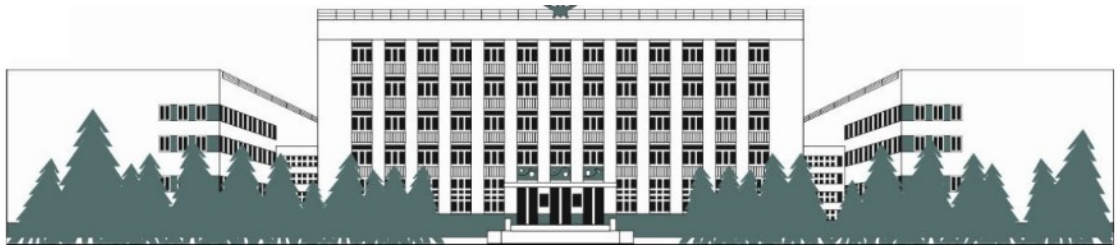
Collector Ring Beam Diagnostics Status



Yury Rogovsky

on behalf of the Budker INP team

28 April 2021, Novosibirsk

We are glad to see you here in a good health. We hope you and you families in a good shape during this COVID-19 time. Take care of yourself.

Yury Rogovsky

on behalf of the Budker INP team

28 April 2021, Novosibirsk

The half a year progress will be reported.

FCT and DCCT for CR

December 2019

~120 k€

~40 k€

NPCT-CF8"-147.6-120-UHV-	6"	DN160 NW150CF	147.6	120.0
NPCT-CF10"-198.4-120-UHV-	8"	DN200 NW200CF	198.4	120.0
FCT-CF10"-147.6-40-UHV	6"	DN/NW200CF	147.6	
FCT-CF12"-198.4-40-UHV	8"	DN/NW250CF	198.4	
		Axial length H	40.0	

Now (Price List November 9th, 2020) stay the same as in April. Next year?

125 k€ and 42 k€
Purchase letter preparation
for FAIR ongoing.

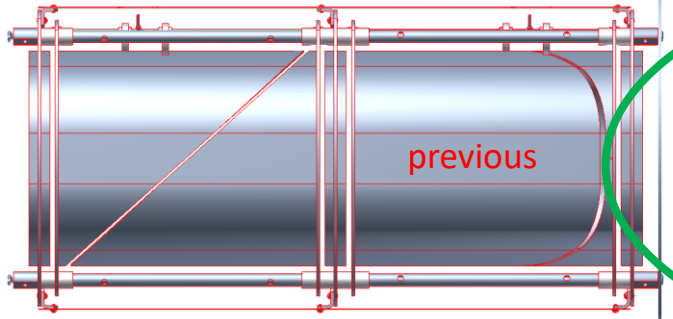
- CDR / FDR passed.
- Commercially available devices from BERGOZ (Genève). We keep contact. Last communication (email) in the end of March 2021.
- Purchase via FAIR is assumed. ~~Looking forward for any news or procedure.~~
- We have a good signature (success with ferrites procurement for injection system), so FCT / DCCCT will be next ones.

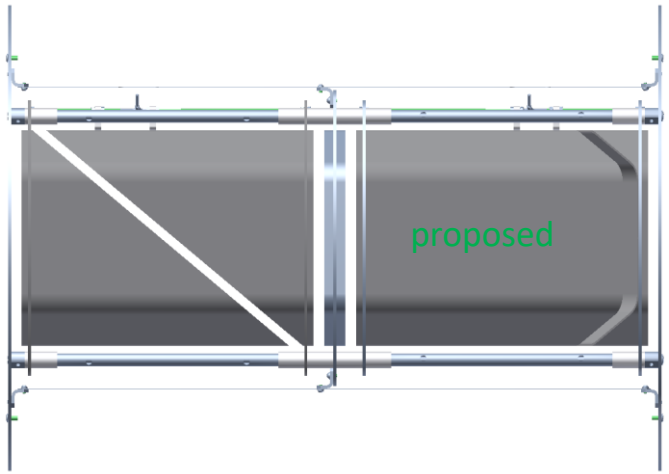
- DCCT: comes with electronics
- FCCT: amplifier required (selected one – DUPWA-1-70 by FEMTO)

Beam Position Monitor for CR (I) 5th Workshop

Type-1 Electrodes was reviewed against: Mechanical stability and rigidity; Production efficiency; EM properties; Positioning and tolerances.

Change the shape (only it) of electrodes: super-elliptical => octagonal.





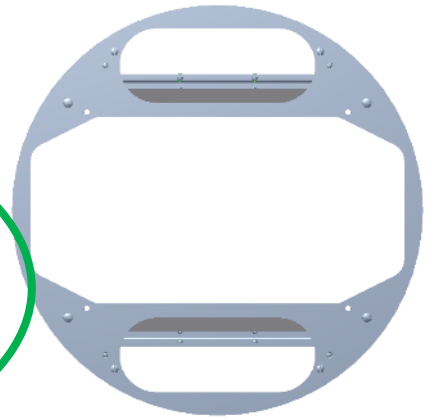
Simulations:

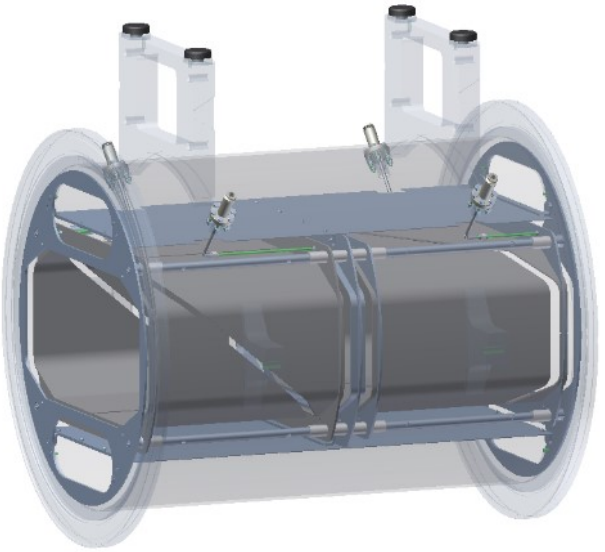
No valuable changes in freq. response @ 0 – 10 MHz;

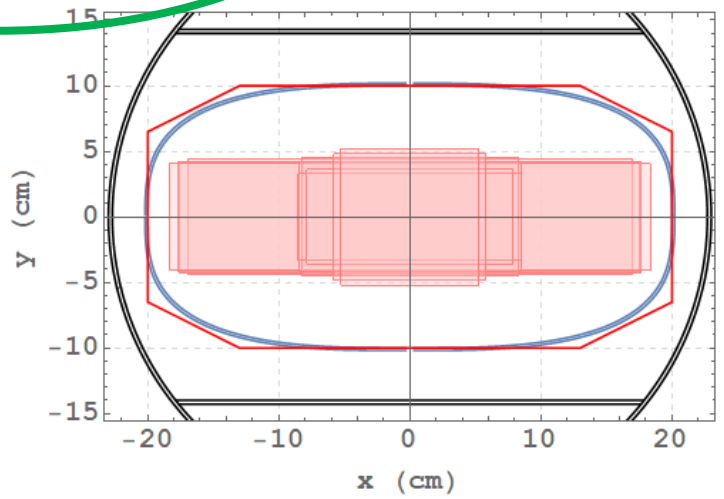
Capacity 5% lower (~150 pF);

Cross-talk approx. “the same”;

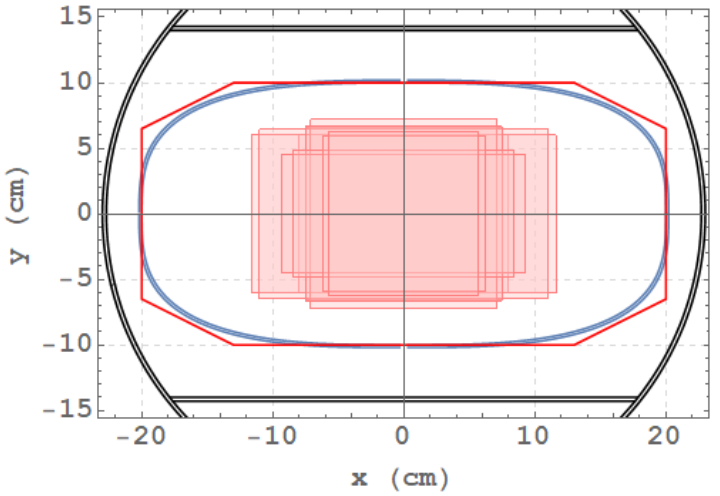
Side view







Beam shape @ BPM Type-1 for Pbar optics.
Proposed shape is shown in red color.



Beam shape @ BPM Type-1 for RIB optics.
Proposed shape is shown in red color.

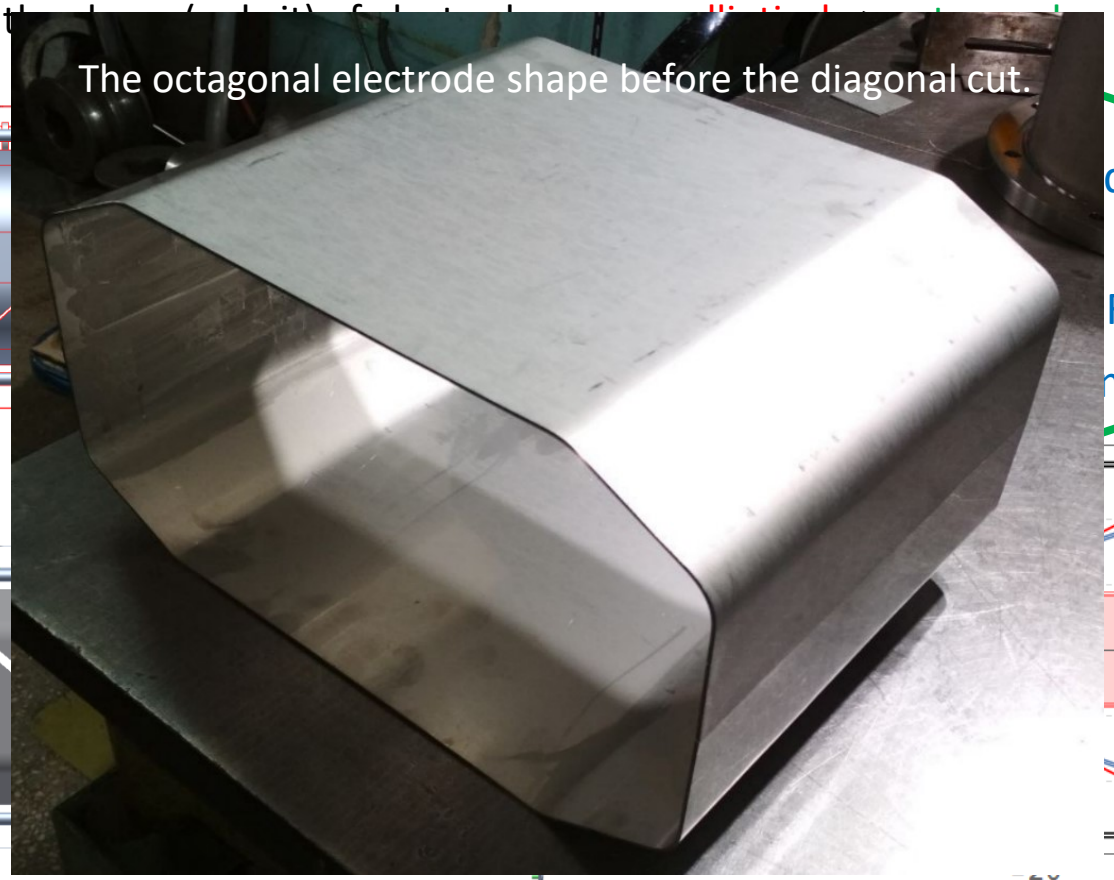
All drawings for the octagonal electrodes are in production. Passed technical checks. Tooling produced. Waiting for materials.

Beam shape in different BPMs shown as pink. We still fit the requirements.

