

Design and prototype tests of the RPC system for the OPERA spectrometers



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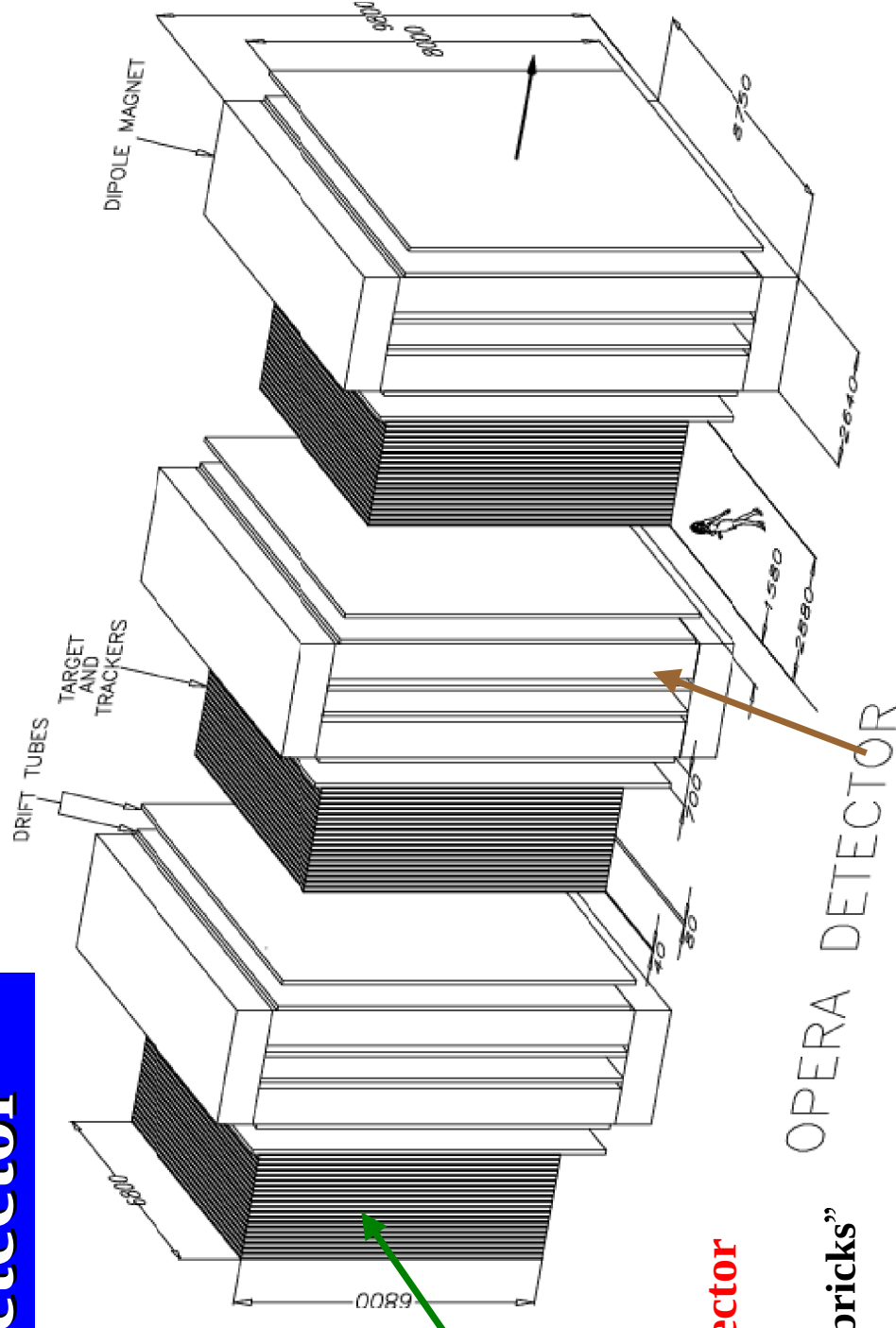
Outline

- **OPERA Detector**
- **RPC Inner Tracker**
 - **Design**
 - **Mechanical support**
 - **Gas & HV**
 - **Production and Quality Test**
 - **Schedule**
- **Conclusion**

Institutions Involved:

