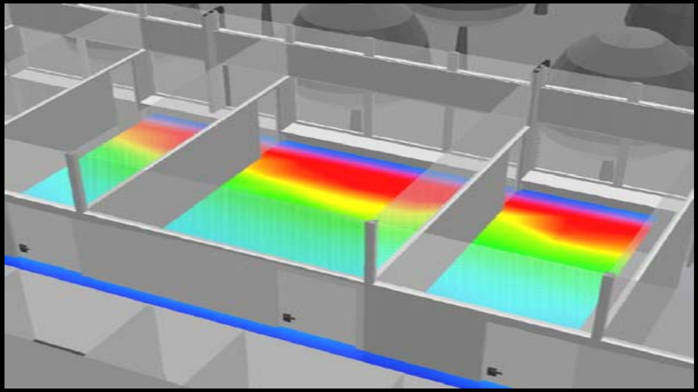
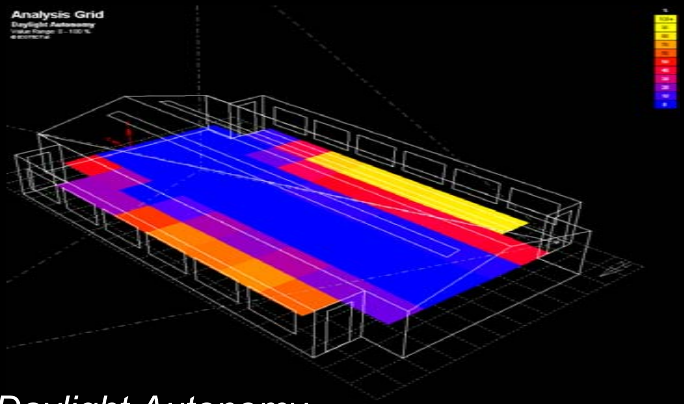
Natural Light in Design

Using simulation tools to explore realistic daylight-responsive solutions

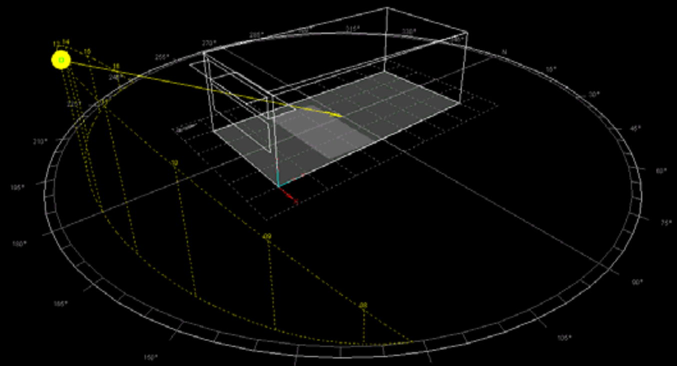


Daylight Factor

Visual Comfort



Daylight Autonomy



Avoidance of Direct Sunlight

Dynamic Daylight Performance Metrics

Christoph Reinhart, Ph.D.

