

Status of **CGEM** Software

(two months later)

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What was done:

- Passive elements implemented (TO)
- Geometry debug done (FE)
- Radiation Length estimated, in agreement with calculations (FE)

What is ongoing:

- Optimizations (GEM holes/effective density)

Next to do:

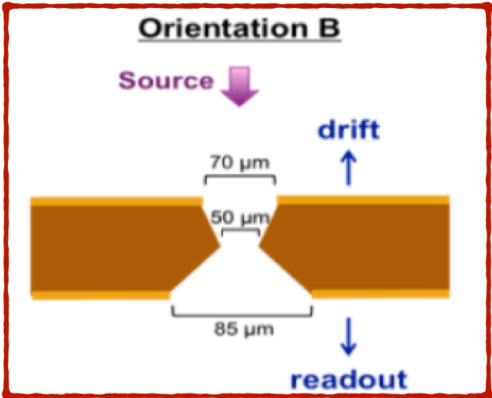
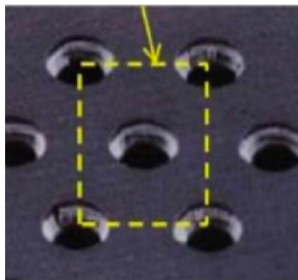
- Updates (layer 3) – (waiting for construction)
- Effects of CGEM in neutrals reconstruction (IHEP)

2 months ago

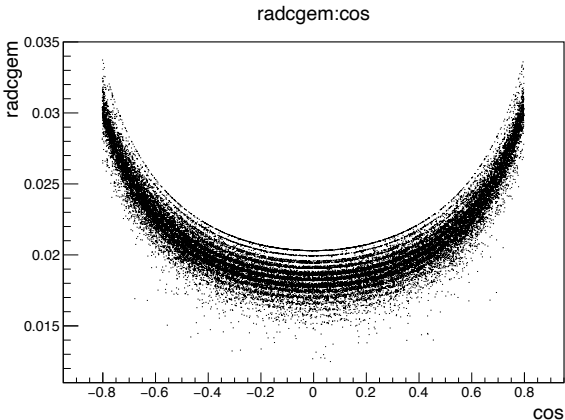


Geometry - now

- Geometry updated successfully (available on CVS)
- Effective density implemented (for holes and strips separately)
- Holes for GEM foils implemented in CgemBoss665f
- Radiation length studies consistent with effective density
- Started studies of effects on EMC (@IHEP)

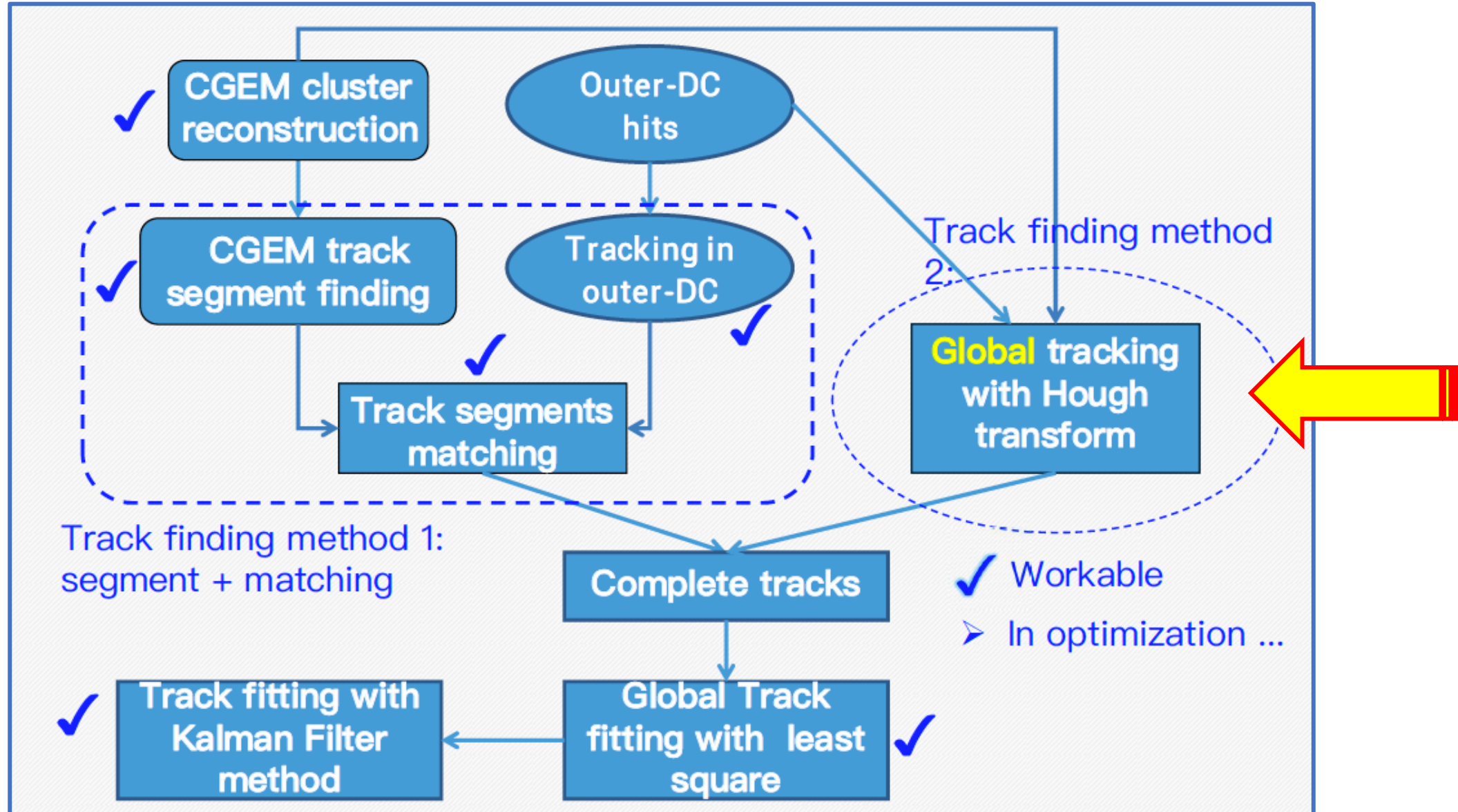


	X ₀ (%)	Cgem eff. Densities (%)	holes sim (%)
tot X ₀ (CGEM+shield)	1.824	1.824 CGEM separator ~ 0.31	1.8 CGEM separator ~ 0.31
CGEM only	1.514	1.514	1.49
Air	0.0245	(CGEM-Air) = 1.49	(CGEM-Air) = 1.47
Arlso	0.0265	(CGEM-Air-gas) = 1.47	(CGEM-Air-gas) = 1.44





