

# STATUS OF THE FRONT-END ELECTRONICS FOR THE TIME-OF-FLIGHT MEASUREMENTS IN THE MPD EXPERIMENT

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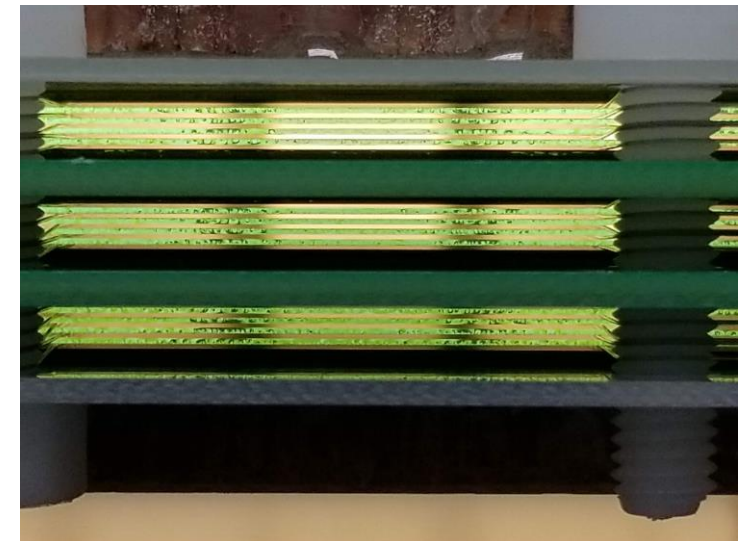
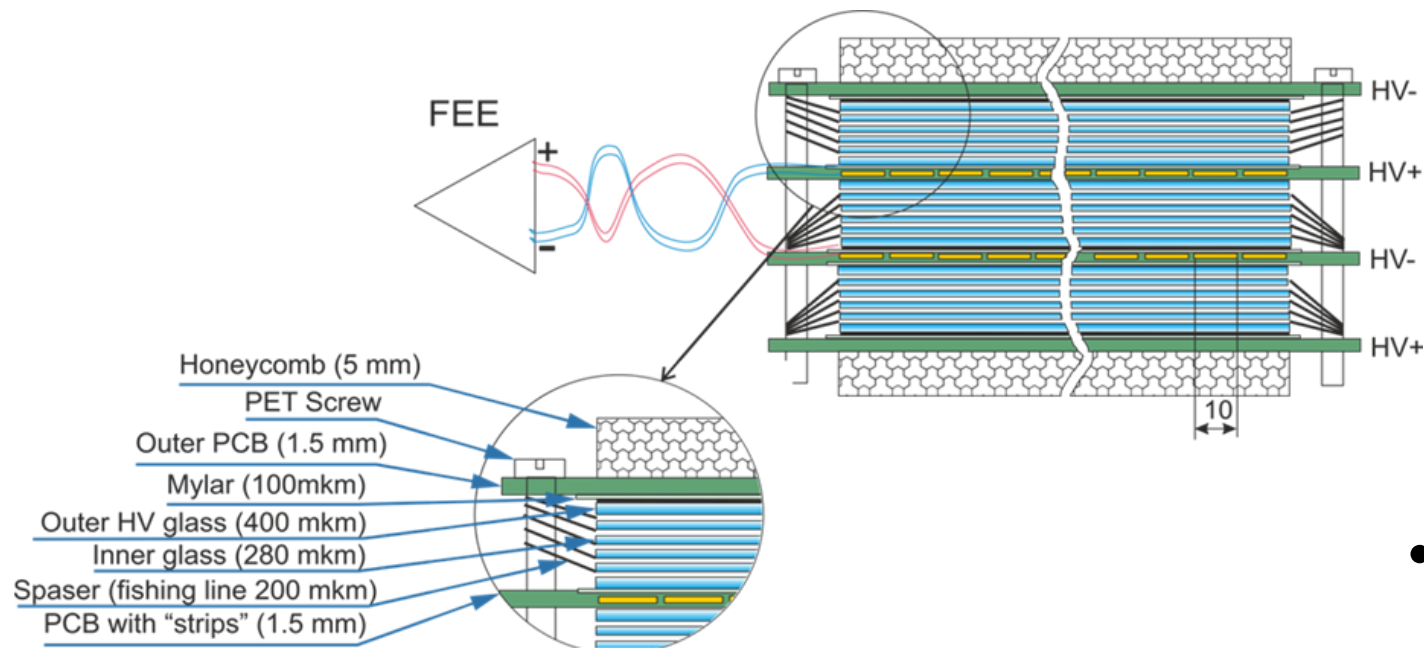
NICA days 2019



# Outline

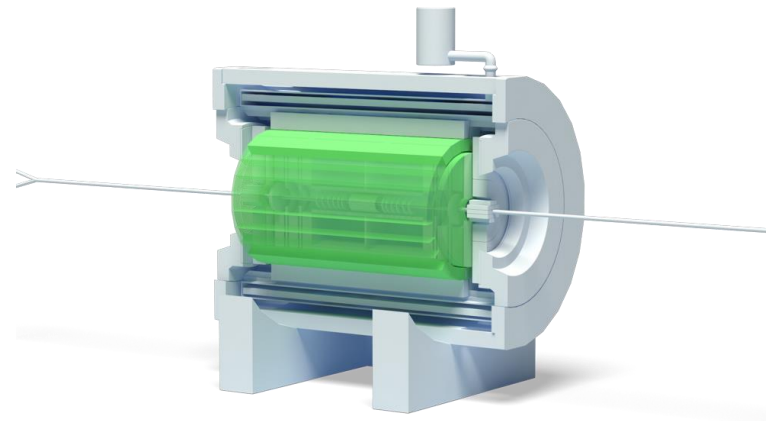
- Detector and Time-of-Flight system at MPD experiment
- Front-End Electronics: functionality and features
- Status, results, plans

