



## Slow Control des OPERA Precision Trackers

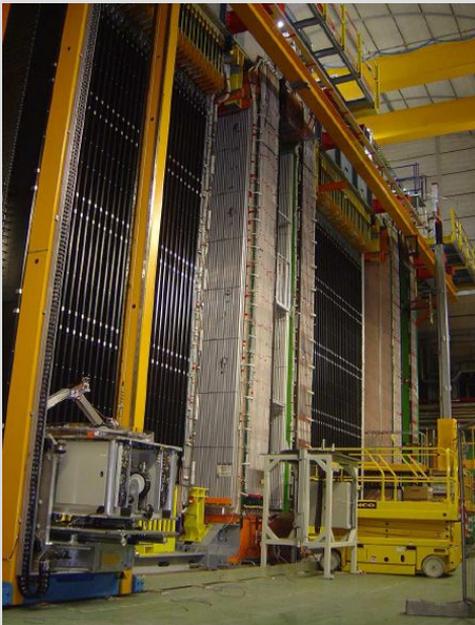


bmb+f - Förderschwerpunkt

OPERA

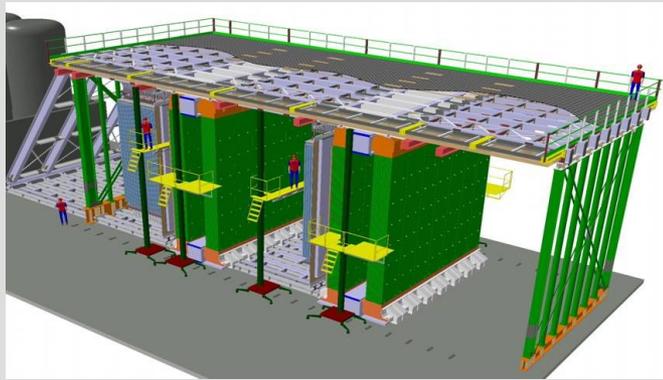
Großgeräte der physikalischen  
Grundlagenforschung

## ► Inhalt

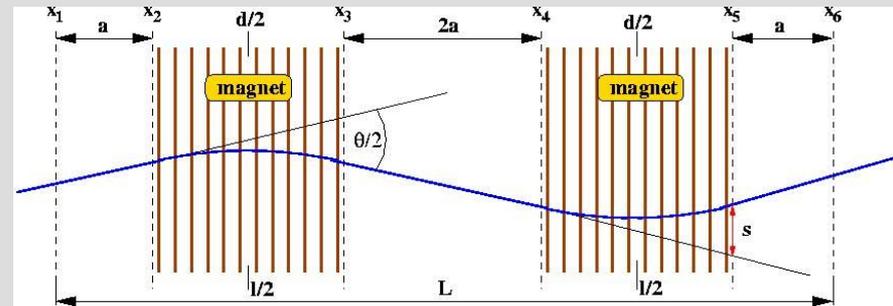


- OPERA und der Precision Tracker
- Übersicht Slow Control
- CAN-Programmierung
- Testpulsmessungen
- Triggersystem
- Zusammenfassung

## ▶ OPERA und der Precision Tracker



Nachweis  $\nu_{\mu} - \nu_{\tau}$  - Oszillation  
OPERA-Detektor



Die Universität Hamburg entwickelt und baut den Precision Tracker aus ca. 10.000 Driftröhren, die in 12 Wänden angeordnet sind und zur Bestimmung des Impulses der Myonen dienen.

Diese Driftröhren müssen mit Gas, Hochspannung, Betriebsspannung versorgt werden, Diskriminatorschwellen gesetzt werden etc. -> **Slow Control**



## ► Übersicht Slow Control

- Gas (-> Vortrag Torben Ferber)
- Hochspannung (HV)
- Betriebsspannung (LV)
- Boards (OSUB und OTB)
  - ★ Schwellen (Diskriminatorschwellen)
  - ★ Temperaturüberwachung
  - ★ Testpulssystem
  - ★ Triggersystem
- SC Datenbank

## ► Übersicht Slow Control

**HV**

CAEN Power Supply  
gesteuert und ausgelesen  
per Ethernet

**OTB**

(Trigger Board)

Ein Board pro Crate  
CAN Bus Anbindung



**Crate  
PowerSupply**

CAN Bus Anbindung  
(Software *WinCRM*)

**OSUB  
(Support Board)**

Ein Board pro TDC  
per CAN Bus gesteuert  
(Controller Area Network)

