

# MEASUREMENT OF $K^+ \rightarrow \pi^+ \nu \bar{\nu}$ DECAY BRANCHING RATIO AT NA62 EXPERIMENT

PIC'08 Perugia 25-28/06/08

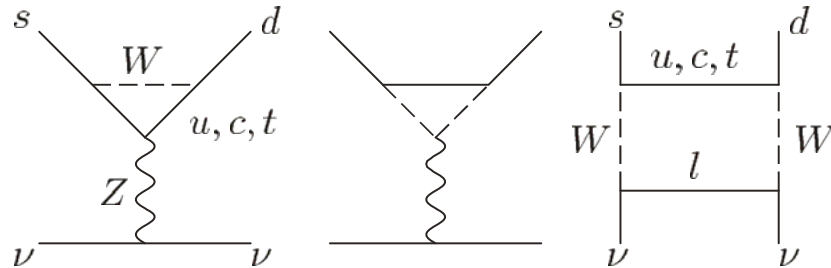
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On behalf of NA62 Collaboration:

*Birmingham, CERN, Dubna, Fairfax, Ferrara, Florence, Frascati,  
Mainz, Merced, Moscow, Naples, Perugia, Protvino, Pisa, Romel,  
Rome II, Saclay, San Luis Potosi, Stanford, Sofia, Triumph, Turin*

# Motivation

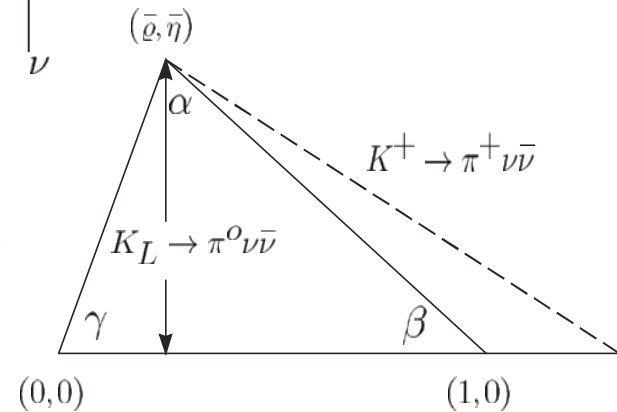
- ◆  $K^+ \rightarrow \pi^+ \nu \bar{\nu}$  and  $K_L \rightarrow \pi^0 \nu \bar{\nu}$  are exceptionally **clean modes**, dominated by short distance dynamics.
- ◆ The leading SM contribution to  $K \rightarrow \pi \nu \bar{\nu}$  is generated by top quark loops and can be computed with **negligible theoretical uncertainty**.
- ◆ The **hadronic matrix element** can be extracted with negligible theoretical uncertainty from well measured  $K \rightarrow \pi e \nu$  rates.



- ◆ Predictions within **SM**:

$$\begin{aligned} \text{BR}(K^+ \rightarrow \pi^+ \nu \bar{\nu}) &= (1.6 \times 10^{-5}) |V_{cb}|^4 [\sigma \eta^2 + (\rho_c - \rho)^2] = (8.22 \pm 0.84) \times 10^{-11} \\ \text{BR}(K_L \rightarrow \pi^0 \nu \bar{\nu}) &= (7.6 \times 10^{-5}) |V_{cb}|^4 \eta^2 = (2.76 \pm 0.40) \times 10^{-11} \end{aligned}$$

- ◆ Precise measurements of  $\text{BR}(K \rightarrow \pi \nu \bar{\nu})$  offer:
  - an independent way of determining the **unitarity triangle**
  - opportunity to make precise test of SM and **search for New Physics**



- ◆ **3 events observed by BNL E949** ( $\text{BR} = 1.47^{+1.30}_{-0.89} \times 10^{-10}$ )

# NA62 principle of measurement

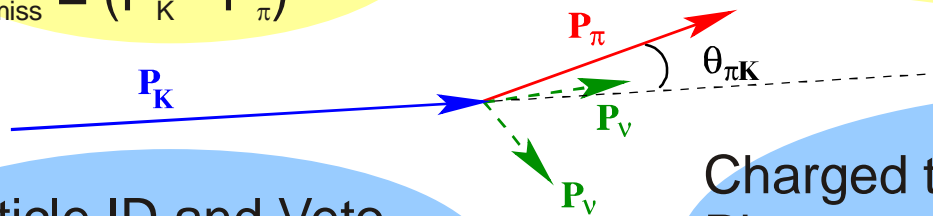
Goal: O(100) events with 10% background

$N(\text{K decays}) = 10^{13}$   
14% acceptance

Kaon decays in flight technique  
400 GeV proton beam from CERN SPS  
High energy  $K^+$  beam ( $P_K = 75 \text{ GeV}/c$ )

Kinematical rejection  
Single track signature  
 $m_{\text{miss}}^2 = (P_K - P_\pi)^2$

Kaon momentum: beam tracker  
Pion momentum: spectrometer



Particle ID and Veto  
in addition to kinematical  
rejection

Charged track veto: spectrometer  
Photon veto: calorimeters  
Beam kaon ID: CEDAR  
 $\pi/\mu/e$  separation: RICH

Budget limitations

Use the existing NA48 infrastructure:  
beam line, LKr calorimeter,...

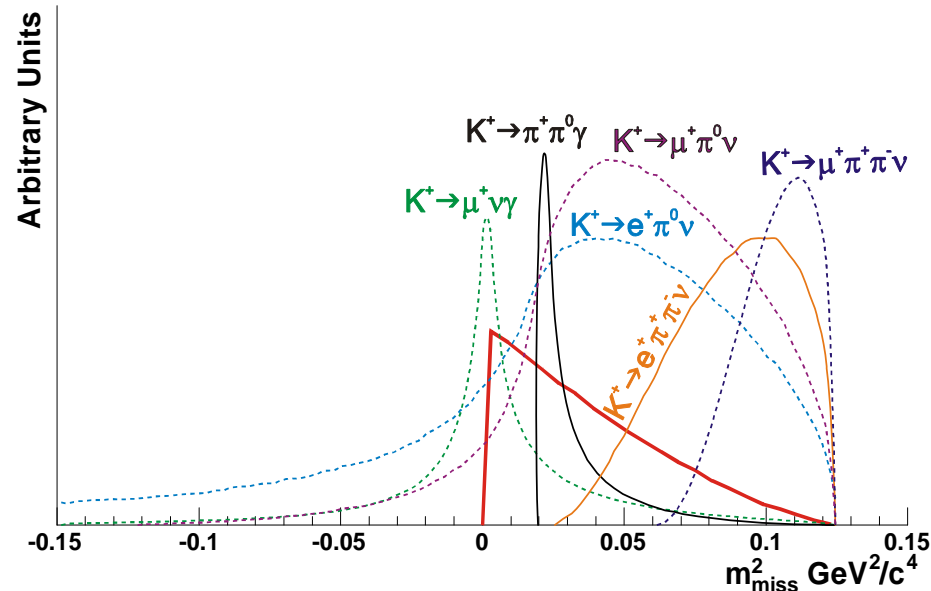
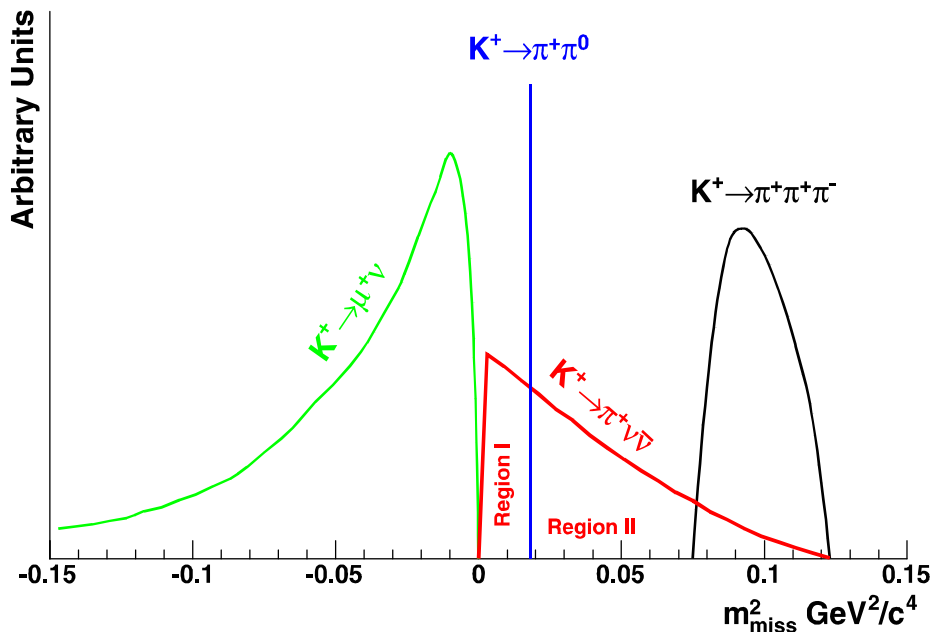
# NA62 schedule

