

Effects of a 20 MeV Proton Beam on Drift-tubes with 15mm Diameter

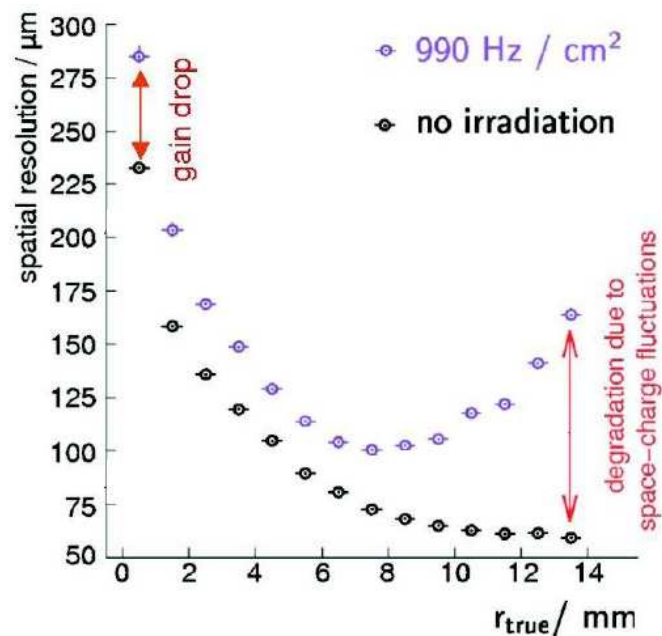
A. Zibell, O. Biebel, R. Hertenberger, A. Ruschke, C. Schmitt
Ludwig-Maximilian-Universität München

B. Bittner, J. Dubbert, H. Kroha, S. Ott, P. Schwegler
Max-Planck-Institut für Physik, München

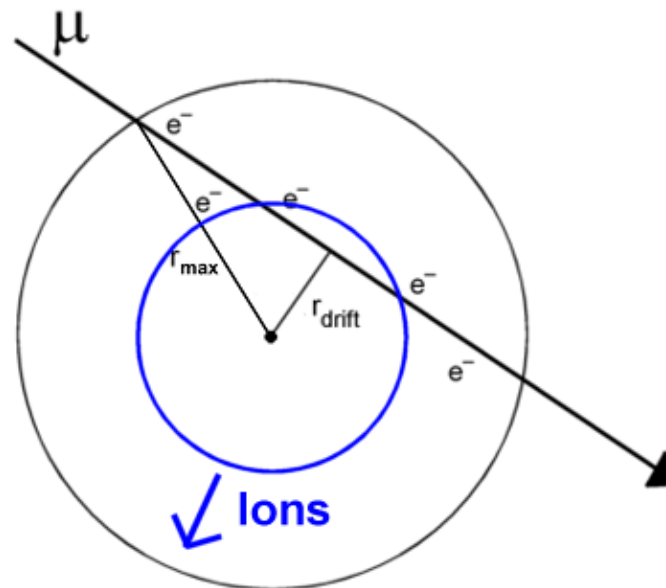
13th ICATPP Villa Olmo, 4.10.2011

Spatial Resolution at High Background Rates (High Luminosity LHC)

GIF 2005, 662 keV γ ,
30mm tubes



Space Charge Effects

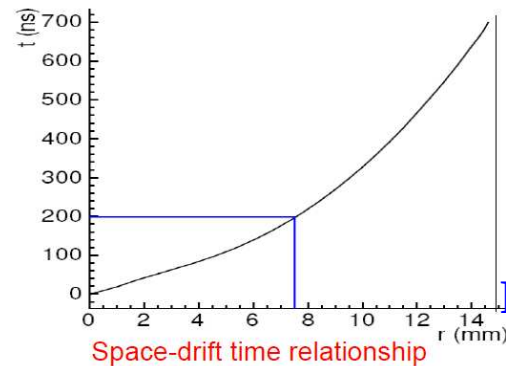
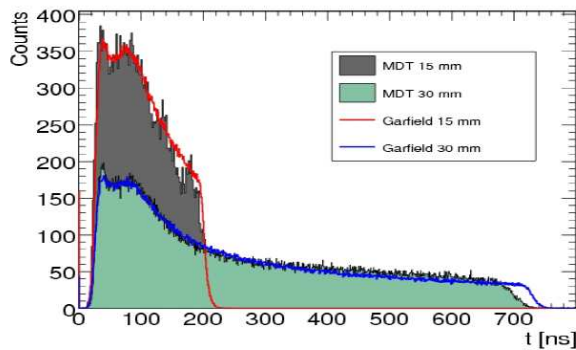


15mm tubes

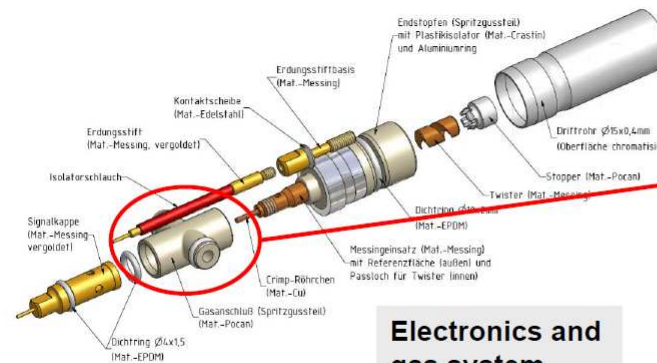
- $D_{\text{tube}} = 15 \text{ mm}$
- $D_{\text{anode}} = 50 \mu\text{m}$
- $U = 2730 \text{ V}$
- Ar:CO₂ 93:7
- 3000 mbar
- $t_{\text{max}} \cong 180 \text{ ns}$
- $t_{\text{Ion}} \cong 1 \text{ ms}$

