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Current Status of the Jalousie detector for the DREAM instrument

CDT

IKON15, Lund, 11.09.2018

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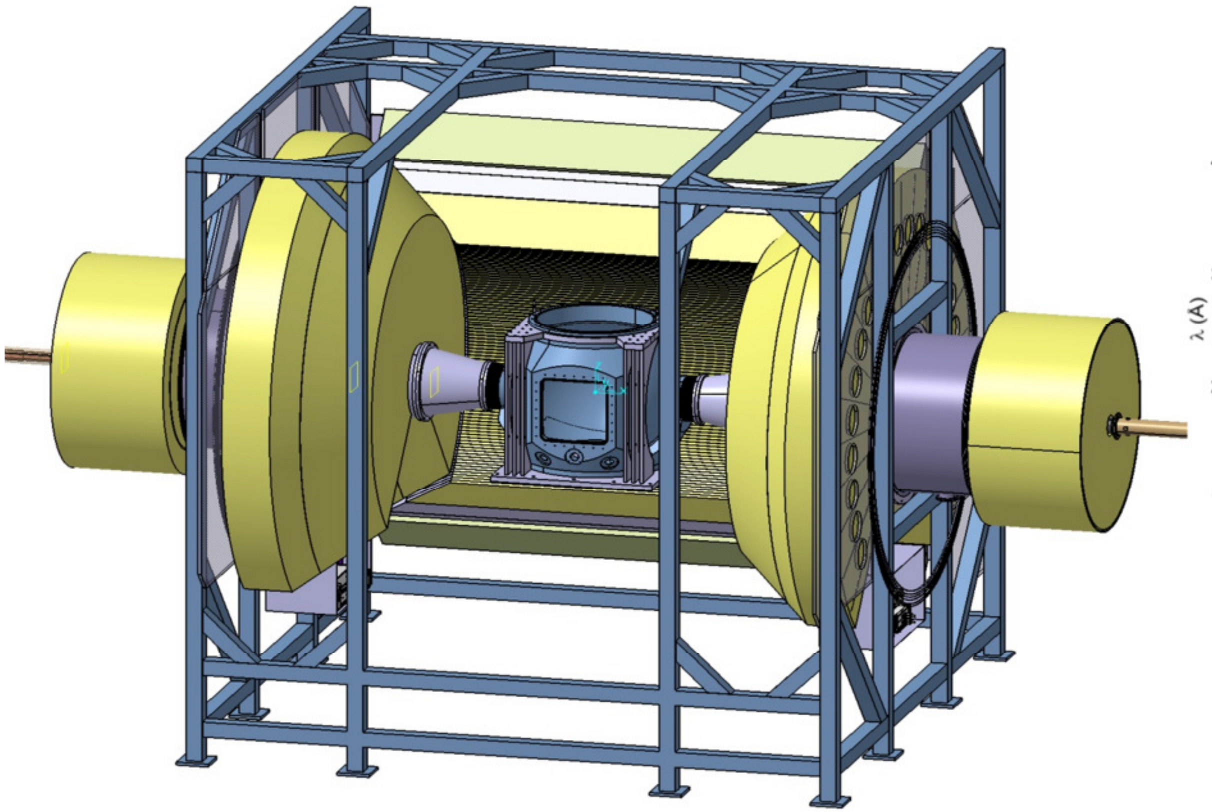
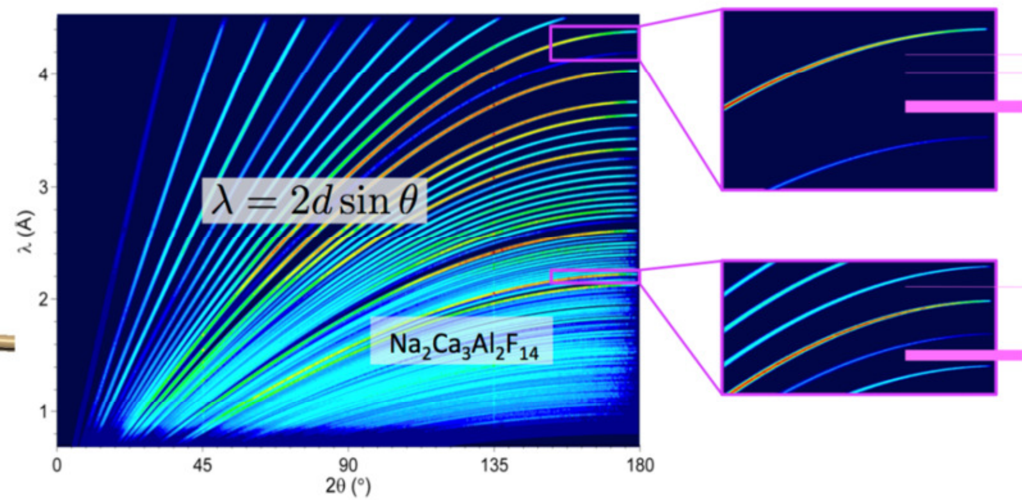
The ESS-Instrument DREAM

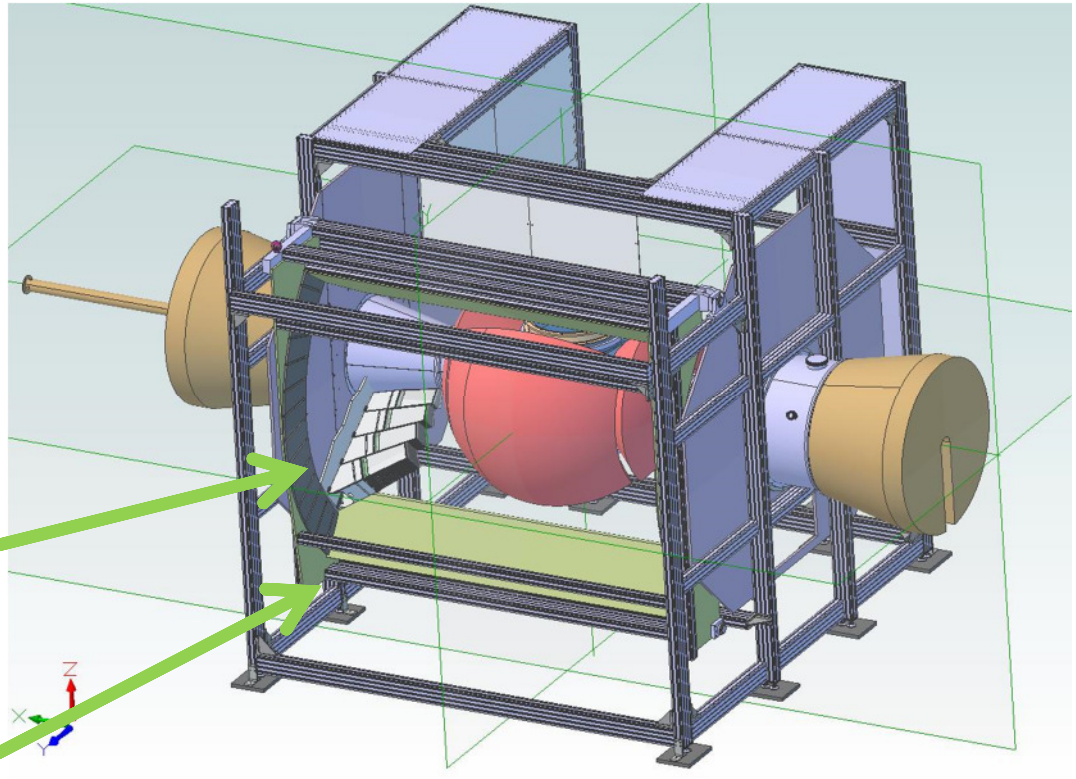
- CDT GmbH contracted by FZJ for concept, design and realization of the 0-series for mantle and end-cap detector as well as readout electronics.
- Perfect in timing for our availability of engineering-resources.
- Production, assembly and QA procedures can nicely be interleaved with POWTEX.





Realization of DREAM-Jalousie at CDT

- **Engineering adaptation:**
  - Full new CAD design realization.
  - Blueprints of all parts.
- **0-series production:**
  - **End-cap detector:** 1 mounting unit (12°-detector segment).
  - **Mantle detector:** 1 mounting unit (6 detector segments).