- ◆ September 2005: presented at CERN SPSC
- ◆ December 2005: R&D endorsed by CERN Research Board
- ◆ Start of the Gigatracker project
- ◆ Start of test beams at CERN in 2006
- ◆ 2007: prototypes construction and test at CERN and Frascati beams
- ◆ 2008 – 2010: Technical design and construction
- ◆ 2011: Start of data taking

# Background

Kinematically constrained background  
(92% of total background)

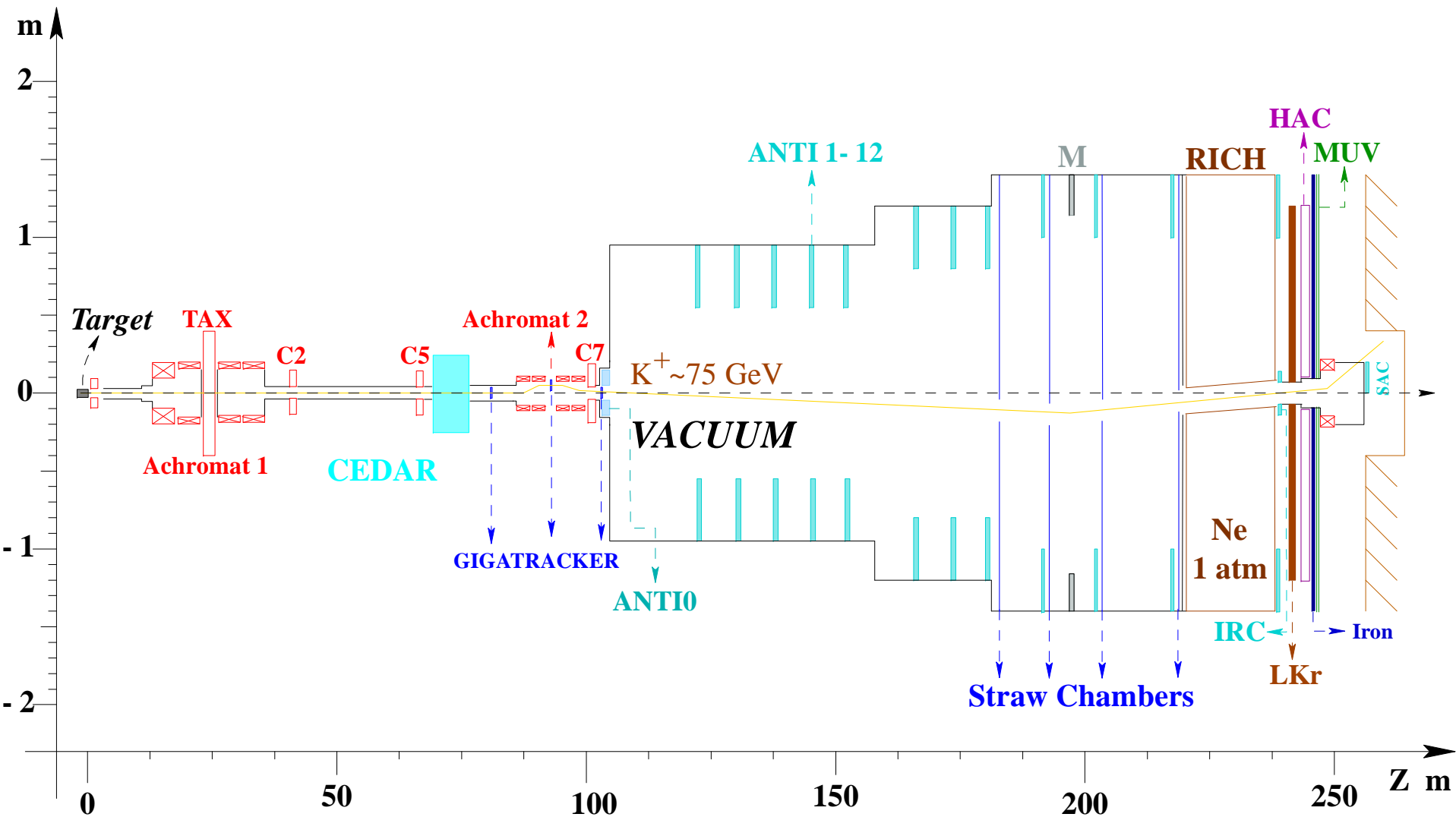
Background not constrained kinematically  
(8% of total background)



