Preparations for the next SRC Run in 2021

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BM@N CM
October 2020

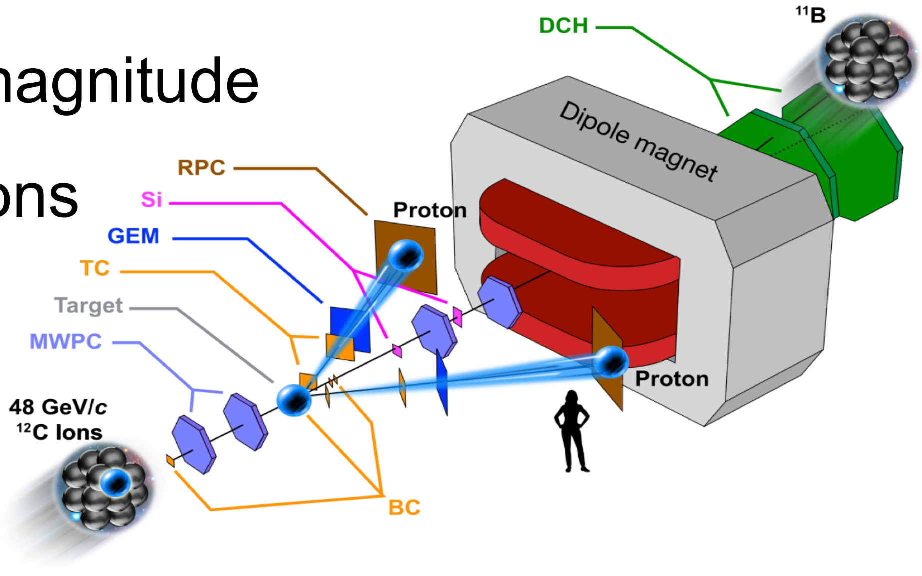
Next Experiment

Following the successful pilot experiment (publication under review):

- **increase statistics** by order(s) of magnitude

for detailed comparison with calculations

- improve detector resolutions
- employ multi-particle tracking
- **event selection: p/pion sampling**
- "learn from lessons previous experiment"

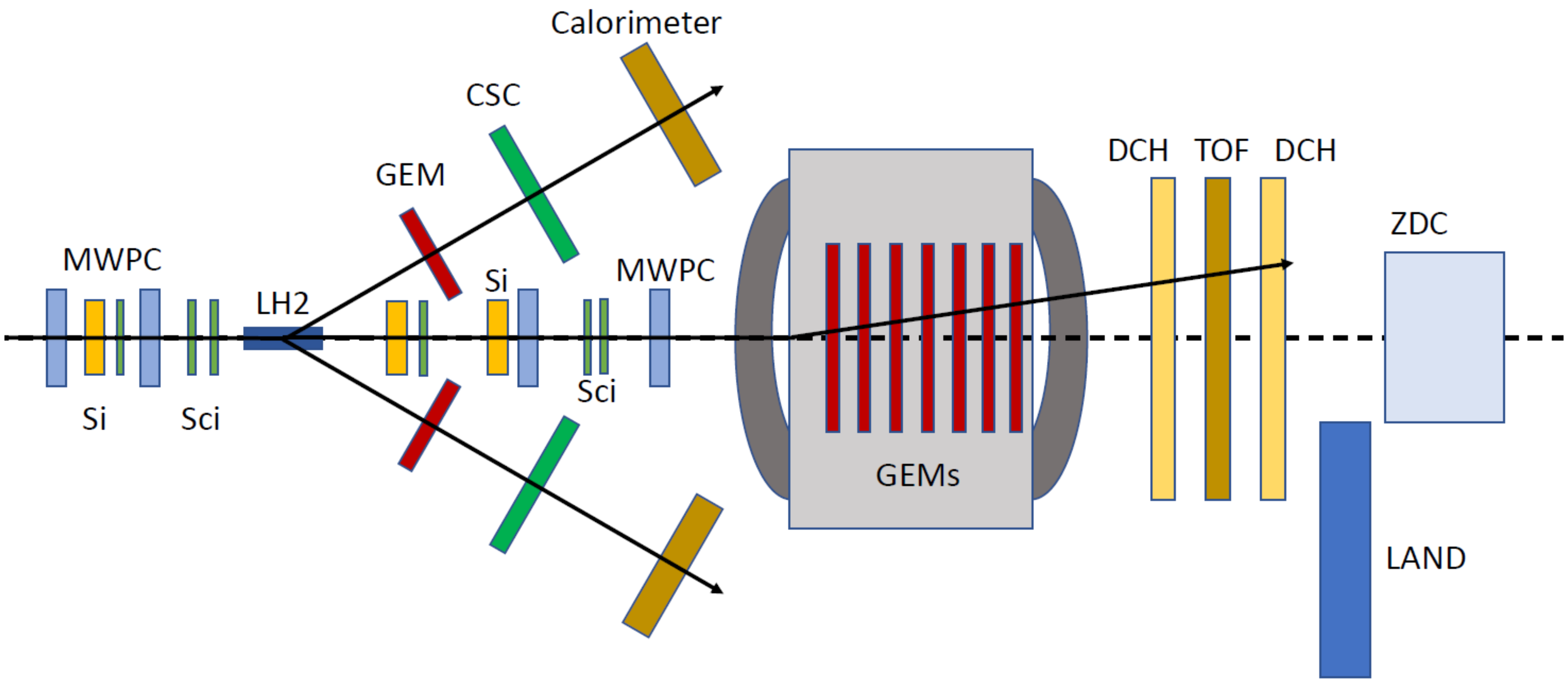


Next Experiment

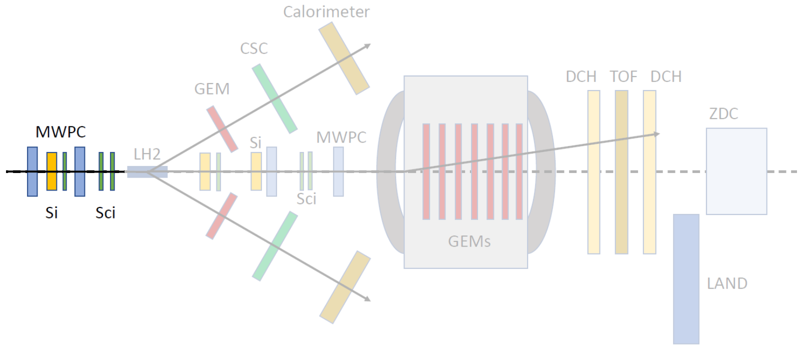
- ^{12}C and deuteron beam
- several beam energies: ~2 – 3 GeV/u
- max. beam intensity ~ 5 x 10^5 ions/s

  (compatible with detector limitations)

Similar Setup as in Run 7



Incoming Beam Monitoring



- Tracking:
  2 x MWPC
  Si detectors for beam tuning

- Energy loss (BC1, 2xBC2):
  3 x 3 mm Scintillator (60x60 mm²)

- T0 (BC2):
  2 x Scintillators with XPM 85112 PMT

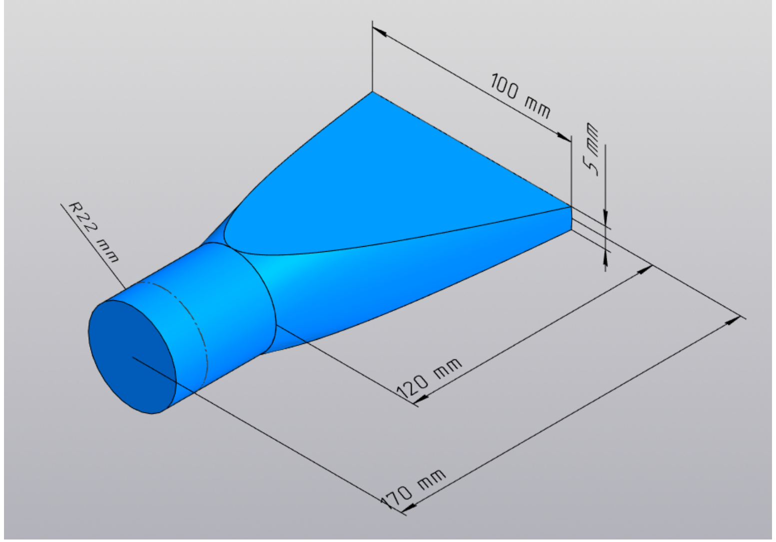
In-beam Scintillator Detectors

General Configuration

- scintillator sheet coupled to light guides and 2 PMTs
  (design for detectors and mechanical support being finalized)

- to be assembled and tested at JINR

- In total: 6 BC detectors
  (BC1, 2xBC2, BC3,4, BC5 + veto)



BC components

	BC3	BC4	BC5	T01	T02
Scint.	100*100*5 mm	100*100*5 mm	100*100*5 mm	60*60*3 mm	60*60*3 mm
LightGuide	Preliminary design	Preliminary design	Preliminary design	Preliminary design	Preliminary design
PMT	Not yet decided	Not yet decided	Not yet decided	XPM85112/ A1 - Q400	XPM85112/ A1 - Q400
Signal cable	+	+	+	+	+
HV cable	-	-	-	-	-
Box	-	-	-	-	-
Mechanics	-	-	-	-	-
Magnet protection	-	-	-	+	+

Equipment for T0 trigger module

№	Equipment / materials	Number (units)	Delivery
1	MCP-PMTs	2	Received
2.1	PMTs Hamamatsu 7724-100 + S5632	5 4	--
2.2	PMTs magnet protection and covers	5	--
3	NIM crate	1	--
4	CAEN digitizer N6742	1	Received
5	CAEN N979 16 ch fast amplifier	1	Received
6	HV cables (10 m) (20 m)	14 1	
7	Scintillators BC418		Received
8	Coaxial cables RG405	120 m	Received
9	MOLEX cables	2	DAQ group
10	VME crate	1	DAQ group
11	TDC72VHL	1	DAQ group
12	TQDC16VS-V	2	DAQ group

