Aerosol Phase Function Monitoring "I"

Auger Collaboration Meeting

Malargue, Argentina

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1. Air Cherenkov Correction to Fluorescence Signal
2. Aerosol Phase Function Measurement ... Concept
3. *Parasitic* analysis of LIDAR Shots
4. Dedicated APF Light Source:
   - Coihueco Deployment
   - Test at HiRes
5. Summary

$\frac{1}{\sigma^a}(\frac{d\sigma^a}{d\Omega})$: aerosol phase function monitors

- Through scattering in the air, some air Cherenkov light appears as a background in the fluorescence data.
- The observed light from an extensive air shower will also include a contribution of multiple-scattered light.
- To estimate the multiple-scattered and air Cherenkov light scattered on aerosols we need the aerosol extinction length, $\Lambda^a(z, 355nm) = (\frac{d\tau^a(z,355nm)}{dz})^{-1}$, and the aerosol phase function.

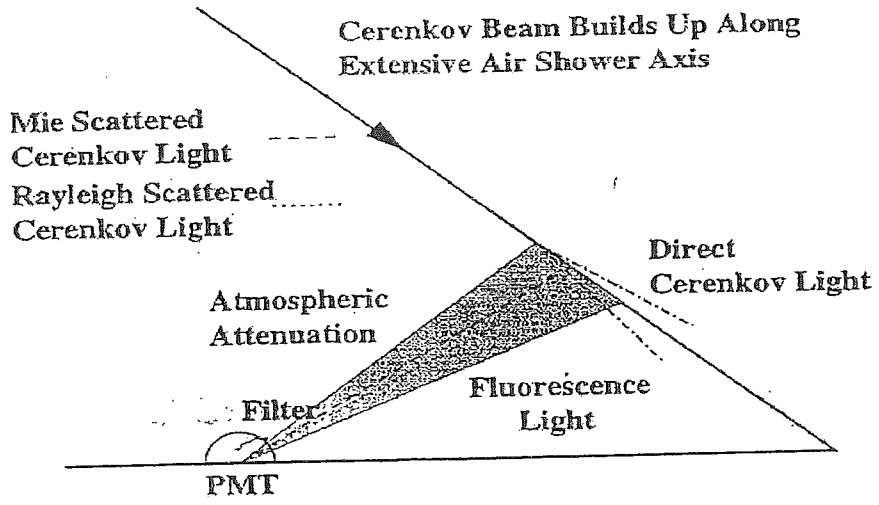


Figure 6.3: A summary of the factors that affect the light signal measured by the detector. Light is generated by the EAS and is attenuated as it travels to the detector. The actual signal measured will further depend upon detector parameters such as the transmission filter and PMT quantum efficiency. Note that most cases the light signal will be dominated by the fluorescence component.

Simulations:

a) $\gamma_{fluorescence}(\lambda)$ $+ T^m T^a$

b) $\gamma_c(\lambda, \theta)$ + single scatter (into F.D. F.O.V.) $+ T^m T^a$

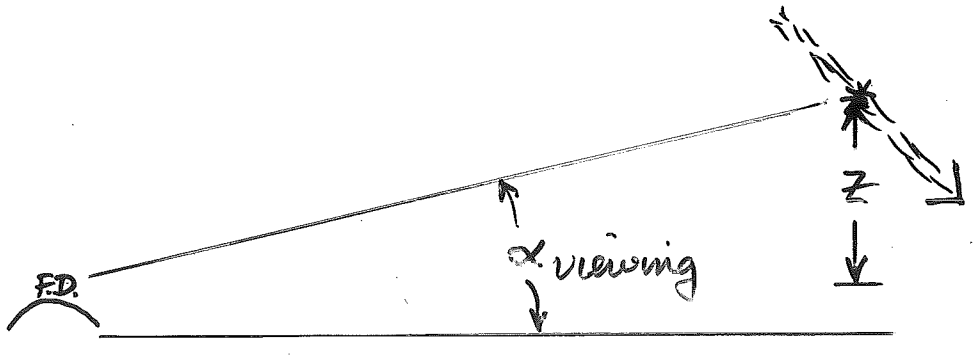
- $\gamma_c(\lambda, \theta)$: with respect to the shower axes
- single scatter: need $\Lambda(z,\lambda)$ and $\frac{1}{\omega}\frac{d\sigma}{d\Omega}$
- $T^m T^a$: need $\Lambda(z,\lambda)$

m = molecular/Rayleigh

a = aerosol/Mie

where: $T(z,\lambda,\alpha_{viewing}) = e^{-\tau(z,\lambda)/\sin\alpha_{viewing}}$

$$\tau(z,\lambda) = \int_0^z \frac{dz}{\Lambda(z,\lambda)}$$



Mie / aerosol component:

Need: $\Lambda^a(z, 355nm)$

$\frac{1}{\sigma^a}\frac{d\sigma^a}{d\Omega}(\theta)$

| vs Time (from atmospheric monitoring)

While you wait:

$$\Lambda^a(z, 355nm) \simeq \Lambda^a(0)\, e^{+z/h_s}$$

$\Lambda^a(0)$: ~ 20 km

h_s: ~ 1 km

$\frac{1}{\sigma^a}\frac{d\sigma^a}{d\Omega}$ from models (Longtin, D'Almeida)

or M. Roberts' fits to Hikes side scattered LIDAR data or ...

