Overview of the analysis session

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for the BM@N collaboration
VBLHEP, JINR, Dubna, Russia

Agenda

Parallel sessions: Analysis meeting - Conference Hall, Building 3 (09:30-13:00)

-Conveners: Alexander Zinchenko

time	[id] title	presenter
09:30	[39] The Status of Identification in Argon Run	PLOTNIKOV, Vasily
09:50	[40] Adaptation of Monte Carlo to experimental data for the SRC experiment	DRIUK, Andrey
10:00	[41] Lambda^{0} reconstruction with embedded and real experimental data in RUN7	BATYUK, Pavel
10:15	[42] TOF700 efficiency comparison between MC and Data in Argon data run 7	KOVACHEV, Lalyo
10:30	Coffee Break	
11:00	[43] Status of the Lambda hyperon analysis in the carbon run	STEPANENKO, Yury
11:20	[44] Geometry update for inner tracker detectors of the BM@N setup for RUN-7 and the next run configurationsrun and in future heavy ion runs	BARANOV, Dmitry
11:35	[45] K^0_S mass resolution	KHUKHAEVA, Anastasia
11:45	[46] Vertex reconstruction - combinatorial approach	ZAVERTYAEV, Mikhail

6th Collaboration Meeting of the BM@N Experiment at the NICA Facility / Programme — Monday 26 October 2020

The status of identification in Argon run - I
Vasily Plotnikov

BM@N

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

Vasilii Plotnikov, 26.10.2020 5

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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

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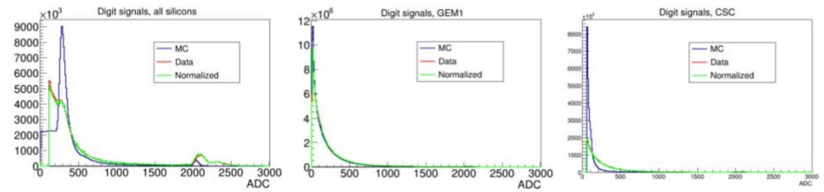
Si/GEM/CSC signals normalization (Lalyo Kovachev)



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

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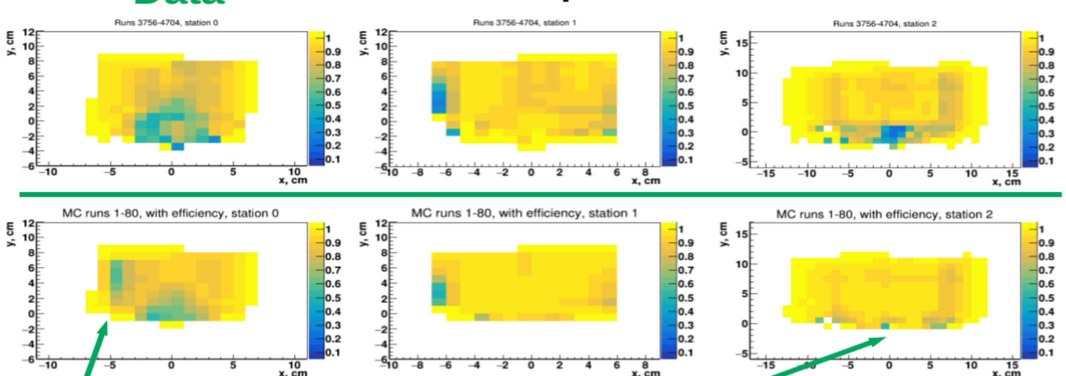
Data and MC Si/GEM efficiencies comparison



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

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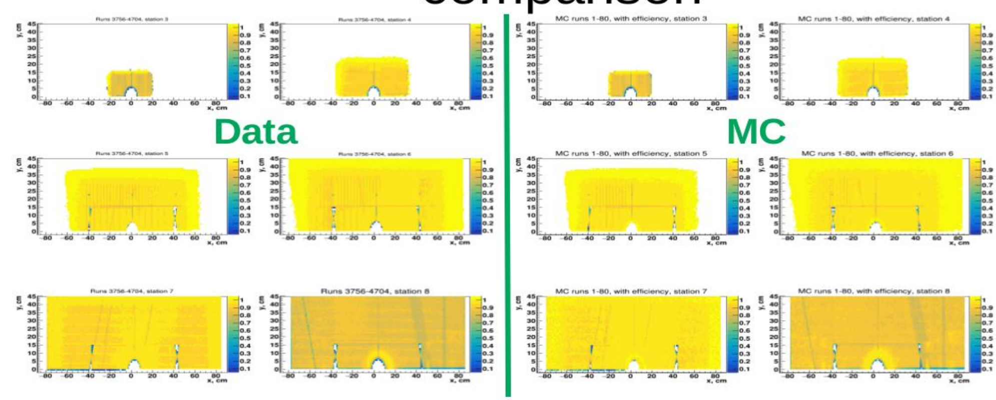
Data and MC Si/GEM efficiencies comparison



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

Vasilii Plotnikov, 26.10.2020 9

The status of identification in Argon run - II
Vasily Plotnikov

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

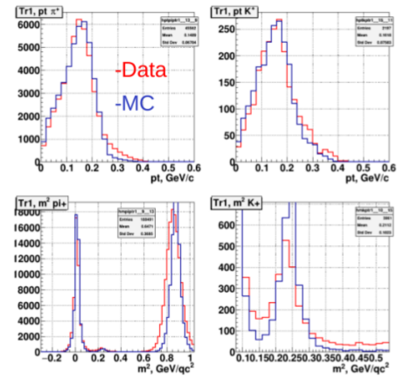
Station Data/MC/EMB	Si1, um	Si2, um	Si3, um	GEM1, um	GEM2, um	GEM3, um	GEM4, um	GEM5, um	GEM6, um
Data	117	76	121	264	323	365	370	300	549
MC	126	83	125	254	319	373	367	294	603
EMB	124	75	119	295	329	346	361	311	517

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

Detector effects implemented in MC

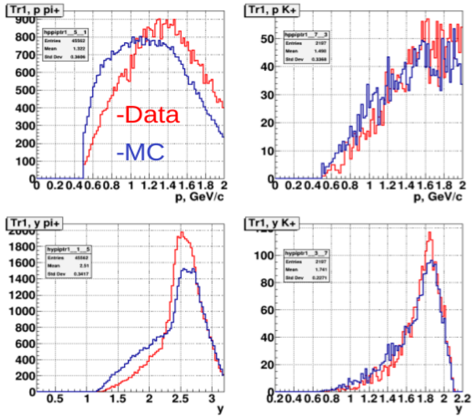
- We use UrQMD generator
- MC geometry for Si/GEM/CSC/TOF400 matches Data geometry by strips
- For MC we use the same Lorenz shifts in GEM as for Data
- MC signals for Si/GEM/CSC match Data signals
- MC Si/GEM residuals match Data residuals
- For Data and MC we use the same reconstruction chain
- MC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



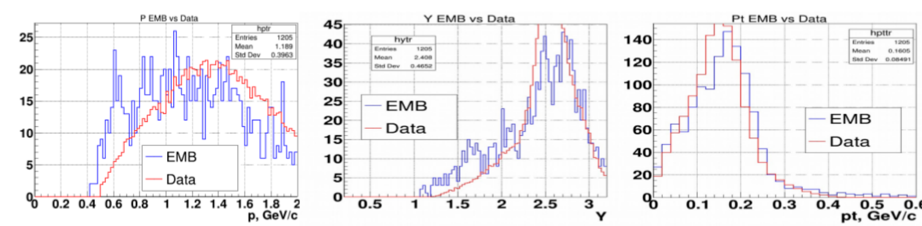
- Left m^2 distribution is normalized to the π^+ peak
- Other distributions are normalized to the integral
- S/B for Data significantly lower than for MC
- m^2 distributions for Data and MC close to each other in (π^+, K^+) region
- Pt spectra of π^+ and K^+ for Data and MC close to each other

