

Status of the muon veto

GERDA Collaboration Meeting

Kraków

February, 18th-20th 2008

Markus Knapp



Outline

1. Overview
2. Photomultiplier assembly line
3. Photomultiplier tests
4. Calibration system for PMTs
5. Muon veto DAQ



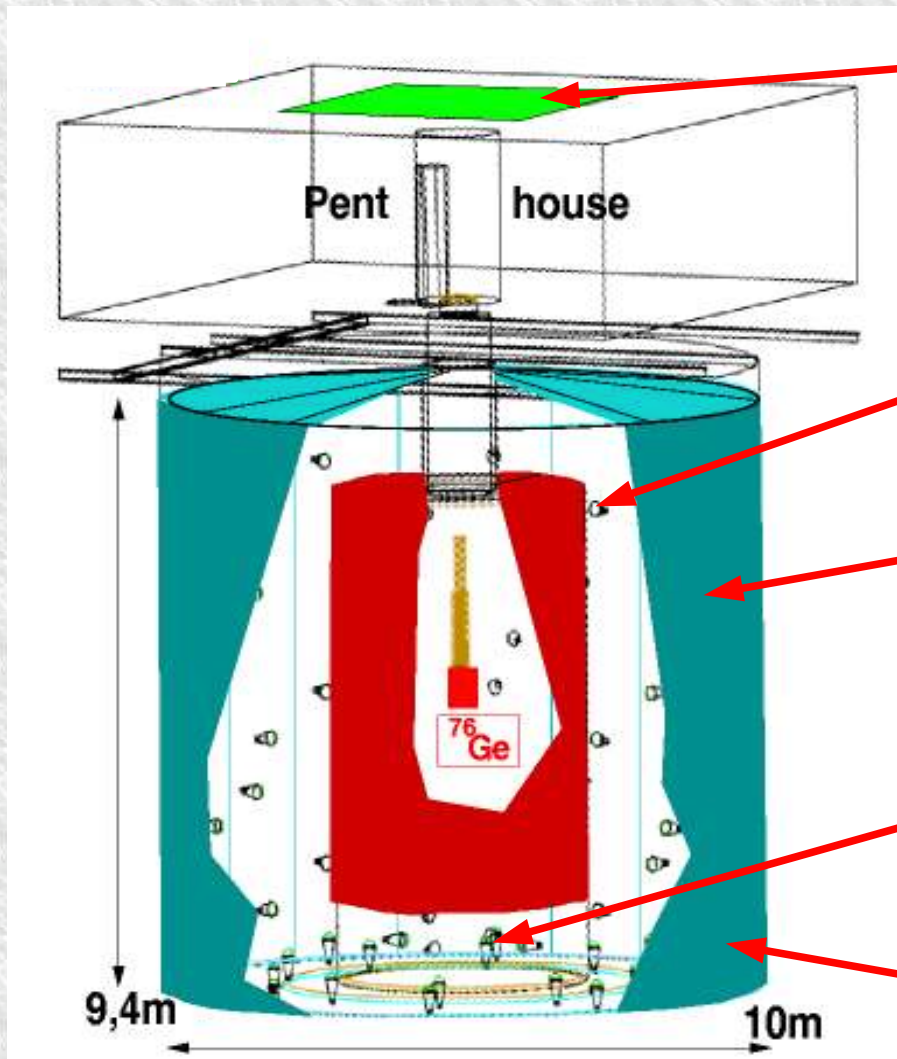
Overview



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Overview: Muon veto



plastic scintillator

photomultiplier

Cherenkov-Veto

„Pillbox“

VM 2000



Status of encapsulation

PMT 9350KB
(ETL)
delivered

small steel parts
delivered

silicon gel
delivered

polyurethane
delivered

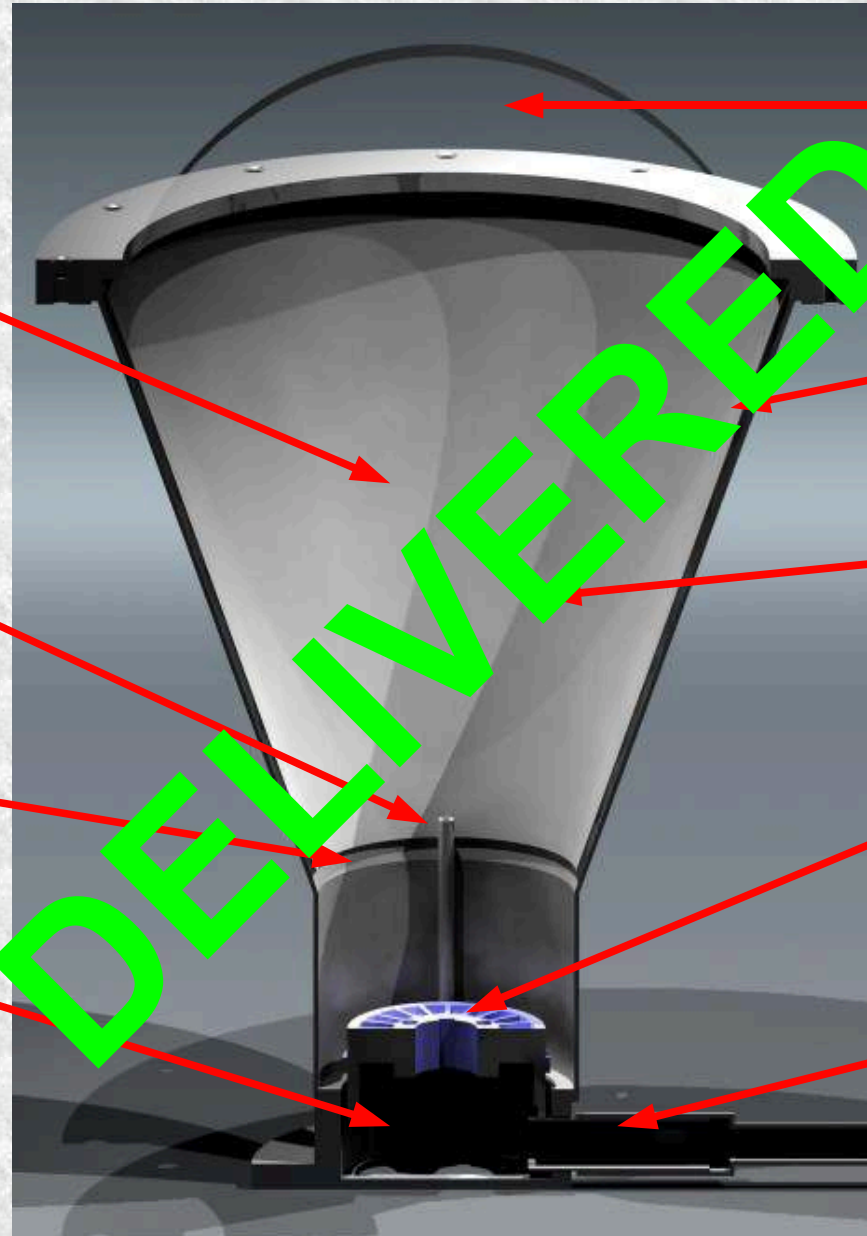
PET-window
delivered

encapsulation
delivered

mineral oil / μ -metal
delivered

B20 socket and
voltage divider
delivered

cable / cable
feedthrough
delivered



Status of encapsulation



Status of VM2000

- 20 rolls of VM2000 are delivered (1,2 m x 45 m, each)
- Test of VM2000 glued on stainless steel in demineralised water has begun
- Till now, the foil is still fixed to the steel (1 week)
- Another sample is put into scintillator (DC-Experiment) and remains also fixed (3 weeks)
- If VM2000 remains glued, we consider gluing it on the watertank (additionally to the studs)



Assembly



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PMT Assembly Line

1. Masterbond gluing



PMT Assembly Line

2. Cable soldering



PMT Assembly Line

3. Pouring of polyurethane



PMT Assembly Line

4. Pouring of silicon gel



PMT Assembly Line

5. Oil filling



PMT Assembly Line Problem with airbubble!



