3' \propto d_0 (e^{iKz} + e^{-iKz}) A_1 A_2 e^{i\Delta k z}$$

$$= d_0 A_1 A_2 \left(e^{i(\Delta k + K)z} + e^{-i(\Delta k - K)z}\right)$$

this modulation allows a buildup in signal if $\Delta k \pm K = 0$

PPLN: periodically-poled lithium niobate



$\chi^{(3)}$ alternates in sign

expand square wave form of $\chi^{(3)}$ to Fourier series

$$d(z) = d_{eff} \sum_{m=-\infty}^{\infty} G_m e^{ik_m z} \qquad k_m = \frac{2\pi m}{\Lambda}$$

can match to diff't order. 1st order QPM is most eff't.

Can tailor layering pattern to tailor bandwidth.

Modulation can be in index or intensities.