MLEM

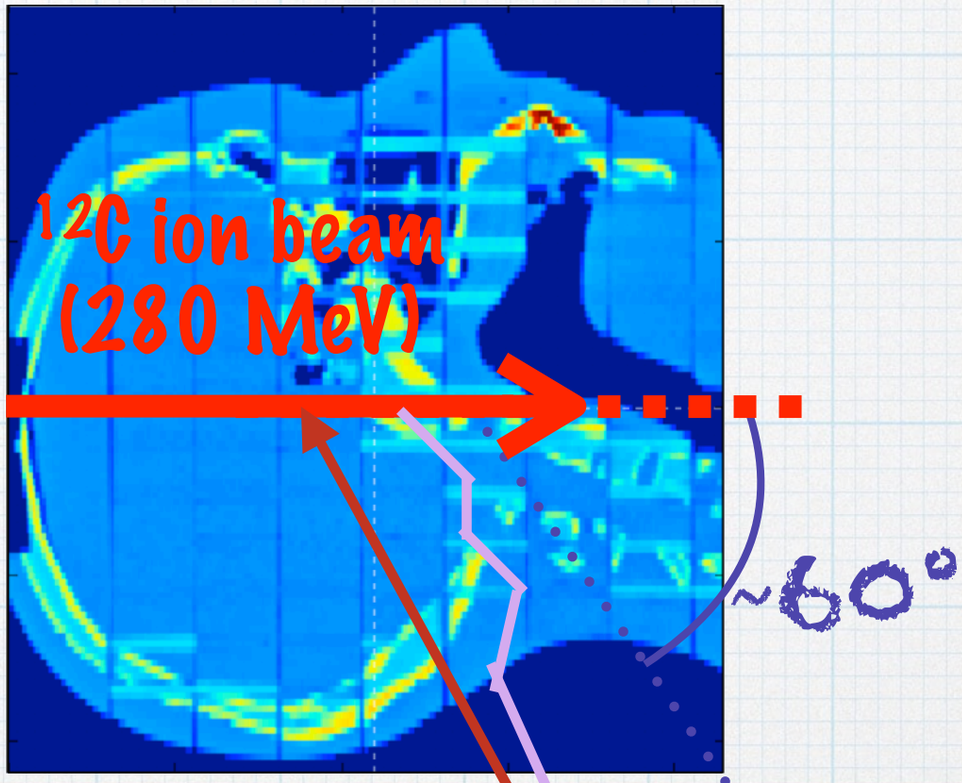
..what are we doing?

Meeting ARPG 21/12/2018

Micol De Simoni

On the previous episodes: Why we need MLEM?

Charged particles emitted inside the body suffer from absorption and multiple scattering interactions in matter



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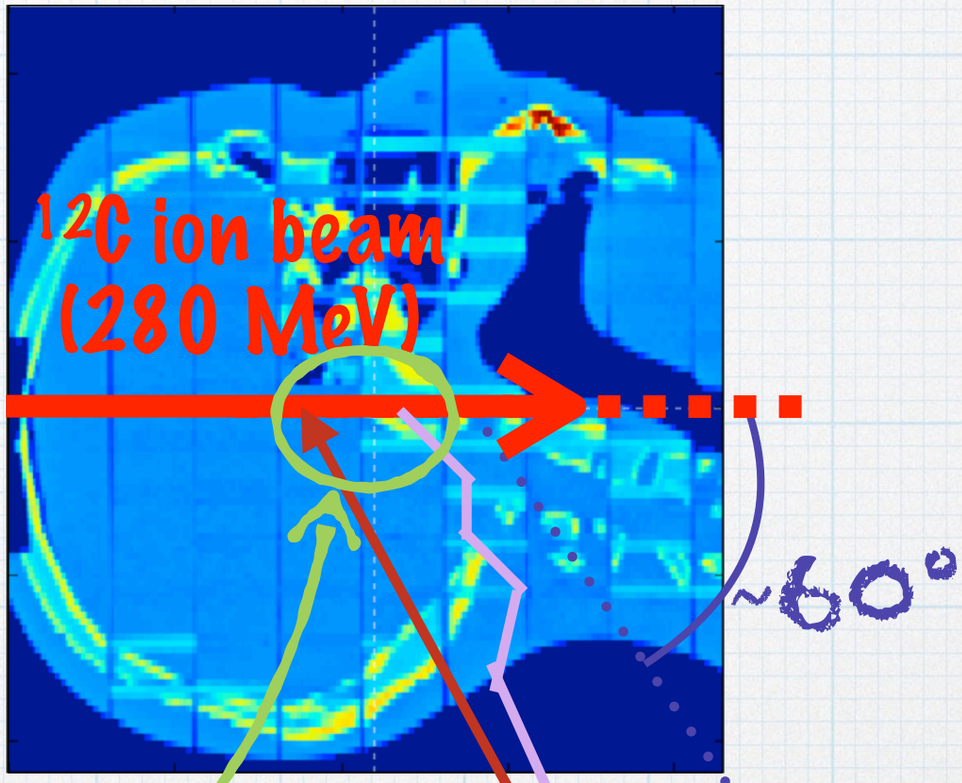
The reconstructed distribution of the secondary production should take into account the matter effect



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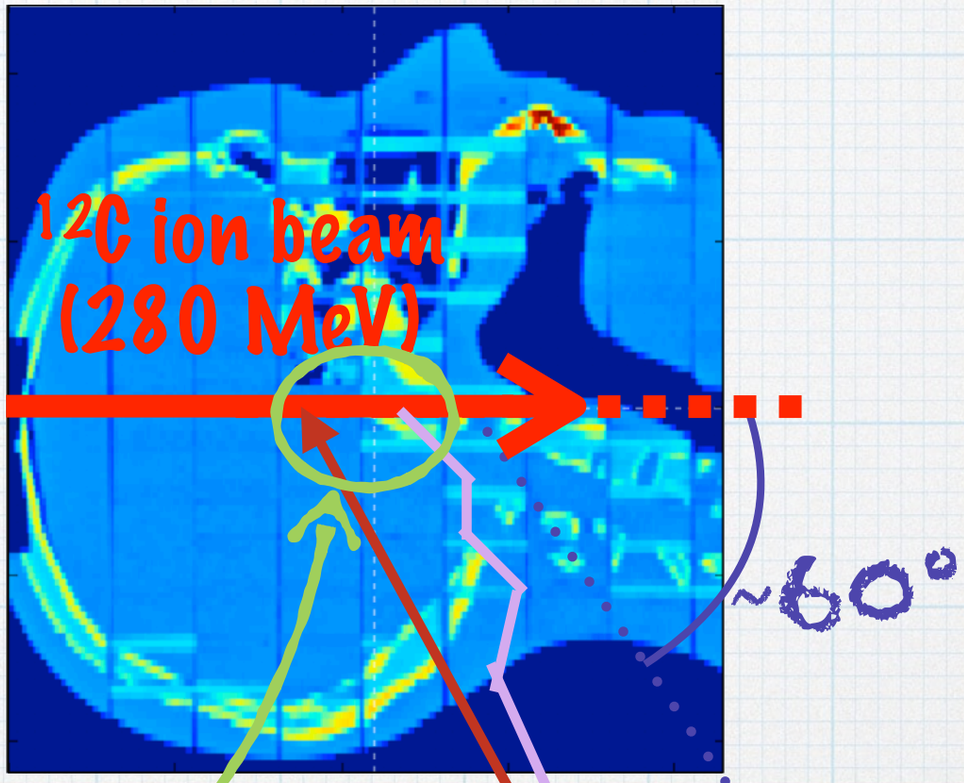

The reconstructed distribution of the secondary production should take into account the matter effect

unfolding with MLEM

On the previous episodes: How we build the unfolding Matrix?

Starting from a sample of events generated by **Fluka**, we select the secondary fragments produced within the target requiring:

- Protons
- Energy in production > 45 MeV
- Angle in production > 20°
- Coordinate of production within 3σ from the beam

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In order to apply the MLEM algorithm correctly, the definition of the **unfolding matrix** is crucial

$$A_{ij} = m_j / n_i$$

m_j = number of particles reconstructed in the bin j

n_i = number of particles that could intercept the detector and are produced in the bin i

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Absorption and multiple scattering are taken into account

is MLEM working in the right way?

