



# Performance of Drift Tube Detectors at Very High Counting Rates at High-Luminosity LHC

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## Motivation

### ATLAS MDT: Monitored Drift Tube Chambers with

- ▶ 30 mm outer tube diameter, 50 μm wire diameter
- ▶ 3080 V operating voltage

⇒ Gas gain 20000

**sMDT**: 15 mm instead of 30 mm diameter, same gas mixture and gas gain.

▶ **Efficiency**: Vast improvement of at high background rates due to:

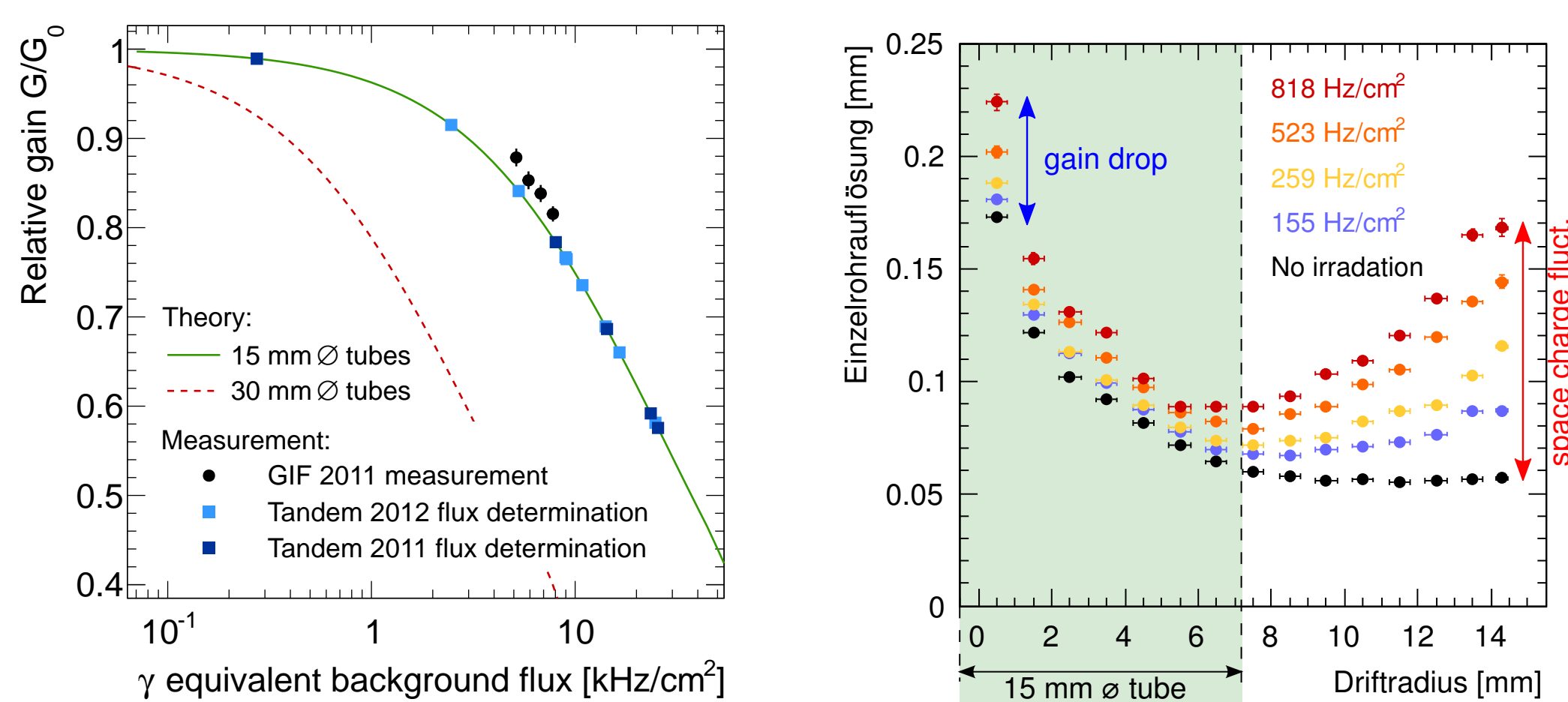
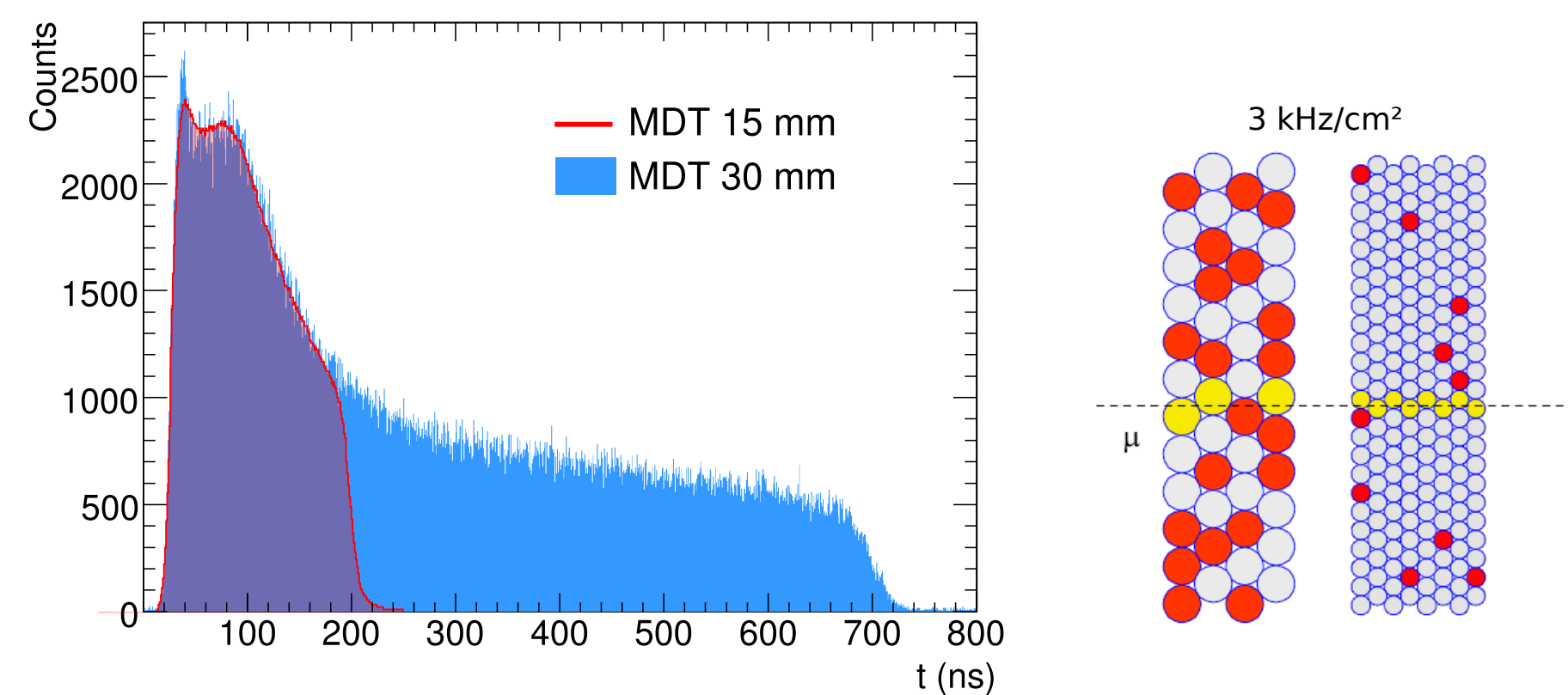
- ▶ Occupancy  $\propto$  max. drift time (700 ns  $\rightarrow$  185 ns): **3.8  $\times$  smaller**.
- ▶ Background hit rate  $\propto$  tube cross section: **2  $\times$  smaller**.

⇒ **Occupancy 7.6  $\times$  smaller** for given tube length.

