GSI2: ^{16}O (200 MeV) on C_2H_4

Update on the Emulsion Chamber Analysis

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VIBE meeting, October 6 2020

Scanning Progress

Target \ Beam	2019		2020
	Oxygen 200 MeV/n	Oxygen 400 MeV/n	Carbon 700MeV/n
Carbon	GSI1	GSI3	GSI5
Polyethylene	GSI2	GSI4	GSI6

- GSI2: Scanning completed, analysis on-going
- GSI1: Scanning completed, alignment between emulsions completed for S2 and S3
- GSI3, GSI4: Scanning completed (quality check on-going)
- GSI5, GSI6: Scanning on-going

WHAT'S NEW

- Improving the search for extra track related to a vertex
- Double check on PCA for charge assignment
- Article's review completed
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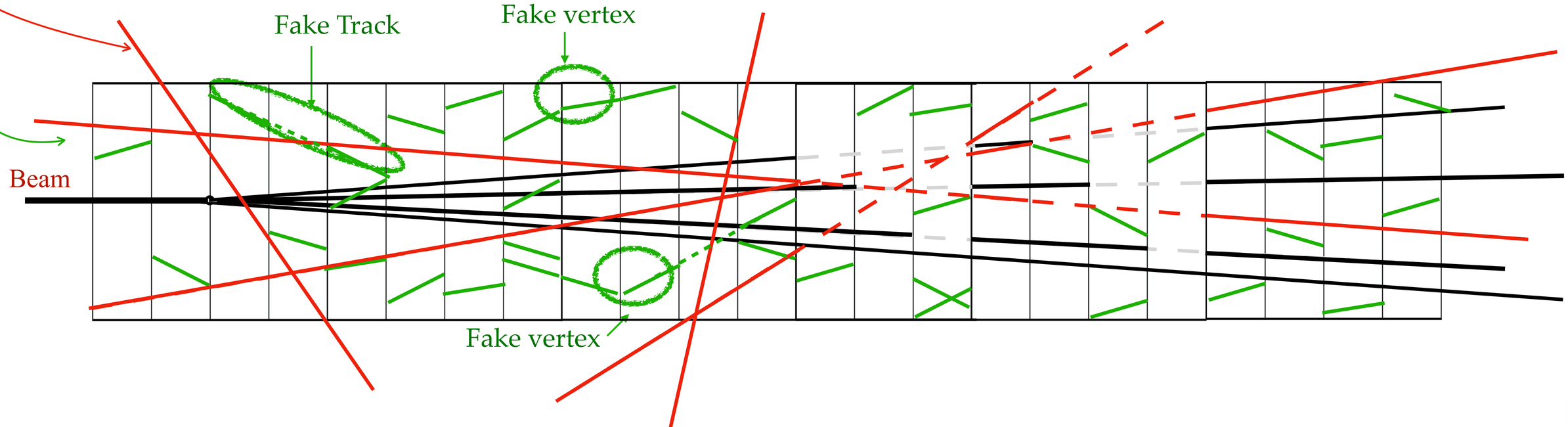
COSMIC RAYS BACKGROUND

- Nuclear emulsions integrate cosmic rays since their production up to their development

- Before and after brick assembling nuclear emulsions are stored all together (no thick passive material) in a different order respect to the brick one. The base-tracks due to the cosmic rays integrated during this period, therefore, should not form any track, apart from combinatorial associations (tracks 2 or 3 base-tracks long).

ADDED TO MONTE CARLO

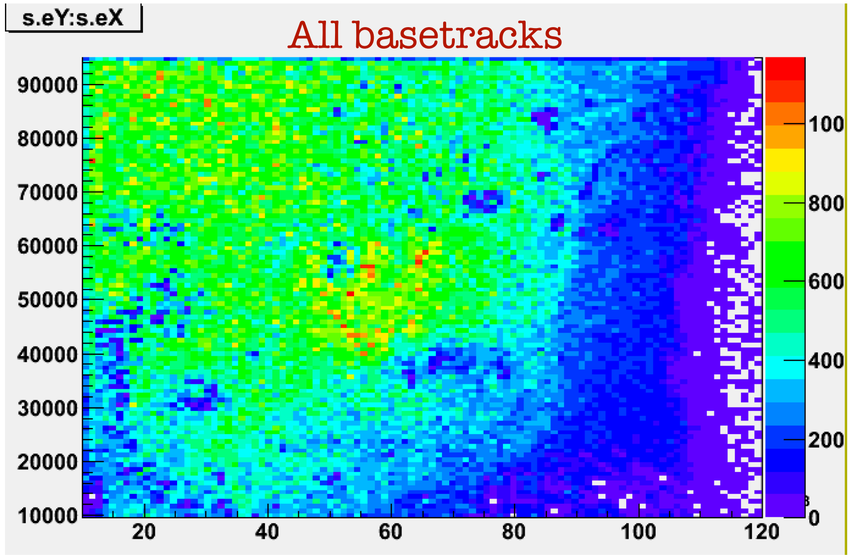
- When the brick is assembled it integrates cosmic rays that are then reconstructed as long tracks. These could mimic a vertex or be associated to a true vertex if they're reconstructed as more than one track



