PMTs used in the DIRC of BaBar

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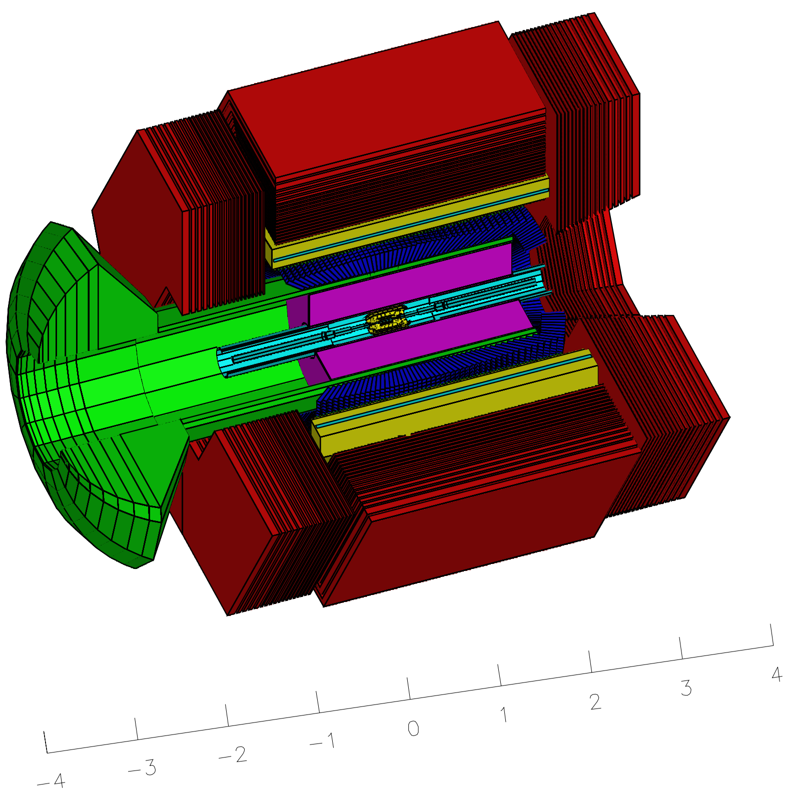
- Introduction
- Performance of the PMTs
- Effect of a magnetic field
- Effect of helium
- Conclusion

The DIRC of *BaBar*

- *BaBar*: high energy physics experiment at the SLAC PEP-II e^+e^- collider.
- DIRC: particle identification device of *BaBar*: new Čerenkov detector.



The PMTs

- 10752 cylindrical ETL 9125FLB17 PMTs (diameter of 28.2 mm).
- Immersed in purified water in a close-packed geometry.
- Working in single photoelectron mode.

