TRT Introduction

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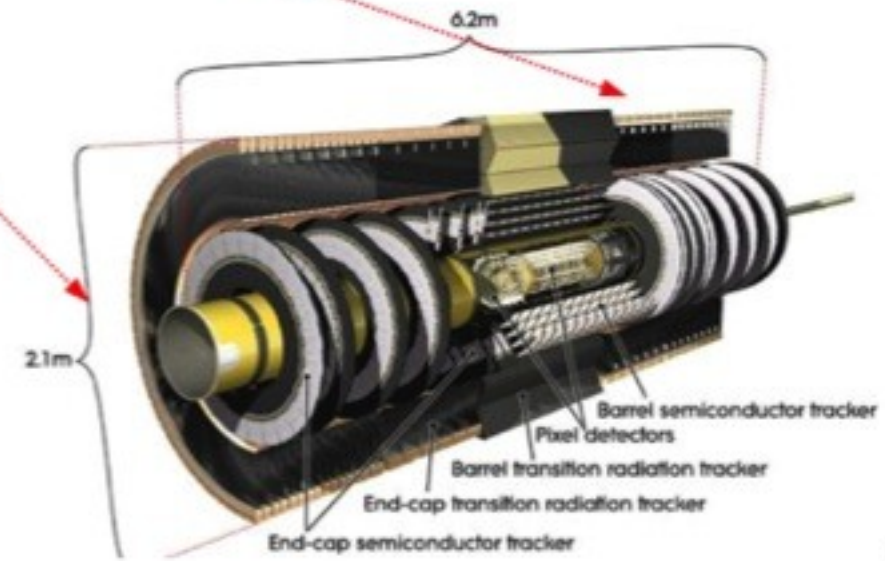
The Inner Detector consists of:

- Pixel detector
- Semiconductor Tracker (SCT)
- **Transition Radiation Tracker (TRT)**
  - All in a 2T solenoidal field

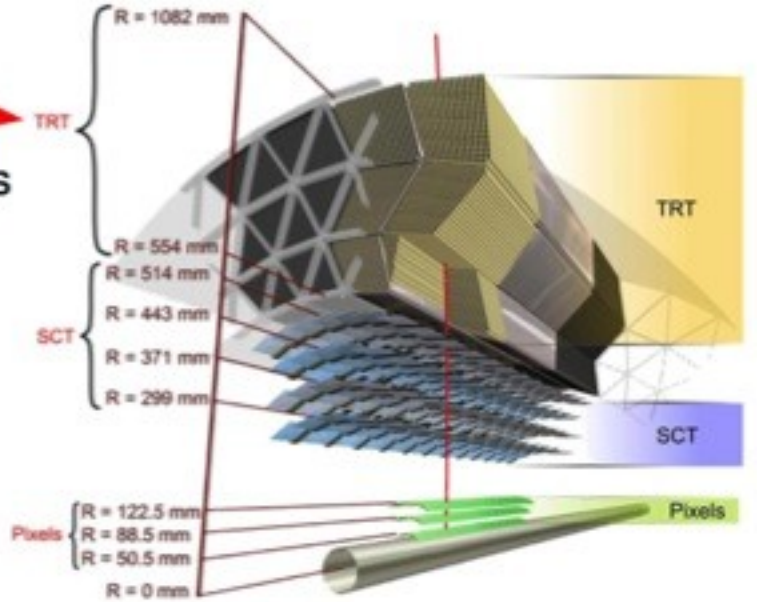
Performance goals:

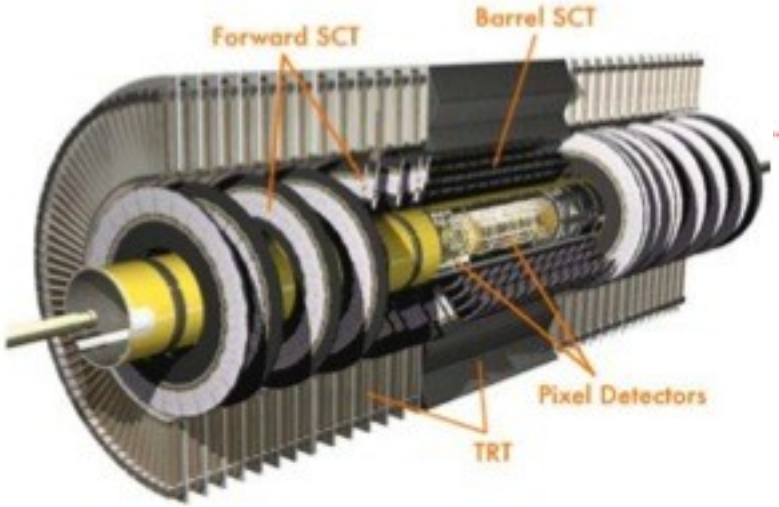
- Tracking for charged particles:
  - $p_T > 0.5$ and $|\eta| < 2.5$
  - $\sigma(p_T)/p_T = 0.05\% p_T \oplus 1\%$
- Electron ID (**TRT**):
  - $0.5 < p_T < 150$ GeV and $|\eta| < 2.0$



TRT Barrel:

- 3 layers * 32 ϕ modules
- 1.44m long straws, parallel to beam axis
- Wires electrically split in middle
  - ~1.5cm dead region
  - Read out on both sides
- 105,088 readout channels



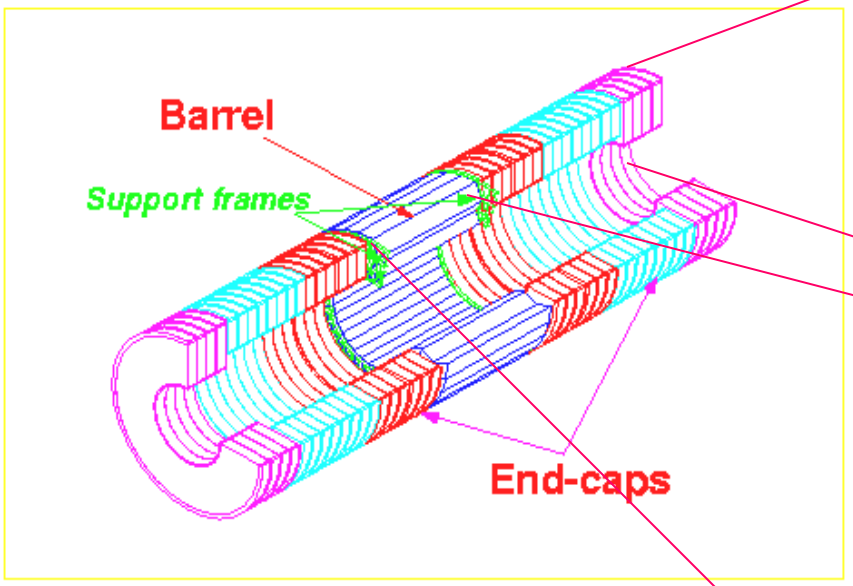


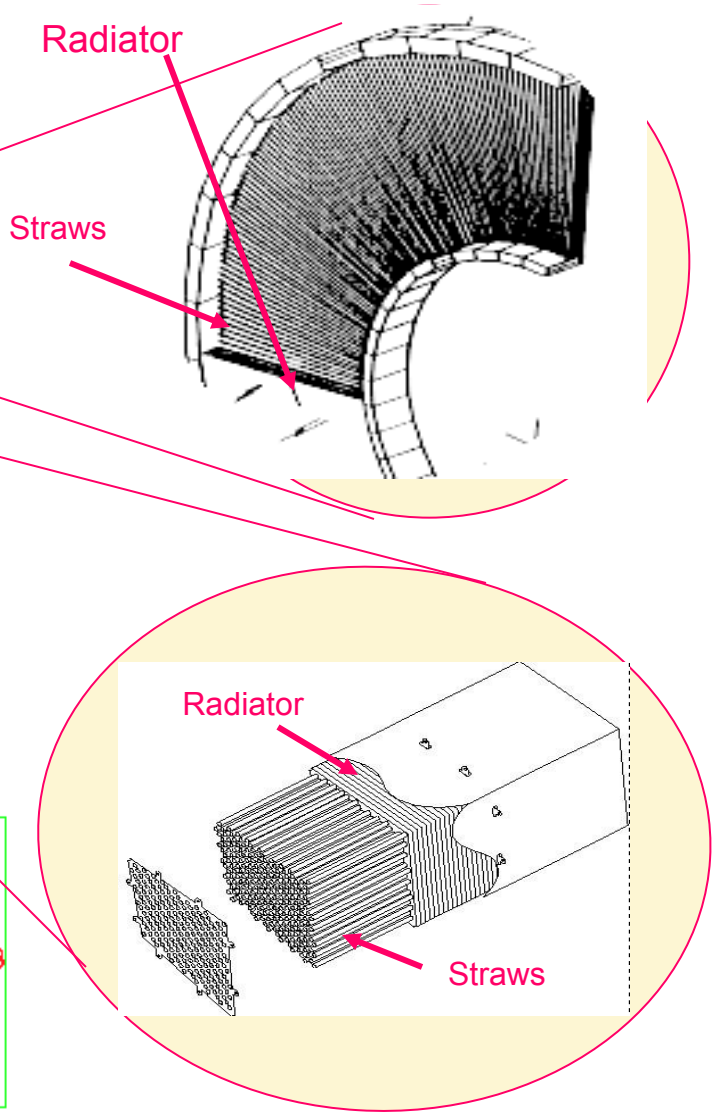
2 TRT Endcaps, each with:

- 20 wheels with 8 straw layers each
- 39cm long radial straws
- 120,880 readout channels

Introduction: TRT concept

TRT global parameters



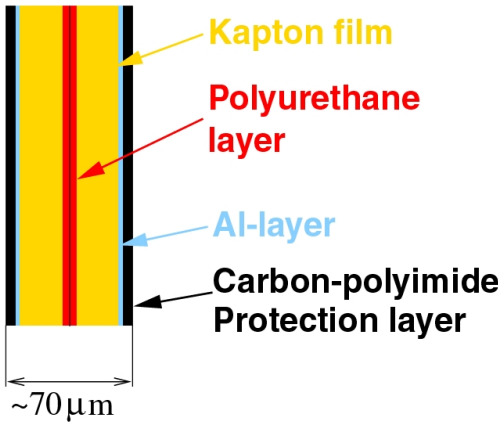


Length:	Total	6802 cm	N straws:	Total	372032
	Barrel	148 cm		Barrel	52544
	End-cap	257 cm		End-cap	319488
Outer diameter		206 cm	N electronics channels		424576
Inner diameter		96-128 cm	Weight		~ 1500 kg