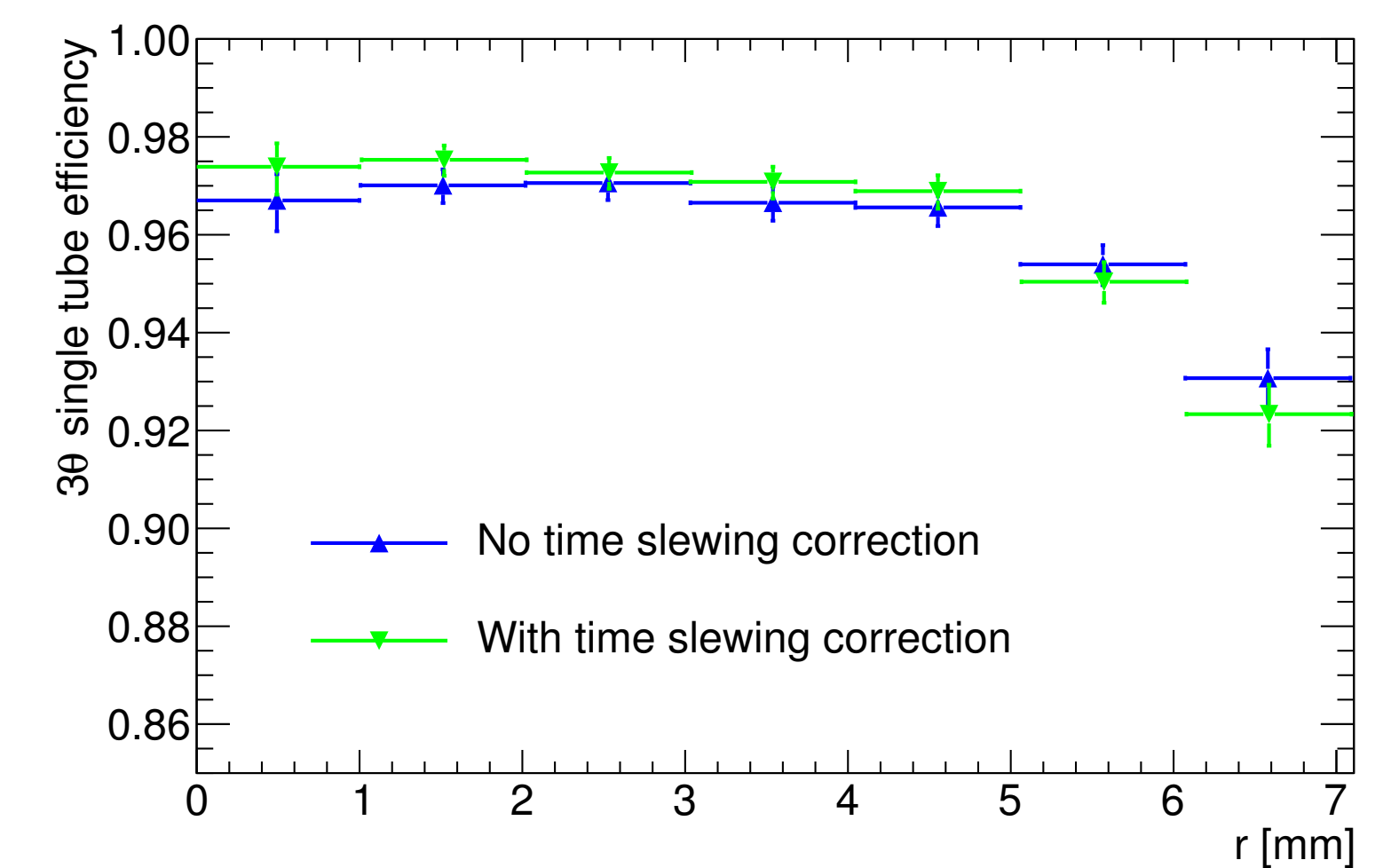
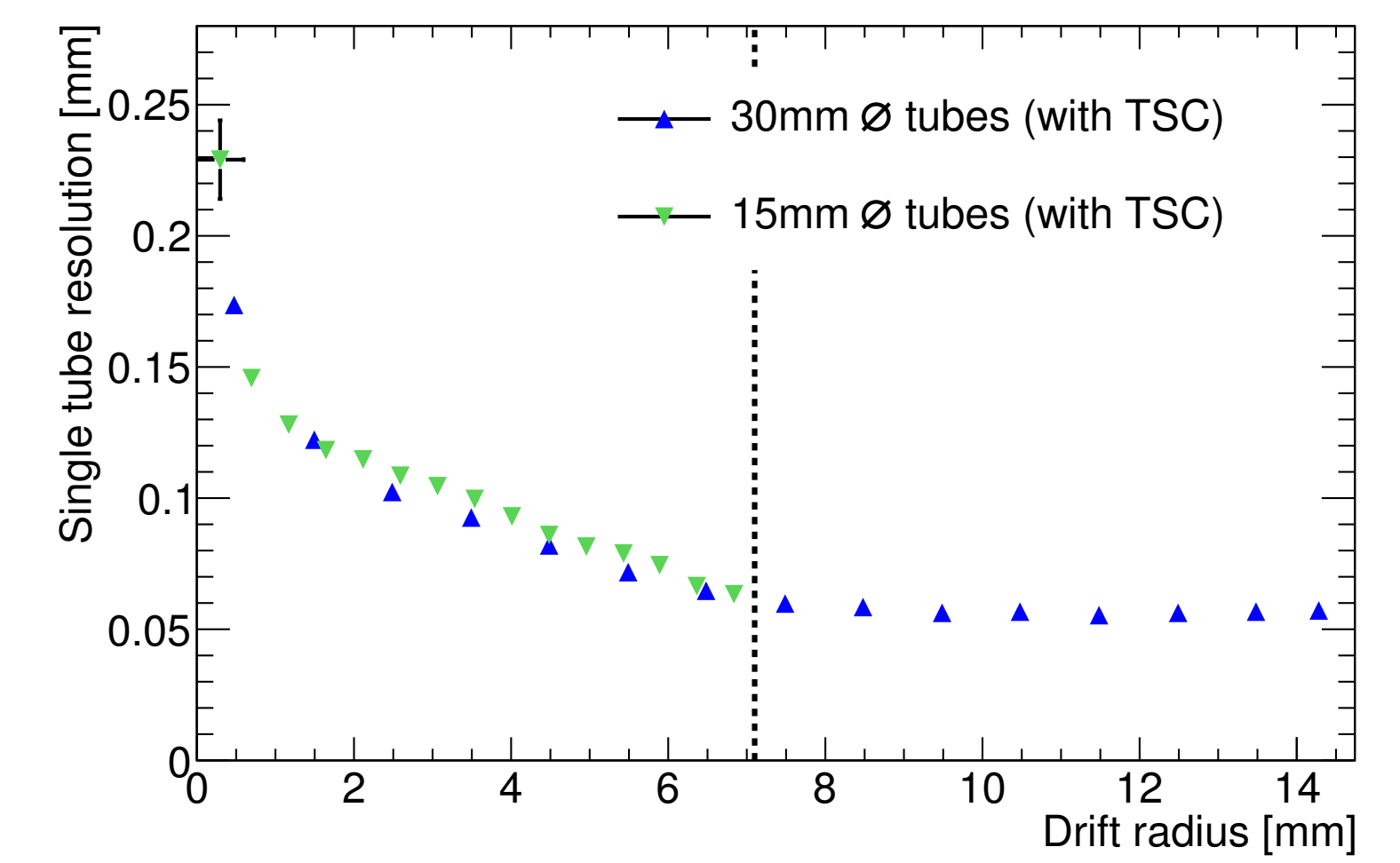
- ▶ Up to twice the number of tube layers fit into the same detector volume.

