Discussion
on small ice particle measurements

Definition of small ice particles:

$1<D<100\mu m$

What is ice particle size?

D_{max}, D_{av}, D_{EqA}, D_{EqM}, D_{eff}

The difference between these definitions may be 20-30%

measurement methods and challenges

- **Short term works (<3 years):**
- **minor improvements of existing probes**
- **developing of retrieval techniques based on theoretical and laboratory calibrations**

ii) Long term works (~10 years)

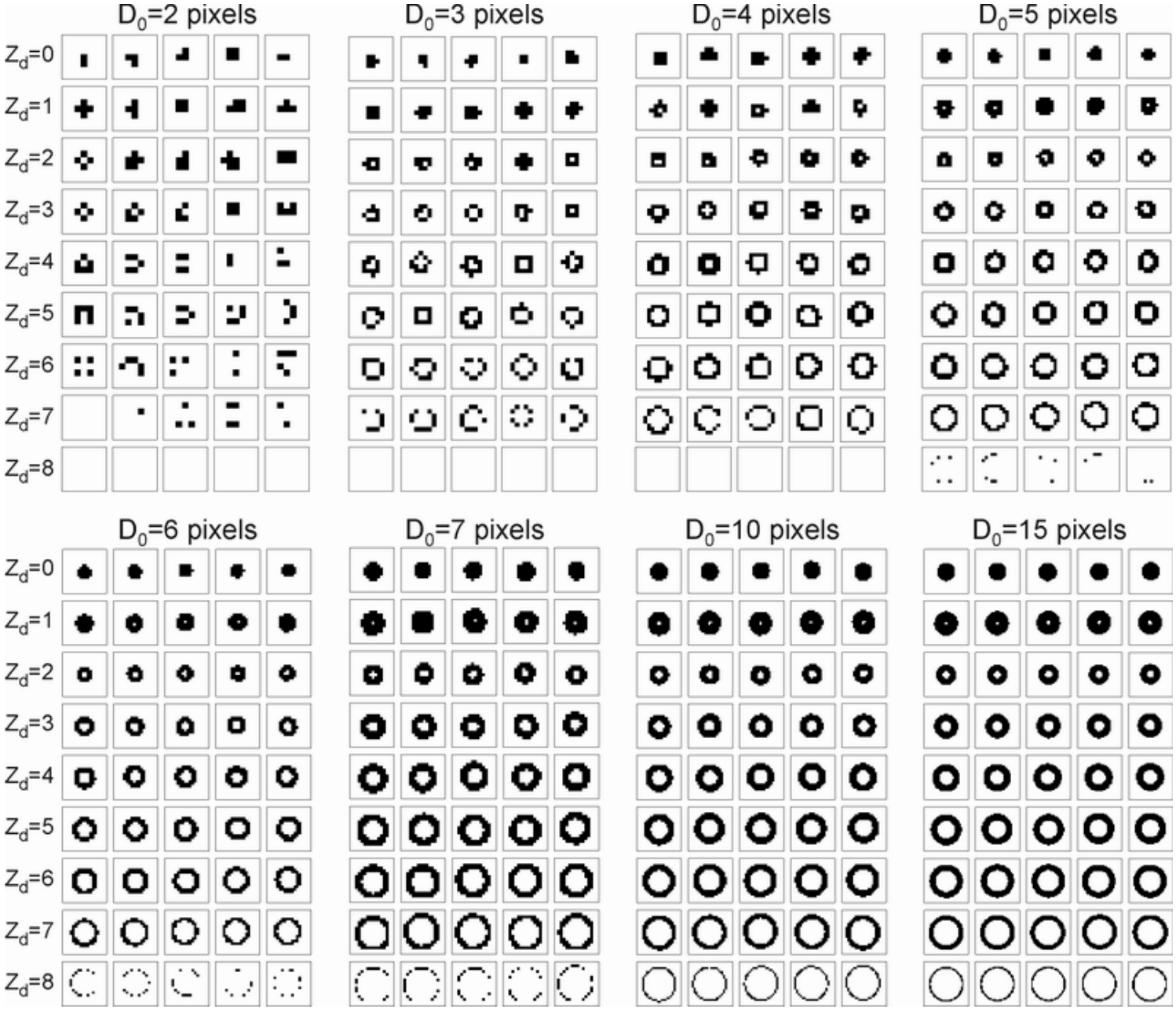
- **Developing of new techniques and new instruments**
- **Facility for standardization of calibration techniques of cloud microphysical measurements**

