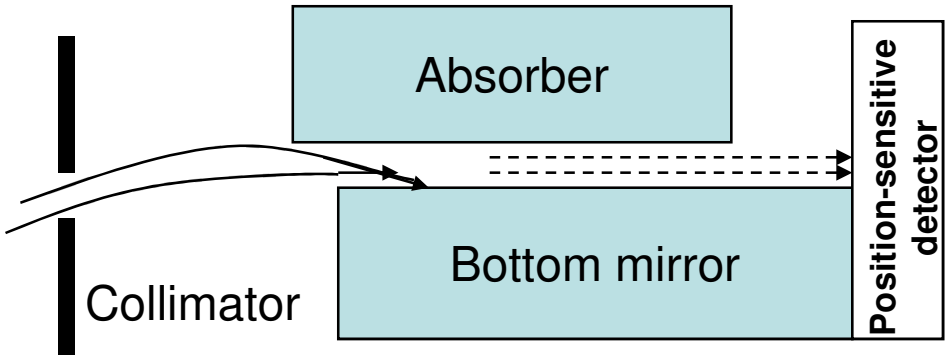
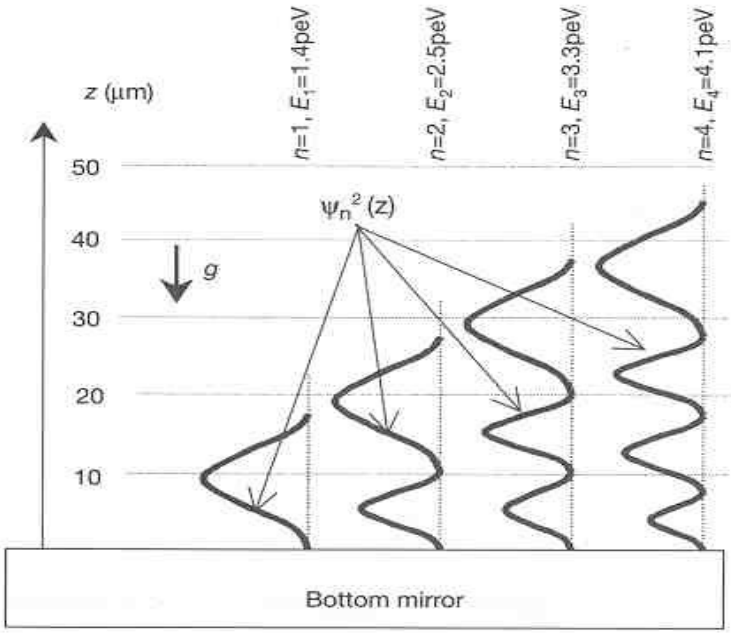
Large-size real-time position-sensitive UCN detector with 100μ spatial resolution

# Position-sensitive UCN detectors for the gravitational levels measurements

# Introduction

Setup for the
gravitational levels measurements




Necessary spatial
resolution of the detector: ~ 1μ

*Position-sensitive UCN detectors for the gravitational levels measurements*

In previous measurements – $^{235}$U track detector

Advantages: – high spatial resolution (~ 1μ)

– low price

Disadvantages: – off-line detector

– long time processing measurements

Dream: on-line detector with a spatial resolution of 1μ

*Position-sensitive UCN detectors for the gravitational levels measurements*

## Attempts to create on-line detectors of UCN with high spatial resolution

1. *A coated pixel device TimePix with micron spatial resolution for UCN detection.*

   J. Jakubek, P.Schmidt-Wellenburg, P.Geltenbort , M.Platkevic, C.Plonka-Spehr, J. Solc, T.Soldner. NIM A 600 (2009) 651–656

   **Achieved resolution:** 5.3μ

2. *Proposal for measuring the quantum states of neutrons in the gravitational field with a CCD-based pixel sensor.*

   T.Sanuki, S.Komamiya, S.Kawasaki, S.Sonoda. NIM A 600 (2009) 657–660

   **Achieved resolution:** 5.3μ

*Position-sensitive UCN detectors for the gravitational levels measurements*

# UCN detection

**UCN** ⟶ absorption ⟶ charge particles ⟶ **detection**

Gas detectors only

$^{3}He + n \rightarrow p(573keV) + {}^{3}H(191kev)$ $\quad \sigma_a = 5333$ barn

$^{10}B + n \xrightarrow{93.7\%} \alpha(1.47MeV) + {}^{7}Li(0.84Mev) + \gamma(0.48MeV)$

$\xrightarrow{6.3\%} \alpha(1.78MeV) + {}^{7}Li(1.01MeV)$ $\quad \sigma_a = 3835$ barn

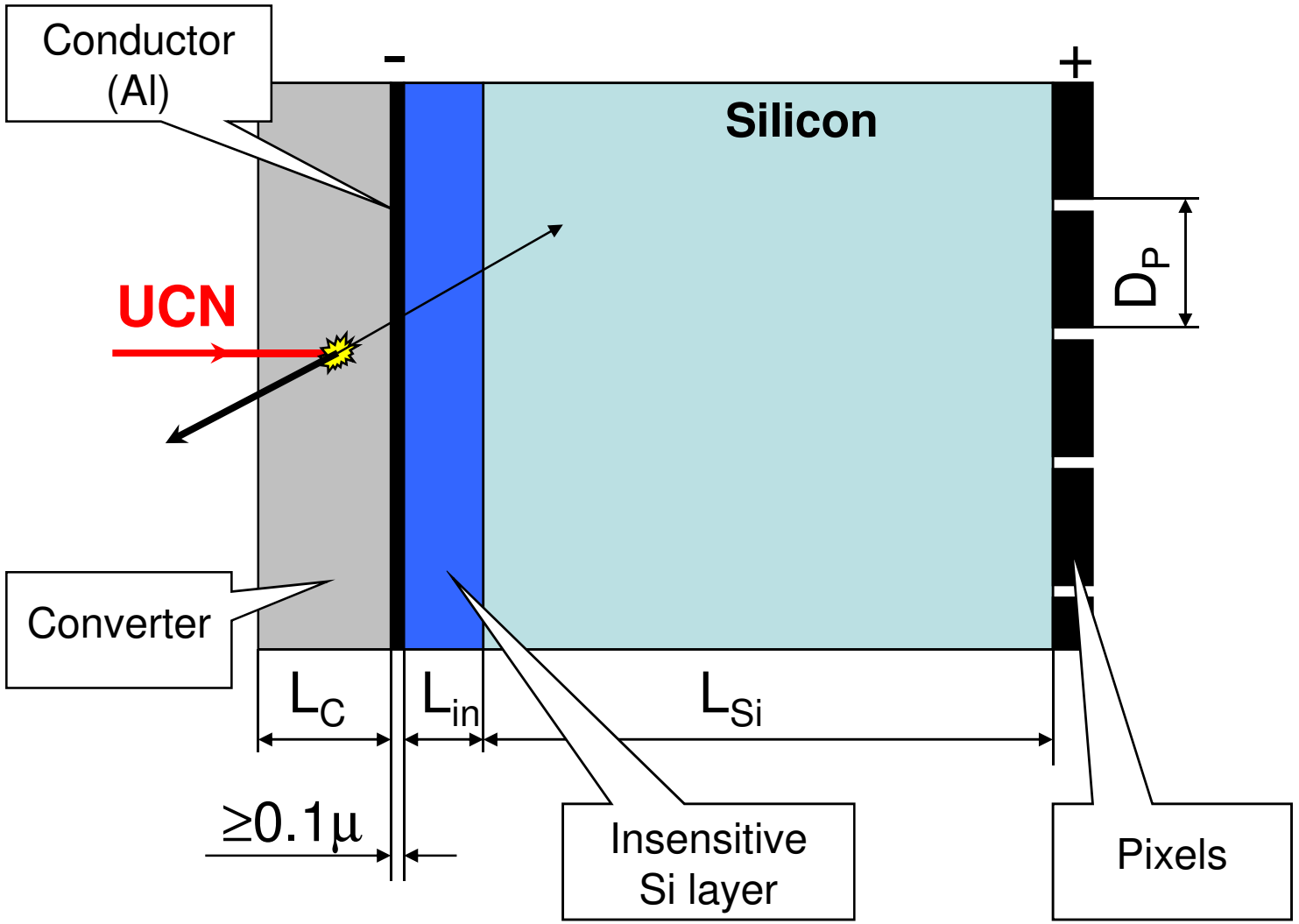
$^{6}Li + n \rightarrow \alpha(2.05MeV) + {}^{3}H(2.72MeV)$ $\quad \sigma_a = 940$ barn

