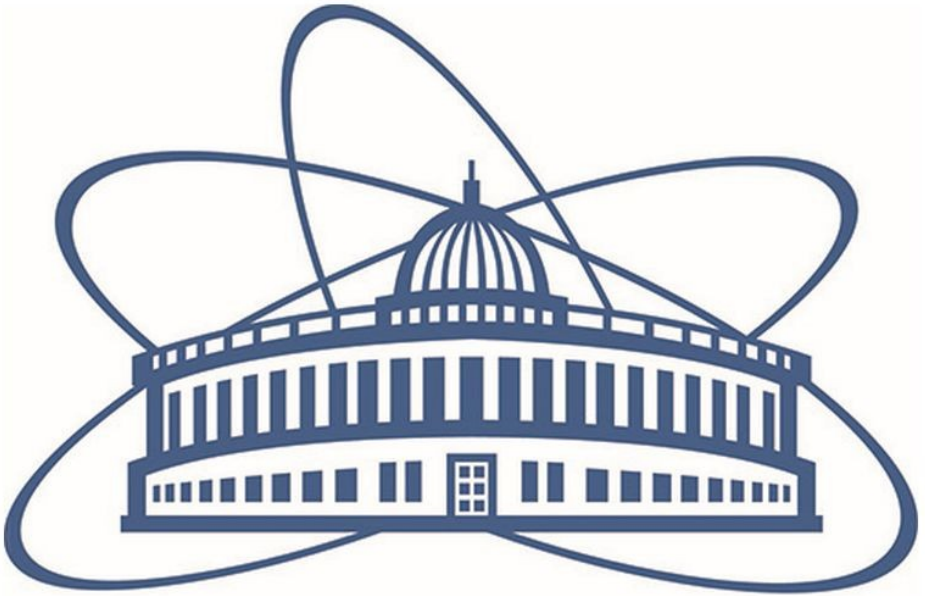
SPD Collaboration Week

FEE for Straw Readout

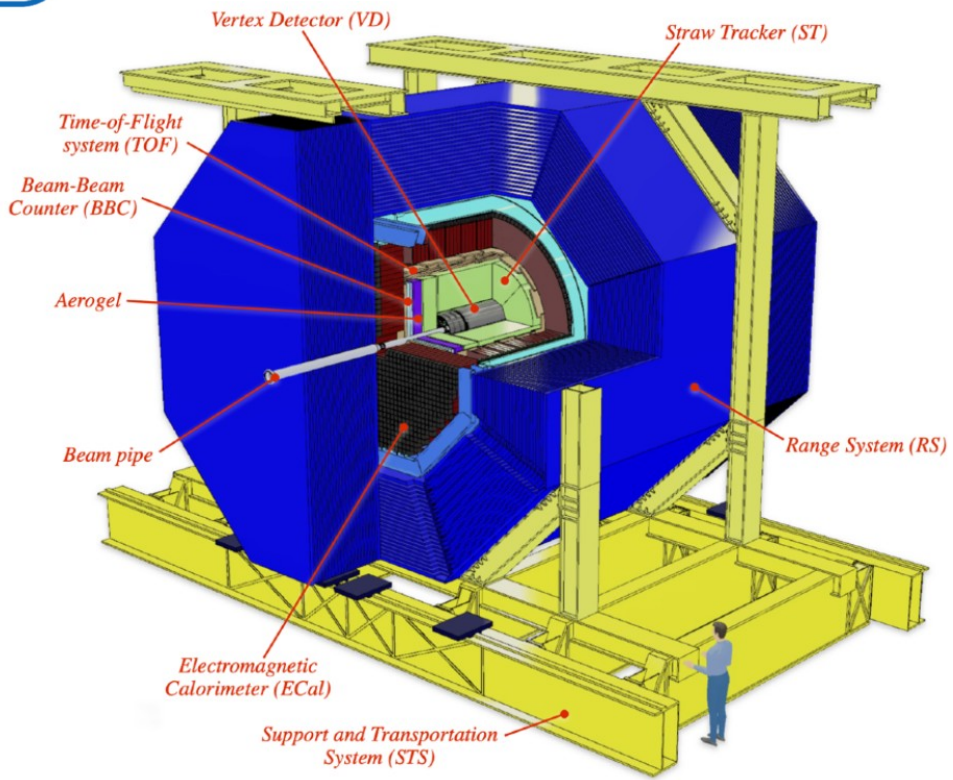


Speaker: Vitaly Bautin
on behalf of Straw Tracker Team

13.05.2025

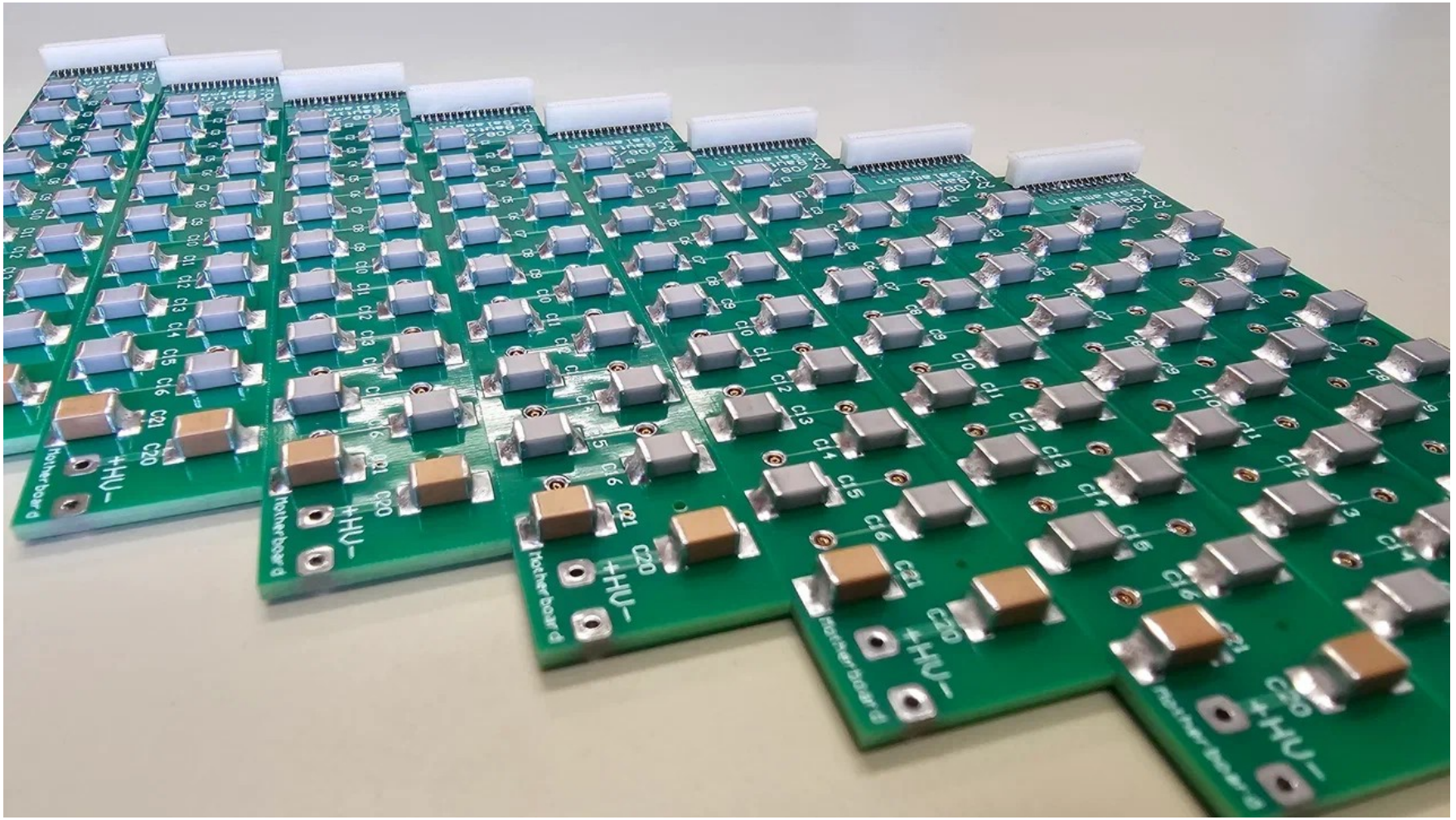
Motivation:

- 30k+ channels
- 150um spatial resolution
- dE/dX charge resolution
- Simultanious Charge & Time measure