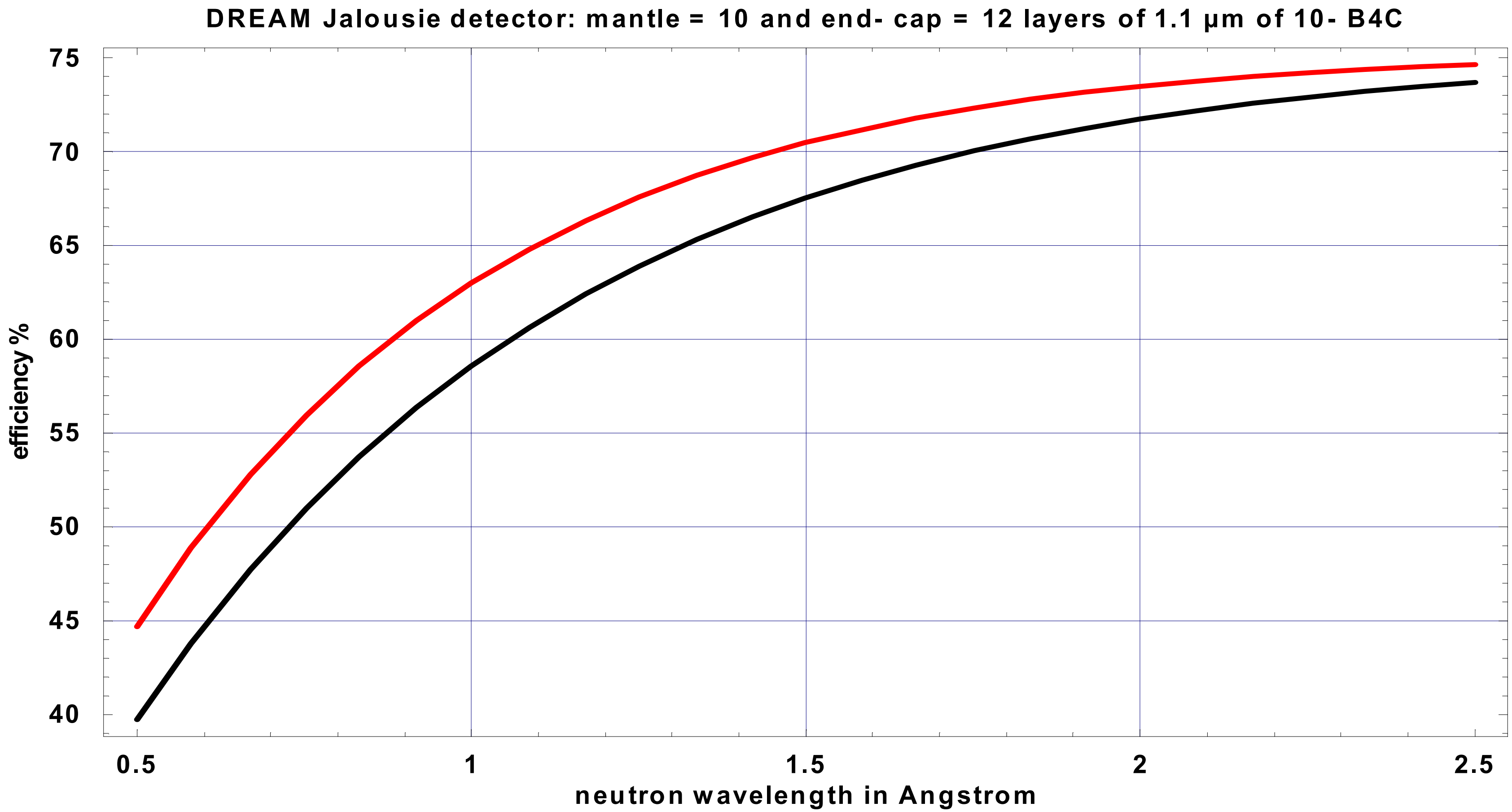
- **First serial production: for ESS day 1 operation of the instrument.**
- **Subsequent serial production: towards fully equipped instrument.**

Projected Detection Efficiency for DREAM

The number of Boron layers increased to

- **10 for the mantle detector and**
- **12 for the end-cap detector**

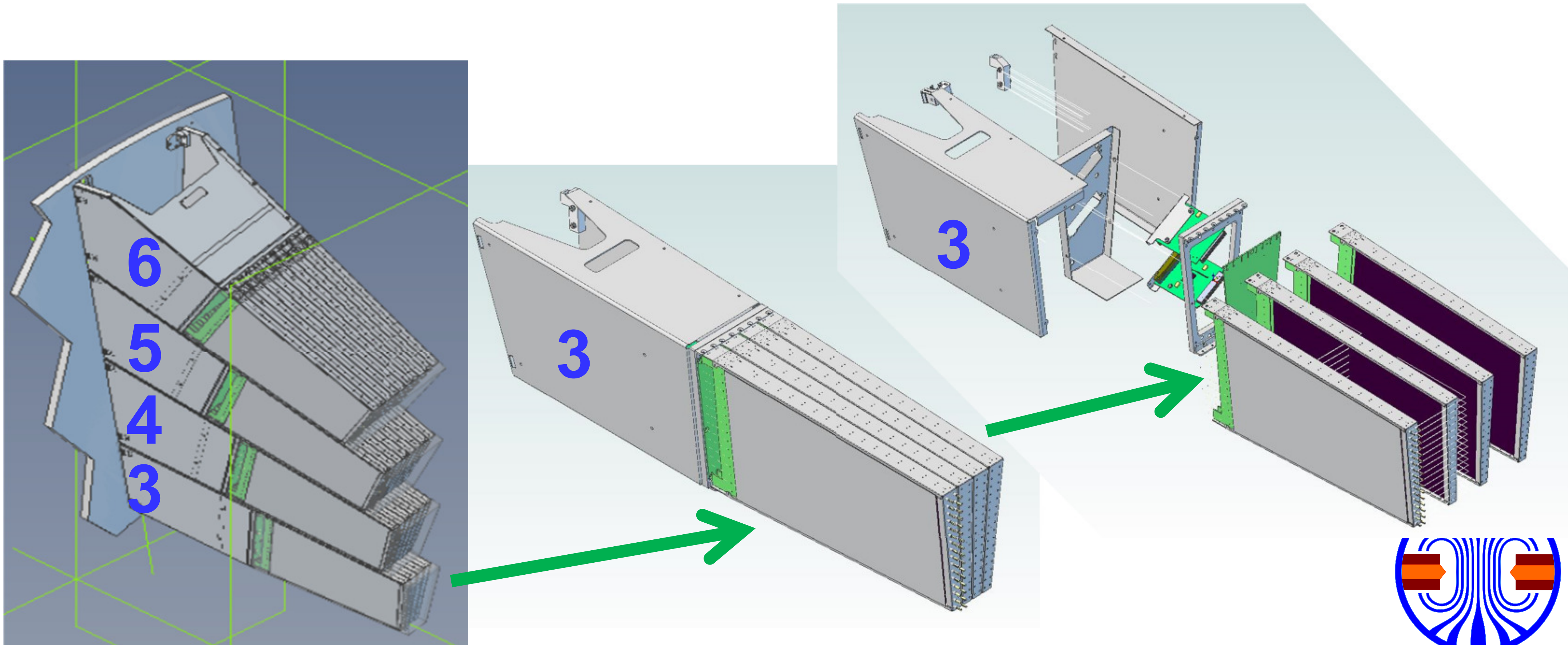
compared to POWTEX with 8 Boron layers !



DREAM End-Cap, hundreds of individually designed parts !

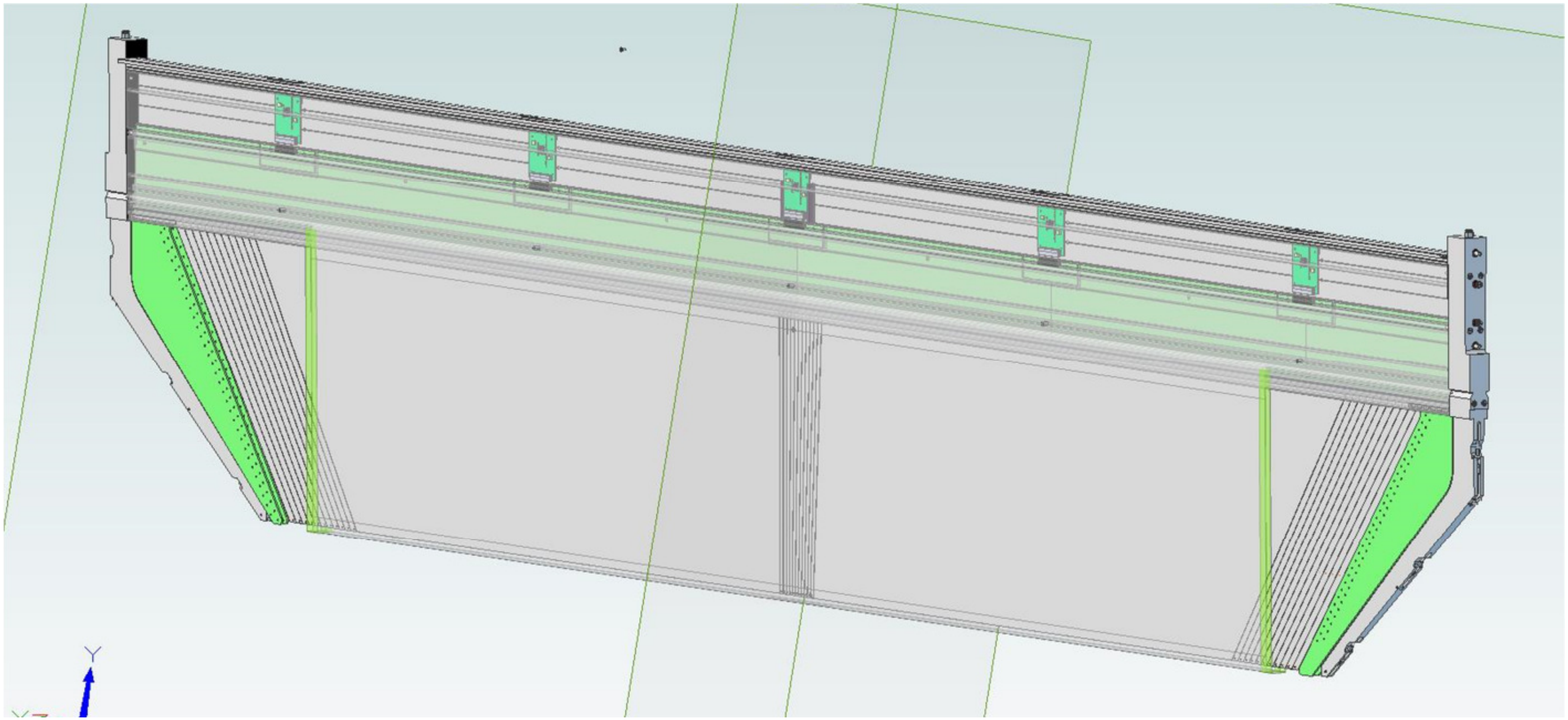
- **End-cap engineering design finished, all parts in procurement:**
  - 12°-Segment substructured in 4 submodules, anode-wires oriented towards sample.
  - Design exploiting all previous POWTEX experiences.
  - 4 more Boron layers → more efficiency!
  - 10° inclination in φ → detection efficiency + avoid blind area!
  - 10° inclination in 2θ → avoid blind area between submodules!

