

Coherent addition of ultrashort laser pulses:

1. Motivation
2. The new approach
3. Conditions for high combining efficiency
4. Polarization combining
5. proof of concept setup
6. next steps

1. Motivation

State of the art:

High power ultrashort pulse systems

- High **average** power(**100W to KW**):

e.g. Fibre lasers

Eidam et. all "Femtosecond fiber CPA system emitting 830 W average output power,"

- High **peak** power (**TW to PW**):

e.g. Ti:Sapphire lasers

ICUIL "International Committee on Ultra-High Intensity Lasers,"

➤ **These systems have been pushed to their limitations**

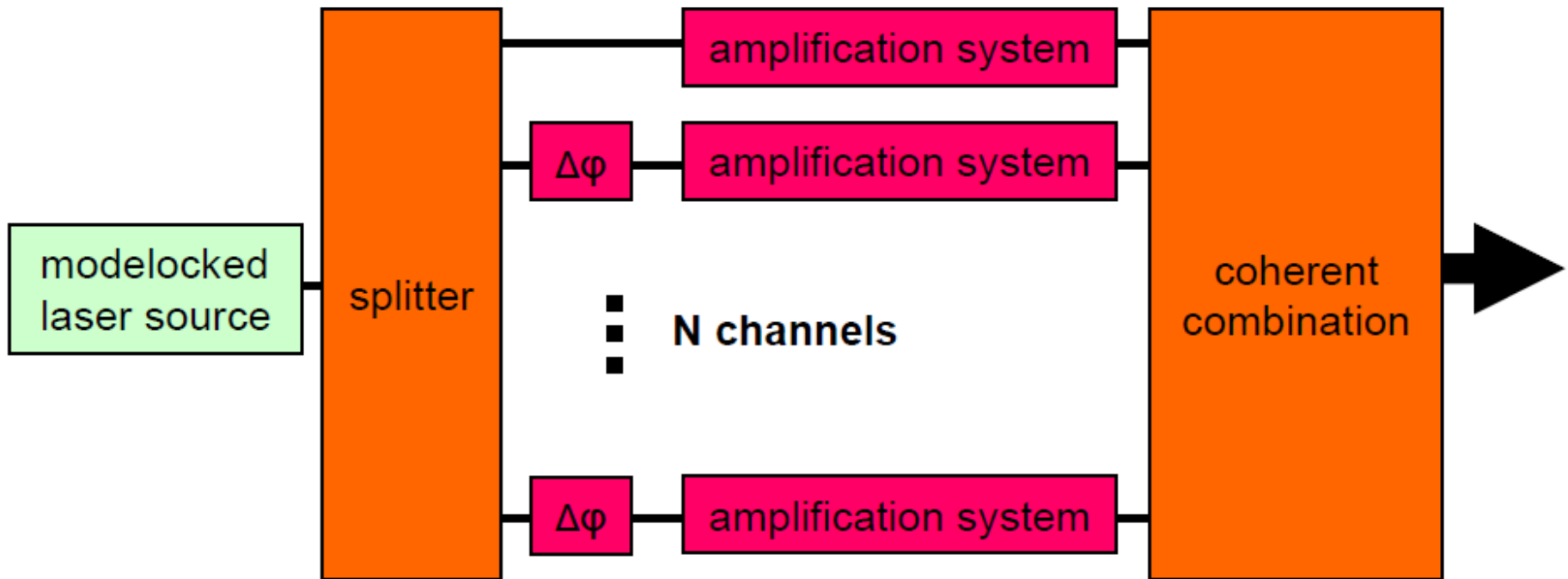
1. Motivation

Scaling of power is limited by:

- Available pump power
- Thermo optical issues
- Damage
- Nonlinearity
- ...

➤ **A new approach for scaling the systems is desired**

2. The new approach



Seise et al. 2017 "Coherent addition of fiber-amplified ultrashort laser pulses", modified

- The output power scales theoretically by the factor N (for ideal combining efficiency)

➤ **High combining efficiency is necessary for a good performance**

2. The new approach

Multi channel approach:

