The Status of Identification in Argon Run

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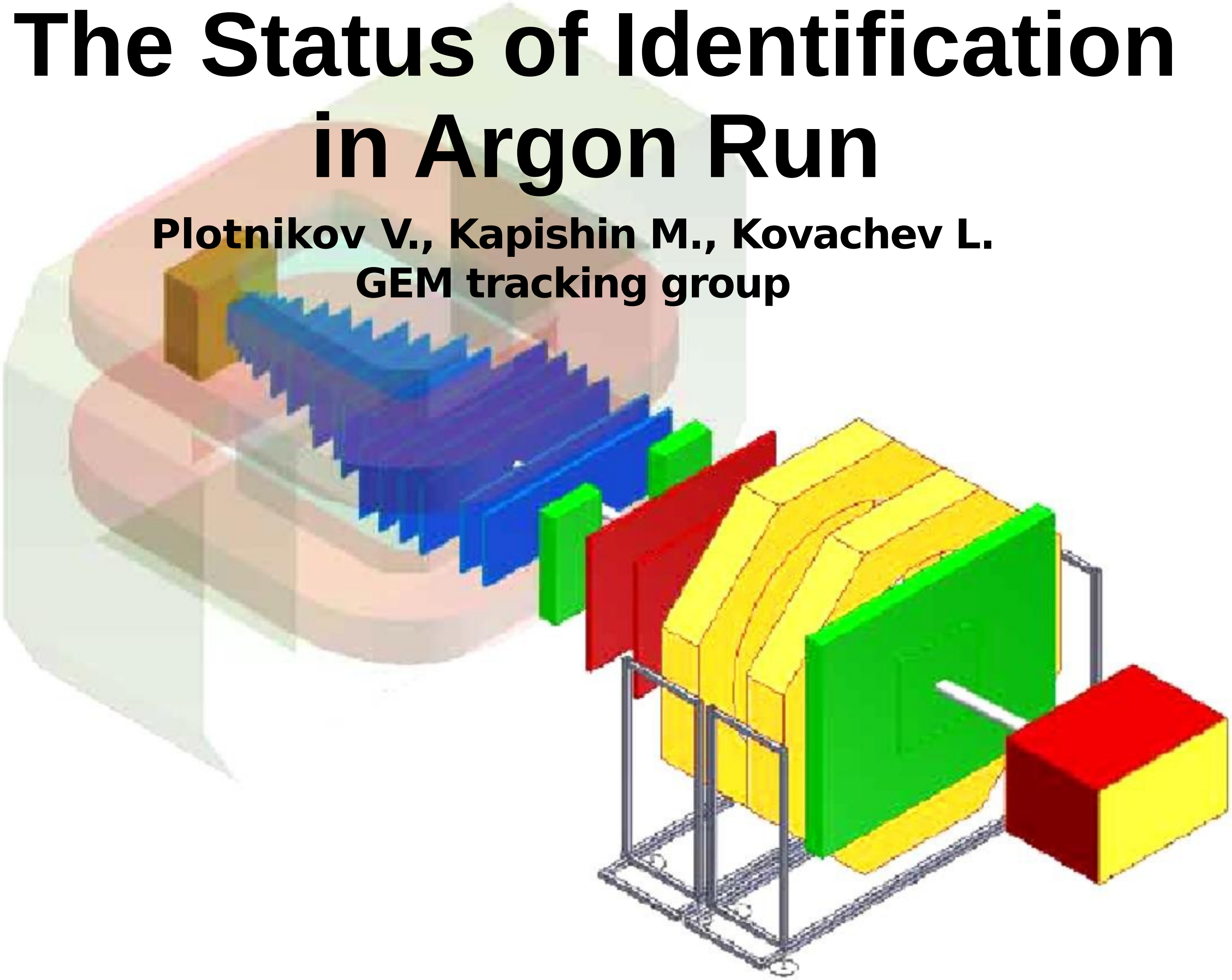
GEM tracking group



6th Collaboration Meeting of the BM@N Experiment at the NICA Facility
26.10.2020

Recap

- What have been done to the 5th CM
- Outlook for 5th CM

What have been done to the 5th CM

- Common identification chain for Data and MC
- Common by strip geometry for Data and MC for Si/GEM/CSC/TOF400

Outlook for 5th CM

- To conform Si, Gem and CSC the cluster sizes and the amplitudes in MC and Data
- To get MC efficiencies of Si, GEM, CSC, TOF400
- To get Data efficiencies of Si, GEM, CSC, TOF400
- To add to the MC efficiencies from the Data normalized to the efficiencies from the MC
- To compare identification results for π^+ and K^+ for the Data and MC

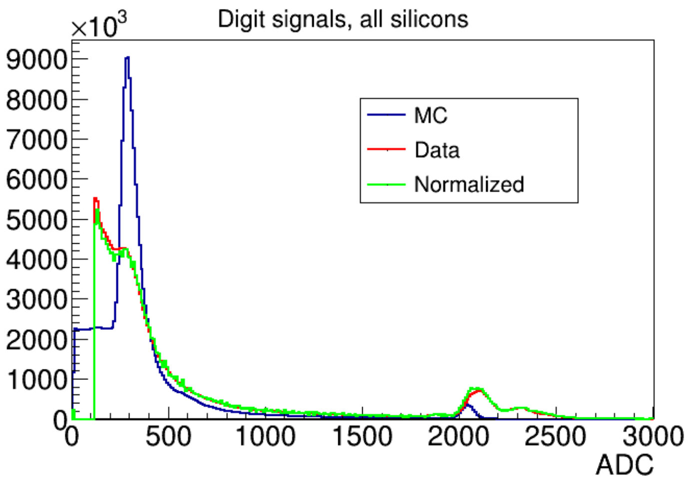
Content

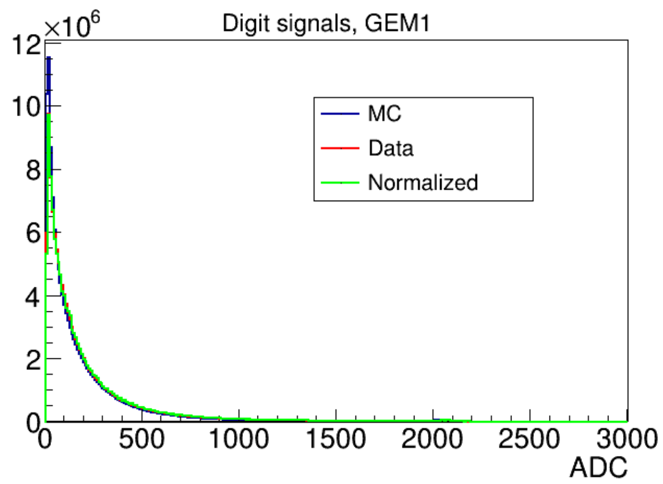
- Si/GEM/CSC signals normalization
- Data and MC Si/GEM efficiencies comparison
- Data and MC CSC efficiencies comparison
- Data and MC TOF400 efficiencies comparison
- Si/GEM residuals for Data and for MC and EMB after smearing
- Detector effects implemented in MC
- Results of identification comparison for Data and MC with detector effects

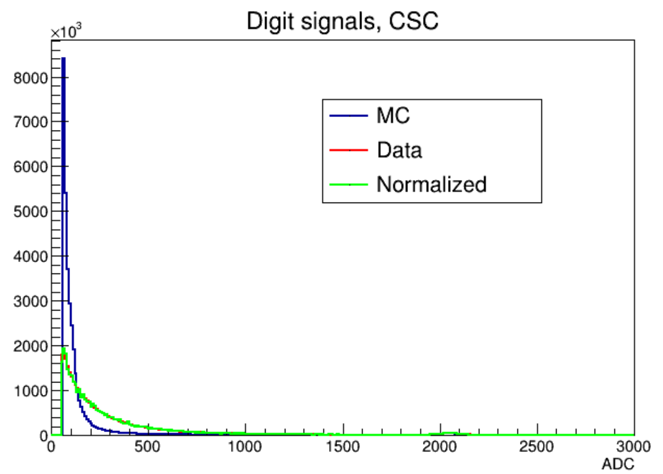
Content

- Embedding QA
- First result of the embedding
- Embedding Efficiency in (Y,Pt) bins
- P, Y, Pt spectra of identified π^+ after embedding
- Possible ways to match MC to the Data
- Using of another MC generator
- Detailed Si/GEM geometry

Si/GEM/CSC signals normalization (Lalyo Kovachev)



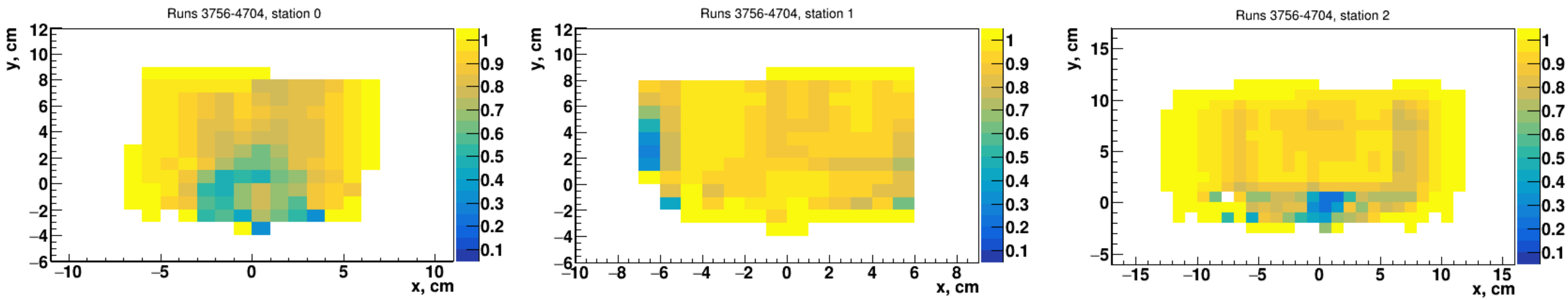


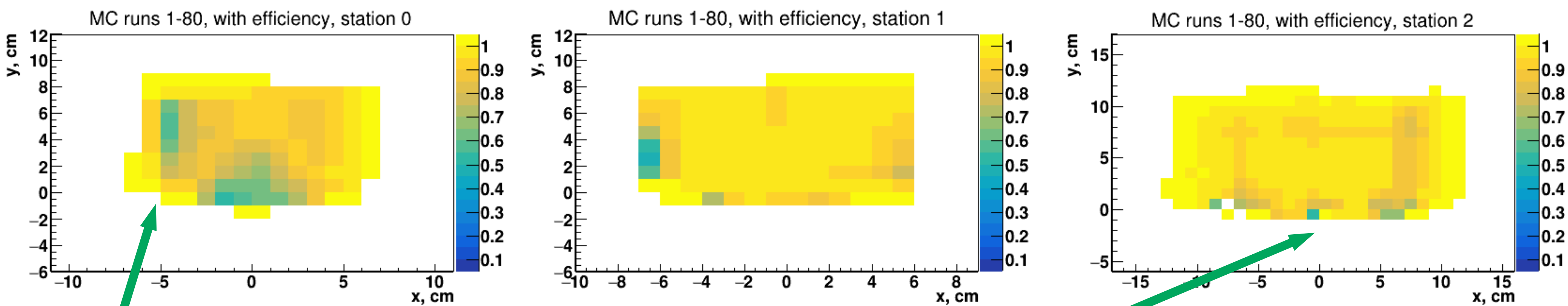


- MC signals for Si/GEM/CSC digits normalized with good accuracy to the Data
- Clusters widths in MC match Data with accuracy ~20%

Data and MC Si/GEM efficiencies comparison

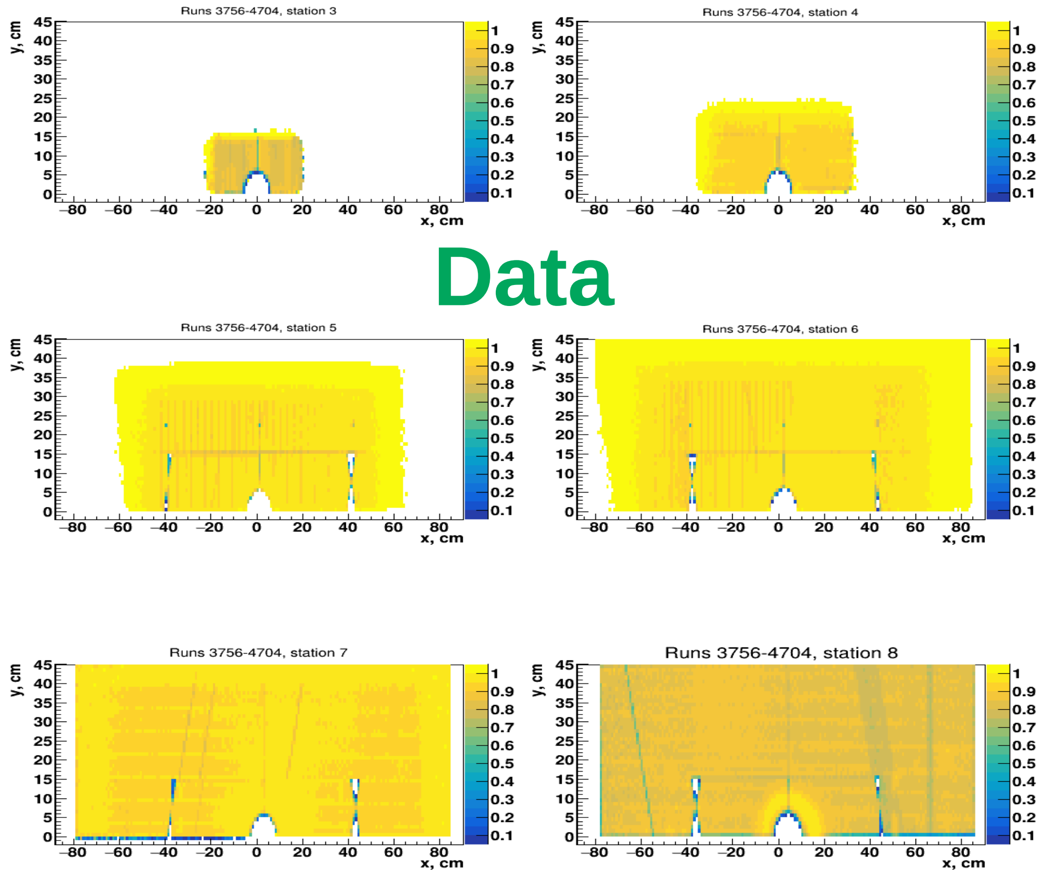
Data

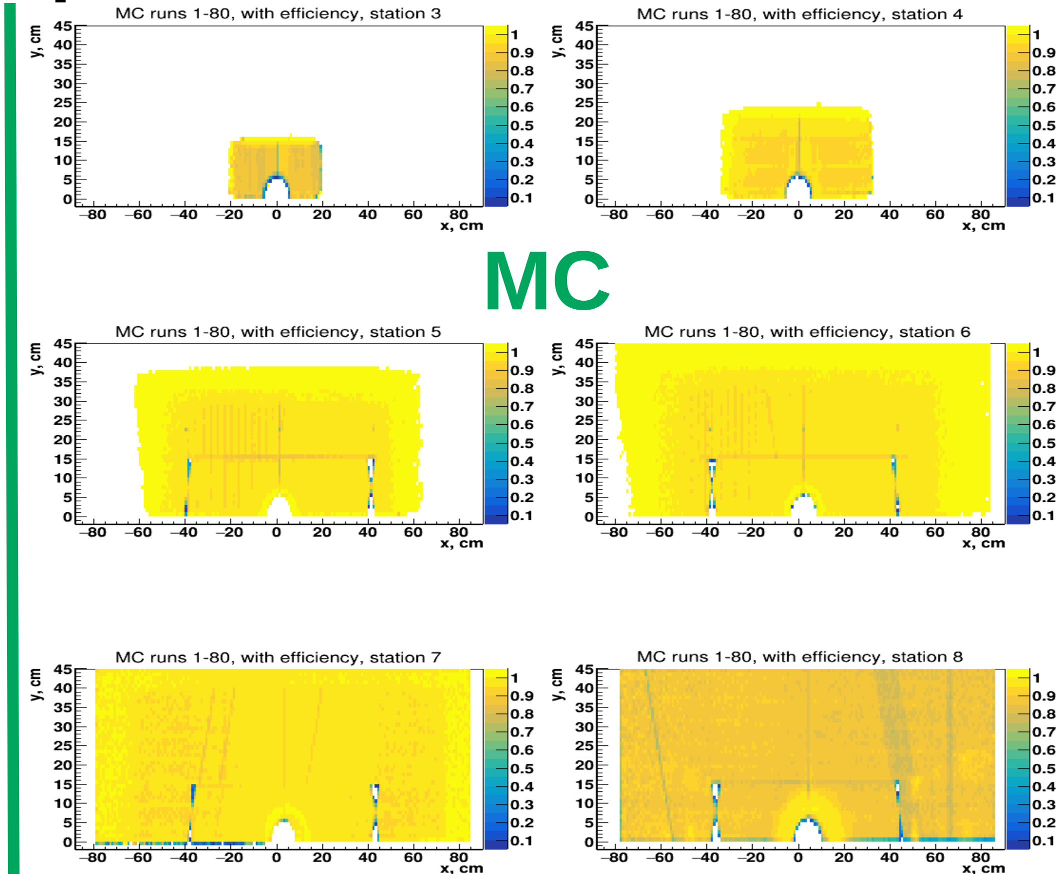




- MC efficiency higher than Data efficiency on 3-5% in average **MC** for all Si
- Low MC efficiency for Si1 at X~-5 cm
- High MC efficiency for Si3 at X~0 cm

