# PICOSECOND LASERS WITH RAMAN FREQUENCY AND PULSEWIDTH CONVERSION FOR RANGE FINDING

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# Solid-state lasers with picosecond pulses

- **mode-locked lasers - pulse energy < 1μJ;**

  T. Beddard, W. Sibbet, D.T. Reid, *et al,* “High-average-power, 1-MW peak-power self-mode-locked Ti:sapphire oscillator”, *Opt. Lett*., **24,** pp. 163-165 (1999)

- **diode pumped microchip lasers - pulse width ≥ 56 ps, pulse energy 1-5 μJ;**

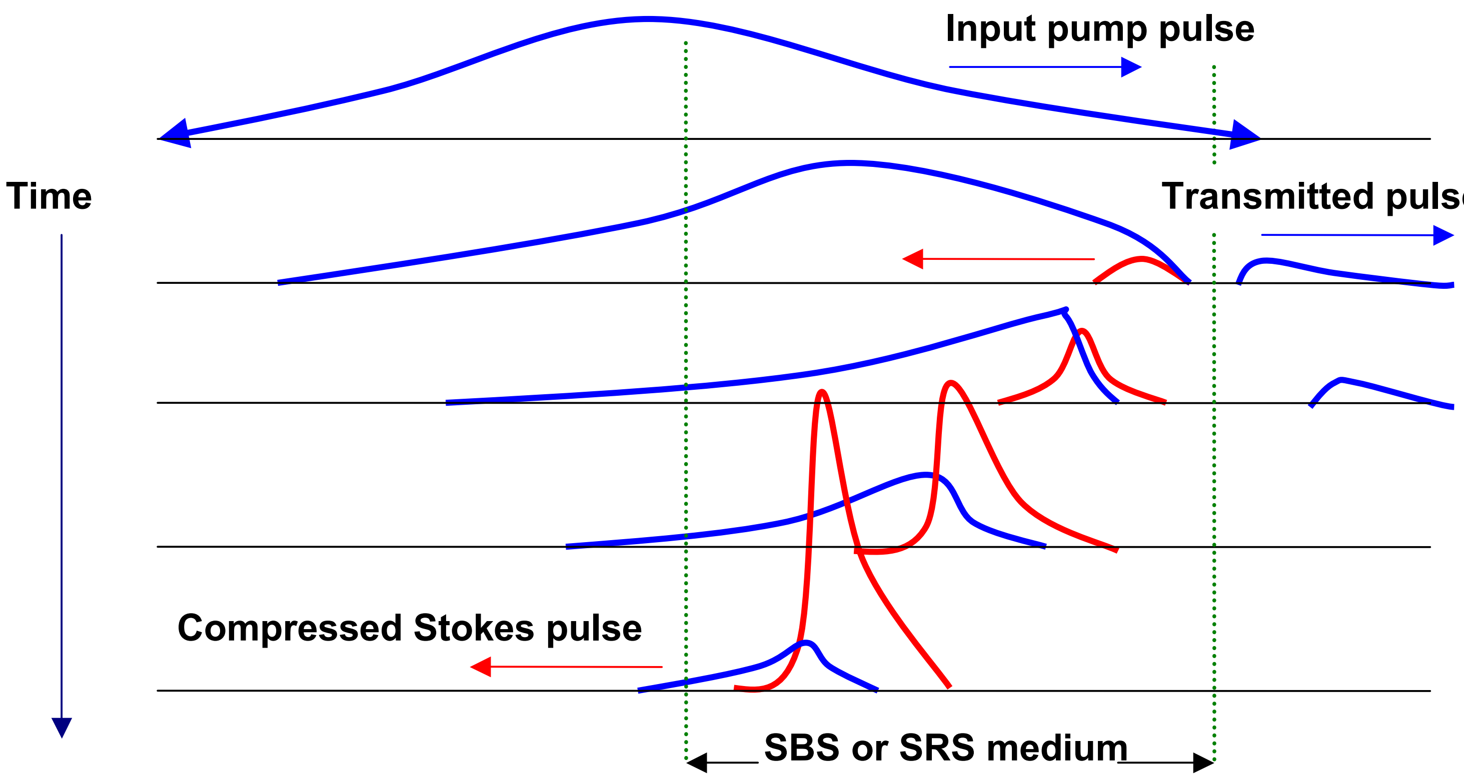
  B. Braun, F.X. Kartner, G. Zhang, *et al.* “56-ps passively Q-switched diode-pumped microchip laser”, *Opt. Lett.*, **22**, pp. 381-383 (1997)

- **lasers with SBS and SRS pulse compression – any pulse energy, pulse compression value ≤ 20 – 25**

  D. Neshev, I. Velchev, W.A. Majevski, *et al,* “SBS-pulse compression to 200 ps in a compact single-cell setup”, *Appl. Phys. B*, **68**, pp. 671-675 (1999).

  A. Dement’yev, E. Kosenko and A. Rodin, “The SRS-amplification of picosecond Stokes pulses”, *Journal of Applied Spectroscopy*, **60,** pp 266-272 (1994).