Check:

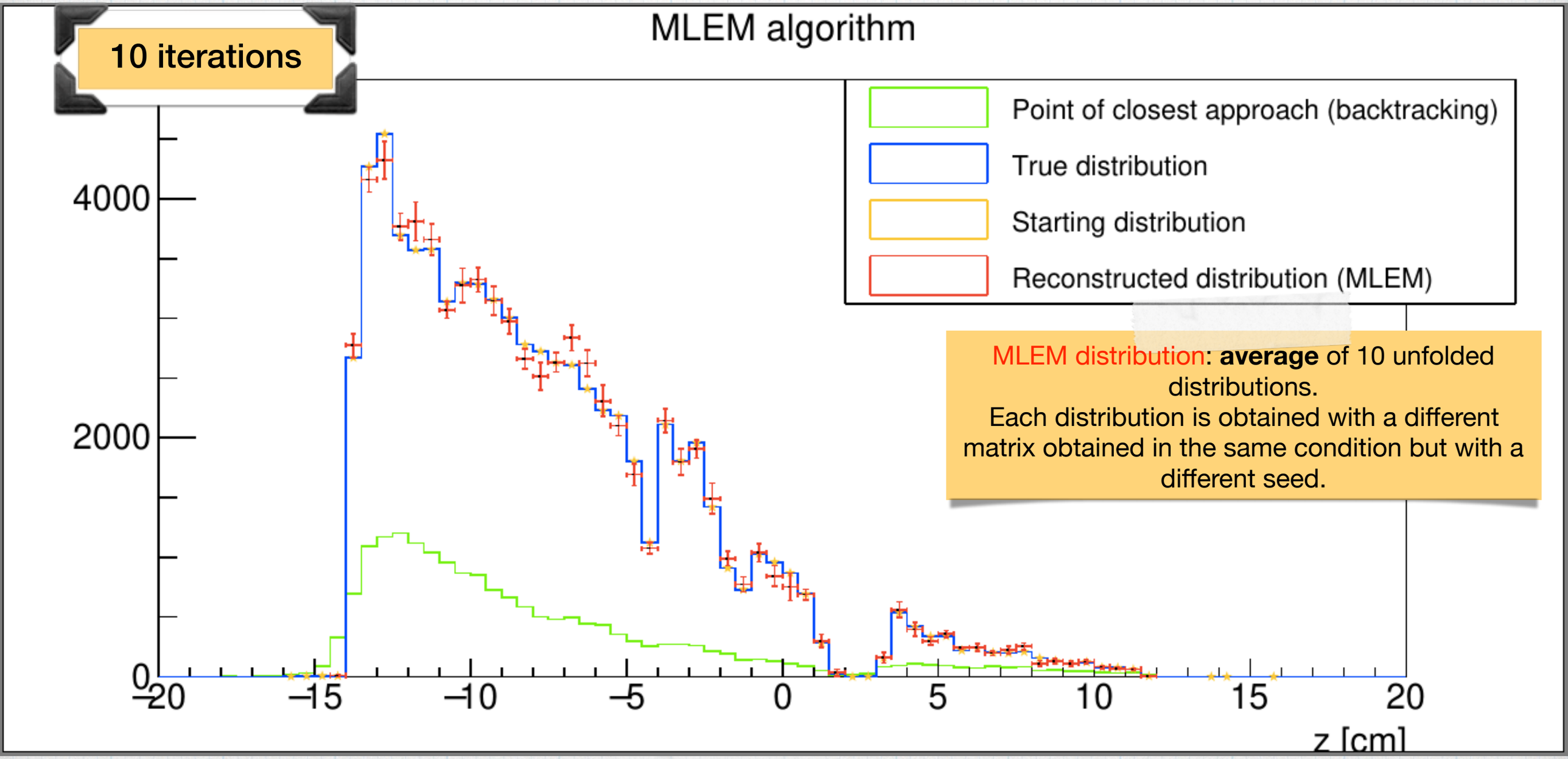
1. TEST 0: code validation

2. TEST 1: Statistical dependence

3. TEST 2: MLEM on MC reconstructed

4. Next step: test with a "data-like" condition

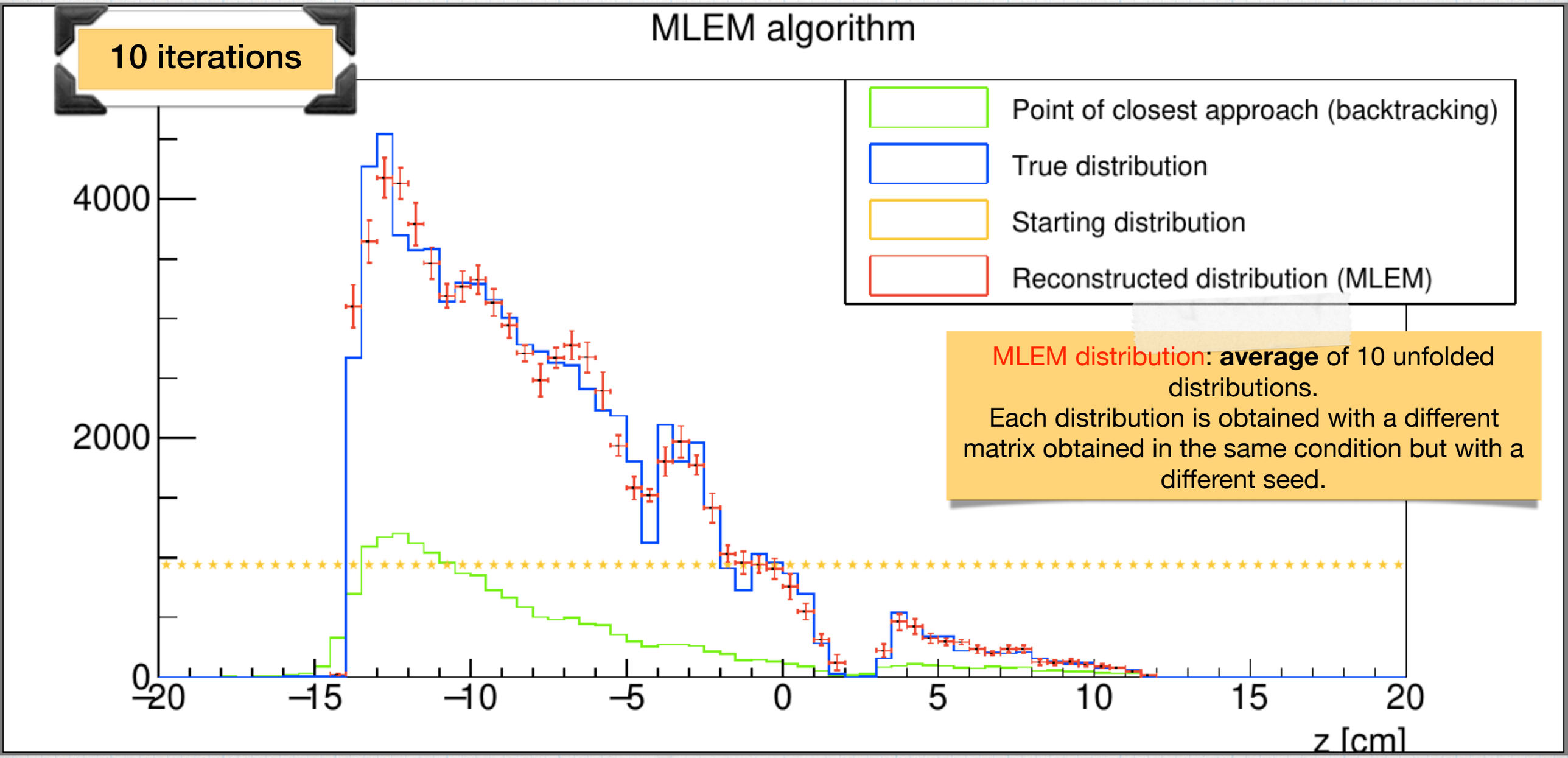
TEST 0: code validation



The algorithm has been applied at the same sample of events used to build the matrices

The initial guess (starting distribution) has been chosen equal to the True Distribution

