# Preliminary analysis on the PS wire scanners

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ACKGT: Ana, Simone and the PS team

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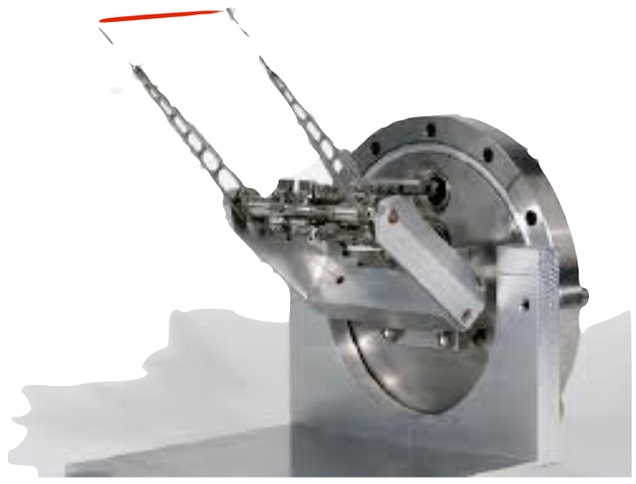
A wire scanner is a versatile BI device that can give information on the

- beam H/V transverse profiles,
- its H/V the positions,
- and the its current.



BUT

- ⚠ it is a mechanical (slow) device (wrt BPMs or BCTs)
- ⚠ its well-behaving region is limited (non-trivial setting)!

# Why WS are important?

They are a key device for understanding and improving the performance of multi-turn machines (i.e., PS).

# How many WS are there?

8 WS in PSB: 1H+1V rotational (x 4 rings).

5 WS in PS: 3H+2V rotational.

9 WS in SPS: 2H+3V, rotational & 2H+2V, linear.

4 WS in LHC: 1H+1V, rotational (x 2 rings).

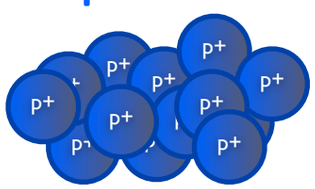
# What is our goal?

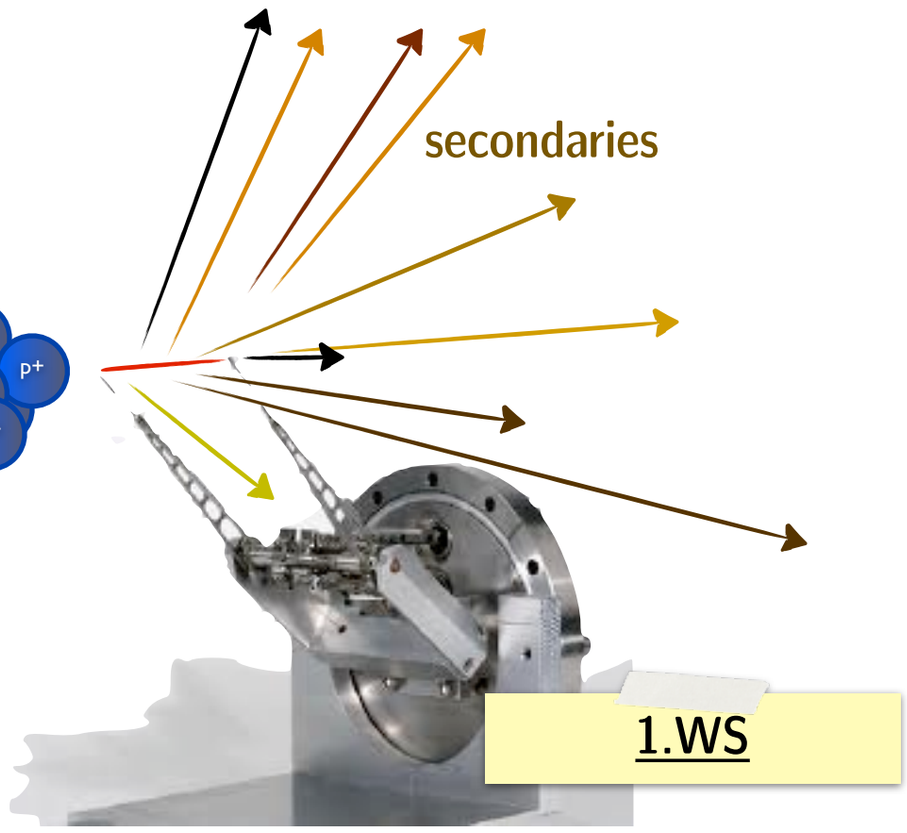
1. Validate the emittance measurements as a function of the different instrument settings (PM voltages, filters, speed).

