GEMC Status

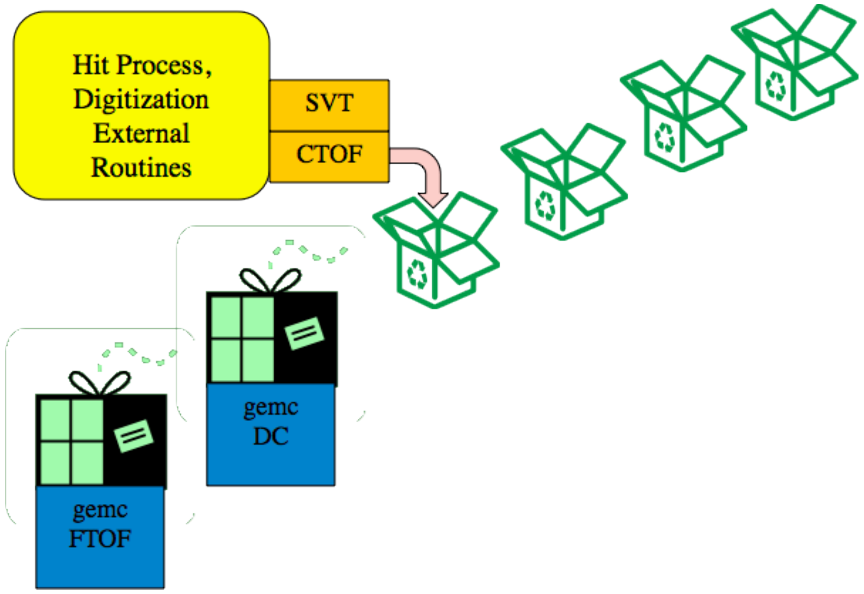
CCDB and geant4 digitization

Share Geometry between simulation/reconstruction

Code updates

Documentation and Roadmap

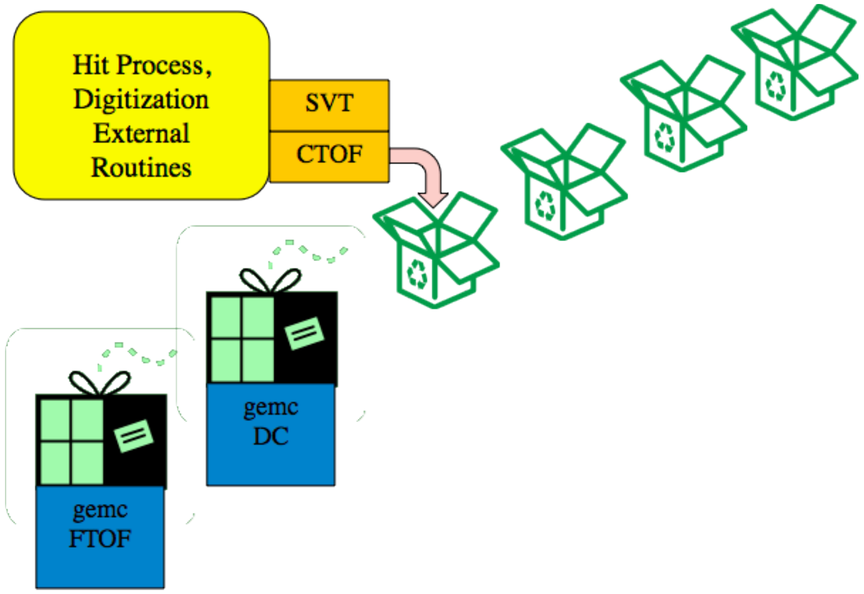
CCDB and geant4 digitization



CCDB and geant4 digitization

User/Detector Defined:

- **Load calibration constants from DB**
- Identify Element hit
- Share Hit Energy
- Digitize Detector Response in Time Window
- Produce Electronic Noise (new!)



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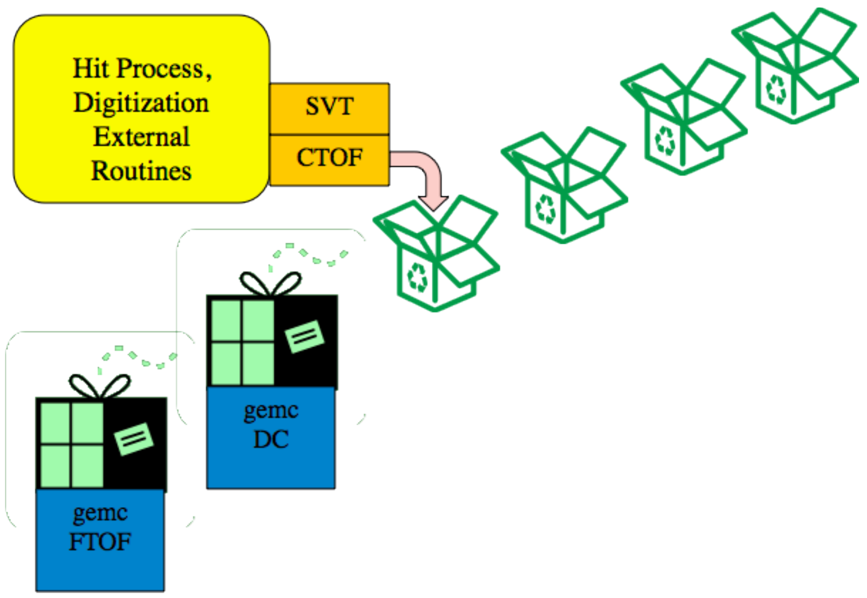

CCDB
Data

Simulation, CED

Reconstruction

Calibration, Monitoring

CCDB and geant4 digitization

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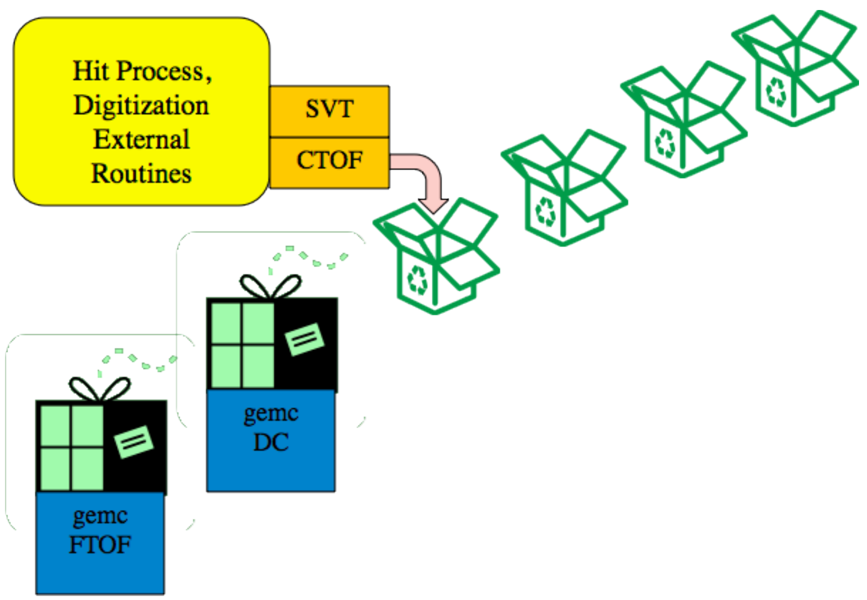


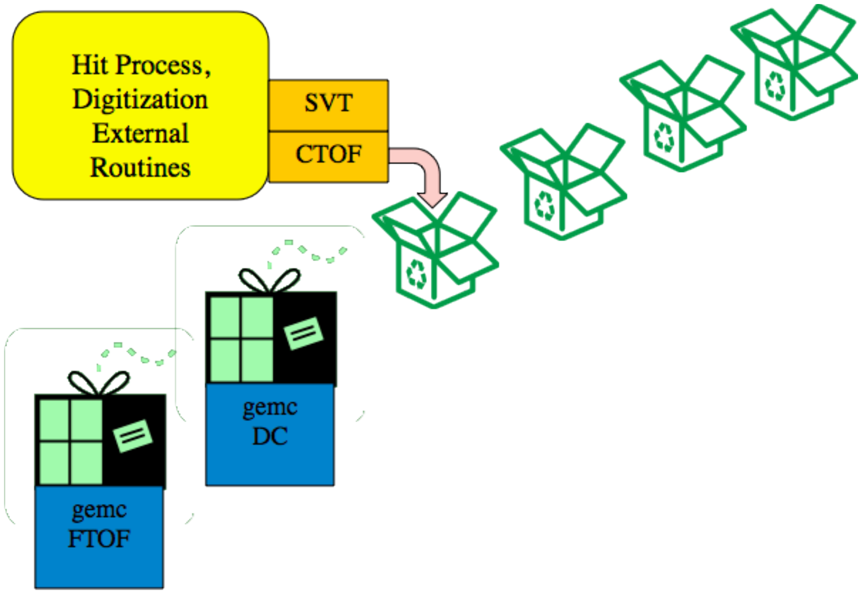
CCDB

```
connection = “mysql://clas12reader@clasdb.jlab.org/clas12";
```

CCDB and geant4 digitization

User/Detector Defined:

- **Load calibration constants from DB**
- Identify Element hit
- Share Hit Energy
- Digitize Detector Response in Time Window
- Produce Electronic Noise (new!)



CCDB

```
connection = “mysql://clas12reader@clasdb.jlab.org/clas12";
```

CCDB_CONNECTION

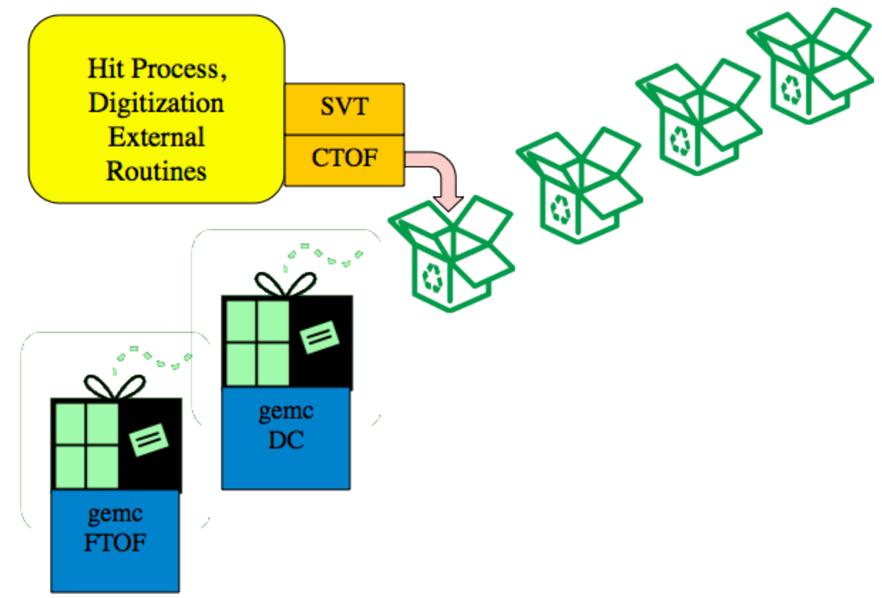
```
connection —> $CCDB_CONNECTION
```

useful for offline, sqlite

CCDB and geant4 digitization

User/Detector Defined:

- **Load calibration constants from DB**
- Identify Element hit
- Share Hit Energy
- Digitize Detector Response in Time Window
- Produce Electronic Noise (new!)



