CRTs installation & performance

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WA105 collaboration meeting
22.3.2017

Reference documents for the CRT design

http://lbnodemo.ethz.ch:2500/3x1x1/35 :

1. feb-v3-0-1.pdf: description of FE electronics and communication
2. sbnd-crt-part1,2: technical design note for SBND CRT (90% compatible)
3. 3D CAD model for 3x1x1

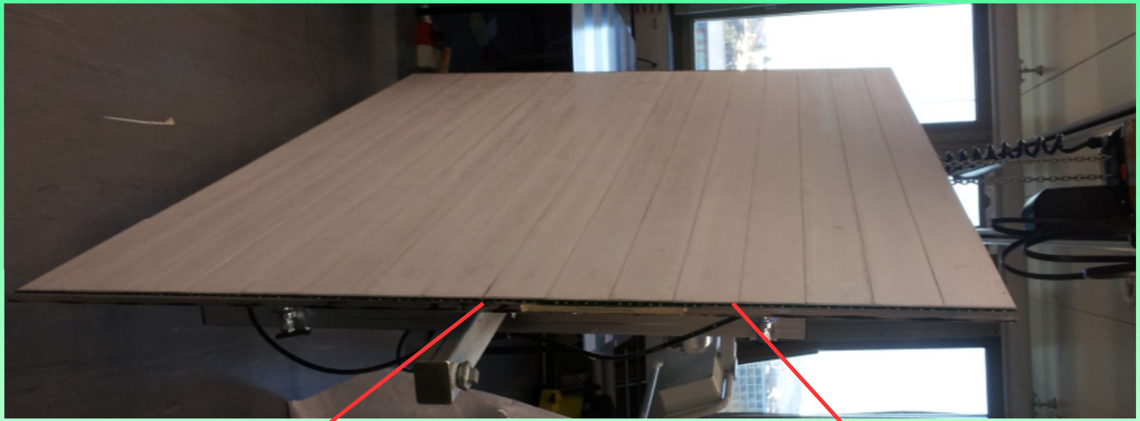
Scintillating module

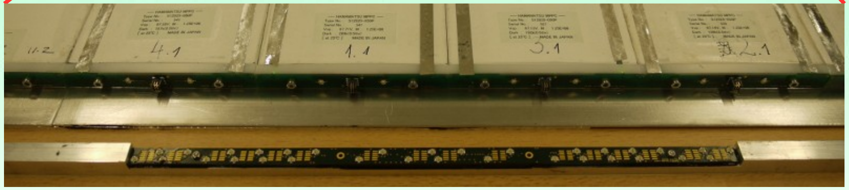
16 strips per module

Strip width: 112 mm
Strip length: 1755mm

Module size:
1.8x1.8m

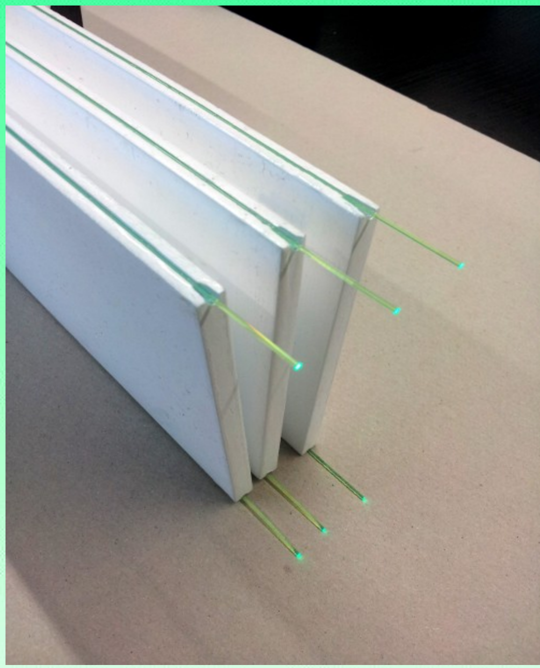
Aluminum case
(2 mm thick)