# Multigap Resistive Plate Chamber (mRPC)



- Active area 300x600 mm<sup>2</sup>
- Good time resolution ~42ps
- Rate up to 100kHz/cm<sup>2</sup>

# Time-of-Flight at MPD



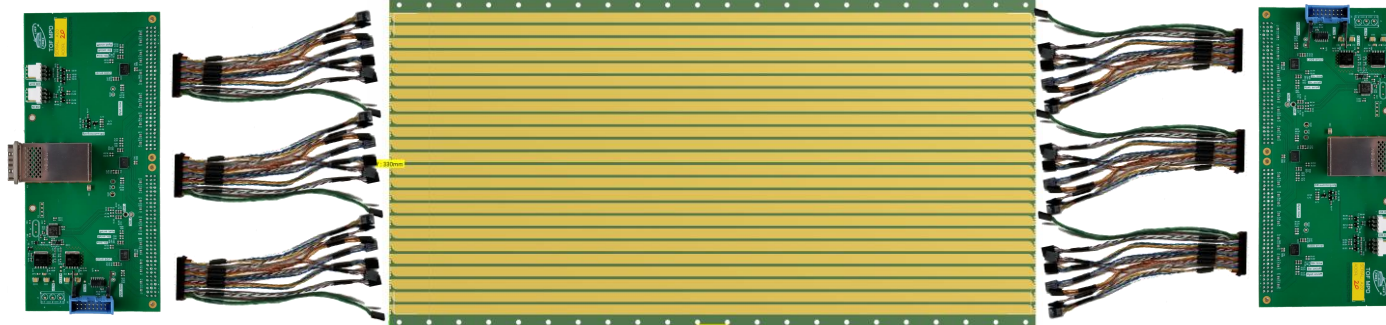
## TOF Requirements:

- TOF detector elements must function in a magnetic field - 0.5 T
- High geometrical efficiency (better than 95%)
- Overall time resolution better than 100 ps
- TOF together with TPC must be able to identify charged hadrons and nuclear clusters in the broad rapidity range and up to total momentum of 3 GeV/c
- Number of FEE channels - 13440



TDC72vhl(HPTDCx9)

Molex's CXP connector system



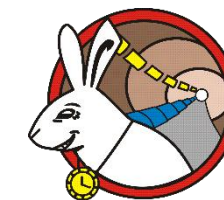
FEE(NINO2x3)

Long strip readout plate (mRPC)

FEE(NINO2x3)



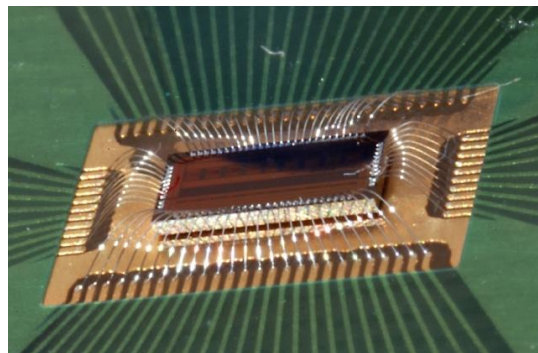
DAQ based on VME  
AFI Electronics



White Rabbit Sync.

# NINO ASIC

- designed at CERN for the multigap-Resistive Plate Chamber TOF systems at the ALICE experiment at LHC.

