The HERA-B Ring Imaging Čerenkov Detector

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HERA-B Collaboration

- Requirements
  - Physics
  - Space Limitations
  - Rate Capabilities and Aging
- Design
  - Radiator
  - Mirrors
  - Photon Detector
- Expected Performance and Status
  - Prototype Test Results
  - Photographs

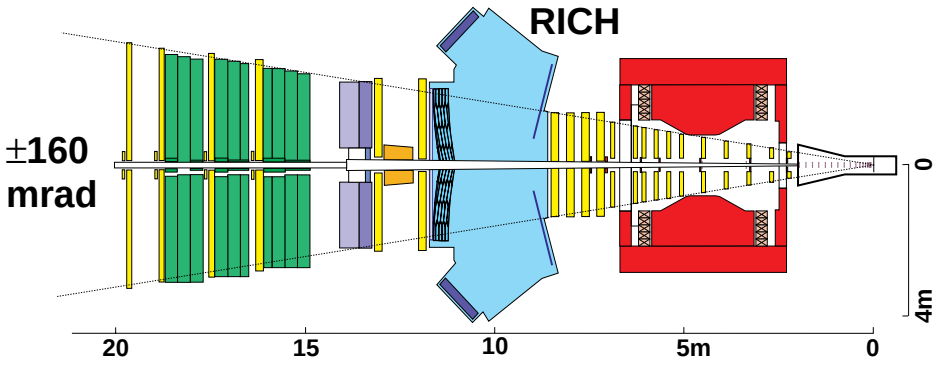
Requirements

Physics

- Identify *pions* and *kaons* over a large momentum range and phase space
  - 90% of K_S from $B_0 \rightarrow J/\psi K_S$ in HERA-B have a momentum between 4 and 60 GeV/c
  - Cover full acceptance: ±160 mrad vertical, ±250 mrad horizontal (bending plane)
  - At least 20 photons per ring

Space in the HERA-B Detector

- Radiator should be less than 3m long



- Space above and below proton beamline is about 4 m.

Events Rates and Aging

- Protons hit multi-wire target every 96 ns
  - Event rates up to 40 MHz possible
  - Up to 3 MHz / cm^2 detected Cerenkov photons

Radiator

❑ Choice of Gas: C_4F_{10} (Perfluorobutane)

- Large refractive index: $n - 1 = 1.35 \times 10^{-3}$
- Low dispersion: 5% between 300 and 480 nm
- Čerenkov angle for $\beta = 1$ particles:

$$\cos\theta_C = \frac{1}{\beta n} \quad \rightarrow \quad \theta_C = 52 \text{ mrad}$$

  - Nicely matches $\gamma_{CM}^{-1} \approx 50$ mrad
    (E_p = 820 GeV, E_{CM} = 40 GeV, γ_{CM} = 21)
- Čerenkov threshold momenta
  π = 2.7 GeV/c K = 9.6 GeV/c p = 18 GeV/c

