ROSI − An object−oriented and parallel computing Monte Carlo Simulation for X−ray imaging

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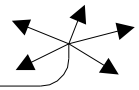


Outline

- Requirements of an X−ray simulation
- ROSI:
  - Components
  - Concept
  - Example
- Conclusion

Requirements of a simulation for medical X−ray imaging

Monte Carlo is the proper choice!

- Valid
- Fast
- Flexible
- Extensionable
- Easy to use

Search for Simulation Code

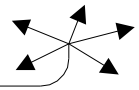
- Transport algorithm GISMO
- Interaction algorithm EGS4 + LSCAT
- Parallel computing LAM

=> ROSI (Roentgen Simulation)

GISMO (the heart of ROSI)

- A transport algorithm
- Object−oriented and intuitional geometry concept
- Interactor−Objects:
  define an interface for interaction algorithms
  - EGS4−interactor
  - LSCAT−interactor
  - User−definable interactors

[GISMO] Atwood et al., *The GISMO−Project*, C++ Report, 1993, p.38−43

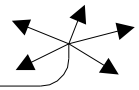


EGS4 (Physics of Electron and Gamma Showers)

- Rayleigh scattering
- Photo effect
- Compton effect
- Pair production

Particle energy above a few keV!

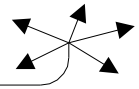
[EGS4] Nelson et al., *The EGS4 Code System*, 1985, SLAC−265



LSCAT (Low Energy Scattering Extension of EGS4)

- Photon transport for energies below a few 100 eV
- Binding effects (Doppler broadening)
- K− and M−Shell processes (Fluorescence photons, Auger electrons)

[LSCAT] Namito et al., *LSCAT: Low−Energy Photon−Scattering Expansion for the EGS4 Code*, May 2000, KEK Internal 2000−4



General aspects of parallel computing

- Result of a MC−Simulation depends on number of events => „the faster the simulation, the better“
- Each photon transport can be simulted independently and therefore can run parallel

Idea of parallel computing:

- Starting the simulation on as many computers as possible
- Collecting and summarizing simulation results

Implementation of parallel computing

- LAM (Local Area Multicomputer) = Environment for parallel computing over a TCP/IP network developed by the Supercomputer Center Ohio
- LAM abstracts from physical network and can start any number of processes (ranks) in the defined cluster
- The communication between the ranks is defined by the MPI−Standard (message passing interface)

Need of random variables: RAVAR

- Energy distribution of photons (mostly X−ray tubes).
- Emission point of photons (typical focus: 1 mm)
- Angular distribution (heel effect)

=> Development of a reusable (object oriented) library of random variables: RAVAR

What’s new in ROSI?

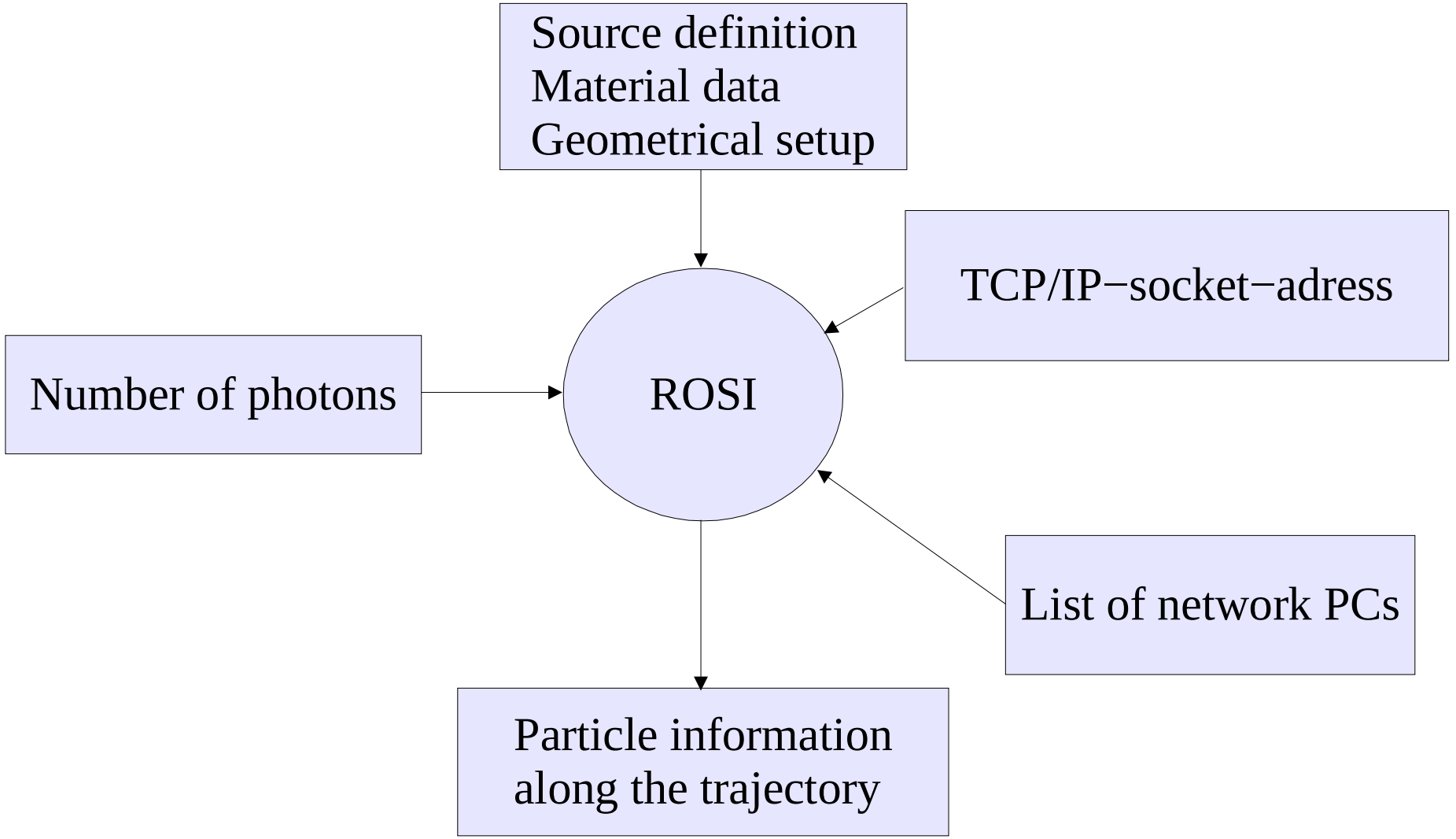
- Combining established standard libraries to a fixed framework, need not be changed by user
- An intuitional and open user interface (because of object−oriented design)
- Adding an implementation of random variabes