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

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

Status of adapation of Monte Carlo to experimental data for the SRC experiment

Andrey Driuk

Motivation

- The main goal is analysis of nuclear cross section in the C+p reaction
- The efficiency of reconstruction can be obtained from the same analysis of Monte Carlo (MC) data.
- The problem of adaptation of MC data for experimental data arose

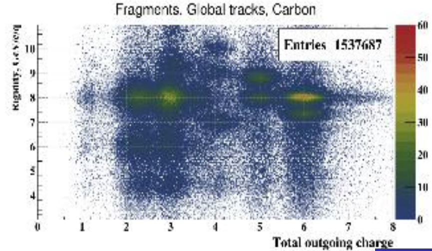


Figure: 1. Fragments of the reaction

The arm triggers in the geometry

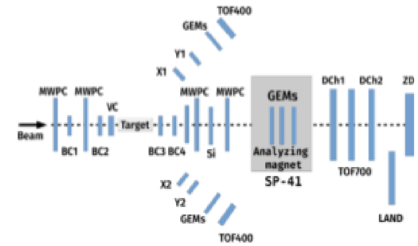


Figure: 2.The experimental setup. The arm triggers are X1-2, Y1-2

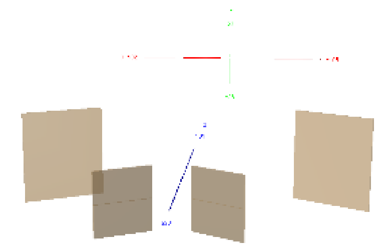


Figure: 3. In the simulation chain

Summary

The main results

- The arm triggers were added in the simulation procedure. It allows us to choose the events in which the triggers worked.
- The efficiency of arm triggers was calculated.

We plan:

- to use D-tracks and U-tracks in reconstruction procedure
- to use Lorentz shift in the simulation procedure
- to add BC3 and BC4 triggers in the simulation procedure

Efficiency of the arm triggers

Table: Efficiency of triggers

Efficiency of triggers	MC	Experiment
X1	96.0	98.0
X2	98.3	96.3
Y1	95.9	96.7
Y2	97.4	96.0
X1 & Y1	91.5	93.8
X2 & Y2	95.0	90.5

$$Eff_{X_i} = \frac{NumberOfEvents_{X_i,Y_i,GEM_i,TOF400_i}}{NumberOfEvents_{Y_i,GEM_i,TOF400_i}}$$

$$Eff_{Y_i} = \frac{NumberOfEvents_{X_i,Y_i,GEM_i,TOF400_i}}{NumberOfEvents_{X_i,GEM_i,TOF400_i}}$$

$$Eff_{X_i\&Y_i} = \frac{NumberOfEvents_{X_i,Y_i,GEM_i,TOF400_i}}{NumberOfEvents_{GEM_i,TOF400_i}}$$

Momentum and matching efficiency

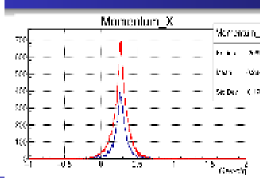


Figure: 4 Momentum along x-direction

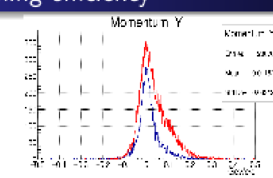


Figure: 5. Momentum along y-direction

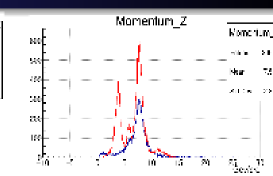


Figure: 6. Momentum along z-direction

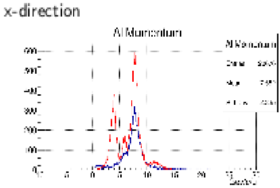


Figure: 7. the summary momentum

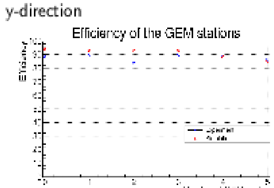


Figure: 8. The efficiency of matching

$$Eff = \frac{N_{globTracksInStation}}{N_{globTracks}}$$

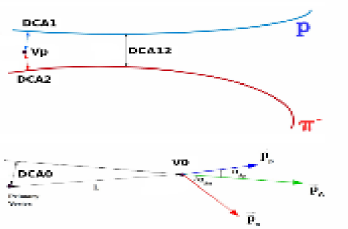
Blue is experiment, Red is MC

Λ-reconstruction in embedded and experimental data in RUN7 - I

Pavel Batyuk

Experimental data, analysis definitions, cuts ...

Λ^0 decay scheme:



- DCA0, DCA12, DCA1 and DCA2 are "minimum required" cuts to be used with given definitions in the figure.
- The cuts do implicit restrictions on a path of Λ^0.

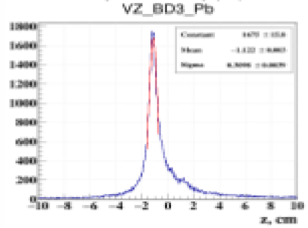
$N_{rec.tracks} > 1$ [MEvents], Ar part of RUN7

No primary vertex cut: 51.5

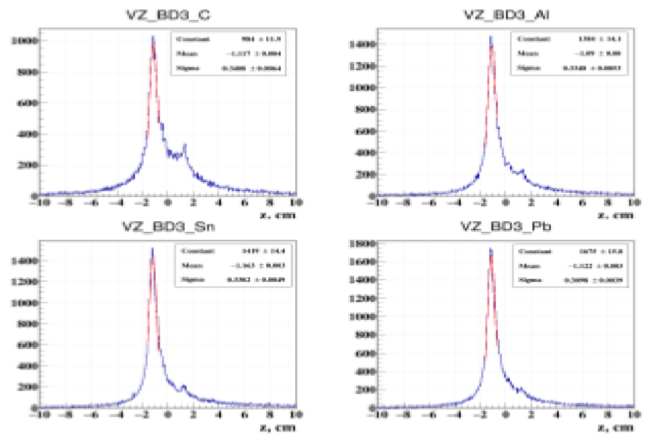
	BD1+FD2	BD2	BD3	FD2	FD3
Pb	2.13	-	1.16	-	2.75
Sn	4.81	0.20	1.88	0.56	5.59
Cu	4.61	0.24	1.89	0.56	5.68
Al	5.23	0.24	2.13	0.80	5.63
C	1.94	0.42	0.54	0.60	1.86
	18.72	1.1	7.6	2.52	21.51

With primary vertex cut: ≈ 5

Cut on V_p: $-3 < V_p(Z) < 3$ cm



Primary vertex resolution

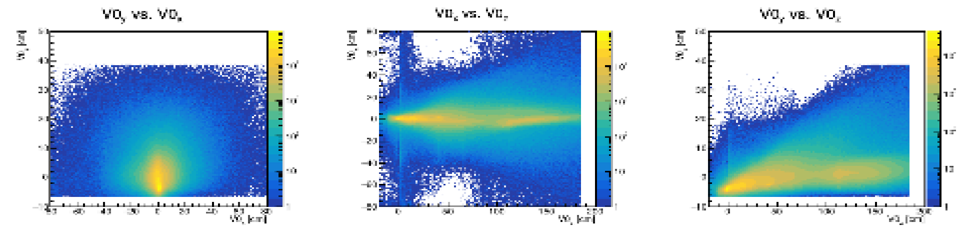


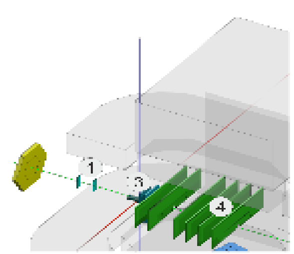
- Average V_p resolution along Z is close to 3 mm for all targets (2.6 - 3.4 mm)
- The resolution has approximately the same trend for all trigger conditions

Searching for V_0, algorithm ...

