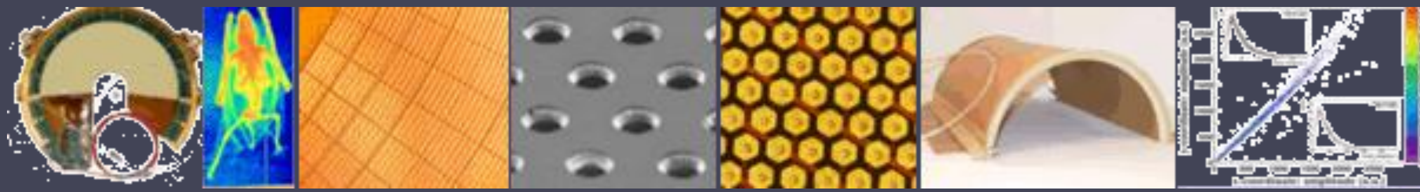


Studying the efficiency and the space resolution of resistive strips MicroMegas

Marco Villa – CERN

RD51 mini week – working group 2

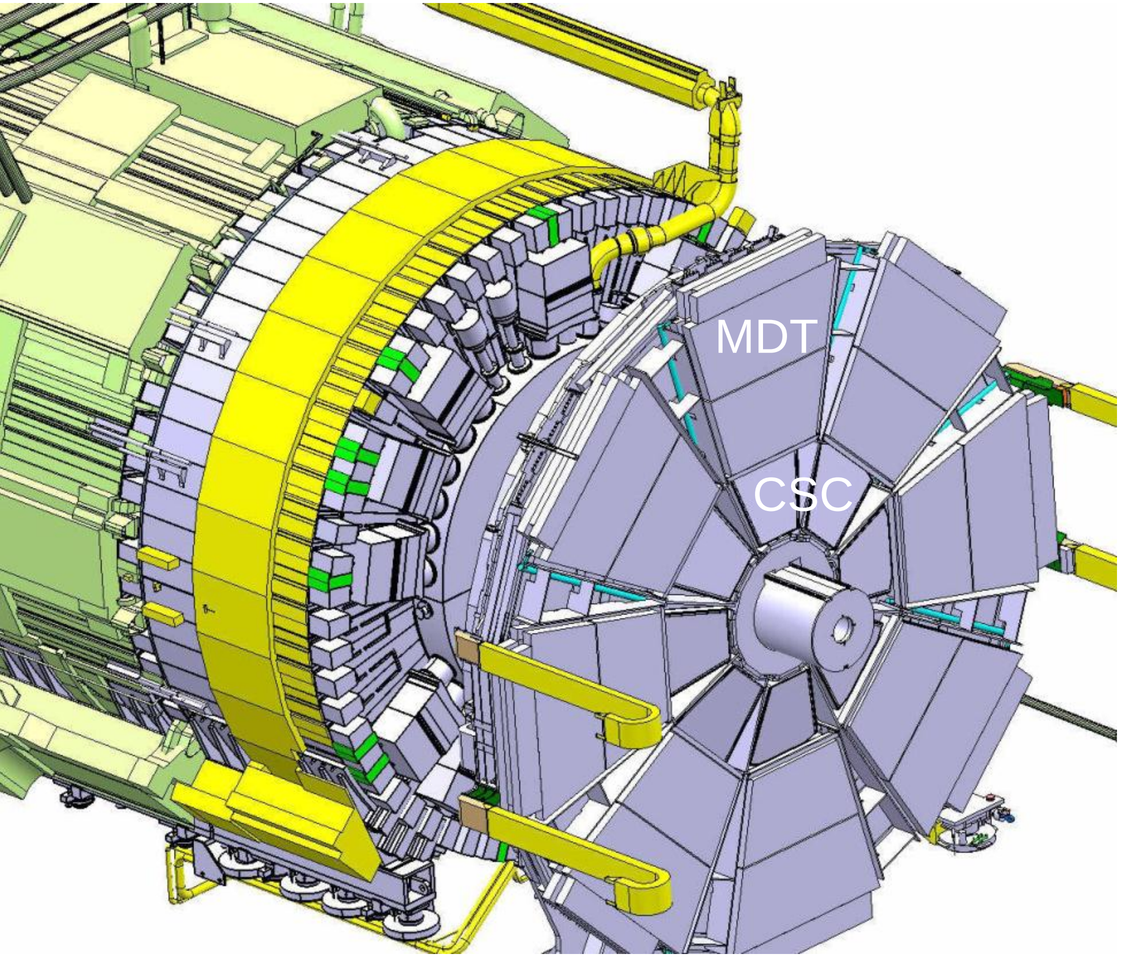
Monday, 21st November 2011

CERN, Geneva

Outline

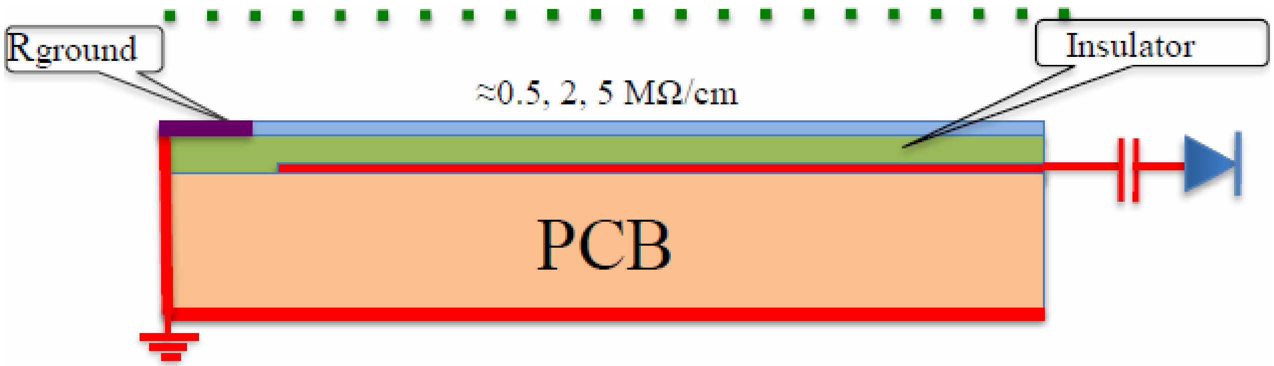
- Introduction
- Data analysis
  - Charge clustering & bad channels correction
  - Center of gravity & impact point estimation
  - Detector rotation compensation
- Efficiency
- Space resolution
- Conclusions & outlooks

What is MAMMA?



