# Spectra distortion by the interstrip gap in spectrometric silicon strip detectors

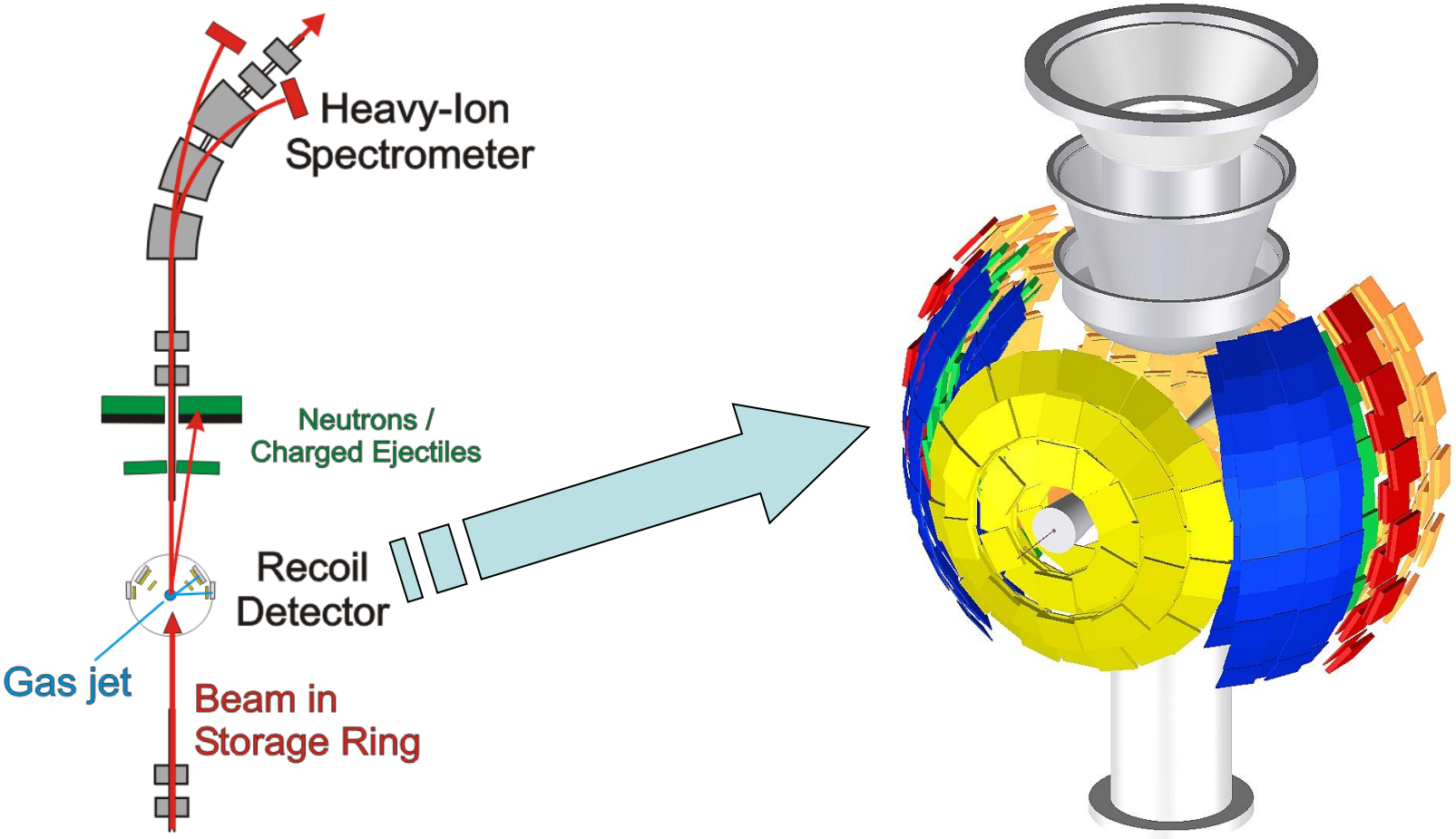
**Vladimir Eremin**
**(vladimir.eremin@cern.ch)**
**and**
**E. Verbitskaya, I. Eremin, Yu. Tuboltsev, N. Fadeeva,**
**N. Egorov, S. Golubkov,**
**W. Chen, Z. Li**

Ioffe Phisical – Technical Institute, St. Petersburg
Research Instjtute of Material and Technology, Moscow
Brookhaven National Lab., Upton, NY

# Outline

- Motivation
- Detector entrance window structure
- Charge collection in the entrance window
- Electric field in inter-strip gap
- Charge collection in inter-strip gap
- Conclusions

