A Start of Simulation Campaign for DUSEL

Chao Zhang, USD

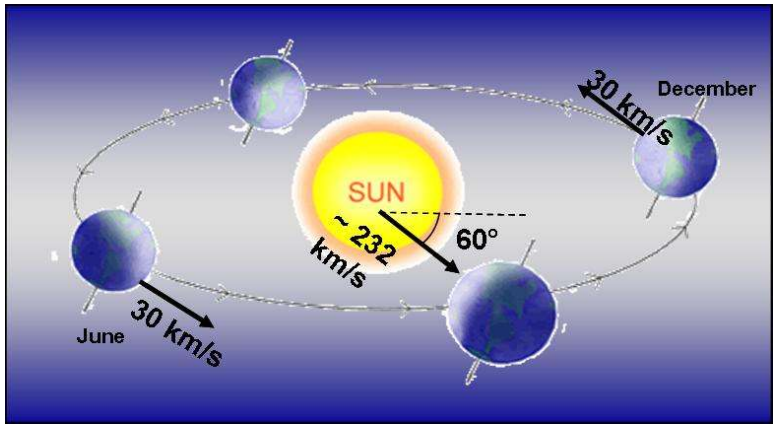
Anthony Villano, UMN

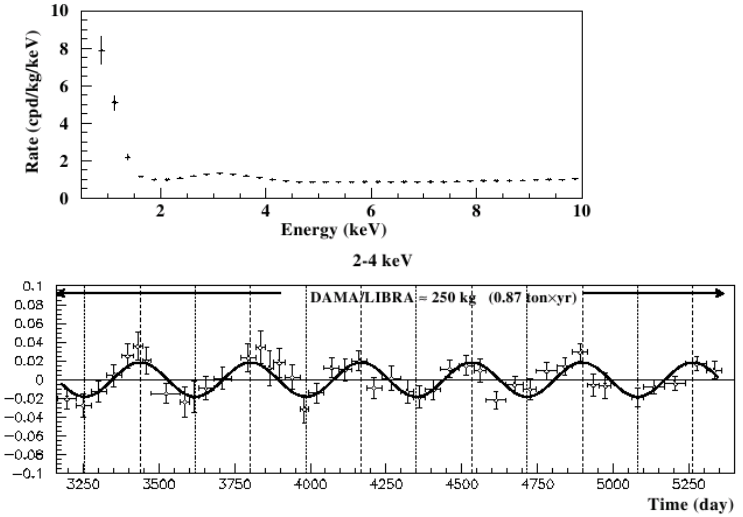
on behalf of the simulation group

AARM Collaboration Meeting --- Lead, SD, Nov 12, 2010

Why a Single Overall Simulation?

- Background/Signal estimation---shielding, detector response, final sensitivity.
- Convince people(funding agency?) to believe your prediction and result.

