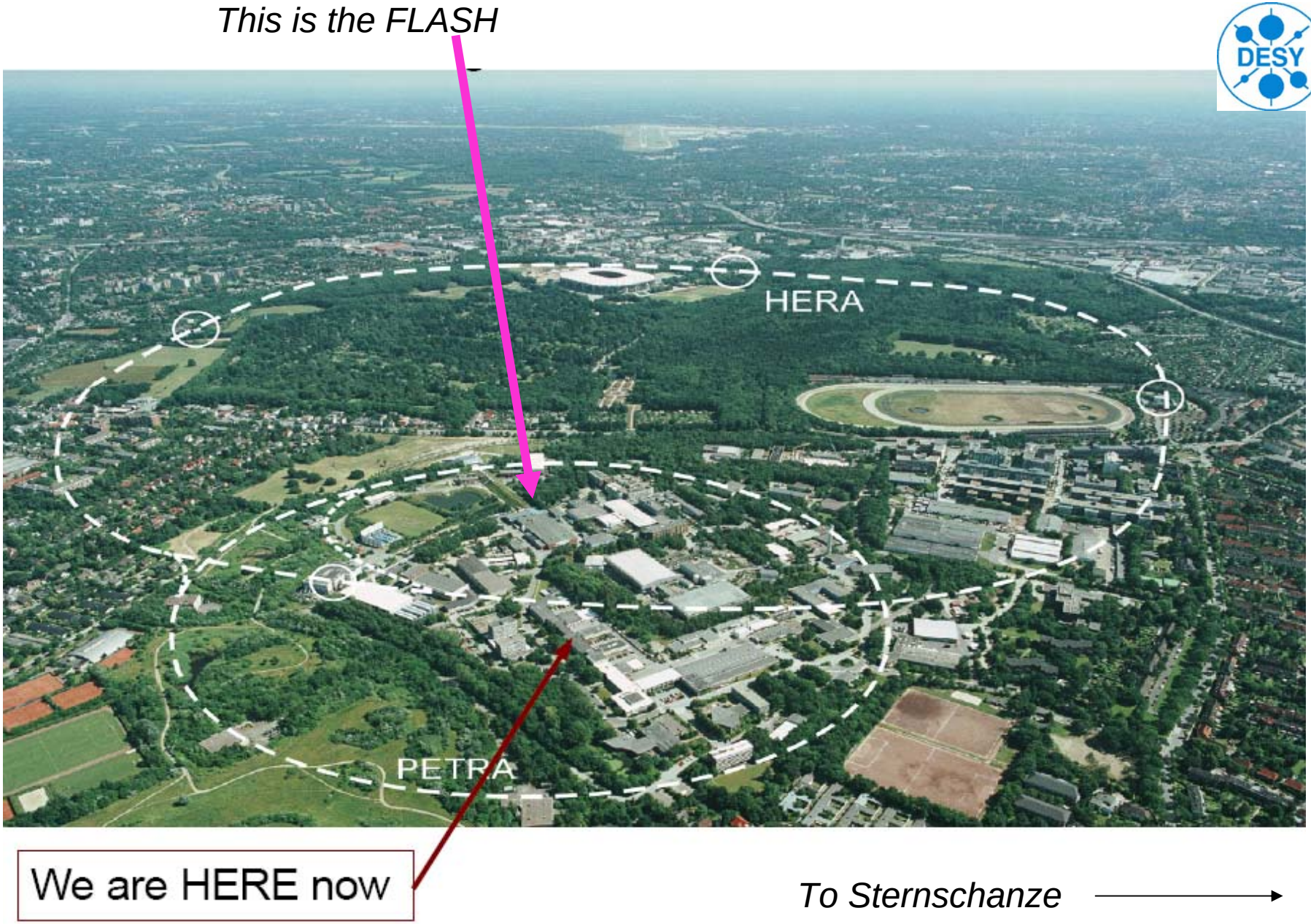
Measuring ultrashort laser pulses

Alejandro Guzman

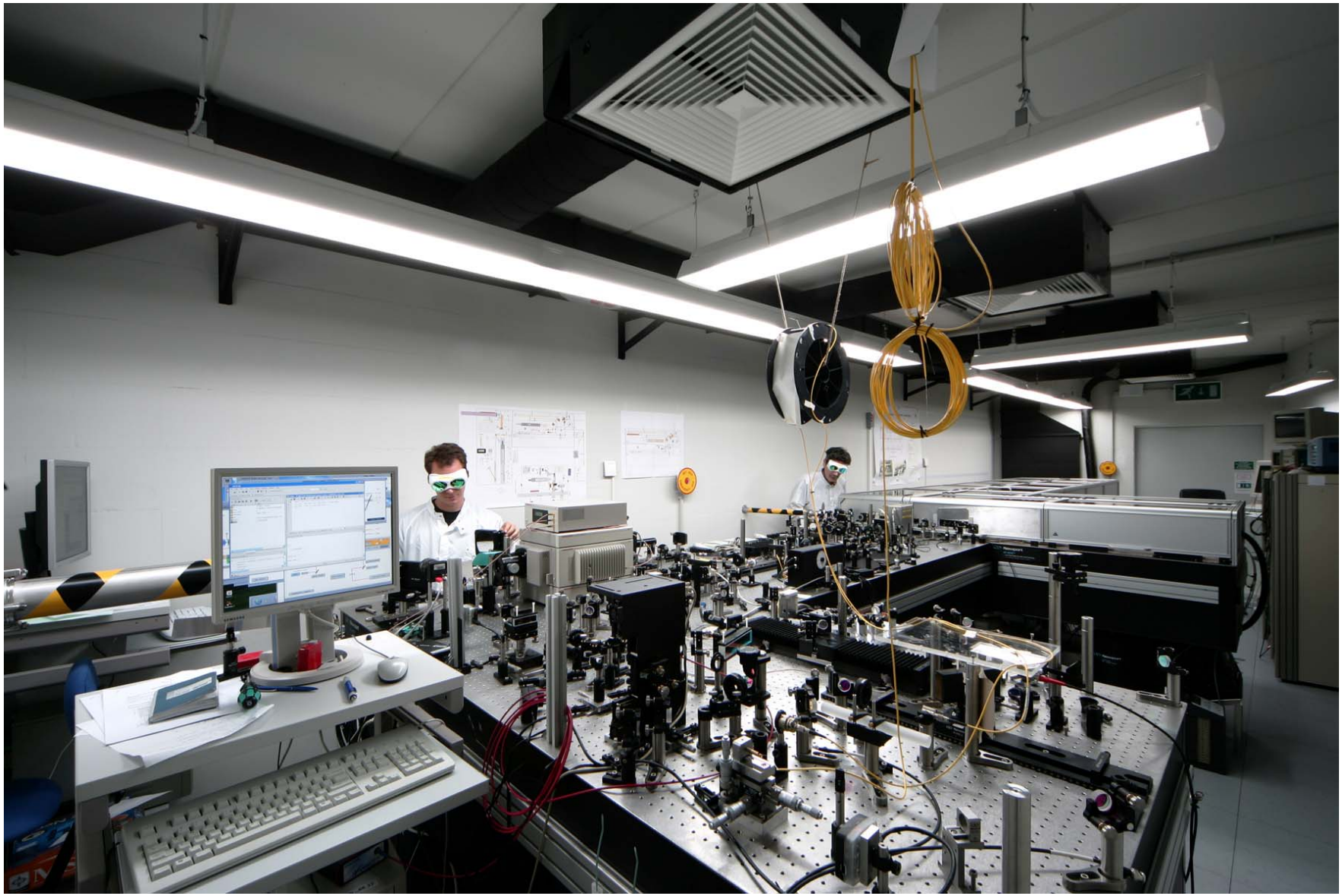
The Earth

Germany

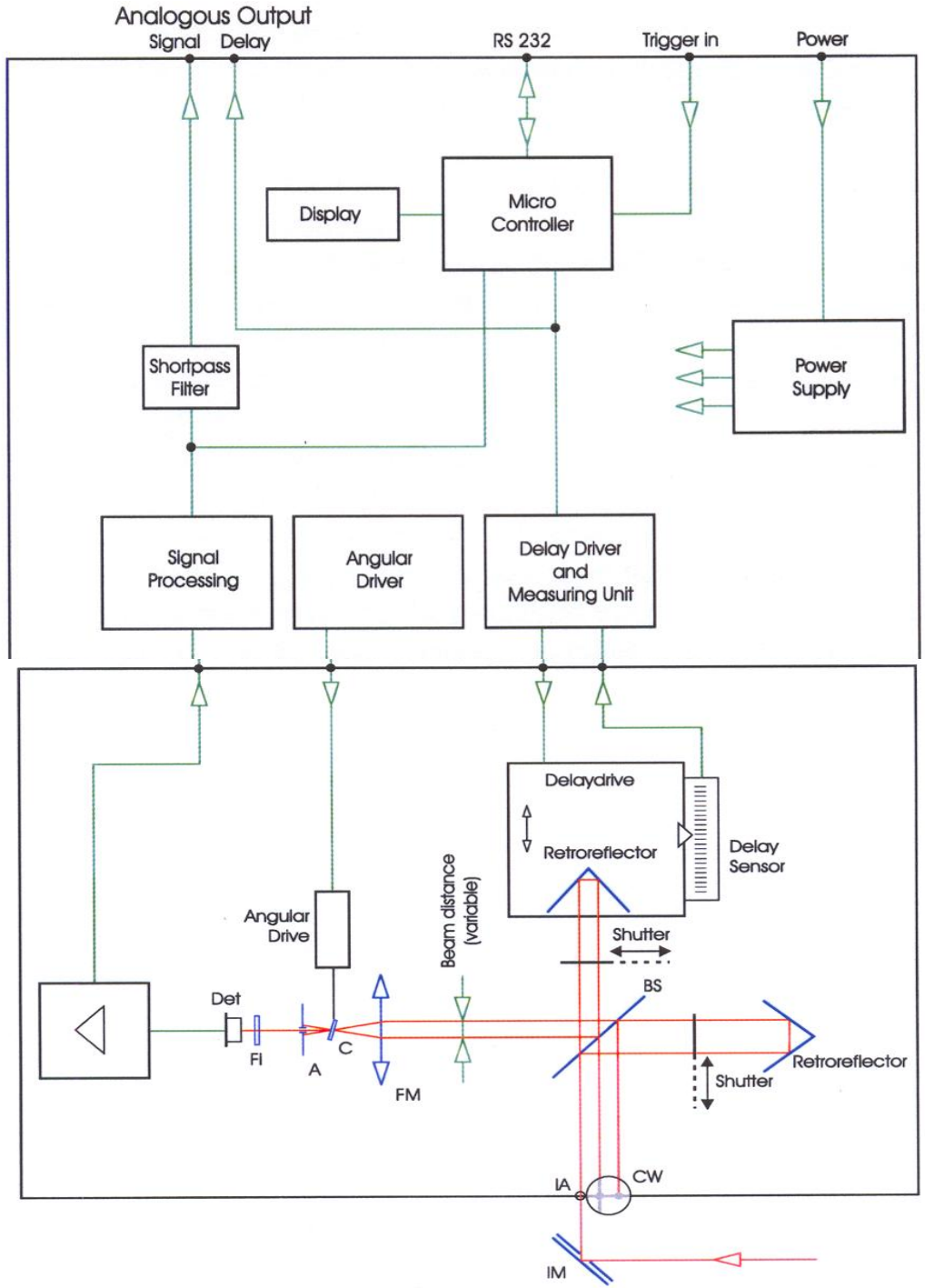
Hamburg


This is the FLASH
HERA
PETRA
We are HERE now
To Sternschanze

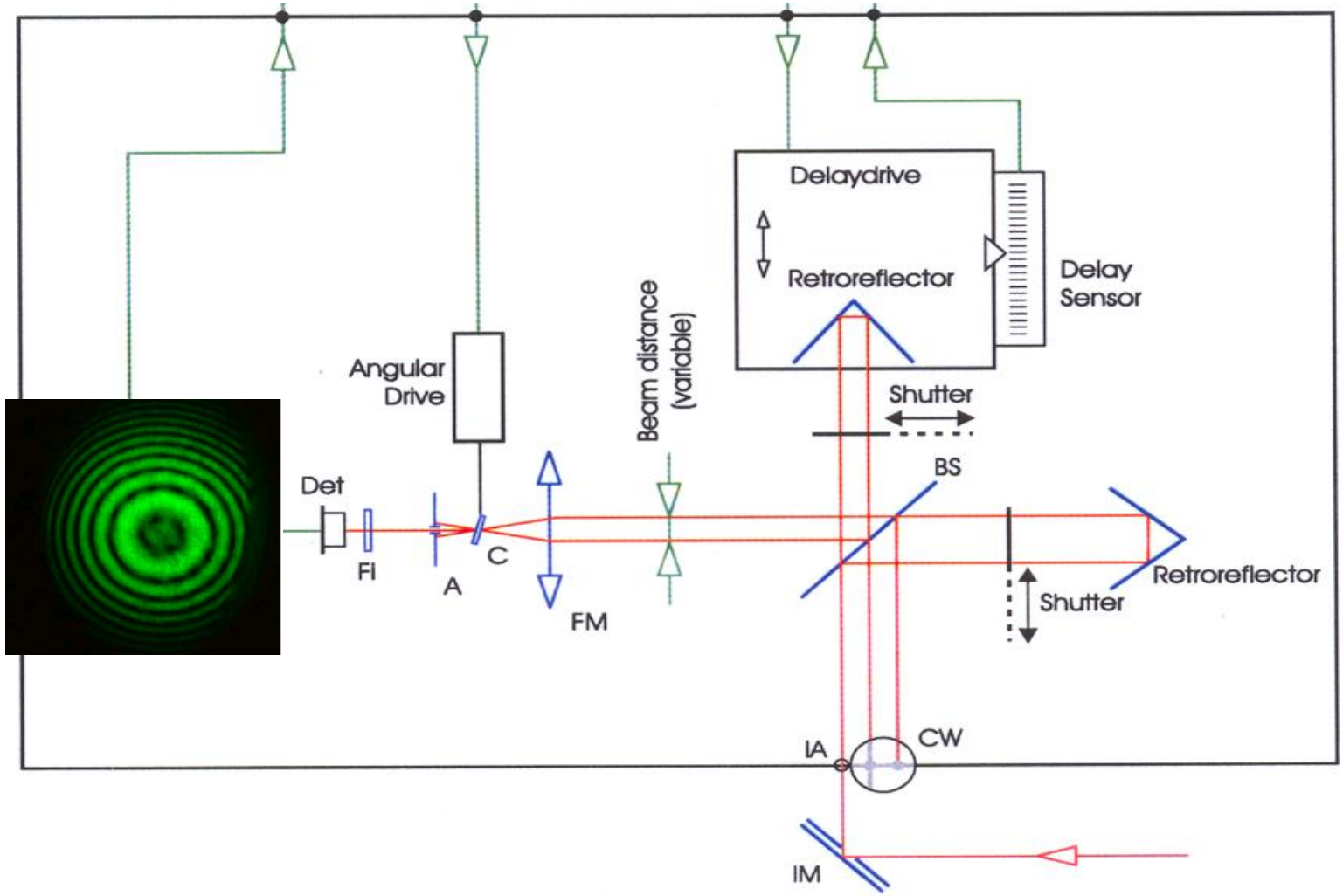
The laser system …



The Autocorrelator