15mm Drift Tubes

- Prototype chamber production at MPI Munich
- No mechanical or electrical problems with the higher tube density
- Full-scale prototype chamber with 1152 tubes successfully tested



Pictures: H. Kroha, MPI Munich



**Electronics and
gas system
interfaces**

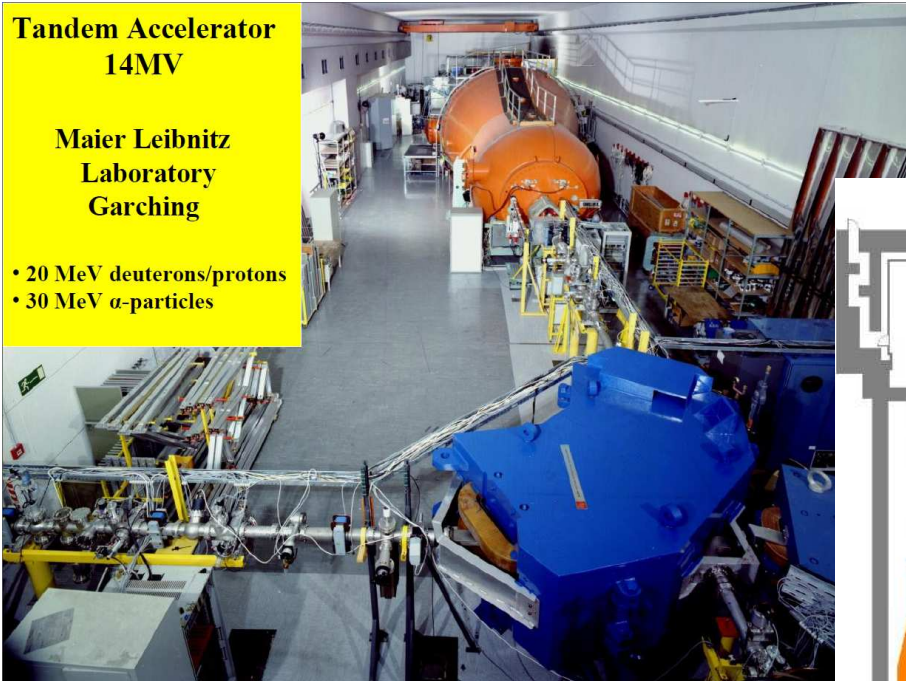