Overview – Dynamic Daylight Performance Metrics

Tuesday, Jan 24th 2006

time slot	Content	instructor
Mon 9.30	Welcome, class introduction, design project (teams formed next morning)	MA, all
Mon 10.00	- General Introduction to daylighting (benefits, history, some case studies)	MA
Mon 10.30	- Introduction to Building Simulation (why simulations for architects, tools used in this course)	CR
Mon 11.00	coffee break	
Mon 11.15	- Photometry (definition, measurement, typical values, DF definition (MA) - Static Daylighting Metrics (context of LEED, selected results from NRC survey, DF & Solar Shading) (CR) - Daylight factor calculations: protractor method, LEED spreadsheet method, sky models CIE and Perez (MA) - Daylight factor simulation: design sky, split flux method in Ecotect (CR) ▪ Hands-on exercise: DF calculation in Ecotect (split flux) (CR) ▪ Hands-on exercise: solar shading module in Ecotect (CR) - Intro to Radiance (CR) ▪ Hands-on exercise: Radiance visualizations (CR) ▪ Hands-on exercise: DF calculation in Ecotect (Radiance) (CR)	MA, CR, all
Mon 13.00	lunch (on your own)	
Mon 14.00	- Climate Data (kind of data and measurement, weather files, E+ weather data directory) (MA) ▪ Hands-on exercise: weather tool in Ecotect (CR) - Overview on visual comfort (glare, contrast, requirements, health) (MA) - Dynamic Metrics & related tools (CR)	MA, CR, all
Mon 15.45	coffee break	
Mon 16.00	▪ Hands-on exercise: Daysim exercise from tutorial interrupted by discussions on: - Short time steps dynamics - Daylight Coefficients - User Behavior Model - Daylight Autonomy Results	all
Mon 17.00	▪ Hands-on exercise: students to repeat at DF, Solar Shading &DA analysis on their own	all
Mon 17.30	end of first day	

Daylight Factor Use in Design

- Argument:
  - overcast sky as a worst case scenario
  - venetian blinds (even if closed) still admit sufficient DL

- view to the outside

Could it be better?

What about:

- ❑ local climate data (Vancouver vs. Regina)
- ❑ building use (occupancy patterns, lighting requirements)
- ❑ movable shading devices (venetian blinds)

Dynamic Daylight Simulations (DDS)

- As opposed to static DL simulations that only consider one sky condition at a time, dynamic daylight simulations generate annual time series of interior illuminances and/or luminances.

Daylight Performance Metrics

- DDS result in thousands of data points for each sensor.
- The task at hand is to reduce the data without diminishing its value for building design.
- Points for discussion:
  - time base (daylit hours vs. occupied hours)
  - lighting requirements (UDI, daylight autonomy, annual light exposure,…)
  - movable shading devices

Time Base

- ❑ Daylit Hours of the year:
  - + building form directly related to building site

- ❑ Occupied hours of the year:
  - + daylight needs “witnesses”
  - + sensitive to building use
  - + self scaling: spans the whole range from 0% to 100%
  - + occupancy profiles for different building zones available from ASHARE etc.

Current trend towards occupied hours of the year.

Lighting Requirements I

- <u>Daylight Autonomy</u> (DA): percentage of working hours when a minimum work plane illuminance is maintained by daylight alone

- <u>Useful Daylight Illuminances</u> (UDI): divides working hours into three bins:
  % < 100lux (insufficient daylight)
  % between 100lx and 2000x (useful daylight)
  % > 2000 lux (too much DL => visual/thermal discomfort)

- <u>CHPS criteria</u>:
  continuous DA >40% 1 credit
  continuous DA >60% 2 credits
  continuous DA >80% 3 credits
  } for 60% of work plane and DA_{max}<1%