Data and MC Si/GEM efficiencies comparison



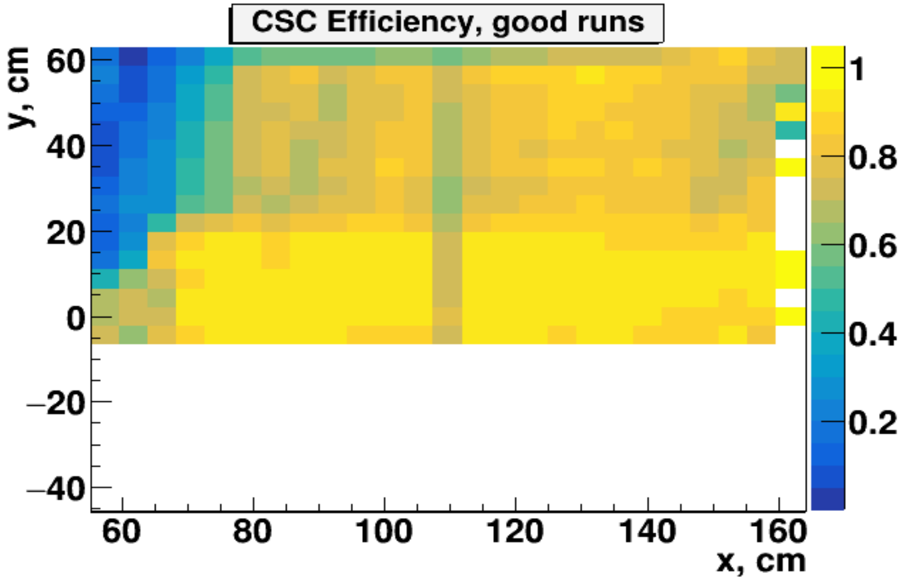


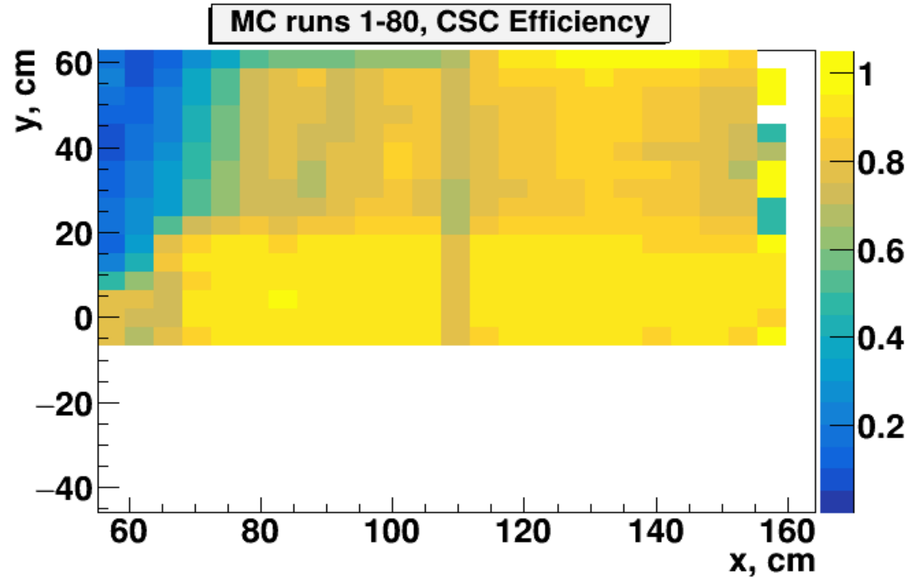
- MC efficiency higher than Data efficiency on 3-5% in average for all GEM

Data and MC CSC efficiencies comparison

Data, good runs

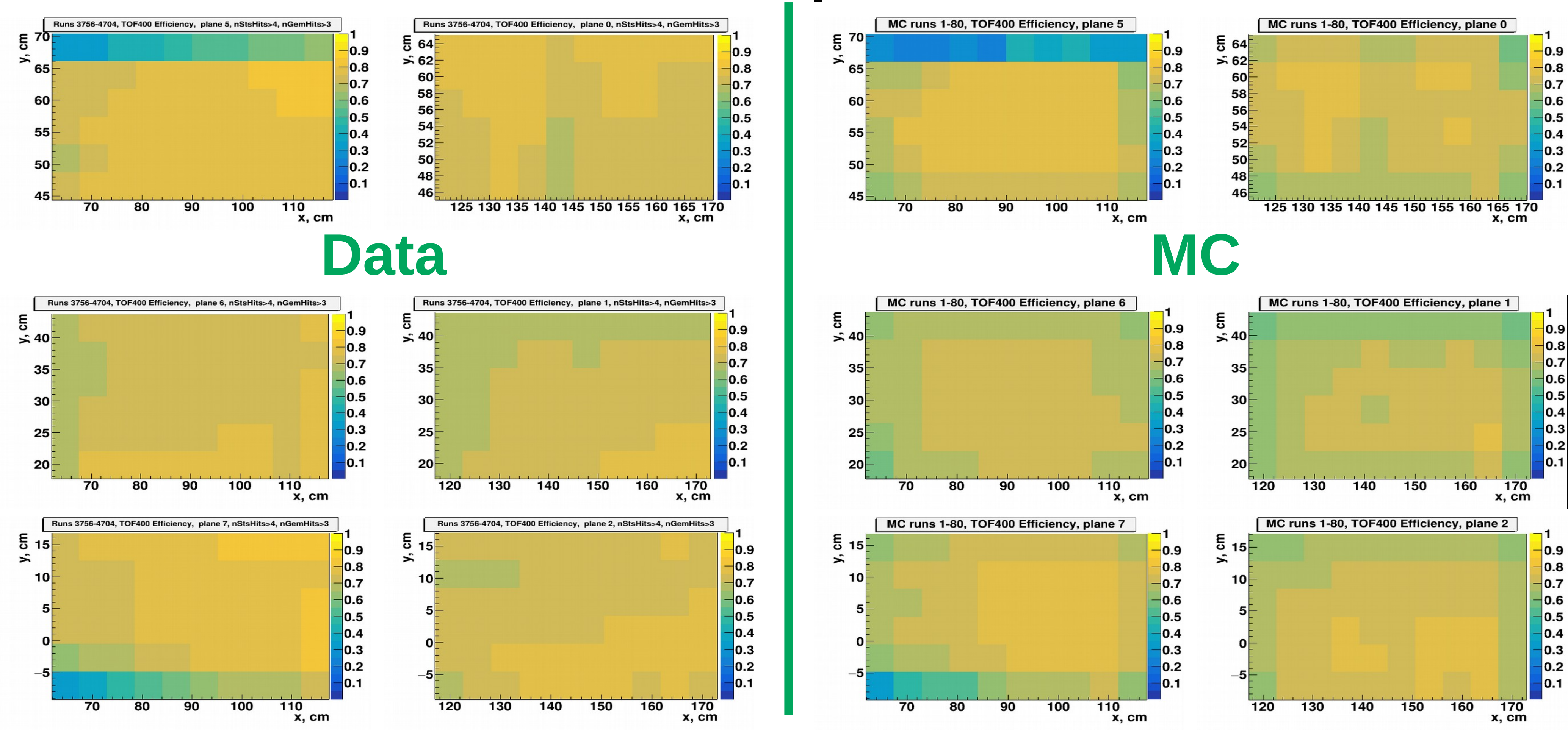
MC





- Good runs - runs with Eff_{CSC}>40% in the Main zone
- MC and Data efficiencies are close to each other

Data and MC TOF400 efficiencies comparison



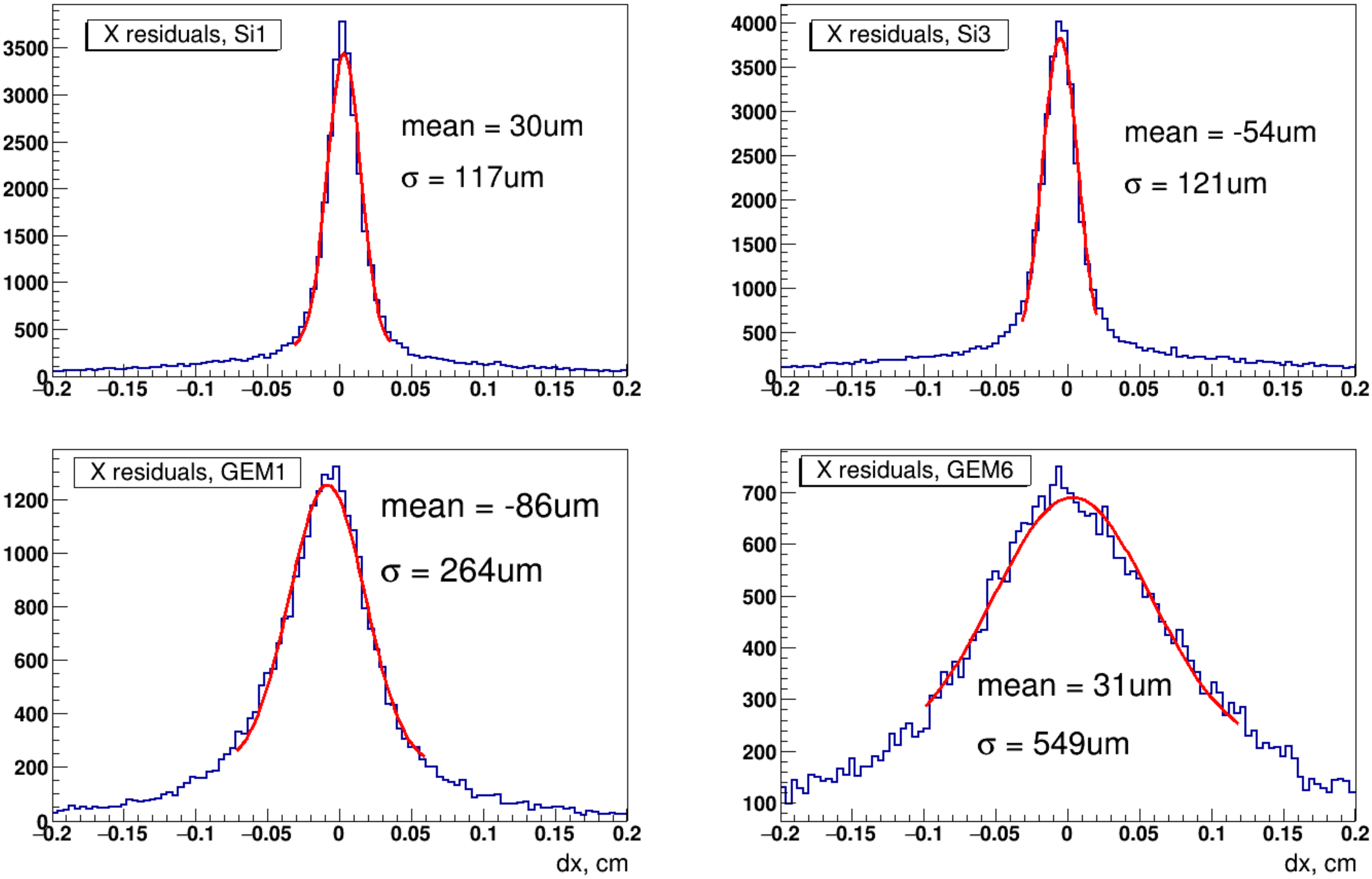
- MC efficiency lower than Data efficiency on ~5% in average for all TOF400 planes

Si/GEM residuals for Data and for MC and EMB after smearing

Station Data/MC/ EMB	Si1, um	Si2, um	Si3, um	GEM1, um	GEM2, um	GEM3, um	GEM4, um	GEM5, um	GEM6, um
Data	117	76	121	264	323	365	370	300	549
MC	126	83	125	254	319	373	367	294	603
EMB	124	75	119	295	329	346	361	311	517

- Lorenz Shifts from Data implemented to the MC and EMB (Lalyo Kovachev)
- $\sigma_{MC} \approx \sigma_{EMB} \approx \sigma_{Data}$ with accuracy ~10%

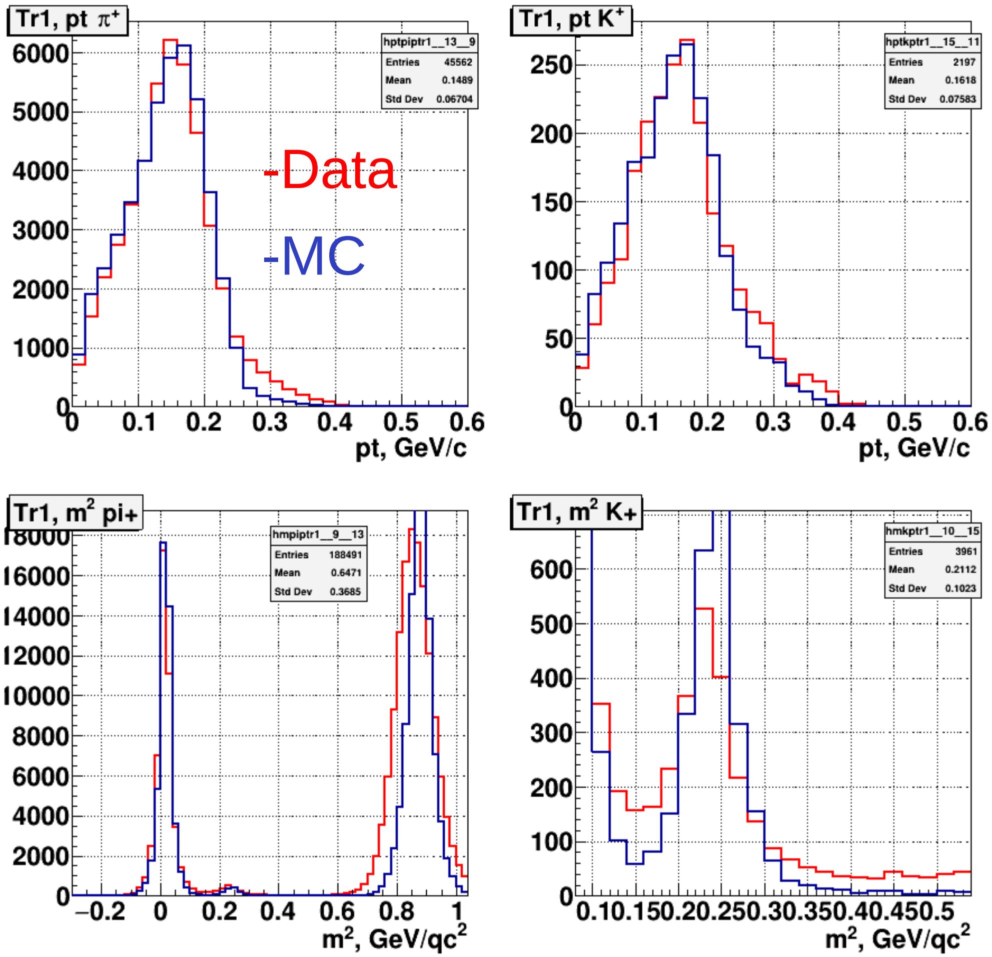
Si/GEM residuals for Data and for MC and EMB after smearing