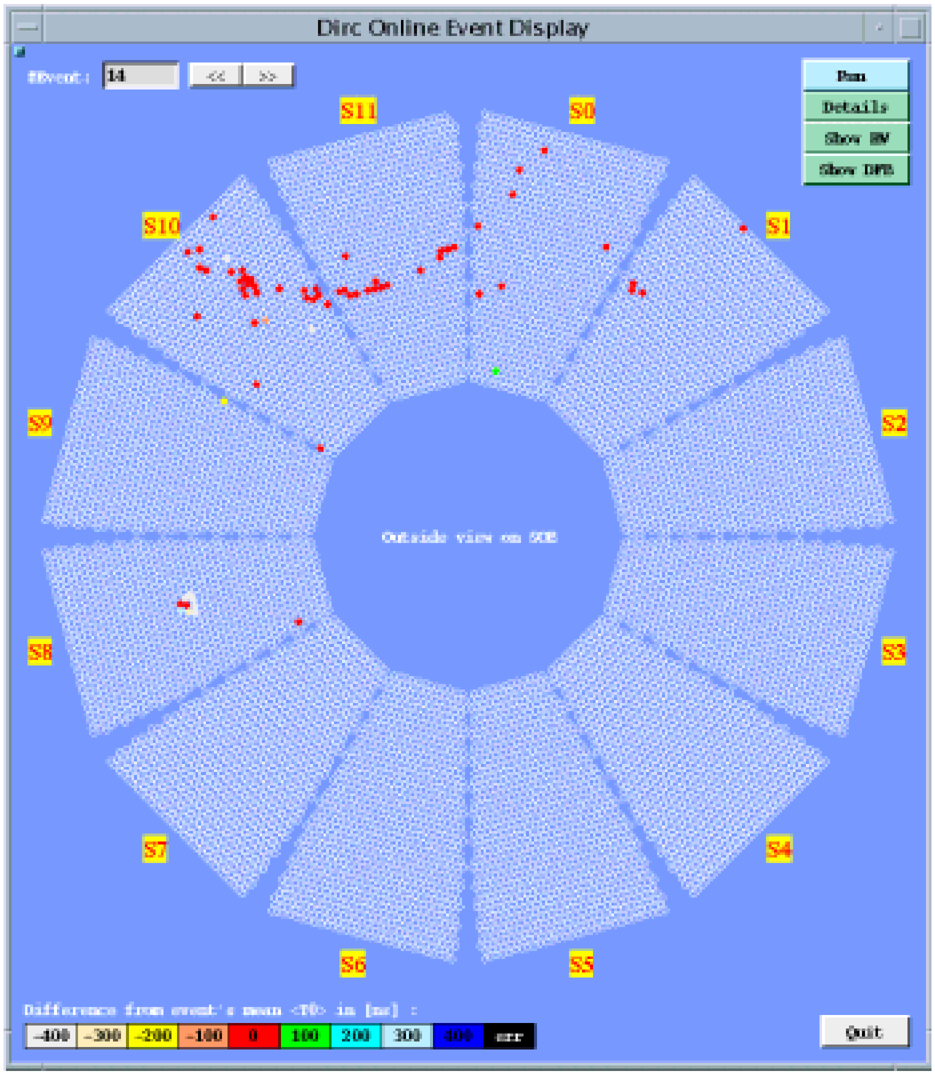
Specifications on PMTs

- Non porous enveloppe (water, helium).
- Good transmission in the visible and near-UV range.
- Good sensitivity to the single photoelectron.
- High gain: 1.7×10^7.
- Good timing resolution: < 2 ns.
- Low price.

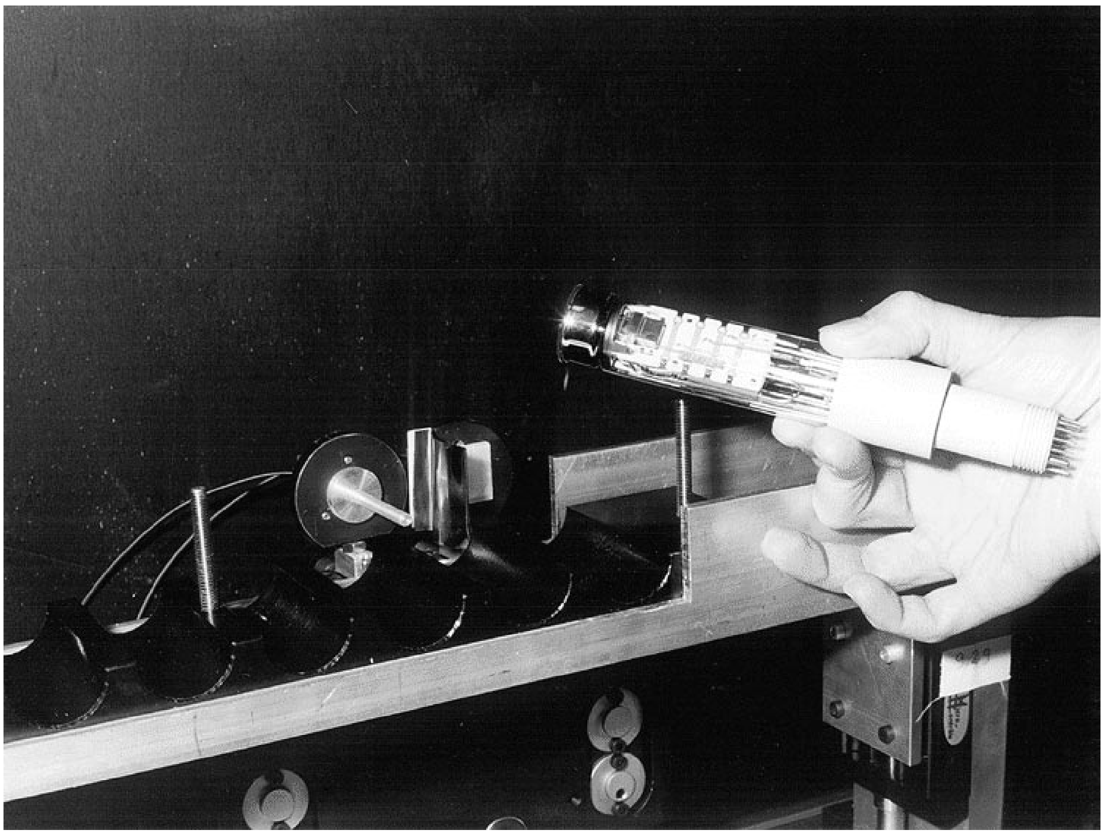
ETL 9125 selected.