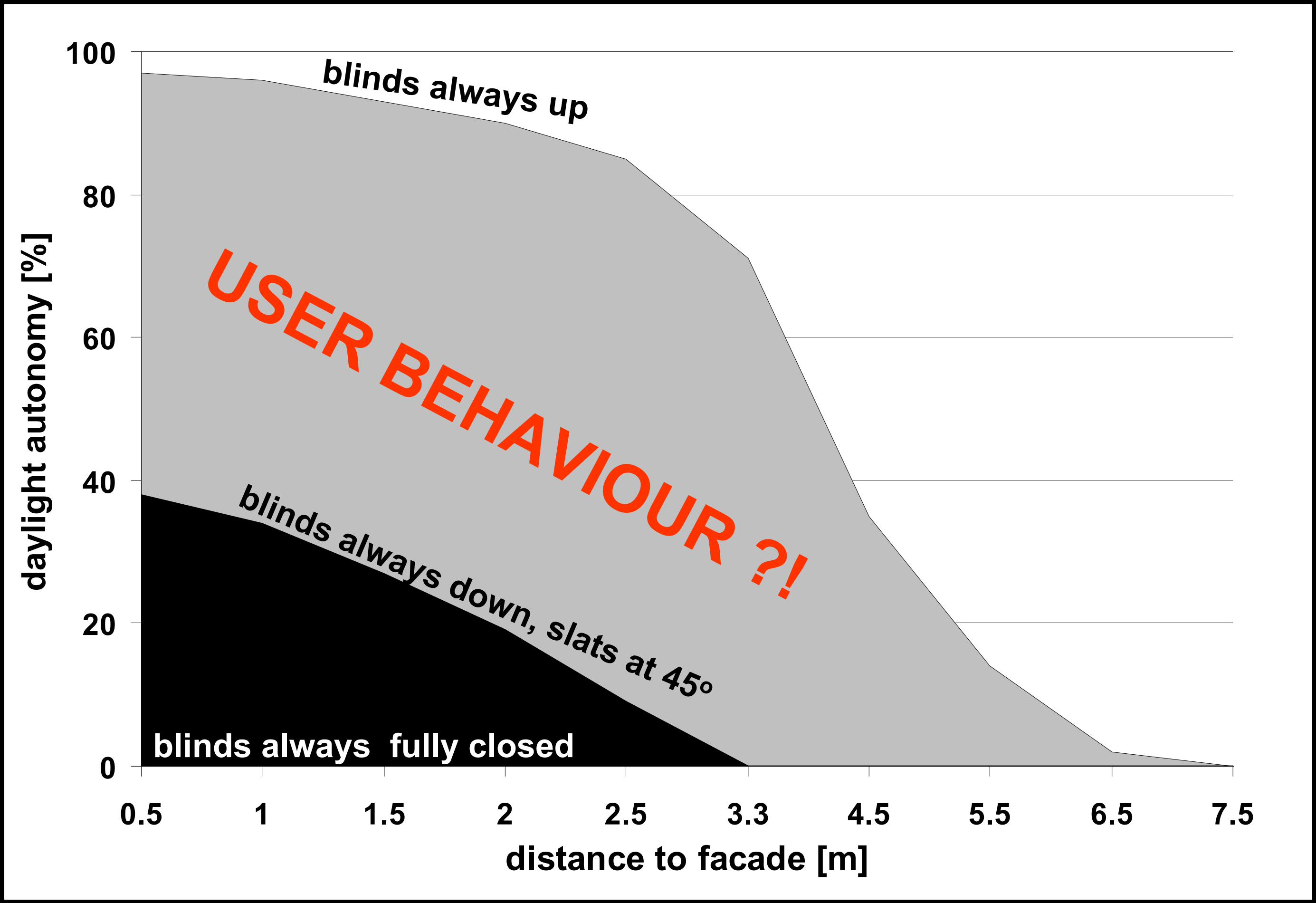
Lighting Requirements II

- <u>Annual Light Exposure</u>: established upper threshold for artwork – already established used used for museums (CIE TC3-22 ‘Museum lighting and protection against radiation damage’)

Lighting Requirements III

- **<u>Light and Health</u>: possible future lighting recommendations for building occupants (light intensity and spectrum)**

