Pre-motor nuclei and the medial longitudinal fasciculus (MLF)

I Hierarchy of control

- Planning- supranuclear regions
- Orchestration- premotor nuclei
- Implementation- final common pathway

II. Premotor nuclei

- 3 functions
  - transform control into Cartesian coordinates
  - Shape responses
  - Reflex actions

III. Interconnections between pre-motor nuclei and Motor nuclei (MLF)

IV. Specialized pre-motor sites

- PPRF- Horizontal saccades
- RiMLF- Vertical and torsional saccades
- Near Response cells- Vergence and accommodation
- Abducens nucleus- Hering's law for horizontal movements
- DLPN- Horizontal Pursuits
- VIII- VOR
- NOT- Horizontal OKN

V. Specific examples

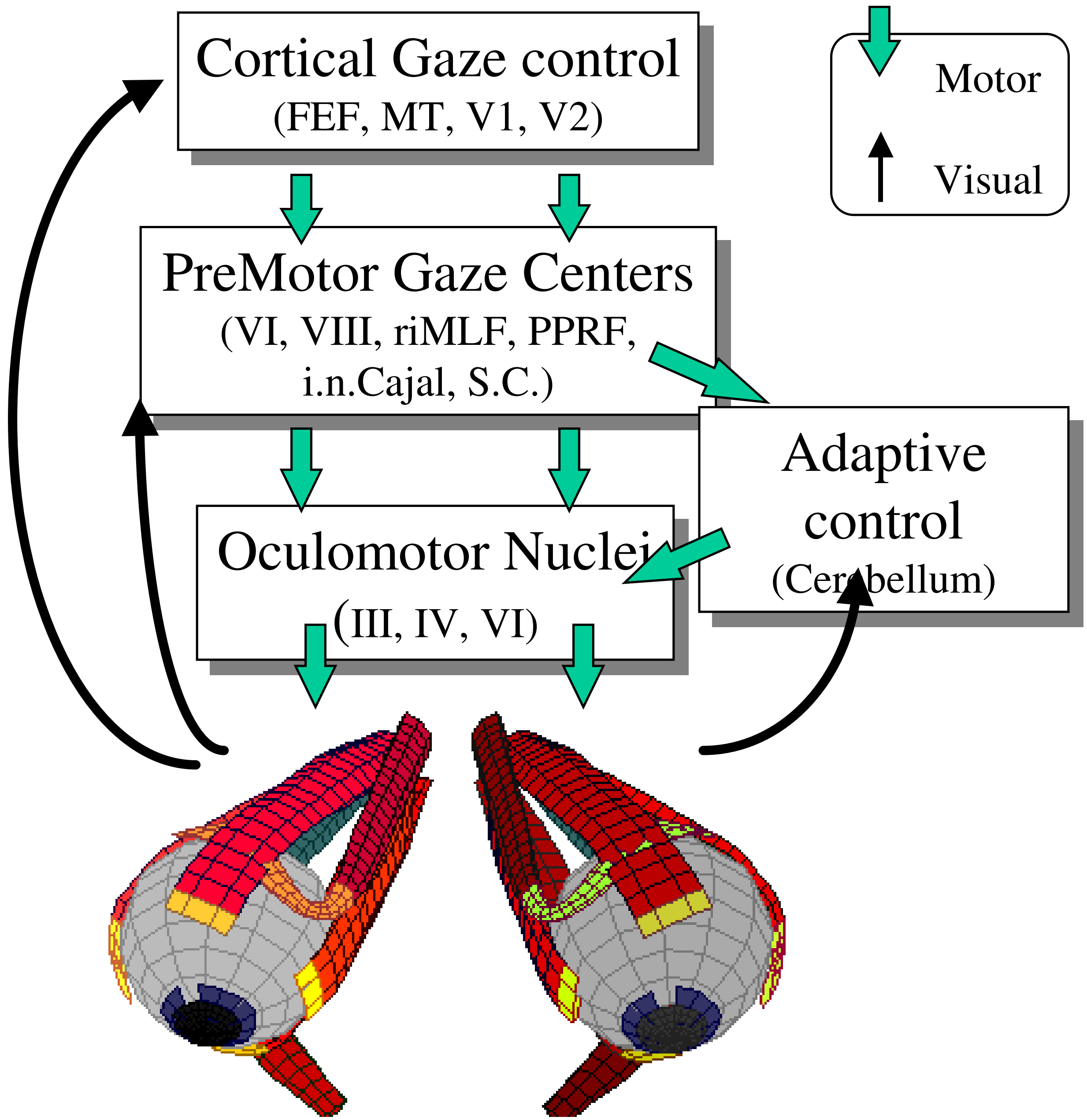
Hierarchy of Oculomotor Control

<u>Supra-nuclear Neurons</u>
Voluntary control,
spatial frame of reference

<u>Pre-motor Neurons</u>
Reflex movement,
pulse generation,
integration

<u>Motor neurons</u>
Final common path,
reciprocal innervation

<u>Muscles</u>
Oculomotor plant



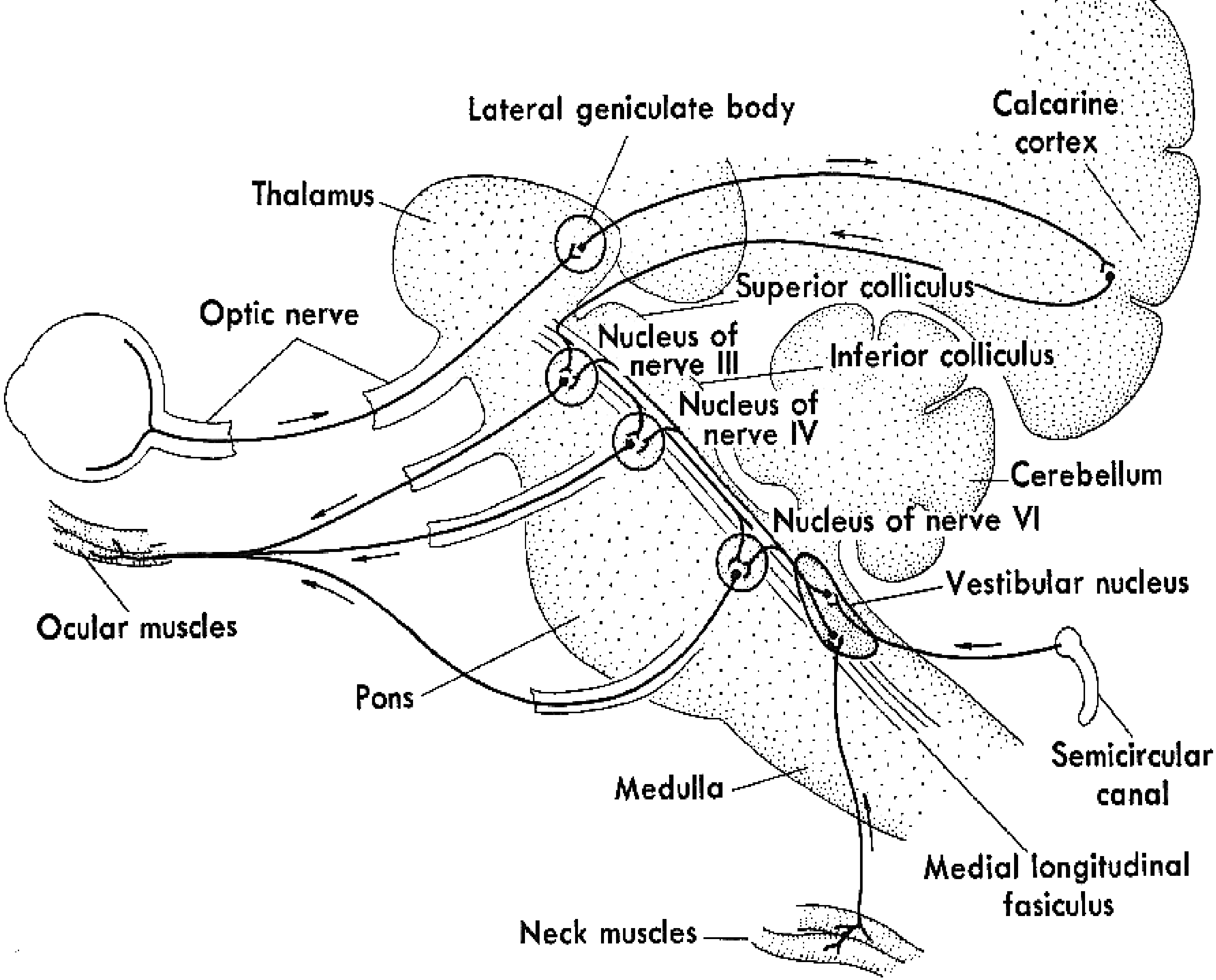
Hierarchy of Control

Planning- Supranuclear regions

Orchestration- Premotor nuclei

Implementation- Final Common Pathway

Brain stem sites of cranial nerves- Final Common Pathway



Orchestration- **Premotor nuclei**

Functions:

Transform eye movement control into Cartesian coordinates.
(Horizontal, Vertical & Torsional)

Activate combinations of muscles needed to perform eye movement (implement Hering's law)

Specialized control the temporal properties (velocity and position codes for saccades)

Separate specialized areas for reflex and voluntary responses-
(e.g. OKN and Pursuits)

Medial Longitudinal Fasciculus (MLF)

Projections from pre-motor nuclei to the Final Common Pathway.

Pathways run longitudinally (rostral-caudal) in the reticular formation. They interconnect pre-and post motor nuclei.

