FRRC - PANDA Meeting, Moscow / ITEP, May 26, 2015

G.Alexeev (for muon group)

Muon System Status Report

* Approval of Muon TDR by FAIR Council (22 Sept. 2014) -> open way to writing the JINR-FAIR contract (available budget ?!)
* Description of Muon System in PANDAroot:
  - Barrel, End Cap, Muon Filter –> JINR, Dubna
  - Forward Range System –> INFN, Torino
* Test beam activity at CERN:
  - Full assembly of Range System Prototype (wire & strip R/O, analog & digital FEE)
  - Design of T9/PS/CERN beam line diagnostics upgrade (time-of-flight, Čerenkov)
  - Stand alone PANDA/COMPASS DAQ at CERN
* Preparation for mass production:
  - contacts with main producers (MDTs components, FEE ASIC chips, …)
* Plans for 2015:
  - Preparation of the JINR-FAIR contract
  - Muon System in PANDAroot – install/debug software (autumn 2015)
  - Range System Prototype – put in operation (cosmic, beam test depends on PID upgrade)
  - Modifications to T9 beam line diagnostic equipment (TOF - autumn 2015, Čerenkov - ?)
  - R&D @ test stand in JINR (high rate effects, new FEE ASIC chips etc.)

Geant4 Computer Model for the Muon System

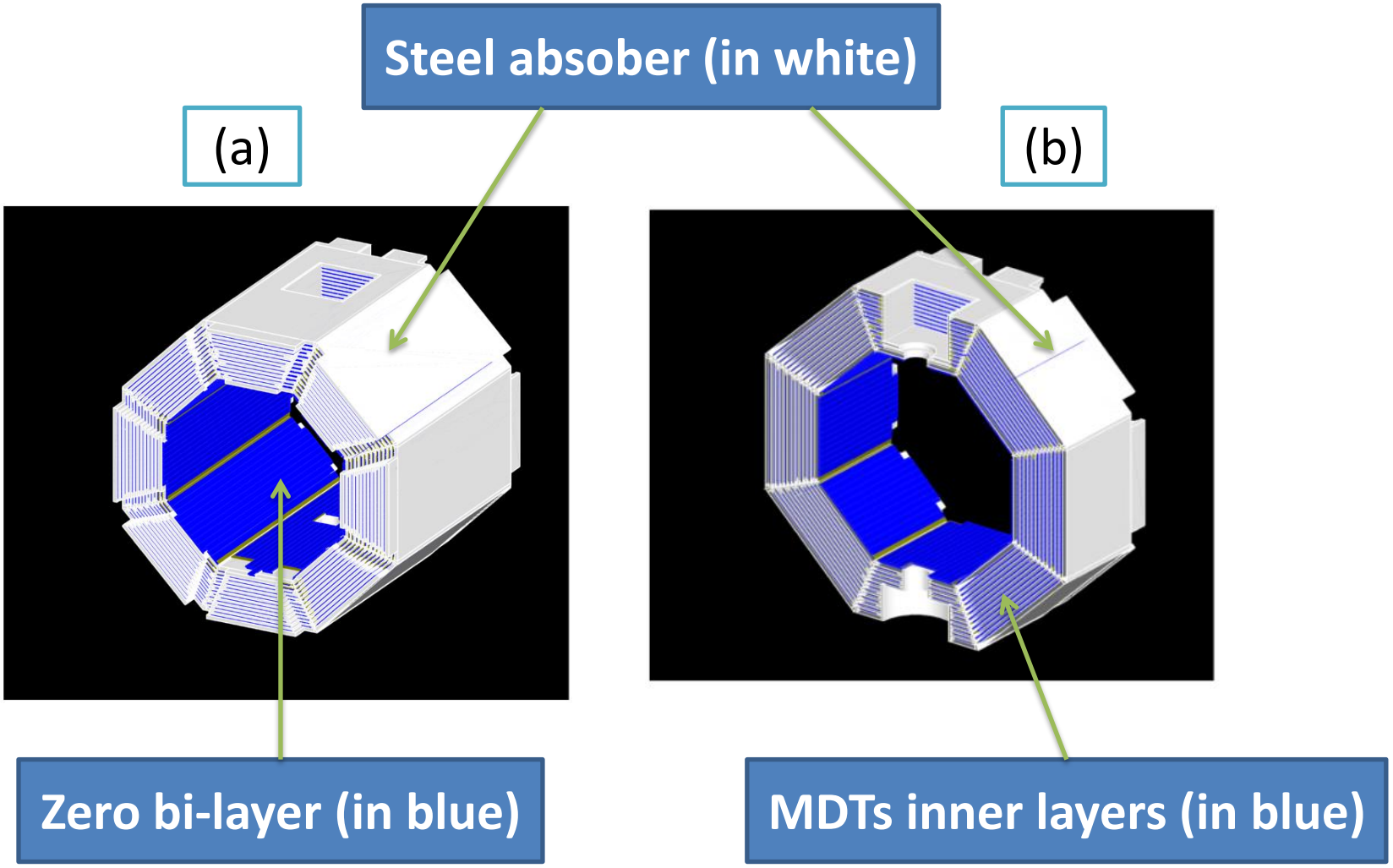
*** Geometrical description**

- *Geant4 geometrical description of the most complex* ***Barrel*** *part of Muon System is practically ready; the* ***End Cap***, ***Muon Filter*** *and* ***Forward Range System*** *are in progress*
- *Description of the* ***Range System Prototype*** *(to be placed on PS T9 beam line) is ready*

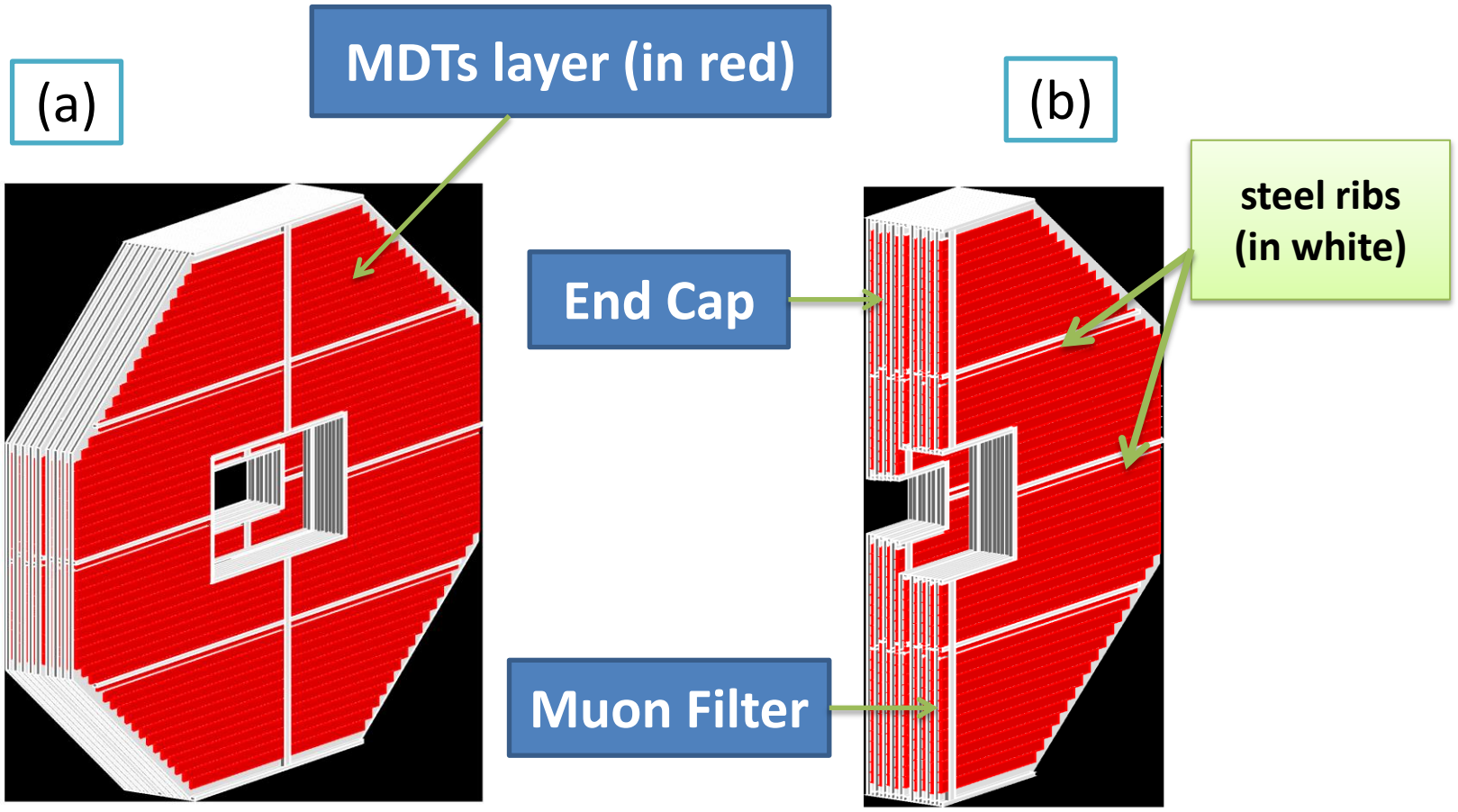
*** Simulation of signals from the MDTs (digitization)**

- *Algorithm based on our experience with Range System Prototype (CERN) is being implemented*

Geant4 view of Barrel (a) and its cut at target zone (b)

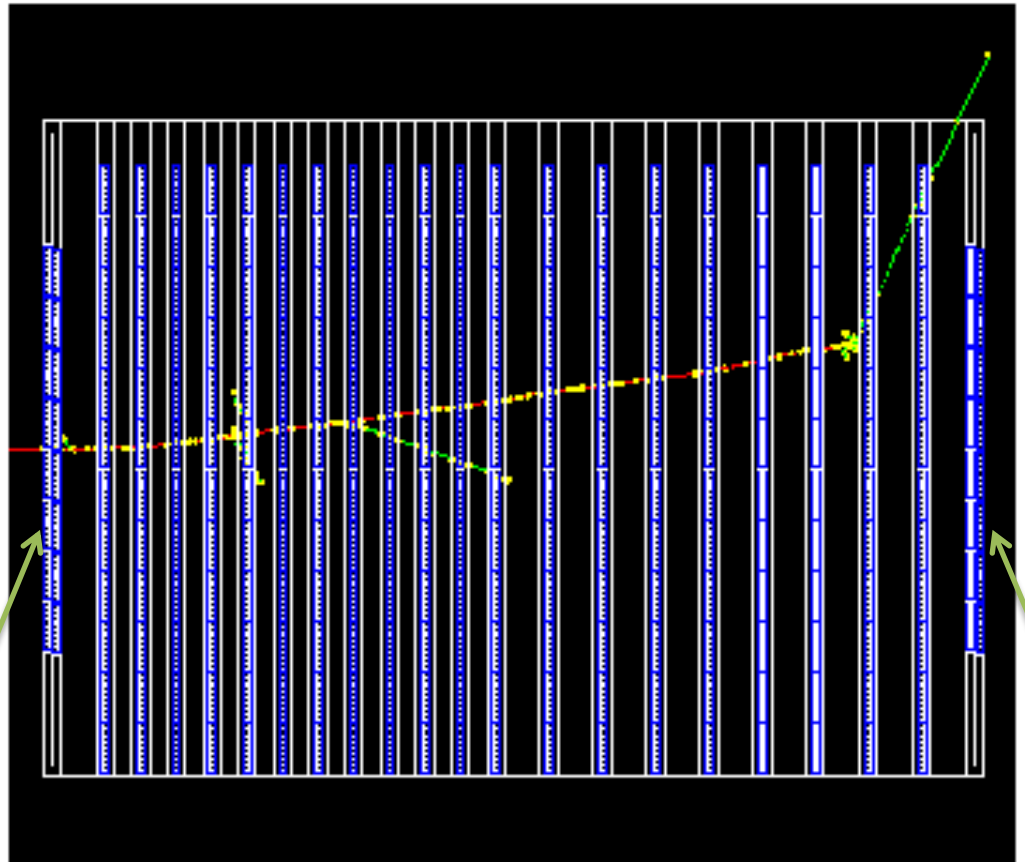


Geant4 view of End Cap and Muon Filter (a) and its vertical cut (b)