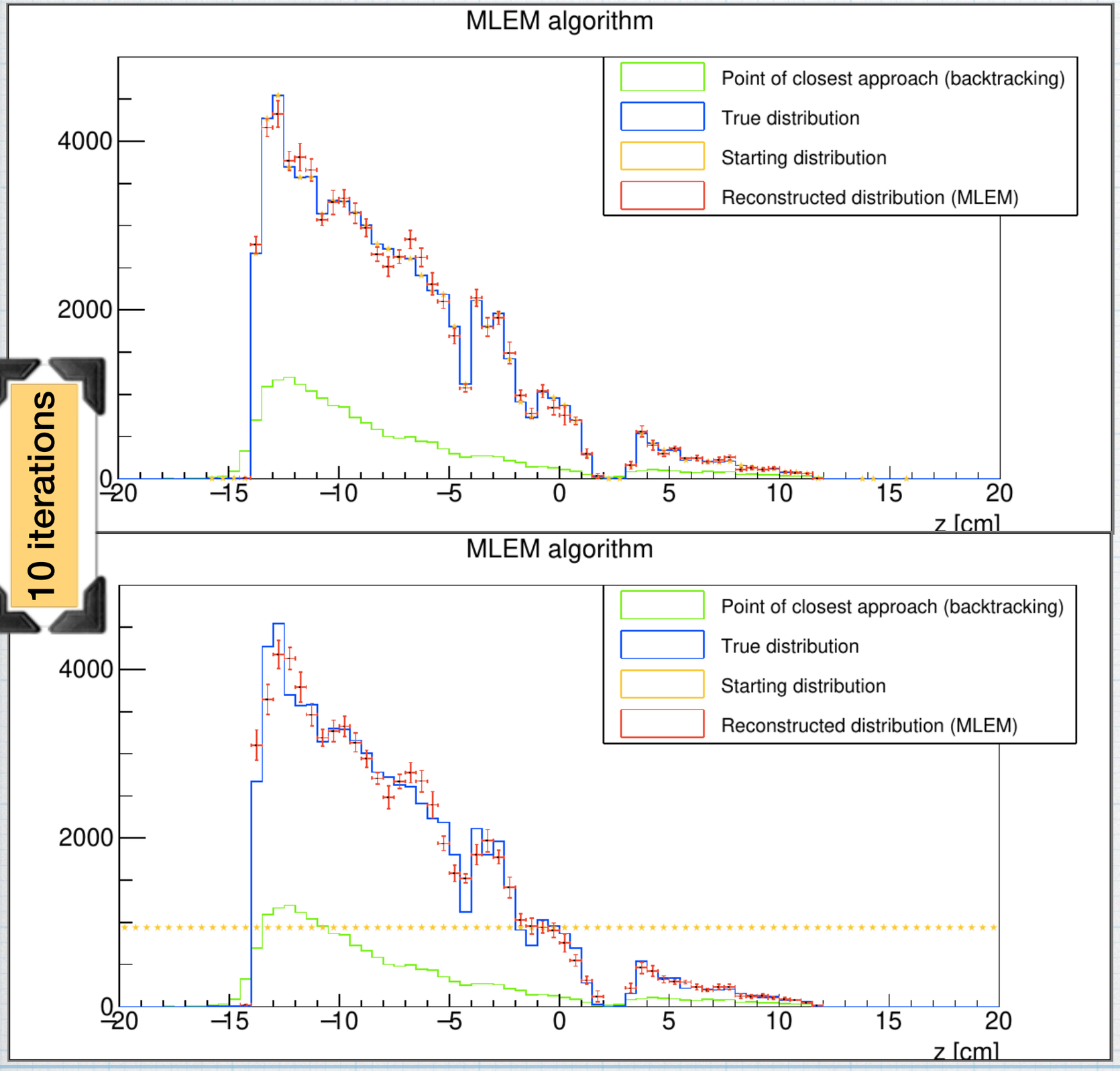
TEST 0: code validation



The algorithm has been applied at the same sample of events used to build the matrices

The initial guess (starting distribution) has been chosen flat

TEST 0: code validation



- Choosing a flat starting distribution, the sensitivity in some bins decrease but, for the unfolding, it is reasonable to use it
- The algorithm has been implemented correctly

is MLEM working in the right way?

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2. TEST 1: Statistical dependence
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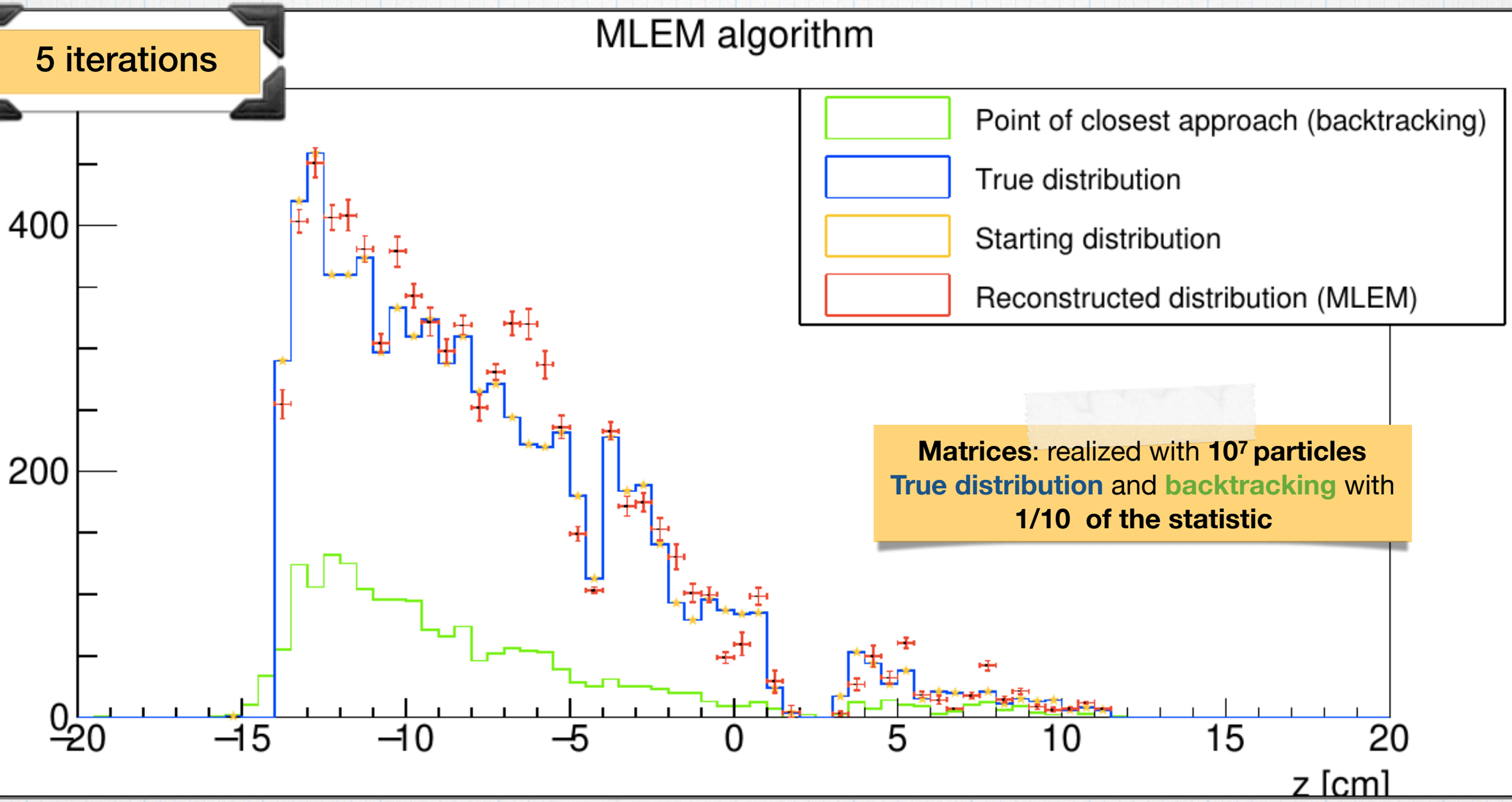
TEST 1: Statistical dependence