❑ Vessel and Gas System

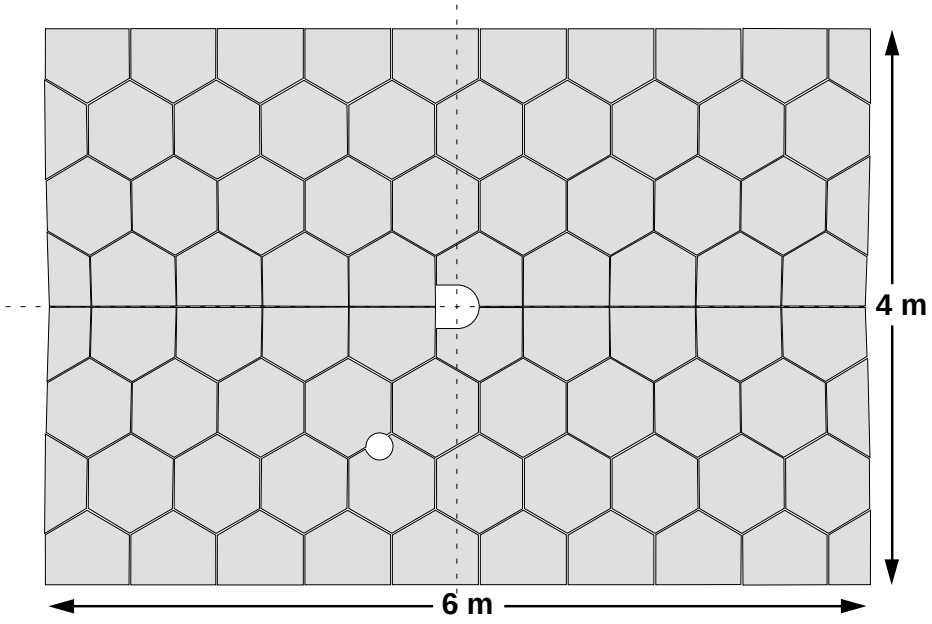
- 100 m^3 stainless steel tank
- C_4F_{10} is liquid at 2 bar and 20°C
- Gas is recirculated, nitrogen separation by cooling to –40°C

▼ Contamination by air or water uncritical; only refractive index matters

Mirrors

Spherical Mirror with R_{sph} = 11.4 m

- Center of curvature at interaction point
- Split horizontally and tilted up and down by 9°
- 80 full or partial hexagons; 7mm thick Pyrex; coating 200 nm Al, 30 nm MgF_2



Mirror area 24 m^2

Planar Mirrors

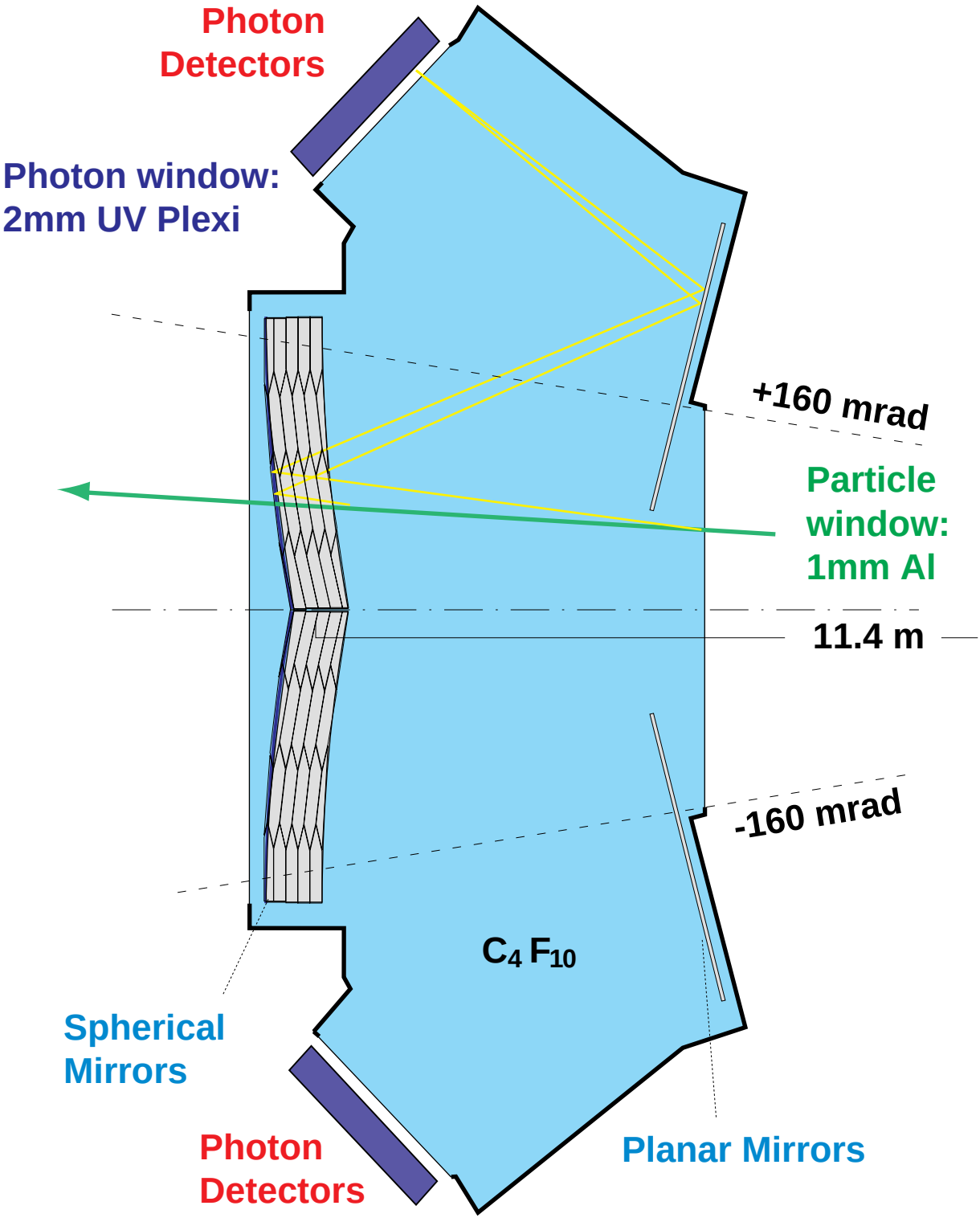
- Move *focal plane* (at $R/2$) out of particle flux
- Made from 24 float glass pieces

