The HADES Π beam line: an update

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16/4/13

Why new calculations ?

- **Tilt angle of the dipole was misinterpreted (and hidden somewhere in the Mirco file)**
- **Visit at GSI on 6-7 march triggered the discovery**
- **The real tilt angle of the dipoles is 22.75 ° (NOT 3.08°)**

(7.5° deviation in bending plane × sin(22.75°) = 2.8 °, necessary to lift the beam line at the HADES level, +0.7 m)

in dipoles, $B_x \approx 0.4 \times B_y$

Price to pay: horizontal and vertical are more intimately coupled, in particular chromatic terms in both x and y are present

How to extract δ (and θ_i, φ_i and y_i): I ?

Before, H and V were almost decoupled

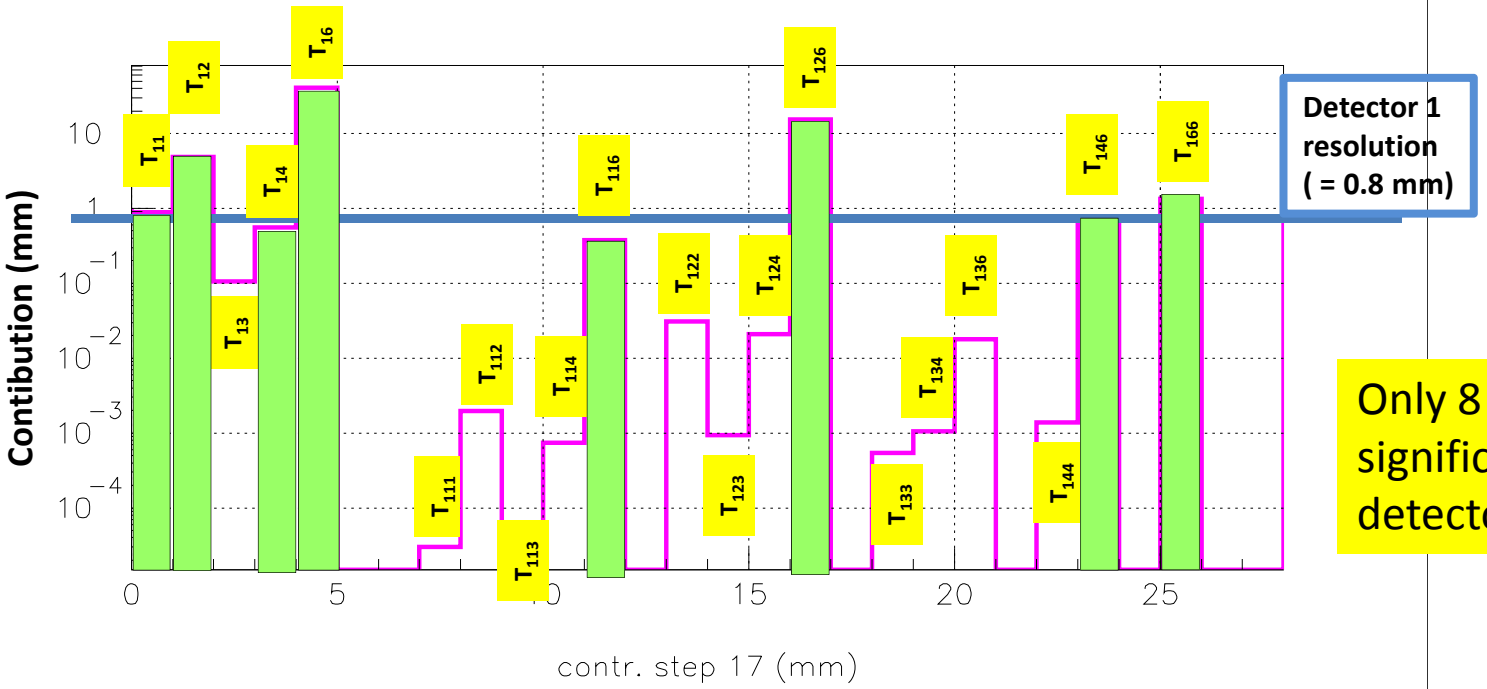
$$X = \cancel{T_{11} x_i} + T_{12}\theta_i + T_{16}\delta + T_{126}\theta_i\delta + T_{166}\delta^2$$

No coupling to φ or y_i
T_{11} x_i 'neglected'
Separation of θ_i then 3rd order equation in δ

