Trigger and Beam Detectors for Heavy Ion Runs

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Based on:

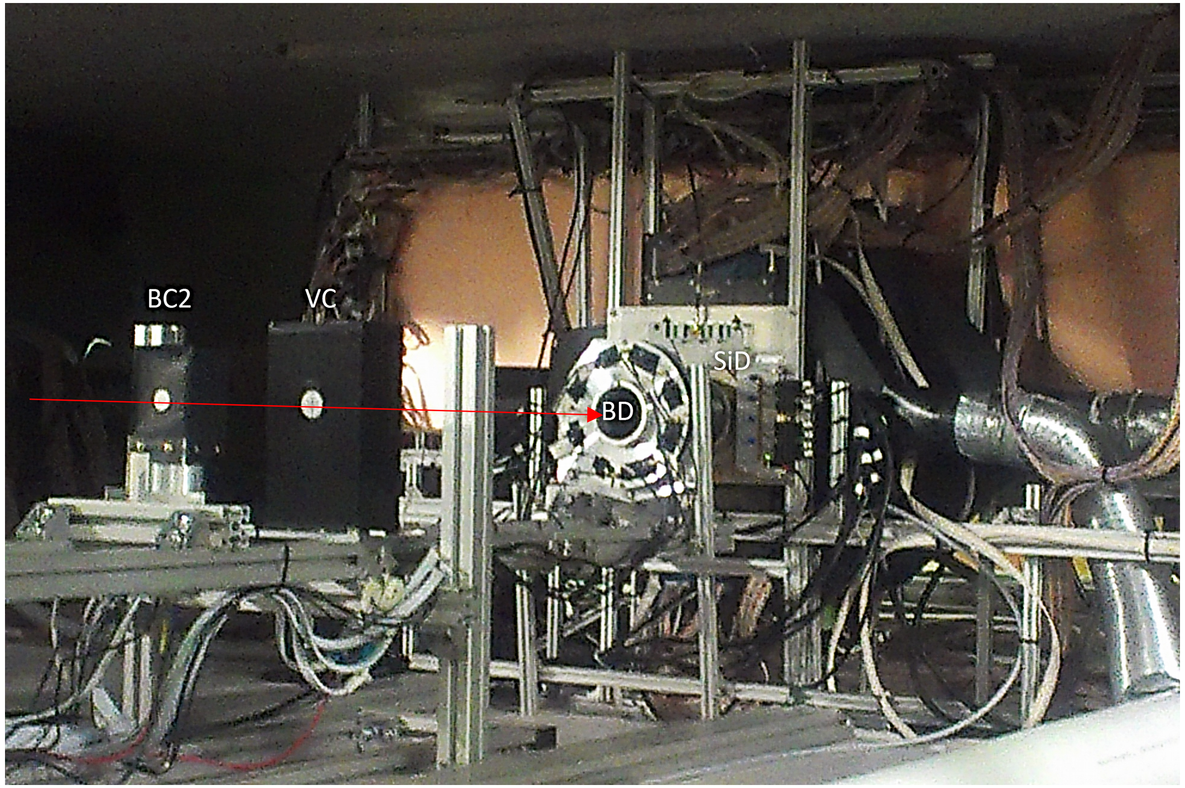
- TDR “Fast Interaction Trigger and T0 Detector”
- Experience in 2018 run with Ar and Kr beams
- Meetings about vacuum line after the 2018 run

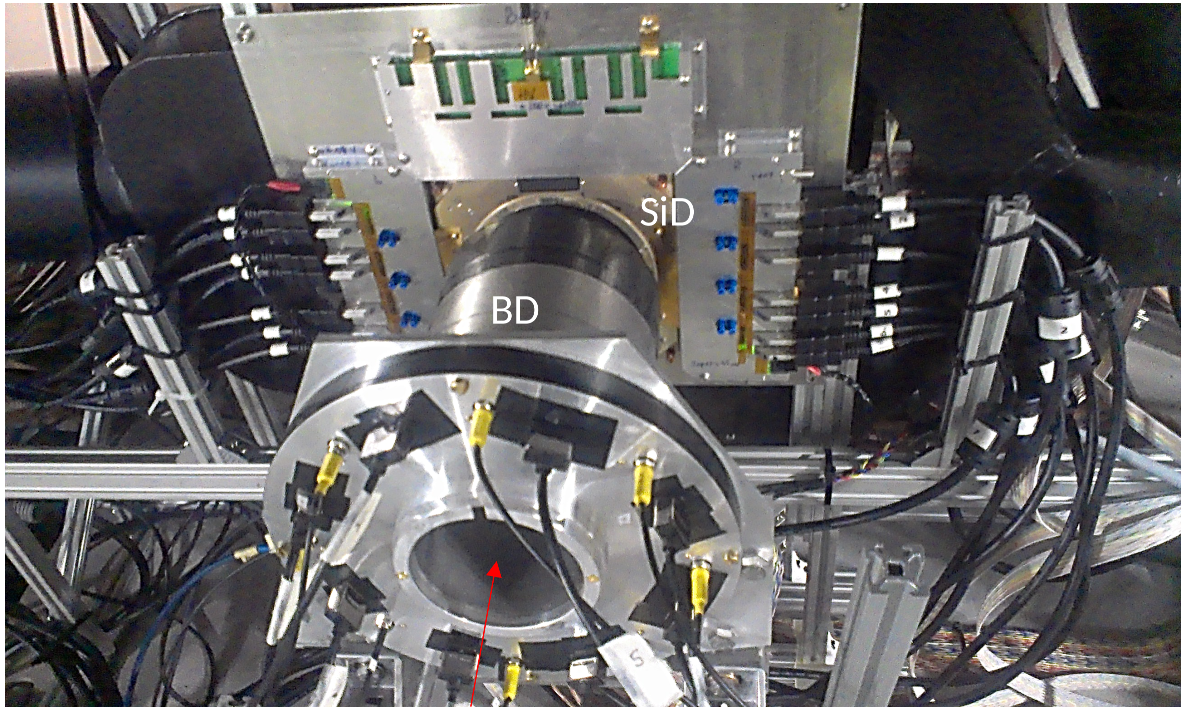
Tasks of Beam Line Detectors

Active transport of beam ion to the target:	BC1 × _VC × BC2
Trajectory of incoming ion:	Si1 – Si2 – Si3
Interaction trigger:	_BC3 × BD(N>N1) × SiD(N>N2)
T0 for TOF	

In addition the beam profile can be determined with a set of Beam Profile detectors which can be removed from beam axis after the measurement.

Beam Counters in Run 2018 with Ar and Kr ions

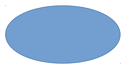




Beam line conditions:

No vacuum beam pipe
BC1 detector: plastic scintillator, 150diam. × 3 mm^3, PMT XP2020
BC2 (T0) detector: plastic scintillator, 20diam. × 0.8, angle 45^o, MCP-PMT PP0365G (Photonis)
VC detector: plastic scintillator, 100diam. × 10 mm^3, hole 27diam.mm, MCP-PMT MCP-PMT XP85012 (Photonis)