assembly to start subsequently



DREAM mantle detector, segments 3400 mm long !

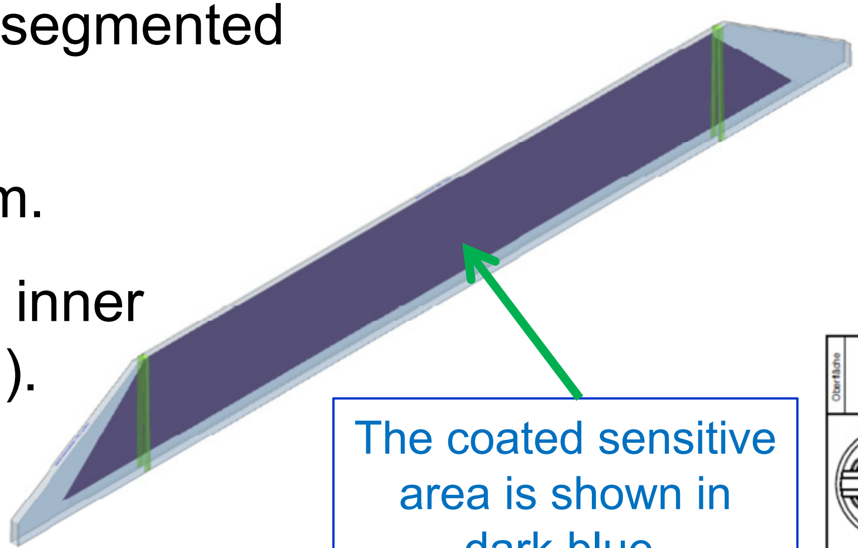
- **Mantle engineering design finished now in September 2018:**
  - Design exploiting all previous POWTEX experiences.
  - 2 more Boron layers → more efficiency!
  - 256 cathode and 64 anode readout channels: 5 ASIC chips per segment.
  - 10° inclination in φ → detection efficiency + avoid blind area!



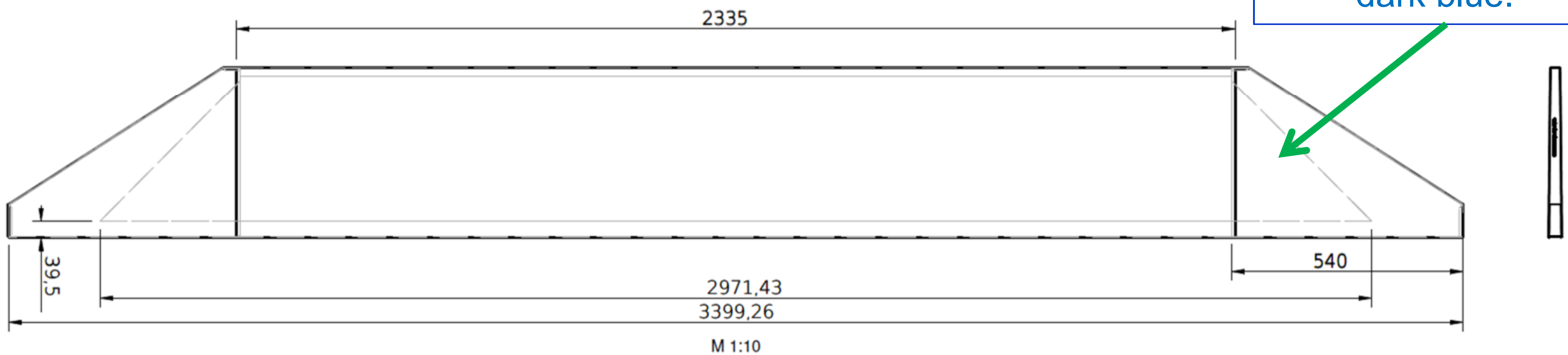
Design enhancements and challenges (compared to POWTEX)

Larger inner diameter of the entire instrument: 2200 mm (versus 1600 mm):

- Results in 3400 mm long detector segments.
- Coated hood for mantle detector will be realized segmented for the 0-series.
- Current max. available coating length is 2400 mm.
- For a start, hood will be realized with one central inner part and two small side parts (individually coated).

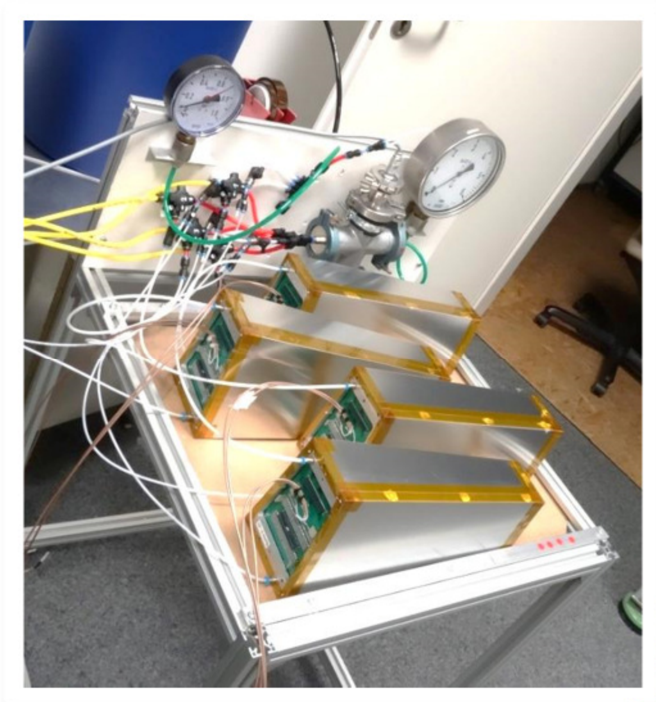


The coated sensitive area is shown in dark blue.