- A pair of two tracks with different signs of Q_p is considered as a candidate to be from Λ^0 decay.
- The chosen tracks are put into a corridor of relatively big width along Z-axis.
- The corridor is separated into small parts by virtual planes corresponding to some values of Z.
- The tracks are extrapolated to those Z by the Kalman filter mechanism aimed at calculating 2d-distance between.
- A set of calculated distances corresponding to the known Z-values is approximated with P(z) $= az^2 + bz + c$. It allows one to reject pairs that can produce a non-diserable edge minimum ($a < 0$) occurred widely when processing pairs.
- If a considering pair has a $P(z)$ parameterization with $a > 0$, a found minimum is considered as approximation to V_0. The minimum is taken from available calculated distances but not the parameterization used.
- The corridor is divided by factor 2 to reproduce the steps of algorithm already mentioned. The algorithm works till to the corridor width is less than a chosen threshold or the pair does not become to satisfy restrictions.

Reconstructed V_0





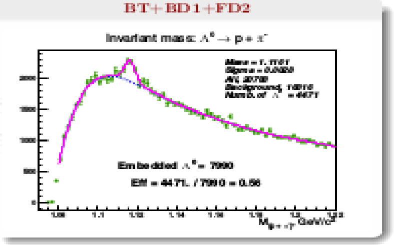
- Seen probable acceptance for reconstructed secondary vertices in all directions
- A really visible kink (break) in XZ-direction around Z = 100 cm is explained by reconstructed tracks having four hits in the second part of GEM-tracker.

Λ-reconstruction in embedded and experimental data in RUN7 - II

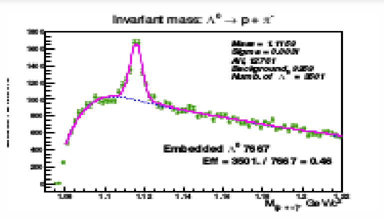
Pavel Batyuk

Reconstruction of embedded Λ^0

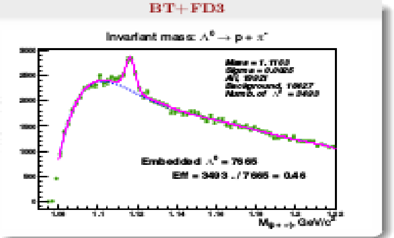
BT+BD1+FD2



BT+BD3



BT+FD3



- Embedding is done with the developed algorithm
- Used only cut on DCA12 (< 0.2cm)

- Embedded Λ^0's look to be reconstructed for all trigger conditions used with approximately the same efficiency
- A room how to fit background and signal regions of spectrum exists ...
- Efficiencies extracted from Monte Carlo (related to tracking procedure) should be calculated and implemented in a more precise manner ...

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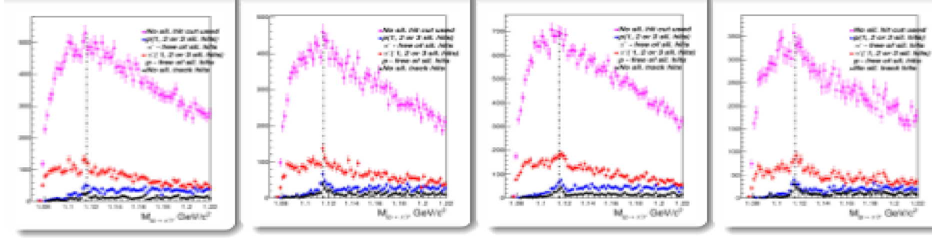
Testing silicon veto scenarios ...

ArAl | ArSn | ArCu | ArPb



Approximate cut values obtained:

	DCA0 [cm]	DCA12 [cm]	DCA1 [cm]	DCA2 [cm]
Pb	1.	0.4	1.	2.
Sn	1.	0.4	1.	3.
Cu	1.	1.	1.	4.
Al	1.	1.	1.	4.

- Silicon veto allowed us to see the signal for all targets
- Trying not to use the veto but the cuts already obtained ...

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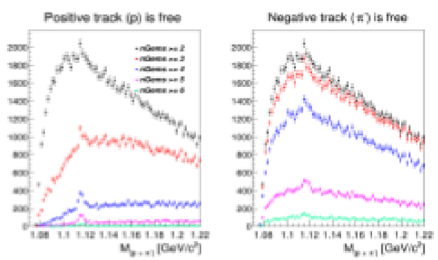
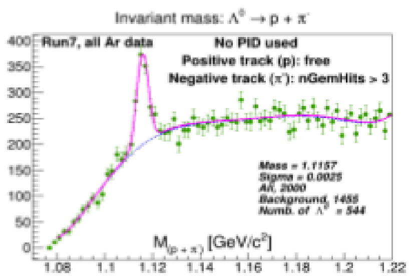
First Λ^0's in experimental data of RUN7





- The analysis covers argon part of the last run
- It is based on 5 MEvents (all targets + all triggers)
- No any type of veto for SILICON / GEM used

Reco track (central tracker):

nHits = nSiliconHits + nGemHits

Λ^0-signal became visible. Trying to increase number of reconstructed Λ^0's ...

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Ok, the signal from $\Lambda^0 \to \pi^- + p$ exists...
What is next?

- To do a fully realistic embedding (by adding the detector efficiencies)
- To use the embedding for "fine" tuning of tracking procedure to maximize the reconstructed signal
- To get Λ^0 efficiency spectra in p_T and η space
- To do an improvement in the alignment procedure of the BM@N Central Tracker (ALCOPACK)
- ...

Thank you for your attention!

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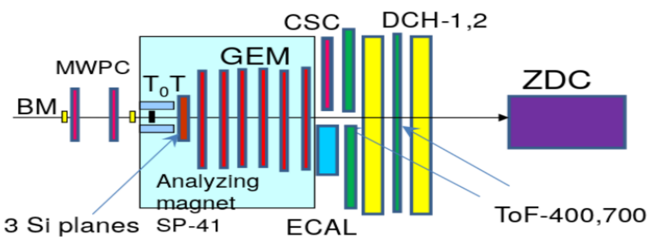
TOF700 efficiency comparison between MC and Data in Argon run 7 - I
Lalyo Kovachev

"Bound by one chain"

Argon data run 7

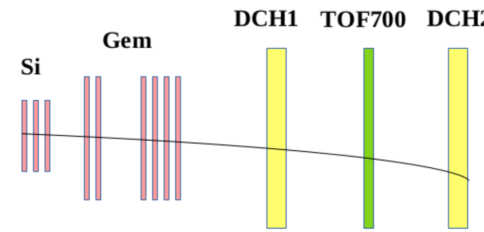
Ar beam 3.2 GeV/n
Targets Al,C,Sn,Cu,Pb



Schematic drawing of the location of the TOF700 on the BM@N setup

TOF700 Particle Identification chain

For **Data** and **MC** we use the **same** Identification chain



We use **DCM QGSM** Generator

Si-GEM(data) tracks from **V. Plotnikov**

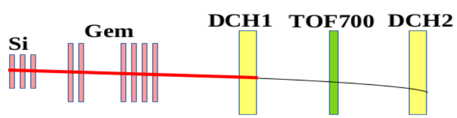
DCH tracks from **DCH group**

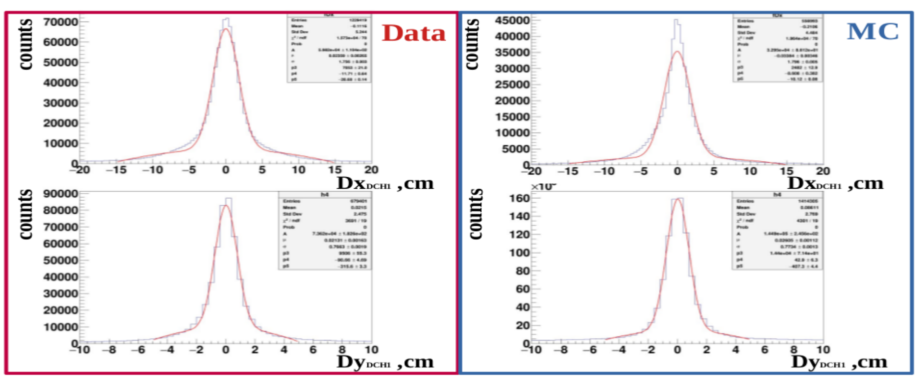
TOF700 hits from **Y. Petukhov**

Si-GEM tracks are extrapolated to the **DCH1** z-position and matched against the **DCH1** tracks

