Проверка временного разрешения быстродействующих кремниевых детекторов

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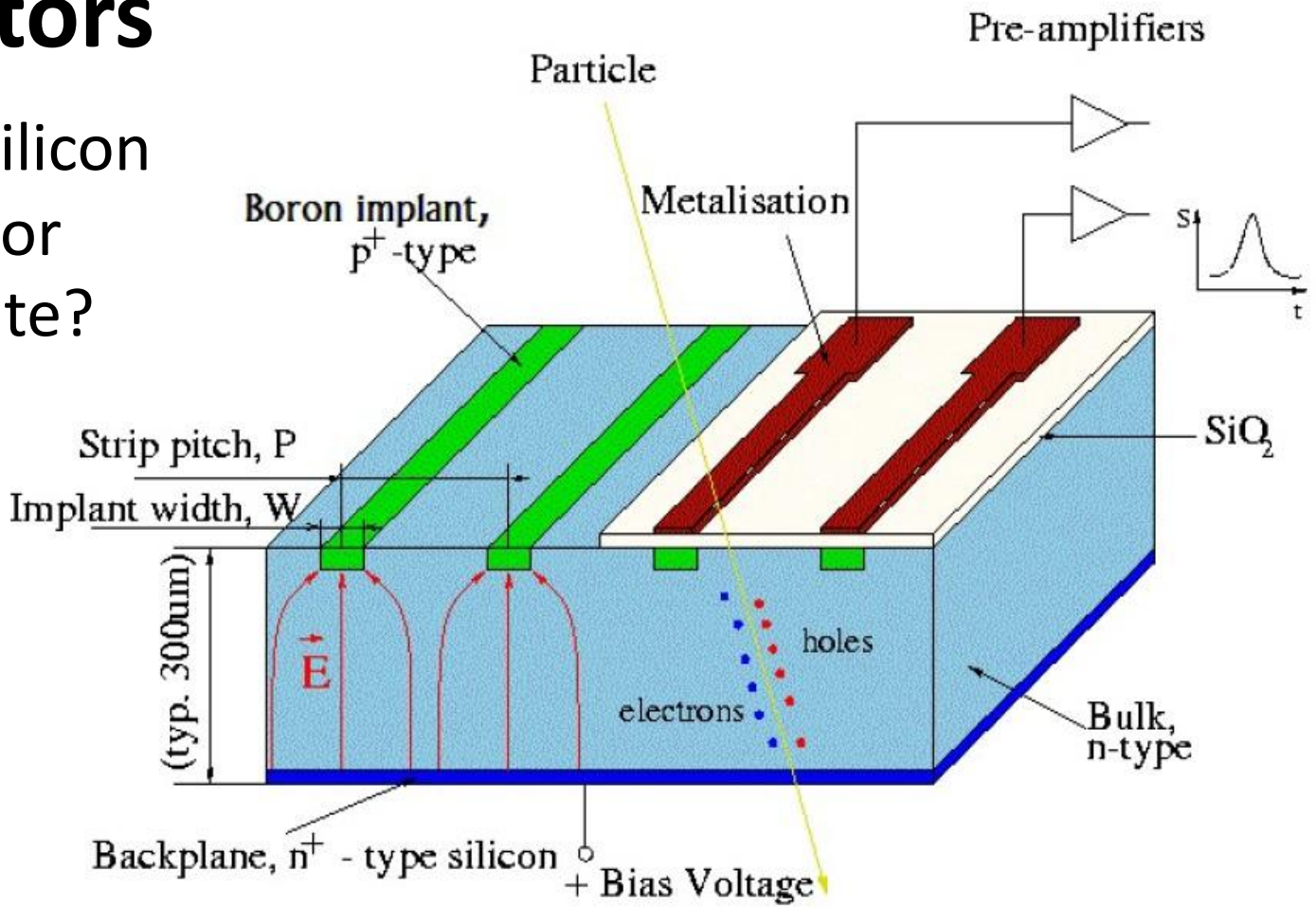
Motivation

- Beam diagnostics of the Super-FRS at FAIR: **position**, **energy loss** and **ToF** measurements.
- The ToF detector should cover an active areas of about 300 x 50 mm^2.
- The required **time resolution** of the ToF detectors is about 50 ps.
- Radiation-hard planar Si detectors have been suggested to be an alternative solution to diamond detectors.

Si detectors

How does **s**ilicon **s**trip **d**etector (SSD) operate?



Experiment "Tests of the beam detectors of Super-FRS":

- 1 big SSD
- 2 pairs of small SSDs - S10 ,S20 and S40, S80
- 2 pairs of small PIN-diodes - LP-1, LP-2 and P100, P300