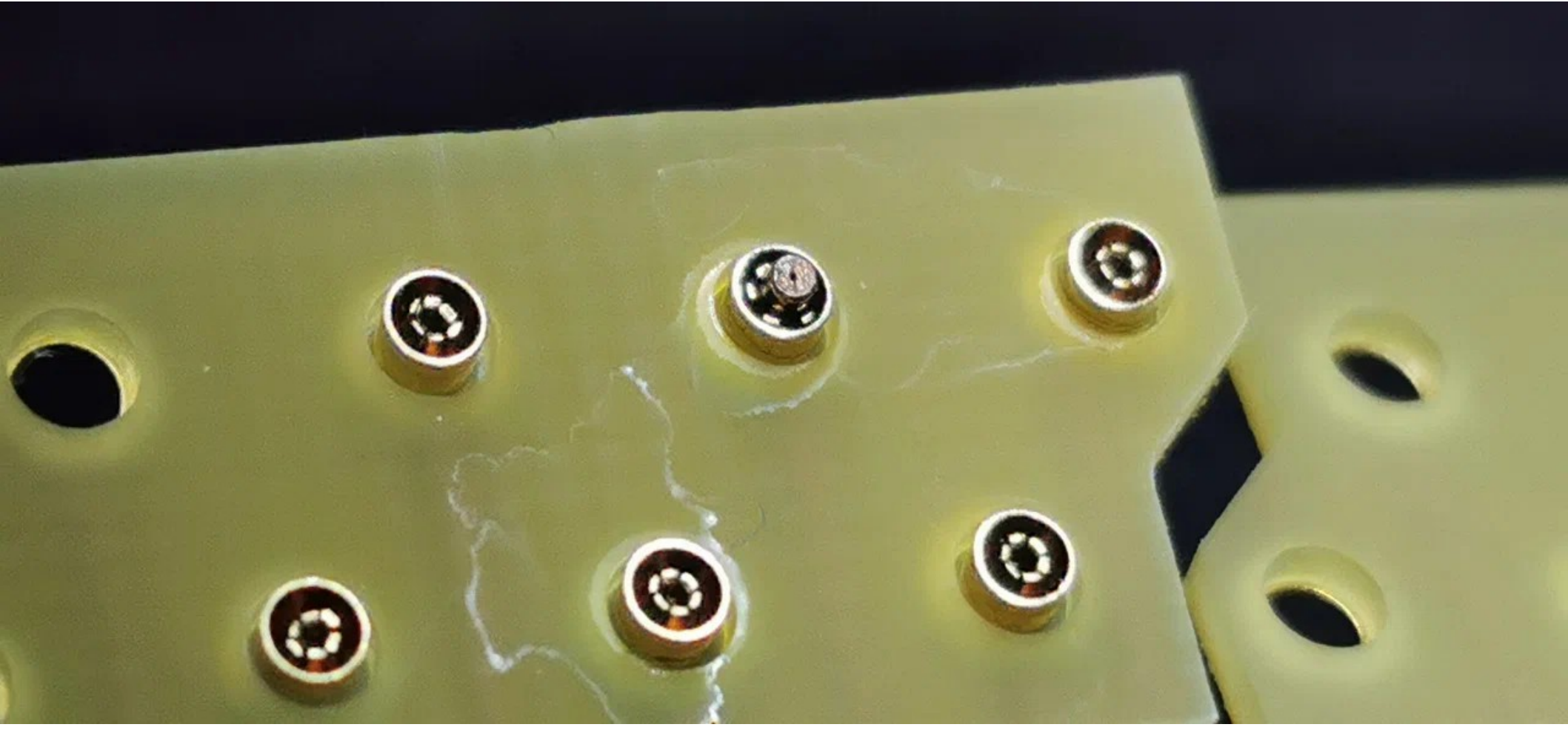


A dedicated R&D is ongoing to study the possibilities for STT Front-End Electronics (FEB) solution.

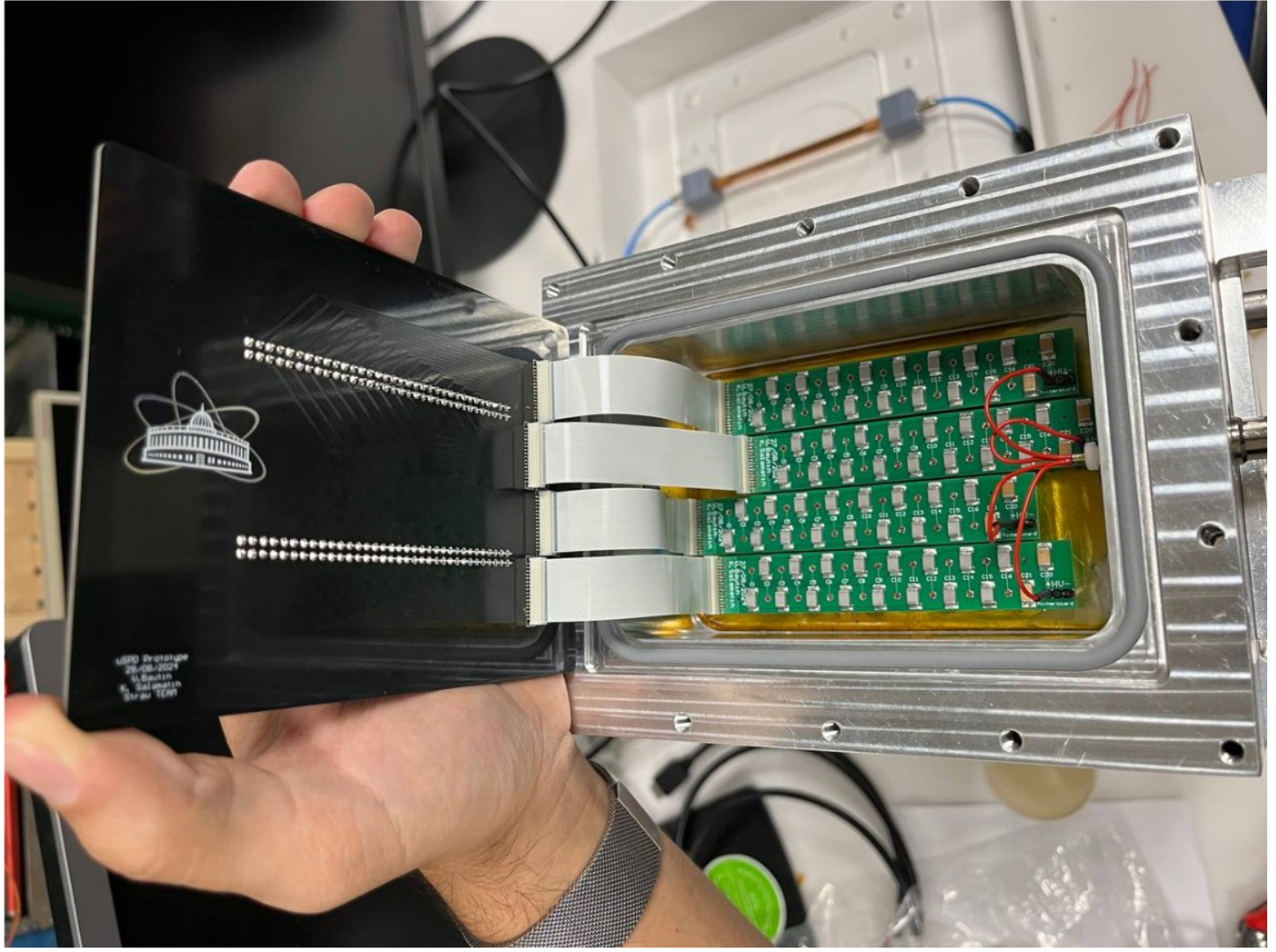
On-Chamber Motherboards



Special 19mm wide on-chamber motherboards have been created for the SPD straw tracker.



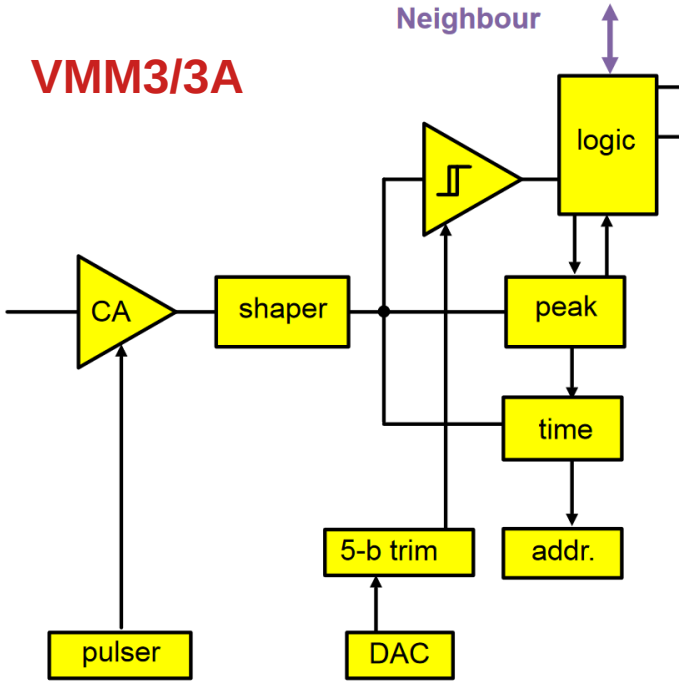
6-petal spring loaded contacts are used to connect straw wires. Easy to mount and dismount



A 64 tube prototype has been developed with X-U-V layers. Boards and FPC tested.

VMM3a FEE Prototype

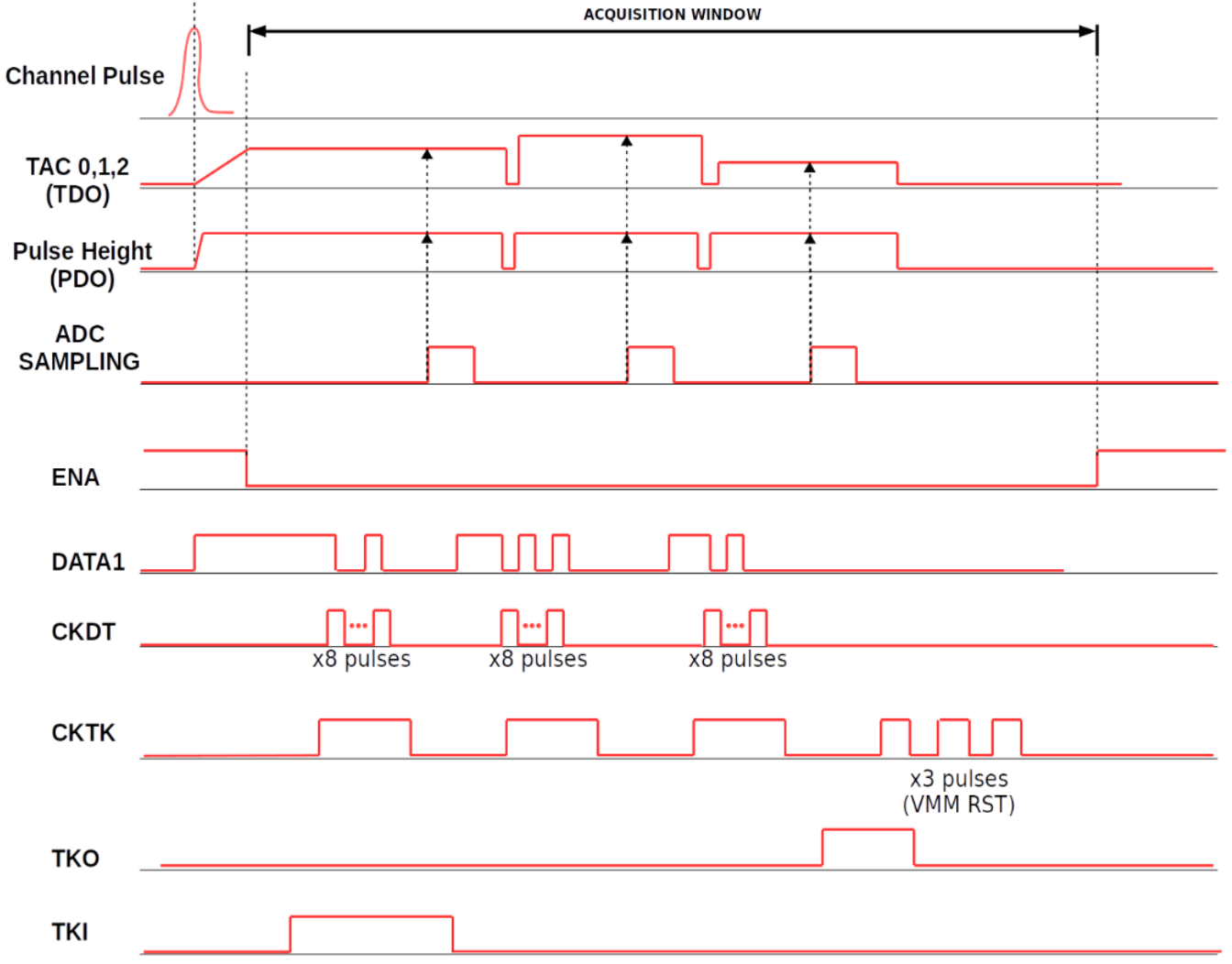
Investigating existing readout solutions



