High resolution detector developement based on solid boron layer

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DENIM
7-9th September , 2015

Contents

- Detectors at BNC
- Detectors based on solid boron converter
  - Motivation
  - Simulation
  - Prototype detector / Experimental results
- Conclusion / Future

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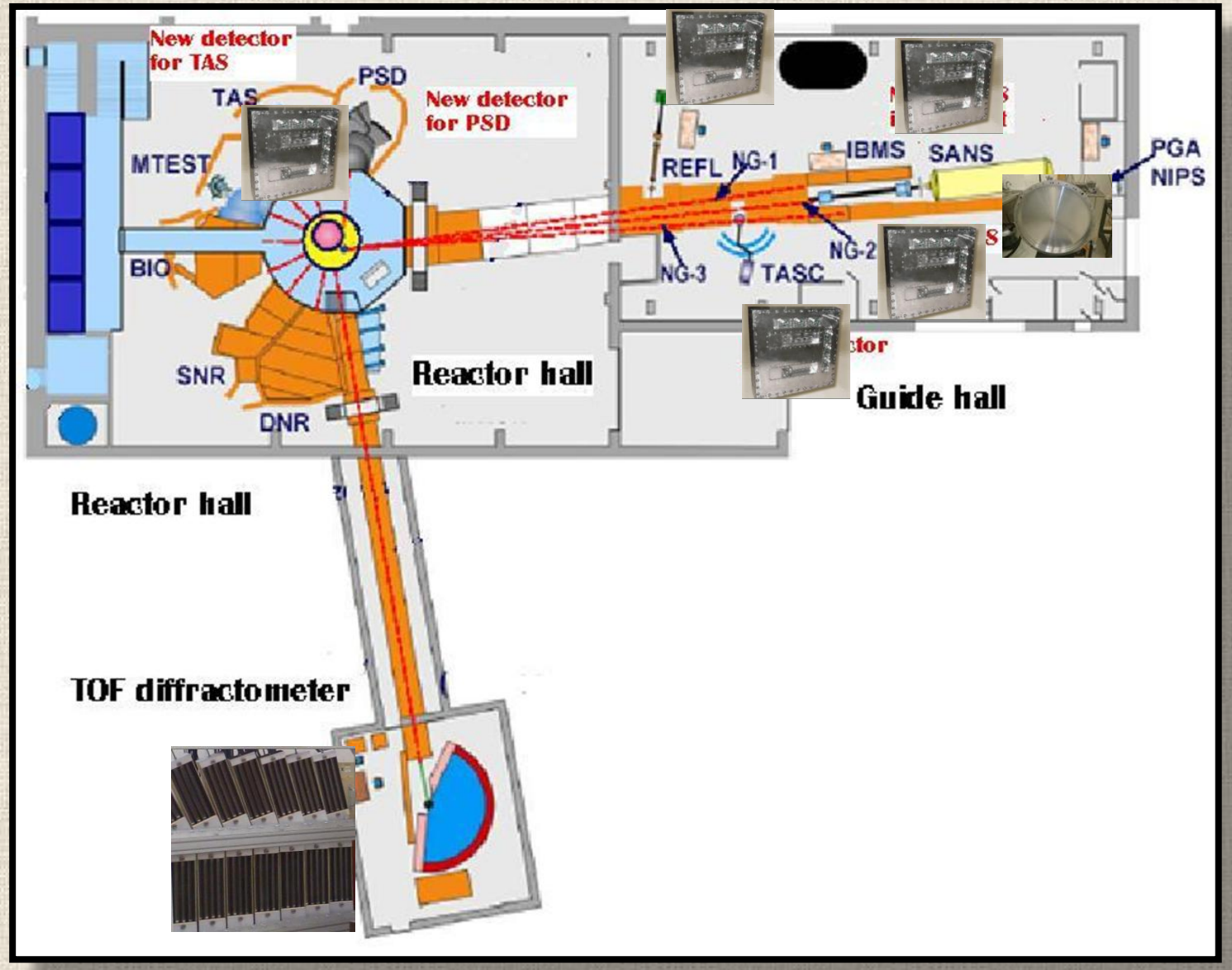
Detectors at BNC



- Detectors based on ^{3}He
- Delay-line readout

Detectors at BNC

Instrument name	Type	Active area	Resolution
TAST	TAS	200 mm X 200 mm	2 mm
PSD	Thermal diffractometer	610 mm X O25 mm 1D tubes	
TOF	TOF backscattering	1 m x 1 m	5 mm
ATHOS	Cold TAS	200 mm X 200 mm	2 mm
REF	Reflectometer	200 mm X 200 mm	2 mm
GINA	Reflectometer	200 mm X 200 mm	2 mm
SANS	SANS	640 mm X 640 mm	10 mm
FSANS	TOF-SANS	200 mm X 200 mm	2 mm

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Motivation of own developement

- Small size chambers for FSANS and REFL
- Optimization of position resolution
  - Focusing technics
  - Miniaturazing
- Optimization for count rate

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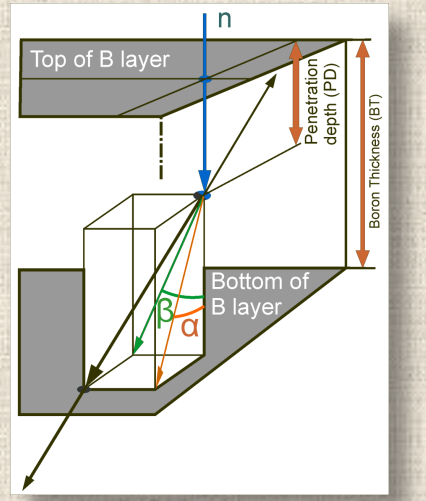
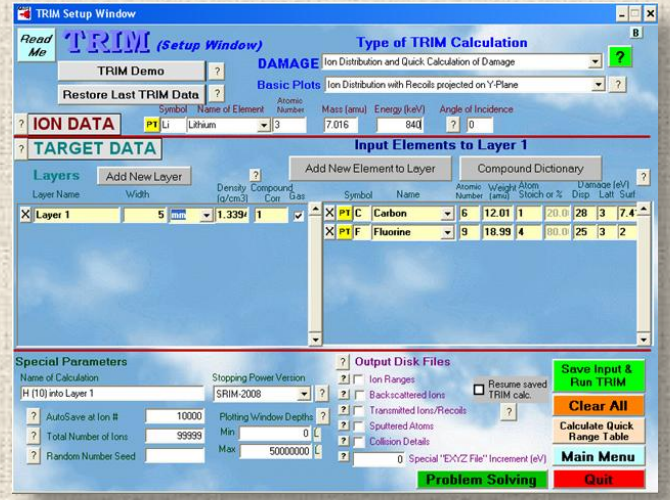
Simulation

$^{10}B + n \rightarrow {}^{7}Li_{(1015\ keV)} + \alpha_{(1777keV)}$ 6%

$^{10}B + n \rightarrow {}^{7}Li_{(840\ keV)} + \alpha_{(1470keV)} + \gamma_{(480keV)}$ 94%