RSP model and data collected at T9/PS/CERN run 2012 are being used to tune digitization algorithm

The Range System Prototype Geant4 simulation



Example with 1GeV muon entering from the left

All hits generated by Geant4 are shown

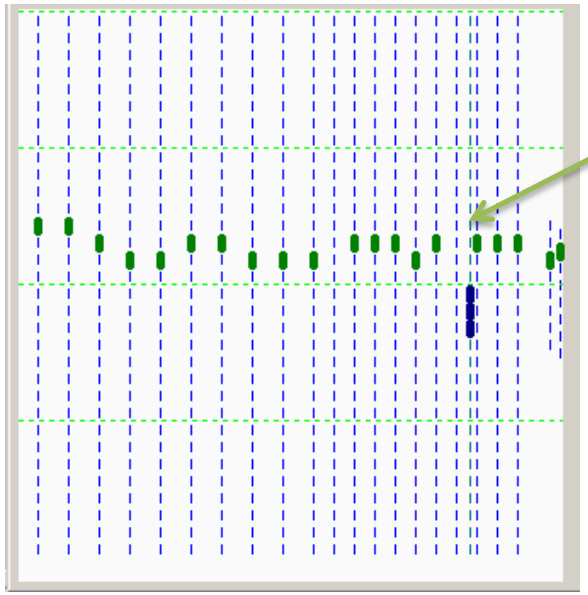
Our task is to analyze them and simulate the signals from MDT wires (and also strips, later…)

digitization

'chess board' zero bi-layer

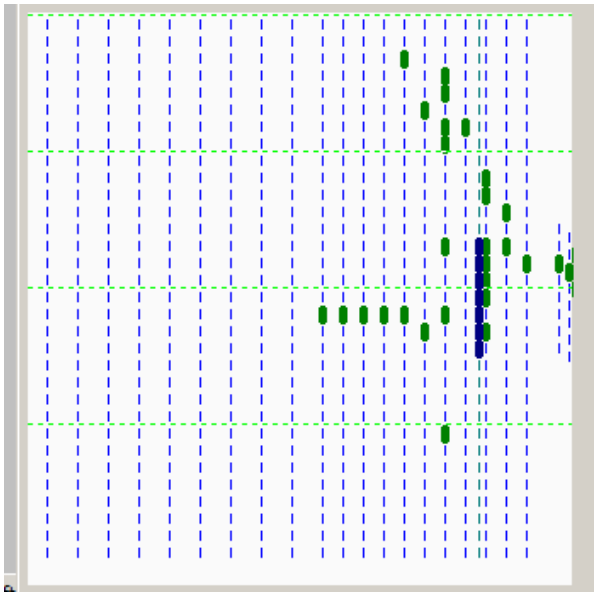
'standard' bi-layer

BEAM: e,μ,π,p (3 GeV/c, trigger: S_1 (Ø 11,5 cm) & S_2 (Ø 3,5 cm)), Range System Prototype data of T9/PS/CERN run 2012

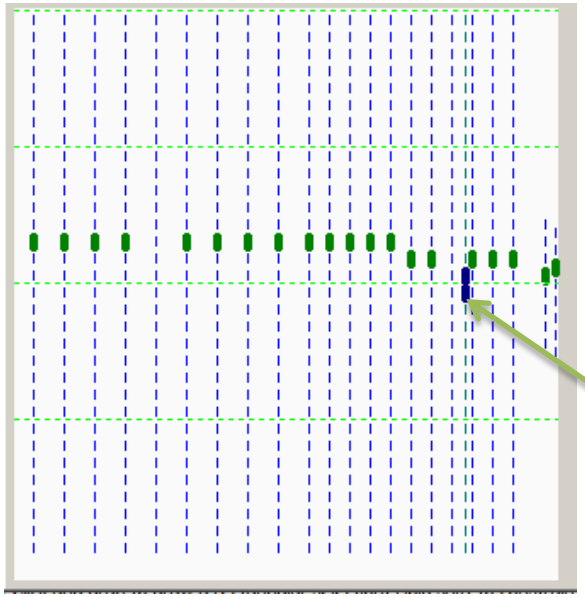


wire hits (in green)

μ

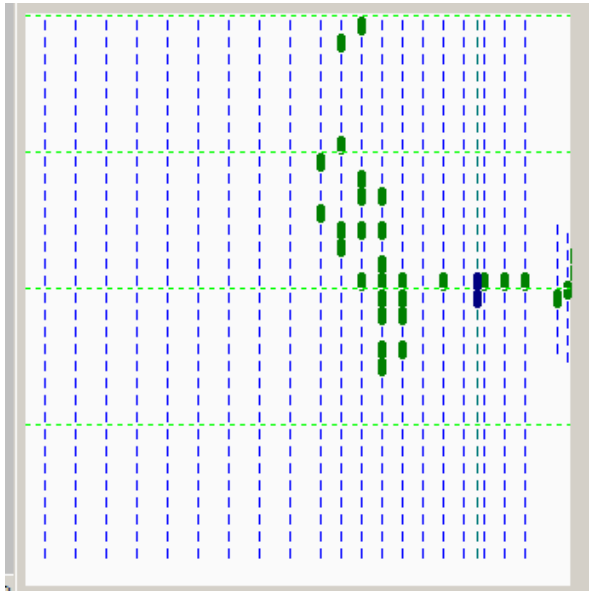


h



μ

strip hits (in blue)



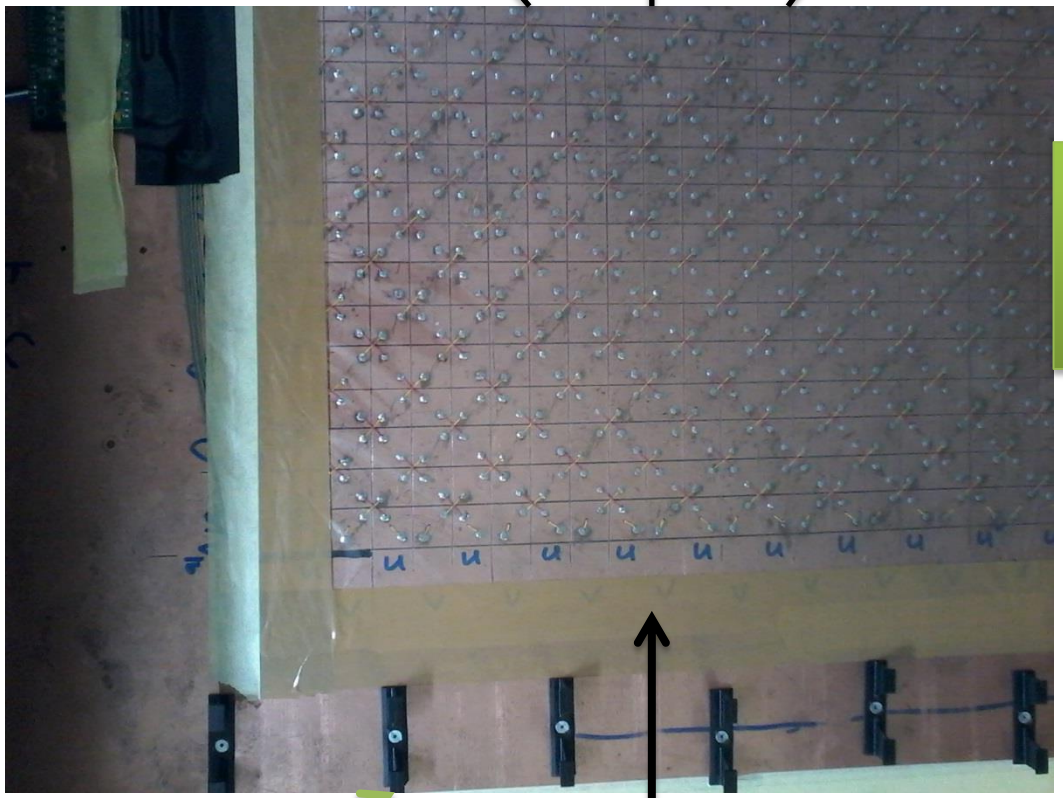
h

‘Chess board’ zero bi-layer (fragment)

wire direction

U-strip, -45 deg.

V-strip, + 45 deg.