Schwellen  
Testpulse und  
Temperaturmessungen

**LV**

Betriebsspannung  
gesteuert und ausgelesen  
per CAN Bus

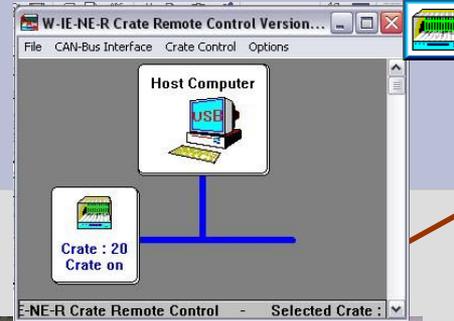
## Übersicht Slow Control Programme



HV

Channel	Power	Status	Set	V Monitor	I Monitor
HPT1-0	235C	0.5	0.2		
HPT1-1	235C	0	0		
HPT1-2	235C	0	0		
HPT1-3	235C	0	0		
HPT2-0	235C	0	0		
HPT2-1	235C	0	0		
HPT2-2	235C	0	0		
HPT2-3	235C	0	0		
HPT3-0-0	235C	0	0		
HPT3-0-1	235C	0	0		
HPT3-0-2	235C	0	0		
HPT3-0-3	235C	0	0		
HPT3-0-4	235C	0	0		
HPT3-0-5	235C	0	0		
HPT3-0-6	235C	0	0		
HPT3-0-7	235C	0	0		
HPT3-0-8	235C	0	0		
HPT3-0-9	235C	0	0		
HPT3-0-10	235C	0	0		
HPT3-0-11	235C	0	0		
HPT3-0-12	235C	0	0		
HPT3-0-13	235C	0	0		
HPT3-0-14	235C	0	0		
HPT3-0-15	235C	0	0		
HPT3-0-16	235C	0	0		
HPT3-0-17	235C	0	0		
HPT3-0-18	235C	0	0		
HPT3-0-19	235C	0	0		
HPT3-0-20	235C	0	0		
HPT3-0-21	235C	0	0		
HPT3-0-22	235C	0	0		
HPT3-0-23	235C	0	0		
HPT3-0-24	235C	0	0		
HPT3-0-25	235C	0	0		
HPT3-0-26	235C	0	0		
HPT3-0-27	235C	0	0		
HPT3-0-28	235C	0	0		
HPT3-0-29	235C	0	0		
HPT3-0-30	235C	0	0		
HPT3-0-31	235C	0	0		
HPT3-0-32	235C	0	0		
HPT3-0-33	235C	0	0		
HPT3-0-34	235C	0	0		
HPT3-0-35	235C	0	0		
HPT3-0-36	235C	0	0		
HPT3-0-37	235C	0	0		
HPT3-0-38	235C	0	0		
HPT3-0-39	235C	0	0		
HPT3-0-40	235C	0	0		
HPT3-0-41	235C	0	0		
HPT3-0-42	235C	0	0		
HPT3-0-43	235C	0	0		
HPT3-0-44	235C	0	0		
HPT3-0-45	235C	0	0		
HPT3-0-46	235C	0	0		
HPT3-0-47	235C	0	0		
HPT3-0-48	235C	0	0		
HPT3-0-49	235C	0	0		
HPT3-0-50	235C	0	0		
HPT3-0-51	235C	0	0		
HPT3-0-52	235C	0	0		
HPT3-0-53	235C	0	0		
HPT3-0-54	235C	0	0		
HPT3-0-55	235C	0	0		
HPT3-0-56	235C	0	0		
HPT3-0-57	235C	0	0		
HPT3-0-58	235C	0	0		
HPT3-0-59	235C	0	0		
HPT3-0-60	235C	0	0		
HPT3-0-61	235C	0	0		
HPT3-0-62	235C	0	0		
HPT3-0-63	235C	0	0		
HPT3-0-64	235C	0	0		
HPT3-0-65	235C	0	0		
HPT3-0-66	235C	0	0		
HPT3-0-67	235C	0	0		
HPT3-0-68	235C	0	0		
HPT3-0-69	235C	0	0		
HPT3-0-70	235C	0	0		
HPT3-0-71	235C	0	0		
HPT3-0-72	235C	0	0		
HPT3-0-73	235C	0	0		
HPT3-0-74	235C	0	0		
HPT3-0-75	235C	0	0		
HPT3-0-76	235C	0	0		
HPT3-0-77	235C	0	0		
HPT3-0-78	235C	0	0		
HPT3-0-79	235C	0	0		
HPT3-0-80	235C	0	0		
HPT3-0-81	235C	0	0		
HPT3-0-82	235C	0	0		
HPT3-0-83	235C	0	0		
HPT3-0-84	235C	0	0		
HPT3-0-85	235C	0	0		
HPT3-0-86	235C	0	0		
HPT3-0-87	235C	0	0		
HPT3-0-88	235C	0	0		
HPT3-0-89	235C	0	0		
HPT3-0-90	235C	0	0		
HPT3-0-91	235C	0	0		
HPT3-0-92	235C	0	0		
HPT3-0-93	235C	0	0		
HPT3-0-94	235C	0	0		
HPT3-0-95	235C	0	0		
HPT3-0-96	235C	0	0		
HPT3-0-97	235C	0	0		
HPT3-0-98	235C	0	0		
HPT3-0-99	235C	0	0		

Programme

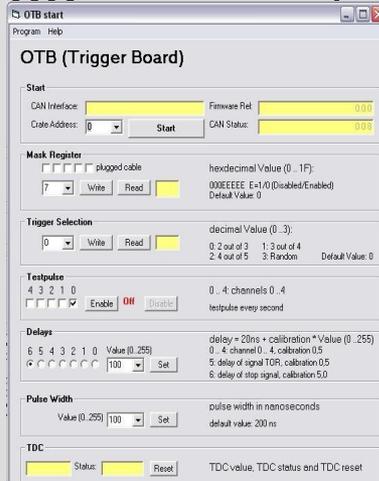


Crate PowerSupply



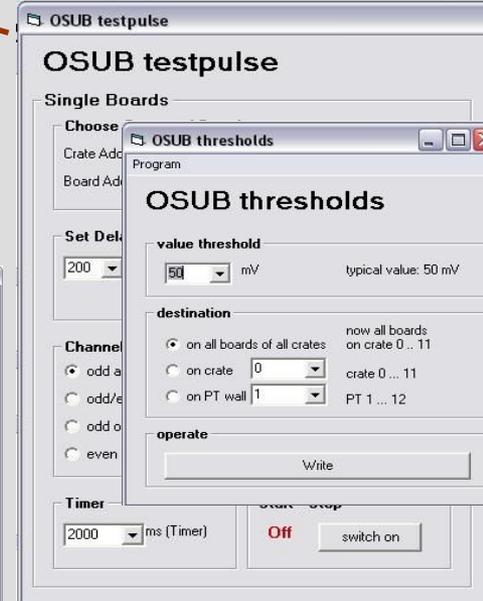
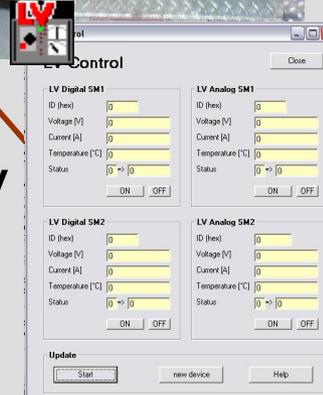
OSUB (Support Board)

OTB (Trigger Board)

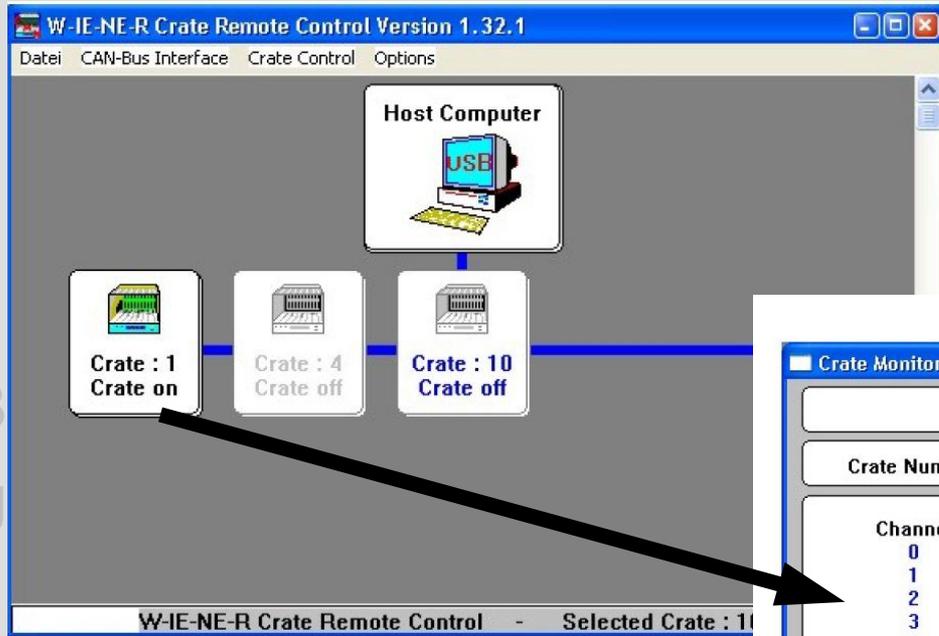


Alles aus Hamburg steuerbar (remote)

LV



## ► Übersicht Slow Control



**Crate PowerSupply**

**Crate Monitoring**

W-IE-NE-R Crate Remote Monitoring

Crate Number: 4    Crate on

Channel	Voltage	Current	Crate Temperatures	
0	5.03	2.45	1	25 °C
1	12.0	0.13	2	—
2	0.00	0.00	3	—
3	0.00	0.00	4	29 °C
4	-5.22	0.84	5	—
5	-12.0	0.13	6	—
6	0.00	0.00	7	29 °C
7	-2.02	1.16	8	—

