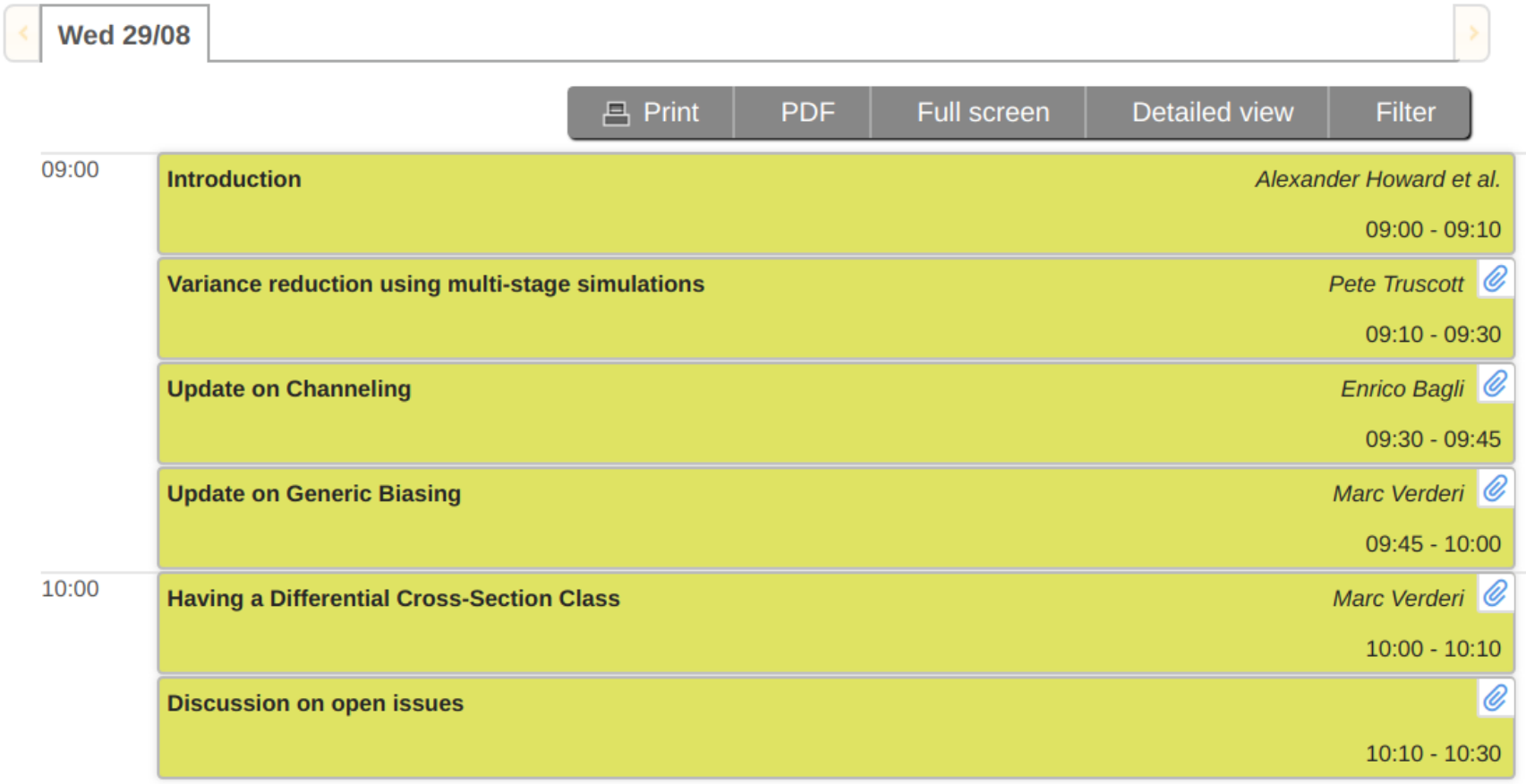
REPORT FROM PARALLEL 5B

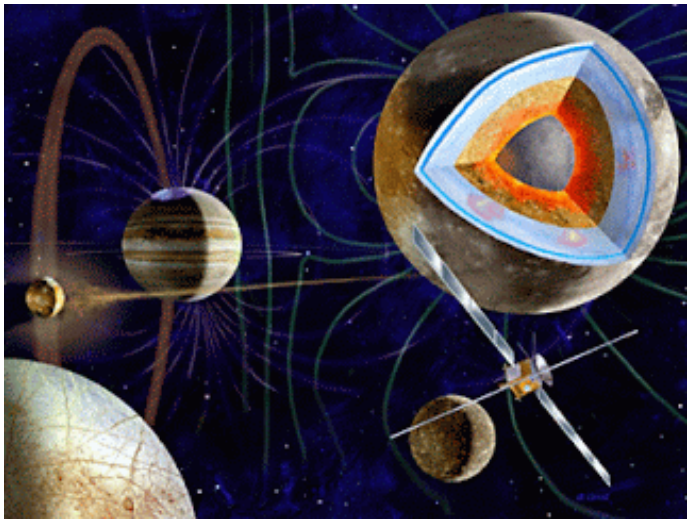
“BIAISING”

Session chairs : Alex Howard & Marc Verderi

Session schedule



"Matryoshka": Variance Reduction Using Multi-Stage Simulations – Some Lessons From the CIRSOS Project



Pete Truscott, Fan Lei, Giovanni Santin & Marco Vuolo
Kallisto Consultancy, RadMod Research, ESA ESTEC/Rhea

Geant4 Collaboration Meeting, Lund University, 29th August 2018

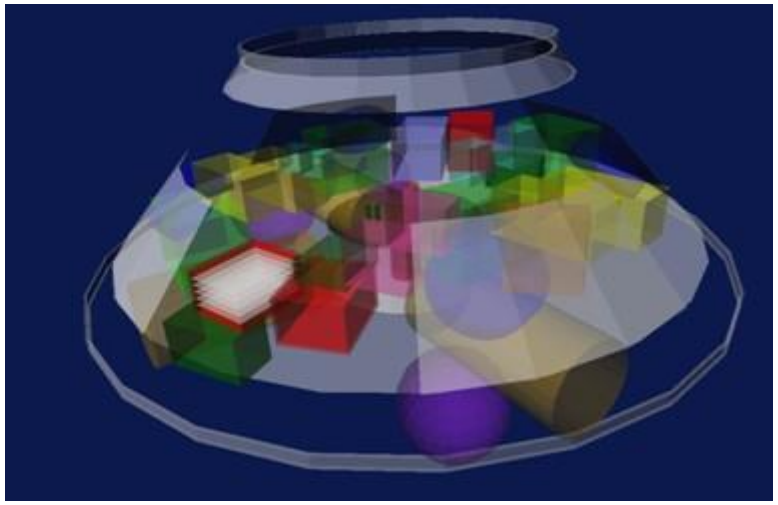
Original work sponsored by ESA Contract 4000108668/13/NL/MV
(Prime contractor RadMod Research Ltd)

Status of GRAS "Matryoshka" Enhancement

- Radiation effects analysis still does not regularly involve the use of Monte Carlo radiation simulation

…"Boxes within boxes within boxes"

- Spacecraft comprise collections of systems, each containing sub-systems, boards and components
- A straightforward method to improve statistics of MC analysis is to:
  - Transport particles to surfaces of equipment boxes
  - Store the phase-space information
  - Use subsequent simulation to resample the particles too sub-box/board/component level