Global Reconstruction





What was done:

- Hough transform with loss of efficiency in high multiplicity events (PEK+IHEP)

What is missing:

- The developer! We don't have news since January after Coronavirus accident

What is ongoing:

- We have found and committed the code which should solve the problematics (two days ago)
- We created a working group TO+FE+IHEP for debugging, to continue developing, sharing tasks and to evaluate performances (no single-point-of-failure)

2 months ago

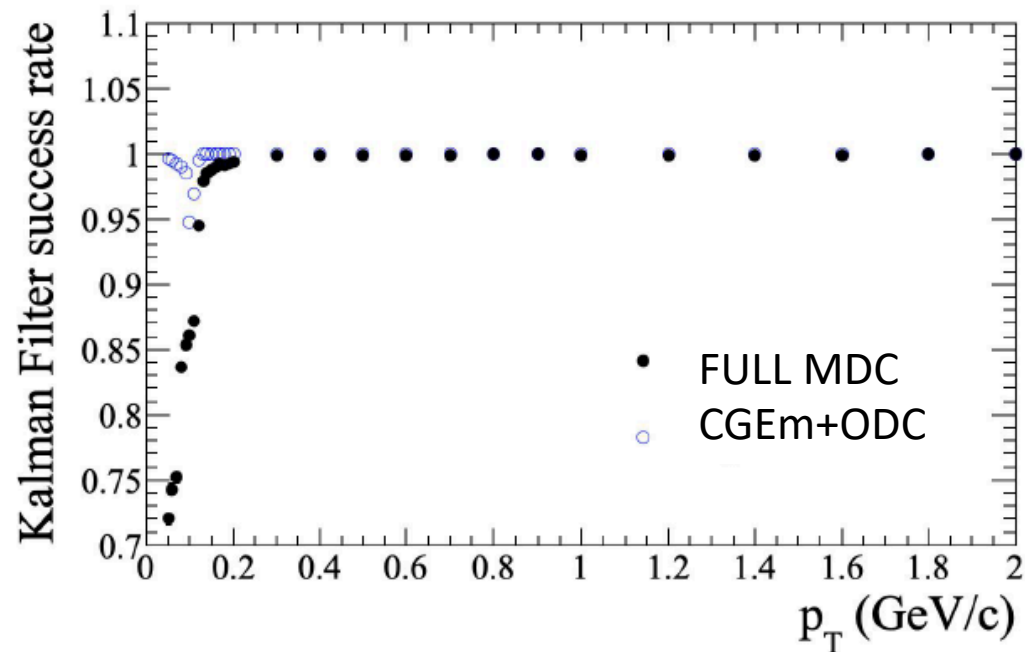
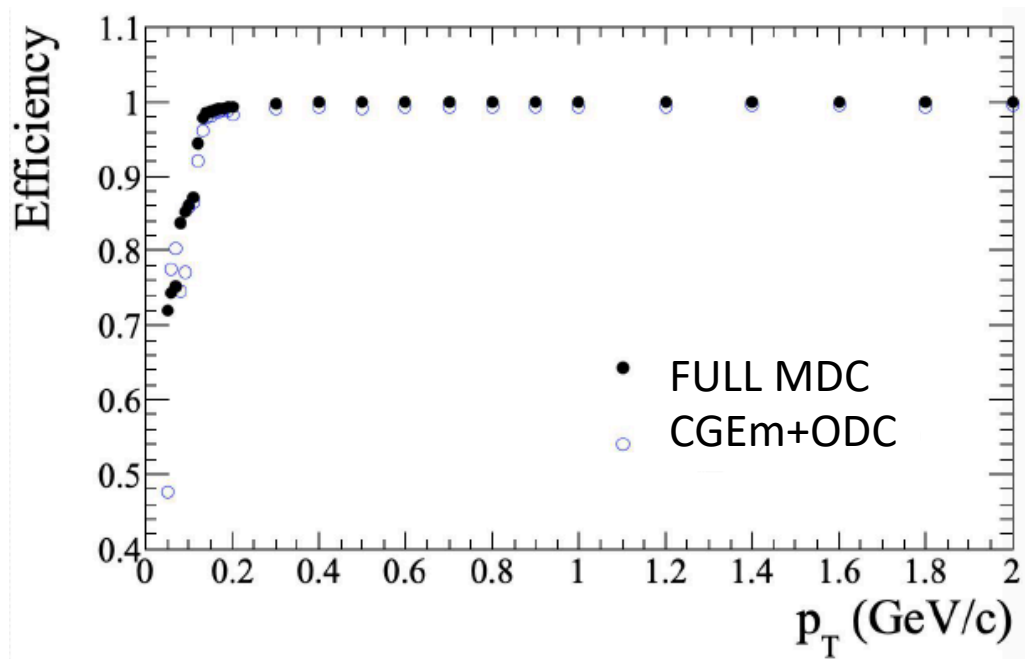


We missed the developer, but we are able to use the code!

What is ongoing:

- Code testing, debugging and improvements

Single muons, new results, comparison with full MDC





- We need to better understand the code at higher multiplicities
- More performance checks
- Italian forces in the game (TO+FE)

$$\psi(3686)\pi^+\pi^-J/\psi \rightarrow \pi^+\pi^-e^+e^-$$

Event selection flow	FULL MDC	1 st Hough Import	Hough after fixes
Ntrack ≥ 4	75.89%	$(69.81 \pm 0.46)\%$	$(69.09 \pm 0.46)\%$
$\pi^+ + \pi^- + e^+ + e^-$ selection ①	59.76%	$(52.80 \pm 0.50)\%$	$(53.55 \pm 0.50)\%$
Loose J/ ψ mass cut ②	57.50%	$(50.11 \pm 0.50)\%$	$(50.86 \pm 0.50)\%$
4C fit($\chi^2 < 60$)	38.19%	$(26.14 \pm 0.47)\%$	$(32.08 \pm 0.47)\%$

