Dr. Ulrich Schmidt Martin Schrön Prof. Dr. Peter Dietrich **Markus Köhli**

Probing nano and macro scales

solid state detectors
and
cosmic neutron
soil moisture determination

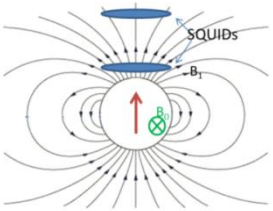
UNIVERSITÄT HEIDELBERG
ZUKUNFT SEIT 1386

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

HEIDELBERG RESEARCH FIELDS

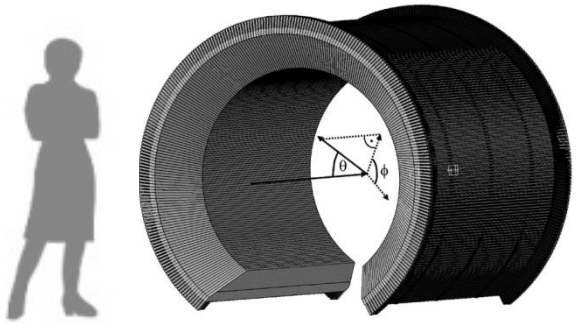
Helium-Xenon EDM

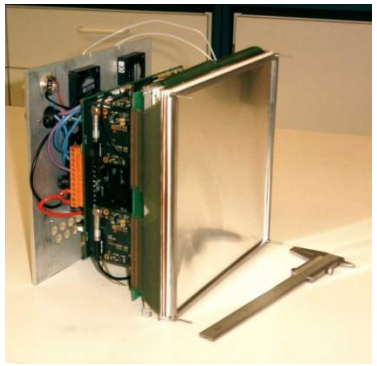
[test of Lorentz invariance]



Neutron Detectors

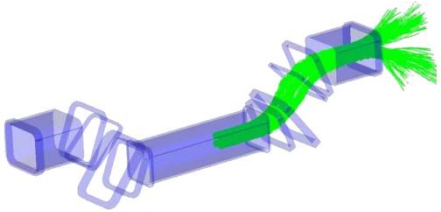
[large area and **high time resolution]**





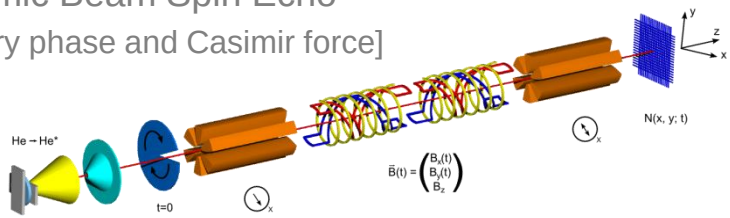
PERC and PERKEO

[neutron lifetime]

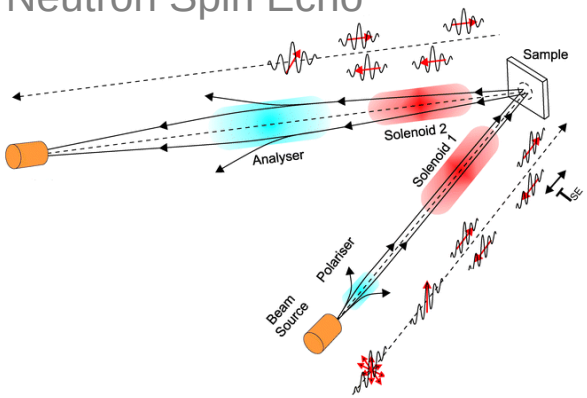


Atomic Beam Spin Echo

[Berry phase and Casimir force]



Neutron Spin Echo



1

Contents

Boron-lined **Solid State Detectors**

---

large area and high time resolution

2

Contents

Soil Moisture Determination

Monte-Carlo Simulations of neutron measurement

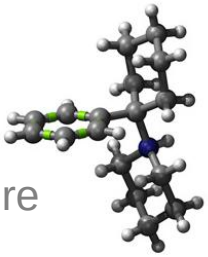
HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

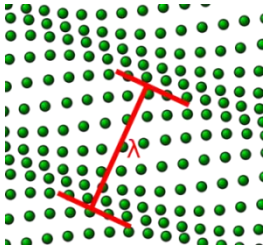
Markus Köhli

1

SCALE

Structure





Dynamics

2

Contents

Soil Moisture Determination

Monte-Carlo Simulations of neutron measurement

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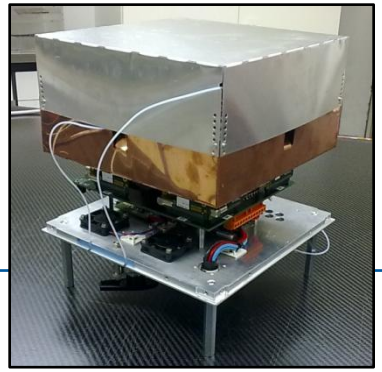
1

AIM



Alternative Technologies to He-3

2

Contents

Soil Moisture Determination

Monte-Carlo Simulations of neutron measurement

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1

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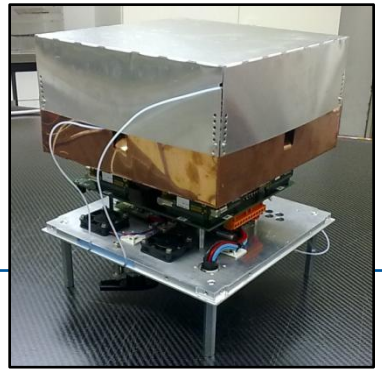
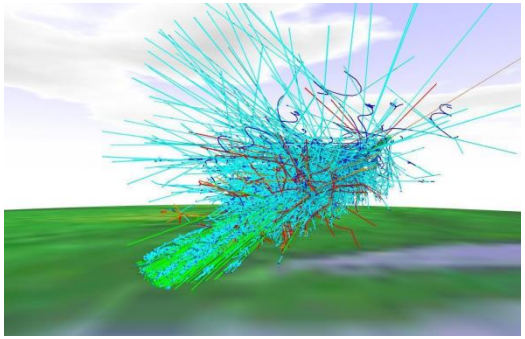


Alternative Technologies to He-3

2

SCALE

Passive Sensing



[1]

[1] Hajo Drescher, Universität Frankfurt

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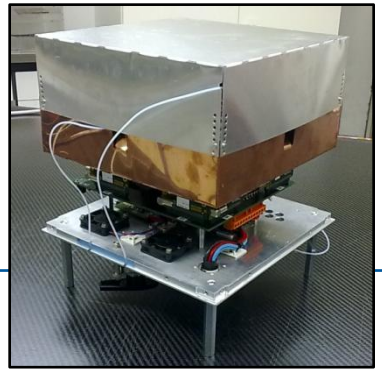
1

AIM



Alternative Technologies to He-3

2

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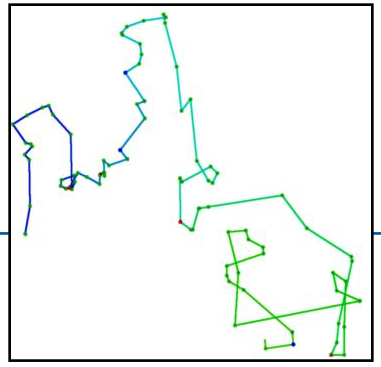

Neutron Transport Simulations

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NEUTRON DETECTORS

Gaseous ⟶ ⟵ Solids

[1]

[2]

Converter:

+ high efficiency

- low resolution

[3]

Converter:

+ high resolution

- low efficiency

[1] FRM II, part of SANS-1 instrument (2010)
[2] SNS, BASIS detector
[3] PSI, neutron radiography

NEUTRON DETECTORS

Gaseous → ? ← Solids

Converter:

+ high efficiency

- low resolution

Converter:

+ high resolution

- low efficiency

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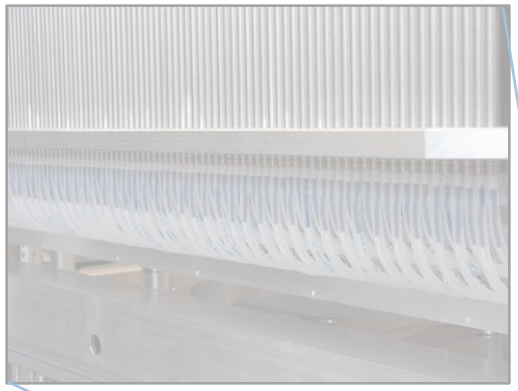
NEUTRON DETECTORS

Gaseous

Solid State Converters

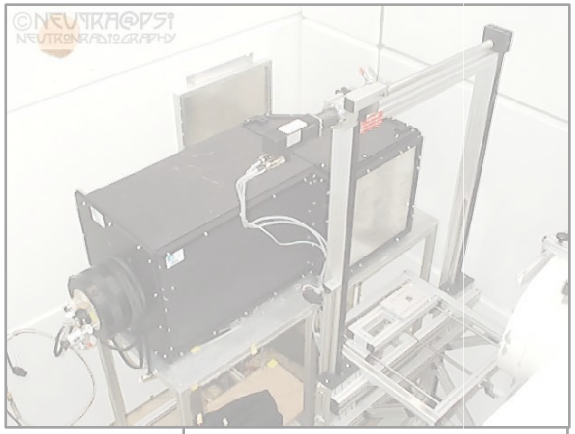
Solids



Converter:

+ high efficiency

- low resolution



Converter:

+ high resolution

- low efficiency

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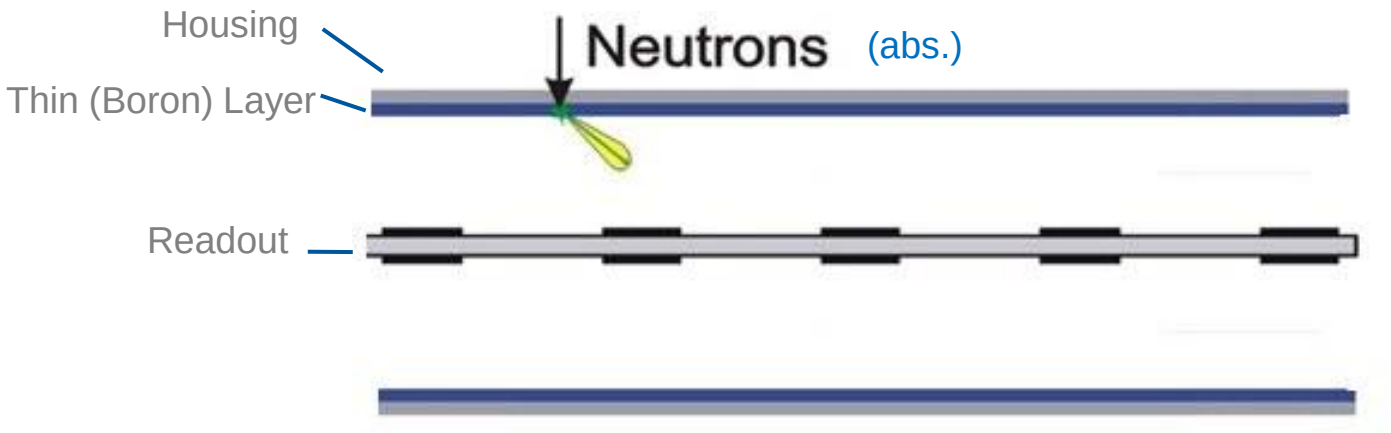
THE CASCADE CONCEPT



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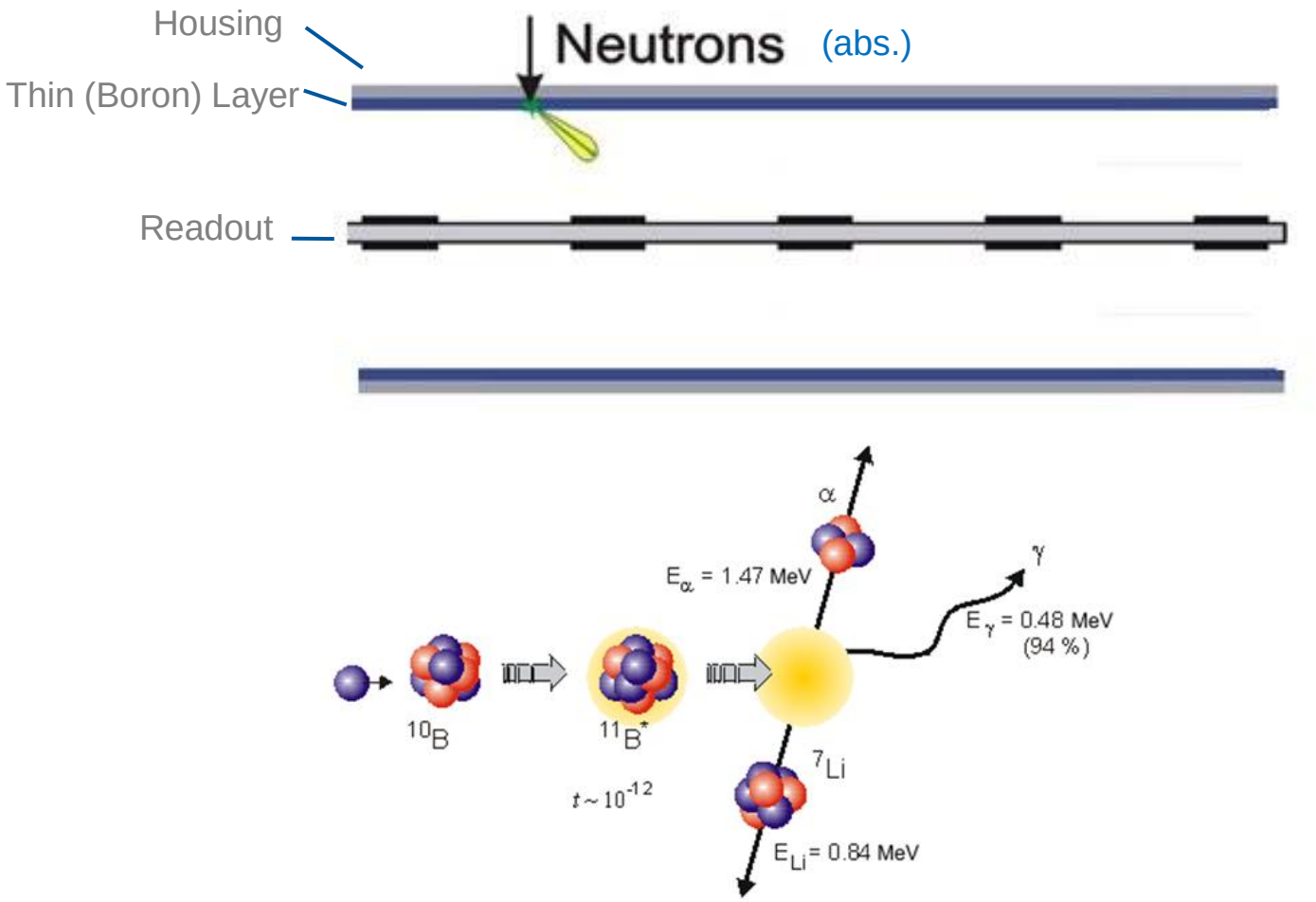
THE CASCADE CONCEPT