PMT Assembly Line One more step!



PMT Assembly Line One more step!



PMT Assembly Line Problem solved!



PMT Assembly Line Finished



Status of mass production

- 5 PMTs are fully encapsuled.
- 10 more are close to being finished.
- The other 60 will be encapsuled till end of June.



Tests



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Status of encapsulation

- pressure test running since 6 months
- two prototypes
- no problems encountered



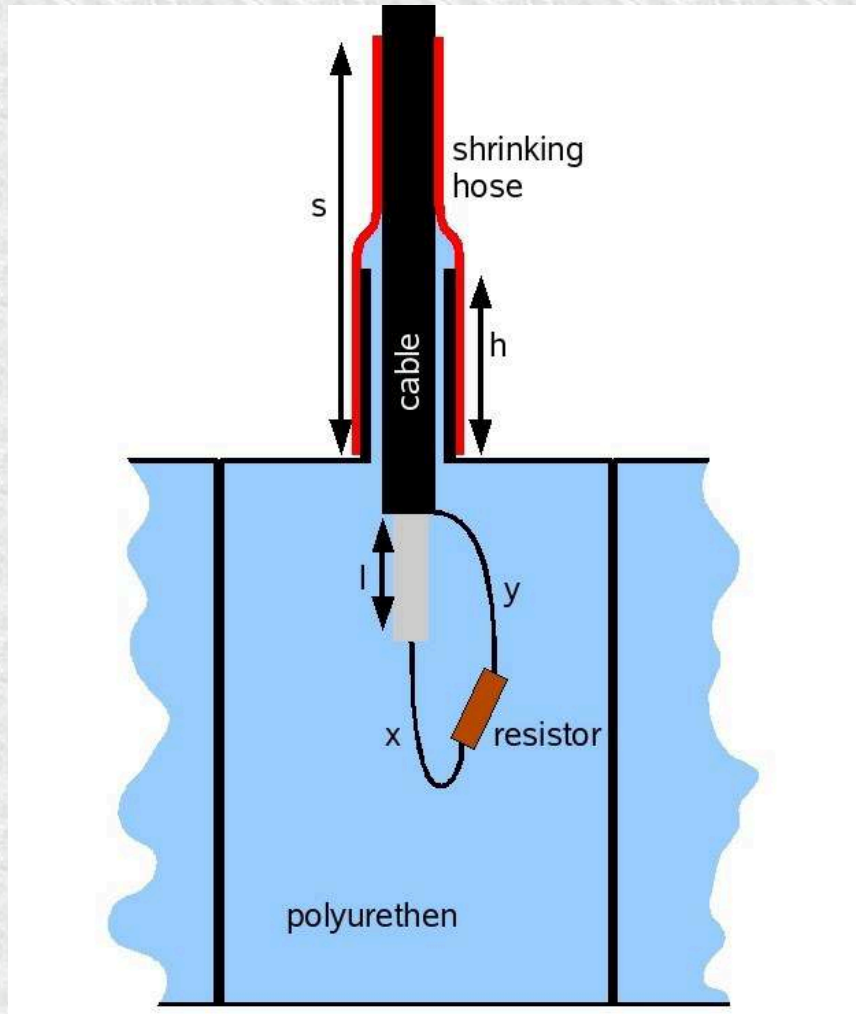
Status of encapsulation

- pressure test running since 6 months
- two prototypes
- no problems encountered

These encapsulations were not "tight", and are nevertheless still working!!

