RPCs for an atmospheric neutrino experiment

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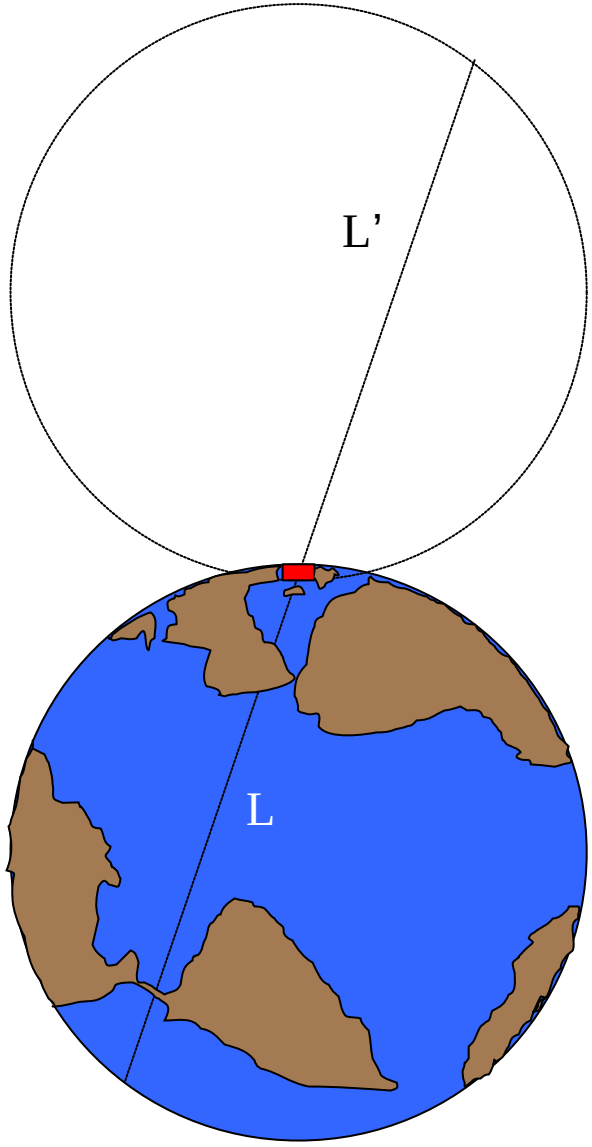
- Detector General Layout
- RPC
- GSC
- Costs
- Possible Readout
- Possible Solutions on Detector Assembling
- Conclusions

The Measurement I



Atmospheric neutrino energy > 1.3 GeV ? $m^2 < 10^{-2}$ eV^2

Downward muon neutrino are not affected by oscillation

They may constitute a *near* reference source

Upward neutrino are instead affected by oscillation since the L/E ratio ranges up to ??^{4} Km/GeV

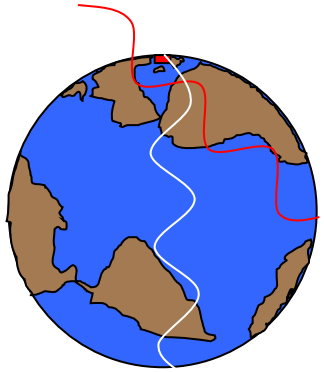
They may constitute a *far* source

Oscillation studies with a single detector and two sources

$$\frac{N_{up}(L/E)}{N_{down}(L'/E)} = P(L/E) = 1 - \sin^2(2?)\sin^2(1.27\,?\,m^2\,L/E)$$

The results are not sensitive to calculation of atmospheric fluxes

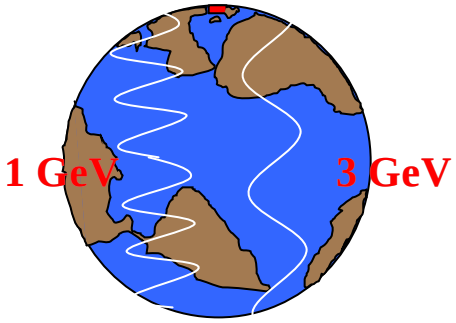
The Measurement II



The survival probability is modulated with a lambda

? ? ?? ? ?(GeV) / (??? ? m^2 ??? ?? ?? ? / ? m^2

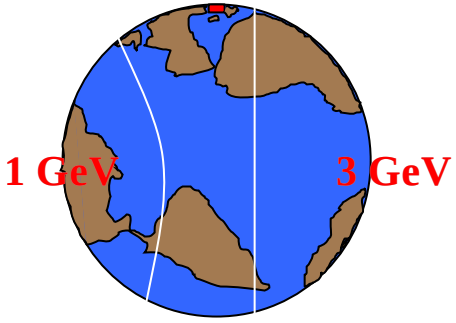
For ? m^2 =5x10^{-4} eV^2 and E=1 GeV ?? **5000 Km**



For ? m^2 =1x10^{-3} eV^2

?? **2500 Km**

?? **7500 Km**



For ? m^2 =1x10^{-4} eV^2

?? **25000 Km**

?? **75000 Km**

Choice of the Detector

The energy **E** and direction ? of the incoming neutrino must be measured in each event.

The **L(?)/E** value obtained should have an error smaller than half of the modulation period.

Leaving aside oscillations involving $?_e$ (see Superkamiokande, Macro, Chooz)

a detector with high efficiency on ? ?? ?rejection is required.

Large mass & high density tracking calorimeter with horizontal sampling planes.

E by range measurement for fully contained events

E by tracking in magnetic field for no-contained events

L(?) by tracking

Up/Down by time of flight (plus vertex identification)

A **Monolith** with 120 iron planes 8 cm thick and 12x32 m^2 surface with sensitive elements with RPC housed in a 2cm gap

A total mass of 35 KTon with 60,000 m^2 of detector with 3cm pitch readout

Disappearance of muon neutrinos

All the events not fully contained in a fiducial volume (85%) is rejected.

