Optical Parametric Oscillator for Water Vapour Differential Absorption Lidar (DIAL)

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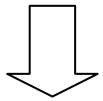
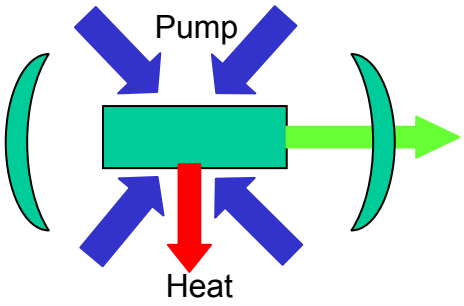
Laser: Stimulated Amplifier

- Energy stored

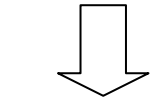


- Pulse length defined by resonator
- Excess energy generates heat
- High seed power required

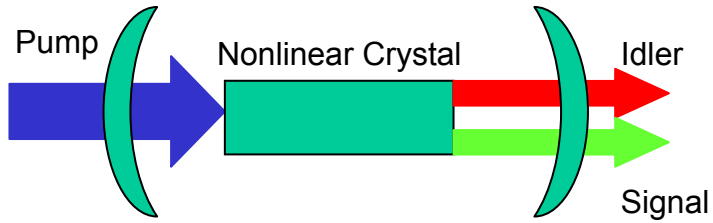


OPO: Parametric Amplifier

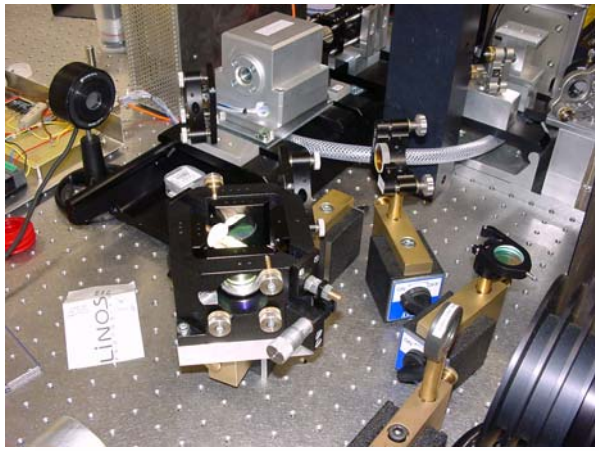
- No energy stored
- Amplification directional



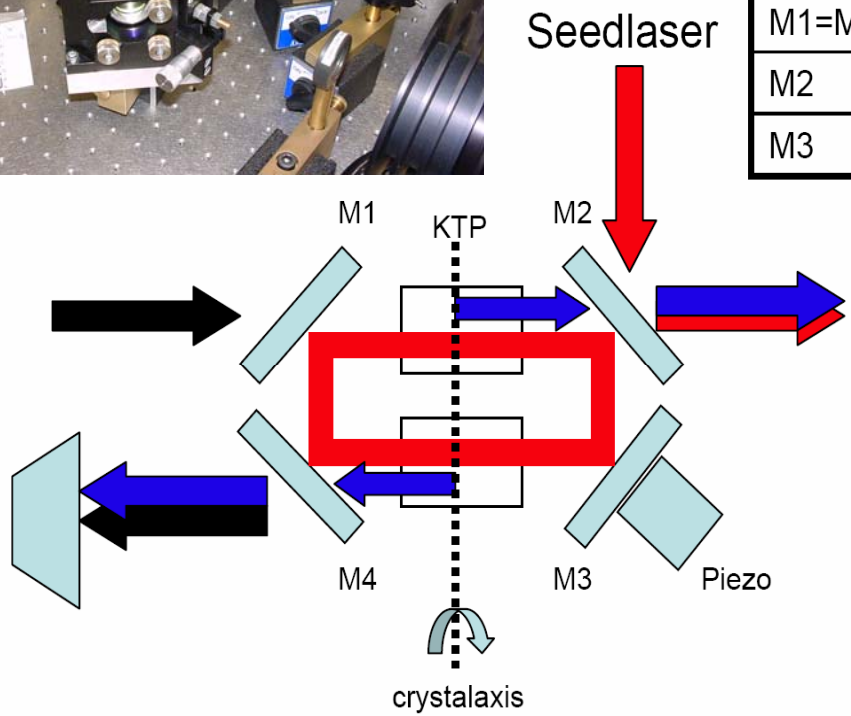
- Pulse length defined by pump laser
- Short resonator required
- Excess energy generates light
- Low seed power required



OPO setup (SRO)



