Vacuum and alignment in Run 1

Peter Winter

Overview

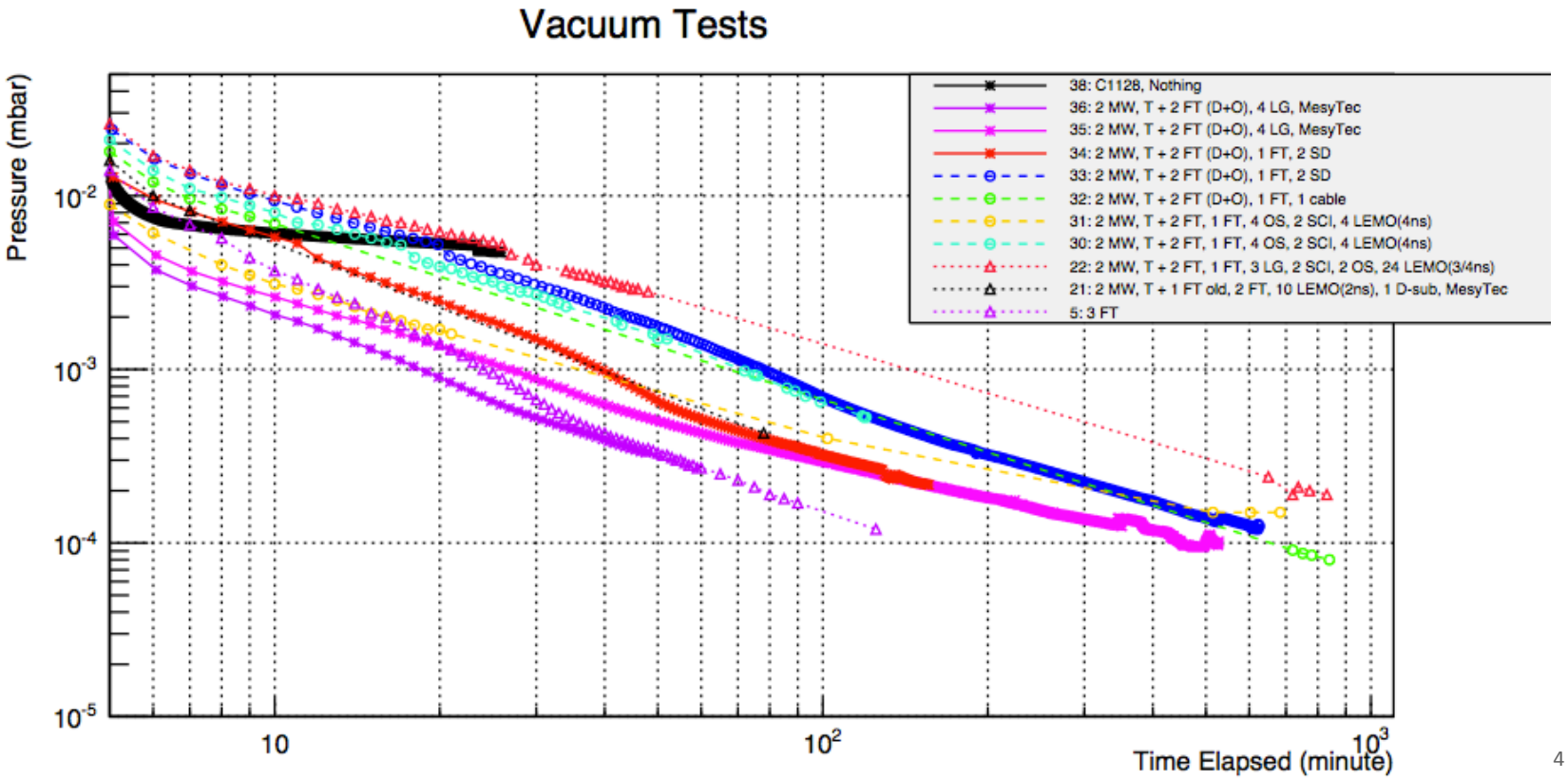
- Vacuum chamber:
  - Chamber configuration, vacuum issues and performance
- Detector alignment
  - Detector and lead configuration
  - Alignment measurements

Vacuum system setup

- Vacuum setup was quite some journey
- Started out with the pump station at the port below the chamber
- Not a good place due to falling pieces from work in chamber (lucky that LEMO connector did not destroy sensitive fins of turbo)
- First change: Use side port for pump connection

Lots of time was spent to eliminate leaks

- We had a long series of various tests
- Several leaks that were fixed
- Many configuration changes took a long time to get it finally good enough for our needs
- Lots of help from the vacuum group!



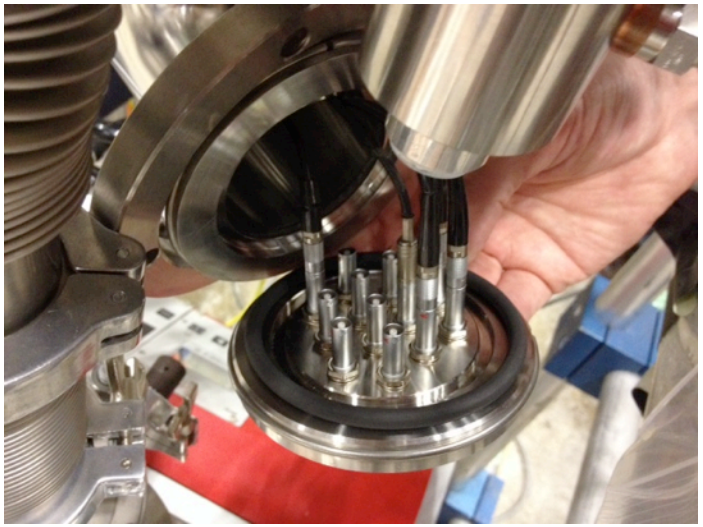
Leak tests of feedthroughs

- We had 3 main types of feedthroughs: AccuGlas, metal Osaka with electrical isolation, Osaka teflon. They all were no problem concerning the vacuum

Flange 1: AcuGlass < 3 x 10-8 mbar liter / s

Flange 2: Osaka (the one we used on the chamber so far, new one) < 2 x 10-8 mbar liter / s

Flange 3: Osaka (the one not used so far, Frederik and Ran tested it at UW) < 2 x 10-8 mbar liter / s

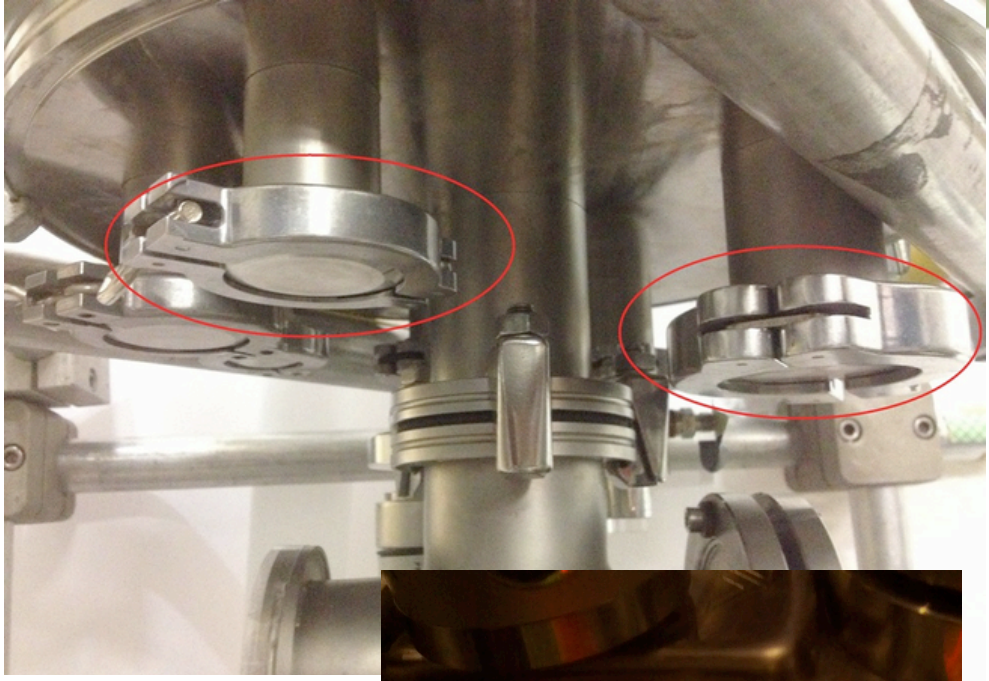


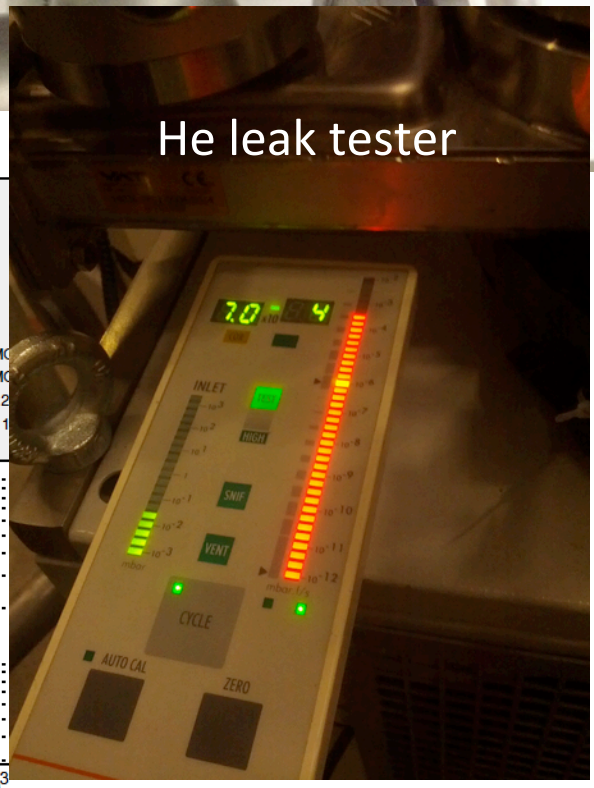
Leak tests: Top flange

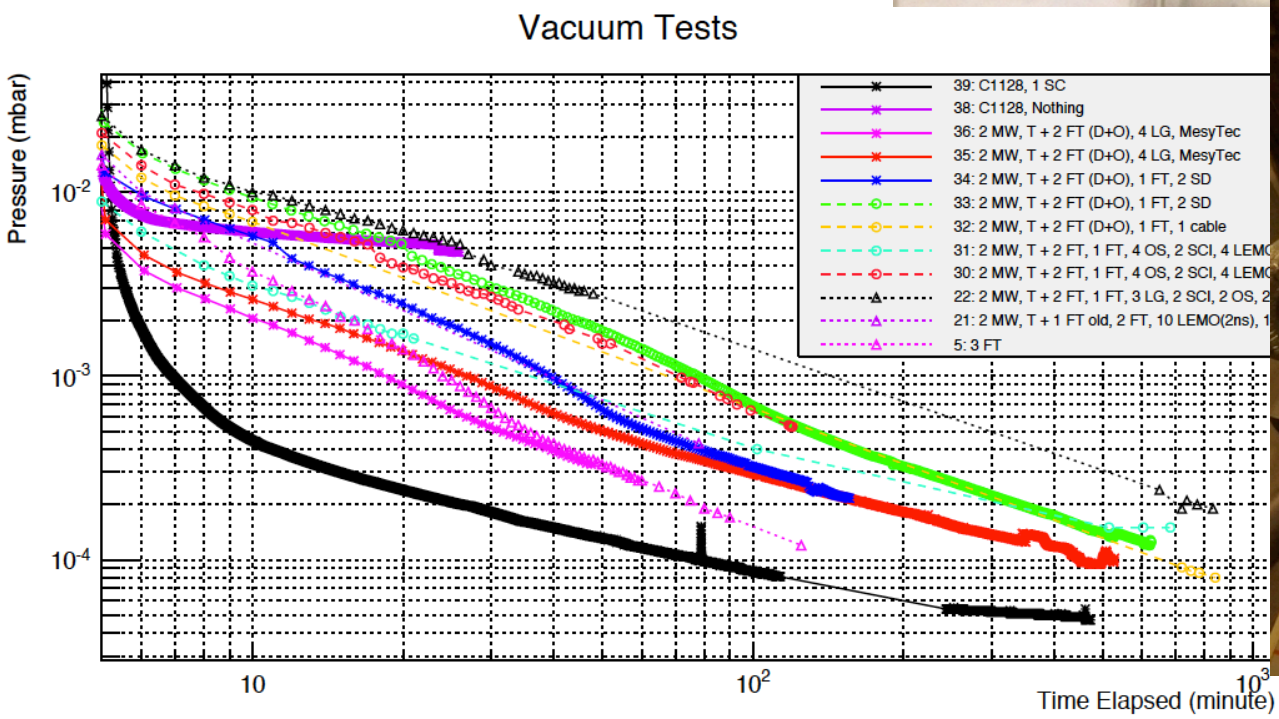
- The top flange is a general source for bad vacuum
  - It is not planar with the vacuum top (from welding?)
  - It scratches easily when mounted (since it is heavy) or when put aside with vacuum side down
- Ended up using 6 clamps instead of typically 3-4
- Needs to be handled carefully to maintain well polished surface