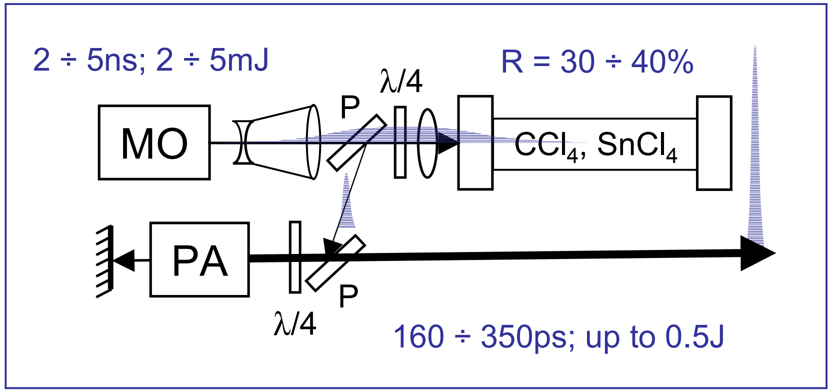
# Formation of the compressed Stokes pulse




V.A. Gorbunov, Sov. J.Quantum Electronics, v.11, p.1368, (1984)

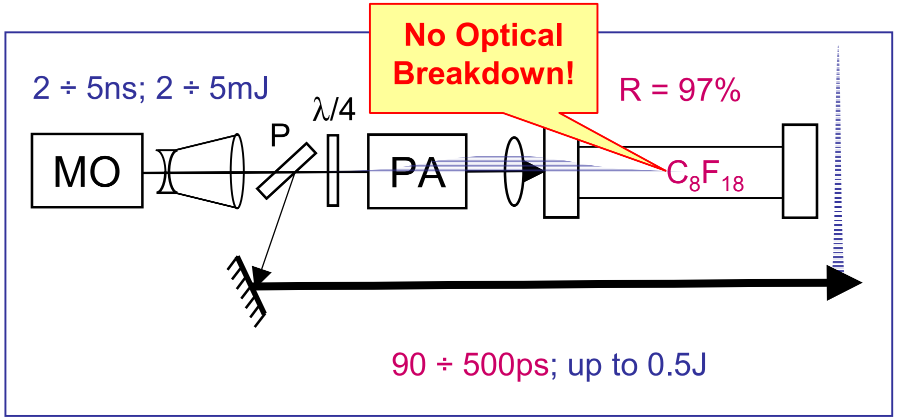
# SBS-compressors schemes:

## Conventional



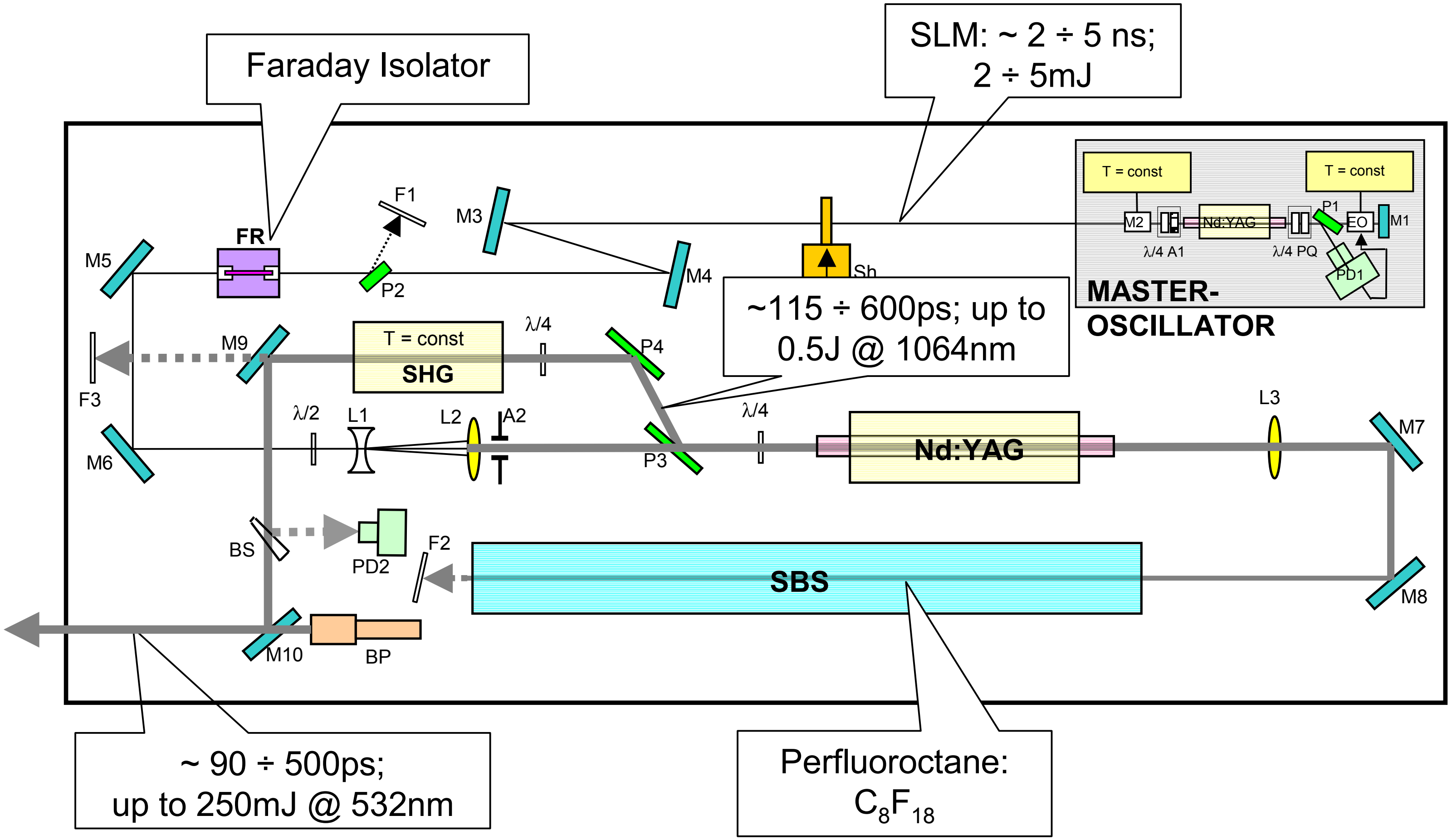

- small SBS-mirror reflectivity
- small amplifier energy extraction
- top-hat output beam profile
- large diffraction distortions
- thermal aberrations in Nd:YAG
- pulse compression up to ~150ps
- energy stability $StDev_{532nm}$ ~6.5%