Specialized pre-motor sites:

PPRF- Horizontal saccades

RiMLF- Vertical Saccades and Torsion

Near Response Cells- vergence and accommodation
AKA supraoculomotor nucleus

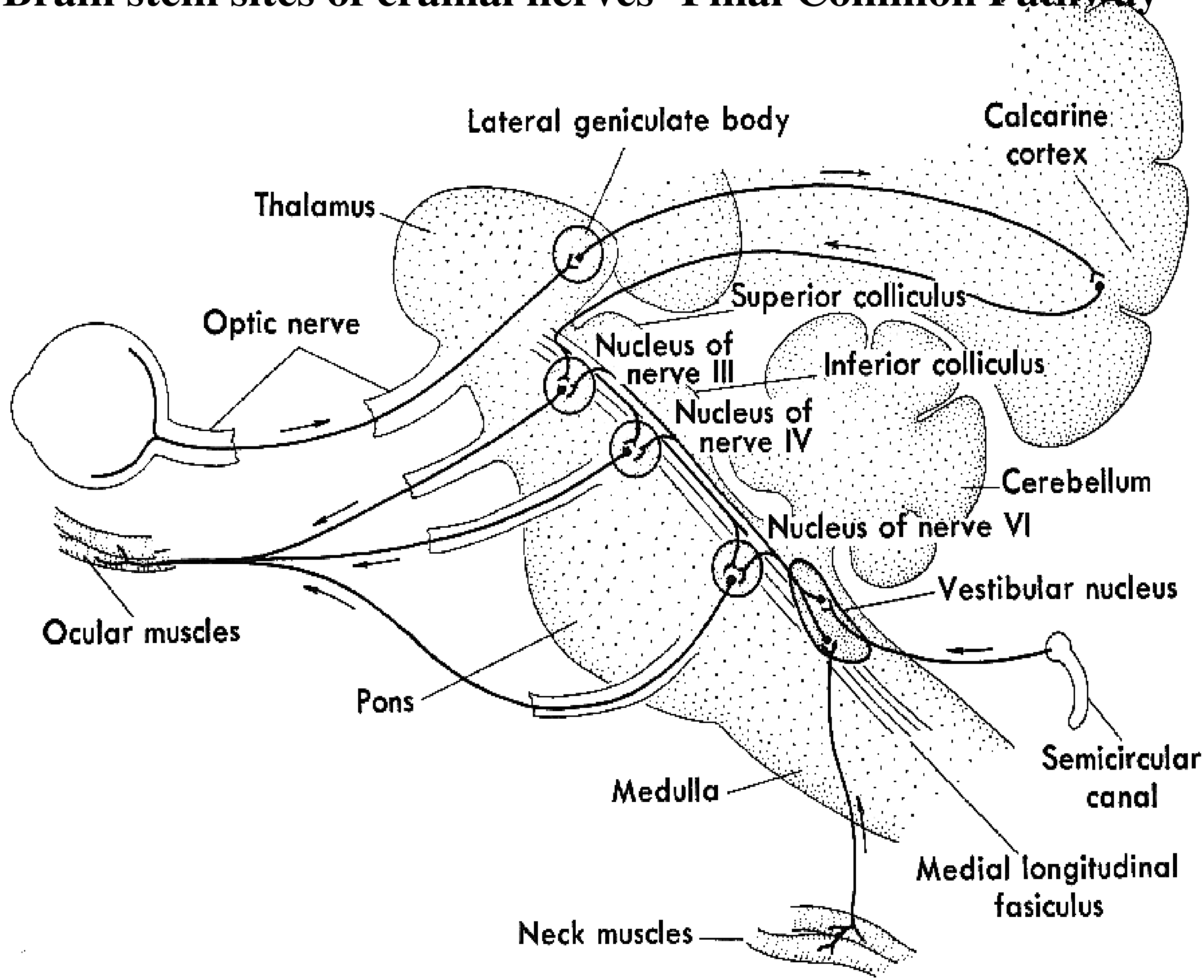
Abducens nucleus- interneurons for Hering's law of yoked horizontal eye movements

DLPN- Horizontal pursuits

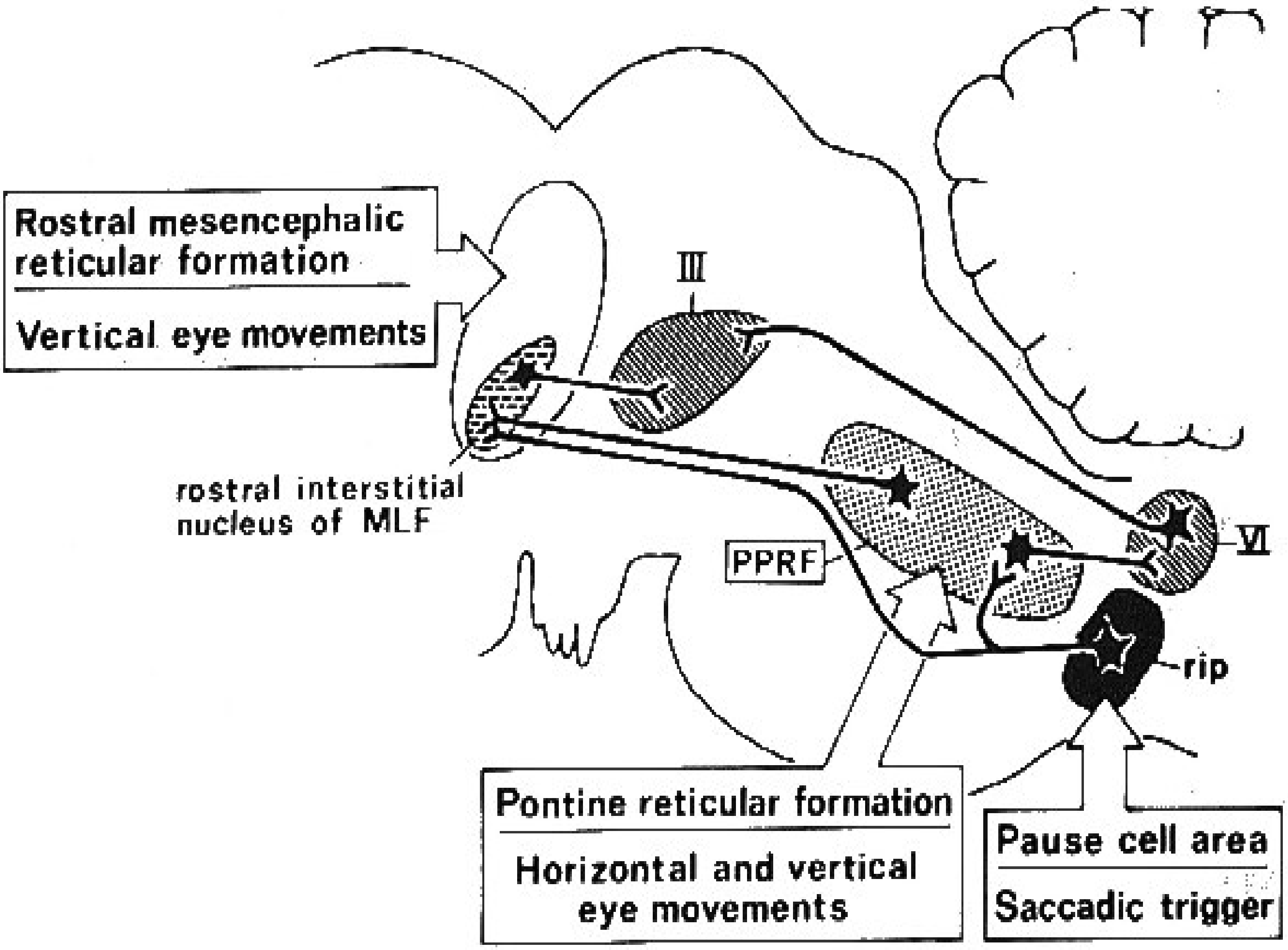
VIII- VOR

NOT- OKN

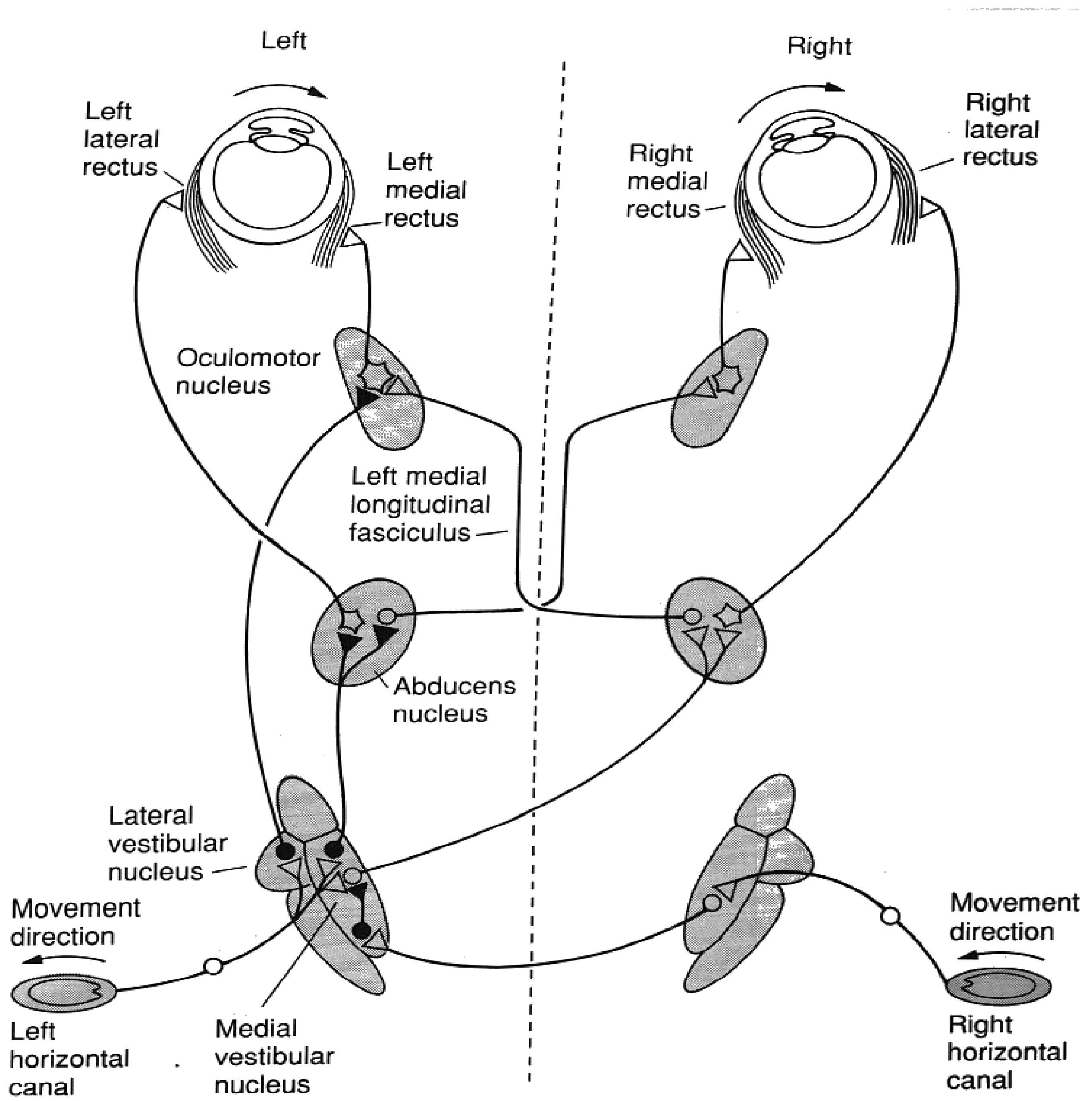
Brain stem sites of cranial nerves- Final Common Pathway



“Whoa! *That* was a good one! Try it, Hobbs—just poke his brain right where my finger is.”