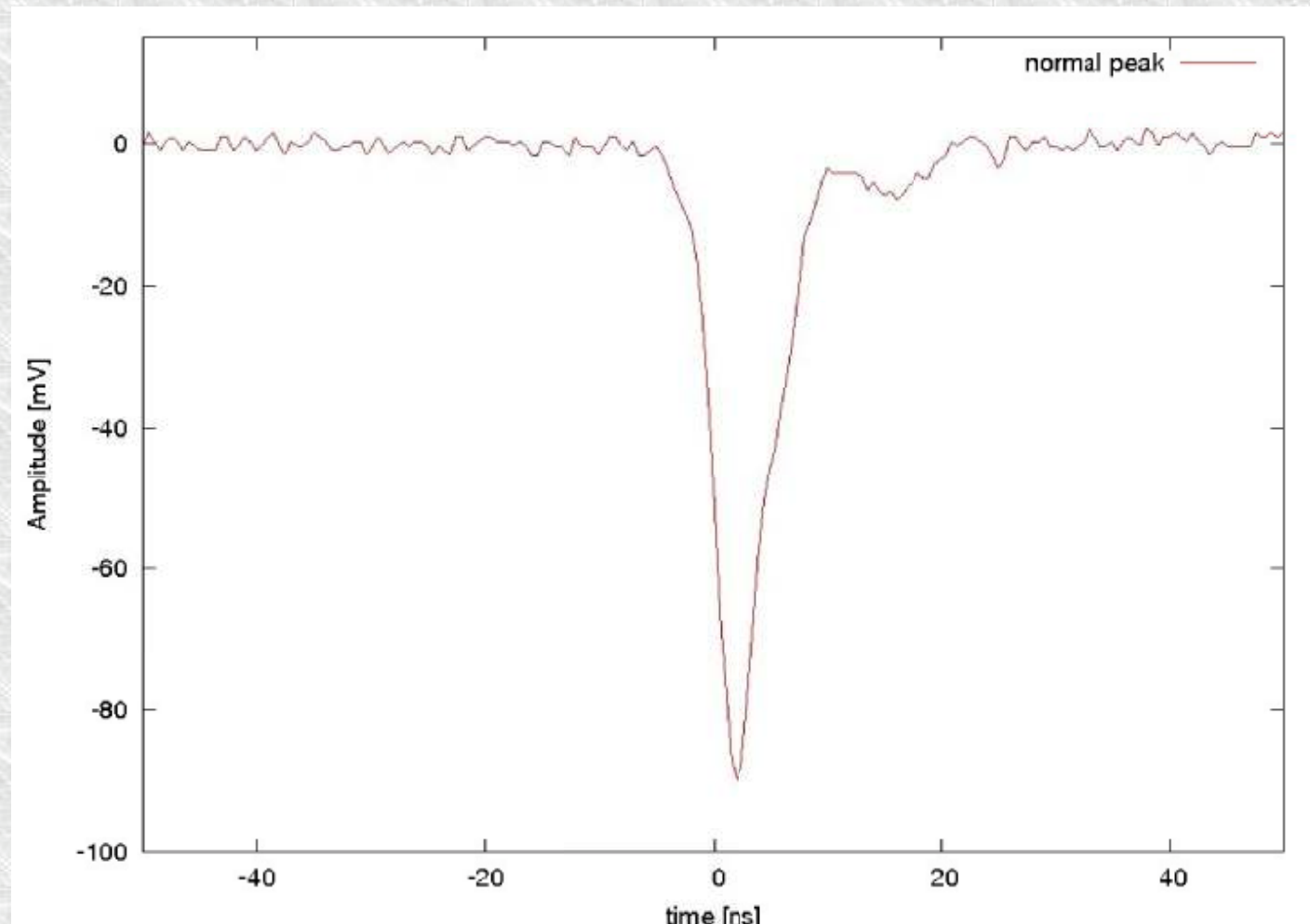


Cable feedthrough tests



- vary lengths: x, y, l, h, s
- worst case scenario (cut, minimal lengths)
- running since 6 months under 2bar pressure
- no problems encountered

Summary: Status of encapsulation



Calibration



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Design: Calibration System

Two independent systems:

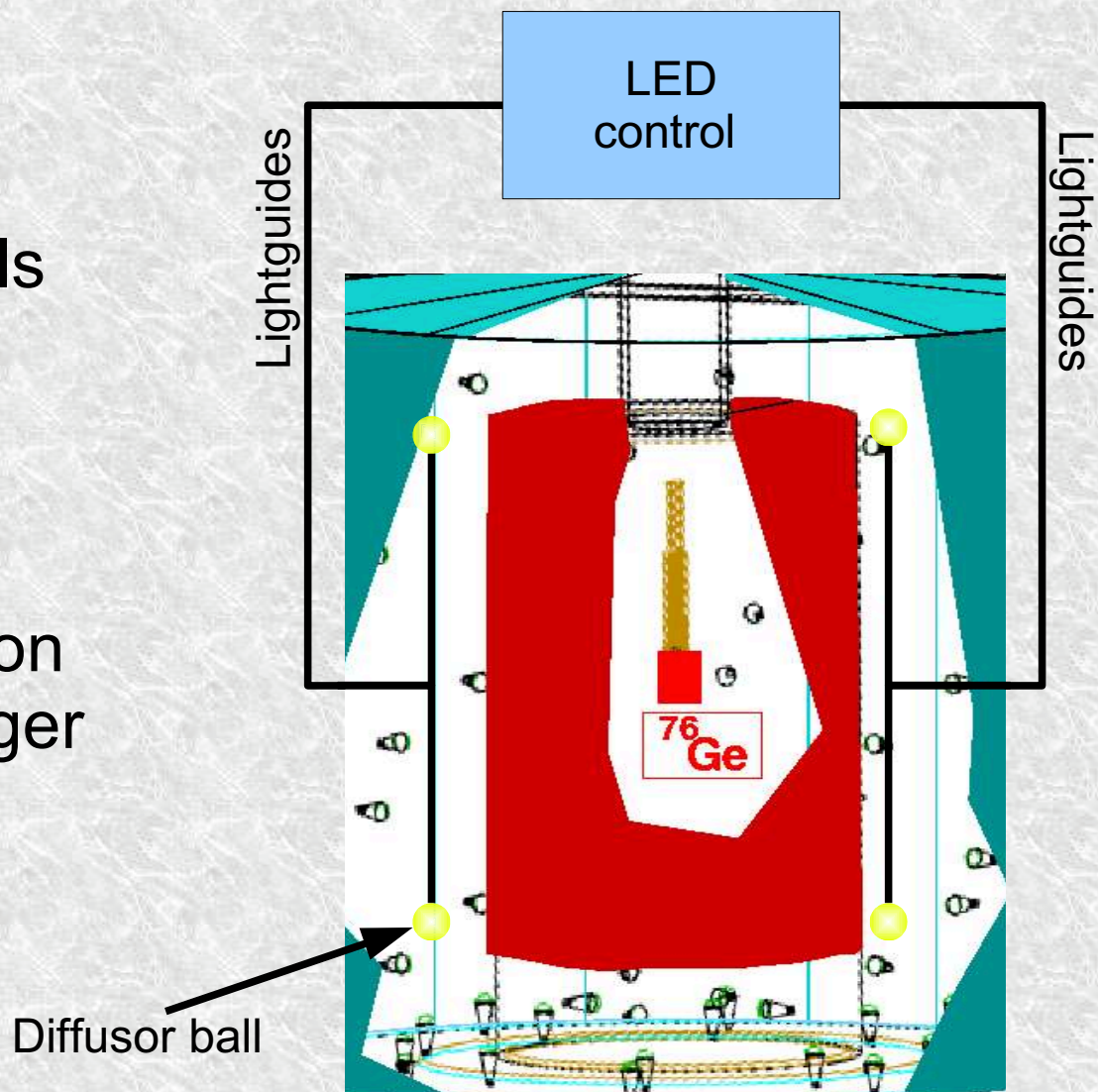
- Lightguides fed with one diode, attached to each PMT for direct calibration.
- Diffusor balls in the watertank, illuminating the whole tank at the same time.



Design: Calibration System

Diffusor balls:

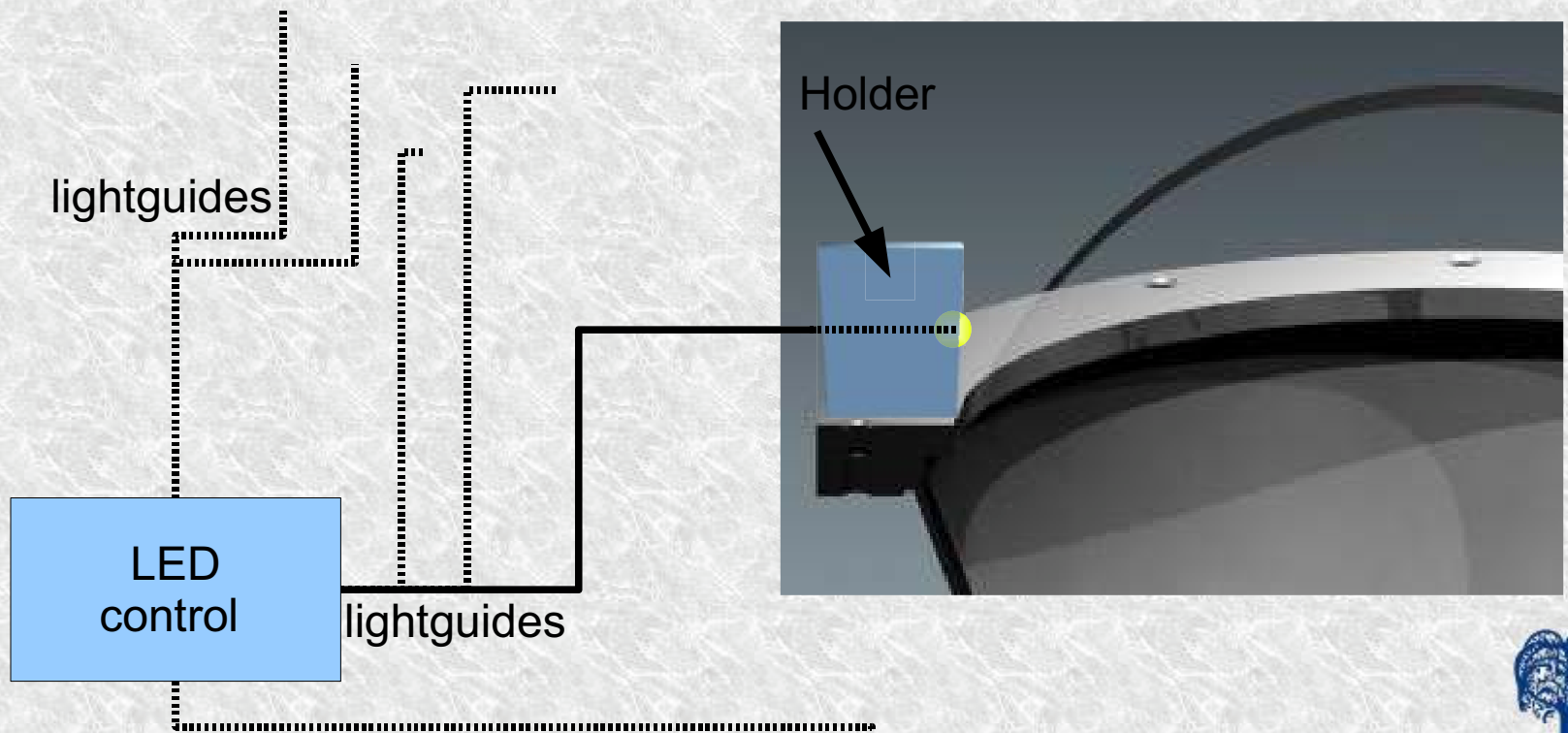
- Several diffusor balls in the watertank
- Supplied by one or more LEDs
- Allows geometry dependant calibration
- Allows tests of Trigger



Design: Calibration System

Single PMT Calibration:

- One LED control with 66 optical fibers as output
- Allows calibration of single PMTs, all with the same light source