Straw - the main detector element

Straw design

Straw wall

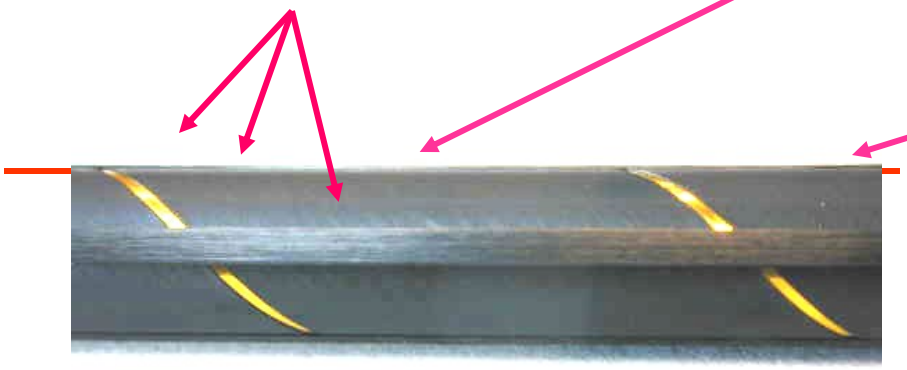


Straw cathode – 4mm

TR optimization:
the larger diameter the better
Wire offset ~300 μm:
the larger diameter the better
Self limited streamer length ~1 mm
the larger diameter the better
Max electron drift-time
the smaller diameter the better

Reinforced straw

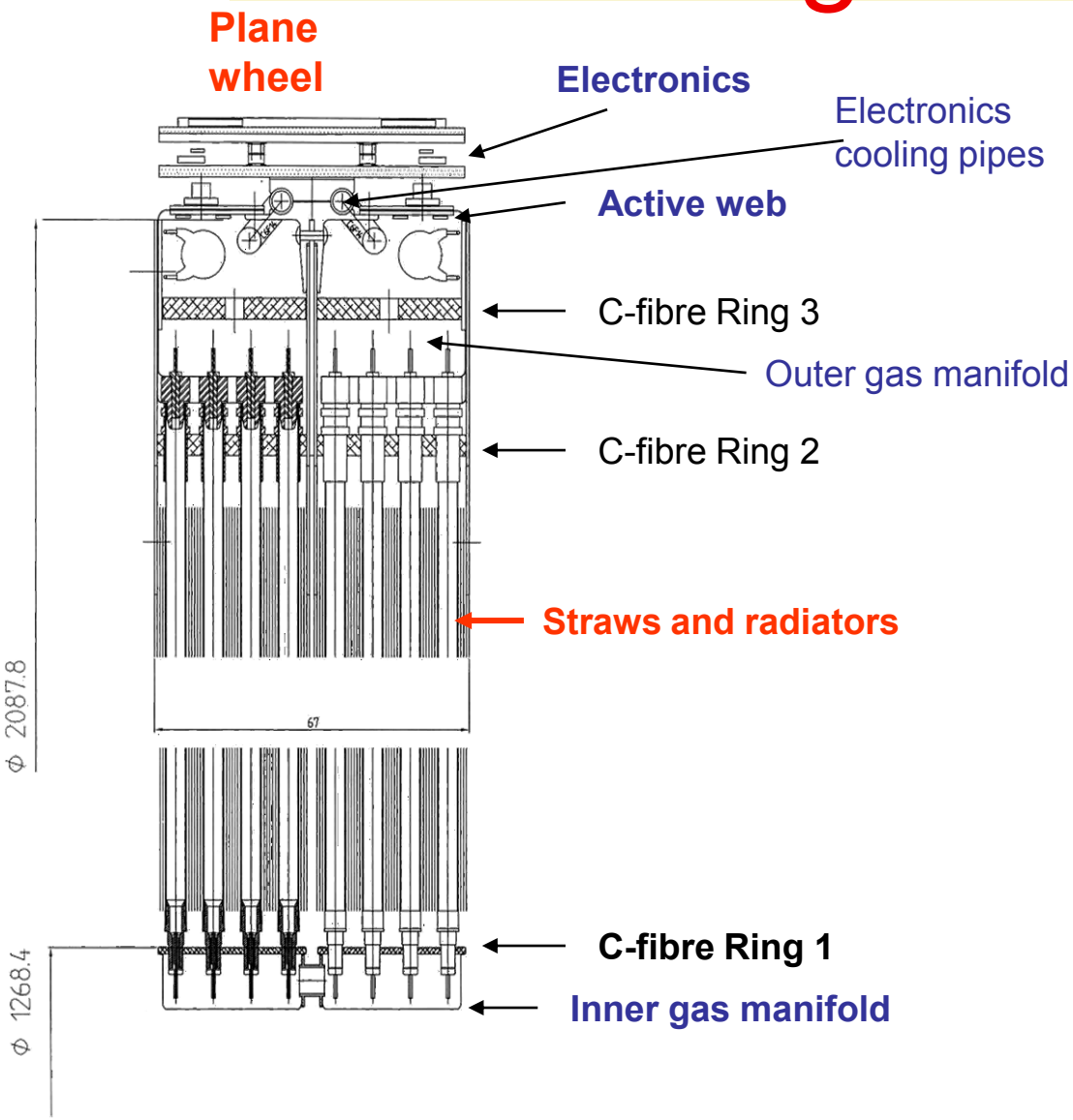
In order to make straw rigid 4 C-fibres are attached along the straw

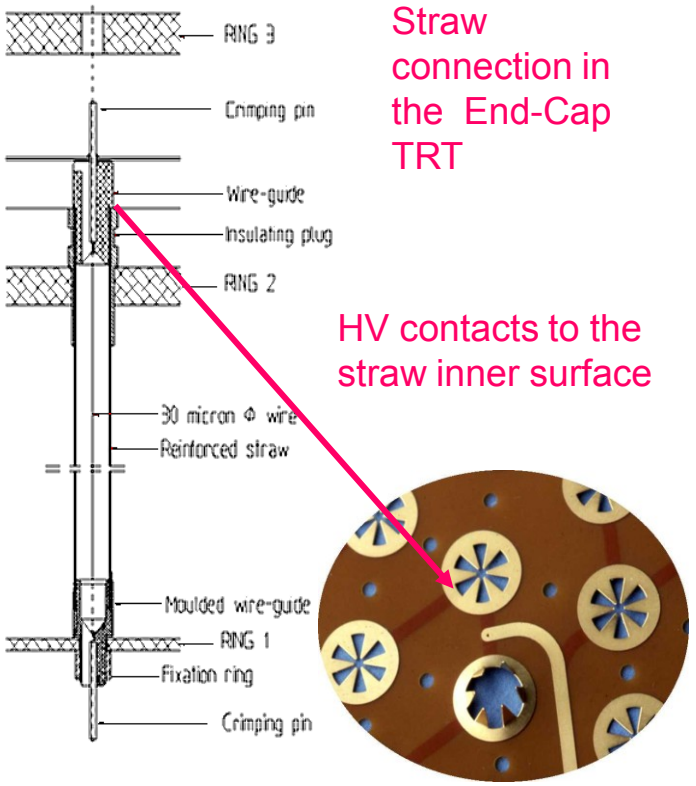


Wire diameter – 30 μm

Max electron drift-time
the larger diameter the better
Operation stability
the smaller diameter the better