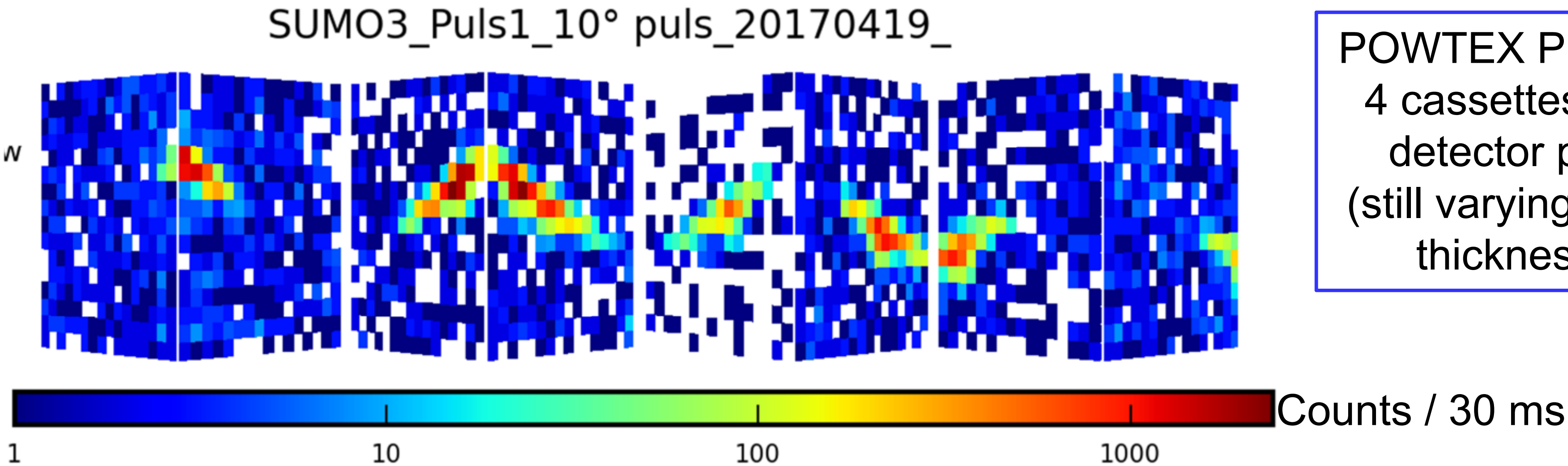


Current Detector Production at CDT GmbH

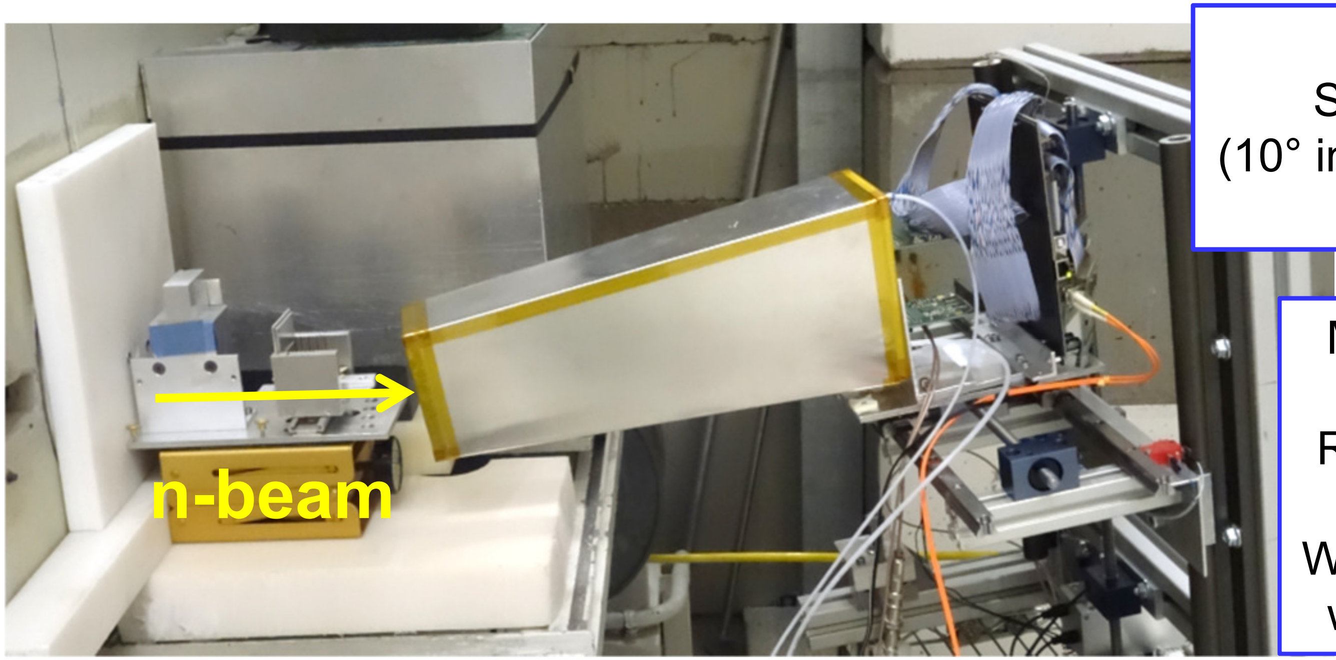
- 0-series end-cap production for DREAM will fit seaming-less into the end-cap production of POWTEX.
- Current capacity: 4 SUMOs per week.



End-Cap Concept Successfully Verified



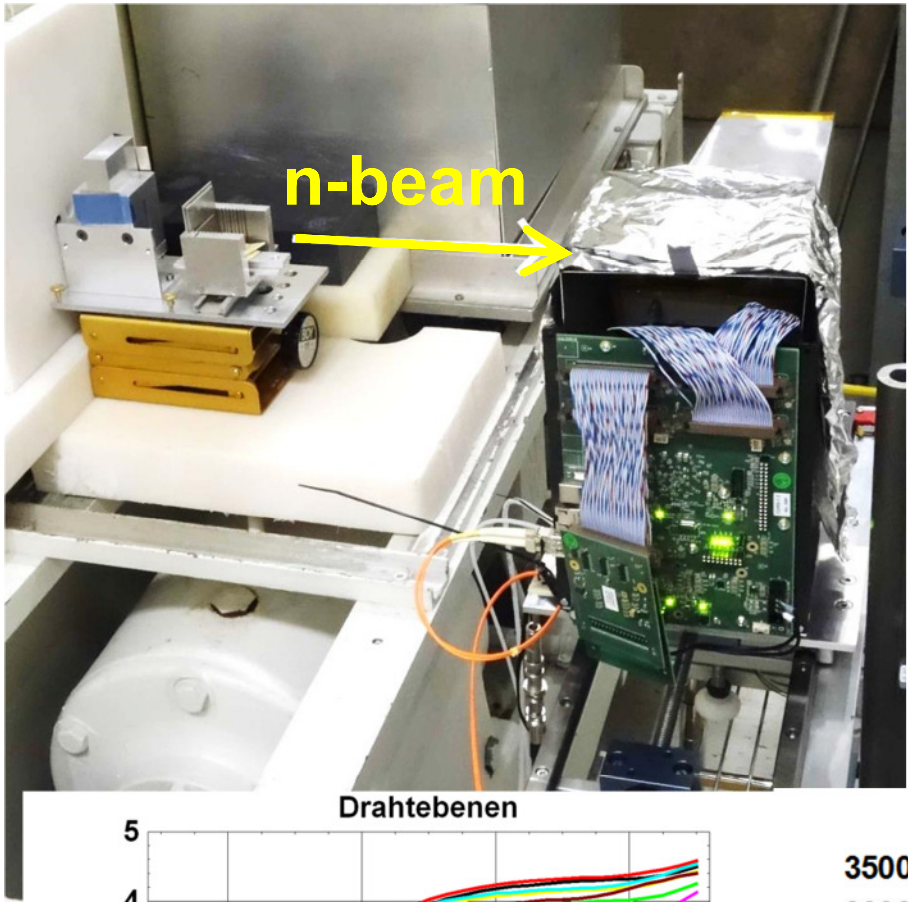
POWTEX Prototype:
4 cassettes with 8
detector planes
(still varying coating
thicknesses)

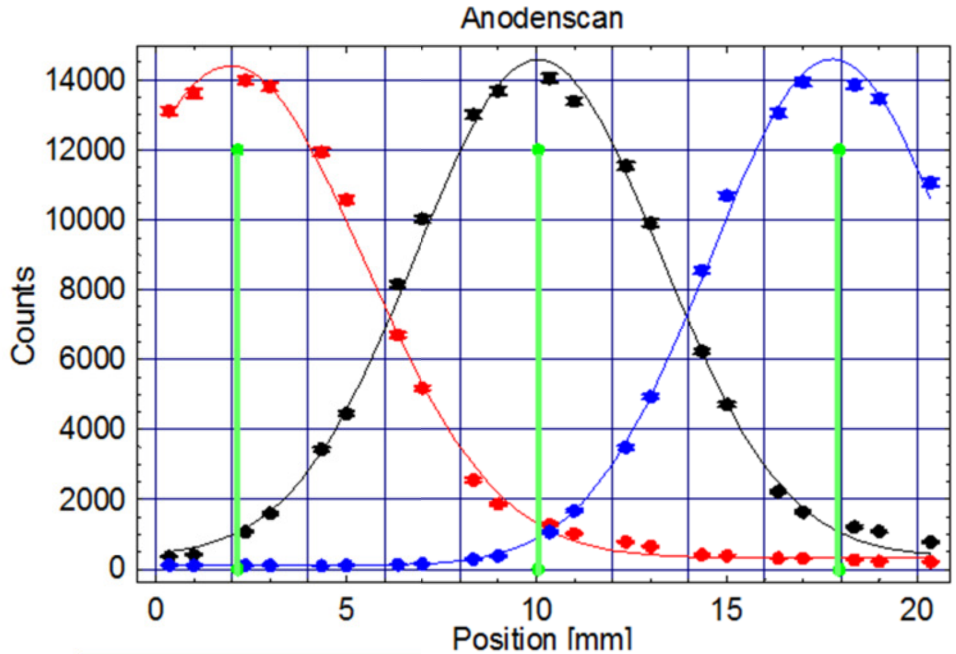


Prototype of POWTEX
Submodule 3 in the direct beam
(10° inclination) at Mainz TRIGA Reactor:
250 MW for 30 ms!