**CERN, Frascati, Napoli,
Padova, Zagreb**

OPERA detector



Target

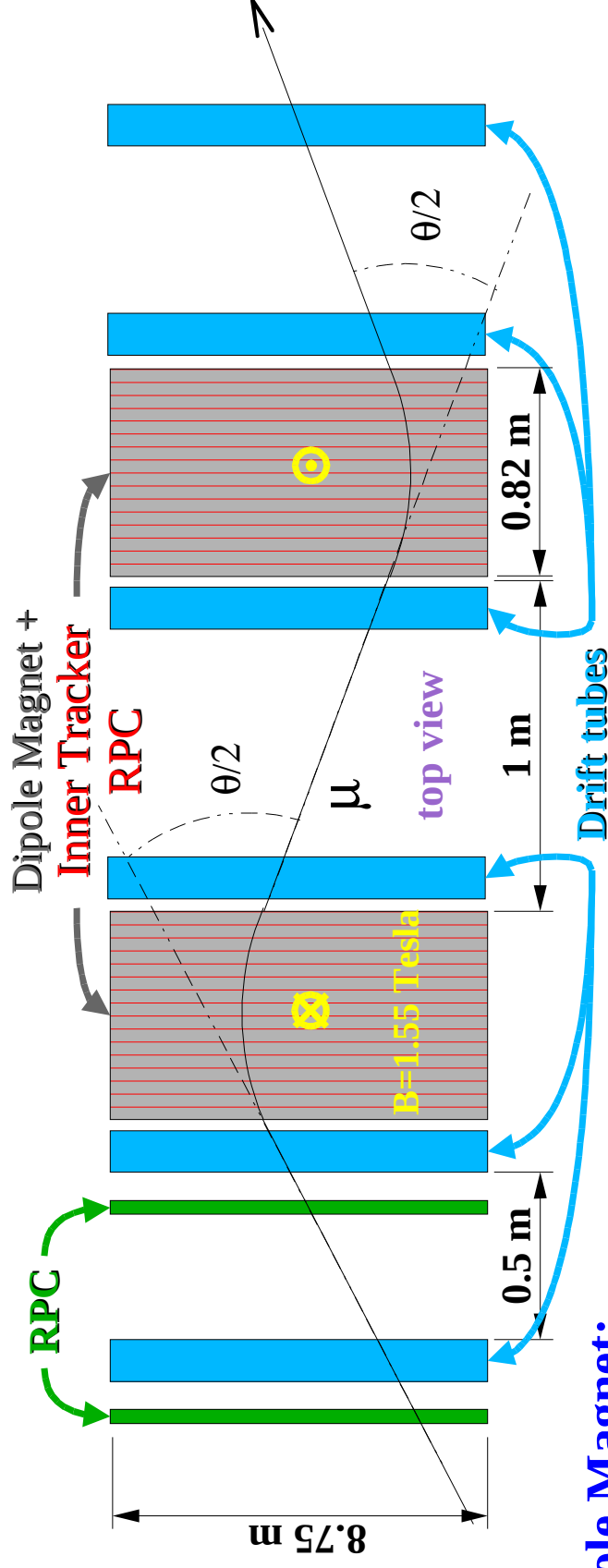
ν target and τ decay detector

- 24 “modules” consisting of
- a “wall” of Pb/emulsion “bricks”
- planes of orthogonal scintillator strips

Muon Spectrometer

- μ identification
- measure charge and momentum
- beam monitoring

Muon Spectrometer



Dipole Magnet:

- 2 x 12 8.75 x 8.2 m² and 50mm thick Fe Walls
- $B = 1.55$ Tesla
- 2 x 11 gap, 20mm thick, instrumented with **RPC** – muon tracking, energy by range

Precision Tracker:

- 6 station of vertical drift tube with **0.5 mm** space resolution

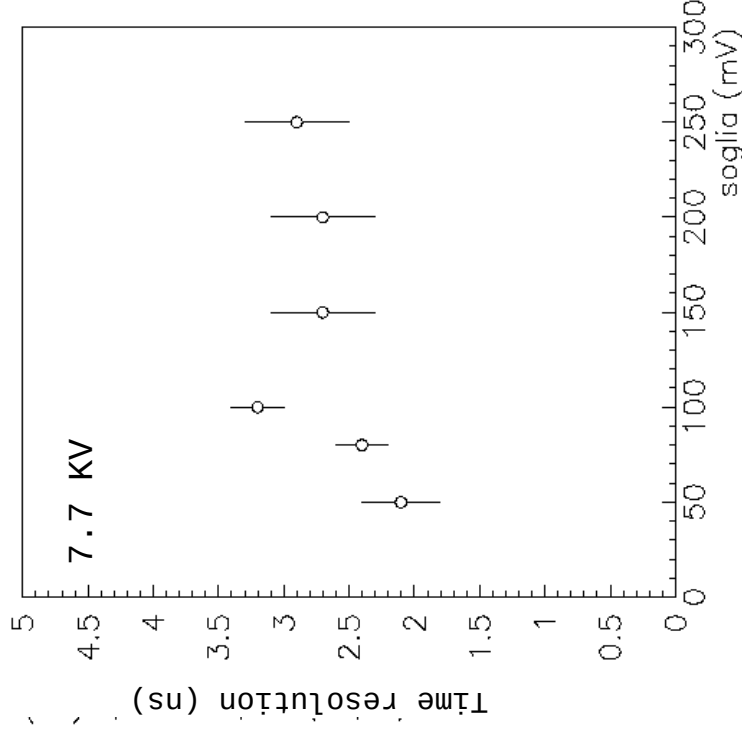
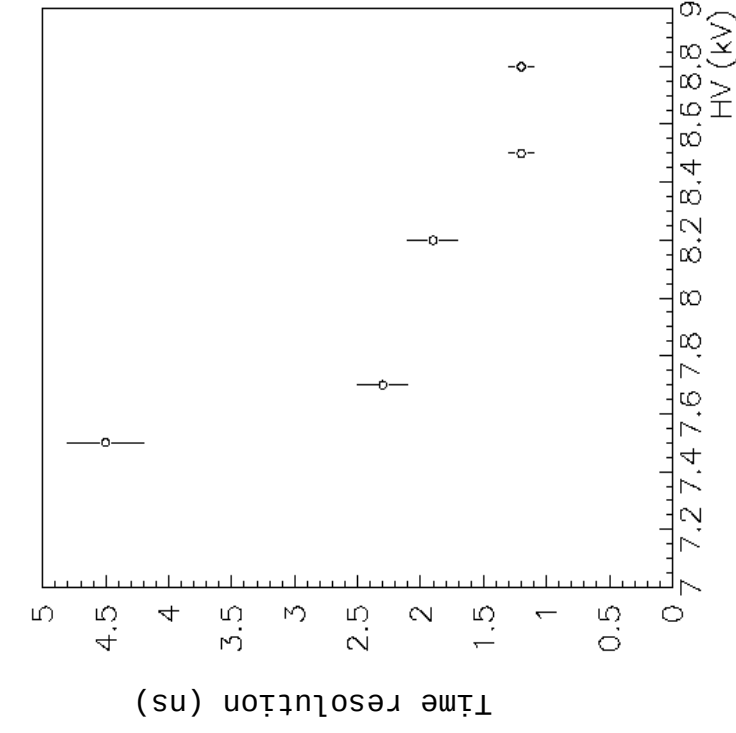
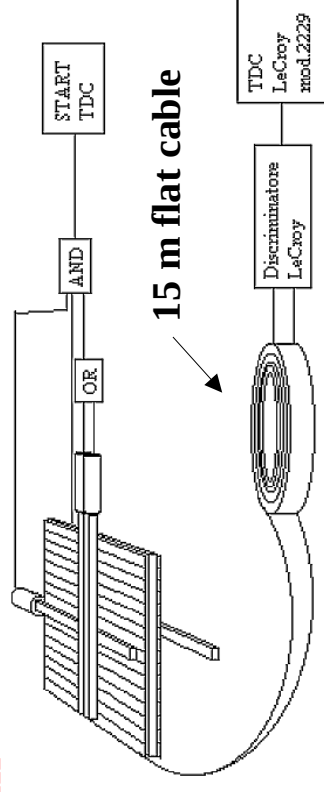
$$\frac{\delta p}{p} \leq 0.25 \quad \text{for } p < 25 \text{ GeV}$$