## New, based on $C_8F_{18}$



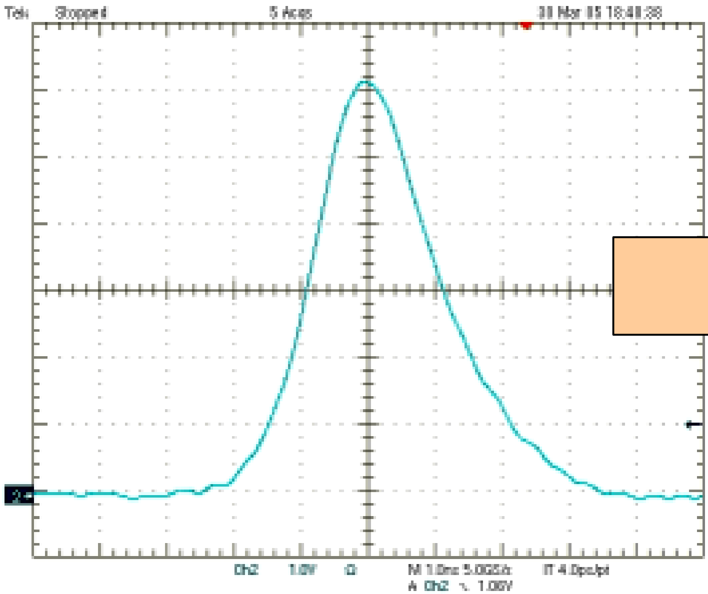

- SBS-mirror reflectivity > 97%
- high amplifier energy extraction
- Gaussian output beam profile
- smooth, diffraction-free beam
- phase-conjugated beam
- pulse compression up to ~90ps
- energy stability $StDev_{532nm}$ ~3%