5 iterations

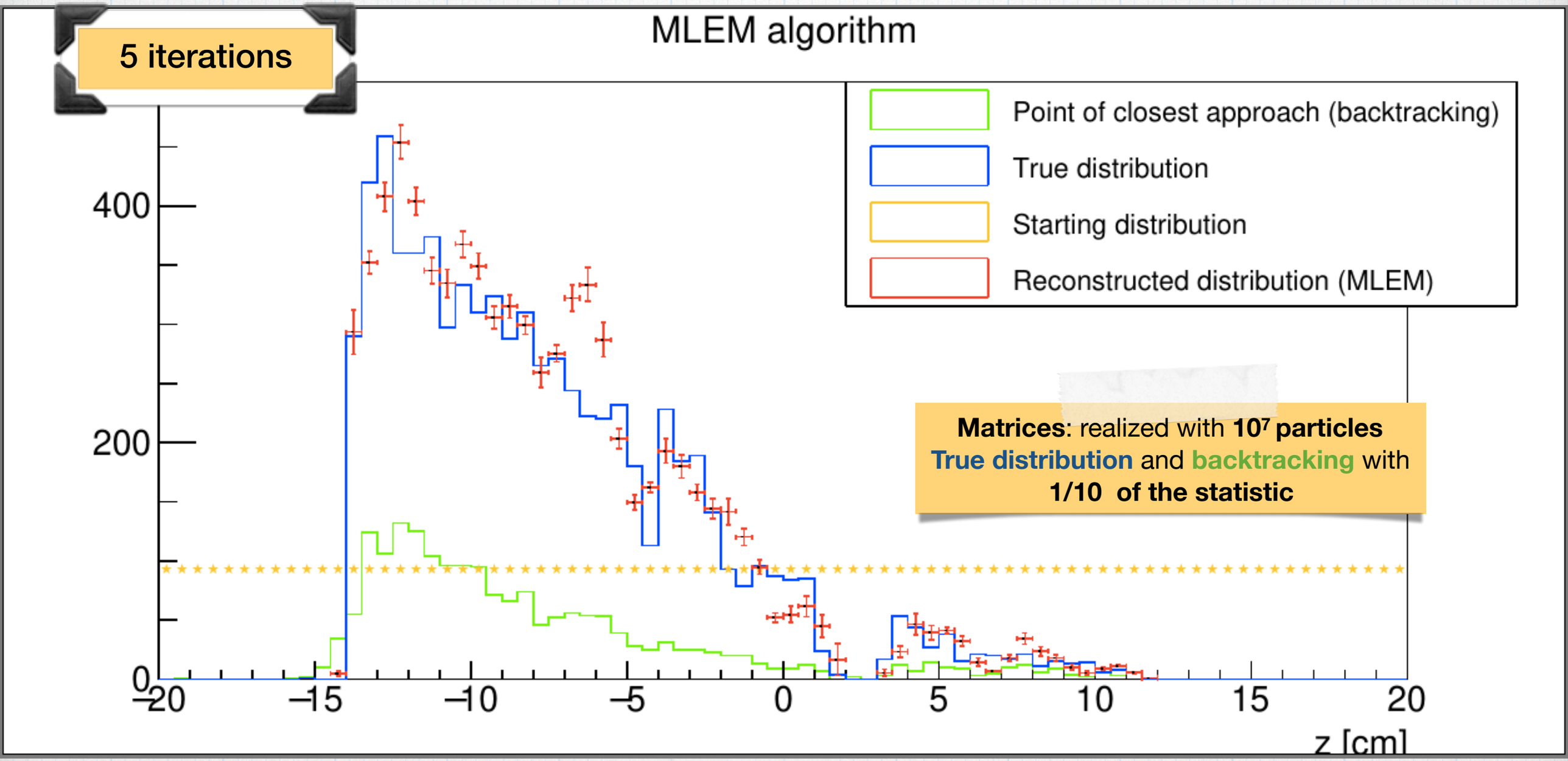


Matrices: realized with 10^7 **particles**
True distribution and **backtracking** with **1/10 of the statistic**

The algorithm has been applied to a sample of 1/10 of the events used for the matrices
The initial guess (starting distribution) has been chosen equal to the True Distribution

TEST 1: Statistical dependence

5 iterations



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True distribution and **backtracking** with **1/10 of the statistic**

The algorithm has been applied to a sample of 1/10 of the events used for the matrices
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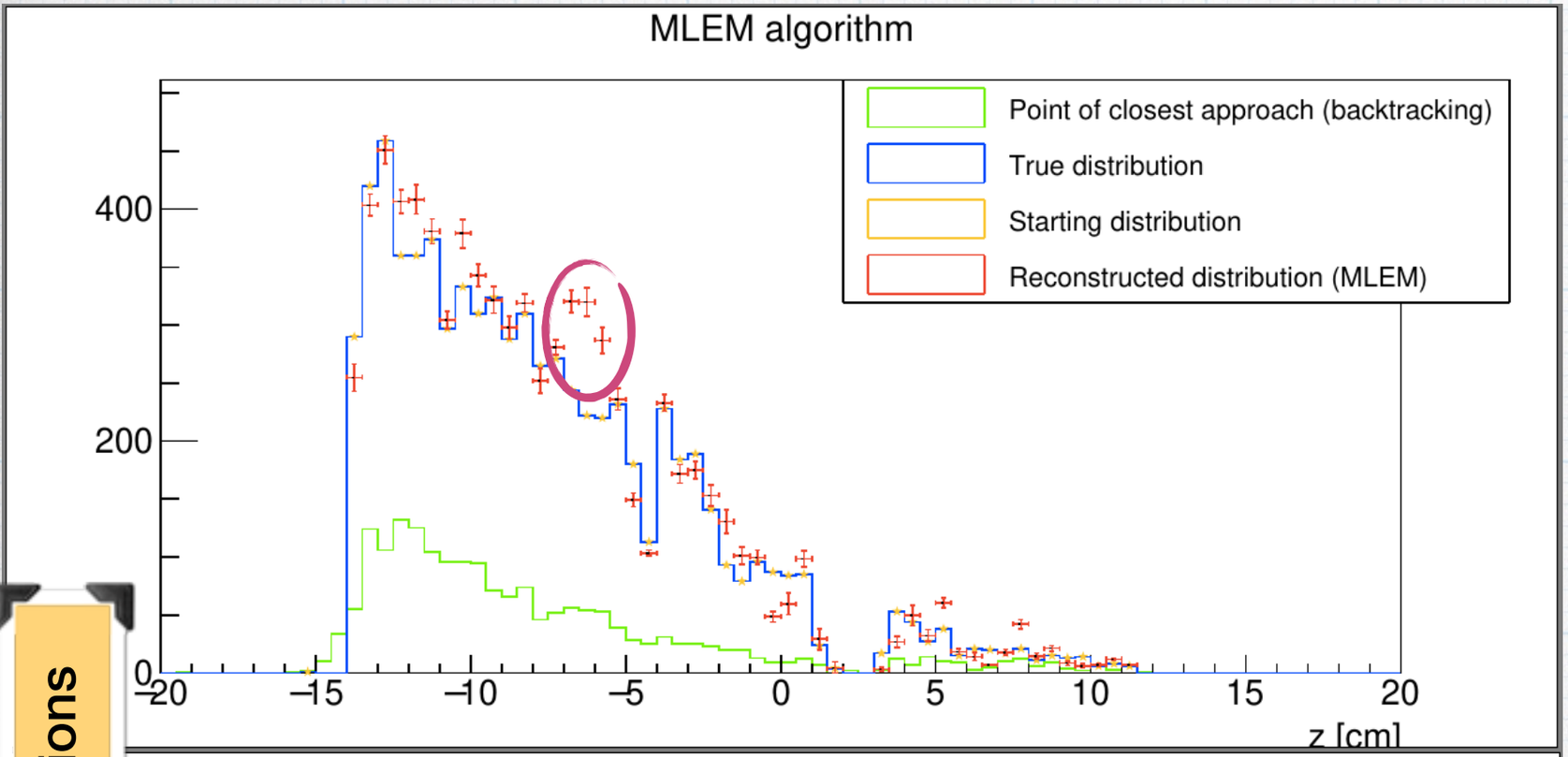