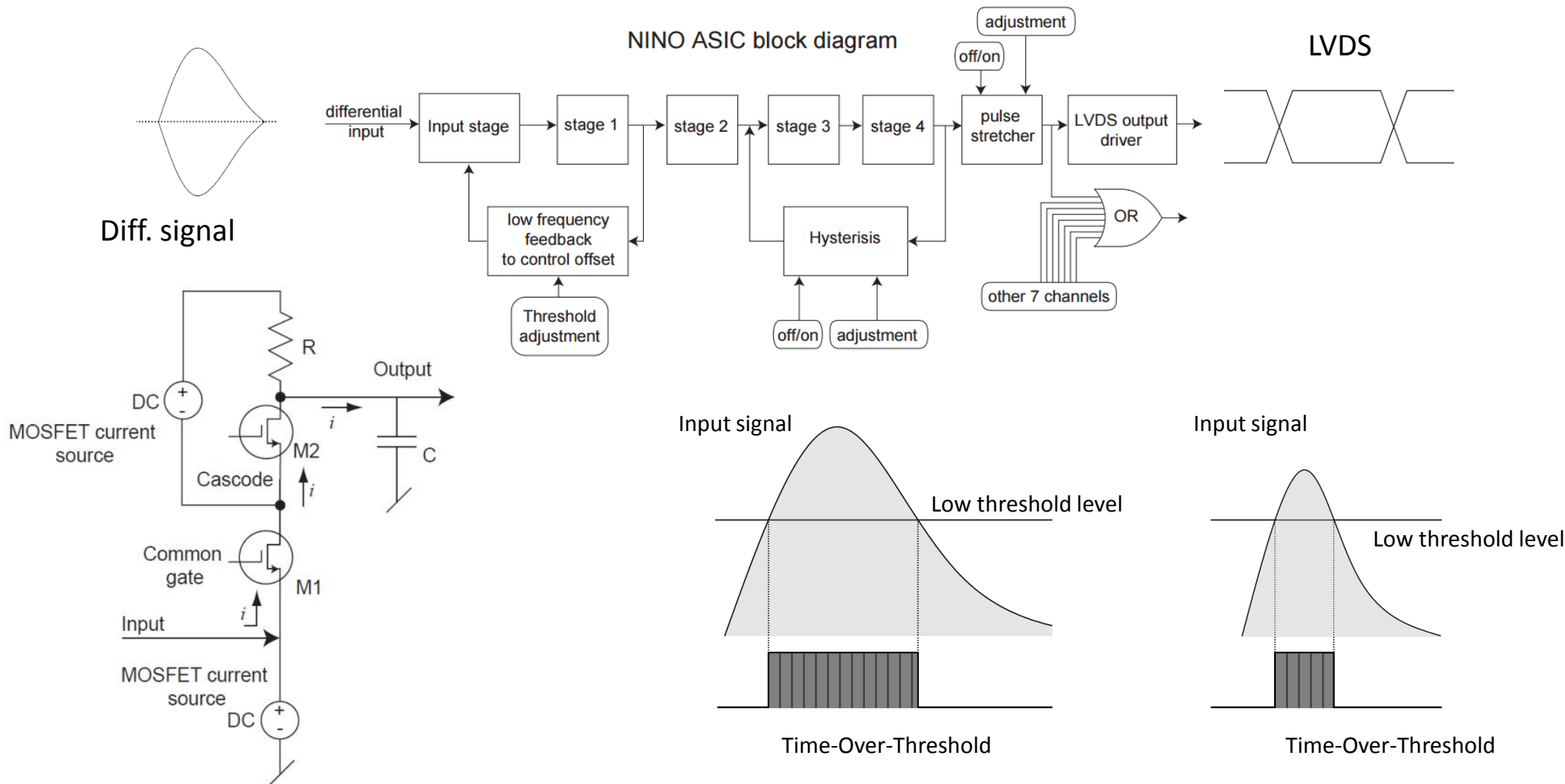


## other applications:

- RICH detector NA62 CERN R7400 PMT readout [Nucl.Phys.B, Proc. Suppl. 215 \(2011\) 125-127](#)
- TOF analysis in PET [Gundacker, S. et al. PoS PhotoDet2012 \(2012\) 016](#)
- Multi-anode Micro-Channel Plate (MCP) PMT [J. Instrum. 9 \(2014\) C02025](#)
- TORCH time-of-flight detector [In: J. Instrum. 9 \(2014\) C02025](#)

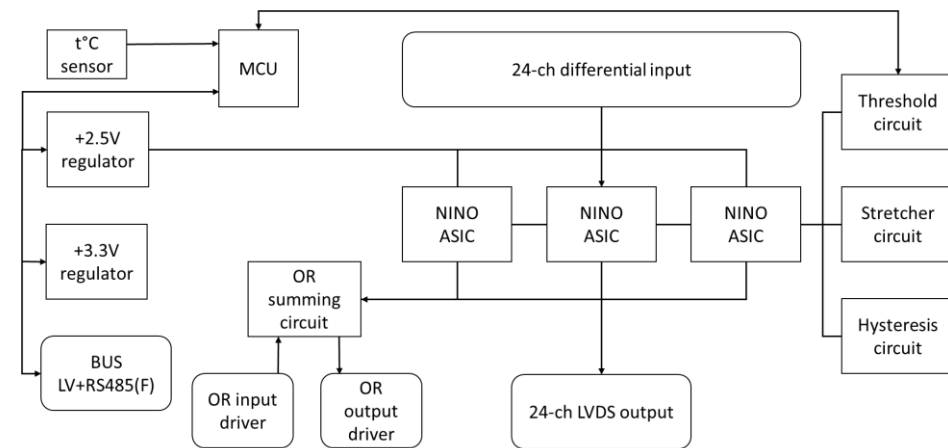
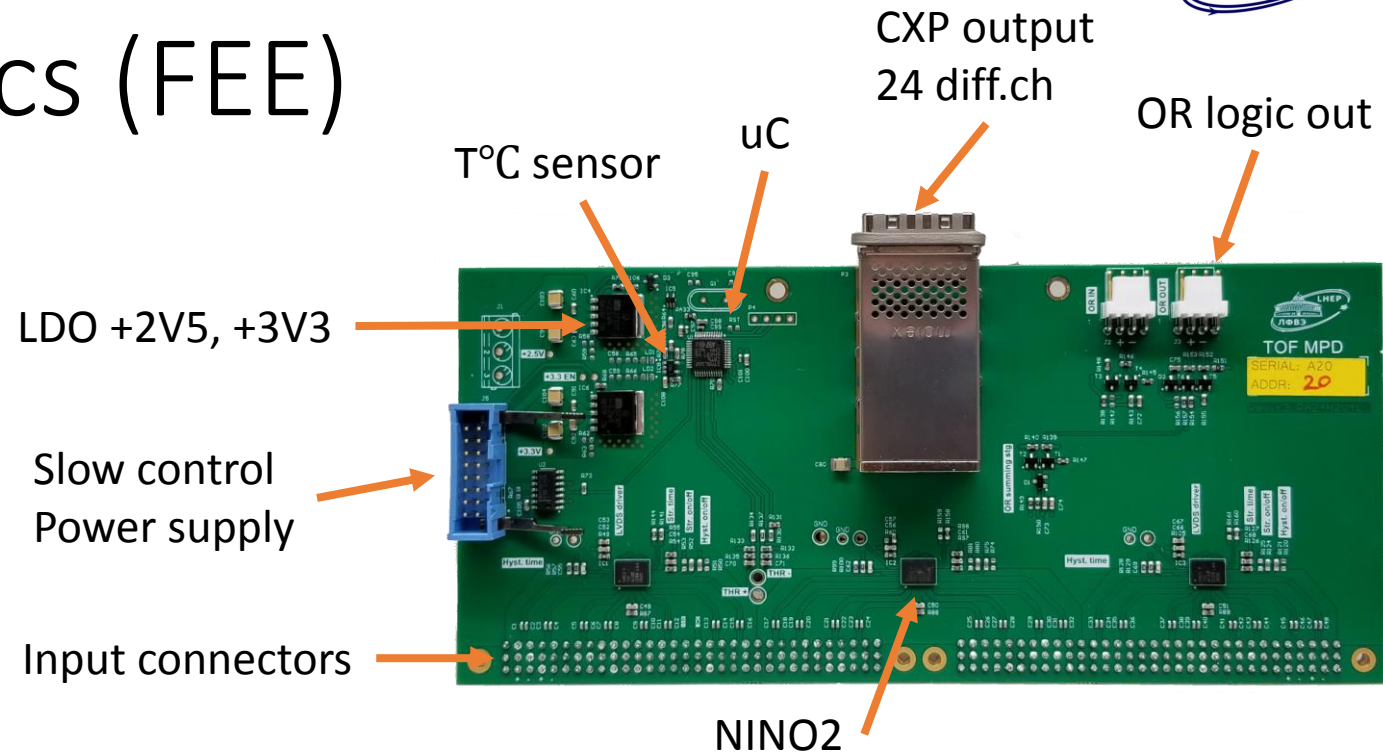
25 mm CMOS technology	8 channel/chip
Input impedance	~50 Ohm, adjustable
Power consumption	27 mW/channel
Supply voltage	+2.5 V
Input peaking time	1 ns
Timing jitter	~10 ps
Sustainable rate	>>10 MHz/chan
Input signal range	30 fC – 2 pC
Noise	< 2.5 x 10 <sup>3</sup>
Discriminator level	10 – 100 fC
Outputs	LVDS

