Quality Assurance in Lighting Simulation

Using CIE report TC3.33 as a basis for a ‘consumer guide’ to lighting simulation tools

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With thanks to…

- Fawaz Maamari and my colleagues in IEA SHC Task 31 '*Daylight for 21st Century*'
- Research assistants:
  - Kat Bowron
  - Jake Lai
  - Marton Mazzag
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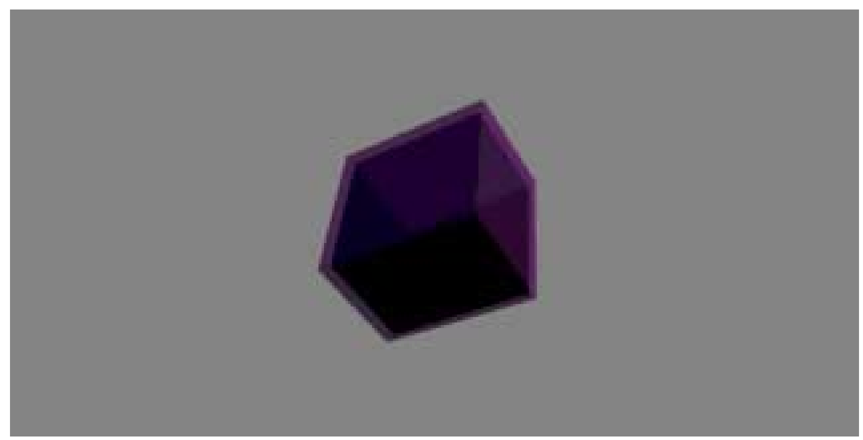
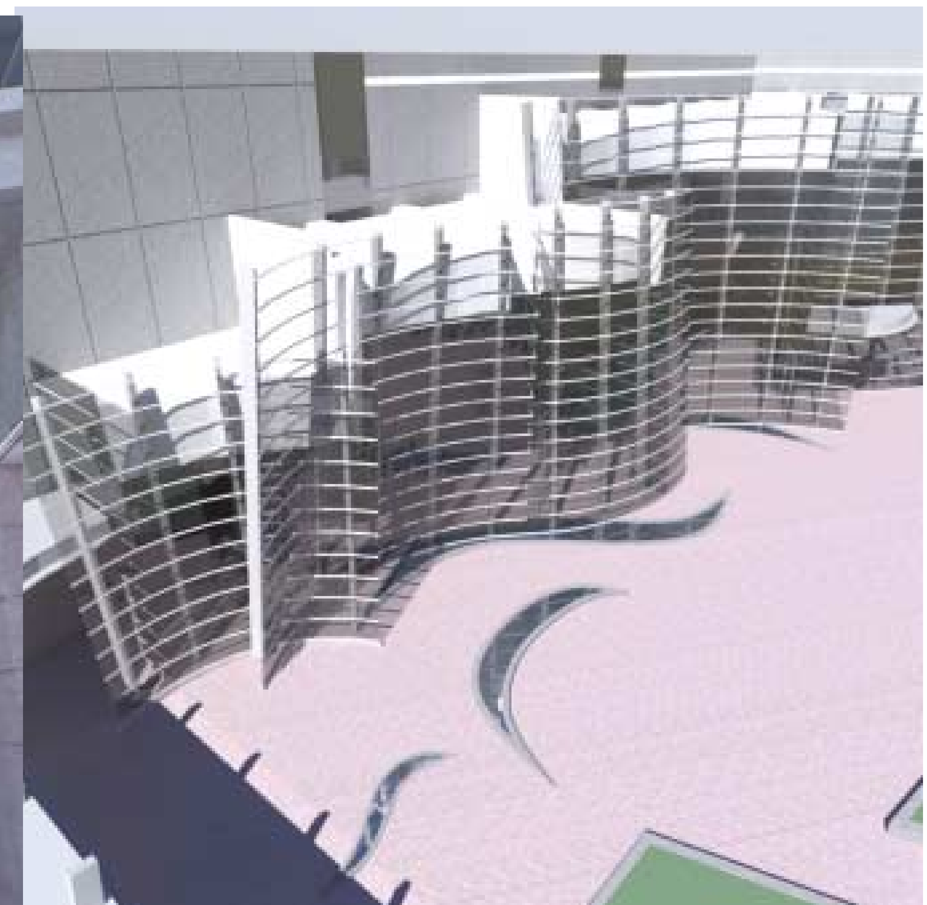