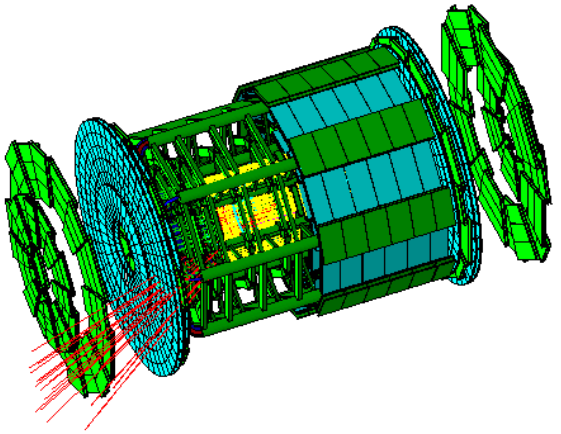




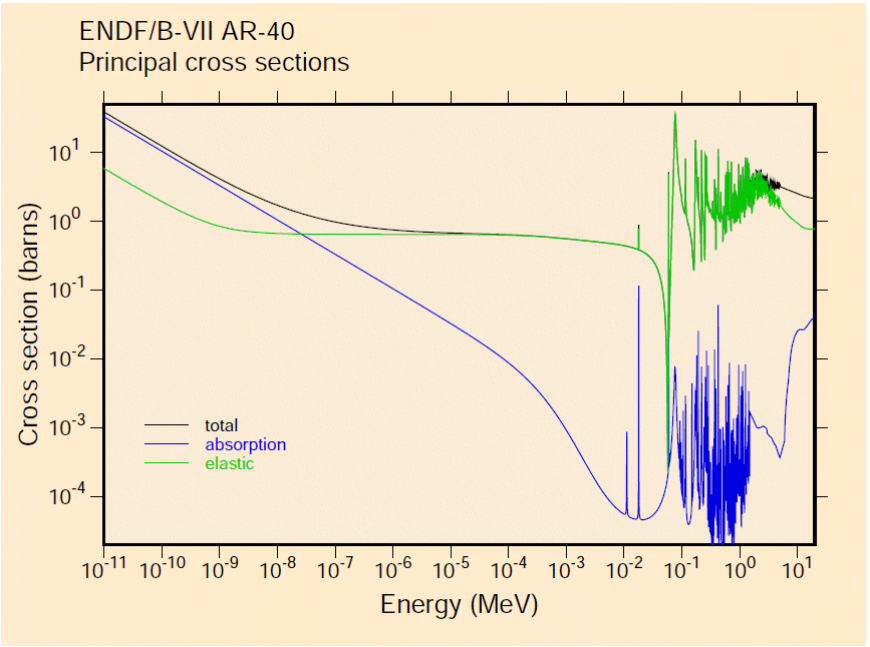
- Simulation results could be very different even for the same geometry --- different physics lists / analysis algorithms.
- Simulation results are repeatable and reusable by others. Better understanding, less duplication.

Existing Tools

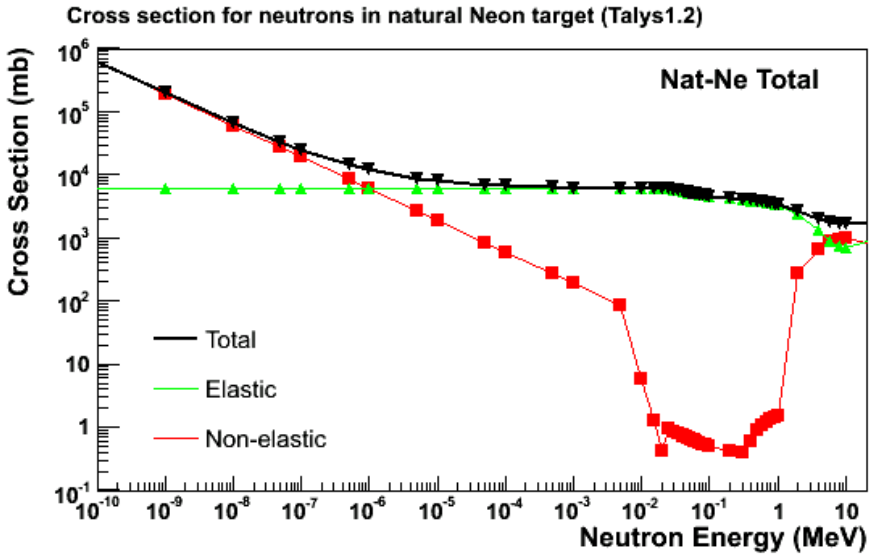
- **Geant 4**
  - Geometry and Tracking
  - A wide set of physics models



- **ENDF**
  - Evaluated Nuclear Data File



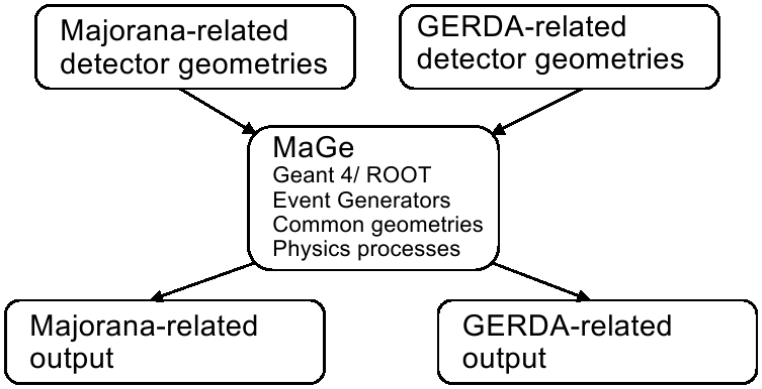
- **TALYS**
  - Calculation of nuclear reaction channels



Existing Packages

(DUSEL-related)