Alignment

- By motor possible for all mirrors
- Done by surveying (autoreflection)

RICH Overview

Vertical Cross section

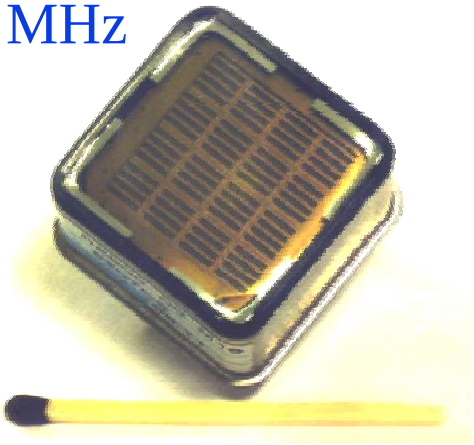


Photon Detector

❑ Focal Plane

- Cylinder with $r \approx 1/2\ R_{sph}$, tilted by 18°
  - Best correction for spherical aberrations and effects of split & tilted mirror
- Incidence angle $\approx 2\ \theta_C$ due to unknown z of photon emission and effect of magnetic field

❑ Only Photomultipliers work at MHz



- *Hamamatsu R5900* with 18×18 mm^2 photocathode
- *1500* with 16 anodes (M16)
  750 with 4 anodes (M4)
- 32×12 PM on 36 mm grid put in *supermodule*

❑ Light Collection by 2-lens Telescope

- Maps 36×36 mm^2 onto photocathode; optimized for 150mrad acceptance
- Aspheric UV-Acrylate lenses
  - Planoconvex field lens, 35.3□ mm^2, f = 95mm;
    Biconvex collector lens, 32 ∅mm^2, f = 30mm