Detector effects implemented in MC

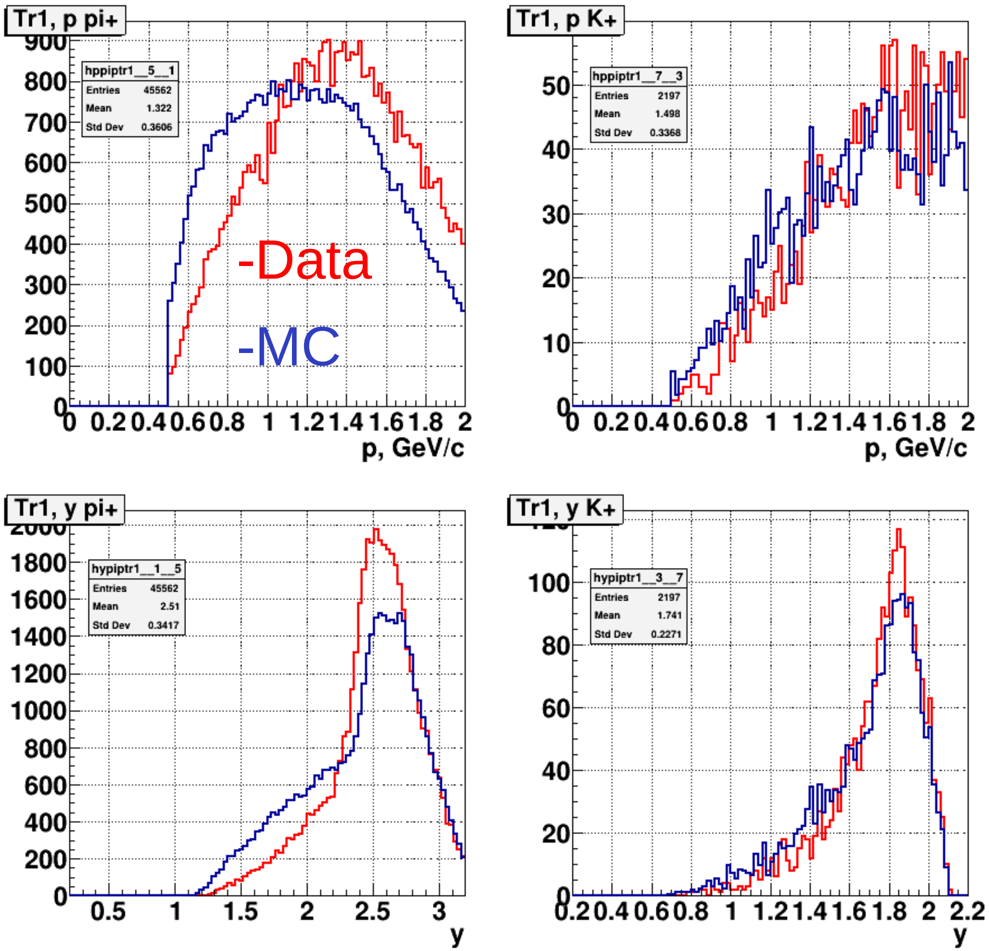
- We use UrQMD generator
- MC geometry for Si/GEM/CSC/TOF400 matches Data geometry by strips
- For MC we use the same Lorenz shifts in GEM as for Data
- MC signals for Si/GEM/CSC match Data signals
- MC Si/GEM residuals match Data residuals
- For Data and MC we use the same reconstruction chain
- MC efficiencies for Si/GEM/CSC/TOF400 close to the Data efficiencies
- We embedd MC π^+ to the Data

Results of identification comparison for Data and MC with detector effects



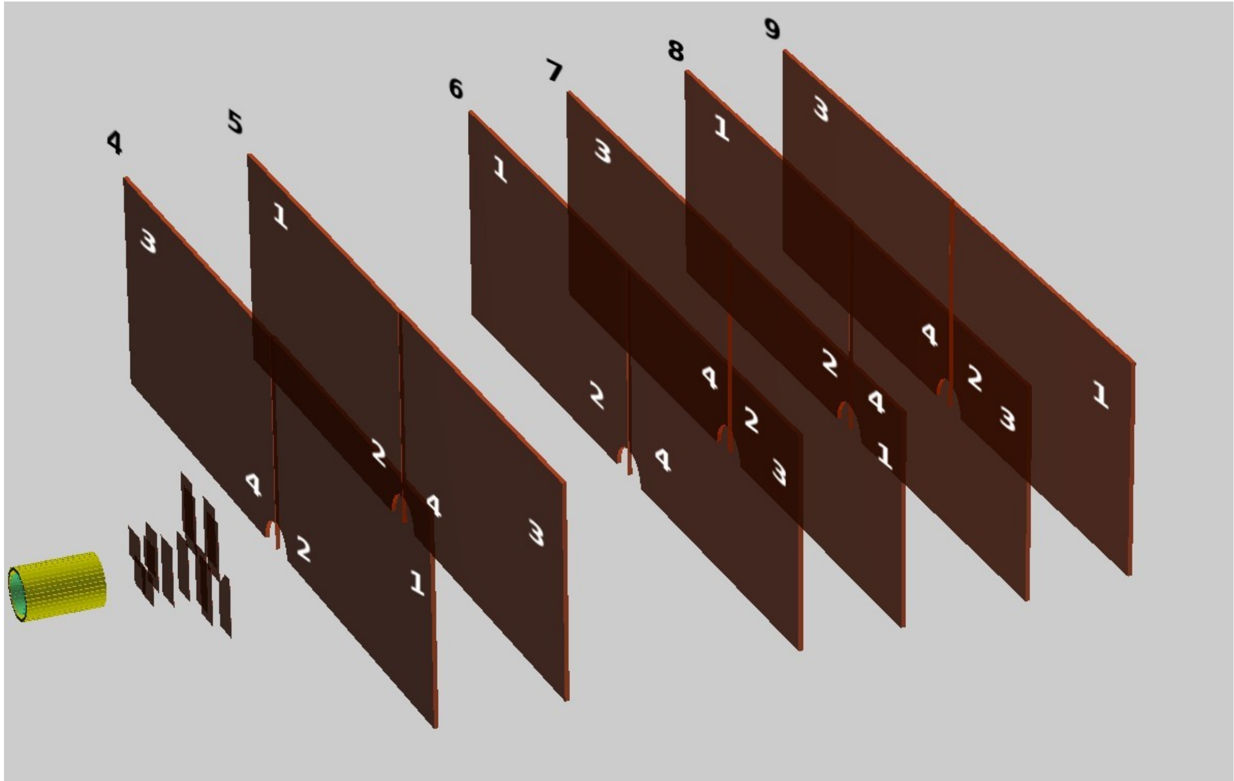
- Left m^2 distribution is normalized to the π^+ peak
- Other distributions are normalized to the integral
- S/B for Data significantly lower than for MC
- m^2 distributions for Data and MC close to each other in (π^+, K^+) region
- Pt spectra of π^+ and K^+ for Data and MC close to each other

Results of identification comparison for Data and MC with detector effects



- All spectra are normalized to the integral
- P and Y spectra of K^+ for Data and MC close to each other
- P and Y spectra of π^+ for Data and MC significantly different

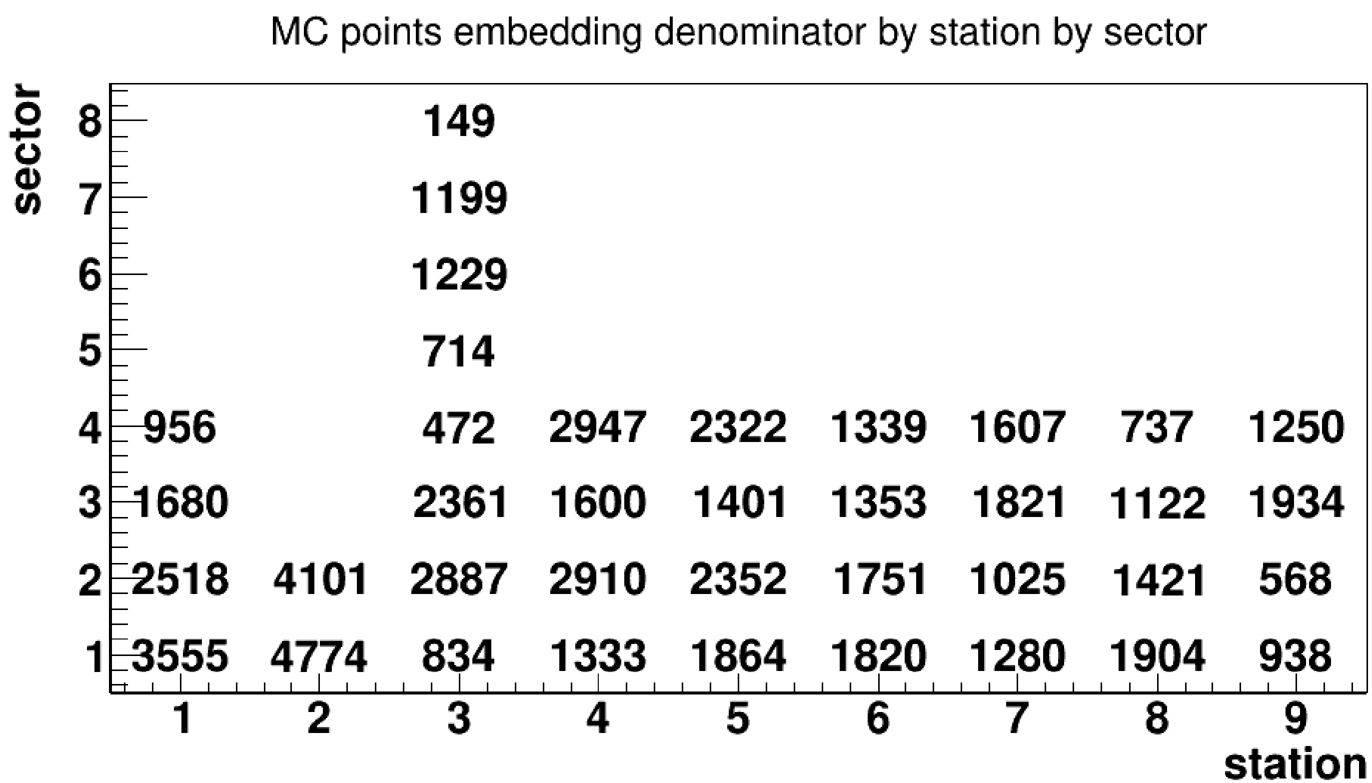
Embedding QA



- Stations 1-3 are Si
- Stations 4-9 are GEM

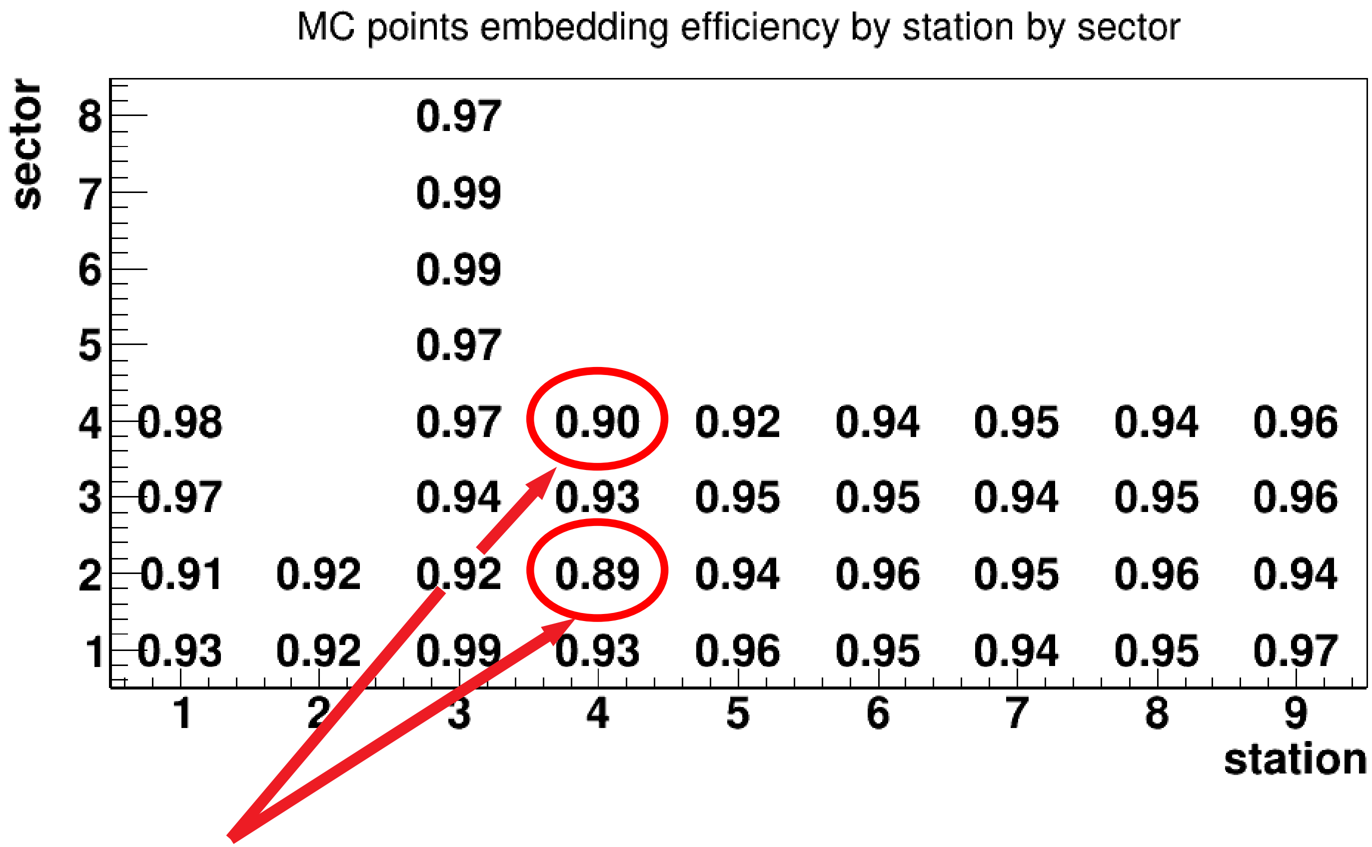
- Even sectors of GEM are hot zones
- Odd sectors of GEM are main zones

Embedding QA



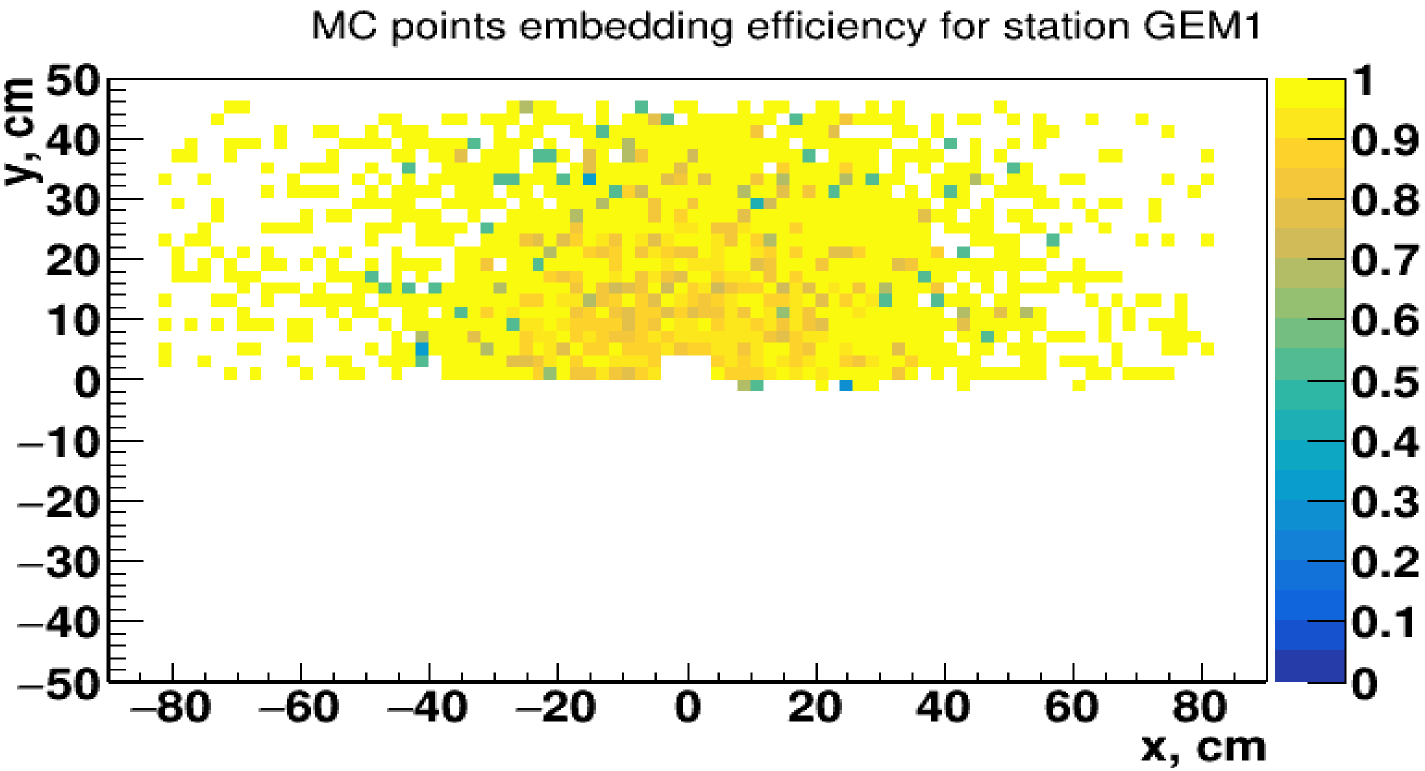
- The number of MC Points to be converted
- Using only points which give digits in the strips
- Enough statistics in the each sector