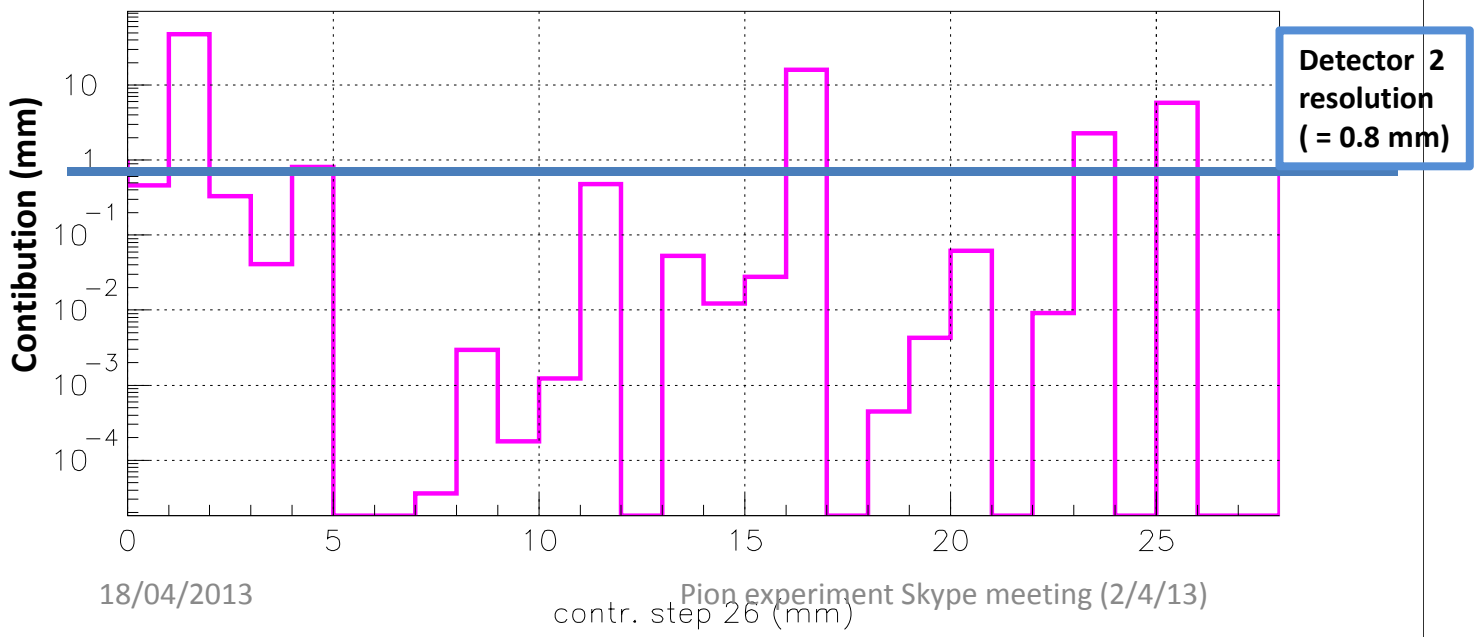
$$Y = T_{33} y_i + T_{34}\varphi_i + T_{36}\delta$$