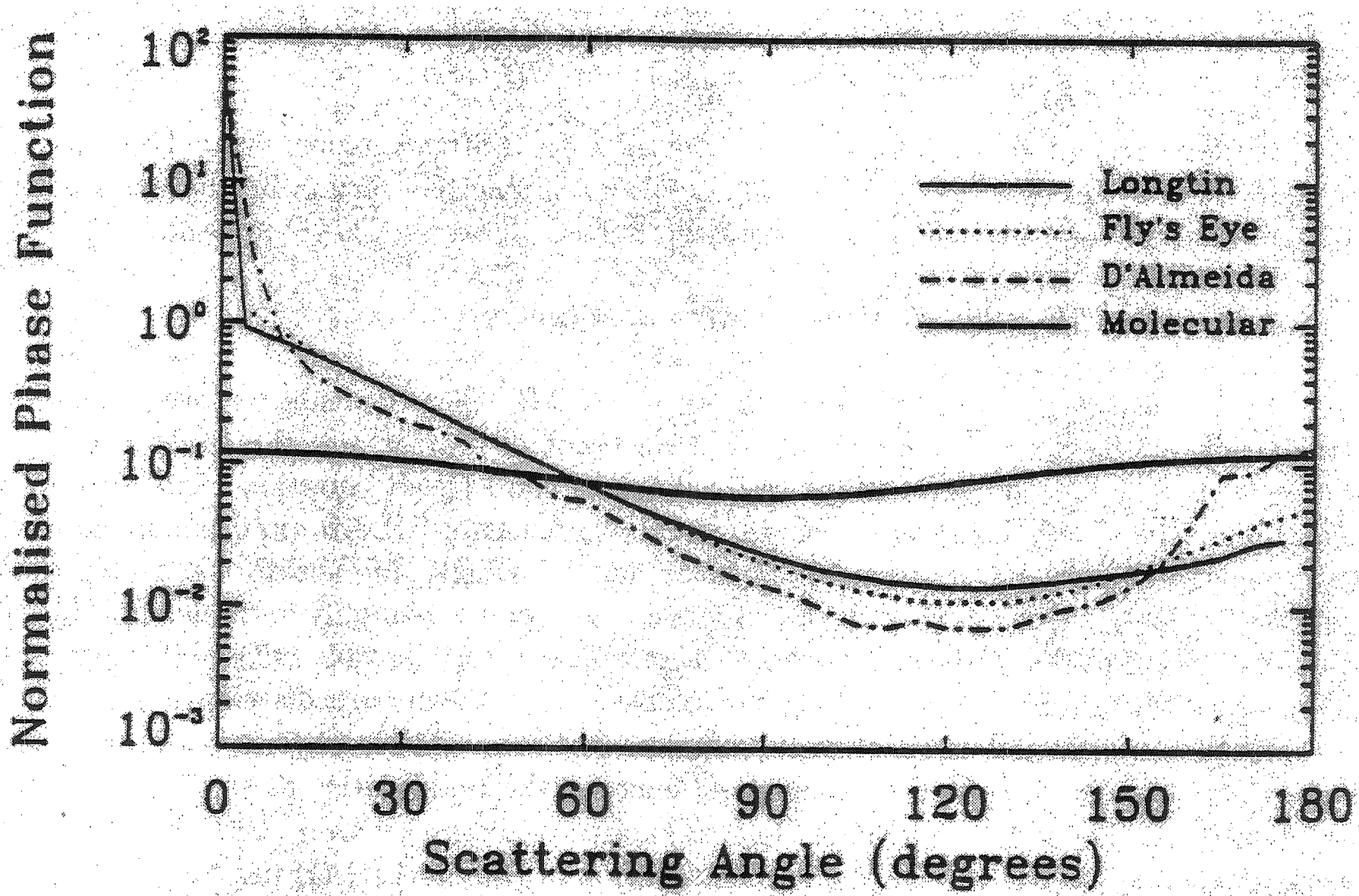
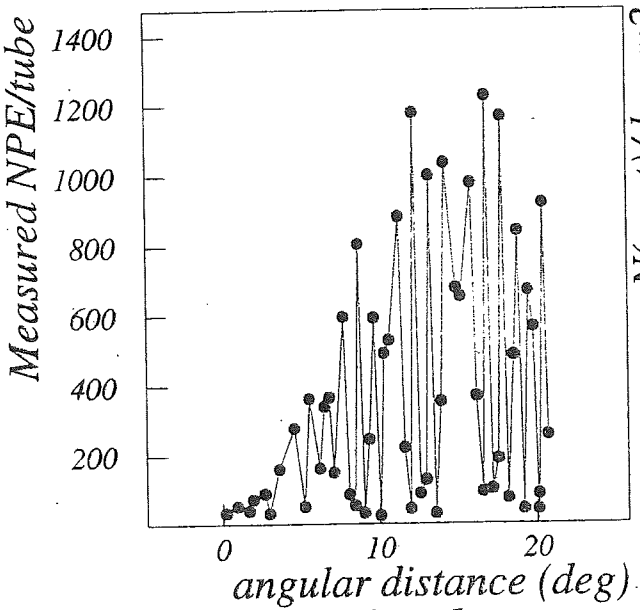
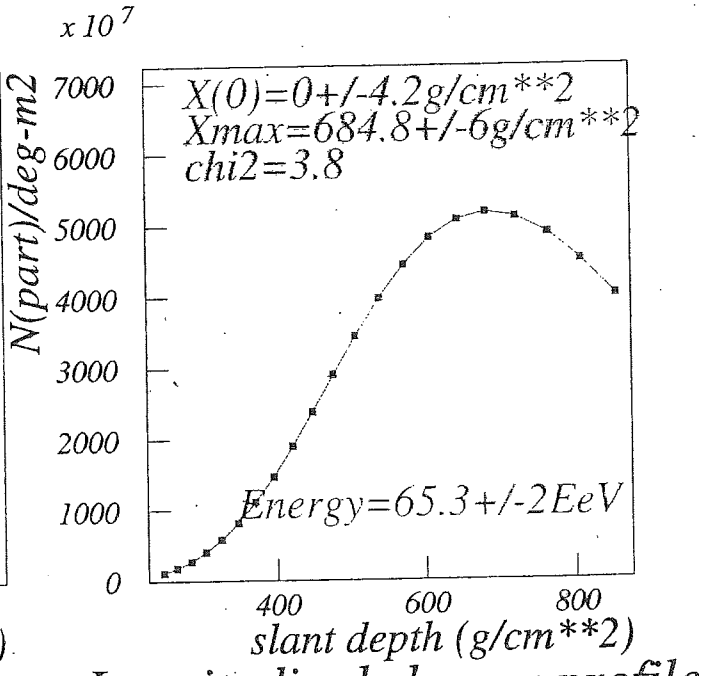