COMBINATORIAL BACKGROUND ADDED TO MC - EXAMPLE

Background base-tracks were taken from data, in a region with no signal…

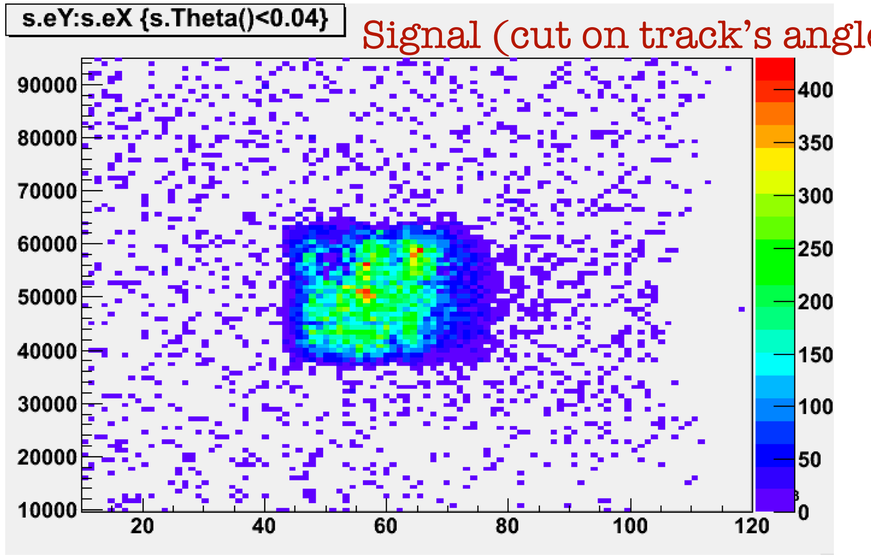
All basetracks



3803509 entries

(DATA)

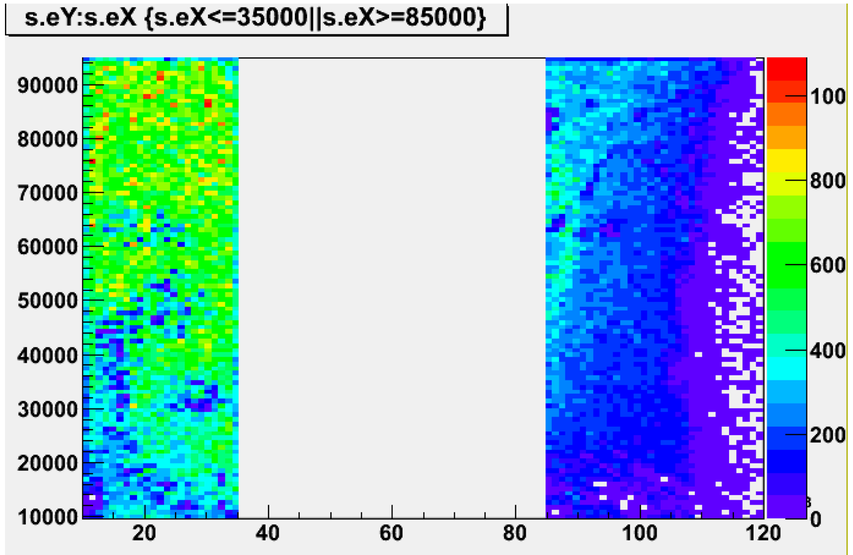
Signal (cut on track's angle)



(DATA)

105744 entries

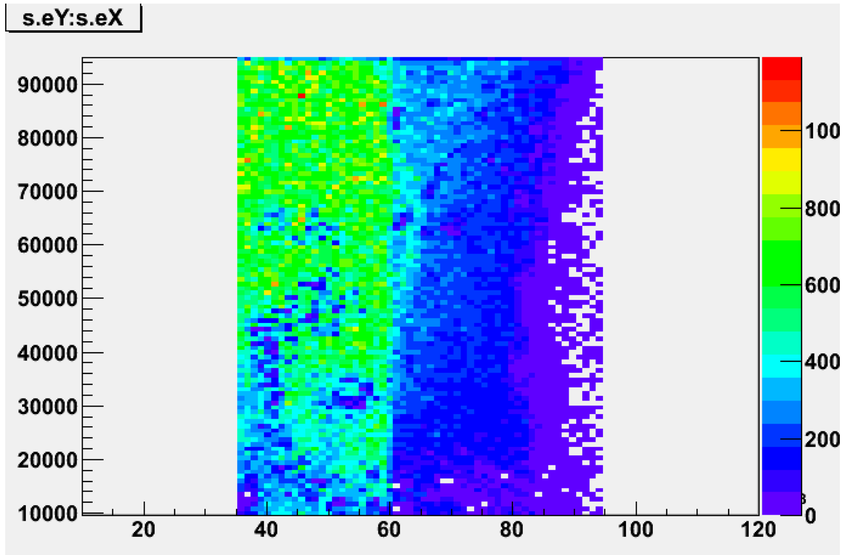
Background (cut on X coordinate)