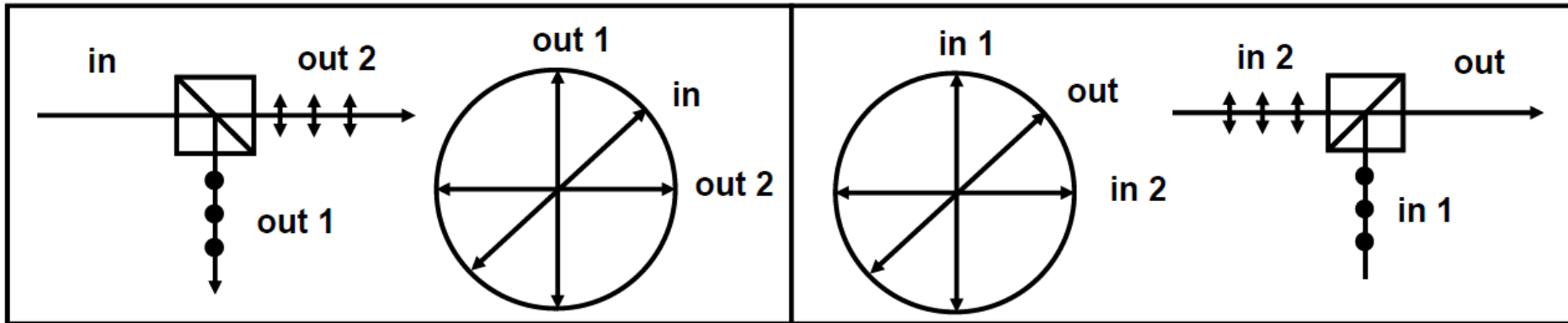
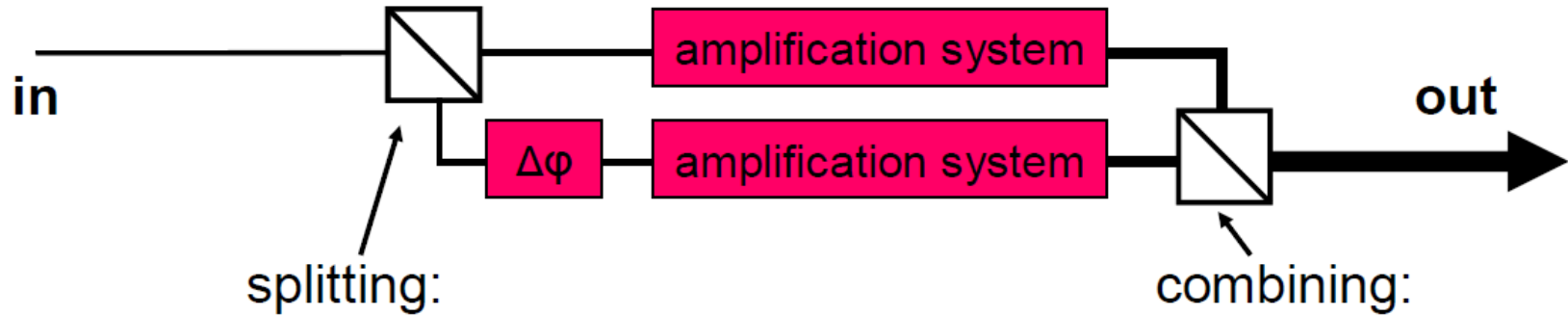
Pro	Contra
<ul style="list-style-type: none">+ Output power scales with the number of channels+ The intensity inside the gain medium can be reduced+ The concept can be applied to different systems, e.g. crystal, fibre, gas, ...	<ul style="list-style-type: none">- A setup with multiple round trip through the same channel was not successfully tested yet.- Getting a high combining efficiency is challenging

3. Conditions for high combining efficiency

- Same optical pathlength for all the channels
- Identical pulses from each channel
 - Spectral amplitude and phase
 - Spatial intensity profile
- Each channel has independent sources of noise
 - **active stabilization is required**

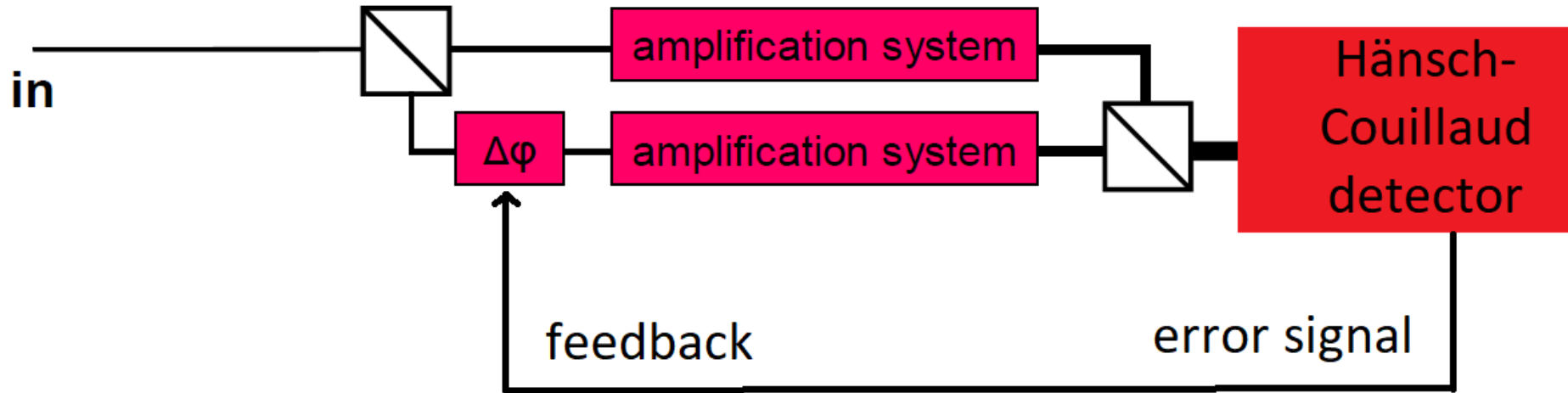
➤ **The combined output should not be distinguishable from a single emission**

