? could DIRC do something for volcanology ?

Geological subsurface investigation – the MagmaDIRC idea –



Logo courtesy of my old colleague Erik Etzelmüller

Klaus Föhl*

Rauischholzhausen
DIRC2019 workshop
12 September 2019

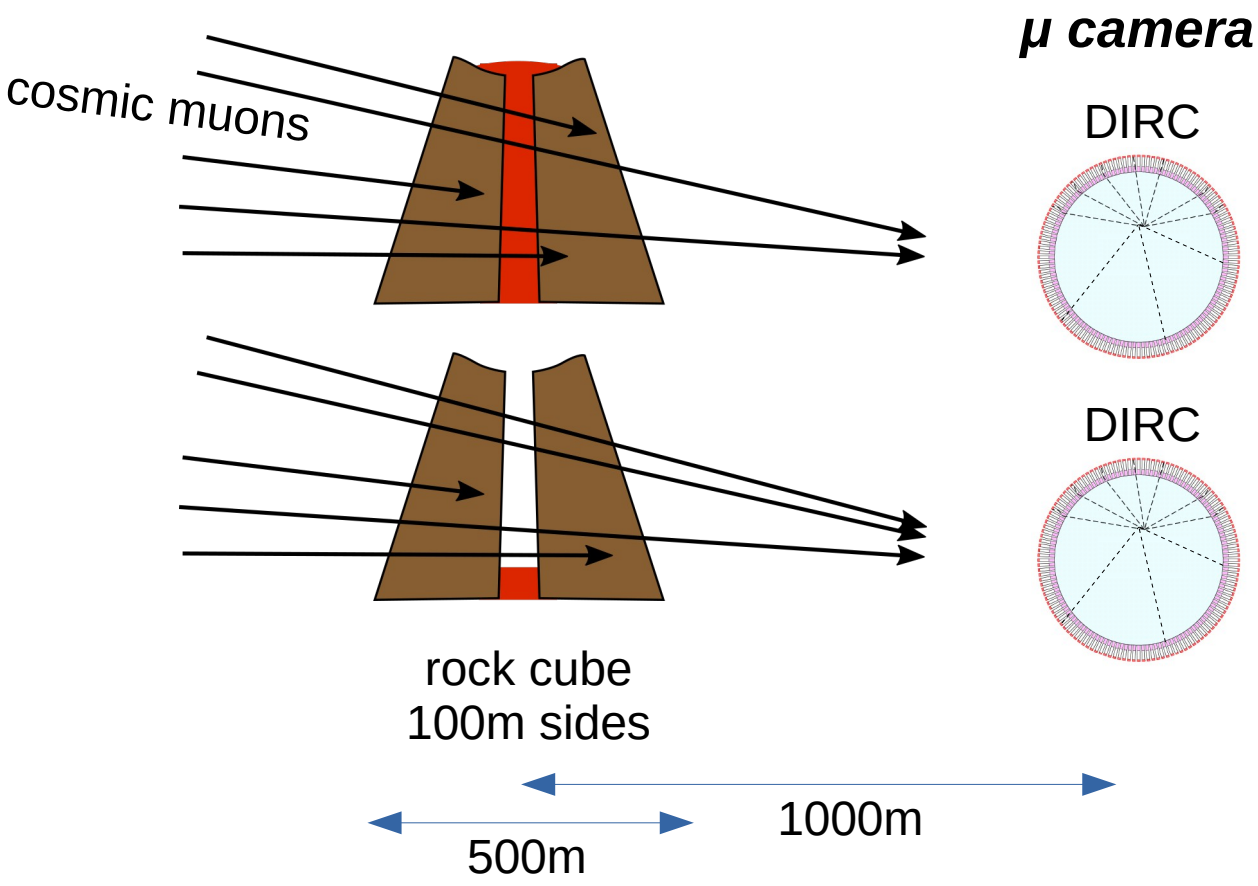
- An ATTRACT application
- Field measurement preparations
  - Simulations, locations, ambitions
- Outlook
  - Main proponent now at new site





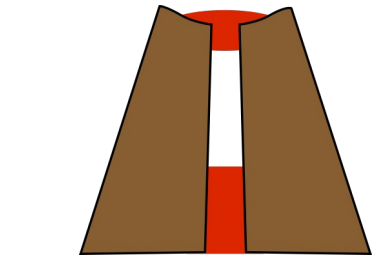
* previously with JLU Giessen, MagmaDIRC project leader, now with BGE (Bundesgesellschaft für Endlagerung)

