EMC – Status

R.Novotny

PANDA-Meeting @ GSI March 6, 2009

- crystal production, delivery and quality control
- prototype experience
- photo sensors (LAAPD, VPT)
- development for PROTO 192, endcap
- FE electronics
- backward endcap

status of production and delivery

Type		Required Quantity (Without spares)	Lot B1	Lot B2	Lot B3	Lot B4	Lot B5	Lot B6	Lot B7	Lot B8
End Cap		*complete*	4400							700
Barrel	1 R	640	21	0				113	695	
	1 L	640	354	0				157		
	9 R	320	0					330	325	
	9 L	320	0					0		
Total			**4775**					**600**	**1020**	**700**
Delivered			✓	✓	✓	✓	✓	✓	✓	**x**
Currently at …			Giessen		CERN	Giessen		Uppsala		BTCP

specification limits

Longitudinal Transmission	at 360 nm	**≥ 35 %**
	at 420 nm	**≥ 60 %**
	at 620 nm	**≥ 70 %**
Light Yield	at T = 18°C	**≥ 16 phe/MeV**
Radiation hardness	at 420 nm due to lateral ^{60}Co irradiation. Integral Dose 30 Gy	**$\Delta k \leq 1\ m^{-1}$** **$\langle \Delta k \rangle \leq 0{,}75\ m^{-1}$**

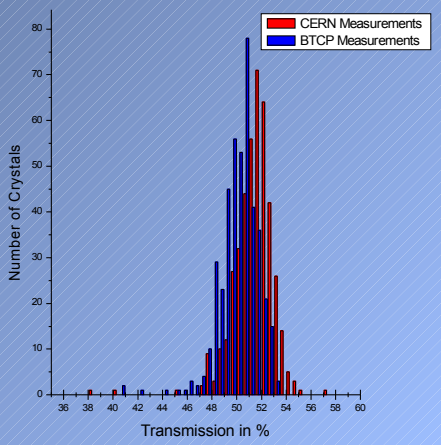
transmission – lot B1
CERN/BTCP Measurements

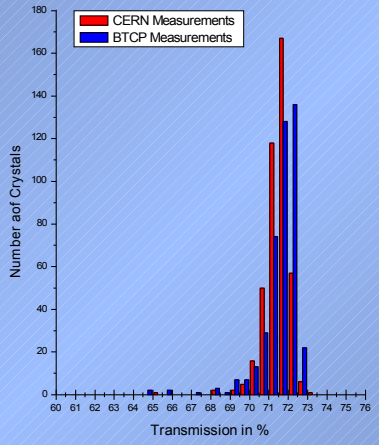
Lot B1

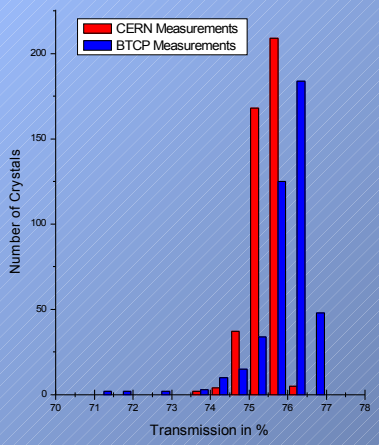
374 Barrel Crystals 425 End Cap Crystals

Distribution of Longitudinal Transmission at Certain Wavelength

360 nm

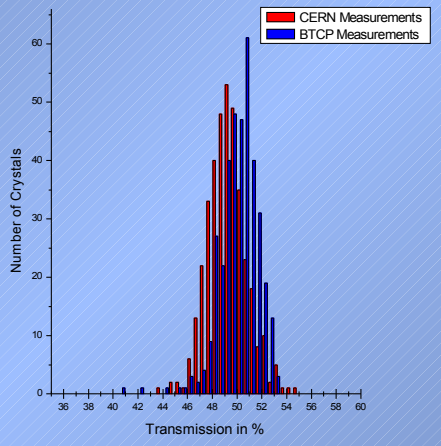


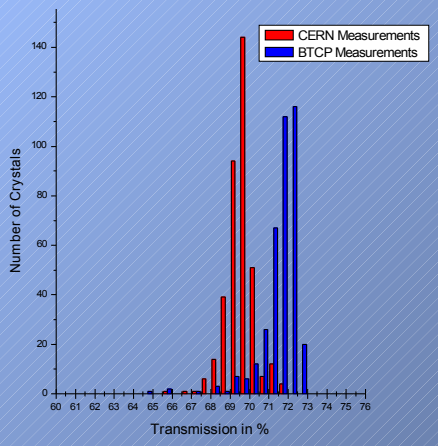


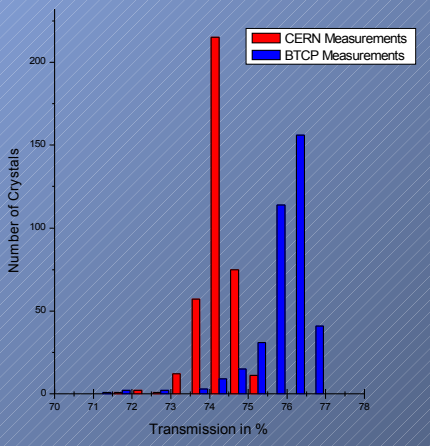


420 nm

620 nm







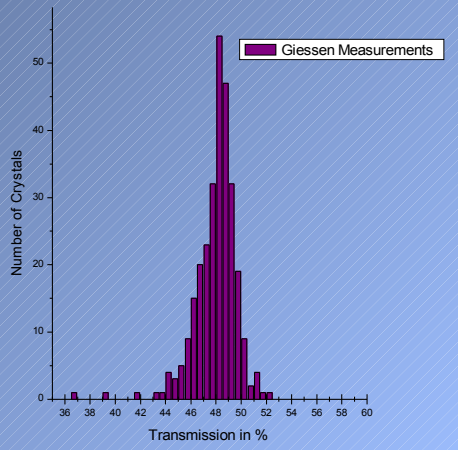
D.Bremer

transmission – lot B1
control measurements @GI

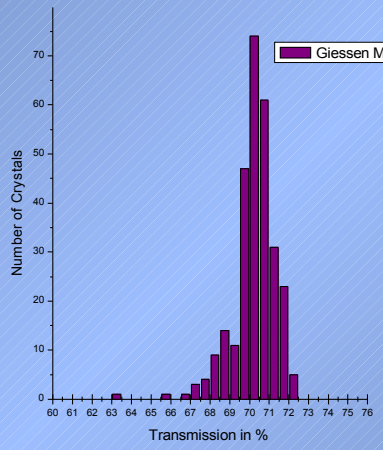
Longitudinal Transmission at Certain Wavelength

Lot B1

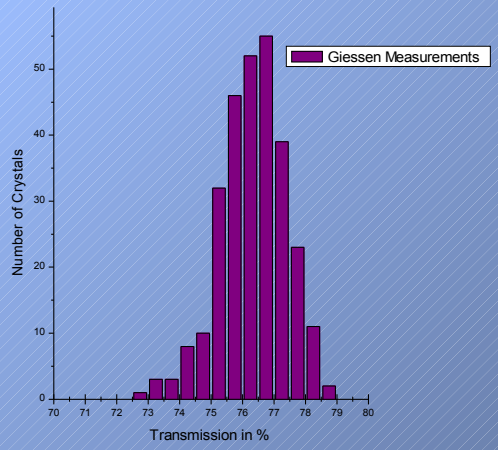
285 End Cap Crystals



360 nm

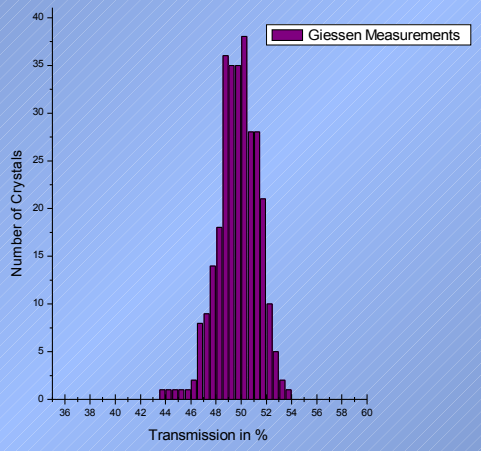


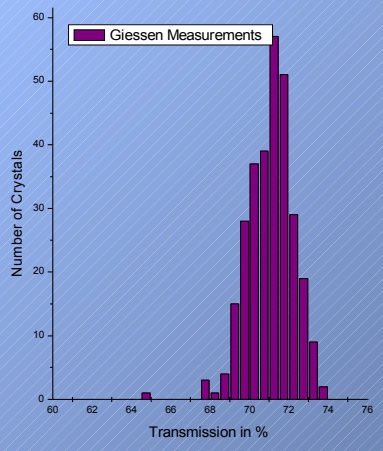
420 nm



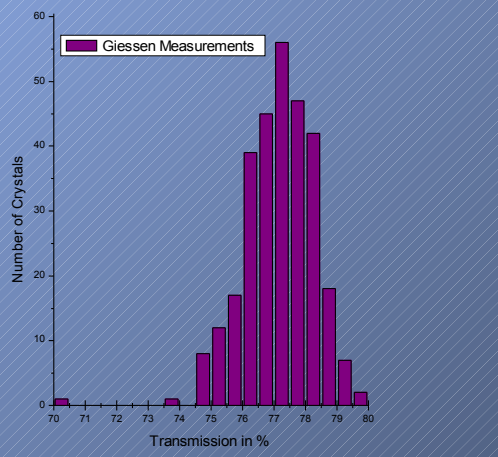
620 nm

295 Barrel Crystals



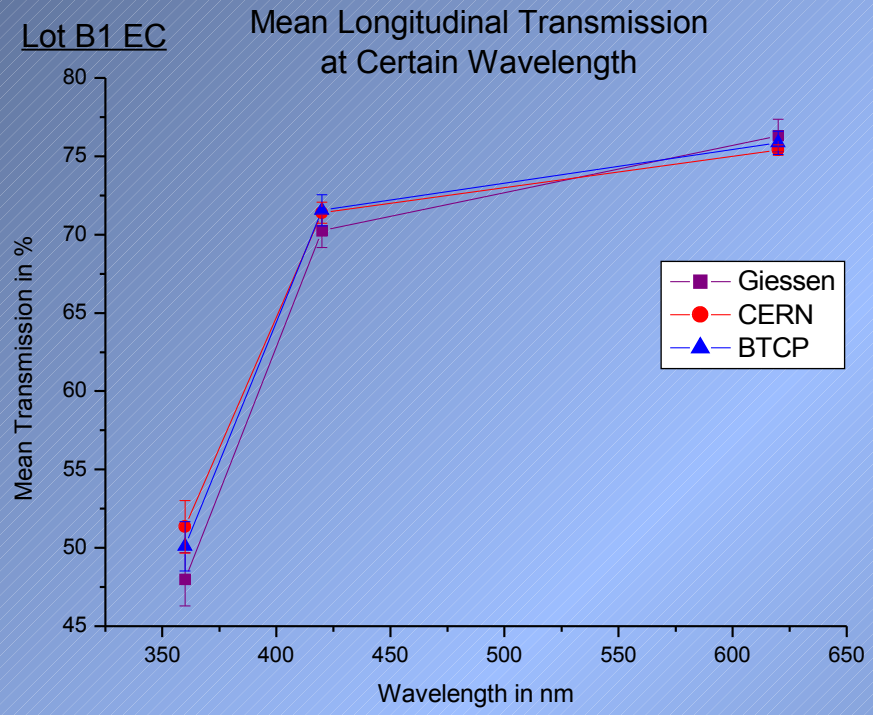


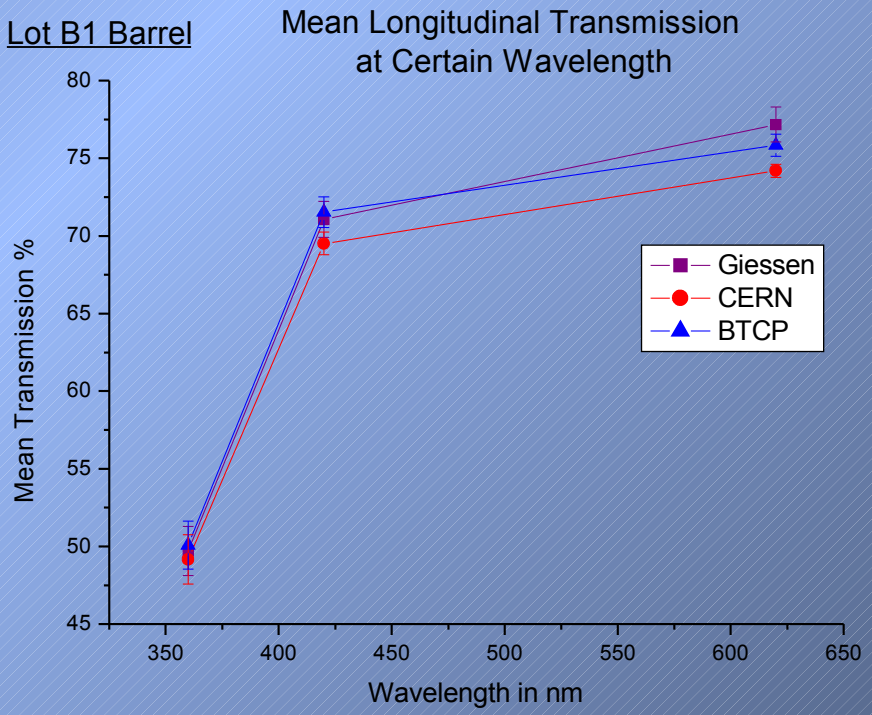
Lot B1 Barrel



D.Bremer

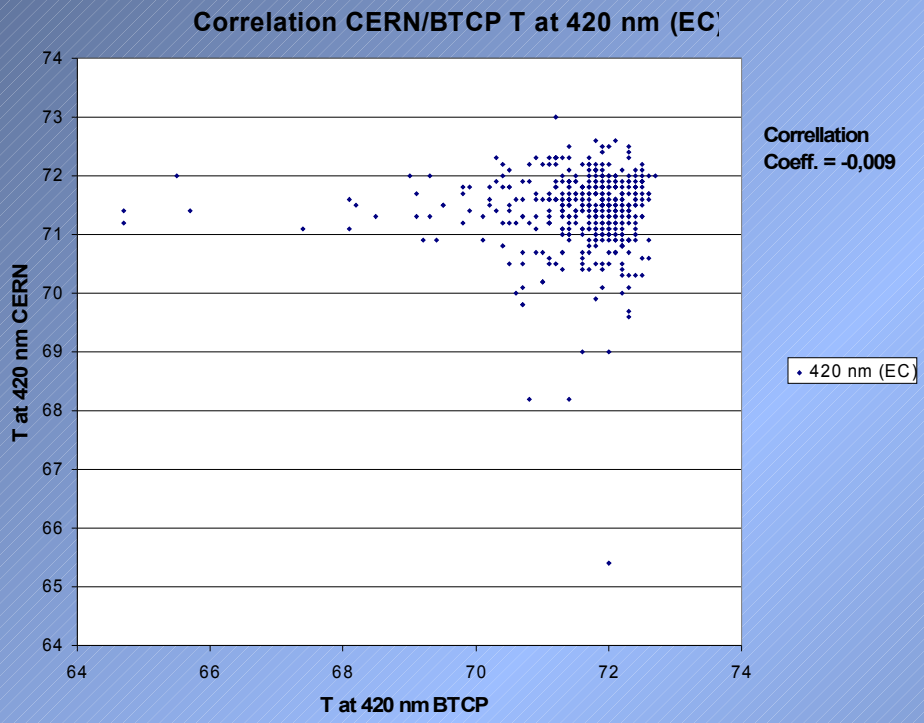
transmission – lot B1
comparison of mean values

