NA61 Silicon Strip BPD development

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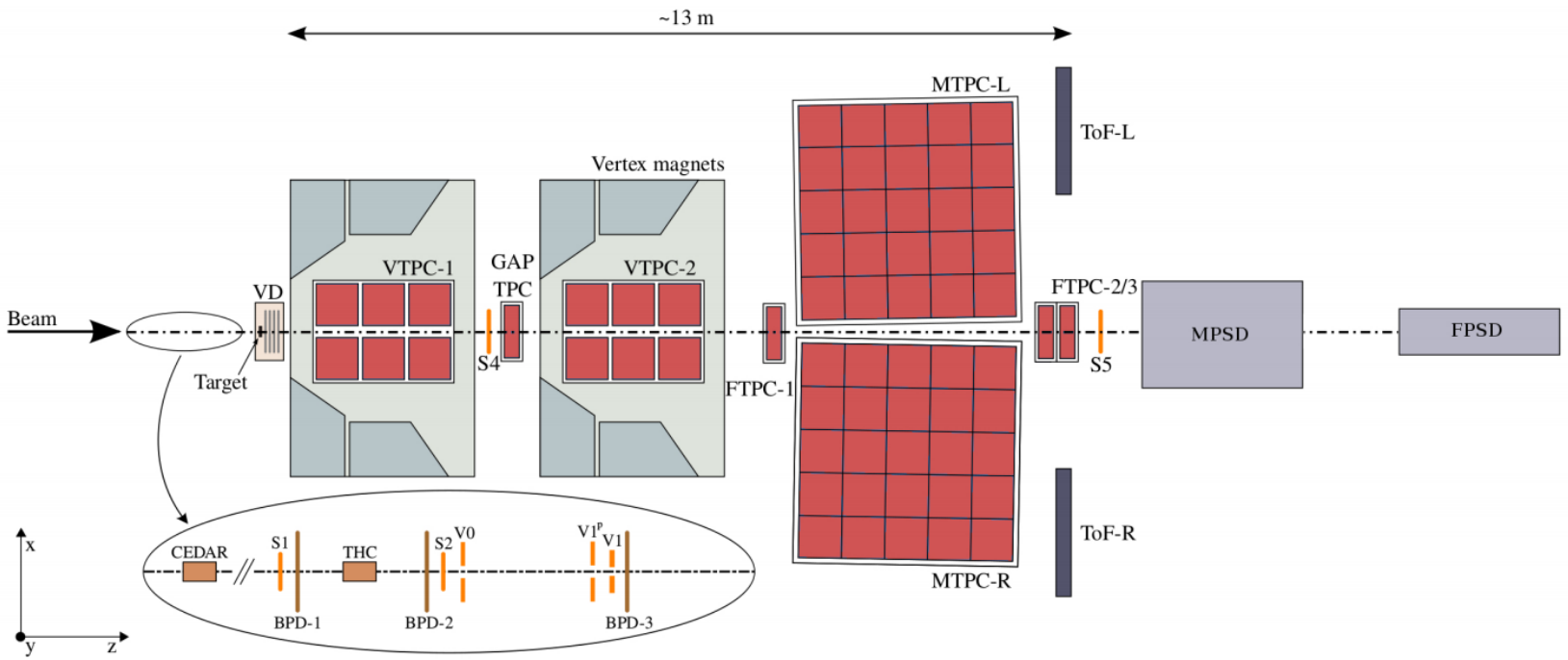
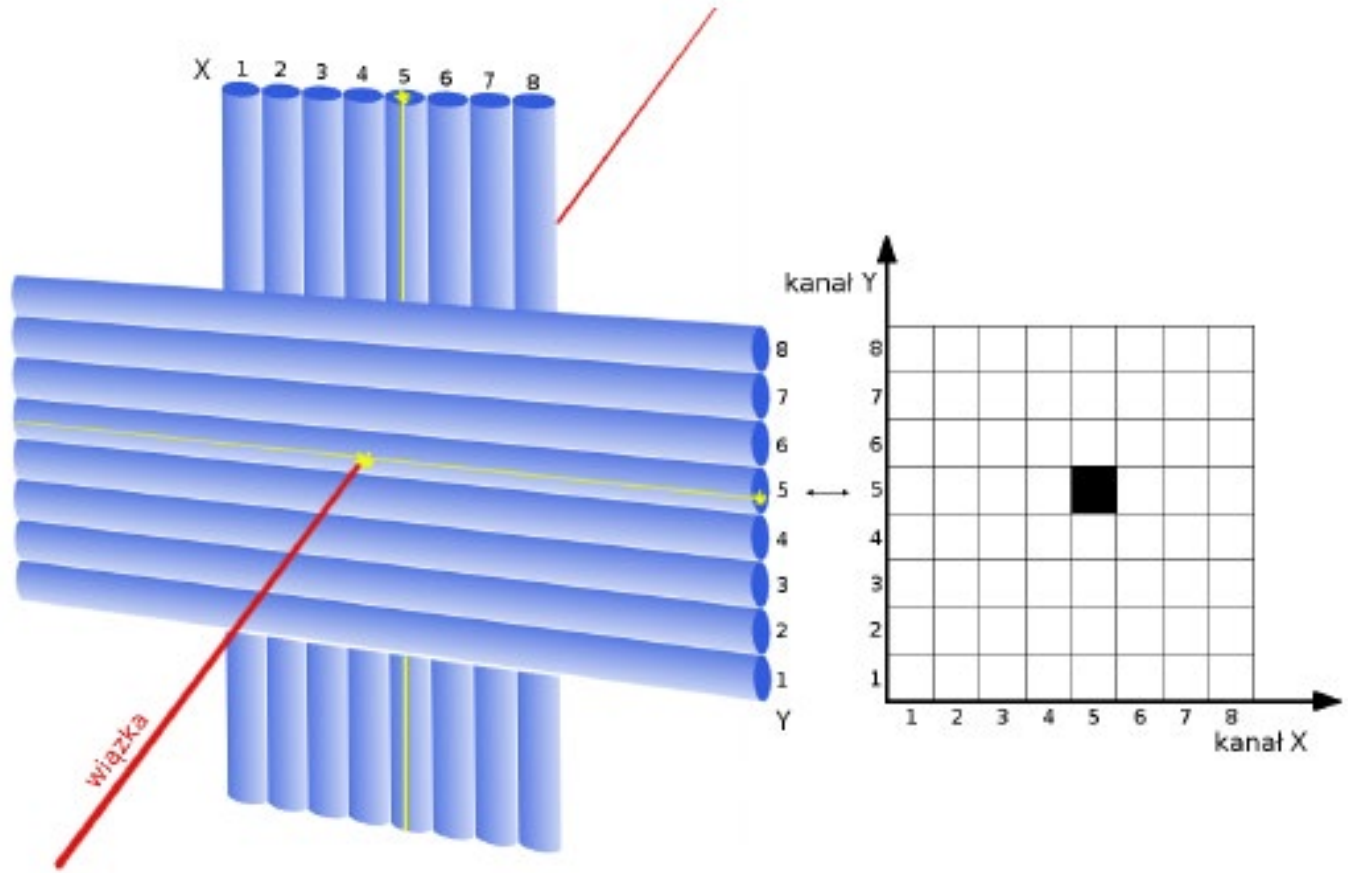
Introduction



