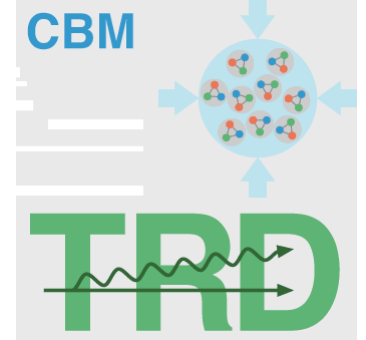




WESTFÄLISCHE
WILHELMS-UNIVERSITÄT
MÜNSTER



General Detector Concept

CBM-TRD TDR review
2017, March 14th

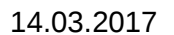
Cyrano Bergmann
WWU Muenster, Germany
cyrano.bergmann@wwu.de



Bundesministerium
für Bildung
und Forschung

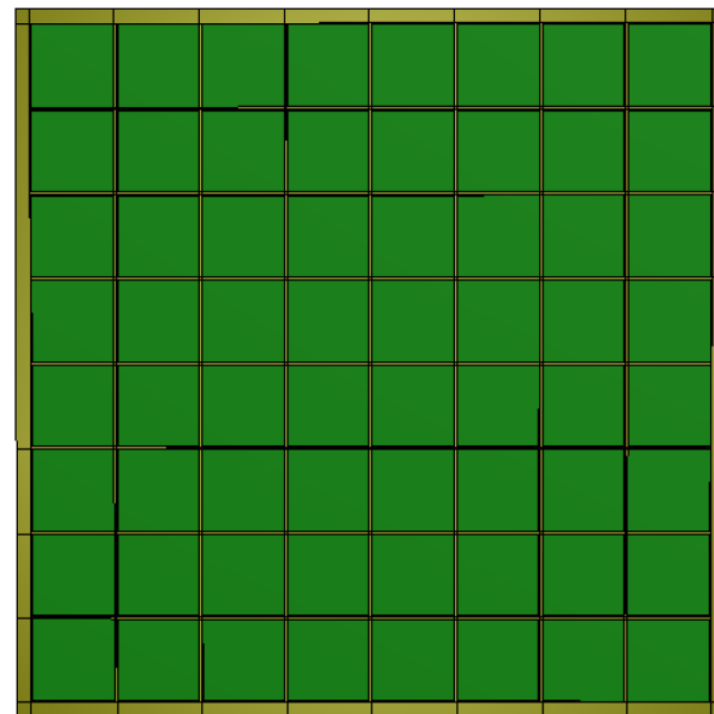
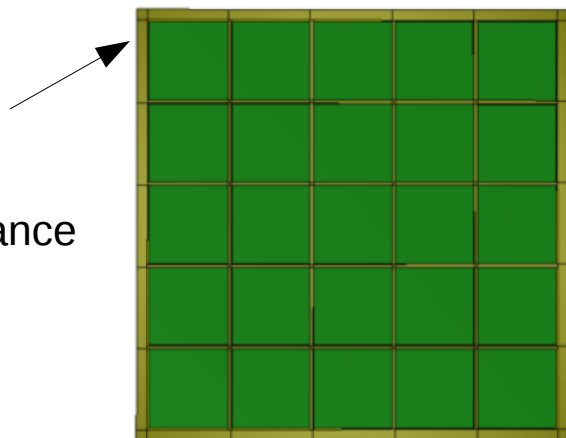


- **TRD Operation Principle**
- **TRD Components**
- **Setup Variants**
- **Detector Optimization process**
 - Trigger Rate
 - Occupancy
 - Wire Geometry
 - TR-Absorption
 - Signal Collection Time
- **Radiation Environment**
- **Material Budget**

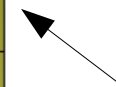


Two Module Sizes & Three Front End Boards

88.1%
acceptance

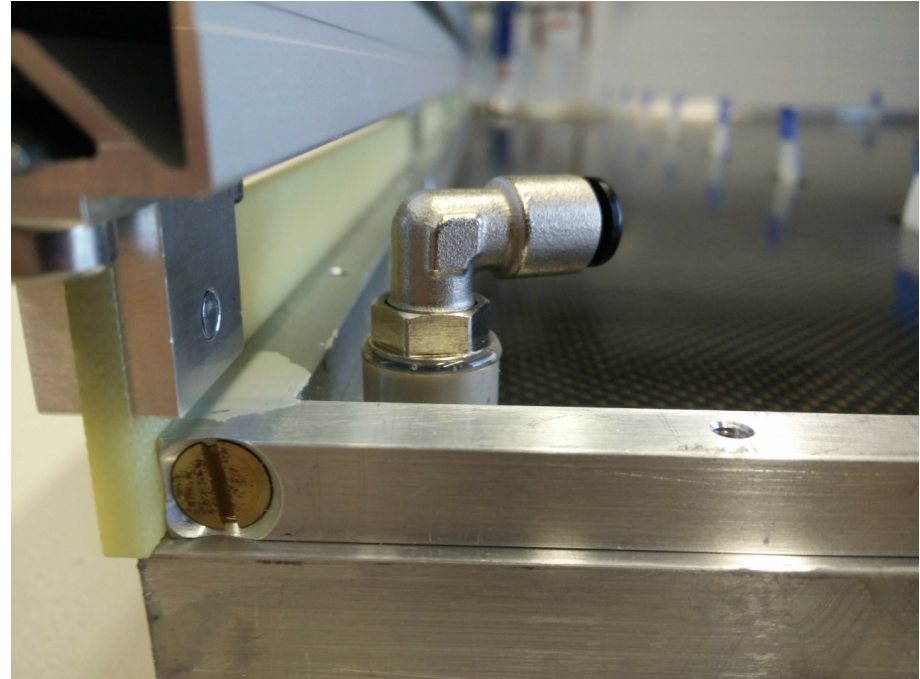
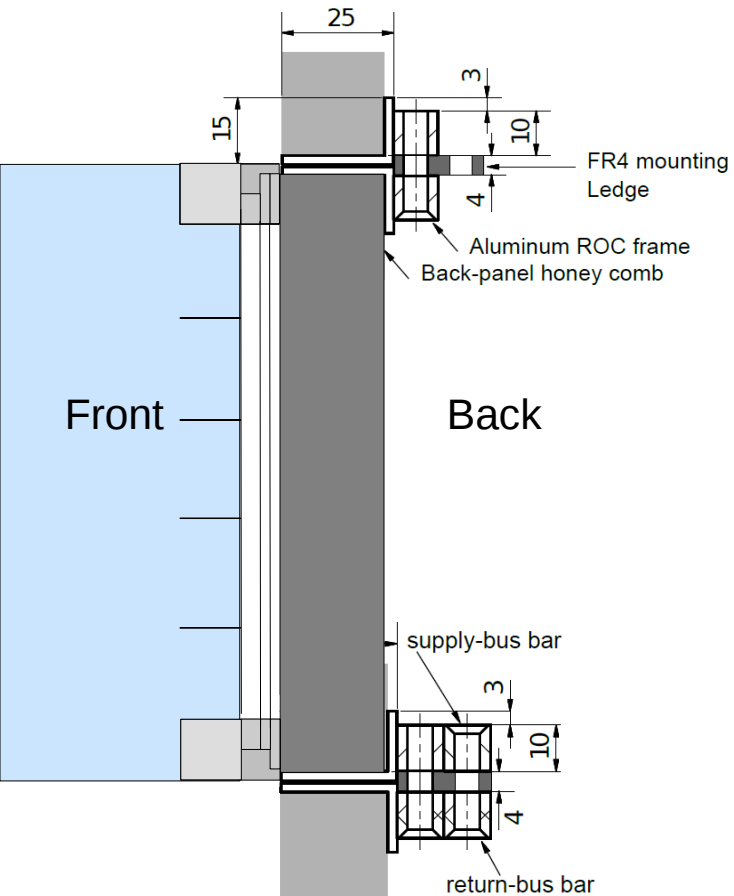


92.8%
acceptance

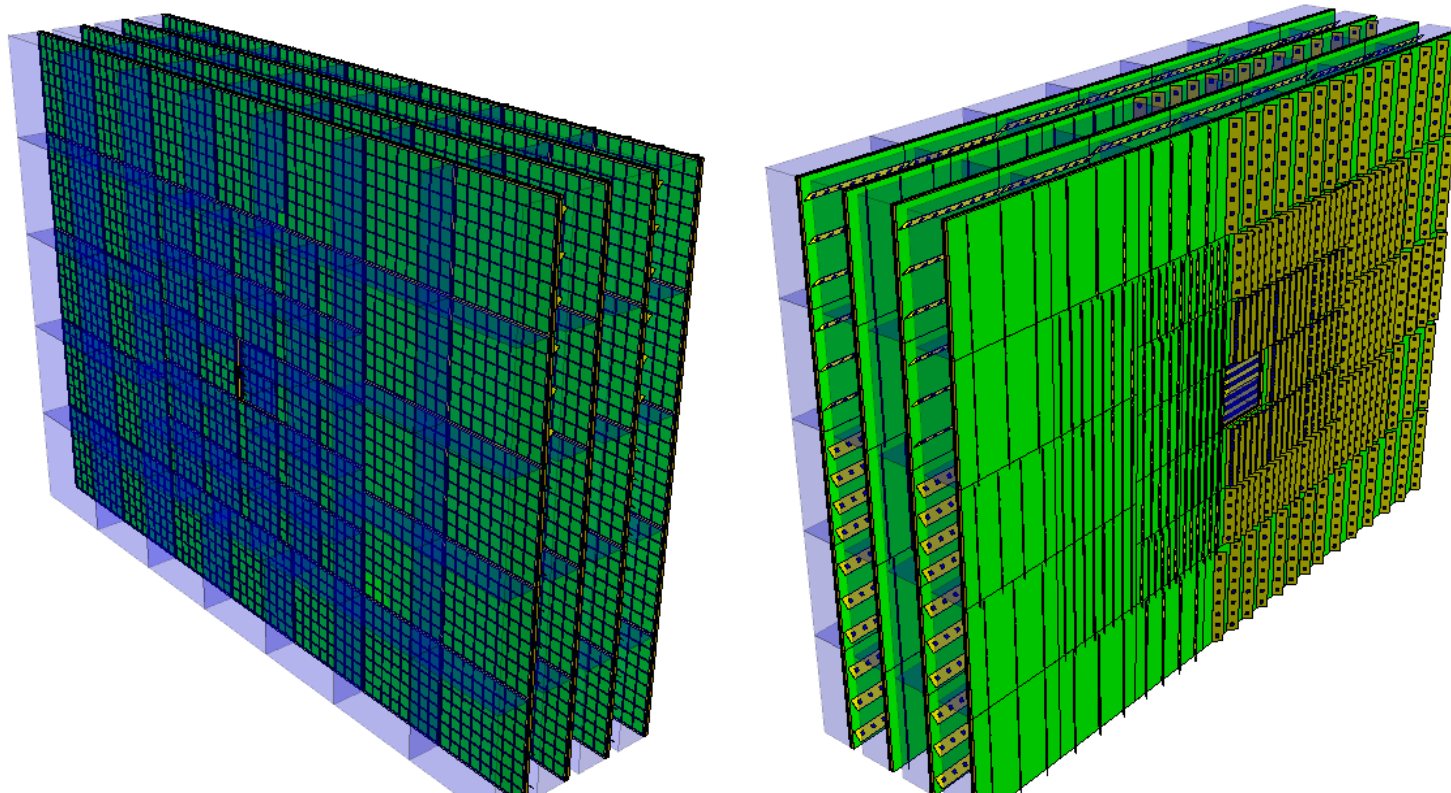


ROC type	small	large
Module type	1, 2, 3	6, 7, 8
Outer dimensions	$57 \times 57 \text{ cm}^2$	$95 \times 95 \text{ cm}^2$
Active area	2862.25 cm^2	8372.25 cm^2
Total height	49.5 mm	
Height amplification region	3.5+3.5 mm	
Height drift region	5.0 mm	