2. Study the errors introduced in the emittance estimations.

# WS working principle

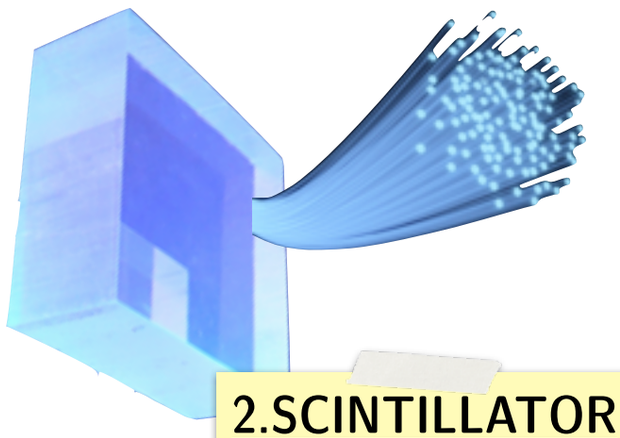
protons





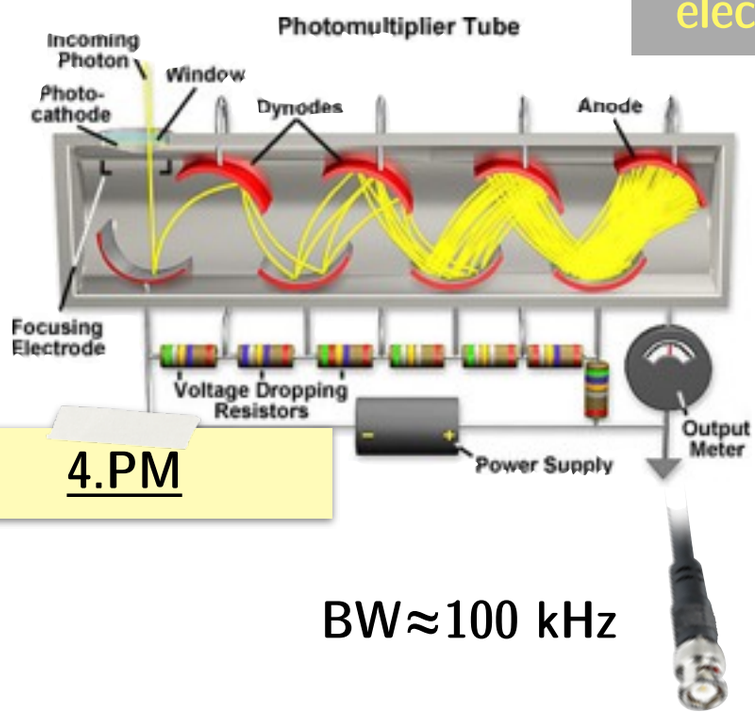

1.WS

photons



2.SCINTILLATOR

3.FILTER

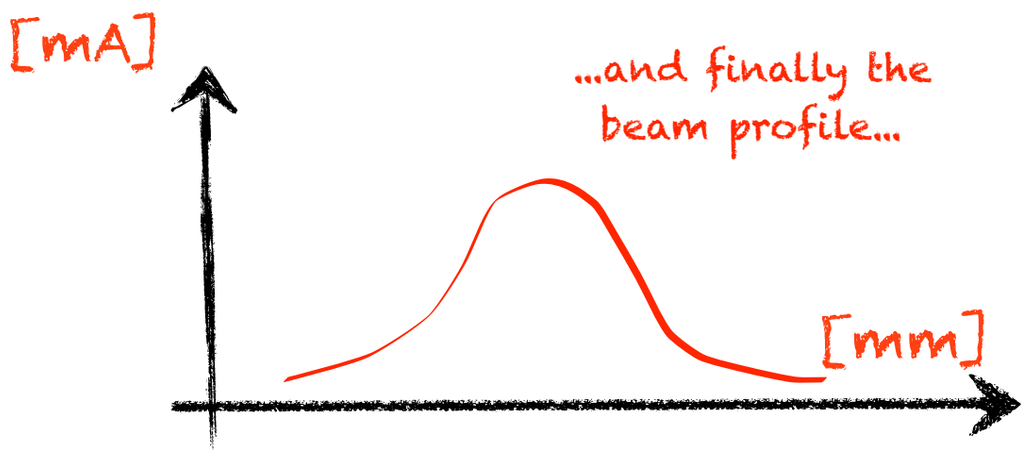



4.PM

electrons

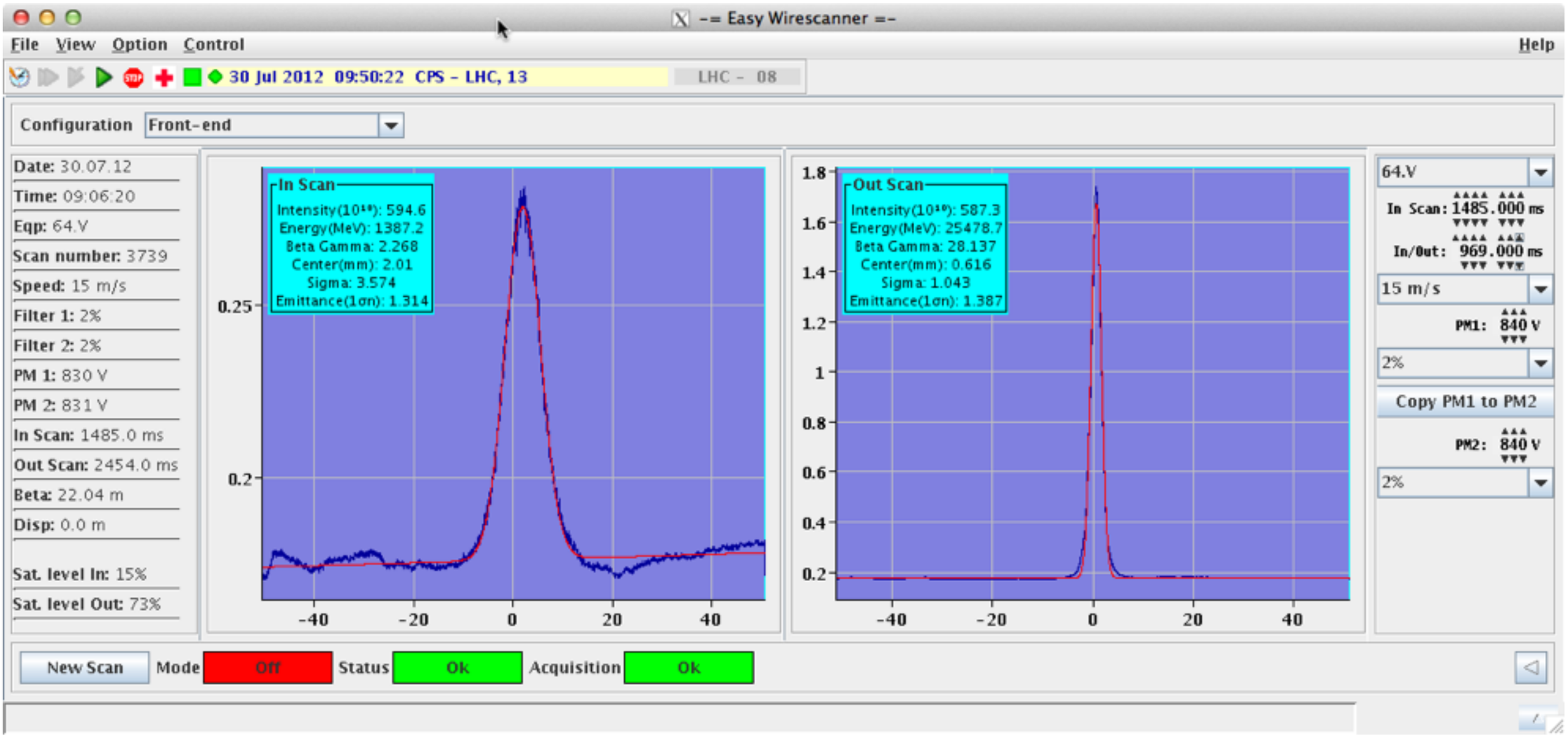
BW≈100 kHz

5.ADC+SERVER



# WS settings

# (1.speed, 2.timing, 3.PM V & filter)



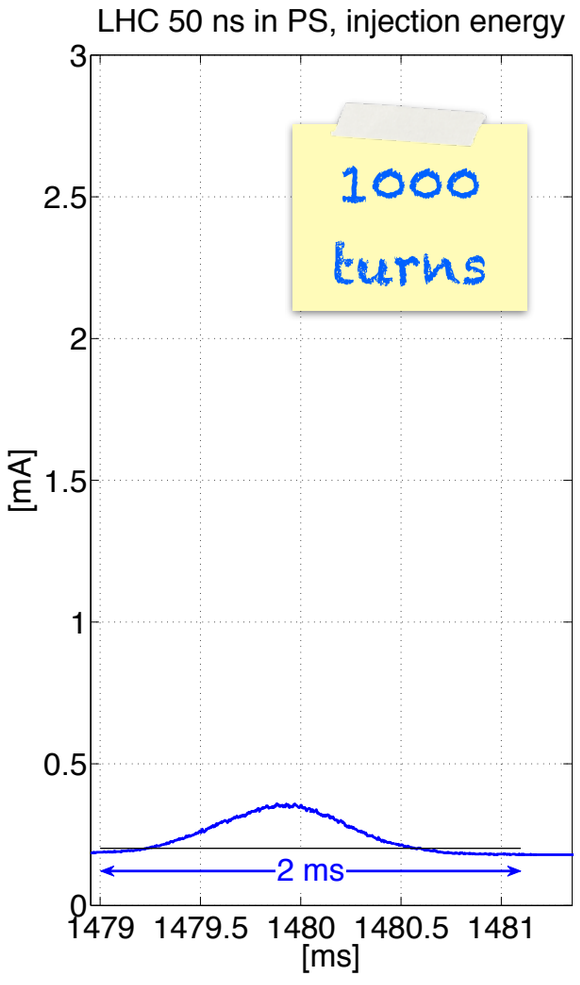
