CBM-TRD High-Rate Detector Tests at the CERN-GIF

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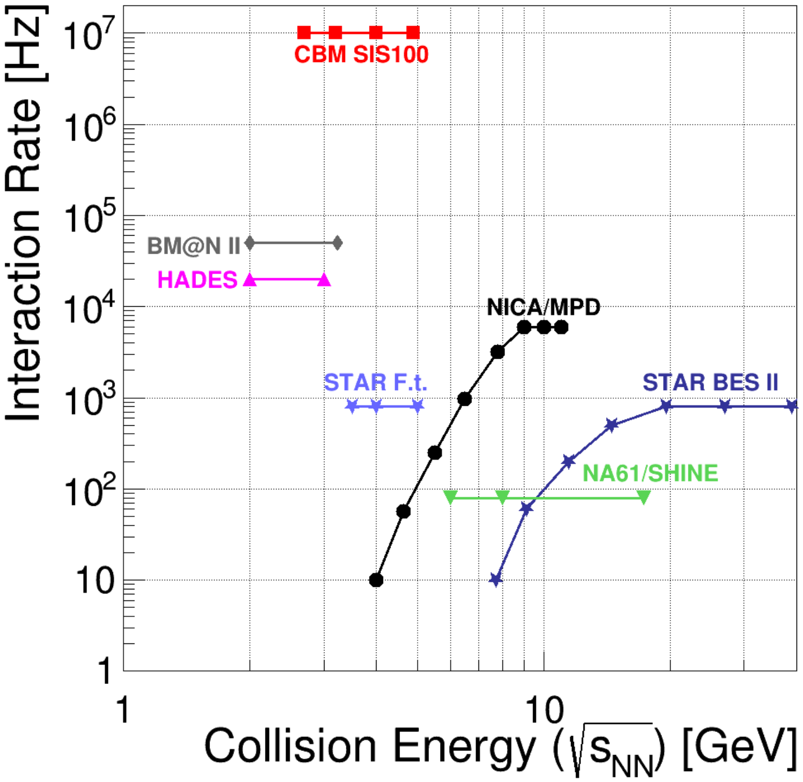
CBM Physics – Rates

Heavy-ion interaction rates up to 10 MHz. Access to rare observables, probing the medium with a new level of precision:

- Low-mass vector mesons by di-lepton pair reconstruction
- Excitation functions of multi-strange hyperons near expected phase boundary (e.g. $\overline{\Omega}^{+}$/week: $\sim 10^5$ @ $\sqrt{s_{\mathrm{NN}}} = 3.5$ GeV)
- Access to collective flow of multi-strange hyperons
- Single and double hyper-nuclei programme, including discovery potential
- Critical point search using event-by-event fluctuations of conserved quantities