MLL Tandem Accelerator

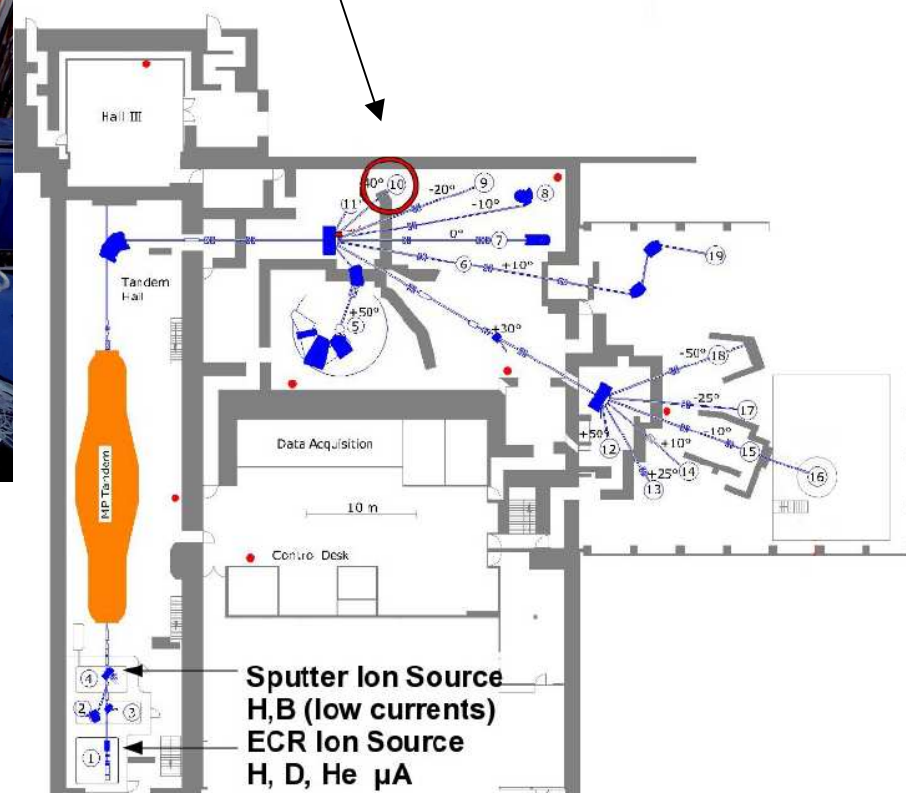
**Tandem Accelerator
14MV**

**Maier Leibnitz
Laboratory
Garching**

- 20 MeV deuterons/protons
- 30 MeV α -particles



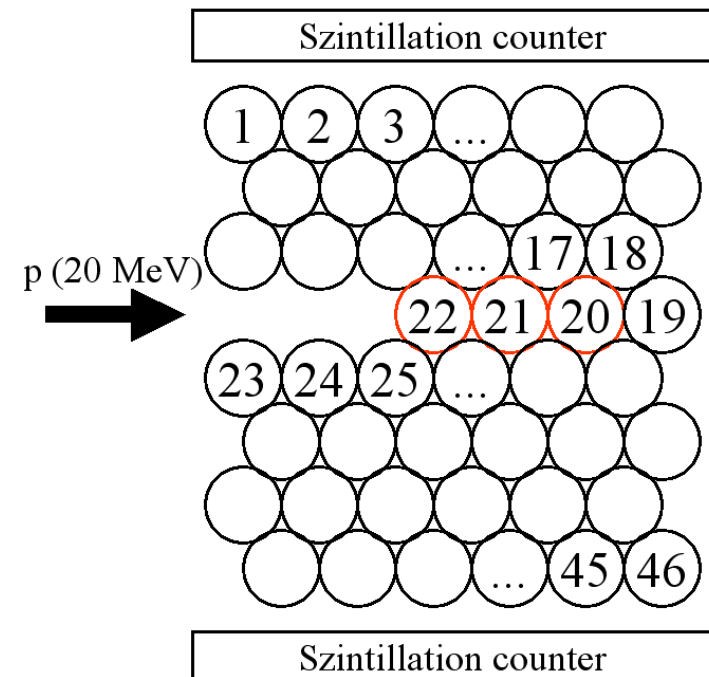
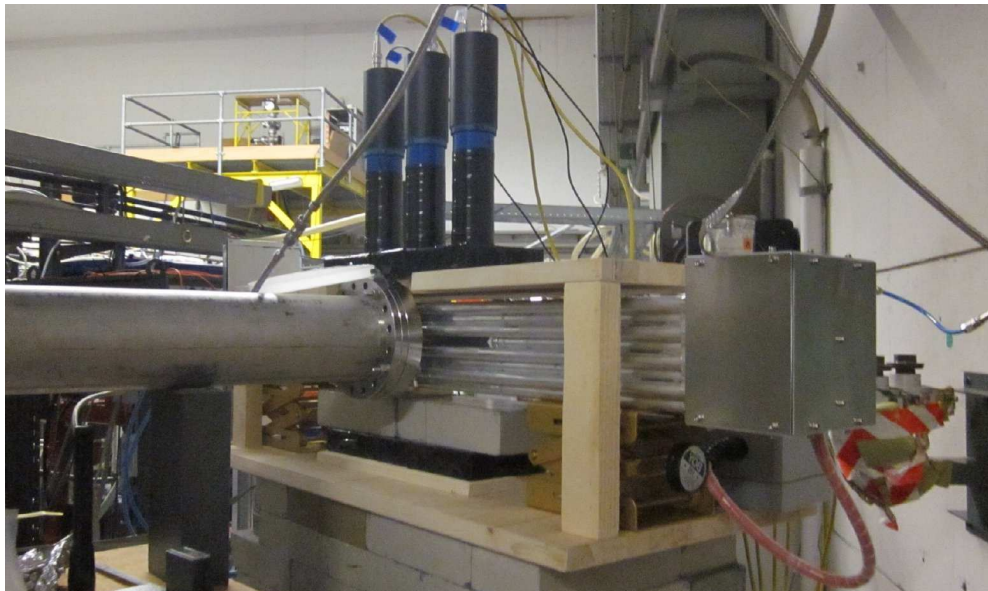
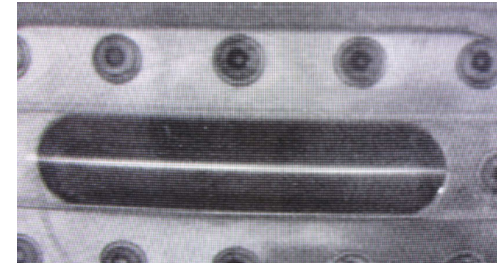
Experiment
location



