Beam Diagnostics:
a PhD Students' Perspective

Adam, Janusz, Massimiliano

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❶ PhD Project Start-Up

❷ Theory & Simulation

❸ Experimental Bits

PhD Project Start-Up

Understanding the Task

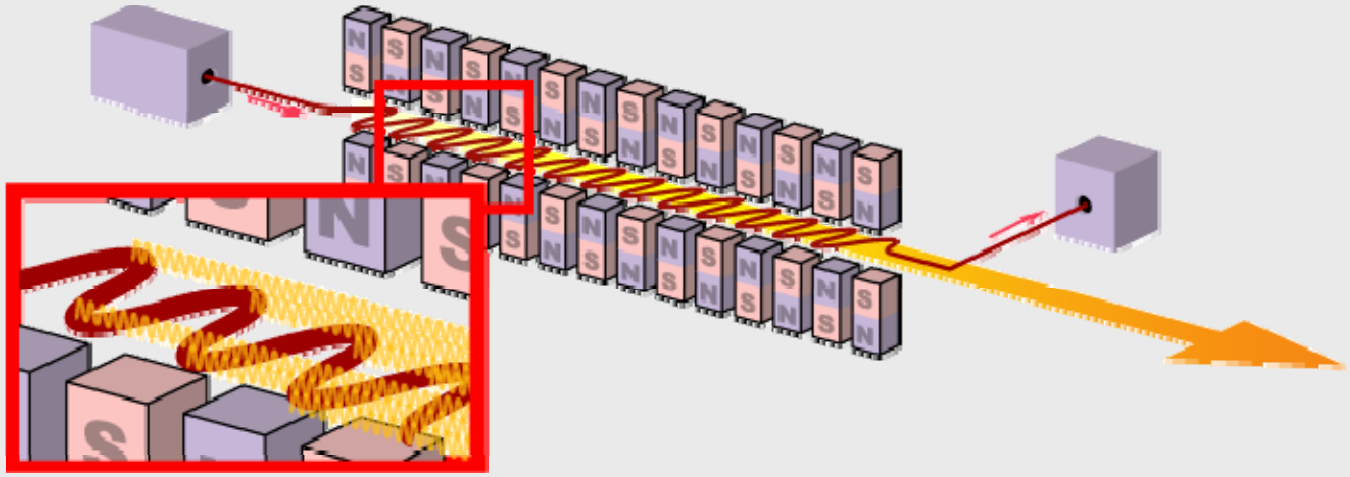
- What needs to be done?
- What has been done already?
- What do we need to develop?
- What are the challenges?