CBM Subsystems

STS
Silicon Tracking System*

MVD
Micro Vertex Detector*

* magnetic field

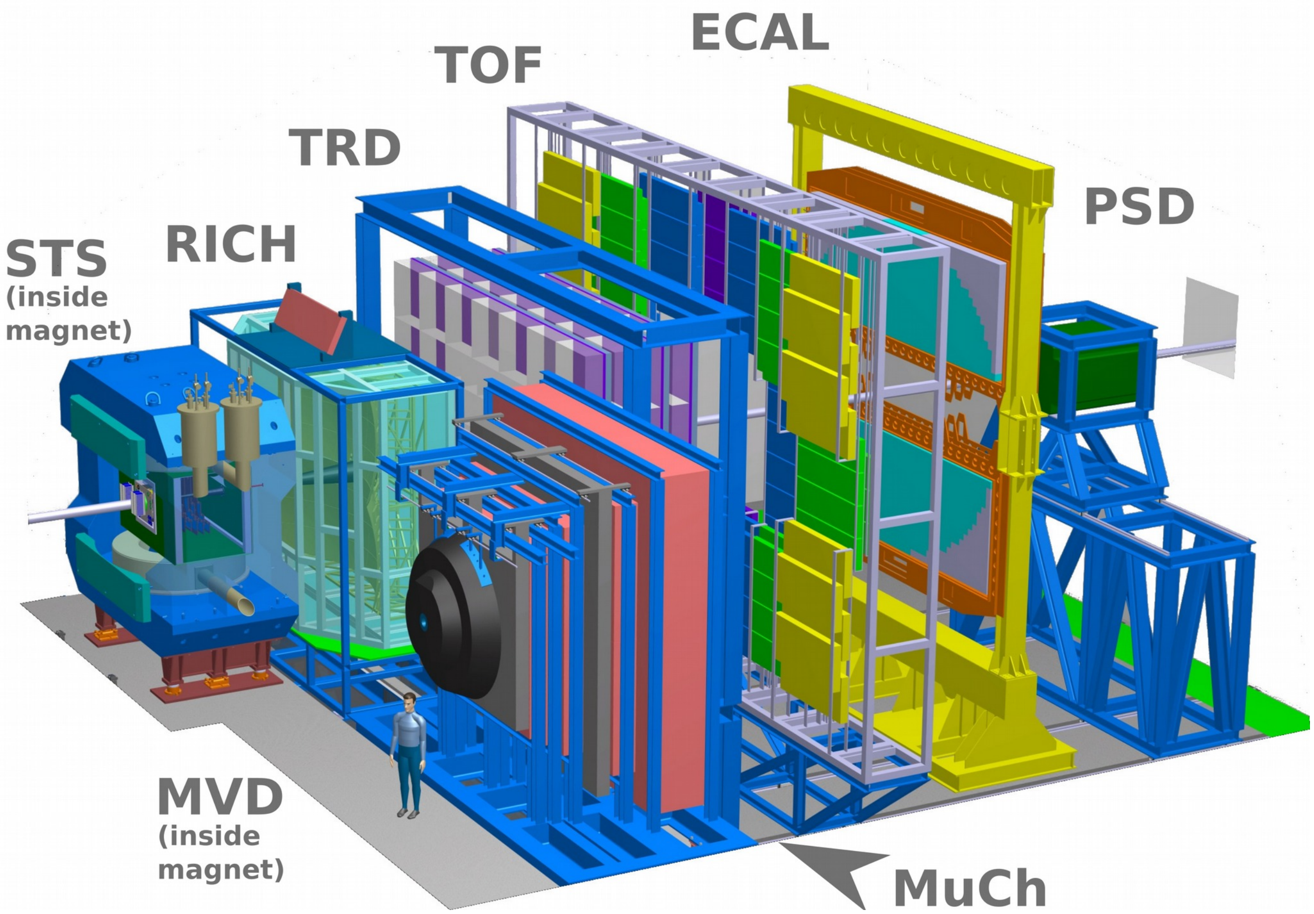
MuCh or RICH
MuonChamber System/
Ring Imaging Cherenkov Detector