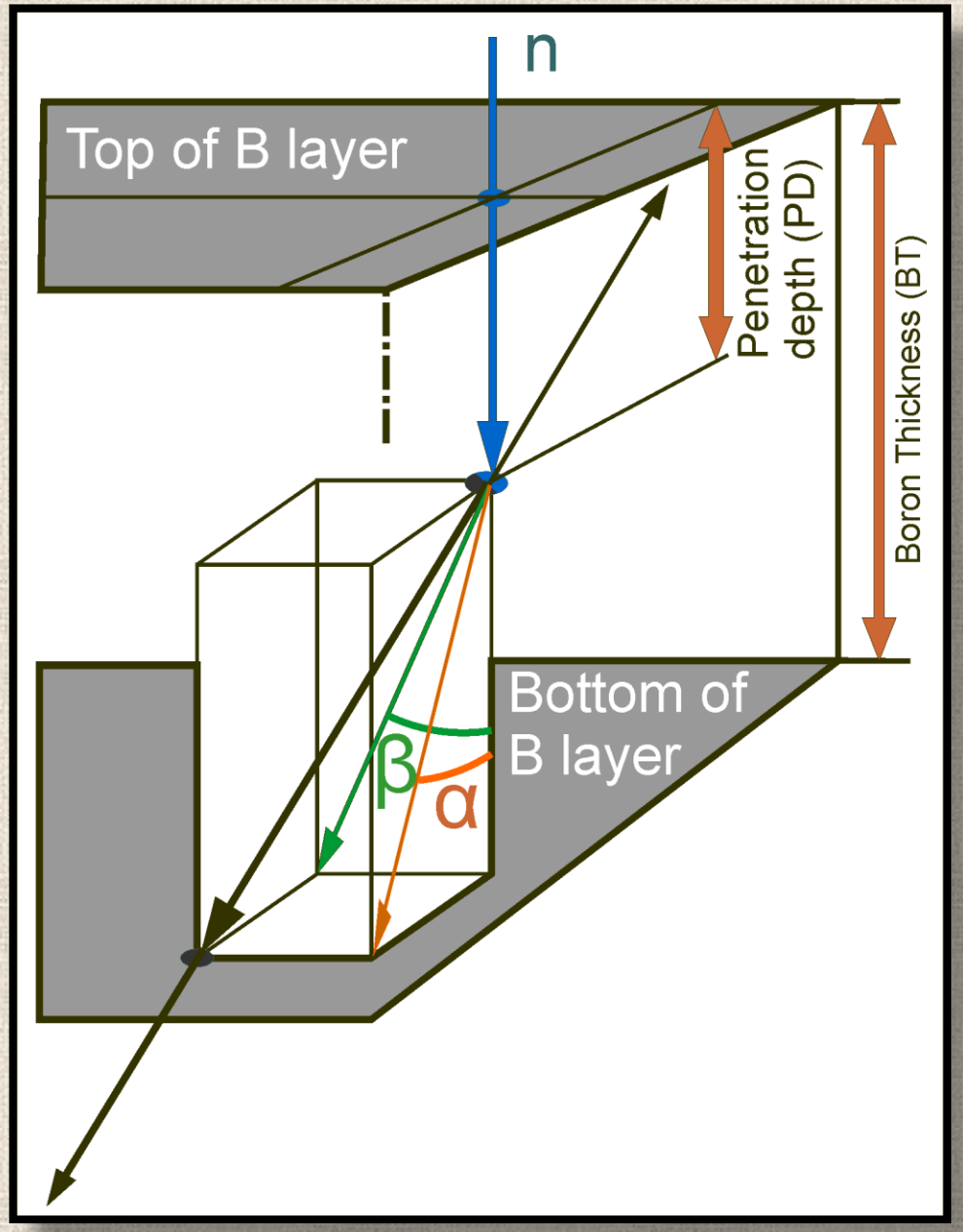


Ionization model

TRIM Simulation of the ionization process

Simulation of the detection process

Simulation



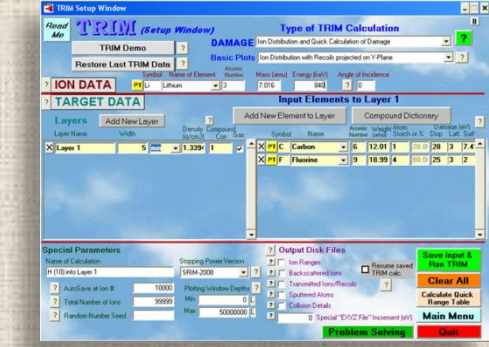
Neutron path

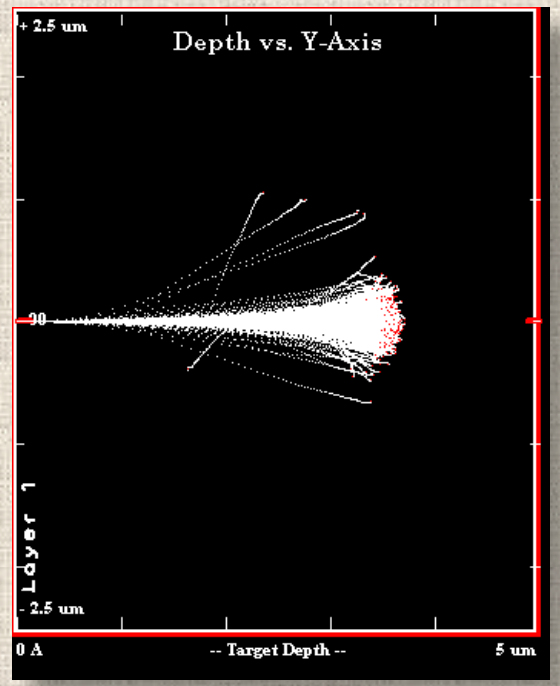
Ionization

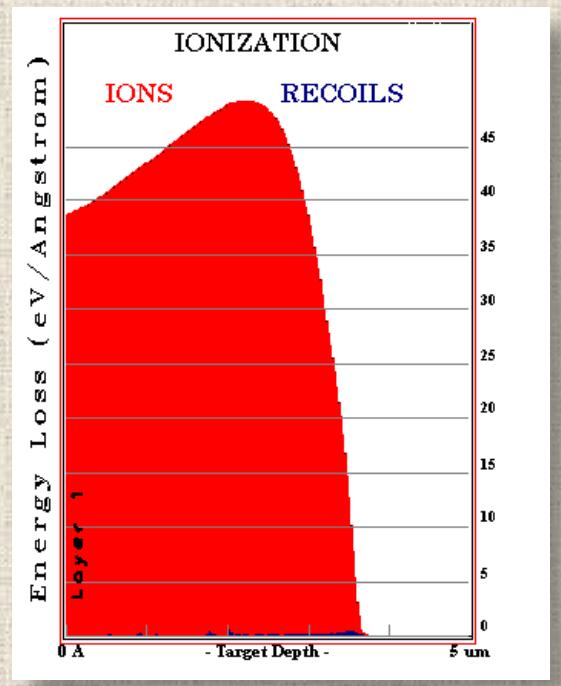
Parameters:

- Neutron penetration depth
- α angle
- β angle
- α or ^{7}Li

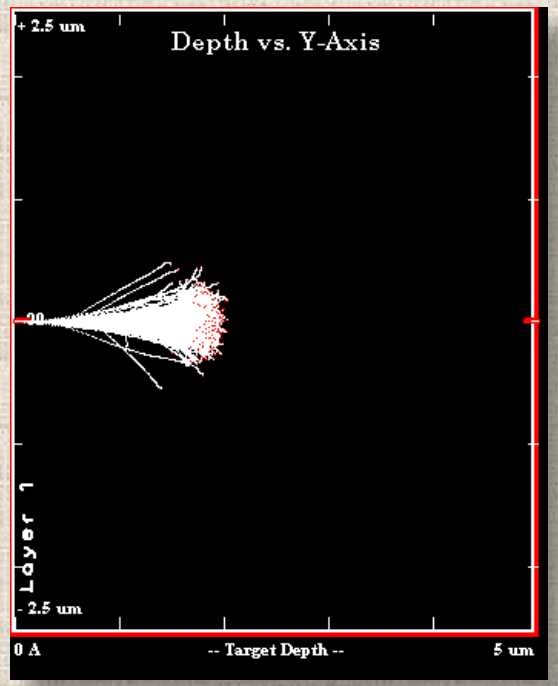
Simulation

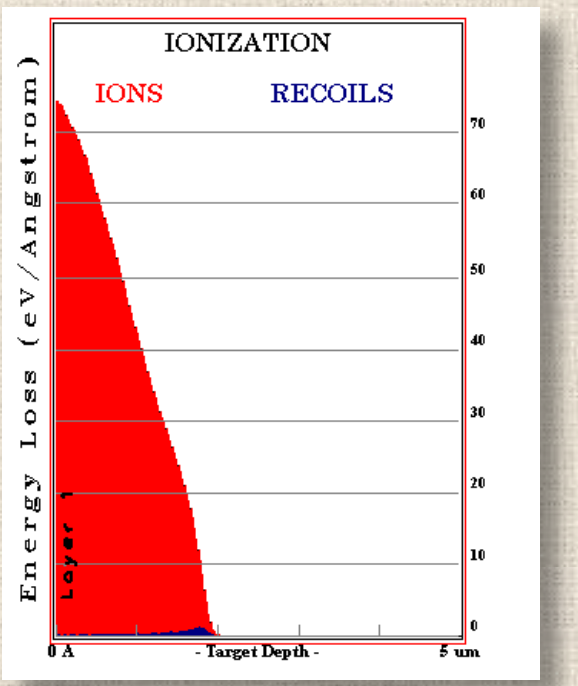






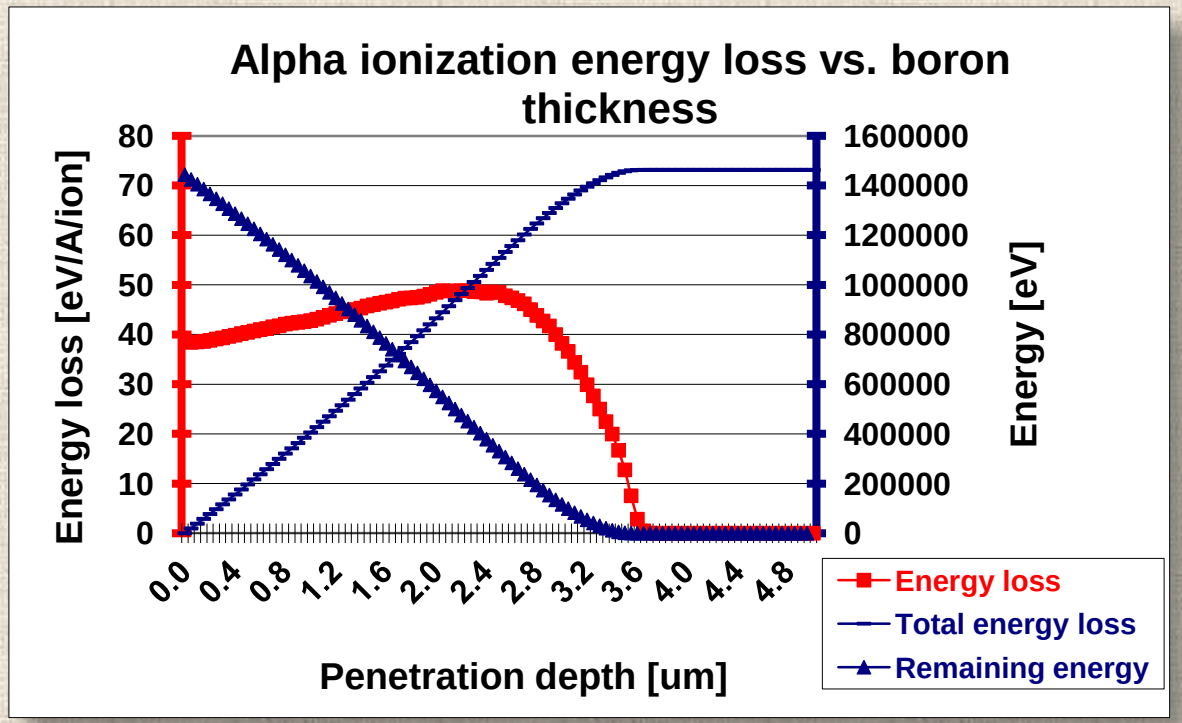
Ionization by α
1470 keV



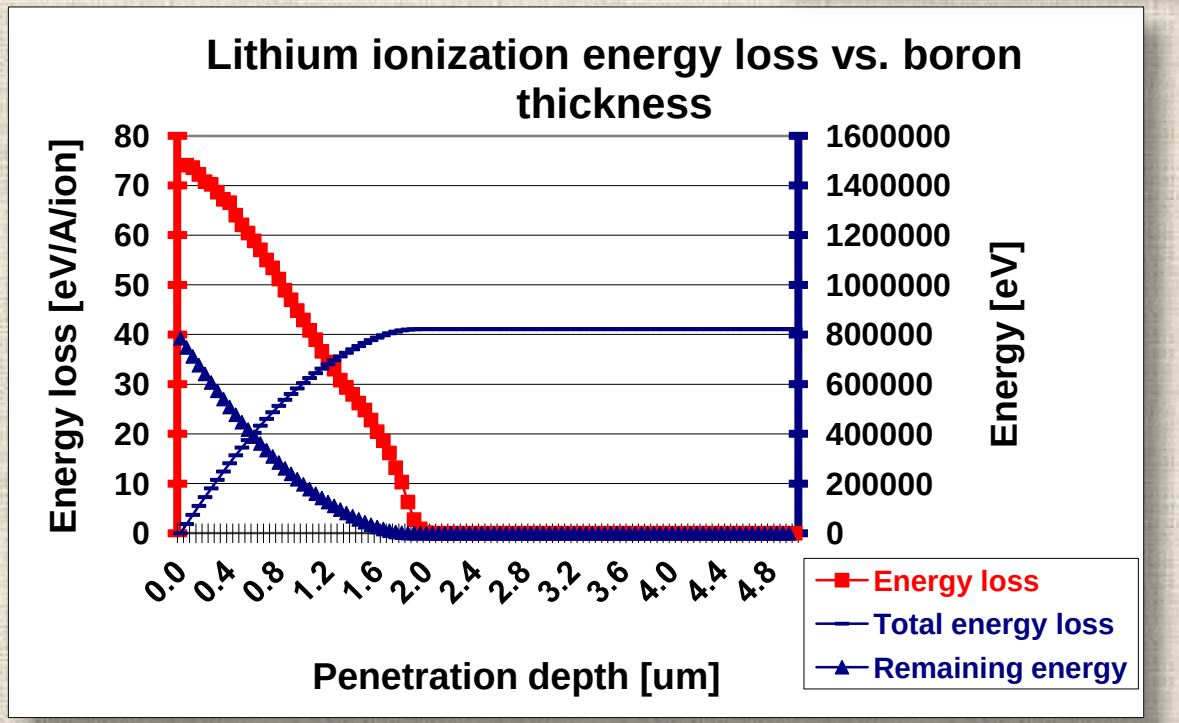


Ionization by ^{7}Li
840 keV

Simulation

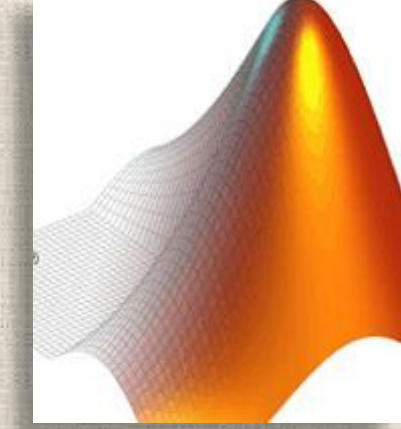


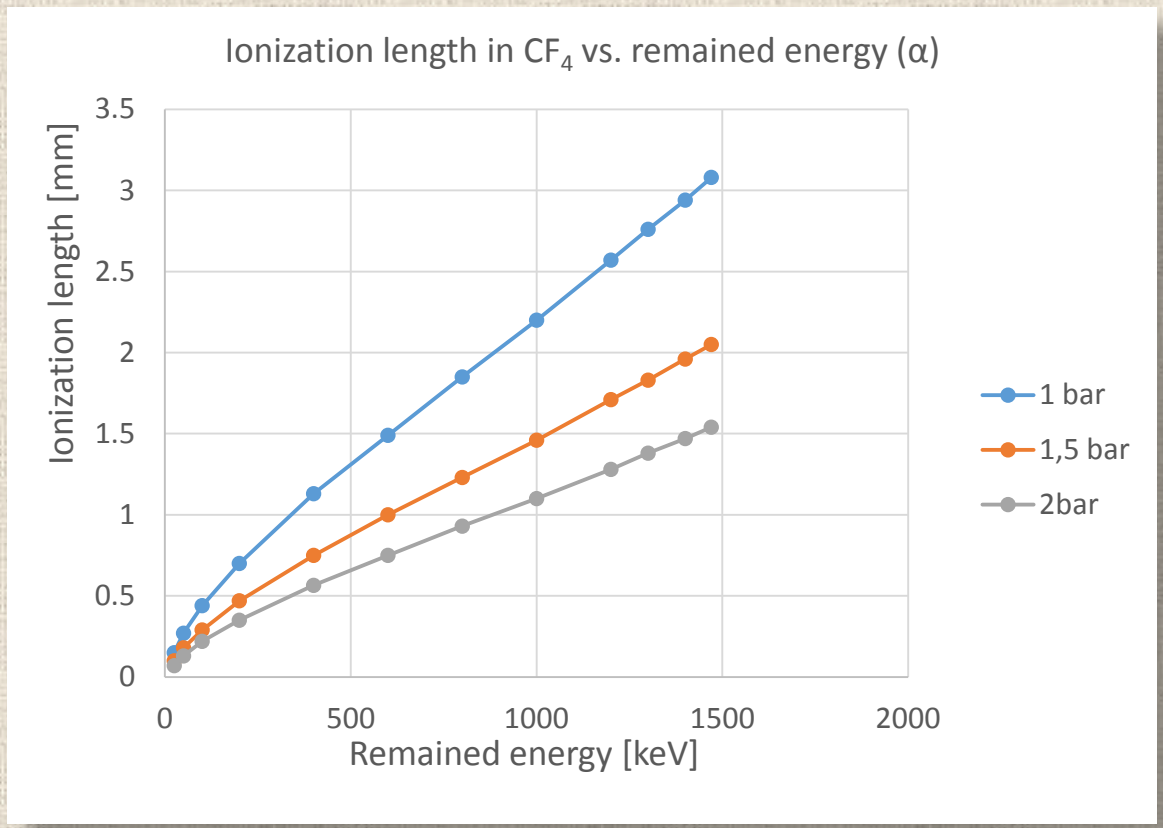
Ionization by α
1470 keV



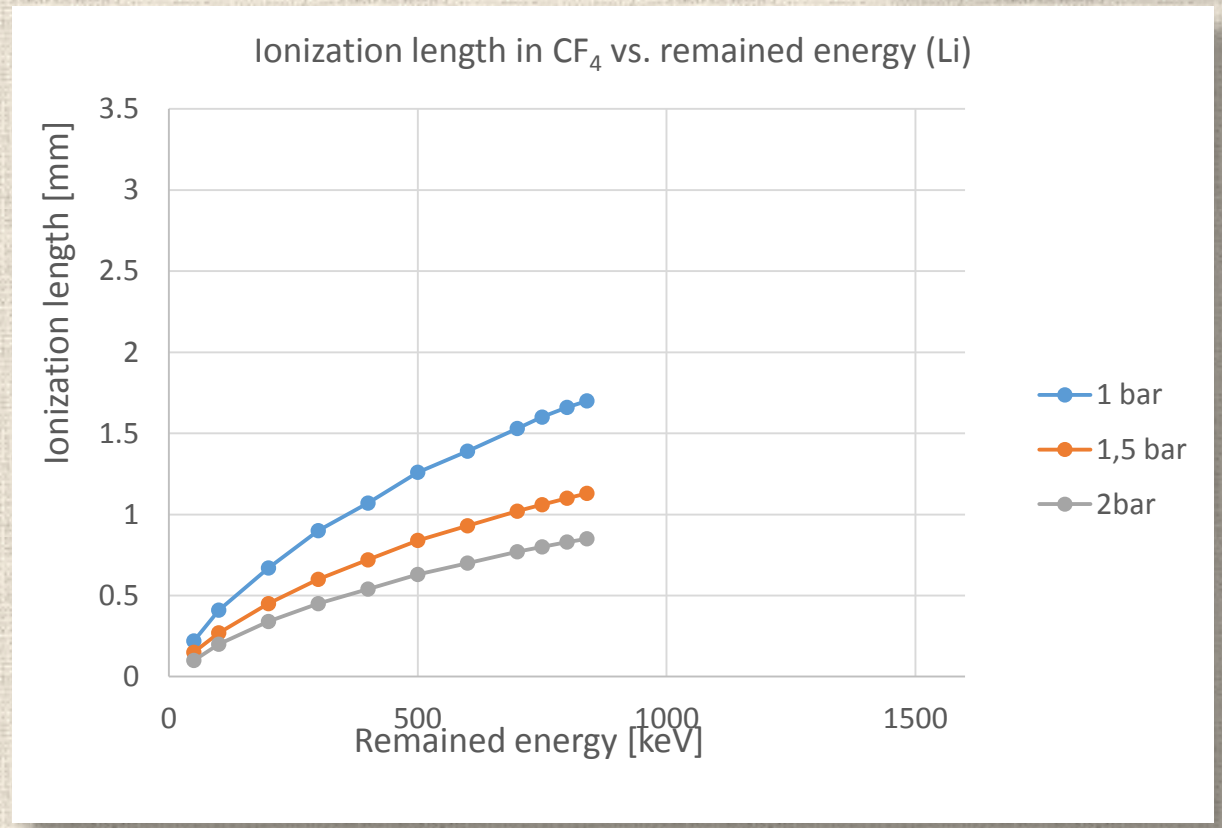
