Beam Simulations

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2014 Joint Workshop of the France-Japan and France Korea Workshop
Bordeaux, France, May 26~27, 2014

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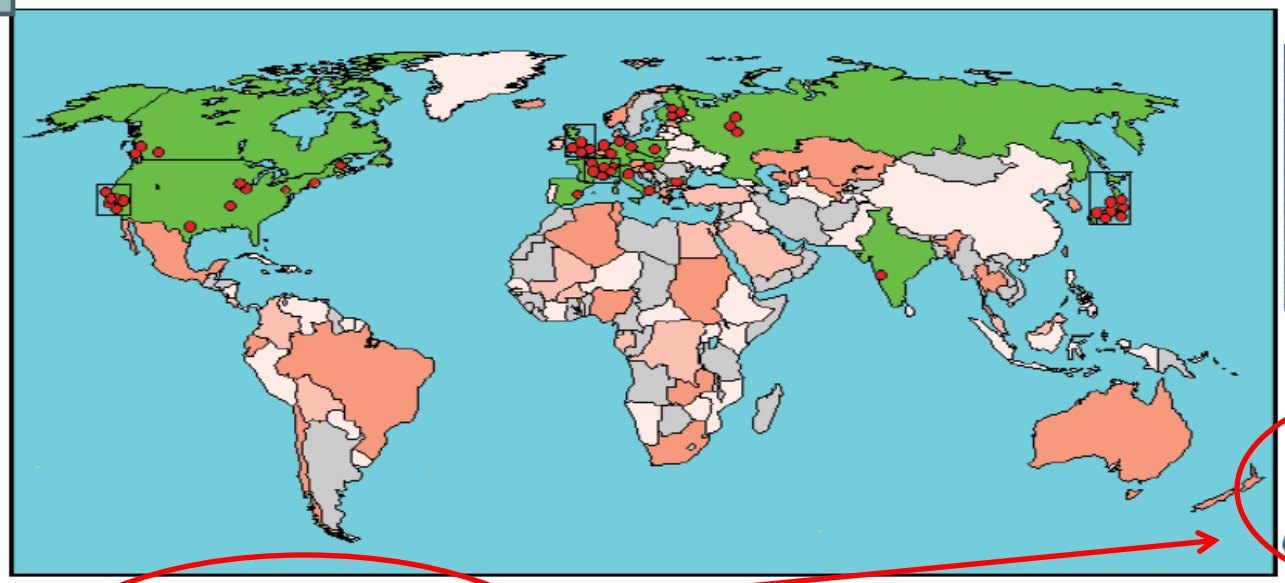
The French and Korean LIA teams

Members

- Korea Group
  - Kihyeon Cho (KISTI)
  - Chan Young Lee, Kyungho Kim, Youngjoon Kwon (Yonsei U.)
  - Huiyoung Ryu, Junghyun Kim, Soo-hyeon Nam (KISTI)
- France Group
  - Marc Verderi (LLR, IN2P3)

Geant4 Collaboration



TRIUMF

Lebedev

J.W.Goethe Universität

Collaborators also from non-member institutions, including
Budker Inst. of Physics
IHEP Protvino
MEPHI Moscow
Pittsburg University
Northeastern University
Wollongong University

Purpose of the Project

- To collaborate on beam simulations based on Geant4
  - Beam here = secondary particles produced by collision on a fixed target.
  - Eg: isotope production by proton beam on carbide uranium target
- Initial motivation is for the Korean "Rare Isotope Science Project" (RISP) project, at the "Institute for Basic Science" (IBS) in Yuseong-gu, Daejeon .
  - Interest in Nuclear physics, Nuclear data for fast neutrons, Material science, Nuclear astrophysics, Atomic & particle physics, Medical and biological science.
  - Proton, oxygen, xenon & uranium beams of a few 100MeV/u
  - ***Proposal budget approved this year.***
- Goals:
  - Assess Geant4 performances in predicting isotope production. Present activity
  - Use it to anticipate isotope natures and production yields.
  - Foresee what measurements apparatus would be appropriate
- Note that the study interest is not limited to RISP