- **RPC** for drift tube timing ambiguities

RPC for drift tube t_0

- **Single RPC plane in front first two drift tube station**
 - **8.75 x 8.0 m²** covered with **21 RPC 2.91 x 1.14 m²**
 - **3 cm wide strip @ ±45°**
 - **~ 3150 channel per spectrometer**
 - **~ 2ns time resolution easily achieved**

Cosmic telescope setup in Padova
 1 RPC (0.7x0.7 m²) – 3cm strip
 48% Ar, 48% C₂H₂F₄, 4% Iso

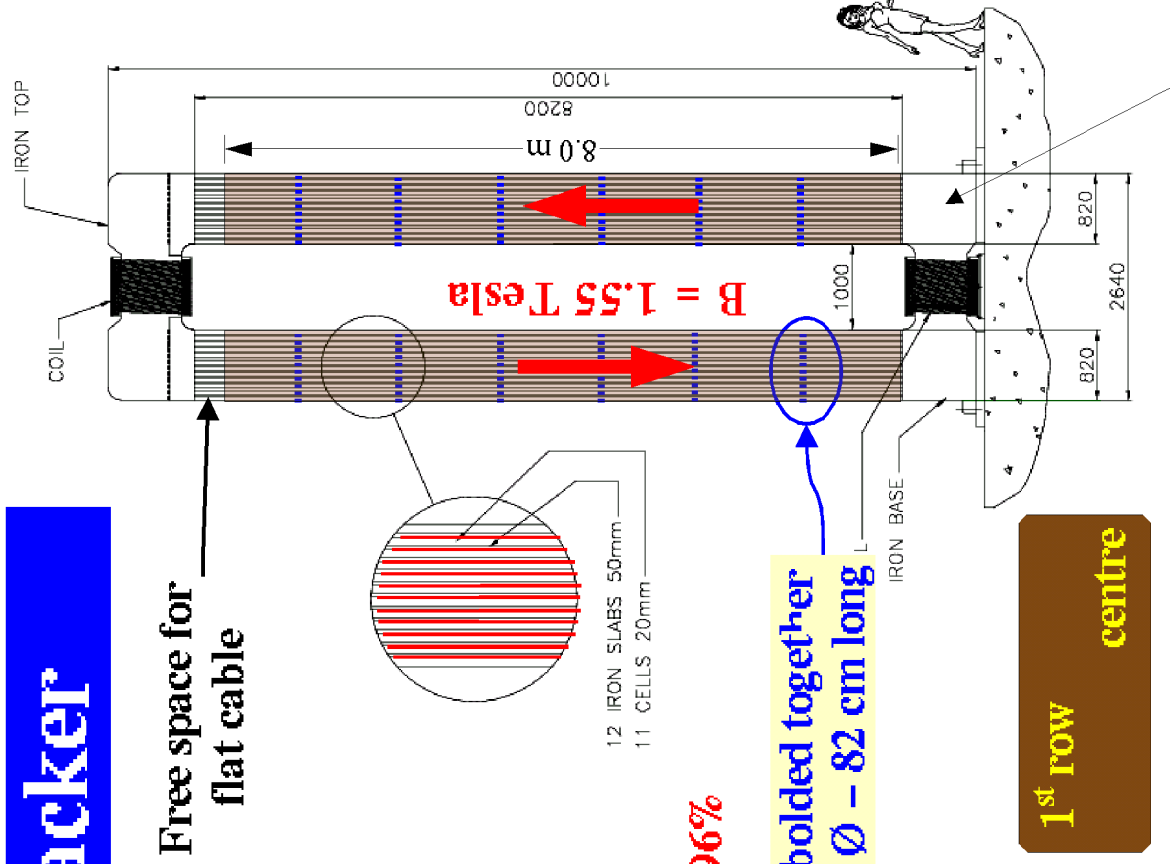
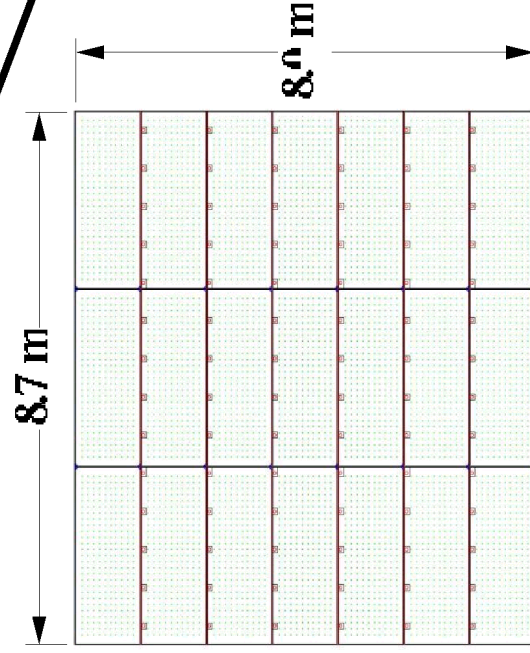


Inner Tracker

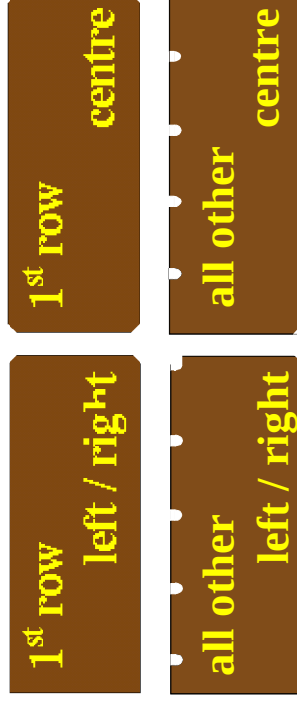
Each half magnet

- 12 iron layer $8.75 \times 8.2 \text{ m}^2$ and 50 mm thick
- 11 gaps 20 mm thick for RPC
- 21 RPC $2.91 \times 1.14 \text{ m}^2$ per plane
- $\sim 4600 \text{ m}^2$ for 3 spectrometer
- Bakelite RPC (latest version of General Technica)
 - ✓ Bakelite $10^{11} \div 10^{12} \Omega \text{ cm}$
 - ✓ Graphite $100 \text{ K}\Omega/\%$
- : Streamer mode