Beam Profile and Steering



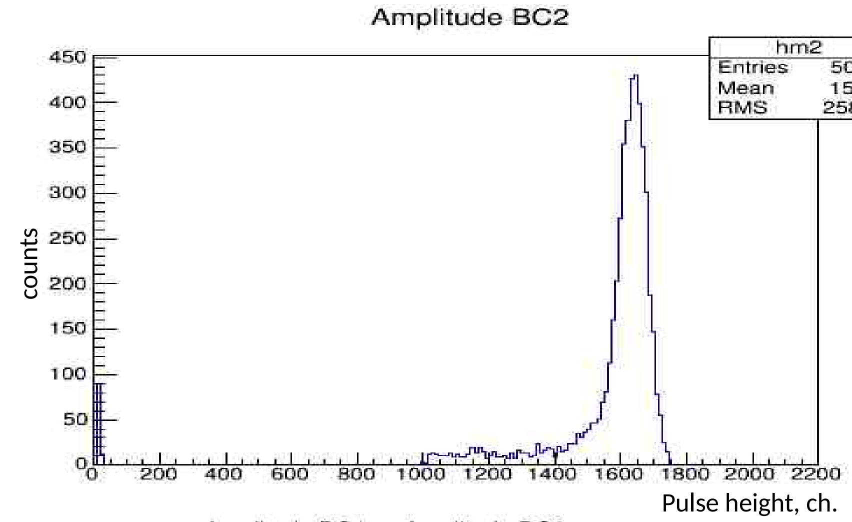
BC2 15 x20 mm^2

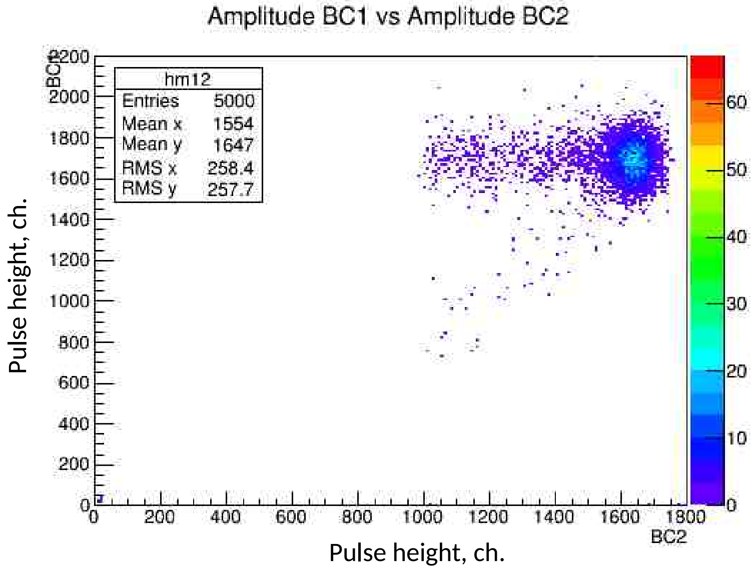
	Ar	Kr
σ_X	5 mm	5.3 mm
σ_Y	5 mm	3.2 mm
BC2/BC1	0.6-0.7	0.5-0.6

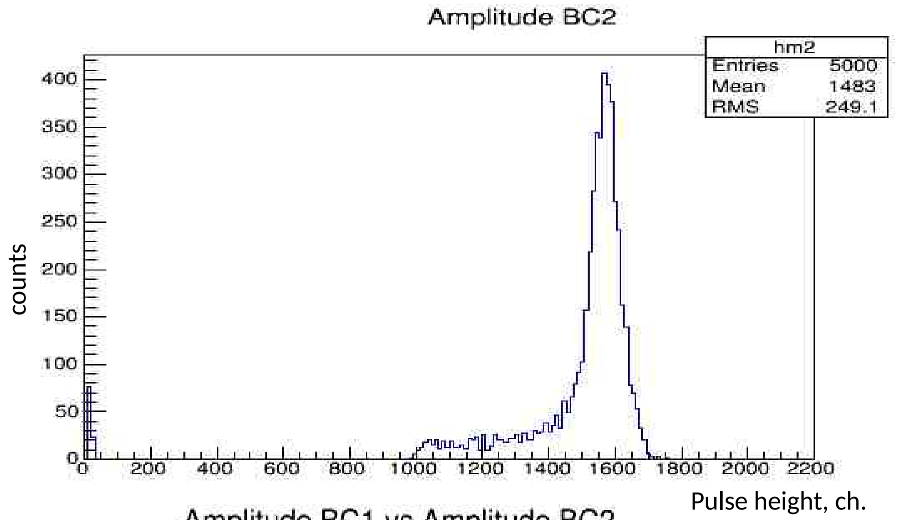
- “wide” beam
- unstable steering
- hard to predict the effect of upgrade

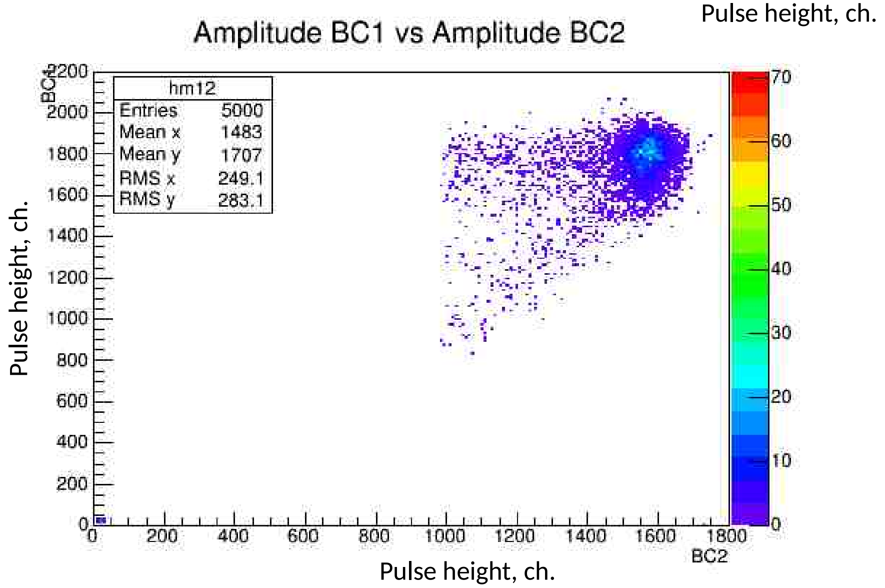
Beam detector responses

Ar ions	Kr ions









Proposal parameters of Beam Detectors

Detector	Active area (mm)	Photodetector	Granularity
BC1	BC400B 100 x 100 x 0.25	R2490-07 (2 units)	1
Si1, Si2, Si3	0.175- mm thick, 2 strip layers, 0.1 – 0.5 mm step	–	
VC		R2490-07 (2 units)	1
BC2(T0)	BC400B 10 x 10 x 0.15	XPM85112/A1-Q400 (2 units)	1-4
BD	BC418 90 diam. x 150	SiPMs (Sensl) Micro FC-60035-SMT, 6 × 6 mm^2	40
BC3	BC400B 30 x 30 x 0.15	SiPMs (Sensl) Micro FC-60035-SMT, 6 × 6 mm^2	1
SiD			64

Material Budget of vacuum beam line for Au ions

Material	H (mm)	P (%)
BC1 scintillator	0.25	0.67
Si1	0.15	0.35
Si2	0.15	-
Si3	0.15	-
BC2 scintillator	0.15	0.40
Al (exit window)	0.050	0.12
Air	60	0.10
Au (target)	0.40	1.64
Air	20	0.04
BC3 scintillator	0.15	0.40

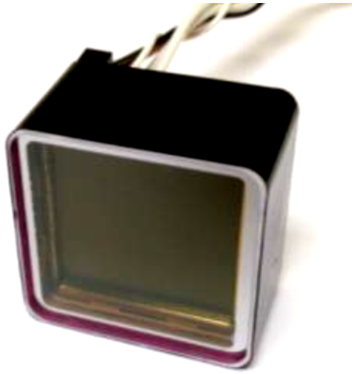
H – thickness
P – nuclear interaction probability

Plan to switch to Cherenkov counters at high
beam density • rate

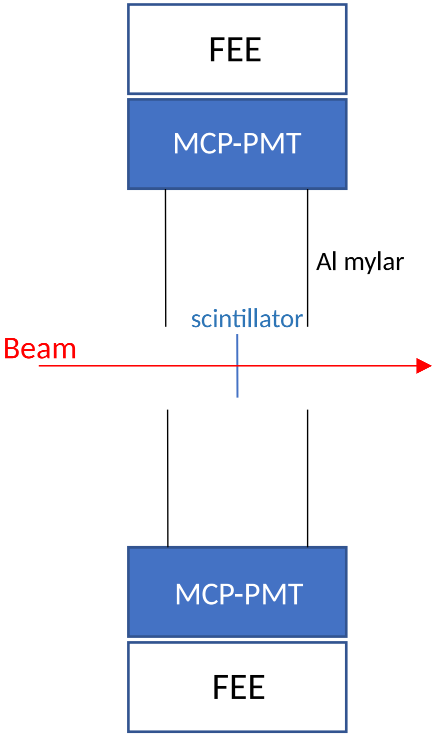
T0 detector (BC2)