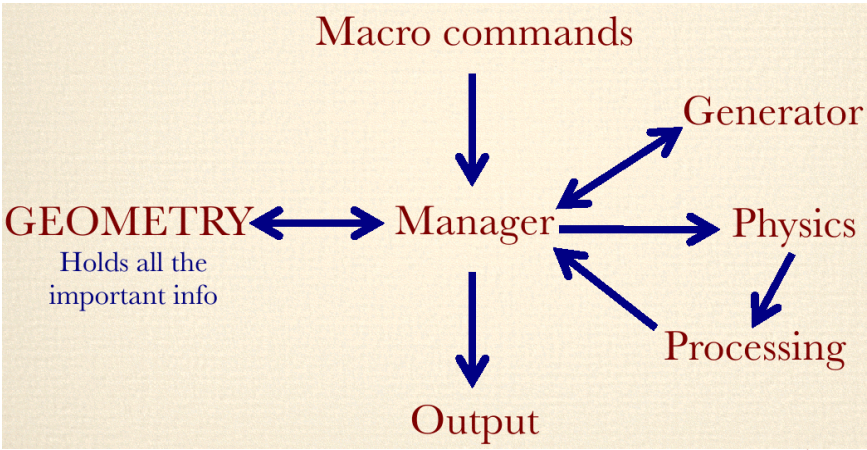
- MaGe – G4 base, integrated simulation package for GERDA and Majorana.
  - rich physical processes included
  - dedicated event generators: radioactive sources, point sources, signal sources...
  - support different geometries(include user defined) and output schemes.
  - well maintained, documented



R Henning

Rich and Robust !!!

- LUXSim – simulation package for LUX.
  - simple but rich physics list
  - component-centric approach, easily scalable to different geometries
  - multiple sources and activities
  - optimized management with sub-system
  - automatic documentation in the data file

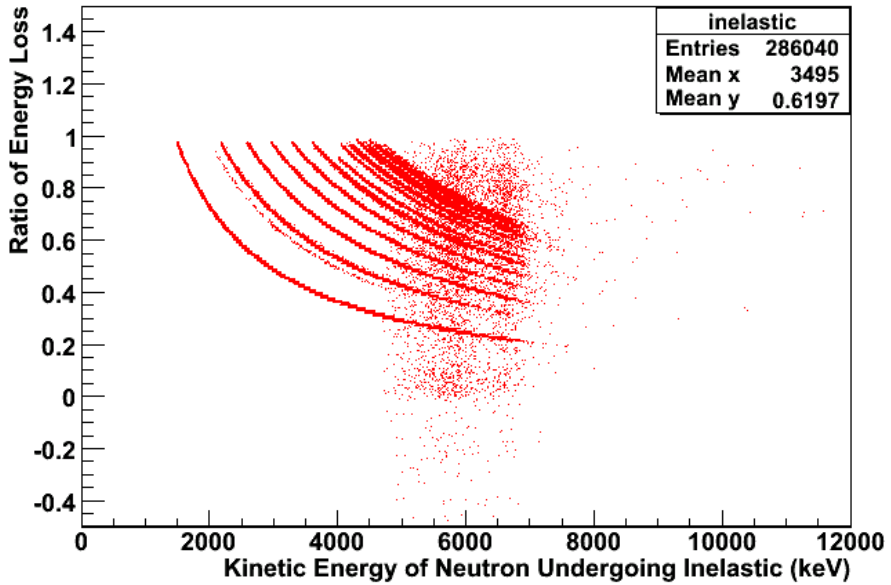


K Kazkaz

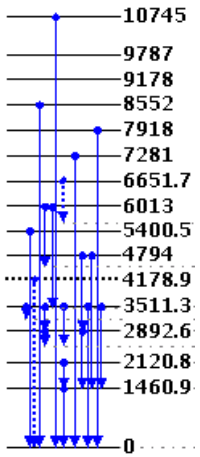
Simple and Dynamic !!!