- ① $\pi^+ + \pi^- + e^+ + e^-$ selection: PID by momentum, $p < 0.8 \text{ GeV} \rightarrow \text{pion}$,
 $p > 0.8 \text{ GeV} \rightarrow \text{electron}$, $|dr| < 1.0 \text{ cm}$, $|dz| < 10 \text{ cm}$, $|\cos\theta| < 0.93$, total charge = 0
- ② Loose J/ ψ mass cut: m_{ee} in $(2.5, 4.0) \text{ GeV}/c^2$, $m_{\pi\pi\text{-recoil}}$ in $(2.5, 4.5) \text{ GeV}/c^2$, m_{total}
in $(3, 5) \text{ GeV}/c^2$



Analysis of Cosmics Data

Several runs for testing and for performances:

- Standard settings
- Higher HV
- Higher thresholds
- Noise runs

What is ongoing:

- Alignment (IHEP) and time calibration (FE)
- Performance studies (FE+TO)
- Noise studies

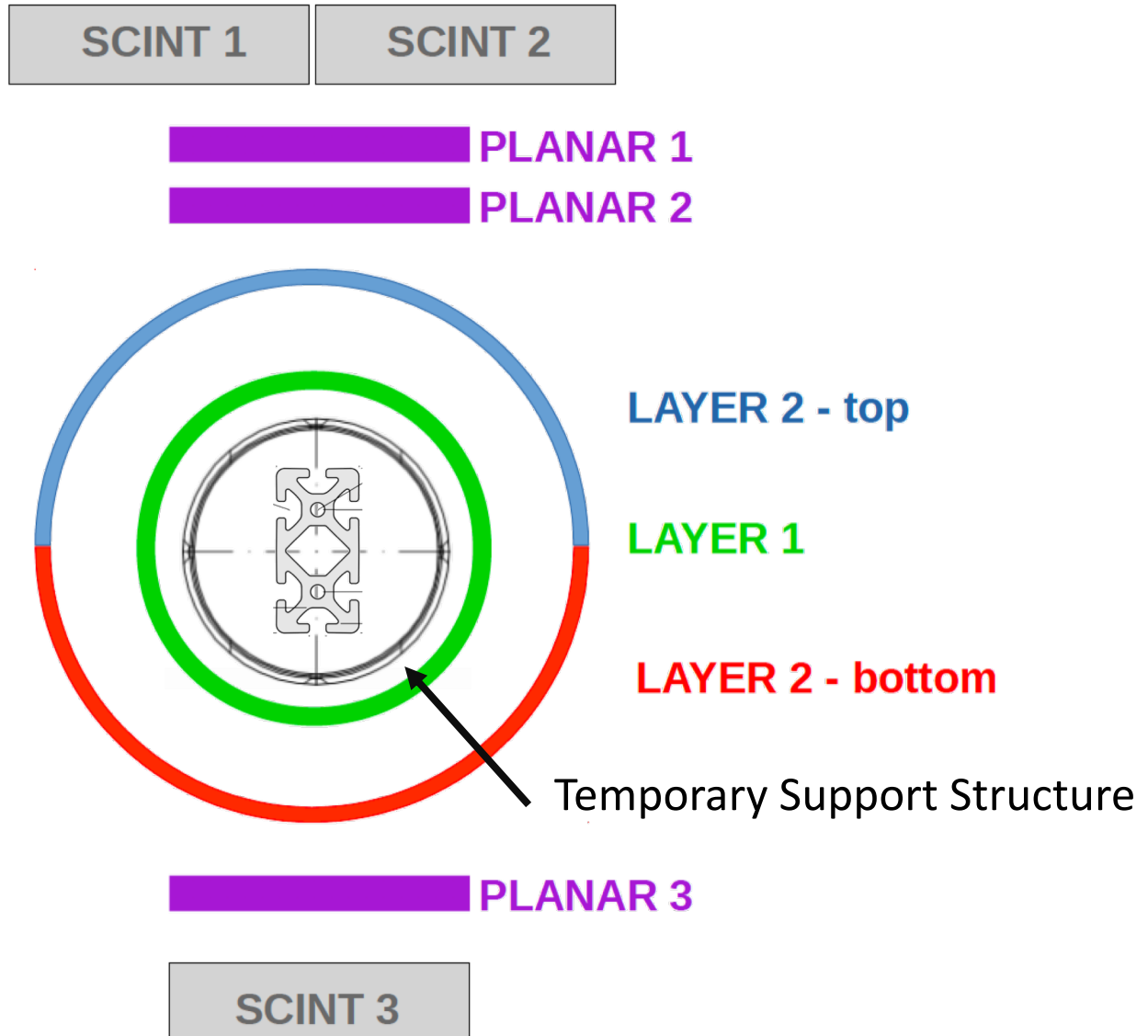
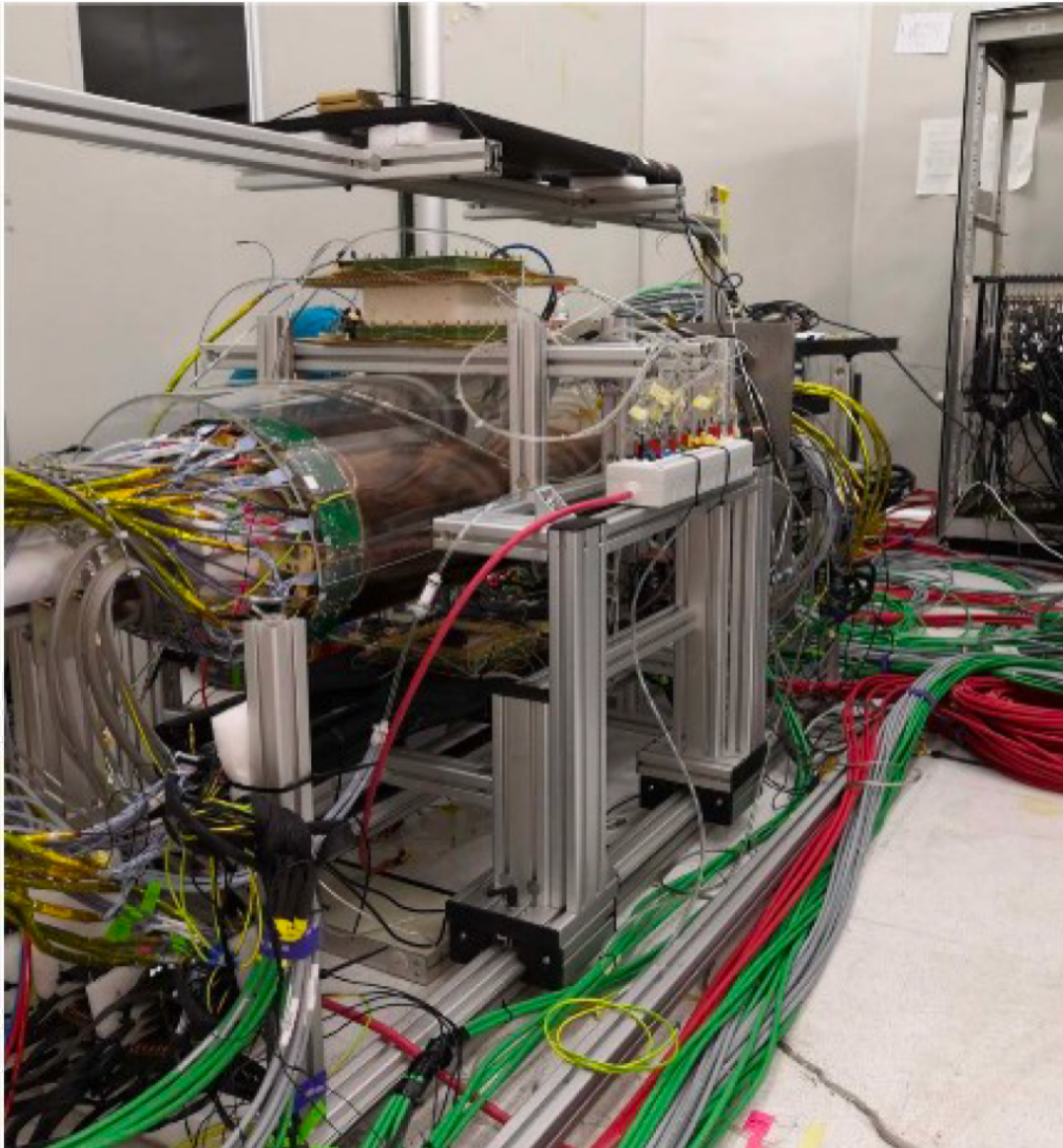
NEW SETUP (2020)