✓ 4 RPC shape to maximise geometrical acceptance $\sim 96\%$



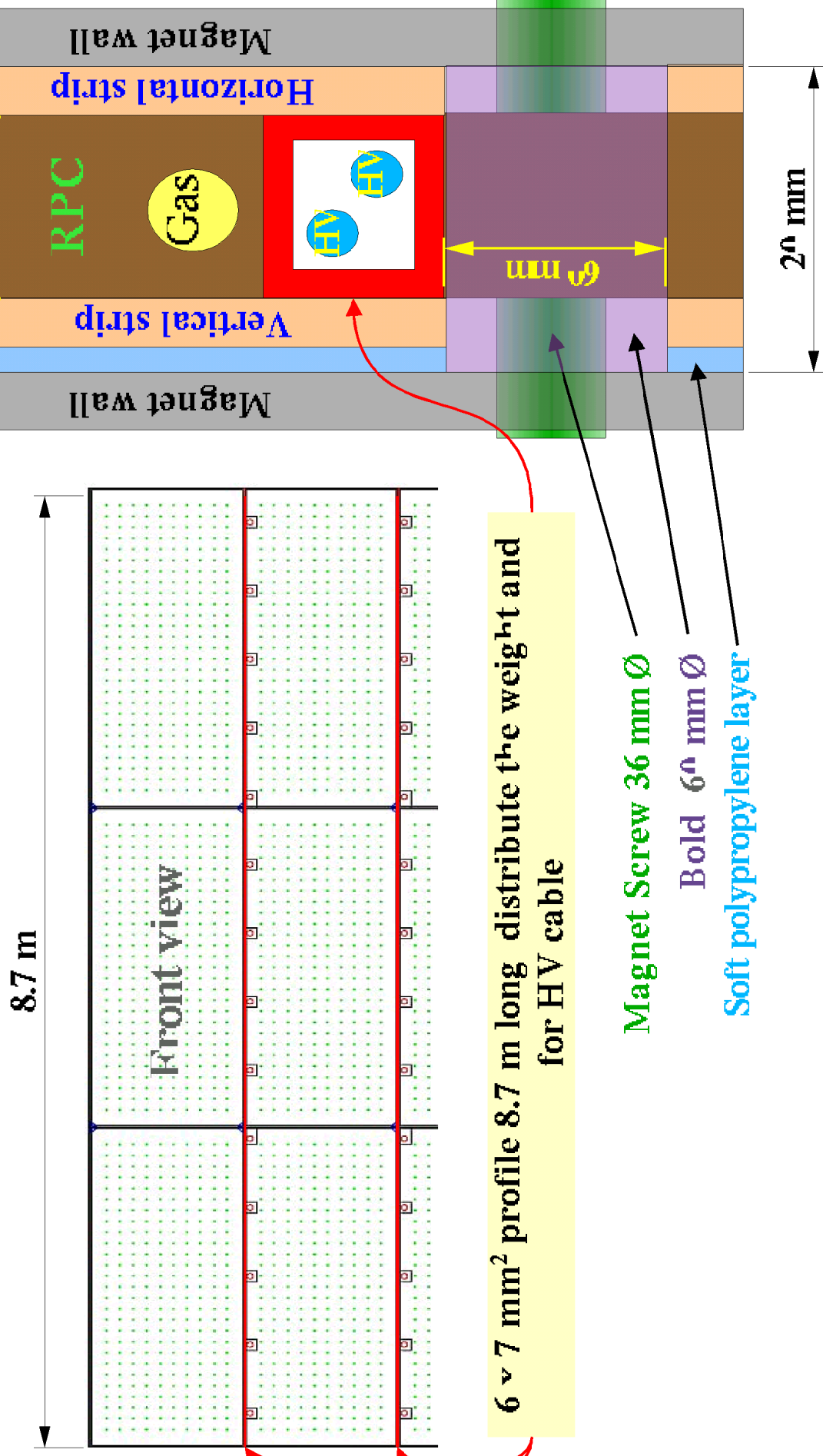
Cooling system of coils
to keep RPC temp low