Buchan Group

- Christchurch City Art Gallery



Stuart Ashdown



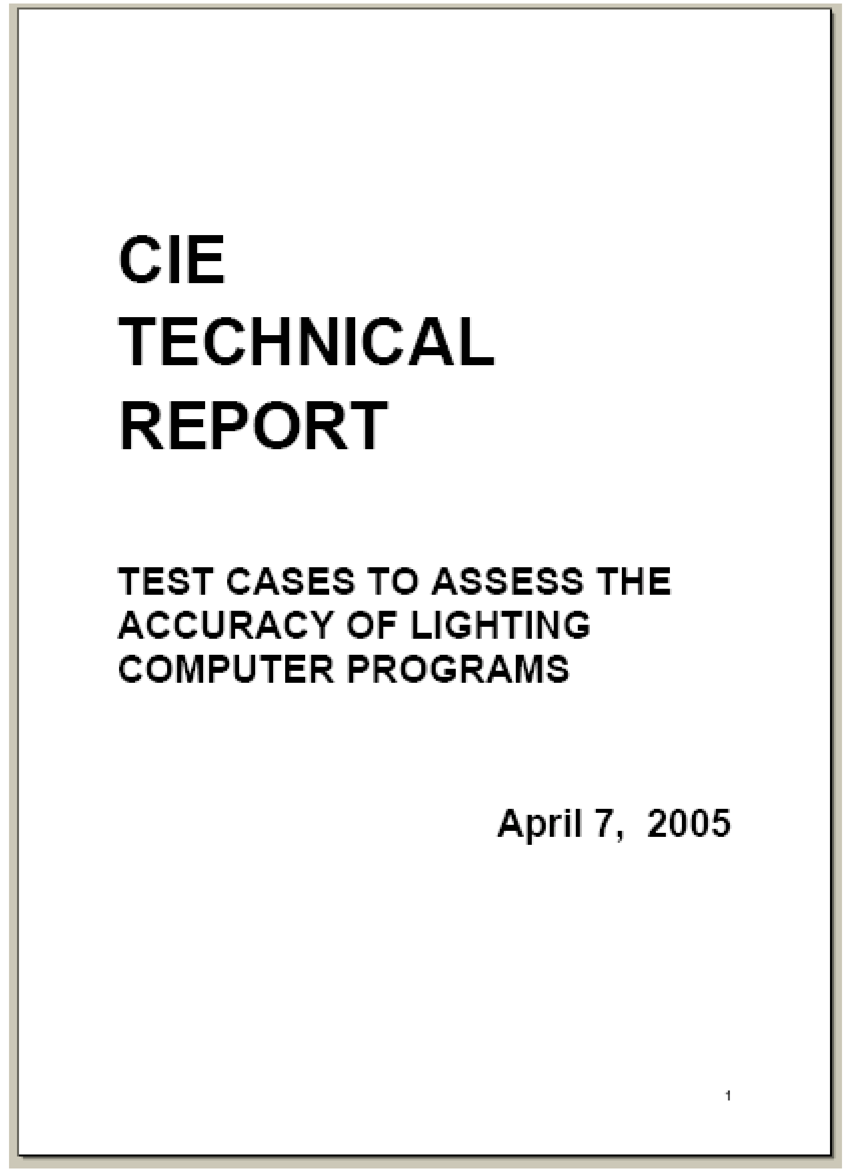
Test components of light simulation

- light source description (luminaire or daylight) and direct lighting calculations;
- light transfer through openings and window components or around obstructions; and
- inter-reflections between different types of materials with different photometric properties.

CIE TC 3.33

To: “help lighting program users and developers assess the accuracy of lighting computer programs and to identify their weaknesses”.

