Status of embedding procedure for BM@N Central Tracker

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Steps of the algorithm:

- Creating a store with Λ^0
- Creating a list of eventIds for reconstructed events where vertex is assumed to be defined
- Passing the stores with Λ^0 to BM@N Central Tracker simulations
- Finding at least one Λ^0 to be reconstructed for a given reconstructed vertex in considering event (pure MC)
- Monitoring events with embedded products from Λ^0 decay
- Creating digits from Λ^0 decay products corresponding to considering event (MC + Digitization)
- Doing correspondence between digits from Λ^0 decay products to channel and serial numbers of ADC
- Doing "pure" convertion from binary data written by DAQ to *.raw.root format
- Doing embedding in *.raw.root
- Decoding converted data with embedded ADC-digits to *.digi.root format to be used for analysis

The Algorithm::Creating a store with Λ^0

- Λ^0 are taken from MC simulations of the tracker with the LAQGSM model.
- Input from the model corresponds to known target, projectile, energy, centrality information got from a DST where protons and pions from Λ^0 decay are embedded to.
- Chosen Λ^0 are primary ones.
- Cut mechanism on written Λ^0 can be used if necessary (η, ϕ, momentum ...).
- Desirable number of stores to be produced is also operated by user.

- **Each store is sampled in a set of files ($lambdaXXX\_vertexXXX.root$) according to a rule: $N_{sets} = N_{stores} \cdot N_{vertices}$**
- **Each file $lambdaXXX\_vertexXXX.root$ contains 50 events (of course, being increased / decreased if necessary)**
- **Simulations take into account remain misalignment (with opposite sign) and Lorentz shift corrections applied to each element of the tracker**
- **Λ^0 "starts" from reconstructed position of vertex in considering event**
- **A Λ^0 to be chosen is considered to be reconstructable if:**
    - **Decay products have, at least, four points in the acceptance**
    - **Their momenta are greater than 300 MeV/c**
    - **Tracks from decay products have one point only for each Z-position of any part of the tracker**
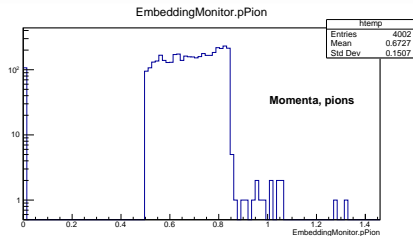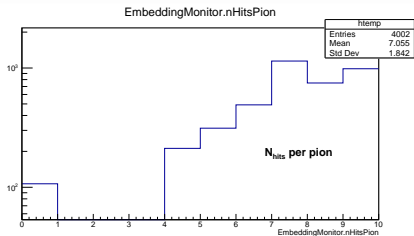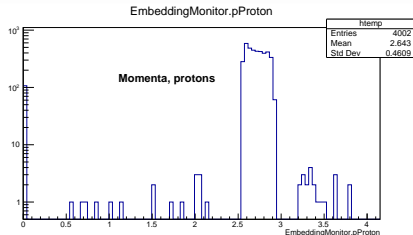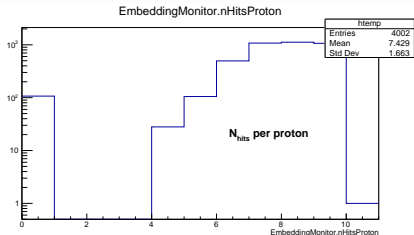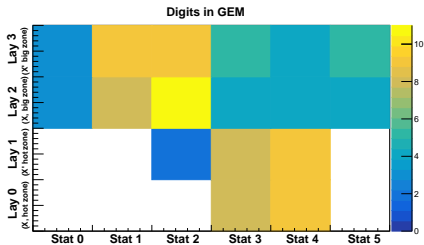- **First event satisfying the conditions mentioned is assumed to be a candidate for embedding**