Plates bolted together
3.6 cm $\varnothing$ – 82 cm long

Mechanical Support

Each RPC row independently supported by the magnet bolts



6 x 7 mm² profile 8.7 m long distribute the weight and for HV cable

Readout Strip

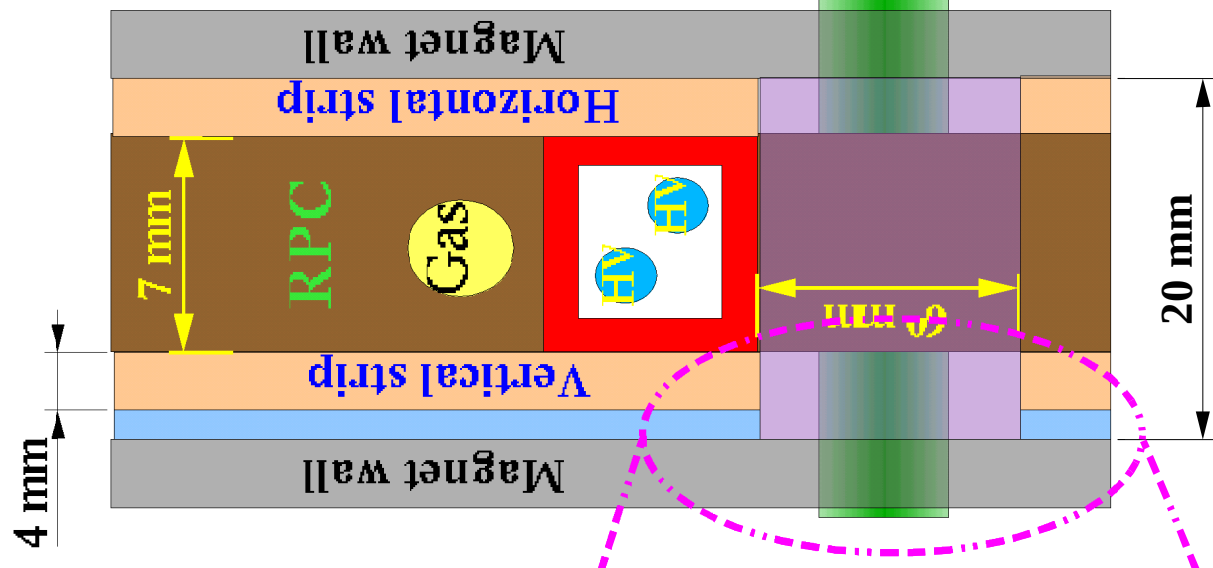
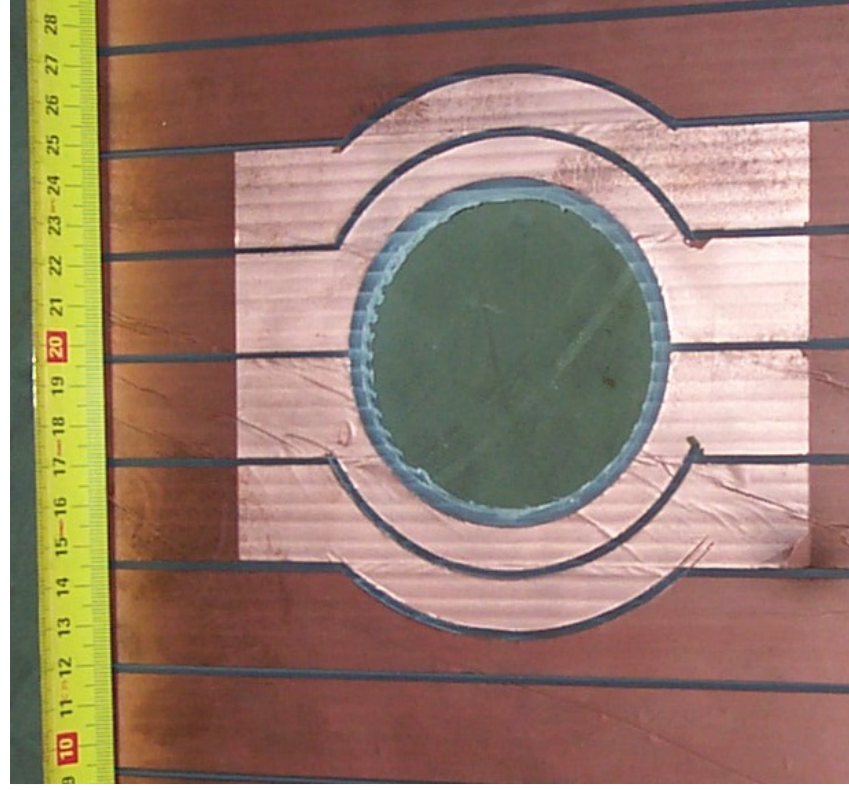
Copper strip on a **4 mm** plastic support

✧ Vertical strip (**bending plane**): **2.6 cm** pitch^h 8m long

✧ Horizontal (**non bending**): **3.5 cm** pitch^h 8.7m long

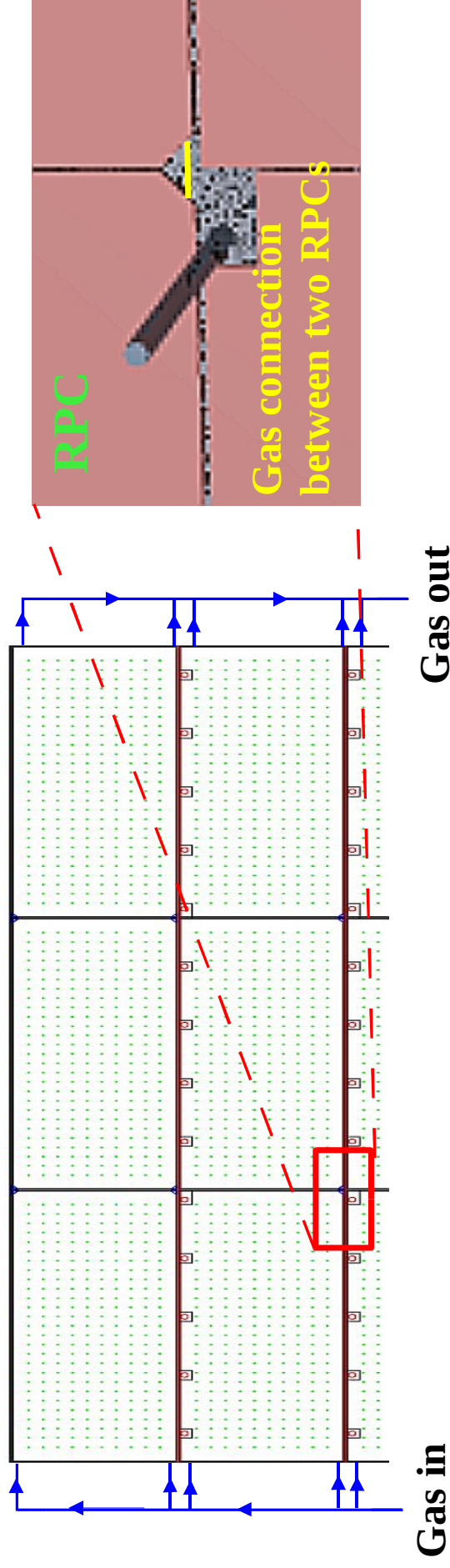
12364 channels per spectrometer

✧ Ferrite to adapt strip impedance to flat cables



Gas

- Gas mixture: **48% Ar** – **48% C₂H₂F₄** – **4% Isobutane**
- Each RPC row is serially fed by 14 parallel line

