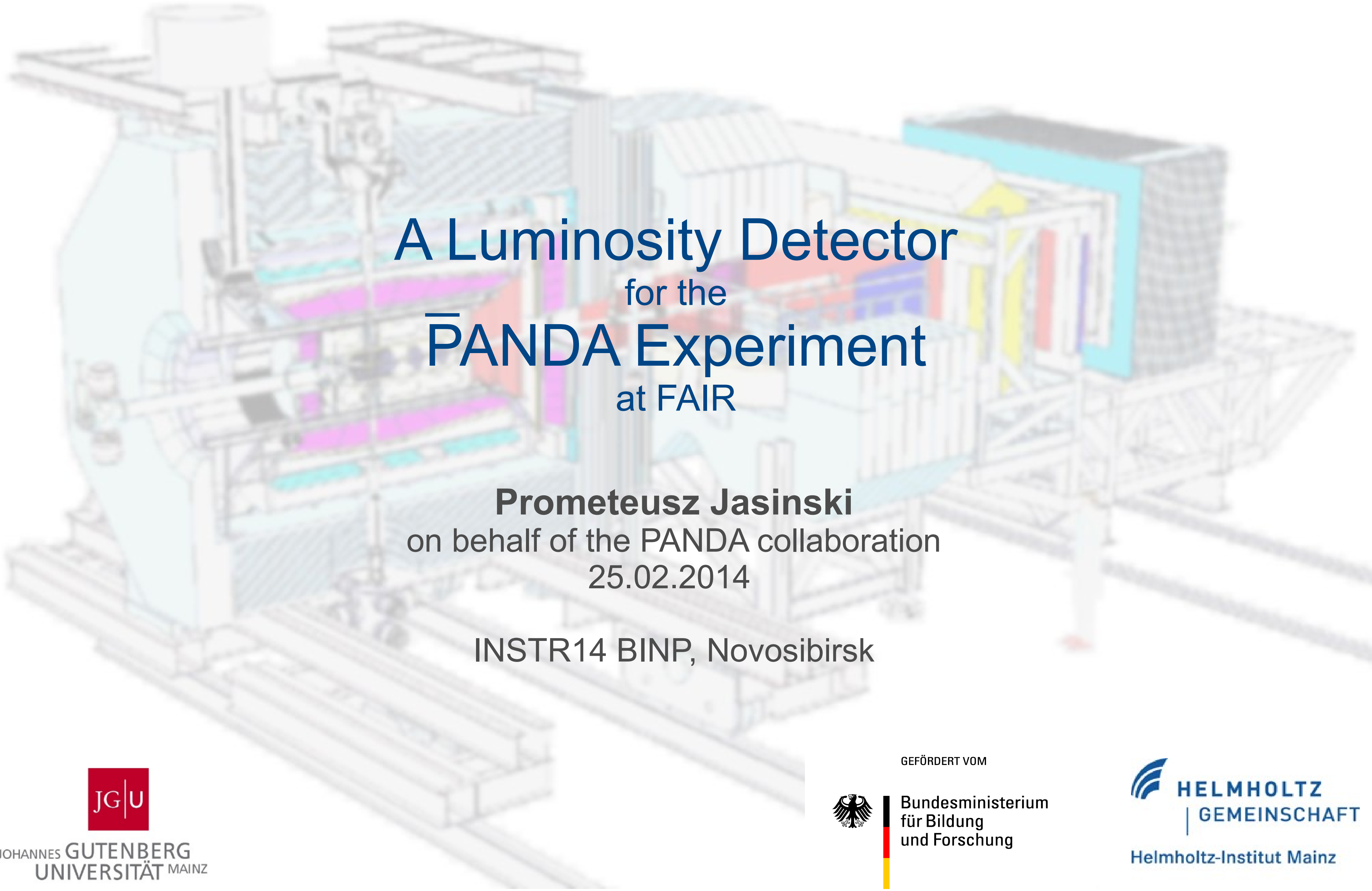
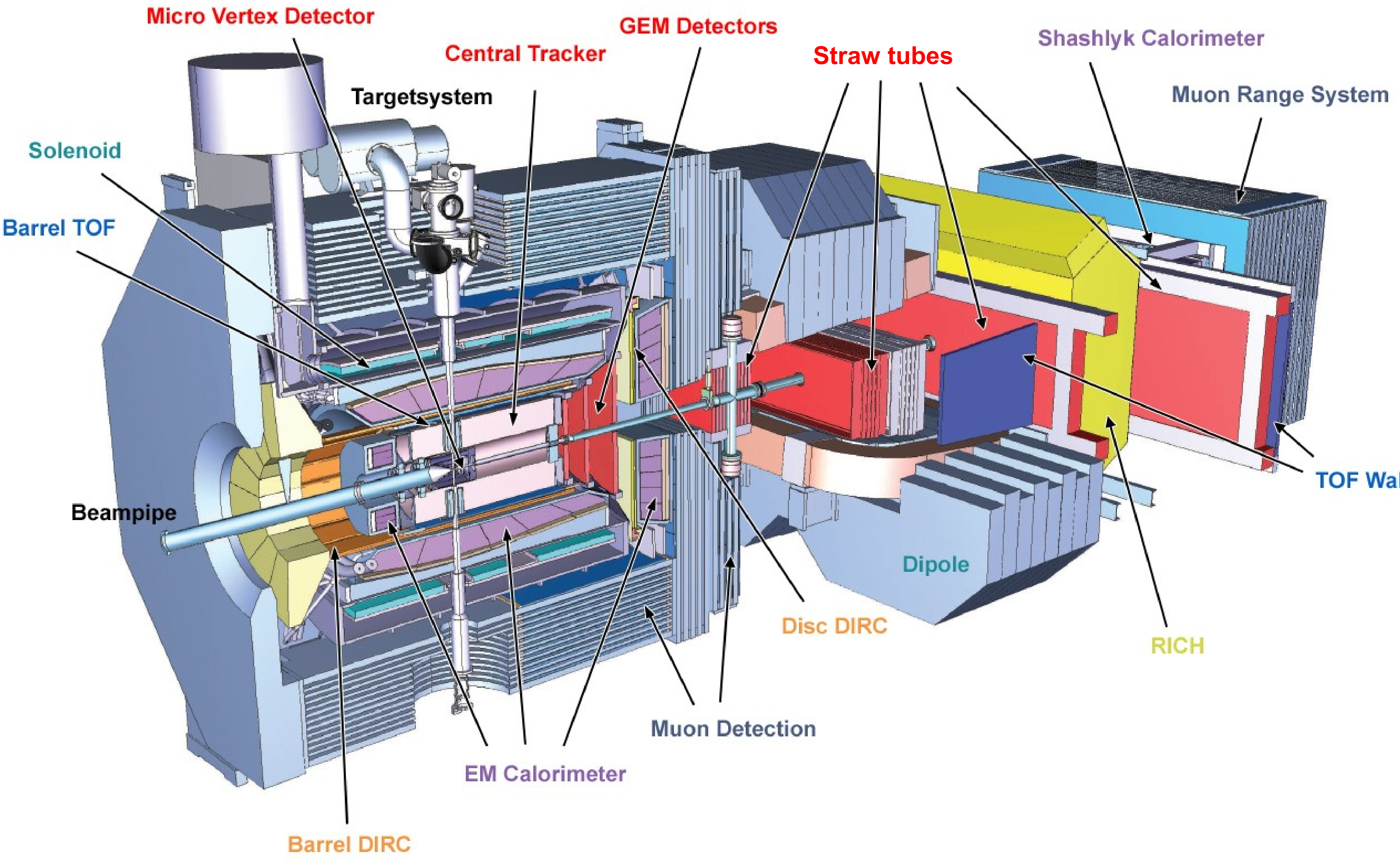


A Luminosity Detector
for the
$\overline{\text{P}}$ANDA Experiment
at FAIR

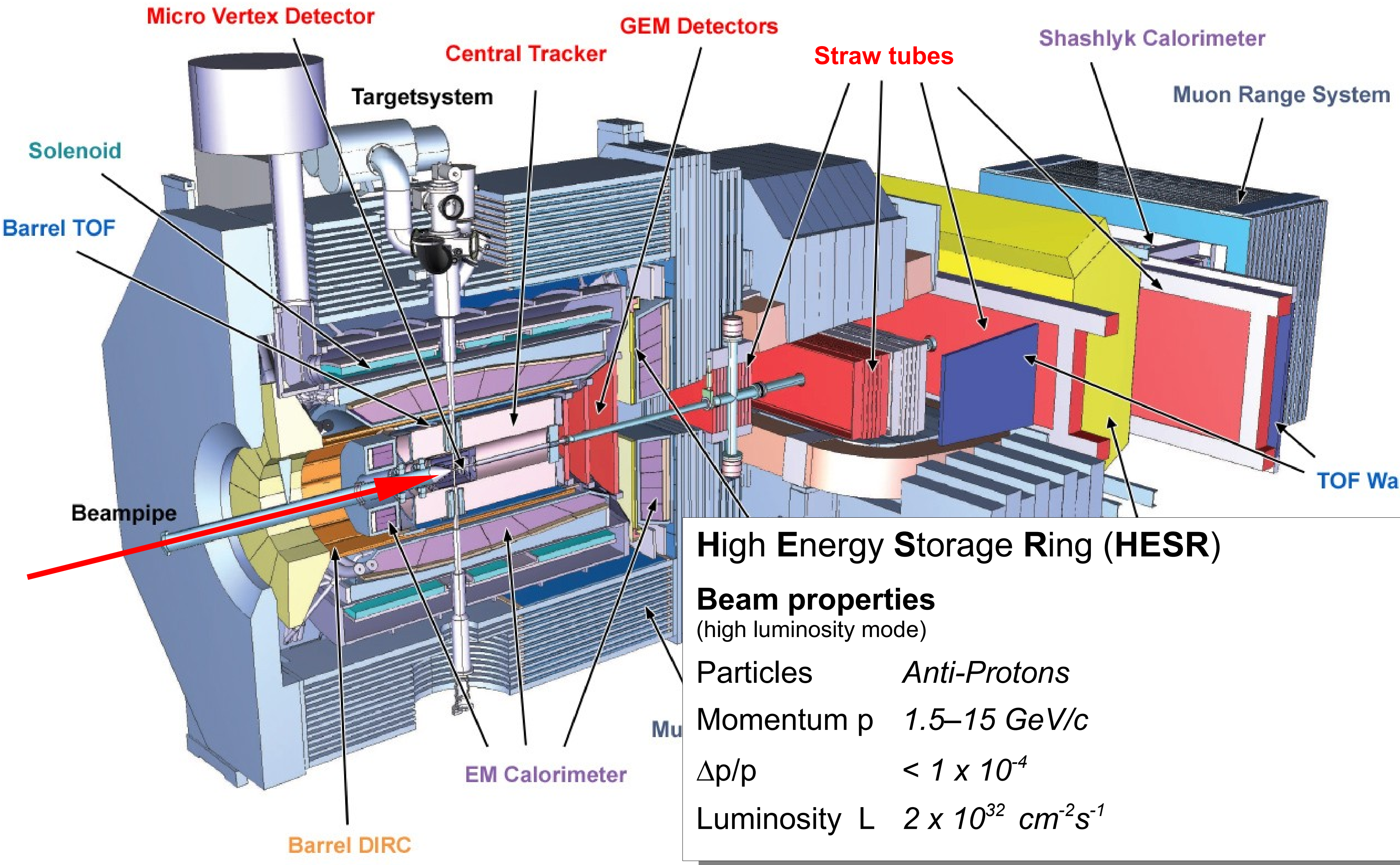
Prometeusz Jasinski
on behalf of the PANDA collaboration
25.02.2014

INSTR14 BINP, Novosibirsk

$\overline{\text{P}}$ANDA – Experiment at FAIR



P̄ANDA – Experiment at FAIR

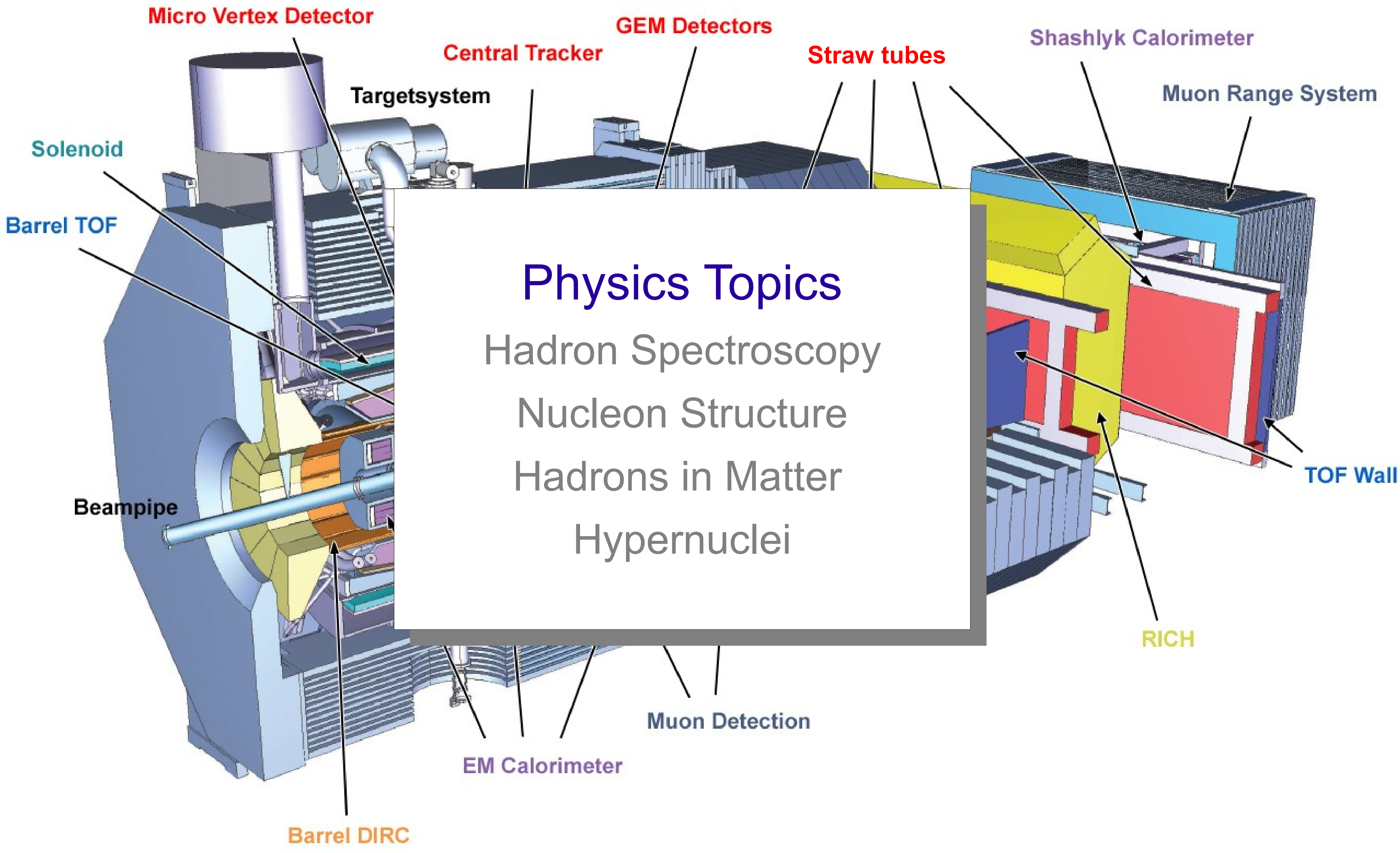


High **E**nergy **S**torage **R**ing (**HESR**)

Beam properties
(high luminosity mode)

Particles	*Anti-Protons*
Momentum p	*1.5–15 GeV/c*
$\Delta p/p$	$< 1 \times 10^{-4}$
Luminosity L	$2 \times 10^{32}\ cm^{-2}s^{-1}$