Set	Fan1	Fan2	Fan3	Fan4	Fan5	Fan6	RPM
1200	1620	1620	1680	0	0	0	

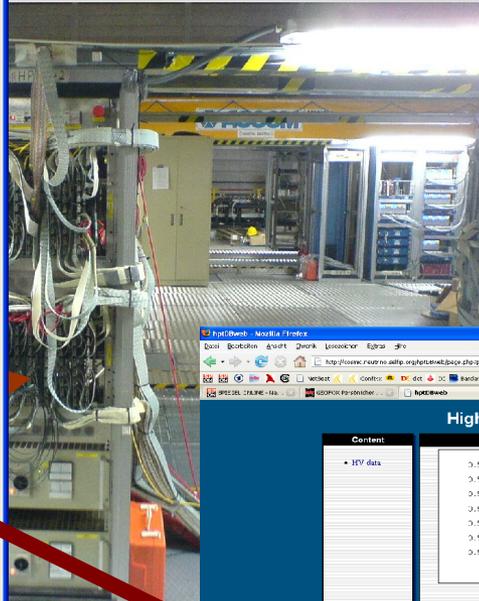
Fan tray software version : UEL6000 3.00  
CAN-bus software version : CAN1.03

## Übersicht Slow Control



HV

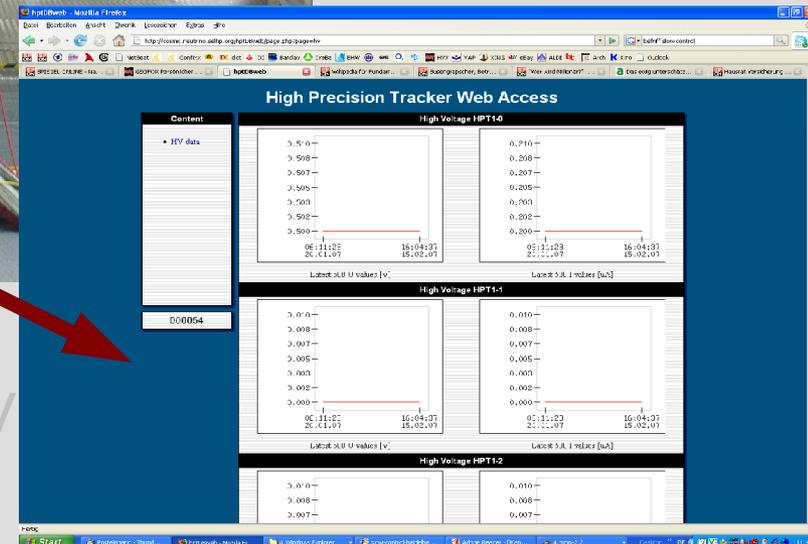
Channel	Power	Status	Set	V Monitor	I Monitor
HPT1-0		good	2350	0.5	0.2
HPT1-1		good	2350	0	0
HPT1-2		good	2350	0	0
HPT1-3		good	2350	0	0
HPT2-0		good	2350	0	0
HPT2-1		good	2350	0	0
HPT2-2		good	2350	0	0
HPT2-3		good	2350	0	0
HPT5+3r-0		good	2350	0	0
HPT5+3r-1		good	2350	0	0
HPT5+3r-2		good	2350	0	0
HPT5+3r-3		good	2350	0	0
HPT3+5l-0		good	2350	0	0
HPT3+5l-1		good	2350	0	0
HPT3+5l-2		good	2350	0	0
HPT3+5l-3		good	2350	0	0
HPT6+4r-0		good	2350	0	0
HPT6+4r-1		good	2350	0	0
HPT6+4r-2		good	2350	0	0
HPT6+4r-3		good	2350	0	0
HPT4+6l-0		good	2350	0	0
HPT4+6l-1		good	2350	0	0
HPT4+6l-2		good	2350	0	0.2
HPT4+6l-3		good	2350	0	0.6



Crate  
PowerSupply

OSUB  
(Support Board)

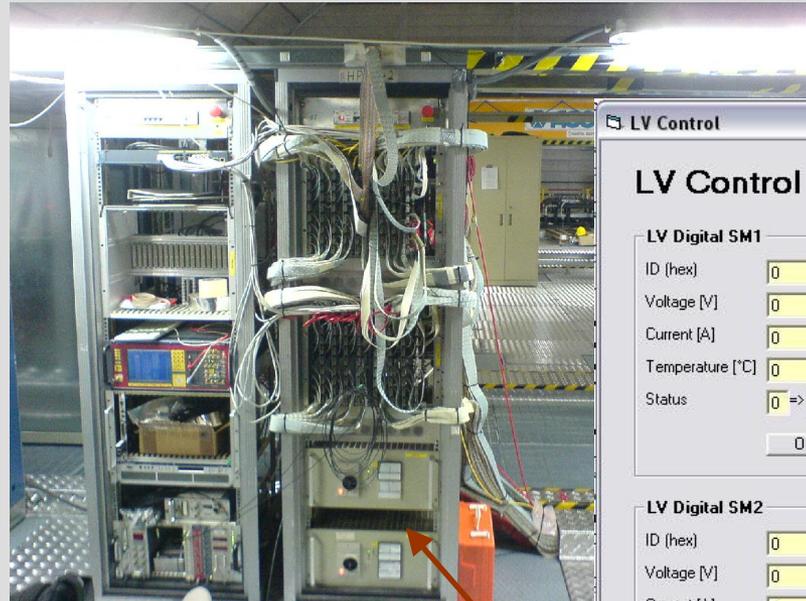
OTB  
(Trig)



## ► Übersicht Slow Control

HV

Crate  
PowerSupply



OTB  
(Trigger Board)



LV Control

Close

LV Digital SM1		LV Analog SM1	
ID (hex)	<input type="text" value="0"/>	ID (hex)	<input type="text" value="0"/>
Voltage [V]	<input type="text" value="0"/>	Voltage [V]	<input type="text" value="0"/>
Current [A]	<input type="text" value="0"/>	Current [A]	<input type="text" value="0"/>
Temperature [°C]	<input type="text" value="0"/>	Temperature [°C]	<input type="text" value="0"/>
Status	<input type="text" value="0 =&gt; 0"/>	Status	<input type="text" value="0 =&gt; 0"/>
<input type="button" value="ON"/> <input type="button" value="OFF"/>		<input type="button" value="ON"/> <input type="button" value="OFF"/>	

LV Digital SM2		LV Analog SM2	
ID (hex)	<input type="text" value="0"/>	ID (hex)	<input type="text" value="0"/>
Voltage [V]	<input type="text" value="0"/>	Voltage [V]	<input type="text" value="0"/>
Current [A]	<input type="text" value="0"/>	Current [A]	<input type="text" value="0"/>
Temperature [°C]	<input type="text" value="0"/>	Temperature [°C]	<input type="text" value="0"/>
Status	<input type="text" value="0 =&gt; 0"/>	Status	<input type="text" value="0 =&gt; 0"/>
<input type="button" value="ON"/> <input type="button" value="OFF"/>		<input type="button" value="ON"/> <input type="button" value="OFF"/>	