Solutions for existing cloud microphysics probes (Short range):

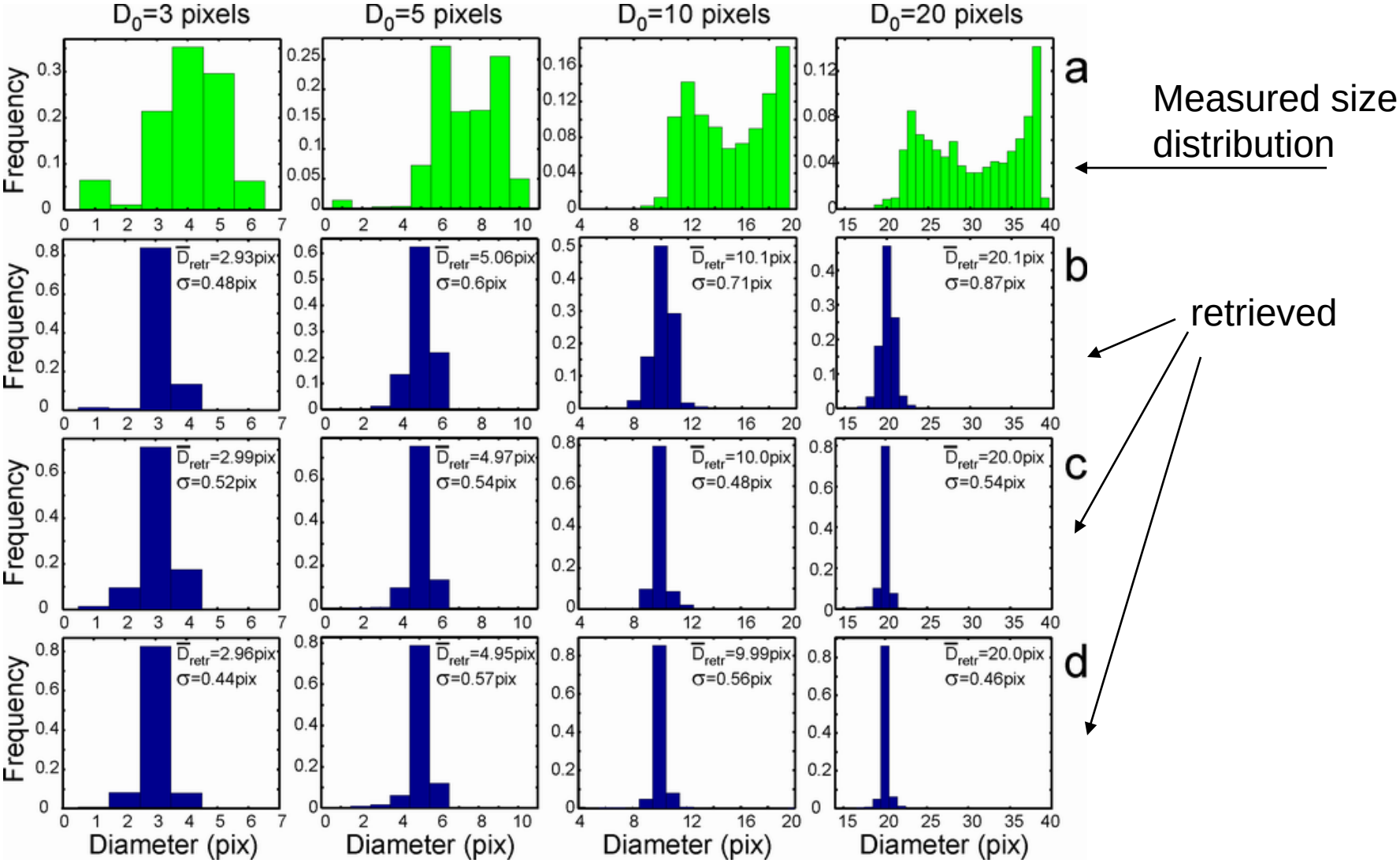
1. Retrieval algorithms for imaging probes
   OAP-2DC/2DP, CIP, PIP, 2DS
   a) use several grey levels to retrieve D and Z of individual images based on Fresnel diffraction calculation
   b) algorithms for statistical retrieval of ensemble of images (distortion function)
   c) algorithms for size retrieval of non-spherical particles based on Fresnel diffraction calculations
   d) theoretical accounting of the response time of probes' electronics
   e) calculation of the effective width of SA for non-spherical particles of different shapes
   f) retrieval of sizes of partial images