P̄ANDA – Experiment at FAIR



Physics Topics

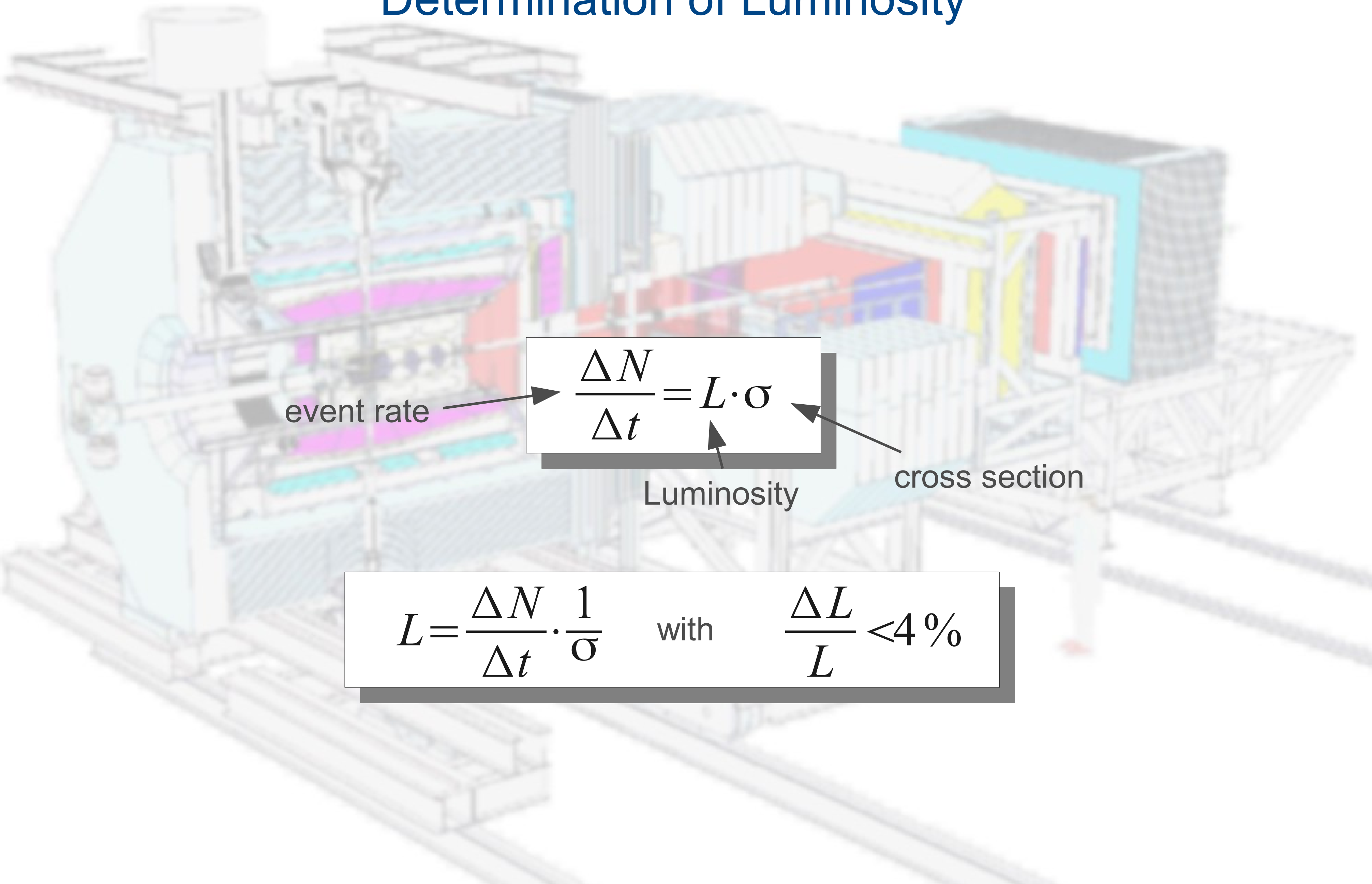
Hadron Spectroscopy

Nucleon Structure

Hadrons in Matter

Hypernuclei

Determination of Luminosity



event rate

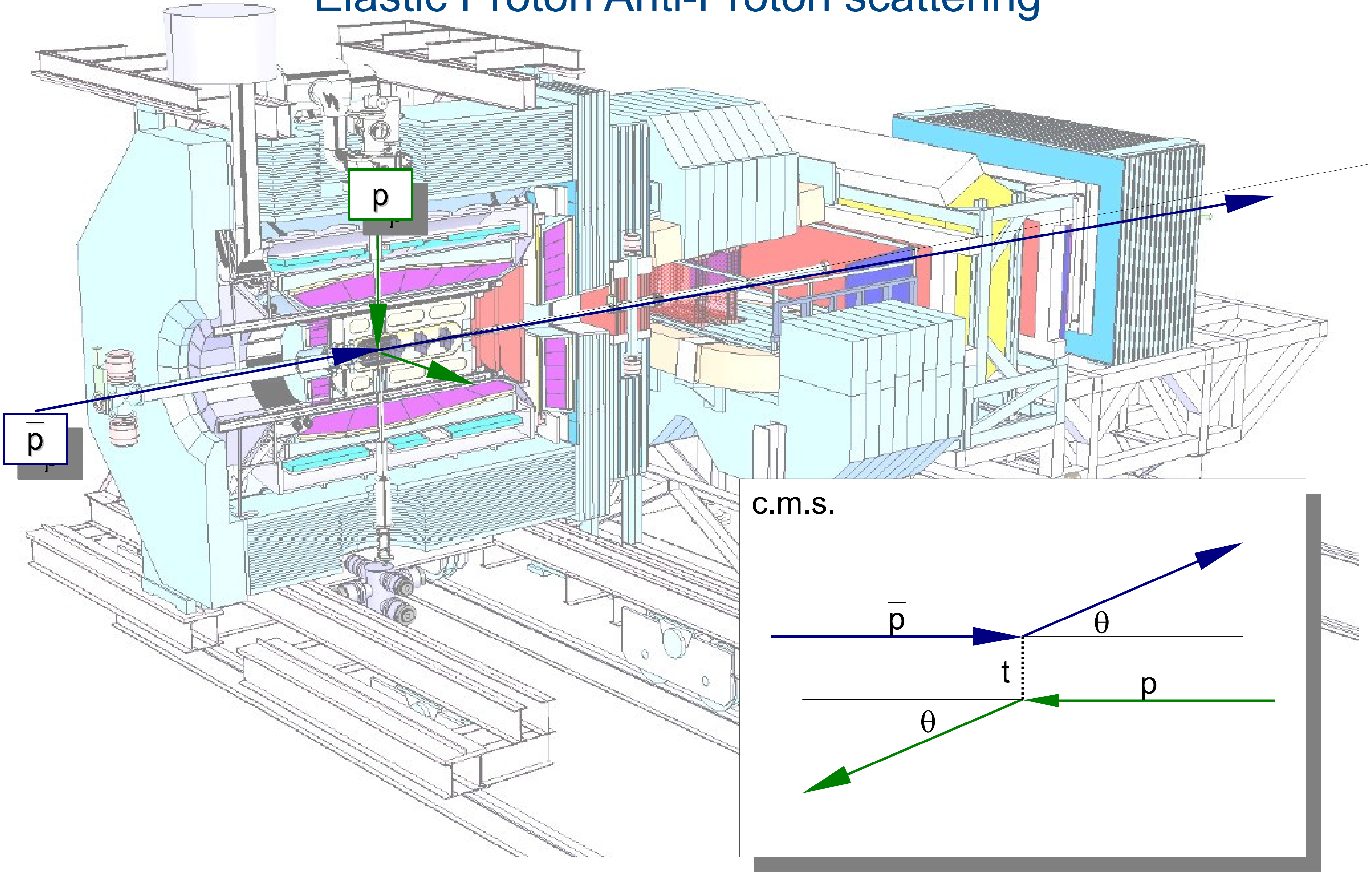
$$\frac{\Delta N}{\Delta t} = L \cdot \sigma$$

Luminosity

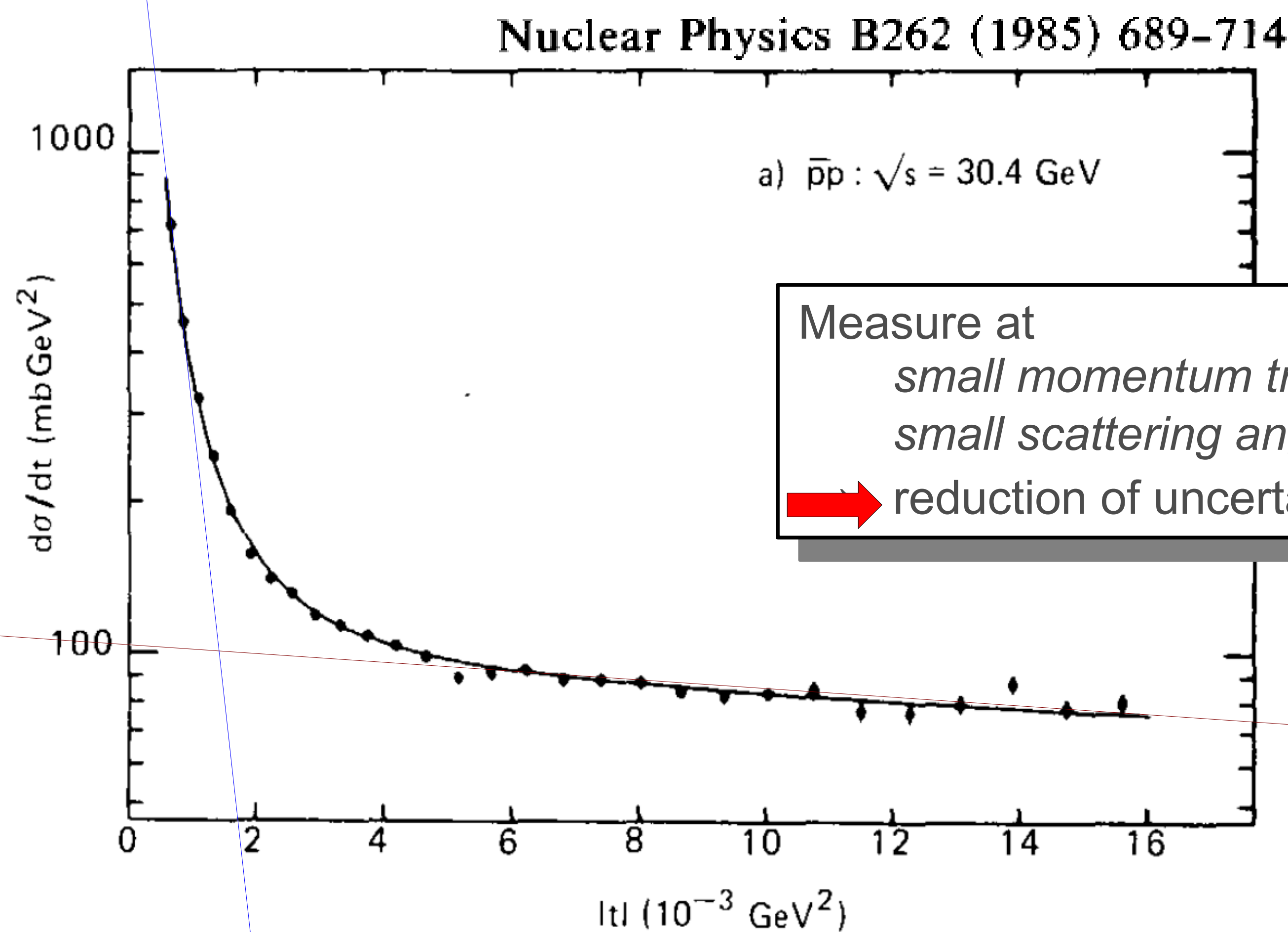
cross section

$$L = \frac{\Delta N}{\Delta t} \cdot \frac{1}{\sigma} \quad \text{with} \quad \frac{\Delta L}{L} < 4\,\%$$

Elastic Proton Anti-Proton scattering



Elastic scattering as reference



Measure at

small momentum transfers |t|

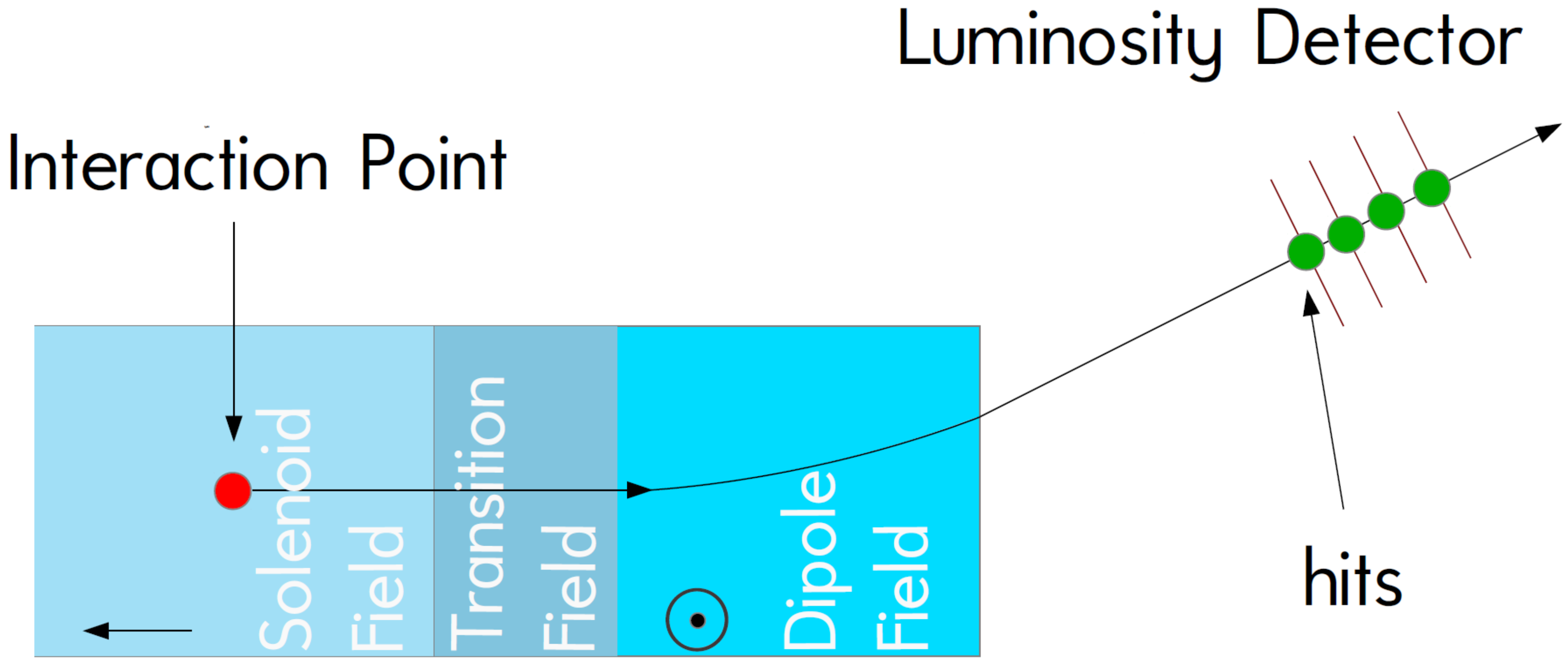
small scattering angles Θ

→ reduction of uncertainties by model

hadronic

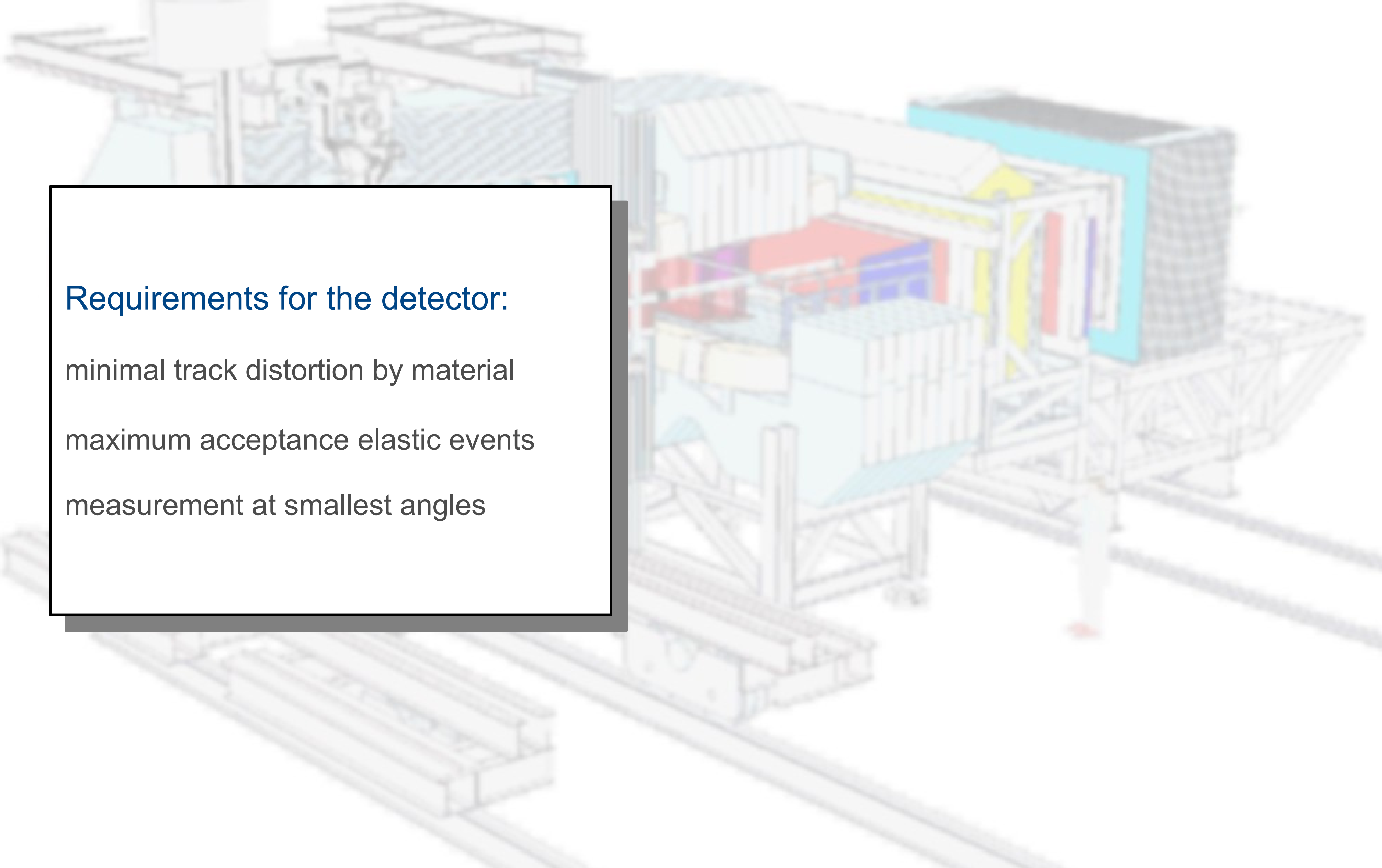
electromagnetic (Coulomb)

Particle track reconstruction



top view

Measurement close to the Beam



Requirements for the detector:

minimal track distortion by material

maximum acceptance elastic events

measurement at smallest angles

Measurement close to the Beam

Requirements for the detector:

minimal track distortion by material

maximum acceptance elastic events

measurement at smallest angles

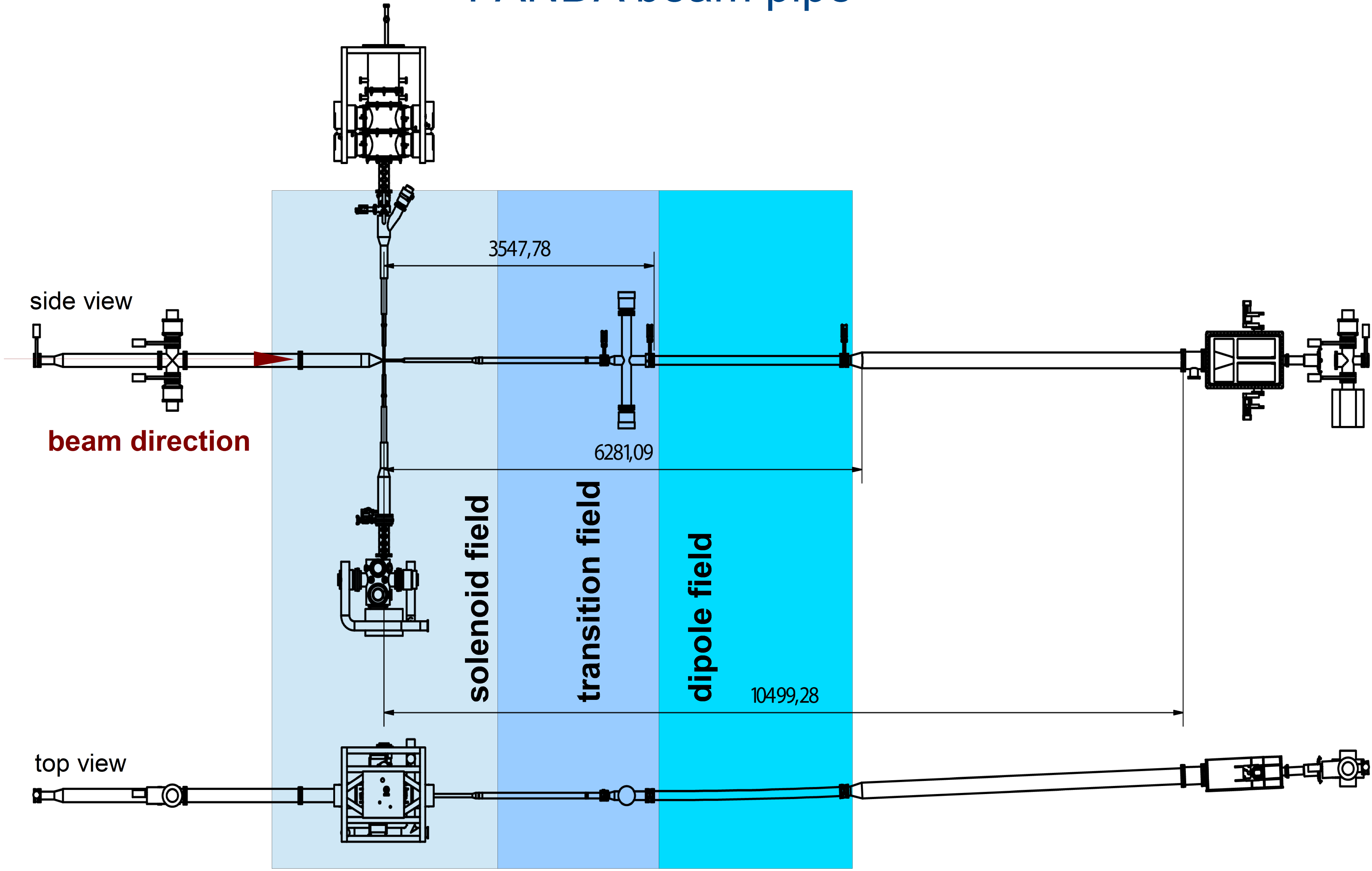
Requirements by the storage ring:

high vacuum < 10^{-9} mbar

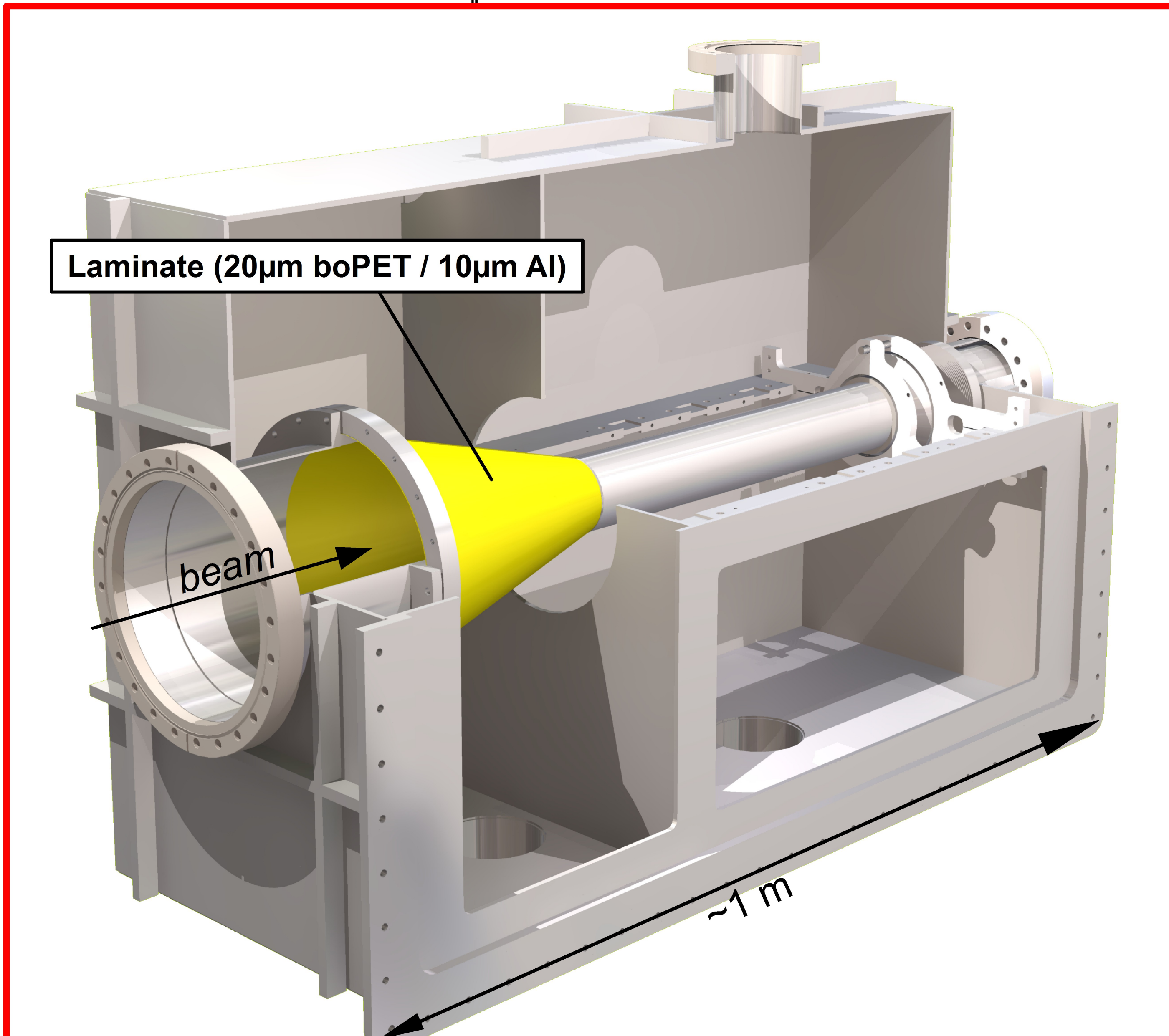
maximum acceptance of the beam

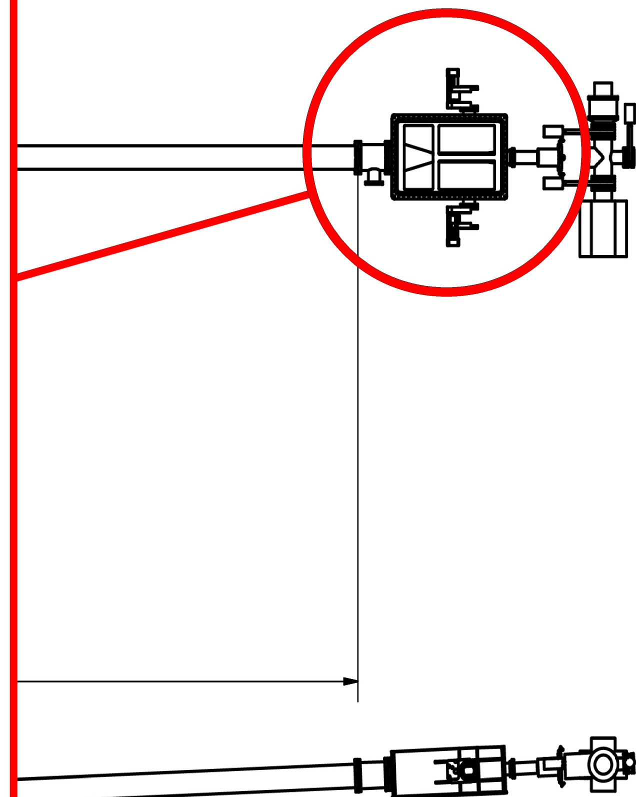
slow changes of beam pipe diameter

P̄ANDA beam pipe

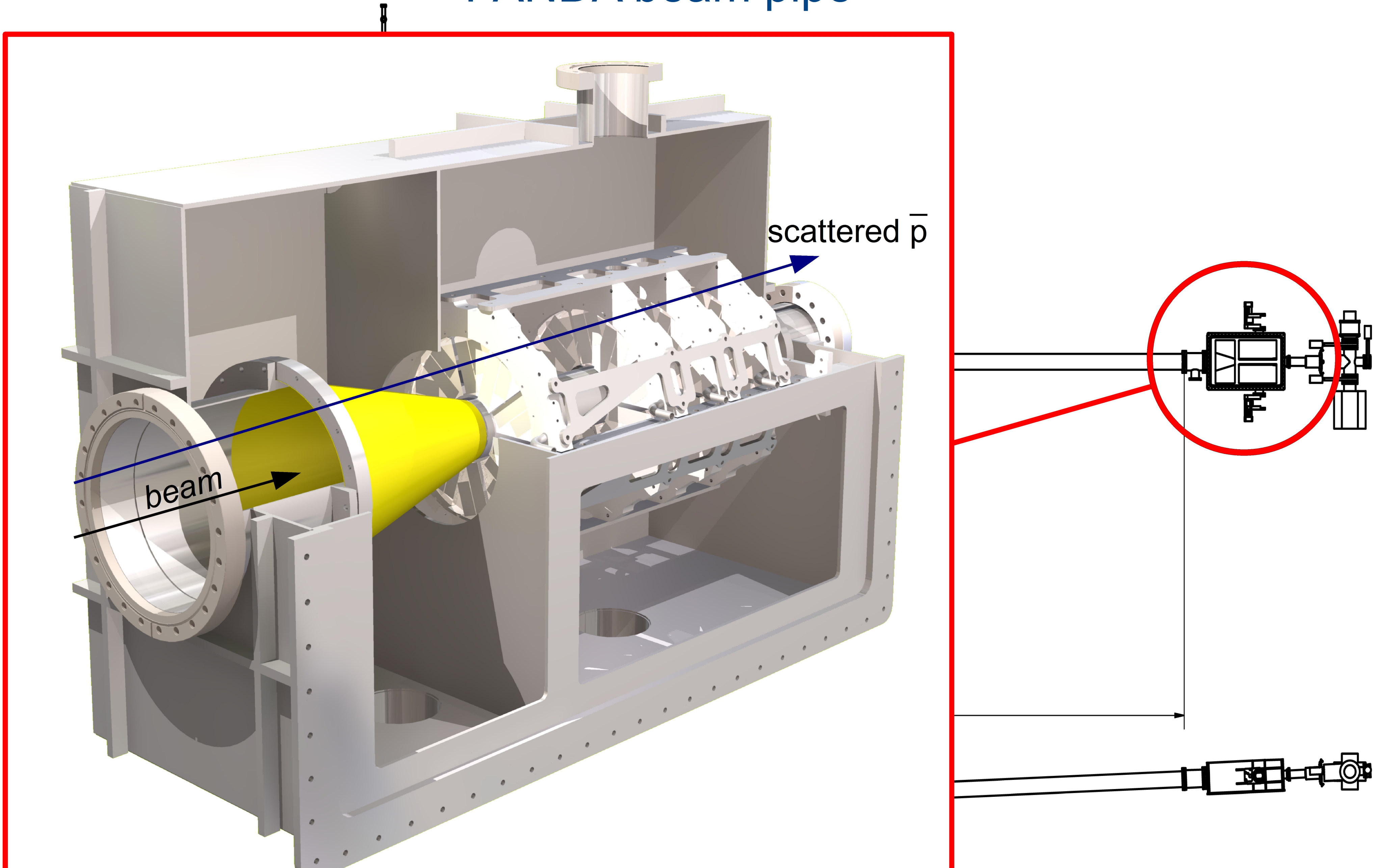


P̄ANDA beam pipe

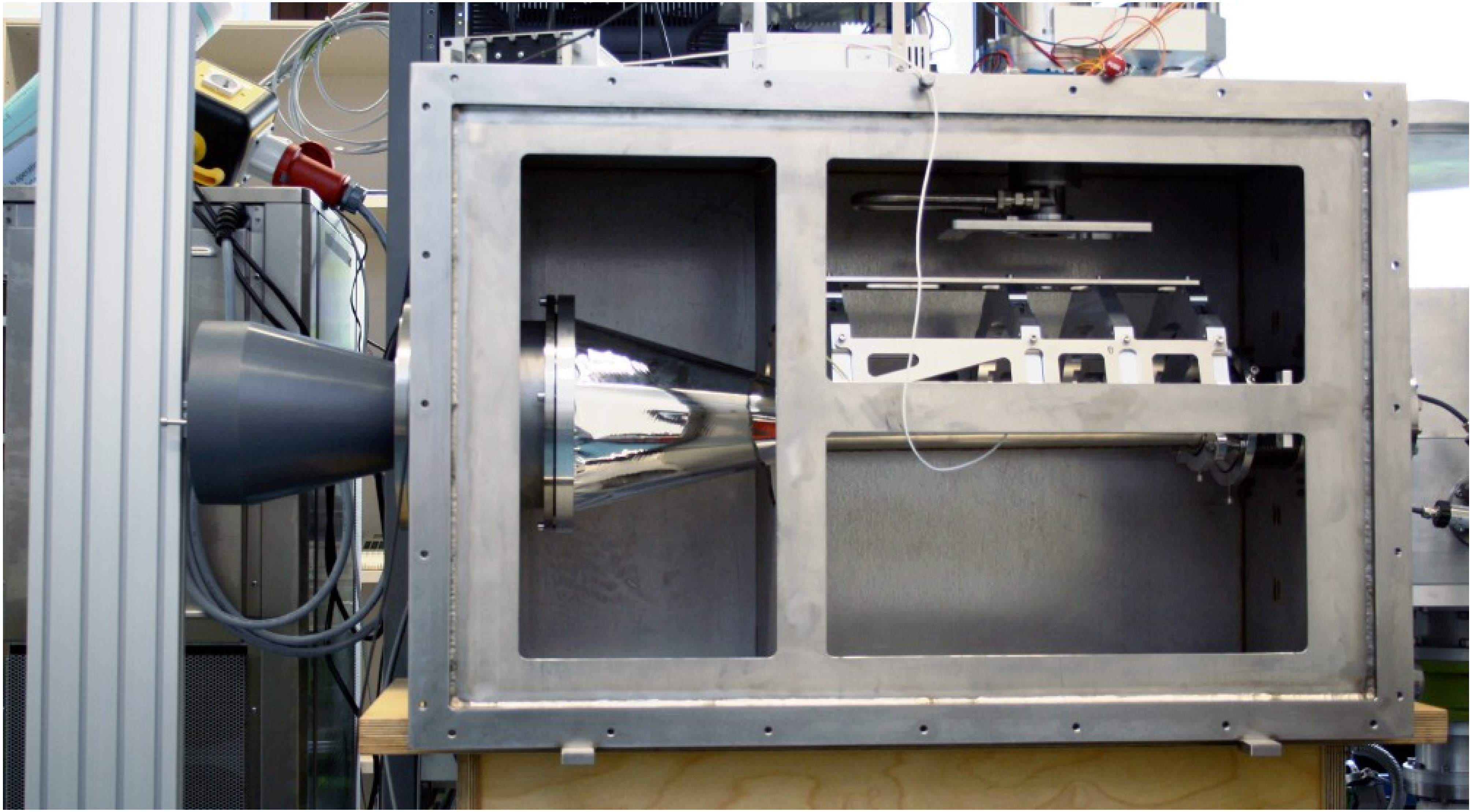




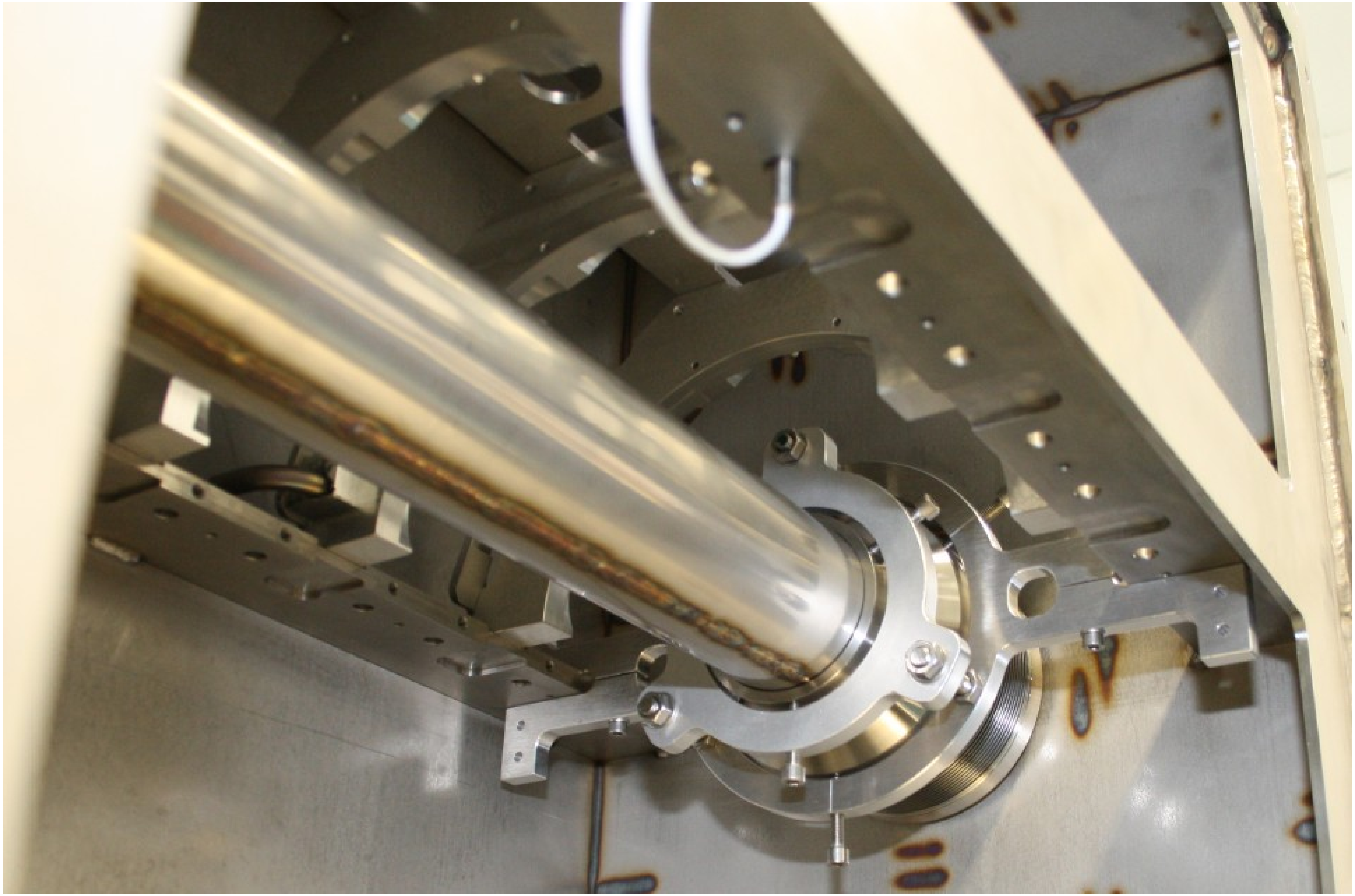
$\overline{\text{P}}$ANDA beam pipe



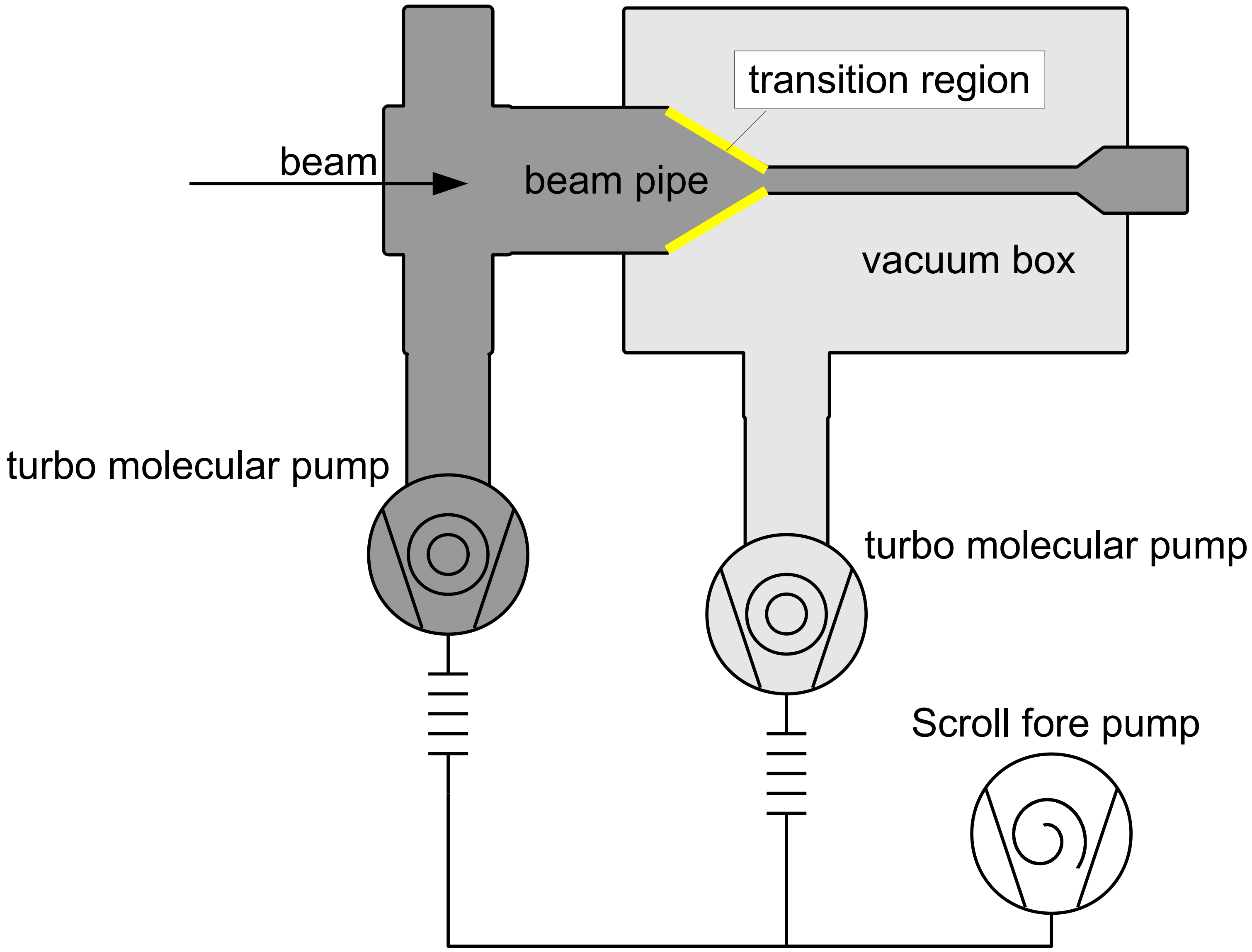
Vacuum Box Prototype



Beam Pipe Prototype

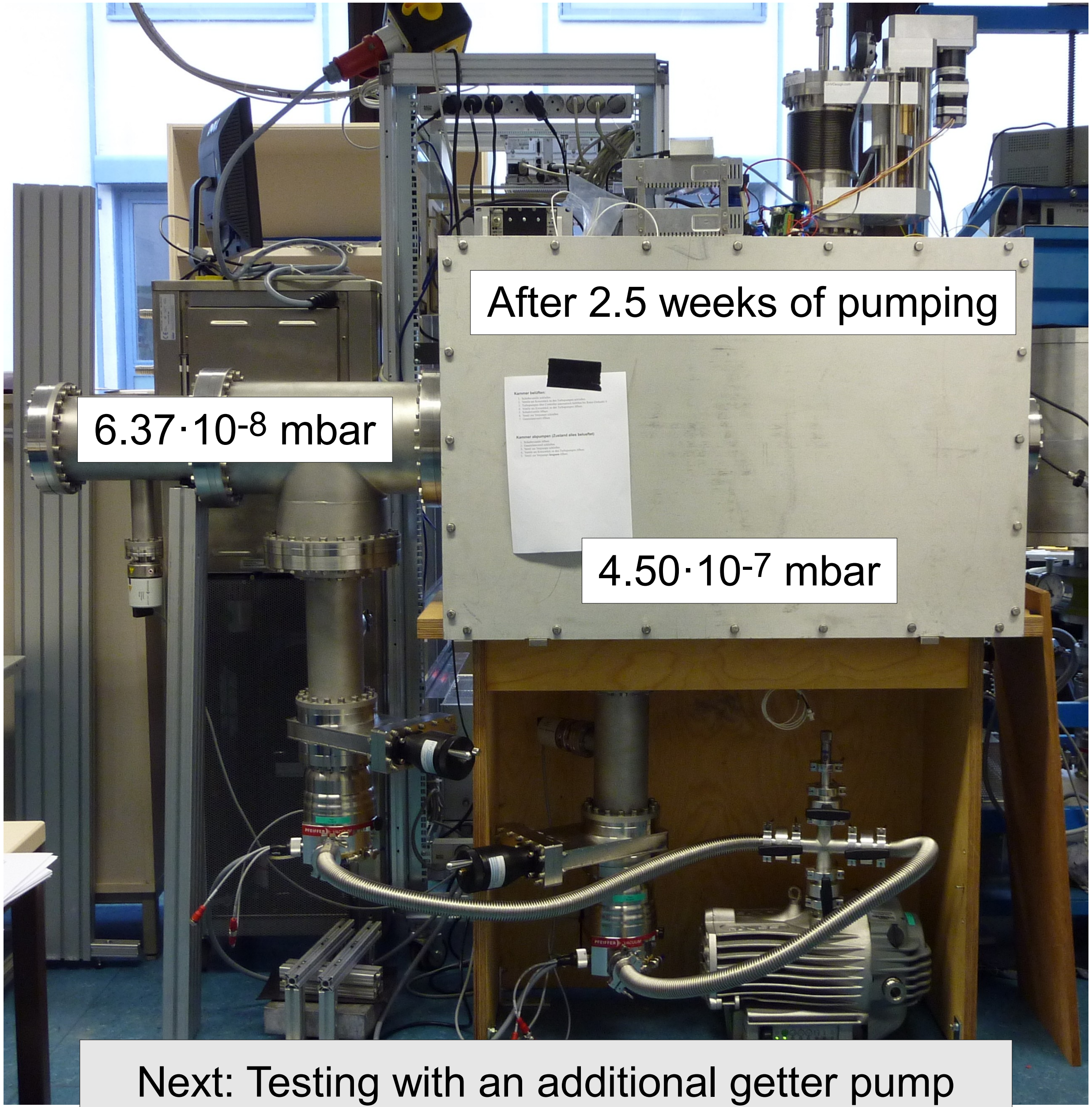