Analogous Output
Signal
Delay
RS 232
Trigger in
Power
Display
Micro Controller
Shortpass Filter
Power Supply
Signal Processing
Angular Driver
Delay Driver and Measuring Unit
Delaydrive
Retroreflector
Delay Sensor
Angular Drive
Beam distance (variable)
Shutter
BS
Det
FI
A
C
FM
Shutter
Retroreflector
IA
CW
IM

The Autocorrelator (inside out)



Second harmonic generation

In any media: $\mathbf{D} = \varepsilon_0 \mathbf{E} + \mathbf{P}$

In linear media: $\mathbf{P} = \chi \varepsilon_0 \mathbf{E}$

$\mathbf{D} = \varepsilon_0 \mathbf{E} + \chi \varepsilon_0 \mathbf{E} = \varepsilon_0 (1 + \chi) \mathbf{E}$

But in a SHG crystal, the polarization (**P**) is also proportional to the square of the electric field (E), in fact the a more general expression for P would be:

$$P = \varepsilon_0 \sum_i \chi_i E^i$$

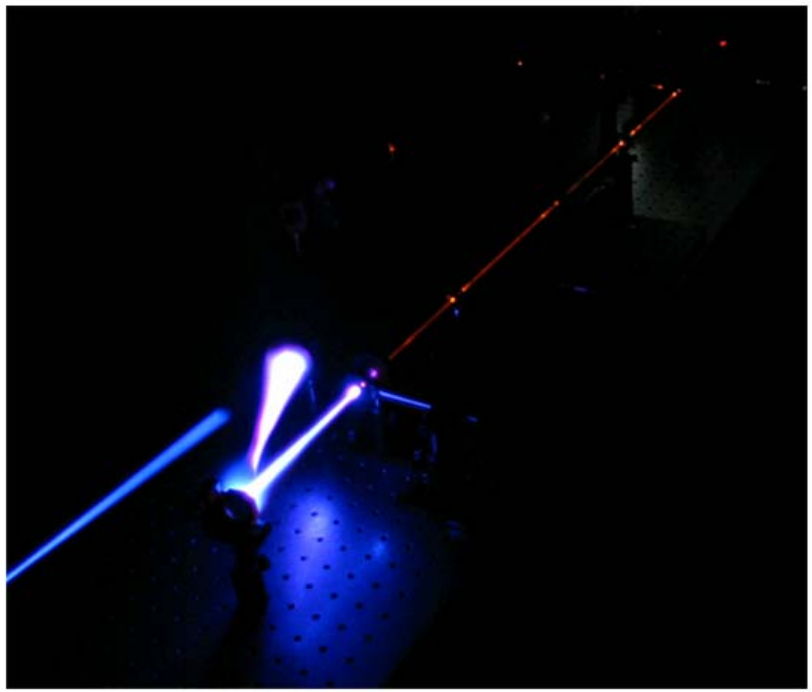
In this case we only take the first 2

$$P = \varepsilon_0 \chi_1 E + \varepsilon_0 \chi_2 E^2$$

For example take an electric field oscillating in time:

$$E(t) = E_0 e^{i(wt+\phi)} \Rightarrow P(t) \propto (E_0 e^{i(wt+\phi)})^2$$

The physical mechanism behind frequency doubling can be understood as follows. Due to the χ_2 nonlinearity, the incident wave generates a nonlinear polarization wave which oscillates with twice the incoming frequency. According to Maxwell's equations, this nonlinear polarization wave radiates an electromagnetic field with this doubled frequency.



$$P(t) \propto (E_0 e^{i(wt+\phi)})^2$$

$$P(t) \propto e^{i2\omega}$$

Autocorrelation function

The intensity autocorrelation is defined by: $$A(\tau) = \int_{-\infty}^{\infty} I(t) I(t-\tau) dt$$

This formula in words, measures how much the function *I*(t) resembles a time shifted version of itself.
The important feature of this function is: its FWHM is proportional to the pulse length. Depending on the shape of the pulse this proportionality factor can be calculated .

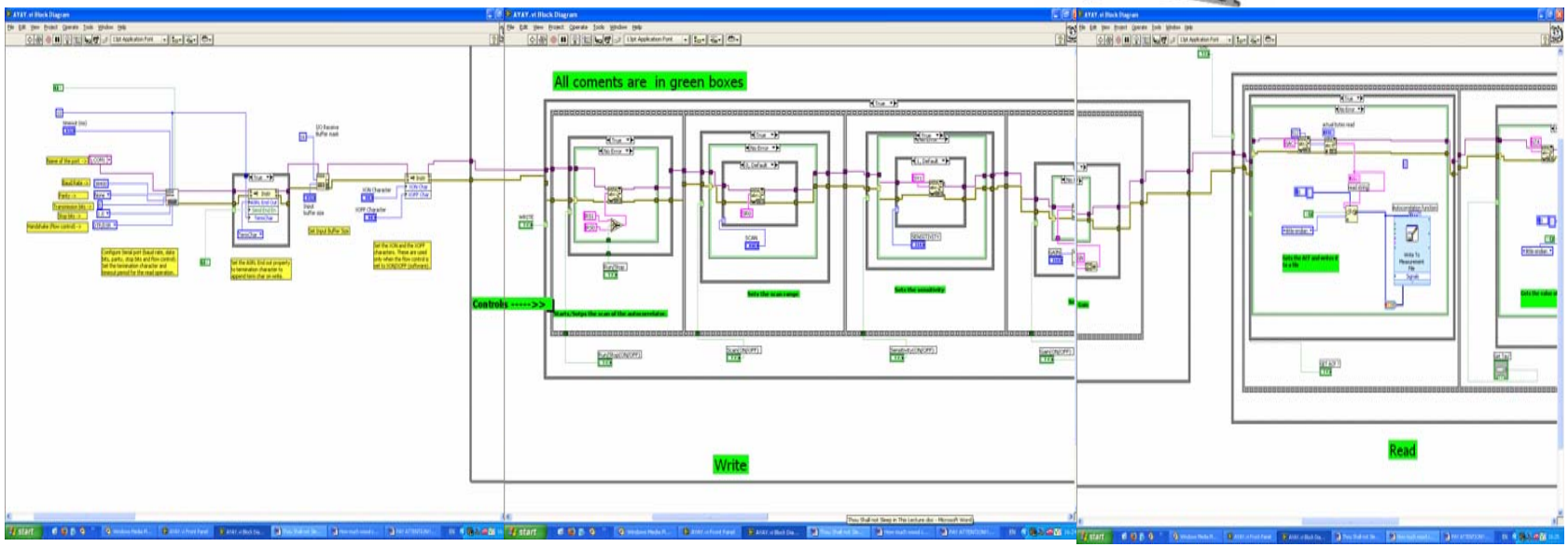
What is measured at the detector's position is the intensity,

