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"Timing in n-nbar experiment

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Idea of n→nbar detection experiment

Slow free neutron in vacuum with shielded zero magnetic field develops probability of transformation to antineutron as

$$P_{n\to\bar{n}} = \left(\frac{t}{\tau_{n\bar{n}}}\right)^2$$ where t is neutron flight time and $\tau_{n\bar{n}}$ is oscillation time predicted by theory

When n is transformed to antineutron, the latter will annihilate in the thin Carbon target producing a star of 5 pions (aver.) that need to be reconstructed to the annihilation point.

Previous n-nbar search experiment with free neutrons

At ILL/Grenoble reactor in 89-91 by Heidelberg-ILL-Padova-Pavia Collaboration

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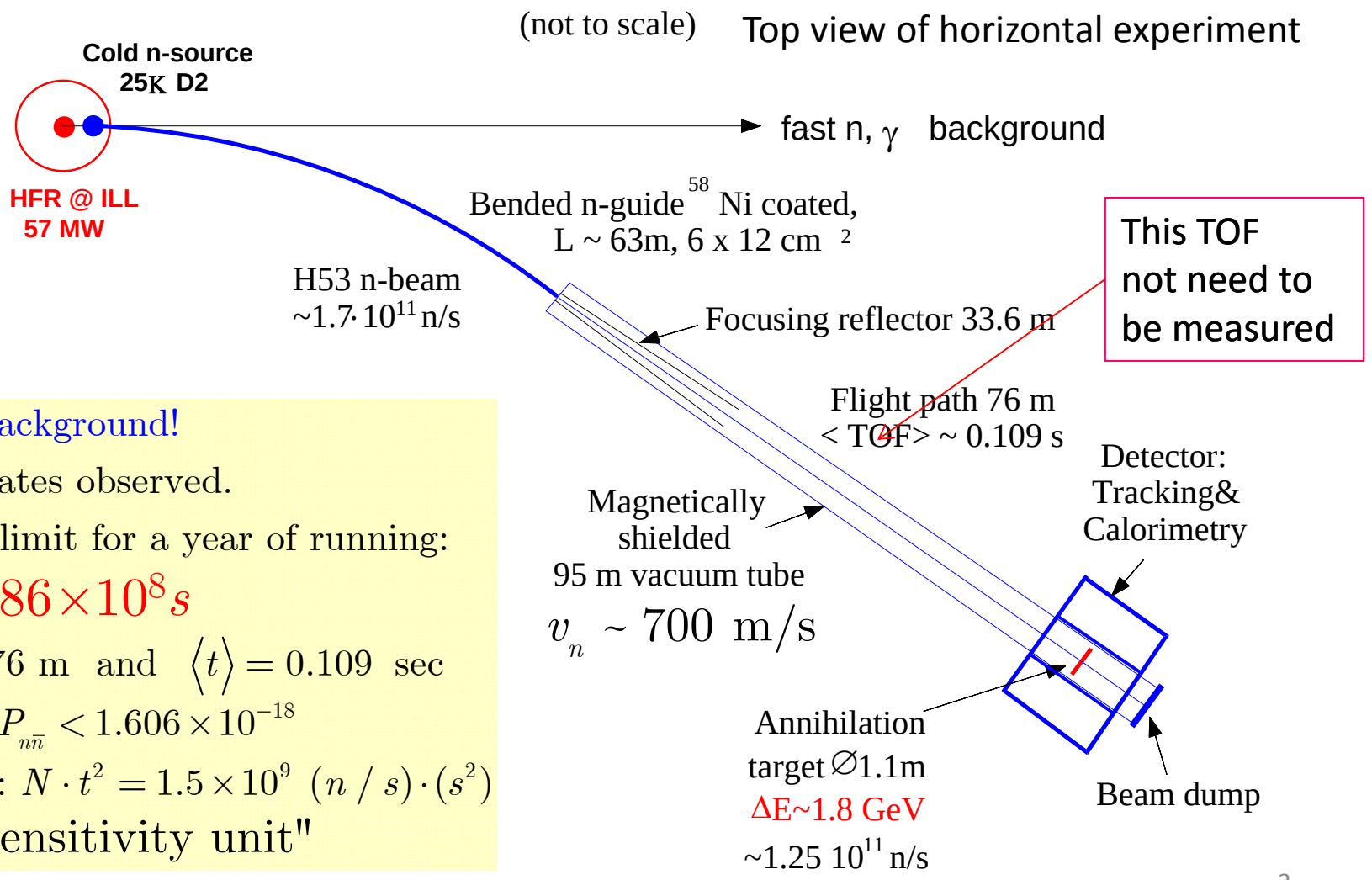