One event in the DIRC

Example of a ring of photons detected by the PMTs.

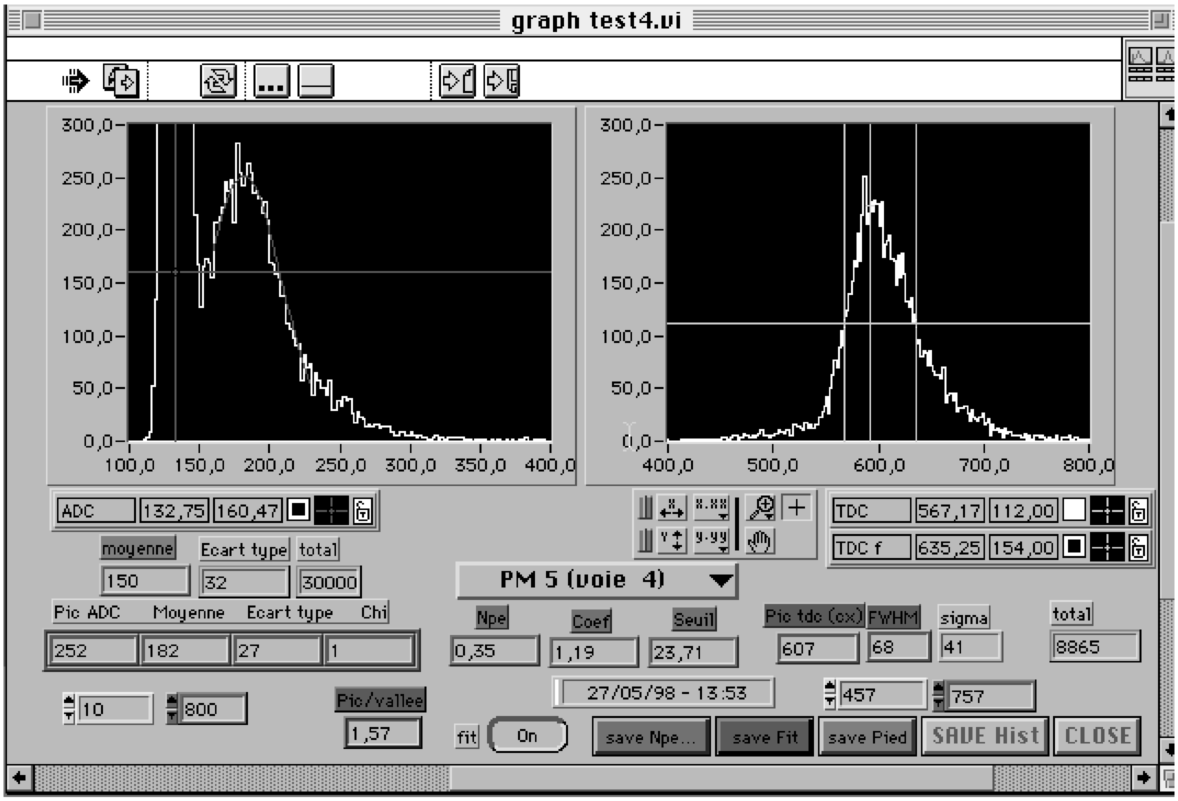


