The DAMNED Simulator for Implementing a Dynamic Model of the Network Controlling Saccadic Eye Movements

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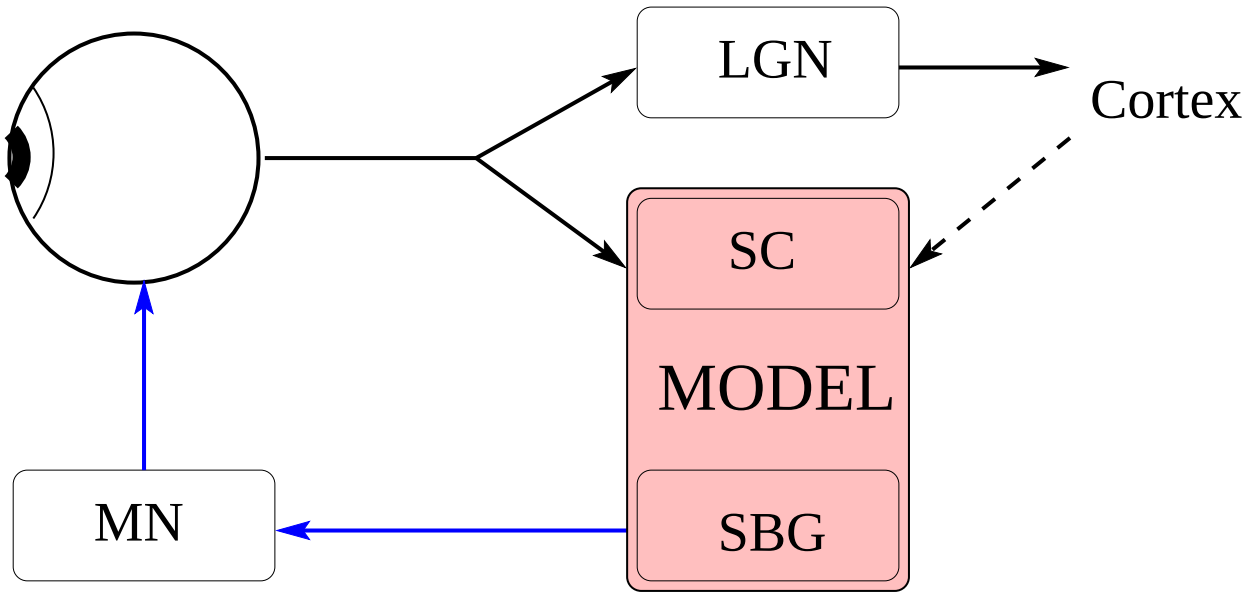
Saccadic eye movements

- Brief and high velocity movements
- Orienting fovea towards target of interest
- Large cortical and subcortical network involved

Focus on Superior Colliculus and Saccadic Burst Genereator

Saccadic eye movements

- **Input :** retina/electrode → Superior Colliculus (SC)
- **Output :** Saccade Burst Generator → MotoNeurons



SBG : Saccade Burst Generator, LGN : Lateral Geniculate Nucleus,

MN : Motoneurons, SC : Superior Colliculus

Claim

Physiological point of view :

- Two SC output pathways
- Feedback loop closes downstream SC

Computationnal point of view :

- Spiking Neurons to study dynamical behavior and neural integration
- DAMNED simulator for distributed implementation