No GeV background!

No candidates observed.

Measured limit for a year of running:

$\tau_{n\bar{n}} > 0.86 \times 10^8 s$

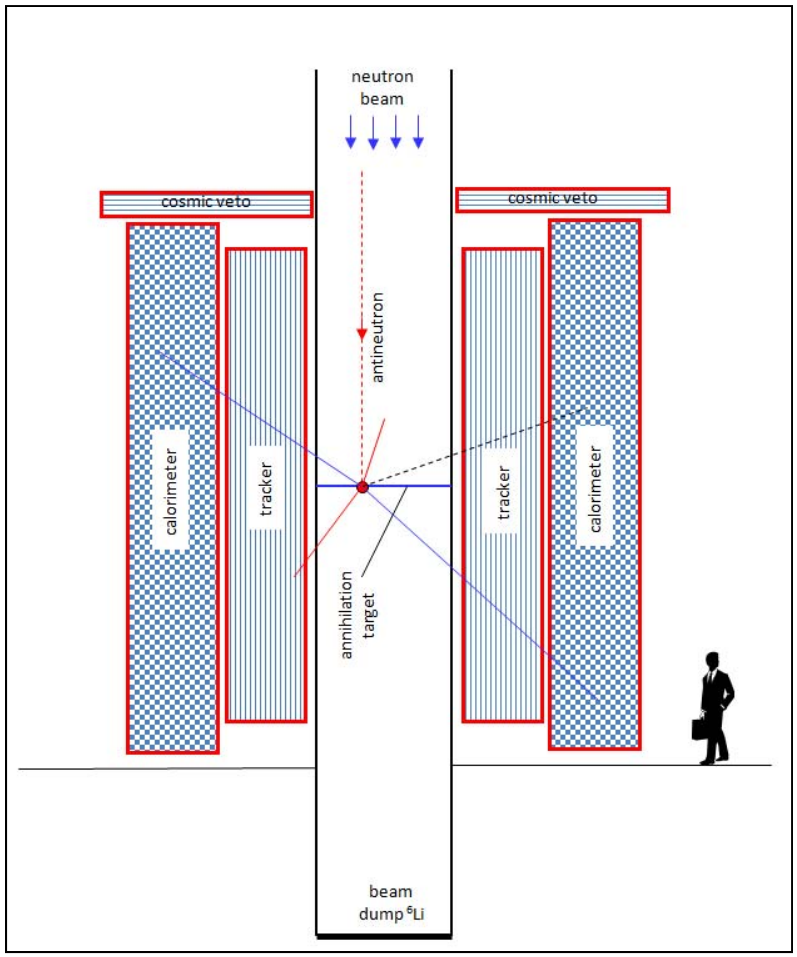
with L ~ 76 m and $\langle t \rangle = 0.109$ sec

measured $P_{n\bar{n}} < 1.606 \times 10^{-18}$

sensitivity: $N \cdot t^2 = 1.5 \times 10^9 \ (n/s) \cdot (s^2)$

$\doteq$ "ILL sensitivity unit"

Annihilation Detector



Annihilation feature: $\overline{n} + C \rightarrow \langle 5\pi \rangle$

- Use ideas of backgroundless ILL detector;
- That can be Vertical and Horizontal;
- Tracker for vertex to thin carbon target;
- Calorimeter for trigger and energy reco;
- TOF before and after tracker to remove vertices of particles coming from outside;
- Veto system to suppress cosmic bkgr;
- Trigger: Calorimeter · TOF · VETO
- Shielding to minimize (n,γ) emission.