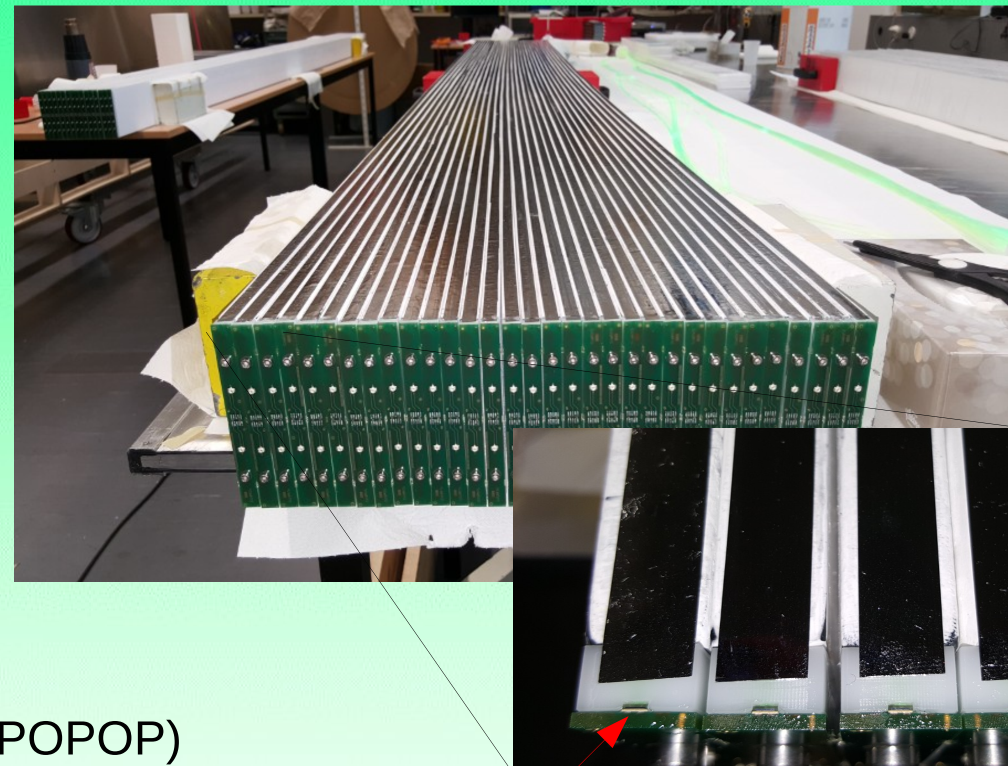




Feed-through PCB

32 coax cables inside

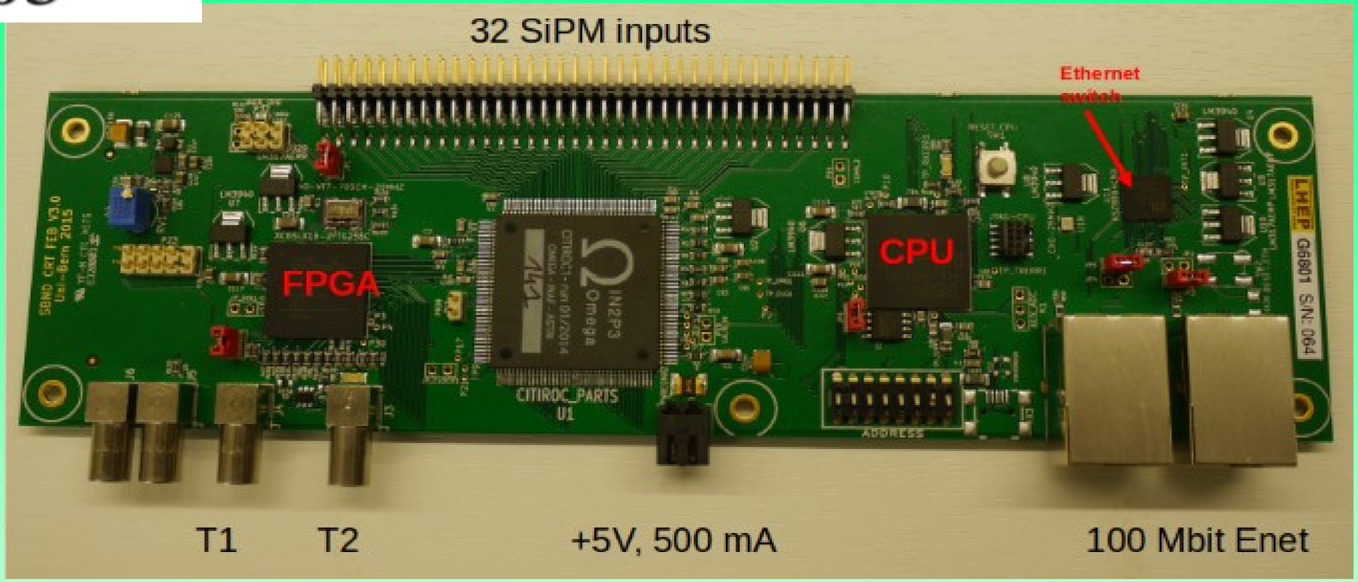




Scintillator: USMS-03 (PS+PTP+POPOP)
Reflective surface (UNIPLAST technology)
WLS fibers: Kuraray Y11(200)MS, 1mm diameter
Optical glue: ESA 7250 polysiloxane compound
SiPM: Hamamatsu S12825-050P