	532 nm	935 nm	1234 nm
M1=M4	AR	HR	AR
M2	HR	OC xx%	AR
M3	HR	HR	AR



2 KTP 8*8*10mm³ θ=70.7° φ=0°

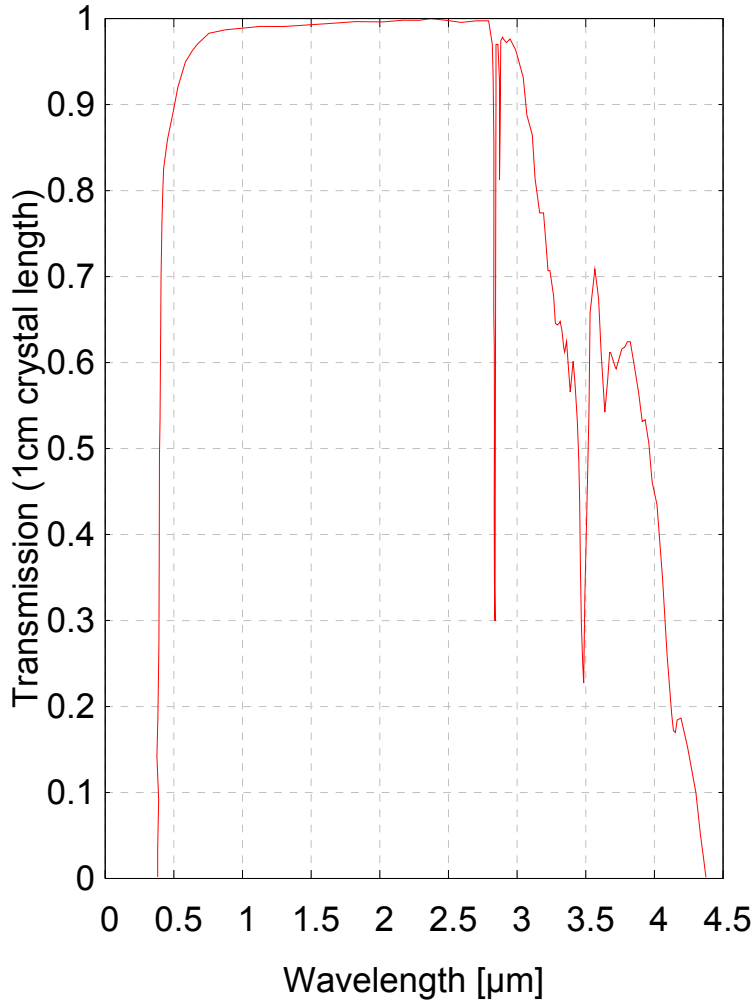
Pump 532 nm
(o) = S-Pol

Signal 935 nm
(e) = P-Pol

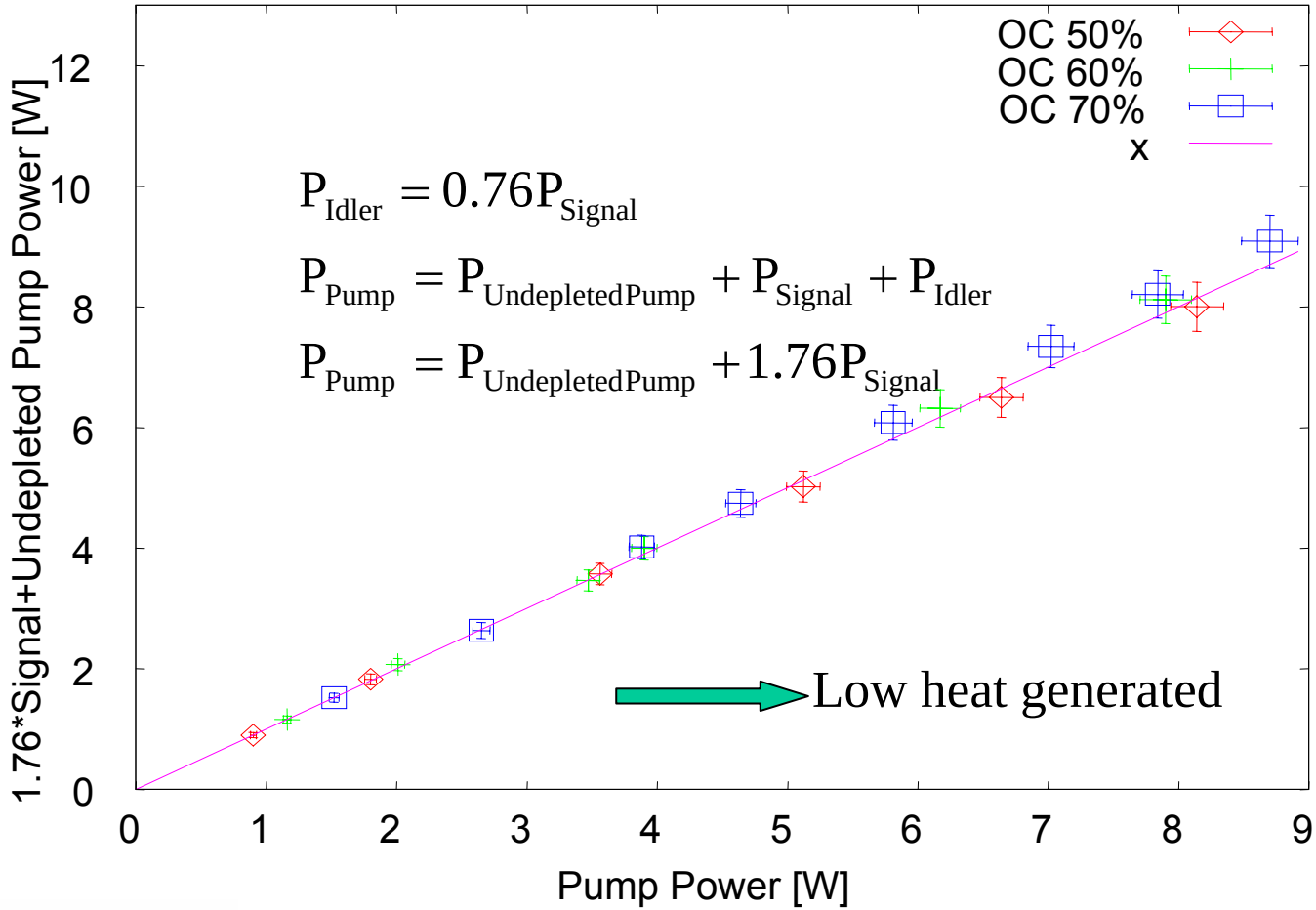
Idler 1234 nm
(o) = S-Pol

Properties of KTP

- Thermal conductivity 0.03 W/(K cm)
- Low absorption from 0.5-3 µm
- Bi-axial crystal
- dn/dT 2-4 10^{-5} K^{-1}
- Thermal drift 0,05 nm/K @ 935 nm
- Damage thresholds (10 ns pulse) = 15 J/cm² @ 1064 nm
- Angular acceptance 2 mrad (for 1 cm crystal)