4. Polarization combining



Seise et al. 2017 "Coherent addition of fiber-amplified ultrashort laser pulses"

4. Polarization combining



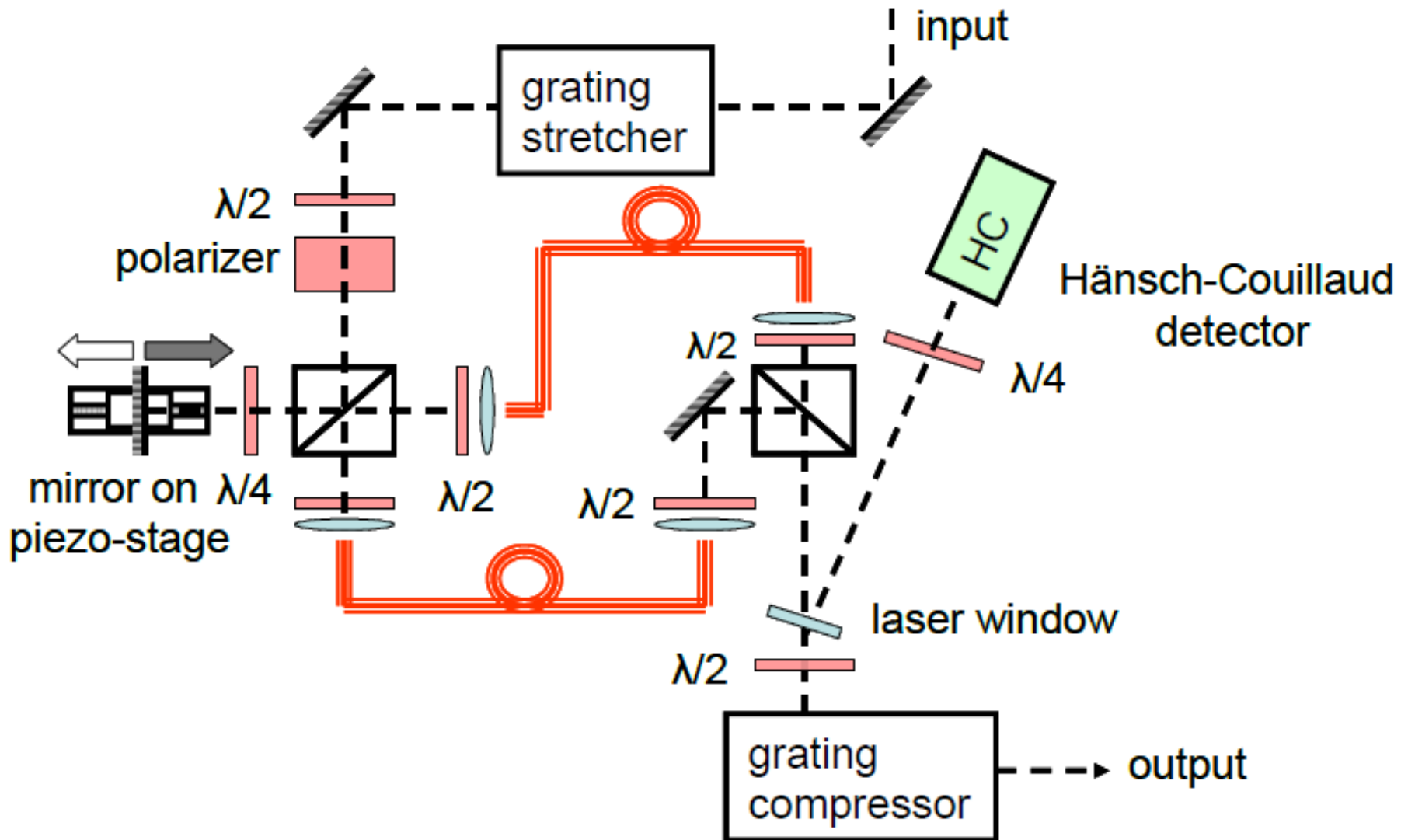
Seise et al. 2017 "Coherent addition of fiber-amplified ultrashort laser pulses", modified

Linear Polarization \rightarrow error signal = 0

elliptical Polarization \rightarrow error signal \neq 0

➤ A control loop stabilizes the synchronisation of the channels

5. proof of concept setup



Seise et al. 2017 "Coherent addition of fiber-amplified ultrashort laser pulses", modified

5. proof of concept setup

Performance of the system:

- The system only has mW

- combining efficiency = $\frac{P_{out}}{P_{channel1} + P_{channel2}} = 97\%$

6. next steps

- More channels
- Other types of gain medium
- For fibers: multicore fibres
- More power
- Shorter pulses

➤ **More research is needed for making the concept useful for research or industry. Anyway it has a great scaling potential**

Thank you!

Figures for questions