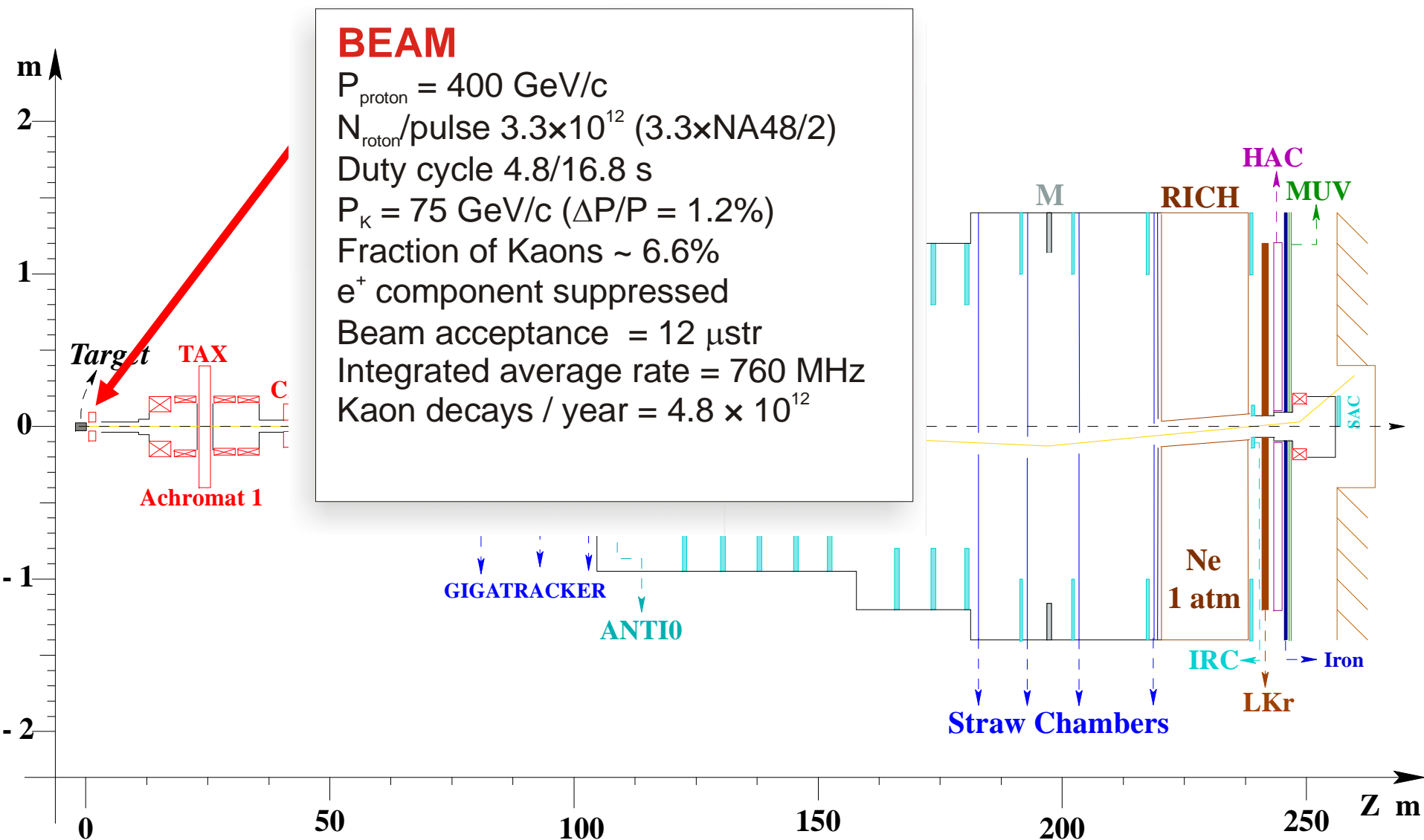
Define signal region  
 $K^+ \rightarrow \pi^+ \pi^0$  forces to split in two parts  
**Region I and II**

Span across the signal region  
 Lower branching fractions  
 Rejection relies on vetoes/ID