▼ 24000 9mm^2 pixels, 3000 18mm^2 pixels
Total coverage: 3 m^2

Photon Detector

Readout Cards

16 ch, using two ASD08 (amplifier, shaper, discriminator) chips each

Base-Board

Socket, voltage divider, output circuitry for 4 multi-anode PMTs

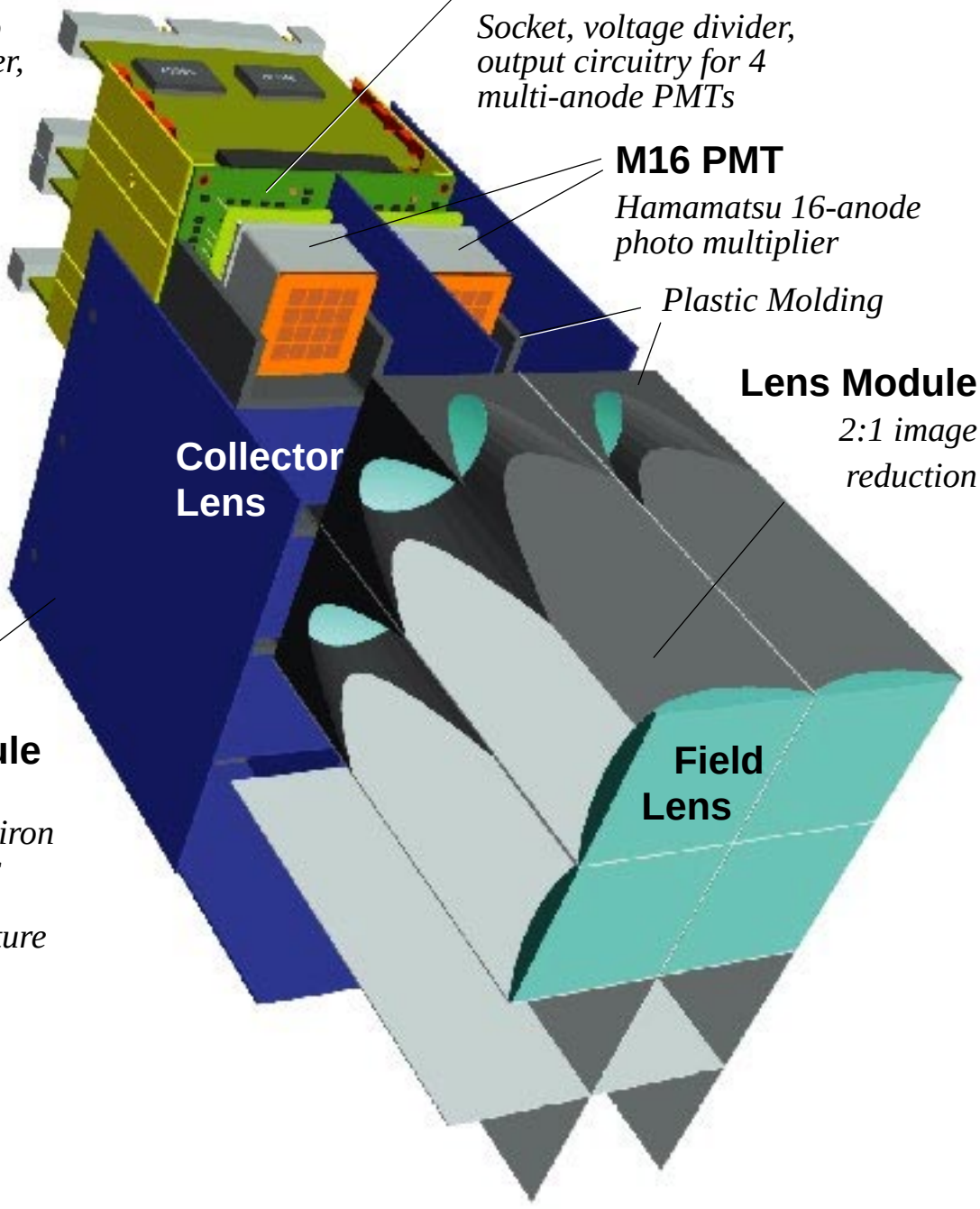