Experimental Setup at Garching Tandem Accelerator

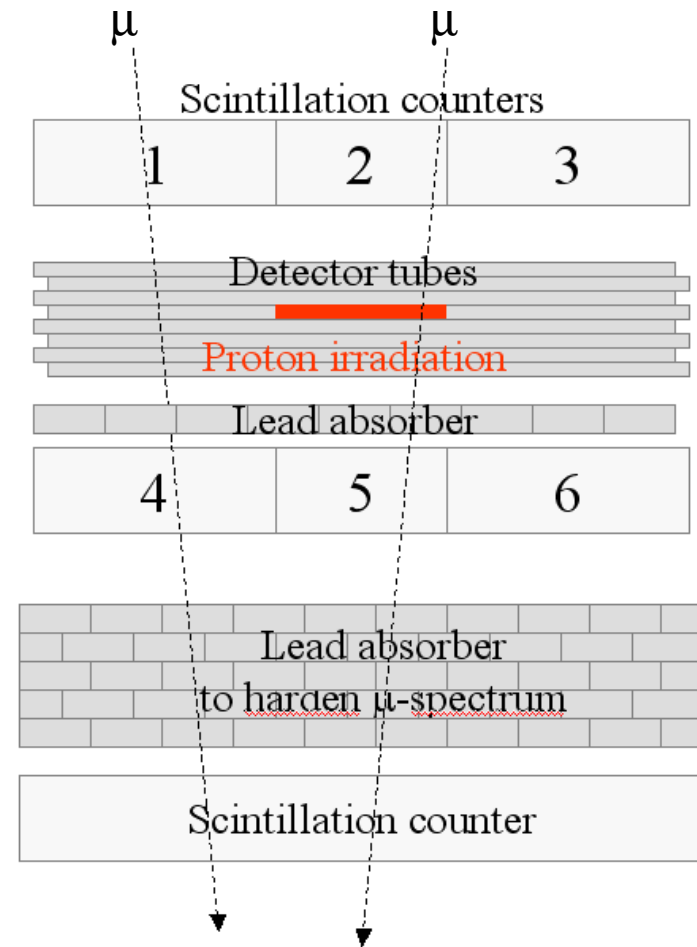
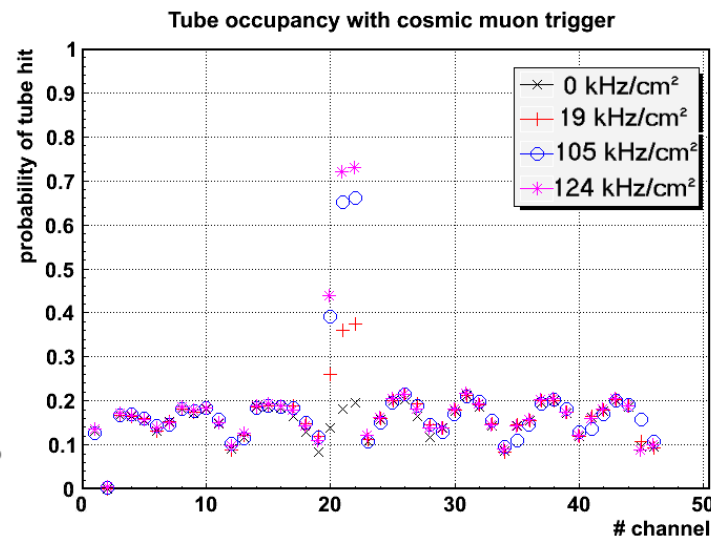
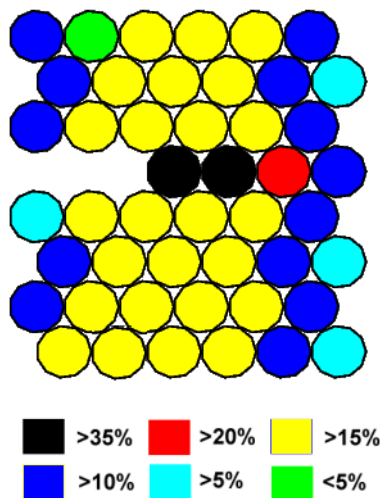
- Beam Spot $7 \times 0.5 \text{ cm}^2$ @800 Hz (Wobbler)
- $\Delta E_{\text{proton}} \cong 200 \text{ keV/tube}$
- $\text{Rate}_{\text{proton}} \cong 0 \text{ Hz}, \sim 200 \text{ kHz}, \sim 1100 \text{ kHz}, \sim 1300 \text{ kHz /tube}$
- $\text{Rate}_{\text{proton}} \cong 0 \frac{\text{kHz}}{\text{cm}^2}, 19 \frac{\text{kHz}}{\text{cm}^2}, 105 \frac{\text{kHz}}{\text{cm}^2}, 124 \frac{\text{kHz}}{\text{cm}^2}$

70 mm, 800 Hz



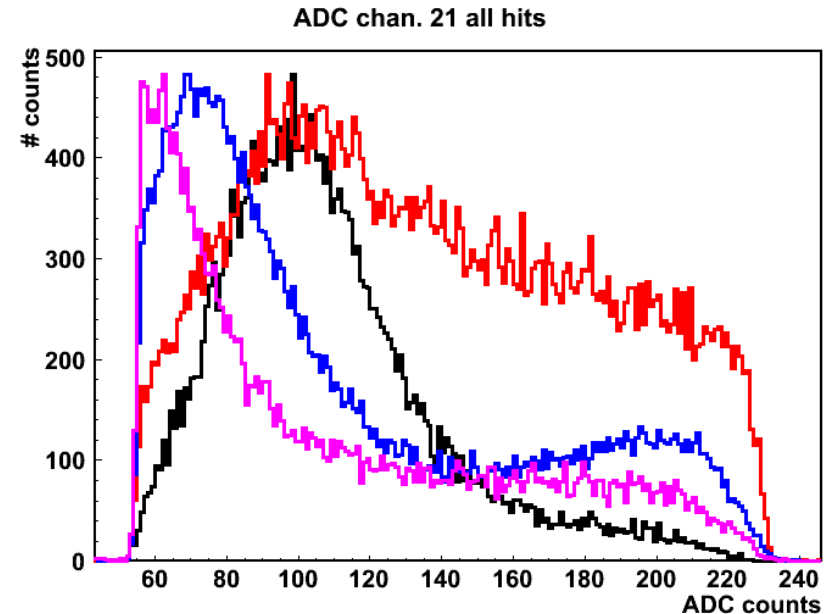
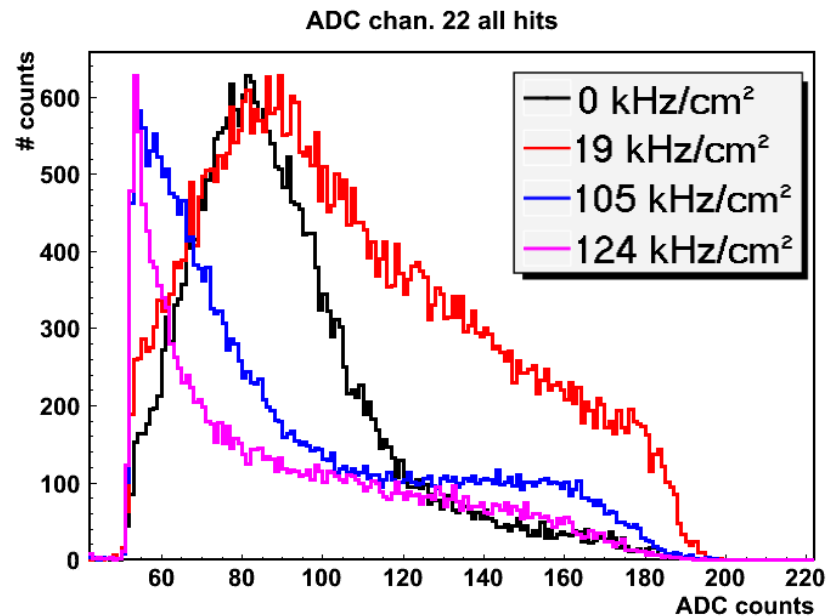
Experimental Occupancy Distributions