TRT design: End-Cap





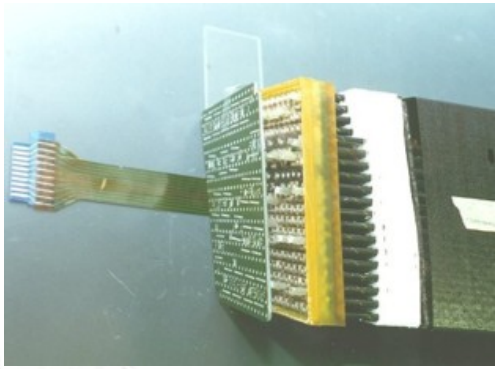
Straw connection in the End-Cap TRT

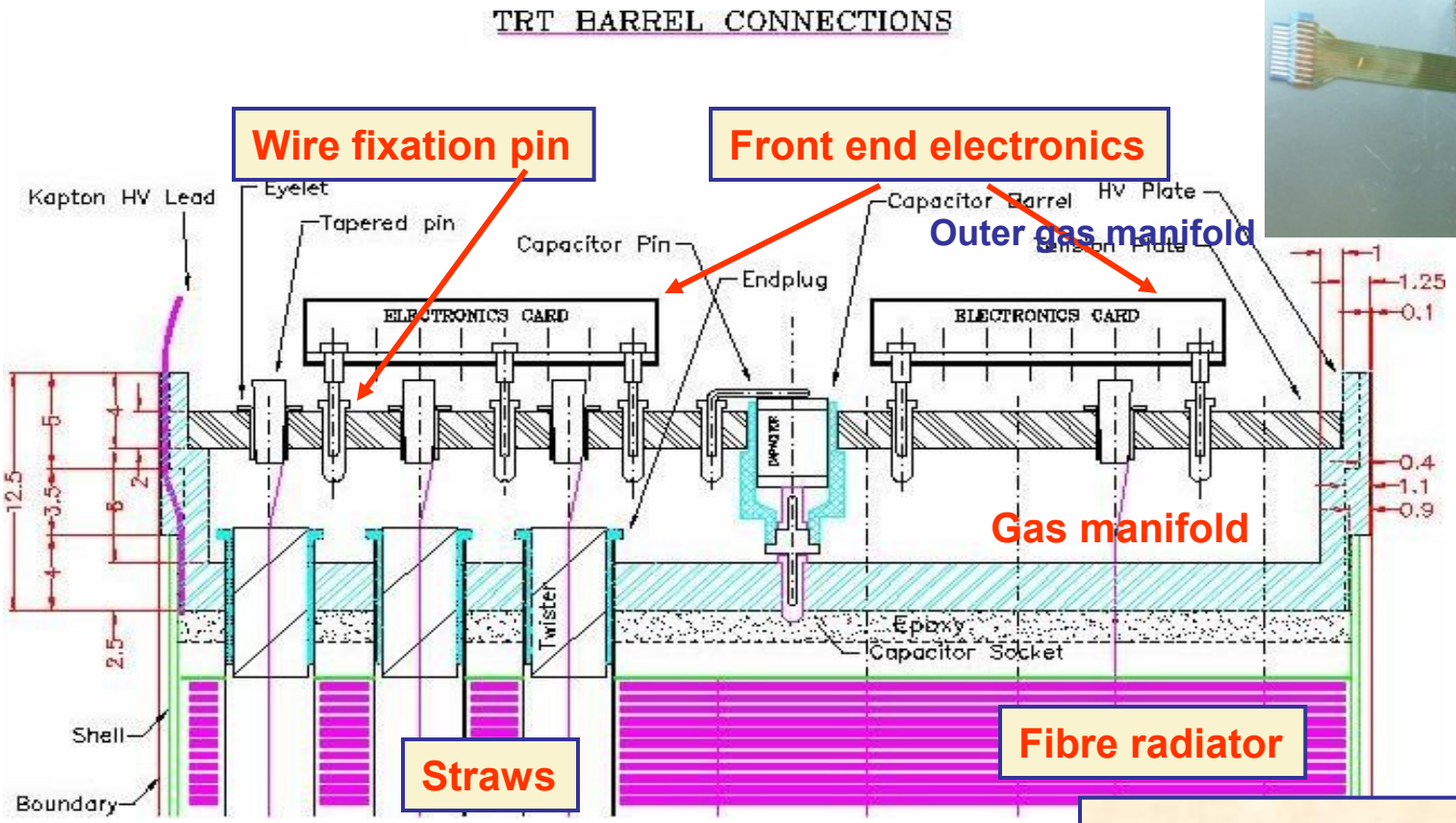
HV contacts to the straw inner surface

One 8-plane wheel:
2 x 4 x 768 = 6144 straws

End-Cap:
40 x 8-plane wheels

TRT design: Barrel

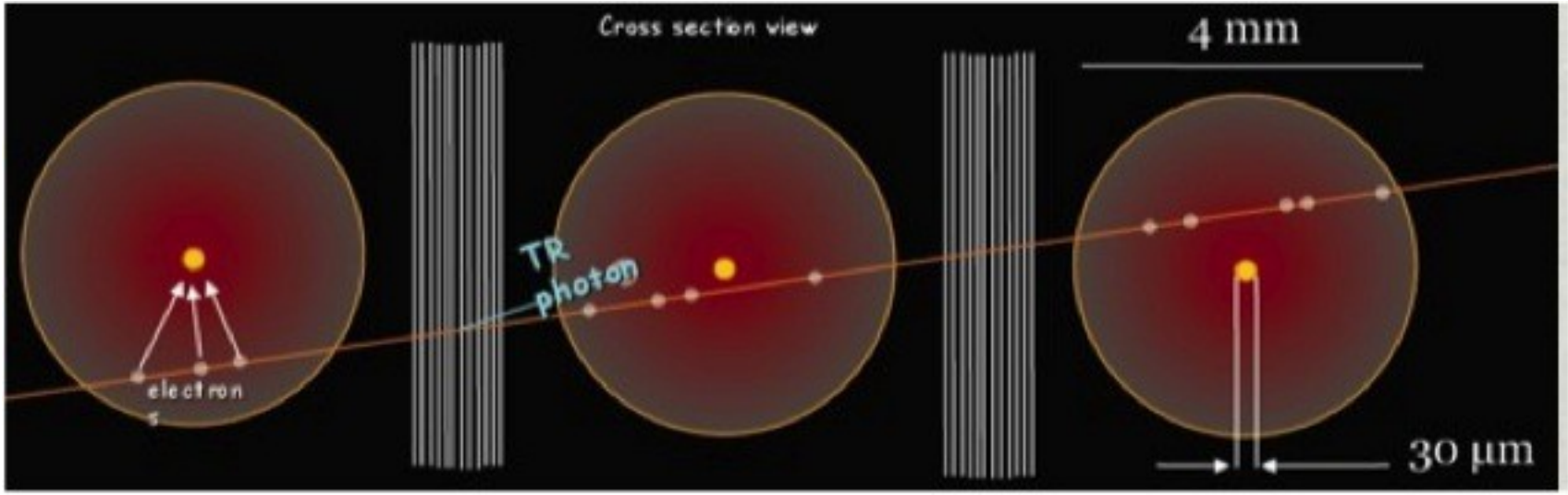




52544 straws

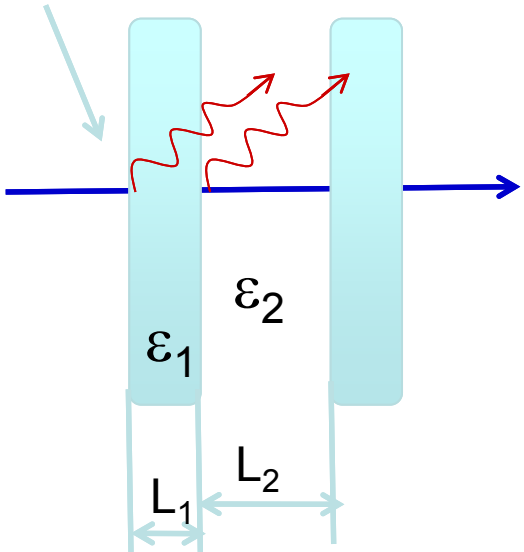
Wire split in two parts at the middle

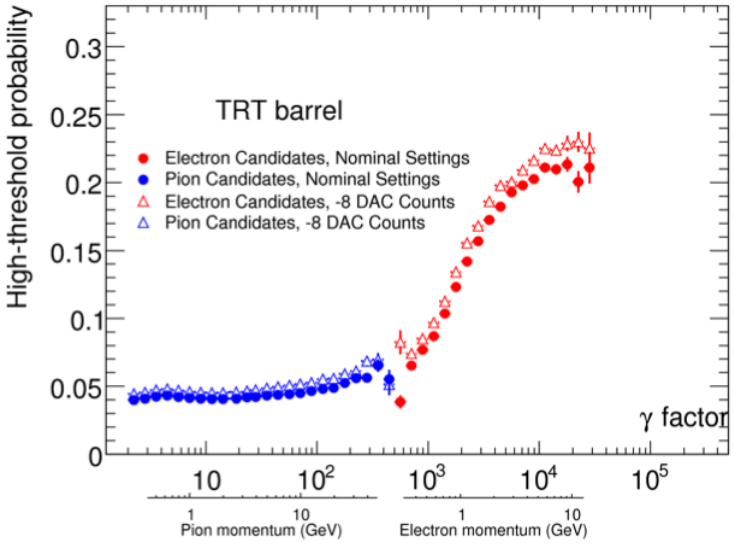
Transition radiation detectors: principle



Radiator.

Photon irradiation probability ~ 1/a (1/137)

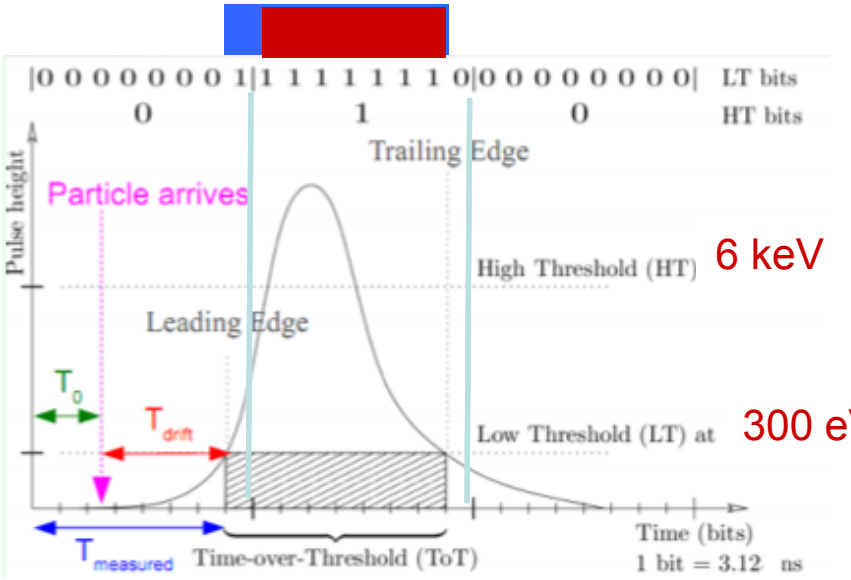


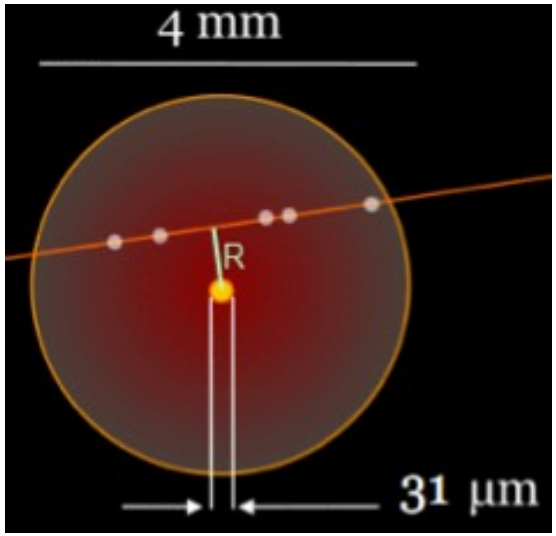


Requirements:

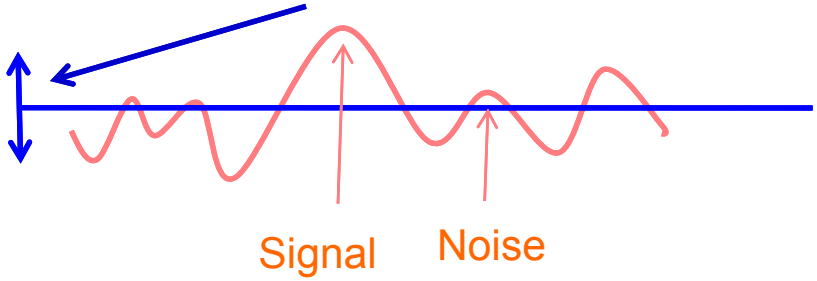
- Maximum $\varepsilon_1/\varepsilon_2$
- Minimum Z
- L_1 & L_2 compatible with the formation zones in corresponding media