RUN ID	gain (HV)	threshold
10	standard	standard
11	standard	standard
12	standard	standard
13	standard	standard
14	standard	standard
15	standard	standard
16	standard	standard
17	standard	standard
18	high	standard
19	high	standard
20	high	standard
21	high	standard
22	no gain (HV = 200V)	standard
23	high	high
24	high	high
25	high	high
26	high	high
27	no gain (HV=0V)	standard
28	no gain (HV=0V)	standard
29	no gain (HV=0V)	standard
30	no gain (HV=0V)	standard

2 months ago



Analysis of Cosmics Data





Effect of the supporting structure

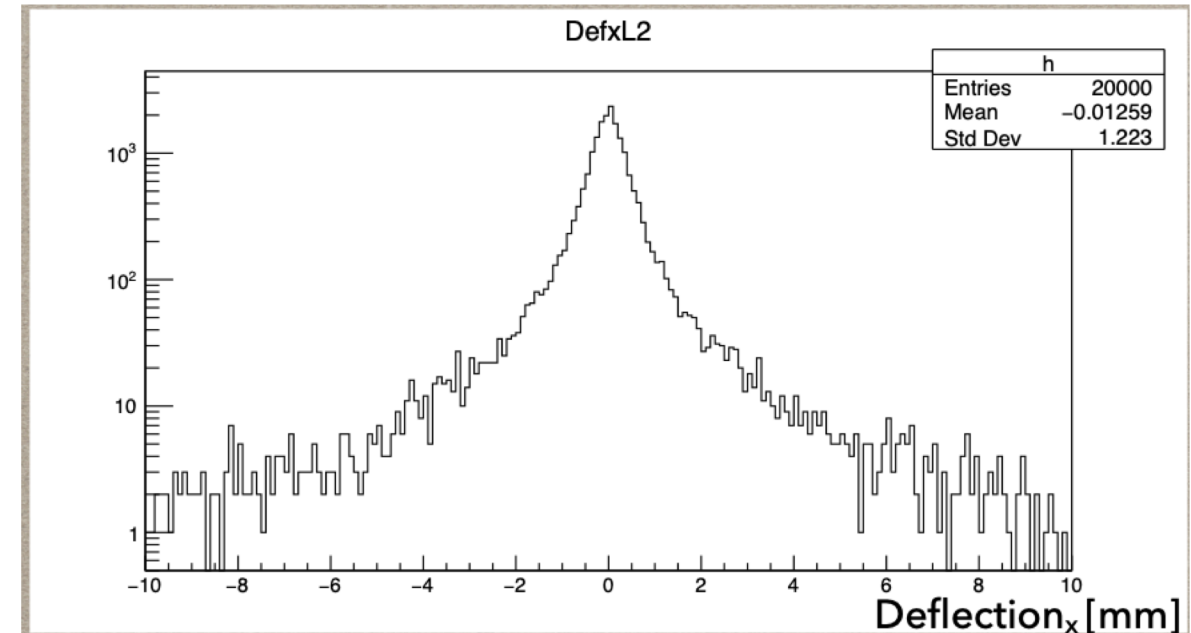
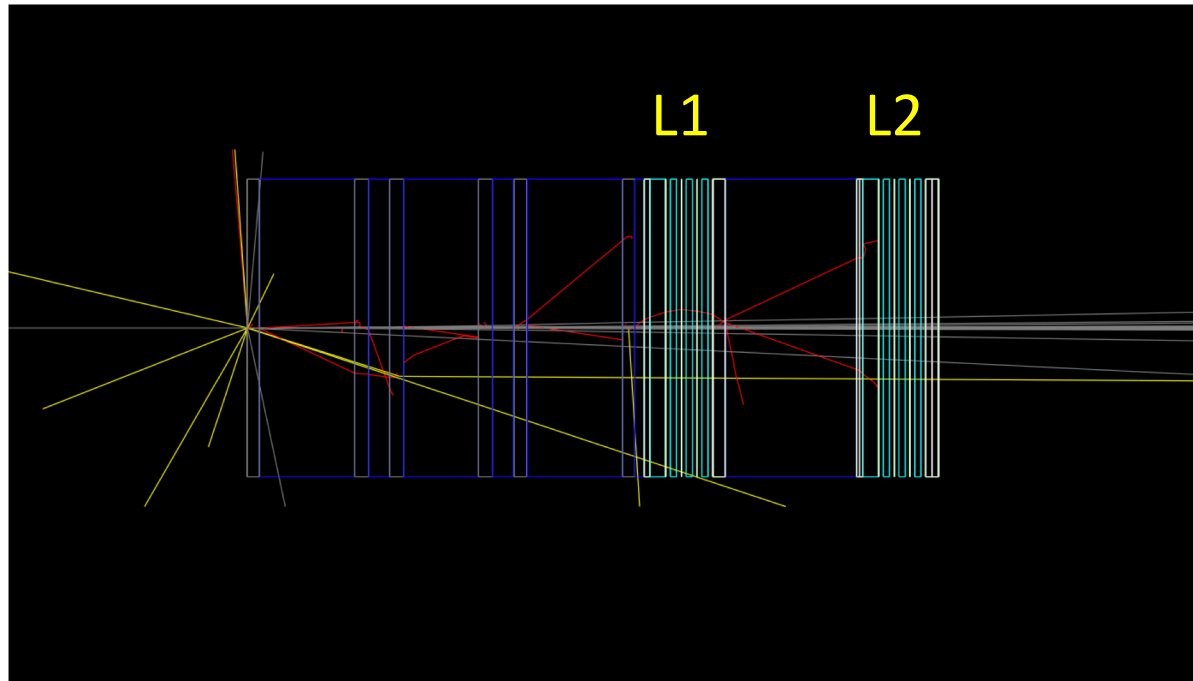
Simplified simulation of material effects in Geant4