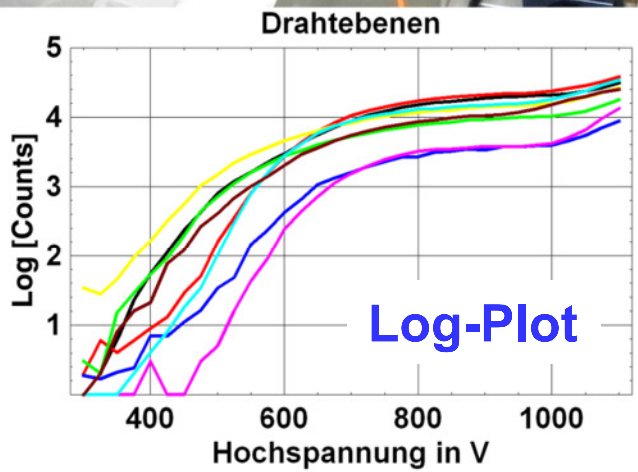
Many thanks to Carina
Höglund and Linda
Robinson from the ESS
Detector Coatings
Workshop for helping out
with the $^{10}B_4C$ coating!

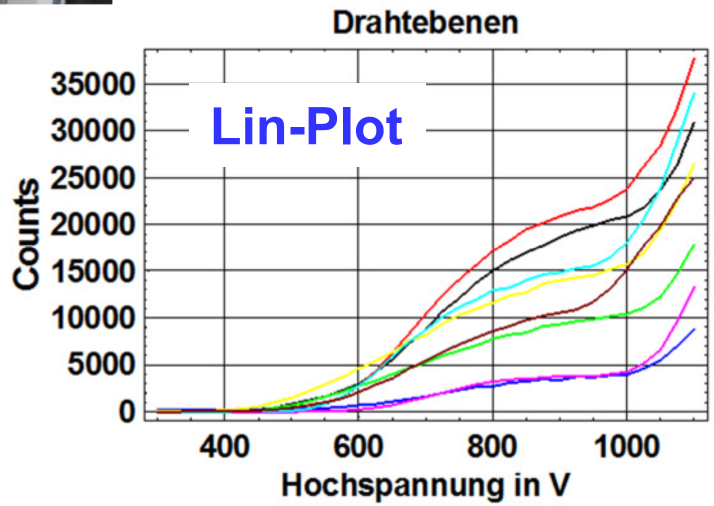
End-Cap Concept Successfully Verified





determined 2Θ resolution FWHM:
(6,5 ± 0,4) mm ⇔ (0,38 ± 0,02)°

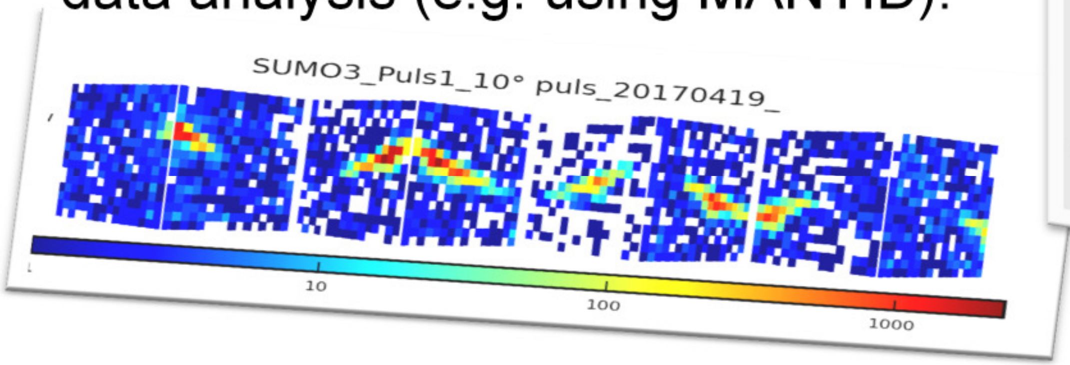


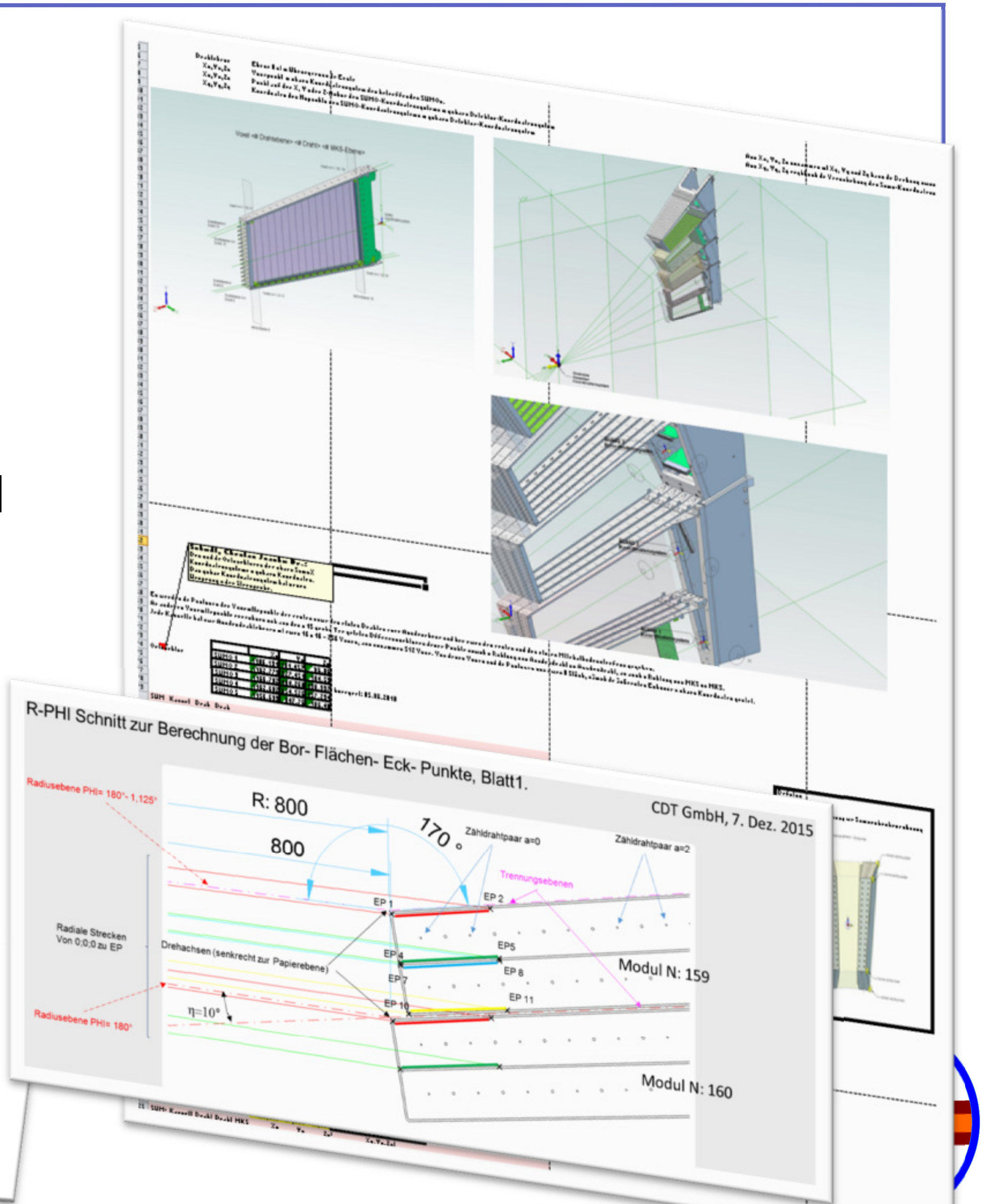


High voltage plateau:
850 - 950 V.

3D-Volume Detector Needs Map of Voxelpositions

- 572229 voxel/sr (mantle detector) and 309239 voxel/sr (end-cap detector)!
- Need to know where they are!
- Python script developed as computer generatable voxel map.
- Deduced from principles of design and voxel segmentation.
- Voxel corner positons as function of integer readout voxel addresses.
- Direct ingredient for simulation as well data analysis (e.g. using MANTID).