TRD
Transition Radiation Detector

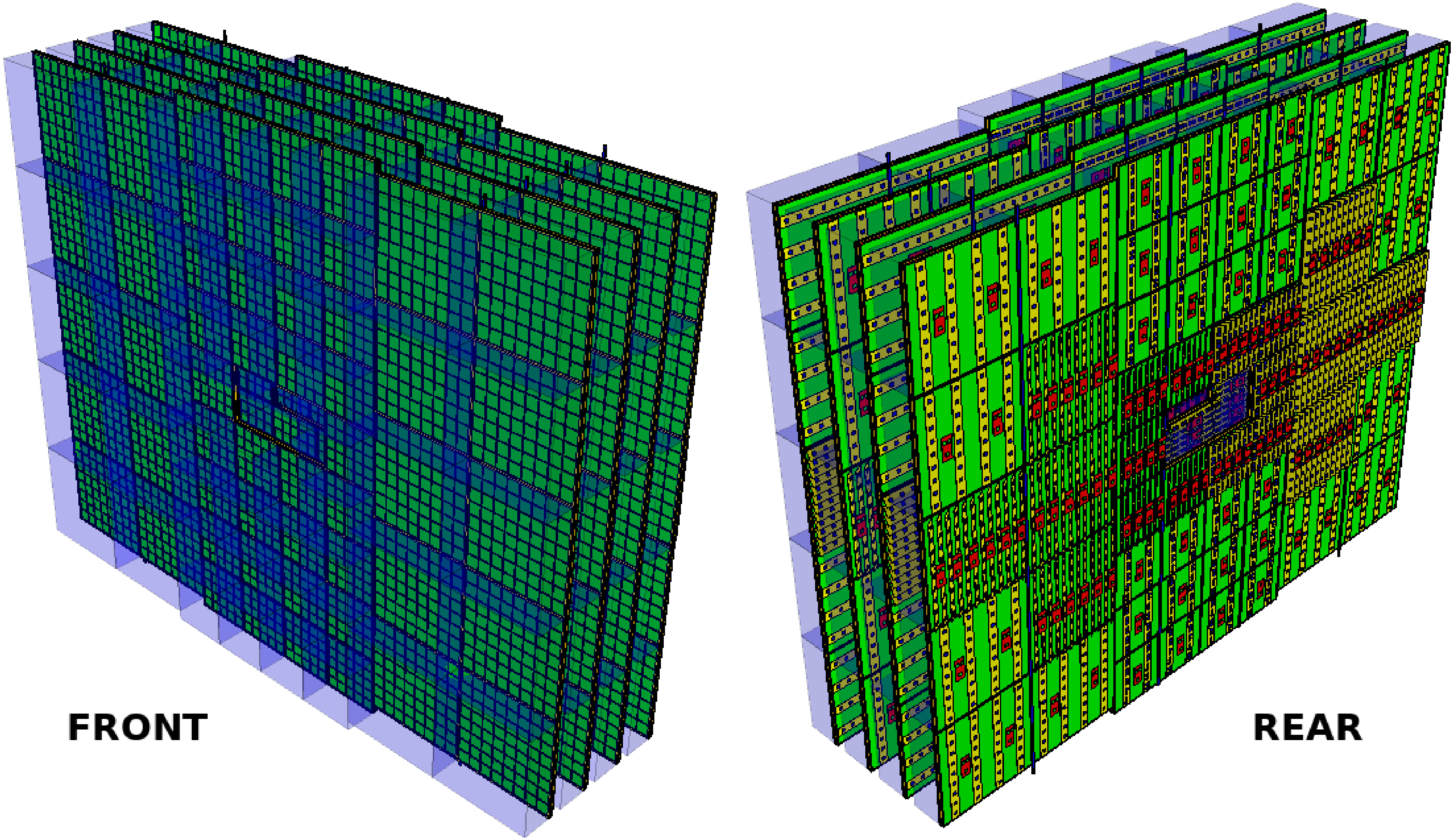
ToF
Time-of-Flight Detector

ECAL
Electromagnetic Calorimeter

PSD
Projectile Spectator Detector



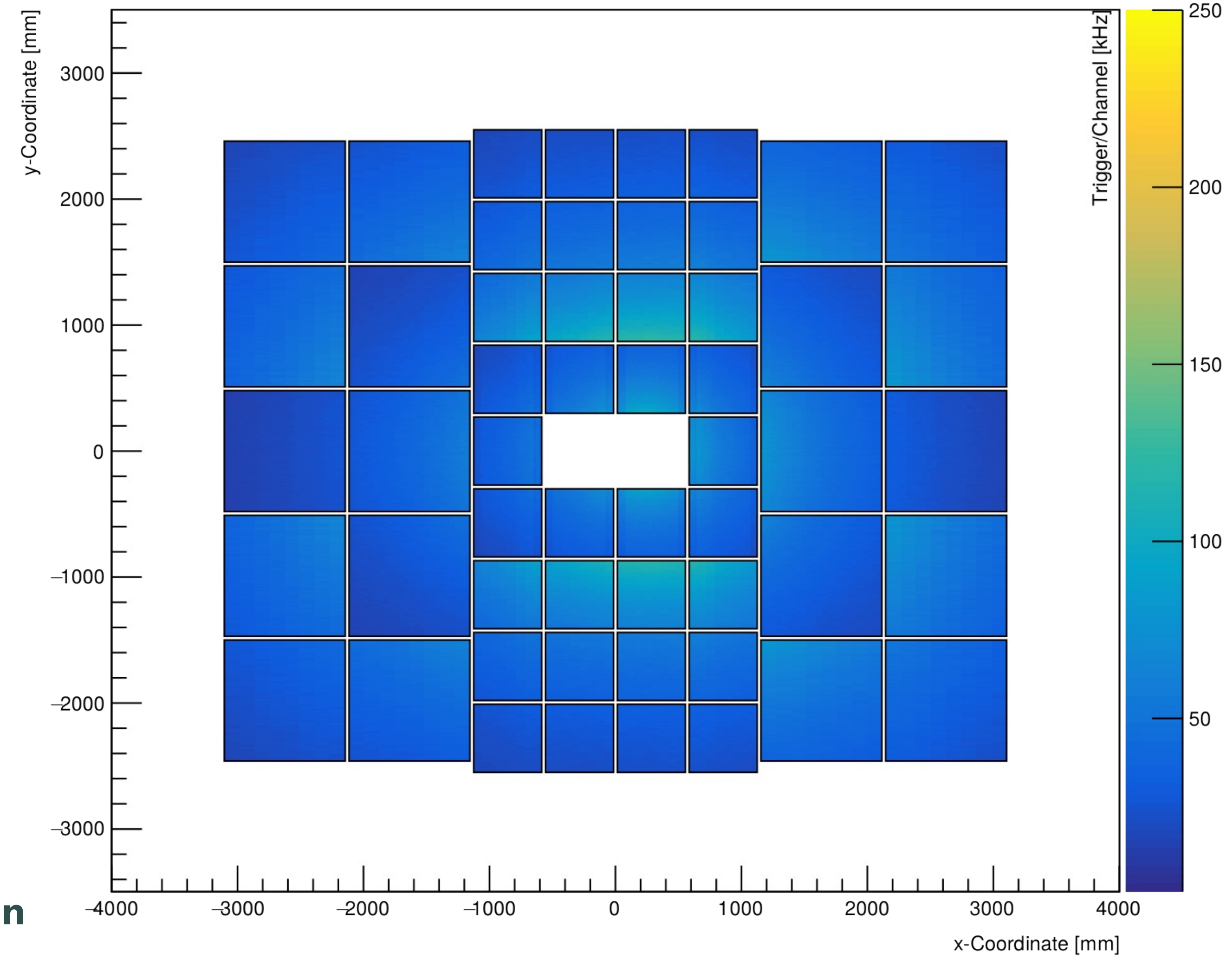
TRD in CBM



Radiator PE-foam **Detector** MWPC, symm. amplification + drift, cathode-pad readout, Xe/CO_2 85:15
Max Acceptance $1.15 < \eta < 3.65$, 2π **Readout** ~330k channel, self-triggered

TRD Hit Rates

- **TRD cathode pad granularity is scaling with local hit rates**
  - 1.2 cm^2 (central modules) up to 8 cm^2 (peripheral modules)
  - Balancing self-trigger rates
- **Simulation of trigger rates per TRD layer**
  - UrQMD, Au+Au min. bias, 10 *A*GeV collision energy