Leak tests: Light guides

- Bad vacuum with light guides in place (huge signal with Helium leak tester)
- Removal of light guide feedthroughs gives good vacuum quickly

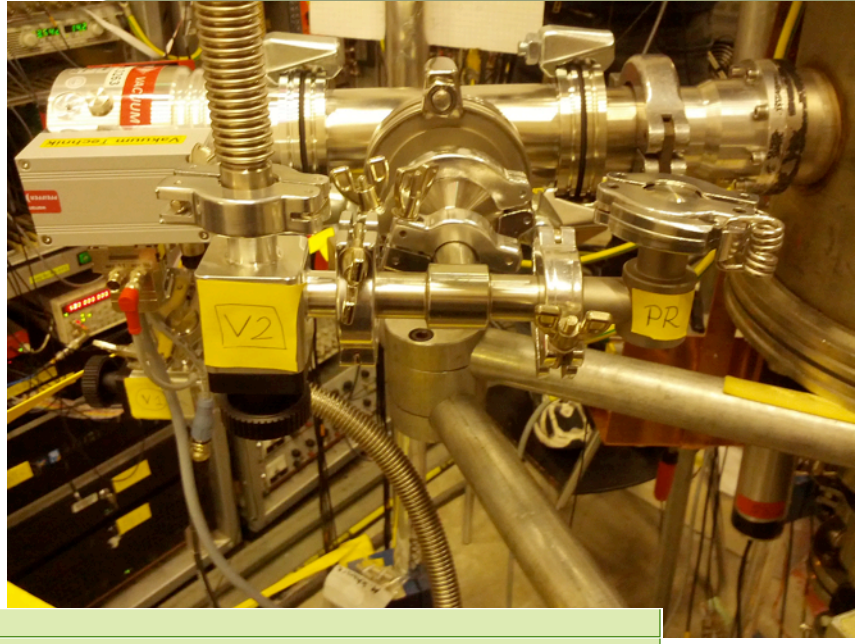






Final setup

- Pump connected via solid T to chamber
- Side port of T is for venting and dry N_2
- Many steps but finally worked well (reaching 3E-4 mbar within ~1.5h)
- Instructions in elog:74, reference for Run2



Subject:	HowTo operate the turbo pump
Type:	Technical

Warning: ALWAYS turn off all detector high voltages before opening the lid or turning the vacuum pump ON when the chamber is at air or turning it OFF when the chamber is under vacuum.

If you do either procedure for the first time by yourself, read first all steps and then proceed with the entire process.

Turning the pump on

- Turn off all detector high voltages (silicon + PMTs)!!!
- Make sure the pumps are actually off and we're vented!
- Make sure that all flanges are closed
- Close the nitrogen valve **V2** (see attachment 1).
- Make sure the main valve on the nitrogen gas bottle is closed (see attachment 2). Do not change the pressure reducer knob.
- Close the pressure relief blind flange **PR** with the fast clamp (see attachment 1).
- Open the valve **V1** below the turbo pump (see attachment 4).
- Turn on the rough pump with the green power button (see attachment 5)
- Press the "On/Off" button (black button with white circle and vertical bar) on the turbo pump (see attachment 6). The top green LED should be permanently on and the lower red LED should be off. You should hear the rattling sound of the pump. The pressure reading should go down after some moments.
- Watch the pressure reading for a bit. If it gets stuck in the low 100 mbar range, you might have forgotten to close the venting blind flange.

Turning the pump off

- Turn off all detector high voltages (silicon + PMTs)!!!
- Make sure the pump is really on: The pressure reading should show some low vacuum, the green LED is permanently on, the second LED is off. The turbo speed is not 0 Hz (full speed would be 1500 Hz).
- Make sure the venting valve **V2** is really closed (see att. 1).
- Open the main valve on the nitrogen bottle (see att. 2). Do not change the pressure reducer knob. Verify that the reduced pressure on the front gauge does not exceed 0.5 mbar.
- Press the "On/Off" button on the turbo to switch it off and verify that the green LED turns blinking (see attachment 6)
- Close the valve **V1** below the turbo pump (see attachment 4).
- While the pump is actually spinning down, open the venting valve **V2**. This is safe despite the turbo still spinning as the venting valve has a very small opening so the venting is slow.
- Carefully remove the fast clamp of the pressure relief **PR** but do not remove the blind flange. (see att. 1).
- Switch off the rough pump with the red power button (see attachment 5)
- Wait 3 minutes until you open any other flange! While the pressure reading might already indicate that you are at normal pressure, the chamber is still venting! The blind flange at the pressure relief will start floating a little bit once it's fully vented.
- Close the venting valve **V2** and then close the main valve of the nitrogen bottle.

Final setu

- Pump conne
- Side port of nitrogen
- Many steps
- Instructions

Subject:	How
Type:	Tec

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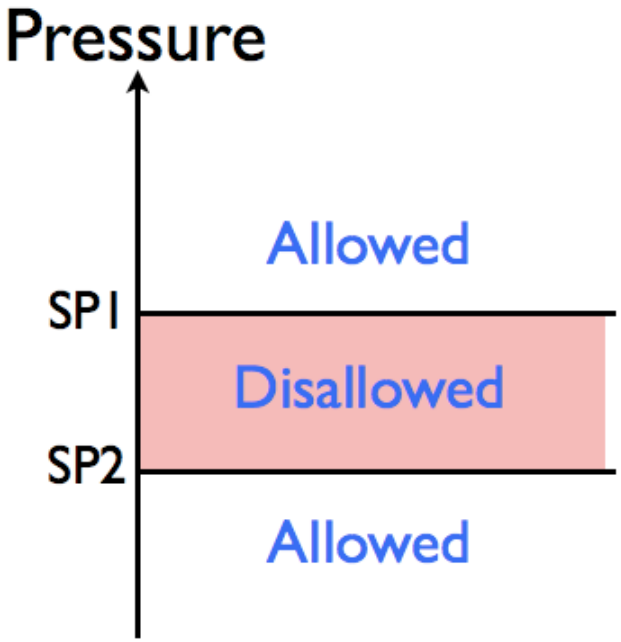
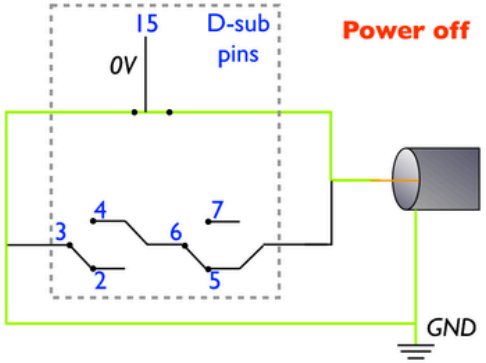
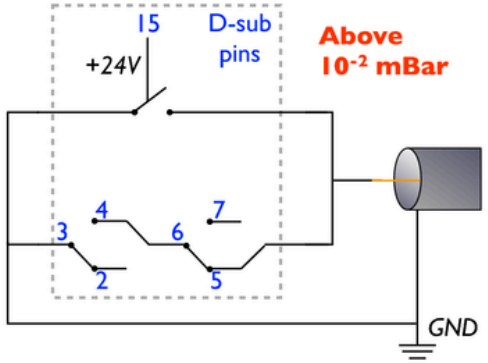
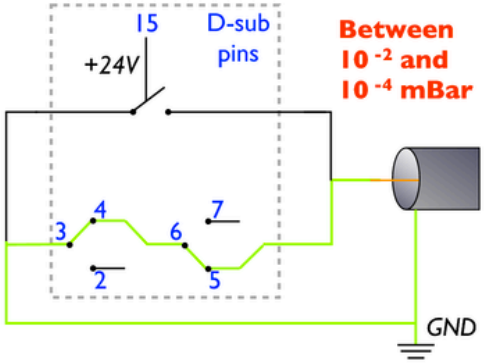
Vacuum interlock

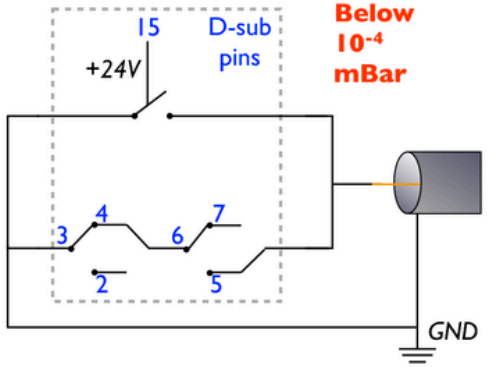
- We want to automatically disable the Si HV when vacuum in dangerous intermediate range





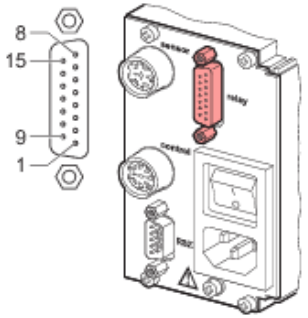






Vacuum interlock

- The pump control has usually set points for such an interlock on the output serial connector
- Reference for setting this up next year in elog:56 and replies.
- Final set points were
  - Enable: P > 300 mBar
  - Disable: 300mBar > P > 3E-4 mBar
  - Enable: P < 3E-4 mBar



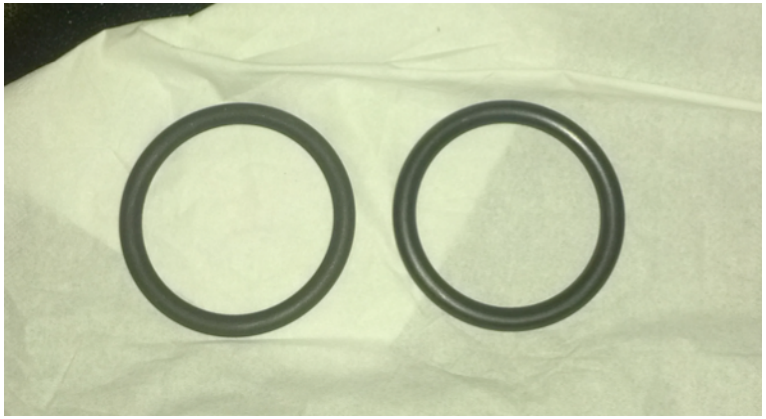
Pin assignment of the female 15-pole D-Sub appliance connector:

Pin	Signal
	Switching function 1 **SP1**
4 3 2	Pressure below threshold / Pressure above threshold or power supply turned off
	Switching function 2 **SP2**
7 6 5	Pressure below threshold / Pressure above threshold or power supply turned off
9 ... 14	Not connected
	Supply for relays with higher switching power
15 1 8	+24 VDC, 200 mA GND GND
	Fuse-protected at 300 mA with PTC element, self-resetting after power off or pulling the *relay* connector. Meets the requirements of a grounded protective extra low voltage (SELV-E according to EN 61010).