# 1. WS speed

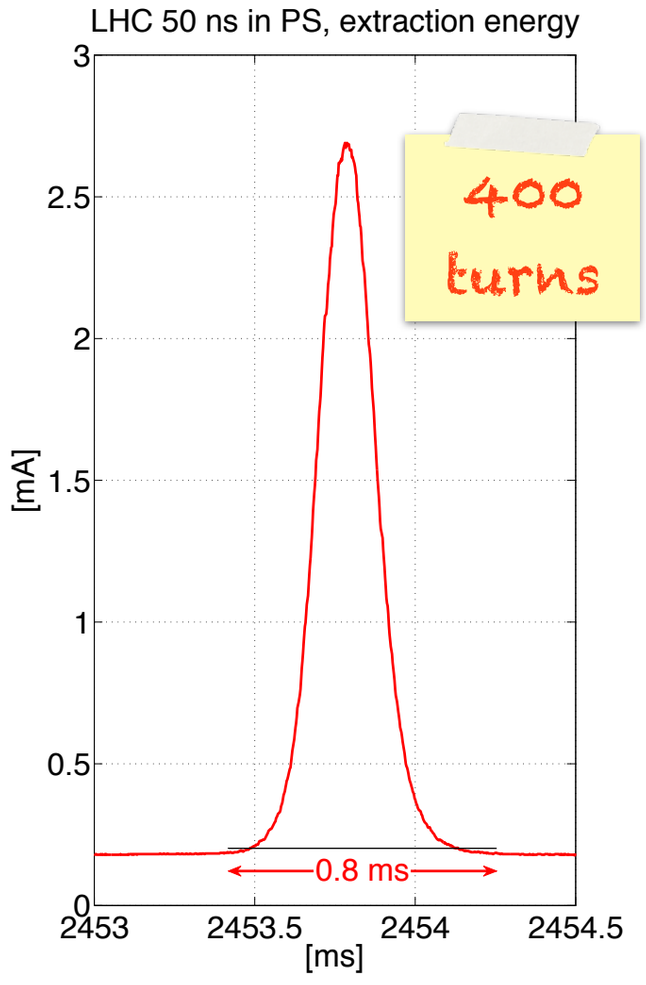
RECIPE: in as fast as possible! 10 m/s, 15 m/s

## WHY 15 m/s?

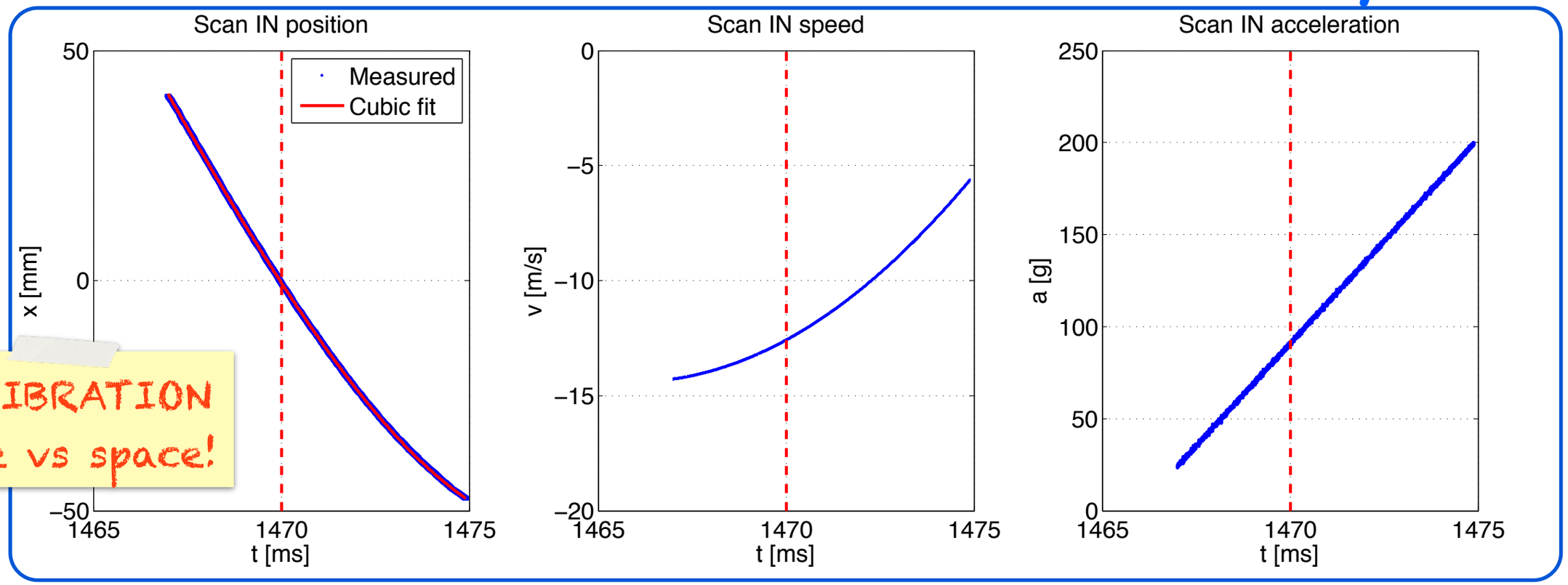
☺ To limit the time of the measure (~2 ms @ inj, ~0.8 ms @ ext)(easier timing).

☺ A faster wire will interact less with the beam (<Δε) BUT less signal... (not a problem in PS).

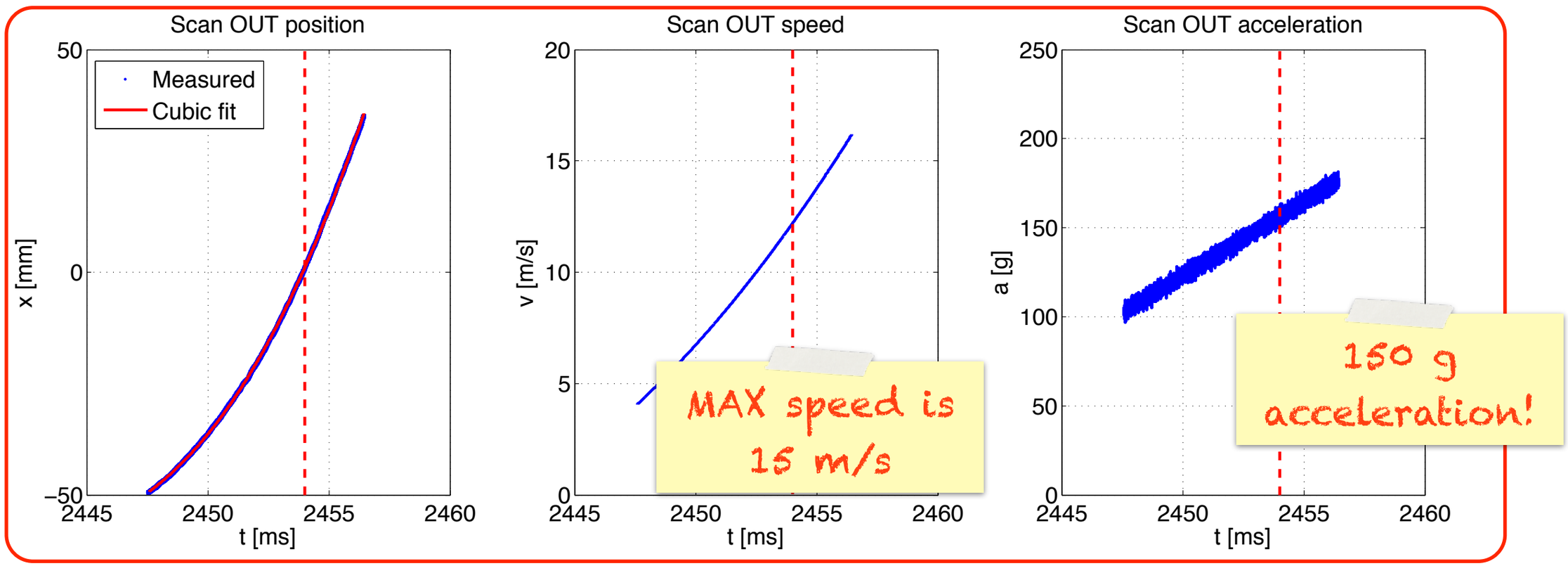


# More in details the 15 m/s...




CALIBRATION time vs space!