Flat energy distribution of muons $[0 \rightarrow 5 \text{ GeV}]$ (must be improved)

Checked effects in resolution and in produced secondaries

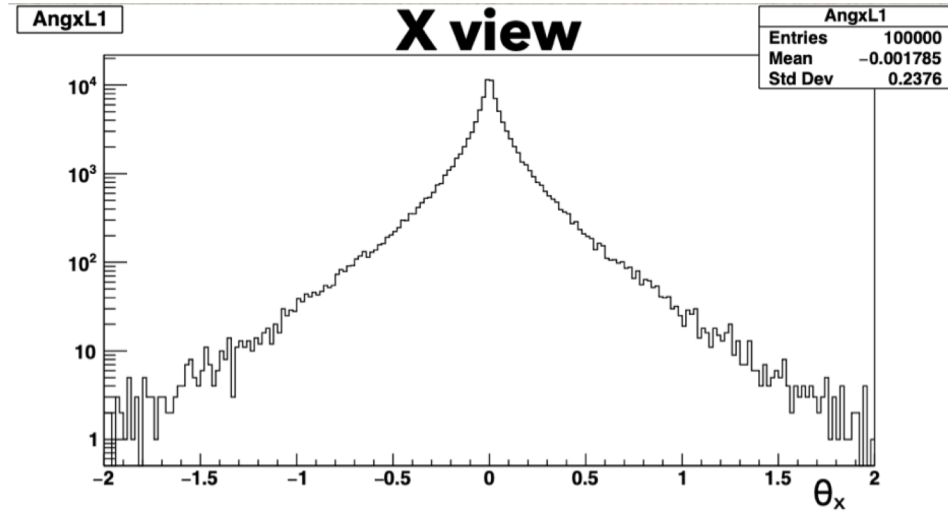
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the structure decreases
significantly the resolution!

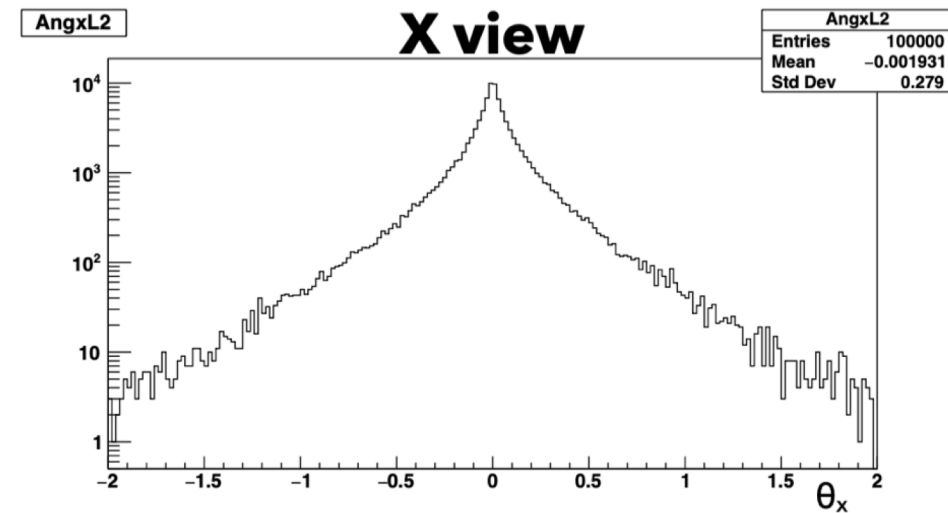




Effect of the supporting structure - NOW



$\sigma_{x,layer1}$ from FWHM = 0.41 mrad ($\sigma_{x,layer1} = 51 \mu\text{m}$)

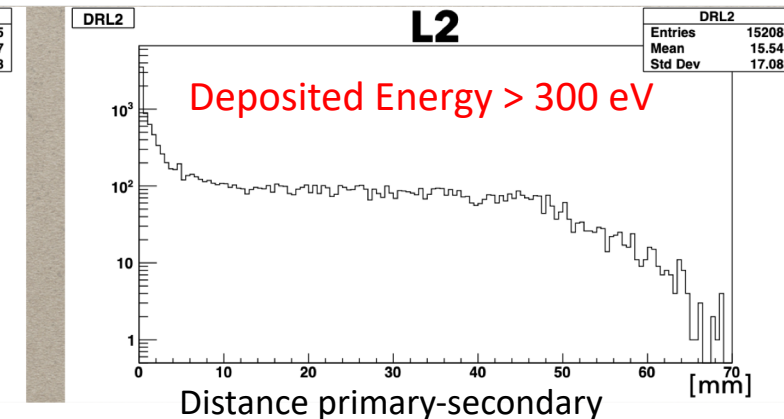
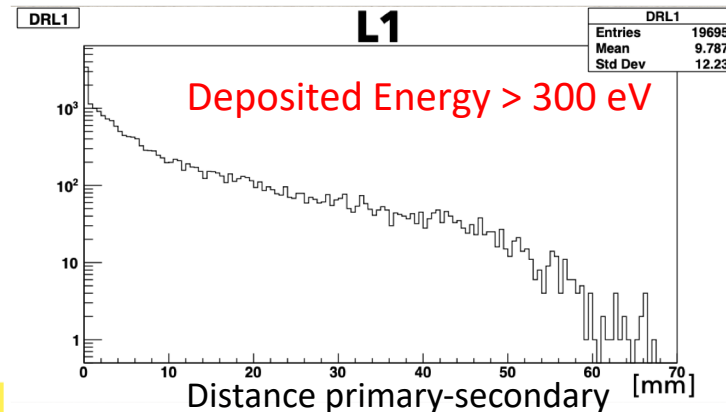