New LH_2 Target

- The target group is developing a new LH2 target with the same parameters (D = 6 cm, length = 30 cm) as the old one

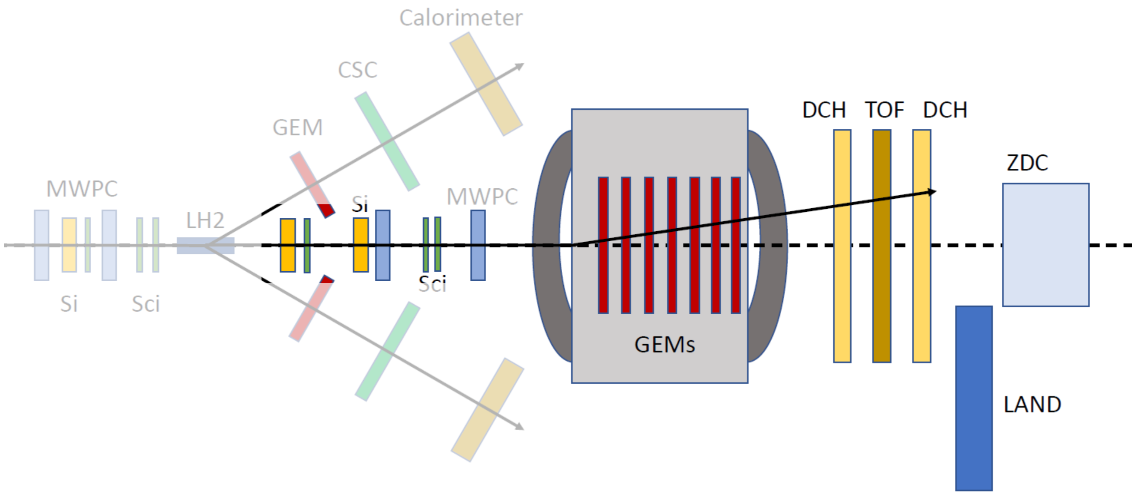
- Target inside the SP-57 magnet gap to gain acceptance for the arms

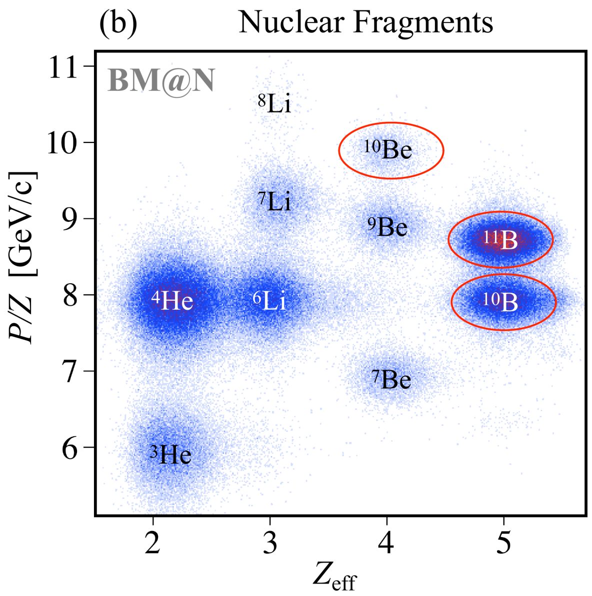
- Veto box around target: thin scintillator detectors

Scintillators around the LH volume read out by 1 PMT each

Fragment ID

Detect protons up to carbon and multiple particles





Fragment Tracking

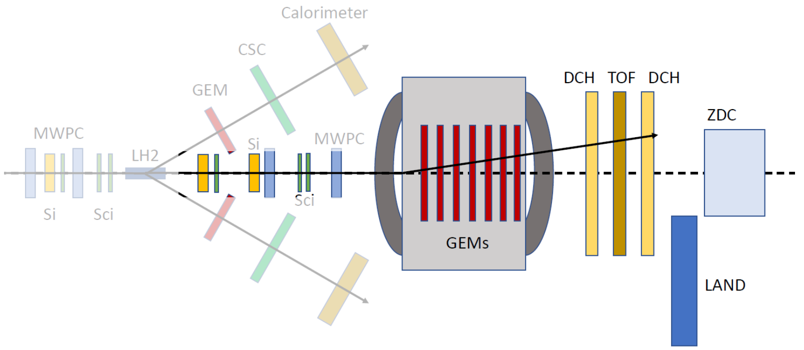
Detect protons up to carbon and multiple particles

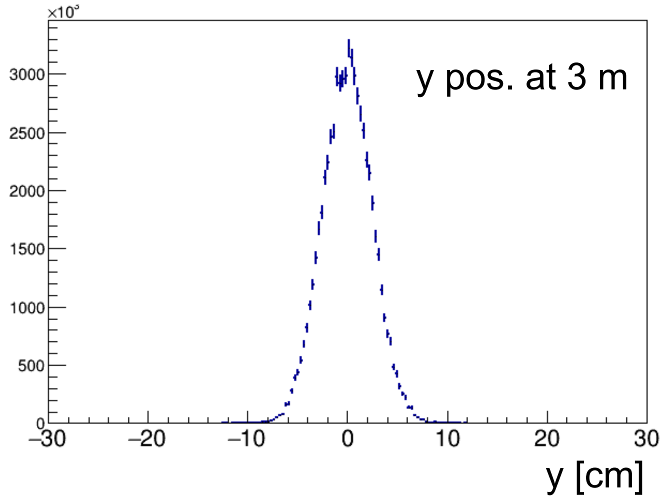
- Tracking:
  - 2 x MWPC
  - Same Si detectors as previously?

- Si detectors:
  2 Si stations that can
  - stay rate
  - large enough
  - dynamic range to cover p and C (?)

- Energy loss:
  - 3 mm (or 5 mm, diff. gain) Scintillator (100x100 mm²) with XP2020 PMT

- no beam pipe

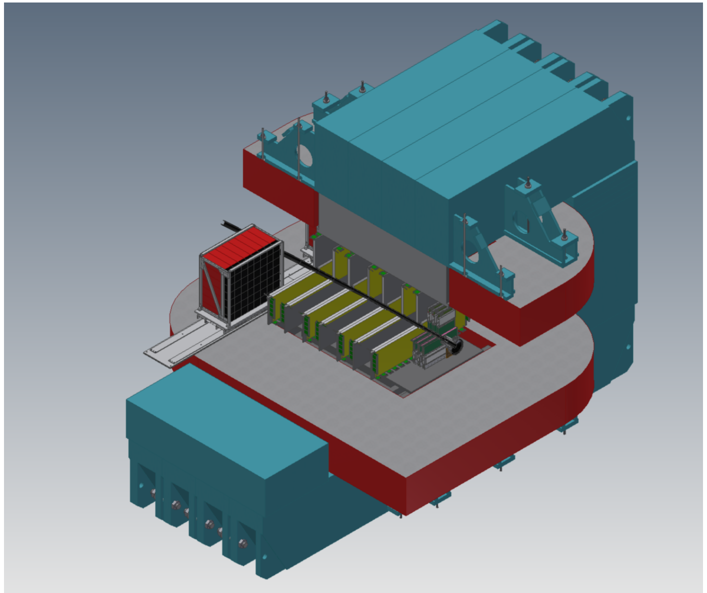




Fragment Tracking

For efficient detection of fragments we need as little material as possible inside the SP-41 magnet

For the SRC setup no beam pipe upstream and inside SP-41, Si detectors, GEM central tracker will be installed

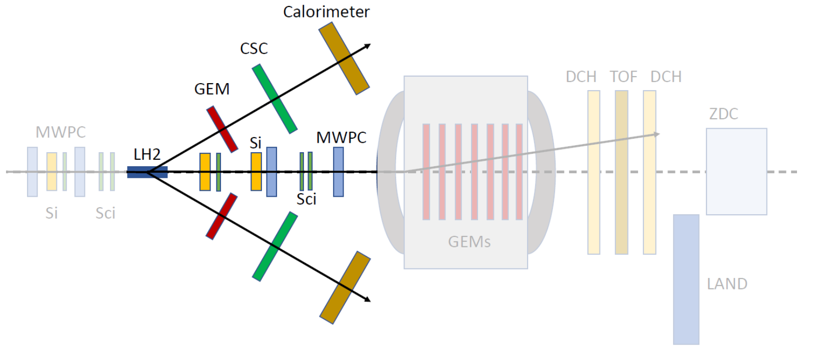


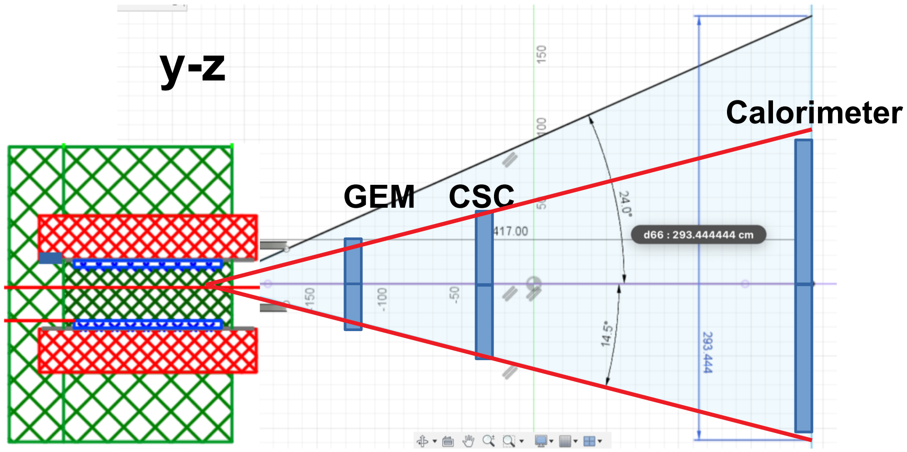
Two Arm Spectrometer

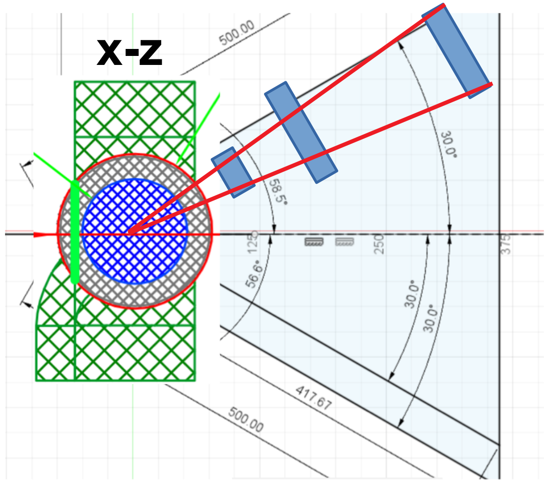
TAS configuration:

- GEM – CSC – Calorimeter
  (no XY trigger counter)

- 2 small GEMs (66 x 41 cm²)
- (min.) 2 CSC (100 x 100 cm²)

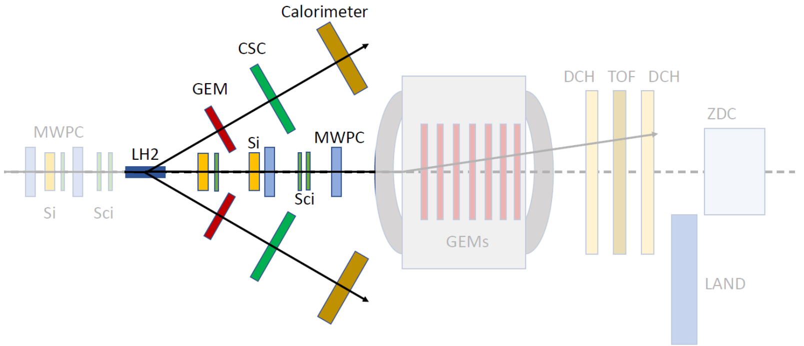






New Calorimeter

(non-magnetic) Calorimeter:
Sandwich like structure of Sci – Fe – Sci
(size tbd ~ 150 x 230 x 25 cm^3,
frames provided by JINR?)



1. Sci layer:
   High-performance Sci. bars (~25 each arm),
   test Sci + PMT to reach < 70ps Tof resolution

2. Fe layer ~10 cm
   to be optimized to achieve strong p-pion separation

3. Sci layer for dE

→ allows to determine number of initial p and pions
→ show in statistical approach that pion contribution is small
and can be subtracted in p_{miss} distribution

New laser calibration system

A new laser calibration system will be brought to calibrate all scintillator counters and the calorimeter without the beam

The laser system will give absolute TOF measurements with all relevant detectors with no need to calibrate with beam and gammas!

Wavelength is 335 nm or 405 nm, and the fibers are 200 um core diameter

Fiber length will be adjusted to fit the setup

Around 50 fibers

DAQ and Trigger

Trigger Module:

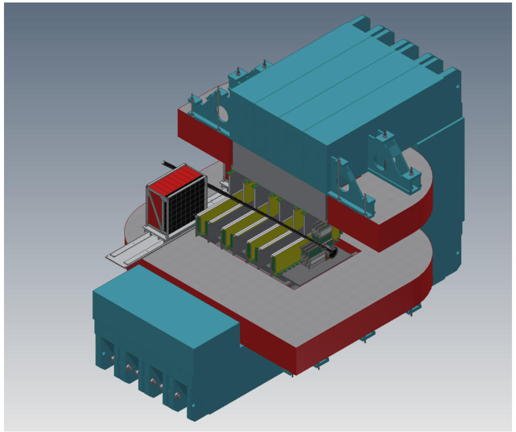
- add coincidence signal from each arm
- off-beam trigger: laser calibration

DAQ:

- 2 more BCs, and 2 PMTs for each counter, veto box
- add <~200 TDC and ADC channels for Calorimeter
- add 2 CSCs
- new readout electronics for LAND

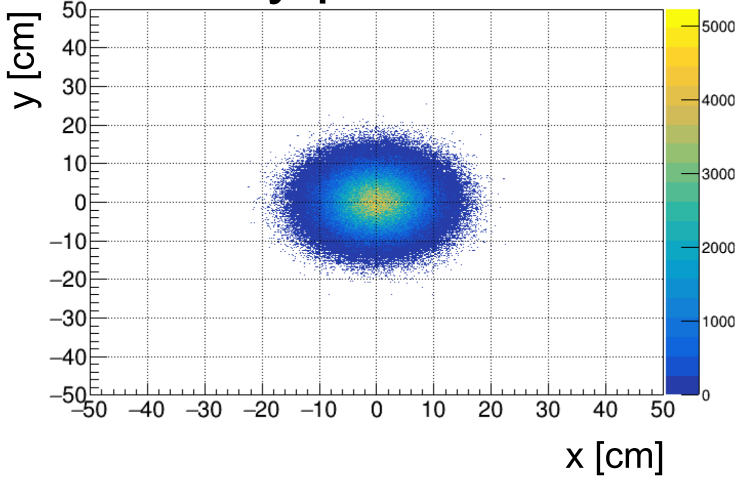
Backup

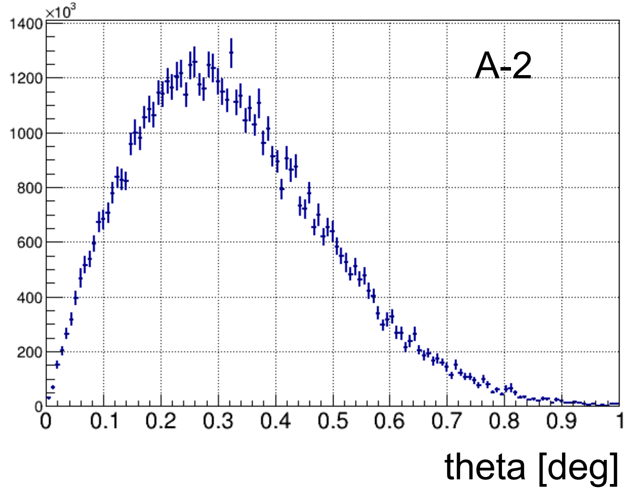
Fragment Tracking



SP-41 Configuration:
Si, GEMs, ECal ?