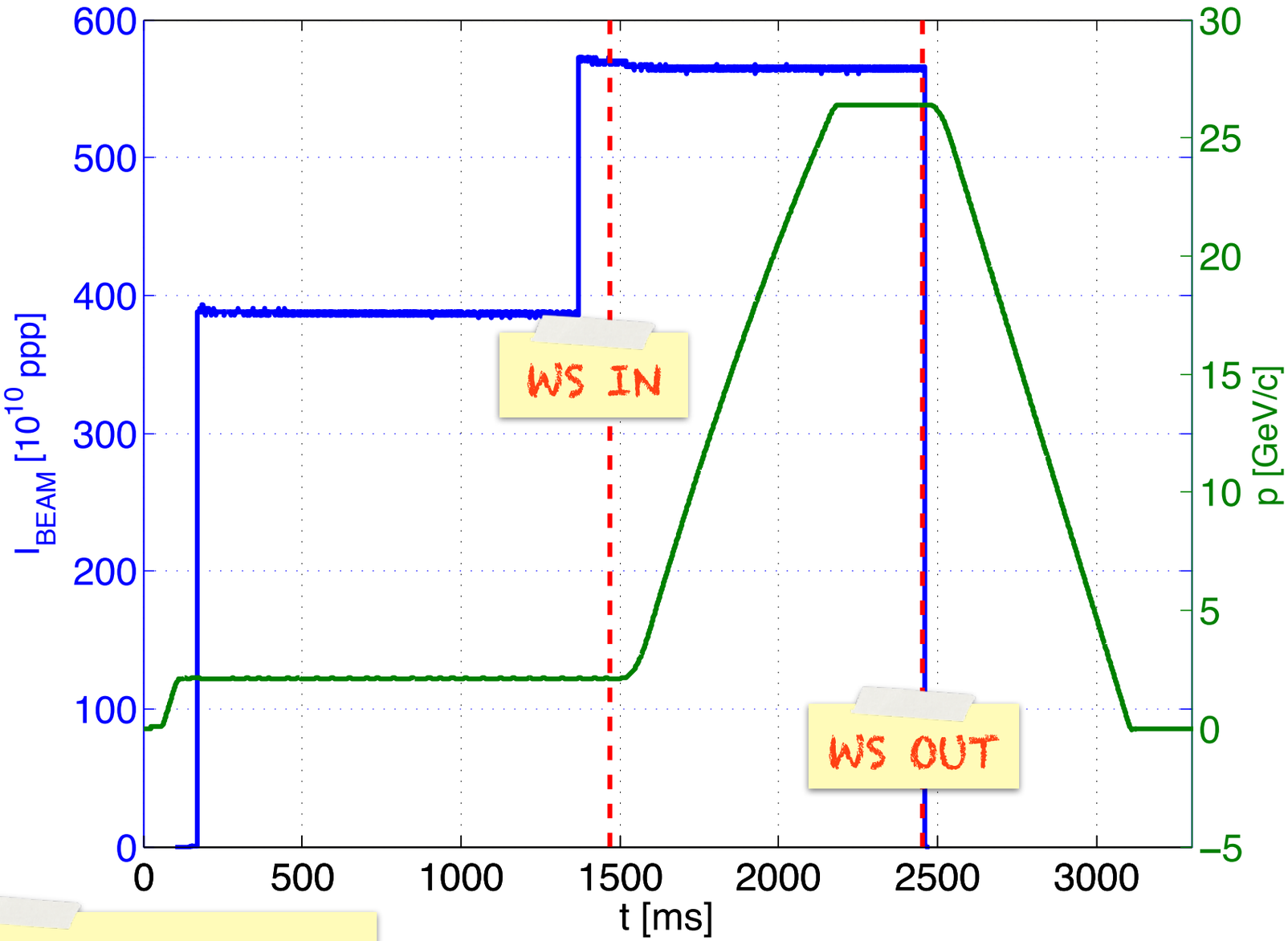



MAX speed is 15 m/s

150 g acceleration!

# 2. WS timing

**You need at least a window of ≈2 ms @ inj, ≈0.8 ms @ extr of "quiet" cycle (NO RF gym, no bumps)**

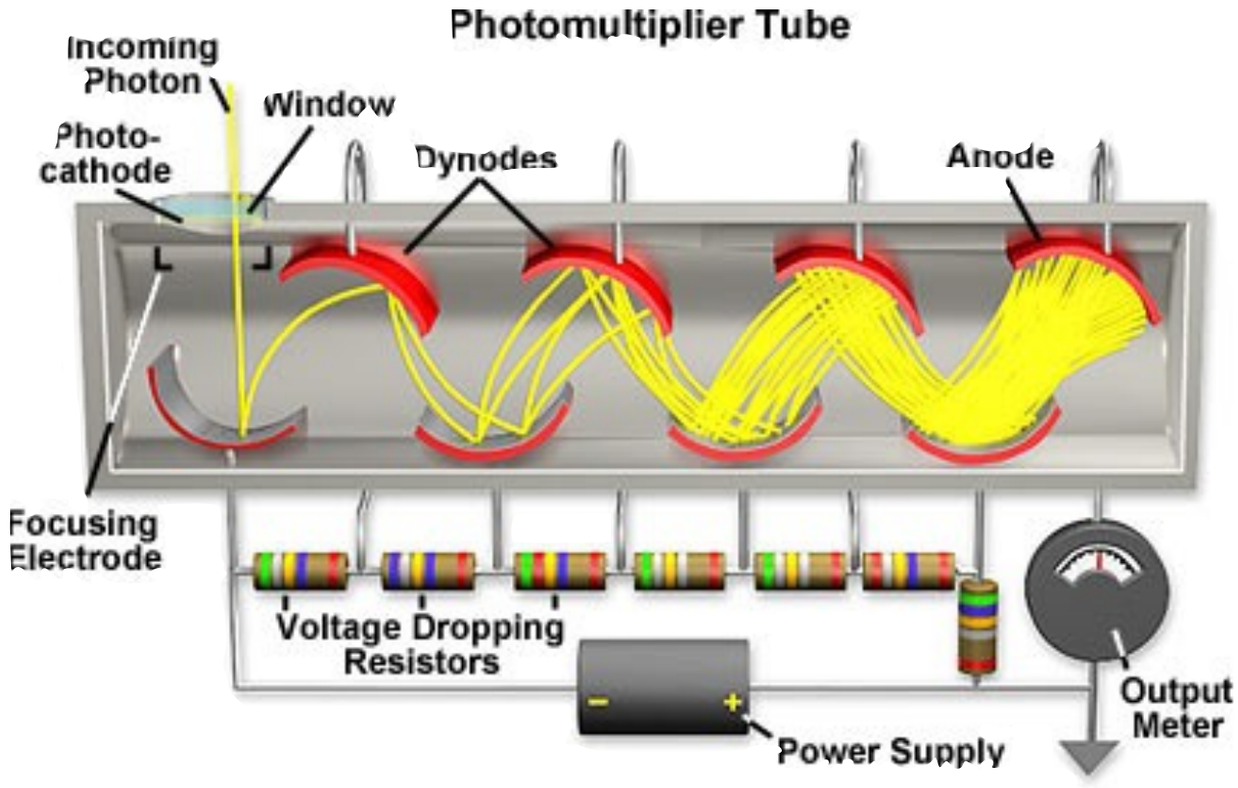



LHC_DB_SQNs:
important for L production

# 3&4. PM V & Filter

For each PS WS there are 2 photomultipliers with 8 dynods.