- Three-fold muon trigger scintillators to identify tracks through the irradiated area
(Scintillator combinations 1-6, 2-5, 3-4)
- Only the fourth layer is hit by protons



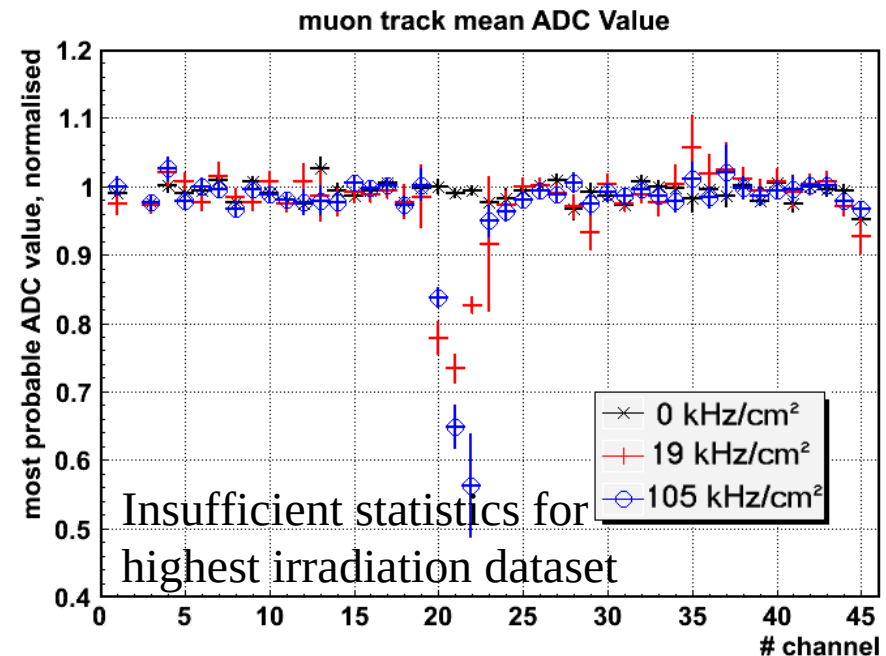
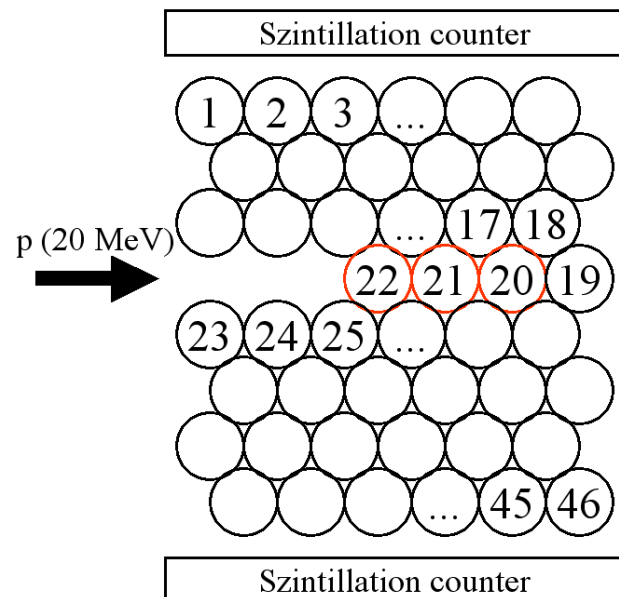
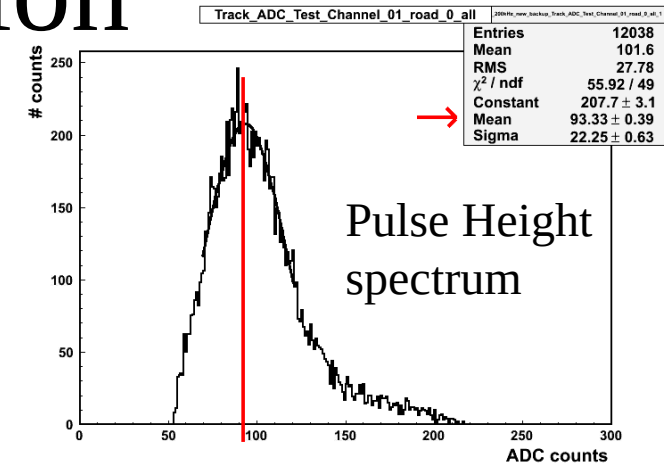
Pulse Height under Irradiation

- Landau-like Signal height distribution for muons @no irradiation
- High proton signals at 19 kHz/cm² kHz irradiation (non-linear ADC-scale), muon peak position unchanged
- Shift of whole spectrum at highest rates, drop of gas amplification due to **space charge effects**