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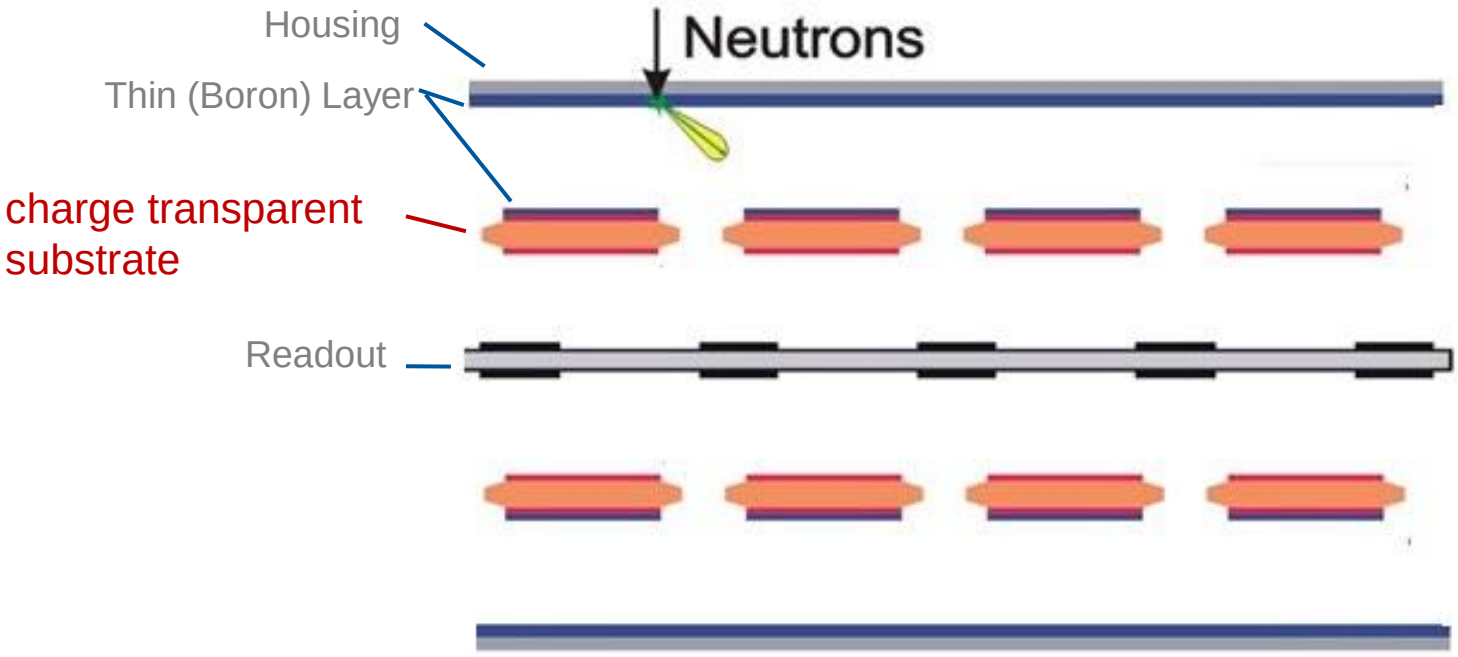
THE CASCADE CONCEPT



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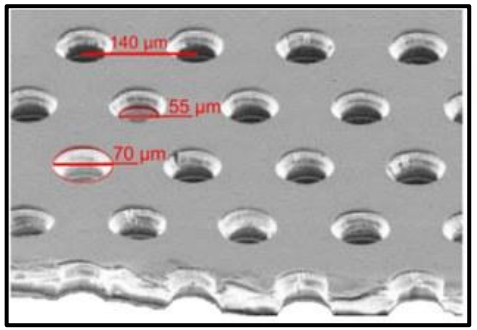
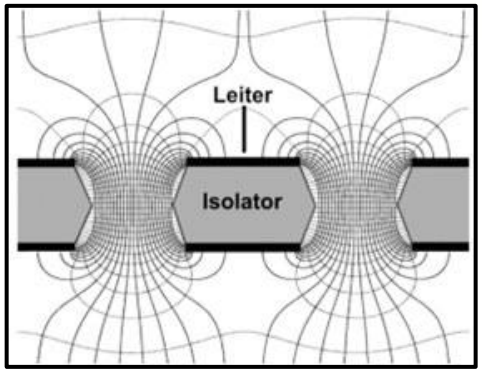
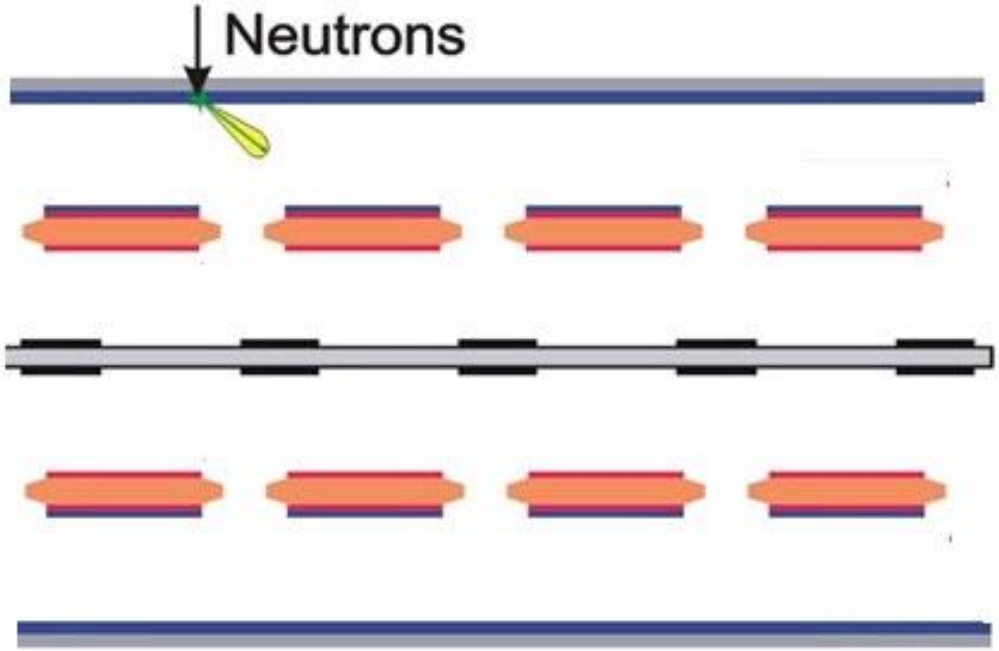
THE CASCADE CONCEPT







GEM

(Gas Electron Multiplier foil)

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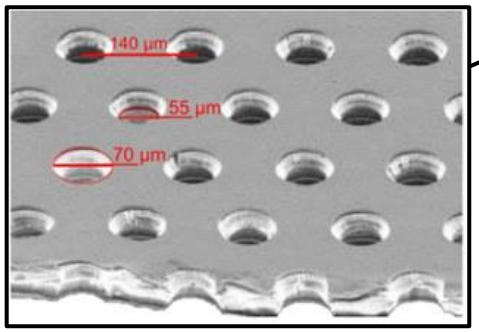
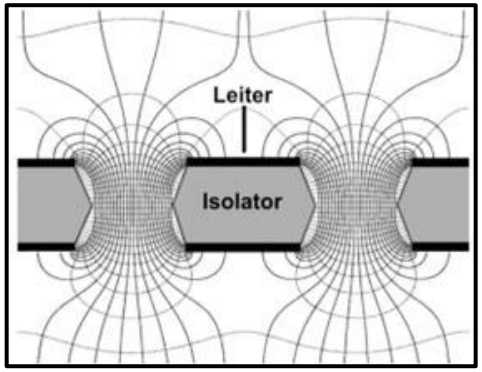
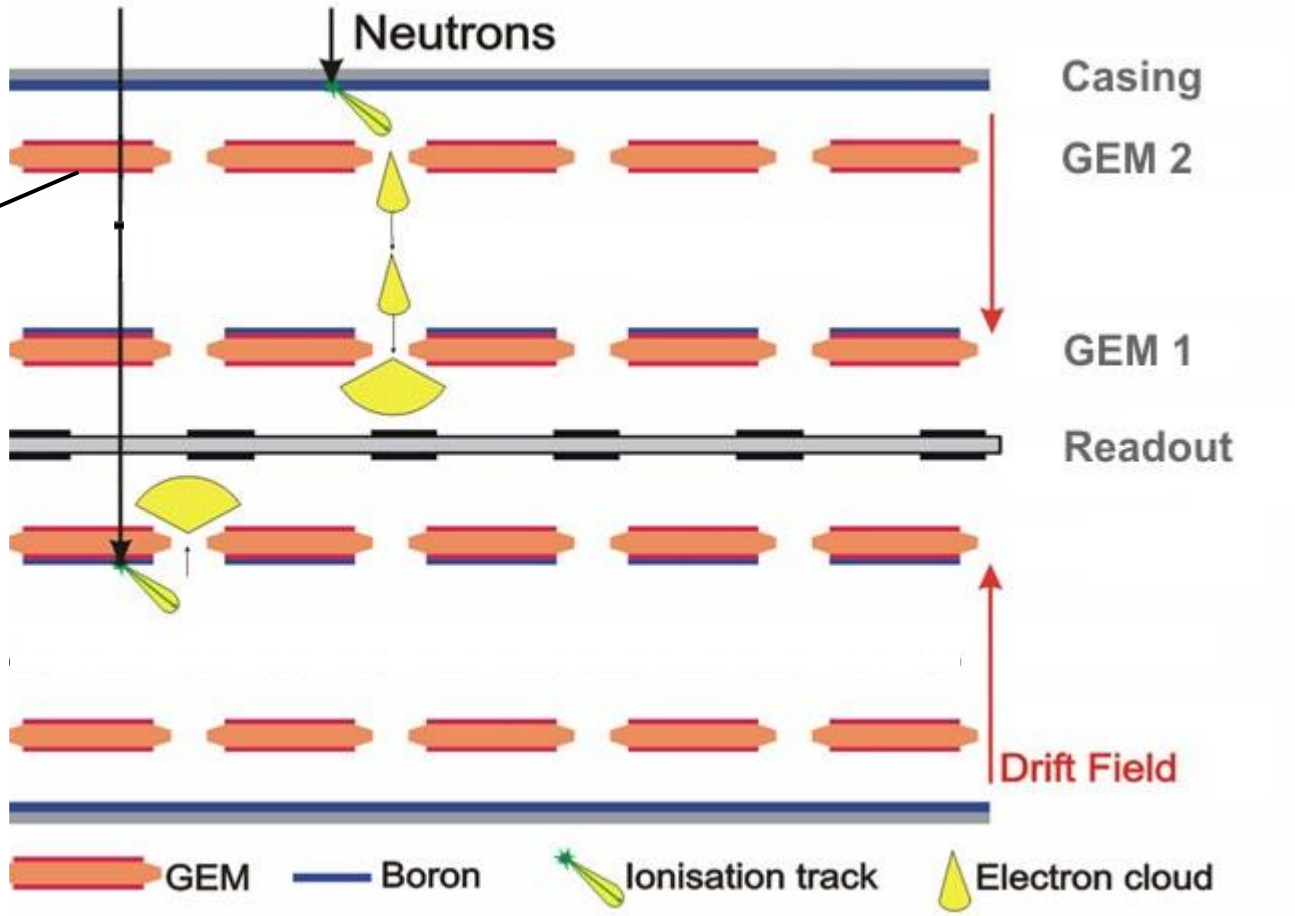
THE CASCADE CONCEPT







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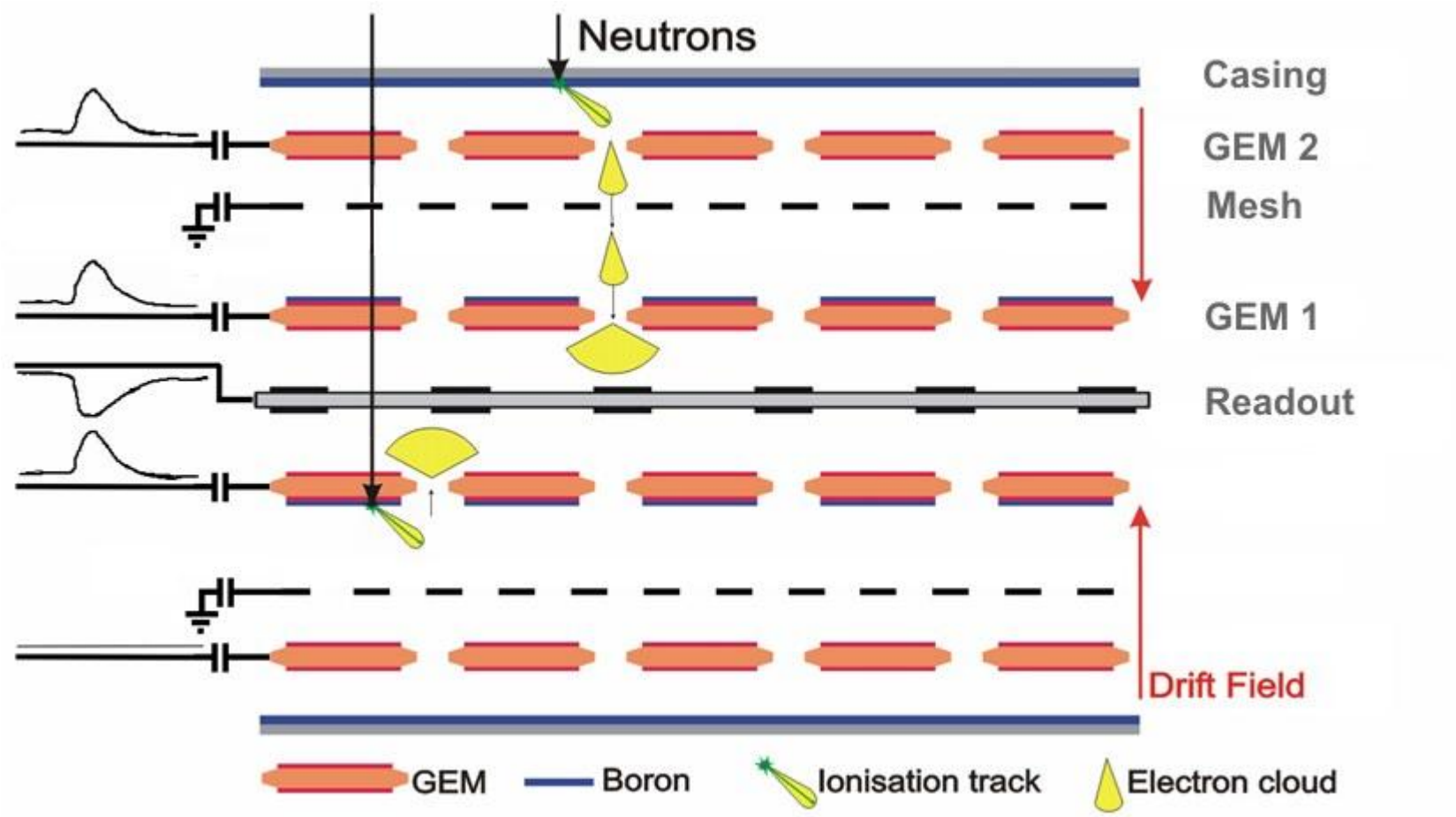
THE CASCADE CONCEPT



