Status of EMC software

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Plan

- Workpackages
- MC simulation
- Digitization
- Calibration/ Energy-position correction
- Error matrix

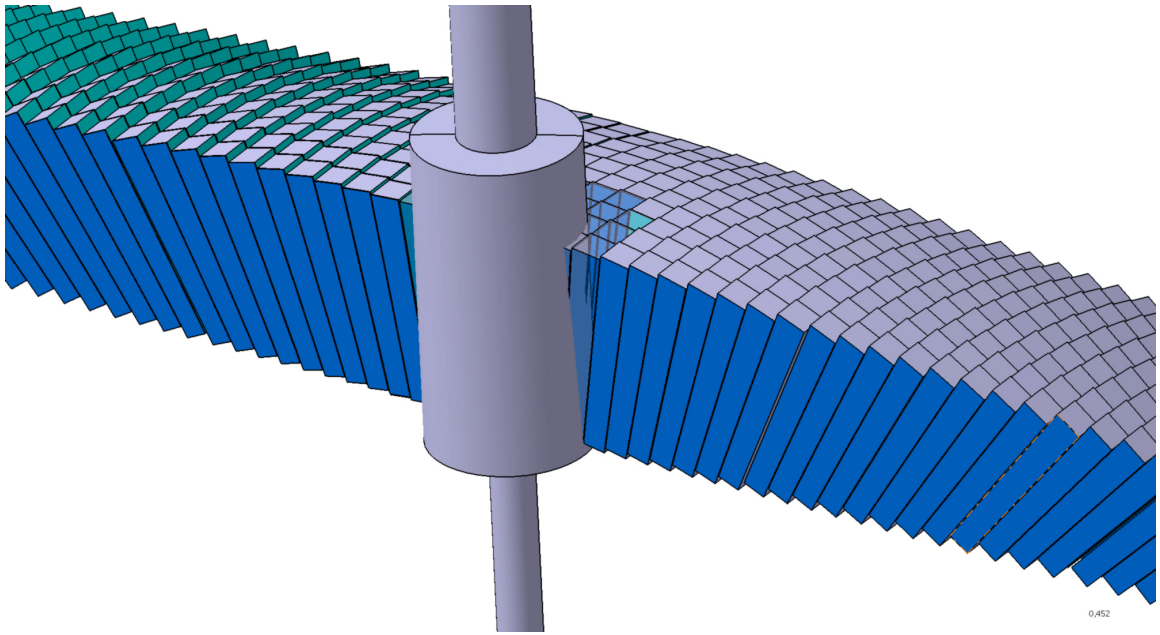
Workpackages

EMC

Project title	Wiki link	Priority	Status	Percentages accomplished	Coordinator	La upd
Barrel Geometry Update	EMCBarrelGeometry	HIGH		0%		28/01/
Forward Endcap Geometry Update	EMCFwdGeometry	HIGH		0%		28/01/
Backward Endcap Geometry Update	EMCBwdGeometry	HIGH		0%		28/01/
Shashlyk Calorimeter	Shashlyk	MEDIUM	Ongoing (D.Morozov)	50%		28/01/
Redesign and implementation of EMC Mapper	EMCMapper	HIGH	Finished (D.Melnychuk)	100%		24/03/
Energy and position correction	EMCEnergyPosCorrection	HIGH	Ongoing	40%		06/03/
Energy calibration	EMCCalibration	MEDIUM	Ongoing (B.Roth)	10%		28/01/
Candidate (analysis interface)	EMCCandidate	HIGH		0%		28/01/
Cluster-Track matching	EMCClusterTrackMatching	HIGH	Ongoing	-		28/01/
MC Truth association	EMCMCTruthAssociation	MEDIUM		50%		28/01/
Error matrices	EMCErrorMatrices	HIGH		-		28/01/
Development/Testing of Bump Splitting Algorithm	EMCBumpSplitting	LOW	Suspended	50%		24/03/
G3/G4 tuning and comparison to data	EMCG3G4Tuning	MEDIUM	Ongoing (Vanniarajan Suyam Jothi, Christian Hamman)	20%		06/03/
Improvement of digitization	EMCDigitization	MEDIUM	Suspended	50%		28/01/
Event Mixing	EMCEventMixing	LOW	Not Assigned	0%		28/01/
Feature Extraction/ Event Filter Simulation	EMCFeatureExtraction	LOW	Not Assigned	0%		28/01/
Pre-Shower detection and correction	EMCPreShowerCorrection	LOW	Not Assigned	0%		28/01/
Misalignment/Alignment	EMCAlignment	LOW	Not Assigned	0%		28/01/
Split-Off recognition (hadronic/electromagnetic)	EMCSplitOffRecognition	LOW	Not Assigned	0%		28/01/
Light-yield non-uniformity in EMC simulations	EMCLYNonuniformity	MEDIUM	Finished (C.Hammann)	90%		24/03/

MC simulation - Geometry

- No dead material is implemented (alveoles, support structure, cooling shielding).
- Geometry of forward endcap with final version of hole is not implemented.
- Target pipe hole is not implemented.



MC simulation - Geant4

Two warnings appears in Geant 4 simulation of EMC for some events and those events are processed much slower than usual. They are related to geant4_vmc + g4root navigation in geometry and have external origin to the pandaroot code.