The polarization voltage of each photomultiplier can go up to 1 kV.

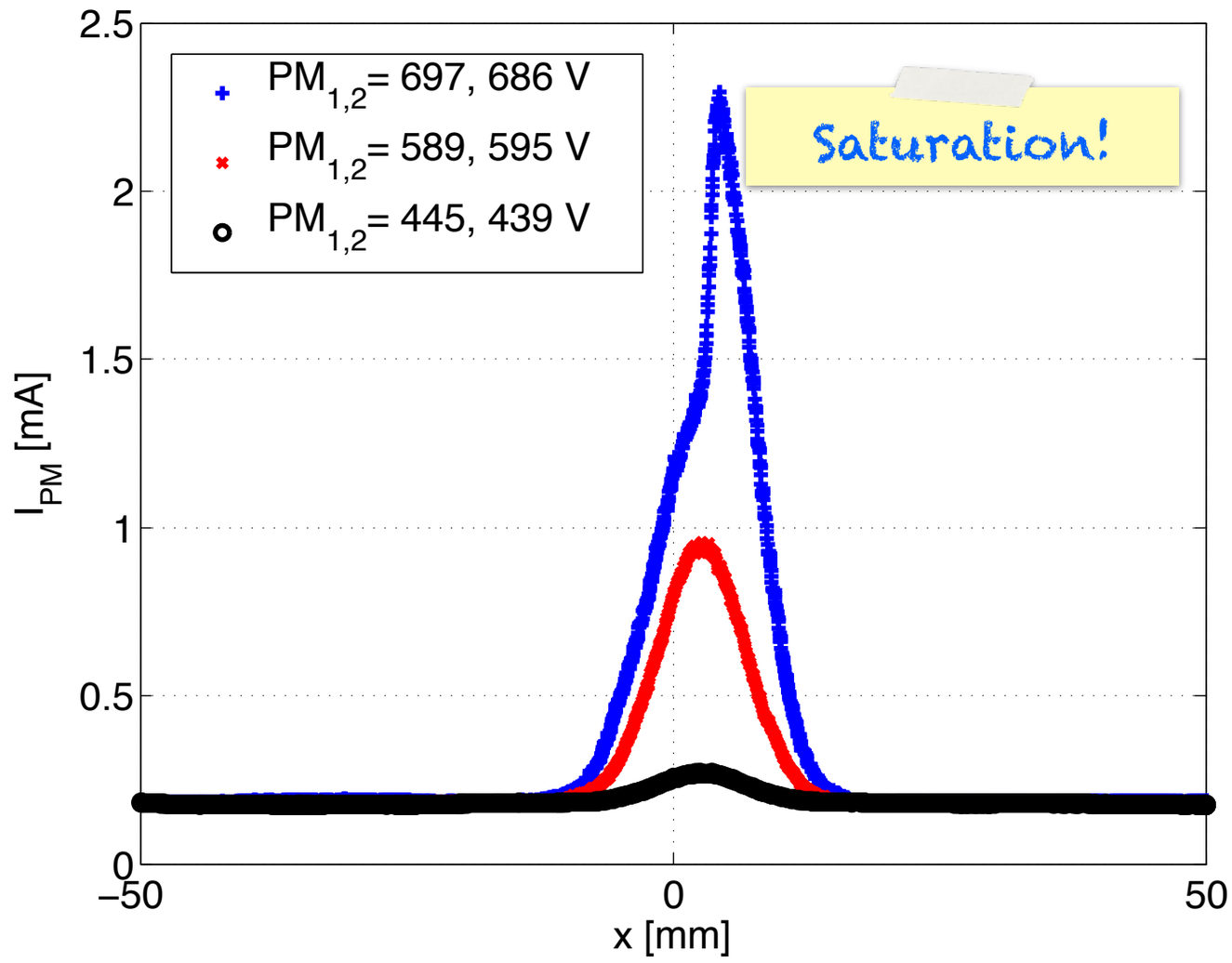



Gain Input signal

$$I_{out} = k(E_{kin}) \times V^7 \times TX_{filter} \times \frac{1}{v_{WS}} \times I_{beam}$$

# PM saturation problem

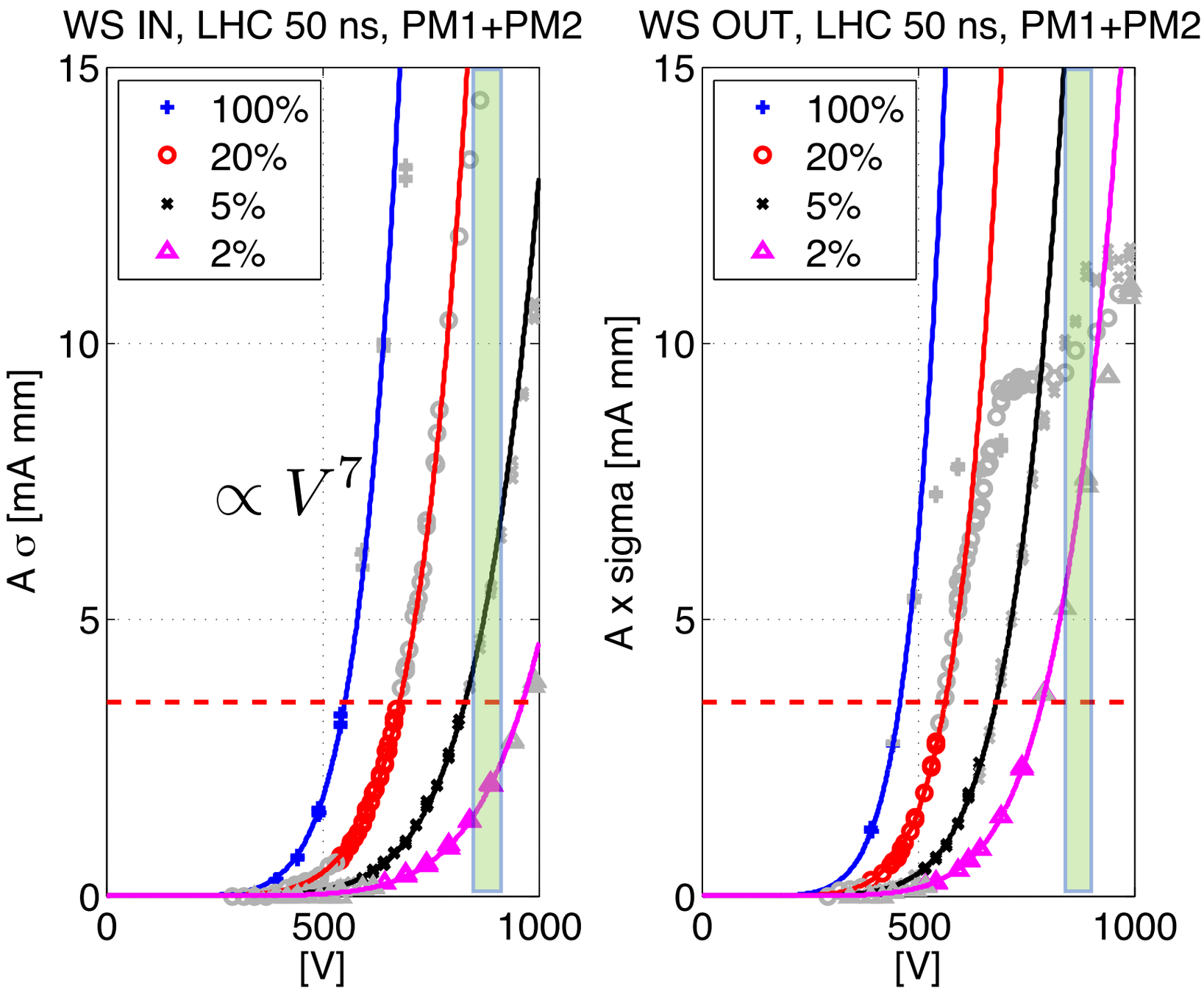
If we increase the PM V to much or we don't filter enough, the PM saturates (its power supply cannot cope with the current requested by the PM).