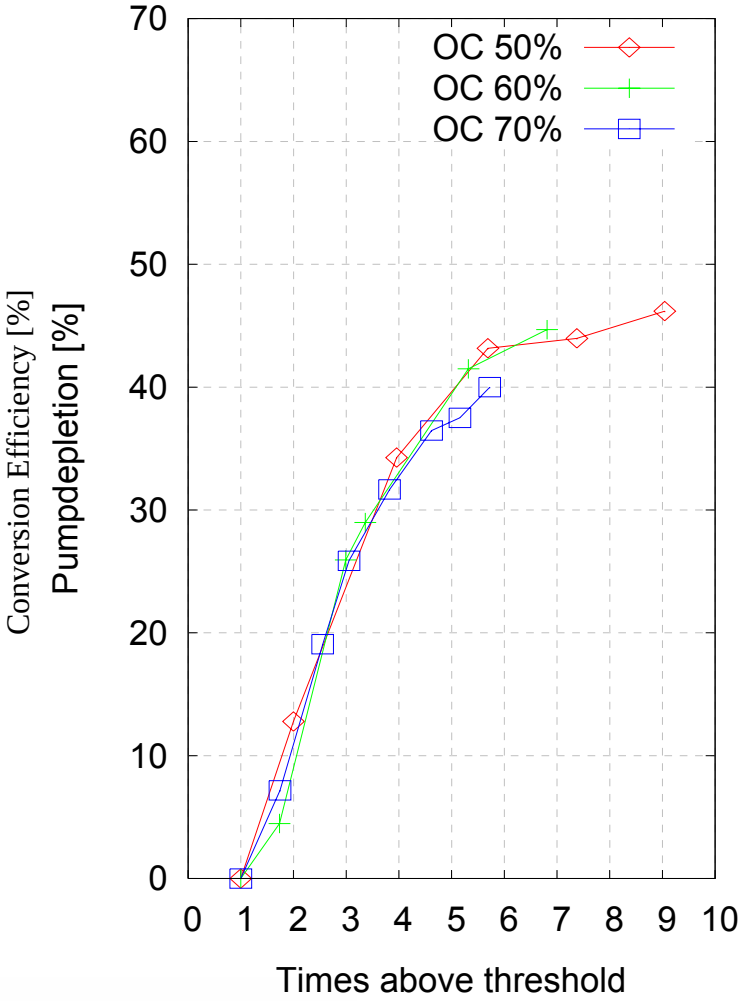


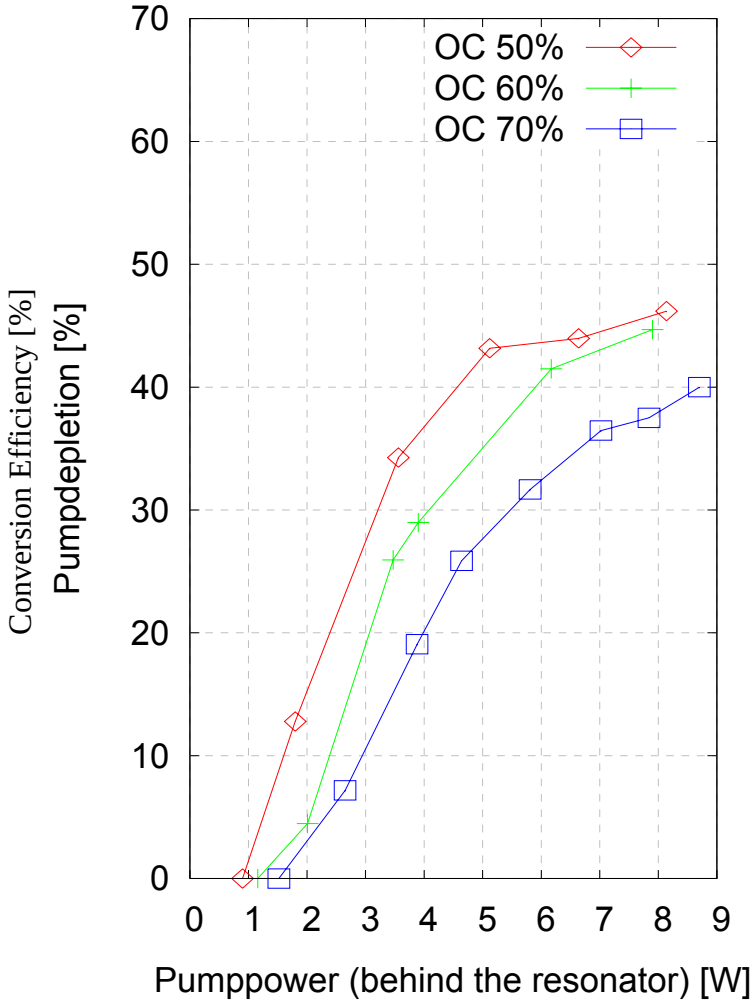
Power balance of the OPO pump, signal and idler power for different output couplers



OPO Performance for different output couplers

Pumpdepletion = Power converted to signal- and idler-radiation





What limits the OPO efficiency ?

