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Boulder, 19 February, 2010

We are ready to make it happen…

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PAYLOADS FOR SUBORBITAL FLIGHTS
atmospheric physics and chemistry

Modern and historical examples as a guide to using
Piloted Suborbital Vehicles

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The sounding rocket – a well-honed tool – how to match it with piloted suborbital vehicles ?

Mass spectrometer launched from Esrange in 1978

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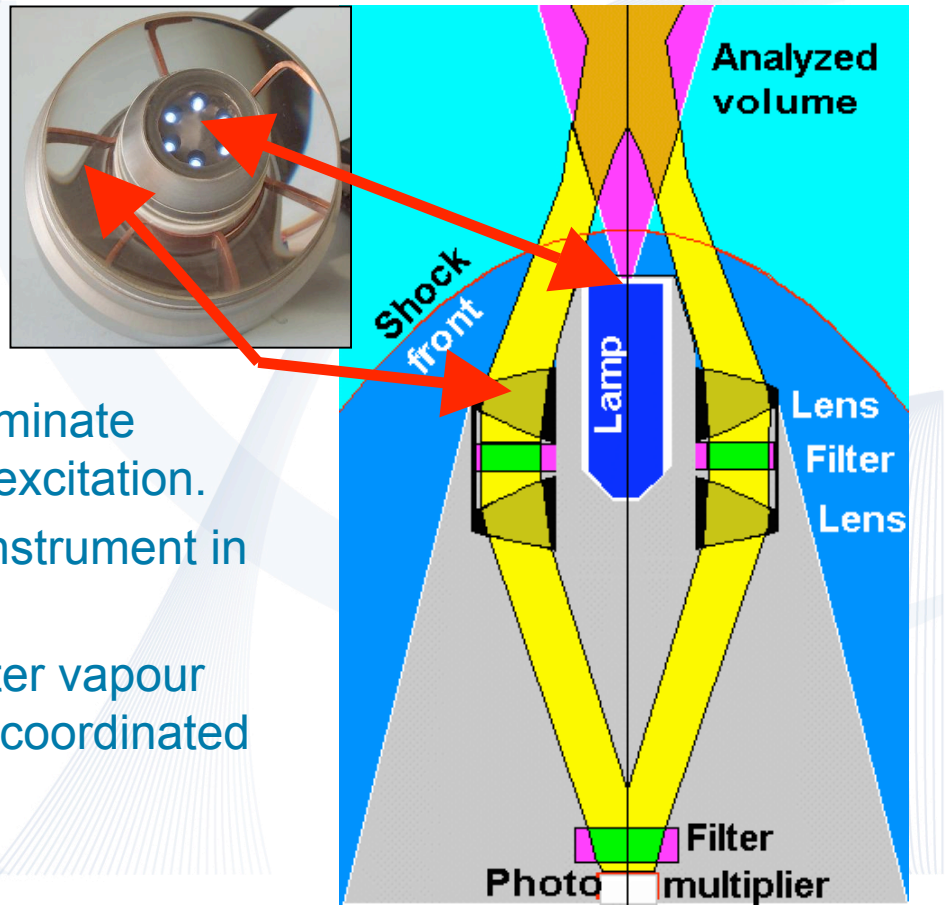
Suborbital atmospheric physics and chemistry research turns to optics



- When observing volatile species: Illuminate volume outside bow shock, observe excitation.
- The vehicle needs to keep such an instrument in the direction of flight.
- Example from Swedish program: water vapour probe Hygrosond (1994) which was coordinated with overhead satellite pass

(instrument design: Institute of Meteorology of the Univ. Of Stockholm).