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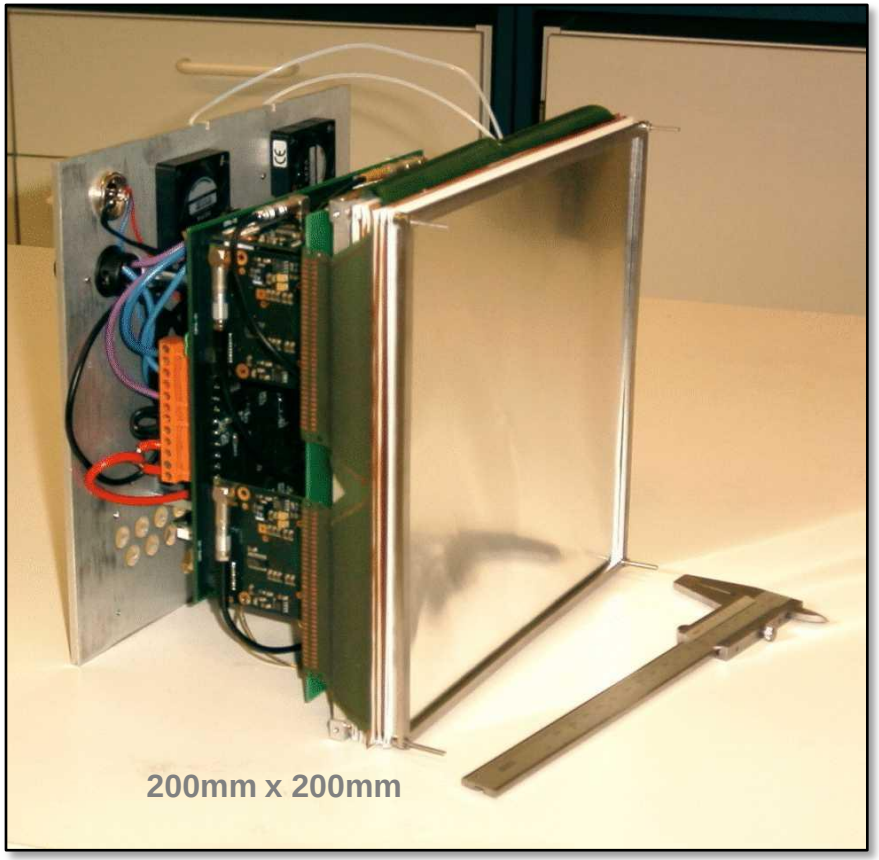
THE CASCADE DETECTOR



(without housing)

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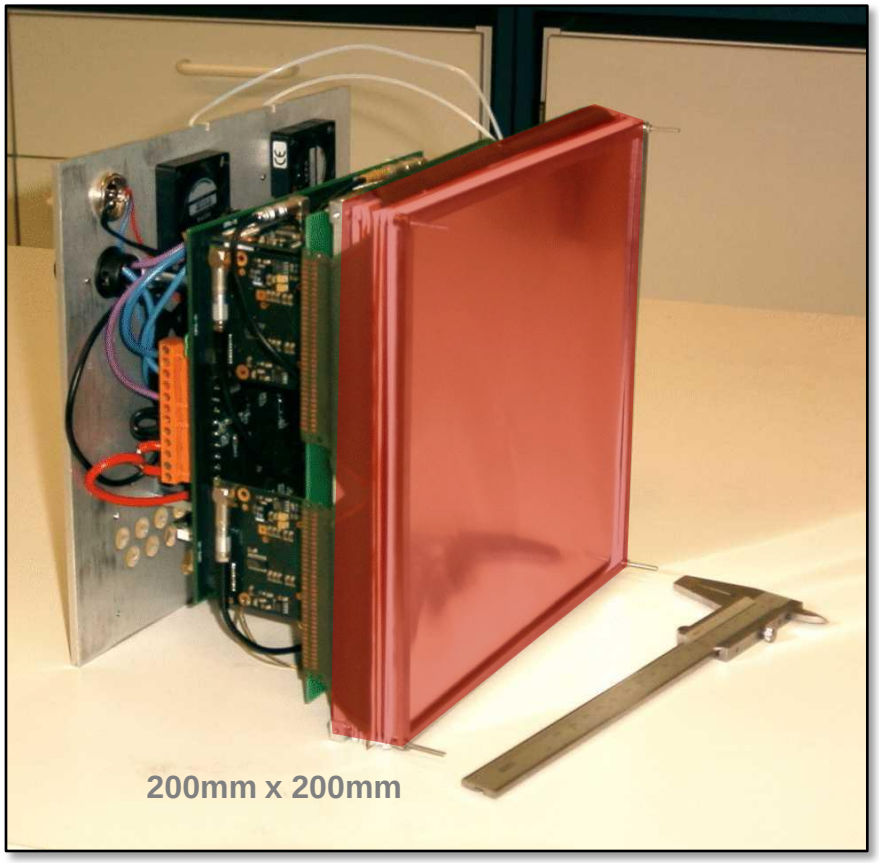
THE CASCADE DETECTOR



(without housing)

Active Detection Volume

- Neutron conversion with Boron-10

$^{10}B + n \rightarrow {}^{7}Li + \alpha + 2.79\ MeV$ (6%)

${}^{7}Li^{*} + \alpha + 2.31\ MeV$ (94%)

- Charge amplification with GEMs in Standard Gas

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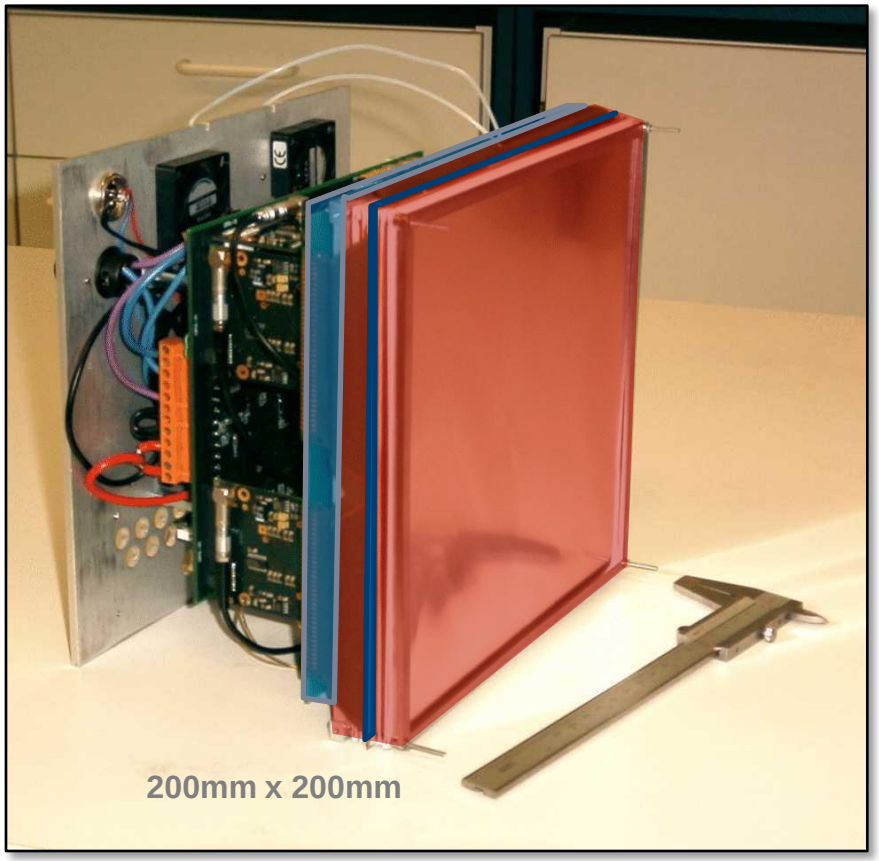
THE CASCADE DETECTOR



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Readout

- readout stripes: 128 x | 128 y @ 1.56mm
- double sided

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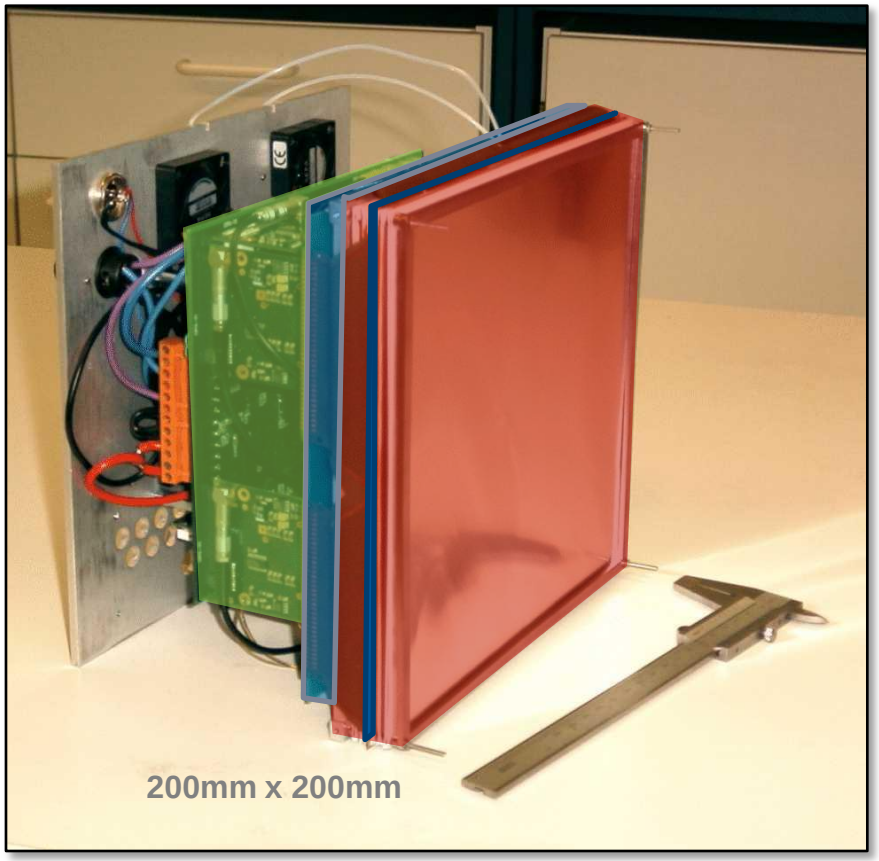
THE CASCADE DETECTOR



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Readout

- readout stripes: 128 x | 128 y @ 1.56mm
- double sided

Electronics

-A/D: CiPix –Chip (ASIC) with 10 MHz

-FPGA based data preprocessing

o histogram (on the fly)

- Optical GBit Interface

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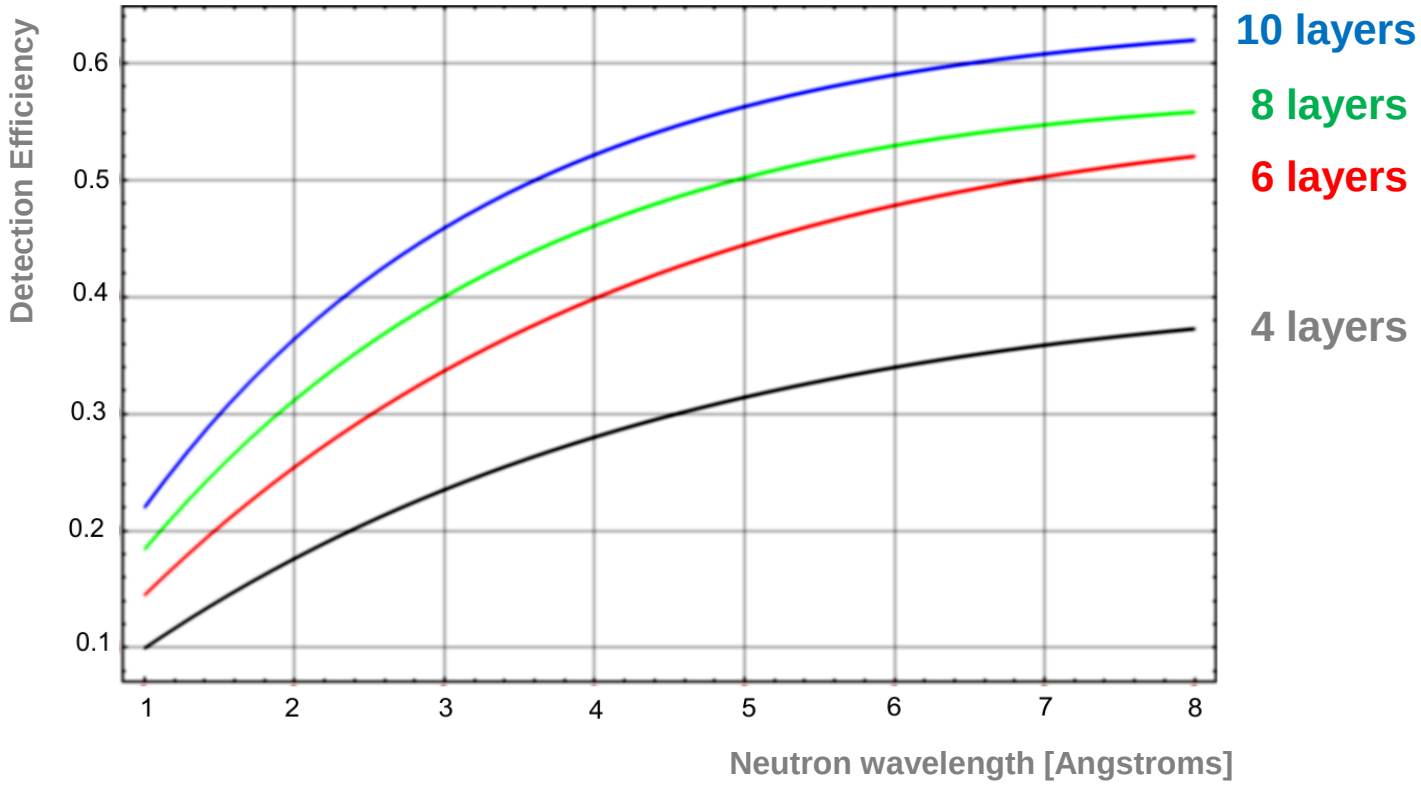
EFFICIENCY OF A MULTI-LAYER SYSTEM