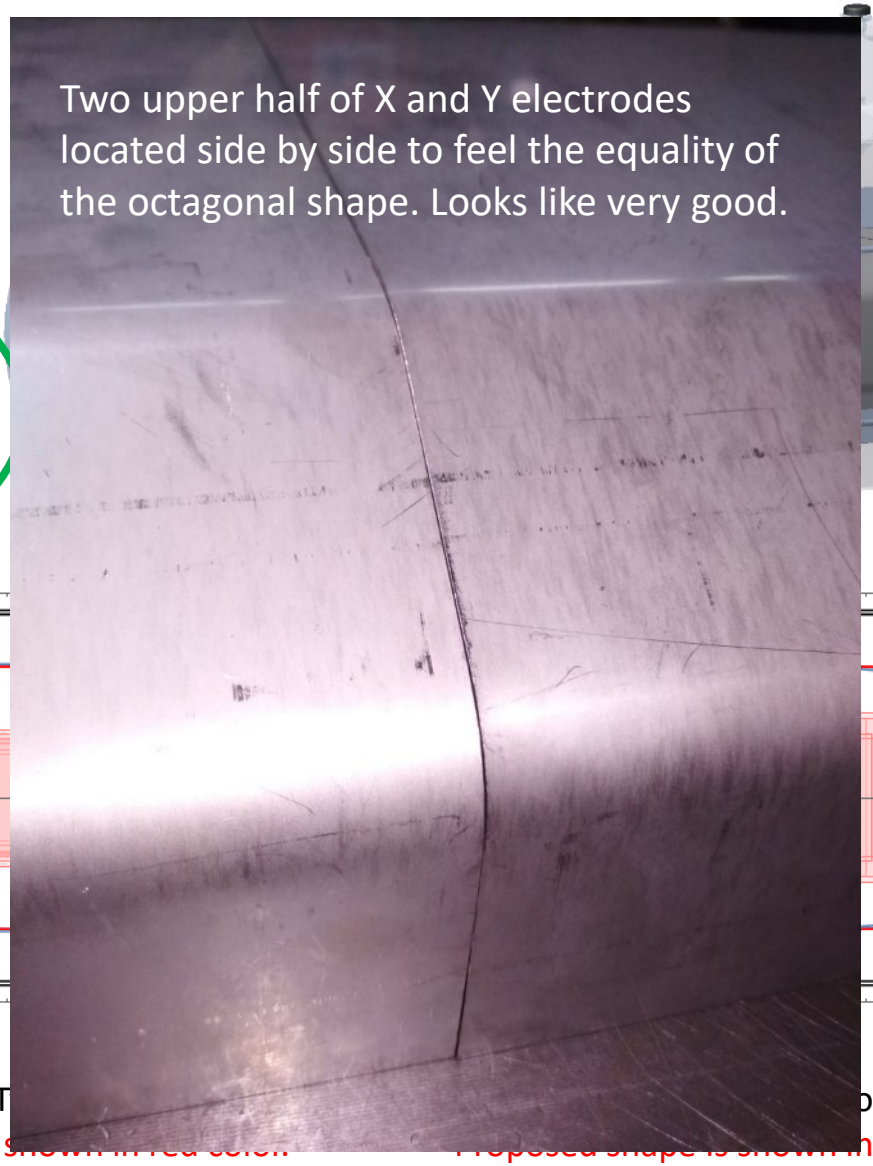
Beam Position Monitor for CR (II)

Type-1 Electrodes was reviewed against: Mechanical stability and rigidity; Production efficiency; EM properties; Positioning and tolerances.

Change t



All drawings for the octagonal electrodes are in production. Passed technical checks. Tooling produced. Waiting for materials.



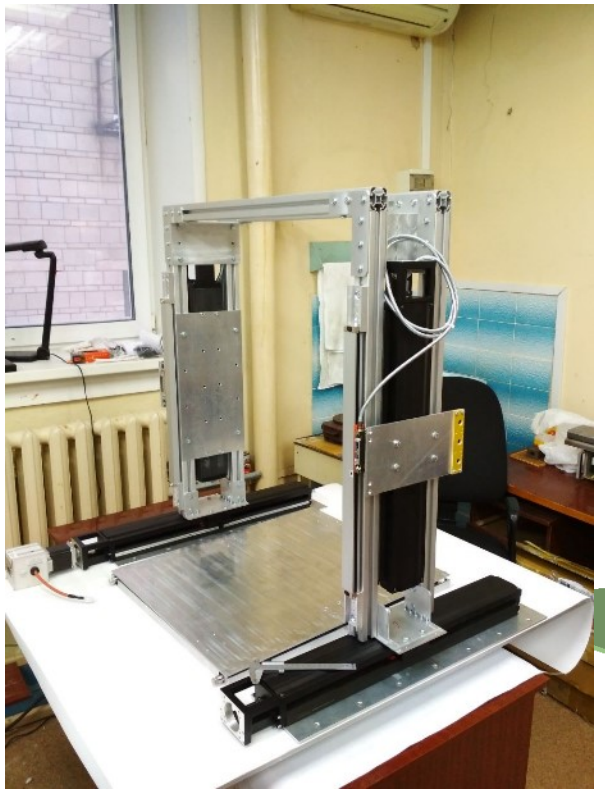
Beam shape @ BPM T or RIB optics.

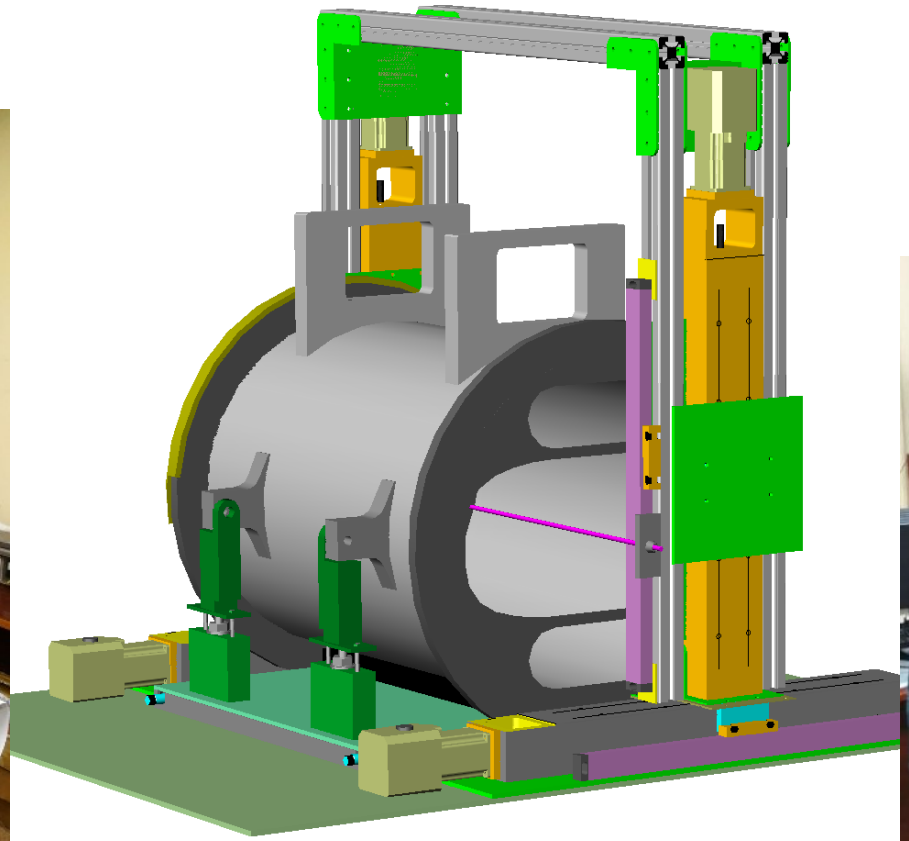
Proposed shape is shown in red color.

Beam shape in different BPMs shown as pink. We still fit the requirements.

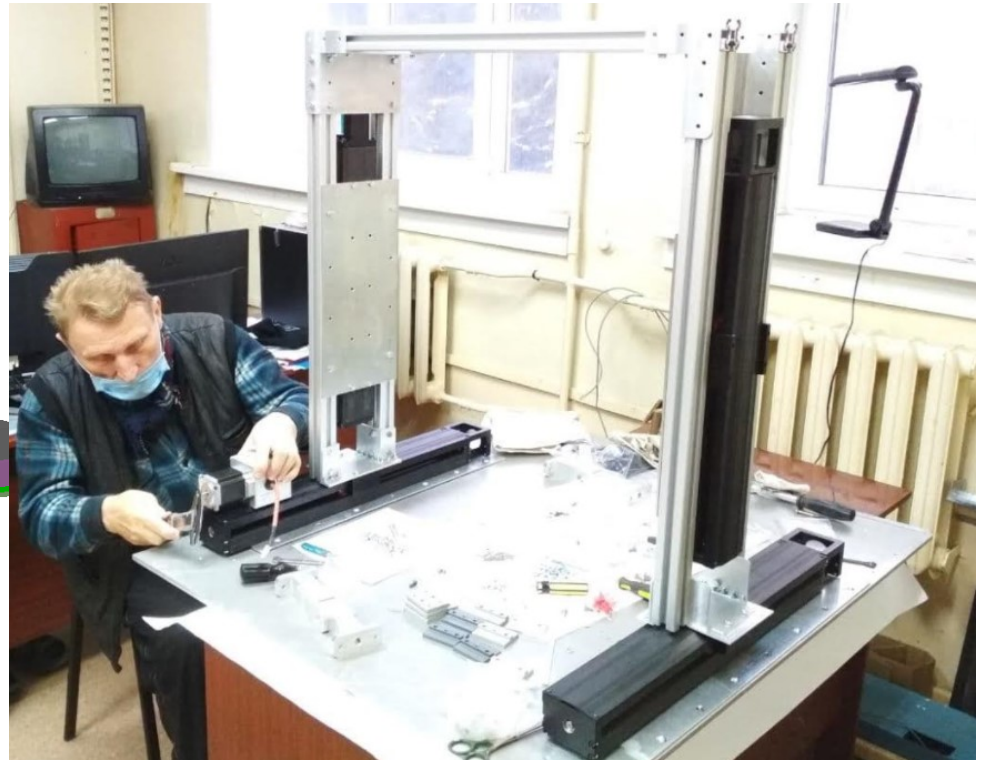
Beam Position Monitor Test Stand (III)

- The 3D view of the whole installation.
- The stand concept can be modified for Type-2,3 detectors.





- LNA and VGA parts prototypes from FZJ delayed due to COVID.
- Production of the test stand is ongoing. About 100% ready.
- Test stand commissioned in Q1 2021.



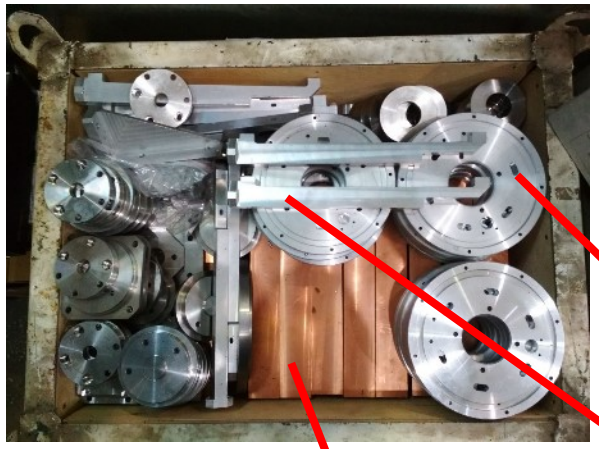
Beam Position Monitor Test Stand (IV)

- First experiments with operation software started.
- “Wire” movements tested.
- Position readout tested.

- FOS: BPM Type-2 combined with XY dipole corrector in the production.
- XY corrector is 80% ready.
- Vacuum tube (without flanges is ready).
- Electrodes (round shape) waiting for materials.