(DATA)

1604247 entries

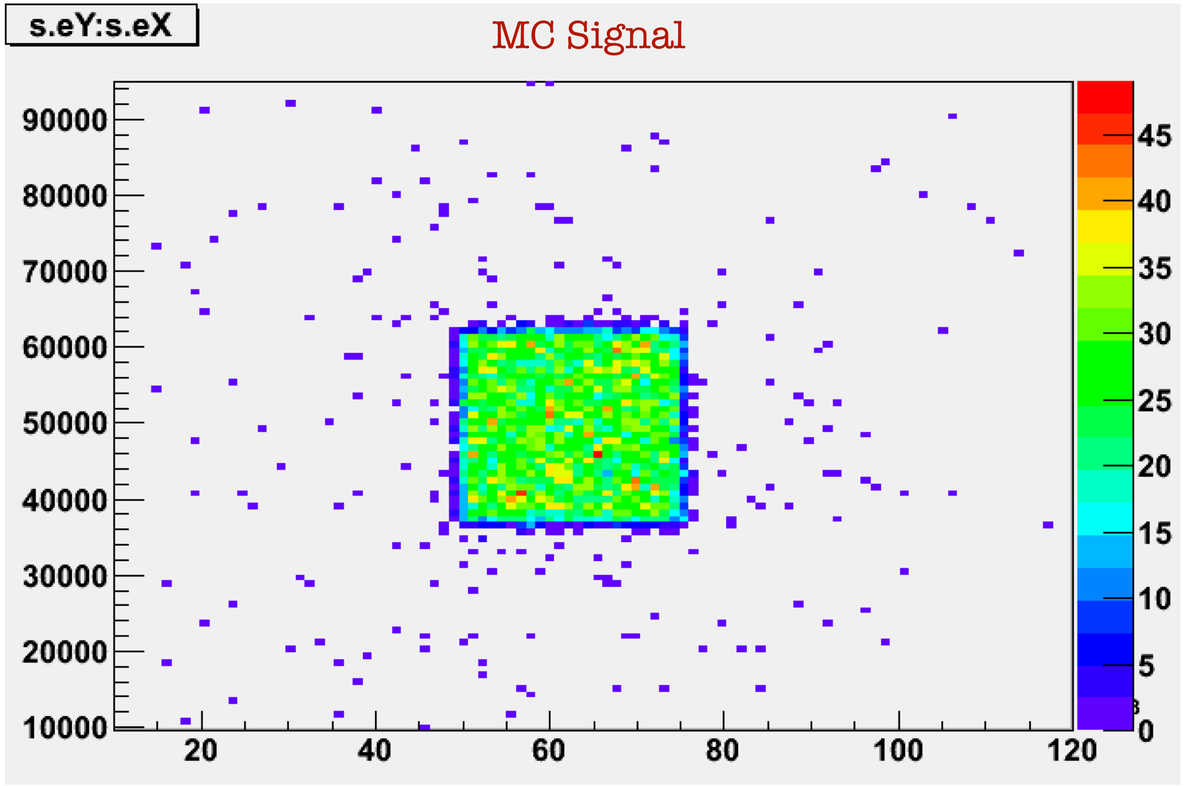
Background translated to the signal region