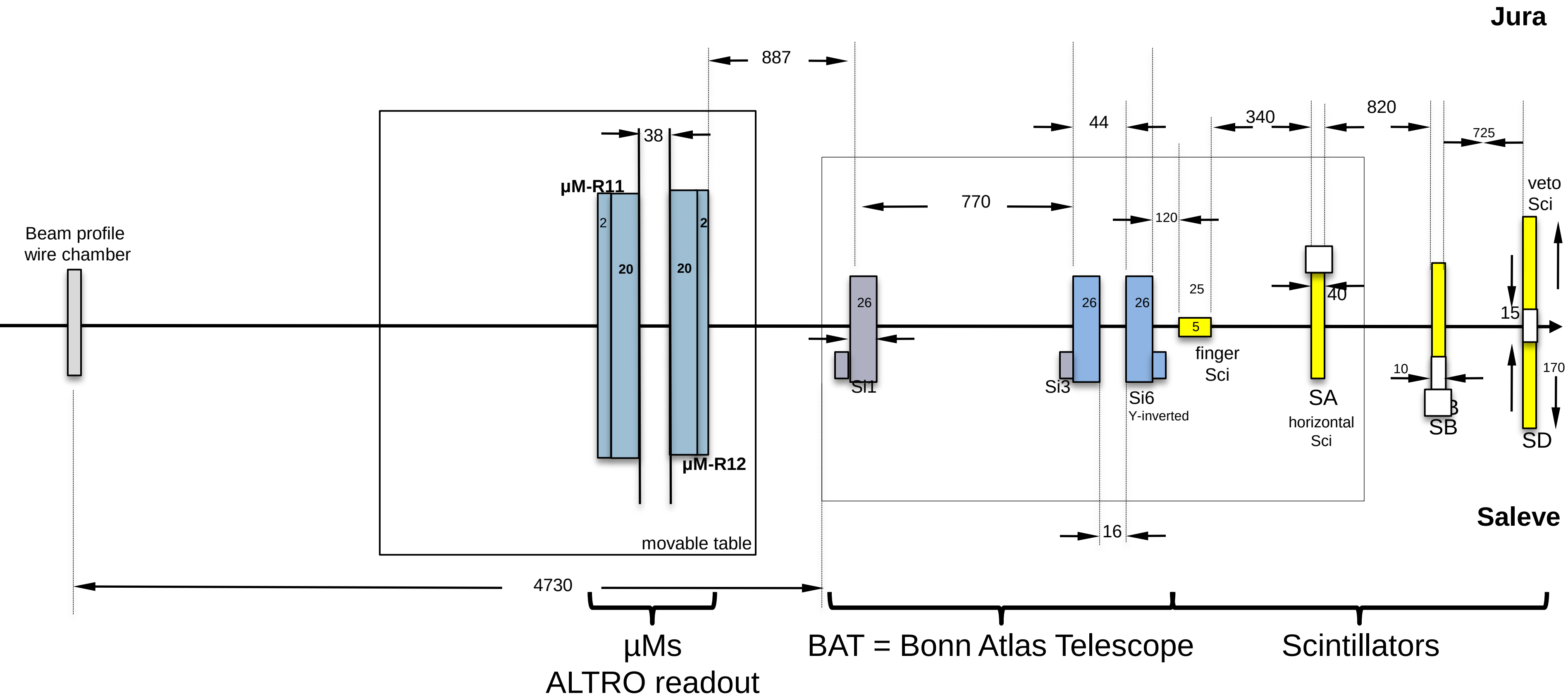
- MAMMA = Muon Atlas MicroMegas Activity
- Upgrade for the ATLAS forward muon system using *MicroMegas* technology
- Small wheels are currently *CSCs* (1.2 x 1.2 m²) and *MDTs* (2.4 x 1.2 m²)
- *Large area* coverage, *hadron background*

Introducing resistive strips μMs



- *Why?* To *neutralize sparks* in environments with heavily ionizing radiation and hadron background
- *How?* The readout plane (1D strips) is covered with an insulating layer and topped with grounded *resistive strips* matching the readout pattern
- Strip resistivity ~ MΩ/cm
- Ground resistor ~ 10 MΩ
- Signals read out through *capacitive coupling* between resistive and readout strips

The test beam setup – July 2010



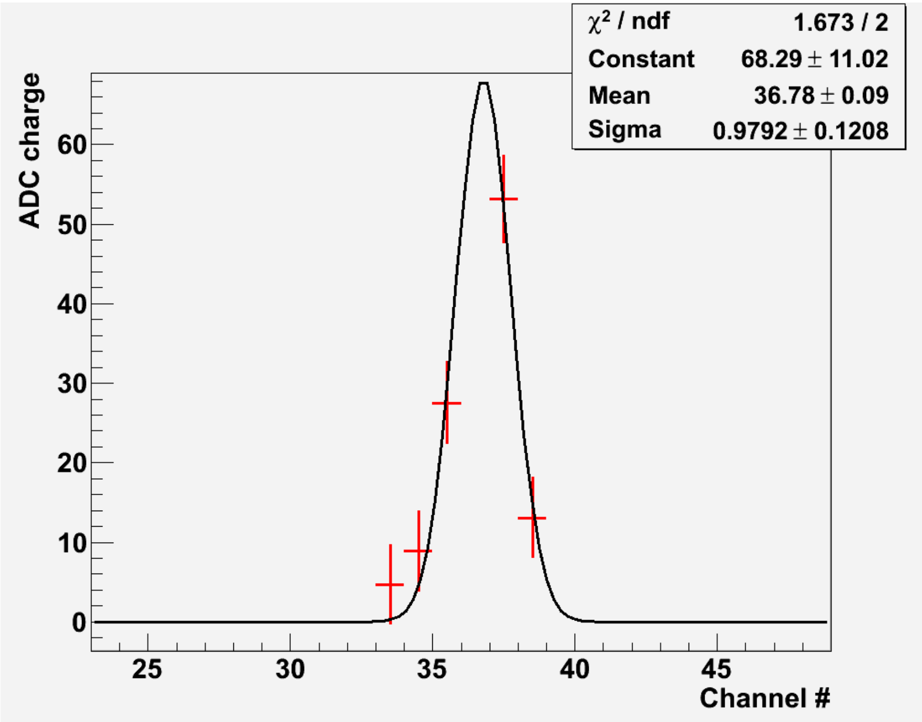
120 GeV π's & μ's – H6 beam line – CERN North Area