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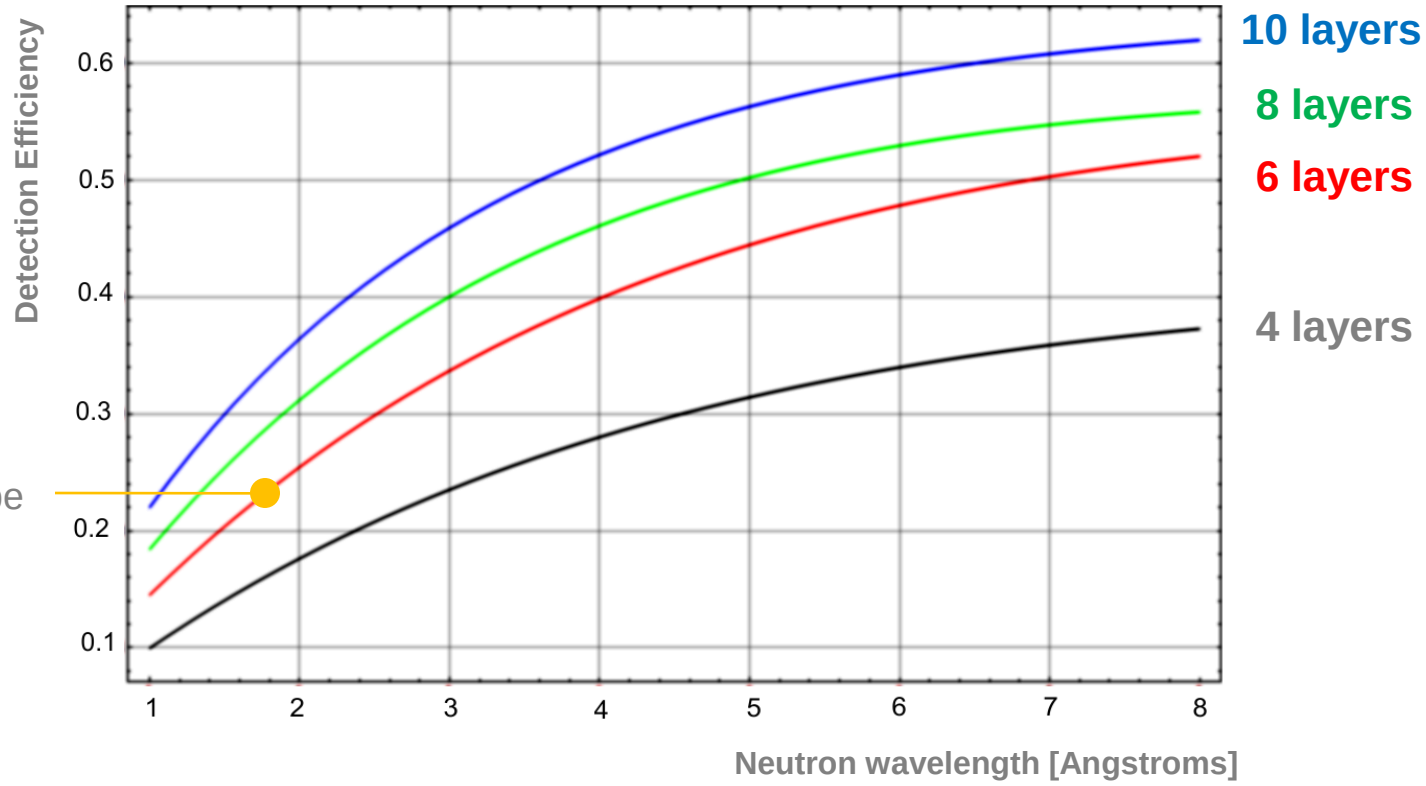
EFFICIENCY OF A MULTI-LAYER SYSTEM



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APPLICABLE FOR TOOLS

?

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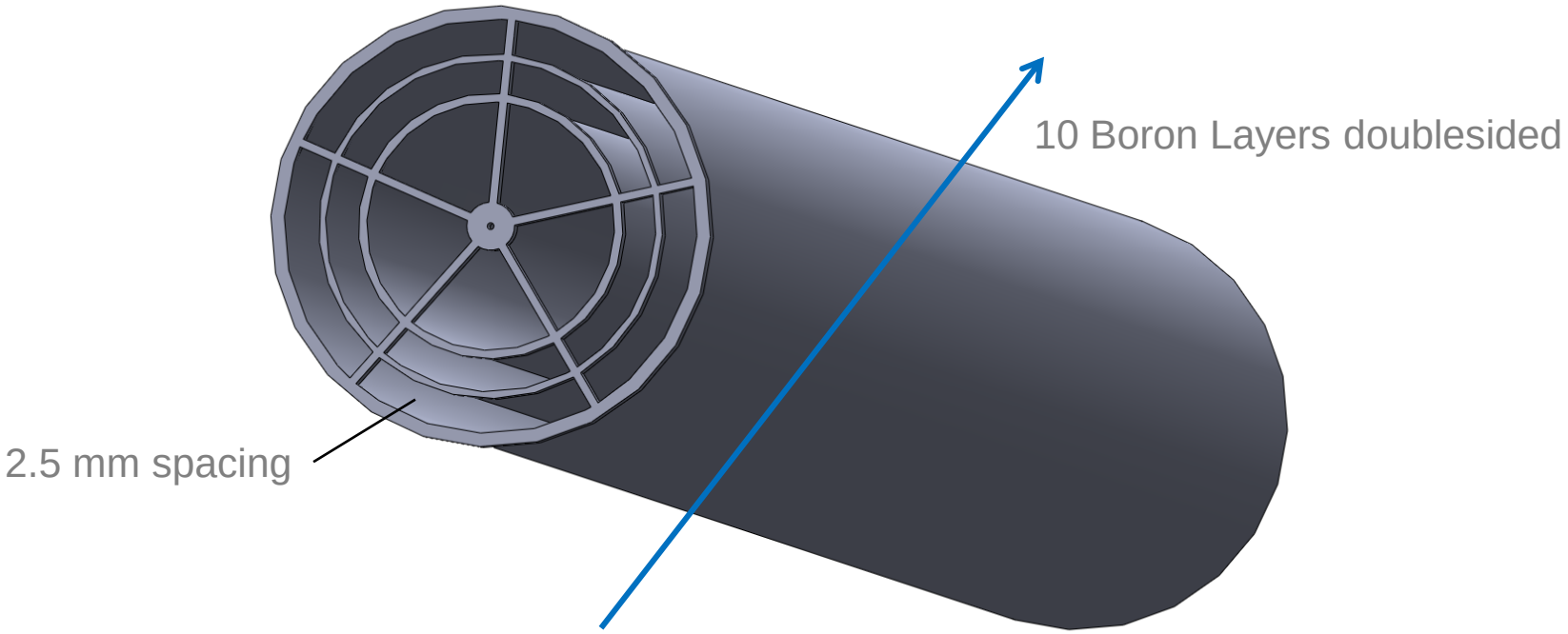
APPLICABLE FOR TOOLS?

Conical Multi-Layer GEM Detector



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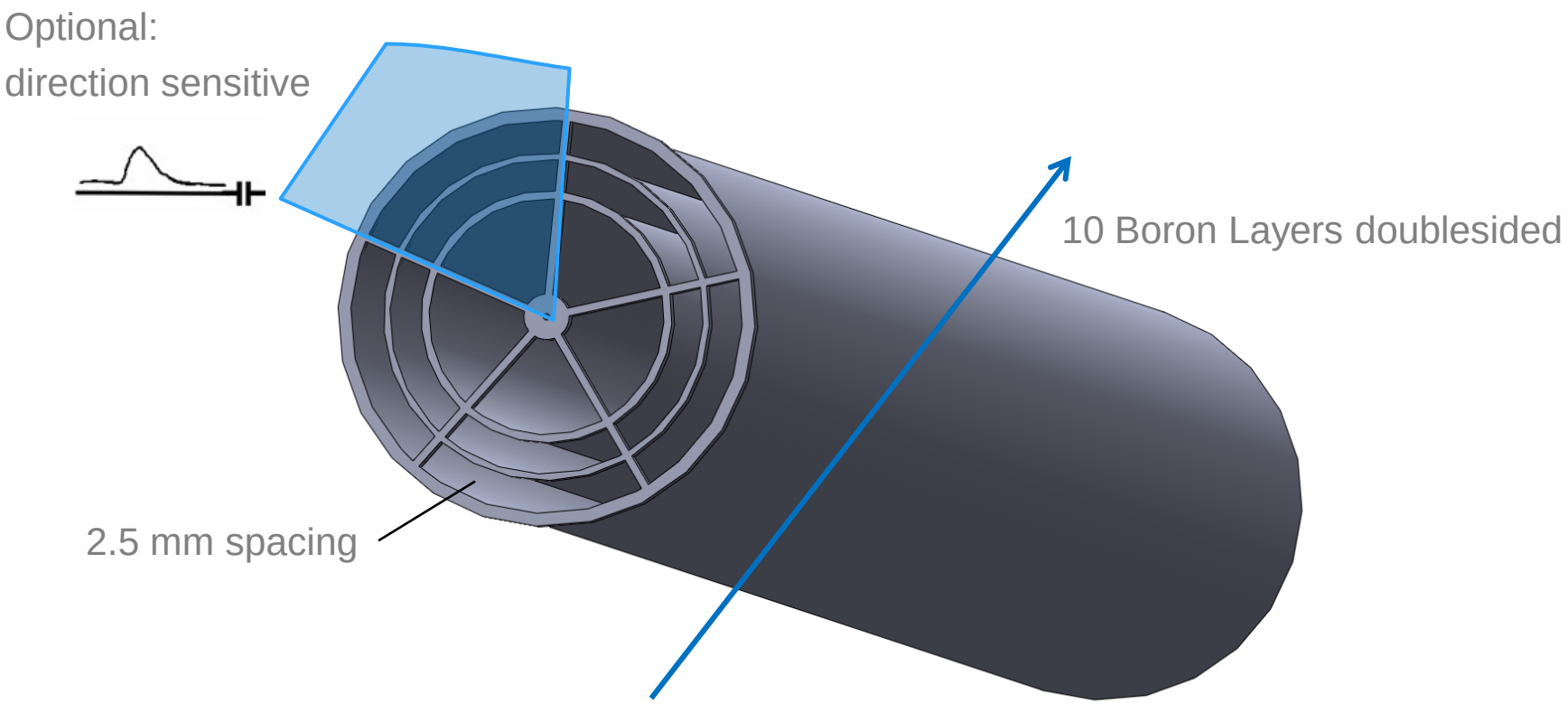
APPLICABLE FOR TOOLS?