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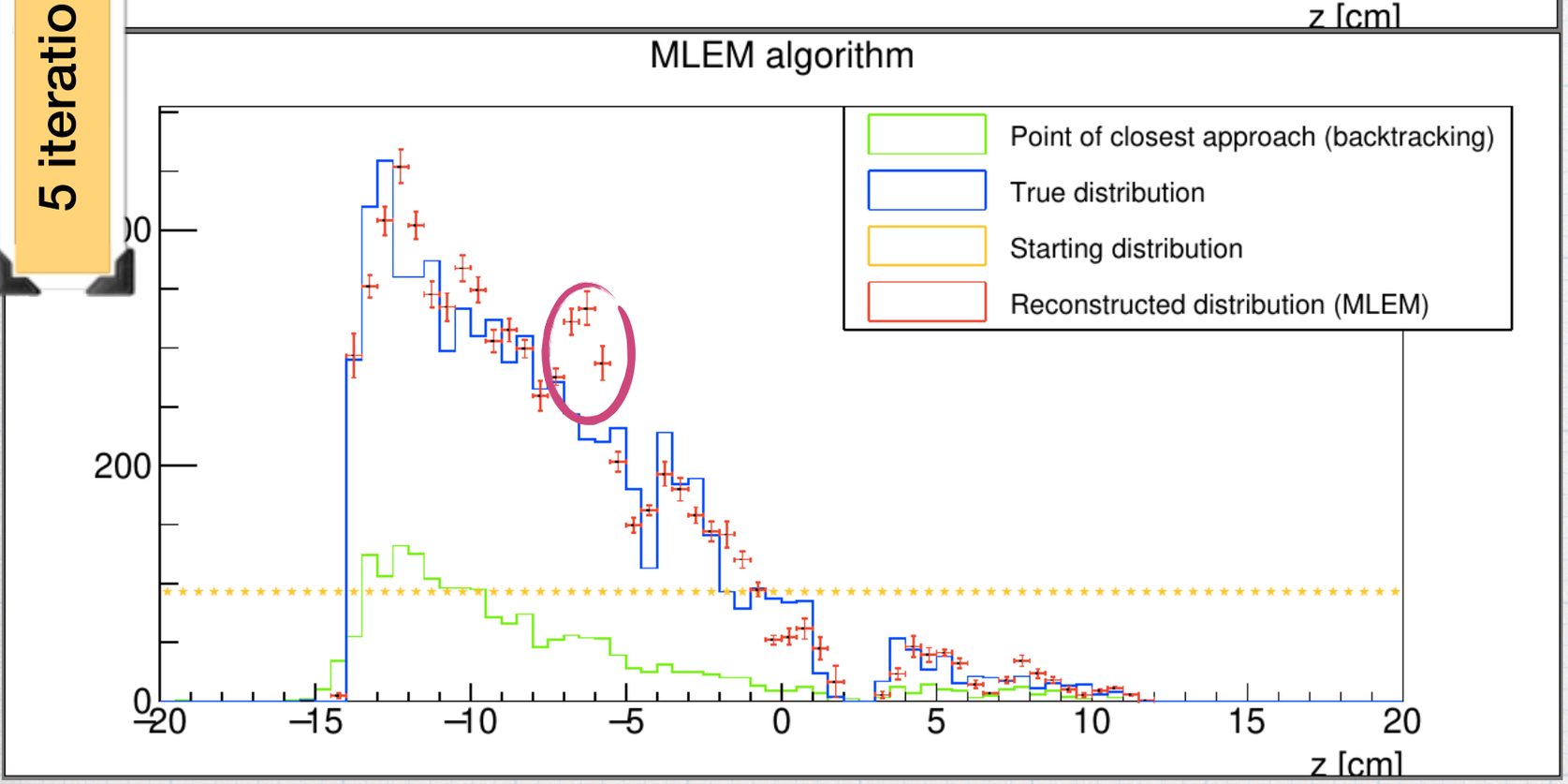


- The initial guess (starting distribution) can be chosen flat for the unfolding
- With the reduced statistics **unexpected peaks**: fluctuations?

is MLEM working in the right way?

Check:

1. TEST 0: code validation ✓

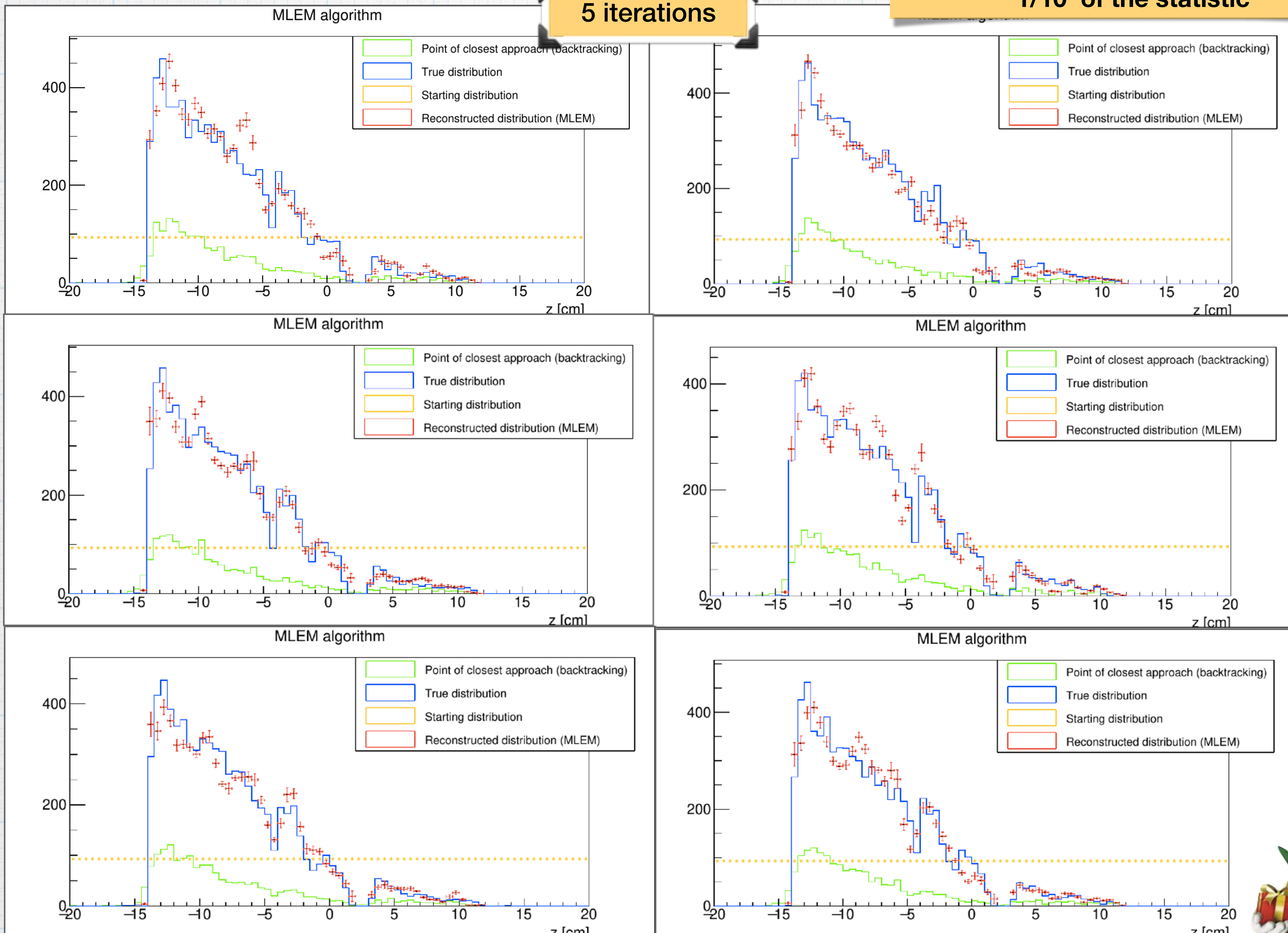
2. TEST 1: Statistical dependence → TESTS

3. TEST 2: MLEM on MC reconstructed

4. Next step: test with a "data-like" condition

TEST 1.1: Statistical dependence

Matrices: realized with **10^7 particles**
True distribution and **backtracking** with
1/10 of the statistic