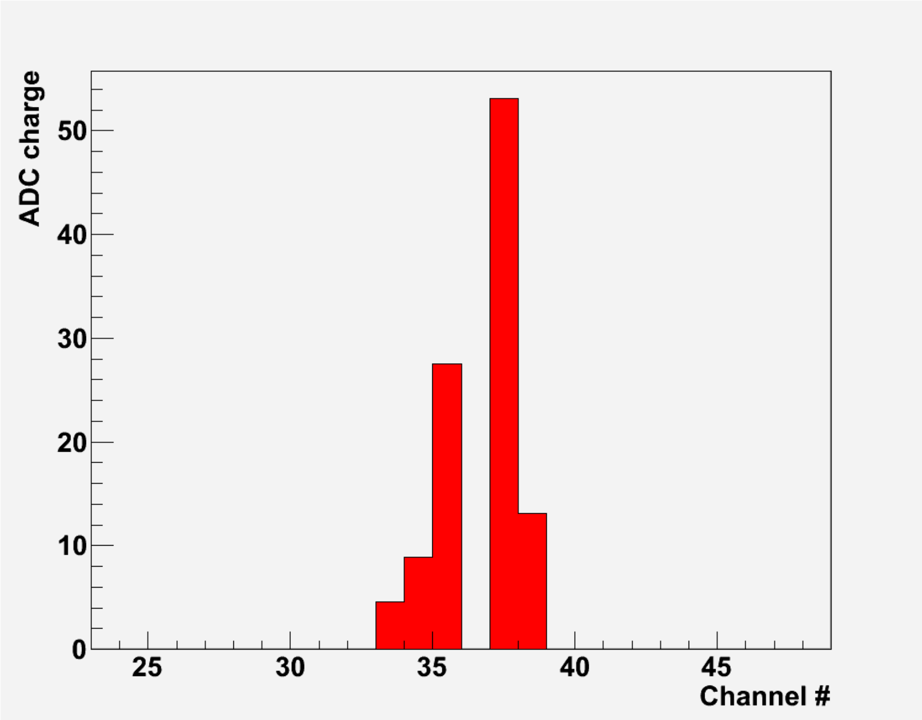
Through the data analysis chain

- µM/BAT raw data to ROOT file conversion
- Data streams *synchronization*
- Beam *tracks reconstruction* (BAT)
- µM hi/low gain channel selection
- Charge *clustering* & bad channels correction
- Center of gravity & *impact point* estimation
- Detector *rotation* compensation
- Event selection
- Efficiency and space resolution studies

Building clusters

- Many *different* run conditions
- *Totally & partially dead* channels
  → need for a *flexible* algorithm





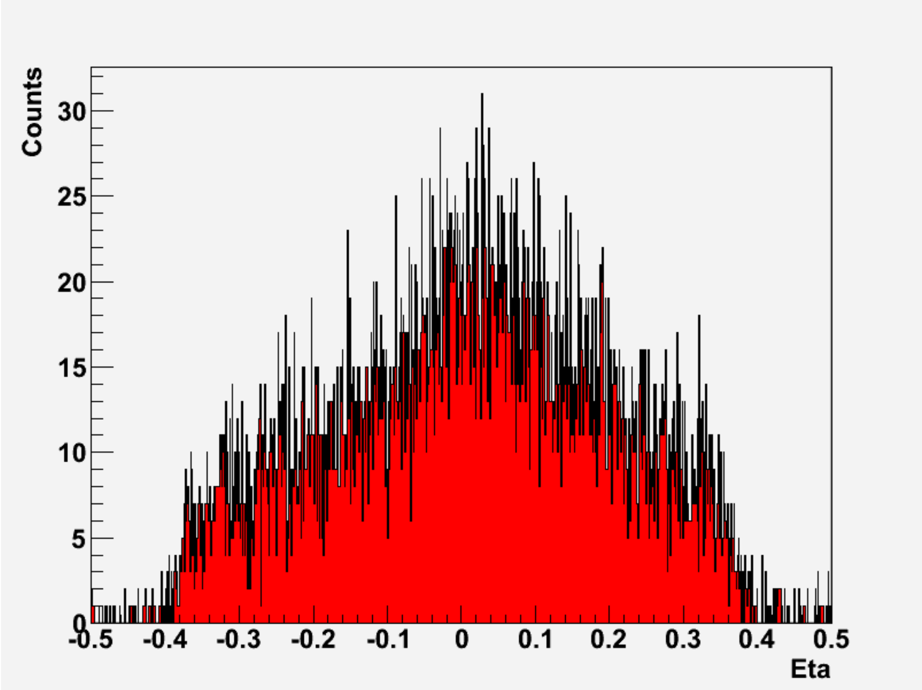
- *Agglomerative hierarchical clustering* (dynamically adaptive)
- 0–step clusters generated from *neighboring firing strips*
- Super–clusters built through χ^2–validated iterative *cluster merging*
- Bad channels *recovery*

Estimating the impact point

- Impact point ε = symmetry point of the *analog* Q–distrib.
- Center of gravity η_N = symmetry point of the *discretized* Q–distrib.

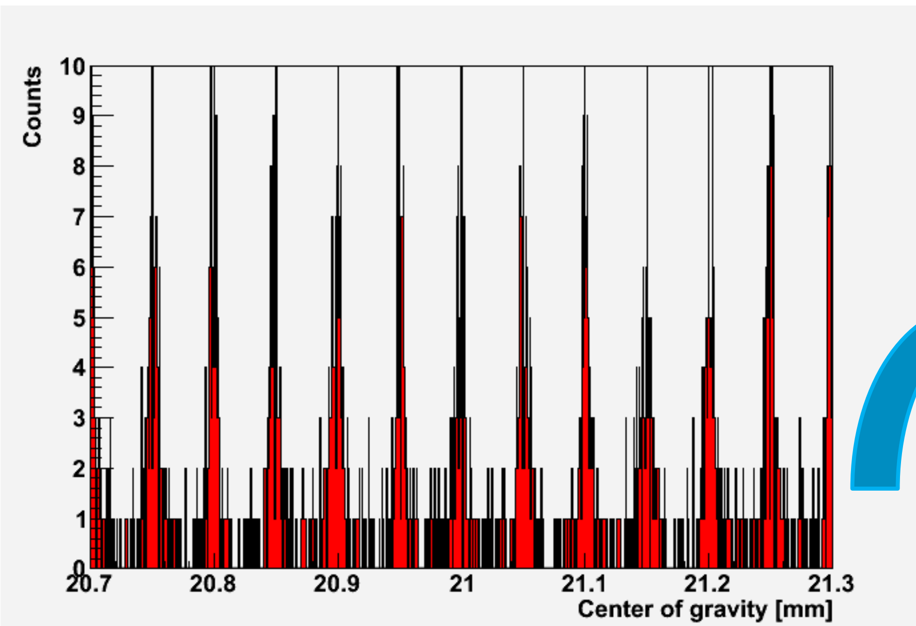
$$\eta_N = \frac{\sum_{i=1}^{N} x_i w_i}{\sum_{i=1}^{N} w_i}$$