Conical Multi-Layer GEM Detector



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MONTE CARLO SIMULATIONS
SOIL MOISTURE DETERMINATION

[1]

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[1] FOF002382 Fotofeeling at Visualphotos.com

NEUTRON SENSING METHODS

active

passive

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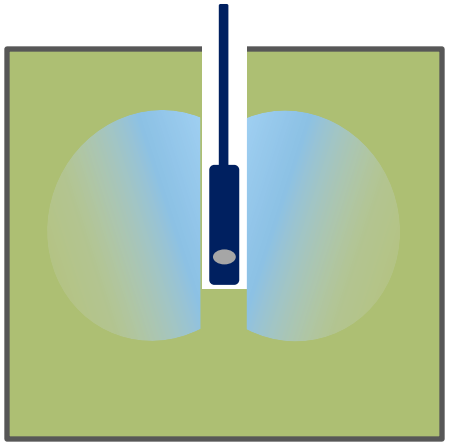
NEUTRON SENSING METHODS

active

small distinct domain



passive

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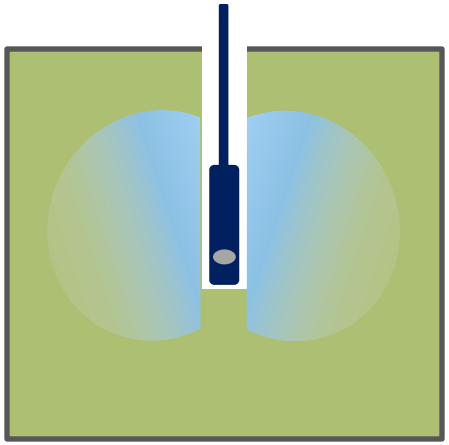
NEUTRON SENSING METHODS

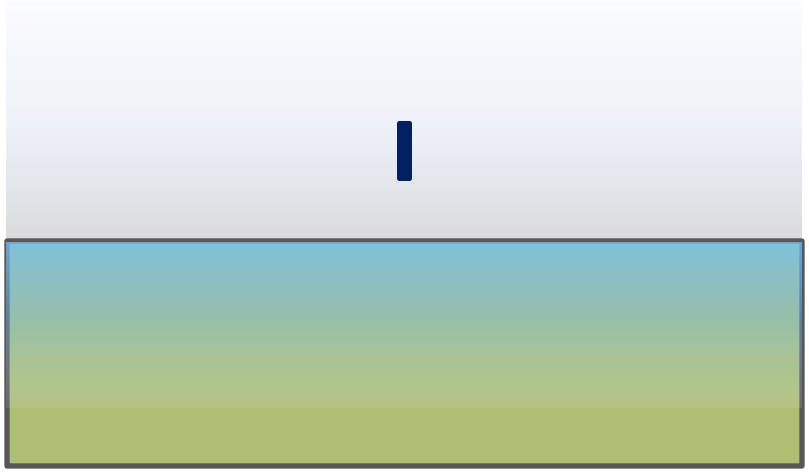
active

small distinct domain



passive

large area, diffusive



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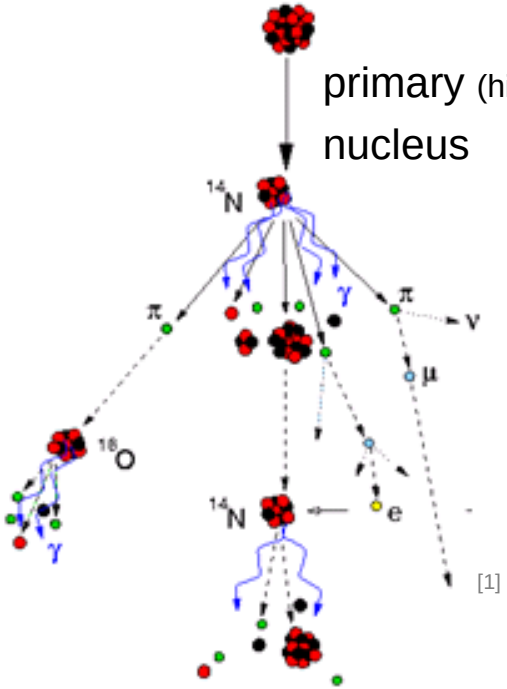
PROBE SOIL MOISTURE

by cosmic radiation induced neutron showers ?



[1]

(dry) soil

water

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

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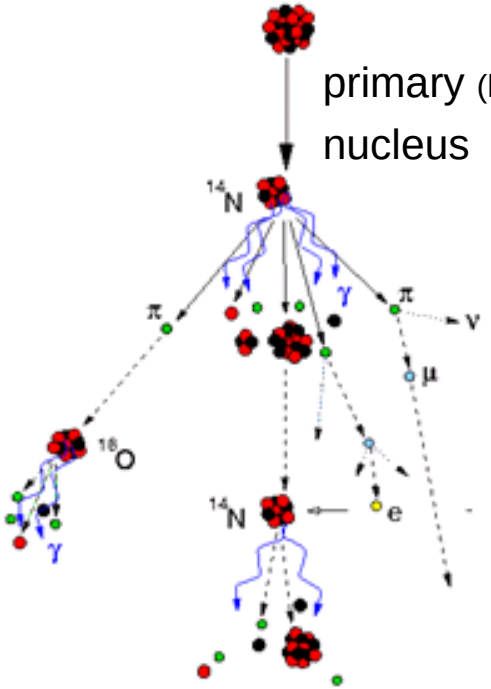
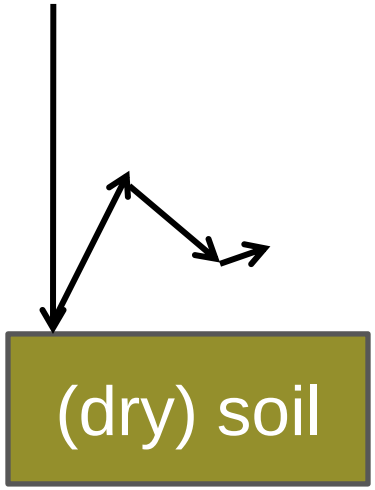
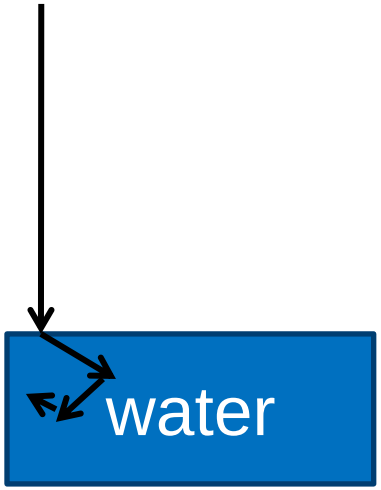
[1] K. Bernlöhr at MPI Heidelberg, 1999

PROBE SOIL MOISTURE

by cosmic radiation induced neutron showers ?







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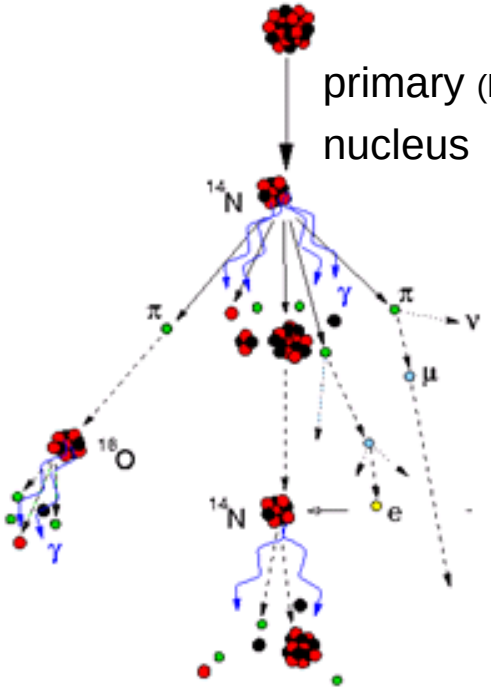
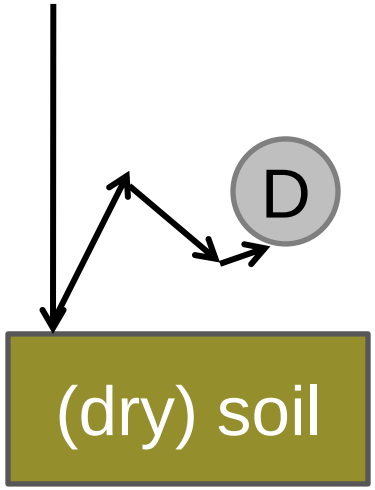
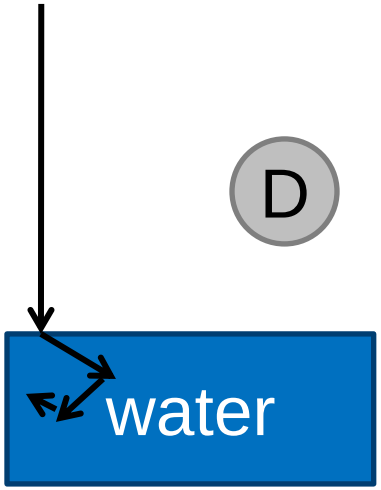
PROBE SOIL MOISTURE

by cosmic radiation induced neutron showers ?







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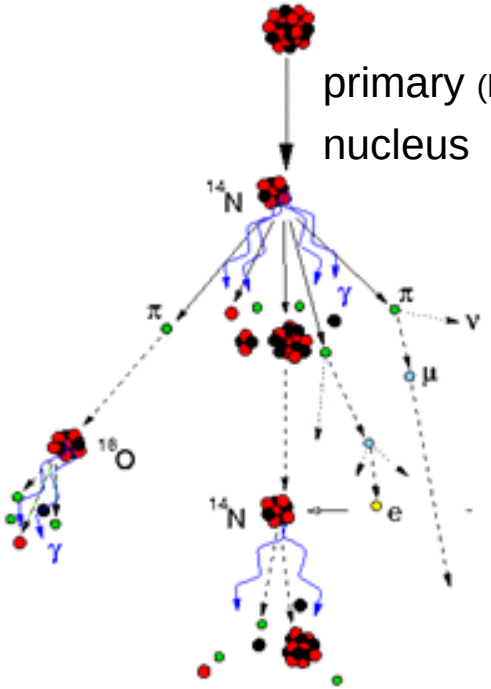
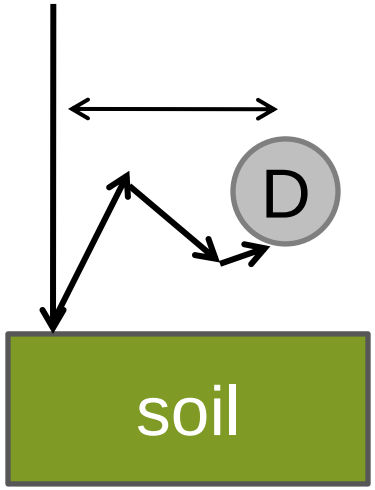
PROBE SOIL MOISTURE

by cosmic radiation induced neutron showers ?





- Range?
- Intensity?
- Energy dependence?

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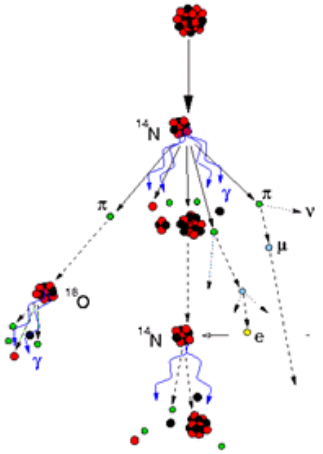
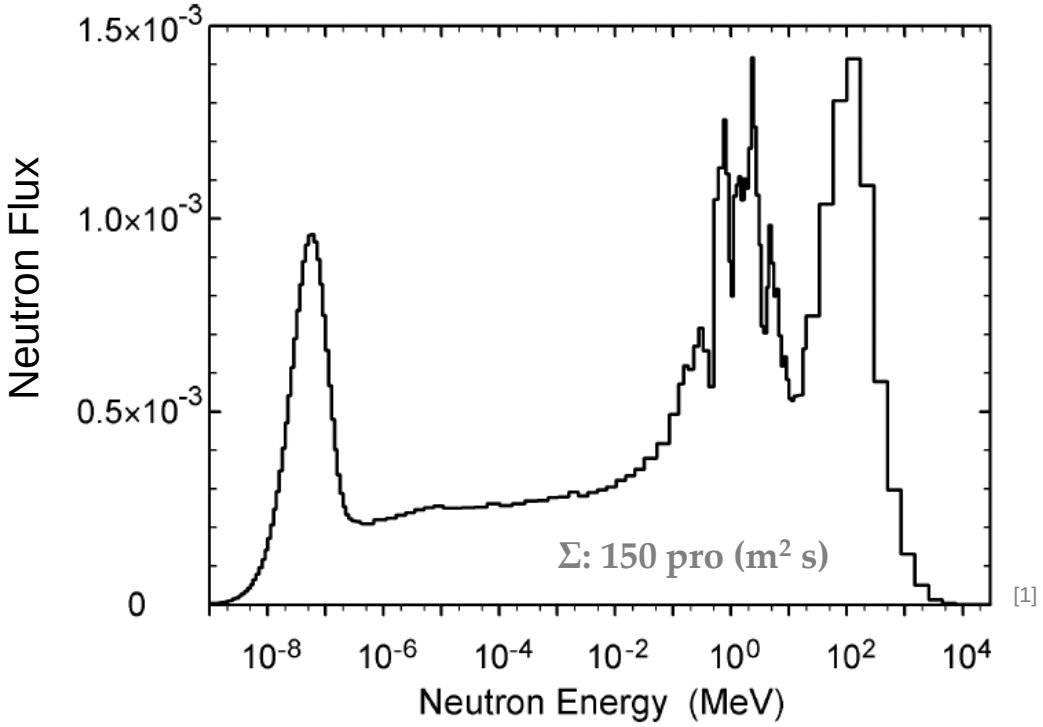
THE COSMIC NEUTRON SPECTRUM





[1]

[1] Goldhagen, P., Clem, J., and Wilson, J. (2004). The energy spectrum of cosmic-ray induced neutrons measured on an airplane over a wide range of altitude and latitude. Radiation Protection Dosimetry, 110(1-4):387–392

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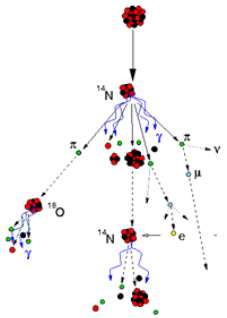
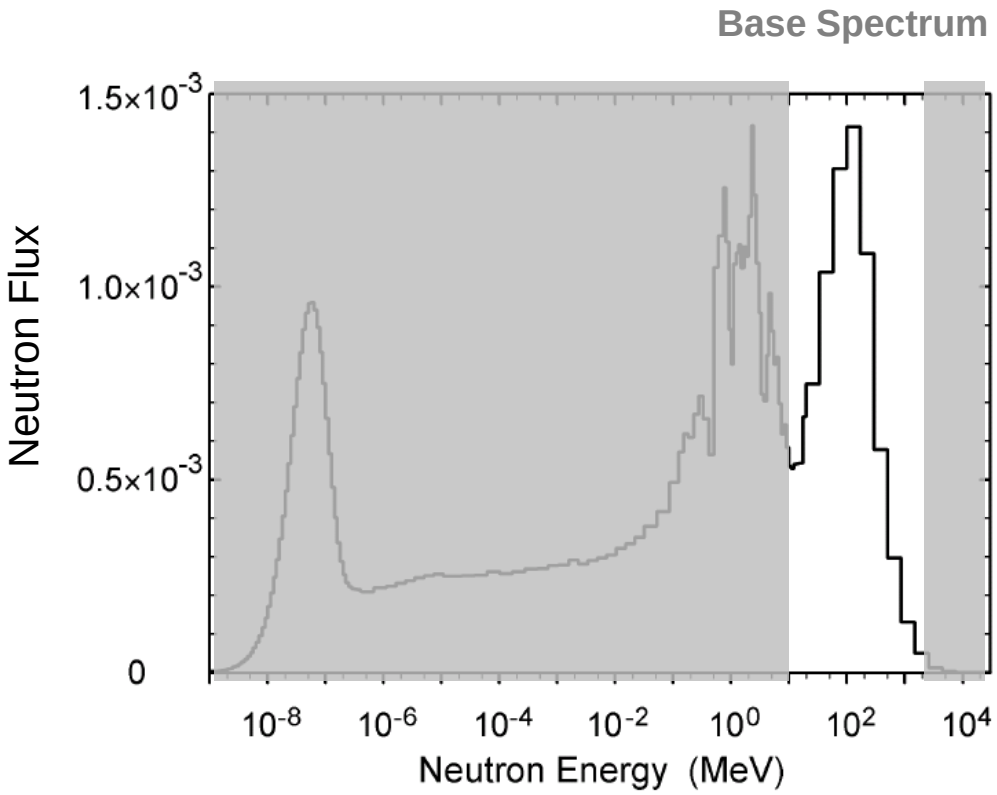
Markus Köhli