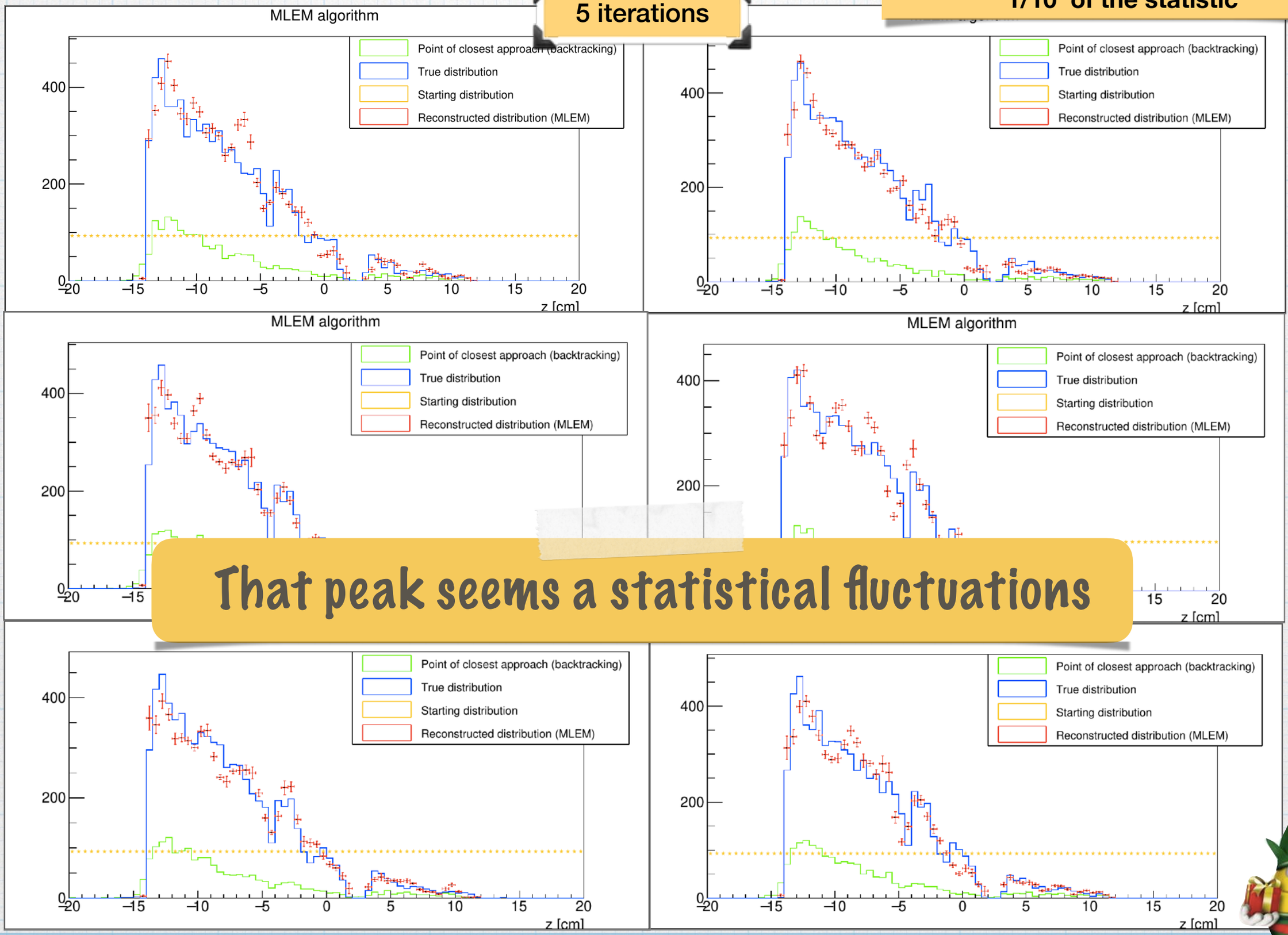


5 iterations

TEST 1.1: Statistical dependence

Matrices: realized with **10^7 particles**
True distribution and **backtracking** with **1/10 of the statistic**

5 iterations



That peak seems a statistical fluctuations

is MLEM working in the right way?

Check:

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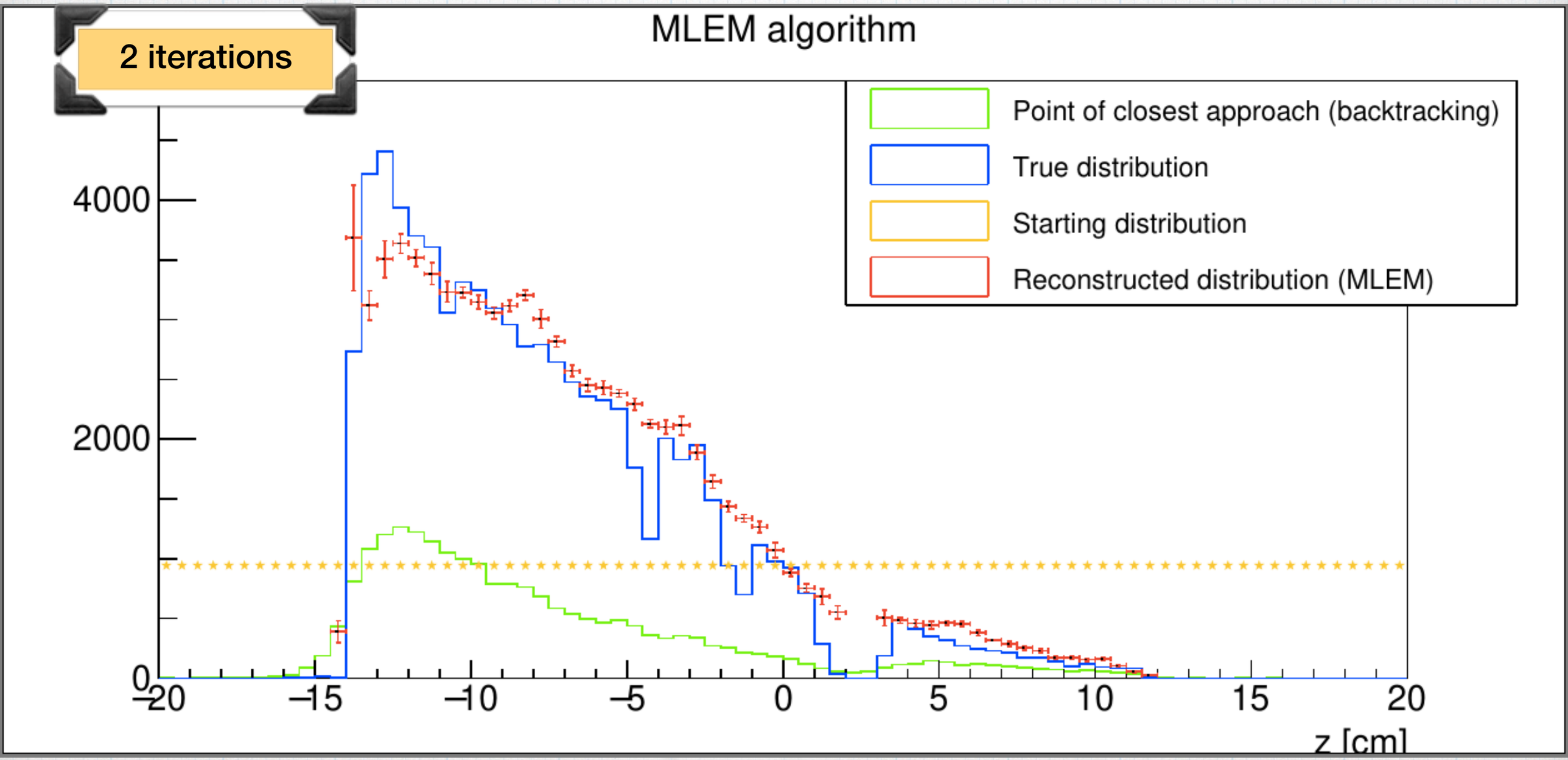
3. TEST 2: MLEM on MC reconstructed
4. Next step: test with a "data-like" condition

TEST 2: MLEM on MC reconstructed

2 iterations



The algorithm has been applied at a MC reconstructed spectrum (using tracking and backtracking) selecting only protons with the matrices selections.

is MLEM working in the right way?

Check:

1. TEST 0: code validation ✓
2. TEST 1: Statistical dependence ✓
3. TEST 2: MLEM on MC reconstructed ✓
4. Next step: test with a "data-like" condition