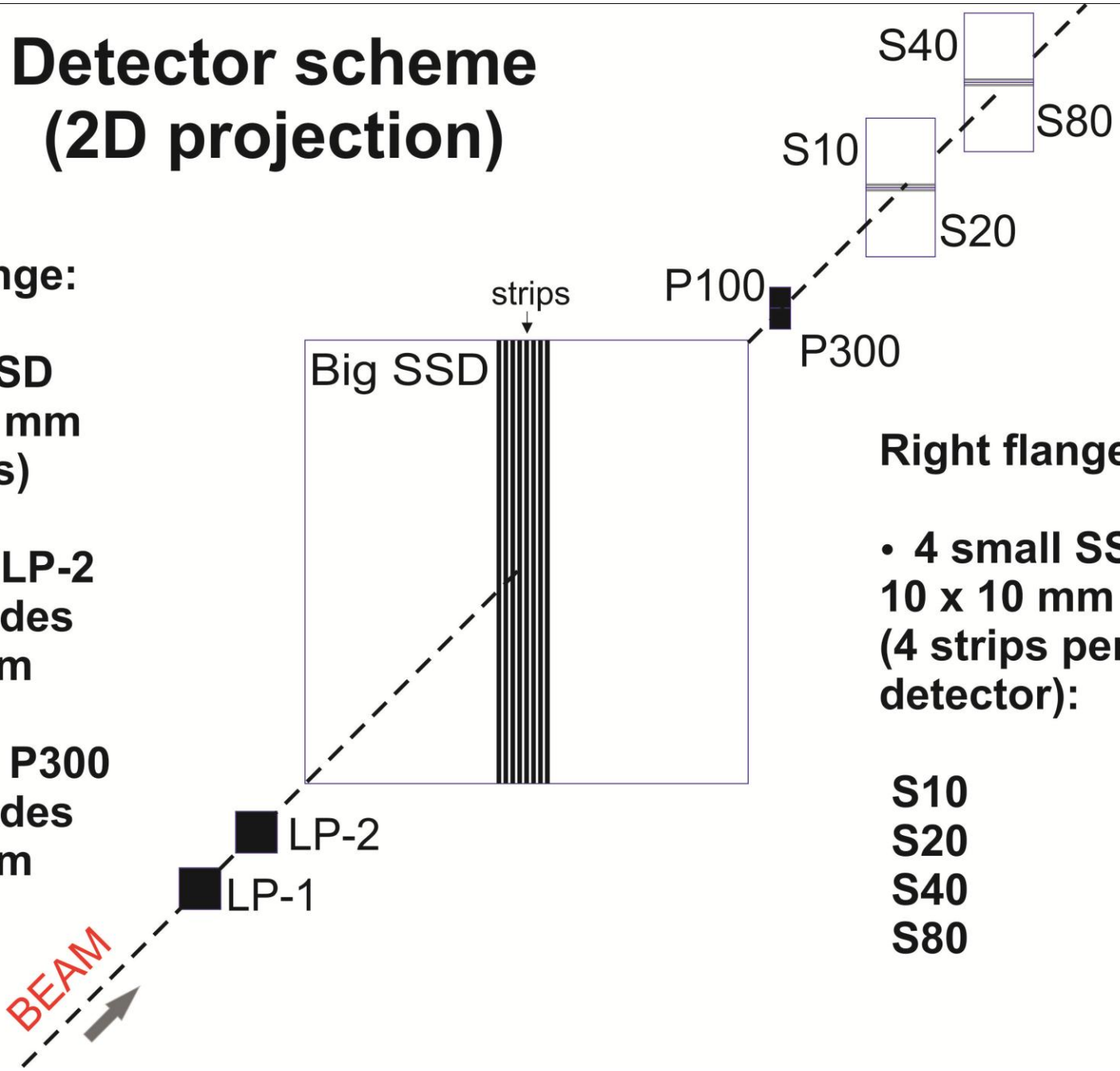
Detector scheme (2D projection)

Top flange:

- **Big SSD**
  64 x 64 mm
  (9 strips)