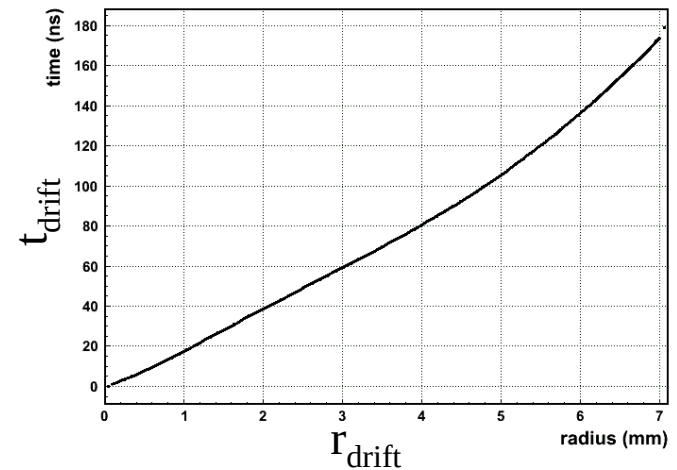
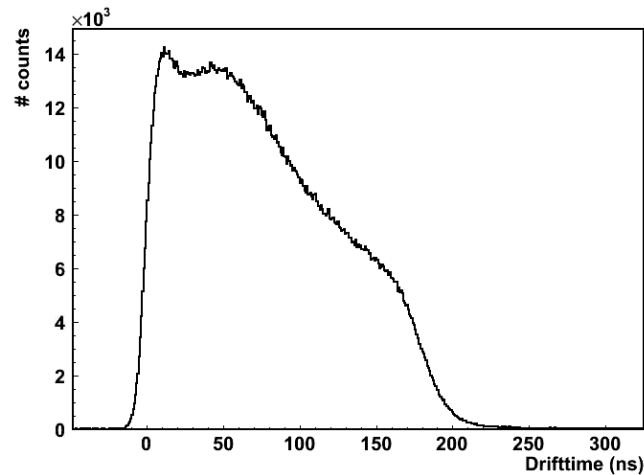
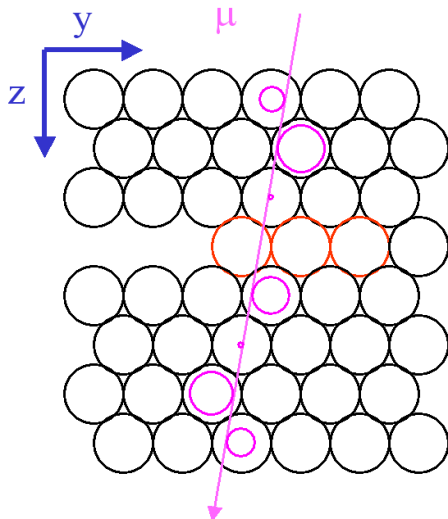
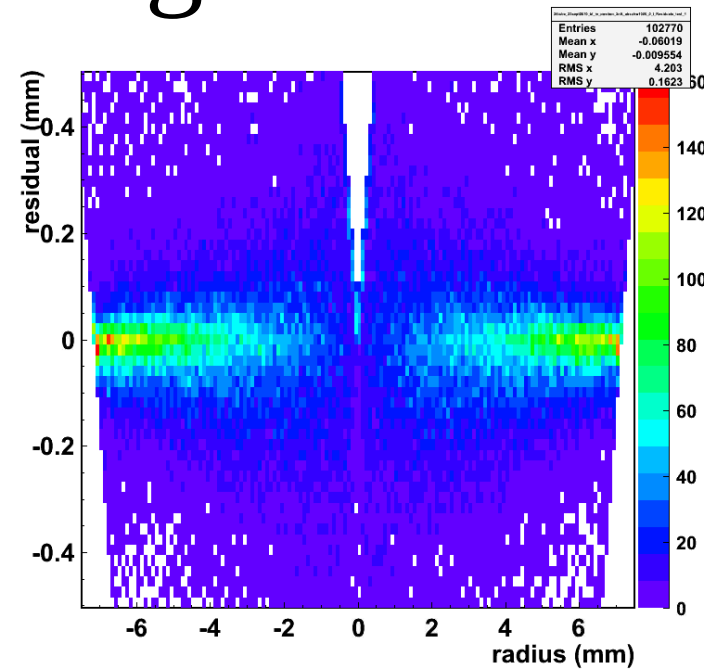
μ -ADC Values for μ -Tracks under Irradiation

- ADC Values for reconstructed muon tracks
- Position of most probable value in ADC spectrum defines gas gain
- Normalised to non-irradiated tube section



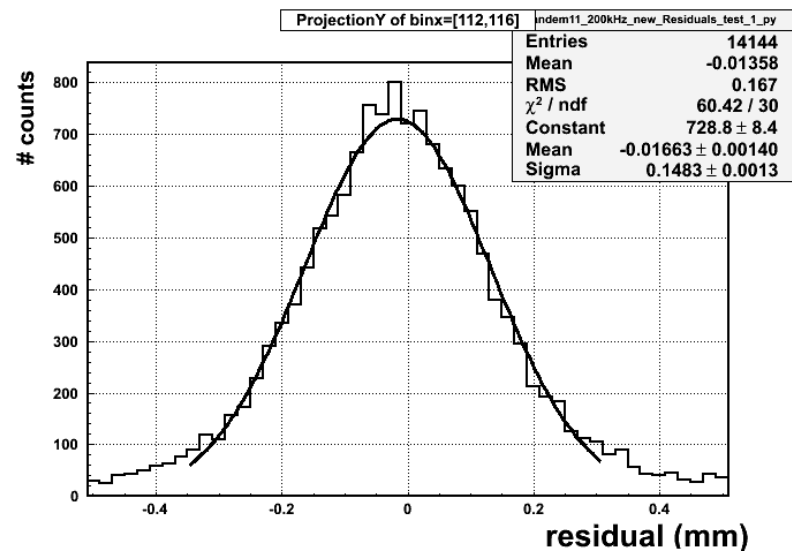
Muon Tracking

- no proton irradiation
- $y = a * z + b$
- Track: 7 layers in Fit, $\chi^2/N_{df} < 10$
- Residual = (track distance - measured radius)

