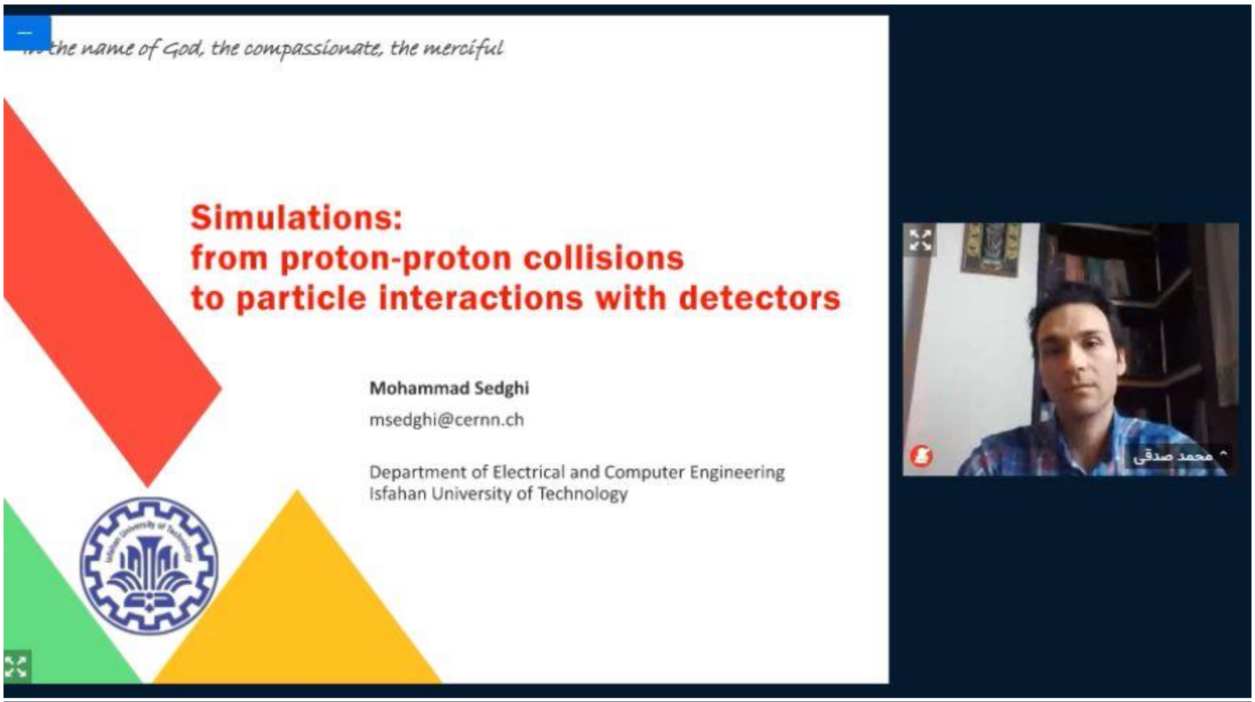
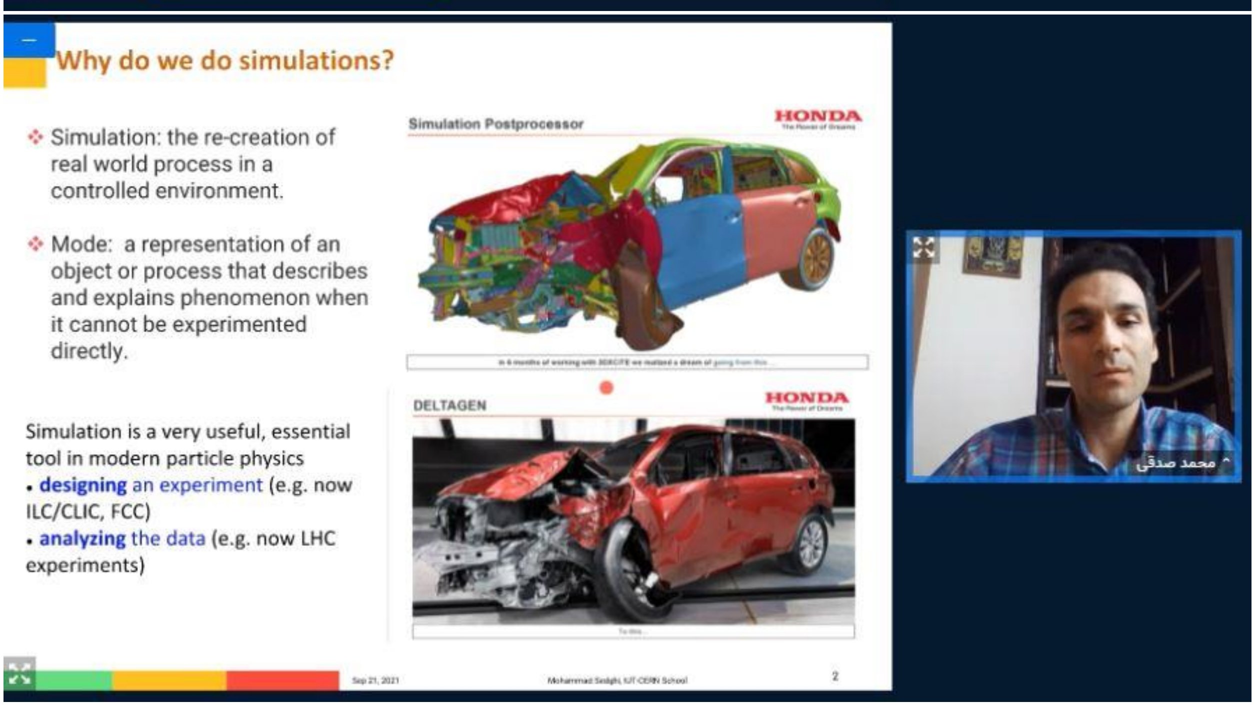
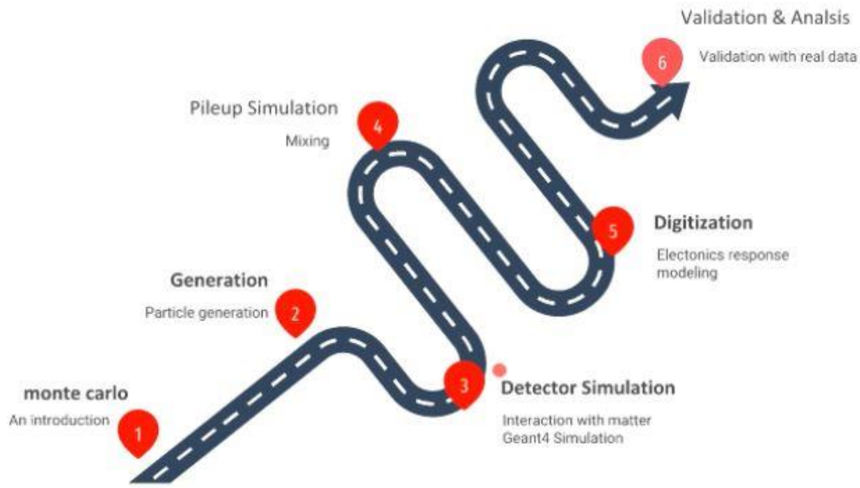
دومین روز گردهمایی سرن در روز یکشنبه ادامه داشت و در این روز ابتدا دکتر محمد صدقی مطالبشان را پیرامون شبیه‌سازی (از برخورد پروتون‌ها تا برهم کنش ذرات با آشکارساز) ارائه دادند که مطالب پربار و مباحث جامعی ارائه شد، همراه با پرسش و پاسخ دانشجویان علاقه مند. که در ادامه تصاویر منتخبی از این بخش آورده شده است:



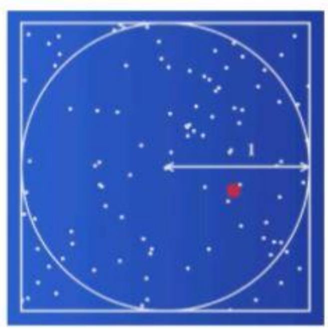


Simulation steps



Laplace's method of calculating π (1886)

- General idea is "Instead of performing long complex calculations, perform large number of experiments using random number generation and see what happens"



- Area of the square = 4
  - Area of the circle = π
  - Probability of random points inside the circle = $\pi / 4$
- Random points : N
  - Random points inside circle : Nc

    $\pi \approx 4\, Nc / N$

Area = (# Hits)/(# Total) x total area

Monte Carlo method : definition

- The Monte Carlo method is a stochastic method for numerical integration.
- Generate N random points x_i in the problem space
- Calculate the "score" $f_i = f(x_i)$ for N points.
- Calculate

$$\langle f \rangle = \frac{1}{N}\sum_{i=1}^{N} f_i \qquad \langle f^2 \rangle = \frac{1}{N}\sum_{i=1}^{N} f_i^2$$

- According to central limit theorem, for large N, then $\langle f \rangle$ will approach the true value f.

$$p(\langle f \rangle) = \frac{1}{\sqrt{2\pi}\sigma}\exp\left(\frac{-(\langle f \rangle - \bar{f})^2}{2\sigma^2}\right), \qquad \sigma^2 = \frac{\langle f^2 \rangle - \langle f \rangle^2}{N-1}$$

Les Houches Accord PDF

- Various models for Parton distribution functions
  - PDF: Parton distribution functions

- 2001 Les Houches meeting – LHAPDF interface was conceived to
  enable the usage of PDF sets with uncertainties in a uniform manner.

- Using LHAPDF routines to evaluate PDFs

- Many PDF sets are now available in the

MC event generation

- HEP MC event generation can typically be split into the following steps:

1) Process level calculations, needing
   - Matrix Element calculations
     - Parton distribution function evaluation

   } There are special purpose software for this step, e.g. Madgraph

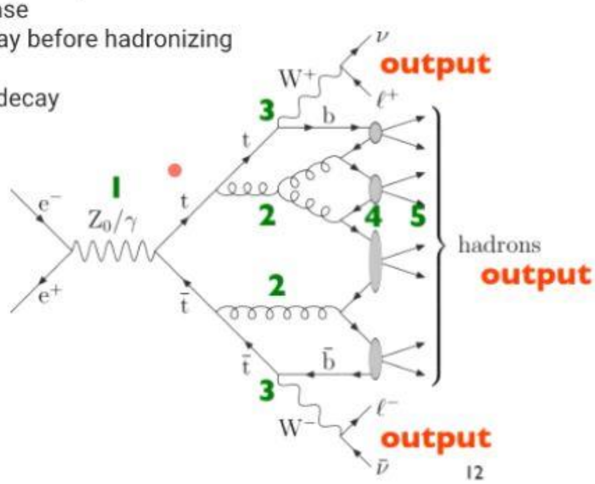
2) Parton Shower
3) Hadronization

   } evolve at the parton-level to its final state

- All these latter steps rely heavily on models and are generally independent from the Matrix Element calculation.
- Therefore only few, typically multi-purpose event generators, implement those additional steps.
  - Examples are
    - Pythia (6 and 8)
    - Herwig (Fortran and C++ versions)
    - Sherpa

Pythia Monte Carlo event generator process

1) Hard process (ME $\oplus$ PDF)
2) Parton-shower phase
3) Hard particles decay before hadronizing
4) Hadronization
5) Unstable hadrons decay



Interface standard between generator

- You may need more than a MC generator to generate particles for the new physics.
- For example you may need mass spectrum from one generator and hadronization process from another.
  - How various generators should talk together?
  - The `Les Houches Events` (LHE) file format is an agreement between Monte Carlo event generators and theorists to define **Matrix Element** level event listings in a common language.

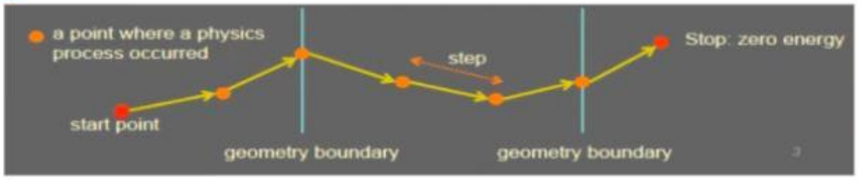
Monte Carlo radiation transportation codes

- The detector simulation is different for each experiment. However, general codes exist that can be used for simulating any detector
- These general codes, e.g. Geant4, are called "**Monte Carlo radiation transportation codes**"
- Non-deterministic (e.g. do not solve equations); use random numbers to reproduce distributions
- Transport particles through matter

Simulation engines
– Geant4 and Fluka are well established packages

Geant4
Geant4 is a toolkit to simulate the interaction of particles in matter, created by the Geant4 Collaboration.