Movable Shading Devices

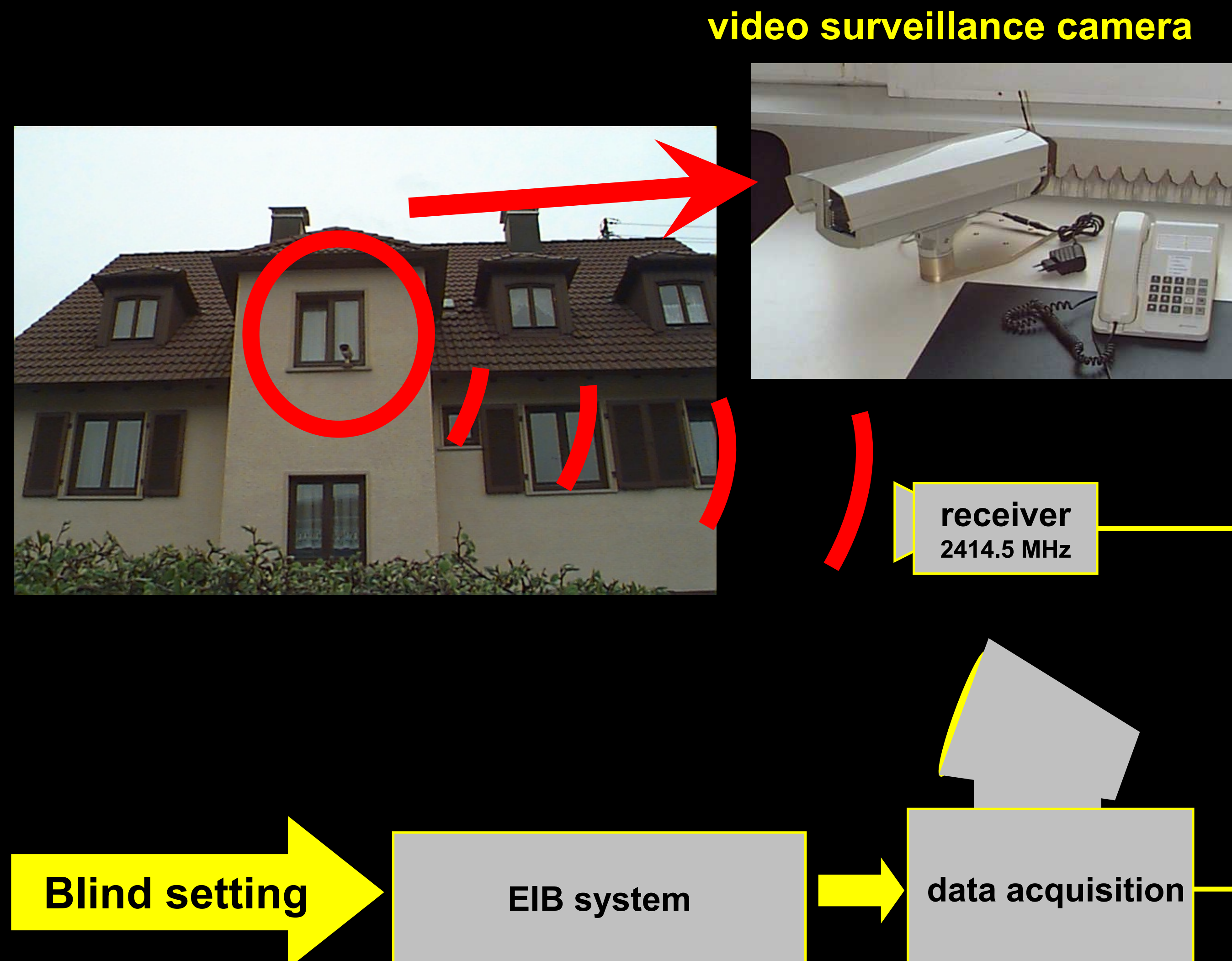


- venetian blinds should be treated as the reference case
- venetian blinds are arguable more suitable than light shelves in predominantly cloudy climates

