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*Slovenia*

# Brachytherapy source localisation

## using vatagp3_1 chips and Silicon pad detectors

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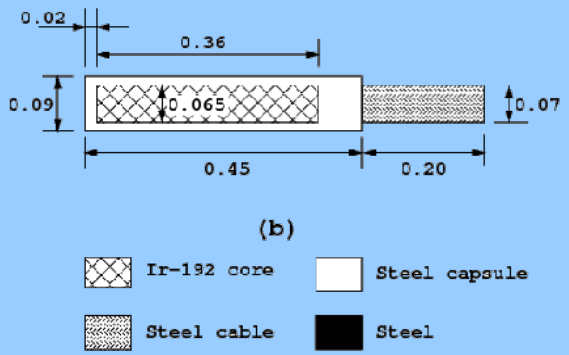
# What is Brachytherapy

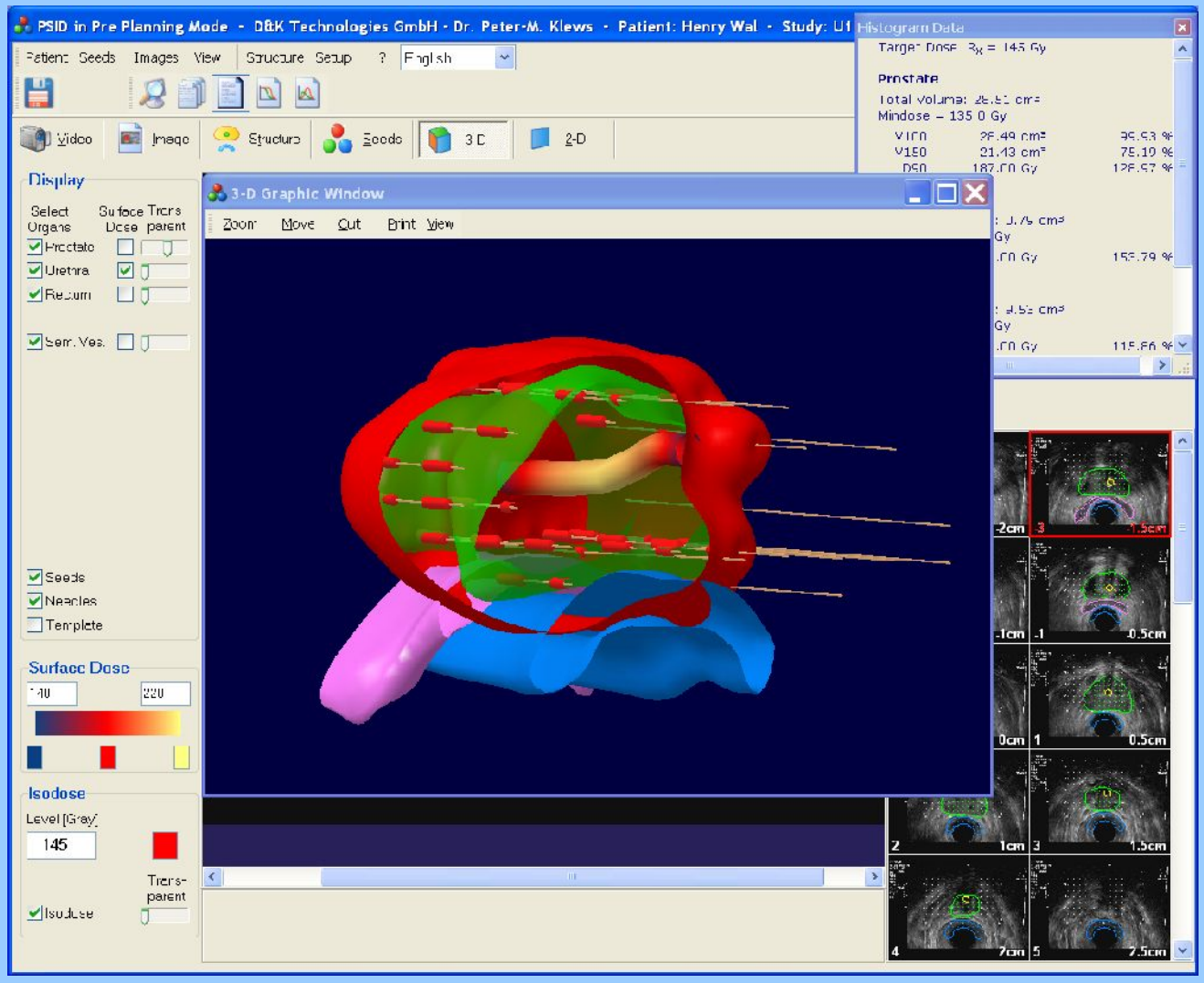
**Brachytherapy** (from the Greek brachy, meaning "short"), also known as *sealed source radiotherapy* or endocurietherapy, is a **form of radiotherapy where a radioactive source is placed inside or next to the area requiring treatment**. Brachytherapy is commonly used to treat localized prostate cancer, cervical cancer and cancers of the head and neck.

→ Strong localisation of radiation dose (inverse square law)

- permanent implants (low dose rate seeds)
- temporary implantation
  - Pulse Dose Rate (PDR) and High Dose Rate (HDR) brachytherapy
  - >12 Gray/hour (typically 100-300Gray/hour)
  - Irridium 192 source pellets of activity 1-10 Ci




  - dwell positions 3-5 mm apart
  - dwell times ~1 s (up to couple of minutes for HDR)



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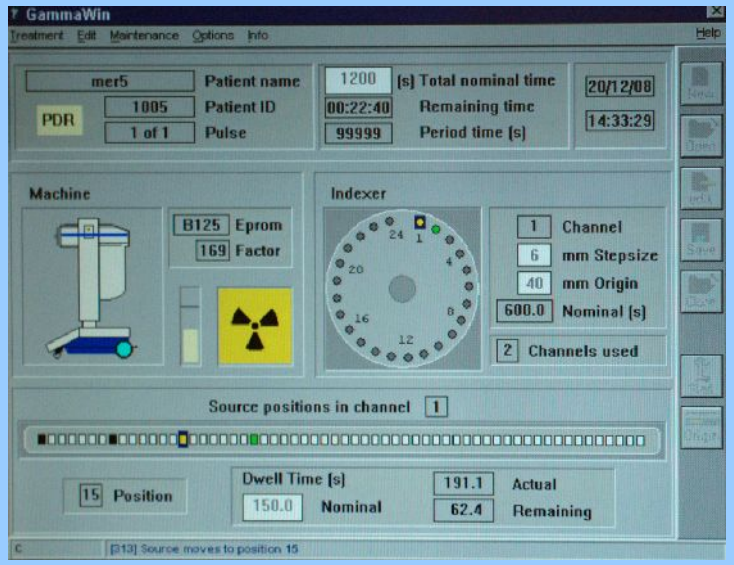
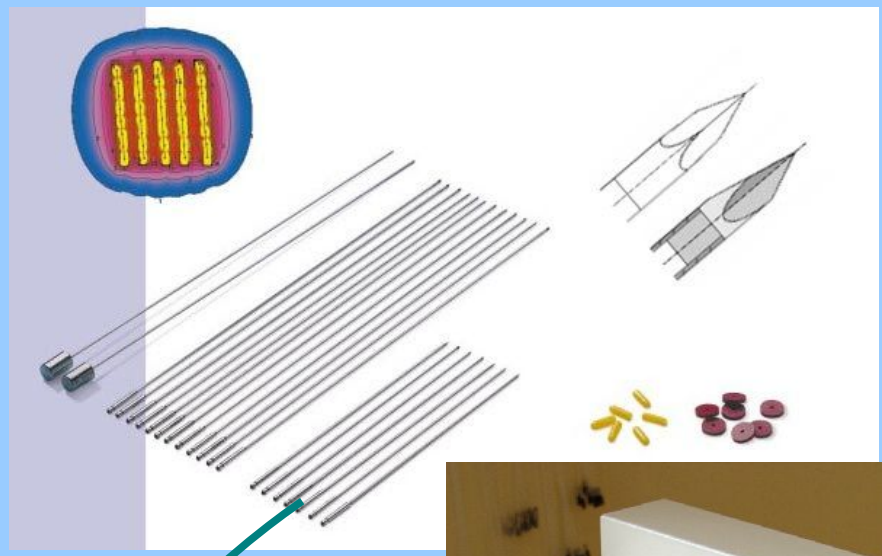
# What is Brachytherapy



## Misadministrations:

- cables connected to wrong needles
- not connected / disconnected cables
- malfunction of afterloading system
- source-wire detachment
- innacuracy of treatment set-up
- ...

