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Pulse Stacker for the Photoinjector Laser System

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- Principles
- Measurements with the TTF1 laser

Thanks to Knut Partes and Karsten Klose for their participation in this work

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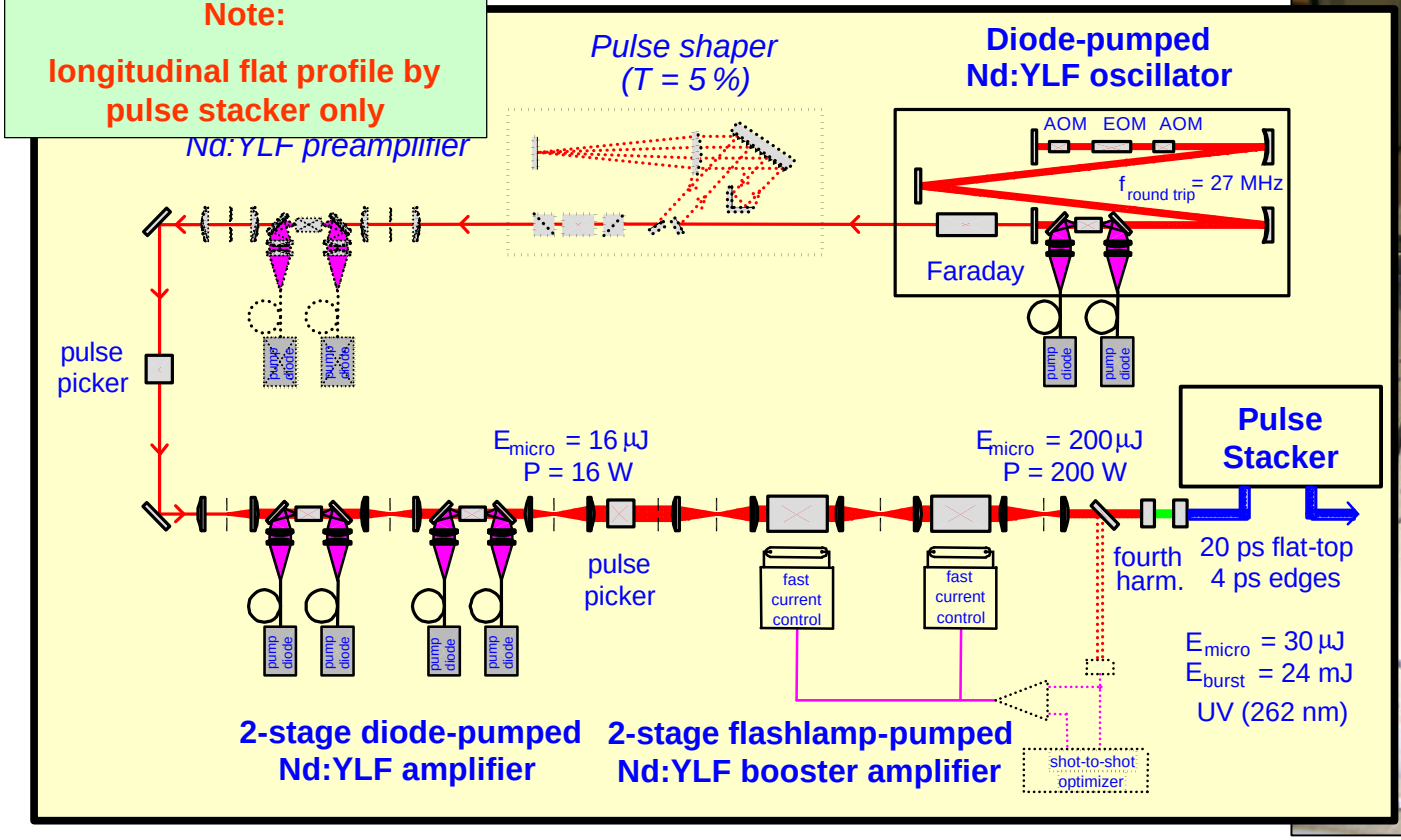
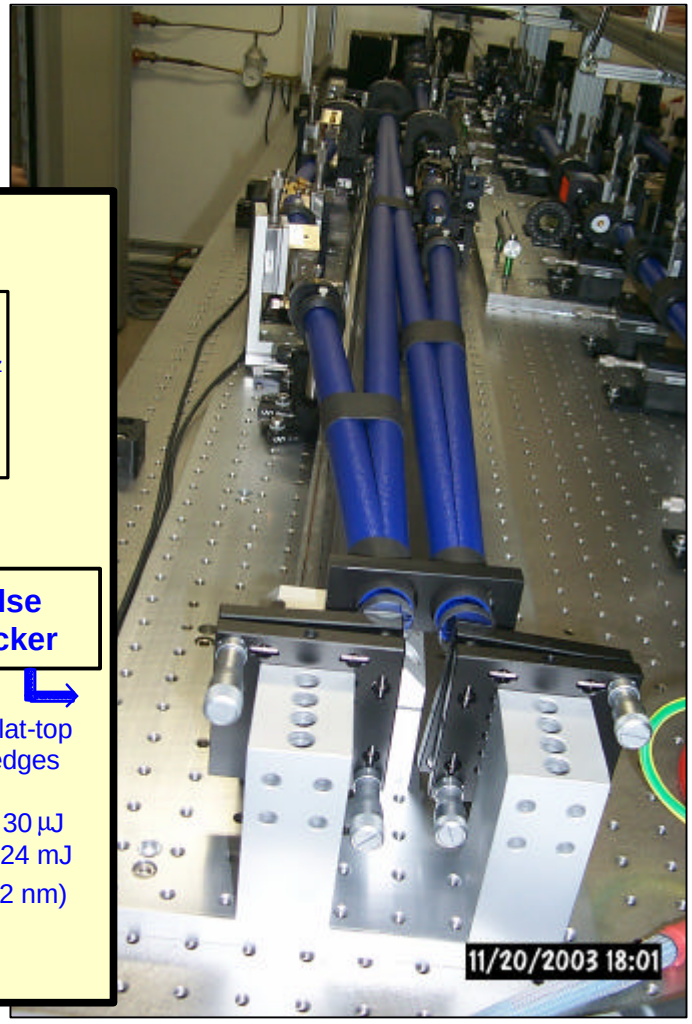
TTF 2 Laser Upgrade