Anti-neutron annihilation detector of the Heidelberg-ILL-Padova-Pavia Collaboration (1994)

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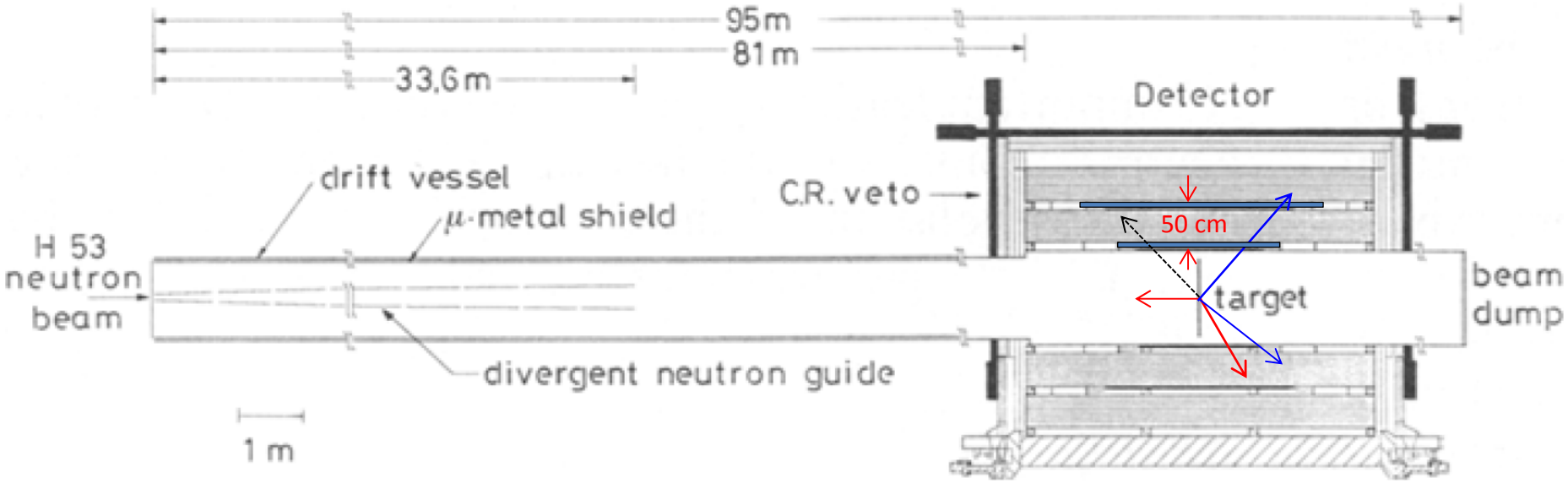

- TOF function: be part of the trigger; select vertices originated inside the vacuum tube; suppress cosmic events coming from outside;
- Two layers of scintillator slabs. ΔR=50 cm; Δt ~ 900 ps;
- Total ~1MeV γ field ~> 10^7/s – higher segmentation would be favorable.