**Independent method for in vivo source localisation needed**

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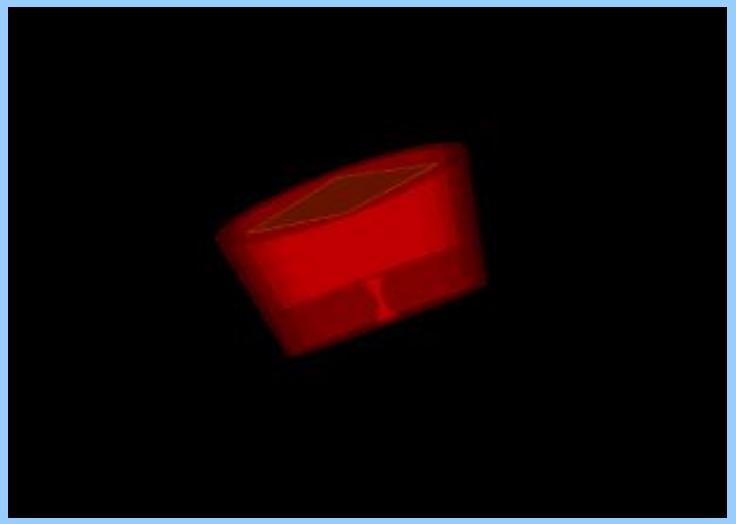
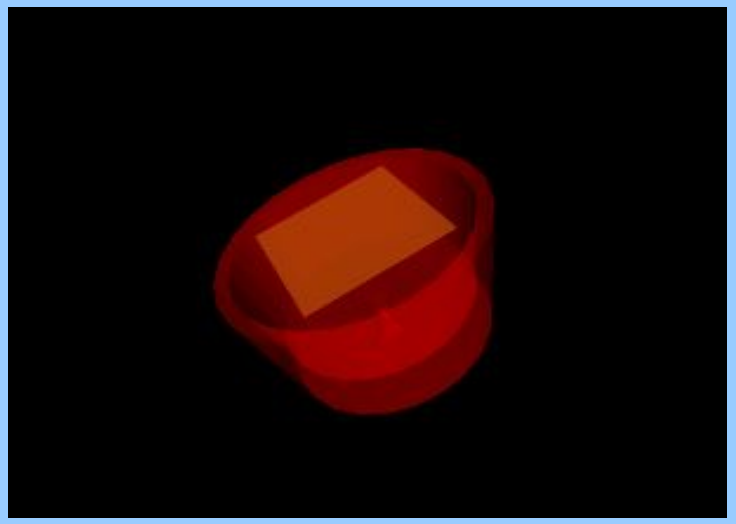
# Idea for solution



Shield with (knife-edge) pinhole

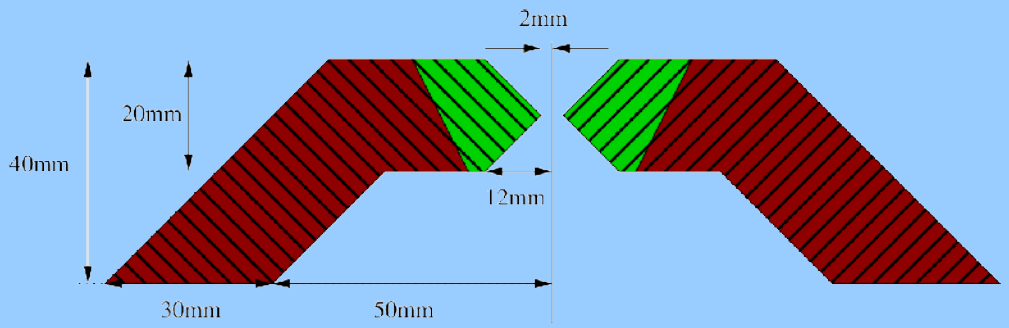
+

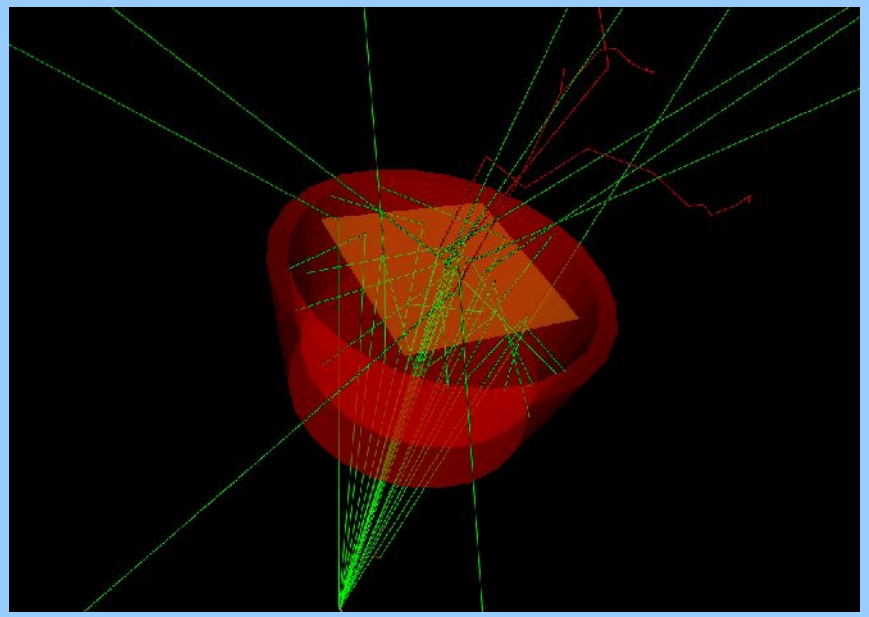


Silicon pad detector

= Pinhole Anger gamma camera

GEANT4 MC simulation for optimization of pinhole geometry to Ir 192 seed source:



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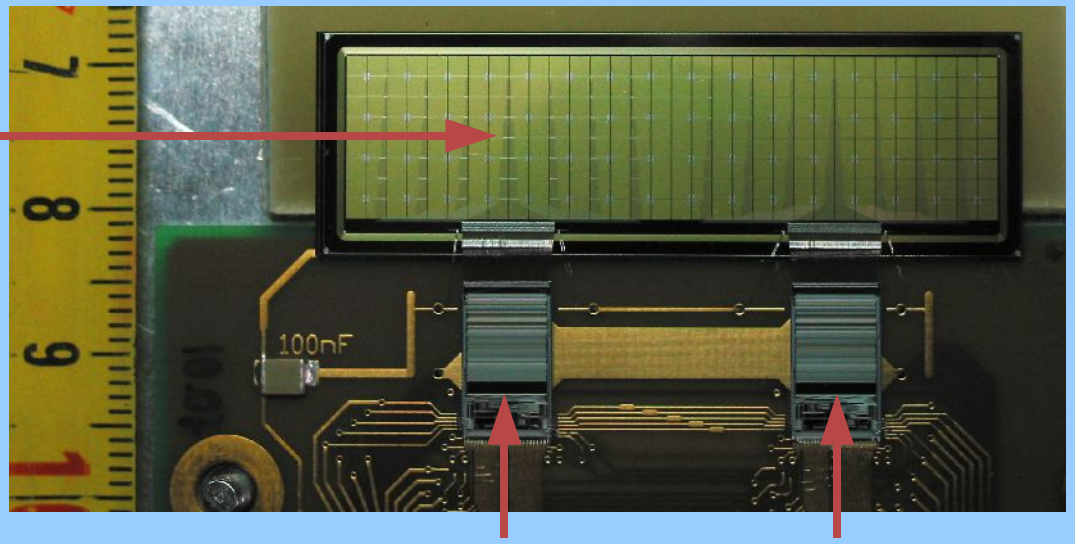
# Set-up scheme