- The NA61/SHINE detector at the CERN SPS is undergoing a major upgrade during the LHC Long Shutdown 2 period (2019-2021).
- New BPDs should monitor lead and proton beam intensities with 10^5 Hz intensity.
- New detectors will operate in vacuum in order to minimize the air on the beam line

Possible solutions for Beam Position Detector

- Silicon Strip detector
  - Matrix available on market
  - Detectors used at LHC, BM@N and JPARC
  - Full detector developed in Japan
  - High radiation hardness (according t the factory information)
- Scintillating fibers detector
  - Known technology
  - Tested
  - Elements available on market



Silicon Strip Detector

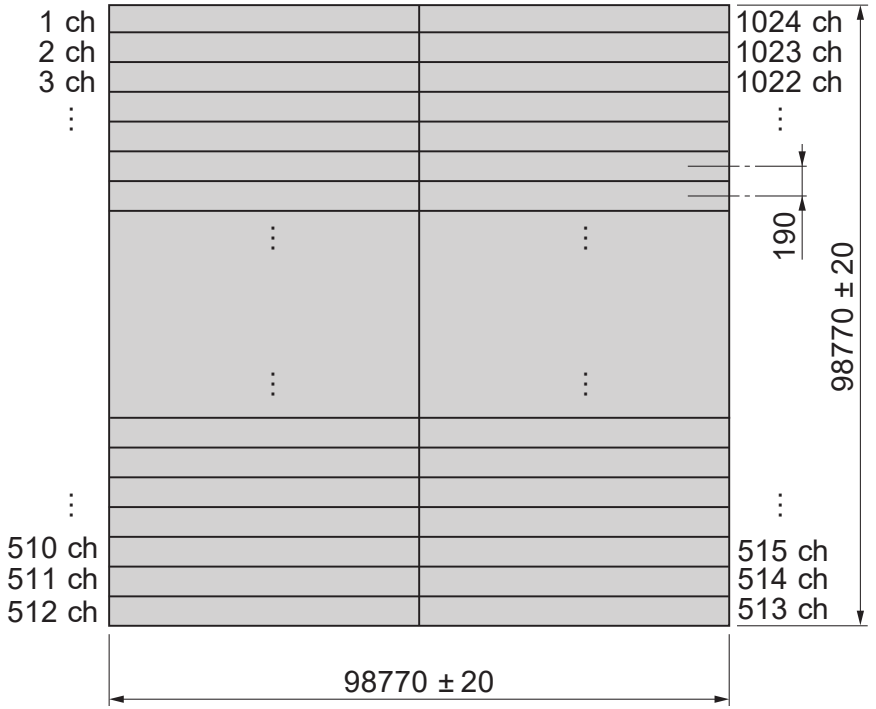
- Single-sided SSD for high energy particle position detection
  - Hamamatsu S13804
  - The only alternative for p beam.
  - One detector has been ordered and delivered for testing