1)

```
No physical volume found at track vertex: (58070.7,332706,114643)
++++  TG4Warning:  ++++
    TG4TrackingAction::UserProcessHits:
    Cannot locate track vertex.
++++++++++++++++++++++
```

2)

```
*****************************************************************************************
* G4Track Information:   Particle = gamma,   Track ID = 477,   Parent ID = 475
*****************************************************************************************

Step#    X(mm)    Y(mm)    Z(mm) KinE(MeV)  dE(MeV) StepLeng TrackLeng  NextVolume ProcName
10002     -305     56.5     -693      1.44        0        0      39.5  CrystalVol Transporta
10003     -305     56.5     -693      1.44        0        0      39.5        cave Transporta
10004     -305     56.5     -693      1.44        0        0      39.5  CrystalVol Transporta
10005     -305     56.5     -693      1.44        0        0      39.5        cave Transporta
*** Particle reached max step number (10000). ***
```

Dizitization/Reconstruction

Digitization

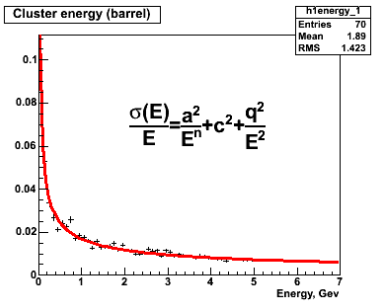
- Realistic digitization is implemented including all first-order effects (photon statistics, electronics noise, non-linearity of light collection) and first version of digitization for shashlyk calorimeter (by D.Morozov).
- Simulation of event time structure is missing (pile-ups, event mixing) but depends on general framework development and is suspended at the moment.

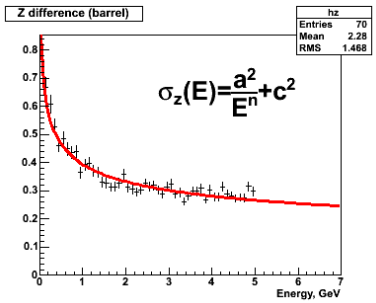
Reconstruction

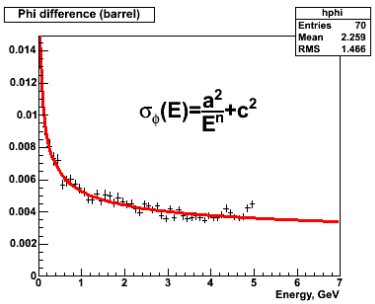
- Reconstruction is in a good shape including clusterization, bump splitting and calculation of cluster properties (Zernike moments etc.)

EMC error matrix

- Covariance matrices for neutral candidate in (E, p_x, p_y, p_z) representation are mandatory for kinematics fitters
- Covariance matrices for PANDA EMC were calculated by Marc Pelizaeus in Babar framework and later obtained values were hardcoded in pandaroot.
- The proposed method is based on (σ_E, σ_x, σ_y) error parametrization as a function of energy in forward/backward endcaps and shashlyk calorimeter and (σ_E, σ_ϕ, σ_z) in barrel EMC with later transformation to (E, p_x, p_y, p_z) representation.







The macros in pandaroot were prepared to simplify recalculation of error matrices for modifications of EMC geometry (e.g. inclusion of dead material) with object containing parameters of errors matrices stored in RTDB.
Final validation with kinematic fitting of $\pi^0 \rightarrow \gamma\gamma$ decay still in progress.

Calibration/ energy-position correction

- Cluster energy-position correction consider energy losses which are not due to the features of a single crystal. These energy losses are due to interactions in front of the EMC, leakage behind the EMC and energy loss in dead material in-between the crystals.
- Two options for energy-position correction, parametrization of energy correction as a function of (E, θ) with $E_{\gamma,\mathrm{cor}} = E * f(\ln E, \Theta)$ and

$$\begin{aligned} f(\ln E, \Theta) = exp(a_0 + a_1\, lnE + a_2\, ln^2 E + a_3\, ln^3 E \\ + a_4\, cos(\Theta) + a_5\, cos^2(\Theta) + a_6\, cos^3(\Theta) \\ + a_7\, cos^4(\Theta) + a_8\, cos^5(\Theta) \\ + a_9\, lnE\, cos(\Theta)) \end{aligned}$$

  and correction by bi-linear interpolation from 2D-histogram (implemented by O.Biegun)
- Calibration based on π^0 peak reconstruction was tested by B.Roth in Babar framework without short-term plan to implement in pandaroot.

Unified approach for energy-position correction

- Till now parametrization of energy correction was hardcoded with parameters calculated in Babar framework.
- Correction based on bilinear interpolation from two dimensional histogram can be used standalone but is not included in simulation-reconstruction-analysis chain.
- PndEmcClusterCalibrator class was created which gives possibility to use both methods in unified way to calculate correction for Geant3/Geant4 engines, two particle hypothesis (γ, e) and different geometry options (e.g. correction depends if the whole PANDA detector or EMC only is used in simulation).
- Macros are provided in /pandaroot/macro/emc/dedicated/EnergyPosCorrection/ to produce data and calculate corrections for both methods.
- The work is still in progress and requires higher statistics since 100 k event studied so far for each option gives large statistics uncertainties.

Additional required features of EMC software

- Pre-Shower detection and correction
- Split-Off recognition (hadronic/electromagnetic)
- Misalignment/Alignment

Summary

- High priority tasks - more realistic geometry and digitization including event time structure.
- Many features of EMC software are missing that required for operation of detector but not critical in short time scale for physics performance studies.