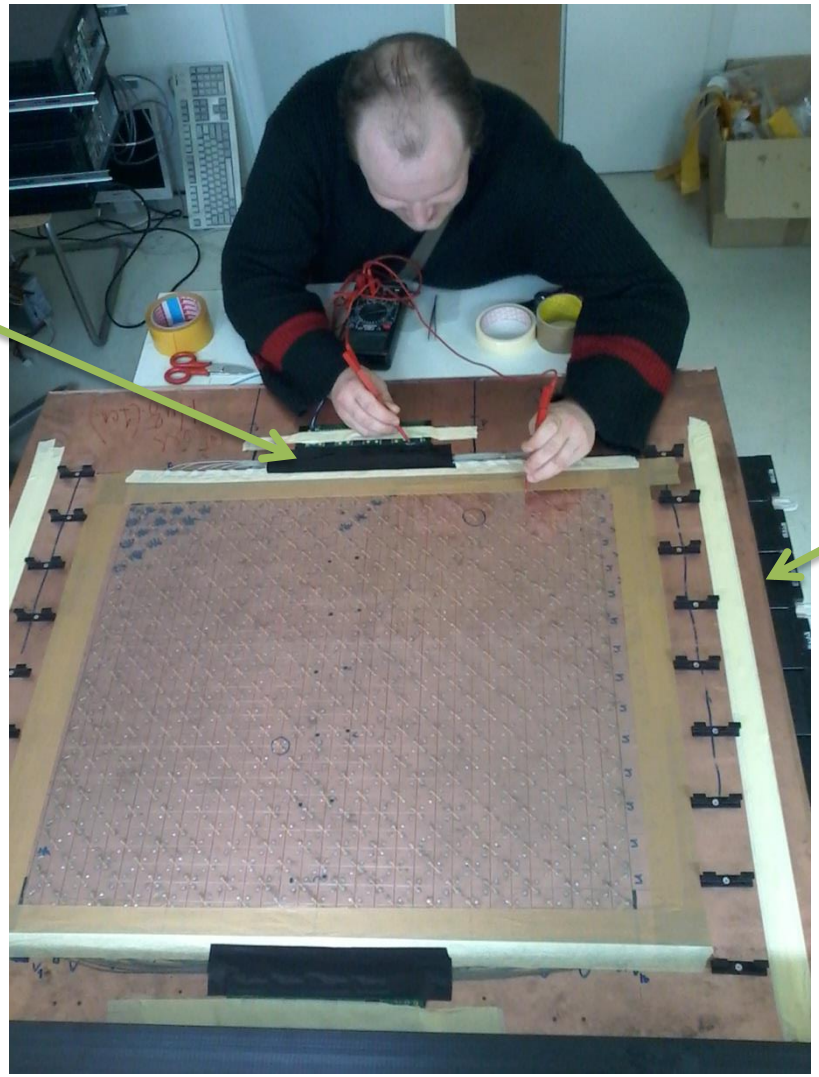


Strips are formed from 2 cm x 2cm squares by soldering

Brackets to fix MDTs to strip board

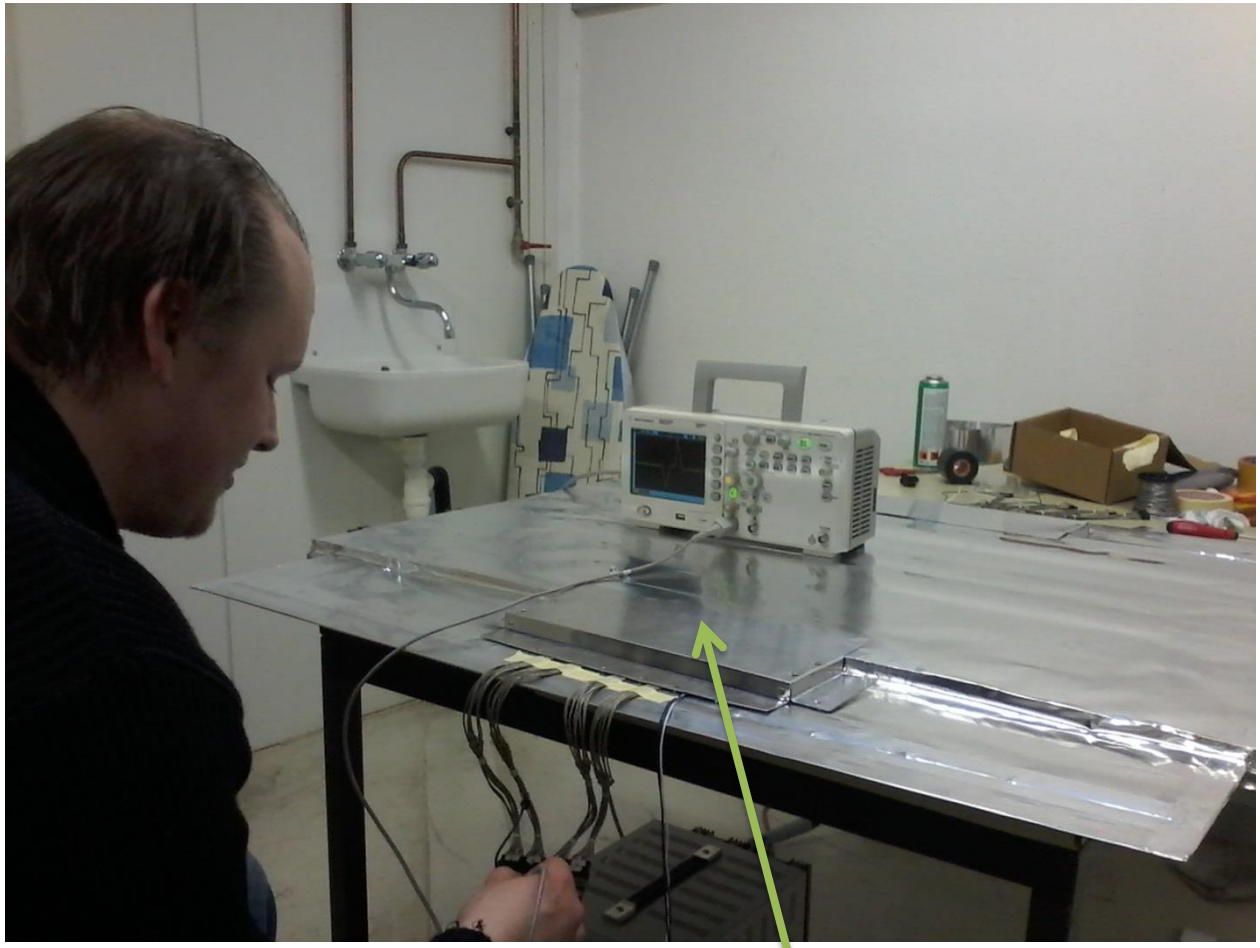
MDT tube

Test of ‘chess board’ zero bi-layer preamplifier A-32

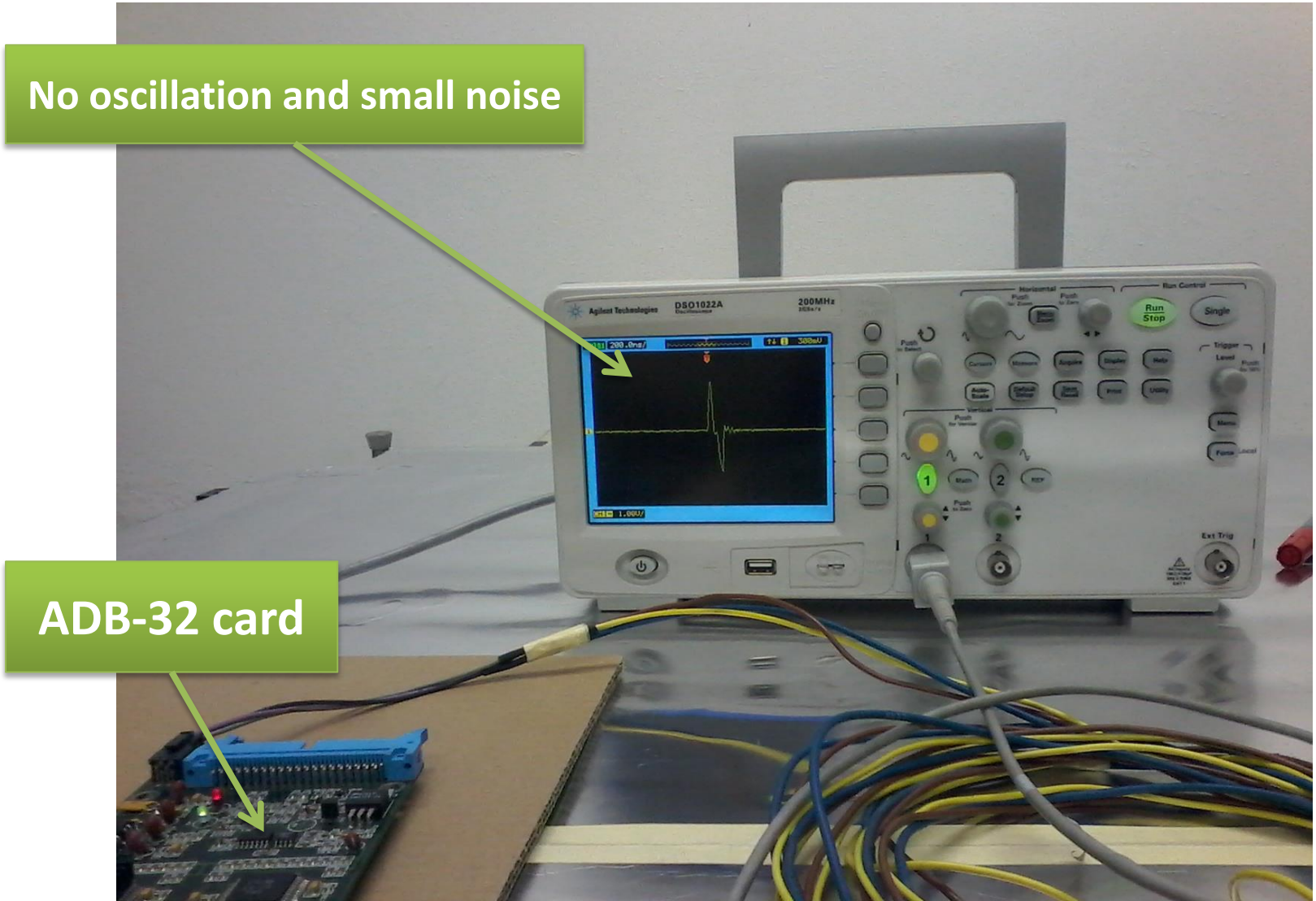


Putting second MDT layer on ‘chess board’ zero bi-layer

Test of ‘chess board’ zero bi-layer fully screened with aluminum foil (~ 0,1 mm thick)

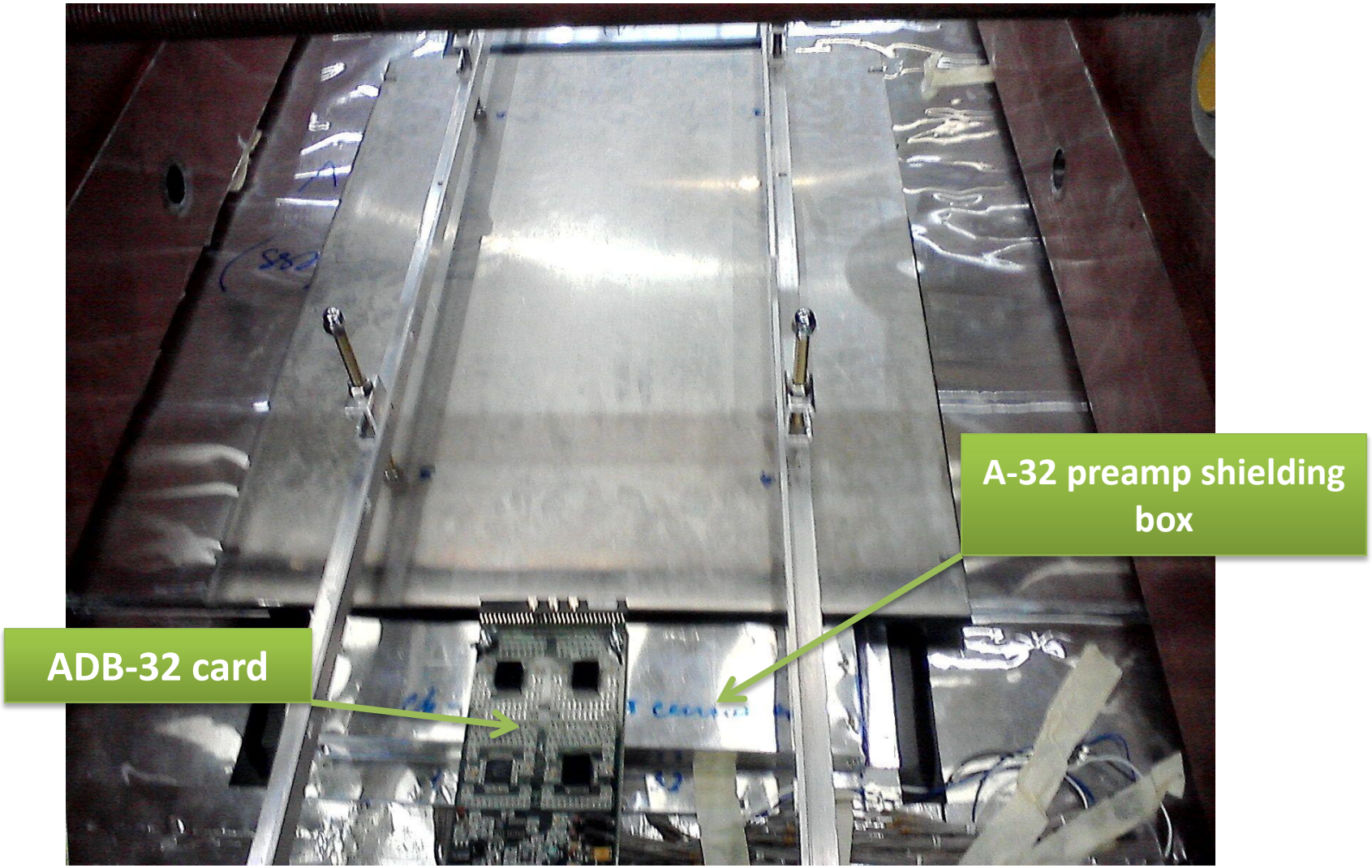


Test pulse from strips as seen after A-32 and ADB-32 amplification (induced by positive pulse on MDT wire)



