



# Radiation defects research in Lithuania and Belarus in the frame of CERN RD50 collaboration

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Vilnius University





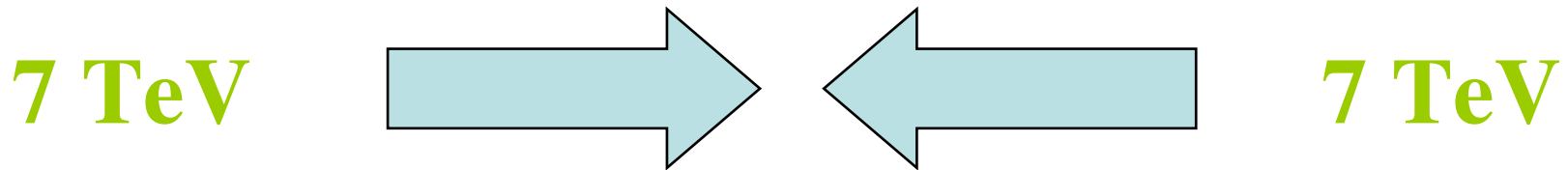
# Outline:

- What is RD50 collaboration?
- How do we contribute to this project?
- Where is our power?
- Outcome from the collaboration with CERN and from other activities to the Lithuania



# The Large Hadron Collider (LHC)

Proton- Proton **OR** Pb nuclears Collider



## Primary targets:

- Origin of mass
- Nature of Dark Matter
- Primordial Plasma
- Matter vs Antimatter

## “Secondary target”:

- Structure of proton when it is 7450 times heavier than at the rest

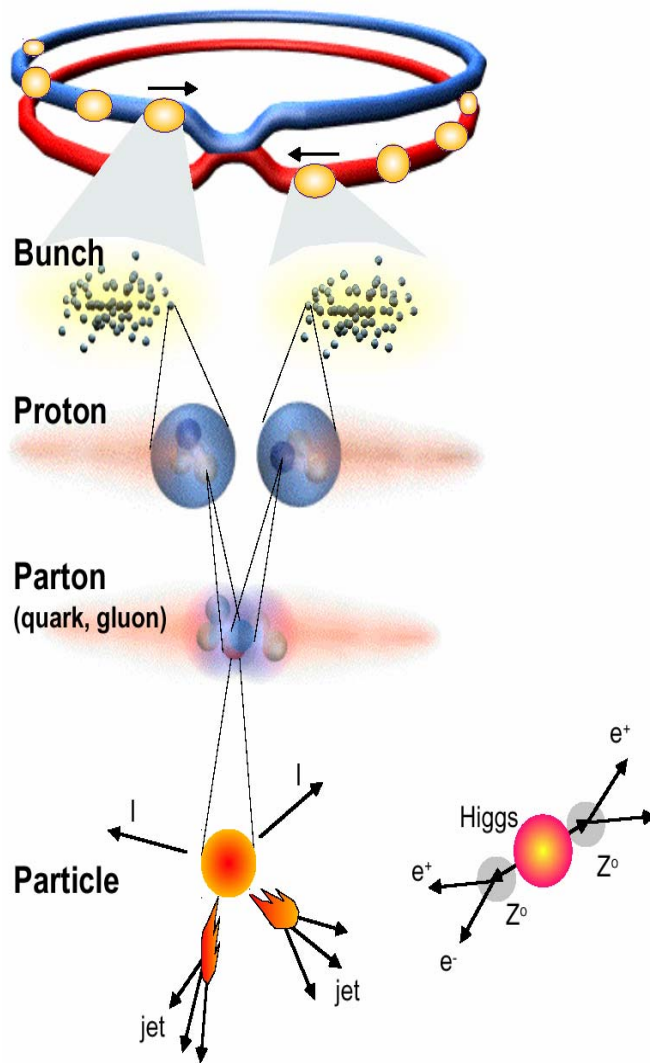
# Example: Large Hadron Collider LHC, start 2008

## Proton-proton collider:

- $2 \times 7 \text{ TeV}$
- $\text{Luminosity: } 10^{34}$
- **Bunch crossing: every 25 nsec,**  
(i.e., rate: 40 MHz)

**Event rate:  $10^9/\text{sec}$  (23 interactions per bunch crossing)**

- Annual operational period:  $10^7 \text{ sec}$
- Expected total operational period: 10 years

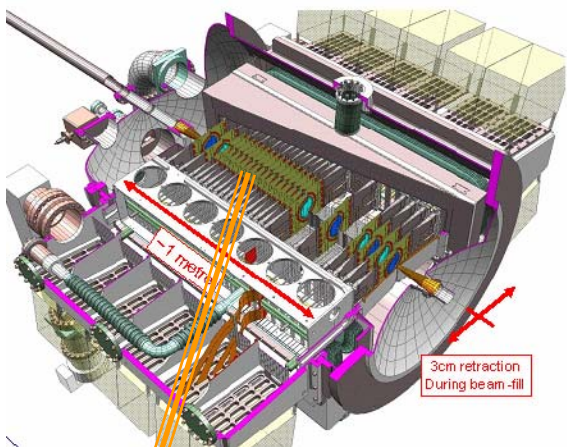
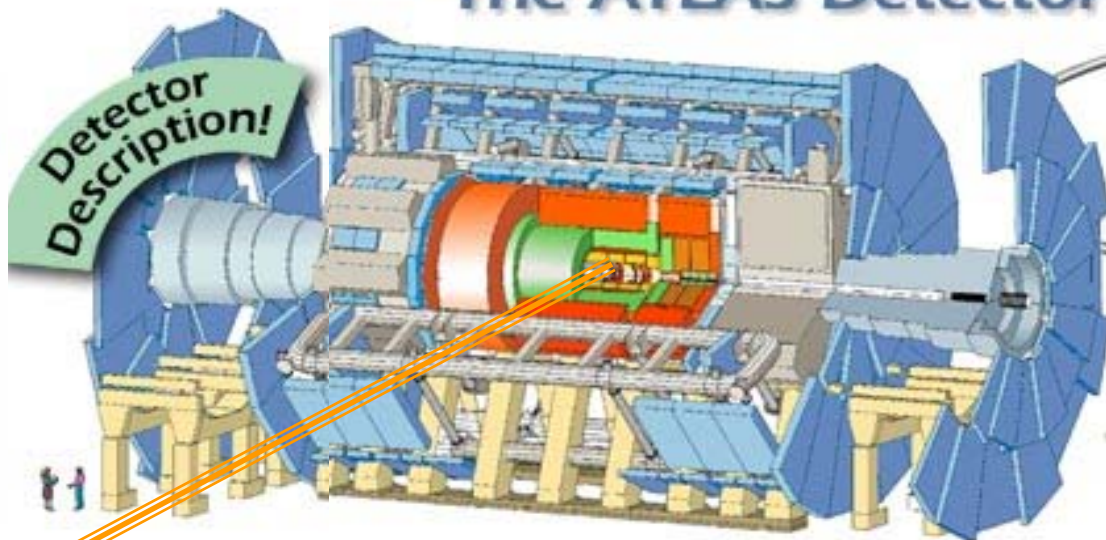