2. Retrieval algorithms for scattering probes: FSSP, CDP, CAS
   a) calculation of forward scattering for non-spherical particles of different shapes (hex columns, plates, hollow hex prisms, spheroids, irregulars, etc.)
   b) Calculation of response functions for non-spherical particles with different orientation

Formation of images for coherent illumination (Fresnel diffraction)



Applying retrieval algorithm to a modeled measured size distribution



Depth-of-Field in imaging probes (coherent illumination)

$$DoF \propto D^2$$

$$n \propto \frac{1}{SampleVolume} \propto \frac{1}{DoF} \propto \frac{1}{D^2}$$

$$\Delta n \propto \frac{\Delta D}{D^3}$$

OAP-2DC

D	25μm	50μm	75μm	100μm	125μm	150μm	175μm	200μm
DoF(mm)	1.5	6.0	13.5	24	38	54	74	96

Solutions for existing cloud microphysics probes (Short range):

3. Laboratory calibrations of imaging probes OAP-2DC/2DP, CIP, PIP, 2DS

a) spinning disc calibrations by circular dots 20μm<D<2mm, 10<V<100m/s
b) spinning disc calibrations by non-circular shapes (DMT has discs)
c) spinning wire (or LED) measurements of the response time
d) calibrations by non-spherical particles (pollens) in lab wind tunnels