Aim: T0 pulse for TOF detectors with $\sigma_t < 50$ ps

Photodetectors



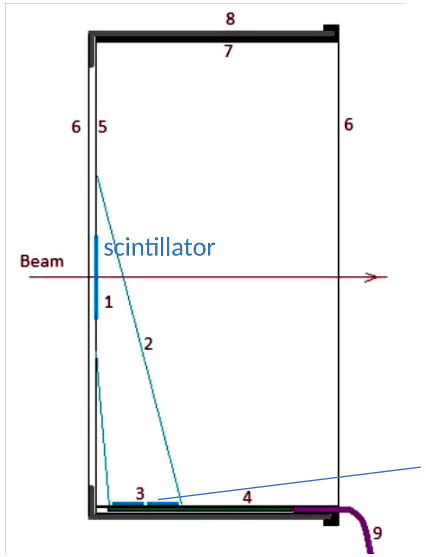
MCP-PMT XPM85112/A1-Q400
(Photonis)
Photocathode: 25 × 25 mm^2



Both detectors operate in magnetic field

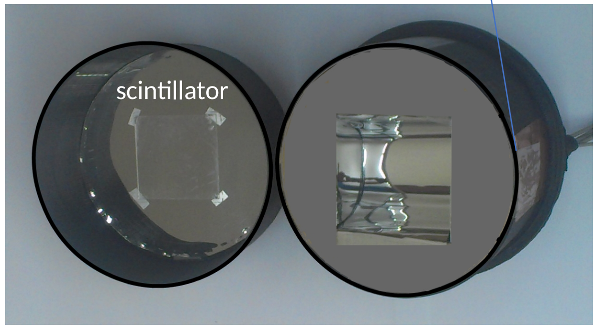
BC3 detector

Aim: Veto of beam ions behind the target



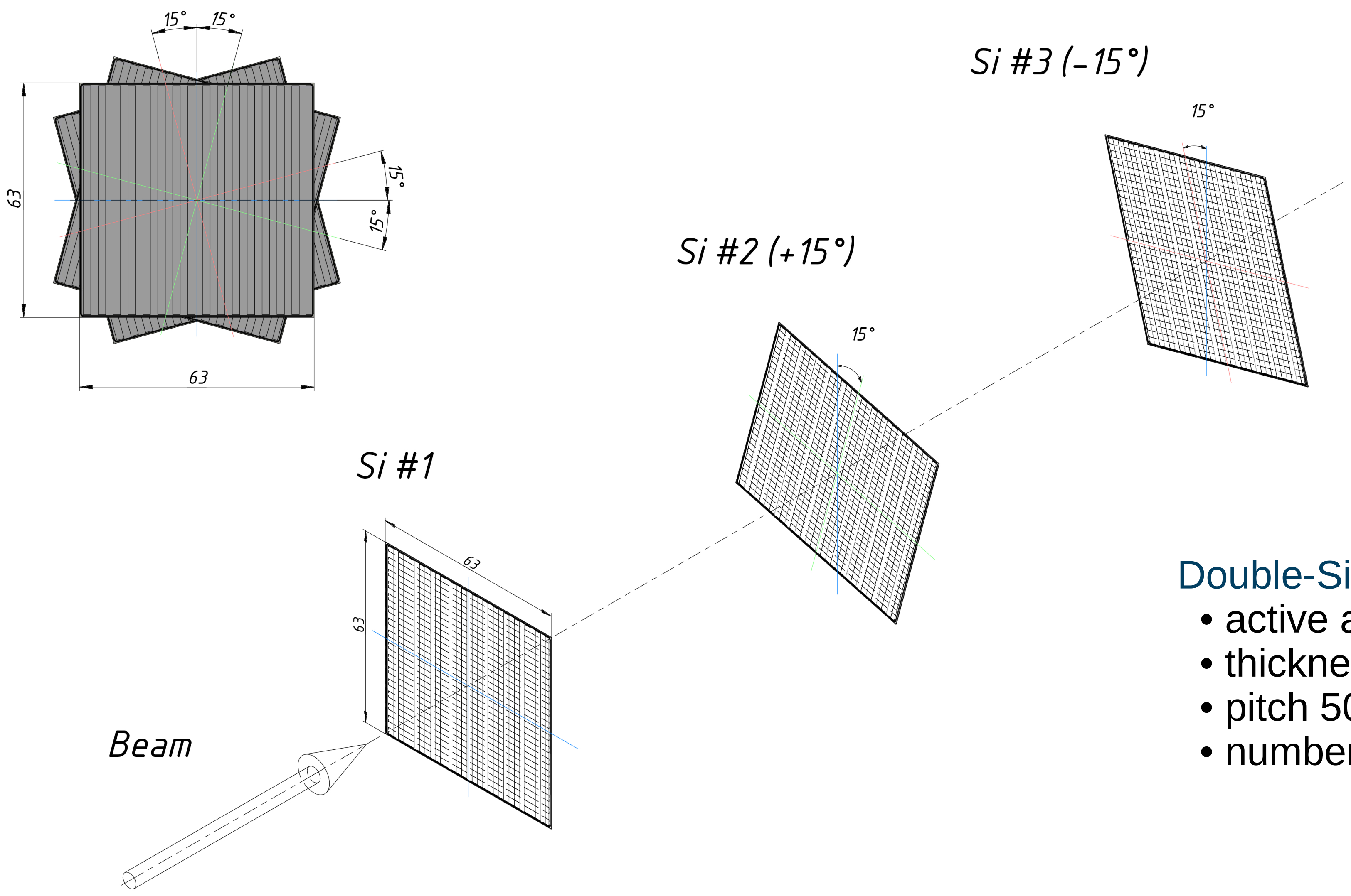
Ar ion pulse

The scintillation light is registered by 4 units of SiPMs (6 x 6 mm, Sensl)