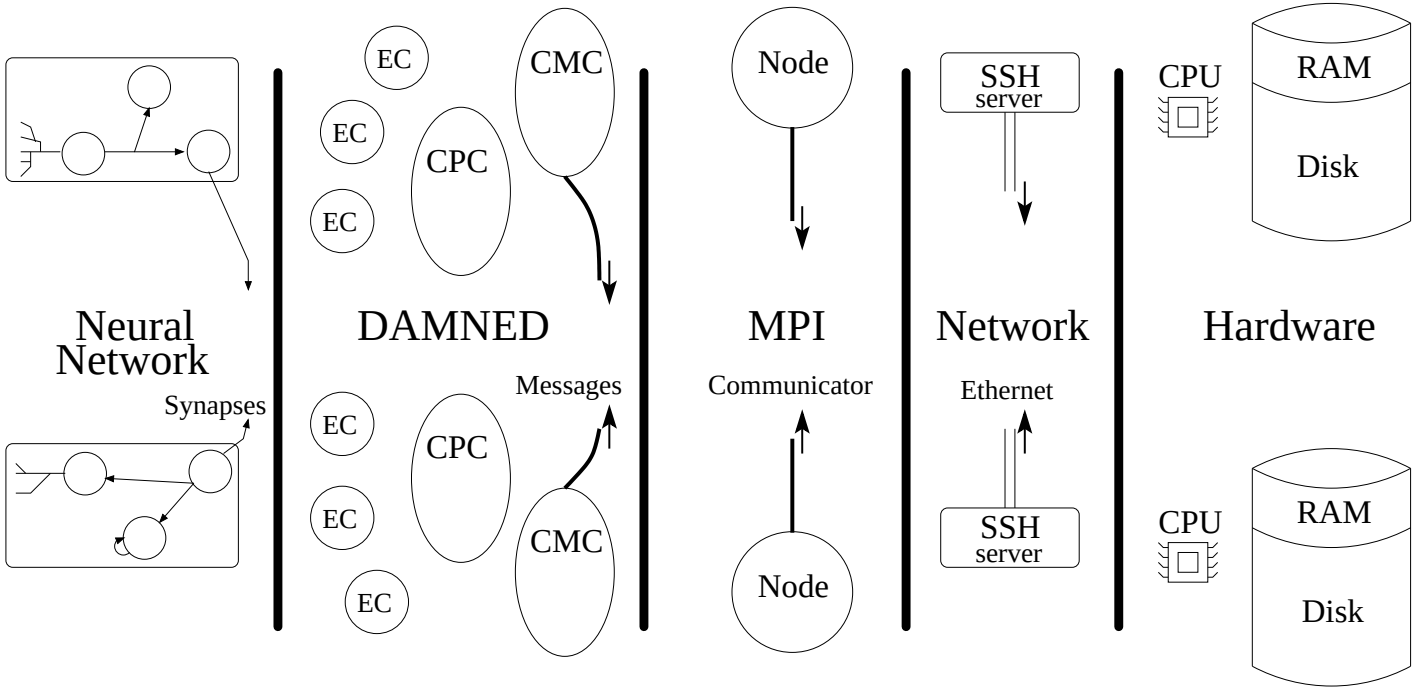
DAMNED simulator

D*istributed* **A***nd* **M***ultithreaded* **N***eural* **E***vent-***D***riven simulator*