MagmaDIRC idea

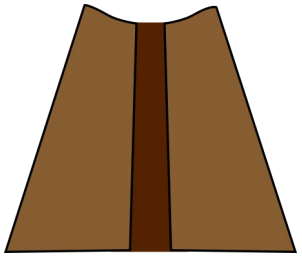


1 m² in 24 hours yields 6σ significance

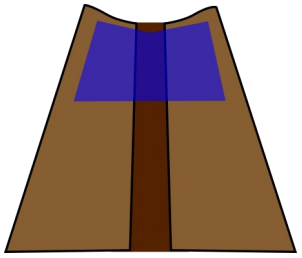
MagmaDIRC idea



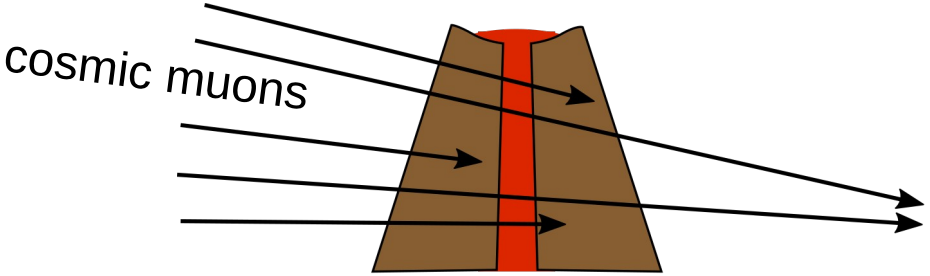
subsurface structure

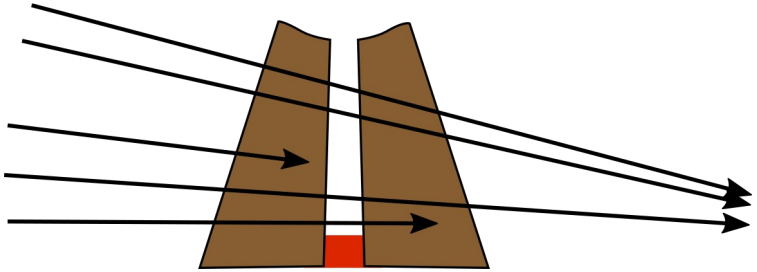


dense core

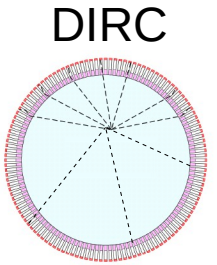


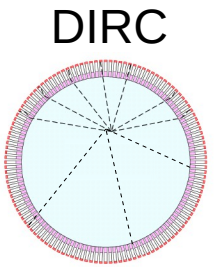
hydrothermal system

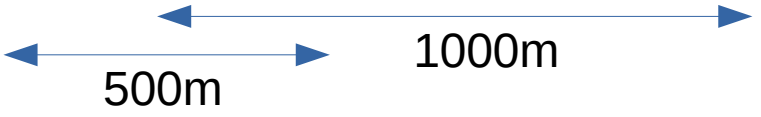




rock cube
100m sides

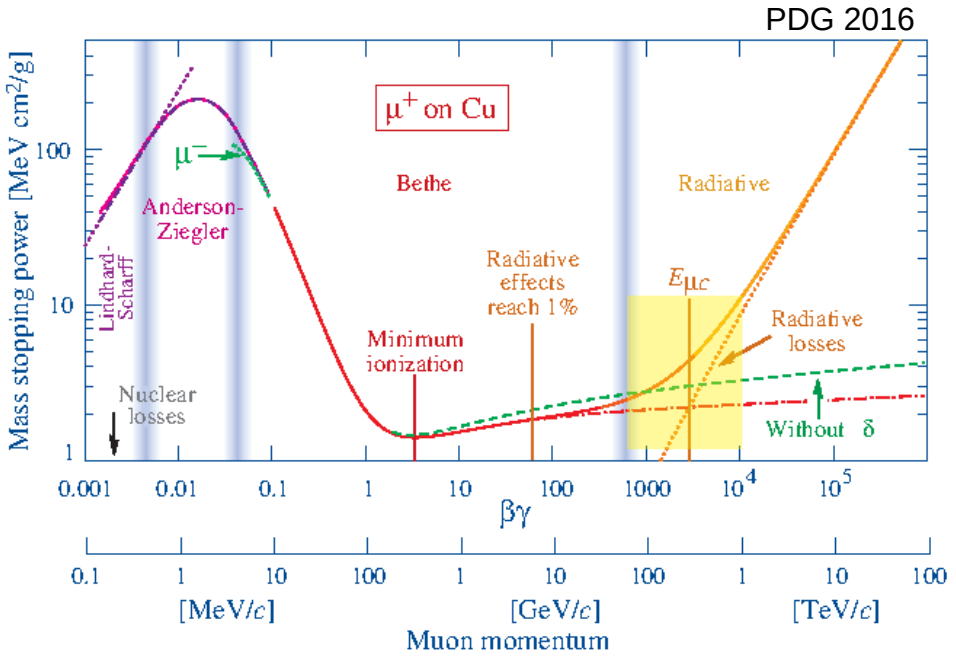


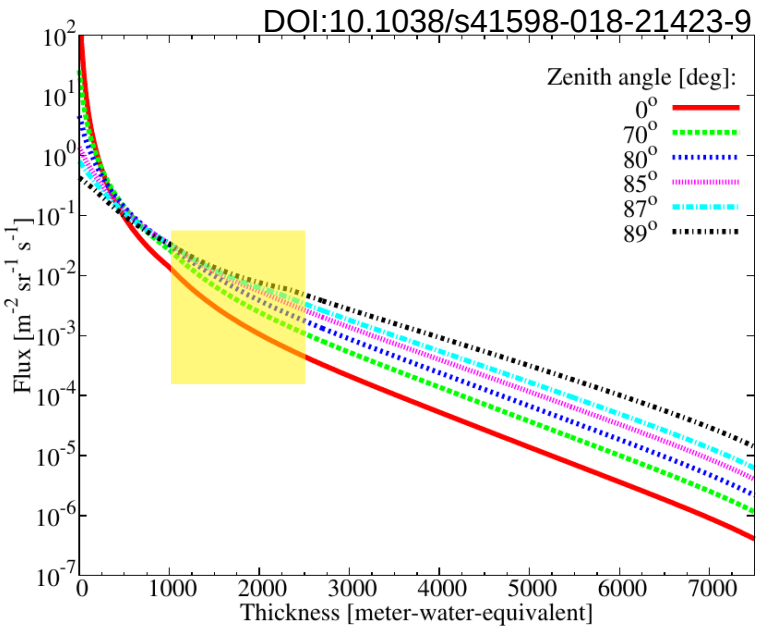


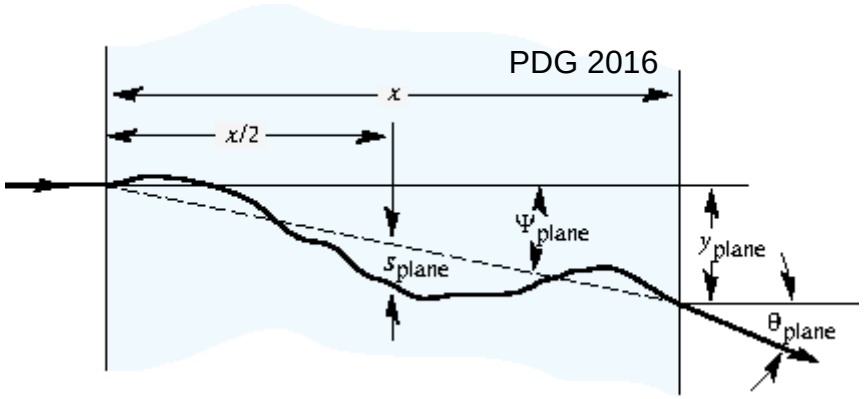


1 m² in 24 hours yields 6σ significance

Physics

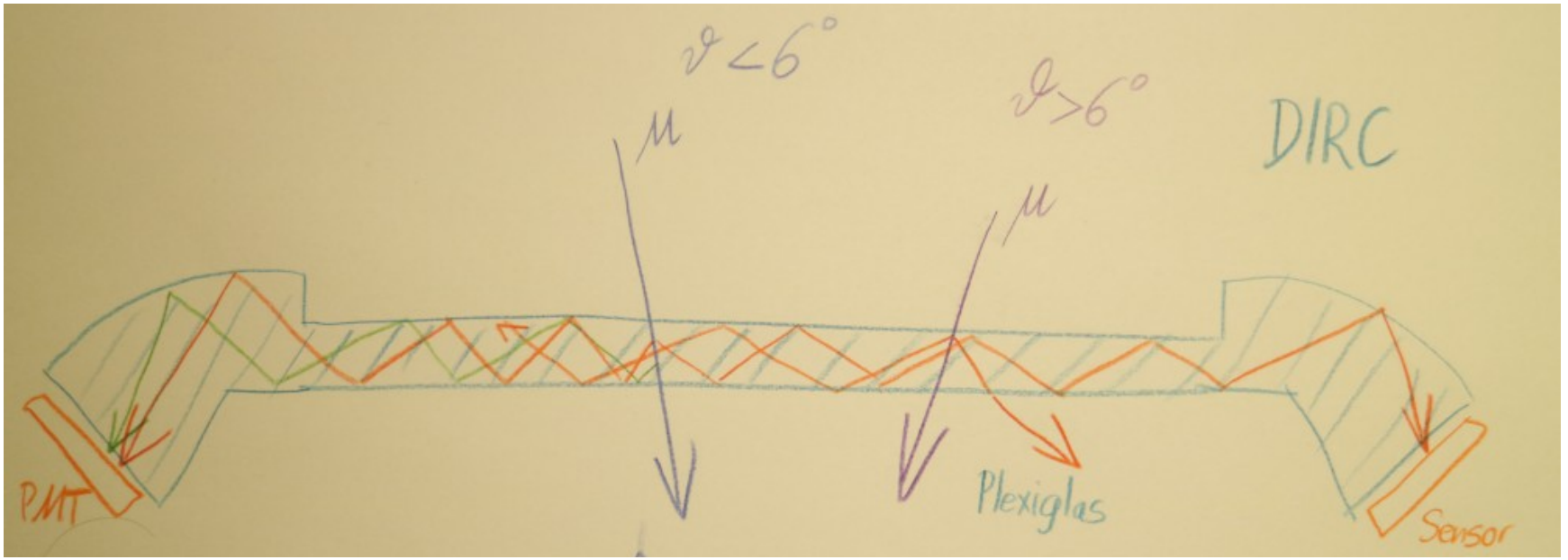


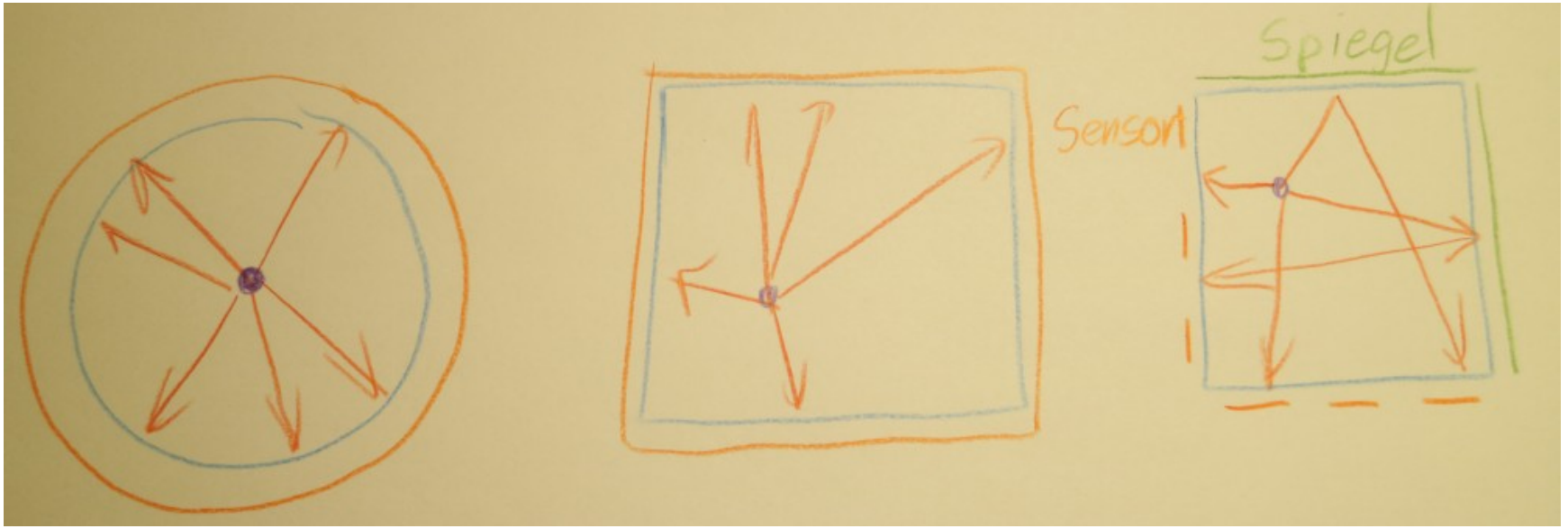




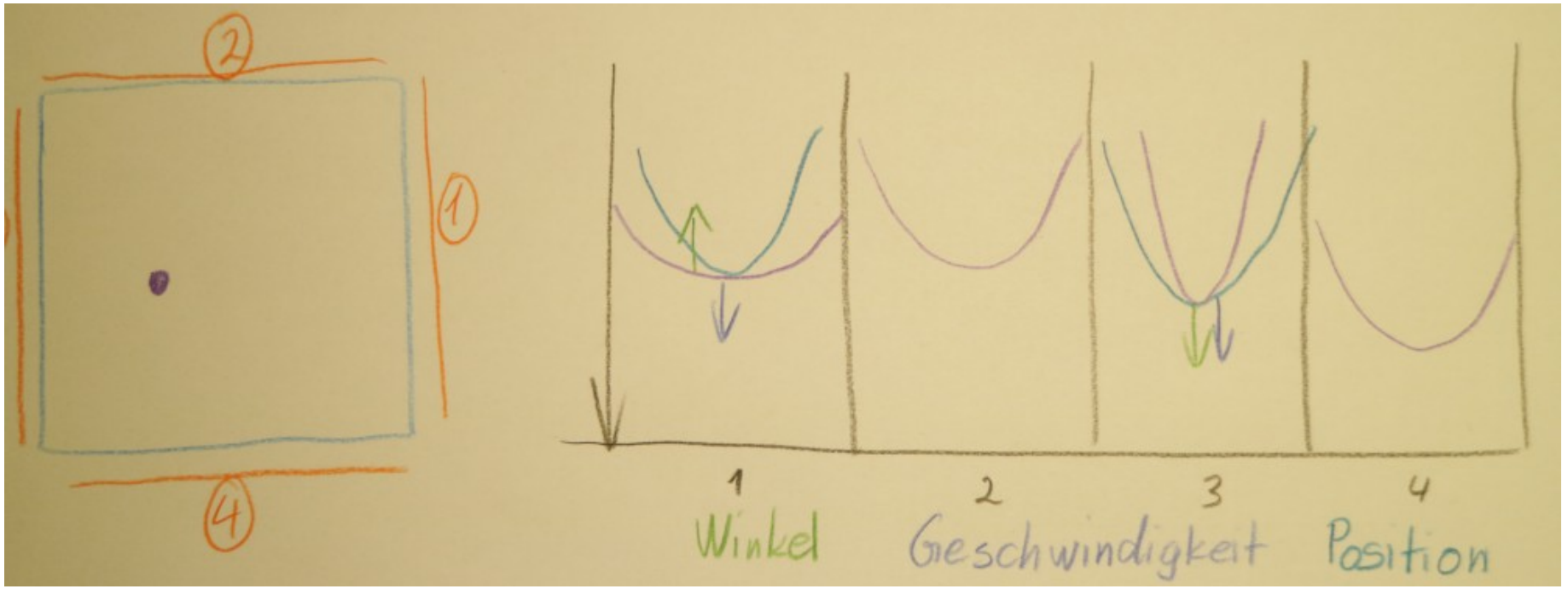
- Typical DIRC resolution
  - Intrinsically 1 to 2 mrad
- Aim at energy threshold T = 1.7 GeV
- Angular straggling
  - Threshold muons still have ~10mrad

Detection 101

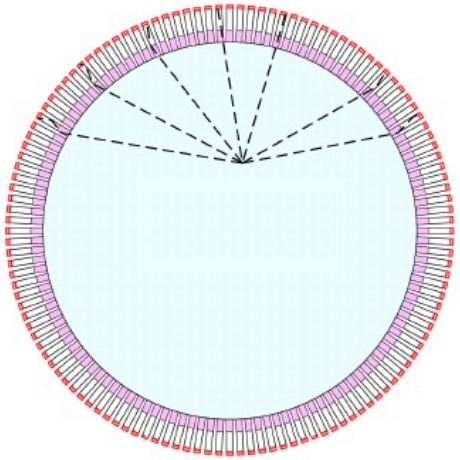




Detection 102

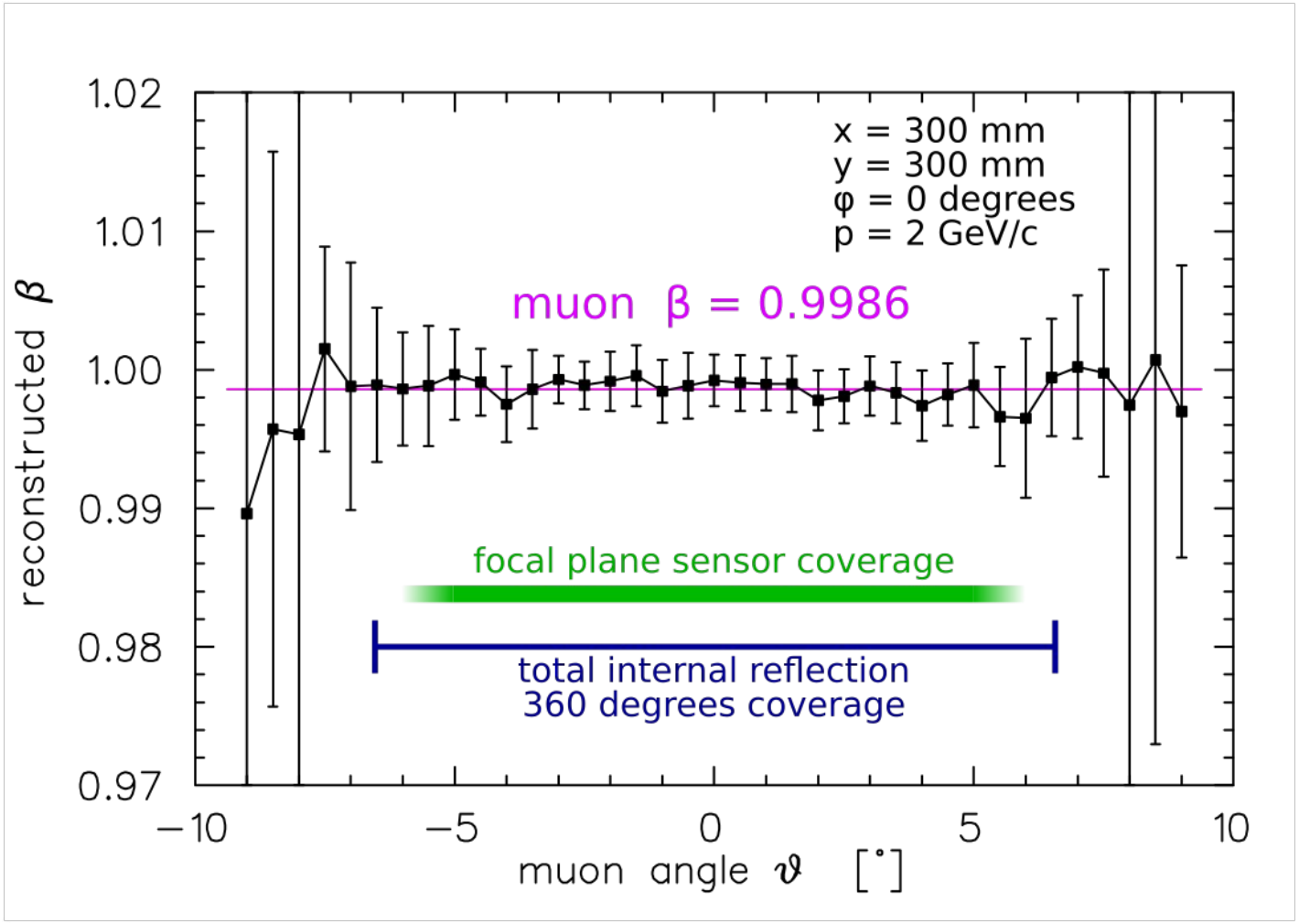


angle change **speed change** **position change**

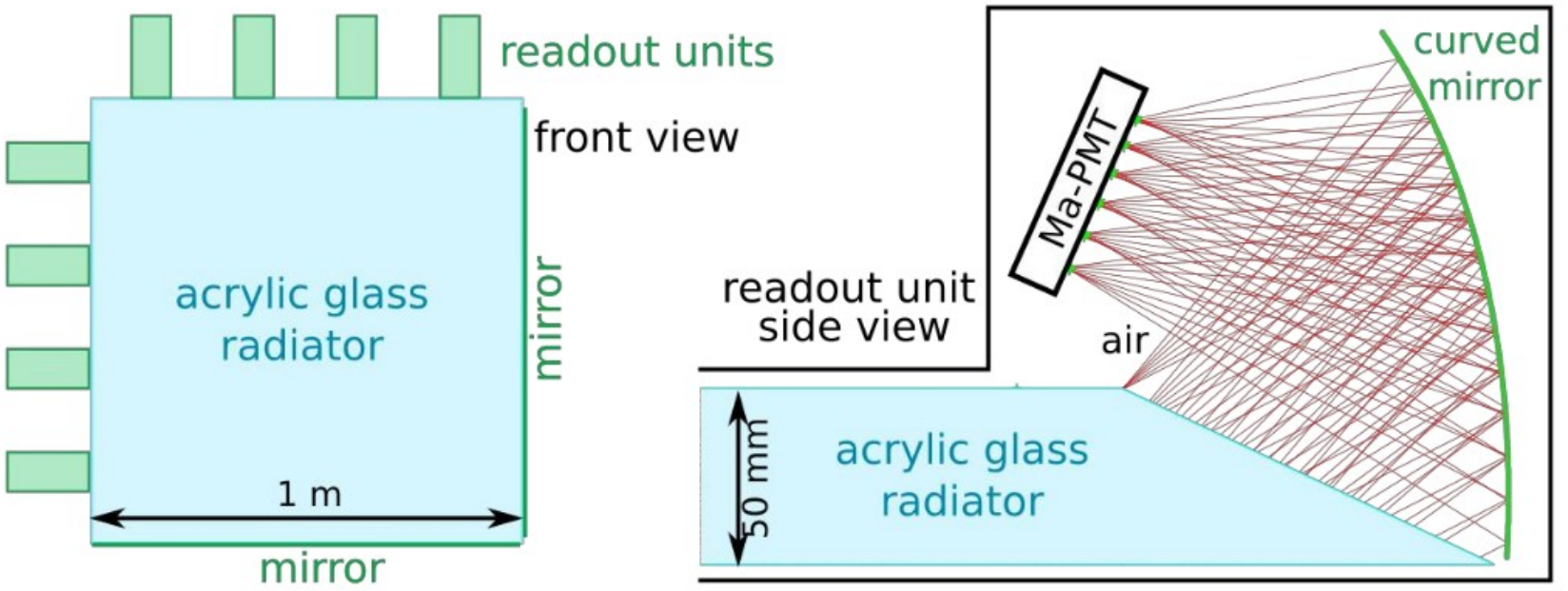


- 360° rim coverage
  - Then DIRC can be analysed stand-alone
  - β measured → energy threshold possible
- DIRC limited to ±6.5° acceptance
- Aim at 2 mrad resolution (particle, not photon)

MagmaDIRC performance simulations



MagmaDIRC technical idea

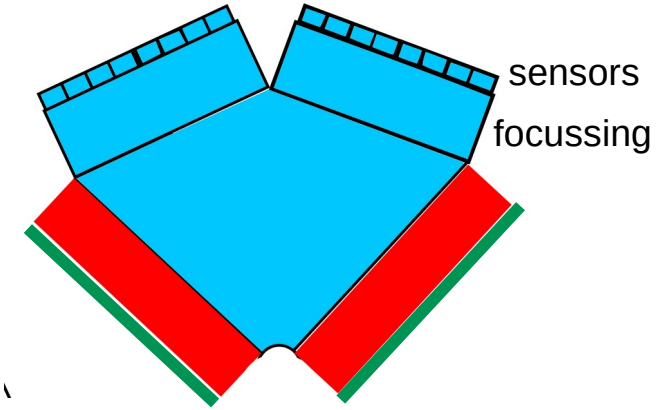


- Detector concept
  - Simple, rugged, inexpensive, lightweight, low power
  - Plexiglas radiator, mirror focussing through air
  - Sparse rim population with read-out units, mirrors