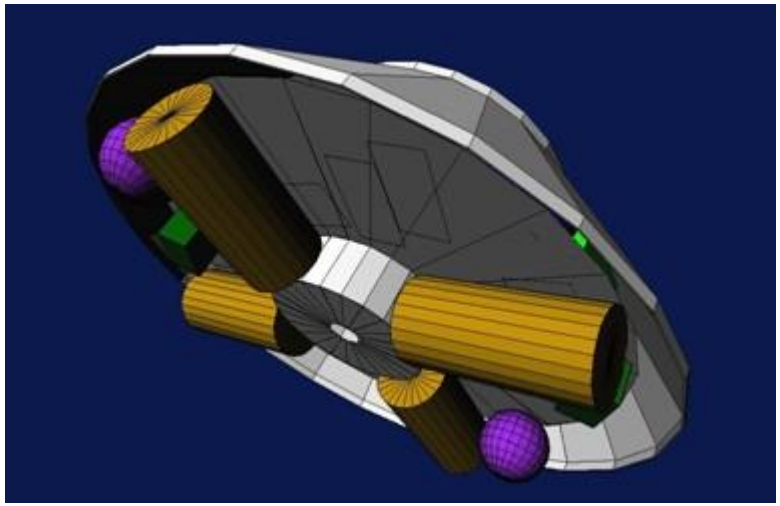
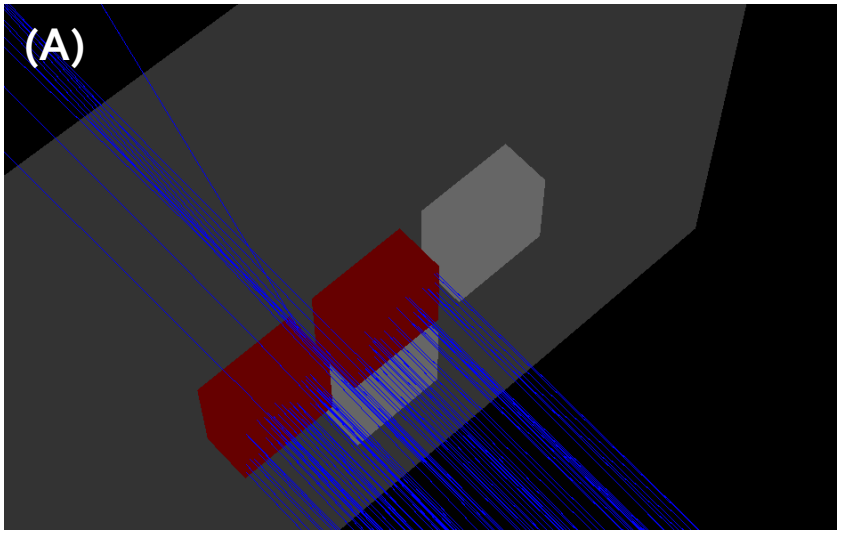
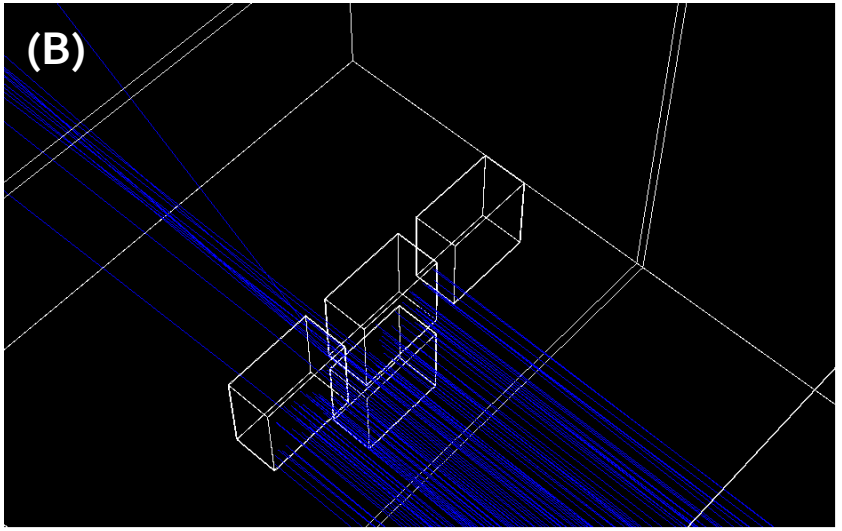
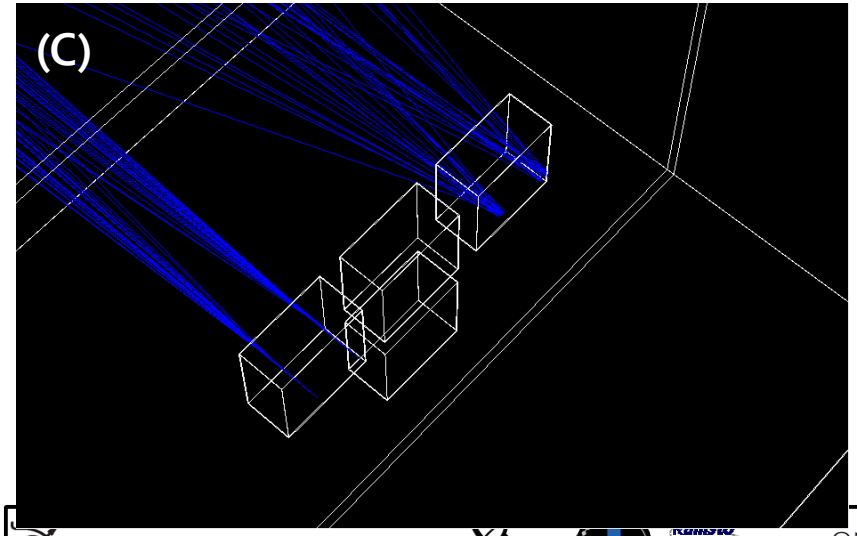


Image Credit: Lindberg & Santin, ESA

Example 1st Stage simulation: Four electronics boxes (200mm × 200mm × 100mm) mounted on plate in satellite. Two of these (in red) are irradiated. In solid (A) and wireframe representation (B).