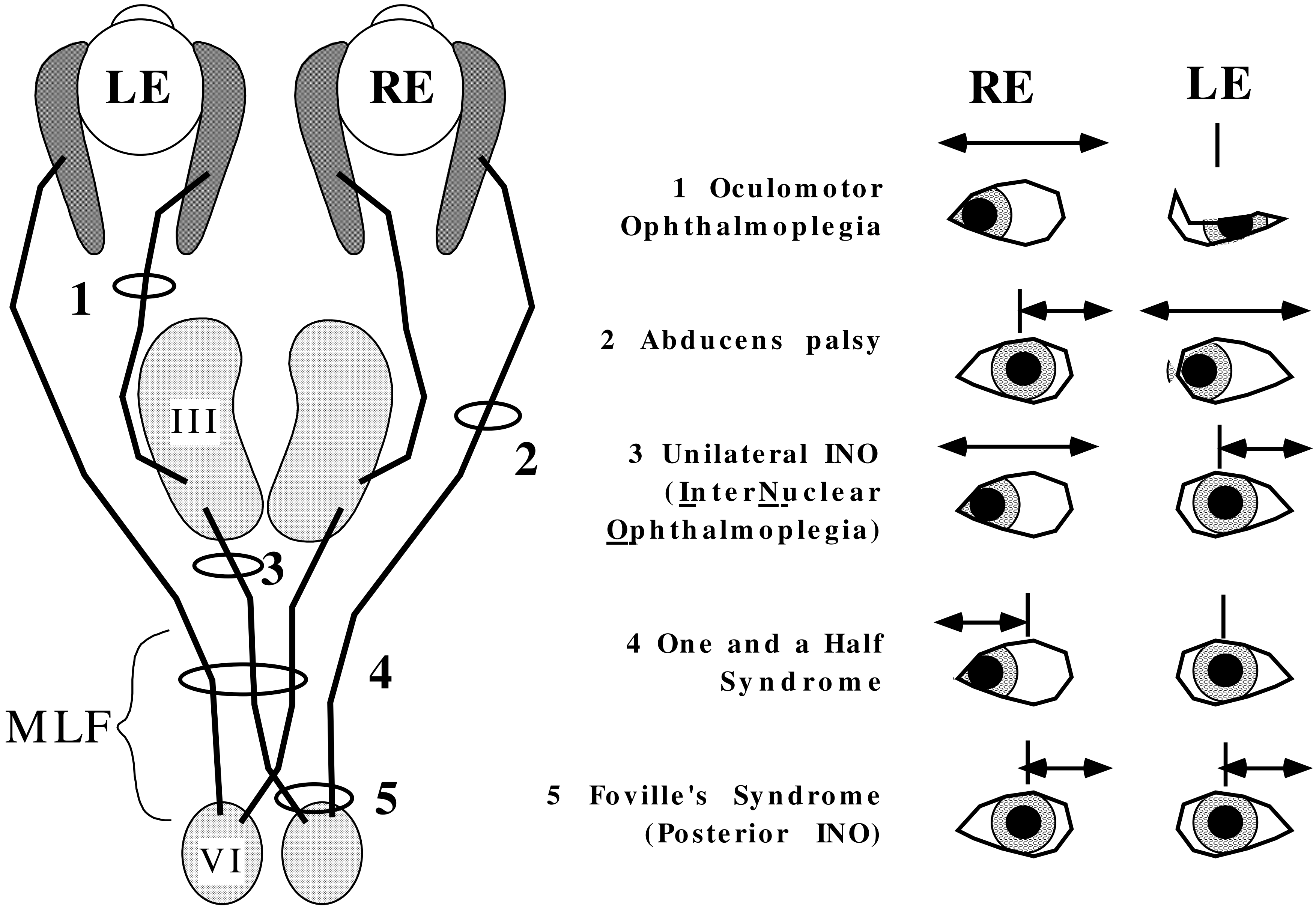


Rostral mesencephalic reticular formation
Vertical eye movements
III
rostral interstitial nucleus of MLF
PPRF
VI
rip
Pontine reticular formation
Horizontal and vertical eye movements
Pause cell area
Saccadic trigger