Update

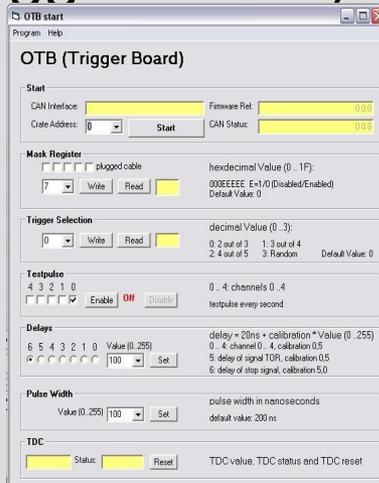
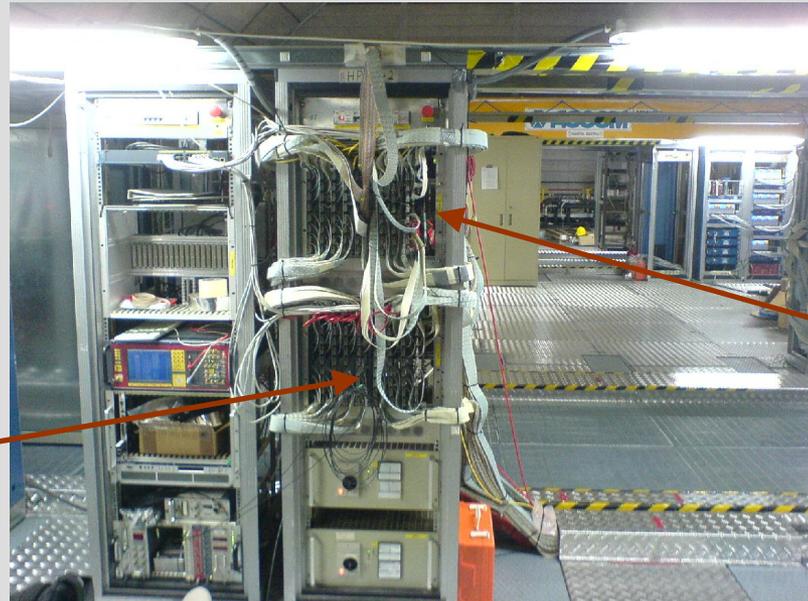
## Übersicht Slow Control

HV

Crate  
PowerSupply

OTB  
(Trigger Board)

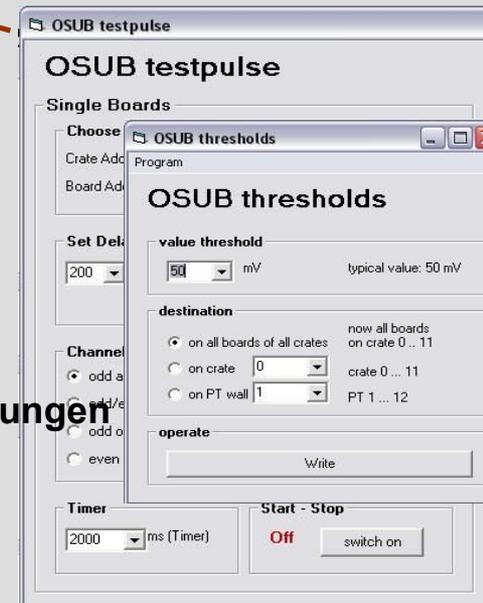
OSUB  
(Support Board)



Triggereinstellungen

Schwellen  
Testpulse und  
Temperaturmessungen

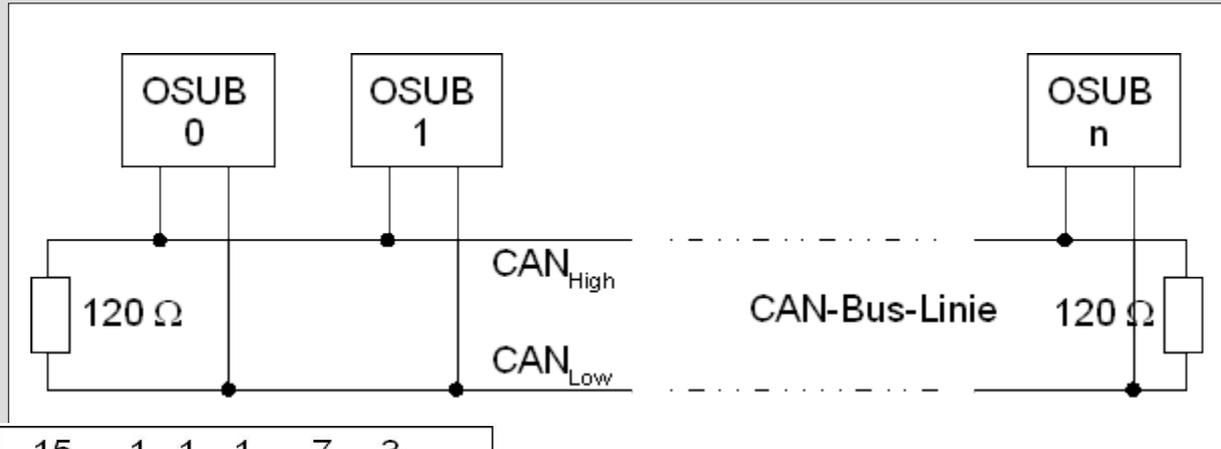
Steuerung per CAN...



## ► CAN-Programmierung

Controller Area Network (Feldbusstandard)

CAN-Netz als Linie



CAN-Nachricht

1	11	1 1 1	4	0 ... 64	15	1 1 1	7	3
Start of Frame	Identifier	Remote Transmission Bit Identifier Extension Bit Reserve	Datenlängengefeld	Datenfeld	CRC-Prüfsumme	CRC-Delimeter Bestätigungs-Slot Bestätigungs-Delimeter	End of Frame	Intermission Bus Idle

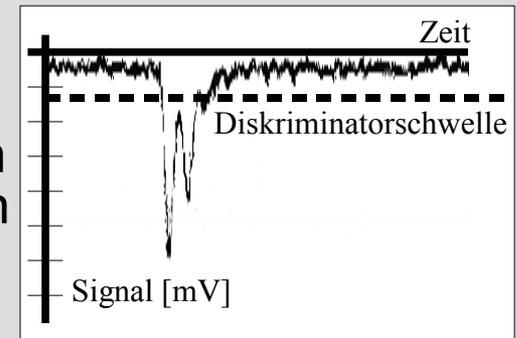
Realisiert  
mit VisualBasic  
und CAN2USB-Adapttern  
(entsprechende .DLL  
und .BAS-Dateien)

## ► CAN-Programmierung

z.B. Software, um Diskriminatorschwellen zu setzen...