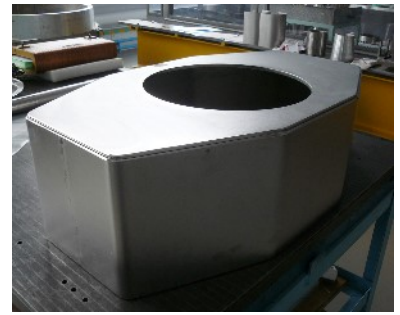
Beam Scraper for CR (I)

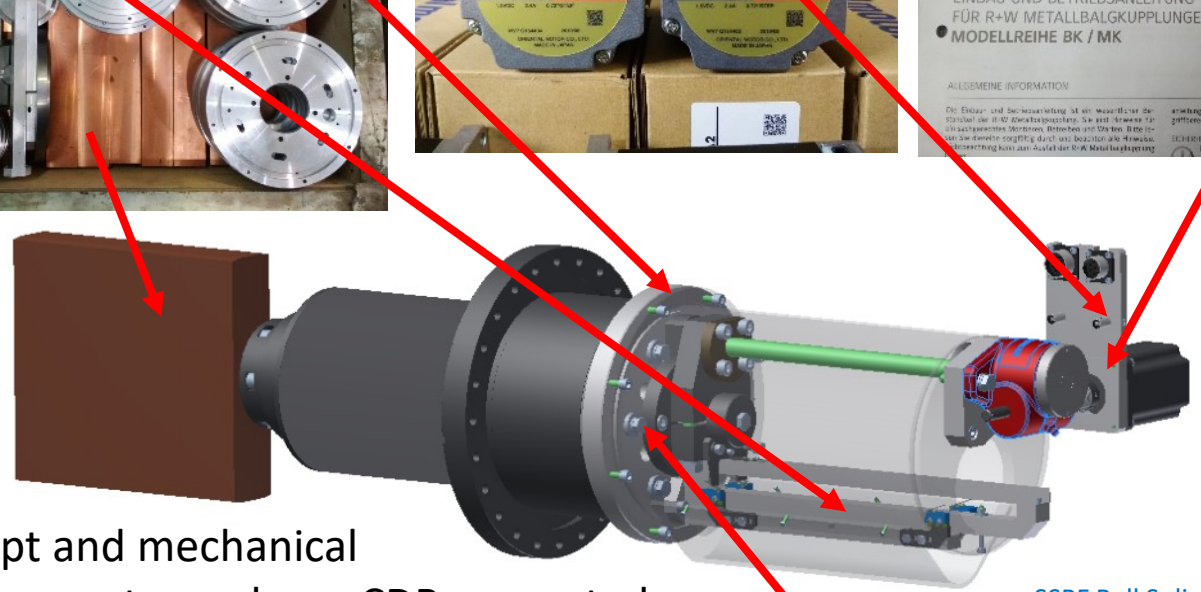
Produced at BINP

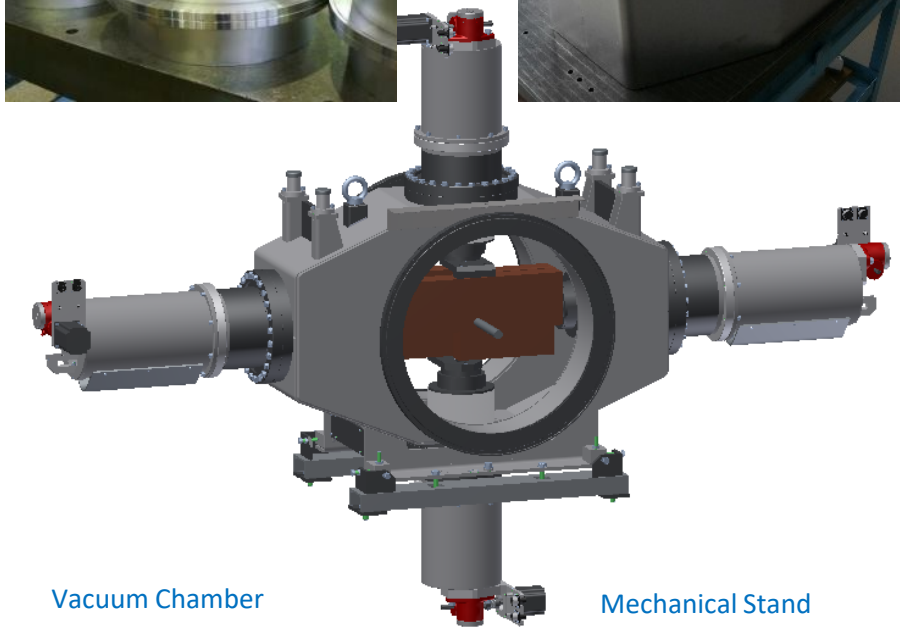


Stepper Motor

Mechanical Coupler







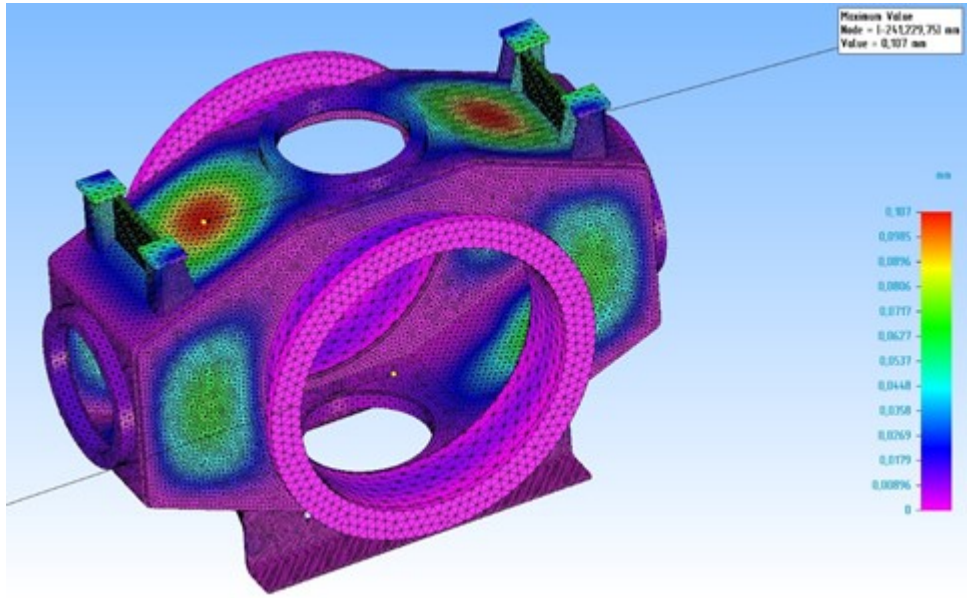
- Concept and mechanical development was done. CDR presented.
- Procurement of most components done.
- Waiting for bellows and flanges delivery.
- FEM analysis done. Shows good results.
- Production is ongoing step by step.
- FDR passed formally.

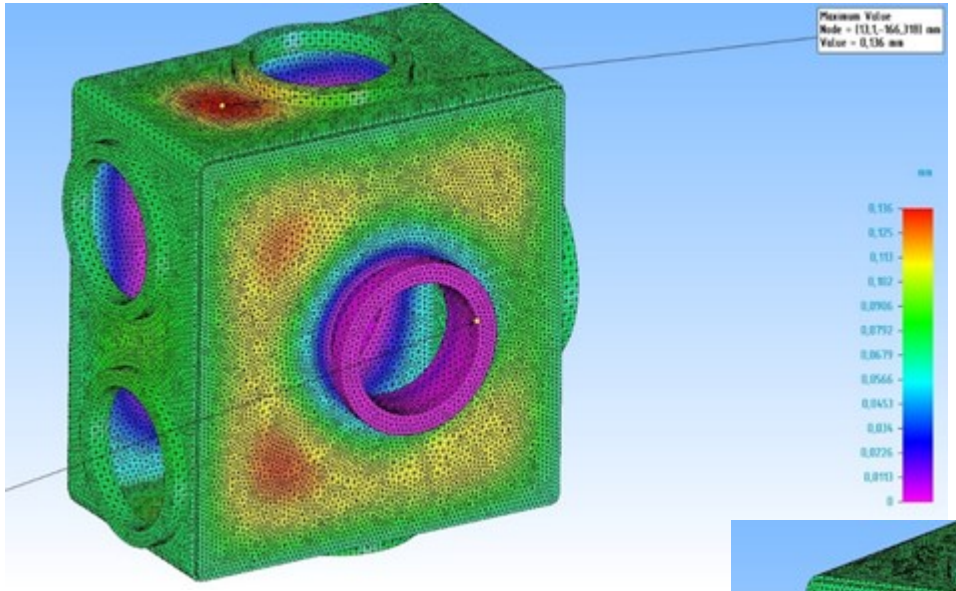
SSPF Ball Spline

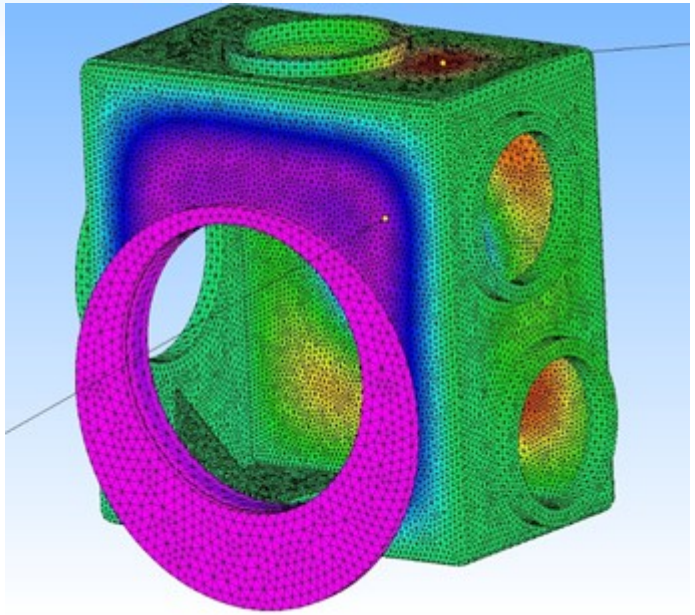
Vacuum Chamber

Mechanical Stand

Beam Scraper for CR (II)