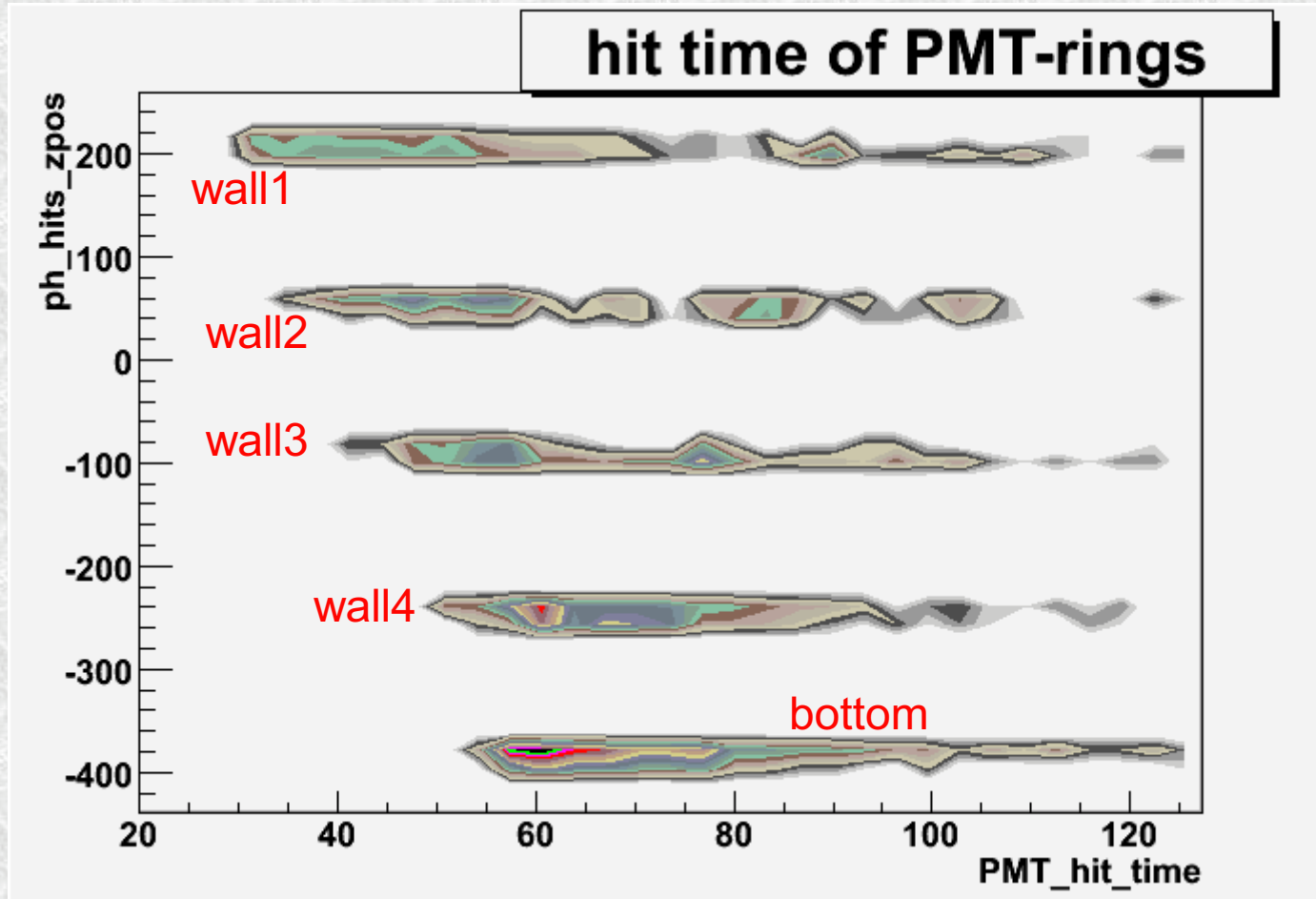
DAQ



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Time information

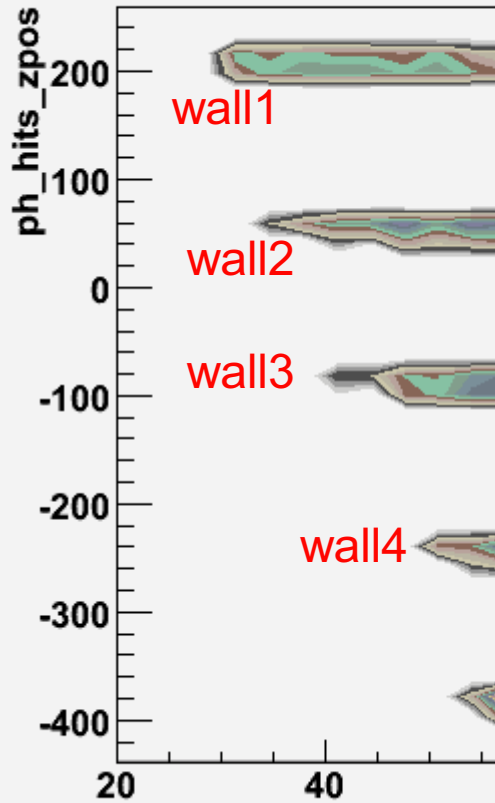


Bottom PMTs register more photons, but later



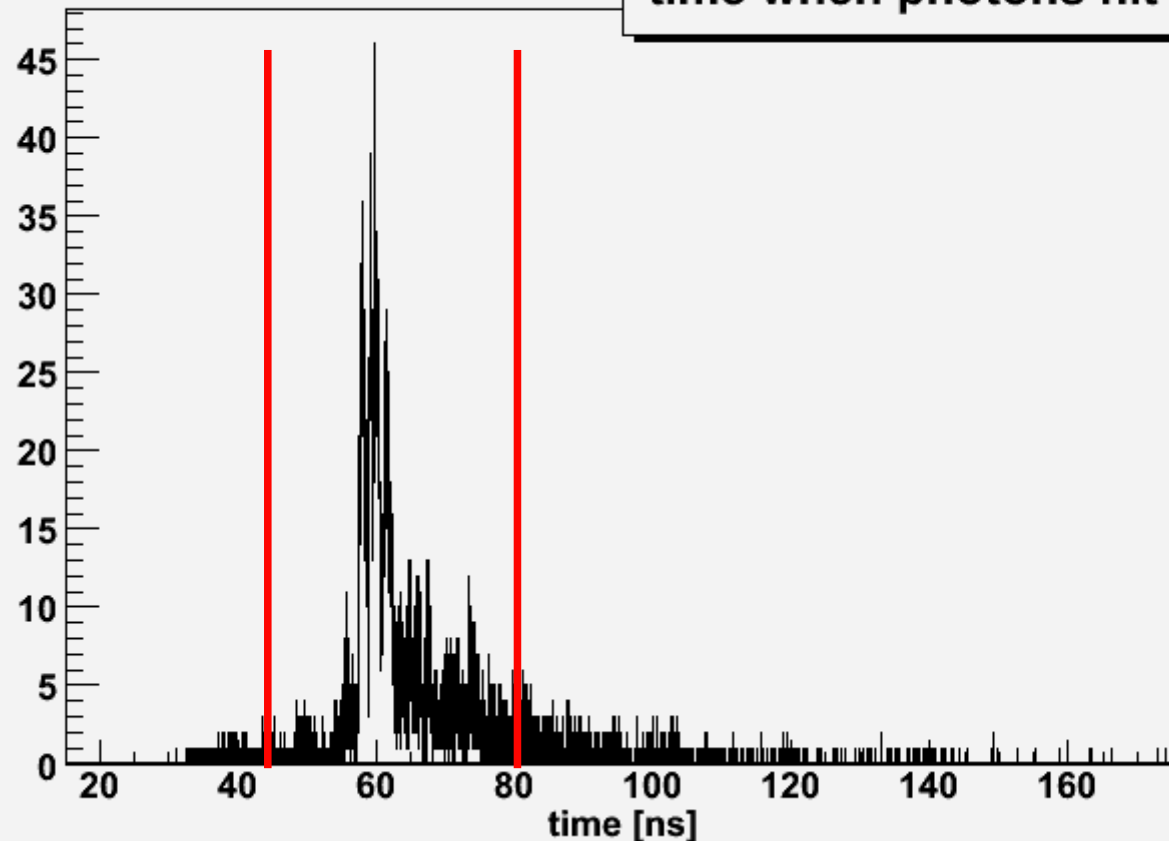
Time information

hit time of PMT-rings



Bottom PMTs register more photons, but later

time when photons hit PMs



~80 % of photons registered within 40 ns

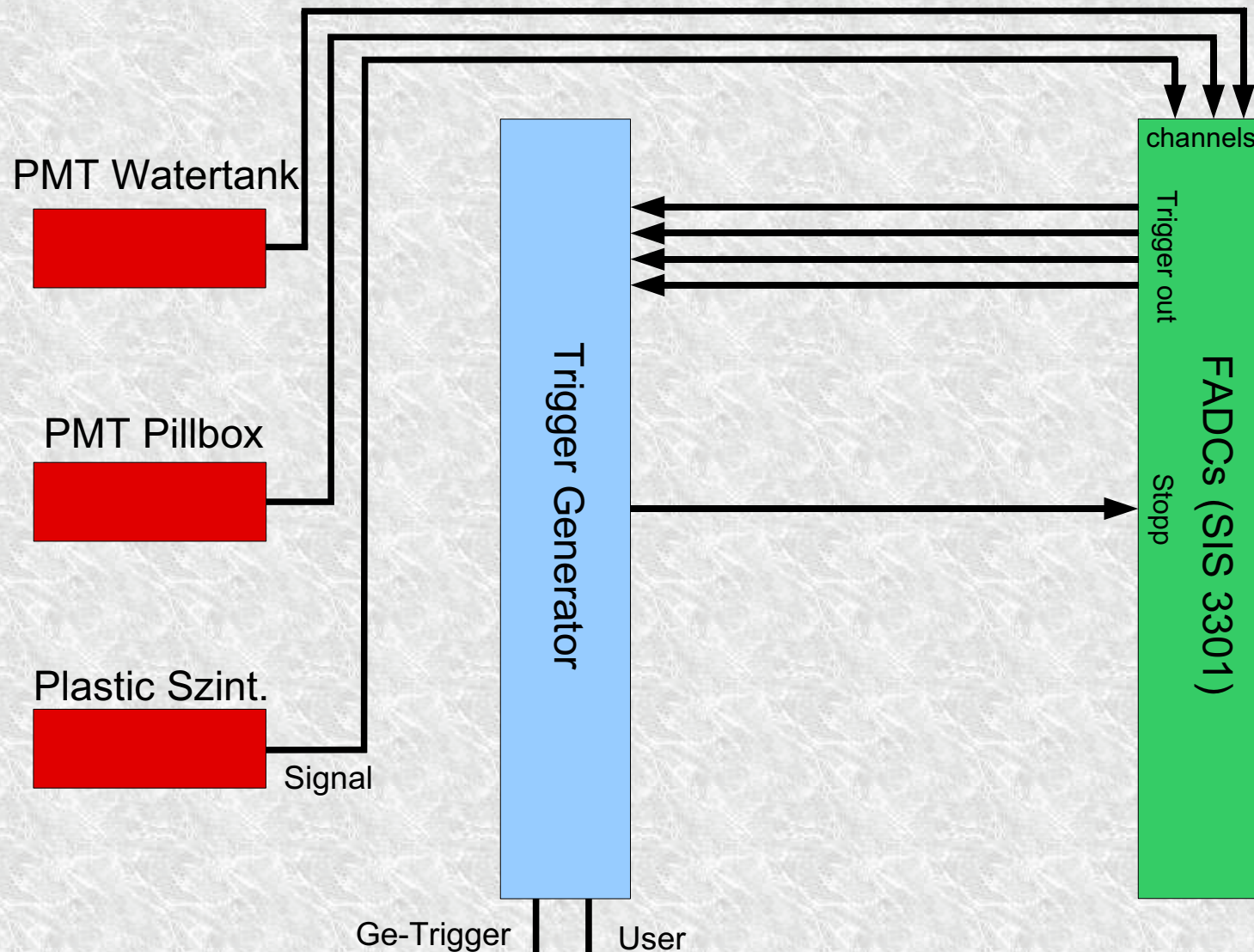


Grouping of photomultipliers - Overview

- Trigger on “Trigger out” of the FADCs (if one channel fires)
- One trigger generator
- an average of 5 kHz random rate per channel
- different FADC channel combinations will be tested
- a simple combination is one PM of the pillbox and one of each ring per FADC
- first results show, high efficiency of more than **98 %** possible
- other combinations will be tested soon