Moving of RSP by crane for putting in vertical position and further assembly with detecting planes and tests with cosmic at CERN

Fixation of ‘chess board’ zero bi-layer to RSP external surface



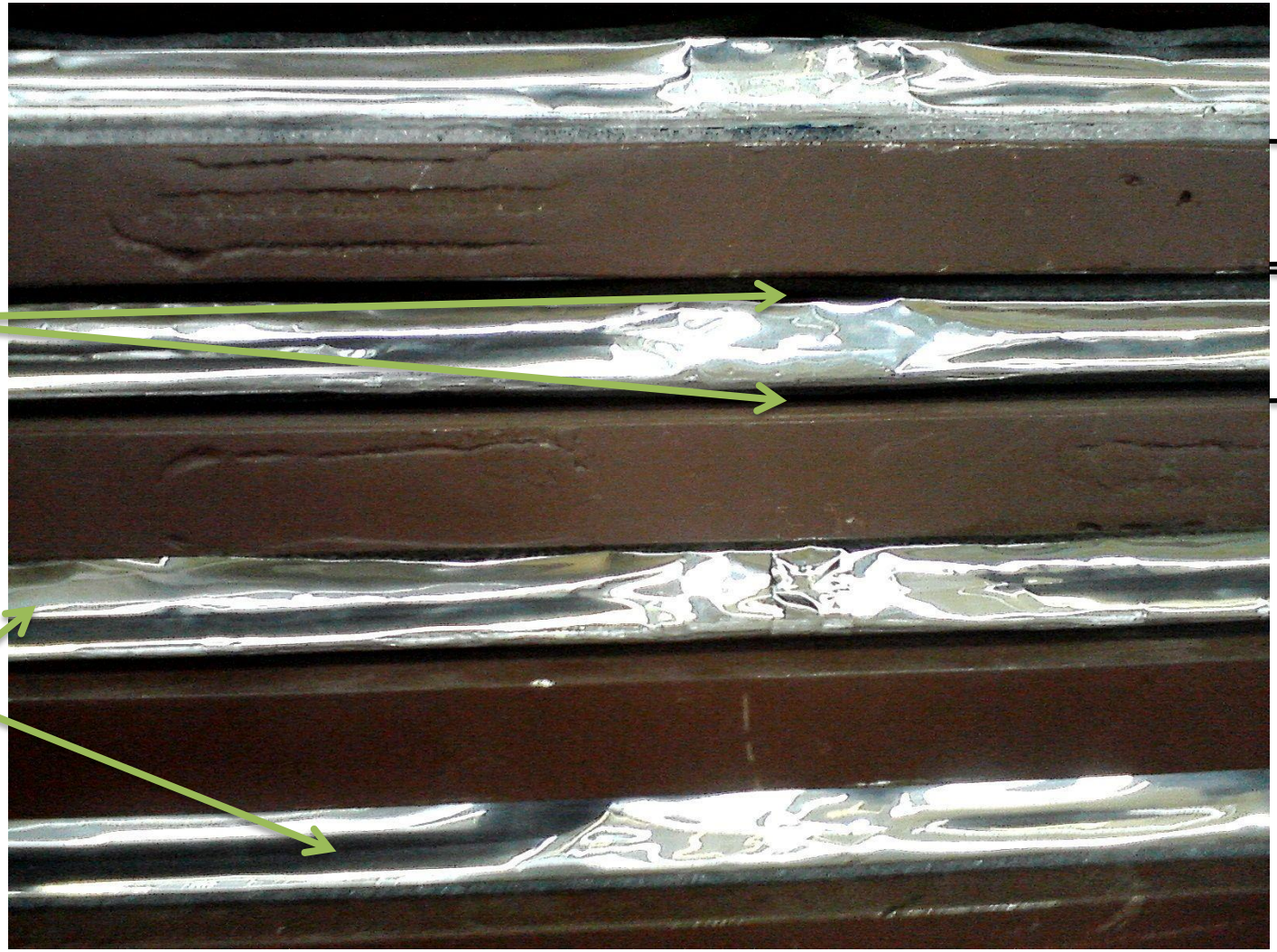
RSP equipped with all detectors and big portion of ‘on chamber’ FEE in vertical position (for cosmic tests)

RSP in vertical (cossmic test) position

‘bottom side’ (for RSP position on beam) is pictured

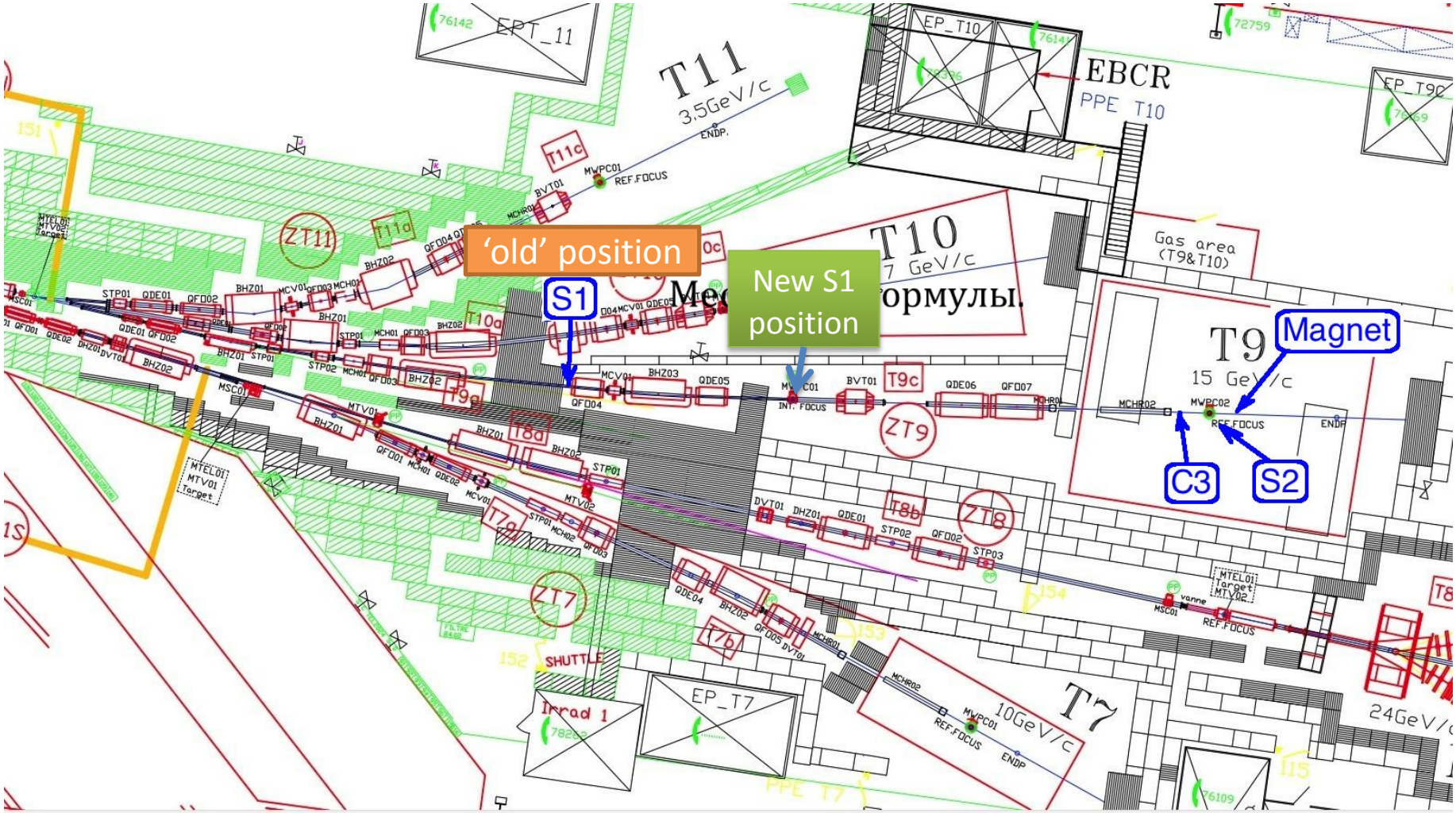
Fragment of RSP 'bottom side'

Barrel structure (Fe/30mm + gap/30mm)