**Event Selection:**  
**1 in 10,000,000,000,000**



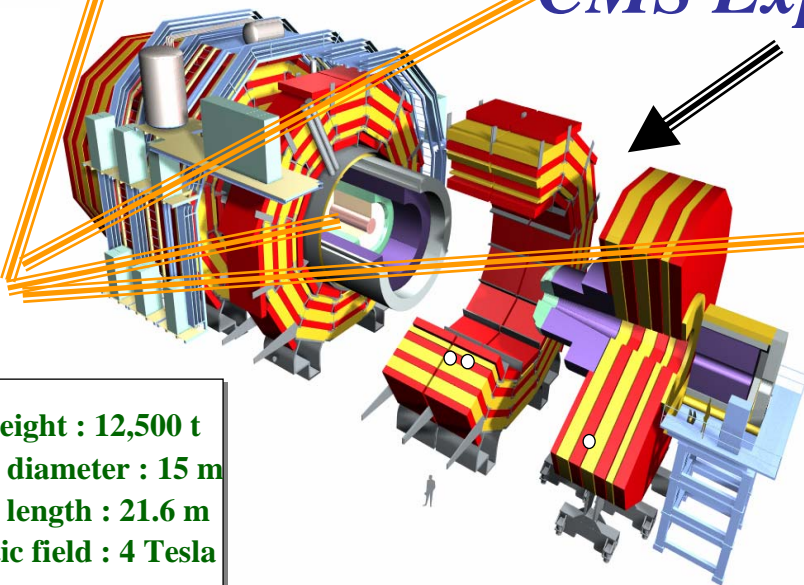
# The main experiments:

## The ATLAS Detector



## VERTEX LOCATOR

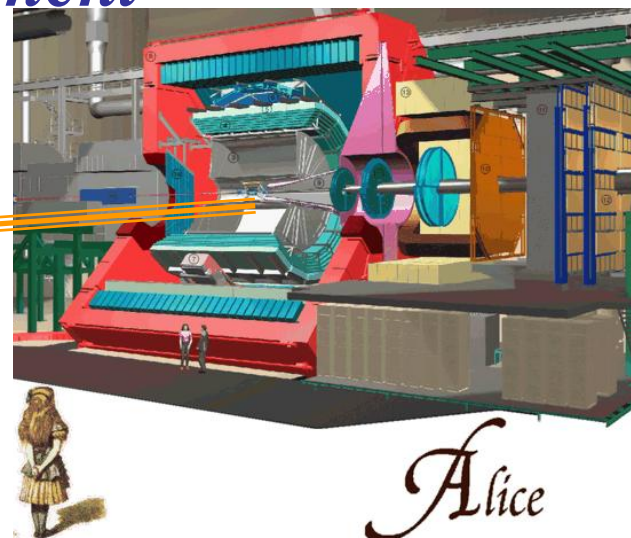
## CMS Experiment



**TRACKER**

Silicon  
Micr -strip  
Pixels

Total weight : 12,500 t  
Overall diameter : 15 m  
Overall length : 21.6 m  
Magnetic field : 4 Tesla



*Alice*

Colliding Ultra-Relativistic Heavy Ions



▪ Expected total operational period: 10 years !!!

Too long !!!

Upgrade LHC to “Super-LHC”:

to reach luminosity  $L = 10^{35} \text{cm}^{-2}\text{s}^{-1}$ ;

to guaranty 5 year operational period

**Radiation environment** (CERN-TH/2002-078)

Distance, cm	Fast hadron fluence, $\text{cm}^{-2}$	Dose, MRAD
4	$1.6 \times 10^{16}$	420
22	$8.0 \times 10^{14}$	35

**Present semiconductor detector technology is not able to operate at such high fluences/doses**

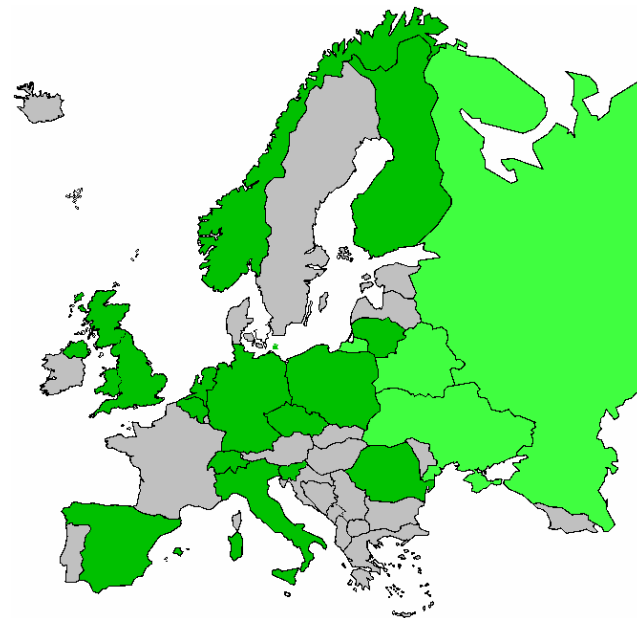


# RD50 - Development of Radiation Hard Semiconductor Devices for High Luminosity Colliders

254 Members from 47 Institutes

38 European institutes

**Belarus (Minsk)**, **Belgium** (Louvain), **Czech Republic** (Prague (3x)), **Finland** (Helsinki, Laappeenranta), **Germany** (Dortmund, Erfurt, Freiburg, Hamburg, Karlsruhe, Munich), **Italy** (Bari, Florence, Padova, Perugia, Pisa, Trento), **Lithuania (Vilnius)**, **Netherlands** (NIKHEF), **Norway** (Oslo (2x)), **Poland** (Warsaw(2x)), **Romania** (Bucharest (2x)), **Russia** (Moscow, St.Petersburg), **Slovenia** (Ljubljana), **Spain** (Barcelona, Valencia), **Switzerland** (CERN, PSI), **Ukraine** (Kiev), **United Kingdom** (Exeter, Glasgow, Lancaster, Liverpool)