# NuSTAR-EXL detecting system in FAIR program

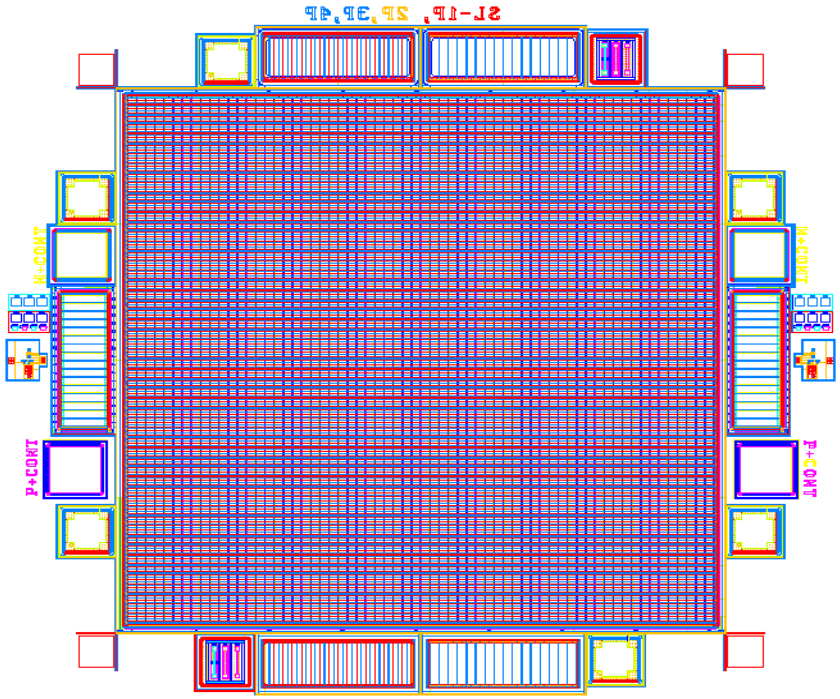


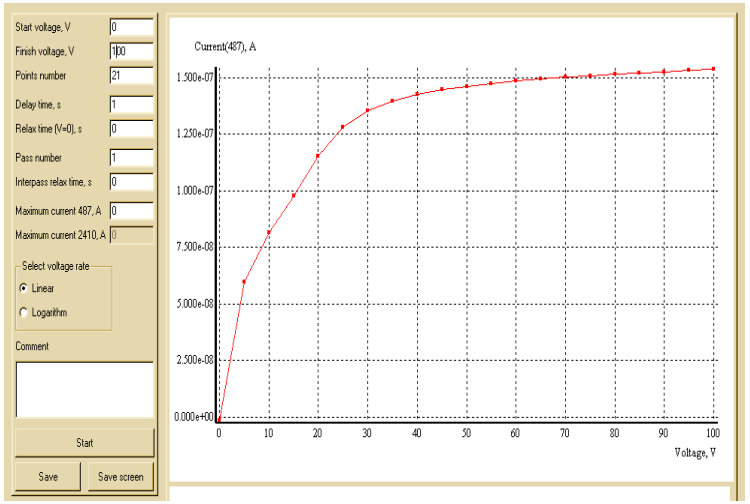
# Specification for DSSD detectors in EXL

| Region | Thickness (mm) | Pitch (mm) | Energy range (MeV) | **Total detectors area, $m^2$** |
|---|---|---|---|---|
| A | 0.3 | 0.1 | 0.1 - 170 | **0.3** |
| B | 0.3 | 0.1 | 0.1 minimum | **0.5** |
| C | 0.1 and 0.3 | 0.1 | 0.1 minimum | **1** |
| D | 0.1 and 0.3 | 0.1 | n/d | **1.2** |
| E | 0.3 | 0.5 (0.3) | n/d | **1** |
| E’ | 0.3 | 0.1 | n/d | **1.5** |

# Wafer layout with full size 6.5x6.5 cm² DSSD

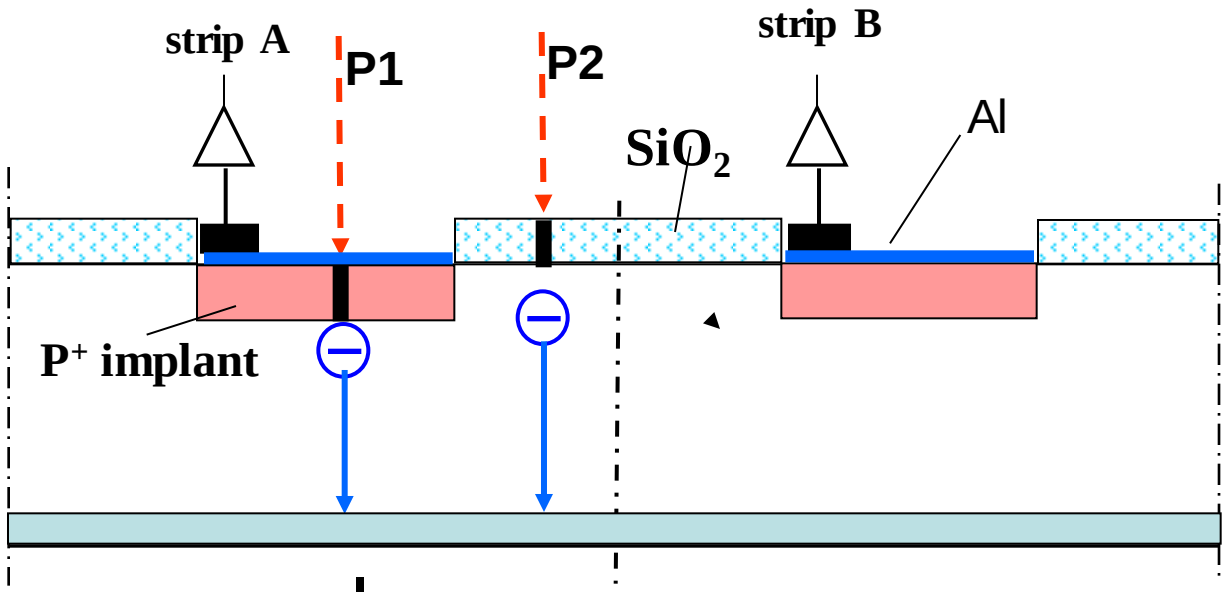
**Consortium:** “Silicon detector lab.”, St. Petersburg, Russia