  - Interactions with detectors and support material included by GEANT3
  - Average of 40 kHz / channel, but peaking > 100 kHz / channel
- **Rate requirements to DAQ chain**

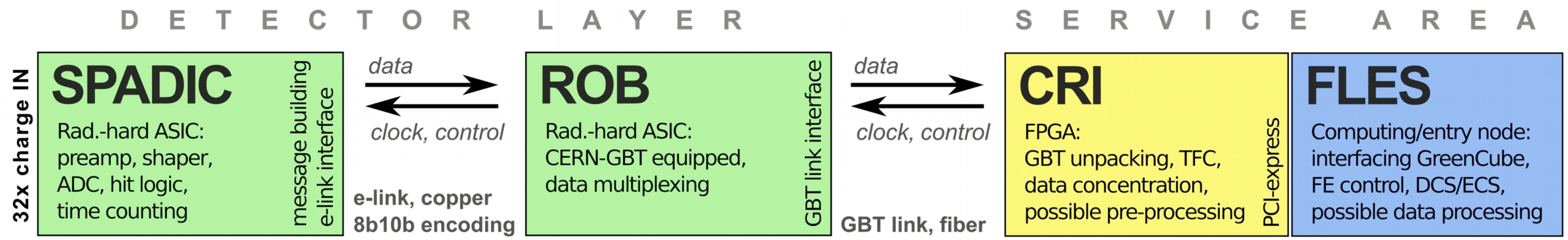


Raw Data Rates and Feature Extraction

- **Front-end message building: rate checks performed**

- **Raw data from front-ends scaling with trigger-rate (free-streaming)**
  - Own SPADIC data format, data per hit varying with: nr. of samples, neighbour-pad readout
  - 7 samples → 96 bit per triggered pad (self or forced-neighbour) plus below 3% higher-level timing information
  - For all ~330k TRD readout channels: up to 1.3 TBit/s of raw data