CCDB

```
connection = “mysql://clas12reader@clasdb.jlab.org/clas12";
```

Database

```
database = "/calibration/ec/attenuation";
```

EC (Cole Smith)

```
database = "/calibration/ec/attenuation";
```

```
+------------------------------------------+
| Type table information                   |
+------------------------------------------+
 Name       :  attenuation
 Full path  :  /calibration/ec/attenuation
 Rows       :  2448
 Columns    :  6
 Created    :  2016-02-12 16-25-20
 Modified   :  2016-02-12 16-25-20
 DB Id      :  152
+------------------------------------------+
| Columns info                             |
+------------------------------------------+

Columns info
 N.   (type)    : (name)
 0    int       : sector
 1    int       : layer
 2    int       : component
 3    double    : A
 4    double    : B
 5    double    : C

+------------------------------------------+
Comment:
 FADC light attenuation A*exp(-x/B)+C. A+C
normalized to 1. Fitted to data of MIP
centroid vs. distance to PMT (x). Units of B
are cm.
```

/> cat /calibration/ec/attenuation:11

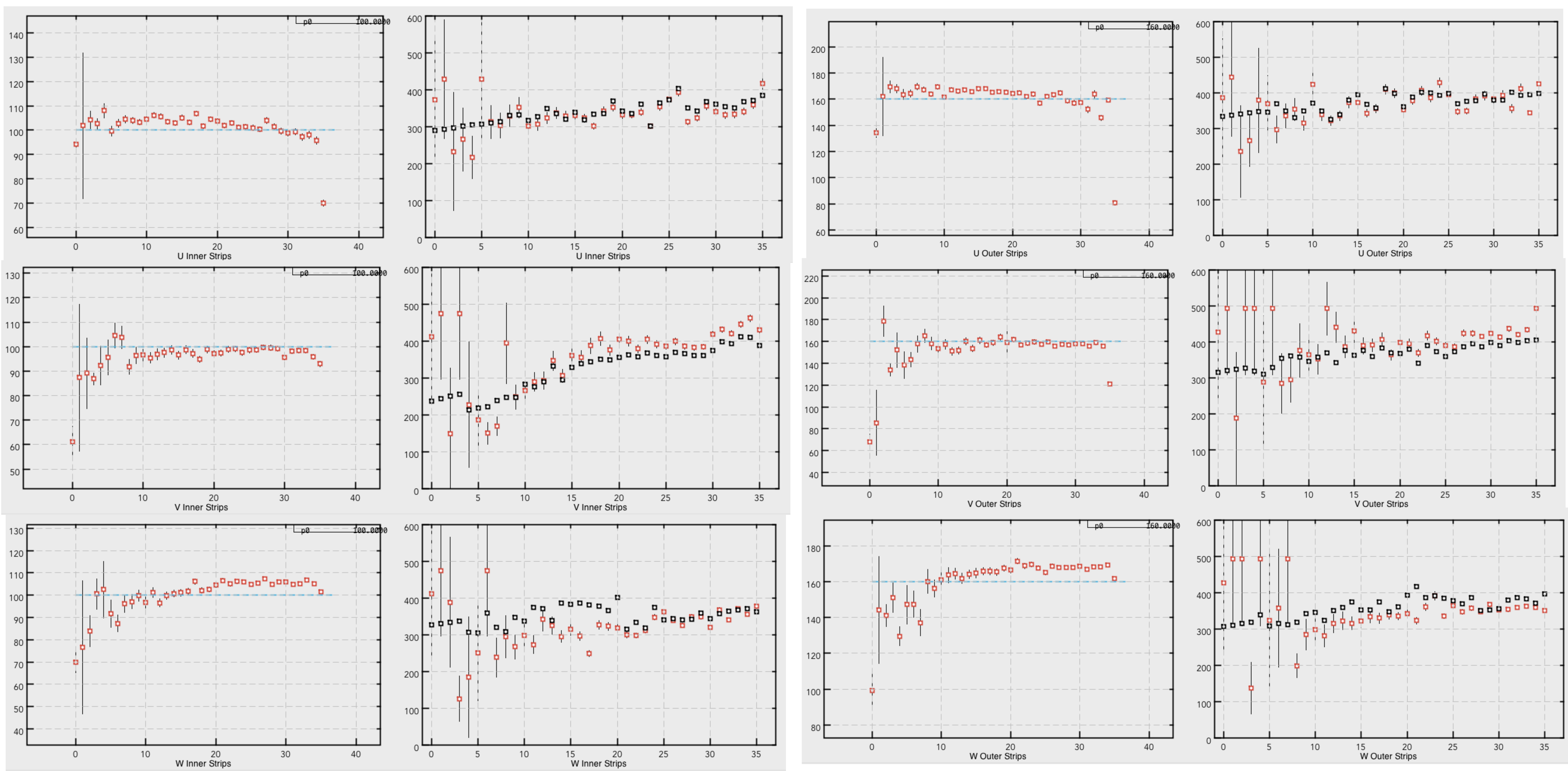
sector int	layer int	component int	A double	B double	C double
1	1	1	1.00	376.00	0.00
1	1	2	1.00	376.00	0.00
2	2	17	0.72	185.87	0.28
2	2	18	0.65	157.73	0.35
2	2	19	0.89	273.97	0.11
2	2	20	0.81	224.21	0.19
2	2	21	0.75	221.24	0.25
2	2	22	0.81	239.23	0.19
2	2	23	0.77	215.05	0.23
2	2	24	0.74	199.60	0.26
2	2	25	0.78	211.42	0.22
2	2	26	0.74	206.19	0.26
2	2	27	0.76	204.92	0.24
2	2	28	0.74	202.02	0.26
2	2	29	0.76	197.63	0.24

EC (Cole Smith)

Gains

GEMC attenuation

ECMon fit to simulated data



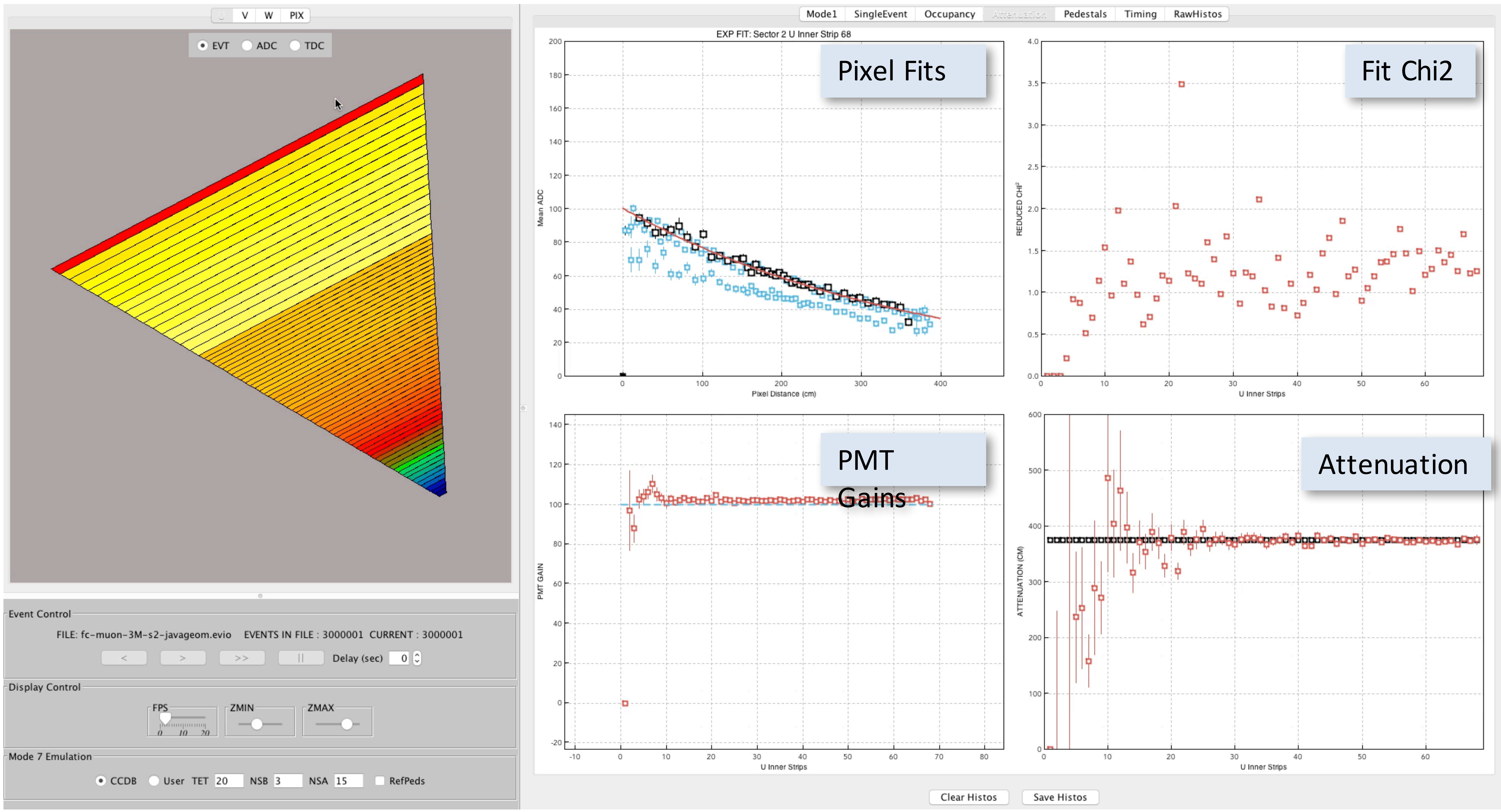
EC Inner

EC Outer

EC (Cole Smith)

- **GEMC** simulations generate muon tracks.
- Same PCAL/EC geometry used in both simulation and reconstruction.
- Validate **ECMon** attenuation and PMT gain extraction algorithm.
- Estimate time and statistics needed to extract 5% calibration from cosmic runs.