Structure

Parameter	Specification	Unit
Type	PolySi-bias AC-readout	-
Si thickness	320 ± 15	μm
Si crystal plane direction	<100>	-
Chip size	(98770 ± 20) × (98770 ± 20)	μm
Active area	97280 × 97280	μm
Strip layout	512 ch × 2 columns	-
Number of strips	1024	ch
Strip pitch	190	μm
Strip implant width	80	μm
Strip readout Al width	90	μm
Readout pad size	165 × 100 × 2	μm

Dimensional outline (unit: μm)

Entire device drawing



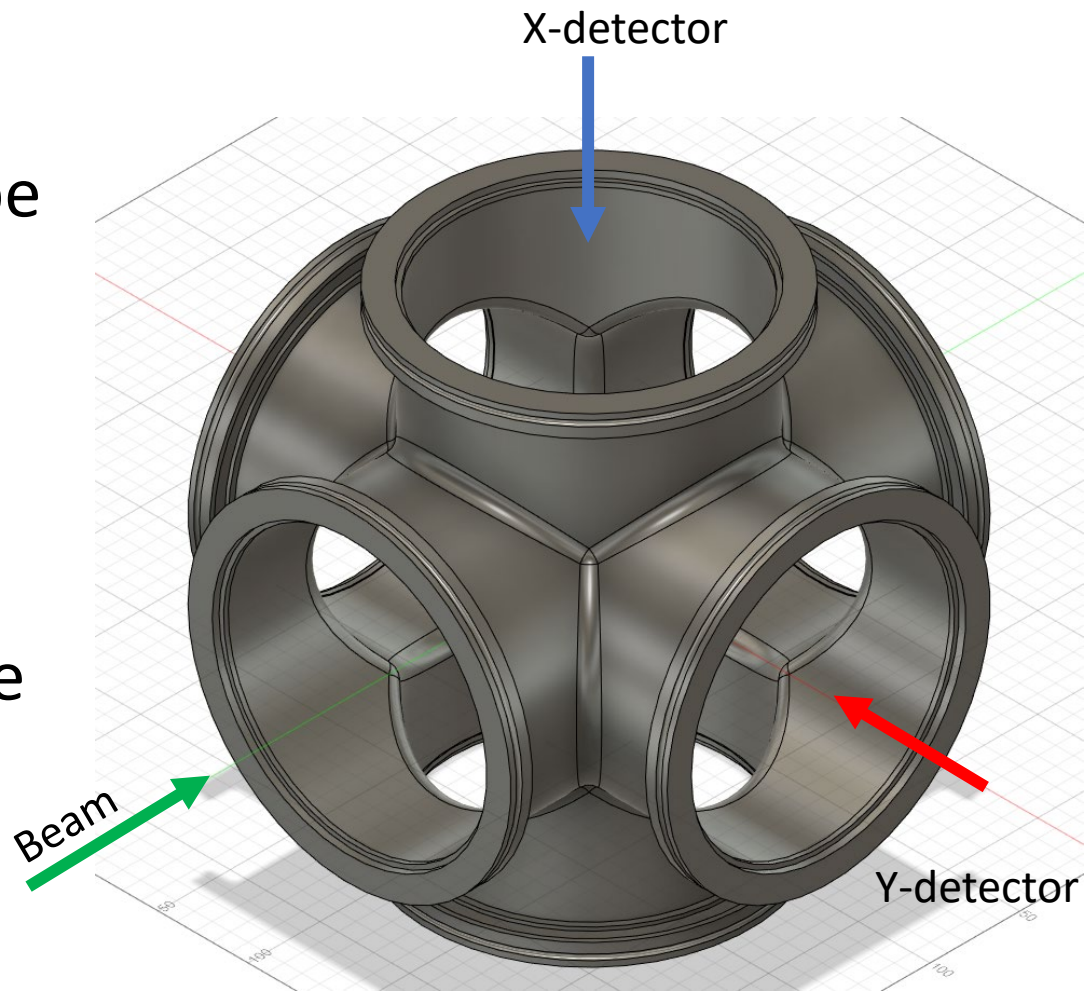
Existing Readout Electronics solutions

- Hamamatsu does not sell a readout solution and/or amplifiers.
- A group at J-PARC has a developed solution for the readout
  - However, it is too slow for NA61 beam intensity
- A new set of electronics should be designed