- Beam Profile:
  - Plane Wave: ~100 %
  - Gaussian Beam: ~73 %
- Temporal Profile
  - Square Pulse (CW) ~100%
  - sech² Pulse ~70 %
- Mirror Transmittance ~xx %

→ 532 to 935 and 1234 **~40-60%**

- Stokes Efficiency

  ω_s/ω_p = 532 nm / 935 nm =56 %

→ 532 to 935 **~20-25%**

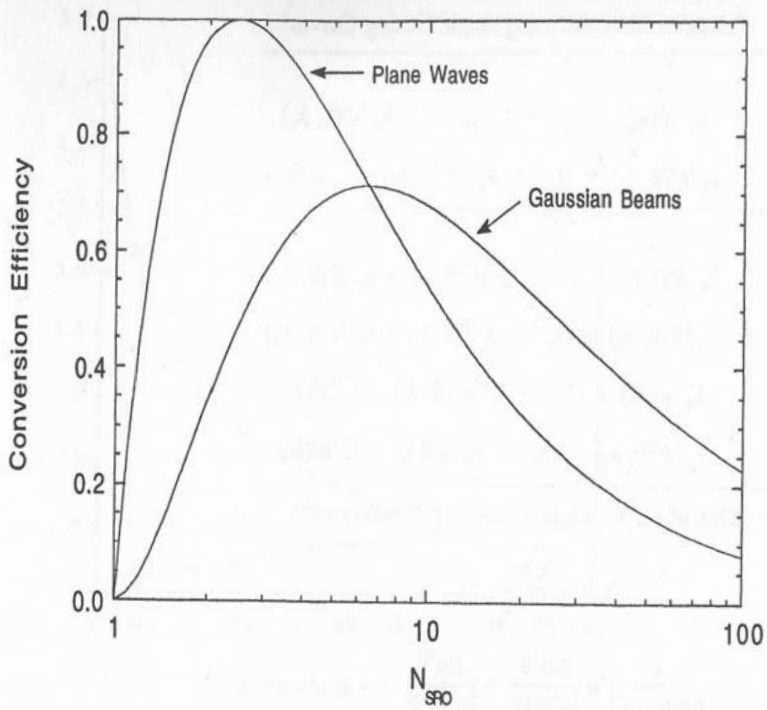


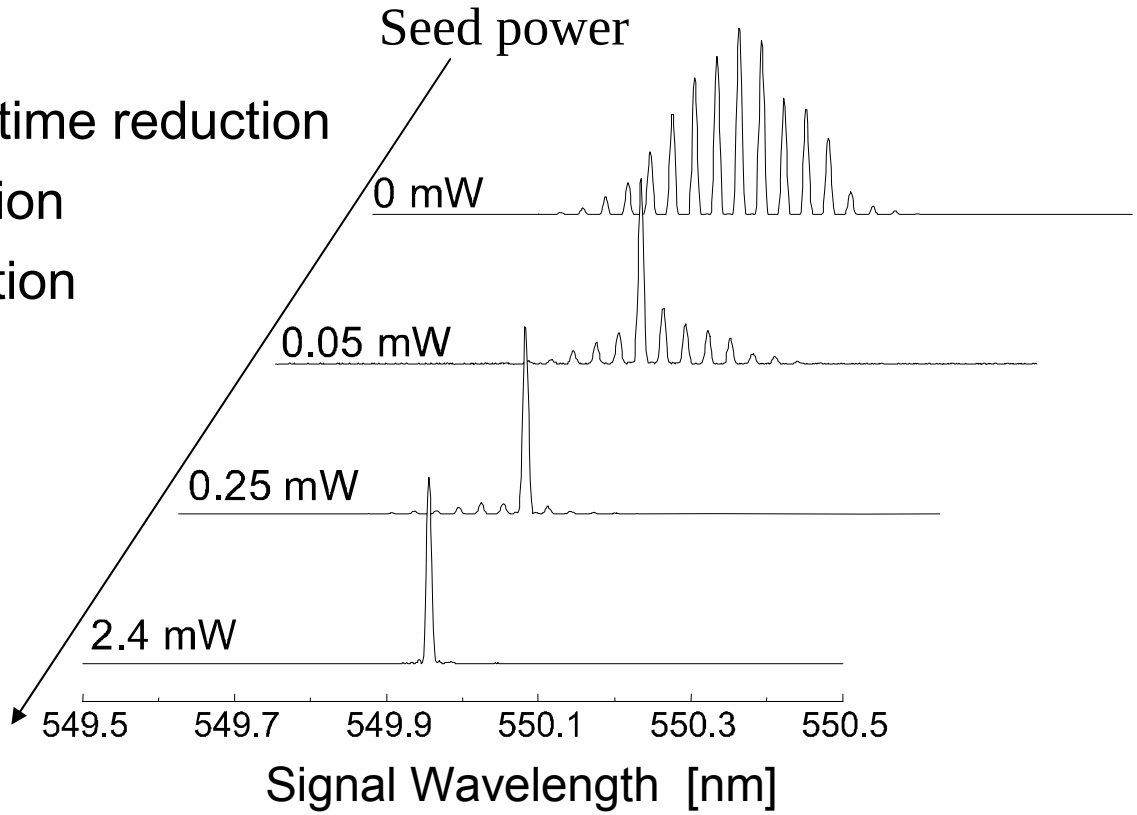
Figure 11 Conversion efficiency as a function of the number of times the pump power exceeds threshold for the SRO, comparing plane wave and Gaussian beam results.