If the PM saturates then the beam profile obtained by the WS is distorted!

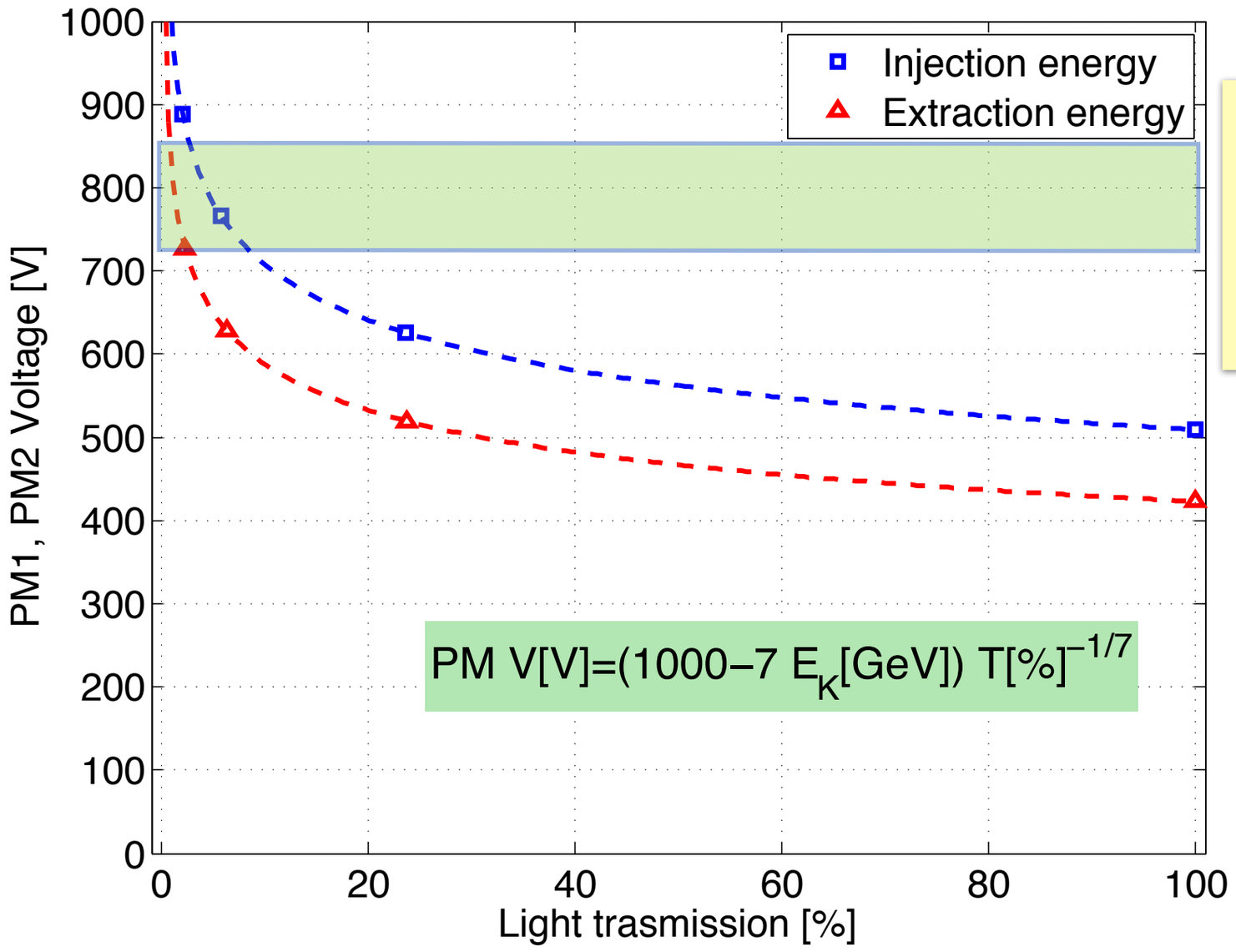
# Studies of the PM response in PS

**Measurement campaign in PS to study the saturation of the PMs for different filter settings.**




**For LHC_DB_50ns: 850 V with filter 2% and 15 m/s to have a good reading and inj and extraction.