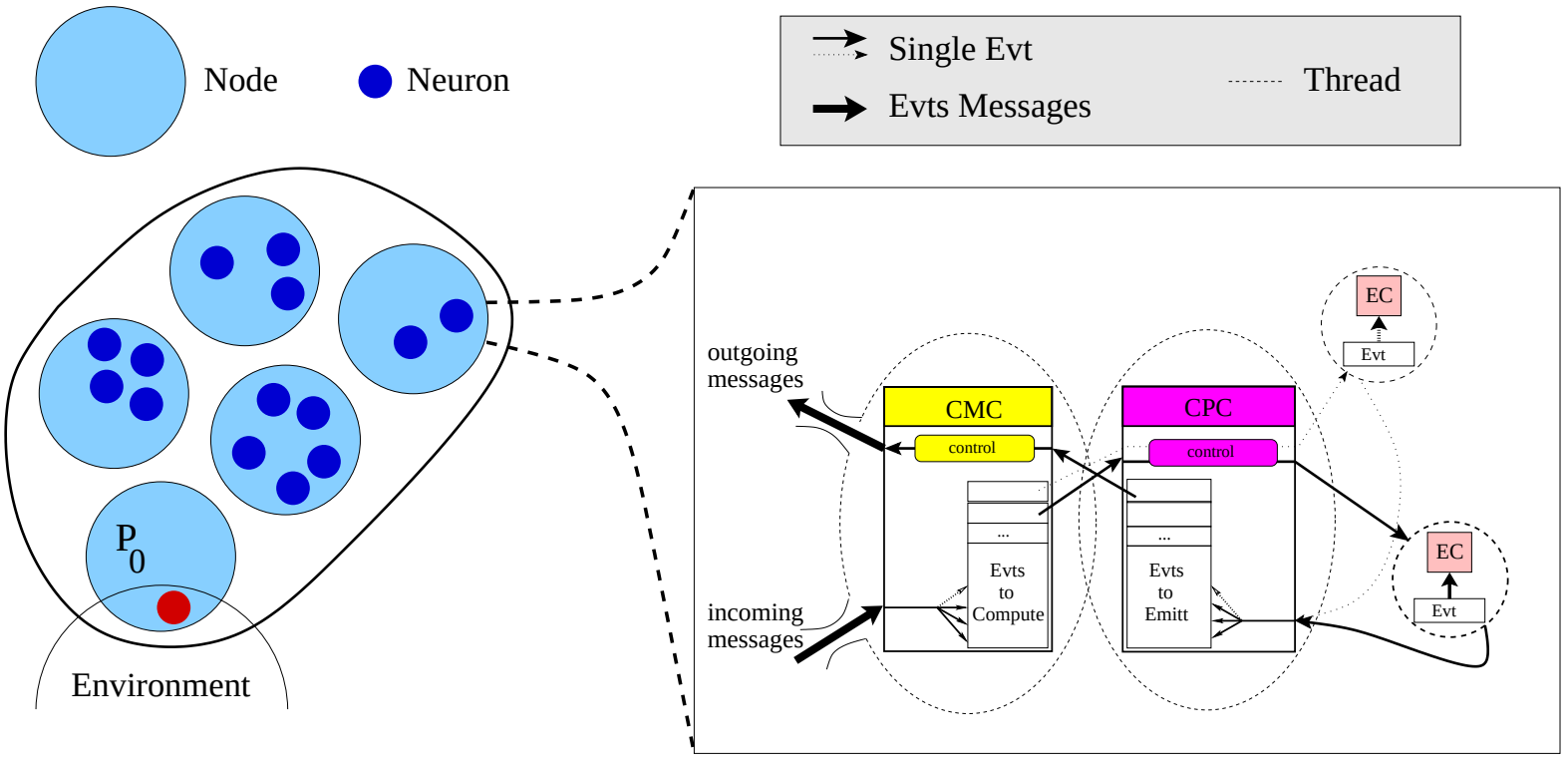
[PDCN'06], [NEUROCOMP'06], [EANN'09]

- **Distributed** : allow large scale simulations
- **Event-driven** : large scale networks with sparse activities
- **Multithreaded** : computations and communications overlap

DAMNED architecture



DAMNED concepts



- Decentralized Global Virtual Time handling
- Mutexes on shared datas structures

Saccade generation characteristics

Spatio temporal transformation :

- Activity location on SC → discharge frequency of Excitatory Burst Neurons (EBN)
- Rostro-caudal and Medio-lateral synaptic density gradient

Feedback loop :

- Duration of EBNs discharge
- Closes downstream SC

Gating :