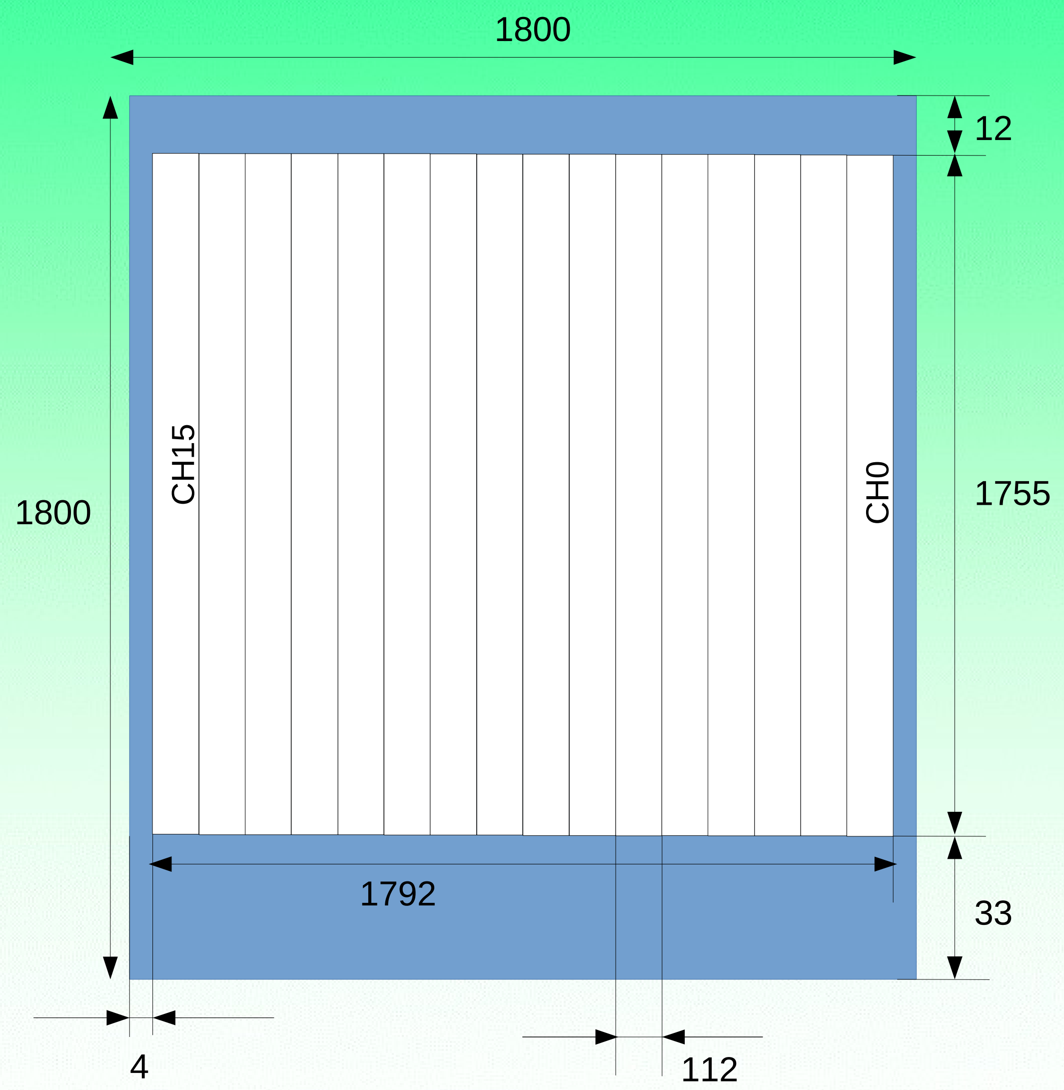
2 SiPMs per strip

Front-End Board Rev3

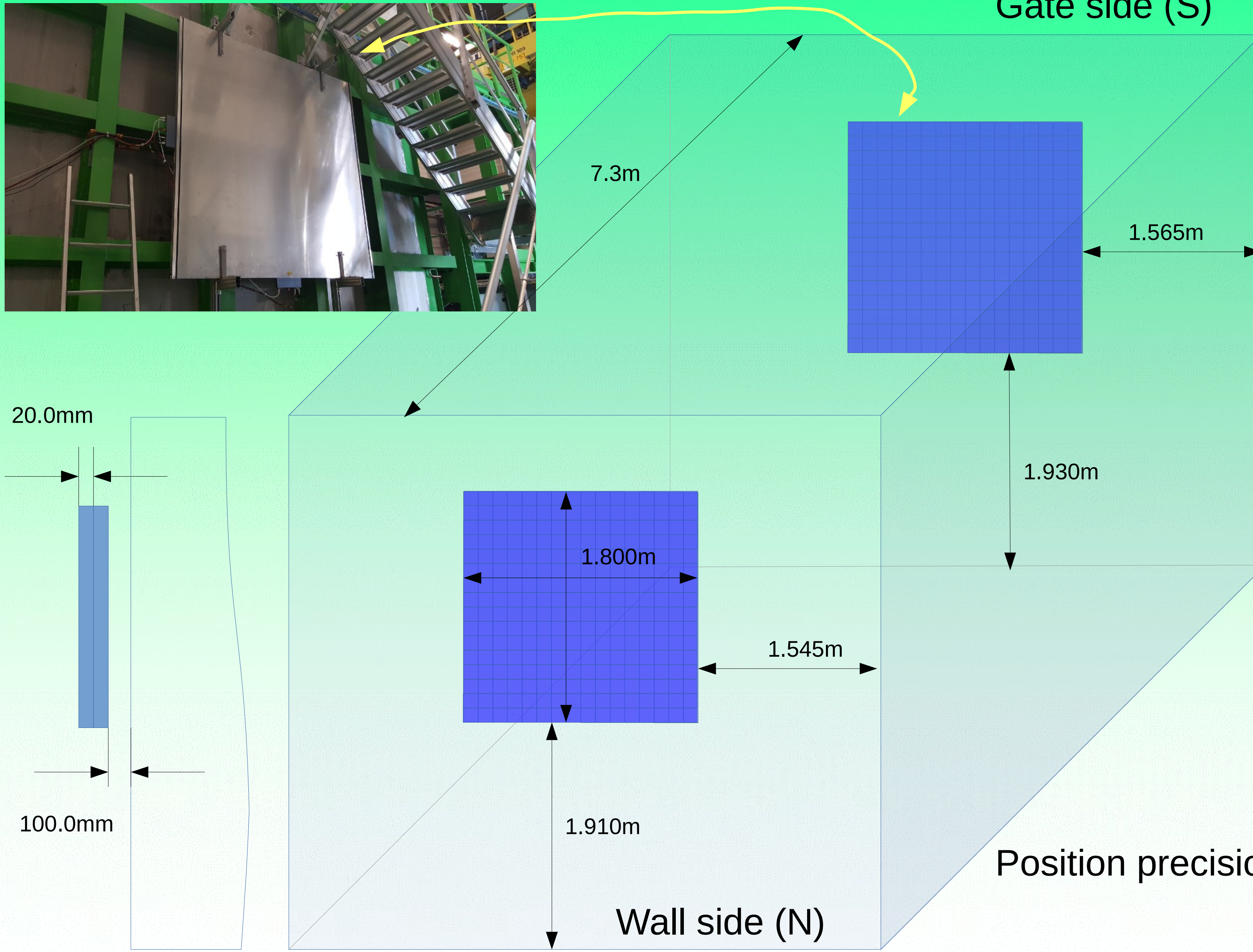


50 used in uBooNE, 140 in SBND, commercialized by CAEN (A1702)