Differential Pumping Scheme



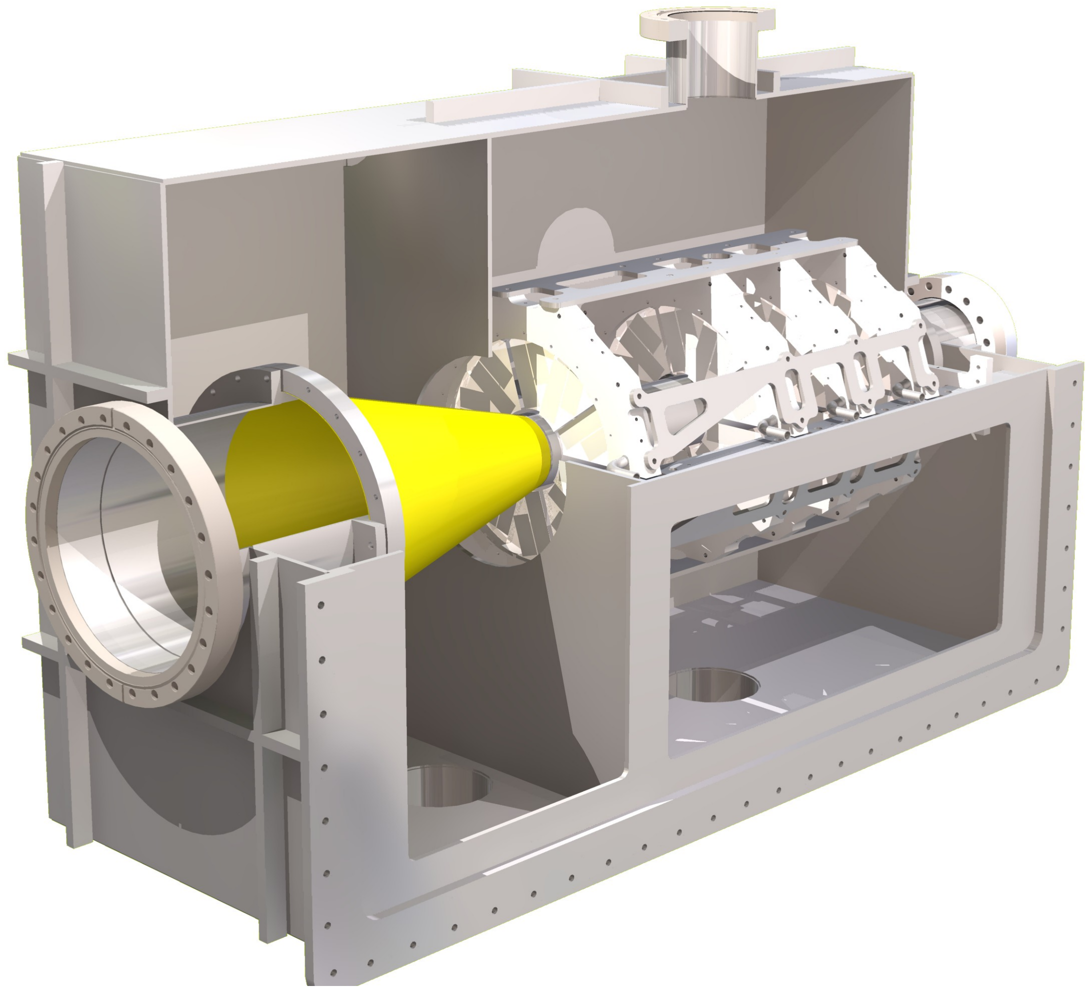
First Pumping Tests

First Pumping Tests

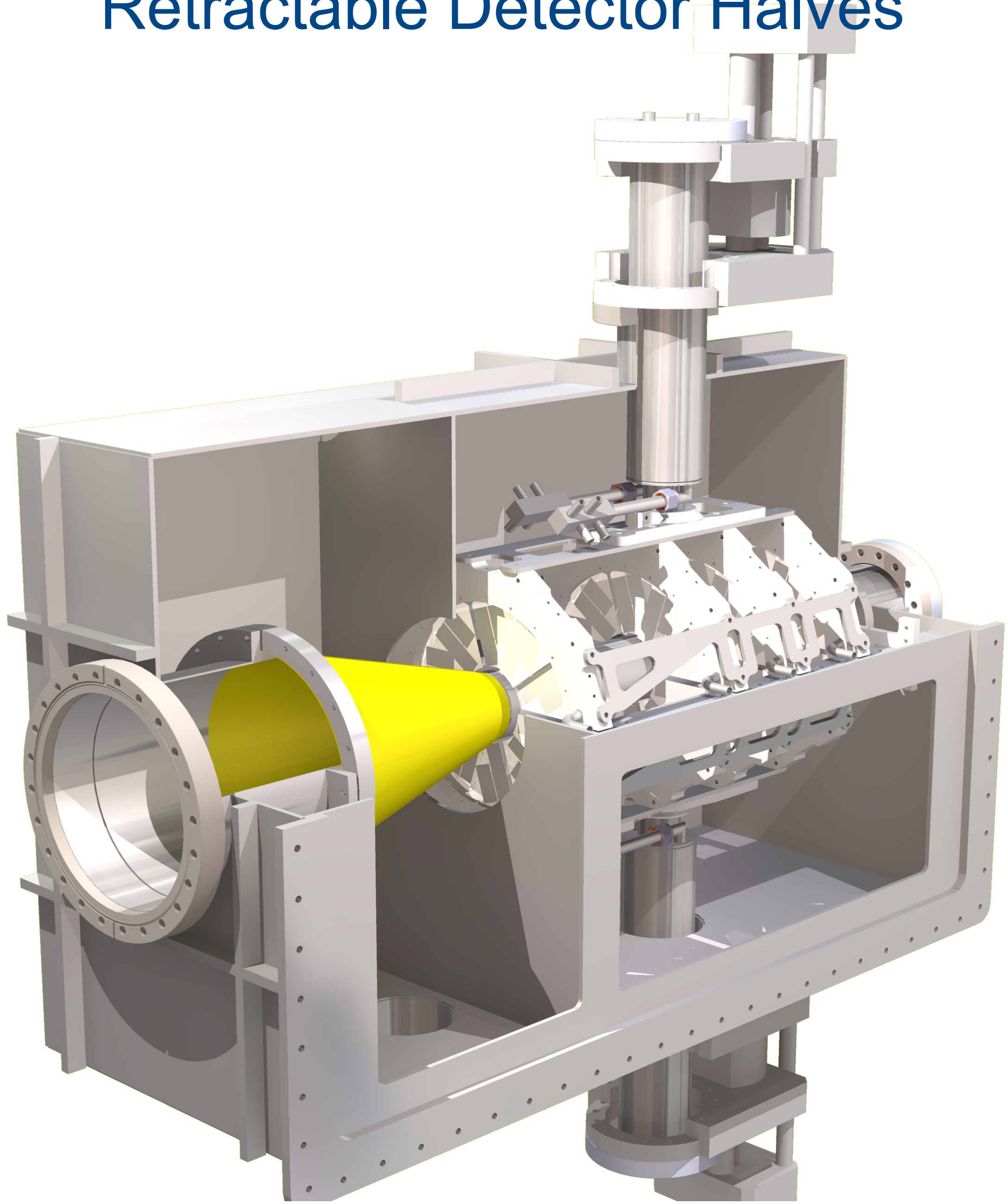


Next: Testing with an additional getter pump

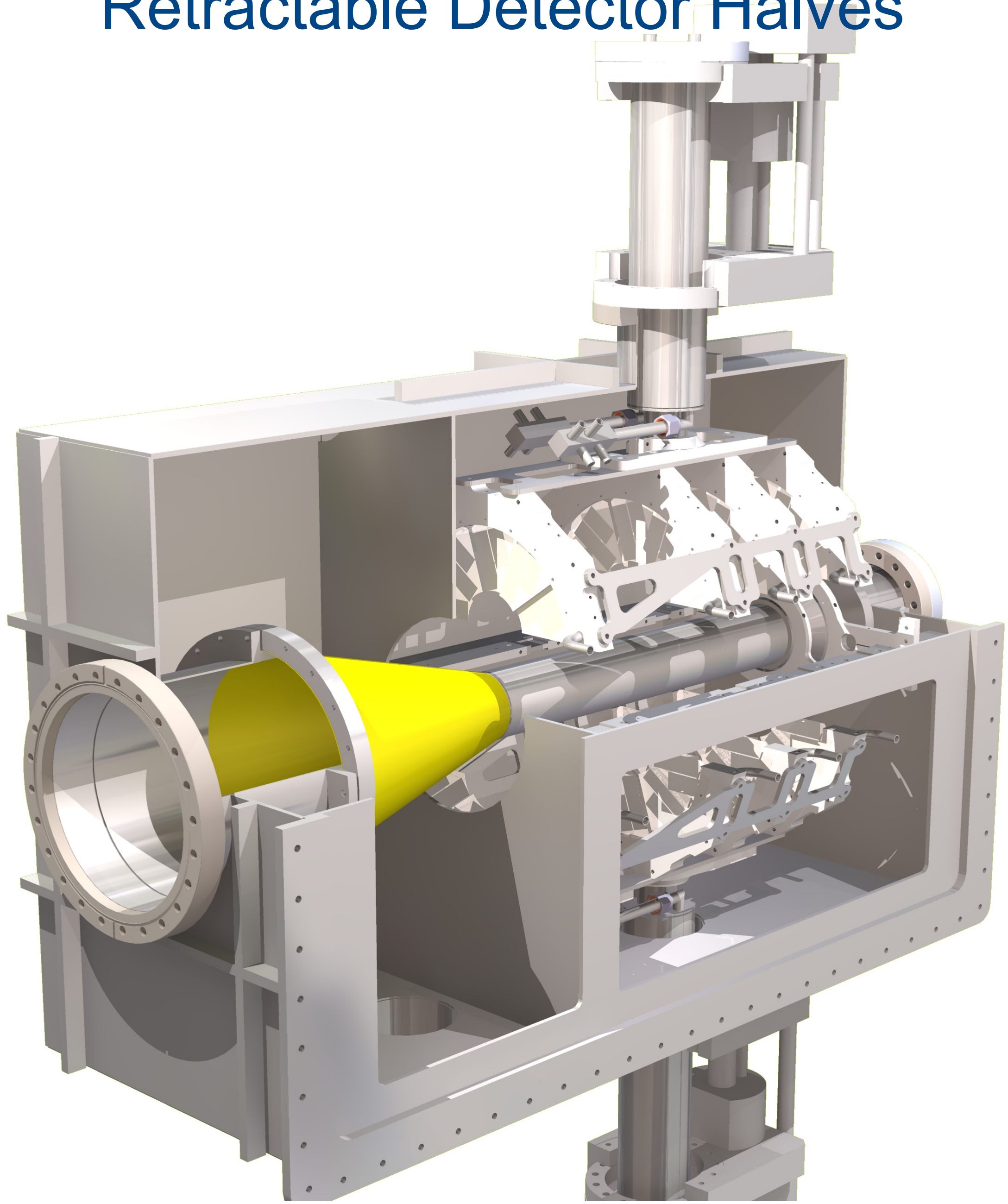
Retractable Detector Halves



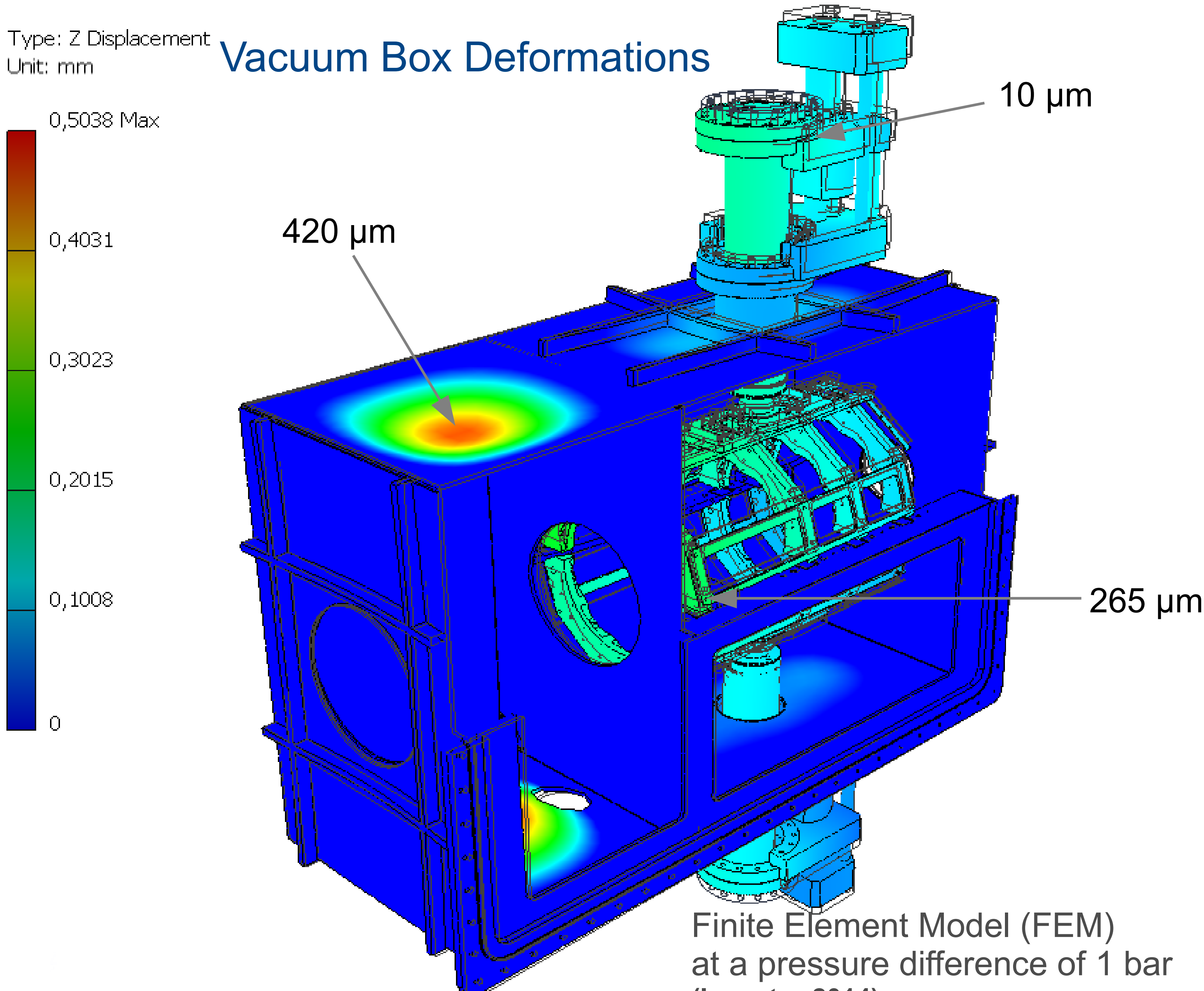
Retractable Detector Halves



Retractable Detector Halves



Vacuum Box Deformations



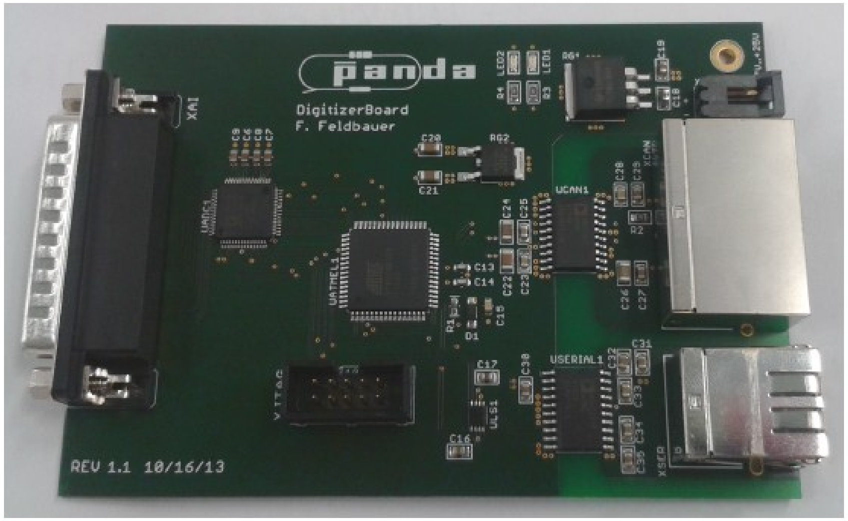
Finite Element Model (FEM)
at a pressure difference of 1 bar
(Inventor 2014)