8 North-American institutes

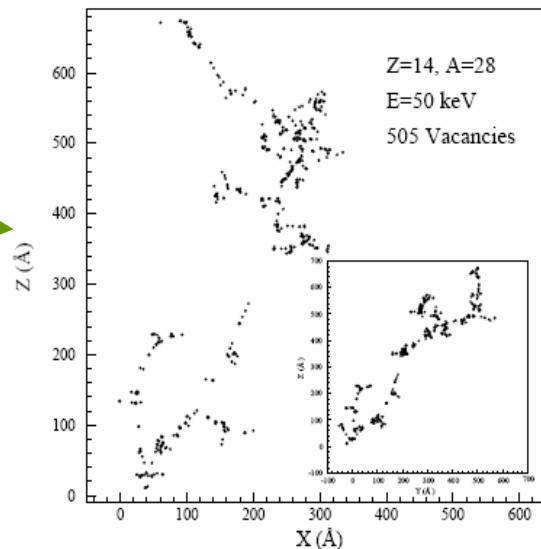
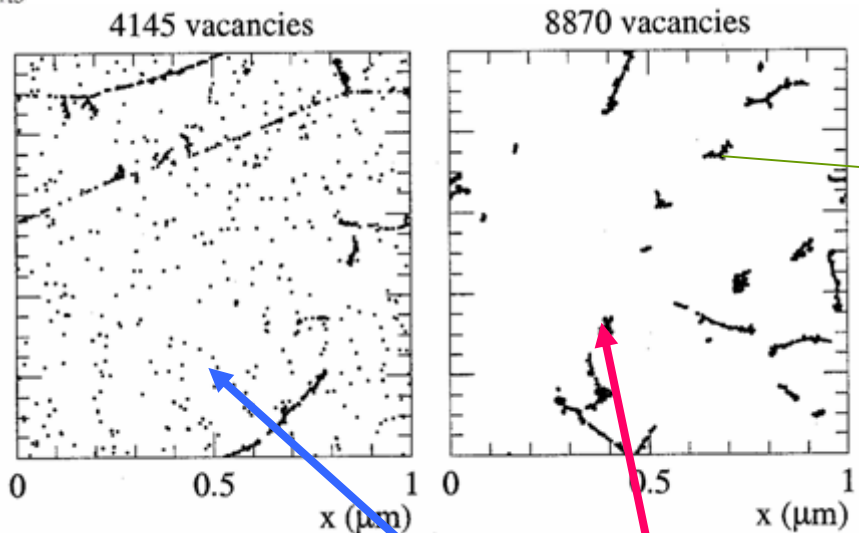
**Canada** (Montreal), **USA** (BNL, Fermilab, New Mexico, Purdue, Rochester, Santa Cruz, Syracuse)

1 Middle East institute

**Israel** (Tel Aviv)

Detailed member list: <http://cern.ch/rd50>

# Where are the problems?



## How problems can be solved?

The insertion of different impurities or creating their complexes is possible to increase the radiation hardness of silicon. All teams are trying to optimize this process.

It will not solve all problems, but the detectors can be improved in comparison with today existing.

Damage effects during proton & neutron irradiation

The different methods register different defects or give the different parameters.

Treatment influences on the defect migration and modification.



## WODEAN project:

### FTIR:

Oslo University and **Minsk Joint Institute of Solid State Physics**

### C-DLTS:

NIMP Bucharest and Hamburg University: I. Pintilie, E. Gaubas

**Minsk University:** L. Makarenko

Oslo University: B. Svensson

### I-DLTS:

INFN and Florence University: D. Menichelli

### TSC:

NIMP Bucharest and Hamburg University: I. Pintilie, E. Gaubas

### PITS:

ITME Warsaw: P. Kaminski, R. Kozlowski

### PL:

Kings College London: G. Davies

ITME Warsaw: B. Surma

**EPR:** NIMP Bucharest: S. Nistor; ITME Warsaw: J. Jurek

### Diode characteristics (C/V, I/V, TCT):

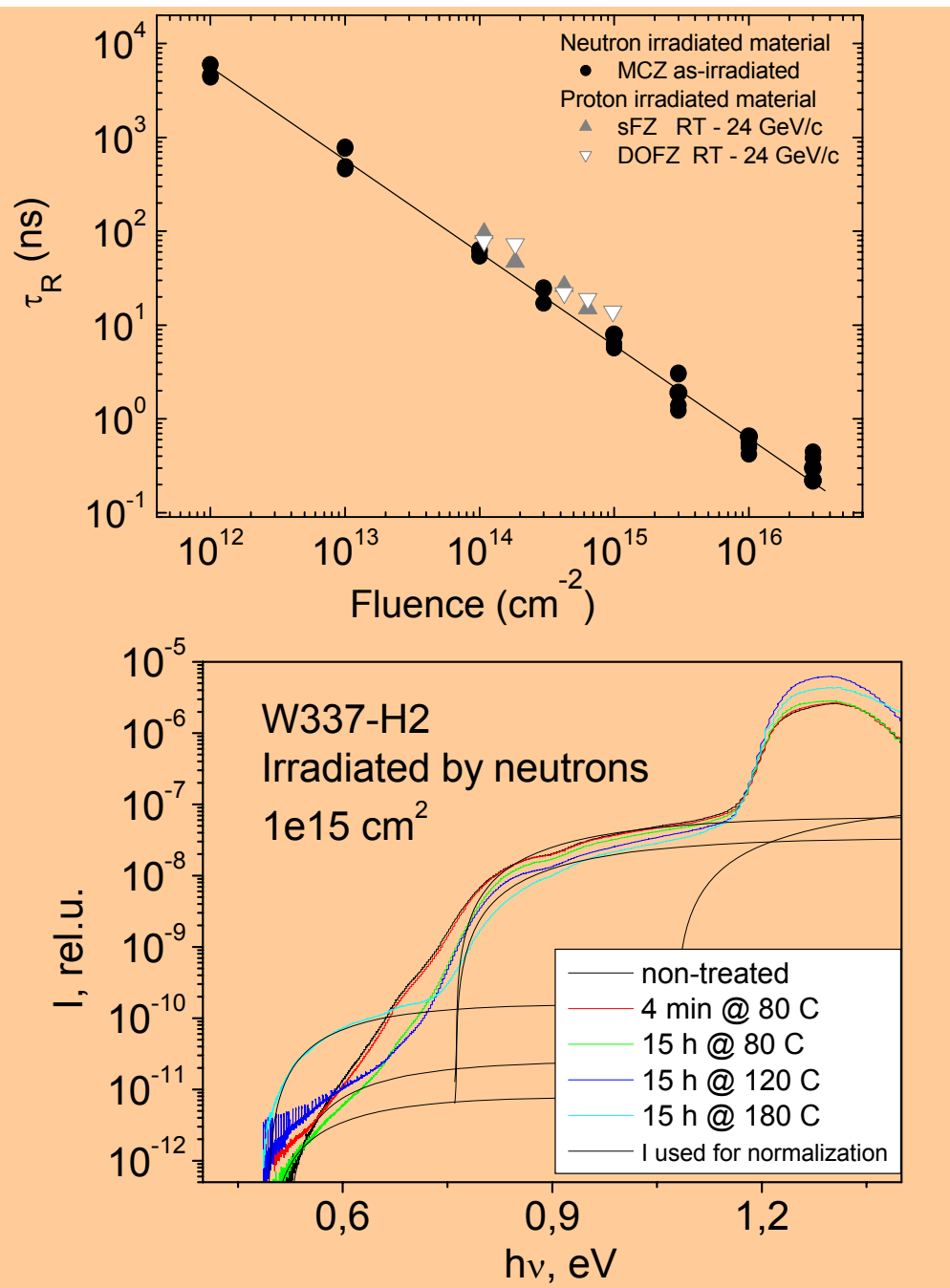
CERN-PH, Hamburg University, JSI Ljubljana: M. Mošič