Beam Vertex Silicon Detectors

N.Zamjatin

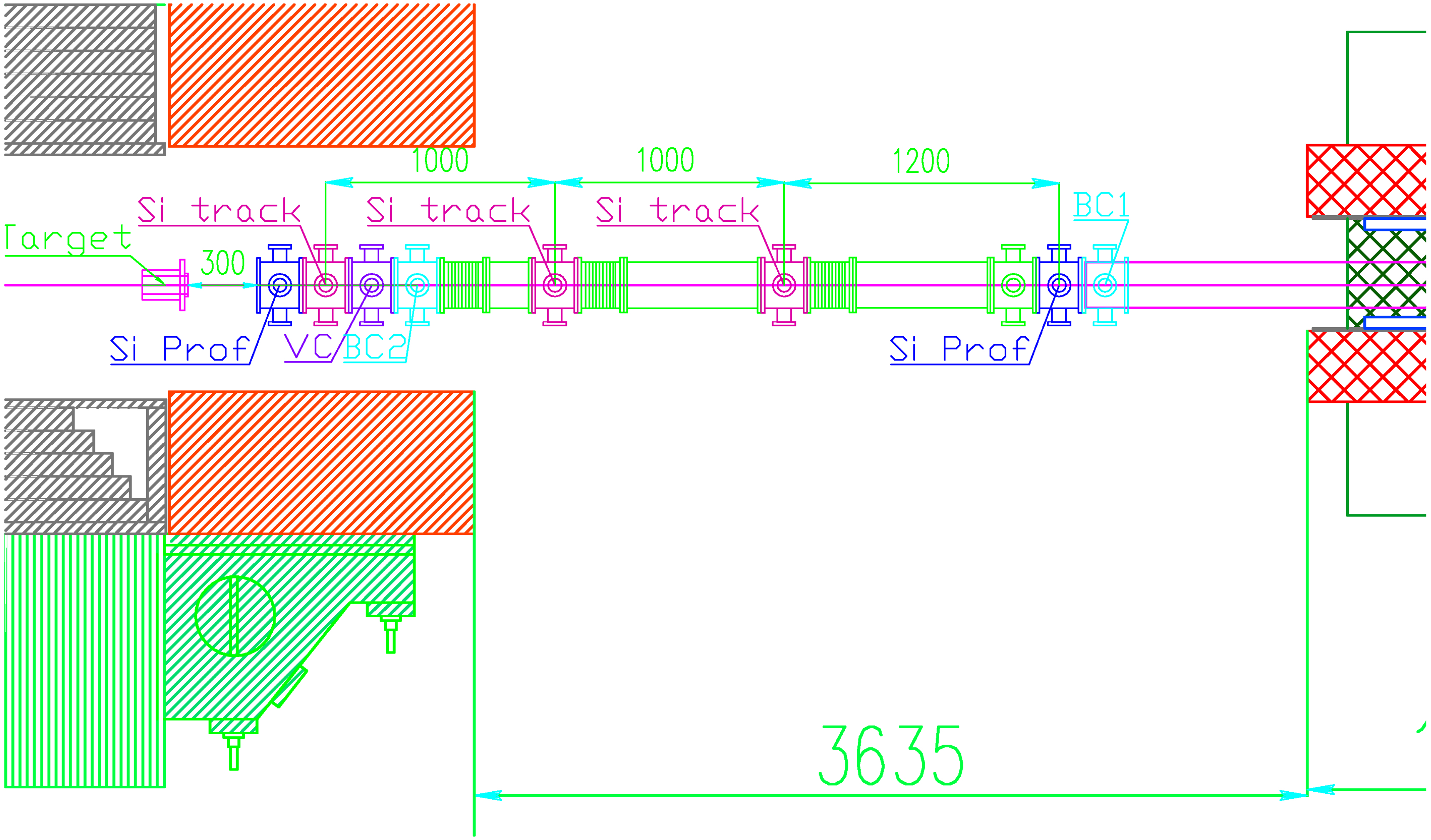


Double-Sided Strip Detectors

- active area 60 x 60 mm^2
- thickness 175 μm
- pitch 500 μm
- number of strips 120 + 120

Beam Line with Vacuum Components

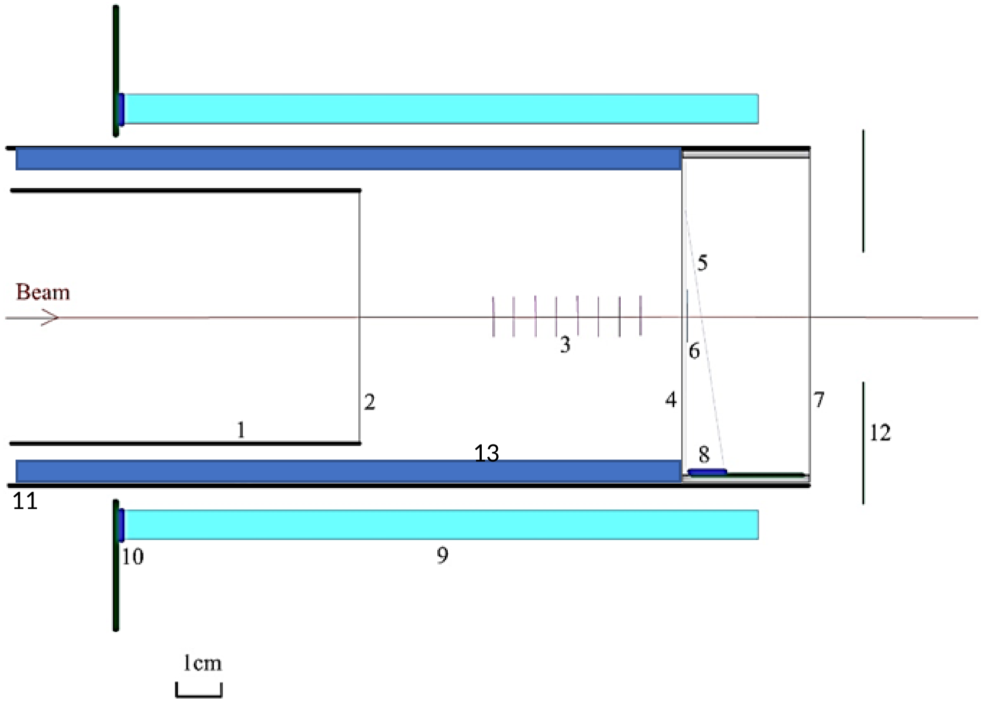
S. Piyadin



Vacom® (Jena, Germany)
- standard components
- specific requests

Points of concern
- pipe dia.: 20 cm → 7 cm
- no room for all detectors
- junction to target area

Target area



A scheme of the target area:
1 – the vacuum carbon beam pipe, 2 – the 100- µm aluminum window,
3 – the multifoil target, 4 – the black paper, 5 – the Al-mylar light guide,
6 – the thin plastic scintillator of BC3, 7 – the black paper,
8 – the SiPM's board of BC3, 9 – the scintillation strips of BD,
10 – the SiPM's board of BD, 11 – the 0.5- mm steel tube, 12 – the SiD,
13 – Pb shield

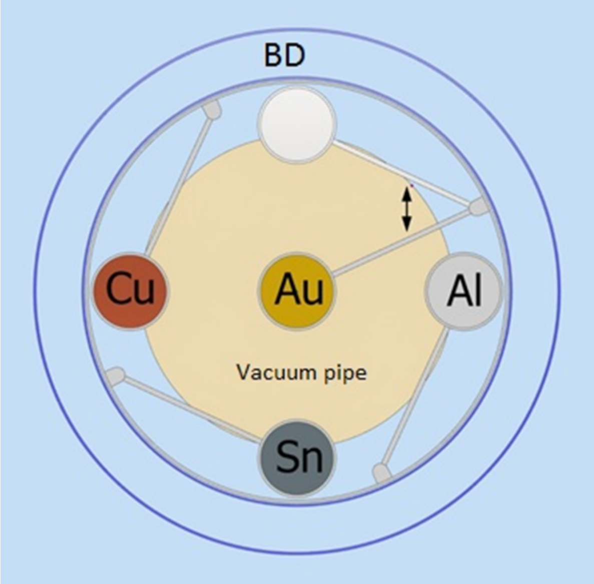
Two modes for different physics programs were discussed:

- *AA*- collisions with various combinations of beam and target nuclei with special target station
- Au + Au collisions with special He or vacuum beam pipe downstream from the target

Material	Thickness	Probability of nuclear interaction of Au ion (%)
Al window of beam pipe	50 µm	0.117
Air (till BC3 scintillator)	80 mm	0.138
BC3 entrance window	20 µm	0.052
BC3 scintillator*	150 µm	< 0.115
Au target	50 µm × 8	1.78
Sum:		2.39

Target station

A set with four targets with different atomic numbers is used for study of nucleus – nucleus collisions with various combinations of colliding nuclei.
The targets can be automatically changed on beam line position including empty target. For this goal a special mechanical system of the target station has been designed.