Embedding QA



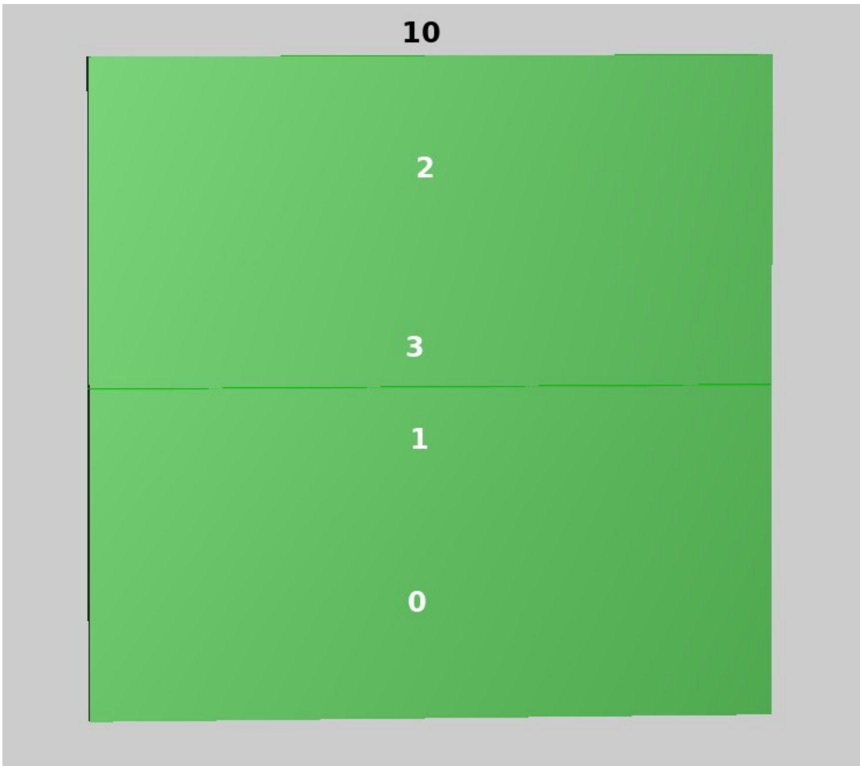
- The lowest efficiency for hot zones of GEM1
- Possibly due to the largest MC Points density according to the pitch size

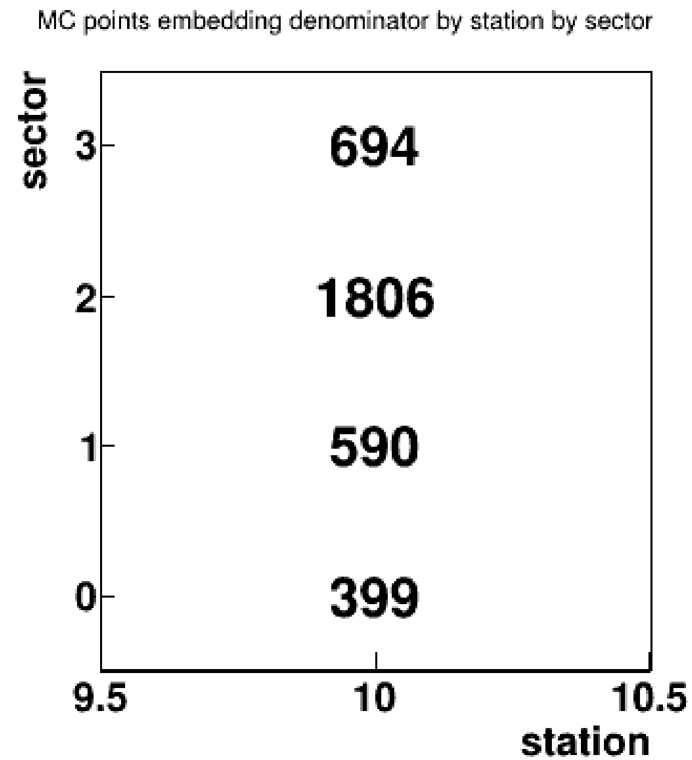
Embedding QA



- The same efficiency for GEM1 using net of squares with the side length 2cm
- No special regions are visible
- Efficiency rises with the distance from the station center

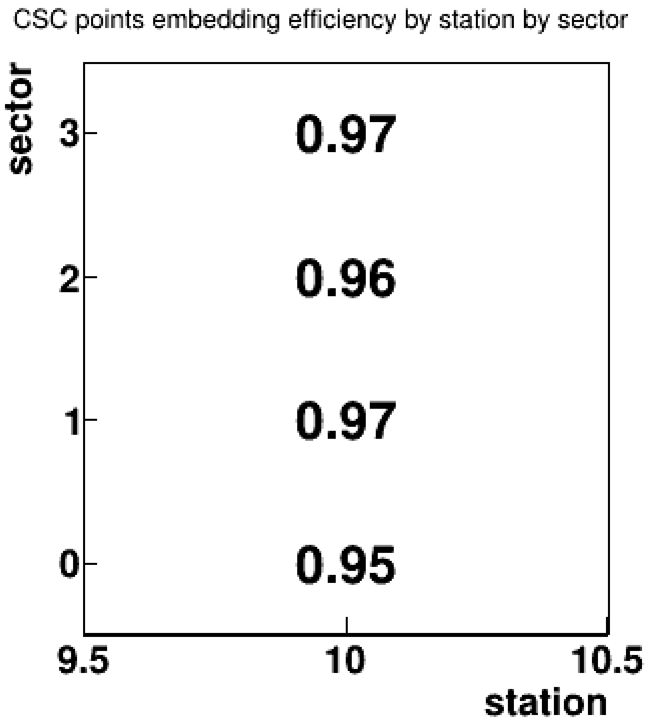
Embedding QA

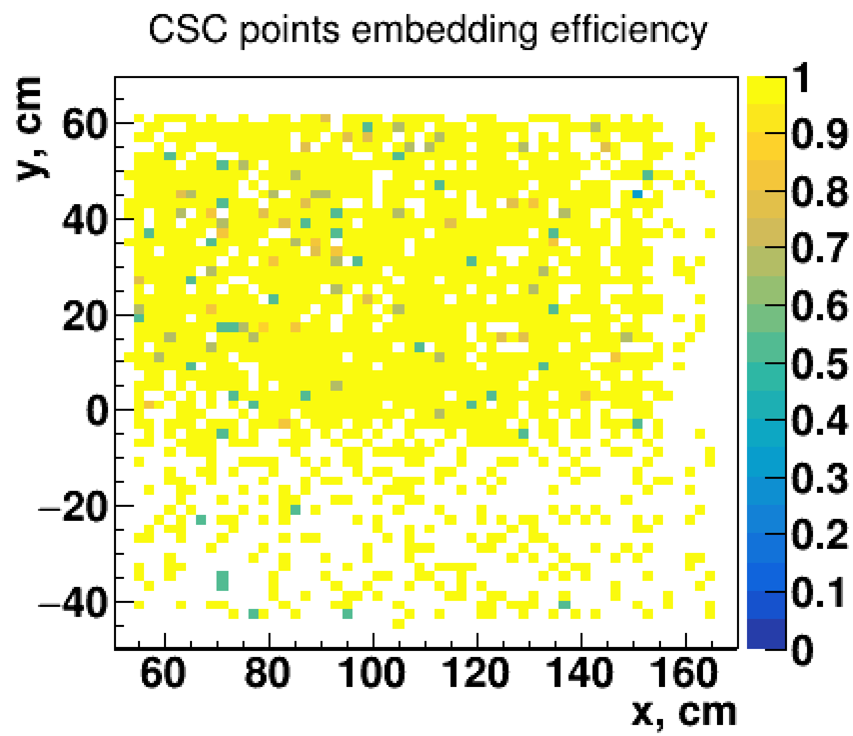




- The number of CSC Points to be converted
- Using only points which give digits in the strips
- Enough statistics in the each sector

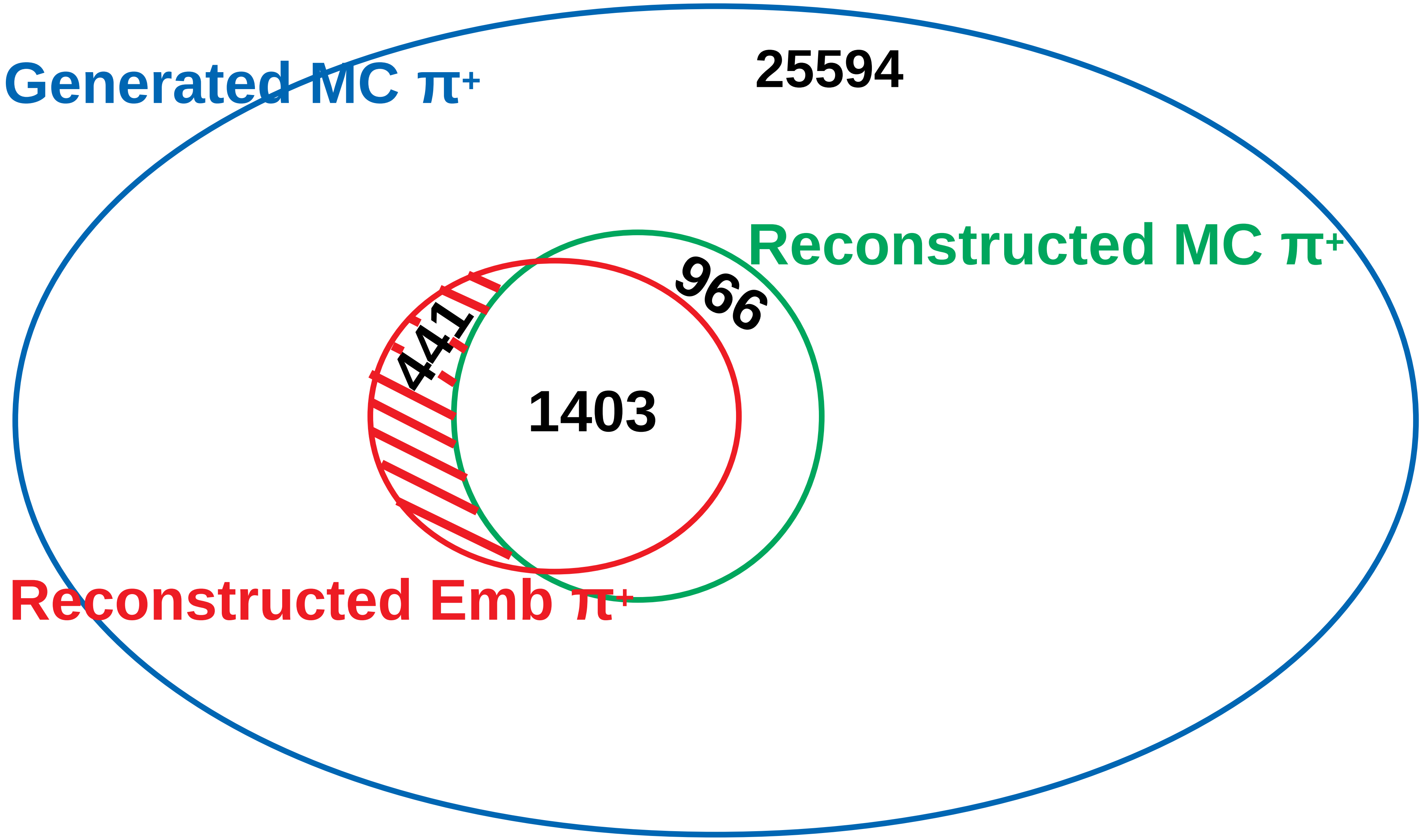
Embedding QA



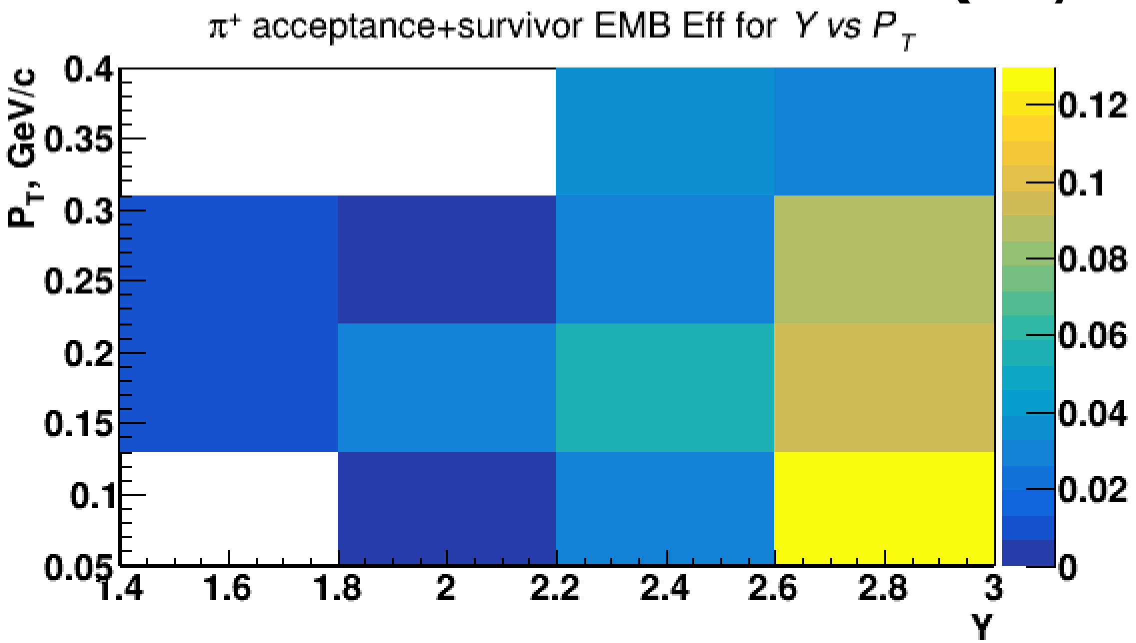


- Large and uniform conversion efficiency in all CSC sectors

First result of the embedding

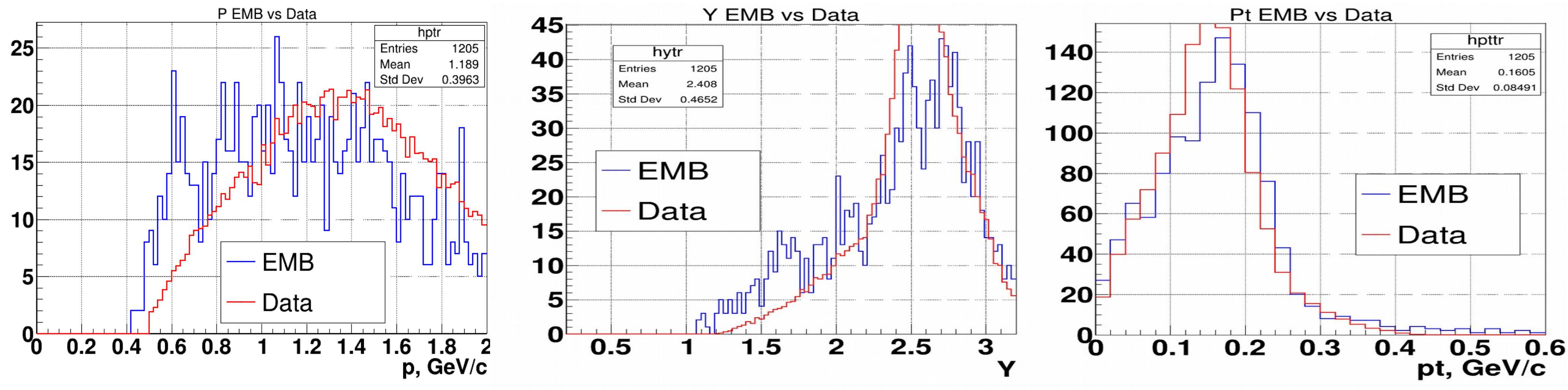


Embedding Efficiency in (Y,Pt) bins



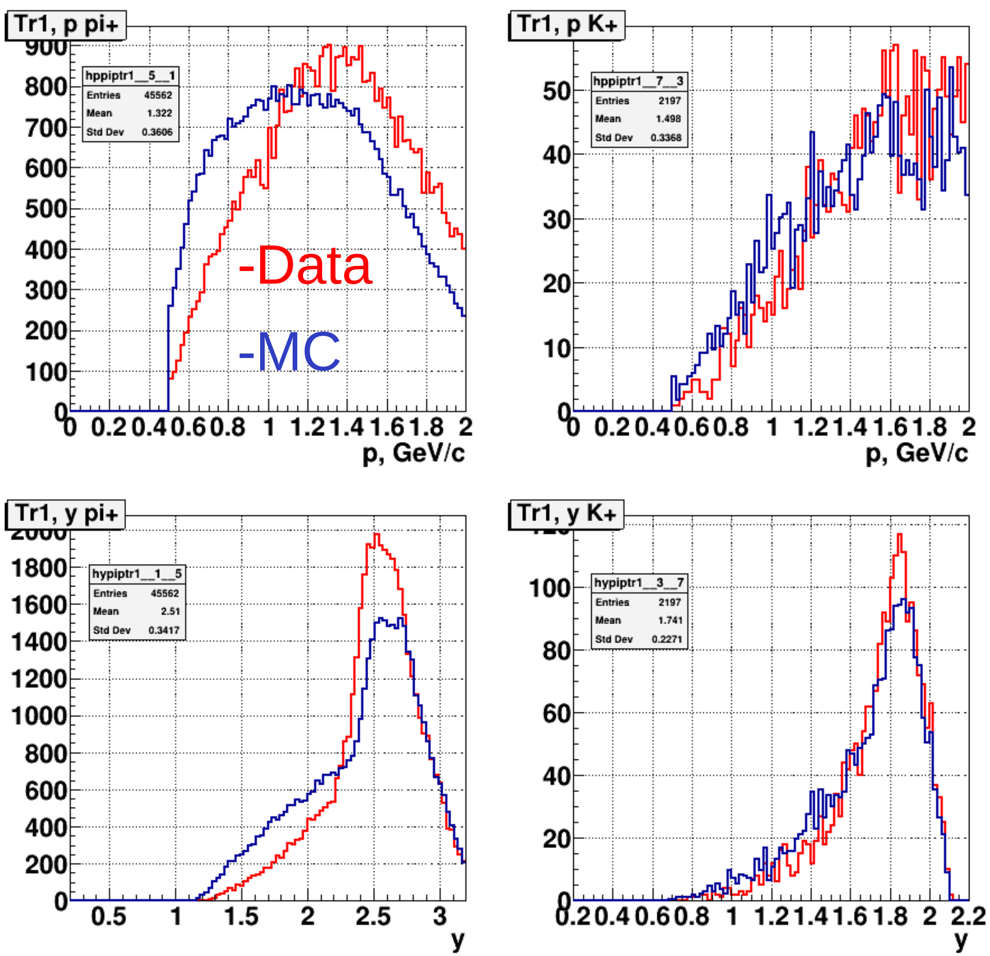
- Detectors effects are implemented to the embedding
- One step approach is implemented to calculate Eff_{EMB}
- (Gleb used two steps approach, $Eff_{EMB}=Eff_{Accept\_MC\_reco}*Eff_{EMB\_MC\_reco}$)
- For now we filter tracks to embedding by “at least 5 StsPoints of MCTrack in acceptance” criteria