Mechanical Mounting Structure



Full TRD for SIS100

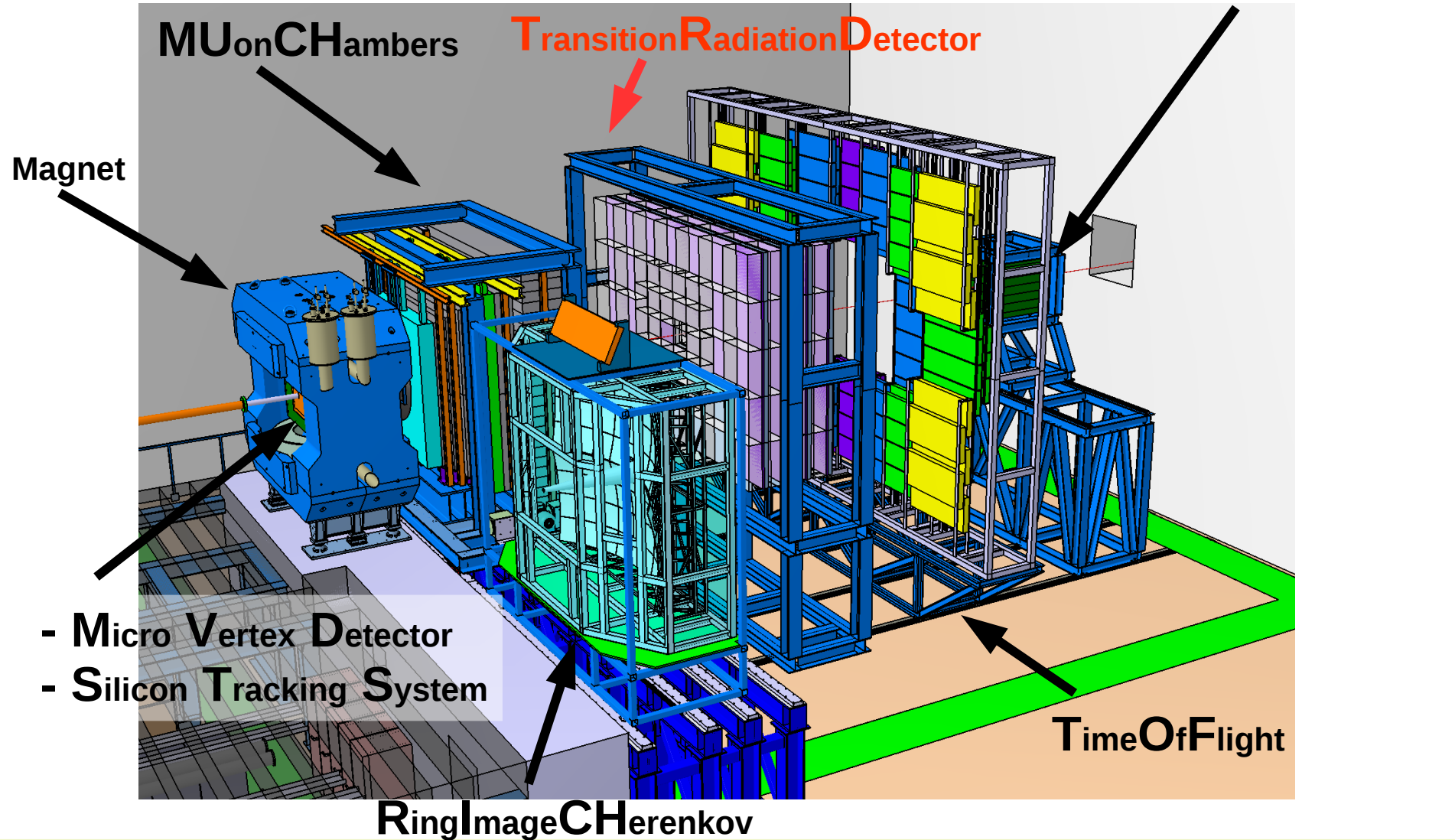


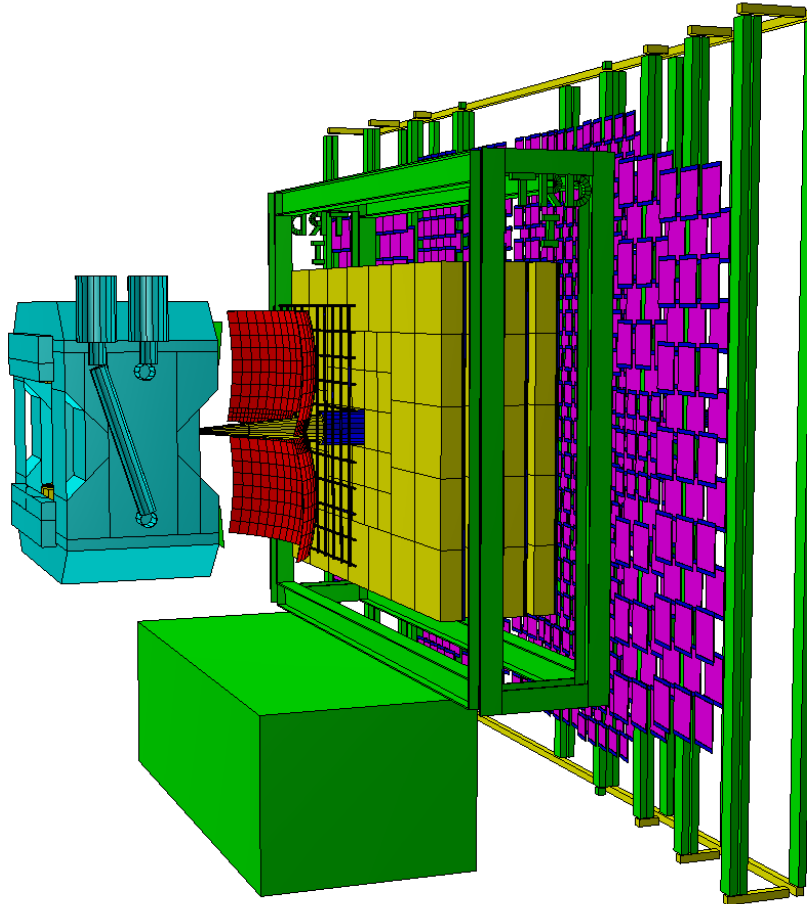
Module type	# Modules/plane	# Pads	Pad area (cm ²)
1	8	23,040	1.01
2	6	9,600	1.69 / 1.86
3	10	9,600	3.04
6	6	12,288	4.13
7	8	8,192	8.27
8	12	9,216	11.14 / 10.96
Total for one TRD layer	50	71,936	

Chamber Types within each Layer

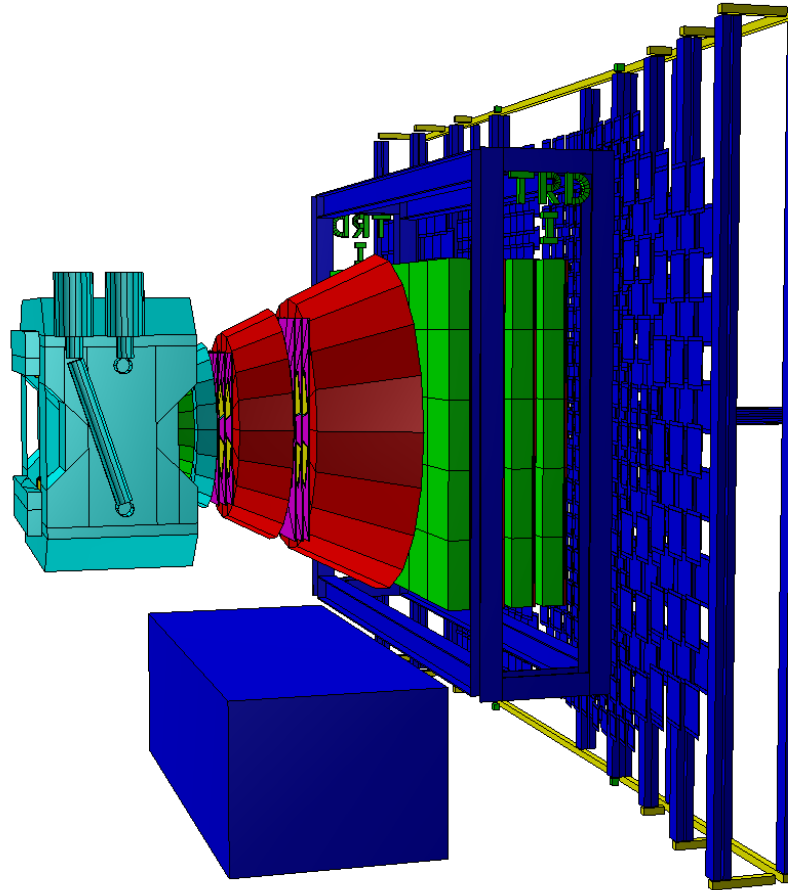
8	8	7		7		7		8	8
8	6	3	3	3	3	3	6	8	
		2	1	1	1	2			
7	6	2	1		1	2	6	7	
8	6	2	1	1	1	2	6	8	
		3	3	3	3	3			
8	8	7		7		7		8	8