# Optical Scheme



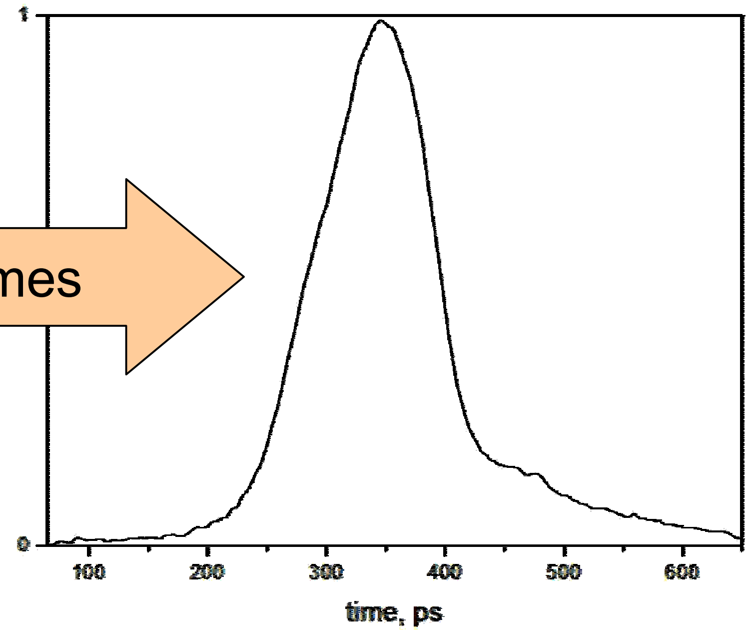
# Pulse compression

From MO: ~2ns, SLM



Tektronix, 1GHz

After SBS-Amplifier-Compressor: ~110ps

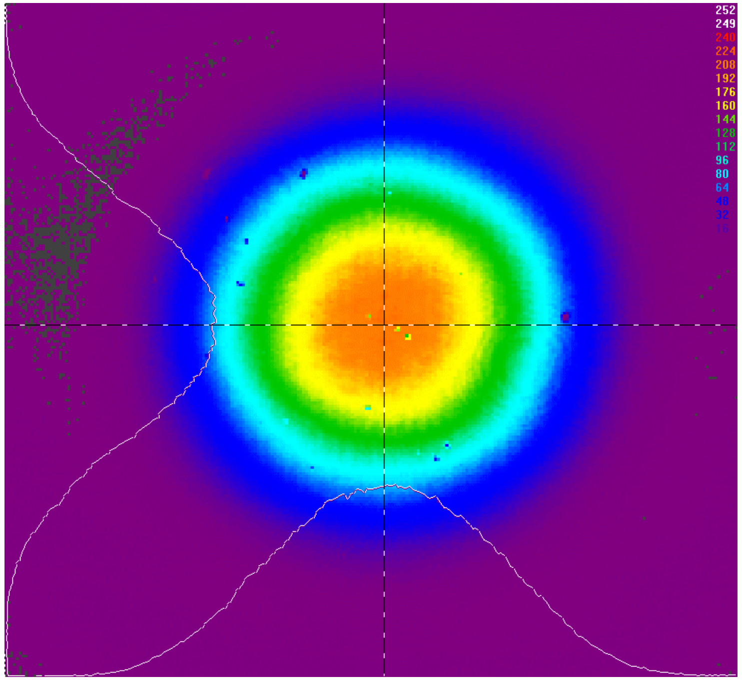


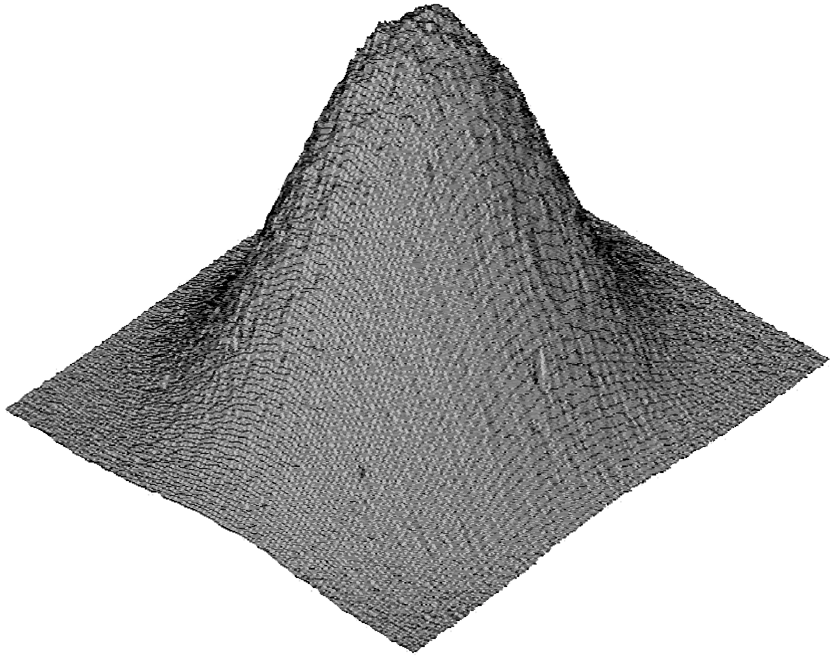

18 times

Hamamatsu, 2ps

# Transverce beam distributions

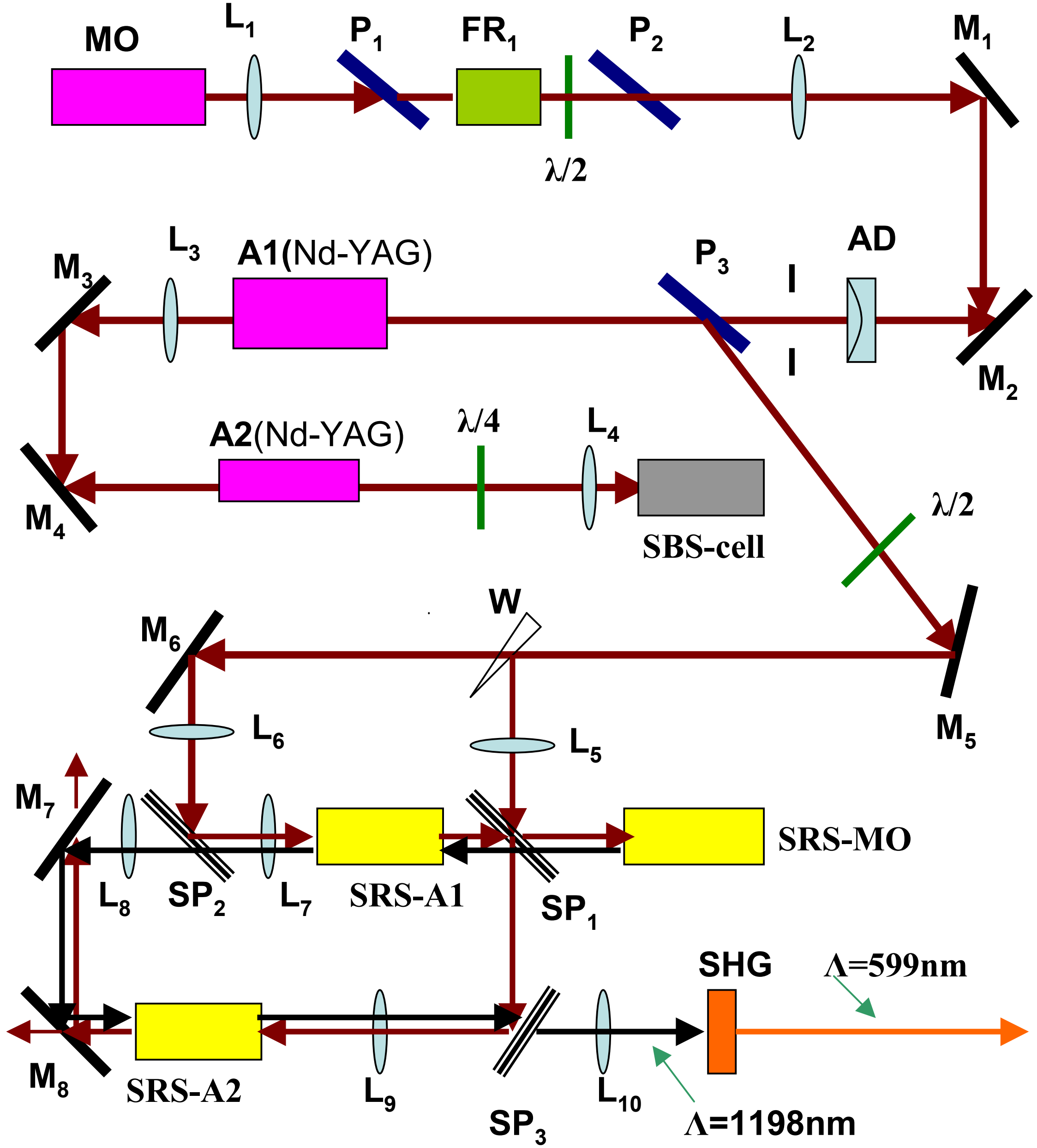
## after SBS-compressor-amplifier



~200mJ; 1064nm
Gaussian Factor: >87%

# SBS and SRS-pulse compressed laser




$W_{1,06} = 200$ mJ, $\tau_и = 0.33$ ns

$W_{1,198} = 100$ mJ, $\tau_и = 30$ ps

$W_{0,599} = 50$ mJ, $\tau_и = 30$ ps

**SBS-cell:** $SiCl_4$ L = 40 cm

**SRS-MO:** $Ba(NO_3)_2$

$W_{пор} \approx 0{,}1$ mJ