- **Feature extraction on FPGA level for live reduction in preparation**
  (F. Roether, HK 24.2 … Tuesday)



MWPC Chamber Load

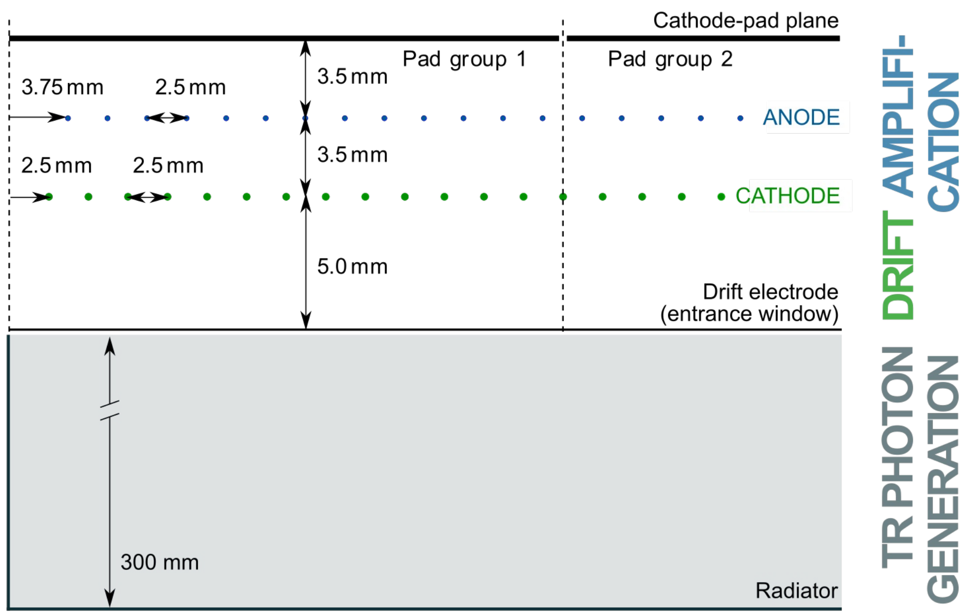
- **Load of the MWPC (gas amplification) characterised by anode currents**
  - Exclusion of space-charge effects to ensure constant gas gain

- **Currents can be calculated from the ionisation process**
  - Per length of anode wire: up to j_w = 3.3 nA / cm expected

$$j_w = n \cdot \epsilon_{\mathrm{MIP}} \cdot k_{\mathrm{particle}} \cdot L \cdot W_{\mathrm{XeCO_2}}^{-1} \cdot G \cdot e \cdot \lambda^{-1}$$