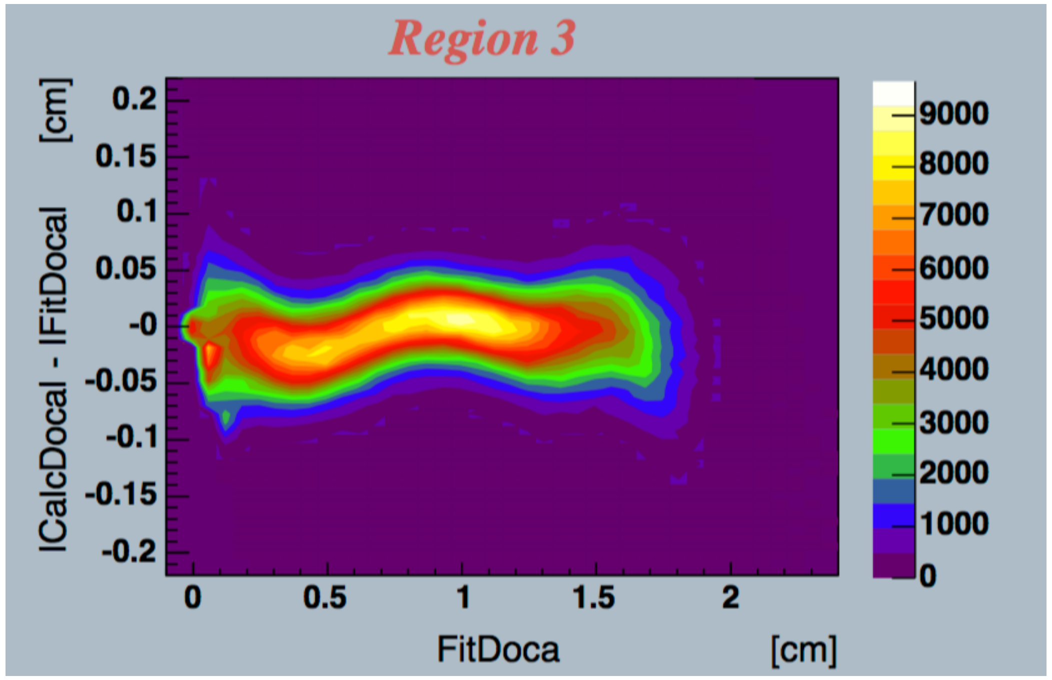
PCAL 3M muon events



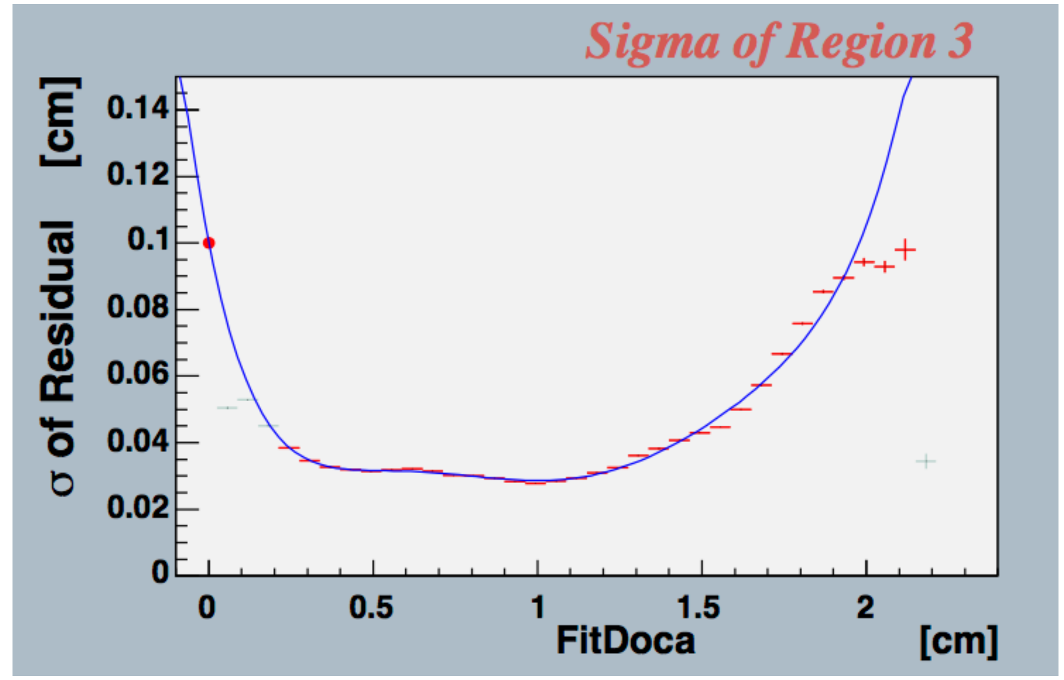
CCDB pars used by full chain: RECO > MON

DC (M. Mestayer, K. Adhikari)

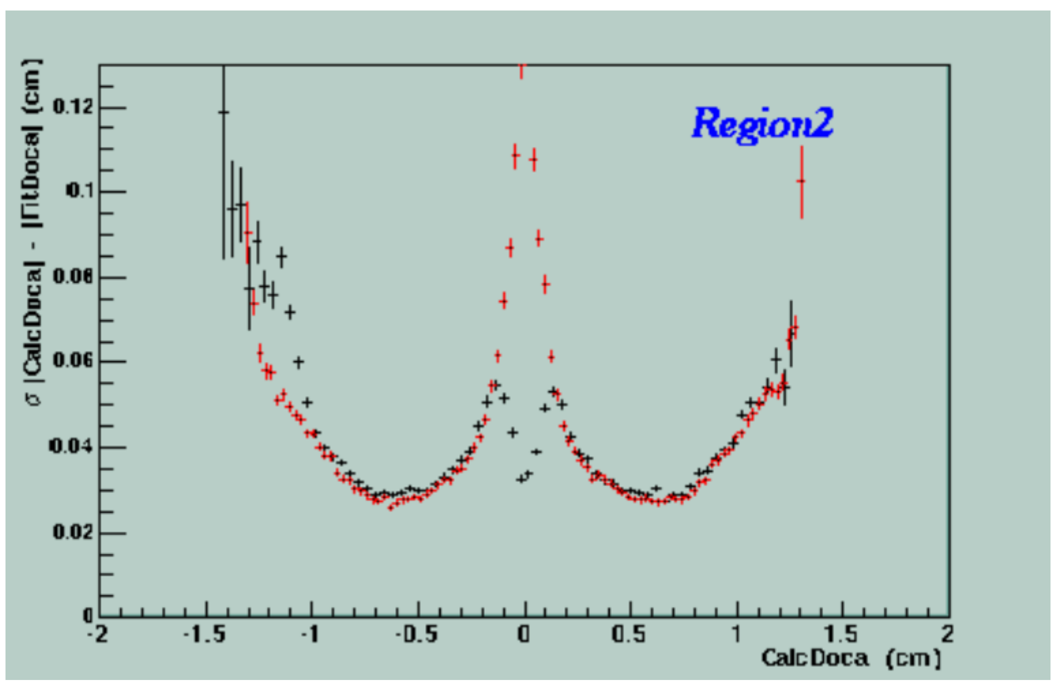
CLAS6: gpp parameters, a,b,c



residual vs fitdoca



σ of residual vs fitdoca



σ of residual vs calcdoca data/gsim

a,b,c = 1
to match dc
response to data

DC (M. Mestayer, K. Adhikari)

`database = "/calibration/dc/signal_generation/dc_resolution";`

```
+-------------------------------------------+
| Type table information                    |
+-------------------------------------------+
 Name       :  dc_resolution
 Full path  :  /calibration/dc/
signal_generation/dc_resolution
 Rows       :  36
 Columns    :  7
 Created    :  2016-03-31 14-31-34
 Modified   :  2016-03-31 14-31-34
 DB Id      :  203
+-------------------------------------------+
| Columns info                              |
+-------------------------------------------+

Columns info
 N.   (type)     : (name)
 0    int        : Sector
 1    int        : Superlayer
 2    double     : parameter1
 3    double     : parameter2
 4    double     : parameter3
 5    double     : parameter4
 6    double     : scale

+-------------------------------------------+
```