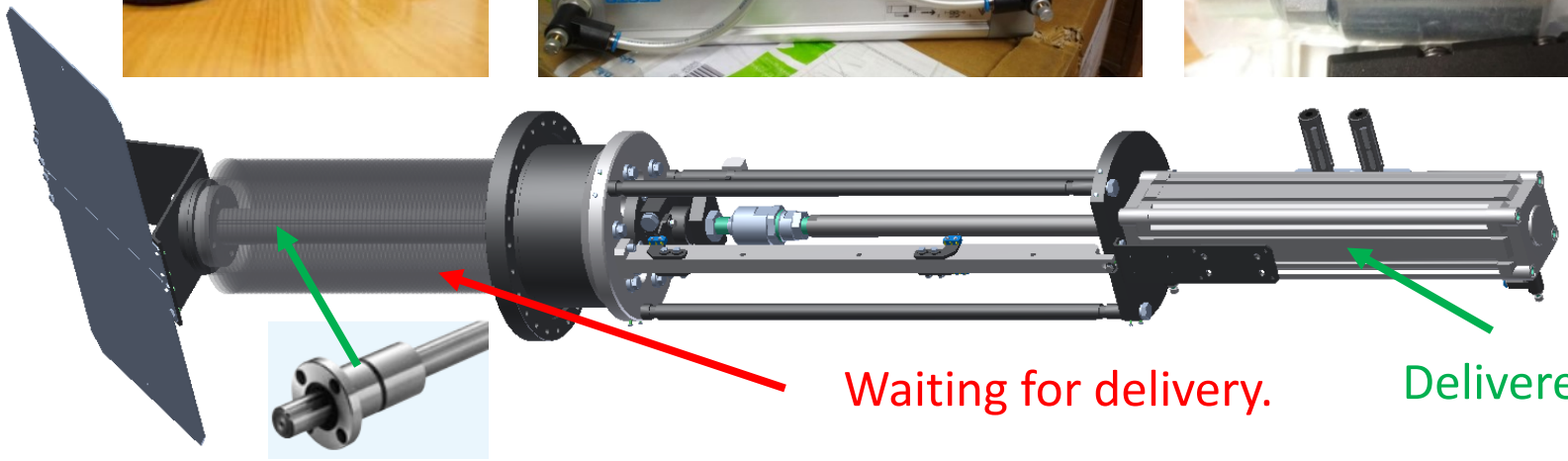




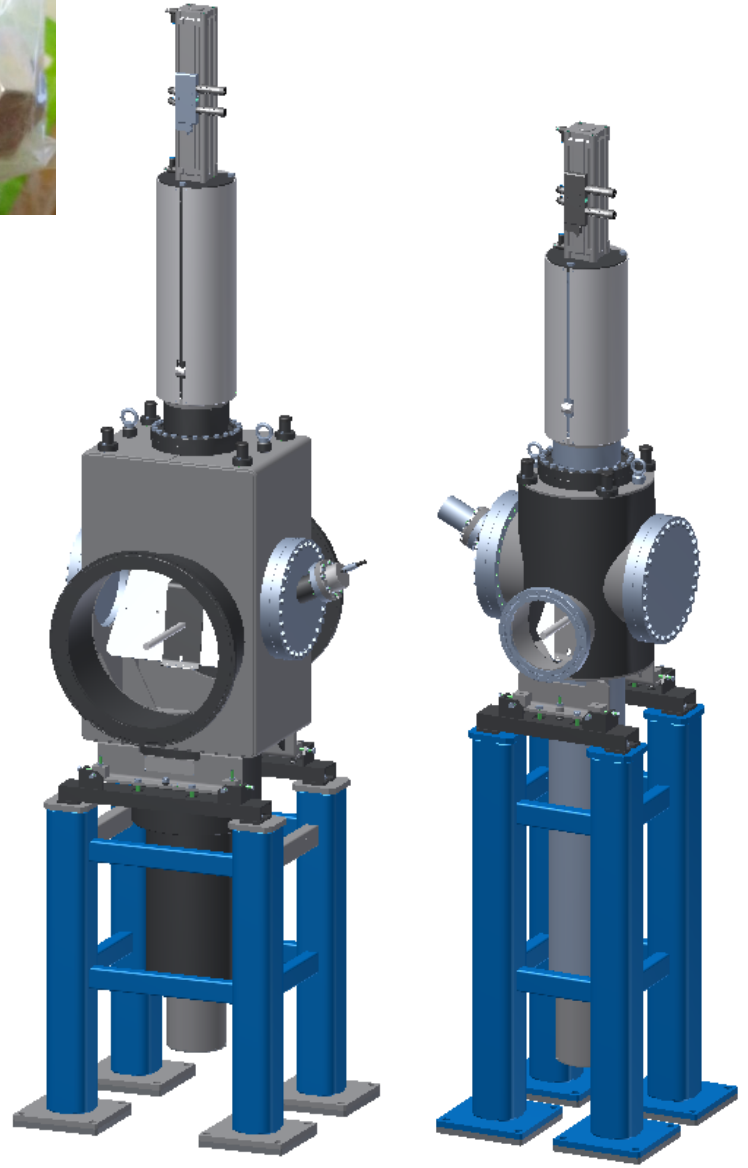


- An atmospheric pressure of 101325 Pa was applied to its outer surfaces
- A force of 2000H, equal to the load from the Electric drive applied to the flange CF200 on all sides of the vacuum vessel.
- Maximal calculated equivalent stress of 218 MPa is less than permissible limit of 236 MPa
- The deformation of the sites for fiducial target is 42.3 µm, which is less than the permissible tolerance of 50 µm.

Scintillating Screen for CR (I)

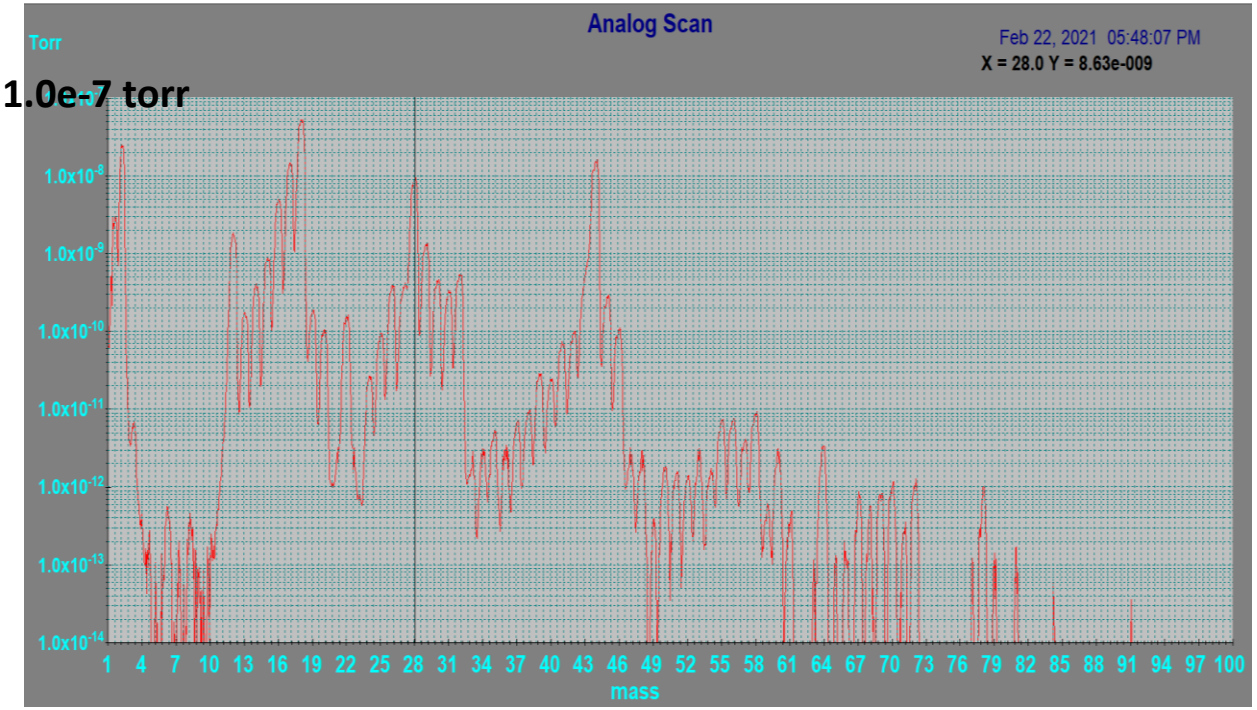


- Concept and mechanical development was done. CDR presented.
- Procurement of most components done. Waiting for bellows and flanges delivery.
- FEM analysis done. Shows good results i.e. low chamber distortions.
- Production is ongoing step by step.
- FDR passed formally. Investigation of vacuum quality of the parts in ongoing.
- Several types of phosphor deposition (different ways) on the detector surface have been tested. Not all finished yet.

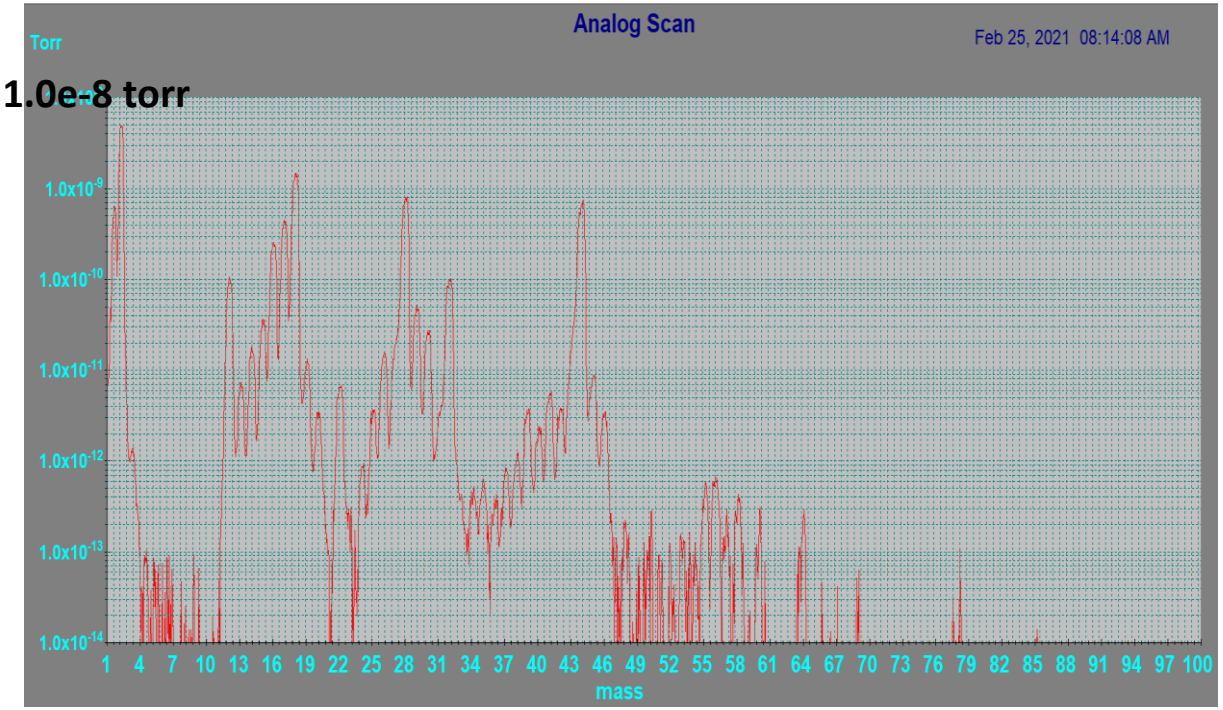


Scintillating Screen for CR (II)

P43 (exact formula Gd2O2S:Tb) electrophoresis coverage vacuum tests



Spectrum after 48 hours (without heating)



Spectrum after 24 hours (after heating)

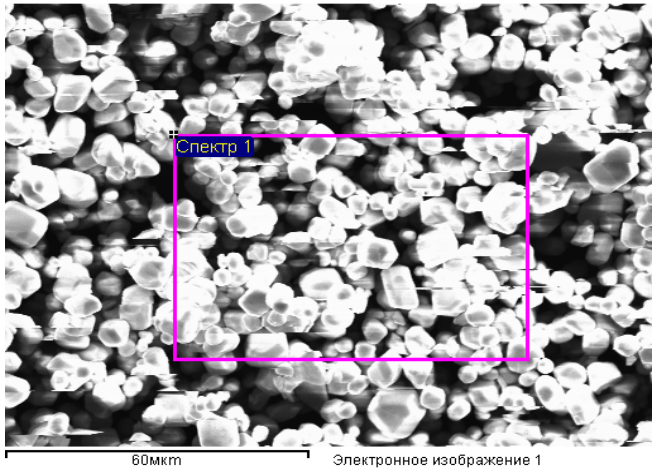
Spectra showed presence of substance with 32 u. This peak seems to be an oxygen, indirect evidence of it can be presence 33 and 34 peaks and dominance 32 peak in comparison with 34 and absent of 64 u.

