SiW-ECAL Long Slab Test Bench
Technical Document

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For long SiW-ECAL testing, a dedicated bench would allow to complete much more efficiently some measurements in controlled mechanical and electrical conditions. The main purpose is to test the response of ASU at the end of a SLAB, typically after a buffering of 5–6 ASU's, using an γ-ray radioactive source for effectiveness. A secondary purpose is to allow precision measurement with the source collimated.

This document summarizes all the technical details concerning the design and realisation of such a test bench. This device could also serve as a support for beam test operation (e.g. at PHIL).

1 Introduction

The SiW-ECAL Slabs are made of several ASU (Assembly Single Units) stitched together. The readout and cooling is performed at one end. All the signal and power must travel across all the ASU. The integrity of the signal and the stability of the LV supply has to be tested for up-to 7 and 10 ASU's (resp. in the barrel and EndCaps of ILD in option of the largest geometry).

For testing purpose a Functional Long Slab (FLS) is typically composed of a DIF, an Adaptor Board, an *equipped ASU*, several *naked PCB*'s and a final equipped ASU.

[DESSIN]

Equipped ASU could either be

- a PCB with glued Wafers (1 to 4) or
- a PCB with Wafers connected via a matrix of springs to a dispatch pannel

Naked PCB do not hold Wafers.

2 Purpose / needs

2.1 Test the powering and signal transmission in the SLAB

2.1.a Powering

The ASICs must be powered in pulsed mode, typically: up to 3-4 ms at 5 to 20 Hz.

Several tensions should be brought to the ASIC with various stability required (see annexe).

Check the stability of the line after *n* ASU.

2.1.b Signal transmission

Check clock distribution (eye diagram)

2.2 Test of response at the end of the SLAB

To test the response of an ASU at the end of the SLAB, a reproducible signal is needed:

- for naked PCB's: electric [possible if polarisation of the ASIC's ?]
  - a PCB could emulate a wafer
- for ASU: physical, either from laser, cosmics or X-rays.

For this a single aperture anywhere is sufficient: a reproducible signal injected at a given time or given rate [to be detailled wrt to expectation in PP mode…] in one or several cells is enough, to be compared between the close and far end of the slab.

2.3 Test of response of individual pixels at the centre of an ASU.

With a collimated source [X-rays or beam] fine scans could be performed across single pixels, pixel boundaries, guard rings, inter-wafer gap. This scans can be performed e.g. along the pixel axis (red, solid path in figure 1), or along the diagonal (purple, dotted path).

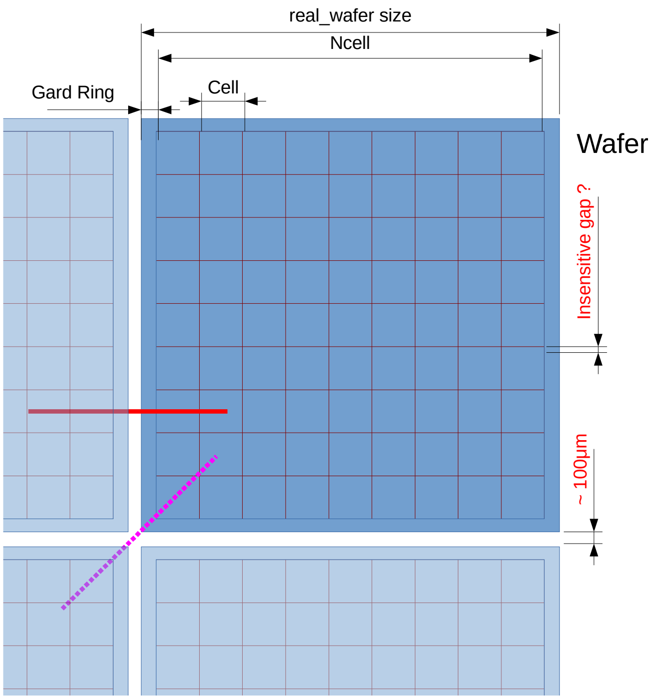


Figure 1: Schematic layout of the wafers, guard rings & gaps (not to scale). The Bold lines indicate possible paths for fine scans.

The needed scan step is typically a fraction of the smallest structure. Typically Inter-wafers gaps are ~ 100 µm wide, guard rings ~ 300–500 µm, inter-cells gaps ~ 50 µm [A VERIFIER]. A step of 20-50 µm should suffice over a span of a couple of centimetres.