- *a suite of test cases each highlighting a given aspect of the lighting simulation domain*
- *reference data based on analytical calculation and experimental measurements.*
  - *Analytical: theoretical scenarios that avoid uncertainties in the reference values.*
  - *Experimental: the scenario and the protocol are defined in a manner that minimizes the uncertainties associated with the measurements.*
- *A set of recommendations for reliable experimental data for validation purposes addressing.*
  - *choice and description of the scenarios*
  - *experimental protocol precautions*
  - *estimation of the error sources*
  - *presentation of the reference data.*



CIE TECHNICAL REPORT

TEST CASES TO ASSESS THE ACCURACY OF LIGHTING COMPUTER PROGRAMS

April 7, 2005

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Analytical test cases

- Sky Component under a roof glazed opening
- Sky component and external reflected component for a facade unglazed opening
- SC+ERC for a facade glazed opening
- SC+ERC for a facade unglazed opening with a continuous external horizontal mask
- SC+ERC for a facade unglazed opening with a continuous external vertical mask
- Simulation of point light sources
- Simulation of area light sources
- Luminous flux conservation
- Direct transmittance of clear glass
- light reflection over diffuse surfaces
- Diffuse reflection with internal obstructions
- Internal reflected component calculation of diffuse surface
- Component for a roof unglazed opening and the CIE general Sky types

Empirical data - CIBSE TM28 – 1C

- Room
  - ceiling white acoustic tiles of reflectance 0.70+/-0.01
  - floor dark brown (R=0.06+/-0.01)
  - walls matt gray (R=0.52+/-0.02)
- Luminaires
  - semi-specular reflector luminaires (category 2, 600 x 600 mm square luminaires Cat. No. U1701/318 P1 with three Philips New Generation TL-18W, color 840 lamps and Phi HF-Performer, warm-start 3x18W high frequency ballast).
- The total lumen output from each luminaire:
  - Luminaire 1: 4087.7 lm
  - Luminaire 2: 4174.7 lm
  - Luminaire 3: 4135.0 lm
  - Luminaire 4: 4114.3 lm