- **LP-1, LP-2**
  PIN-diodes
  6 x 6 mm

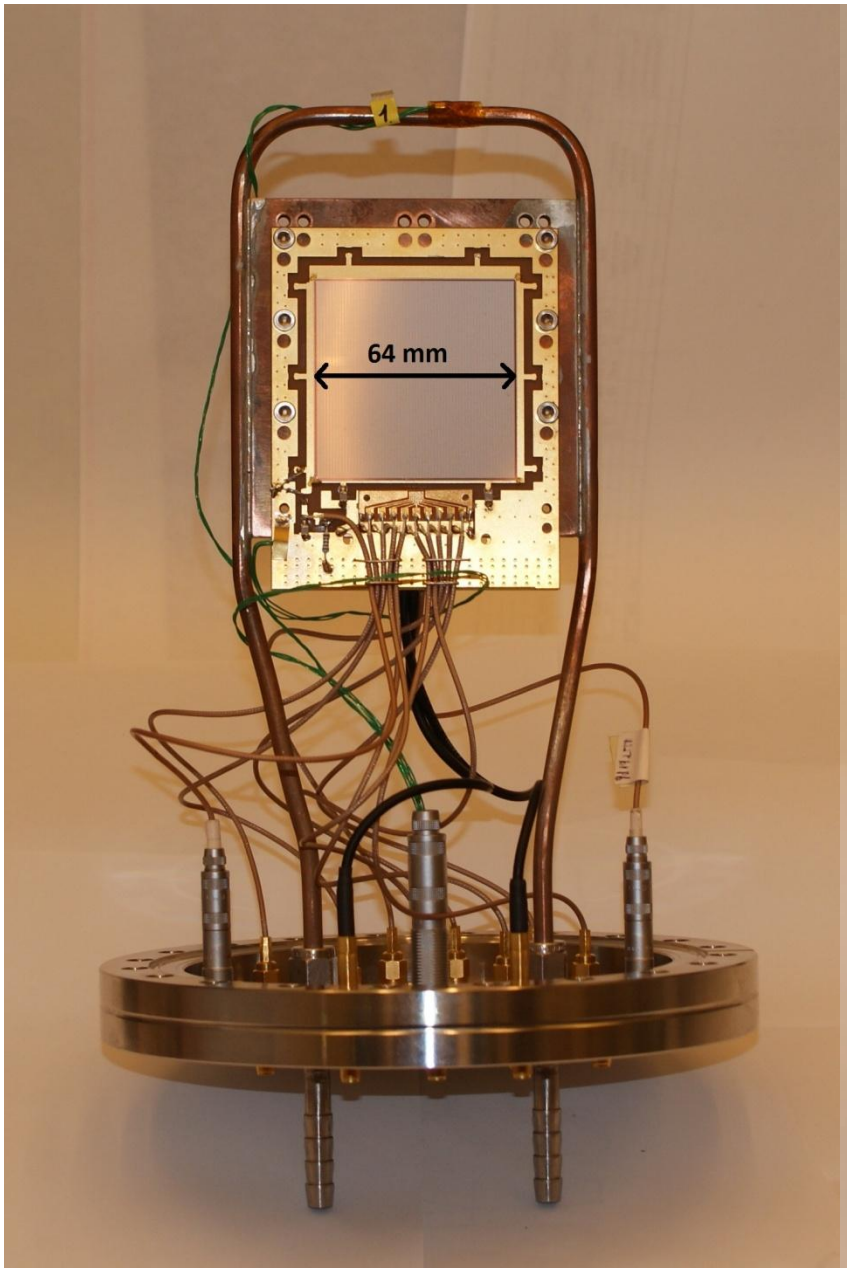
  P100, P300
  PIN-diodes
  3 x 3 mm



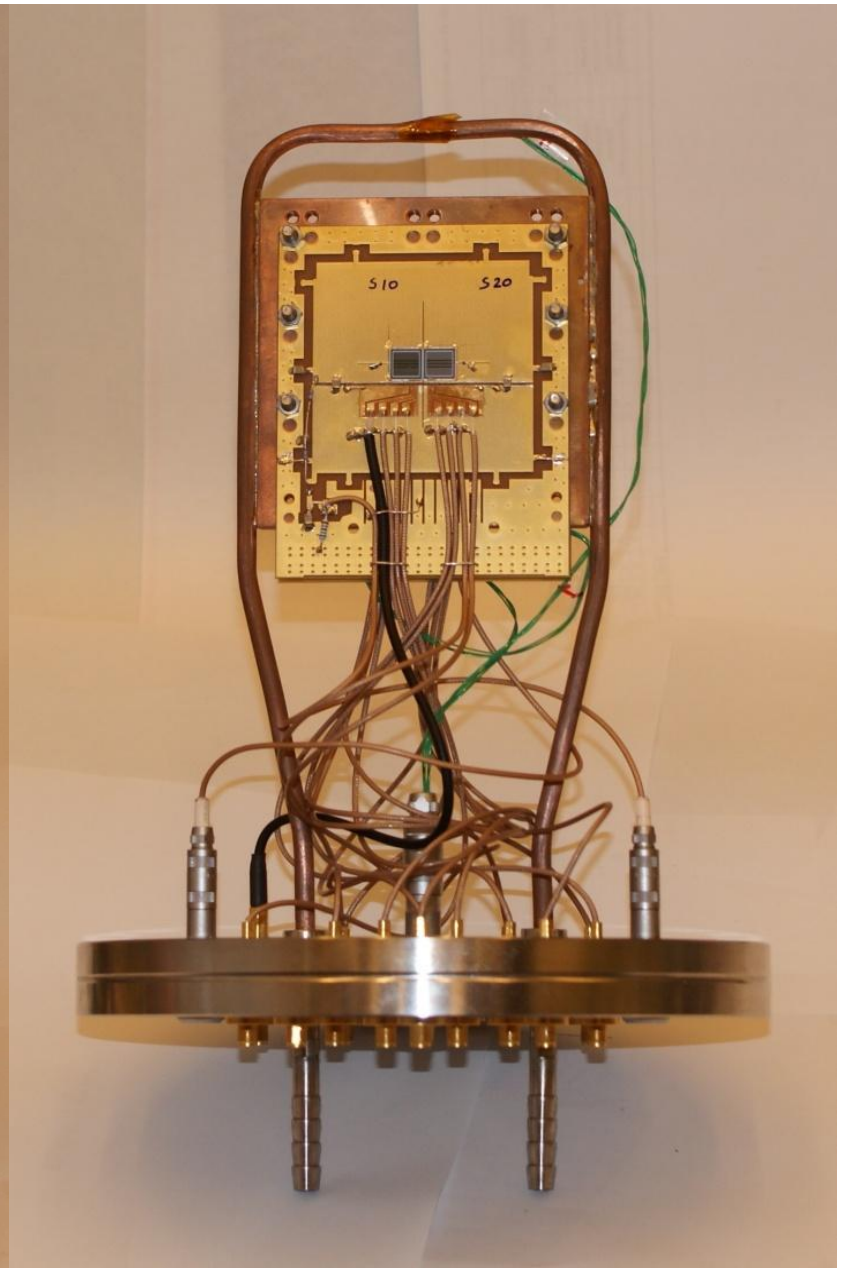
Right flange:

- **4 small SSDs**
  10 x 10 mm
  (4 strips per detector):