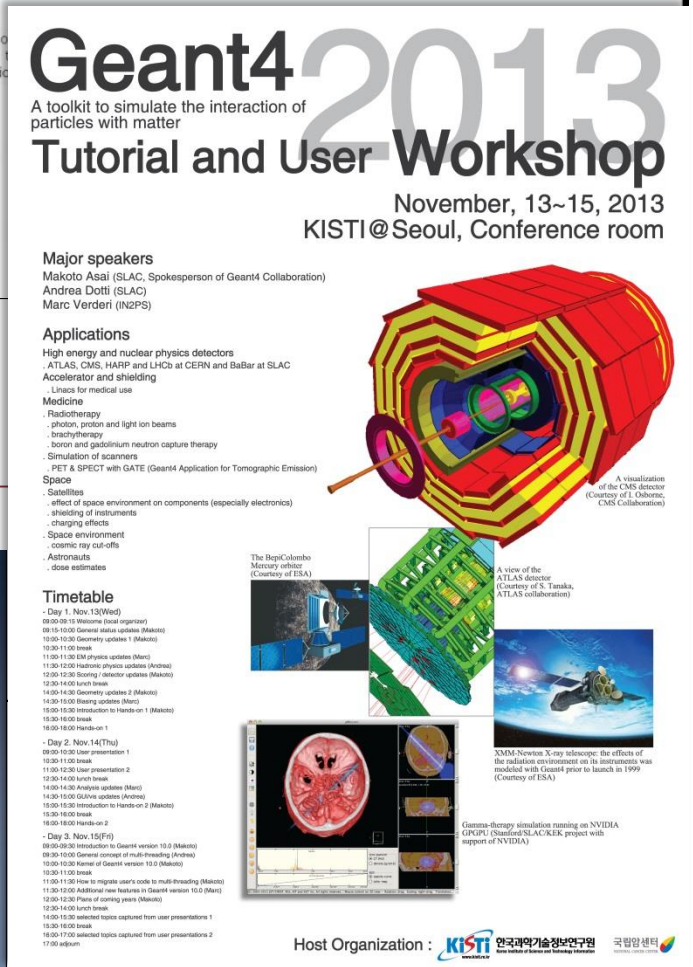
Past and present group activities, relevant for the project

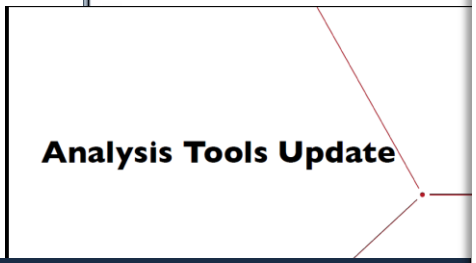
- The Korean and French teams have indeed developed Geant4 R&D working within Geant4 collaboration.
- KISTI team has been working on Geant4 R&D (AIX, MT) and also Geant4 beam simulations for secondary beam.
- The French team has been working on beam simulations for particle physics accelerators (ATF2) and is now involved in medical applications. It is also developing the "event biasing" techniques in Geant4.

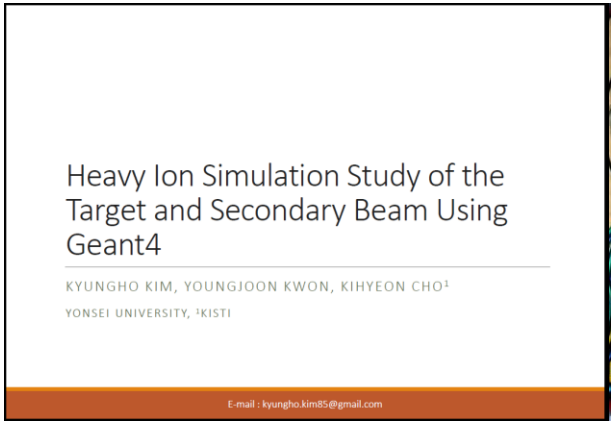
- Note that we also keep having interest in fundamental topics in High Energy Physics namely the B physics.