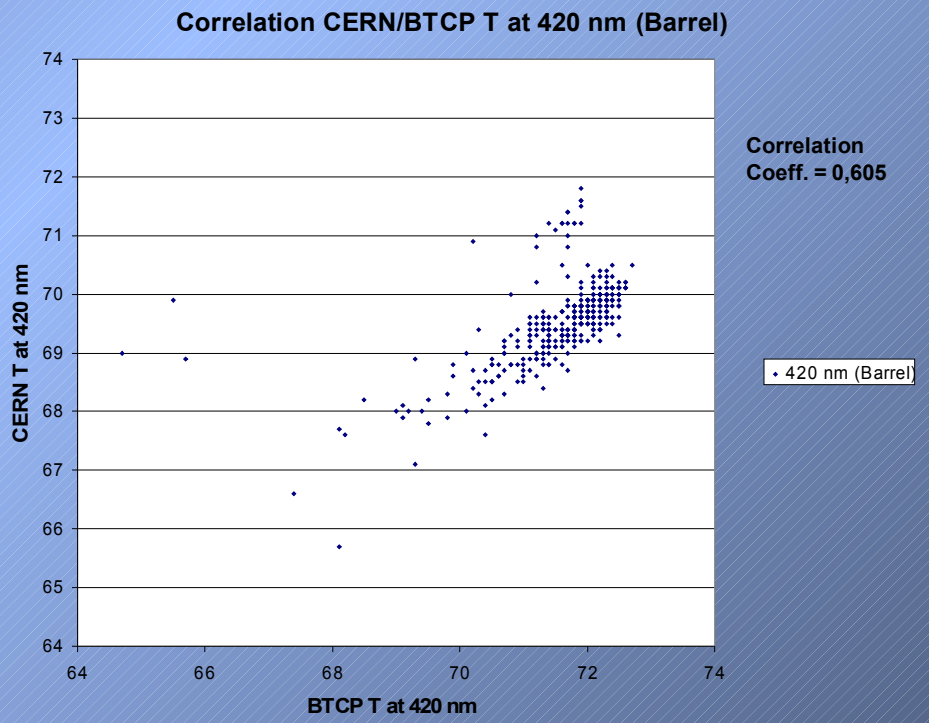




D.Bremer

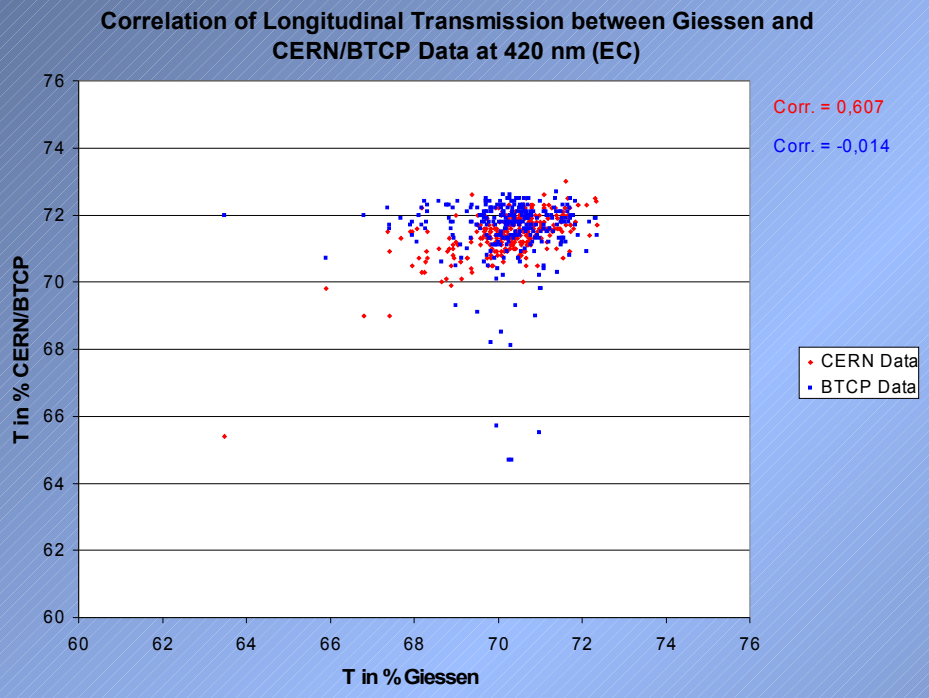
correlations - lot B1 T@420nm CERN and BTCP

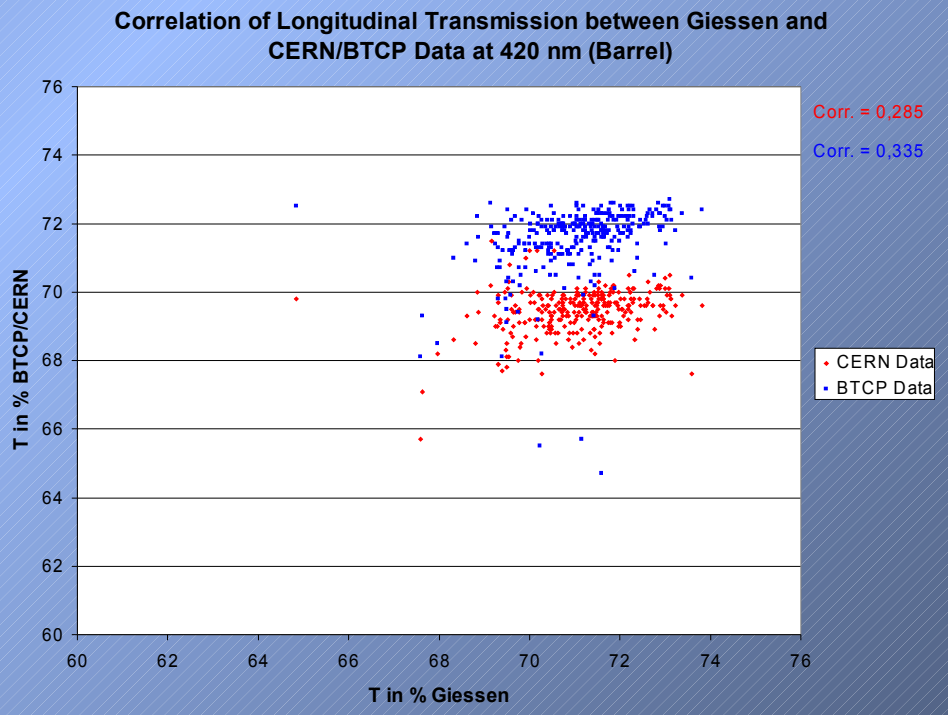




D.Bremer

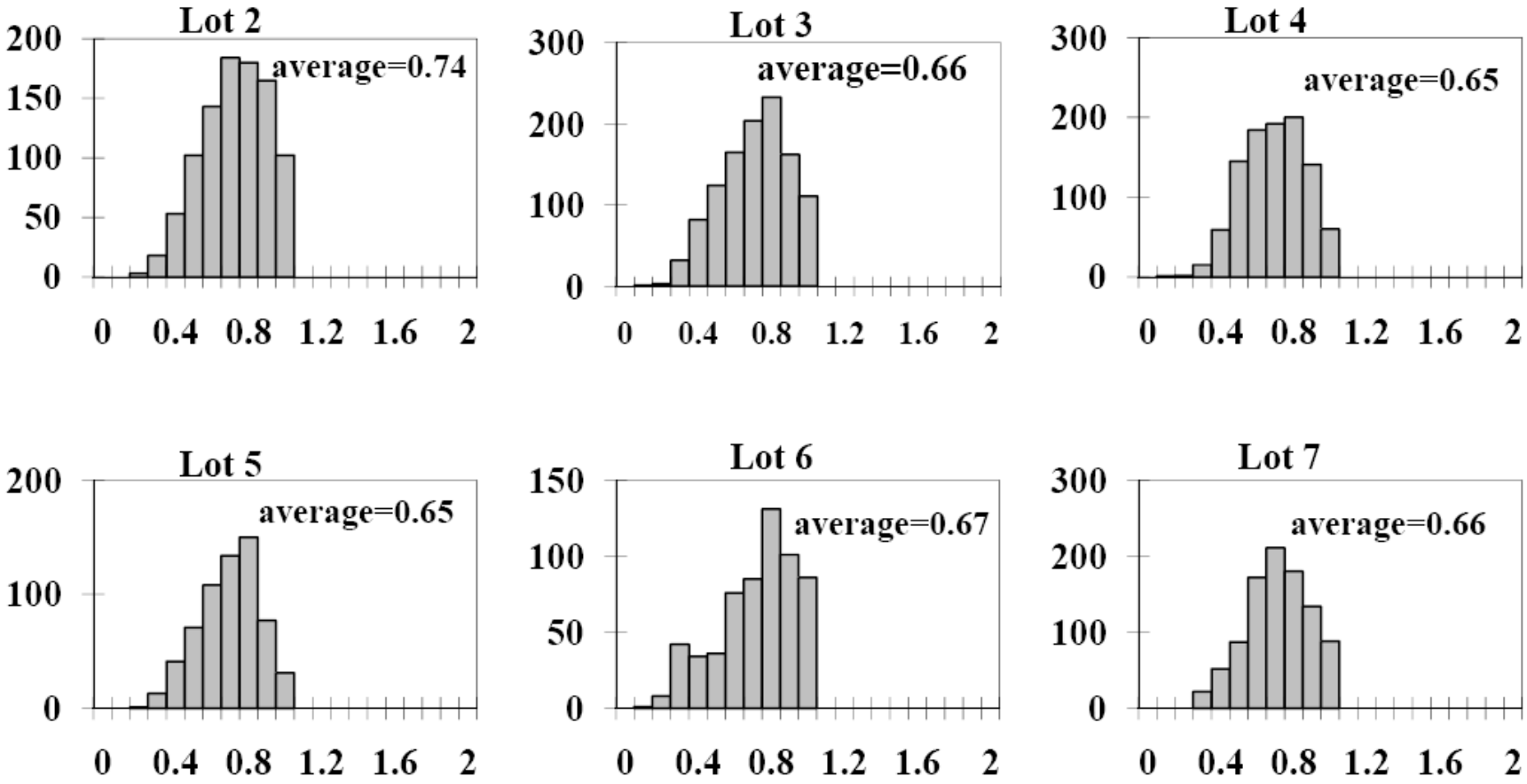
correlations - lot B1 T@420nm
GI vs CERN/BTCP