Basic performance



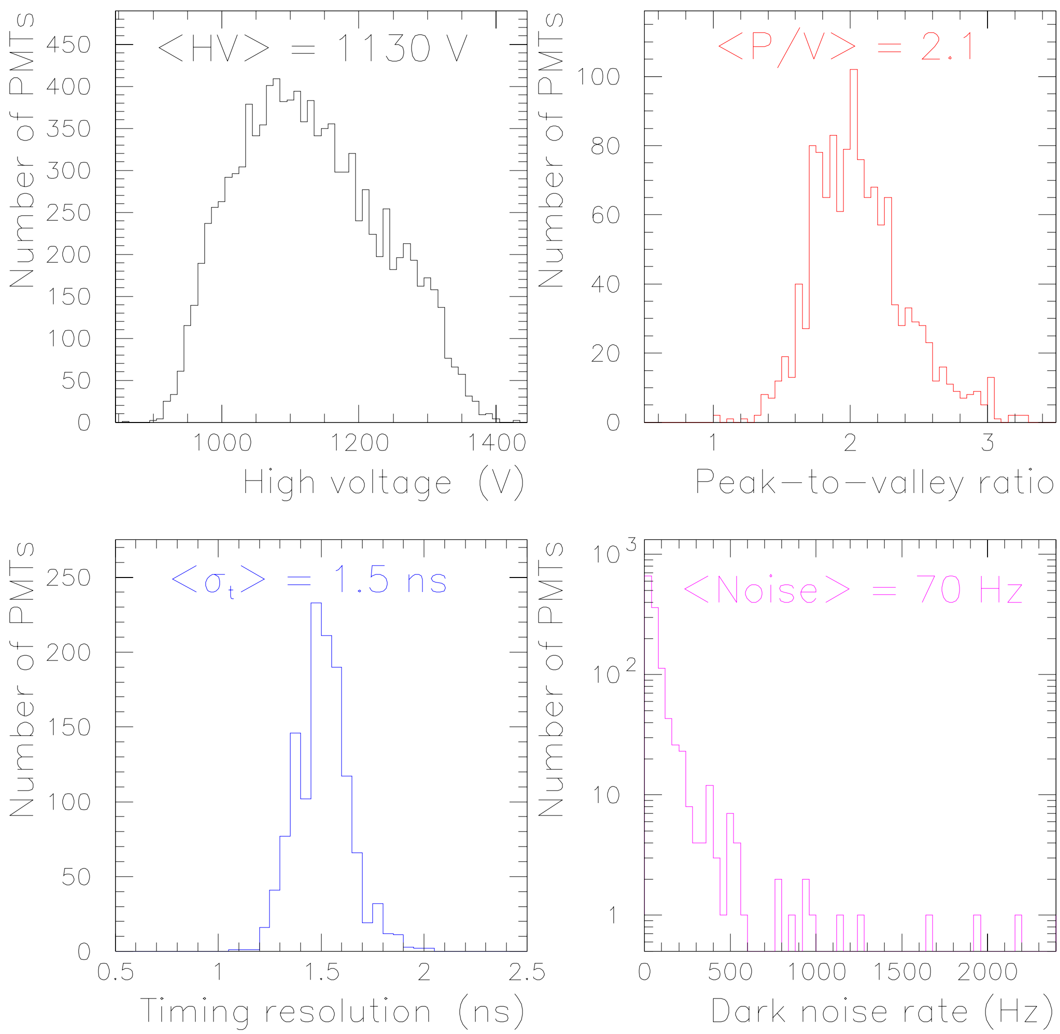
- 12 % of all PMTs have been tested (quality control).