$\sigma_{x,layer2}$ from FWHM = 0.52 mrad ($\sigma_{x,layer2} = 102 \mu\text{m}$)

Realistic cosmic energy parametrization

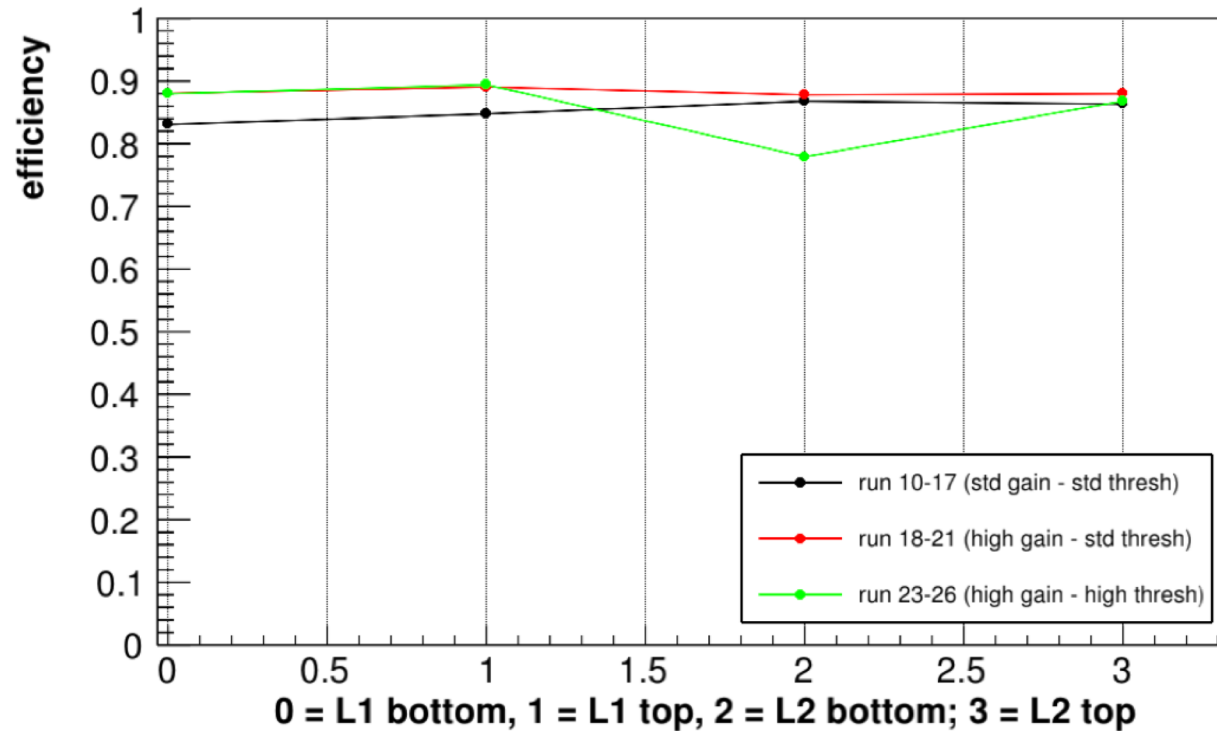
$$\frac{I(E)}{I_0} \propto (E_0 + E)^{-n} \left(1 + \frac{E}{\epsilon}\right)^{-1}$$

- Estimated resolution worsening around 100 μm (at least)
- Large number of secondaries emitted far from primary, which could induce fake clusters
- **Must be removed once in Beijing again**