Final CBM Setup

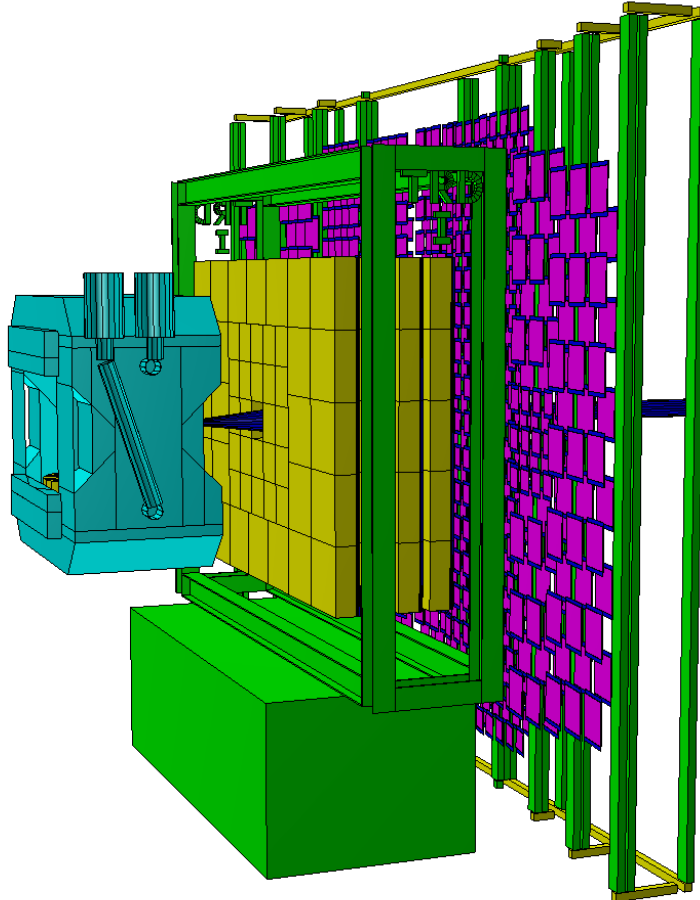




- Magnet
- MVD
- STS
- RICH
- TRD
- TOF

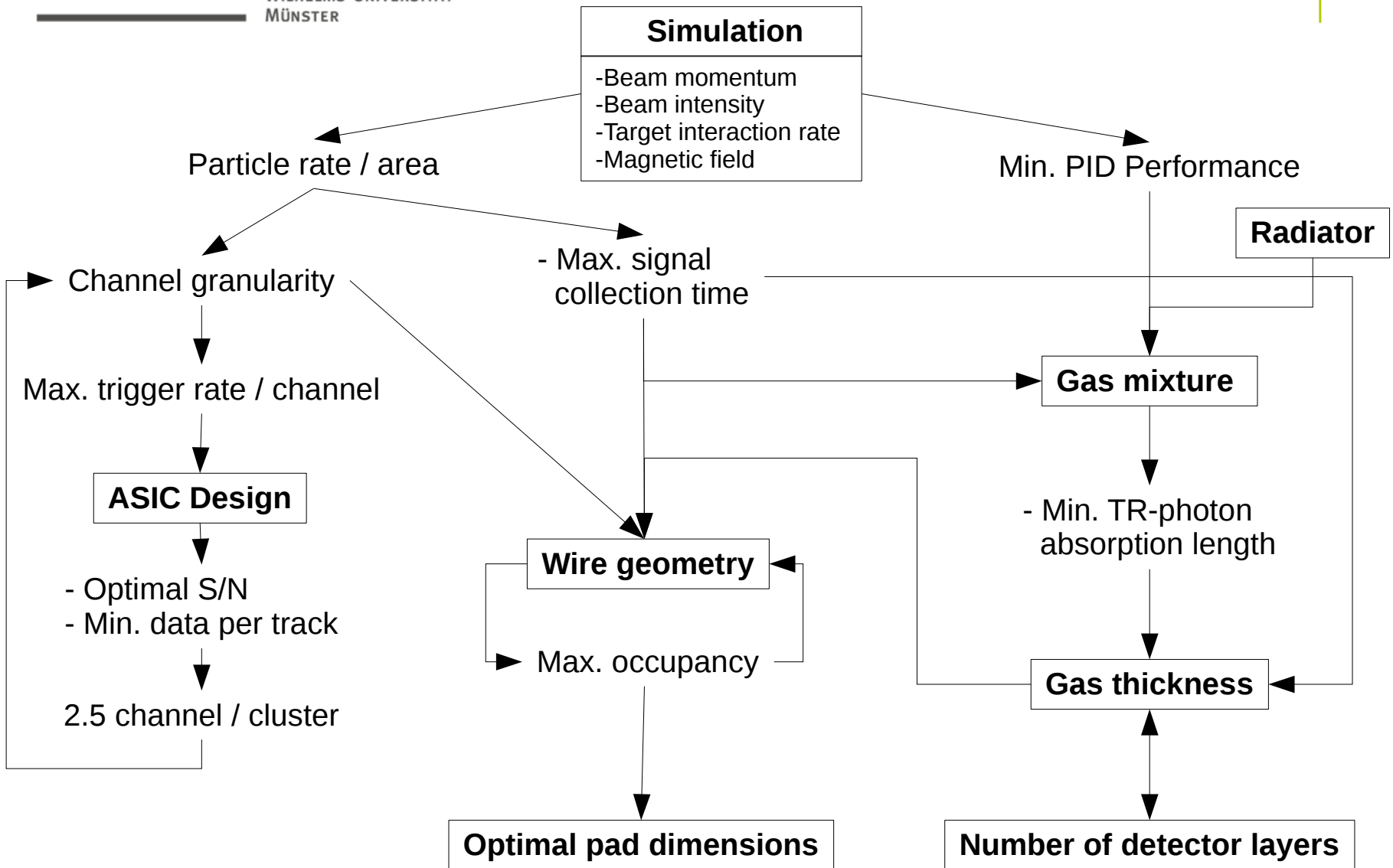


- Magnet
- MVD
- STS
- MUCH
- TRD
- TOF



- Magnet
- MVD
- STS
- TRD
- TOF

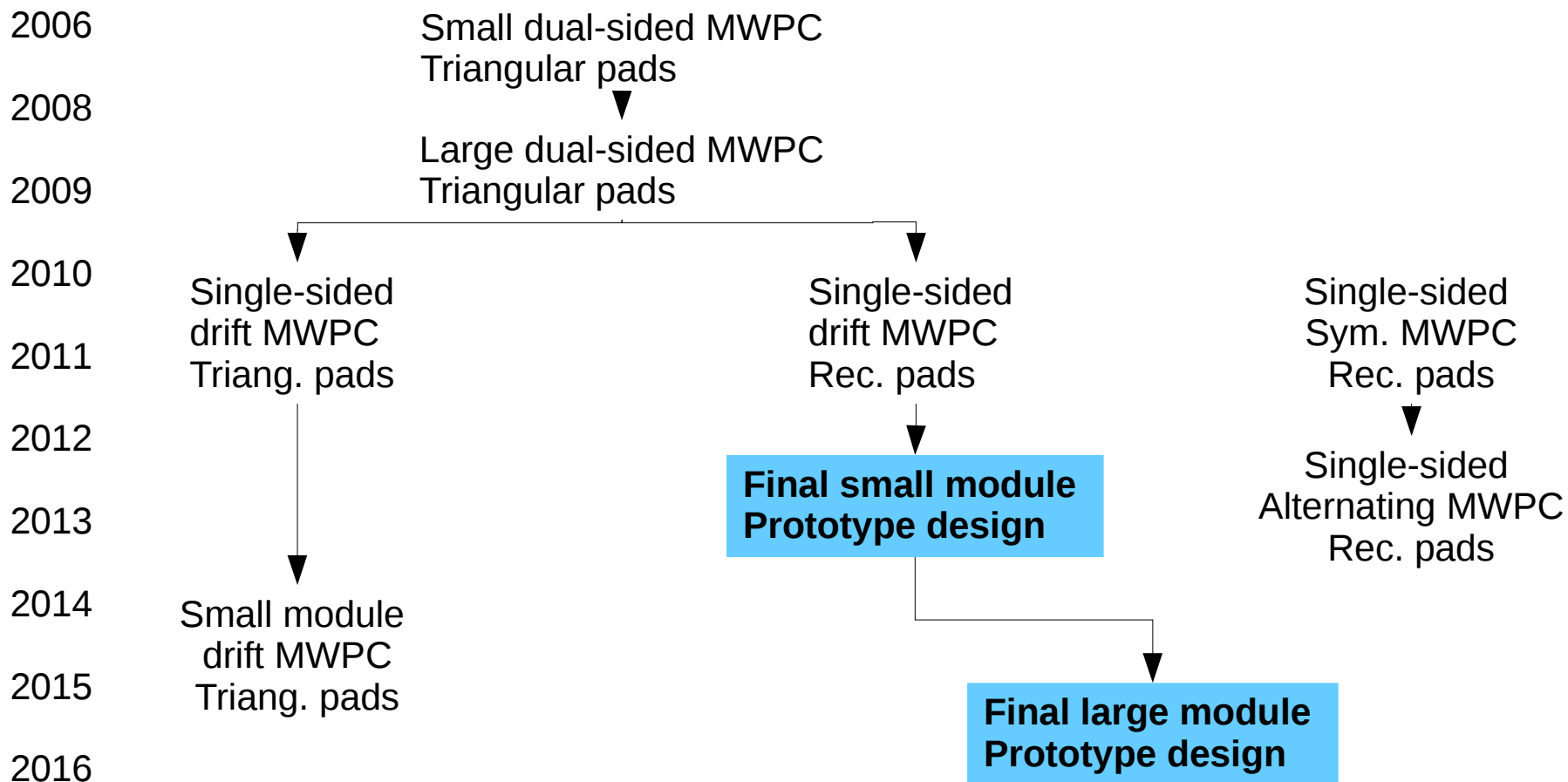
How to Design CBM TRD



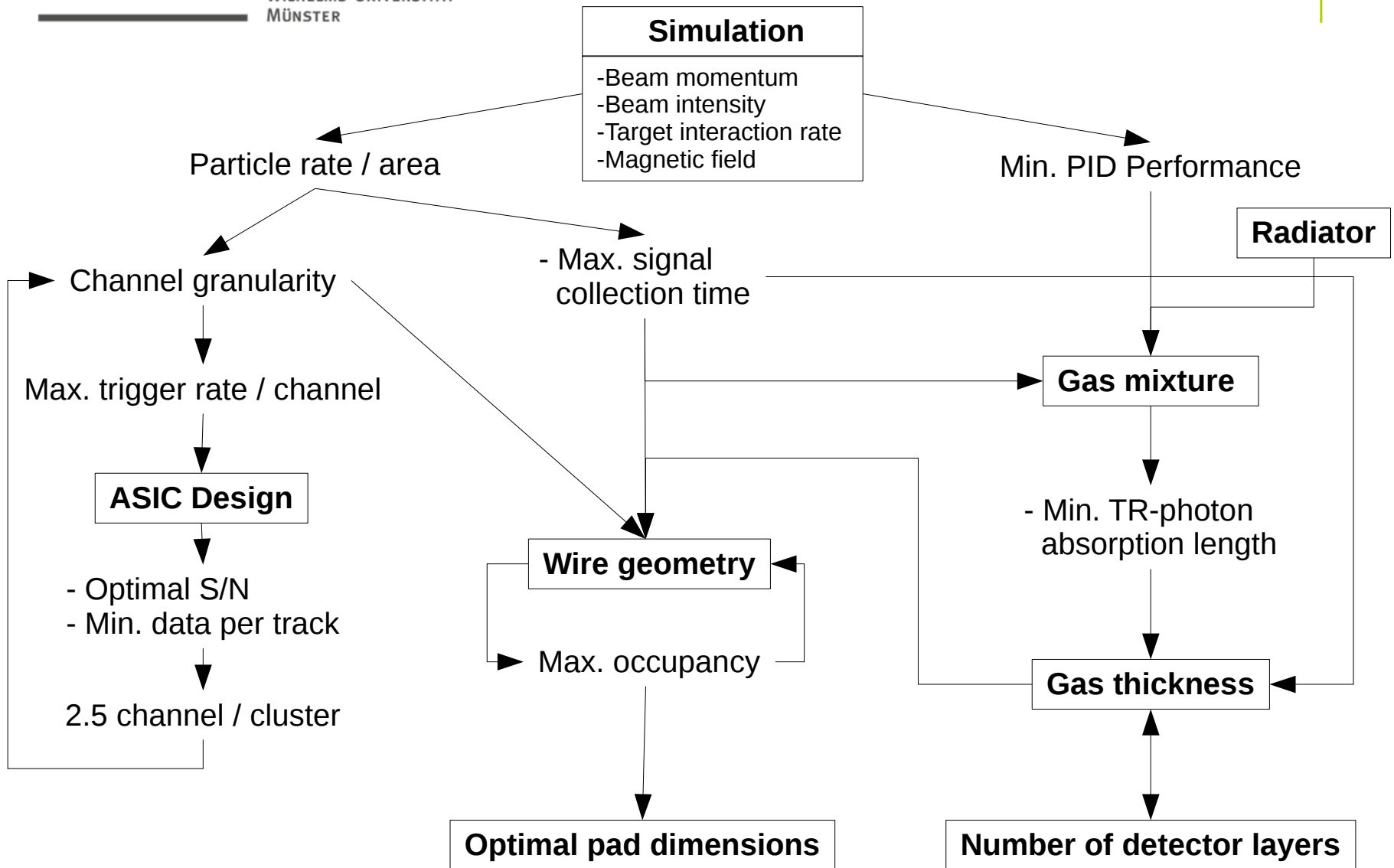
Bucharest

Münster

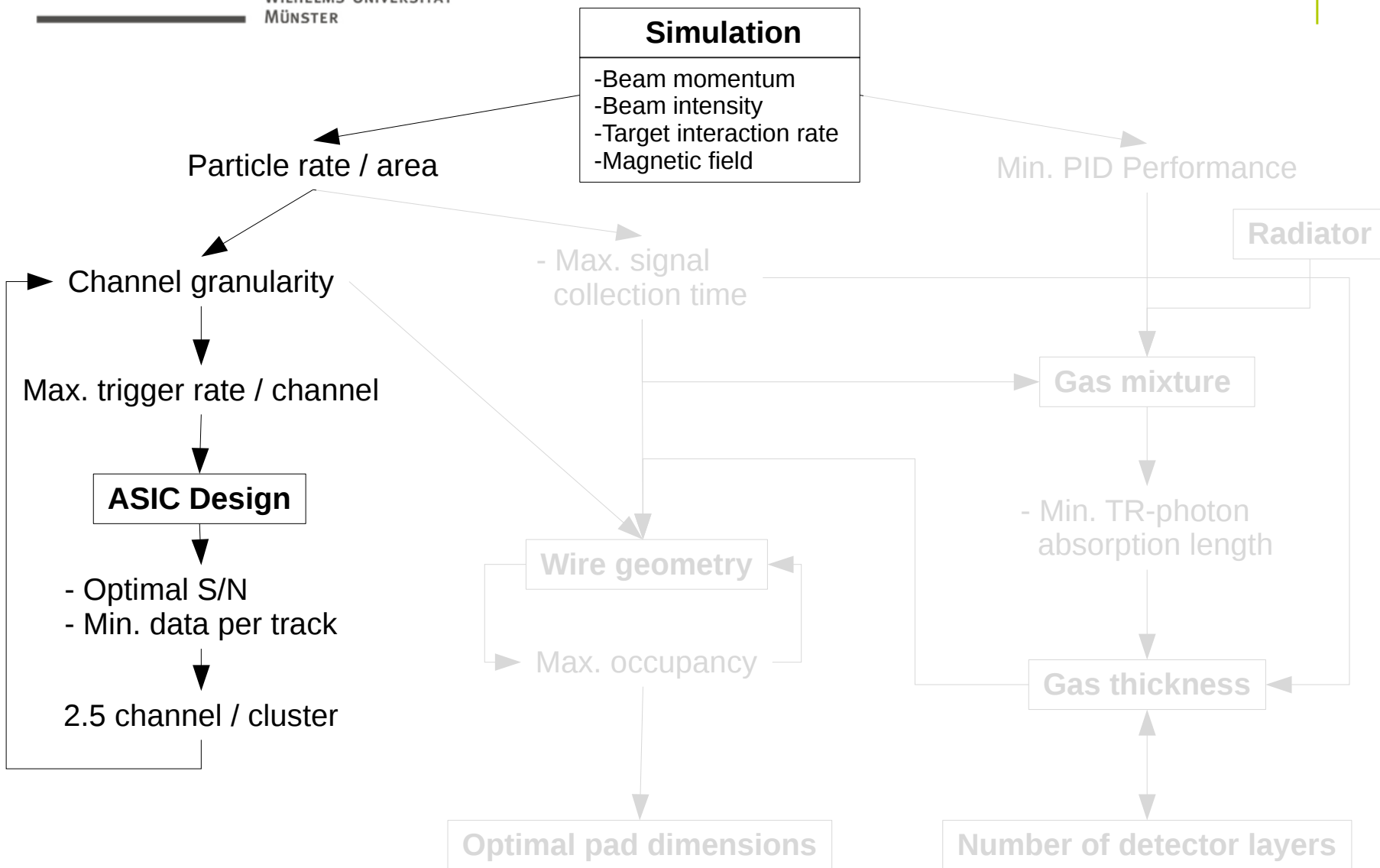
Frankfurt

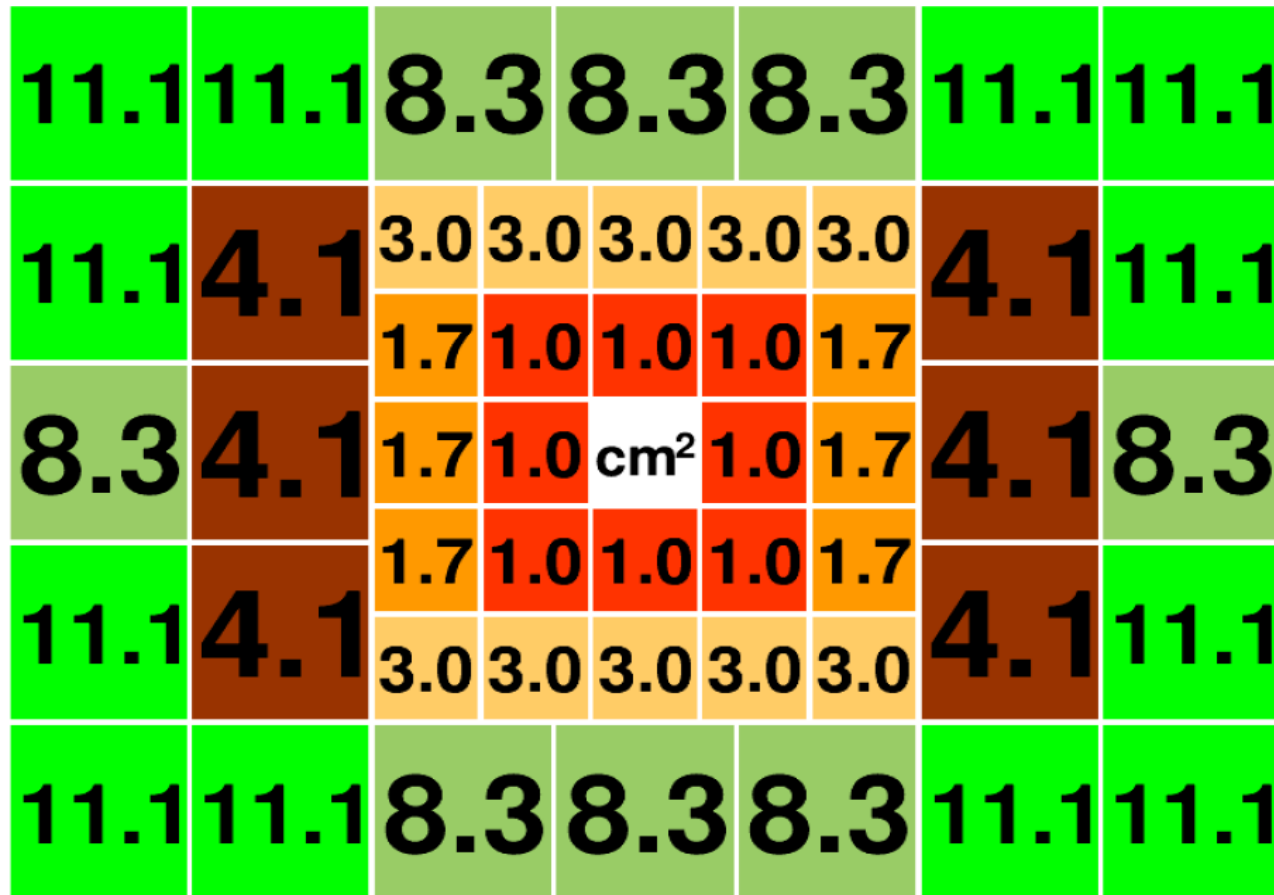


How to Design CBM TRD



How to Design CBM TRD

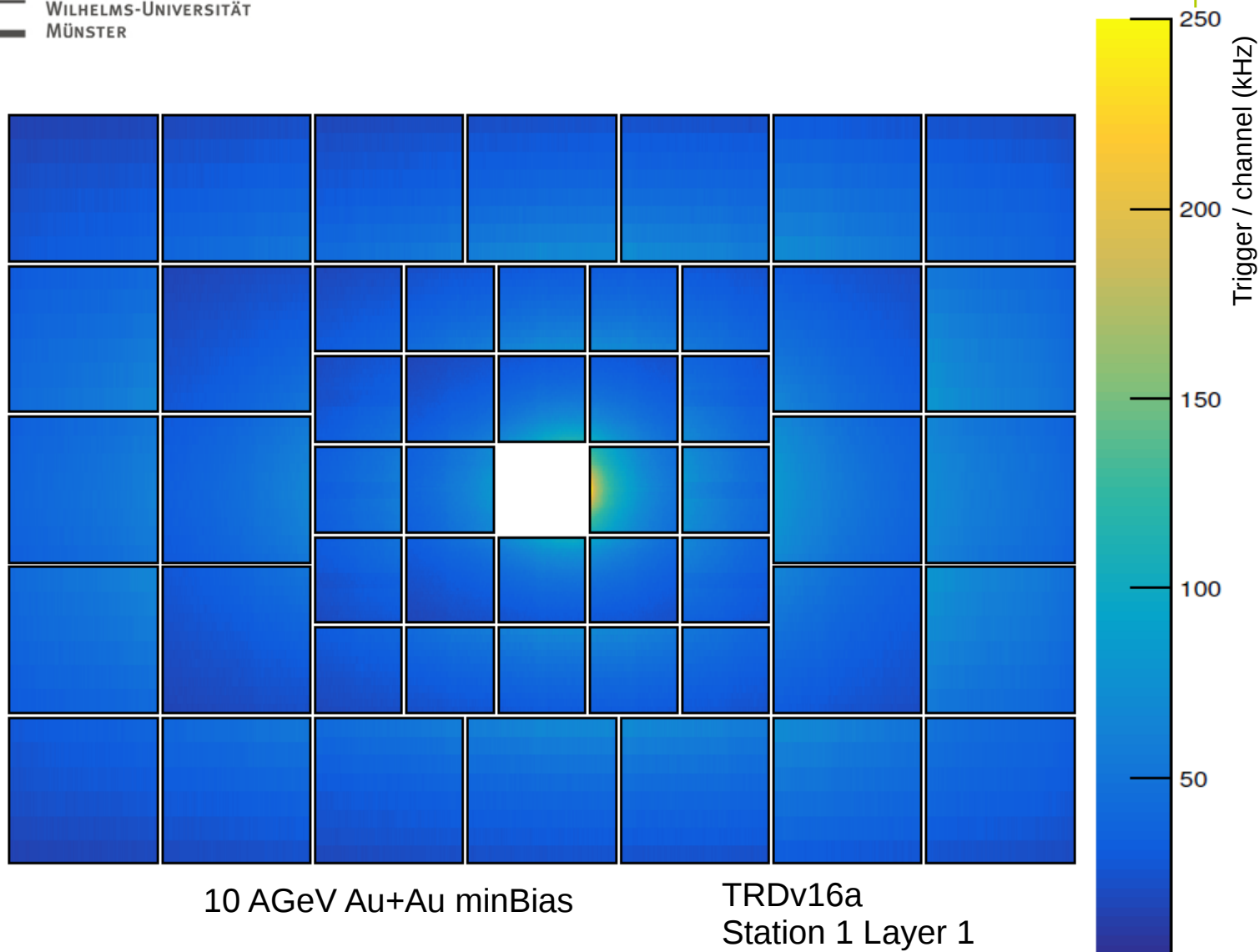




TRDv16a
Station 1 Layer 1

Min Bias SLS100 Trigger Rate

19



SIS100 Average Occupancy