- Together with Max-Born-Institute, Berlin (I. Will et al.)
- Upgrade has been tested at PITZ

Note:

longitudinal flat profile by pulse stacker only





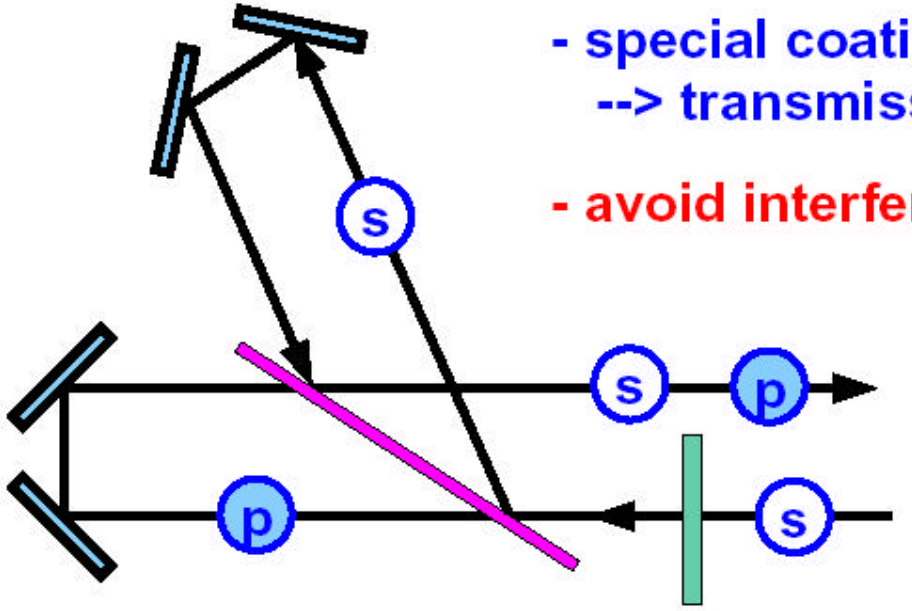
Why do we need a stacker?