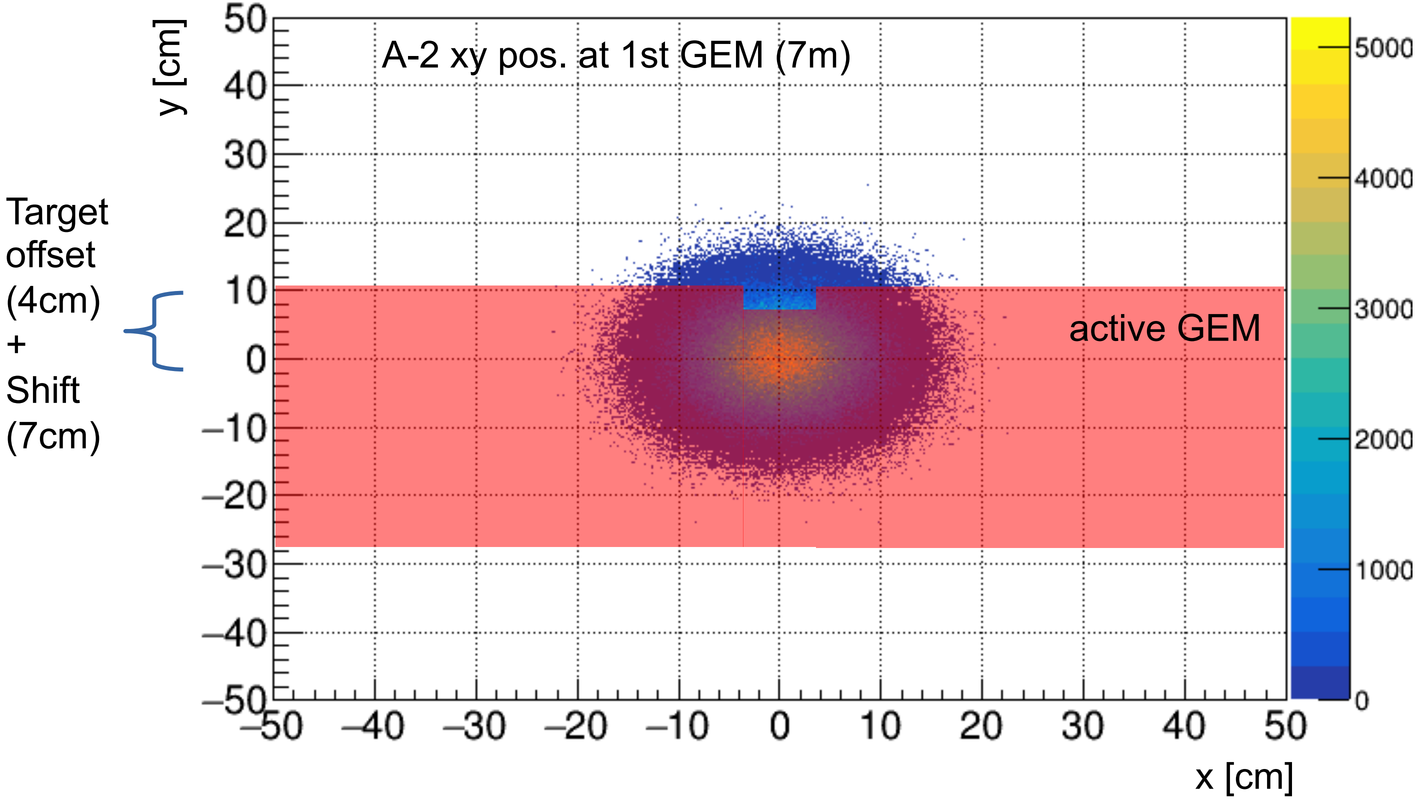
A-2 xy pos. at 7 m





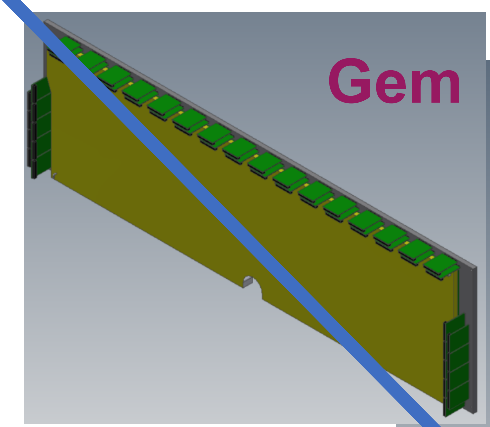
Fragment Tracking

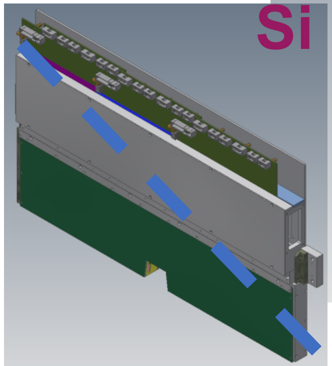
Option: install lower half of GEMs and lift system by max. 7 cm: simulations show that this is not sufficient to keep fragments undistorted

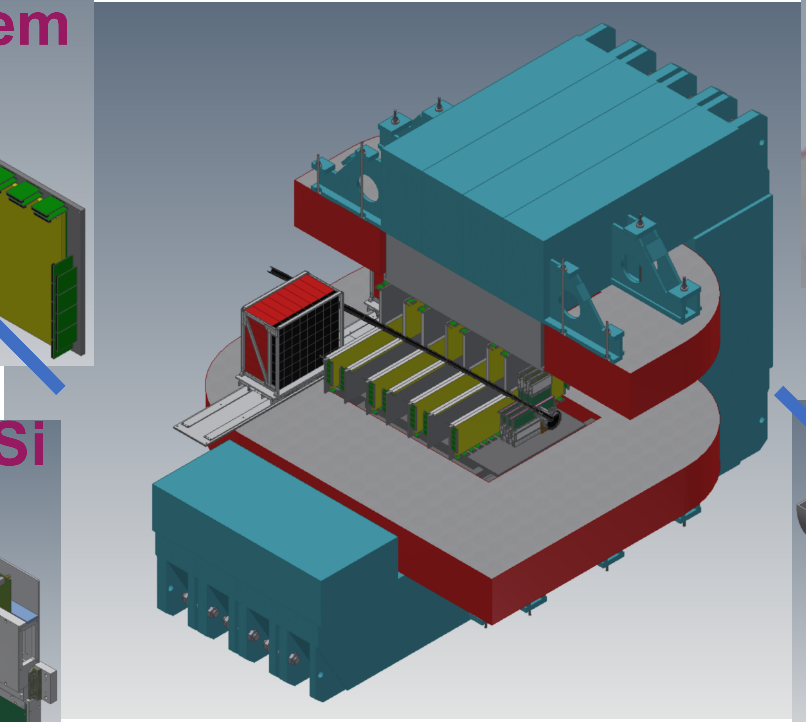


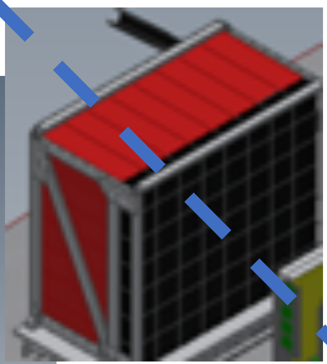
SP-41 Configuration

ECal position $\leftrightarrow$ p acceptance ?

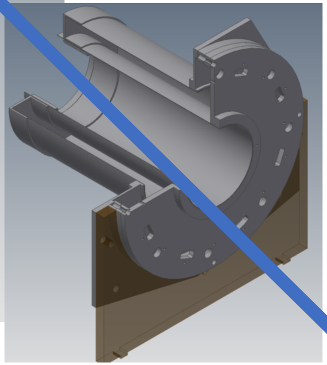






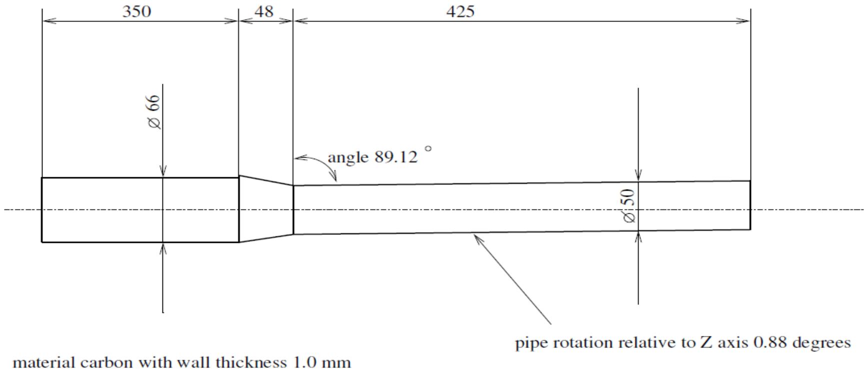


Barrel



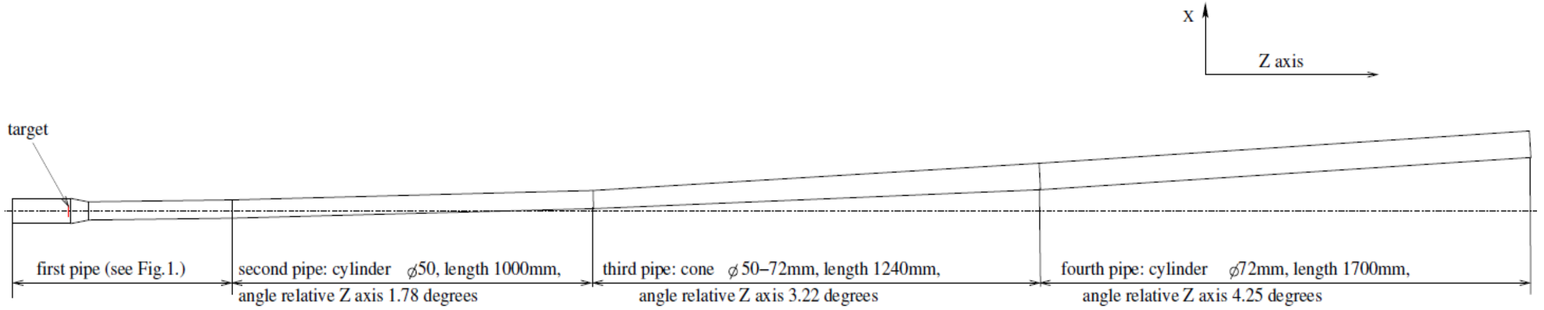
and no beam pipe

Carbon fiber beam pipe



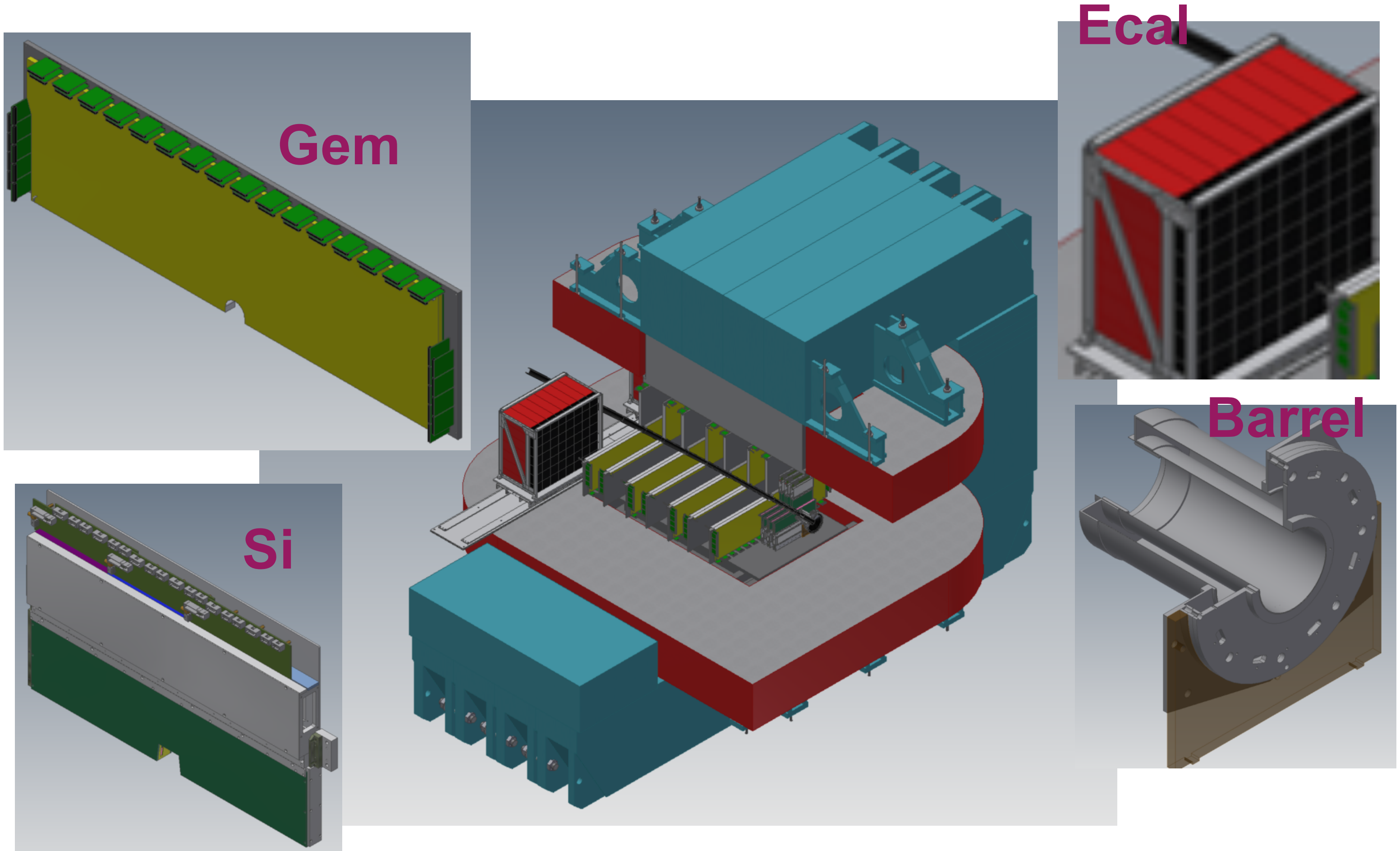
Material carbon with wall tickness 1.0 mm