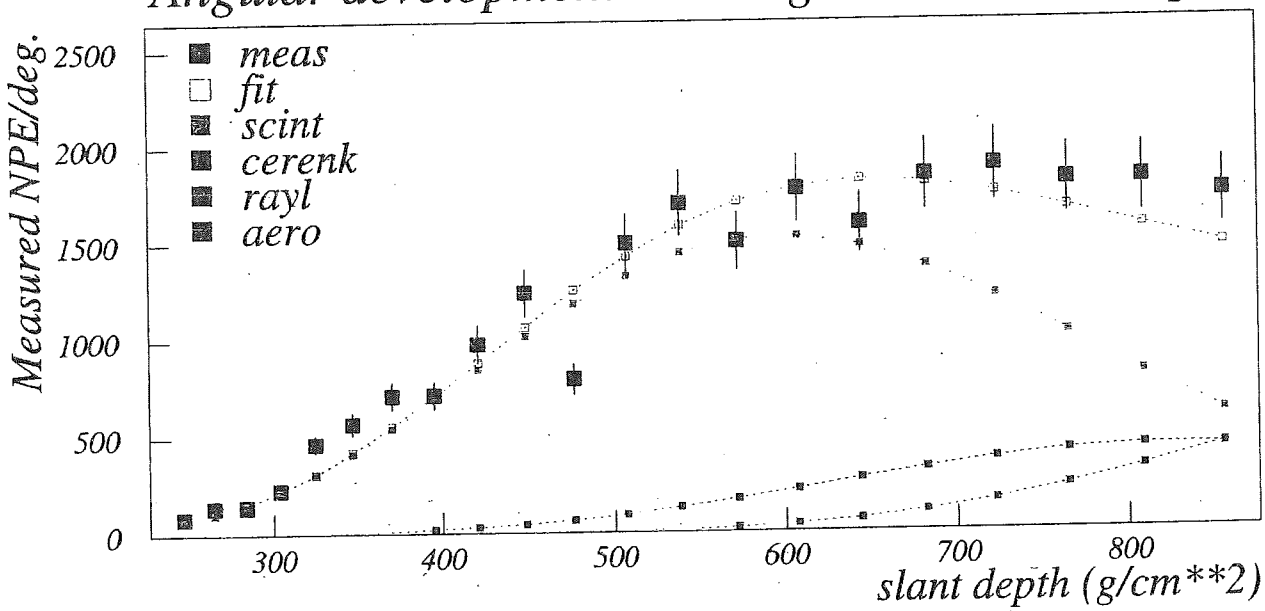
Figure 2: Examples of aerosol phase functions obtained with Mie theory (assumes all aerosol particles are spherical). Also shown is the Rayleigh (molecular) phase function. For typical aerosol densities the sideways scattering (90° to 120°) is dominated by well known Rayleigh scattering cross section