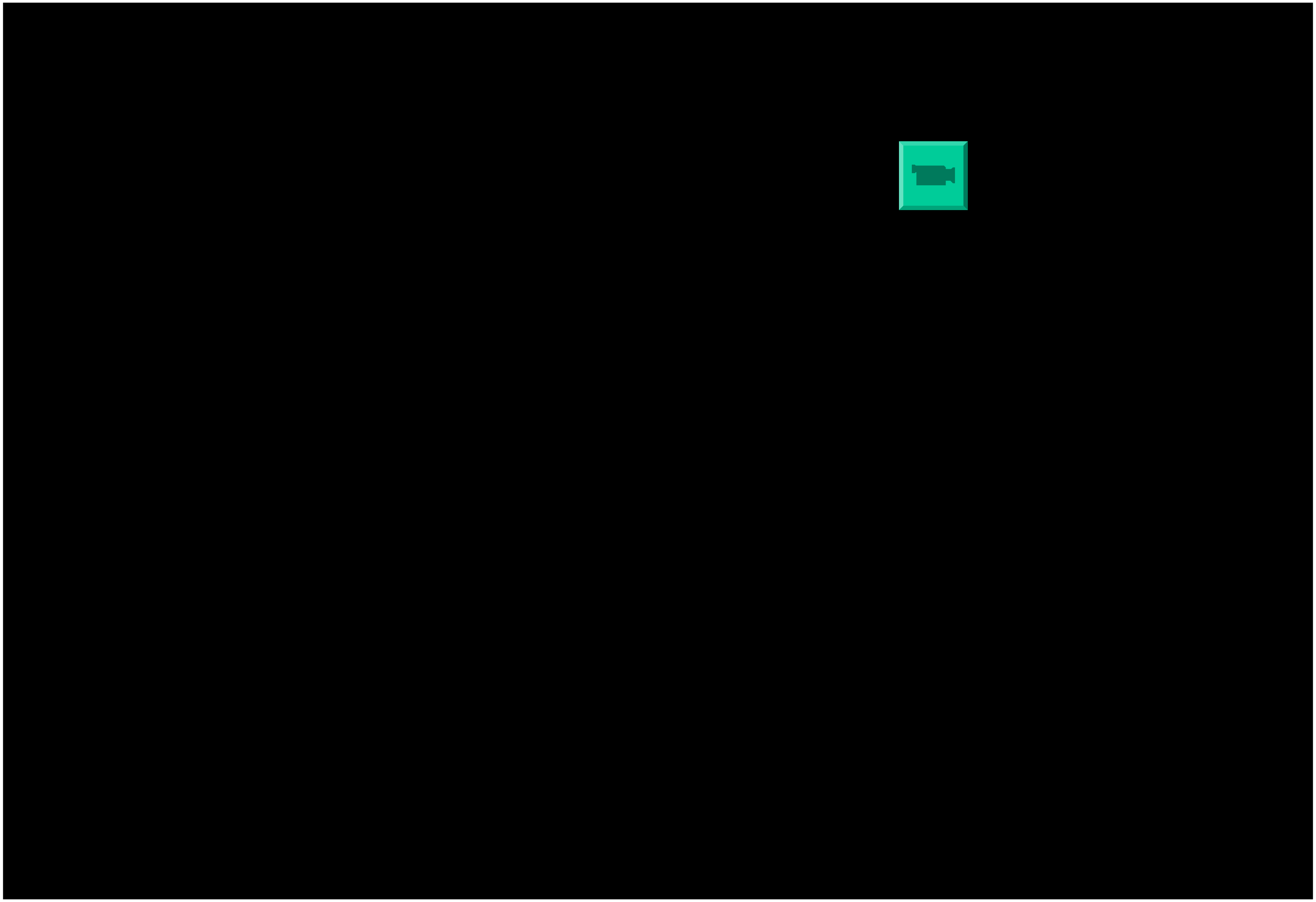


Pathways for the Horizontal VOR during leftward head rotation

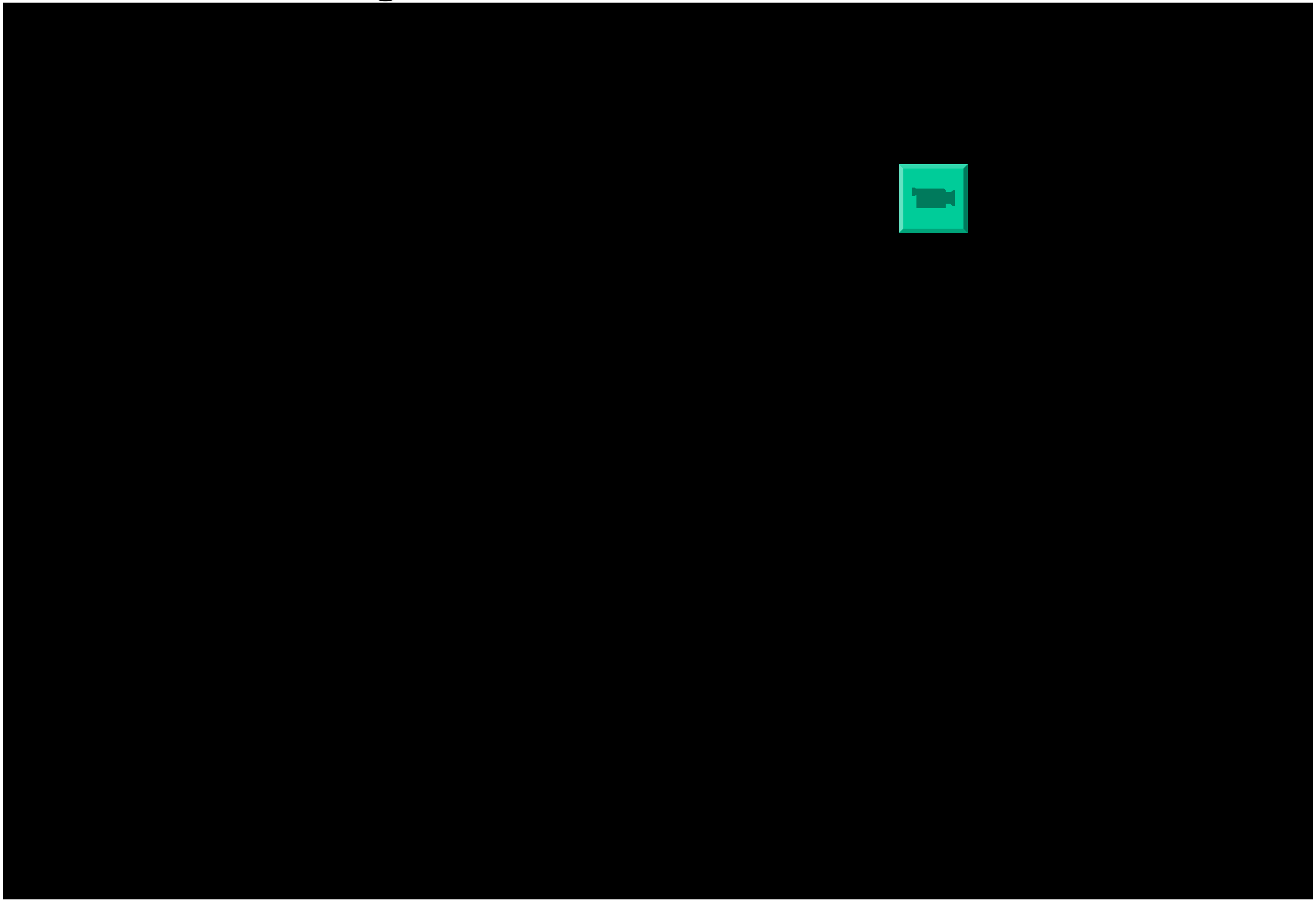
Lesions affecting horizontal version



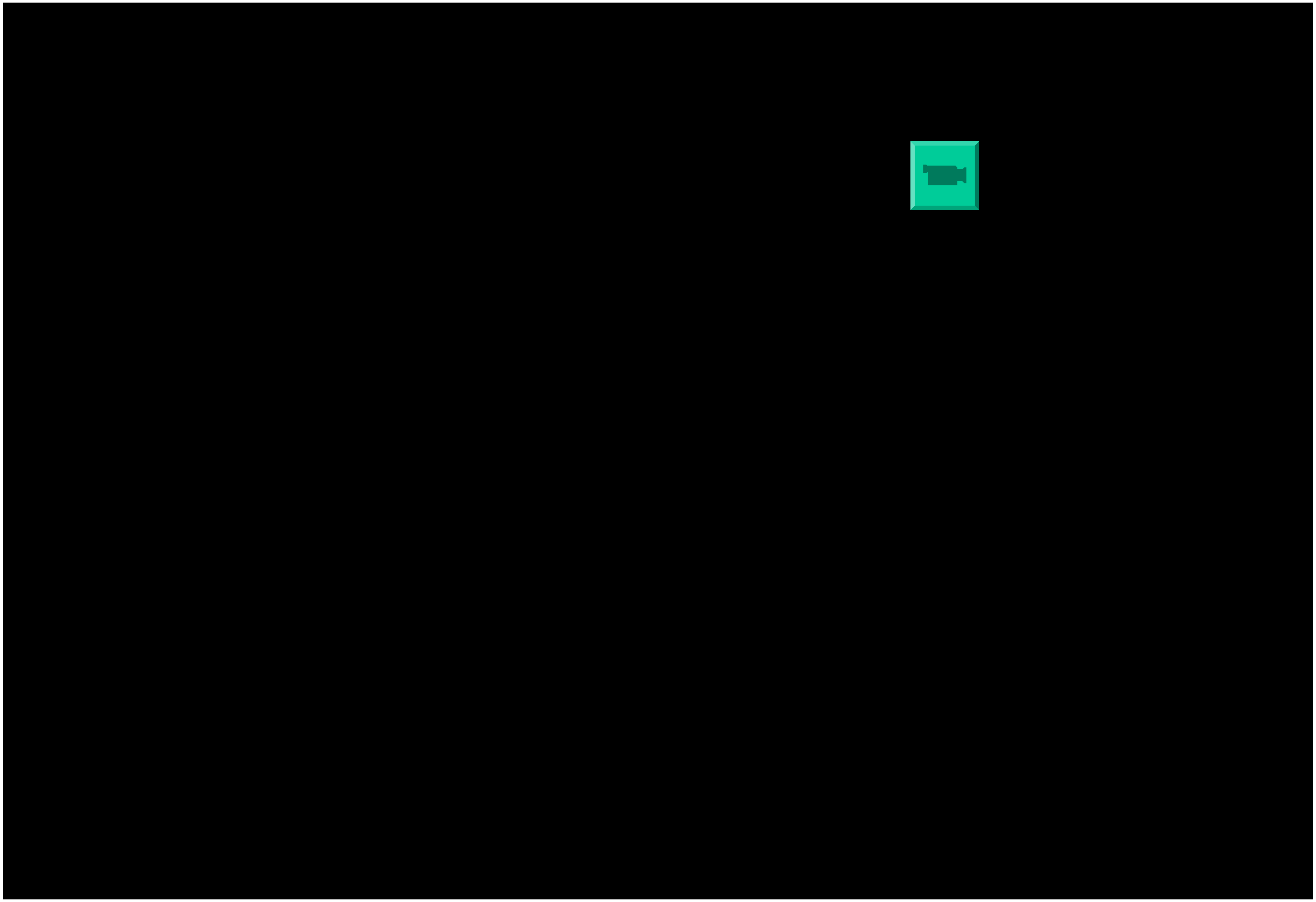
Bilateral INO



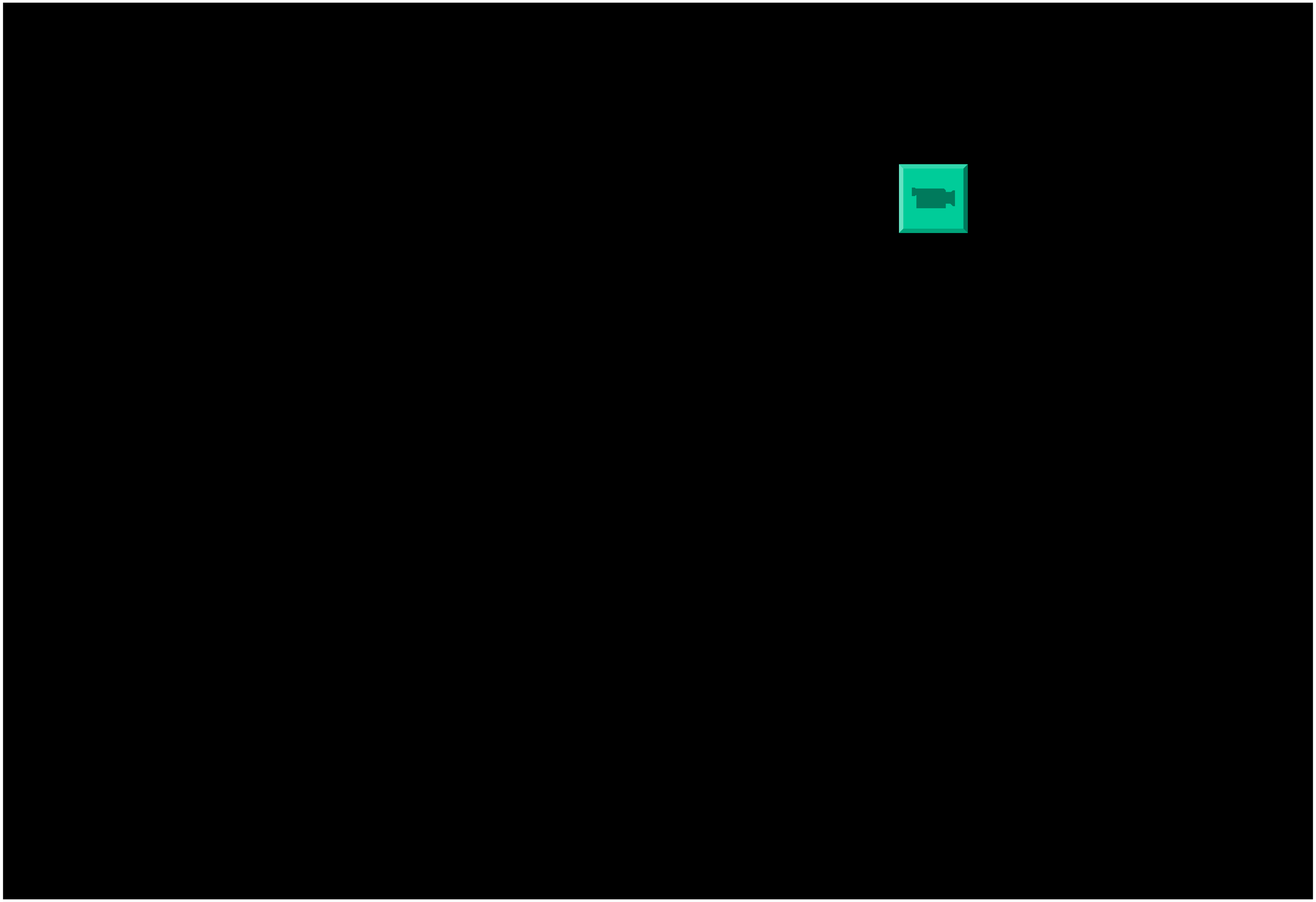
Right Unilateral INO



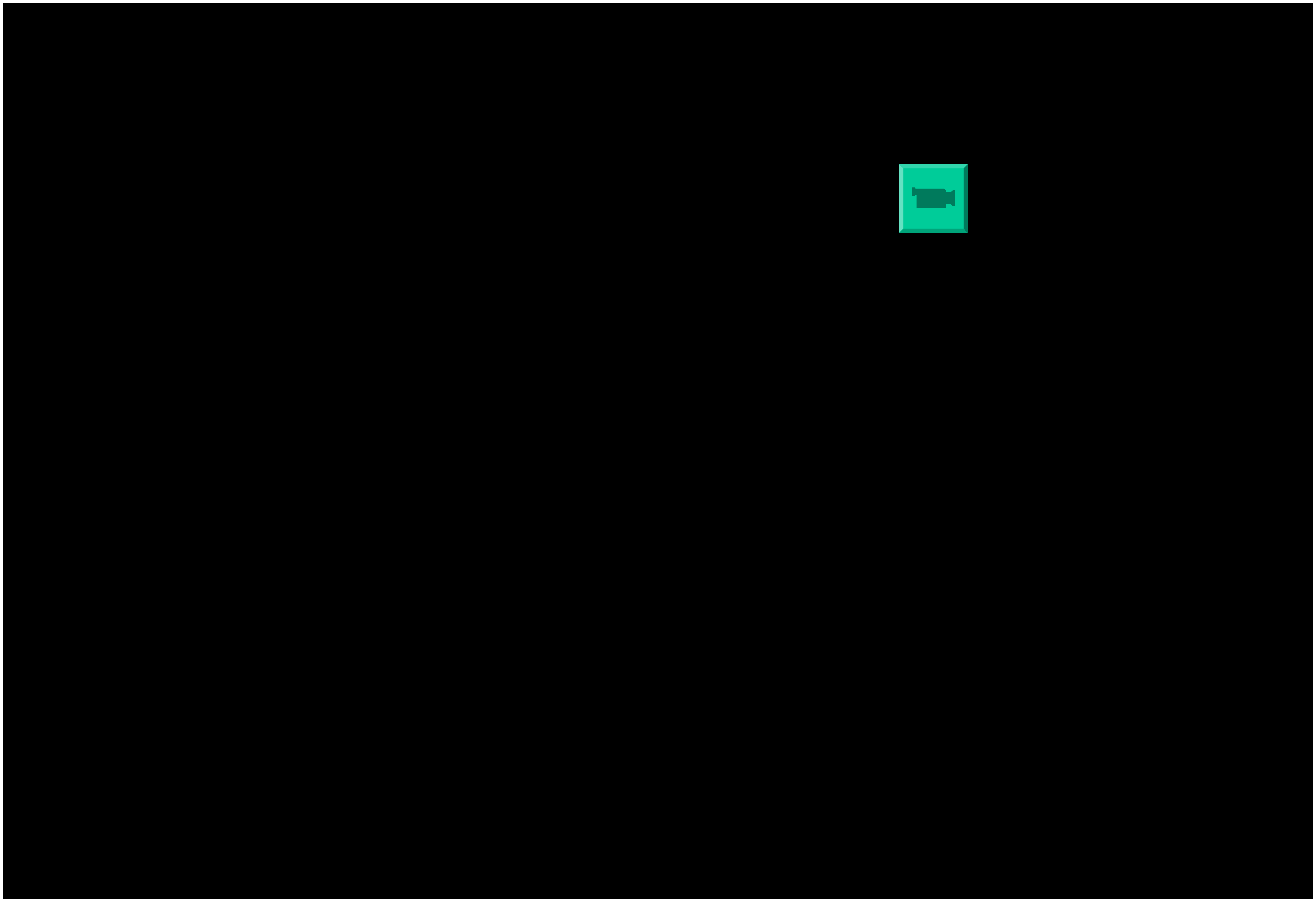
Foville's Syndrome with saccades



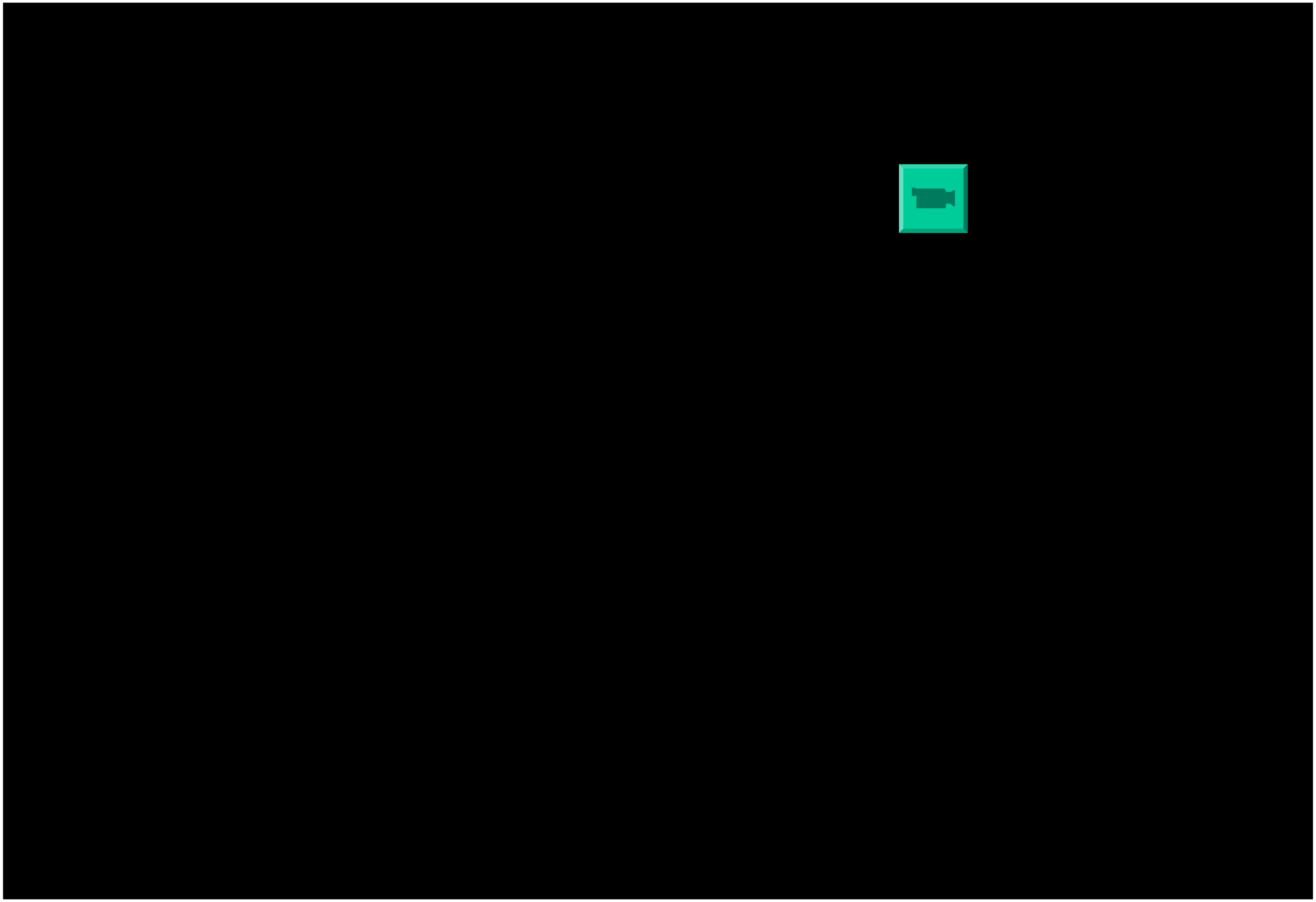
Foville's Syndrome VOR



Foville's Syndrome and convergence



Parinaud's Syndrome- vert saccades



Specialized cells within the premotor area PPRF for generating saccades.