Vacuum lessons for next run

- We should start with the final setup from Run 1
- Always use the PSI oil free o-rings, ports and tubes

Dull = GOOD

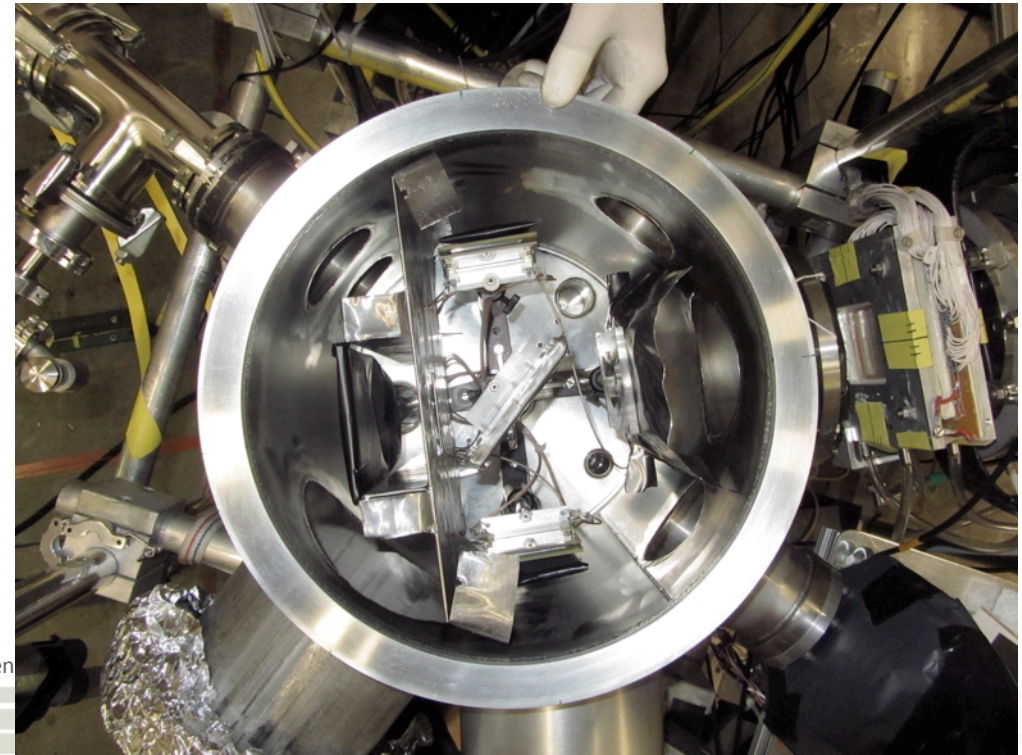


Shiny = BAD

- Vacuum interlock should be in place for detector HV
- We should involve the PSI vacuum group and use their knowledge rather than do it ourself as they are experts
- Flanges, o-rings need careful handling as little scratches can lead to time consuming leak search (especially heavy top flange)

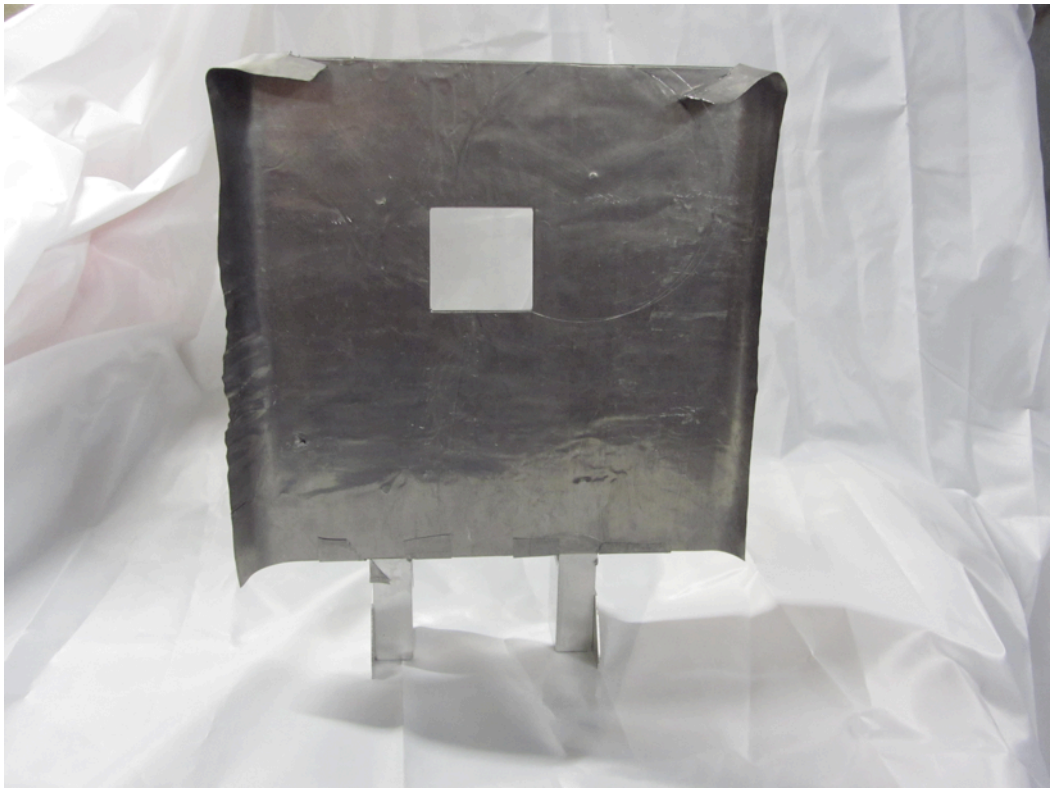
The vacuum chamber

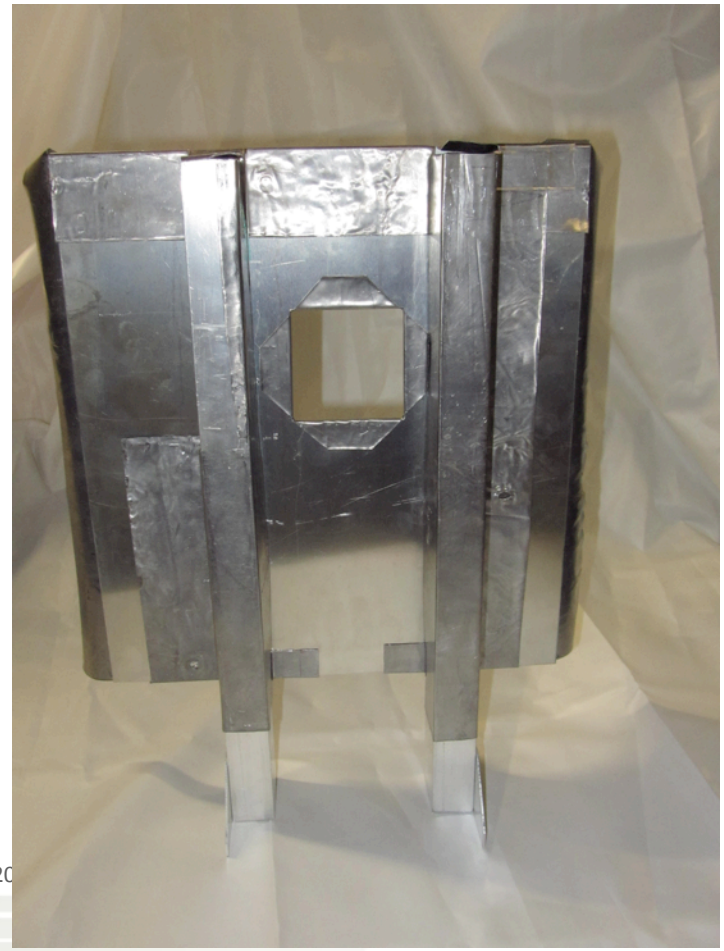
- The vacuum chamber contains many items
  - Collimator with lead at the entrance
  - Target holder with 45 degree angle
  - Si detectors with scintillator on either side at 90 degrees
  - Lead shield and veto scintillator



The lead shielding

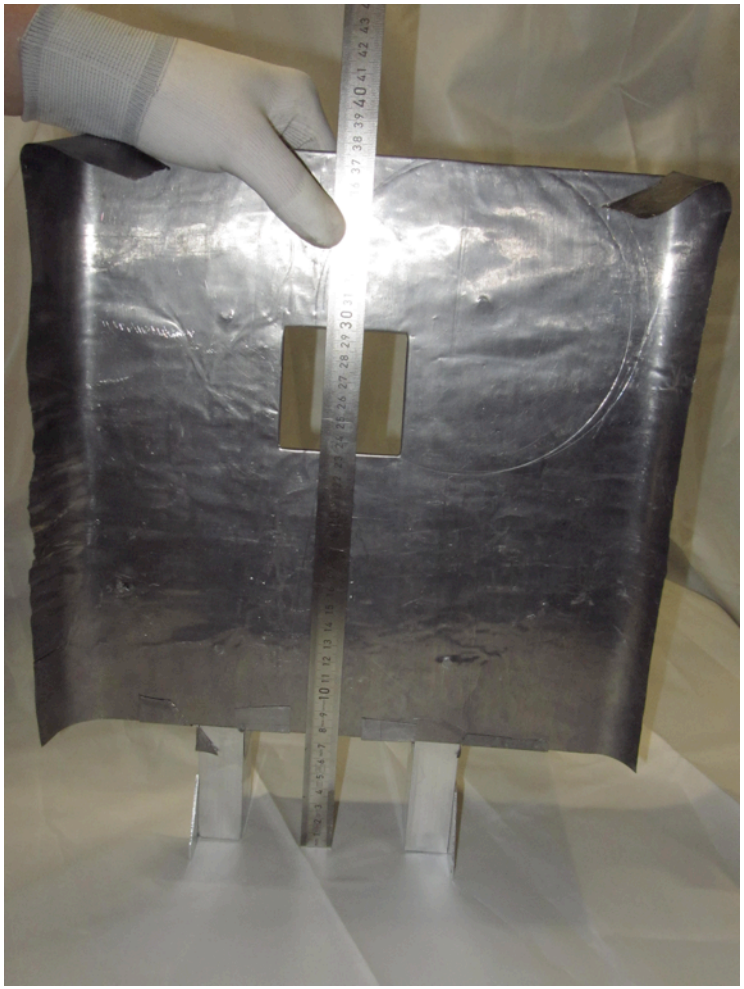
- Aim: Cover all possible locations of stopped muons with lead
- Last minute development since it was missing to start production data. Master work of Volodya from 11pm – 5am!