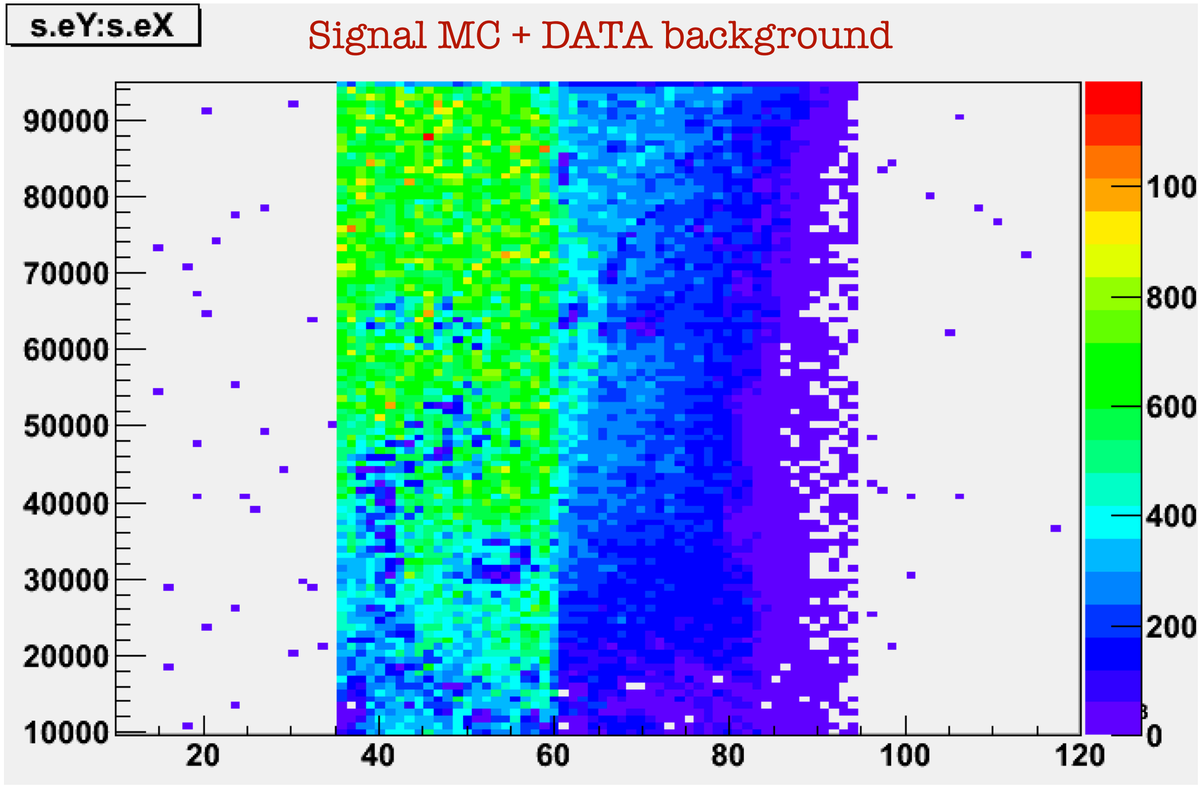
COMBINATORIAL BACKGROUND ADDED TO MC - EXAMPLE

… and added to Monte Carlo

(MC)



18746 entries



1622993 entries

VERTEXING - TRACKS SEARCHING APPLIED TO ALL VERTICES

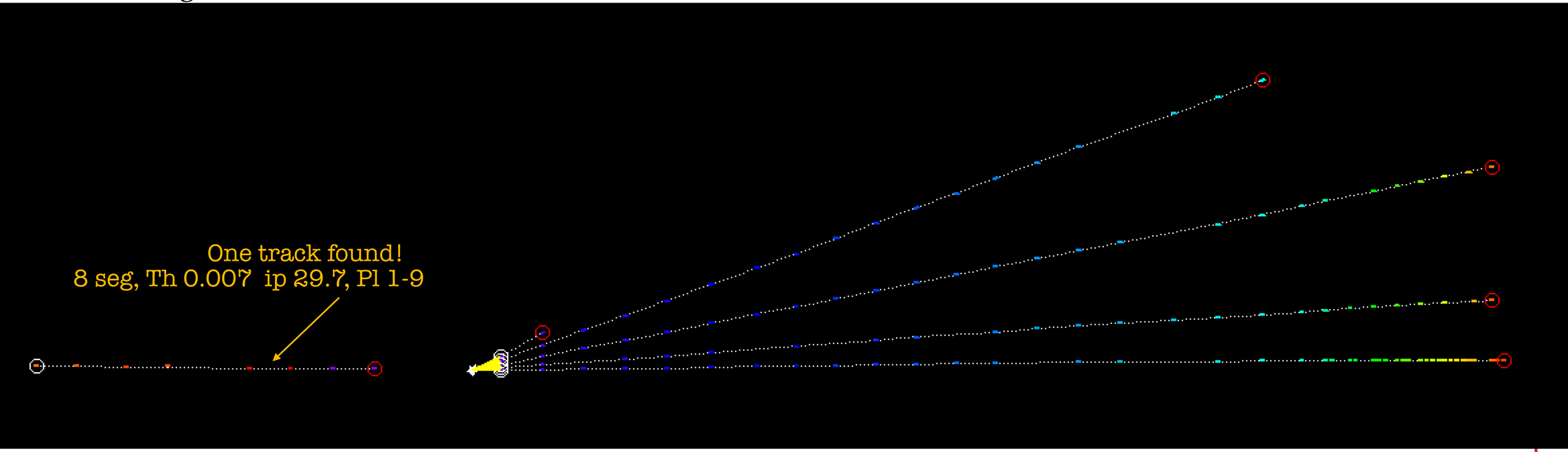
- Search for tracks starting or ending within:

Preliminary

  - ✓DX or DY < 1000 micron from the vertex
  - ✓DZ=8000 micron from the vertex
  - ✓IP < 100 micron

- Incoming tracks: if the oxygen track is found, only tracks with nseg≤3 are accepted as incoming

- The script was very slow (several hours for 1000 vertices)
- New strategy: saving the tracks in the vertex neighborhood during vertexing procedure
- Apply the search for tracks related to the vertex only within the neighbor ones
- Script much faster (about 1 min for 1000 vertices)



Extra Tracks Searching

Preliminary

	MC		DATA	
	before	after	before	after
Entries	7968		14193	
n≥3	3663	5686	4216	8716
vtx good (2 trks ok)	3291	5237		
vtx fake	372	449		
vtx good (3 trks ok)	2830	4493		
vtx fake	833	1193		
n=2	4305	2282	9977	5477
vtx ok (same event, different track)	1394	606		
same track	400	227		
vtx fake (different event, different track)	2511	1449		

True MC vtx: ~ 6500

the number of vertices with high multiplicity increases

2-prongs vertices decrease

Next steps

- Improve results tuning the algorithm and its parameters
- Visual check of vertices
- BDT analysis to separate good and fake vertices

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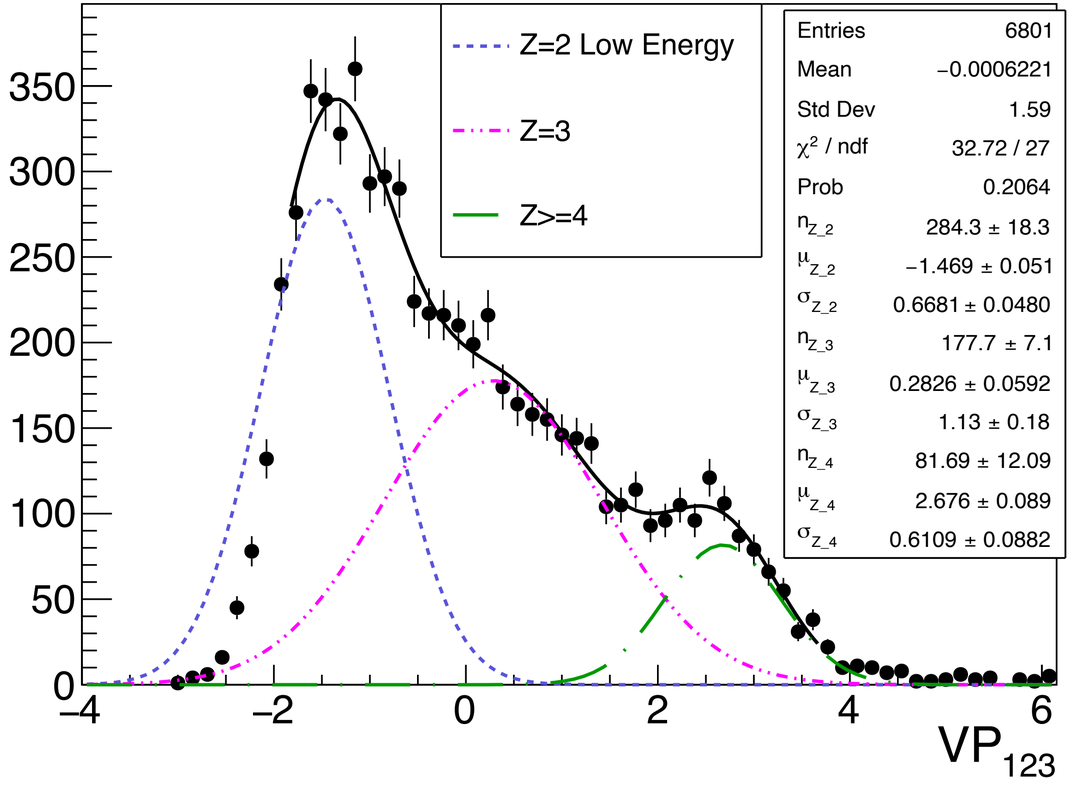
A Double Check On Charge Identification with PCA