▶ **Spatial resolution**:

- ▶ Gain loss due to space charge induced by neutral particles is reduced by a factor of 8.7 compared to 30 mm diameter tubes and by a factor of 18 for charged particle irradiation.
- ▶ Effect of space charge fluctuations on the drift-tube resolution is eliminated.



## Chamber Performance without Background Irradiation

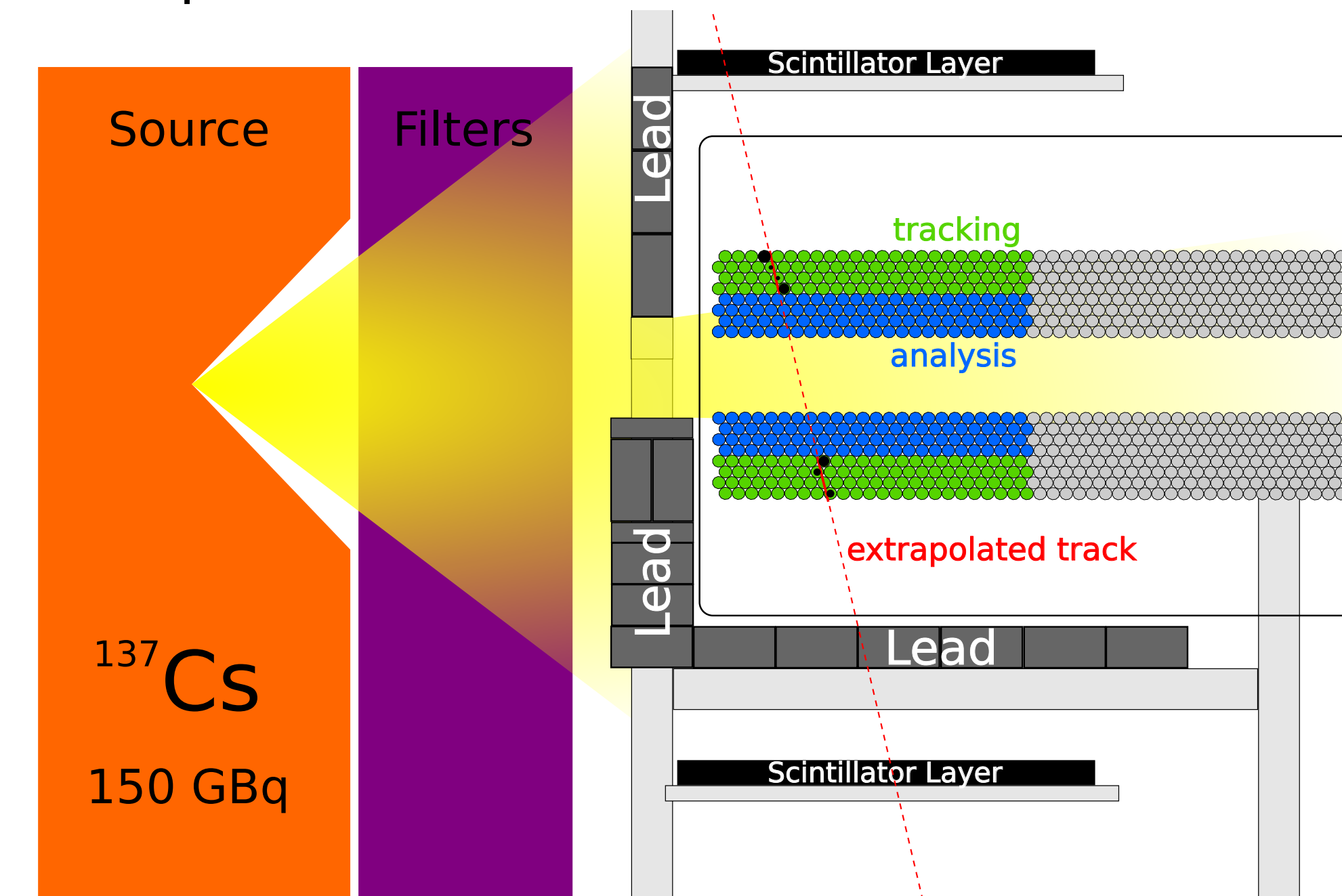


- ▶ average single tube resolution: (108±2) μm (128±2 μm without time slewing corrections).
- ▶ average 3σ single tube efficiency: 94%.