=> Using ROSI saves time!

A Goody: The communication−interface

- Very useful to check dead locks
- Implementation by server−client model via TCP/IP−socket
- Graphical client by GTK

Black box model of ROSI



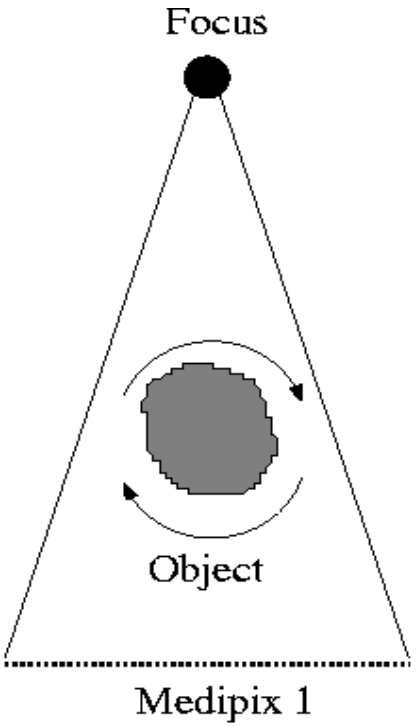
Capability of ROSI

Examples:

- Photon Counting
- Energy−sensitive computed tomography
- Compton camera

See also talks of Ch. Bert, D. Niederlöhner, K.−F. Pfeiffer on the 4th IWORID

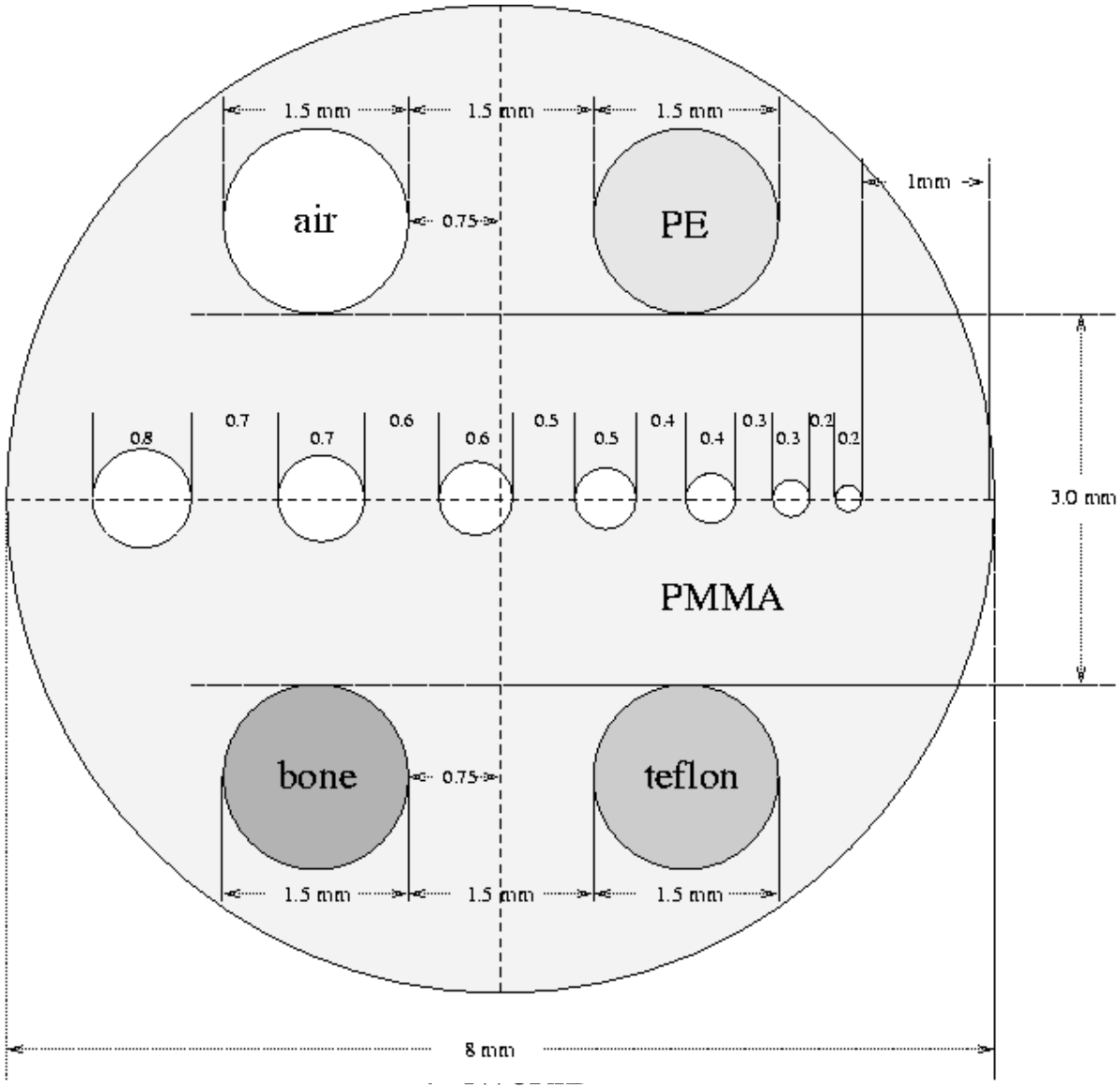
Simulating a real CT−Setup with ROSI



- Energy spectra: Mo−Mo−Tube 35 kV
- Focus: 0.42 mm x 0.63 mm
- Distance Focus −Object: 78.3 cm
- Distance Focus −Detector: 92.7 cm