The first section of the beam pipe made of carbon fiber. Will be installed at the upstream end of the SP-41 pole. The wide part has the diameter of 66 mm and will hold the target assembly. This beam pipe will be installed inside the barrel detector.



The full beam pipe made of carbon fiber. The diameters and angles of each element are shown in the pic. Right now we do not know how the connections between pipe sections will look. The detachable connections will be: 1. between the first and the second parts, 2. between the second and the third parts.

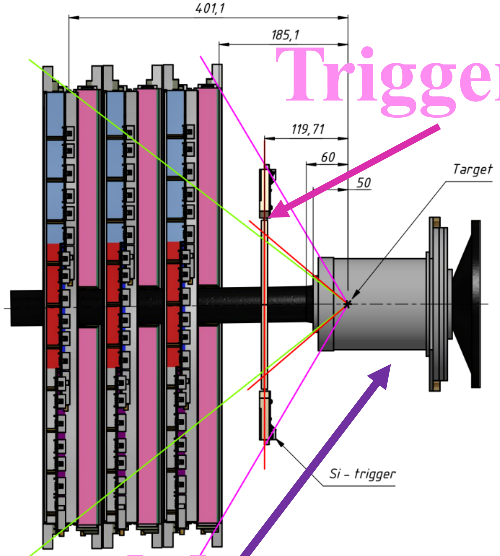
Detectors inside SP-41



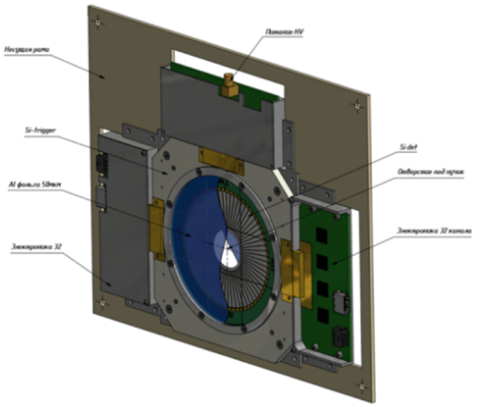
What will stay inside SP-41 for the SRC run?

Forward Si

Trigger Si



Barrel detector will be taken out for the SRC run



All the other detectors will stay for the SRC run

- The following detectors will stay inside the SP-41:

1. trigger Si,
2. Forward Si, 3 planes
3. Gem, 7 planes
4. Ecal, 2 arms

- Also the beam pipe will stay inside the SP-41 in the full configuration

Will be removed

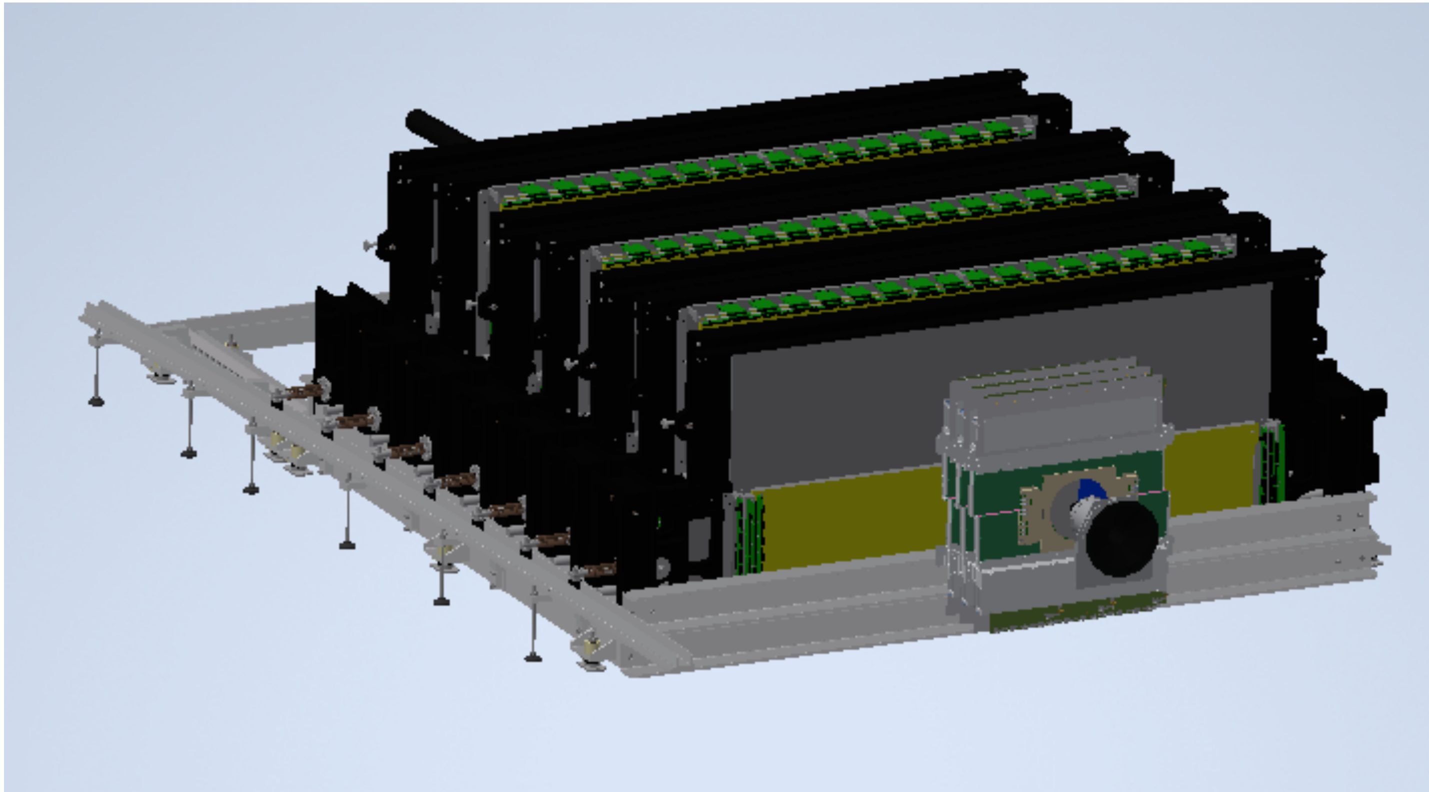
Inside SP-41

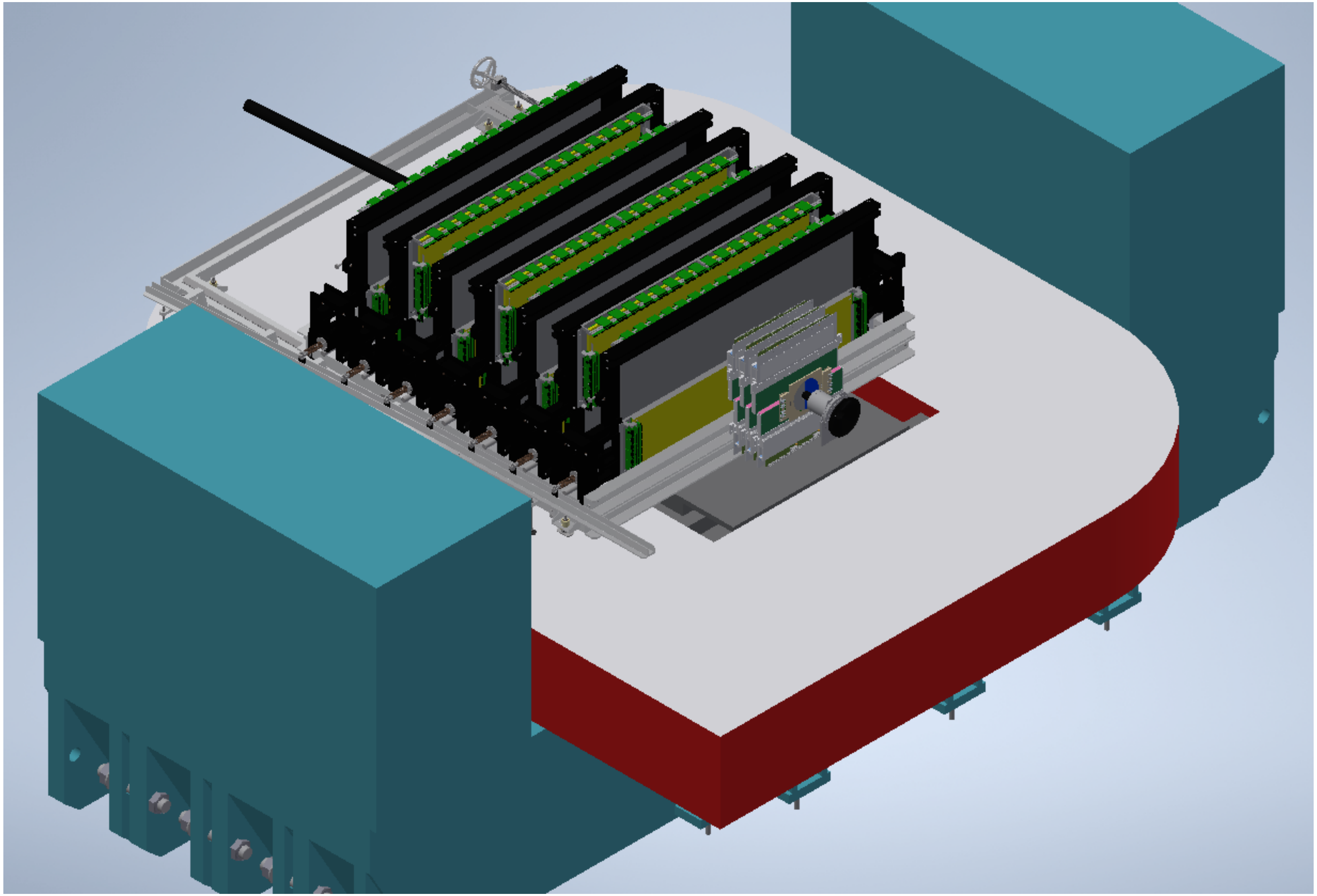
Barrel detector
Target assembly
Support of the target assembly

Upstream SP-41

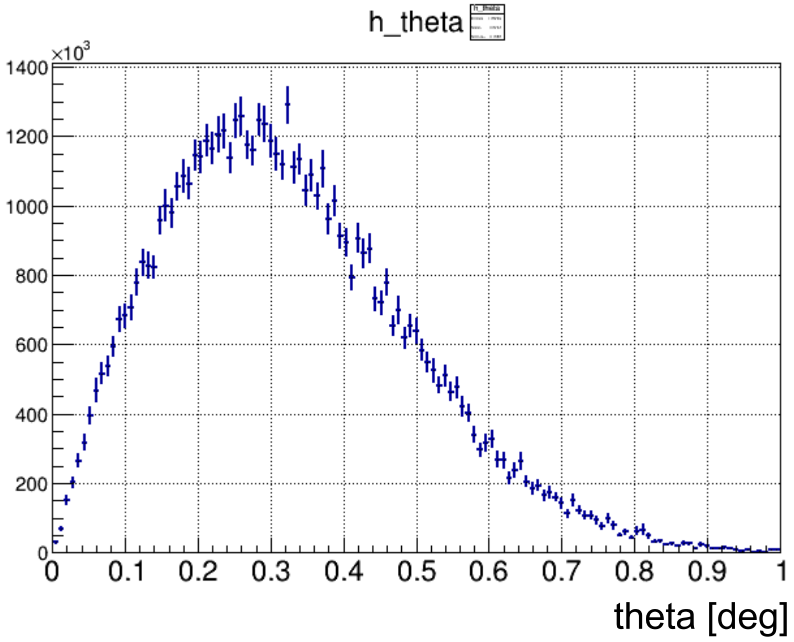
Stainless steel beam pipe
Support for the steel beam pipe