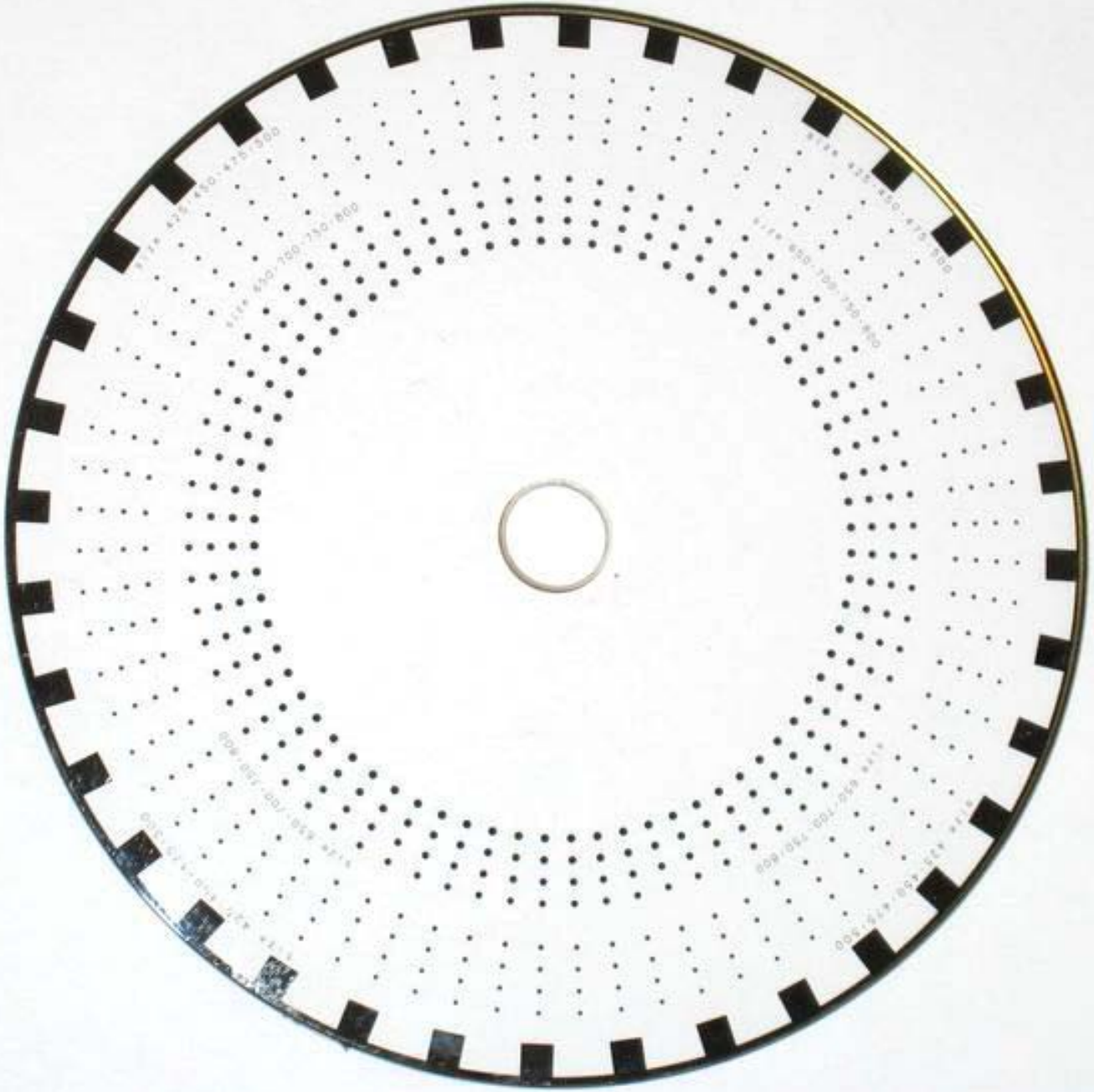
4. Laboratory calibrations scattering probes: FSSP, CDP, CAS

a) spinning disc calibrations (pinholes)
b) calibrations by ice particles in cloud chambers/ towers
c) calibrations by non-spherical particles (pollens) in lab wind tunnels