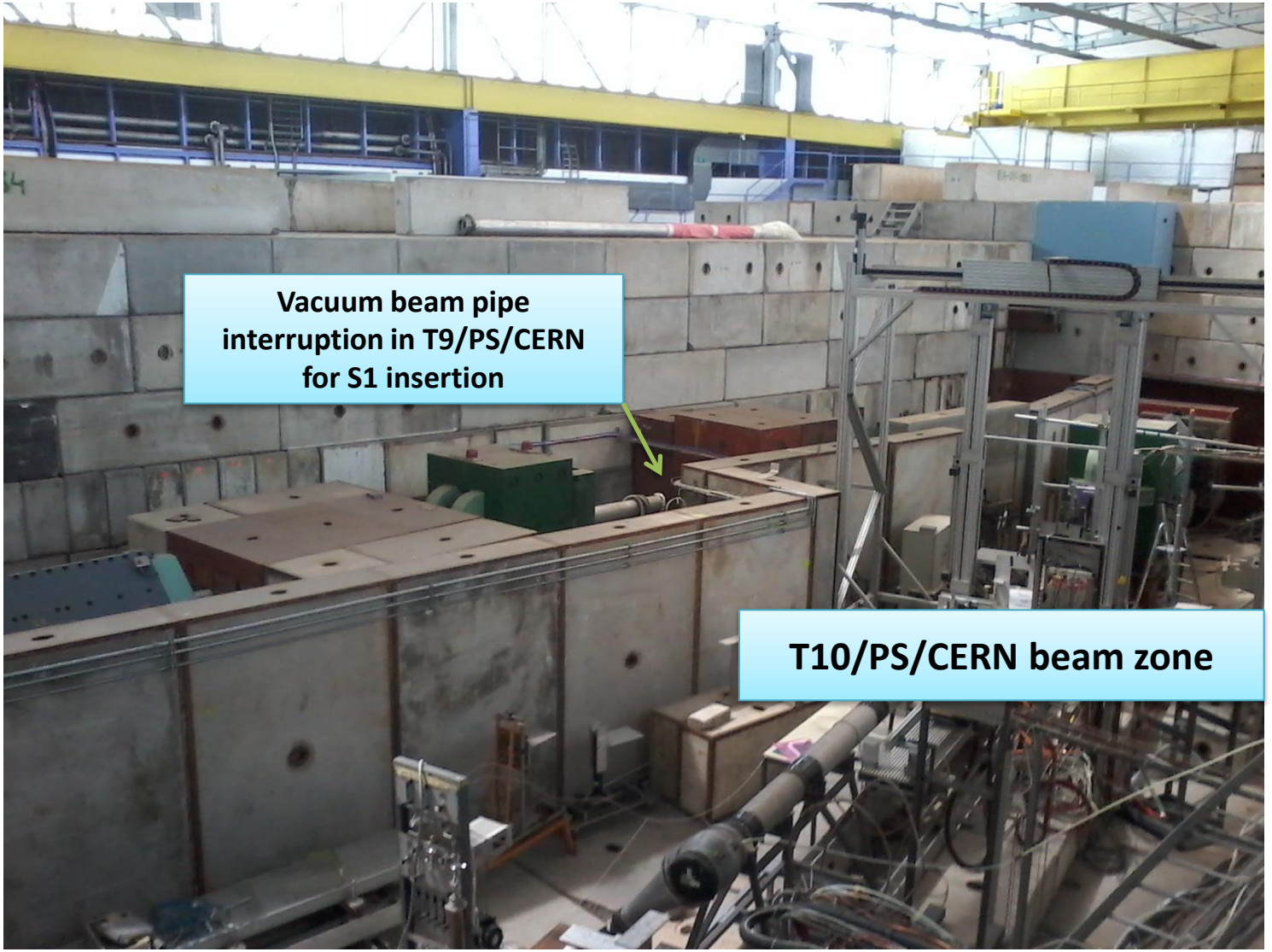
Assumed upgrades to T9 beam line for π/μ separation < 1-2 GeV/c:

S1,S2 time-of-flight scintillator counters based at ~ 16-24 m to each other,
pressurized (up to 60 atm) Cherenkov counter C3,
magnetic analysis of incoming muon momenta with ~ +/- 1% accuracy

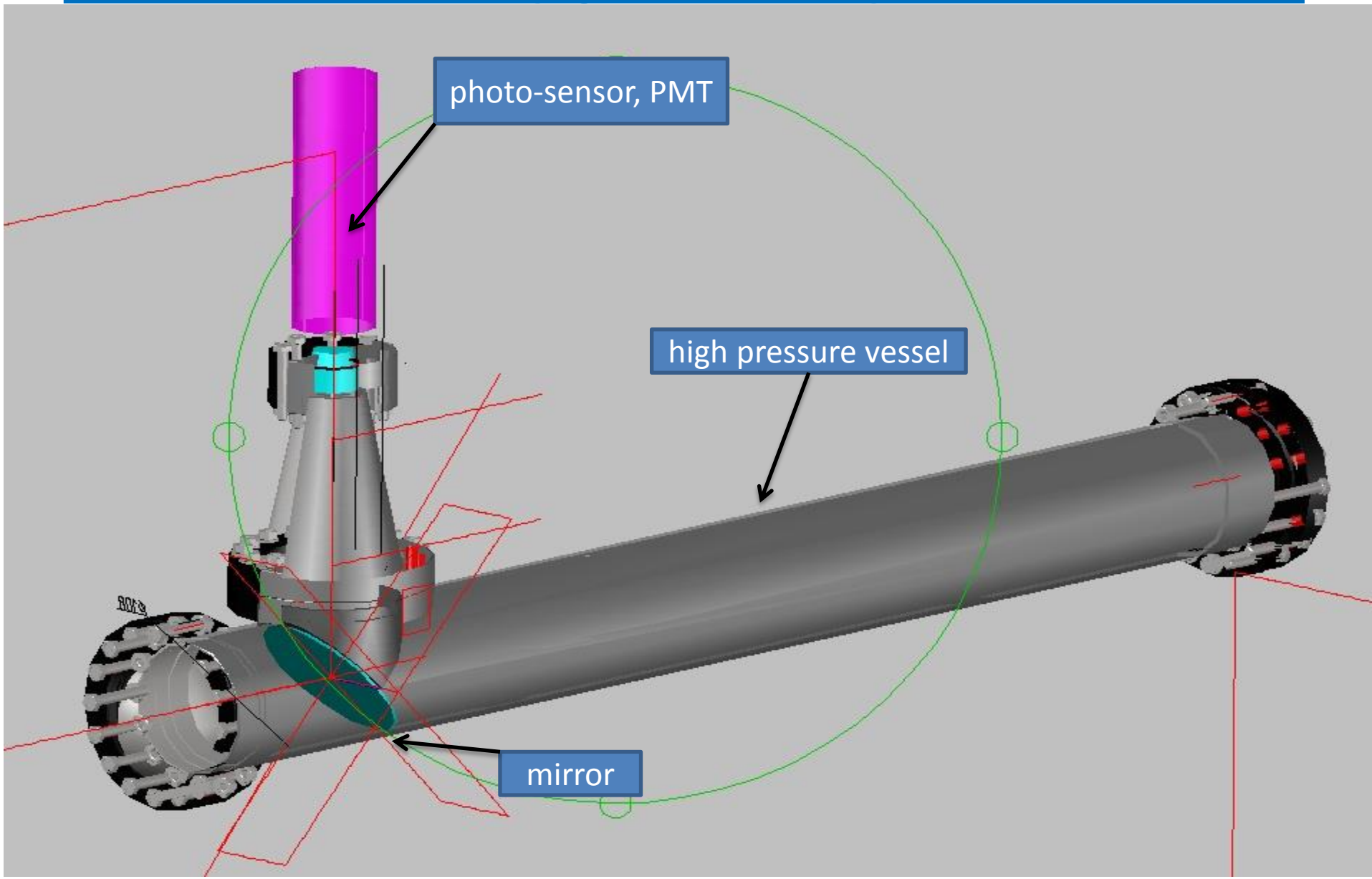


T9/PS/CERN beam line

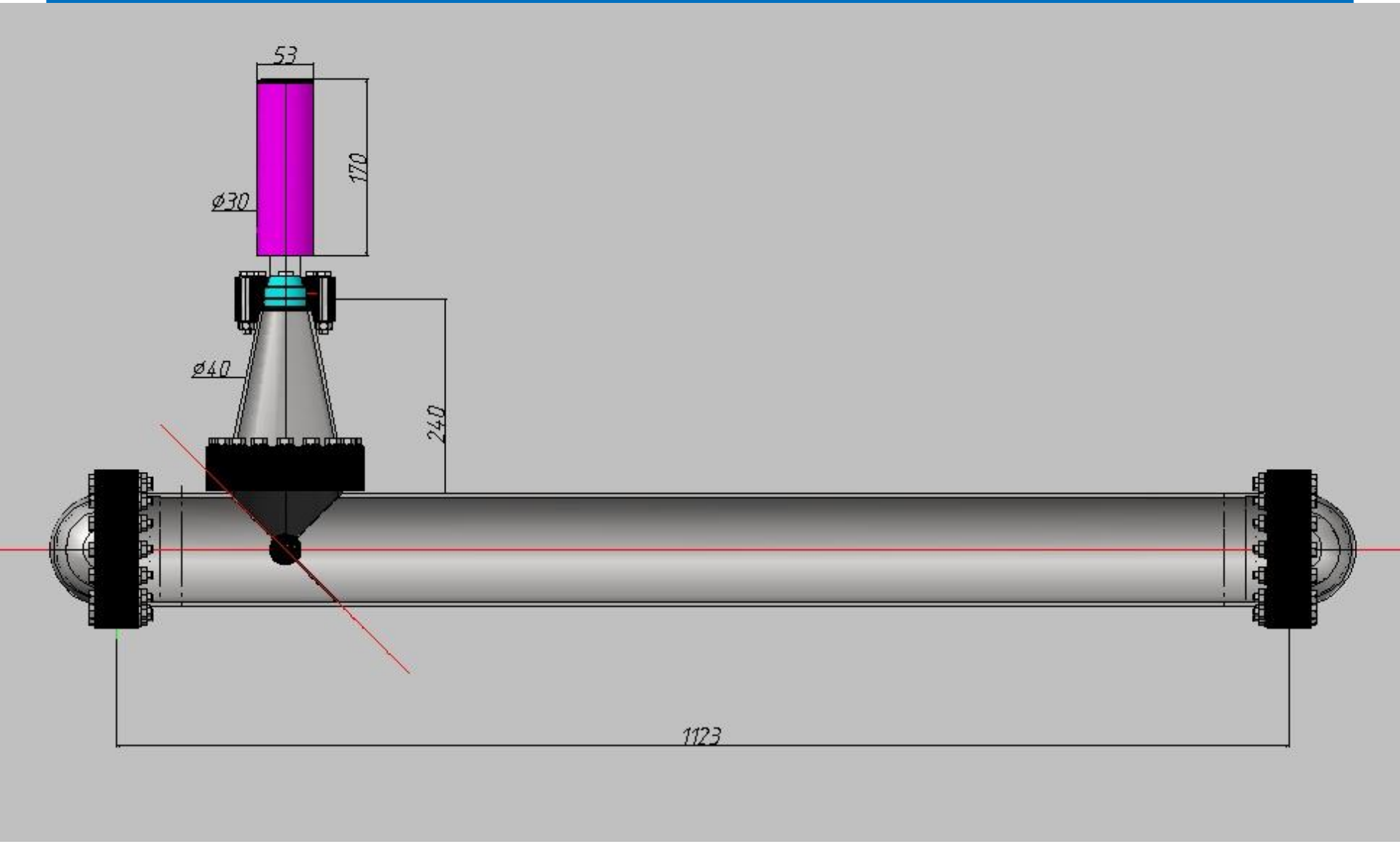
after reconstruction of 2013-14



Čerenkov counter (up to 60 atm), schematic view



Čerenkov counter (up to 60 atm), main dimensions



T9 Test Beam Diagnostic Equipment (photo-detectors)