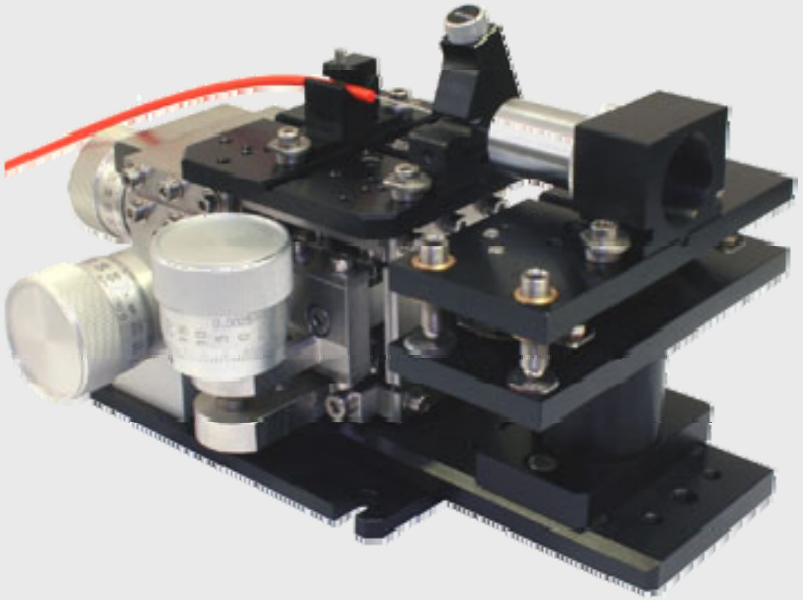
Projects: Adam

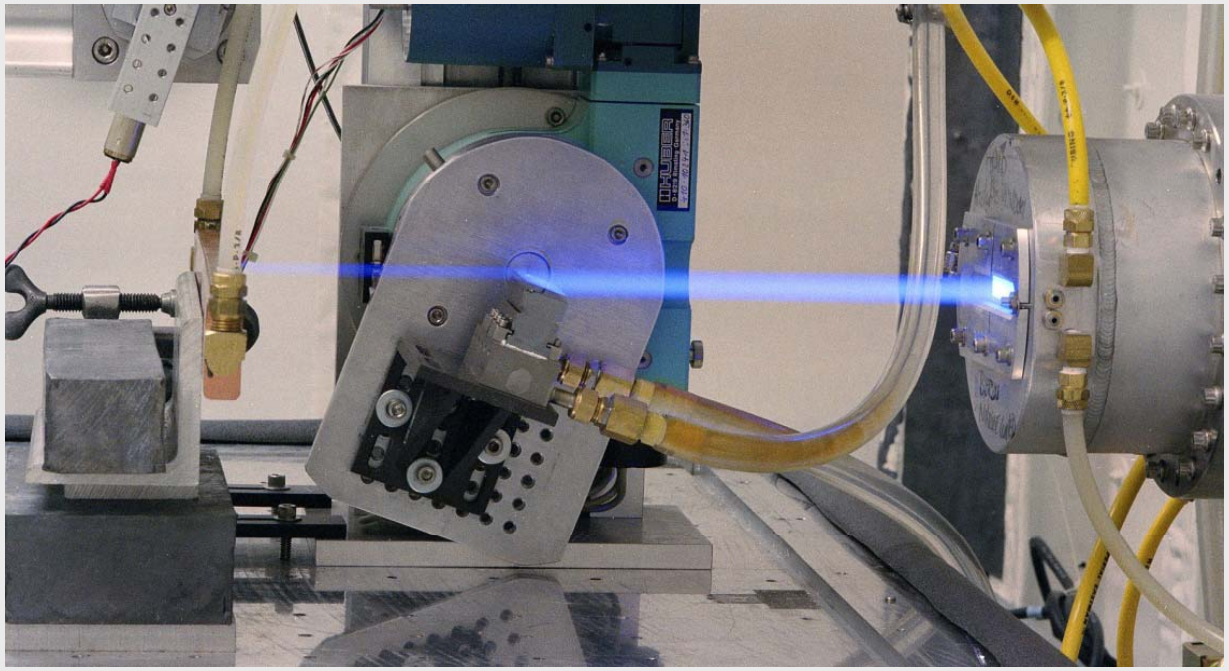
Development of a Longitudinal Beam Distribution Monitor for LHC