Successfully matched tracks are extrapolated to the **TOF700** planes and matched against the **TOF700** hits

Si-GEM-DCH1 Matching Criteria

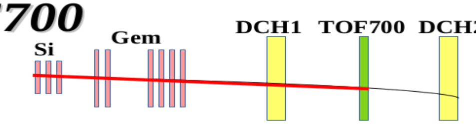


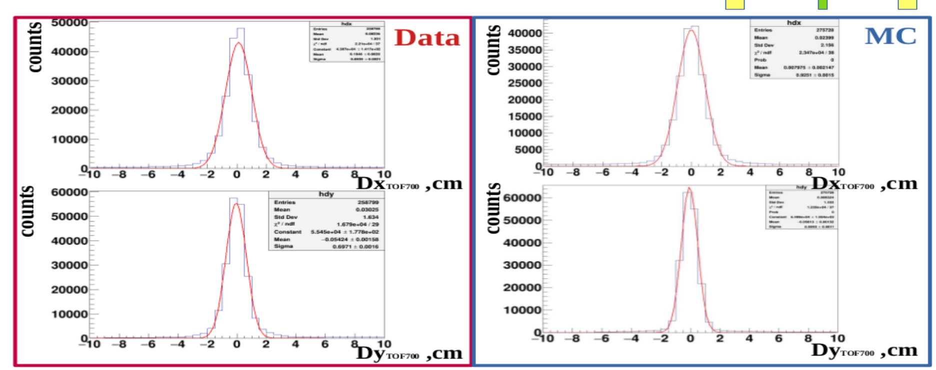


Function: Gaus+pol2 σDx ~ 1.7, σDy ~ 0.75
Matching criteria: |Dx| < 5 cm, |Dy| < 2 cm

6

Si-GEM-DCH-TOF700 Matching Criteria





Function: Gaus σDx ~ 0.8, σDy ~ 0.65
Matching criteria: |Dx| < 2.5 cm, |Dy| < 2 cm

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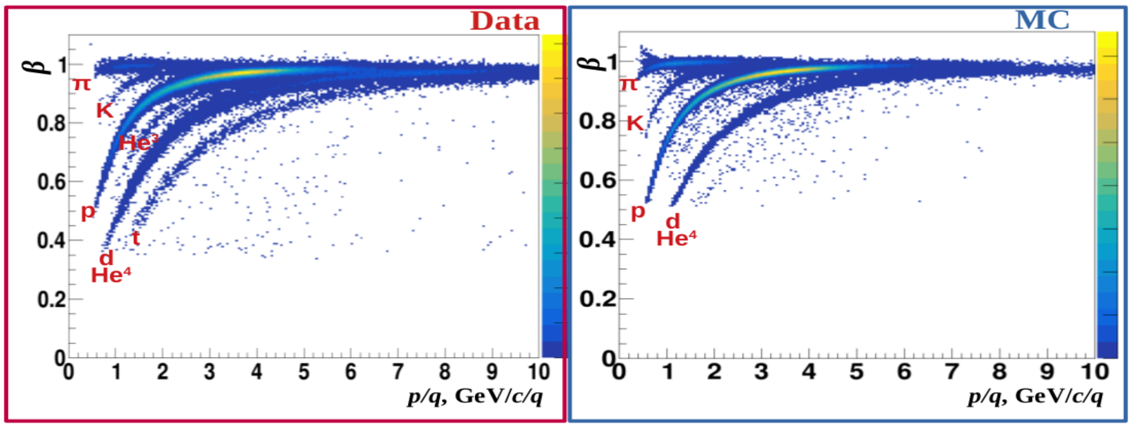
TOF700 efficiency comparison between MC and Data in Argon run 7 - II
Lalyo Kovachev

β vs p/q



Data plot chosen to represent **similar statistics**
actual data statistics on the next slide

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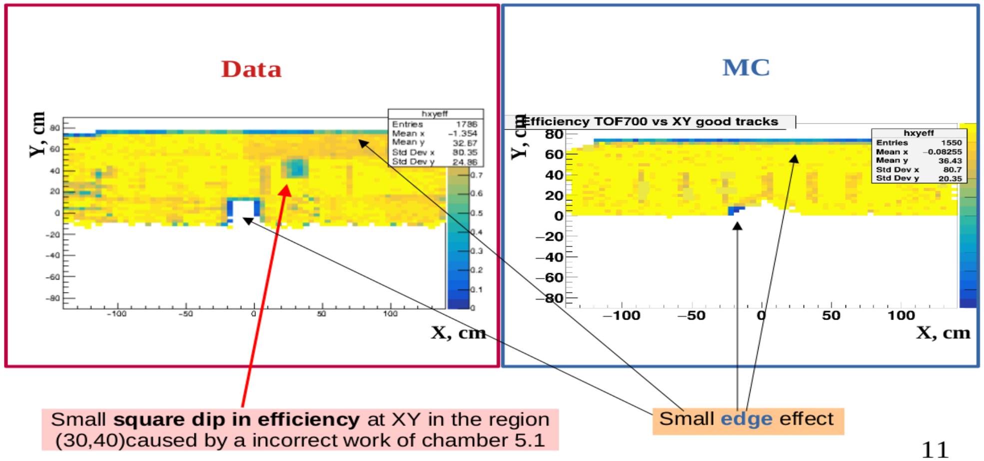
Efficiency for a good track Si-GEM + DCH matching with hit TOF700.



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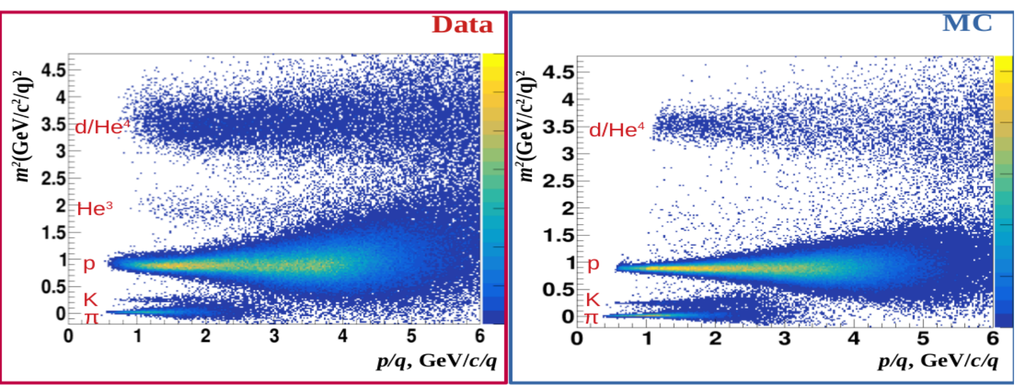
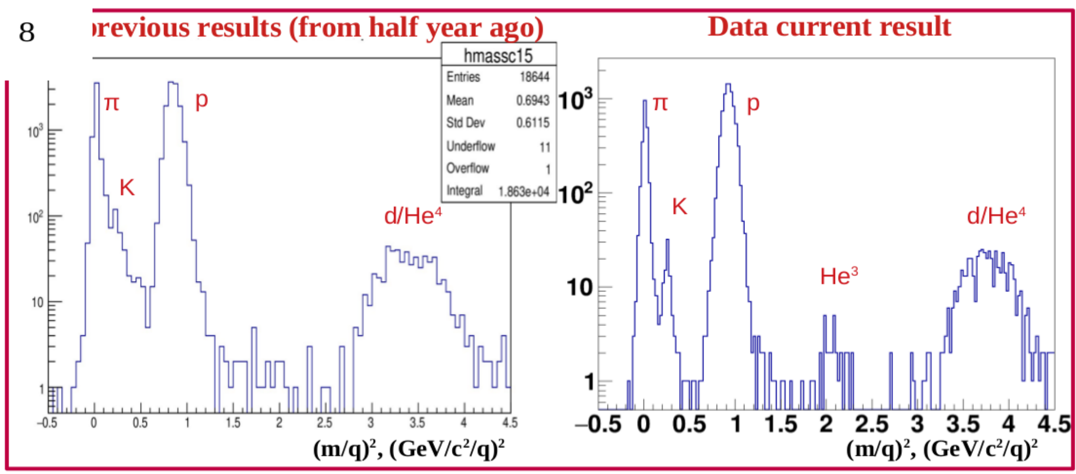


There is a **negligeble** momentum systematics effect.