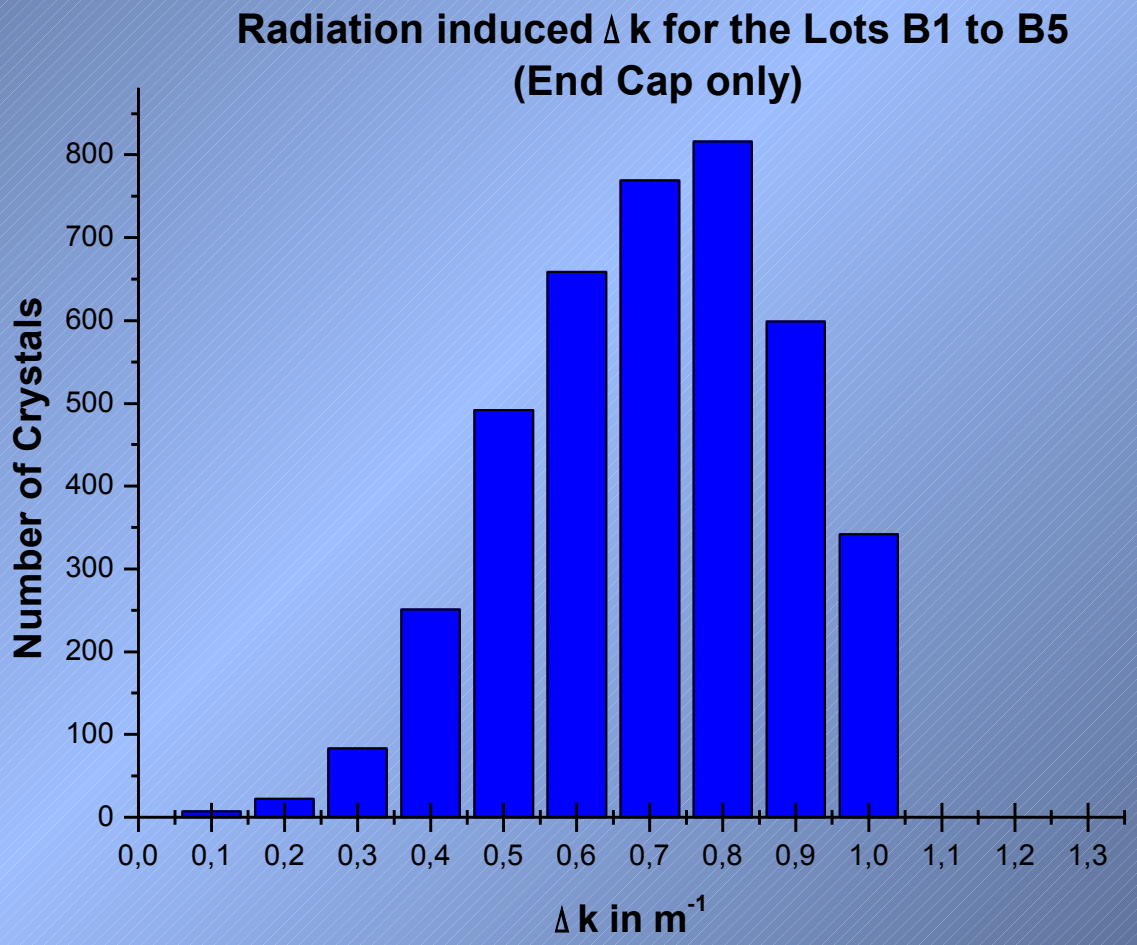
D.Bremer

Induced absorption coefficient at 420 nm, m^{-1}



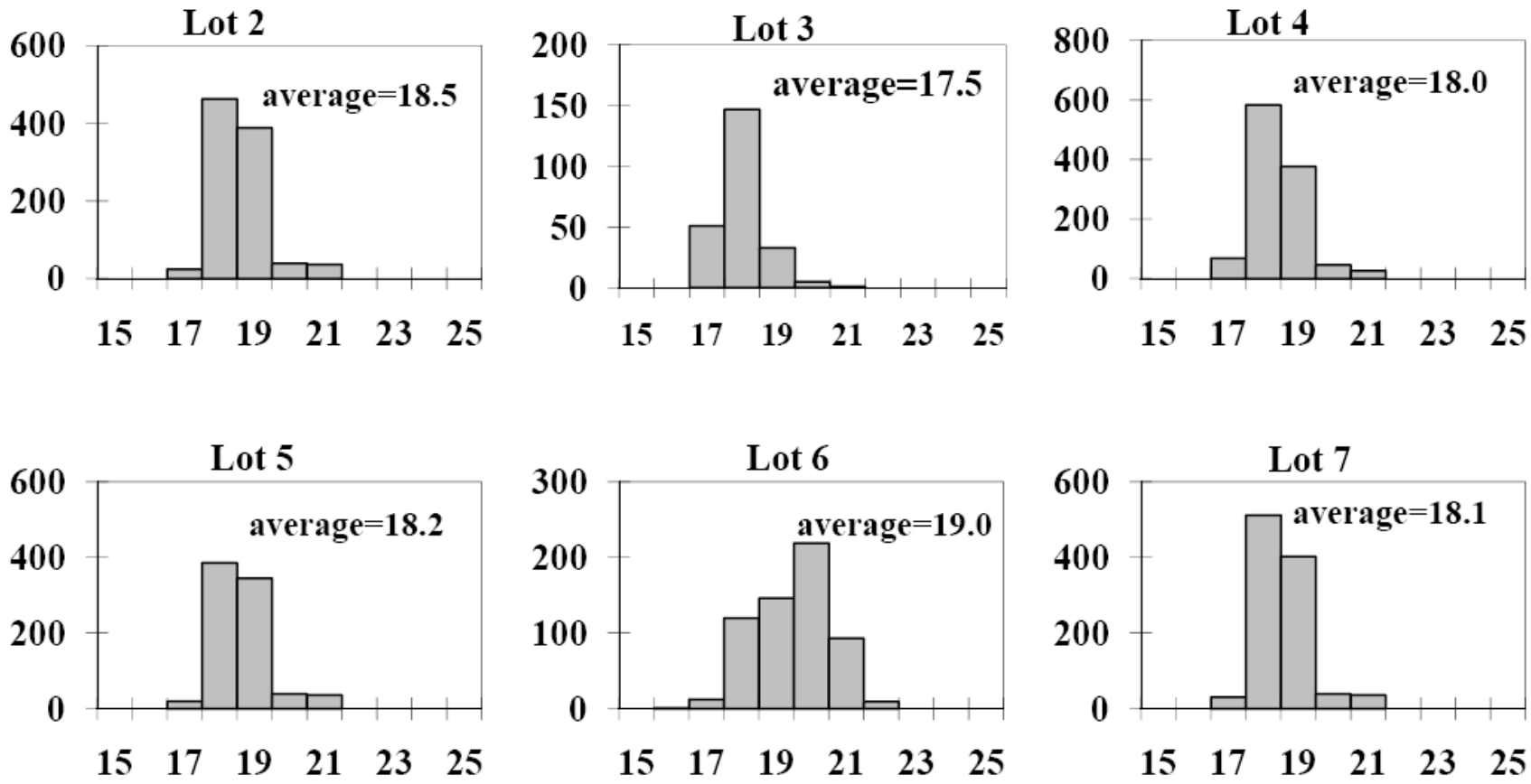
O.Missevitch

radiation induced Δk
based on BTCP quality control

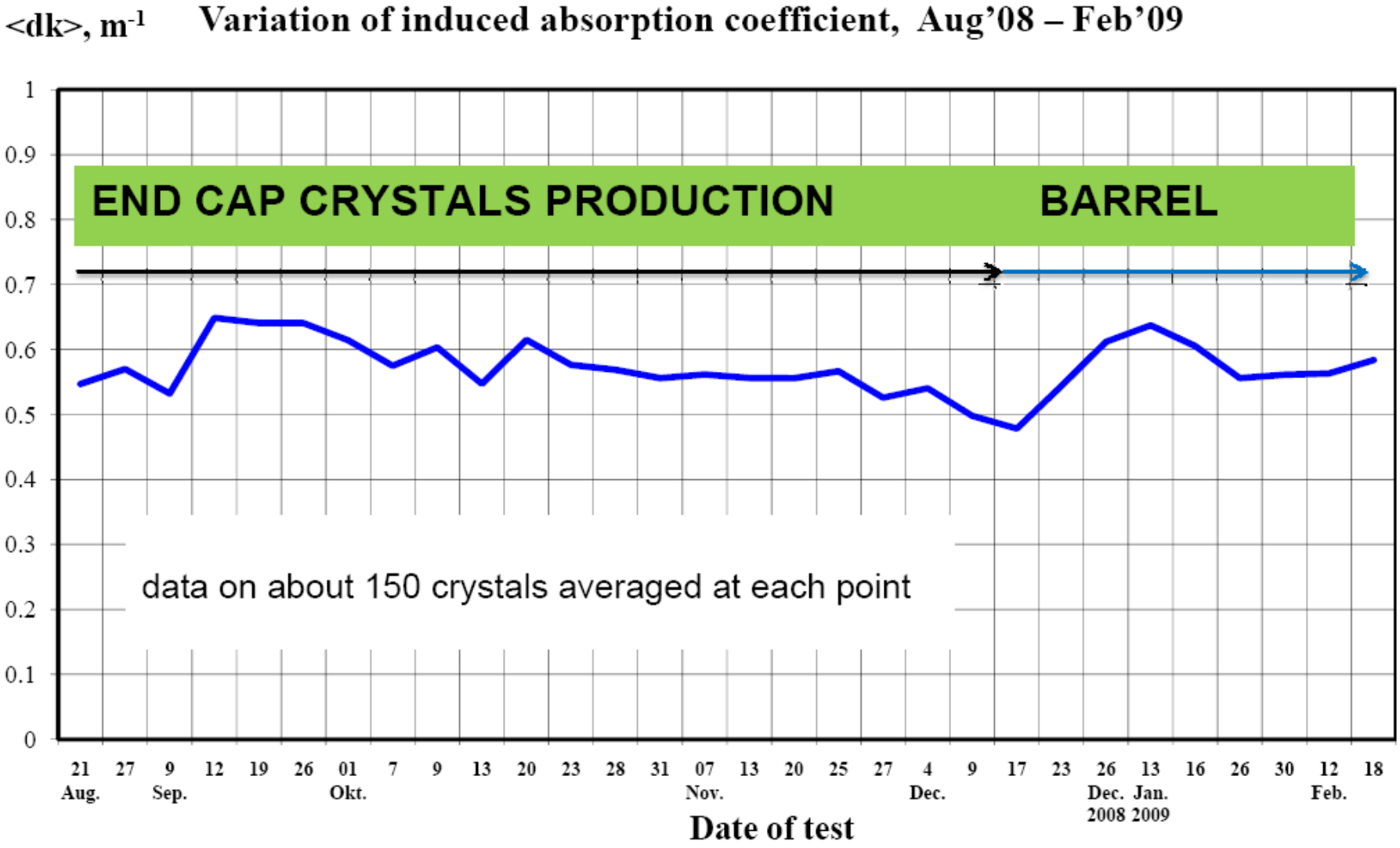


D.Bremer

Light Yield, phe/MeV



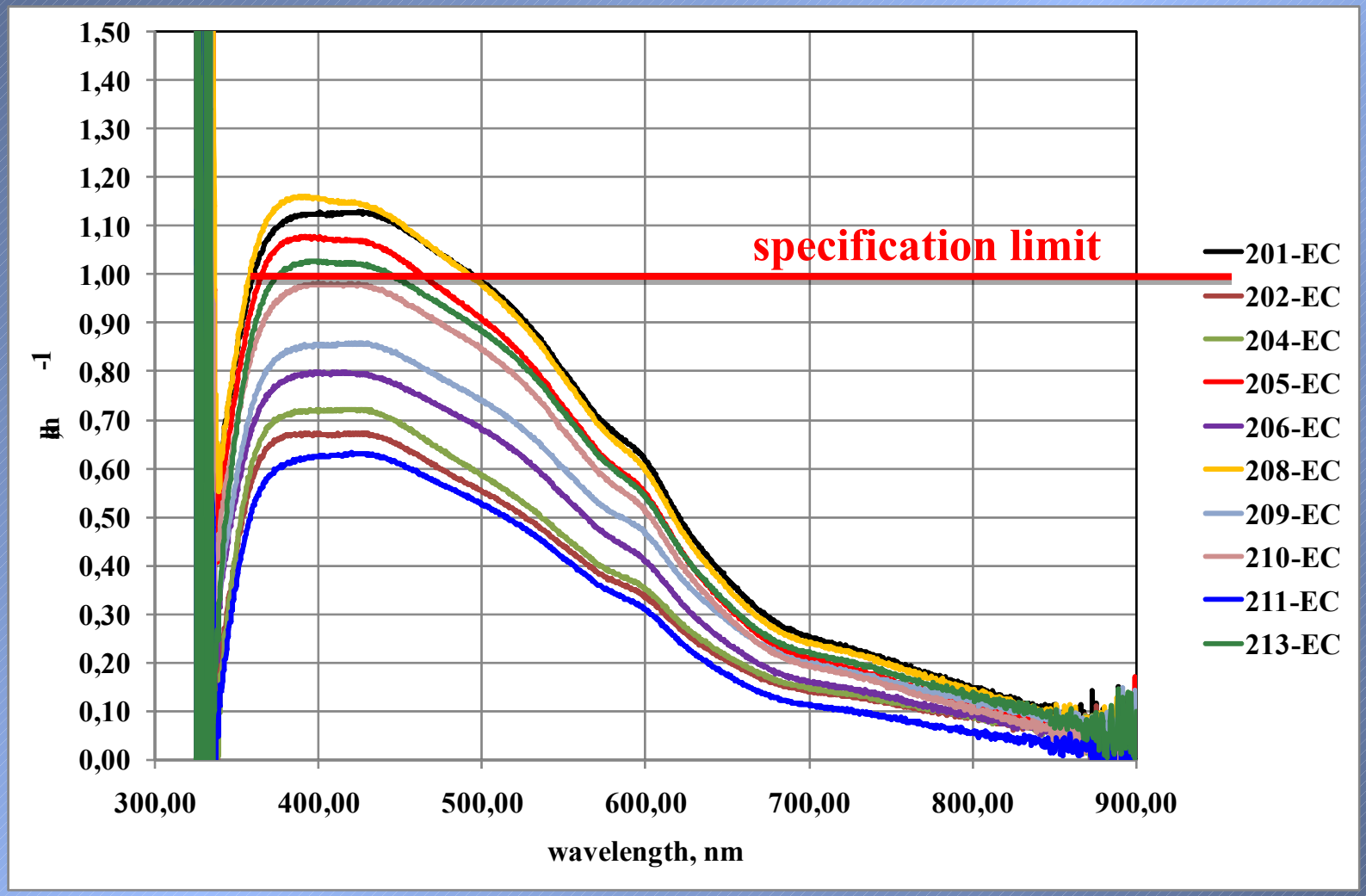
O.Missevitch



O.Missevitch

spectra of the radiation induced absorption coefficient dk

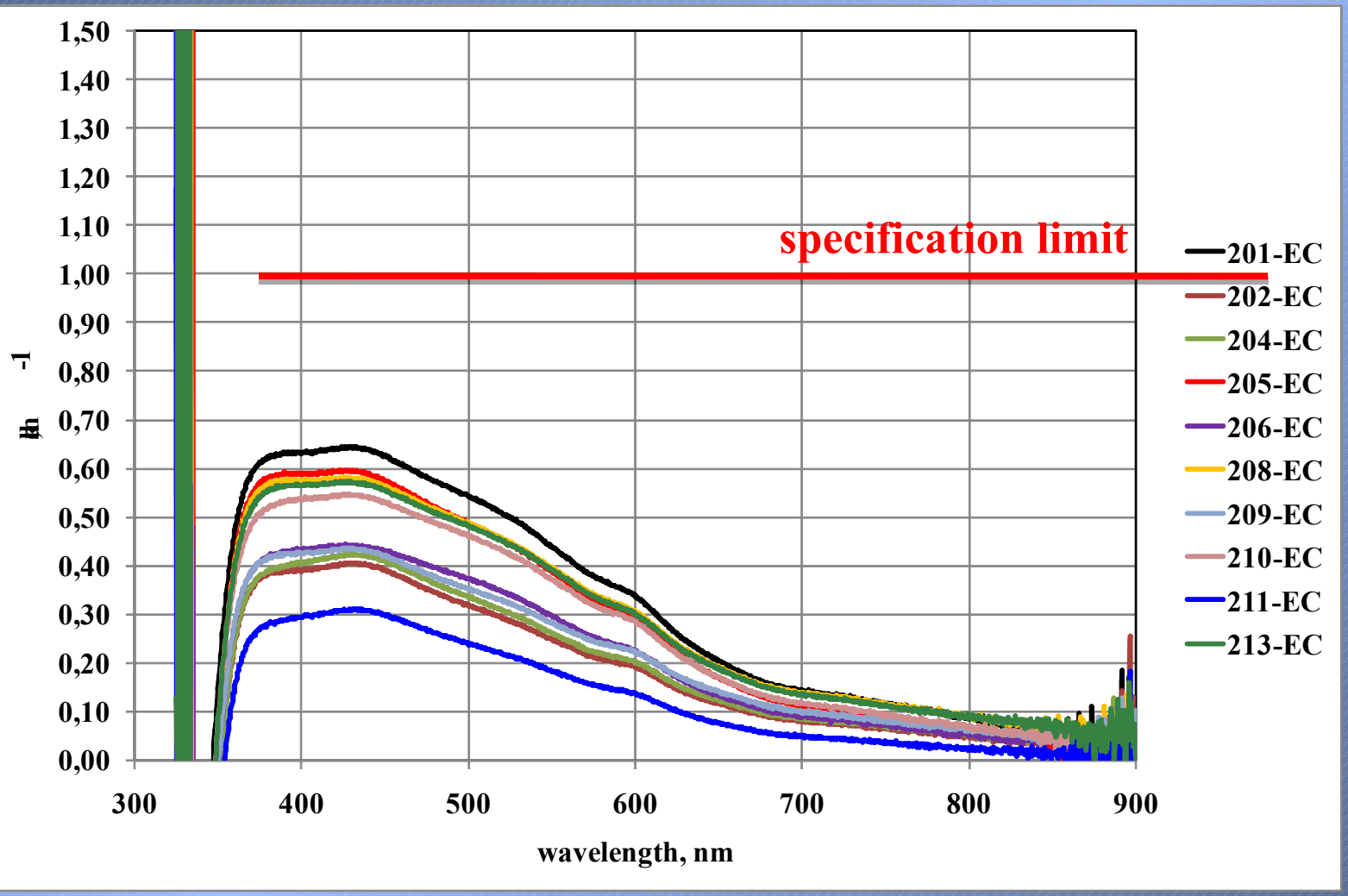
time delay of measurements after irradiation ~ 1-5 minutes



V.Dormenev

spectra of the radiation induced absorption coefficient dk

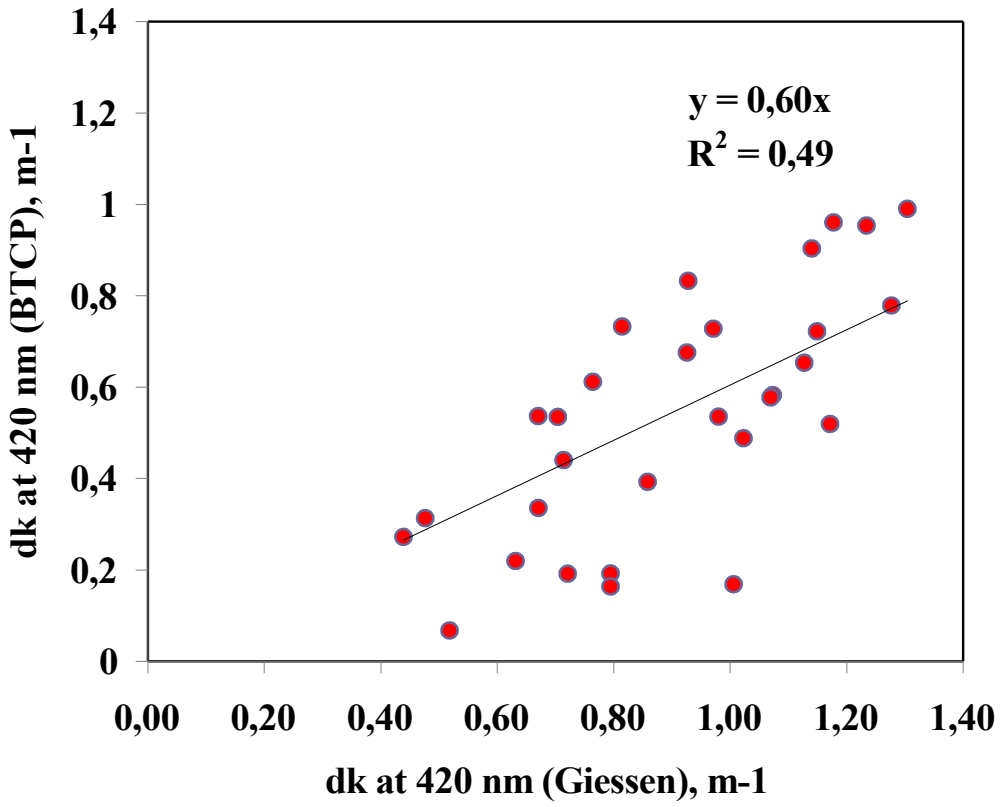
time delay of measurements after irradiation ~ 1 day