M16 PMT

Hamamatsu 16-anode photo multiplier

Plastic Molding

Lens Module

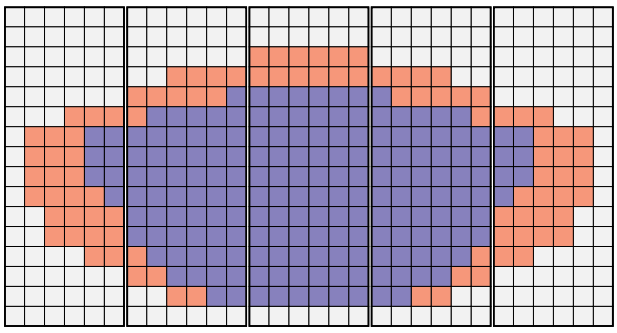
2:1 image reduction



Super Module

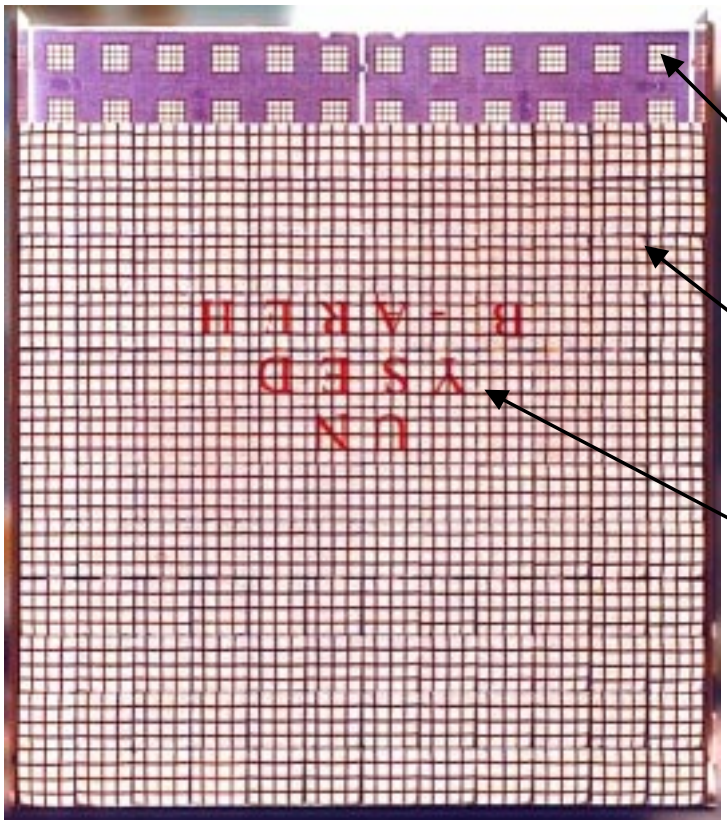
Box made from plastic-molded iron sheet; magnetic shield and mounting structure