- *Discretization* process due to segmented readout destroys the analog Q–distrib. symmetry, introducing a *systematic error*
- $\eta_N \neq \varepsilon$
- ε can be *reconstructed* from η_N

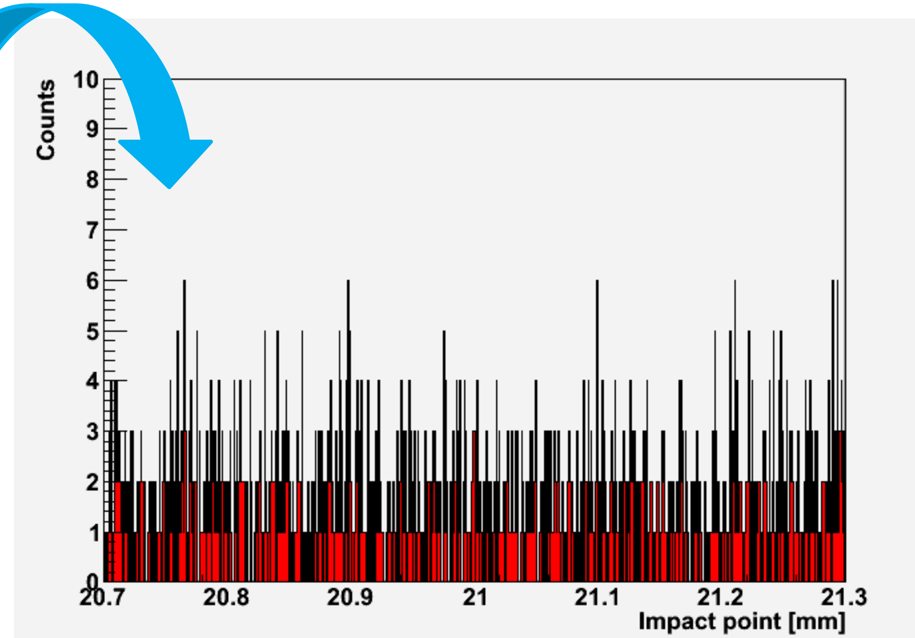


$$P(\eta_N) = \frac{d\varepsilon}{d\eta_N} = \frac{dH(\eta_N)}{d\eta_N} \xrightarrow{\frac{d\varepsilon}{dx}=k} \varepsilon = \varepsilon(\eta_N 0) + \int_{\eta_N 0}^{\eta_N} \frac{dH(\eta_N')}{d\eta_N'} d\eta_N'$$

η correction: before & after

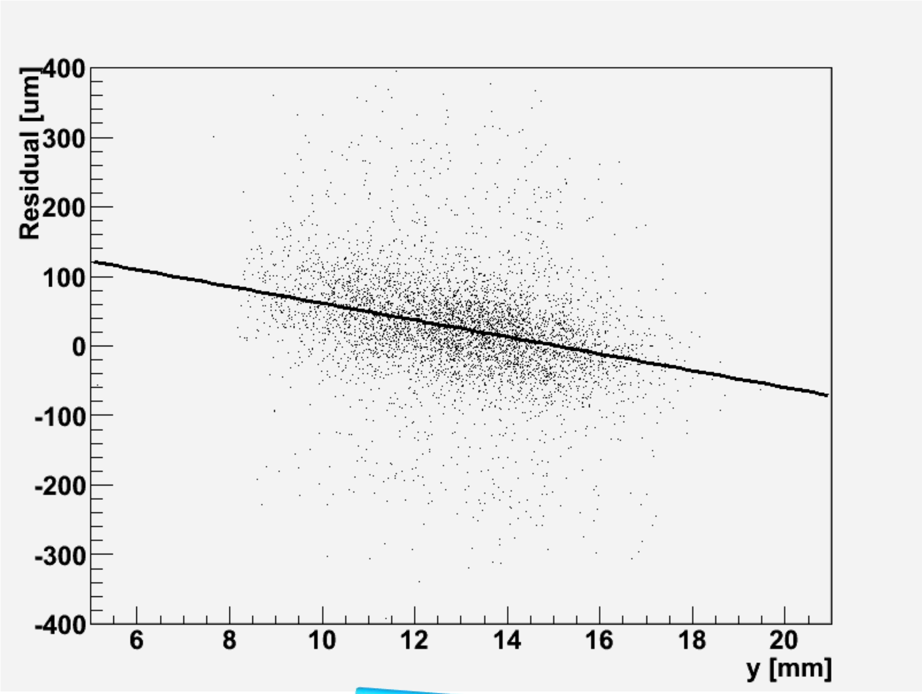


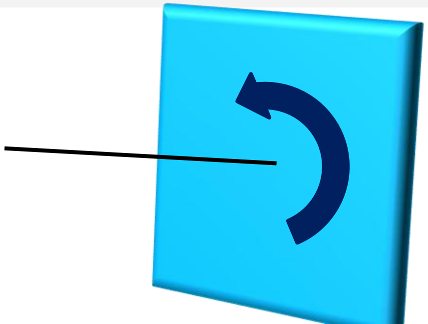
- Cluster *center of gravity (η_2)* in BAT1 strongly peaks around strips position (strip pitch 50 µm)



- Cluster *impact point (ε)* is uniformly distributed after applying the η correction algorithm