### Recombination lifetime:

**Vilnius University:** E. Gaubas, J. Vaitkus

### PC:

**Vilnius University:** J. Vaitkus, E. Gaubas





# WODEAN

## 2nd WODEAN batch sample list

$\Phi$ (1MeV n)	C-DLTS	I-DLTS	TSC	PITS	PL	$\tau_{recomb}$	FTIR	PC	EPR
3E11	HH,Oslo, Minsk								
6E11	HH,Oslo, Minsk								
1E12									
1E13		Florence	HH, NIMP	ITME	KC, ITME	Vilnius		Vilnius	
3E13			HH, NIMP						
1E14		Florence	HH, NIMP	ITME	KC, ITME	Vilnius		Vilnius	

## 1st WODEAN batch sample list

$\Phi$ (1MeV n)	C-DLTS	I-DLTS	TSC	PITS	PL	$\tau_{recomb}$	FTIR	PC	EPR
3E11	HH,Oslo, Minsk								
6E11	HH,Oslo, Minsk								
1E12				ITME	KC, ITME	Vilnius		Vilnius	
1E13		Florence	HH, NIMP	ITME	KC, ITME	Vilnius		Vilnius	
3E13			HH, NIMP	ITME	KC, ITME	Vilnius		Vilnius	
1E14		Florence	HH, NIMP	ITME	KC, ITME	Vilnius		Vilnius	
3E14		Florence	HH, NIMP	ITME	KC, ITME	Vilnius		Vilnius	
1E15		Florence		ITME	KC, ITME	Vilnius	Oslo	Vilnius	NIMP ITME
3E15				ITME	KC, ITME	Vilnius	Oslo	Vilnius	NIMP ITME
1E16				ITME	KC, ITME	Vilnius	Oslo	Vilnius	NIMP ITME
3E16				ITME	KC, ITME	Vilnius	Oslo	Vilnius	NIMP ITME

ITME	KC, ITME	Vilnius	Oslo	Vilnius	NIMP ITME
ITME	KC, ITME		Oslo		NIMP ITME
ITME	KC, ITME	Vilnius	Oslo	Vilnius	NIMP ITME
ITME	KC, ITME		Oslo		NIMP ITME

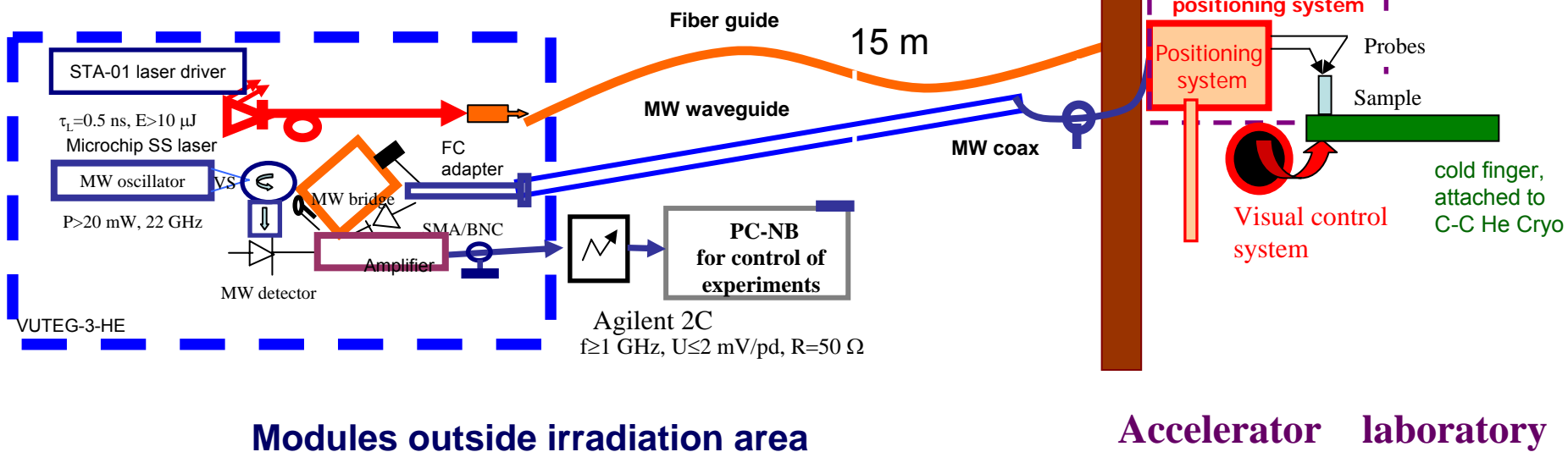
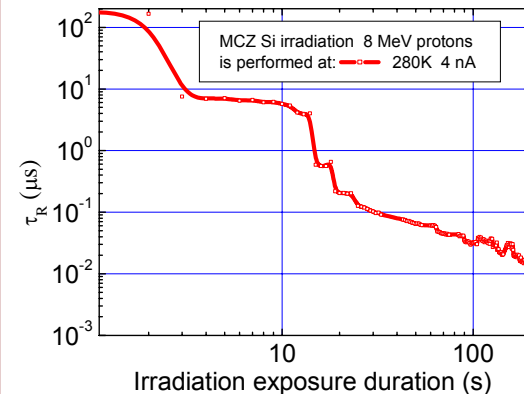
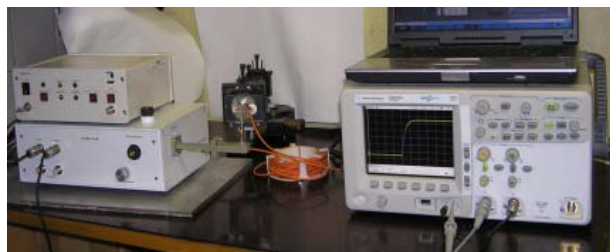
*ker, STM): 67 diodes, 24 nude thick samples;*

150 samples n-MCz <100>1 k $\Omega$ cm (OKMETIC, CiS): 84 diodes, 48 nude standard, 16 nude thick



# Where are we unique?

## PC decay measurement, especially, remote mode.



*The microwave probed photoconductivity (MW-PC) modules for the direct measurements of the carrier decay transients by employing MW absorption are assembled.*



Long term experience of Minsk  
(microelectronics technology) and Vilnius  
(semiconductors investigation methods)  
have been exploited for this program

What are the Vilnius possibilities?

and

Where they can be used additionally for  
other collaboration lines?