Choice of the thresholds

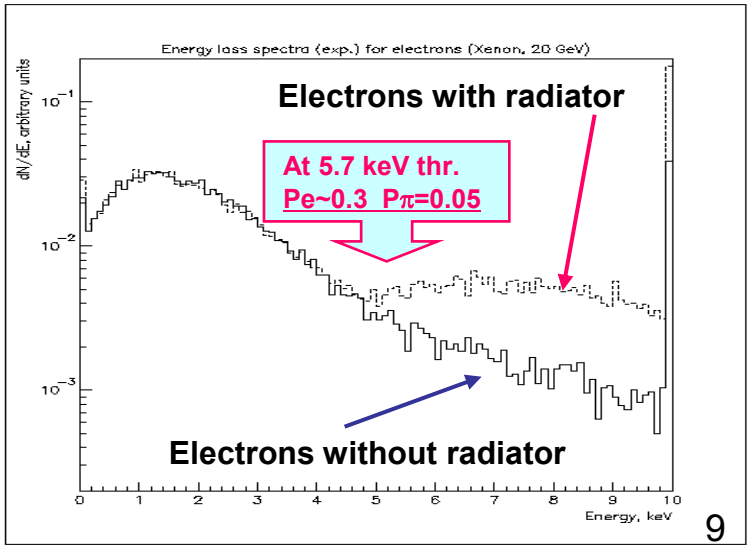




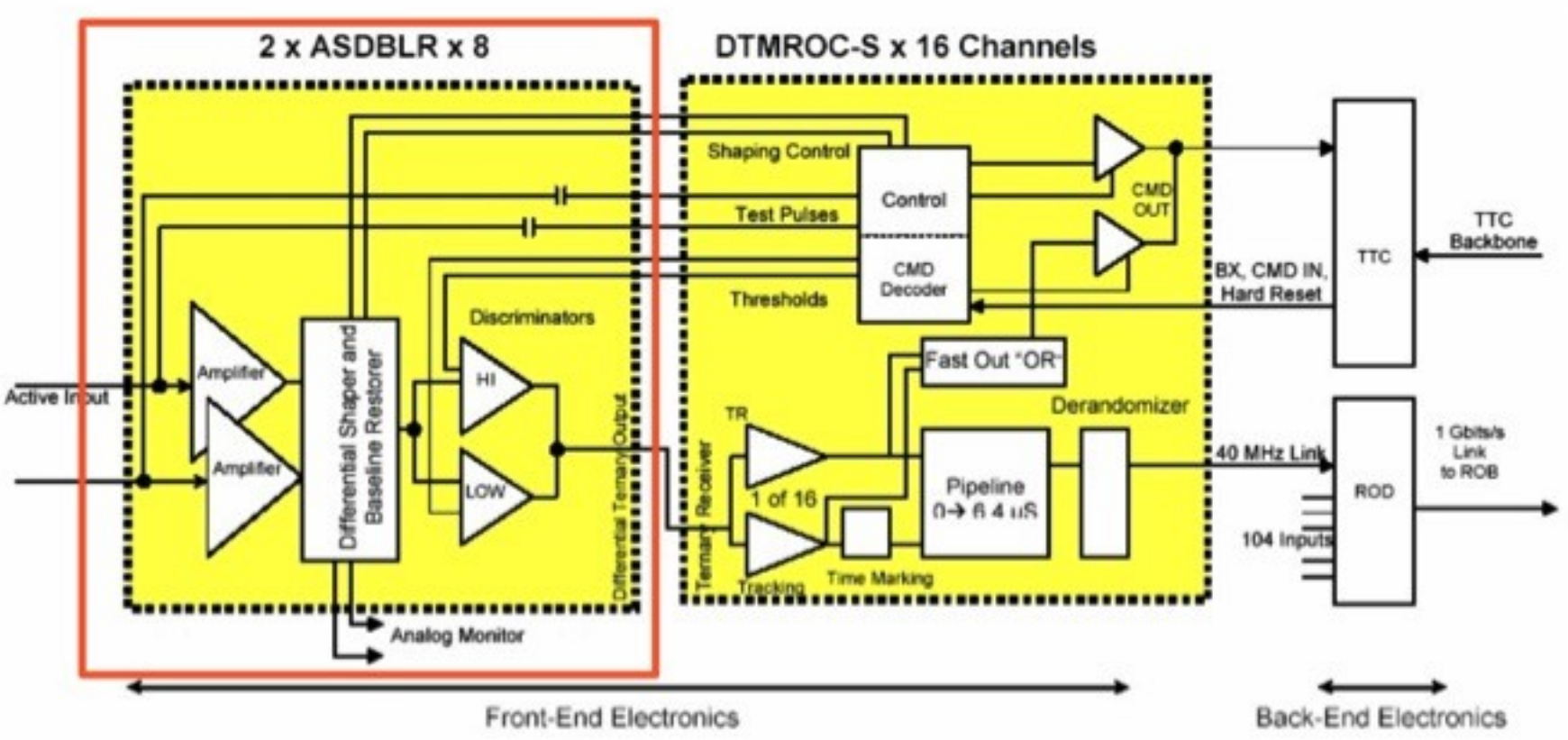
Low level threshold



High level threshold

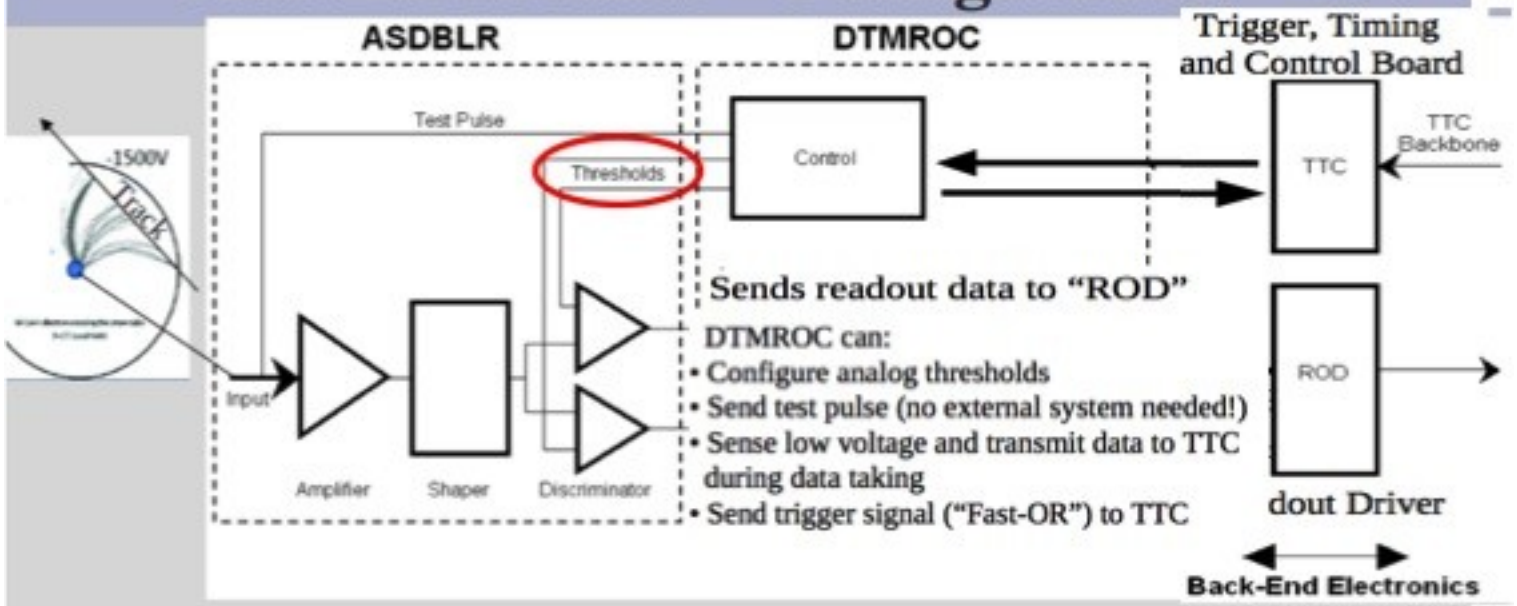


The less threshold
the better drift-time accuracy and efficiency
The higher threshold
the less noise



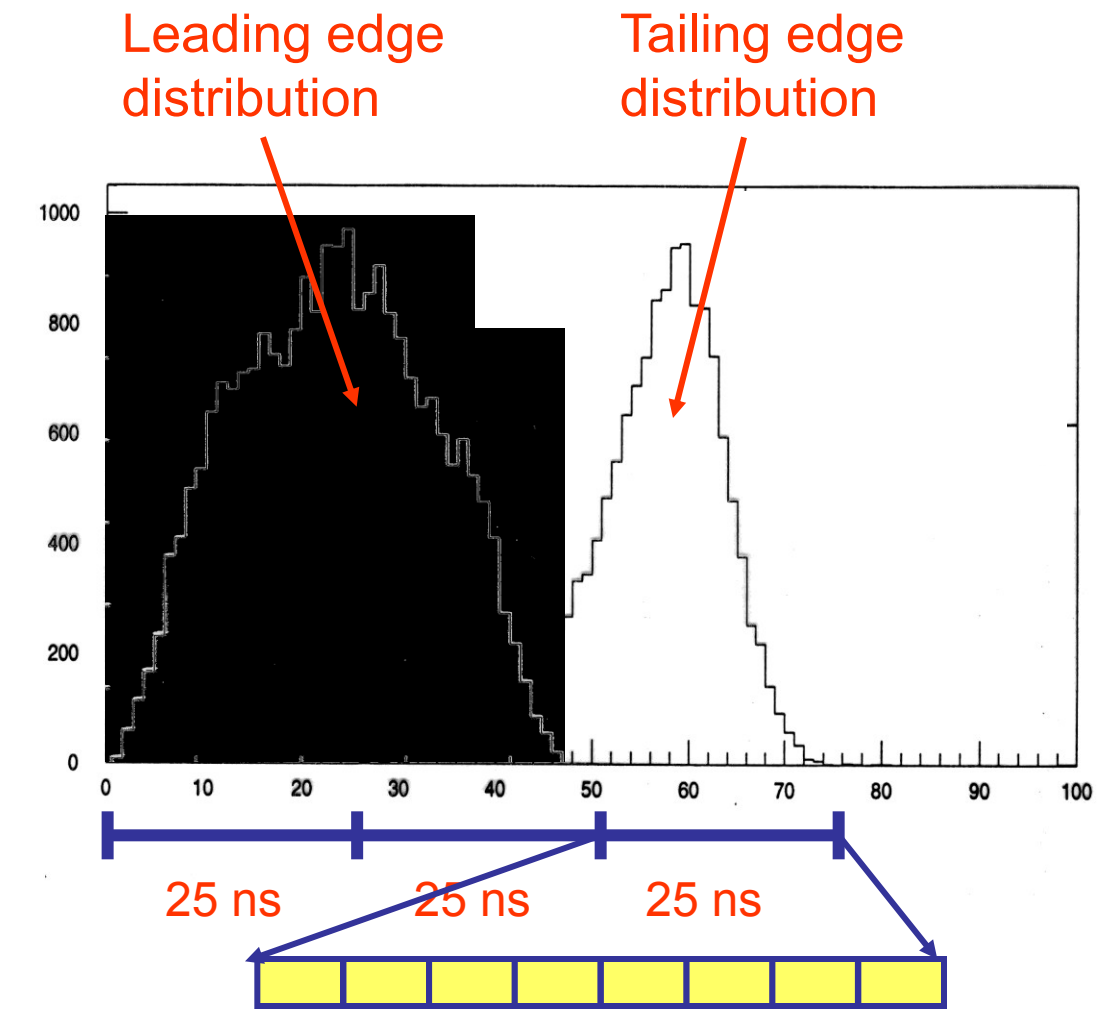
- Amplifier, shaper, discriminator, baseline restorer (**ASDBLR**)
  - Analog chip, receives input from **8 channels**
- 2 discriminators, for **low** and **high** thresholds
  - **Ternary output** to DTMROC

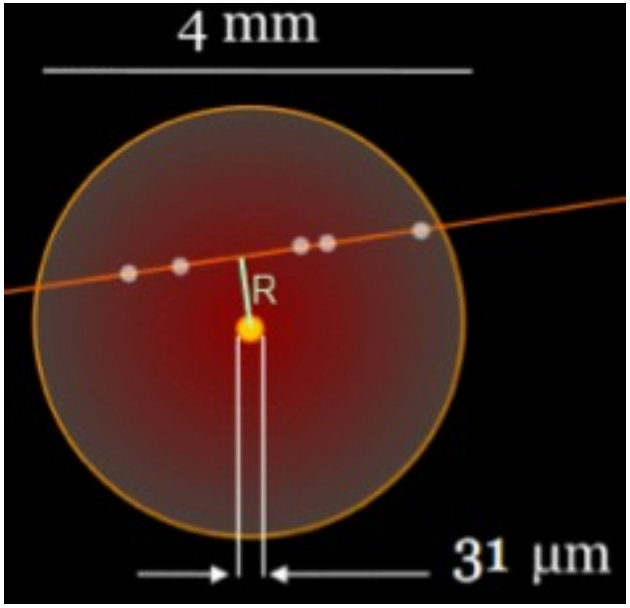
TRT Electronics - Configuration



- Analog and digital boards powered separately (in barrel: grounds separated by impedance)
- Inaccurate board powering (low voltage) can have an effect on thresholds