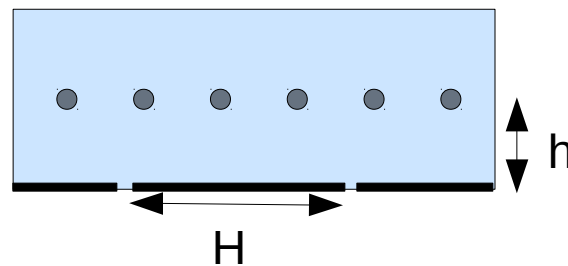
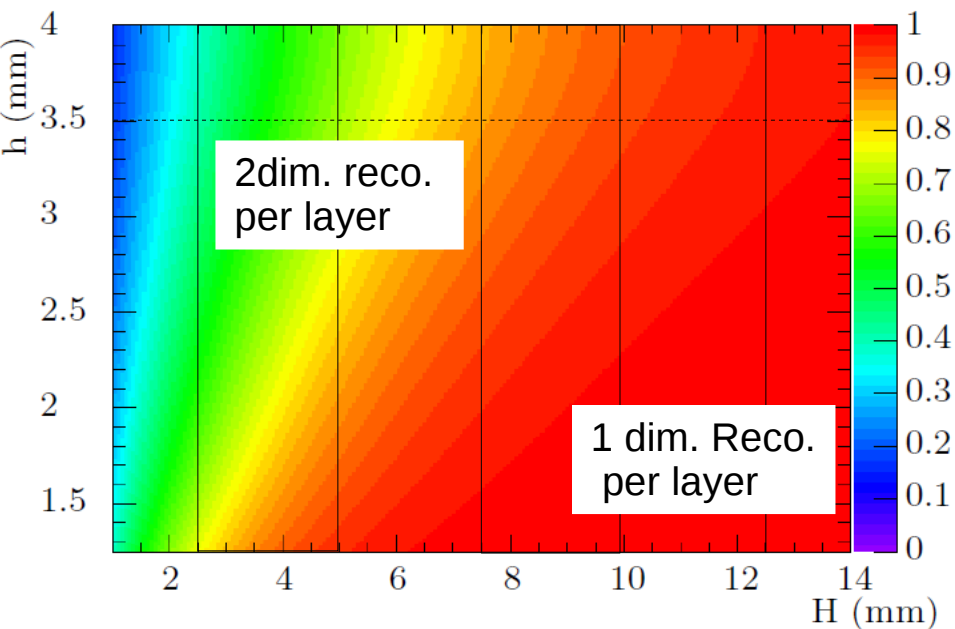
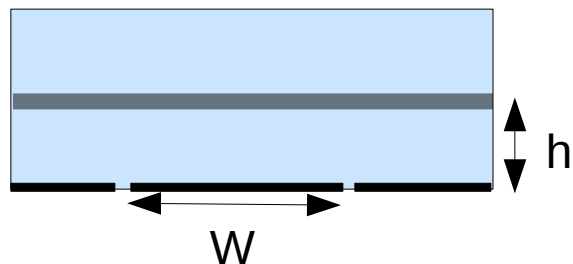
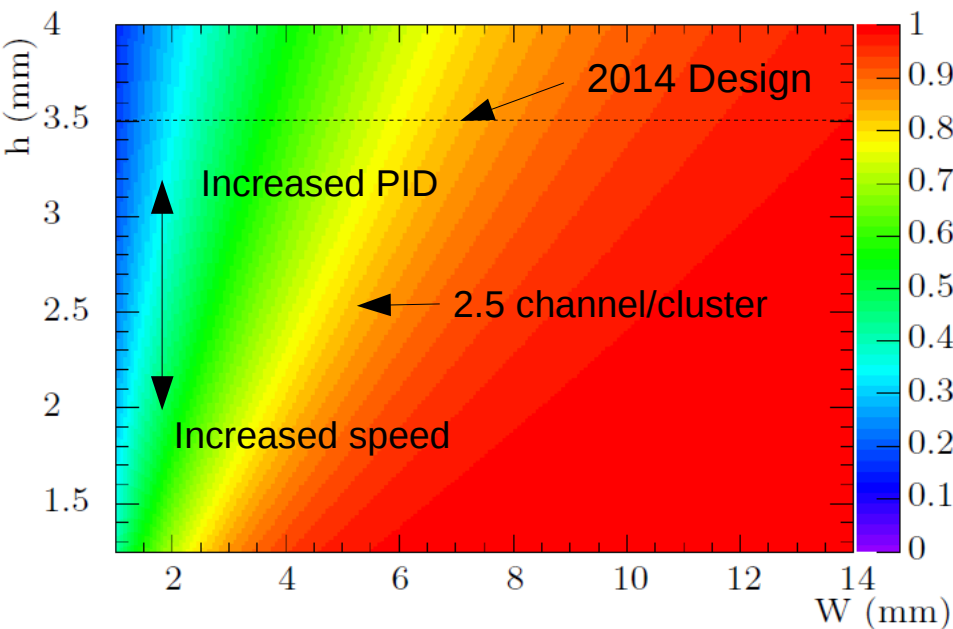
0.6±0.8%	0.6±0.7%	0.7±0.7%		0.8±0.9%		0.9±0.8%		1.0±1.1%	0.5±0.8%
0.9±1.1%	0.7±0.7%	0.7±0.7%	0.8±0.7%	1.0±1.1%	1.1±1.1%	0.9±0.8%		0.8±0.7%	1.2±1.3%
		0.7±0.7%	0.8±0.7%	1.3±0.9%	1.2±1.0%	1.0±1.0%			
1.0±1.0%	0.9±0.9%	1.1±1.1%	1.5±1.2%			2.4±1.5%	1.3±1.2%	1.2±1.2%	1.0±1.2%
		0.7±0.8%	0.8±0.8%	1.3±1.1%	1.0±0.8%	1.0±0.9%			
1.0±1.2%	0.6±0.6%	0.6±0.6%	0.9±0.9%	1.1±1.0%	1.0±1.2%	0.9±1.0%		0.8±0.7%	1.1±1.2%
0.5±0.7%	0.7±0.9%	0.7±0.8%		1.0±0.9%		0.9±0.9%		1.0±1.1%	0.7±0.9%