**

# An empirical rule for the PM



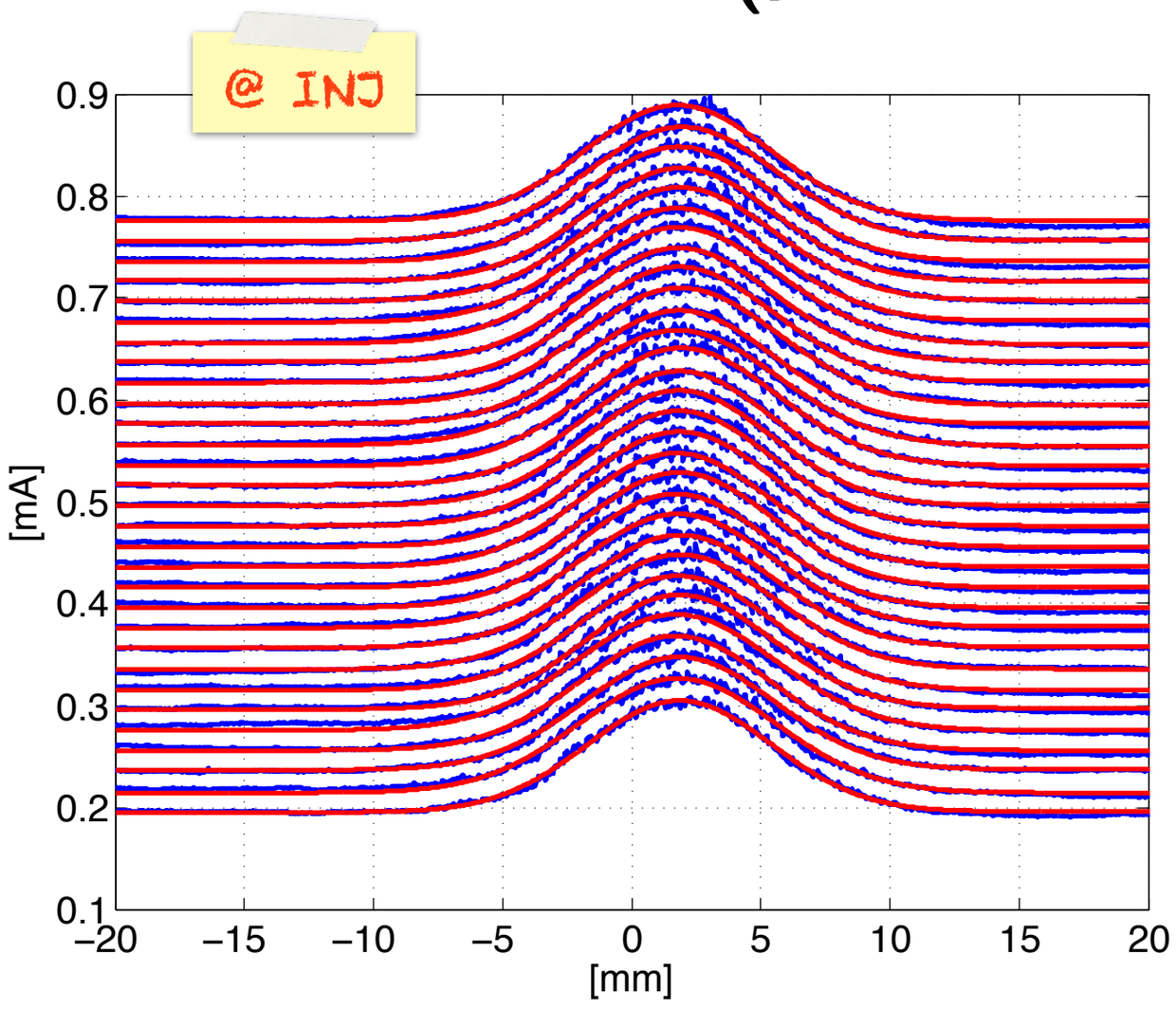

HINT: the filter should be chosen to work in the region 750-850 V

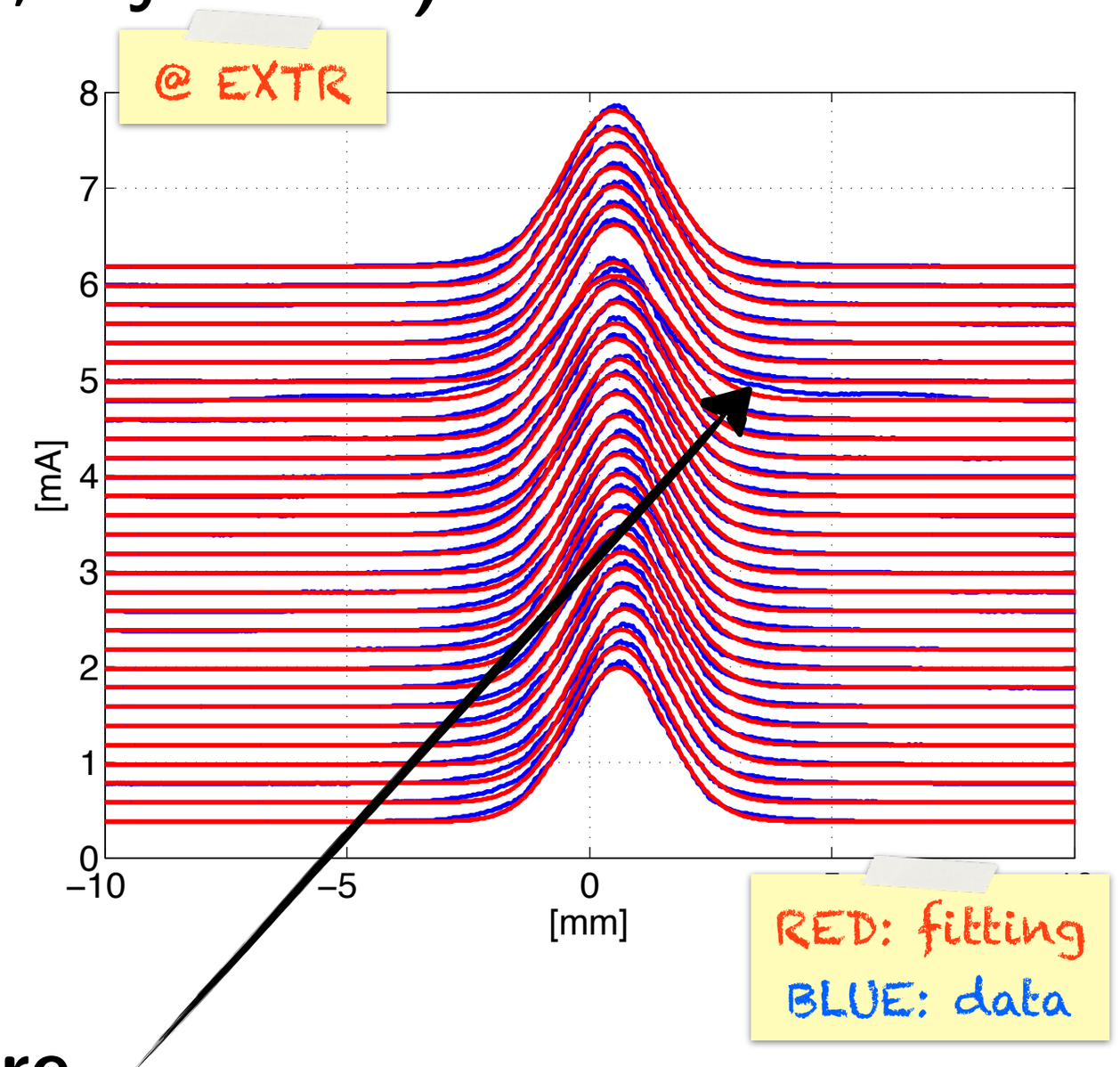
$$V_{PM}\ [V] \approx (1000 - 7 \times E_k\ [GeV]) \times \left( TX\ [\%] \times \frac{I_{beam}\ [ppp]}{600e10} \times \frac{15}{v_{PM}\ [m/s]} \right)^{-\frac{1}{7}}$$