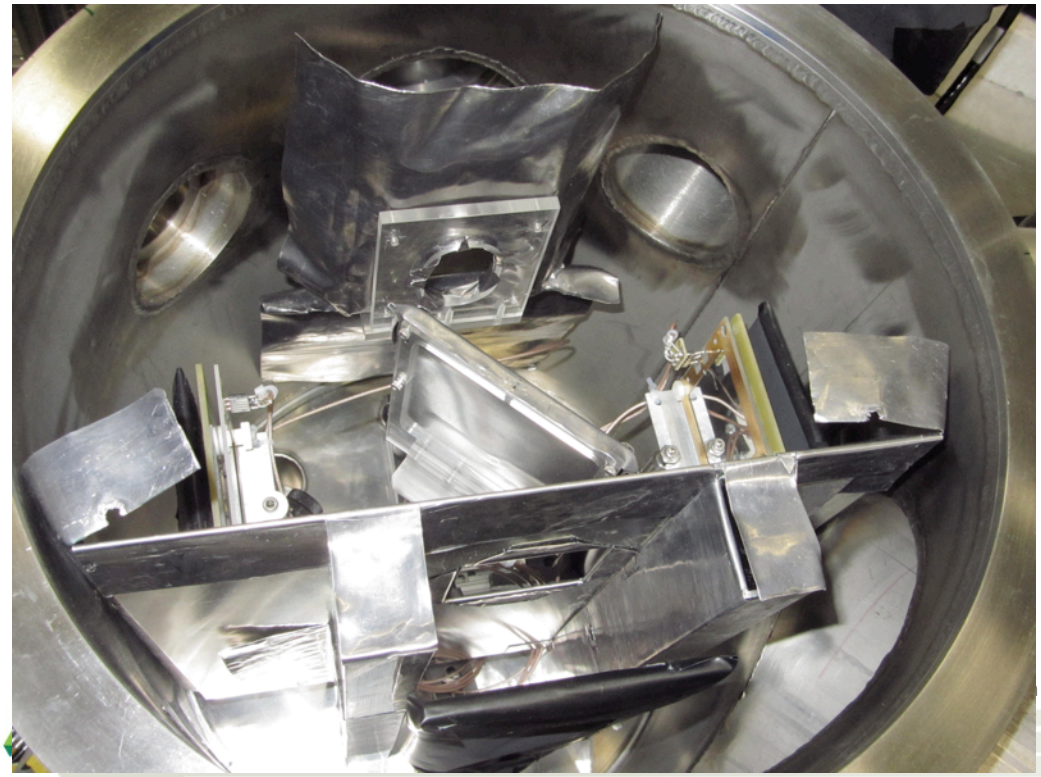




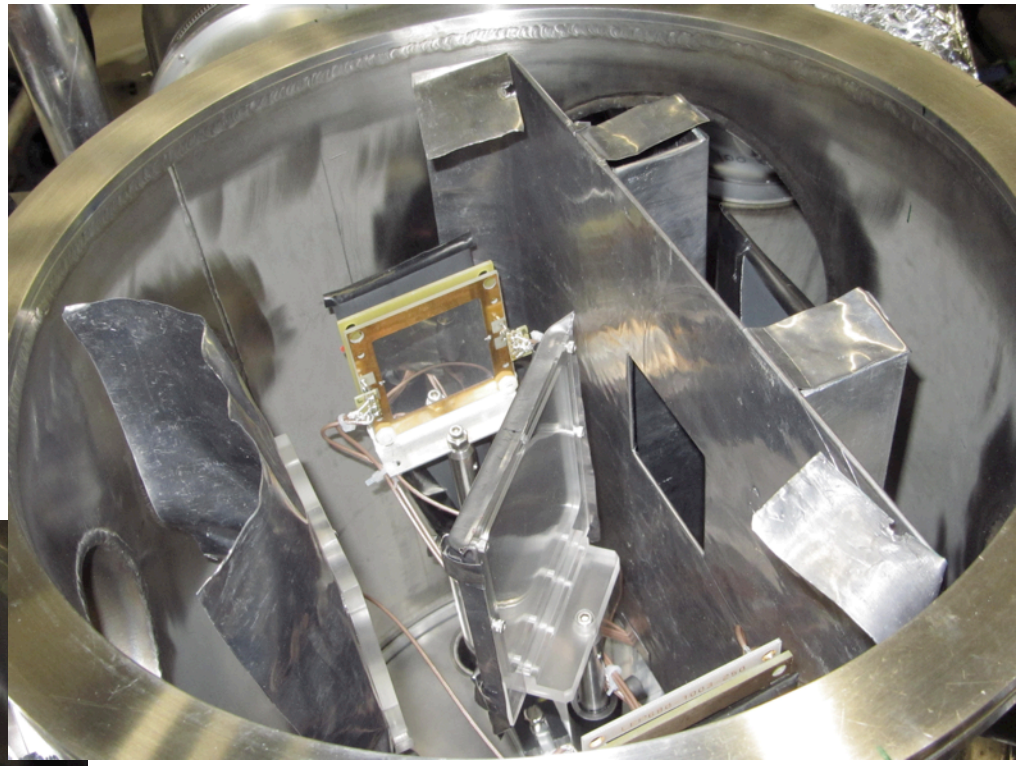
How was the size of the opening determined?

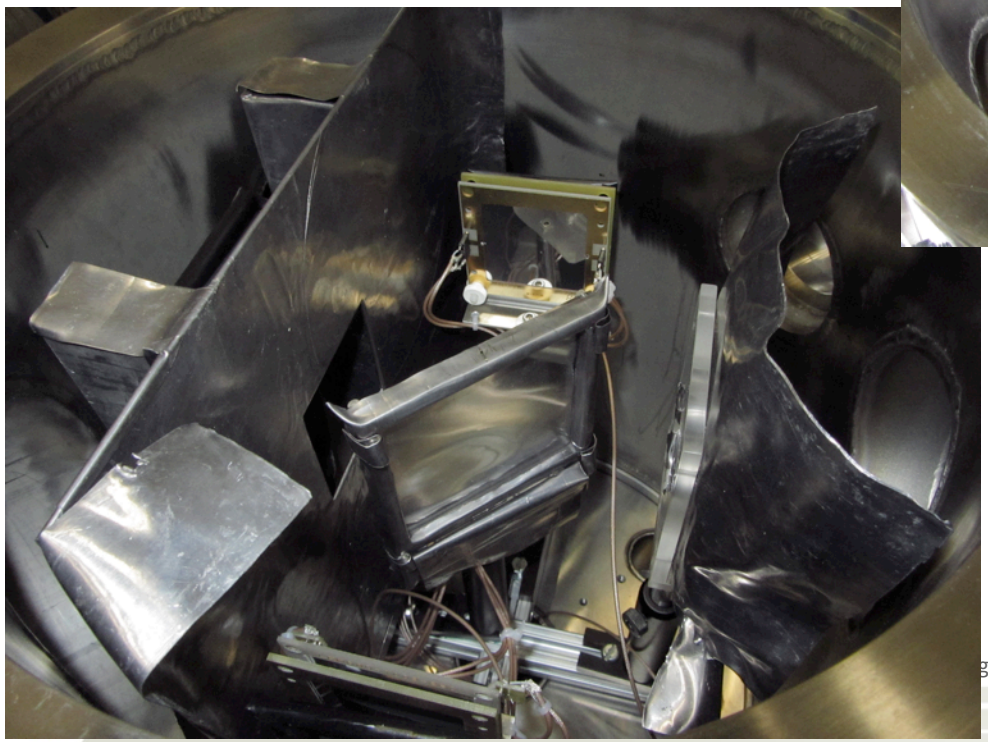
- Opening is 6 cm x 6 cm, no physics / Monte Carlo driven dimension
- We even considered closing it entirely
- Size was to make it small to minimize muons possibly stopping in low-Z material