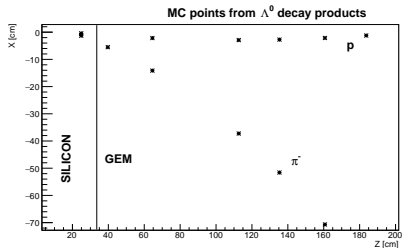# The Algorithm::Monitoring events with embedded products from Λ^0 decay
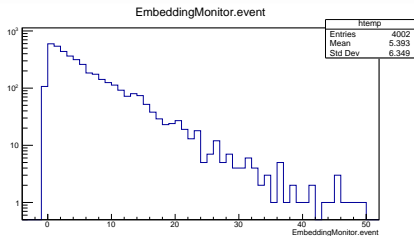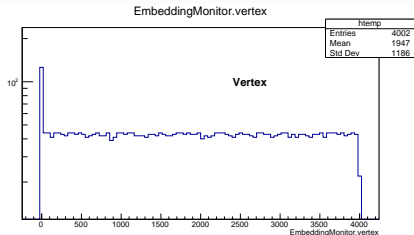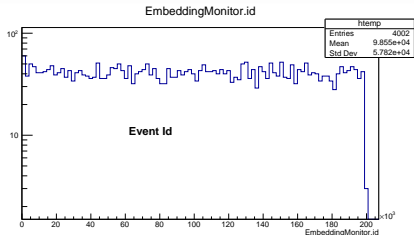
The Algorithm::Monitoring events with embedded products from Λ^0 decay

To get info on different characteristics of particles

MC points from Λ^0 decay products

Digits in GEM

Cluster sizes, GEM, Lay 2 (X, hot zone)

Cluster sizes, GEM, Lay 0 (X, big zone)

Clusters with $N_{strips} > 5$ produce hits being reconstructed with a slightly pure efficiency (see next slides)
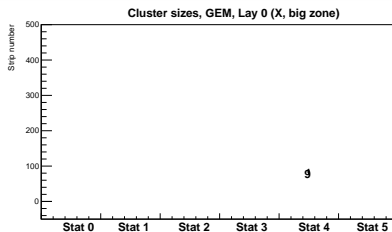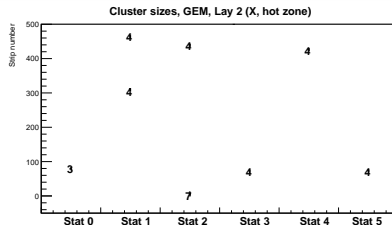
- Equal amplitudes for each strip in the cluster assumed
- Scenarios with different Gaussian smearing are being tested

Central Tracker, mappings

```
                        GEM
// GEM_id: the second digit 0=left, 1=right;
// Module: 0=00 (mod0,hotZone), 1=01 (mod0,bigZone),
// 2=10 (mod1,hotZone), 3=11 (mod1,bigZone)
   Serial    Ch_lo    Ch_hi   GEM_id  Station  Module
==================================================
0x76CD410     1024     2047     110       0       0
0x76C8320        0     2047     110       0       1
0x76CB9C0        0     2047     111       0       3
0x76CA266     1024     2047     111       0       2
0x76D08B9      512      767     110       0       1
0x76D4D2B        0     1023     100       1       2
0x76D5044        0     2047     100       1       3
...


                      SILICON
// Station: 0 - vertex (near), 1 - vertex(far),
// 2 - Forward detector
//Layer: 0 - vertical strips, 1 - sloped strips
Serial    Ch_lo    Ch_hi   GEO_mod   Layer  Station
==================================================
0x80BCBFC     42       46       0        0       2
0x80BCBFC     37       41       0        1       2
0x80BCBFC     32       36       1        0       2
0x80BCBFC     26       30       1        1       2
0x80BCBFC     16       20       2        0       2
0x80BCBFC     21       25       2        1       2
0x80BCBFC      5        9       3        0       2
...
```

BmnStripDigit (GEM or SILICON)

```
Int_t fStation;
Int_t fModule;
Int_t fStripLayer;
Int_t fStripNumber;
Double_t fStripSignal;
```

