On-line monitoring of deposited dose distribution in proton therapy using heavy scintillating fibres

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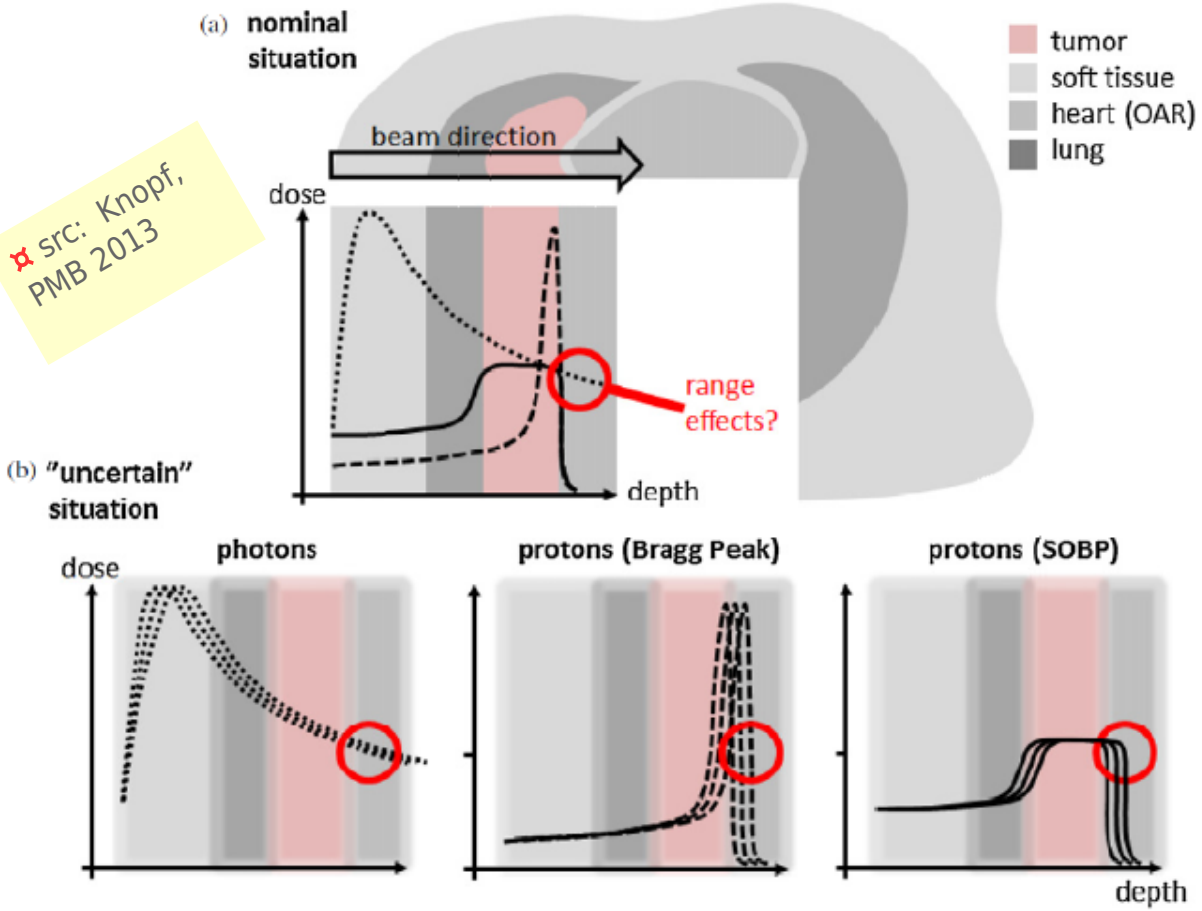
Why to monitor beam range?



src: Knopf, PMB 2013

Proton therapy is a precise and selective treatment method...

... provided you have a perfect 3d map of patient in terms of stopping power!