## Measurement with Gamma Irradiation

### CERN Gamma Irradiation Facility (GIF)

- ▶ 150 GBq <sup>137</sup>Cs source
- ▶ flux up to 10 kHz/cm<sup>2</sup>

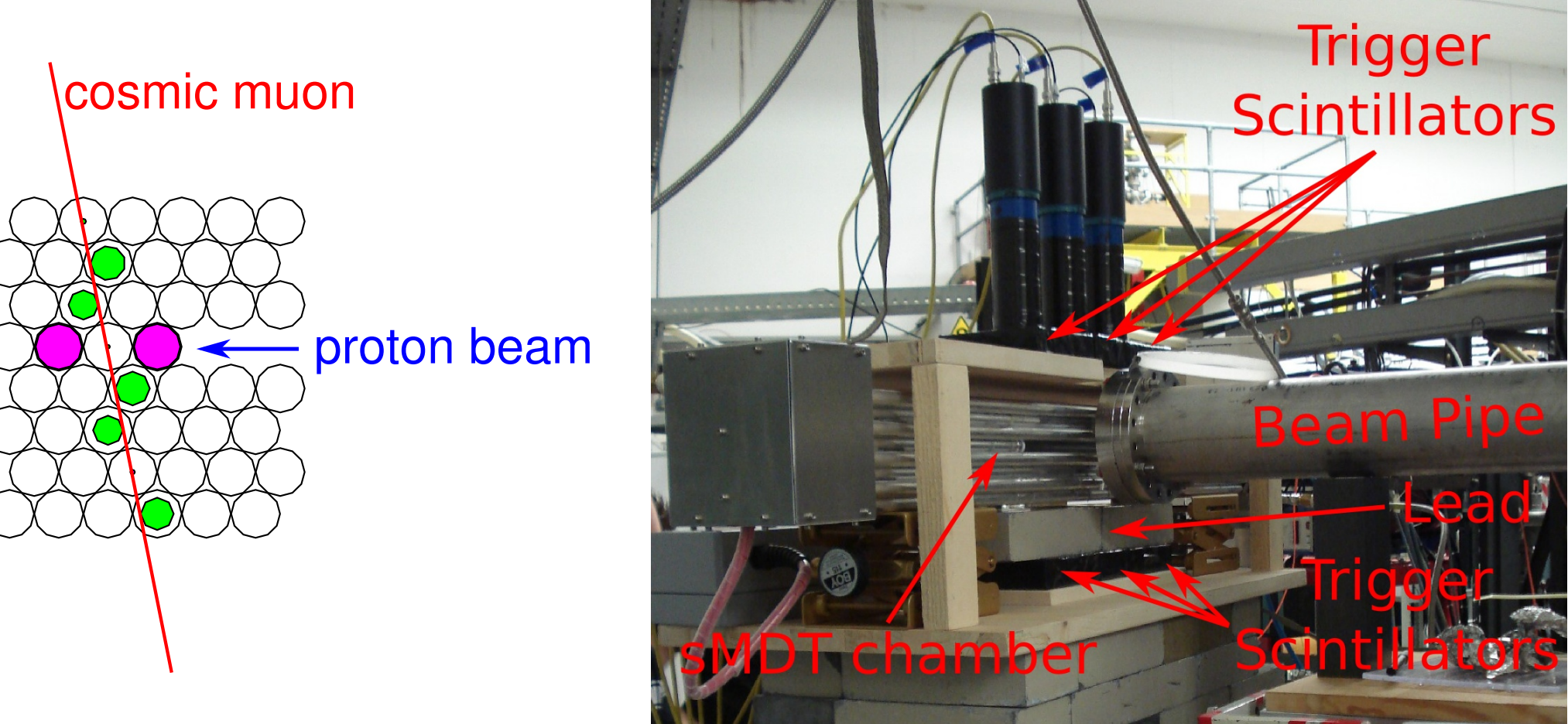


- ▶ Central tube layers of the chamber irradiated, outer (shielded) layers used for tracking of cosmic muons.
- ▶ Use track reconstructed in shielded part of the chamber to determine off-track residuals in irradiated tubes.