A scheme of the target station

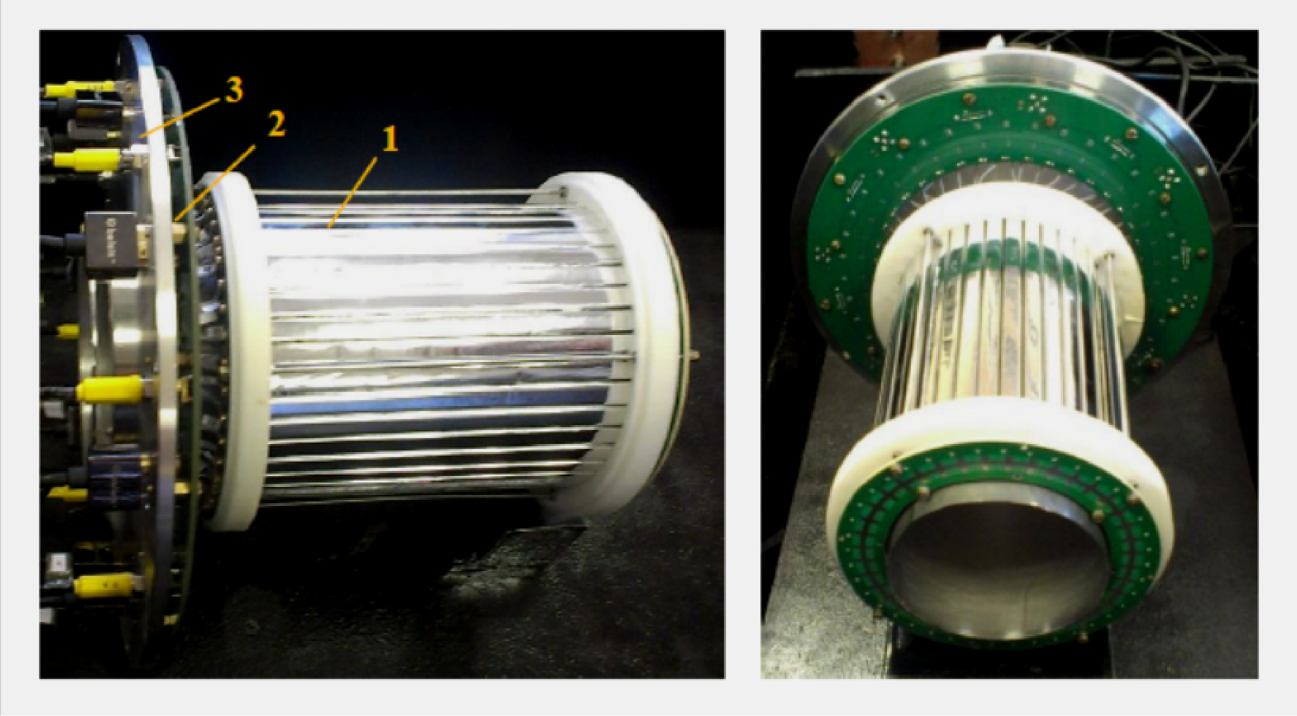
Each the target consists of 8 micro-target foils with 5- mm gaps between them and it corresponds to 1 – 2 % probability of nuclear interaction.

#	Target	A	Thickness, mm	Probability of nuclear interaction, %
1	Al	27	0.15 × 8 = 1.2	1.13
2	Cu	63.5	0.05 × 8 = 0.4	1.07
3	Sn	118.7	0.1 × 8 = 0.8	1.52
4	Au	197	0.05 × 8 = 0.4	1.78

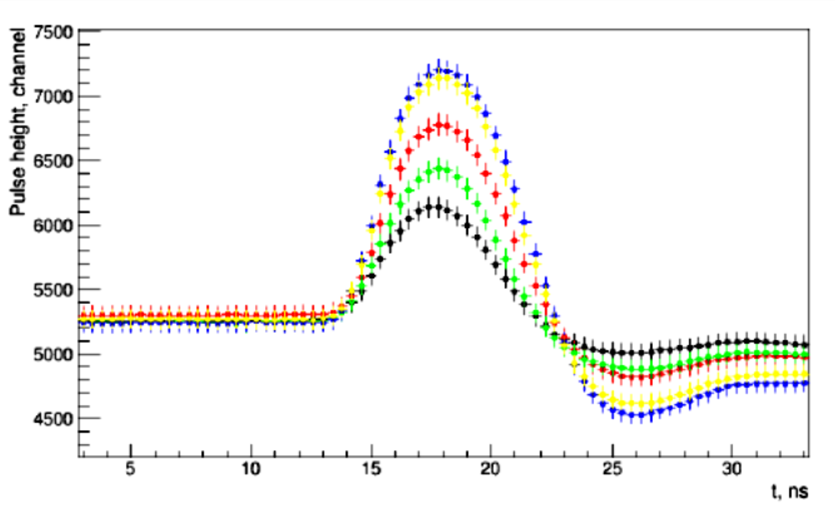
Rotation of a single target to the target position on the beam axis is made automatically by a compact pneumatic cylinder.

Interaction trigger. Barrel Detector (BD)

The active area of BD has radius of 45 mm and length of 150 mm and it consists of 40 strips 150 × 7 × 7 mm^3 made from polished scintillator BC418 wrapped by Al- mylar.
Each strip is directly connected with SiPM Micro FC-60035-SMT, 6 × 6 mm^2.



A view of the new BD prepared for run 2018:
1 – the scintillation strips, 2 – the board with SiPMs,
3 – the board of front-end electronics.

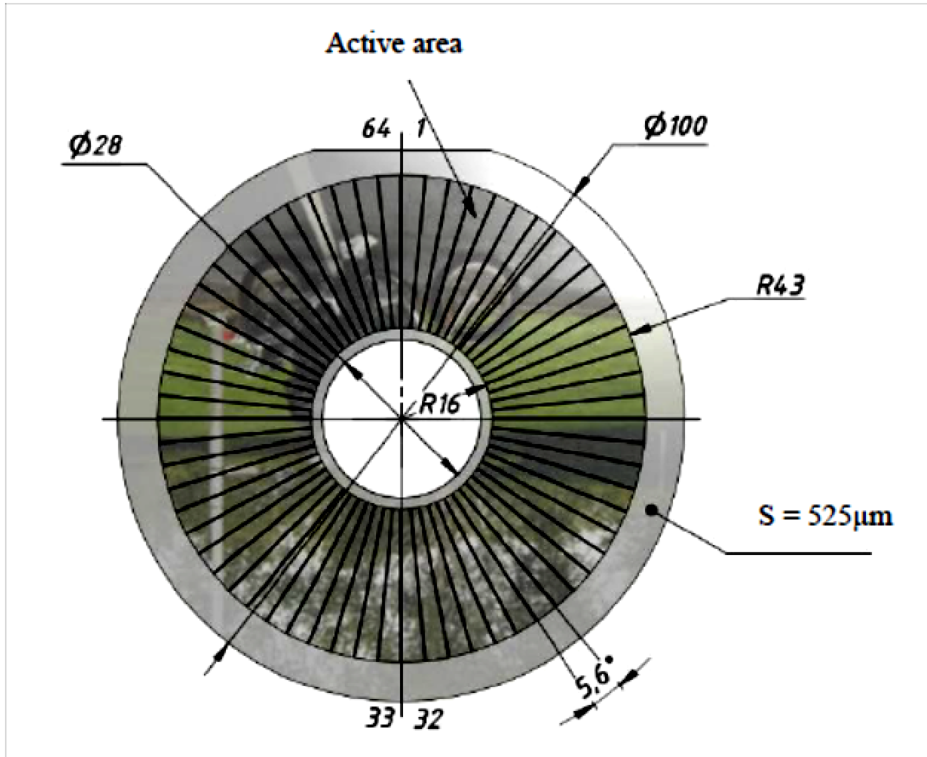


The typical analog pulses coming from a single BD channel.