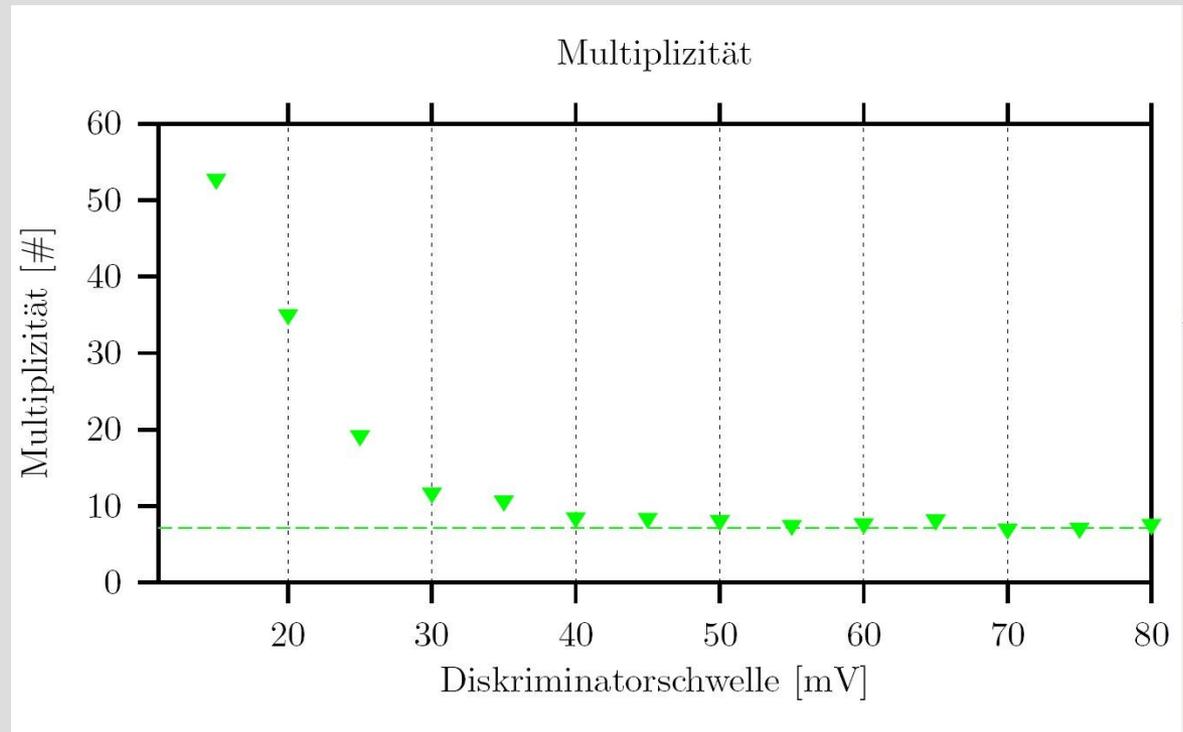


Die Schwellen werden per OSUB auf Vorverstärkerplatinen an den Driftröhren gespeichert und Rauschen dadurch herausgefiltert.



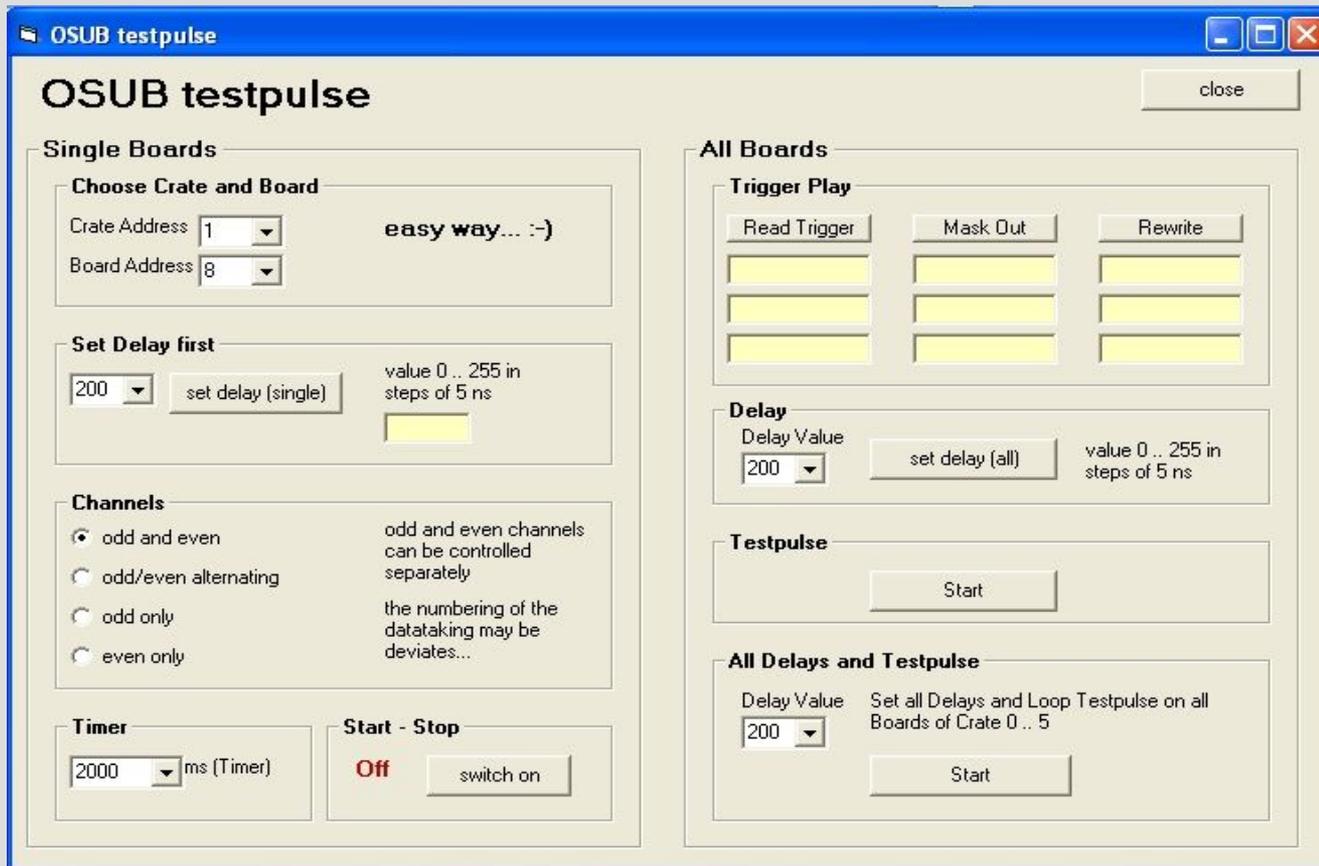
## ► CAN-Programmierung

z.B. Software, um Diskriminatorschwellen zu setzen...