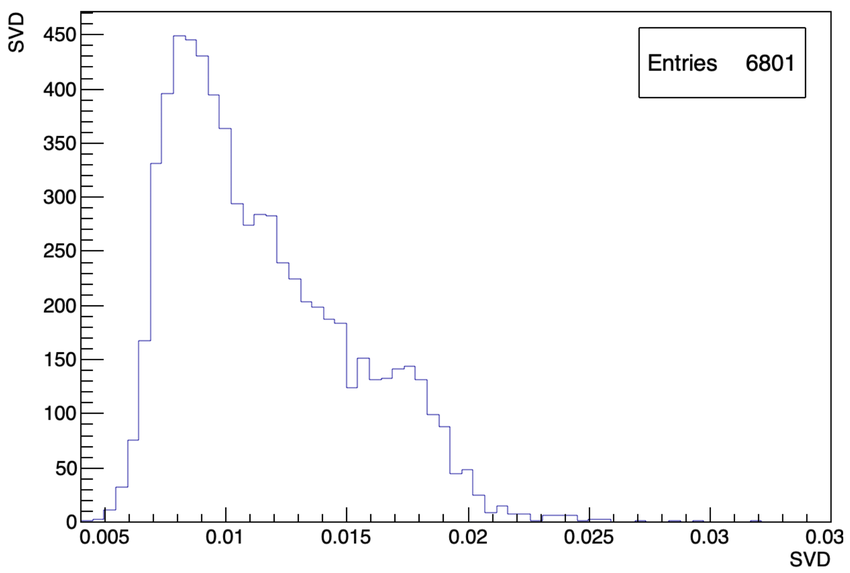
- "Problem": with PCA we obtain negative values, even if our starting matrix is non-negative → this *could* be a hint that the PCA method is not adequate

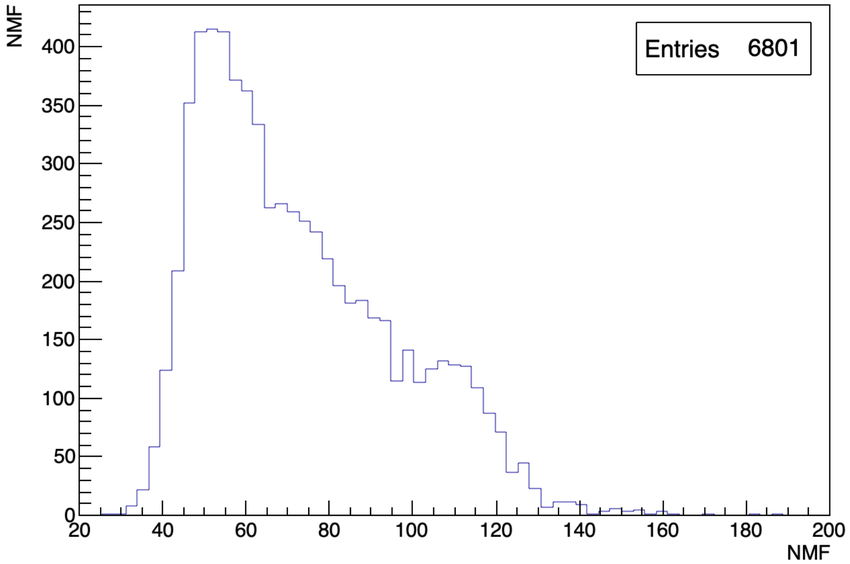
- Trial using other methods to check if the shape of the distribution of VP_xxx is the same

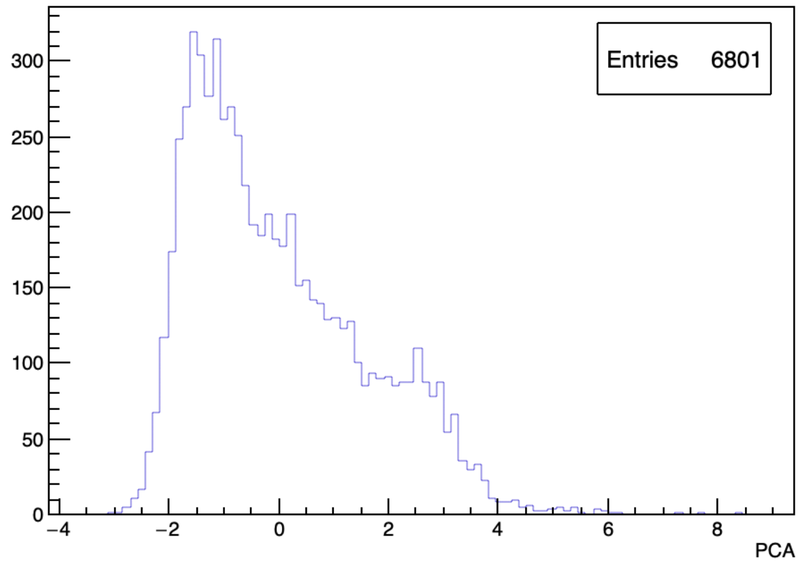
- We want the best matrix of rank 1 that approximates data: three methods are exploited:
  - SVD: *Singular Value Decomposition*
  - NMF: *Non-negative Matrix Factorization*
  - PCA: *Principal Component Analysis*



SVD, NMF, PCA







SVD: ***Singular Value Decomposition***

- Minimize the 2-norm between the data matrix and the rank-1 approximation
- Theorem: the SVD matrix is unique