- First, as a guideline, the transverse emittance is smaller for rectangular shaped bunches in both planes, longitudinal and transverse.
  A gaussian shaped bunch has a different space charge behavior in its core as in its wings.
- Second, in contrast to TTF1, the laser now is prepared to reach the design goal, a 20 ps flat-hat pulse with sharp rise times.
  Thus, its pulses are still gaussian, but shorter, by a factor of 2 compared to TTF1 (estimate sigma of 3.5 ps)
- To reduce space charge effects, flat-hat pulses are required, even without a 3rd harmonic cavity
- Open is, to which extend we should stack, probably a 10 ps flat-hat is sufficient.

The Splitting Principle

- Splitter at Brewster angle (56 dg)
  --> reflectivity for s-pol 100 %
- special coating:
  --> transmission for p-pol close to 100%

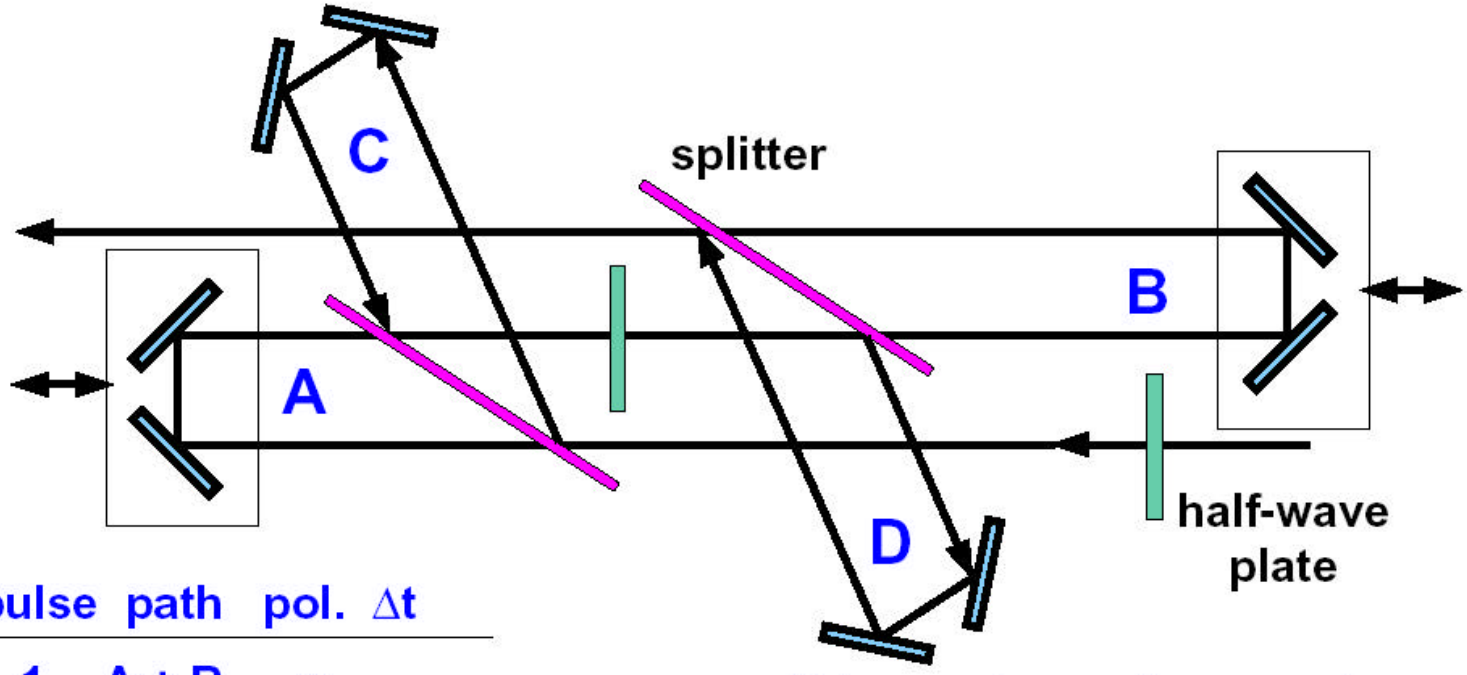
- avoid interference by alternating s and p