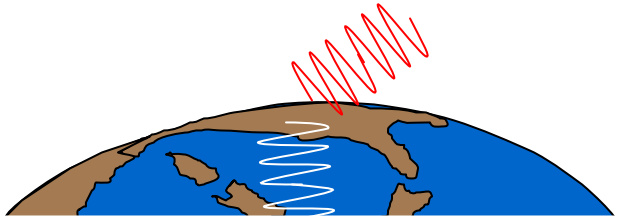
Events are retained if a muon is identified with a minimum energy of 1.3 GeV with at least seven layer fired.

Events are retained if the relative error on L/E < 50%

Selection of 7 events kTon $^{-1}$ y^{-1} (20% of total rate of ?$_{??}$with E>1 GeV)

? m^2 and sin2? measurable in the range 10^{-4} : $5{\cdot}10^{-3}$ using upward neutrinos

Only sin2? measurable in the range $5{\cdot}10^{-3}$: 10^{-2}



? m^2 and sin2? measurable at few 10^{-2}

using downward neutrinos and fully oscillated upward neutrino as flux reference !

Requirements

Detector requirements

Massive detector 35 Kton
Large detector surface ~ 60000 m^2
Tracking resolution ~ 3 cm (X and Y coordinate)
Time resolution < 2 ns (for asymmetry upward/downward)

⇩

Resistive Plate Counter

Mechanical requirements

35 Kton detector have to be built in a "short time" (2.5 years)

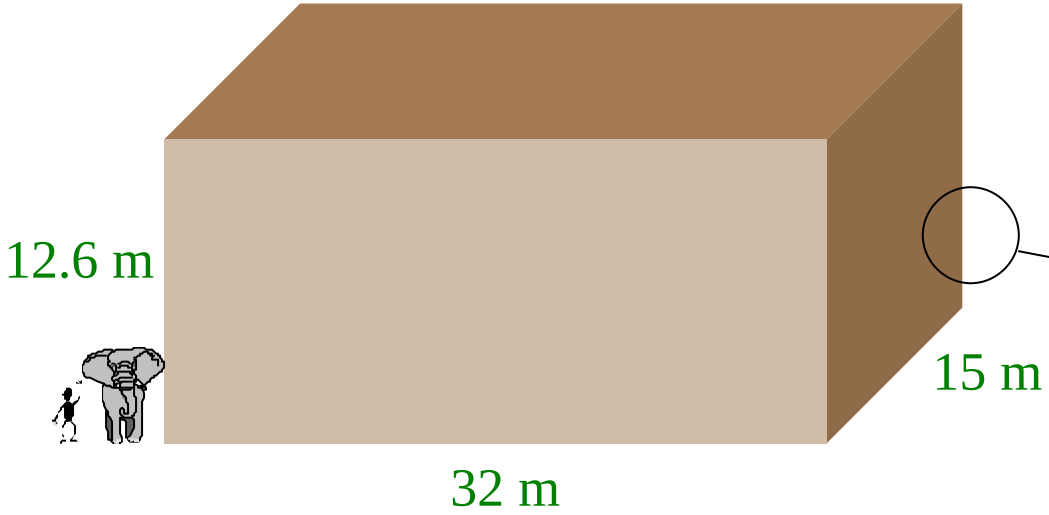
⇩

Iron assembling and detector installation should be decoupled

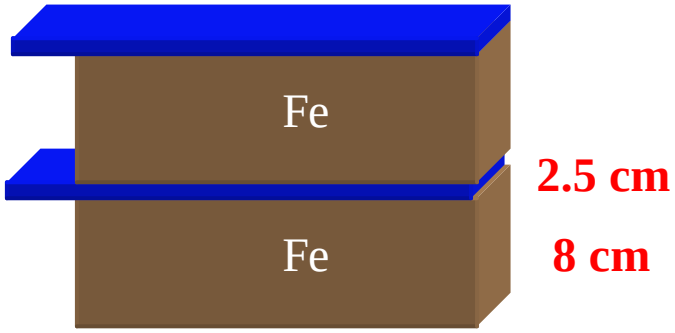
Detector insertion **after** the iron structure construction.

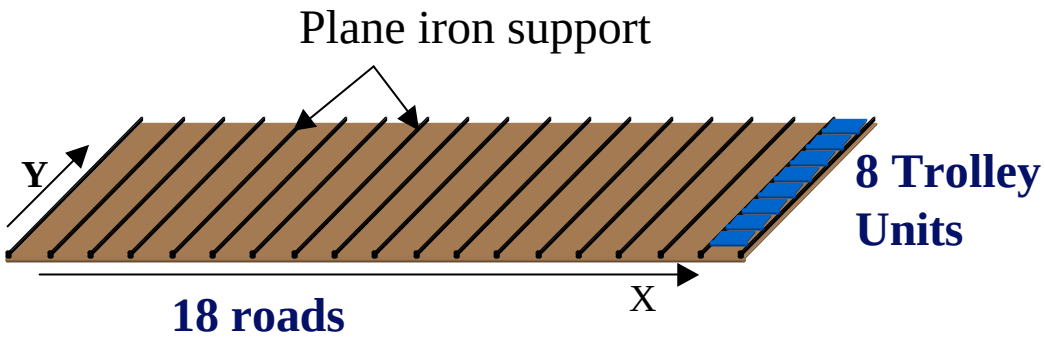
Detector Design

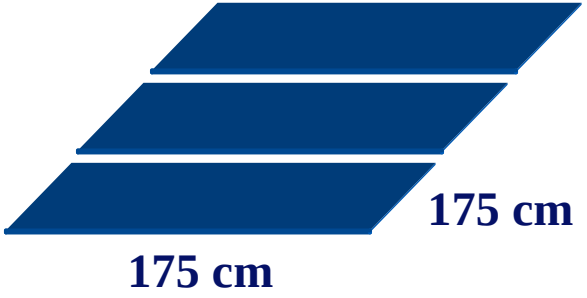
8.0 x 3200 x 1500 cm^3 x 7.87 g/cm^3 = 302 Ton/plane 120 planes = 36 KTon