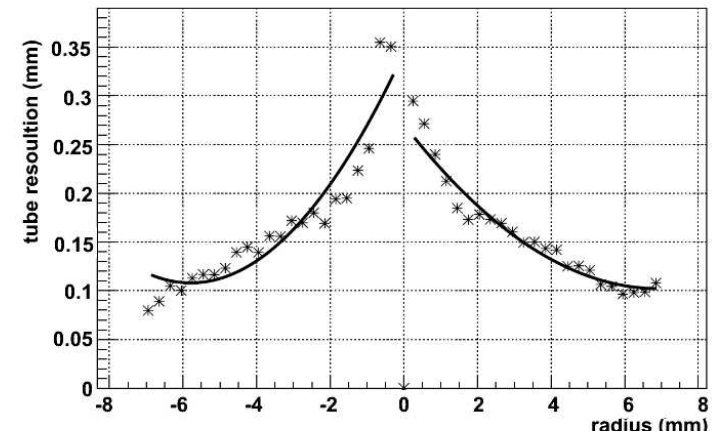


Spatial Resolution

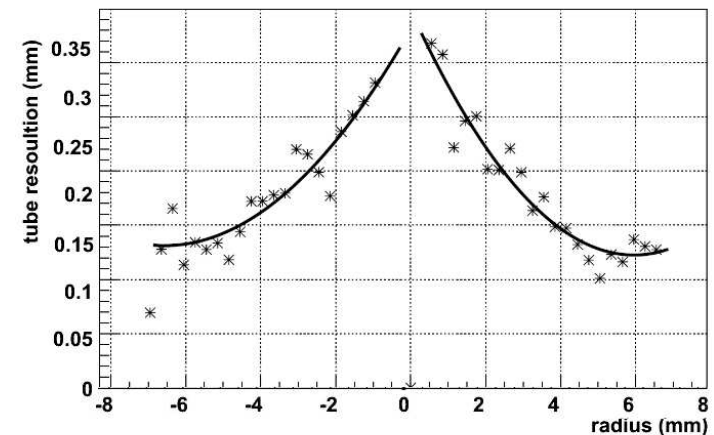
- Determination of spatial resolution:
 - Slice in residual distribution
 - Gaus fit to slice -> Sigma
 - subtract error of track prediction
- No significant change in spatial resolution with and without irradiation



Average Tube resolution @0 kHz/cm²

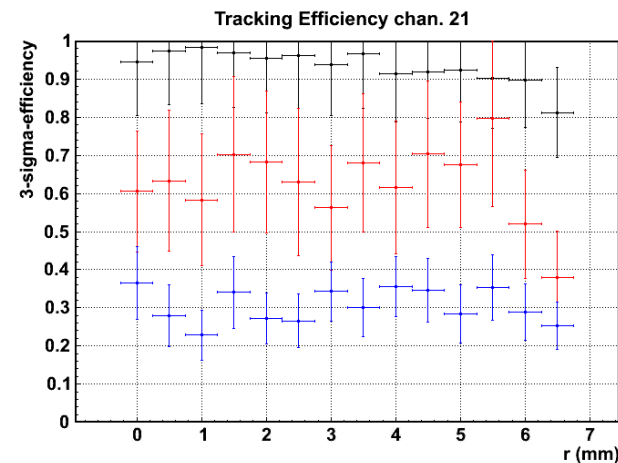
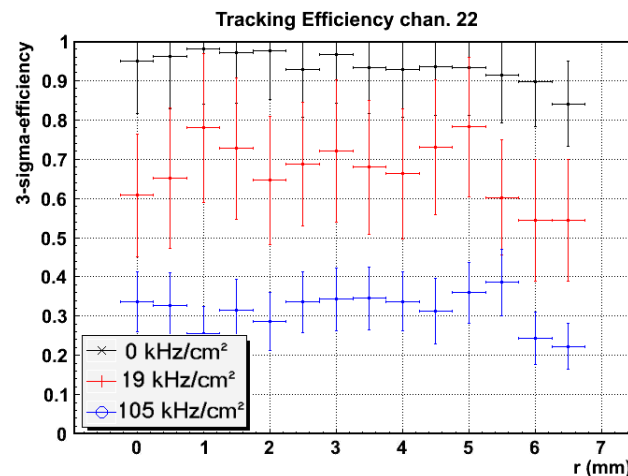
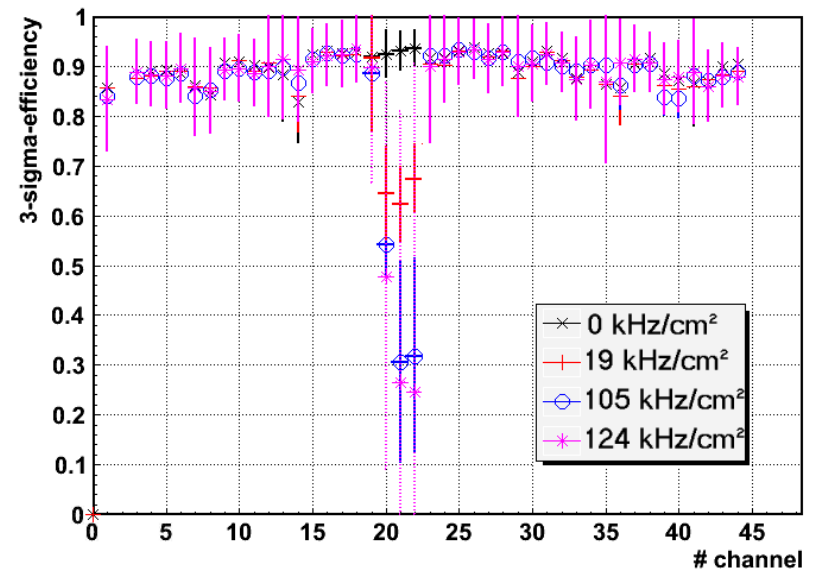