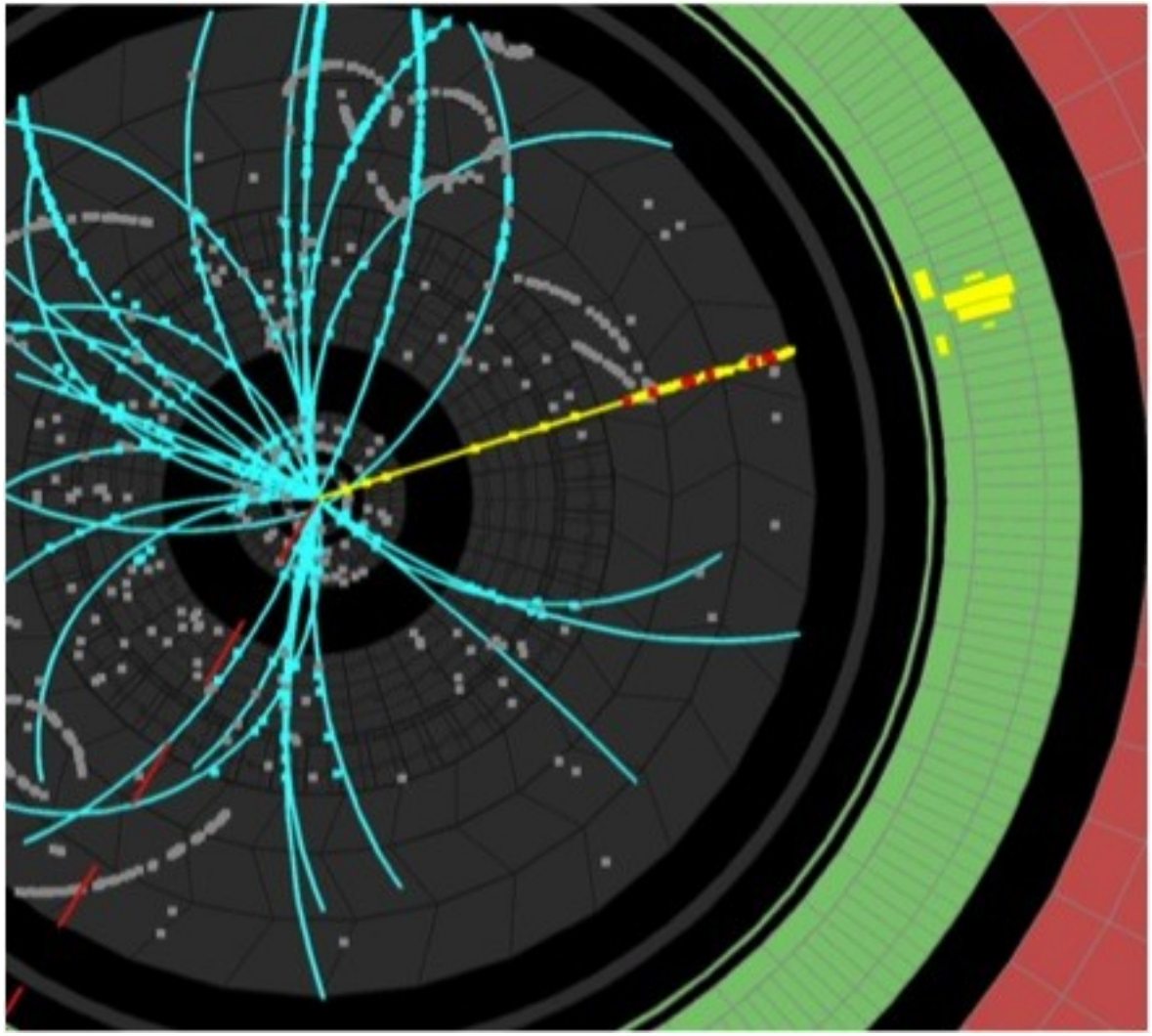
Tracking



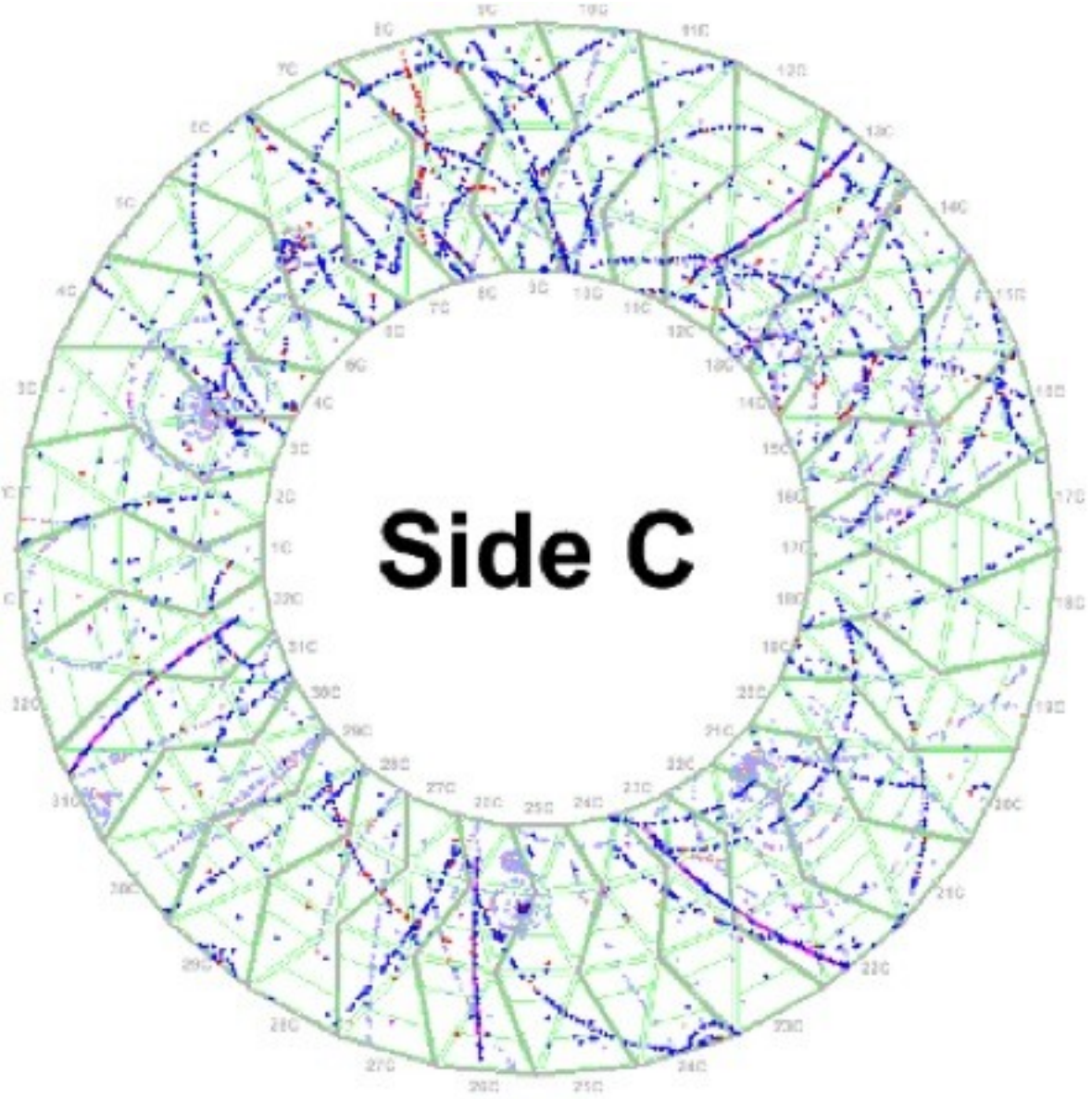


For low level discriminator bit status each 3.125 ns

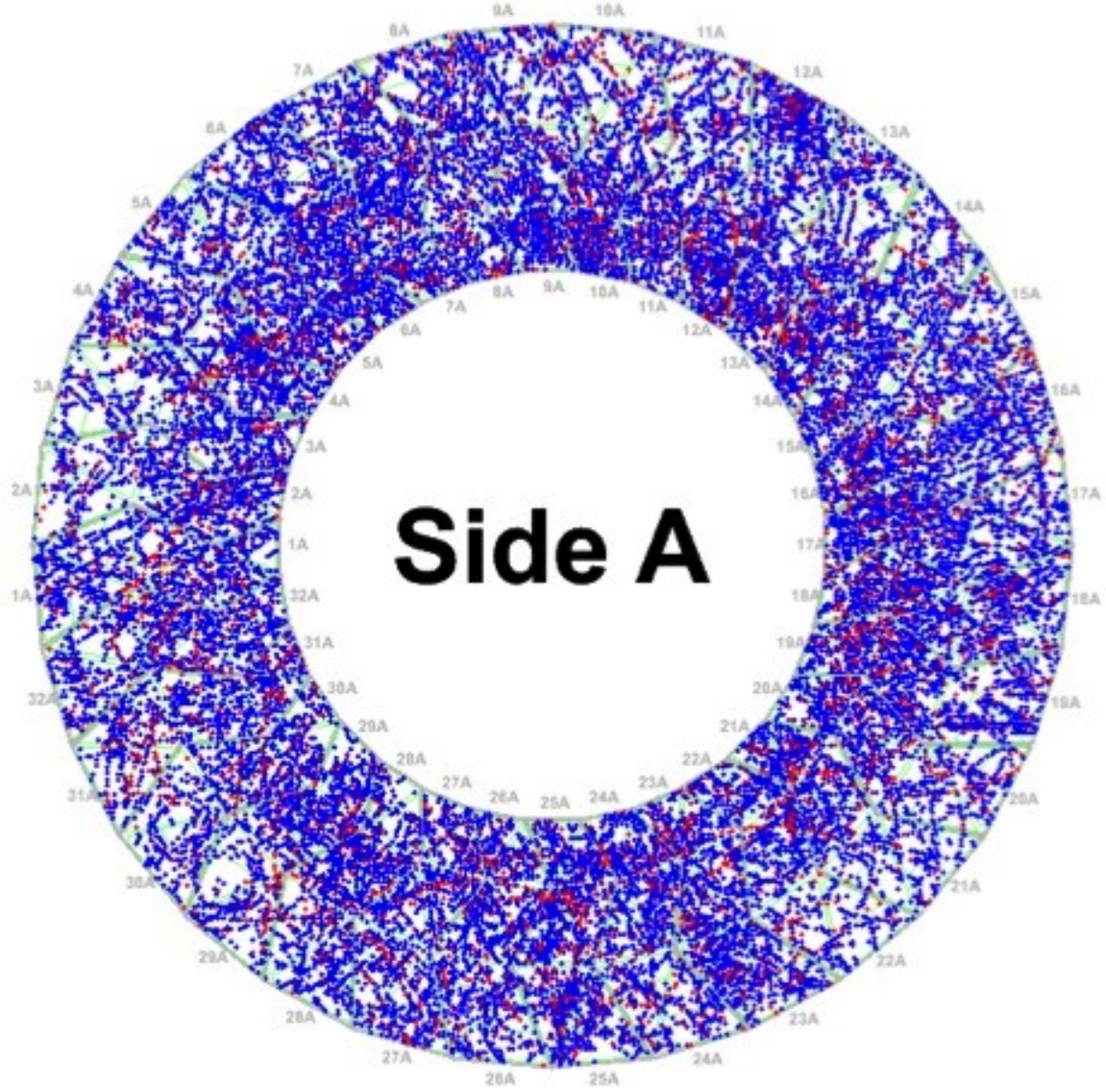
ATLAS event display: electron from Z decay