New BPD development

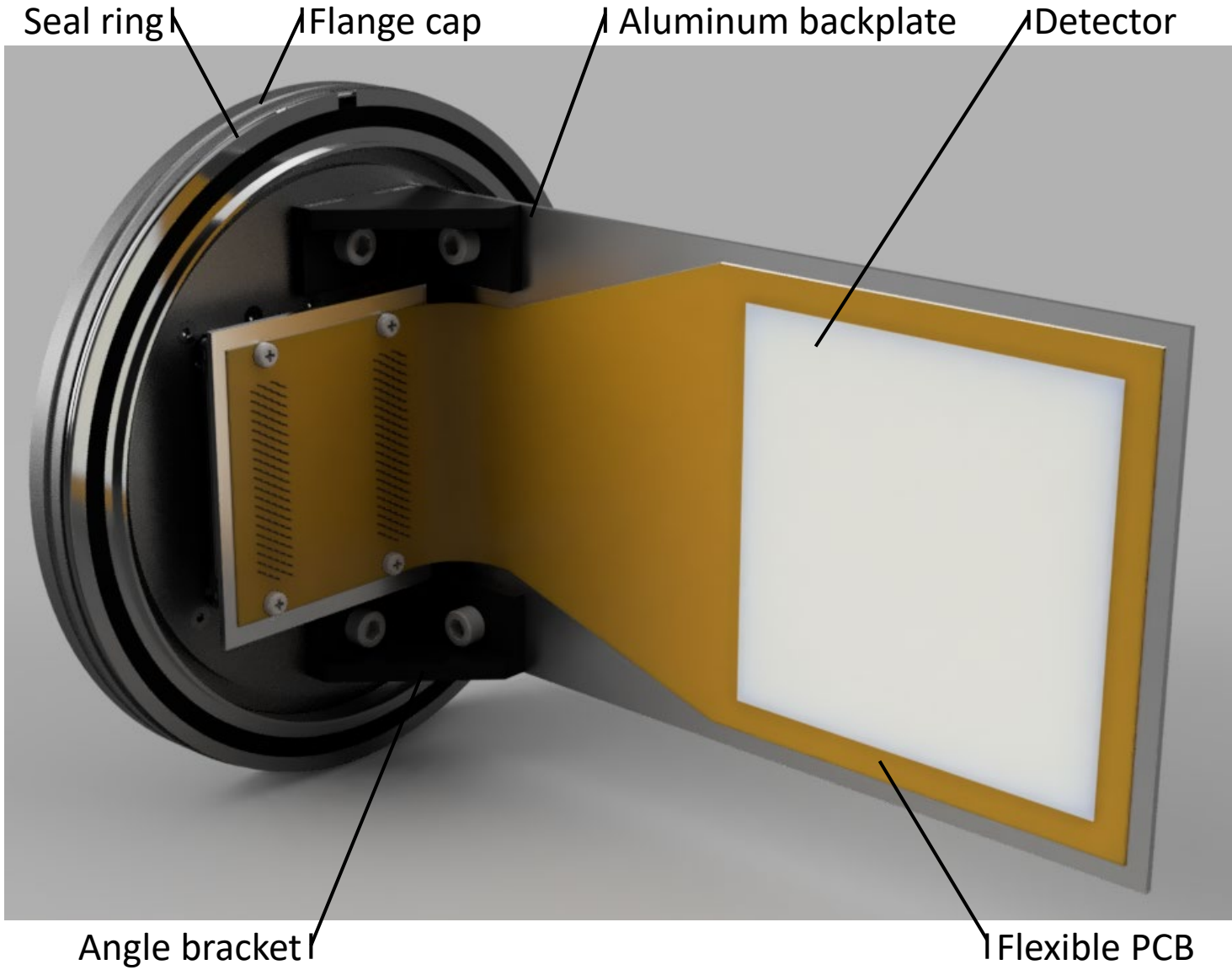
Mechanical design

- Beam position is measured via a telescope consisting out of 3 detectors
- For each BPD a 6-way fitting will be used
- 2 sides of 6-way fitting are connected to the beam pipe (possibly with adapters)
- Other 2 sides of 6-way fitting will hold the detectors
- 2 remaining sides will be plugged