$^{235}U + n \xrightarrow{85\%} f_L\,(\sim 100MeV) + f_H\,(\sim 70MeV)$ $\quad \sigma_a = 681$ barn

Semiconductor detectors have the best spatial distribution

$\Rightarrow {}^{10}B,\ {}^{6}Li$ or $^{235}U$

# UCN detection by semiconductor detectors



# Converter efficiency

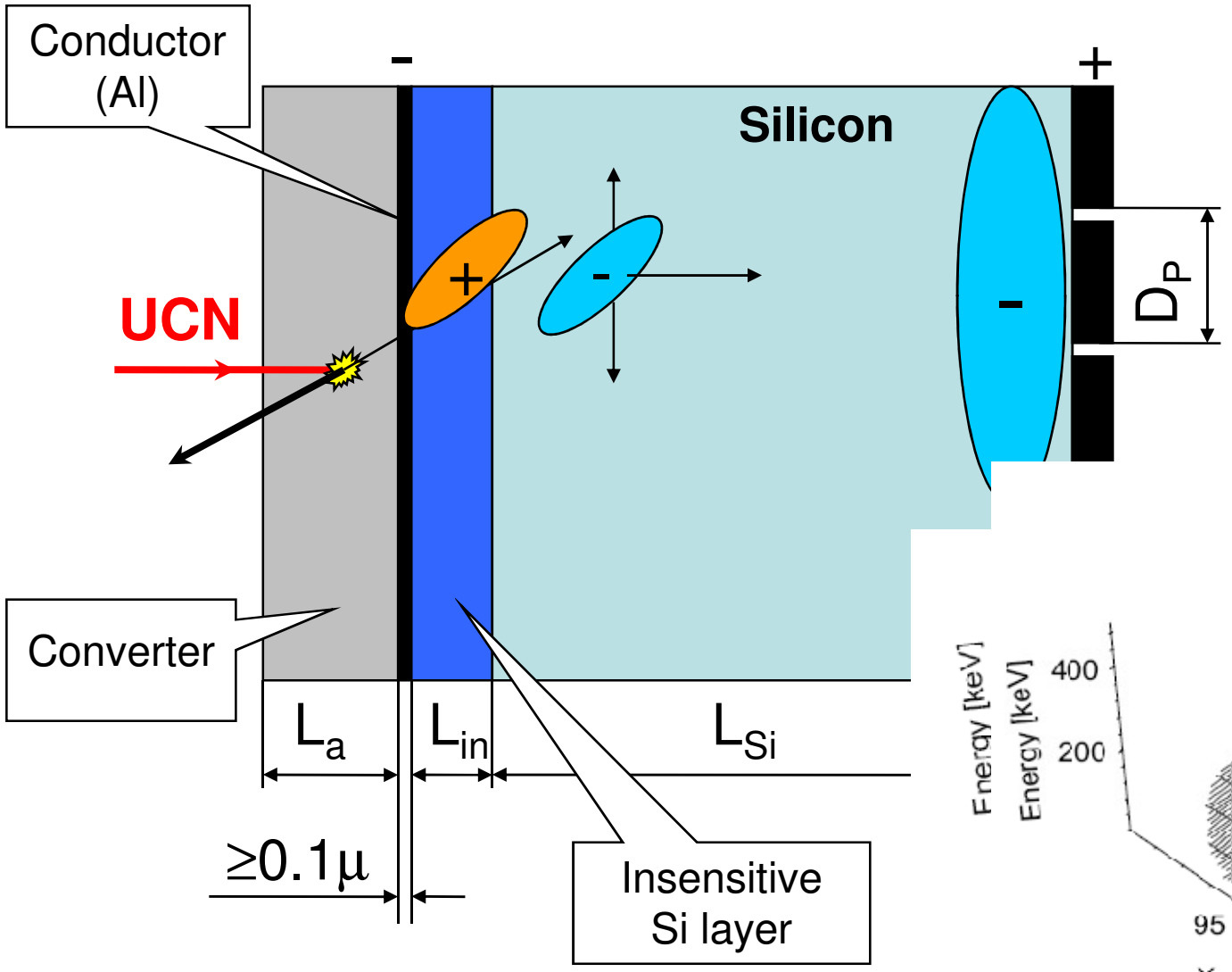
**If: $V_{UCN}$=6m/s $P_a$=87%**

| Converter thickness: | Path length of the heavy particle in the converter: | Characteristic of the efficiency of the converter: |
|---|---|---|
| $L_C$ ($^{10}$B)= 0.11μ | $L_P$ ($^{10}$B)= 2.46μ | $L_P/L_C$ ($^{10}$B)= 22 |
| $L_C$ ($^{6}$Li)= 1.2μ | $L_P$($^{6}$Li)= 22.5μ | $L_P/L_C$ ($^{6}$Li)= 18.8 |
| $L_C$ ($^{6}$LiF)= 2μ | $L_P$($^{6}$LiF)= 6.5μ | $L_P/L_C$ ($^{6}$LiF)= 3.25 |
| $L_C$ ($^{235}$U)= 1.35μ | $L_P$ ($^{235}$U)= 4.1μ | $L_P/L_C$ ($^{235}$U)= 3 |