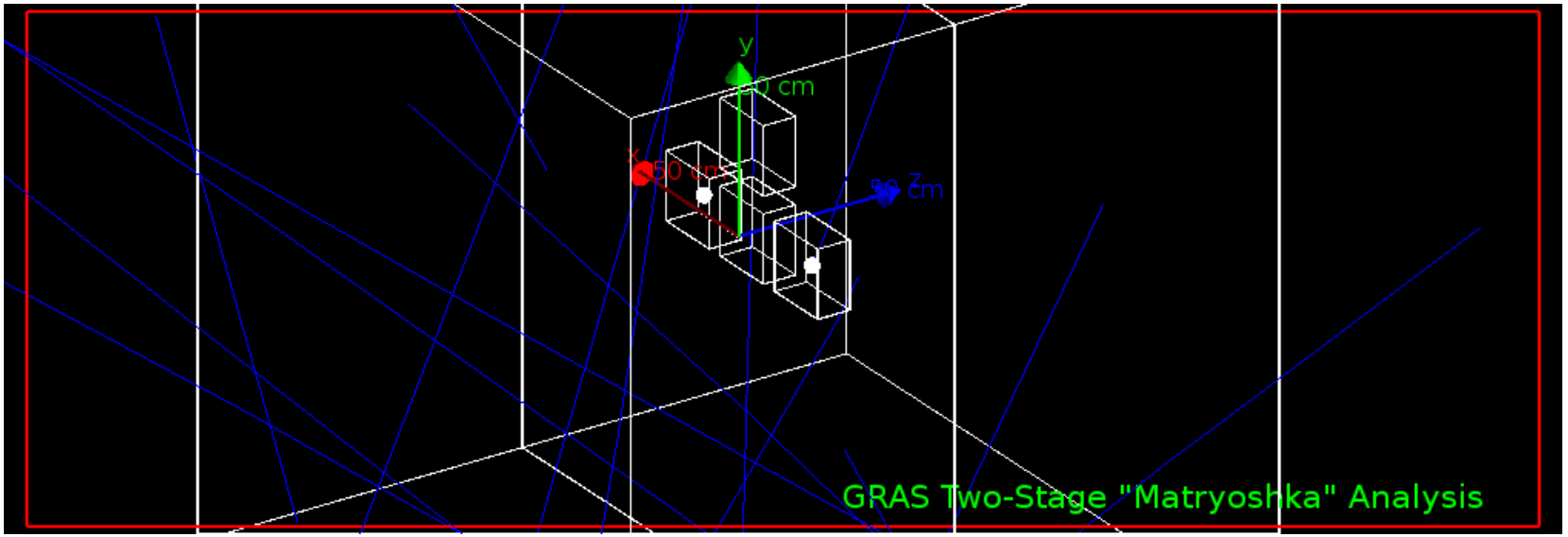




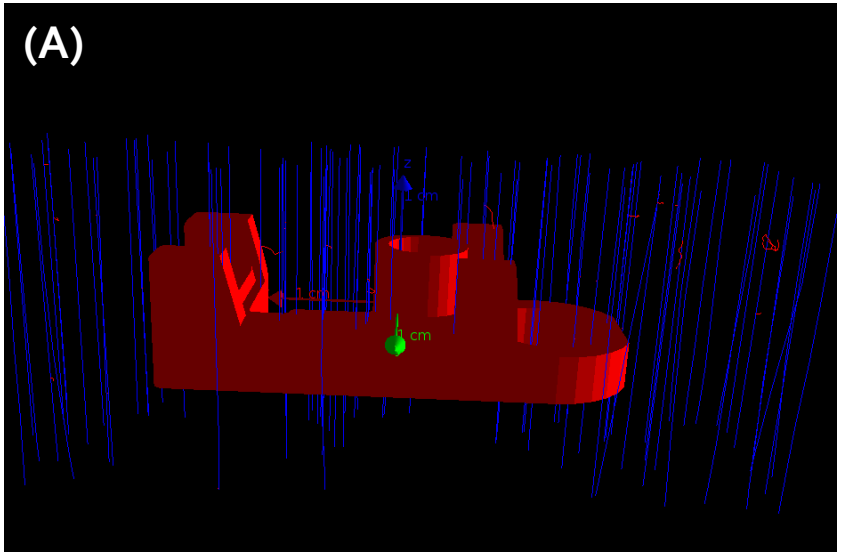
(C): Example 2nd Stage simulation: The source is generated on one of the original red volumes with no position nor angular "dithering", but split (***samples***=20). The source is also used for one of the PVs irradiated in the first stage: grid resampling (gridded in 10x10x10), and angular dither with