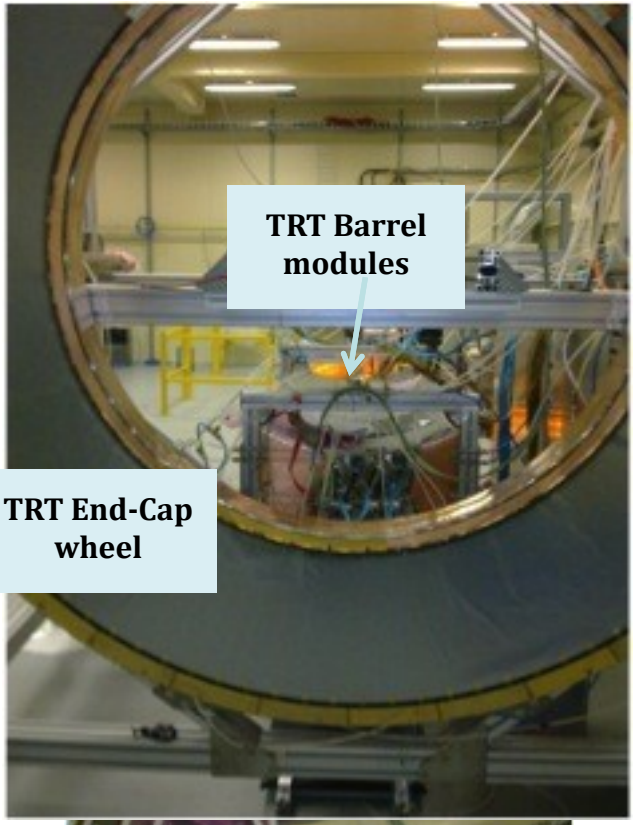
Real event display: Heavy Ions non-central collisions



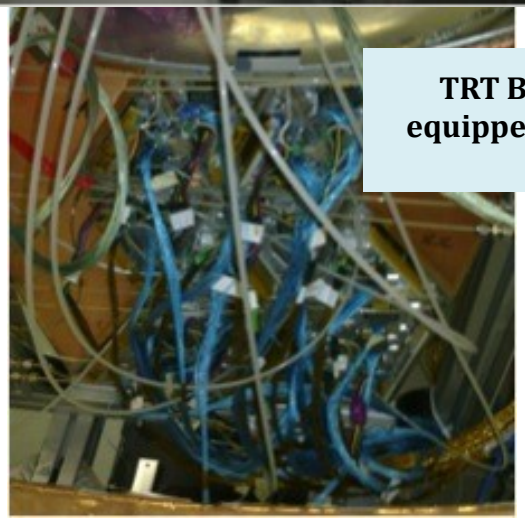
Real event display: Heavy Ions central collisions