Ionization by ^{7}Li
840 keV

Simulation



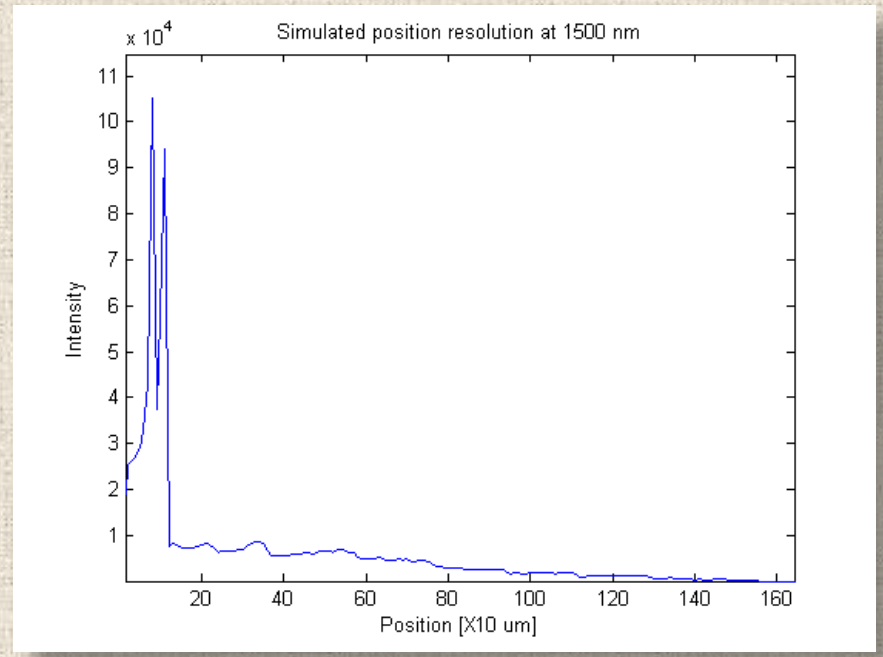


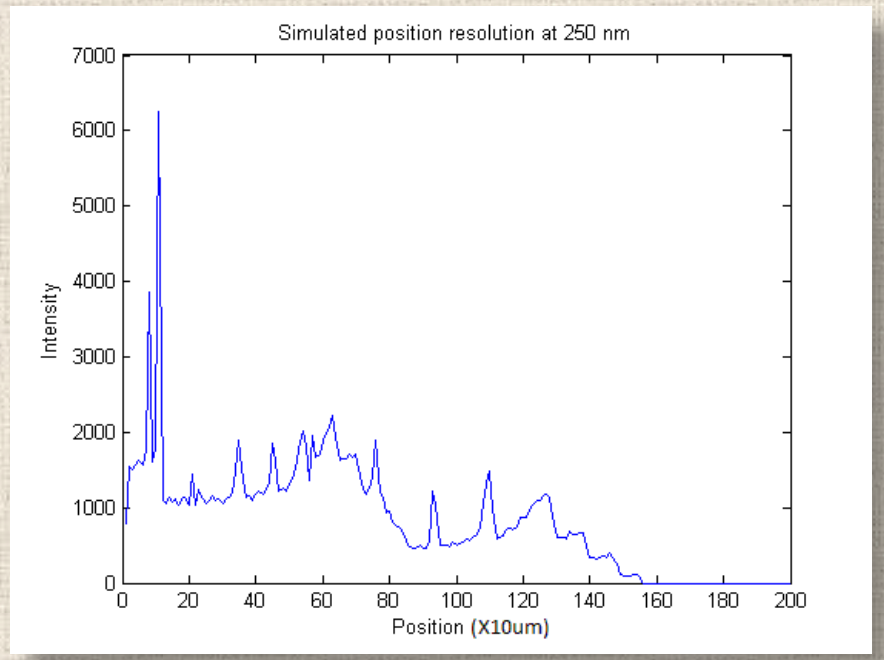
Ionization length in CF_4 by α

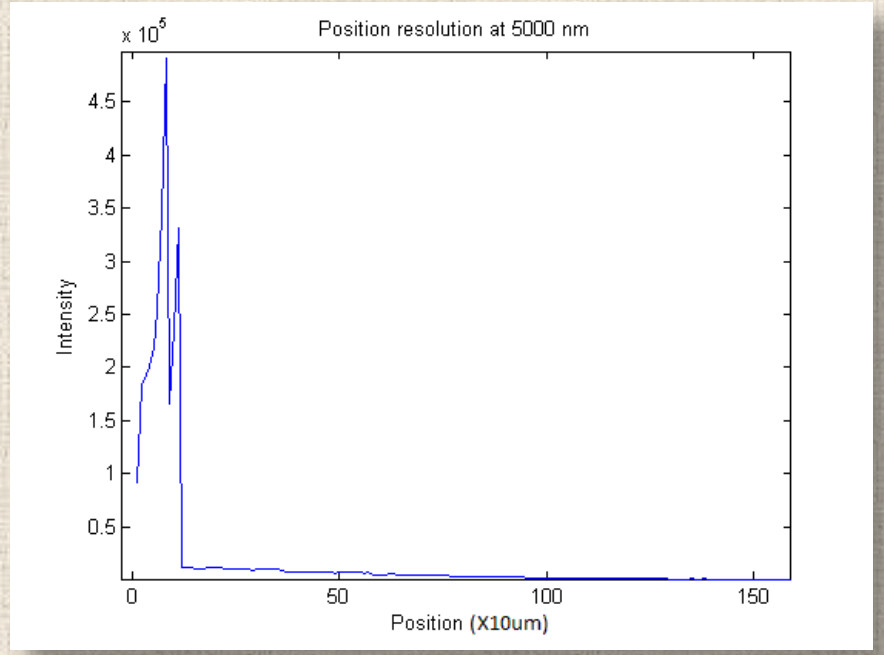


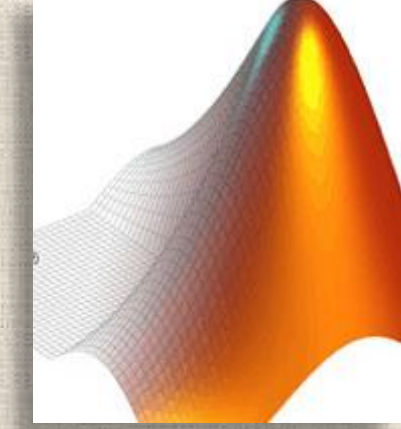
Ionization length in CF_4 by ^7Li

Simulation


Simulated position resolution at 1500 nm
x 10^4
Intensity
Position [X10 um]


Simulated position resolution at 250 nm
Intensity
Position (X10um)