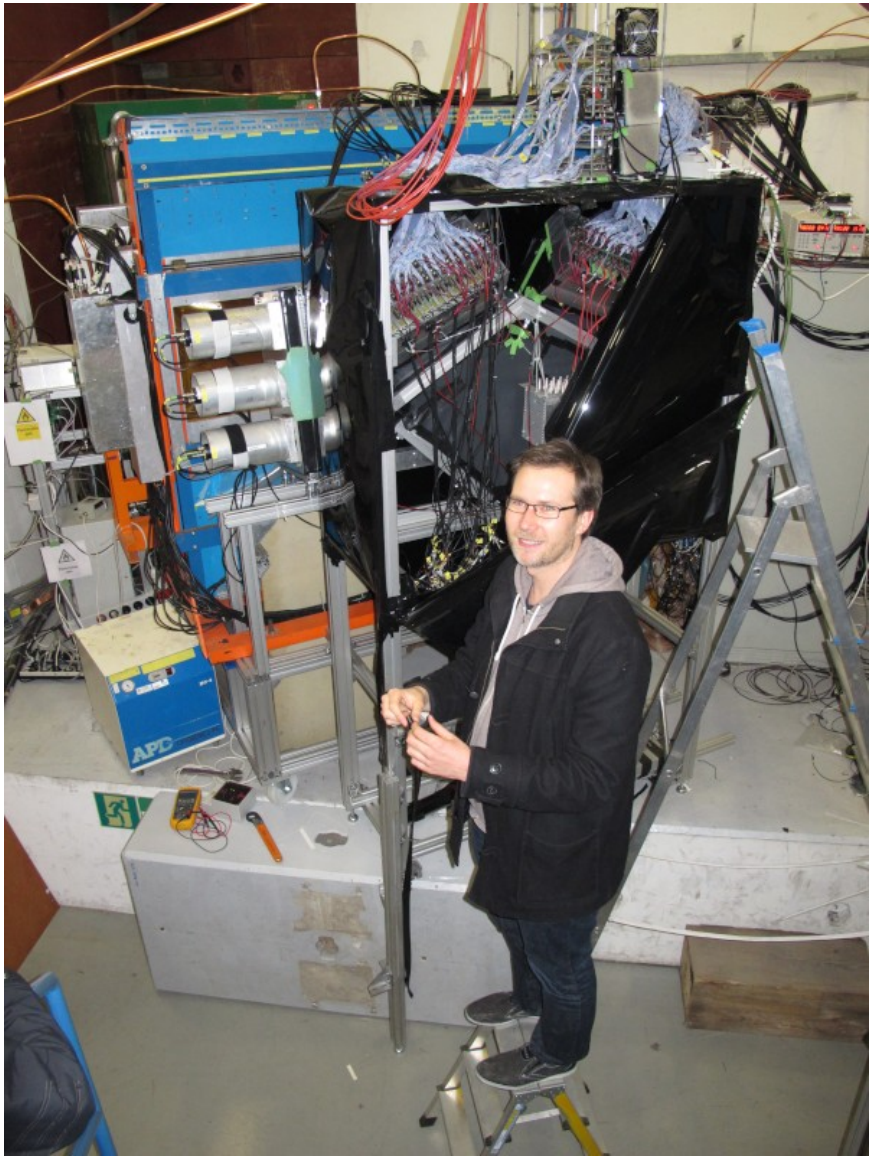
First: Proof-of-Principle

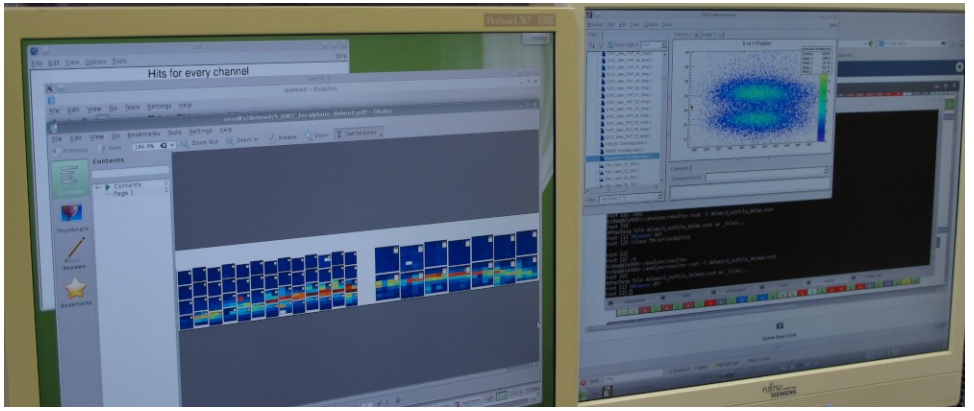
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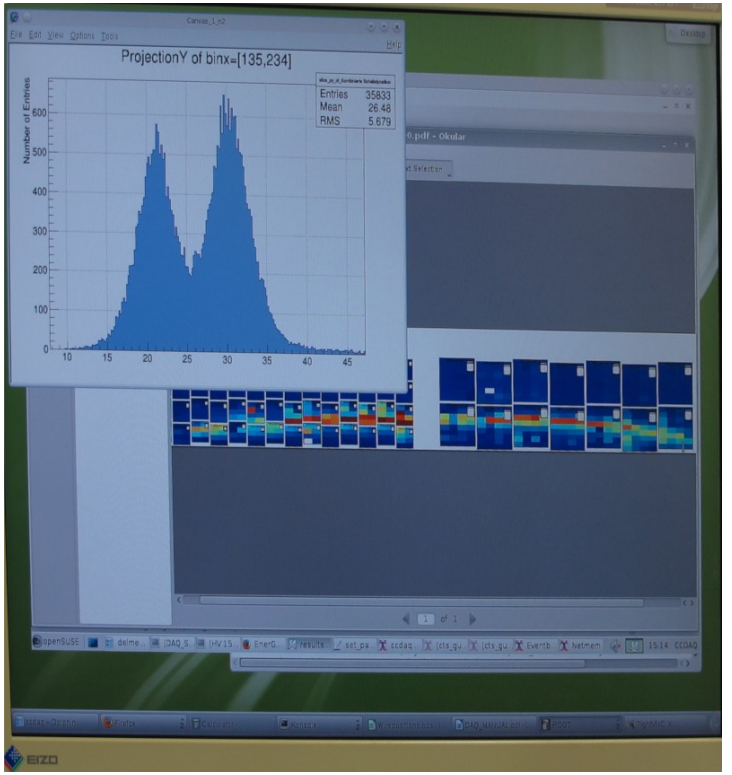
- Proposal of proof of principle
  - Existing WASA-DIRC prototype
  - Small mechanical modifications to function stand-alone
    - Extra distance for reflections
    - Vertical end surface with mirror



Erlangen DIRC prototype

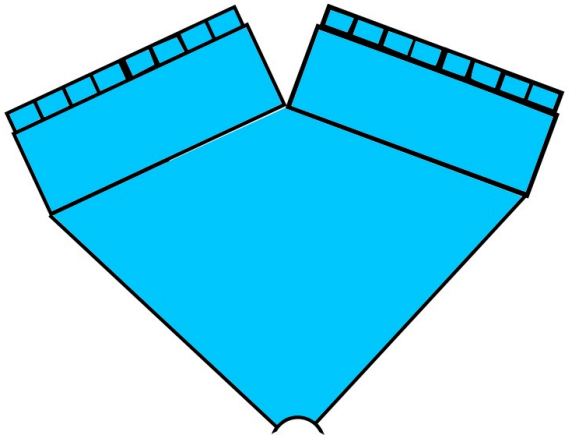




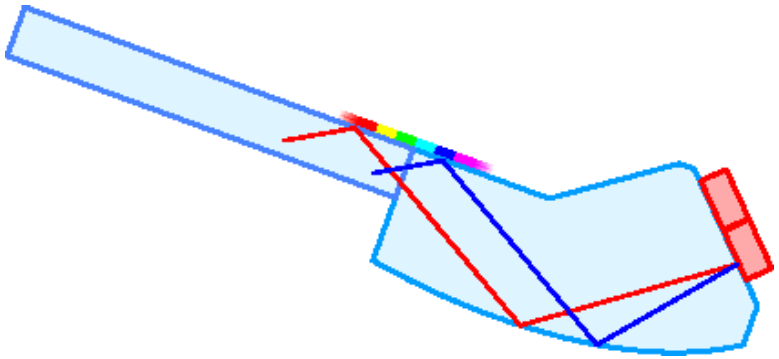


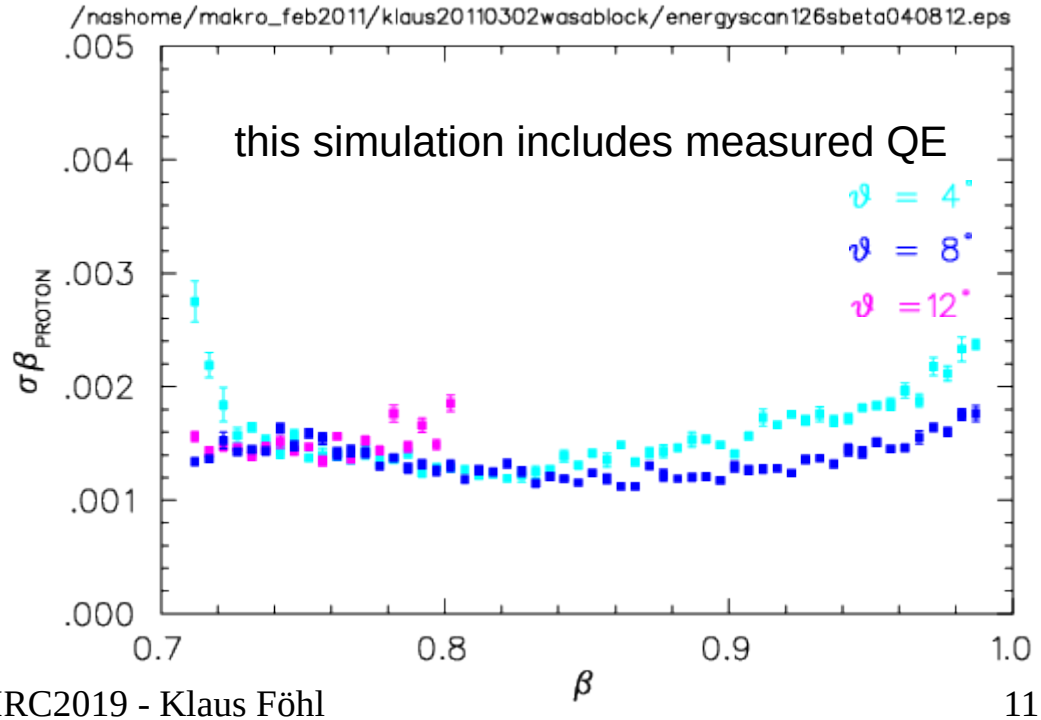
Erlangen WASA DIRC

- Erlangen:
- r=500mm, d=50mm
- theta=25-50 degrees
- FLG „Edinburgh“
  - 2x200mm, 1x400mm
  - total internal reflection
  - 7 mrad optical (sigma)
  - 8 mrad pixel equiv.
- 333mm width needed



- Erlangen:
- better phi resolution
- sensors further outside
- pattern more complex





Software and Analysis (ATTRACT work package)

- Simulations
  - Cosmic rays: particle type, energy, direction
  - Propagation: particle decay, B field
  - Energy loss in matter / geological structure
  - Detector set-up
- Analyses
  - Fast analysis, online analysis, offline analysis
  - Track finding and track fitting
  - Count rate, background suppression
- Online reconstruction
  - Track finding with masks, event class determination
  - Photon selection from hit pattern for further processing
  - Look-up table: each pixel → Vector & Hessian Matrix
  - then sum up, compute → results (**β**, position, **direction**) and error (matrix)

Candidate locations



Hornbergbecken – Black Forest



Hohenkrähen – Hegau Volcanic Field



Stromboli – Italy

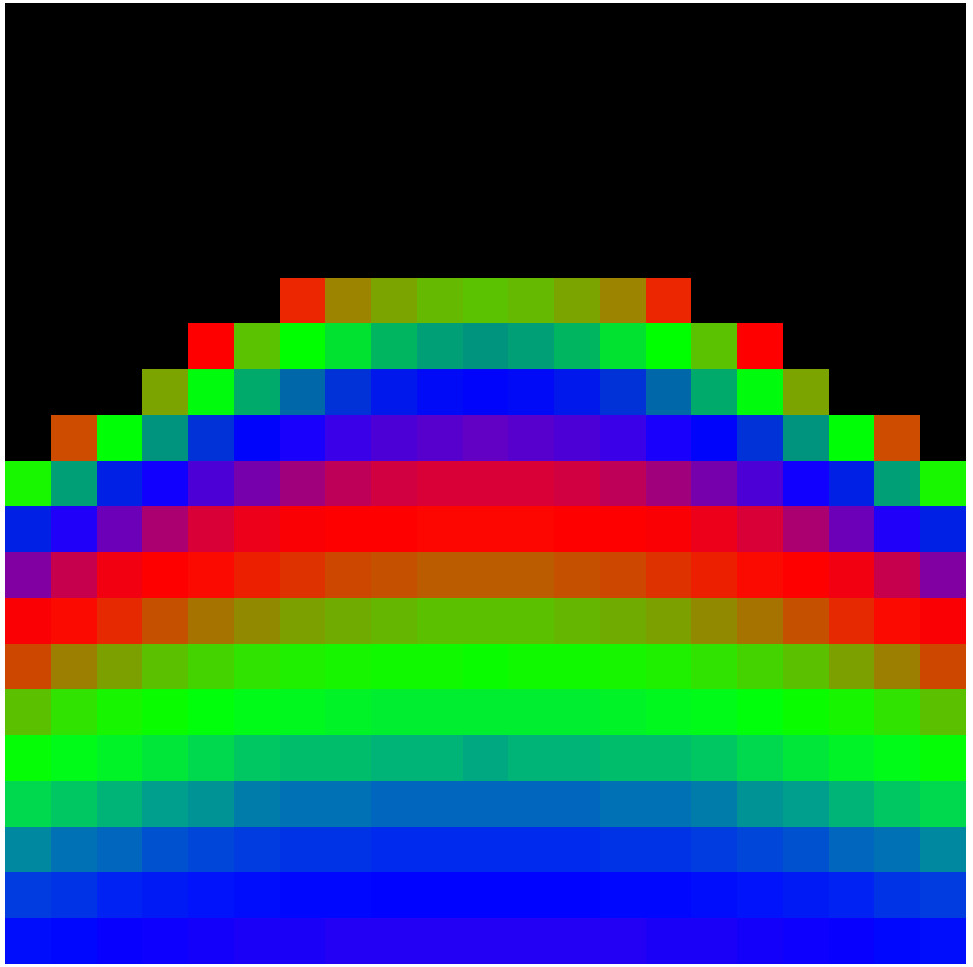


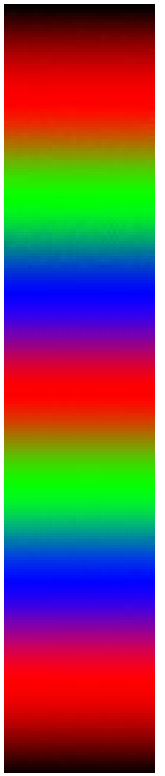
Popocatépetl – Mexico

Hohenkrähen – denser core?