# NINO ASIC

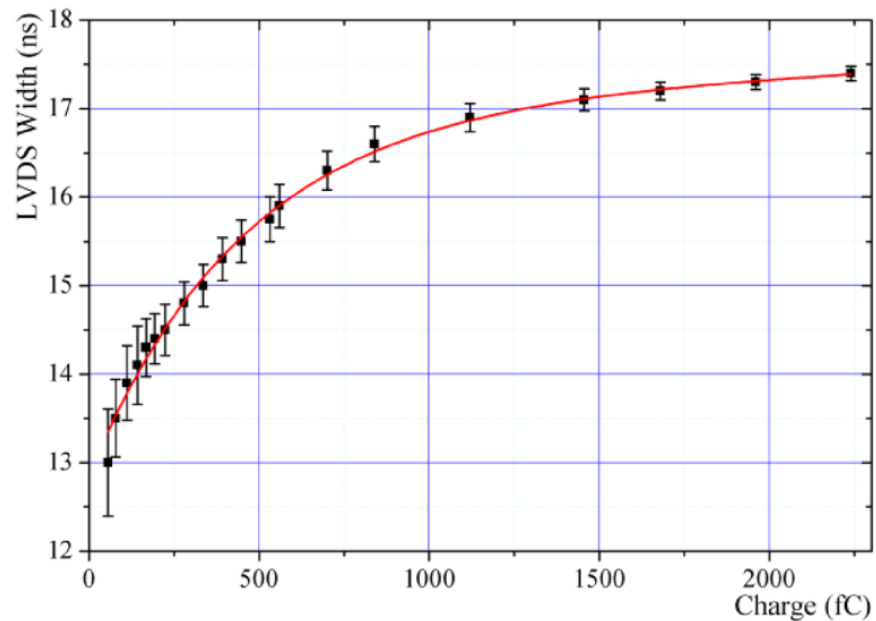


# Front-End-Electronics (FEE)

- 3V6 to 6 V power supply range
- stabilized of the voltage (+2V5, +3V3);
- AC coupled differential input channels;(  $Z_{diff} = 58 \text{ Ohm}$ )
- double-ends strip readout;
- High bandwidth output transmitting line;
- the possibility to use as T0 (series "OR" logic outputs);
- controlling and monitoring of the thresholds, voltages, thermal control.



# FEE time character measurements



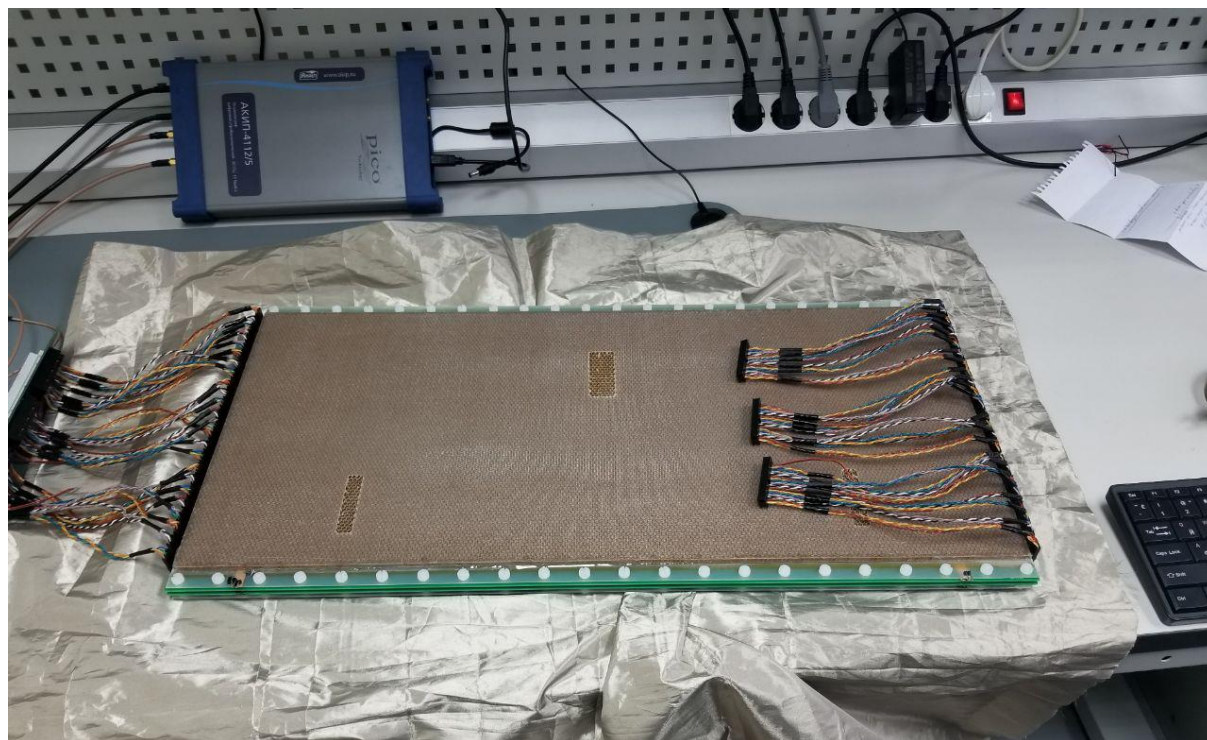
Charge dependence of the width of output LVDS impulse from NINO preamplifier.