1. **PMT XP1020UR (Čerenkov counter)**

   time resolution σ_t = 70 ps

   3σ TOF μ/π separation for P≤0.9 Gev/c

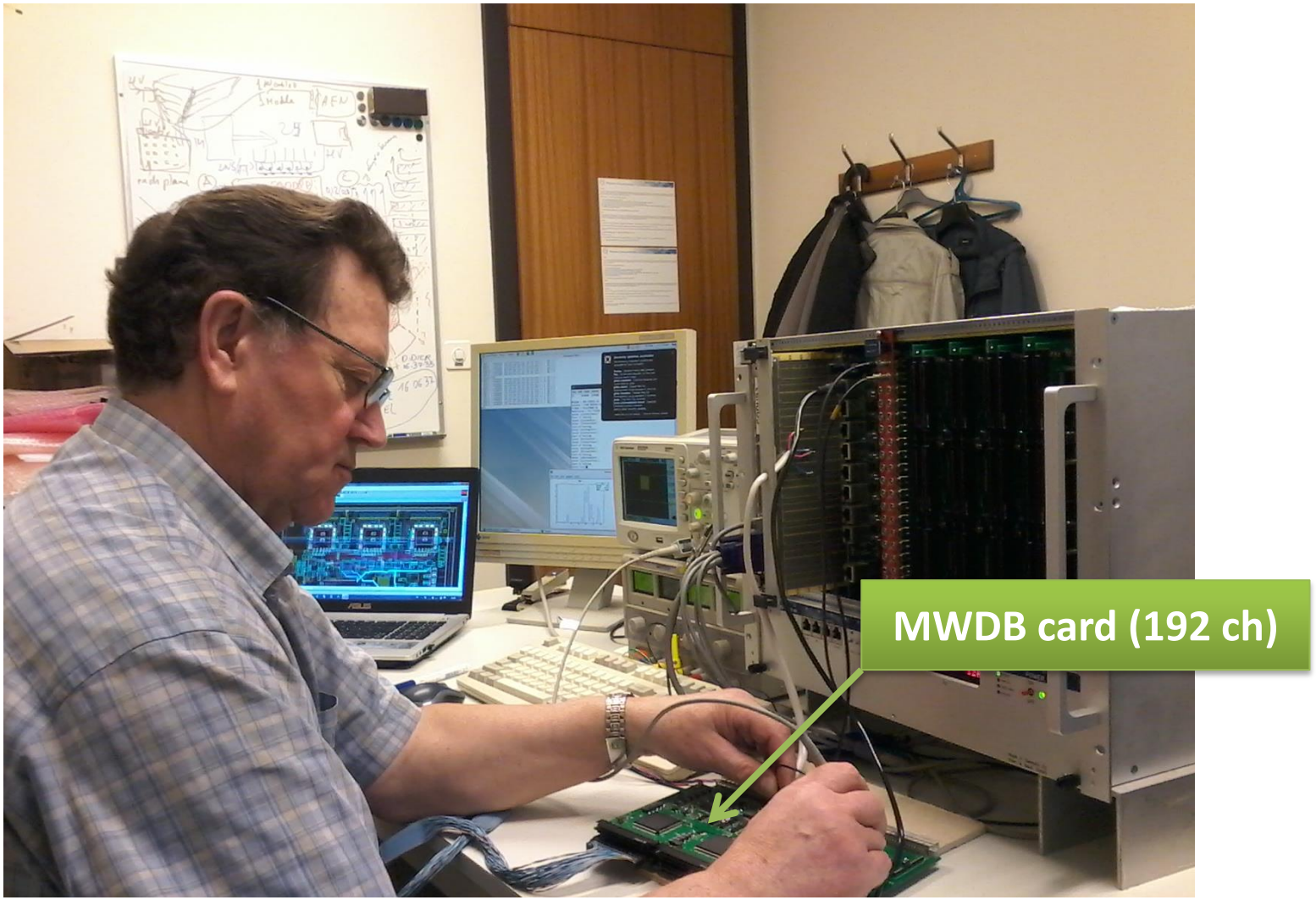
2. **MCP-PMT XP85112 (TOF counters)**

   time resolution σ_t = 36 ps

   3σ TOF μ/π separation for P≤1.3 Gev/c

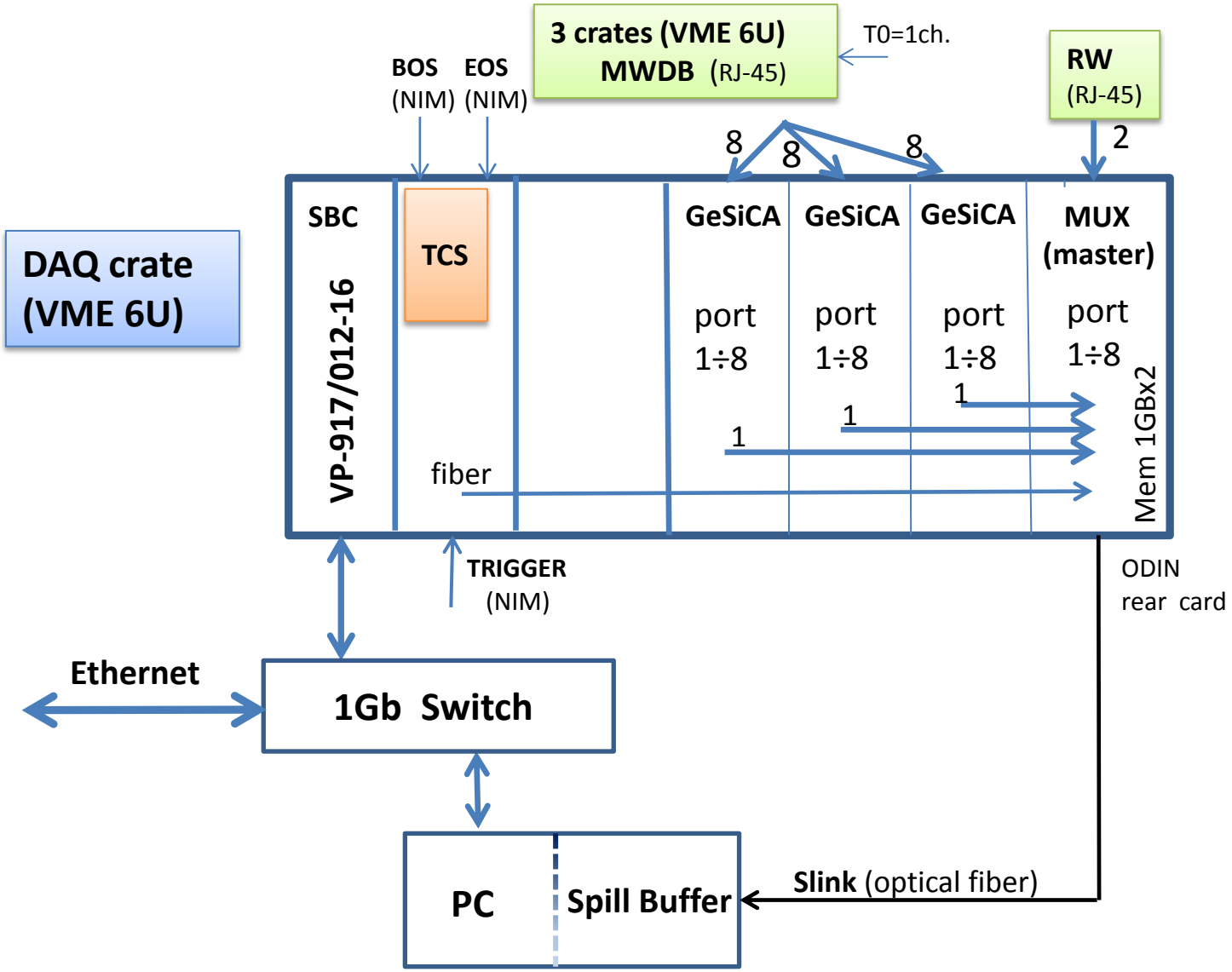
Test stand for digital R/O cards MWDB at CERN

21 cards (4032 ch) were tested/debugged/repaired



Stand-alone DAQ Block-diagram

(version 5, developed and completed in cooperation with COMPASS DAQ experts)



Stand-alone DAQ units status

1). **VME crate x 3 (**received & tested**)**
VME64 crate; 8U; 21 slots; fan; +5V 115A/230A;
+/-12V 46A

2). **6U VME Single Board Computer** VP 917/012-16 x 2 units **(**received & tested**)**
2-core 2.5 GHz i7-3555LE; 16GB DRAM; 2PMC/XMC slots;
Ethernet port; 2.5 “HDD SATA-III 500GB;
Splitter cable for VGA/Keyboard/Mouse/COM-Port/USB

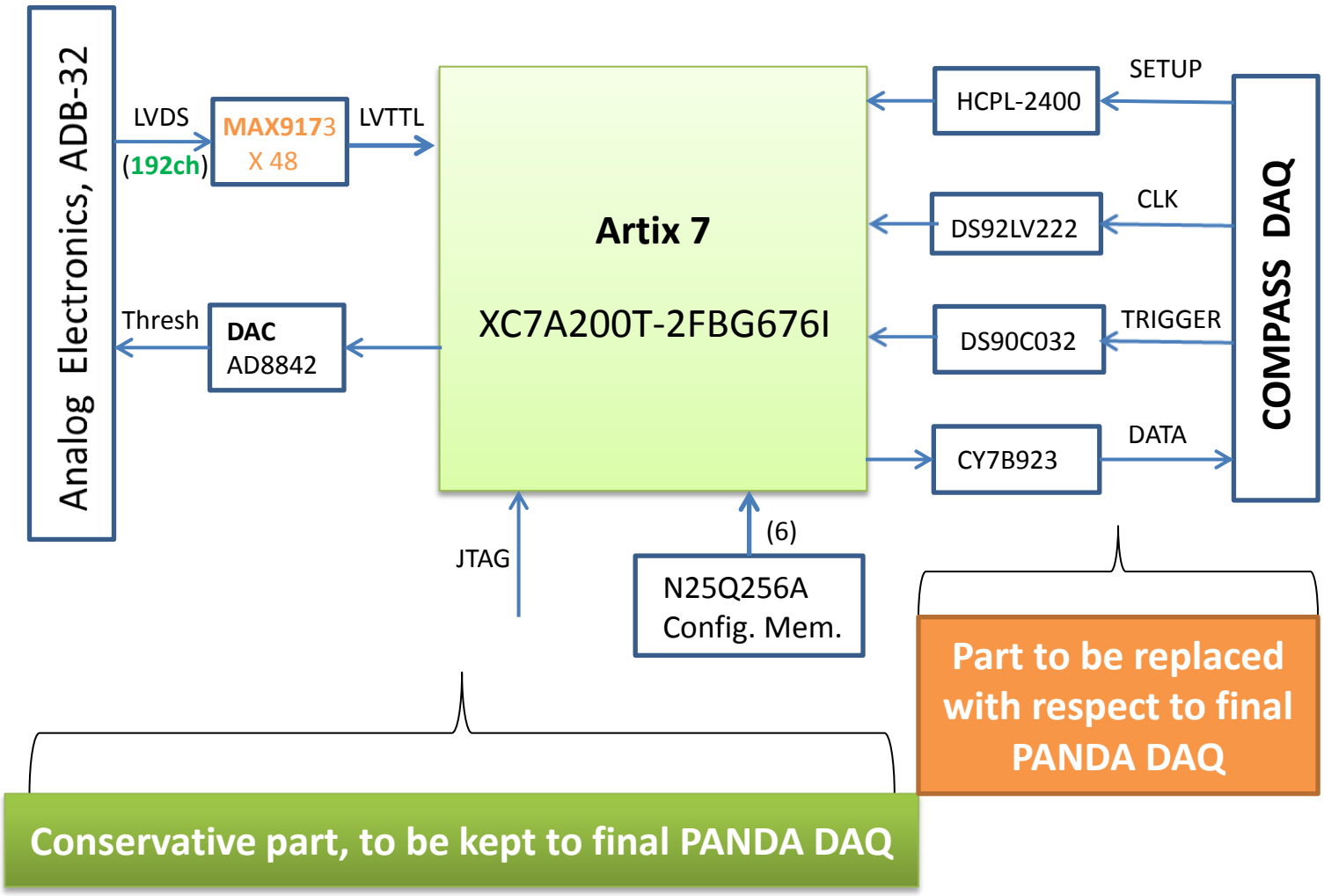
3). **6U VME Single Board I/O Register** V977 x 2 units **(**received & tested**)**
16 channels; NIM or TTL Input/Output signals