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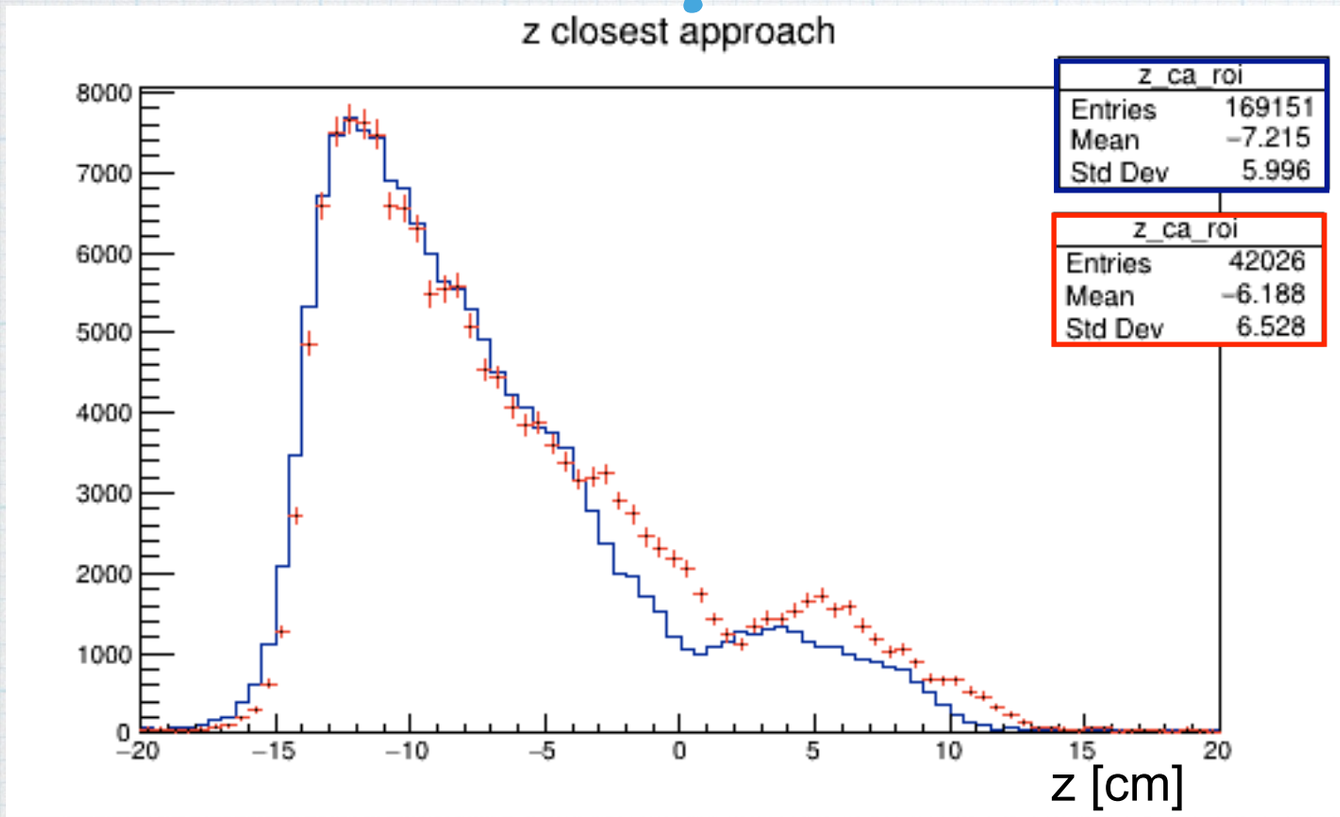
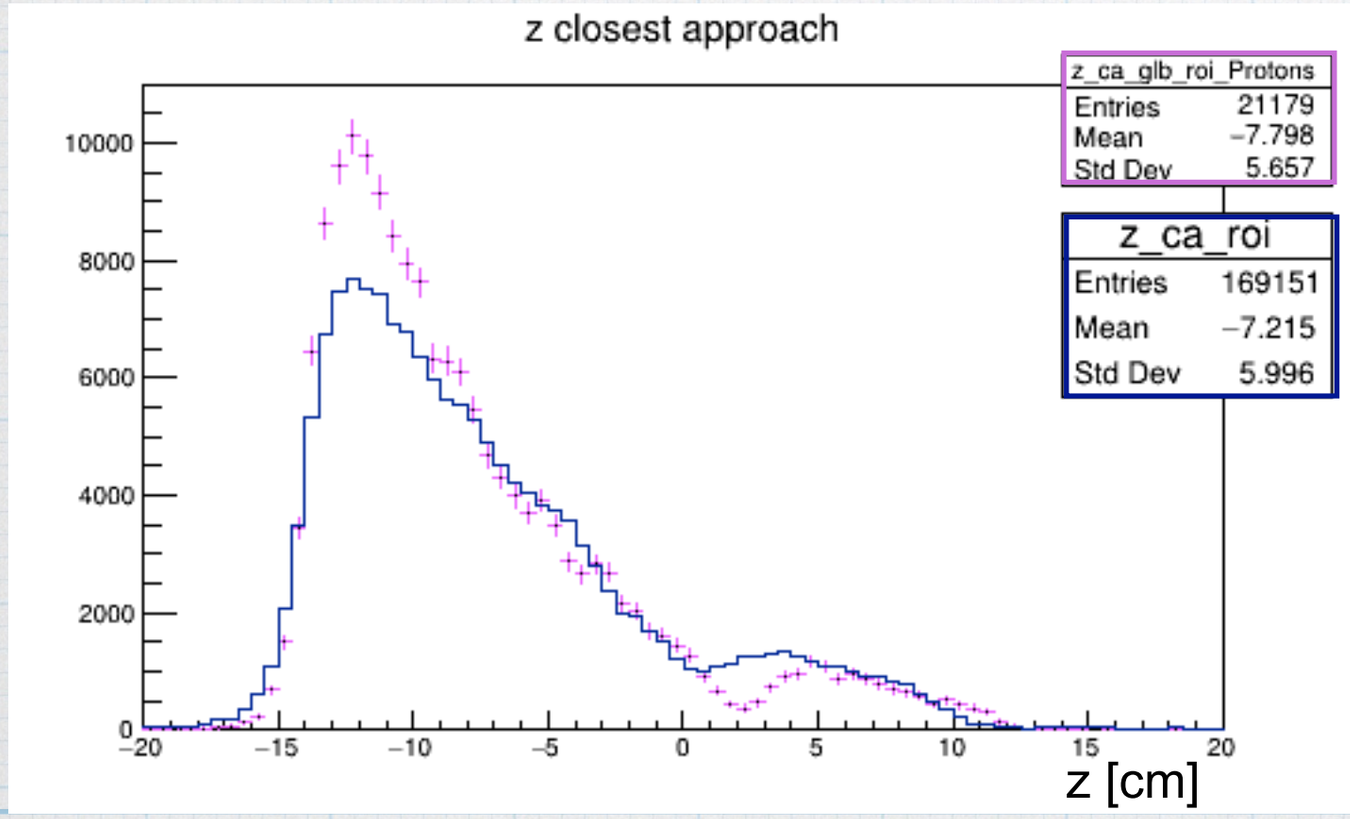




Real data
(Test beam @CNAO)

MC reconstructed considering tracks of any particles

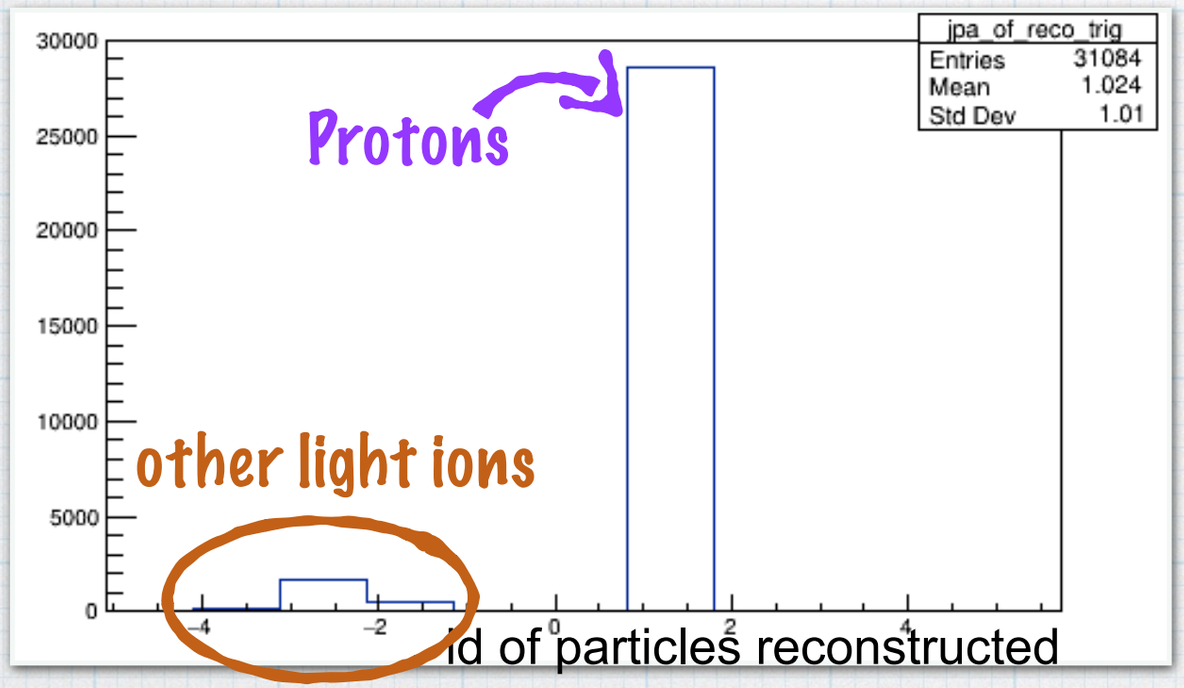
MC reconstructed considering only tracks of protons