NMF: ***Non-negative Matrix Factorization***

- Minimize the 2-norm between the data matrix and the rank-1 approximation <u>with positive elements</u>

PCA: ***Principal Component Analysis***

- Data are normalized so that all columns have mean 0.
  Then SVD is applied

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ARTICLE ON CHARGE IDENTIFICATION

- Draft circulated within the Collaboration
- Paper improved thanks to all the comments received
- Waiting for the comments of the Editorial Board

Charge identification of fragments with the emulsion spectrometer of the FOOT experiment

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v3.1

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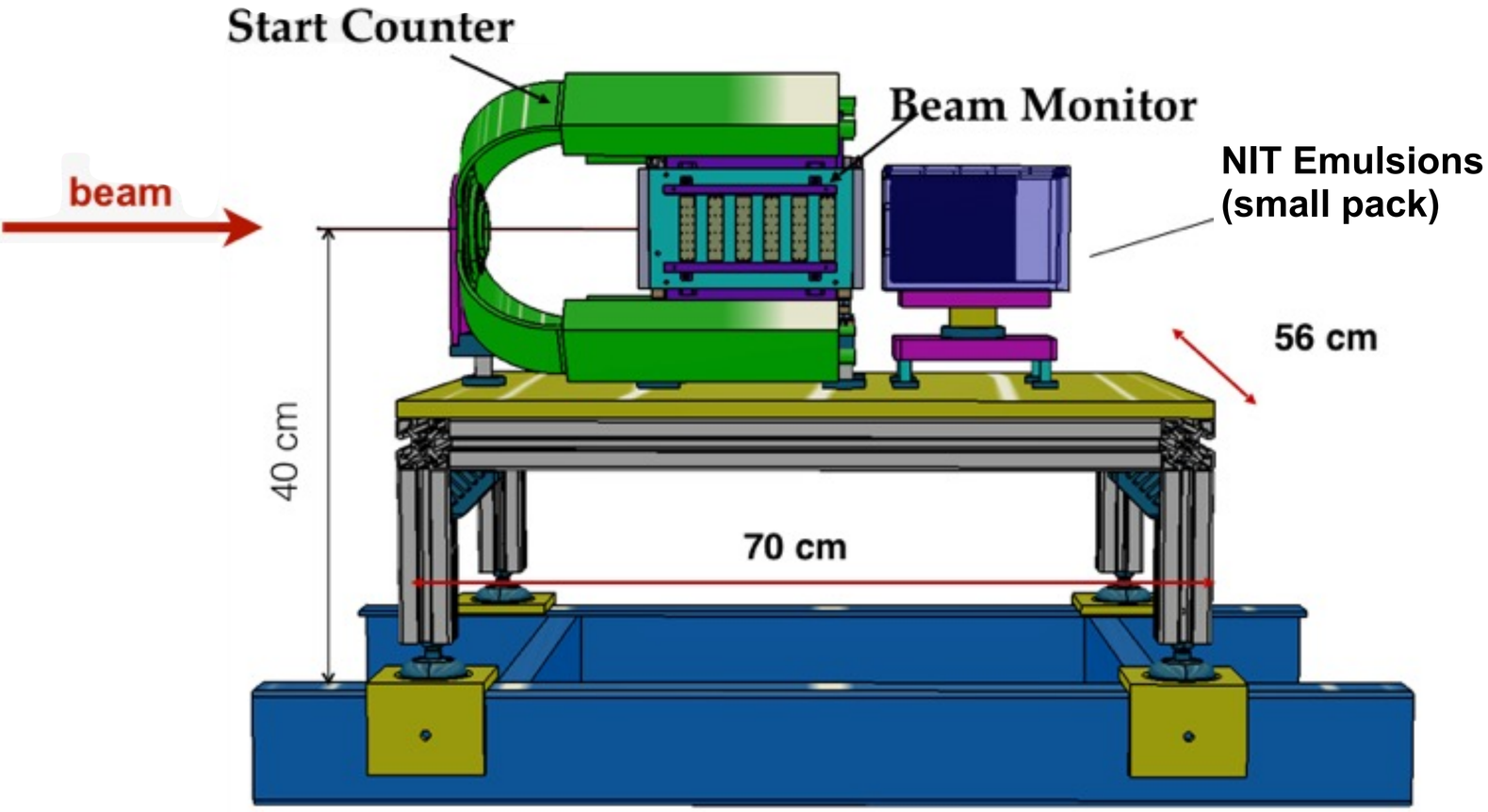
CNAO Technical Test for NIT Emulsions

- New generation nuclear emulsions with nanometric grains: NIT (*Nano Imaging Trackers*)
- Granularity one order of magnitude higher: grain diameters down to a few tens of nm
- Emulsion gel with about ten basic chemical elements: heavy elements, such as silver and bromine, plus lighter elements, such as Carbon, Nitrogen, Oxygen and Hydrogen to improve sensitivity