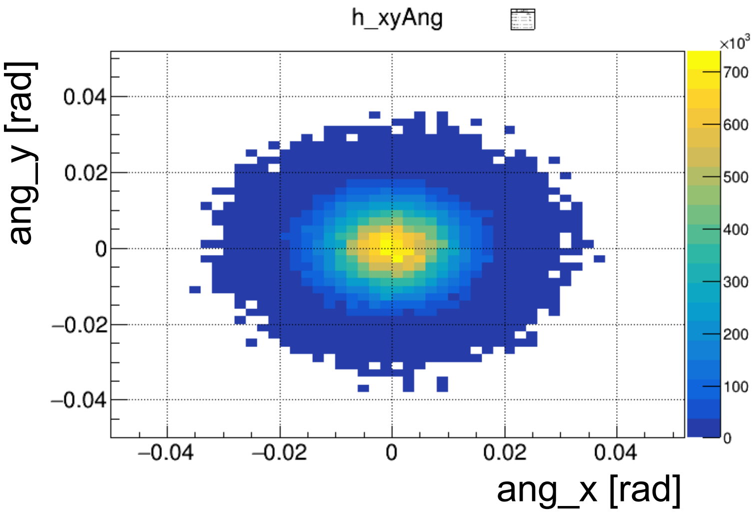
Some additional pics

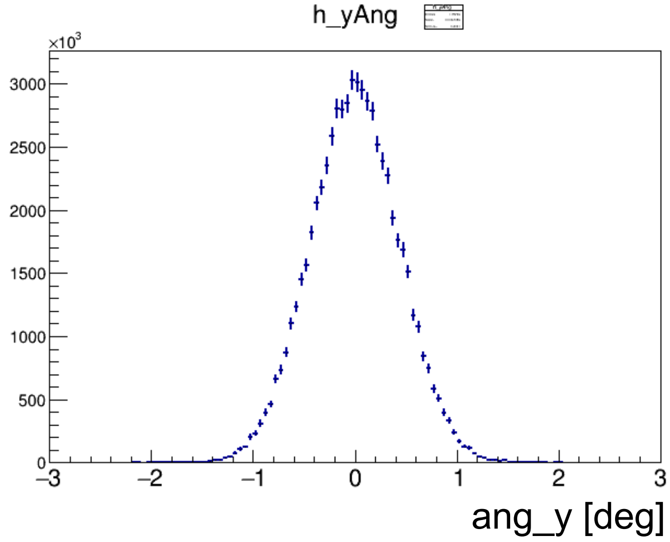


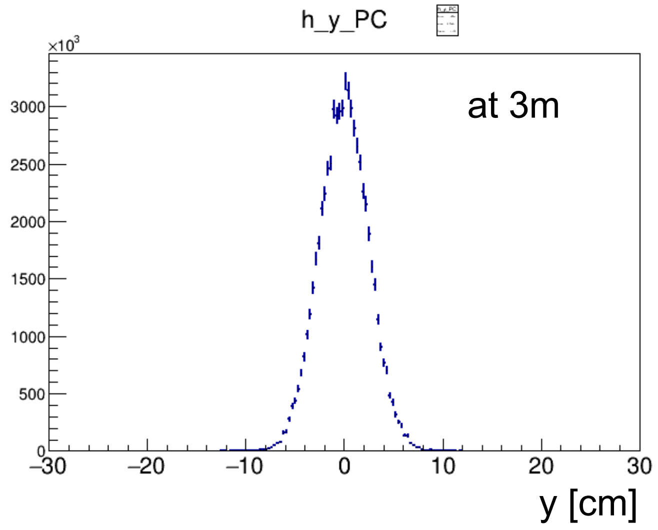


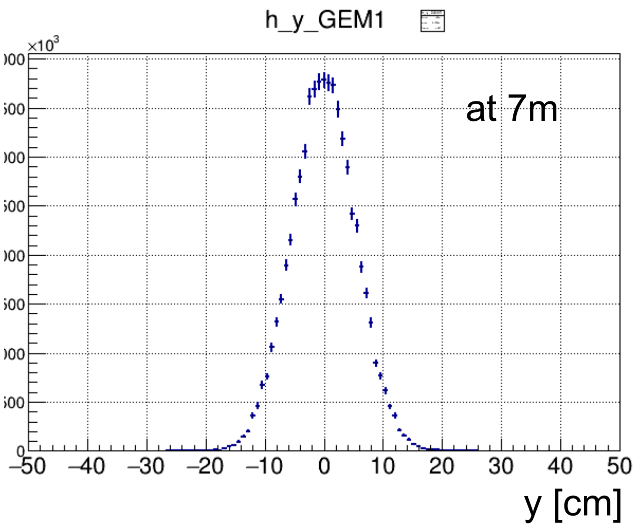
SRC Events at 2.5 GeV/u

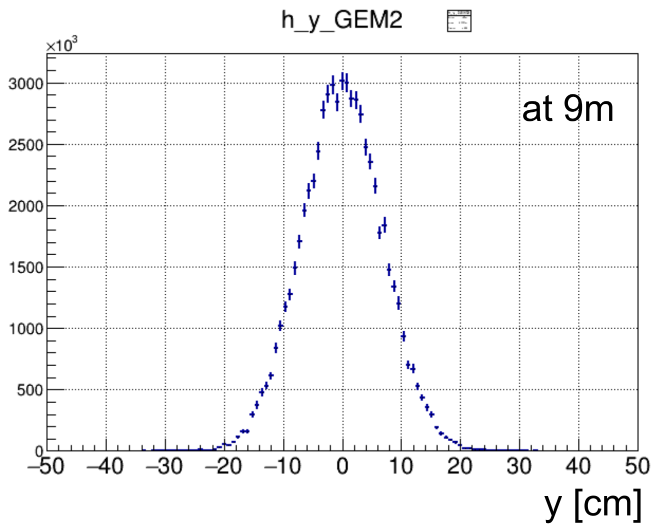




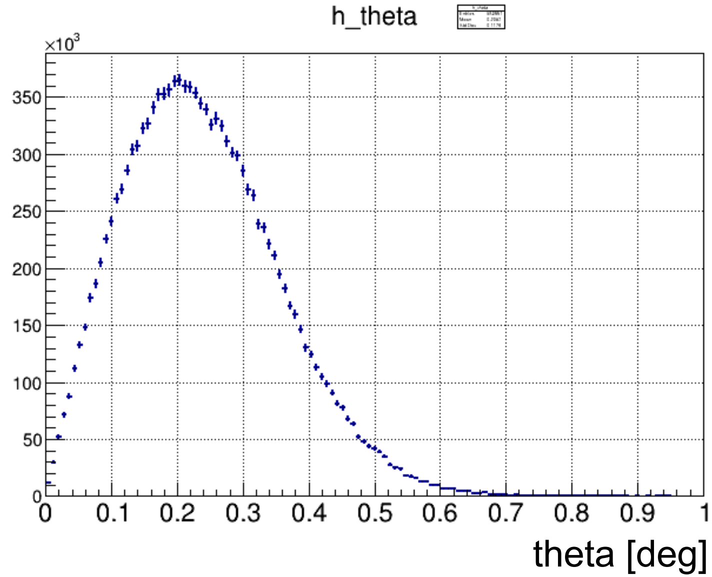


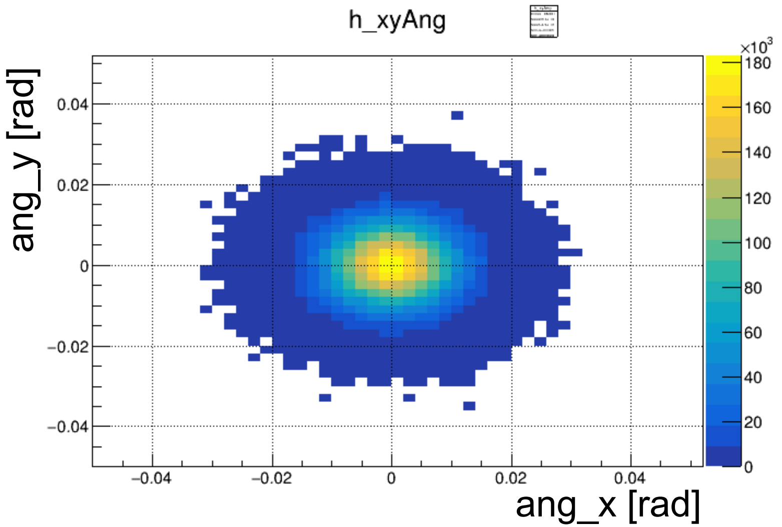

h_y_PC
×10³
at 3m
y [cm]

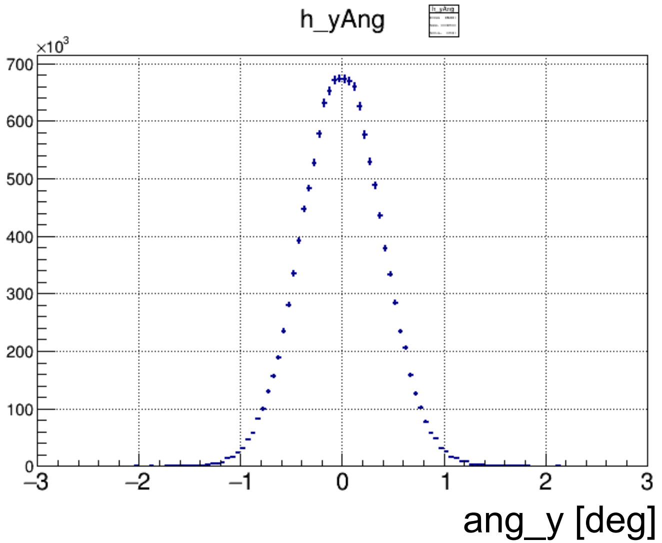

h_y_GEM1
×10³
at 7m
y [cm]

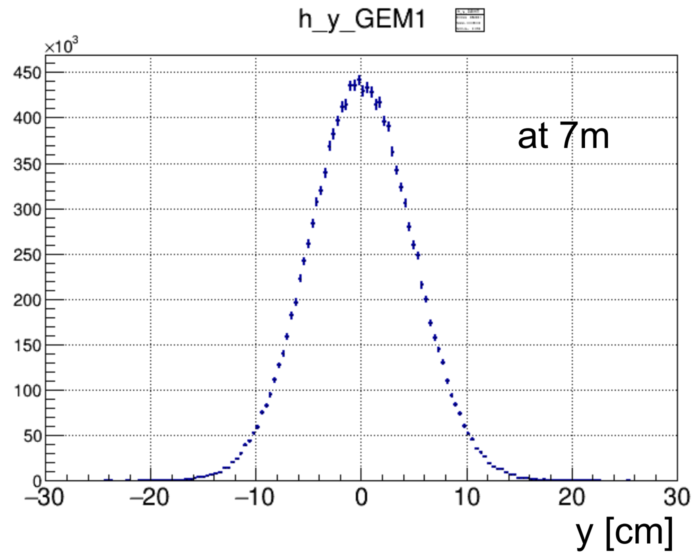

h_y_GEM2
×10³
at 9m
y [cm]

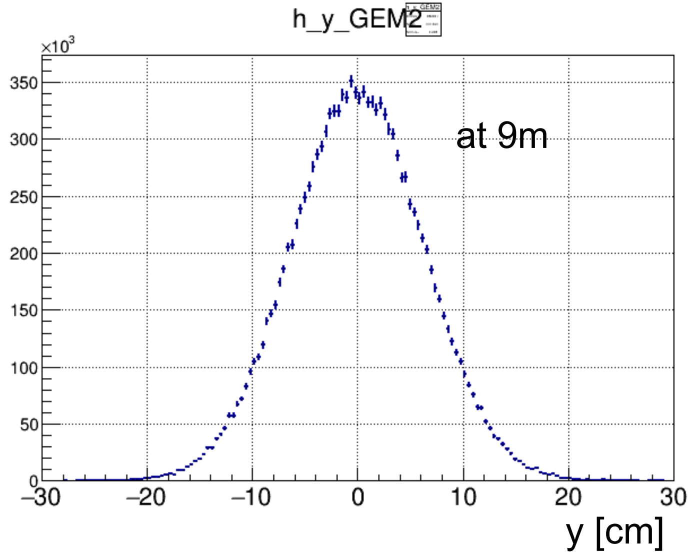
(p,2p) Events at 2.5 Gev/u

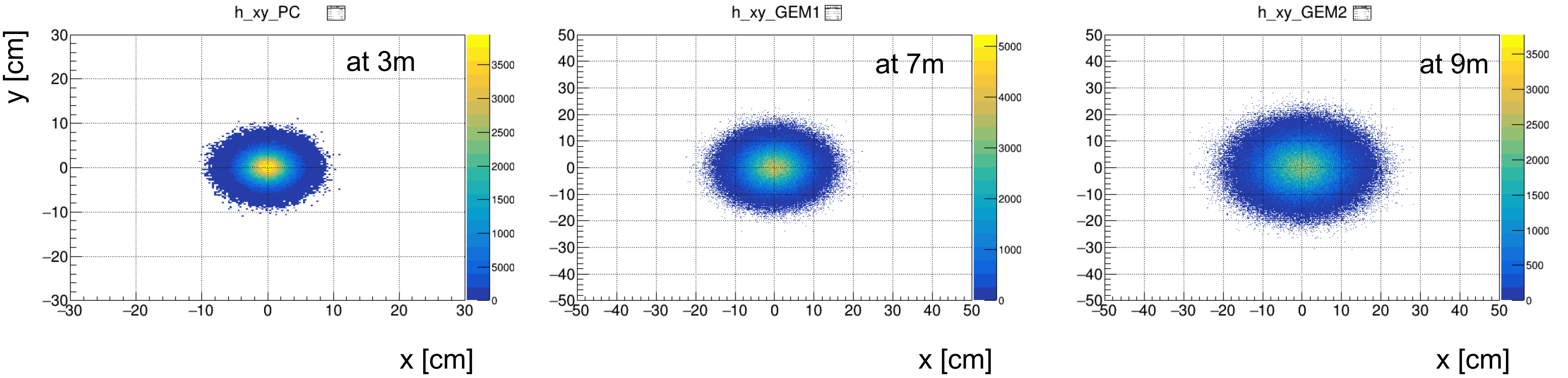







h_y_GEM1
$\times10^3$
450
400
350
300
250
200
150
100
50
0
−30
−20
−10
0
10
20
30
at 7m
y [cm]


h_y_GEM2
$\times10^3$
350
300
250
200
150
100
50
0
−30
−20
−10
0
10
20
30
at 9m
y [cm]


h_xy_PC
h_xy_GEM1
h_xy_GEM2
at 3m
at 7m
at 9m
y [cm]
x [cm]
x [cm]
x [cm]