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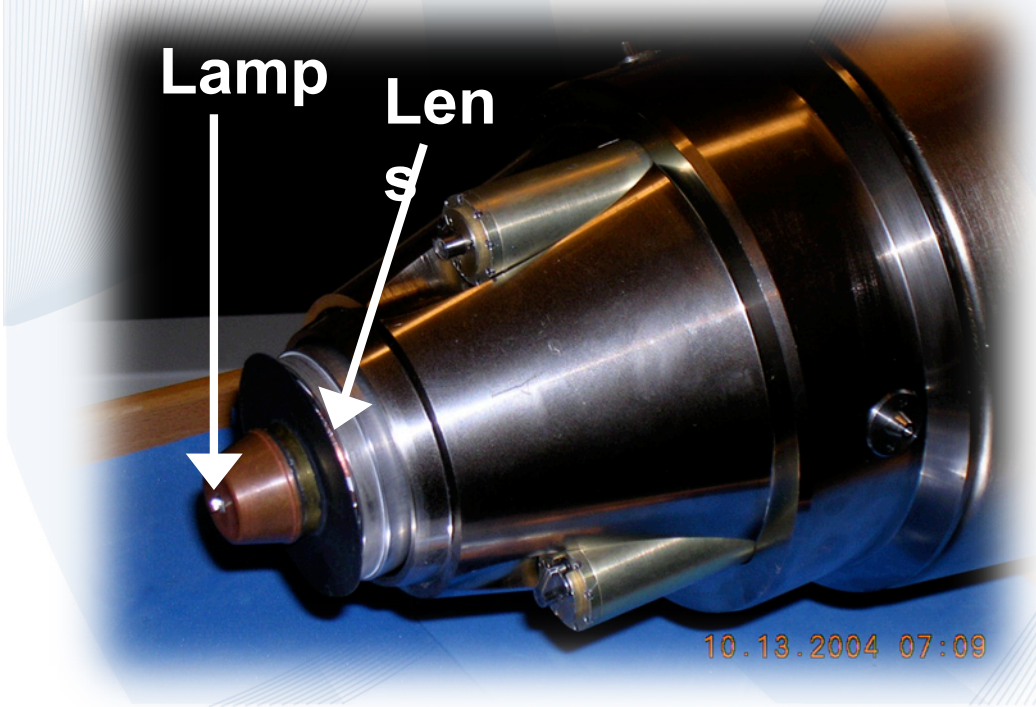
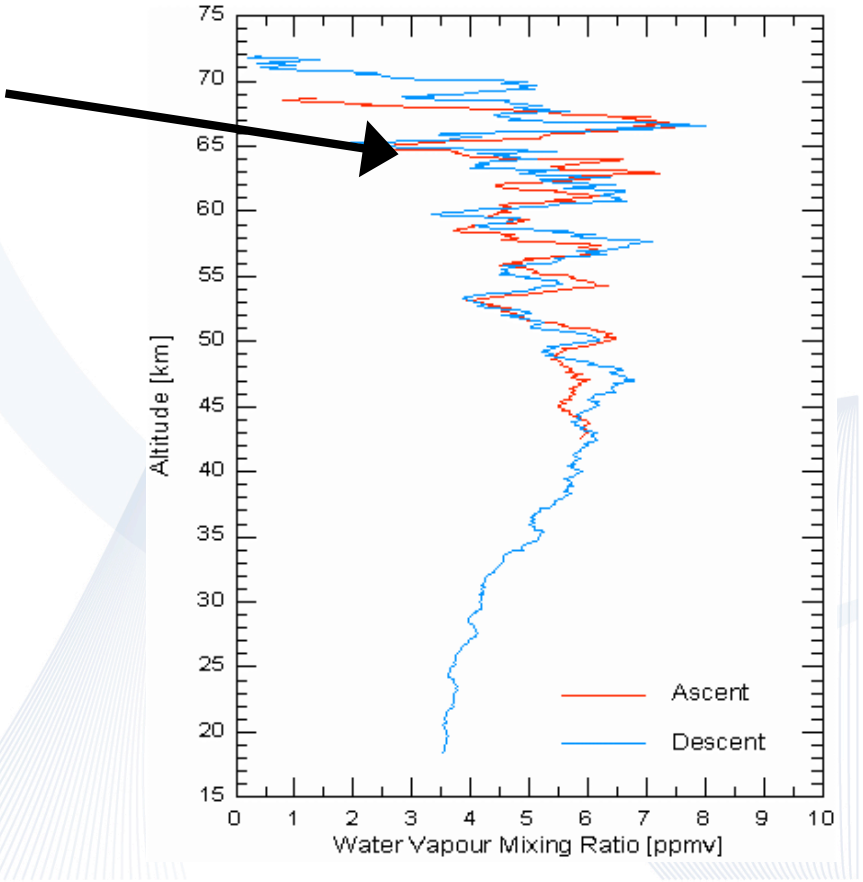
Suborbital atmospheric physics and chemistry use optics

