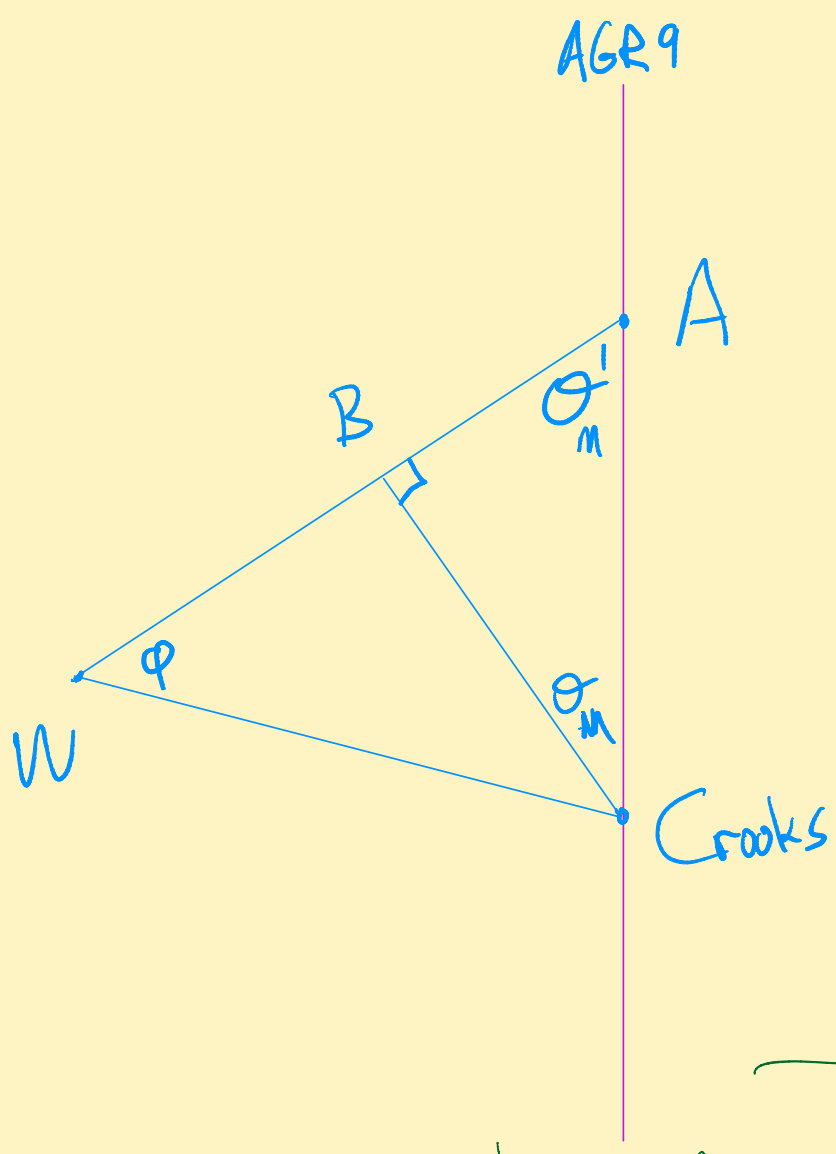

V = speed of bullet

c = " " sound

$$\sin\theta_M = \frac{c}{v} = \cos\theta'_M$$

$$= \frac{AB}{AC}$$

Hence

$$\boxed{\frac{AB}{c} = \frac{AC}{v}}$$

Crack heard by W originates at A.

Bang " " " C

time gap between W recording crack and bang

$$= \frac{AC}{v} + \frac{CW}{c} - \frac{AW}{c}$$

$$= \frac{AB}{c} - \frac{AW}{c} + \frac{CW}{c}$$

$$= \frac{CW}{c} - \frac{BW}{c}$$

For crack and bang to be heard simultaneously, this must be zero, i.e.

$$CW = BW$$

But this is impossible, since

BW is a leg

CW is the hypotenuse

of the same right triangle.

Unless the triangle is degenerate,

with $\varphi = 0$, in which case

W lies on the edge of

the Mach Cone.