Number of channels	64
Clock frequency	10...80 MHz
Input capacitance	<300 pF
Dynamic range	up to 2 pC
Gain	0.5, 1, 3, 4.5, 6, 9, 12, 16 mV/fC
Peaking time	25 / 50 / 100 / 200 ns
ENC (energy branch)	<3000 e^-
TDC binning	~1 ns
Maximum event rate	140 kHz/ch
Consumption	15 mW/ch

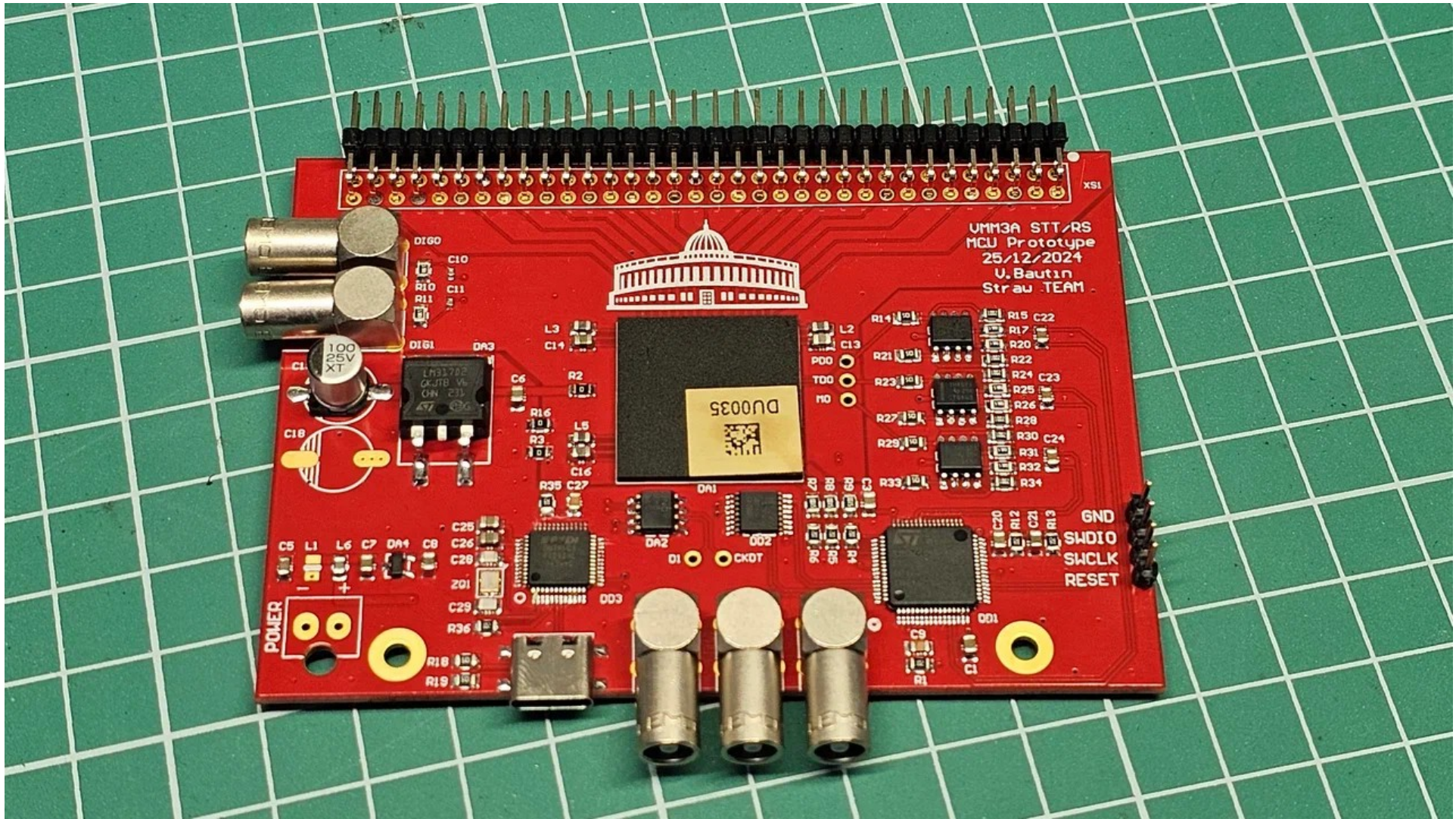
VMM3/3A ASIC is well known chip for gaseous detectors. It has amplifier and shaper adjustable in a wide range. But it was not really done for the timing measurements so fastest shaping is 25ns and ToA mode has some issues.

VMM3 with External ADC



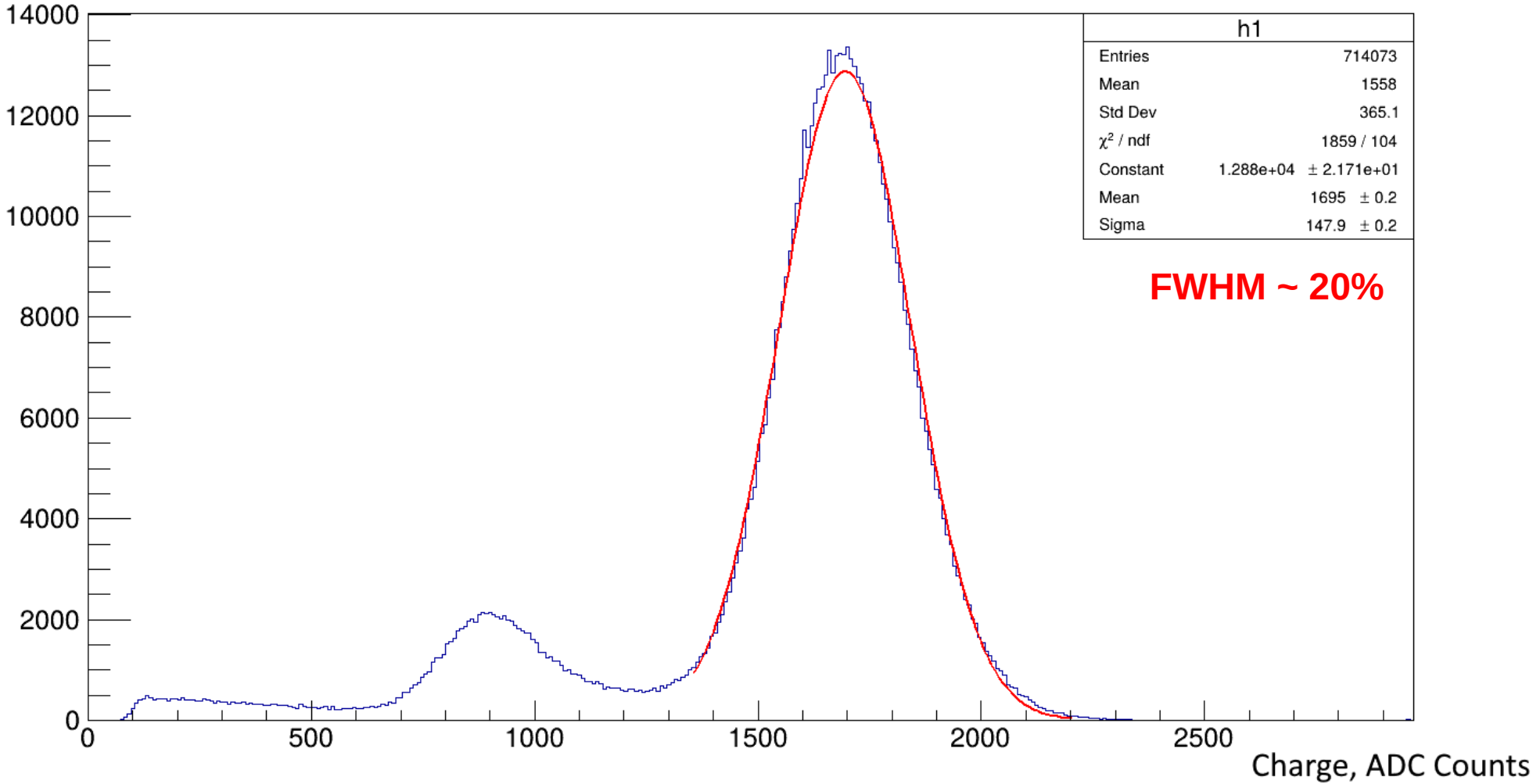
- Once the process is complete the **ASIC can be switched readout phase**. The first set of amplitude and time voltages is made available at the **analog outputs**. The **address of the channel is serialised** and made available at the digital output using **six data clocks**.