Fully parameterized, Python-enhanced CAD

Our CAD-System provides a Python interface and allows fully parameterized design flow so that:

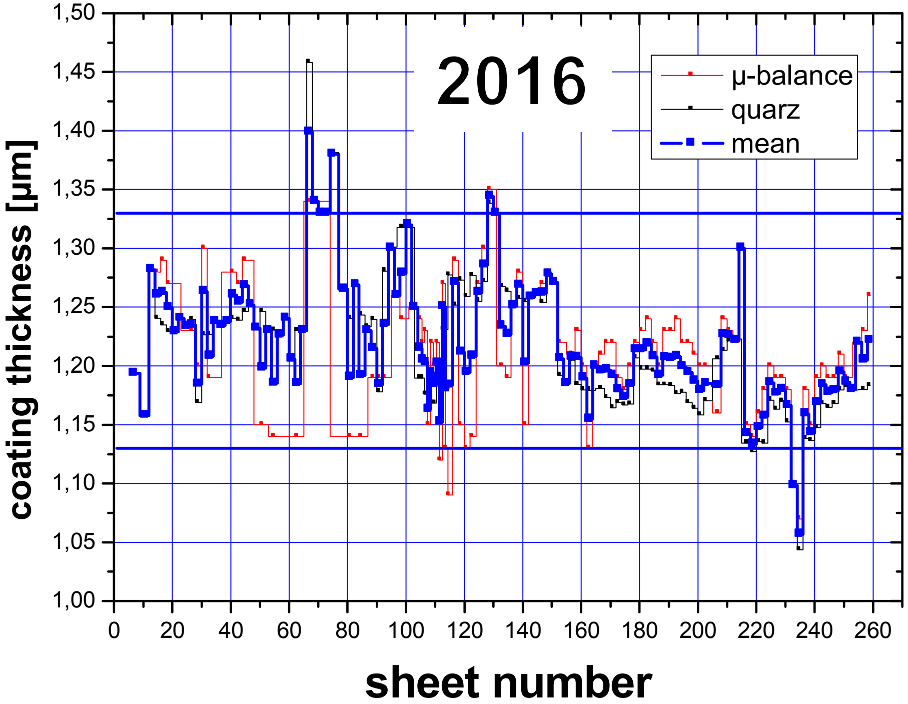
- Fundamental CAD reference points of construction can be generated in CAD-talk via a python script.
- The individual sub-designs deduced from these reference points can be fully parameterized.
- From DREAM to MAGIC as well as HEIMDAL:
  - this will accelerate the needed re-design and
  - guarantee continous design quality.
- Finally, the Voxel Map may be deduced from the resulting design faster.

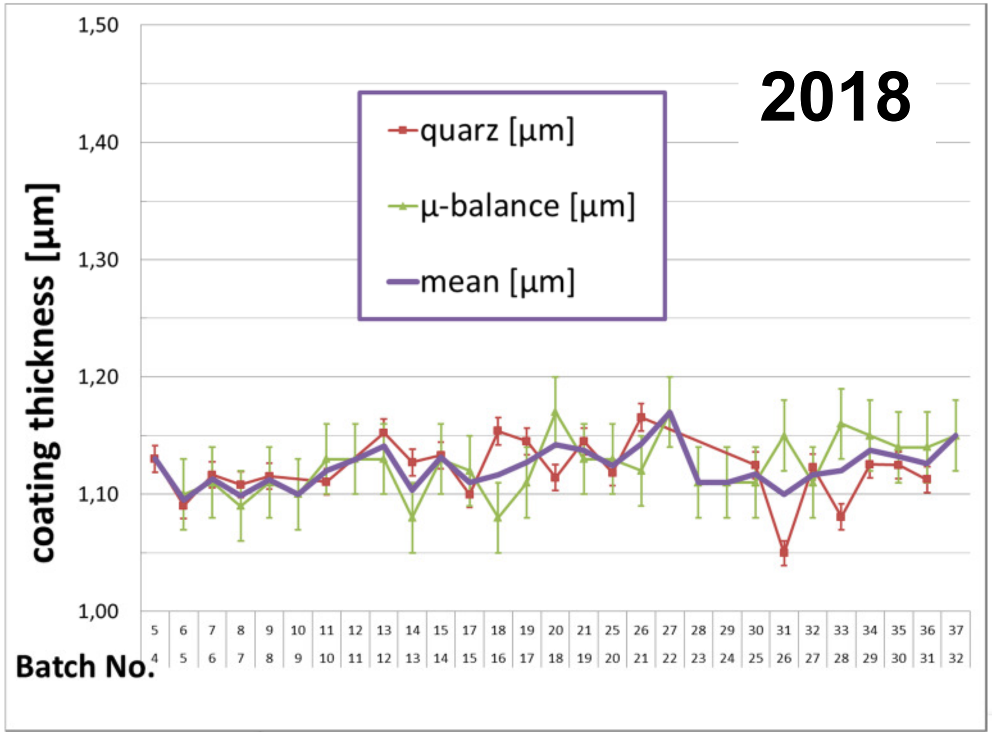
POWTEX Mantle Detector production finished Q1 2017!

The entire POWTEX Mantle Detector stored at CDT in transport boxes:
Waiting to be shipped and mounted at FRM-II East Hall!

DREAM Mantle Detector Parts-Procurement and Production to start November 2018

$^{10}B_4C$ Coating Process Improved: from POWTEX to DREAM

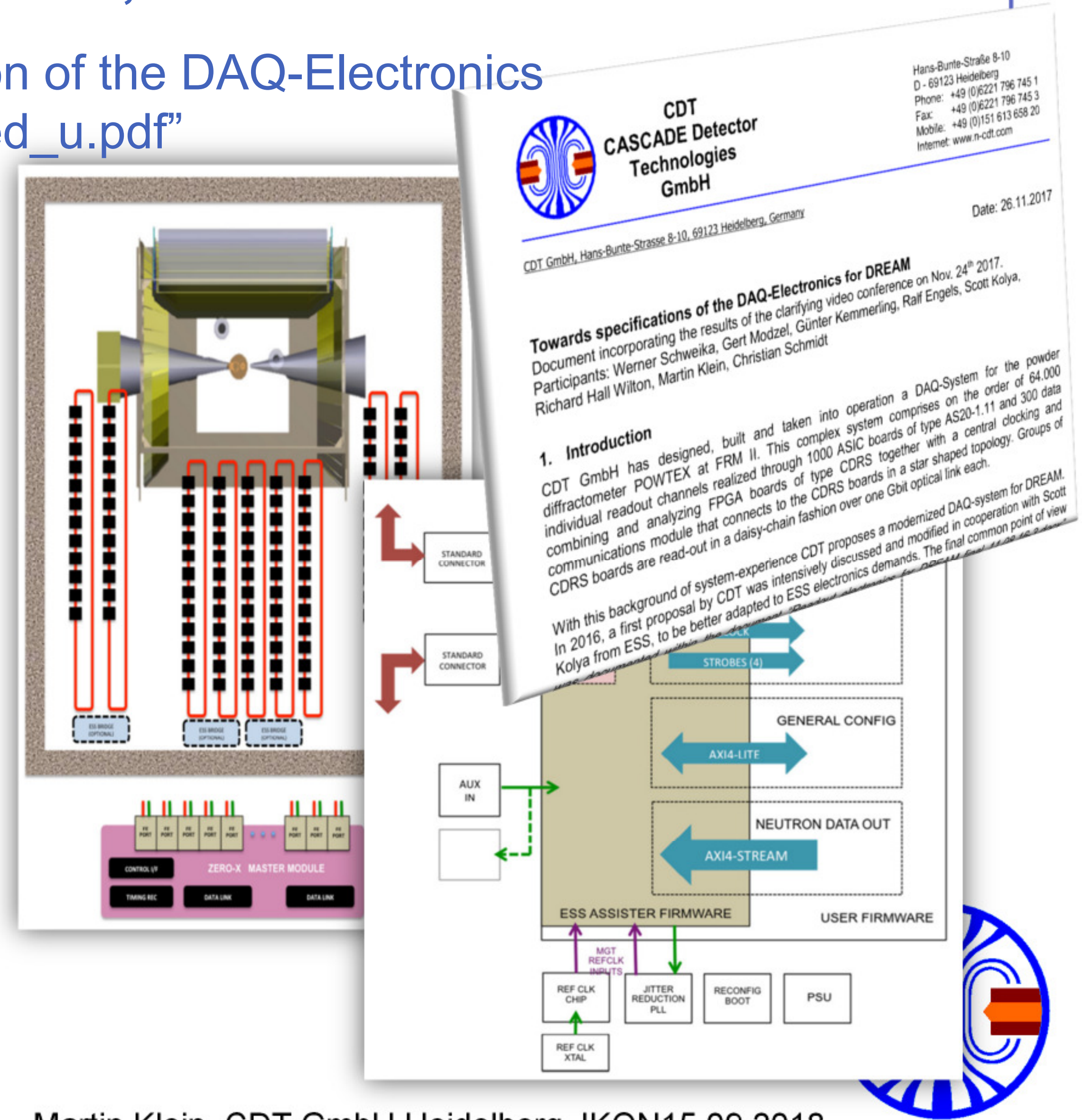




- Coating at S-DH: our neighbor and expert in neutron guides.
- S-DH has developed further its coating process on their large sputter plant (more than 10m long):
  - much more homogenous and reproducable.
  - even neutron guides are now produced there.
- Movatec in Munich as a further new supplier is currently under our evaluation.

Towards the DREAM Readout Electronics

- Specifications and documentation of the entire readout scheme iterated and agreed upon between ESS, FZJ and CDT.
  - Documented in „Towards specification of the DAQ-Electronics for DREAM 24.11.17-Minutes_iterated_u.pdf"
- Conceptual scheme along CDT´s previously developed system concepts.
- Fully consistent with ESS demands and integration needs.
- Schematics done, prototyping and zero-series for DREAM this year.
- Need ESS Zero-X Master Module and ESS Assister Firmware.