Direct problem: ADC-digits from DAQ → Physical digits (decoding)
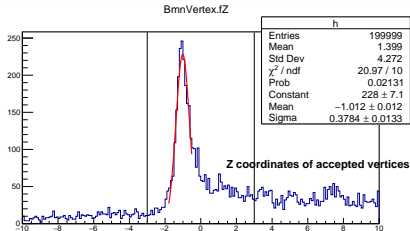**Inverse problem: Physical digits → Incorporation to ADC-digits (embedding) + direct problem**
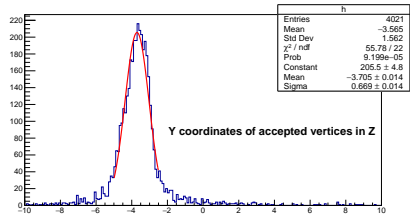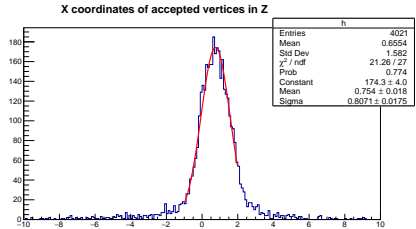
Operating dig. info one has to define corresponding channels & serials using mappings
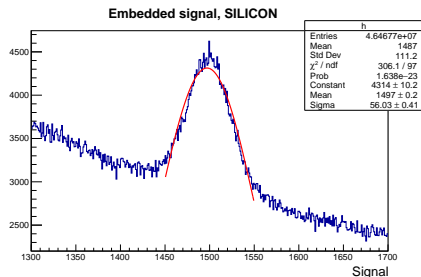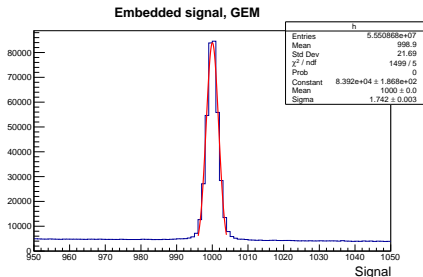
DST used as a start point for the procedure

Reconstructed Z_{vertex} over all file

- **bmndst_4649.root, ArAl-interactions**
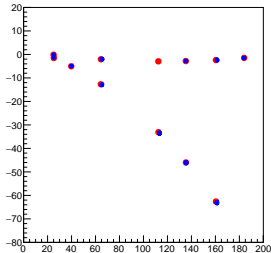- **Old (not recently improved) algorithm of vertex finder used**
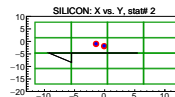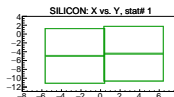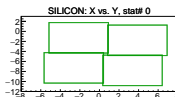
Embedded signal for the BM@N Central Tracker

Embedded signal, GEM

Embedded signal, SILICON

Embedded signal for SILICON part of the tracker looks wider (if comparing with GEM) due to more significant fluctuations of Command Mode when decoding

QA of the embedding procedure
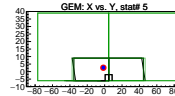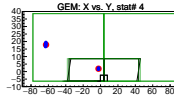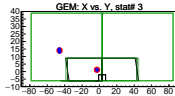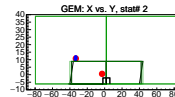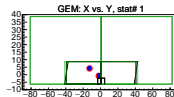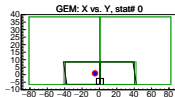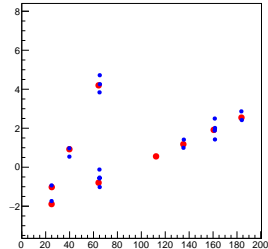
Efficiency of the embedding procedure

- Calculated for different pseudorapidity ranges of Λ^0 to test precisely the procedure for different elements of the BM@N Central Tracker (stations, modules, zones)

- Tested different approaches to parameterizations of cluster amplitudes (signals) (equal amplitudes, Gaussian distribution of amplitudes)

Embedding for different η-ranges of Λ^0

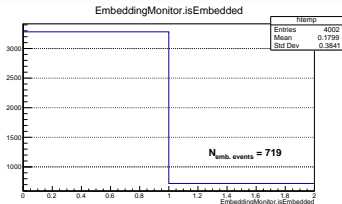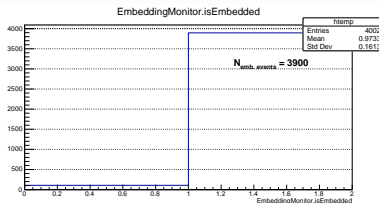## $1 < \eta < 1.5$

$N_{emb.\ events} = 719$

$2 < \eta < 3$

$N_{emb.\ events} = 3900$

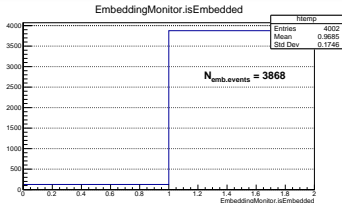## $1.5 < \eta < 2$

$N_{emb.events} = 3868$

- Number of events in the DST-file is **199000**
- Number of events with reconstructed vertex satisfying to cuts is **4002**
- Embedded particles are MC decay products (p, π^-) from Λ^0 decay
- Each product has, at least, **four** hits in the BM@N Central Tracker acceptance (not depending where, either GEM+SI or GEM only)