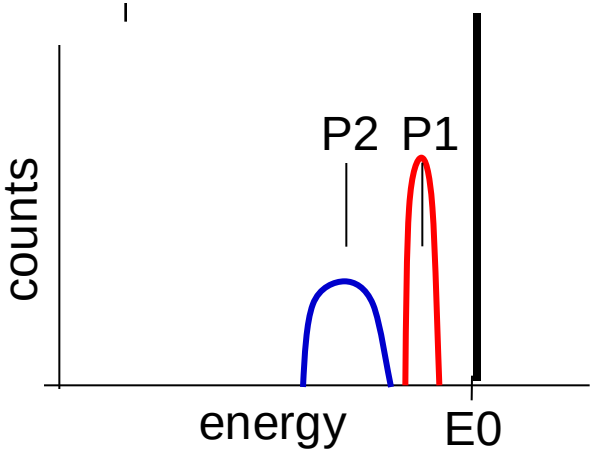





**Current density 3.8 nA/cm²**

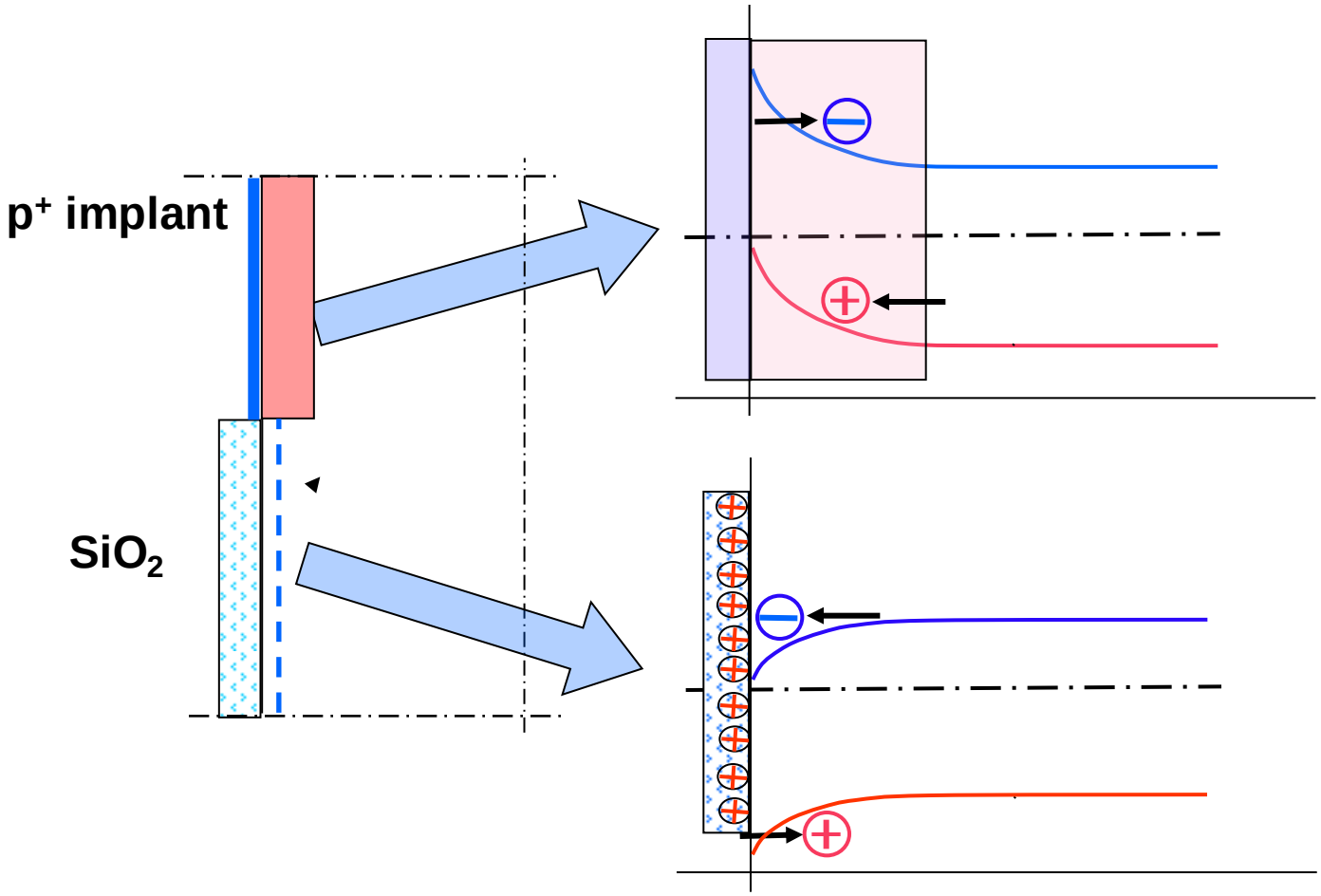
# The problem



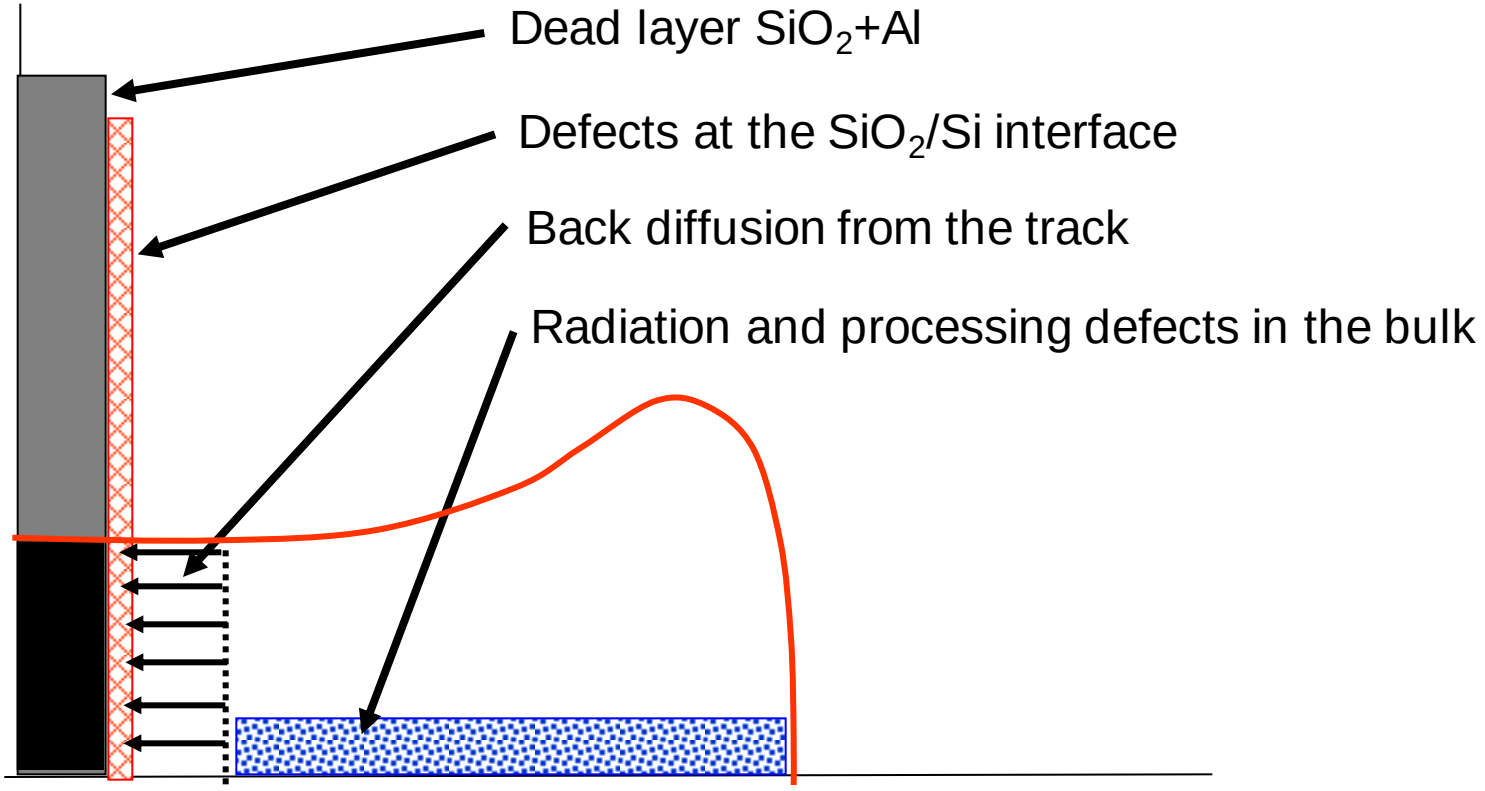




| | |
|---|---|
| Al thickness | 0 µm |
| $P^+$ entrance window | 20 nm |
| $SiO_2$ thickness | 700 nm |
| Energy losses (5.5 MeV, Si) | 130 keV/µm |