V.Dormenev

corelation of radiation absorption: BTCP vs GI

time delay of measurements after irradiation ~ 1-5 minutes_

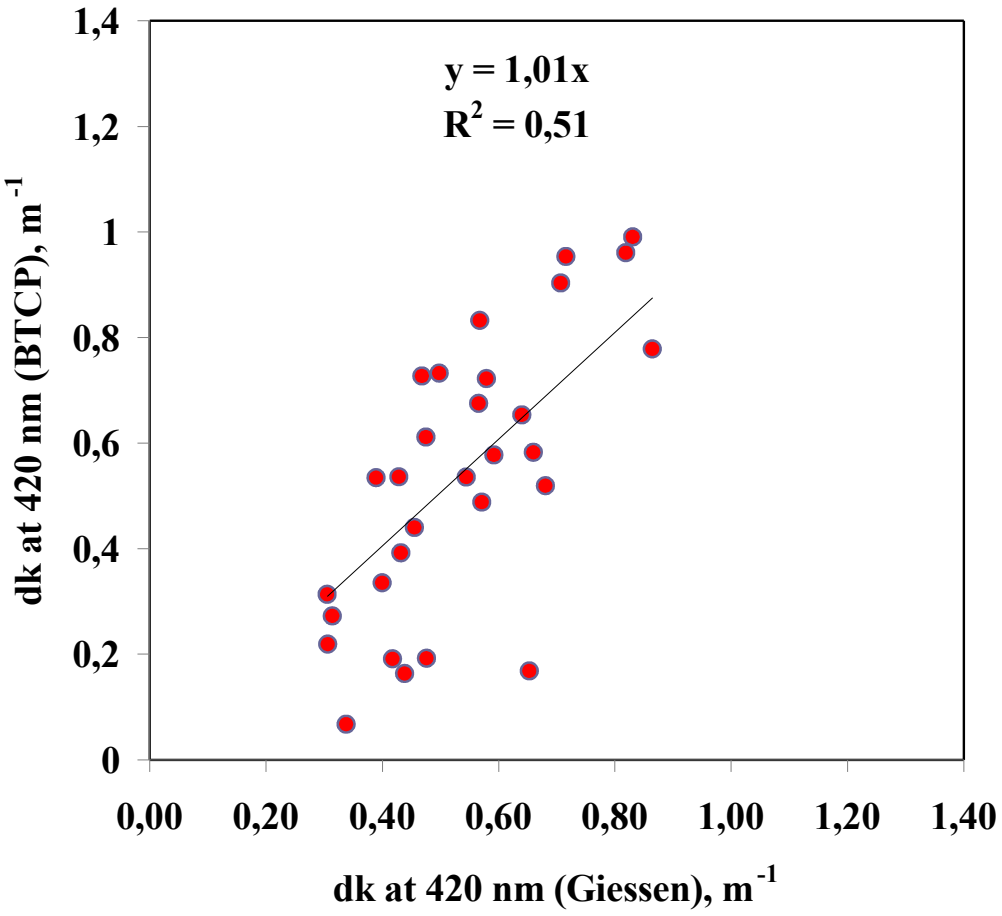


correlation coef.=0.72
average dk (Giessen)=0.90 m-1
average dk (BTCP)=0.54 m-1

V.Dormenev

corelation of radiation absorption: BTCP vs GI

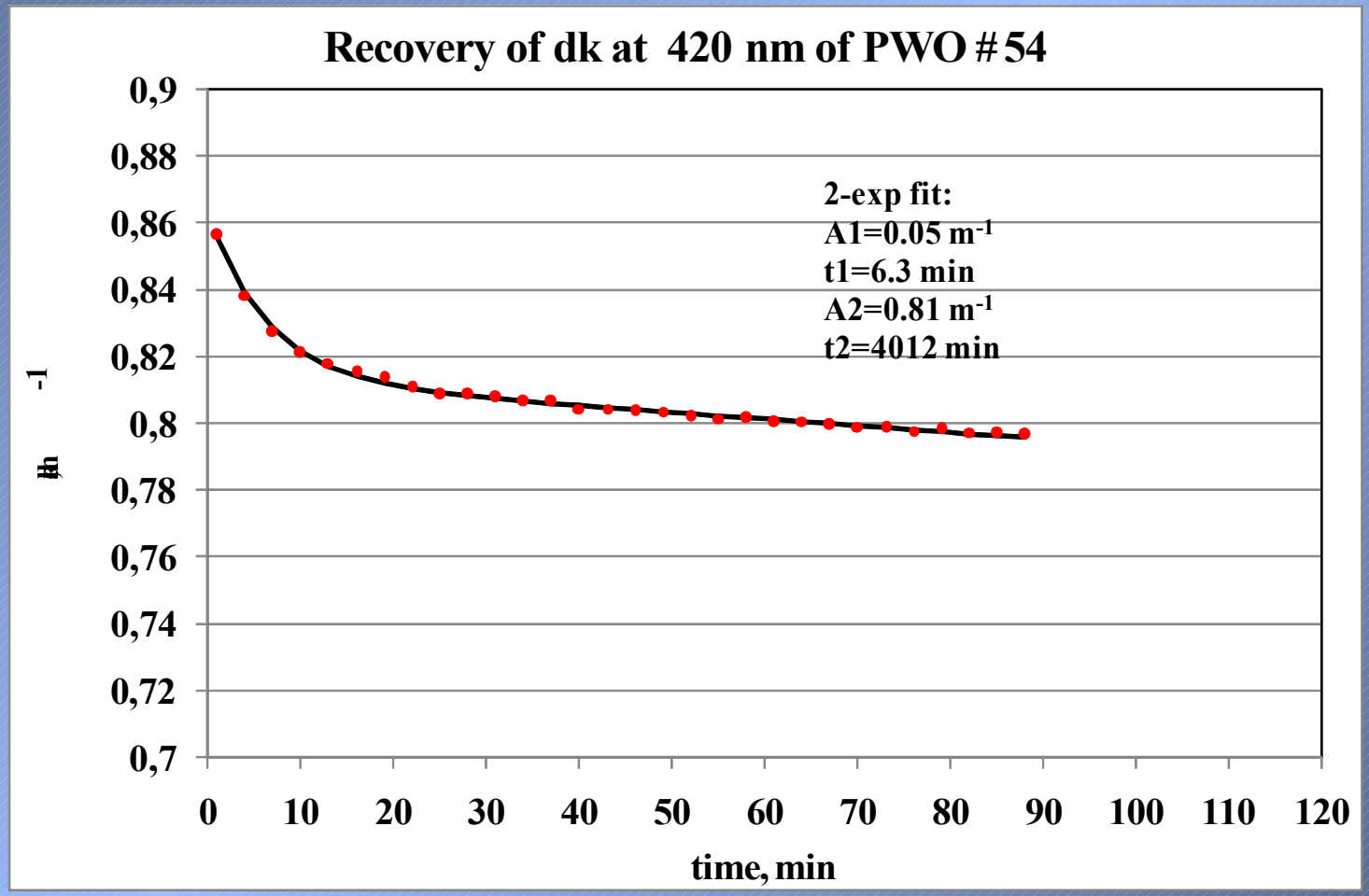
time delay of measurements after irradiation ~ 1 day_



correlation coef.=0.72
average dk (Giessen)=0.54 m-1
average dk (BTCP)=0.54 m-1

V.Dormenev

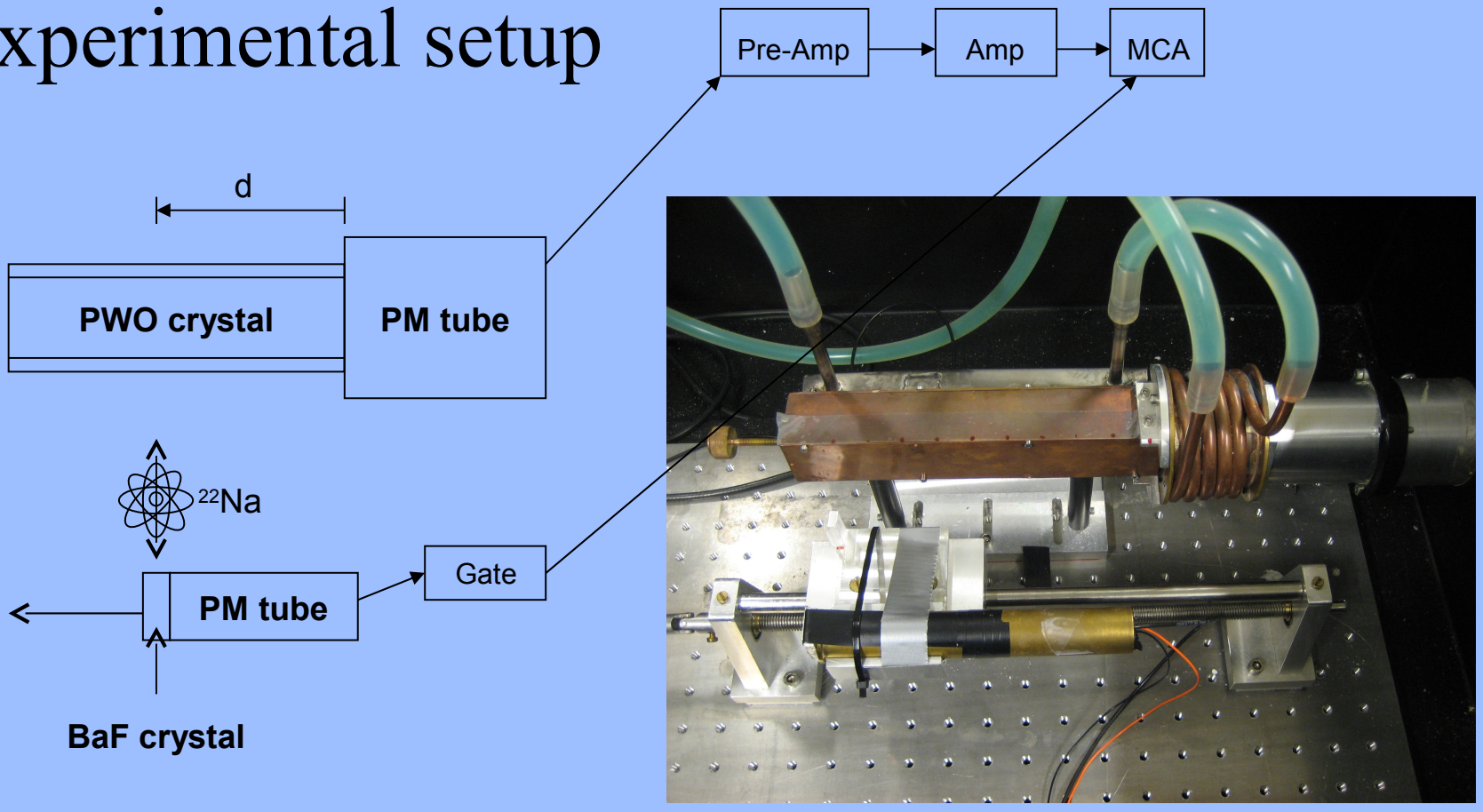
recovery of PWO radiation absorption @ 420 nm



V.Dormenev

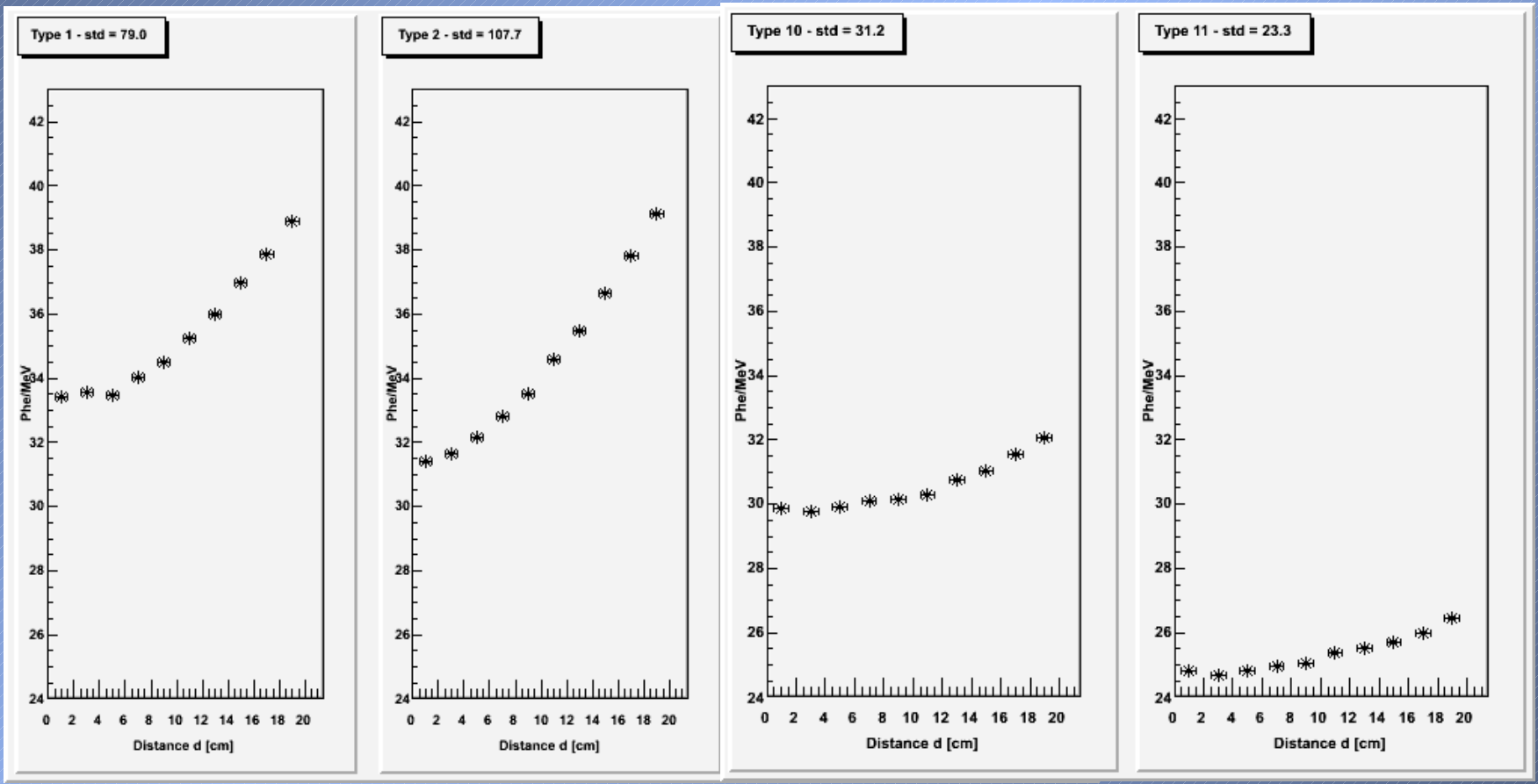
linearity of crystal response for all barrel shapes

experimental setup



non-linearity of light collection

Type 1 | Type 2 | Type 10 | Type 11



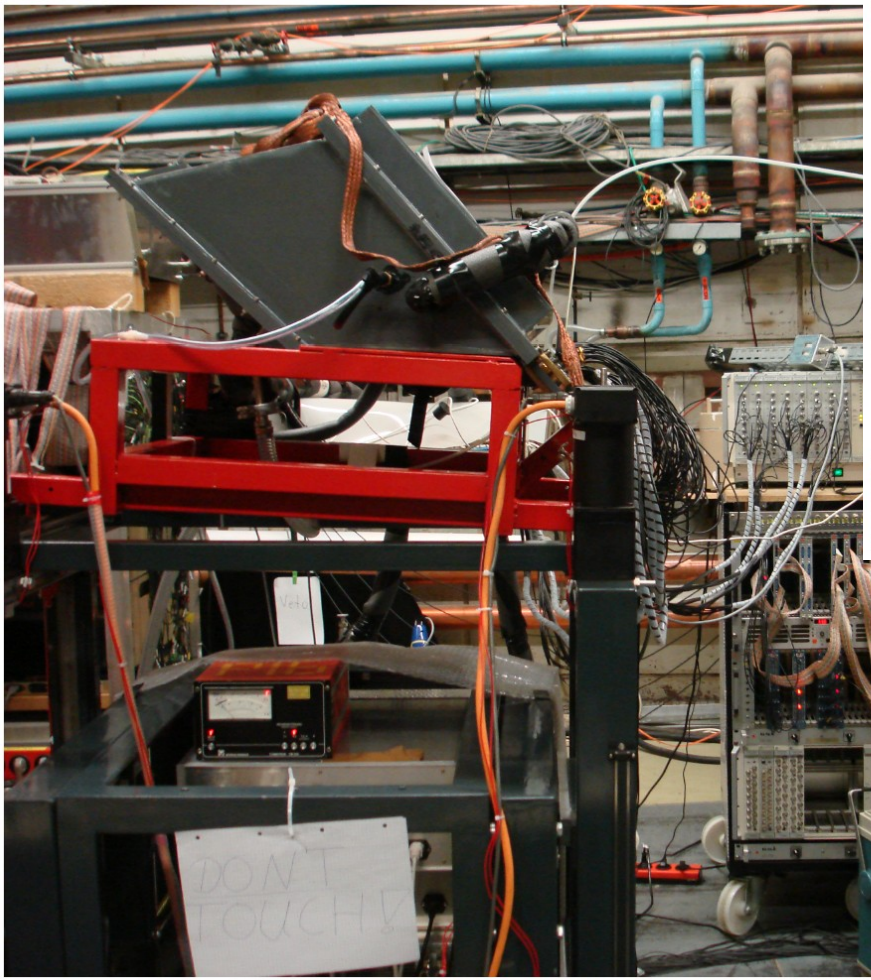
M.Marteinsdottir

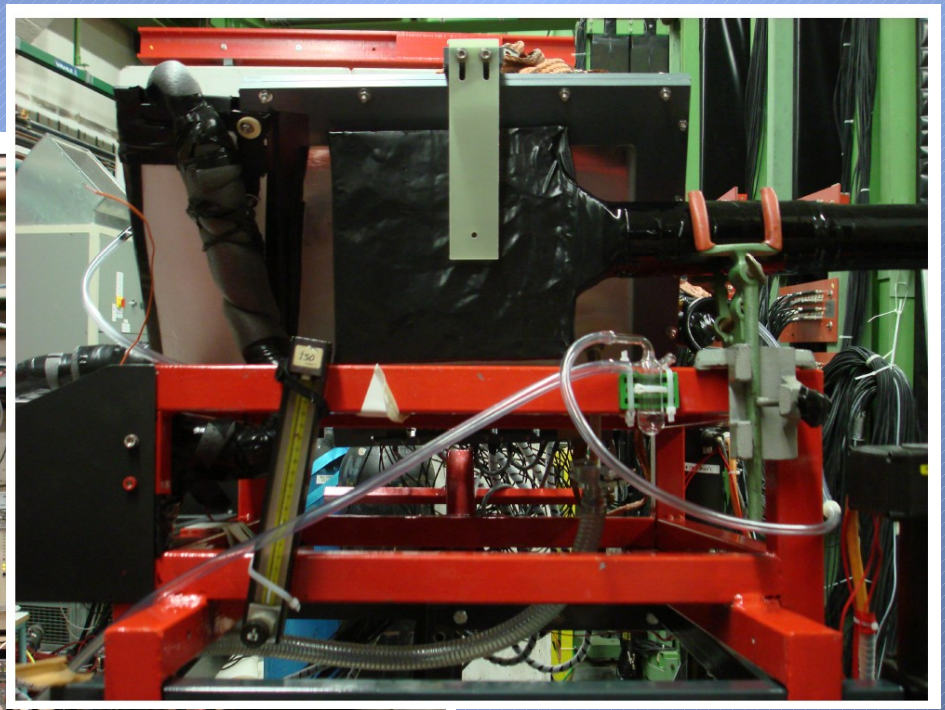
summary

Type	Volume [cm^3]	θ_B [°]		θ_A [°]	θ_C [°]	Mean Value of Nonuniformity	
						phe/MeV	Rel. Std %
1	126.86	2.1	2.2	2.2	35.4		5.6
2	126.56	2.1	2.1	2.2	34.5		7.8
3	125.79	2.1	2.1	2.1	38.6		5.4
4	120.85	1.7	1.9	2.0	26.8		6.1
5	119.69	1.7	1.8	1.8	31.9		6.8
6	118.35	1.7	1.6	1.6	31.3		5.5
7	112.90	1.2	1.4	1.5	27.6		4.9
8	111.75	1.2	1.3	1.3	31.9		3.9
9	110.52	1.2	1.1	1.2	31.5		2.0
10	107.01	0.9	1.0	1.0	30.5		2.6
11	106.25	0.9	0.9	0.9	25.3		2.3
Front end cap crystal			0.5		21.5		0.9