## ► CAN-Programmierung

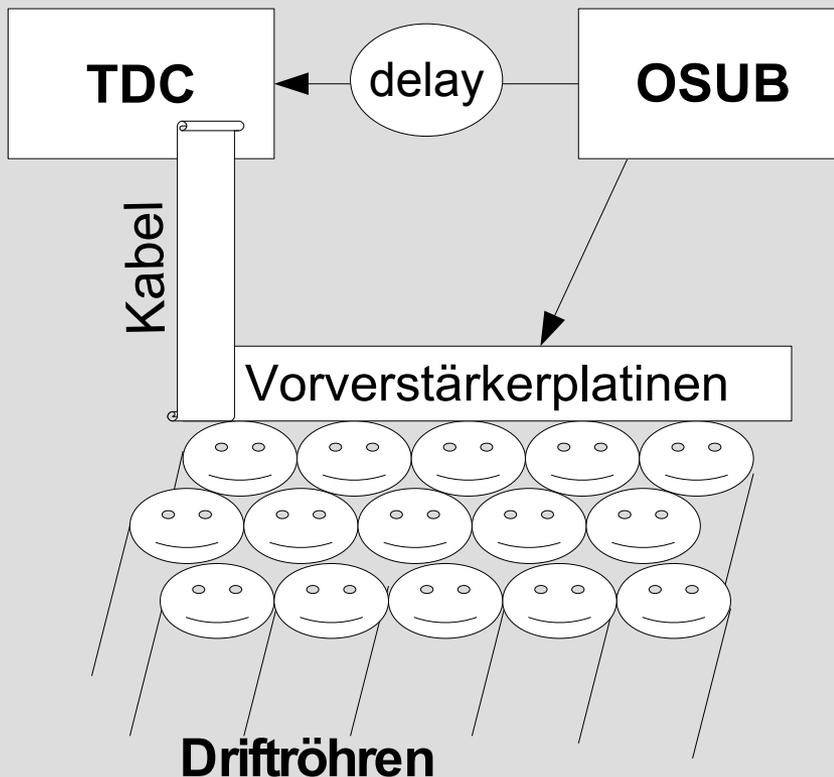
...oder um Testpulse zu generieren



The screenshot shows the 'OSUB testpulse' software window. It is divided into two main sections: 'Single Boards' and 'All Boards'.  
**Single Boards:**  
- **Choose Crate and Board:** Crate Address: 1, Board Address: 8. A note says 'easy way... :-)'  
- **Set Delay first:** Delay value: 200. A note says 'value 0.. 255 in steps of 5 ns'. A 'set delay (single)' button is present.  
- **Channels:** Radio buttons for 'odd and even' (selected), 'odd/even alternating', 'odd only', and 'even only'. Notes explain that odd and even channels can be controlled separately and that numbering may deviate.  
- **Timer:** 2000 ms (Timer).  
- **Start - Stop:** 'Off' status with a 'switch on' button.  
**All Boards:**  
- **Trigger Play:** Buttons for 'Read Trigger', 'Mask Out', and 'Rewrite'. Below each button are three yellow rectangular indicators.  
- **Delay:** Delay Value: 200. A 'set delay (all)' button. Note: 'value 0.. 255 in steps of 5 ns'.  
- **Testpulse:** A 'Start' button.  
- **All Delays and Testpulse:** Delay Value: 200. Note: 'Set all Delays and Loop Testpulse on all Boards of Crate 0.. 5'. A 'Start' button.

## ► Testpulsmessungen

Per OSUB werden Testpulse zu den Driftröhren und somit in die Ausleseelektronik gesendet.



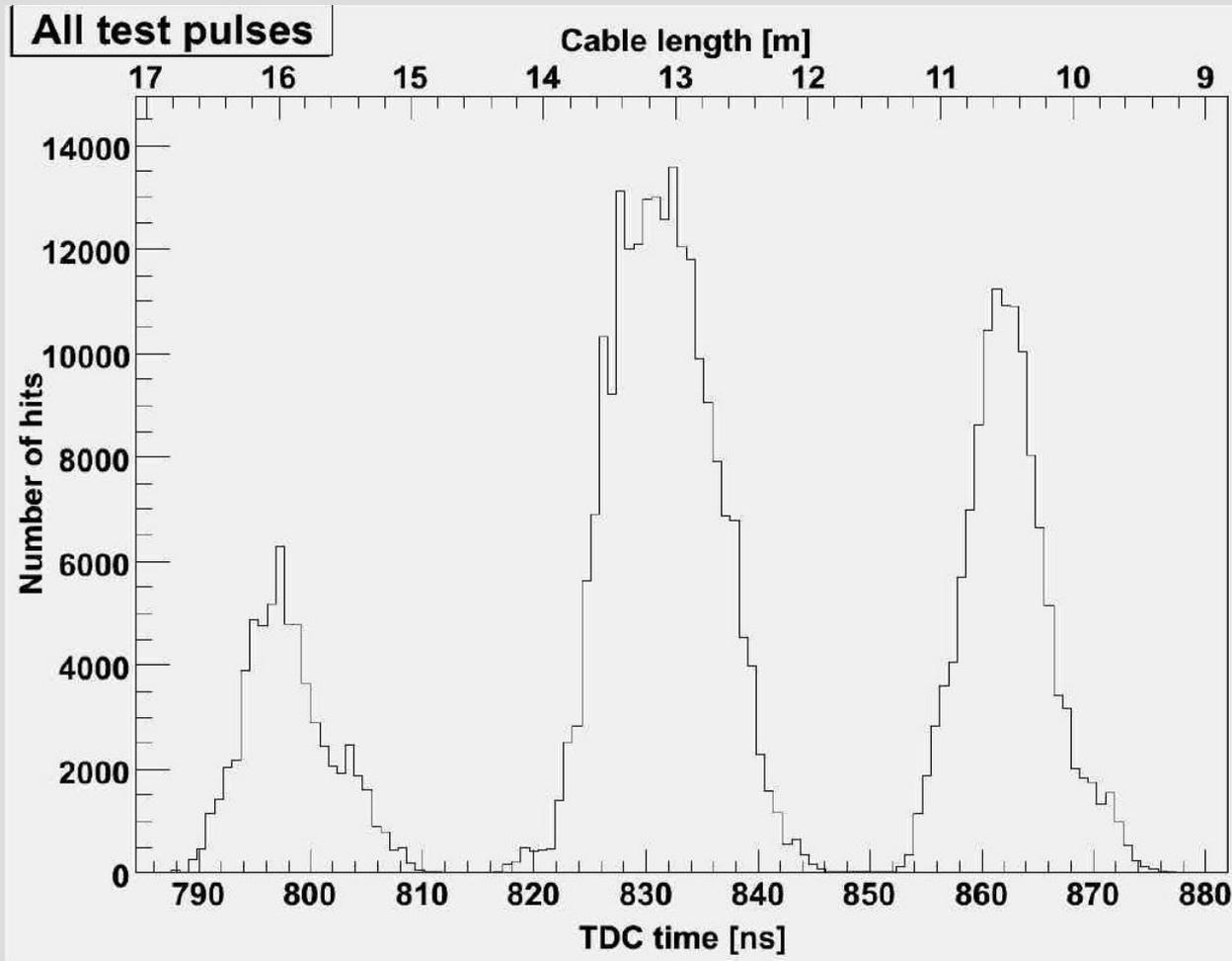
## Funktion der Testpulse

- **Kanalfunktion** testen
- **Übersprechverhalten (Crosstalk)** testen, gerade/ungerade Kanäle separat steuerbar
- **Signallaufzeiten** messen