Linear system
2 equations
2 unknown y_i and φ_i

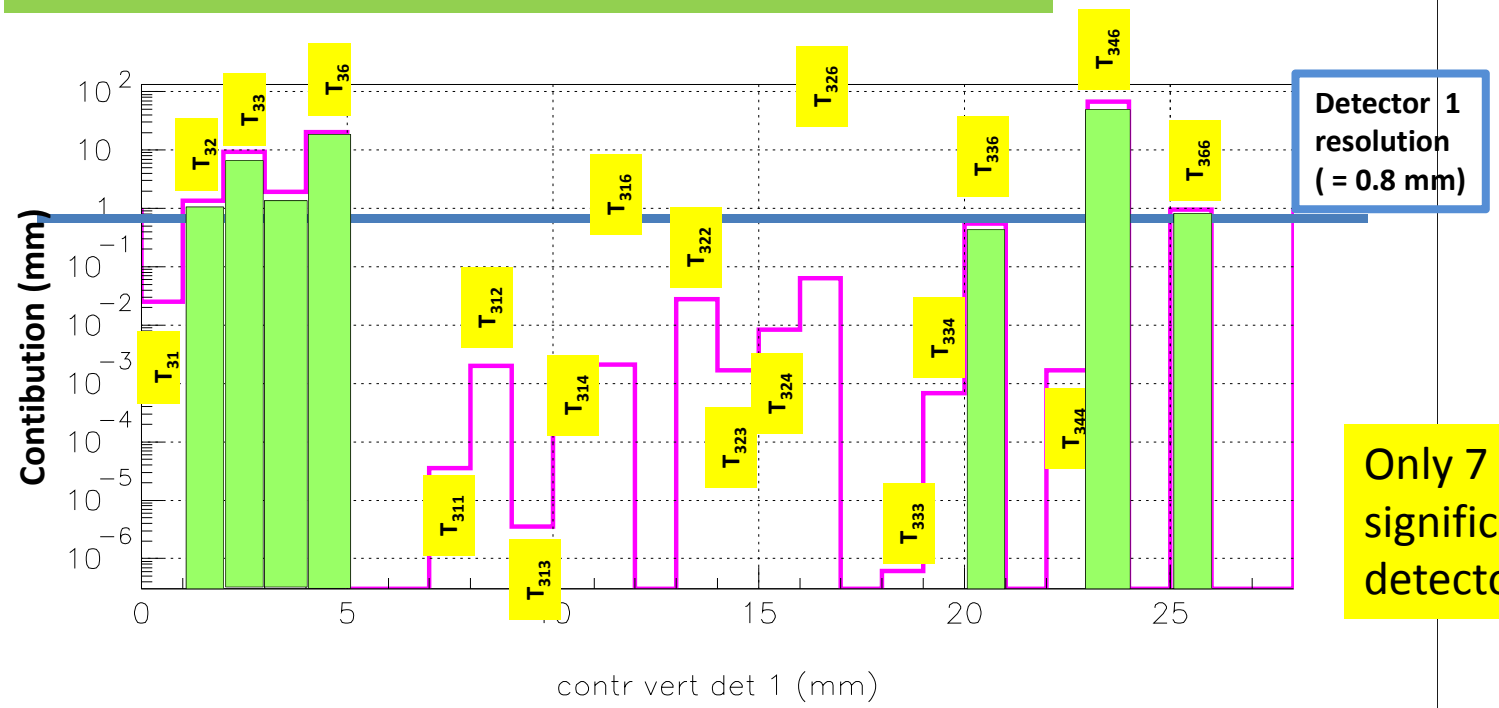
Individual contributions in X



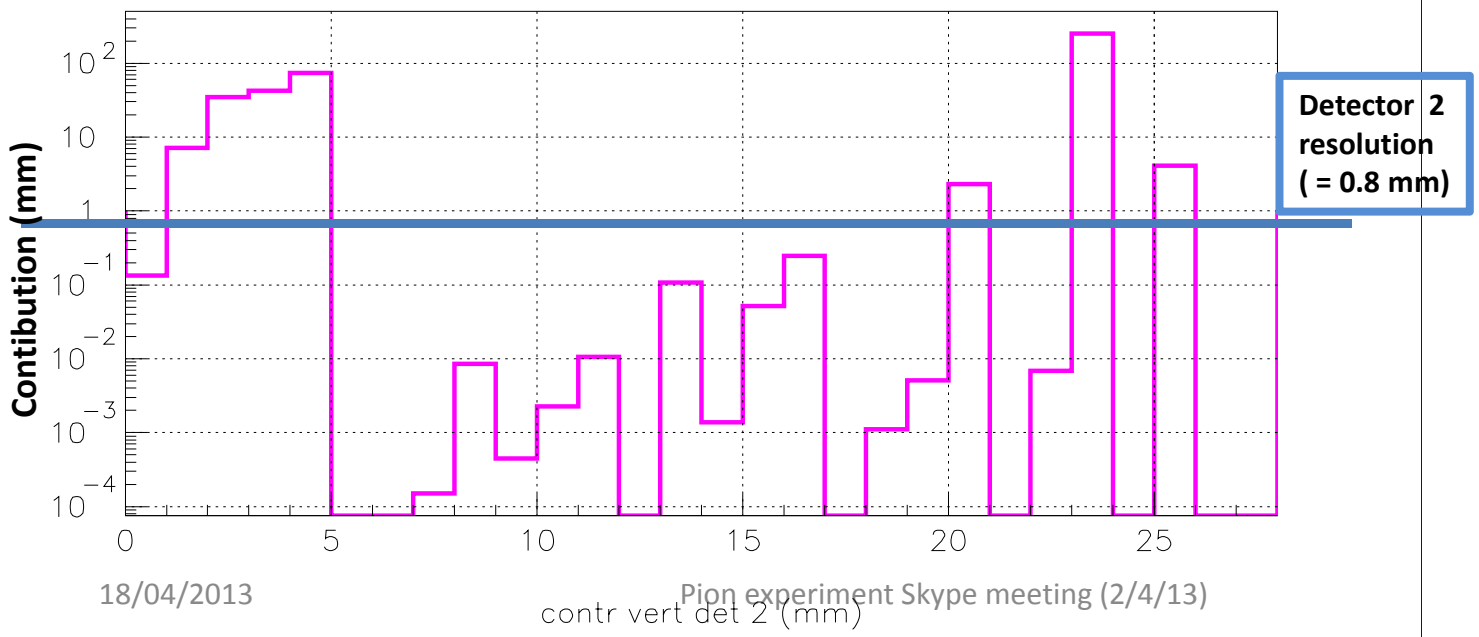
Only 8 terms contribute significantly : i.e. > 0.5 × detector resolution)



Individual contributions in Y



Only 7 terms contribute significantly : i.e. > 0.5 × detector resolution)



How to extract δ (and θ_i, φ_i and y_i): II ?

Now, H and V are strongly coupled + chromatic terms in vertical

2 equations (one measured X position at detector 1, another one at detector 2) with 8 terms

Coupling to φ

HV coupling