Sources of uncertainties:

- Transformation of imaging info CT→ dE/dx
- Patient positioning
- Anatomical changes
  - Weight loss
  - Change of tumour size/shape
  - Runny nose

„In-vivo range verification methods would represent an optimal solution for full explotitation of the advantages afforded by the ion beam"

src: NuPECC report „Nuclear Physics for Medicine" 2014

- Reduction of safety margins
- Better/safer treatment plans

New project in Cracow

Goal: development of a method for on-line monitoring of deposited dose distribution in proton therapy

IMPORTANT

Technique: imaging exploiting prompt gamma rays emitted during irradiation

CONFIRMED

Technology: Detector based entirely on new, heavy scintillating materials; DAQ and (partly) image reconstruction based on FPGA → implantation of HEP technologies to medical application;

Realization: dual-modality setup

- Coded mask **CM** NEW
- Compton camera **CC**

Synergy with J-PET

Financed by as SONATA BIS by NCN (National Science Centre)

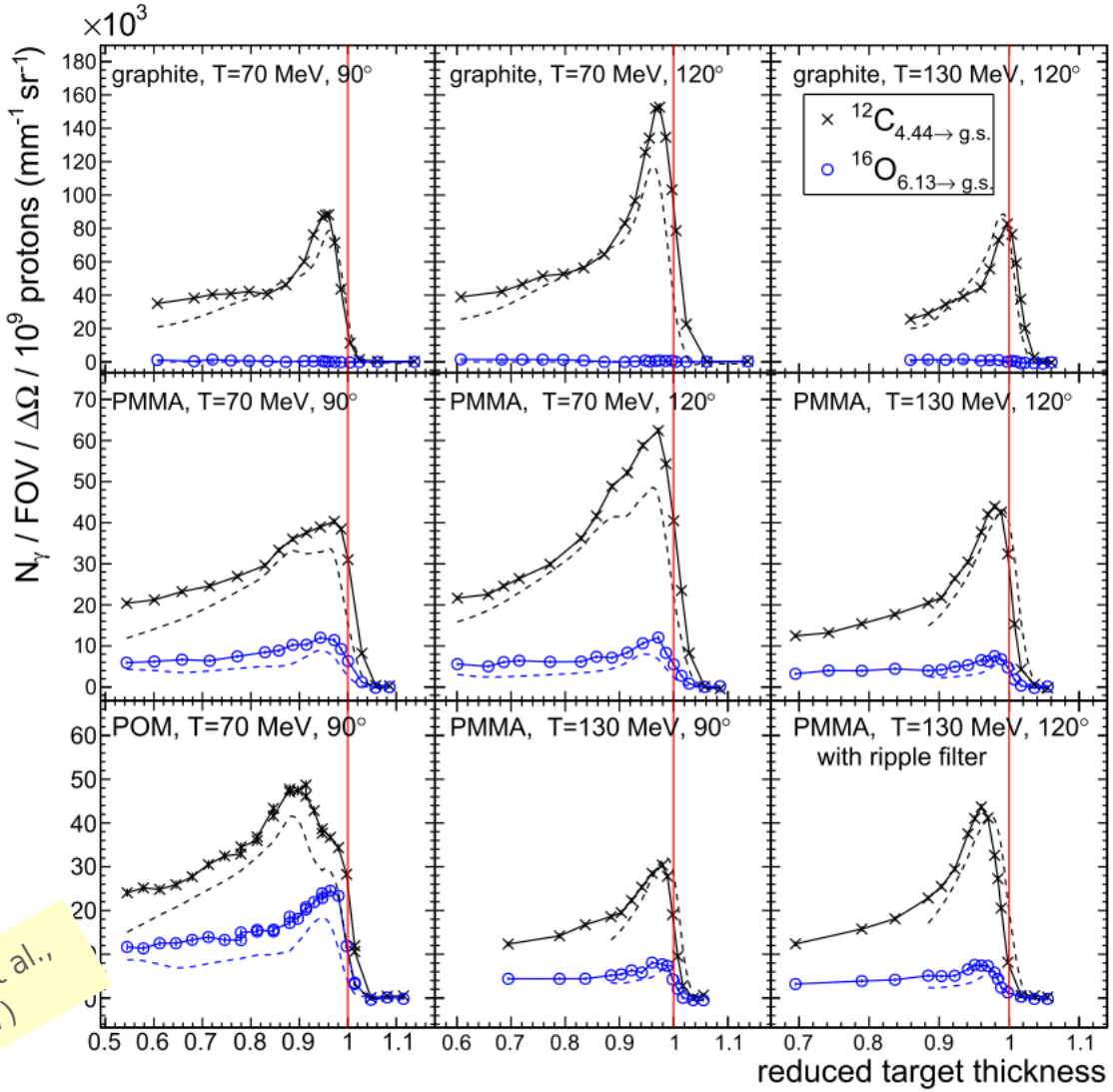
Previous experience

γCCB: Investigation of gamma emission in experimental modelling of hadron therapy

Study dependence σ(depth) for key discrete transitions at

- Various beam energies,
- Various phantom materials,
- Various angles.

financed by FNP – Foundation for Polish Science



src: Kelleter, Wrońska et al., Physica Medica 34 (2017)

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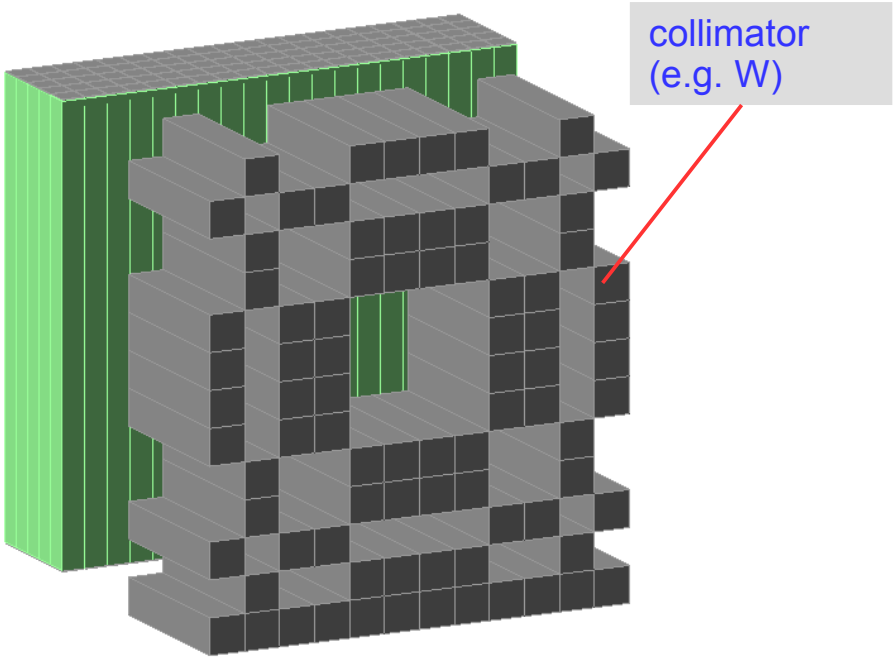
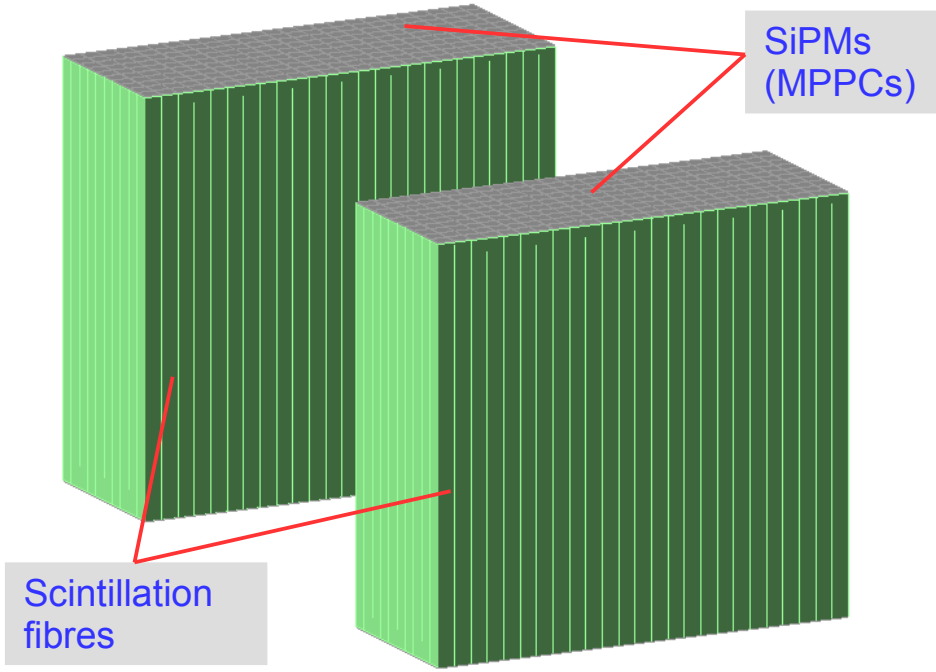
Dual modality - synergy