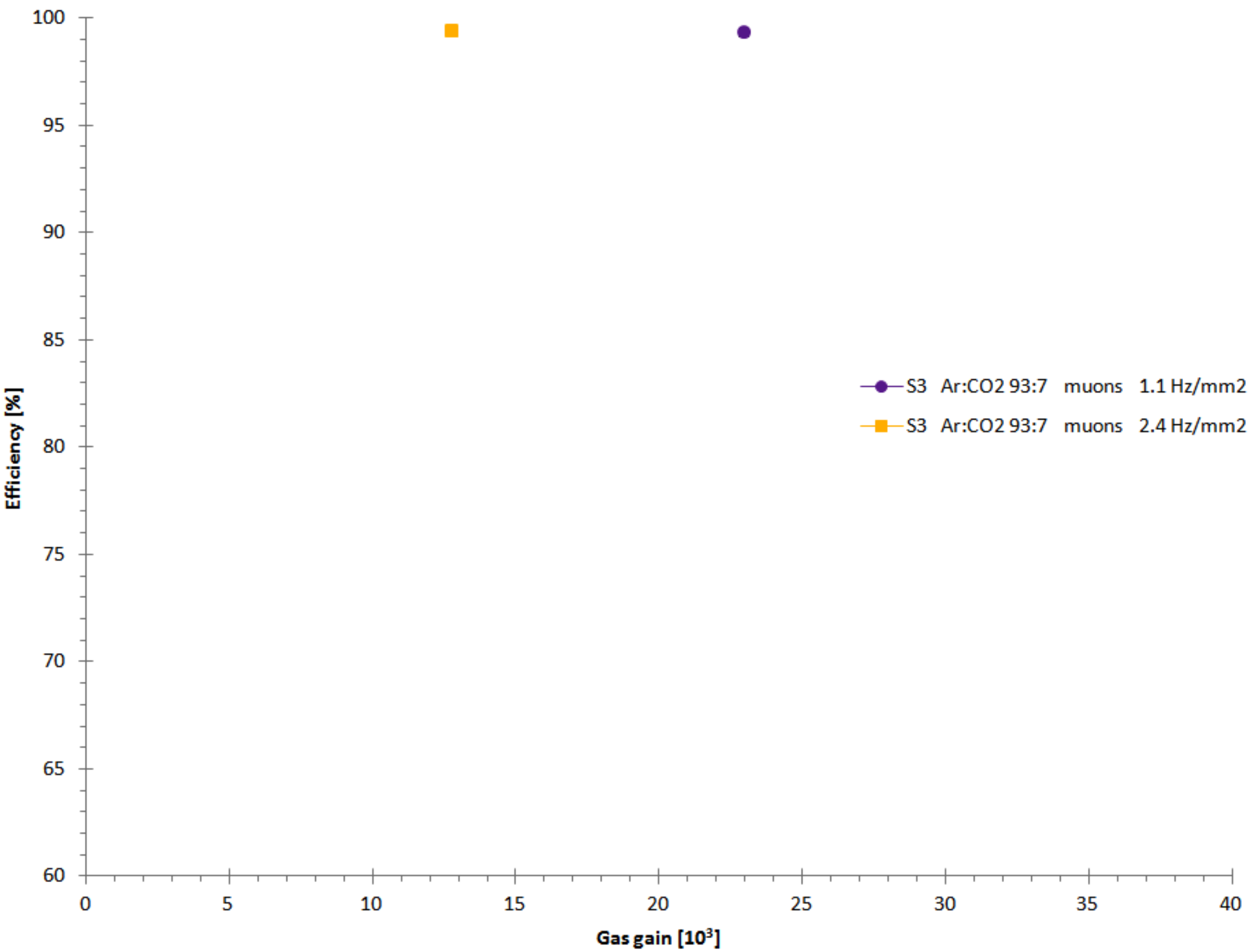
Correcting for the μM rotation





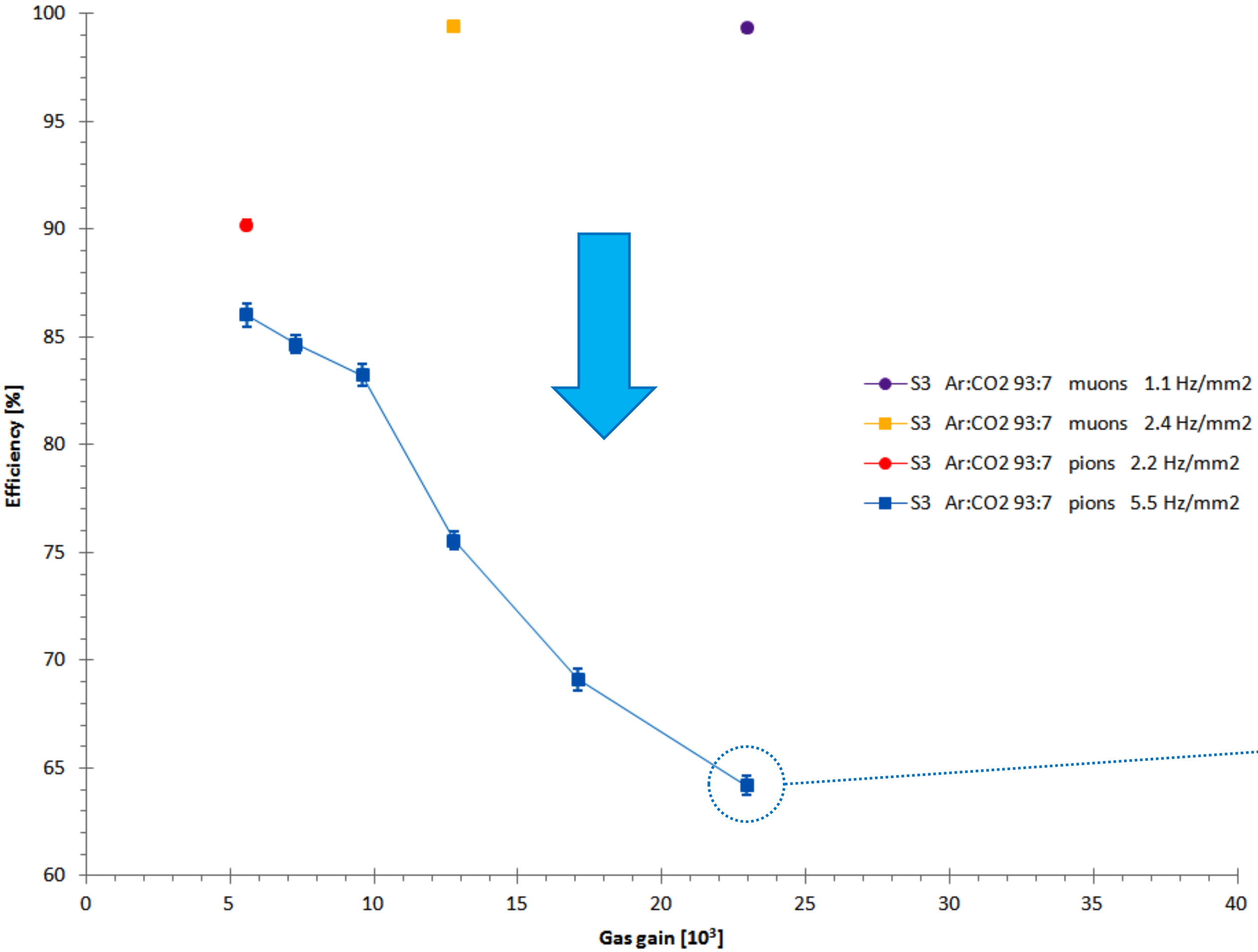
- μM rotation *around beam axis*
- *Residual distribution* deviates from gaussian shape (flat top)
- *Space resolution* is worsened
- μM rotation can be *reduced* by careful *alignment*, but can't be completely removed
- Easy to *correct offline* with a *linear regression* on the residual vs. y–coordinate scatter plot
- Rotation correction gives *μM alignment* for free