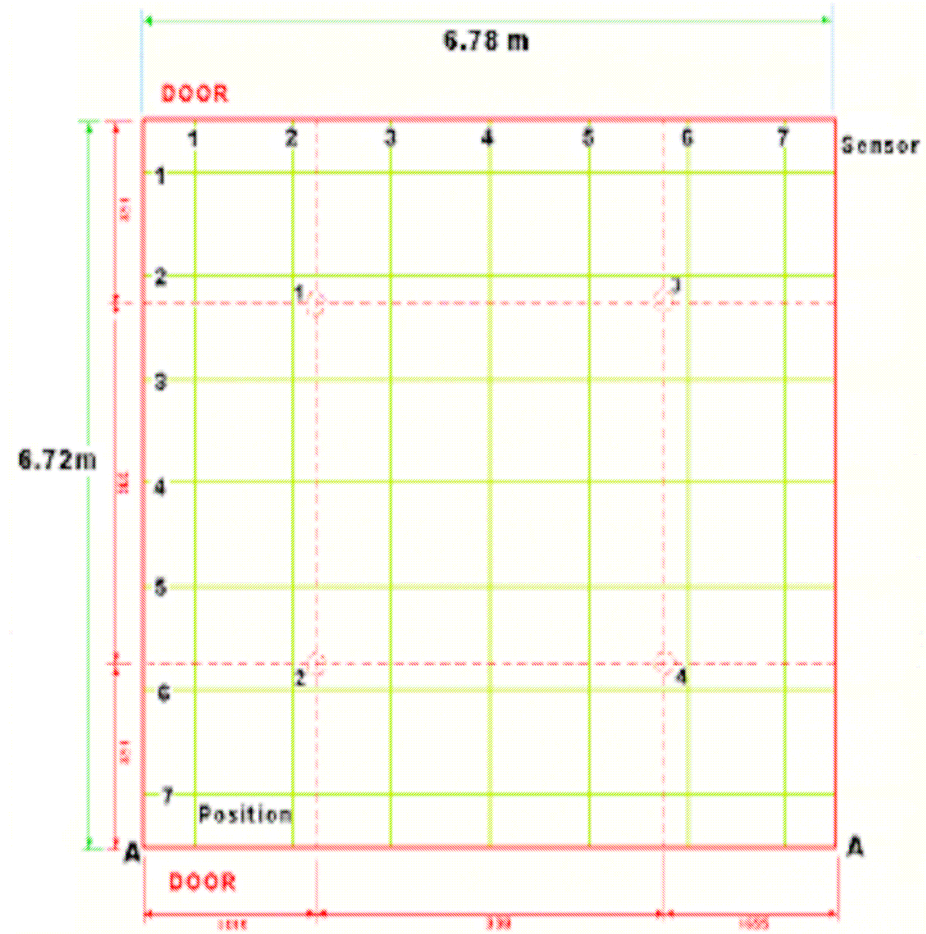
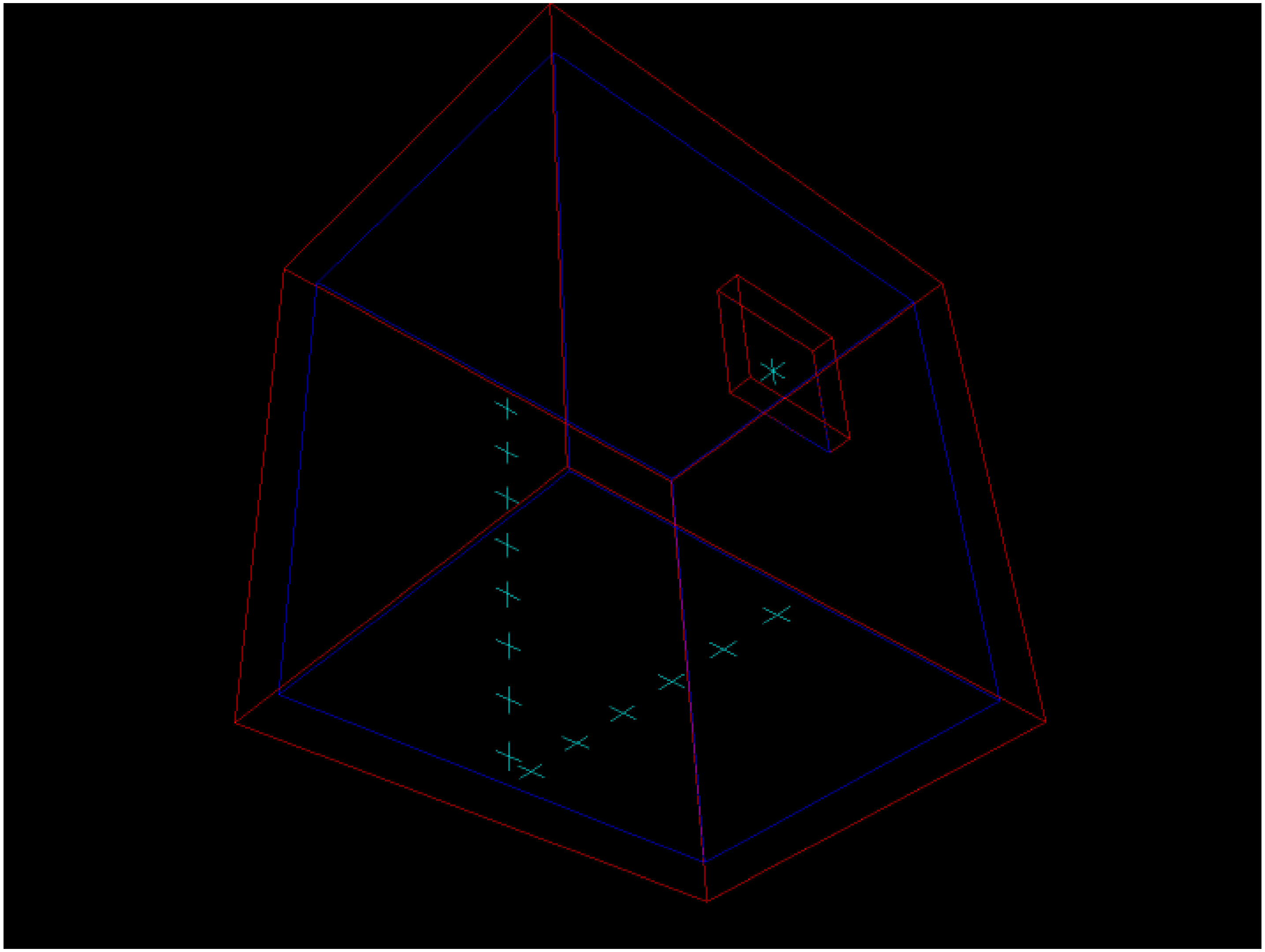