Hosted "The int'l Geant4 Tutorial and User Workshop"

1) Date: Nov. 13~15, 2013
2) Place: KISTI, Seoul, Korea
3) Attendee: ~50 persons
4) Korean Group (Kyungho Kim)
   - Heavy Ion Simulations Study of Target and Secondary Beam Using Geang4
5) French Group (Marc)
   - Physics Overview
   - Physics infrastructure
   - Biasing in Geant4







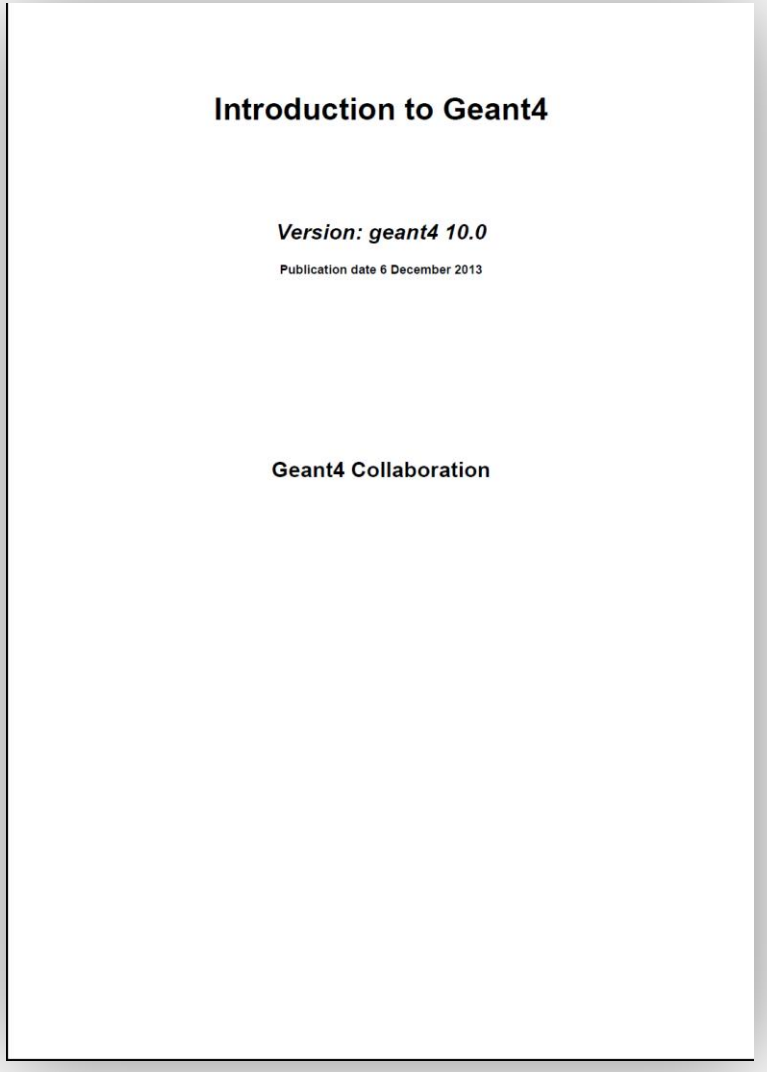
To release Geant4 10.0

- Geant4 10.0 released
  - Date: Dec. 6, 2014
  - Content: MT included

- Korea Group contributes
  - Validation for beam simulations using supercomputers and grid farms

  => Porting to KISTI supercom (tachyon2)
- French Group contributes
  - Leading the event biasing effort in Geant4,

  => Interest in beam background and beam-based medical simulation applications, space…