**SRS-A1,2:** $Ba(NO_3)_2$

g = 11cm/GW,

$\Delta\nu = 1048$ cm$^{-1}$

**Compression geometry:**

$L/l_f = M$, $\tau_и = 2L/v$,

# Altay Optical\Laser center

Institute for Precision Instrument Engineering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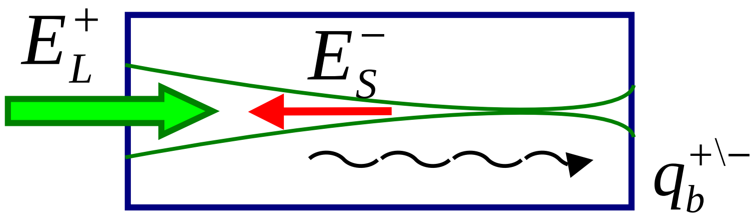
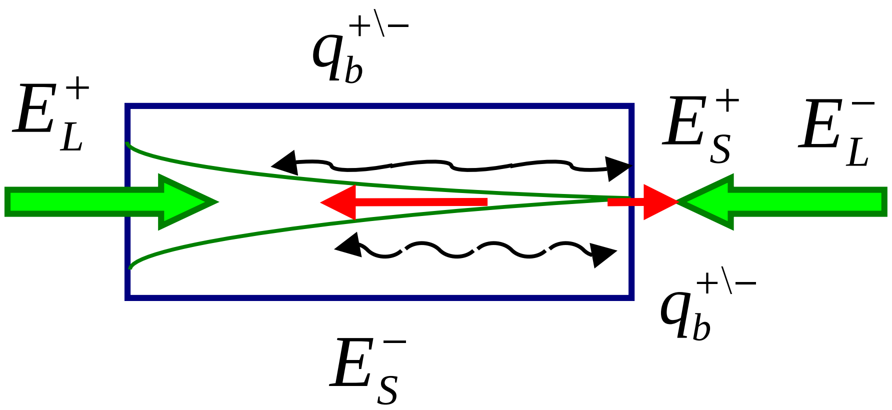
# Interaction geometry

- usual (one pump beam) SRS pulse compression

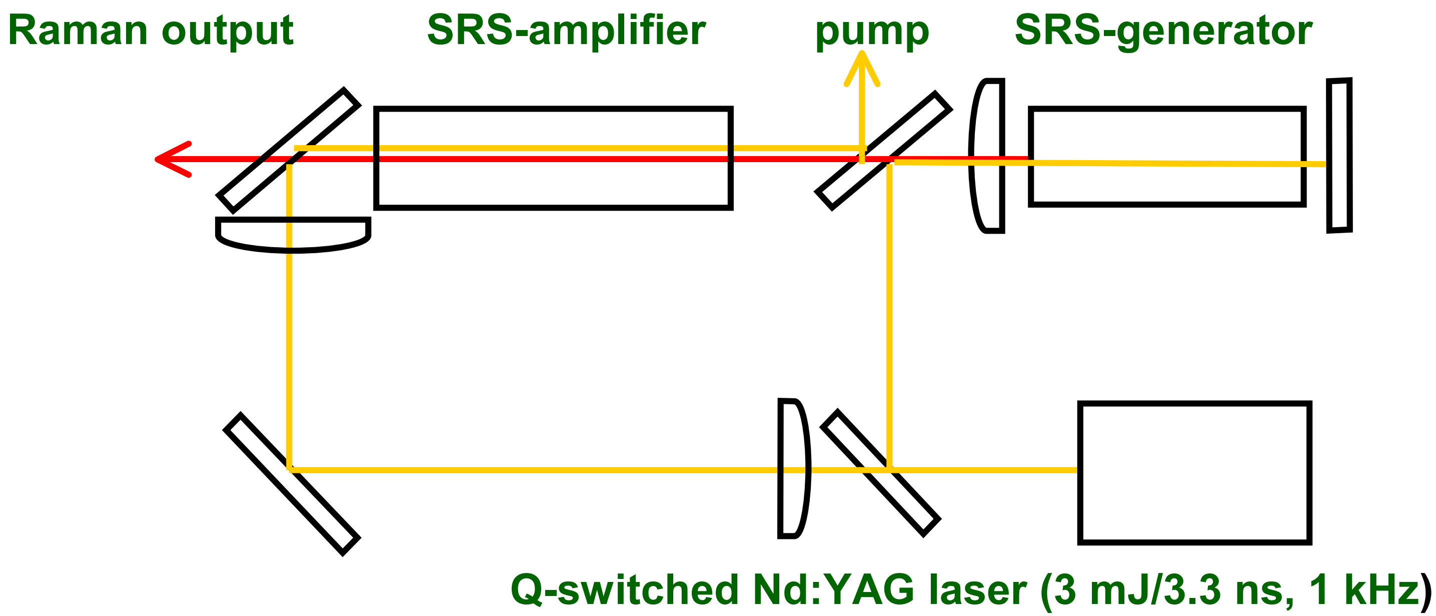


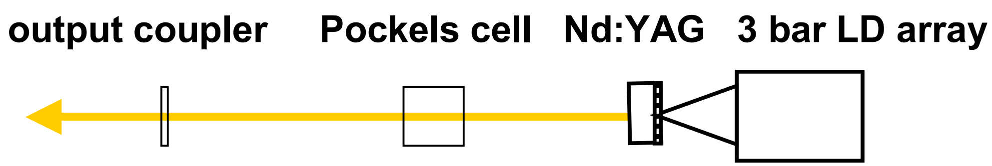

- two pump beam SRS pulse compression




O.V. Kulagin, A.K. Kotov, G.A. Pasmanik, CLEO Pacific Rim, Proceedings, v.2, p.475, (2003)

