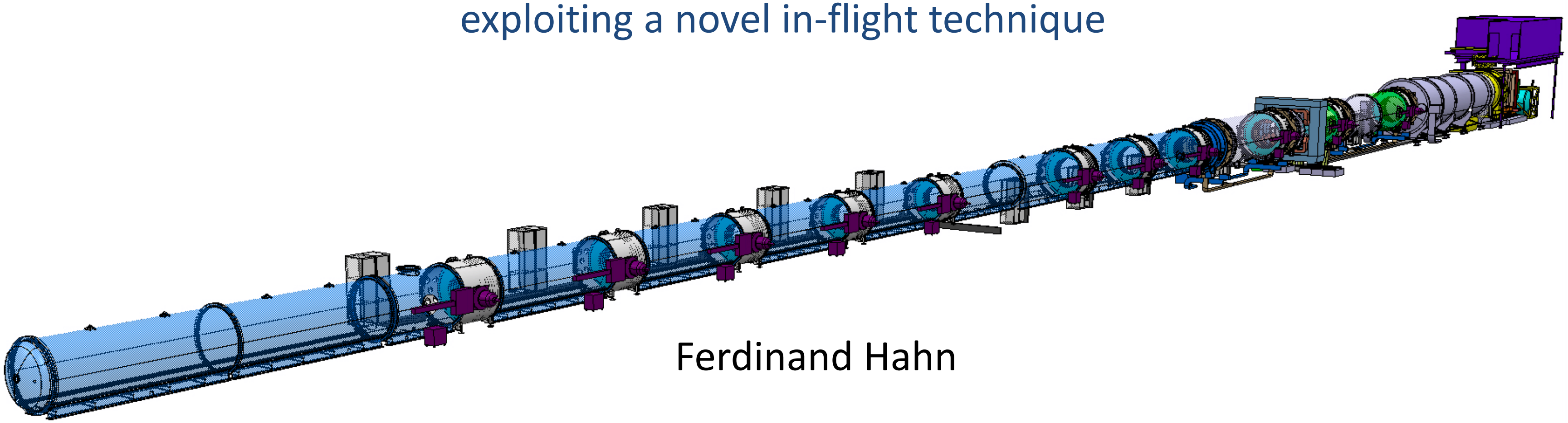
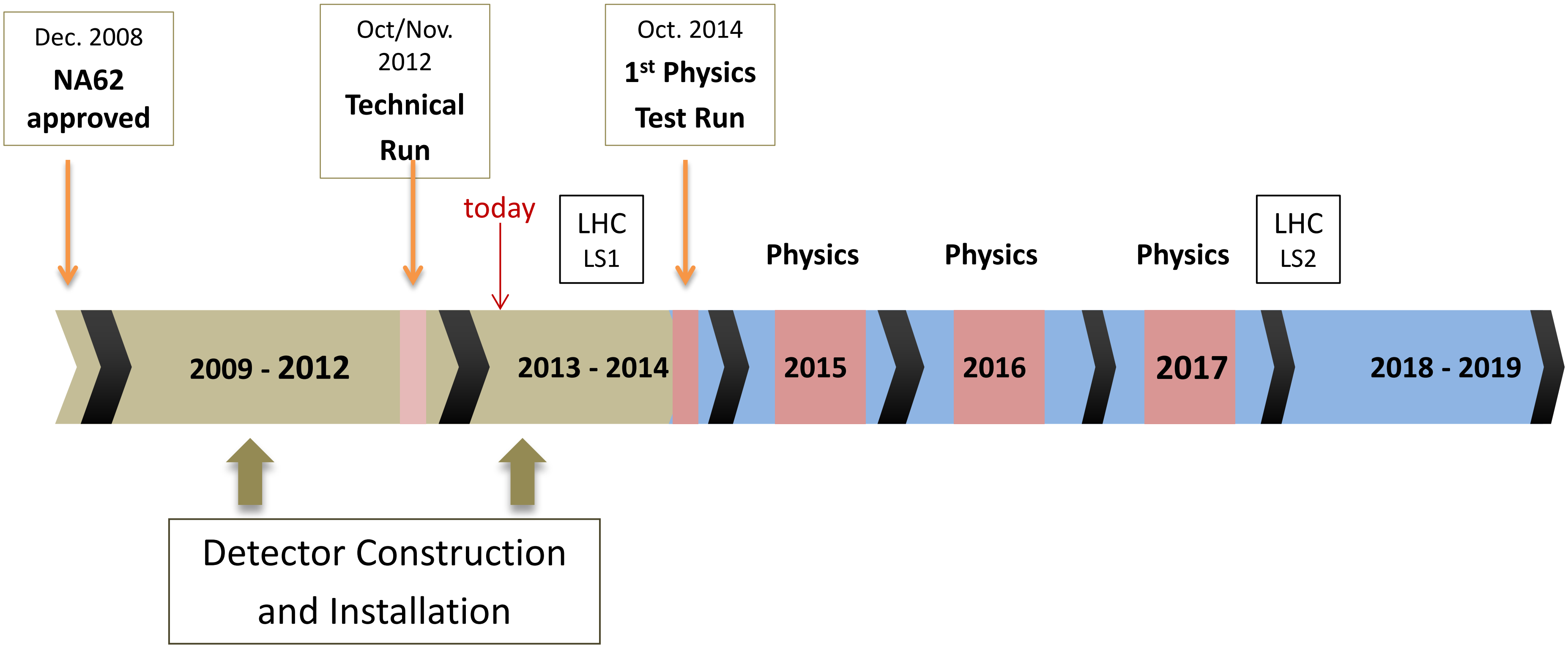
The NA62 Experiment at CERN: Status of the Construction

NA62 aims to measure precisely $BR(K^+ \rightarrow \pi^+ \nu\ \nu)$
exploiting a novel in-flight technique



Ferdinand Hahn

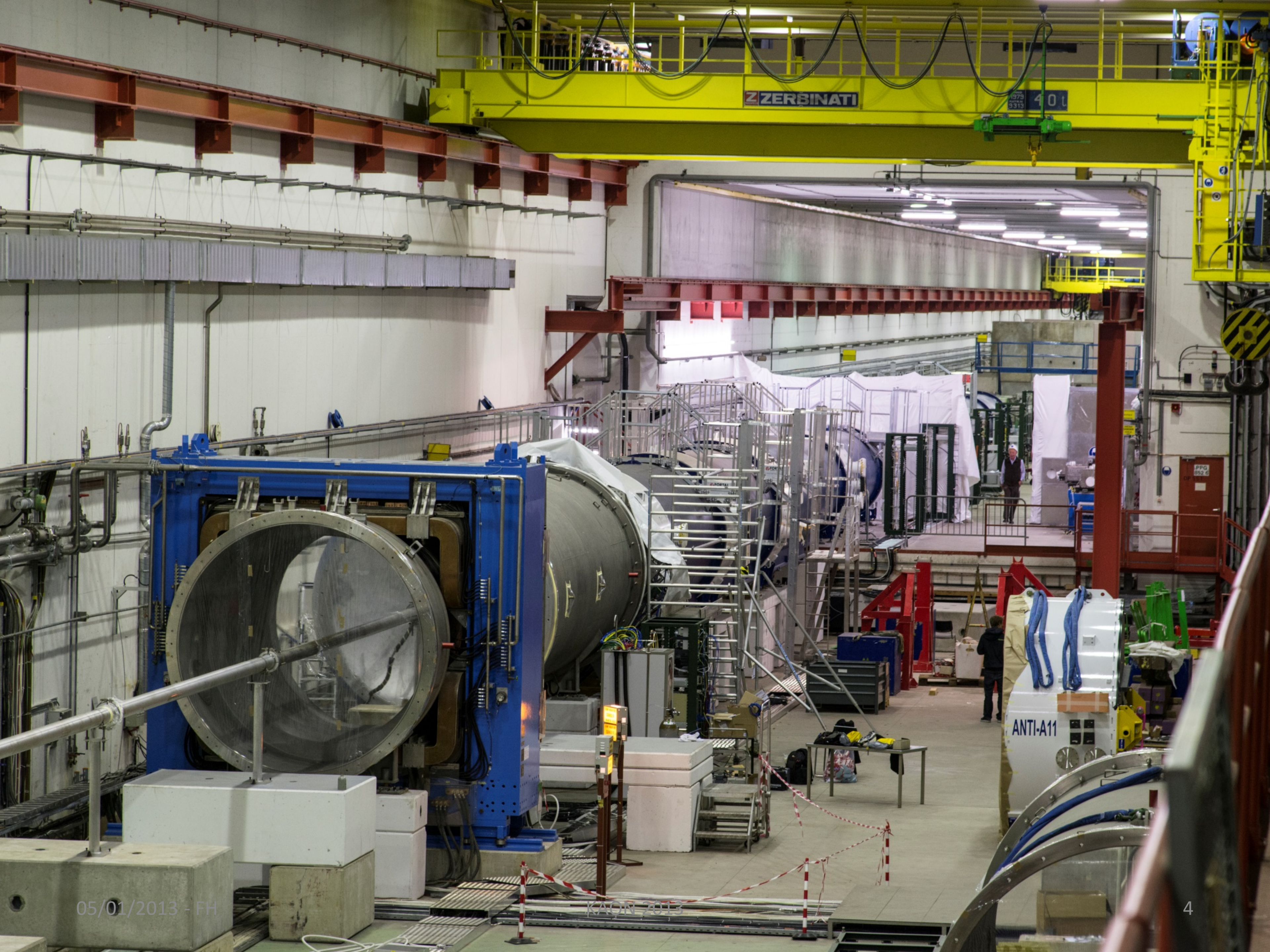
NA62 Timeline



- 5 years of construction interleaved with a Technical Run in fall 2012
- In 2014 a first Run with full detector
- Plan 3 years of Physics data taking before LHC Long Shutdown 2 (LS2)

Civil Engineering Work

Construction of New Dump Tunnel (2010)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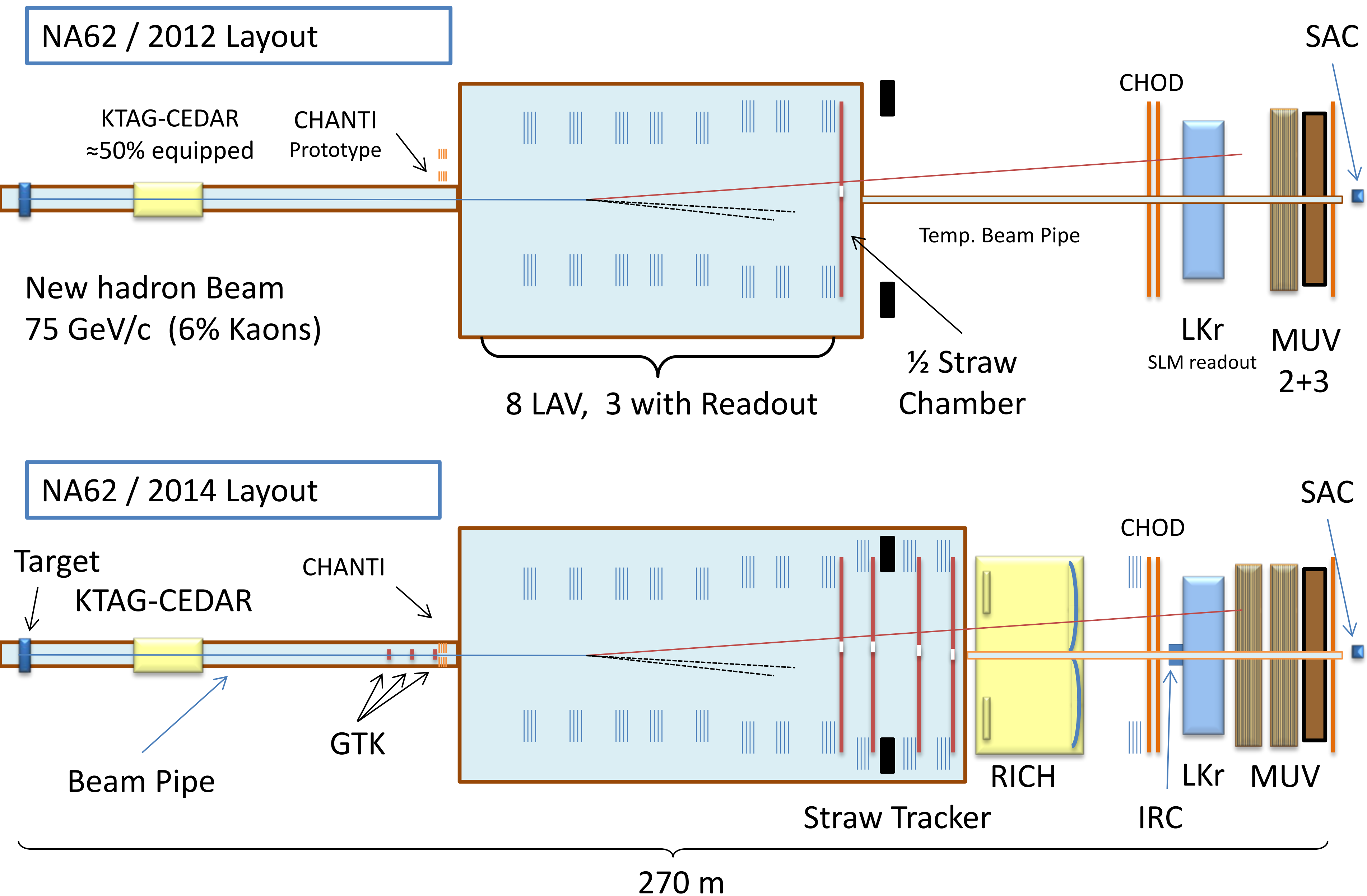
Content