**The best converters: $^{10}$B and $^{6}$Li**

*Position-sensitive UCN detectors for the gravitational levels measurements*

# UCN detection by semiconductor detectors

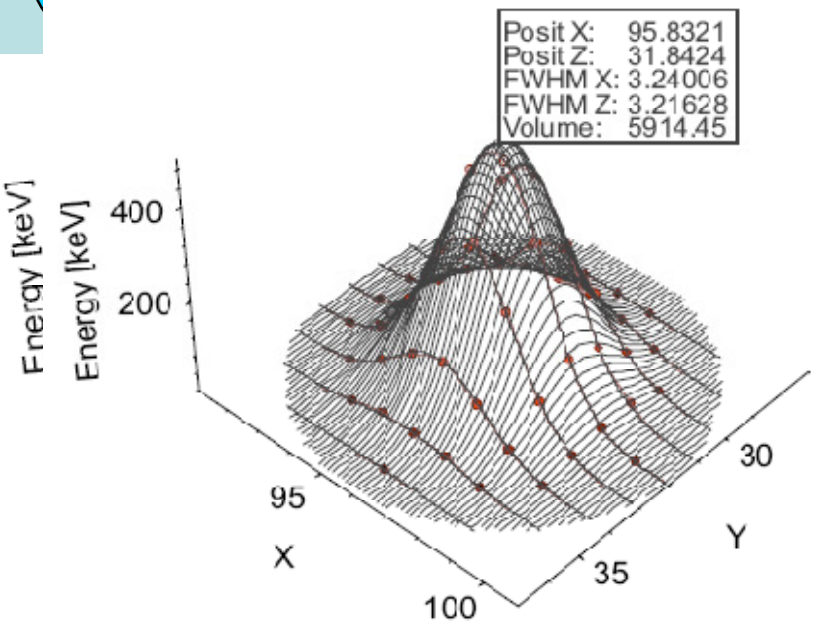



$0.1\mu < L_a < 4\mu$

$L_{in} \geq 0.15\mu$

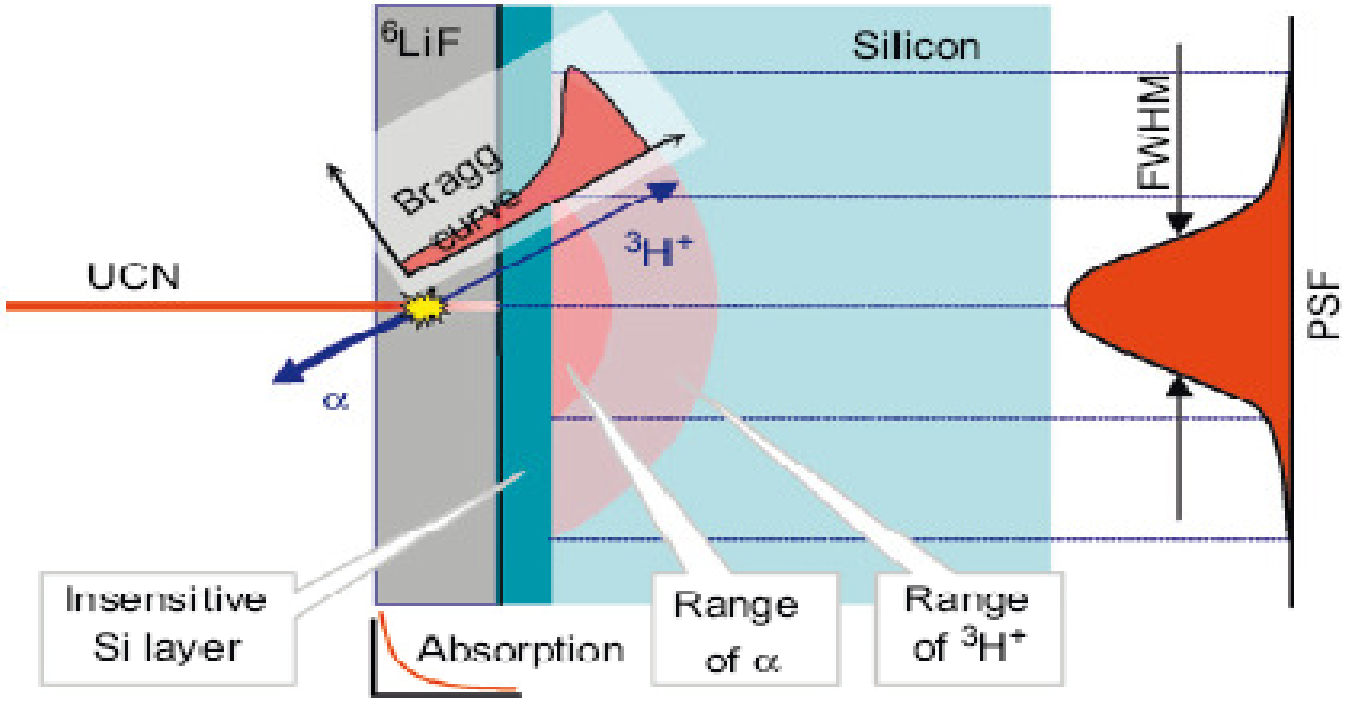
$L_{Si} \geq 0.3mm$

$D_P = 50x50\mu$



*Position-sensitive UCN detectors for the gravitational levels measurements*

## Spatial resolution dependence of the path length of charged particles

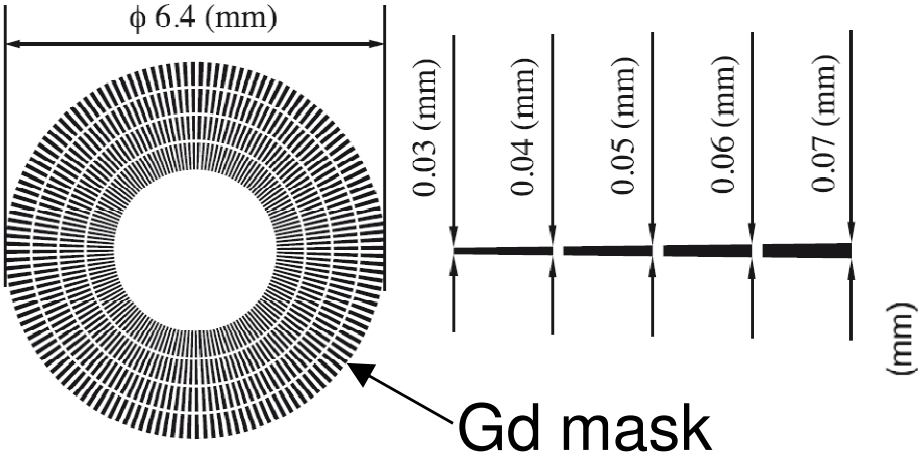