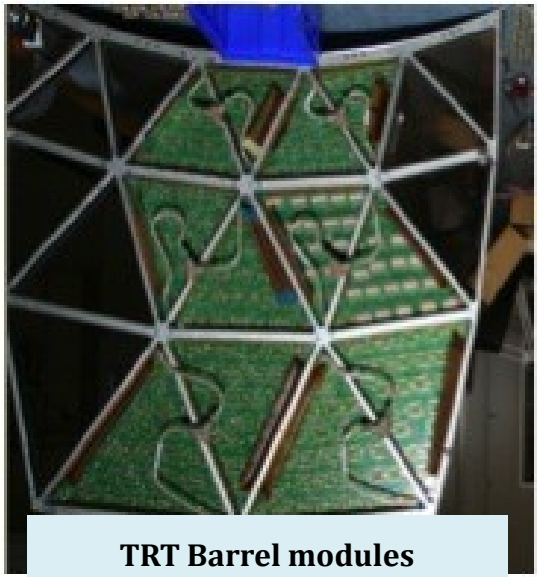


Test set-up


TRT Barrel modules
TRT End-Cap wheel

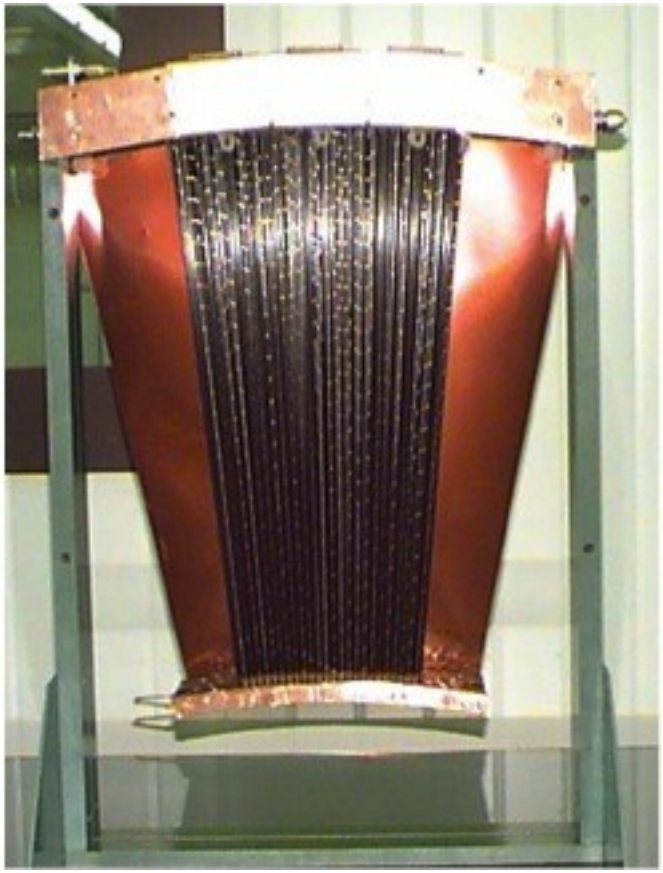

TRT Barrel module

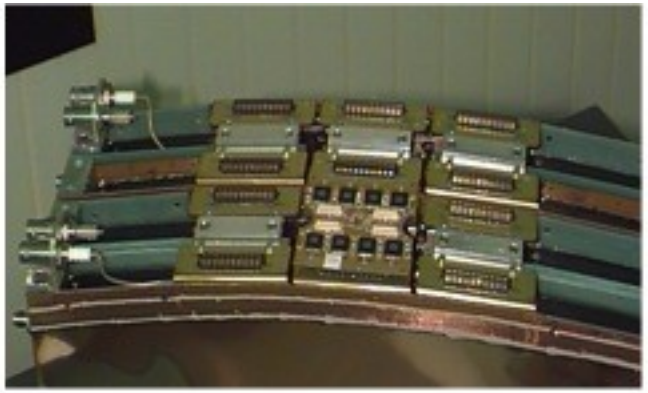

TRT Barrel modules equipped for the readout


TRT Barrel modules assembles in the support structure

Service racks

Straw-electronics connectivity

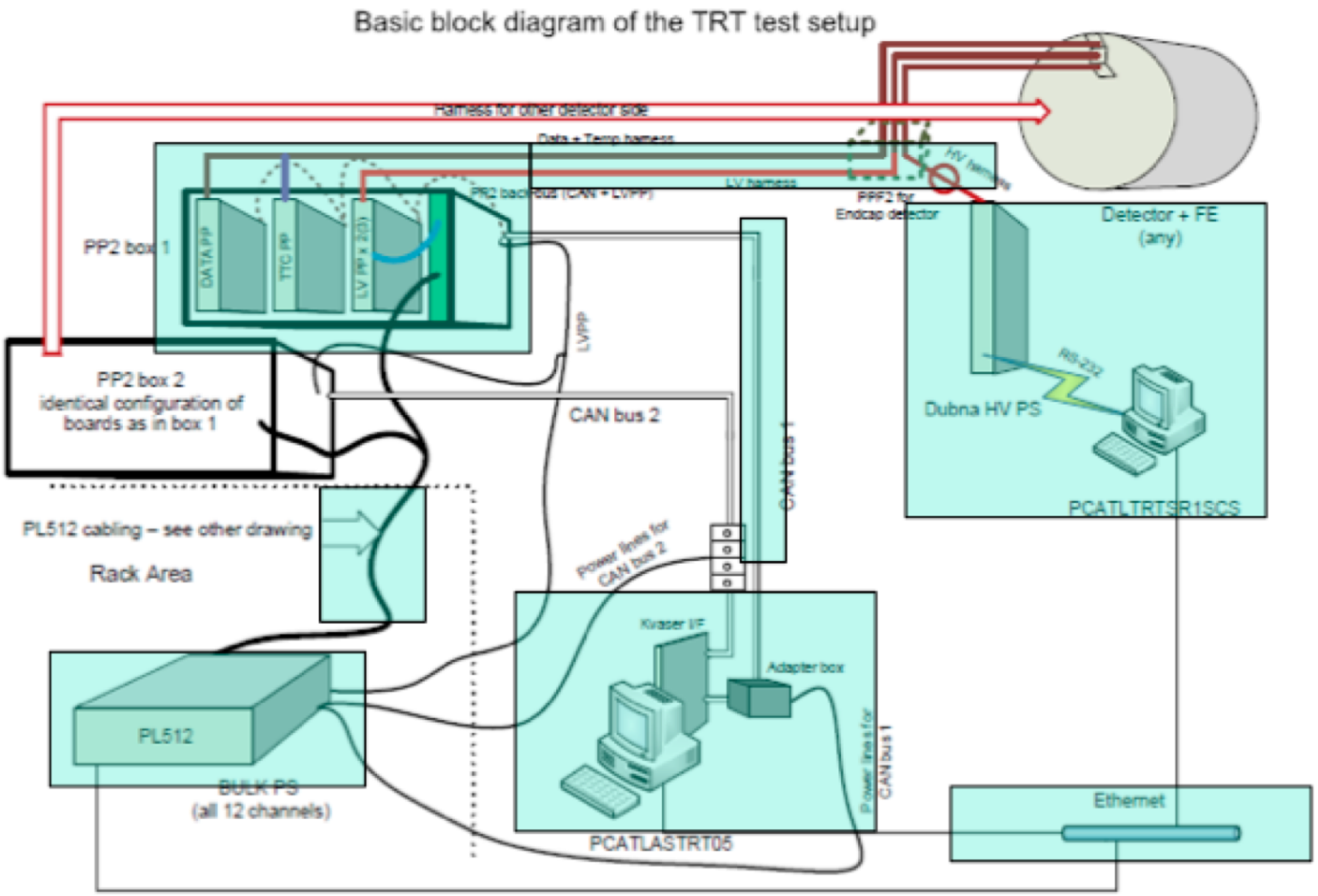




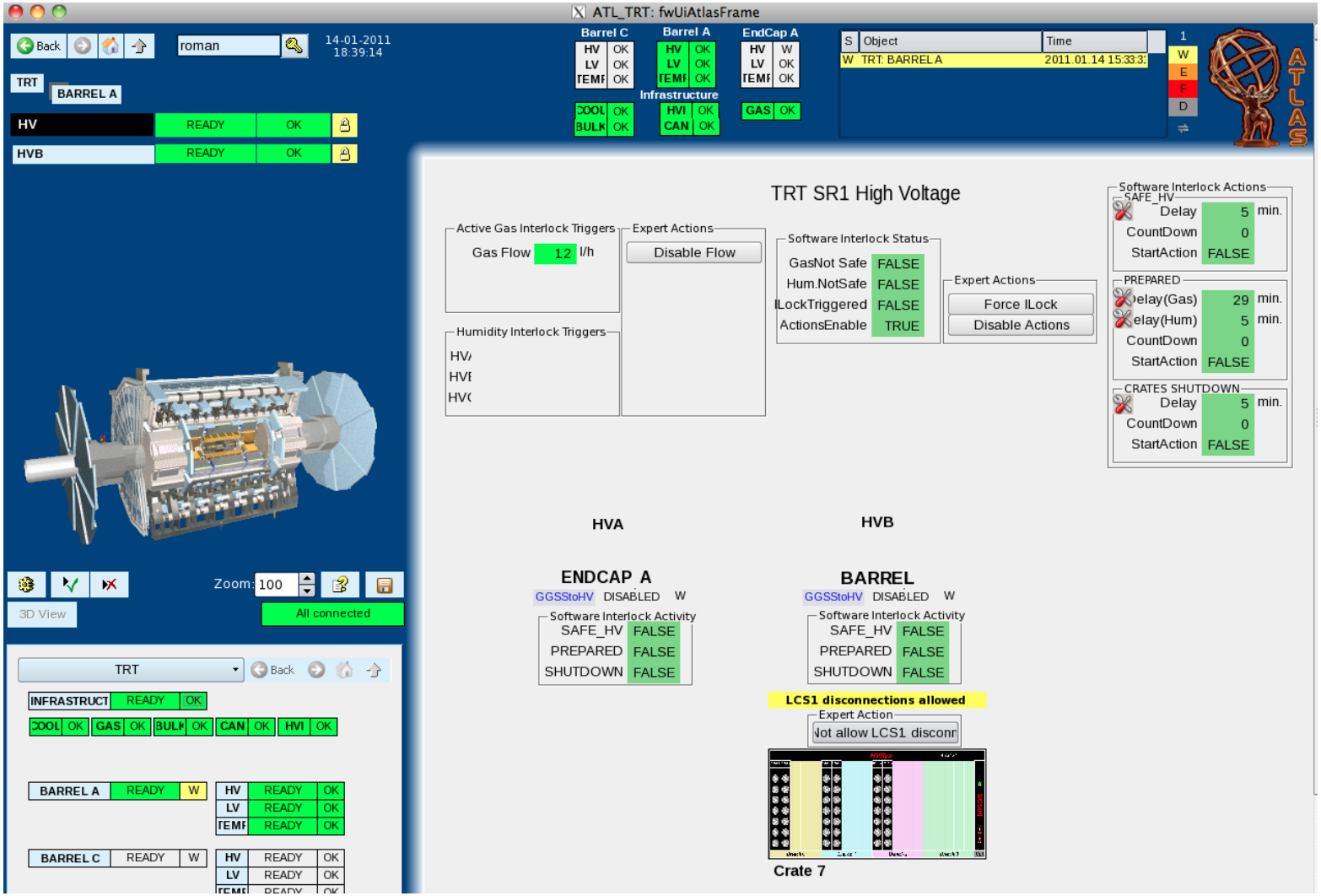
End-Cap Wheel prototype: Front-End Electronics connections

End-Cap Wheel prototype: Straw-electronics connectivity

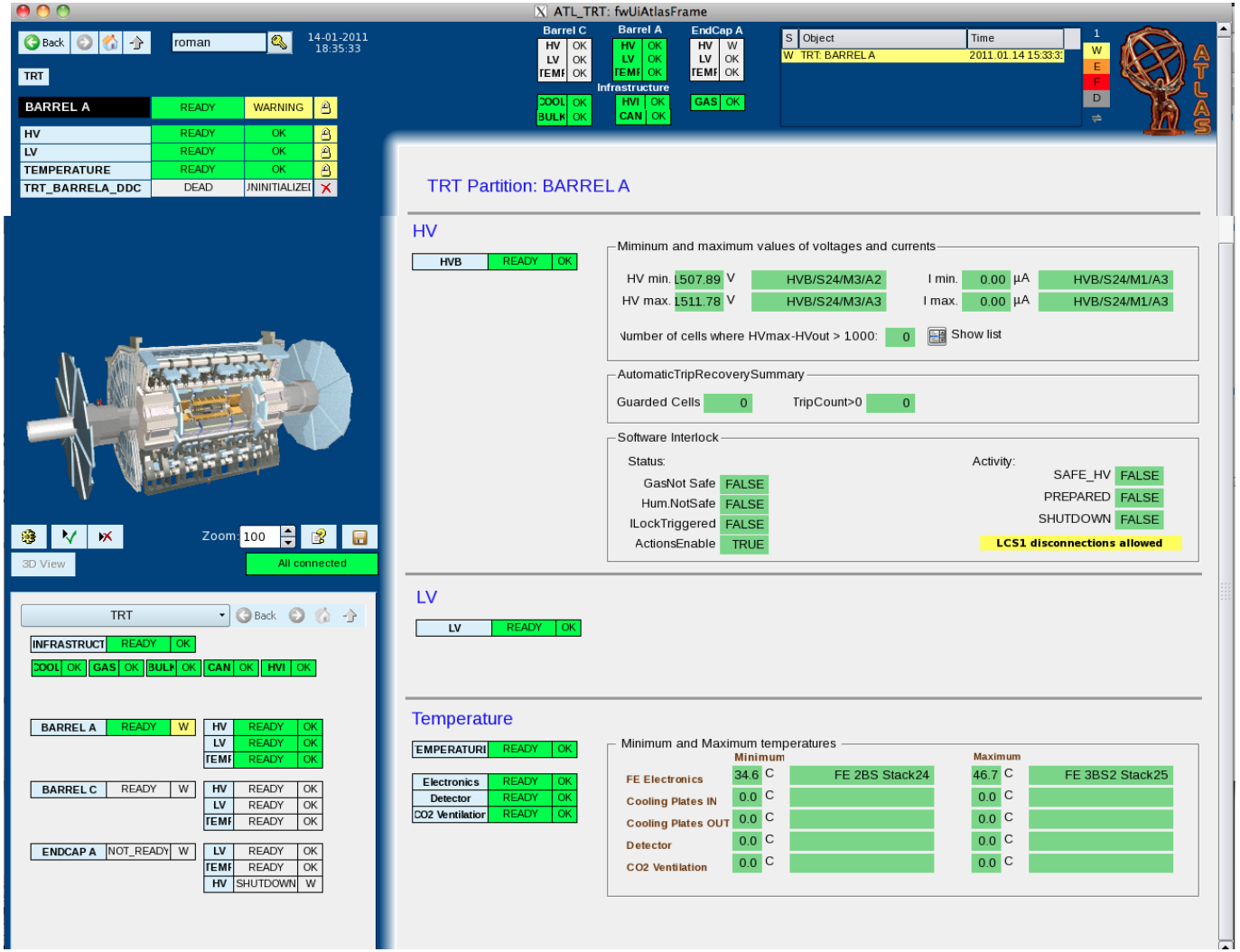
TRT test stand DCS.