Module internal geometry

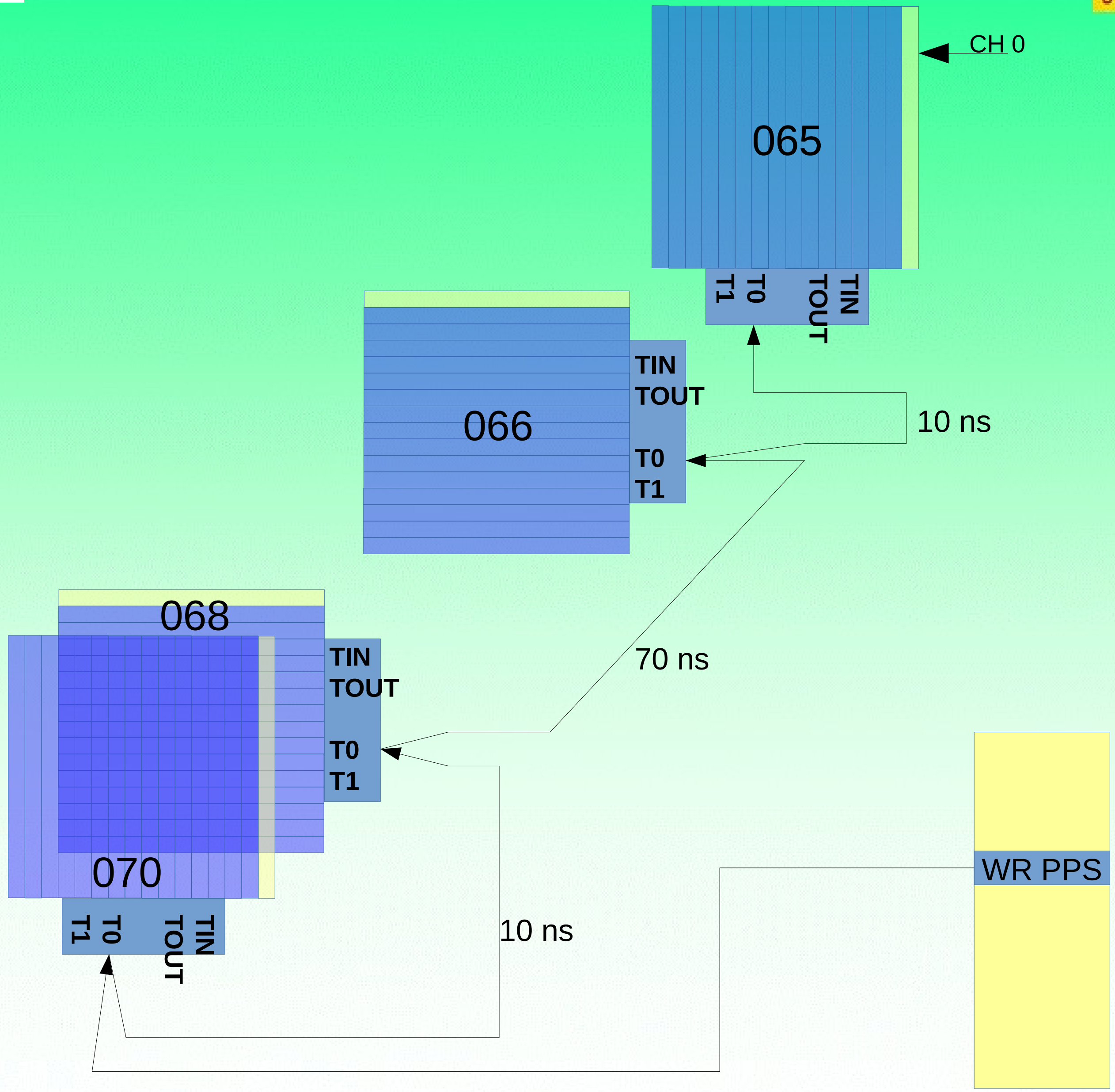


Installation at 3x1x1 cryostat



Position precision ±3 mm

Timing reference signal distribution

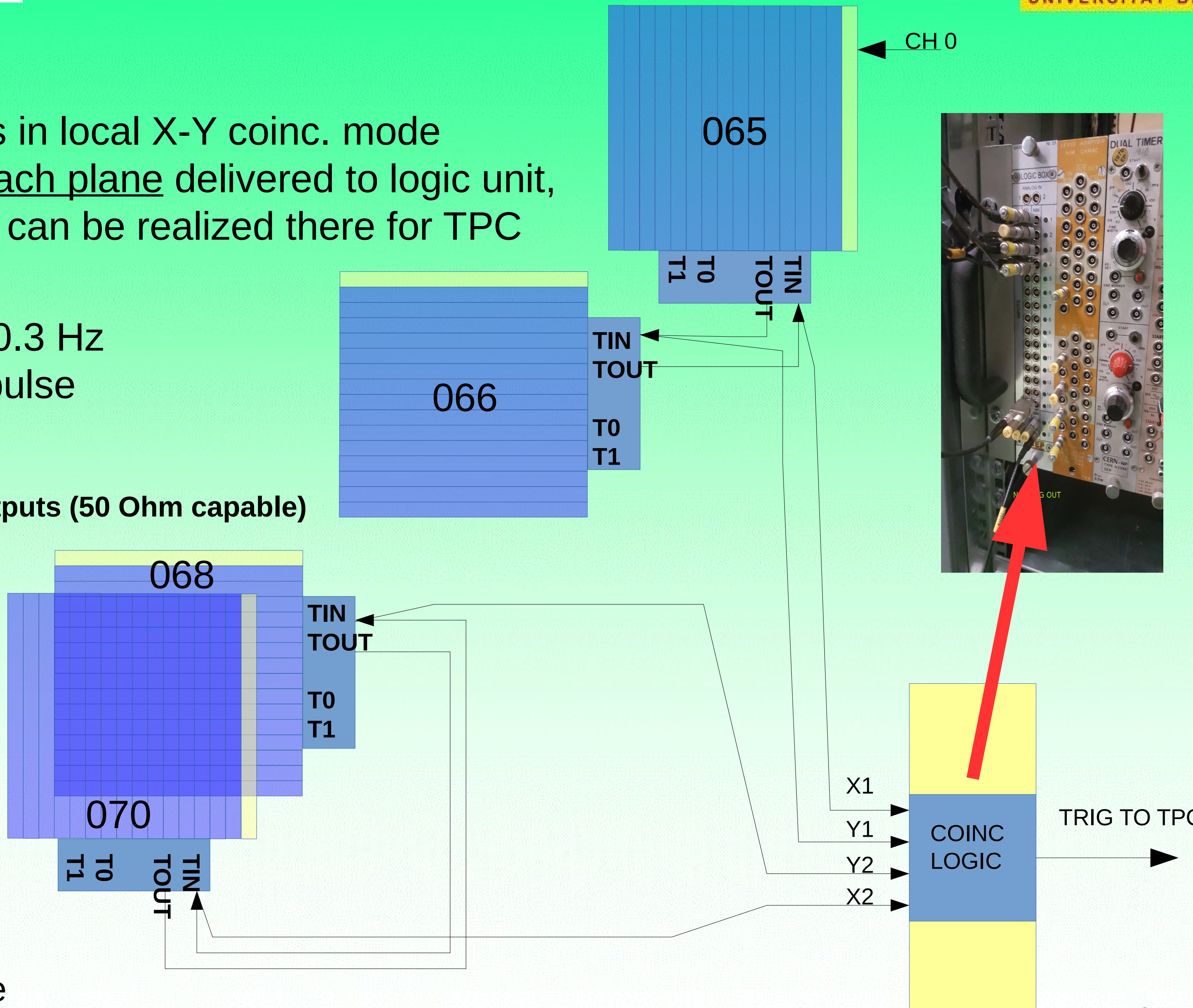


Trigger signal distribution

<u>Each pair</u> works in local X-Y coinc. mode
Triggers from <u>each plane</u> delivered to logic unit,
any coinc. logic can be realized there for TPC

Trigger rate ~ 0.3 Hz
500 ns - long pulse

2 x NIM outputs
2 x 3.3LVCMOS outputs (50 Ohm capable)