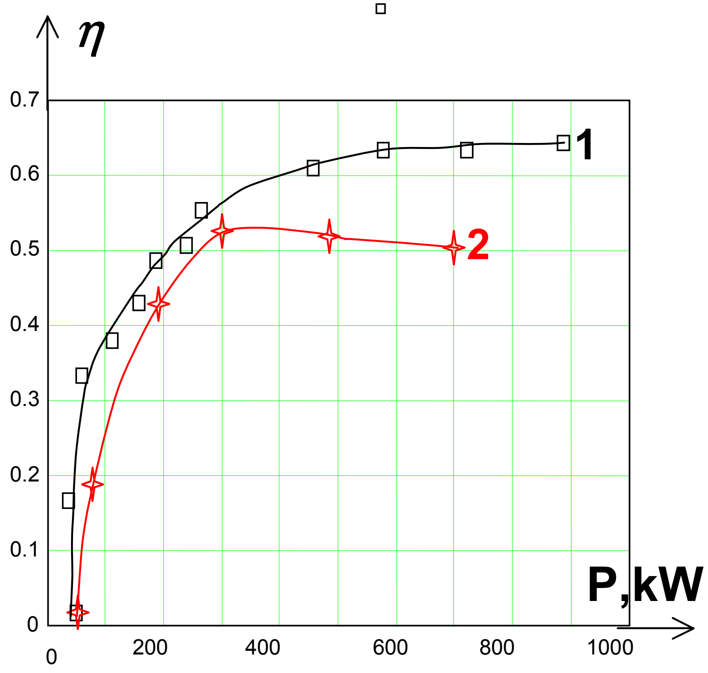
# Experimental scheme of SRS-oscillator + SRS-amplifier



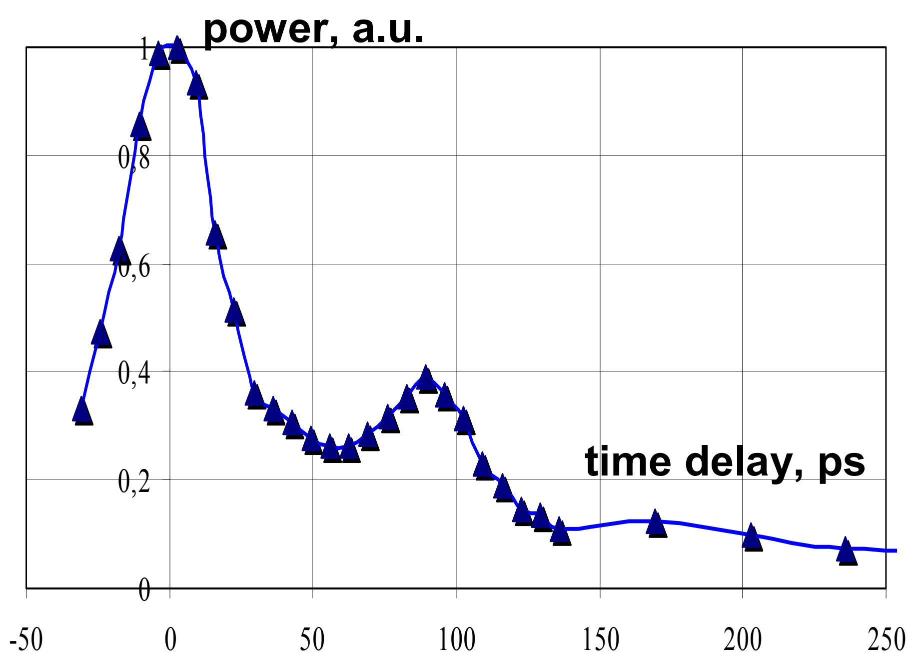



# Two-pump SRS-compression efficiency

- Raman conversion efficiency $\eta$ vs. the peak power of the pump pulse (**1** - 100 Hz, **2** – 1kHz)