# Semiconductor Physics Department & Institute of Applied Research: **Research Groups**

Luminescence  
Photoreflec-  
tance, Raman  
spectra

Prof.A.Žukauskas

Light  
amplification,  
luminescence  
intensity and  
decay time  
spectra

Prof.S.Jursenas

Light induced  
transient  
gratings for  
lifetime and  
diffusivity  
measurement

Prof.K.Jarašiūnas

Photoconducti-  
vity spectrum  
for the deep  
level analyze

Prof.

**V.Kažukauskas**

I(V), C(V),  
TOF  
at different  
temperature  
measure-  
ment

Simulation  
by  
functional  
theory and  
TCAD

Dr.E.Žasinas

Microwave  
methods for  
light induced  
photoconduc-  
tivity analyze

**H.Dr.E.Gaubas**

Hall and  
magnetoresistance  
effects in  
semiconductors  
and its decay after  
light excitation pulse

Dr.J.Storasta

Thermally  
stimulated  
current and  
polarisation,  
DLTS

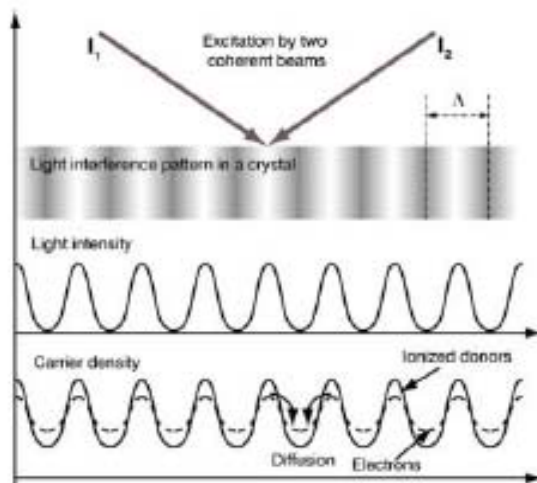
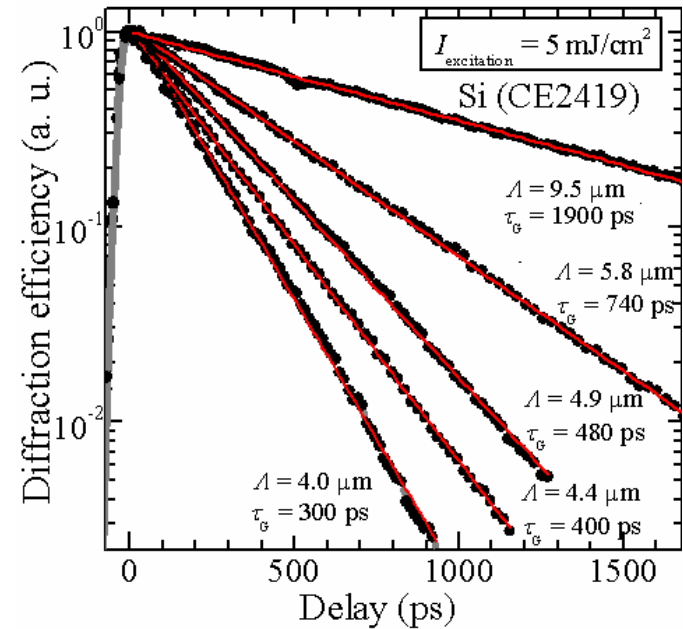
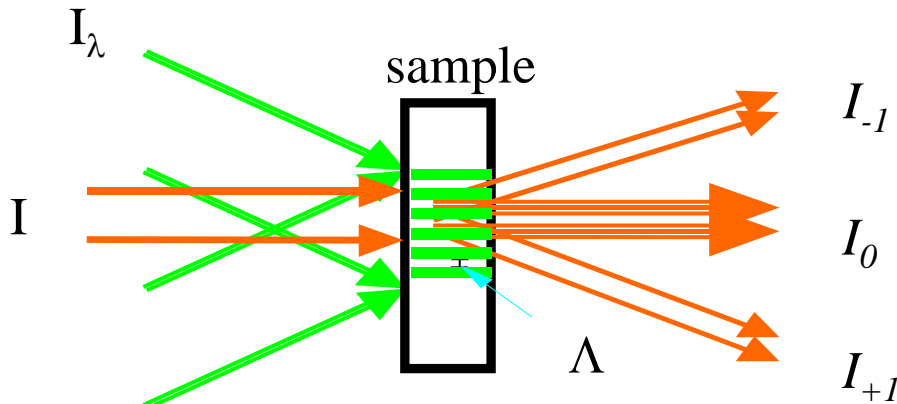
ESCA, SIMS,  
AES

(Riber3000)  
Dr.V.Kazlauskiene

**European Centre of Excellence SELITEC (joint centre with SPI)**

# Free carrier lifetime (trapping time and diffusion) measurement by transient grating method

(Prof.K.Jarasiunas Lab., VU)