Chromatic 2nd HV coupling

$$X = \cancel{T_{11} x_i} + T_{12}\theta_i + T_{14}\varphi_i + T_{16}\delta + \cancel{T_{116} x_i}\delta + T_{126}\theta_i\delta + T_{146}\varphi_i\delta + T_{166}\delta^2$$

$$Y = T_{33} y_i + T_{34}\varphi_i + T_{36}\delta + T_{32}\theta_i + T_{336} y_i\delta + T_{346}\varphi_i\delta + T_{366}\delta^2$$

Chromatic 1st order

HV coupling

Chromatic 2nd order

- **Coupling to θ**
- **1st order + 2nd order terms × 10**

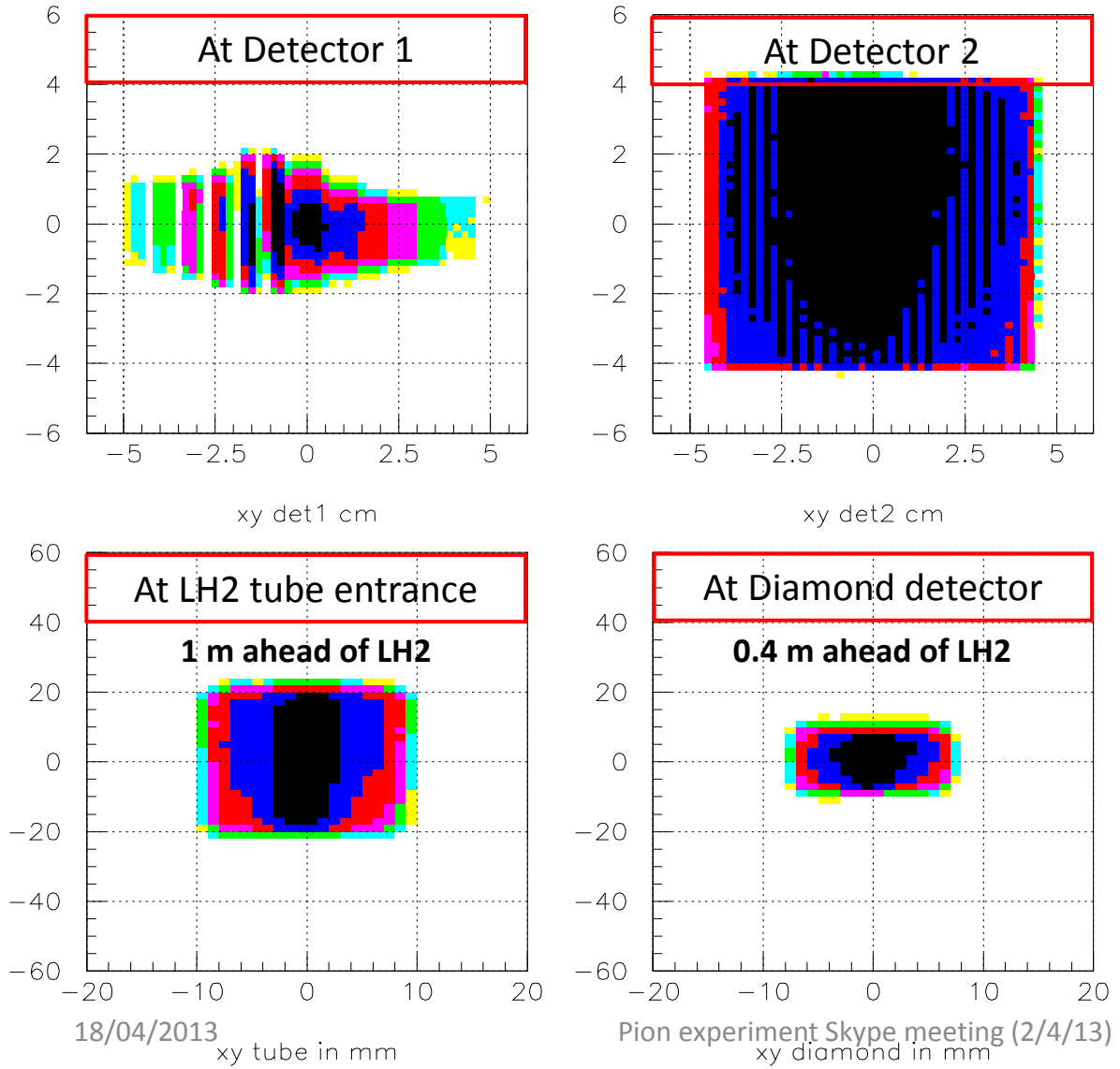
2 equations (one measured Y position at detector 1, another one at detector 2) with 7 terms