## ► Testpulsmessungen

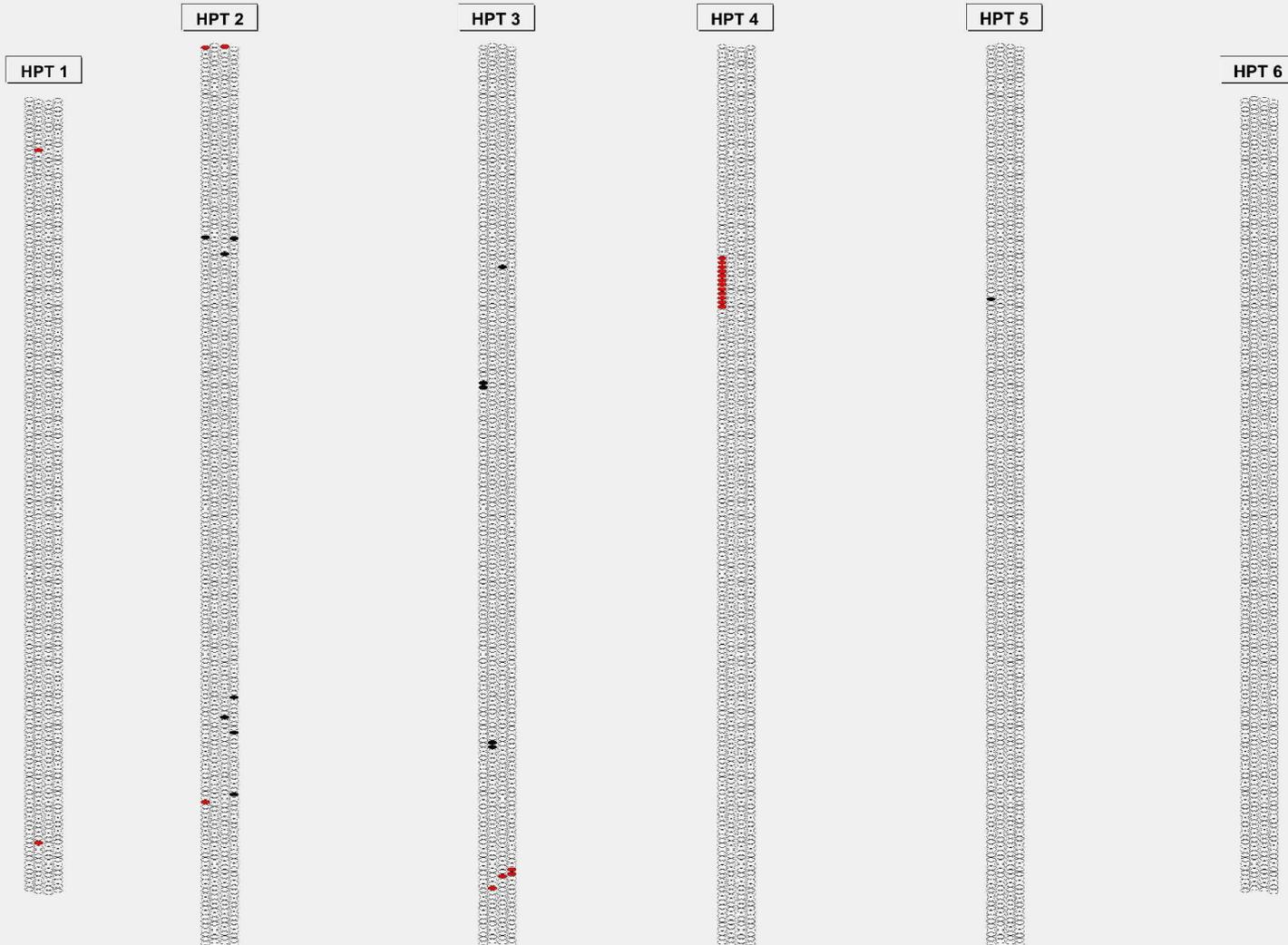
(von Eike Frank)

Kabellänge



## ▶ Testpulsmessungen

(von Eike Frank)

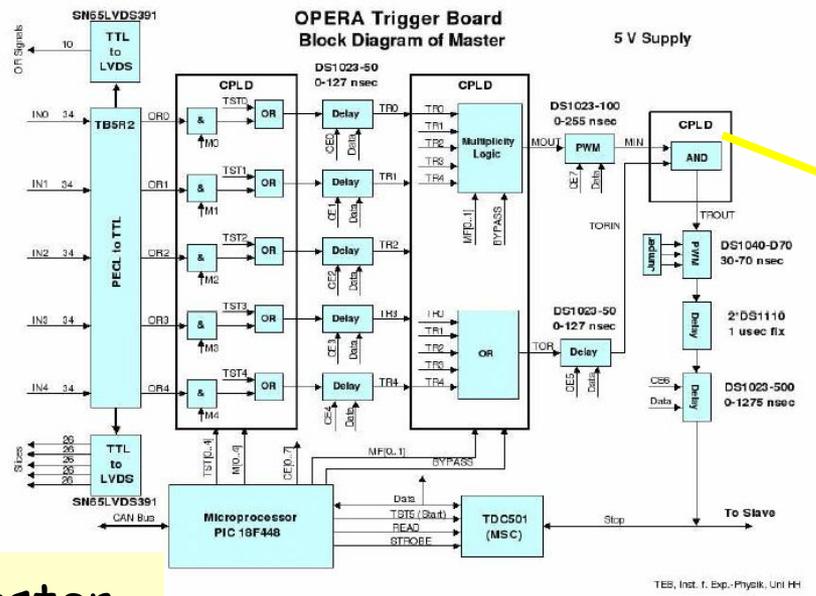


### Kanal- funktion:

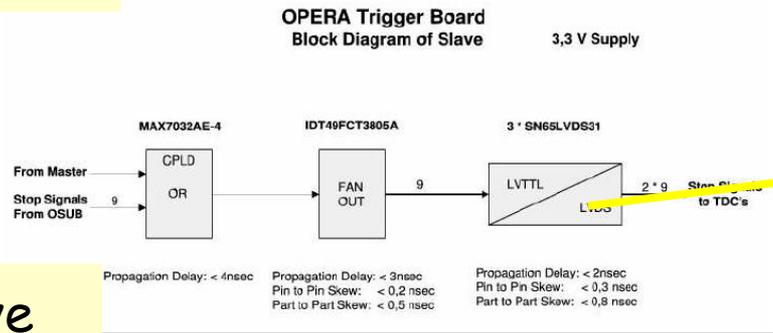
>99% der  
Röhren  
funktionieren  
einwandfrei