Grouping of photomultipliers - DAQ scheme



Grouping of photomultipliers - Expected random rate

ΔT (ns)	# FADCs	rand. rate (Hz)	efficiency
30	4	3,42E-02	98.5%
30	3	1,27E+01	99.5%

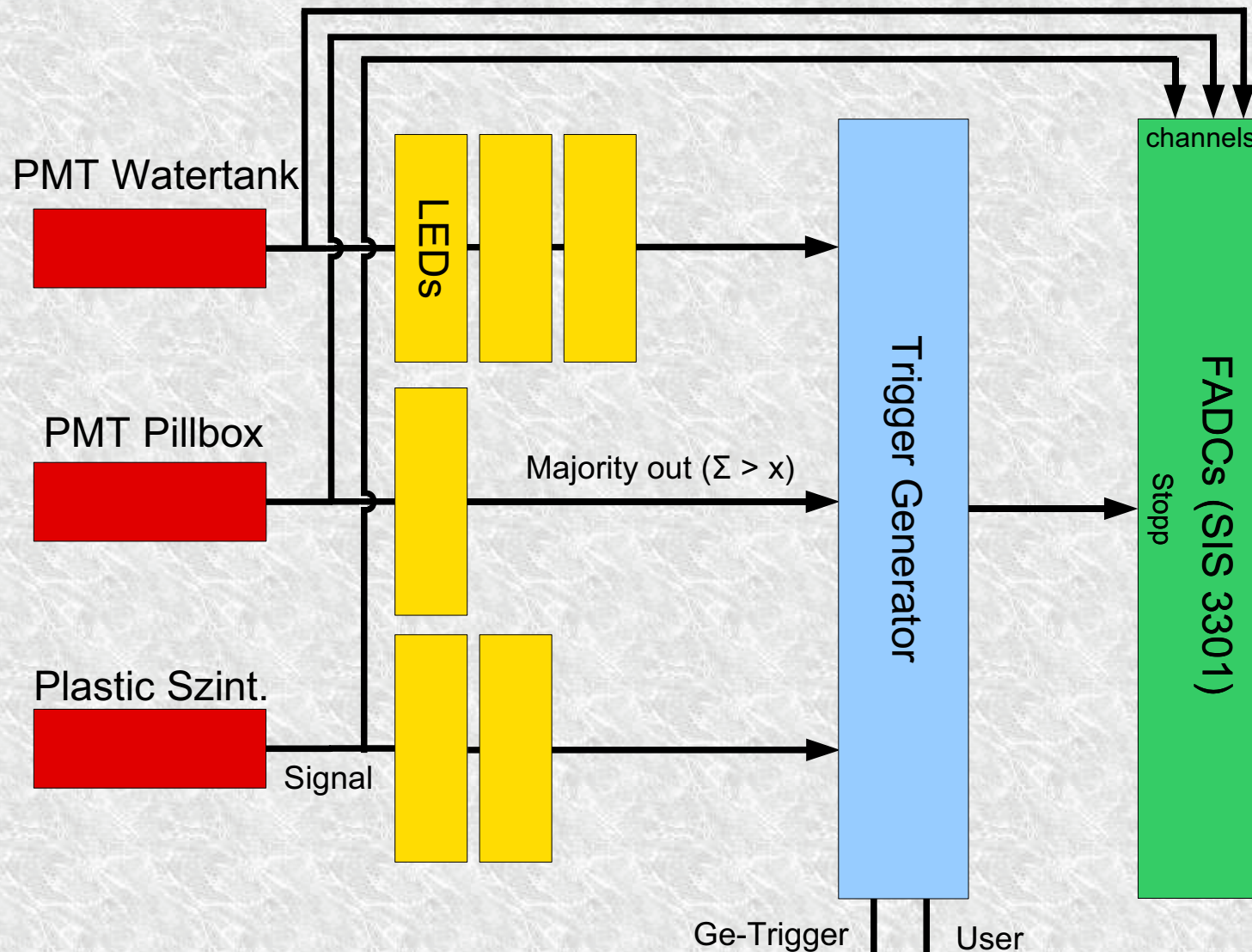


No grouping of photomultipliers - Overview

- Trigger on single photomultiplier signals
- 86 Leading Edge Discriminator channels
- One logic module as trigger generator
- More cost intensive



No grouping of photomultipliers - DAQ scheme



No grouping of photomultipliers - Watertank

ΔT (ns)	# PMTs	rand. rate (Hz)	efficiency
30	5	1,38E-05	81,9%
30	6	1,90E-08	79,8%
30	7	2,20E-11	78,0%



No grouping of photomultipliers - Pillbox

ΔT (ns)	# PMTs	rand. rate (Hz)	efficiency
30	2	1,13E+01	38,2%
30	3	2,25E-03	37,2%
30	4	2,53E-07	36,9%



No grouping of photomultipliers - Pillbox

ΔT (ns)	# PMTs	rand. rate (Hz)	efficiency
30	2	1,13E+01	38,2%
30	3	2,25E-03	37,2%
30	4	2,53E-07	36,9%

Dominates random rate



No grouping of photomultipliers - Some reasonable examples

# pill	# water	ΔT (ns)	total eff.	random rate (Hz)
2	5	30	99,6%	1,13E+01
3	5	30	99,4%	2,25E-03
4	6	30	99,2%	2,53E-07



Comparison of the two DAQ-schemes

- PMT Triggering:

- ▶ Better random rate
- ▶ Easier to implement
- ➔ Higher cost

- FADC Triggering:

- ▶ Less Modules
- ▶ Less expensive
- ➔ Higher random rate
- ➔ More complex in finding the best grouping of PMTs



Cherenkov veto schedule

- February: Continuing of mass production
- April: First batch of encapsuled PMTs will be delievered to LNGS
- May/June: Finishing of mass production

- Delievery of PMTs and additional testing
- Mounting of PMTs in watertank



Summary

- All encapsulation parts are delivered
- Encapsulations are tight and the encapsuled photomultipliers show good signals
- Pressure tests running, and PMTs still working
- Calibration system will be designed
- DAQ with trigger on PMT signals shows lower random rates and similar detection efficiencies
- Production of encapsulations will be finished till May or June.