P, Y, Pt spectra of identified π^+ after embedding



- π^+ P and Y spectra after embedding are softer than for Data (the same as for MC)
- One MC run (50K events) and one Data run are used to embedding

P, Y spectra of identified π^+ in MC with detector effects (*slide 15*)

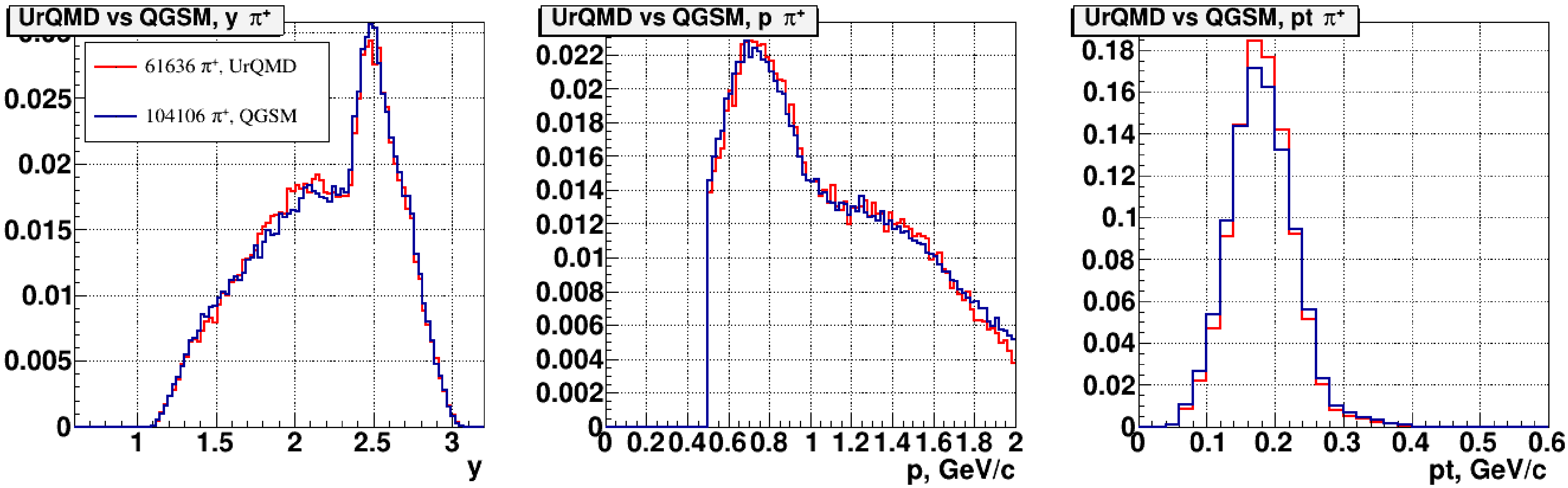


- All spectra are normalized to the integral
- P and Y spectra of K^+ for Data and MC close to each other
- P and Y spectra of π^+ for Data and MC significantly different

Possible ways to match MC to the Data

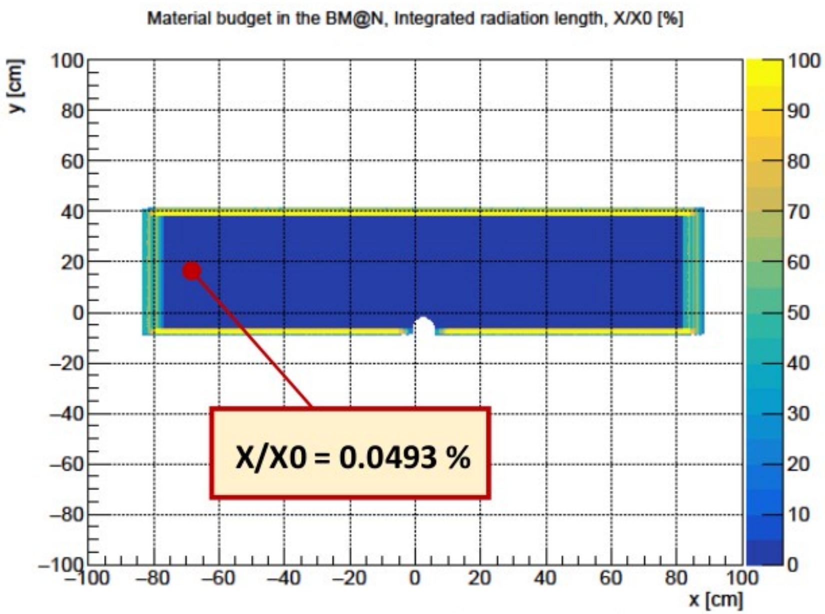
- To use of another MC generator (QGSM for example)
- To implement Detailed Si/GEM geometry from Dmitriy Baranov
- To match of MC residuals for CSC/TOF400 to the Data

Using of another MC generator

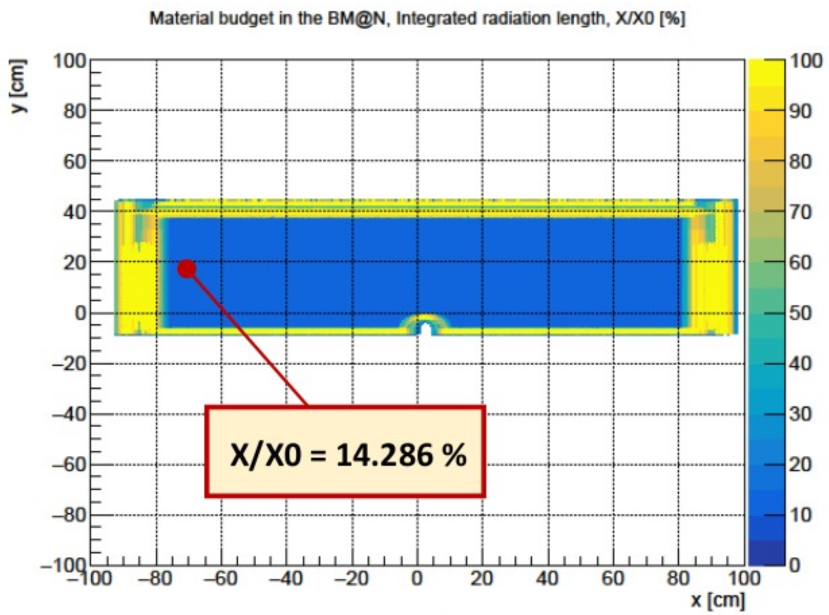


- Red line – UrQMD, blue line – QGSM (the same old identification chain for both)
- Both spectra are close to each other (the difference less than 10%)
- So QGSM cannot reduce the existing difference

Detailed Si/GEM geometry



Material budget of six stations for tracks parallel to Z axis (simplified geometry)



Material budget of six stations for tracks parallel to Z axis (detailed geometry)

- Made by Dmitriy Baranov
- Left plot – current geometry, right plot – new geometry
- New geometry gives additional background (embedding is aimed to solve it) and prevents π^+ from passing through identification detectors

Thank you!

Backup

Embedding Steps

- Select events with appropriate PV from the Data
- Use selected PV in the simulation
- Process realistic digitization of MC points (mark digits to embed)
- Convert digits to the experimental format
- Merge digits from Data and MC (common modes and pedestals calculation for Si and GEMs)
- Process full reconstruction and identification chain as for the Data
- Extract embedded tracks which was identified and calculate Embedding Efficiencies

π^+ reconstructed in Emb but not in MC

Δ = 441		
Reason	**Not in MC**	**% of Δ**
Bad reco PV	14 π^+	3
DCA cut	72 π^+	16
TOF400 residual cut	55 π^+	12
Low number of GEM hits per station	150 π^+	34
Duplicate tracks	31 π^+	7
Low number of hits per track	4 π^+	1
Other tracks	115 π^+	27

- Example for "Bad reco PV" and "DCA cut" - one digit changes x_{PV} on 1.8 cm
- TOF400 residual cut – CSC hit residual cut is circle with diameter 3 cm and TOF400 residual cut is square with side 2 cm

π^+ reconstructed in Emb but not in MC

- Low number of hits per GEM station – skip event if $nHits_{GEMi}<5$ (in digitization and track extension stages)
- Duplicate tracks – single MC track fragments into GEM-track and Si-track or coincidence obtains with momentum components of another track
- Low number of hits per track - $nHits<5$

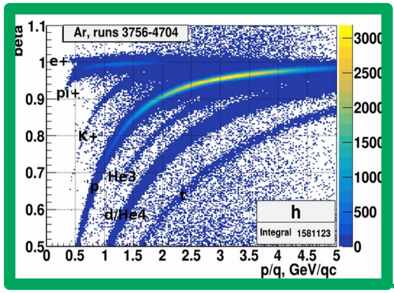
Other tracks

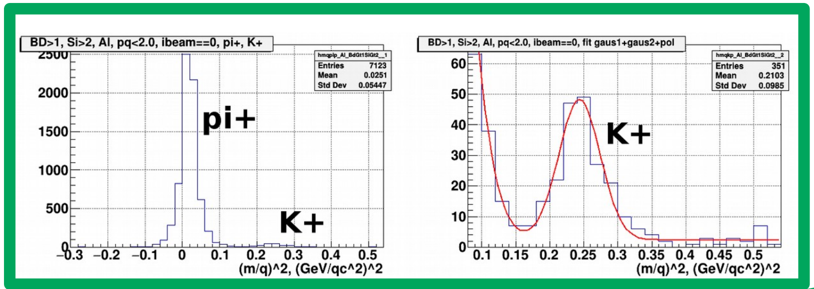
Reason	% of tracks
Fake tracks take one or two hits in the extension stage (algorithm can be improved)	**~10**
Low momentum (<0.85 GeV/c) reconstructed track (possibly with few fake hits) does not match CSC hit (we can expand matching window for such tracks)	**~20**
Long reconstructed track but with few fake hits cannot match CSC hit due to momentum shift	**>50**
Cannot reconstruct CSC hit or shifted CSC hit reconstruction (due to CSCPoints interference)	**few percent**

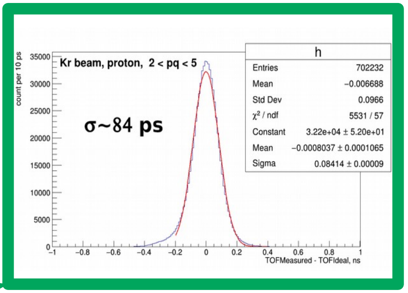
- Common reason of track misidentification is interference of StsDigi from different StsPoints which gives shifted StsHit or fake StsHit
- Also common reason is close or intersected tracks
- New bugs do not found in the identification algorithm

Sketch of used detectors with their status

Good result :)

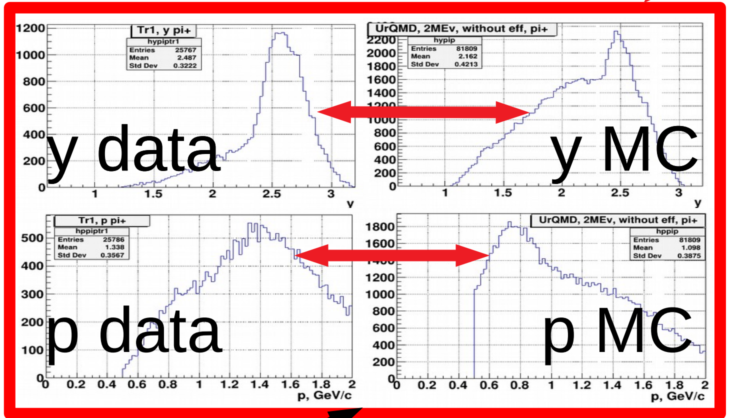






Si+GEM **CSC** **TOF400**

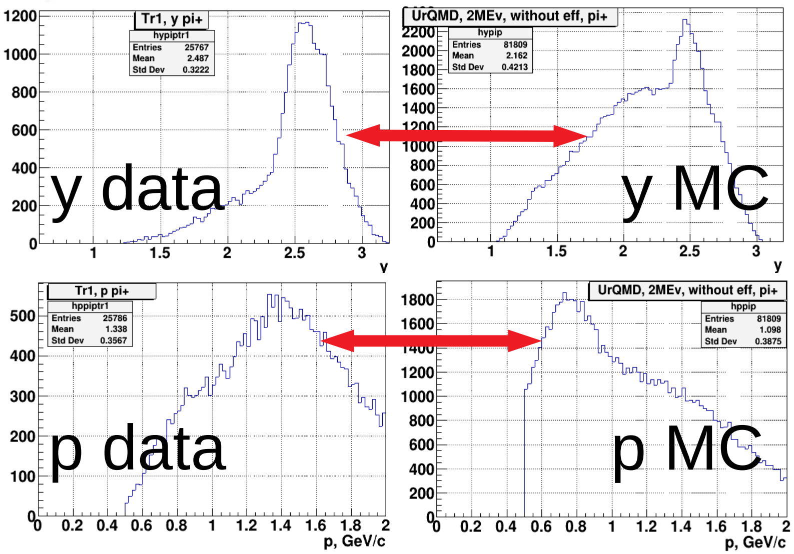
Problem :(



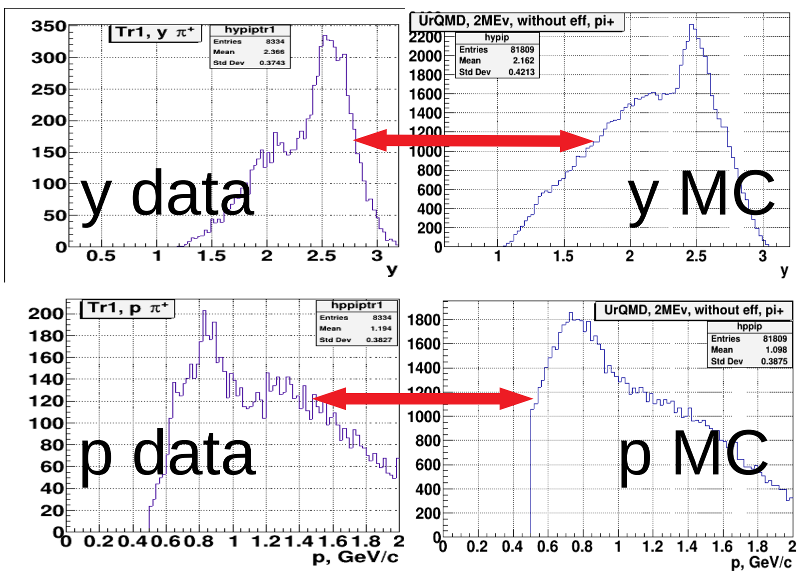
π^+

- **Si+GEM** – detailed description in MC
- **TOF400** – only TOF400Point in MC
- **CSC** – absent in MC