Angular development



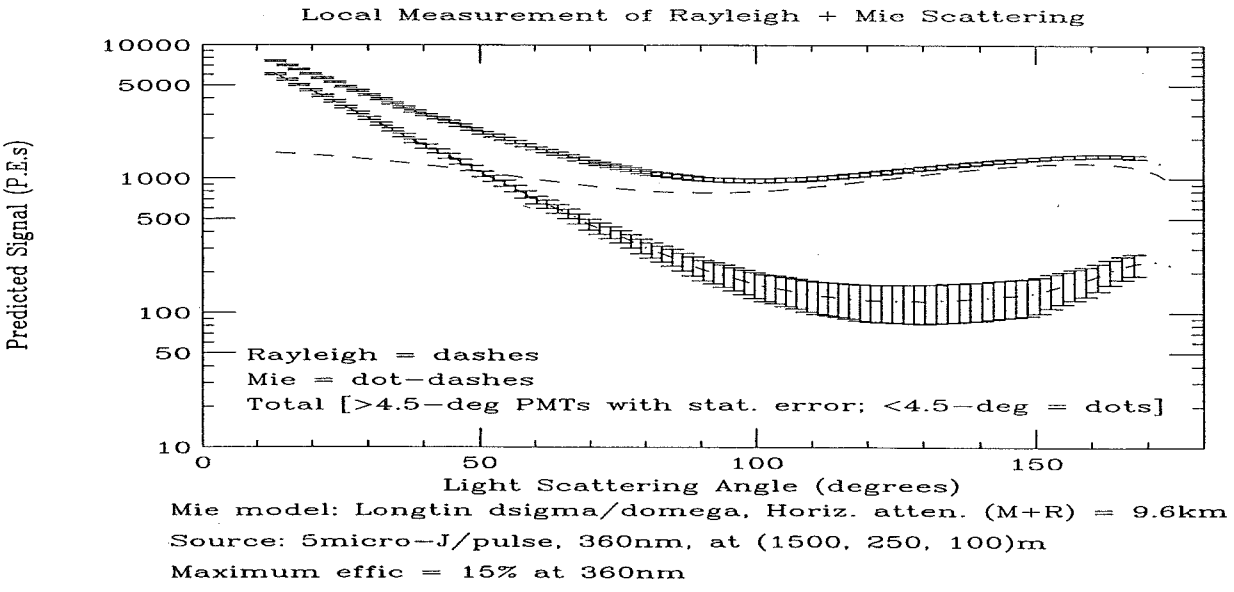
Longitudinal shower profile



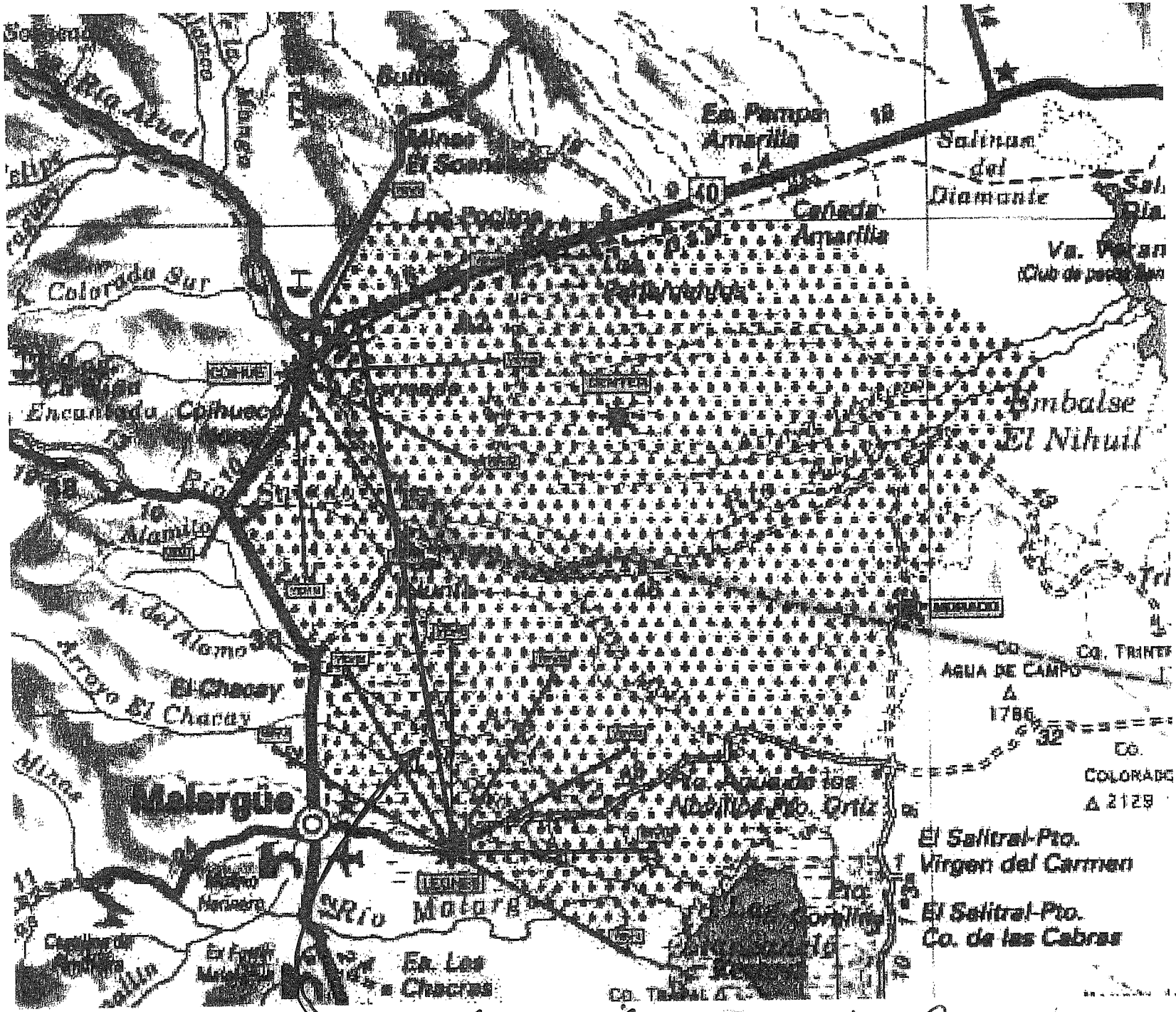
Components of Detected Light

$\frac{1}{\sigma^a}(\frac{d\sigma^a}{d\Omega})$: aerosol phase function monitors

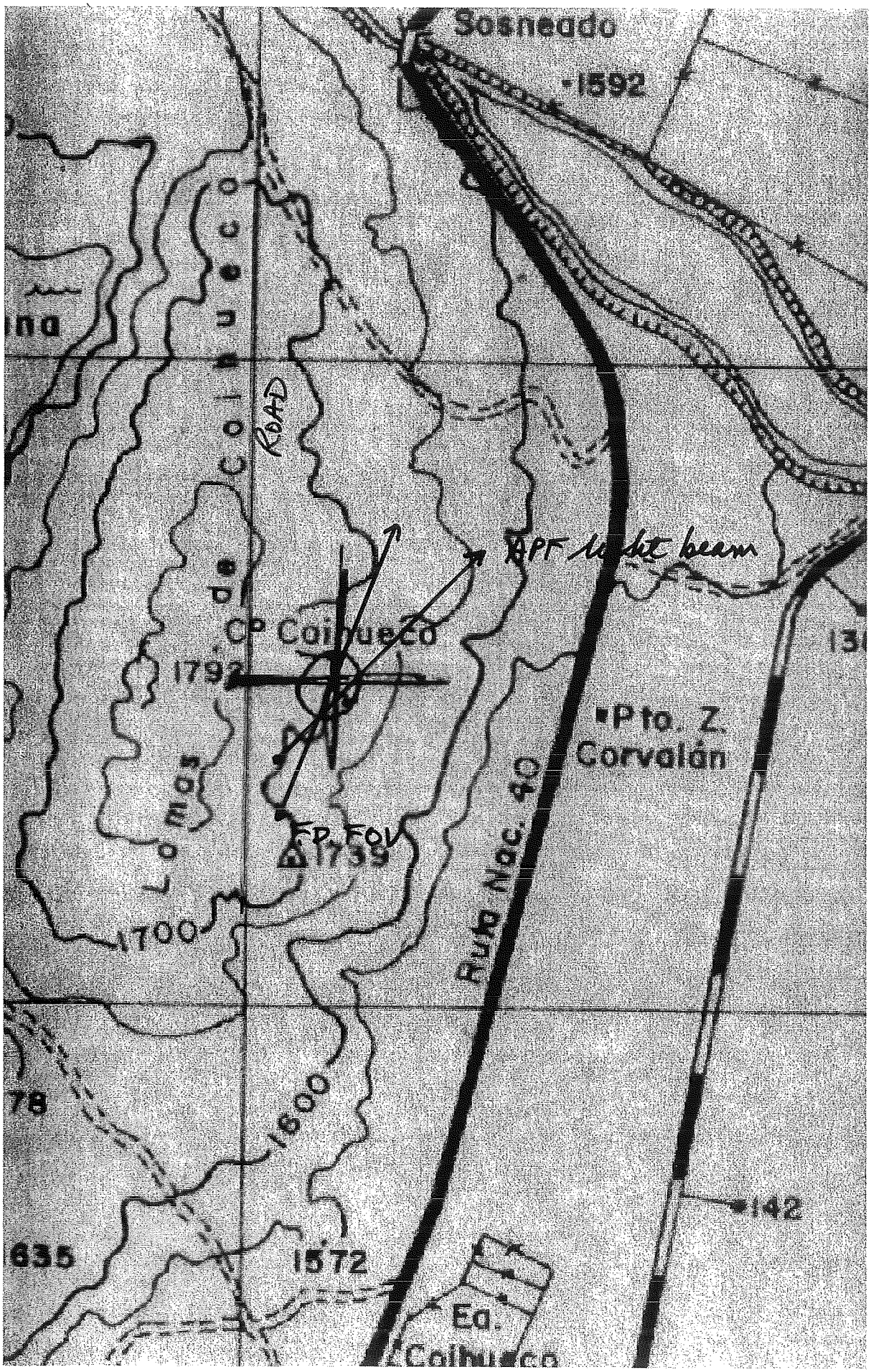
- The air Cherenkov and multiple-scattering corrections need best knowledge of the Mie phase function at forward scattering angles.
- As the fluorescence detectors view $\sim 180°$ in azimuth, even a fixed direction light beam crossing the fluorescence field of view allows $\frac{1}{\sigma^a}(\frac{d\sigma^a}{d\Omega})$ to be determined.
- Dedicated *aerosol phase function* light sources will be located near 2 fluorescence sites. In addition LIDAR beams, at near grazing incidence, provide a cross check and a measurement at the most forward angles.



- **Simulated $\frac{1}{\sigma^a}(\frac{d\sigma^a}{d\Omega})$ measurement using one of the nearby *aerosol phase function* light sources.**



example of side scattered LIDAR geometry.