Displacement Measurement in Vacuum

Capacitive probes:
Capacitec 208-ACU

2 mm range ~ 40 nm resolution

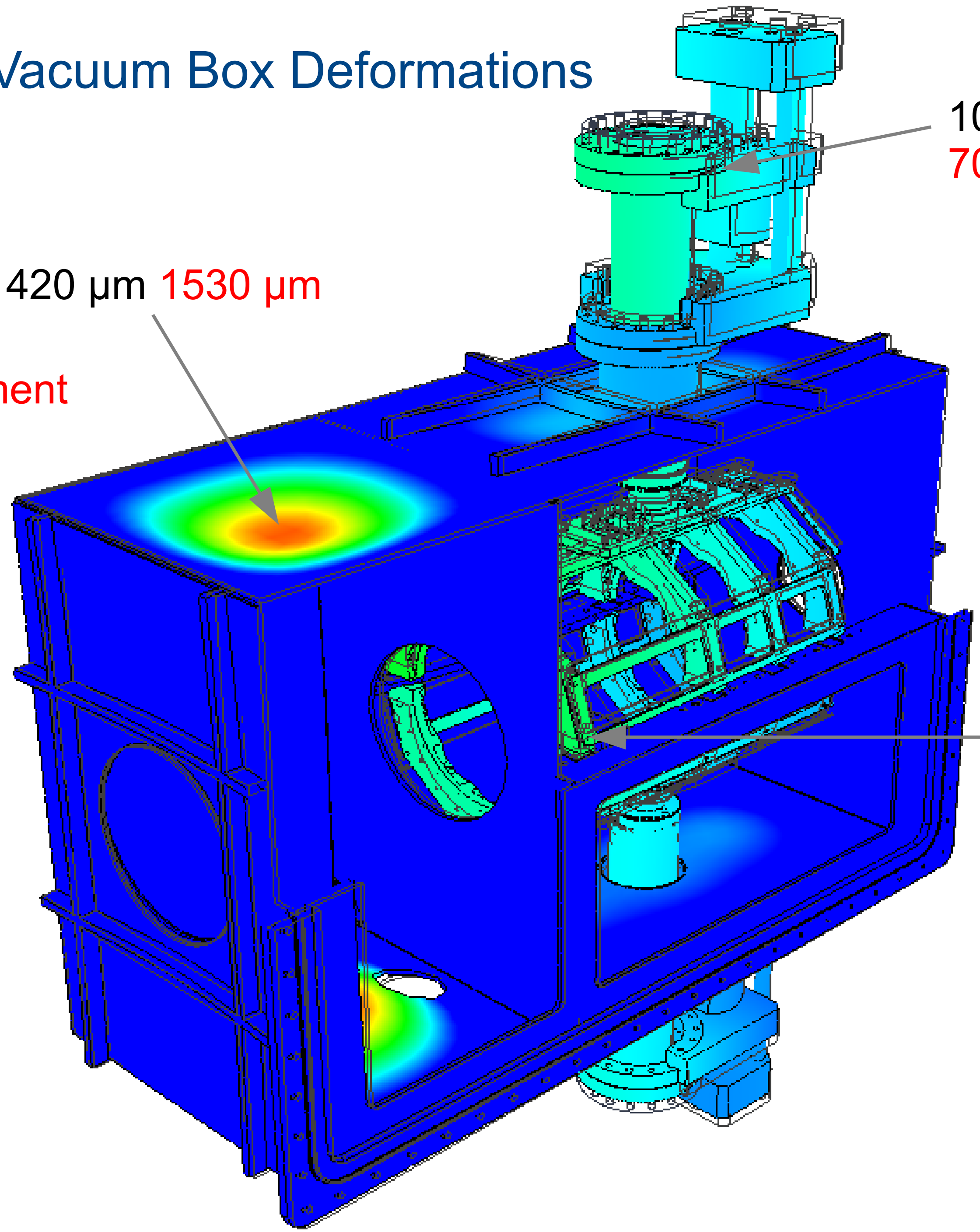
Aquisition via 18-bit differential ADC
and microcontroller with CAN interface



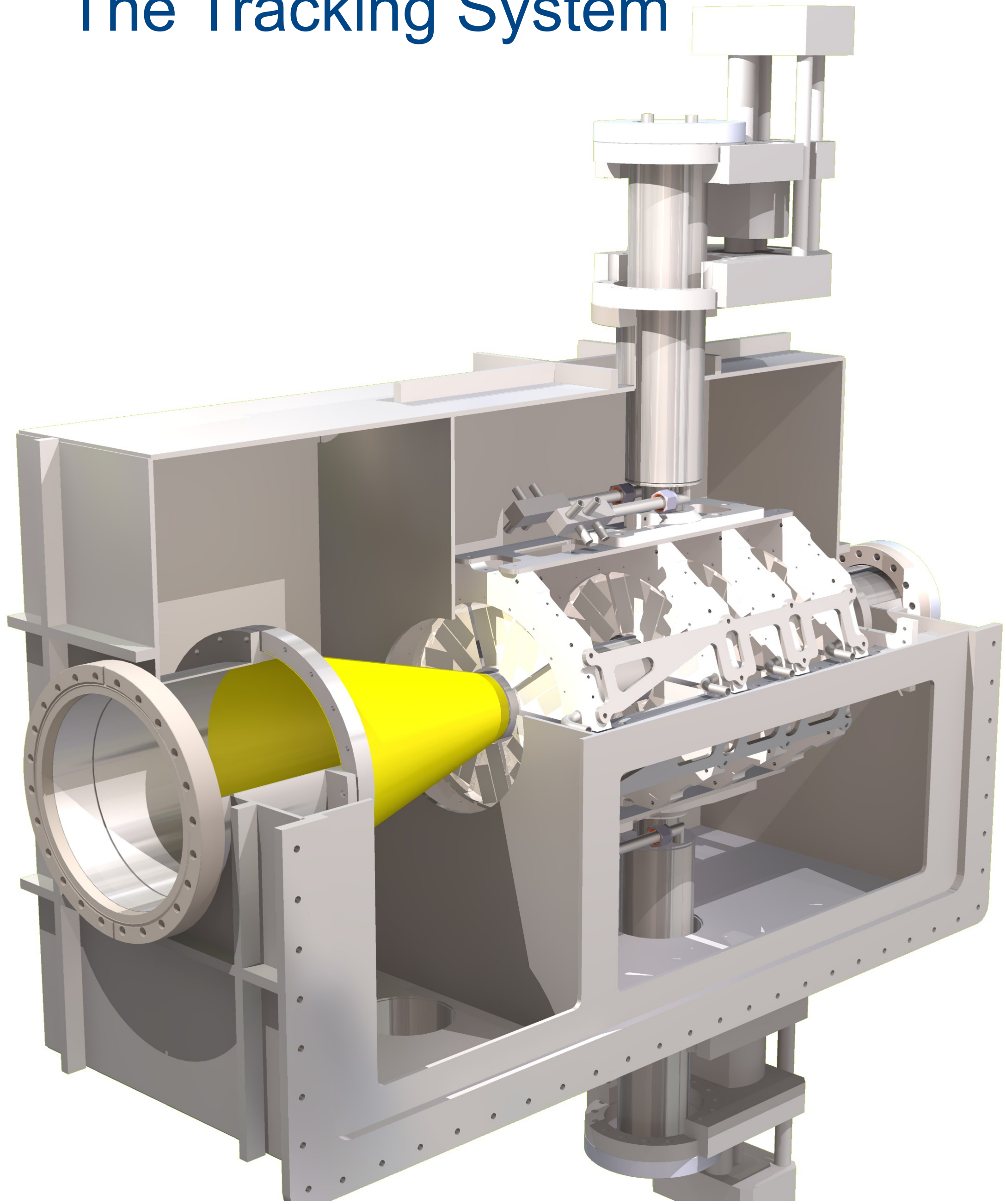
DCS via Epics: Florian Feldbauer Sat 9:00 am

Vacuum Box Deformations

simulation vs measurement



The Tracking System



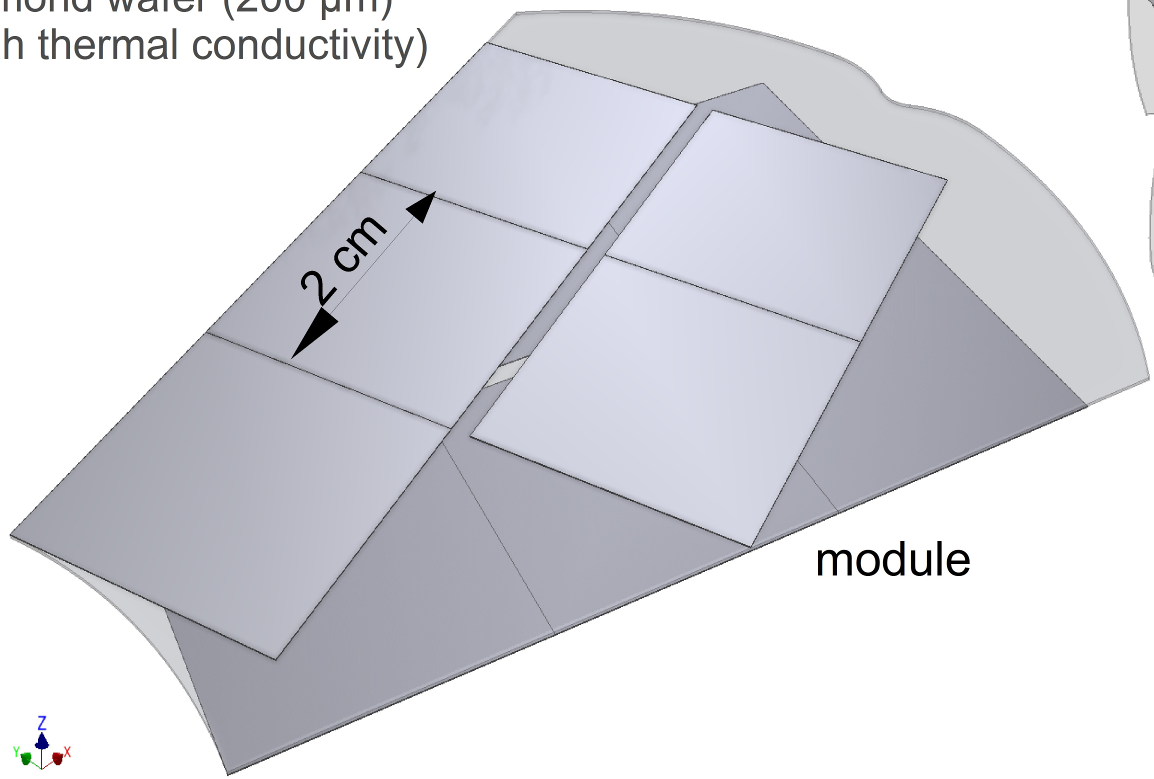
Cooling of HV-MAPS

2 x 2 cm² individual HV-MAPS (50 μm)
400 in total

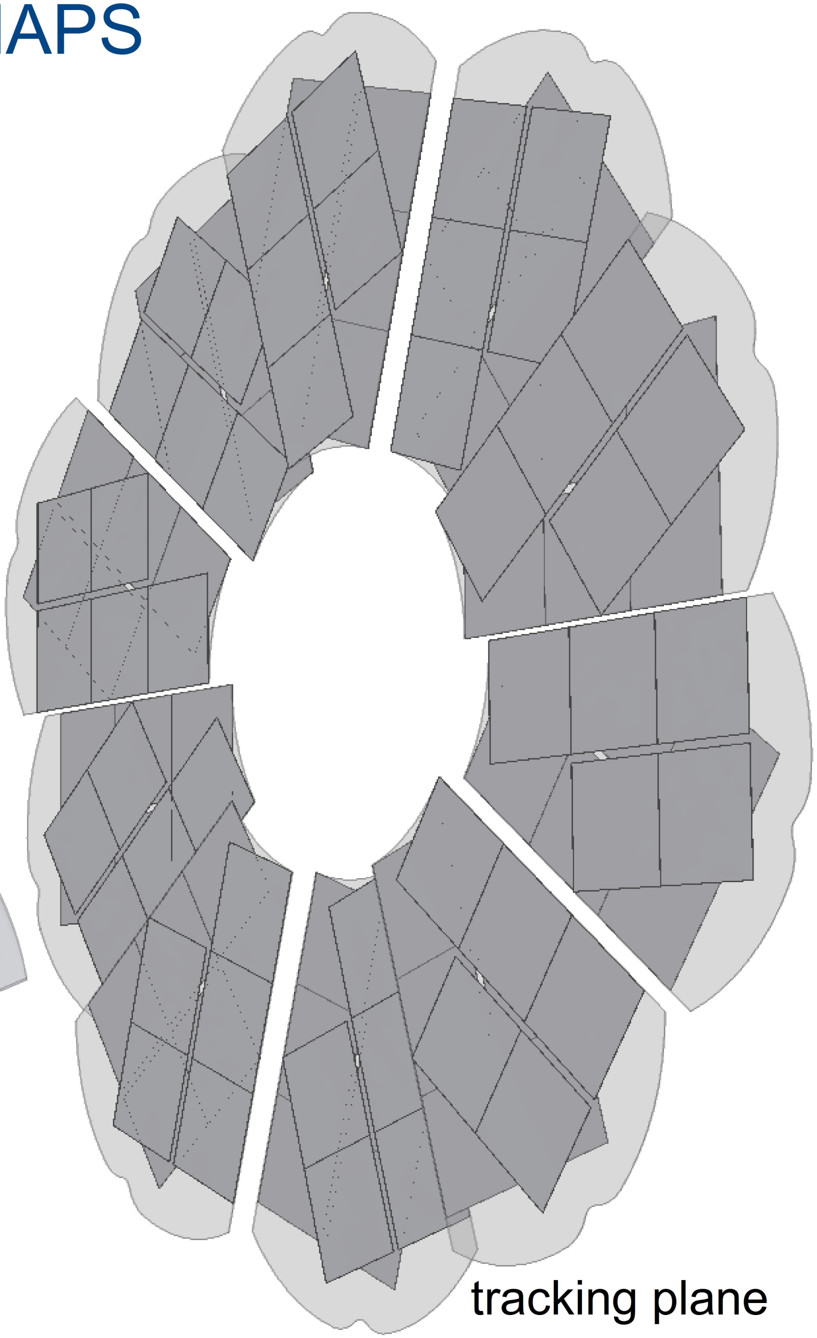
digitization on chip
(more: Tobias Weber today 3:35 pm)

expected power consumption :
2 mW/mm²

glued on a
diamond wafer (200 μm)
(high thermal conductivity)