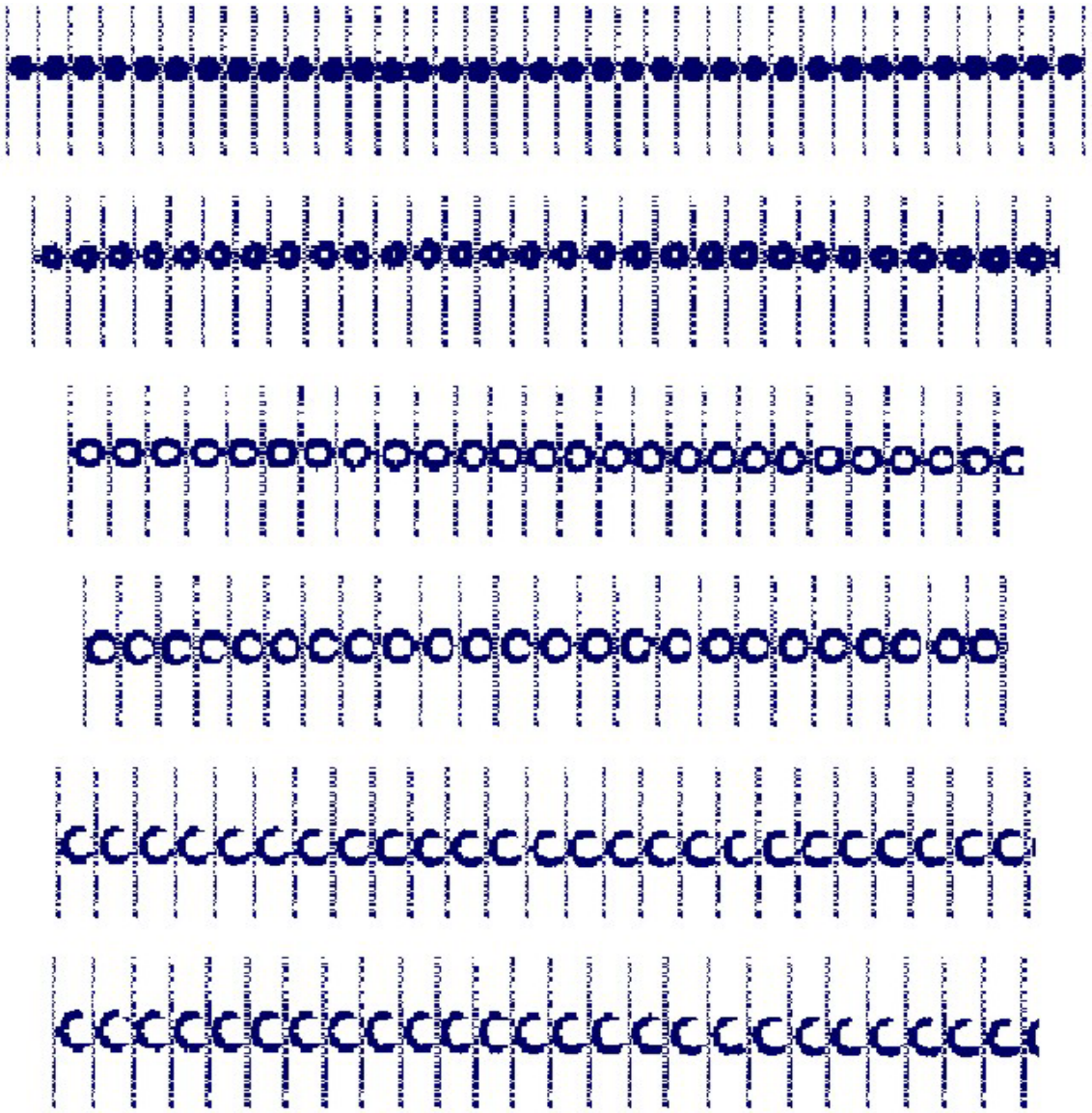
5. Prepare a manual describing theoretical algorithms and laboratory calibrating techniques