with

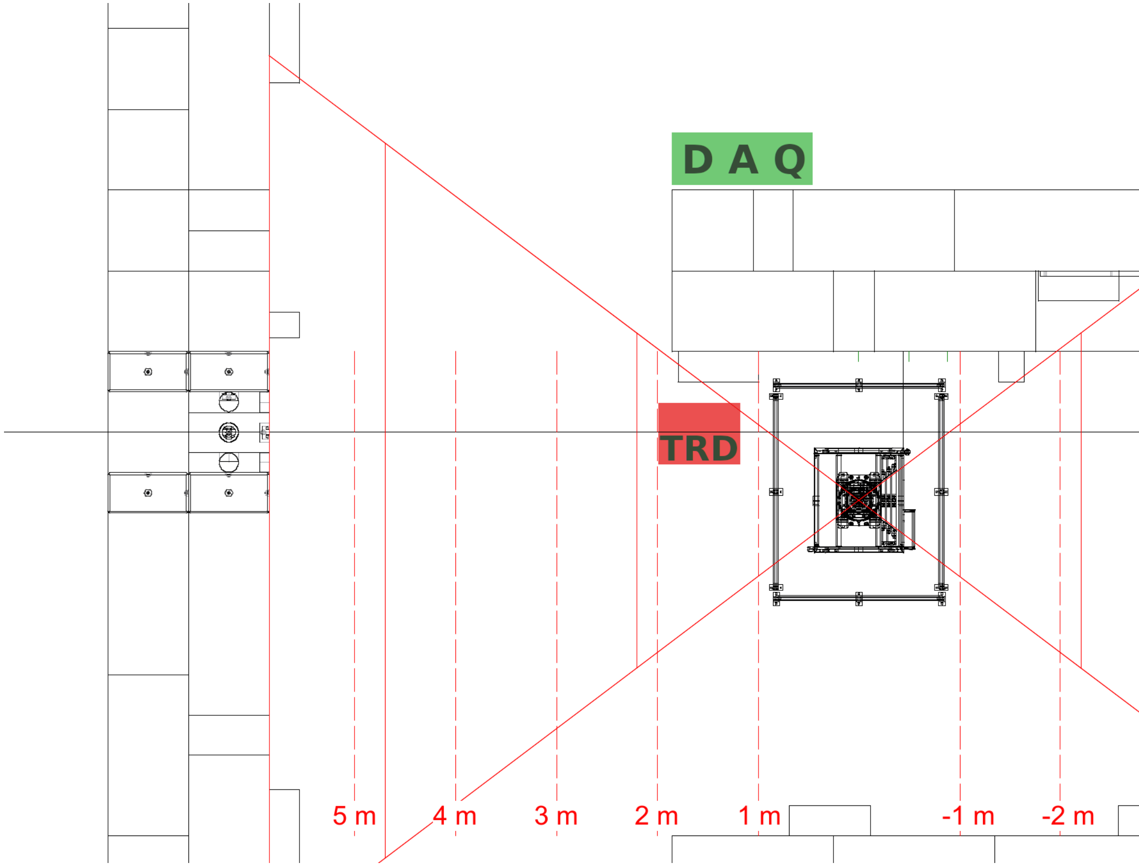
Variable	Value	Interpretation
n	100 kHz cm^{-2}	Track rate density
ϵ_{MIP}	5 keV cm^{-1}	Energy loss of minimum-ionising particle
k_{particle}	1.5	Factor from minimum ionisation to mean energy loss
L	1.2 cm	Track length in active volume (straight case)
$W_{\mathrm{XeCO_2}}$	22 eV e^{-1}	Ionisation work per electron
G	2000	Gas amplification
e	$1.6 \cdot 10^{-19}$ C	Elementary charge
λ	4 cm^{-1}	Anode wire length per area



Test Setup at the CERN Gamma Irradiation Facility

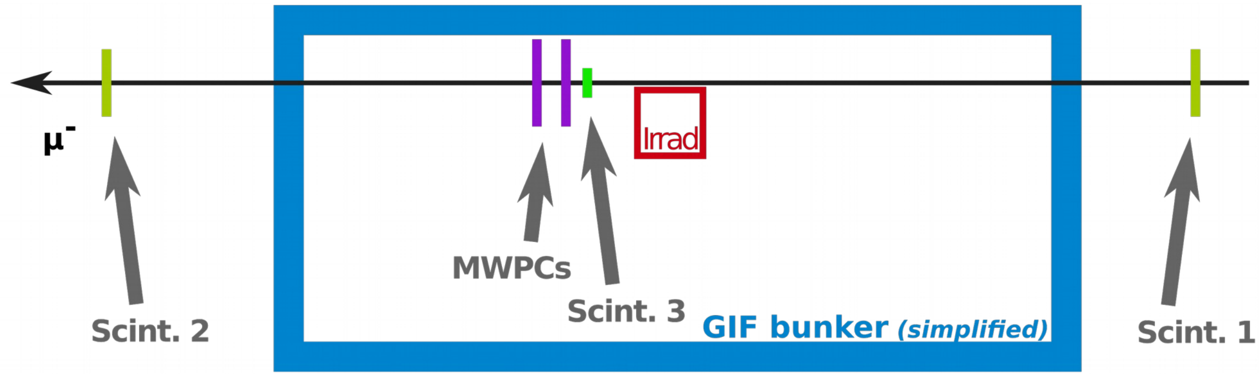
- **^{137}Cs source, 14 TBq**
  - Gamma emission of 662 keV
  - Compton scattering:
    E_{e-} (180°) = 478 keV (upper edge)
    $E_{\gamma'}$ (180°) = 184 keV (lower edge)
    and continuing interactions
  - Attenuation system
    for variable irradiation levels,
    but comparable γ spectra