~58000 m^2 of detector : RPC or GSC



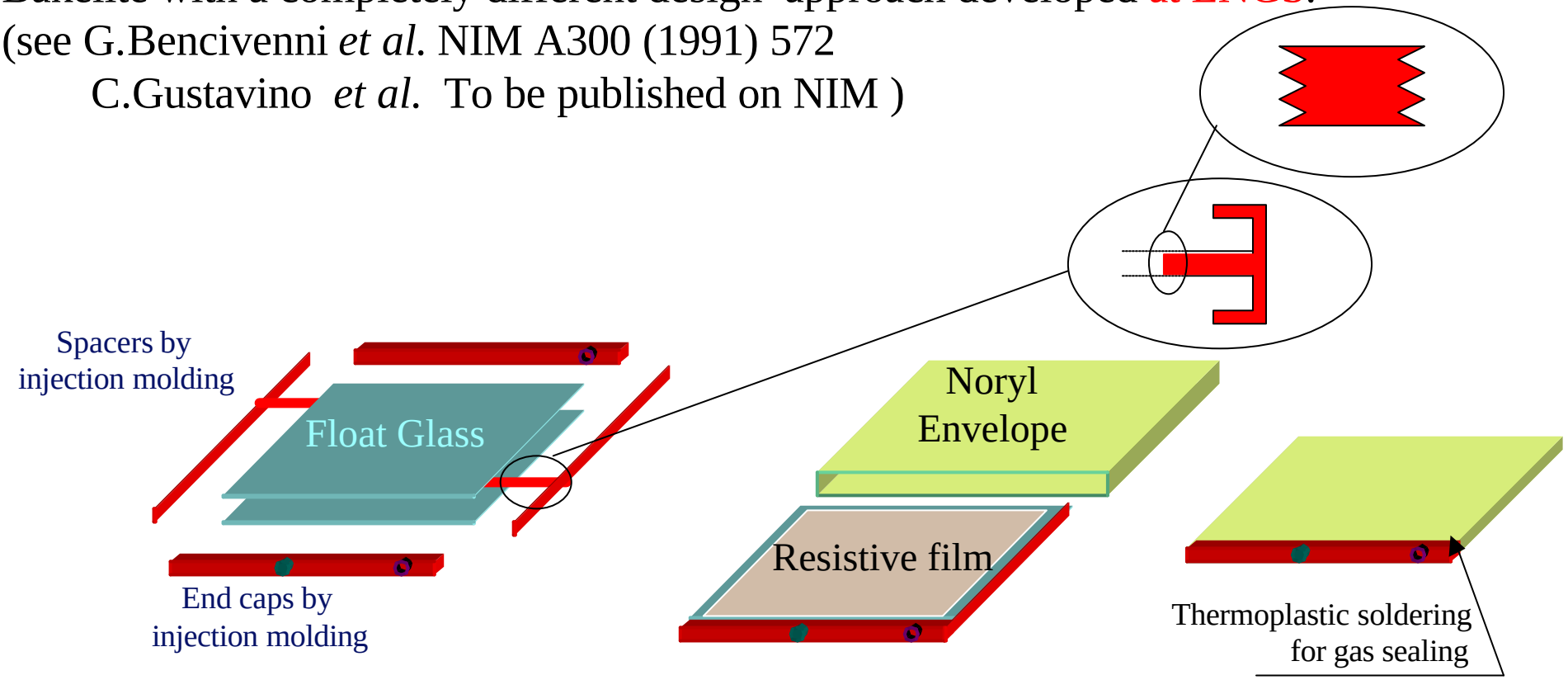




175cm is the maximum detector length allowing insertion after iron assembling

Glass Spark Counter I

It is an RPC with electrodes made of standard float glass instead of Bakelite with a completely different design approach developed at LNGS.
(see G.Bencivenni *et al.* NIM A300 (1991) 572
C.Gustavino *et al.* To be published on NIM)

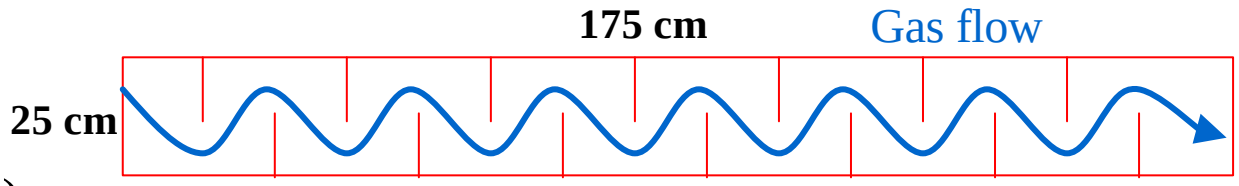


Easy and fast and cheap construction
Ready for mass production.

Glass Spark Counter II

Glass Advantages

Excellent surface uniformity (< 1 ?m) and material homogeneity.
No surface treatment needed.
Cheap and well known technology.
Relative high volume resistivity (10^{12} ? cm) is not a limitation (Low rate environment).



Design Advantages

Gas flow optimization (spacers).
Uncritical gas pressure operation (plastic envelope avoid changes on the detector gap).
No graphite coating but adhesive resistive films for HV supply (Shintron, 3M, Dupont).
HV contact without soldering (harmonic metal contact).
Spacers clamped without glue with a tolerance ±5 ?m (uniform electric field)

No graphite coating, gluing , soldering, linseed oil … → fast assembling

LNF Jobs

- Policarbonate Honeycomb strips
  - Better impedance strip line (35 ? **)**
  - Very stiff ***strip-GSC–strip*** sandwich
  - Contact with different specialized industries and with General Tecnica for R&D
- Electronics *(for Test Beam)*
  - Project defined
  - Prototype ready by the end of month
- Calorimeter Iron Structure
  - New iron slab assembly under study to allow
  - the insertion of the boards for the 2nd coordinate

Milestones (?)