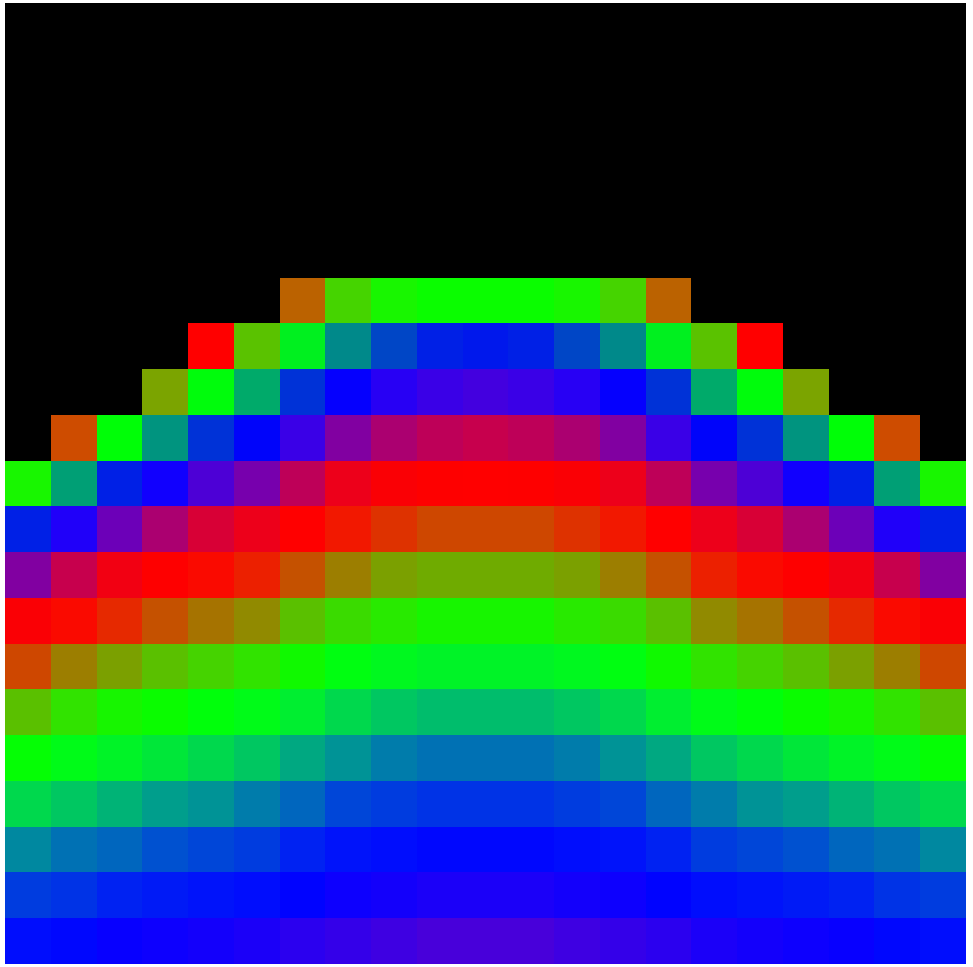
Hohenkrähen – constant density

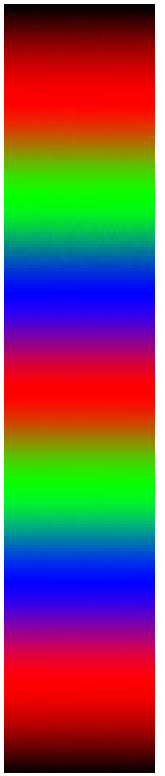




cone stump density 2.2 gcm-3

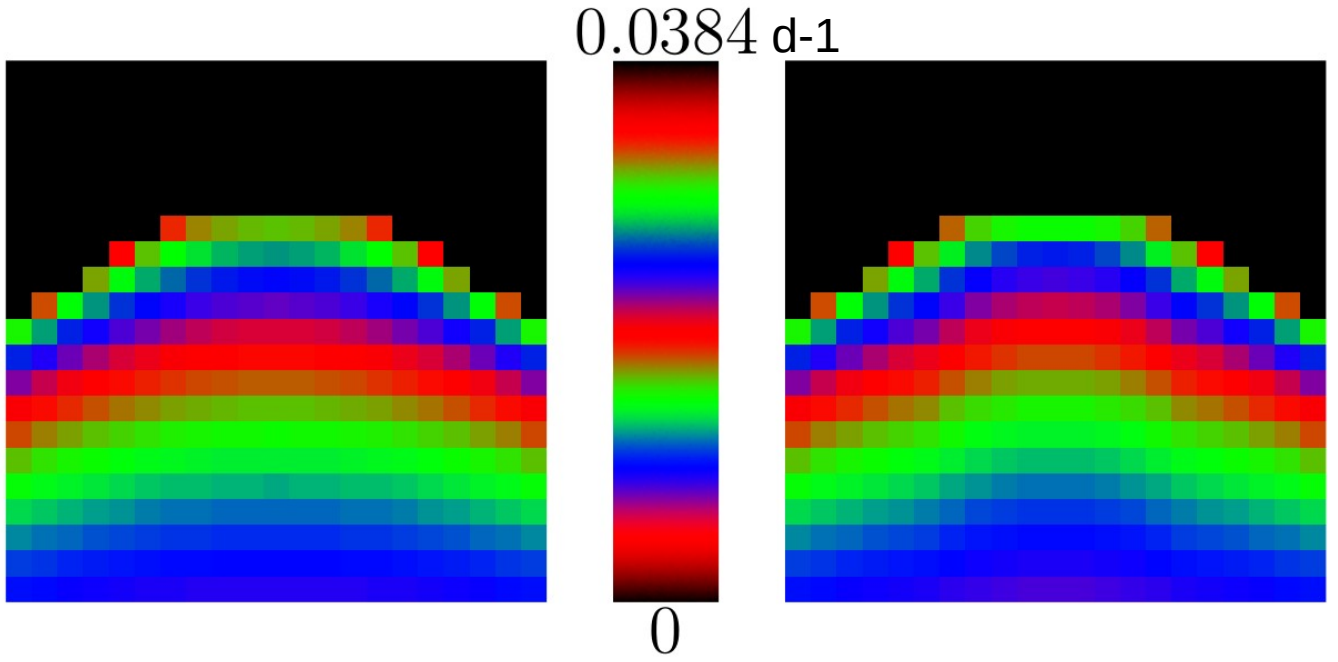
Core cylinder of higher density



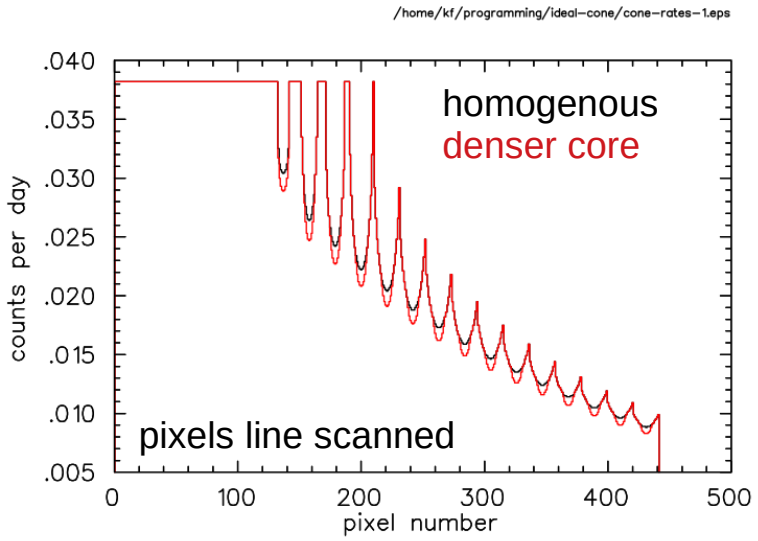


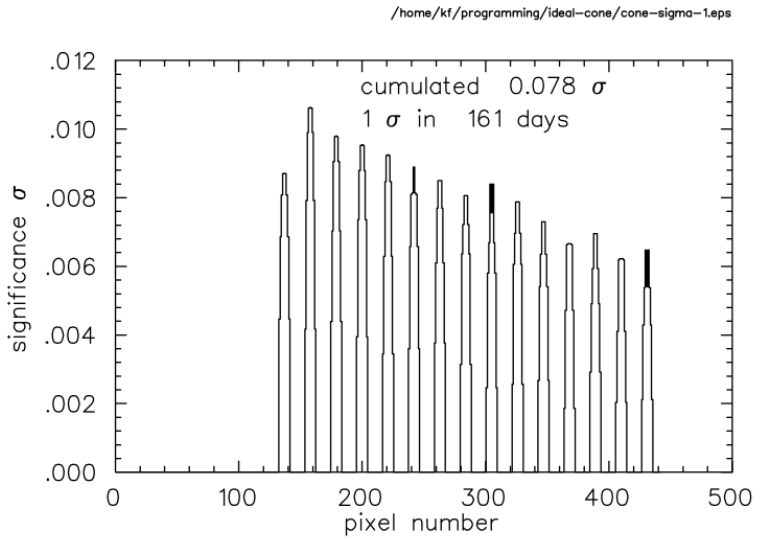
cone stump density 2.2 gcm-3
core cylinder density 2.8 gcm-3

Feasible statistics and sigmas



square
10 mrad
pixels



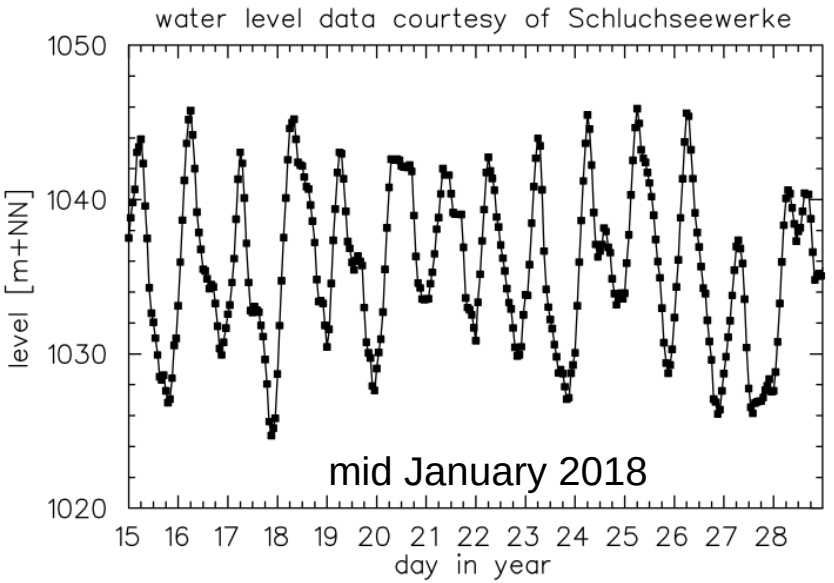


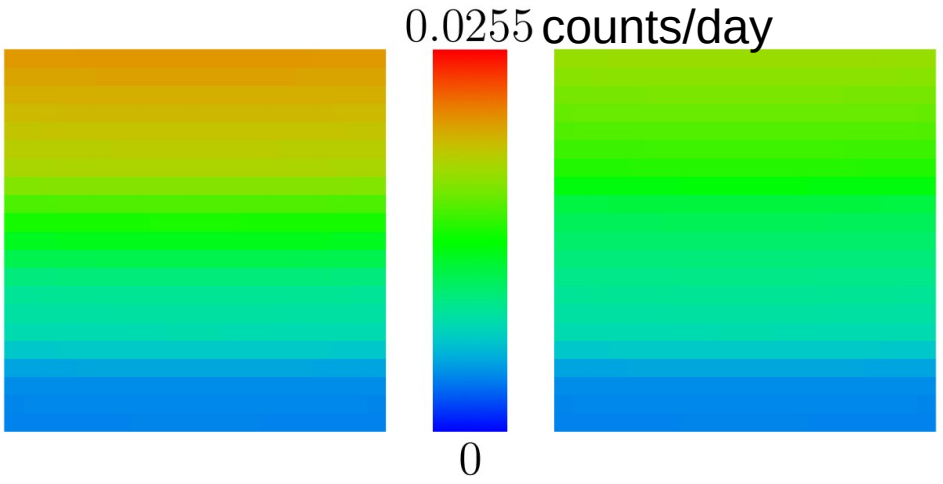
Hornbergbecken – 5 June 2019

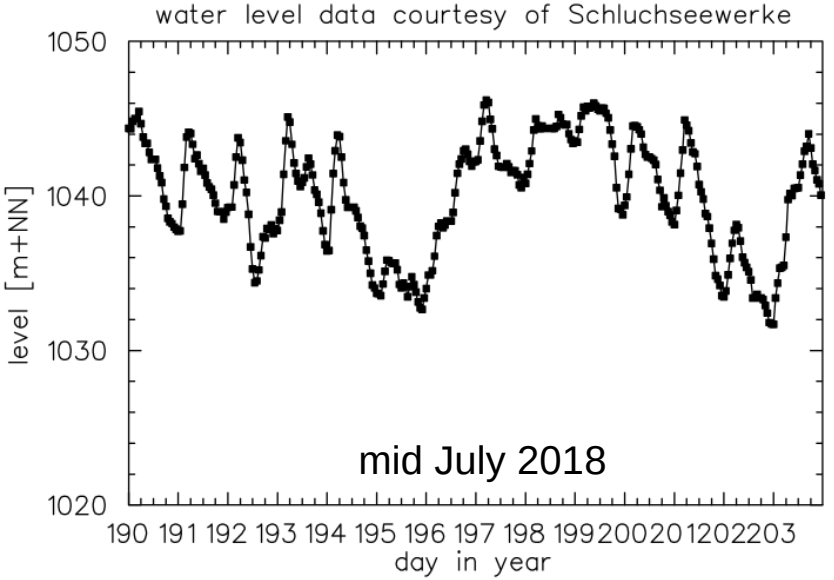


Water level variations

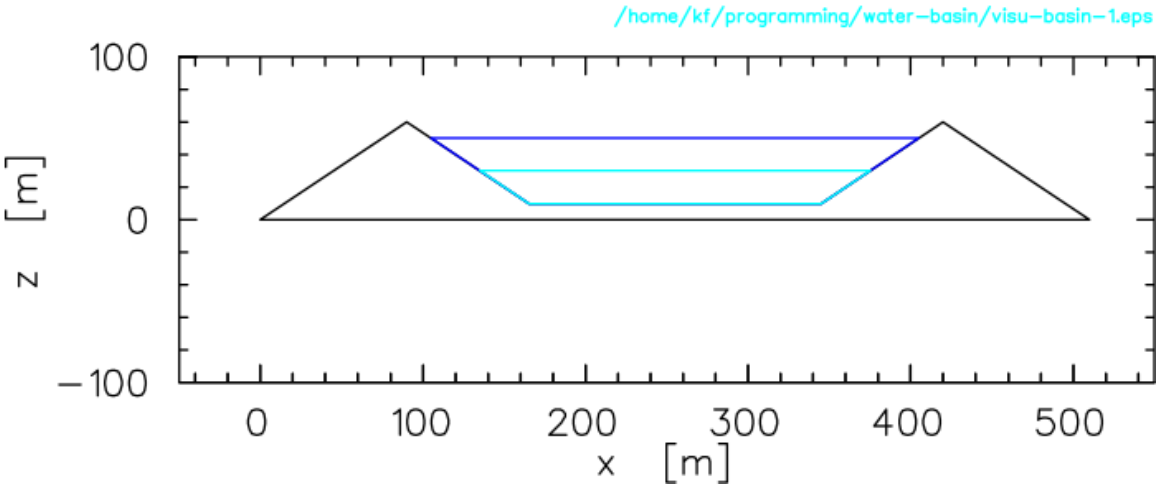




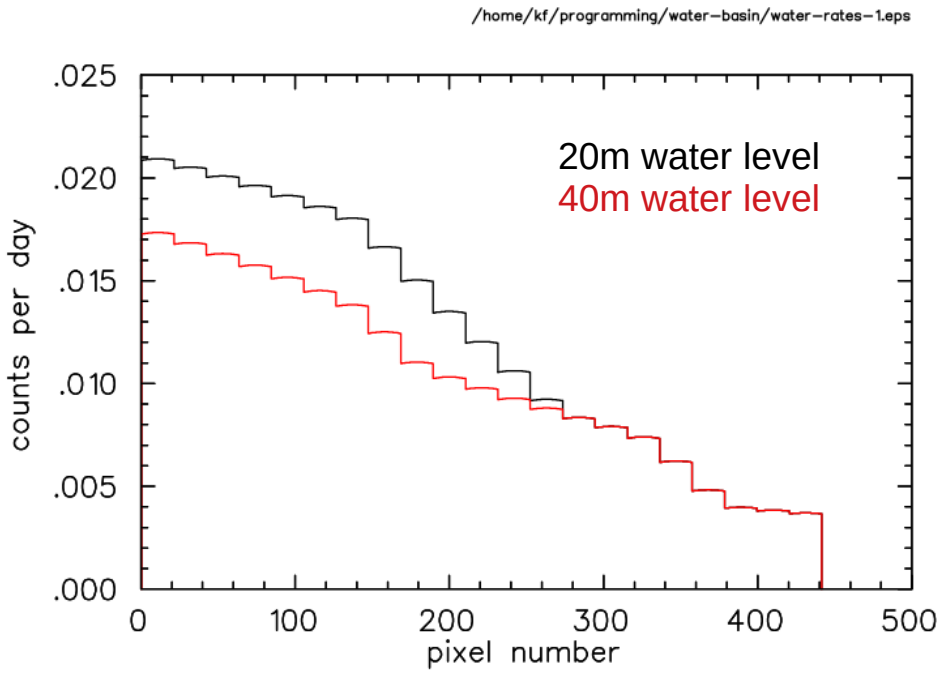


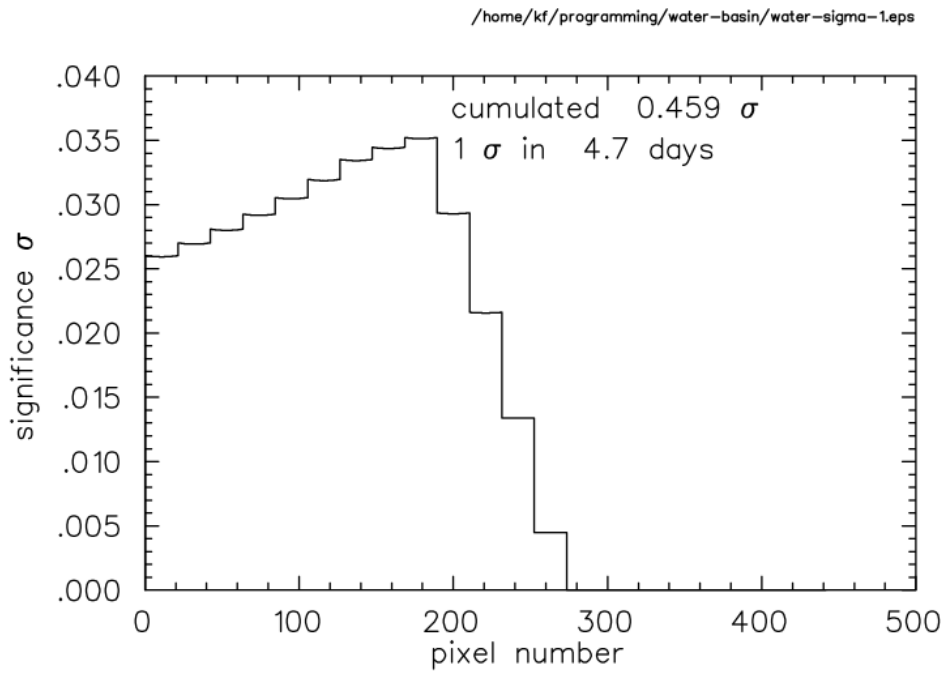


Achievable significance



- 20 metres water level changes modelled





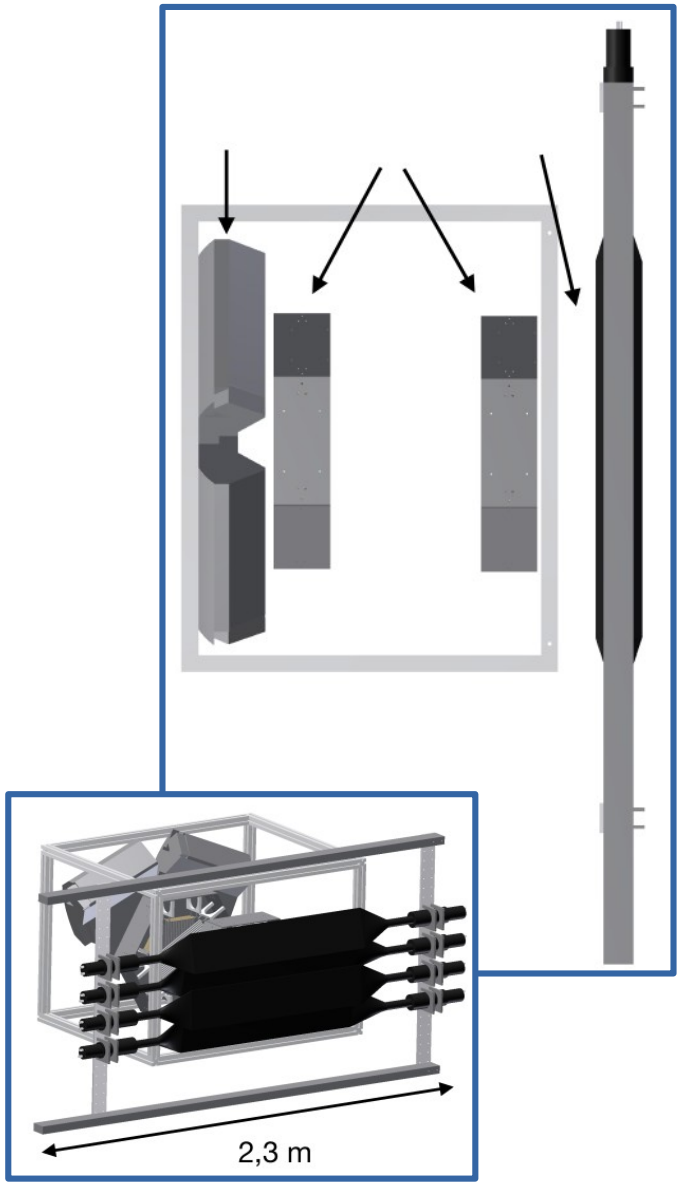
Three DIRC variants

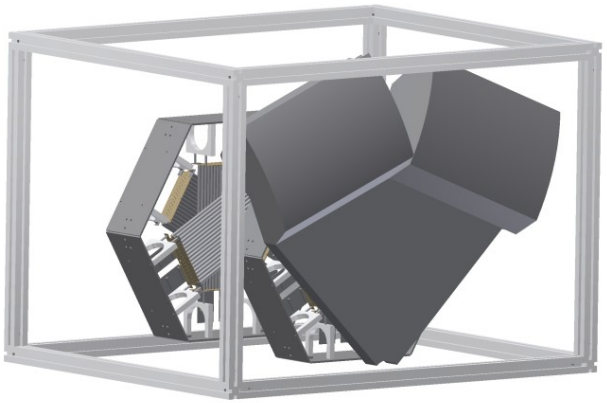
- Detector idea
  - Simple, rugged, inexpensive, lightweight, low power
  - Plexiglas radiator, mirror focussing through air
  - Sparse rim population with read-out units
- Proposal of proof of principle
  - Existing WASA-DIRC prototype
  - Small mechanical modifications to function stand-alone
- Recent developments