- incoming beam
  is linear polarized,
  eg. s-pol

- half-wave plate to turn polarisation
  by 45 dg

Stacker for Four Stacked Pulses



pulse	path	pol.	Δt
1	A + B	p	
2	A + D	s	D-B
3	C + B	p	(C-A)-(D-B)
4	C + D	s	D-B

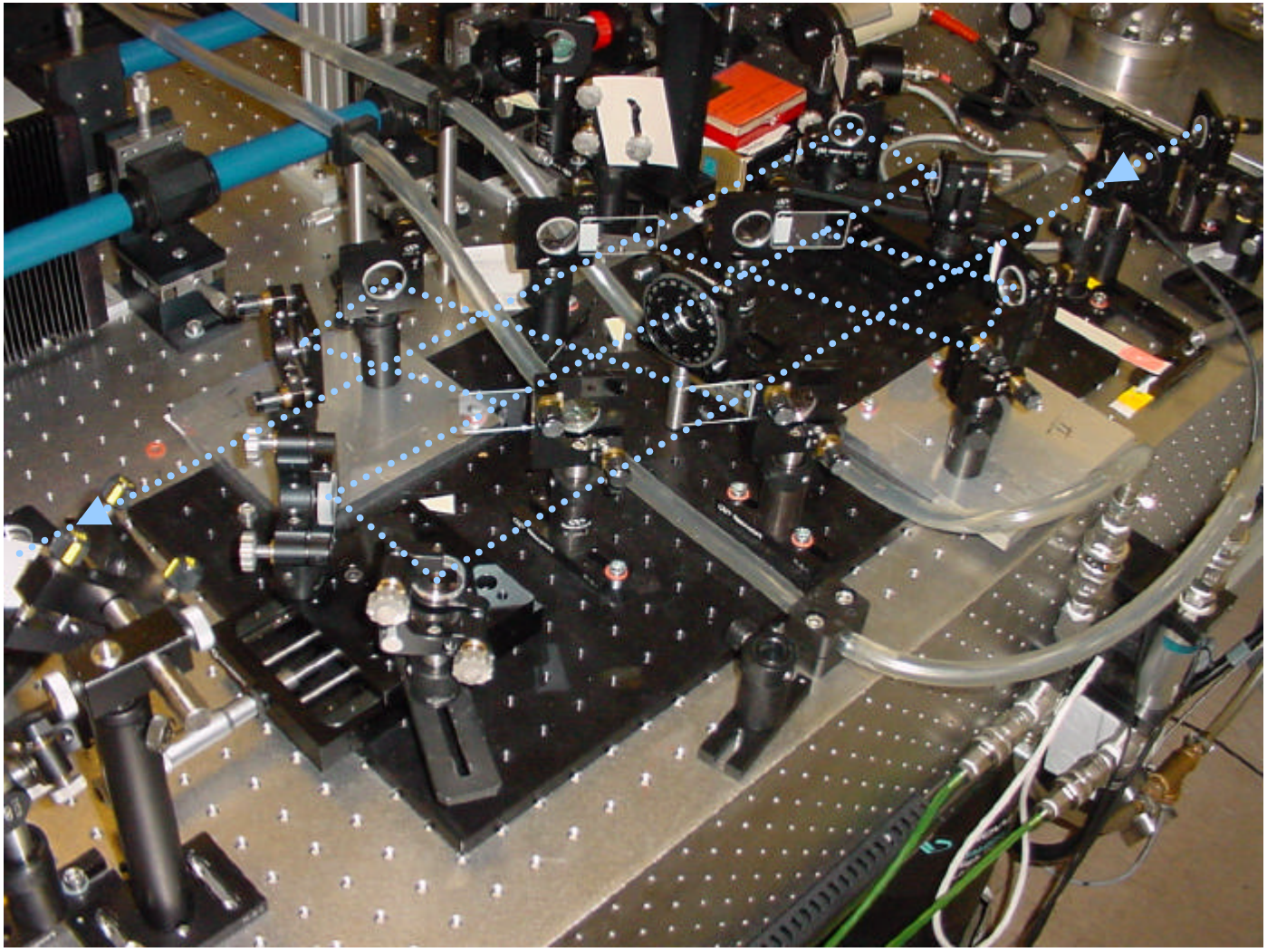
condition, to have all Δt equal:

A = C - 2(D-B)

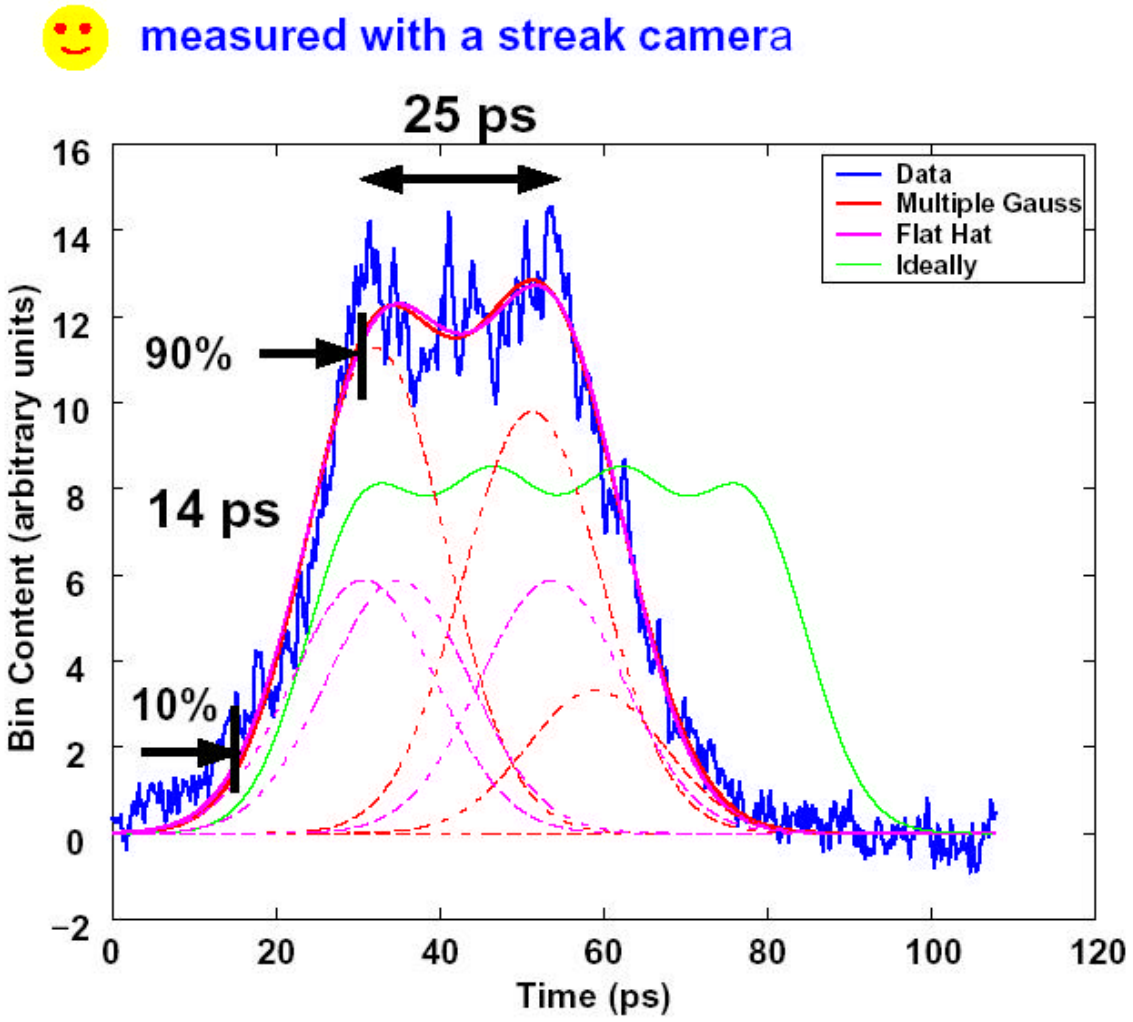
for C=D -> A = 2B-D

and D/2 < B < D

Pulse Stacker set-up on the laser table



Example of a Measured Profile (7 ps laser)