System of 4 non-linear equations with
4 unknown θ_i, y_i, φ_i and δ (x_i term 'neglected')
→ solved iteratively

SET 6
Q7 Foc, 1m
Q8 Defoc, 1 m
Q9 Foc, 0.4 m

xy occupancy

Condition at HADES_LH2
|x|,|y|< 6 mm

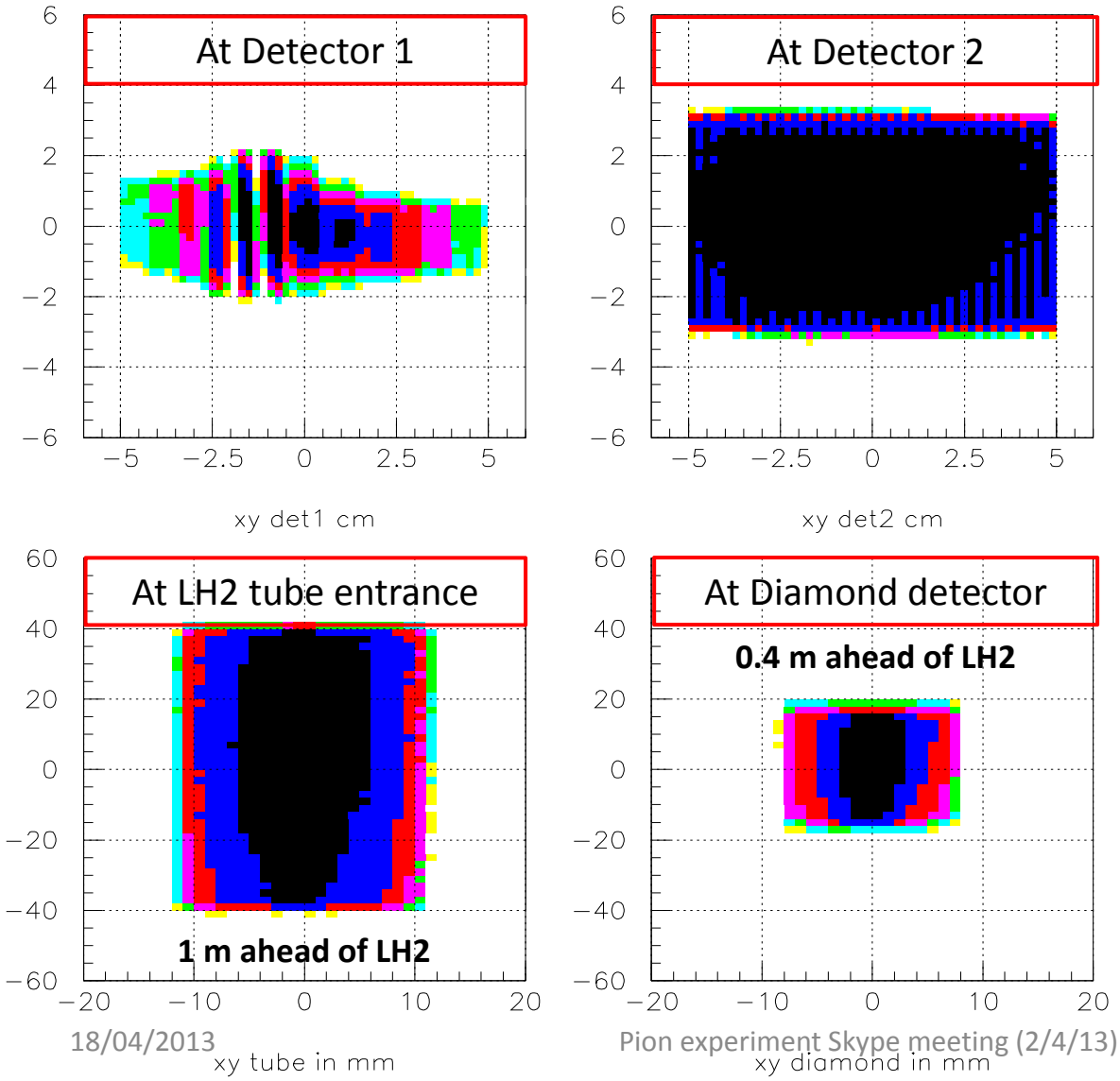


z: log scale

xy occupancy

SET 7
Q7 Foc, 0.4 m
Q8 Foc, 1 m
Q9 Defoc, 1 m

Condition at HADES_LH2
|x|,|y|< 6 mm



z: log scale

CONCLUSION
Configuration FDF is much better: 'beam' profile much narrower

First results for FDF: with HADES LH2 condition

$\Delta p/p$	-6 %	-5 %	-4 %	-3 %	-2 %	-1 %	0 %	1 %	2 %	3 %	4 %	5 %	6 %
Yield (%) After Q9	5.0	8.5	14.6	18.6	25.0	36.6	55.5	60.7	49.1	28.4	20.7	14.0	6.2
Yield (%) $\|x\|,\|y\|<6$	0.05	0.57	2.2	6.1	13.3	33.8	55.5	60.7	31.3	11.6	4.6	1.8	0.64
σ_δ (%)	0.6	0.31	0.26	0.23	0.18	0.15	0.13	0.11	0.10	0.11	0.12	0.13	0.14
σ_x (mm)	7.1	3.7	3.0	2.3	1.7	1.2	1.0	1.0	1.2	1.4	1.7	1.9	2.1
σ_y (mm)	0.48	0.41	0.38	0.35	0.22	0.11	0.07	0.10	0.17	0.20	0.25	0.32	0.41

Yields correspond to the initial conditions:
$-10. < \theta < 10.$ mrad
$-50. < \varphi < 50.$ mrad

Useful range [- 4 % , + 5 %]

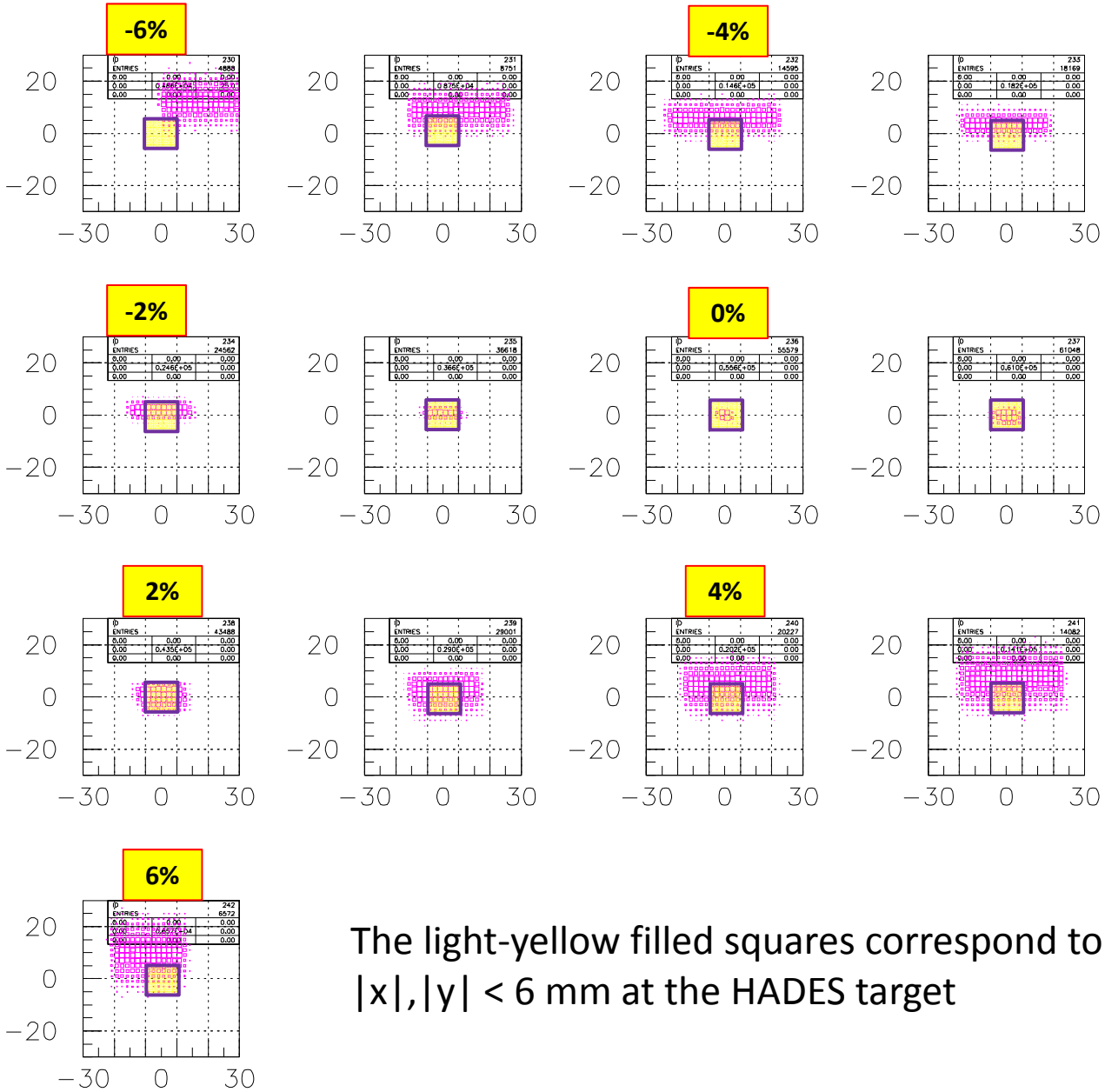
No loss for $\delta = \Delta p/p = 0$ and 1%
Slight asymmetry: positive δ values better than negative ones
Graphic representation of the XY distribution and of the induced cut by the condition $|x|,|y| < 6$ mm in next slide

First results for FDF: after Q9

$\Delta p/p$	-6 %	-5 %	-4 %	-3 %	-2 %	-1 %	0 %	1 %	2 %	3 %	4 %	5 %	6 %
Yield (%) After Q9	5.0	8.5	14.6	18.6	25.0	36.6	55.5	60.7	49.1	28.4	20.7	14.0	6.2
σ_δ (%)	0.54	0.36	0.28	0.23	0.19	0.16	0.13	0.11	0.11	0.11	0.12	0.13	0.15
σ_x (mm)	6.2	4.4	3.0	2.35	1.75	1.25	1.0	1.0	1.2	1.45	1.65	1.9	2.2
σ_y (mm)	1.2	0.75	0.53	0.36	0.23	0.11	0.07	0.10	0.16	0.20	0.37	0.52	0.76

Yields correspond to the initial conditions:
$-10. < \theta < 10.$ mrad
$-50. < \varphi < 50.$ mrad

Resolutions are almost the same as with the LH2 condition, except for σ_y at the higher δ values.