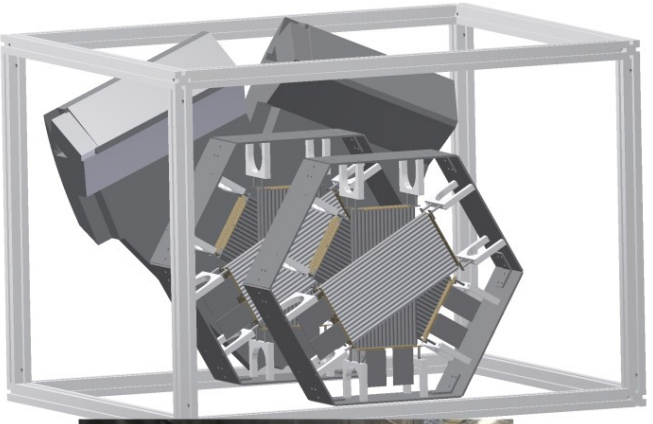
money to make

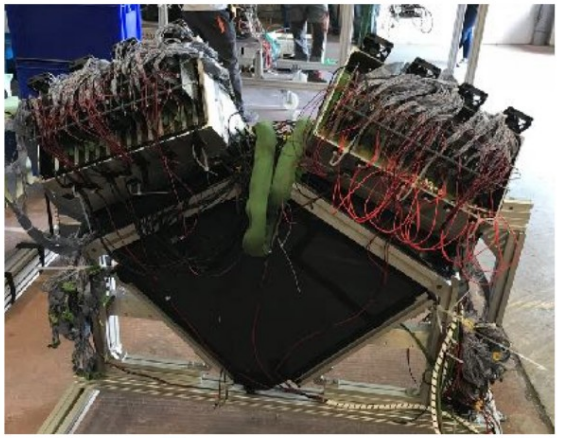
  - No changes to prototype, include tracking, this is available
  - Make to work on a shoestring budget

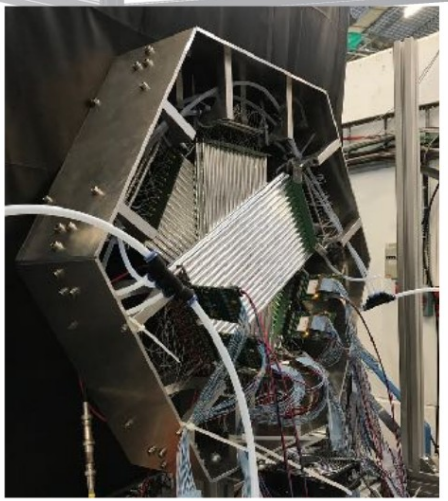
DIRC “as is” plus tracking and time wall



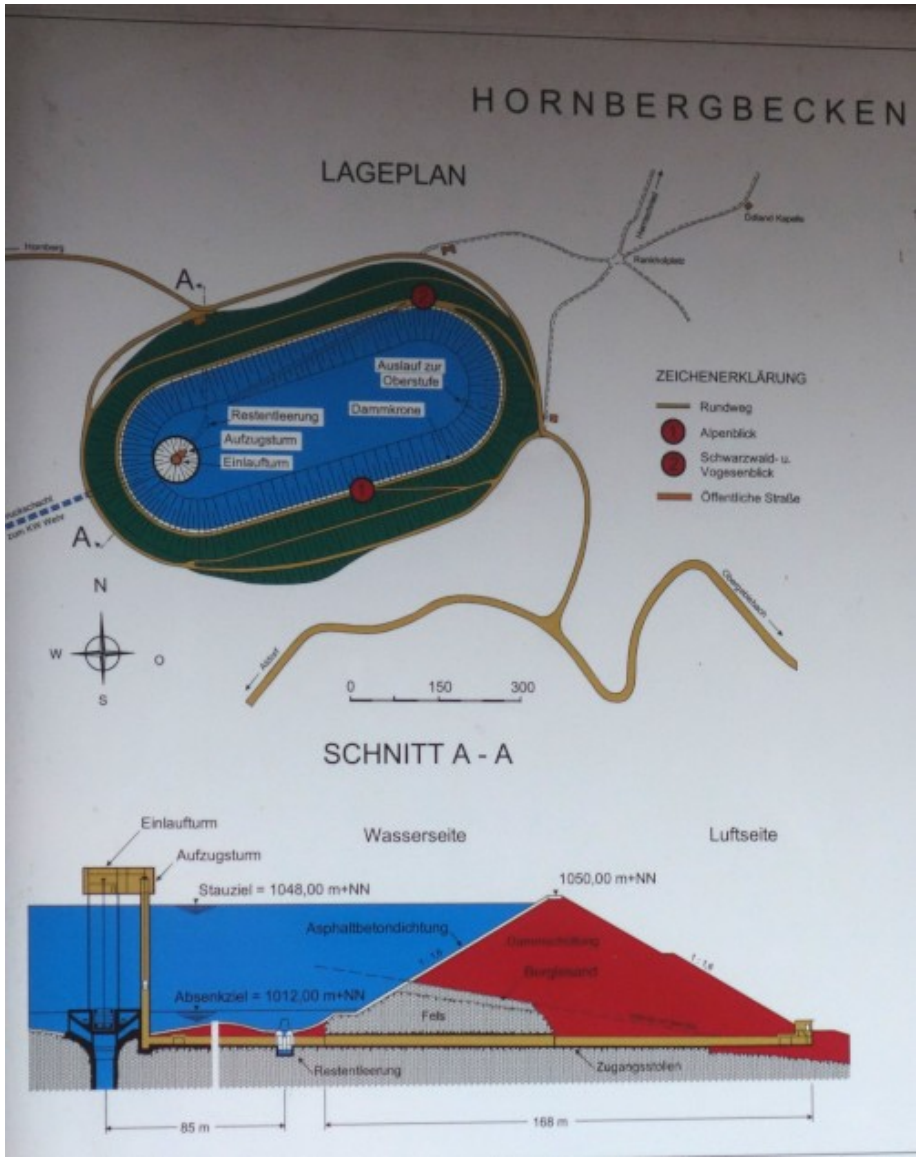








Hornbergbecken – June 2019







Summary – current status

- ATTRACT Project Application
  - Simulations
  - limited Reconstruction Algorithms
  - Erlangen WASA-DIRC
  - Two proof-of-principle sites



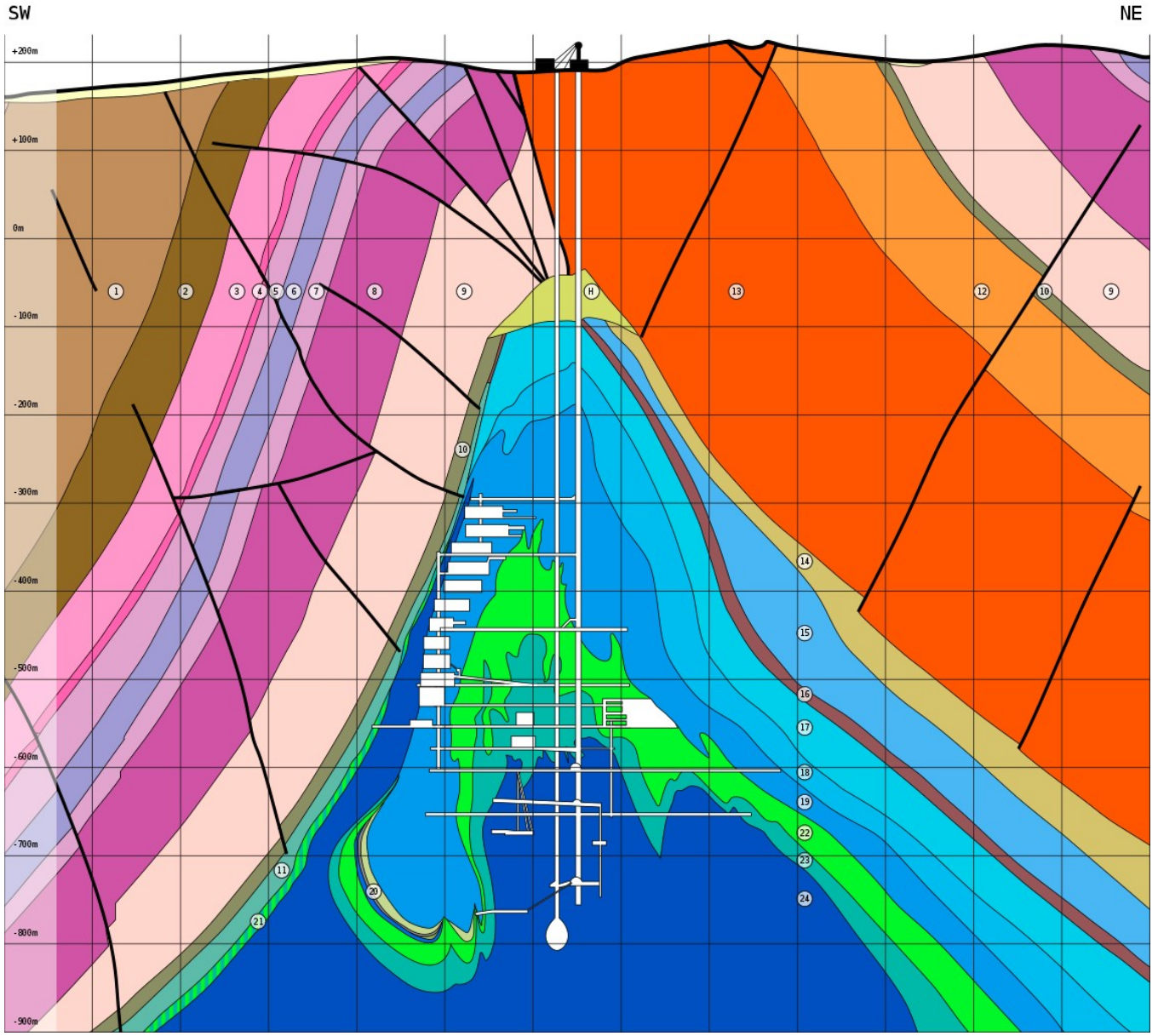
Courtesy of my old colleague Erik Etzelmüller

- Continuation after the ATTRACT verdict
  - Continued site exploration
  - Concept of using sensor system “as is”

Autumn 2018: ATTRACT Project Application
Spring 2019: can one continue on a shoestring budget?
Summer 2019: main player’s professional situation

- Current situation
  - Field measurement activities paused
  - main MagmaDIRC proponent recently started a new job
  - Muography with DIRC might add to employer’s activities

Outlook - Asse ?



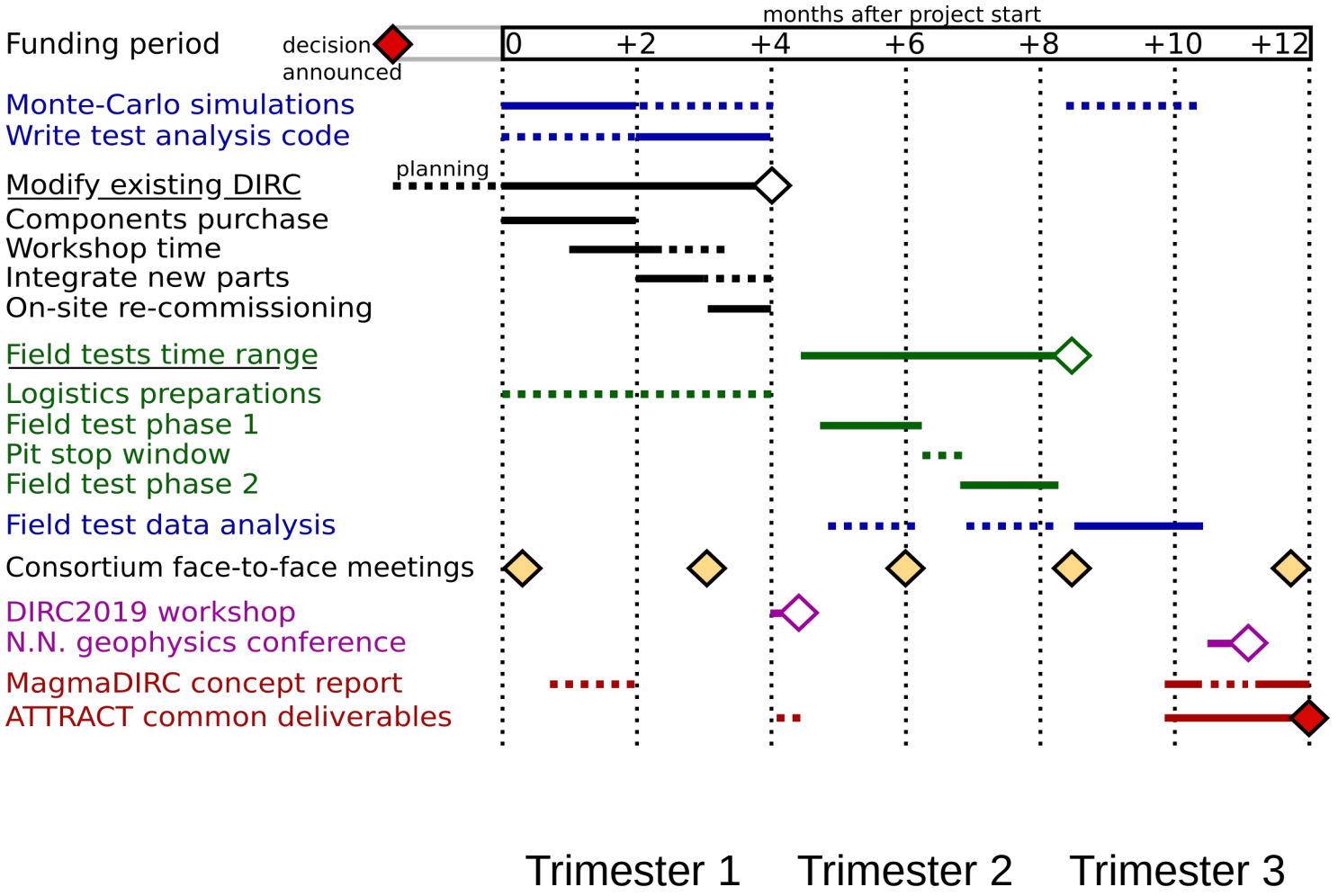
https://commons.wikimedia.org/wiki/File:Schnitt-Schachtanlage_Asse.svg