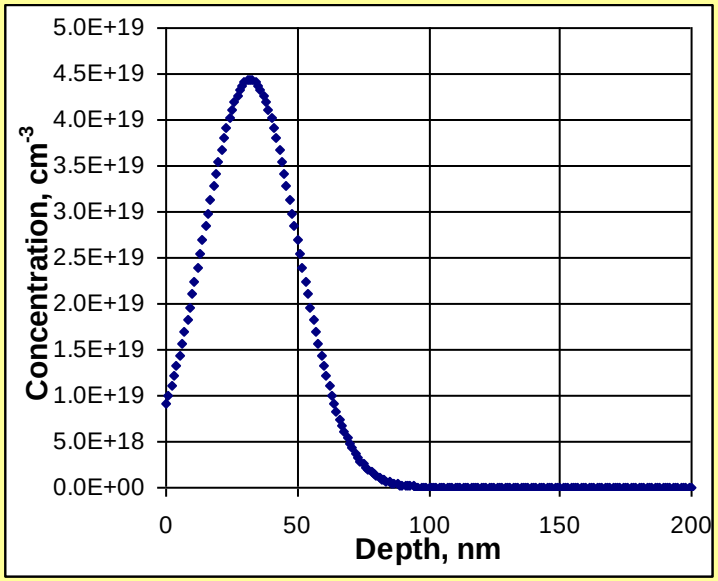
# P+-side effective window

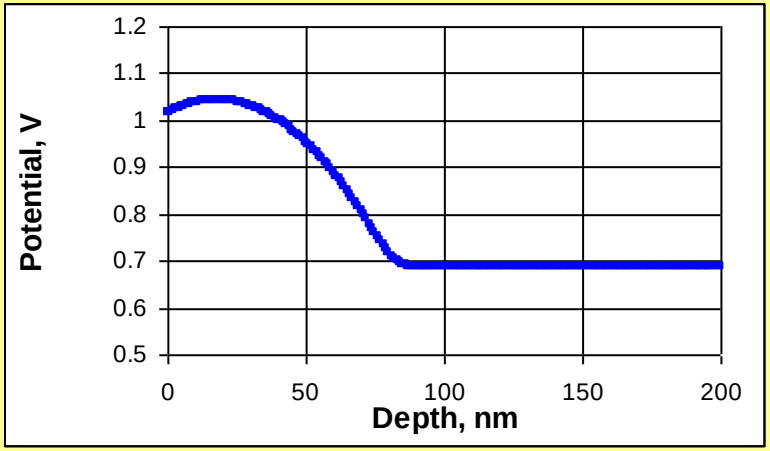


# Track at the planar detector entrance window
## (energy and charge losses)

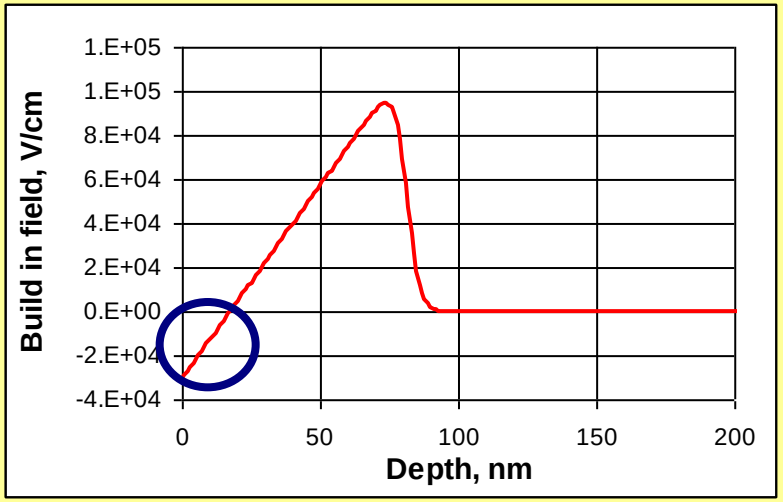


# Electric field in the detector entrance window

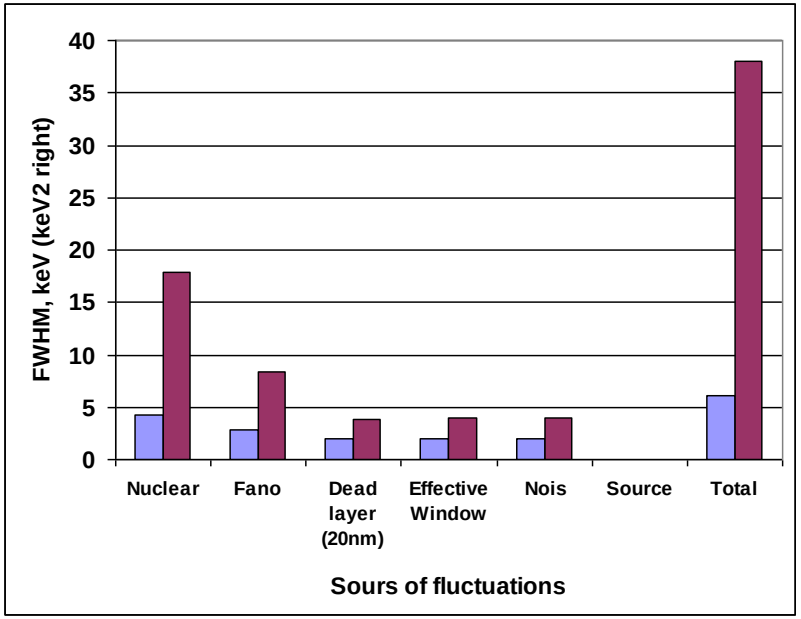


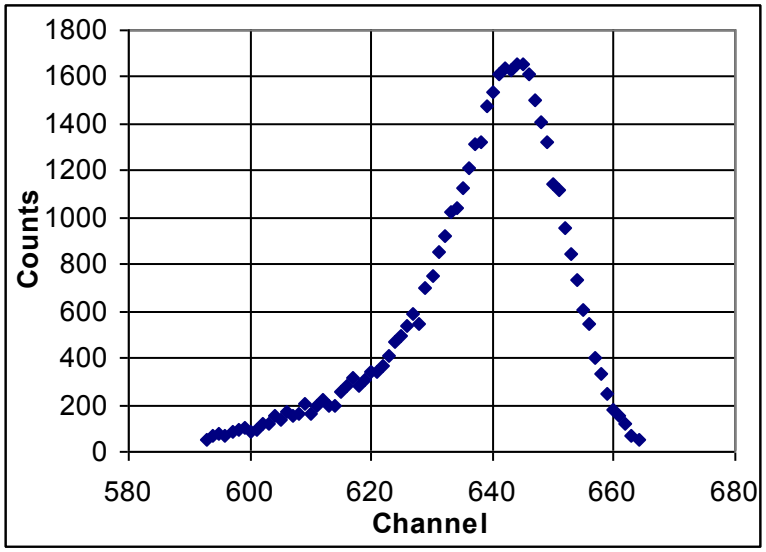




**The effective window thickness for the developed detectors is 20 nm (for 5.5 MeV alphas)**



# The energy resolution components



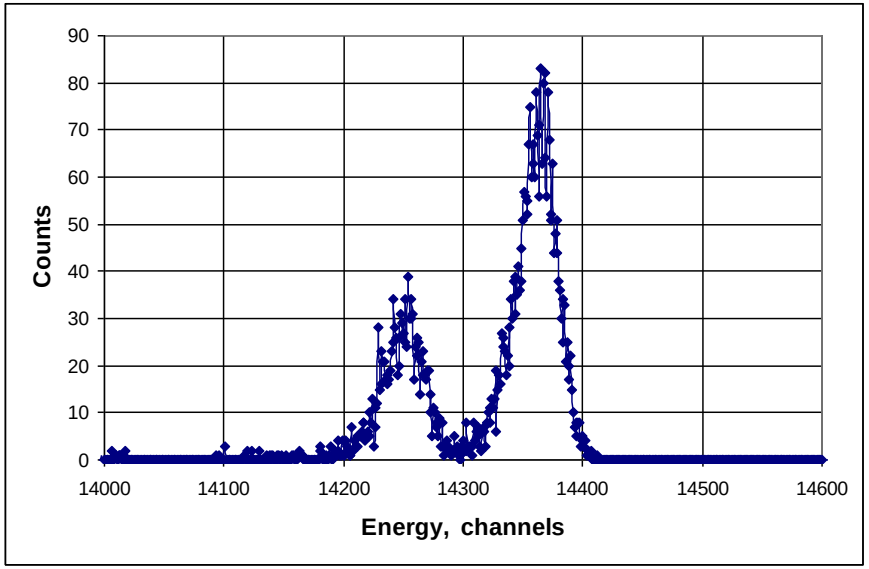