Sosneado
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Road
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1600
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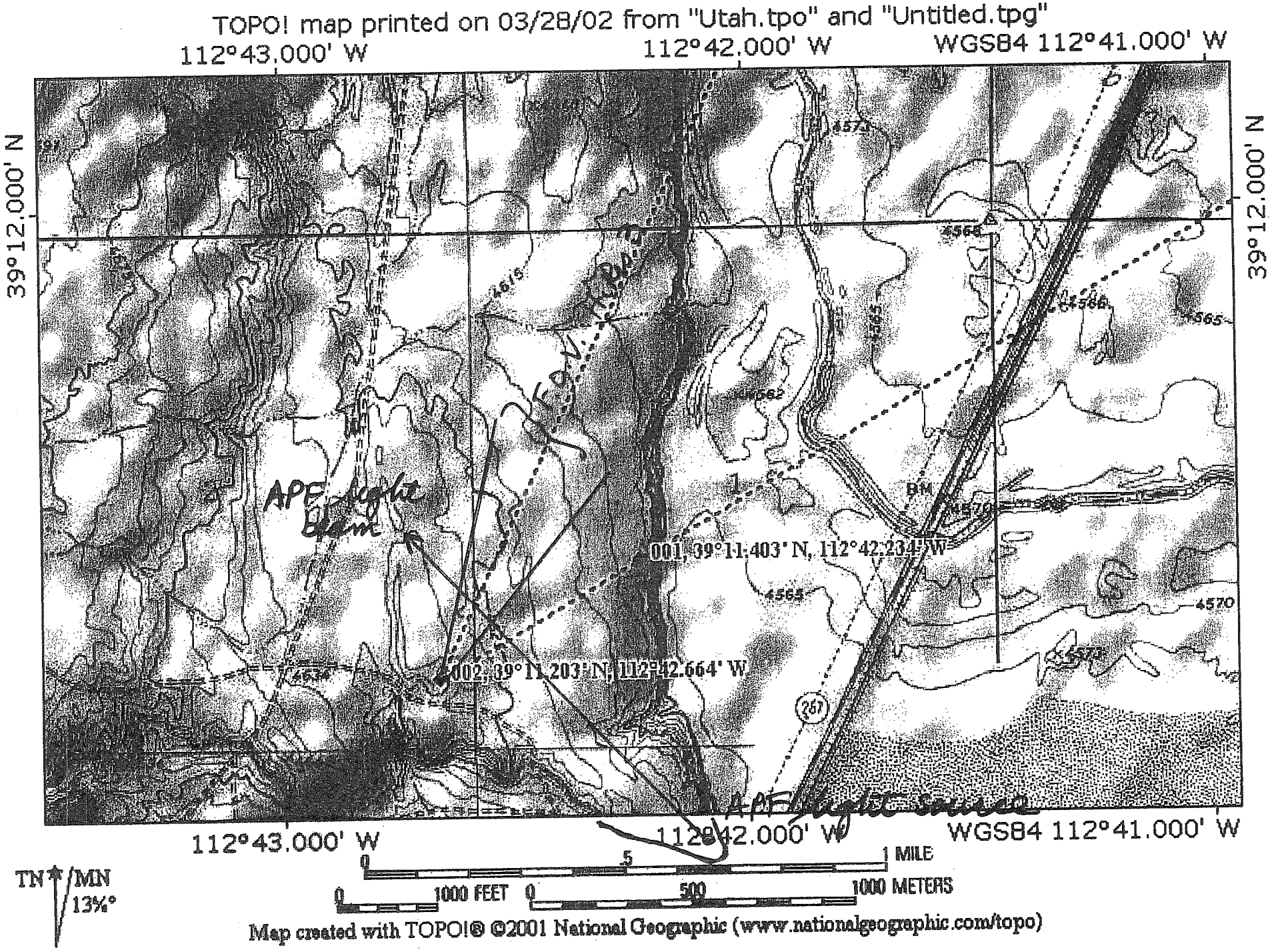
142
Ea.
Colhueco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001, 39°11.403' N, 112°42.234' W