Spinning disc calibration installation

Custom designed DMT spinning disc



Spinning disk calibration: D=150μm



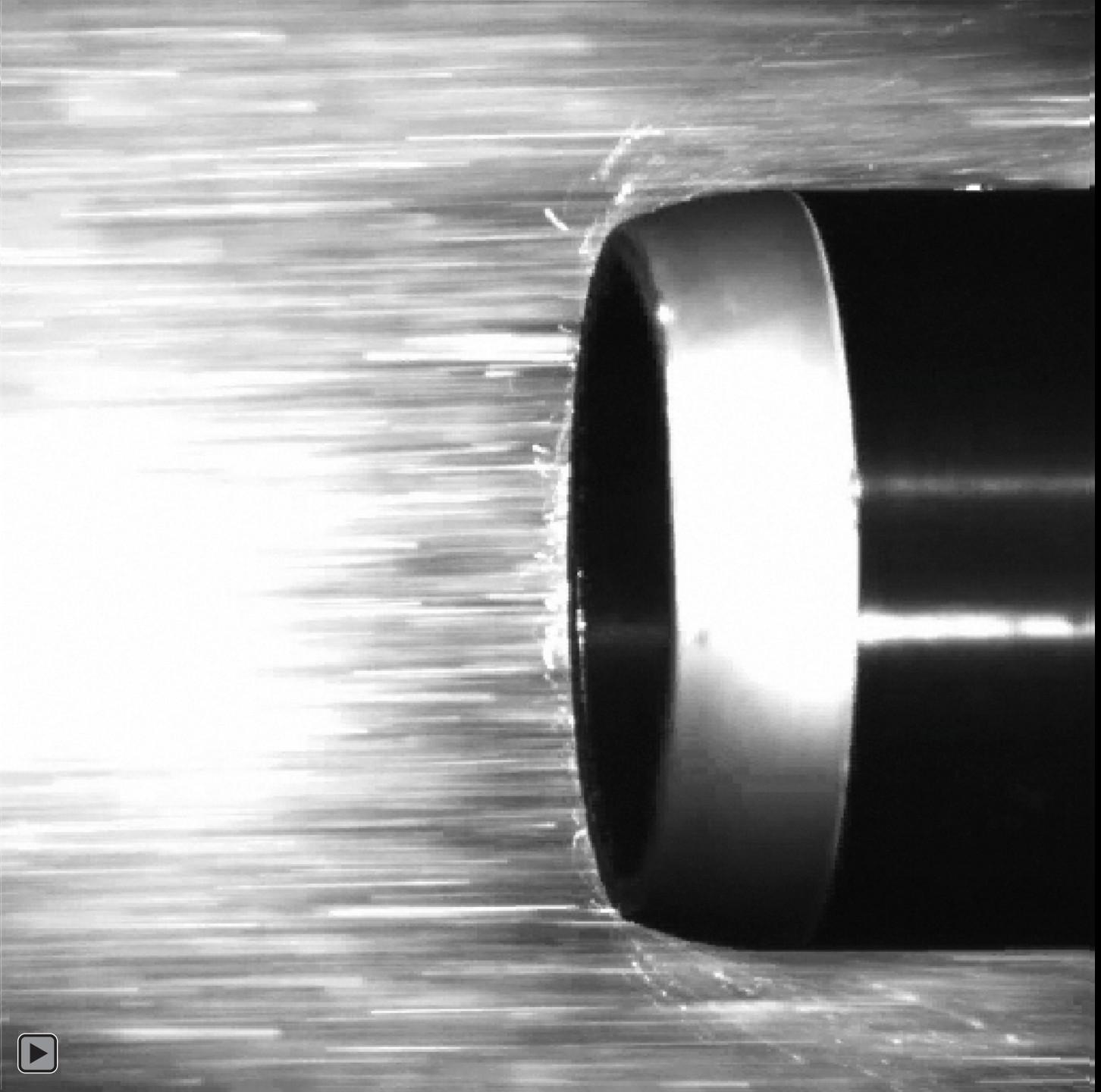
Solutions for existing cloud microphysics probes (Short range):