THE COSMIC NEUTRON SPECTRUM



soil



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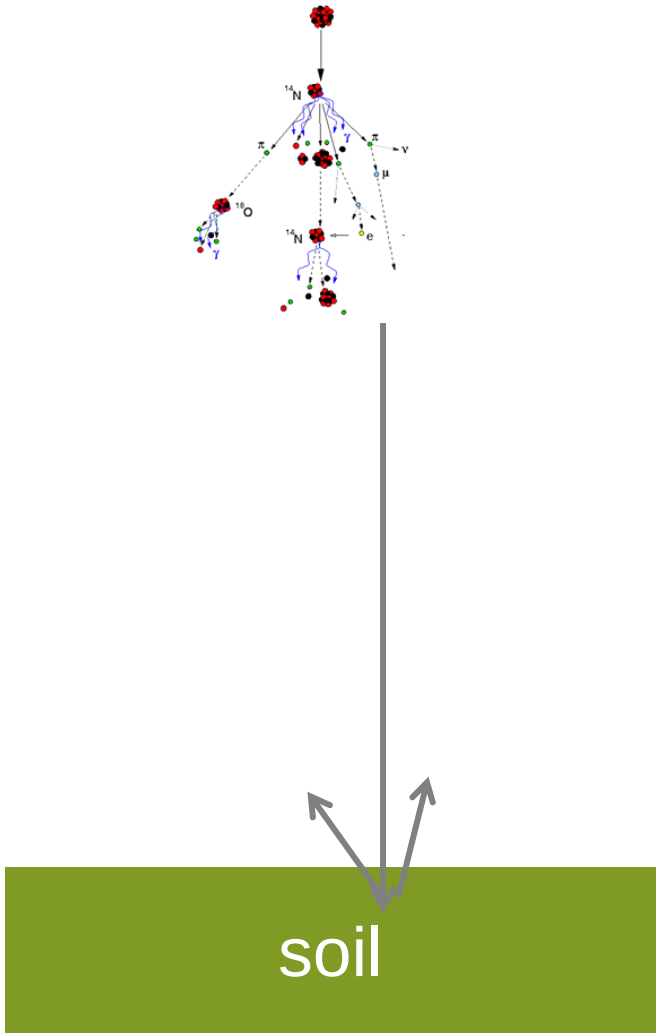

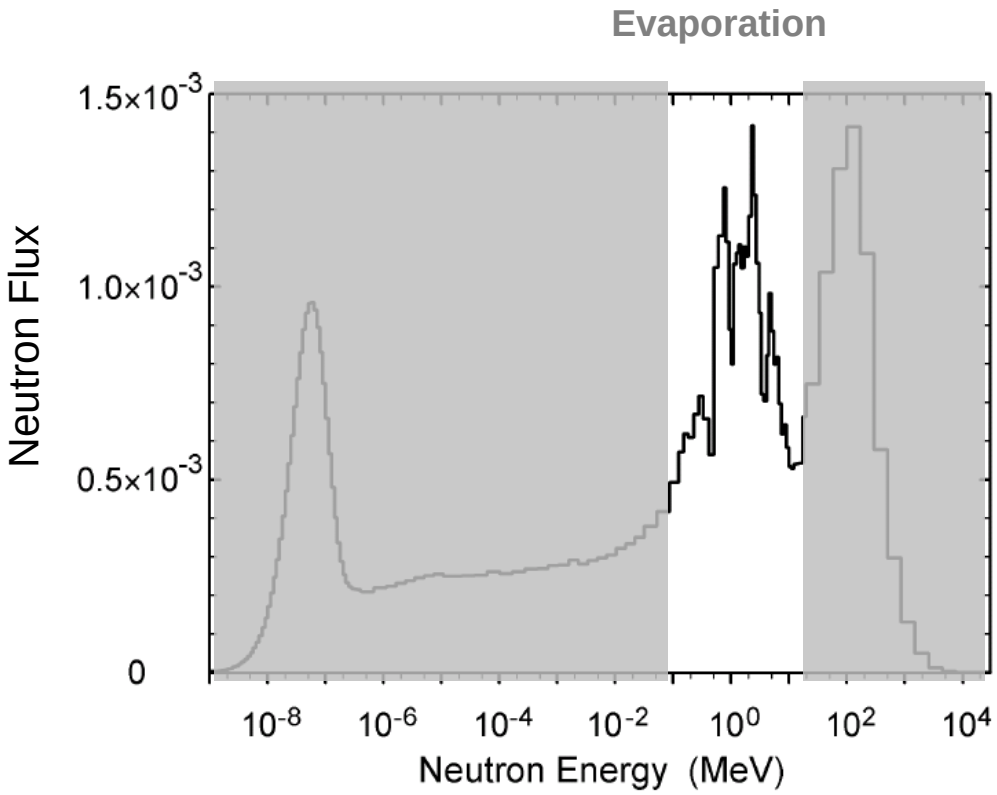

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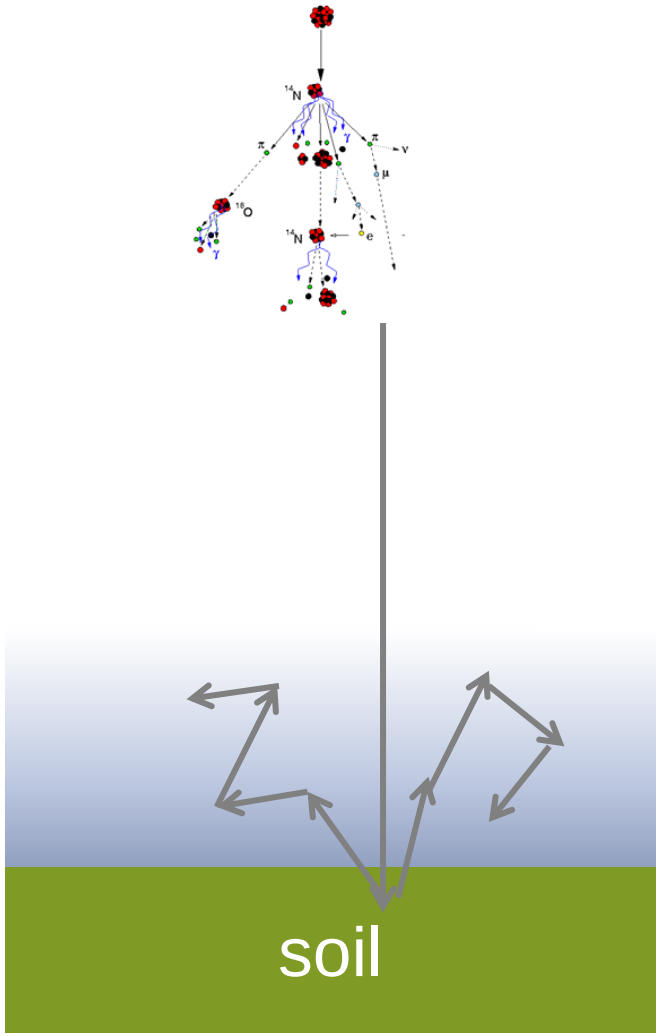

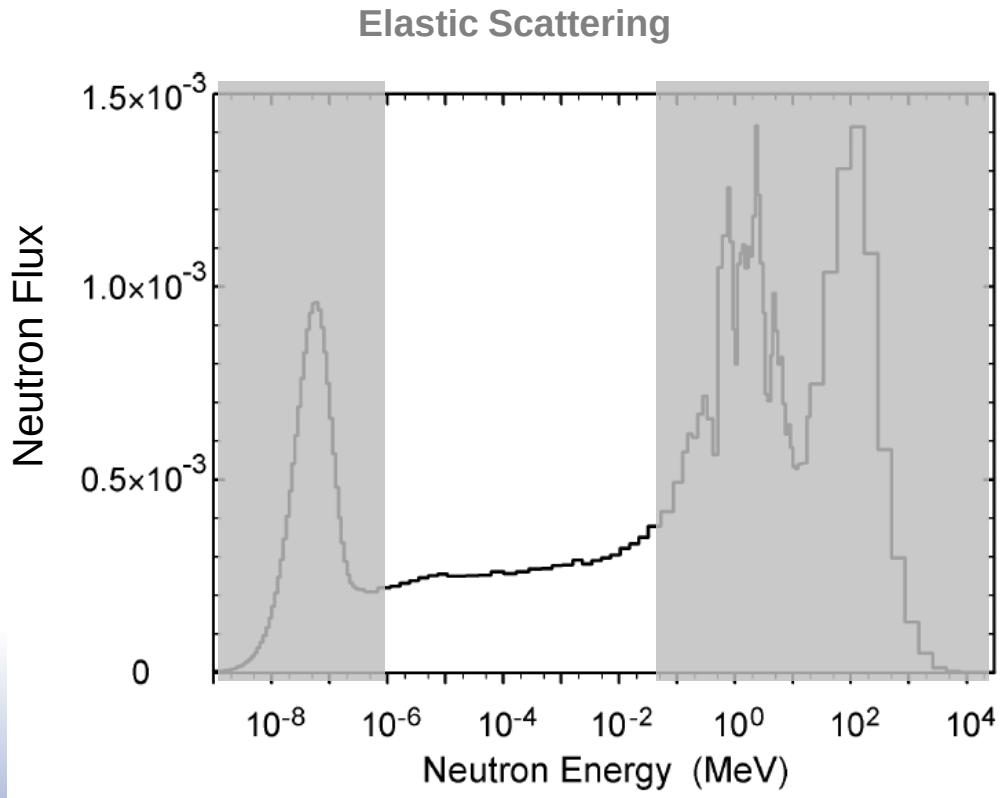

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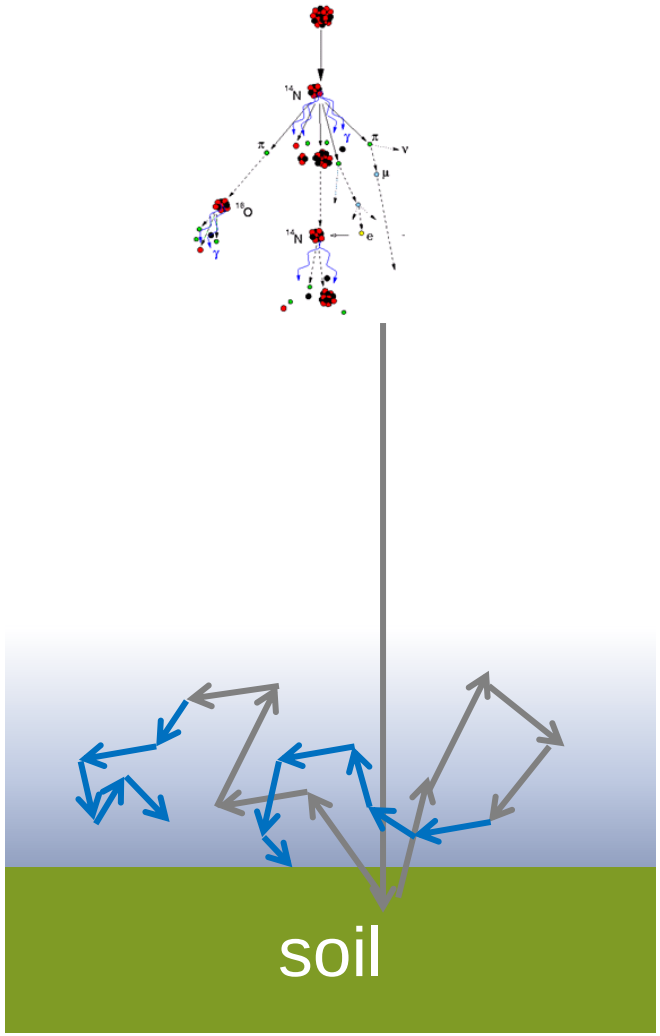