Introduction to Geant4

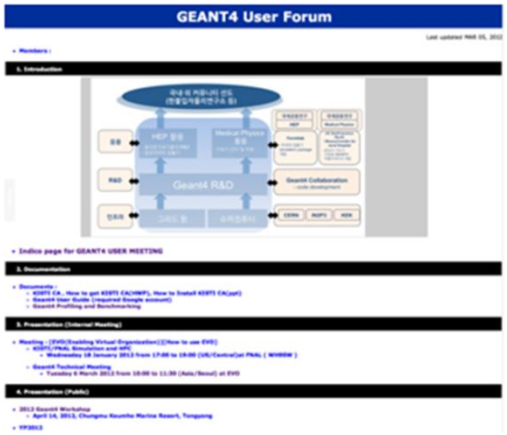
Version: geant4 10.0

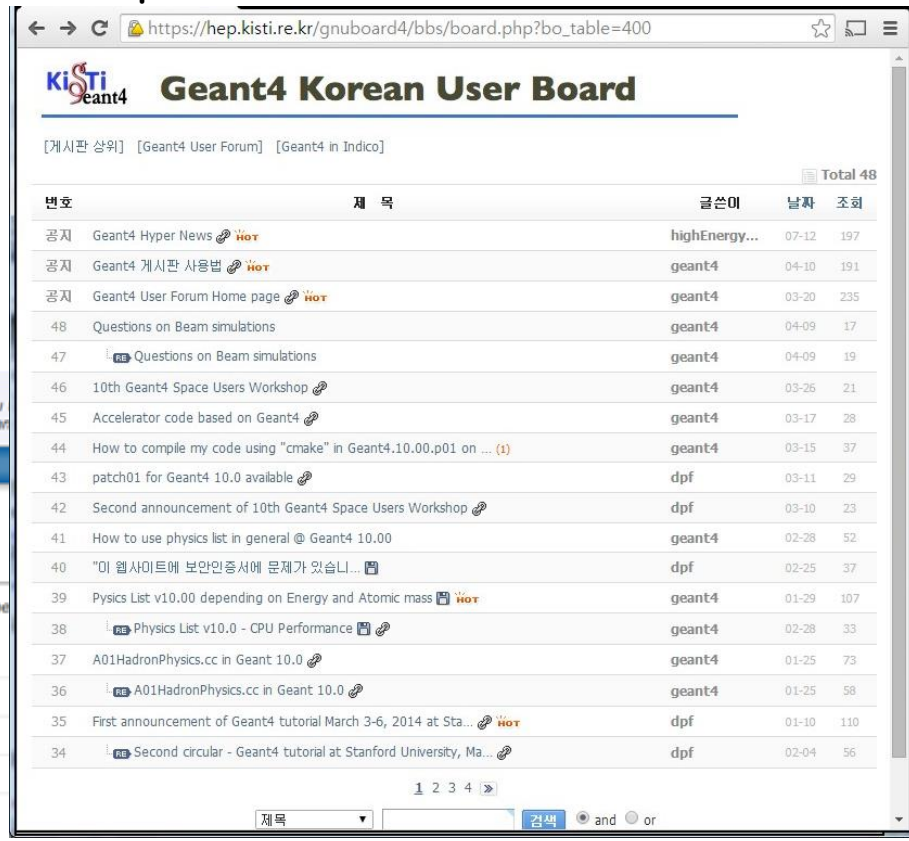
Publication date 6 December 2013

Geant4 Collaboration

Geant4 Community Supports

- To support "Geant4 Korean User Board"
  - https://hep.kisti.re.kr/gnuboard4/bbs/board.php?bo_table=400
  - 48 (25 hot) items (2013.3~2014.5)
  - French group support answers for the questions.
- Geant4 & Indico homepage
  - https://hep.kisti.re.kr/geant4
  - https://hep.kisti.re.kr/indico
- Q&A Contact person:
  hep@kisti.re.kr