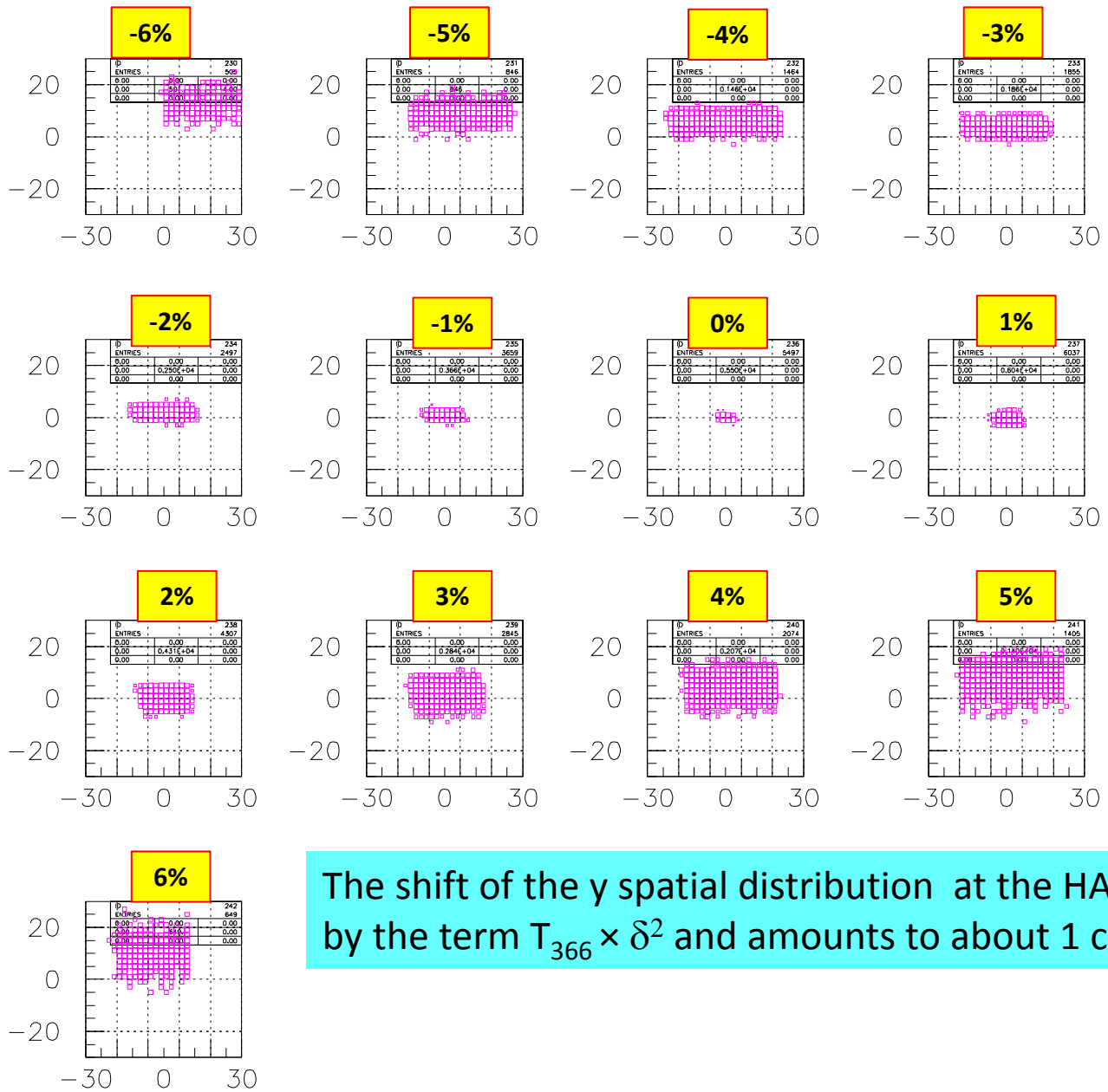


z: linear scale

The light-yellow filled squares correspond to the condition:
|x|,|y| < 6 mm at the HADES target