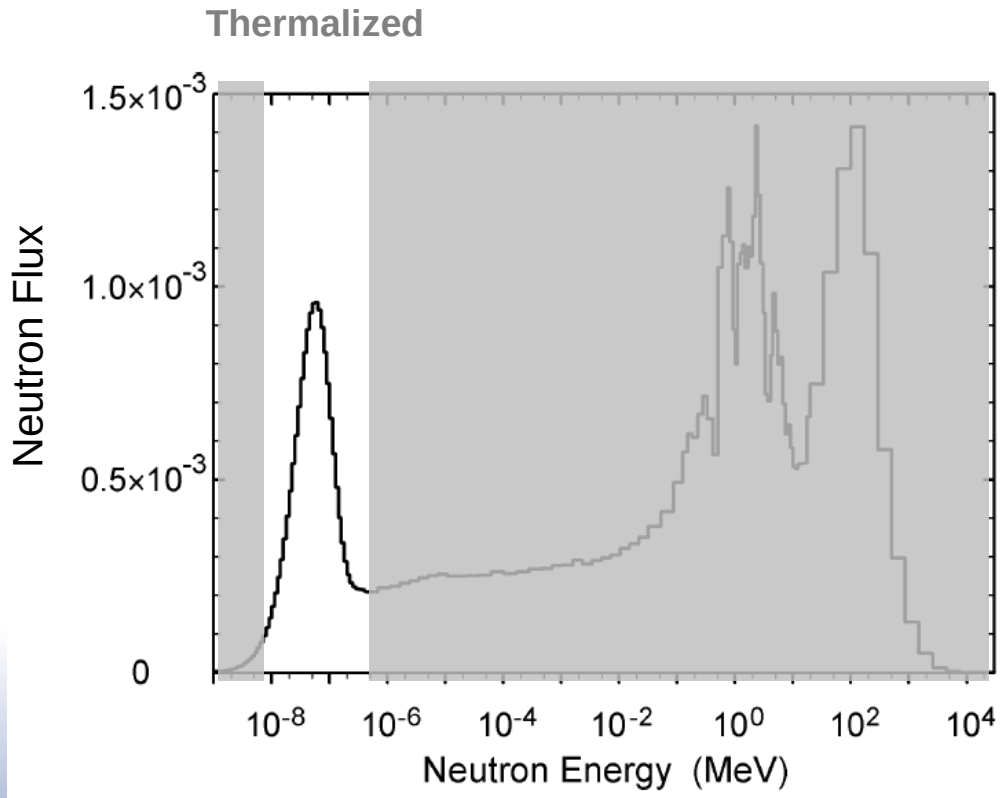

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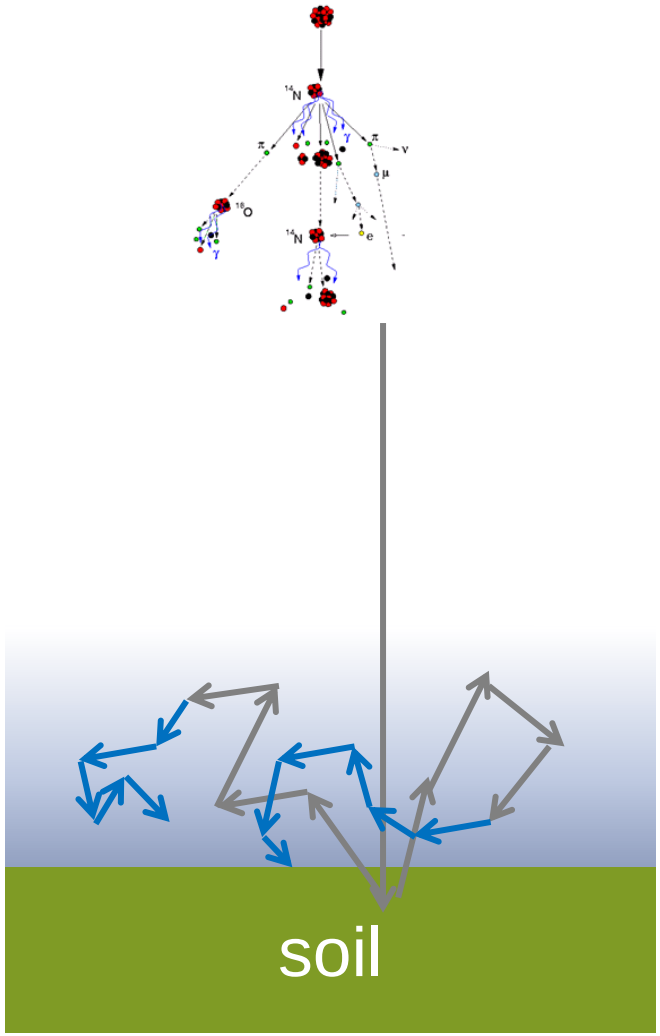

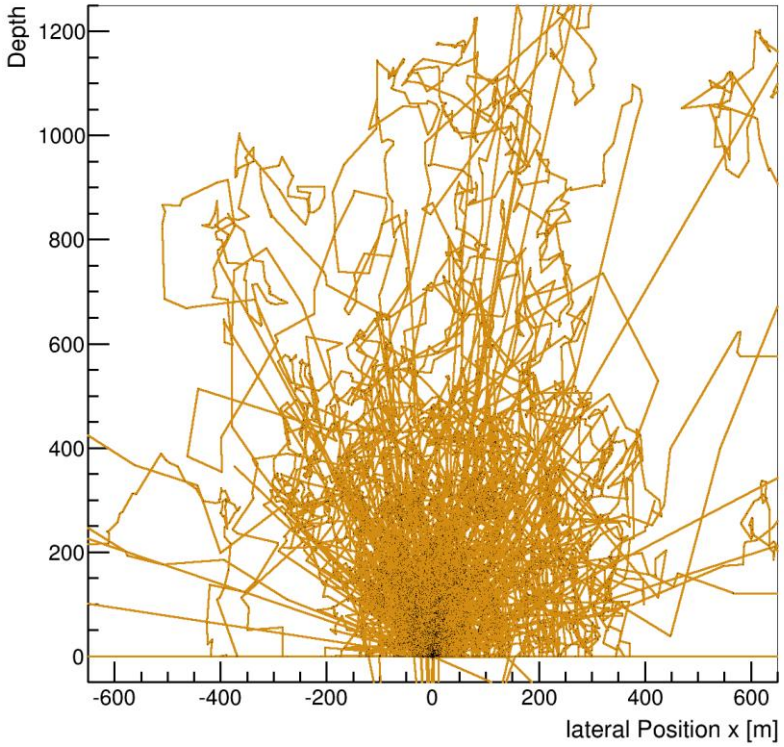

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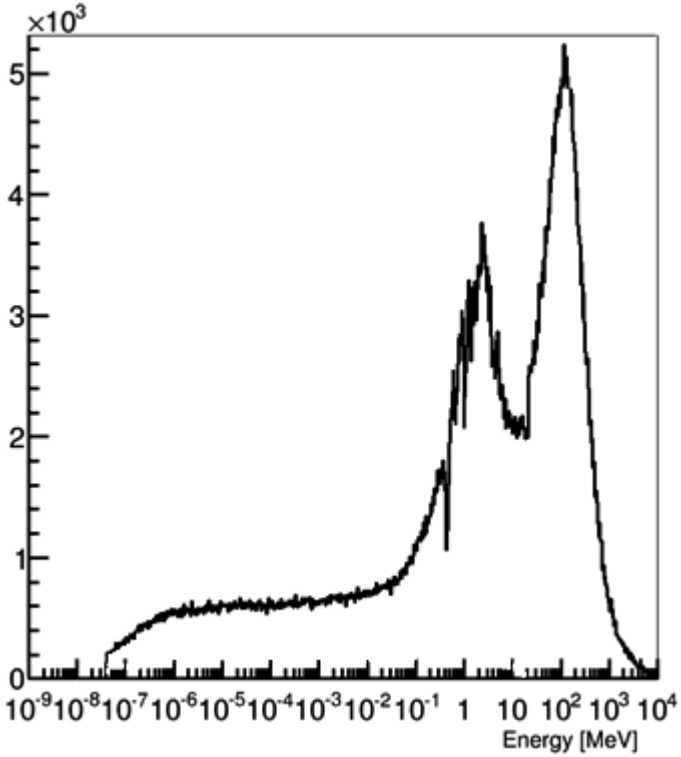
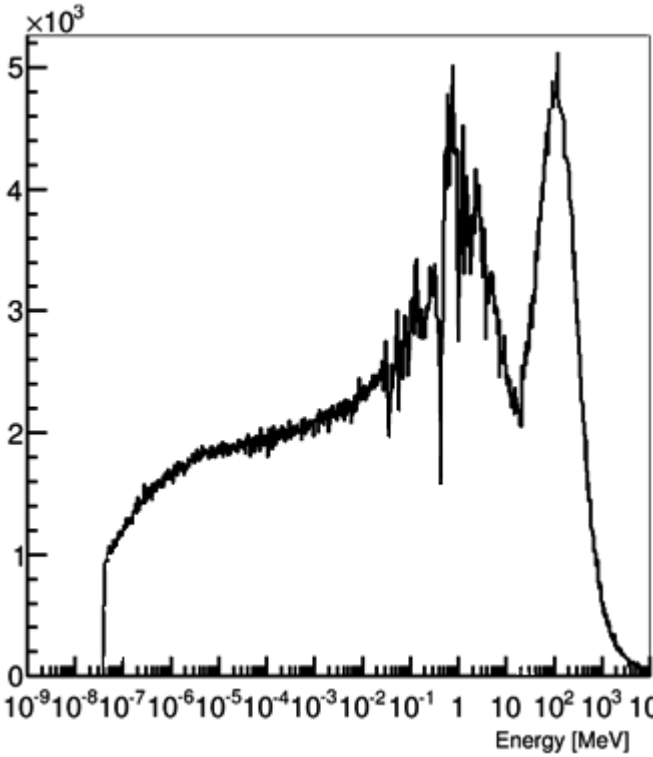
SPECTRUM VARIATION BY WATER

(with thermal neutron cutoff)

100 % water



0 % water



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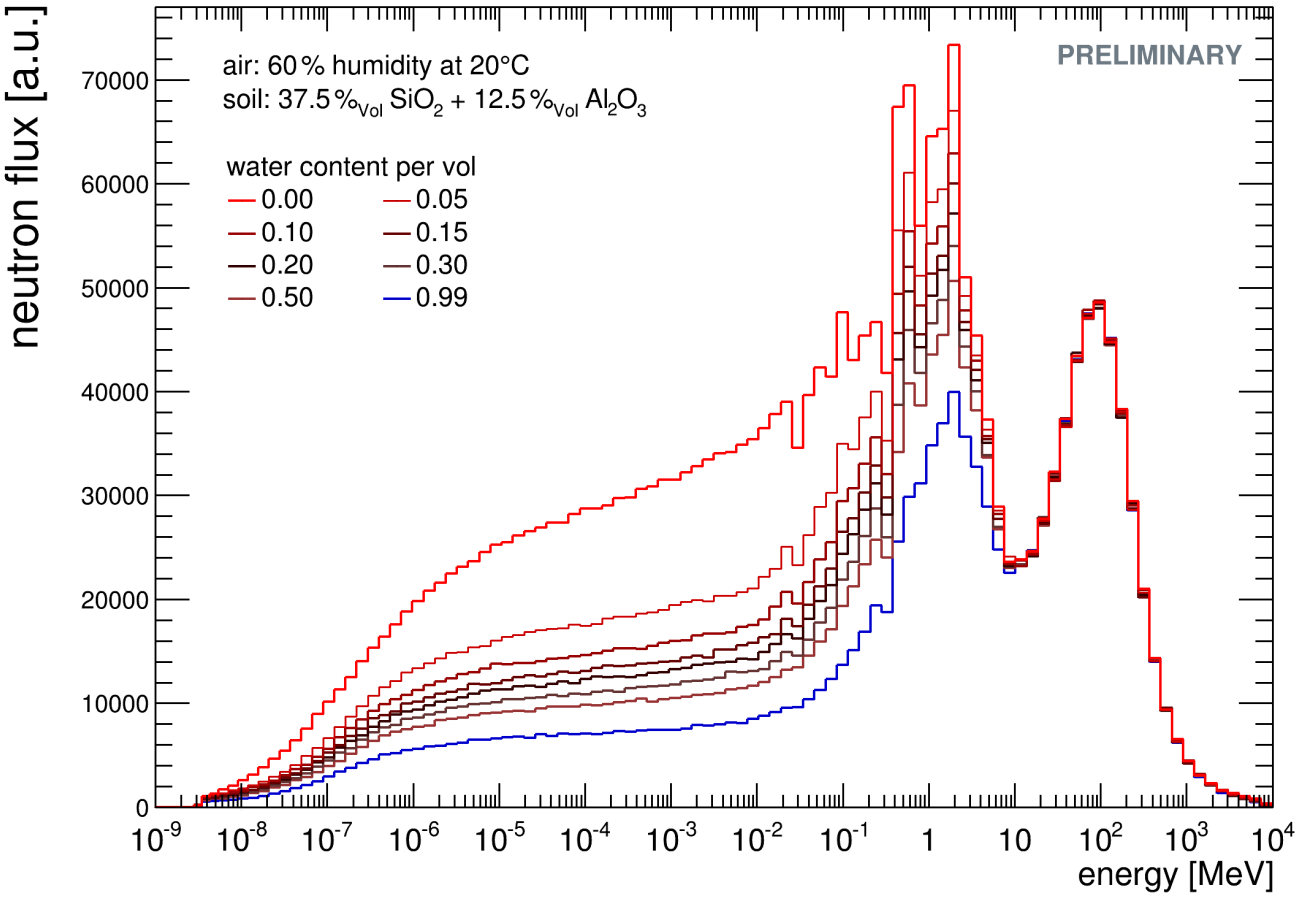
SPECTRUM VARIATION BY WATER



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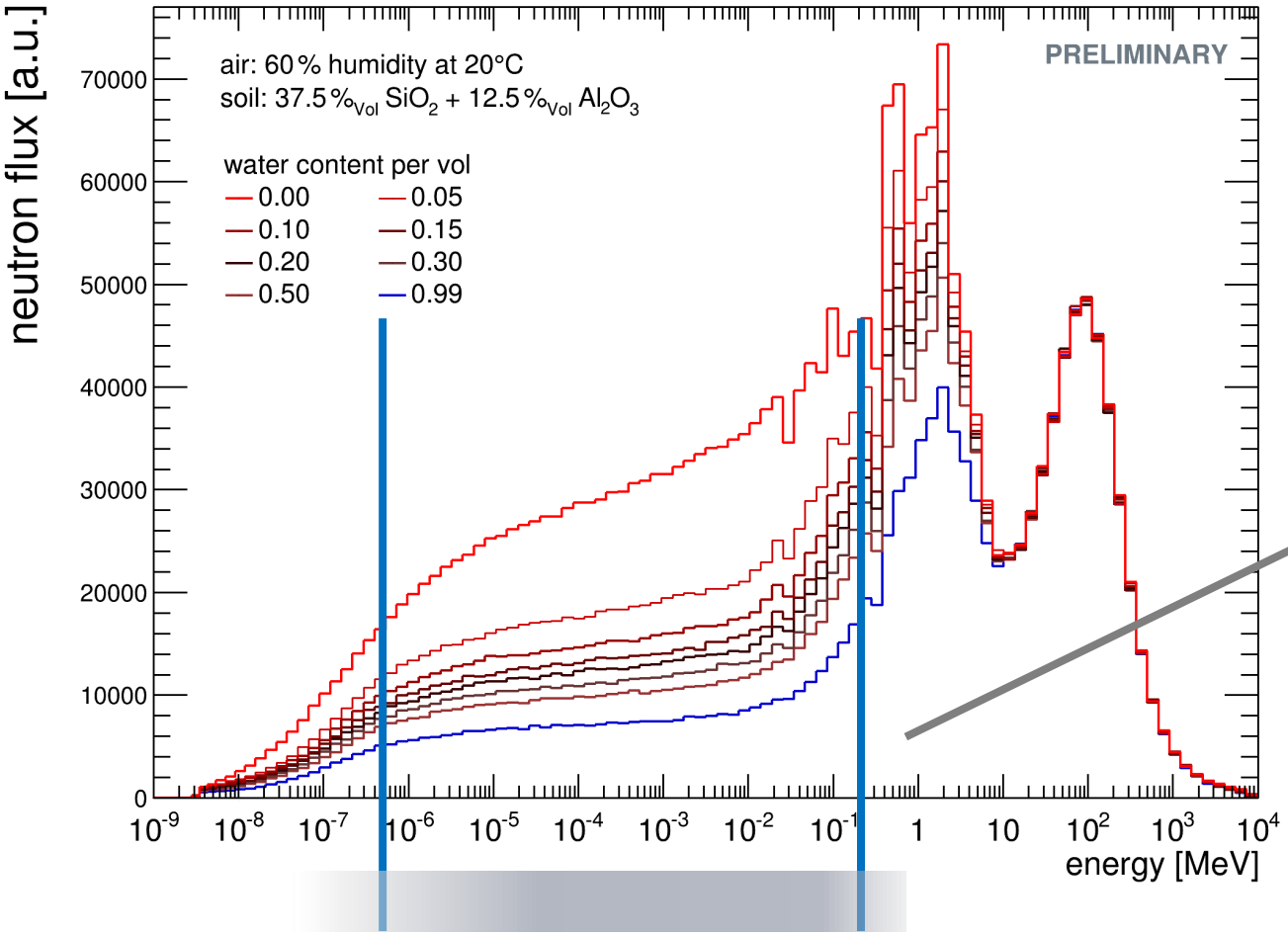

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APPLICATION FOR PNN

?