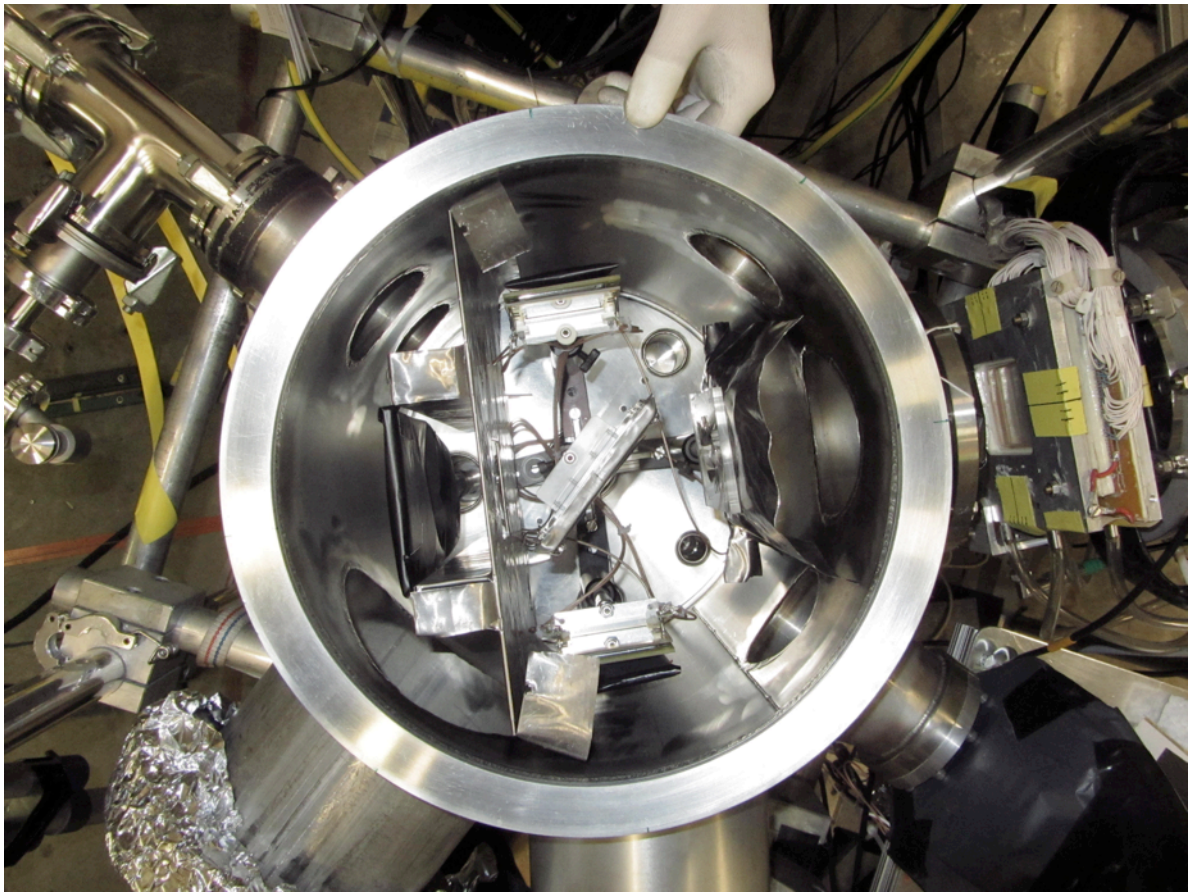
Some more pictures of the lead shield





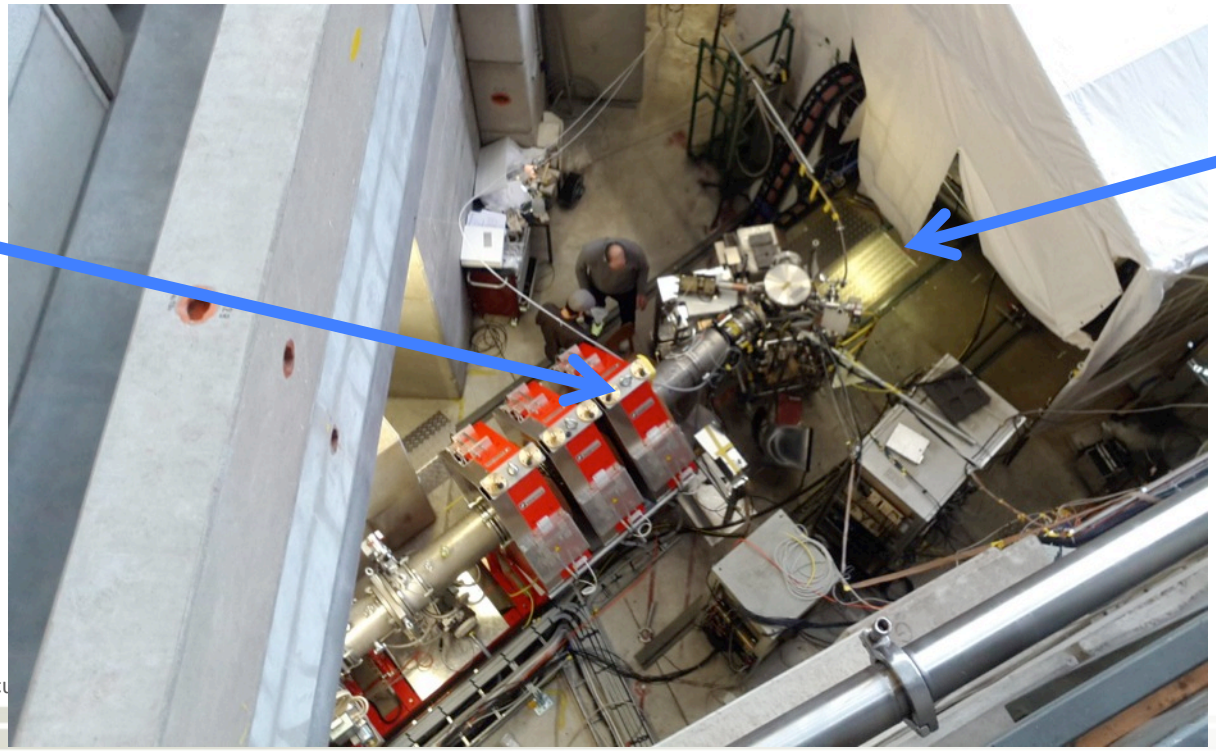
The vacuum chamber alignment

- Collimator, detector and target alignment is tricky because
  - no real alignment mechanism and difficult to measure inside chamber
  - sensitive objects require to be careful



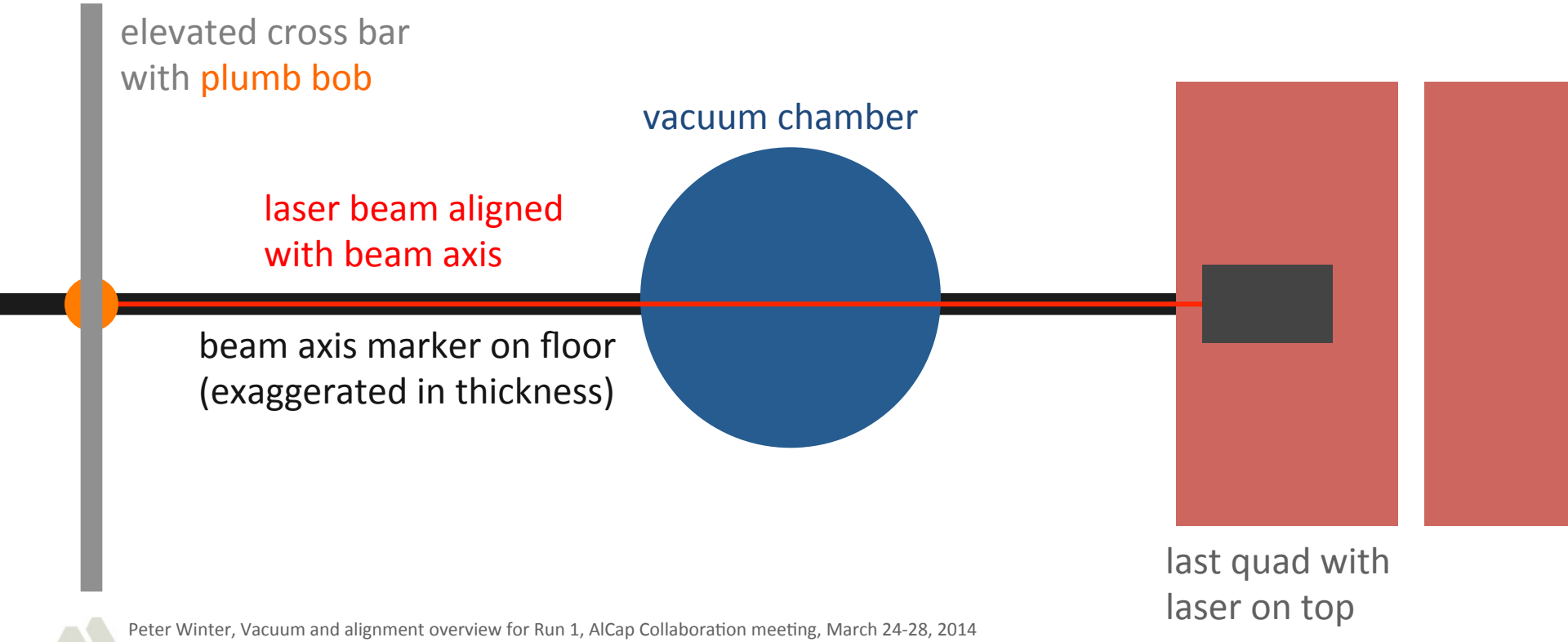
Alignment strategy

- Want to align the collimator, target and detectors relative to the nominal beam axis and in height relative to the muon entrance chamber
- We used a laser parallel to the nominal beam axis to center / align objects
- Metrology group at PSI brought a device with a view point with a center mark inside
- The marker of this device was aligned with the nominal beam axis, allowed to verify our alignment of objects relative to beam axis with laser
- Height of detectors was measured with ruler (will describe)

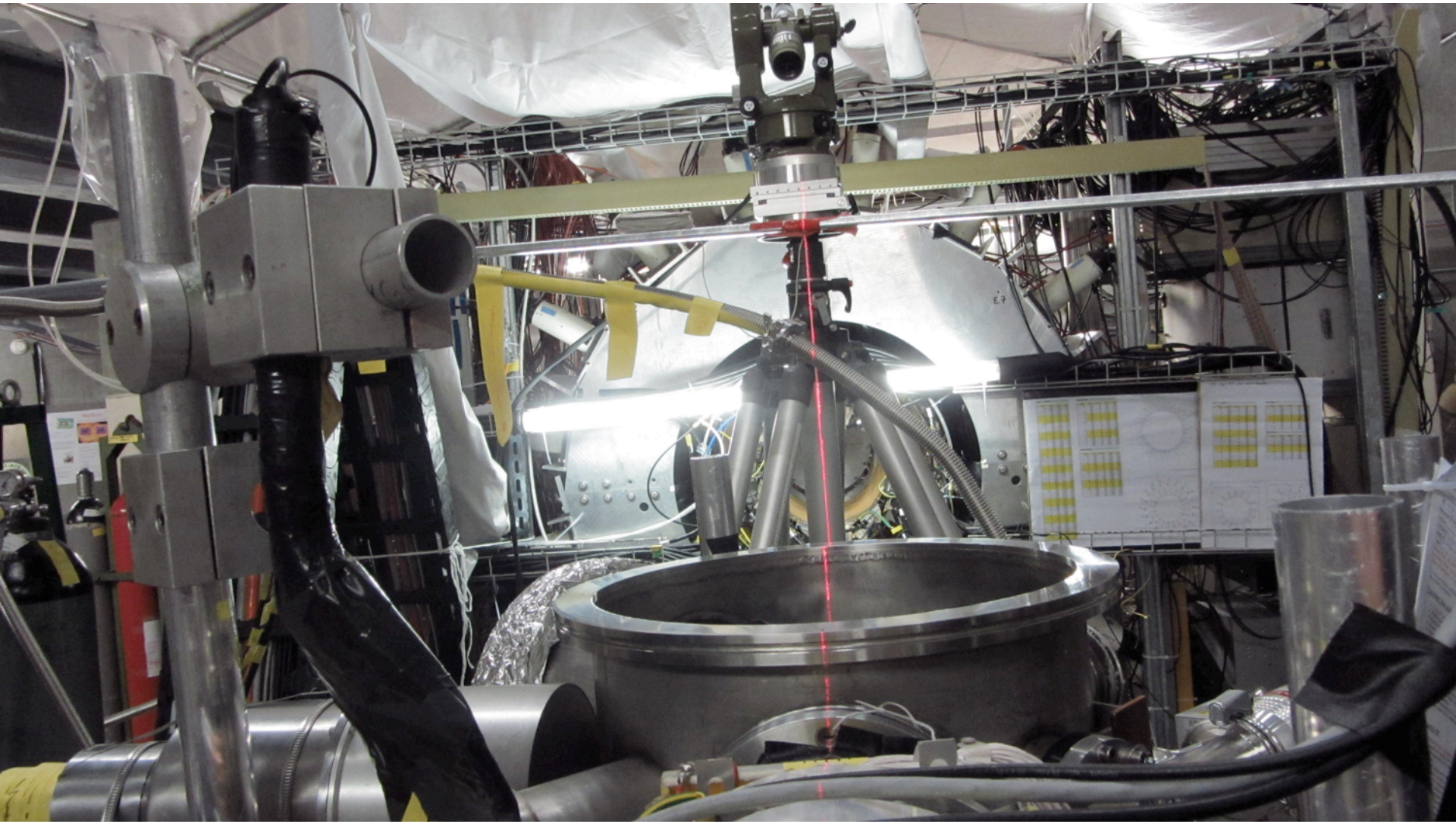


Vacuum chamber alignment with laser

1. The laser was mounted centered on the last quad on a camera tripod
2. Installed an elevated cross bar downstream of chamber with plumb bob aligned to nominal beam axis on the floor
3. Align laser beam with string of the plumb bob to generate a vertical laser plane on the beam axis