Coded mask CM



- Technique widely used in astronomy, also for observation of γ sources
- Technique not tested so far for the purpose of proton therapy
- 2d image
- Much larger statistics compared to single-slit detectors without compromising image resolution

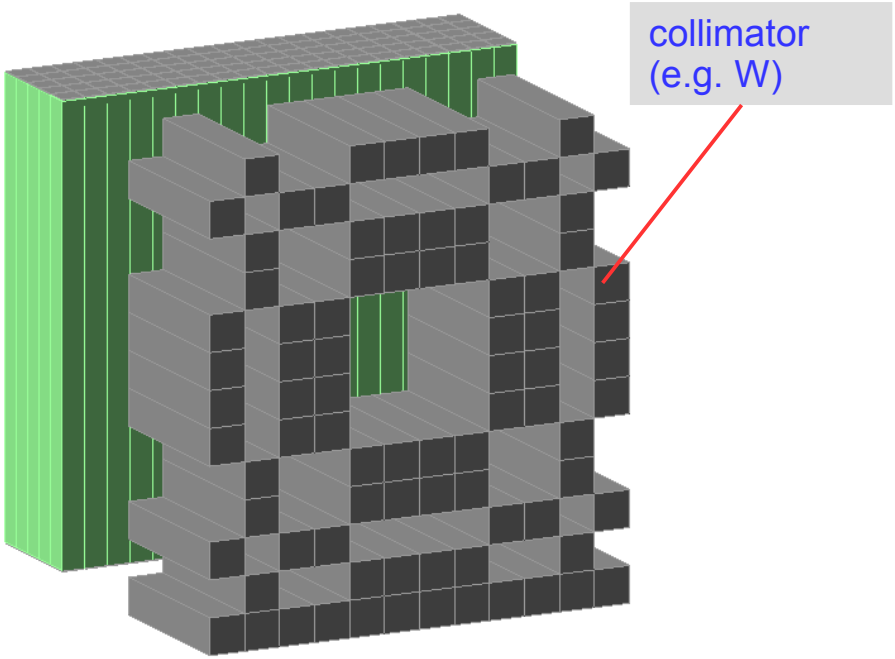
Compton camera CC



- Solution considered and tested for the use in proton therapy
- 3d image
- Problem faced so far: small statistics (efficiency), background from random coincidences
- Proposed solution: detectors of larger efficiency and better time resolution ($\rightarrow$electronic collimation)