Position resolution at 5000 nm
x 10^5
Intensity
Position (X10um)



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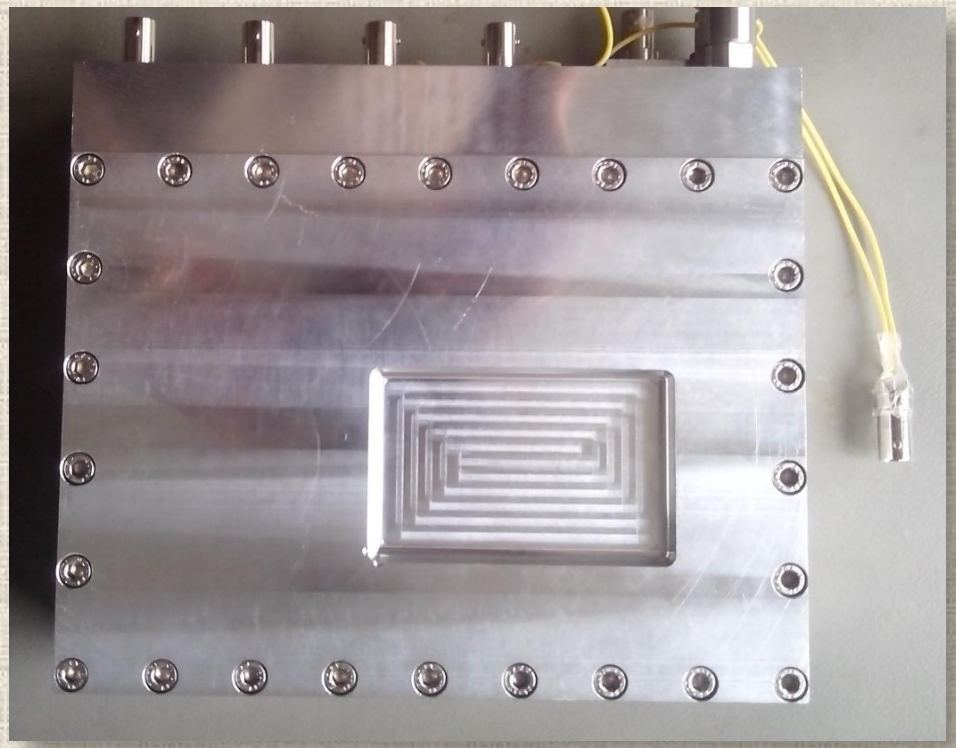
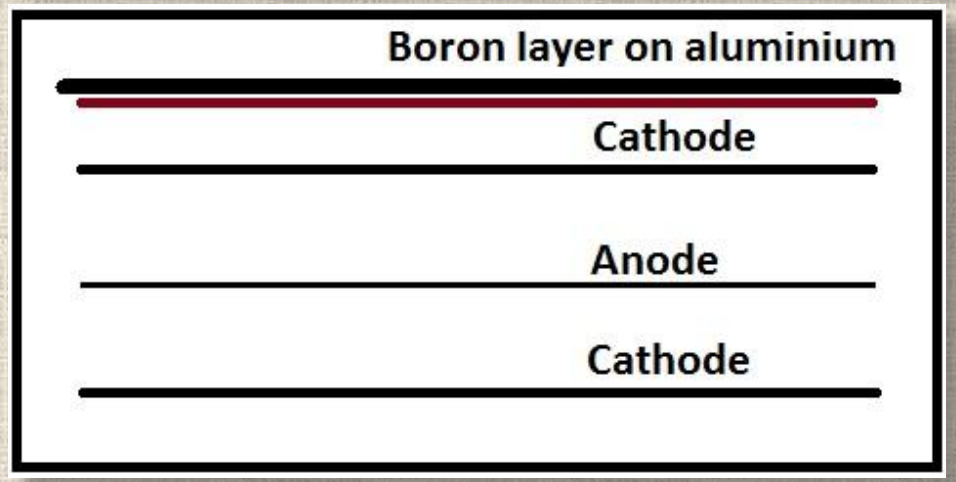
B_4C layer sputtering at Mirrotron LTD

- B_4C layer with different thicknesses
- Characterization of the layers made by Wigner
- DC Magnetron sputtering
- Polished aluminium substrate
- Collaboration with Mirrotron LTD in prototype fabrication