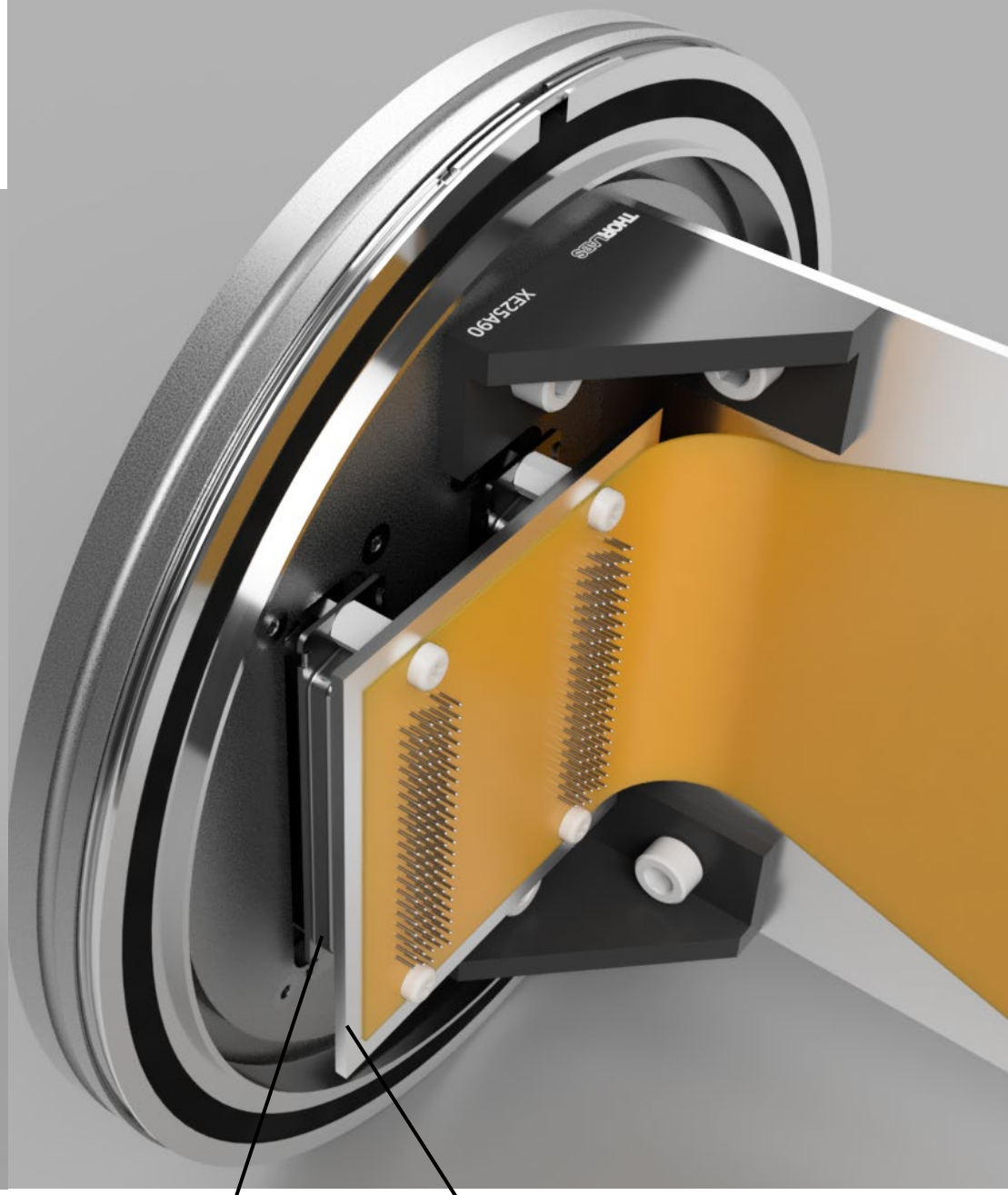


Mechanical design

- Detector assembly consists out of:
  - ISO-K round vacuum flange cap and centering/sealing ring
  - Aluminum plate mounted perpendicular to the cap via optical angle brackets
  - Flexible PCB glued to the plate and the detector mounted to it
  - Two 104-pin D-Sub High Density feedthroughs with O-ring seals
  - Mating connectors, mounted to an aluminum plate and the flexible PCB