Fits:

1. four gaussians,
   σ same for all 4
2. flat hat
   σ and intensities
   are the for same for all

Ideal profile:

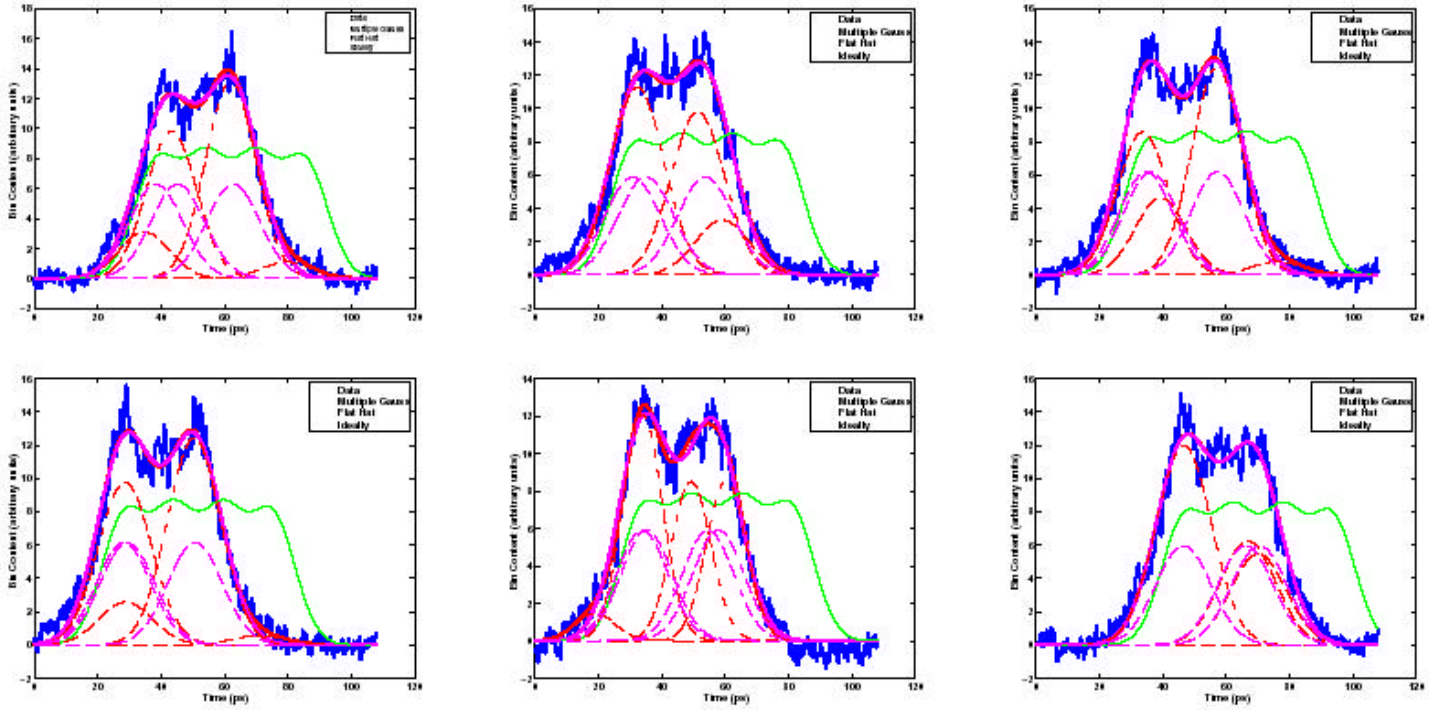
distance of pulses = 2.25 σ
σ = 7 ps

Results:

from flat hat fit:
- rise time = 14.8 ps
- flat top width = 23 ps

from multiple gauss fit
(same sigma for each gauss):
- rise time = 14.2 ps
- flat top width = 27 ps