Vacuum team recommendation:

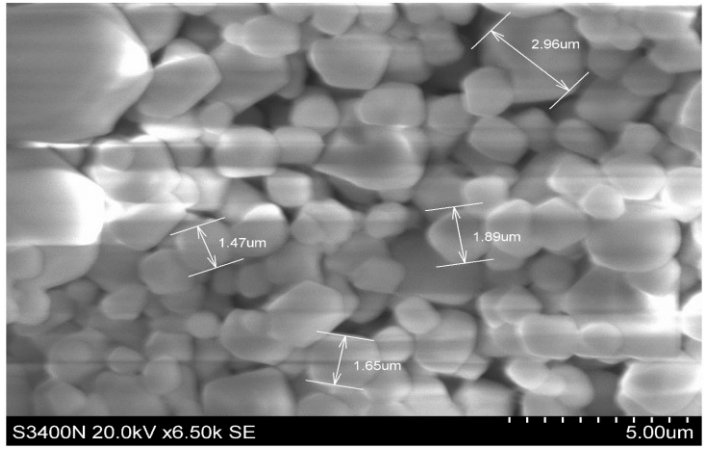
- Required vacuum 3e-9 torr is reachable after 2-3 day scintillating heating by 120-140 °C
- Screens detector should be heated in BINP before delivering to GSI
- Screens detector should be delivered under vacuum or nitrogen. We should have valve for nitrogen inlet to GSI

Scintillating Screen for CR (III)

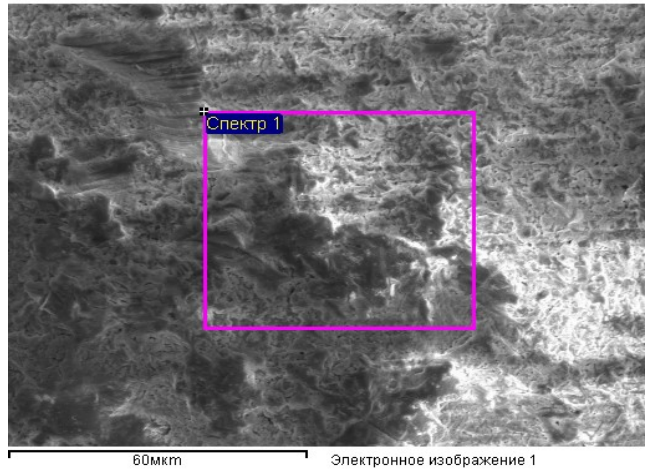
Scanning electron microscopy image of different samples



Pure P43



Electrophoresis



Gas-dynamic jet

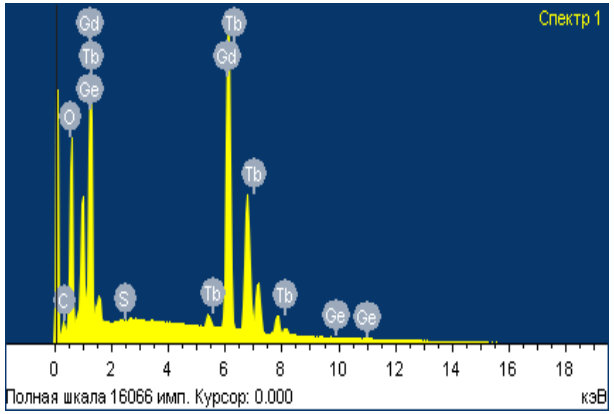
- P43 has good light yield due to charging particles irradiation
- We thought we had an electrophoresis method of deposition the scintillator, which was intendent to be appropriate for our situation
- First samples tests showed very poor adhesion (we can simply erase the scintillating surface by sliding finger over it)
- Also, P43 vacuum tests wasn’t perfect
- We apply a new method of deposition P43 powder on the surface of the screen – gas-dynamic jet (right picture)
- Gas-dynamic jet samples has very good adhesion (it’s hard to erase scintillator from screen by hard knife edge)
- Significant light yield decreasing was observed

Scintillating Screen for CR (IV)

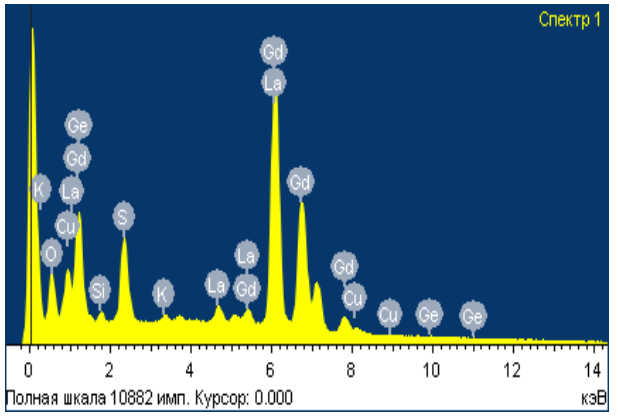
Chemical composition

Substance	Pure P43	Coverage (Gas-dynamic jet)	Coverage (Electrophoresis)
Oxygen	47.27 %	62.31 %	50.07 %
Gadolinium	37.44 %	23.54 %	33.26 %
Sulfur	13.45 %	0. 12 %	11.76 %
Terbium	~ 1.84 %	Absent	Absent
Other	Insignificant presence of other elements on the test samples	Big amount of: Carbon (~8.7 %), Aliminium (~3 %), Copper and Germanium (~0.5%)	Silicon (~ 2 %), Lanthanum (~ 1.69 %), Potassium (~ 0.8%), some traces of Copper, Germanium, Chromium

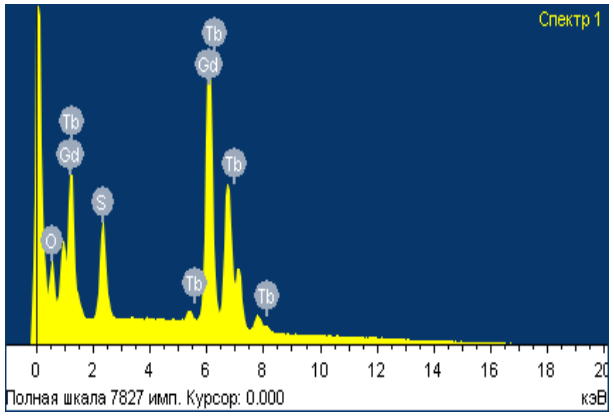
Gas-dynamic jet



- Gas-dynamic jet method gives not only another P43 coverage structure but chemical composition too – due to heating P43 powder more than to 2000 °C
- As we can see on spectra and table this way of cover leads to absent of sulfur and terbium – this is the reason for significant decreasing of light yield



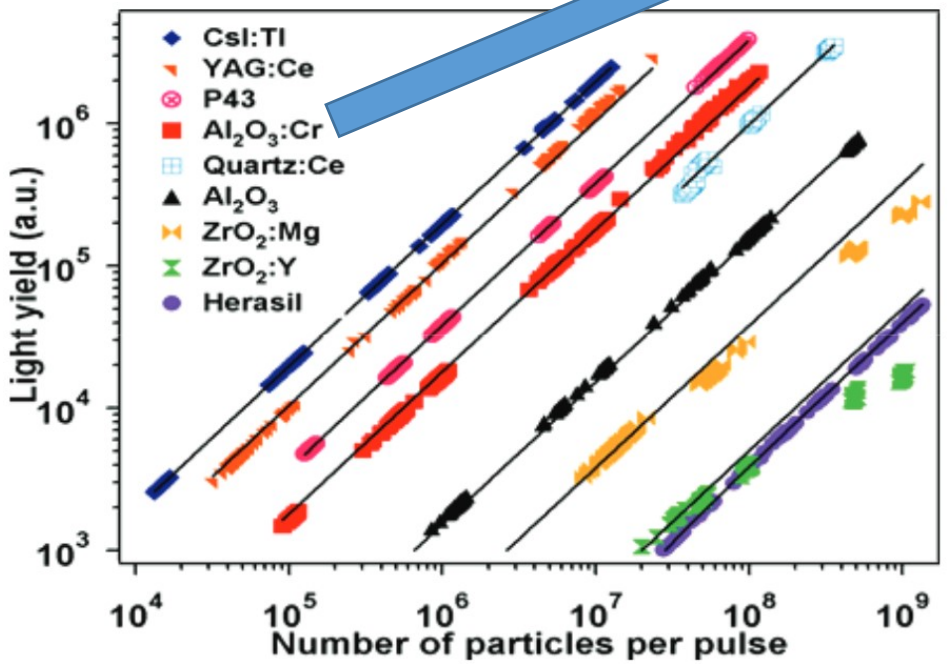
Electrophoresis



Pure P43

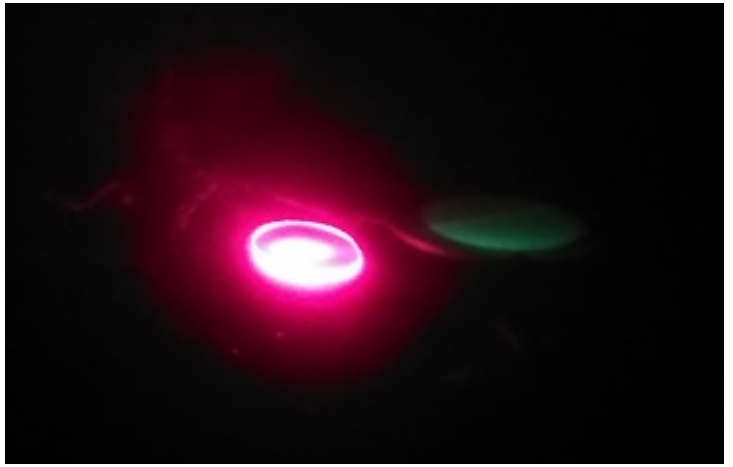
Scintillating Screen for CR (V)

- Possible way to overcome our obstacles is to use ruby instead P43
- Ruby has a slightly lower light output than P43, but still suitable for us (see comparison on pictures)
- We has a technique to cover screens detector with material which has better adhesion