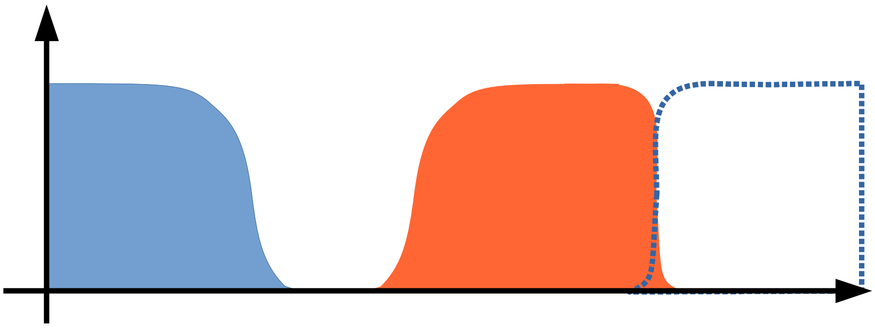
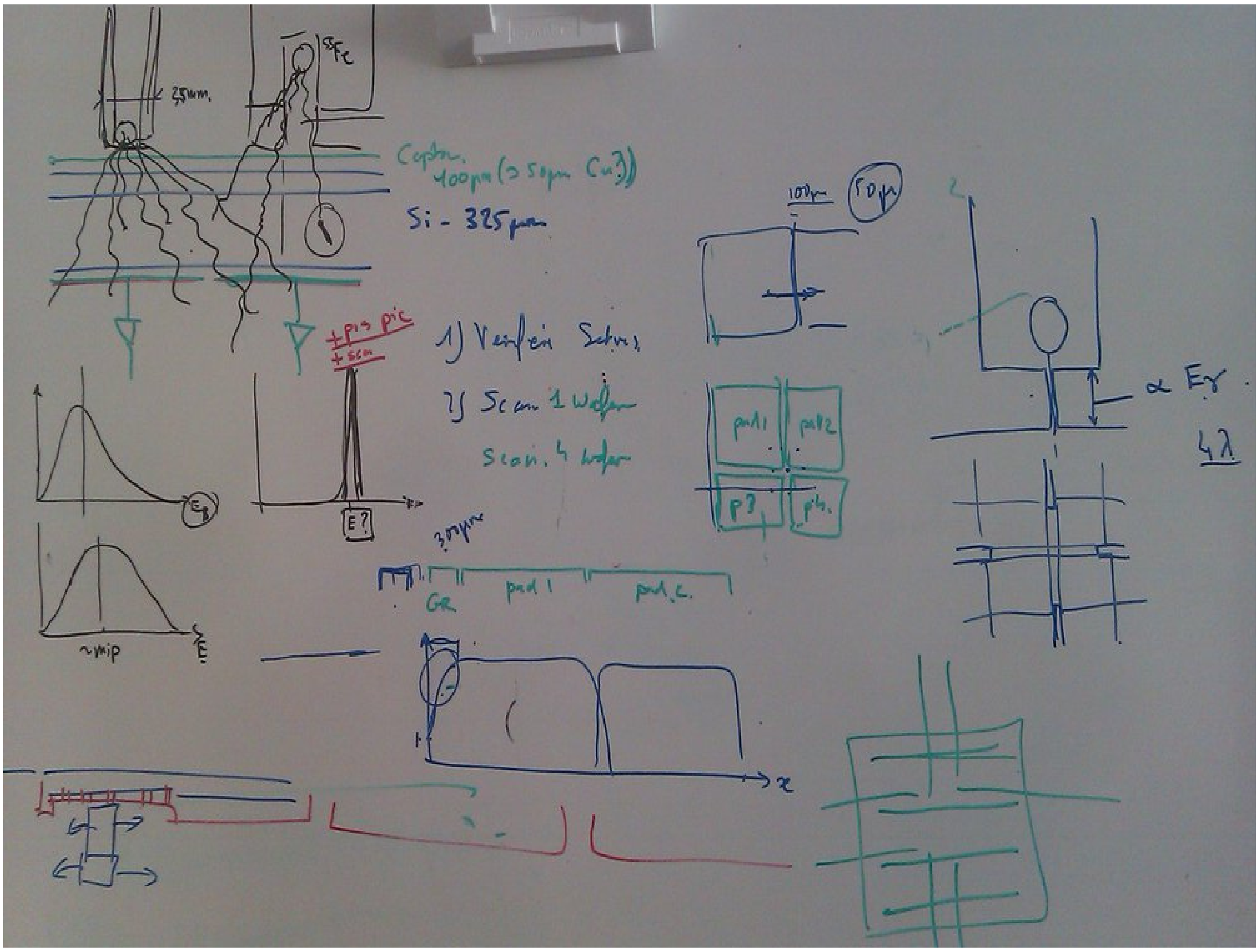


Figure 2: Expected response from the scans across 3 pixels and an inter-wafer gap



3 Implementation

3.1 Service and test trays

One *Service Tray* for the adaptor board + DIF board stitched to up-to 3 *Test Trays* having a capacity of 3 ASU's or PCB's each.