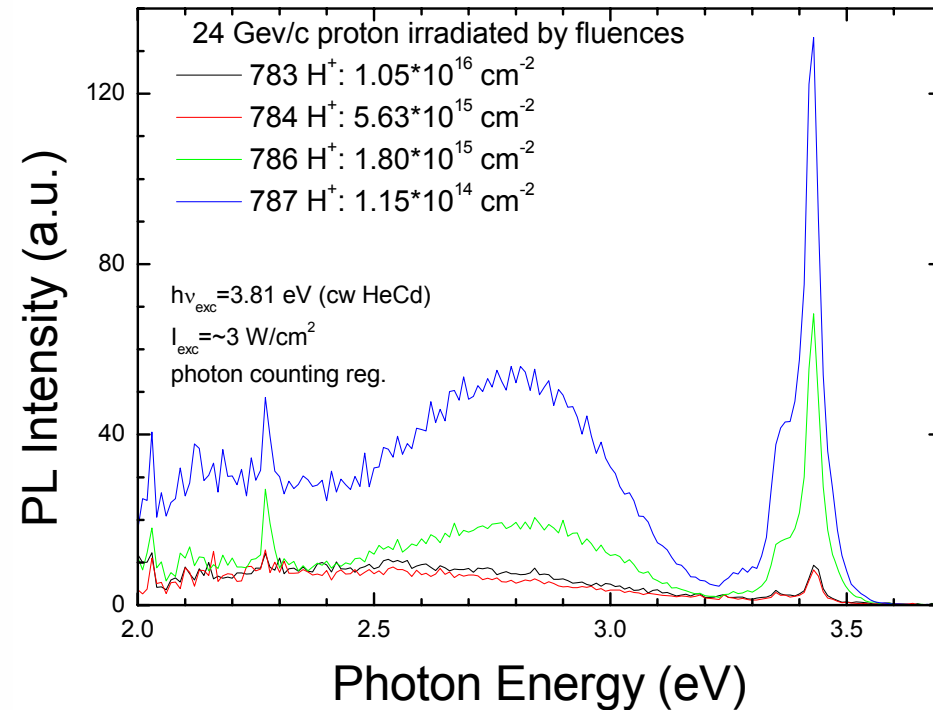
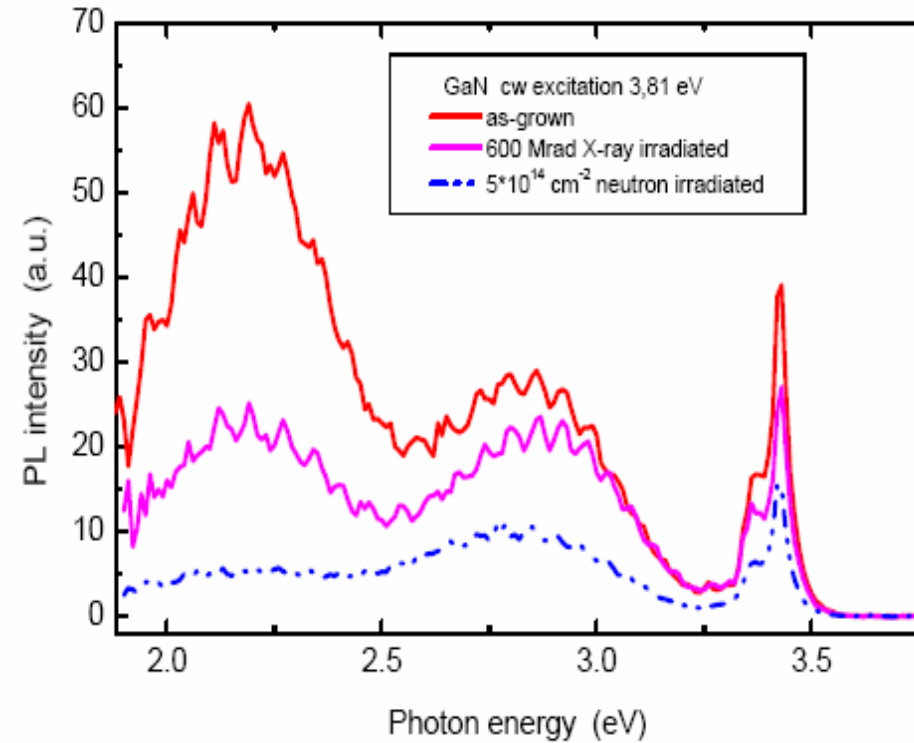


$$\frac{1}{\tau_G} = \frac{1}{\tau_R} + \frac{4 \cdot \pi^2}{\Lambda^2} \cdot D$$



# The examples of the exciton and defect luminescence spectra measurement

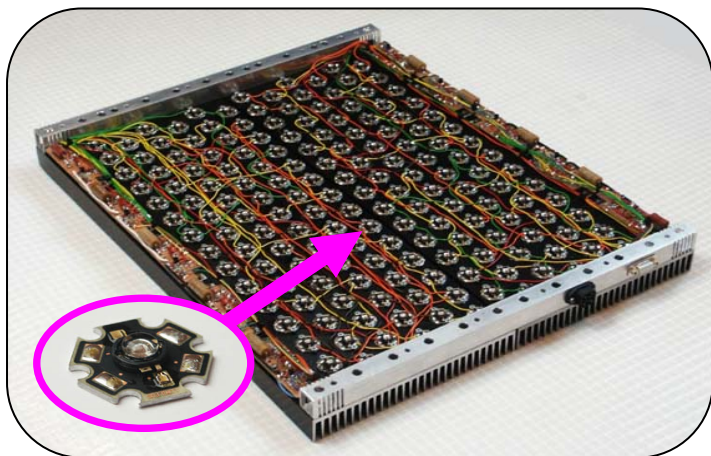
(Prof. A. Žukauskas Lab., VU)



Spectral distribution of the photoluminescence intensity depending on the irradiation dose or fluence in **GaN** (a new material that we proposed promising for radiation hard detectors)

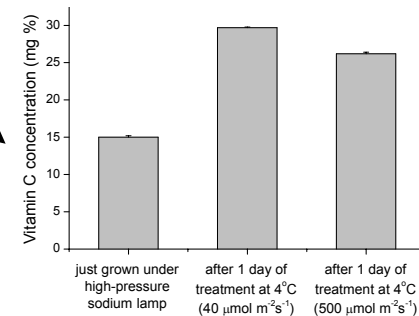
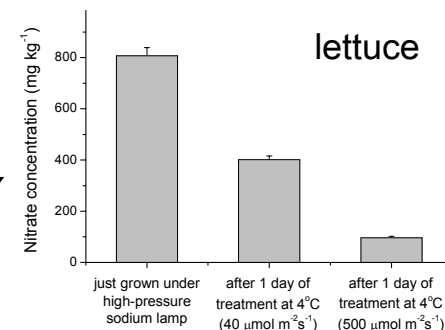
# Multi-LED illumination panel

(Prof. A. Žukauskas group) (A few patents)



**Photomorfogenesis: changing the 669 nm and 731 nm intensity ratio**

Nitrates  
Vitamine C



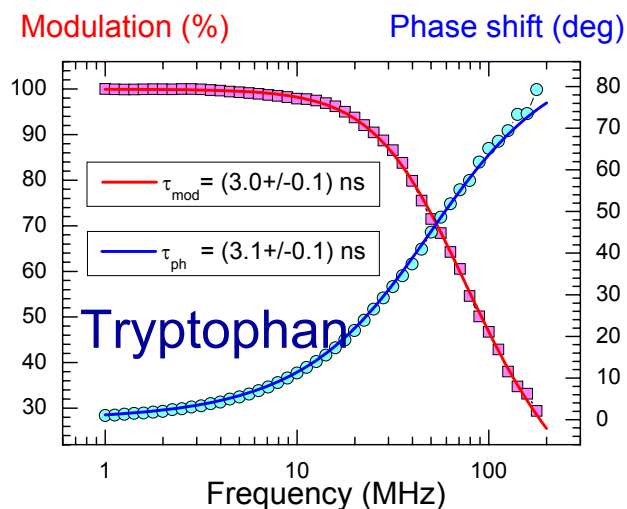
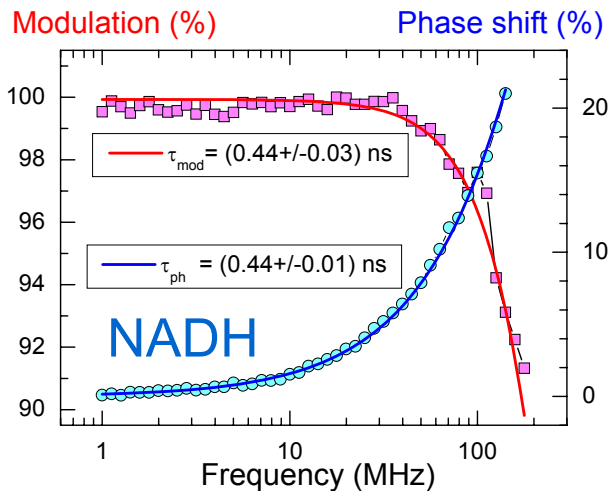
Prof. A. Zukauskas, R. Vaicekauskas, F. Ivanauskas, G. Kurilcik, Z. Bliznikas, K. Breive, J. Krupic, A. Rupsys, A. Novickovas, P. Vitta, A. Navickas, V. Raskauskas, M. S. Shur, R. Gaska, *Proc. SPIE* (2004).