Vacuum chamber alignment



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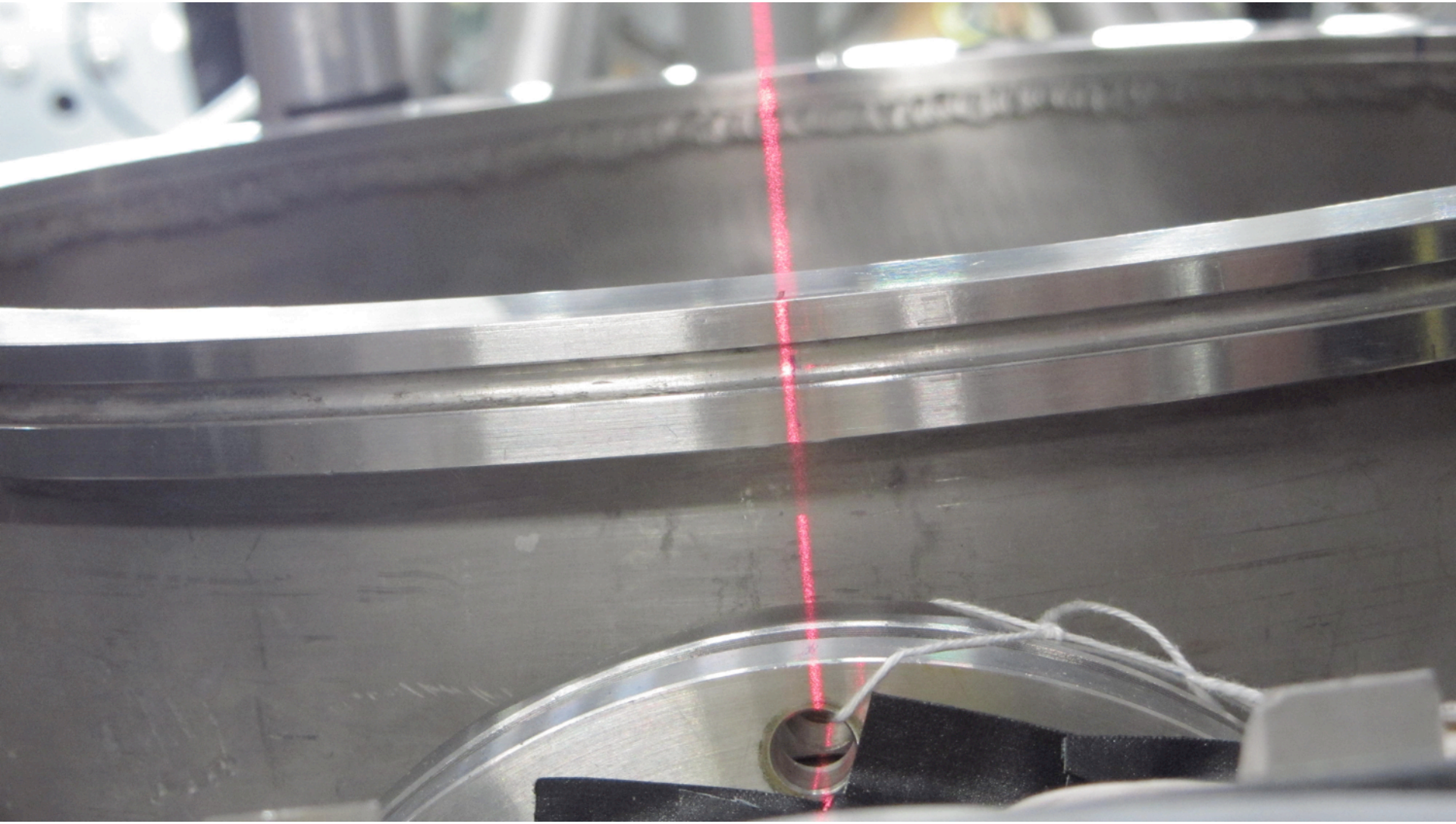
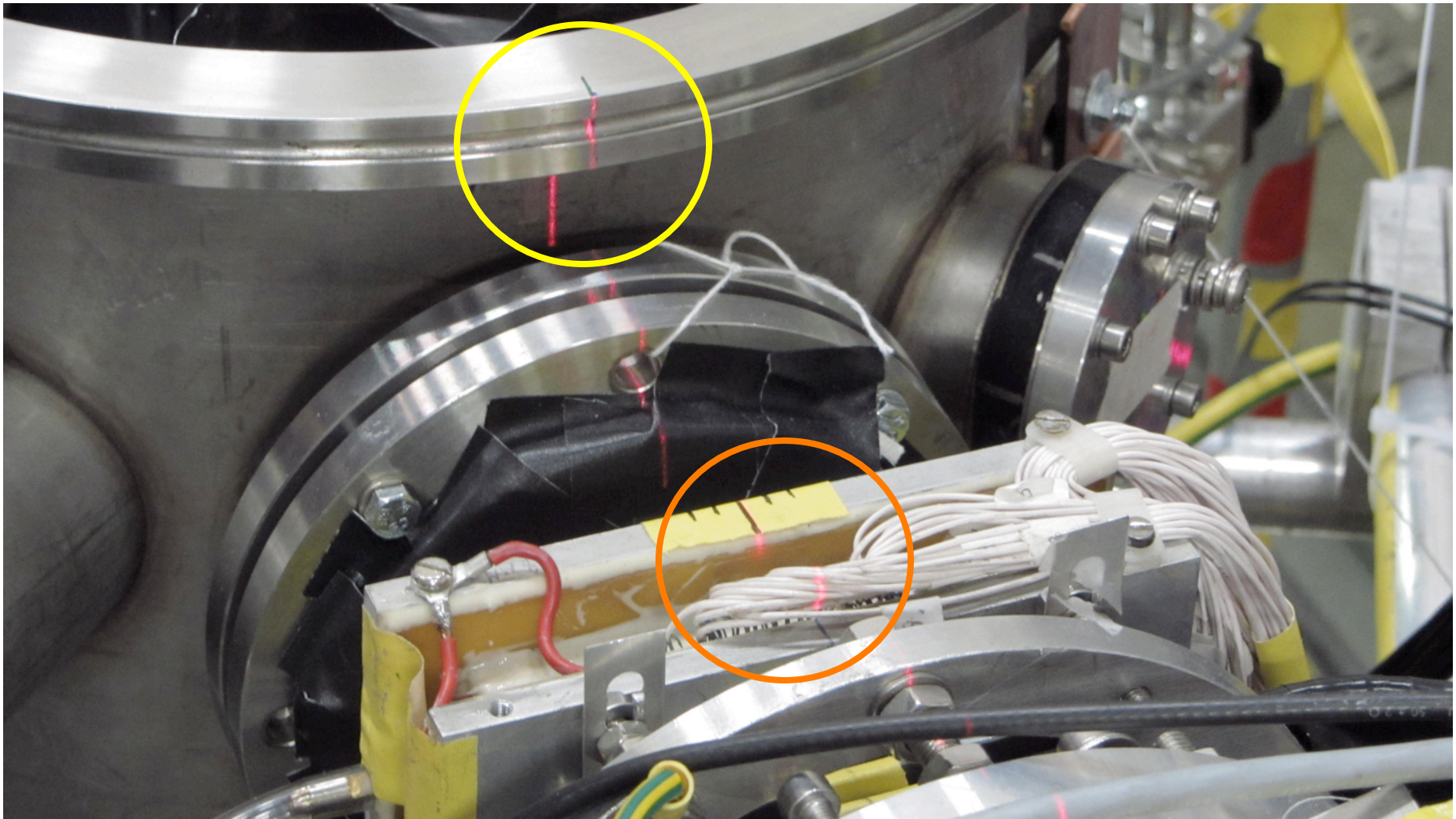
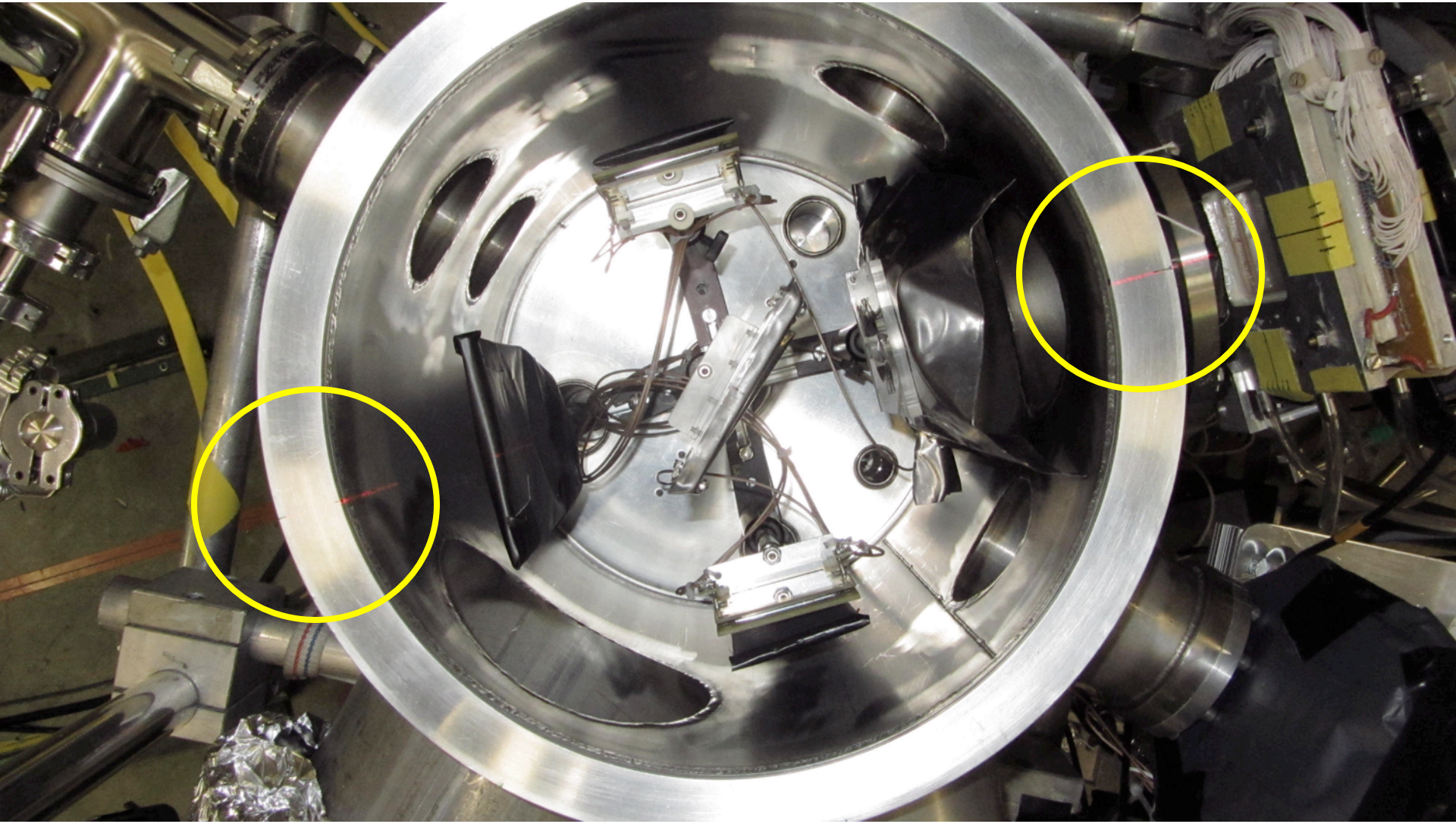


Vacuum chamber alignment with laser

- Added marks on the top surface of the vacuum vessel at 0 (beam entrance) and 180 degrees (beam exit)
- Use laser to center the vacuum chamber relative to beam axis (muPC well centered, too)