Preliminary Efficiency



Good track selection

$$\chi_{xy} < 0.01 + \chi_{rz} < 1$$

→ Residual on test plane

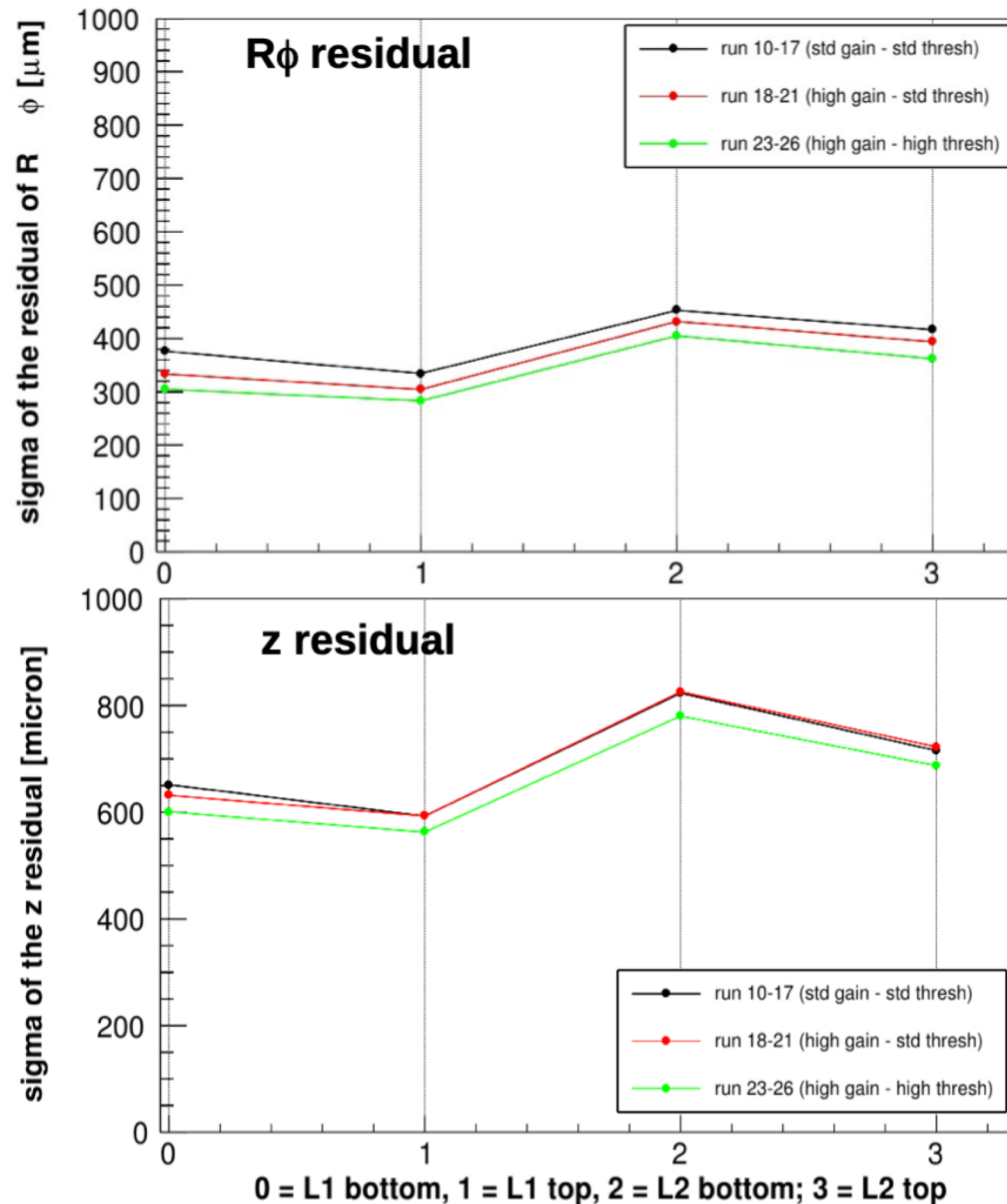
→ Efficiency

$$\epsilon = \frac{n^{\circ} \text{ of events in } N_{\text{sigma}}}{n^{\circ} \text{ of goodtracks}}$$

- Higher gain → slightly better efficiency (black vs red)
- These threshold values do not affect efficiency (green vs red)
- The drop in L2 bottom in the green line is due to FEB 34 (switched off),
- The difference in efficiency is minimum → no need to increase the gain



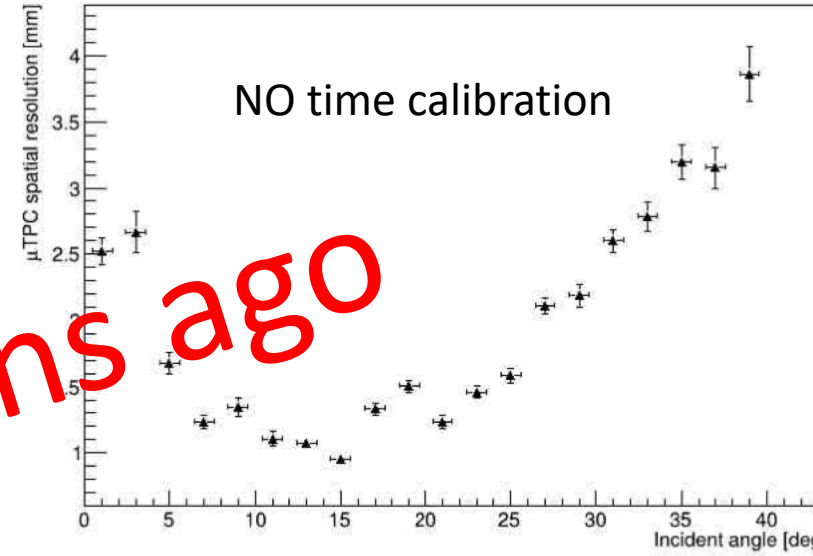
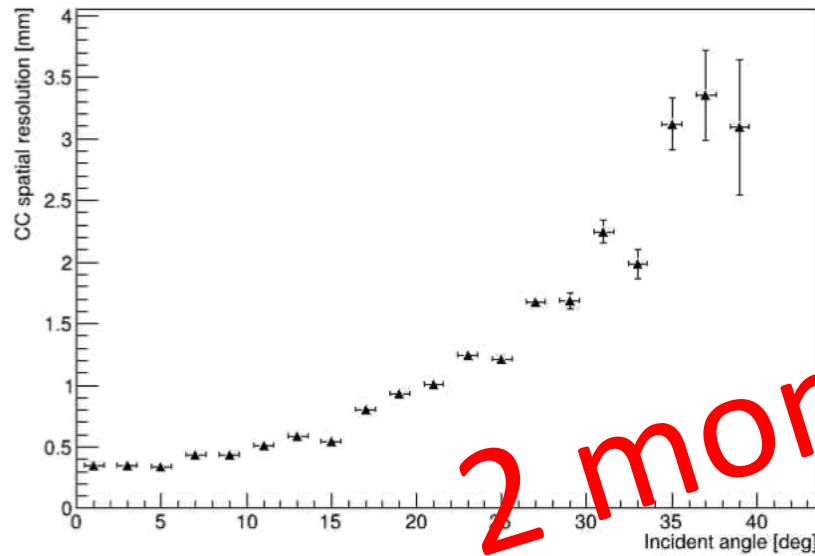
Preliminary Residual Widths - CC



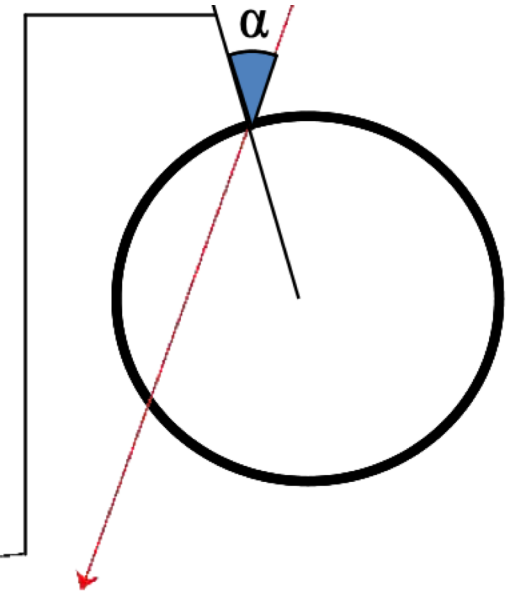
- The results are averaged on *all* the incident angles, also where CC is not performing well
- The residual width does not change much by changing the electrical settings
- Higher threshold \rightarrow slightly better (higher thresholds \rightarrow less noise hits)
- L1 (L2) top is slightly better than L1 (L2) bottom \rightarrow pole & secondaries effect?