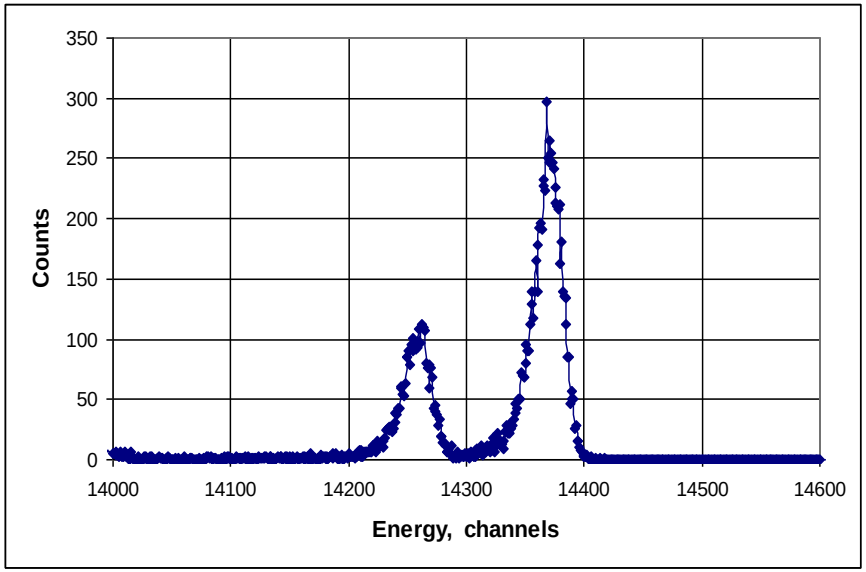

| | FWHM | |
|---|---|---|
| Process | keV | $keV^2$ |
| Nuclear scatterin | 4.22 | 17.8084 |
| Ionization | 2.9 | 8.41 |
| Dead layer (20nm | 1.95 | 3.8025 |
| Effective window | 2 | 4 |
| Noise | 2 | 4 |
| Source | | 0 |
| Total | 6.166109 | 38.0209 |

Spectrum of $^{210}Po$ measured by detector with optimized structure of p-n junction. The energy resolution of 8.1 keV.