<0,45%  
Rauschen  
<0,28% ohne  
Signal

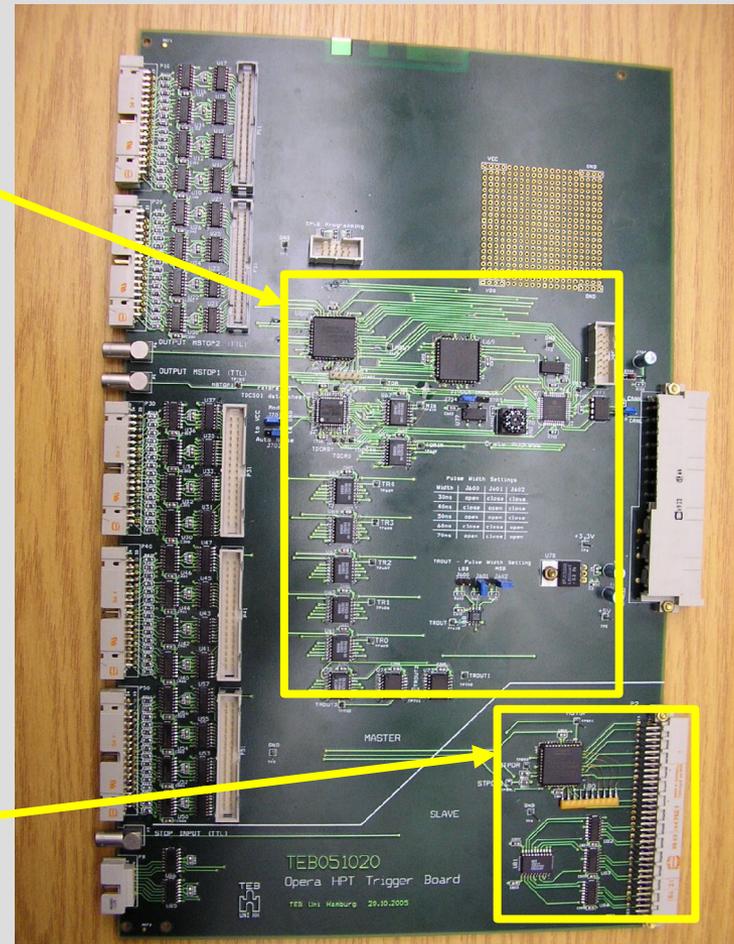
## Triggersystem



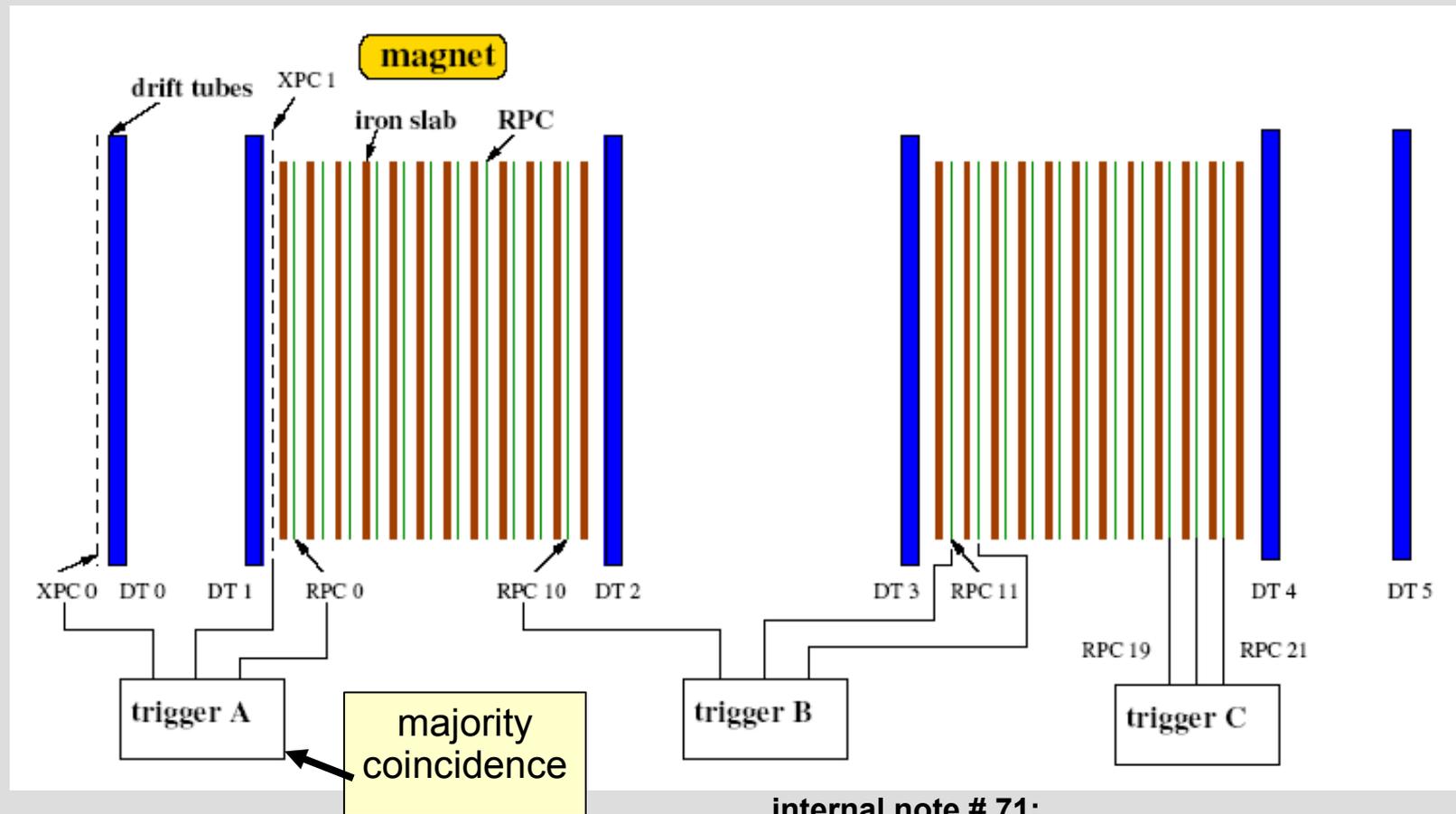
master



slave



## ▶ Triggersystem

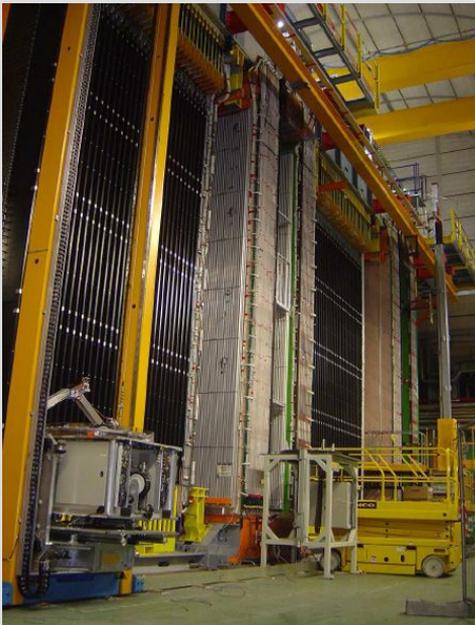


internal note # 71:  
 "Concept of the Trigger System for the Precision Tracker"  
 G. Felici, A. Paoloni, R. van Staa, R. Zimmermann



## ► Zusammenfassung

- ★ Für den OPERA-Detektor baut und entwickelt die Universität Hamburg den Precision Tracker aus ca. 10.000 Driftröhren.
- ★ Slow Control System für den PT größtenteils fertig.
- ★ Boards zum Setzen von Diskriminatorschwellen, Generieren von Testpulsen und Temperaturmessung (OSUB) sowie Boards zum Steuern der Triggereinstellungen (OTB) werden per CAN betrieben.
- ★ LV-Geräte und Crate-PowerSupplies werden per CAN gelesen.
- ★ HV-Gerät wird über integrierten Ethernetanschluss gesteuert.
- ★ Gesamte Slow Control Software auch von Hamburg aus steuerbar (remote).



## Slow Control des OPERA Precision Trackers



bmb+f - Förderschwerpunkt

OPERA

Großgeräte der physikalischen  
Grundlagenforschung

*Ende...*