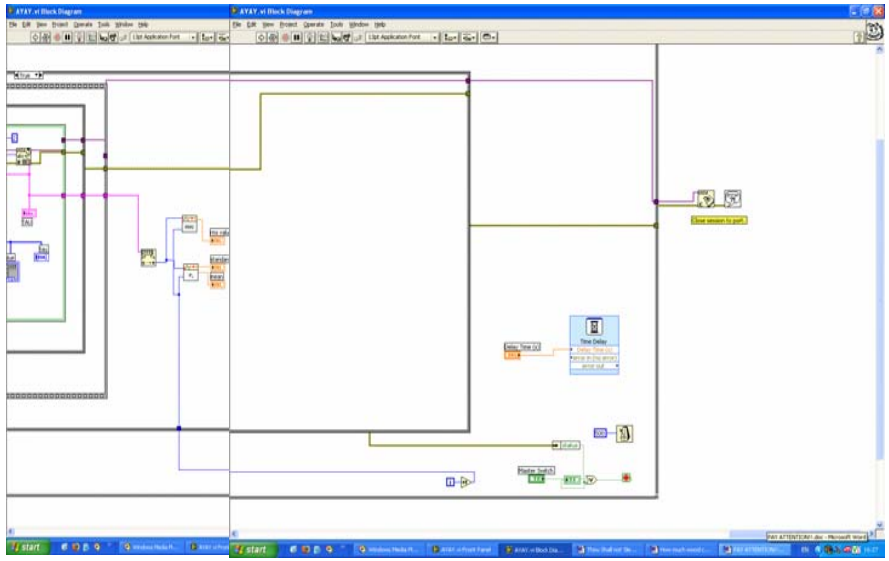
$$I(\tau) = \int_{-\infty}^{\infty} \left| E_1(t'-\tau) + E_2(t') \right|^2 dt'$$

Expanding we get the term we are looking for:

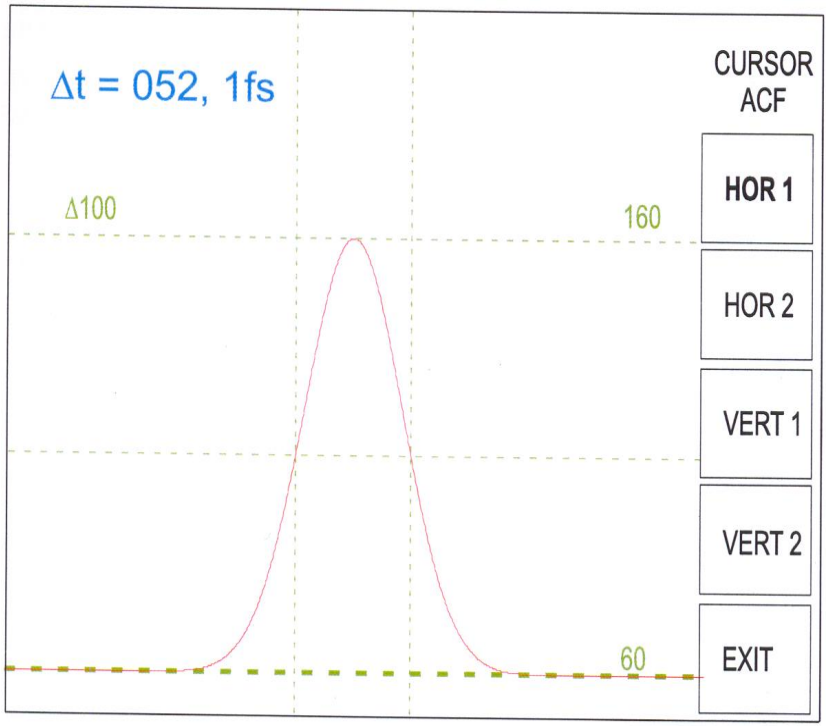
$$I_s(\tau) = \int_{-\infty}^{\infty} \left| E(t) E(t-\tau) \right|^2 dt = \int_{-\infty}^{\infty} I(t) I(t-\tau) dt$$