Figure 1: Plan of test room with lamp/luminaire and measurement positio

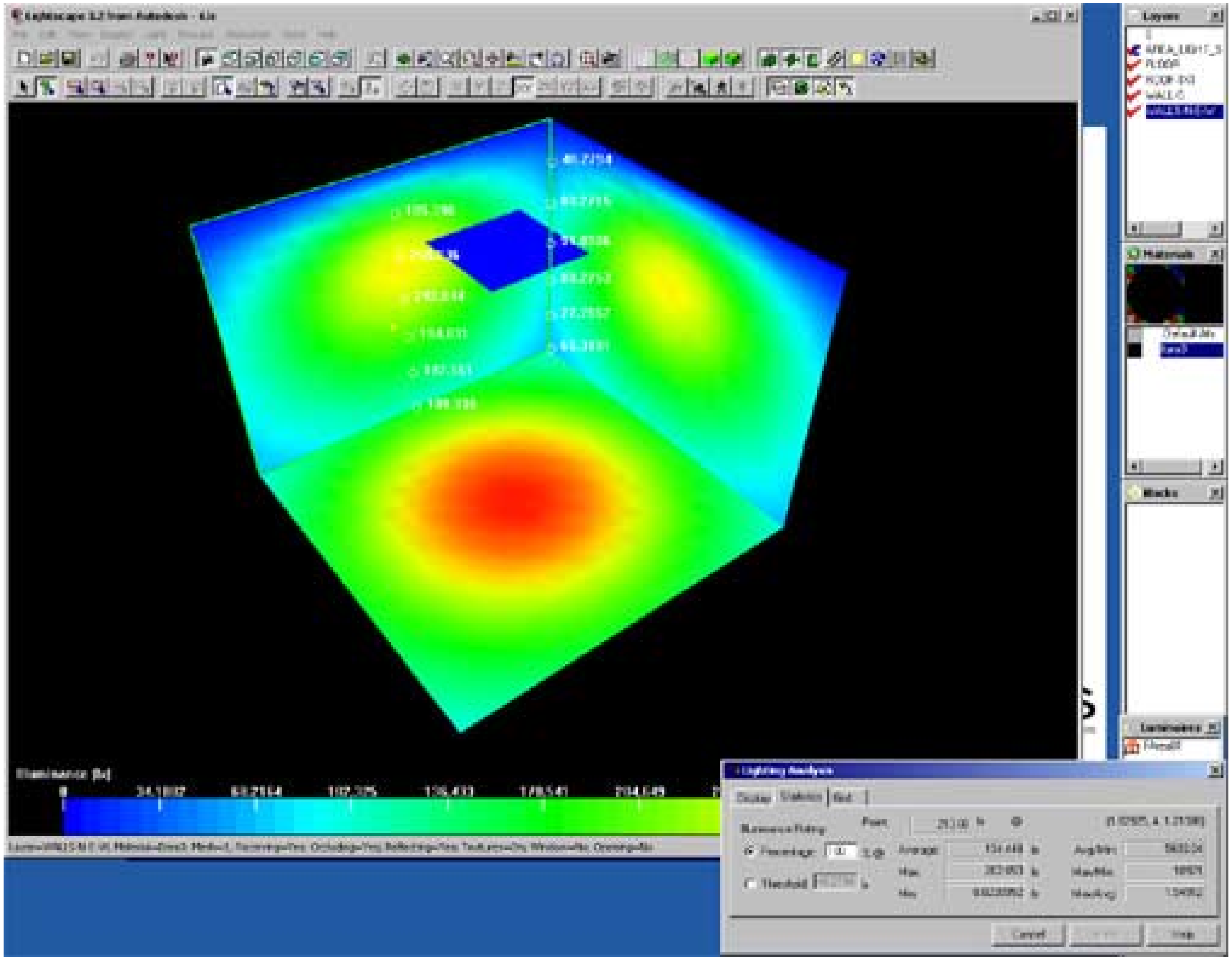
Empirical test cases

- *Artificial lighting scenario – CFL, grey wall*
- *Artificial lighting scenario – opal luminaire, grey wall*
- *Artificial lighting scenario – semi-specular reflector luminaire, grey wall*
- *Artificial lighting scenario – CFL, black wall*
- *Artificial lighting scenario – opal luminaire, black wall*
- *Artificial lighting scenario – semi-specular reflector luminaire, black wall*