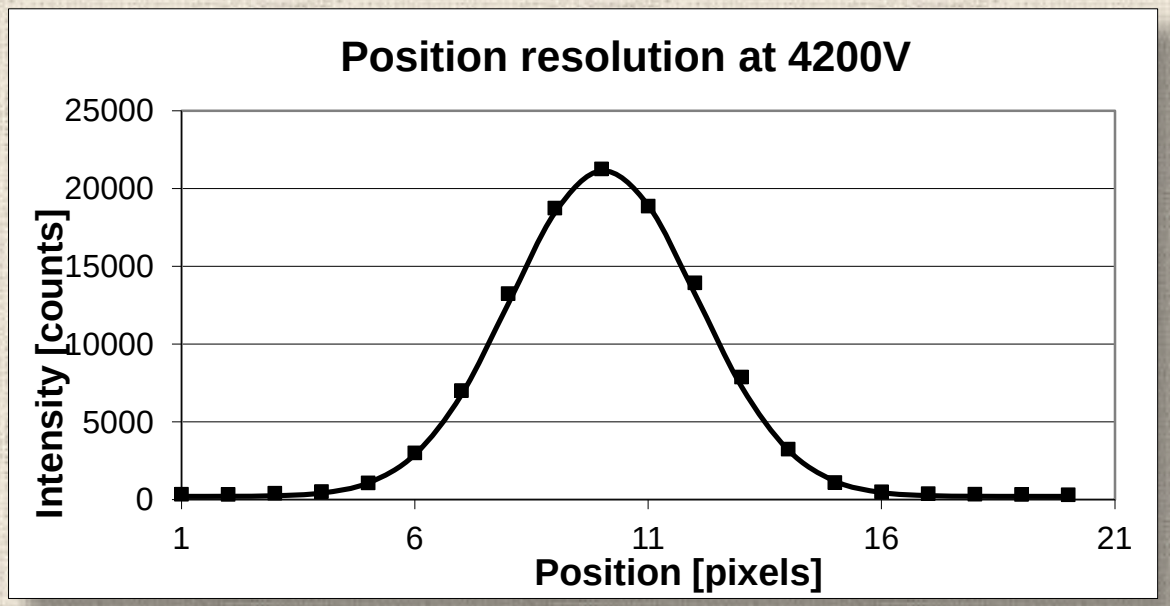
Prototype detector

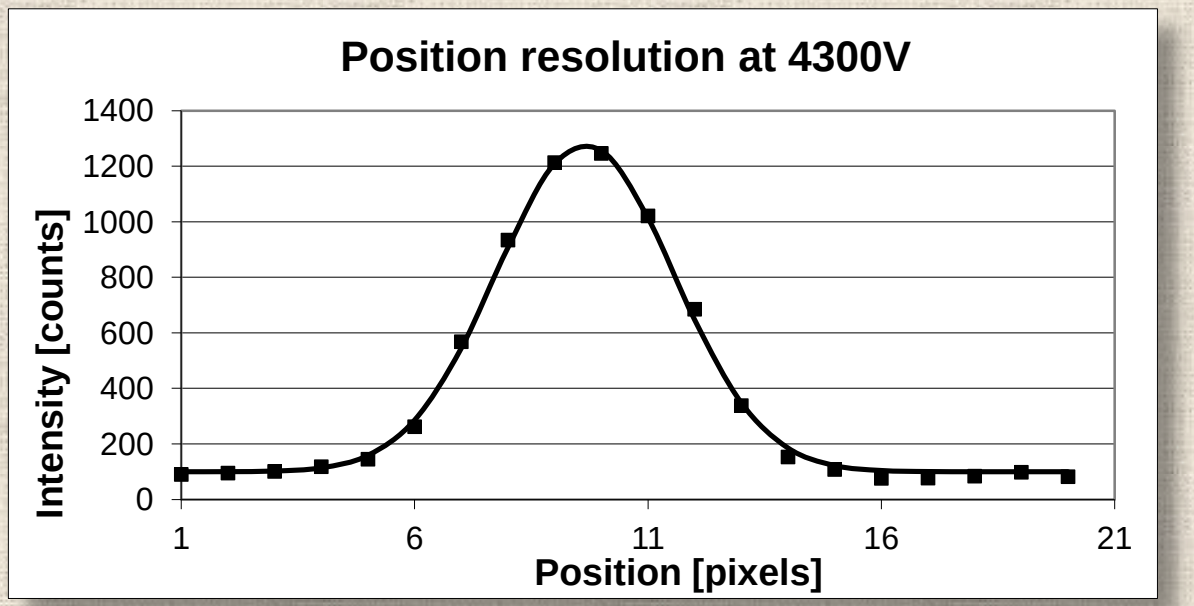


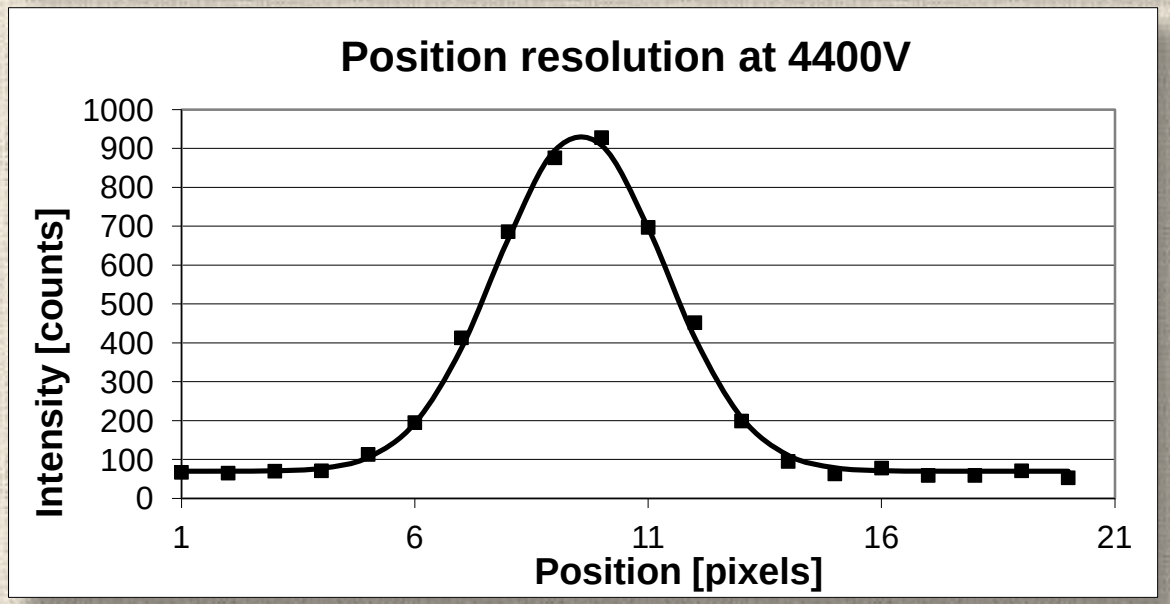


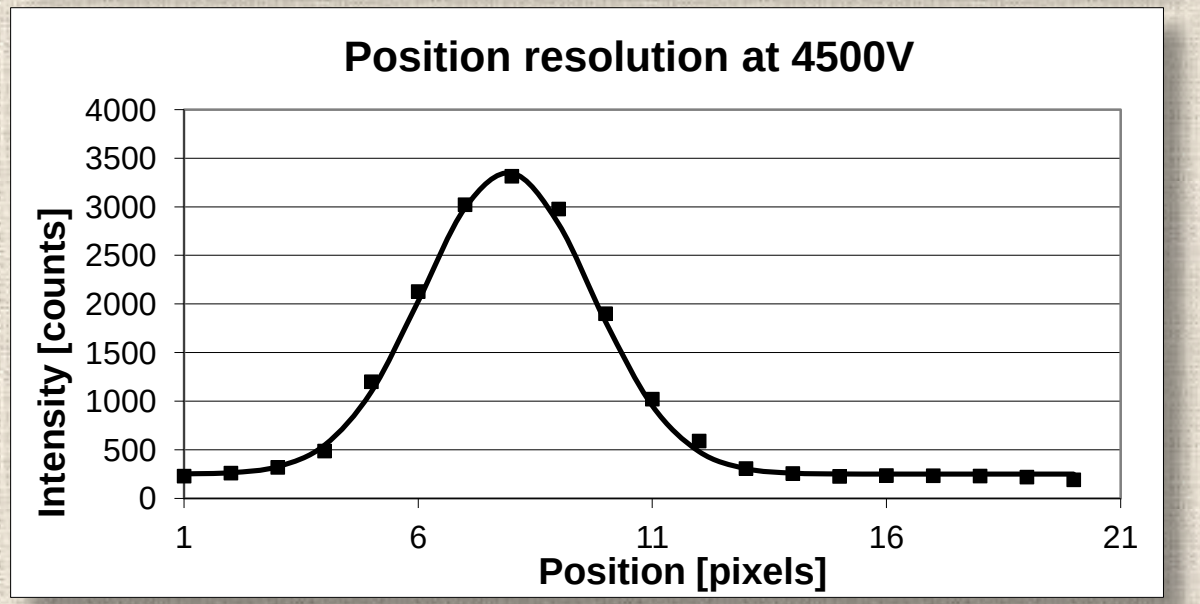
- Thickness of boron layer: 1.5um
- Wire pitch: 0.8 mm
- Active area: 80 mm X 50 mm
- Readout: delay-line
- Filling gas: 2 bars CF_4
- Anode - cathode distance: 3.2 mm
- Cathode - Boron layer distance: 2 mm
- 10 um / 30 um wire diameters
- Back cathode: PCB with conductive lines