Dwa mody pracy - synergia

Coded mask CM



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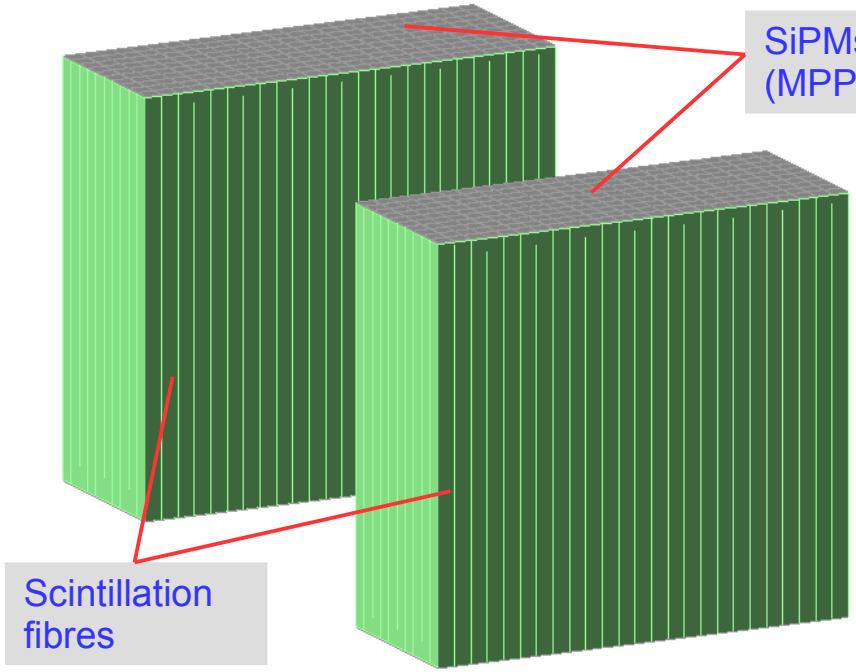


Common parts:

- Detection technique
- FEE
- DAQ

→ *expensive hardware*

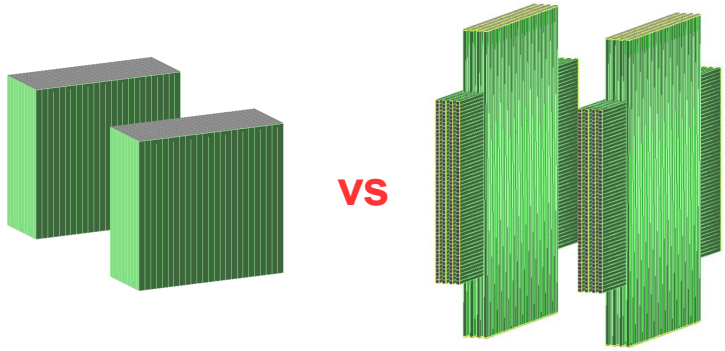
Modality-specific parts:

- Collimation
- Image reconstruction

→ *mostly software (manpower)*

Tasks

- Optimization of setup design by MC simulations (Geant4) ongoing



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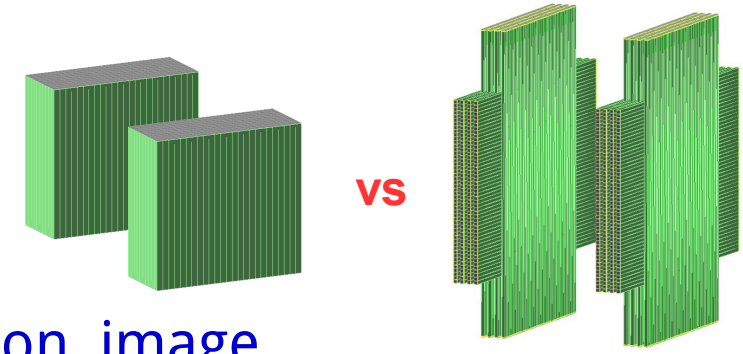
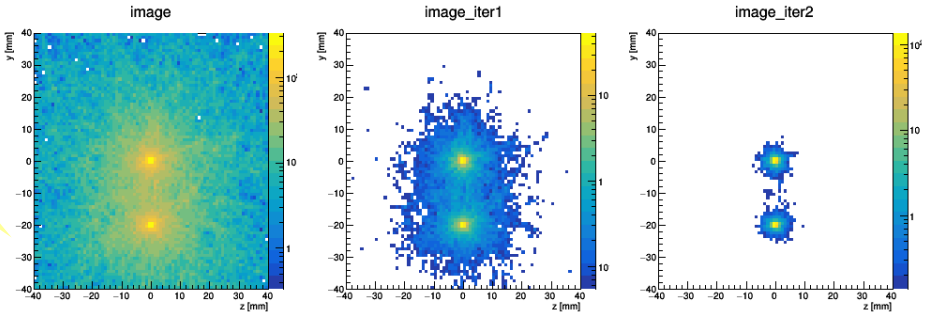