6. Wind tunnel calibrations
   Cox (New York, US), NRC M7 (Ottawa, Canada)

7. Redesign of probe inlets:
   FSSP, CDP, CAS, OAP-2DC, CIP, PIP, 2DS

8. Redesign of hot-wire sensors to minimize ice bouncing (Nevzorov probe, T-probe)

9. Extinction probe: “must” probe

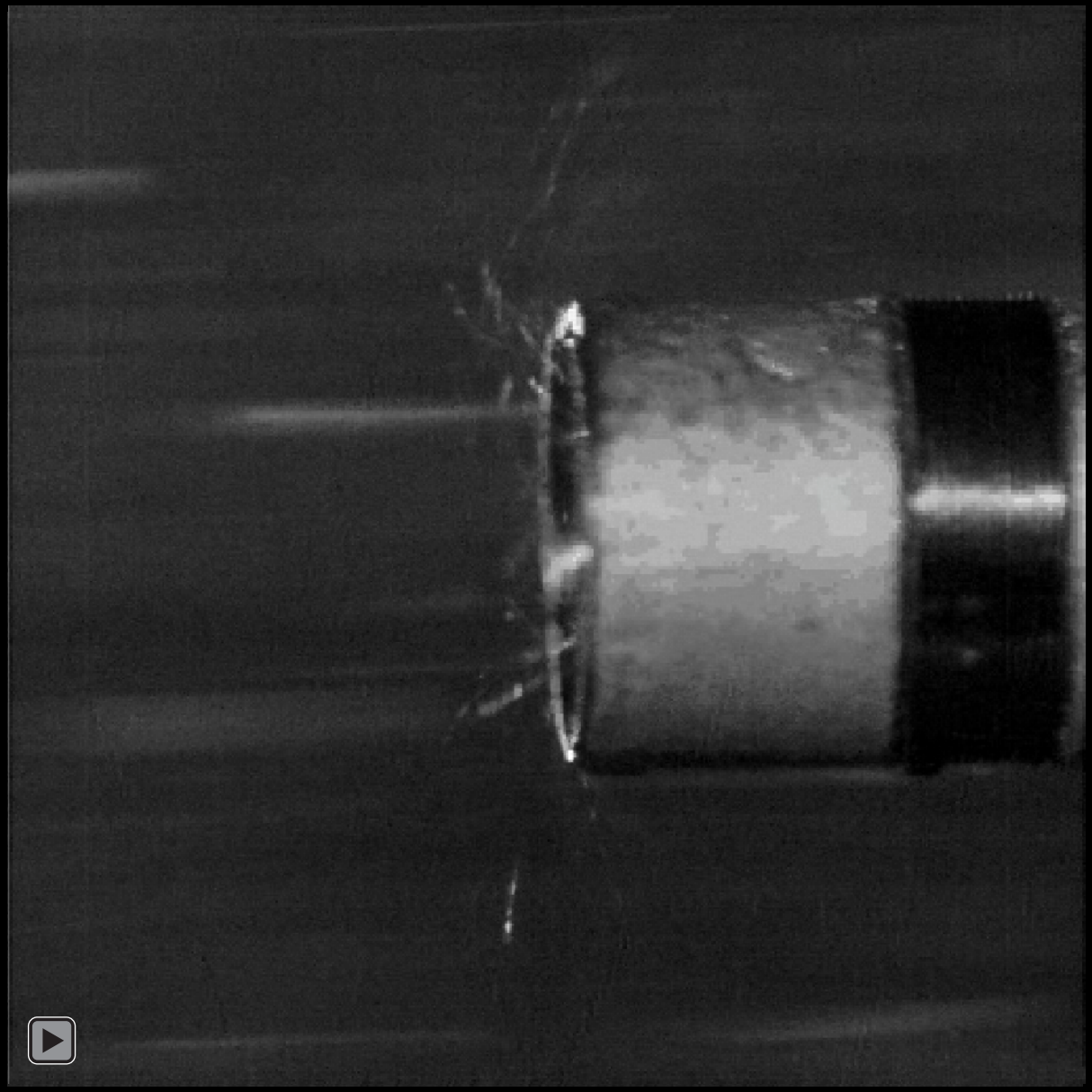


Cox Wind Tunnel

NASA High Speed Video

FSSP inlet
D ~ 5cm
TAS ~ 70m/s

Nevzorov TWC sensor (Shallow Cone)



Cox Wind Tunnel

NASA High Speed Video

TAS=80m/s

Solutions for existing cloud microphysics probes (Short range):

10. Processing software

a). Standardization of retrieval algorithms and processing software (bank of subroutines for existing aircraft probes).

b). Intercomparison of cloud microphysics software

11. Field campaigns:

a) Develop simple portable calibrating tools

b) Preflight and postflight calibration cloud microphysical probes

Long term works (~10 years)

- **Developing of new techniques and new instruments**
  a) “non-intrusive” techniques (e.g. PDA)
  b) Change coherent to non-coherent illumination in imaging probes

- **Slow moving platforms (balloons, helicopters)**

- **Facility for standardization of calibrating techniques of cloud microphysical measurements**