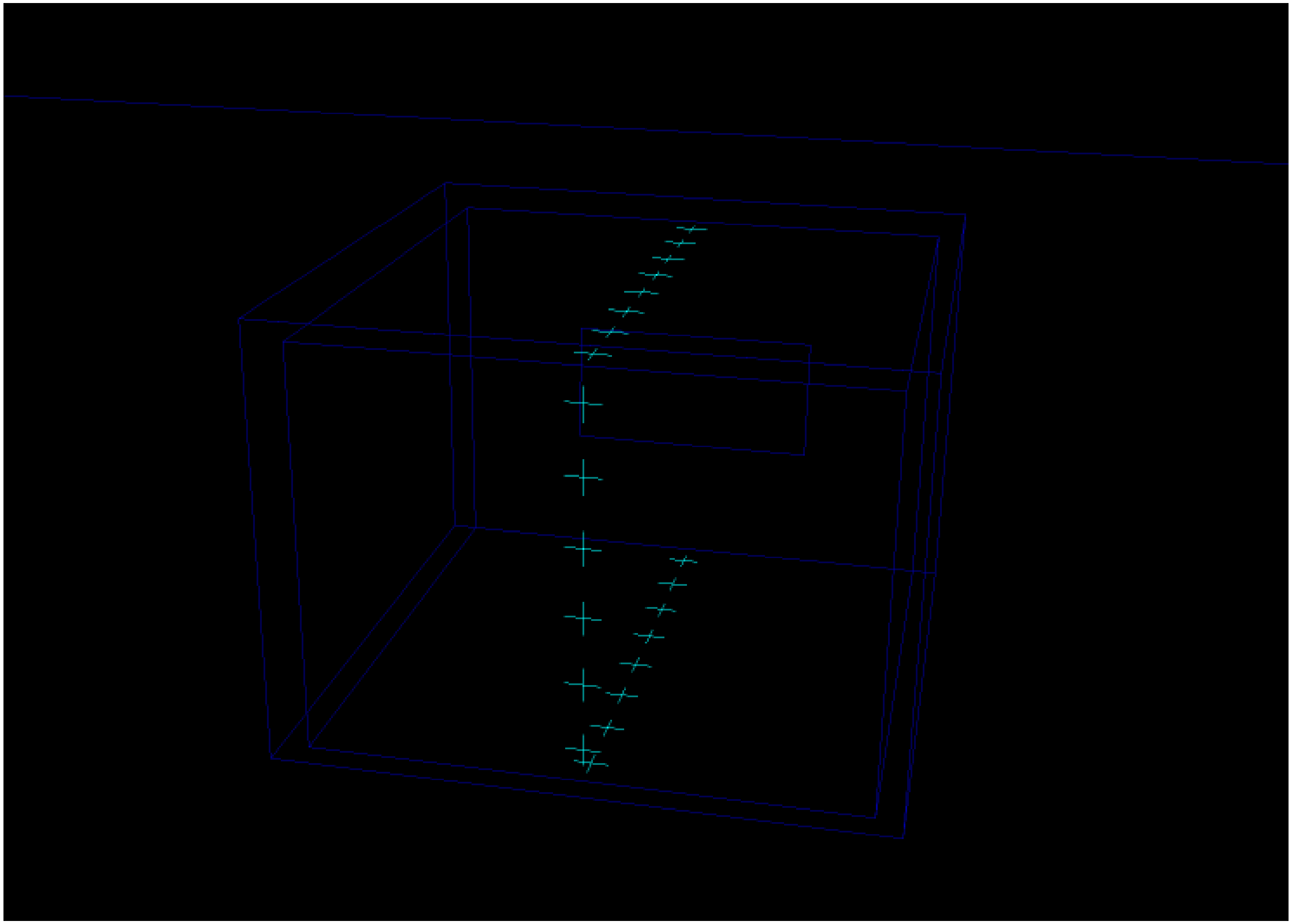
Test cells – area light source



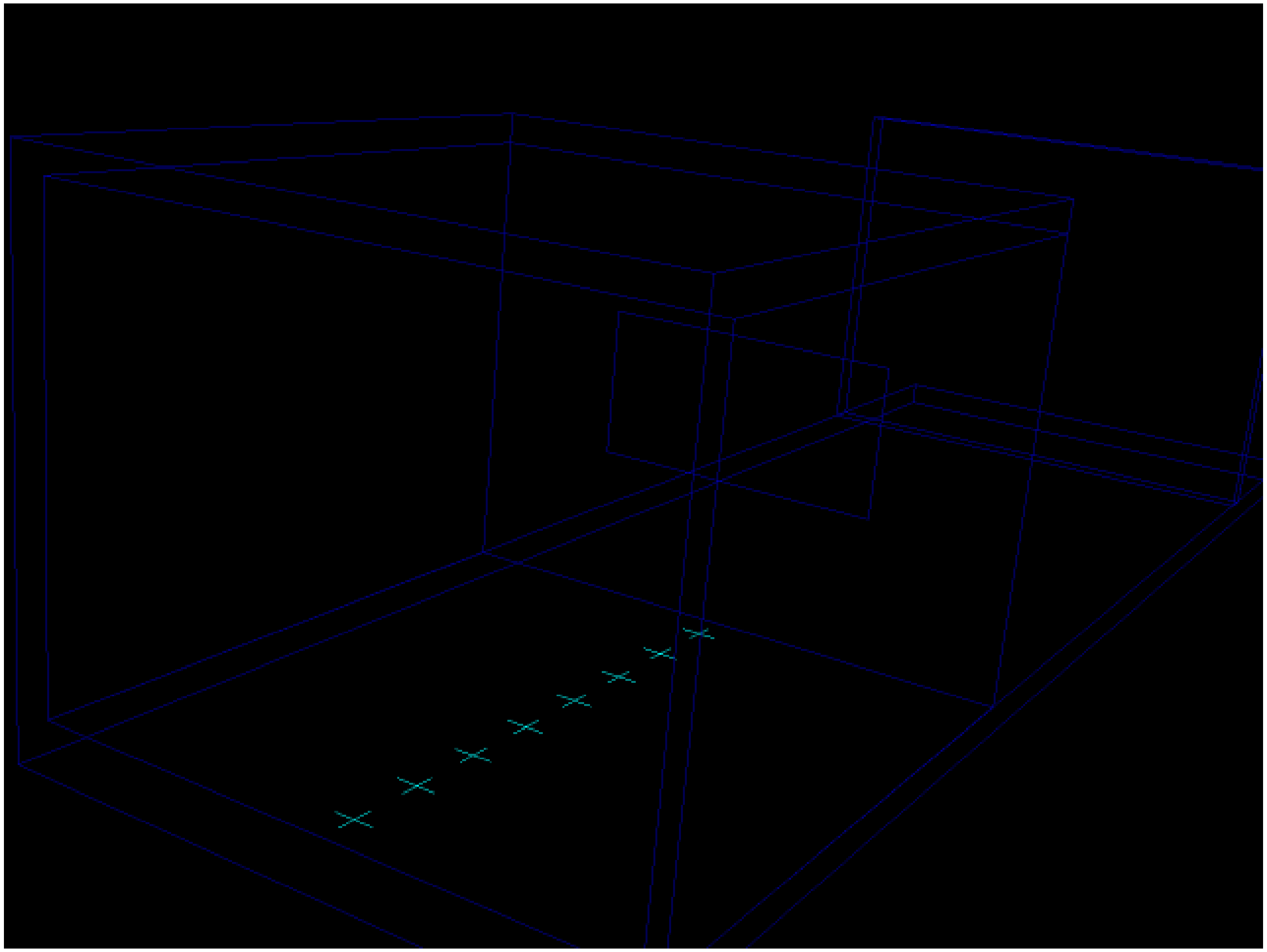
Test cells – area light source



Test cells – SC + ERC



Test cells - SC + ERC - obstruction



Quality Assurance?

- In simulation – how do you know you have the right answer?
- If you do the simulation:
  - In visual simulation - is a sight check enough (it looks the way we want it to…)
  - In numerical simulation – if you know the situation well enough to be able to say it is like ‘job x’ in 1999, why simulate?
- If the firm’s reputation depends on the simulation quality
  - How do you guarantee the grad student software expert has produced an accurate prediction of reality?
  - How accurate / precise do you need to be?

Proposal: use CIE TC3.33 as basis for QA web site

- Web site because:
  - the software tests can be routinely updated
  - because it is relatively easy to add more tests
  - so tests are not lost on a research bookshelf
- Web site enables:
  - Submission of tests by any person
    - Rate / rank significance of test by its source – independent government certified lab high; grad student medium; author low.
    - E-bay style reliability rating for testers develops over time
    - Normal publication systems (reporting format standardized) but NOT refereed