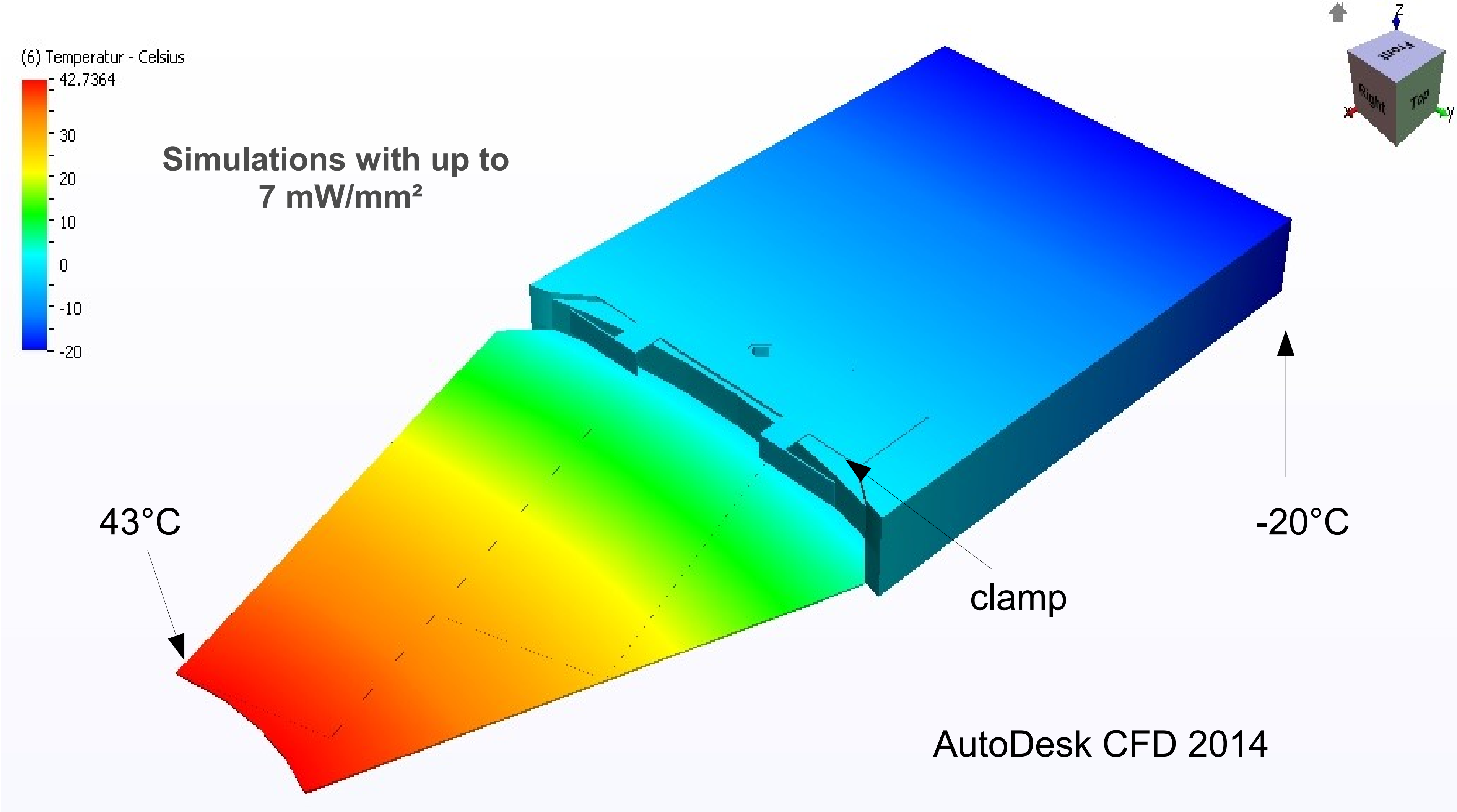


module



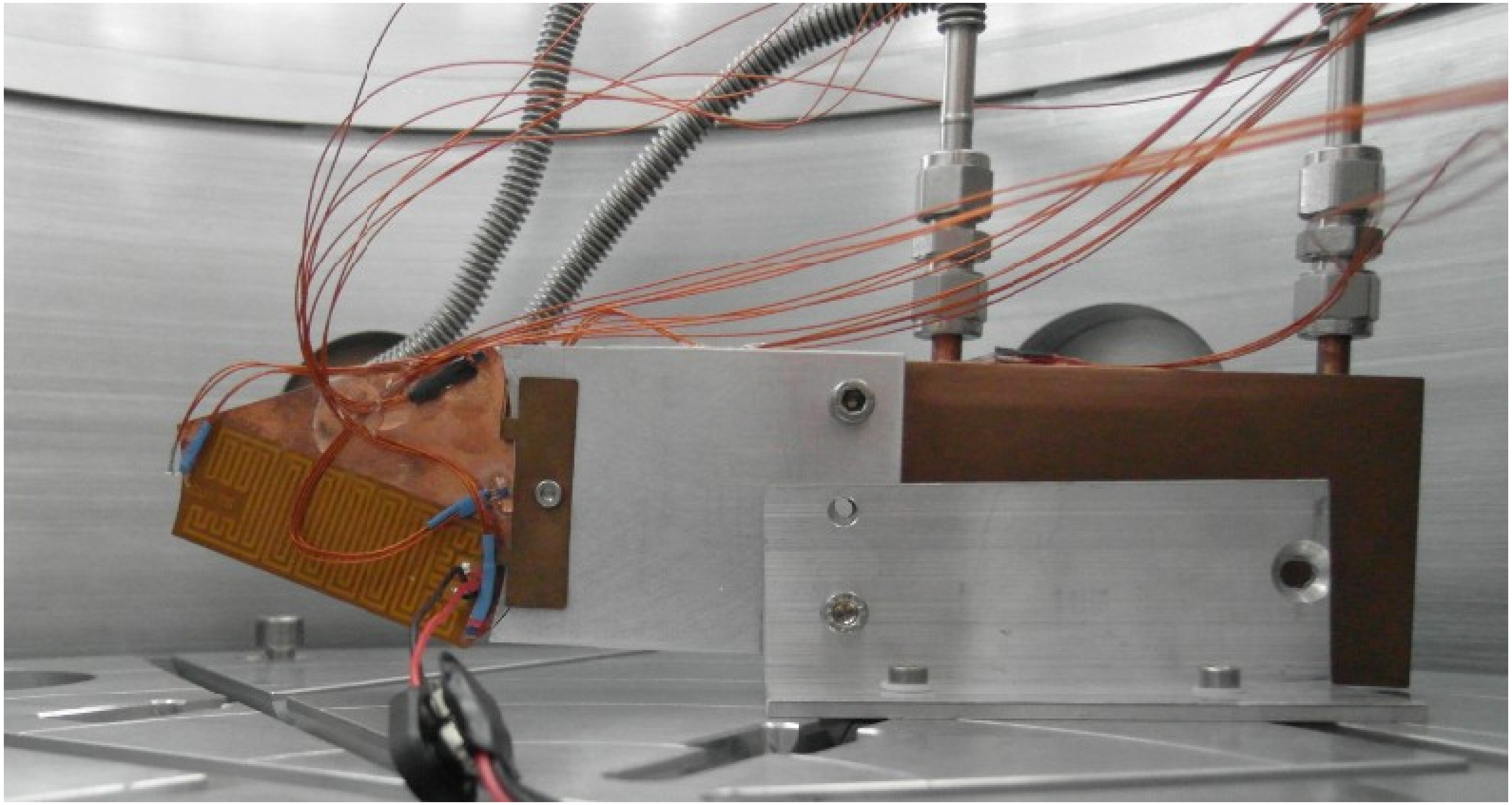
tracking plane

Simulations on cooling



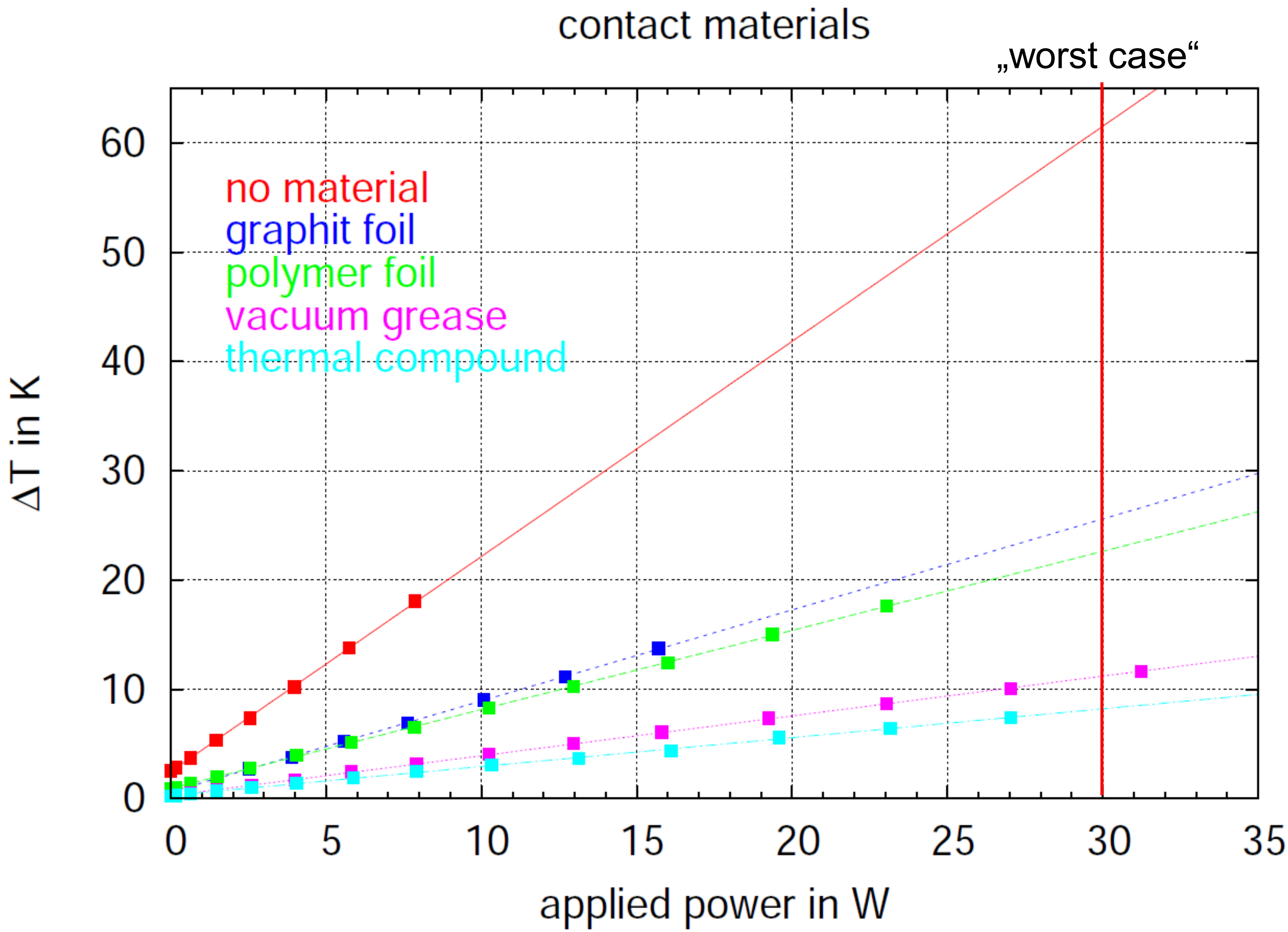

Hmmm, why don't we ...
Институт Ядерной Физики СО РАН
РАН
-20°
… dammit, we need vacuum!

Simulations vs. Reality

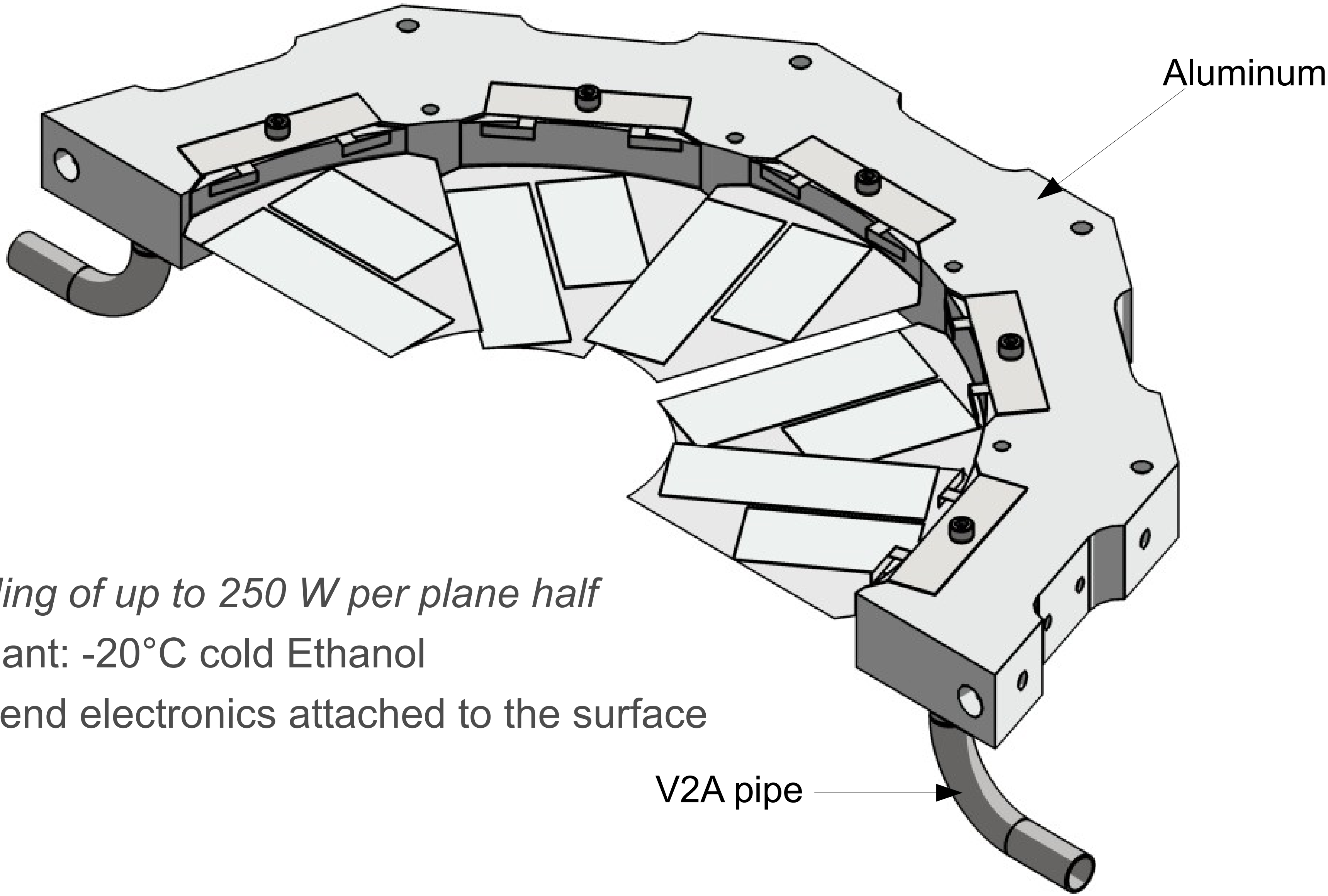


Testing contact materials for the module clamp and a copper dummy

Simulations vs. Reality



A Support Structure as a Heat Sink



Cooling of up to 250 W per plane half

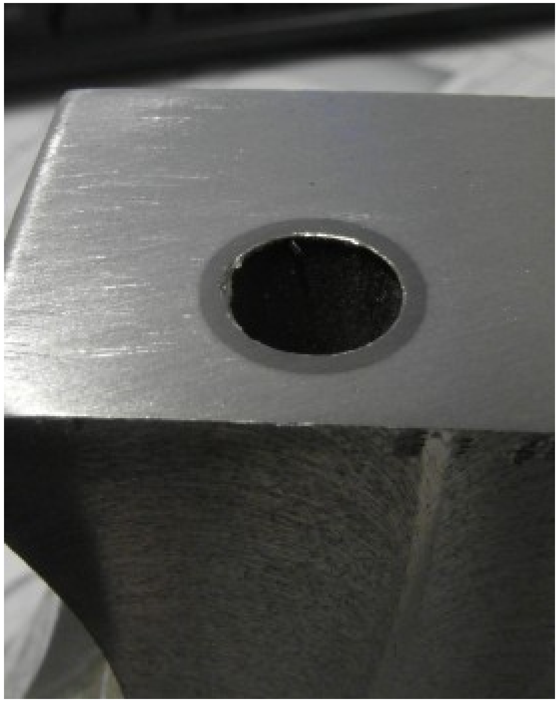
Coolant: -20°C cold Ethanol

frontend electronics attached to the surface

Production of Heat Sink Supports

Original idea: LHCb Velo Detector

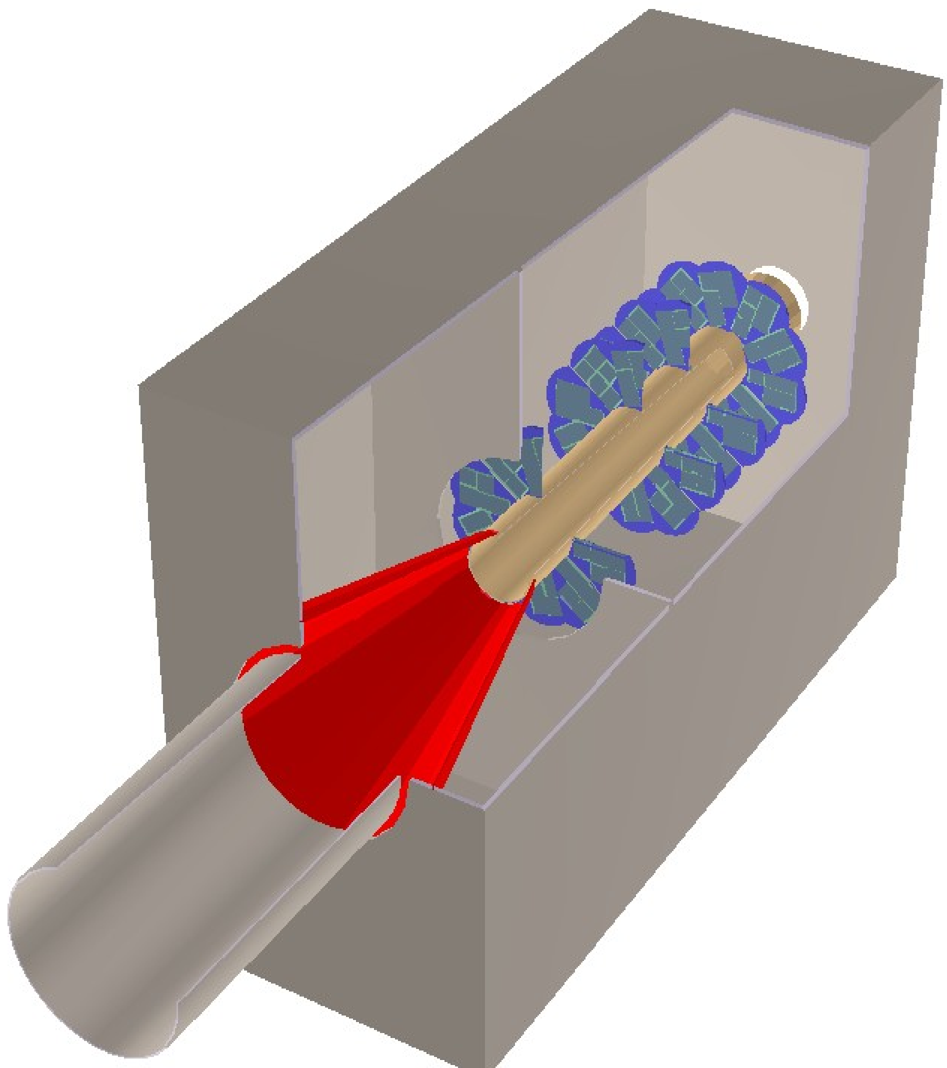
melting AlMg4.5Mn alloy for
730°C 90 min in argon atmosphere



Production of Heat Sink Supports

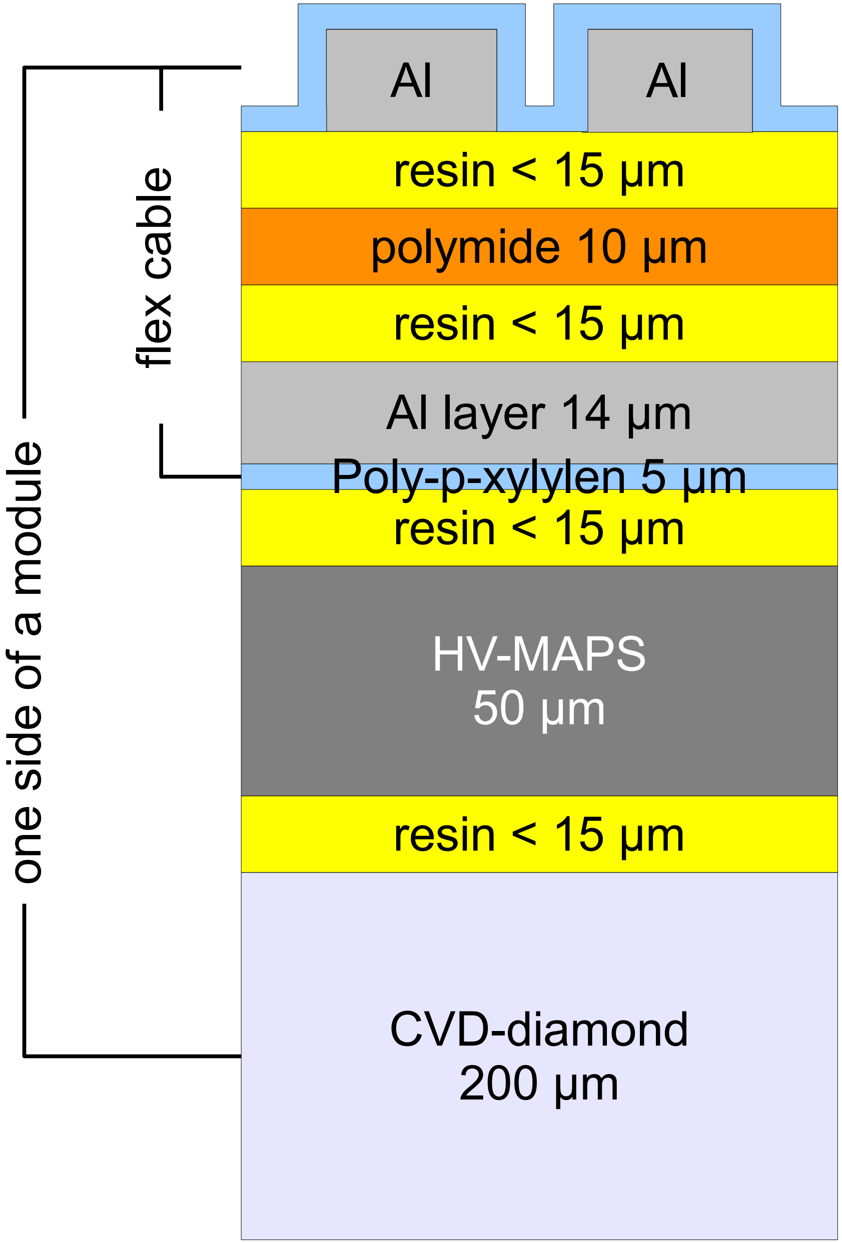
Right now:
Tests of the
cooling performance
in vacuum