*© J. Jakubek et al.*

*Position-sensitive UCN detectors for the gravitational levels measurements*

# Spatial resolution dependence of the path length of charged particles

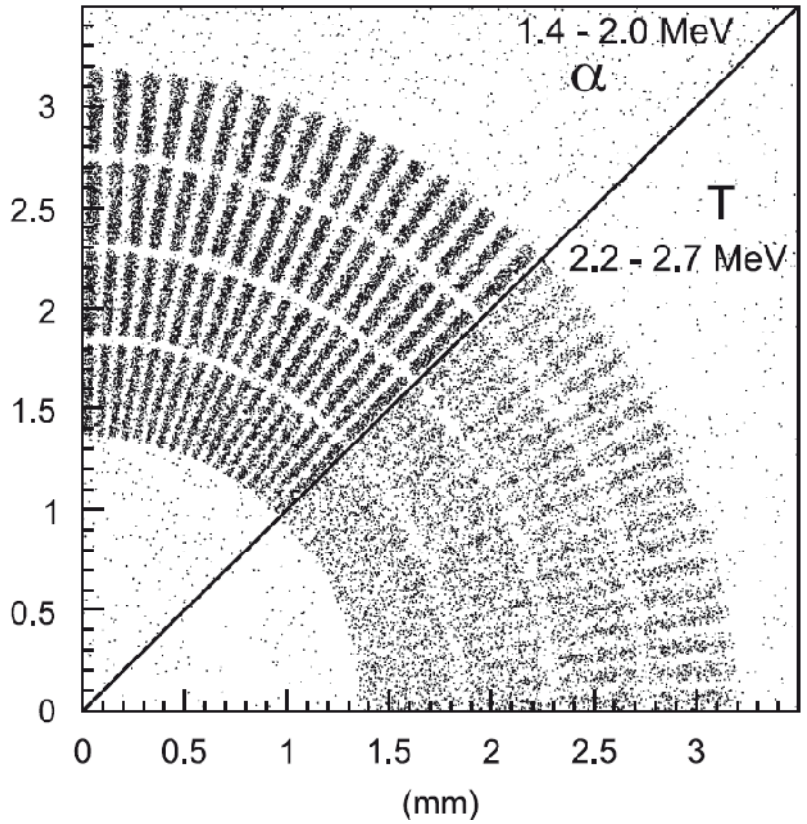
*T. Sanuki et al.:*




Converter: $^{6}$Li

Path length in Si:

$L_P(\alpha)=7.5\mu$ $L_P(^3H)=13.5\mu$



*Position-sensitive UCN detectors for the gravitational levels measurements*

# UCN detection by semiconductor detectors

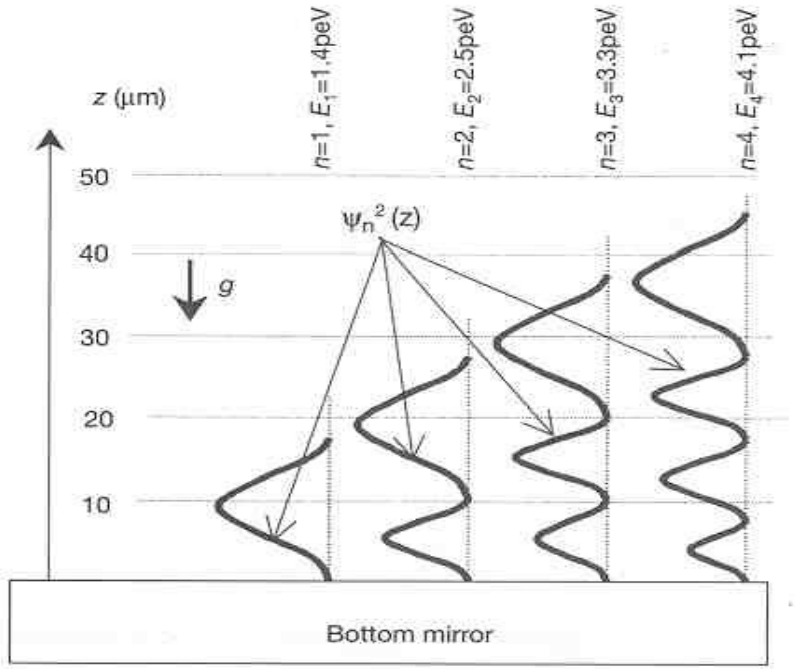
## Achieved spatial resolution:

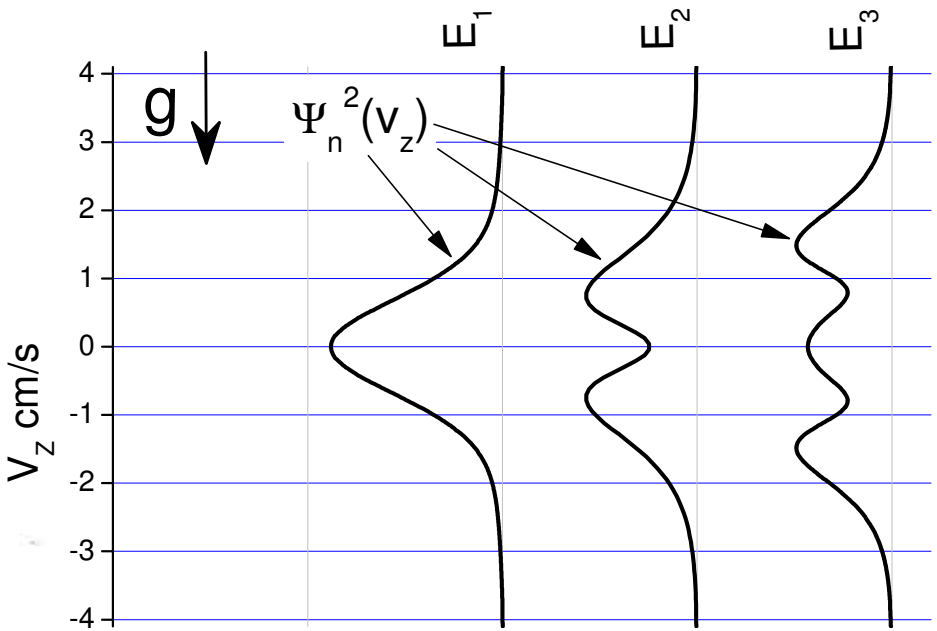
## 5.3μ

**The world record of spatial resolution of the UCN on-line detector (unfortunately)**

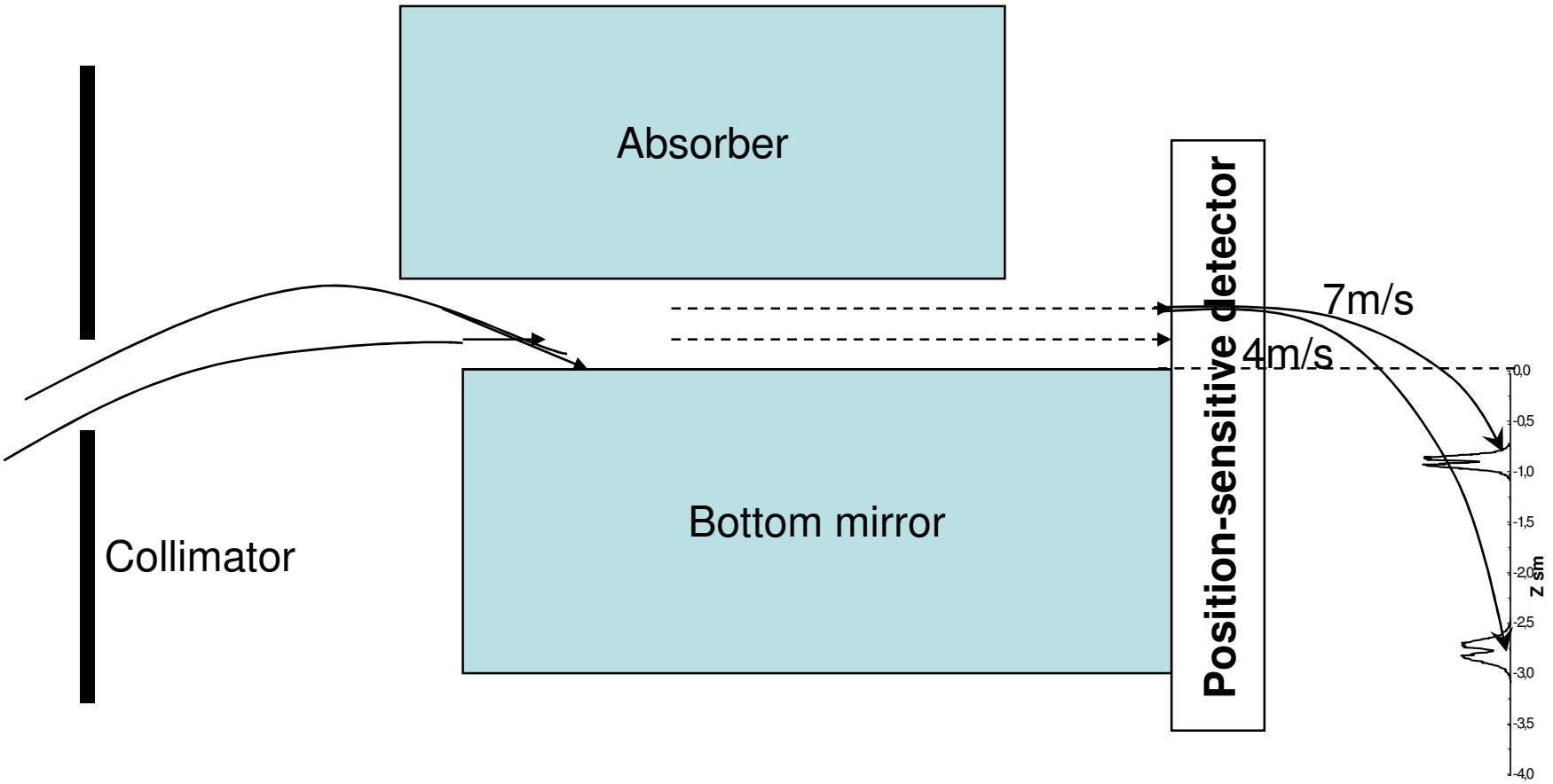
*Position-sensitive UCN detectors for the gravitational levels measurements*