Average Tube resolution @19 kHz/cm²

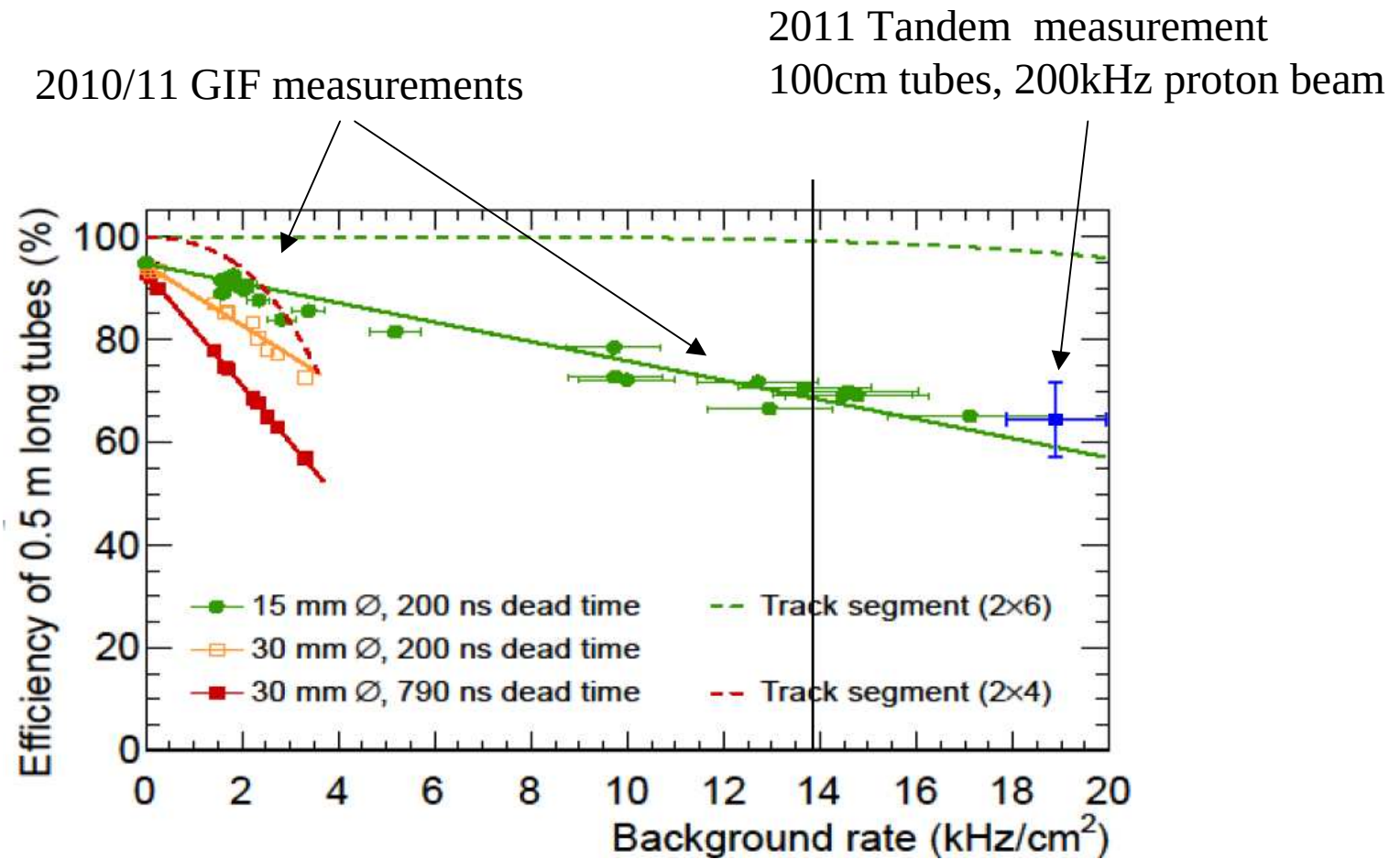


Efficiency of irradiated tubes

- Compare μ -Track prediction through 7 non-irradiated layers with drift radius in irradiated layer
- 3-sigma-efficiency: percentage of hits with residual smaller than 3 times the spatial resolution
- Efficiency drops with higher proton rates
- Possible reasons: space charge fluctuations, electronic deadtime



Comparison of measurements



Picture: H. Kroha, MPI Munich

Summary

- Garching MLL Tandem accelerator: 20 MeV proton beam to simulate high luminosity LHC environments.
- 200 kHz irradiation equals $\sim 19 \text{ kHz/cm}^2$, about two times the expected hit rate expected at high luminosity LHC. The higher irradiations used exceed this rate by a factor of 10 – 12.
- Irradiation shifts ADC spectrum to lower values due to space-charge effects.
 19 kHz/cm^2 : $\sim 20 \%$ effect.
- Minor effect on spatial resolution at 19 kHz/cm^2 .
- A chamber of multiple layers of 15mm tubes delivers a sufficient muon tracking efficiency for ATLAS.
Track segment efficiency $> 95 \%$ @ 19 kHz/cm^2
 $> 99 \%$ @ 10 kHz/cm^2 (High luminosity LHC)
- The results are in agreement with the results of measurements at the Gamma Irradiation Facility @CERN.