0.6 mA, 60 keV electron beam

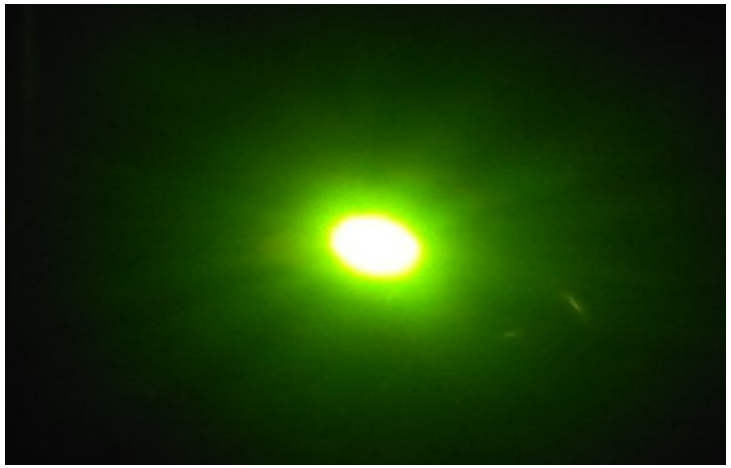
Ruby



See spot and surroundings

VS

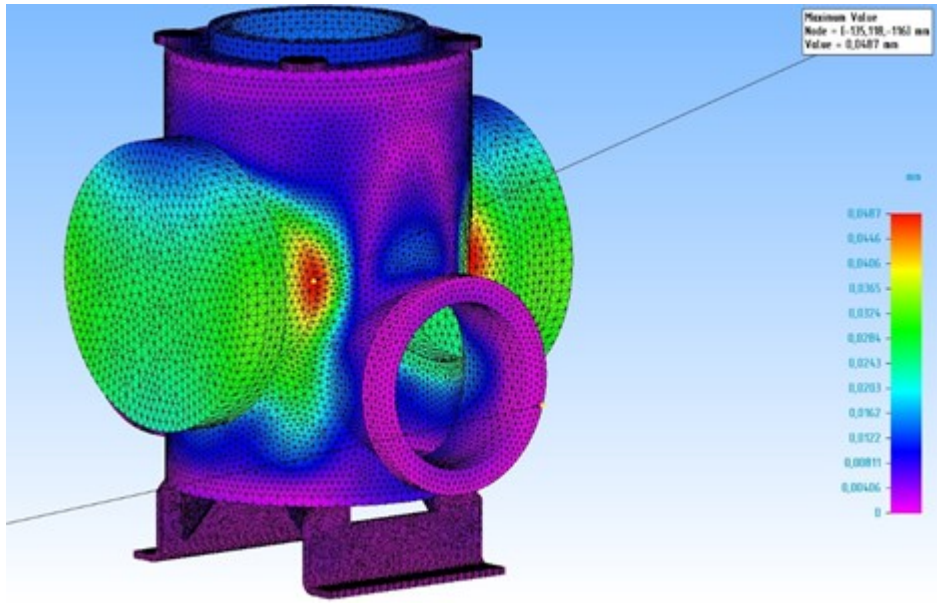
P43

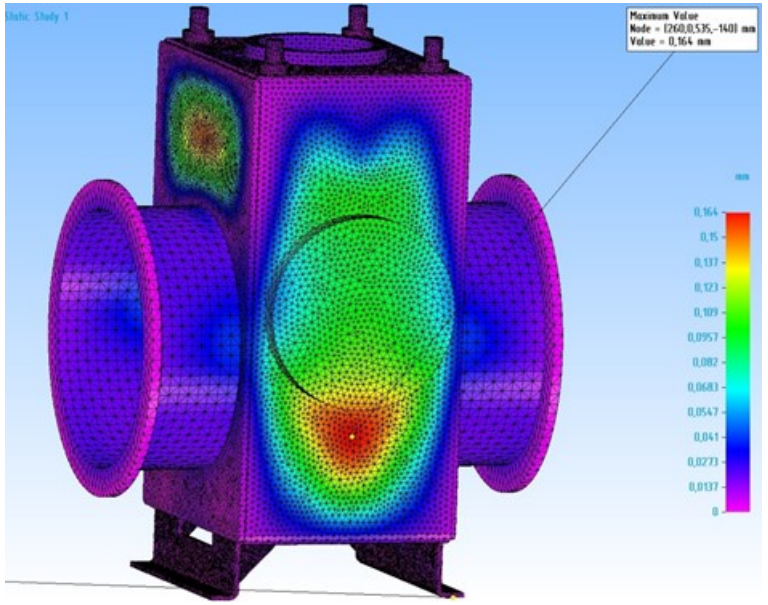


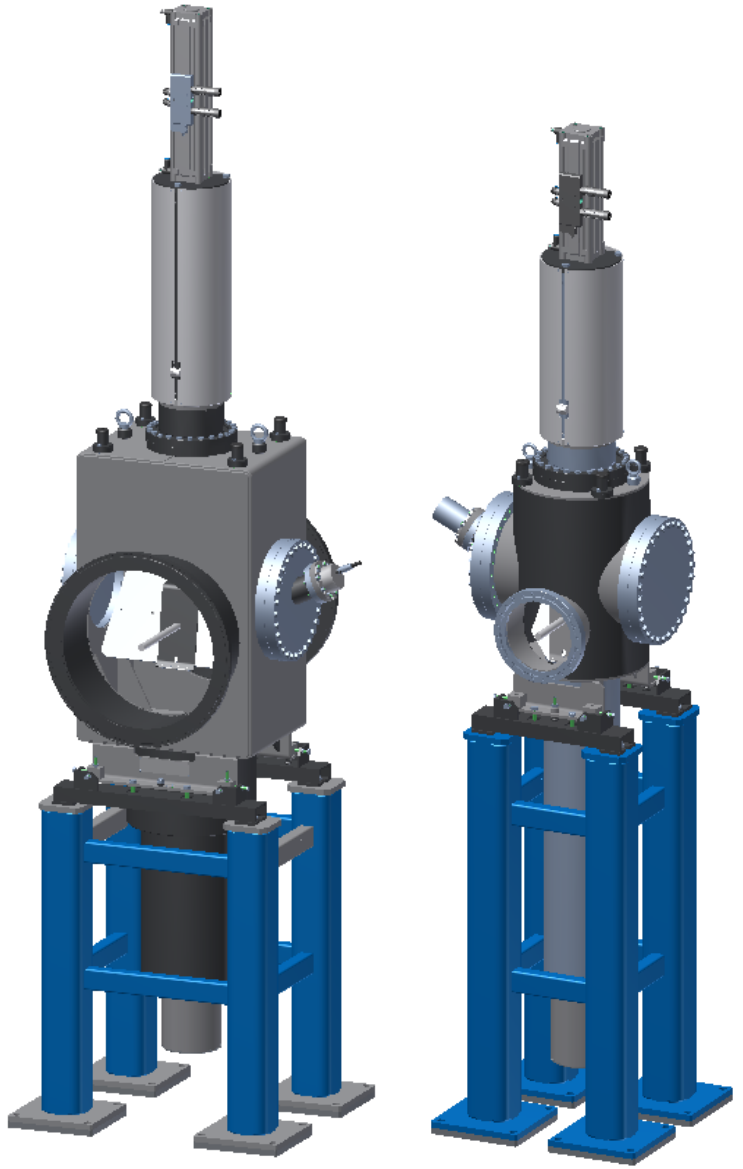
See nothing except spot

- Experiments with ruby (Al2O3:Cr) now are under carrying out

Scintillating Screen for CR (VI)

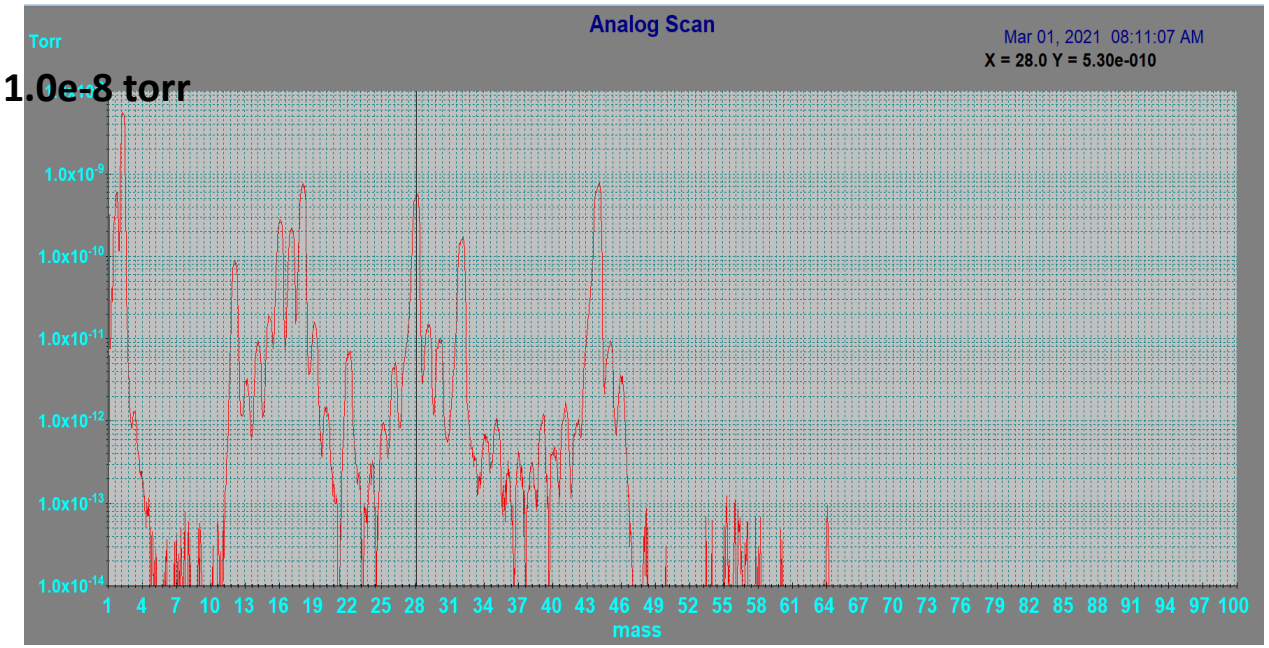




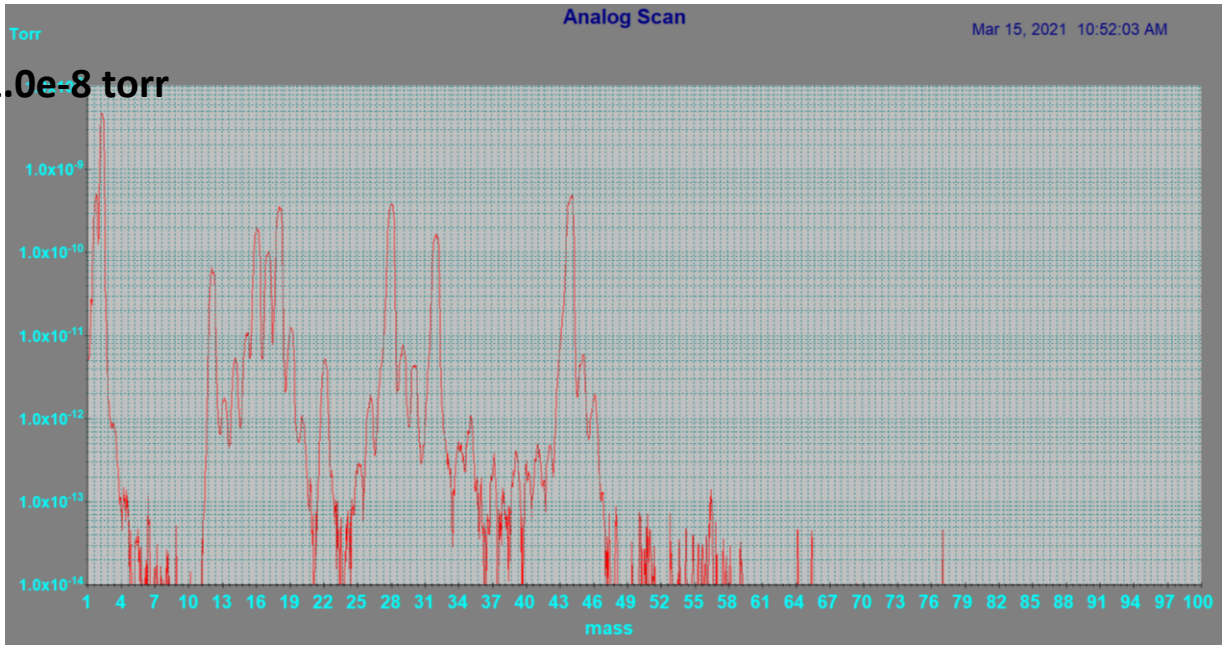


- An atmospheric pressure of 101325 Pa was applied to its outer surfaces
- A force of 2000H, equal to the load from the Electric drive applied to the flange CF200 on top of the vacuum vessel.
- Maximal calculated equivalent stress of 74,2 MPa is less than permissible limit of 236 MPa
- The deformation of the sites for fiducial target is 8.3 µm and 9.5 µm, which is less than the permissible tolerance of 50 µm.

Scintillating Screen for CR (backup)



Spectrum after 5 days (after heating)



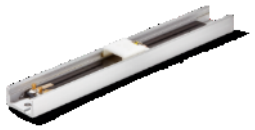
Spectrum after 19 days (after heating)

- Obtained vacuum values fully satisfied to the Specification requirements.
- Obtained values did not changes significantly after certain time.
- Bake-out option for the detector only must be investigated carefully.
- Use case: we open the ring for the insertion of the experimental devices (TOF, Schottky, BTF etc) for a some time (say 1-2 hours or half a day). After such opening we will require to heat the detector to receive required vacuum values.

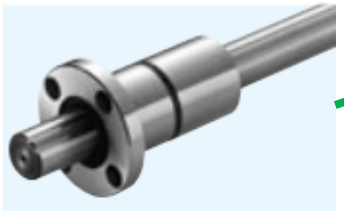
Beam Stopper for CR (I)

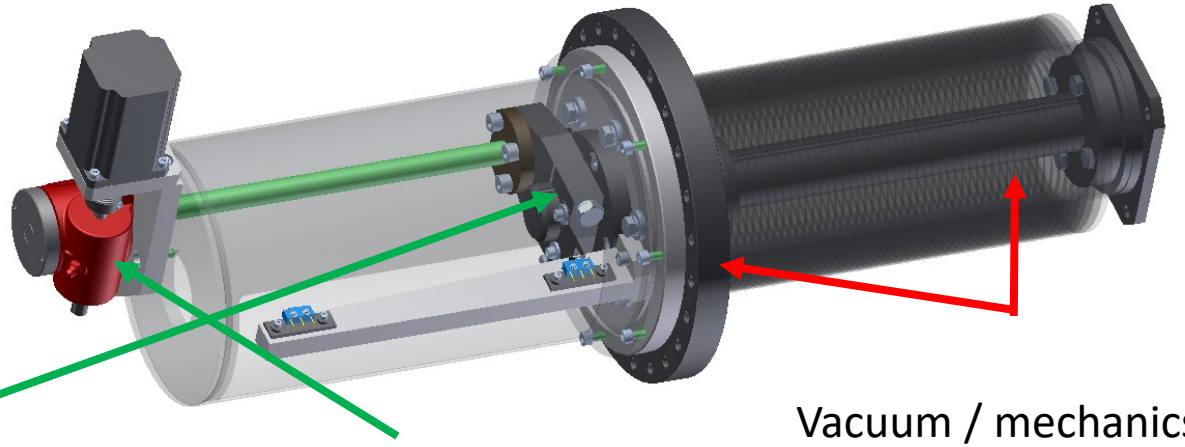
Received

Oriental 5-phase motor.
Micro Switch. Ball Spline.
Potentiometer.