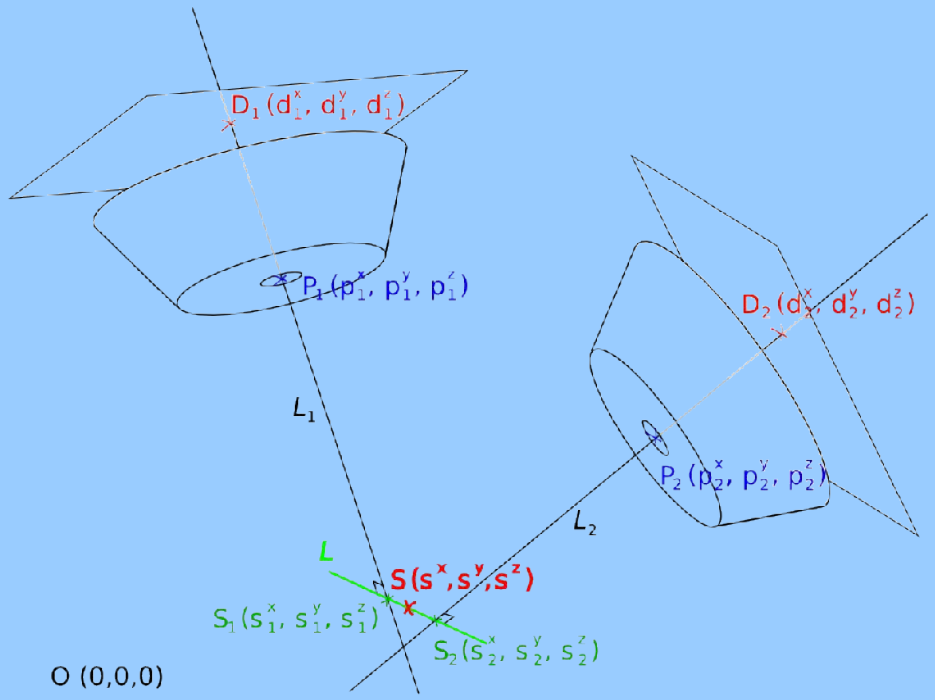
Silicon pad detector
- 256 pads (1.4 x 1.4 mm2 pad size)
- 1 mm thickness




VaTa GP3_1 chips from Ideas

With **one** detector and pinhole only a **line** to the source can be established.

**2 cameras** are necessary for **3D reconstruction** of source location .



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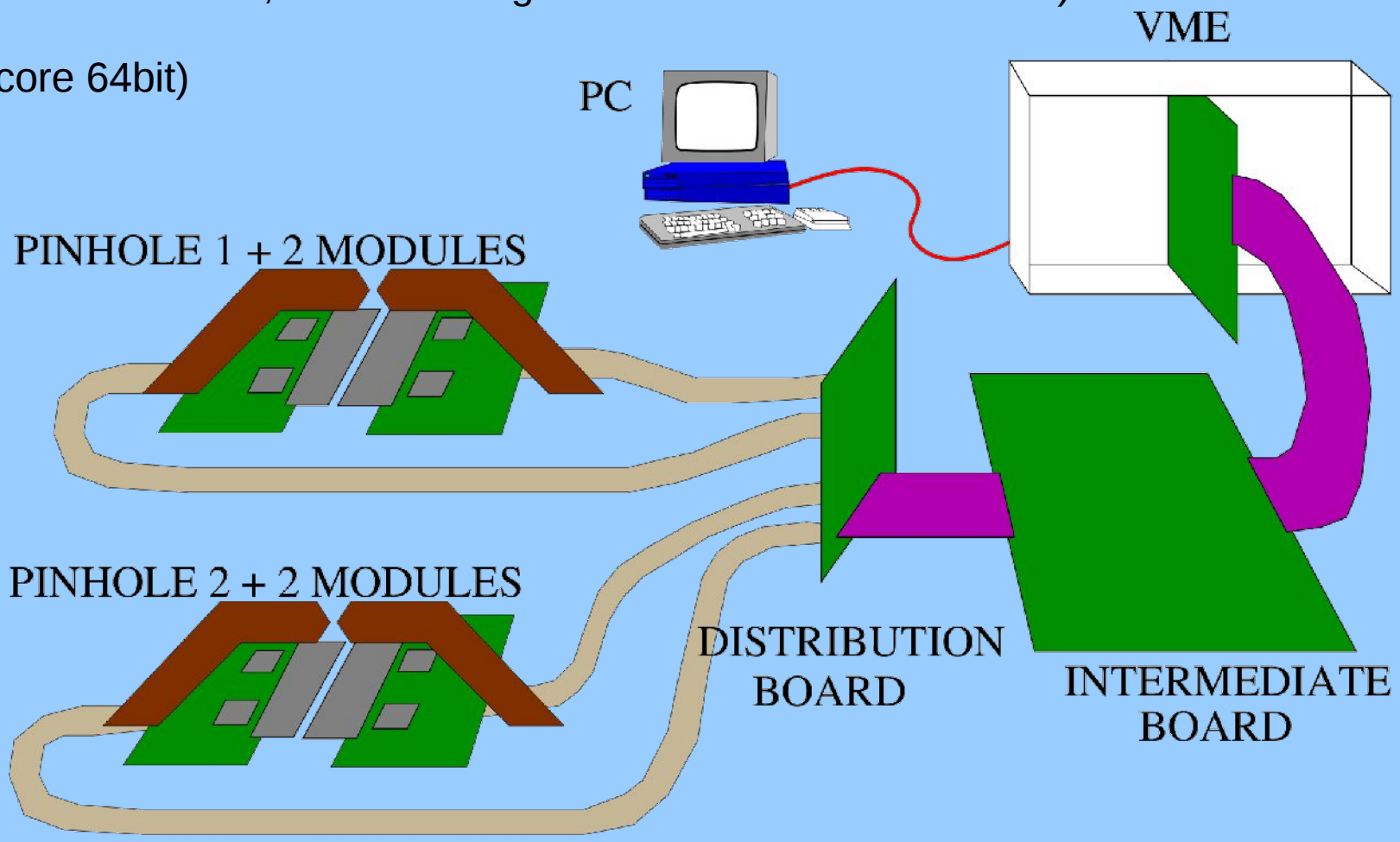
# Set-up scheme

- 4 Si pad detectors (2 for each pinhole, for larger field of view)
- 8 VaTaGP3_1 chips (2 per each detector)
- 2 Lead shields with 1 pinhole each
- aluminum support structure
- VaTa distribution board (daisy chaining the chips)
- Intermediate board ()
- VME board (ADC conversion, data handling and communication with PC)
- Optolink
- PC (Intel dual core 64bit)