Room for Improvement

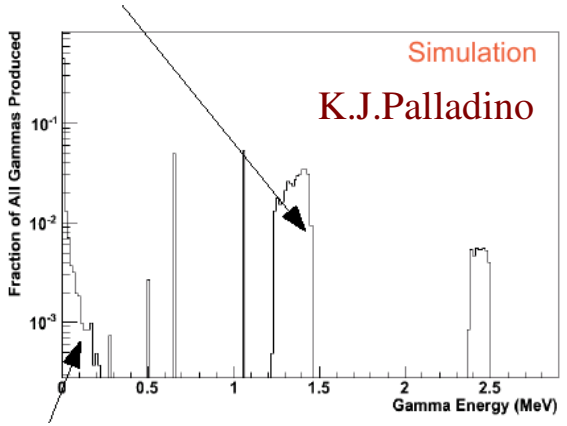
- Energy non-conservation / unexpected gamma emission



^{40}Ar Level Scheme



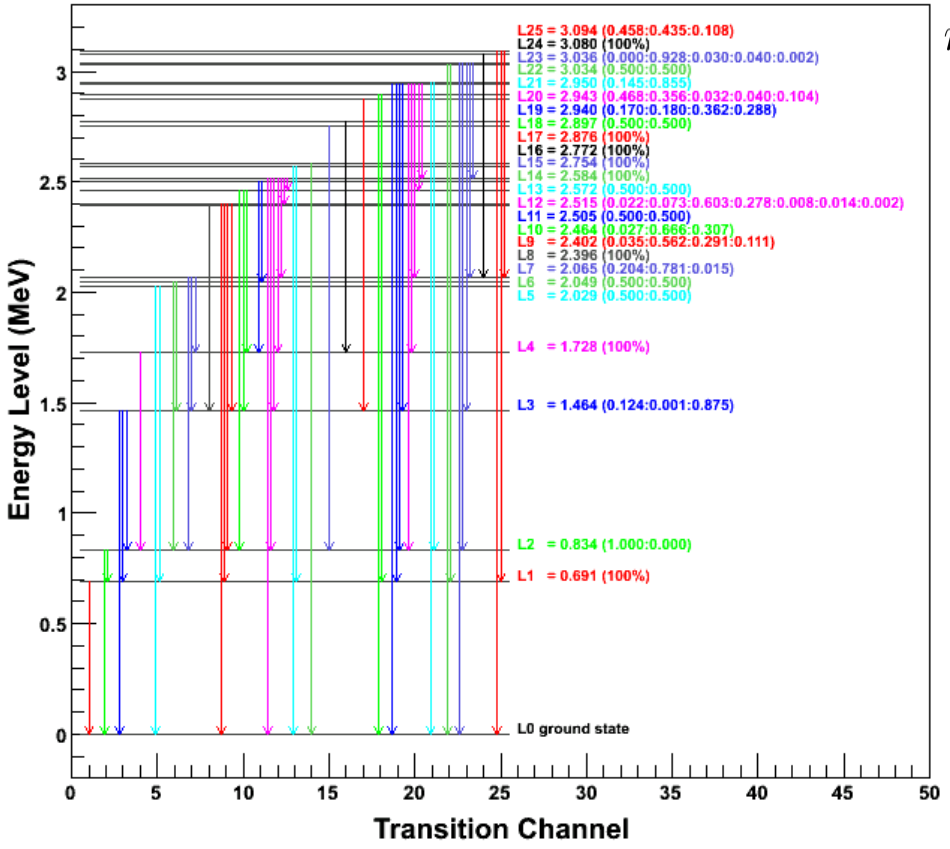
Peculiar energies of gammas from first excited state: not monoenergetic at 1460.9keV as expected.



Lots of keV gamma seems to be unphysical --- G4 bug report#1054 (http://bugzilla-geant4.kek.jp/show_bug.cgi?id=1054)