- Omnipause neurons (OPN) inhibits EBNs
- OPN stop discharge during saccades

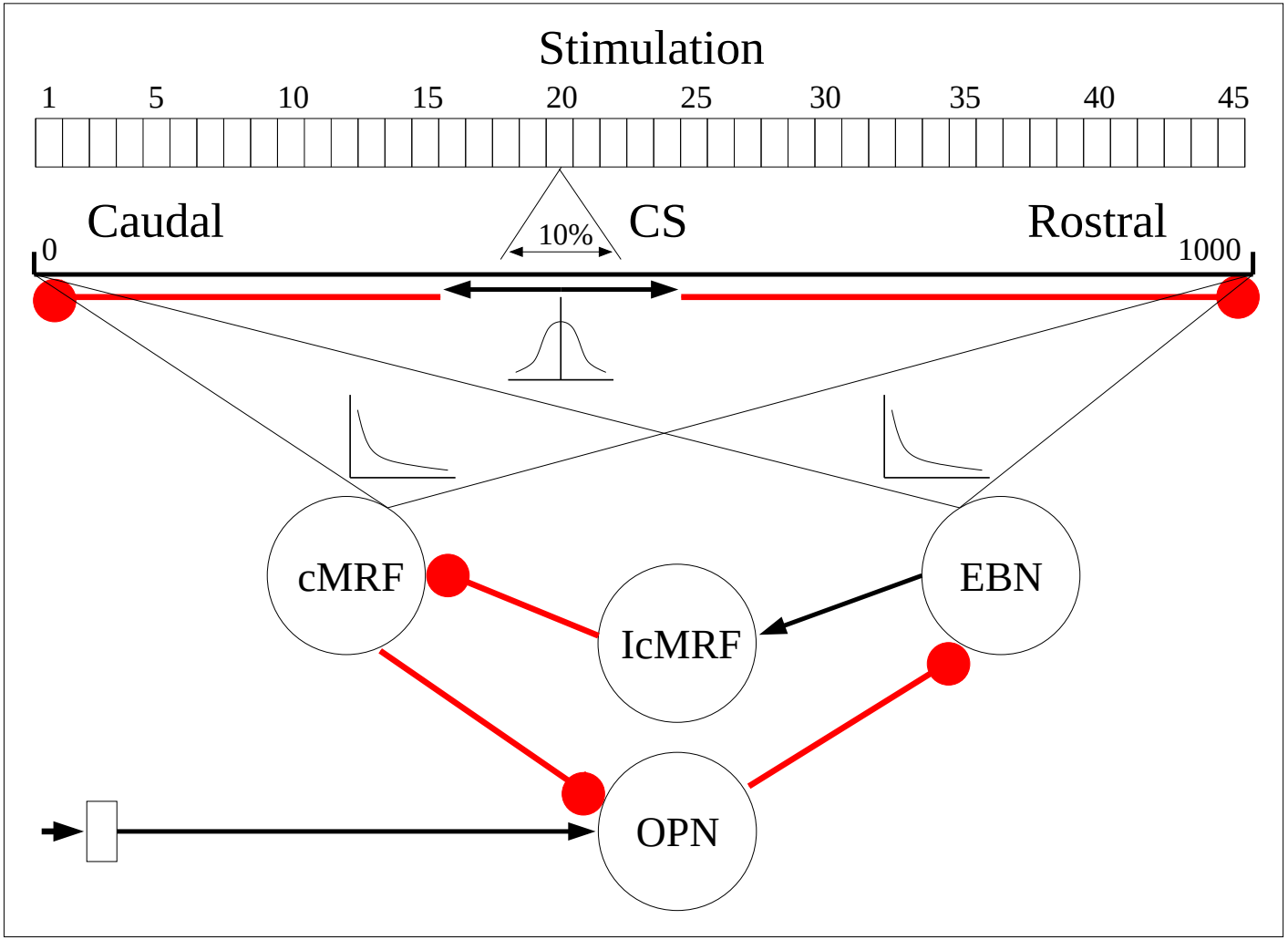
Role of cMRF

Central Mesencephalic Reticular Formation (cMRF) :

- is reciprocally connected with SC
- projects to OPNs
- receives feedback from EBNs

cMRF is a **good candidate** for desired displacement computation in **feedback loop**.