- Lots of fine structure in water vapour profile → need for high data rate (telemeter or store)





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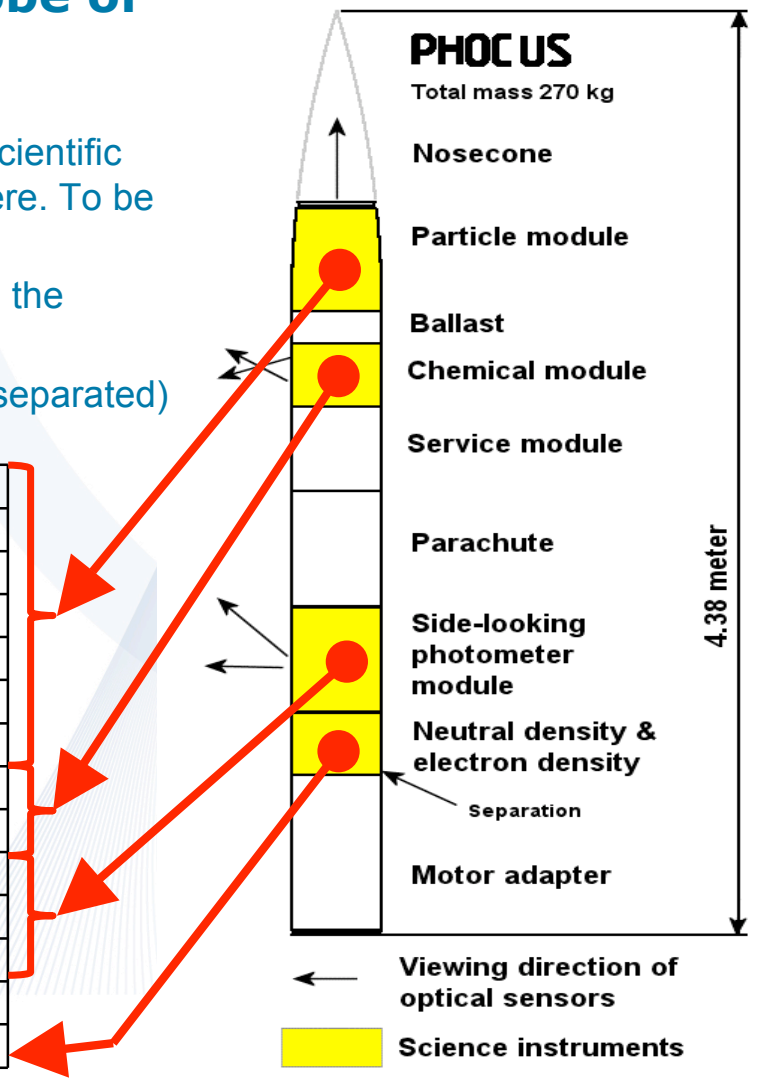
PHOCUS – a modern suborbital probe of the mesosphere

- **Co-ordinated set of instruments** explore common scientific theme: Noctilucent clouds and the summer mesosphere. To be launched in 2011 from Esrange.
- Most (but not all) **instruments interact optically** with the surrounding atmosphere
- **Tight control of outgassing** from payload (motor is separated)