10 AGeV Au+Au minBias

TRDv16a
Station 1 Layer 1



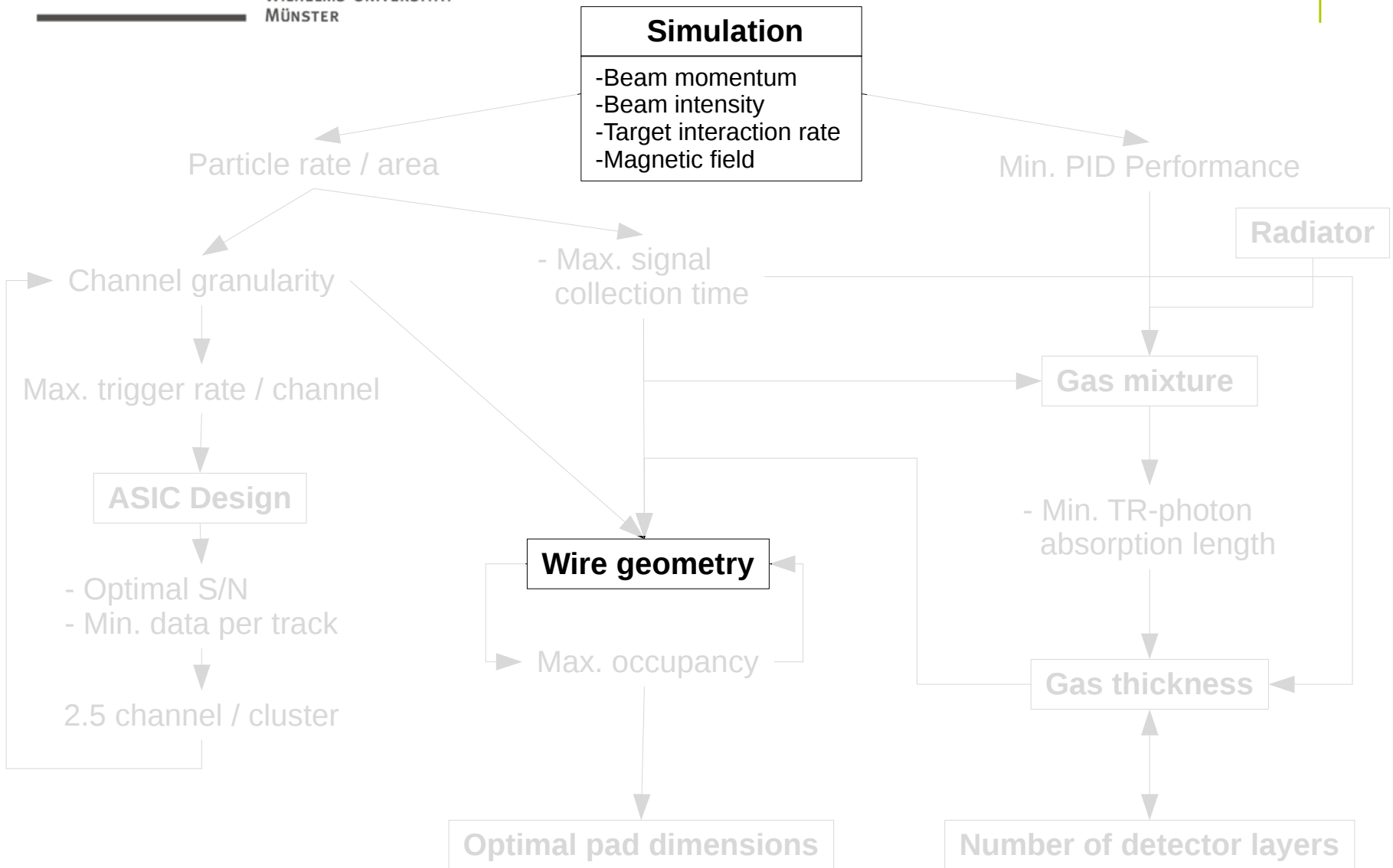
Charge Fraction on Central Pad Optimal Pad Dimensions



Maximum trigger rate per channel (ASIC)

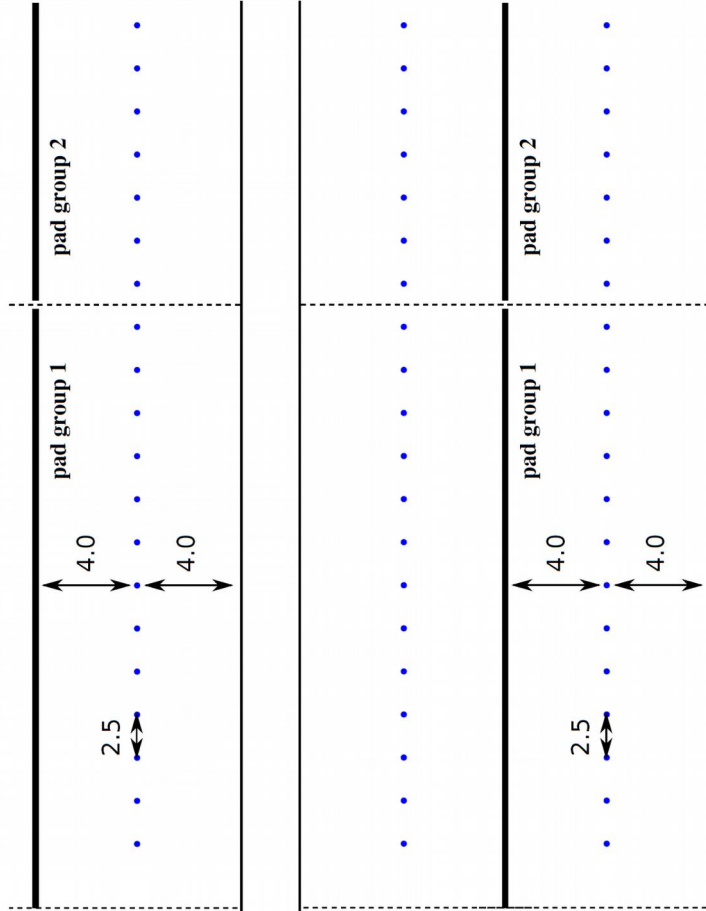
- Maximum pad area
- Optimal charge sharing (2.5 channels per cluster)
- Pad width (W)
- Pad height (H) integer multiple of 2.5mm anode pitch
- Distance between anode and pad-plane (h)