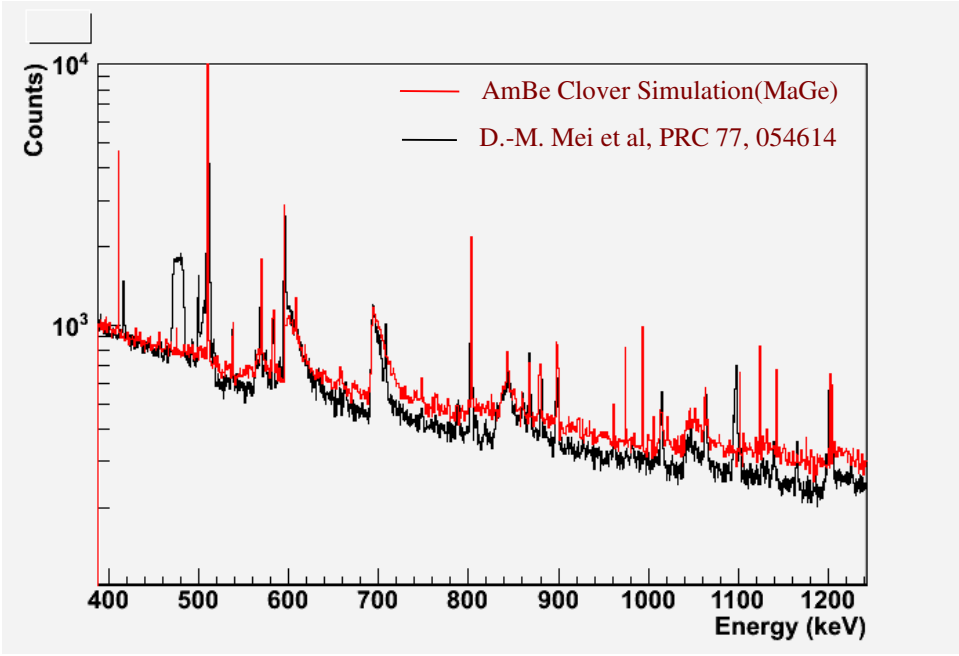
Room for Improvement

- Physical process / Database missing



$$n + {}^{72}Ge \rightarrow n' + {}^{72}Ge^{*} \rightarrow n' + {}^{72}Ge' + e^{-} + X$$

Physical process missing: G4 bug report #957 (http://bugzilla-geant4.kek.jp/show_bug.cgi?id=957)



- Add/fix the corresponding G4 code to active the process
- Supplement the corresponding database to make the processes happen