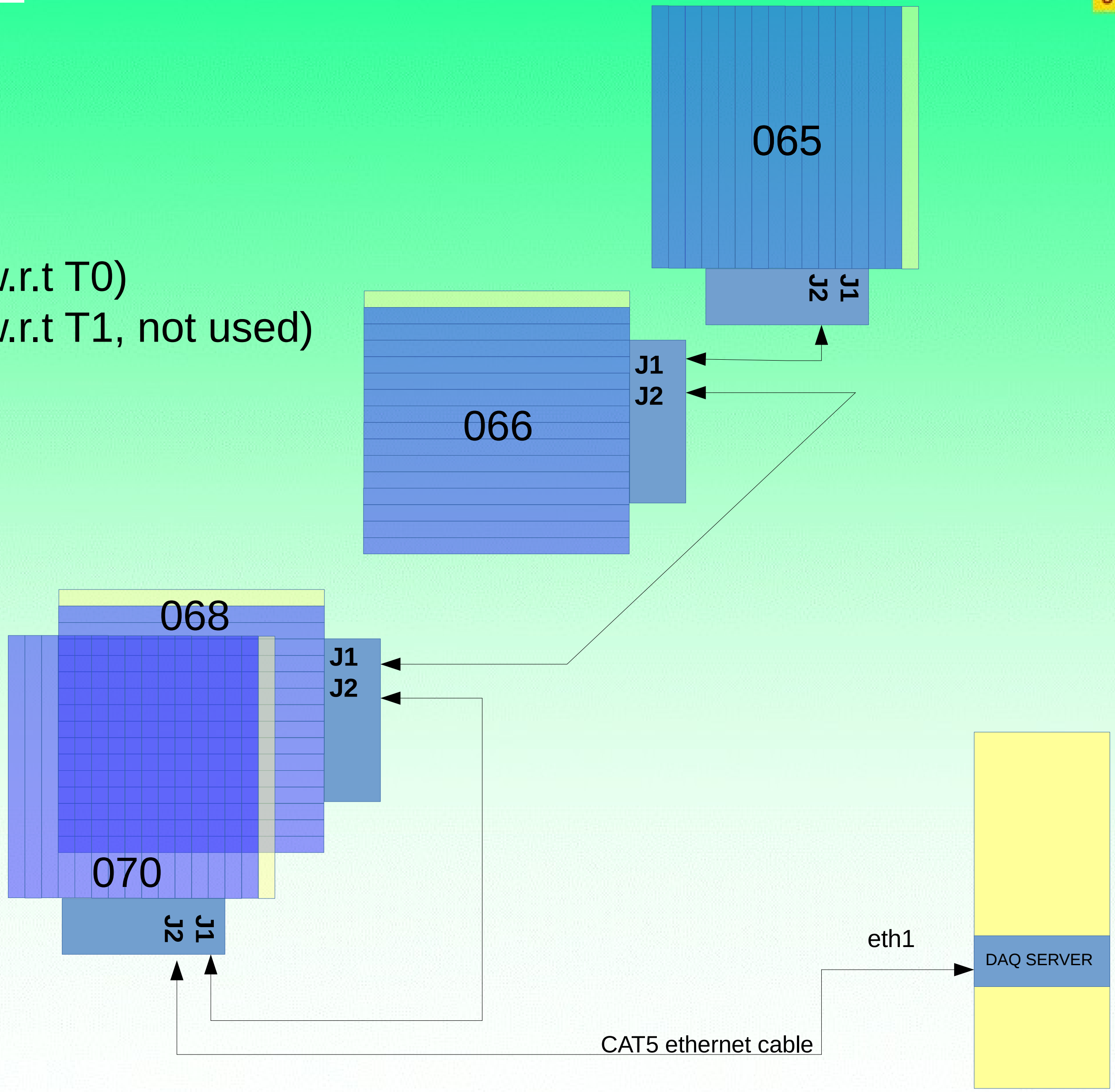


Configurable:
channels can
be active/inactive

Data readout

Event:

flags
ts0, ns (time w.r.t T0)
ts1, ns (time w.r.t T1, not used)