002, 39°11.203' N, 112°42.664' W
APE Light Beam
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1000 FEET
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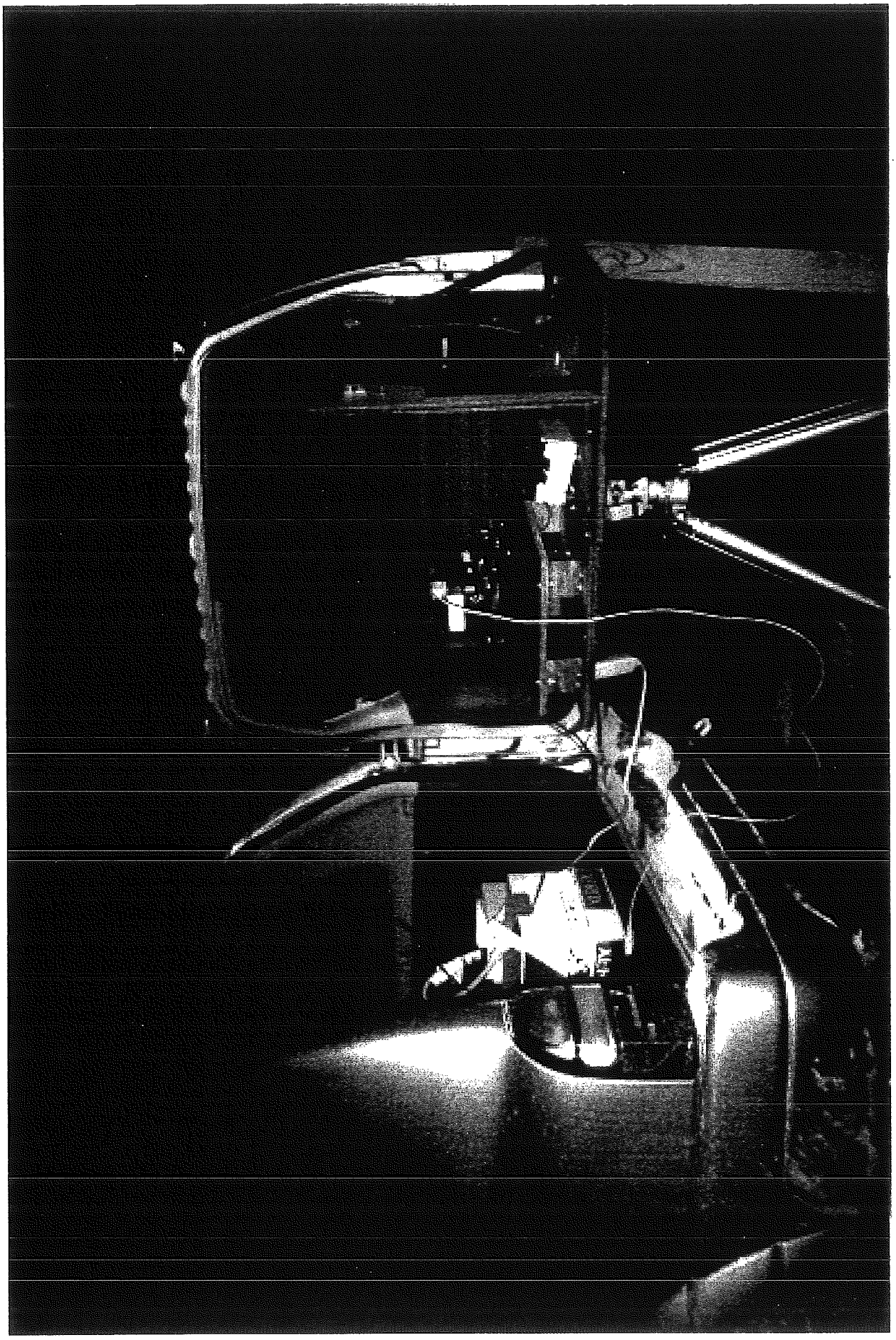
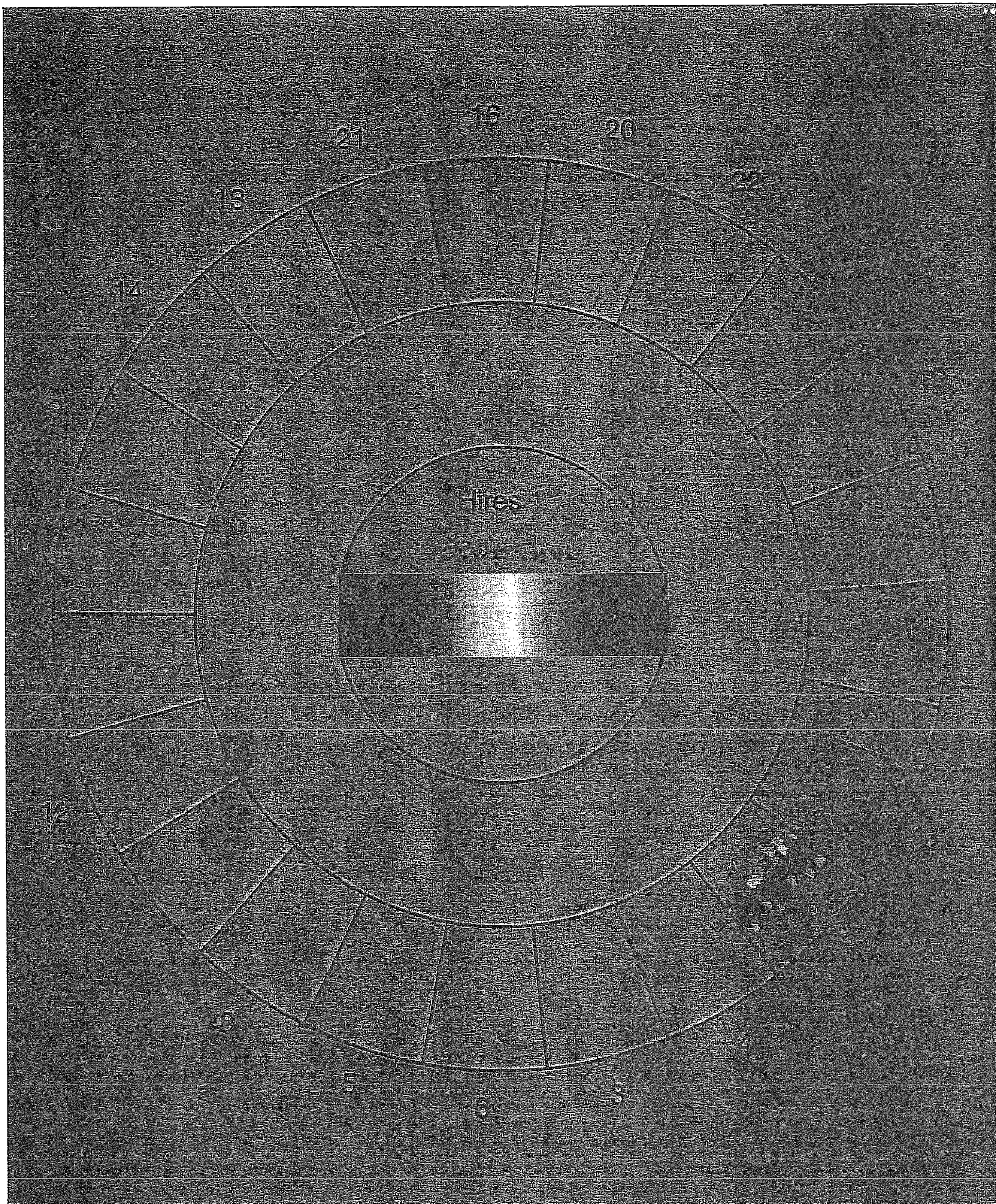
Map created with TOPO!® ©2001 National Geographic (www.nationalgeographic.com/topo)