Series of Measured Profiles



- problem:
  due to the narrow entrance slit (50 um) of the streak camera,
  inhomogeneities in the transverse laser profile translate into a
  fake amplitude variation of the single pulses during the measurement

-> the streak measurement does not give a reliable estimate of
flat hat homogeneity

Polarization Imperfection of the Splitters

1. perfect splitter: S=1, P=1

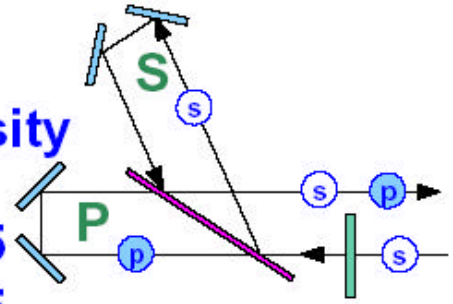
fields $\vec{E} = \begin{pmatrix} s \\ p \end{pmatrix}$

initial field: Ei = 1, 0

Path	pulse path	l/2 angle	field	1st split	field	1st split	field	l/2 angle	field	2nd split	field	2nd split	field	Intensity
1 A+B	1 aBb	22.5	0.71	1	0	1	0	22.5	- 0.5	1	0	1	0	0.25
			- 0.71	1	- 0.71	1	- 0.71		- 0.5	1	- 0.5	1	- 0.5	
2 A+D	2 a+d		0.71	p	0	p	0		- 0.5	s	- 0.5	s	- 0.5	0.25
			- 0.71		- 0.71		- 0.71		- 0.5		0		0	
3 C+B	3 c+b		0.71	s	0.71	s	0.71		0.5	p	0	p	0	0.25
			- 0.71		0		0		- 0.5		- 0.5		- 0.5	
4 C+D	4 c+d		0.71	s	0.71	s	0.71		0.5	s	0.5	p	0.5	0.25
			- 0.71		0		0		- 0.5		0		0	

intensity

0.25 (A+B)
0.25 (A+D)
0.25 (C+B)
0.25 (C+D)



- cure with attenuator in path D
- overall transmission: 4*0.18 = 72 %

2. realistic splitter: S=0.99, P=0.95

half-wave plate angle

initial field: Ei = 1, 0

Path	pulse path	l/2 angle	field	1st split	field	1st split	field	l/2 angle	field	2nd split	field	2nd split	field	Intensity
1 A+B	1 a+b	24	0.67	0.99	0.01	0.99	0	22.5	- 0.47	0.99	0	0.99	0	0.18
			- 0.74	0.95	- 0.71	0.95	- 0.67		- 0.47	0.95	- 0.45	0.95	- 0.43	
2 A+D	2 a+d		0.67	p	0.01	p	0		- 0.47	s	- 0.47	s	- 0.46	0.22
			- 0.74		- 0.71		- 0.67		- 0.47		- 0.02		0	
3 C+B	3 c+b		0.67	s	0.66	s	0.66		0.46	p	0	p	0	0.18
			- 0.74		- 0.04		0		- 0.47		- 0.44		- 0.42	
4 C+D	4 c+d		0.67	s	0.66	s	0.66		0.46	s	0.46	p	0.45	0.21
			- 0.74		- 0.04		0		- 0.47		- 0.02		0	

0.18 (A+B)
0.22 (A+D)
0.18 (C+B)
0.21 (C+D)

Summary

- The pulse stacker has been set-up and tested with the TTF1 laser system
- Transmission efficiency about 75 %
- It will be used until the MBI pulse shaper is ready to be installed at DESY
- May stack 2 or 4 pulses or may be bypassed allover
- Measurements of the longitudinal electron bunch shape for different stacker settings required.
  However, once set-up, no or little adjustments required occasionally