Measurements



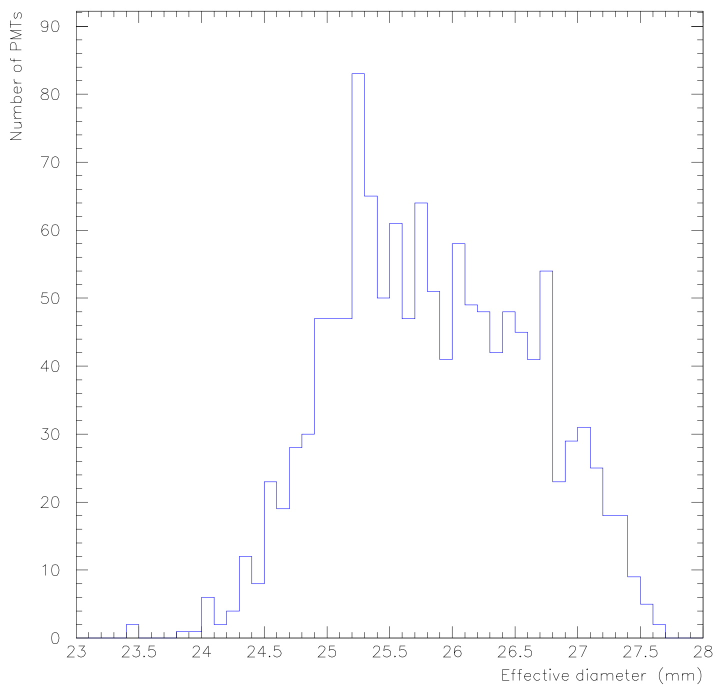
- Charge measurement in an ADC.
- Time measurement in a TDC.

PMT performance



Scan of the photocathode

Determine the useful diameter of the photocathode.



<effective size> = 25.8 mm

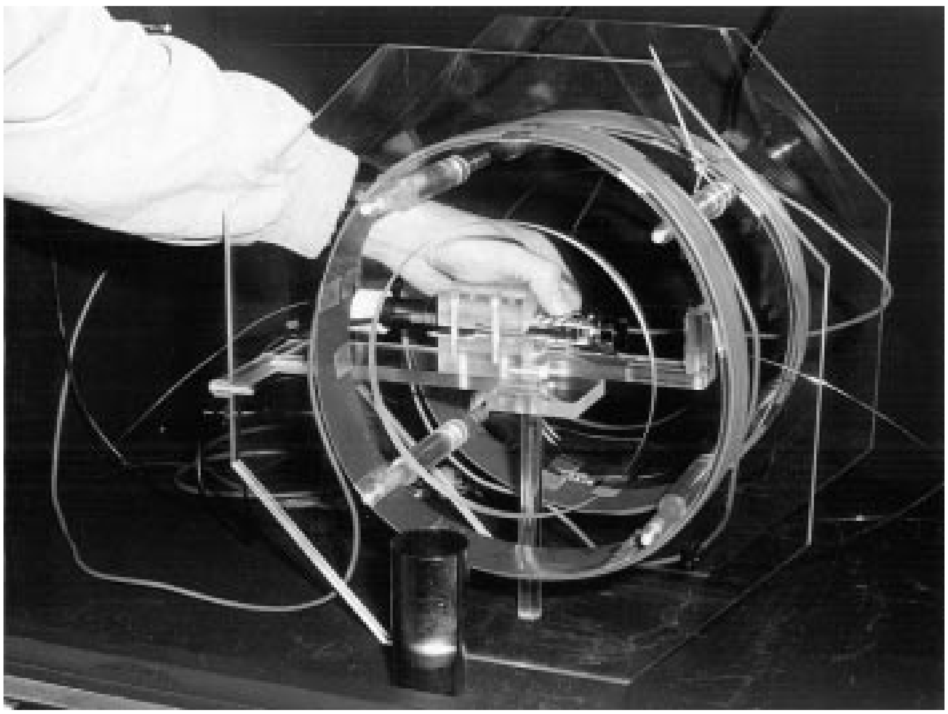
Conclusion of the quality control tests:

The PMTs satisfy the needs for the physics.