Sutherland: Handbook of Nonlionear Optics

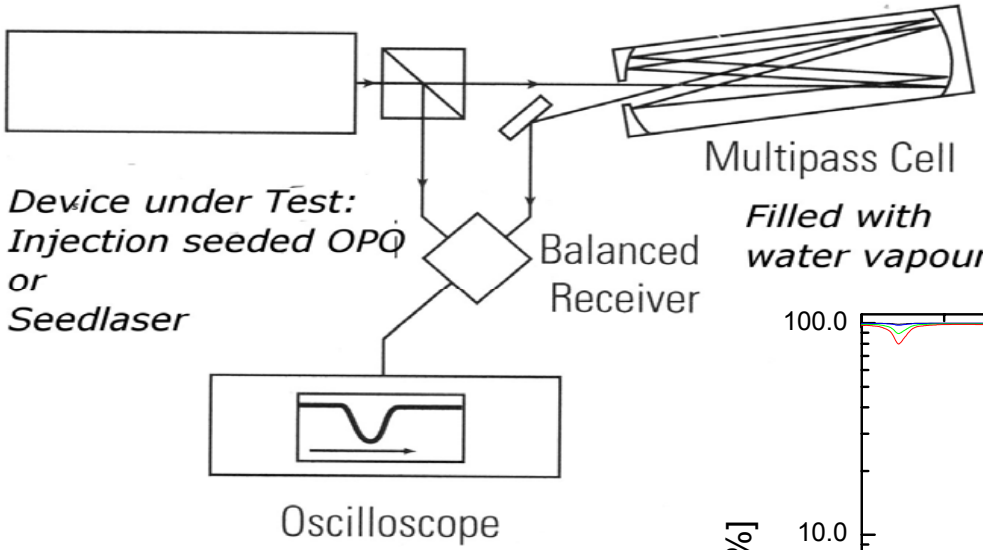
Effects of injection seeding

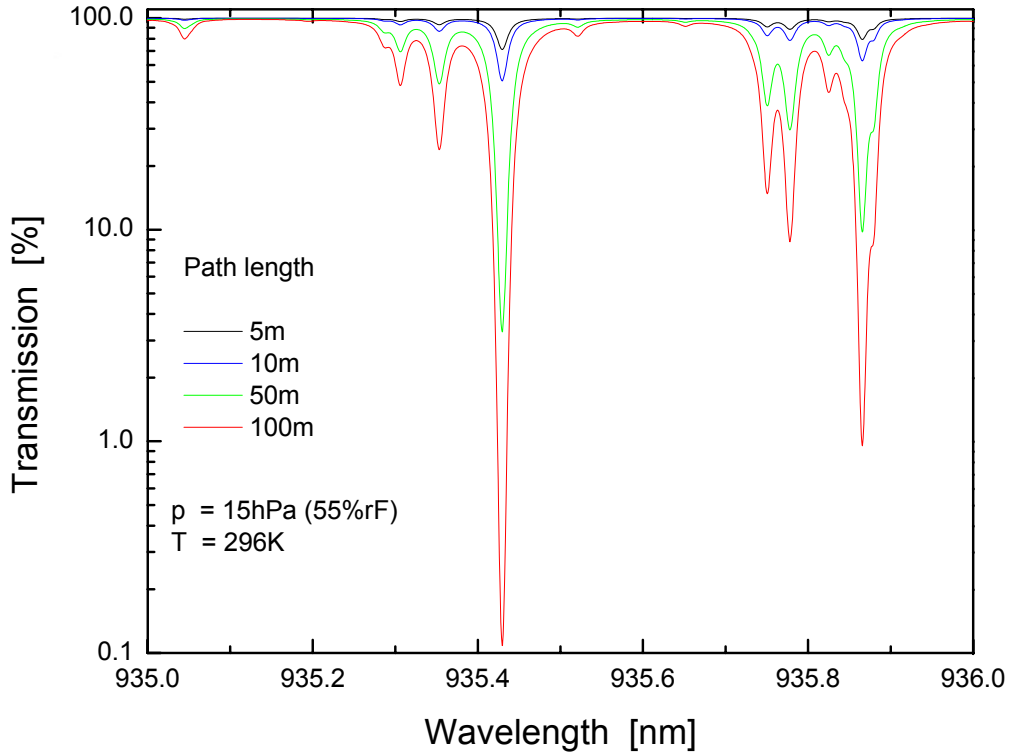
- Impulse build up time reduction
- Threshold reduction
- Bandwidth reduction