Overview

Four Principles of the NA62 Detector

1. High Intensity and fast Timing
2. Low Mass Tracking
3. Hermetic Vetoing for Photons and Muons
4. Particle ID

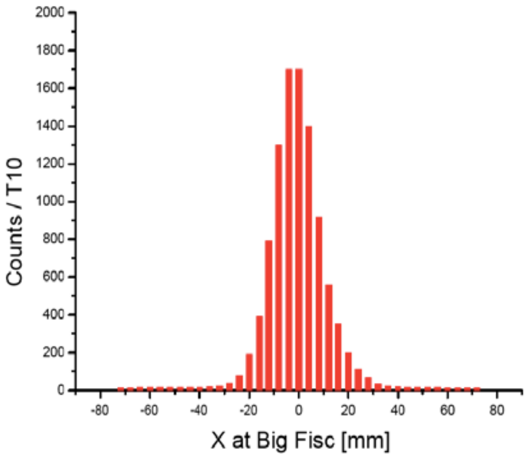
NA62 Detector 2012 and 2014

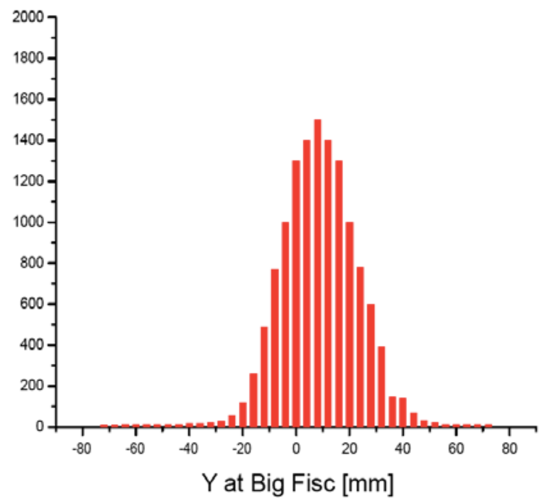


New Beam Line

Lau Gatignon

Measured Profiles



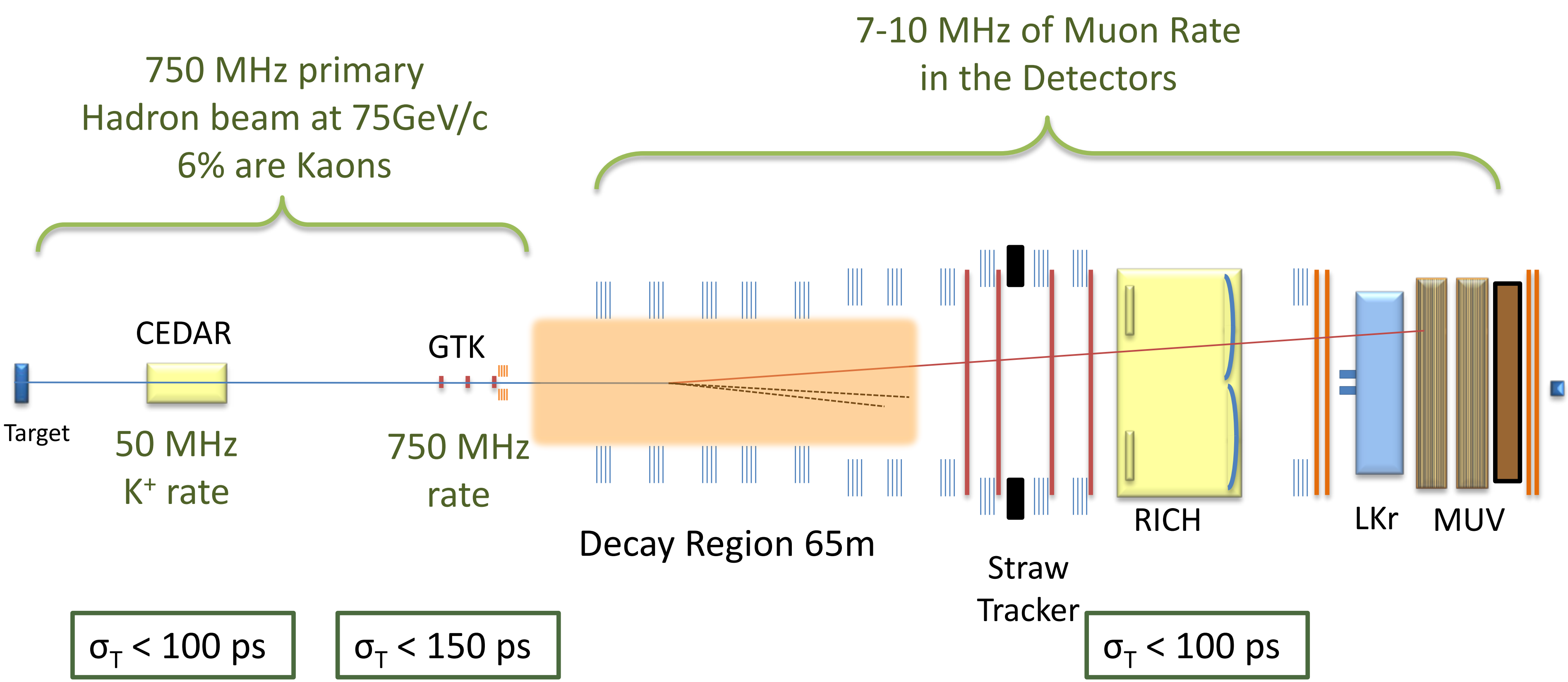


Beam Parameter		
400 GeV/c	Protons on Target / s	1.1×10^{12}
75 GeV/c	Hadrons / s (6% Kaons)	750×10^{6}
75 GeV/c	K^+ decays / s	4.5×10^{6}

Parameter	Measured In TR	Simulated
2 RMS at CEDAR: X (mm)	28	27
2 RMS at CEDAR: Y (mm)	15	15
Intr. ang. spread X' (mr)	<80	70
Intr. ang. Spread Y' (mr)	<80	70
RMS at Big Fisc: X (mm)	12	12.6
RMS at Big Fisc: Y (mm)	14.6	15.1
RMS at MWPC: X (mm)	14.3	14.0
RMS at MWPC: Y (mm)	17.3	17.5
K^+ Rate (normalized to full intensity)	3.6×10^{6}	4.5×10^{6}

Four Principles of NA62

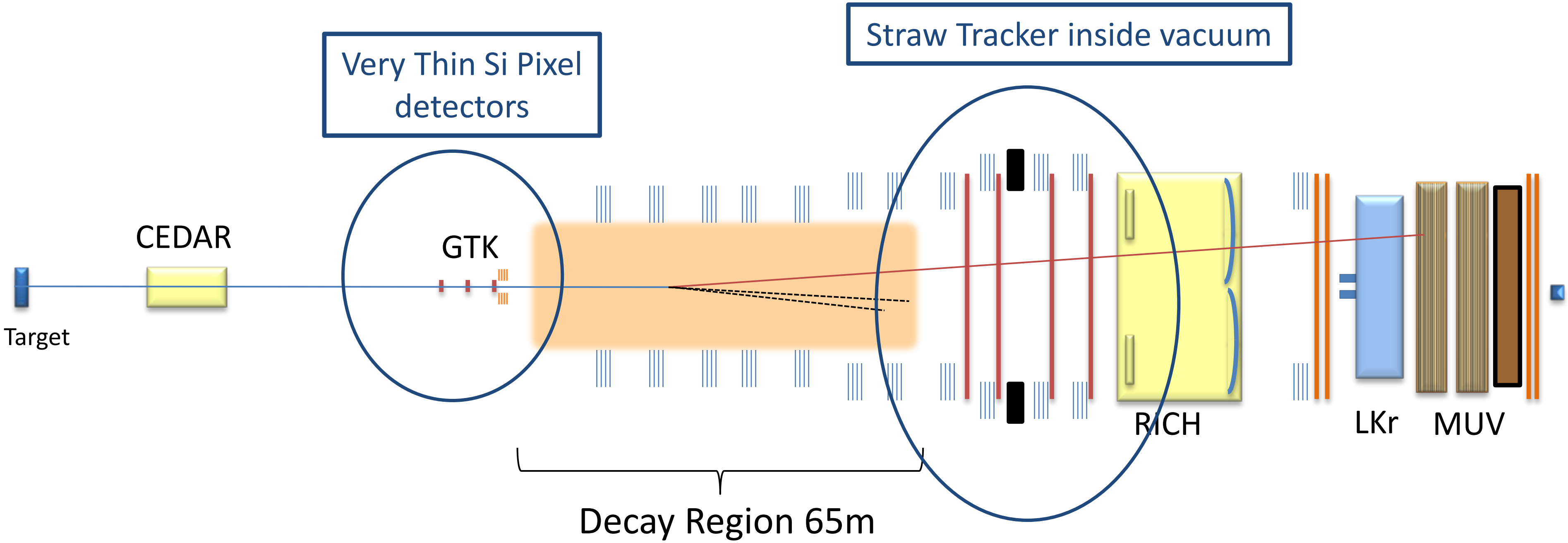
(1) High Intensity and fast Timing



4.5 10^{12} K^+ decays/ year in fiducial region

Four Principles of NA62

(2) Low mass tracking

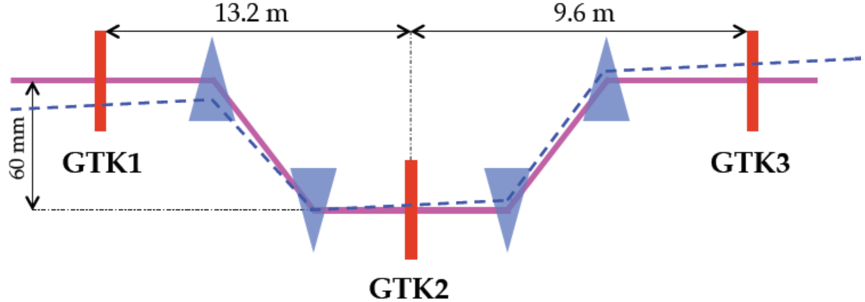


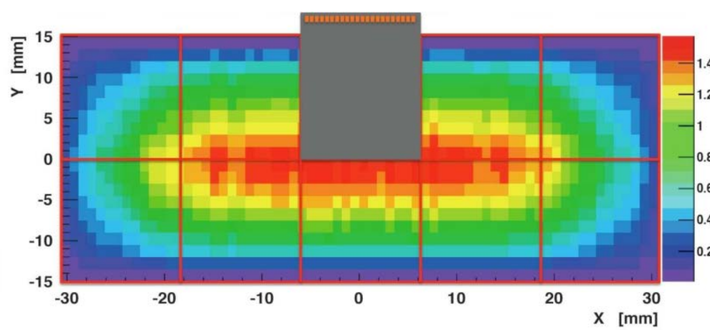
GigaTracKer (GTK)

Overview

3 stations of Si pixel detectors
- Pixel size:
  - 300 x 300 μm^2 or 300 x 400 μm^2
  - 18’000 pixels/ station
  - 54’000 pixels grand total
- Thickness:
  - < 500 µm = 200(sensor) + 100(readout) + (≈) 150 Cooling
  - 0.5% of X_0 (per Station)
- Active area ≈ 60 (X) * 27 (Y) mm^2
- Divided in 10 read-out chips

Mounted inside beam pipe around 4 achromat magnets





Beam Conditions:

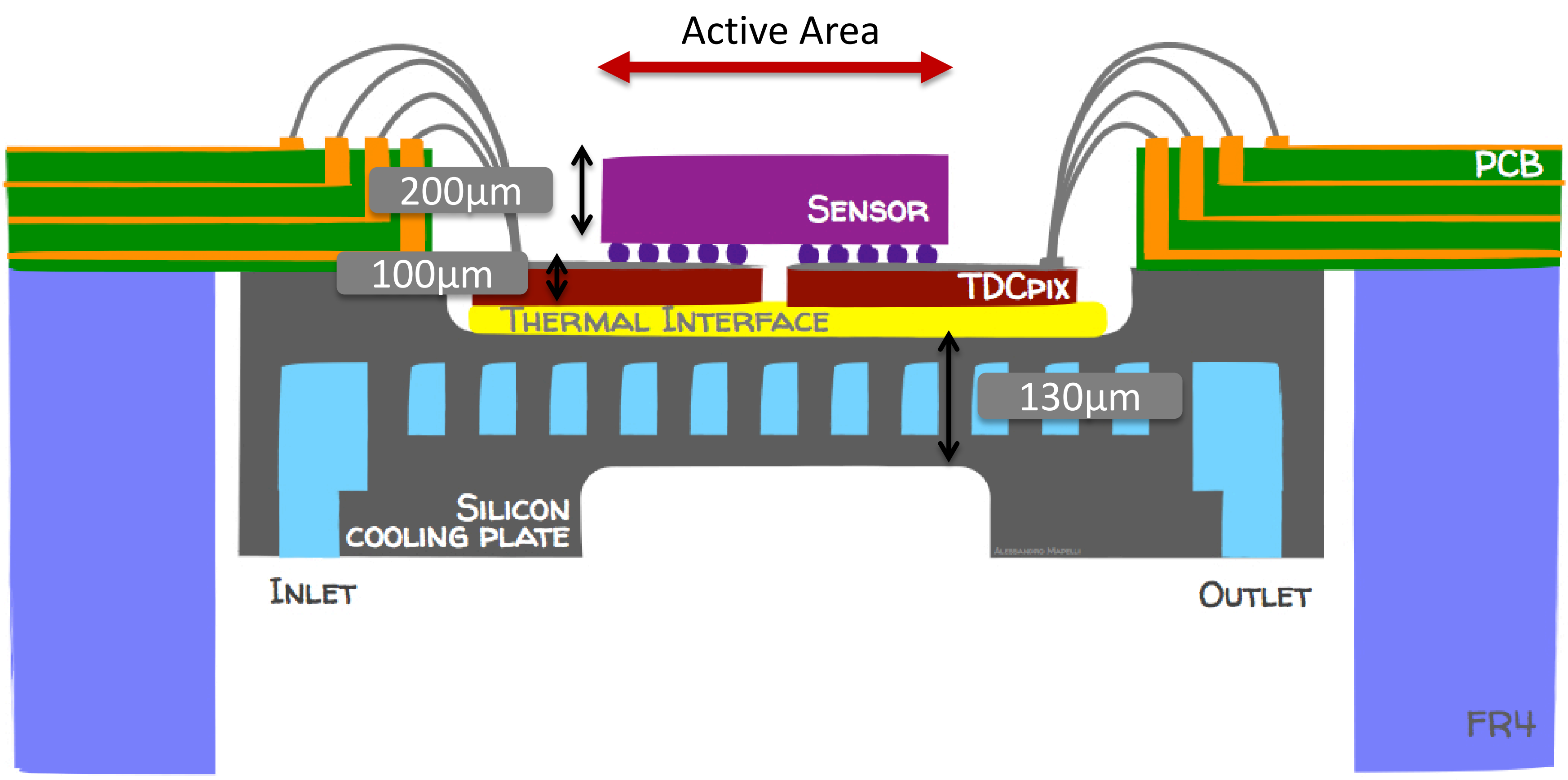
- **Overall Rate 750MHz**
- In beam centre 140kHz/pixel

Meaures precisely Kaon

- **Time (σ_t ≈ 200ps per station)**
- Direction ($\sigma_{dx,dy}$ ≈ 0.016mrad)
- Momentum ($\Delta P/P < 0.4\%$)

GigaTracKer (GTK)

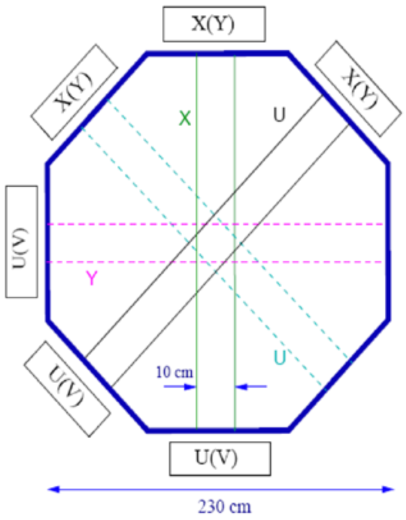
Artistic Cross-section



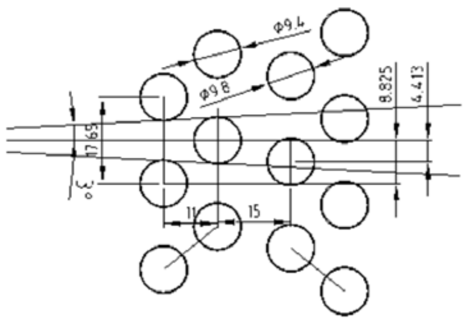
Straw Tracker

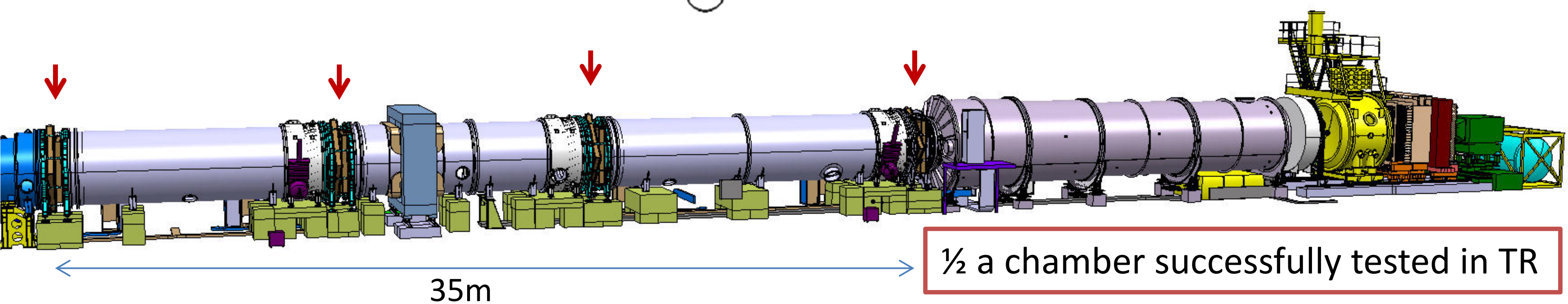
- Ultra-thin Straws installed in Vacuum
- 4 Chambers each measures 4 coordinates (views)
- High accuracy (130μm per View)
- High efficiency