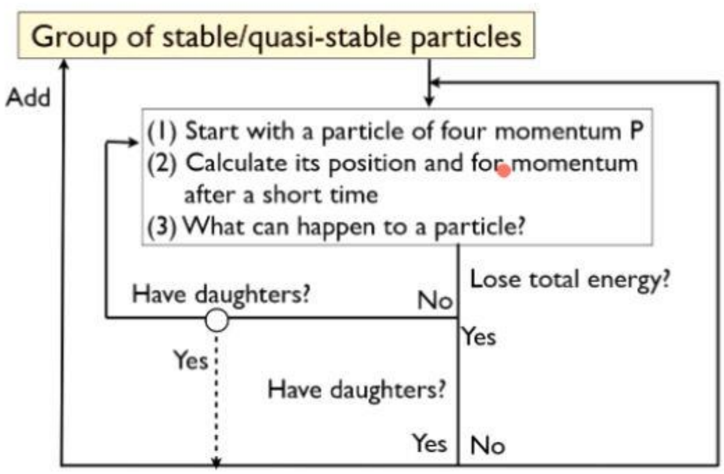
How does it work?

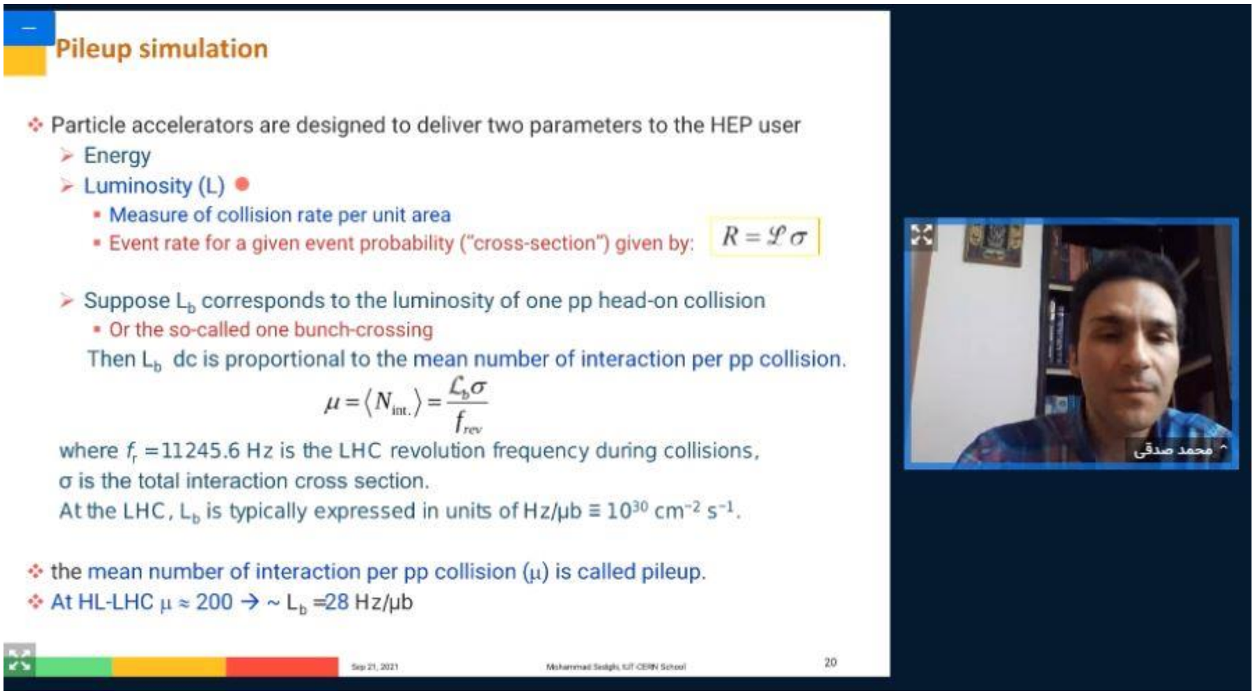


- Treat one particle at the time
- Treat a particle in steps
- For each step
- the step length is determined by the cross sections of the physics processes and the geometrical boundaries; if new particles are created, add them to the list of particles to be transported;
  - local energy deposit; effect of magnetic and electric fields;
  - if the particle is destroyed by the interaction, or it reaches the end of the apparatus, or its energy is below a (tracking) threshold, then the simulation of this particle is over; else continue with another step.
- Output - new particles created (indirect)