α=15°, ***samples***=20. Only 2 of the original 1st stage events are used for each PV

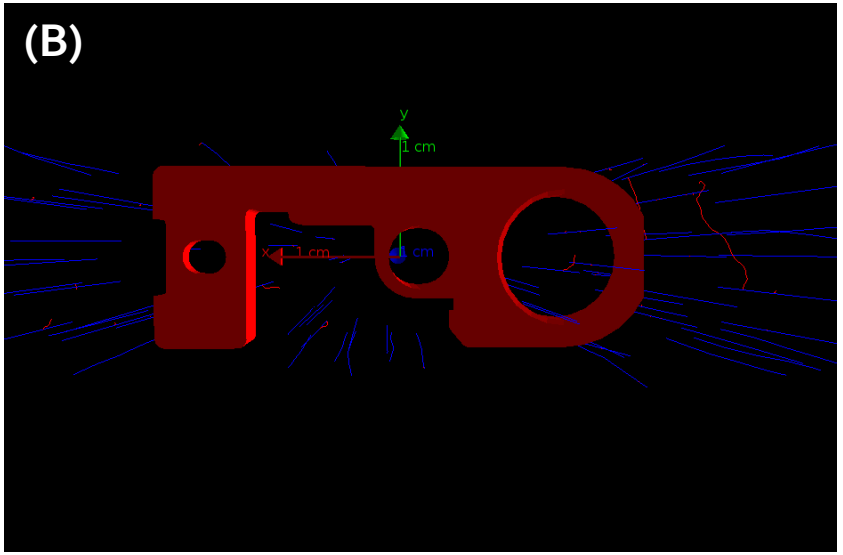
Example

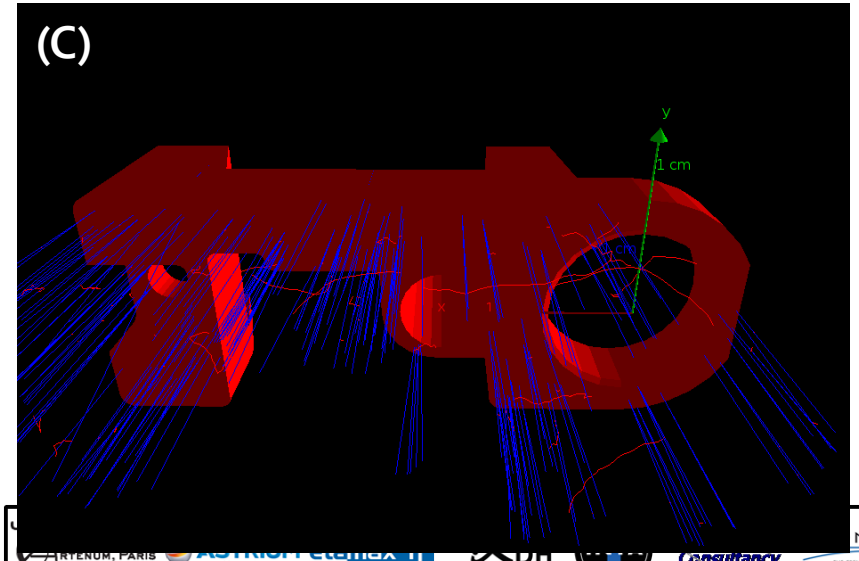
- Test case with 2cm radius Si spheres, 50 MeV protons isotropic
  - $(1.44 \pm 0.10) \times 10^{-12}$ rad(Si)/event (conventional)
  - $(1.41 \pm 0.02) \times 10^{-12}$ rad(Si)/event (2-stage with splitting)