VMM3A FEB designed

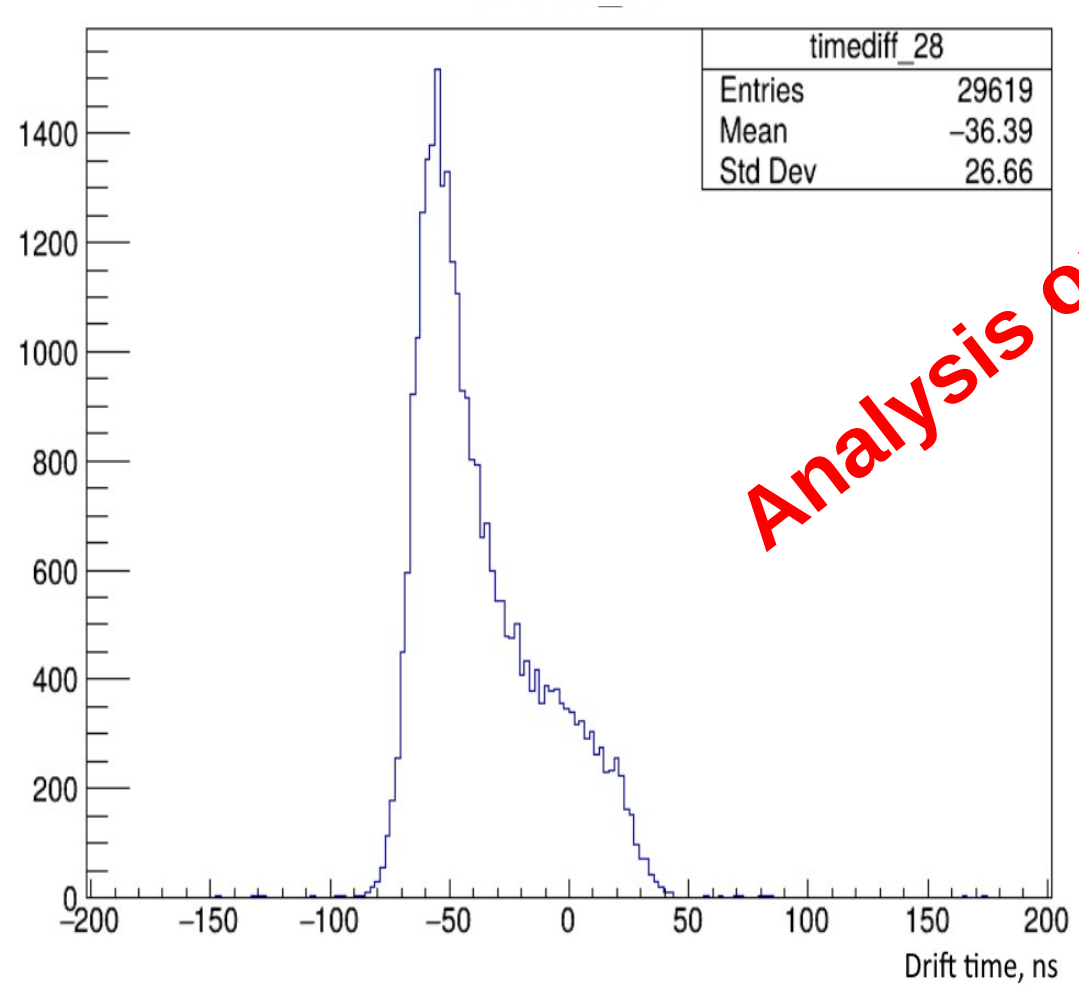



Утилиты
Дисплей
СборИнф
Синхр
Курсоры
Измерения
Матем
Анализ
Акип
Trig'd
f(C1) < 2.0Hz
МАТЕМ
DC средн(C1): 1.725V
C1
C2
F1
C1 DC1M 10X 500mV/ FULL -555mV
C2 DC1M 10X 500mV/ FULL -640mV
F1 C1-C2 1.00V/ -3.87V
Развертка
34.1us 20.0us/div
1.00Mpts 5.00GSa/s
Синхр C1 DC
Ждущий 1.74V
Фронт Нарост
16:00:23
2025/2/17

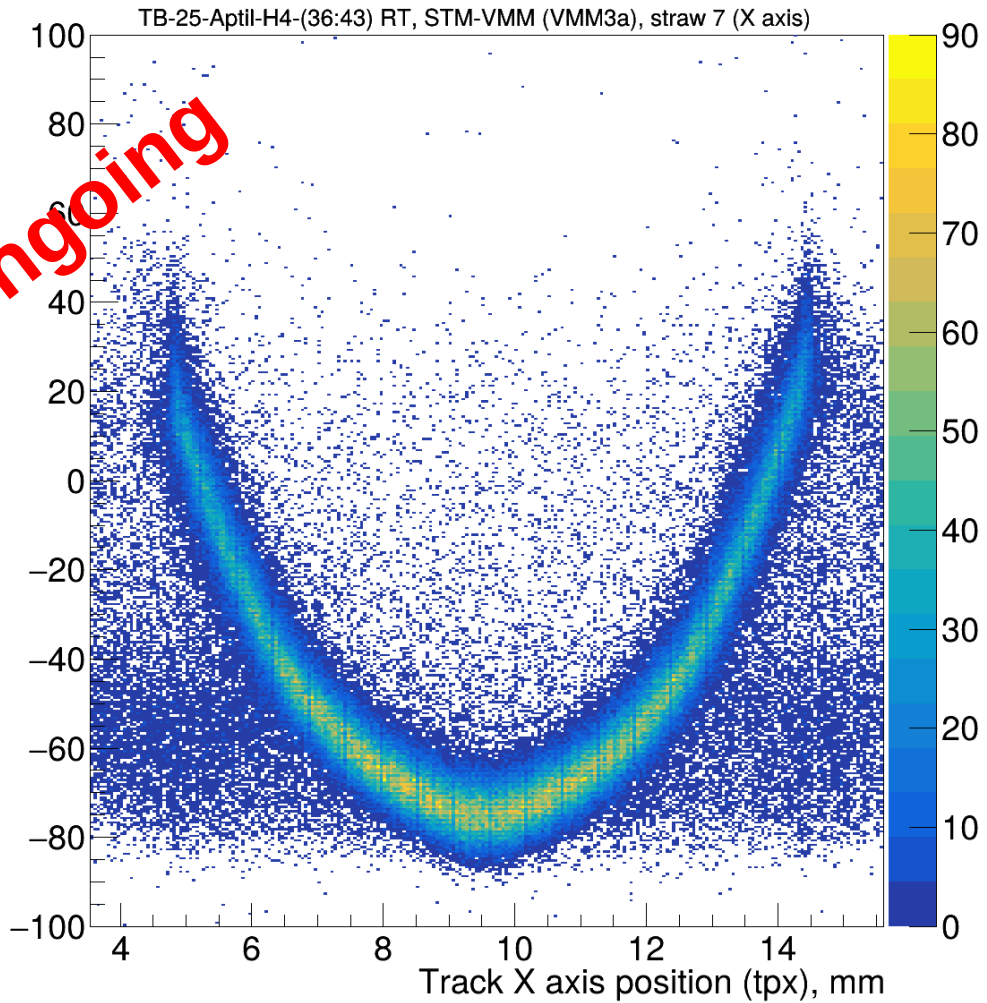
Fe55 Source, Ar/CO2 70:30 Mixture



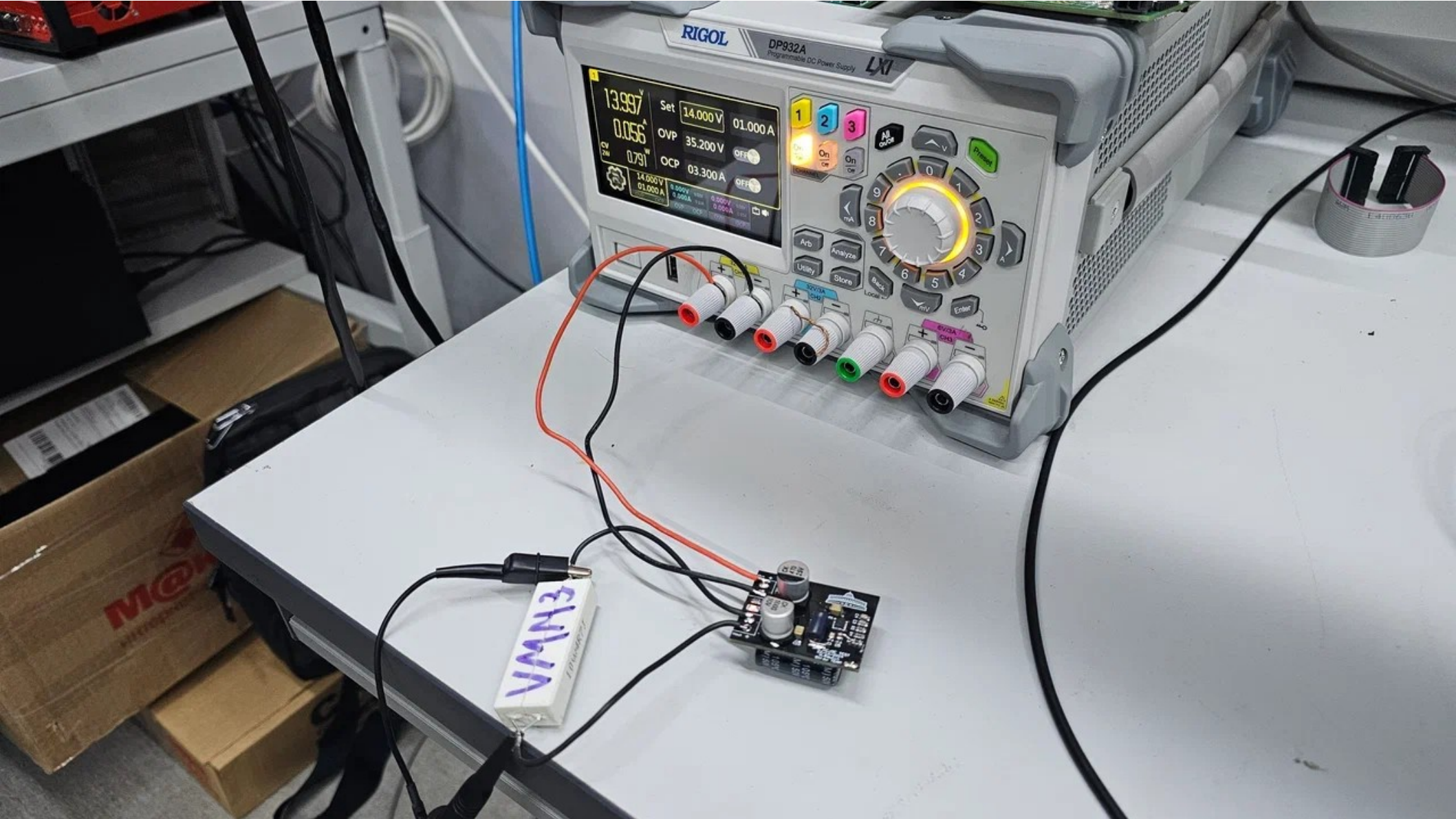
Time Measurements (Muon Testbeam April 2025)