- PMT arrangement on focal plane



M4 M16

Lens System



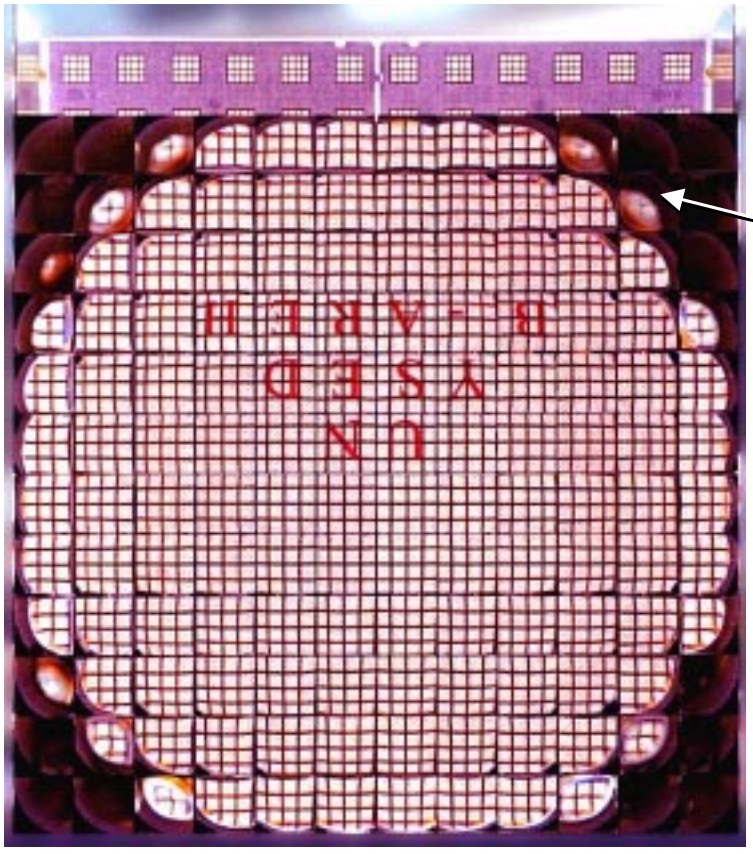
Camera at 3 m

4×4 pixel photocathode on 36mm grid

$\times 2$ magnified photocathode

Original image

H E R A - B
D E S Y
N U



Camera at 1.5 m

Telescope cuts off at 140 mrad

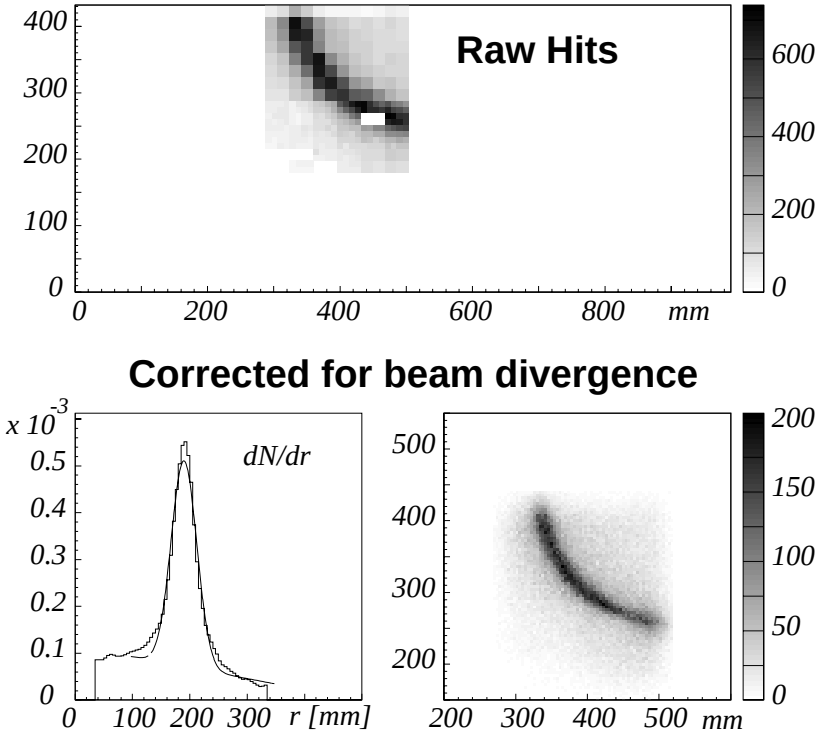
- Efficiency of Telescope 65%

Losses:
15% reflection
15% absorption
5% geometry

Performance / Status

❑ Based on Full Scale Supermodule Tests

- Equipped with 64 PMTs, lenses and final readout
- 5m radiator with mirror at 3 GeV electron beam
- Test with 80% C_4F_{10}