first in-beam test of PROTO60 @ MAMI

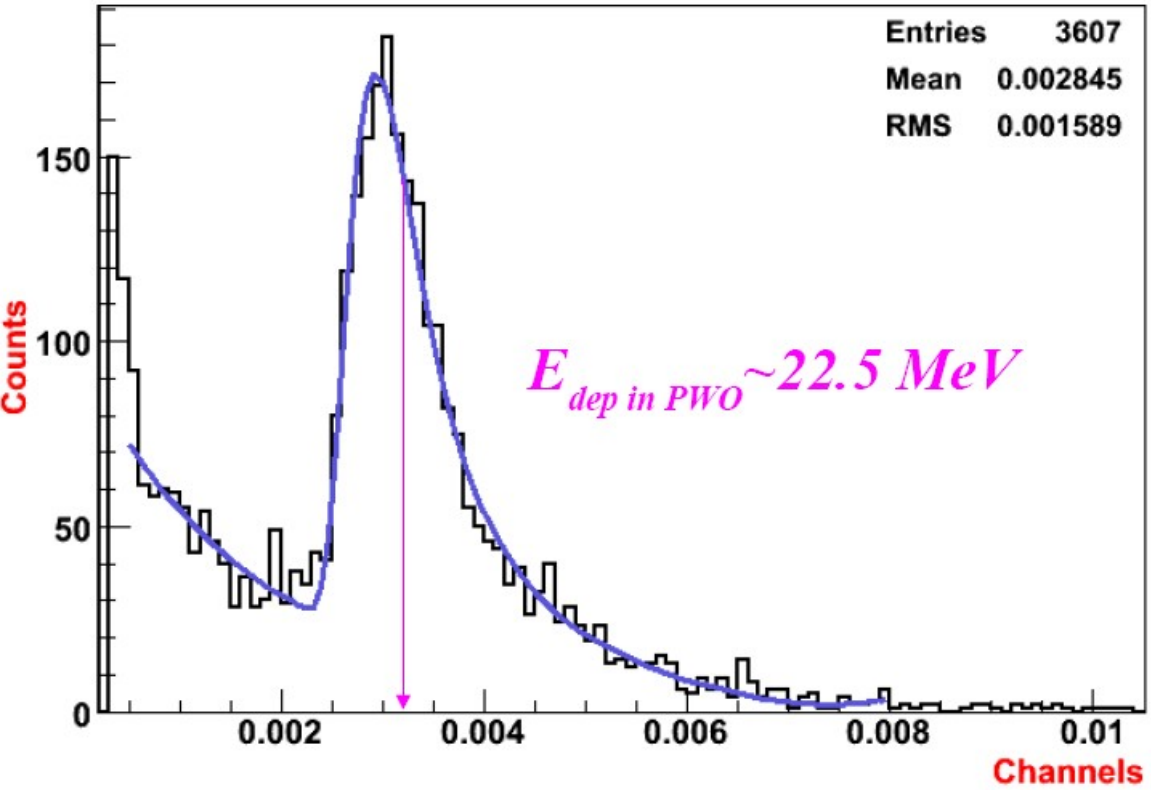
E_γ: 124MeV ….. 1.44GeV



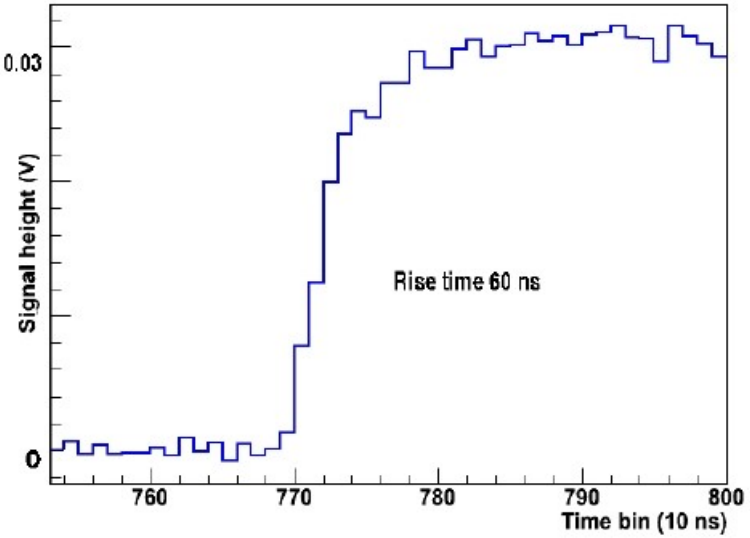


M.Moritz

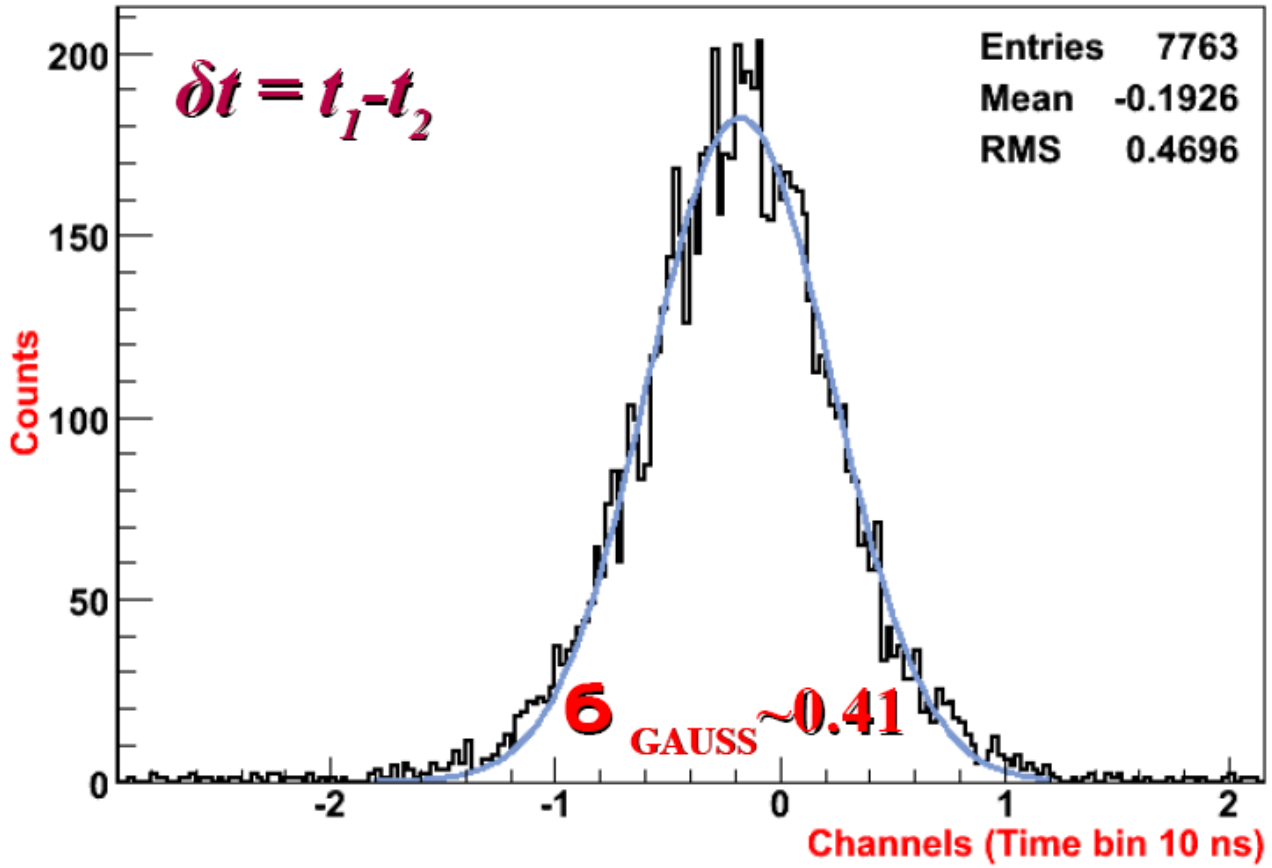
response to cosmics recorded with SADC

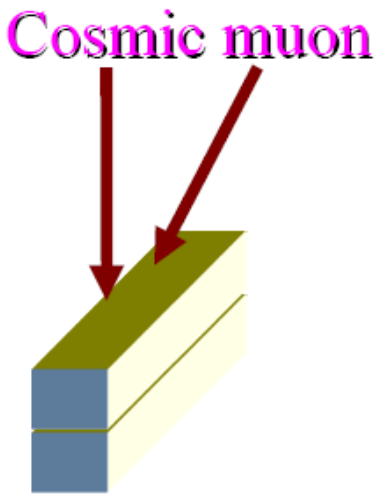


Signal trace for Cosmic Muon



time resolution: cosmics

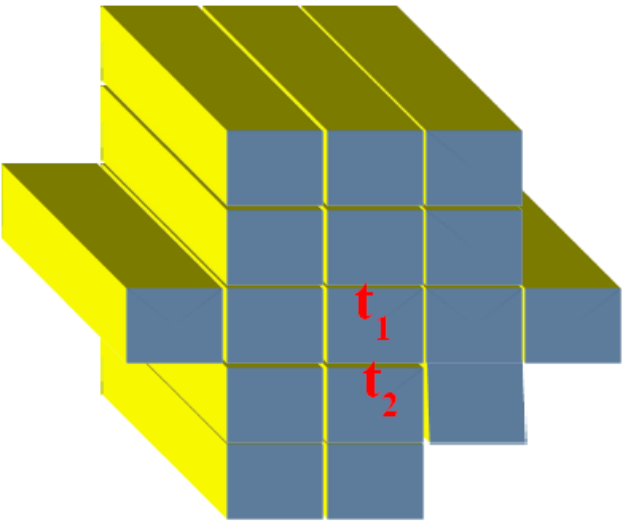


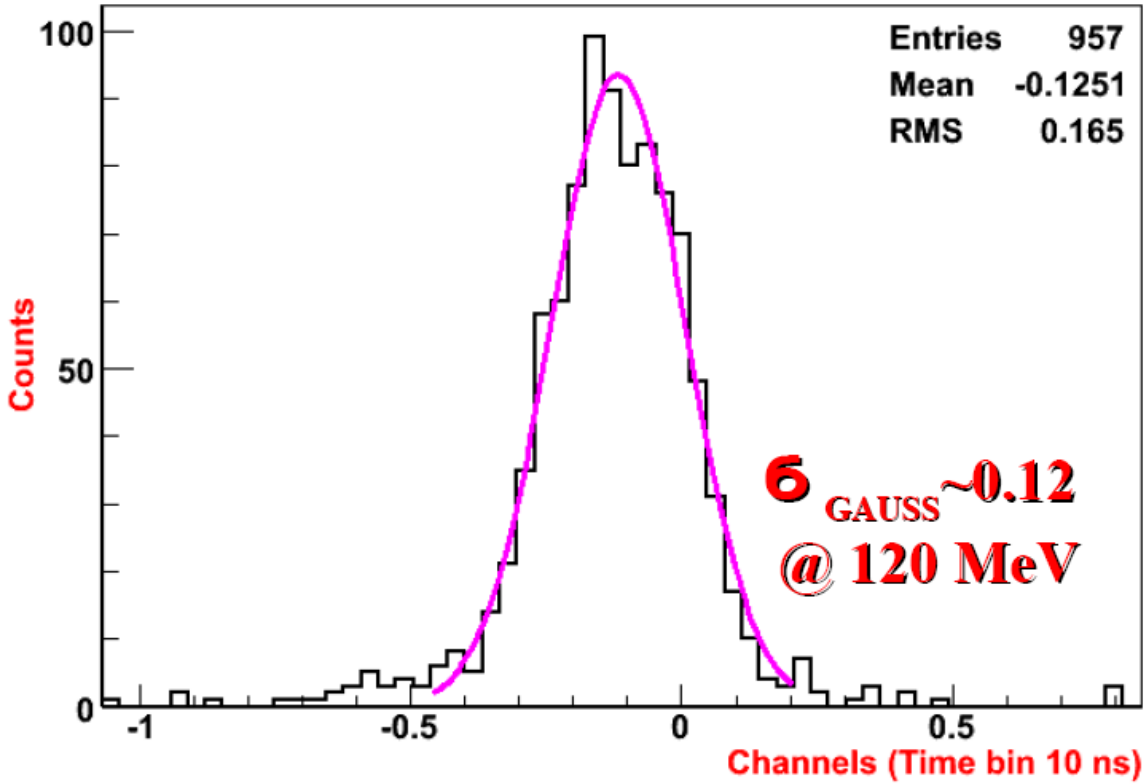


Time resolution = σ_{GAUSS} * Time bin = 0.41*10 ns = 4.1 ns

time resolution: high energy photons

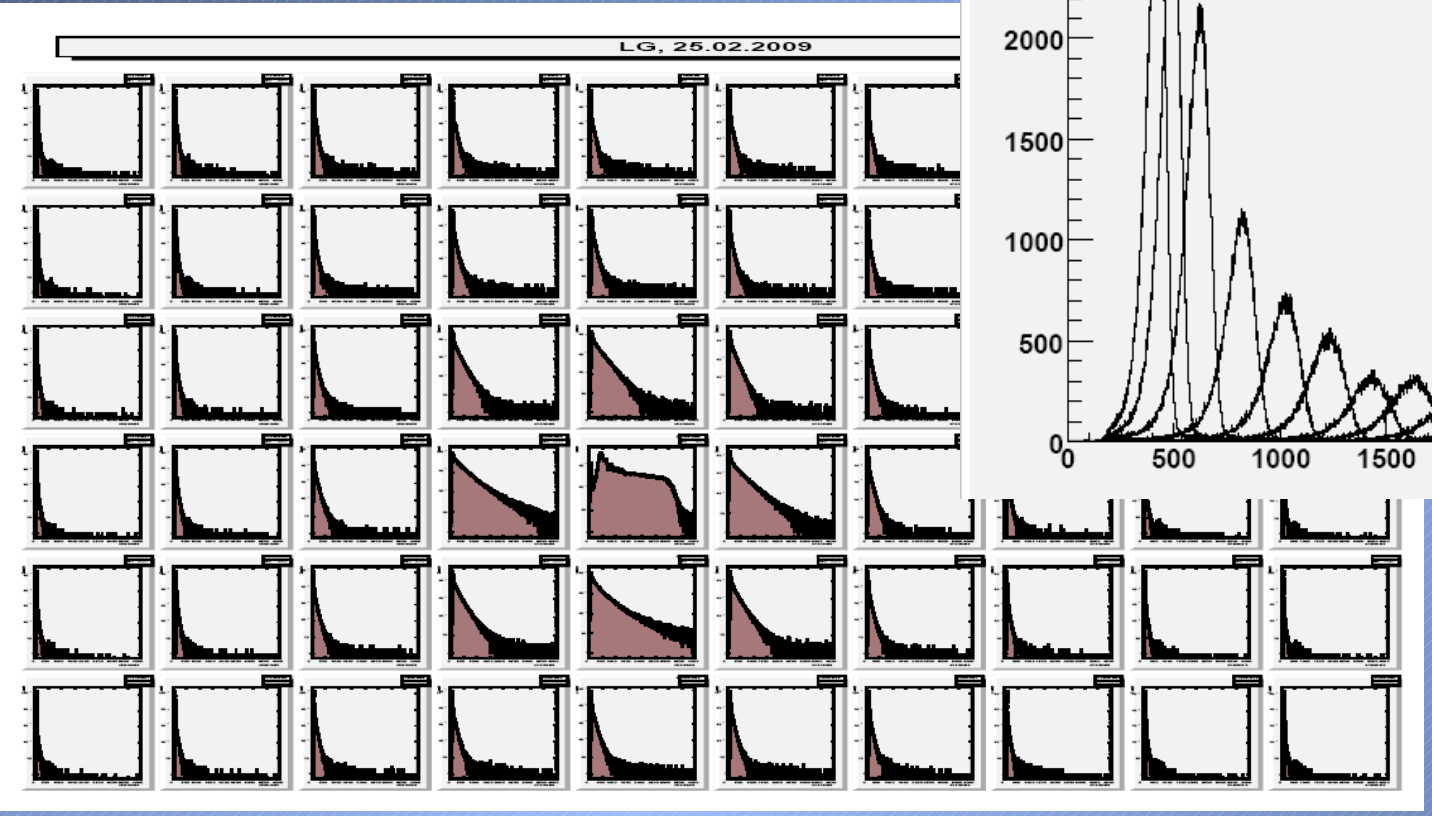
Difference between time stamps of 2 neighbour crystals