- Monolith Proposal

  Final version before June

- Measurements

  GSC time resolution with cosmic rays for up-down discrimination (with old set-up).

  BO, LNF, MI, NA, TO, LIONE, HAMBURG

  must help LNGS (shifts could be organized)

- Test beam preparation *(duties/responsibilities to be defined)*

  GSC construction should start on February :

  - Orders for materials: glass electrodes, spacers, envelopes, end-caps …
  - Graphite (LNF order OK , Torino missing) should arrive by the end of jan.
  - Strips layout to be defined (LNGS or LNF design?)
  - Technician/physicist shifts must be organized (asap)

Costs

Streamer Tubes ~ 500 KLit /m^2 (30 GLit @ 60.000 m^2) 15Meuro

Copely & PoliHiTeck

Jacket e Profile (Noril) 275 KLit /m^2

Varnish, Wiring, Soldering and Test 235 KLit /m^2

Delivery (preliminary) 15 000 m^2/year

RPC (ATLAS like) ~250 KLit /m^2 (15 GLit @ 60.000 m^2) 7.5Meuro

General Tecnica

Dimensions : 125 x 300 cm^2

Jacket & Bakelite 250 KLit / m^2

Delivery (preliminary) 8 000 m^2/year

Glass Spark Chamber ~ 130 KLit /m^2 (7.5 GLit @ 60.000 m^2) 3.7Meuro

Gran Sasso Lab

Dimensions 25 x 175 cm^2

Glasses, Films, Spacers (Noril) 100 KLit /m^2

Detector Assembling (by external manpower) 30 KLit /m^2

Delivery (preliminary) 25 000 m^2/year

Chamber Assembling and Test

Assuming GSC modularity (present design)
1 Trolley Unit : 7 GSCs 1 Road consist of 8 Trolley : 56 GSCs
The whole apparatus will consist of 121 000 GSCs

The detector assembling can be efficiently performed by external manpower with physicists supervisions.

Assuming a production rate of 6 GSC h^{-1} per operator
With 2 shifts of 6 hours each with 4 operators : 24 GSC h^{-1} : 288 GSC /day (126 m^2)
Total production in 500 days (2 years) with 2 shifts per day.

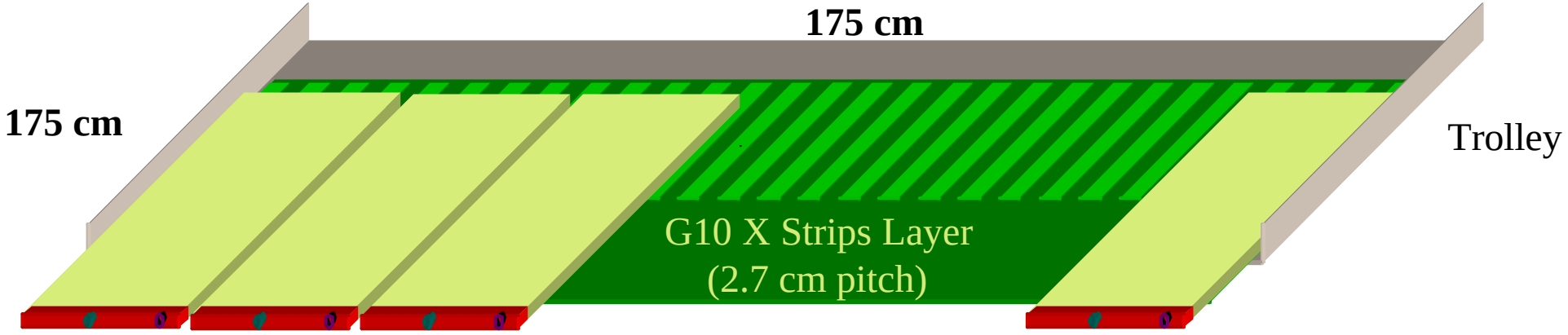
The Chamber test consist of :
- gas tightness
- current check
- single counting level check

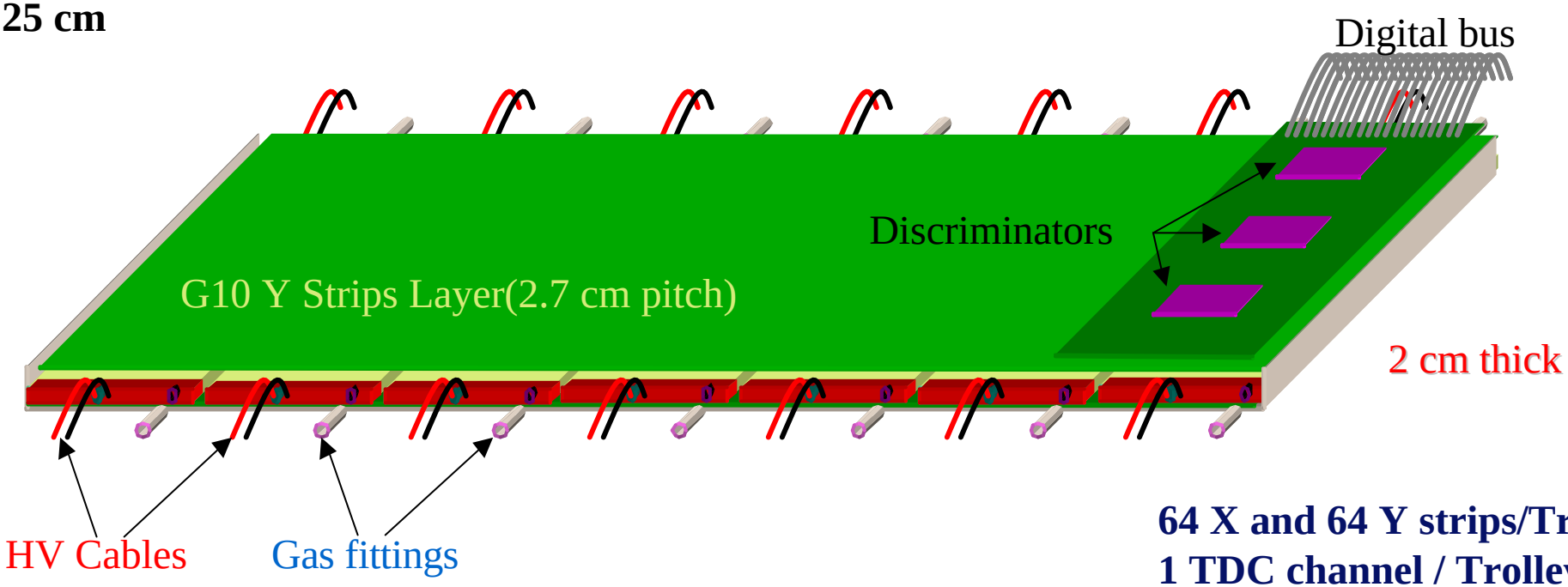
Can be performed during the night with automatic procedure.