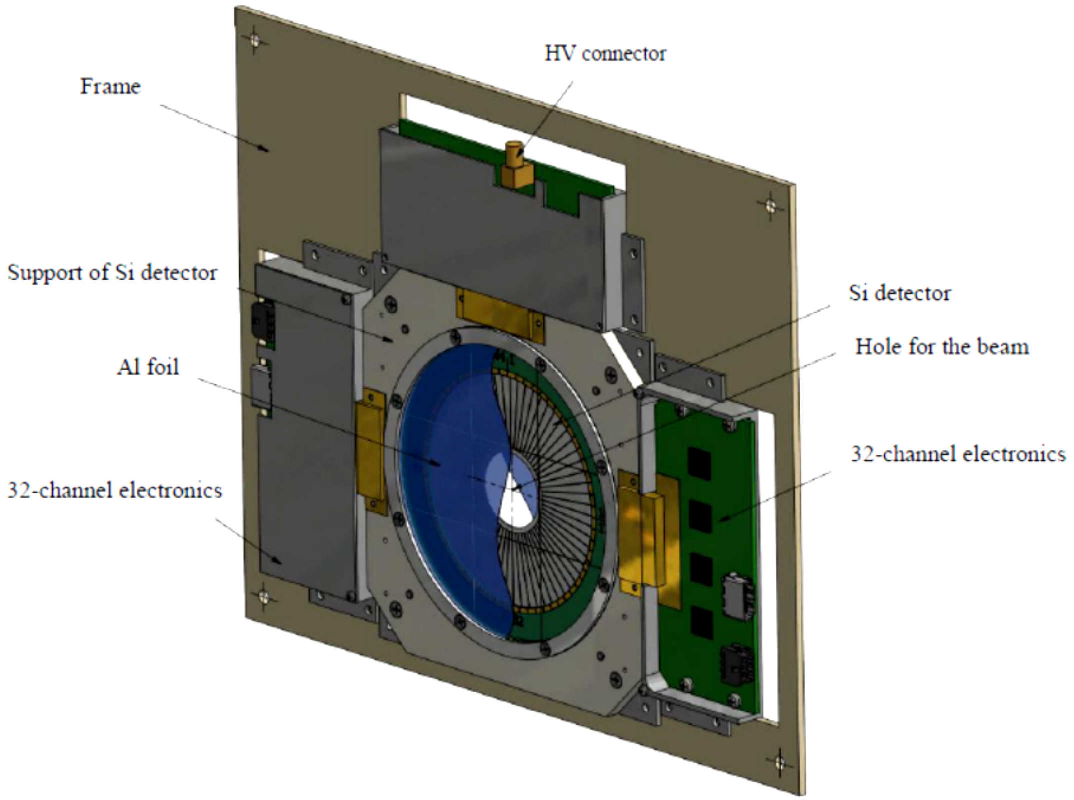
16-channel LV power supply unit for SiPMs in NIM standard

Interaction trigger. Si detector

The Si detector has 64 independent segments / channels and it provides fast determination of multiplicity of charged particles emitted in forward direction by measuring a number of fired segments.



A view of the front side of Si detector.



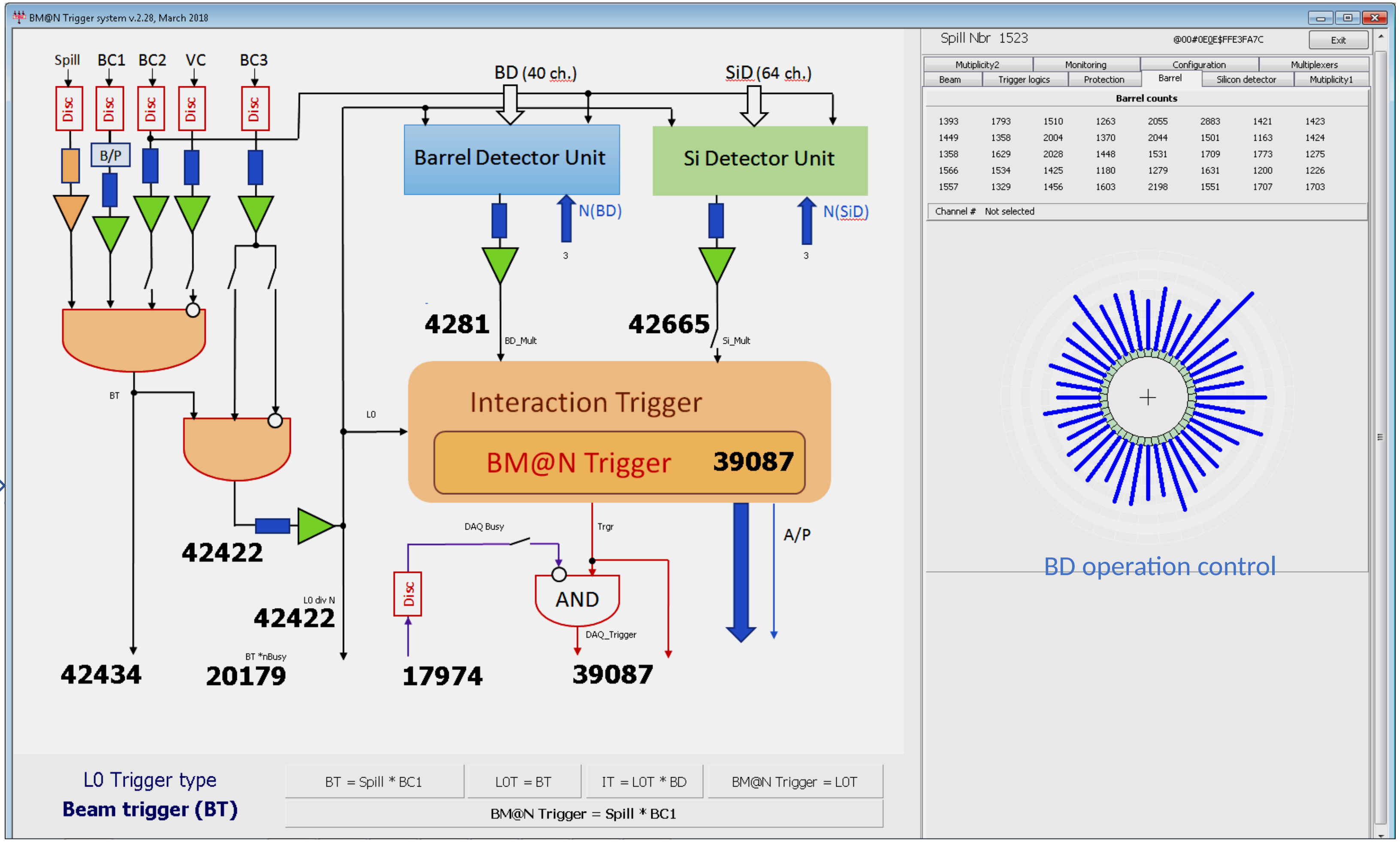
A general view of the Si detector with electronics.

Trigger interface

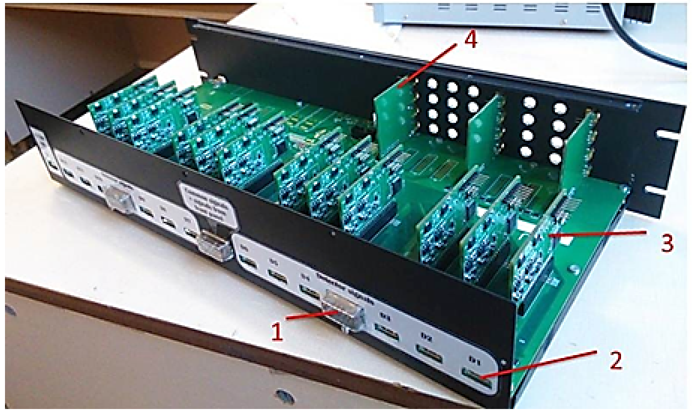
T0U Manager

controls the hardware of T0U module and reads out the summary spill data containing counts in input channels and in some internal points of the trigger logic