The Challenge

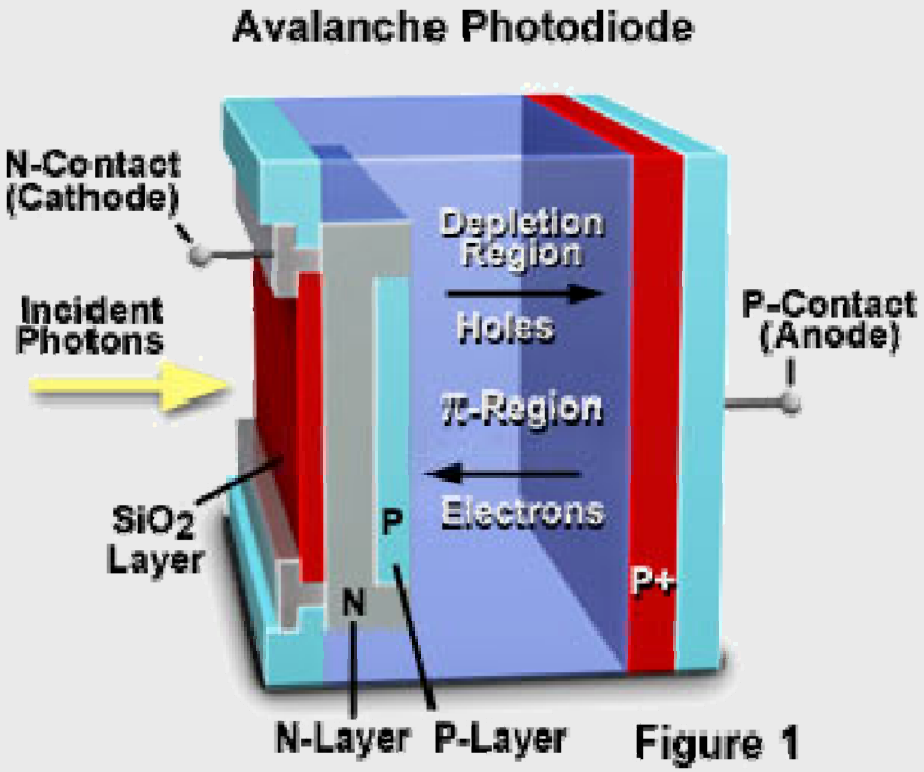
- **What exists:**
  - **Continuous bunch shape measurements**
    (eg. wall-current monitor)
  - **Fast bunch length measurements**
    (eg. electro-optic methods)
  - **High dynamic range measurements**
    (e.g. deflecting cavity)
- **What doesn't:**
  - **Something that combines them all**

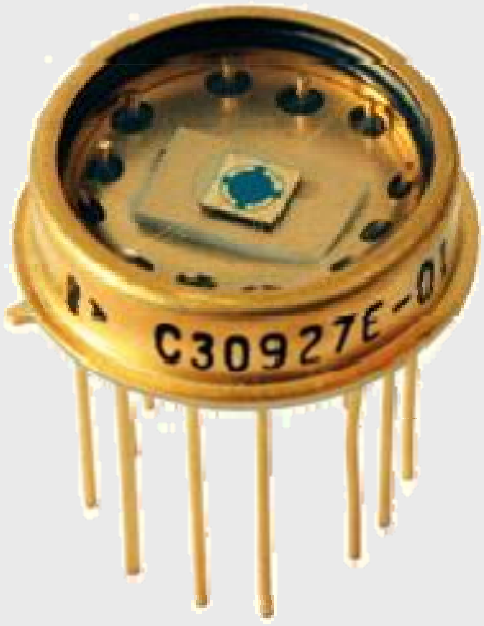


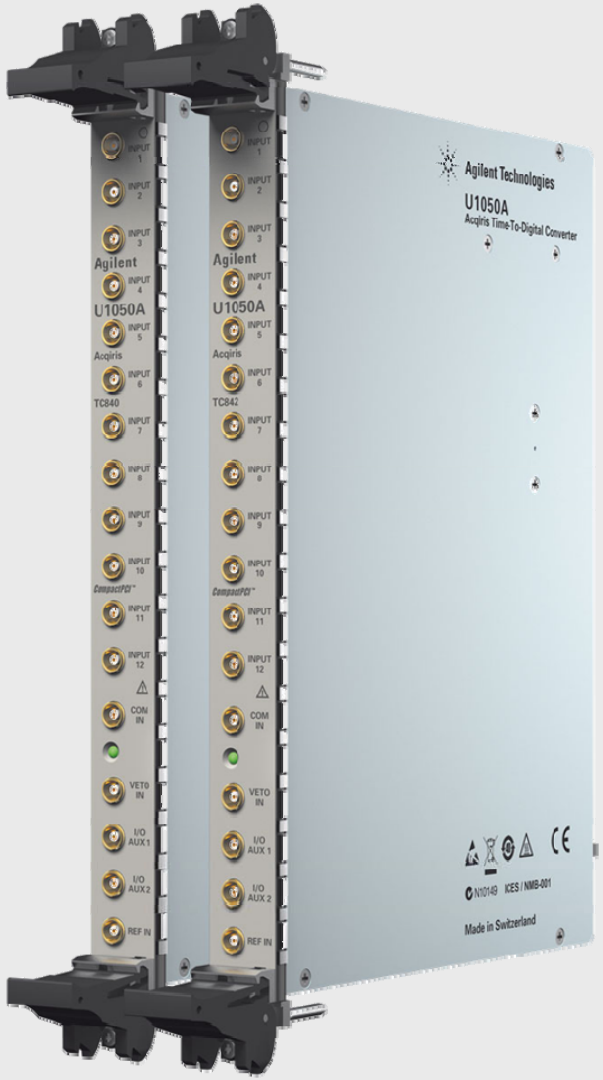




How to interact with the beam?