xy at HADES_LH2 with |x|,|y|< 30 mm

z: log scale

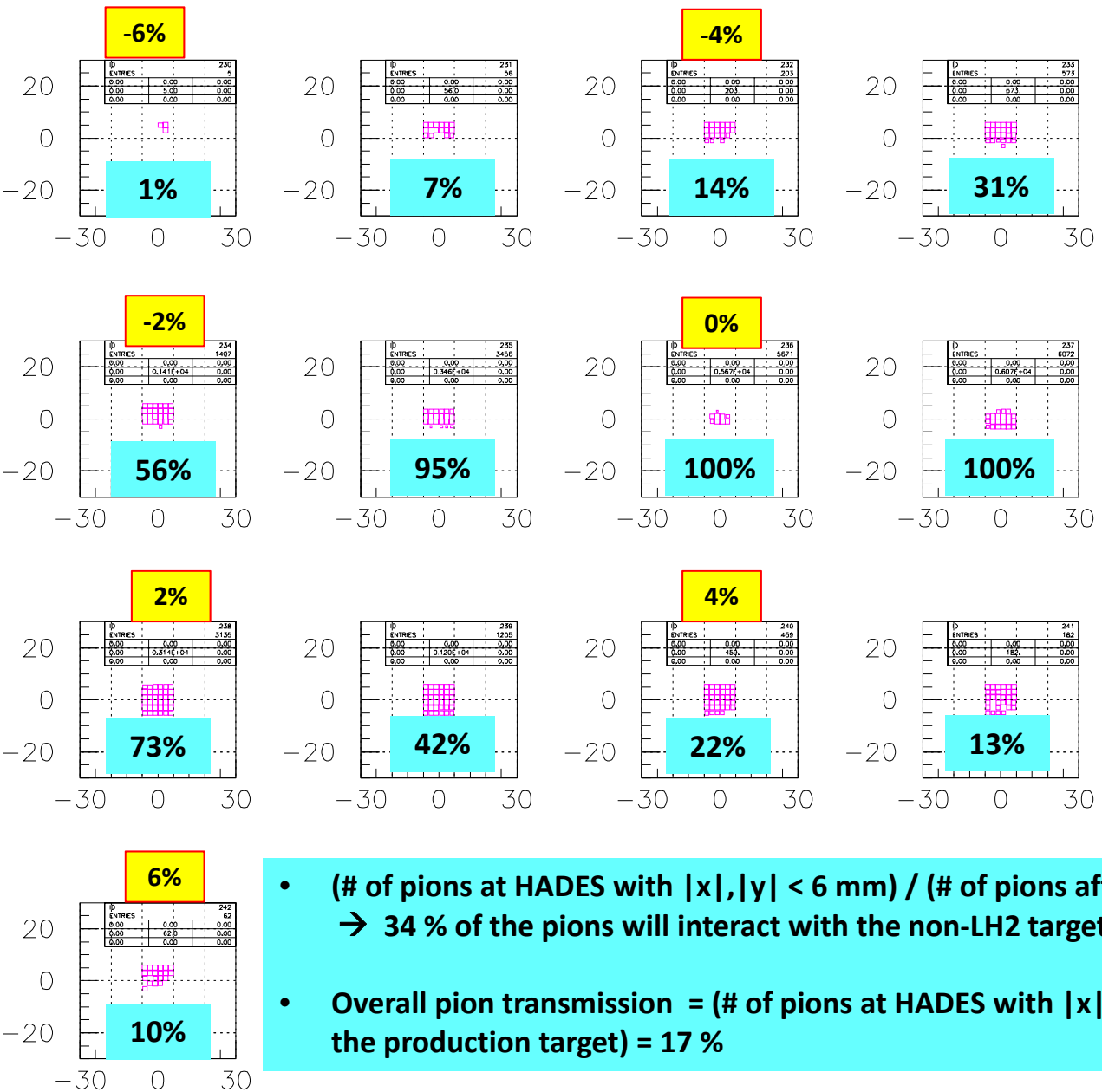


The shift of the y spatial distribution at the HADES target is mostly given by the term $T_{366} \times \delta^2$ and amounts to about 1 cm for $|\delta| = 6\%$

xy at HADES_LH2 with |x|,|y|< 6 mm

Fraction left (in %)

z: log scale



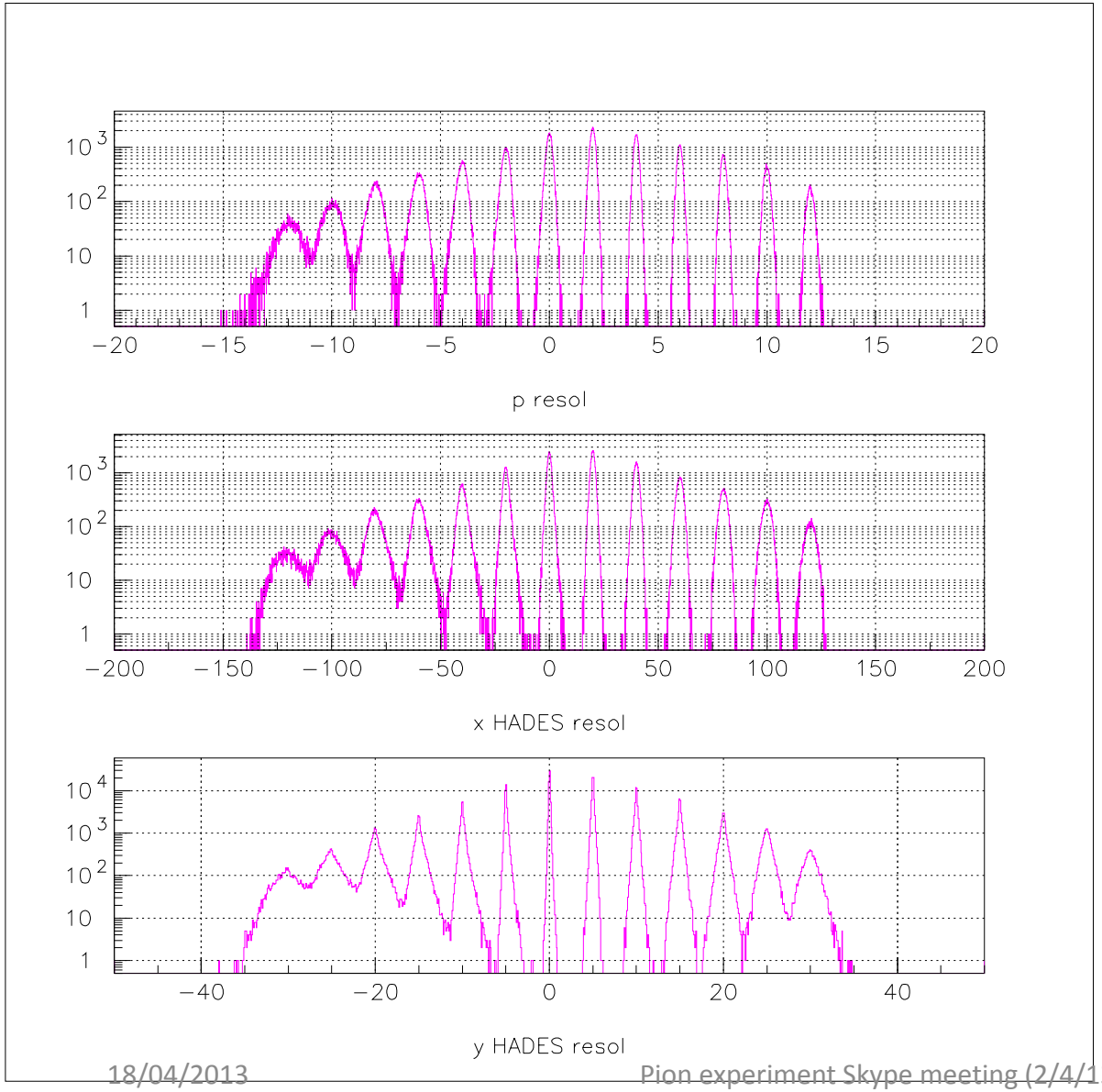
- **(# of pions at HADES with |x|,|y| < 6 mm) / (# of pions after the last quadrupole) = 66 %**
  → 34 % of the pions will interact with the non-LH2 target material