- DIRC sensors might be useful to determine properties of the Asse – for some features maybe best suited
- Official approval is required in Schachtanlage Asse for pretty much anything before this thing can be done

back-up slides

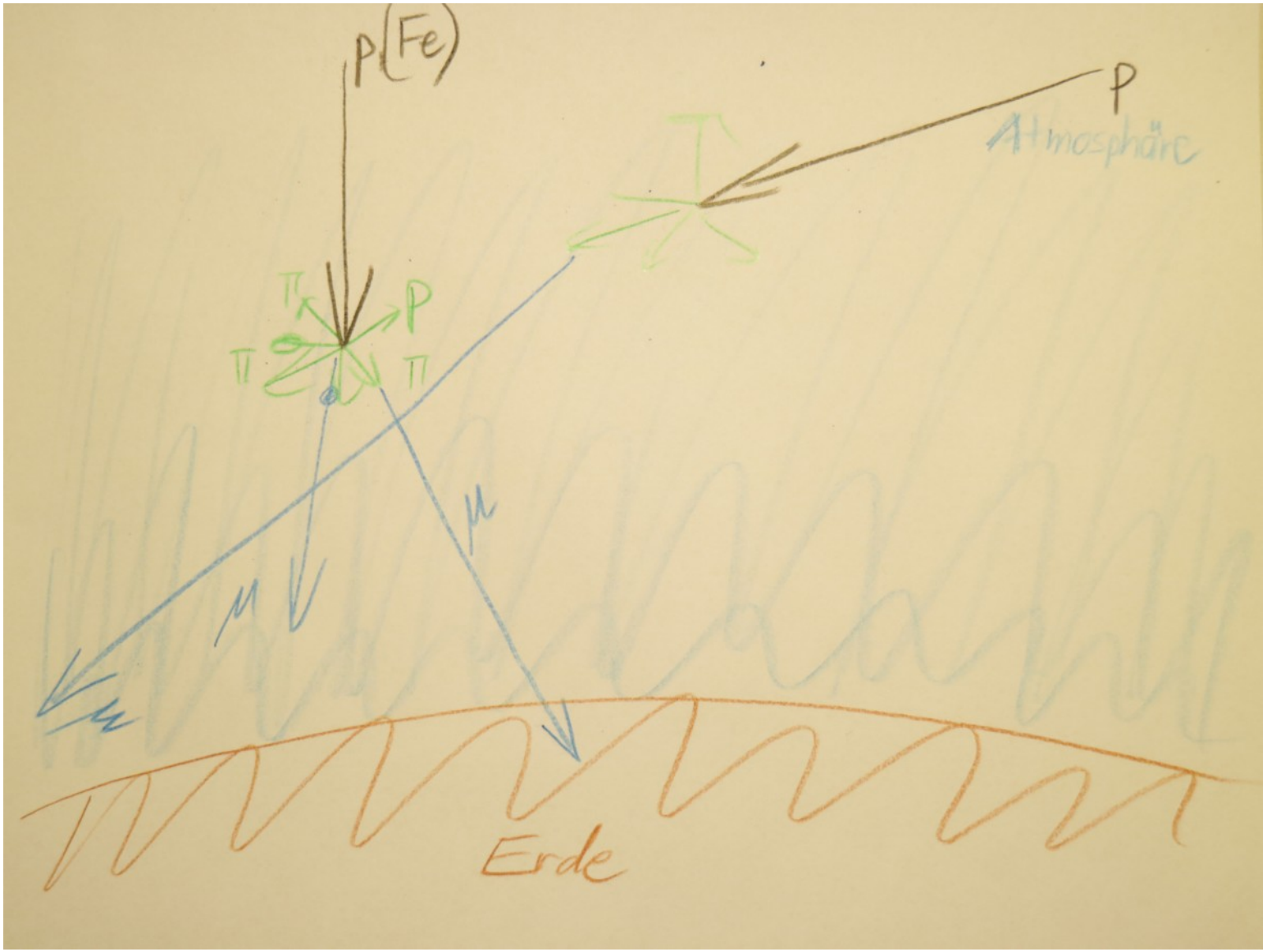
Project Outline

Beginning
of March 2019

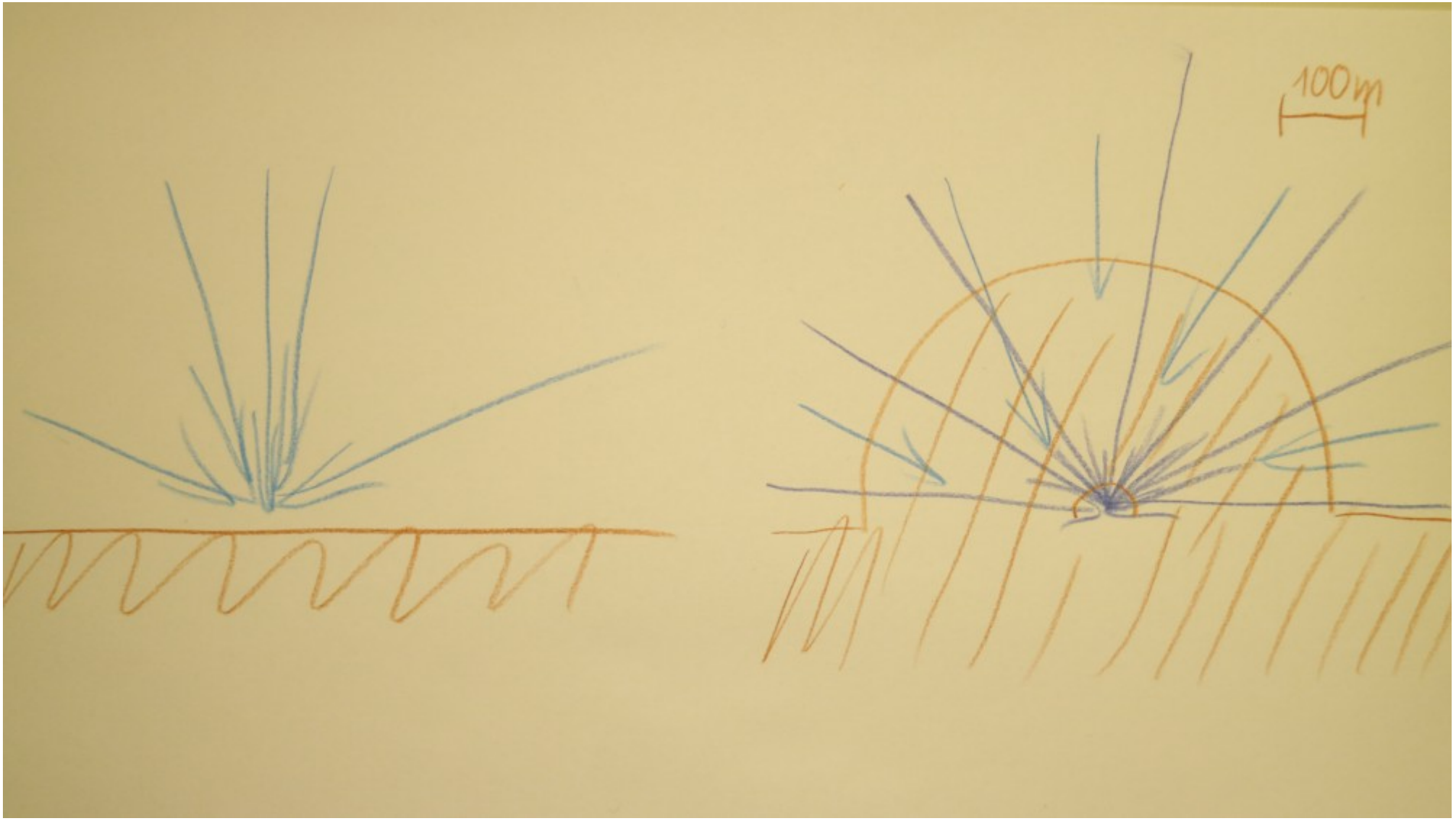


Trimester 1 Trimester 2 Trimester 3

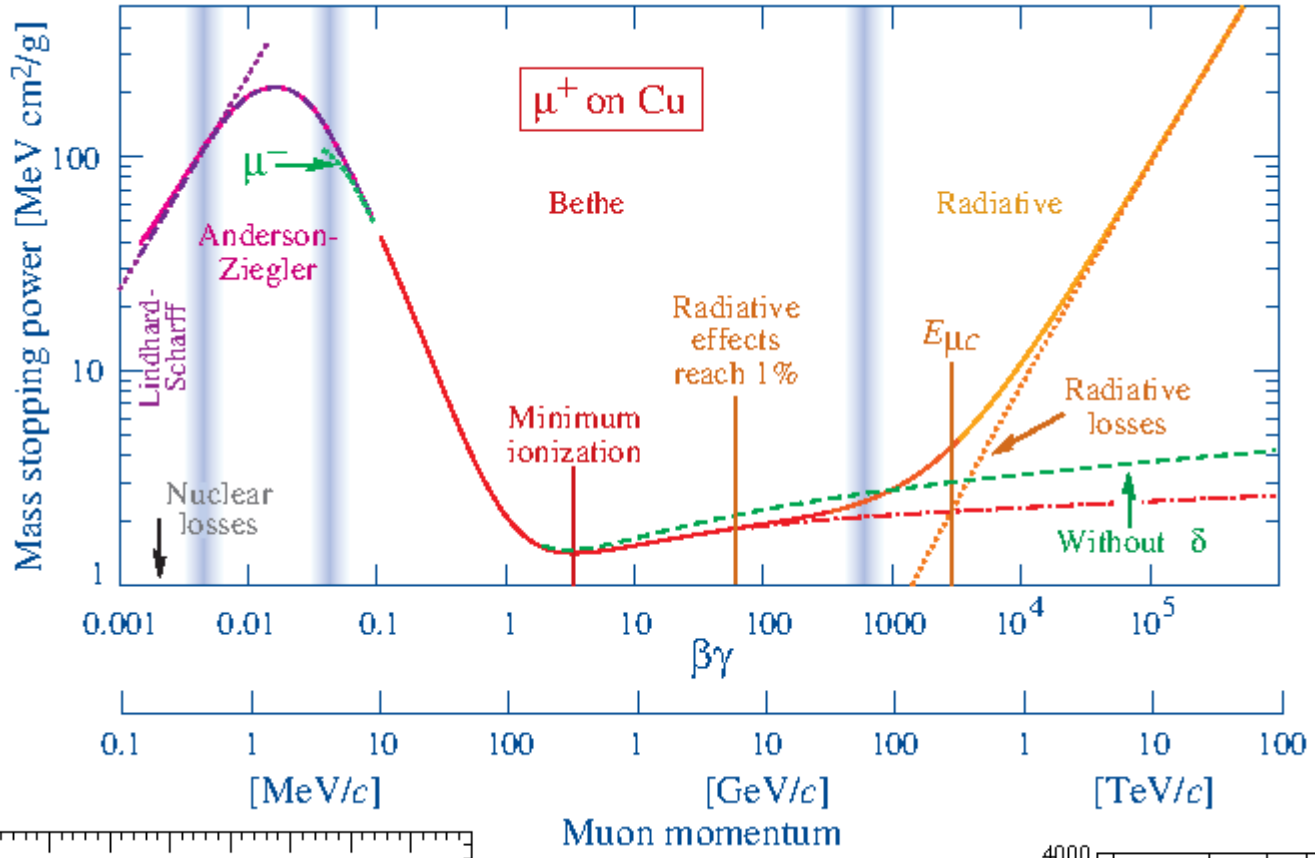
Muon source

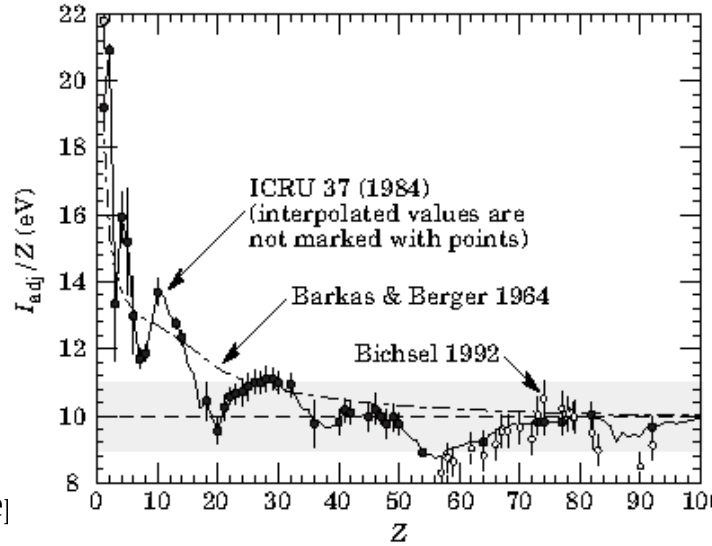


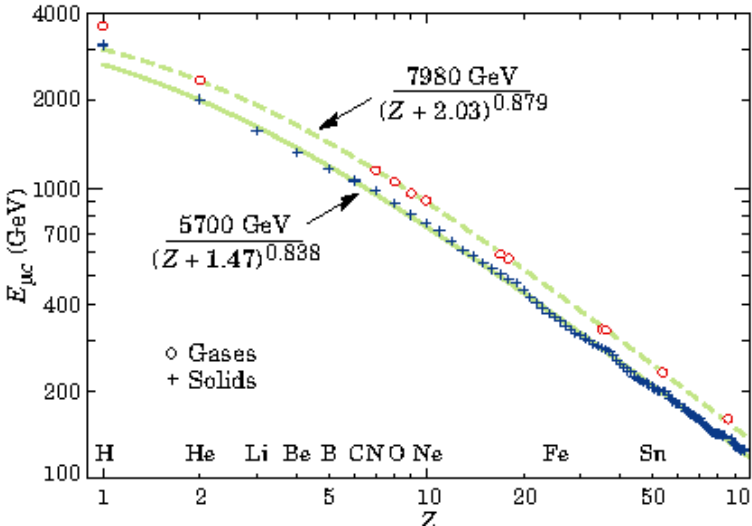
Soft and hard muons



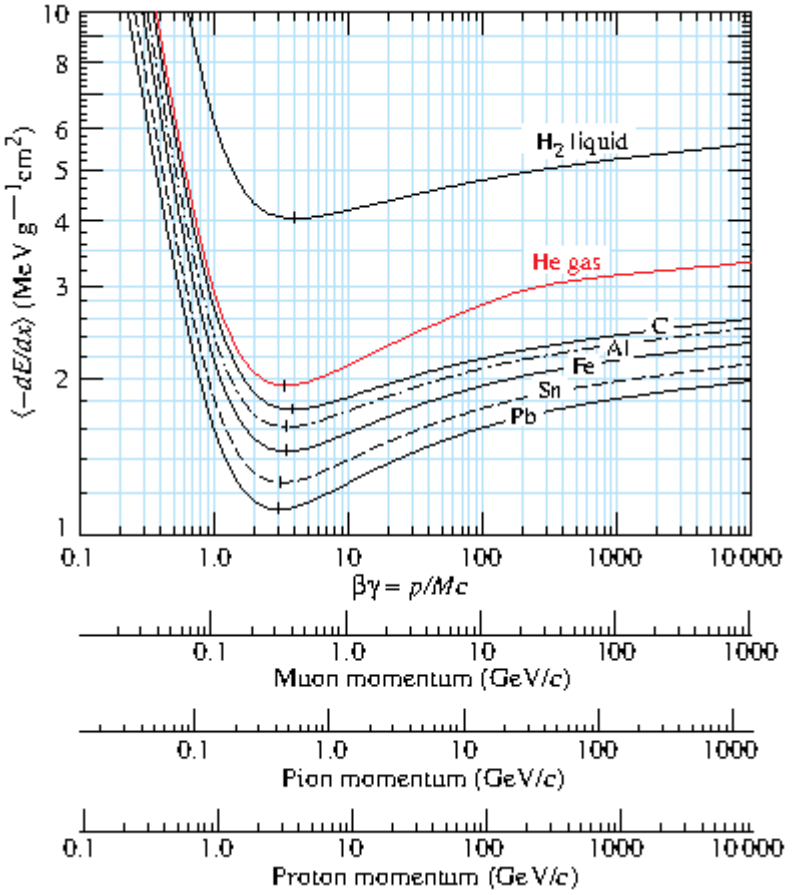