Room for Improvement

- Atomic physics / Solid state physics

Atomic-Electron Binding Energy

El	K	L_1	L_2	L_3	M_1	M_2	M_3	M_4	M_5	N_1	N_2	N_3	N_4	N_5
1 H	0.0136													
2 He	0.0246													
3 Li	0.0548	0.0053												
4 Be	0.1121	0.0080												
5 B	0.1880	0.0126	0.0047	0.0047										
6 C	0.2838	0.0180	0.0064	0.0064										
7 N	0.4016	0.0244	0.0092	0.0092										
8 O	0.5320	0.0285	0.0071	0.0071										
9 F	0.6854	0.0340	0.0086	0.0086										
10 Ne	0.8701	0.0485	0.0217	0.0216										
11 Na	1.0721	0.0633	0.0311	0.0311	0.0007									
12 Mg	1.3050	0.0894	0.0514	0.0514	0.0021									
13 Al	1.5596	0.1177	0.0732	0.0727	0.0007	0.0055	0.0055							
14 Si	1.8389	0.1487	0.0995	0.0989	0.0076	0.0030	0.0030							
15 P	2.1455	0.1893	0.1362	0.1353	0.0162	0.0099	0.0099							
16 S	2.4720	0.2292	0.1654	0.1642	0.0158	0.0080	0.0080							
17 Cl	2.8224	0.2702	0.2016	0.2000	0.0175	0.0068	0.0068							
18 Ar	3.2060	0.3263	0.2507	0.2486	0.0292	0.0159	0.0158							
19 K	3.6074	0.3771	0.2963	0.2936	0.0339	0.0178	0.0178							
20 Ca	4.0381	0.4378	0.3500	0.3464	0.0437	0.0254	0.0254							
21 Sc	4.4928	0.5004	0.4067	0.4022	0.0538	0.0323	0.0323	0.0066	0.0066					
22 Ti	4.9664	0.5637	0.4615	0.4555	0.0603	0.0346	0.0346	0.0037	0.0037					
23 V	5.4651	0.6282	0.5205	0.5129	0.0665	0.0378	0.0378	0.0022	0.0022					
24 Cr	5.9892	0.6946	0.5837	0.5745	0.0741	0.0425	0.0425	0.0023	0.0023					
25 Mn	6.5390	0.7690	0.6514	0.6403	0.0839	0.0486	0.0486	0.0033	0.0033					
26 Fe	7.1120	0.8461	0.7211	0.7081	0.0929	0.0540	0.0540	0.0036	0.0036					
27 Co	7.7089	0.9256	0.7936	0.7786	0.1007	0.0595	0.0595	0.0029	0.0029					
28 Ni	8.3328	1.0081	0.8719	0.8547	0.1118	0.0681	0.0681	0.0036	0.0036					
29 Cu	8.9789	1.0961	0.9510	0.9311	0.1198	0.0736	0.0736	0.0016	0.0016					
30 Zn	9.6586	1.1936	1.0428	1.0197	0.1359	0.0866	0.0866	0.0081	0.0081					
31 Ga	10.3671	1.2977	1.1423	1.1154	0.1581	0.1068	0.1029	0.0174	0.0174	0.0015	0.0008	0.0008		
32 Ge	11.1031	1.4143	1.2478	1.2167	0.1800	0.1279	0.1208	0.0287	0.0287	0.0050	0.0023	0.0023		
33 As	11.8667	1.5265	1.3586	1.3231	0.2035	0.1464	0.1405	0.0412	0.0412	0.0085	0.0025	0.0025		
34 Se	12.6578	1.6539	1.4762	1.4358	0.2315	0.1682	0.1619	0.0567	0.0567	0.0120	0.0056	0.0056		
35 Br	13.4737	1.7820	1.5960	1.5499	0.2565	0.1893	0.1815	0.0701	0.0690	0.0273	0.0052	0.0046		
36 Kr	14.3256	1.9210	1.7272	1.6749	0.2921	0.2218	0.2145	0.0950	0.0938	0.0275	0.0147	0.0140		
37 Rb	15.1997	2.0651	1.8639	1.8044	0.3221	0.2474	0.2385	0.1118	0.1103	0.0293	0.0148	0.0140		
38 Sr	16.1046	2.2163	2.0068	1.9396	0.3575	0.2798	0.2691	0.1350	0.1331	0.0377	0.0199	0.0199		
39 Y	17.0384	2.3725	2.1555	2.0800	0.3936	0.3124	0.3003	0.1596	0.1574	0.0454	0.0256	0.0256	0.0024	0.0024
40 Zr	17.9976	2.5316	2.3067	2.2223	0.4303	0.3442	0.3305	0.1824	0.1800	0.0513	0.0287	0.0287	0.0030	0.0030
41 Nb	18.9856	2.6977	2.4647	2.3705	0.4684	0.3784	0.3630	0.2074	0.2046	0.0581	0.0339	0.0339	0.0032	0.0032
42 Mo	19.9995	2.8655	2.6251	2.5202	0.5046	0.4097	0.3923	0.2303	0.2270	0.0618	0.0348	0.0348	0.0018	0.0018
43 Tc	21.0440	3.0425	2.7932	2.6769	0.5440	0.4449	0.4250	0.2564	0.2529	0.0680	0.0389	0.0389	0.0020	0.0020
44 Ru	22.1172	3.2240	2.9669	2.8379	0.5850	0.4828	0.4606	0.2836	0.2794	0.0749	0.0431	0.0431	0.0020	0.0020
45 Rh	23.2199	3.4119	3.1461	3.0038	0.6271	0.5210	0.4962	0.3117	0.3070	0.0810	0.0479	0.0479	0.0025	0.0025