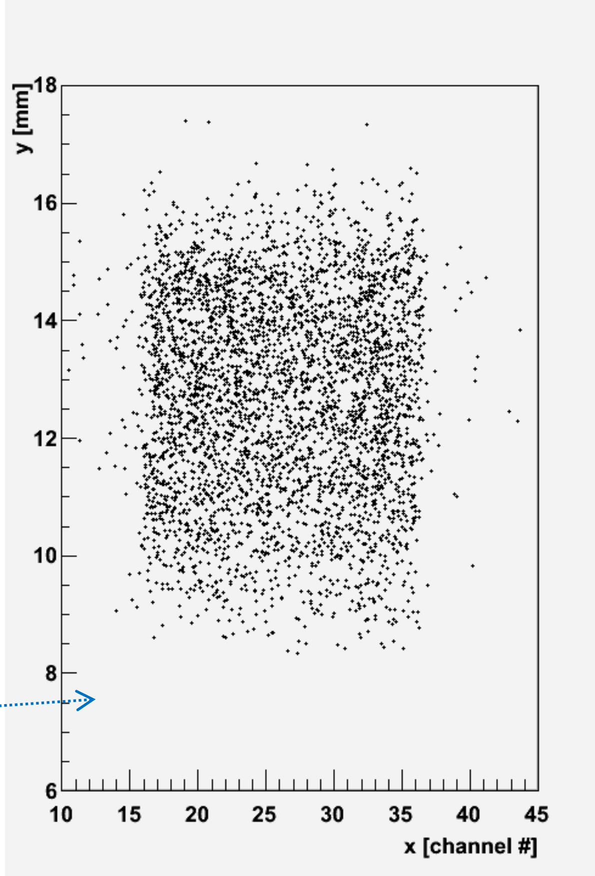
A non-resistive μM in a μ's beam...



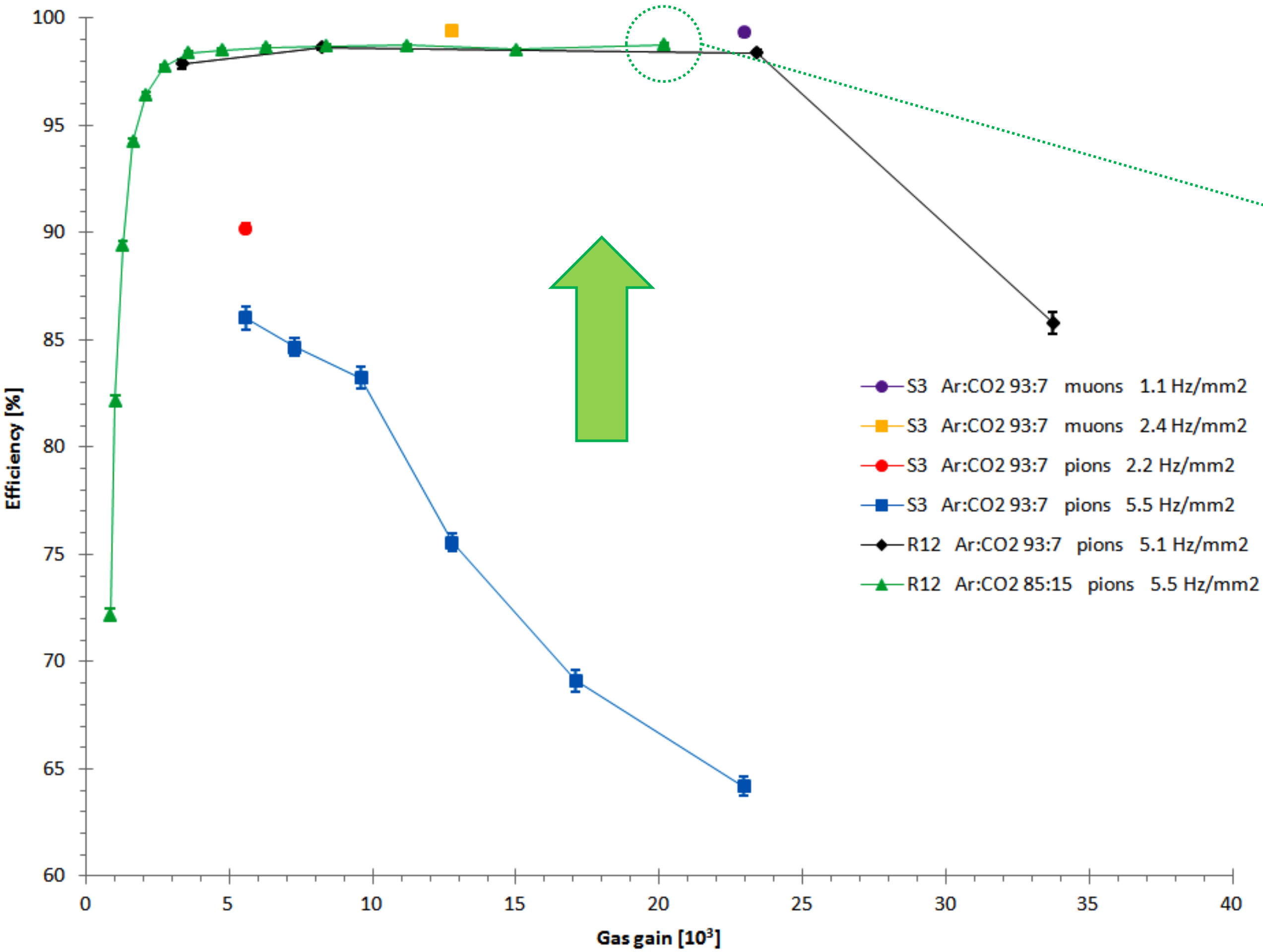
- Reconstructed *tracks* are *extrapolated* to the μM plane
- *Closest cluster* in the μM is *found*
- *δ–rays* are *excluded* by cutting on the cluster size
- Efficiency *errors* are computed assuming *binomial* hypothesis