Energy loss mechanisms

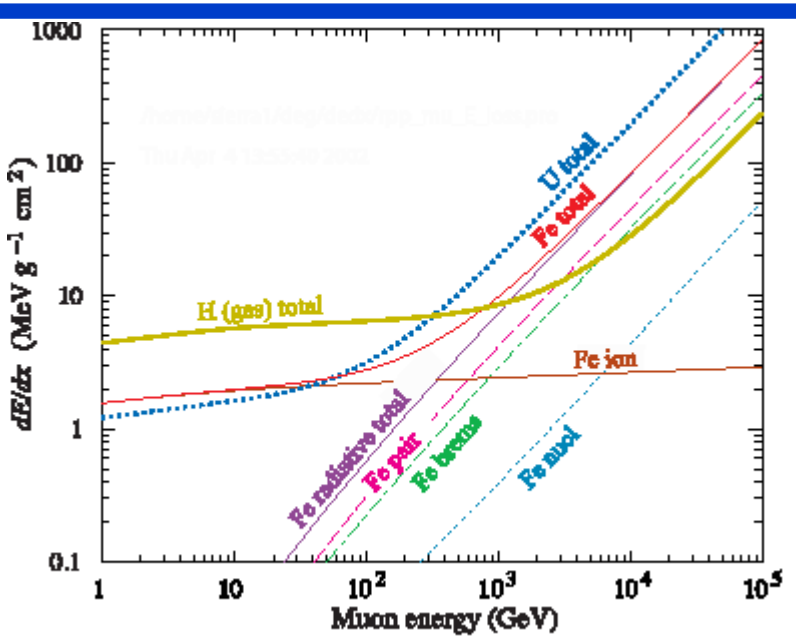


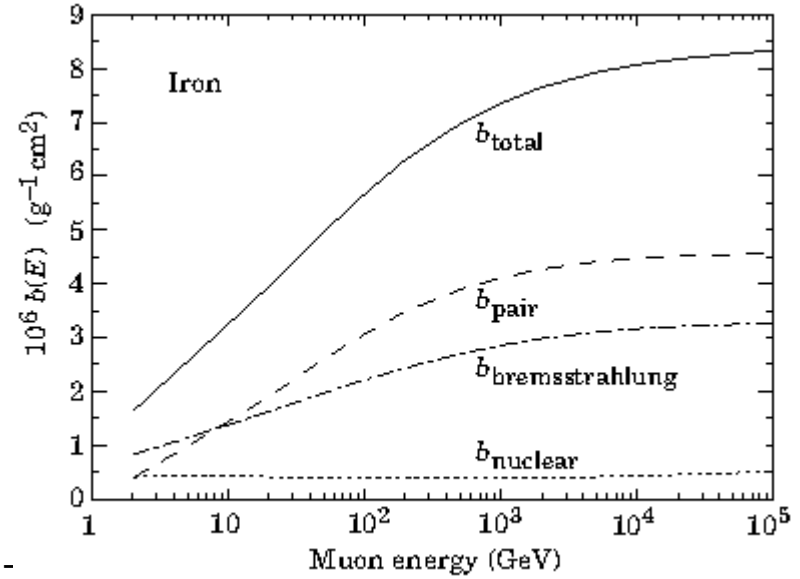




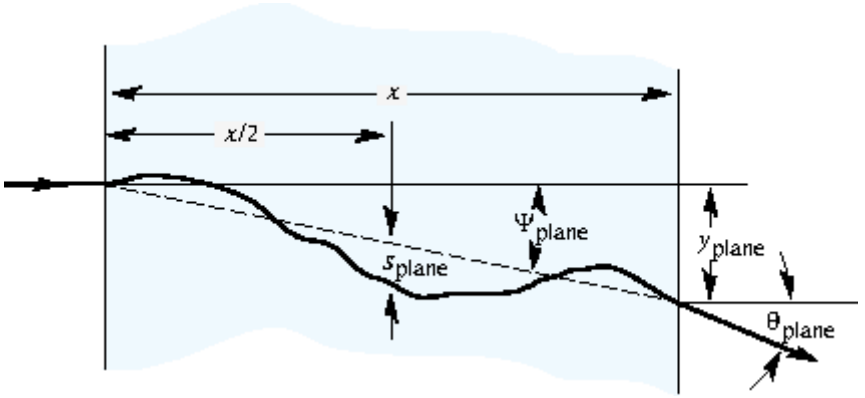
High energy muons



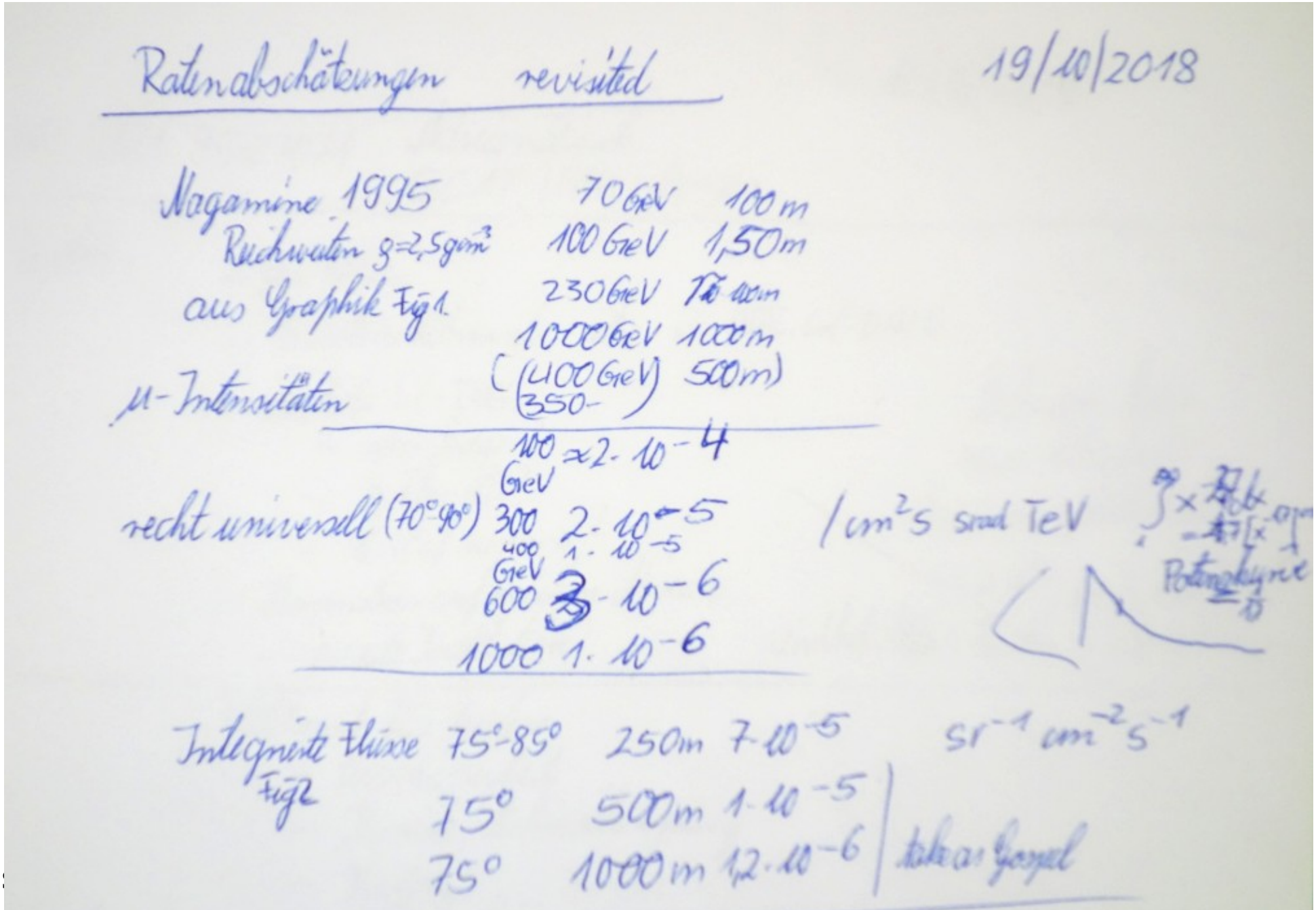




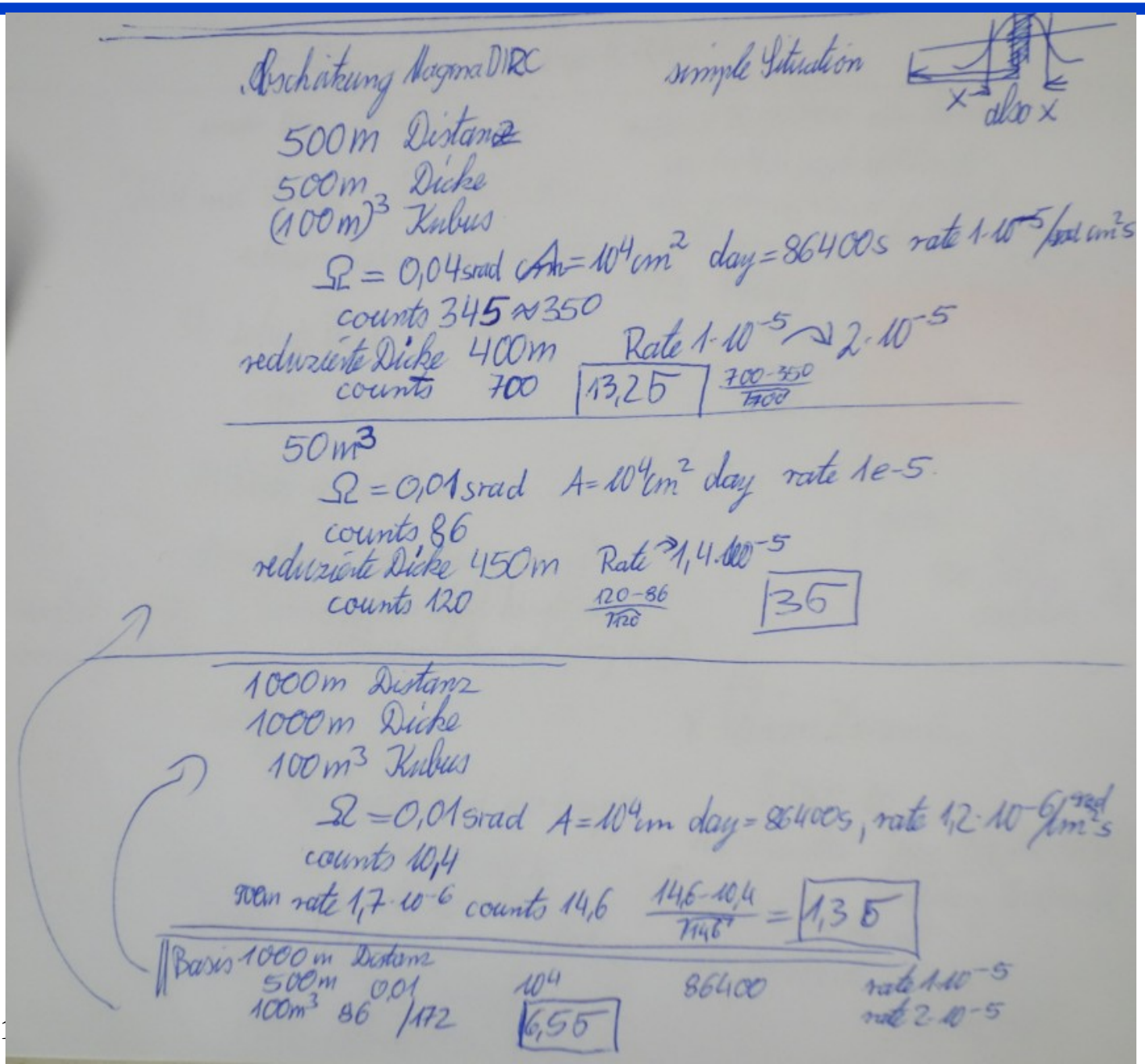
Angular straggling

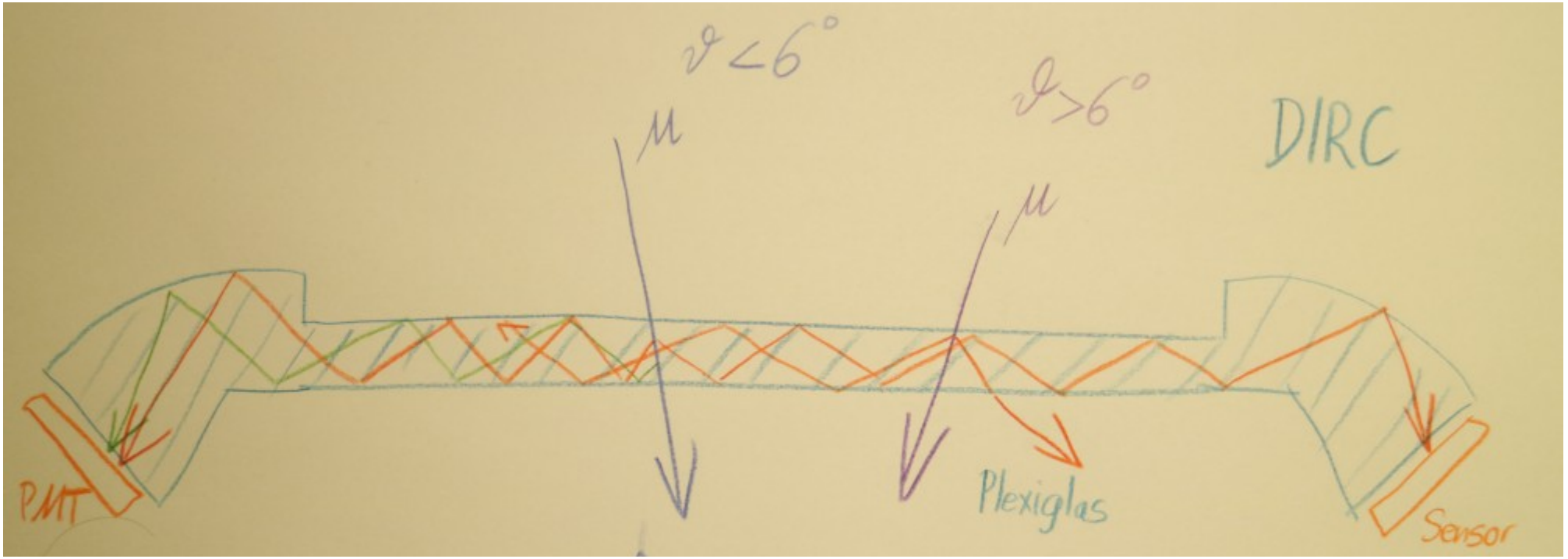


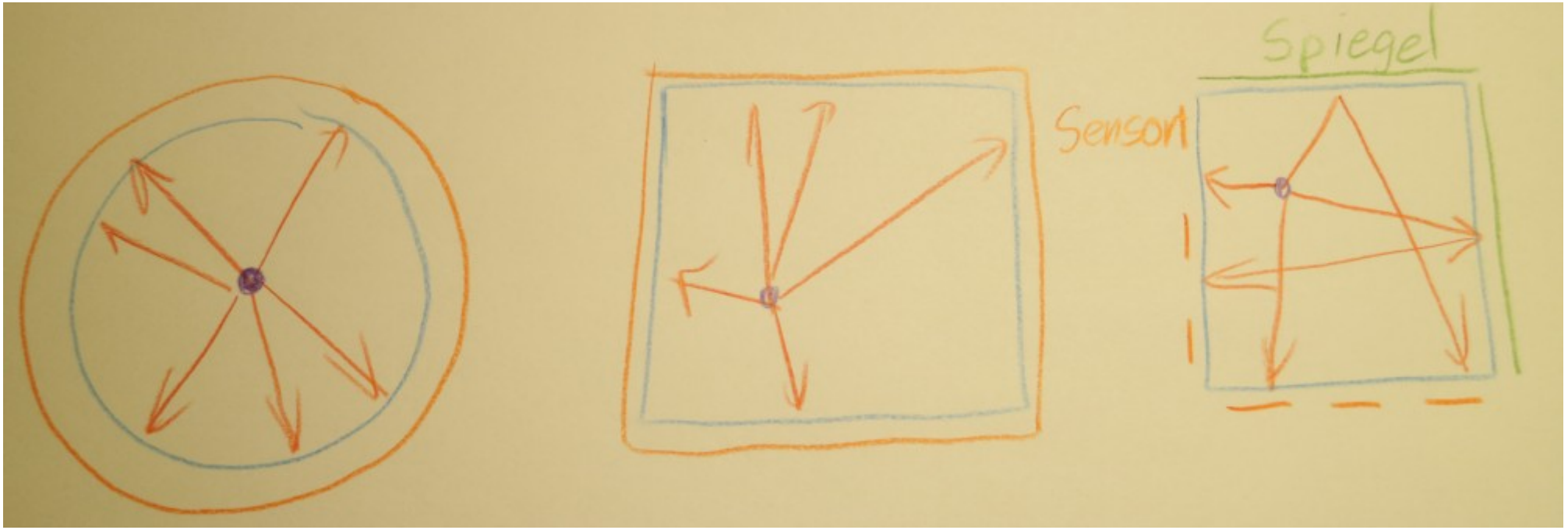
Rate estimates 1

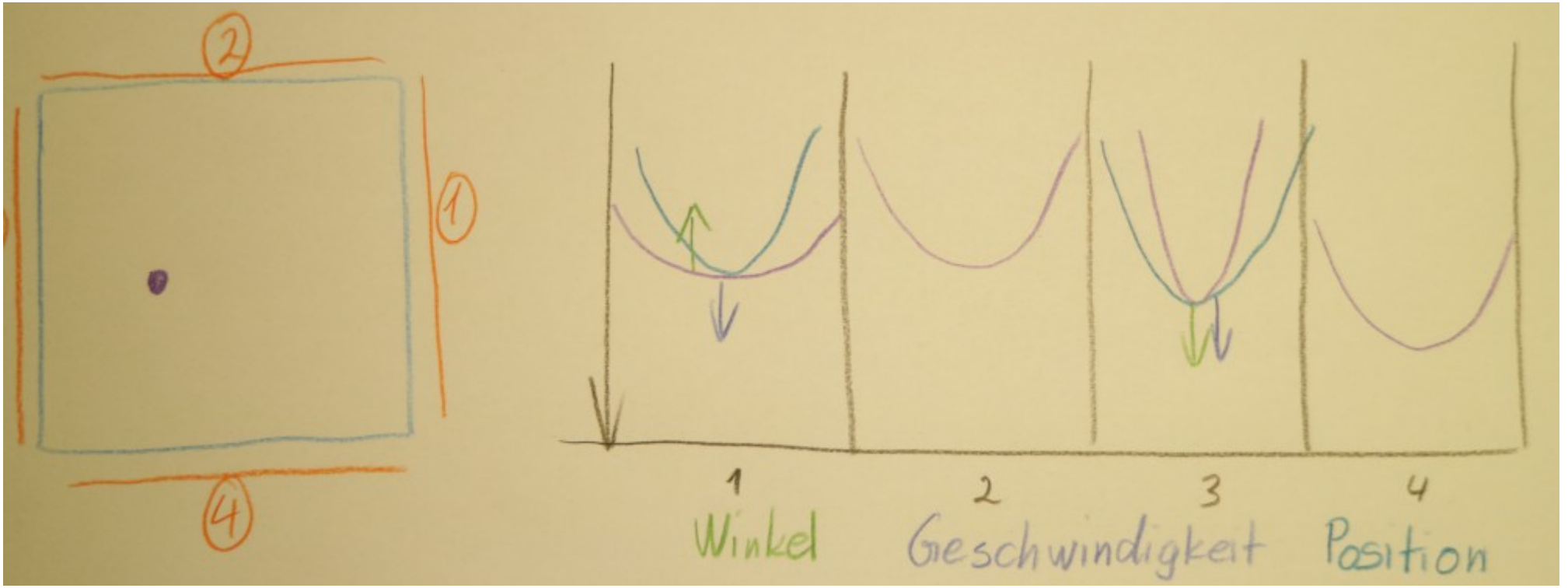


Rate estimates 2

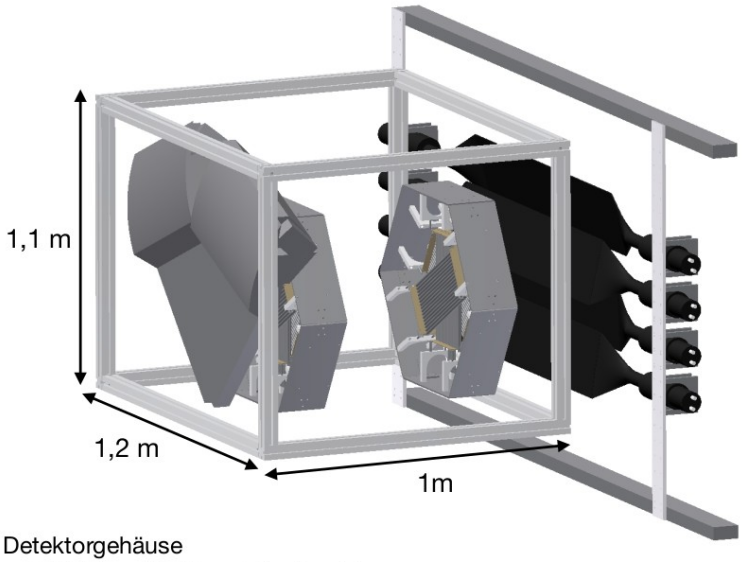


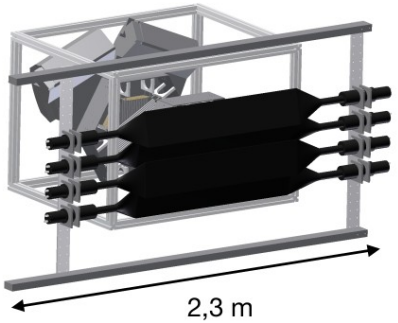

ϑ<6°
ϑ>6°
DIRC
μ
μ
PMT
Plexiglas
Sensor


Spiegel