X-section of the chamber



X-section of one View



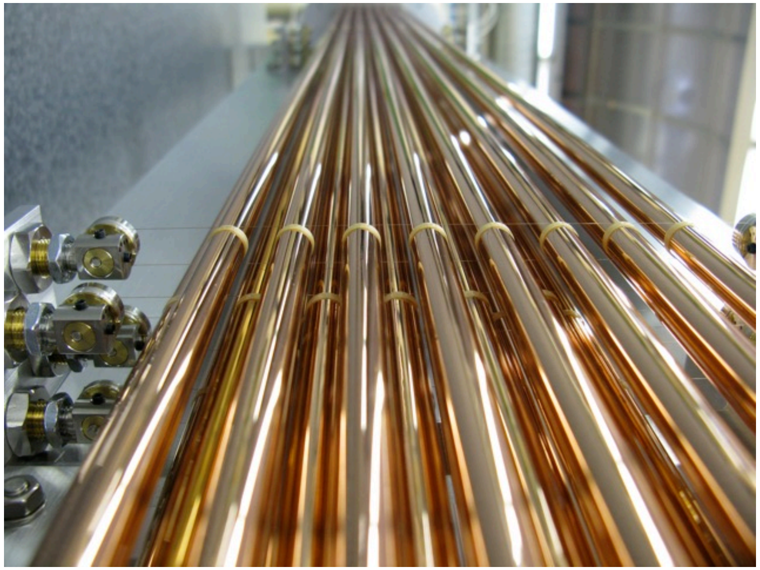


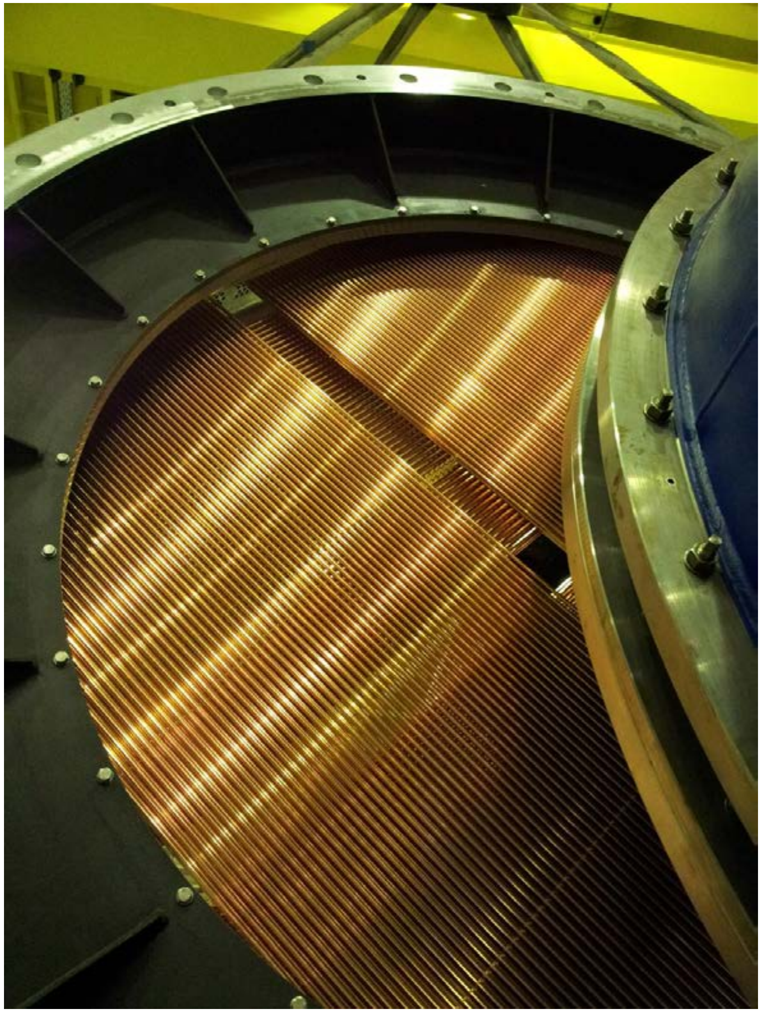
½ a chamber successfully tested in TR

Straw Tracker

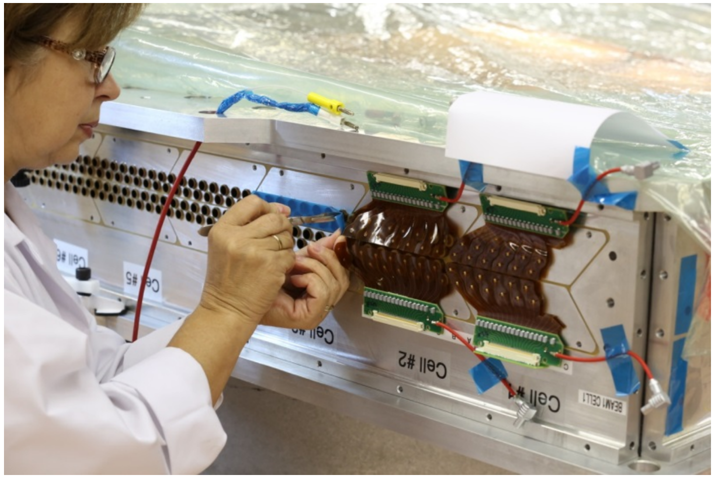
Straws installed inside vacuum tank

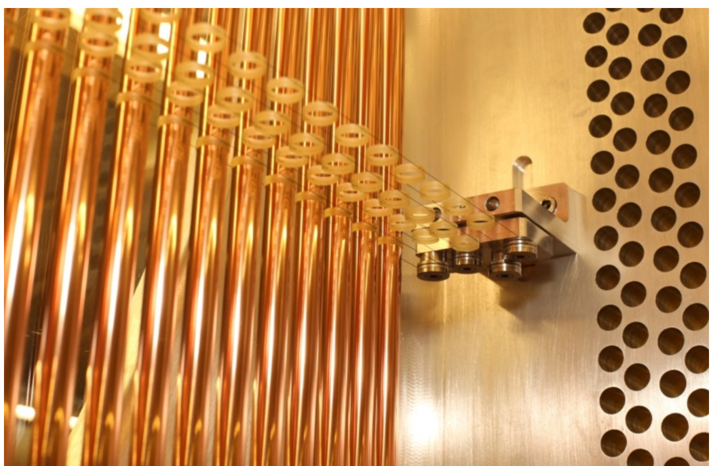
- Straws: 2.1m long and ϕ_i =9.8mm;
- Straw Material:
  - 50 nm Cu + 20 nm Au on 36 μm of Mylar
- Total 7168 Straws (4x4x4x112)
- Gas: Ar/CO_2 (70/30)
- Material Budget of the Spectrometer: 1.8% of X_0





Straw Tracker



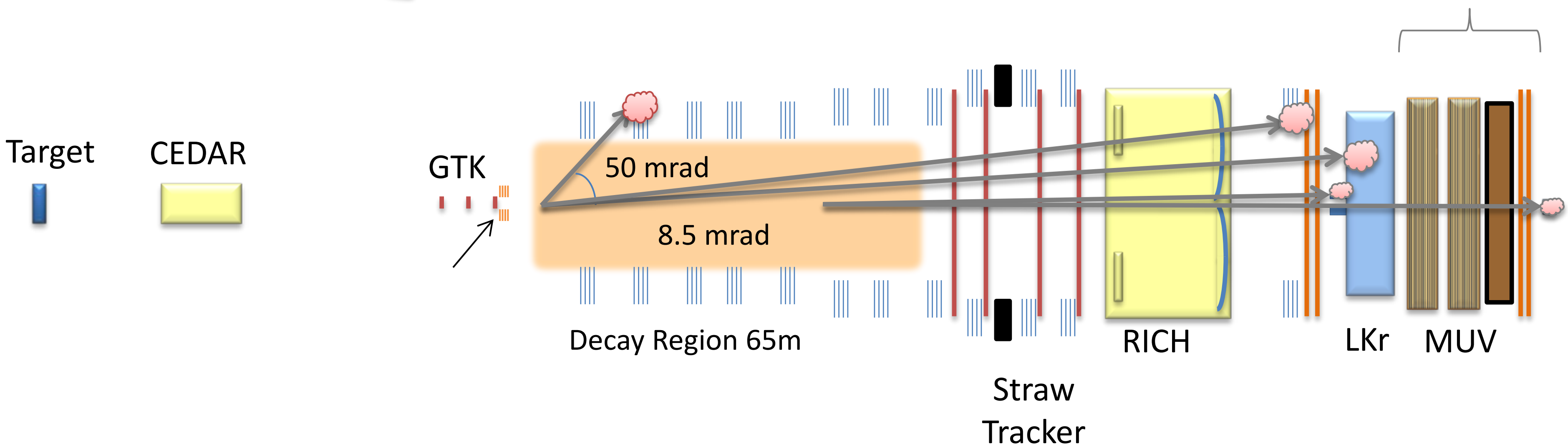


Four Principles of NA62

(3) Hermetic vetoing for photons (<50mrad) and muons

Photon Veto's
- Large Angle Veto: 8.5 -50mrad
- LKR: 1 – 8.5 mrad
- Small Angle Veto ≤ 1mrad

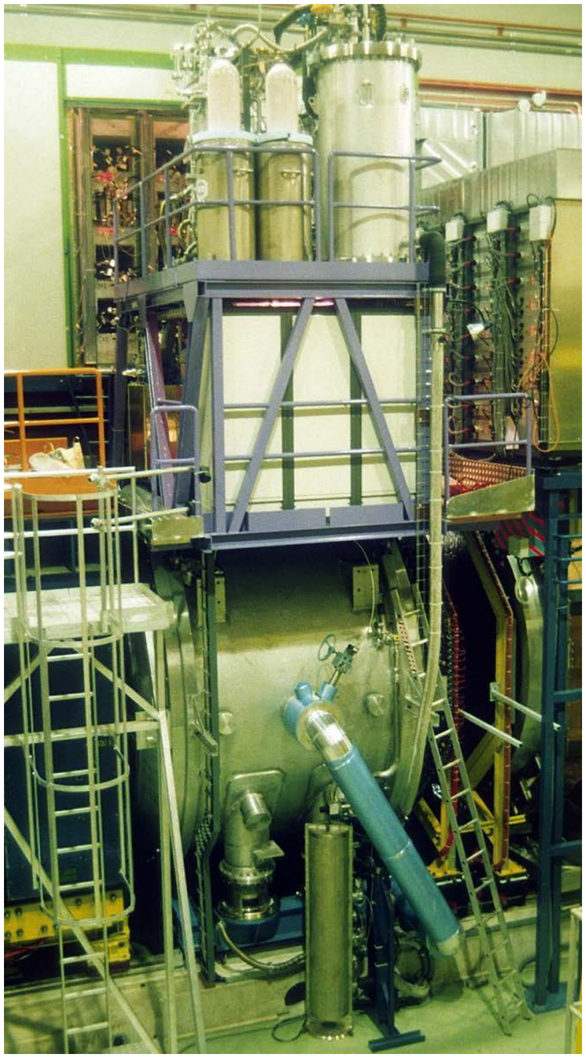
Fast Muon Veto's

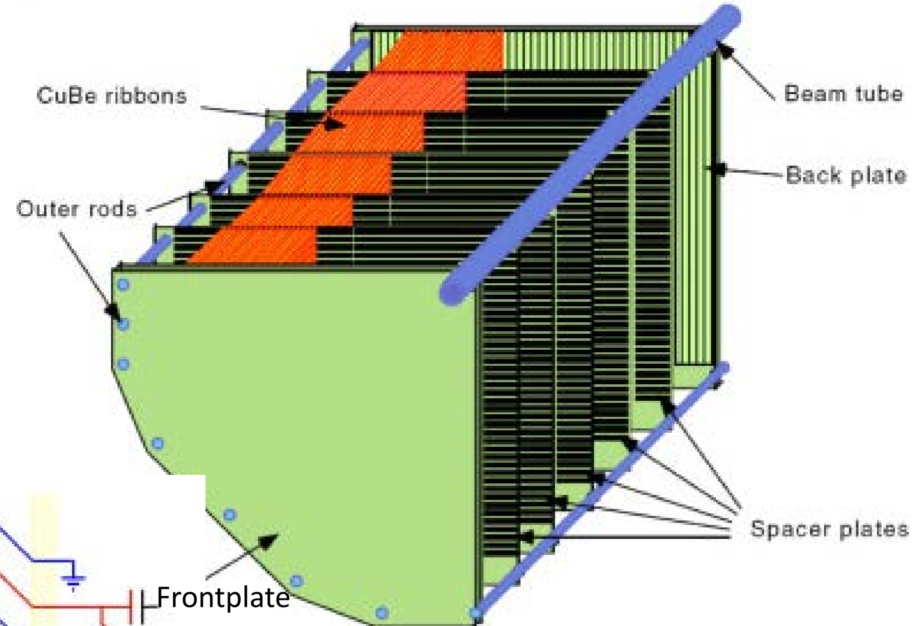


- Inefficiency for rejection of the π^0 must be at the level of 10^{-8}
- Photon detection inefficiencies between 10^{-4} and 10^{-5}

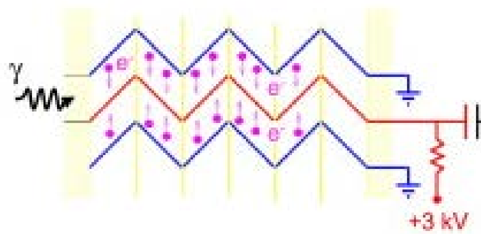
Large Angle Veto (LAV)

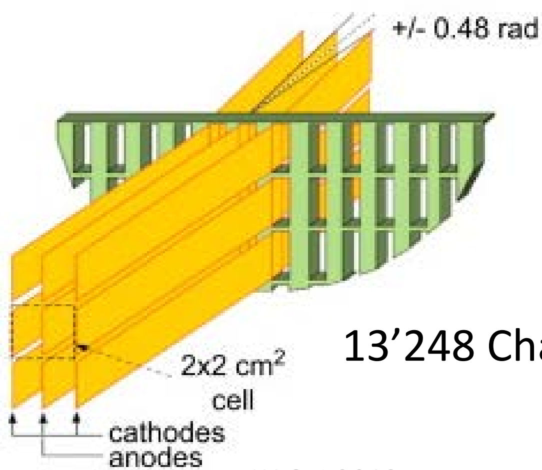
Liquid Krypton Calorimeter



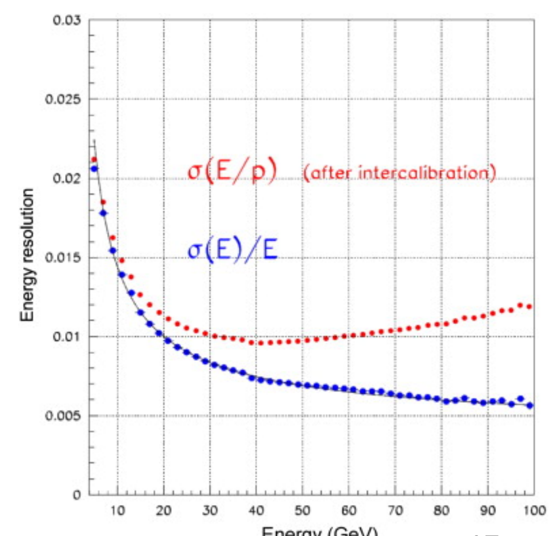


Read out cells:

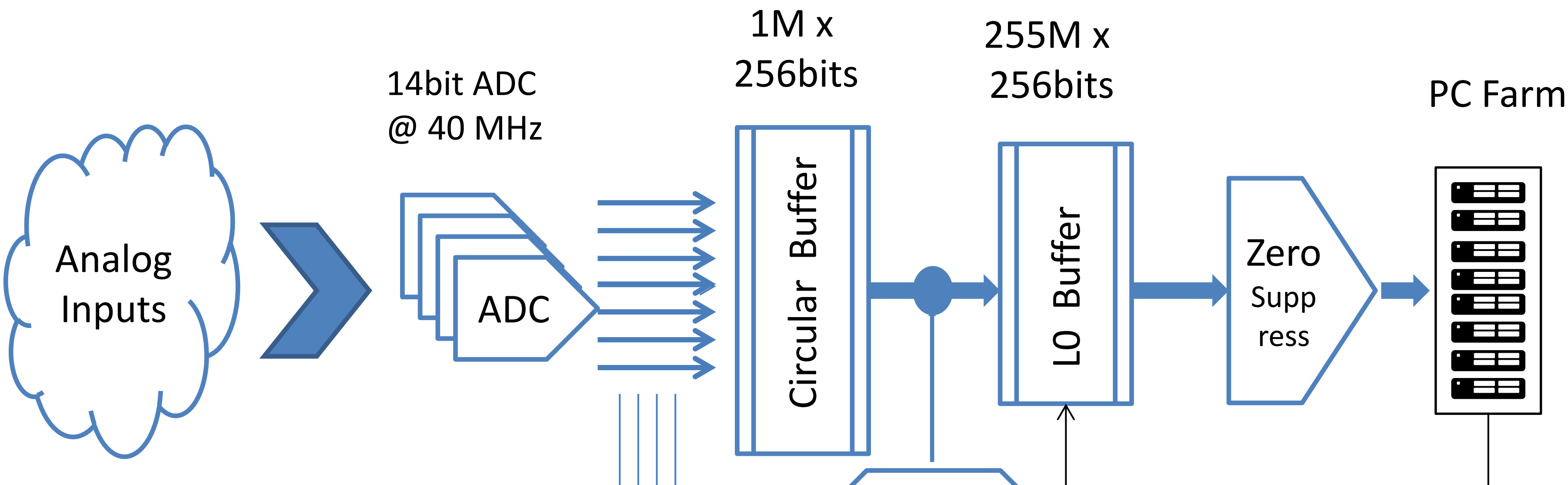


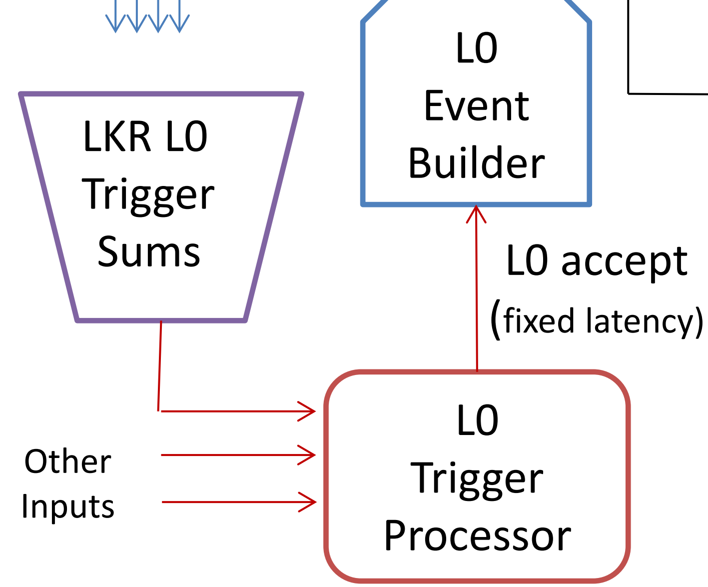


13'248 Channels



LKR CREAM Readout



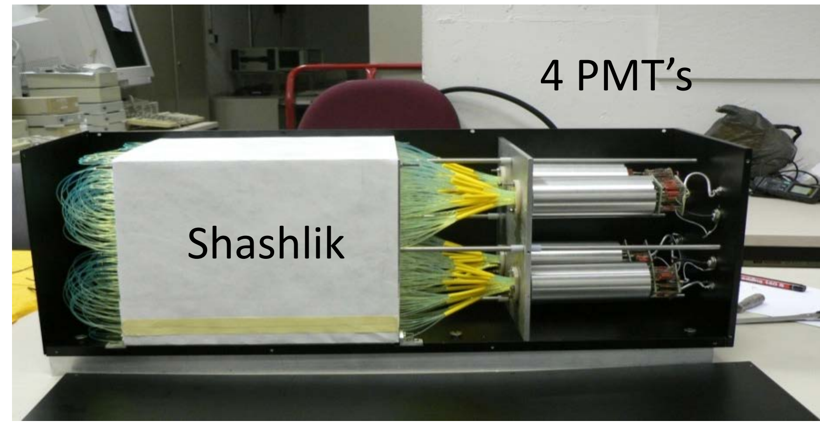


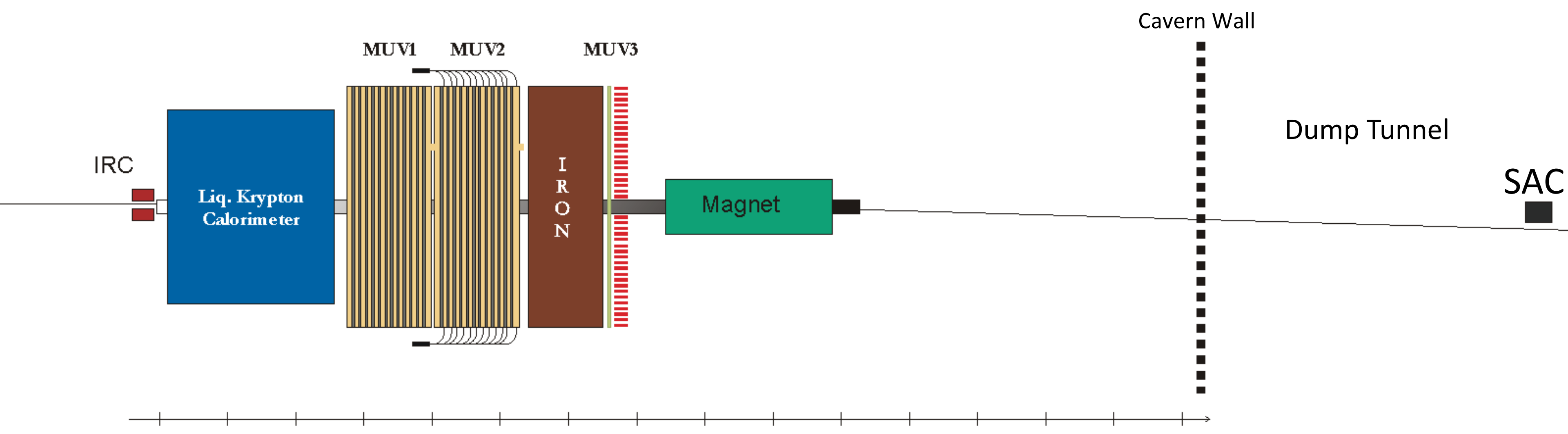
Small Angle Vetos (SAV)

Two Shashlik Calorimeters

IRC (lead absorbers)

SAC

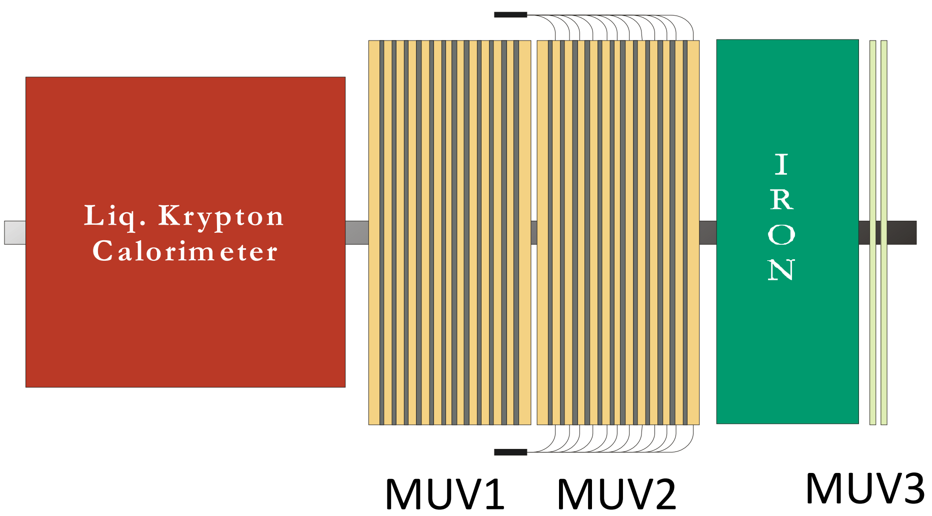




Muon Veto

Two functions: μ veto and hadron energy

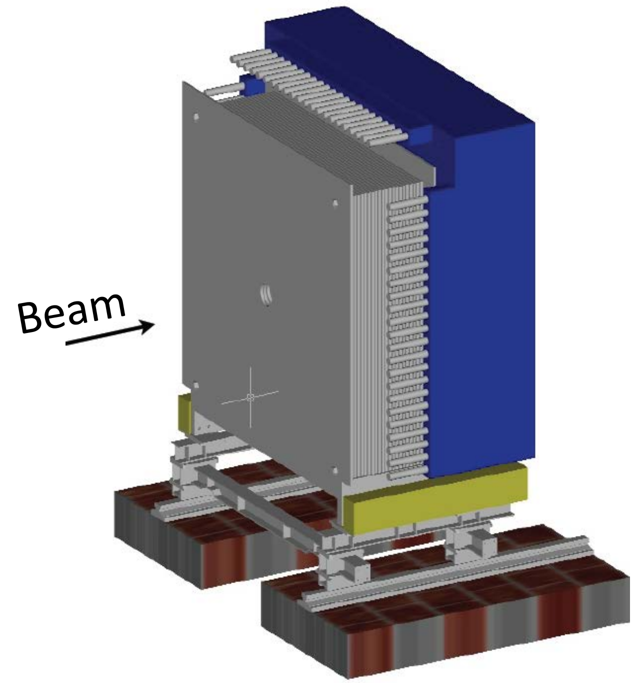
- Online
  - Muon Veto => MUV3
    - Requires very fast detector / time resolution $\sigma_T \leq 0.5$ ns
    - Reduce L0 trigger factor >10
    - 10 MHz Muon rate + coincidence window $\leq 5\sigma_T$ => dead time < 3%
  - Hadron Trigger (optional)
- Offline:
  - Muon identification
  - Energy of hadron showers
  - Target muon < inefficiency 10^{-7} (together with RICH)



Muon Veto

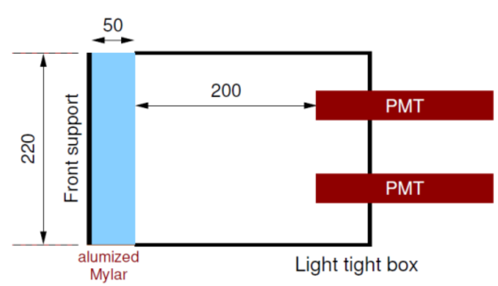
Detector Layout

MUV1+2



- **MUV 1 + 2** iron/scintillator sandwich
  - 24(MUV1) and 22(MUV2) detection layers
  - Alternating horizontal and vertical scintillator strips
  - PMT’s

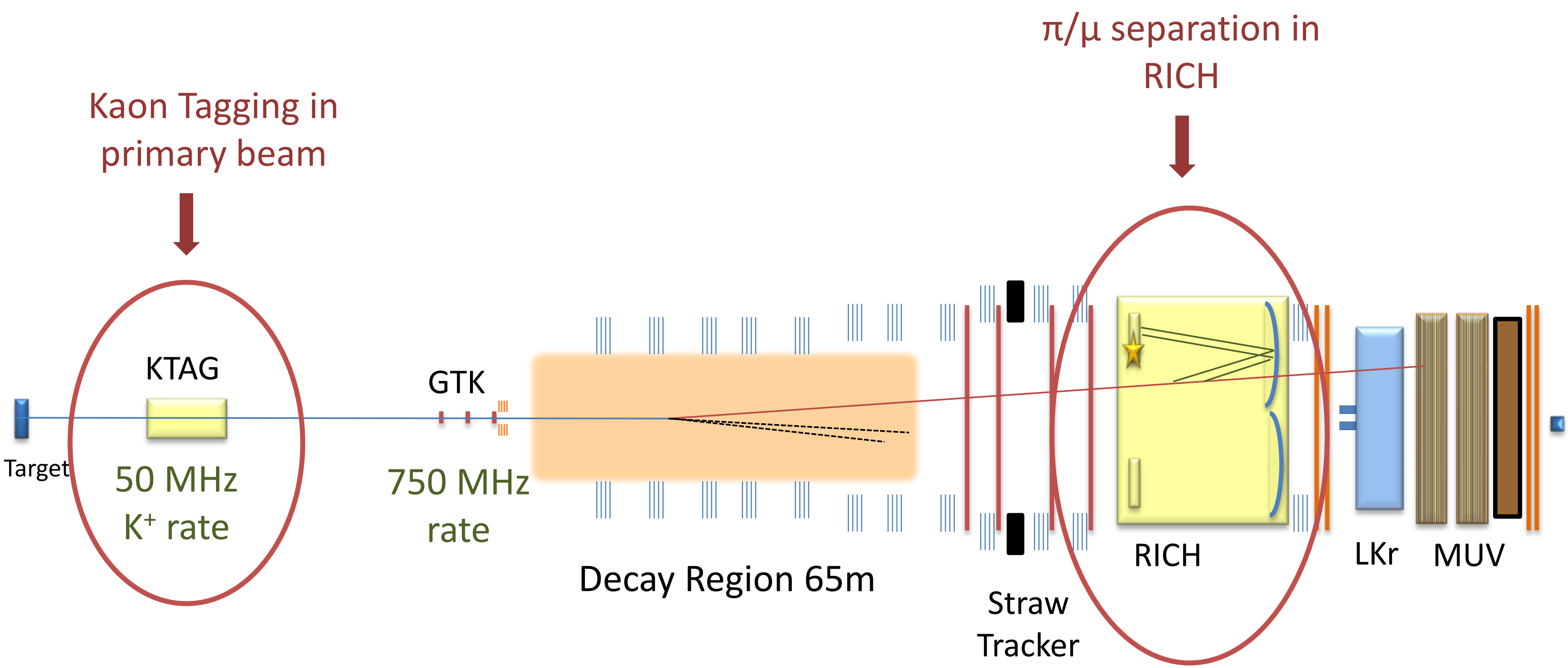
- **MUV3** (fast veto trigger)
  - After 80 cm of iron
  - Fast muon trigger
  - Tiles scintillators + PMT



$\sigma_T \leq 0.5$ ns

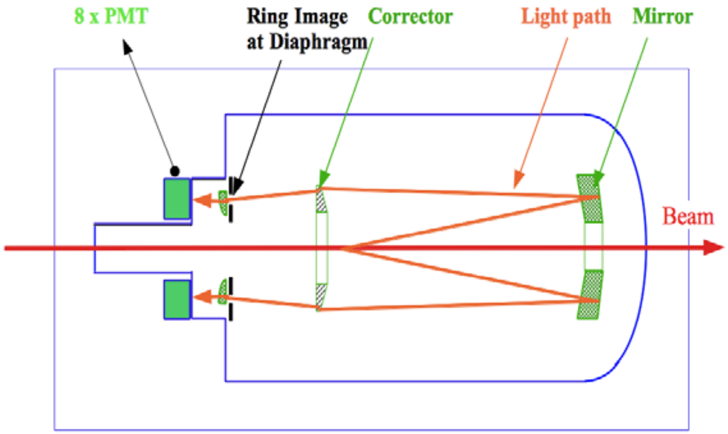
Four Principles of NA62

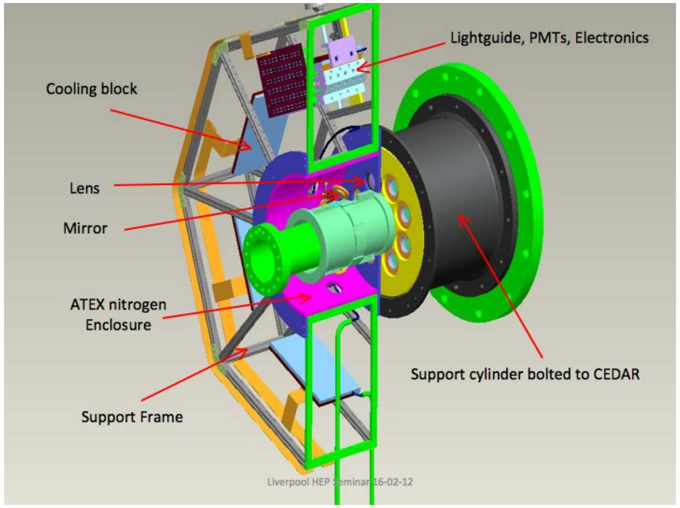
(4) Particle ID



KTAG (CEDAR)