- Object diameter: 8 mm
- Detector: MEDIPIX1 bonded to GaAs (300 µm)

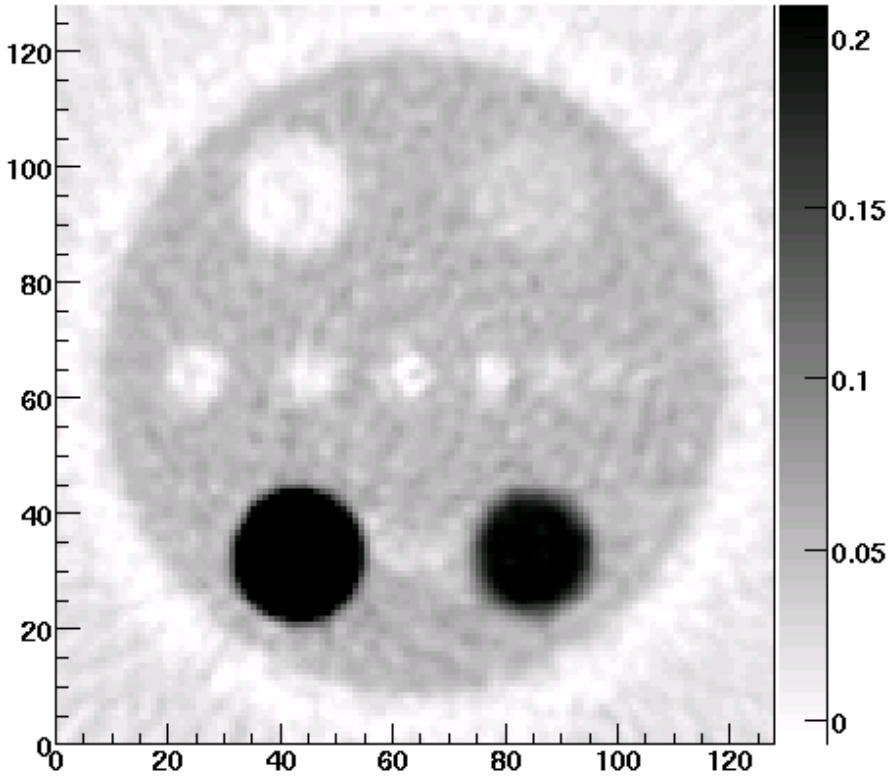
[MEDIPIX1] www.medipix.web.cern.ch/MEDIPIX

The Object in detail



Simulation...

- 180 images (1 degree step)
- 10^7 photons per image
- 12.5 h (6 x Pentium III 800 MHz)
- After reconstruction...



Outlook

- Download via internet
- Biological materials data base
- Interactor for scintillation photons

Conclusion

ROSI is:

- Object−oriented and therefore
  - Intuitional
  - Extensible
  - Reusable
- Capable of defining flexible photon sources
- Based on established EGS4 + LSCAT code
- Fast by parallel computing

=> use ROSI!