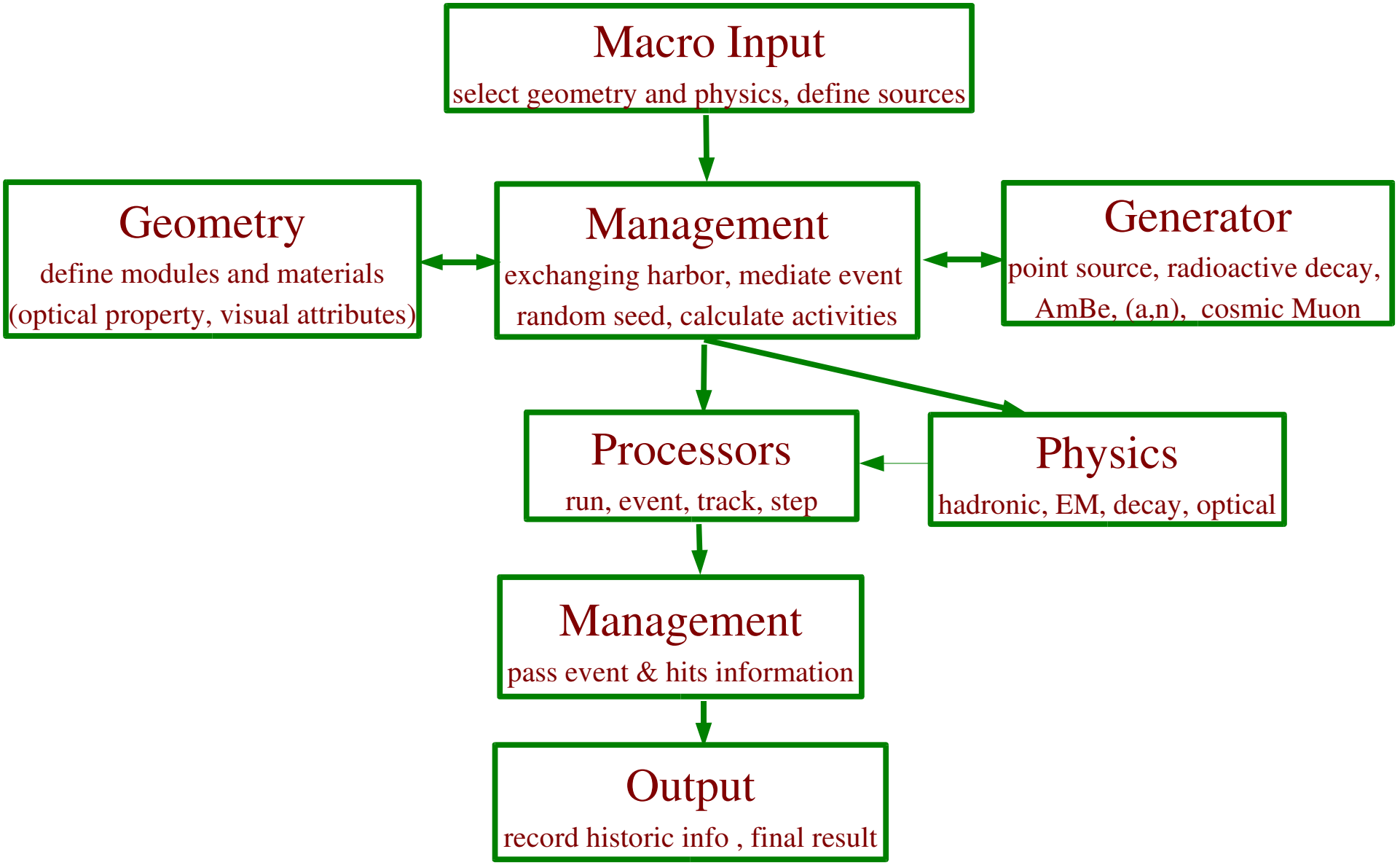
Wishlist for Simulation Package

1. Uniformed simulation framework with the capability to easily load different geometry modules.
2. Include all known physical processes.
3. Add low energy atomic / solid state physics and database.
4. Physical processes and databases are well checked with experimental data(especially for neutron), element by element. If not exist, fix or supplement it.
5. Compatible with different platform. Multiple input sources with single repeatable output(binary file?). Multiple readers to convert output (ROOT, MATLAB?).
6. ...

Simulation preparation

- GEANT4 base v4.9.3 ?
- Simulation version control: SVN repository?
- Where to host the code ?
- A webpage to post information and organize the working group(mailing list?).
- Once simulation structure code is ready, subdivide jobs to various task leaders.
- Manpower?