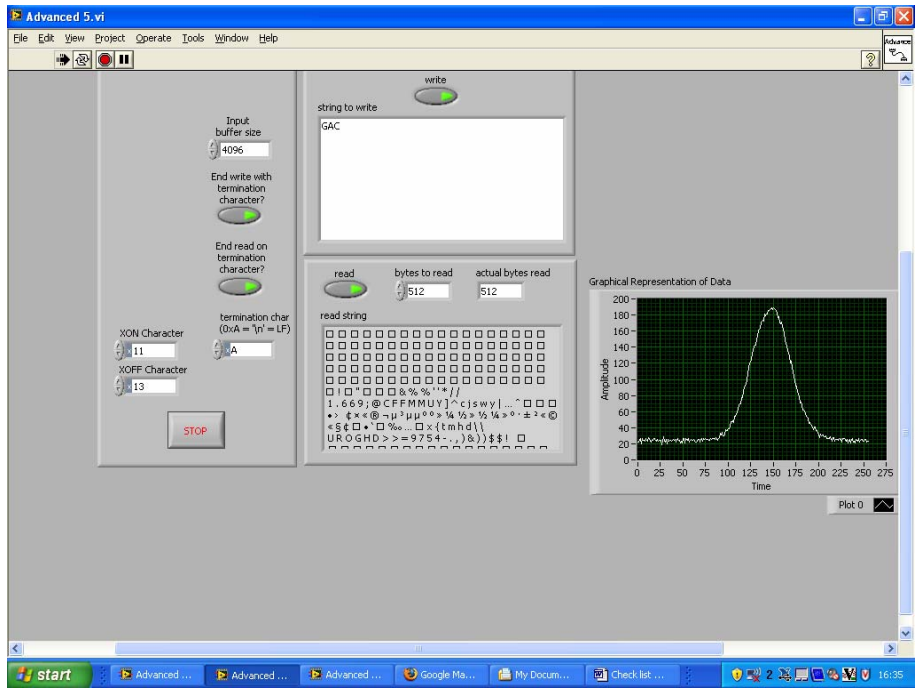
Using Lab view

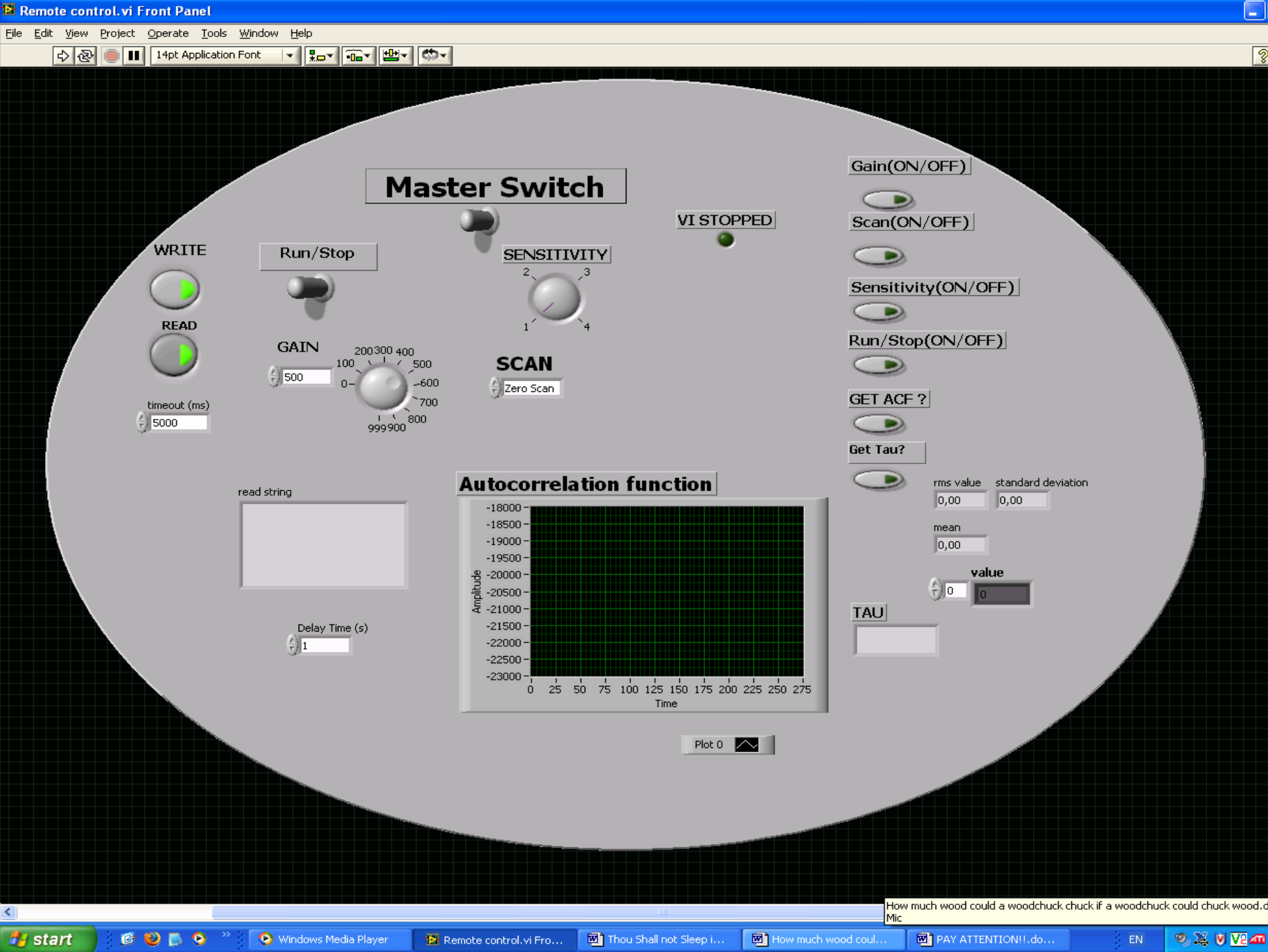




Using Lab view

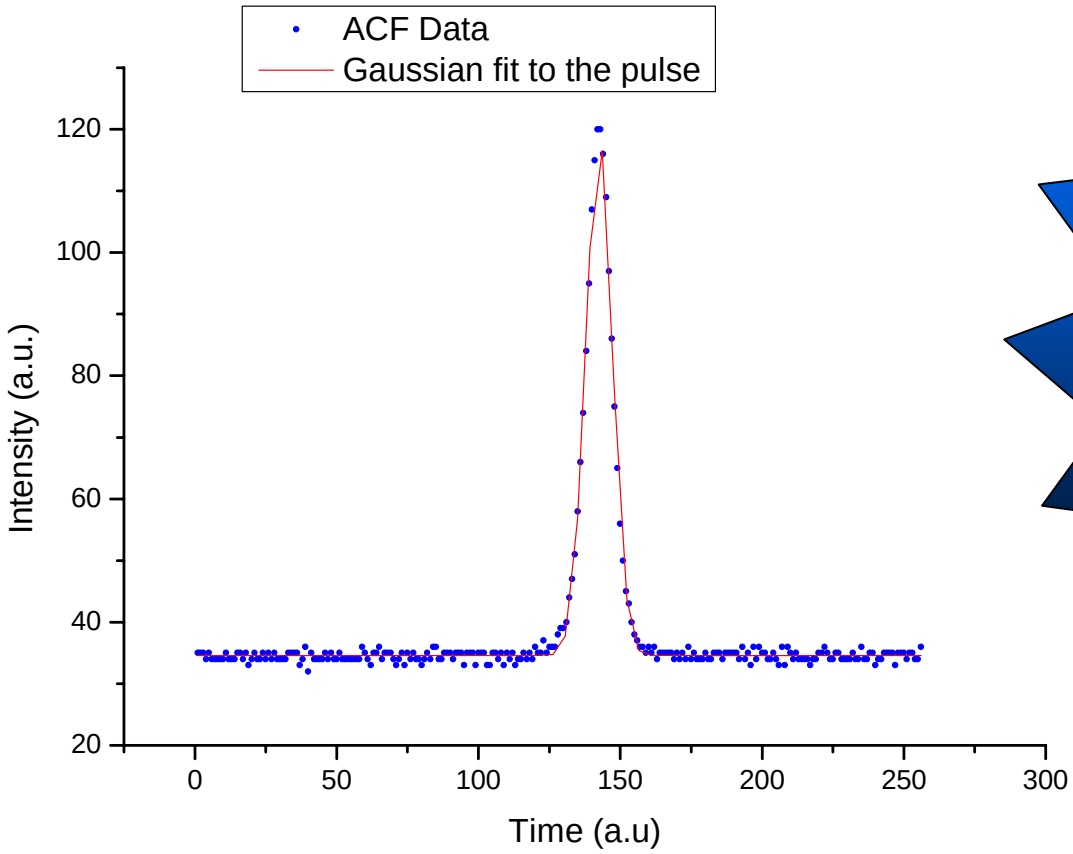





Remote control.vi Front Panel
File Edit View Project Operate Tools Window Help
14pt Application Font
Master Switch
VI STOPPED
Gain(ON/OFF)
Scan(ON/OFF)
Sensitivity(ON/OFF)
Run/Stop(ON/OFF)
GET ACF ?
Get Tau?
WRITE
Run/Stop
SENSITIVITY
READ
GAIN
SCAN
timeout (ms)
5000
500
Zero Scan
read string
Autocorrelation function
Amplitude
Time
rms value
standard deviation
mean
value
TAU
Delay Time (s)
1
Plot 0
How much wood could a woodchuck chuck if a woodchuck could chuck wood.
Mic
start
Windows Media Player
Remote control.vi Fro...
Thou Shall not Sleep i...
How much wood coul...
PAY ATTENTION!!.do...
EN

VERY, VERY FAST!

Using this techniques:



63.3 fs ± 1fs

A troubling dilemma: asking questions or…

coffee?