Thank you



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Grouping of photomultipliers - Expected random rate

time window	coincidence	random rate (Hz)
30 ns	4 FADC	3,42E-02
30 ns	3 FADC	1,27E+01
50 ns	4 FADC	1,58E-01
50 ns	3 FADC	3,52E+01



Grouping of photomultipliers - Expected efficiency

time window	coincidence	efficiency
30 ns	4 FADC	98.5%
30 ns	3 FADC	99.5%
50 ns	4 FADC	98.9%
50 ns	3 FADC	99.5%



No grouping of photomultipliers - Expected efficiency ($\Delta T = 30$ ns)

# pill	# water	pill eff.	water eff.	total eff.
2	5	38,2%	81,9%	99,6%
2	6	38,2%	79,8%	99,5%
2	7	38,2%	78,0%	99,3%
3	5	37,2%	81,9%	99,4%
3	6	37,2%	79,8%	99,2%
3	7	37,2%	78,0%	99,1%
4	5	36,9%	81,9%	99,4%
4	6	36,9%	79,8%	99,2%
4	7	36,9%	78,0%	99,1%



No grouping of photomultipliers - Expected efficiency ($\Delta T = 50$ ns)

# pill	# water	pill eff.	water eff.	total eff.
2	5	38,4%	81,9%	99,6%
2	6	38,4%	80,5%	99,5%
2	7	38,4%	78,6%	99,3%
3	5	37,7%	81,9%	99,5%
3	6	37,7%	80,5%	99,3%
3	7	37,7%	78,6%	99,2%
4	5	37,2%	81,9%	99,4%
4	6	37,2%	80,5%	99,2%
4	7	37,2%	78,6%	99,1%



No grouping of photomultipliers - Expected random rate: Watertank

time window	coincidence	random rate (Hz)
30 ns	5 PMTs	1,38E-05
30 ns	6 PMTs	1,90E-08
30 ns	7 PMTs	2,20E-11
50 ns	5 PMTs	1,07E-04
50 ns	6 PMTs	2,44E-07
50 ns	7 PMTs	4,71E-10



No grouping of photomultipliers - Expected random rate: Pillbox

time window	coincidence	random rate (Hz)
30 ns	2 PMTs	1,13E+01
30 ns	3 PMTs	2,25E-03
30 ns	4 PMTs	2,53E-07
50 ns	2 PMTs	1,88E+01
50 ns	3 PMTs	6,25E-03
50 ns	4 PMTs	1,17E-06



No grouping of photomultipliers - Expected random rate: Pillbox

time window	coincidence	random rate (Hz)
30 ns	2 PMTs	1,13E+01
30 ns	3 PMTs	2,25E-03
30 ns	4 PMTs	2,53E-07
50 ns	2 PMTs	1,88E+01
50 ns	3 PMTs	6,25E-03
50 ns	4 PMTs	1,17E-06

Dominates



Mounting



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Mounting of PMTs

In principal, a very easy mounting:

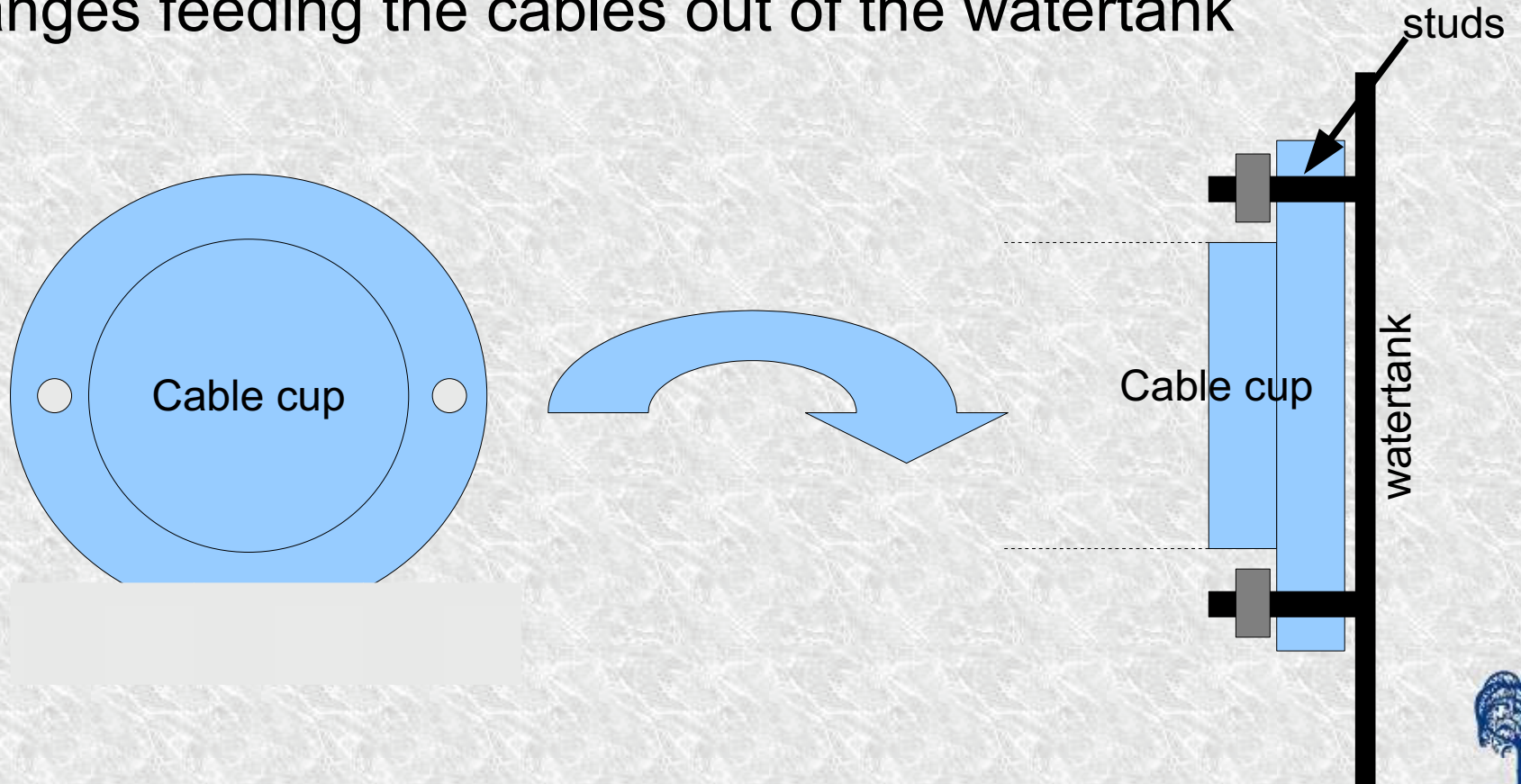
- Two studs per PMT
- Several clamps for the cable
- Cable channel in the upper part of the watertank
- Flanges feeding the cables out of the watertank



Mounting of PMTs

In principal, a very easy mounting:

- **Two studs per PMT**
- Several clamps for the cable
- Cable channel in the upper part of the watertank
- Flanges feeding the cables out of the watertank