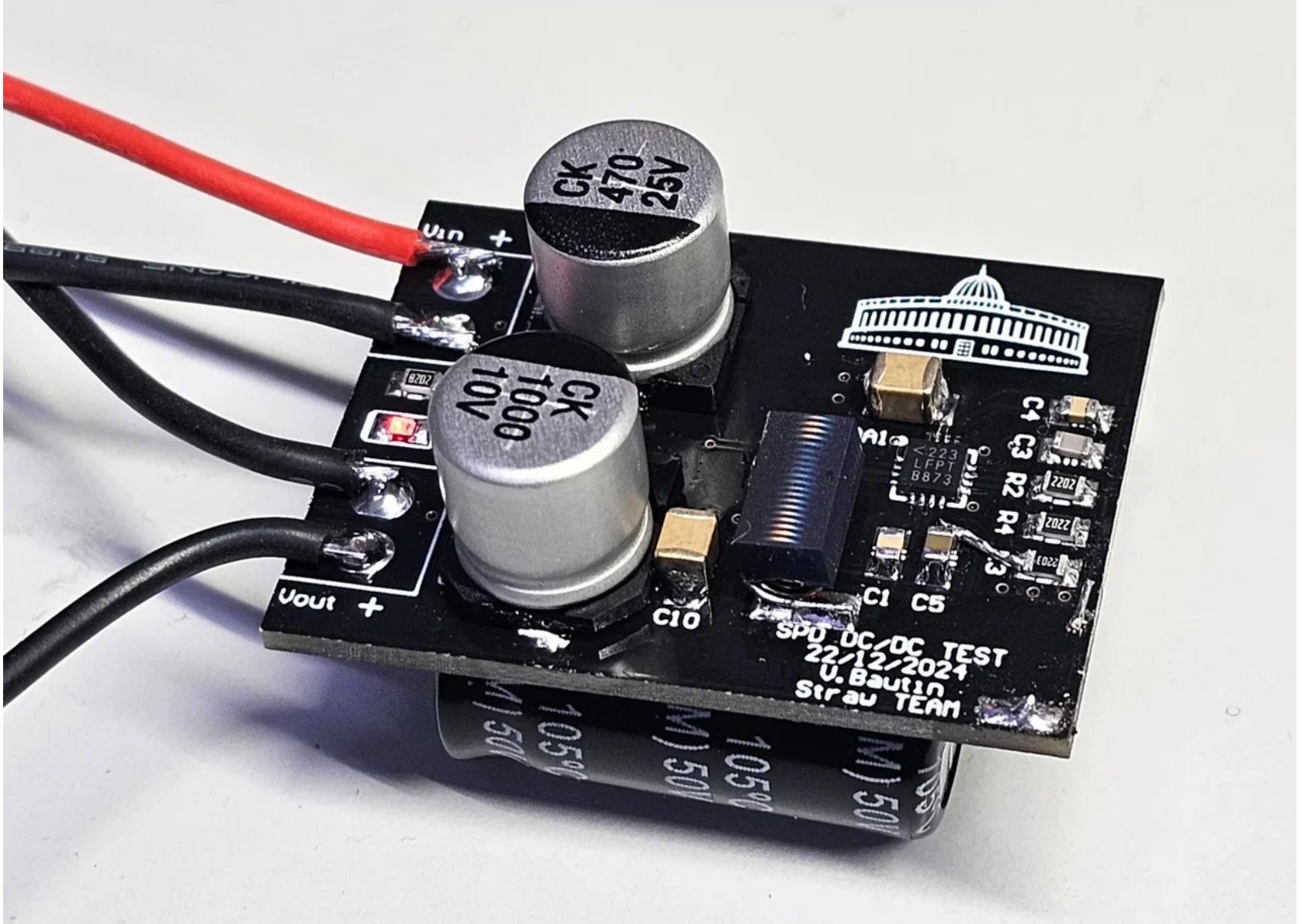


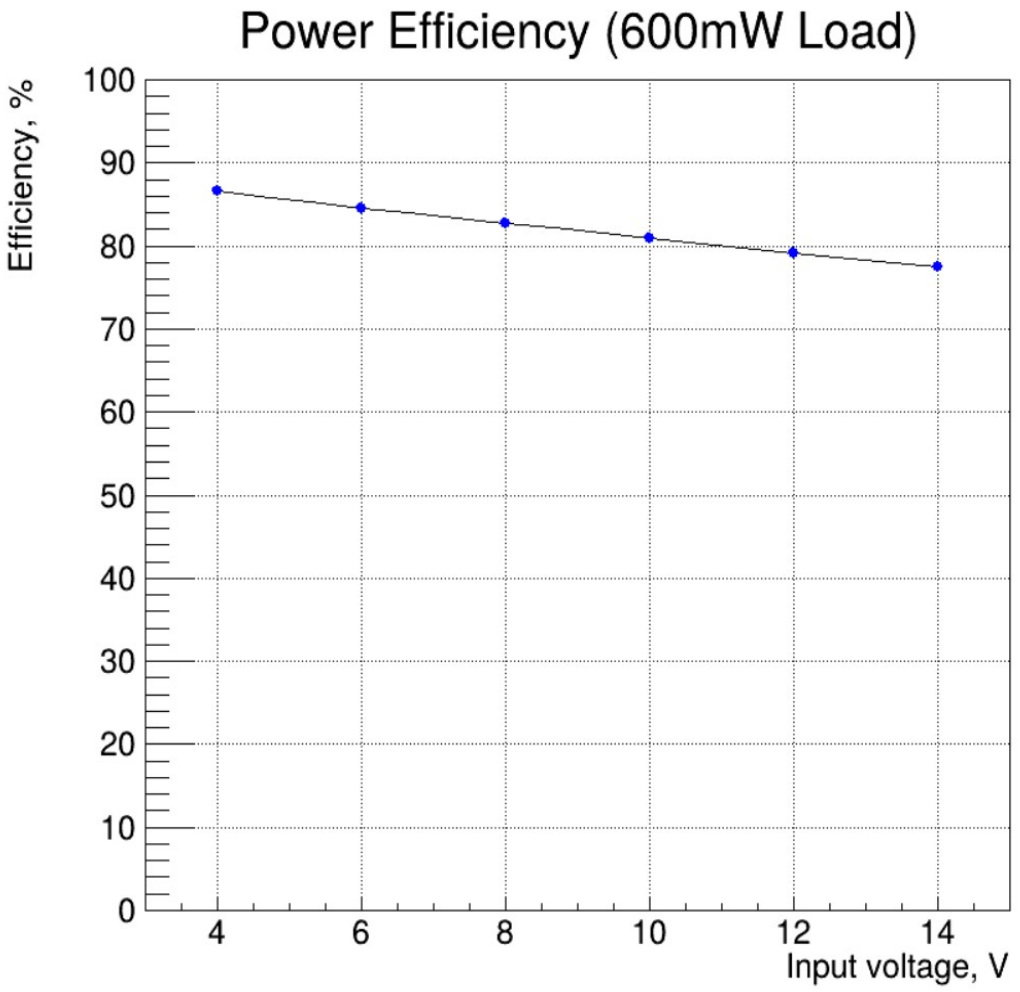
Analysis ongoing

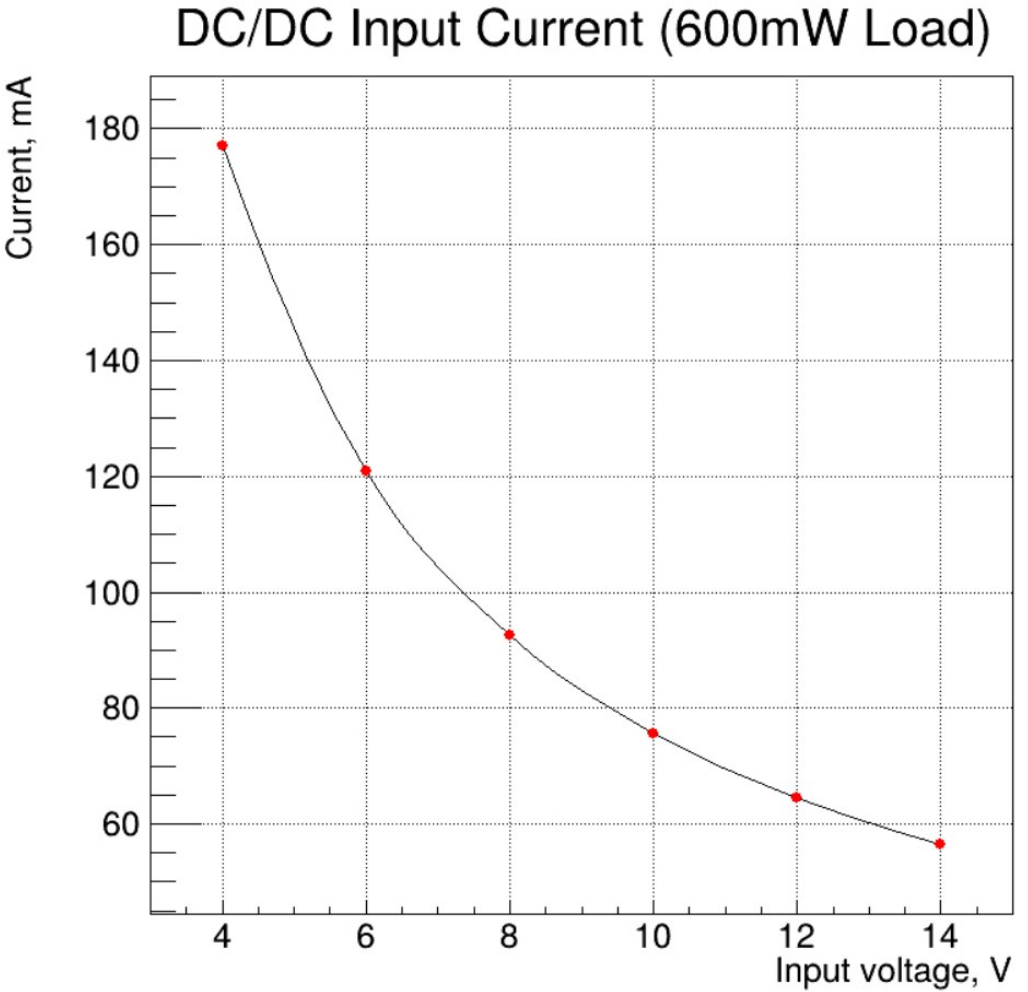


DC/DC with Magnetic Field

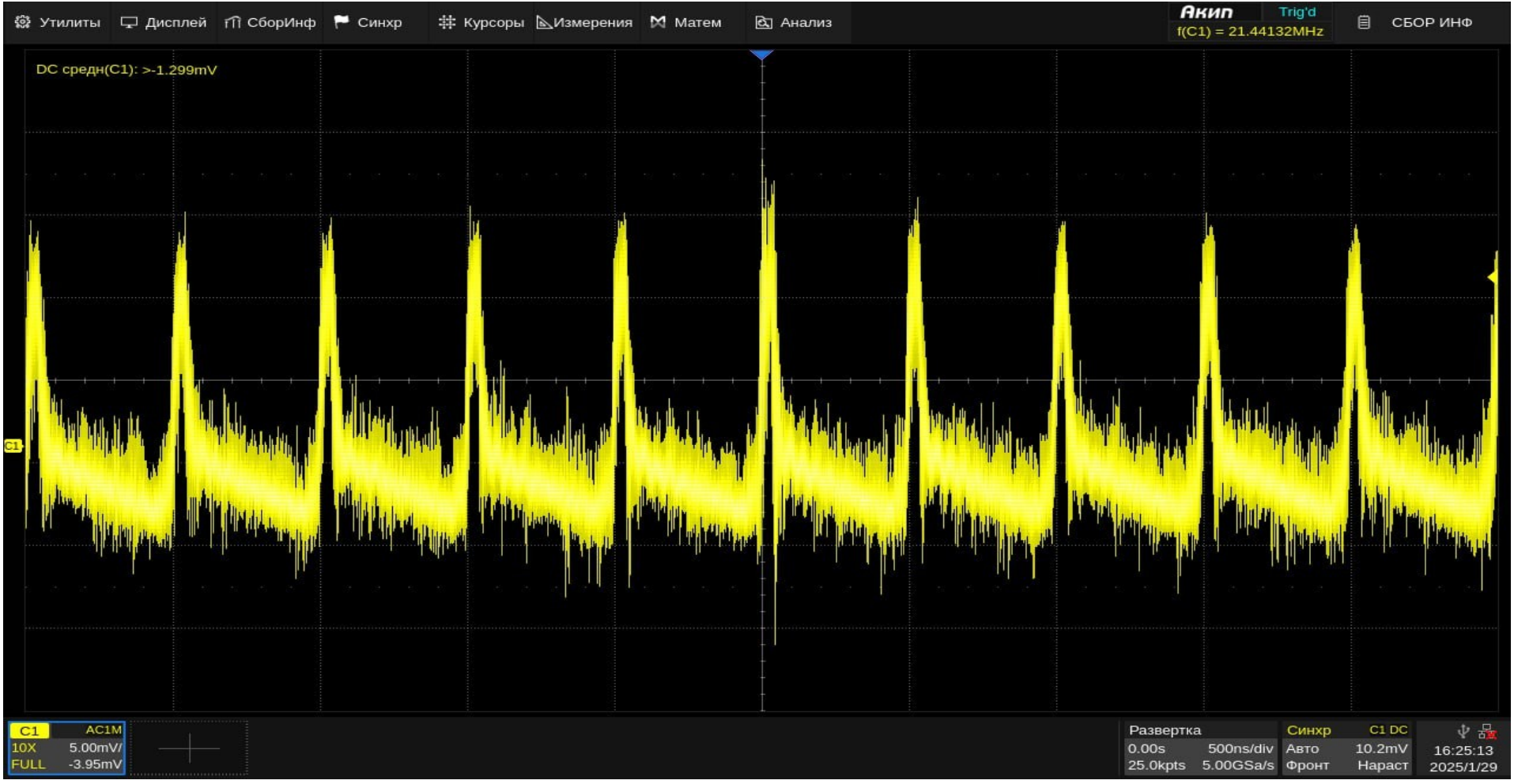

RIGOL
DP932A
Programmable DC Power Supply
LXI
13.997
0.056
0.791
Set
14.000 V