<u>Burst Cell</u> determine the velocity of a saccade

Overcome viscosity to achieve high velocity

<u>Tonic cells</u> maintain the new eye position at the end of a saccade

Cells in other areas of the brainstem (prepositus) that interact with burst and tonic cells

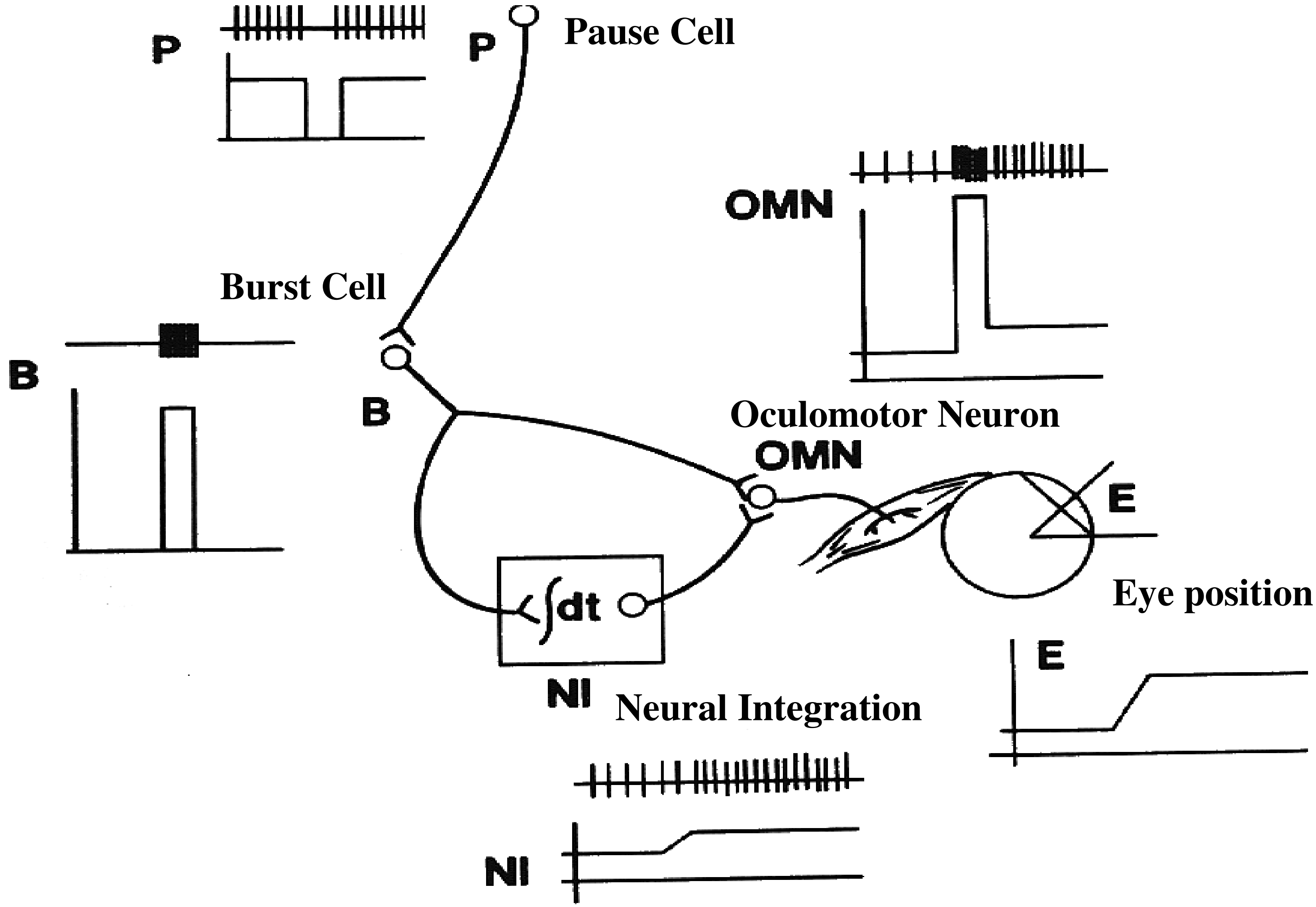
<u>Neural Integration</u> transforms burst activity into tonic cell activity

<u>Pause Cell</u> determine the duration of a saccade

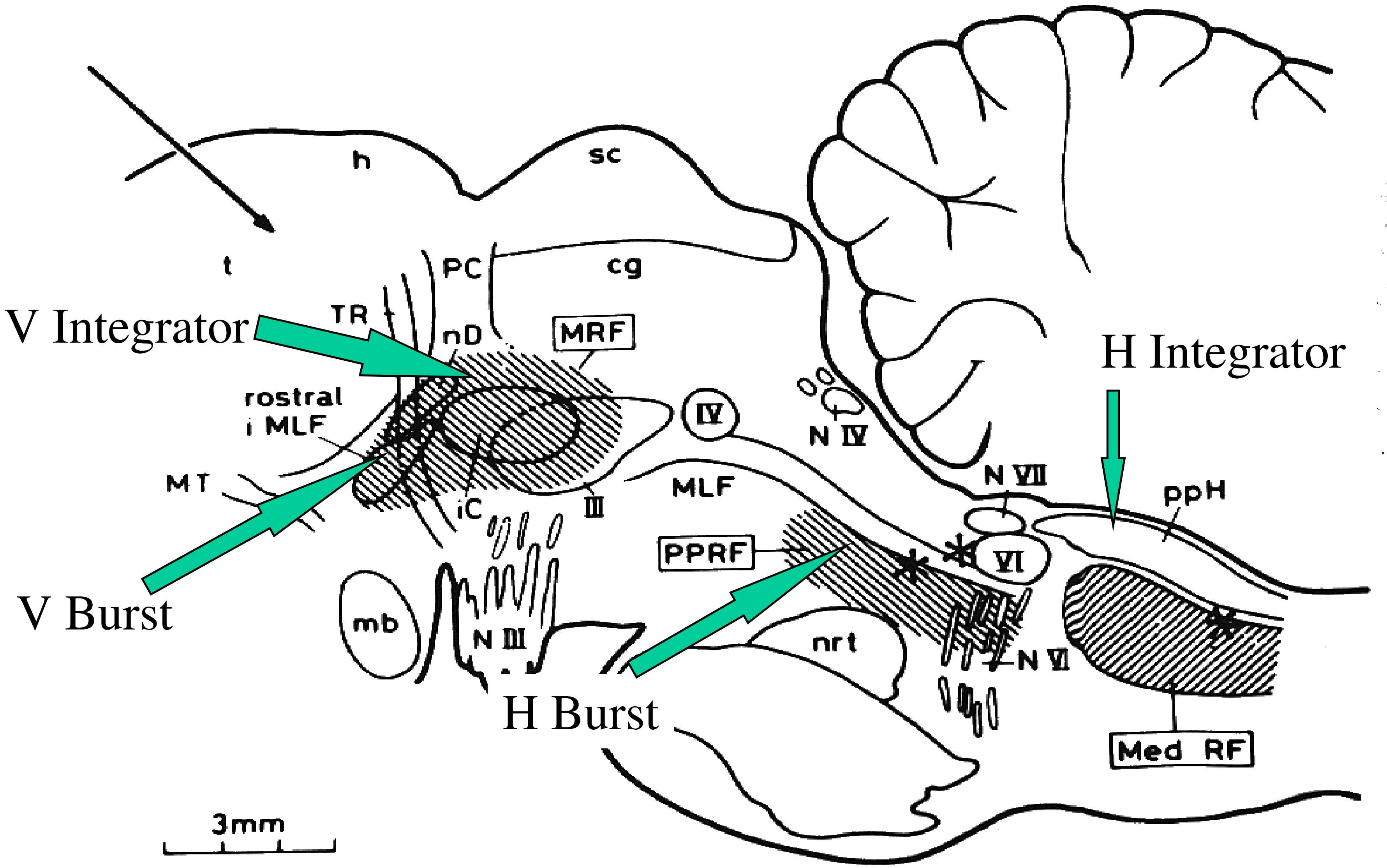
Triggers the burst cell activity like a car clutch