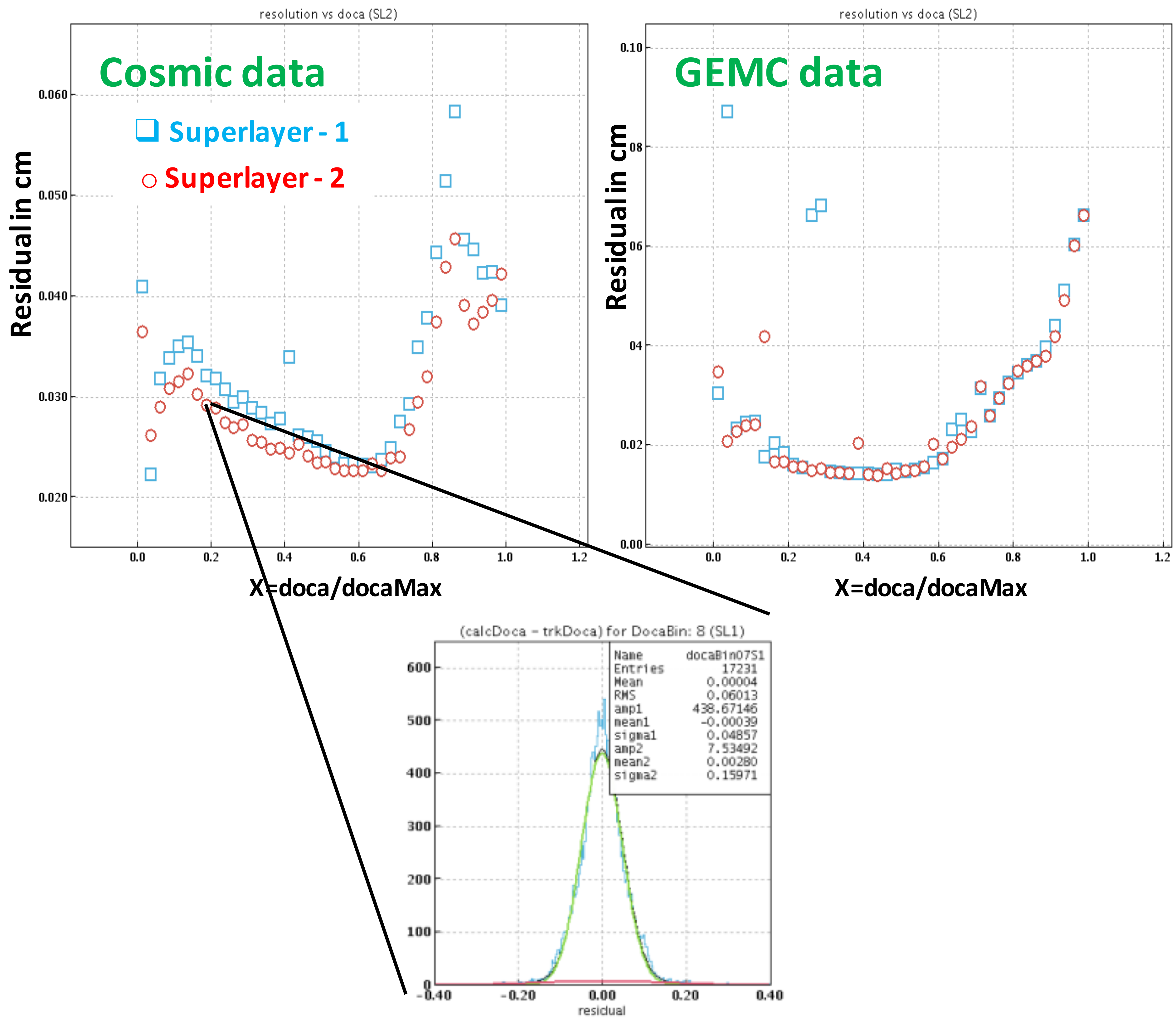
/>/calibration/dc/signal_generation> cat dc_resolution

Sector int	Superlayer int	parameter1 double	parameter2 double	parameter3 double	parameter4 double	scale double
1	1	0.16	0.005	0.1	0.8	1.0
1	2	0.16	0.005	0.1	0.8	1.0
1	3	0.16	0.005	0.1	0.8	1.0
1	4	0.16	0.005	0.1	0.8	1.0
1	5	0.16	0.005	0.1	0.8	1.0
1	6	0.16	0.005	0.1	0.8	1.0
2	1	0.16	0.005	0.1	0.8	1.0
2	2	0.16	0.005	0.1	0.8	1.0
2	3	0.16	0.005	0.1	0.8	1.0
2	4	0.16	0.005	0.1	0.8	1.0
2	5	0.16	0.005	0.1	0.8	1.0
2	6	0.16	0.005	0.1	0.8	1.0
3	1	0.16	0.005	0.1	0.8	1.0
3	2	0.16	0.005	0.1	0.8	1.0
3	3	0.16	0.005	0.1	0.8	1.0
3	4	0.16	0.005	0.1	0.8	1.0
3	5	0.16	0.005	0.1	0.8	1.0
3	6	0.16	0.005	0.1	0.8	1.0
4	1	0.16	0.005	0.1	0.8	1.0
4	2	0.16	0.005	0.1	0.8	1.0
4	3	0.16	0.005	0.1	0.8	1.0
4	4	0.16	0.005	0.1	0.8	1.0
4	5	0.16	0.005	0.1	0.8	1.0
4	6	0.16	0.005	0.1	0.8	1.0
5	1	0.16	0.005	0.1	0.8	1.0
5	2	0.16	0.005	0.1	0.8	1.0
5	3	0.16	0.005	0.1	0.8	1.0
5	4	0.16	0.005	0.1	0.8	1.0
5	5	0.16	0.005	0.1	0.8	1.0
5	6	0.16	0.005	0.1	0.8	1.0
6	1	0.16	0.005	0.1	0.8	1.0
6	2	0.16	0.005	0.1	0.8	1.0
6	3	0.16	0.005	0.1	0.8	1.0
6	4	0.16	0.005	0.1	0.8	1.0
6	5	0.16	0.005	0.1	0.8	1.0
6	6	0.16	0.005	0.1	0.8	1.0

Same parameters used by reconstruction (weight/error)

DC (M. Mestayer, K. Adhikari)

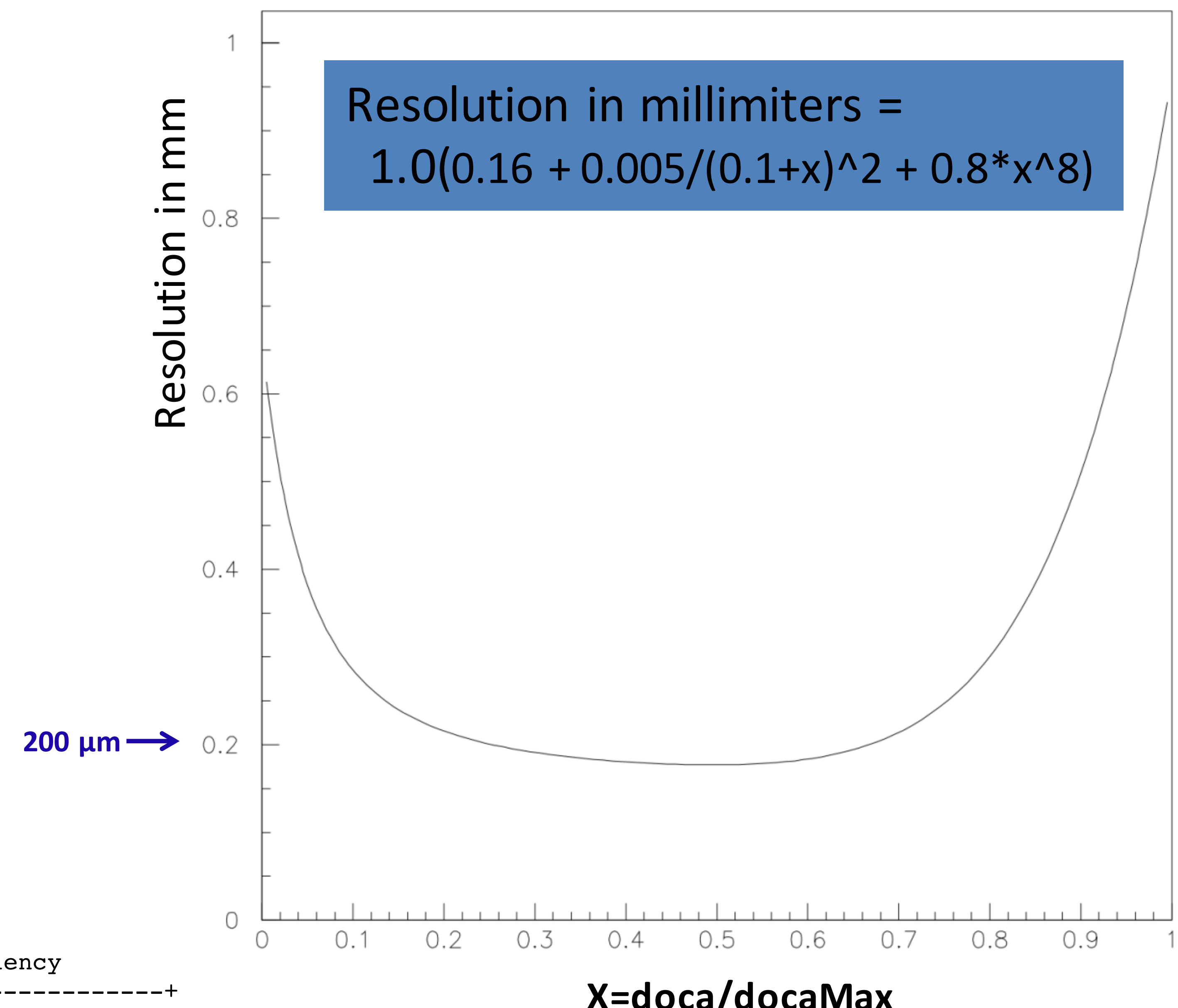
Comparison of DC-resolution with Cosmic & GEMC data



DC (M. Mestayer, K. Adhikari)

```
database = "/calibration/dc/signal_generation/intrinsic_inefficiency";
```

```
+----------------------------------------+
| Type table information                 |
+----------------------------------------+
 Name        :  intrinsic_inefficiency
 Full path   :  /calibration/dc
                /signal_generation
                /intrinsic_inefficiency
 Rows        :  6
 Columns     :  6
 Created     :  2016-03-31 14-31-09
 Modified    :  2016-03-31 14-31-09
 DB Id       :  202
+----------------------------------------+
| Columns info                           |
+----------------------------------------+

Columns info
 N.   (type)      : (name)
 0    int         : Superlayer
 1    double      : parameter1
 2    double      : parameter2
 3    double      : parameter3
 4    double      : parameter4
 5    double      : scale

+----------------------------------------+
```



/> cat /calibration/dc/signal_generation/intrinsic_inefficiency

Superlayer int	parameter1 double	parameter2 double	parameter3 double	parameter4 double	scale double
1	1.25e-4	0.05	25.0e-4	0.15	0.0
2	1.25e-4	0.05	25.0e-4	0.15	0.0
3	1.25e-4	0.05	25.0e-4	0.15	0.0
4	1.25e-4	0.05	25.0e-4	0.15	0.0
5	1.25e-4	0.05	25.0e-4	0.15	0.0
6	1.25e-4	0.05	25.0e-4	0.15	0.0

CTOF, FTOF (D. Carman, C. Smith, R. DeVita)

`database = "/calibration/ftof/attenuation";`

ADC:

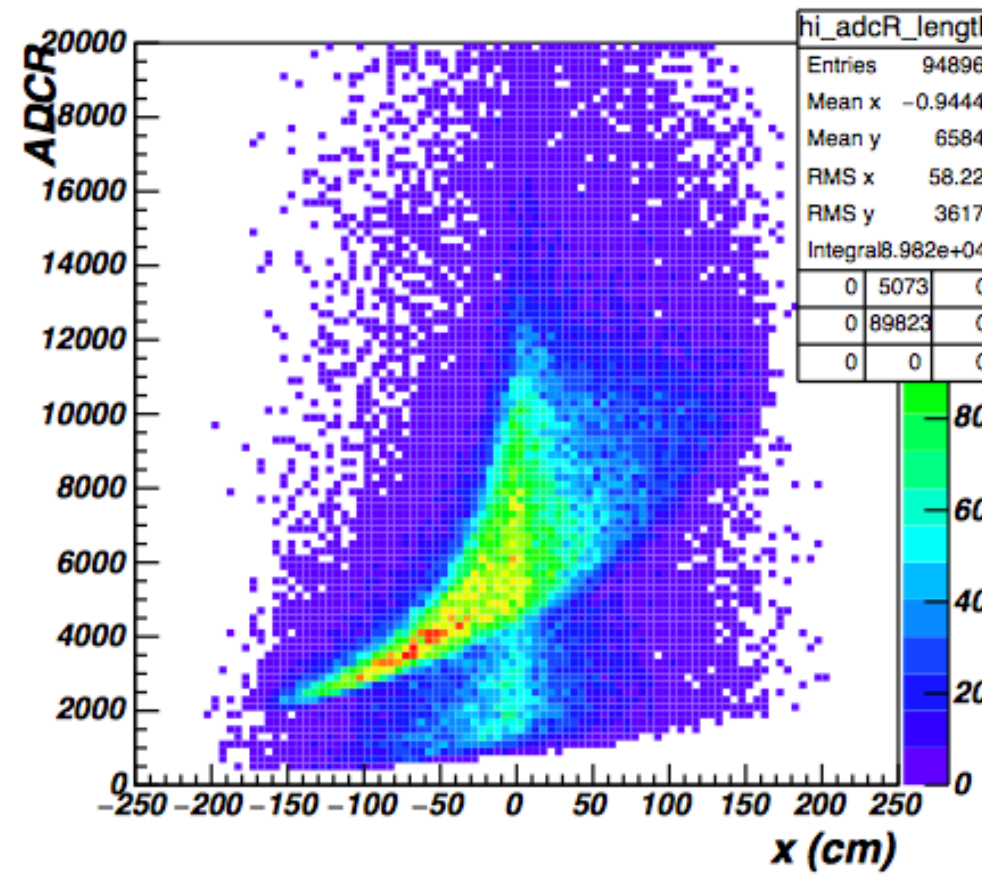
- Attenuation according to exponential law
- Conversion from energy to ADC based on MIP signal (dEdxMIP=2 MeV/cm, countsForAMinimumIonizing=2000)

TDC:

- Delay due to light propagation in the paddle (effective velocity)
- Parameterized Time Walk
- Gaussian time spread based on parameters that will be matched to data ($\sigma 2=\sigma 02+\sigma 12/\sqrt{}EPMT$ Conversion from time to TDC (time2tdc=20ns−1)

Output: both "smeared" and "unsmeared" TDCs

Status:
0 – fully functioning
1 – noADC
2 – noTDC
3 – noADC, noTDC (PMT is dead)
5 – any other reconstruction problem