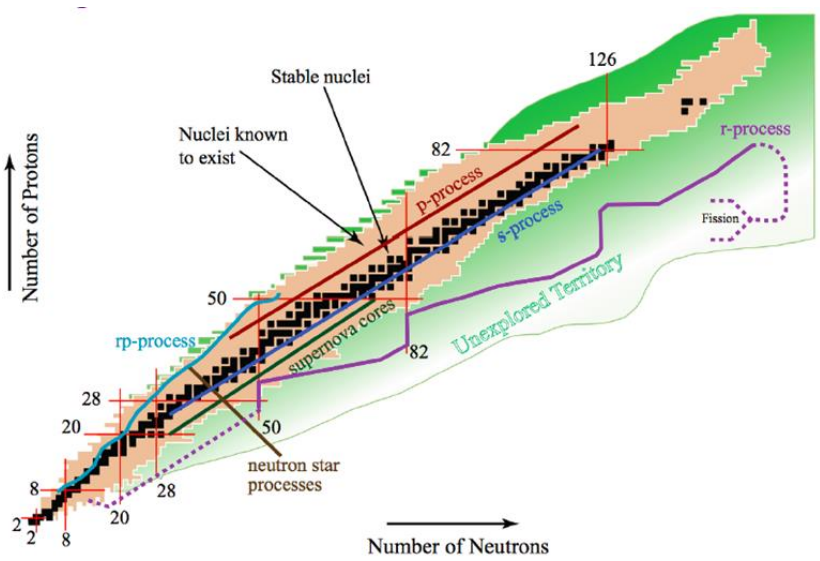


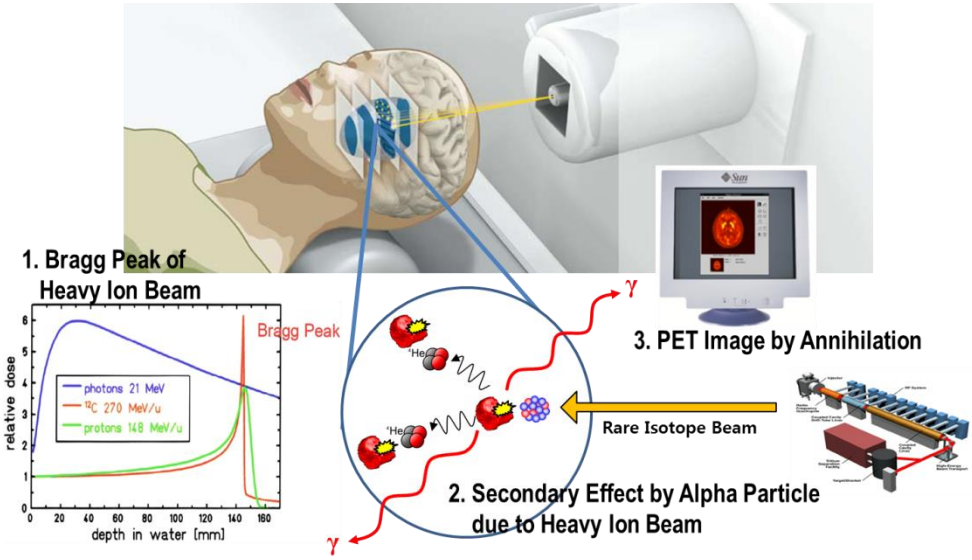


Other Products

- *Beam Simulations*
  - Kihyeon Cho and Marc Verderi, The 2nd FKPPL workshop, Yonsei University, Seoul, Korea, June 4~5, 2013
- *Geant4 Study for Heavy Ion Accelerator*
  - Kyungho Kim and Kihyeon Cho, Geant4 User Workshop, Daejeon, Korea, Feb. 22, 2013
- *Status of Geant4 at KISTI*
  - Kihyeon Cho, Geant4 User Seminar, Daejeon, Korea, April, 2, 2013
- *Geant4 at KISTI*
  - Kihyeon Cho, Seminar at Kyungpook Natonal University, Daegu, Korea, May 7, 2013
- *Geant4 Activities at KISTI*
  - Kihyeon Cho, Seminar at National Cancer Center, Ilsan, Korea, May 16, 2013
- *Heavy Ion Simulation Study of Target and Secondary Beam Using Geant4*
  - K. Kim, Y. Kwon and K. Cho, Korean Physical meeting, Changwon, Korea, Oct. 30 ~ Nov. 1, 2013

Korean Group Activities (Beam Simulations)