S10
S20
S40
S80

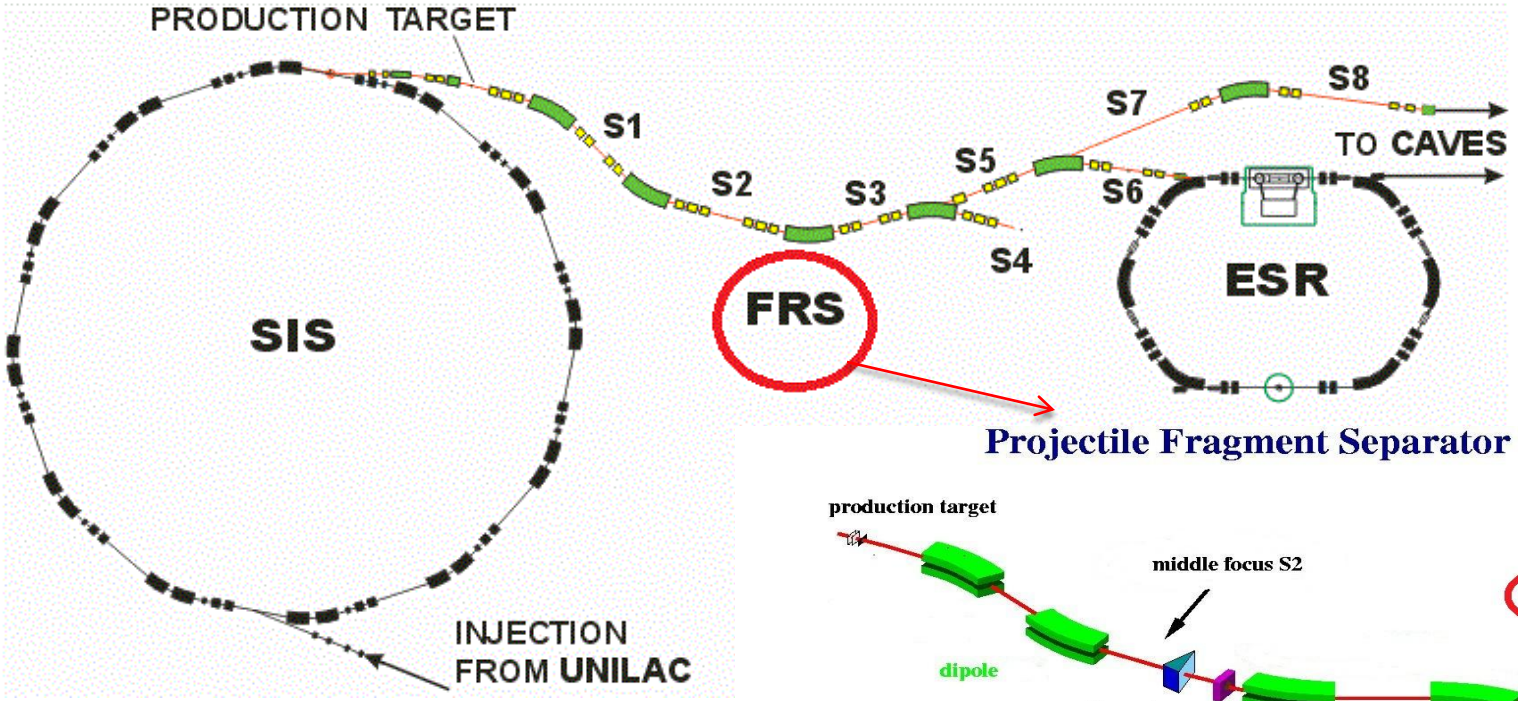


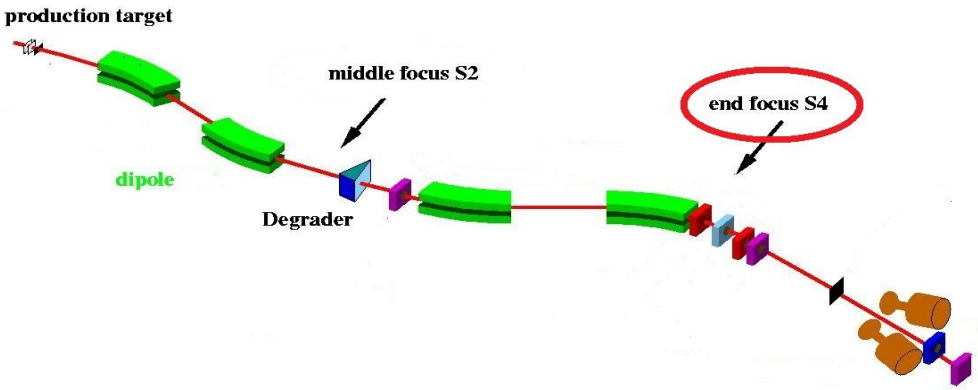
Big SSD



Small SSDs – S10, S20

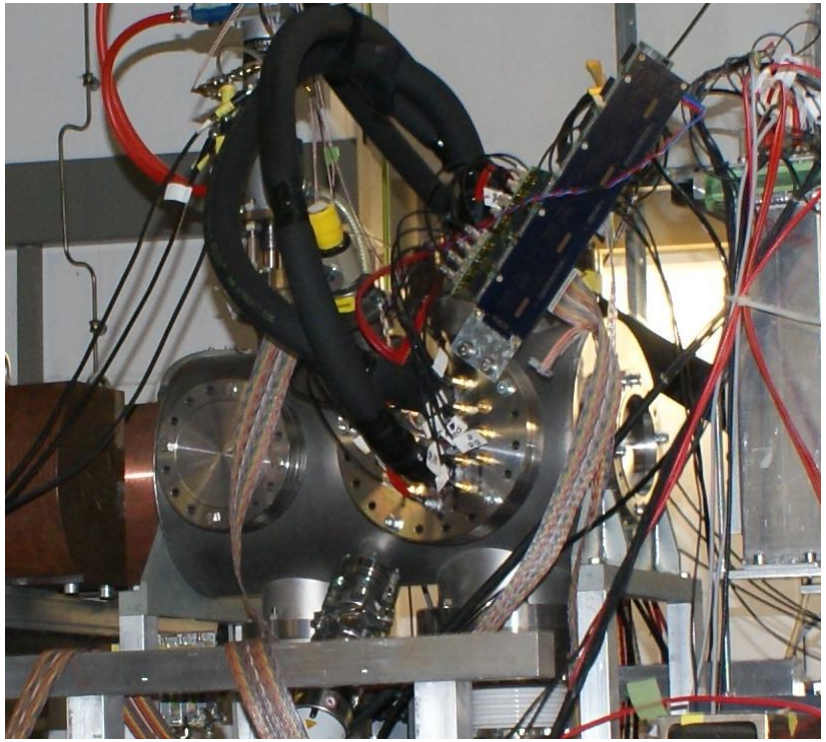
Experimental setup

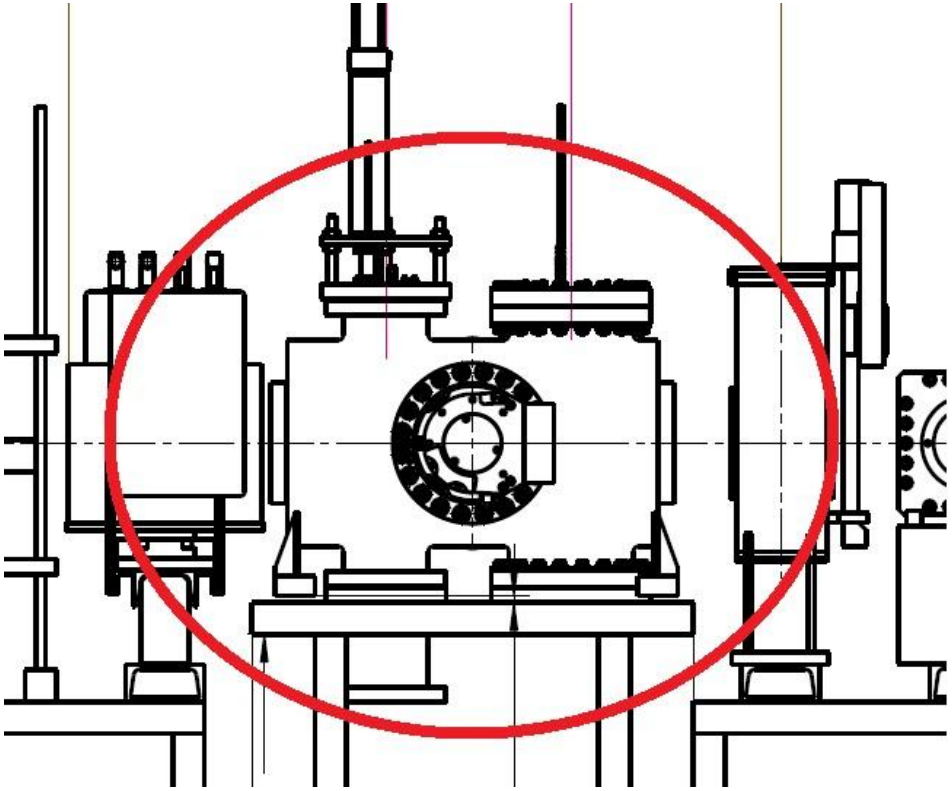




Goals:

- Compare Si detectors with different parameters
- Test of time resolution with different versions of fast electronics