Conclusions

- DREAM Engineering ongoing full blast and almost finished.
- Modern fully parameterized CAD concepts employed.
- Blueprints of all parts of endcap detectors being generated and prepared for procurement, assembly subsequently
- Will interleave coating and assembly of DREAM 0-series with ongoing production.
- Targeting evaluation beamtime May 2019.

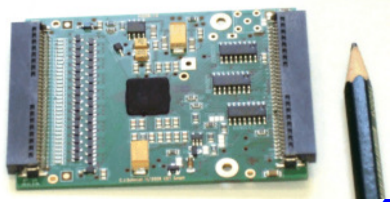
Backup Slides

CDT CASCADE Detector Technologies GmbH

- Founded in 2006 as spin-off of Physikalisches Institut Heidelberg
- Focus: ^{10}**B based area detectors for thermal and cold neutrons as complete system solutions with electronics and software**

  - JALOUSIE detector, the alternative for ^{3}He PSDs
    large areas, medium resolution → POWTEX and DREAM
  - CASCADE 2D-200 – high rates GEM-based solution with extraordenary contrast of 10^5. → expansion to 2D-300 (300 x 300mm^2)

  - CASCADE-MIEZE – special variation to resolve 1MHz intensity variations
  - CASCADE-BM position sensitive Beam Monitors
  - UCN detectors
  - ASIC and FPGA-based multi-channel readout electronics

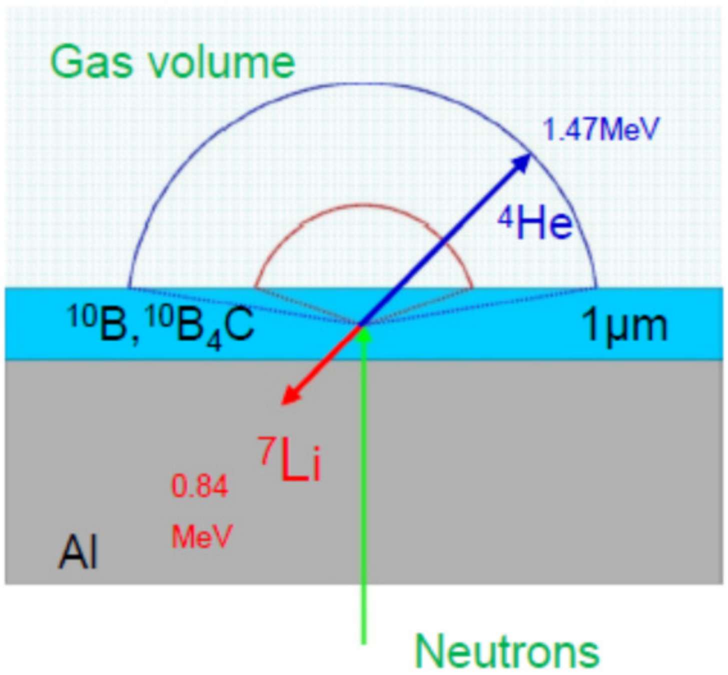


- Customers: FRM-II, FZJ, ESS, PSI, ILL, KIT (IBR-II), IHEP (CSNS, China), KEK & JAEA (Japan) via REPIC, KACST (Saudi Arabia),

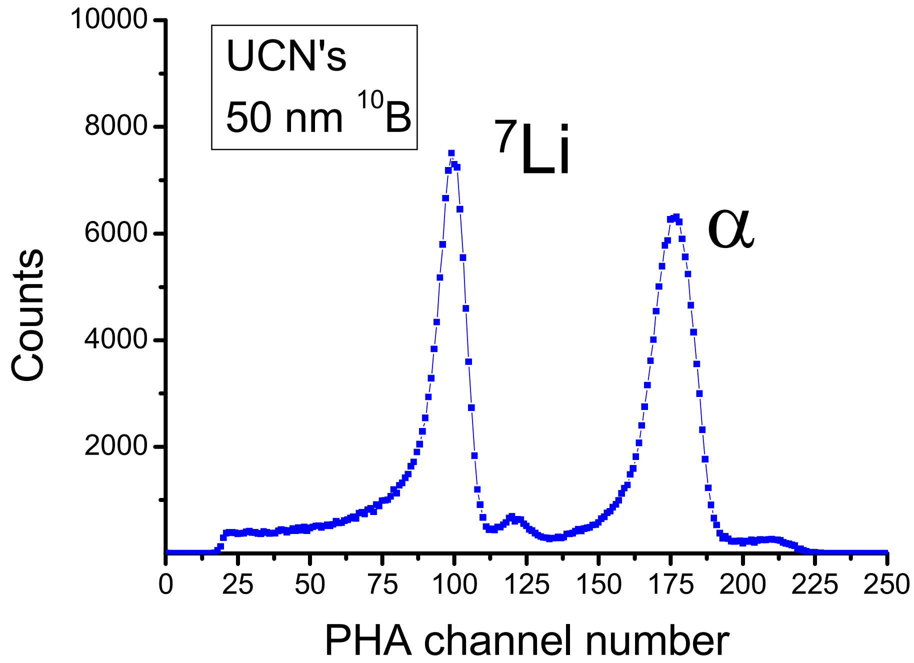
Neutron detection with ^{10}B converters

$^{10}B + n \rightarrow {}^{7}Li\ (1.02\ MeV) + \alpha\ (1.78\ MeV)$ (6%)
$\rightarrow {}^{7}Li\ (0.84 MeV) + \alpha\ (1.47\ MeV) + \gamma\ (0.48\ MeV)$ (94%)
3838 b (1.8 A)

- ^{10}B and $^{10}B_4C$ are stable, inert (compared to BF_3) and non hygroscopic (as e.g. Li, BF_3)
- > 96% enriched ^{10}B available (large industrial demands for ^{11}B)
- large charge-signal inside detector
- Ranges of α (3.14 µm) and ^{7}Li (1.53 µm) limit single layer detection efficiency to ~ 5% for thermal neutrons at vertical incidence