**(From: E.Verbitskaya, et.al., Nucl. Instr. Meth.. B 84 (1994) 51)**

# Spectra for the strip region (alphas $^{238}Pu$)




**Version 1**

**Effective thickness of entrance window:**

**$W_{eff}$ = 110 nm**

**Energy resolution - 12.8 keV**

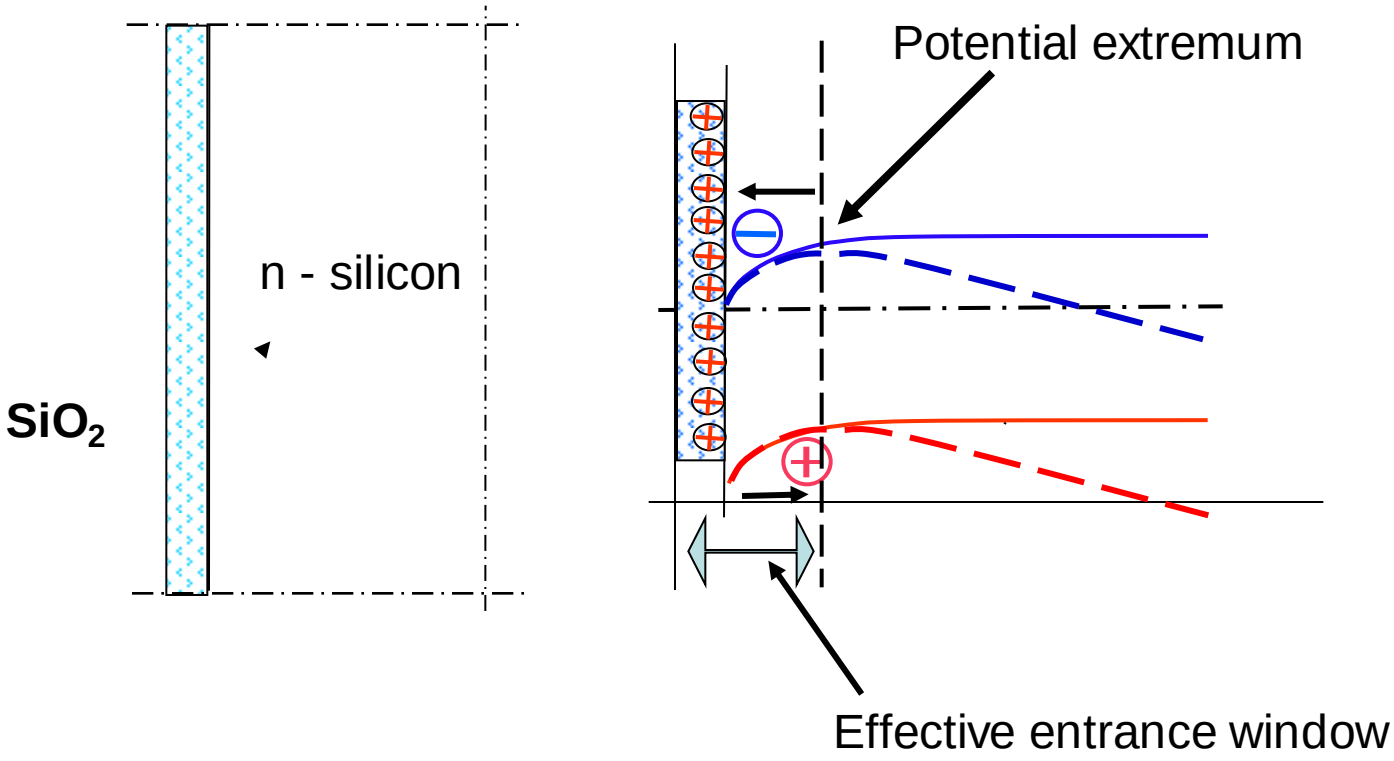
**Version 2**

**Effective thickness of entrance window:**

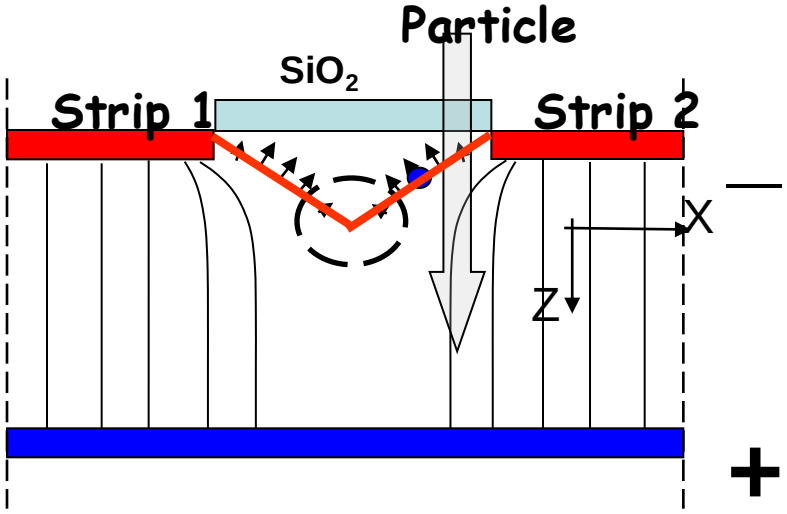
**$W_{eff}$ = 25 nm**

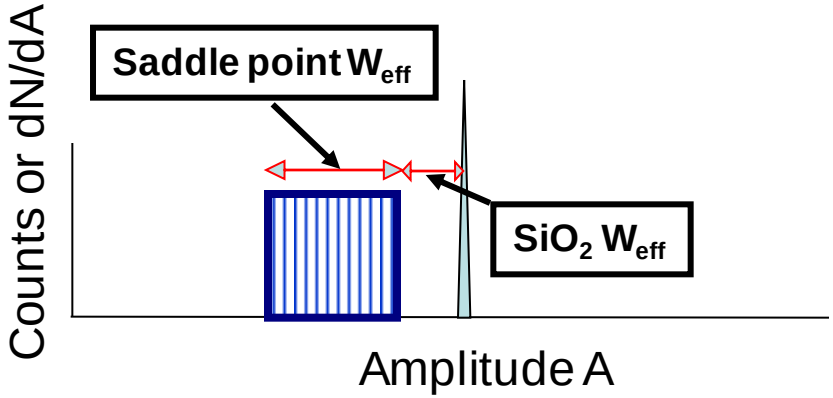