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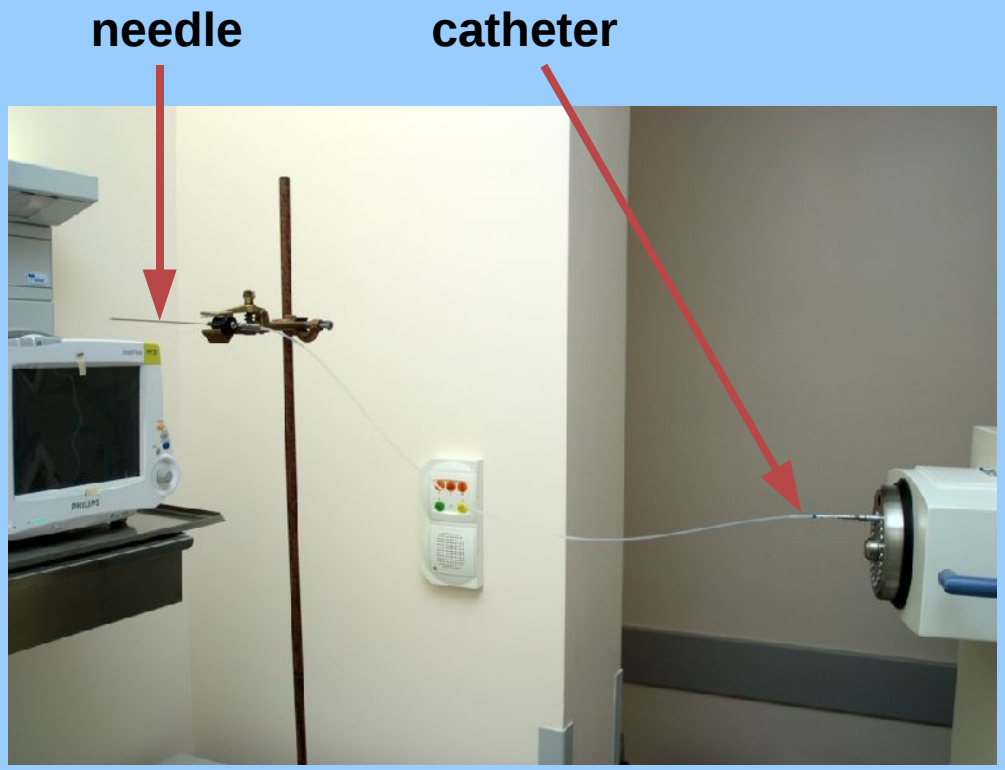
# Measurements at Institute of Oncology, Ljubljana

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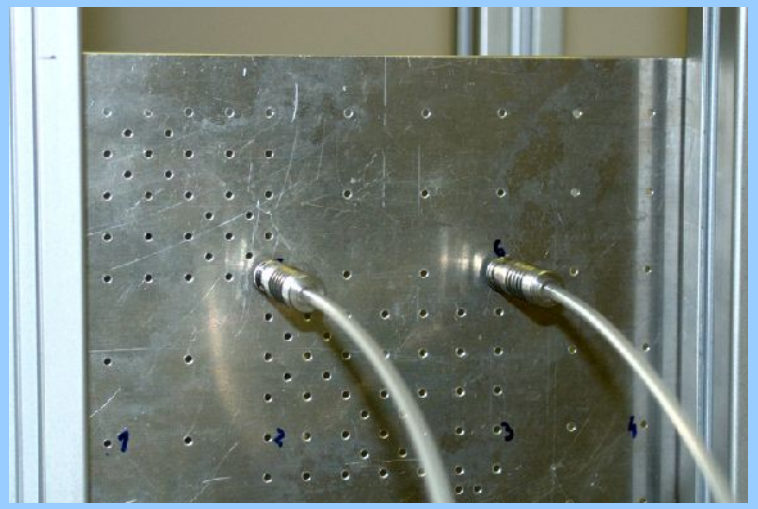

Measurements performed:

- flood image (Ir192 far away, no shields)
- alignment positions
- „real data" positions
- measurement with plexi-glass phantom

Measurements info:

- dwell times 4 min
- serial read-out mode (125Hz ro rate)
- dwell position displacements from 25mm down to <5mm

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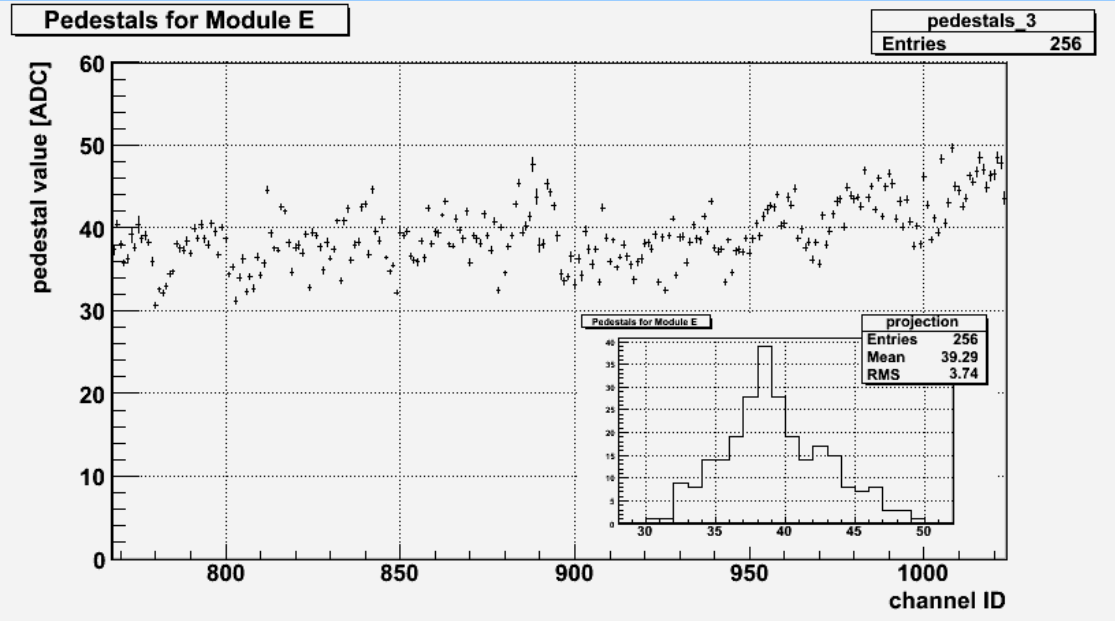
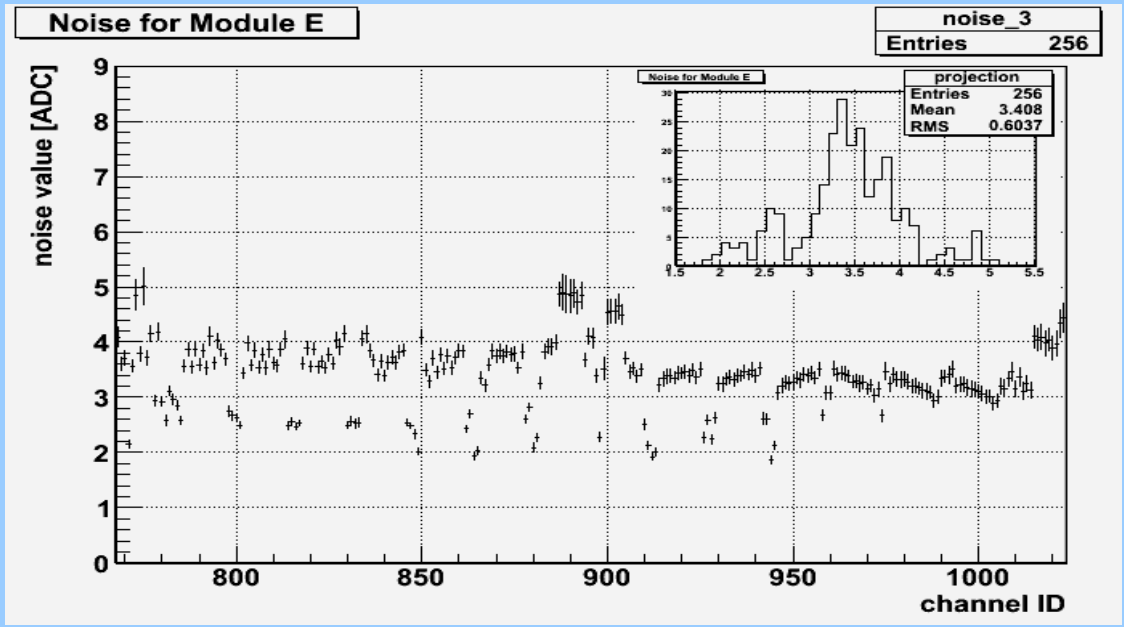



measurements threshold:
28 mV

decoding threshold:
pedestal+4.2*sigma(noise)