ADC[32]



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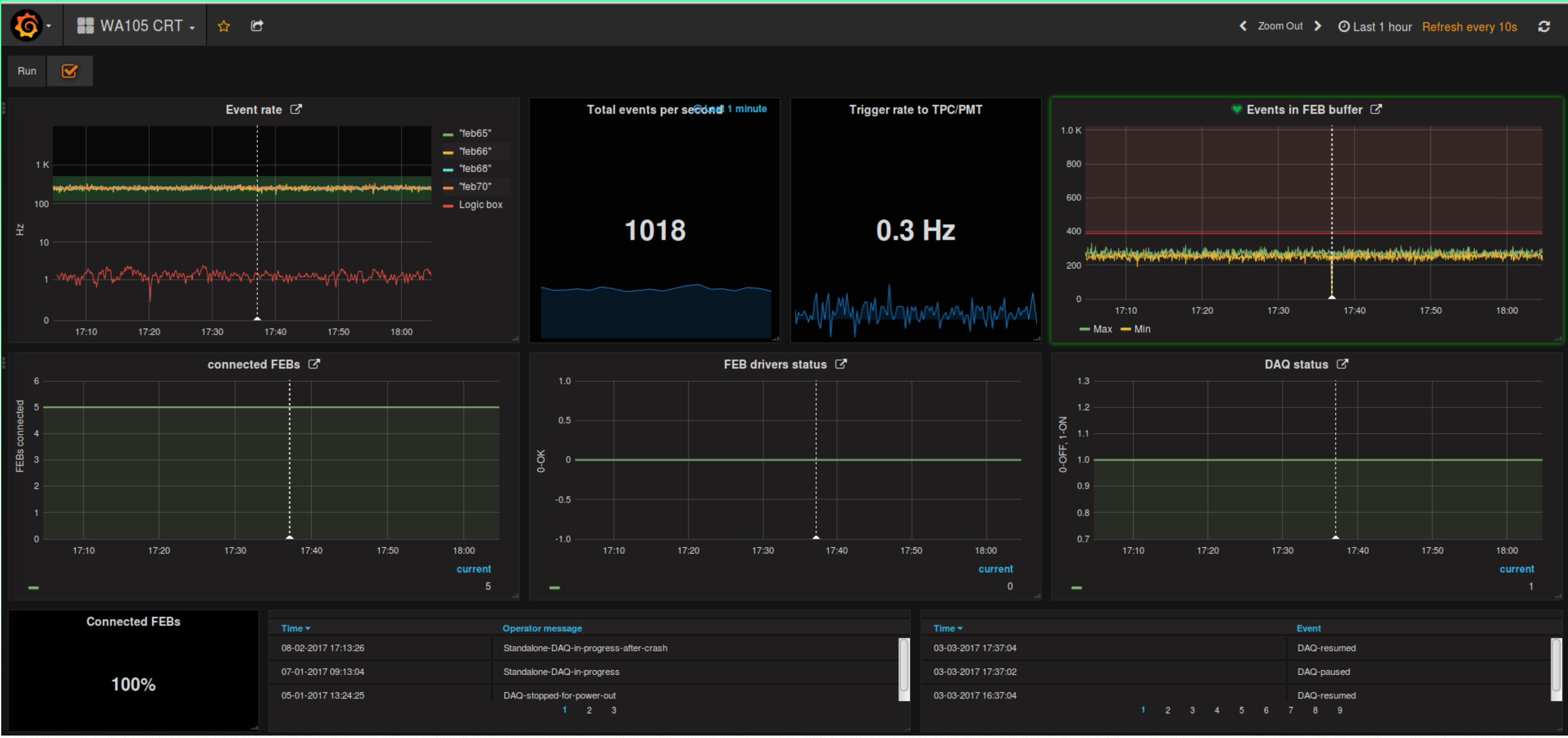
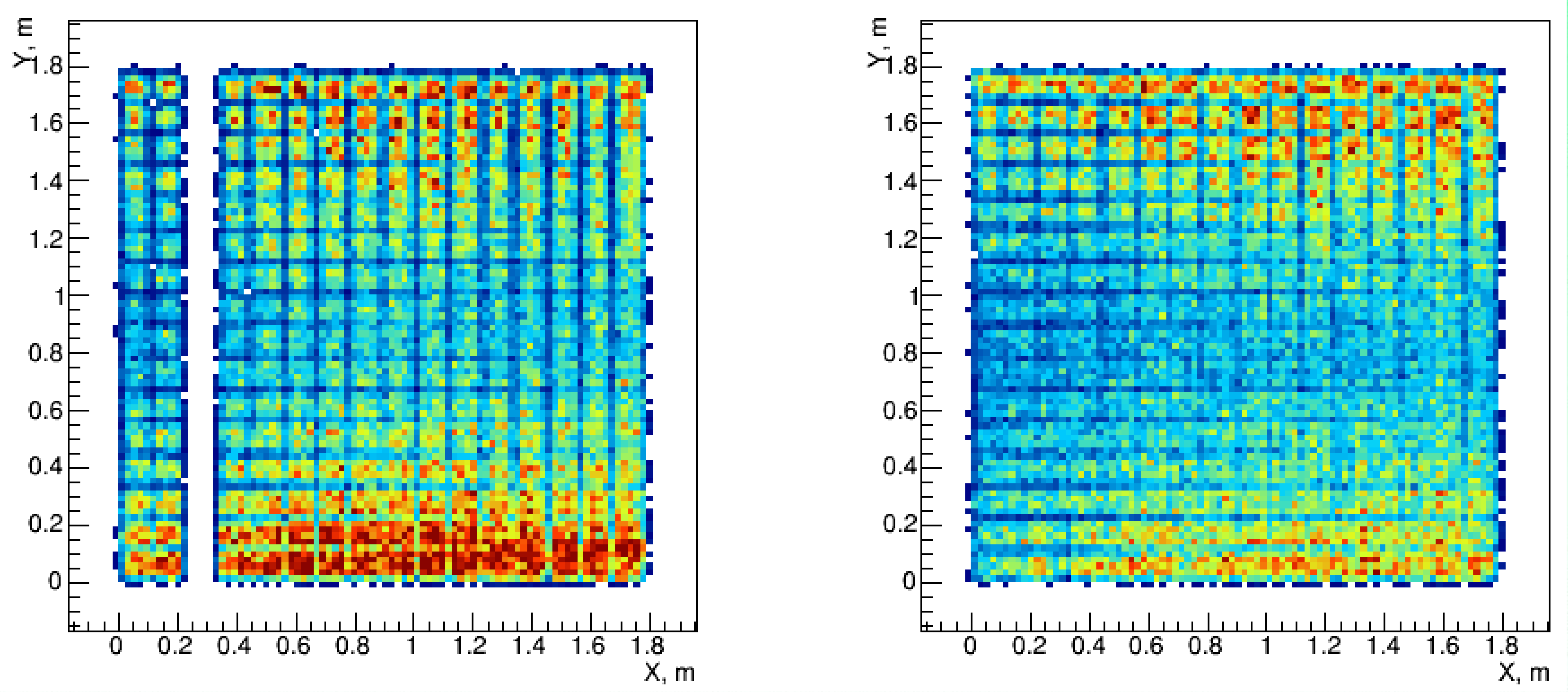
CRT Slow Monitor (based on Grafana)