Primary Resolution - μ TPC



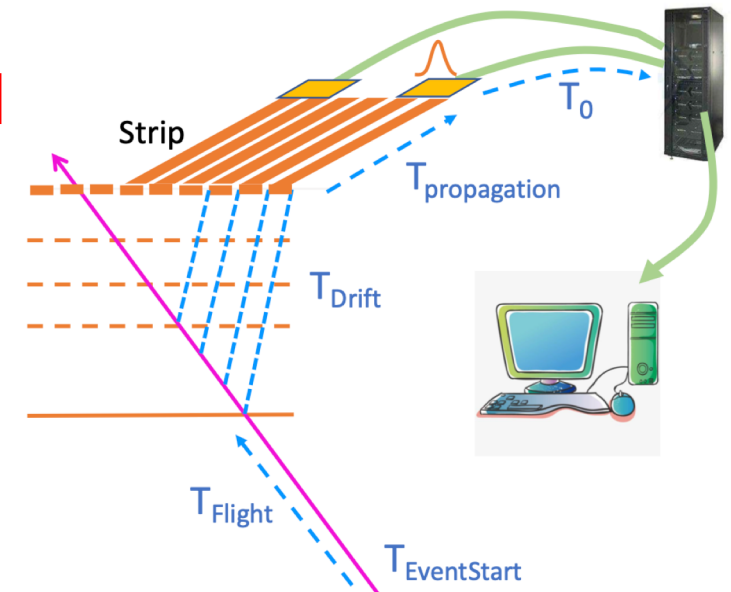
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- In μ TPC time calibration is essential to achieve good performances

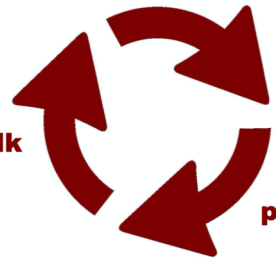
$$\text{TDC} = T_{\text{EventStart}} + T_{\text{Flight}} + T_{\text{Drift}} + T_{\text{Walk}} + T_{\text{propagation}} + T_{0\text{el}}$$

- Time calibration just started

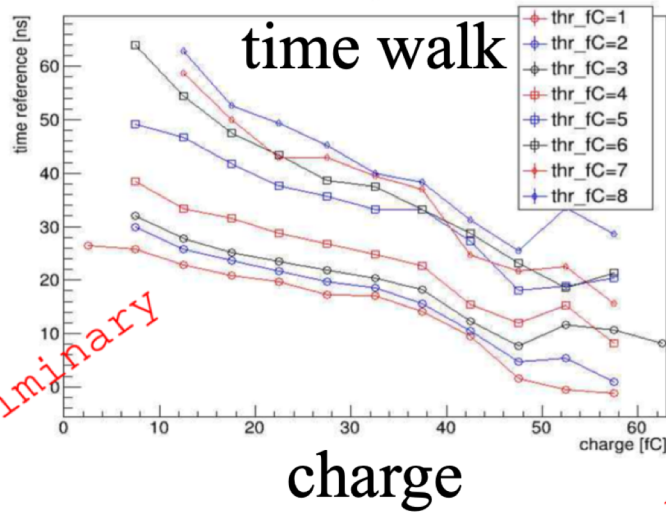


Time Calibration

Time reference
for each channel



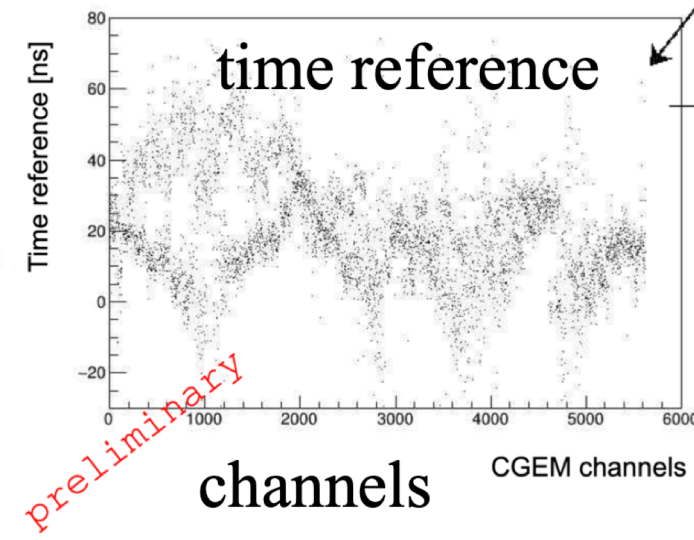
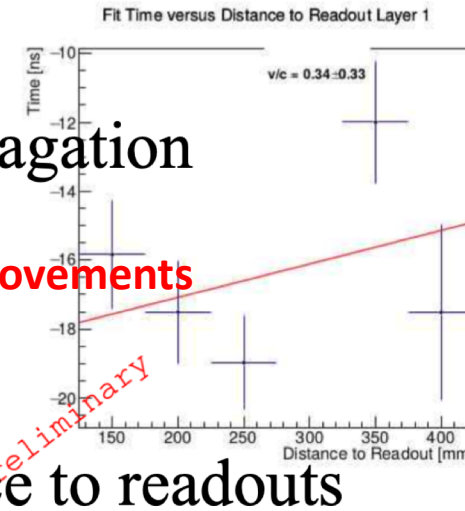
$$\text{TDC} = T_{\text{EventStart}} + T_{\text{Flight}} + T_{\text{Drift}} + T_{\text{Walk}} + T_{\text{propagation}} + T_{\text{Oel}}$$



one FEB of L1



all FEBs of L1



μ TPC Resolution can be estimated
only at the end of the whole time calibration procedure



31/07/2020

SOFTWARE CGEM. Misura delle prestazioni del CGEM-IT con run di cosmici utilizzando software ufficiale CGEMBOSS

Current status: **80%**

- Full characterization of Charge Centroid method done, estimated efficiency and resolution for different HV and noise values, and at different angles.
- μ TPC characterization ongoing, needed finalization of time calibration to estimate properly the performances



Conclusions



Several activities in the past two months

Global tracking code now available, released, under tests

Good single particle performances, benchmark channels must be studied

Analysis of cosmic ray data ongoing:

Estimated the effects of the support structure

Efficiency and resolution values stable under different HV and threshold ,

Time calibration ongoing, in good shape