Track Reconstruction



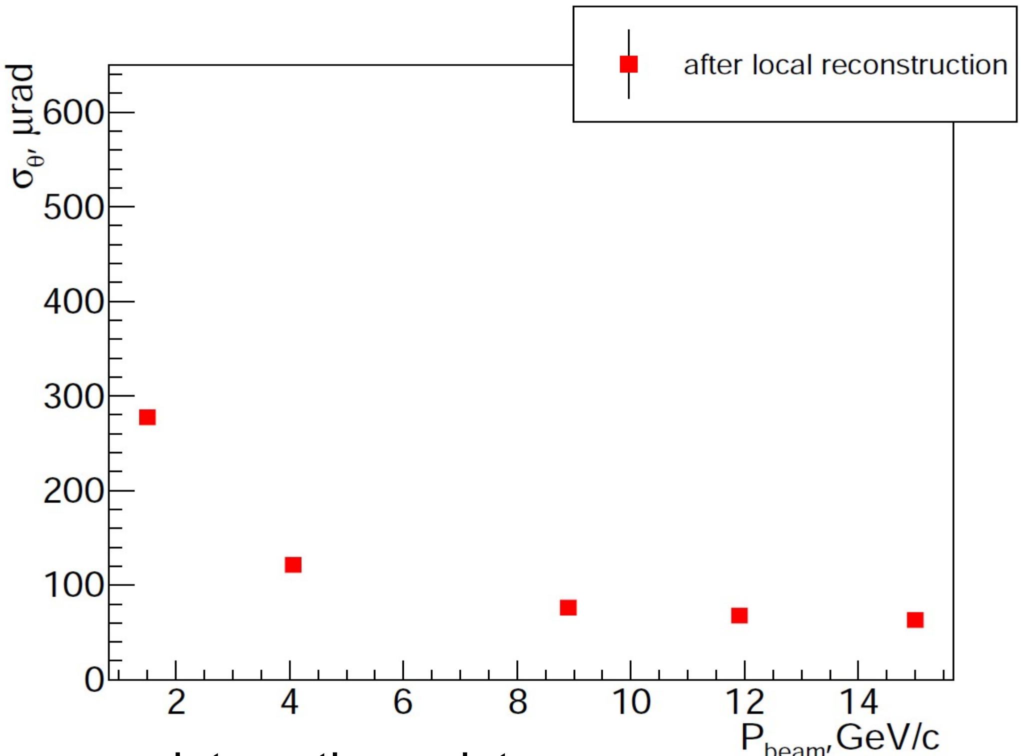
4 planes with distances of 20-10-10 cm in between
(Geant 4 simulation model)

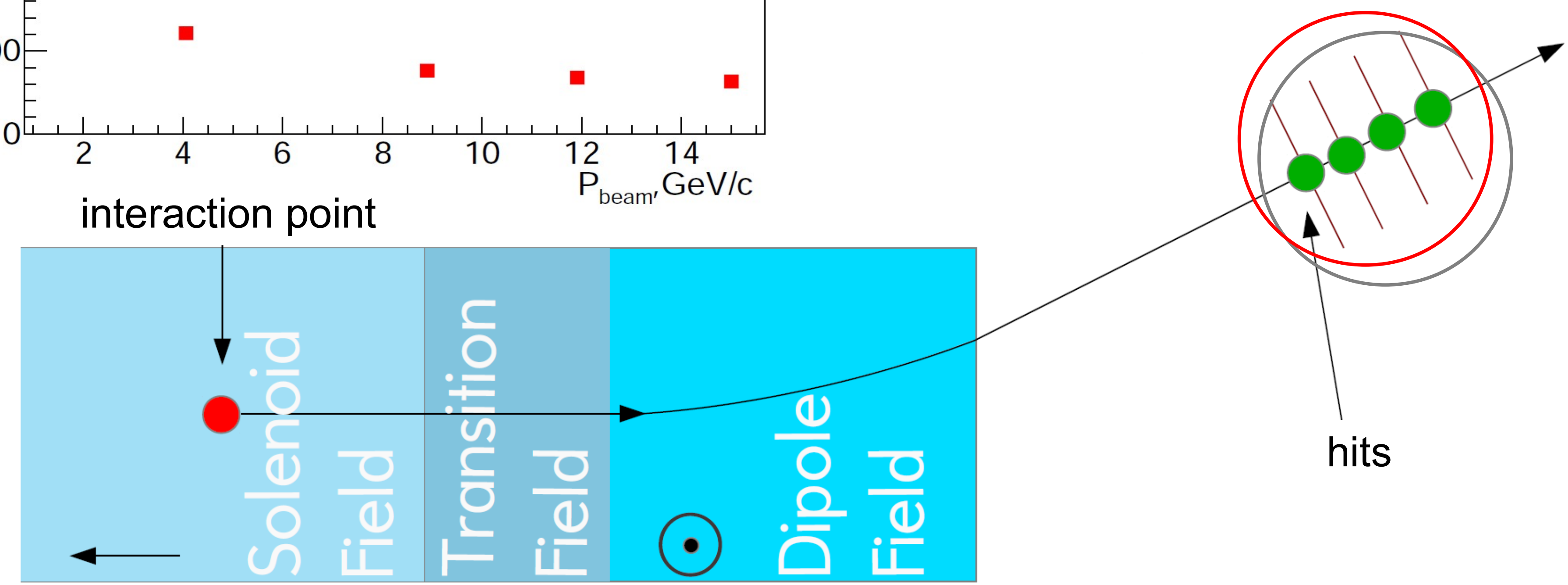
Material Budget of one Plane



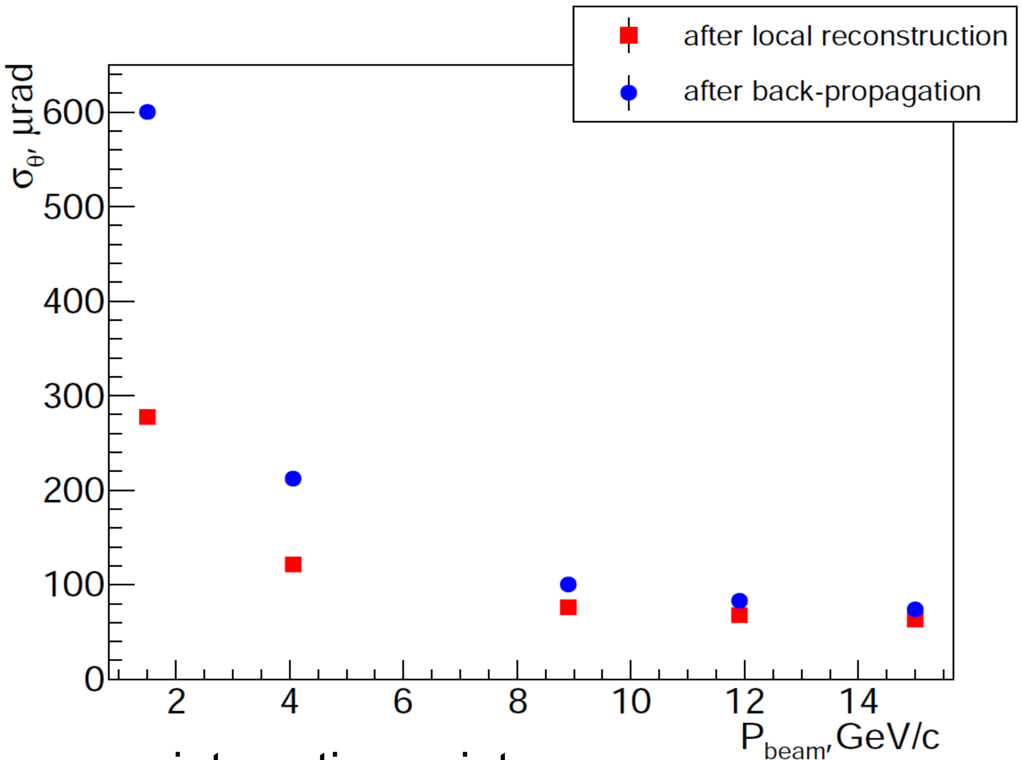
X/X_0 (2 sides) = 0.37%
(eq. 350 µm thick silicon)

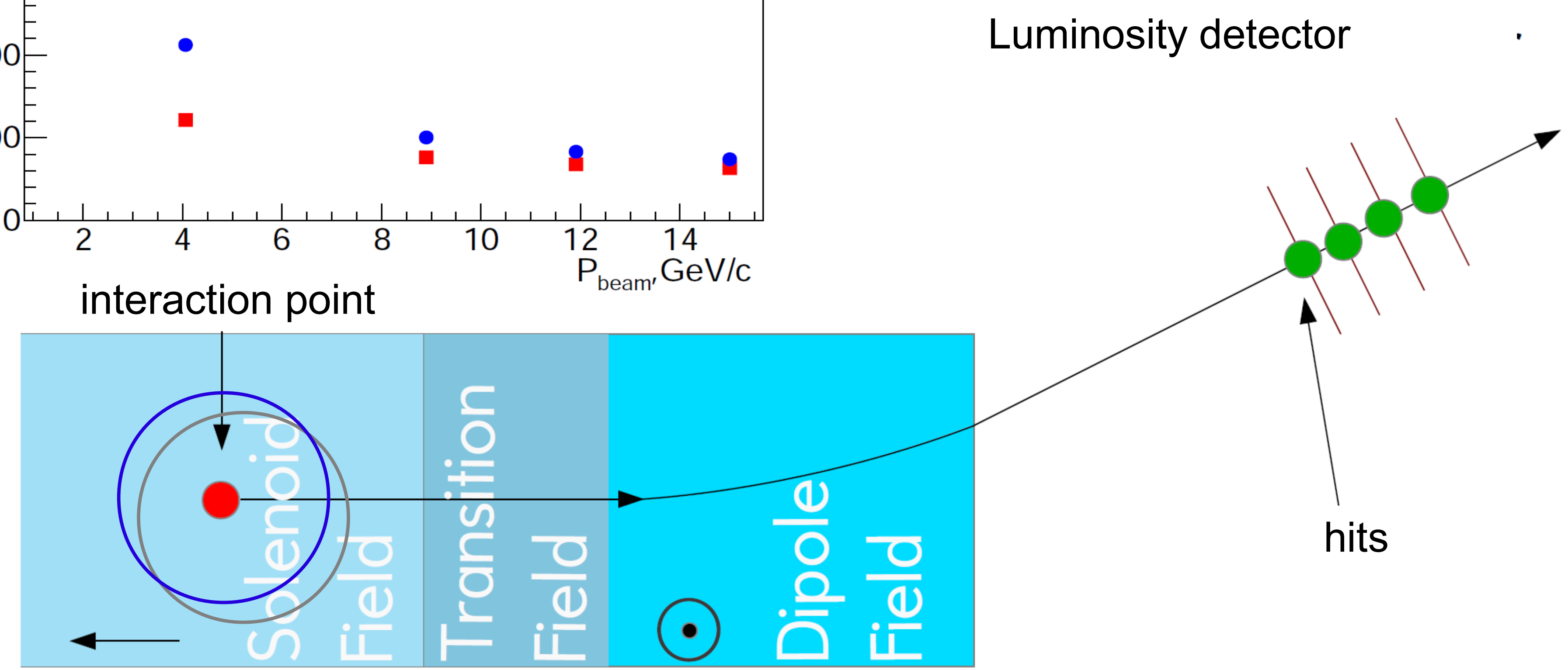
Resolution at the Detector



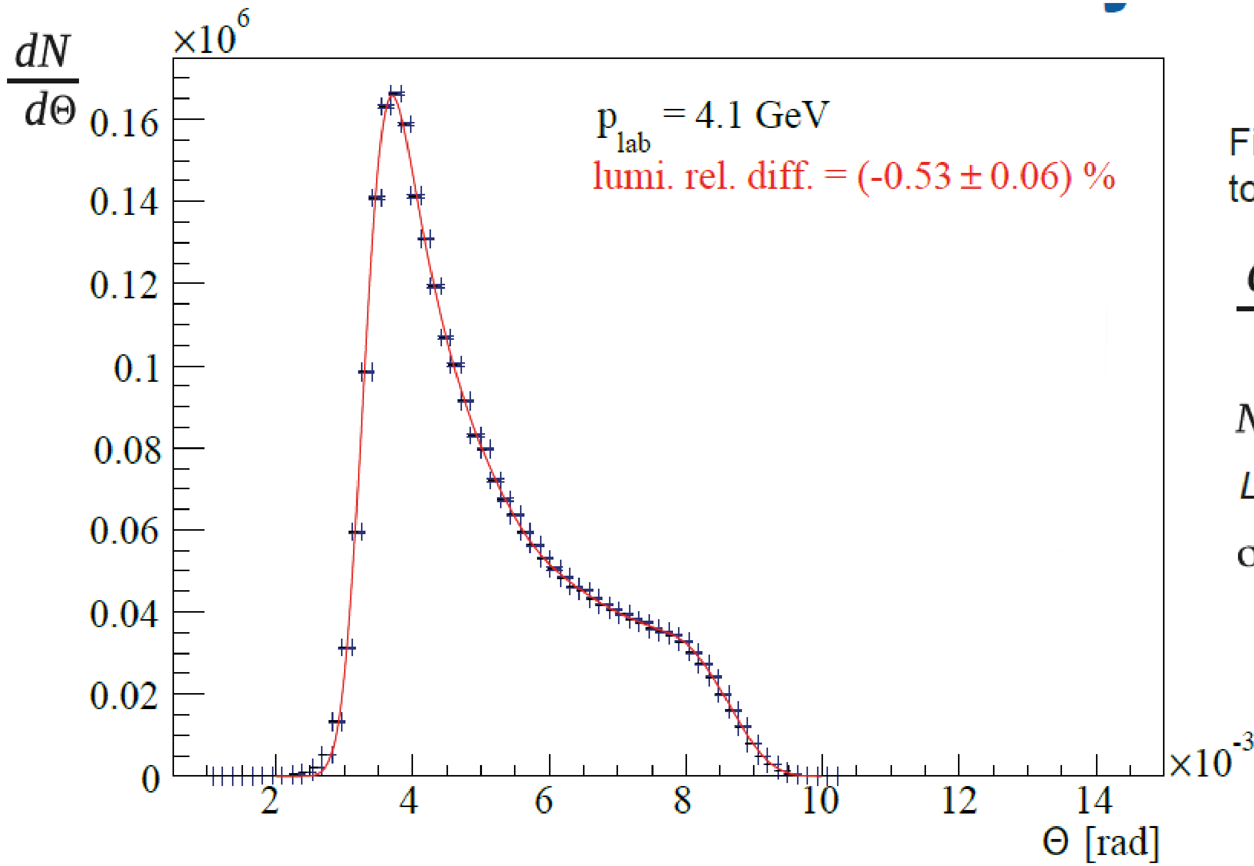


Resolution after back propagation





Fit of the Luminosity at 1.5 GeV/c



Fit of the model of the elastic cross section to the MC generated data distribution

$$\frac{dN}{d\Theta} = L \cdot \left(\frac{d\sigma}{d\Theta} \cdot \epsilon(\Theta) \right) \otimes R(\Theta)$$

N Number of events

L Luminosity

σ Elastic cross section

ϵ Efficiency

R Detector resolution

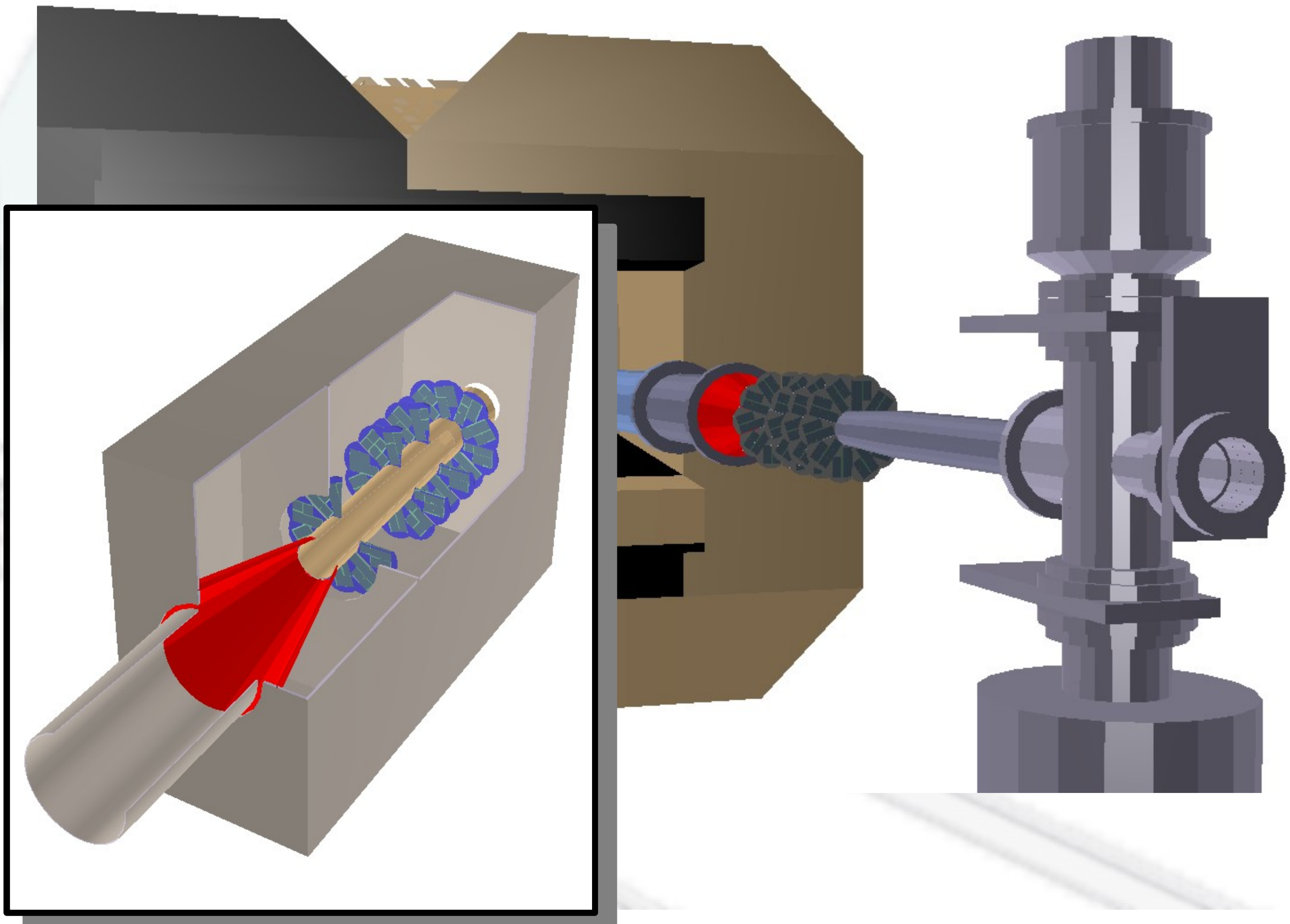
What's next?