Monitoring User Behavior

Lighting Research & Technology
Reinhart, Voss 2003

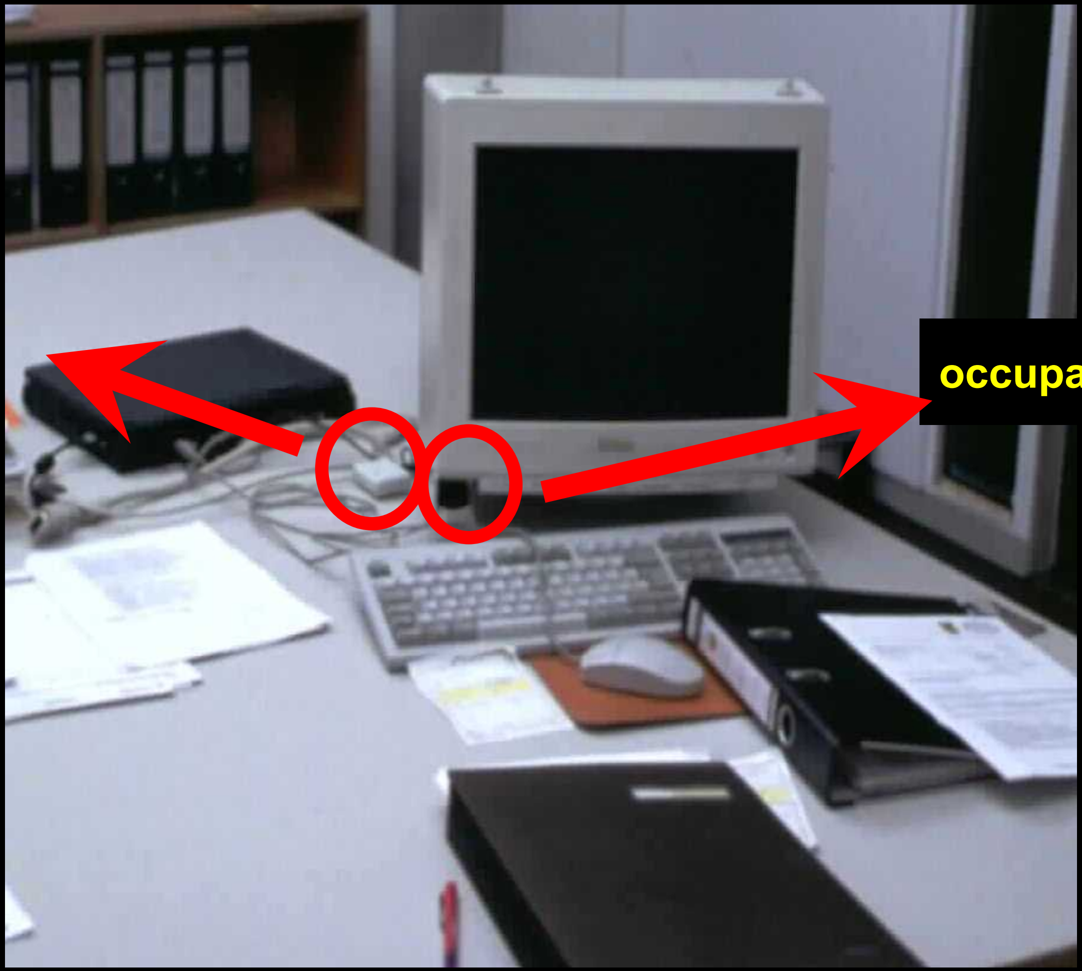