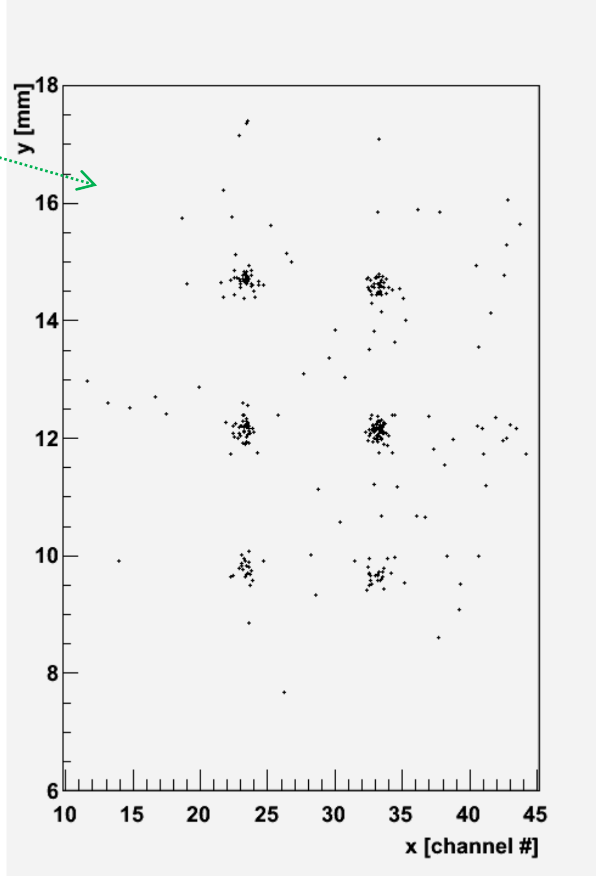
...and in a π's beam



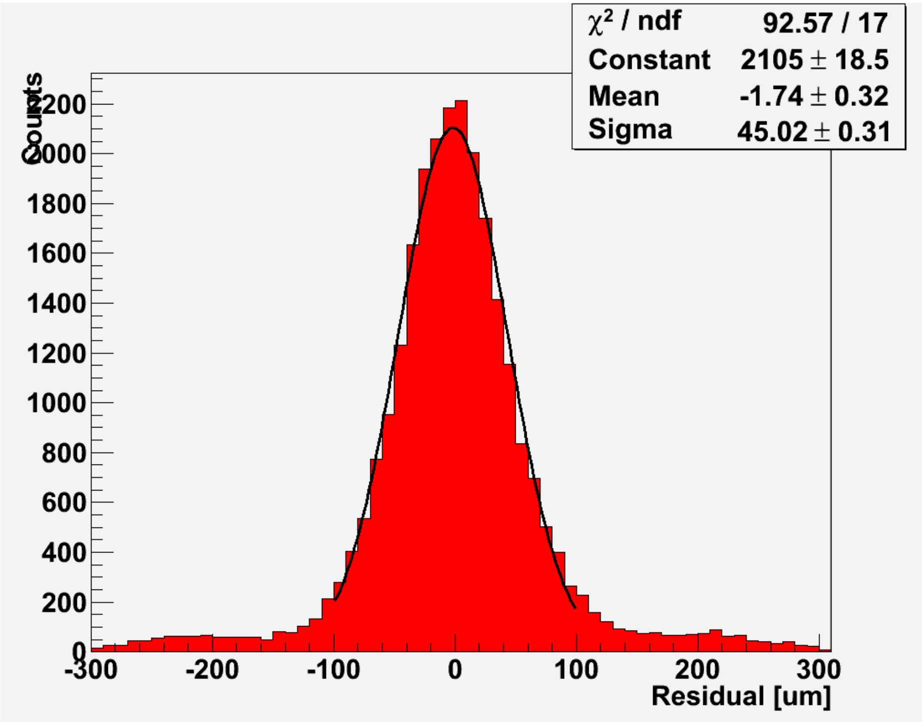


Resistive µMs: improved efficiency





Extracting the space resolution

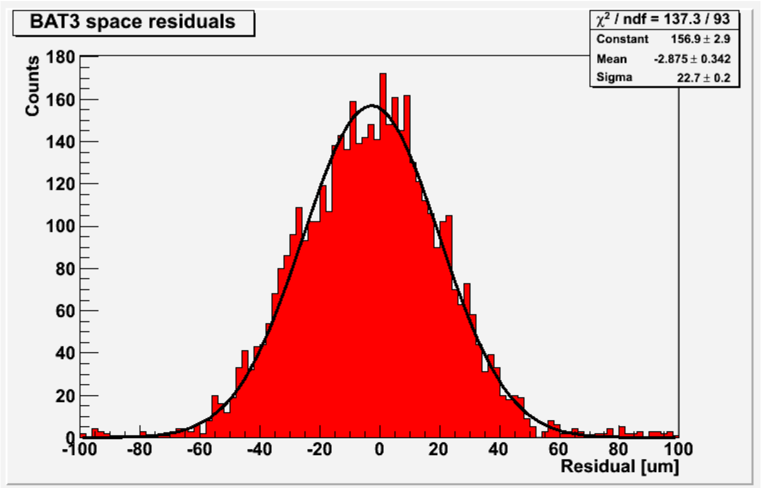


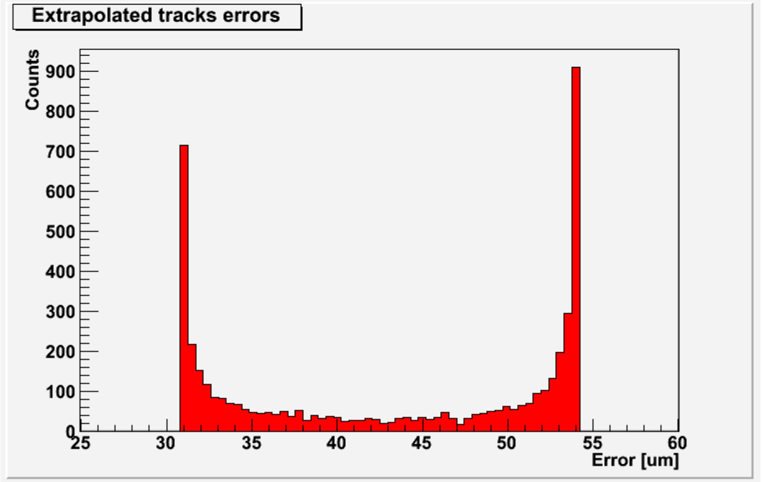
- Space residual ≡ difference between *μM impact point* and *extrapolated reconstructed track*
- The space residual distribution width is the *convolution* of:
  - Intrinsic μM space resolution
  - Multiple scattering in materials
  - Track reconstruction uncertainty
- *Independent* contributions
- Coulomb component of *multiple scattering* is well described by:

$$\theta_{plane}^{rms} = \frac{13.6MeV}{\beta cp} z \sqrt{\frac{x}{X_0}} \left(1 + 0.038 \ln \frac{x}{X_0}\right)$$

Evaluating the reconstruction error

- Space residual ≡ difference between *BAT3 impact point* and *interpolation of BAT1 and BAT6*
- The space residual distribution width is the *convolution* of:
  - Intrinsic BAT3 space resolution
  - Track reconstruction uncertainty
- *Intrinsic resolution* of each BAT module is $\sigma/\sqrt{2}$
- Error on *extrapolated hit position* on µM is computed for each reconstructed track

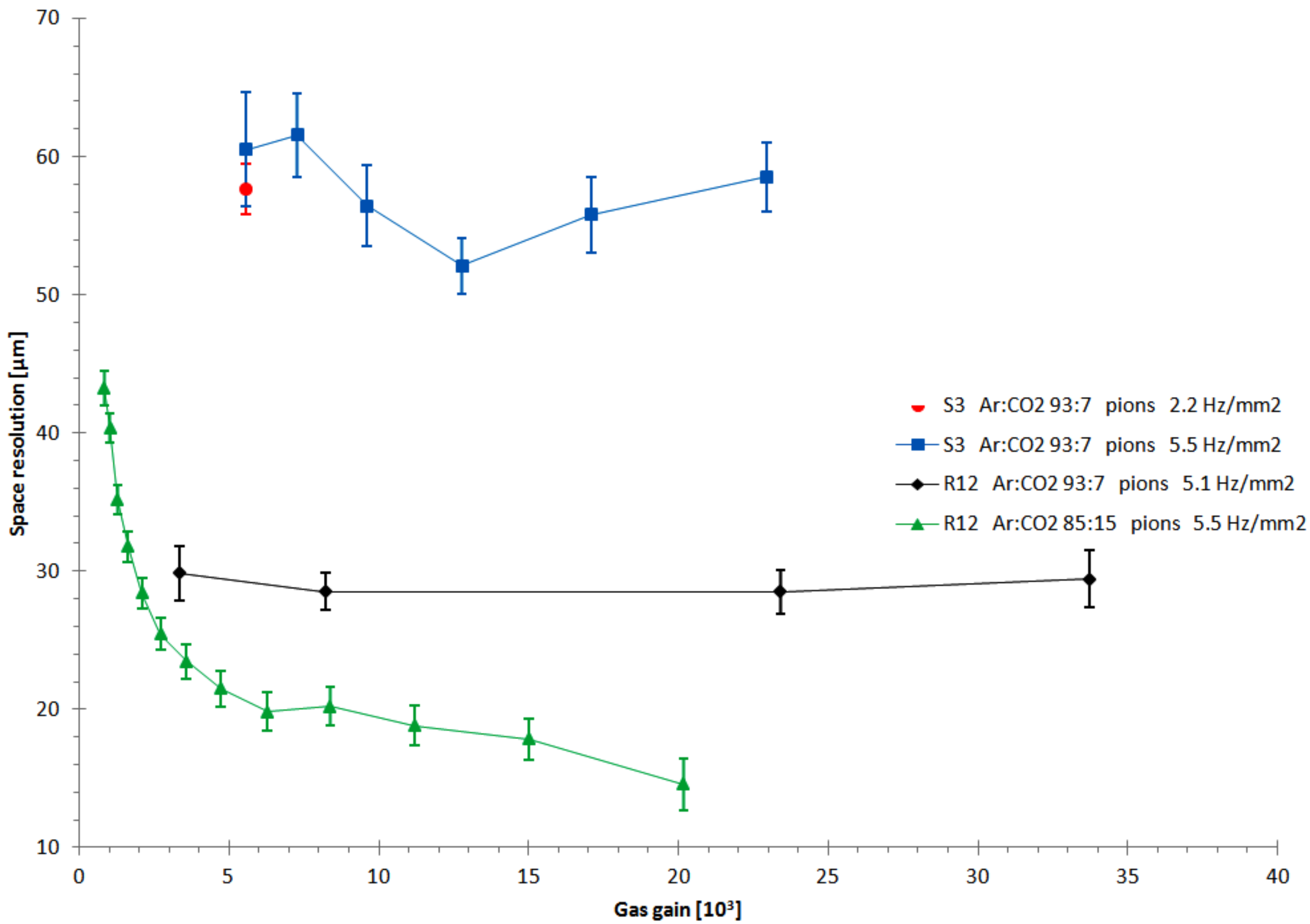




Resolution uncertainty: a summary

Error source	Contribution to total space resolution
BAT1 multiple scattering	$\sigma_{BAT1} = (4.5 \pm 0.5)\ \mu m$
BAT3 multiple scattering	$\sigma_{BAT3} = (8.4 \pm 0.9)\ \mu m$
BAT6 multiple scattering	$\sigma_{BAT6} = (8.6 \pm 0.9)\ \mu m$
Air multiple scattering	$\sigma_{AIR} = (6.8 \pm 0.7)\ \mu m$
Track reconstruction	$\sigma_{REC} = (40.1 \pm 0.5)\ \mu m$
Total	$\boldsymbol{\sigma_{TOT} = (42.6 \pm 0.5)\ \mu m}$

Resistive µMs: improved resolution



Conclusions & outlooks

- Resistive strips MicroMegas show *high MIP detection efficiency* (> 98 %) over a wide gas gain window even in hadron beams
- *Space resolution is much improved* with respect to non–resistive MicroMegas
- Manufacturing technique compatible with bulk processing and *scalable up to square meter size*
- Door is open to new exciting applications…

Thank you!