Overview





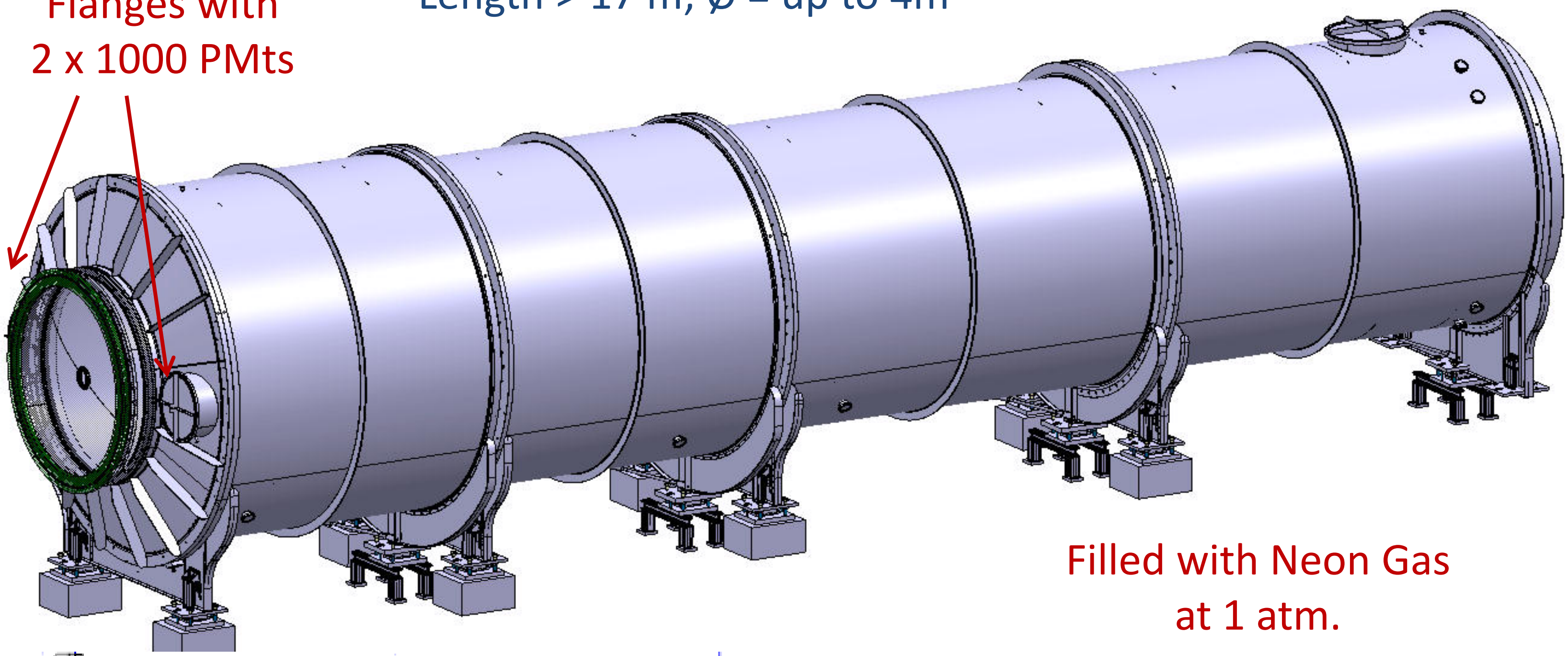
- The **KTAG** is a CERN CEDAR West with:
  - extended external optics
  - new photo-detectors
  - new readout
- Up to 512 PMT's

RICH Detector

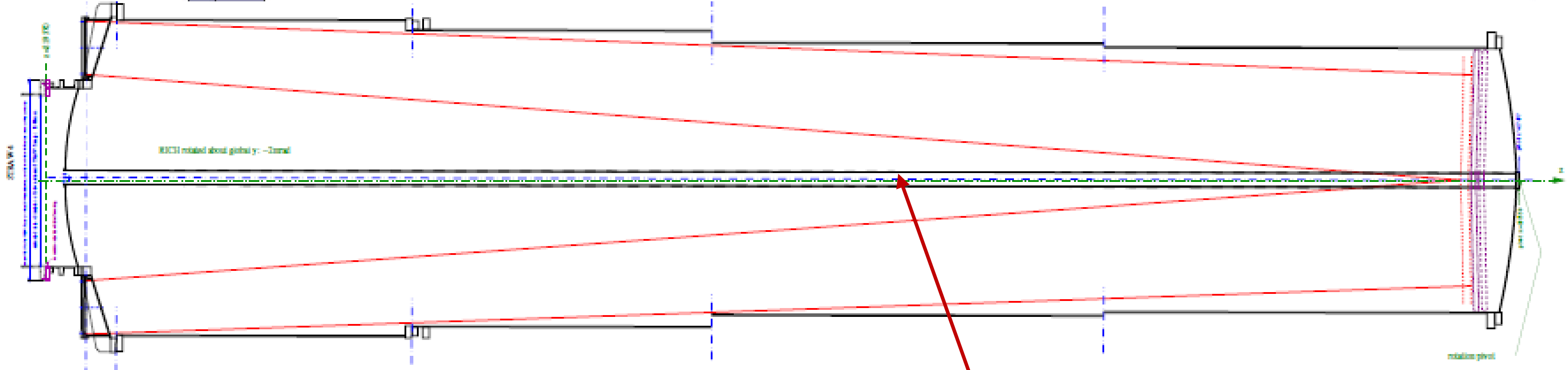
Length > 17 m; Ø = up to 4m

Flanges with
2 x 1000 PMts

Mirror mosaic



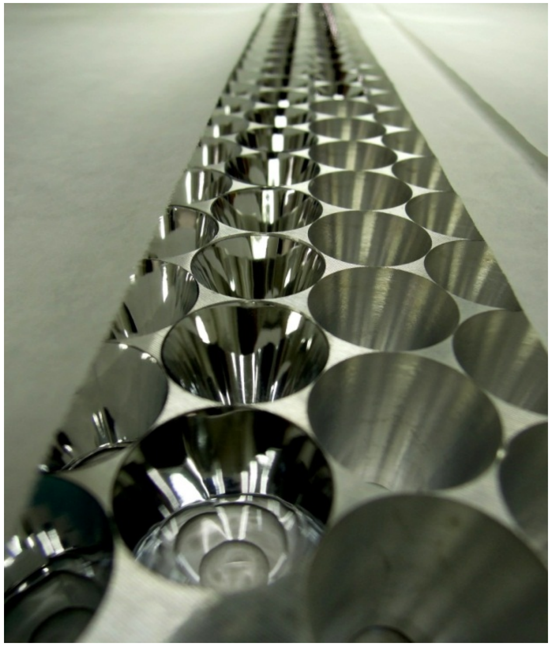
Filled with Neon Gas
at 1 atm.

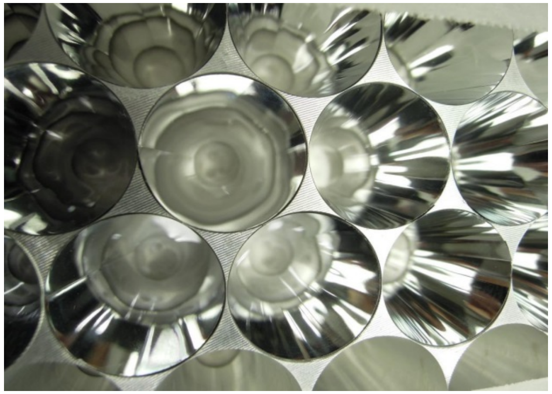


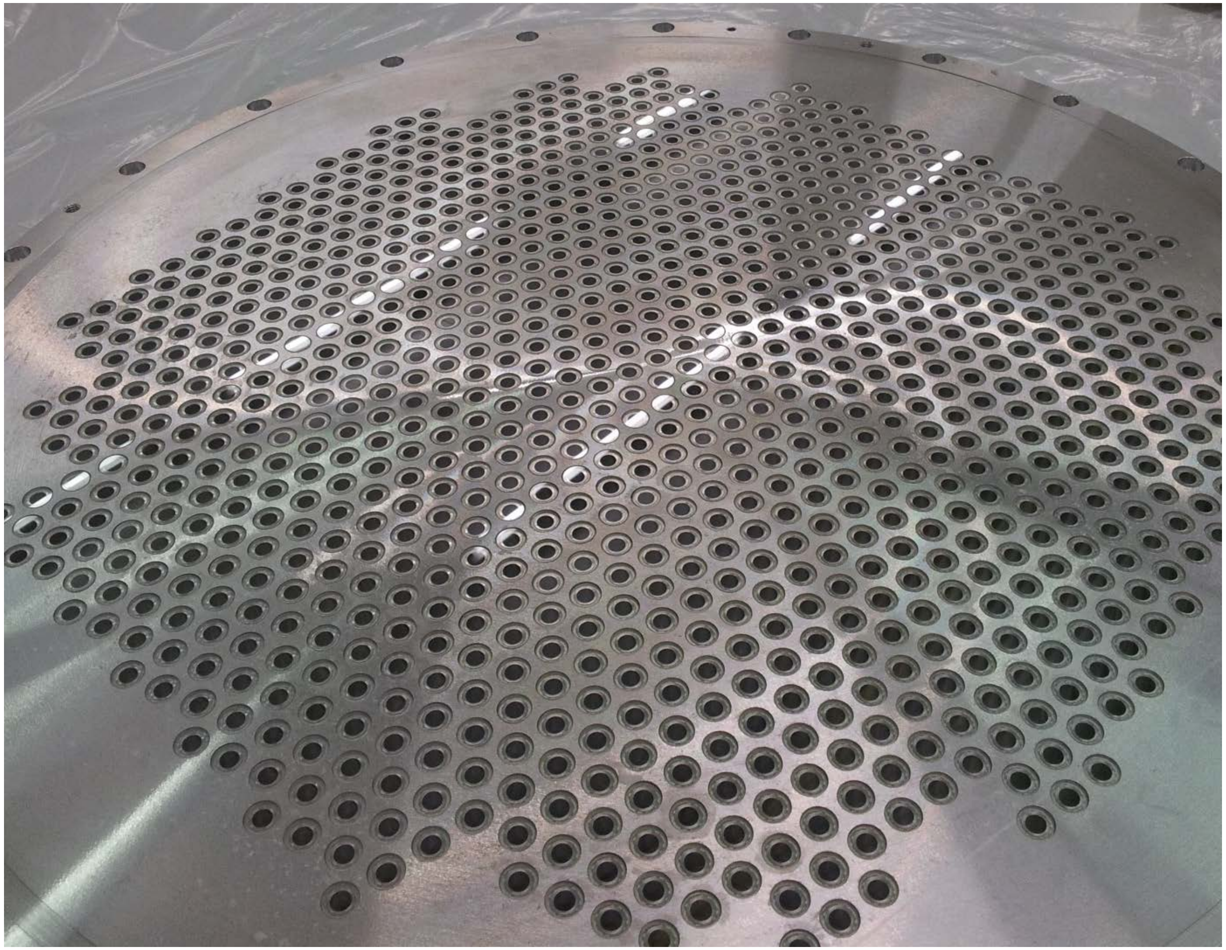
Beam Pipe

RICH Detector

Winston Cones and quartz windows







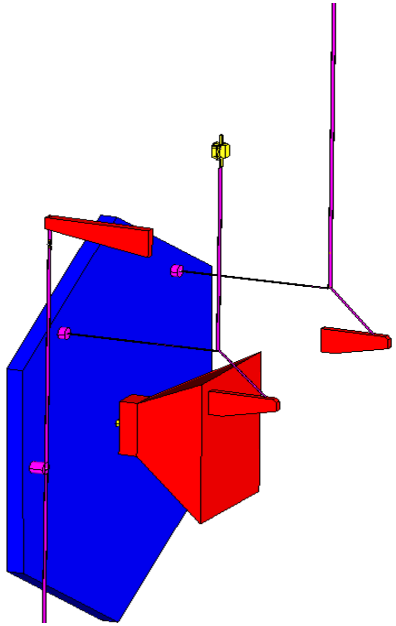
RICH Detector

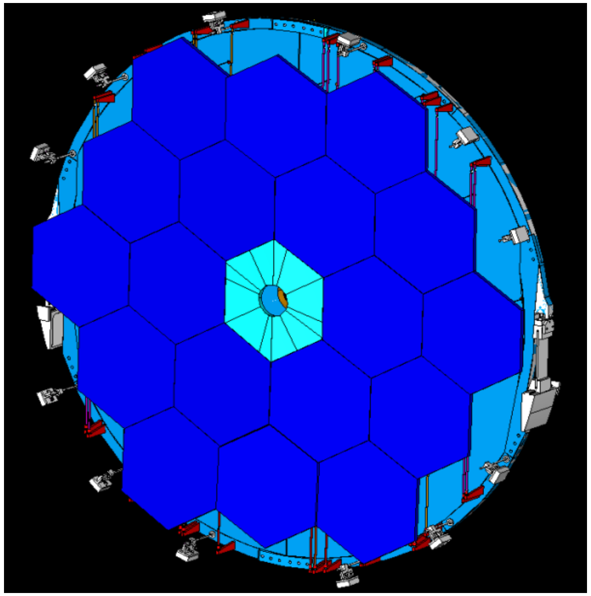
Mirror assembly

Mirror Assembly

– 18 hexagonal mirrors
– 2 half mirrors around the beam pipe.
– Online Alignment:

  The inclination of the 18 hexagonal mirrors is remotely adjustable using piezo-micrometric actuators

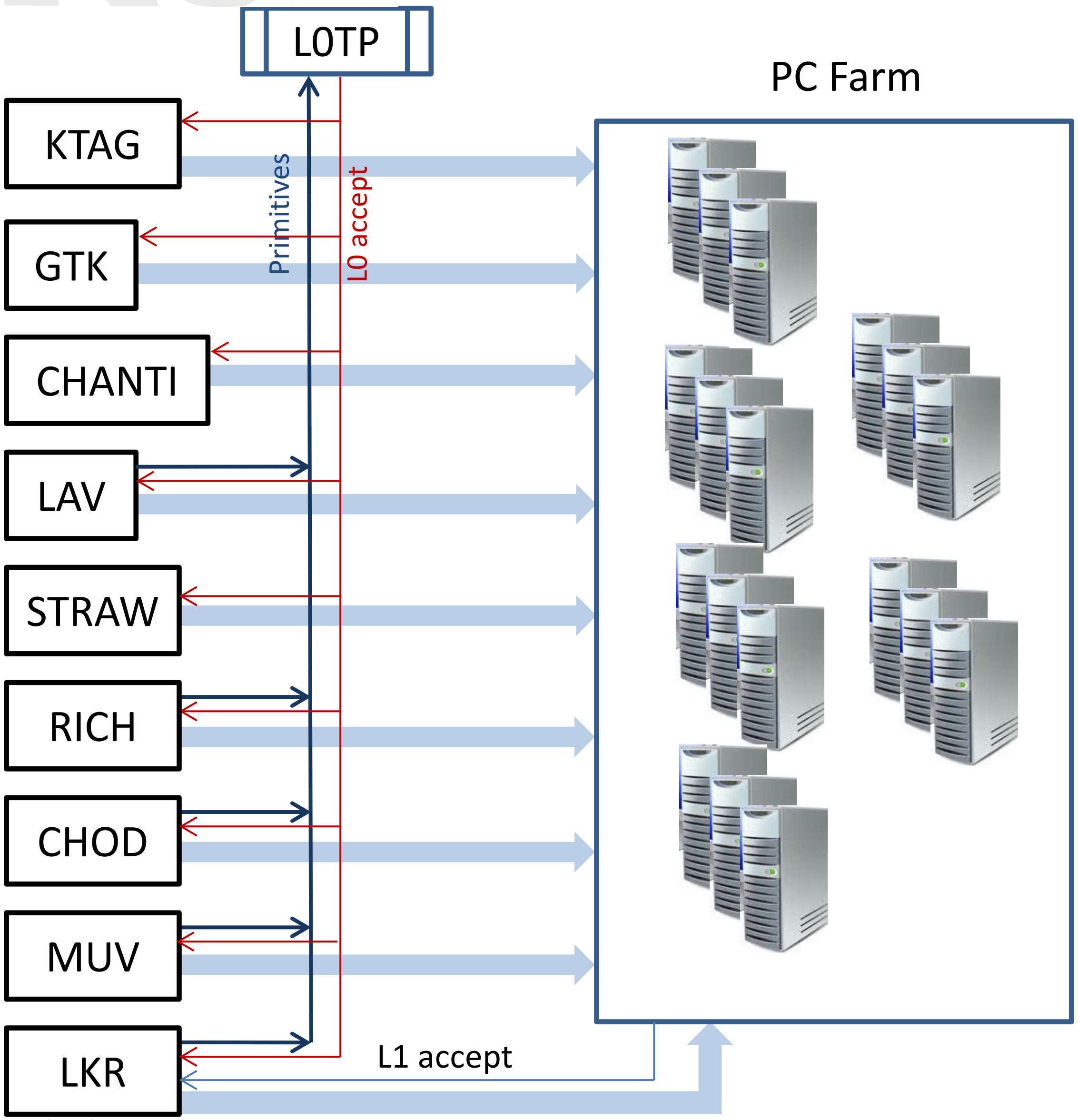




Mirror Parameters + Quality:

- Spherical mirrors f= 17±0.1 m
- Reflectivity > 90% (195 – 650nm)
- $D_o \leq 4$mm (circle which collects 90% of the reflected light.)