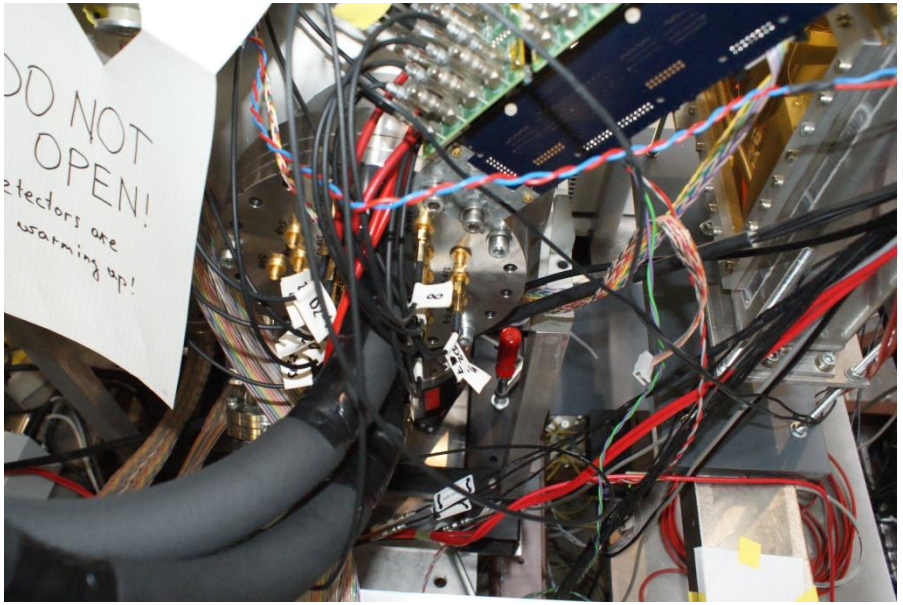




- ^{197}Au @ 1 GeV/u
- Accelerator complex (UNILAC + SIS18) providing beam to FRS
- The temperature of cooling tube –13^{o} C, detector PCB - at +7^{o} C
- Cooling of the detectors is reducing dark current and noise; cooled detectors are **more radiation-hard**.
- Vacuum about 10^{-4} mbar