New electronics for LAND based on TRB3

IPC 21694

TRIXOR1

KINPEX1A

EXPLODER

TAMEX3_IN2

FEBEX_POW1A

TAMEX3_BKP2

TAMEX3_PWR3

TAMEX3_OUT2

TAMEX3A

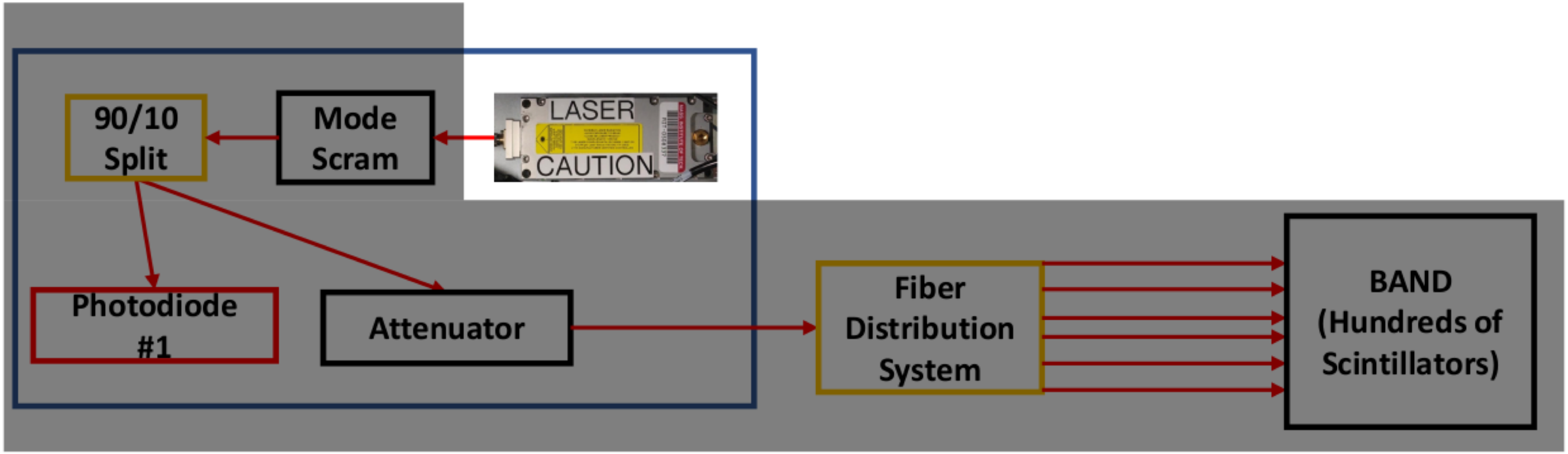
NEULANDFQT1 – QDC

FQTINT1

CLK-TRG-DISTR2

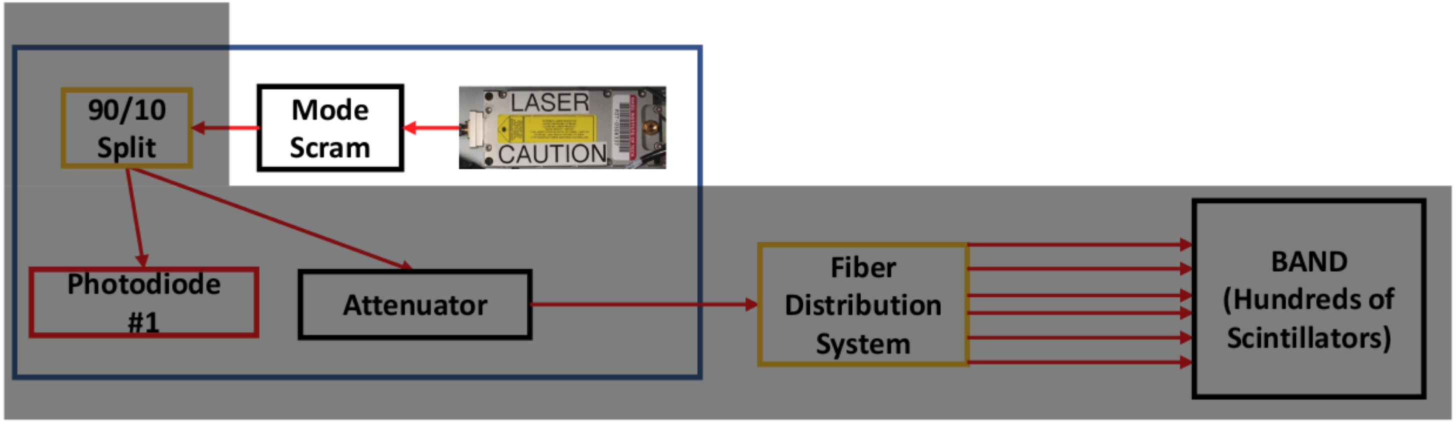
This is a new electronics (not the one used last time).

BAND Setup

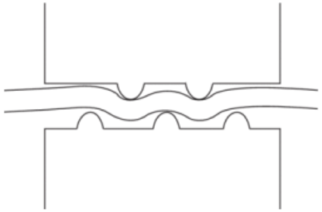


- Laser
  - 355 nm
  - ~0.3ns pulse width
  - 1kHz pulse frequency
  - Controlled by Raspberry PI

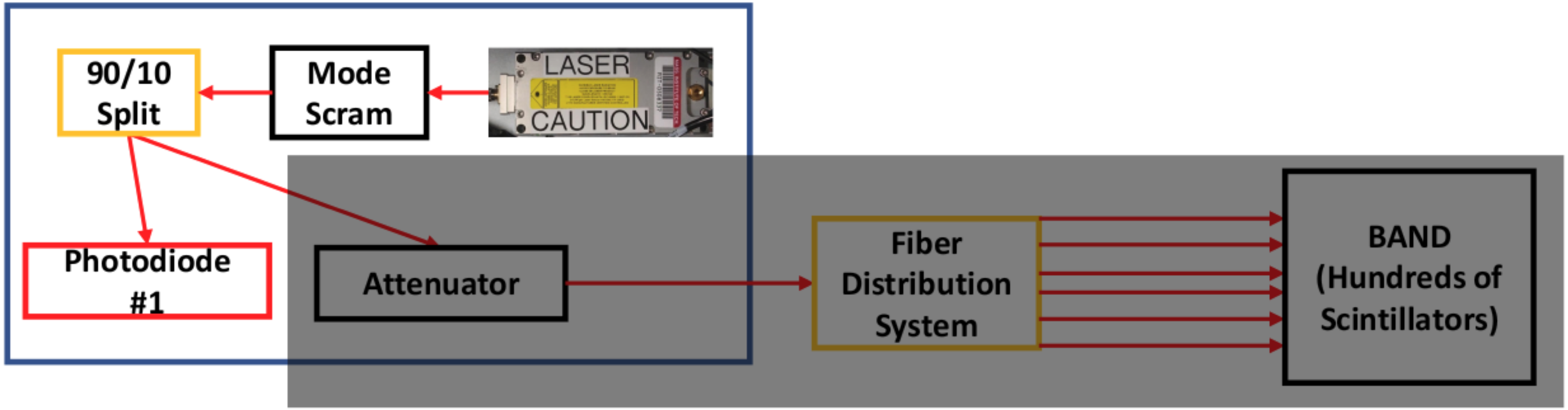
BAND Setup



- Mode Scrambler
  - Single mode laser
  - Multimode splitter

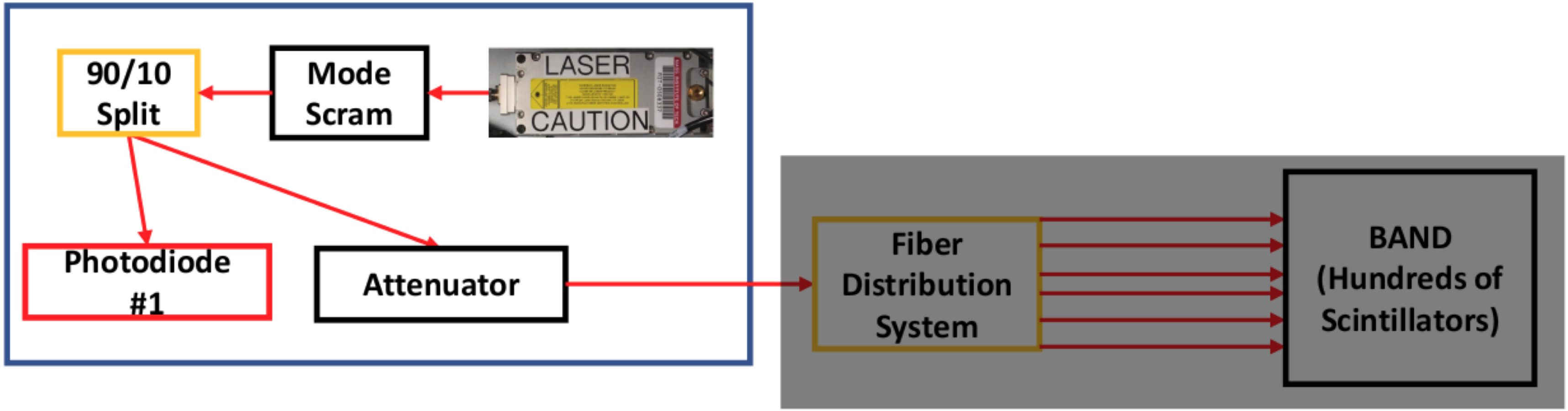


BAND Setup



- Photodiode #1
  - Fast Photodiode
  - Si Biased Detector

BAND Setup



- Attenuator
  - Variable optic attenuator
  - Range of 5 orders of magnitude

Fiber Distribution System

New BC counters + new trigger module

BC1, VC – same as last time

BC2 – two new detectors, each read out by two PMTs (last time it was one detector read out by 1 PMT)

BC3, BC4 – new detectors, each read out by 2 PMTs

Additional BC5 – read out by 2 PMTs

T0Module – same module with additional channels and corresponding logic modifications

Next run improvements

Measure the beam momentum in the hall to evaluate the actual energy loss

T0 did not provide design timing resolution → two T0 devices next time read out by 2 PMTs each

BC counters provided poor charge separation and low efficiency → new design of BC counters

TDC counts were not written out properly to the file → high discriminator threshold?

Gas mixture in the MWPC was not adjusted properly

X’ readout for the Si was poor

DCHs were not sensitive to protons (single charge particles)