GSC ASSEMBLING

TEST

Trolley Assembling





64 X and 64 Y strips/Trolley
1 TDC channel / Trolley

Trolley Assembling and Insertion

OUTSIDE

The 7 GSC are placed between the the X and Y strip planes (G10).

The strip planes are connected with the front end cards on top of the trolley.

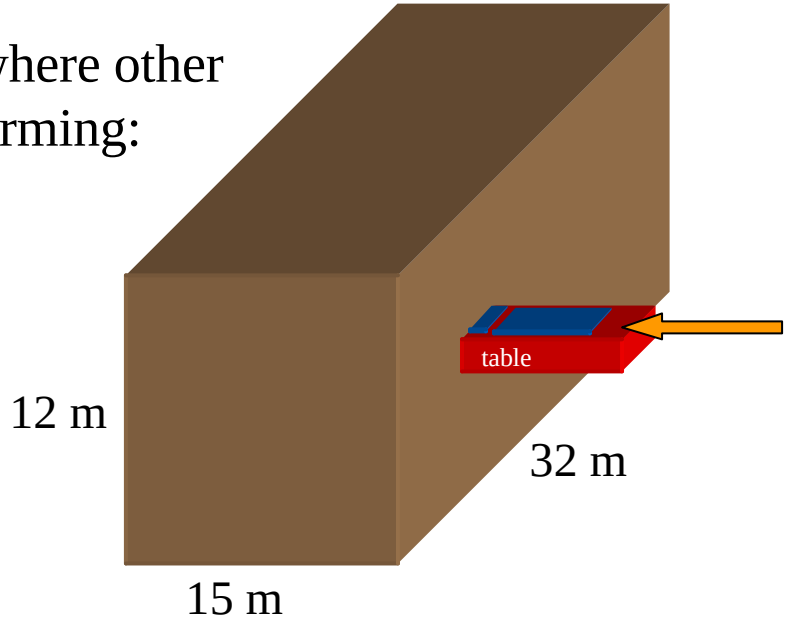
With a production of 288 GSC day^{-1} 41 trolley can be assembled per day.

A 4 people crew is able to perform the task in 6 hours (2 trolley/person h^{-1})