Monitoring Blind Usage



Example Picture

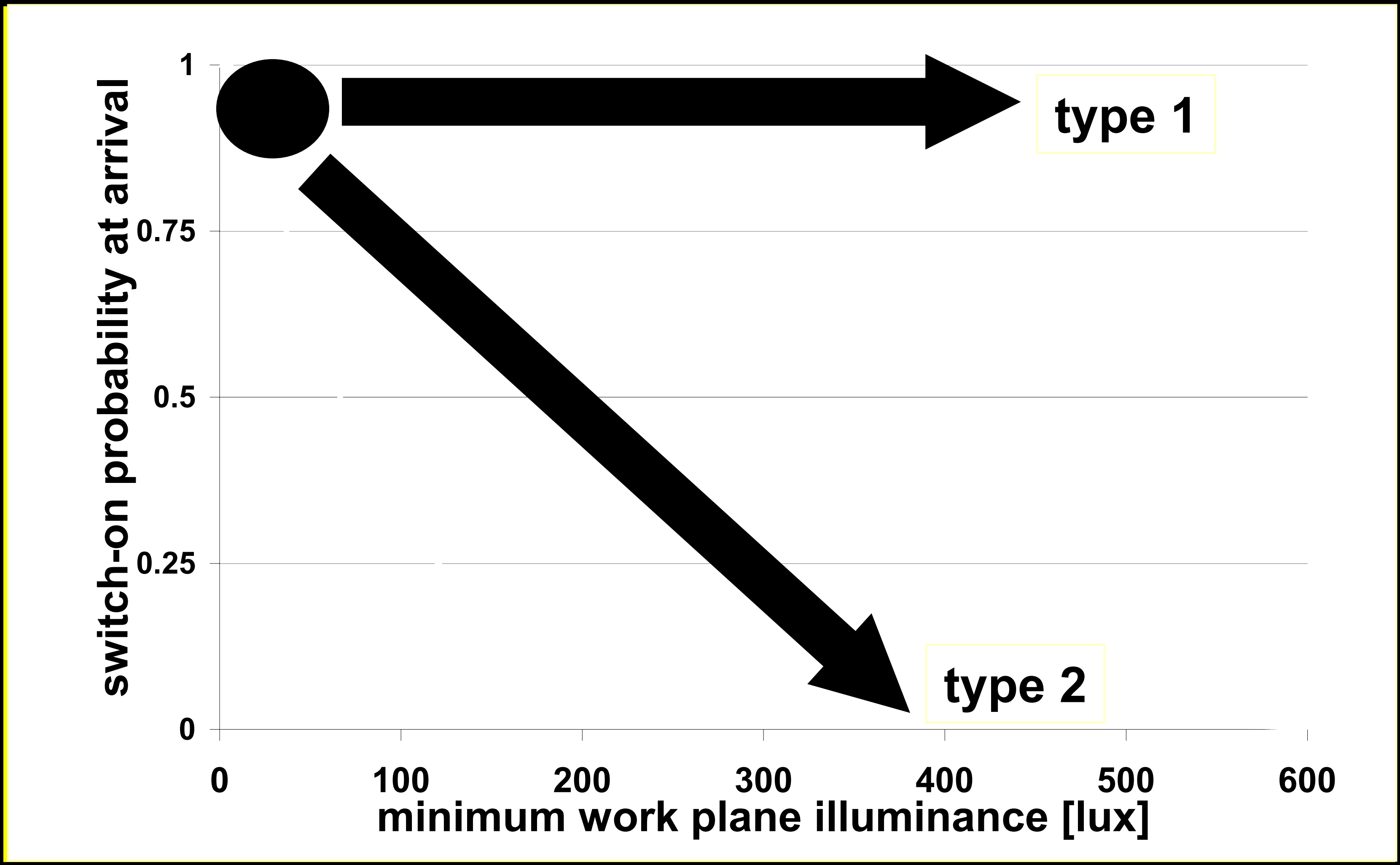
Monitoring Setup in the Offices