Trigger and Data Acquisition



L0 trigger

- rate ≤ 1 MHz
- Min Δt for L0 = 75ns
- Synchronized L0 accept fixed latency (1-10ms)

L1 trigger

- rate ≤ 100 kHz
- Max. latency 1 s

L2 trigger

- rate ≤ 15 kHz
- Spill length ≈10 s

Conclusions

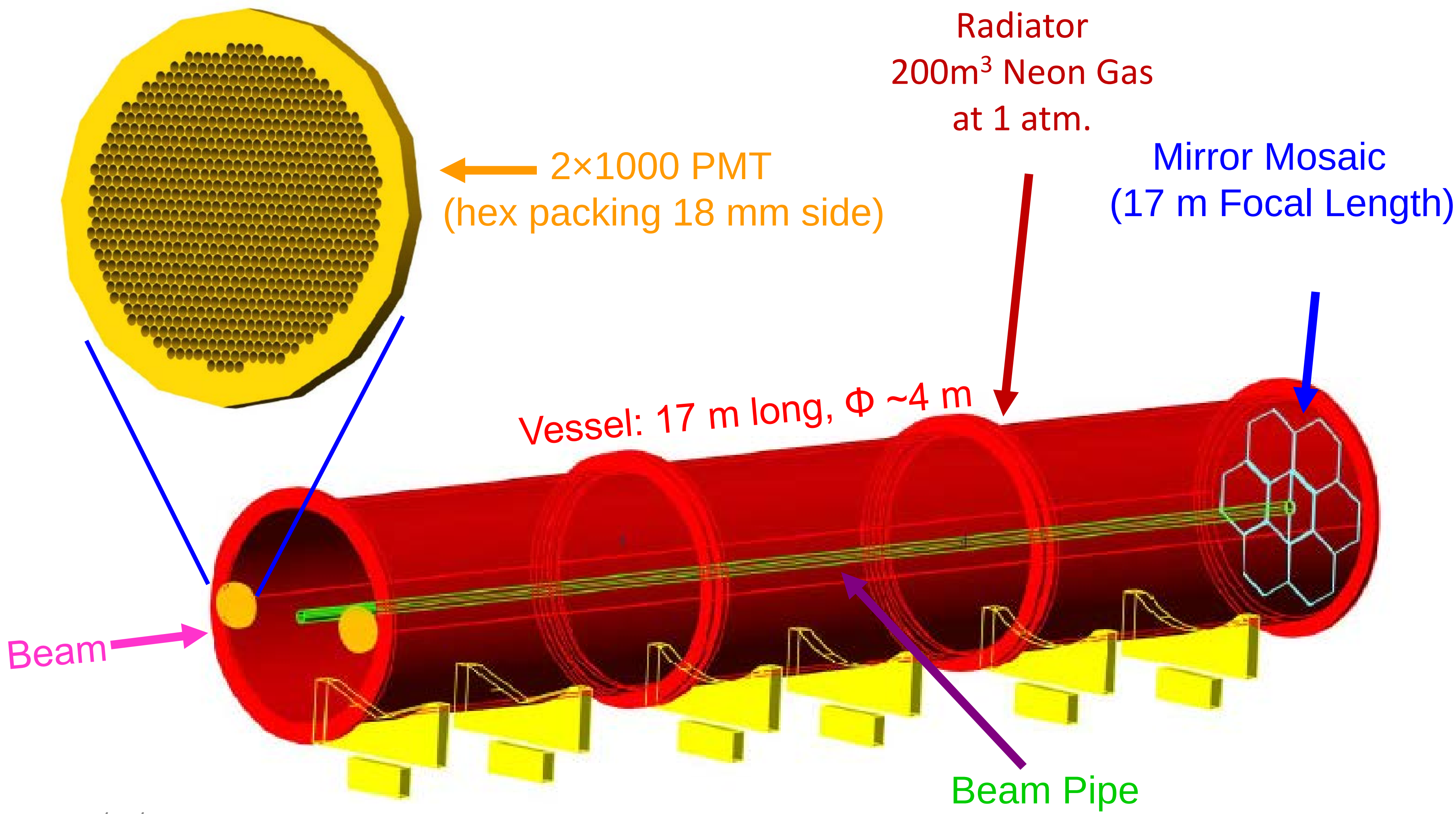
- The Construction and Installation of the NA62 detectors is in full swing.
- The Technical Run in fall 2012 was very successful and the experience extremely valuable for the collaboration
- We look forward to take data with the full detector in fall 2014.

Thank you

Additional Material

RICH Detector

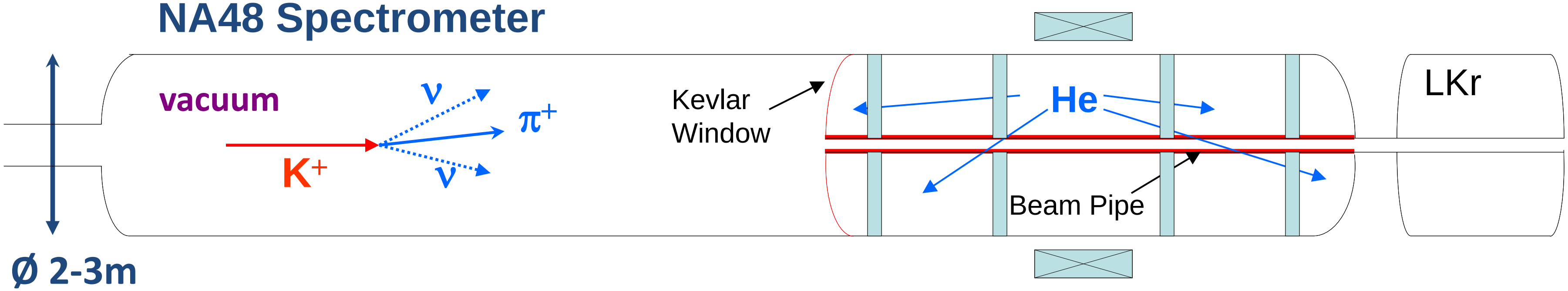
Schematic Visualisation



Compare NA48 versus NA62

Spectrometer Material ≈ 2.8% of X_0 (without beam pipe)

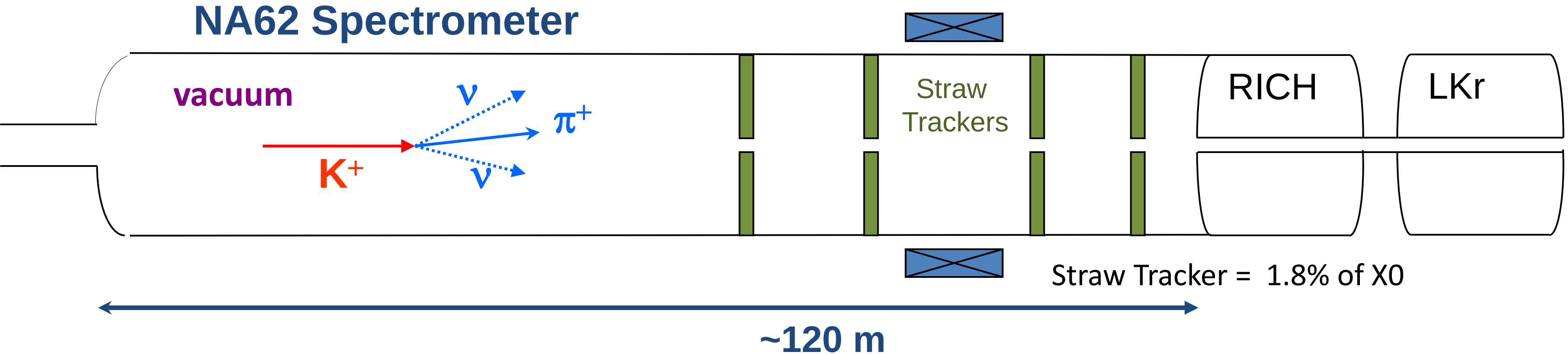
NA48 Spectrometer



The Straw Trackers operated in vacuum will enable us to:

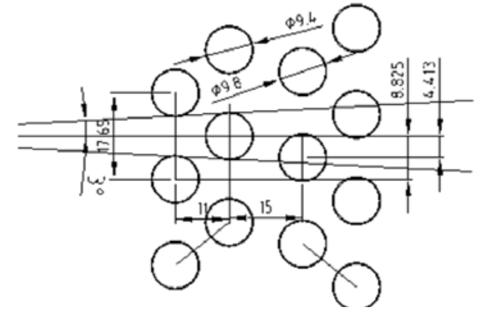
- Remove the multiple scattering due to the Kevlar Window
- Remove the acceptance limitations due to the beam-pipe
- Remove the helium between the chambers

NA62 Spectrometer

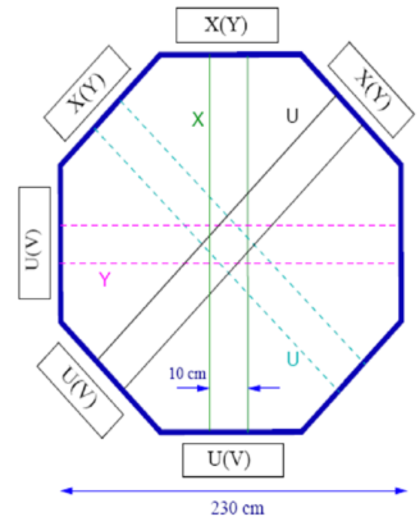


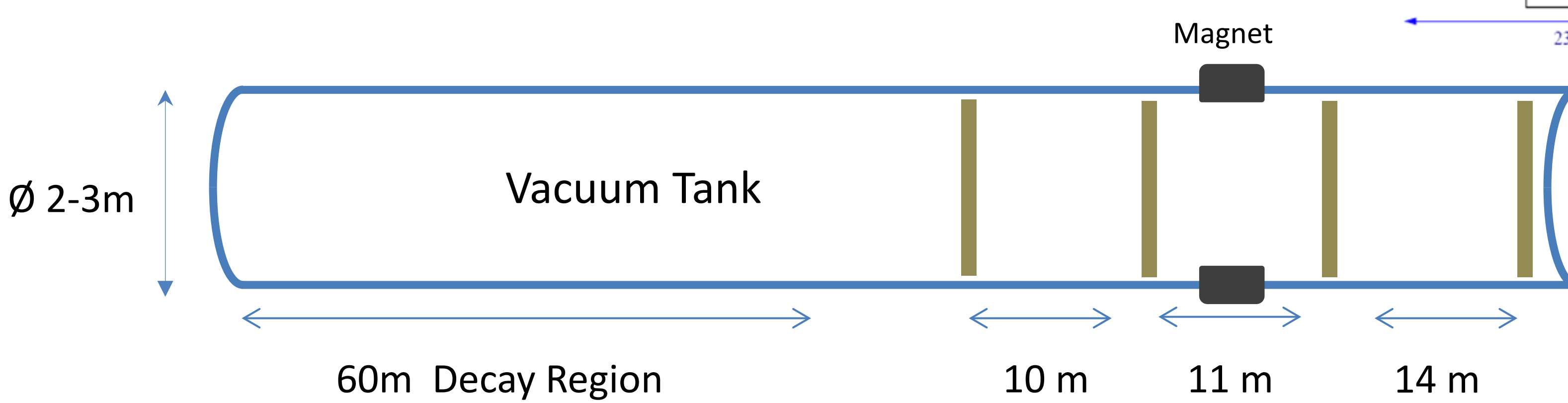
Straw Tracker

X-section of
1 View

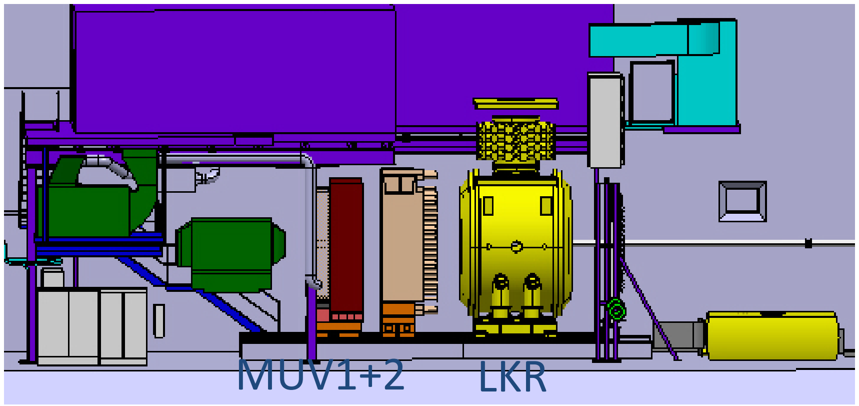


- Ultra-thin Straws installed in Vacuum
- 4 Chambers each measures 4 coordinates (views)
- High accuracy (130μm per View)
- High efficiency