13



Reconstructed mass square of momenta **below** 1.5 GeV

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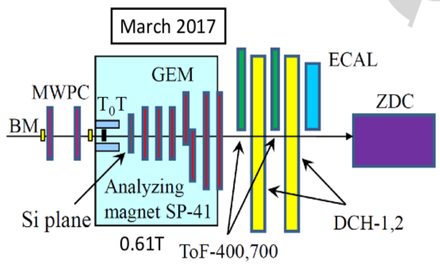
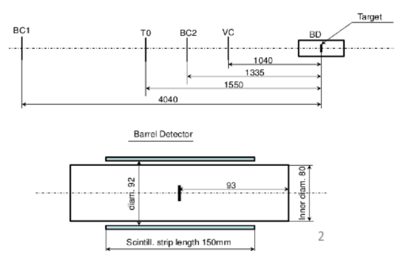
Status of the Λ hyperon analysis in the carbon beam - I

Yury Stepanenko

BM@N configuration in Run6

- Central tracker
  - One plane of a forward Si detector
  - 6 GEM stations
    - 5 GEM detectors (66x41 cm2)
    - 2 GEM detectors (163x45 cm2)
- Triggers: BD, BC1, BC2, T0, VETO
- Beam Ekin=4.0 and 4.5 GeV
  - Intensity 10^5 per spill
  - Spill duration 2-2.5 sec.
- Physics: measure inelastic reactions C+A→X
  - Targets: C, Al, Cu, Pb





Analysis flow & current status

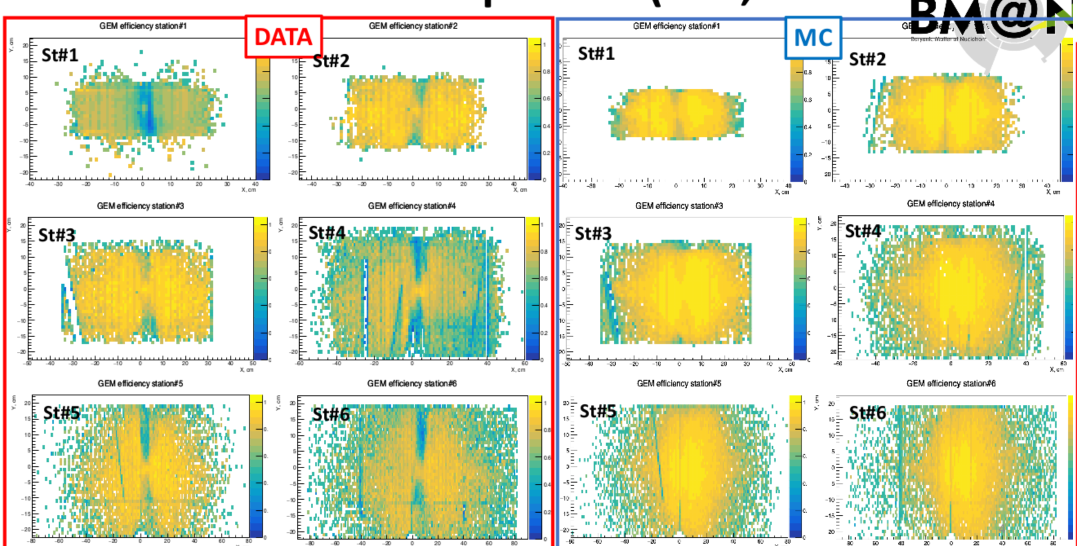
- **Main goal of current analysis** – cross-check with previous analysis (was performed by Gleb Pokatashkin)

- **Embedding procedure:**
  - Extract Primary Vertices (PV) from data
  - Simulate DQGSM events from extracted data PV
    - Create set of events for the PV
    - Find event in set with at least one Λ^0 to be reconstructed
  - Insert digits from the Λ^0 events in the data events

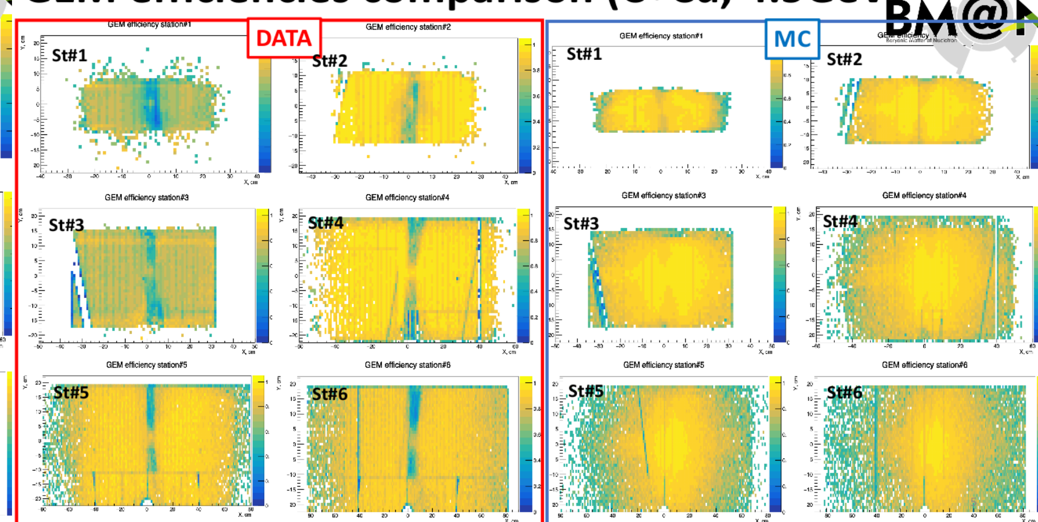
Please contact me for more detailed info

- Data reconstruction & analysis **<= now we are here!!**
  - Apply detectors efficiencies to embedded events
  - Make control plots, calculate embedding efficiency, calculate cross-sections of the Λ^0's & etc...