Electronics

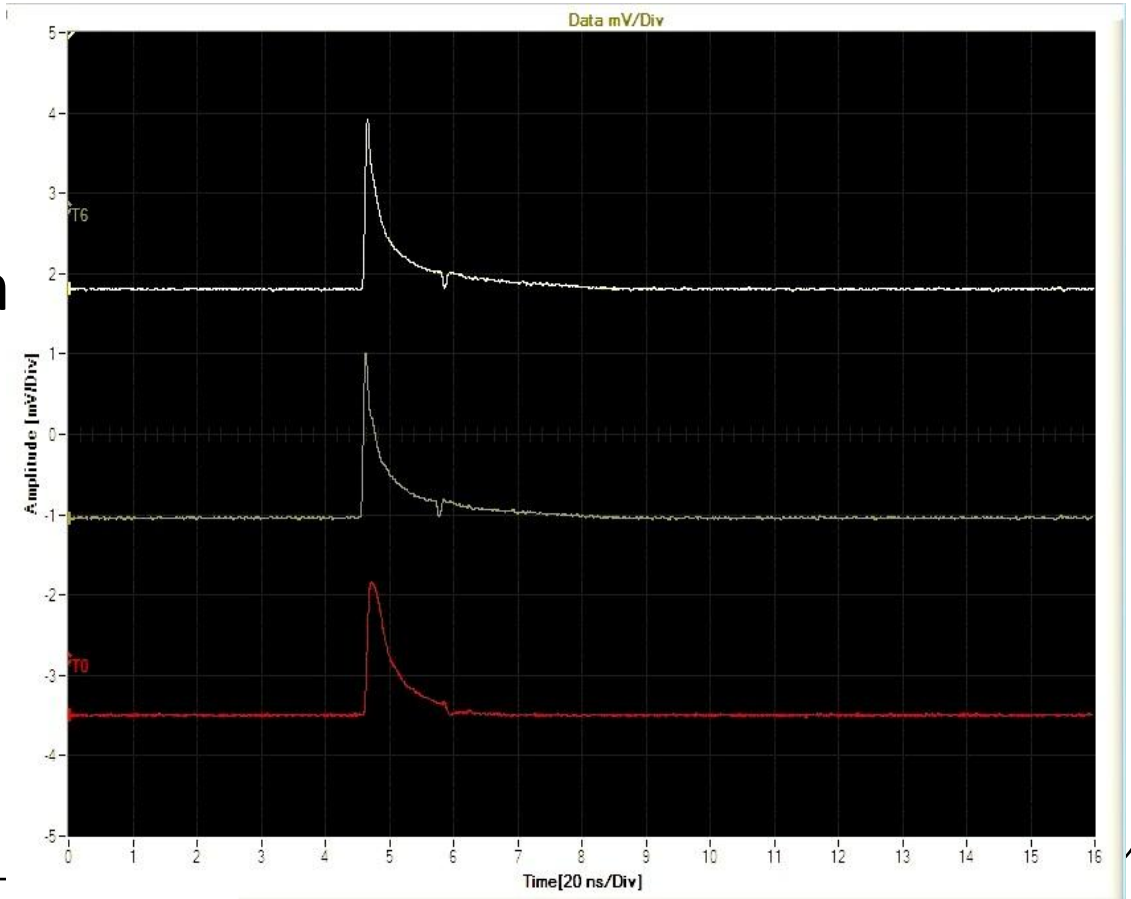
- Fast oscilloscope with 2 GHz analog bandwidth
- CAEN FADC DT5742. Sampling frequency up to 5 Gs/s
- **CAEN FADC DT5743. Sampling frequency up to 3.2 Gs/s**
- **PADI preamplifier/discriminator + VFTX2 TDC**