Effect of a magnetic field

The PMTs are in the fringe field of *B*A*B*AR.

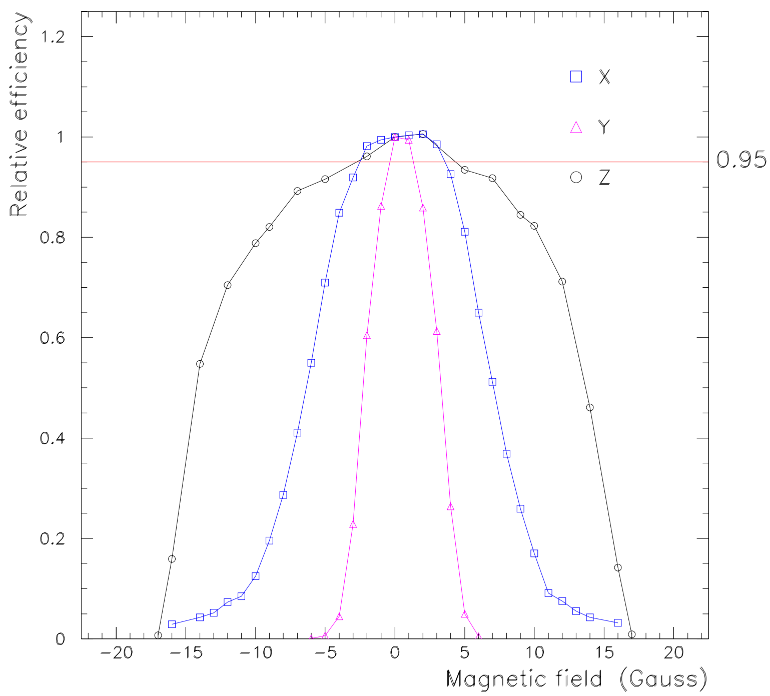
We need to measure PMTs performance in a magnetic field.

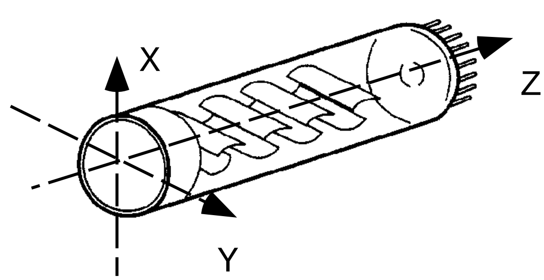


- Magnetic field created by Helmholtz coils,
- measured by a Hall effect magnetometer.