Illuminance
Temperature



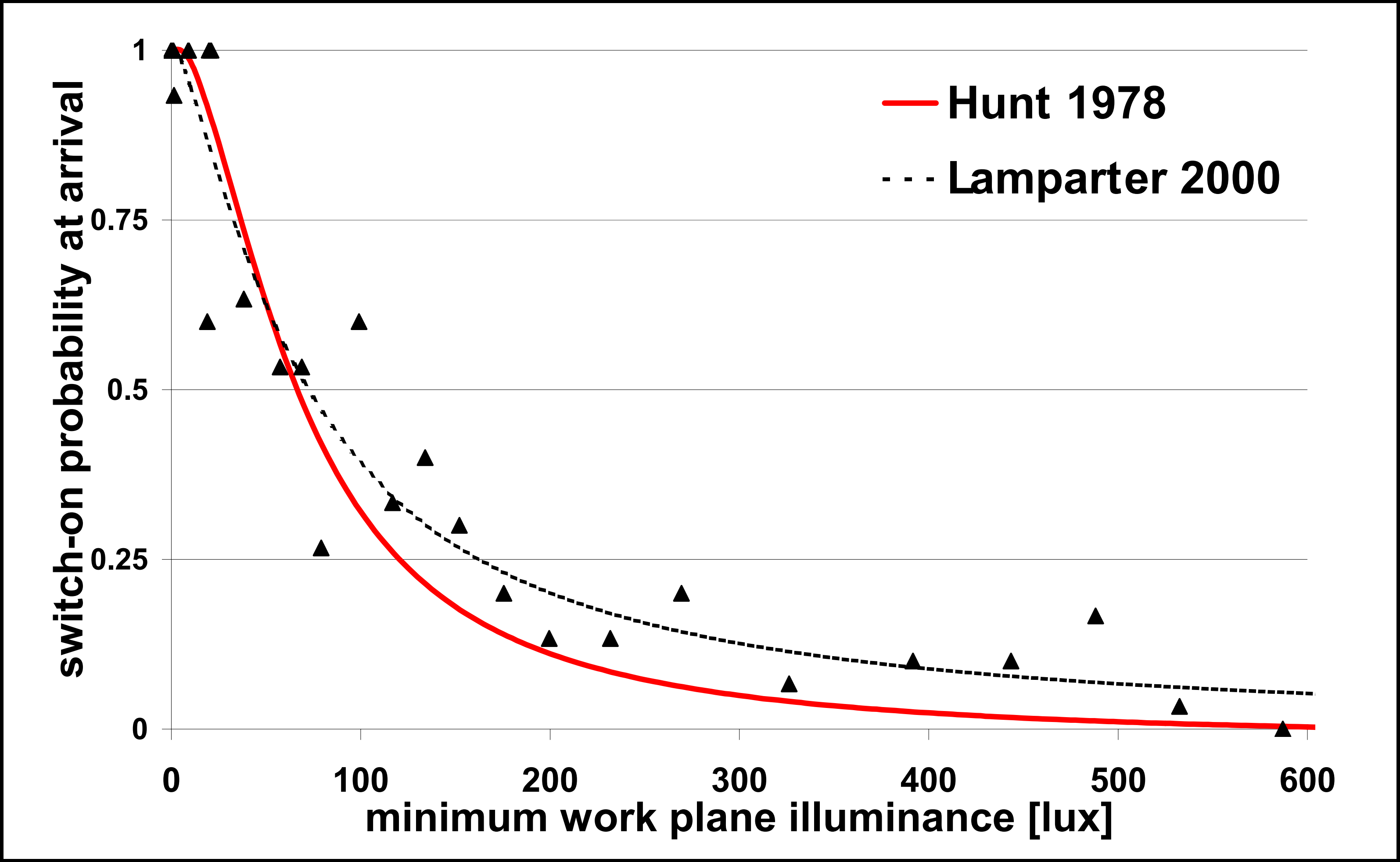
HOBO data logger

Switch-On Probability (I)