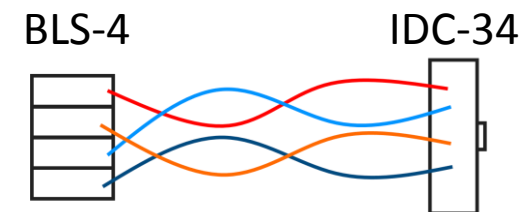
the timing resolution is  $10.39/\sqrt{2} = 7.34$  ps for one channel



# Read-out transmitting line mRPC->FEE



Detector on the test bench



from mRPC -250mm- > to FEE

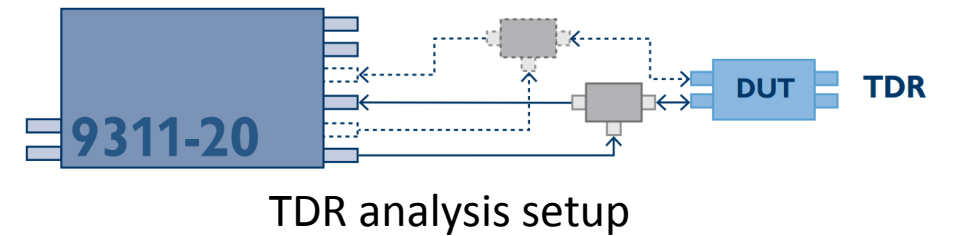
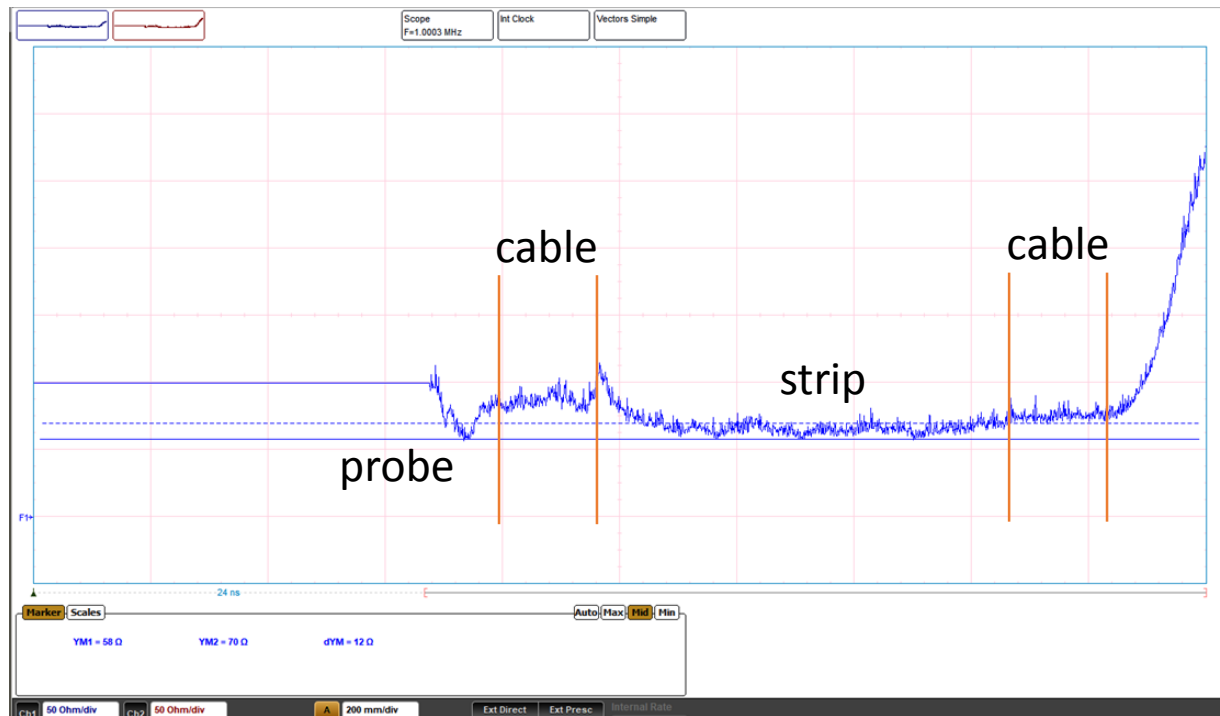