**Energy resolution – 9.8 keV**

# The interstrip gap structure



# Model for spectra response of interstrip gap




Point generation – no charge sharing
Symmetric E(X, Z) in the gap
Linear $W_{eff}(Z)$

$$A(x) = A0 - \varepsilon(\Delta_{SiO2} - mX)$$

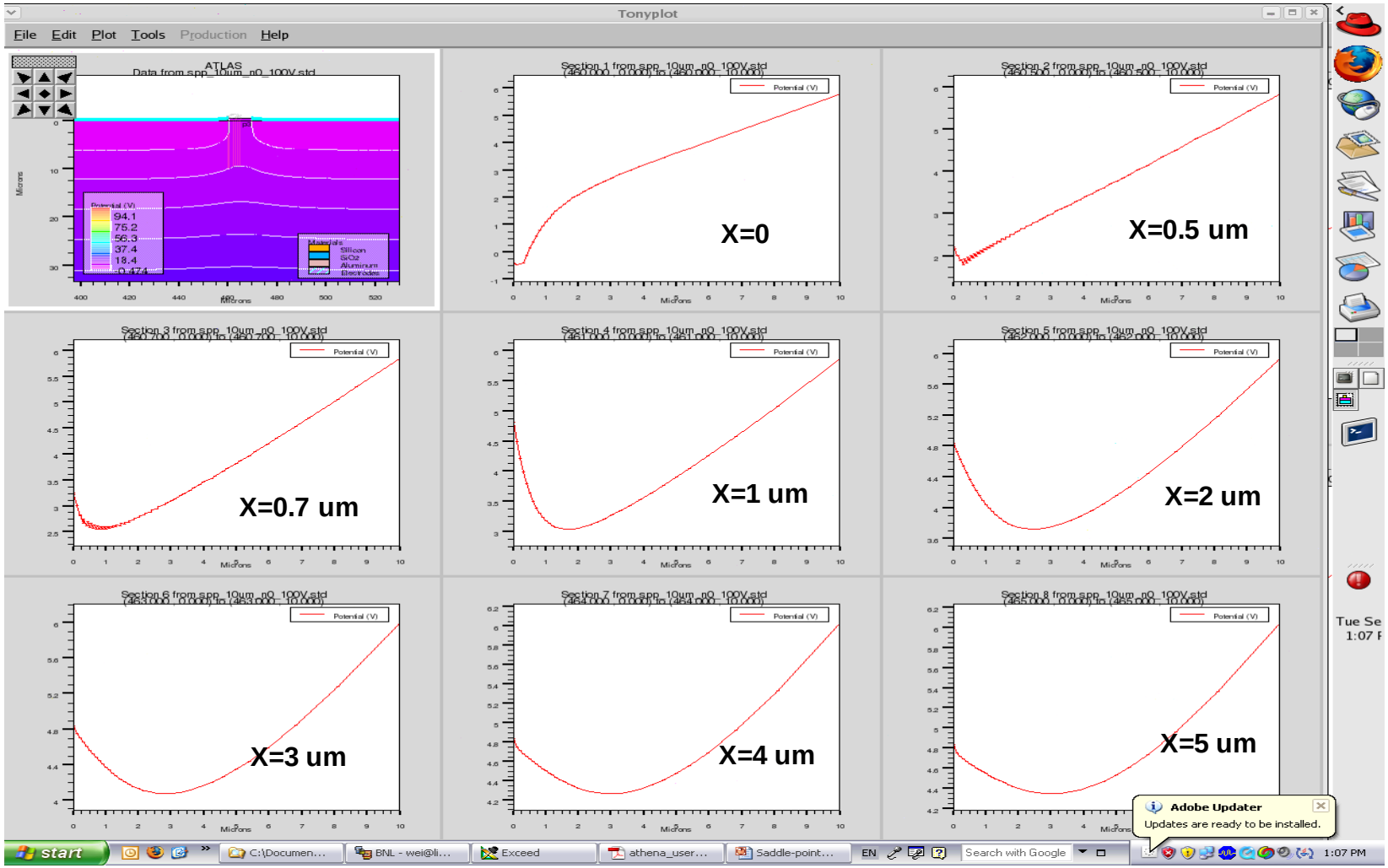
Spectra response

$$\frac{dN}{dA} = \frac{\partial N}{\partial x} \times \frac{\partial x}{\partial A}$$