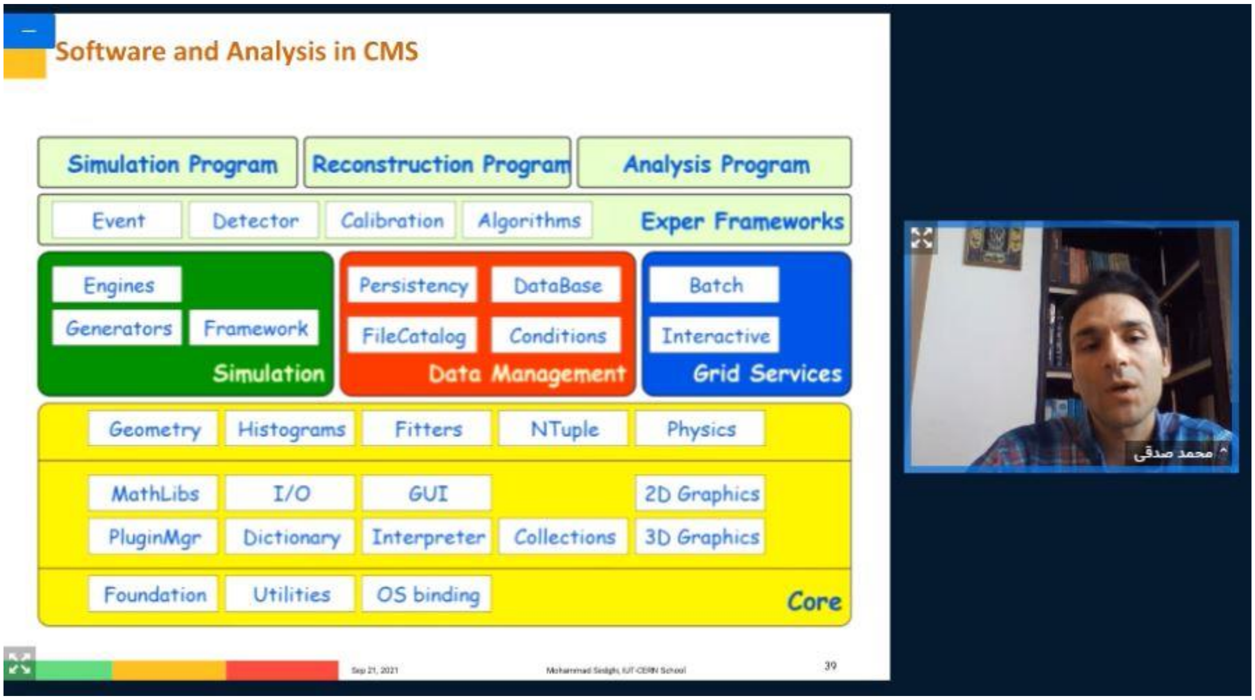
- local energy deposits throughout the detector (direct)

How does MC work in detector simulation




Pileup simulation
Particle accelerators are designed to deliver two parameters to the HEP user
Energy
Luminosity (L)
Measure of collision rate per unit area
Event rate for a given event probability ("cross-section") given by: $R = \mathscr{L}\sigma$
Suppose L_b corresponds to the luminosity of one pp head-on collision
Or the so-called one bunch-crossing
Then L_b dc is proportional to the mean number of interaction per pp collision.
$\mu = \langle N_{\text{int.}} \rangle = \frac{\mathcal{L}_b \sigma}{f_{rev}}$
where f_r =11245.6 Hz is the LHC revolution frequency during collisions,
σ is the total interaction cross section.
At the LHC, L_b is typically expressed in units of Hz/μb ≡ 10^{30} cm^{-2} s^{-1}.
the mean number of interaction per pp collision (μ) is called pileup.
At HL-LHC μ ≈ 200 → ~ L_b =28 Hz/μb
Sep 21, 2021
Mohammad Sedghi, IUT CERN School
20
محمد صدقی


CMSSW
CMS software
framework
محمد صدقی



در ادامه عکس دسته جمعی گروهی گرفته شد که در زیر مشاهده می کنید: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