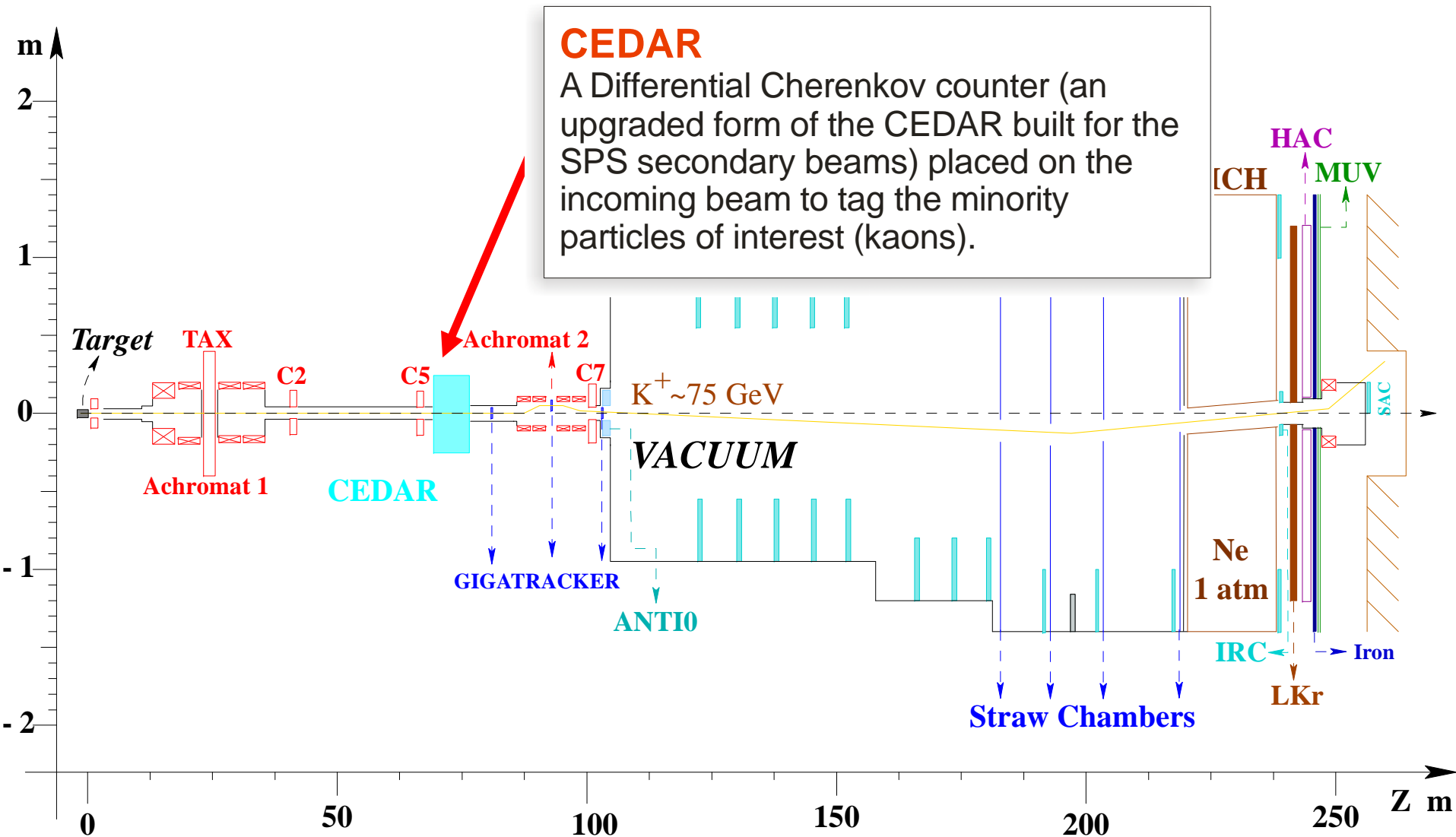
# Experimental layout



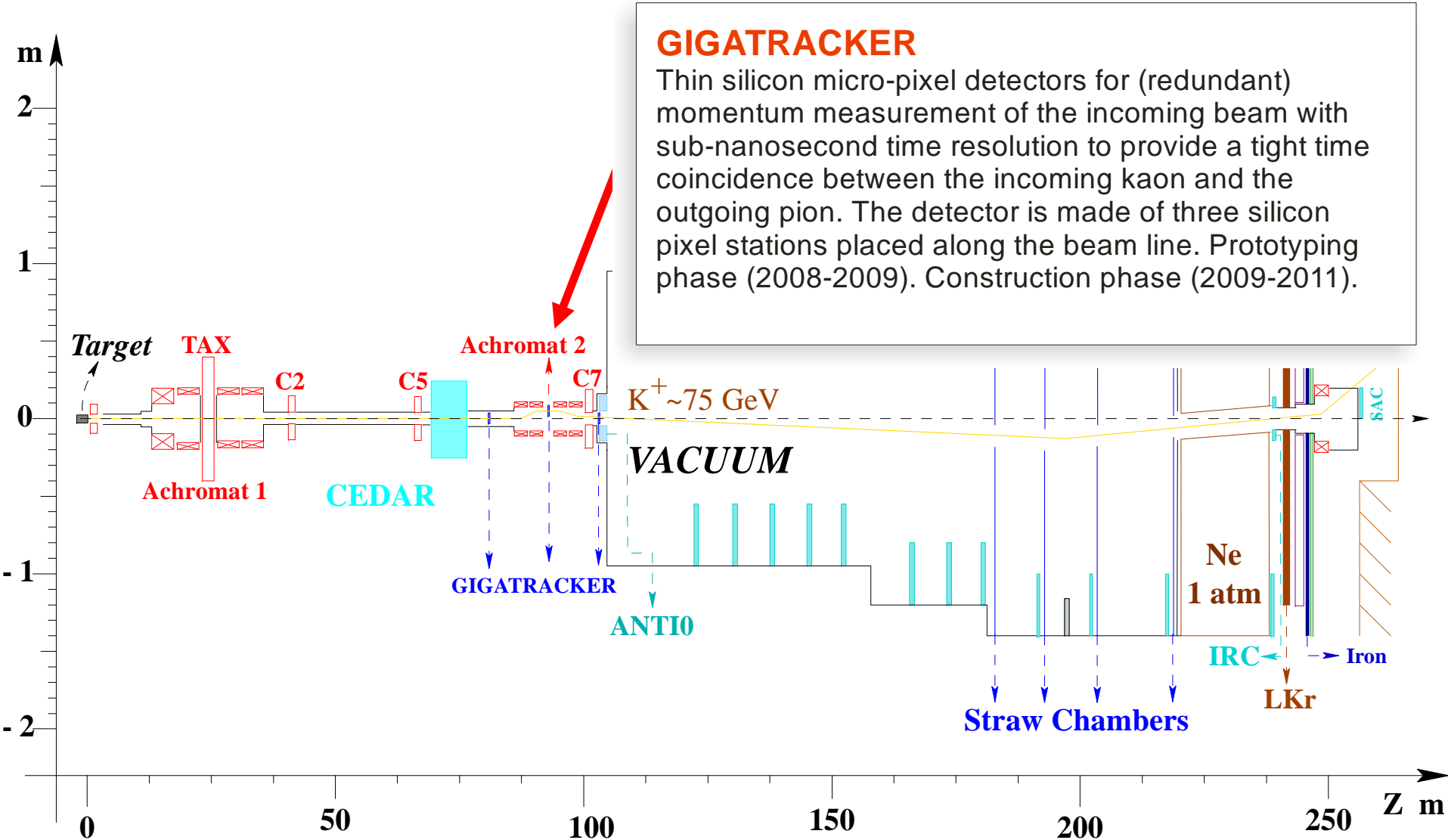
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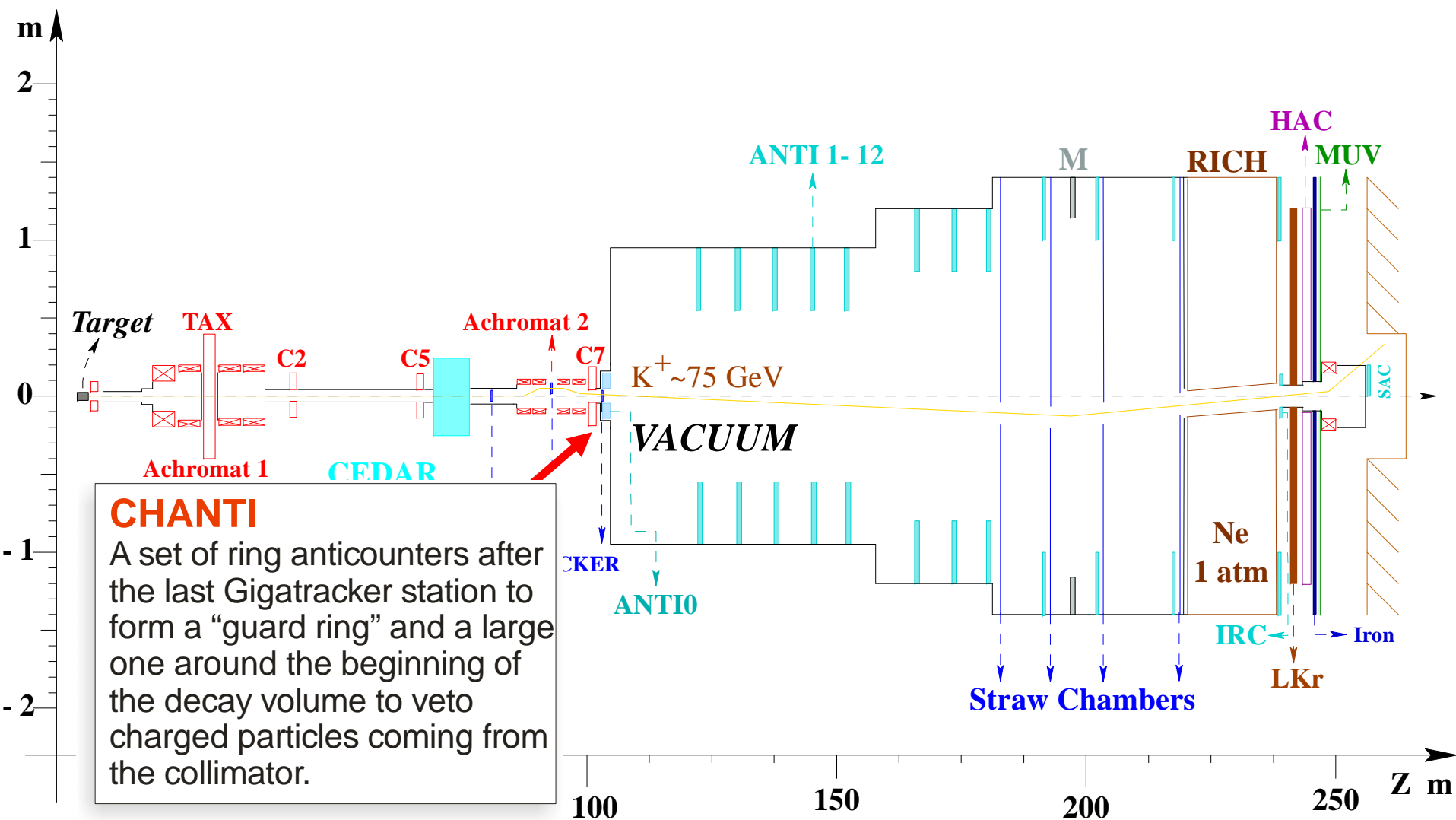
# Experimental layout