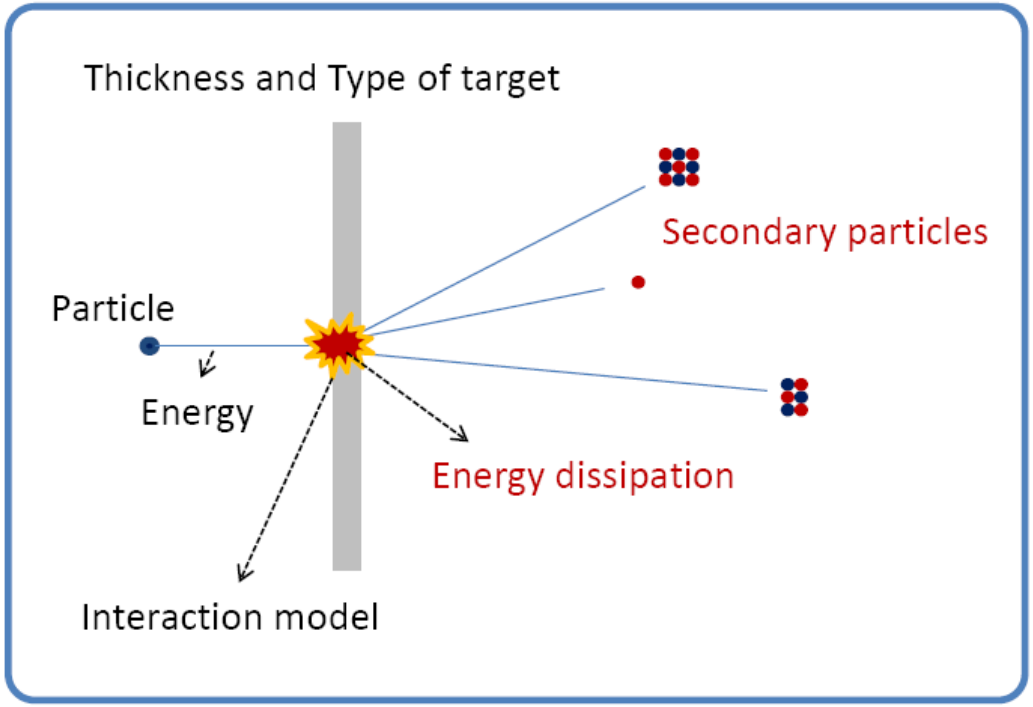
Nuclear Physics

Medical Physics

Beam Simulations (1/3)

- Goal
  1. To find optimal physics list compared to reference data
  2. Using the optimal physics, to do beam simulation
  3. To study the physics properties of secondary beam (mass, momentum, etc.) for experiments
- Beam and target
  - Beam: p, ^{12}C, …
  - Target: ^{238}U, UC, …

⇒ French Group supports physics list and event bias.



Beam Simulations (2/3)

To find optimized physics list

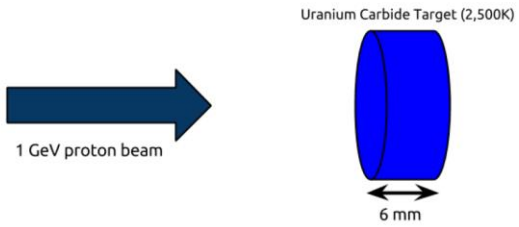
1. Simulation Environment

   a. **Geant4.10.0**

   b. **CPU**
      - AMD Athlon 64 X2 5400+ (2.8GHz)

   c. **Beam Status**
      - 2M protons
      - Energy : 1 GeV

   d. **Target Status**
      - Uranium Carbide
      - Temperature : 2,500 Kelvin
      - Shape : Cylinder (6 mm thick)



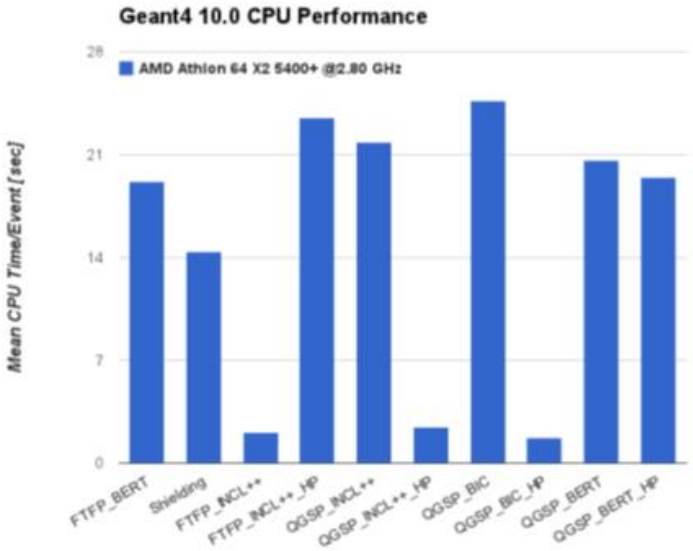
   e. **Runned Physics Lists**
      - FTFP_BERT
      - Shielding
      - FTFP_INCL++
      - FTFP_INCL++_HP
      - QGSP_INCL++
      - QGSP_INCL++_HP
      - QGSP_BIC
      - QGSP_BIC_HP
      - QGSP_BERT
      - QGSP_BERT_HP