The trigger window of T0U_Mgr

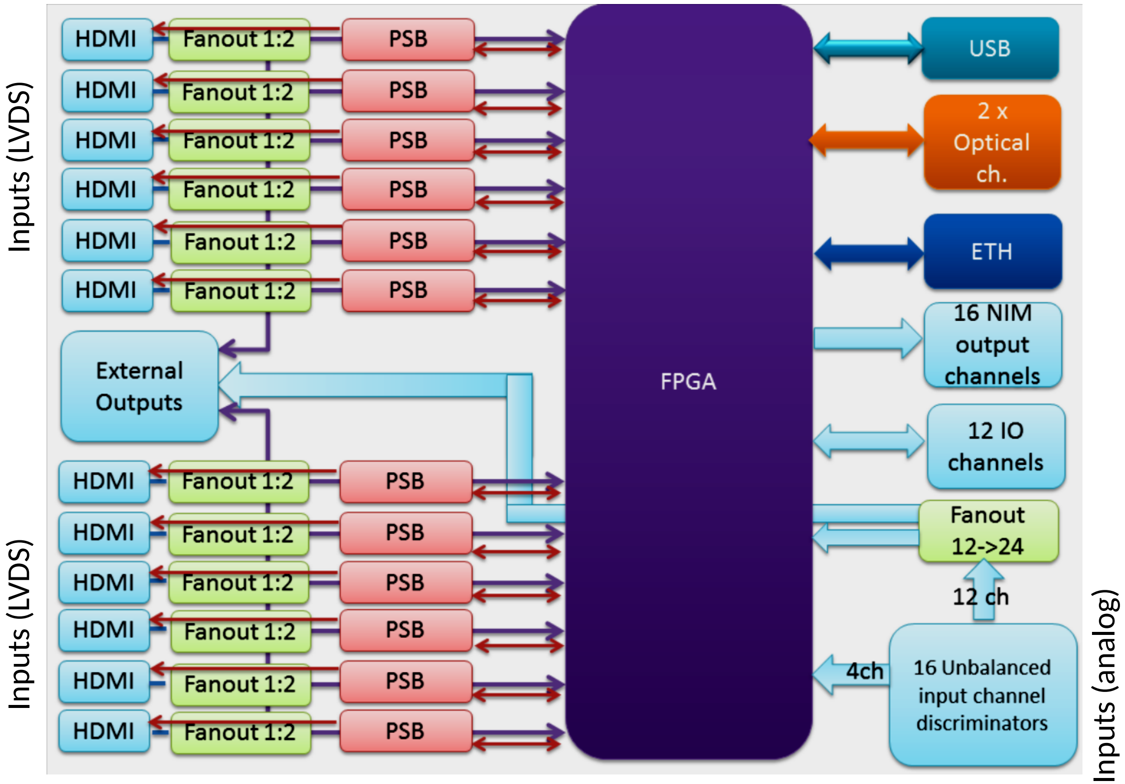


Trigger electronics



A photo of T0U module: 1 – the output Molex connector;
2 – the input HDMI connector; 3 – the power supply board;
4 – the IOB output connectors of trigger signals generated by T0U.

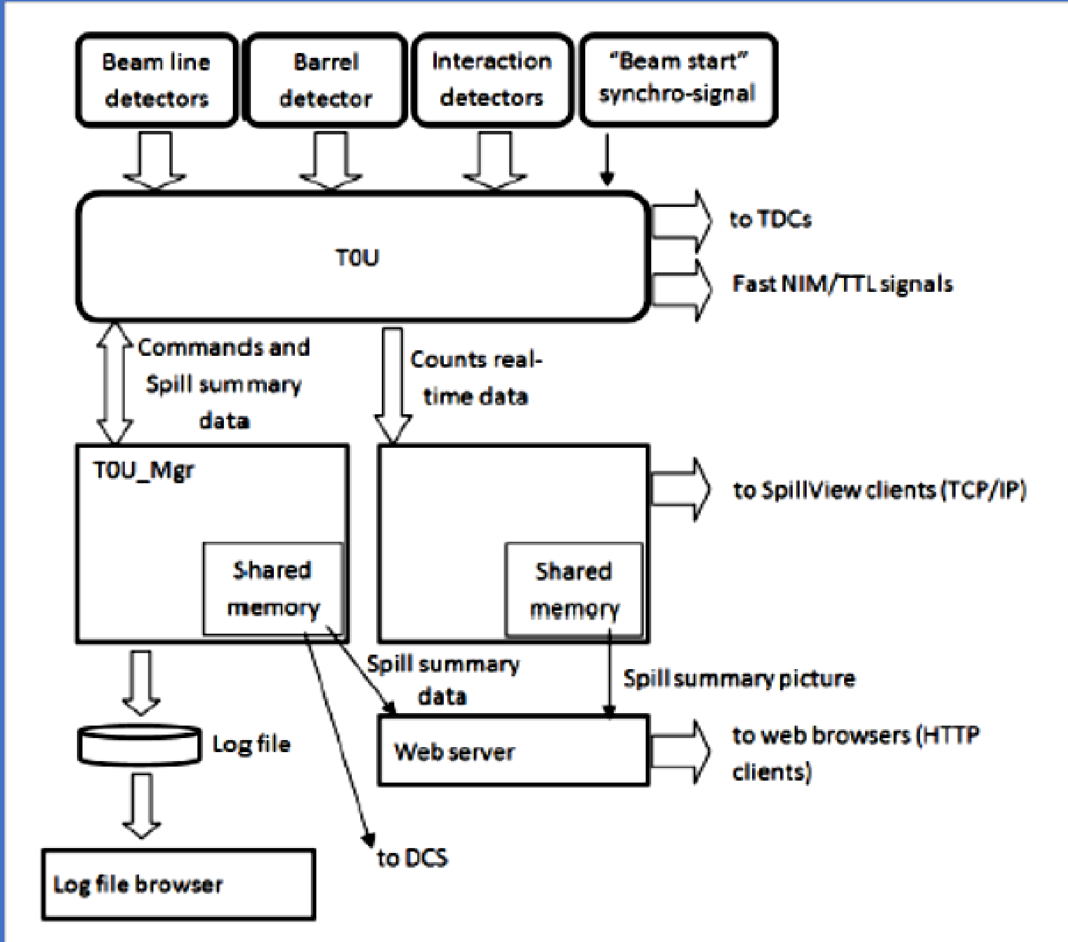
The T0U module generates a trigger pulse according to a programmable trigger logic based on FPGA and also provides control and monitoring of the FEE power supplies, detector operation, trigger and beam conditions.



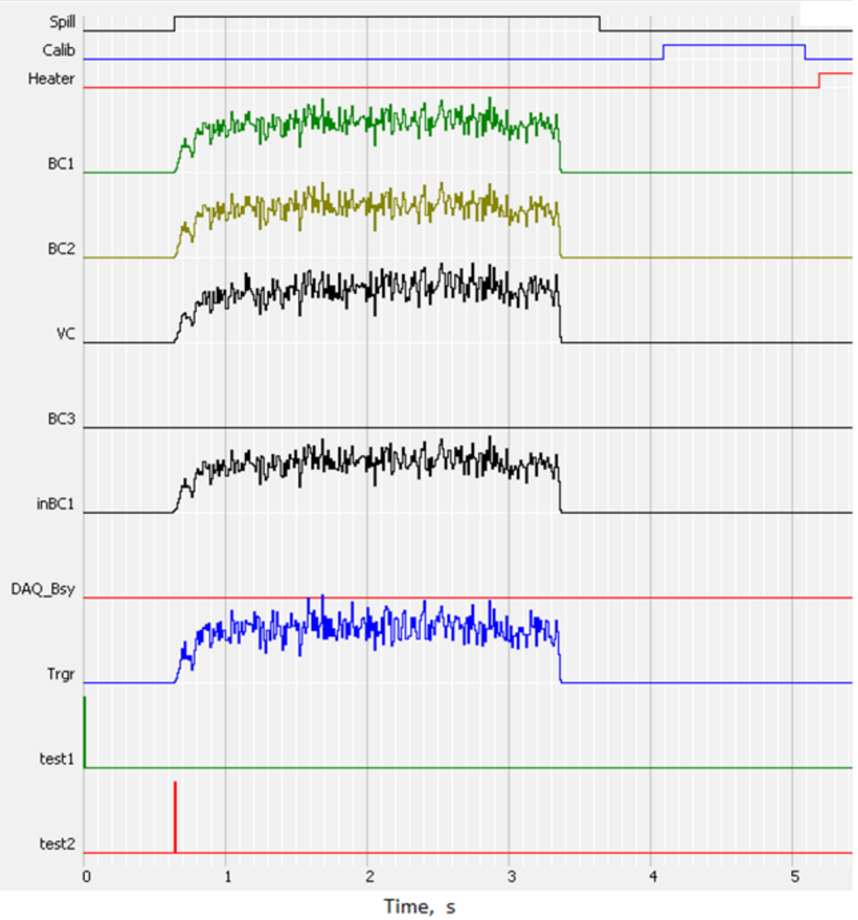
A scheme of the T0U structure

Trigger electronics II. Control and Beam Monitoring

BM@N trigger control/monitoring system Block diagram



The SpillView TCP/IP server has been developed for control of the spill intensity in a real time mode