- **μ beam, up to 100 GeV**
  - Scintillator system for μ tagging



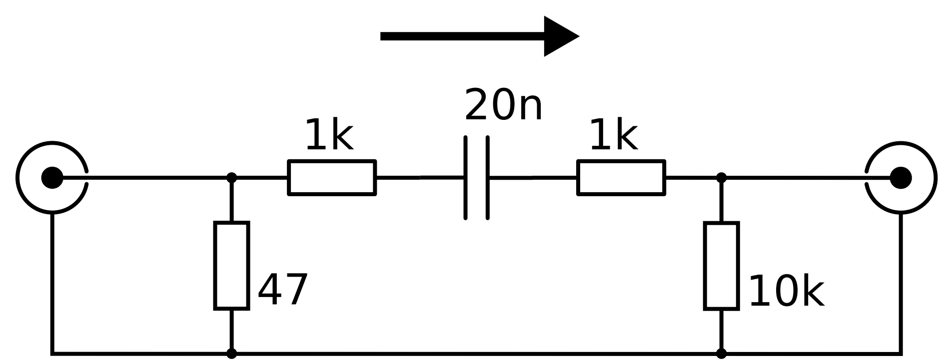
Beam Coincidence Signal

- **Scintillators in μ beam**
  - Scint. 1 and 2 outside the GIF cave
  - Scint. 3 directly matching TRDs
- **Coincidence on NIM electronics**
  - Twofold: *Coinc = Scint. 1 & Scint. 2*
  - Threefold: *Coinc & Scint. 3*



- **Integration of coincidence signals via signal adaption and SPADIC into CBM-DAQ**

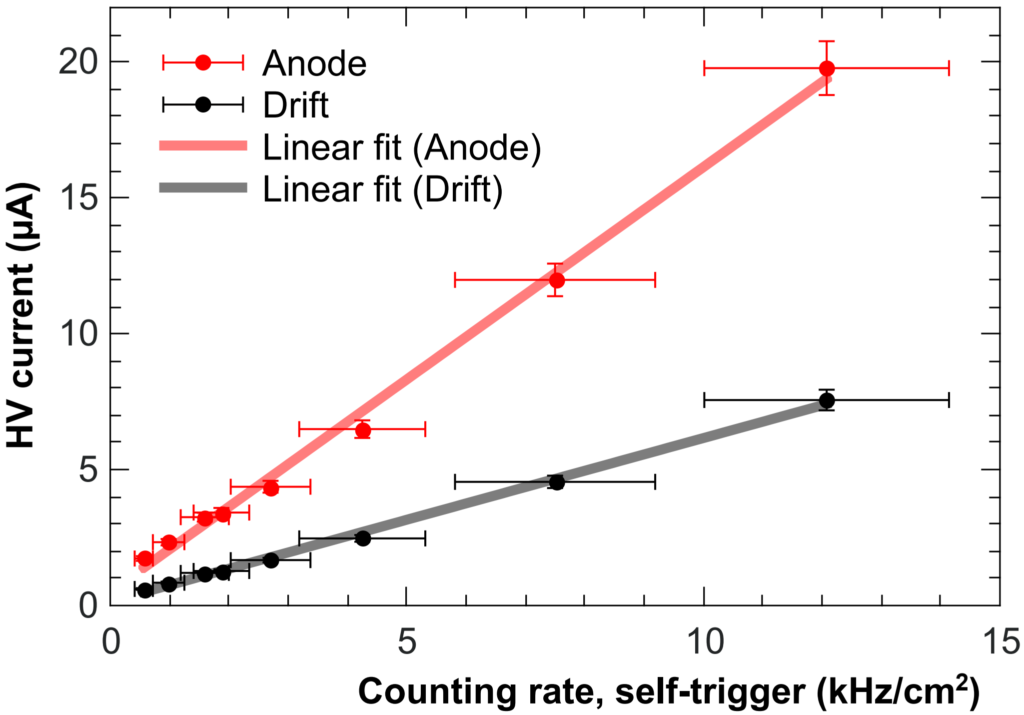
- ***Outlook*: μ efficiency determination, ongoing analysis**



NIM signal adaption to SPADIC front-ends

MWPC Load Linearity

- **Hit rate determined from front-end data, counting of self-trigger (threshold ~ MIP)**
- **Anode and drift currents from HV supply of MWPC**
- **Drift and anode currents compatible with linear scaling**
- ***Ongoing*: mean ionisation per event to be checked against expectation**