Amplitude of a saccade is determined by the duration and amplitude of the burst.

Pause, Burst and Integration circuit



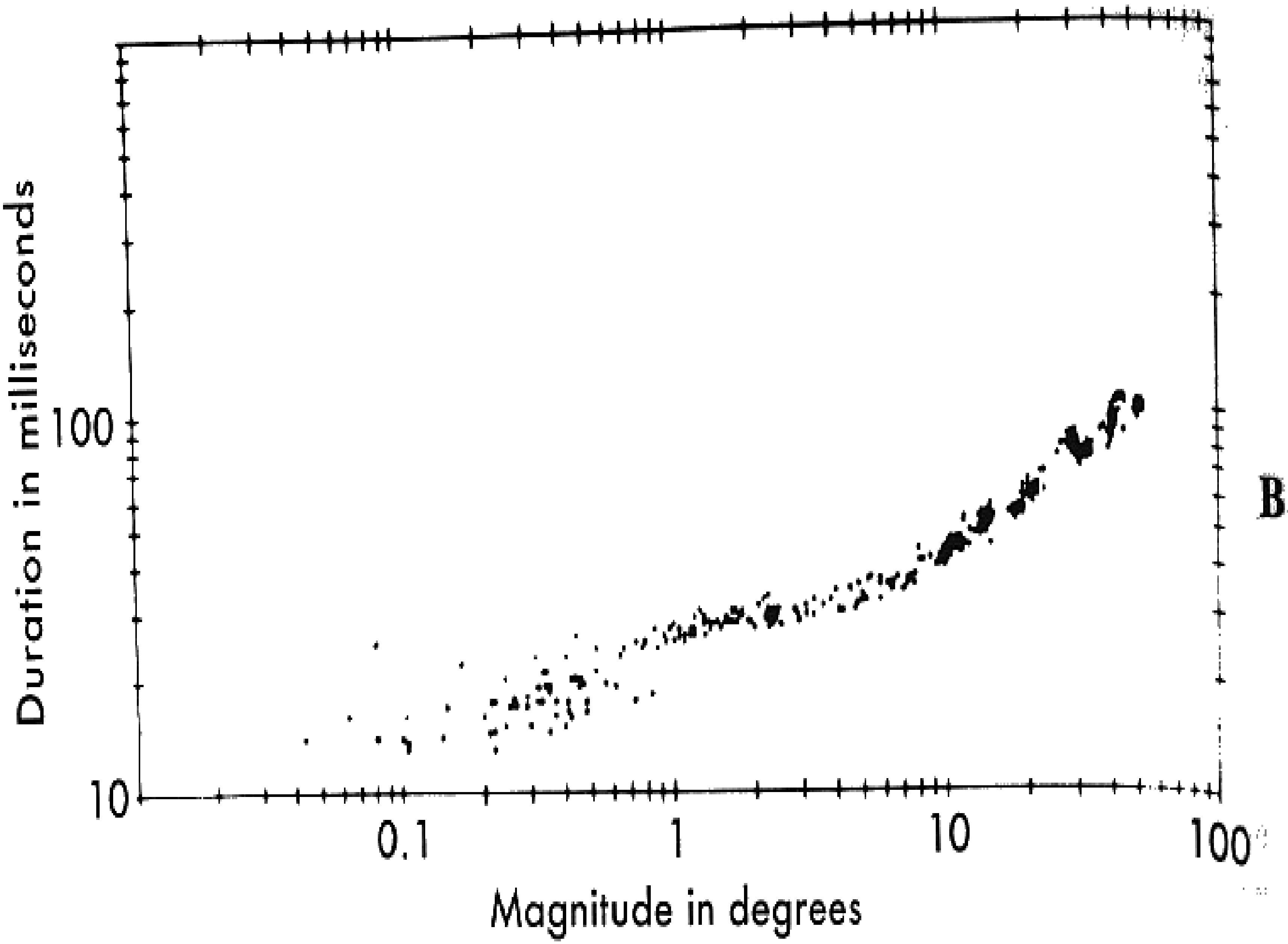
Brainstem Burst and Integrator regions



Main sequence diagram plots velocity or duration as a function of saccade amplitude.

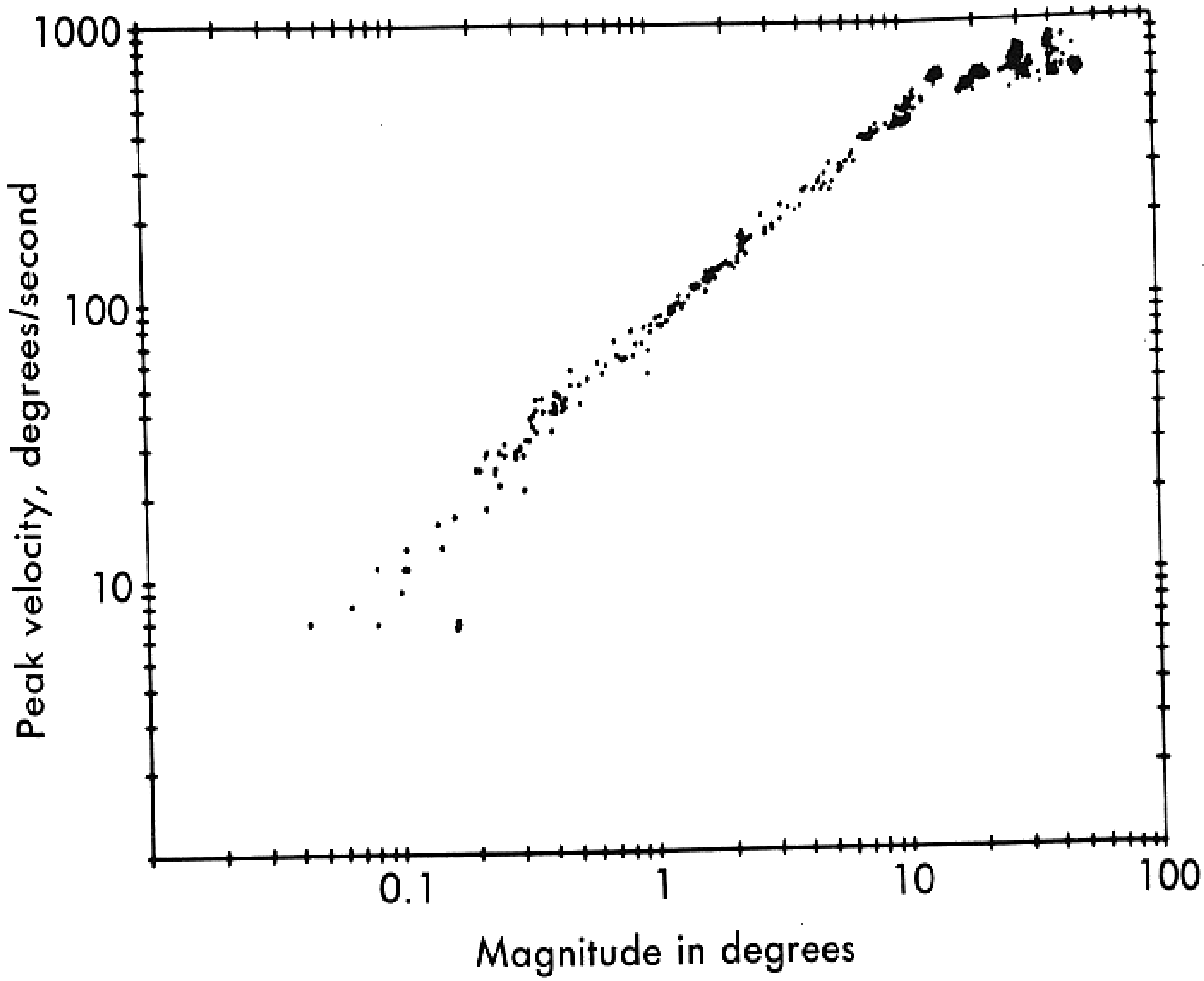
10 deg saccade lasts 50 msec. Saccades are rarely longer than 100 msec