Sensor


2
1
4
1
2
3
4
Winkel
Geschwindigkeit
Position

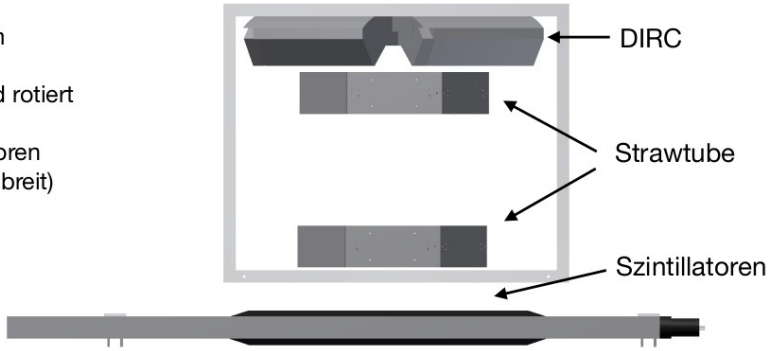
Dieter Grzonka sketch



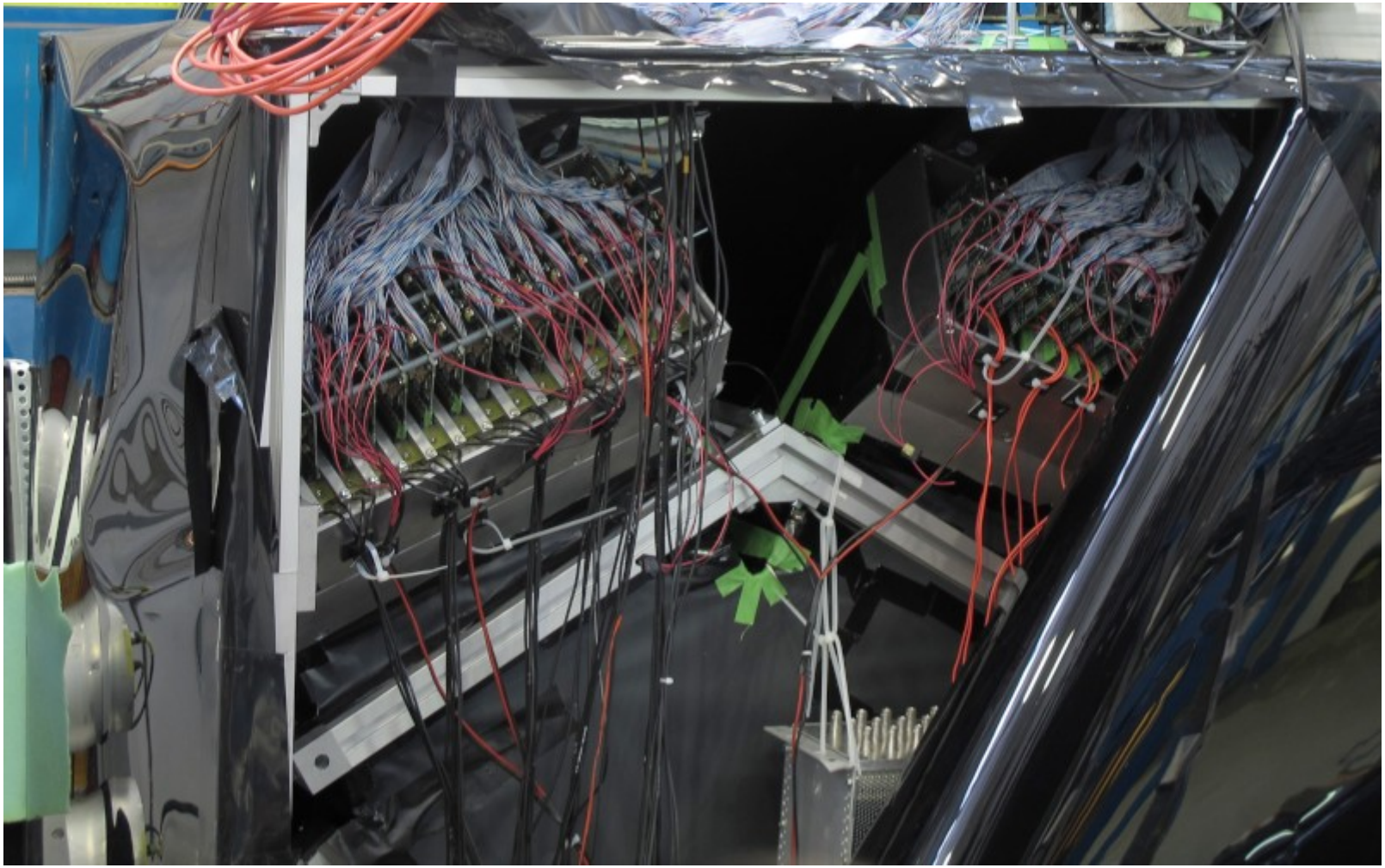


Detektorgehäuse
mit DIRC und 2 Strawtube-Modulen
aus Alu-Profilen,
Breite 1,2 m, Höhe 1,2 m, Länge 1m
Strawtube-Module:
je Modul 3 Doppellagen um 60 Grad rotiert

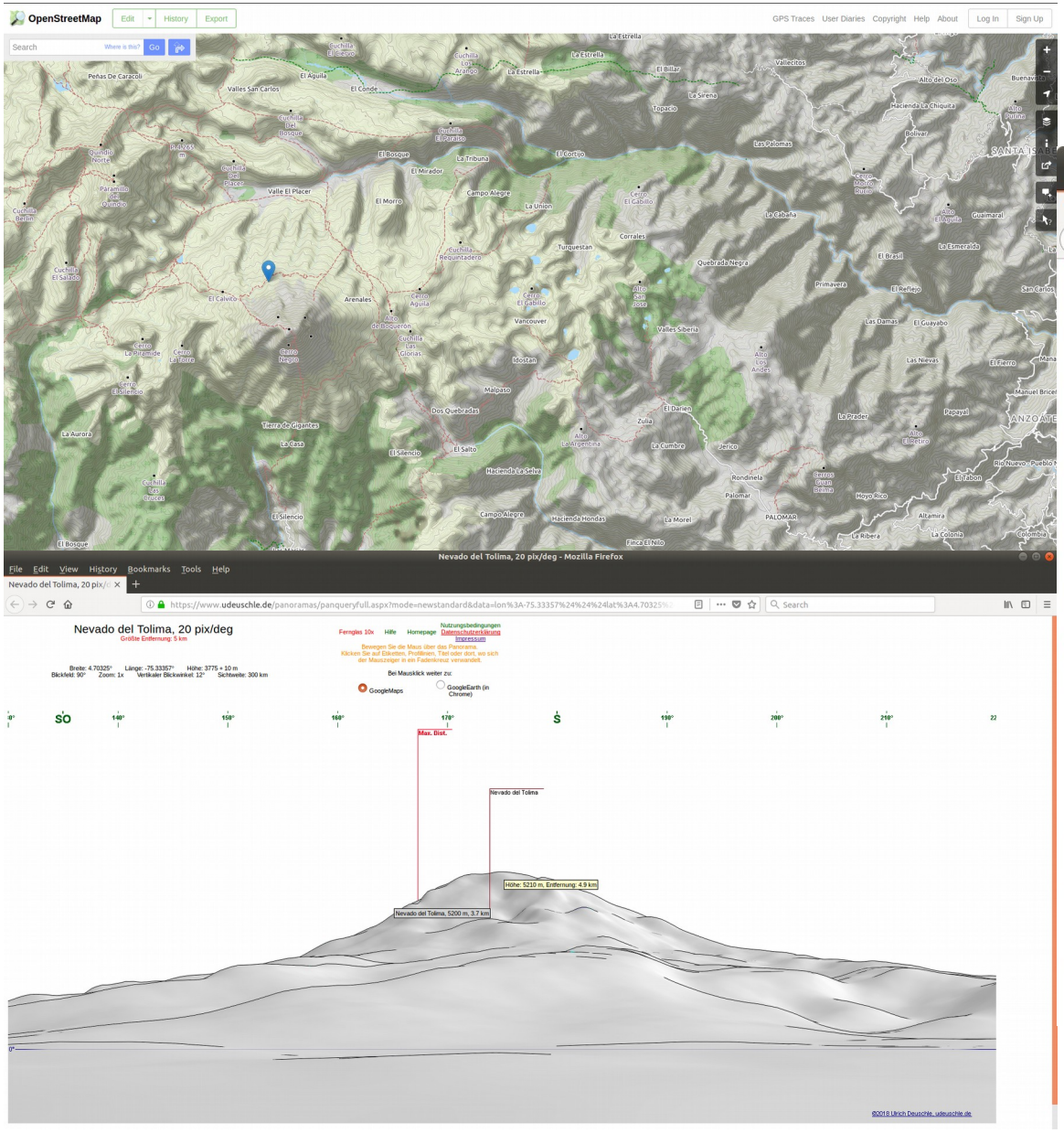
separate Einheit mit Plastikszintillatoren
(Szintillatormodule: 1m lang, 20 cm breit)

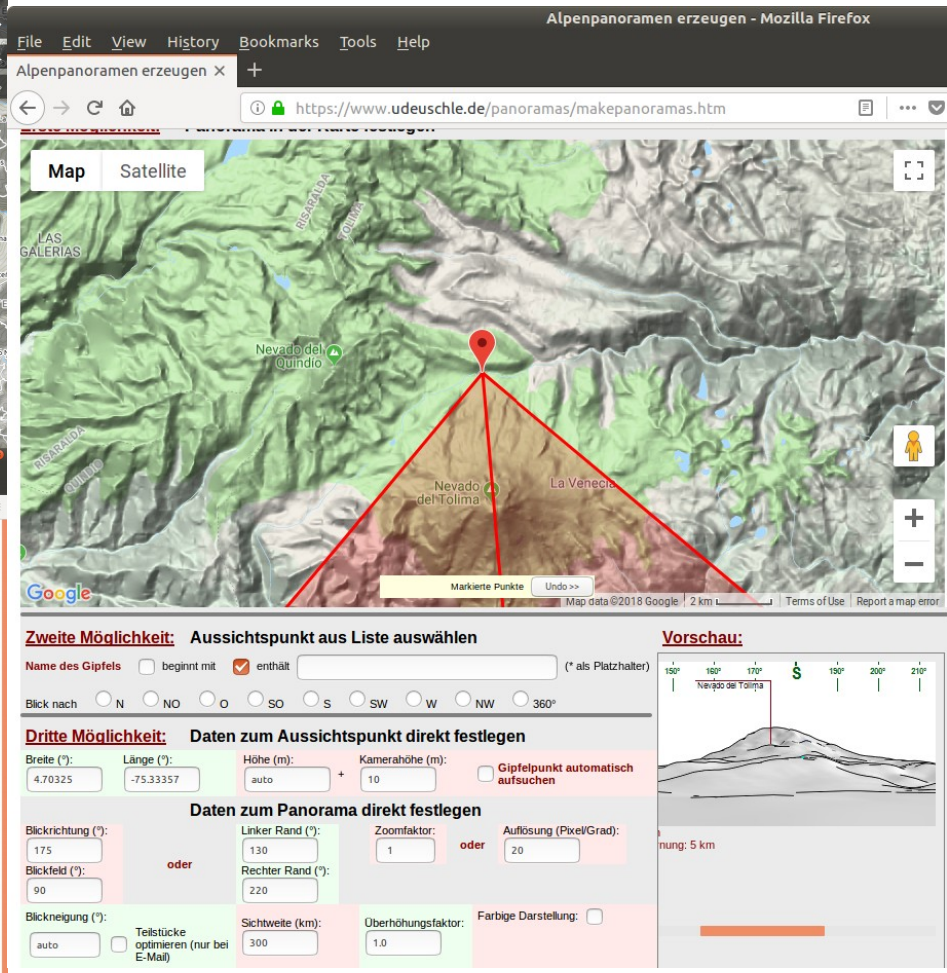


Erlangen DIRC prototype



Location remote scouting





Are there similar tool used at GFZ?