01.000 A
OVP
35.200 V
OCP
03.300 A
VMN3


CK
470
25V
CK
1000
10V
Vin +
Vout +
C10
C1 C5
C4 C3 R2 R1
SPD DC/DC TEST
22/12/2024
V.Bautin
Strau TEAM



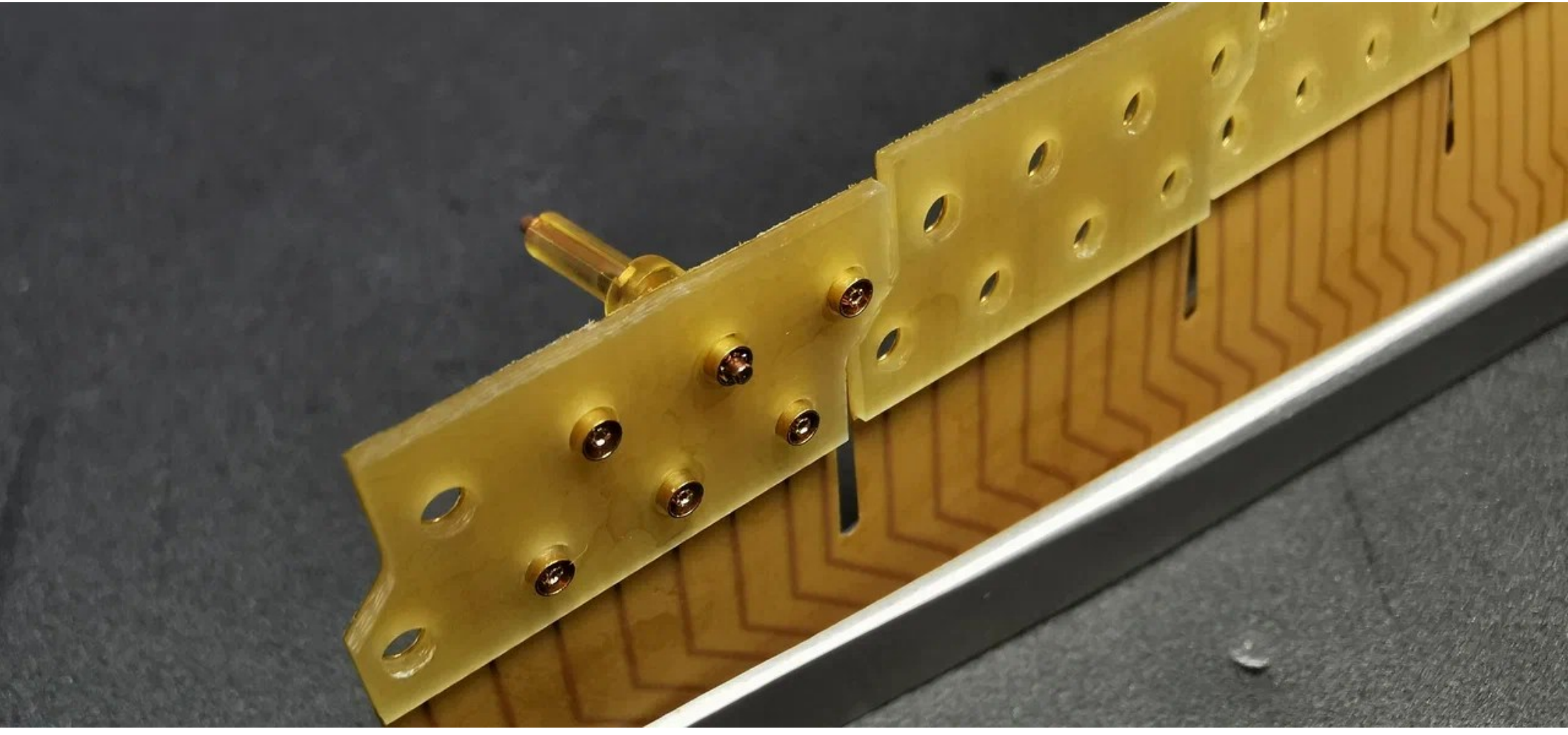


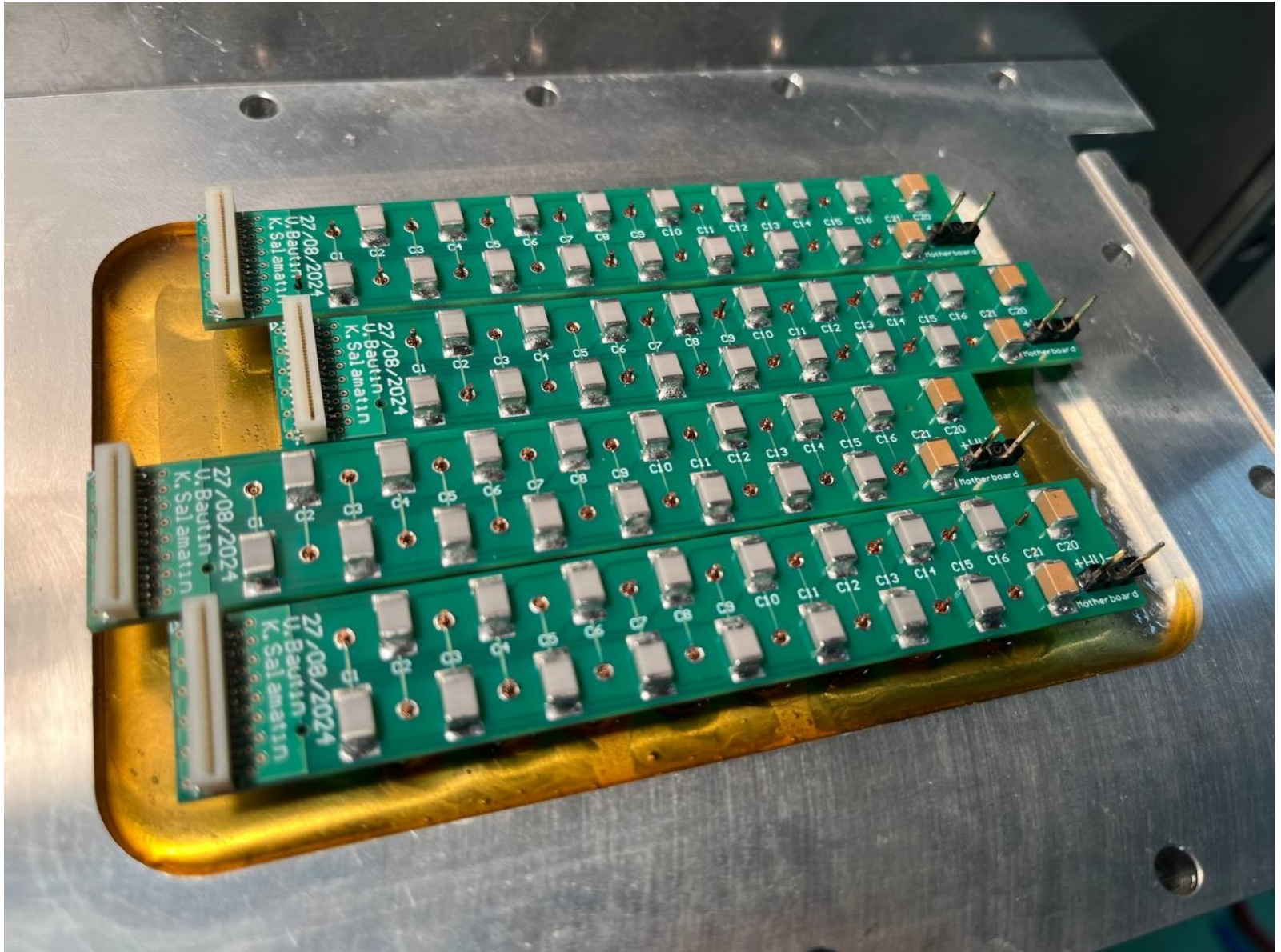
Without DC/DC VMM3a consumption is 600mW @ 1.2V (500mA)