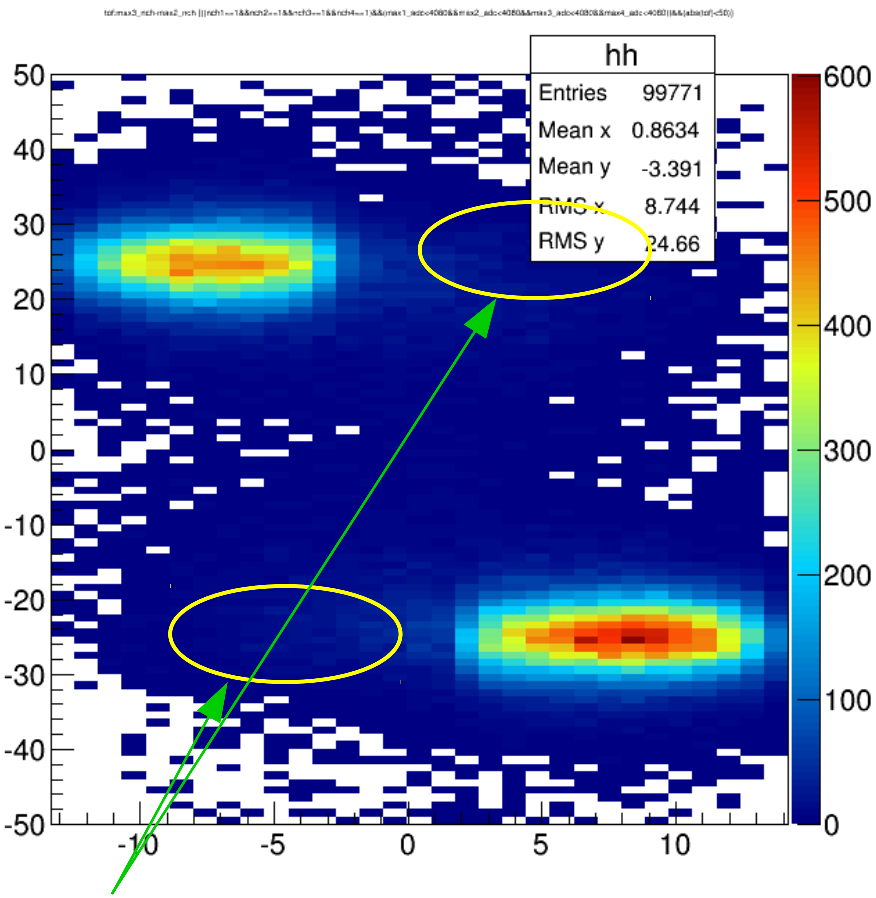


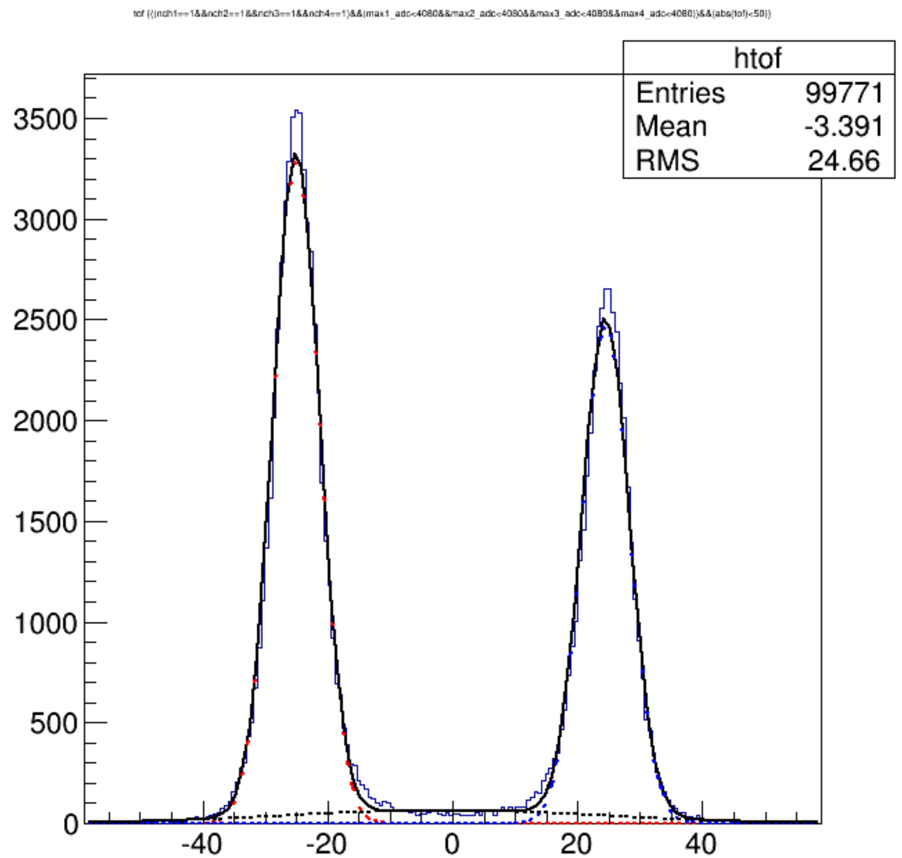
available at http://wa105crt.cern.ch:3000

Hit map in two planes (muons in both directions summed up)



Muon TOF test results (~38 days accumulated)





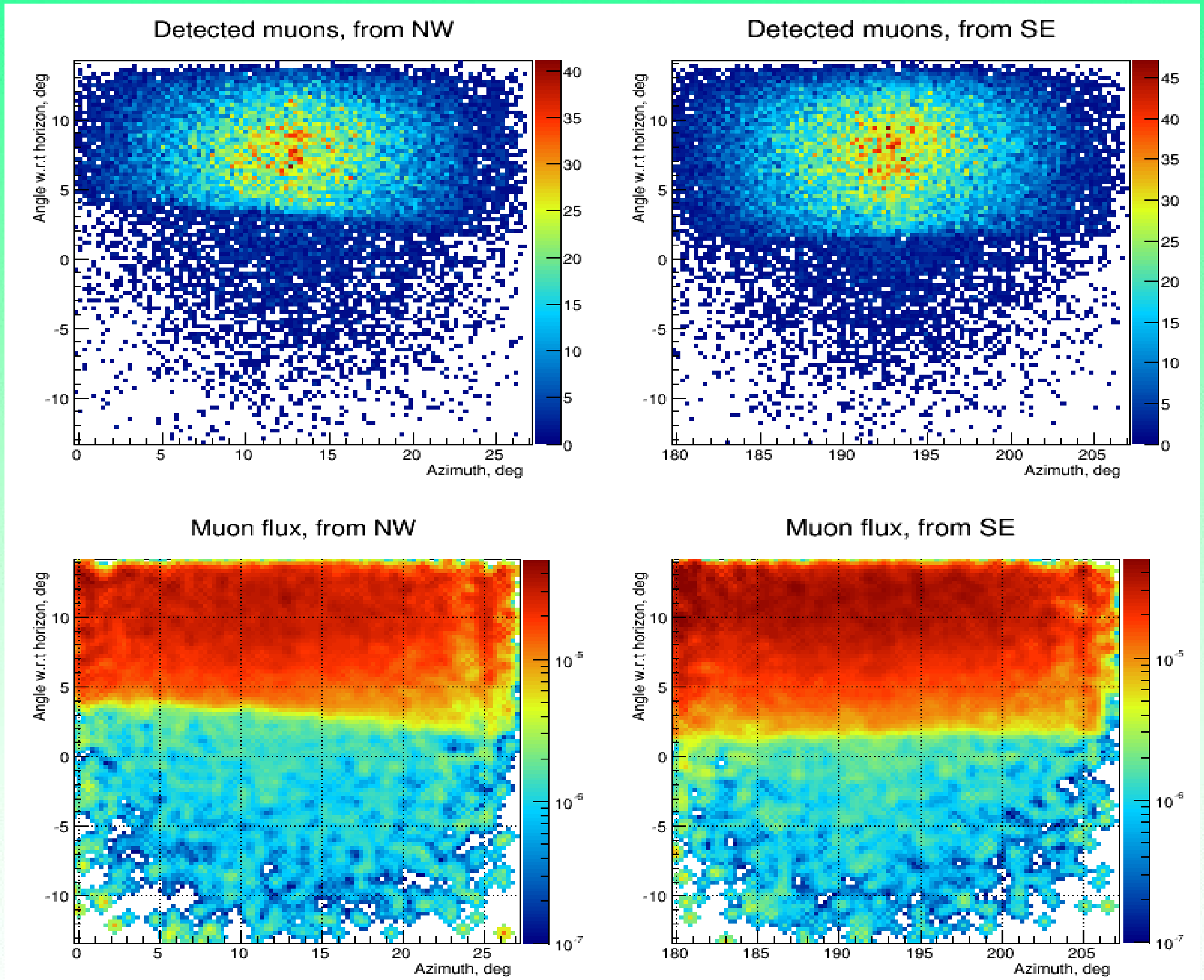
TOF resolution ~3.7 ns

Upward-going muons

Detected “good” muon flux:
N->S direction: ~0.9 muons/min
S->N direction: ~1.0 muons/min

Muon flux angular distribution

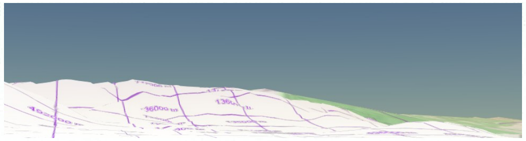
Raw events



Normalized to:

1. acceptance
2. run time

(flux in $s^{-1}sr^{-1}cm^{-2}$)



CRT trigger for TPC/PMT

1. Hardware trigger (NIM/LVTTL pulse, 500 ns)

2. Event data available at Zero-MQ socket at TCP port 5600
   request- response logic

3. Event matching by sequence + crosscheck by event time stamp

Conclusions

1. Cosmic Ray Tagger for 3x3x1 is installed and operative
2. Configurable geometry - possible to select narrow solid angles
3. Trigger provided to the experiment
4. DAQ is deployed, Slow Monitor is operative
5. Extensive data on the triggered event is stored: time, coordinates, pulse hights
6. Interesting data being collected
7. Ready for “wet&cold” commissioning

Backup slides

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Upward going muons at surface
(literature refs)

- Lack of information or not very reliable measurements
- PDG review on cosmic rays says almost nothing about flux near horizon
- “Effects of upward-going cosmic muons on density radiography of volcanoes”
  K. Jourde et al., arXiv:1307.6758v1