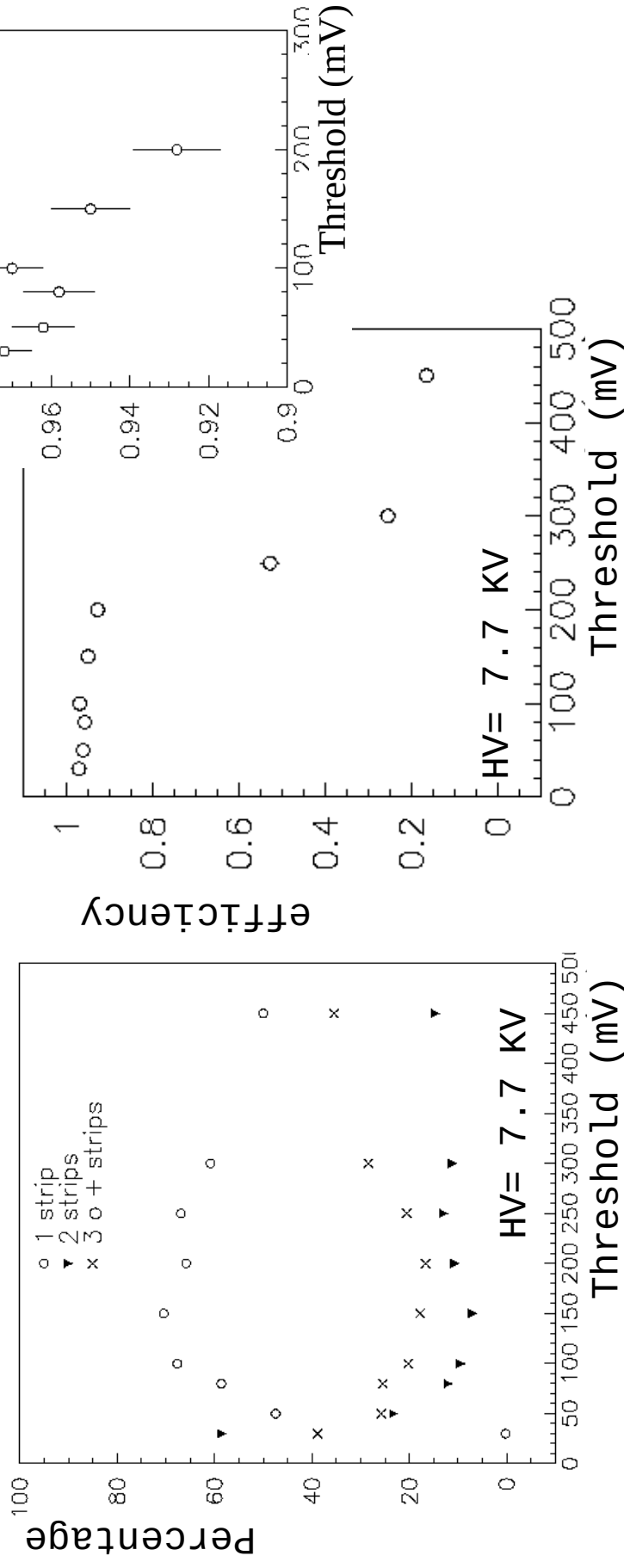


High Voltage

- RPC operating in **Streamer mode** ~7.7KV
- Each chamber **independently supplied** – **1386 HV channel**
- Standard CAEN HV supplier + distribution box

Signal & Readout Electronics

- RPC in **streamer mode**
- simple discriminator with **variable threshold**
- 32 channel VME card is under development in Padova

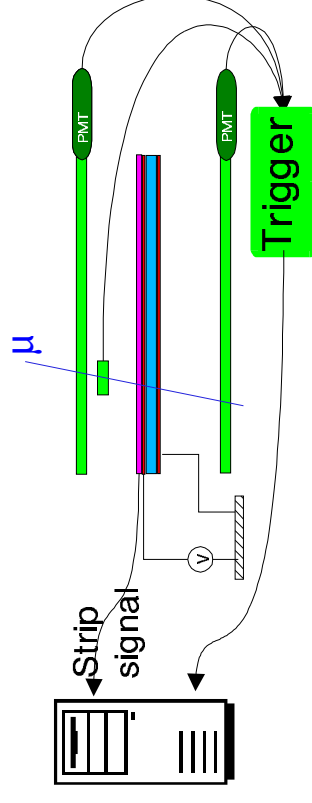


Measures made in Padova with a cosmic telescope

2 RPC (0.7 x 0.7 m²) – 3 cm strip

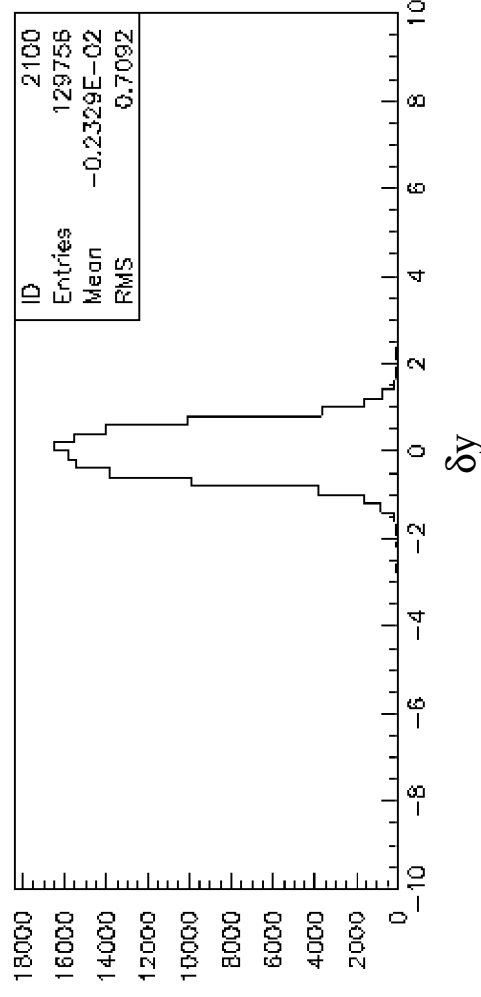
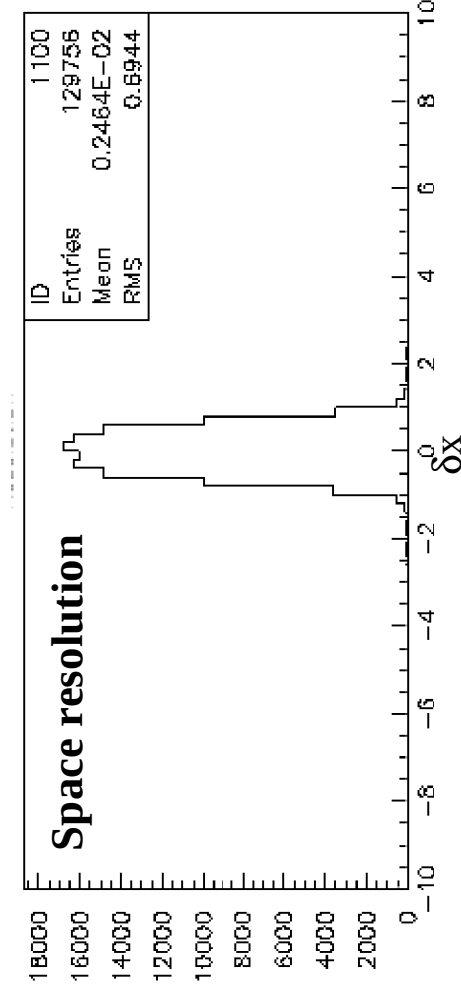
Standard Gas mixture (48% Ar, 48% C₂H₂F₄, 4% Iso.)