Board with test points  
Testing probe

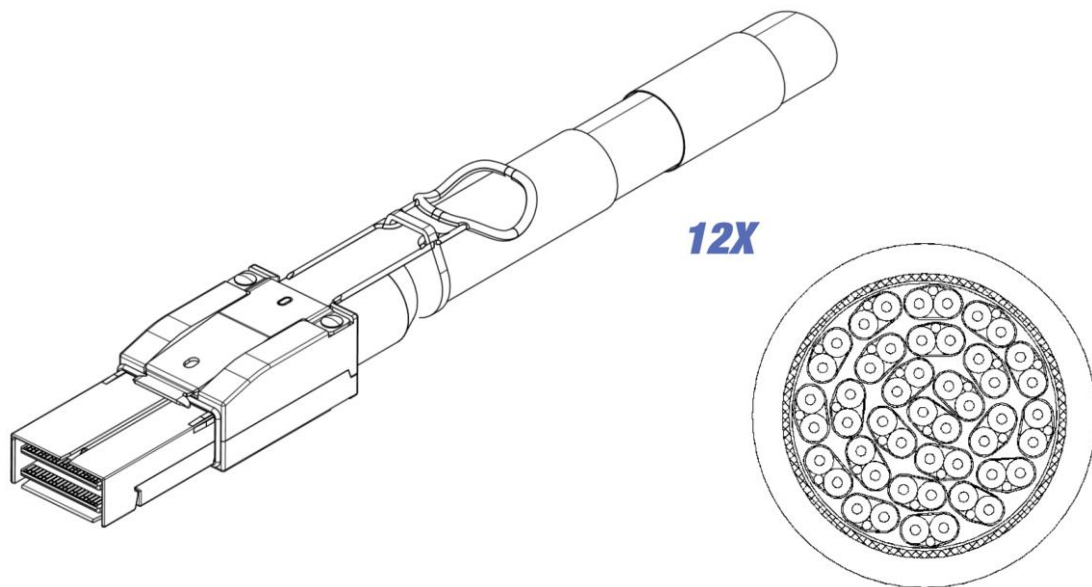


Sampling Oscilloscope  
9321/20

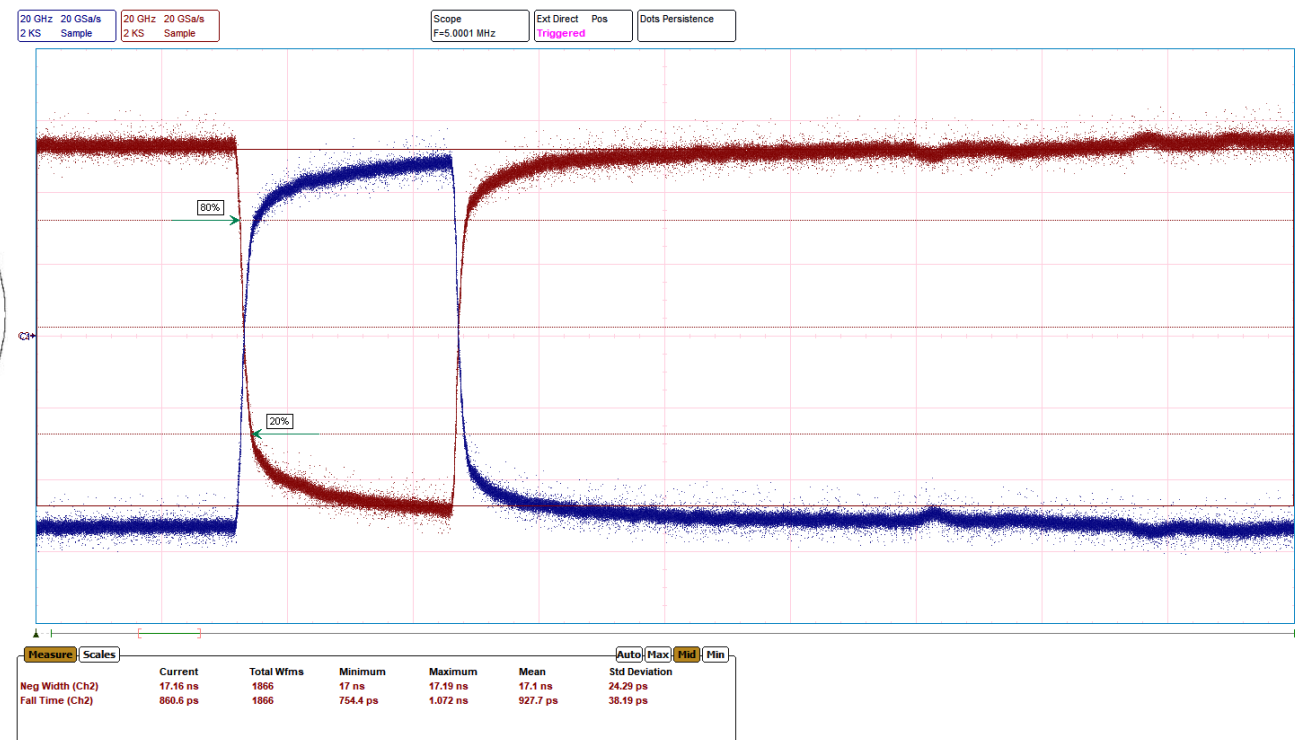
# Impedance measurement for read-out cable



# Read-out transmitting line FEE->TDC



MOLEX P/N	LENGTH (M)	LENGTH TOL (M)	AWG
1110251217	10.0	± 0.15*	26
1110251311	6.0	± 0.08*	26
1110251312	7.0	± 0.10*	26
1110251313	8.0	± 0.10*	26
1110251314	9.0	± 0.10*	26



Output signal from FEE (direct 50ohm)

# Slow control FEE

SC applications for single mode tests:

- HV, LV monitor and settings
- FEE and gas are temperature monitor

ID	V+, mV	V-, mV	Vdelta, mV	Vpower, mV	DAC, mV	Tboard, °C	Tgas, °C
1	1591	1429	162	2479	1070	33	26
2	1631	1457	174	2538	1083	30	25
3	1604	1441	163	2496	1083	33	26
4	1627	1455	172	2535	1070	31	26
5	1606	1442	164	2497	1083	33	26
6	1623	1451	172	2525	1083	31	26
7	1608	1441	167	2507	1070	33	26
8	1592	1424	168	2477	1057	32	26
9	1604	1438	166	2497	1070	33	26
10	1611	1445	166	2503	1083	32	26
11	1607	1441	166	2504	1057	32	26
12	1691	1494	197	2628	1083	30	26
13	1599	1432	167	2487	1070	32	26
14	1681	1486	195	2619	1057	30	26
15	1615	1450	165	2510	1096	32	26
16	1673	1486	187	2603	1096	31	26
17	1615	1448	167	2516	1070	31	26
18	1647	1465	182	2563	1070	30	25
19	1605	1439	166	2502	1070	30	25
20	1631	1459	172	2533	1096	31	25