Experimental results:resolution









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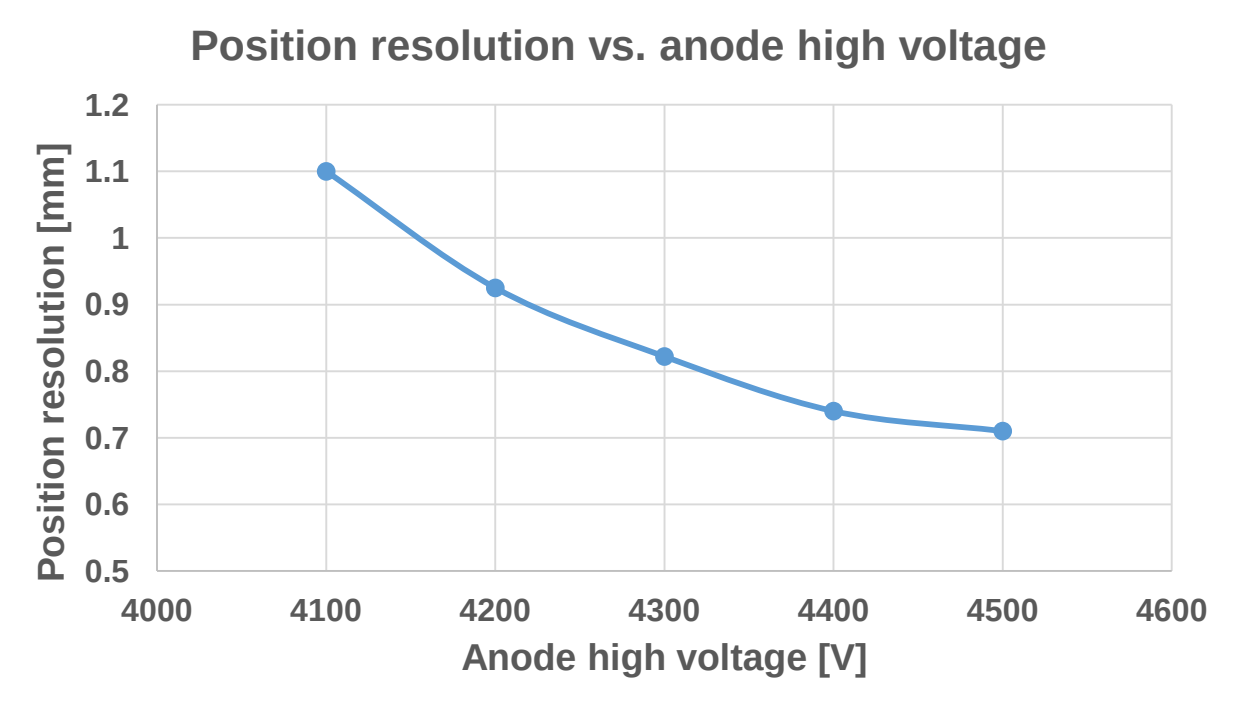
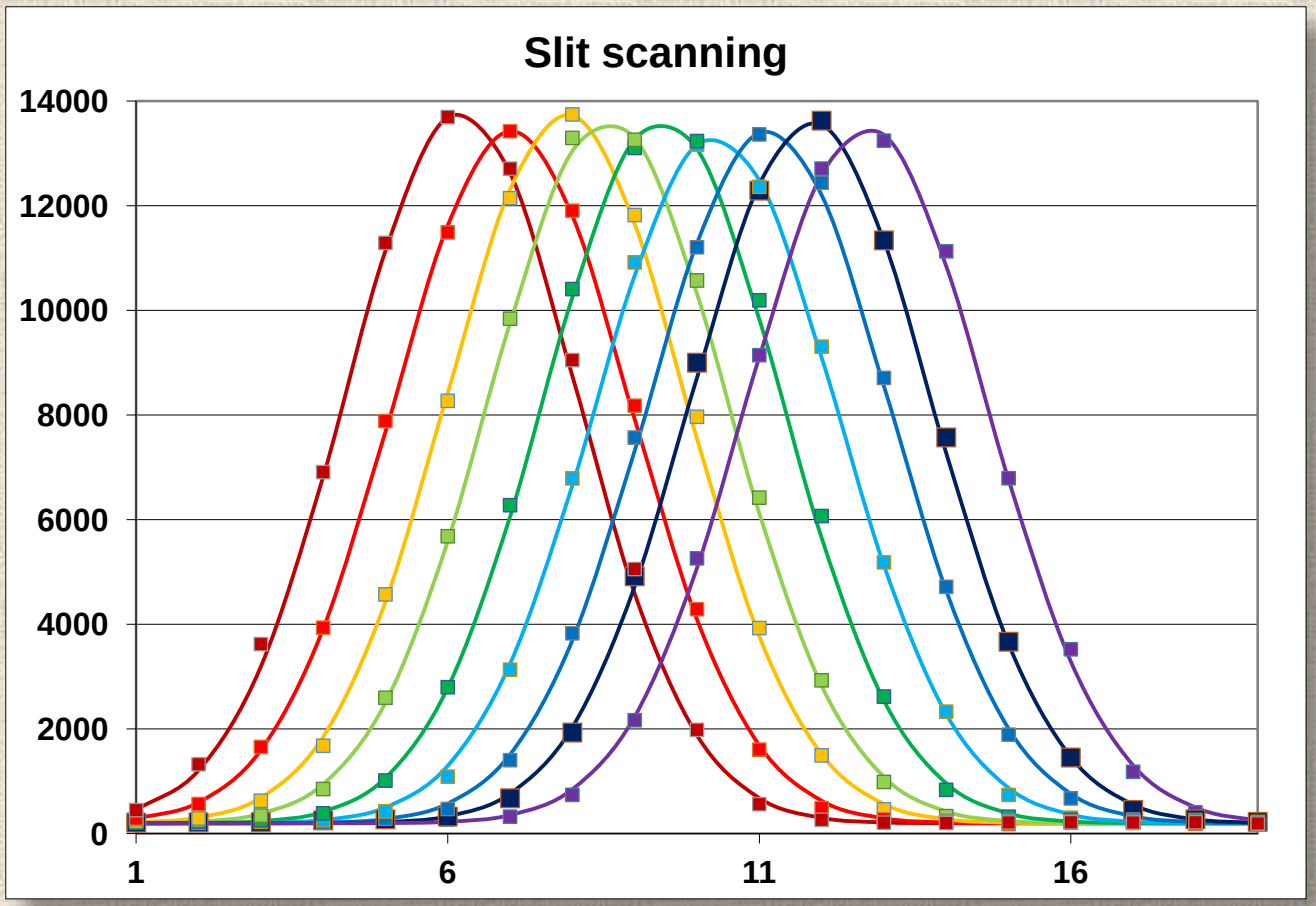