# Experimental layout



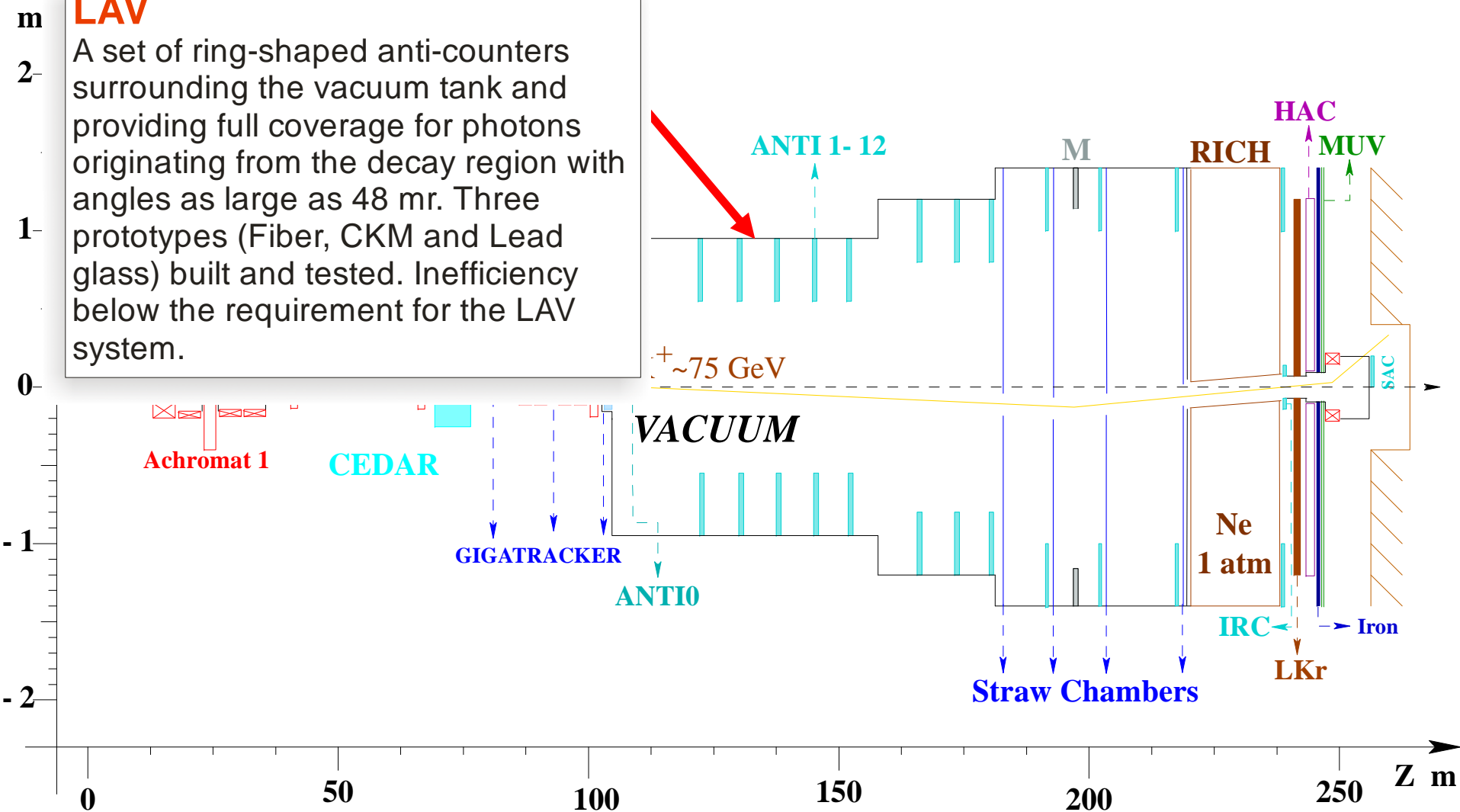
# Experimental layout



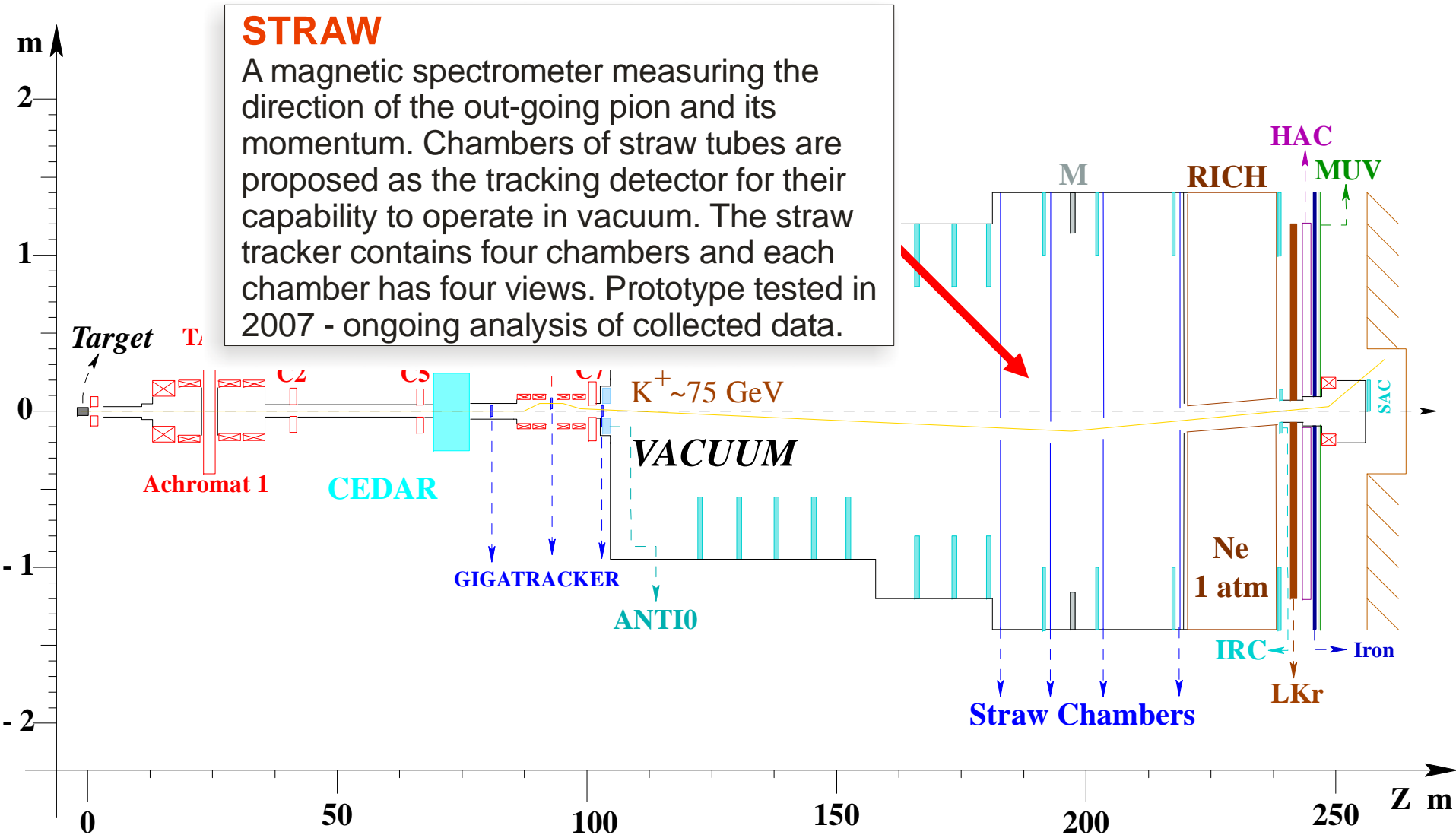
# Experimental layout

## LAV

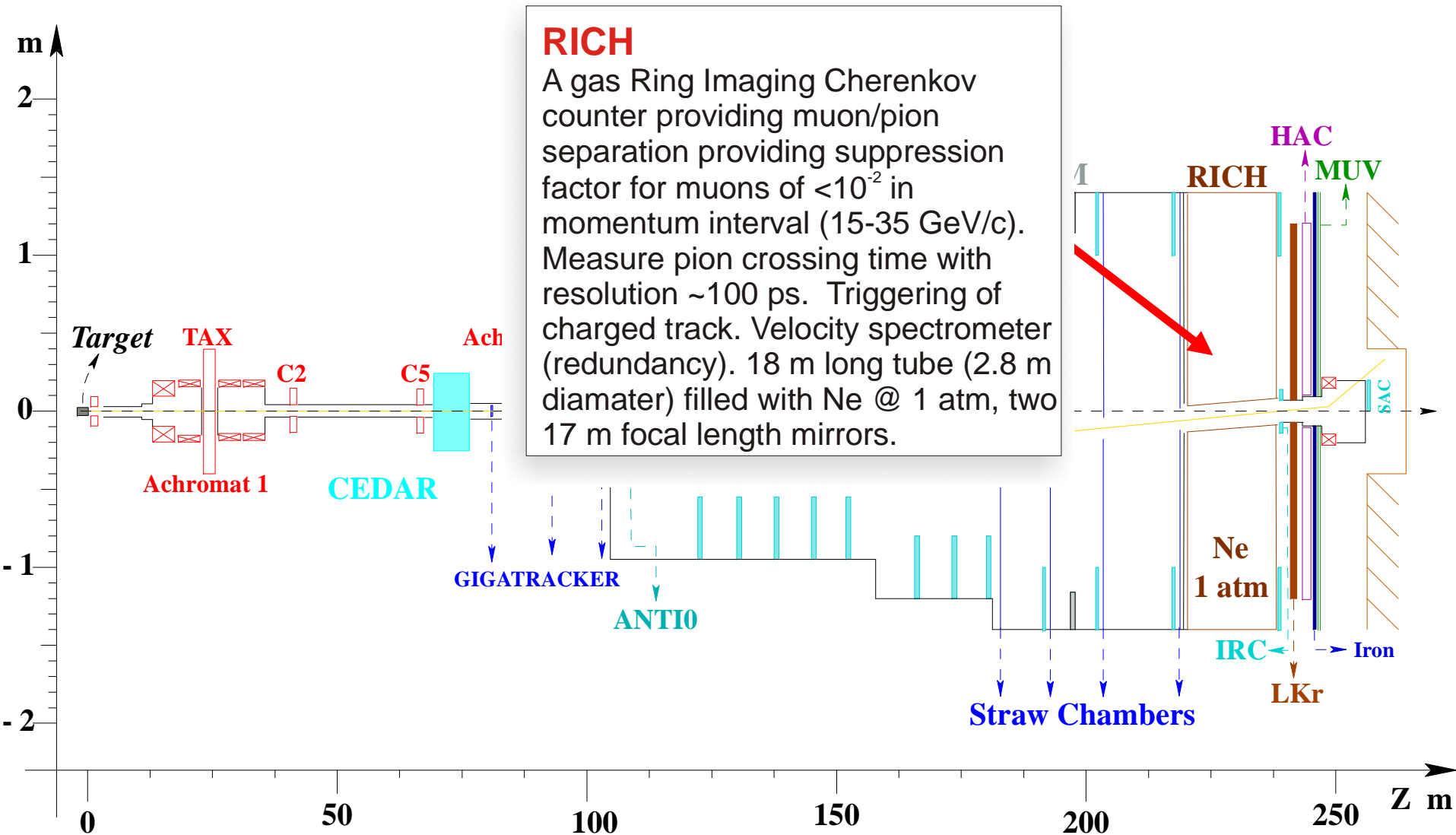
A set of ring-shaped anti-counters surrounding the vacuum tank and providing full coverage for photons originating from the decay region with angles as large as 48 mr. Three prototypes (Fiber, CKM and Lead glass) built and tested. Inefficiency below the requirement for the LAV system.