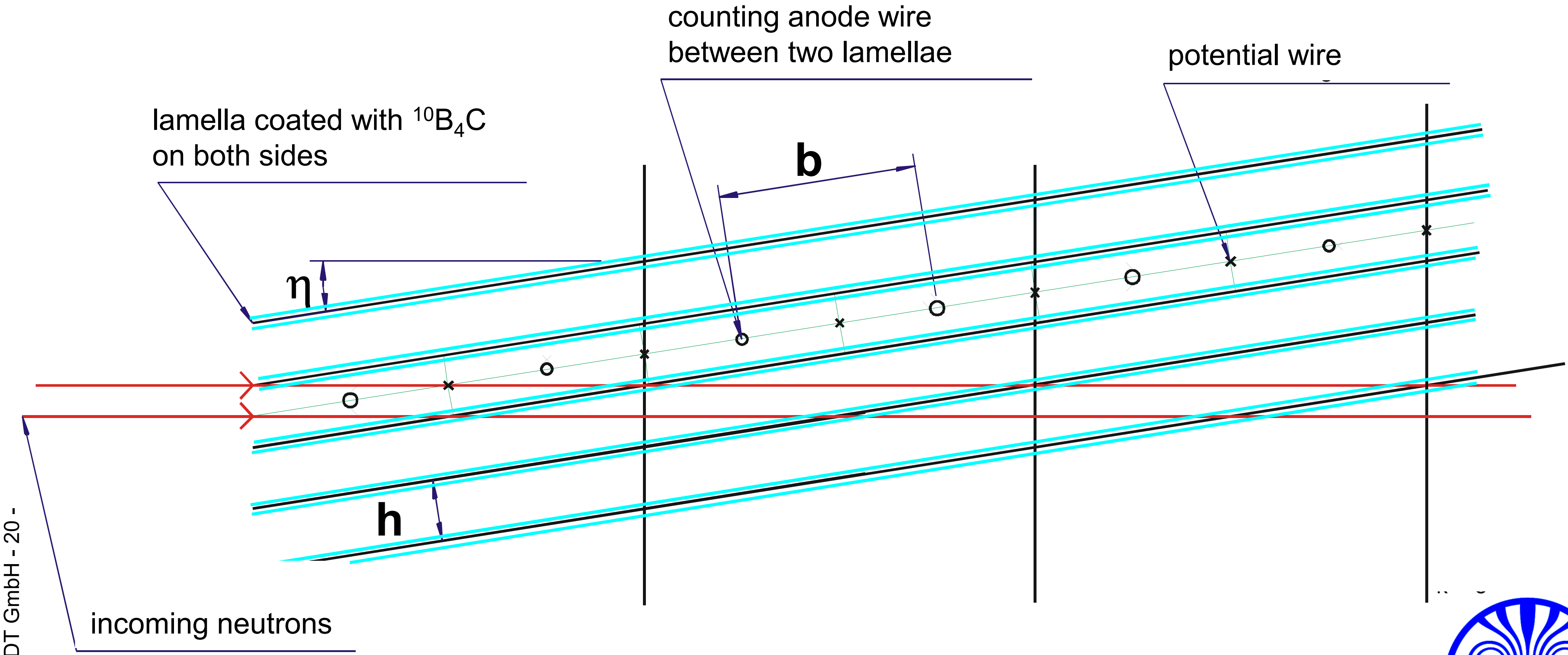


picture from K. Zeitelhack, FRM 2



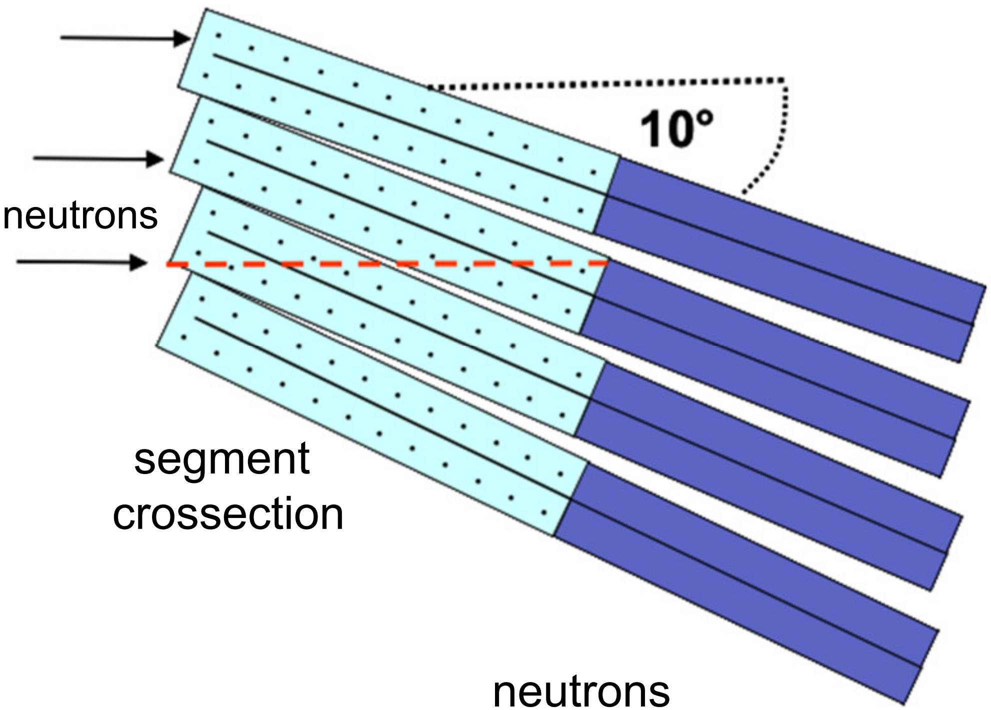
Jalousie: Detector Concept – neutrons at scraping incidence

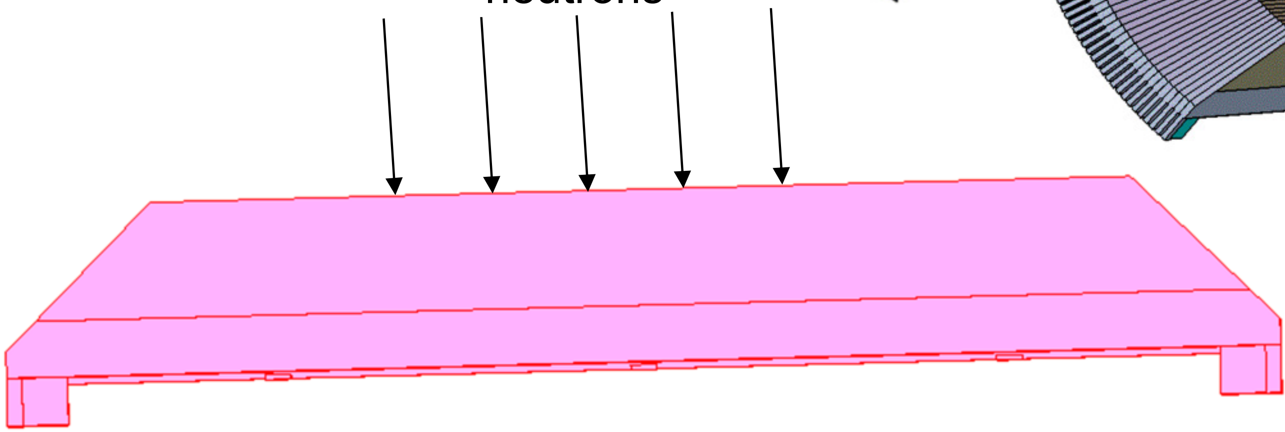
^{10}B-coated lamellae inclined to incoming neutron intensity at an angle of η = 10°



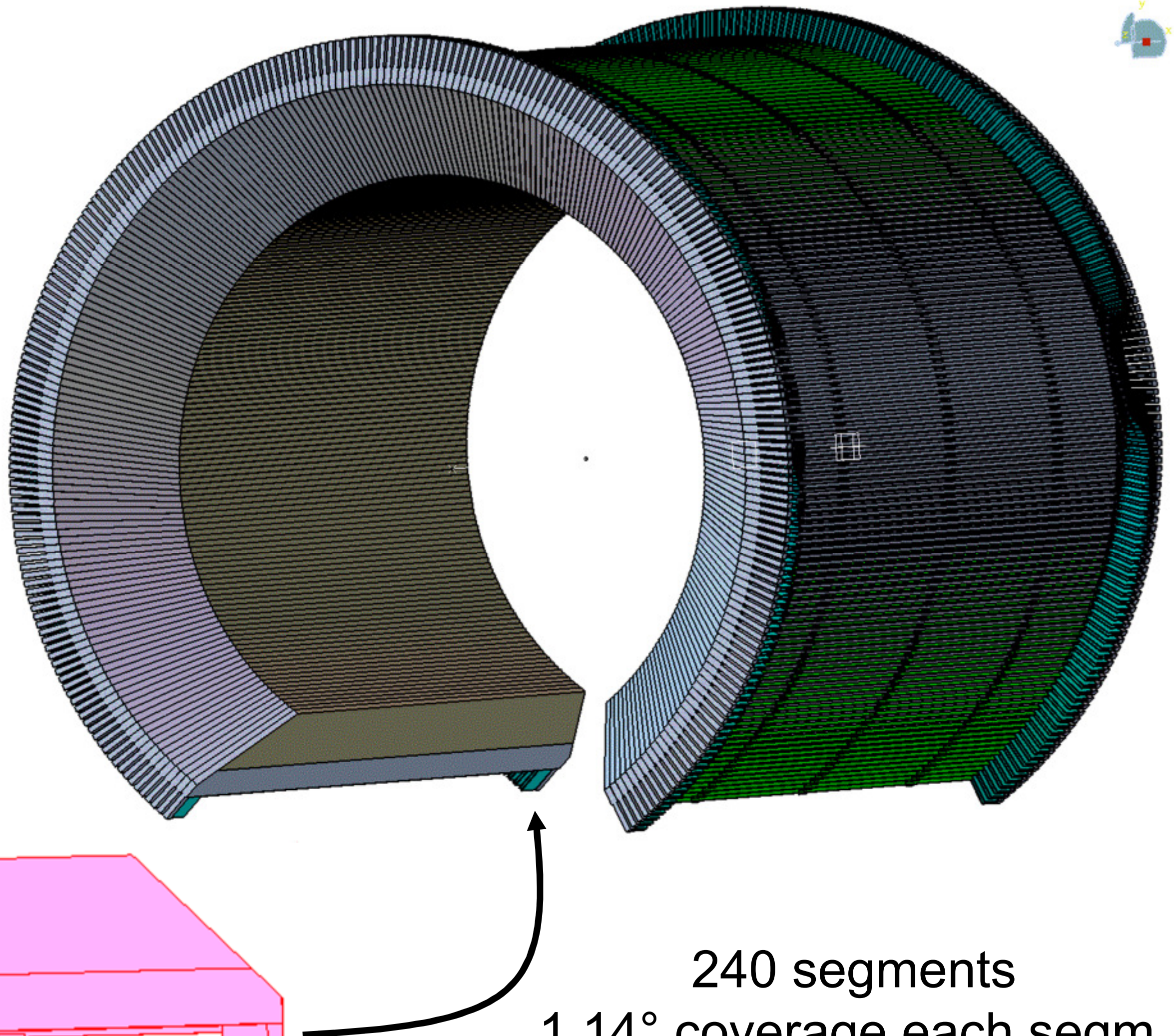
realized depth: 8 Boron/B_4C layers

Jalousie: Modular and Segmented for POWTEX Cylinder





segment side view, 1,6m active length



240 segments
1,14° coverage each segm.
cylinder inner radius: 80cm

All-active detector entrance area, no blind areas !

Projected Detection Efficiency at POWTEX

Efficiency as function of wavelength, η = 10°, 8 $^{10}B_4C$ layers