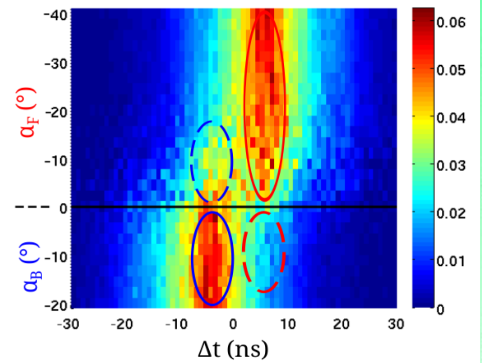
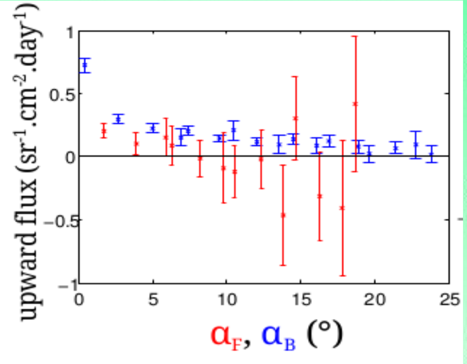


Figure 4. TOF distribution for the SMTOMO data set shown as normalized histograms as a function of zenith angle. The horizon is represented by the dashed line. The blue and red solid ellipses respectively show the backward ($\alpha_B < 0$ and $\Delta t < 0$) and forward ($\alpha_F < 0$ and $\Delta t > 0$) events corresponding to the downward fluxes. The dashed ellipses show events corresponding to upward-going muons from forward (red ellipse, $\alpha_B < 0$ and $\Delta t > 0$) and backward (blue ellipse, $\alpha_F < 0$ and $\Delta t < 0$).



Question remains:
Low or high energy?
(Scattered or through-going?)

- Monte Carlo simulation for background study of geophysical inspection with cosmic-ray muons, R. Nishiyama et al., Geophys. J. Int. (2016) 206, 1039–1050

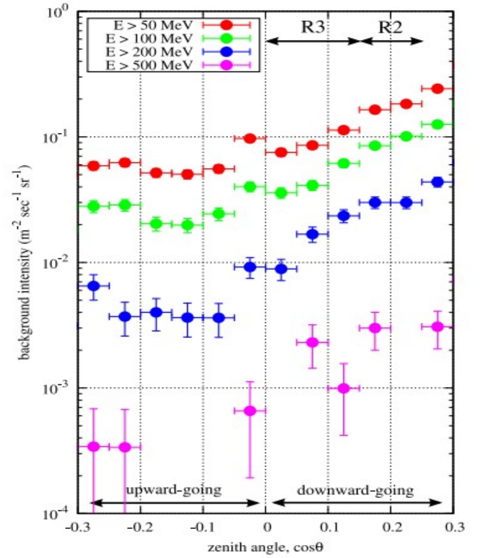
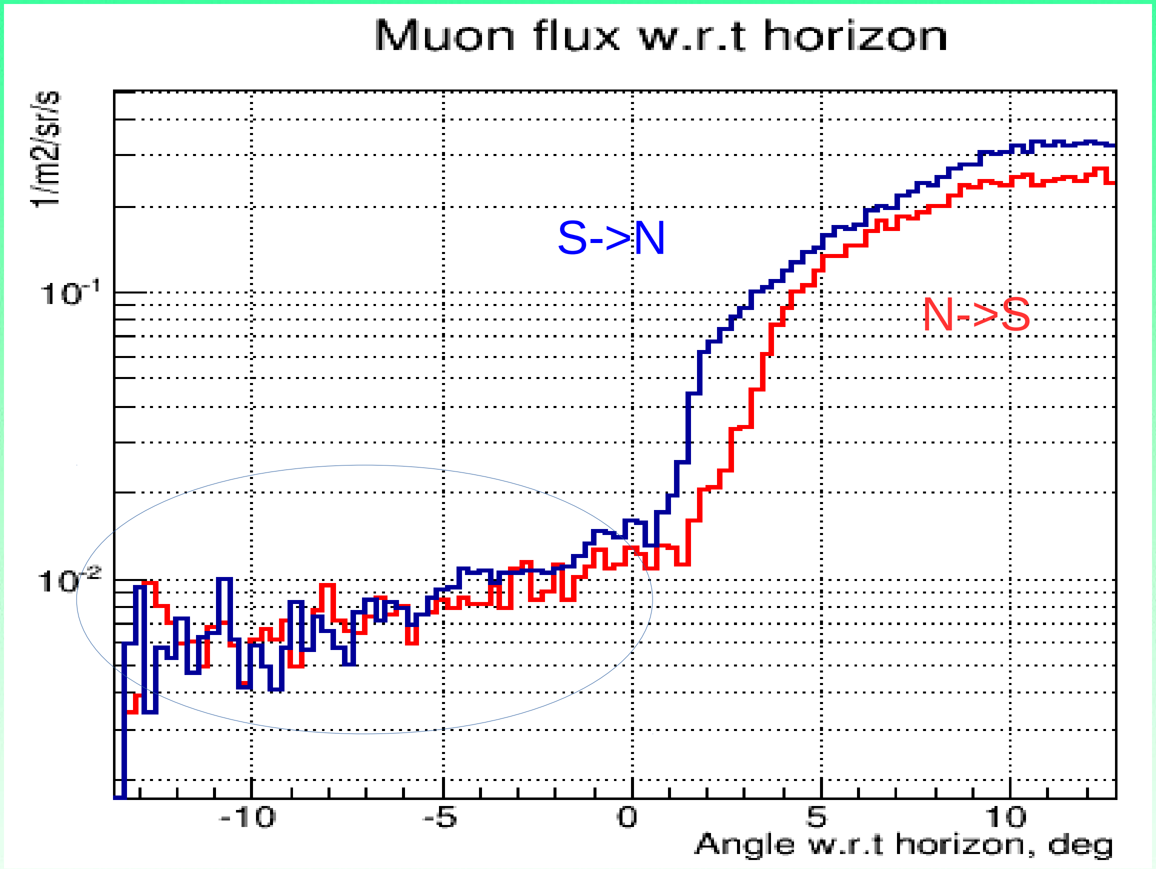


Figure 6. Zenith angle dependence of the calculated flux of the background particles for kinetic energy above 50, 100, 200 and 500 MeV (protons, electrons and muons are added). $\cos\theta < 0(>0)$ indicates downward (upward) going particle.

Upward going muons at 3x1x1



Proposal:

measure energy spectrum of particles near (below) horizon with the TPC data.
(if fast- delta ray count, delta ray spectrum, shower reco; if slow - MCS, dE/dx)
Clarify “through-going vs scattered” dilemma.