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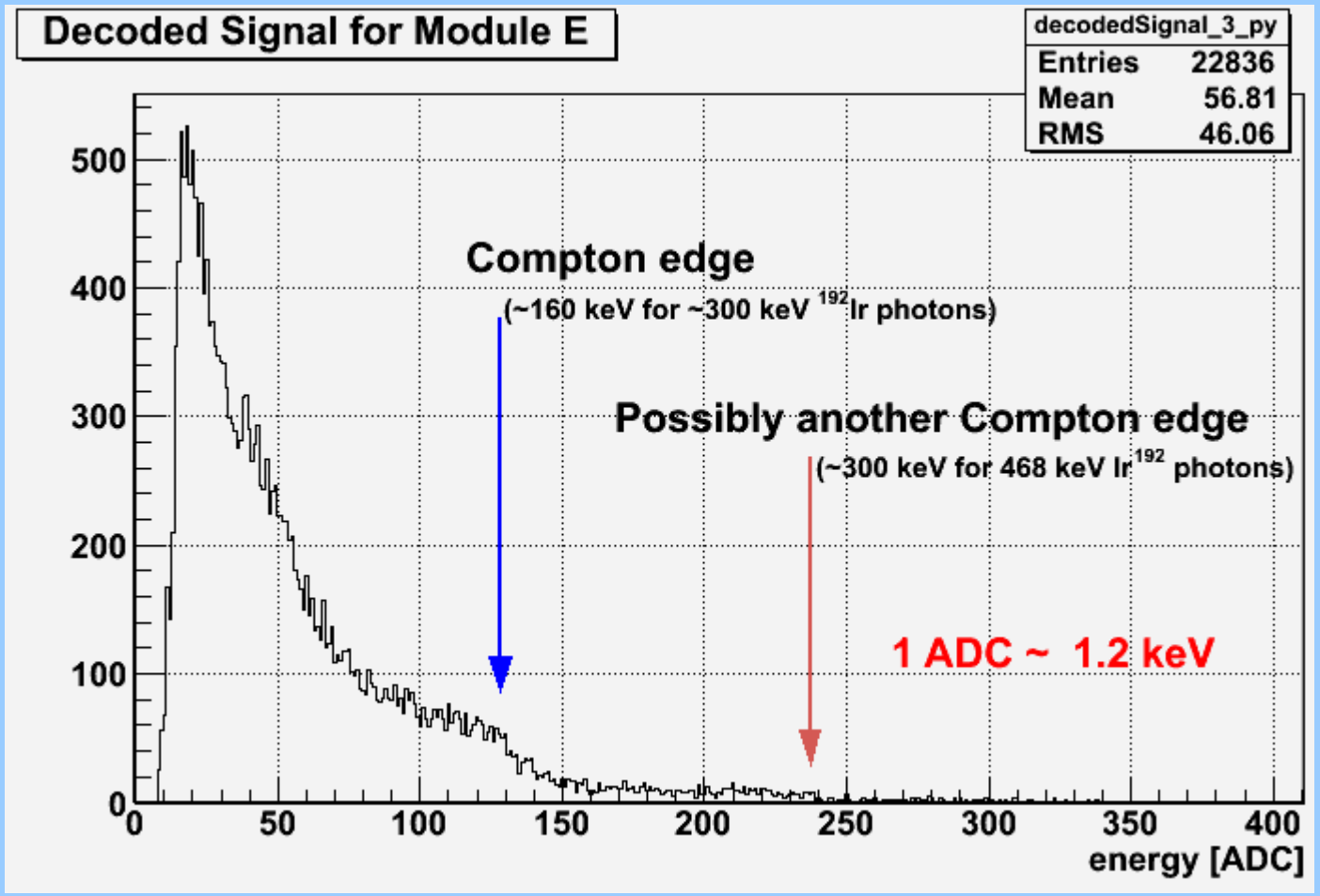