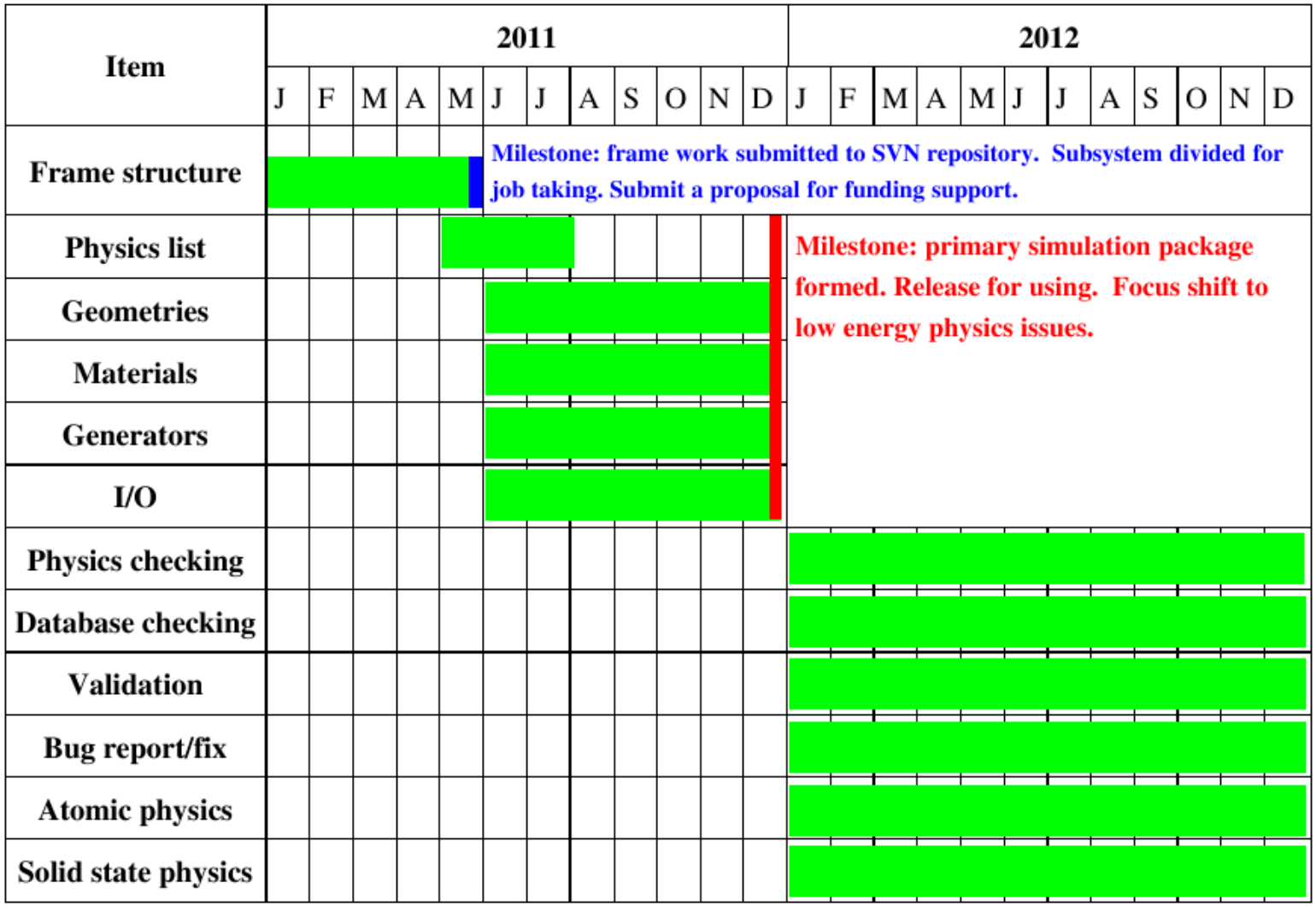
Simulation Structure



Job Dividing

- GEANT4 based simulation architecture code and management
- Physics list and database crosscheck
- Materials(optical property?) and Geometry
- Event Generators
- Input/Output
- Result: comparison/validation
- SVN administration
- ???

Road Map


Item
2011
2012
J F M A M J J A S O N D J F M A M J J A S O N D
Frame structure
Milestone: frame work submitted to SVN repository. Subsystem divided for job taking. Submit a proposal for funding support.
Physics list
Geometries
Materials
Generators
I/O
Milestone: primary simulation package formed. Release for using. Focus shift to low energy physics issues.
Physics checking
Database checking
Validation
Bug report/fix
Atomic physics
Solid state physics

Simulation Workshop Plan

- A simulation workshop planned to be held at USD, spring 2011.
  - Discuss the simulation needs from the community
  - Discuss the draft of the proposal
  - Discuss the whole management and tasks assignment
- USD Resources
  - A high performance computing cluster:

    128 processing cores

    26 compute nodes

    dedicated gigabit ethernet compute and storage networks
  - Manpower

    Douglas Jennewein --- Computer Research Analyst

    Dongming Mei --- Faculty supervisor

    Chao Zhang --- Postdoc

    Oleg Perevozchikov --- Posdoc

    Wenchang Xiang --- Posdoc

Thanks For Your Attention!

Questions?

Backup Slides