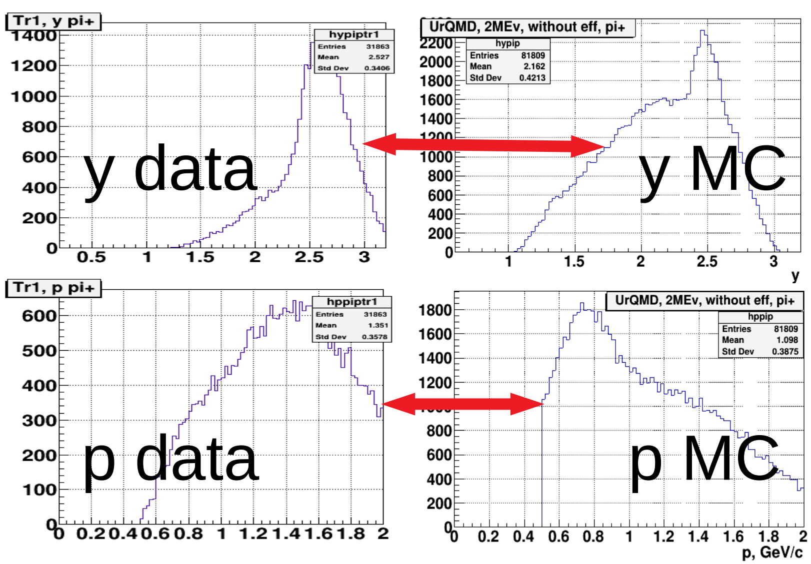
Three tracking algorithms and their problems



- **GEM+CSC**
- **Problem:** Significantly less particles in low part of p_{full} spectrum for Data than for MC

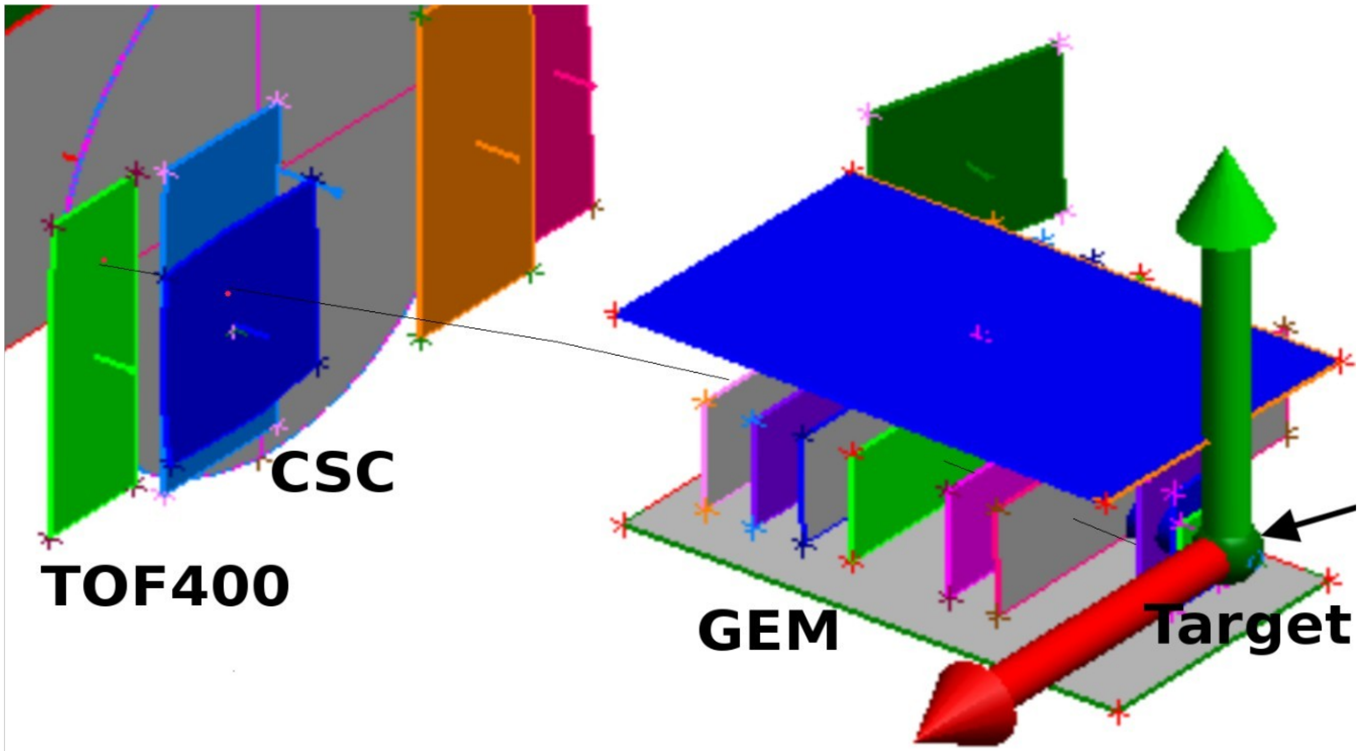


- **Si+GEM+CSC**
- **Problem:** 3-4 times less identified particles than for **GEM+CSC** tracking



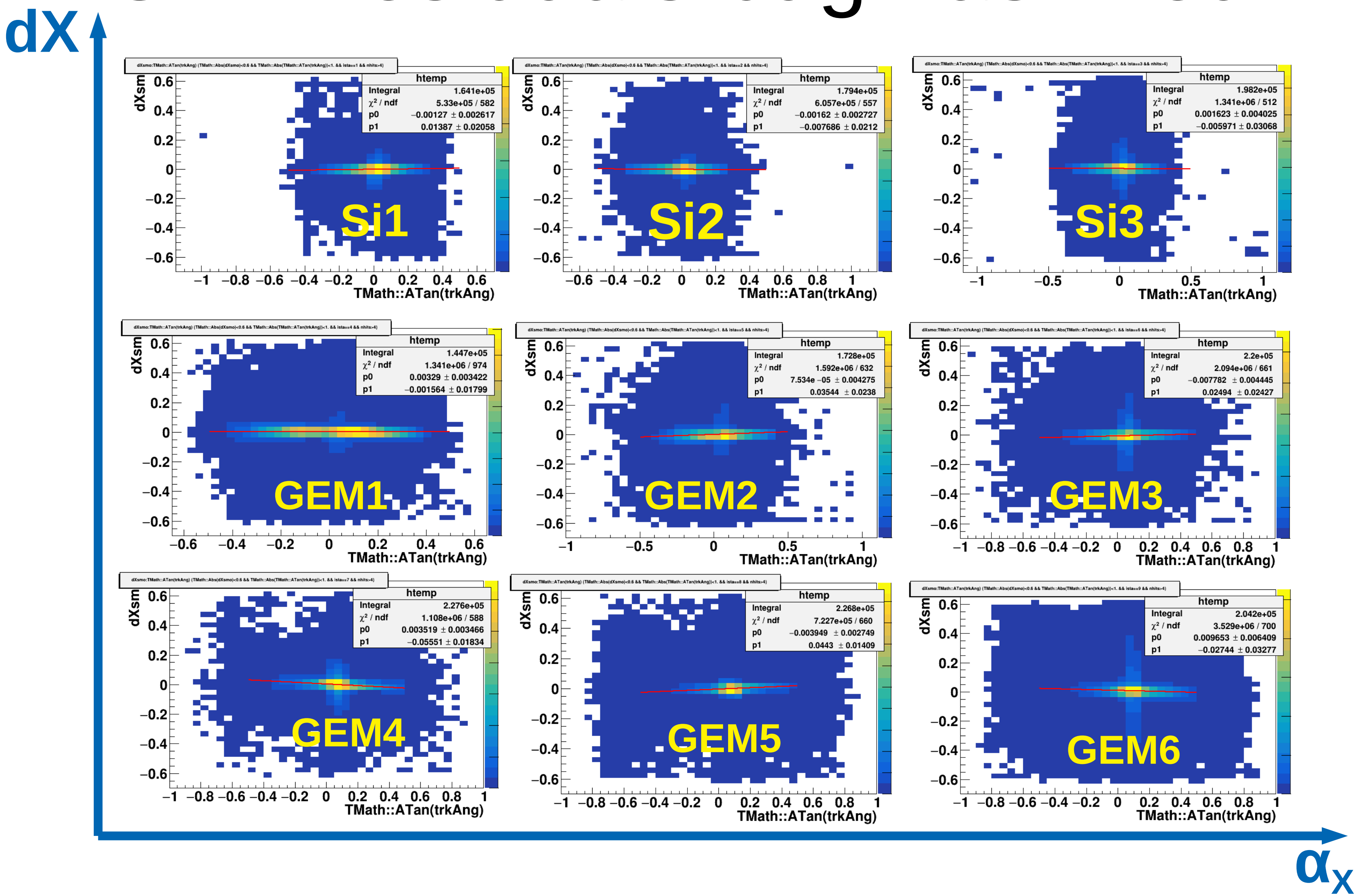
- **Si+GEM+CSC+Extend**
- **Problem:** The same as for **GEM+CSC** tracking

Si+GEM+CSC+Extend features



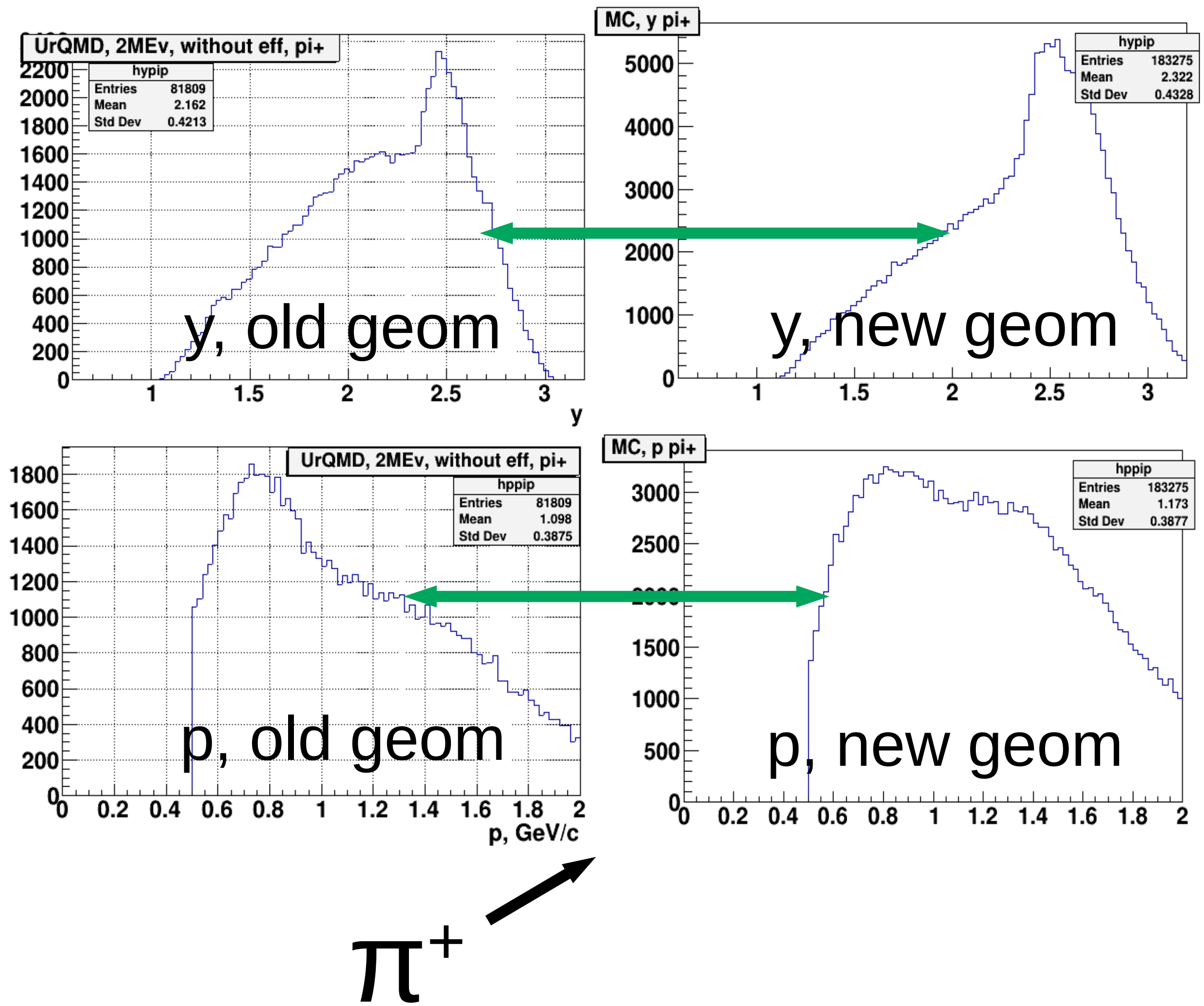
- Short tracks are reconstructed using hits from last four GEMs
- Short tracks are extrapolated upstream and refitted with matched hits from first two GEMs and Silicones
- Tracks are extrapolated downstream and refitted with matched hits from CSC

GEM residuals bug has fixed



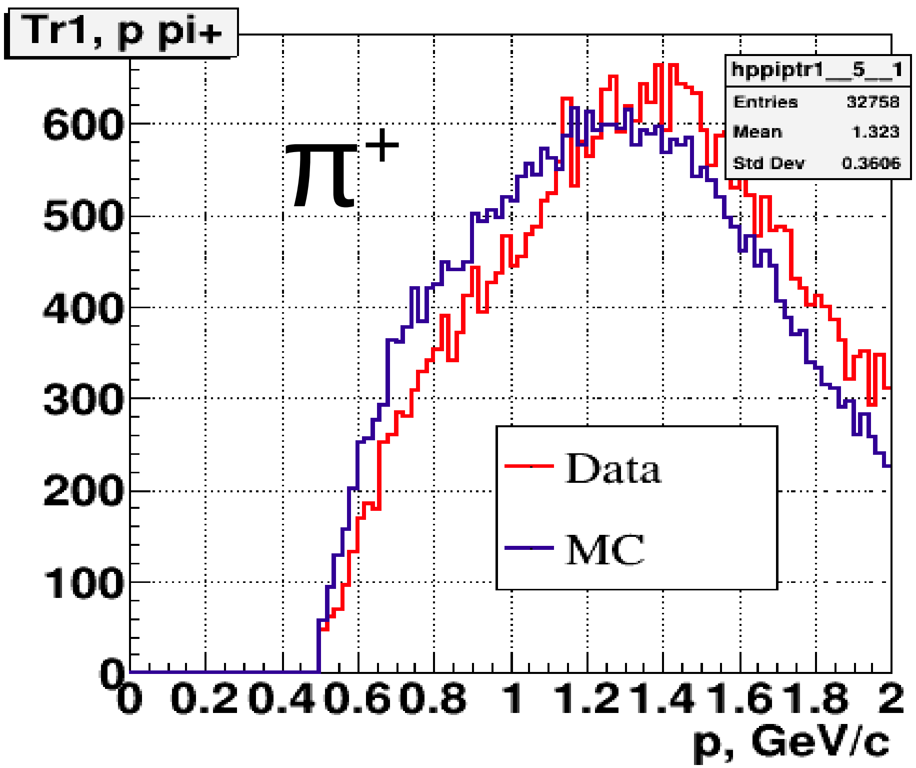
- **Bug reason:** mixed up signs for Lorentz shifts in the digitizer