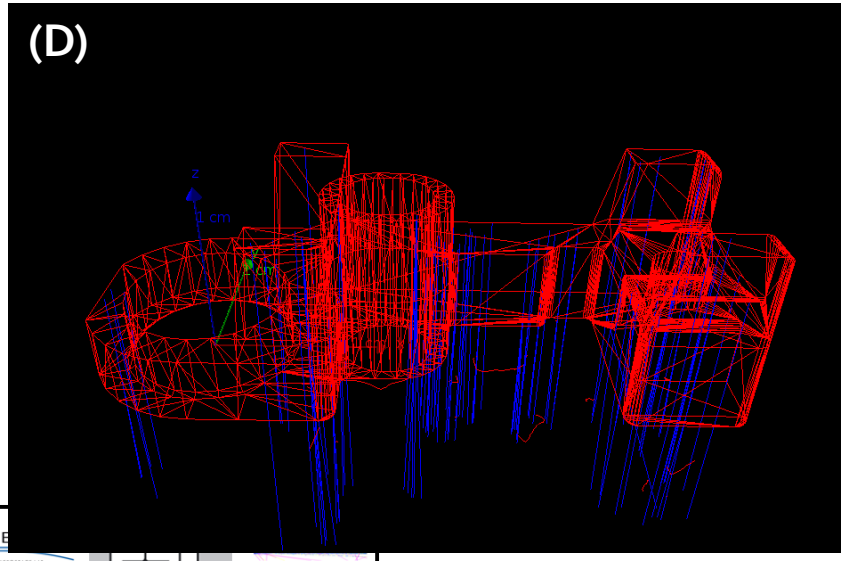


Example Two Stage simulation for arbitrary Al geometry in air irradiated in –z-direction by protons. (A) & (B) 1st stage simulation. (C) and (D) 2nd stage simulation, with each 1st-stage event split into 5, and uniform repositioning within a disc radius 2mm.









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CONSULTANCY
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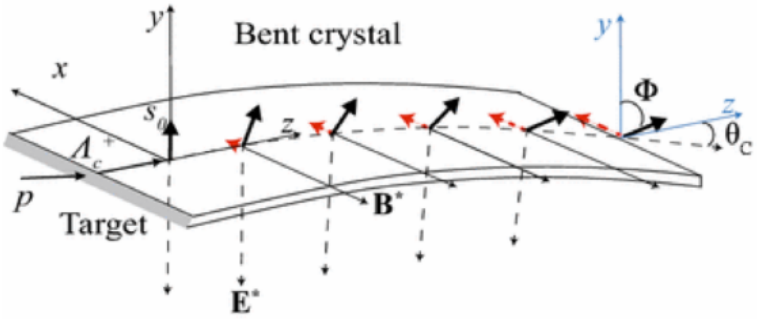
Research

UPDATE ON CHANNELING

ENRICO BAGLI
INFN DIVISION OF FERRARA

SPIN PRECESSION UNDER CHANNELING

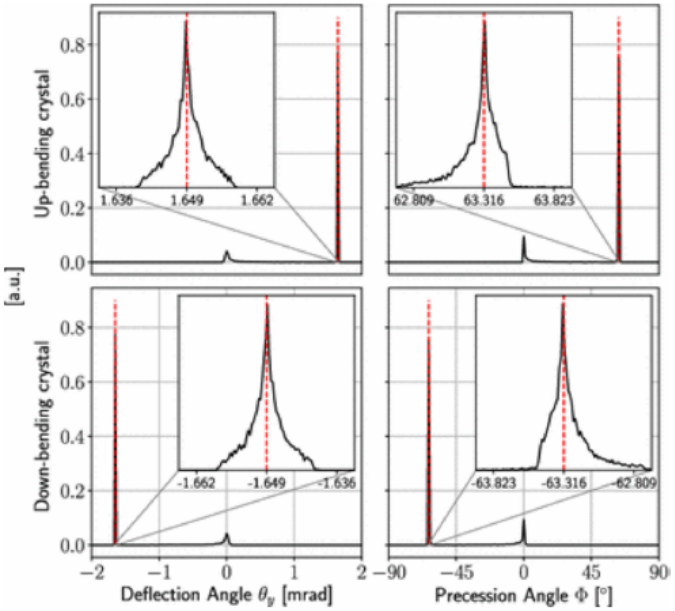
- The spin precession of a charged particle is induced by the interaction of its electromagnetic dipole moments, e.g. MDM and EDM, with external electromagnetic fields.
- The possibility to measure MDM using channeling in bent crystals was firstly pointed out by V. G. Baryshevsky in 1979.
- The method is based on the interaction of the MDM of the channeled particles with the intense electric field between crystal atomic planes.