    - Quality score ‘guarantee’ is: People who falsify evidence risk public ‘outing’
  - Comparative rating of programs
    - all tests for one program, all programs for one test
  - Linked documentation of the tests
    - Full CIE document
    - Full CIBSE TM28 document
  - Other relevant information:

    Comparison of different ‘solution techniques’ (radiosity / raytrace etc)

    Standardised time to calculate

QA – how does it work?

- If the behaviour of my model is the same as the behaviour of a test case, then I have reason to believe that I can trust my model
- Basis:
  - Trust the modeller (at web site OR in firm):
    - real building x with standard reflectivities and light source
    - Simulation model of building x behaves the same when I model it with my software (I trust my / my firm's modelling approach)
  - "Behaves the same" means when I change reflectivities or light source the change is the same
    - Start with comparing real to model to establish baseline;
    - Then develop a wider range of theoretical tests
    - Ensure that the focus is on the differences in performance
    - Eventually, software developers do the QA as a standardised report

IF QA – then also 'Consumer guide'?

- If people are looking at a web site that reports this 'accuracy' data – what more might they add to make it a consumer guide?
  - Modelling
    - Modelling in the tool itself
    - Importing other geometry
    - Portability of model
  - Materials
    - Library available!
    - Customising in language that is normal in lighting
    - Mapping scaling / uvw coordinates
  - Luminaires
    - Ease of use of non-standard (ELUMDAT etc) data
    - Ease of placement / aiming of
  - Simulation
    - Setting up
    - Creating the working plane
    - Speed of calculation
    - Stability
  - Output
    - Display of illuminance / luminance
    - Image display
  - Accuracy (CIE tests)

Draft for comment

- Dan Xu – BBSc (Hons) 2005 student
  - CIE TC 3.33 as consumer guide
  - Collaboration within IEA Task 31
  - Lighting paper including survey of NZ practitioners as to what they are looking for
- Completion planned for Oct 21 2005
  - Interest now is:
    - list of factors sufficient?
    - best way to present data on what each solution technique is good / not so good at

Ideas?

- Modelling
  - Modelling in the tool itself
  - Importing other geometry
  - Portability of model
- Materials
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- Output
  - Display of illuminance / luminance
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- Accuracy (CIE tests)
- NOTES:
  - Sky models
  - annual simulation scripts
  - Provenance of material definitions guaranteed –
  - Real cases
  - Other validations