The trays have a hole or a thinner lower surface under the middle [end if they are reversible]

[DESSIN IMPLEMENTATION DE MICHAEL]

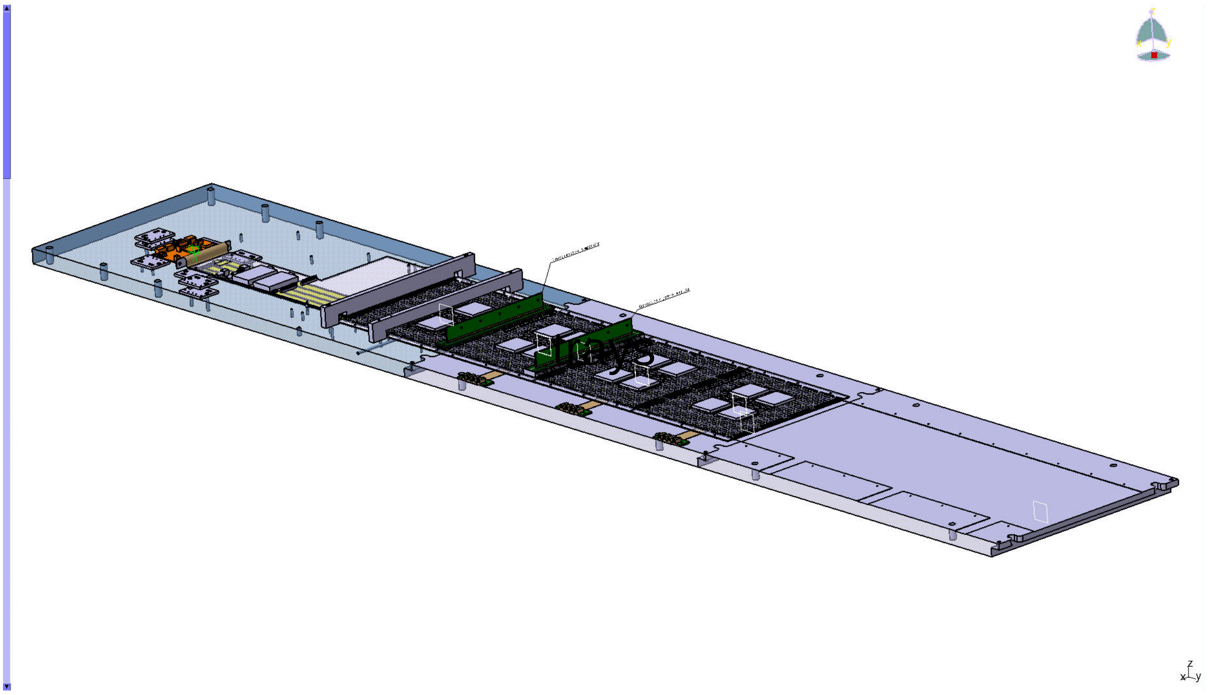
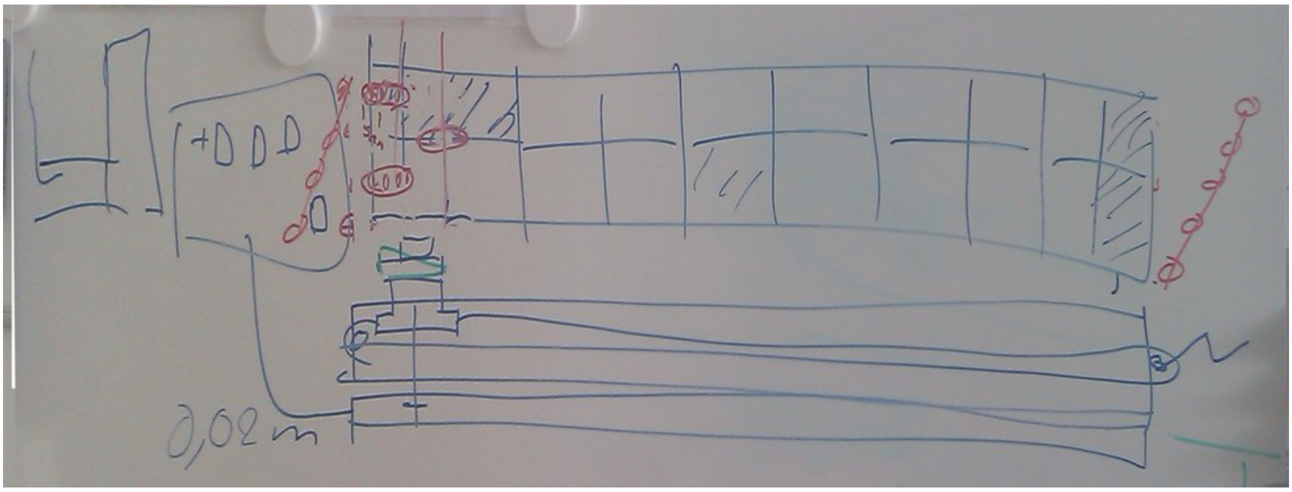