Mechanical design



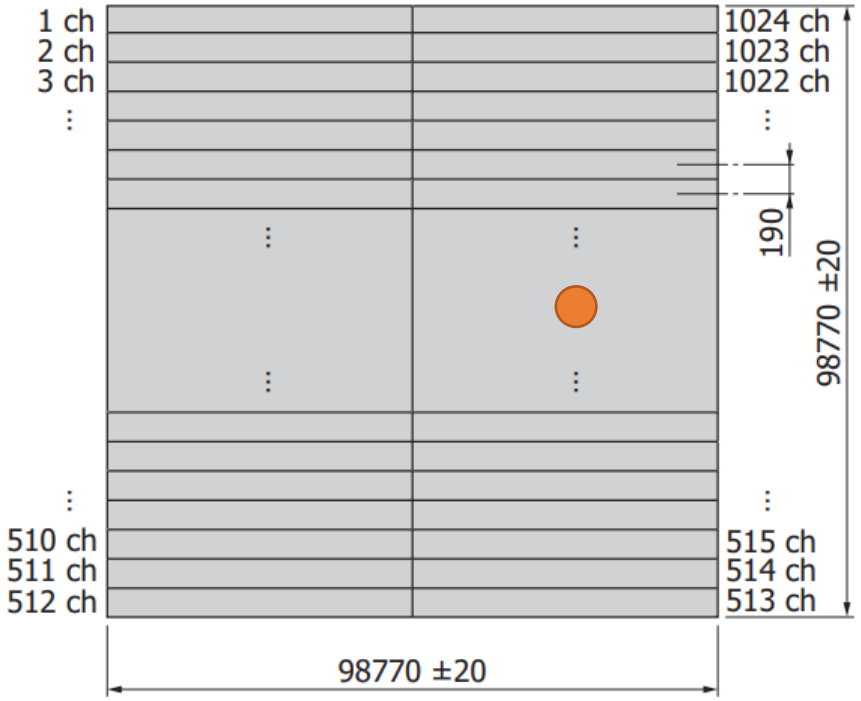
Feedthrough

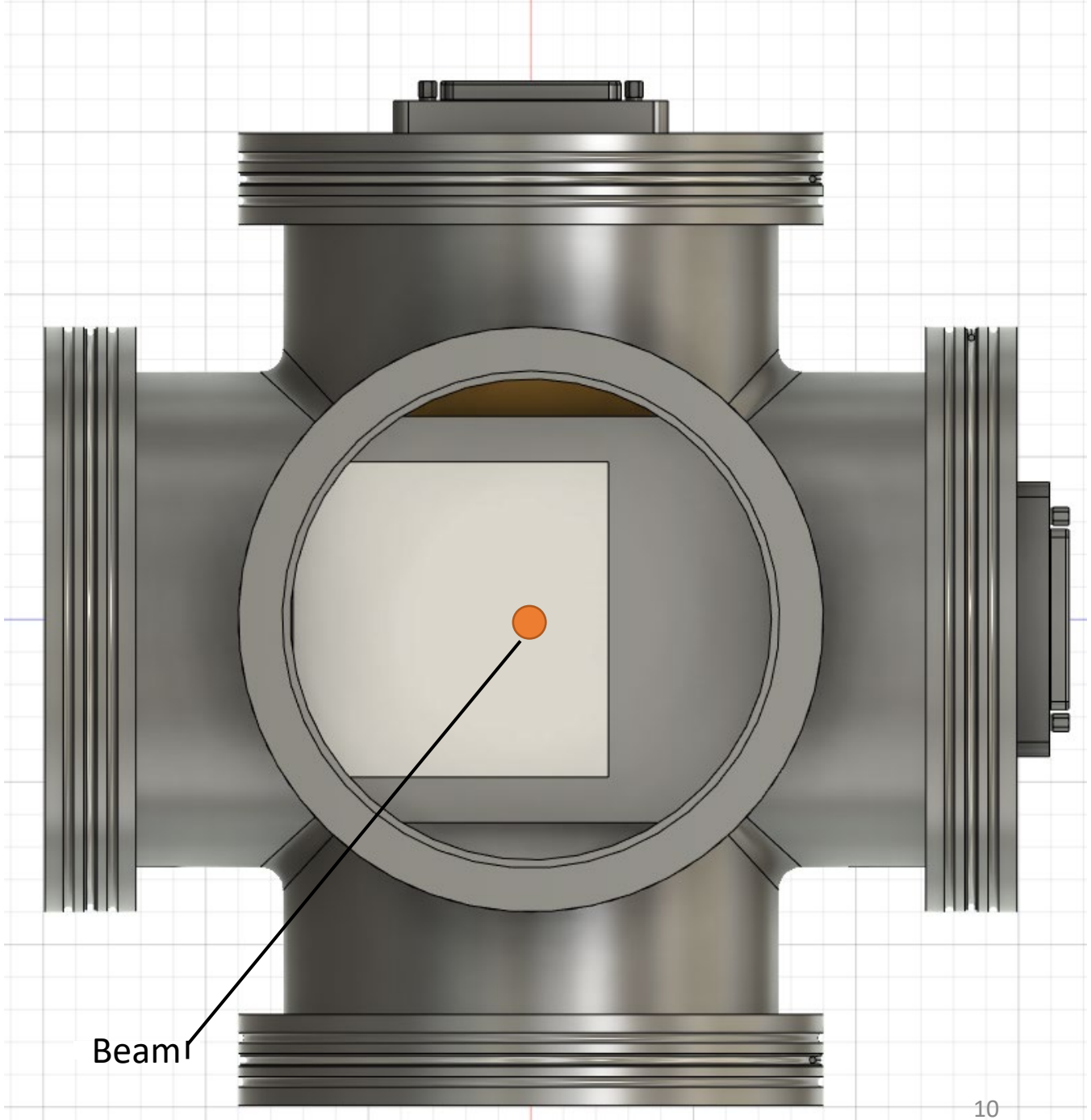
Mating connector

Aluminum plate

Mechanical design

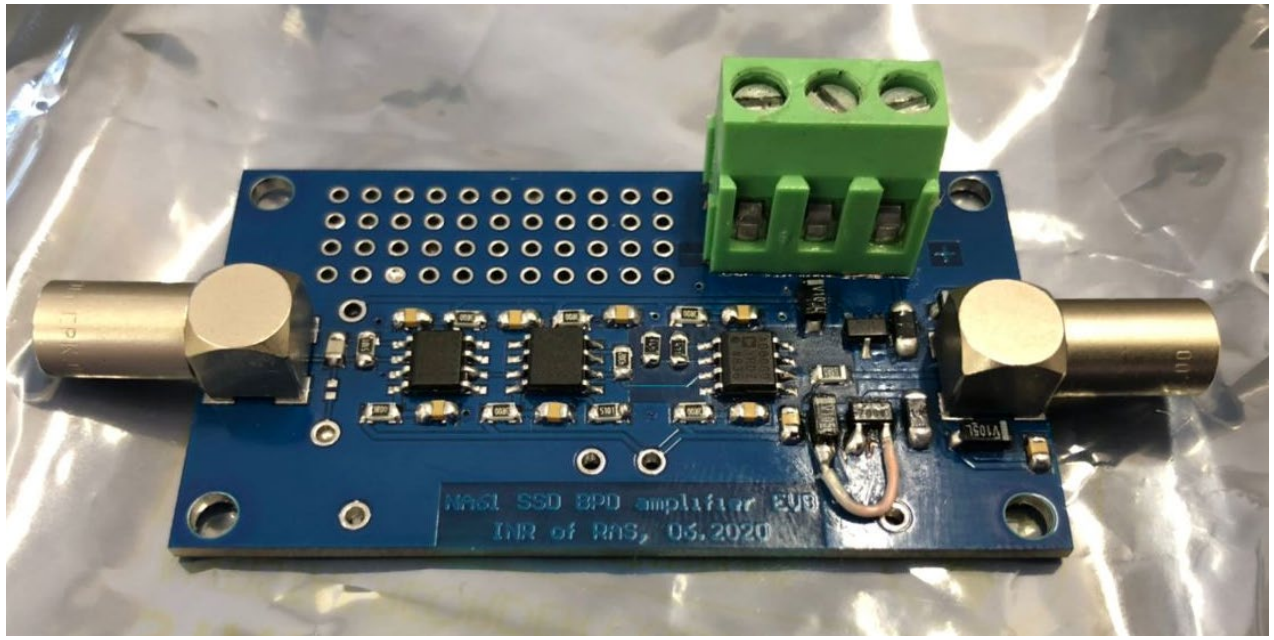
- Mounting fixtures are offset so the beam hits the middle of the detector's sensitive area