2. Simulation Results

   a. **Number of Events**

Physics List	# of Events
FTFP_BERT	2744
Shielding	9217
FTFP_INCL++	2521
FTFP_INCL++_HP	2891
QGSP_INCL++	2528
QGSP_INCL++_HP	2754
QGSP_BIC	2420
QGSP_BIC_HP	2893
QGSP_BERT	2606
QGSP_BERT_HP	2986

   b. **CPU Performance**

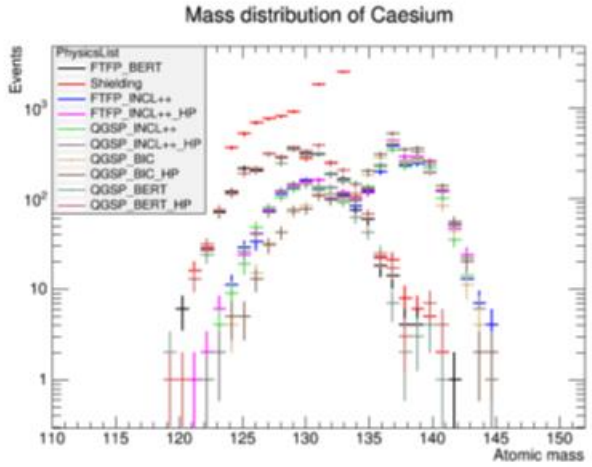


Beam Simulations

Results (Simulation)

c. Mass Distribution Released from the Target

- Cs



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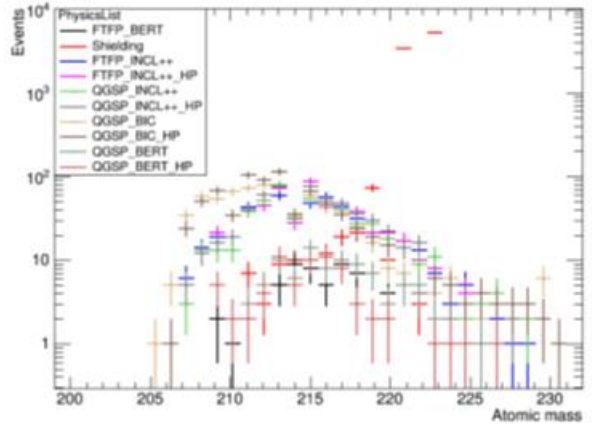
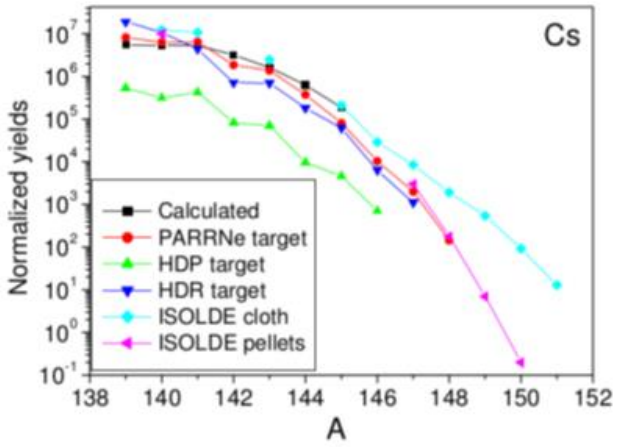