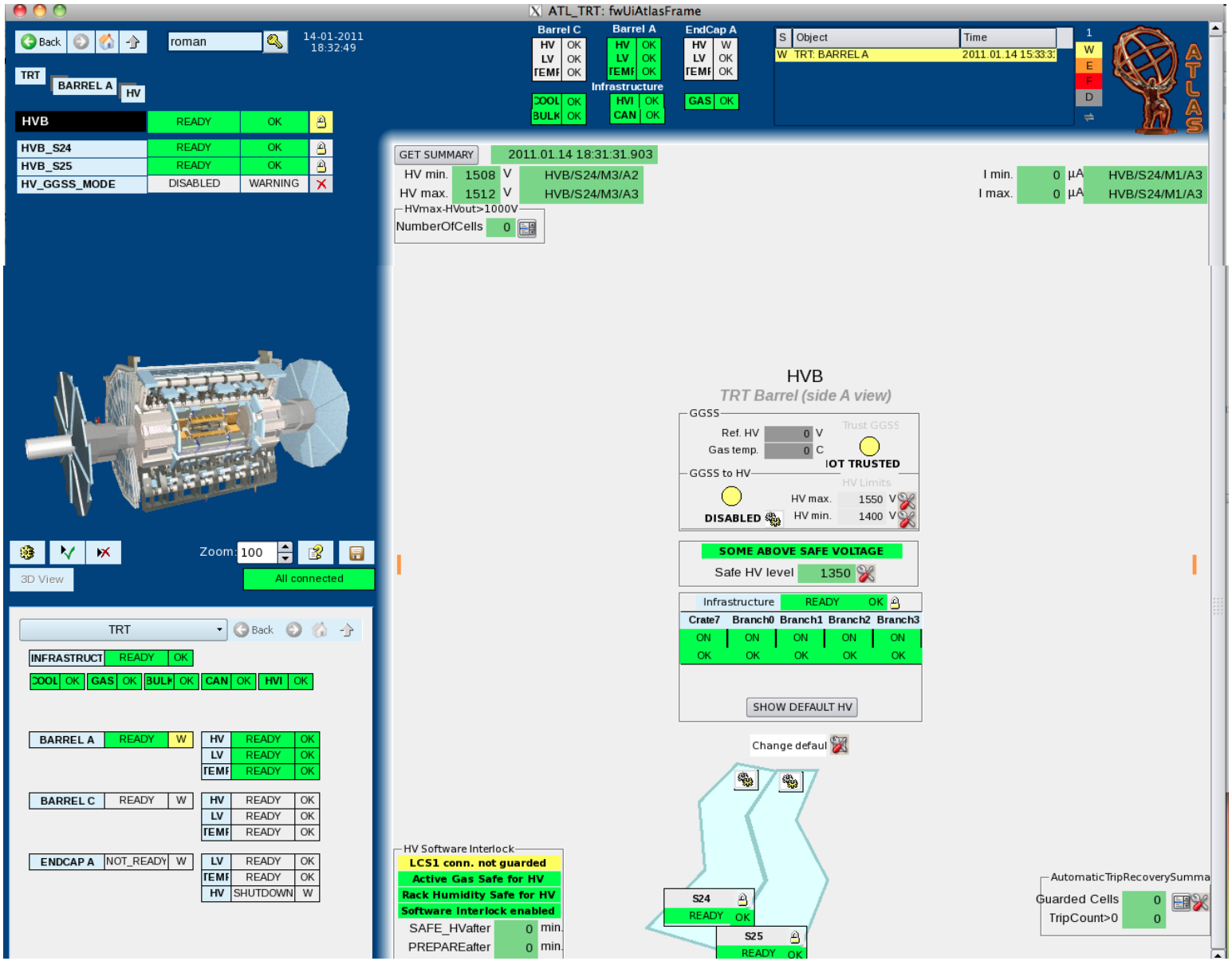
Test stand DCS



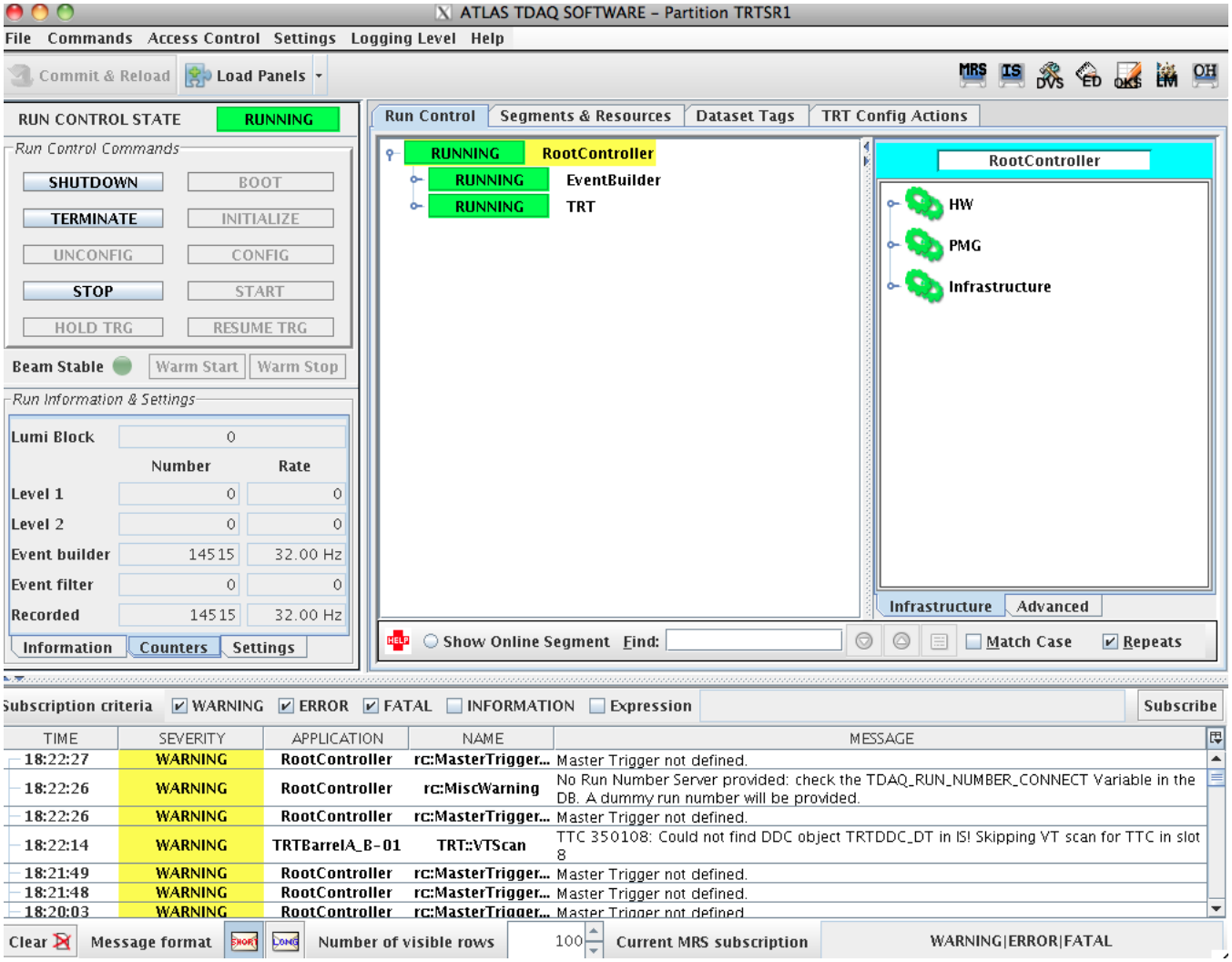
Test stand DCS



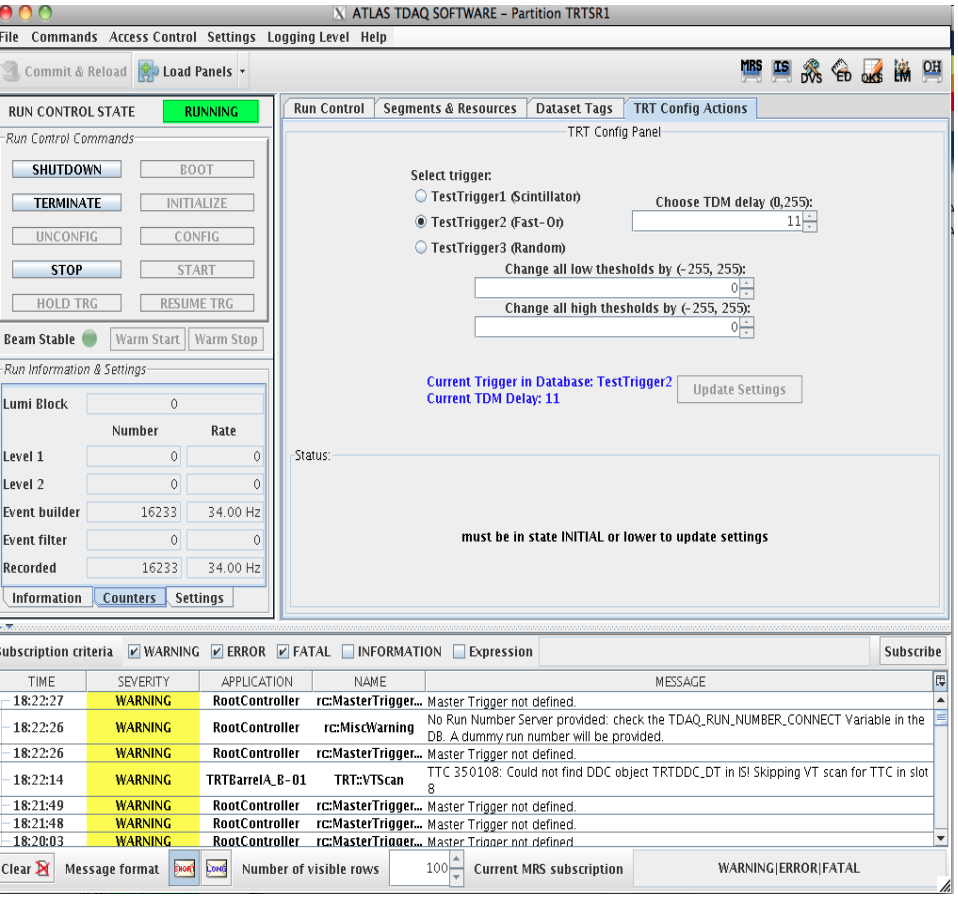
Test stand DCS

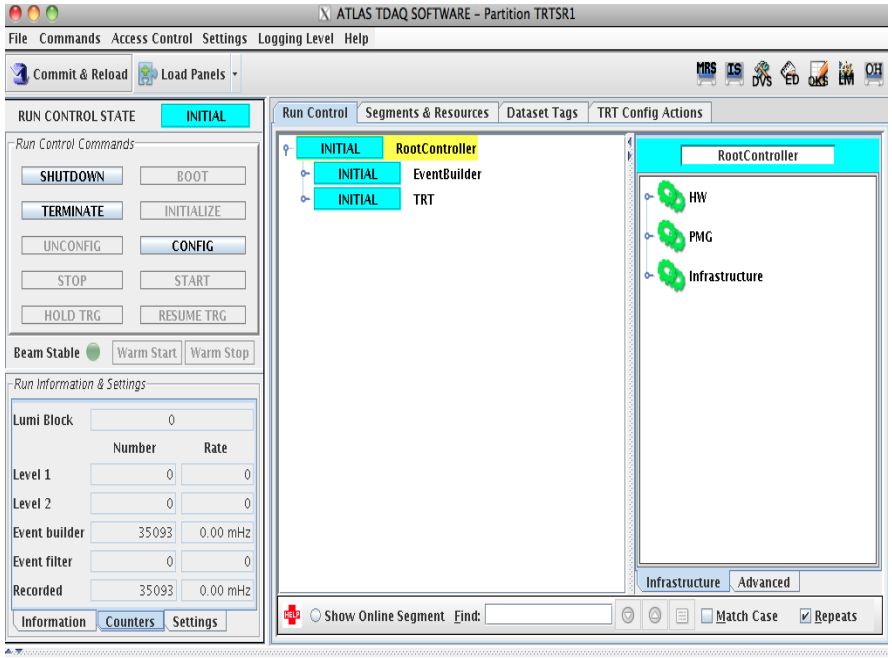


Test stand DAQ GUI



Test stand DAQ GUI





Tasks1: Noise characterization

1. Sources of the noise
   - Thermal noise
   - External pick up noise
   - Internal pick up noise
2. Dependence on threshold
   - The less threshold
     - the better accuracy
     - the larger noise
   - Particle loses ~ 1 keV in Ar-mixture
   - One primary ionization cluster ~ 80-100 eV (3-4 el)
   - Electronics noise with the detector ~3000 el
   - Nominal threshold should be >4 sigma above the noise (now ~14000 el)
   -
   - Phys. Threshold = El.Thr* W/(Gas gain * Signal fraction)

   - In our case ~14000 el*27/5*10^4*0.12 = 63 eV
   - We are sensitive to a 1 primary ionization cluster!
3. Threshold are set in DAC counts

   10 DAC counts =~1400el or 6.3 eV

Tasks1: Noise characterization

Identify problematic channels and choose the operating threshold.

1. Misbehaving channels
   - Requirements
   - Analysis noise maps at different thresholds
   - Dead channels
   - Readout problem
   - Large noise
   - Too high or too low thresholds
2. Methods of the noise source identification and noise signal suppression
   - Signal shape.
   - Time distribution.
   - Noise rate estimate.
3. Operating threshold
   - What noise occupancy is allowed to be?
   - Noise scan

Analysis Tool: TRTVeiwer (see test manual)

Task 2:Operation with cosmic particles

Identify detector problems, straw efficiency, tracking accuracy as a function of the electronics threshold

1. Signal from particles
   - Signal shape
   - Drift-time distribution (hit arrival time, trailing edge)
   - Method of timing of the signals from particles
   - Cosmic particle track characterization.
2. Misbehaving channels
   - Dead
   - HV problems
   - Straw mapping with particles
3. Straw efficiency and drift-time accuracy
   - Straw efficiency as a function of threshold
   - Drift-time accuracy as a function of threshold
   - Tracking at high occupancy and noise suppression
4. Basic principles of the particle Identification
   - Compare HL threshold distributions at different conditions
   - Choice of the correct representation of the results

Analysis Tool: TRTVeiwer (see test manual)