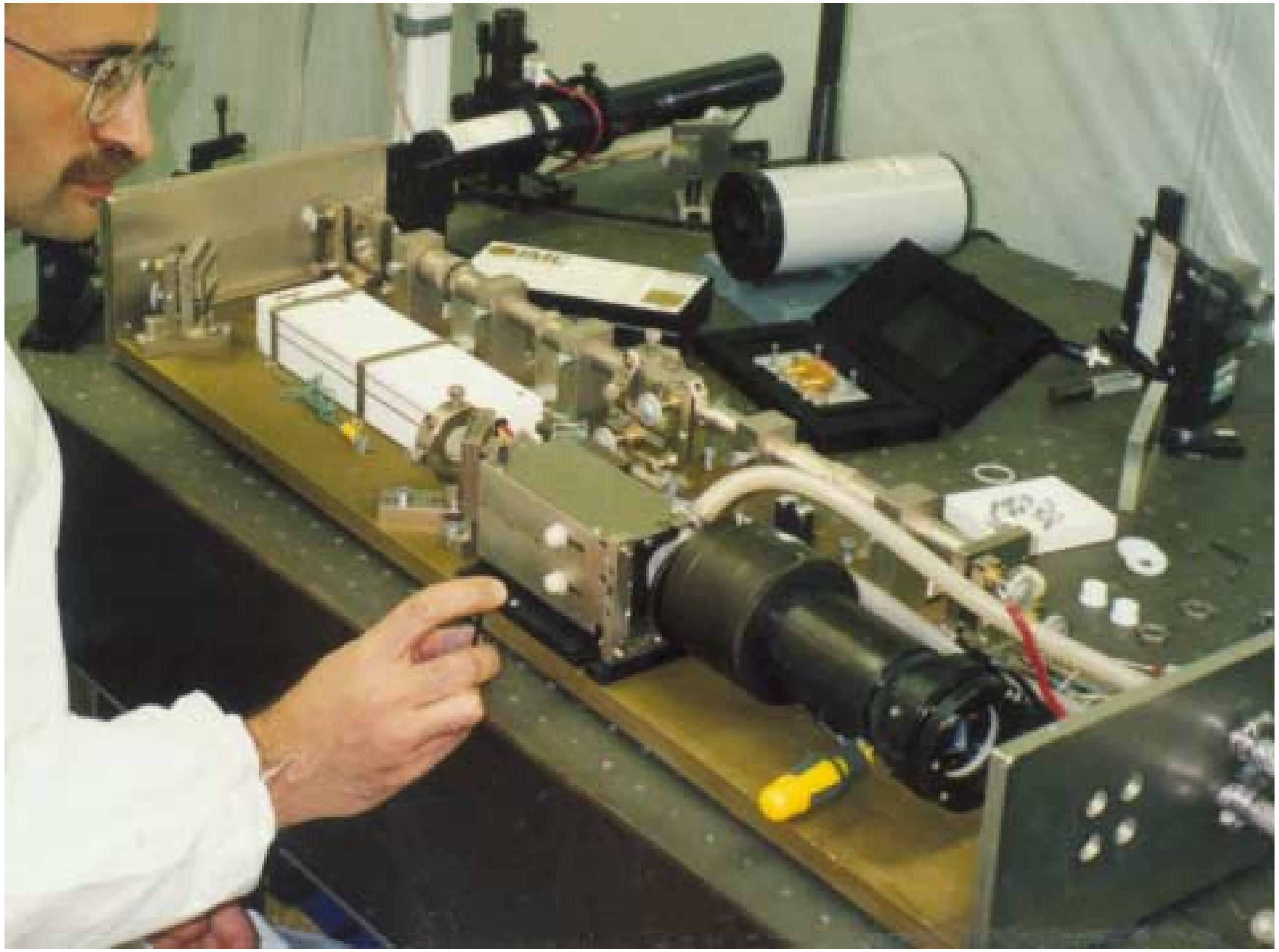



- Autocorrelation function of SRS output radiation



# Compact diode-pumped picosecond Raman laser

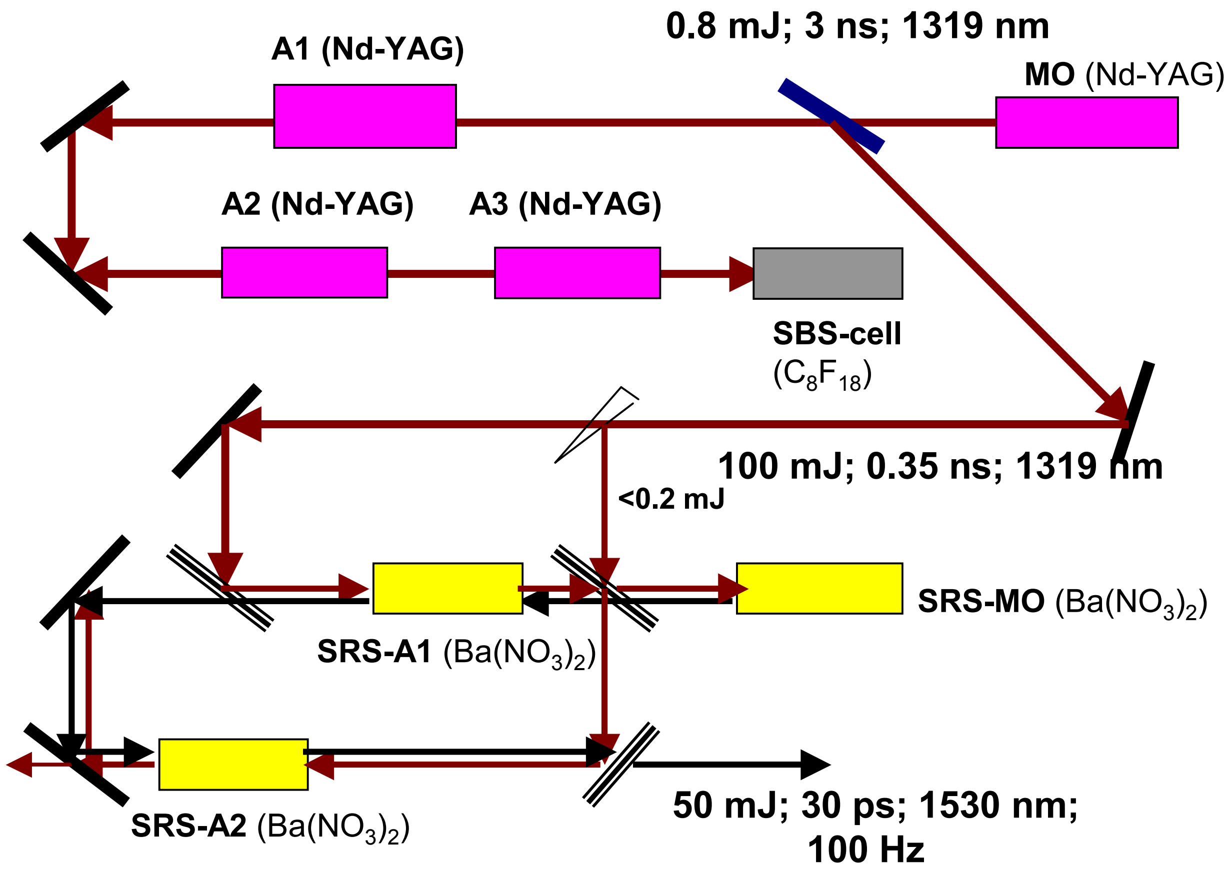
- $W \sim 0.8\text{-}1\,\mathbf{mJ}$
- $\tau = 25\ \mathbf{ps}$
- $f = 1\ \mathbf{kHz}$
- $M^2 \sim 1.1$
- $\lambda = 1.2\ \mu\mathbf{m}$