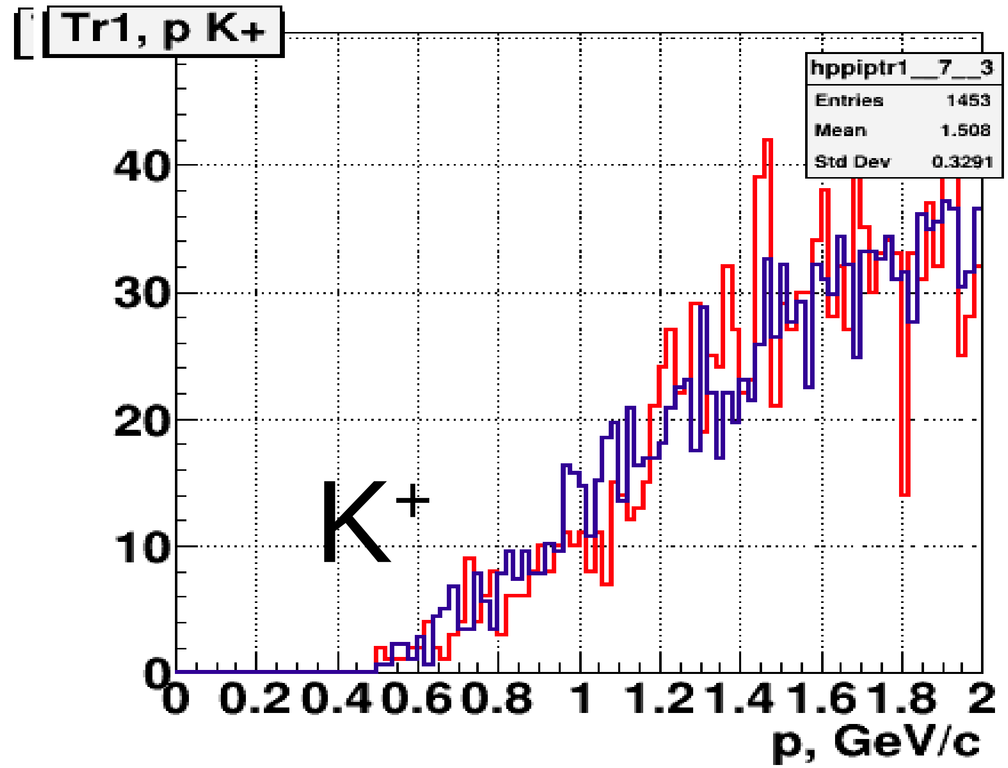
MC target geometry is improved



- **Result:** low part of MC p_{full} spectrum decrease by ~20%

First result of MC v2 identification in comparison with Data

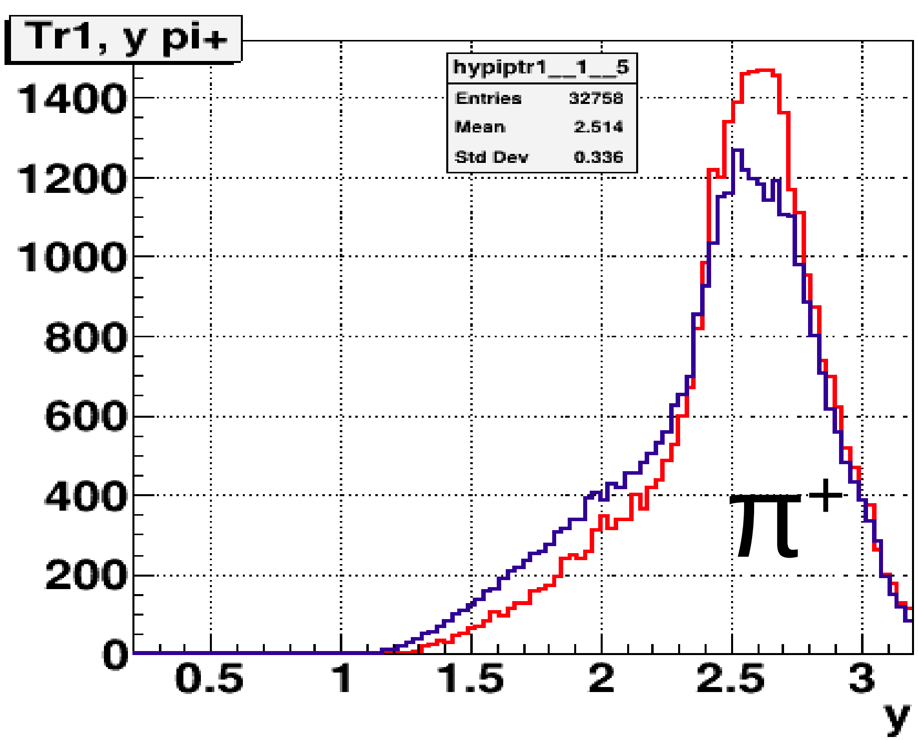


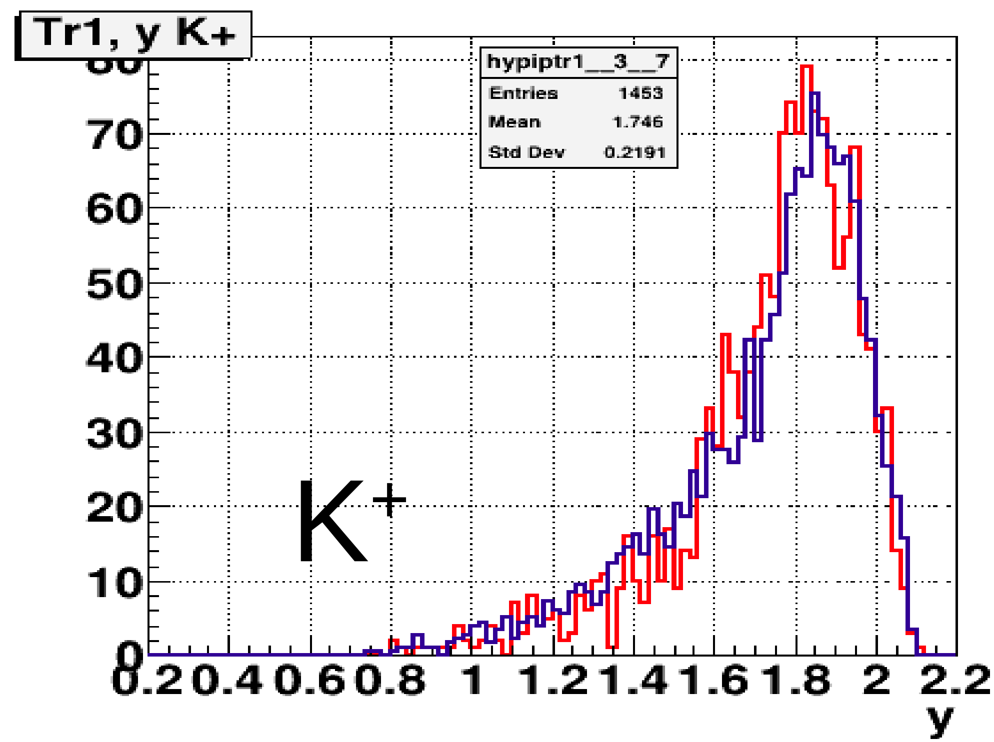


— Data — MC

- Normalization on Integral
- Data slightly shifted to right for π^+
- Spectra pretty similar for K^+

First result of MC v2 identification in comparison with Data

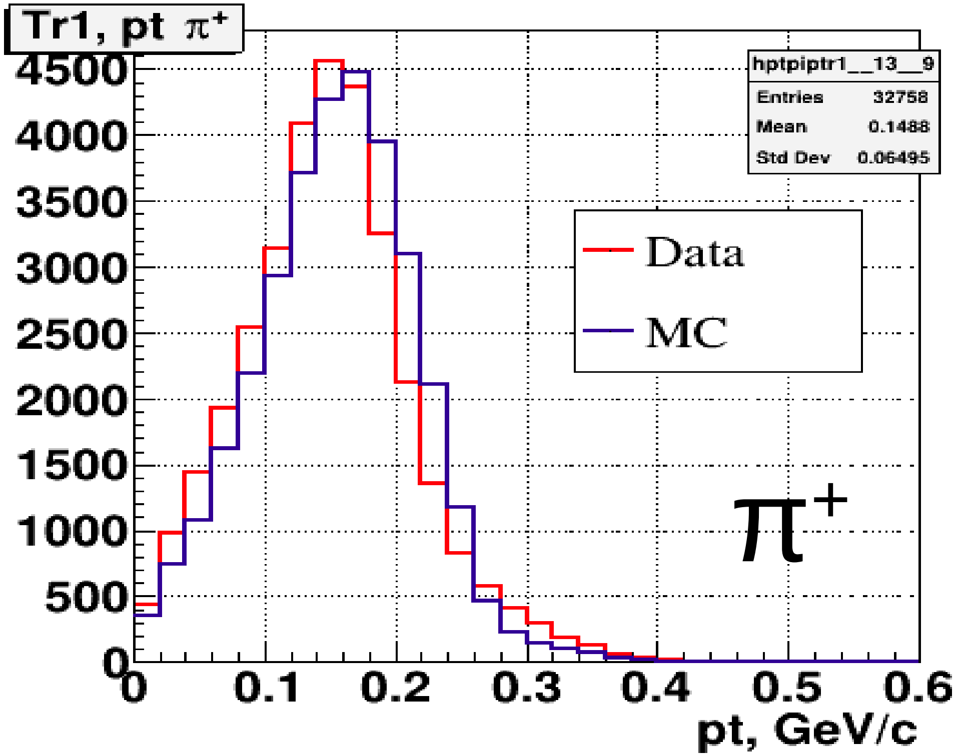


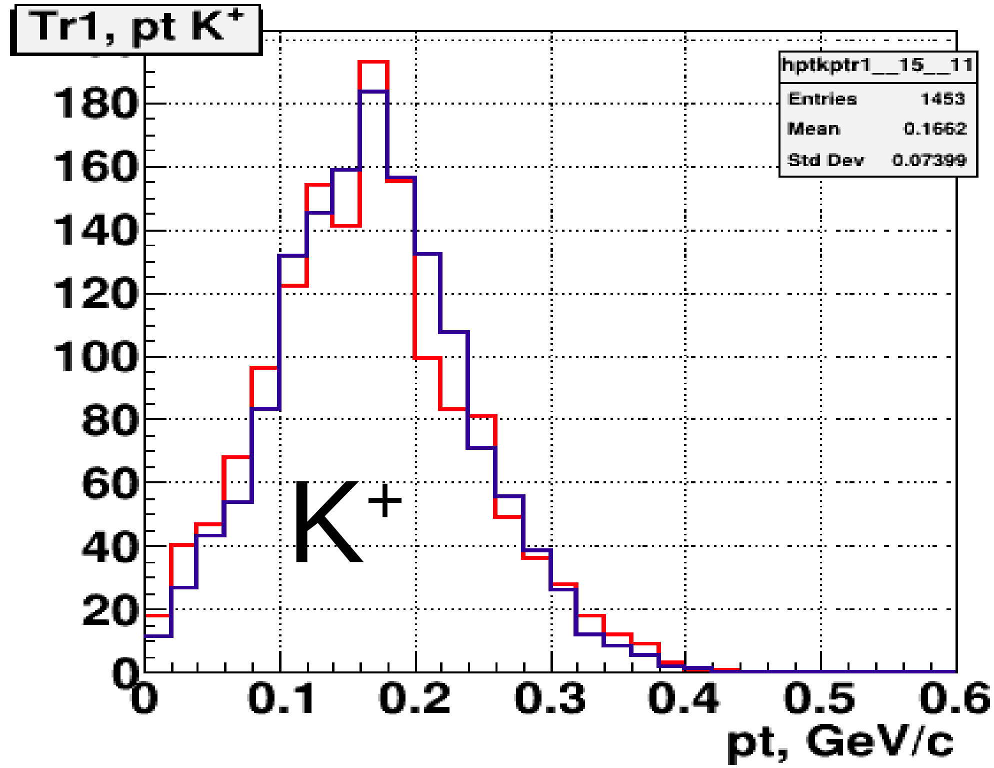


Data MC

- Normalization on Integral
- Number of low y Data tracks slightly less than MC tracks for π^+
- Spectra pretty similar for K^+