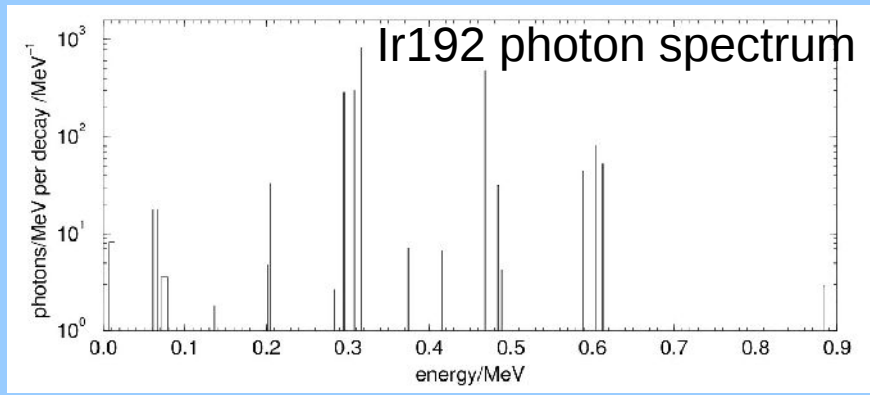

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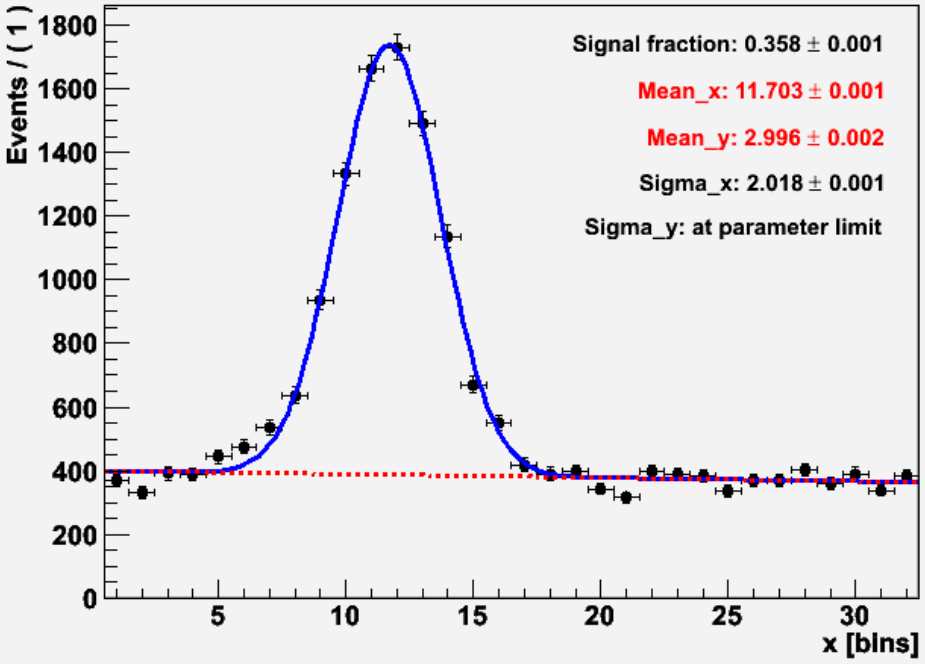
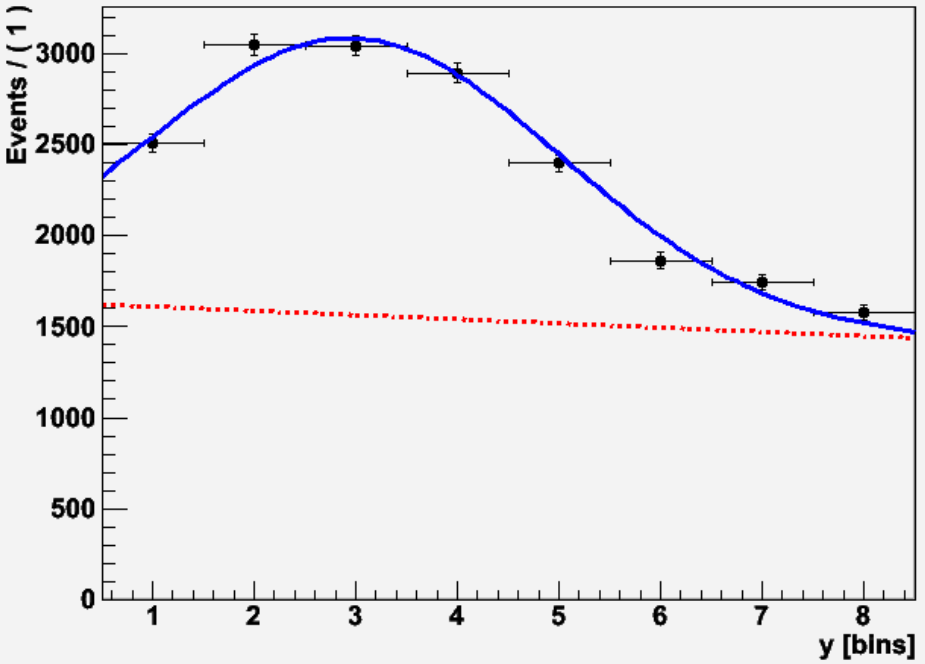
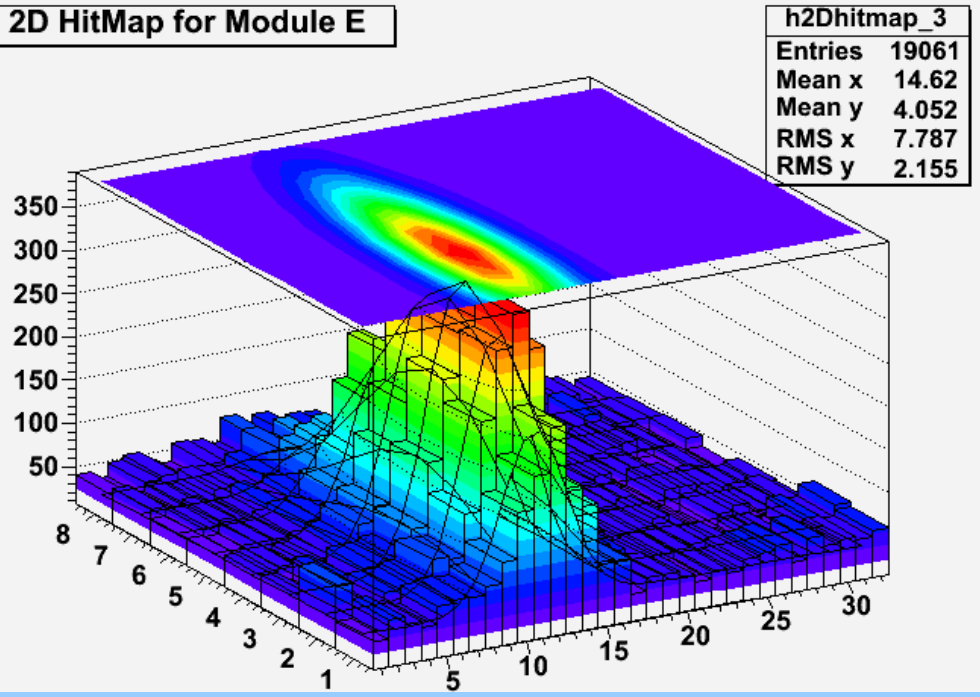
## A RooPlot of "x"