How to Design CBM TRD

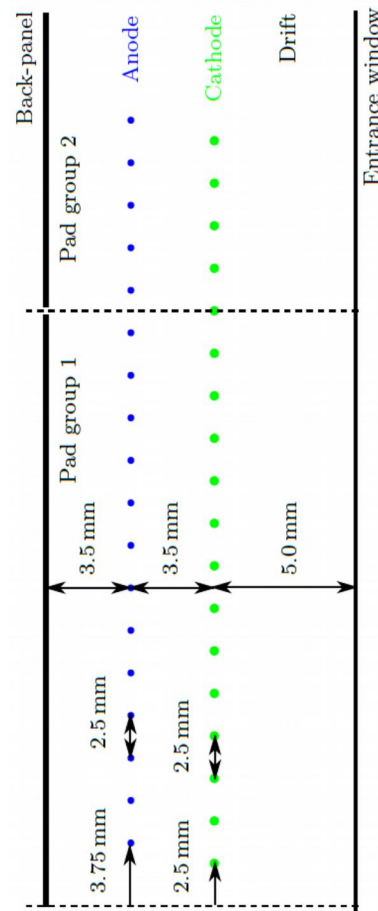


Symmetric MWPC

single dual sided

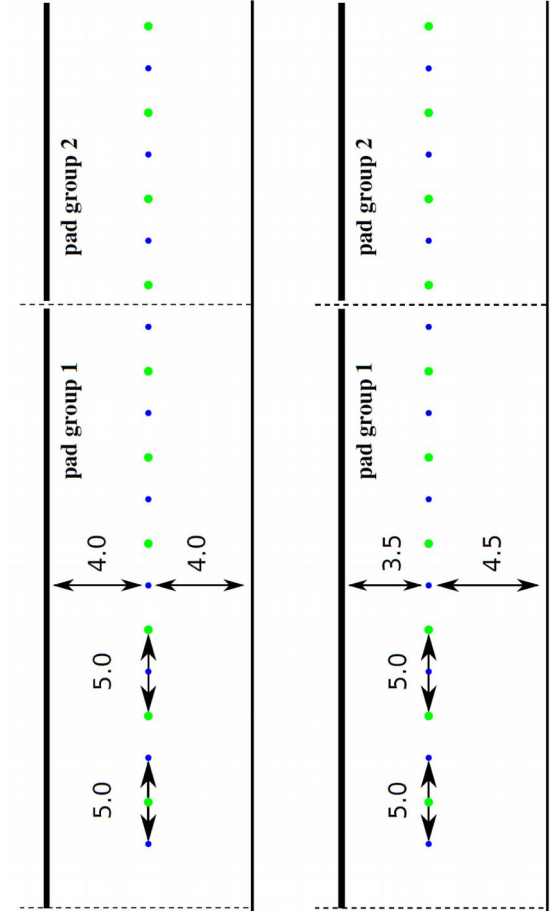


Drift MWPC

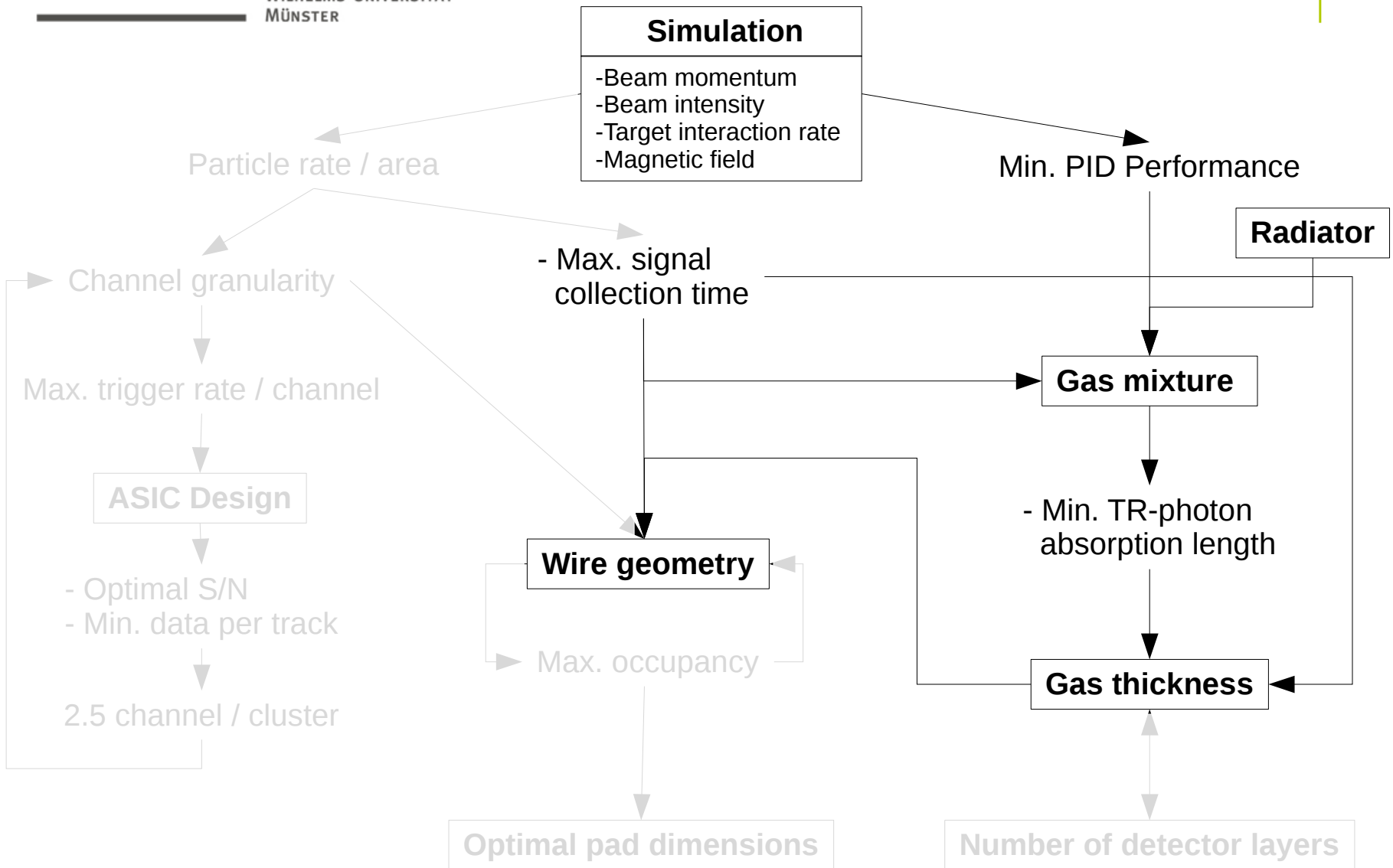


Alternating w. MWPCs

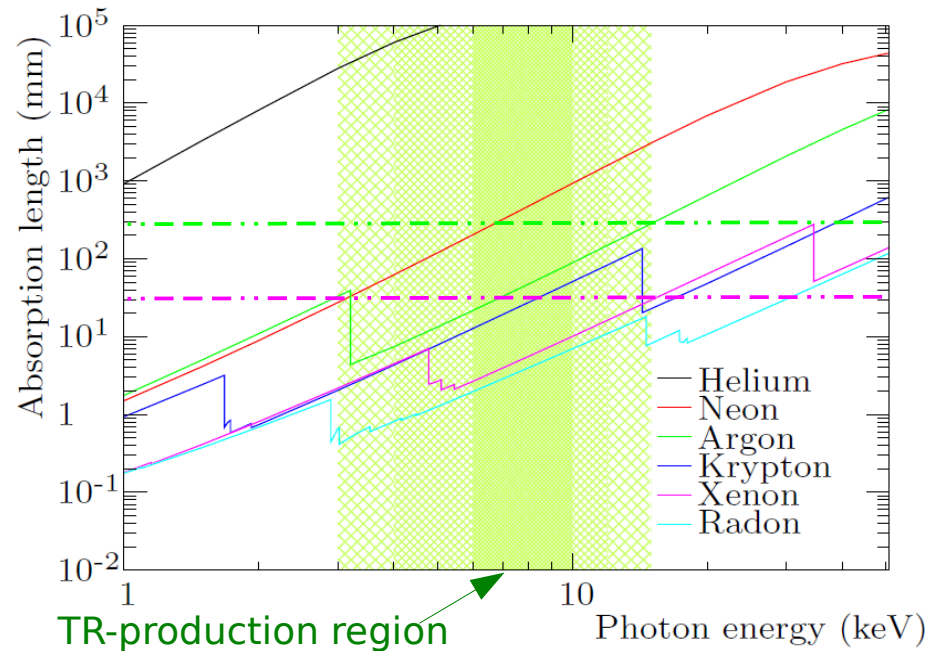
symmetric asymmetric



How to Design CBM TRD

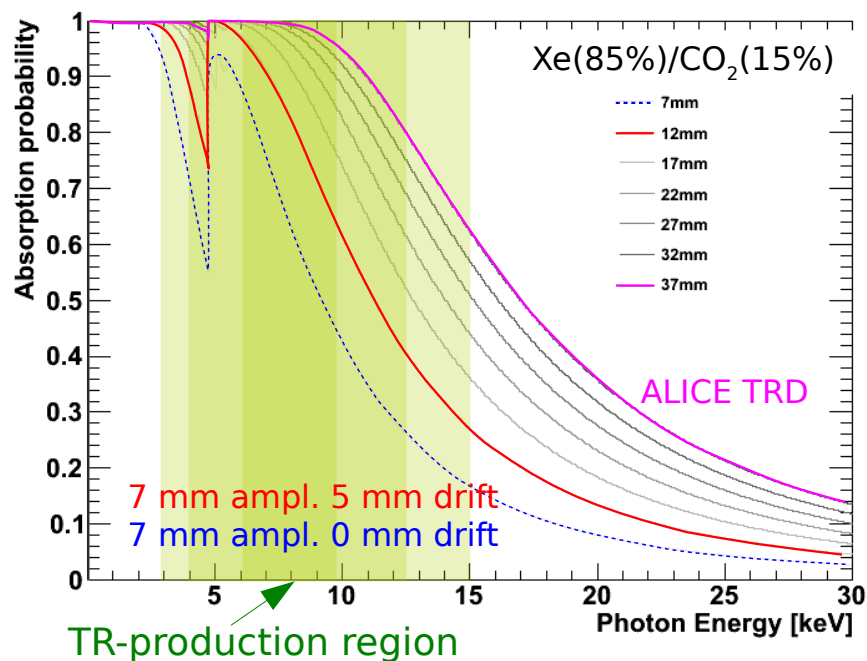


Noble Gas mixture

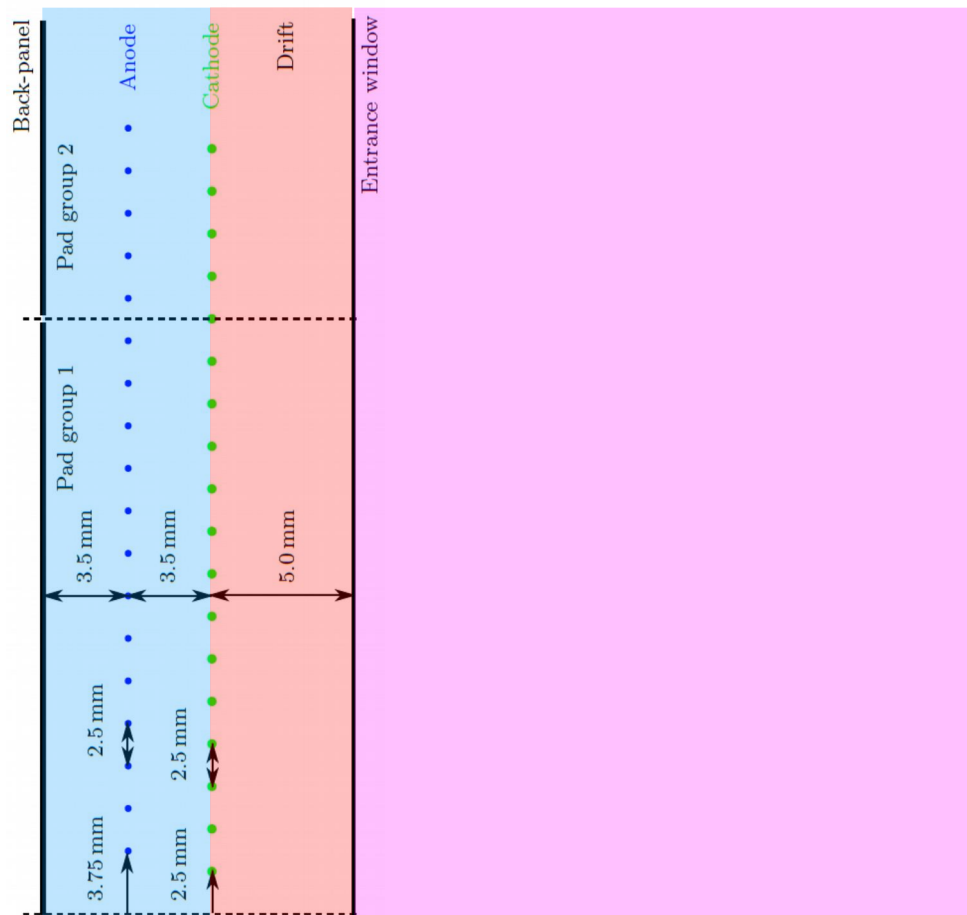


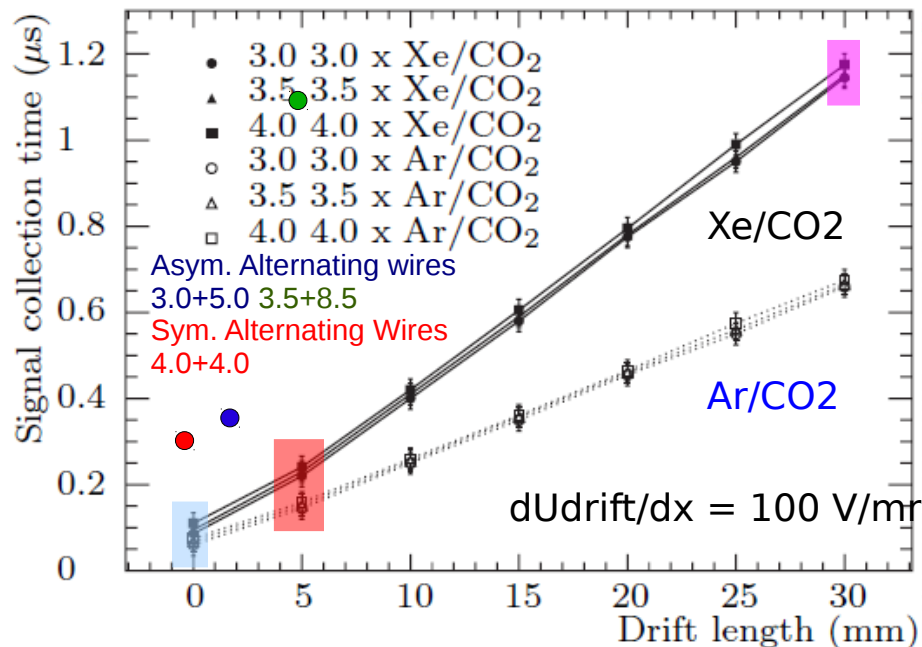
Stable isotope with shortest absorption length
at 20 keV photon energy:

Argon	200-300 mm
Xenon	10-30 mm



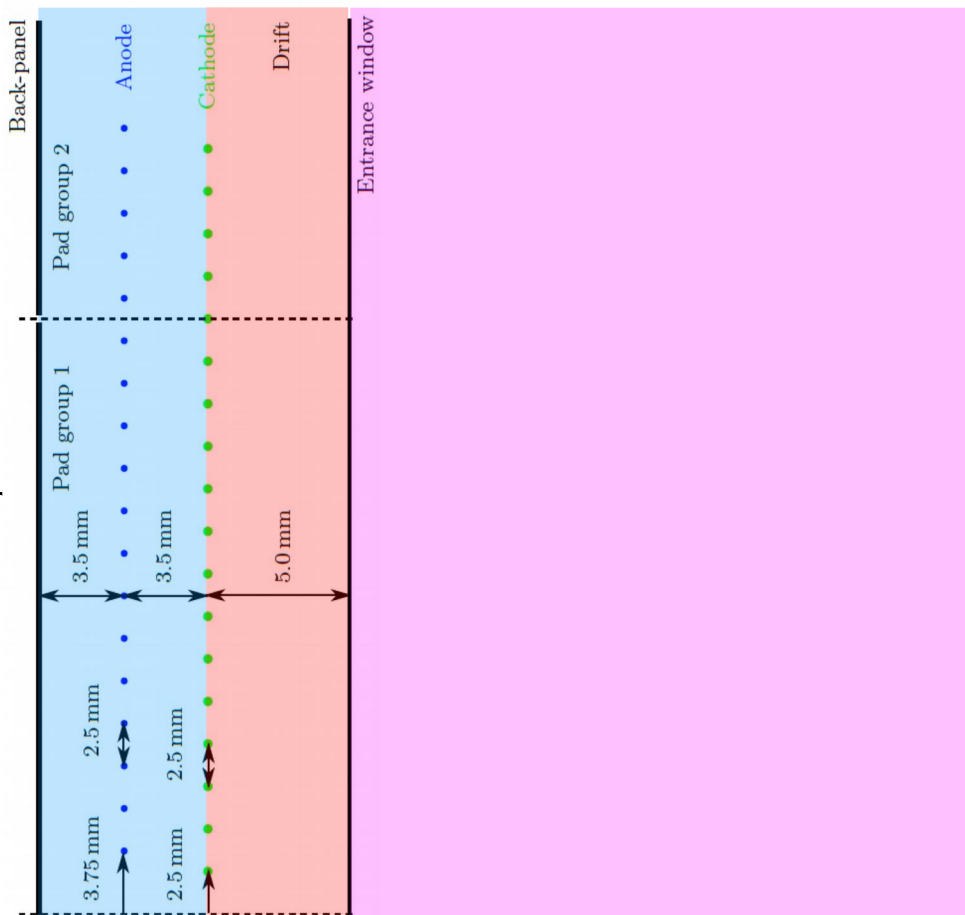
TR-photon absorption probability and
PID performance are correlated to
gas thickness,
which influences the **signal collection time**.



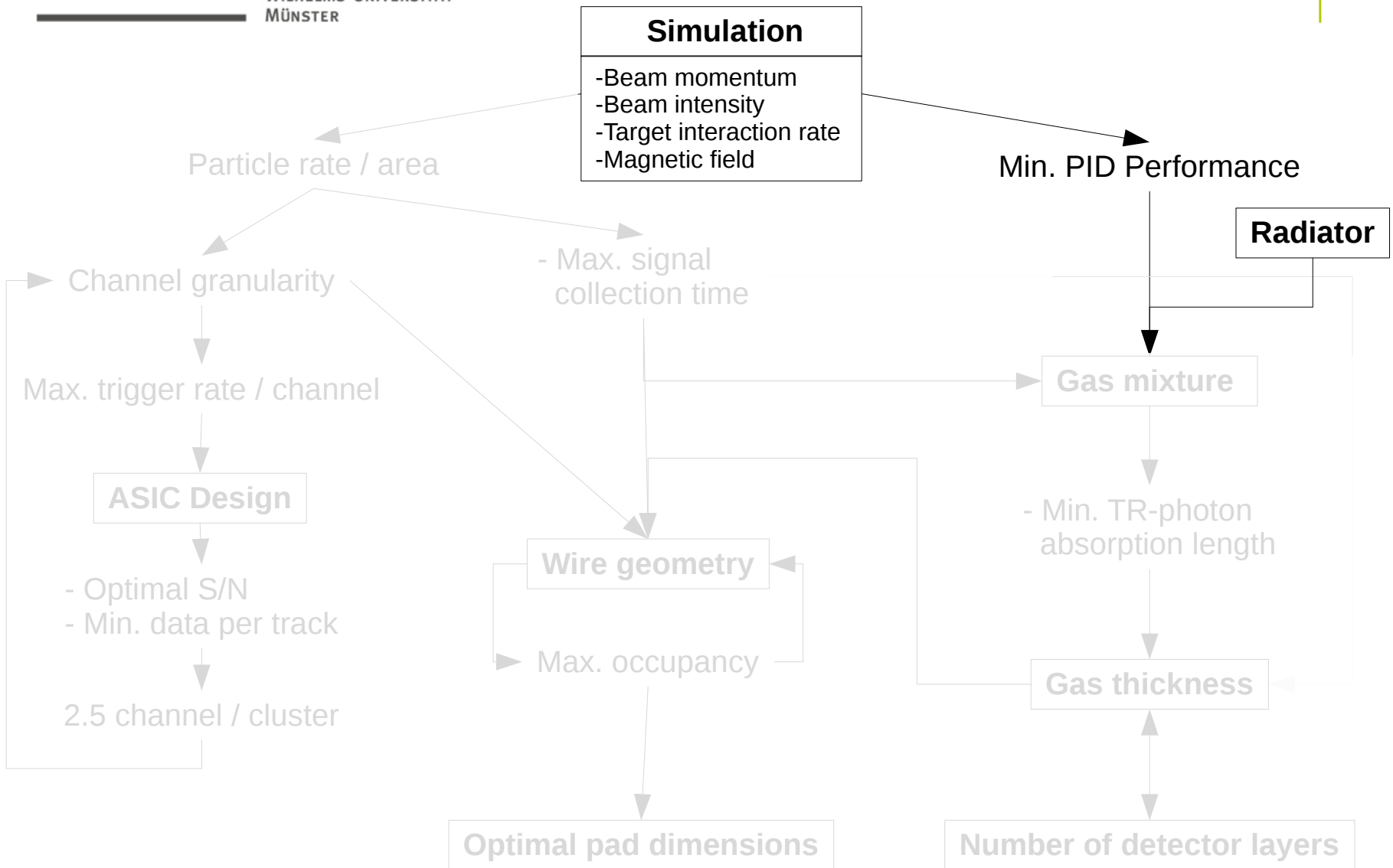


Linear dependence between drift length and signal collection time at constant drift voltage