Scintillator for trigger,



Performance

- Full GEANT3 simulation of the Inner Tracker
- RPC signal modelled using beam (CERN) and laboratory (Padova) test
- Simulation shows **resolution $\sim 0.7\text{cm}$** with 2.6 cm strip

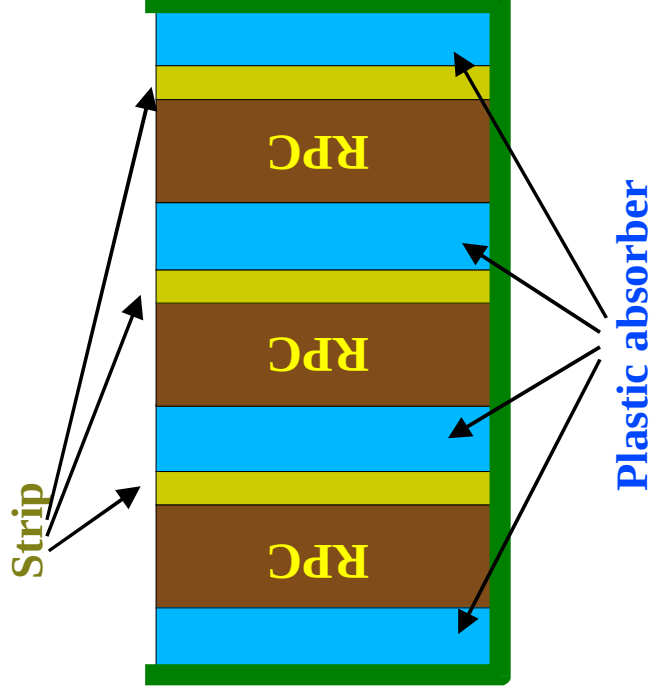


Production

- RPC are produced by General Tecnica (Italy)
 - ✓ Babar production protocol
 - ✓ RPC packed vertically in box; $310 \times 120 \times 60 \text{ cm}^3$, 12 chambers/box. $\Rightarrow$ LNGS
- Quality test @ L'naboratori Nazionali Gran Sasso (copying from Babar)
 - ✓ GAS leakage tests
 - ✓ HV and chamber conditioning tests;
 - ✓ Chamber radiography with cosmic muons.

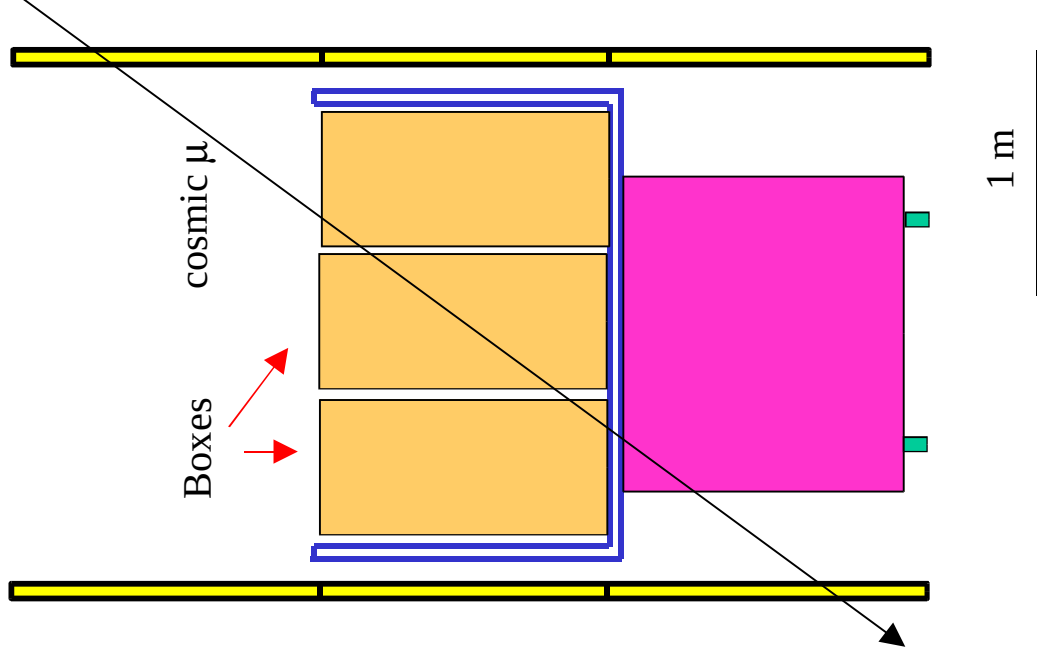
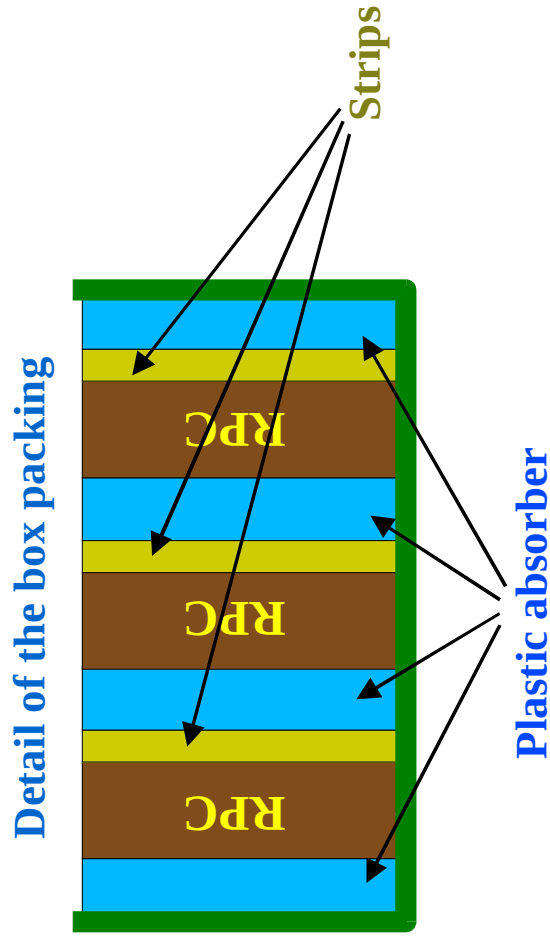
	N. chambers
Inner Tracker	1386
XPC	126
Total	1512