SPIN PRECESSION UNDER CHANNELING

- The numerical integration of the classical equations of motion allows to introduce the modification of the particle spin under the effect of the strong electric field generated by the crystalline lattice.
- The step-by-step variation of the spin is tracked by numeric integration of the T-BMT equation.
- The process for spin precession has been validated against the solely available experimental data provided by the E761 experiment at FNAL. The average of experimental values 60±17 degrees is consistent with the predicted value of 62±2 degrees.

E. Bagli et al., "*Electromagnetic dipole moments of charged baryons with bent crystals at the LHC*", Eur. Phys. J. C77 (2017), 828



Geant4 simulated distributions of the deflection angle and spin precession angle for Σ+ baryons of 375GeV/c momentum interacting with 4.5 cm long (top) up-bent and (bottom) down-bent crystals.

TO DO

- Open issues:
  - Biasing weight of channeled particles are changed by the biasing processes.
  - Channeling needs single-scattering: the usage of a different EM physics list for a G4Region which contains crystals would allow to reduce computation time (see MicroElec and DNA)
  - Some inelastic hadronic models seem to modify the channeling efficiency for negative particles. To be investigated.

- Desiderata:
  - Create a «biased» EM physics list for channeling which is automatically to G4ExtendedMaterial with crystals.

UPDATE ON GENERIC BIASING

PARALLEL 5B

Marc Verderi
LLR/Ecole polytechnique
Lund Collaboration Meeting
August 2018

Statistical test suite

- Development ongoing under test49
  - Some code committed at the trunk
  - But not ready to go at this point !

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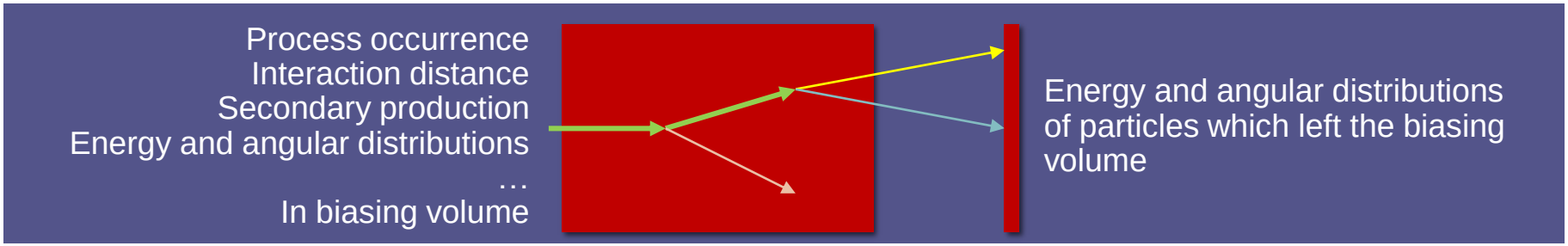
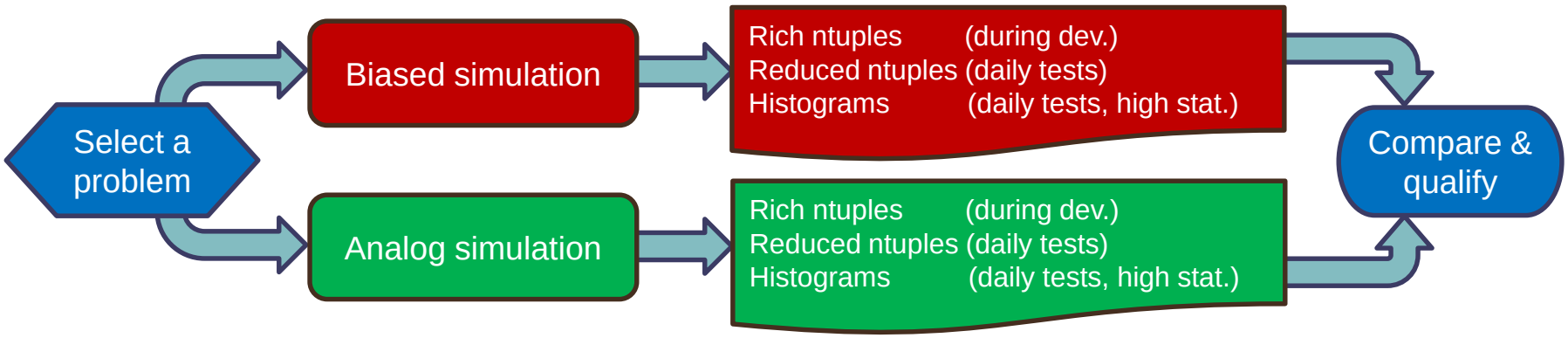