4). **6U VME GeSiCA** x5 units + **MUX** x 2 units (Control and Acquisition unit)
readout-driver **(**received, to be tested with DAQ**):** 8 front-end serial interfaces (Rj-45); 512 MB internal FIFO memory; S-Link output interface

5). **TCS module** x 2 units **(**offer is being paid, to be tested with DAQ units**)**

Simplified Schematic of Xilinx FPGA Prototype R/O Module (192ch)

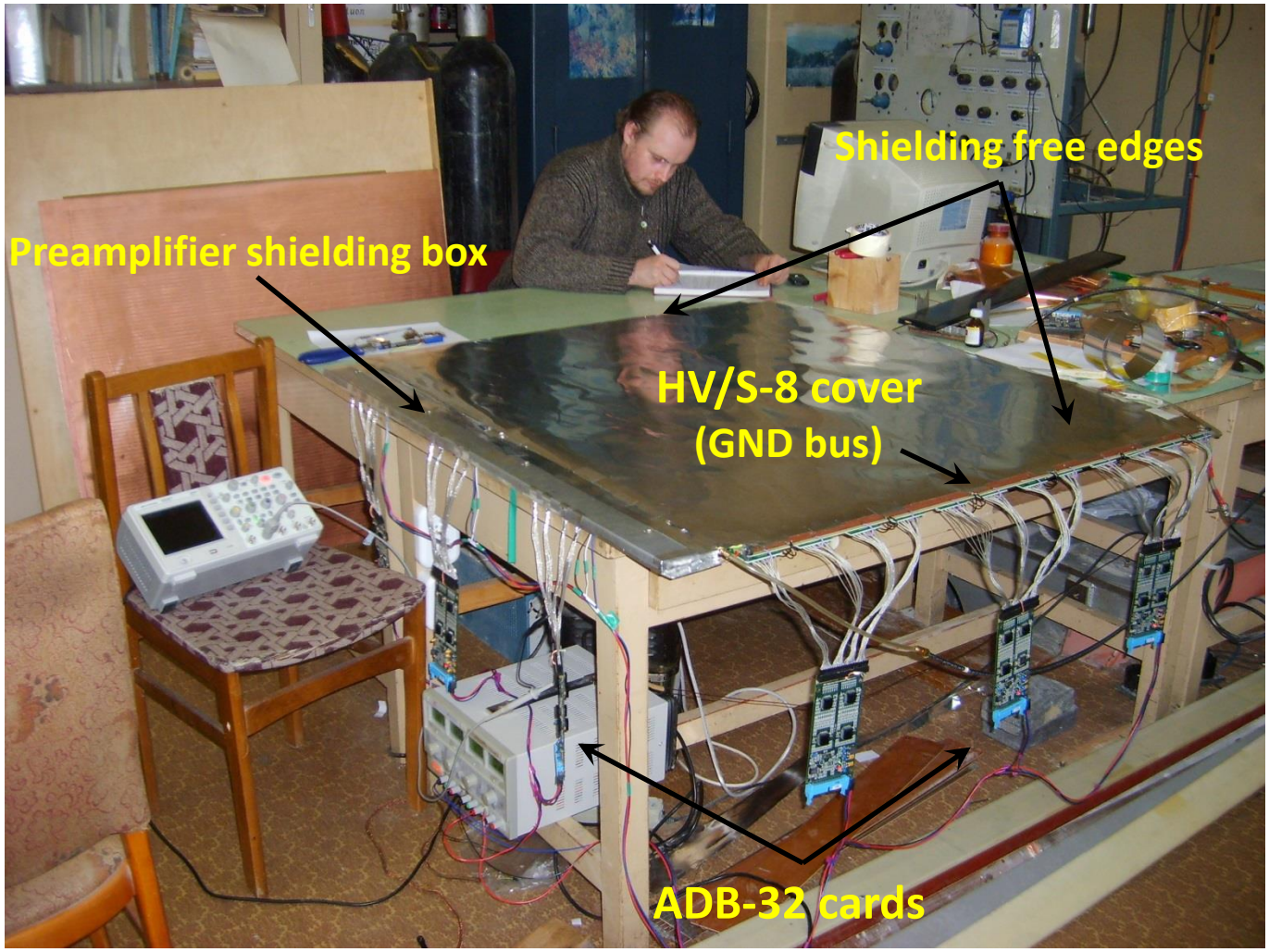
(to be tested with Range System Prototype at CERN; if results will be positive, the Artix 7 chip may be regarded as basis for the final PANDA/DAQ)



Contacts with industry

* **MDTs components:**
  - ALU profile -> **Agrisovgaz** (www.agrisovgaz.ru), **reliable partner**, Kaluga Region, Russia
  - End plugs (active & passive) -> **Mars**, **reliable partner,** Erevan, Armenia
  - Plastic envelope (Noryl) -> in search for partner, two companies study the technology to extrude Noryl plastic (**Mars**, Erevan and **EPPI limited**, Moscow
* **Front End Electronics:**
  - ASIC chips -> **Integral**, **reliable partner**, Minsk, Belorussia
  - Assembly of cards -> **Marathon**, **reliable partner**, Moscow, Russia
* **Mechanical structures:** pending clarity with magnet

Final variant of detector plane shielding developed at Dubna test stand – was implemented in Range System Prototype at CERN



All results of shielding tests were applied to this final detector plane version

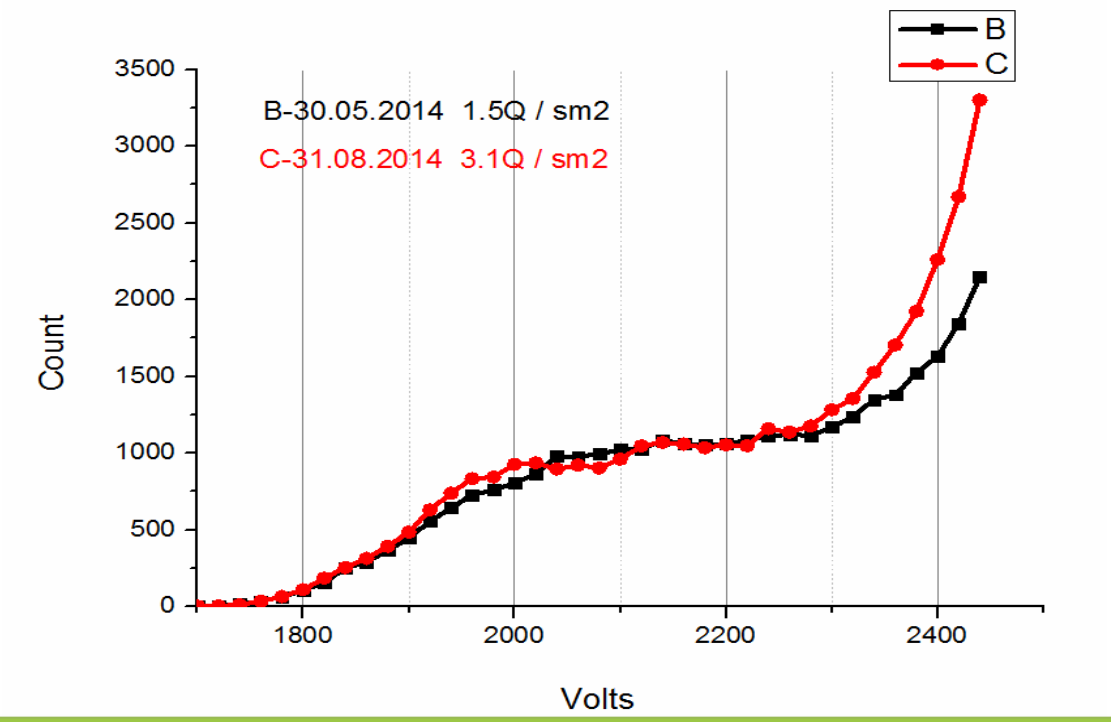
Preamplifier shielding box consists of several Al plates which provide:

- shielding of A-32 cards (from detector and each other),
- shielding of input strip-to-preamp-wires
- preamplifier GND connections

Fully equipped detector plane was tested for a month – no performance changes were observed

MDT counting characteristics after irradiation by 1.5 and 3.1 Coulomb / cm2

NO AGEING !



Collected charge is increased by factor 3 compared to 'threshold value' in 1 C/cm presented for ECE referees last year

High rate performance (wires & strips) studied at Dubna test stand

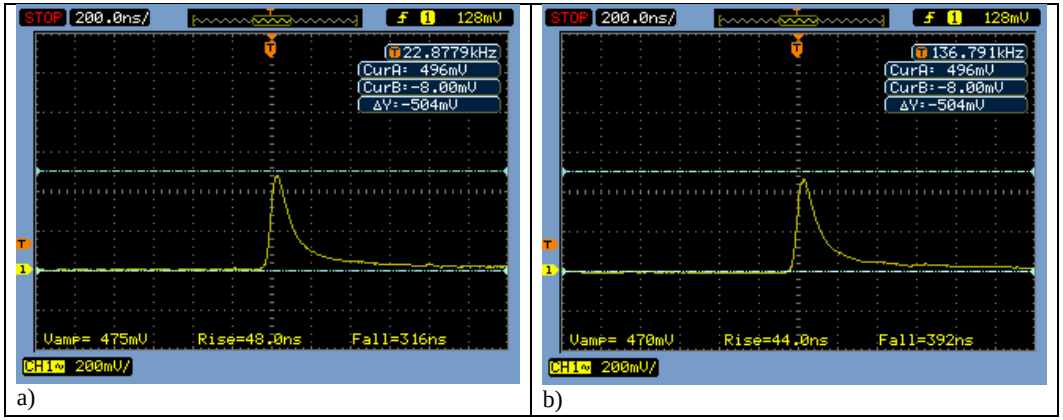


Fig.9 Average strip signals for (a) 70 kHz and (b) 250 kHz strip r/o channel loads

To check the stability of MDT operation at very high irradiation intensities we also made a measurement of counting rate curves for different loads up to 900 kHz. Normalized (to the plateau) counting rate curves are presented in Fig. 10. No counting rate curve plateau (2150 – 2300 V; spread of plateau beginnings is within 20 V) constriction was observed up to the 900 kHz load.