100 ns ampl. + 130 ns drift time in Xe/CO₂
for 7 mm ampl. + 5 mm drift @ 100 V/mm
→ 230 ns total signal collection time

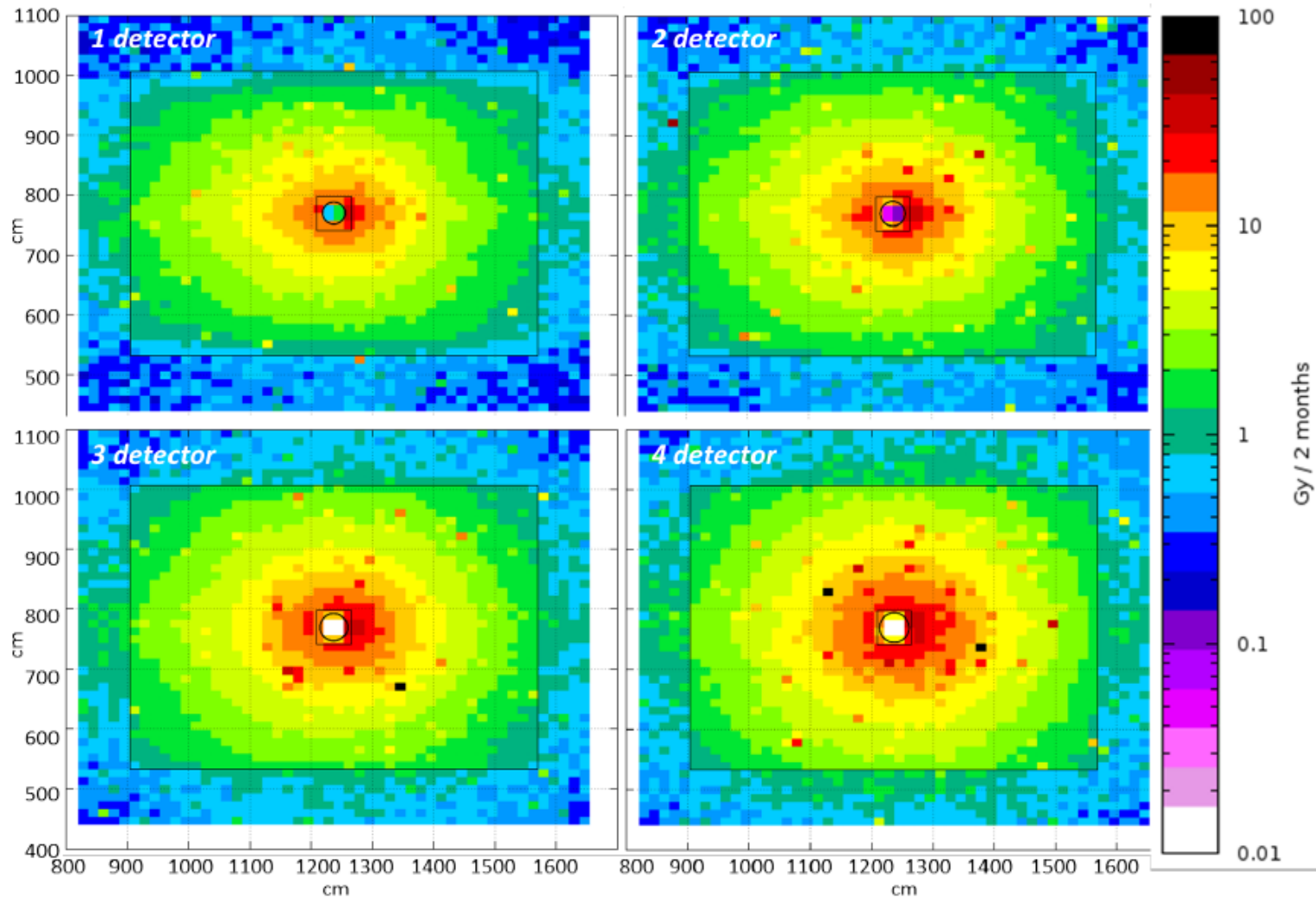


How to Design CBM TRD



Total Ionizing Dose

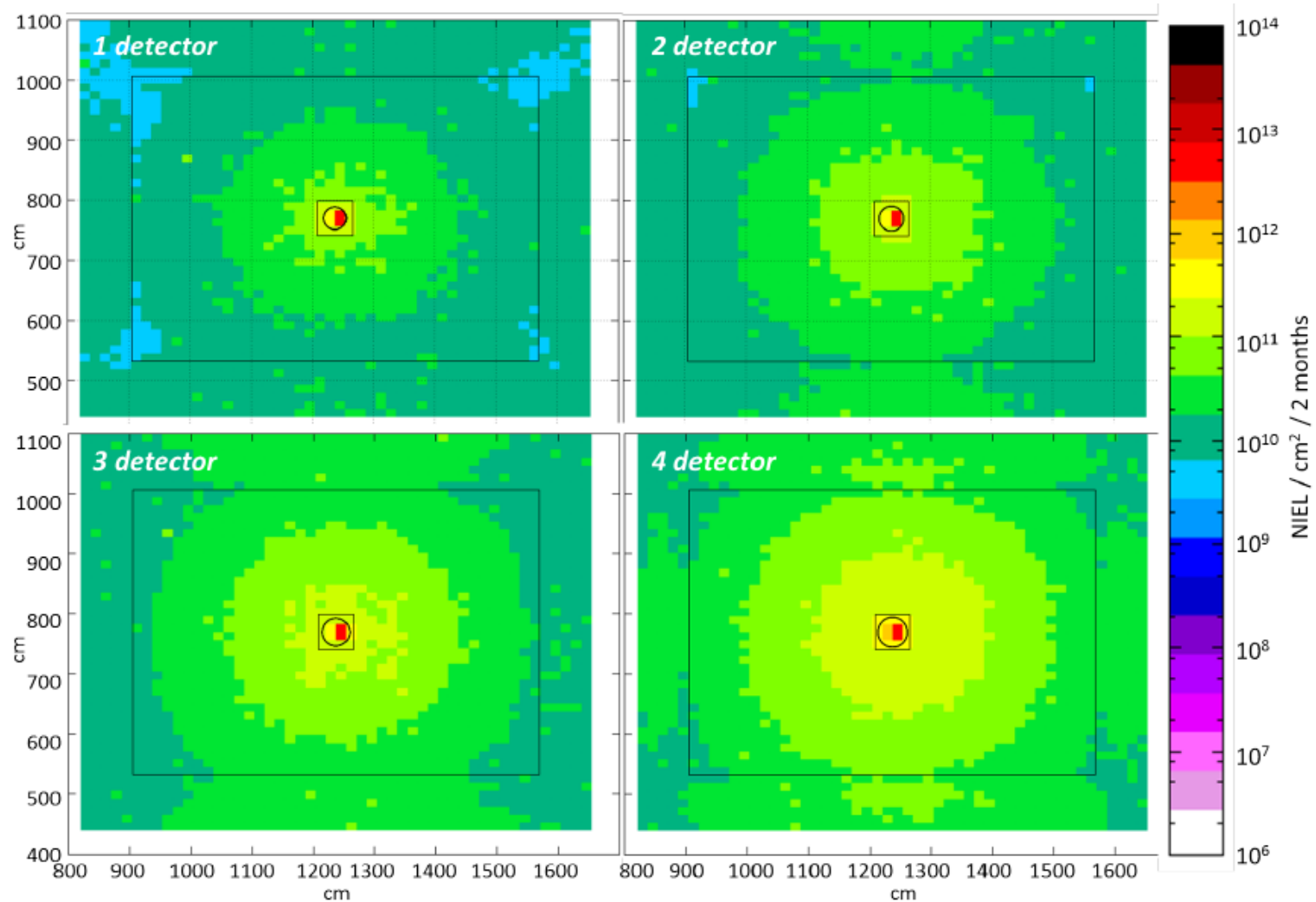
50



@ 10 AGeV Au+Au at an interaction rate of 5 MHz
corresponding to 2 month of operation

Total Non-ionizing Dose

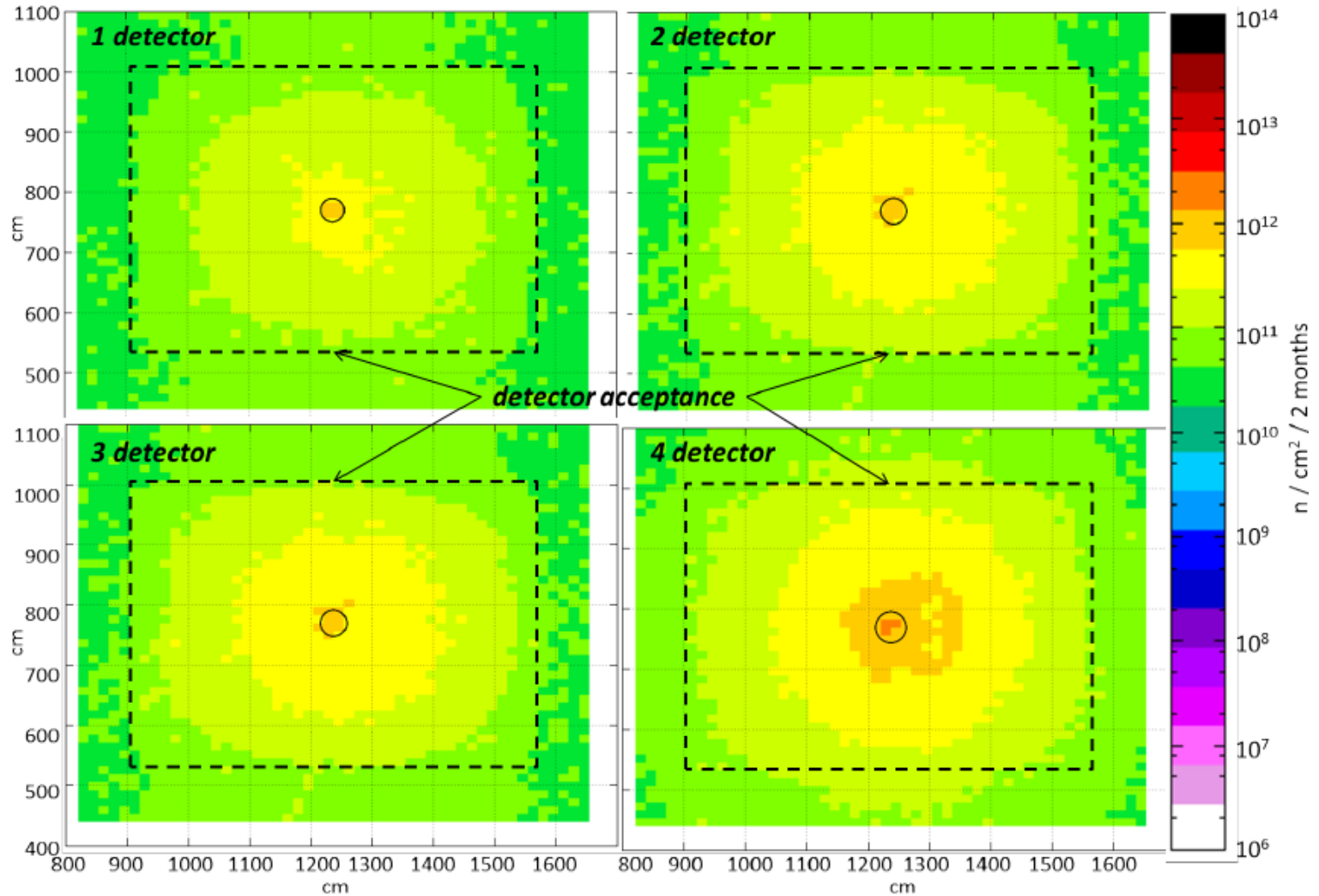
51



@ 10 AGeV Au+Au at an interaction rate of 5 MHz
corresponding to 2 month of operation