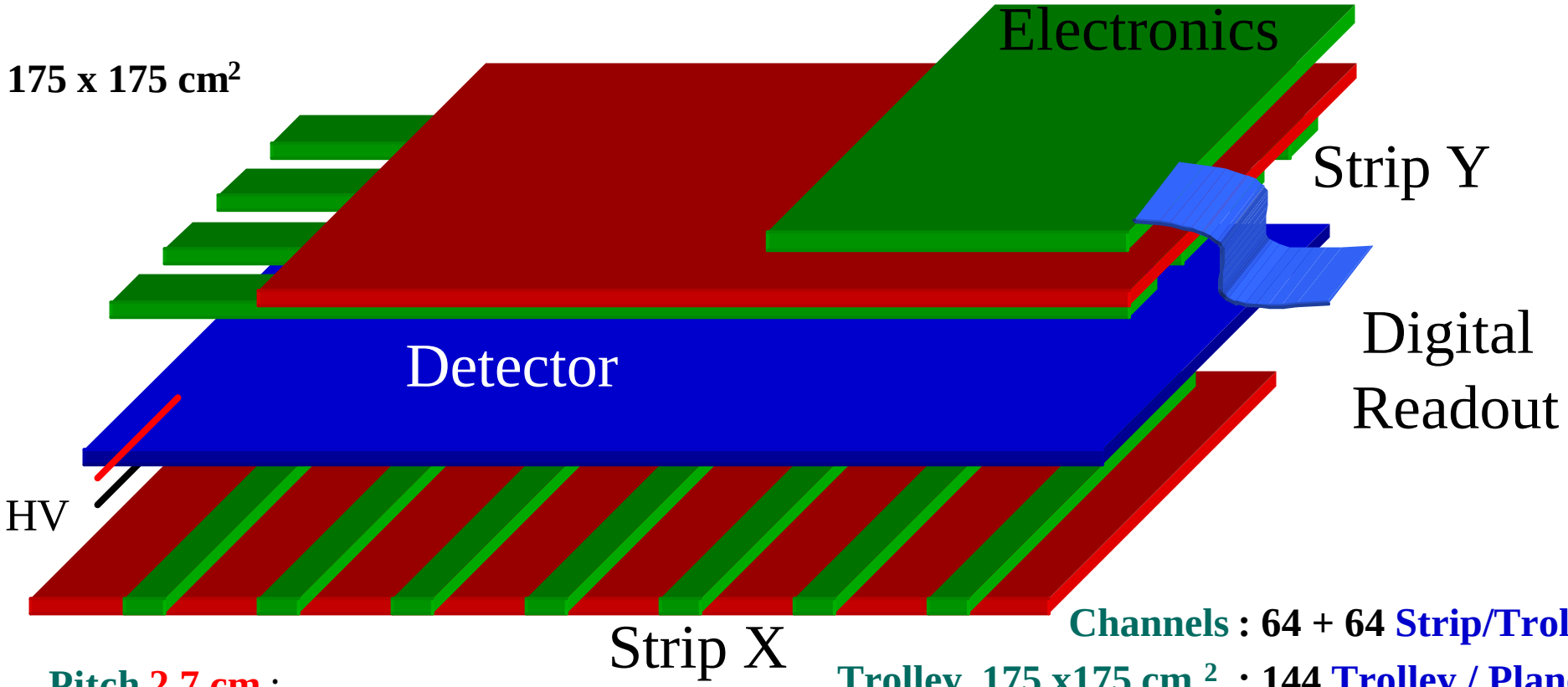
INSIDE

The trolleys are then transported in the cavern where other two people insert them inside the iron road performing:

- gas fitting
- HV cables connections
- Digital cables connection between trolleys
- TDC cables (1 per trolley)



Readout and X/Y Strips embedded



Pitch 2.7 cm :

Strip X (64) spatial

Strip Y (64) spatial info and

time info (?t=1 ns)

TDC 1

Channels : 64 + 64 Strip/Trolley

Trolley 175 x175 cm ^{2} : 144 Trolley / Plane

Number of Trolley : 17 280

Discriminator Channels(X+Y) : 2 200 000 ~ 4 Glit

Digital Channels(X+Y) : 300 000 ~ 3 Glit

TDC Channels : 17 280 ~ 1 GLit

HV Channels : 17 280 ~ 3 GLit

Iron and Detector Assembly

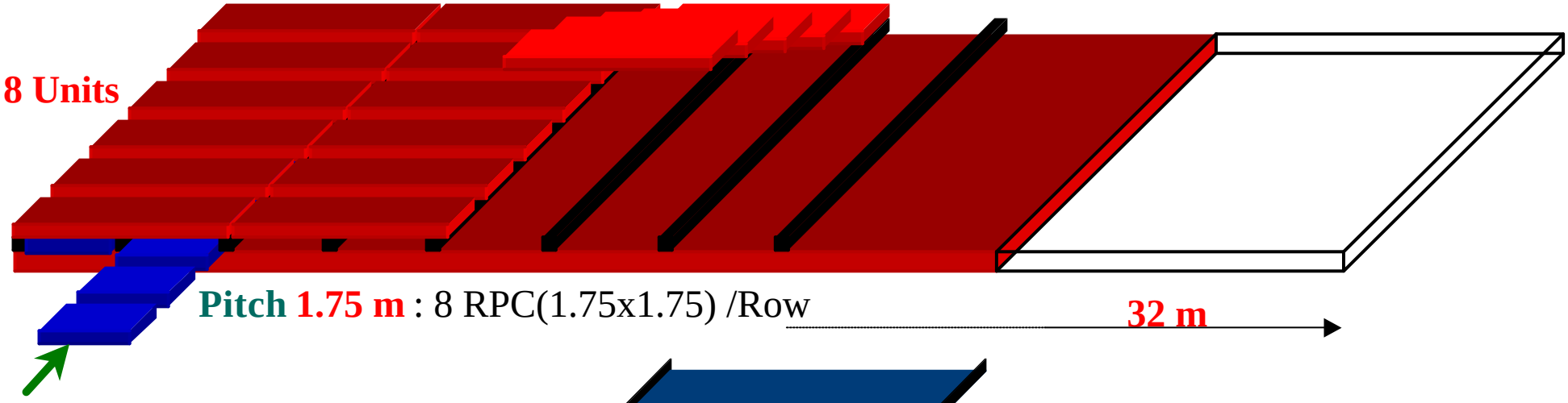
Iron Tables 1.8 x 3.7 x 0.08 m^3 : 4.2 Ton

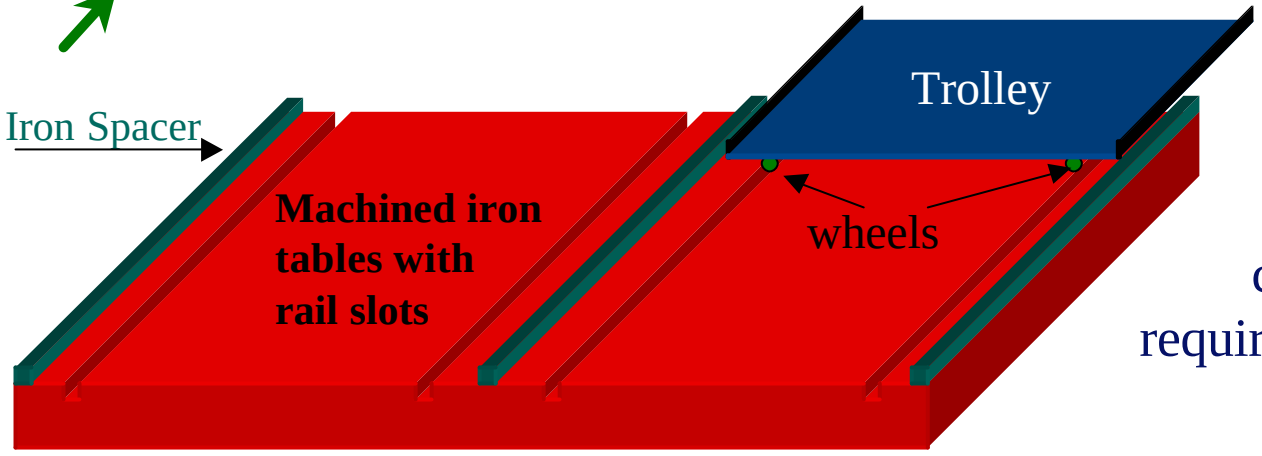
Tables/Layer 64 Total : 7680 Tables

Transport : 5 Tables (21 Ton)