Received

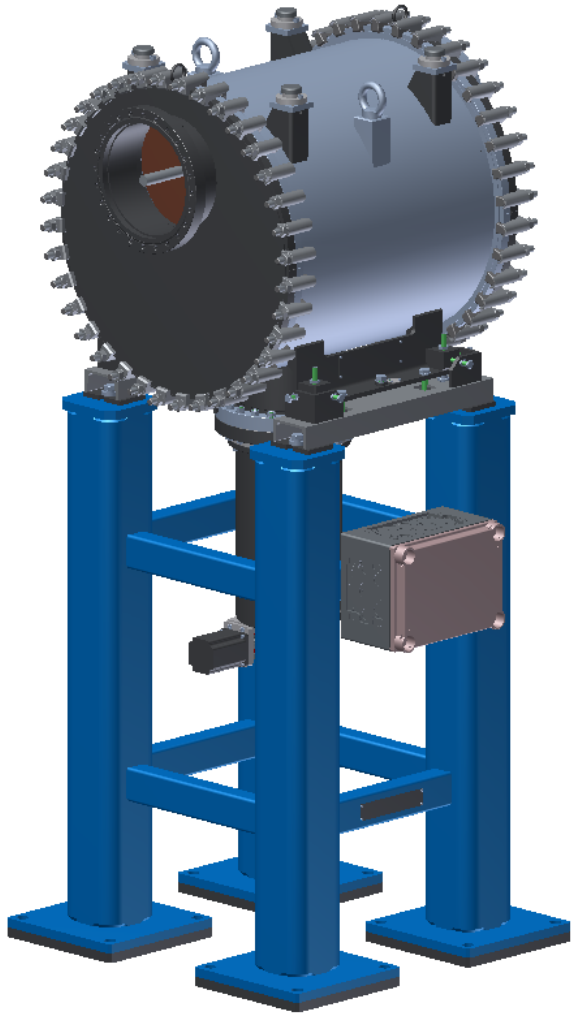




Delivered

Vacuum / mechanics components ordered.

Expected in Q2 2021



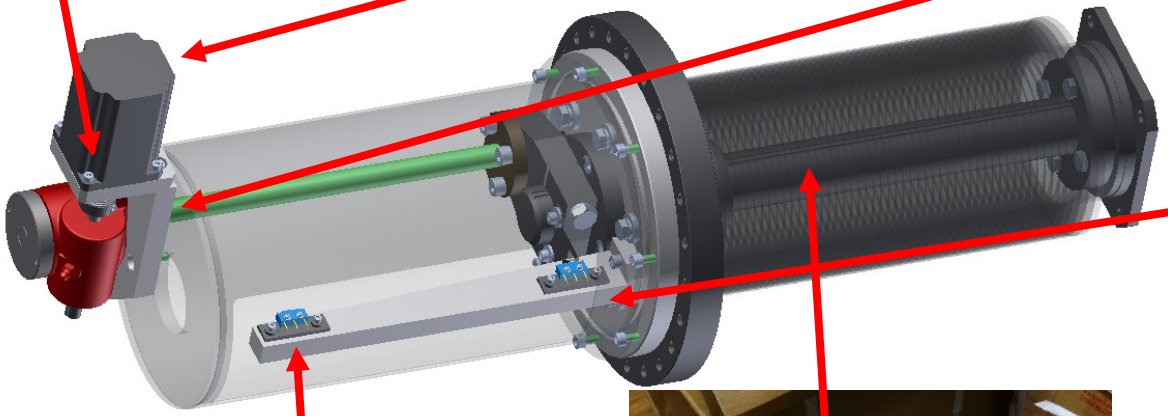
- Concept finished. Mechanical development was done.
- Features: Sensitive to bunch charge (80 mV for 10^7 pBar @ 20 pF).
- Model / Drawings ready. Procurement of most components done (see pictures).
- Production started (see pictures).
- FDR documents at final stage pack – Expected in Q2-Q3 2021.
- FEM: Stress analysis done (see pictures).
- Open questions: MBOX PDC – 2pcs – not in 2nd Amendment for the "FAIR orders components for BINP“.

Beam Stopper for CR (II)

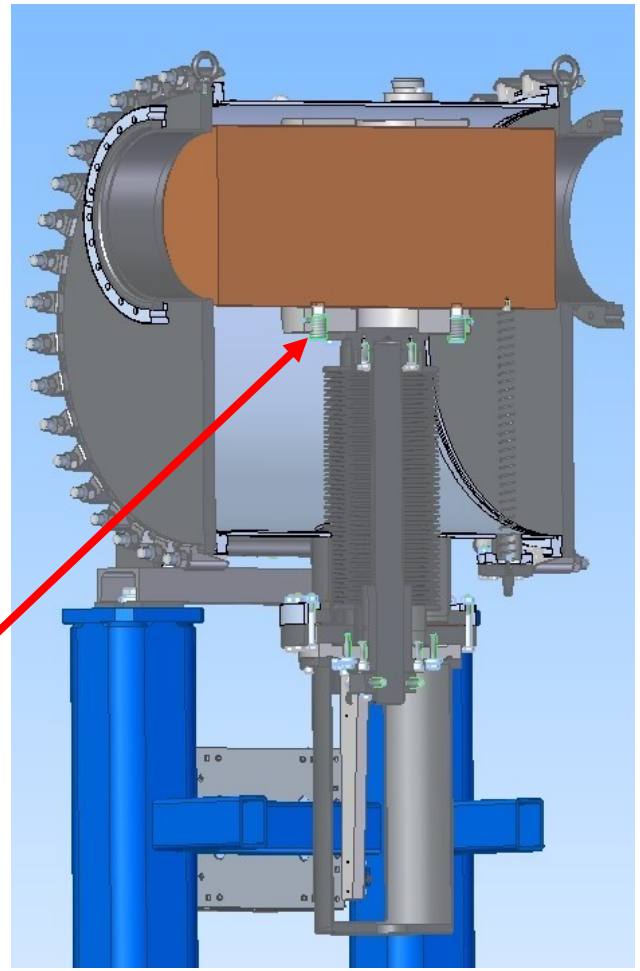
Mechanical Coupler

Stepper Motor

Mounting plate



Bracket

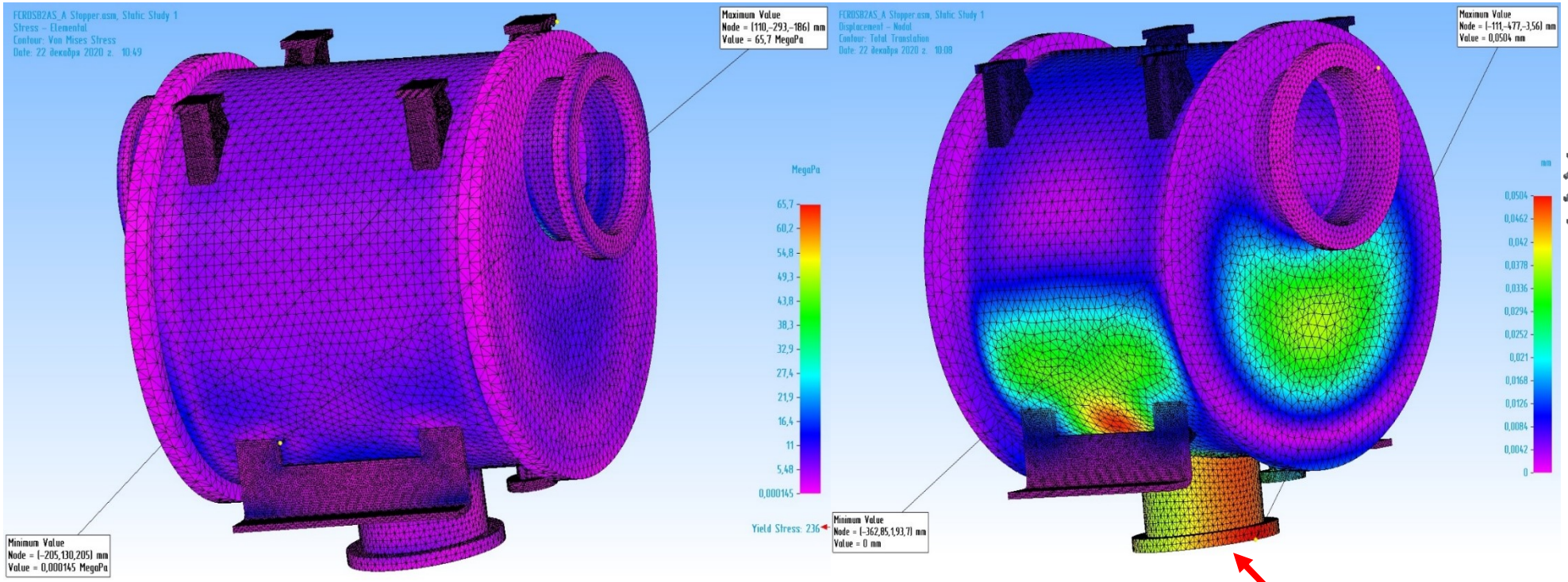


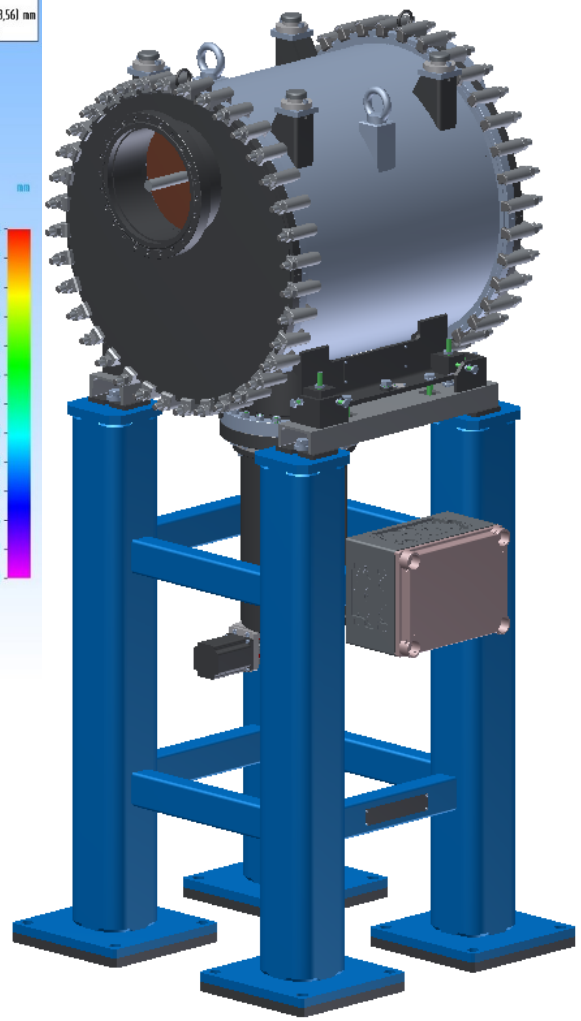
End Switches and Connectors

SSPF Ball Spline

Ceramic holders

Beam Stopper for CR (III)





- An atmospheric pressure of 101325 Pa was applied to its outer surfaces
- A force of 2000H, equal to the load from the Electric drive applied to the flange CF200 on the bottom of the vacuum vessel.
- Maximal calculated equivalent stress of 65,7 MPa is less than permissible limit of 236 MPa
- The deformation of the sites for fiducial target is 8.3 µm, which is less than the permissible tolerance of 50 µm.