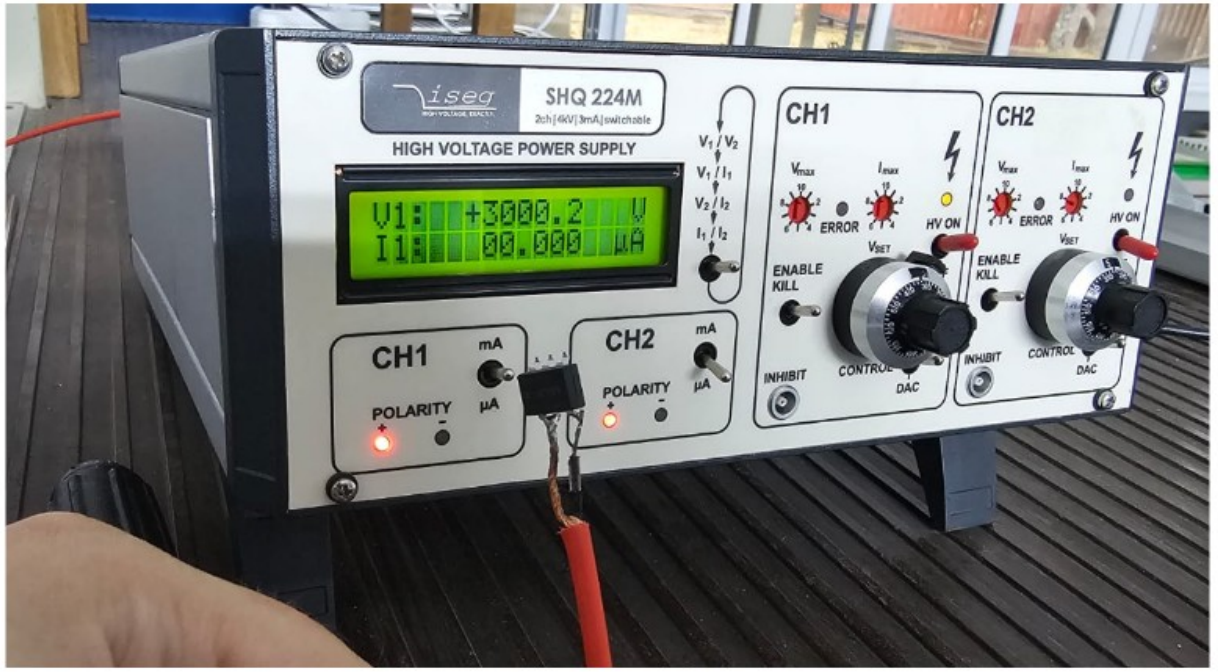
20mVpp pulsations so far. To be improved

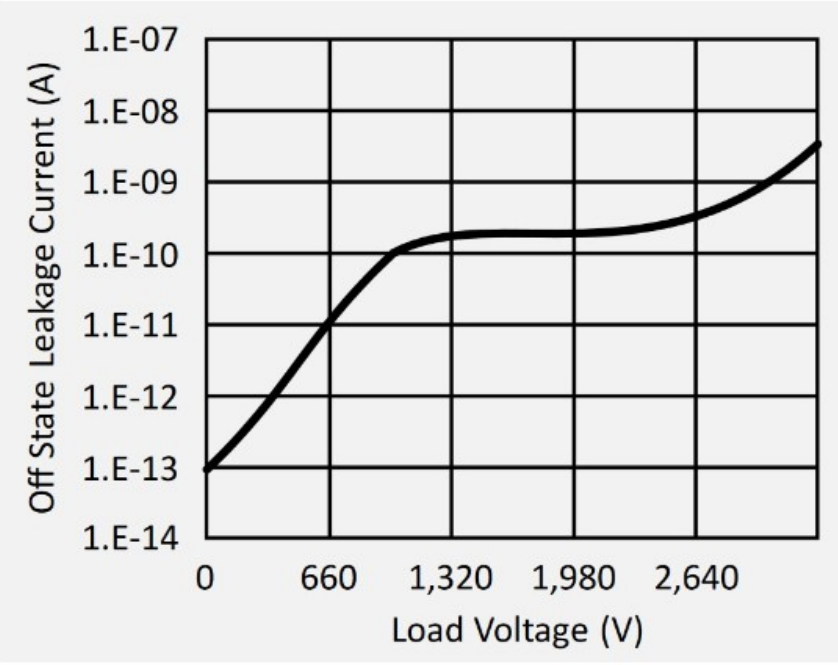
Backup




27/08/2024
V.Bautin
K.Salamatin
Mother board

HV Segmentation





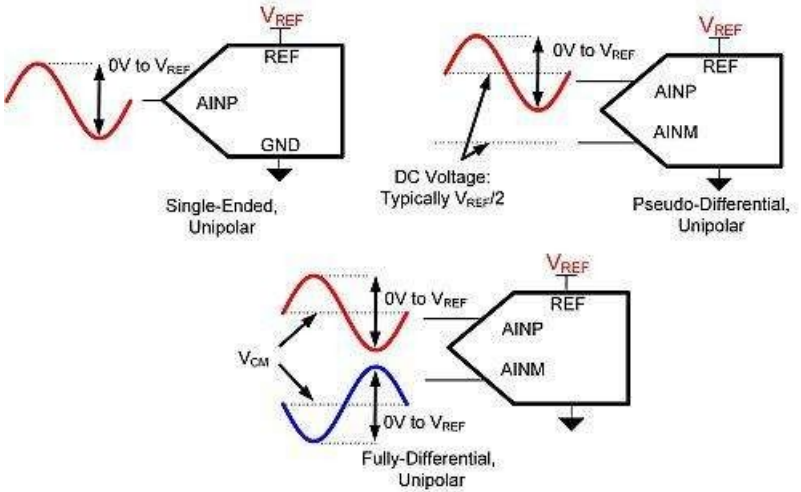
Tests of the solid state relay for the STT readout boards at 3000 V

Summary table of SPD Straw Tracker parameters

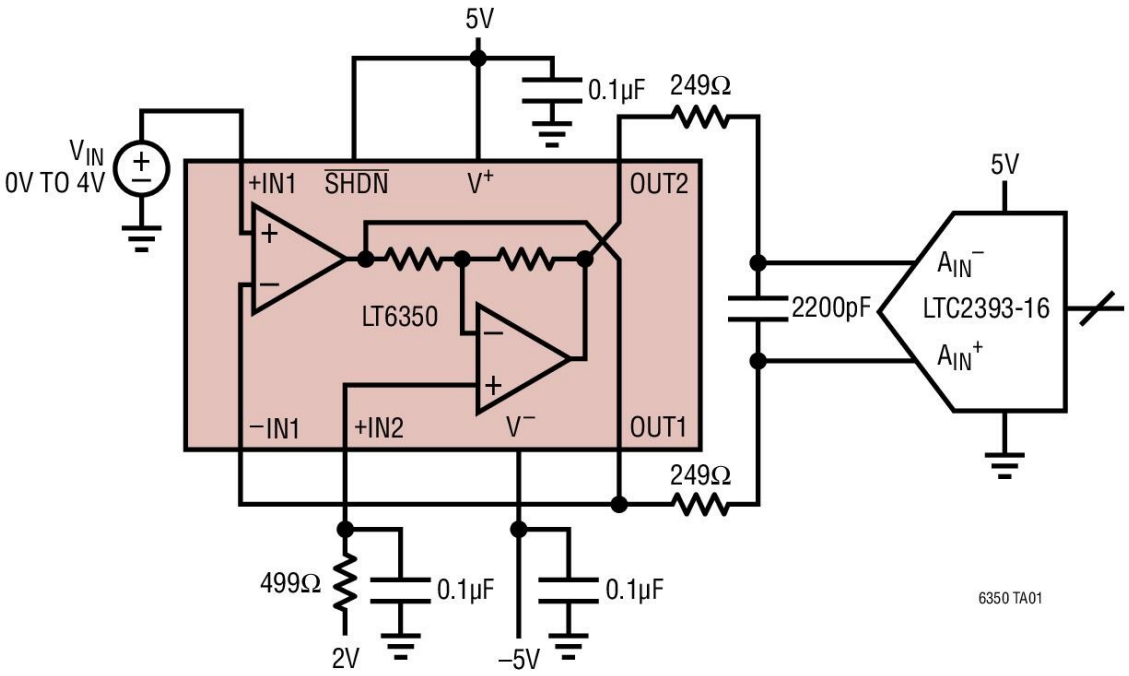
Detector type	barrel	end-cap
Detector tasks	dE/dx	xy coordinates, dE/dx
Working mode	triggerless	triggerless
Detector inner diameter, mm	540	
Detector outer diameter, mm	1700	
Number of layers	30 (double layer)	2x, 2y, 2u, 2v
Number of stations, sections	8 sections	12 stations
Number of channels	32288	8192
Tube diameter, mm	10	10
Maximum tube length, mm	2400	1700
Central core diameter, mm	0.03	0.03
Maximum detector capacitance, pF	26	18,5
Gas detector	70 Argon, 30 CO_2	70 Argon, 30 CO_2
Operating voltage, V	+1650	+1650
Multiplication factor, HV=1750	4.5E4	4.5E4
Charge from the first electron, fC	7.7	7.7
Electron drift velocity, μm/ns	65	65
Electron drift time, ns	120	120
Ion drift time, μs	100	100
Spectral resolution, μm	150	150
Maximum load, kHz per tube	150	

See A. Solin report at SPD Coll. Meeting: https://indico.jinr.ru/event/3189/contributions/17520/attachments/13230/22121/14_Development%20of%20an%20ASIC%20for%20straw%20and%20micromegas%20detectors%20of%20the%20NICA-SPD.pdf