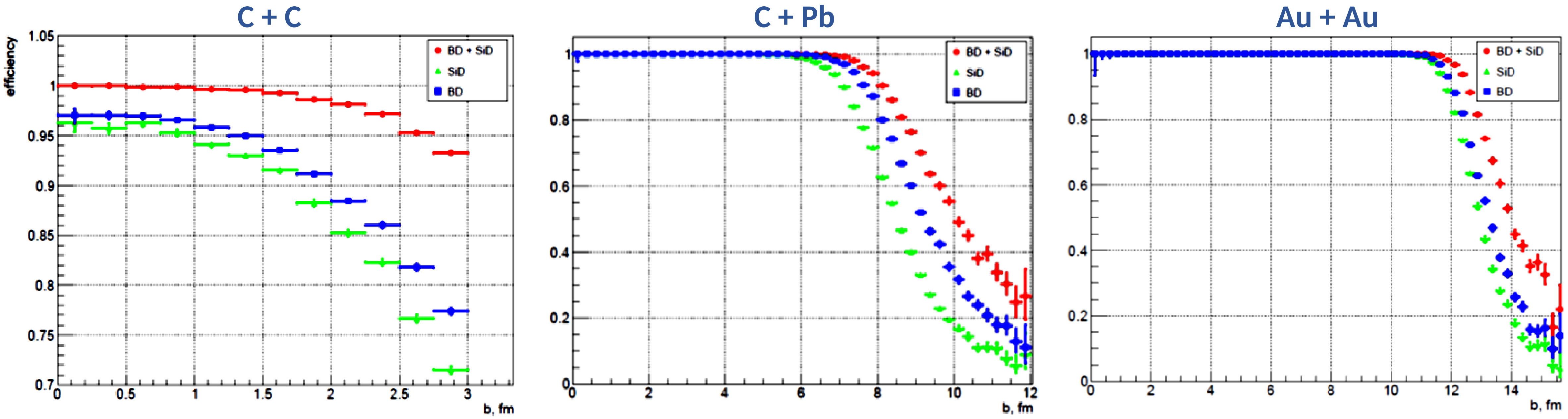
Time structure of Ar ion spill and counting rates of the beam detectors and trigger.

S. Lobastov

Simulation of trigger performance

Monte-Carlo simulation with QGSM + GEANT4 codes

Ion energy = 4 GeV/nucl.
Magnetic field B = 0.9 T

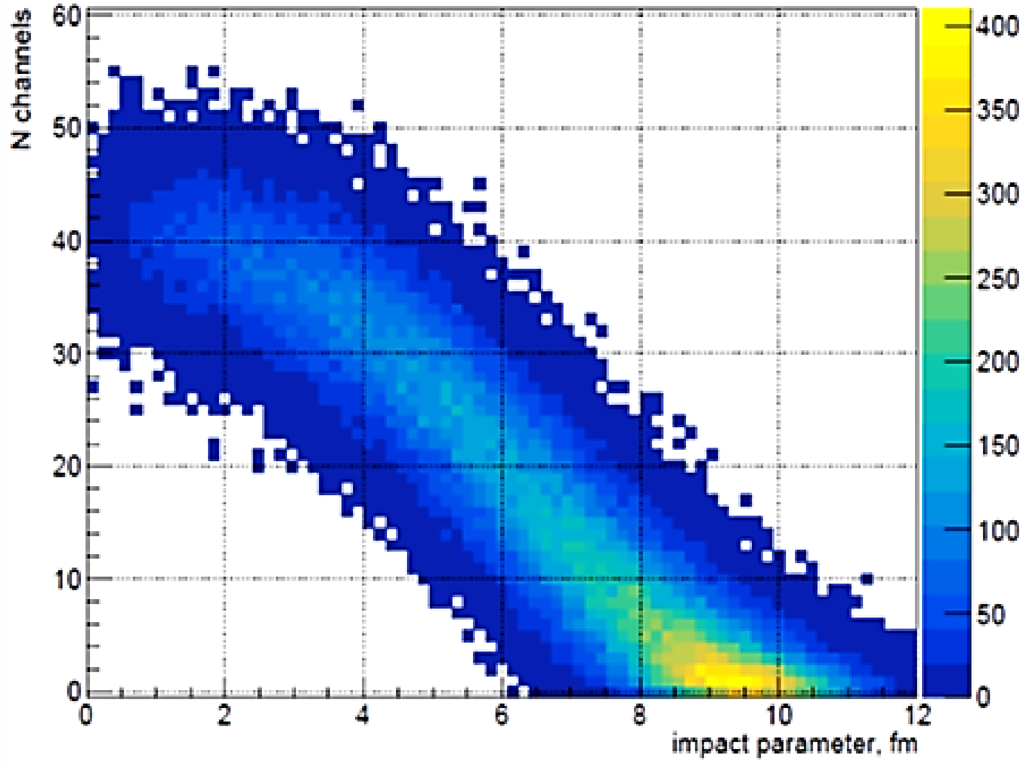


Trigger efficiency as a function of impact parameter.

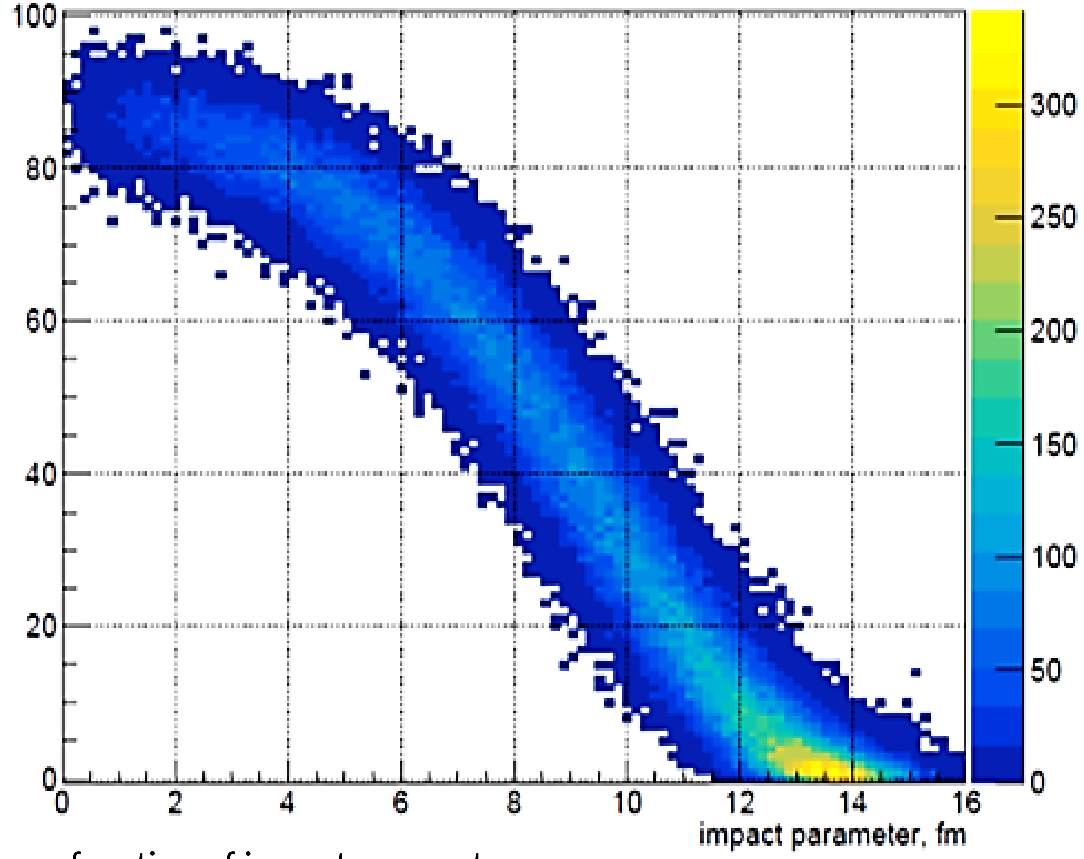
S. Lobastov

Simulation of trigger performance

C + Pb



Au + Au



Number of fired channels BD + SiD as a function of impact parameter

- Plans for Ar, Kr data analysis and simulation. Nikita Lashmanov recently started this work.