Upcoming tests:

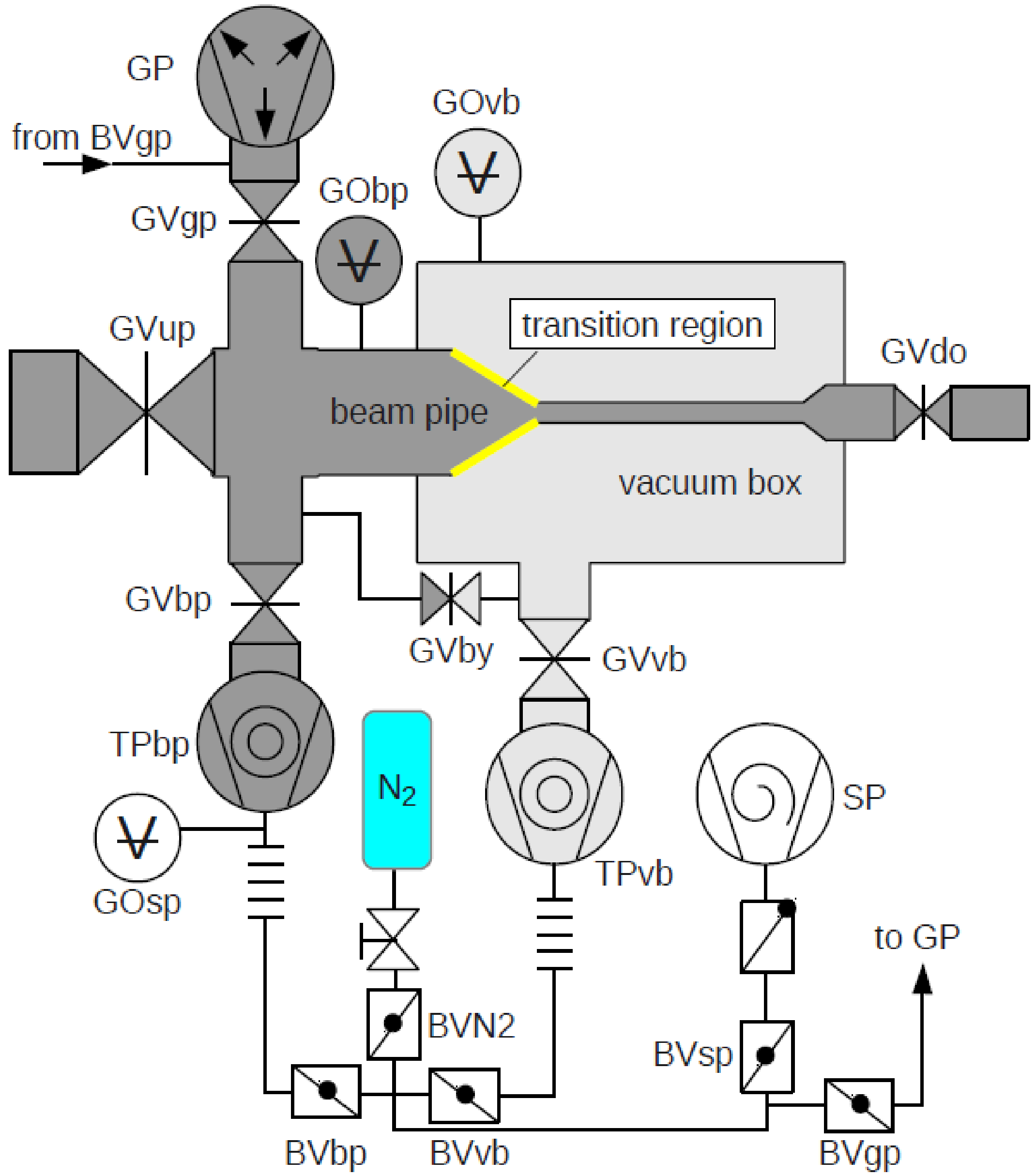
- A full cooling circuit at full load
- More on the mechanical precision
- Glued flex print vacuum feed throughs
- Gluing of thin sensors
- Systematic fit studies

Our goal: finalizing our TDR this year!

Simulations with PANDAROOT (Geant)



Differential Pumping Sheme



Cooling stations for cooling liquids

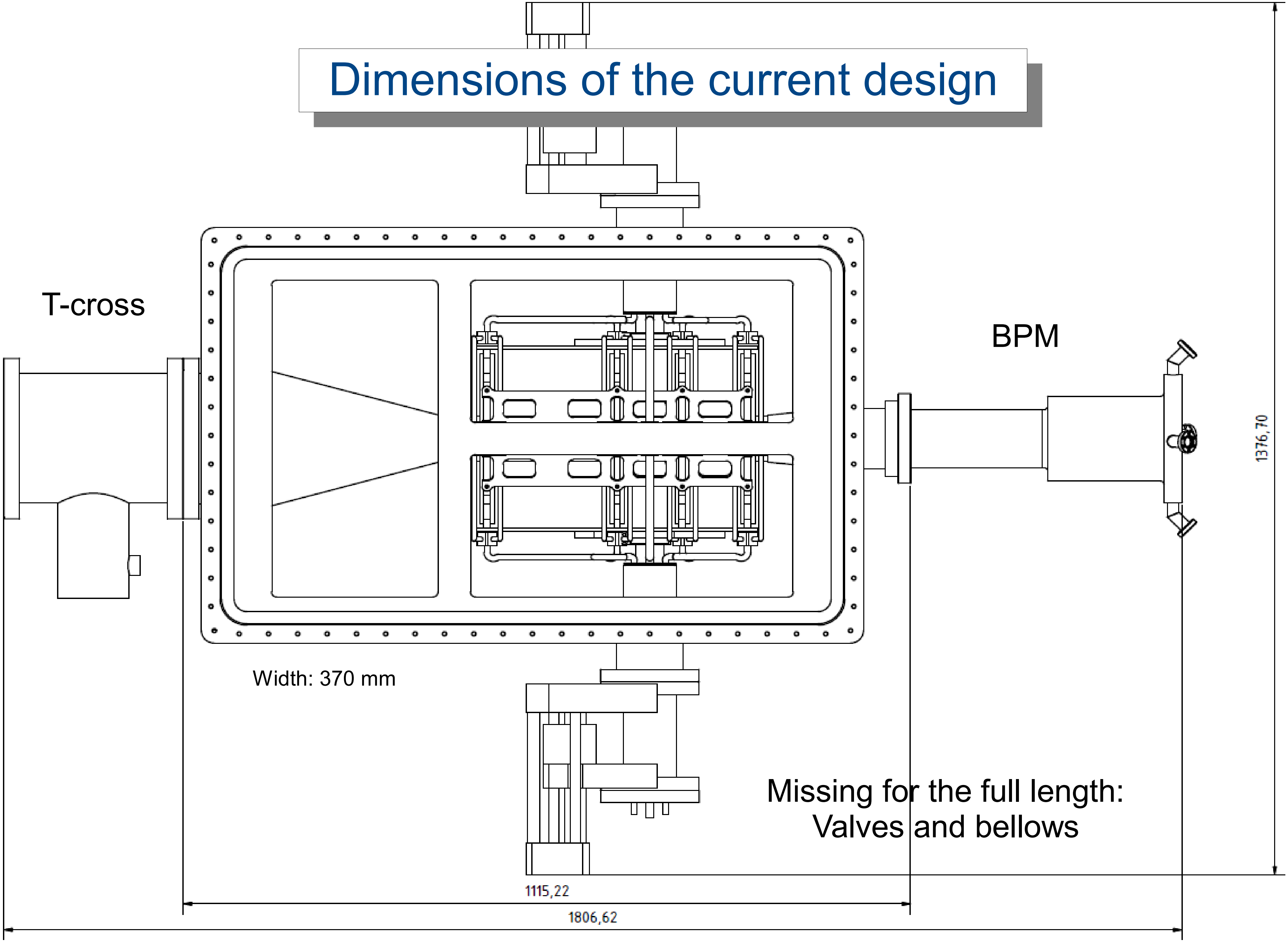
Huber Unistate 425 w

versus

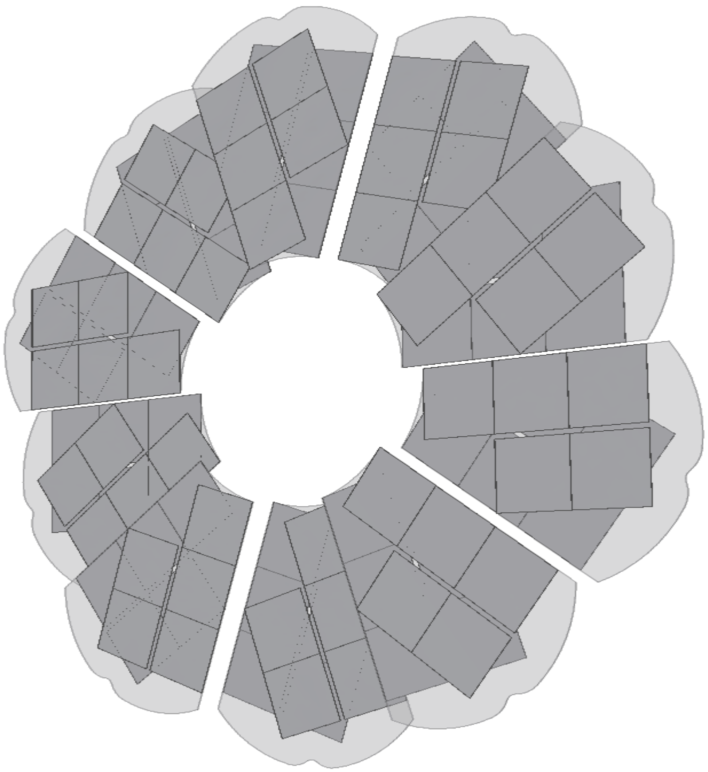
Cooling power @-20°C
1.9 kW 2.2kW
max. pumping speed
105 l/min 45 l/min
max. pumping pressure
2.5 bar(special version) 2.9 bar

Lauda XT 550 (W)

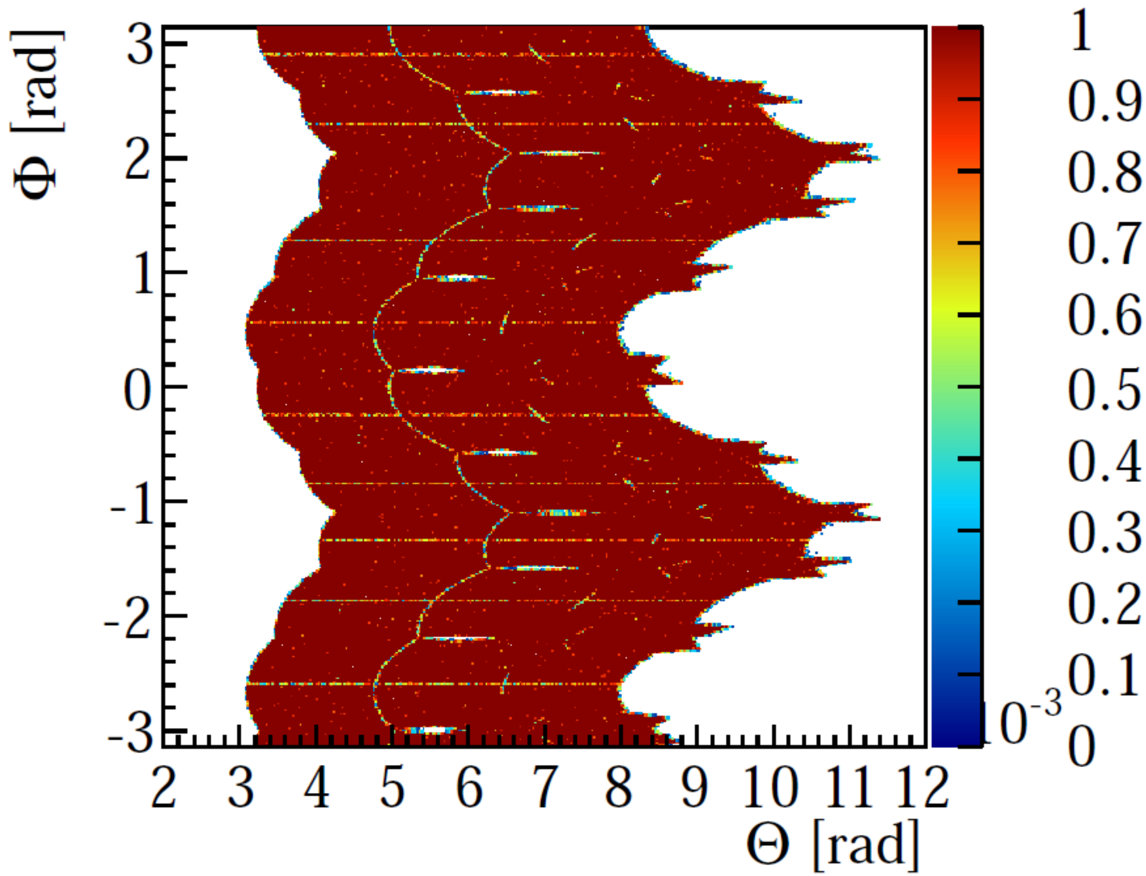
Dimensions of the current design



Geometrical Acceptance



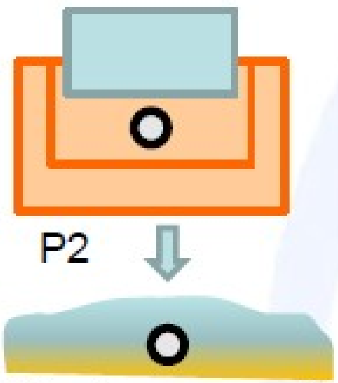
Acceptance at 1.5 GeV/c beam momentum



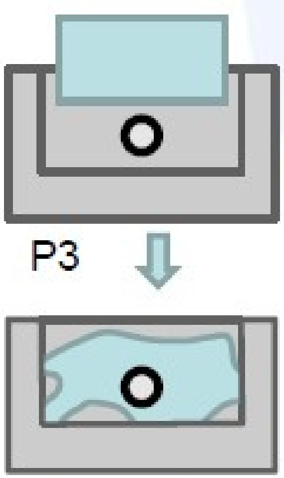
bverlaat@nikhef.nl

The biggest fun we had: *"Baking cookies"*

Welding tube inside



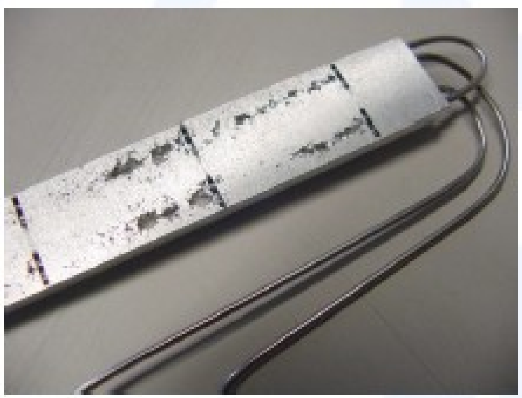
Melting in a copper mold



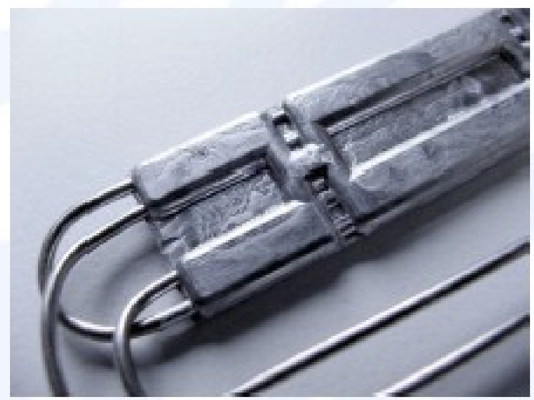
Melting in a SS mold with inert gas

- Question was: Can we melt aluminum cooling blocks around a stainless steel pipe?
  - As Aluminum crimps more we must get a nice crimp contact though?

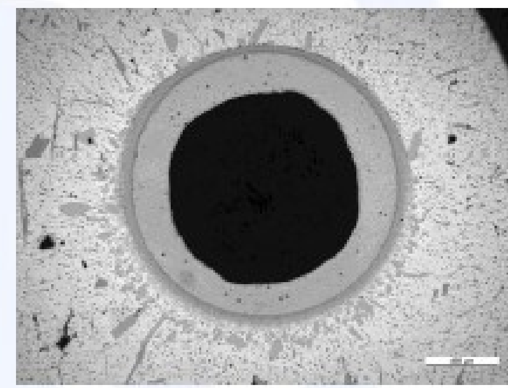
Prototype 4: Mg vapor bubbles due to vacuum



Prototype 5: Vacuum melting / pressurized freezing.. Perfect!



Applied vacuum method bonded SS to Alu by diffusion of Fe into Al



Result of vacuum baking:
A: Perfect contact around the pipe, B: perfect contra shape of the mold

- Aluminum cookie recipe:
  - Take a stainless steel tin and fill with aluminum blocks or bars (AlMg4,5Mn)
  - Melt aluminum under vacuum <1e-3 mbar at 700ºC for 1.5 hour
  - Apply 1 bar Argon pressure for 10 minutes
  - Switch of oven and let cool down.
  - Remove cookies from the mold and machine

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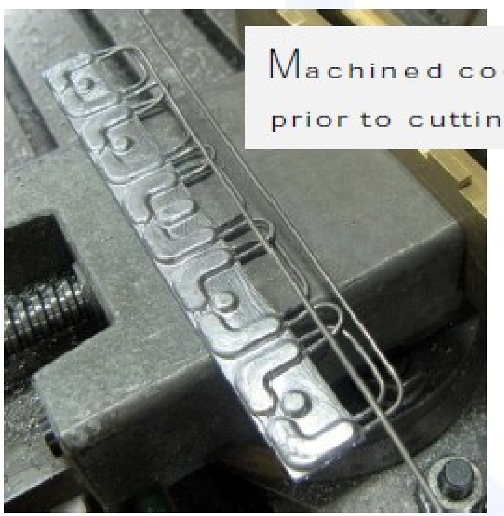
"The cookie bakery"


The bakery oven


Serial production baking


A bare cake

A sliced cake


Machined cookie prior to cutting


Tube bend jig


Mold detail


A delicious aluminum cake!

Magic pen to stop "super fluid aluminum"

First Pumping Tests