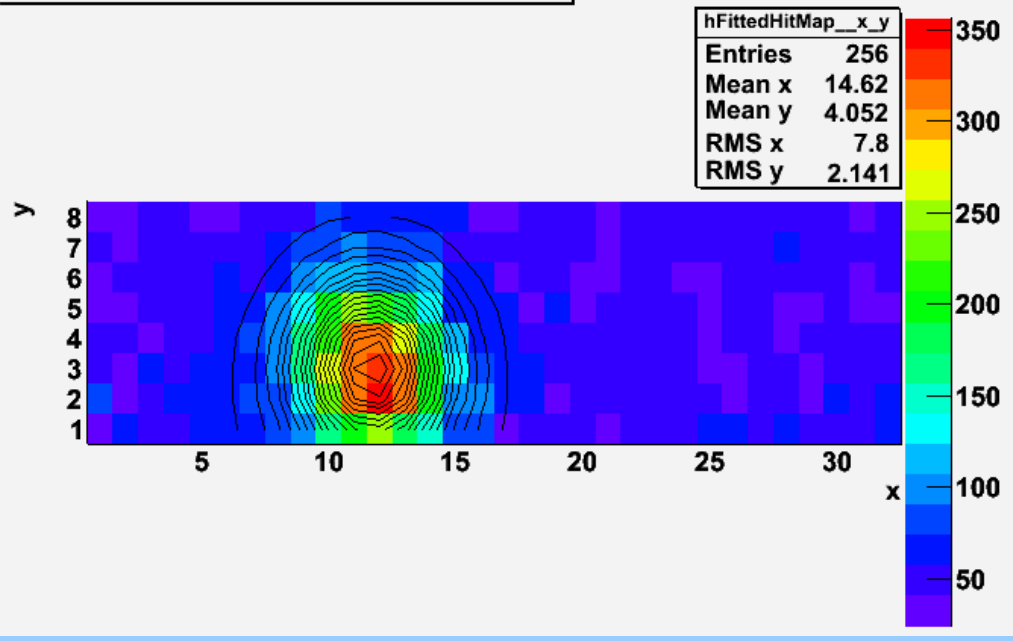

## A RooPlot of "y"




## 2D HitMap for Module E




## Histogram of hFittedHitMap__x_y



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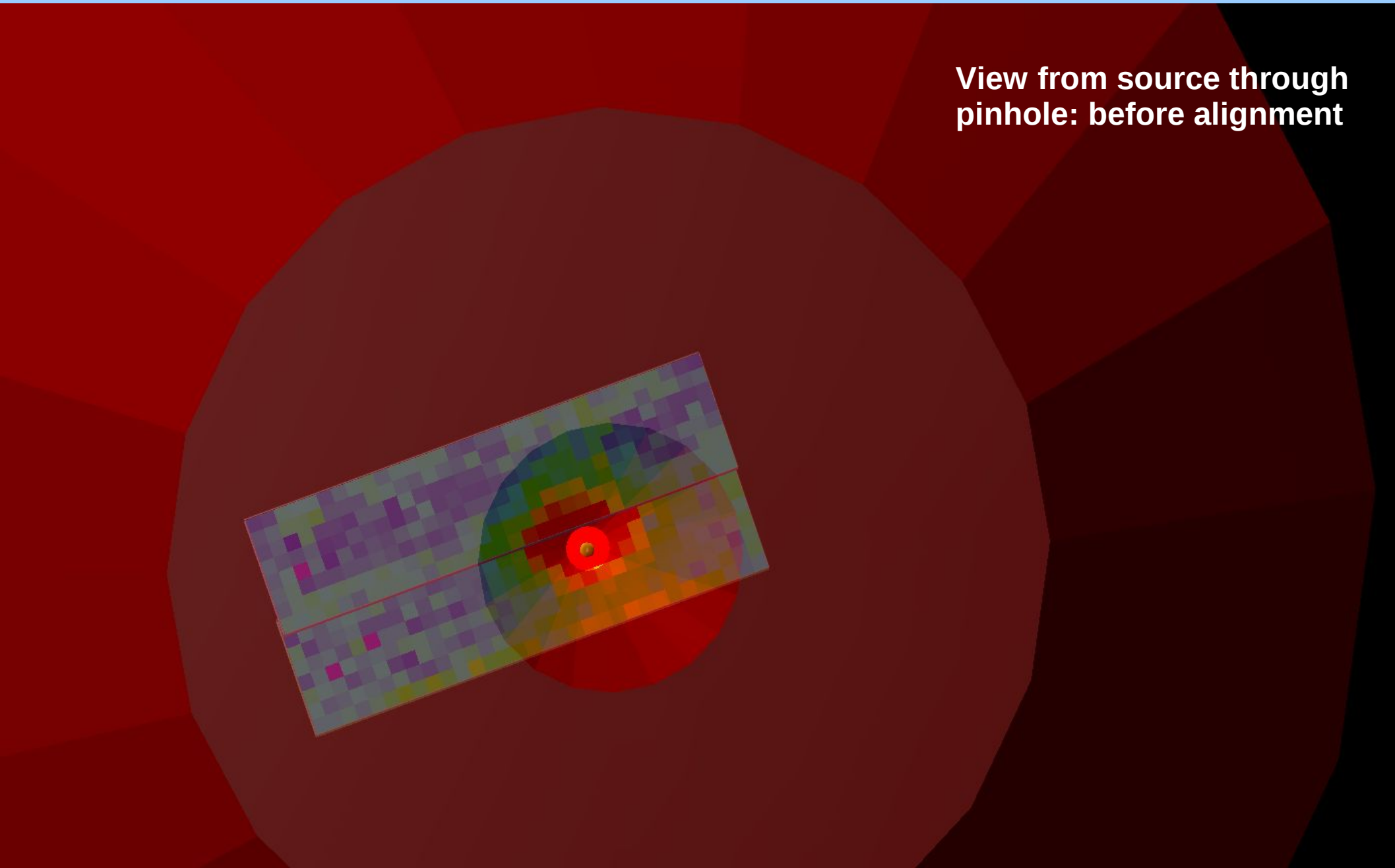

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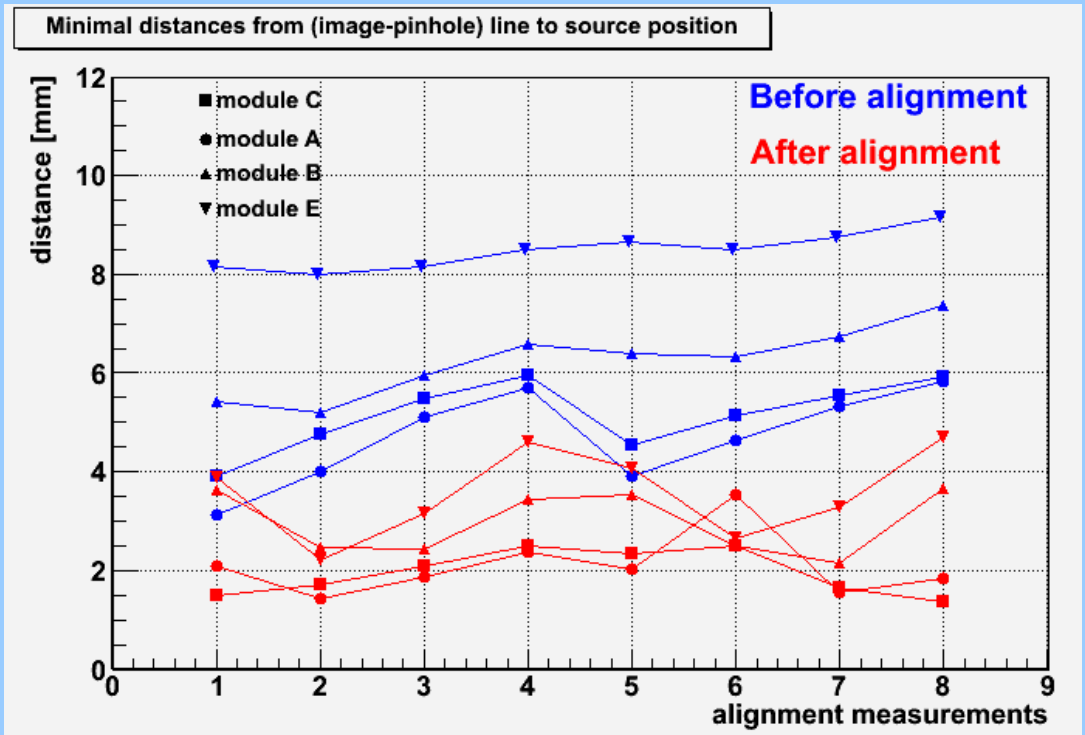
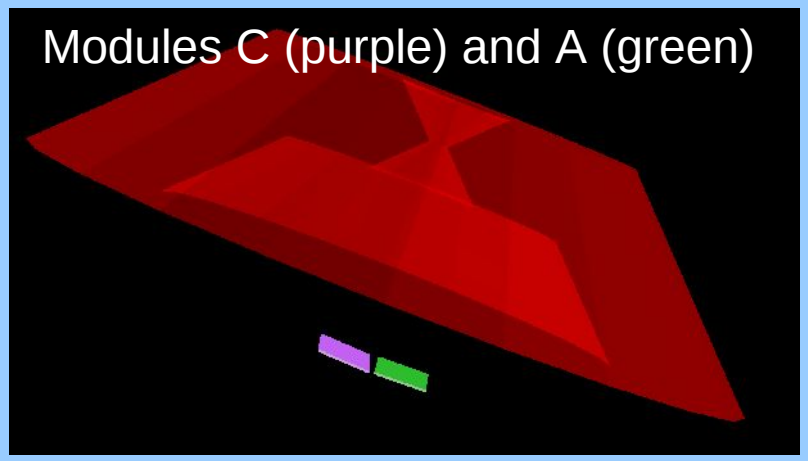
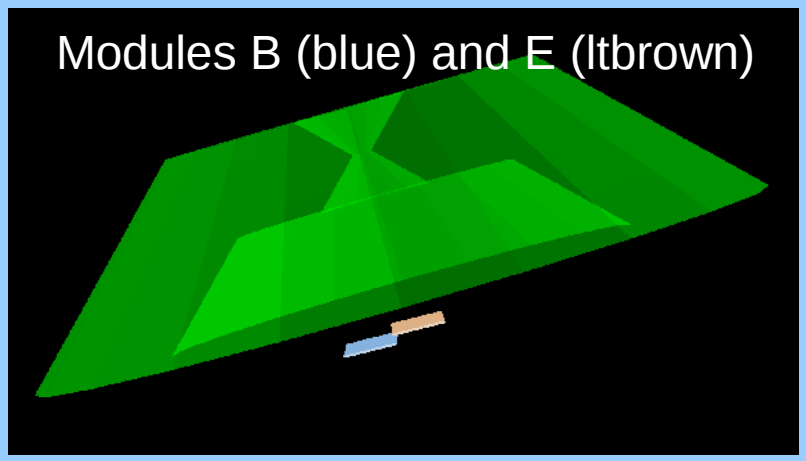