# The momentum (velocity) representation of the wave function



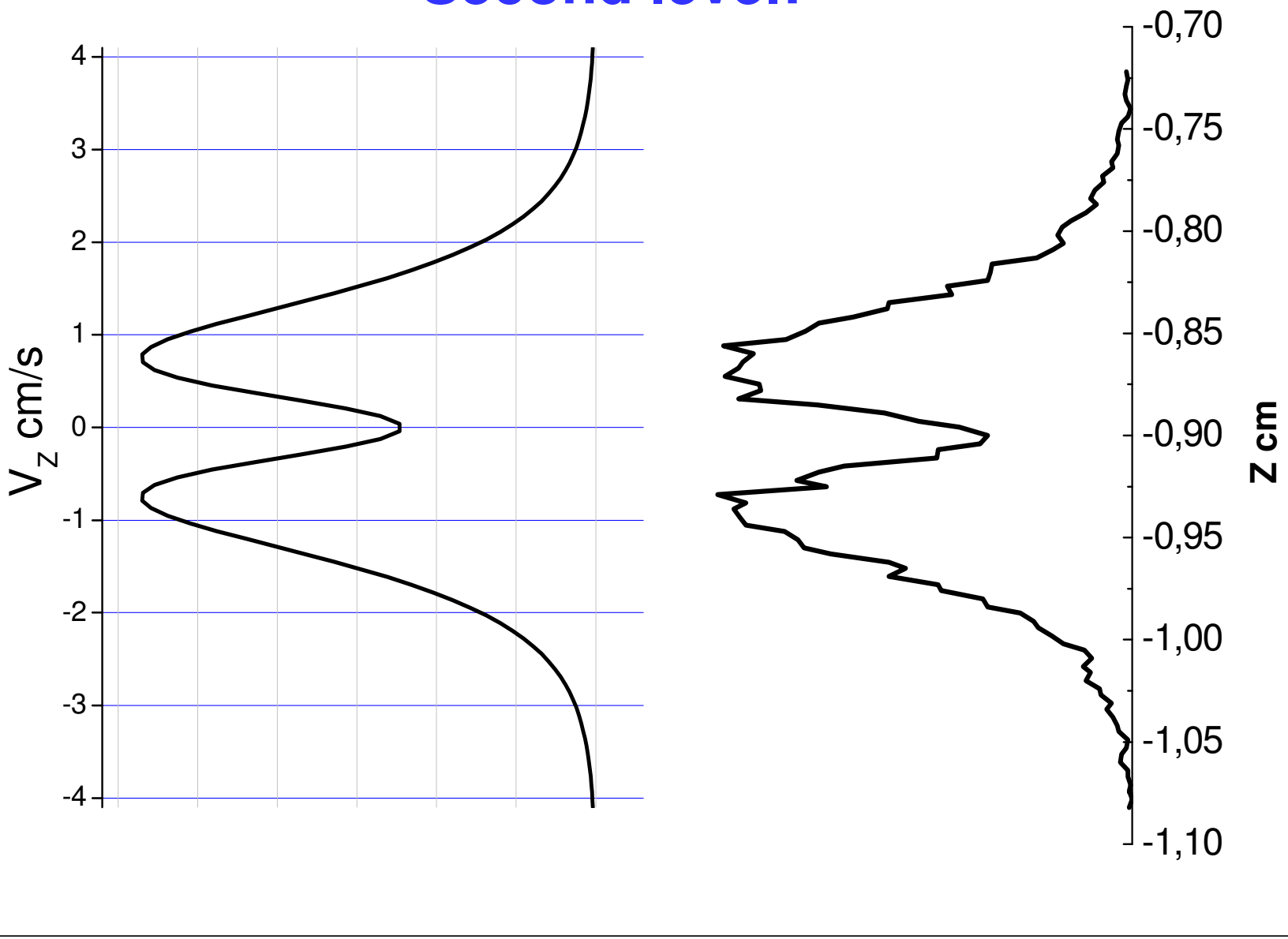



# The momentum (velocity) representation of the wave function

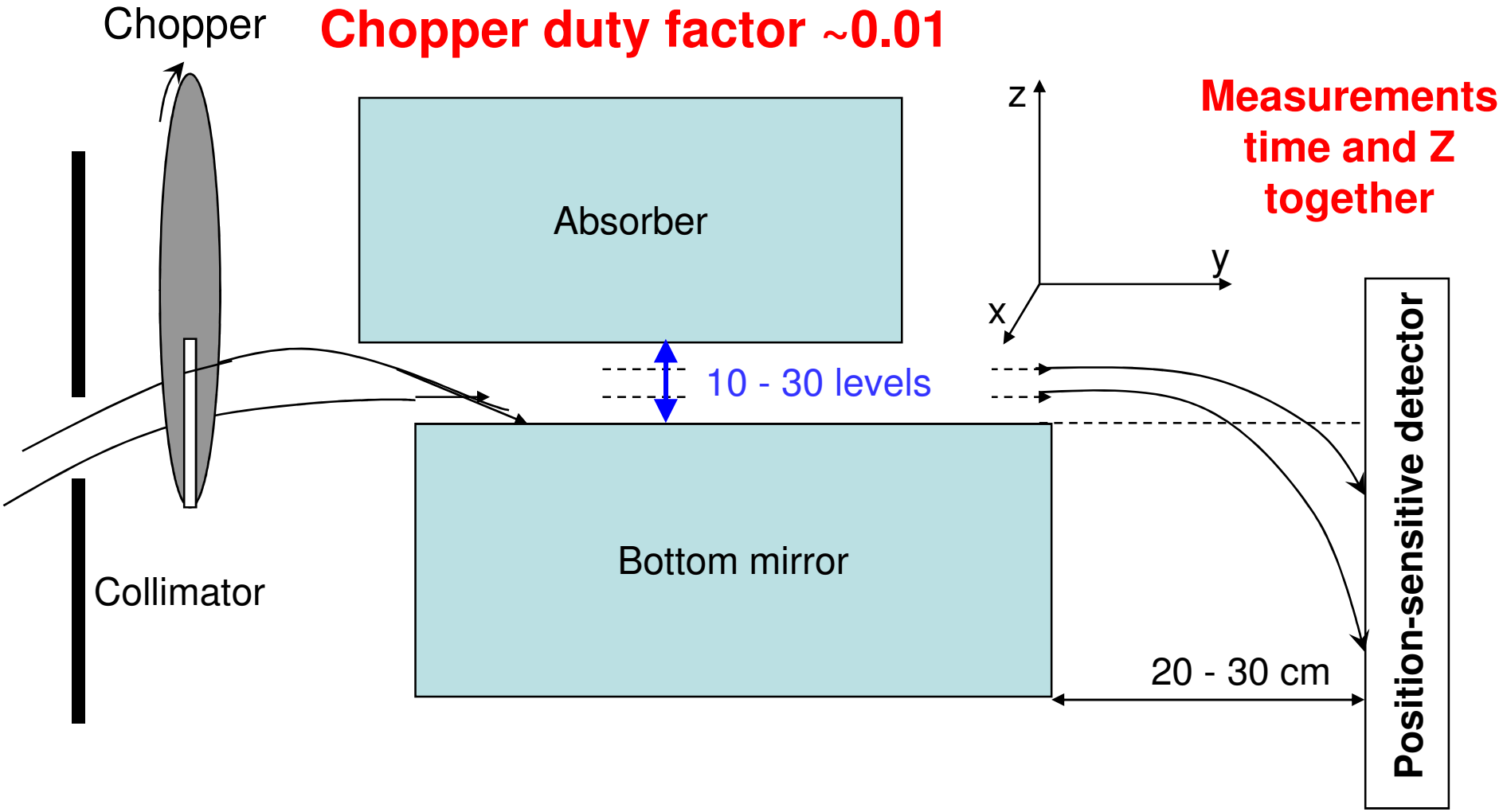


*Position-sensitive UCN detectors for the gravitational levels measurements*