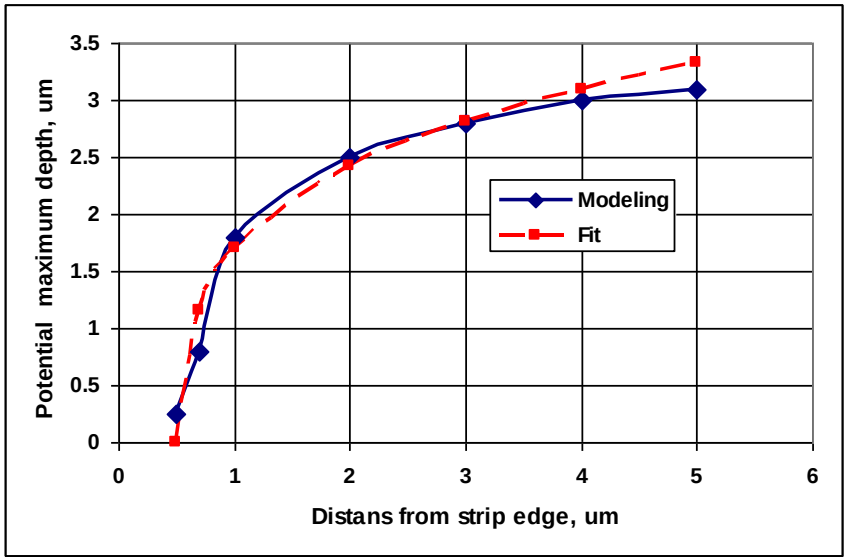
Spectra shape is:
***dN/dA = 1/m***

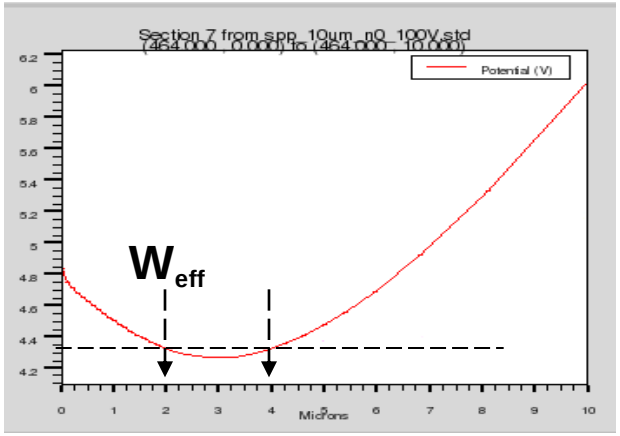
# Potential in interstrip gap

Parameters: Gap width – 10 um, Charge in $SiO_2$ – $4x10^{14}$ $cm^{-2}$,
Si resistivity – 5 kOhm-cm, d = 300 um, $V_b$ = 100V



# Parameterization of potential extremum and $W_{eff}$ in the interstrip gap




$W_{max} = 2.2\ (X - X_0)^{0.28}$

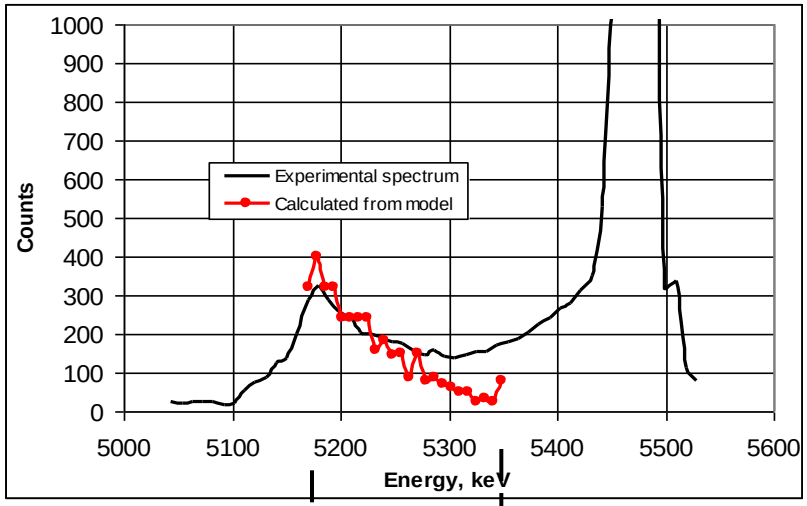
with $X_0 = 0.6$um

$W_{eff} = \gamma\ W_{max}$

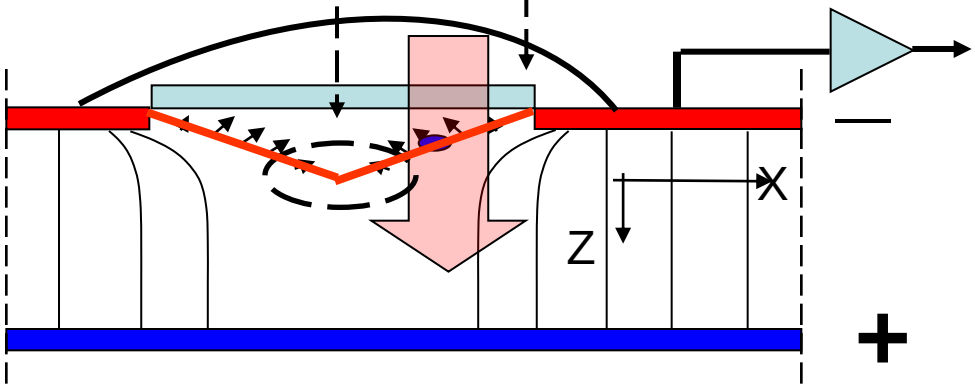
$\gamma = 0.6$

for kT/q = 25 mV

# Alpha spectrum for interstrip gap




Parameters: **Gap width – 10 um,**
**Charge in $SiO_2$ – $4x10^{14}$ $cm^{-2}$,**
**Si resistivity – 5 kOhm-cm,**
**d = 300 um,**
**$V_b$ = 100V**




Simulated "**Gap spectrum**" correlates with the experimental in major features:
- the energy range
- triangle shape

# Conclusions

1. *The developed model predicts the main features of short range particle spectra measured with strip detectors:*

   *triangle shape of the spectra generated in interstrip gap.*
2. *The model can be simply extended for detection of any short range particles.*
3. *The model gives a background for parameterization of interstrip gap properties as an element disturbing the detector spectra response.*


## *Acknowledgement*

***This work was supported by:***
***Russian Academy of Sciences (program # 9C237)***
***Physico-technical institute RAS (program # ГР0120ю080052)***
***Consortium PTI-RIMST - "Silicon Detector Lab."***

# Thank you
# for your attention