How to detect the light?

Projects: Janusz

Development of Novel Beam Instrumentation for Future Low-Energy Storage Rings

The Challenge

- **What exists:**

  All sort of monitors for various applications

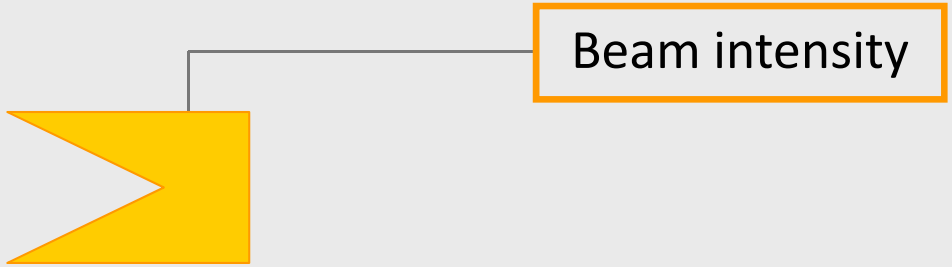
- **What doesn't:**

  Monitors optimised for exotic machines:

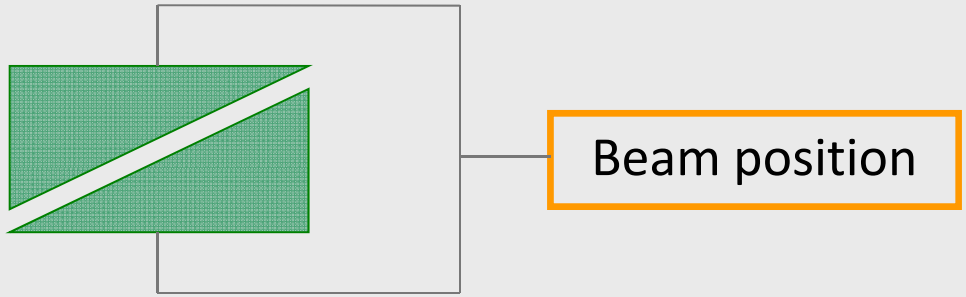
  - **Particle types:** **antiprotons & ions**
  - **Low energies:** **20 – 300 keV**
  - **Few particles:** **$<2\times10^{7}$**
  - **Low currents:** **down to 100 fA**
  - **High vacuum:** **$<10^{-11}$ mbar**

Detectors

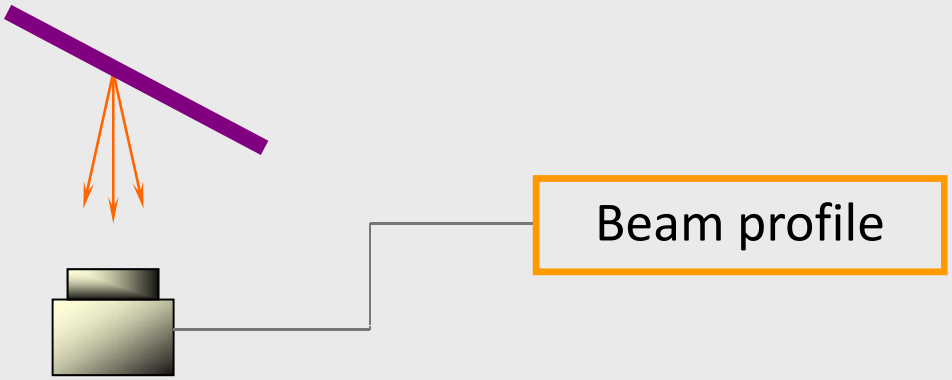
- **Faraday Cup**



- **Capacitive Pick-Up**



- **Scintillating Screen**
  (Secondary Emission Monitor)