## Measurement with Proton Irradiation

### Tandem accelerator at the MLL Garching

- ▶ 20 MeV protons
- ▶ flux up to 100 kHz/cm<sup>2</sup>



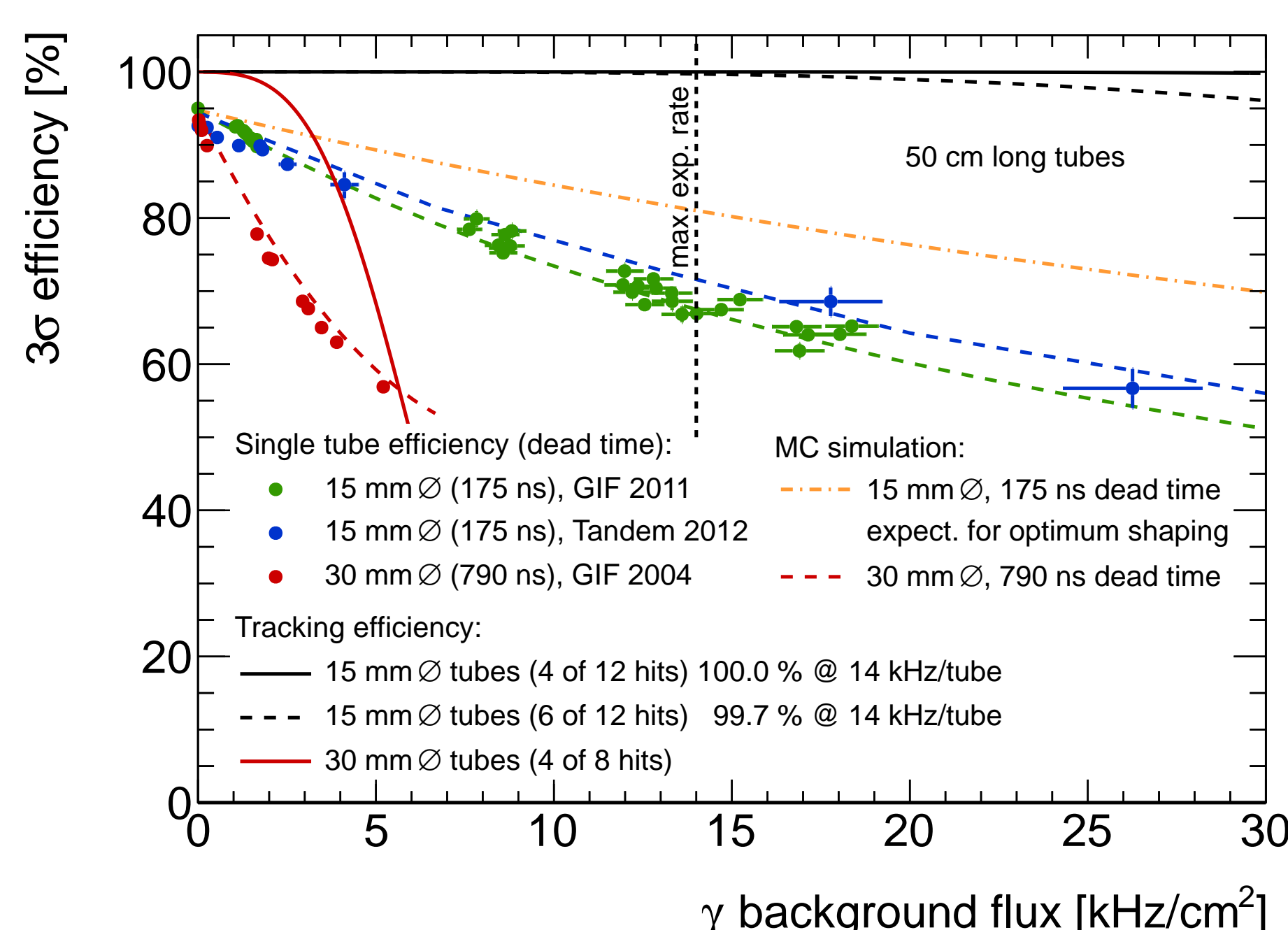
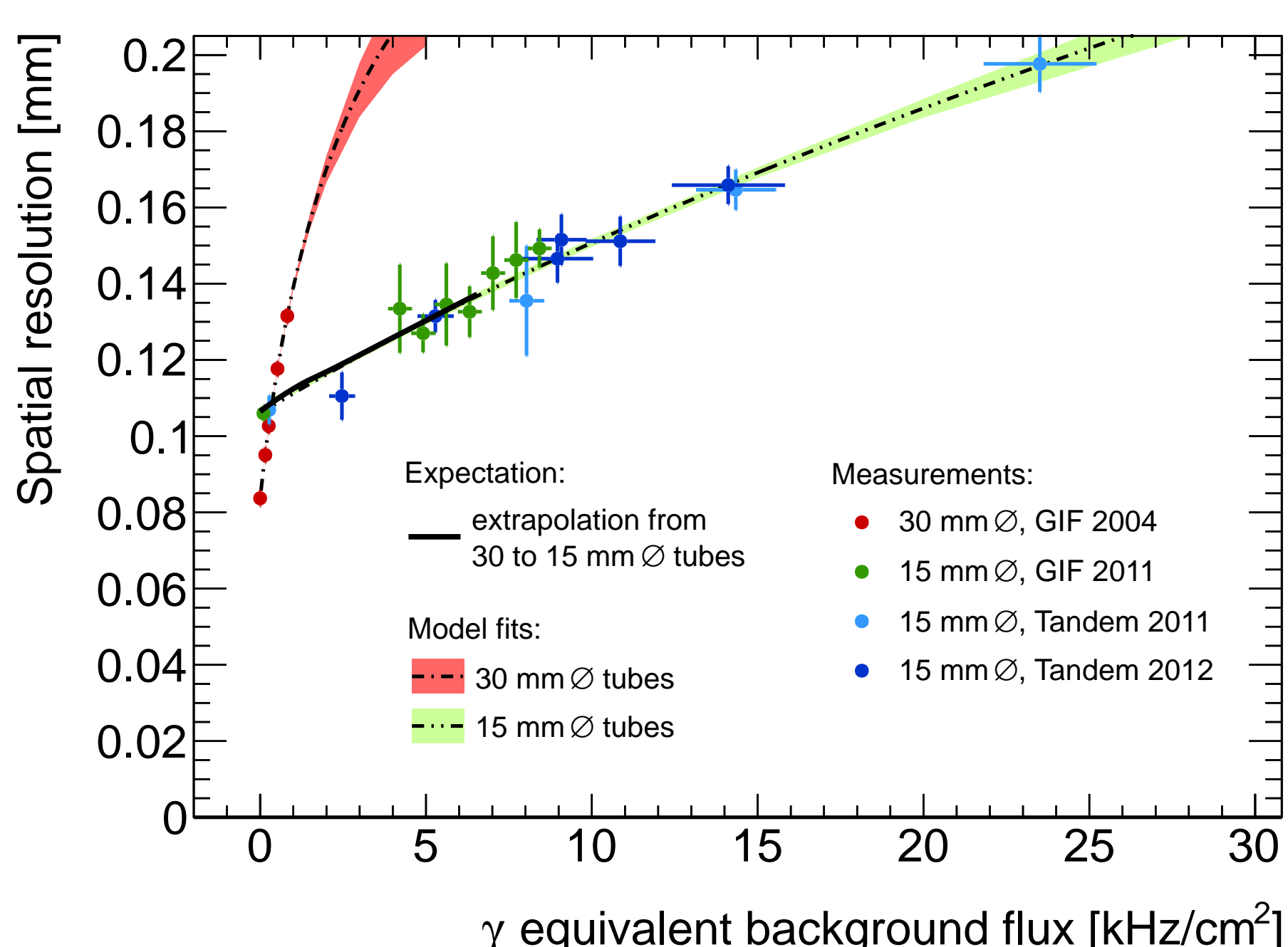
Using a custom sMDT chamber to maximize cosmic muon acceptance:

- ▶ Reconstruct cosmic muon tracks in upper and lower tube layers.
- ▶ Calculate off-track residuals in irradiated tube layer.
- ▶ Monitor proton rate and current drawn by the irradiated tubes for gas gain measurement.

## Full-sized sMDT prototype chamber



## Results



- ▶ Single-tube spatial resolution stays better than 150 μm up to the highest expected background flux of 14 kHz/cm<sup>2</sup>.
- ▶ 3σ single-tube efficiency at the maximum expected counting rate at HL-LHC of 1050 kHz/tube is higher than the one of the standard MDT chambers at their maximum ATLAS design rate of 300 kHz/tube (74%).
- ▶ Expect further improvement of the 3σ single-tube efficiency with new electronics with optimized shaping.
- ▶ Full efficiency up to a γ background flux of 50 kHz/cm<sup>2</sup> and still 70% at 100 kHz/cm<sup>2</sup>.