International Scientific Conference "Science in Baltic Region: Achievements and Perspectives of Cooperation", September 16 – 17, 2009, Vilnius, LITHUANIA



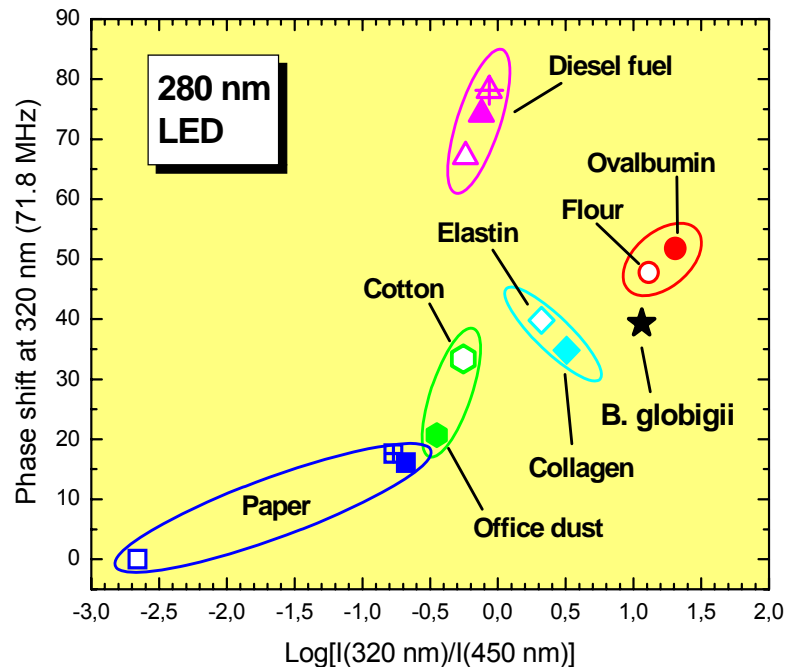
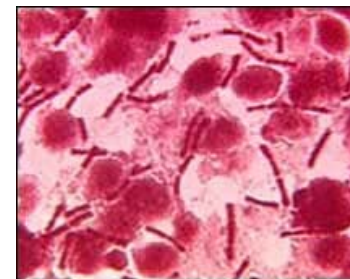
# Fluorescence decay in basic bacterial fluorophores

(Prof.S.Juršėnas lab, VU)

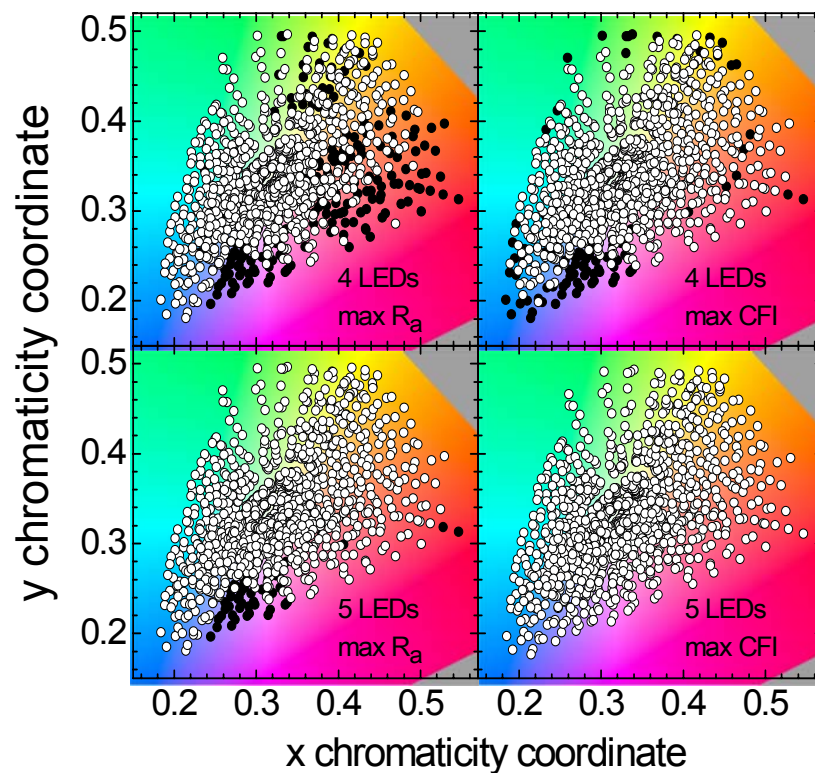
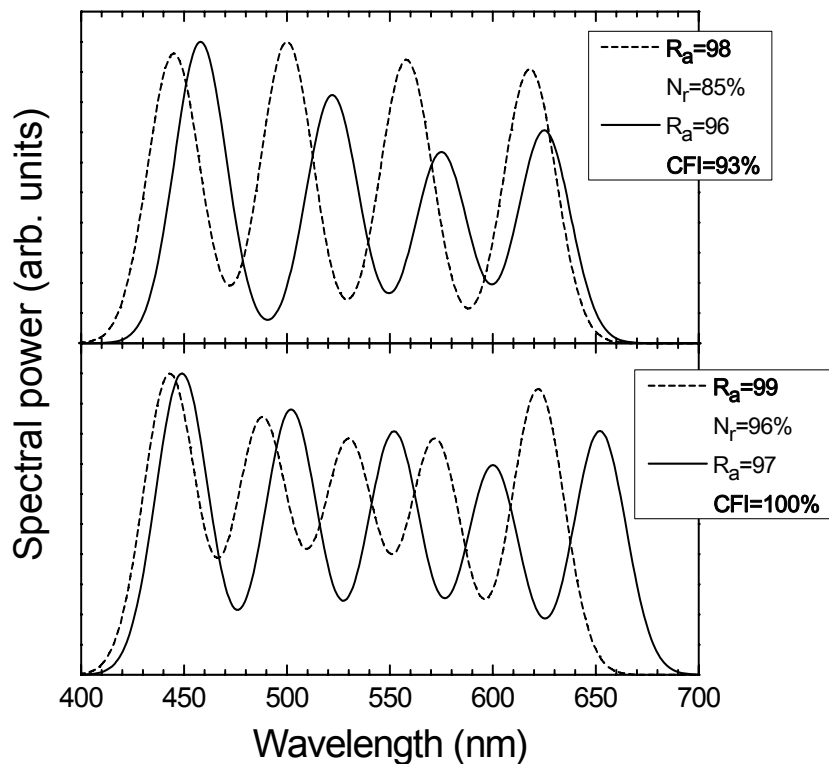