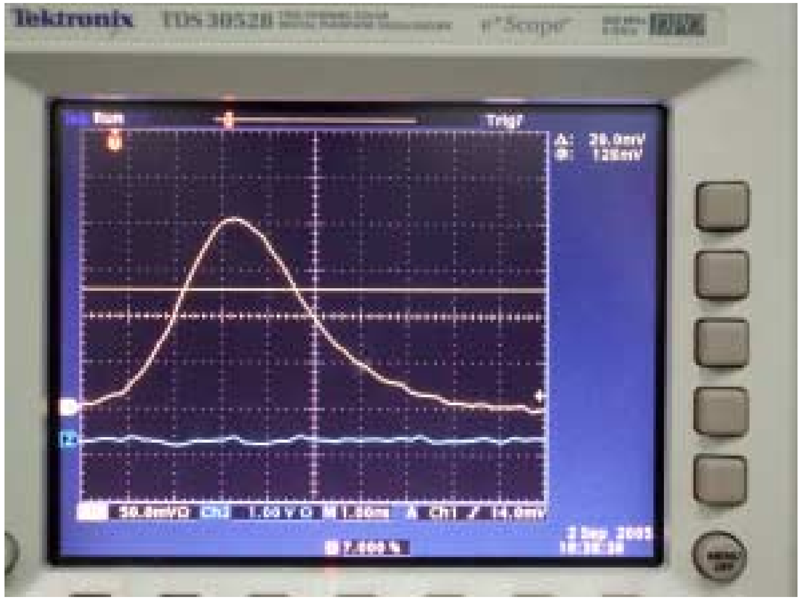
# Mobile Laser Tracker Quantification Of Flight Dynamics

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company,
for the United States Department of Energy's National Nuclear Security Administration
under contract DE-AC04-94AL85000.

# Picosecond eye-safe laser



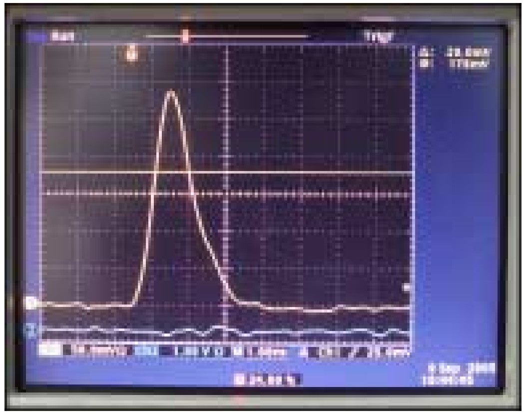
# Output parameters of Nd:YAG master oscillator for 1318 nm



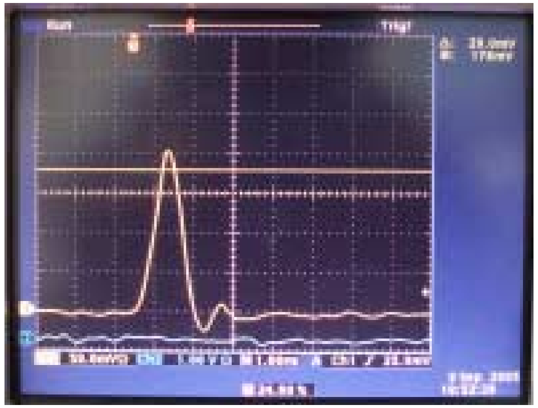

Spectrum analyzer systematic error....≈ +2.6 nm

- pulse energy……………....up to 0.82 mJ (at R.M.S. deviation < 0.5%);
- pulse width…………….......3.0-3.6 ns;
- near diffraction-limited single-mode and single-frequency generation
- pulse repetition rate………1-100 Hz

# Generation of 1.5μm-radiation via SRS in $CH_4$ and $Ba(NO_3)_2$

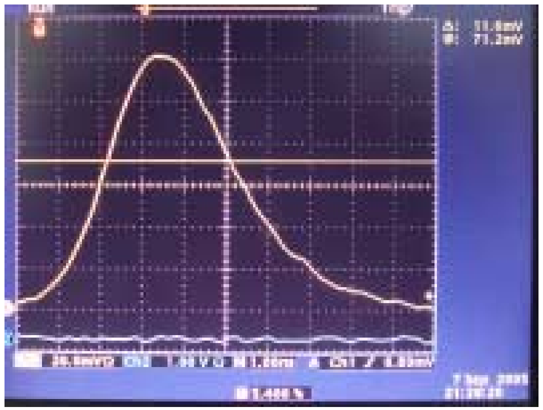


Methane,
P = 8 MPa:
$\lambda_P = 1.064\ \mu m$
$\tau_P \sim 1.1$ ns
$W_{th} \approx 1.9$ mJ
$\lambda_{SRS} = 1.543\ \mu m$
$\tau_{SRS} < 0.8$ ns



Pump pulse

Compressed Raman pulse



Barium nitrate:
$\lambda_P = 1.319\ \mu m$
$\tau_P \sim 3.5$ ns
$W_{th} \approx 0.4$ mJ
$\lambda_{SRS} = 1.530\ \mu m$
$\tau_{SRS} < 0.8$ ns