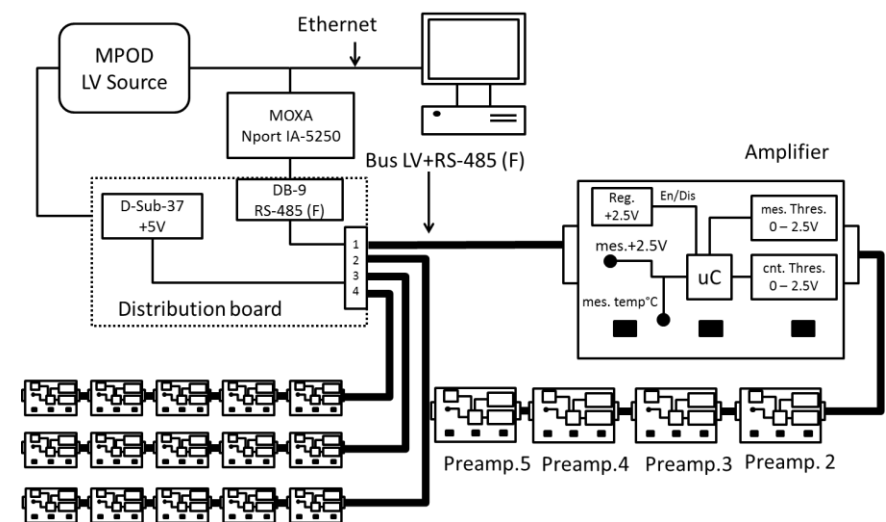
FEE control window

Channel	Vset (V)	measure (V)	/nominal (V)	Iset (mA)	measure (mA)	nominal (mA)	Status	CV	CC
Channel 0	5.00	0.00	17.60	T 2.500.000	0.000 mA	5.050.049	Off		
Channel 1	5.00	0.00	17.60	T 2.500.000	0.000 mA	5.050.049	Off		
Channel 2	5.00	0.00	17.60	T 2.500.000	0.000 mA	5.050.049	Off		
Channel 3	5.00	0.00	17.60	T 2.500.000	0.000 mA	5.050.049	Off		
Channel 4	5.00	5.00	17.60	T 2.500.000	2.162.598 mA	5.050.049	On		
Channel 5	5.00	5.00	17.60	T 2.500.000	2.149.902 mA	5.050.049	On		
Channel 6	5.00	5.00	17.60	T 2.500.000	2.162.842 mA	5.050.049	On		
Channel 7	5.00	5.00	17.60	T 2.500.000	2.171.875 mA	5.050.049	On		

Module Information	Module Supplies and Temperature	Module Settings
Serial Number: 10467	+ 5 Volt (V): 0.0	Voltage Limit (%): 0
Firmware Name: MPV8016	+ 24 Volt (V): 0.0	Current Limit (%): 0
Firmware Release: n/a	- 24 Volt (V): n/a	Voltage Ramp Speed (%): 0
Channel Number: 8	Temperature (°C): 0.0	Current Ramp Speed (%): 0
Device Class: -1		

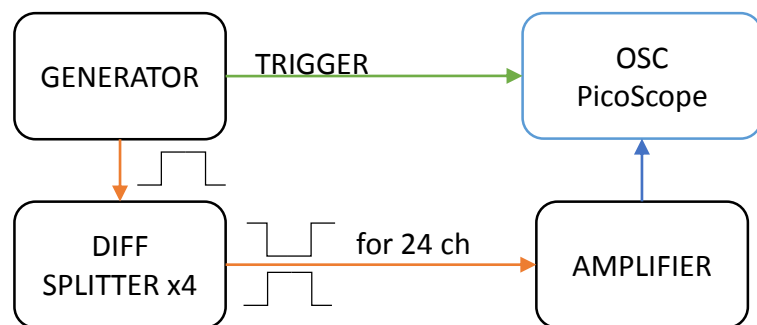
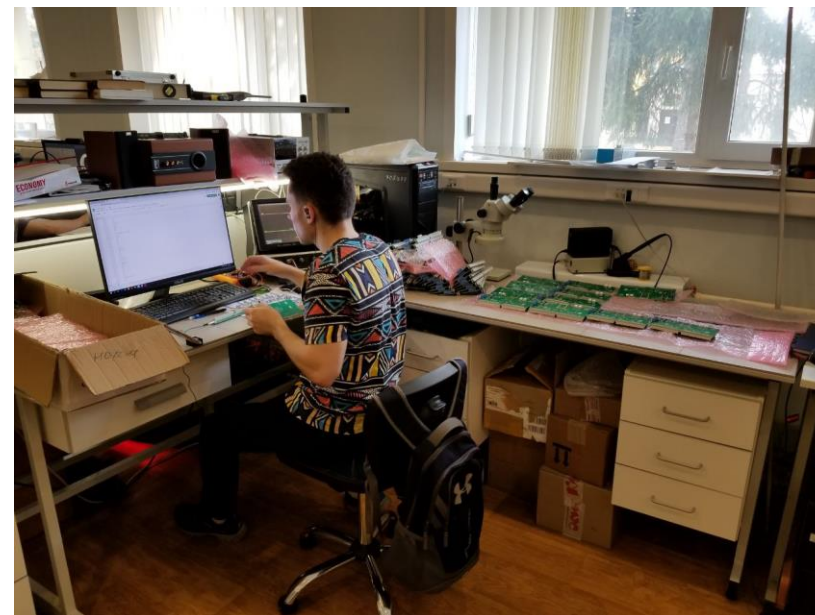
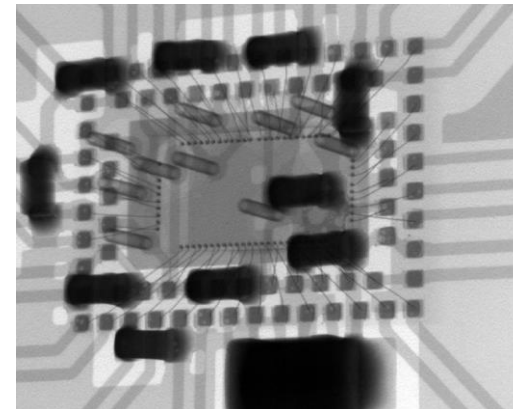
Power supply MPOD control window