# LEDs for biomedicine

## Discrimination of bioparticles



# 2, 3, 4, 5 LEDs for the colour recognition

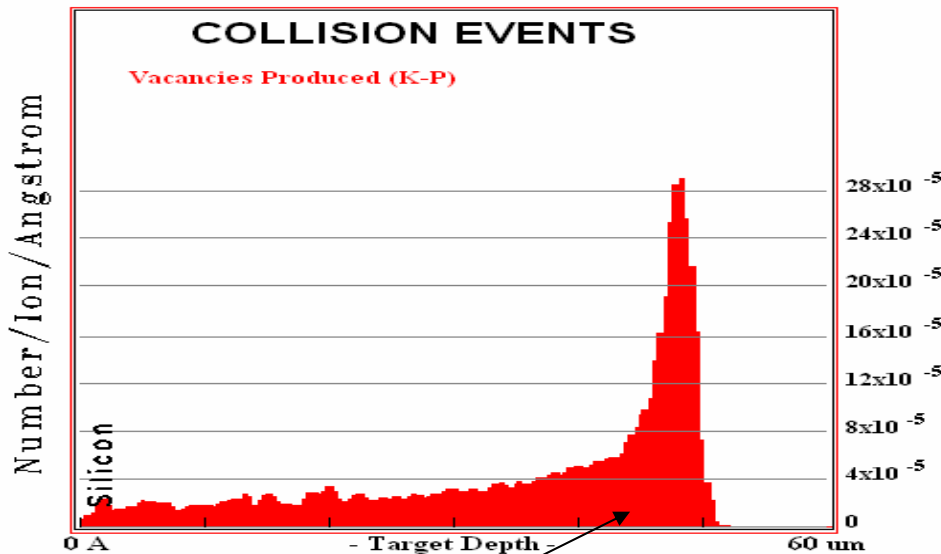


After A. Žukauskas *et al.*, Appl. Phys. Lett. **93**, 021109 (2008)

Patented a new method for the white light rendering measurement

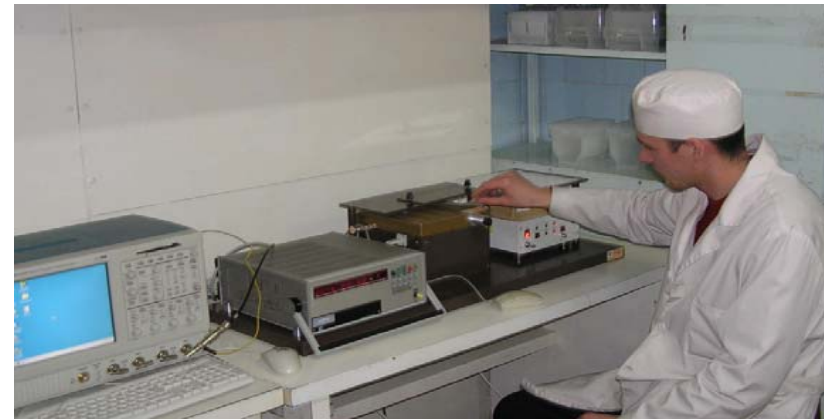
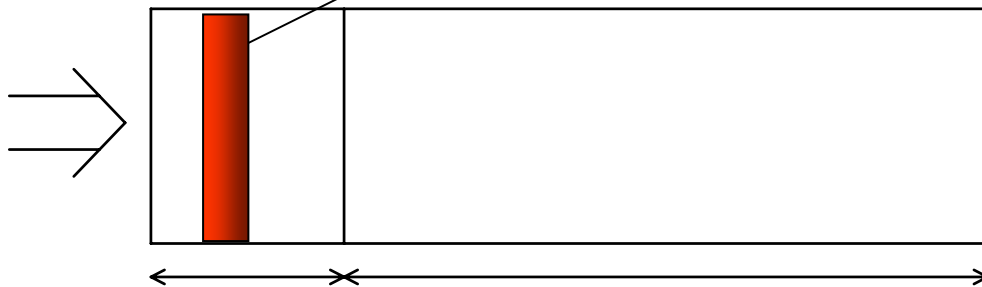
# New radiation technology

*(H.Dr. E.Gaubas)*



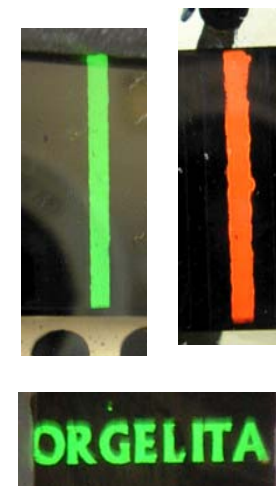
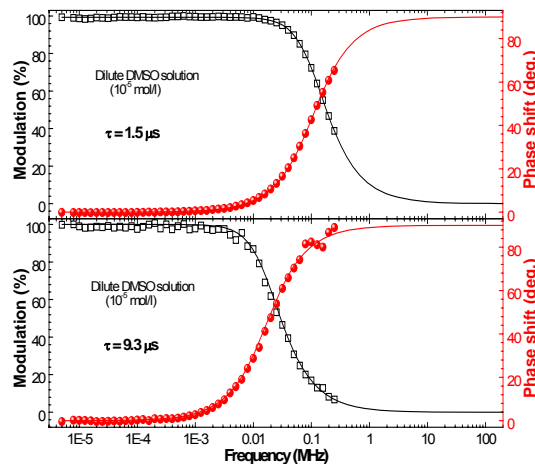
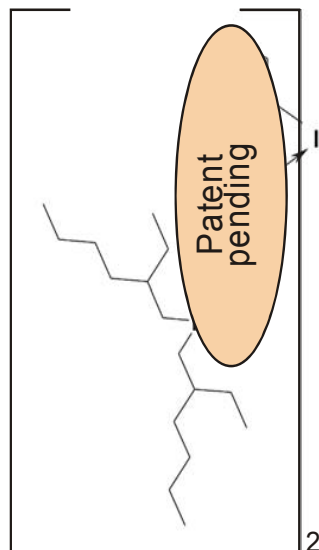
Proton beam for  
semiconductor  
device technology

Lifetime for  
microelectronics  
technology



# Collaboration with chemistry (in Vilnius and Kaunas)

# New OLEDs



Synthesis of novel OLED compounds based on iridium-organic complexes with strong spin-orbit coupling resulting in radiative emission from the triplet states:

- phosphorescence decay times ( $1.5 \mu\text{s}$ )
- high-quantum-yield ( $>90\%$ )



# Summary:

- Research labs participate in the prestigious international projects (and contribute to fill the requests of different customers)
- The existing methods of semiconductor research has a wide area of applications: from the high energy physics experiments, via materials science to lighting, biomedicine and agro technology
- Direct collaboration makes effect faster and better



*THANK YOU FOR YOUR  
ATTENTION!*