References (Experiment)

d. Mass Distribution from Reference (HDR target)
(Eur. Phys. J. Special Topics 150, 297-300 (2007))

- Cs



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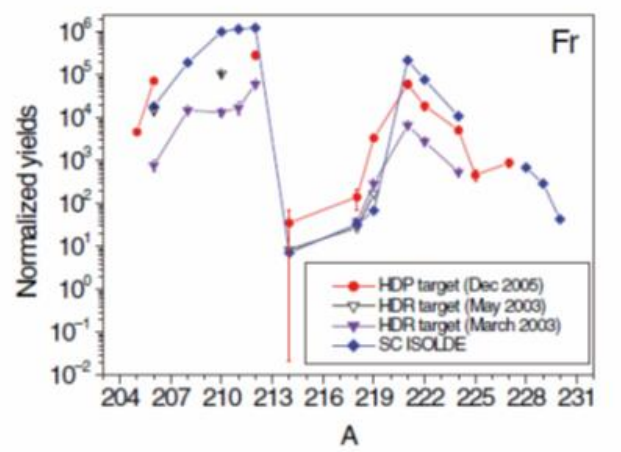
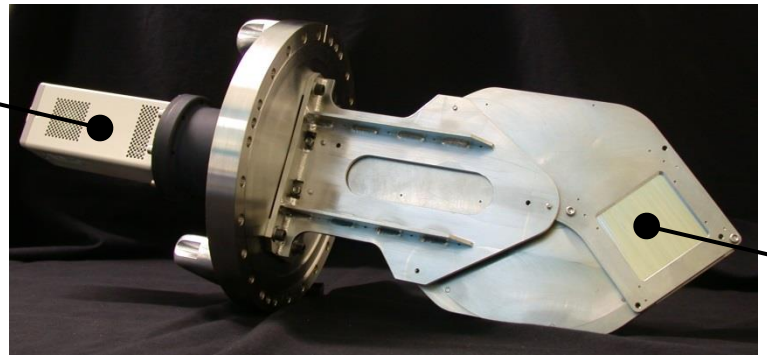


French Group Activity

French group activity (1/2)

- French group involved in development for medical beam instrumentation.
  - In the context of the French "GDR MI2B"
  - Development and delivery of beam profilers (hodoscopes made of plastic fibers + camera) used in CNAO (Pavie, Italy) and MedAustron (Wiener Neustadt, Austria). Now done.

CCD camera



Hodoscope developed by M. Haguenauer & Co., now retired.

Fiber plane (other direction plane on the other side)

- Started feasibility study of beam profiler using secondary electron emission
  - Motivated by IBA company needs

French group activity (2/2)

- Development of "event biasing" techniques in Geant4
  - Revision and uniformisation of the set of existing techniques
  - Extension to other techniques:
    - Popular in other simulation packages, but not present in Geant4 up to now
    - Biasing of physics process interaction laws
      - Allow forcing an interaction in a thin volume
      - Allow changing a process cross-section, etc.
      - Still computing a statistical weight to account for the biasing
    - Biasing in final state production
    - Both.
  - Development released in last Geant4 version 10.0 .
  - Still continuing now.
- Expecting to provide biasing functionalities at the level of other existing simulation packages
  - With the advantage of Object Oriented technologies: the user can extend the functionalities, not only use them.

Plan

We are going

1. On the scientific side:
   - To continue with beam simulation:
     - Continue assessing Geant4 physics on isotope production
       - And give feed-back to Geant4
   - Study target optimization:
     - Thick enough for good isotope yield
     - Thin enough to not having them trapped in
       - May require event biasing if target becomes very thin in the simulation
2. On the organizational side:
   1. To exchange visitors

      ⇒To stay at IN2P3/KISTI or other places for co-work
   2. To organize workshops/tutorials
   3. To perform analyses in collaboration and work together
   4. To achieve common goals

Future Conferences

- 2014 Geant4 Collaboration meeting
  - Sep. 29 ~ Oct. 4, 2014 @ Okinawa, Japan
- International Geant4 Tutorial in Seoul
  - November, 2014 @ Seoul, Korea

=> Products and off-line meetings

Thank you.