→ Power increase
Better efficiency

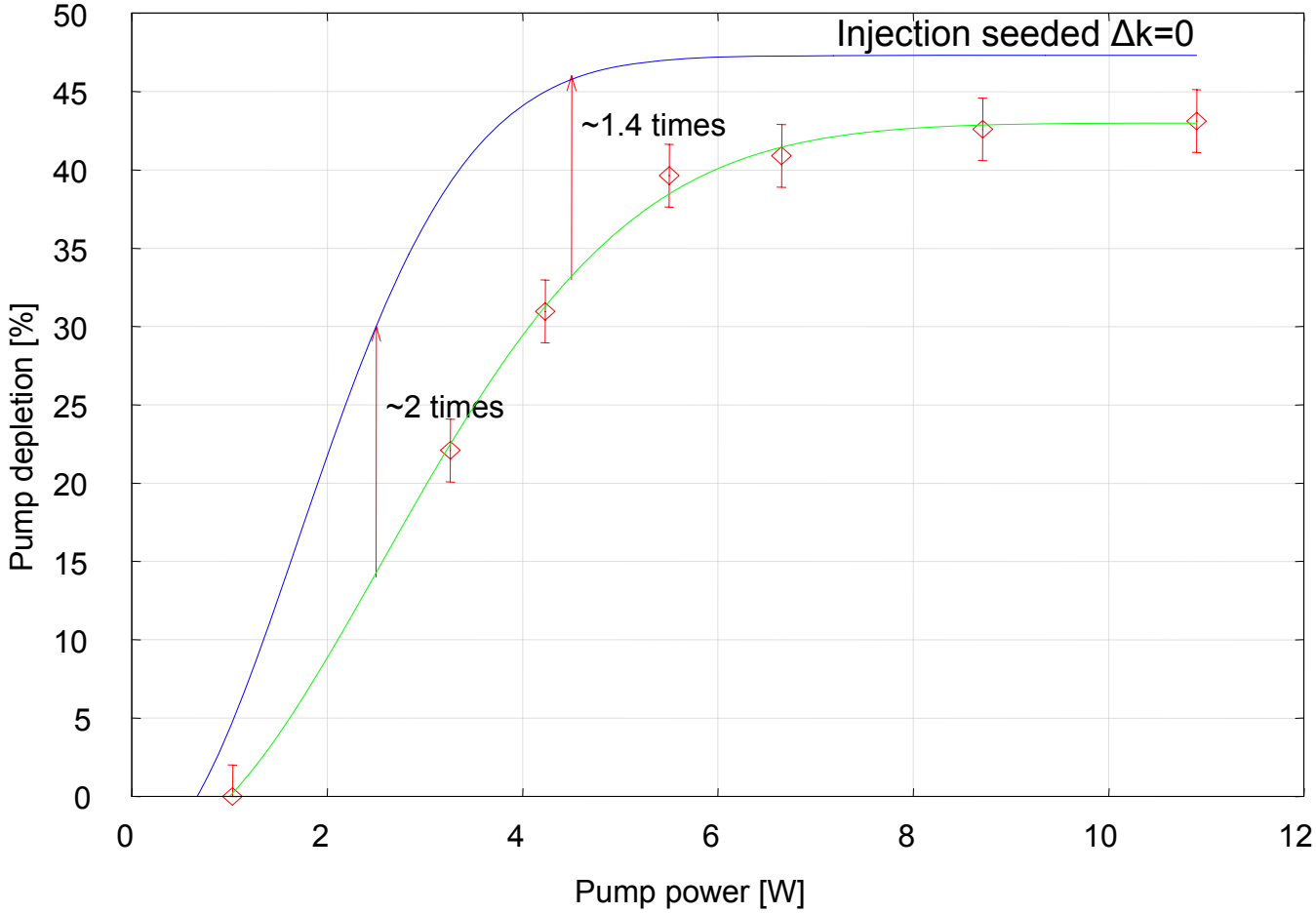


Measurement of the spectral purtity



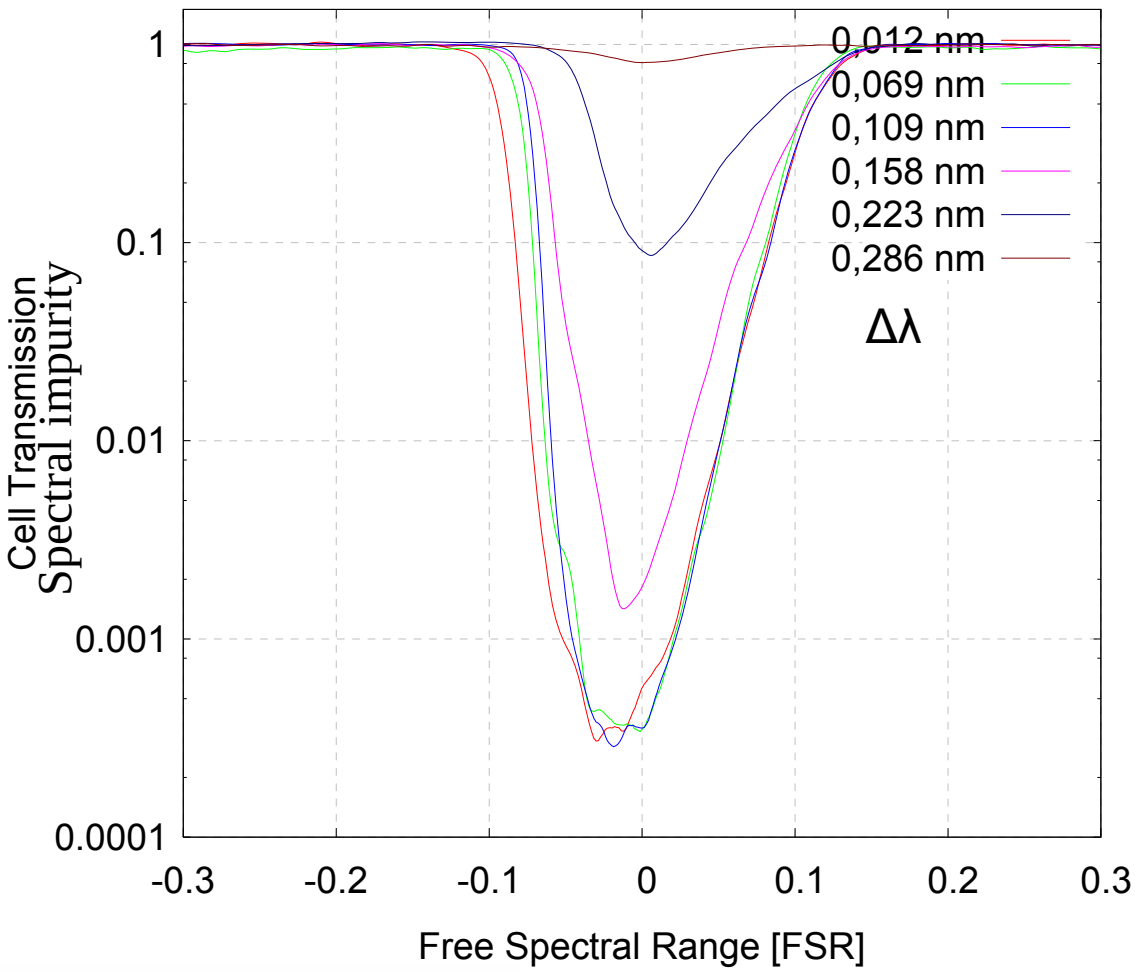