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Hires 1
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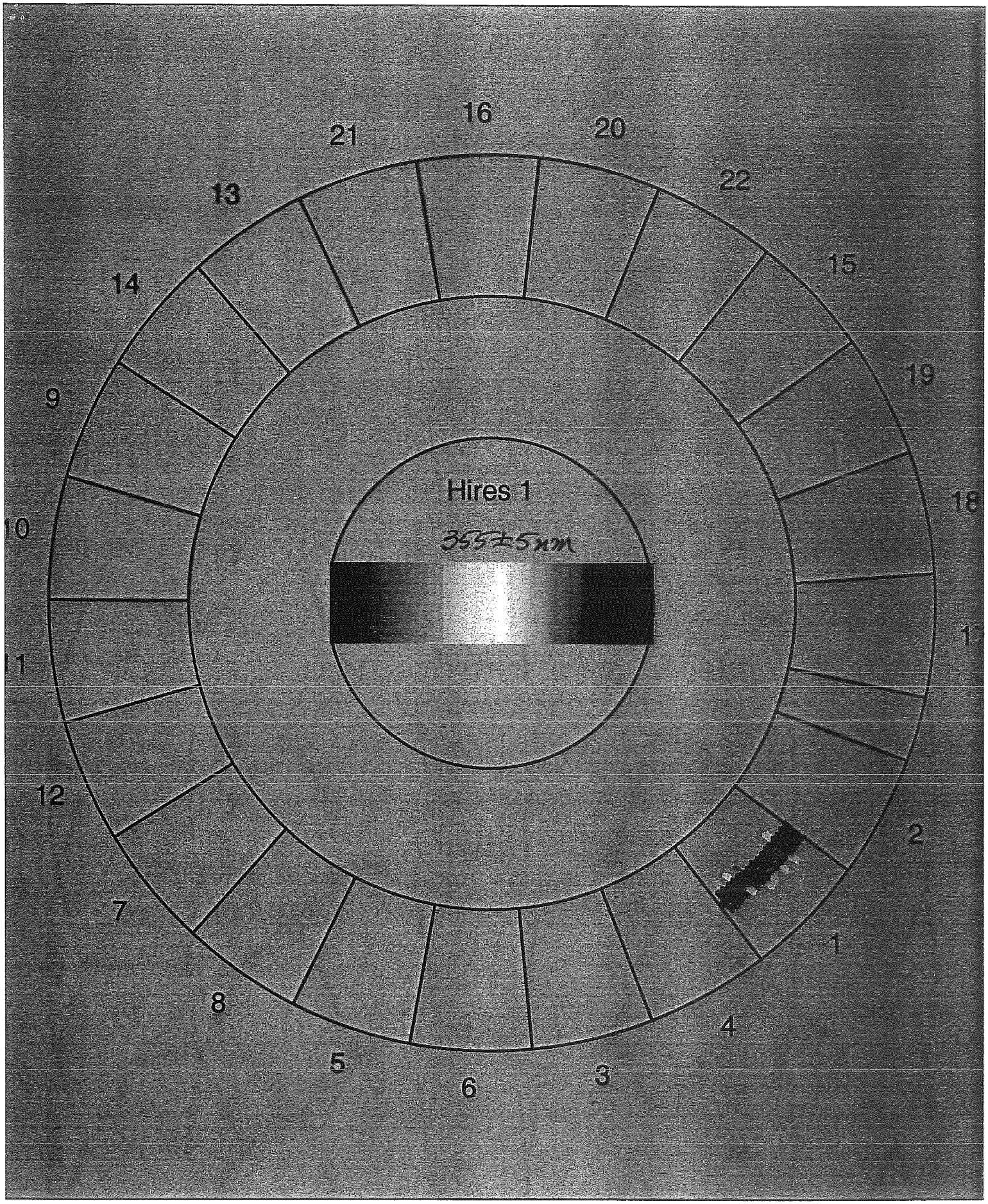
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Hires 1
355±5nm
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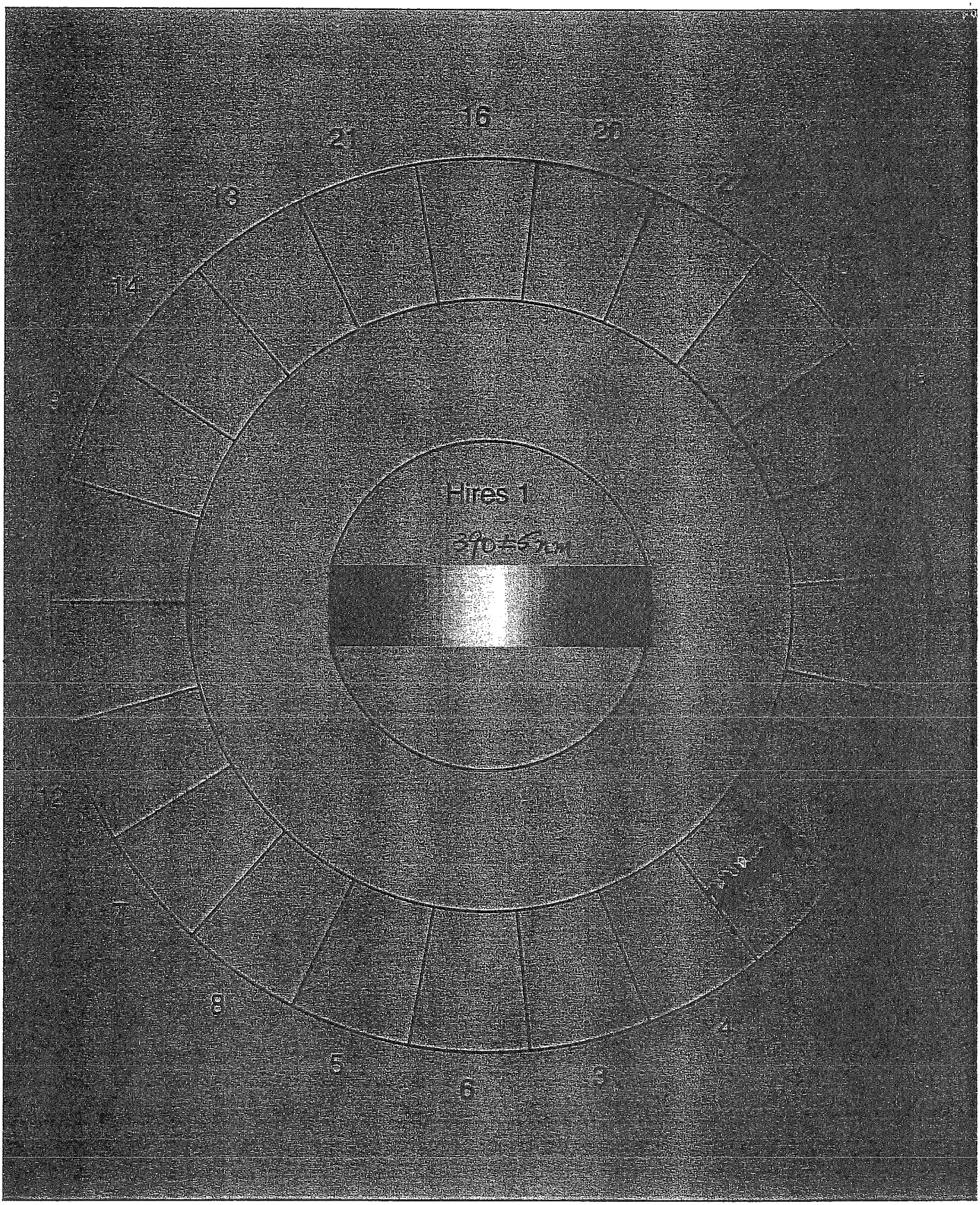
16
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Hires 1

5. Summary:

- We need to measure and monitor the aerosol differential scattering cross section ... the normalized version is called the aerosol phase function "APF"

- A dedicated "APF" light source has been designed, prototyped, and is in the process of being installed at the Coihueco FD.

- It is conceivable that simpler (one λ) sources could be installed next to each of the FDs.