Modular spiking neural network



Implementation with DAMNED

Populations

- Neuron Model
- Size

Projections

- Populations involved
- Projection Model
- Weight

Stimulation protocol

- Input / output populations
- Simulation duration
- Stimulation events

Hardware

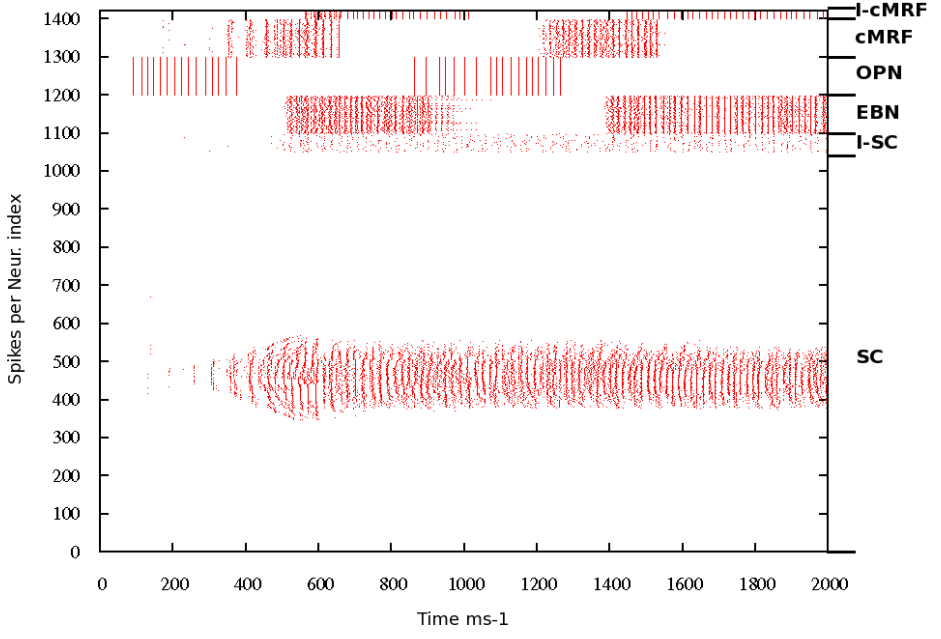
- Number and adresses of hardware hosts
- Number of MPI nodes
- Mapping neural network onto hardware

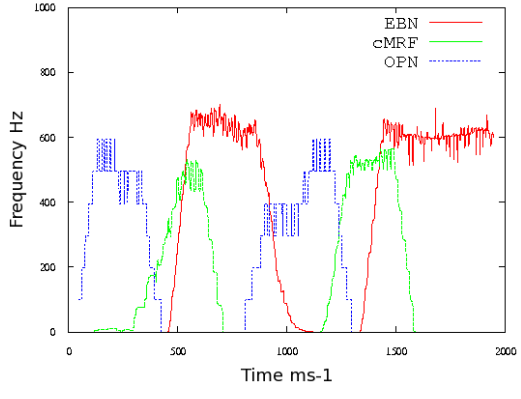
Experimental protocol

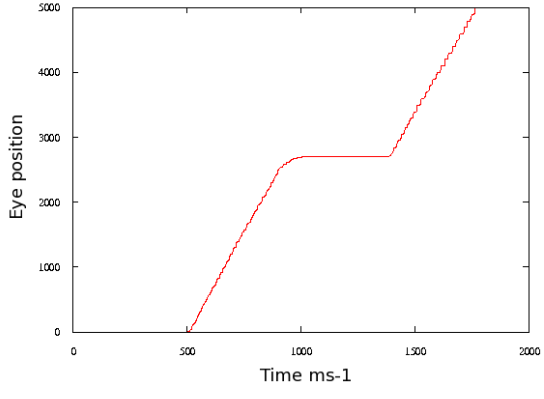
- SC map stimulation
- 150ms duration
- EBN activity