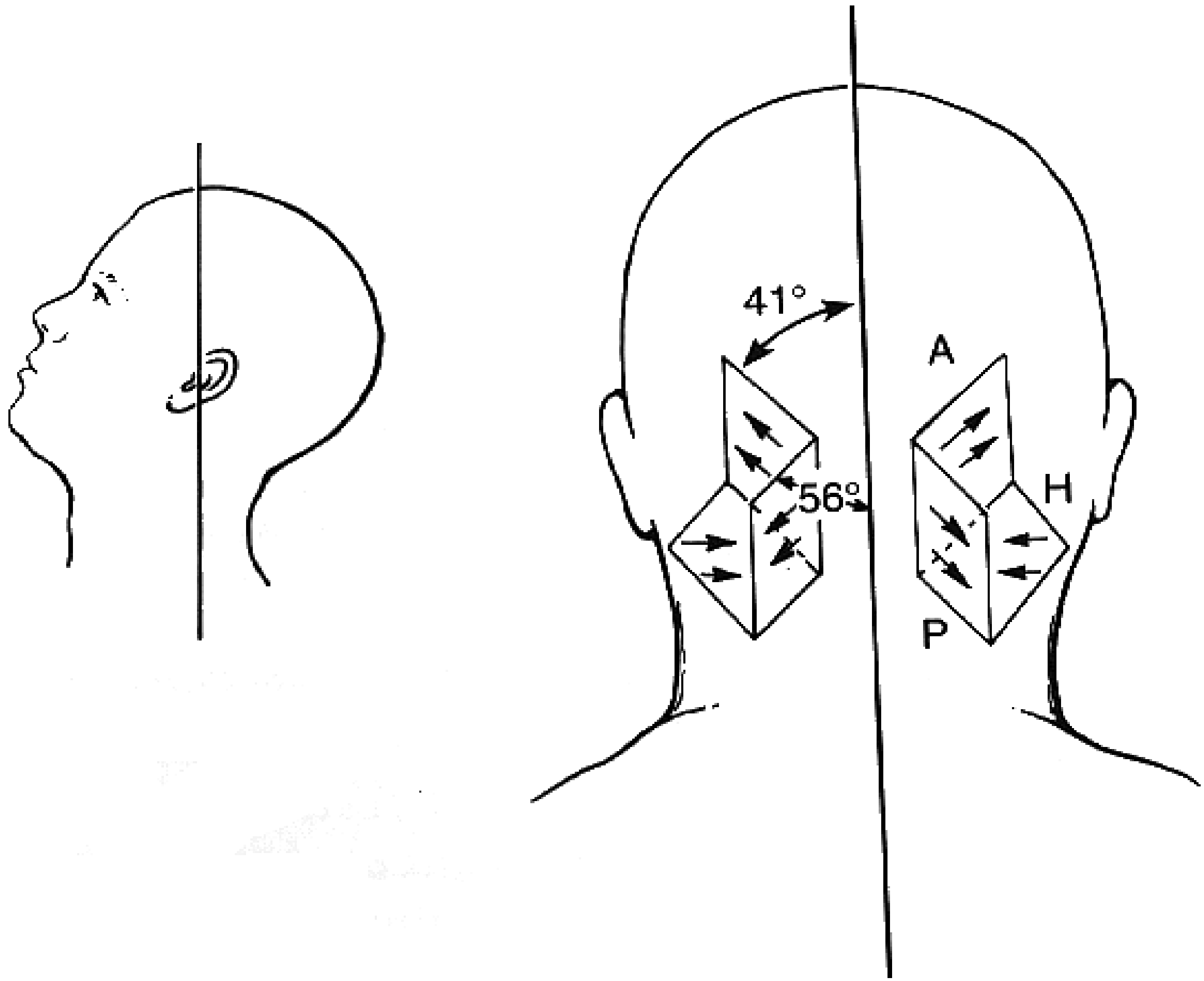
Main sequence reflects the activity of Burst neurons.



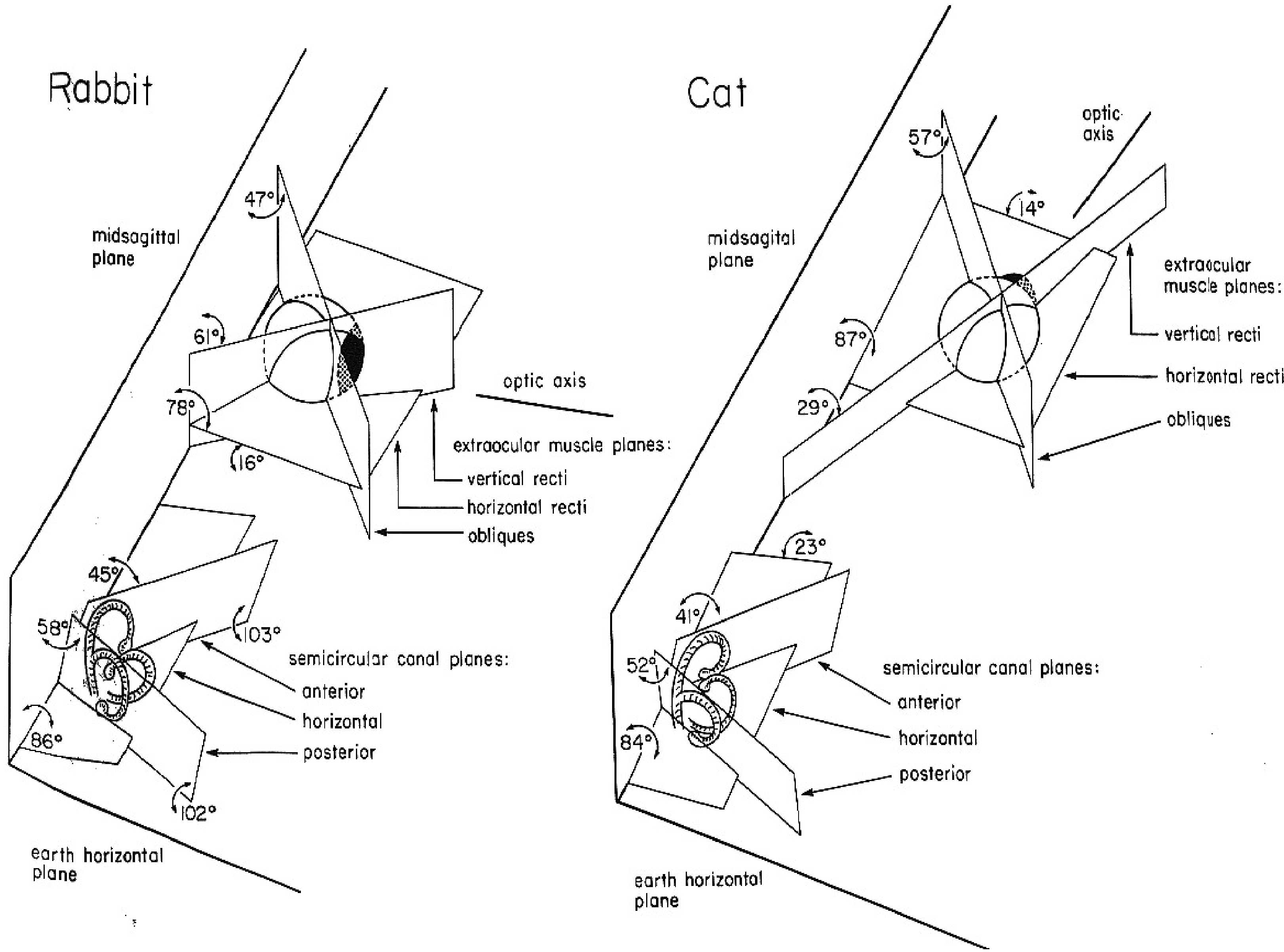
Duration in milliseconds
100
10
0.1
1
10
100
Magnitude in degrees
B