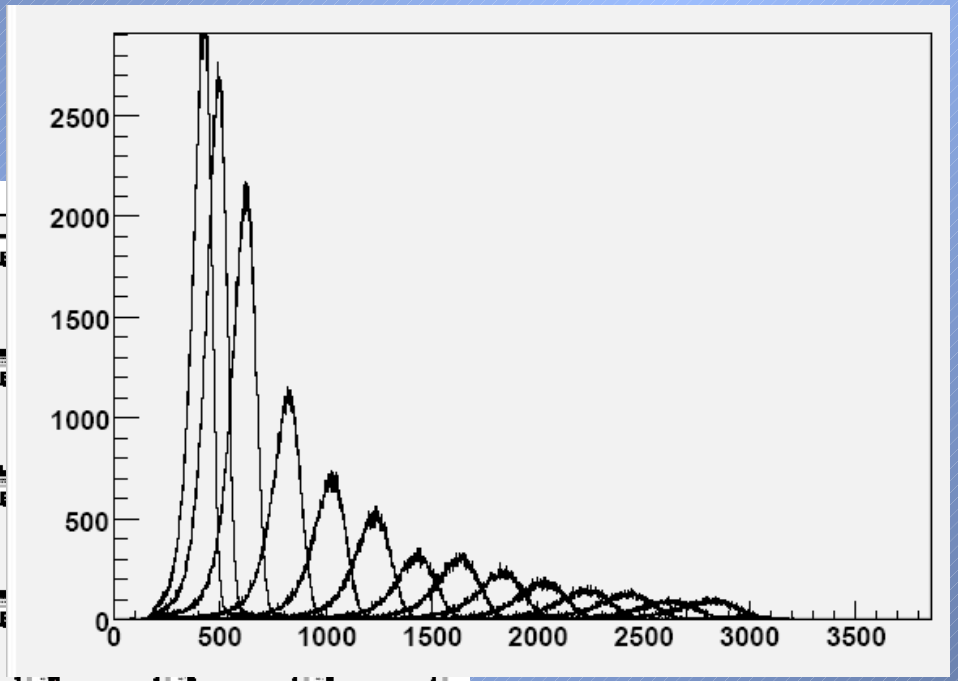




Time resolution at 120 MeV photon energy ~ 1.2 ns

PROTO60





- response function and resolution
- position reconstruction
- simulation of conversion (2mm Pb)
- read-out with: peak sensing ADC / SADC

M.Moritz

PROTO60: energy resolution

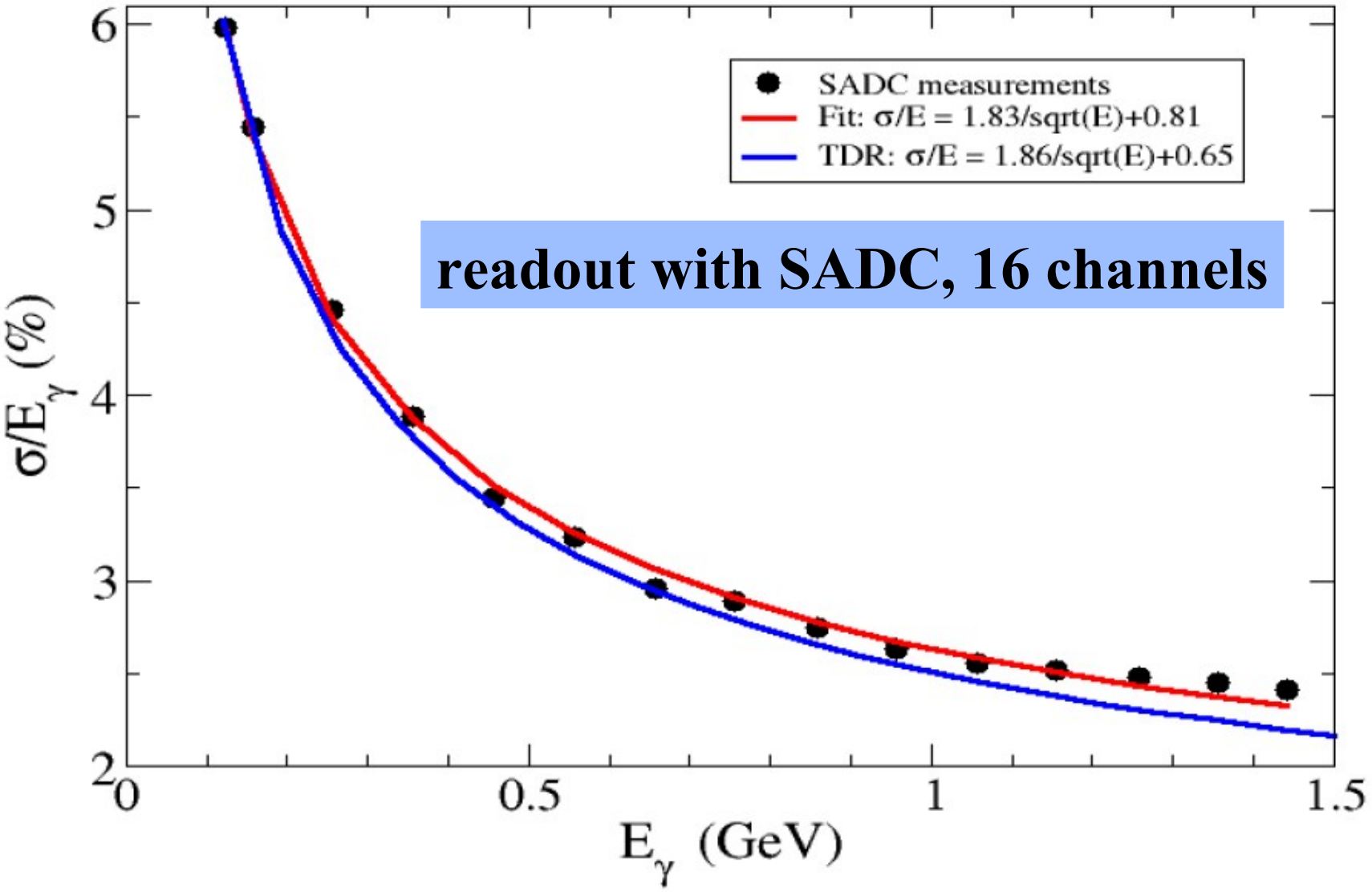
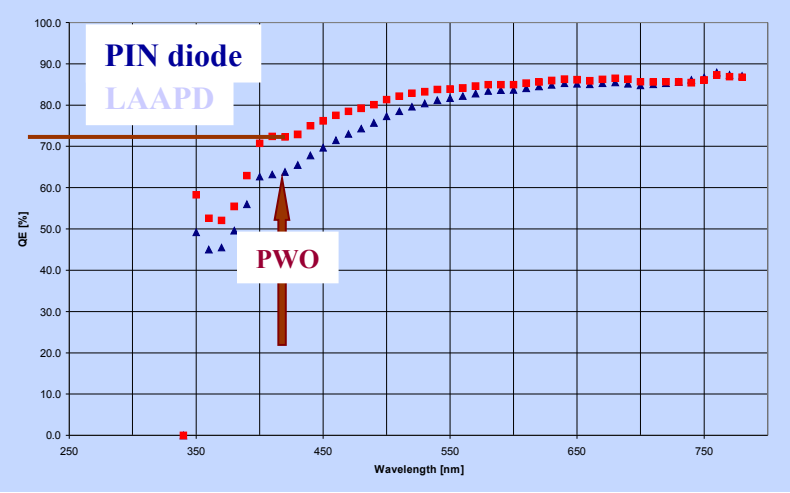
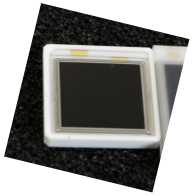


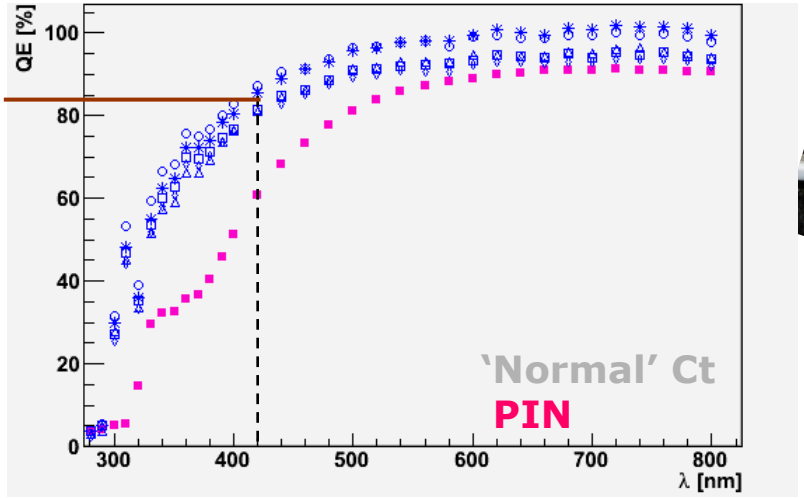
Photo sensors: LAAPD





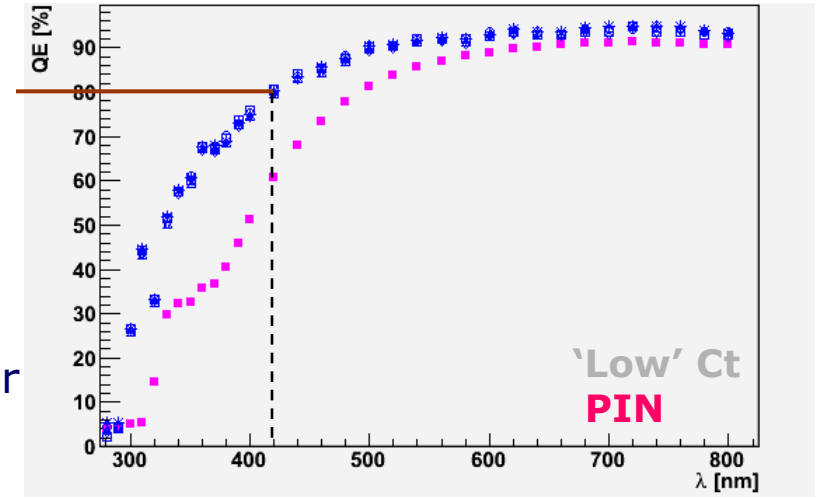
One APD of quadratic shape, 'Normal' Ct:

QE @ λ = 420 nm:
≈ 72%



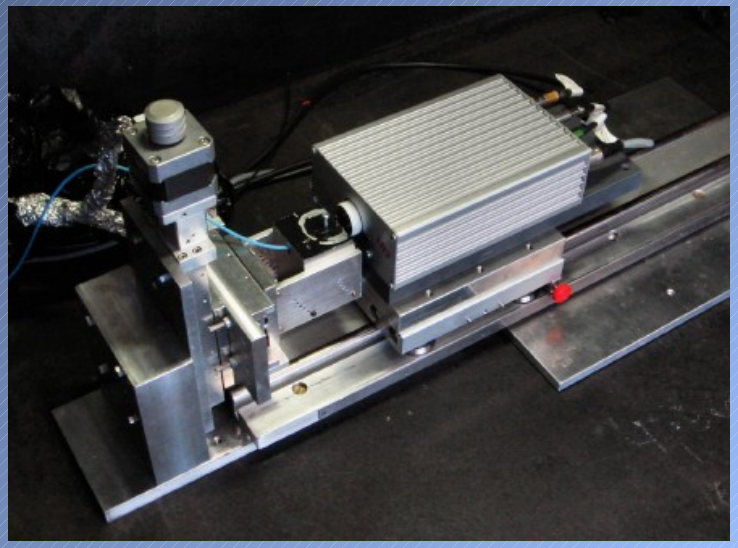
QE @ λ = 420 nm:
≈ 83%

5 APDs of rectangular shape



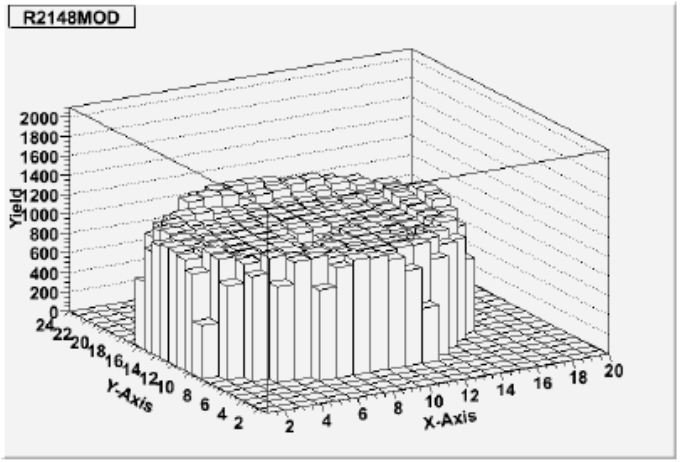
QE @ λ = 420 nm:
≈ 80%

Photo sensors: VPT



Hamamatsu R2148MOD
especially made for $\overline{\text{P}}$ANDA, $\varnothing < 24$ mm

- $\varnothing = 23.7$ mm
  $\ell = 30$ mm
- $U_A = 750$ V
  $U_D = 500$ V
- G = 9.3
- QE = 32 %
  (at 420 nm)



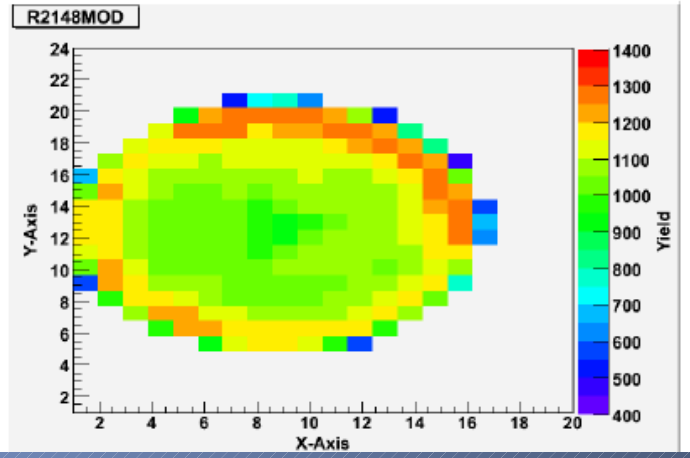
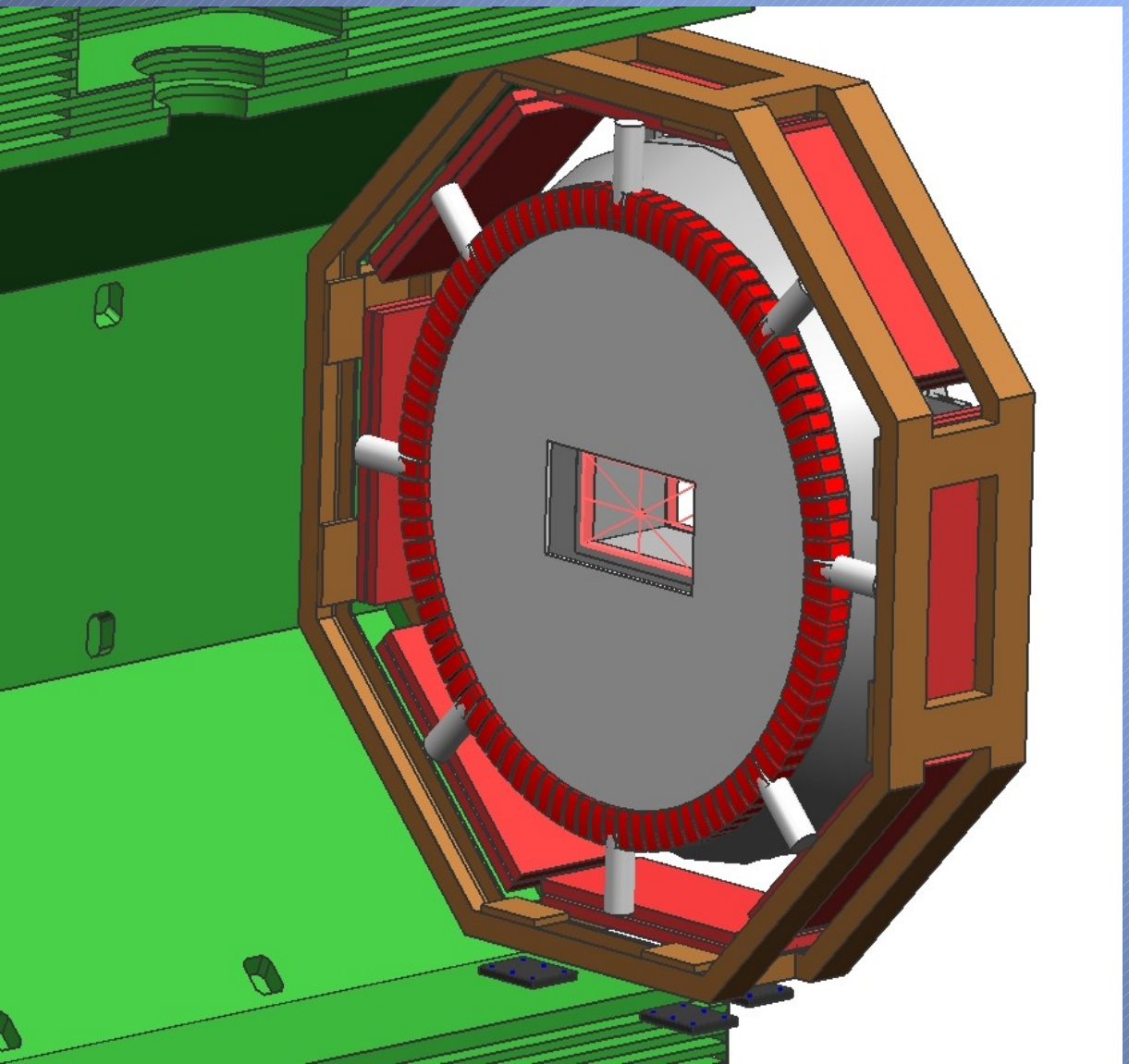