GEM efficiencies comparison (C+C, 4.0GeV)



GEM efficiencies comparison (C+Cu, 4.5GeV)

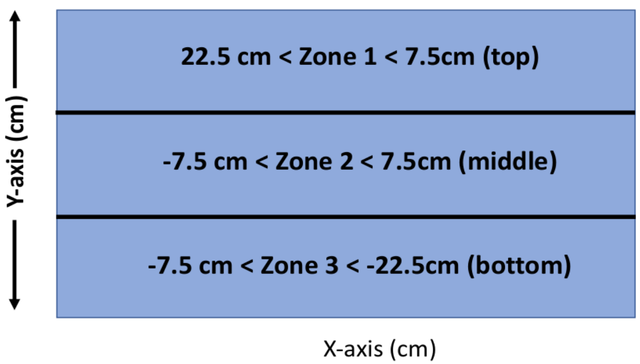


Status of the Λ hyperon analysis in the carbon beam - II

Yury Stepanenko

Apply efficiencies (check)

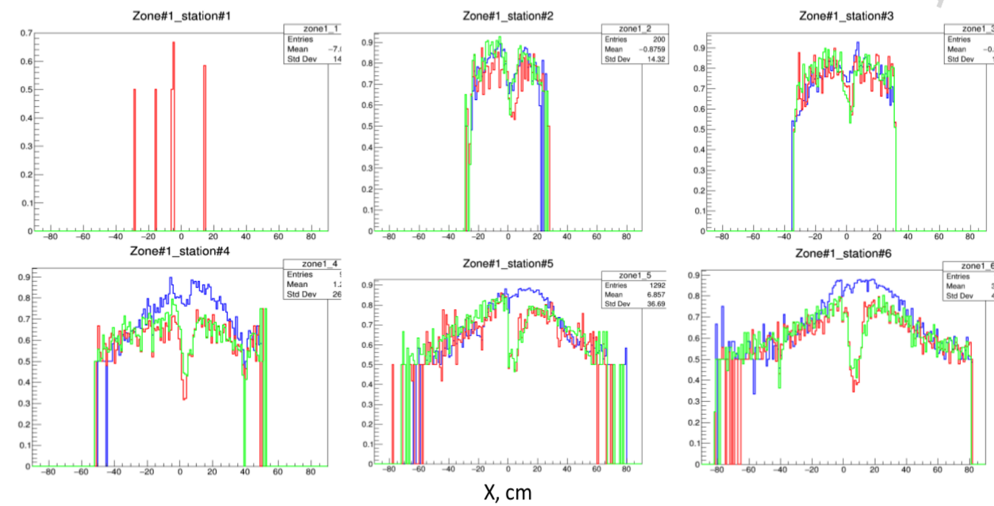
- Each GEM plane was divided into to 3 regions along Y-axis
  - Compare integral for efficiencies at each regions



6

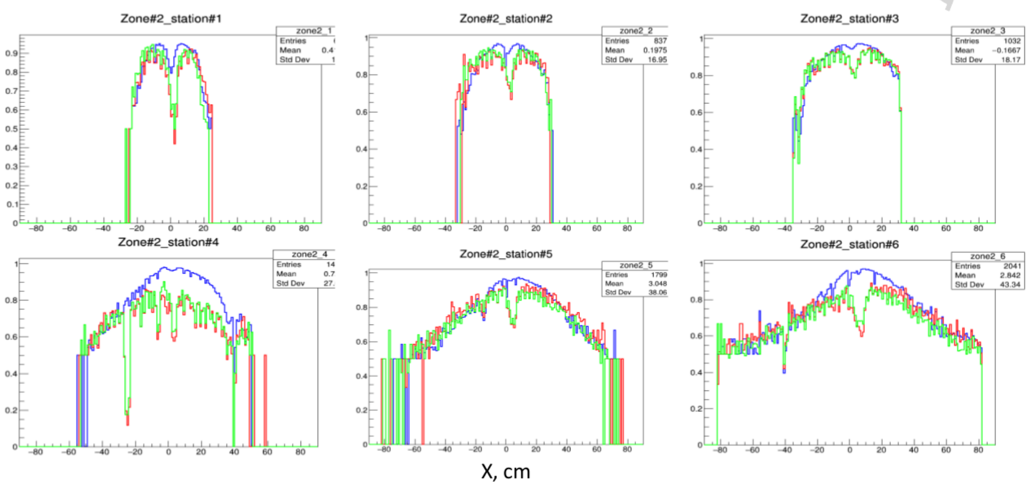
Apply efficiencies (C+C, 4.0GeV, top)

Red: Data; Blue: pure MC; Green: Data EMB (22.5 cm < Zone 1 < 7.5cm (top))



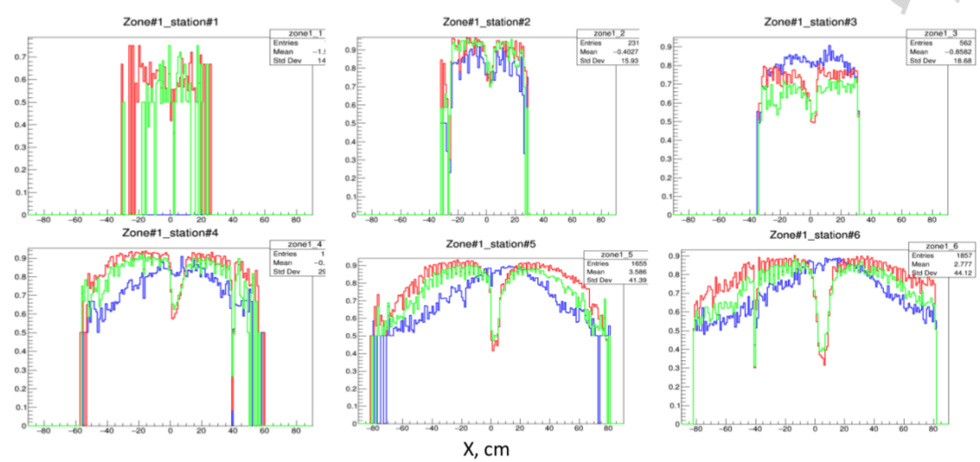
Apply efficiencies (C+C, 4.0GeV, middle)

Red: Data; Blue: pure MC; Green: Data EMB (7.5 cm < Zone 2 < -7.5cm (middle))



Apply efficiencies (C+Cu, 4.5GeV, top)

Red: Data; Blue: pure MC; Green: Data EMB (22.5 cm < Zone 1 < 7.5cm (top))



Geometry update for inner tracker detectors of the BM@N setup for RUN-7 and the next run configurations - I

Dmitry Baranov

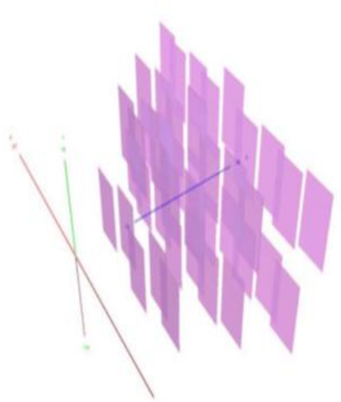
Detailed geometry creation

- ❑ The detailed ROOT geometry was created for the following configurations:
  - GEM RUN-7 (Spring 2018)
  - GEM RUN SRC (Spring 2018)
  - GEM Future Configuration (2020-2021)
  - Forward SILICON Future Configuration (2020-2021)

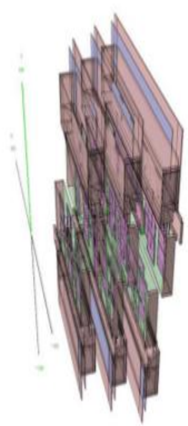
❑ The design of these detector has a lot of supporting elements, such as frames, electronics and others. It influences the detector efficiency.

❑ There are two versions of the ROOT geometry (simplified and detailed) for each configuration.