- **Overall pion transmission = (# of pions at HADES with |x|,|y| < 6 mm) / (# of pions emitted at the production target) = 17 %**

element layout

Element number	Element nature	Length of element (meter)	Integrated length at the end of the element
22	Drift	3.0	22.053
23	Dipole 2	1.4726	23.525
24	Drift	2.81	26.335
25	Q7 (Hor. Focusing)	1.0	27.335
26	Drift (detector 2)	0.91	28.335
27	Drift	1.9	29.245
28	Q8 (Vert. Focusing)	1	31.145
29	Drift	0.6	31.745
30	Q9 (Hor. Focusing)	0.4	32.145
31	Drift (start of the 48 mm diameter LH2 tube)	0.5	32.645
32	Drift (diamond detector)	0.6	33.245
33	HADES target	0.4	33.645

Resolution: all pions left after Q9

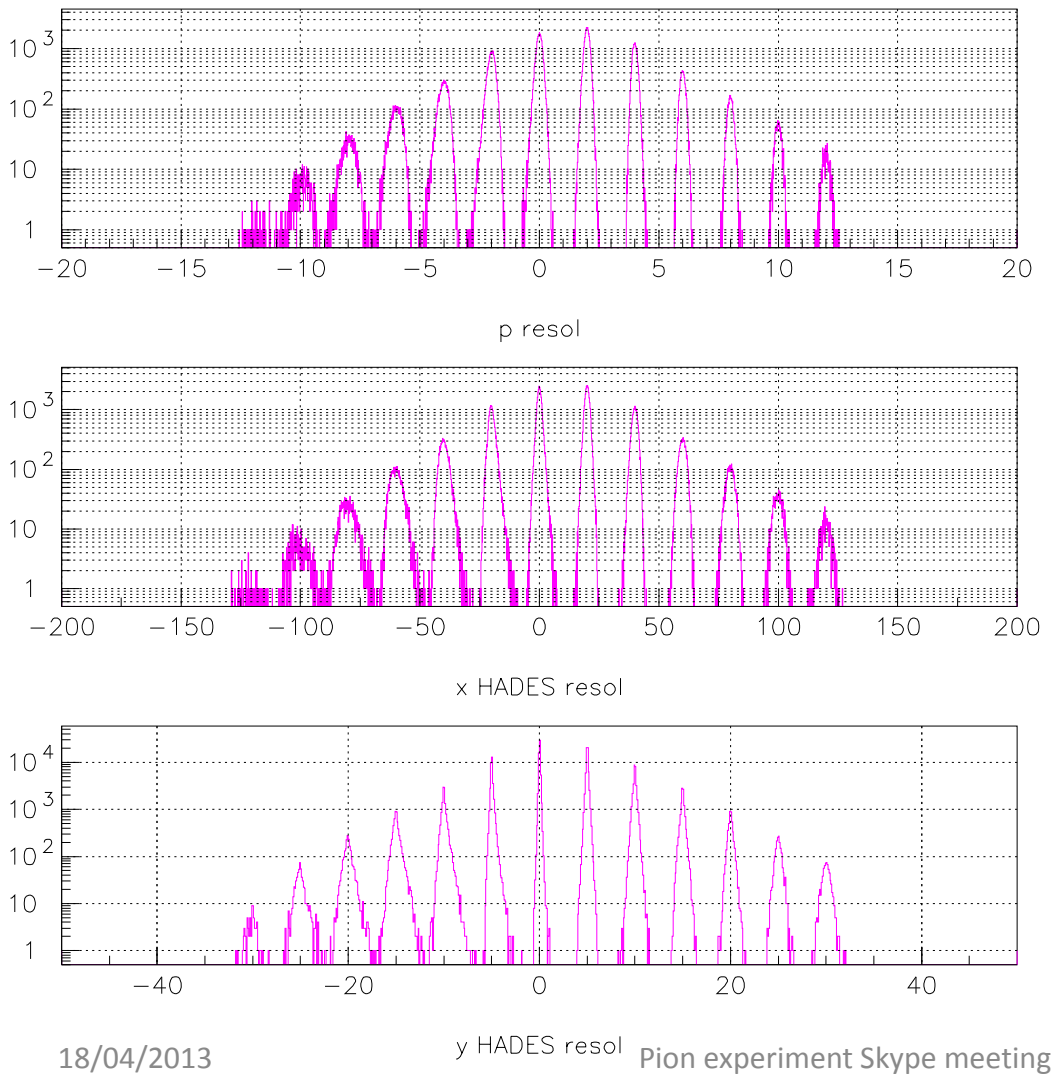


Resolutions in:

- momentum,
- x at the HADES target
- y at the HADES target

For |x|,|y| < 30 mm

Resolution: pions within the LH2 target



Resolutions in:

- momentum,
- x at the HADES target
- y at the HADES target

For |x|,|y| < 6 mm