EC, PCAL, CTOF, FTOF, DC connects to CCDB

can use these digitization routines as template

Sharing Geometry Parameters

A. Kim

Mother Parameters

COATJAVA

GEMC

C++
Perl

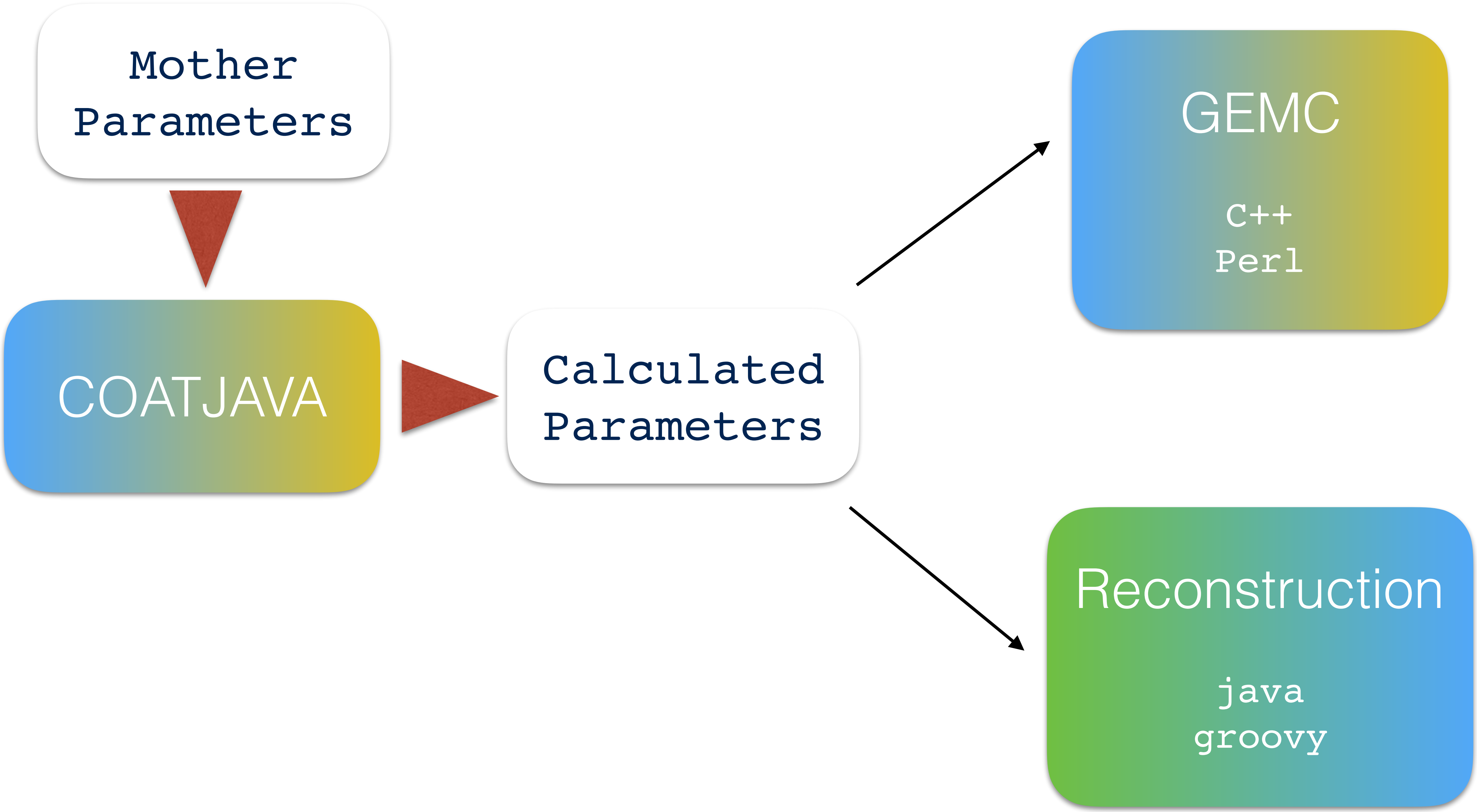
Calculated Parameters

Reconstruction

java
groovy

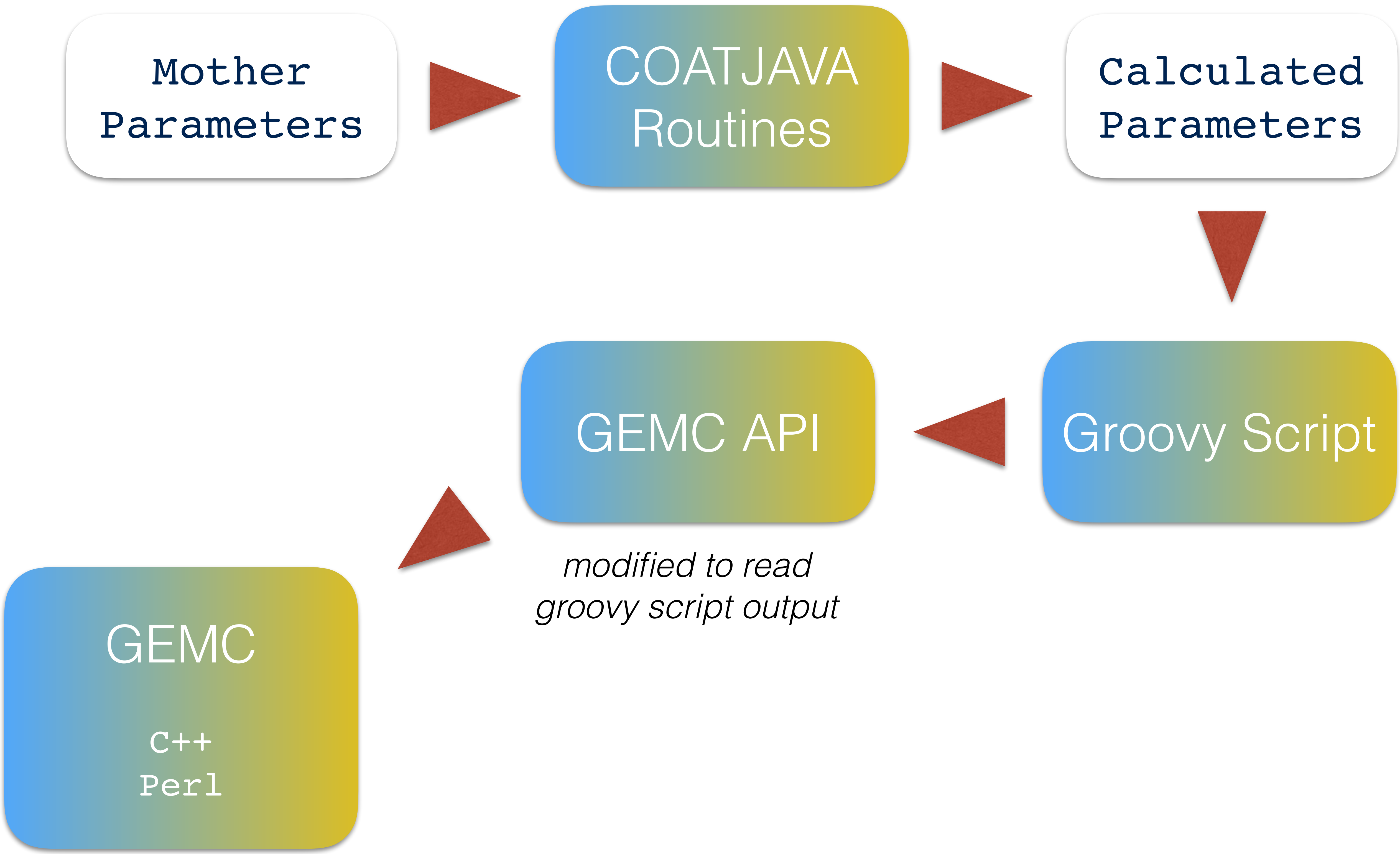
Sharing Geometry Parameters

A. Kim



Sharing Geometry Parameters

A. Kim



Sharing Geometry Parameters

A. Kim

```
my %detector = init_det();

my $vname                  = "ftof_p1b_s".$sector;

$detector{"name"}          = $vname;
$detector{"mother"}        = "fc";
$detector{"pos"}           = panel_1b_pos($sector);
$detector{"rotation"}      = panel_1b_rot($sector);
$detector{"type"}          = "Trd";
$detector{"dim

$detector{"des
$detector{"col
$detector{"mat
$detector{"mfi
$detector{"nco
$detector{"vis
$detector{"sty
print_det(\%ma
```

```
sub panel_1b_rot
{
    my $sector = shift;

    my $tilt  = fstr(-90 - $tilt_p1b);
    my $zrot  = -($sector-1)*60 - 90;

    return "ordered: zxy $zrot*deg $tilt*deg 0*deg ";
}
```

Coming from Perl code,
pars hardcoded

Sharing Geometry Parameters

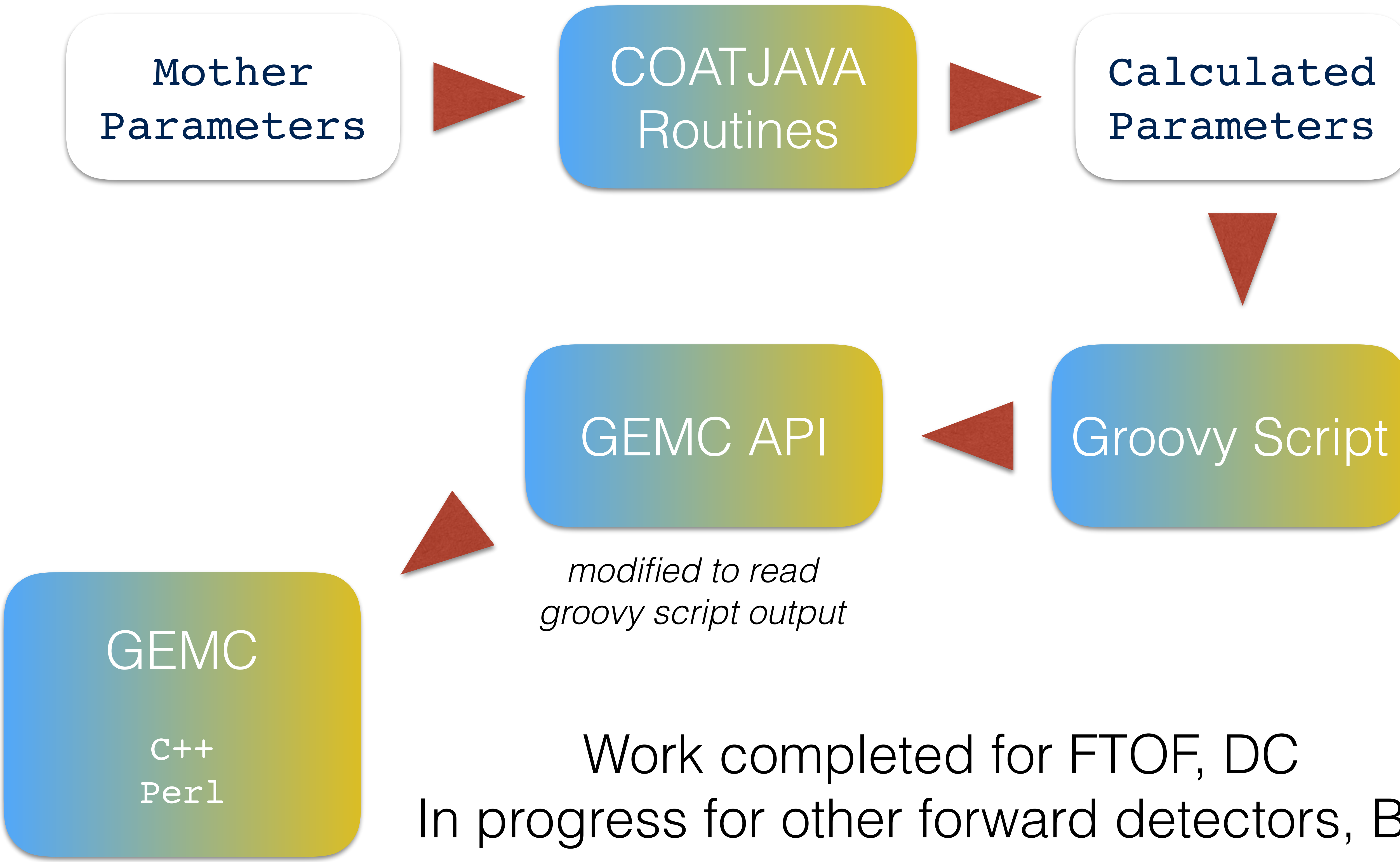
A. Kim

```
my %detector = init_det();

my $vname                   = "ftof_p1b_s".$sector;

$detector{"name"}           = $vname;
$detector{"mother"}         = $mothers->{$vname};
$detector{"pos"}            = $positions->{$vname};
$detector{"rotation"}       = $rotations->{$vname};
$detector{"type"}           = $types->{$vname};
$detector{"dimensions"}     = $dimensions->{$vname};

$detector{"description"}    = "Forward TOF - Panel 1b - Sector ".$sector;
$detector{"color"}          = "000000";
$detector{"material"}       = "G4_AIR";
$detector{"mfield"}         = "no";
$detector{"ncopy"}          = "1";
$detector{"visible"}        = 1;
$detector{"style"}          = 0;
print_det(\%main::configuration, \%detector);
```

Coming from COATJAVA

Sharing Geometry Parameters

A. Kim



Work completed for FTOF, DC

In progress for other forward detectors, BST

Other Code Updates

FIELD PROPERTIES
(option, gcard)

```
> FIELD_PROPERTIES: Mapped field minimum step, integration method, interpolation

Usage:
-FIELD_PROPERTIES="fieldname, minStep, integralAlgorithm, (interpolationMethod)"

Example: -FIELD_PROPERTIES="srr-solenoid, 1*mm, G4ClassicalRK4, linear"


Available Interpolation Methods:
- none: closest grid point.
- linear: linear interpolation (default)    < new!
```

Other Code Updates

FIELD PROPERTIES
(option, gcard)

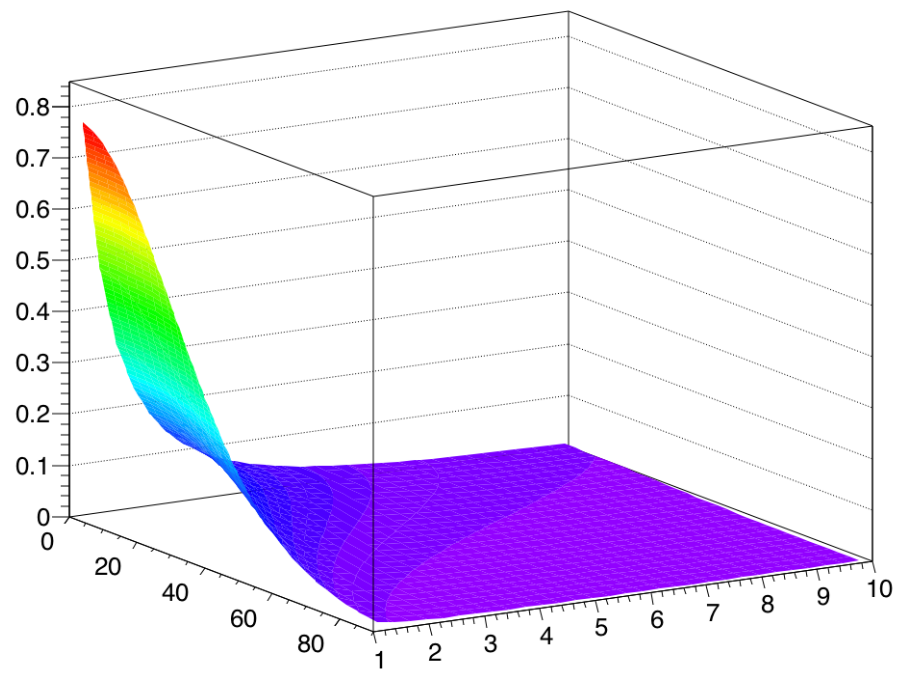
```
> FIELD_PROPERTIES: Mapped field minimum step, integration method, interpolation

Usage:
-FIELD_PROPERTIES="fieldname, minStep, integralAlgorithm, (interpolationMethod)"

Example: -FIELD_PROPERTIES="srr-solenoid, 1*mm, G4ClassicalRK4, linear"


Available Integration Methods:

- G4CashKarpRKF45: Fifth Order Range Kutta, for very smooth fields.
- G4ClassicalRK4: Fourth Order Range Kutta. Robust for every field.
- G4SimpleHeum: Third order stepper.
- G4SimpleRunge: Simplified (second order) Range Kutta (faster).
- G4ImplicitEuler: Second order stepper, for faster varying fields.
- G4ExplicitEuler: First order stepper, for rough fields.
- G4HelixImplicitEuler: Second order, specialized for helix-like trajectories.
- G4HelixExplicitEuler: First order, specialized for helix-like trajectories.
- G4HelixSimpleRunge: Second order Range Kutta, specialized for helix-like trajectories.
- G4NystromRK4: provides accuracy near that of G4ClassicalRK4 with a significantly
  reduced cost in field evaluation.
```