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A new experimental limit on neutron-antineutron oscillations

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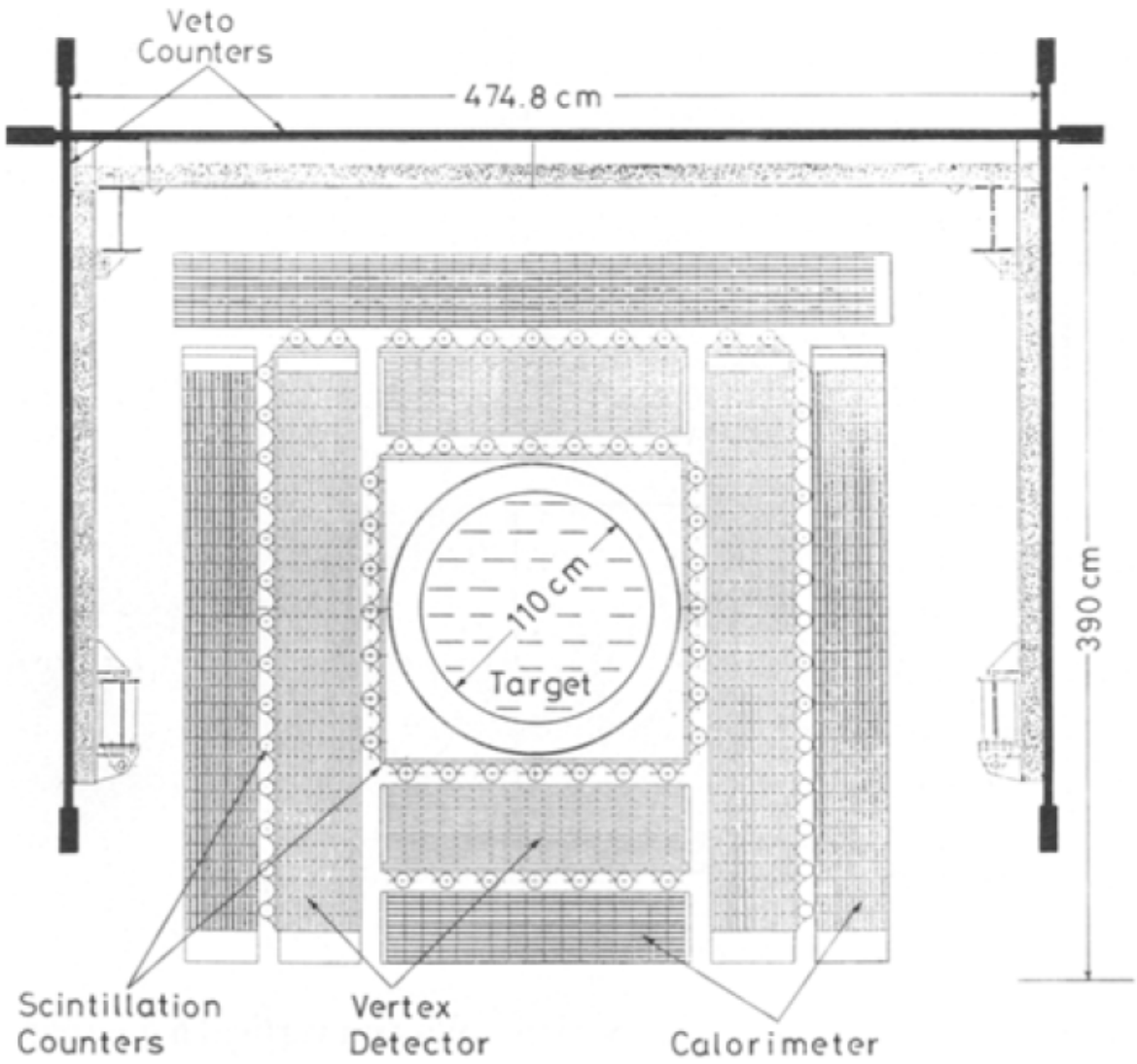

Fig. 5. The $\bar{n}$ annihilation detector (cross sectional view)

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NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A

The suppression of beam-related background in the ILL neutron–antineutron oscillation experiment