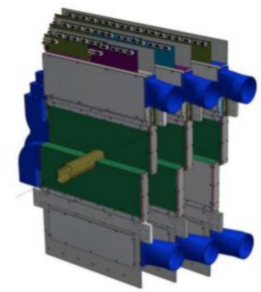
***Simplified ROOT geometry**: only sensitive planes composed of basic silicon-modules*



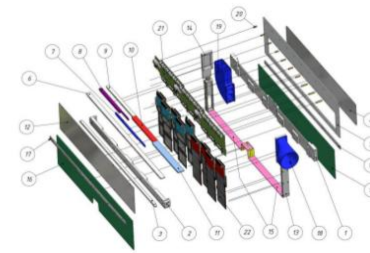
***Detailed ROOT geometry**: sensitive planes and supporting elements (passive volumes)*



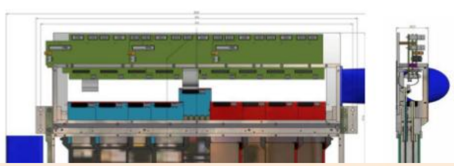
Forward Silicon Detector



Full assembly of Forward Silicon detector

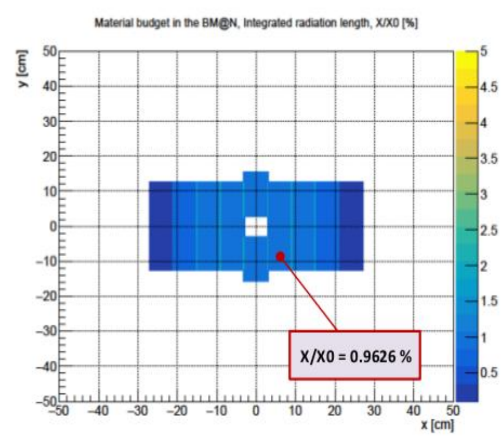


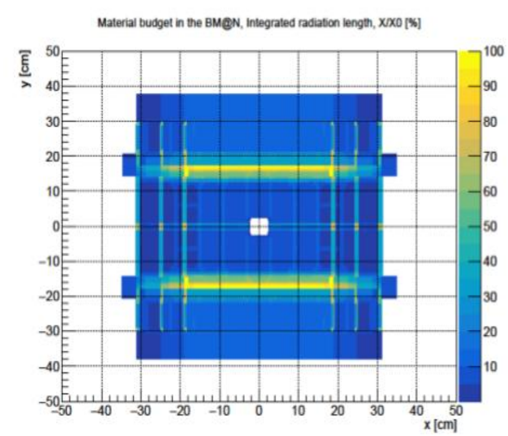
Parts of one half-plane of Forward Silicon Detector



	Описание	Материал	Размер вдоль пучка	
1	Базовая планка	Алюминиевый сплав	8…14 мм	Вне чувствительной зоны Si-сенсоров
2	Планка	Алюминиевый сплав	6…12 мм	Вне чувствительной зоны Si-сенсоров
3	Планка	Алюминиевый сплав	10 мм	Вне чувствительной зоны Si-сенсоров
4	Пластина	Алюминиевый сплав	1.5 мм	Вне чувствительной зоны Si-сенсоров
5	Пластина	Алюминиевый сплав	3 мм	Вне чувствительной зоны Si-сенсоров
6…11	Рейка	Алюминиевый сплав	Суммарная толщина	Вне чувствительной зоны Si-сенсоров
12	Пластина	Алюминиевый сплав	1.5 мм	Вне чувствительной зоны Si-сенсоров
13	Боковая стенка экрана	Алюминиевый сплав	27 мм	Вне чувствительной зоны Si-сенсоров
14	Боковая стенка экрана	Алюминиевый сплав	27 мм	Вне чувствительной зоны Si-сенсоров
15	Горизонтальная стенка экрана	Пенопласт	27 мм	В чувствительной зоне Si-сенсоров
16	Лицевая стенка экрана	Пенопласт	3 мм	В чувствительной зоне Si-сенсоров
17	Планка экрана	Алюминиевый сплав	3 мм	Вне чувствительной зоны Si-сенсоров
18…19	Тонкостенный патрубок	Пластик АБС	Стенка - 2 мм	Вне чувствительной зоны Si-сенсоров
[illegible]	Втулка крепления плат [illegible]	[illegible]	[illegible]	[illegible]

Forward Silicon Detector: material budget

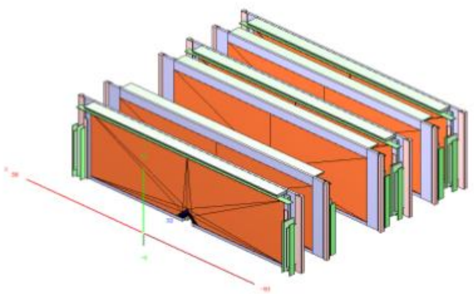




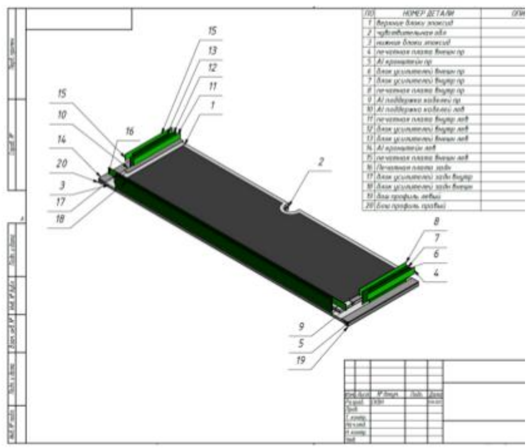
Geometry update for inner tracker detectors of the BM@N setup for RUN-7 and the next run configurations - II

Dmitry Baranov

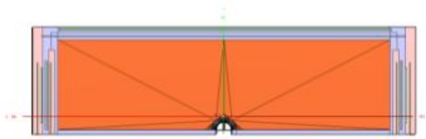
GEM: configuration for RUN-7 (RunSpring2018)



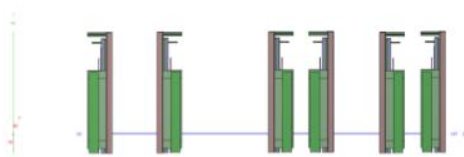
Detailed geometry of GEMs for RUN-7: common view



Detailed ROOT geometry have been prepared according to
schemes of half-planes provided by S. Piyadin (and others

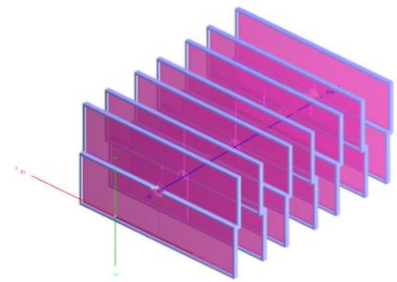


Detailed geometry of GEMs for RUN-7: front view (XY)

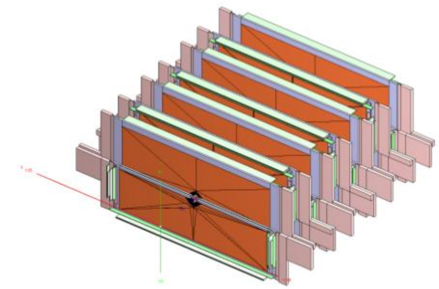


Detailed geometry of GEMs for RUN-7: side view (ZY)

GEM: configuration for the next run (FutureConfig2020)

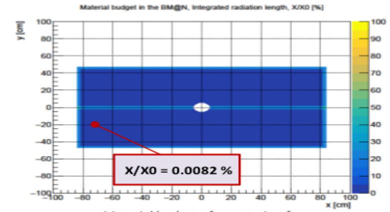


Simplified ROOT geometry of GEMs for the next run: only sensitive planes (as volumes filled with a gas mixture) and ordinary frames.
ROOT file: GEMS_FutureConfig2020.root

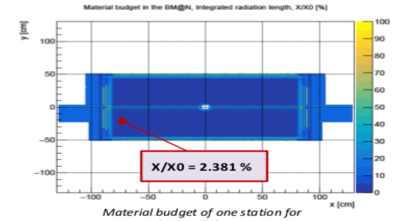


Detailed ROOT geometry of GEMs for the next run: passive elements (such as frames, electronics and material layers in sensitive areas) were added .
ROOT file: GEMS_FutureConfig2020_detailed.root

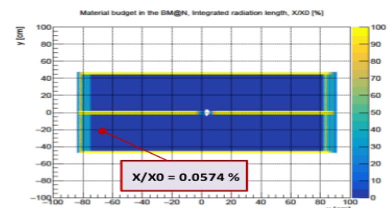
Material budget: GEM configuration for the next run (FutureConfig2020)