G4HelixSimpleRunge is 35% faster than G4ClassicalRK4 for the solenoid

Other Code Updates

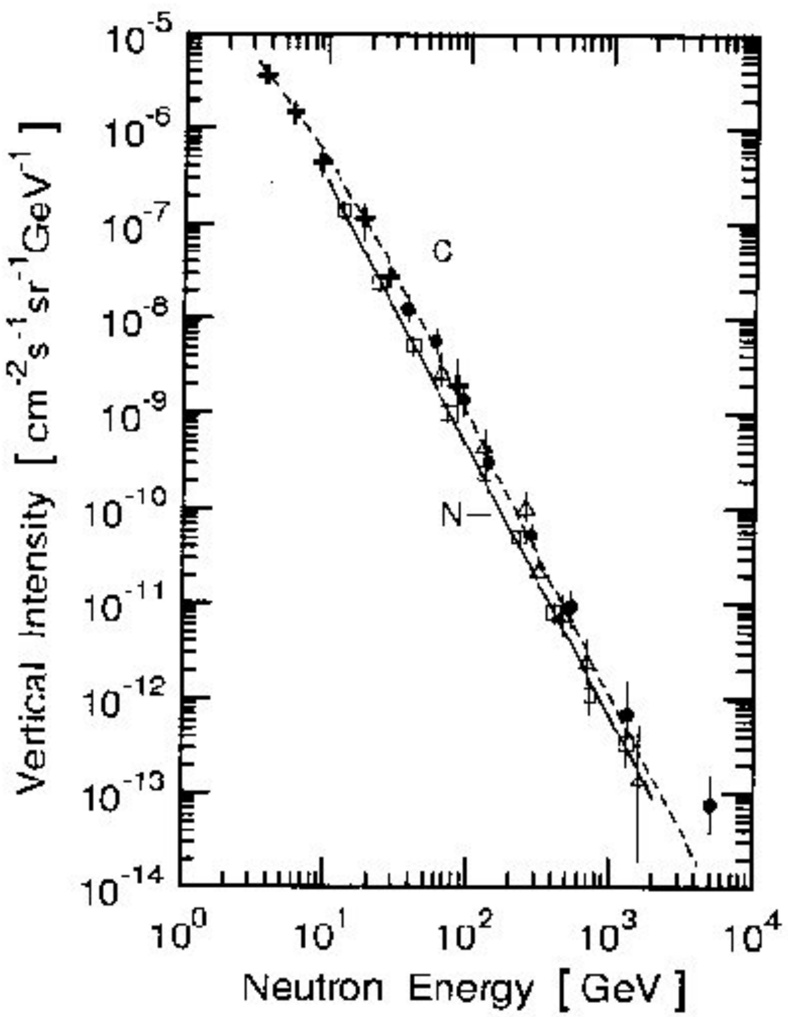
Cosmic Rays (A. Filippi)

muons



$$\frac{a^{cos(b*\theta)}}{p^2}$$

neutrons



The zenith angle dependence is given by: I(theta) = I(0)*cos^n(theta) with theta = 3.5 +- 1.2 (from Heidbreder et al., J. Geophys. Pres. 76, 2905 (1971))

Other Code Updates

New options

- added option “CHANGEVOLUMEMATERIALTO” to change a volume material:
  `Usage: -CHANGEVOLUMEMATERIALTO="volume, new material"`

- added option “SWITCH_MATERIALTO” to change a material into another:
  `Usage: -SWITCH_MATERIALTO="oldmaterial, newmaterial"`

  Both CHANGEVOLUMEMATERIALTO and SWITCH_MATERIALTO can be repeated.

- Option REMOVESENSITIVITY to remove a volume sensitivity:
  `Usage: -REMOVESENSITIVITY="volumename1, volumename2, ..."`

Other Code Updates

Electronic Noise

New pure virtual function vector<MHit*> **electronicNoise()** to generate electronic noise / hot channels

User implementation:

```
MHit* thisNoiseHit = new MHit(E, T, IDF, pid);
```

energy time identifier pid

The electronic noise hits are then added to the normal geant4 hits. Each process routine will have them available in the output.

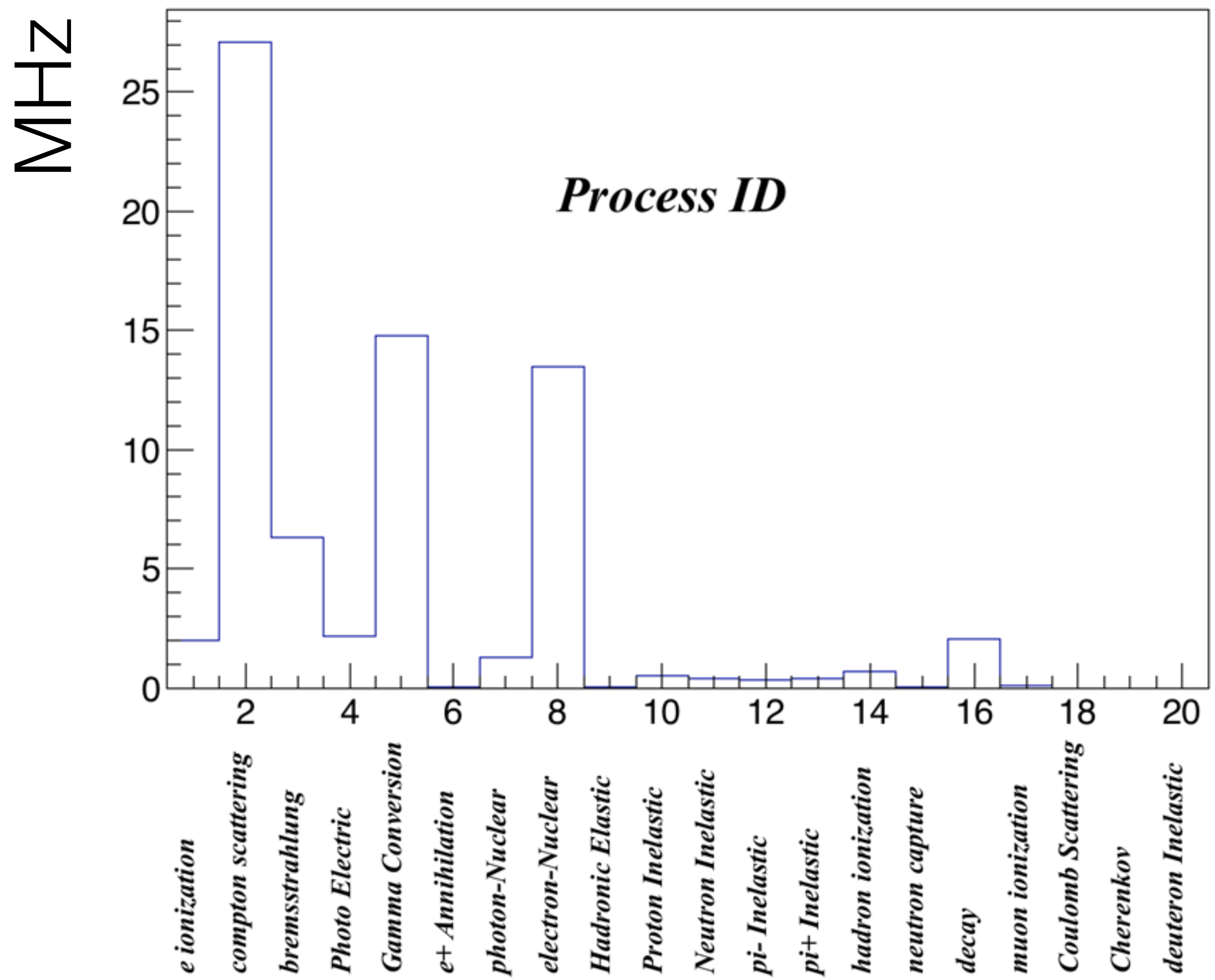
Other Code Updates

Process Catalogue

Process Name	ID (int)
e ionization	1
compton scattering	2
e bremsstrahlung	3
Photo Electric Effect	4
Gamma Conversion	5
e+ Annihilation	6
photon-Nuclear	7
electron-Nuclear	8
positron-Nuclear	9
Hadronic Elastic	10
Proton Inelastic	11
Neutron Inelastic	12
pi- Inelastic	13
pi+ Inelastic	14
hadron ionization	15
neutron capture	16
decay	17
muon ionization	18
Coulomb Scattering	19
Cherenkov	20
deuteron Inelastic	21
muPairProd	22
ion ionization	23
hadron pair production	24
triton Inelastic	25
kaon- Inelastic	26
kaon+ Inelastic	27
kaon0 Inelastic	28
kaon0L Inelastic	29
alpha Inelastic	30
lambda Inelastic	31
sigma- Inelastic	32
hadronic bremsstrahlung	33
muon decay With Spin	34
na	90

procID is in the true info output bank

example from beam on target background



Documentation

gemc.jlab.org

GEMC Documentation

- GEMC Options
  - Command Line Options
  - Gcard
- Generator
  - Internal Generator
  - Cosmic Rays Generator
  - Neutrons
  - Source Area
  - Luminosity (background) Generator
  - Saving and merging background
  - List of all particles
  - Muons
  - Target Area
  - The LUND format
- Electro-Magnetic Fields
  - Assigning a field to a volume
  - Turning off one or all fields
  - Constant Fields
  - Field maps properties
  - Scaling a Field
  - Getting the field value at one point
  - Assigning a field to *root*
  - Fields are files
  - Field maps
  - Multipoles
  - Translating/Rotating a Field
- GEMC Detector
  - Detector Definition
  - Detector type, dimensions
  - Color, Transparency
  - Detector Attributes
  - Rotations
- GEMC Hit
  - Hit Definition
  - True Information
  - Process Names / ID Table
  - Example
- GEMC at Jefferson Lab
  - Sourcing the environment
  - Command line/gcard options
  - Using the internal generator
  - Generating Background
  - Command line help
  - Running GEMC
  - Loading / Unloading detectors
  - Using a custom generator
  - Scaling Magnetic Fields

Physics Processes

- Physics
  - Electromagnetic Processes
  - References
  - Hadronic Processes

Latest news
Complete changelog
How to contribute
Roadmap
Mailing list
Doxygen

GEANT4 Links:

Physics Processes Docs
Forum
User's Guides
Reference Manuals

Documentation

gemc.jlab.org

Physics Processes

- Physics
  - Electromagnetic Processes
  - Hadronic Processes
  - References

Physics

The electromagnetic, hadronic and optical physics process can be individually activated using the PHYSICS option. For example:

```
<option name="PHYSICS" value="FTFP_BERT + STD + Optical"/>
```

will activate the hadronic list FTFP_BERT, the standard electromagnetic process and also the optical physics. The order in the list is irrelevant.