Instrument	Measurements
Ion Probe	Electron and ion density
Faraday rotation	Electron and ion density
Dust detector	Meteor smoke particles
2 visible light photometers	NLC particles
2 IR photometers	NLC particles
2 Impact detectors	NLC particles
Microwave radiometer	Water vapour density
Atomic oxygen probe	Atomic oxygen density
Atomic hydrogen probe	Atomic hydrogen density
Side-looking photometer	NLC particles
Microwave radiometers	Water vapour density
2 Ion detectors	Ion density
”CONE”	Temperature, density



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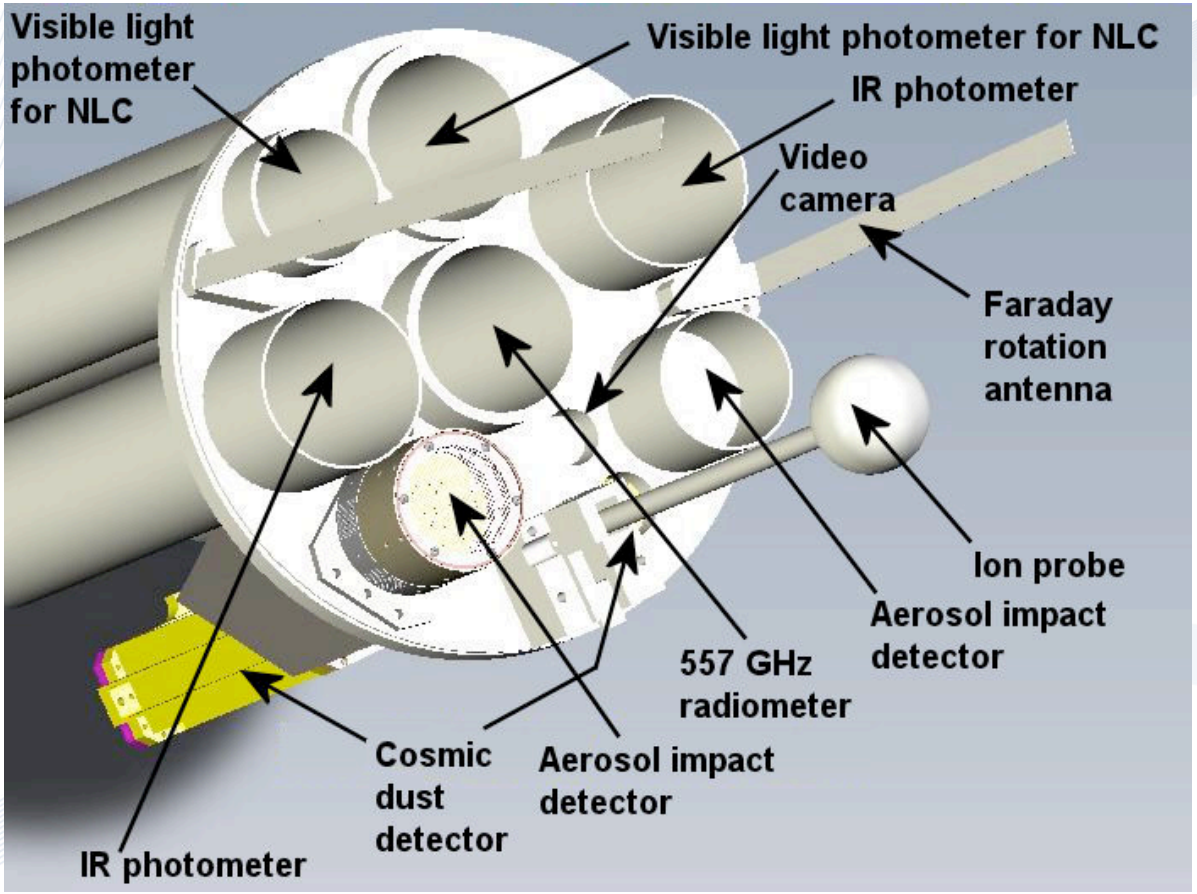
PHOCUS Particle Module pointing in the direction of flight



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Protecting sensors during ascent

Separation of the nose cone of the MAGIC sounding rocket (2005). The water vapour sensor is under the nose cone. No moisture must penetrate during ascent.