Photo sensors: VPT

	RIE	Photonis	R2148MOD1	R2148MOD
HV	1000 V	1090 V	800 V	750 V
G	10	30	11	9.3
QE	22 %	20 %	19 %	32 %
∅	26.5 mm	25.2 mm	25.8 mm	23.7 mm
$\varnothing_{sen.area}$	19 mm	25 mm	18 mm	16 mm
rel. width	7.8 %	22.1 %	9.2 %	7.4 %
$G \cdot QE$	2.20	6.00	2.09	2.98
AMP	916	1728	649	1110
$\frac{AMP}{G \cdot QE}$	1.1	0.8	0.8	1

S.Bolte

integration DIRC and FwEndcapEMC

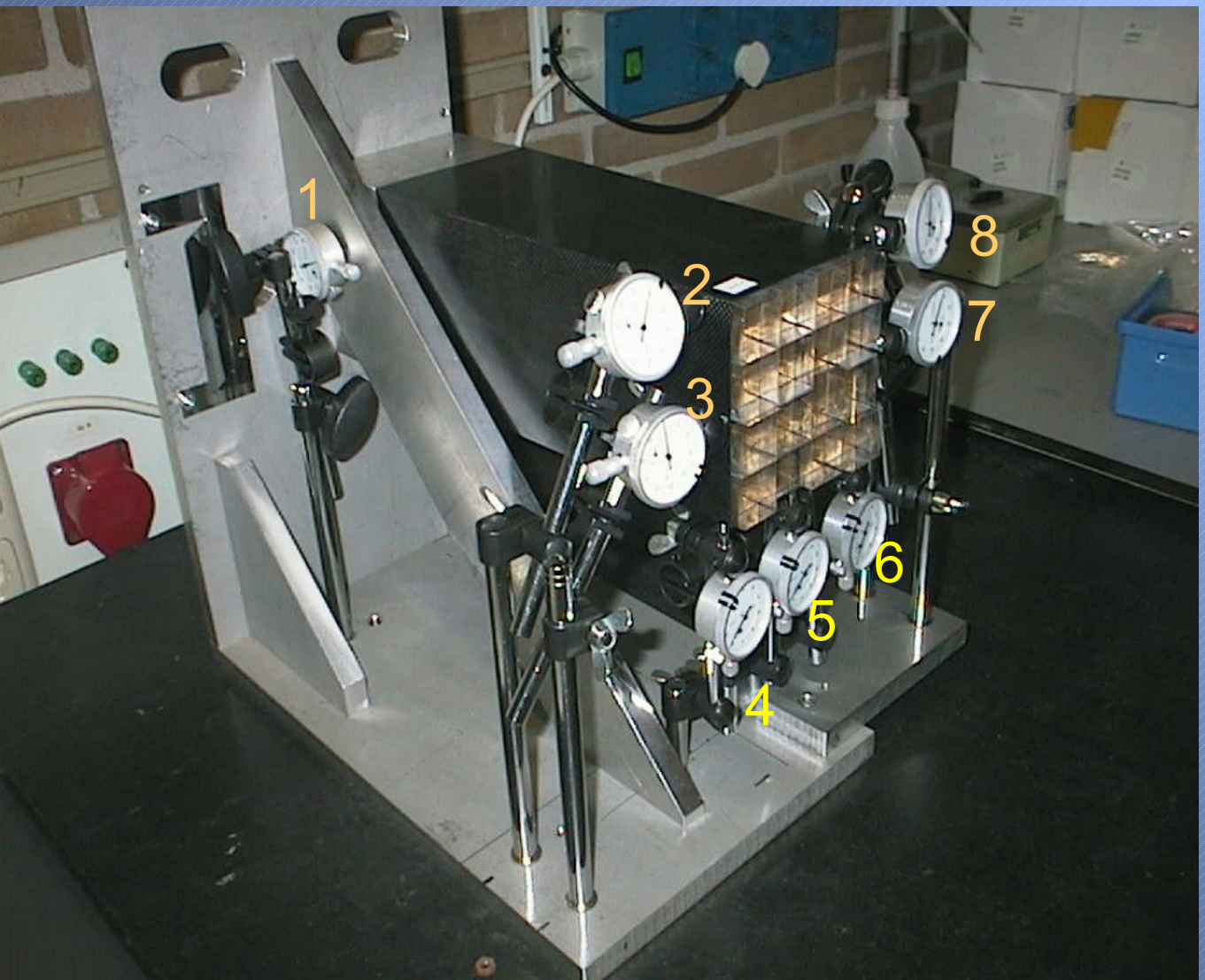


light Al frame (540 kg)
supported by solenoid,
space for
digitizing electronics:
16 times
0.4 m^2 = in total 6.5 m^2

inserts with
alignment crosses
foreseen in central hole

final decision needed:
rectangular / elliptic hole?

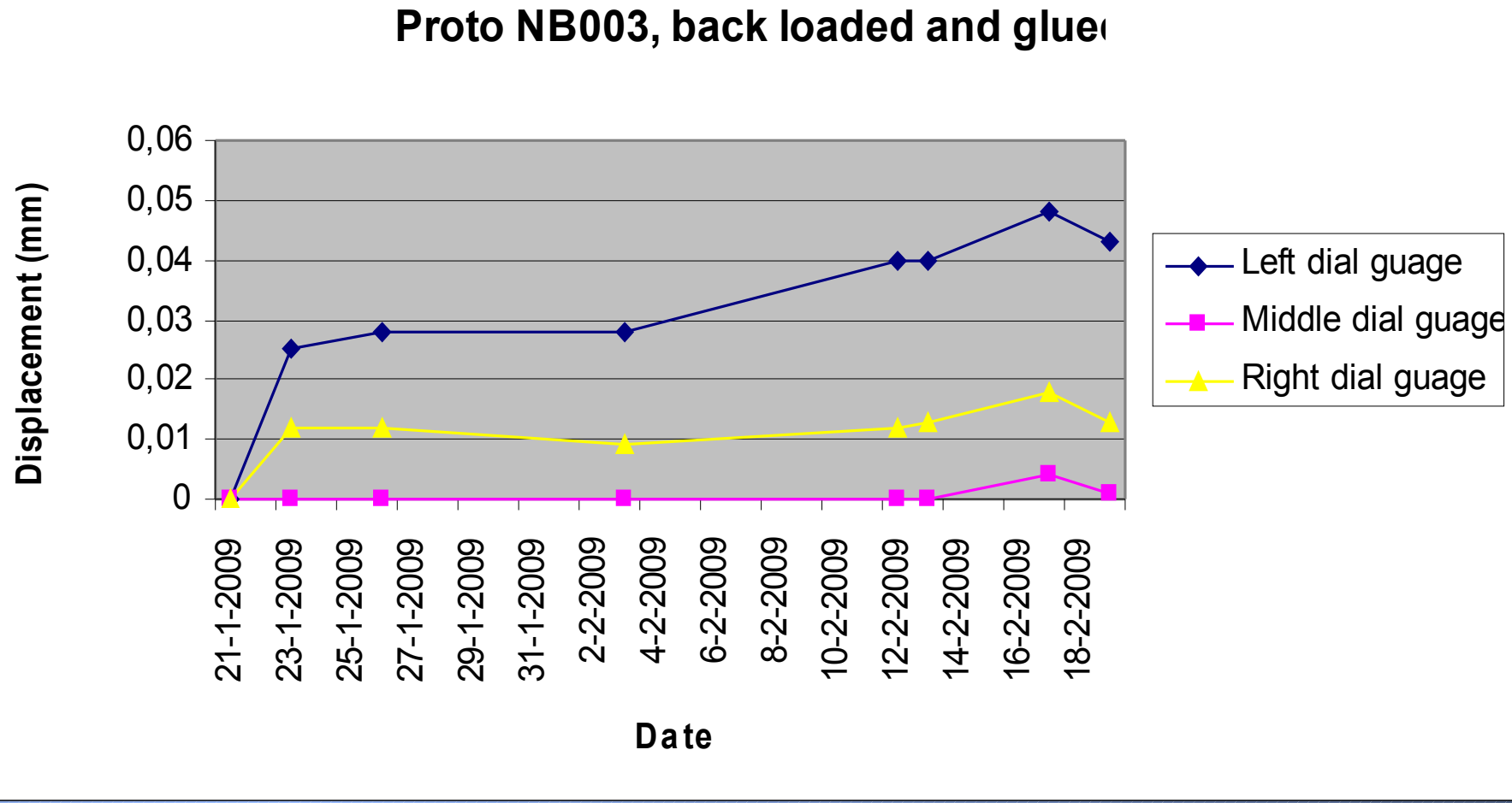
identification of position gauges



reading
accuracy
0.005 mm

H. Löhner

alveole # NB003 sag progression after loading “crystals” from the back side

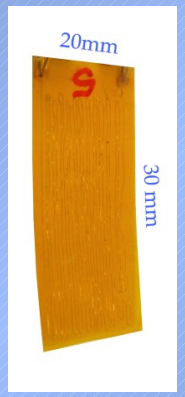


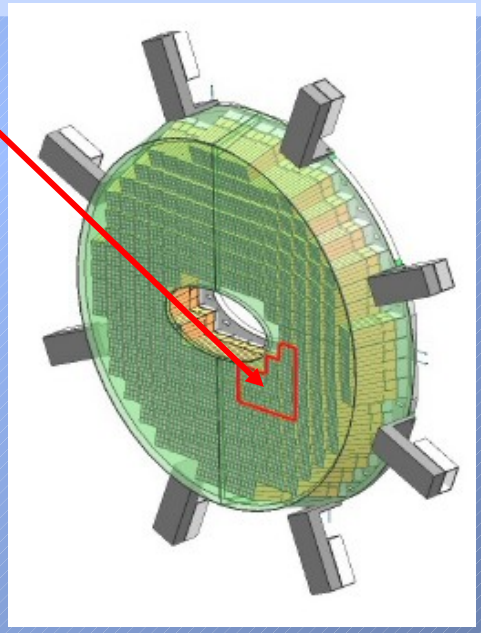
displacement < 0.05 mm during 30 days

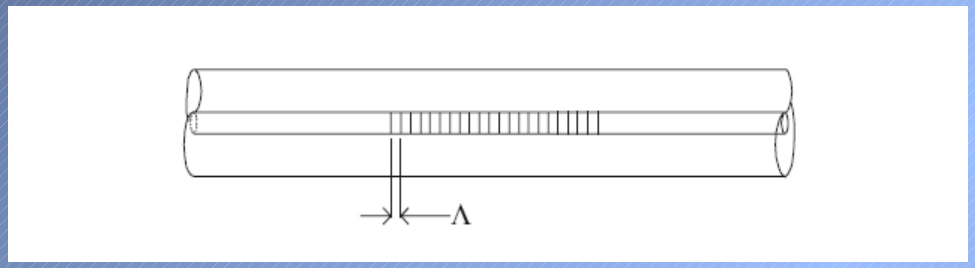
H. Löhner

development for FW-Endcap and PROTO 192

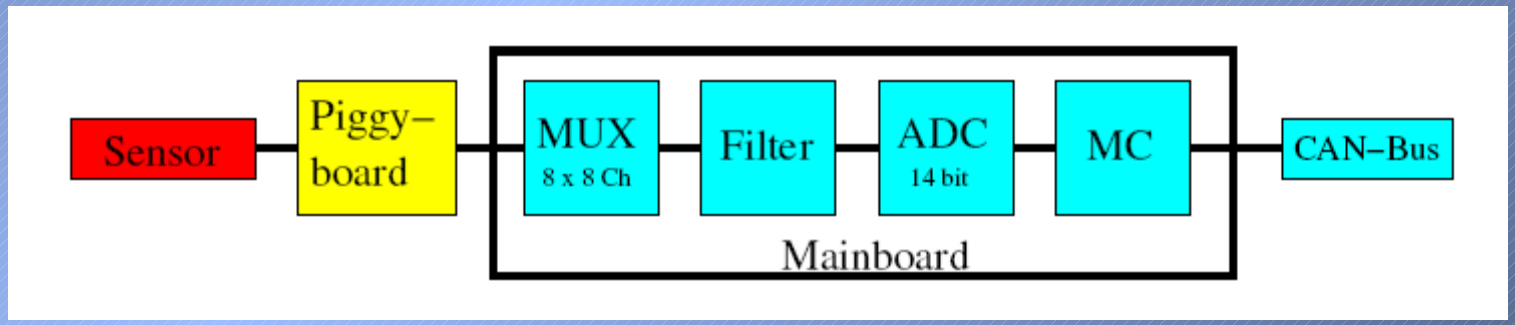
- temperature and humidity sensors
  F. Feldbauer
- Fiber Bragg Grating Sensors
  H. Löhner



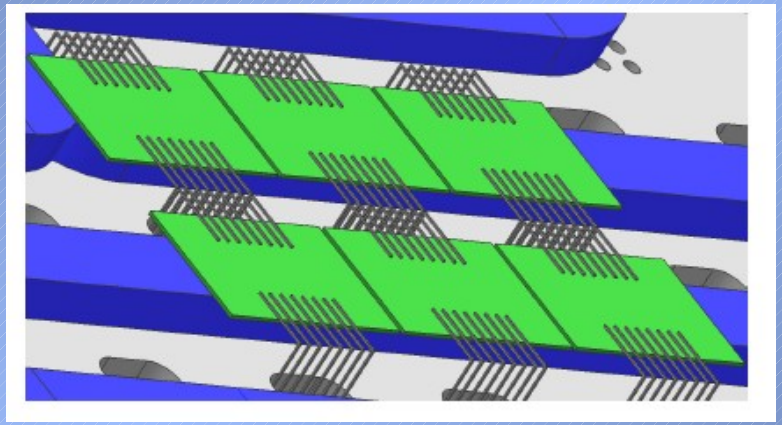




- humidity measurement: THMP
  F. Feldbauer

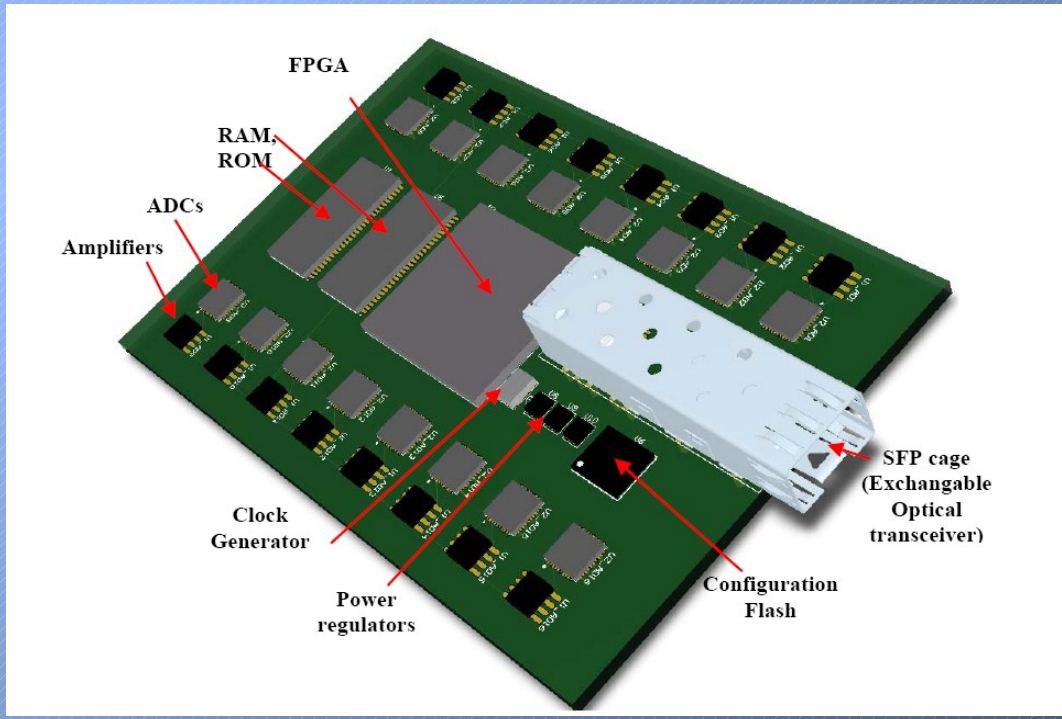


- integration of ADC cooling !
  J. Becker

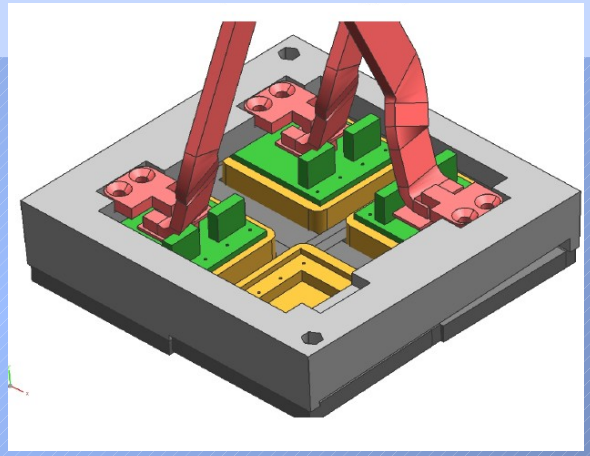


- ADC development
  P.Marciniewski

- 12bit …. 15bit
- sampling rate > 50MHz
  energy/time resolution
- power consumption
- radiation hardness
  ADC, FPGA, …