Mounting of PMTs

In principal, a very easy mounting:

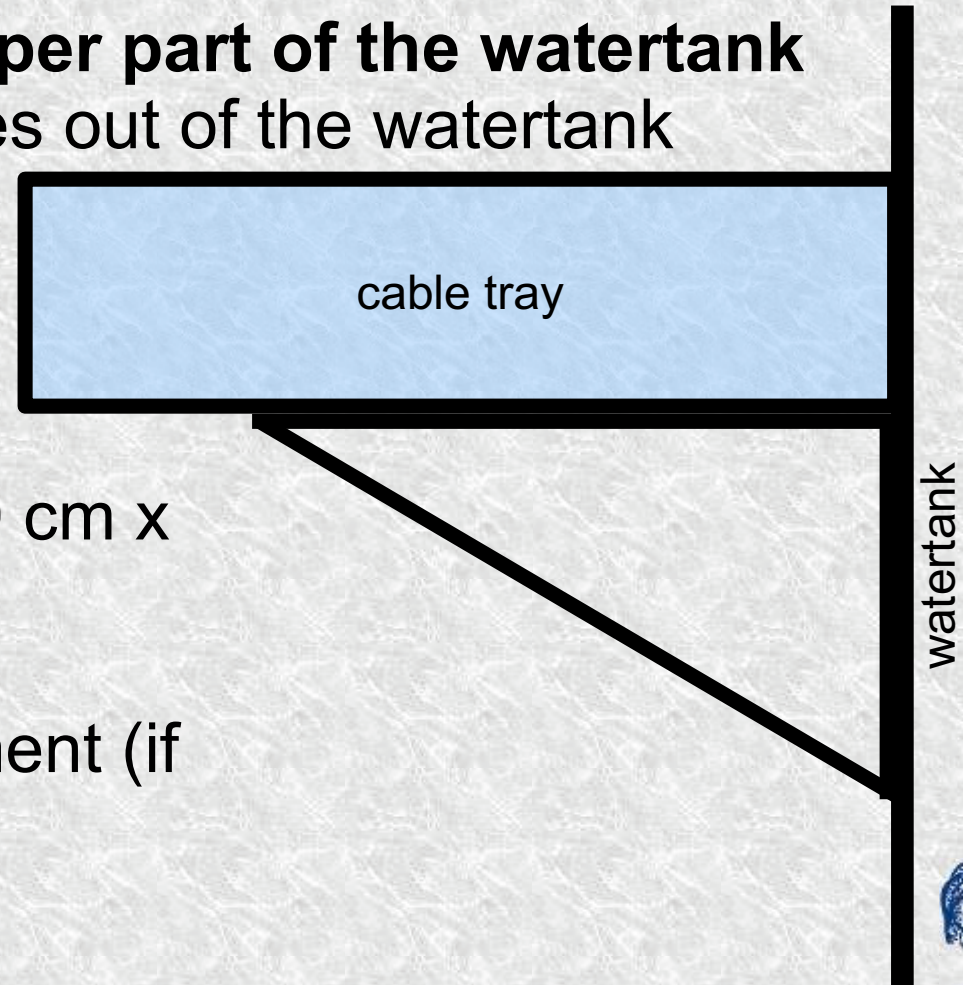
- Two studs per PMT
- **Several clamps for the cable**
- Cable channel in the upper part of the watertank
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Mounting of PMTs

In principal, a very easy mounting:

- Two studs per PMT
- Several clamps for the cable
- **Cable channel in the upper part of the watertank**
- Flanges feeding the cables out of the watertank



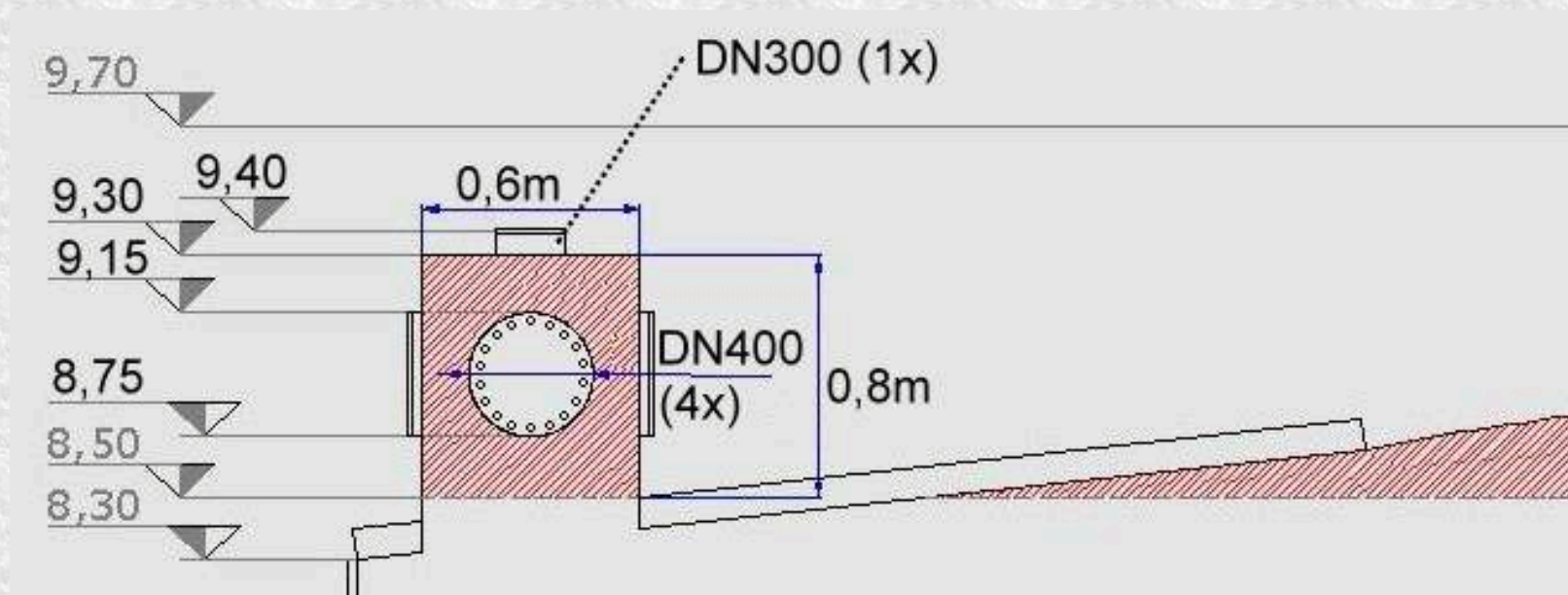
- 30 segments (about 100 cm x 40 cm)
- every 6° one segment
- 2 holders for each segment (if possible)



Mounting of PMTs

In principal, a very easy mounting:

- Two studs per PMT
- Several clamps for the cable
- Cable channel in the upper part of the watertank
- **Flanges feeding the cables out of the watertank**



Mounting of PMTs

Main problem:

How to reach the upper studs

Two possibilities:

- A mobile rack that will be shifted from segment to segment inside the watertank
- A mobile hoisting platform
- For both solutions offers are already available