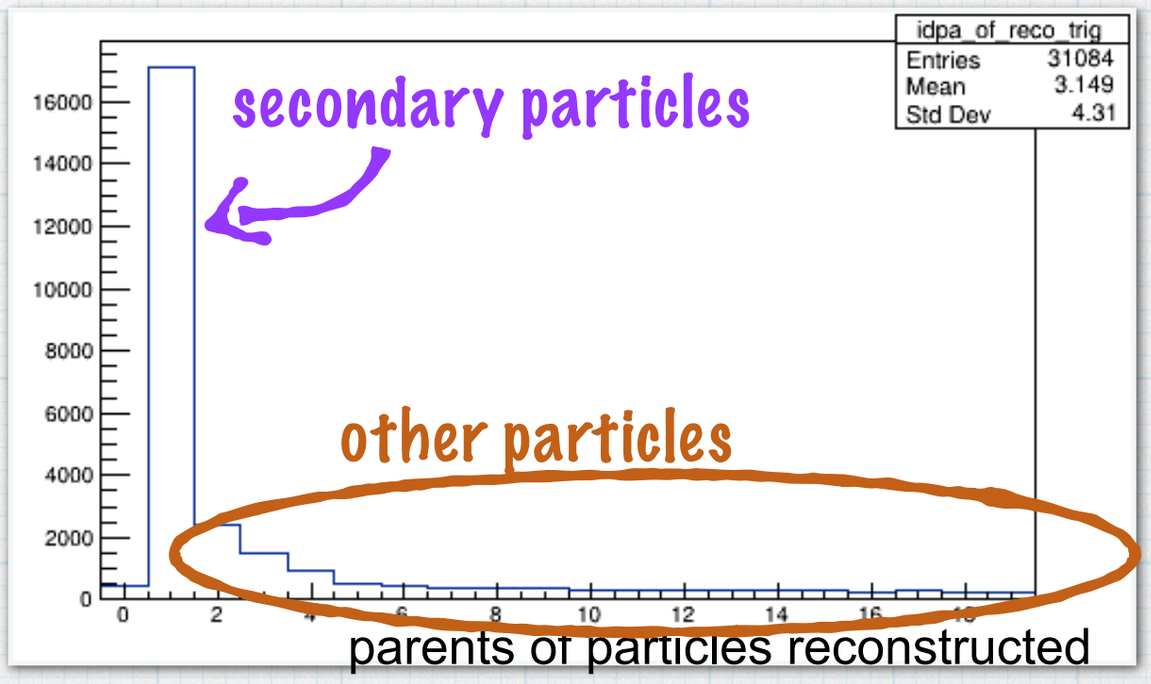
MC reconstructed are normalized considering the number of entries

4. Next step: test with a "data-like" condition

Real situation:

- The DP doesn't detect only protons
- Particles which arrive to the DP are not only the ones emitted by the beam





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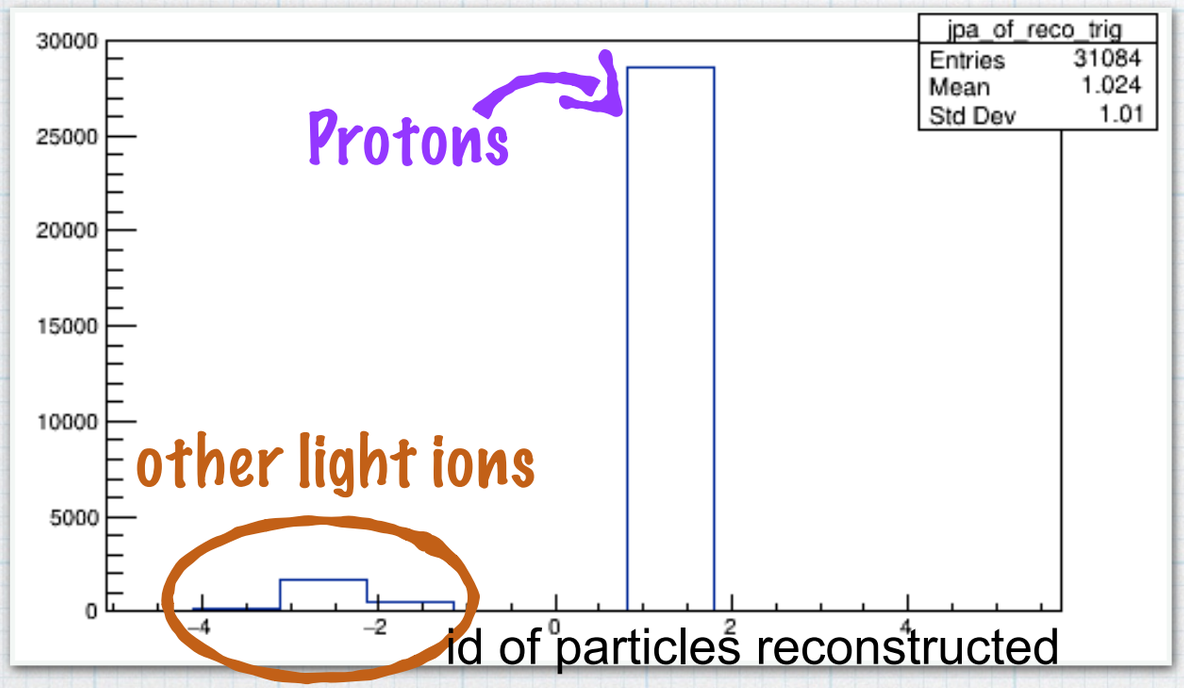

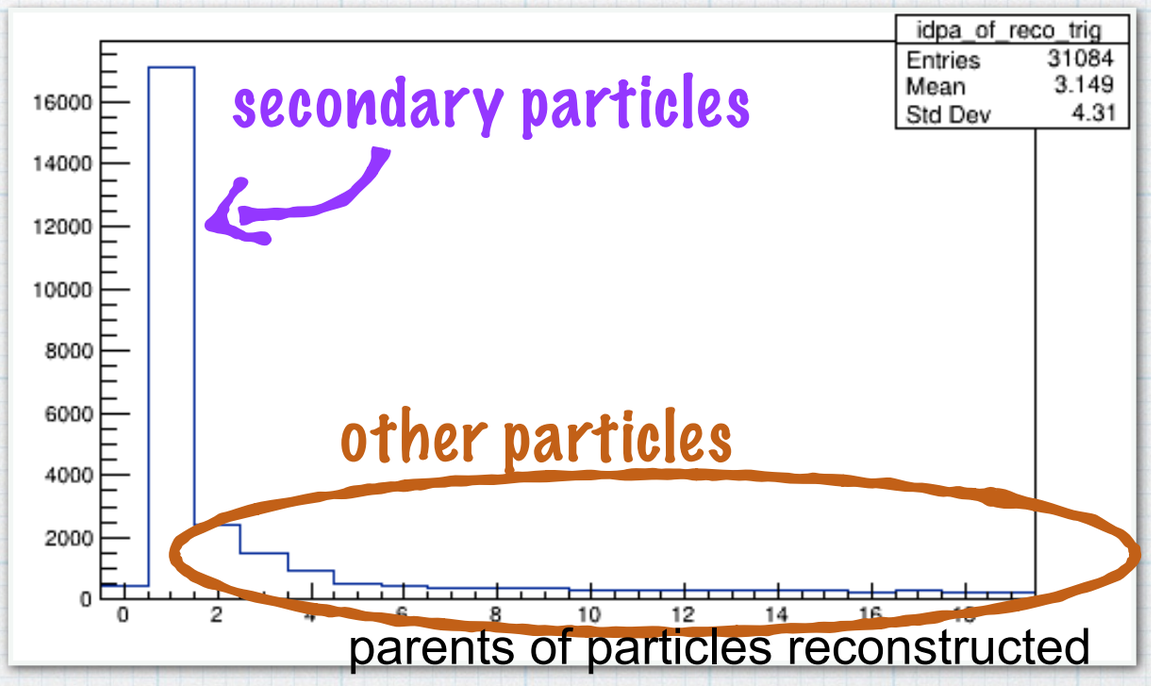

Study of a correct improvement of the unfolding matrix

Thanks

Merry Christmas and Happy New Year