Figure 3: Service Tray and two Test Tray.

blablabla

3.2 Moving arm

Precision, length needed from the mechanical point of view…



3.3 DAQ

Rate limitation ?

Conversion times ? → max rates with PP

3.4 Sources

Five types of signals could be envisaged: cosmics, high energy beta or low energy gammas from a radio-active source, IR laser source, 3 MeV electron beam (PHIL).

The energy deposited in the depletion region, its shape (pic or spread) and the amount of material to to cross before deposition, as well as the rate of the signal, will determine the source.

3.4.a Cosmics

High energy muons from cosmics rays provide a minimum signal of:

$$\text{mip}_{\perp} = 3.876\ \text{MeV cm}^{-1} \times 0{,}0320\ \text{cm} = 0.124\ \text{MeV} = 124\ \text{keV}$$

The distribution is $\propto \cos^2\theta$ with θ being the angle wrt the vertical.

The flux is ~$1/\text{dm}^2/\text{s}$, so typically 1/400 Hz for $5\times5\text{mm}^2$ cells.

3.4.b Beta source

A source of ^{90}Sr-^{90}Y provides betas of up-to 546 keV and 2.2 MeV following a continuous spectrum. High energy electrons will traverse the 320 µm thick Silicon, but not always along a straight path. An initial energy of at least 250 keV is needed (see attached Annex)

A small (in dimension) 37 MBq ^{90}Sr source is available at LLR with a holder and a collimator, still usable for a couple or years. A new collimator would need to retrain the beam signal spread for the fine scan measurements.

An aperture of 50 µm at 1 cm from the centre of the source would provide ~ 1.162 MHz of ß.

[WHICH FRACTION ABOVE 250 KEV ?]

3.4.c Gamma source

Gamma sources of low energy would provide a peaked signal that could be at the value of the expected mip response. Photons would traverse shielding and only a small fraction would interact in the Silicon wafers. One could place a source at ~1cm from the wafers behind an aluminium plate. At this distance, it would covers well ~8×8 cells (4 çm²) with 1/6th of the flux.

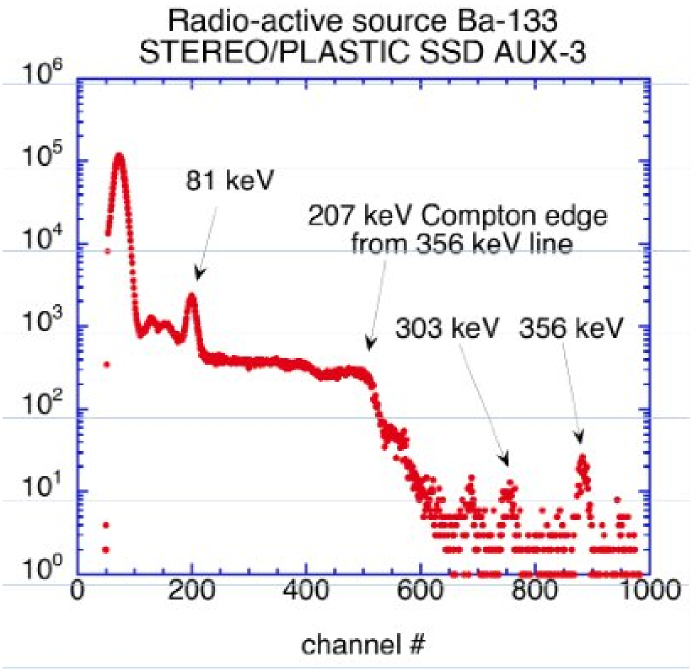
Baryum133 (^{133}Ba)

A source of ^{133}Ba would provide 81keV (34%) and 356keV (64%). It has a $T_{½}$ of 10 years.