➥ Expect 34 ± 2 photons/ring for $\beta = 1$ particles

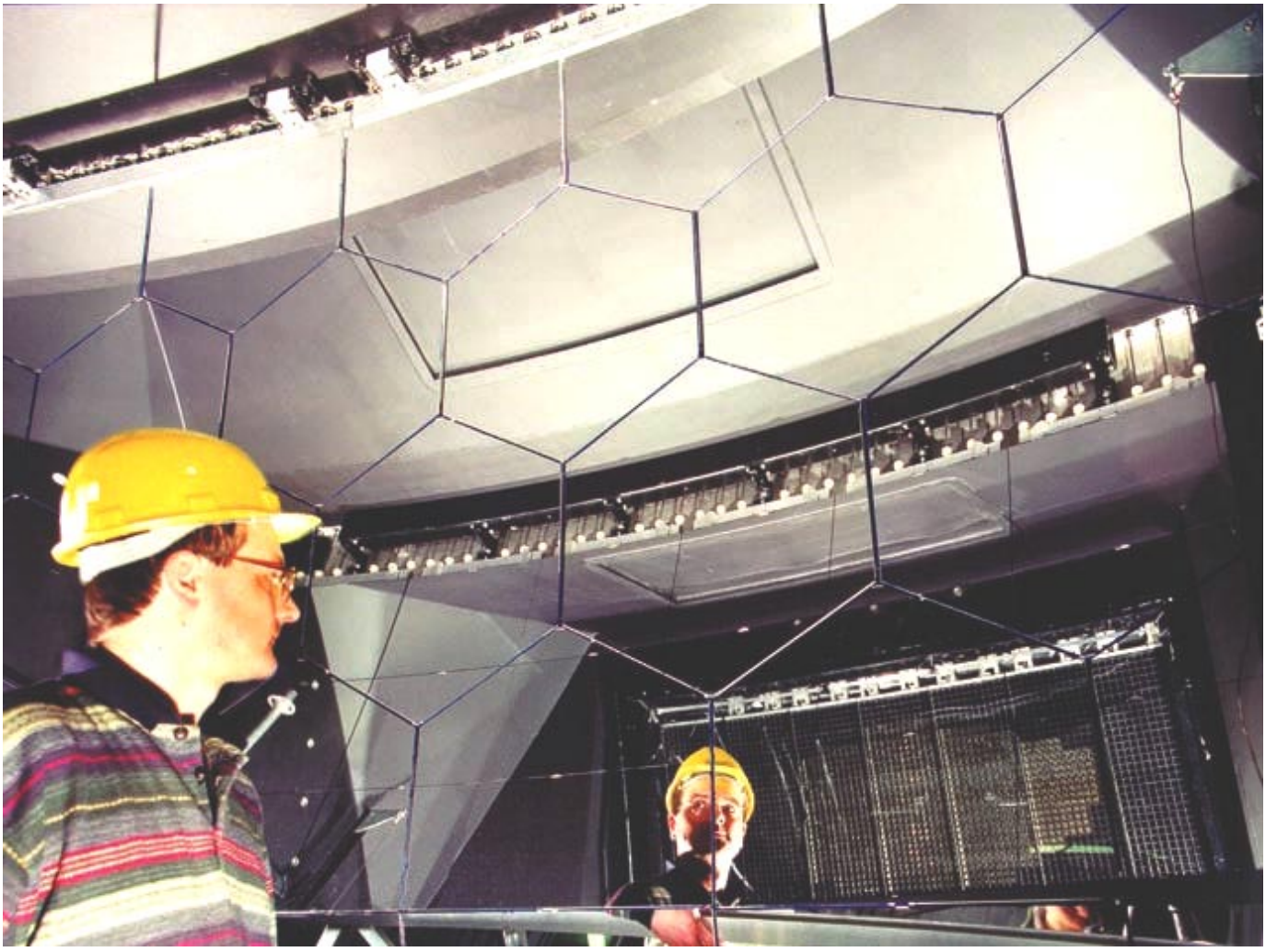
➥ π-K separation from 5–80 GeV/c

❑ Status of the HERA-B RICH

- Complete, except for radiator gas system
- Will be fully operational in Fall 1998

Inside RICH 1

Looking along the proton direction



Inside RICH 2

Looking up from bottom