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More PHOCUS characteristics

- Extremely high vertical resolution: 10 cm resolution on neutral atmosphere density leads **to ≥ 1 Mbps data rate** (telemeter or store on SD), up to 20 Mbps capability.
- **Attitude determination ≤1^{0}** in all axes using MEMS IMU.
- **Maintain attitude within 5^{0}.**
- **GPS for trajectory data** (apogee 110 km)**.**
- **Support from co-located ground instruments** (lidar, VHF radar)
- **Price 1.5 M$** (excl. Instruments).

Nike-Orion

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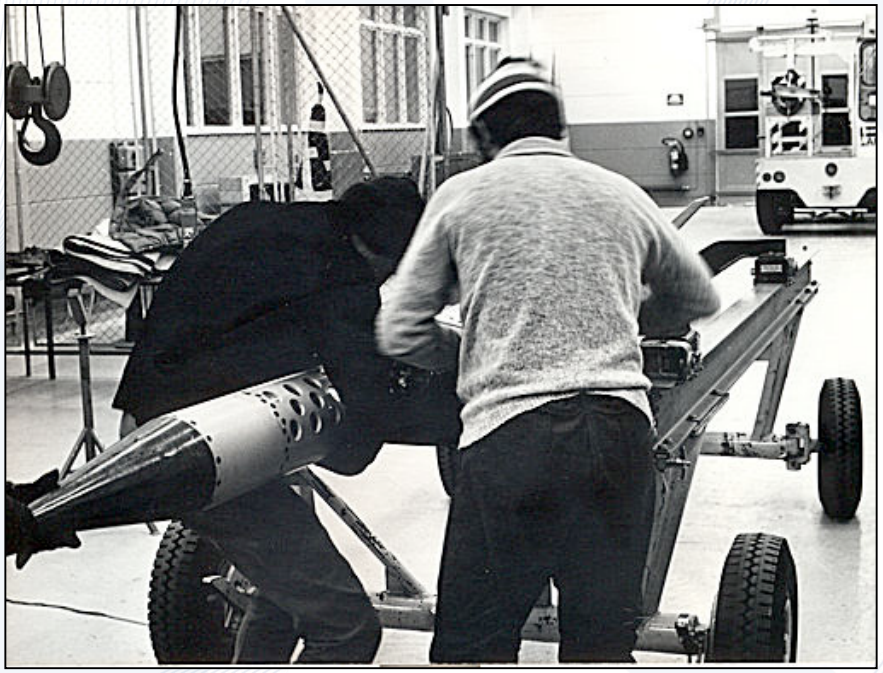
Synoptic atmospheric measurements – a lost capability that can be resurrected by piloted suborbital vehicles ?

In the past many sounding rocket ranges were active so synoptic measurements were possible. **Perhaps possible again with piloted suborbital vehicles?**



Sound grenade payload for temperature and wind soundings prepared at Esrange in 1969.

Co-ordinated rocket launches in sudden warming campaign					
January 1969	ESRANGE	Wallops Island	Fort Churchill	Point Barrow	Hebrides
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
Total # of rockets	4	2	2	3	5

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Important requirements from atmospheric research payloads

- Launch on warning
- Launch at precise time (co-ordinate with satellite).
- Launch at any time of the day.
- Synoptic launches.
- Protect sensors at low altitude
- Tight control of outgassing
- Very high data rate
- Maintain attitude to within a few degrees
- Accurate attitude and trajectory determination
- Co-located ground instrumentation.

Science Services division

Experiment Payloads

Sounding Rockets
Parabolic Flights
Space Shuttle
Balloons

Sounding Rockets

Programs and Systems

Balloons

Programs and Systems

Launch Service

Rocket and balloon launch services
Flight test services

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