The radiation length of 356 keV-γ in Silicon is $1/(1.009\text{e-}01\ \text{cm}^2/\text{g} * 2.33\ \text{g/cm}^3) = 4.25$ cm. About 0.7% of the γ's will interact in 320 µm of which only 4‰ in photoelectric.

The radiation length of 80 keV-γ in Silicon is $1/(6.469\text{e+}01\ \text{cm}^2/\text{g} * 2.33\ \text{g/cm}^3) = 66\mu\text{m}$ mostly in photoelectric.

Voir: http://space.unibe.ch/staff/wurz/7474/Course_6a.pdf]



Cobalt 57 (^{57}Co):

T ½ = 0.744 years, EC

From Taikan’s presentation: 122keV (86%), 136 keV (11%)

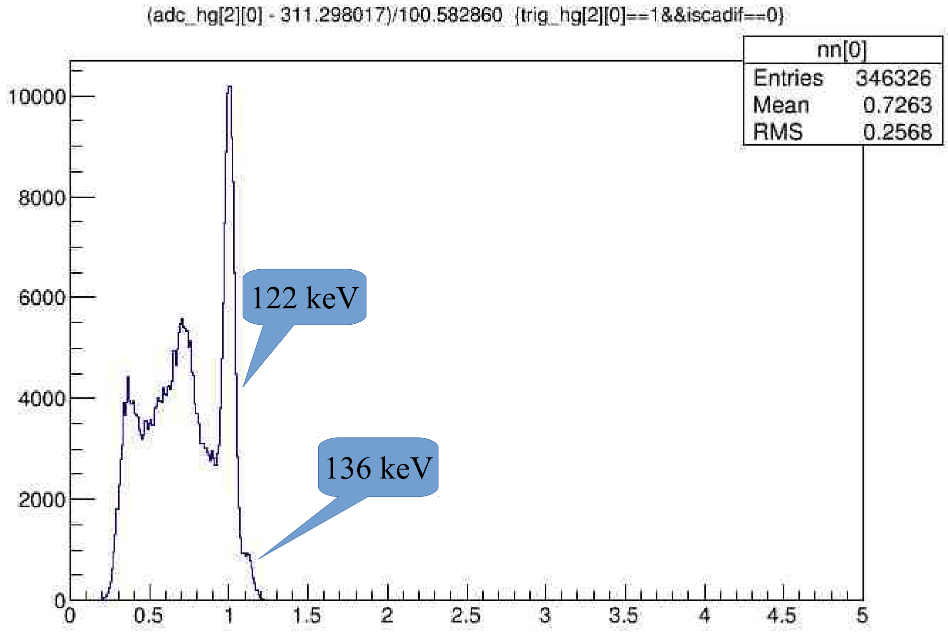


Illustration 1: ^{57}Co spectrum in 300μm wafers (?) from Kyushu group (after pedestal & Gain calibration).

The radiation length of 122 keV-γ in Silicon is 1/(1.318E-02 cm²/g * 2.33 g/cm³) =32 cm mostly in photoelectric. 1% in 300μm Si.

3.4.d IR-Laser

3.4.e Pulsed electron beam (PHIL)

4 Planning

5 Resources

References:

[1] http://www3.nd.edu/~wzech/Application-Note-AN34-ExperimentsNuclear-Science-Experiment-6.pdf: ORTEC manual for TP of electrons in Si: 133 Ba spectrum, etc

[2] Physics for Radiation Protection: A Handbook by James E. Martin {in google books}

Revisions

Author	Date	Change
V. Boudry	31/03/2015	Original layout
V. Boudry	23/05/2017	Addition of injection pattern