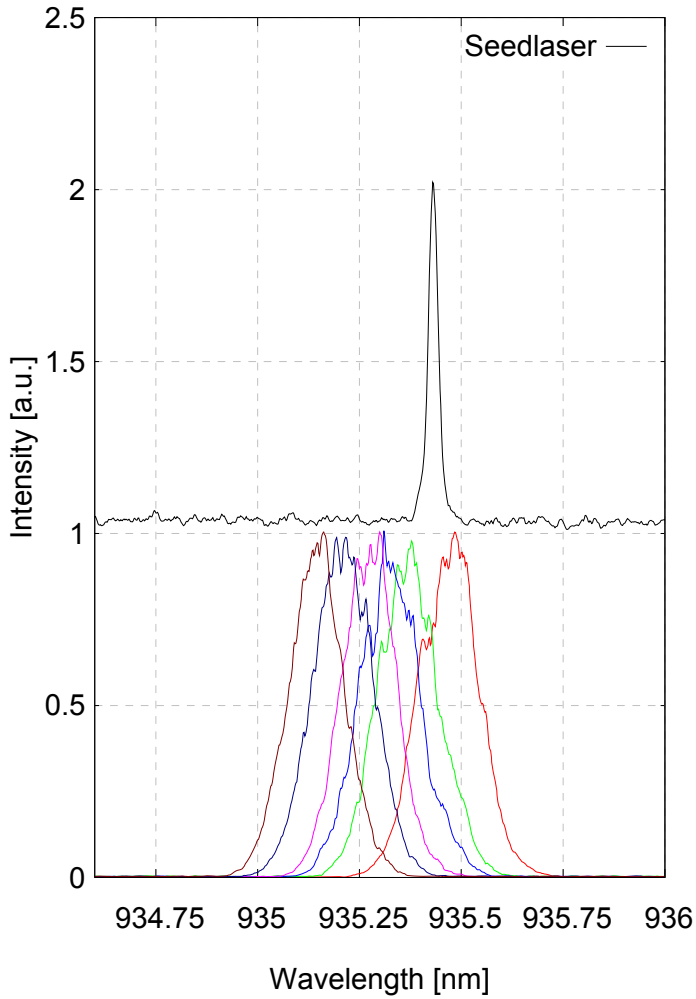
Conversion efficiency
Pump depletion



Cell transmission for resonator piezo scans and different Δk(Δλ)