Schematic view SC BUS

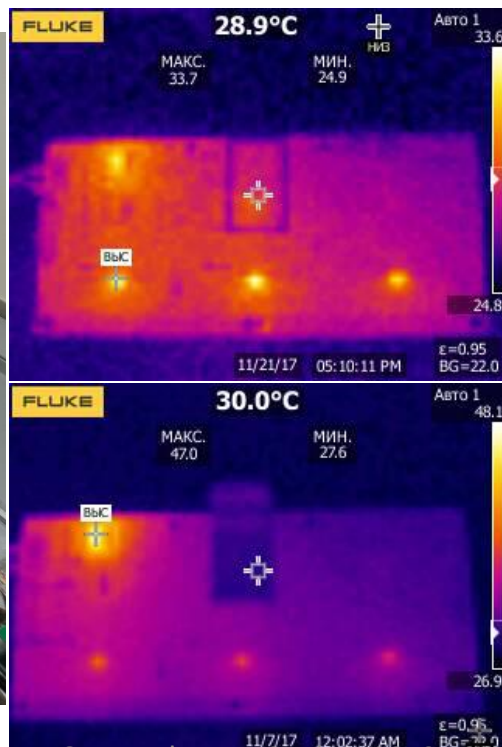
# Assembling, quality control, tests FEE

- X-Ray control (at factory during assembly)
  - Visual test
  - Electrical test: +2V5, +3V3, Thresholds, biasing
  - Electrical signal test: Mask test (OSC)
- 
- If it's all fine: adding serial number, addressing, flashing firmware, adding to the database and labeling



# Quality control, tests

- In electronics area  $26,5 \pm 0,2 \text{ }^\circ\text{C}$  (at 5V DC, no air flush,  $T_{amb.} 24 \pm 0,5 \text{ }^\circ\text{C}$ )
- In gas area  $25 \pm 0,2 \text{ }^\circ\text{C}$
- Power consumption: 43,24W (for 1 module)



DC3V6  
33,7 °C

DC6V  
47 °C

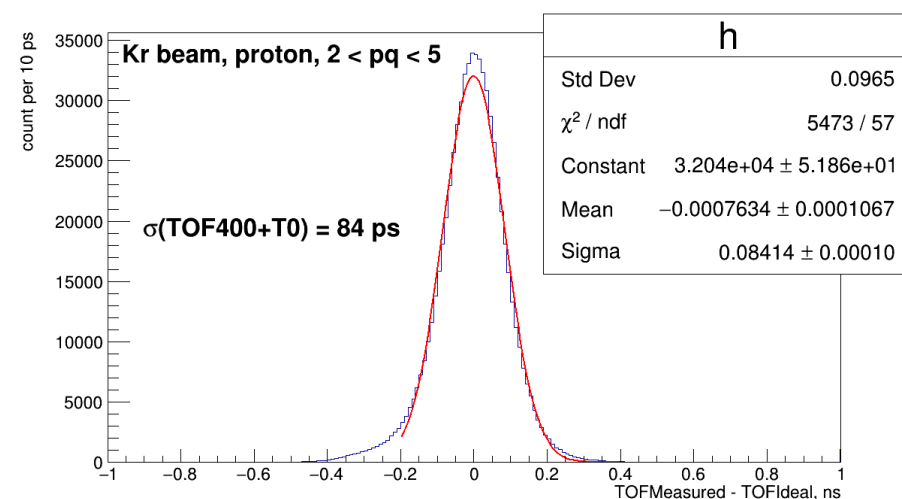
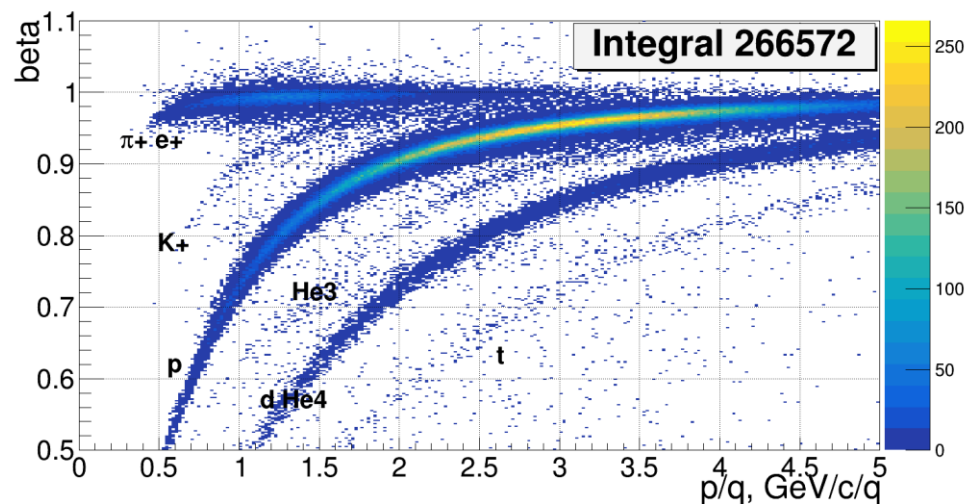


# Conclusion, results

- Setup tested with beam at experiments BMN, NA61
- Expected total consumption FEE: 1040 W
- Produced 560 + 10 FEE boards (65pcs. not pass QC – will be fixed soon)

Description	Average time resolution, ps
$\sigma_{MRPC}$	50
$\sigma_{FEE}$	8
$\sigma_{T0}$	40
$\sigma_{TDC}$	20
$\sigma_{WR}$	10
$\sigma_{tot}$	71

$$\sigma_{tot} = \sigma_{MRPC} + \sigma_{FEE} + \sigma_{T0} + 2\sigma_{TDC} + 2\sigma_{WR}$$



**Thank you for your attention!**