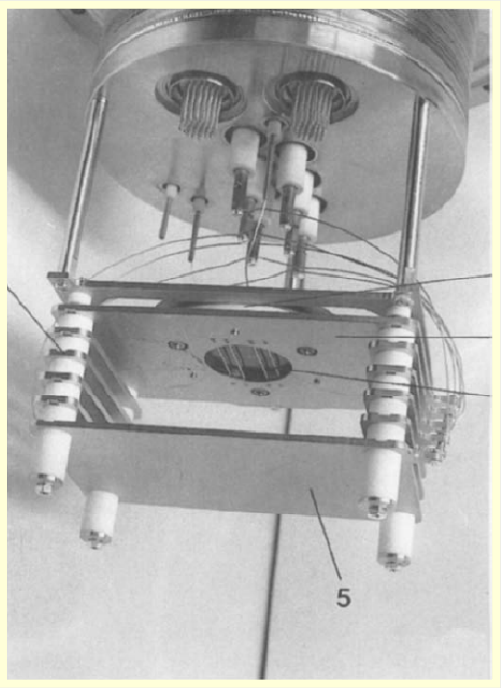
Challenges

- **Intensity**
  - Current range: μA → fA
  - Close to noise limitations (fA)
  - No standard UHV components for low level measurements
- **Position**
  - Low signal: ~250 nV @ 0.1 mm
  - Noise level: >2.5 μV @ 20 MHz
  - Low velocity: 0.025 c → 0.006 c
- **Profile**
  - Low energy: <300 keV
  - Low intensity: ~10^6 pps (sub-pA)
  - Particles: antiprotons AND protons