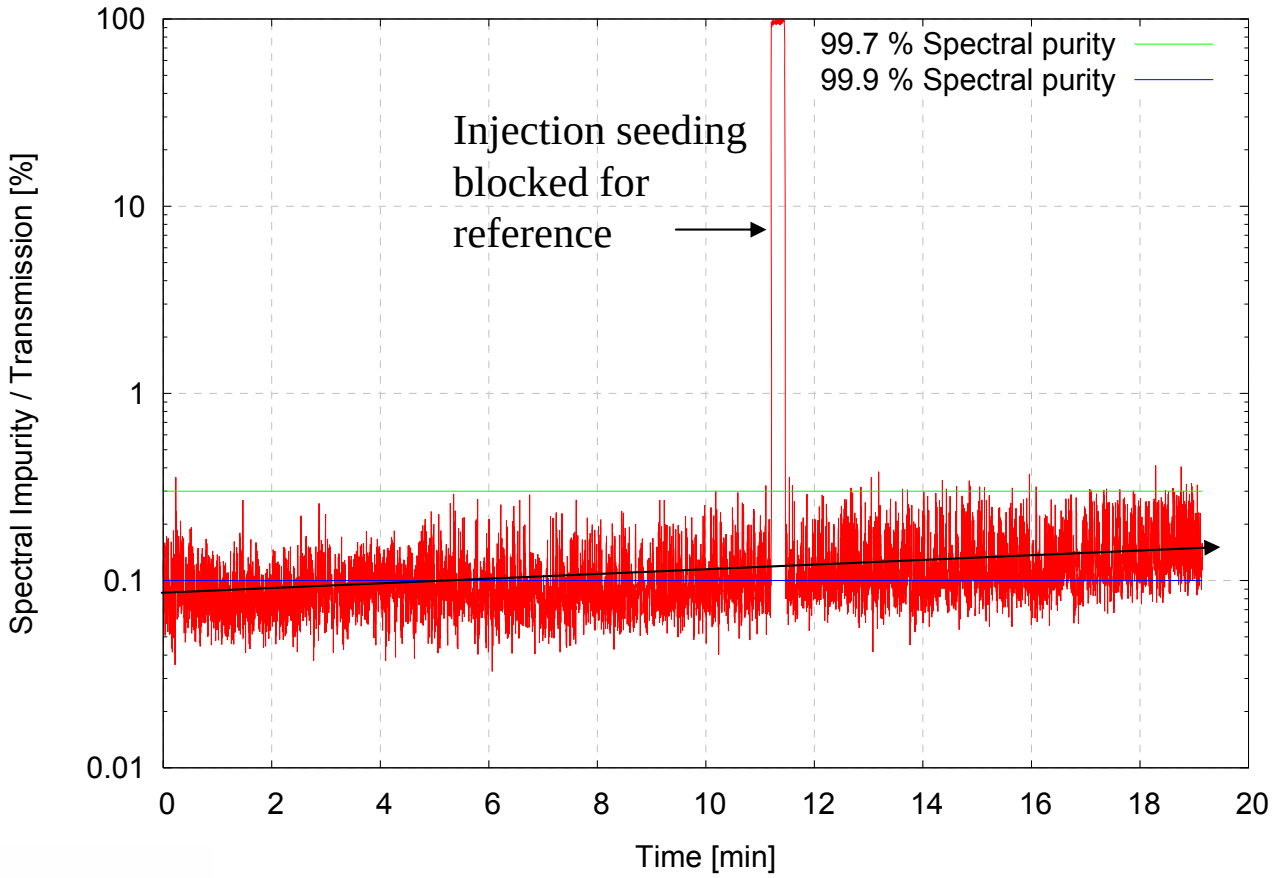
2.5 times above threshold



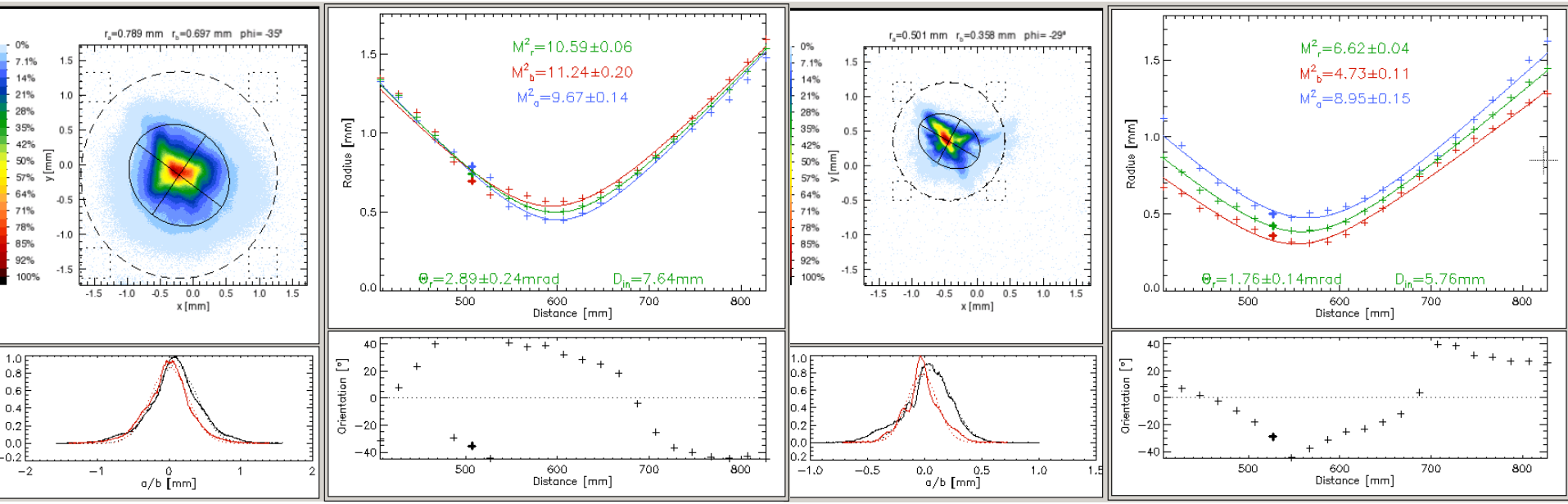


Spectral Purity (20 min Measurement)

10 times above threshold, ~32 mJ @ 935 nm 100Hz, M² 8-10, 2 mW seed power, 22% conversion P_{935nm}/P_{532nm}



Beam Quality M² 10 times above threshold



Unseeded M² ~ 8.2

Seeded M² ~ 6.6

Threshold	M² unseeded
2.5	2.4
4	2.5
10	8.2

Summary

Divergence	M^2~7-10 → 1.7 mrad Ø 5.8 mm
Spectral purity	> 99.7 %
Pulse length	~7 ns
Average pulse energy	~32 mJ @ 935 nm, 100 Hz
Conversion efficiency P_{935nm}/P_{532nm}	22%