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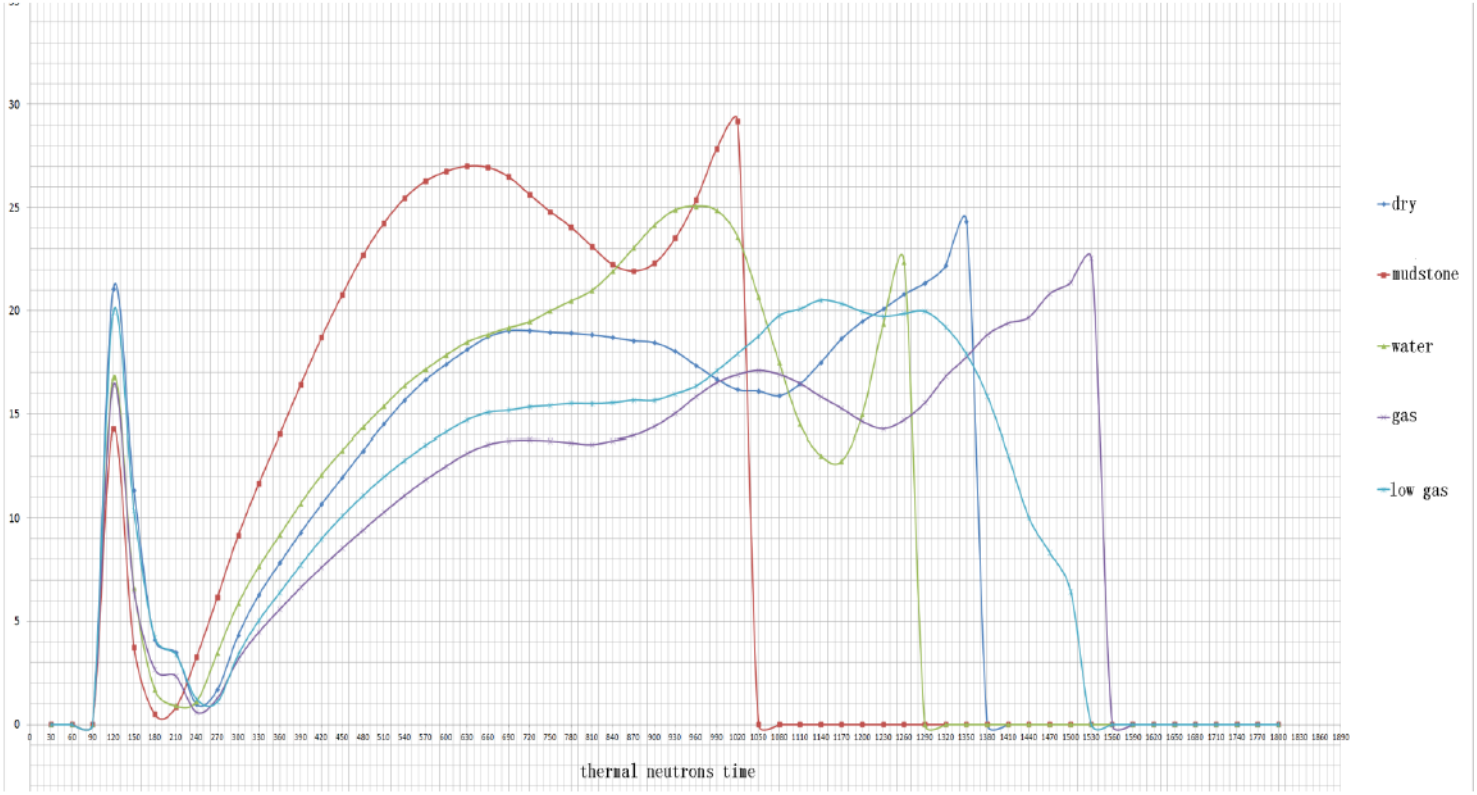
APPLICATION FOR PNN

Understanding Response Curves



Zhang and Kang, GPN

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CURRENT ACHIEVEMENTS

- Design, construction and operation of **boron-lined detectors proofs success of that technology**

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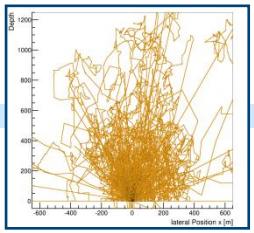

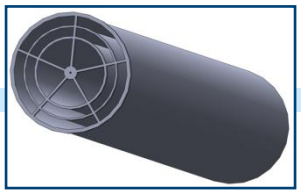

Further development depends on funding

BACKUP SLIDES

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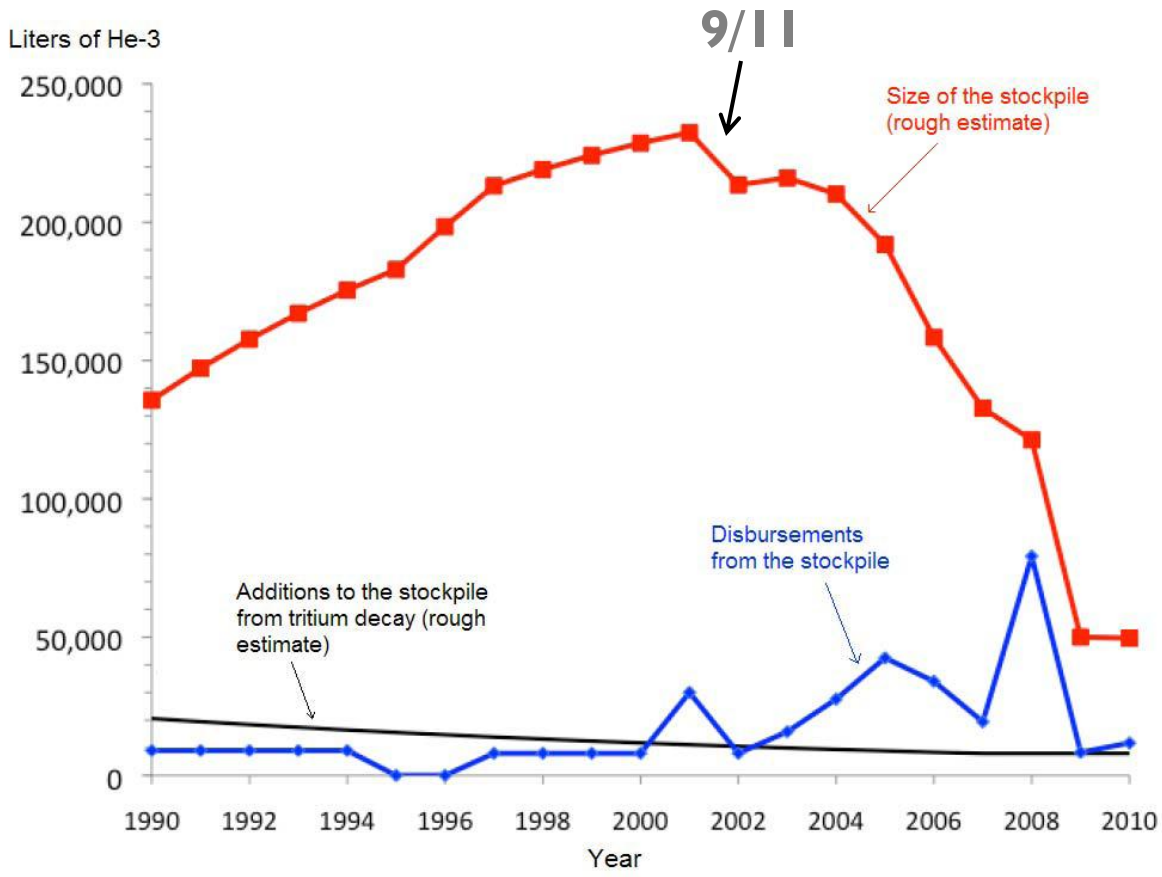
Detector Development

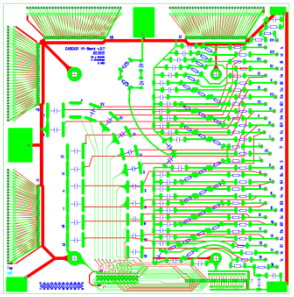
BORON DETECTORS - 2

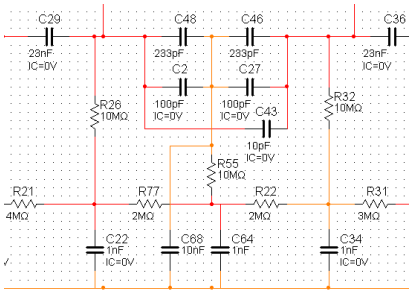


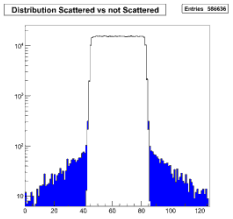
Costs:

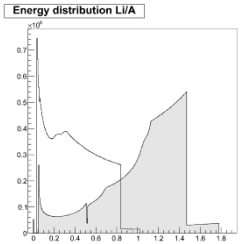
2000-3000 €/L

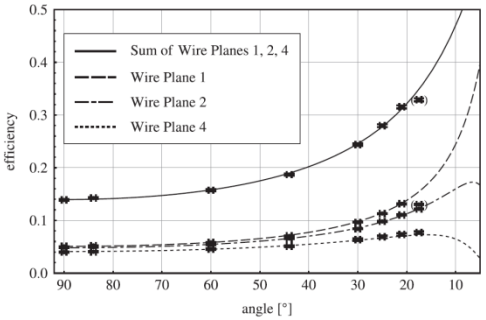
HEIDELBERG NEUTRON DETECTORS

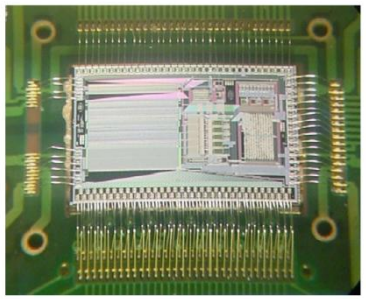


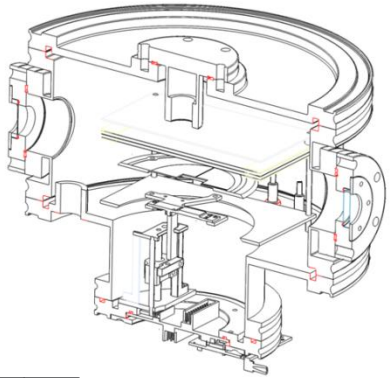


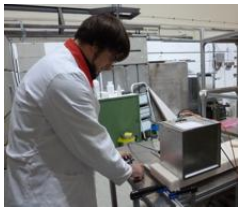


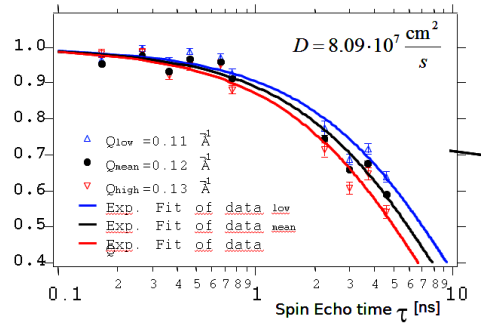


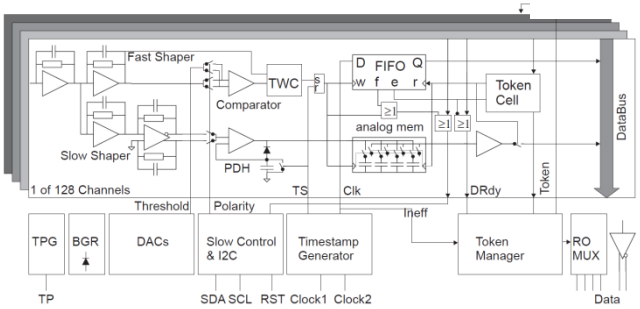


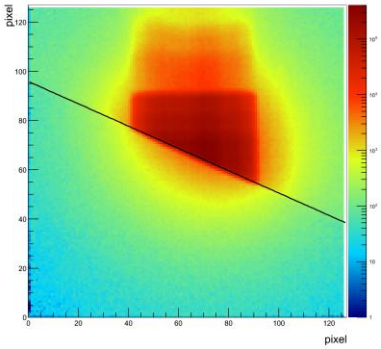


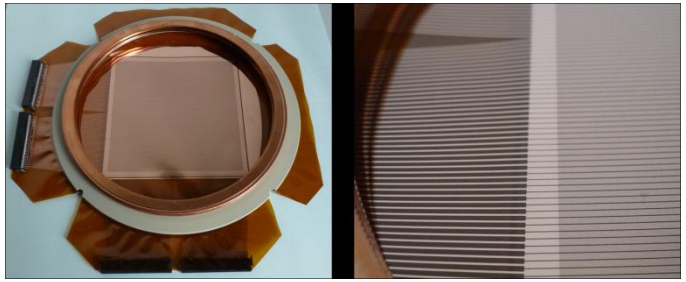












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