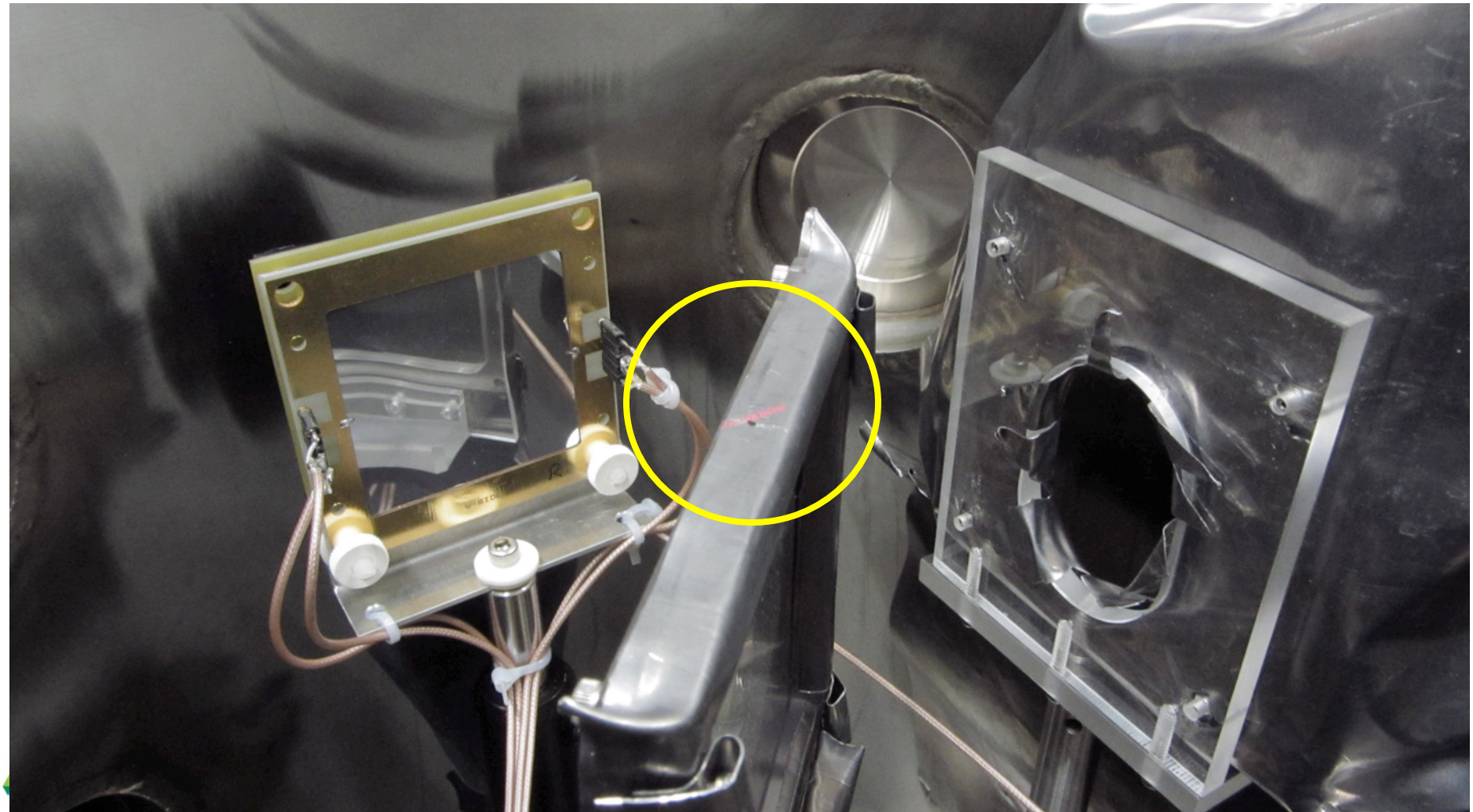


Vacuum chamber alignment with laser



Target alignment

- Aligning target on beam axis and at 45 degrees was trickier since it has two rotation centers
- Maybe one can think of an improvement for next run?



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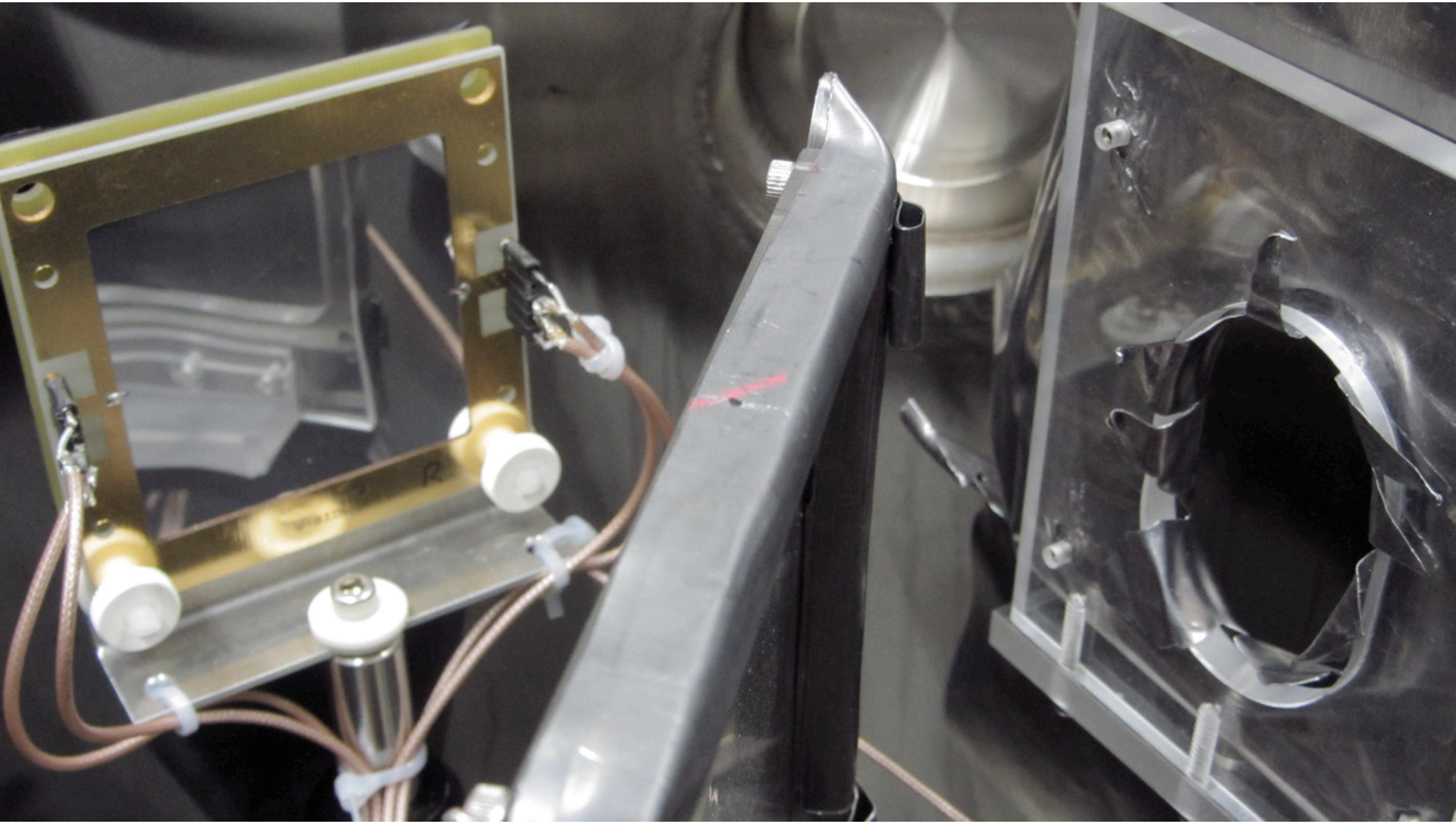
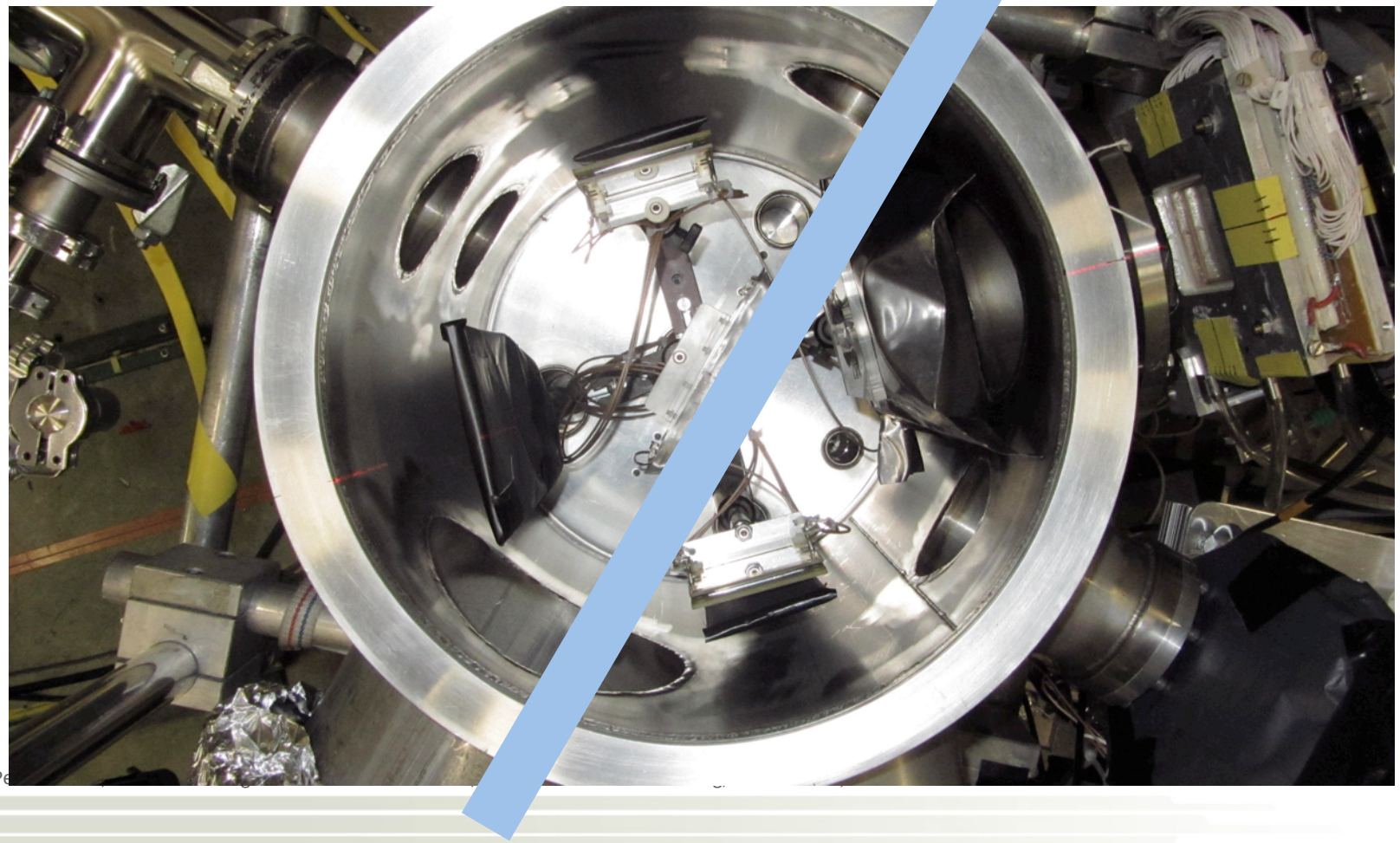