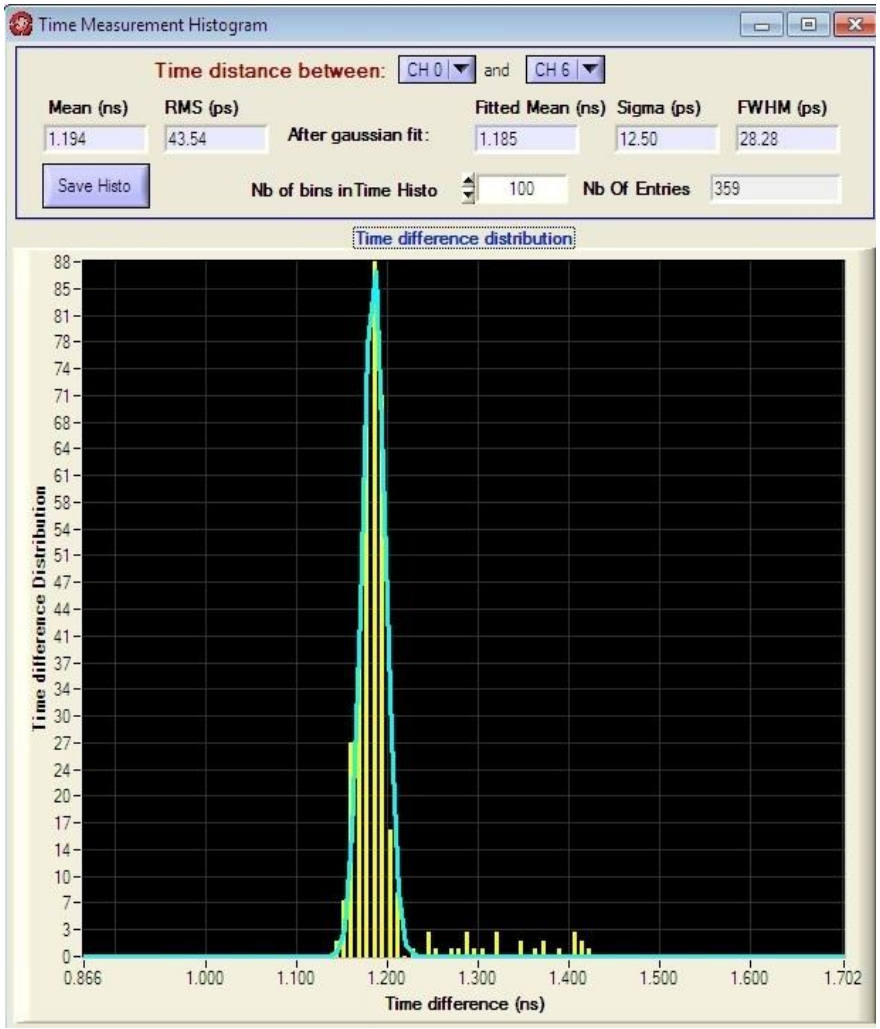
Data acquisition with CAEN DT5743

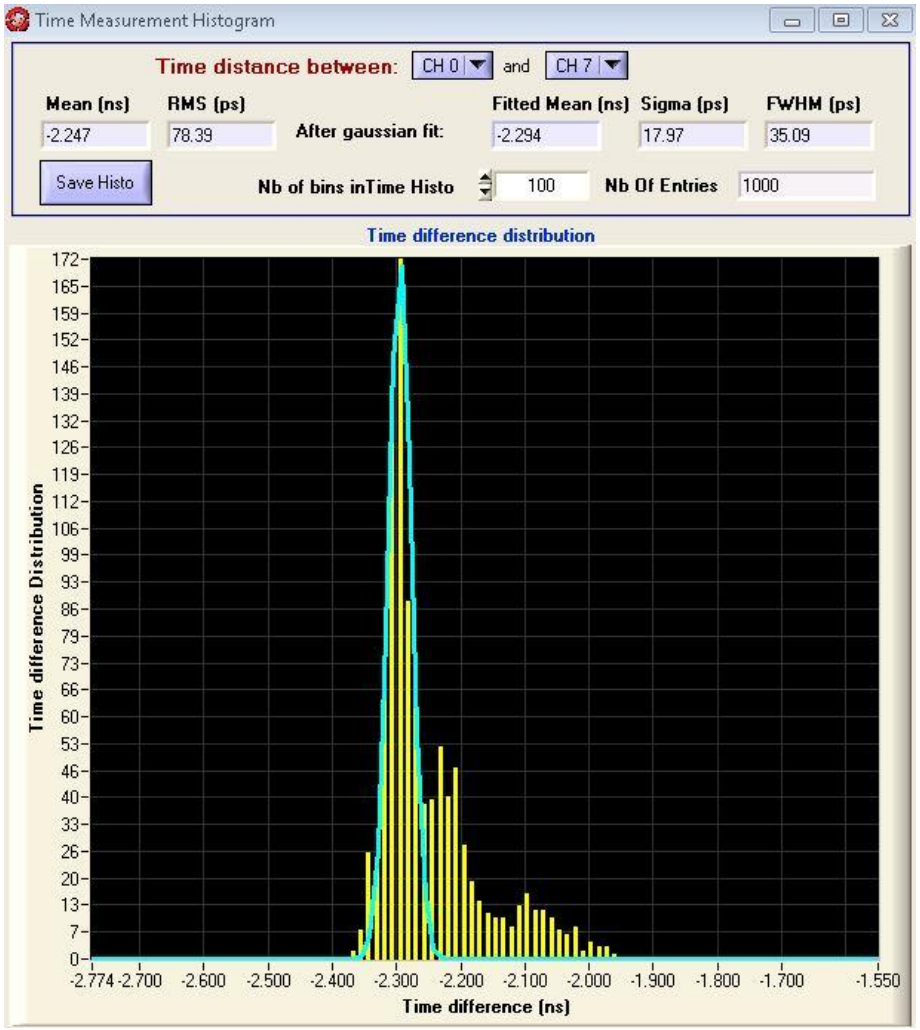
- CAEN DT5743 - desktop module housing a 8-channel 12-bit 3.2 GS/s switched capacitor digitizer.