Residual Gas Monitor for CR (I)

Camera

Calibration

Prosilica GE680 CCD camera

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L7293 deuterium lamp (L2D2 lamp)

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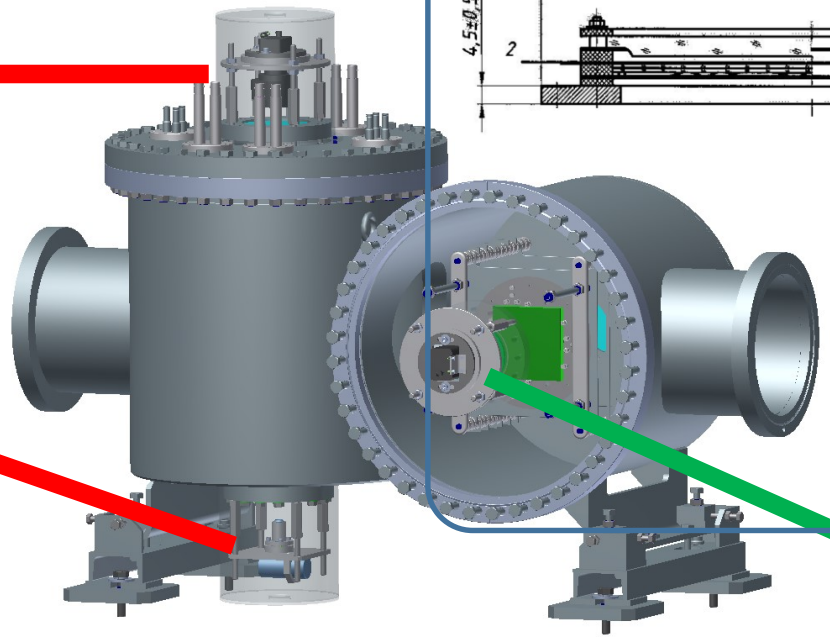
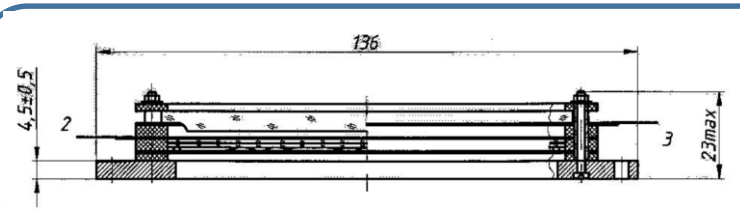
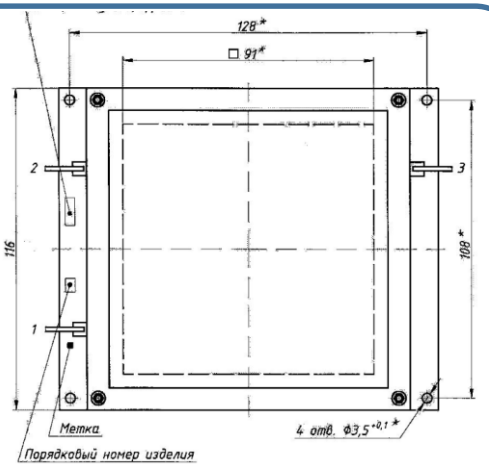
▲Left: C9598, Right: M9596

C9598 power supply deuterium UV lamp

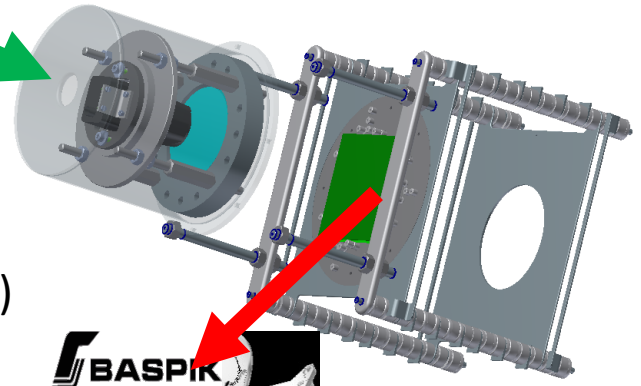




(6 k€ / detector)



Sketch of the 100x100 detector. By plans, the first detector will be shipped to BINP in May



MCP detector
100 x 100 mm

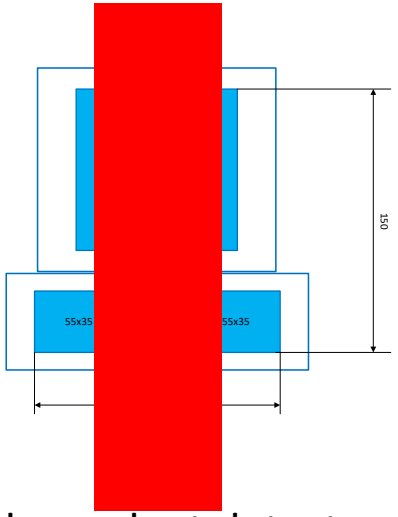
Restrictions: Aperture 160 mm (chamber diameter), Bunch size 85 x 120 mm as in Specification. Detector size ~140 mm requested in Specification.

- Development (by BASPIC) of the MCP detector with 120x50 mm MCP costs 50 k€ (minimum) with no guarantee of result.
- PHOTONIS has standard MCPs 123x41 mm. Development of larger size MCP would be very expensive (according to PHOTONIS). Price of development of the detector based on MCP 123x41 is 30 k$.

Residual Gas Monitor for CR (II) MCP detector

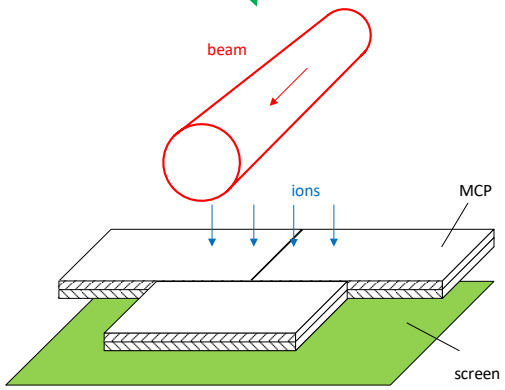
Another way is combining of several MCP. There are two ways: 1) stacked MCPs in one detector and 2) several detectors

2



Independent detectors for measuring “tails”

1

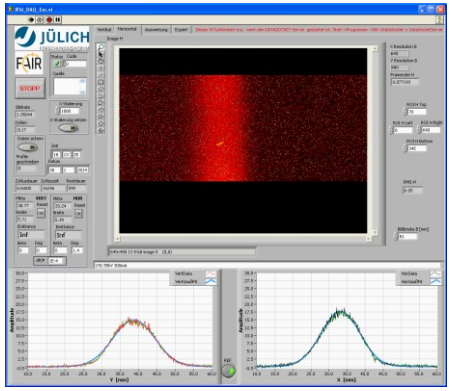


Detector with stacked MCPs

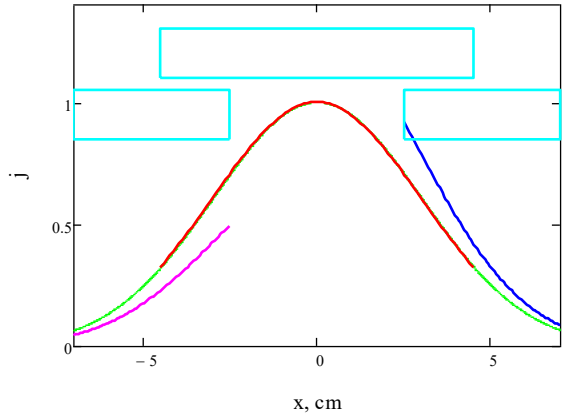
The base variant is several (3) detectors (variant 2):

- ❑ Cost of one detector 100x100 mm (chevron stack of MCP + phosphor screen K67 (analog of P43)) is about 4.5 k€ / pcs (3 required)
- ❑ Cost of one detector 43x63 mm is about 2 k€ / pcs (6 required)

Three measured curves may independently change in time due to HV PS imperfection. In order to eliminate this effect online fit can be made.



Measurement from COSY RGM



Model result of measurement with 3 independent detectors

Residual Gas Monitor for CR (III) Electronics

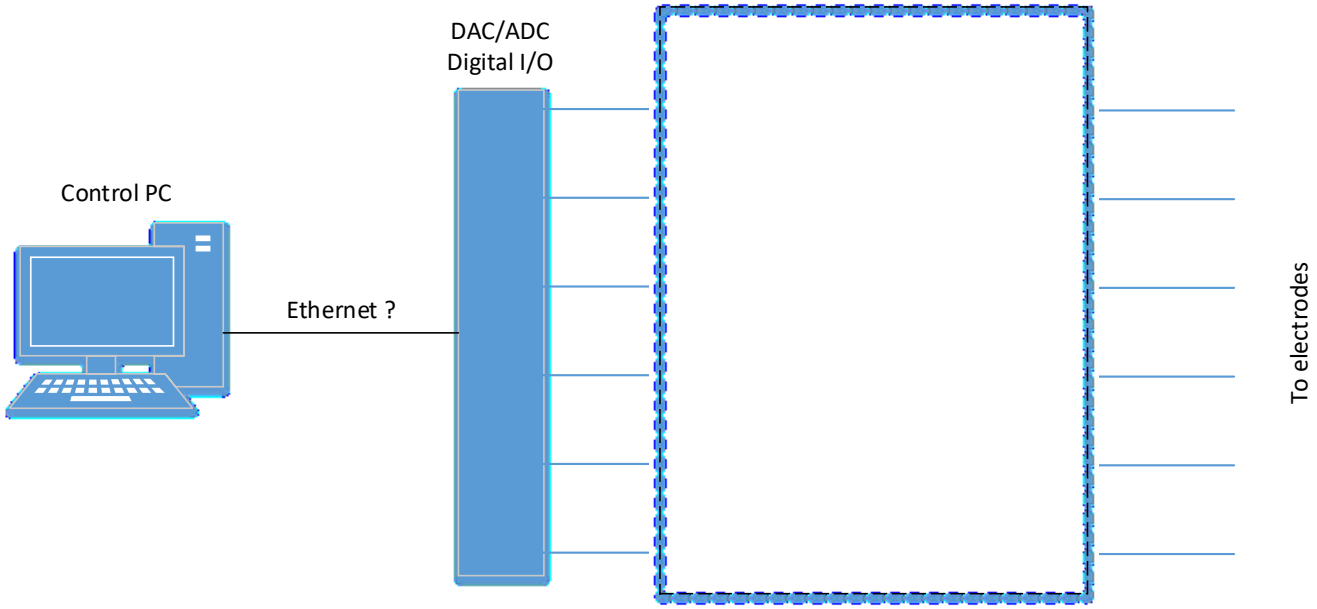
For one direction of RGM
1) EFB requires 4 HV power supplies (PS)
2) One detector requires 2 HV PS, 3 detectors (variant 2) require 6 HV PS

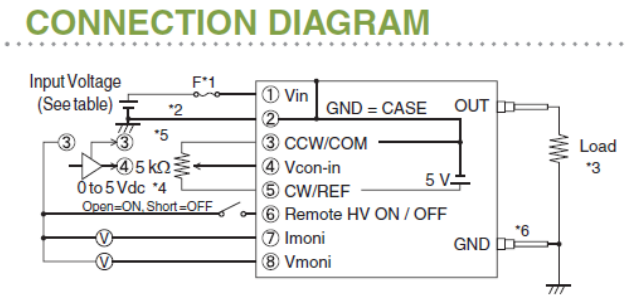
In sum: 6-10 independent HV PS are needed for one direction (depending on variant).
For one HV PS: 1 DAC channel (for control) and 2 ADC channels (for measurements).
Also, digital inputs and outputs are needed.

Matsusada Precision

RA/RB series power supply modules up to 40 kV DC.

Camera is connected to control computer via Ethernet





Summary

- Sub-packages for CR Beam Instrumentation one by one goes forward from design phase to the manufacturing phase.
- The work does not stop even during the COVID-19 time.
- BPM test stand mechanics is ready. Software design is started. First experiments with electronics and hardware (wire movement and position readout) ready.
- BPM Type-1 octagonal electrodes production is ongoing. We expect a result in the end of Q2 2021.
- Many efforts was made in investigations of vacuum / mechanical /scintillating properties of P43 scintillator. Not all questions is clear.
- Local bake-out for scintillator detector solution is under investigation.
- Thanks to all BINP BD team and BINP employers involved for a good job!

Thank you for your attention!