Conclusions

- **Self-trigger rate capabilities of SPADIC front-ends checked in measurements and simulation**
- **Feature extraction methods for data reduction live in DAQ chain currently in evaluation**
- **High MWPC loads measured at the CERN-GIF, current scaling compatible with linearity**
- ***Evaluation of μ detection efficiency in different loads is ongoing work***

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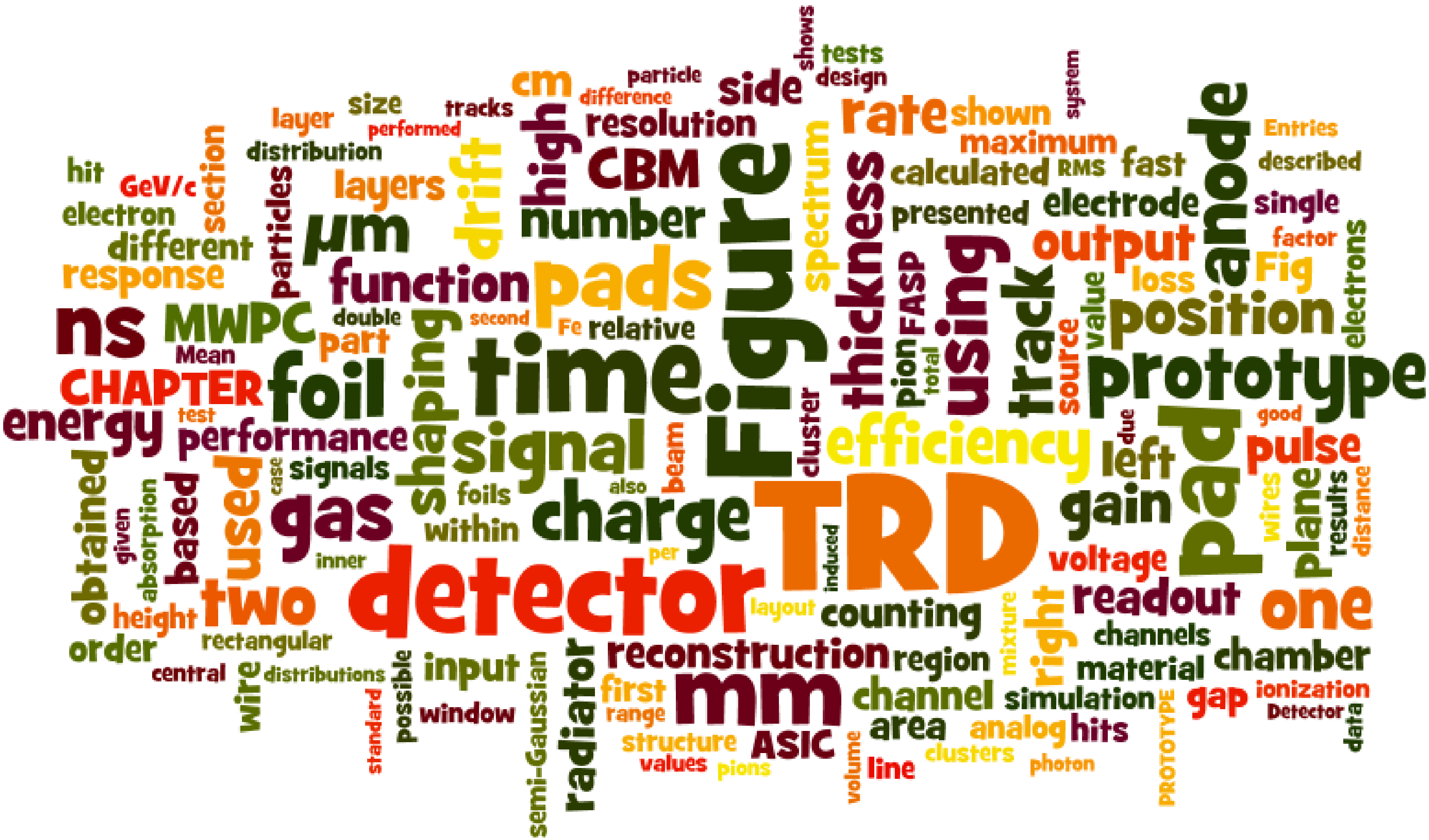
… thanks for your attention, a safe trip home!

FAIR-SIS100 working site, February 2019

BACKUP



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