Electromagnetic Processes

The EM physics processes included in geant4 are:

- **standard**:

  multiple scattering, electron ionization, electron bremsstrahlung, e+e- annihilation, e+e- annihilation to hadrons, e+e- annihilation to mu pair, muon ionization, muon bremsstrahlung, e+e- pair production by muons, hadron ionization, ion ionization, Compton scattering, polarized Compton scattering, photo-electric effect, gamma conversion, gamma conversion to muons, Cerenkov radiation, scintillation, synchrotron radiation, forward transition radiation, transition radiation, gamma, transition radiation, regular, transition radiation, straw tube, transition radiation, transparent
- **low energy**:

  ionization, bremsstrahlung, hadron ionization, Compton scattering, polarized Compton scattering, photo-electric effect, gamma conversion, Rayleigh scattering, polarized Rayleigh scattering
- **Penelope**:

  ionization, bremmstrahlung, e+e- annihilation, Compton scattering, photo-electric effect, gamma conversion, Rayleigh scattering
- **very low energy (Geant4 DNA)**:

  elastic scattering, excitation, ionisation, charge decrease, charge increase
- **Optical photons**:

  Rayleigh scattering, bulk absorption, reflection, refraction, wavelength shifting

The models are collected and their parameters are adjusted in several EM packages. In the table below you can find the code used by gemc to call the various packages.

Code	geant4 package	Summary Description
STD	emstandard	The default EM constructor is used in major part of reference Physics Lists (FTFP_BERT, FTF_BIC, QGSP_FTFP_BERT, QGSP_BIC, ...).
EMV	emstandard_opt1	Designed for HEP productions. Production thresholds are enabled on secondary particles for all EM processes.
EMX	emstandard_opt2	Designed for HEP productions. Alternative G4Generator2BS angular generator is used for the bremsstrahlung process.
EMY	emstandard_opt3	Higher accuracy of electrons, hadrons and ion tracking without magnetic field.
EMZ	emstandard_opt4	Higher accuracy of electrons, hadrons and ion tracking. Use the most accurate standard and low-energy models.
LIV	emlivermore	Higher accuracy of electrons, hadrons and ion tracking without magnetic field. Livermore model on top of emstandard_opt4.
LVP	emlivermore_polar	emlivermore with polarized photo electric effect, compton scattering, gamma conversion and rayleigh models.
PEN	empenelope	Higher accuracy of electrons, hadrons and ion tracking without magnetic field. Penelope model on top of emstandard_opt4.
LEM	emlowenergy	Designed on top of Livermore physics for validation of new low-energy models.

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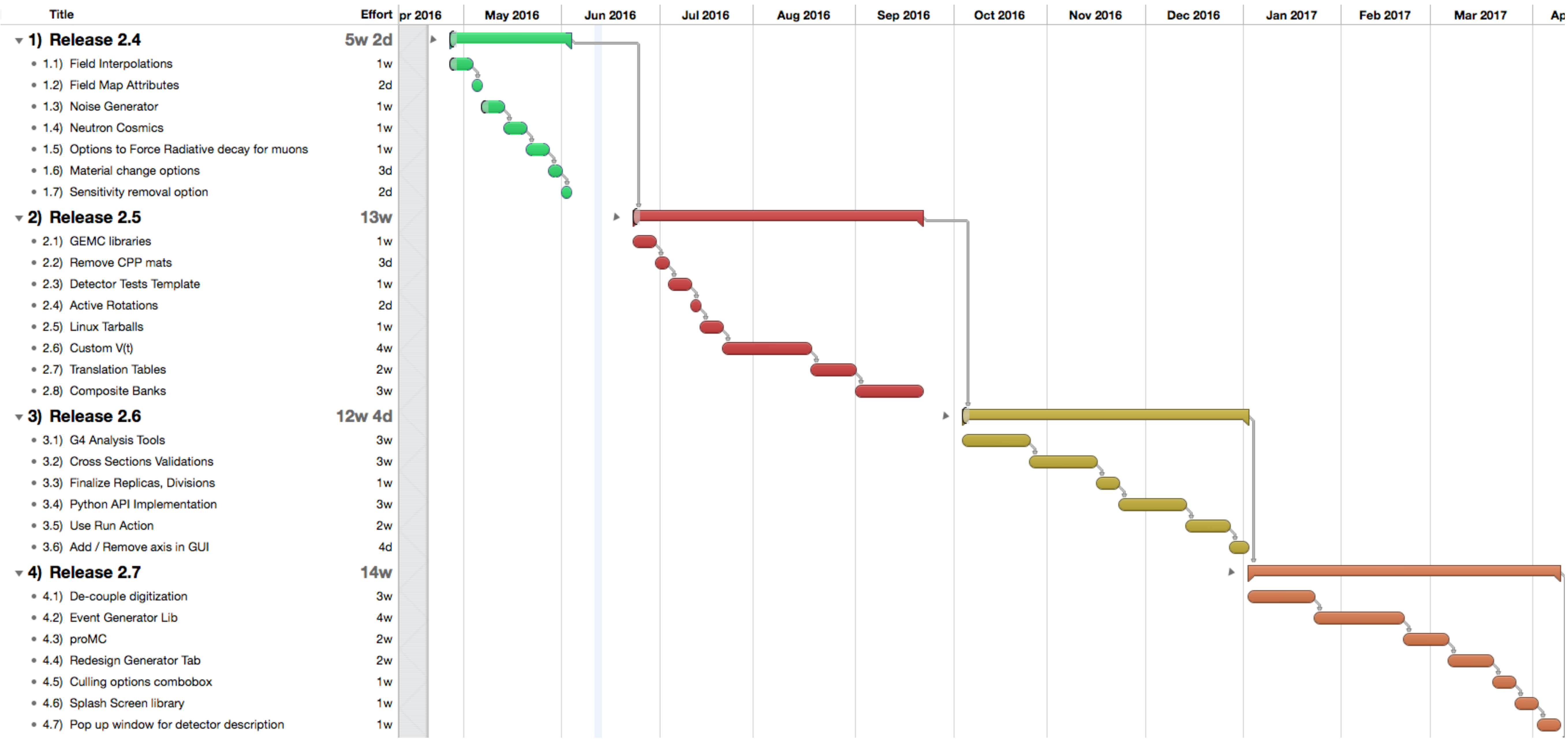
GEANT4 Links:

Physics Processes Docs
Forum
User's Guides
Reference Manuals

Roadmap

gemc.jlab.org



Roadmap

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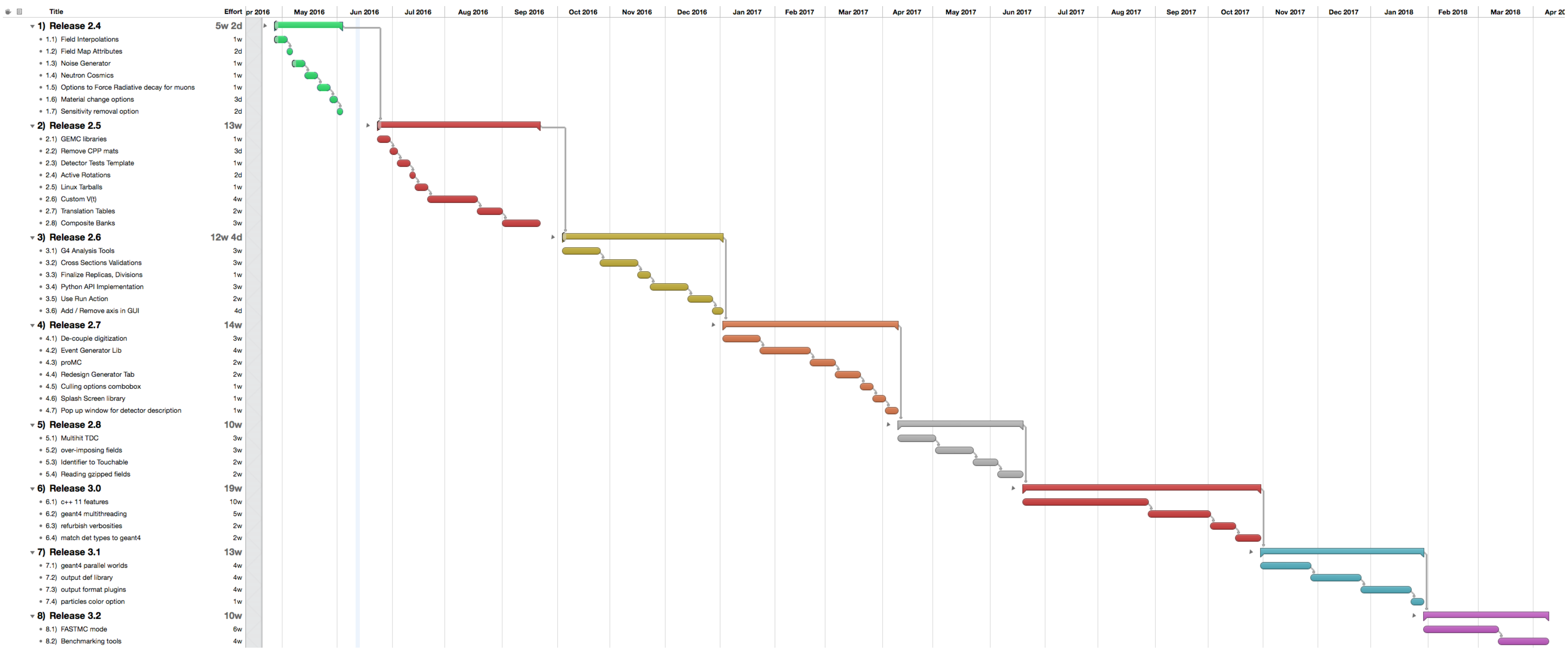

Summary

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  Available for EC, PCAL, FTOF, CTOF, DC

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  In progress for forward detectors, BST

- ☑ Code updates
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  Material change options (material name, volume)
  Cosmic Neutrons
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