A


1000
100
10
Peak velocity, degrees/second
0.1
1
10
100
Magnitude in degrees

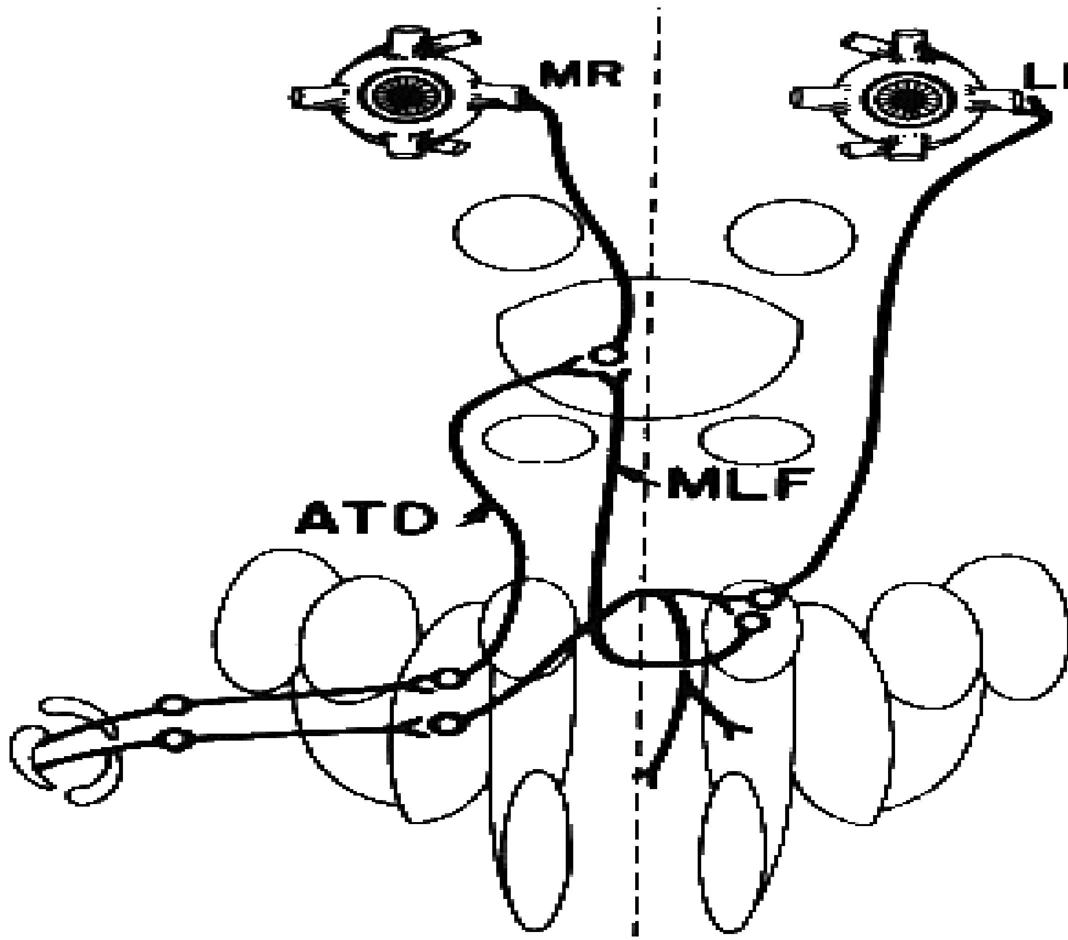


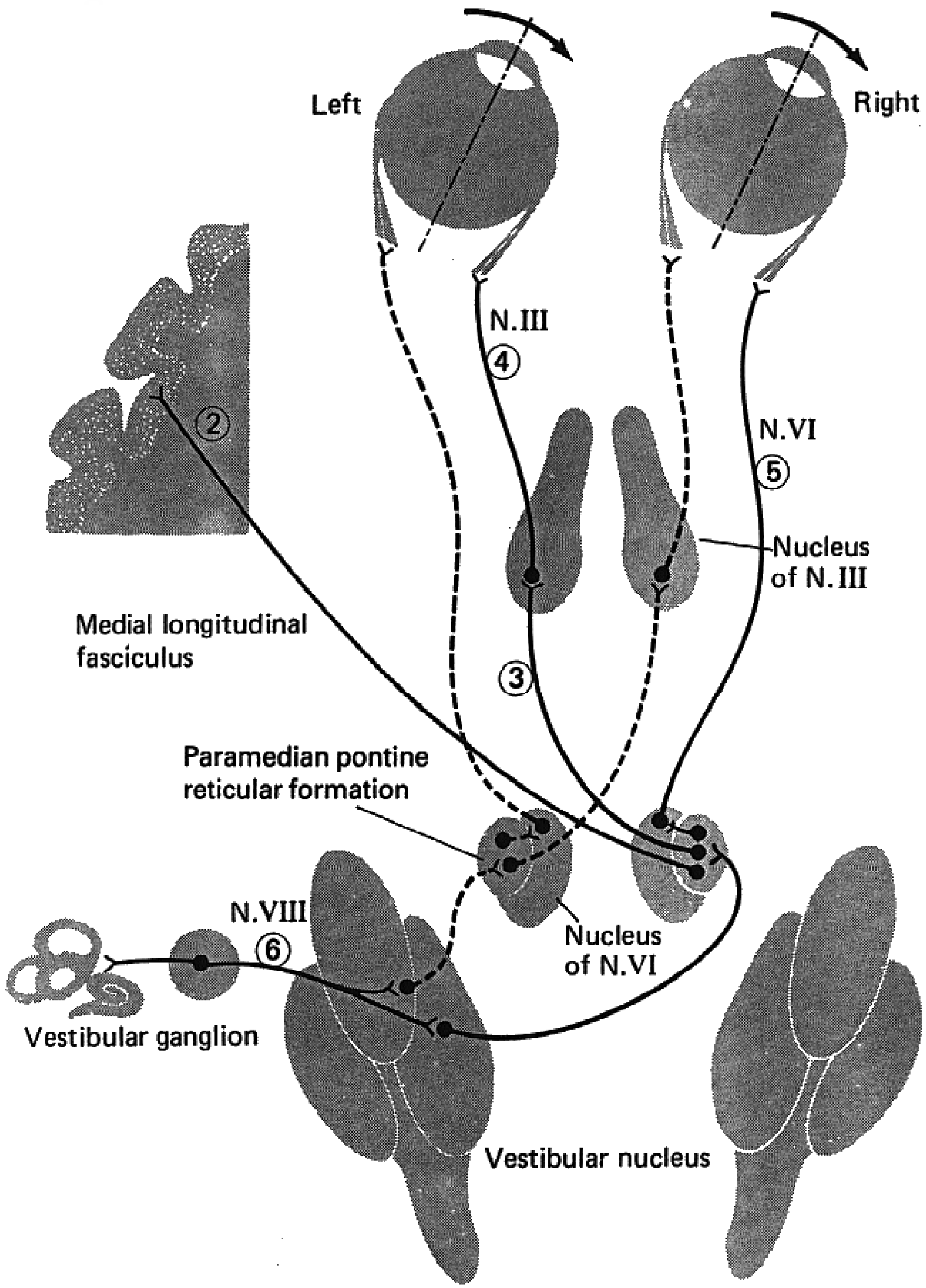
41°
56°
A
H
P

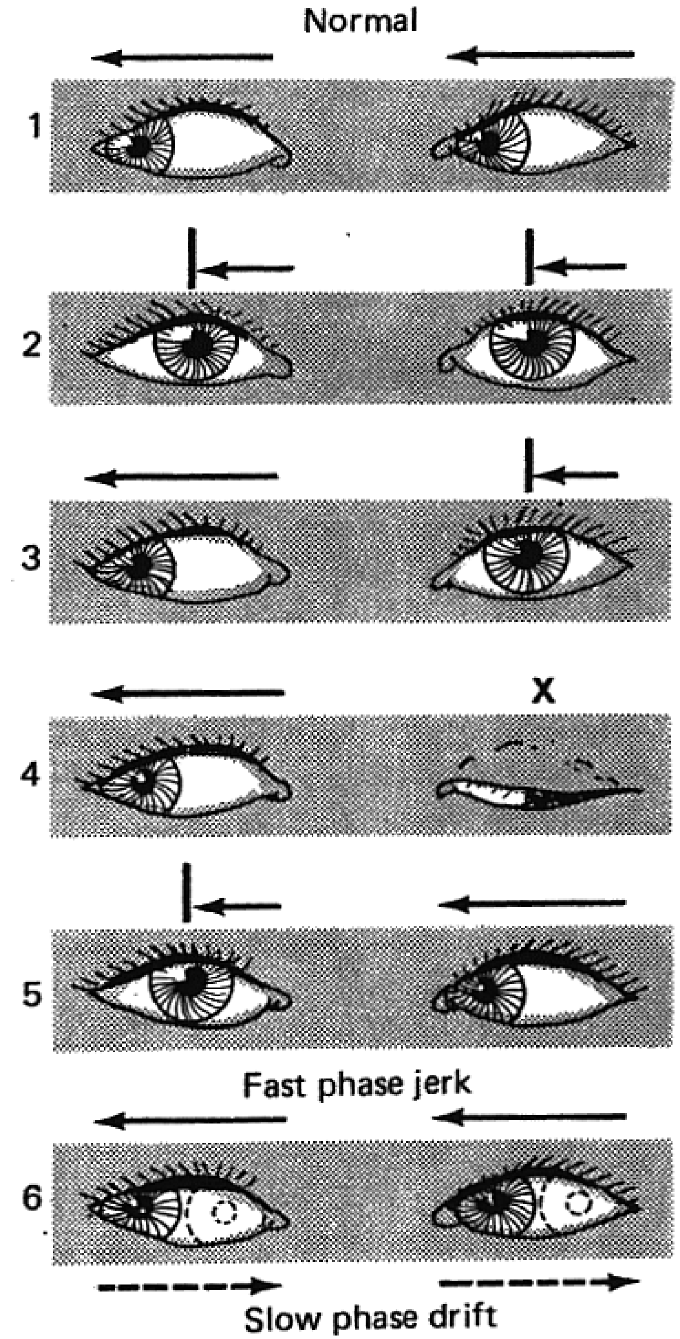


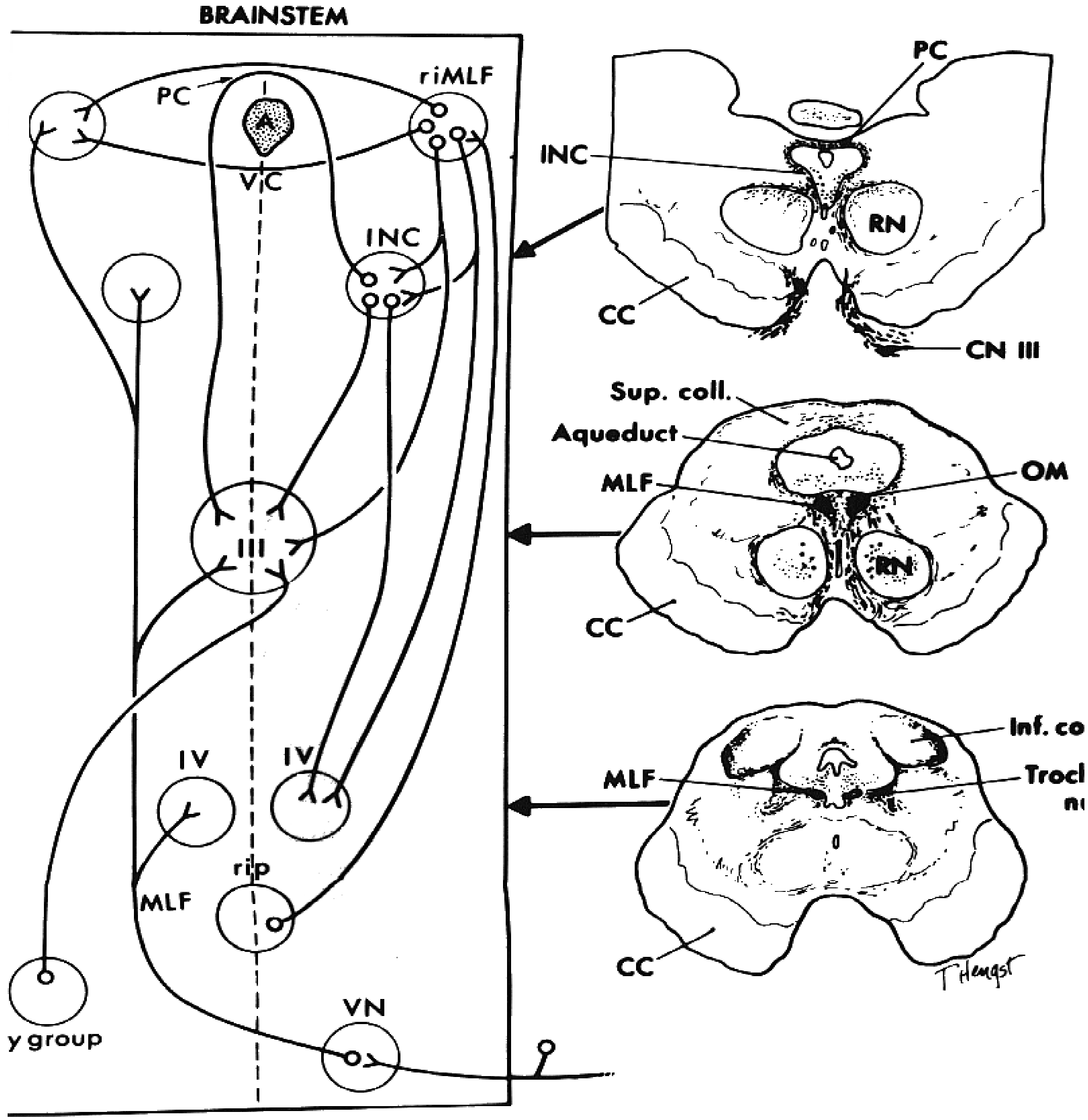
Rabbit
midsagittal plane
47°
61°
78°
16°
optic axis
extraocular muscle planes:
vertical recti
horizontal recti
obliques
45°
58°
103°
86°
102°
semicircular canal planes:
anterior
horizontal
posterior
earth horizontal plane
Cat
57°
optic axis
14°
midsagital plane
extraocular muscle planes:
vertical recti
horizontal recti
obliques
87°
29°
23°
41°
52°
84°
semicircular canal planes:
anterior
horizontal
posterior
earth horizontal plane

HORIZONTAL CANAL-EXCITATORY PROJECTIONS




Left
Right
N.III
4
2
N.VI
5
Nucleus
of N.III
Medial longitudinal
fasciculus
3
Paramedian pontine
reticular formation
N.VIII
6
Nucleus
of N.VI
Vestibular ganglion
Vestibular nucleus


Normal
1
2
3
X
4
5
Fast phase jerk
6
Slow phase drift



BRAINSTEM
PC
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VC
INC
III
IV
IV
rip
MLF
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VN
PC
INC
RN
CC
CN III
Sup. coll.
Aqueduct
MLF
OM
RN
CC
Inf. co
MLF
Trocl
n
CC
T Hengst