Detail of the box packing



Cosmic test @ LNGS

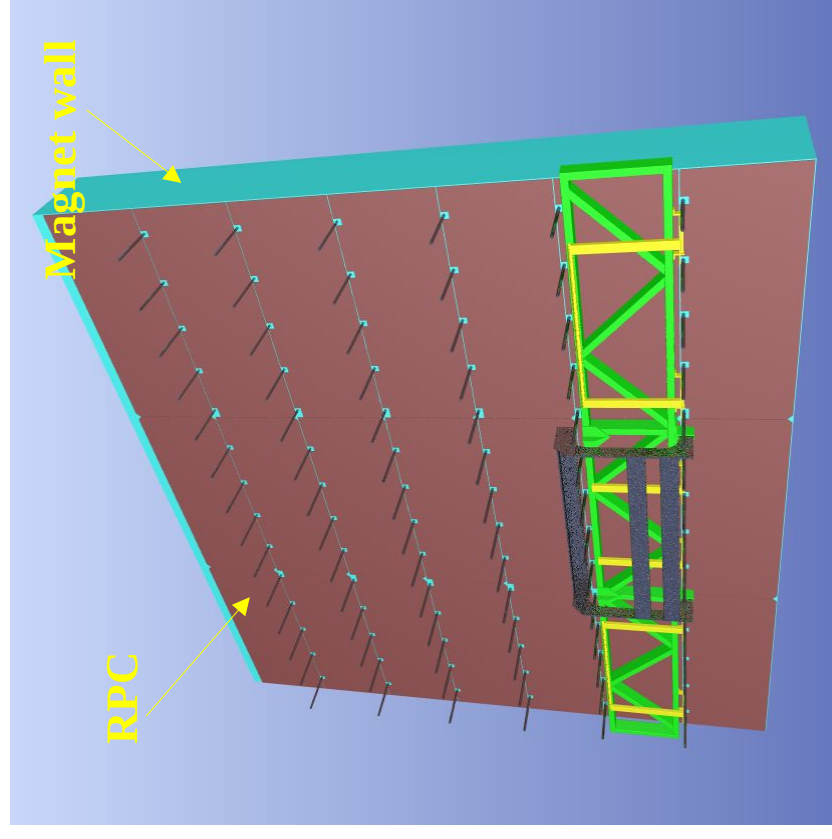
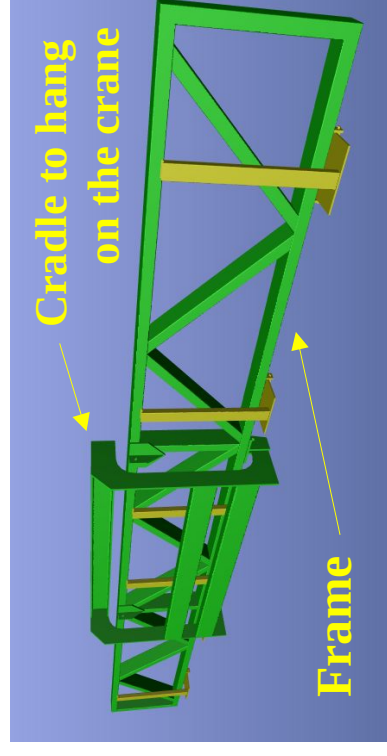
- RPC stay vertical in the box
- Two walls of Glass RPC for cosmic trigger.
- Top side free for access and load/unload.
- Horizontal readout strips mounted on site: commercial flat cables on a honeycomb support.
- Readout: digital on one strip side, time difference on both sides (existing electronics).



Mounting

Mounting schema

- Mounting Magnet Wall
- Glue horizontal strip on spectrometer wall
- Each RPC row mounted + HV cable + gas on the frame
- Each RPC row mounted at once
- Vertical strip
- Test the whole plane
- Spacer



Schedule

(very tight)

- ✓ **February 2002:** start RPC production
 - 20 chambers per week $\Rightarrow$ 6 month for 1 spectrometer
- ✓ **September 2002:** start underground installation
 - 1 plane (21 chambers) per week $\Rightarrow$ 6 month for 1 spectrometer
- ✓ **Cosmic test in parallel with production and installation**

Conclusions

- Large application of RPC in OPERA spectrometers
 - ✓ **1512 RPC** chambers of $2.91 \times 1.14 \text{ m}^2 \sim \mathbf{4600 \text{ m}^2}$
 - ✓ **~40000** channels read with variable threshold discriminator
- Way RPC
 - ✓ **maximise the geometrical acceptance**
 - ✓ **construction simplicity**
 - ✓ Low rate exp. $\Rightarrow$ **streamer mode** $\Rightarrow$ **simple read out electronic**
- RPC used also for timing