**After alignment**



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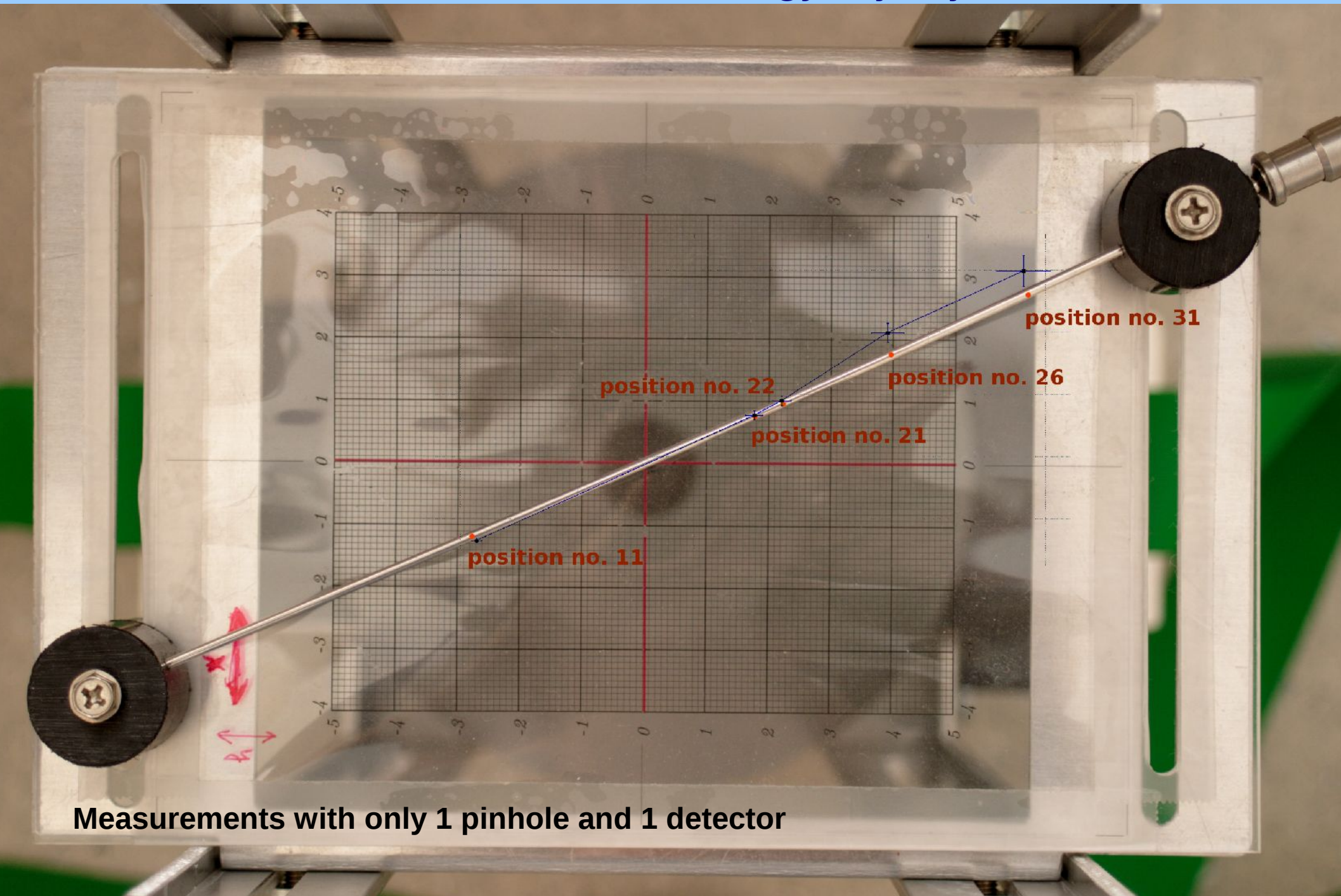


**Measurements with only 1 pinhole and 1 detector**

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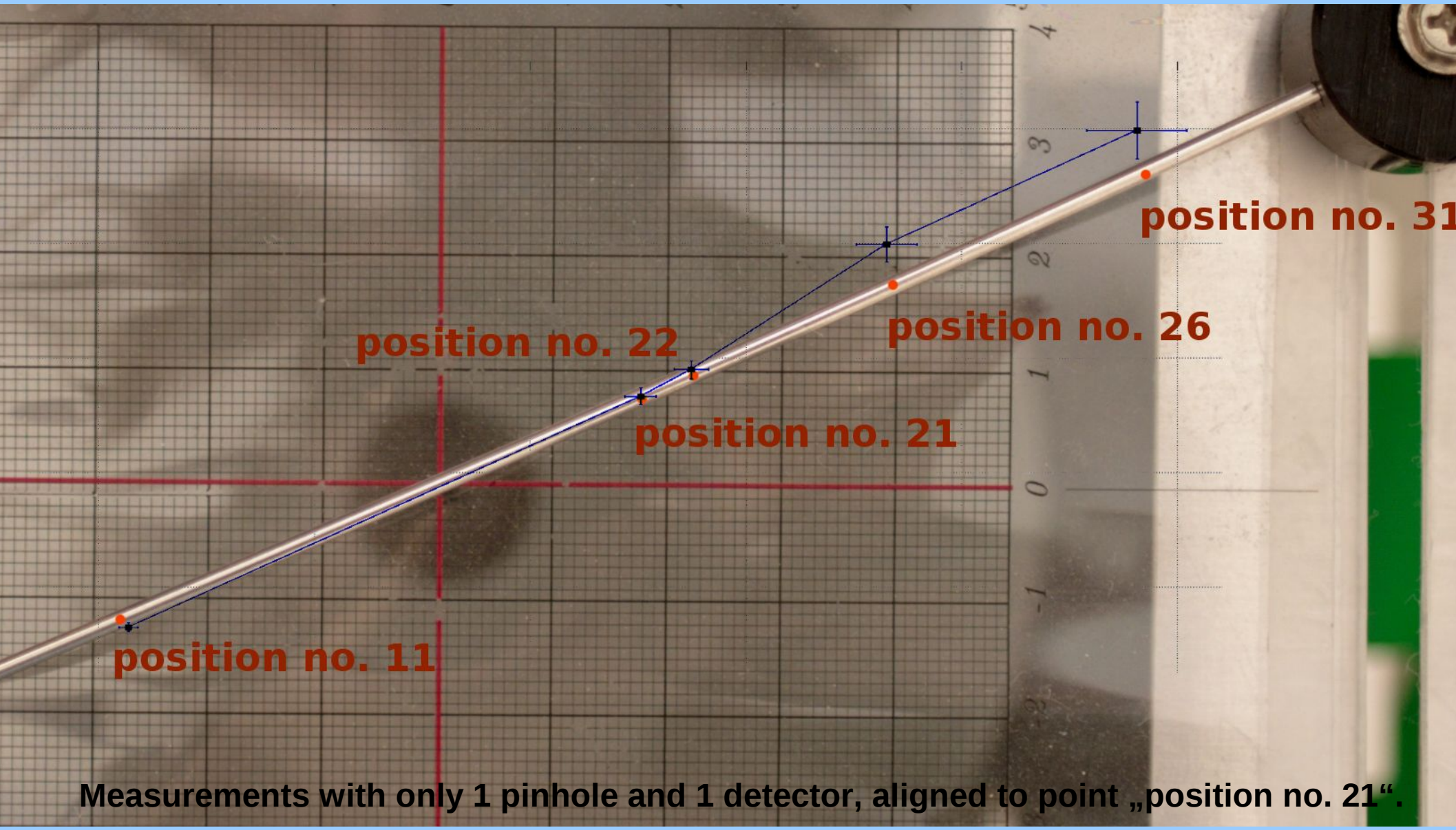
# Measurements at Institute of Oncology, Ljubljana




**Measurements with only 1 pinhole and 1 detector, aligned to point „position no. 21".**

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# Summary

- The system for localisation of $^{192}$Ir source is built and working.
- Measurements were done on (real) brachytherapy source.
- Source positions can be determined with <5mm accuracy in field of view approx. 30x30x30 cm$^3$.
- We estimate that approx. 3s of data-taking with sparse (+ adjacent) read-out mode is sufficient for localisation of 0.5 – 1 Ci $^{192}$Ir source with 5 mm accuracy.