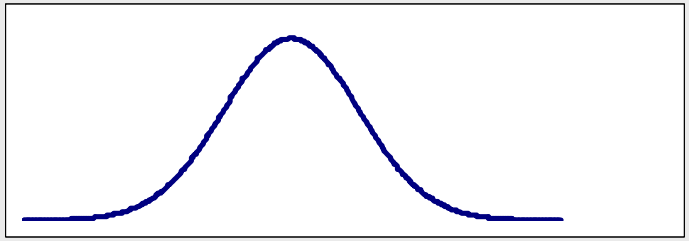
Projects: Massimiliano

Development of a Modified Neutral Beam Scanner

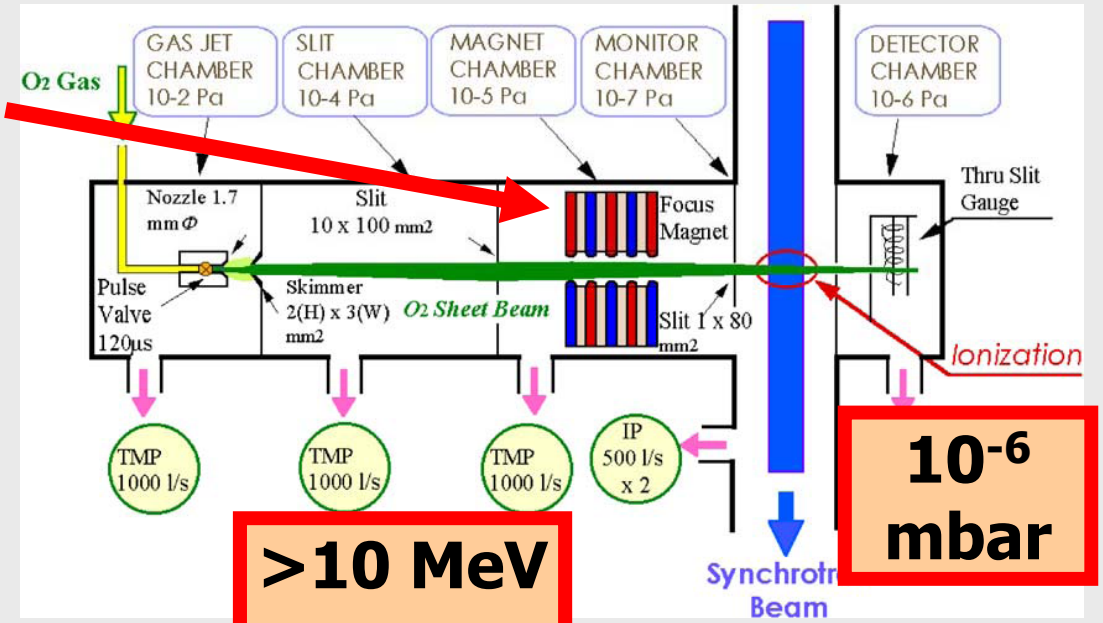
State of the Art



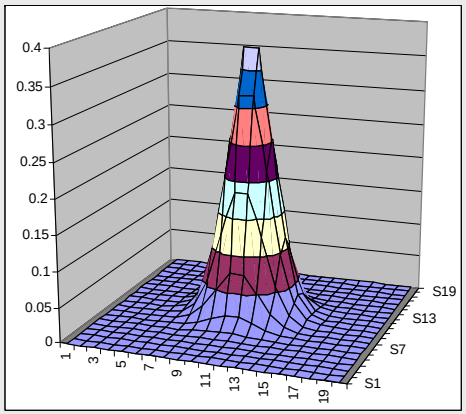
- High pressures (>10^{-7} mbar)
- 1D profiles