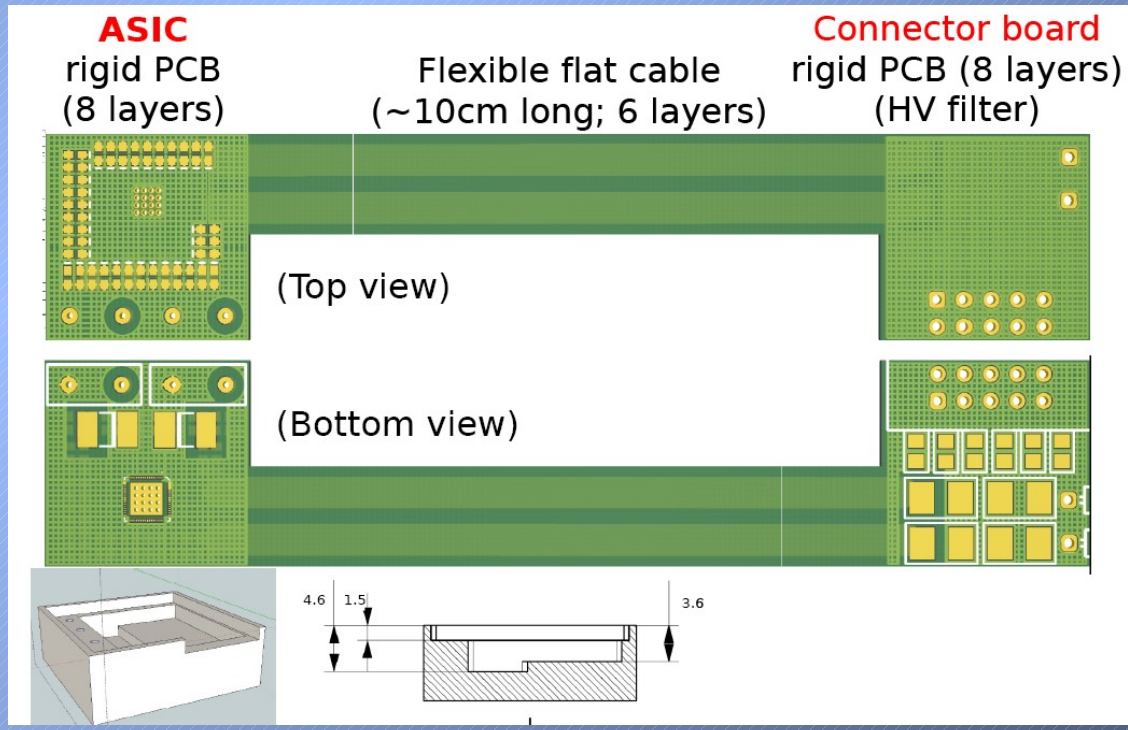
barrel: FE-electronics , inserts , cables



progress but:

many open questions:

- selection of components
- layout of PC-boards
- arrangement
- flexibility
- energy/time resolution
- link to other detectors ?

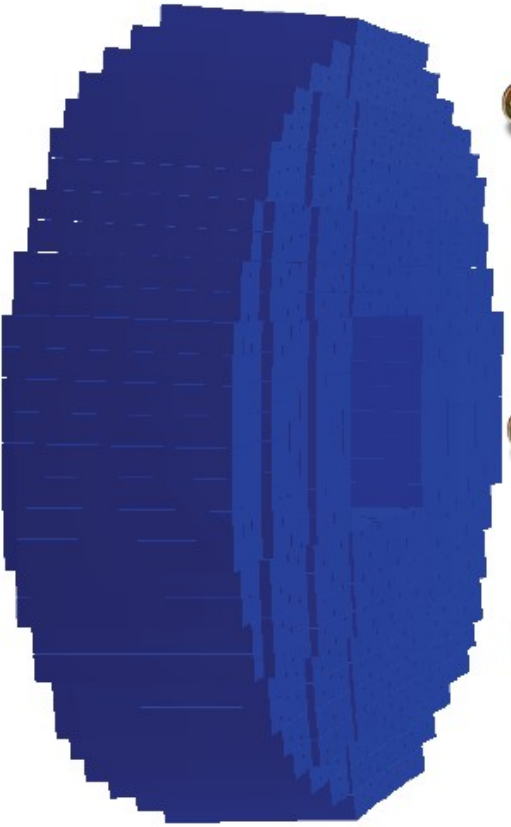


EVO-meetings

M.Kavatsyuk

Backward Endcap: simulations and many open questions

1) Tapered crystals
(Forward EndCap geometry)



- *Crystal size (mm):*
  front: 24.4x24.4x200
  back: 26x26x200
- θ *range:*
  146.1° - 169.5°
- *Diameter (mm)*
  front face: 752.85

2) Straight crystals

- *Crystal size (mm):*
  26x26x200
- θ *range:*
  144.4° - 170°
- *Diameter (mm):*
  801.60

Fiber Bragg Gratings (FBG)

C. Doyle, Smart Fibres Ltd. 2003

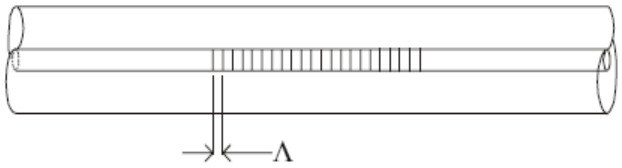
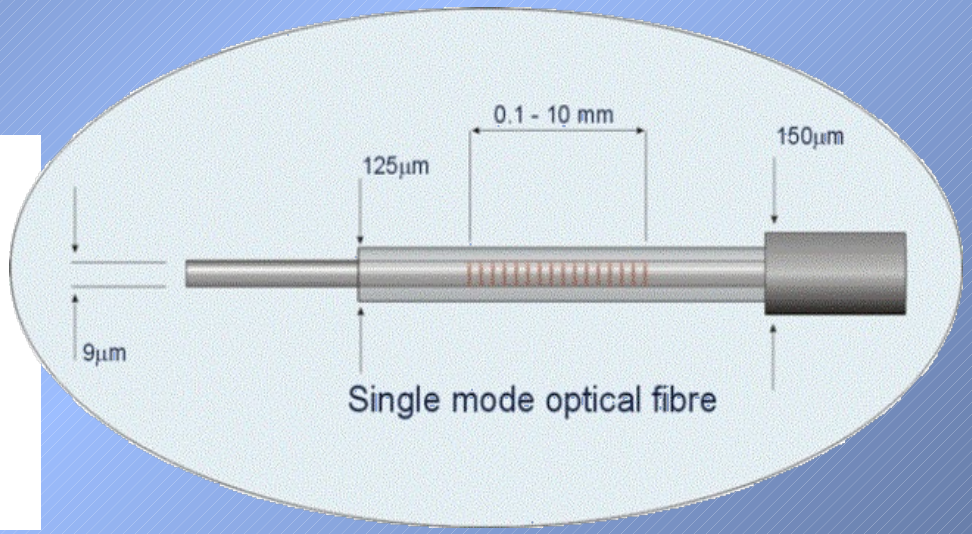


Figure 1. FBG, indicating core refractive index variations



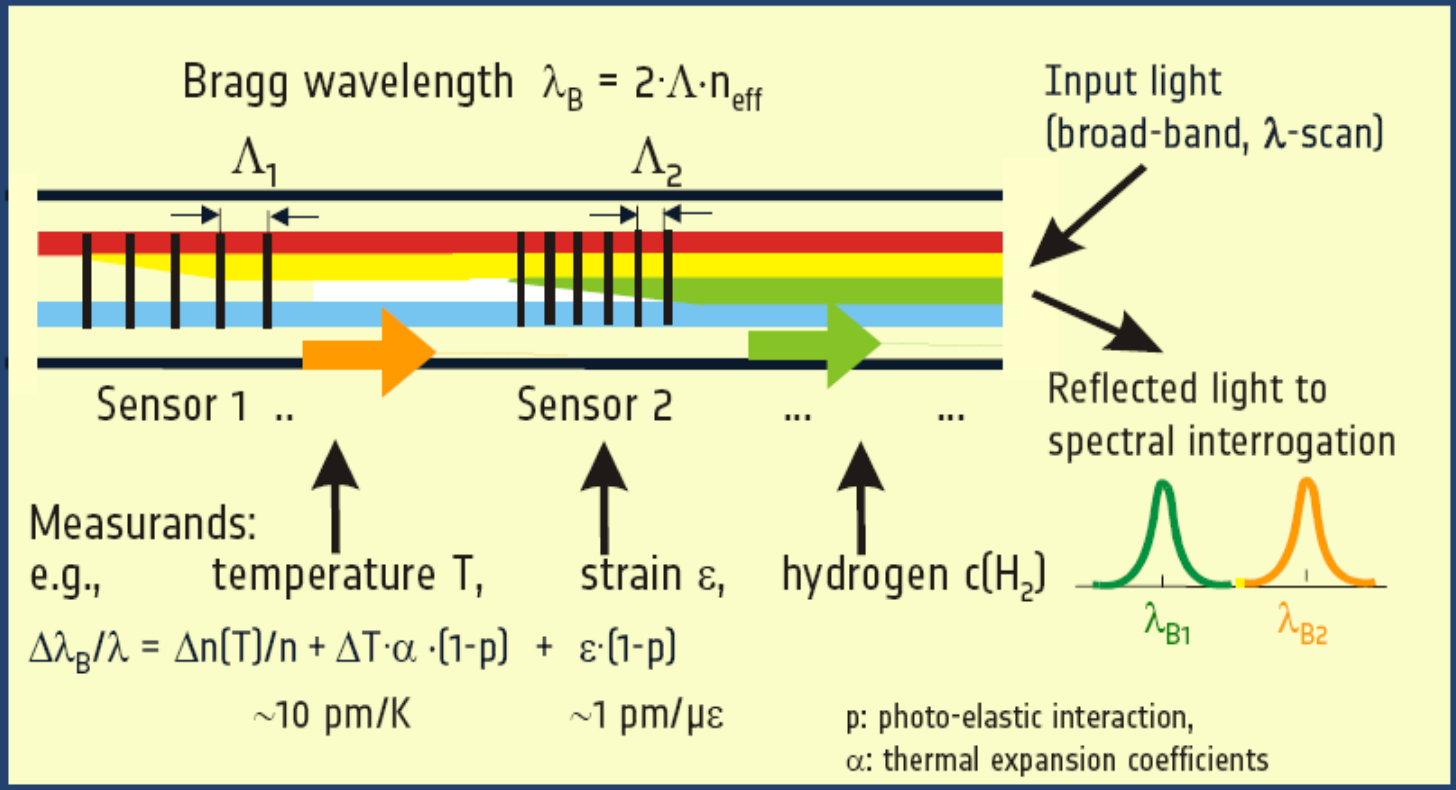
maximum reflectivity occurs at Bragg wavelength λ_B with

$\lambda_B = 2\, n_{eff}\ \Lambda$

where n_{eff} = effective refractive index of mode of propagation in fiber,
and Λ = FBG period

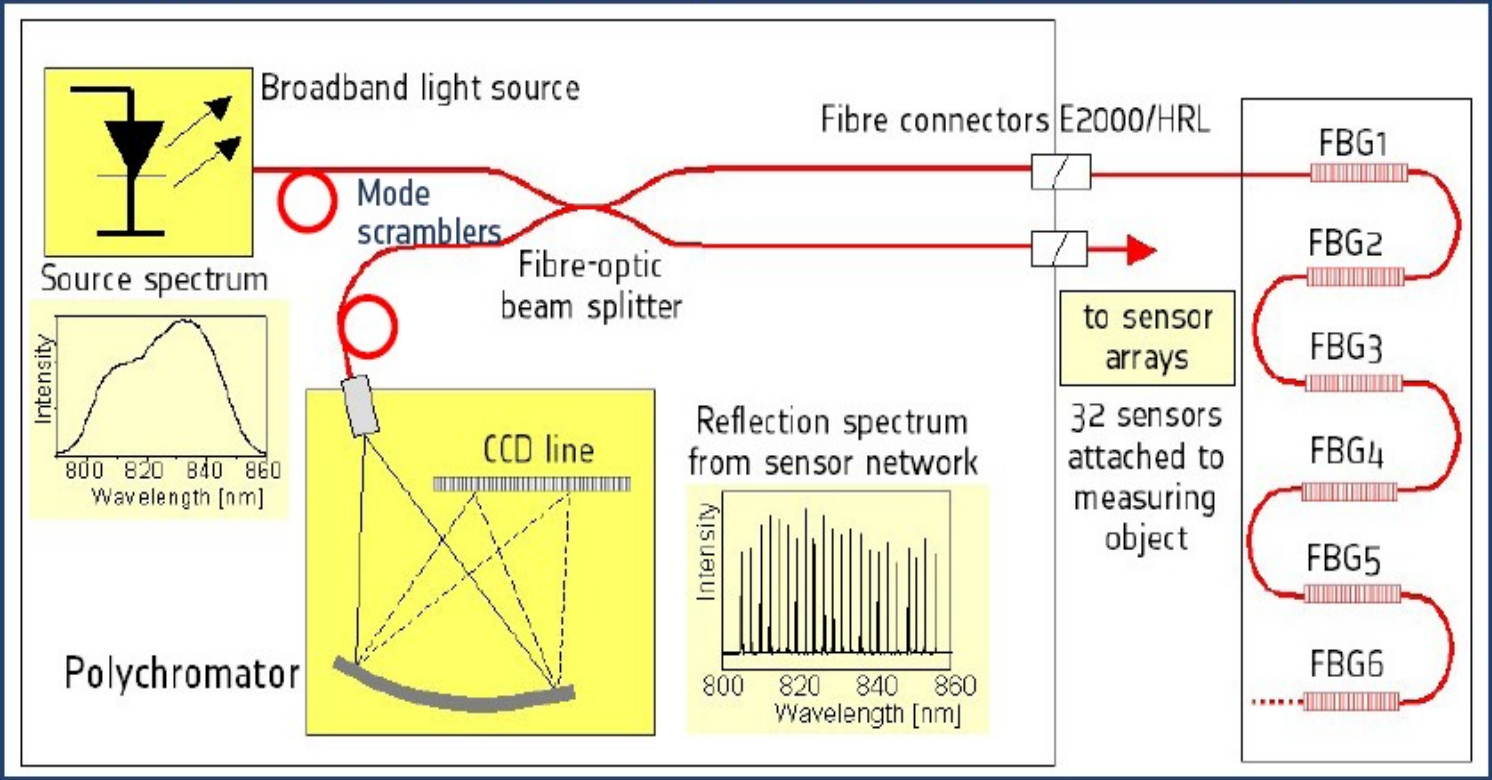
Fibre Bragg Grating Sensor and Multiplexing Principle

- FBG sensor systems: distributions of strain, temperature, refractive index, ..
- Wavelength Division Multiplexing (WDM)



Polychromator FBG Interrogator: Fibre Optics/Optoelectronics

- SLD broadband light source 800 .. 860 nm: higher WDM capacity than @ 1550 nm
- Low-cost polychromator: imaging diffractive grating (polymer replicated) & CCD detector
- Simultaneous measurement of all sensors; no interference of scan rate/distance/wavelength!



Technical Parameters of Polychromator Based FBG Sensor System

- Broadband source wavelength range: 805 .. 870 nm (= 10% strain)
- 32 sensors, measurement exactly simultaneously
- Measuring speed: 1000.00 measurements/s; Ethernet data to PC
- SPU operational temperature range: -40 .. +70 °C
- Sensor reflectivity: 2 .. 90 %
- 1σ rms noise at spectrometer full scale: 0.4 pm (= 0.6 με, 0.05 K)
- Noise reduction: Gaussian correlation, averaging, Kalman filter
- Sensor temperature operation range: -270 °C .. +300 °C (.. +900 °C)
- Sensor strain range: ±0.5 % (standard FBG), ±5 % (draw tower FBG)
- Bragg wavelength accuracy: 25 pm
- Max. length of fibre-optic transmission cable: ~ 1 km