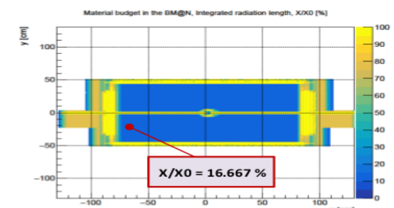
Material budget of one station for tracks parallel to Z axis (simplified geometry)



Material budget of one station for tracks parallel to Z axis (detailed geometry)



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



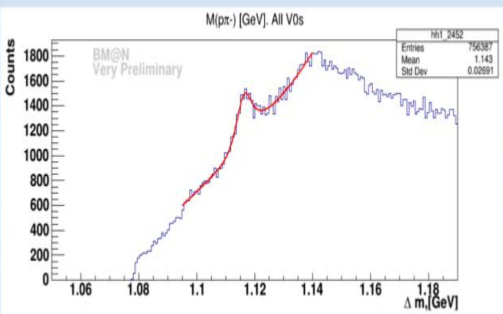
Material budget of seven stations for tracks parallel to Z axis (detailed geometry)

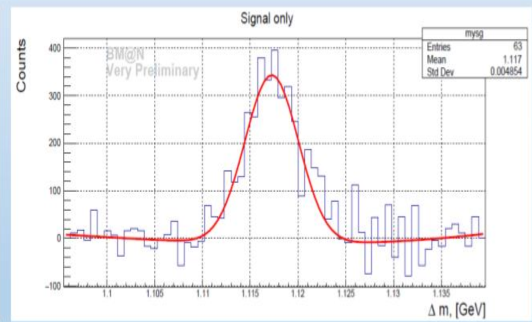
17/19

K^0s mass resolution
Anastasia Khukhaeva

Real data in Run6

The fit reveal the width of the signal equal to 4.85 Mev



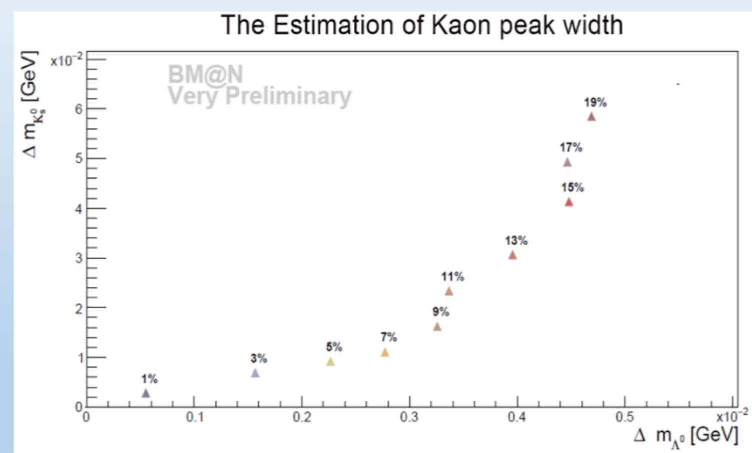


25 October 2020

The resulting graph

- We may expect the width of the K_S^0 in the region of

  58.53 ± 1.22 MeV



25 October 2020

Vertex reconstruction - combinatoric approach
Mikhail Zaveryaev - I

Full Combinatoric Algorithm.

1. The basic principle : if among **N** tracks the deviation of at least one track exceed a certain limit then look through **N** combinations of **N-1** tracks.

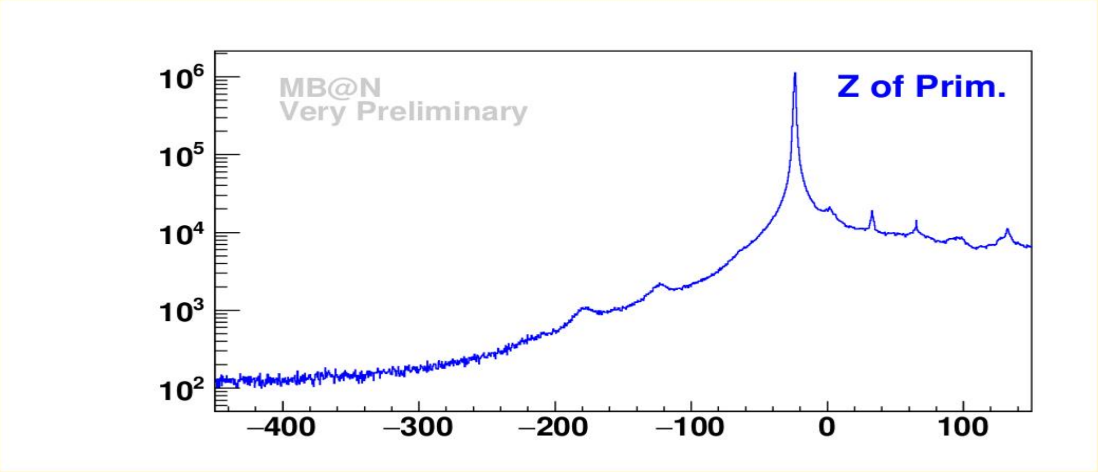
2. If in each **N** combinations among **N-1** tracks at least one track exceed a certain limit then look through C^k_{N-k}, k=2, combinations. 3. Process continue up to 2 tracks combinations.

Problem : to run through C^k_{N-k} takes time.

The only tuning parameter is the maximum deviation of the track from the primary vertex.

M.Zavertyaev

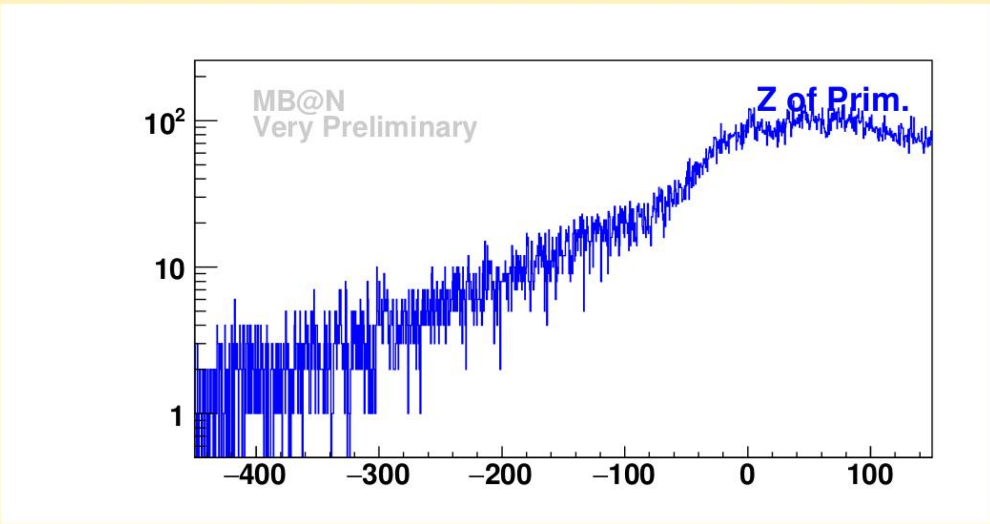
Z of Primary vertex position.



M.Zavertyaev Moscow, October 25, 2020 – 4 / ??

Vertex reconstruction - combinatoric approach
Mikhail Zaveryaev - II

Z of Primary vertex position. Beam Data, run 1403.



Luminosity Evaluation Procedure.

- The position of the beam counter is visible in the vertices positions.
- The $X - Y$ of the vertices distribution at beam counter gives the information about beam profile.
- The $X - Y$ of the vertices distribution at target gives the information about beam profile.
- Cut on $X - Y$ at beam counter and target positions for the events with the only one track let us evaluate the number of beam particles at target and finally calculate the luminosity.
- The efficiency of the beam track reconstruction will be taken from simulation.

Summary

- ✓ Analysis efforts in several directions: Run6, Run7 PID, Run7 V0s, SRC, preparations for future runs.

Bound by one chain,

Tied by one aim.