First result of MC v2 identification in comparison with Data

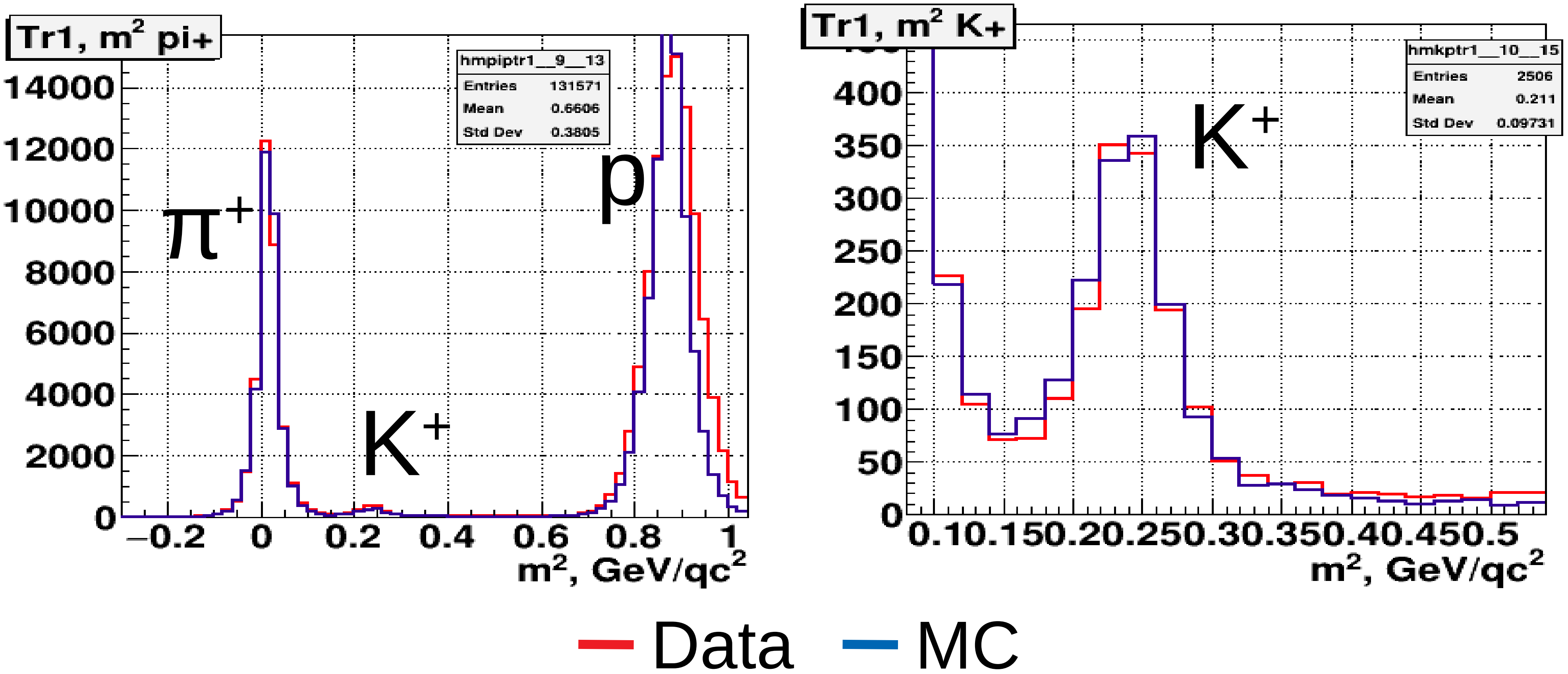




Data MC

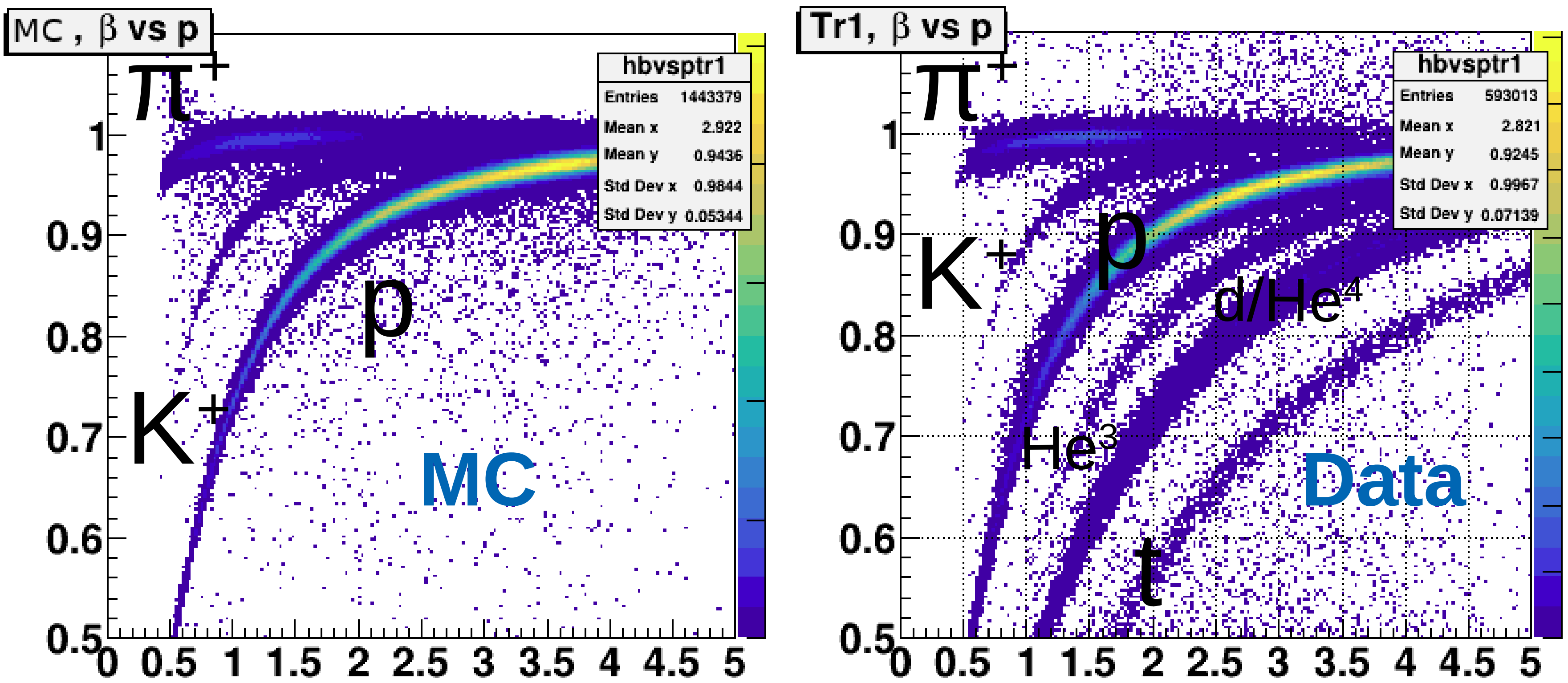
- Normalization on Integral

First result of MC v2 identification in comparison with Data



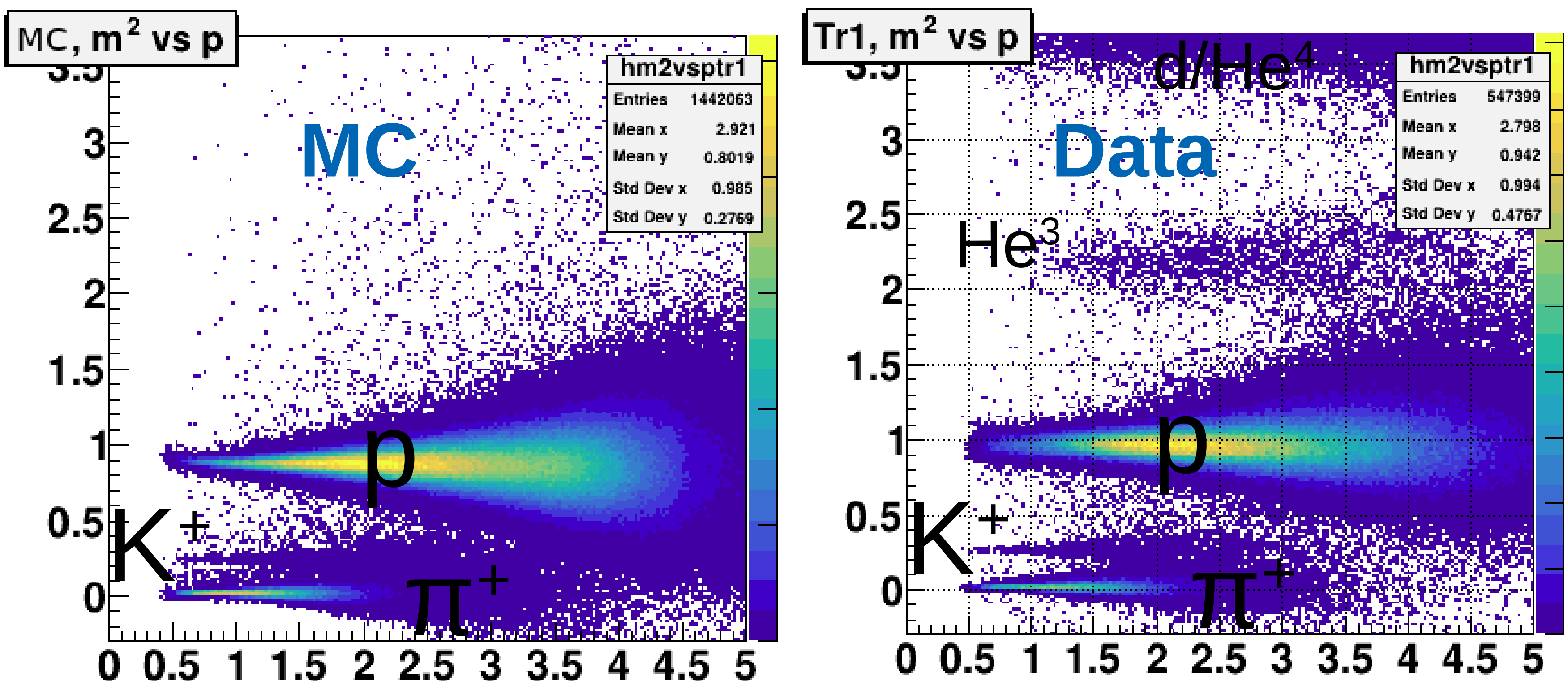
- Normalization on π^+ on the left
- Normalization on K^+ on the right

First result of MC v2 identification in comparison with Data



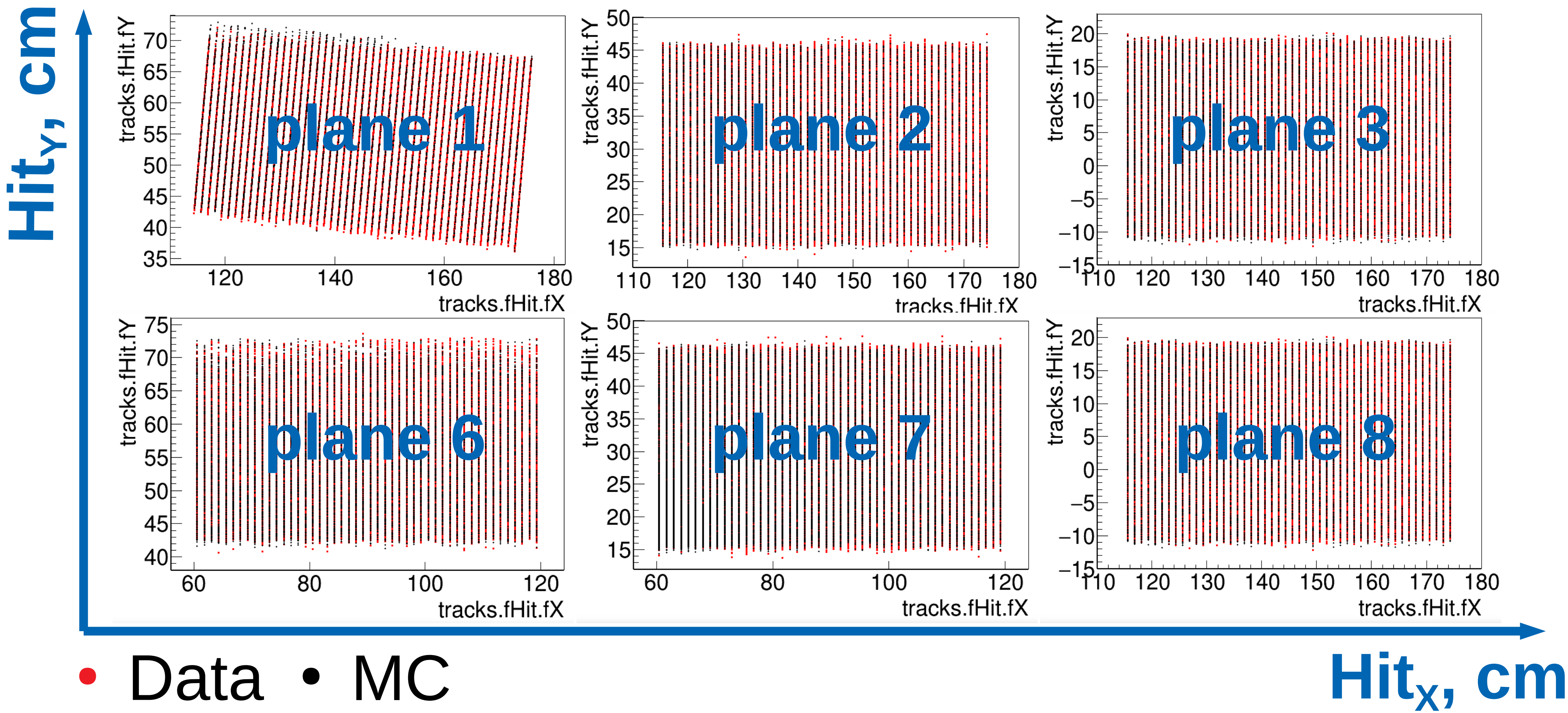
- No light nuclei for UrQMD

First result of MC v2 identification in comparison with Data



- No light nuclei for UrQMD

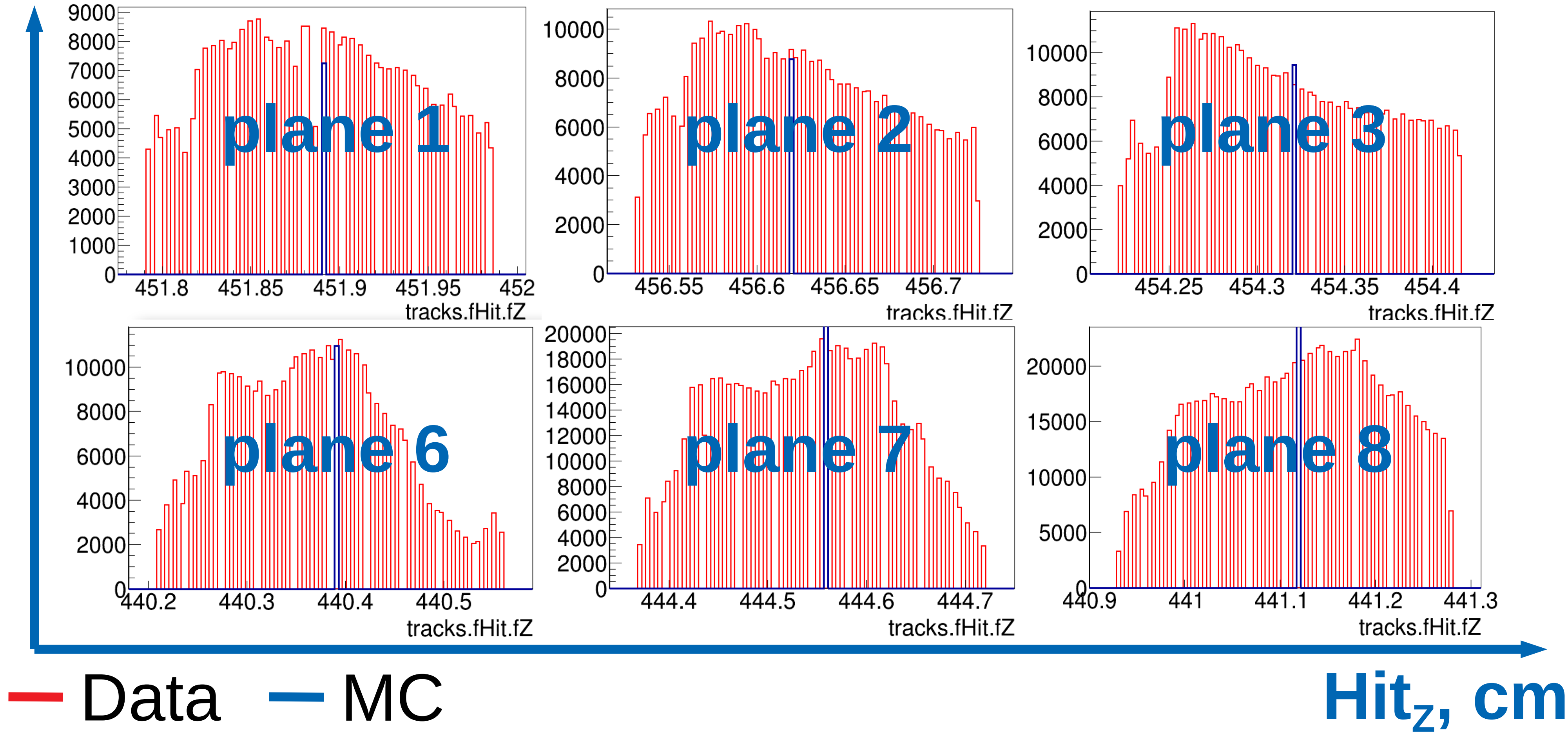
TOF400 geometry is improved



- Data • MC

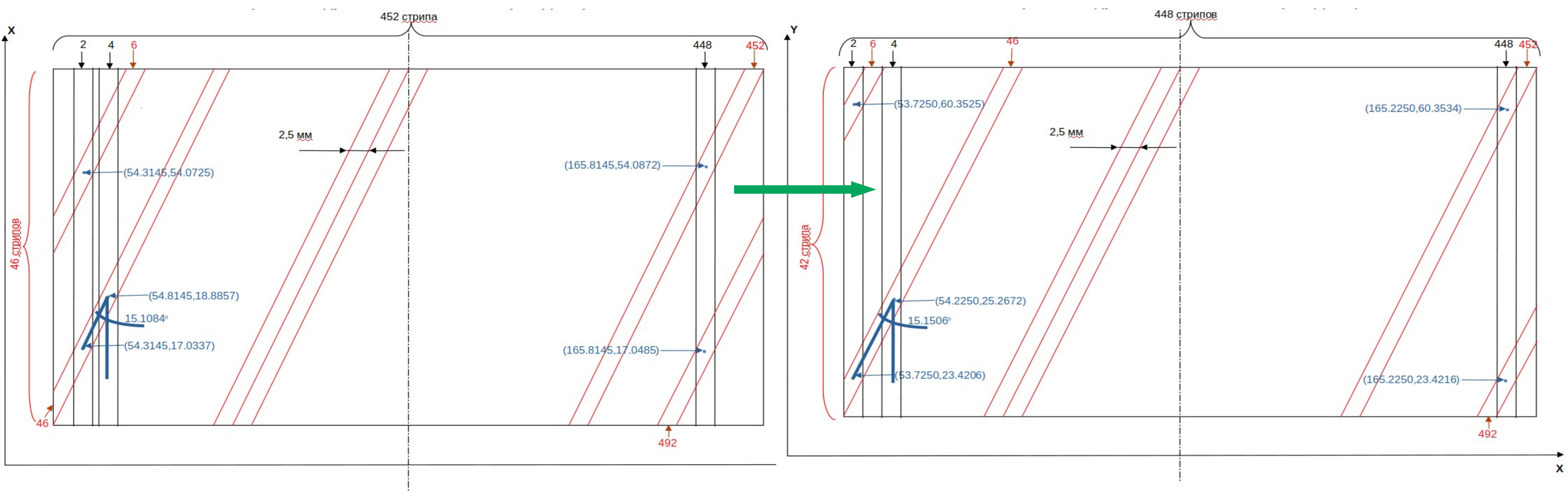
- TOF400 for MC aligned as for Data

TOF400 geometry is improved



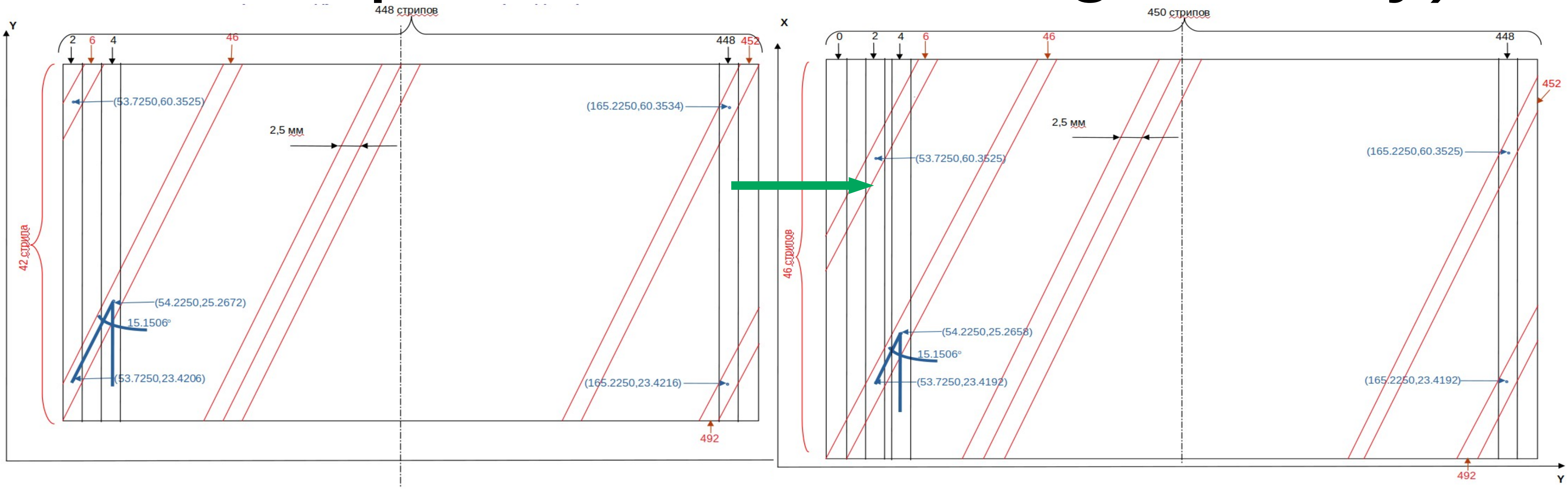
- TOF400 for MC aligned as for Data
- TOF400Hit is used in identification

CSC geometry is improved



- X shift ~ 6 mm
- Y shift ~ 6.3 cm
- Strip's slope shift ~ 0.05˚ (~0.5 mm difference at 60 cm distance)
- CSCHit is used in identification

CSC geometry is improved (in comparison with Data geometry)



- X shift < 1 µm
- Y shift < 20 µm
- Strip’s slope shift < 0.0001˚ (< 2 µm difference at 60 cm distance)