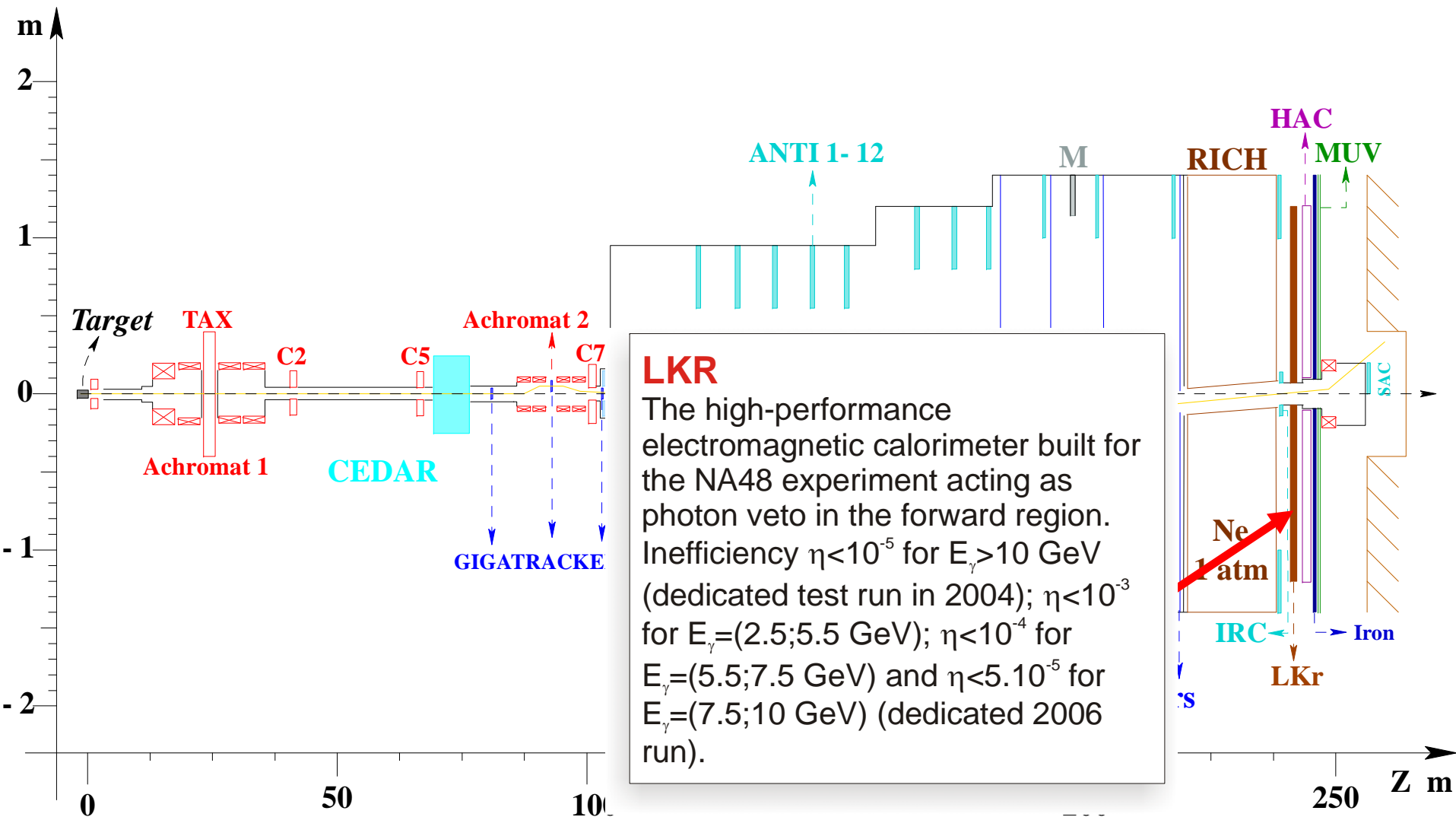
# Experimental layout



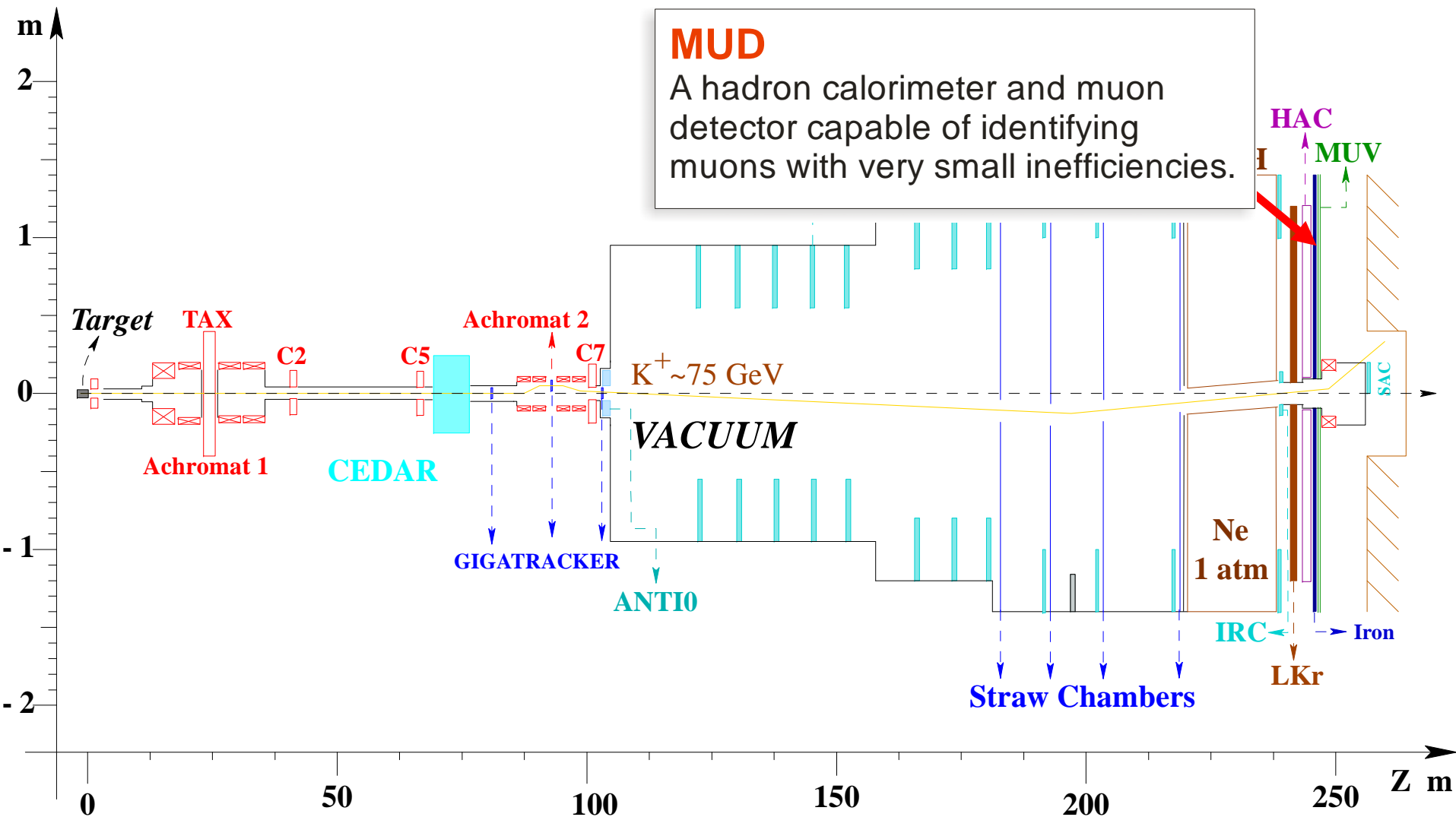
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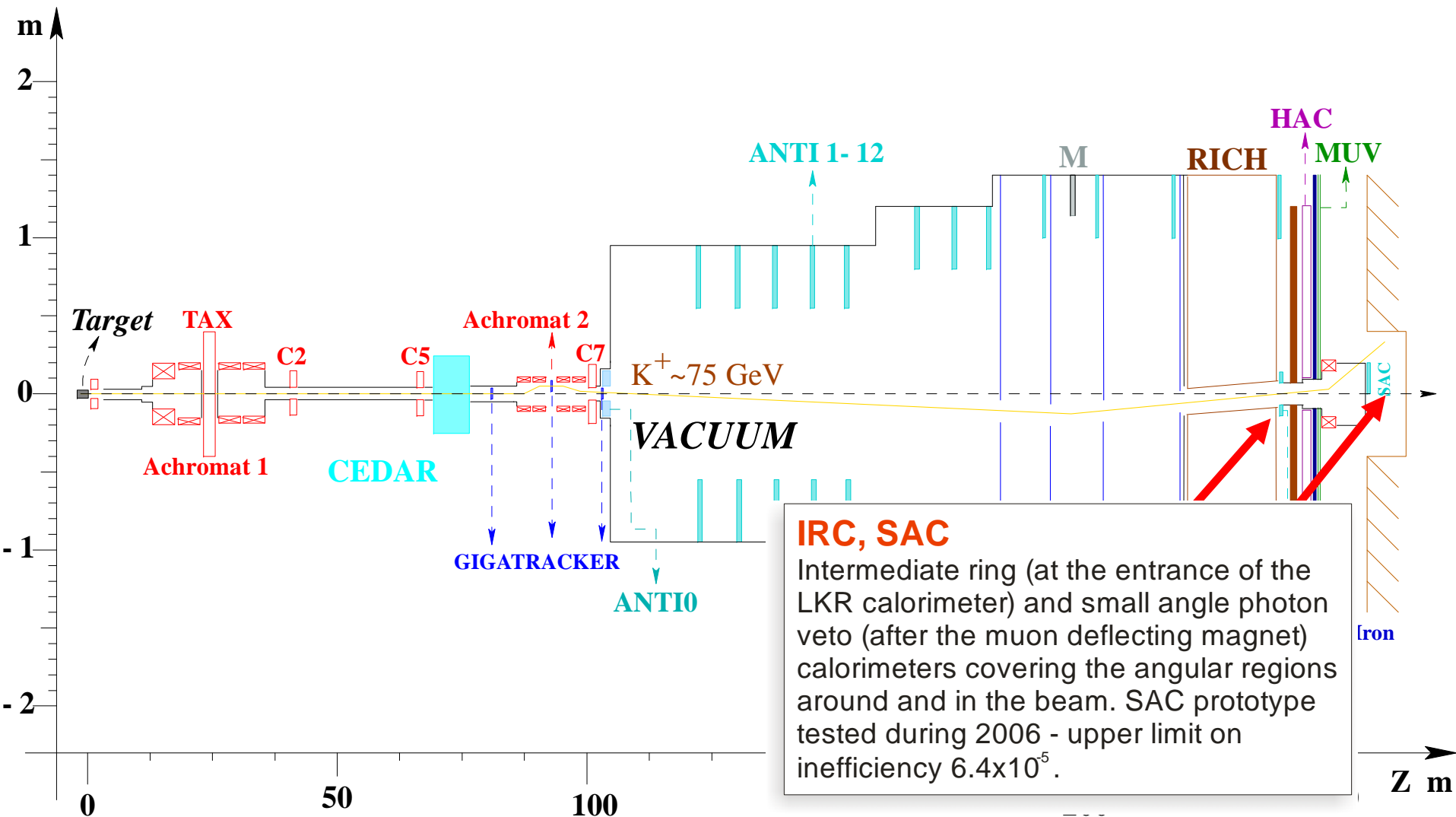
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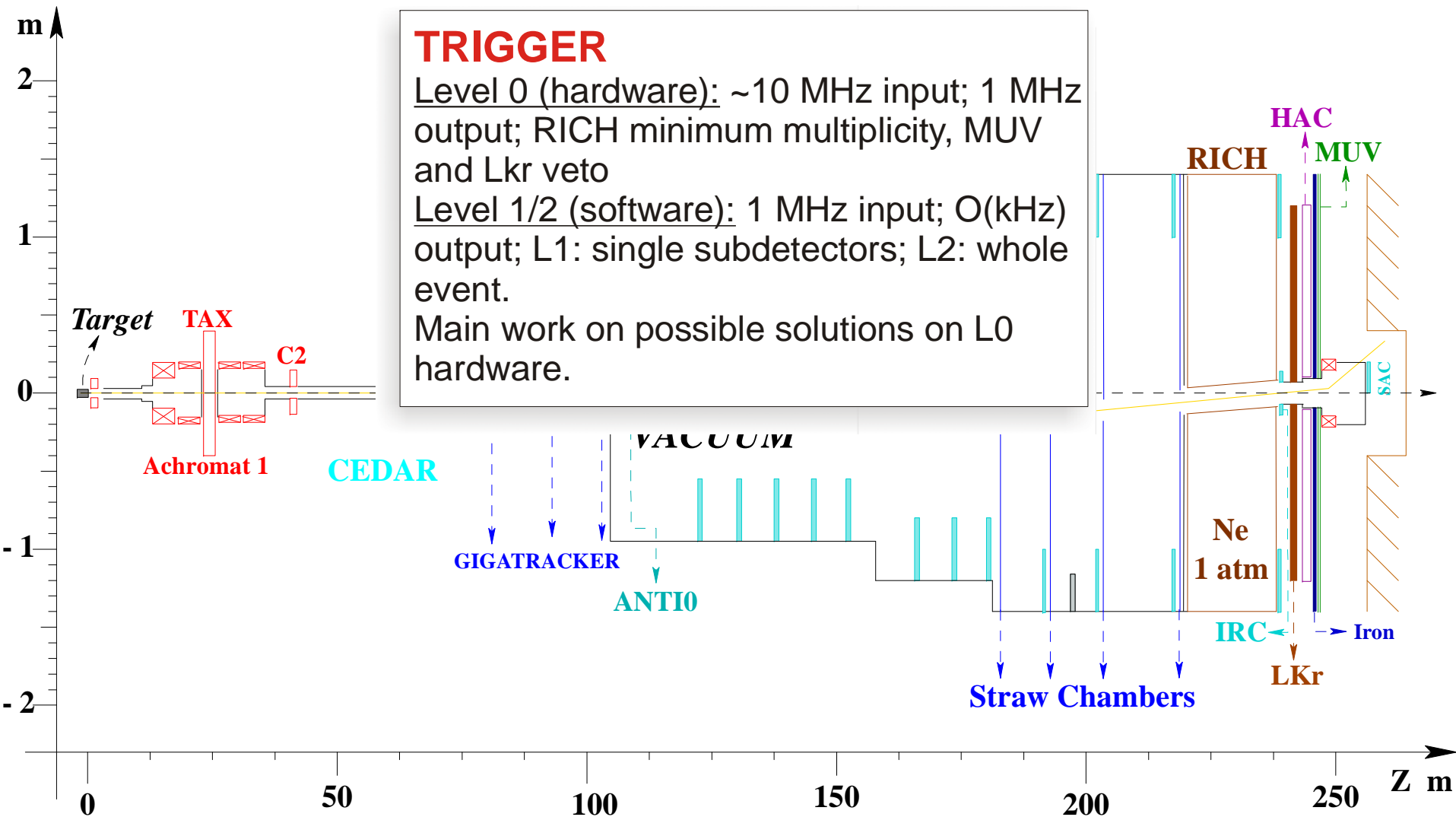
# Experimental layout



# Experimental layout



# Experimental layout



# Background estimations

<b>Signal (acc=14.4% flux = <math>4.8 \times 10^{12}</math> evts/year)</b>	<b>55 events/year</b>
$K^+ \rightarrow \pi^+ \pi^0$	4.3%
$K^+ \rightarrow \mu^+ \nu$	2.2%
$K^+ \rightarrow e^+ \pi^+ \pi^- \nu$	~3%
<b>Other 3 – track decays</b>	~1.5%
$K^+ \rightarrow \pi^+ \pi^0 \gamma$	~2%
$K^+ \rightarrow \mu^+ \nu \gamma$	~0.7%
$K^+ \rightarrow e^+ (\mu^+) \pi^0 \nu$ , others	negligible
<b>Total bckg.</b>	<b>~13.5%</b>

# Conclusions

- ◆ The experiment NA62 is proposed to search for new physics by measuring the **BR( $K^+ \rightarrow \pi^+ \nu \nu$ ) with 10% accuracy**.
- ◆ **Other physics opportunities** part of the experimental program (lepton universality, LFV, search for new low mass particles...)
- ◆ **General design is mostly defined**. Overall simulation and performances are under review.
- ◆ The **R&D program is well advanced**: construction of detector prototypes and tests are in progress (in some cases completed).
- ◆ The new experiment should be able to reach **sensitivity  $\sim 10^{-12}$  per event** using the existing infrastructure at CERN.