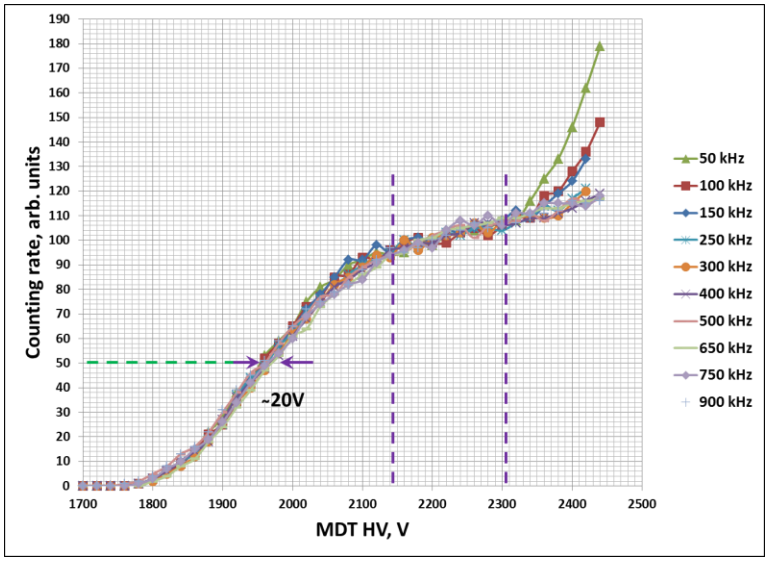
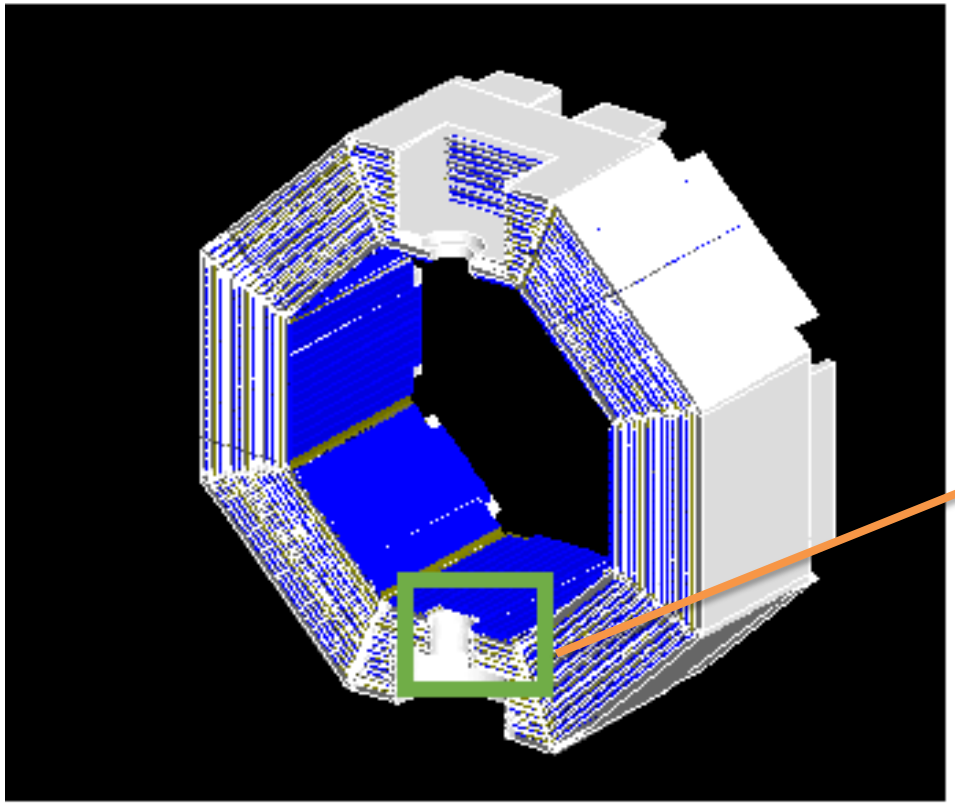


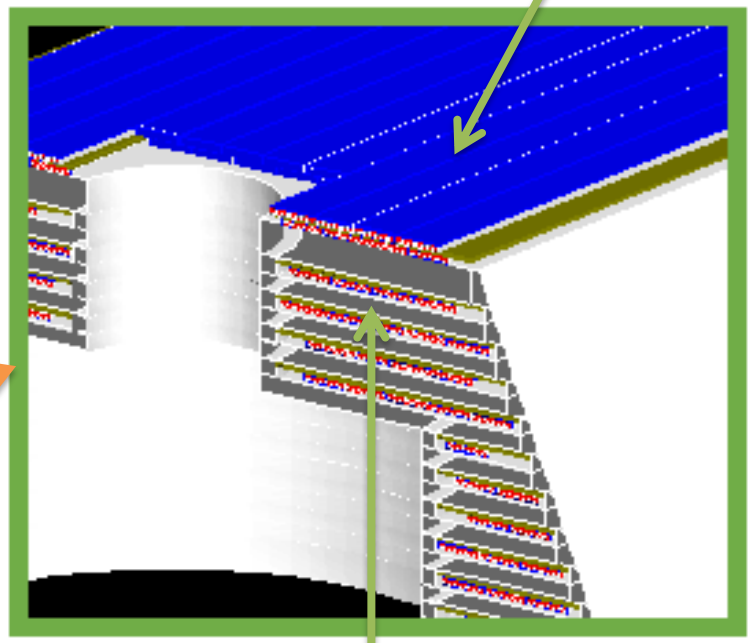
Fig.10 Normalized MDT counting rate curves for different wire channel loads (X-ray intensities)

Thus, the data presented above demonstrate absence of the rate effects dangerous for the MDT operation, both for nominal luminosity and its instant fluctuations.

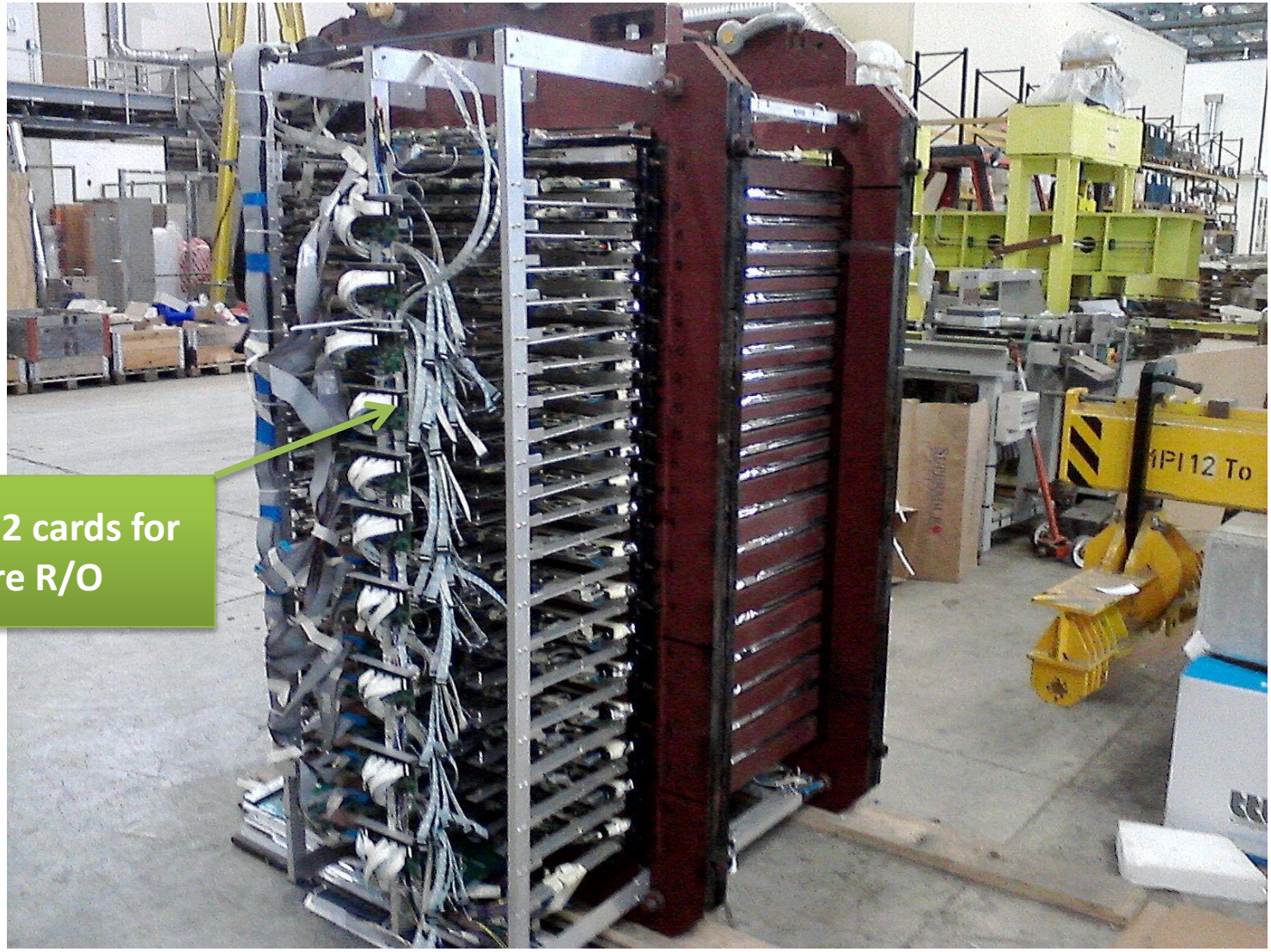
Backup slides

Cross section of Barrel in target region





RSP in vertical position (for cosmic test)



DAQ Status Summary

1). The final version of the stand-alone DAQ is ready

2). Hardware for DAQ was mostly received, last unit is expected in summer 2015

3). The development of the DAQ software/firmware is currently in progress at CERN, ready/tested code is expected in autumn 2015

Table of conditions for written events; T9/PS/CERN run 2012

P[Gev/c]	Trigger	Composition	N of events	file # , Comments
Spectrum	S3*S4	cosmic	635	f39, S3 & S4 on RSP top
Spectrum	S3*S4	cosmic	8375	f41,S3 on top & S4 on bottom
0.5	S1*S2	- (e,μ,π)	6575	f85, strips on
0.5	S1*S2	+ (e,μ,π,p)	27374	f83, strips on
1	S1*S2	+ (e,μ,π,p)	3087	f65
1	S1*S2*vetoC1	+ (μ,π,p)	90 000	f68
2	S1*S2	+ (e,μ,π,p)	3161	f80, strips on
2	S1*S2+Pb	+ (μ,π,p)	1087	f81, 2.5 cm Pb brick in beam, strips on
3	S1*S2	+ (e,μ,π,p)	11766	f77
3	S1*S2*C2	+ (e,μ)	3283	f78
3	S1*S2*C2+Pb	+ (μ)	299	f79, 2.5 cm Pb brick in beam, strips on
5	S1*S2	+ (e,μ,π,p)	9702	f56
5	S1*S2*C1*C2	+ (e)	2181	f57
5	S1*S2*C1*C2	+ (e,μ)	1217	f58
5	S1*S2*C1*C2	+ (e,μ)	200 000	f59
5	S1*S2	+ (e,μ,π,p)	6407	f69, strips on
5	S1*S2*C2	+ (e,μ)	3201	f70, strips on
5	S1*S2*C2	+ (e,μ)	13266	f71, strips on
7	S1*S2	+ (e,μ,π,p)	11940	f75, strips on
7	S1*S2*C2	+ (e,μ)	3492	f76, strips on
10	S1*S2	+ (e,μ,π,p)	9899	f72, strips on
10	S1*S2*C2	+ (e,μ)	1213	f73, strips on
10	S3*S4	+ (e,μ,π,p)	7405	f74, beam + halo, strips on