GEM

eff. hot zone

	Stat# 0	Stat# 1	Stat# 2	Stat# 3	Stat# 4	Stat# 5
Mod# 1	0.984609	0.981477	0.978413	0.976699	0.966326	0.969055
Mod# 0	0.977523	0.982643	0.970966	0.940762	0.934509	0.937778

eff. big zone

	Stat# 0	Stat# 1	Stat# 2	Stat# 3	Stat# 4	Stat# 5
Mod# 1	0.822034	0.789634	0.947885	0.950556	0.935338	0.934894
Mod# 0	0.921739	0.909786	0.953712	0.970051	0.973173	0.969029

SILICON

eff. silicon

|	Stat# 0	Stat# 1	Stat# 2
Mod# 7			0.833333
Mod# 6			0.862963
Mod# 5			0.830986
Mod# 4			0.959184
Mod# 3	0.934685		0.976632
Mod# 2	0.957143		0.948566
Mod# 1	0.929953	0.896991	0.89322
Mod# 0	0.902206	0.870572	0.970314

Parameterization of cluster amplitudes tried

Equal amplitudes for all strips are used now by default
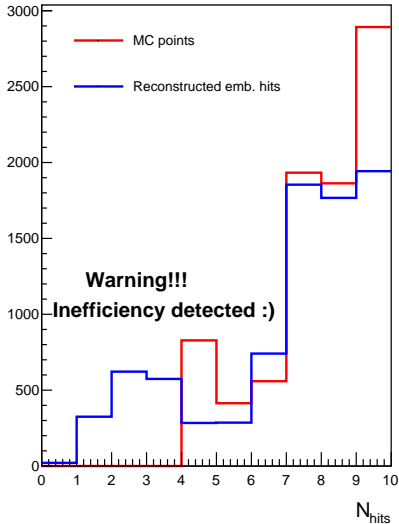
Total integral is close established value
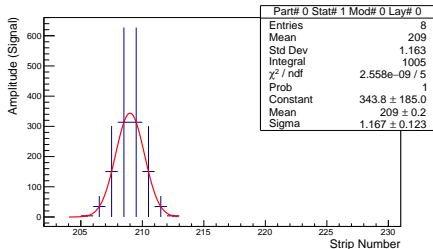
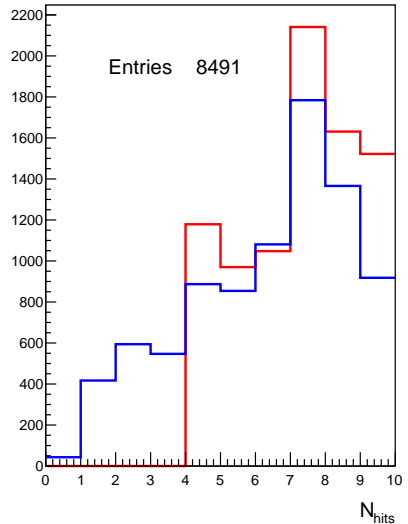## Maximum amplitude is set to established value
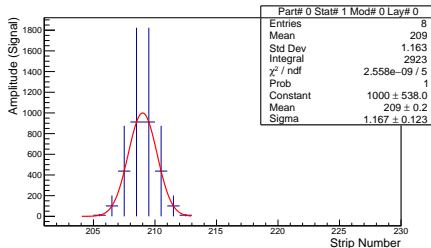
At the moment, no one additional parameterization used did not increase efficiency in case of wide clusters :(

Efficiency of the procedure

Protons

MC points
Reconstructed emb. hits

Warning!!!
Inefficiency detected :)

Pions

Entries   8491

N_{hits}

TODO list:

- **To find out why we have a visible inefficiency in big zones, especially, for first two GEM stations of the BM@N Central Tracker**

- When being done, try to do a preliminary set of tracking to reconstruct Λ^0 decay products with a high efficiency

- After that, try to perform a correct scaling of embedded signals (from digitizer) to those ones got from experimental data

- Finally, measure efficiency for both procedures, embedding and tracking

- Further tests aiming at Λ^0 reconstruction with improved tracking using existing code (**$VMCWORKDIR/physics/particles/BmnTwoParticleDecay.h**)

- More unknown as yet tests to be done :)