# Second level:

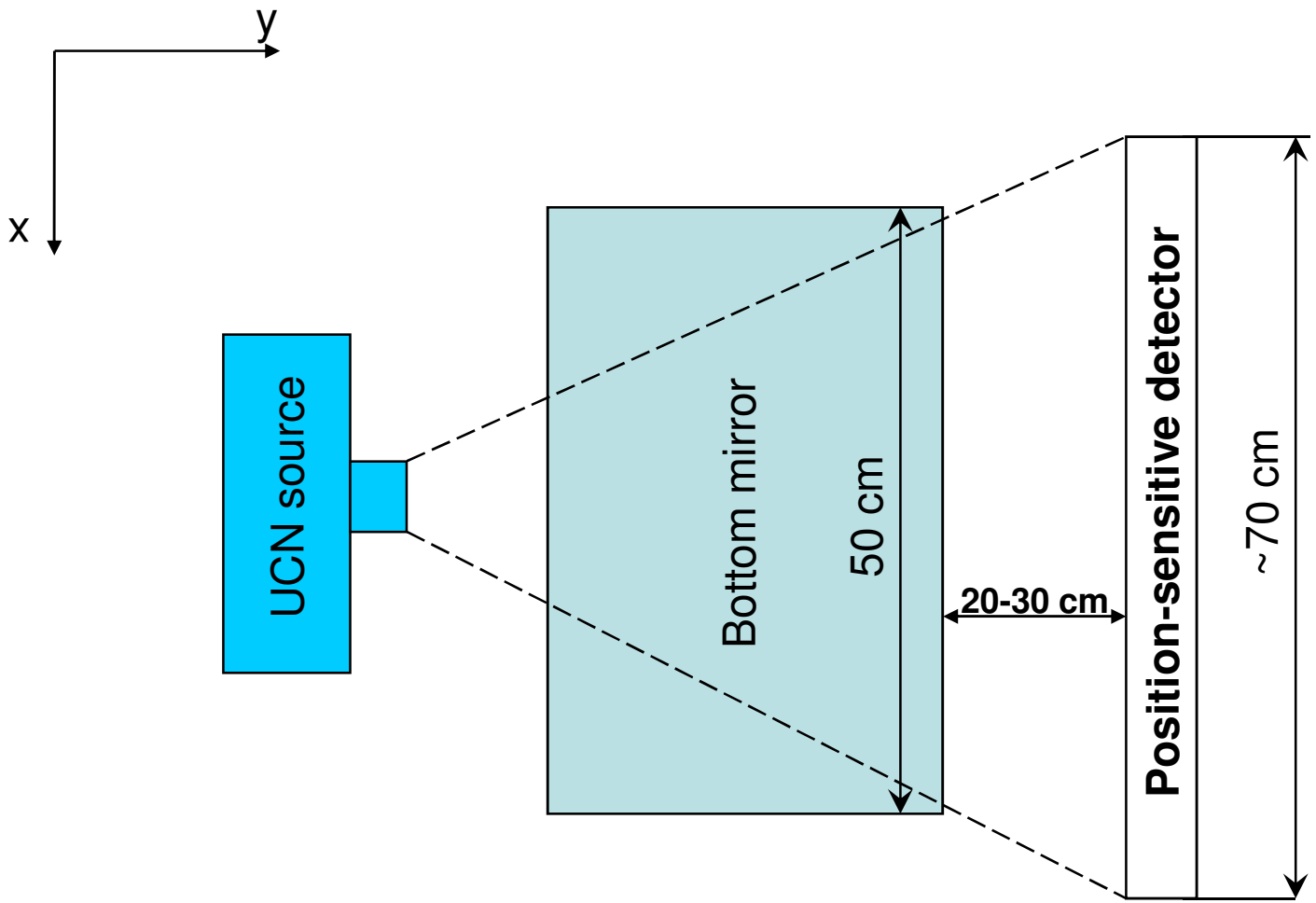


# The momentum (velocity) representation of the wave function



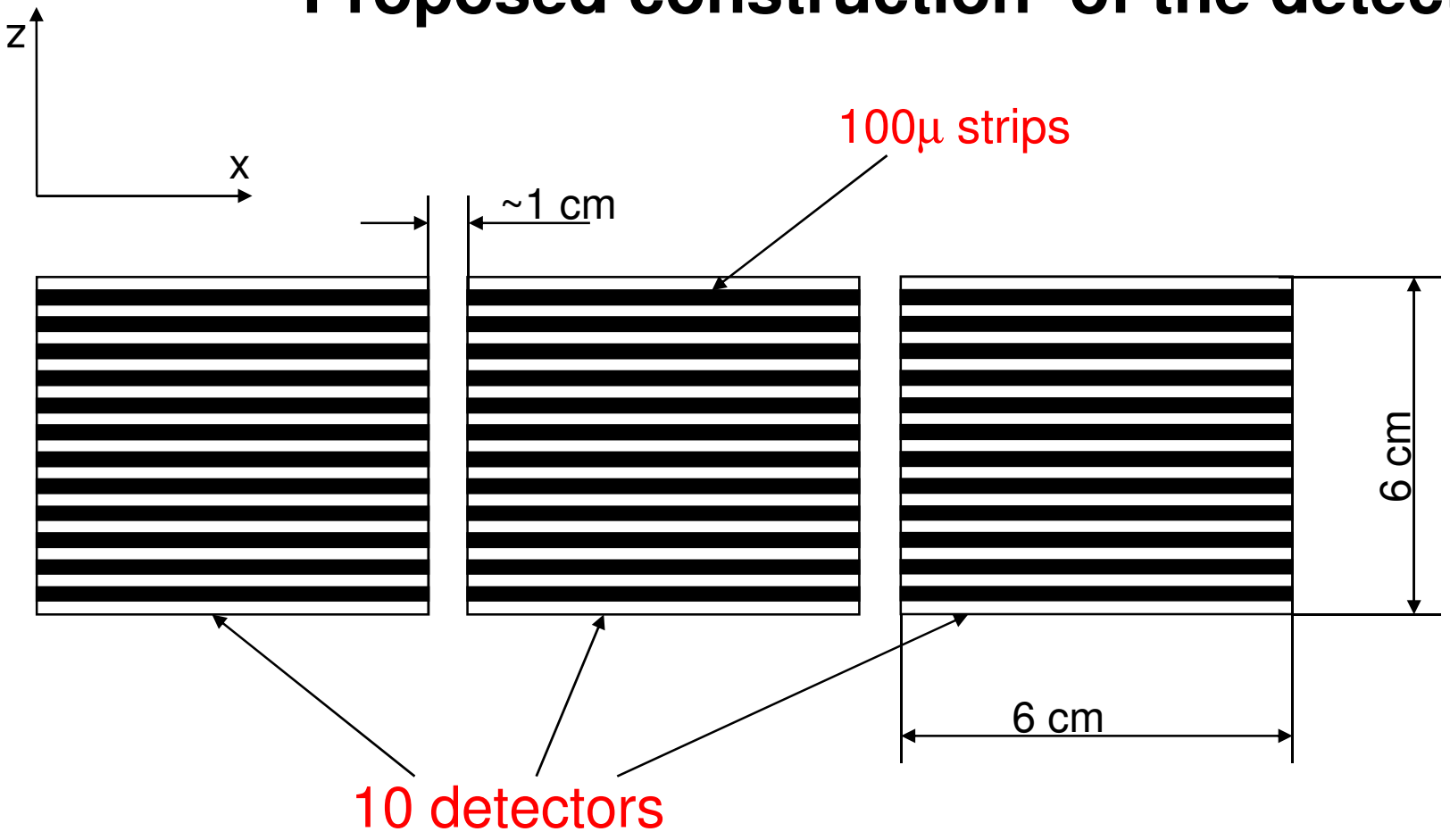
*Position-sensitive UCN detectors for the gravitational levels measurements*