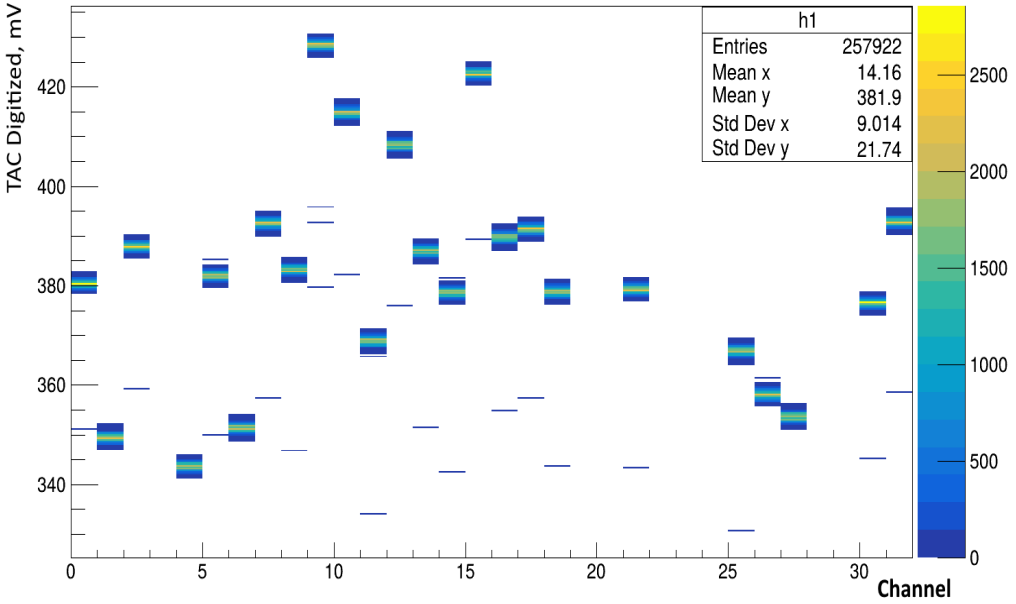
Single Ended vs Differential ADC

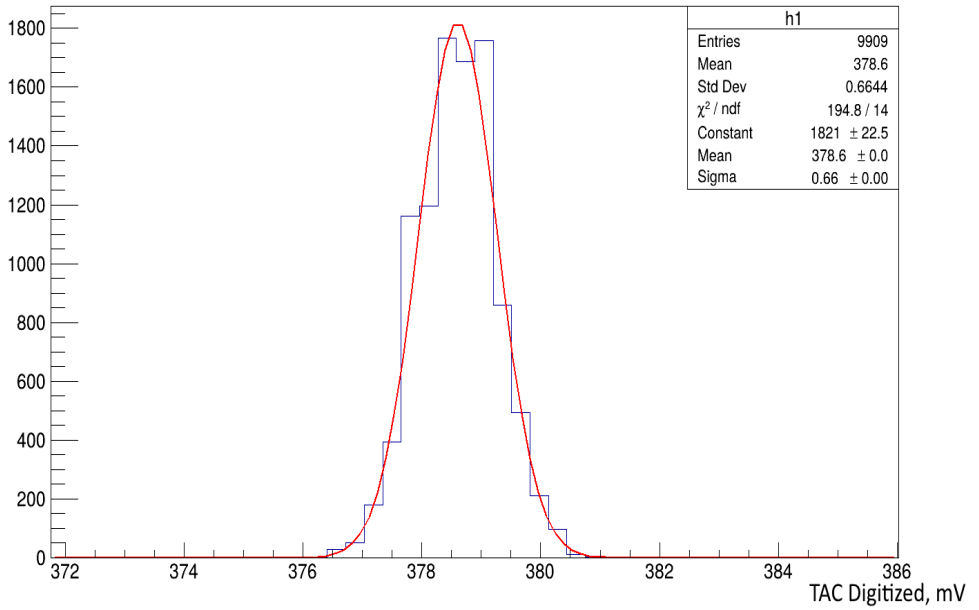


ADC Driver: Single-Ended Input to Differential Output



The real benefit of differential signals is in noisy environments, because of increased common mode rejection



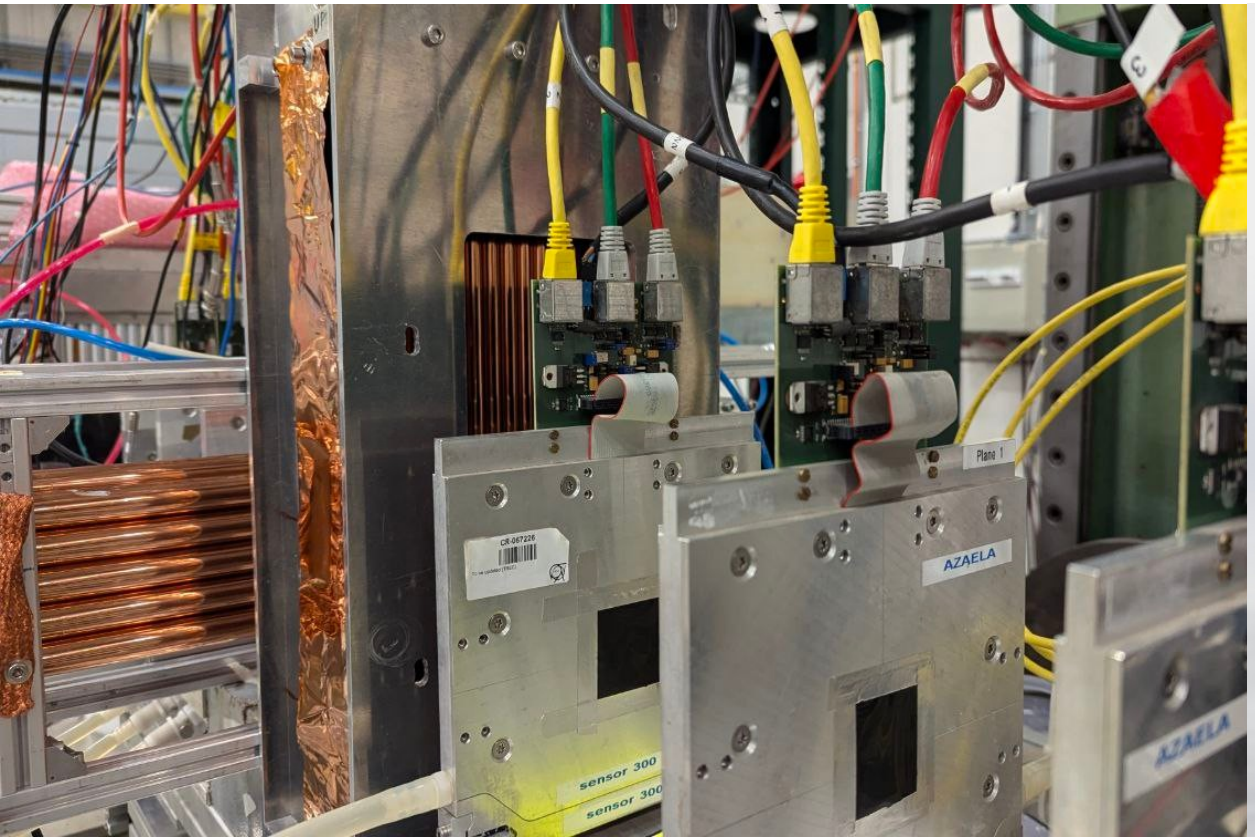


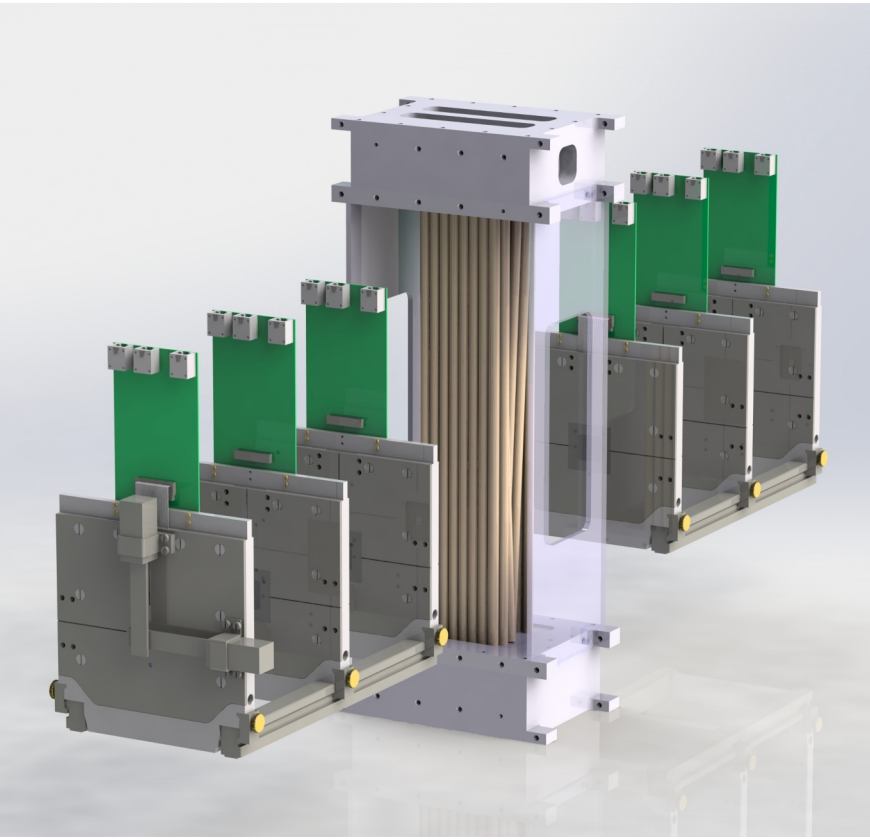
Timing resolutions obtained from a readout board equipped with VMM3a, MCU, and differential drivers for the internal ADC of the MCU with test pulses (300 fC) and different TAC slopes.

	TAC slope 100 ns	TAC slope 350 ns	TAC slope 650 ns
Slew rate	10 V/μs	2.8 V/μs	1.5 V/μs
Bin size	30 ps	110 ps	200 ps
Timing resolution	70 ps	230 ps	440 ps

Extremely Preliminary

Test beam setup evotution





CERN, H8 + H4 (**2024**)
6x Si planes
VMM / TIGER/ ATLAS ASD readout