Annexes

5.1 Poweringof the Skiroc2

Name	**Value**	**A / D / Mixed**	**Precision**	**Power**	**Pin numbers**
vdda_pa (pre-amp)	3.3 V	A			1, 3, 30, 58, 60, 67, 234
vdd_bg (band-gap)	3.3 V	A			73
vdd_dac (10-bit dual DAC)	3.3 V	A			79
vdd_tdc (TDC)	3.3 V	A			91
vdd_4bits (adc dac adj.)	3.3 V	M			103
vdd_adc (adc disci)	3.3 V	M			105
vddd_delay (trigger delay)	3.3 V	D			109
vdd_discadc (adc discri)	3.3 V	M			115
vddd_tdc (tdc ramp control)	3.3 V	D			125
vddd (POD, LVDS receivers & digital glue)	3.3 V	D			126, 153
vdd! (Digital ASIC)	3.3 V	D			128, 173
vddd_test	3.3 V	D			172 (NC), 203 (NC)
vddd_sc (Slow Control Register)	3.3 V	D			184
vdd_gs (Gain Selection, Analog Trigger Delay, OTAq)	3.3 V	M			190
vdd_trigger (Trigger discriminator)	3.3 V	M			196
vdd_sca (Switched Capacitor Array)	3.3 V	A			204
vddd_sca (Switched Capacitor Array)	3.3 V	D			205
vdd_fs (fast shaper)	3.3 V	A			213
vdd_amp10 (Amplifier Gain 10)	3.3 V	A			217
vdd_ss10 (Slow Shaper Gain 10)	3.3 V	A			223
vdd_ss1 (Slow Shaper Gain 1)	3.3 V	A			227
vdd_pa (PreAmplifier)	3.3 V	A	vdda_pa ?		229

5.2 Stopping power of electron in Silicon

<head><title>NIST STAR Database</title><script language="JavaScript

SILICON			Density	
Kinetic Energy MeV	Total Stp.Pow. MeV cm2/g	CSDA Range g/cm2	g/cm³	
			2,33	
1,00E-002	1,69E+001	3,46E-004	**0**	
1,25E-002	1,43E+001	5,07E-004	**0**	
1,50E-002	1,25E+001	6,95E-004	**0**	
1,75E-002	1,12E+001	9,07E-004	**0**	
2,00E-002	1,01E+001	1,14E-003	**0**	
2,50E-002	8,56E+000	1,68E-003	**0,001**	
3,00E-002	7,49E+000	2,31E-003	**0,001**	
3,50E-002	6,69E+000	3,02E-003	**0,001**	
4,00E-002	6,08E+000	3,80E-003	**0,002**	
4,50E-002	5,58E+000	4,66E-003	**0,002**	
5,00E-002	5,18E+000	5,59E-003	**0,002**	
5,50E-002	4,85E+000	6,59E-003	**0,003**	
6,00E-002	4,57E+000	7,65E-003	**0,003**	
7,00E-002	4,12E+000	9,96E-003	**0,004**	
8,00E-002	3,77E+000	1,25E-002	**0,005**	
9,00E-002	3,50E+000	1,53E-002	**0,007**	
1,00E-001	3,27E+000	1,82E-002	**0,008**	
1,25E-001	2,87E+000	2,64E-002	**0,011**	
1,50E-001	2,59E+000	3,56E-002	**0,015**	
1,75E-001	2,39E+000	4,57E-002	**0,02**	
2,00E-001	2,25E+000	5,65E-002	**0,024**	
2,50E-001	2,04E+000	7,99E-002	**0,034**	<-------------
3,00E-001	1,90E+000	1,05E-001	**0,045**	
3,50E-001	1,81E+000	1,32E-001	**0,057**	
4,00E-001	1,74E+000	1,61E-001	**0,069**	
4,50E-001	1,69E+000	1,90E-001	**0,081**	
5,00E-001	1,65E+000	2,20E-001	**0,094**	
5,50E-001	1,62E+000	2,50E-001	**0,107**	
6,00E-001	1,60E+000	2,81E-001	**0,121**	
7,00E-001	1,57E+000	3,44E-001	**0,148**	
8,00E-001	1,55E+000	4,09E-001	**0,175**	
9,00E-001	1,54E+000	4,73E-001	**0,203**	
1,00E+000	1,53E+000	5,39E-001	**0,231**	
1,25E+000	1,53E+000	7,02E-001	**0,301**	
1,50E+000	1,54E+000	8,65E-001	**0,371**	
1,75E+000	1,55E+000	1,03E+000	**0,441**	
2,00E+000	1,57E+000	1,19E+000	**0,51**	
2,50E+000	1,60E+000	1,50E+000	**0,645**	
3,00E+000	1,63E+000	1,81E+000	**0,778**	