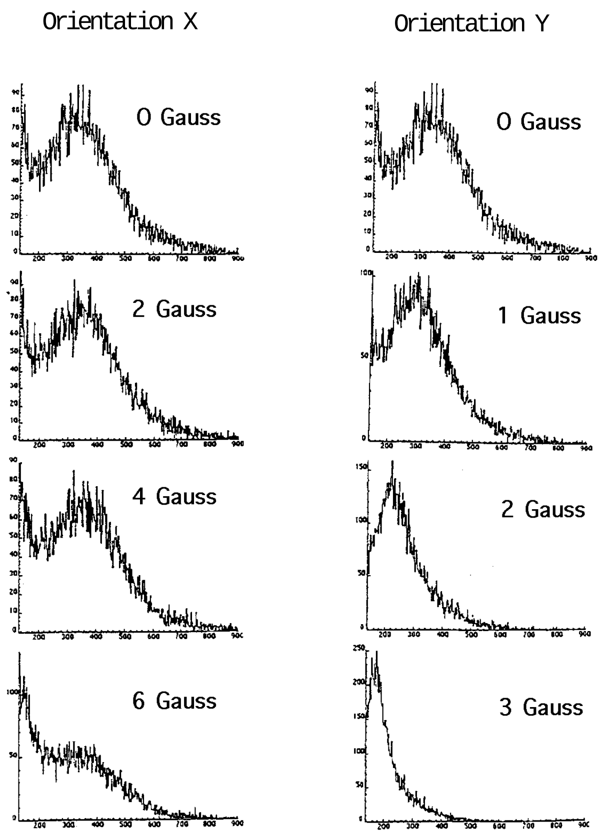
Effect of orientation

- Longitudinal field least troublesome.
- Big difference between the two transverse orientations.





Effect on the gain

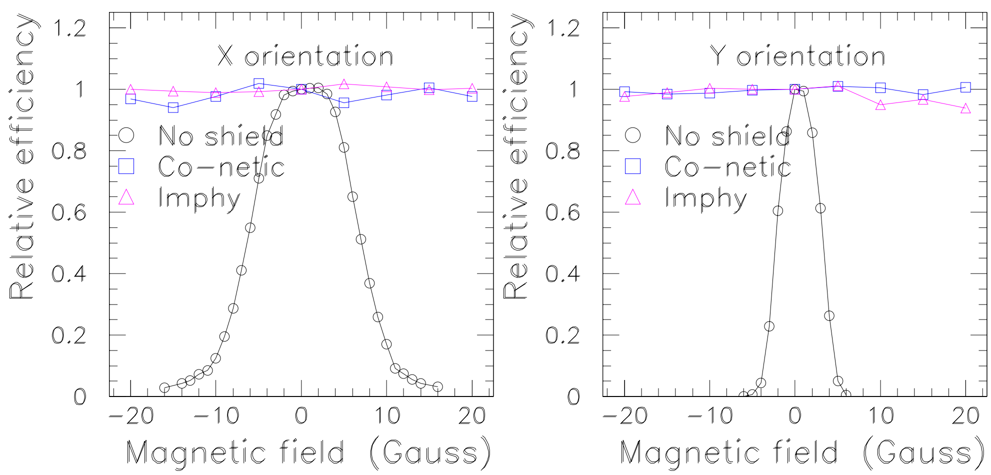


Main effect of the magnetic field:

- X orientation: reduction of the collection efficiency.
- Y orientation: drop of the gain.

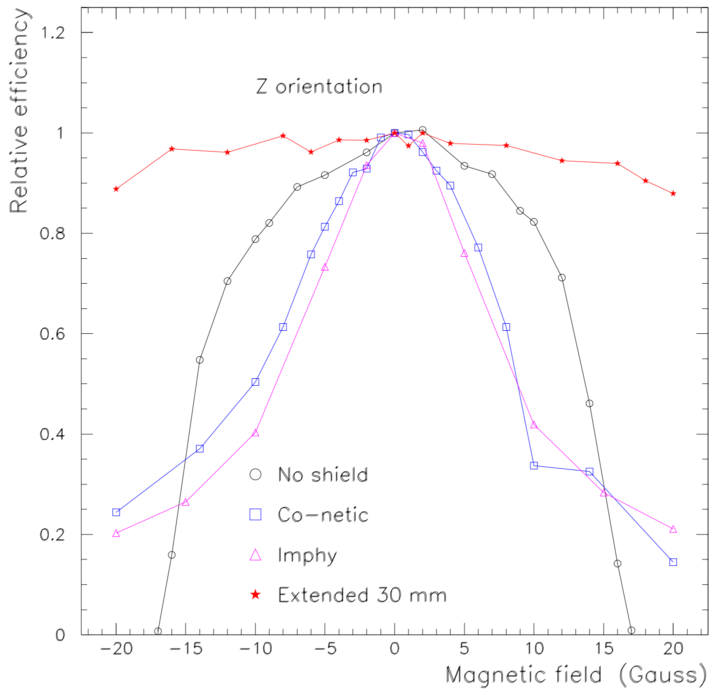
Mu-metal: transverse fields

- Can we shield PMTs individually ?
- 2 types of mu-metal used: Co-netic and Imphy (0.1 mm thick foil).