Implicit Capture

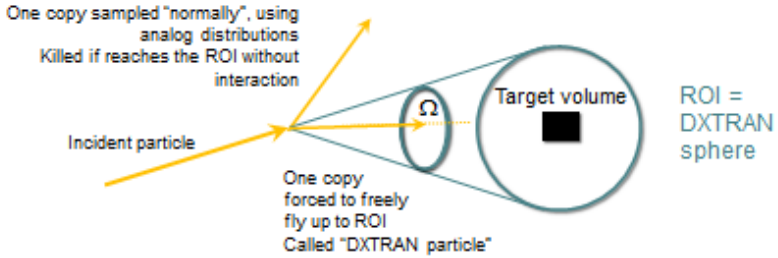
- Aka "survival biasing," and "absorption by weight reduction"
- Biasing technique used for neutrons (and gammas) to avoid "loosing" neutrons by absorption.
  - Keep neutrons alive wrt absorption to make it exploring more detector domains.

(A) - Suppress capture but update track weight to reflect this suppression

(B) - Or sample the interaction length without absorption ($\sigma_{abs.} = 0$) and by setting it to some value.

DXTRAN

- An other option also re-conducted in work plan several times…
- Option in MCNP to scatter particles toward a preferred solid angle
  - Has some similarities in its use-case with the Reverse MC as it targets small ROI
- DXTRAN = stands for deterministic transportation



- Addressing Problem 1941 - Cannot use importance sampling for more than one particle type
  - In geometry importance biasing scheme, for which the problem is reported
  - Or with generic biasing, to be demonstrated in example GB03, allowing for more than neutrons
- Extension of generic biasing scheme to AtRest case
- Extending generic biasing scheme to volumes with an internal structure

HAVING AN ABSTRACT CLASS FOR DIFFERENTIAL CROSS-SECTION

PARALLEL 5B

Laurent Desorgher & Marc Verderi

Lund Collaboration Meeting

August 2018

Motivations

1. DXTRAN biasing:
   - Biased particles –gammas, neutrons- are scattered toward a ROI
   - Analog diff-XS needed for the weight correction
2. Reverse MC:
   - The availability of all diff-XS able to produce a given secondary type would ease the implementation of the reverse process
3. Information on the physical process or model:
   - Having a diff-XS class would make easier to users to get cross-section tables of the related models.

Status

- Several discussions happened this year together with Laurent D.

- We want an abstract class that calculates:

  proba. = diff-XS (initial state, final state)

- We limit ourselves to the case of PostStepDoIt
- And we propose:
  - “initial state”:
    - Could be G4track* and G4Material*
    - General, even though G4Track maybe cumbersome for 3.
  - “final state”:
    - Final state can be complicated : many correlated particles + energy deposit
    - Limit to one secondary particle, and propose:
      - Energy and angular deviation of the primary (if still alive)
      - PDG, E, angular deviation wrt primary of the secondary (if any)

- This definition of diff-XS is enough to serve the use cases of previous page.

One point of discussion by Vladimir Grichine

Hi,

I am sending some issues for tomorrow discussion concerning biasing. These are came from simulation very rare events like neutrino or dark matter:

1 - how to bias integral cross section with factor ~ 10^14?

2- how to provide uniform (not exponential) distribution of events inside sensitive volume? (natural distribution is uniform due very high mean free path).

3 - how to provide p. 2 in a tree of volumes (G4 region and daughters inside)?
Thanks.

Best regards, Vladimir

PS. Unfortunately, tomorrow I'll be busy and will not join the session