Assembly : 15 Tables/day (3 Trucks/day)

500 days (5 days/week) : 2 years





Only iron spacers and the coupling zones of the iron tables require (relative) precision machining

Detector Assembling Schedule

Detector assembling

Chambers assembling

Chamber Test

Trolley Assembling

Iron assembling

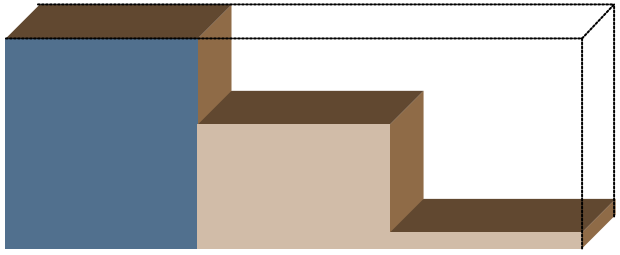
Floor Preparation

Tables Machining

Tables Assembling

Trolley insertion

Cables to Crates

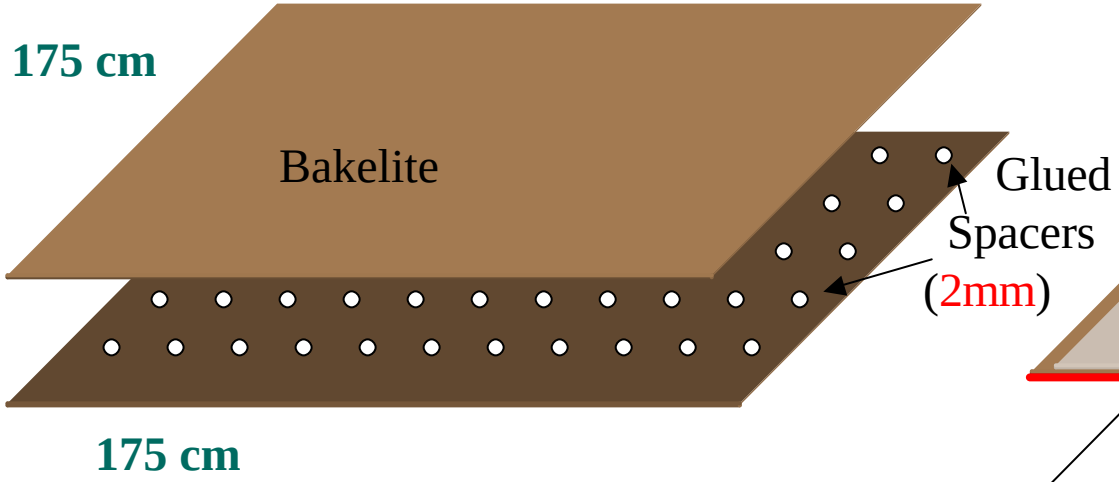


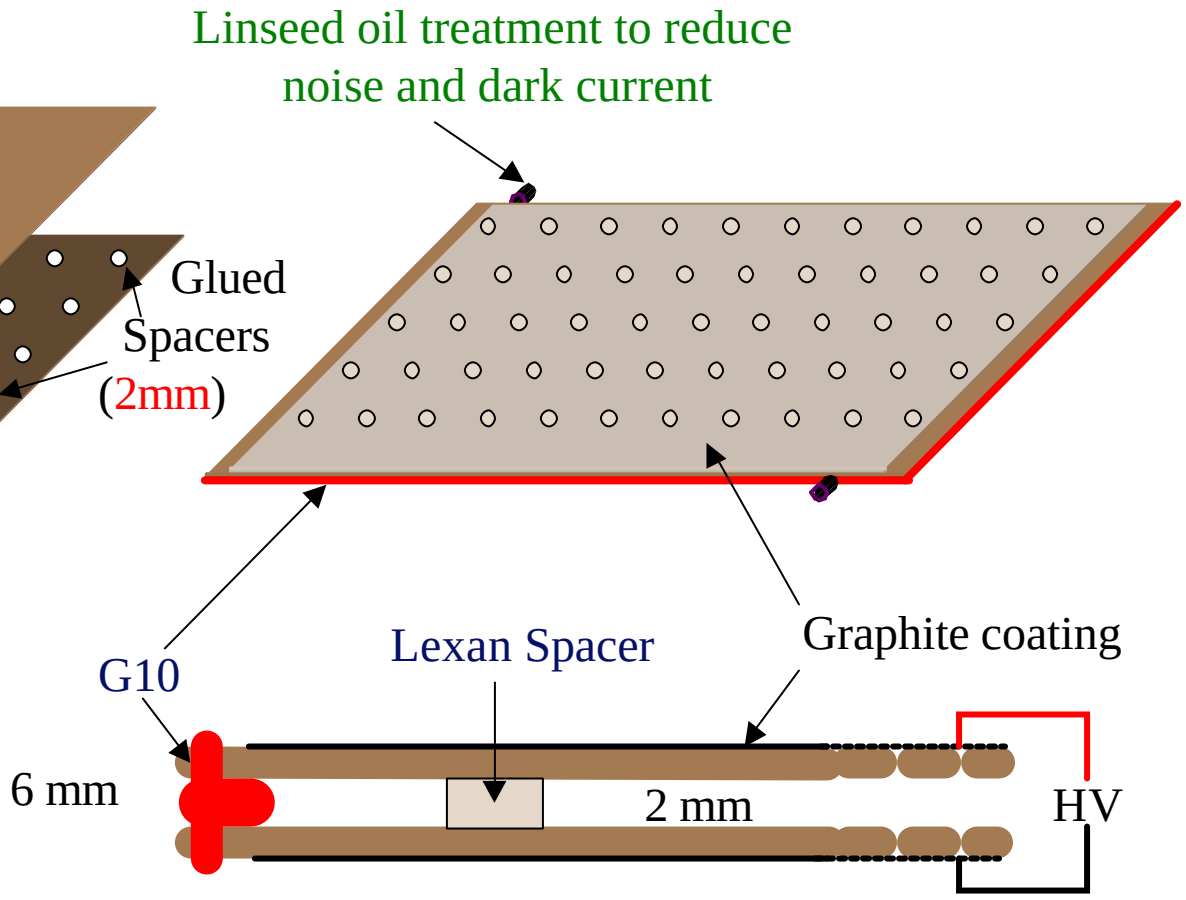
Conclusions

- GSC fulfill the requirements of an atmospheric neutrino experiment (good performance, fast production, low cost)
- The decoupling between the iron assembling and the detector installation optimizes the construction.
- Open problems :
  - iron assembling and machining
  - electronics design and engineering
  - studies on strip read-out