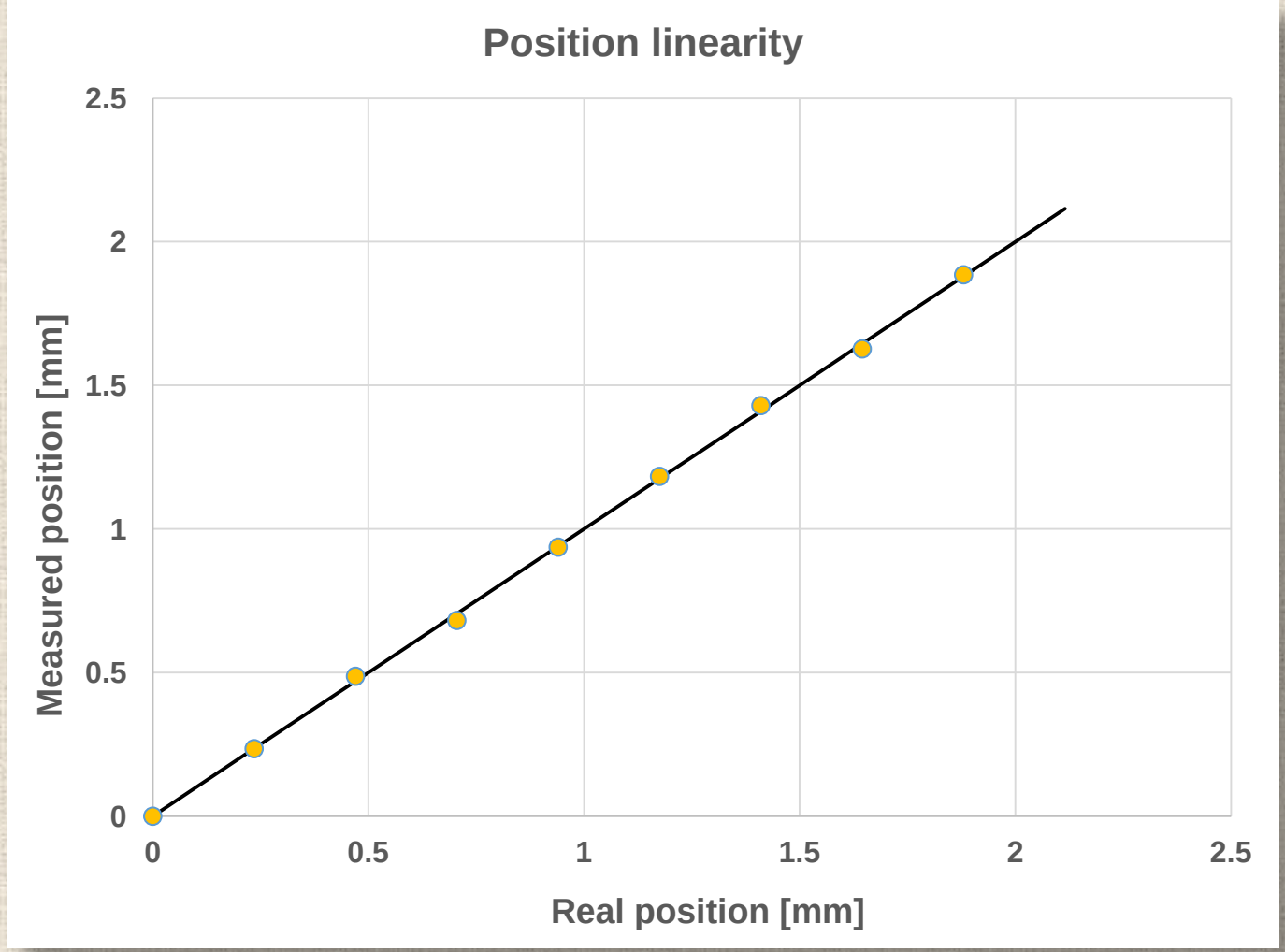
- Position resolution is saturated at 0.7 mm (FWHM)

Experimental results: linearity



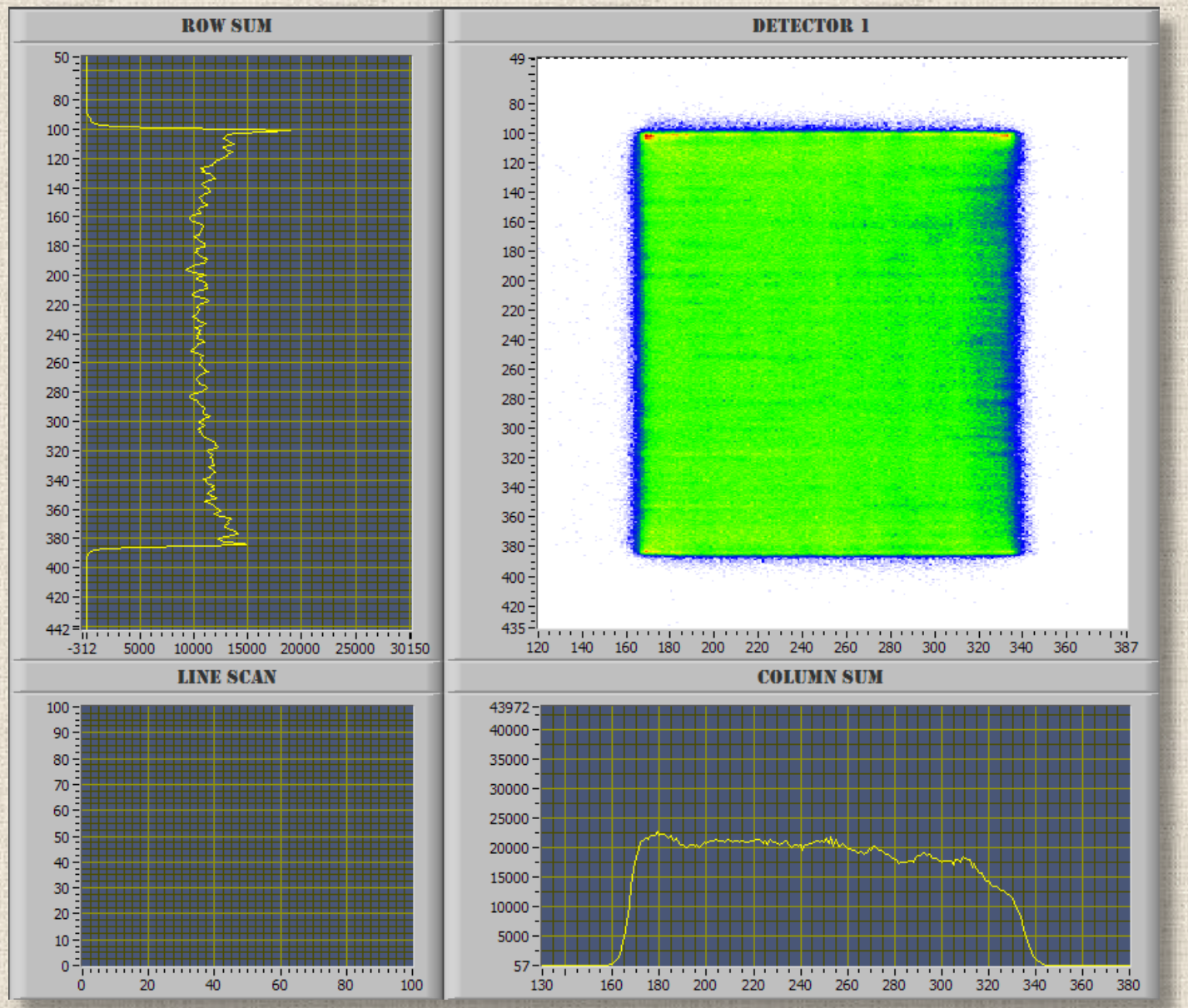
- Detector is moved behind the slit by 0,25 mm steps

Experimental results:linearity



- Detector is moved behind the slit by 0,25 mm steps

Experimental results: homogeneity



Experimental results: dead time

- Anode signal width: 100 ns
- Cathode signal width: 50 ns
- Length of delay line: 200 ns
- Conservative estimation: 250 ns dead time
- Global count rate capability › $4*10^5$ events/s at 10% loss
- Global and local count rate capability is not measurable due to low efficiency
- Beam flux was too low for local count rate measurement

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Conclusions

- Boron detector is a good candidate for our plans
- Delay-ine readout is a good compromise for low-cost read-out
- 0.7 mm position resolution is achieved with solid boron layer
- 0.8 mm wire pitch is a limitation
- Count rate capability and position resolution is sufficient for our applications
- Position linearity is good

Future

- Investigation of the possibility of smaller wire pitch
- Multigrid construction for high efficiency
- TPC algorithm with delay-line readout to decrease the dispersion of position resolution
- Further measurements (characterization of local count rate capability, efficiency, gamma sensitivity…)

Thank you for your attention!