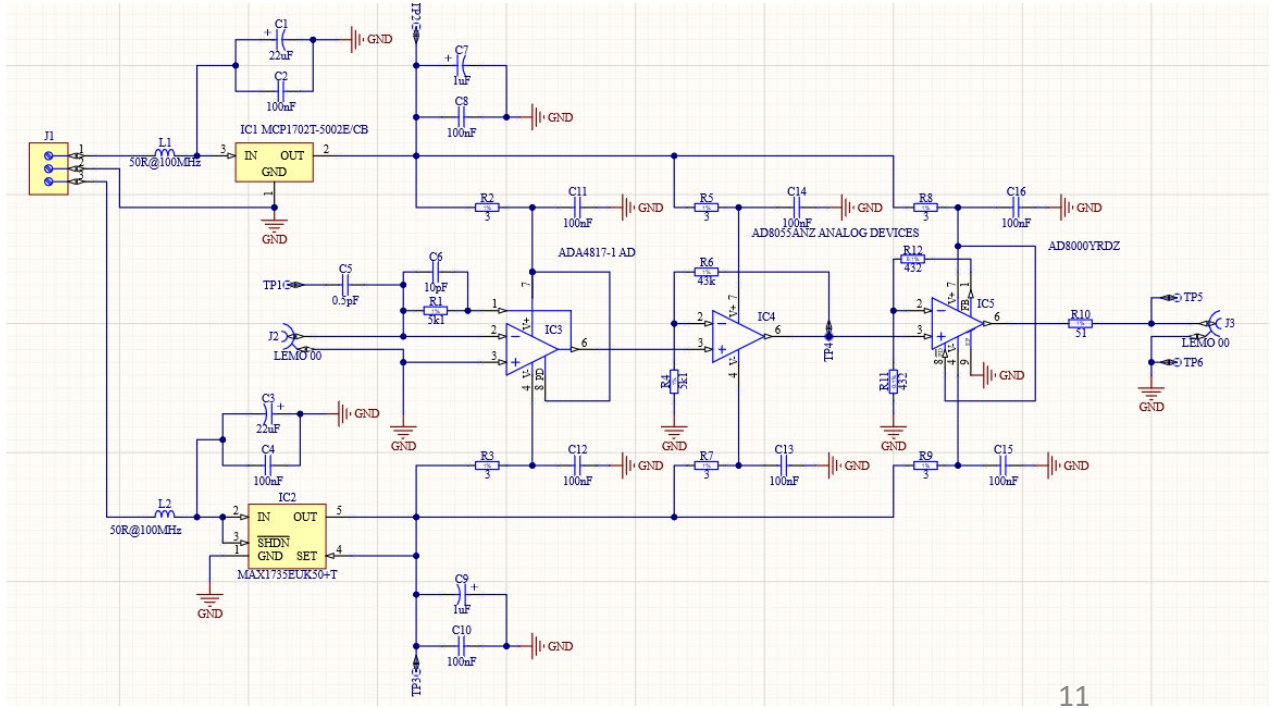




Electronics design

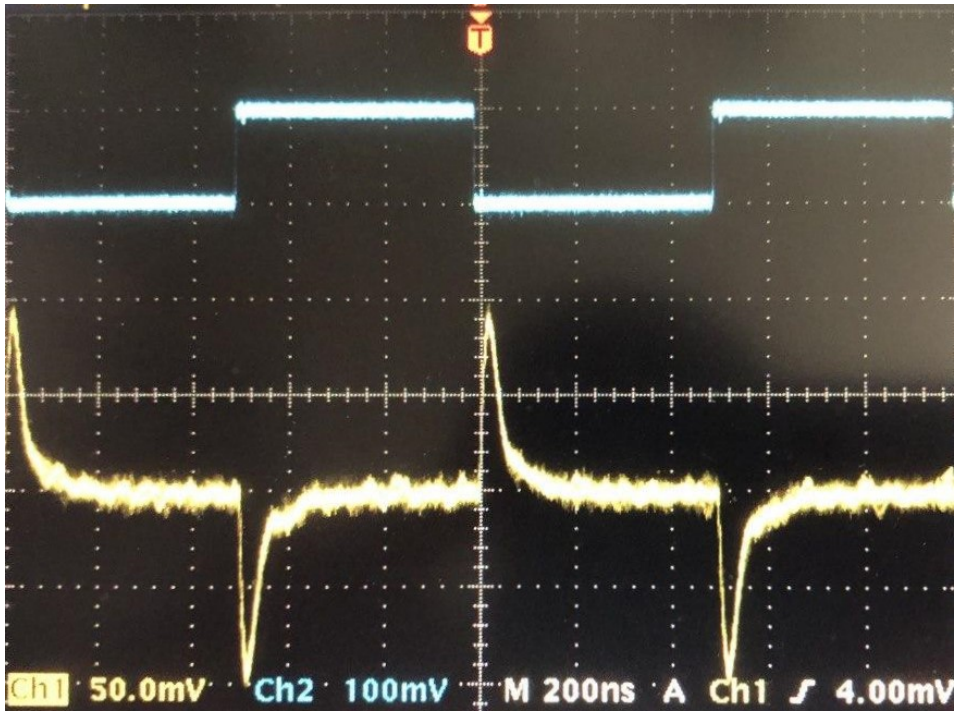
- Discrete amplifiers with off-the-shelf components
- A typical amplifier consists out of:
  - Fast charge-sensitive amplifier
  - Intermediate amplifier
  - 50-Ohm output buffer
  - Power regulators
- A prototype PCB is manufactured
- Prototype has been fitted with scale-changing circuitry to operate at both heavy ion beams and proton beams