Impressive protection in both transverse orientations.

Mu-metal: longitudinal field



- Degradation if mu-metal does not extend beyond the photocathode.
- Not possible in the DIRC (light catchers, shadowing effects).

Magnetic field: conclusion

- Effect of orientation: PMTs can sustain 1 Gauss in the unfavorable orientation and 3 Gauss in the favorable orientation.
- PMTs are oriented in the calculated lower field component.
- Individual mu-metal shields are very performant, but cannot be used here.
- A global soft iron shield and a bucking coil reduce the fringe field to less than 1 Gauss at the PMTs.
- There should be no problem with the magnetic field.

Effect of helium

- In *BaBar*, helium is used in:
  - the gas of the drift chamber,
  - the cryogenics of the supraconducting coil.

  Potential hazard for the PMTs.

  We need to quantify this effect.

- Evolution of pressure of helium inside a PMT with time:

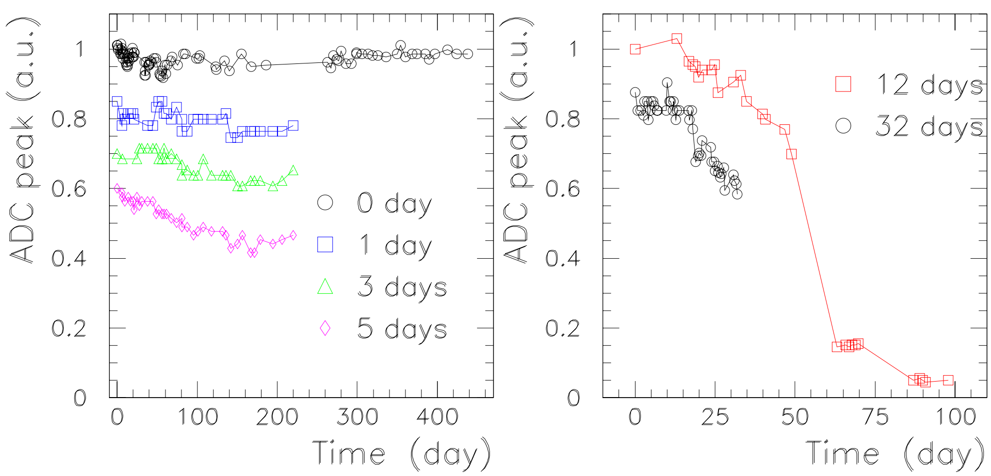
  $\frac{P}{P_0} = \frac{t}{\tau}$, $\tau \simeq 590\,\text{years}$.

  $P_0 = 5.2 \times 10^{-6} P_{atm}$ in 10 years is equivalent to 1 day in pure helium.

Evolution with time

Study the evolution of the PMT gain with time for various lengths of stay in pure helium.

Main effect seen on the gain (no clear effect on dark noise).



Helium: conclusion

- The borosilicate glass is resistant to helium leackage: it takes $\sim$ 20 days for helium to enter the PMT.
- A long stay ($\geq$ 12 days) in pure helium eventually kills the PMT.
- For a short stay, we observe a stabilisation of the gain.
- For 5 days, there is a $\sim 25\%$ reduction in the gain.
- For 3 days, there is a $\sim 10\%$ reduction in the gain.
- For 1 day, there is a very small effect.

Summary

- The PMT performances meet our needs.
- The PMTs are resistant enough to the magnetic field. No individual mu-metal shields, but a global magnetic shield.
- The PMTs are quite resistant to helium.

BaBar has just started to take data.