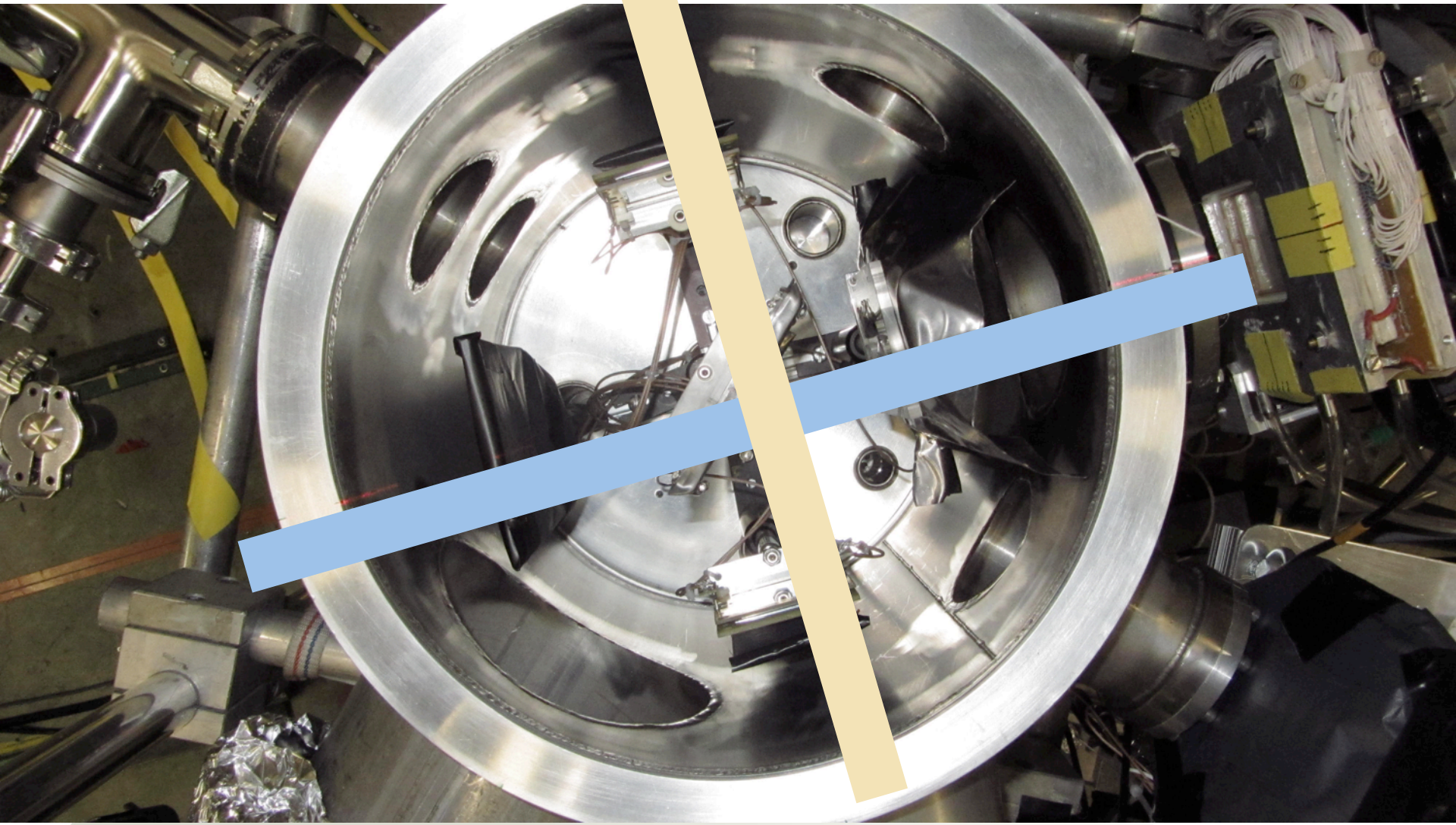
Target alignment

- 45 degree alignment with long ruler along 45 degree marks on chamber top (similar to beam axis marks used with the laser)
- Precision for angle 1-2 degrees at best



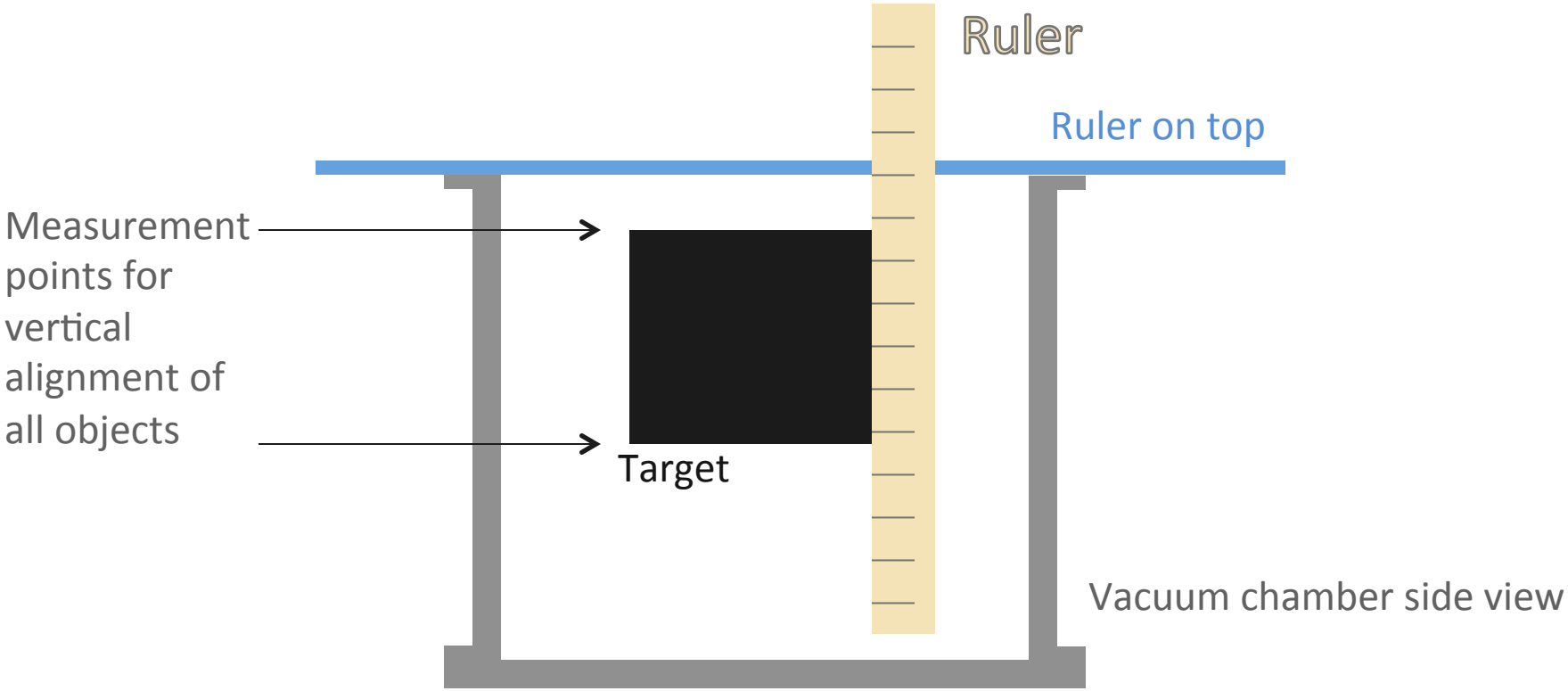
Silicon and scintillator alignment at 90 degrees

- Use perpendicular rulers and beam axis marks to align symmetrically around target center
- Angular alginment of detectors to bem axis again with 1-2 degree precision



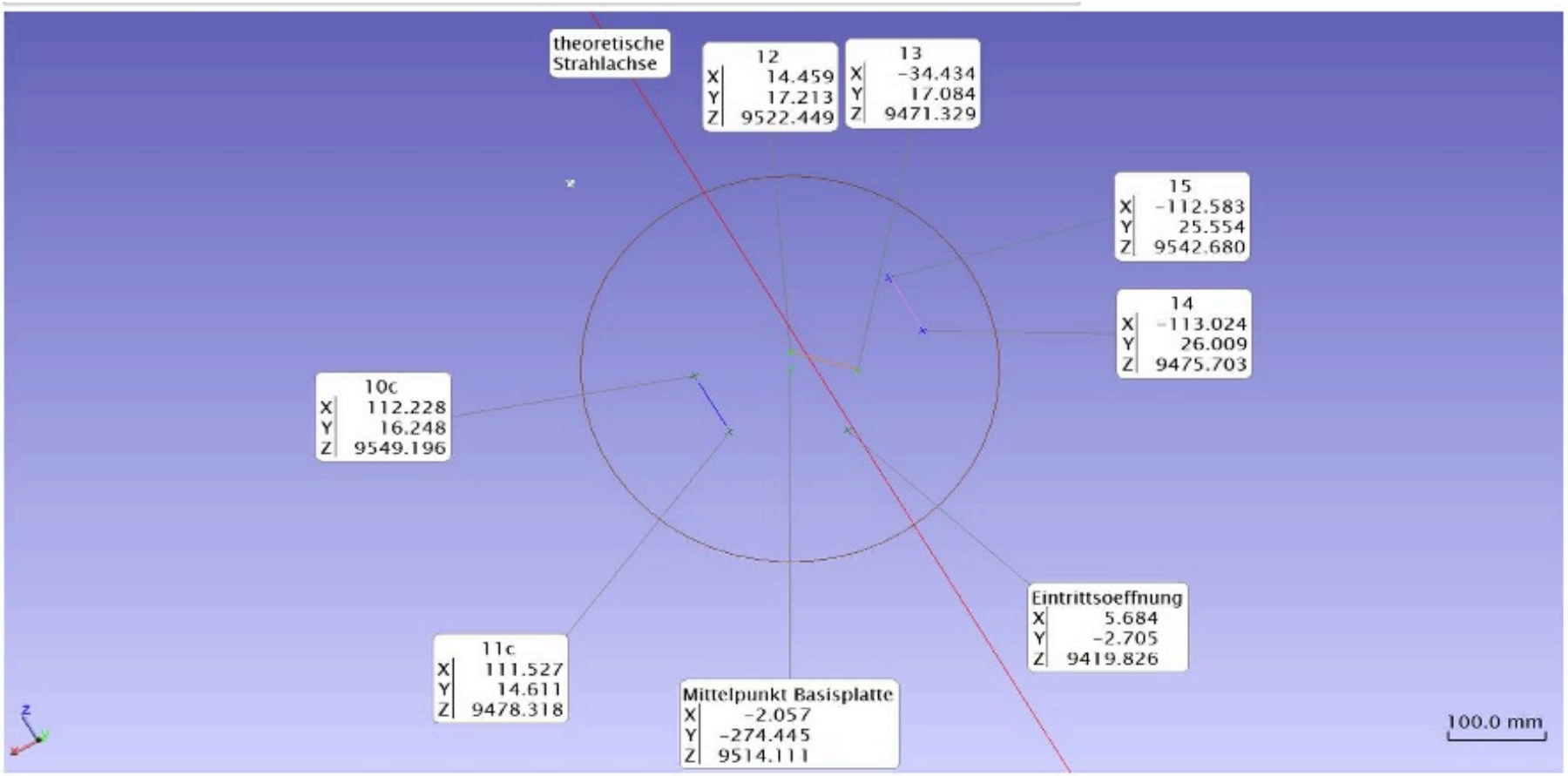
Height alignment of all components

- Height alignment inside the chamber performed relative to the muPC center
- Method: Ruler on top of chamber and one perpendicular to measure top and bottom of object to calculate its center and adjust relative to muPC
- Aligned collimator, target, Si detectors and veto counter to ±5mm precision



Vacuum chamber survey by PSI

- Document in [elog:19]
- Not sure that relative position to beam axis should be taken serious since this is after the run and the chamber was most likely moved during shutdown
- Measurement precision 2-3mm due to shaky chamber holder



Alignment summary

- Alignment of objects relative to beam axis with estimated ±2mm precision
- Angles of objects aligned to ±2 degrees
- Height adjusted relative to muPC with ±5 mm
- Some of these measurements can be cross checked from PSI survey report (at least relative alignment of objects, maybe not the absolut relative to the beam axis)
- We might want to think about a way to improve alignment of objects for Run2 as this was tedious and not very precise
  - Marks / grid on the bottom plate
  - Laser mounted above the chamber to produce required pattern via mask
  - ...?