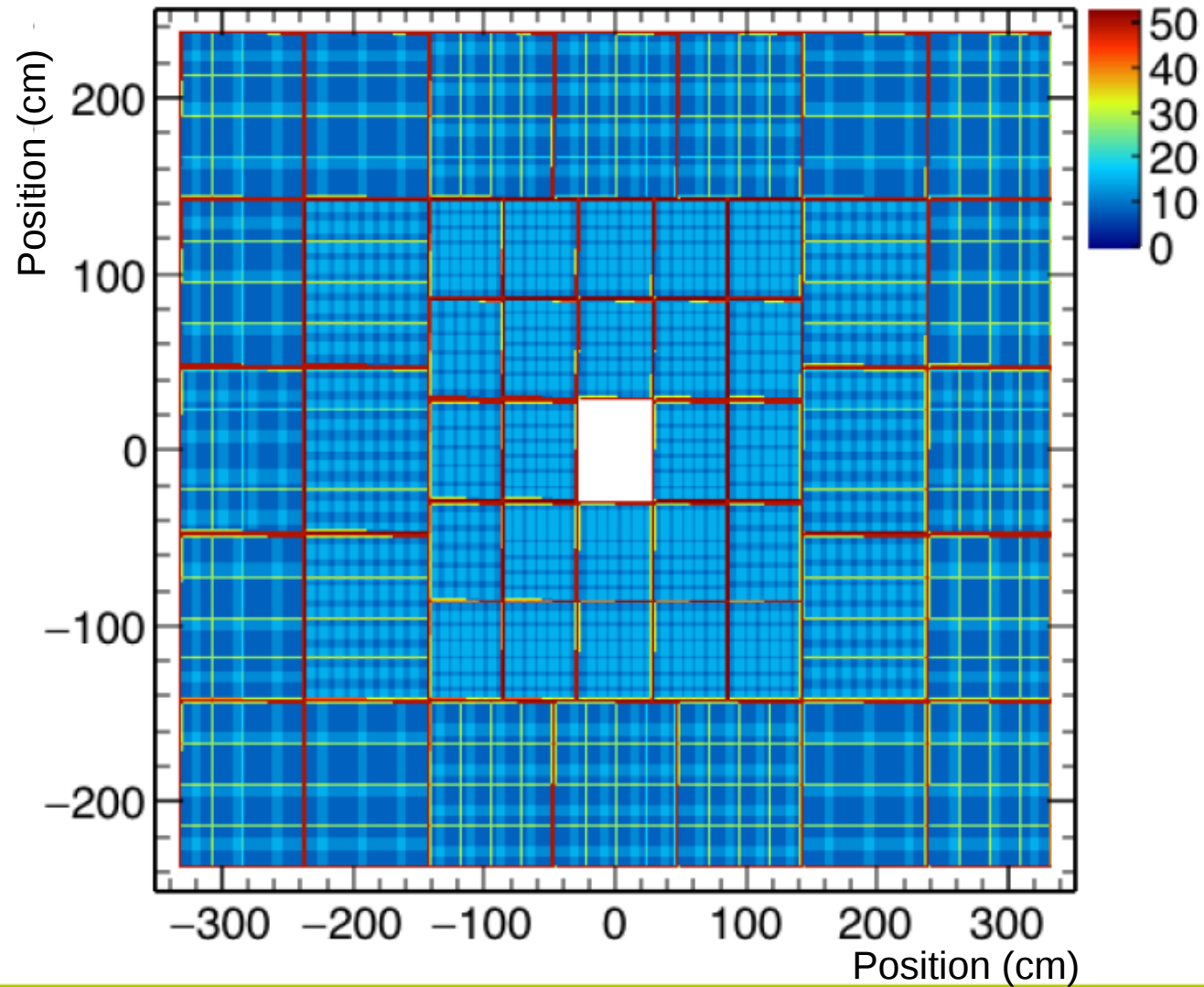
Total Neutron Density

52



@ 10 AGeV Au+Au at an interaction rate of 5 MHz
corresponding to 2 month of operation

Radiation Length



Radiation Length

Radiator:

Prototype	Material	Density (g/cm ³)	Thickness (cm)	X/X_0 (%)
G30	PP fibers	0.064 – 0.074	12	1.70 – 1.96
H	PE foam	0.026	30	1.39 – 1.75
K++	POKALON		25	3.09

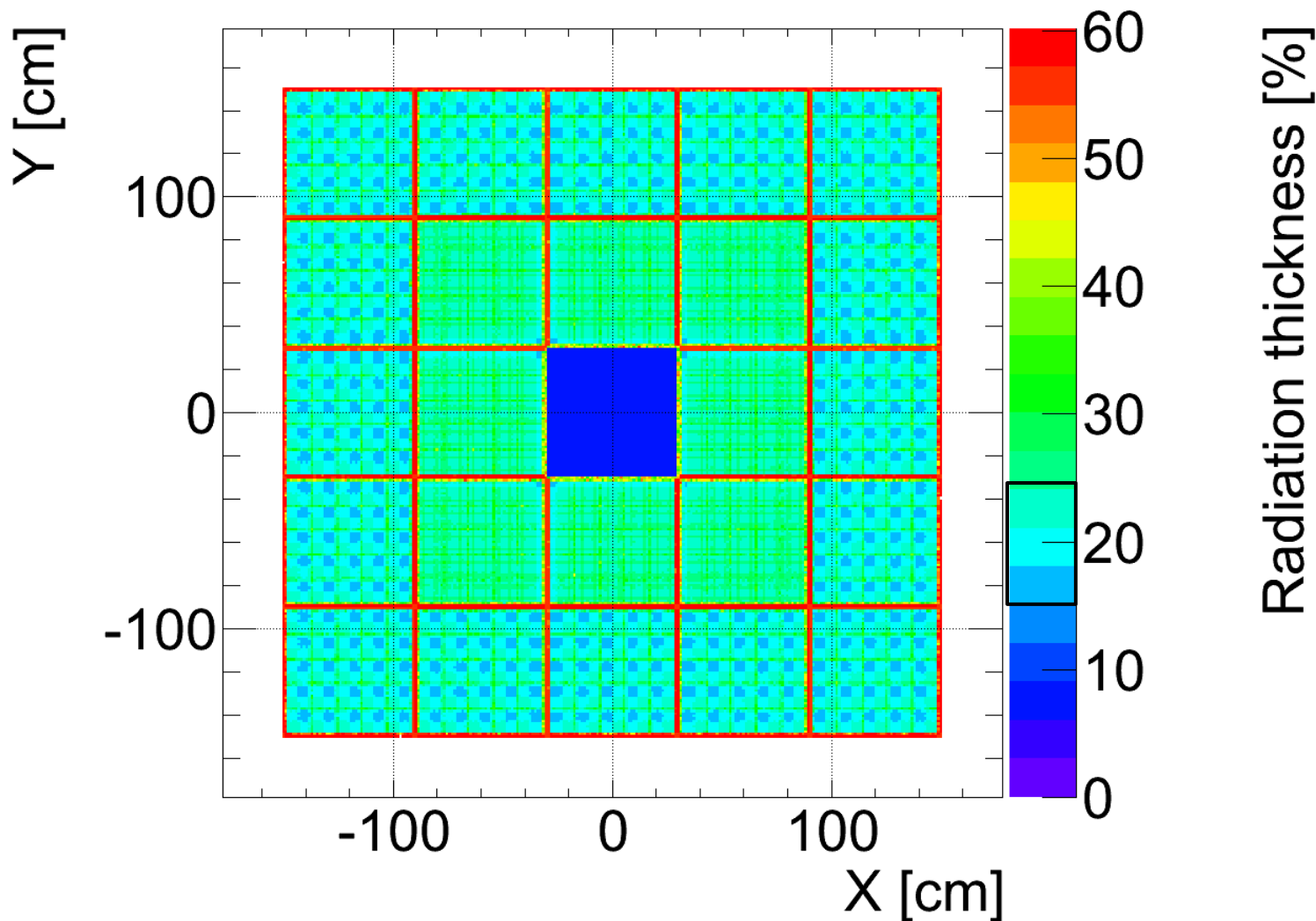
Entrance window:

Material	Thickness (μm)	X/X_0 (%)
Aluminum	3	0.003
Kapton	25	0.009
CF	10000	(4.215)
CF	15000	(6.323)
Sum		0.012
CF support grid		+ (4.215 – 6.323)

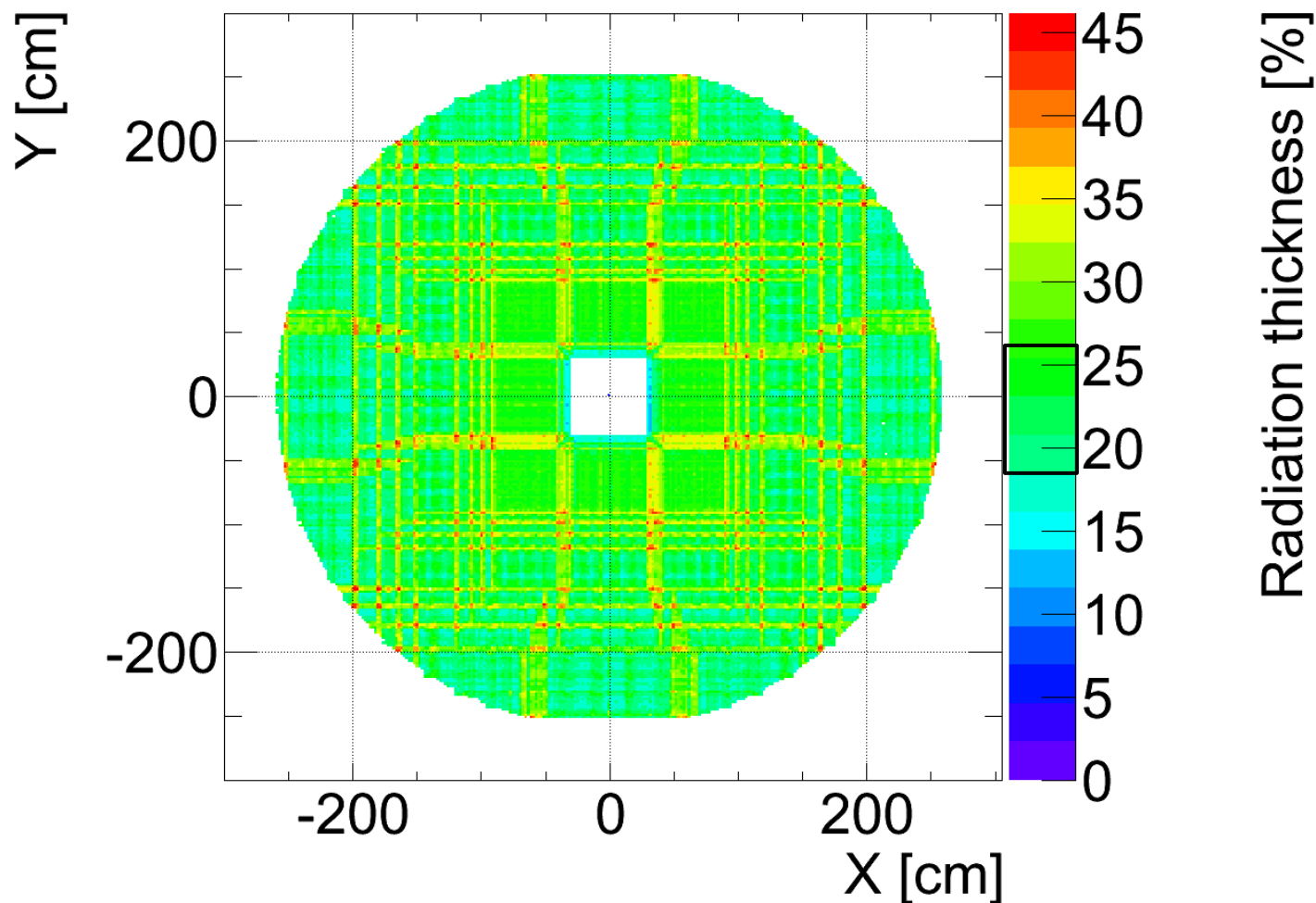
Back Panel:

Material	Thickness (μm)	X/X_0 (%)
Honeycomb	22000	0.170
Air	22000	0.007
Epoxy	100	0.028
CF sheet	2 × 300	0.253
FR4	360	0.226
Cu	25	0.174
Aluminum frame	27000	(30.045)
Sum		0.858
Aluminum frame		+ 30.045

Radiation Length SIS100: Parallel



Radiation Length SIS100: Cone



CBM-TRD default detector design:

- Drift MWPC 3.5+3.5+5mm
- Operated with Xe/CO₂ (85/15)
- ~0.2μs electron collection time
- 2 module sizes → 6 module types
- 4 detector layers
- Detector acceptance: 88.1% for small modules and
92.8% for large modules
- Radiation environment → ASIC technology
- Material budget: < 1% X/X₀ per layer in active area (88.1 – 92.8%)
< 40% X/X₀ in frame area (7.2 - 11.9%)