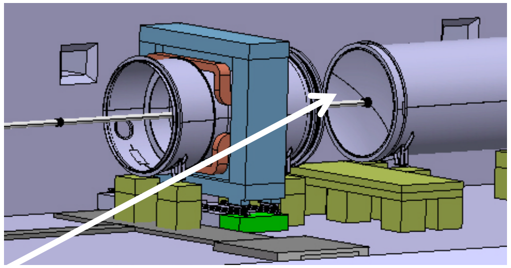




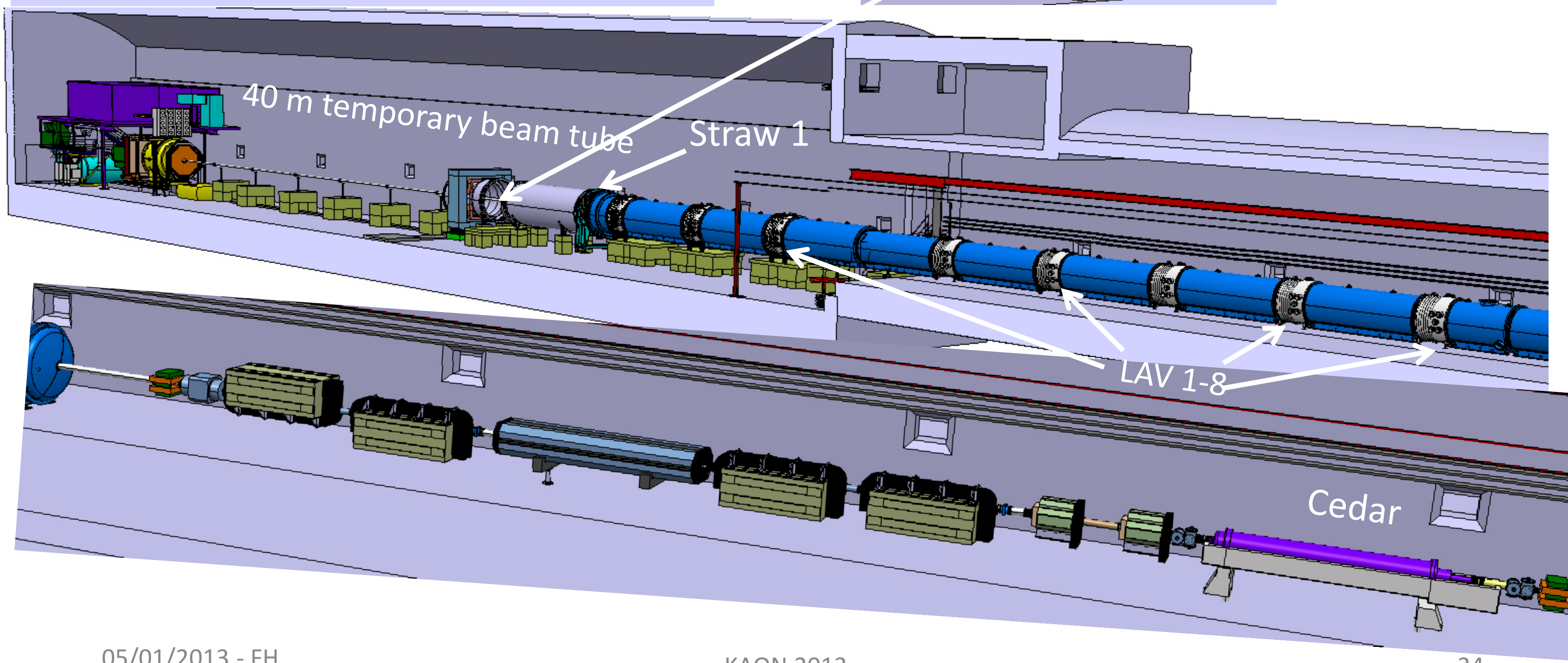
Illustrations of the 2012 Layout



from Olivier Jamet



Al-window to close vacuum tank

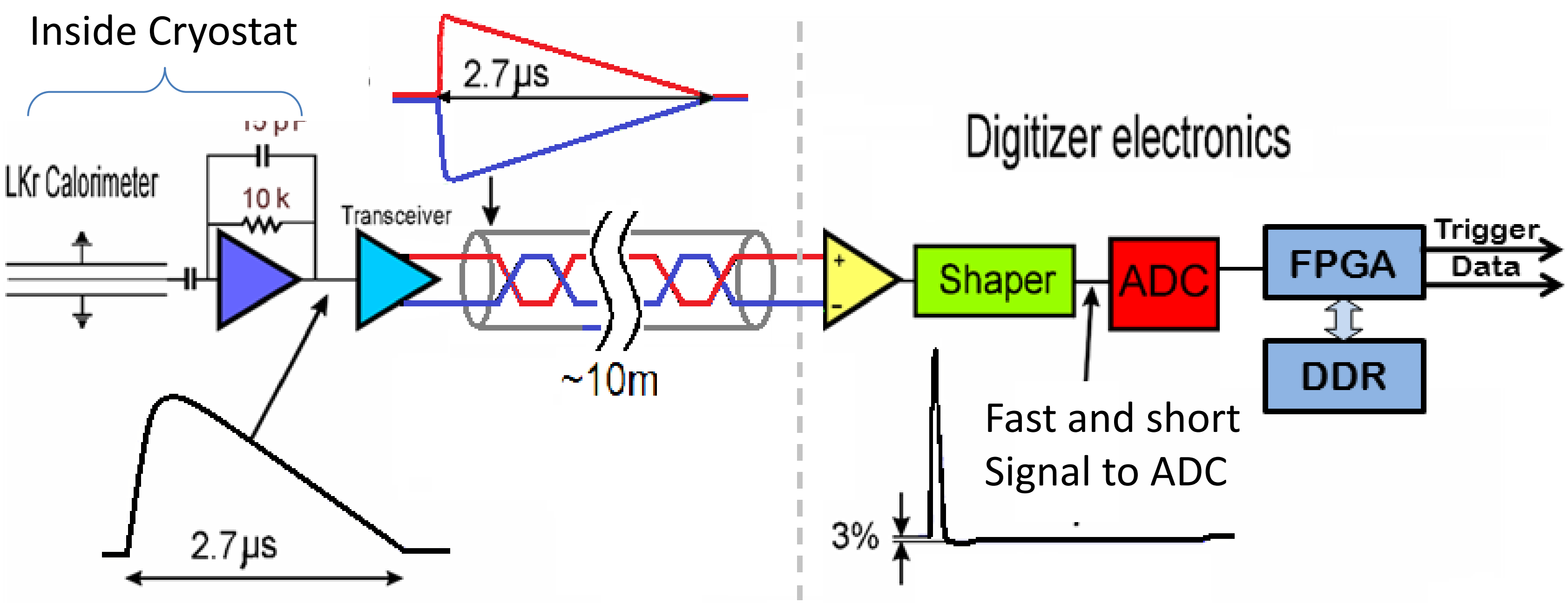


LKR Readout

New requirements:

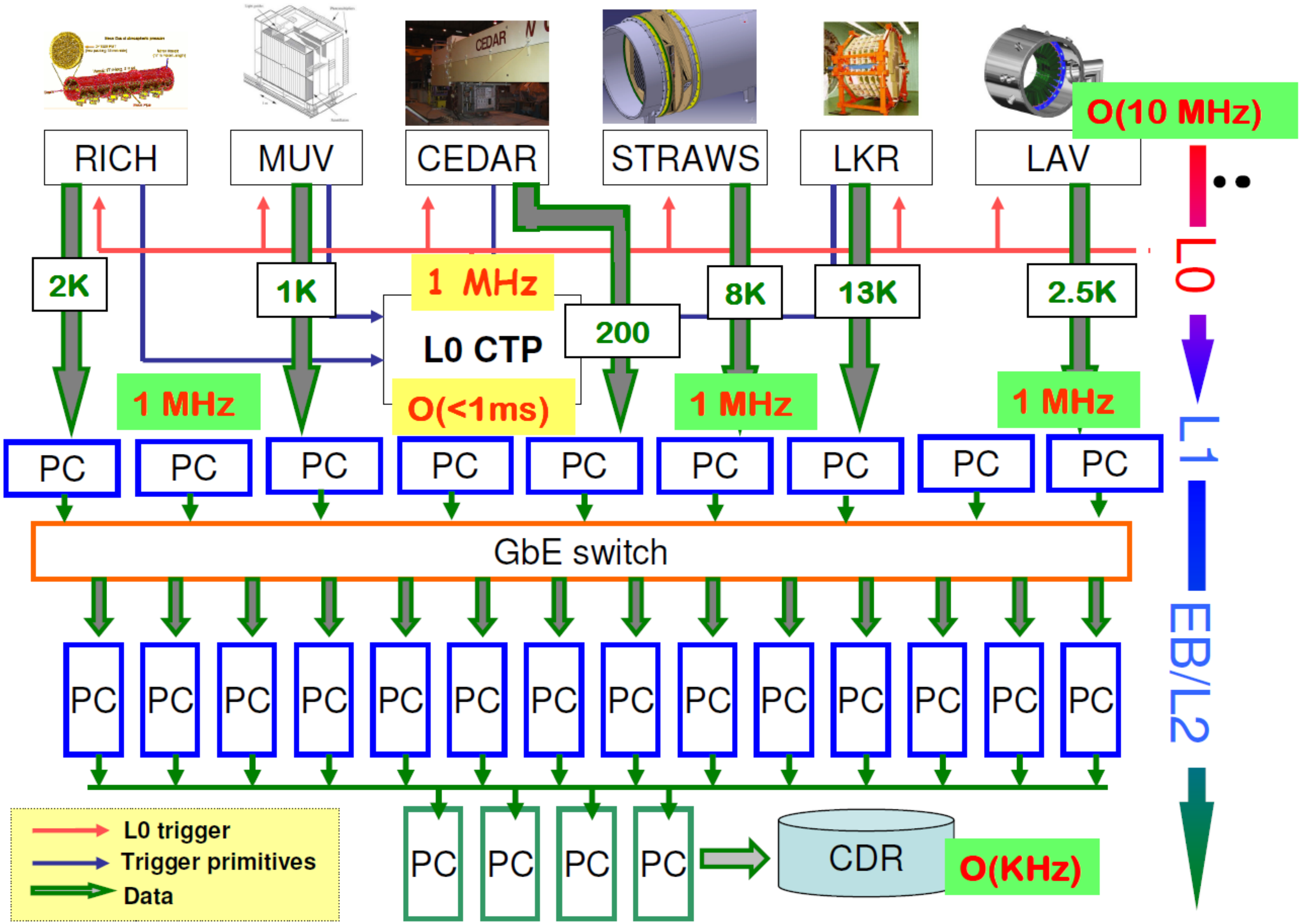
- Photon detection inefficiency < 10^{-5} for energies > 35 GeV
- Rate capability increased from to 1 MHz

Front-end **Back-end**



- 32 channels / CREAM board
- 14bit ADC @ 40 MHz -> 4/board
- Full system ≈ 500 boards