Influence of

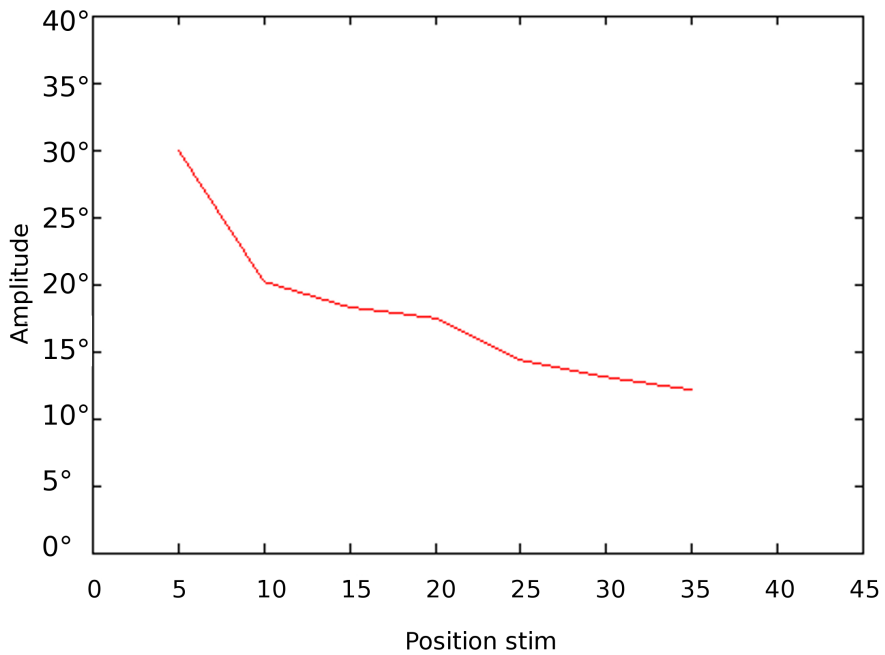
- Position
- Intensity
- Frequency





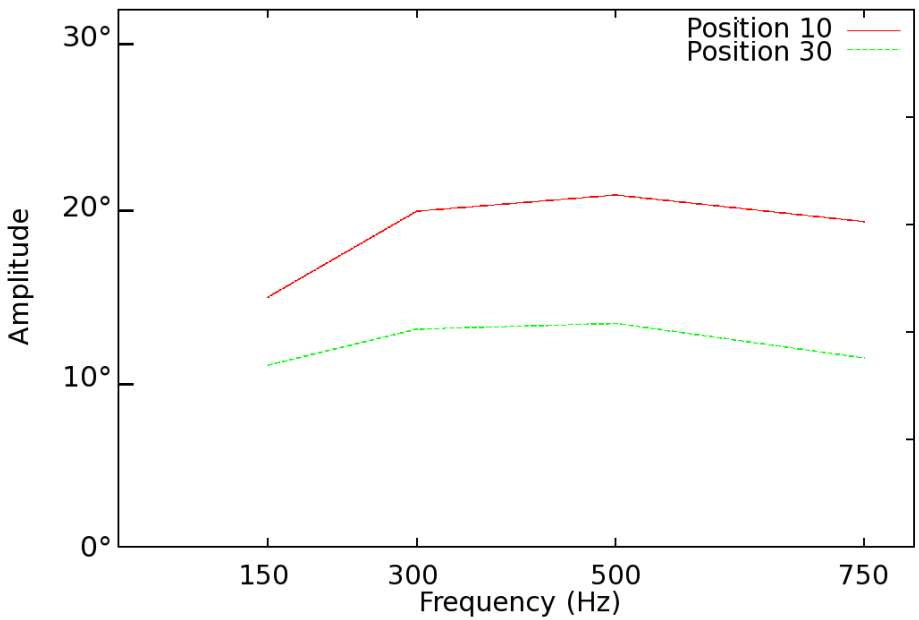


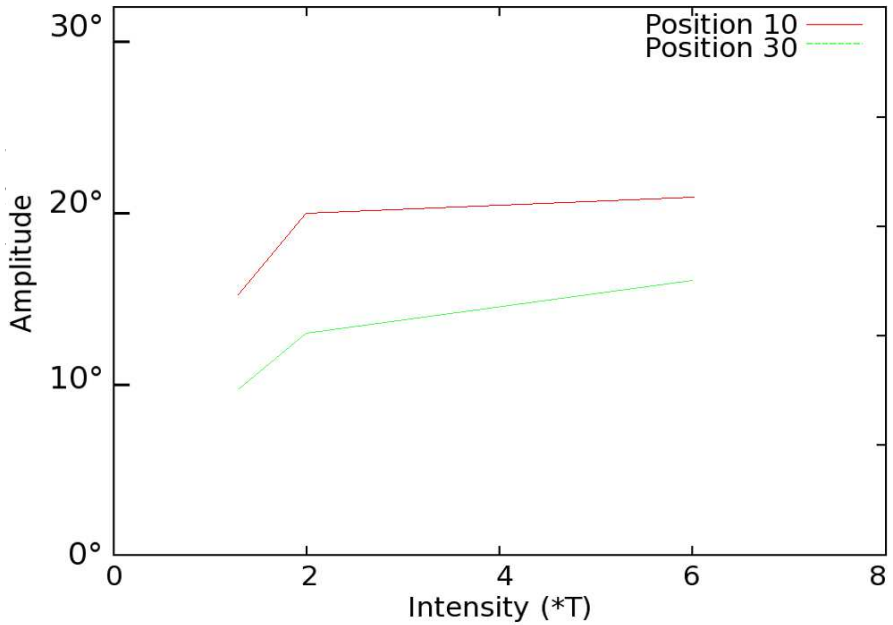
Influence of input position on amplitude