RPC

Bakelite RPC is built by General Tecnica (Rome) with a production rate of 8000/10000 $m^2\ y^{-1}$
The same firm have to build RPCs for ATLAS, CMS and ARGO.

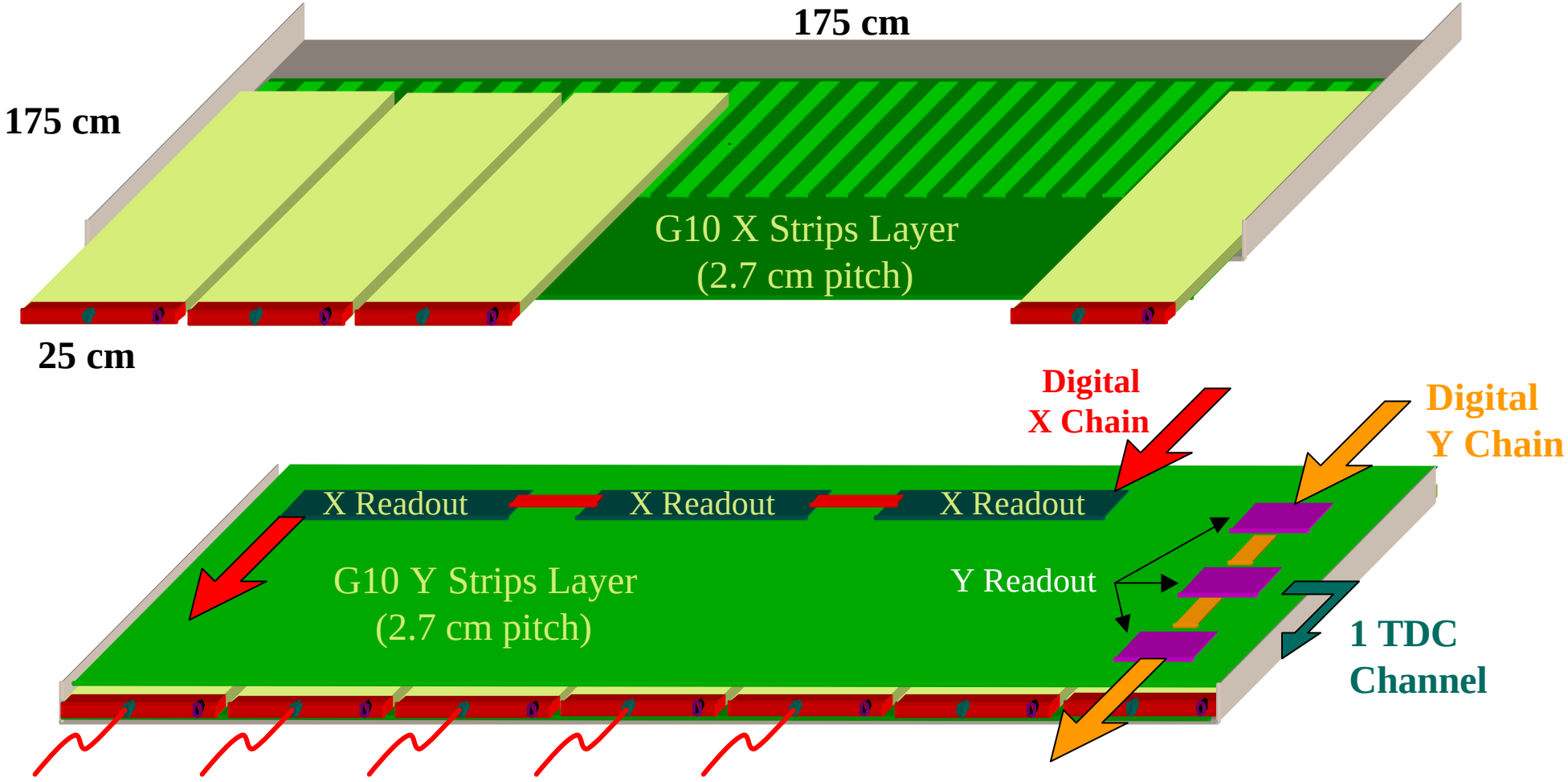




Costs 250 Klit m^{-2} (125 euro)

Total production in > 6 years

Trolley Unit



64 X (orY) strips/Trolley : Total of 1.2 Mstrip /view
1 TDC channel / Trolley : Total of 17 Kchannels of TDC

Appearance of tau neutrinos

The method consist in measuring the up/down ratio of the high energy muon less events with vertex clearly identified.

The up/down direction is determined by the shape of hadronic shower (or hit mult vs planes)

Good ?$_?$ CC rejection with non interacting track longer 1m

Good ?$_e$ CC rejection with em component cut off (8 cm of iron)

The integrated NC event rate is about one third of ?$_?$ + ?$_e$ event rate