# Detector's geometry



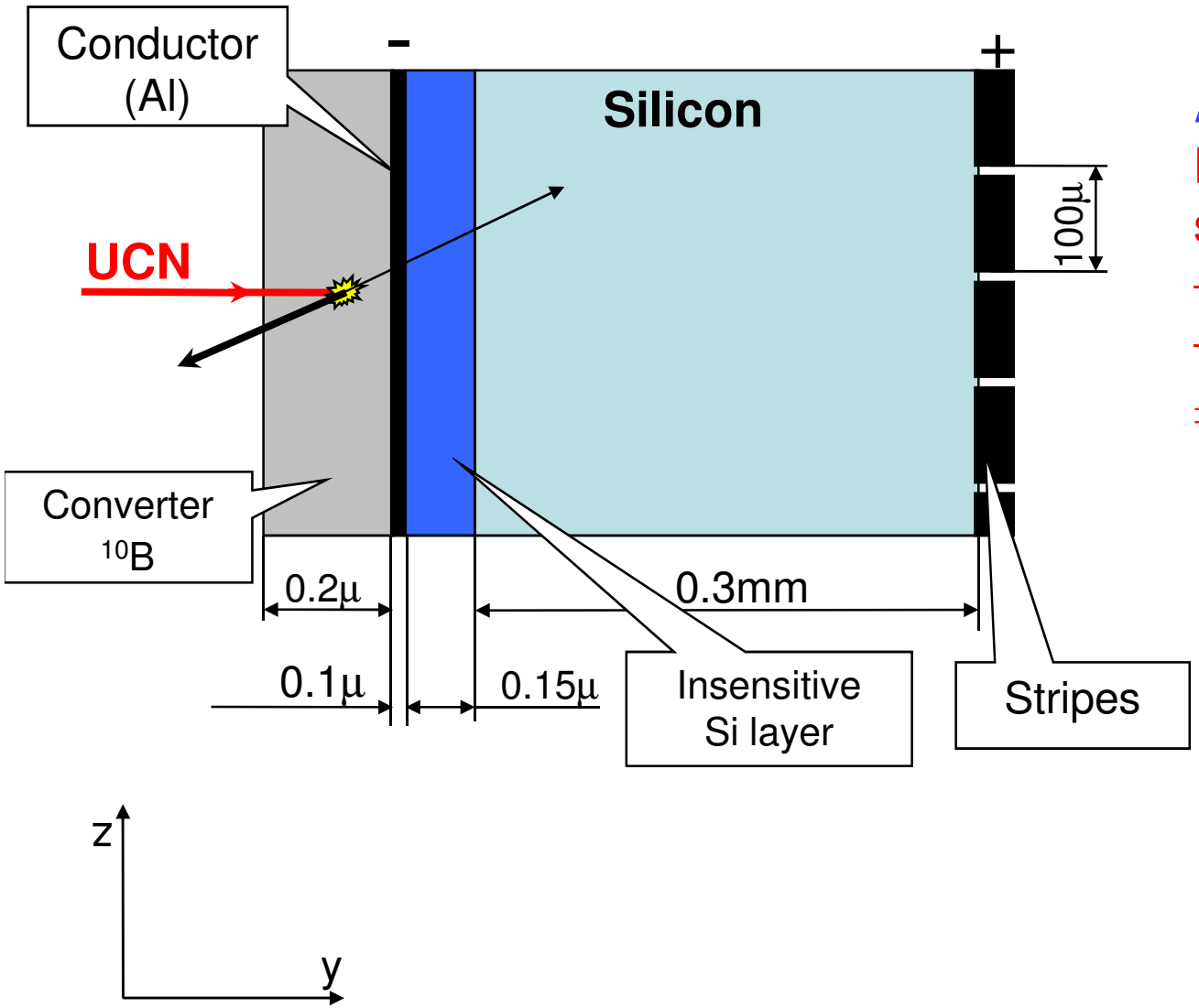
*Position-sensitive UCN detectors for the gravitational levels measurements*

# Proposed construction of the detector



*Position-sensitive UCN detectors for the gravitational levels measurements*

# Proposed construction of the detector

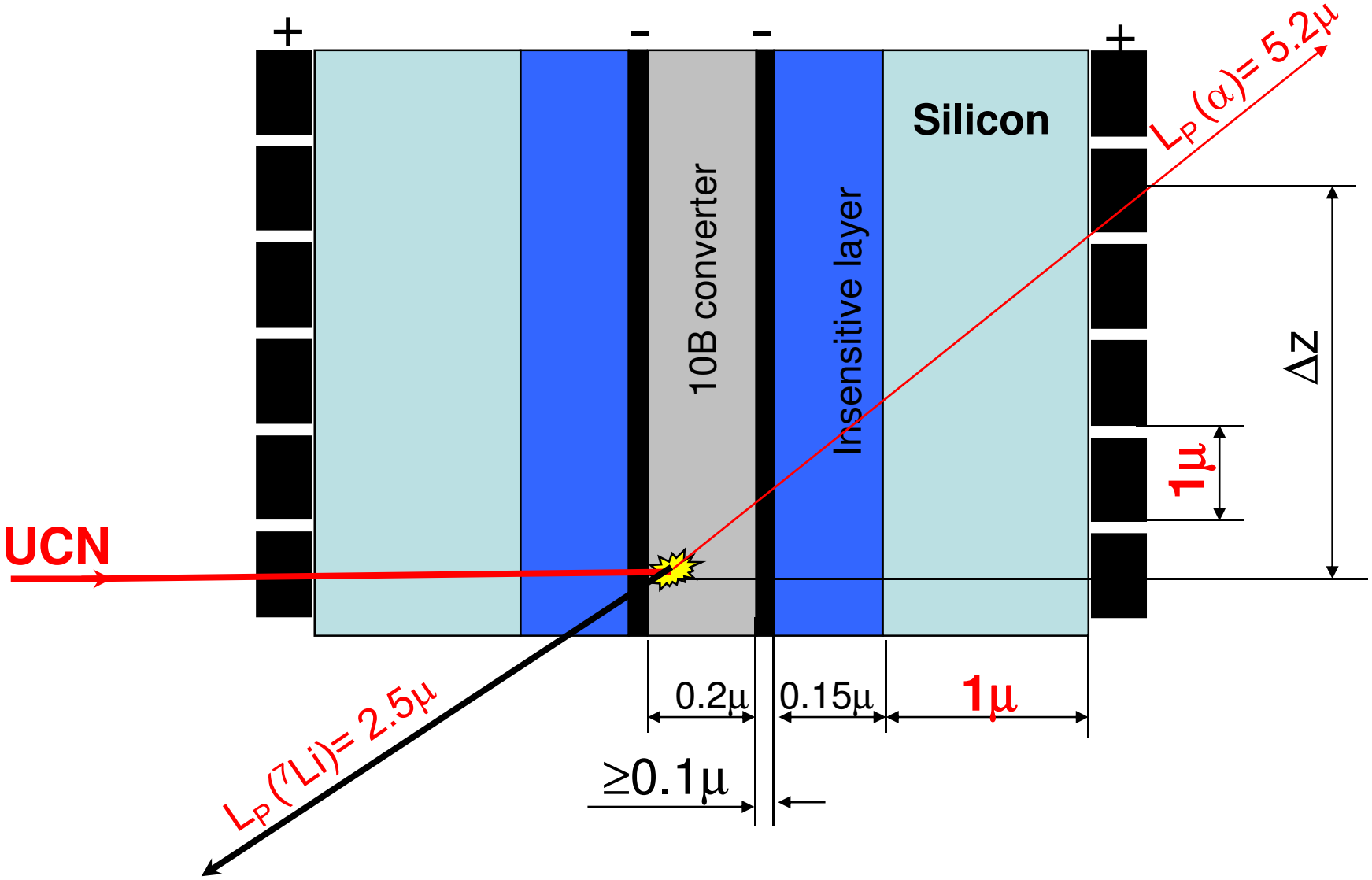



**Advantages:**

Low requirements for spatial resolution ⇒
– standard technology
– standard electronics
⇒ low price

*Position-sensitive UCN detectors for the gravitational levels measurements*

**UCN semiconductor detectors with spatial resolution 1μ**



# The End

*Position-sensitive UCN detectors for the gravitational levels measurements*