- Software development: decoding, calibration, image reconstruction, ... ongoing

LM-MLEM



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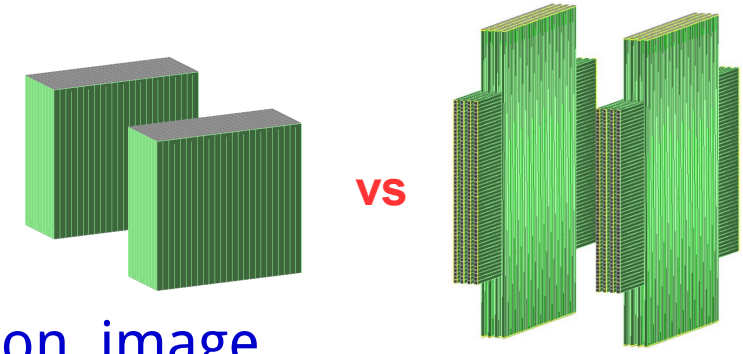

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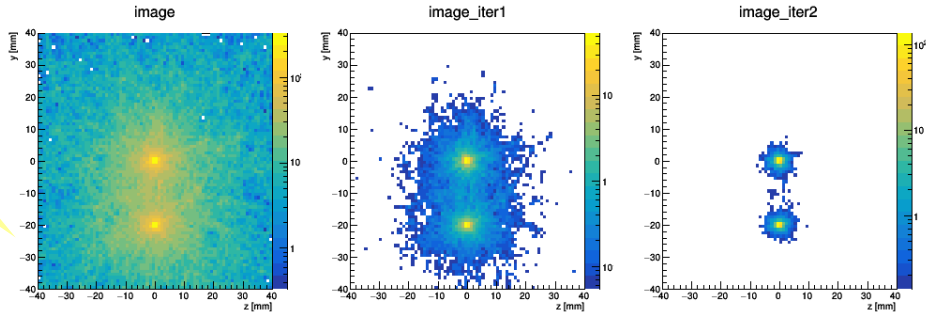
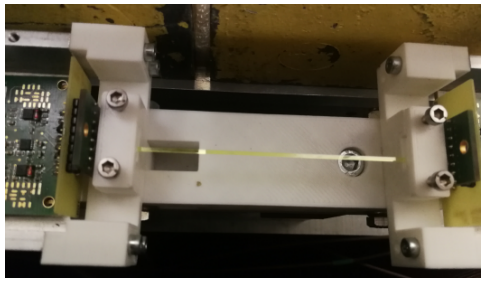
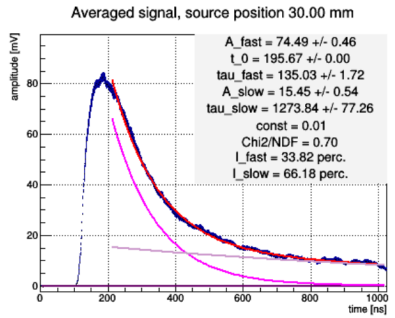