- Technical test: check the sensitivity of NIT emulsion films to Carbon ions and protons
- Physics goal: use protons to study the fragmentation of the target

SETUP



- NIT emulsions
- Low temperature chamber
- Cooling system
- Linear motorized stage

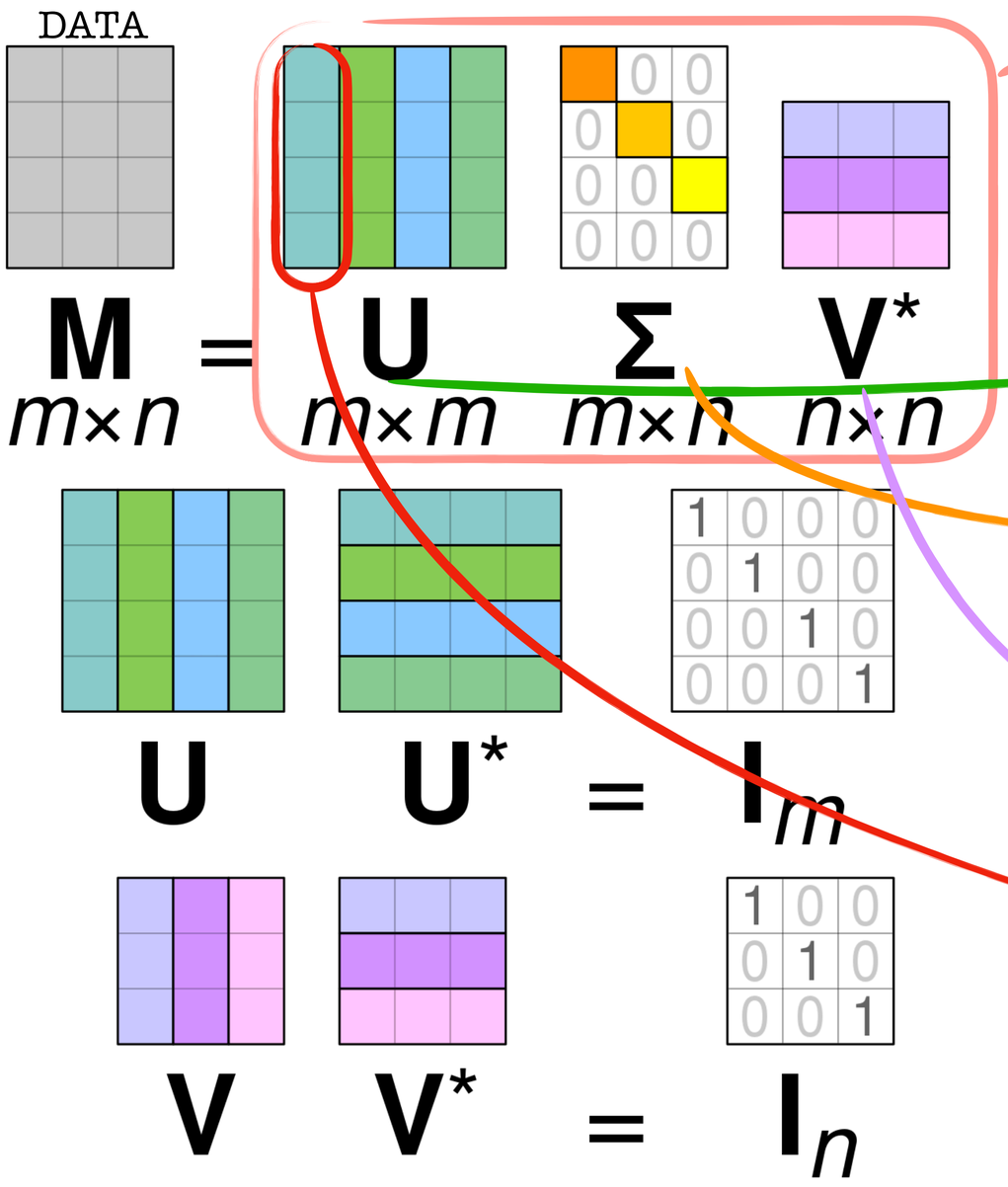
- Margherita or Margarita
- Beam monitor
- Big and small tables as support

- Carbon and proton beams with the lowest possible energy and intensity

- People at CNAO: 3

Back up slides

SVD Explanation



SVD

U is a base of **M** with orthogonal vectors since its singular values are all non-zero, meaning that the matrix **M** has maximum rank

Σ singular values are ordered: (1,1) is the biggest, the others can be neglected

V* contains the coefficients of the linear combination

The best rank-1 approximation of data is given by the first column of **U** x **Σ**(1,1) x the first row of **V***