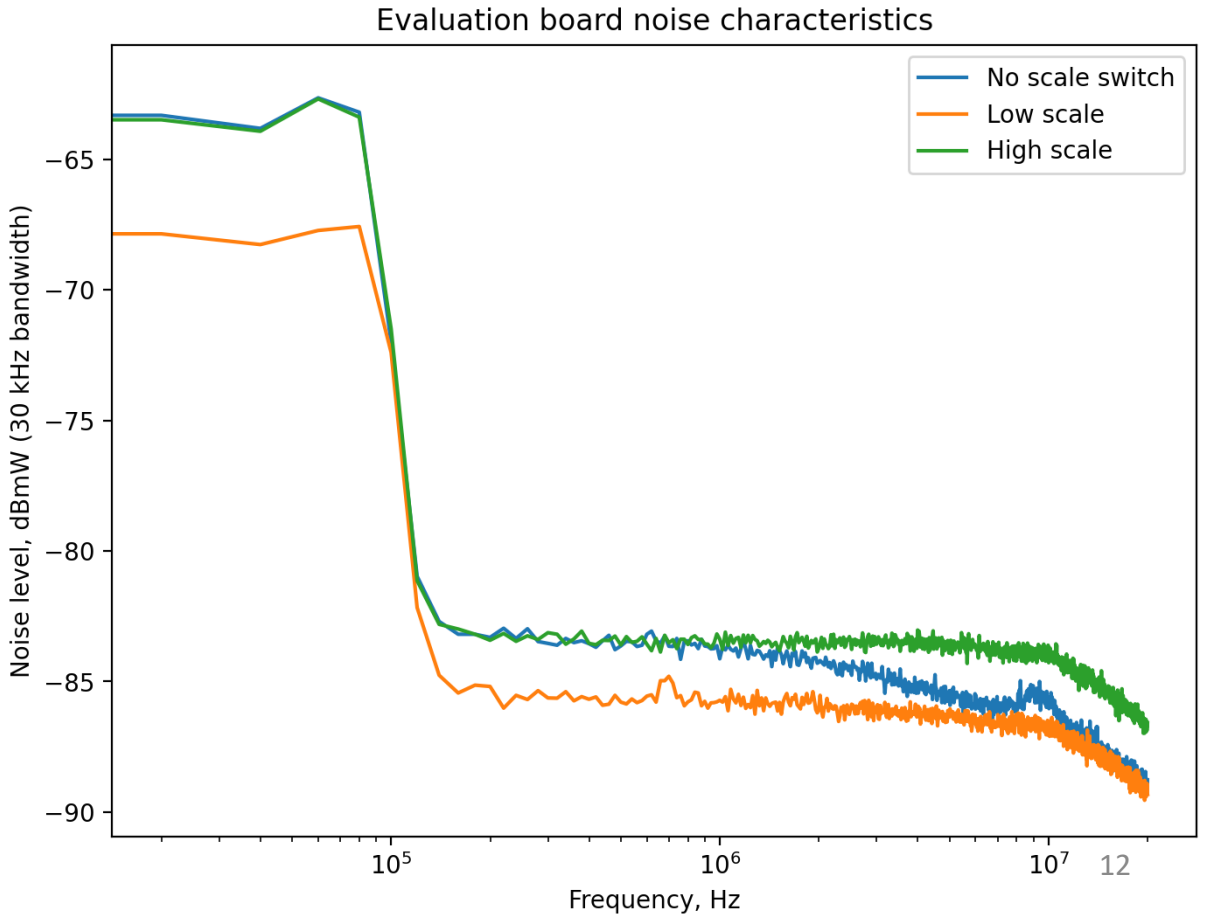




Verification

- Prototype has been tested for:
  - Proton beam-scale and heavy ion-scale charge amplification
  - Noise spectrum





Planned activities

- Finishing the mechanical design (to be completed by the middle of October)
  - Tracing of the flexible PCB
  - Verification and approval
- Designing the amplifier board with 100 channels (to be completed by the end of October)
- Assembling and verification of the amplifier boards (@INR RAS, scheduled until the end of 2020)
- Assembling of the detector (@Institute of Physics, University of Silesia, scheduled until the end of 2020)
- Single detector test (@JINR or GSI or CERN, beginning of 2021)

Summary

- Silicon strip BPD development is ongoing and showing progress
- Readout electronics prototype is manufactured and tested
- Design is expected to be done in the following months
- Detector is expected to be manufactured by the end of the year

Reserve

■ Detailed chip diagram