- Saccades ends depending on stimulus position
- Physiologically observed amplitudes reproduced
- Non-linear relationship

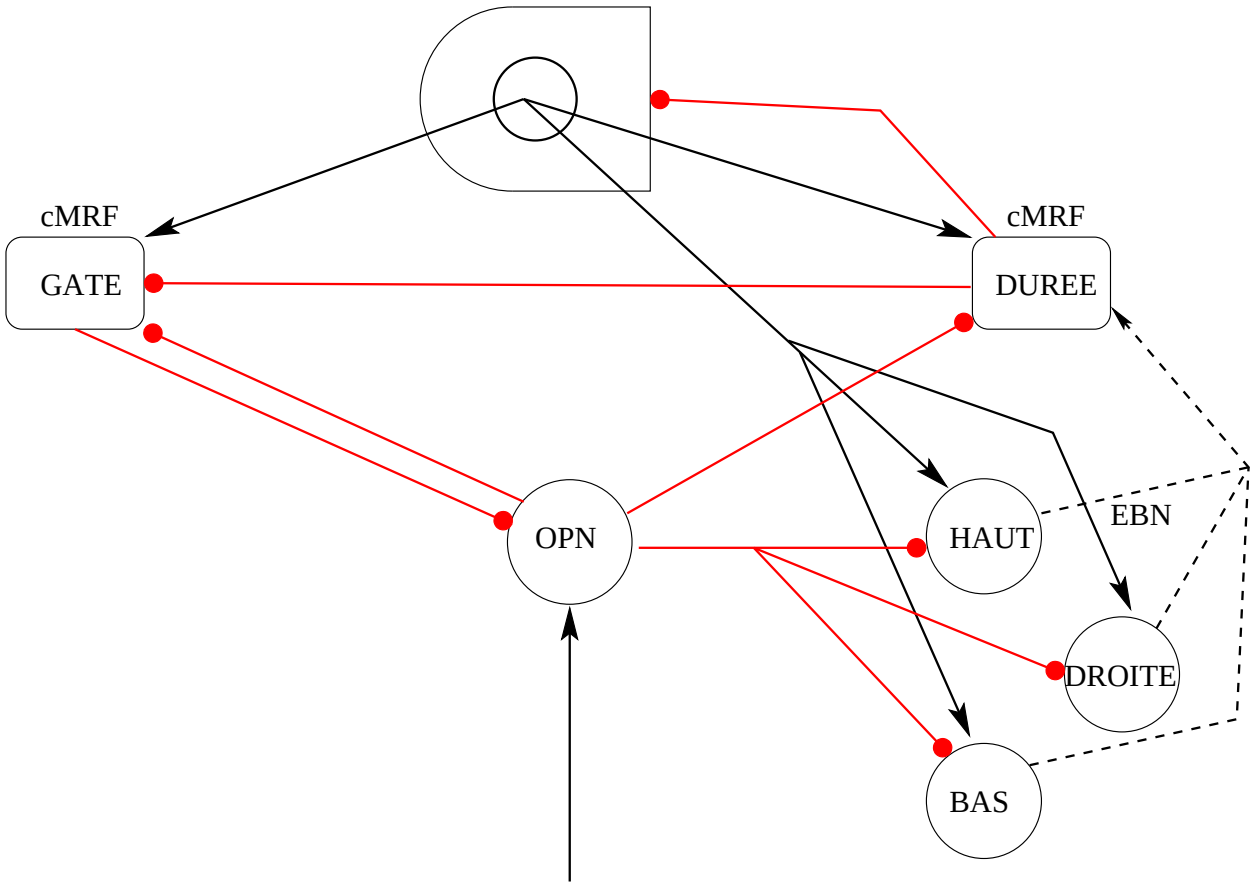
Influence of input intensity and frequency





- Low intensity → decrease in amplitude
- Low frequency → decrease in amplitude
- Increases → no increase in amplitude

Saccade Burst Generator



The end

Thanks for your attention

http ://sourceforge.net/projects/damned

Simulator dependencies

- make
- C++ compiler
- libdl (dynamic library load)
- Posix threads
- MPI (MPICH2)
- ssh

Plots : imagemagick (convert tool)