- Visualization of the signal forms from each channel
- Typical amplitude around 200 mV
- CFD method



Software (CAENWaveCatcher)





- Gauss fit of the histograms -> σ
- **Time difference between any of two channels**

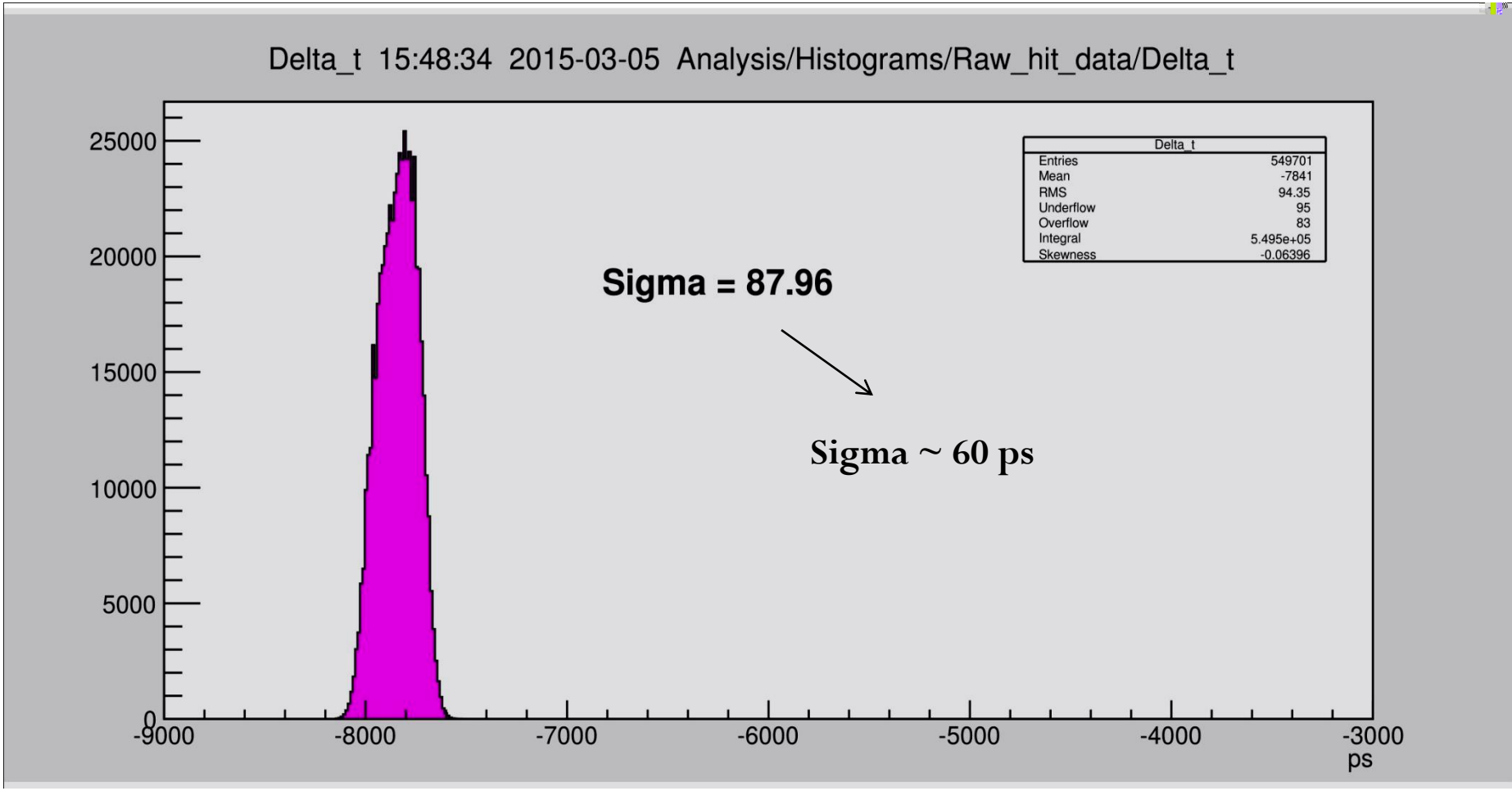
Results of analysis with DT5743

•standard deviation parameter of time difference distribution between different detectors:

Detectors	**Strip width (μm)**	**б (ps)**
big SSD vs LP-1	900 - 300	17.8
big SSD vs LP-2	900 - 300	16.4
big SSD vs S80	900 - 80	15.2
big SSD vs S20	900 - 20	59.6
S80 vs LP-1	80 - 300	29.8
S80 vs LP-2	80 - 300	37.4
S20 vs LP-2	20 - 300	51.0
S10 vs LP-1	10 - 300	55.7
S10 vs LP-2	10 - 300	97.2

Data acquisition and analysis with PADI + VFTX2 TDC

- **PADI** – **P**re**A**mplifier + **DI**scriminator, analog data processing. This configuration was invented for short signal rise times (ns). 9 channels of PADI were connected to different Si detectors.
- Output data from PADI -> VFTX2
- **VFTX2** – VME-FPGA-TDC, a multihit TDC (time-to-digital converter). It gives the information about relative times in different channels.
- Data analysis is currently being made with analysis frameworks Go4 and ROOT.



Time difference in ps for 2 different detectors (LP-2 and BigSSD). The analysis is currently going on, the preliminary results for this detector pair is ~ 60 ps.

Conclusions

• DT5743 - the time resolution ≈ 17 ps, and it was expected to get the time resolution of the same order from PADI+VFTX2.

• DT5743: there is **an optimum strip size** for which better time resolution can be obtained. Achieved t**ime resolution** is **similar** or **better** then of diamond detectors.

• PADI+VFTX2: analysis is going on. It is planned **to compare results of time resolutions of different readout systems**.