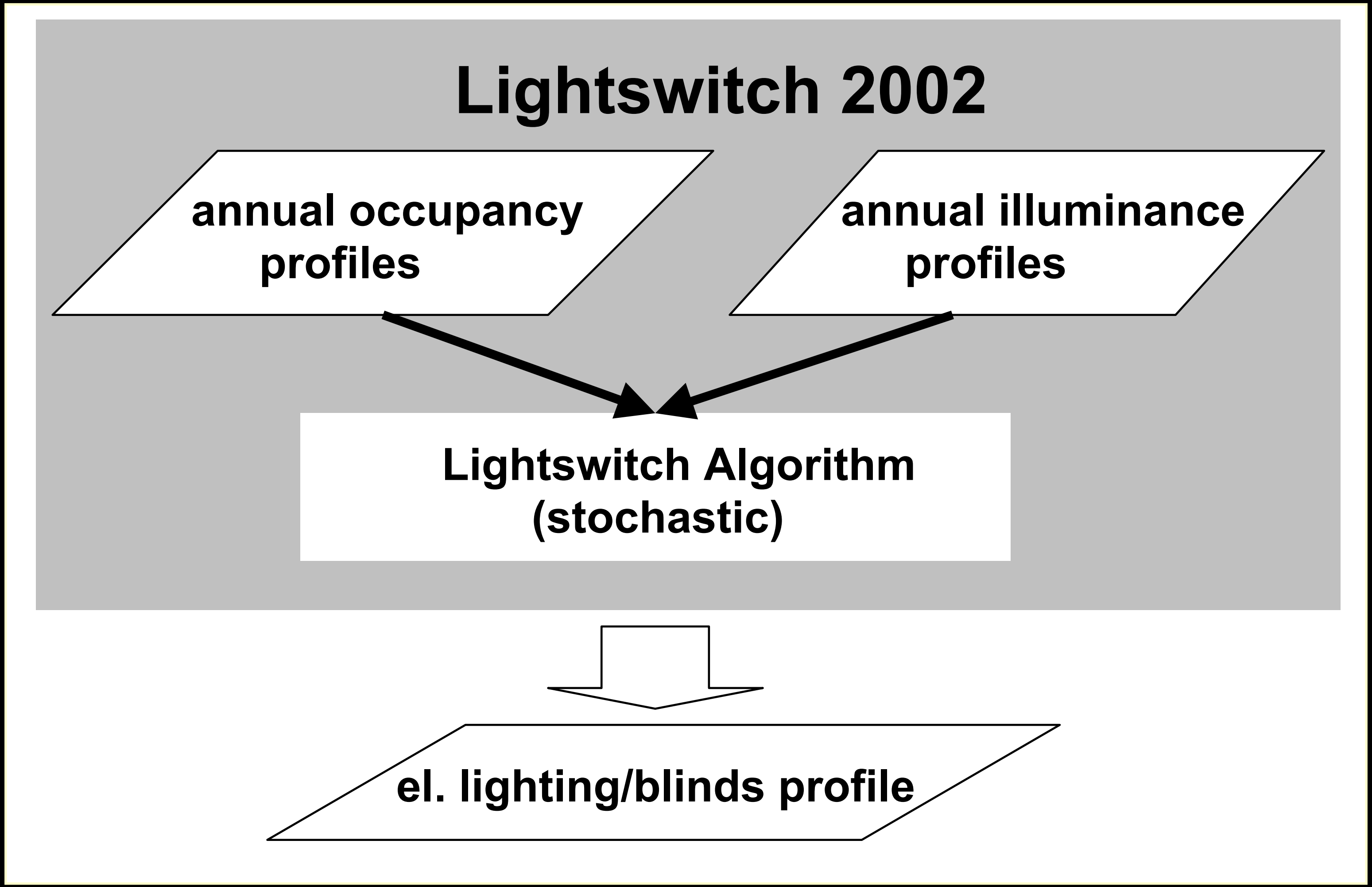
Jim Love, University of Calgary

Switch-On Probability (II)



User Behavior Model

Solar Energy
Reinhart, 2004



DDS Programs

- ❑ ADELINE (http://www.ibp.fhg.de/wt/adeline/)
- ❑ Daysim (www.daysim.com)
- ❑ ESP-r (http://www.esru.strath.ac.uk/Programs/ESP-r.htm)
- ❑ Lightswitch Wizard (www.buildwiz.com)
- ❑ SPOT (http://www.archenergy.com/SPOT/)