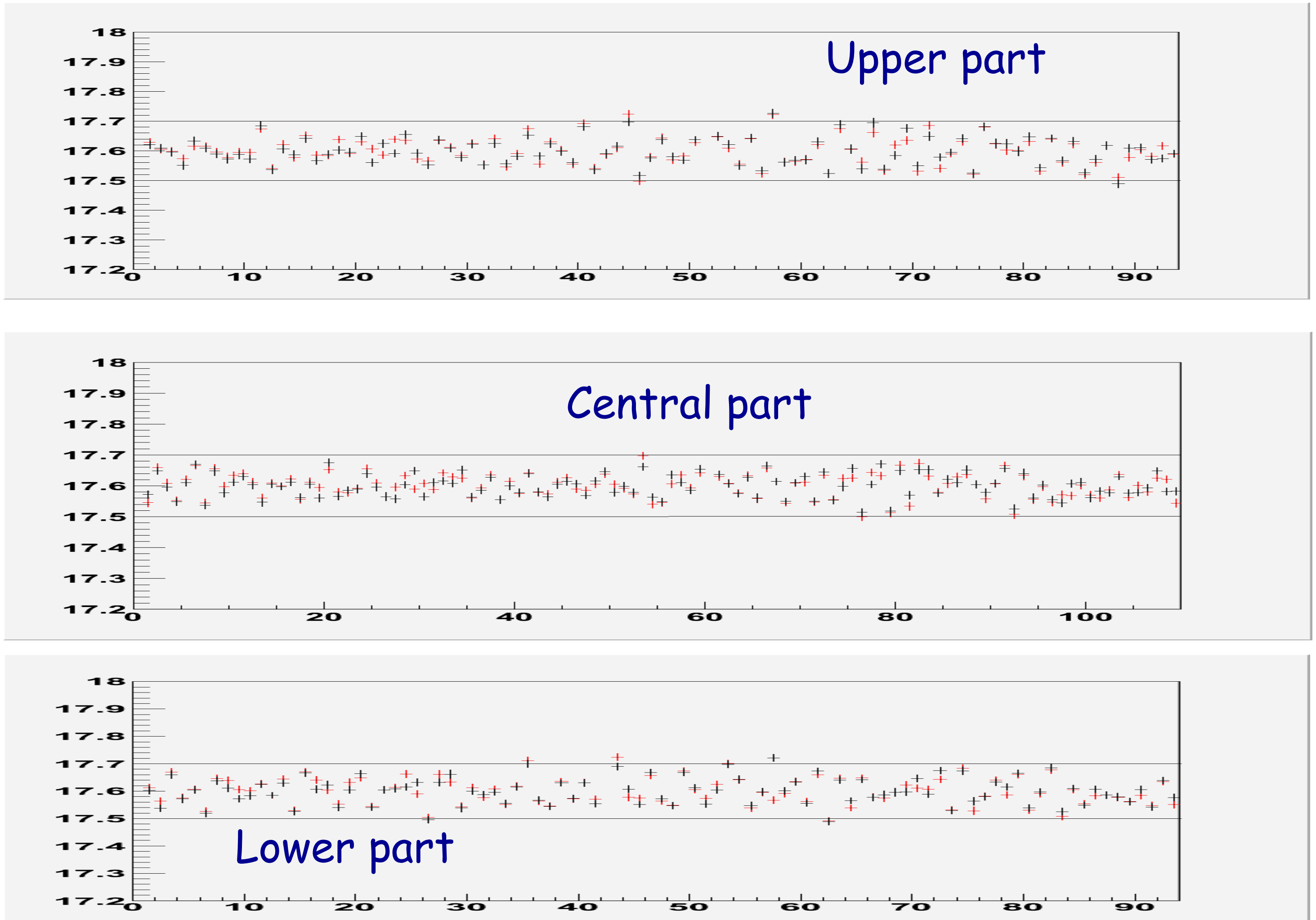
NA62 TDAQ - OVERVIEW



Precision of the Straw positioning

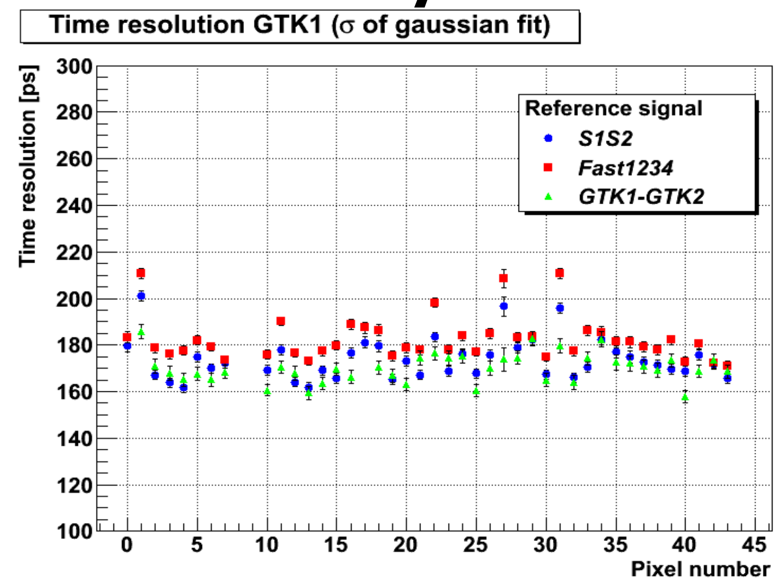
Layer 2, Module 3

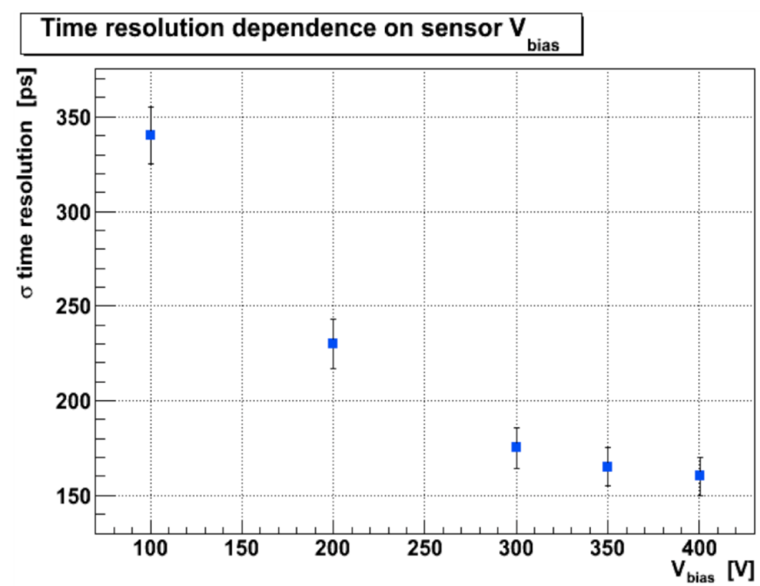
mm



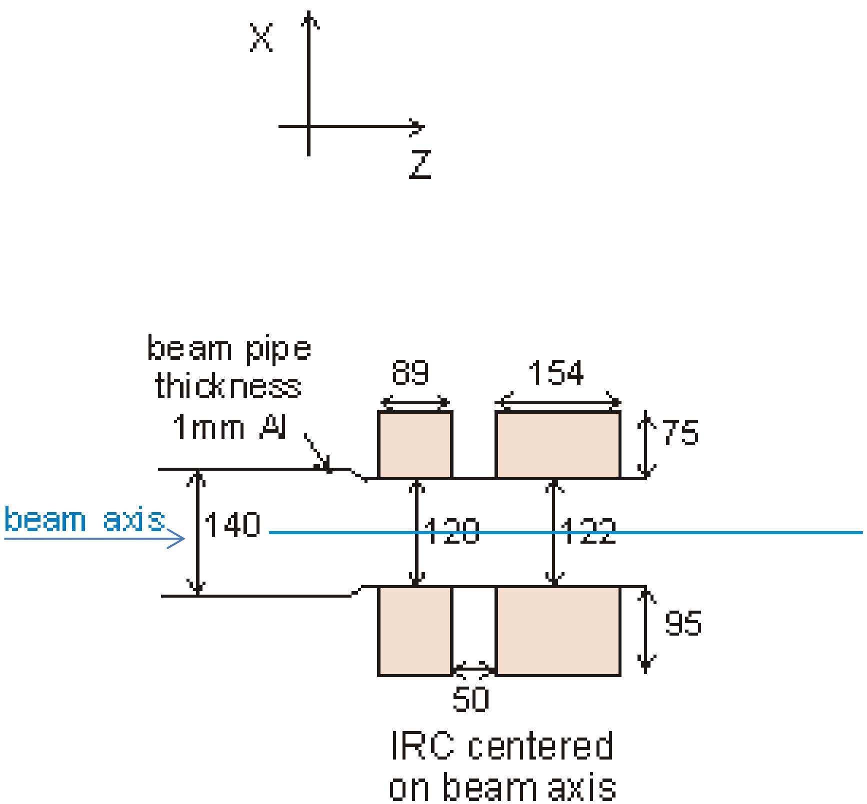
GTK: Test Beam Analysis

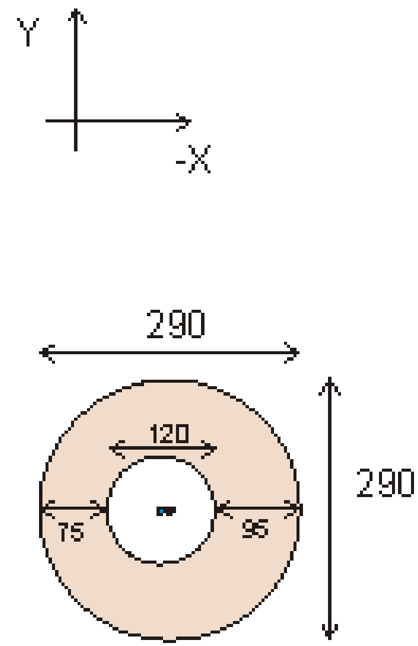
- Refined analys confirms a resolution of better than 200 ps per hit for sensor bias voltages higher than 300 V
- Time-walk correction and alignment procedures have been validated with real data
- Clear dependence of time resolution on sensor bias voltage
- The operation at 300 V over-depletion is mandatory
- Paper on test-beam results under preparation



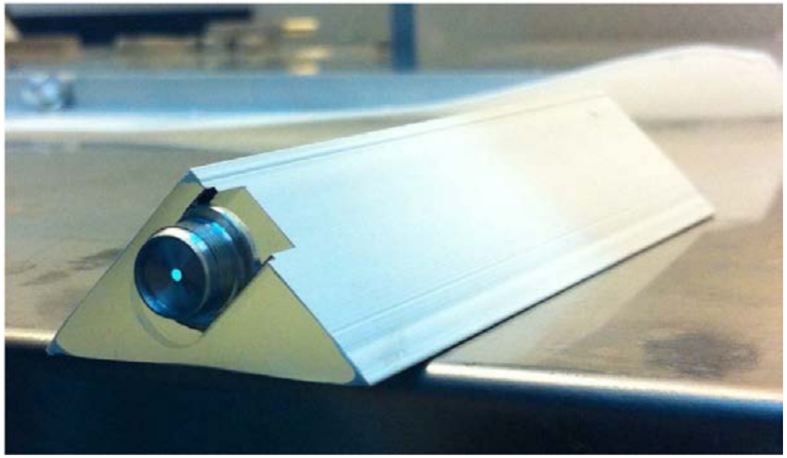


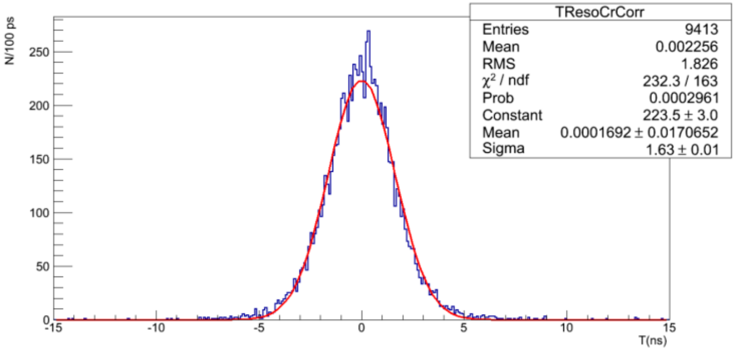
IRC


X
Z
beam pipe thickness 1mm Al
89
154
75
beam axis
140
120
122
95
50
IRC centered on beam axis


Y
-X
290
120
290
75
95

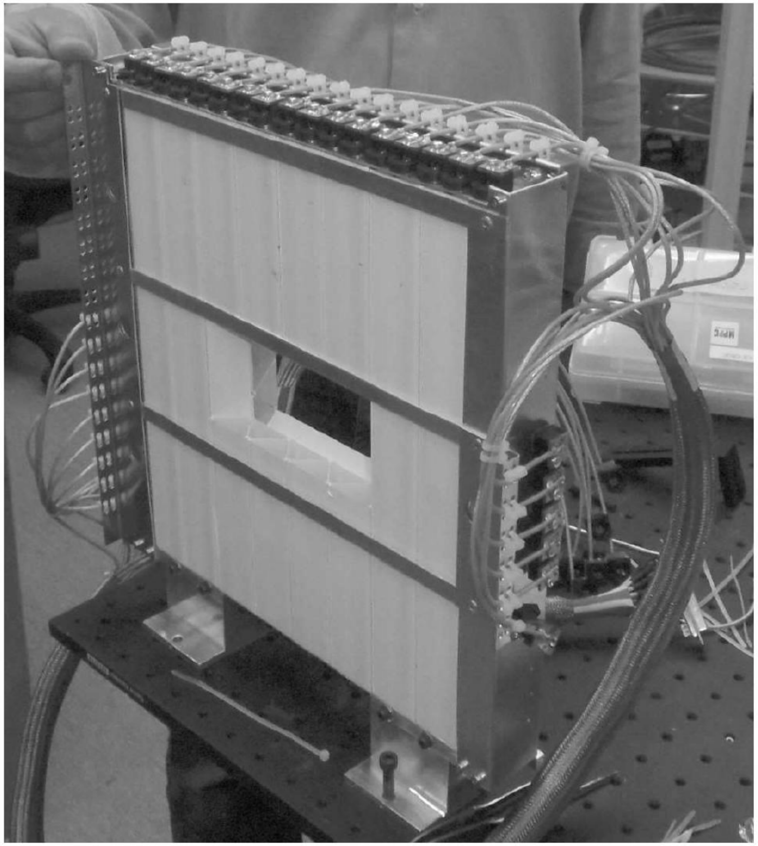
CHANTI





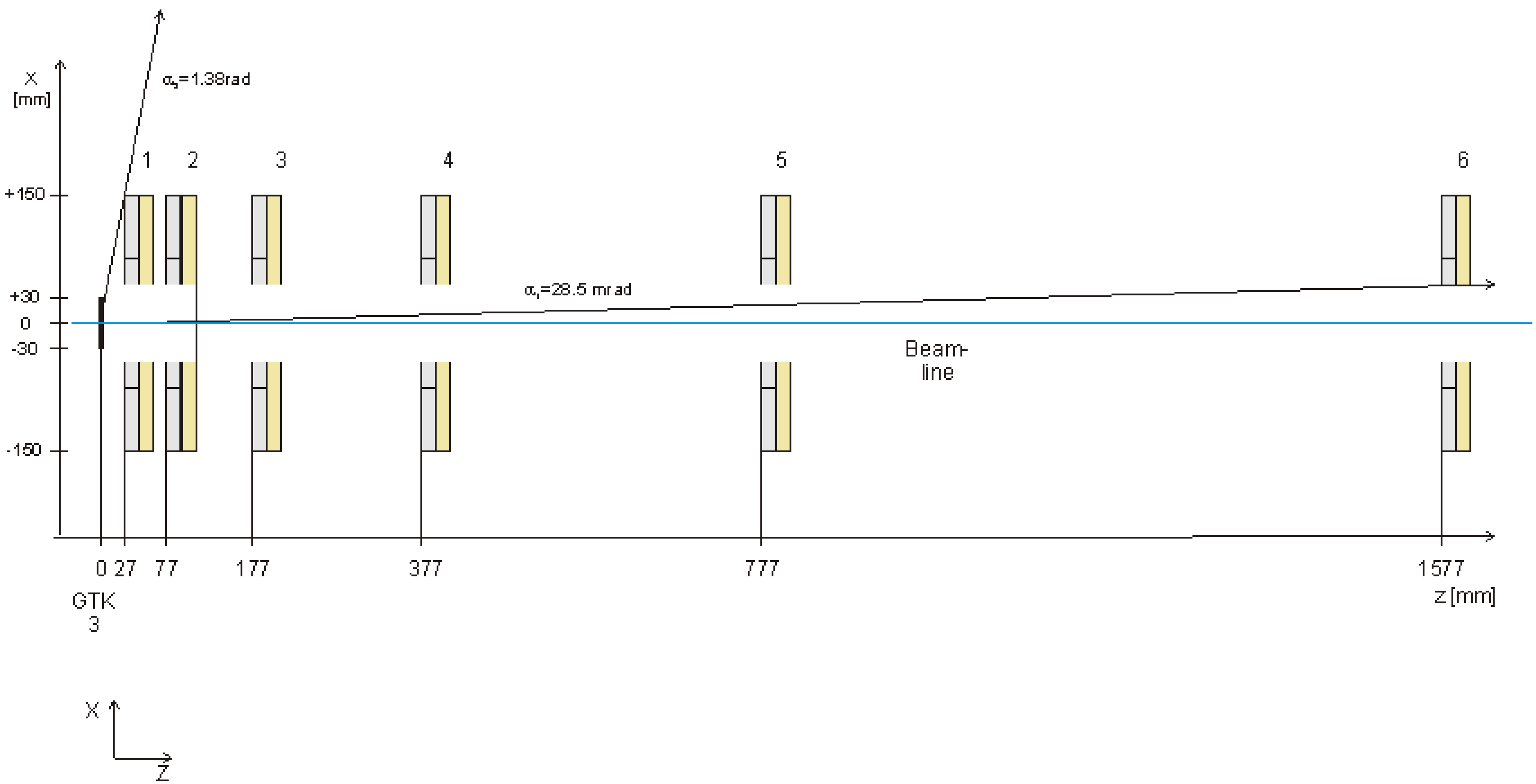
Time difference between two fired bars during the TR

One CHANTI station



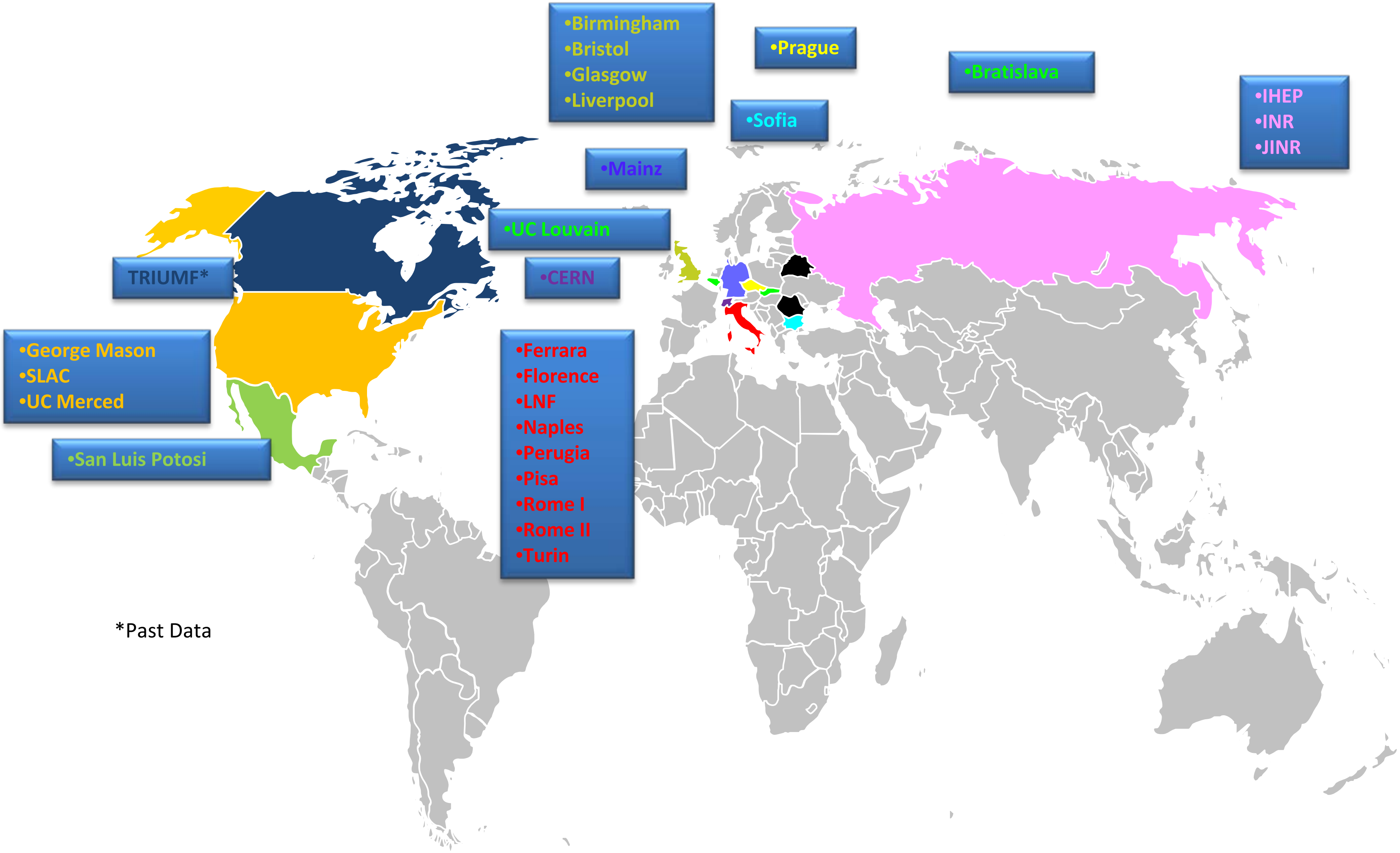
The CHANTI detects the charged particles produced by inelastic interactions in GTK3

CHANTI



X
[mm]
α_s=1.38rad
1
2
3
4
5
6
+150
+30
0
-30
-150
α_l=28.5 mrad
Beam-
line
0 27
77
177
377
777
1577
z [mm]
GTK
3
X
Z

The NA62 Collaboration



*Past Data