- Detector development (tests of materials, coating, coupling, etc.) ongoing





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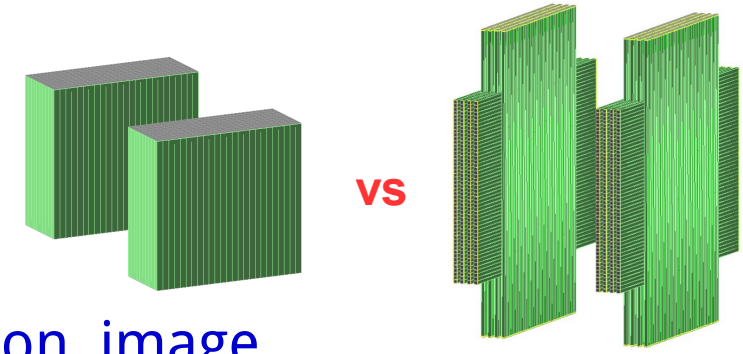

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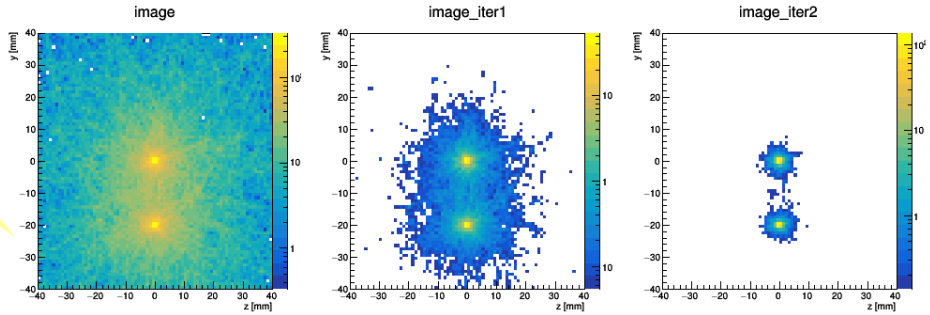

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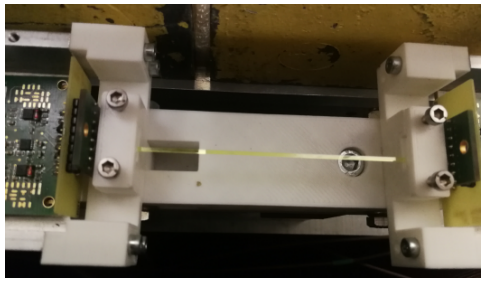

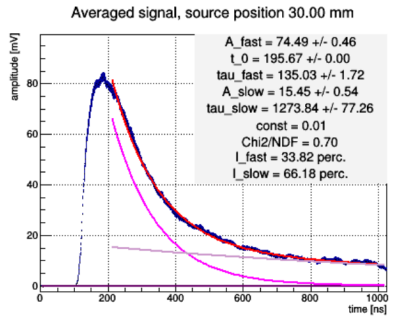

- DAQ (inc. FEE+slow control) will start soon
- Test measurements (CCB/HIT) in ~2 years

Team

A. Wrońska
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JU Kraków

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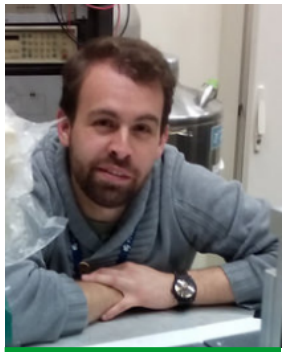

J. Kasper
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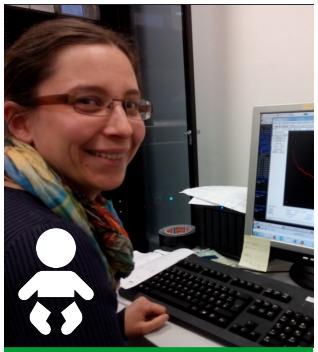

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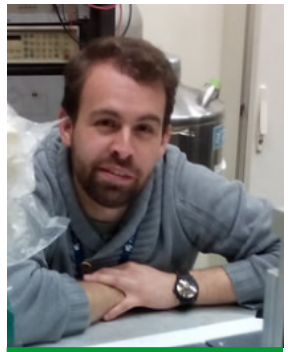

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