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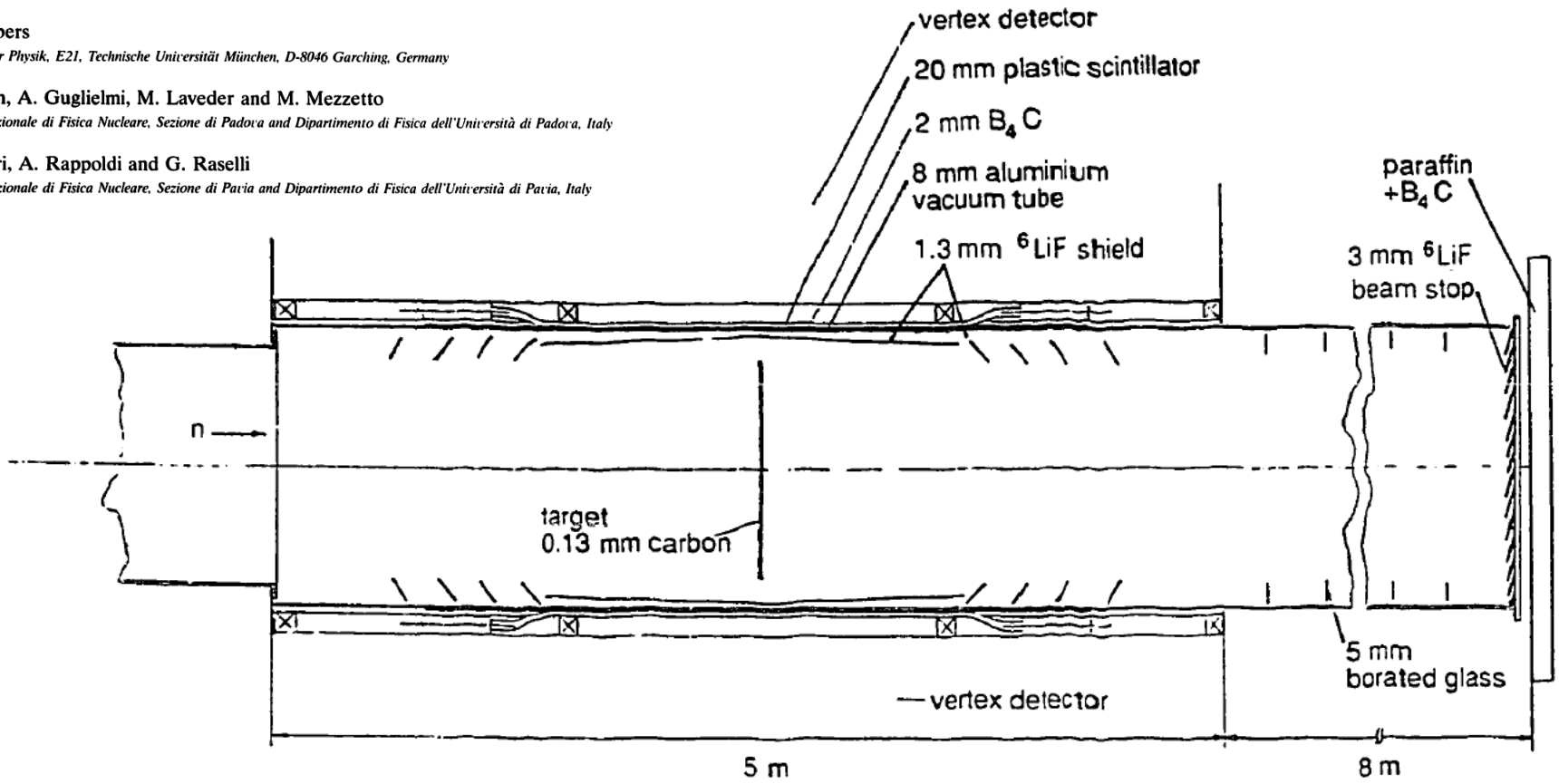

Fig. 1. The target region of the nn̄ experiment and its surroundings.