# The measure on WS64V

## We have some statistics (350 shots) on the vertical 64V

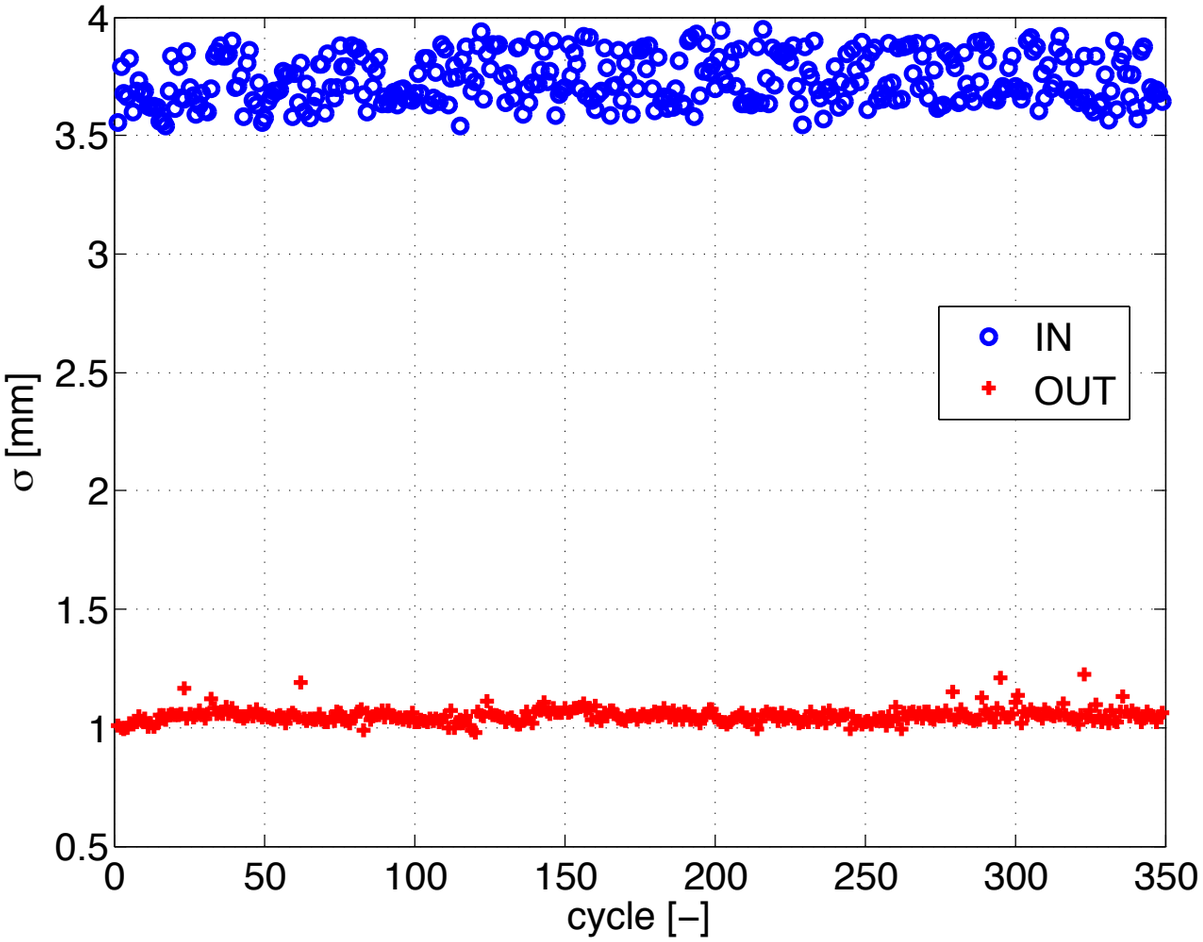
## (β=22.04 m, Dy≈ 0 m)

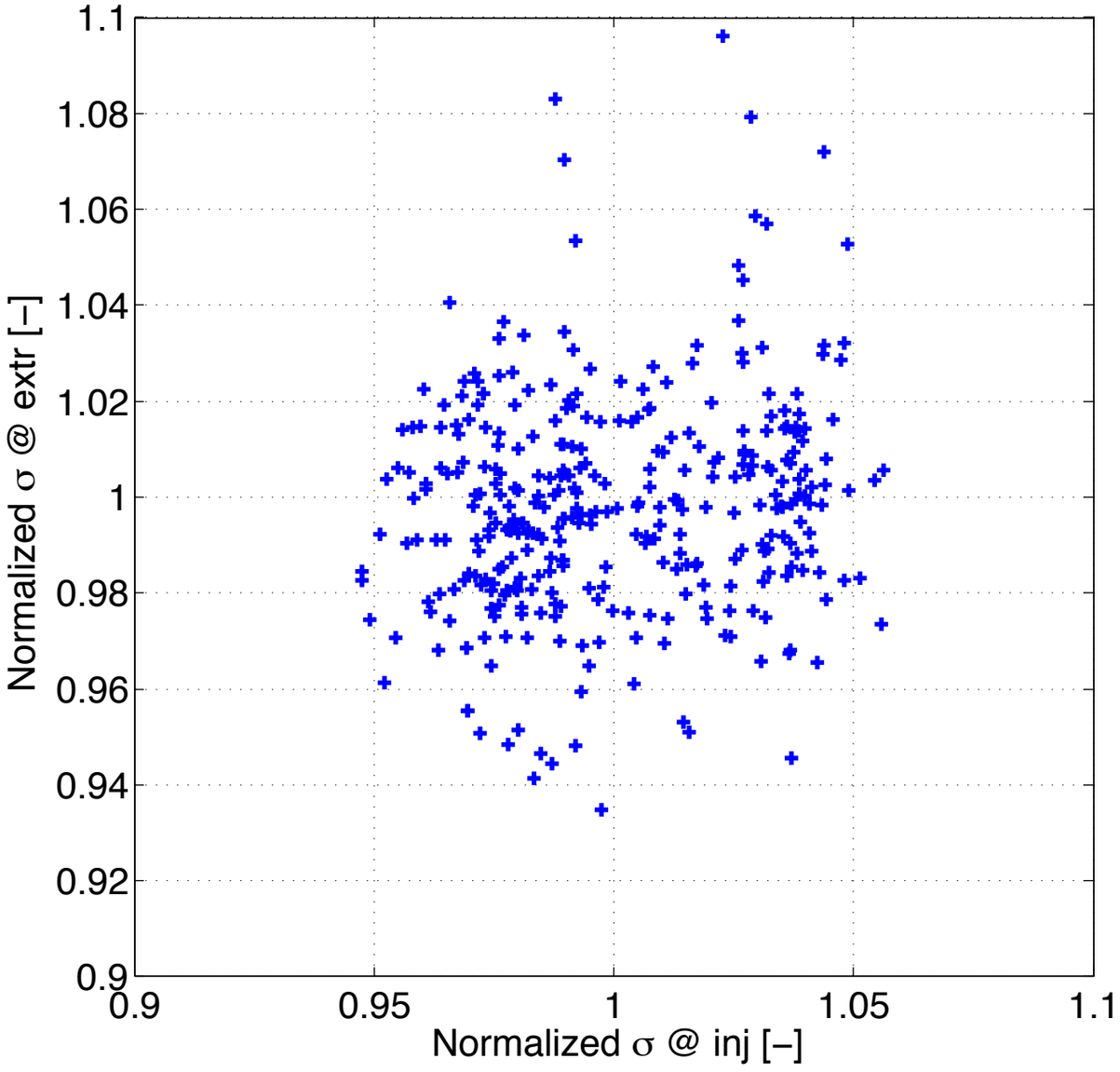



## @EXTR sometimes there are very heavy-tailed shots

# The measure on WS64V




**2.7% reproducibility of σ**

**No correlation!!!**

To establish the WS precision I would like to do a “real” correlation test.

For the moment we can conclude that is

$\lesssim 2.7\ \%$


# Non Gaussian-fit…

1. A matched beam can be put in the form of a stable distribution (aka Lévy α-stable).
2. A mis-matched beam will filament onto a stable distribution.
3. If all transport between the PS and LHC is linear and matched the stable distribution is preserved along the chain so we could infer the LHC transverse profile starting from the injectors.


# Regarding the fitting...

$$\sigma_{eq} = \frac{1}{2\sqrt{2\pi}\int_{-\infty}^{\infty}\rho^2(x)dx}$$

Measure
Made even
Gaussian fit
Levy fit

Difference of 4% in luminosity prediction btw Gauss and Levy Fit!

[mA]
[mm]

# Summary

- An empirical law to set the WS has been proposed.
- A trade-off on the WS setting has been found for measuring the $\sigma$ @inj and @inj on LHC_DB_50ns.
- The observed jitter in the $\sigma$ is $\approx$2.7% in the vertical direction.
- Correlation studies btw inj/extr showed no correlation of the $\sigma$ jitter. This seems to indicate that the precision of the device is $\approx$2.7 % (assuming that the correlation should be much better than $\approx$2.7 %).
- For the study to have the possibility to launch 2 WS on the same beam (2V, 2H) would be extremely beneficial (Ana will try this week).
- There is a proposal to add additional filters to have a better palette of choice (LS1).

# Thank you.