>2 Tesla



10^{-6} mbar

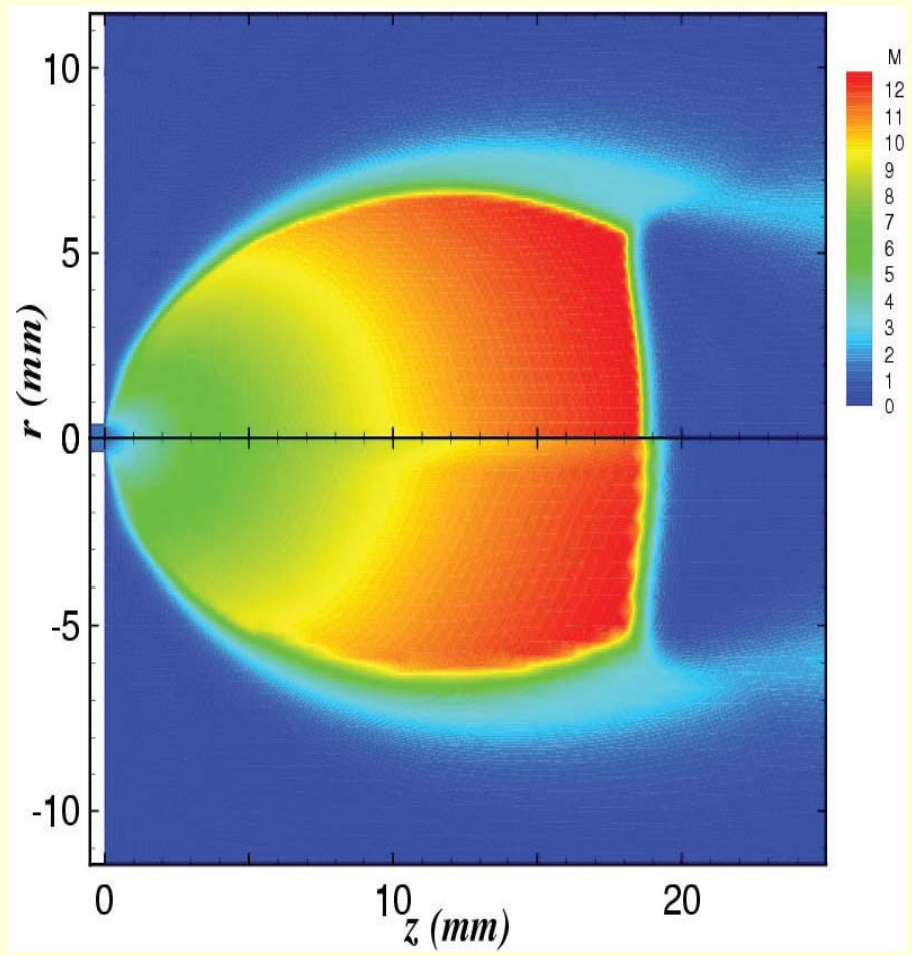


- 2D profiles

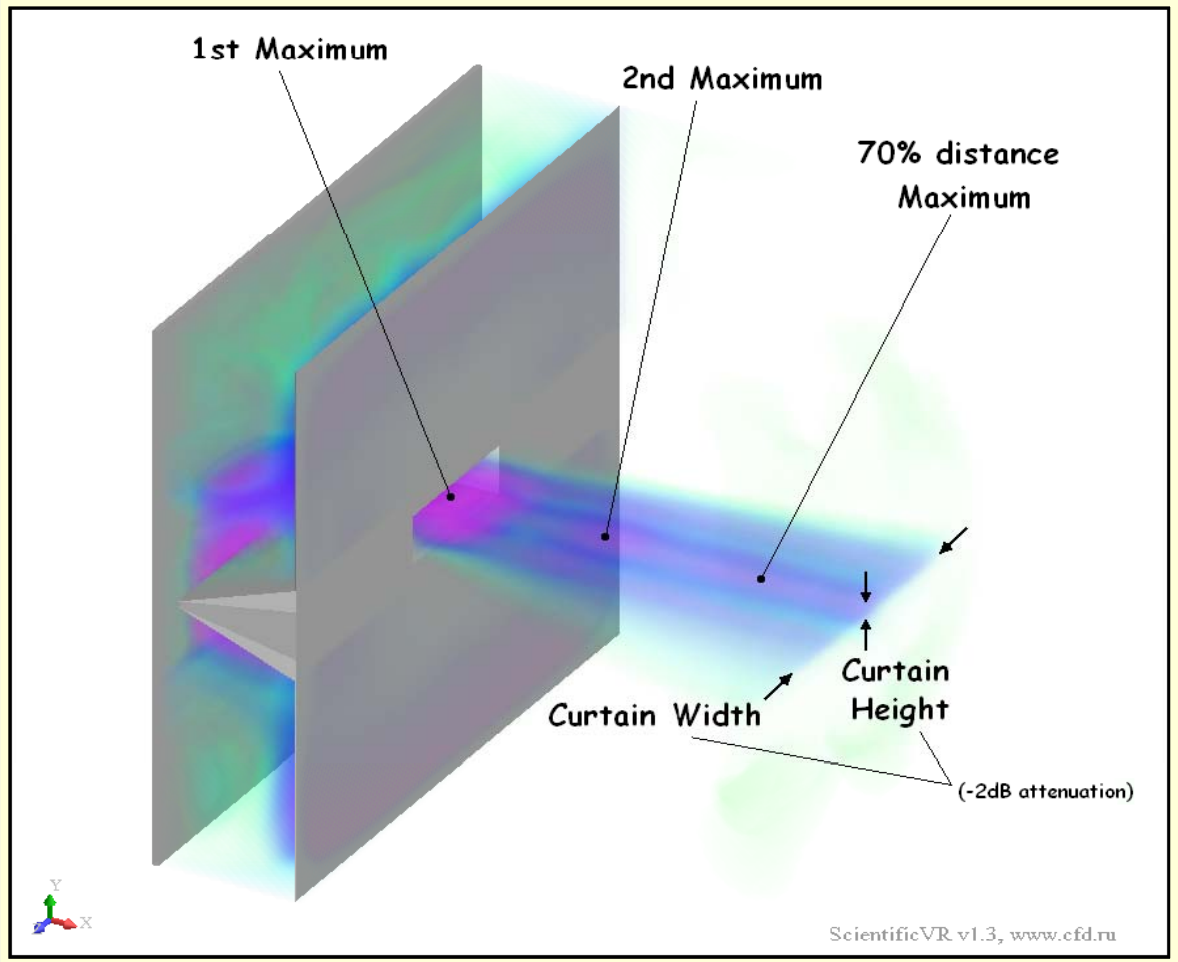
>10 MeV energy

The Challenge: gas curtain

What exists:

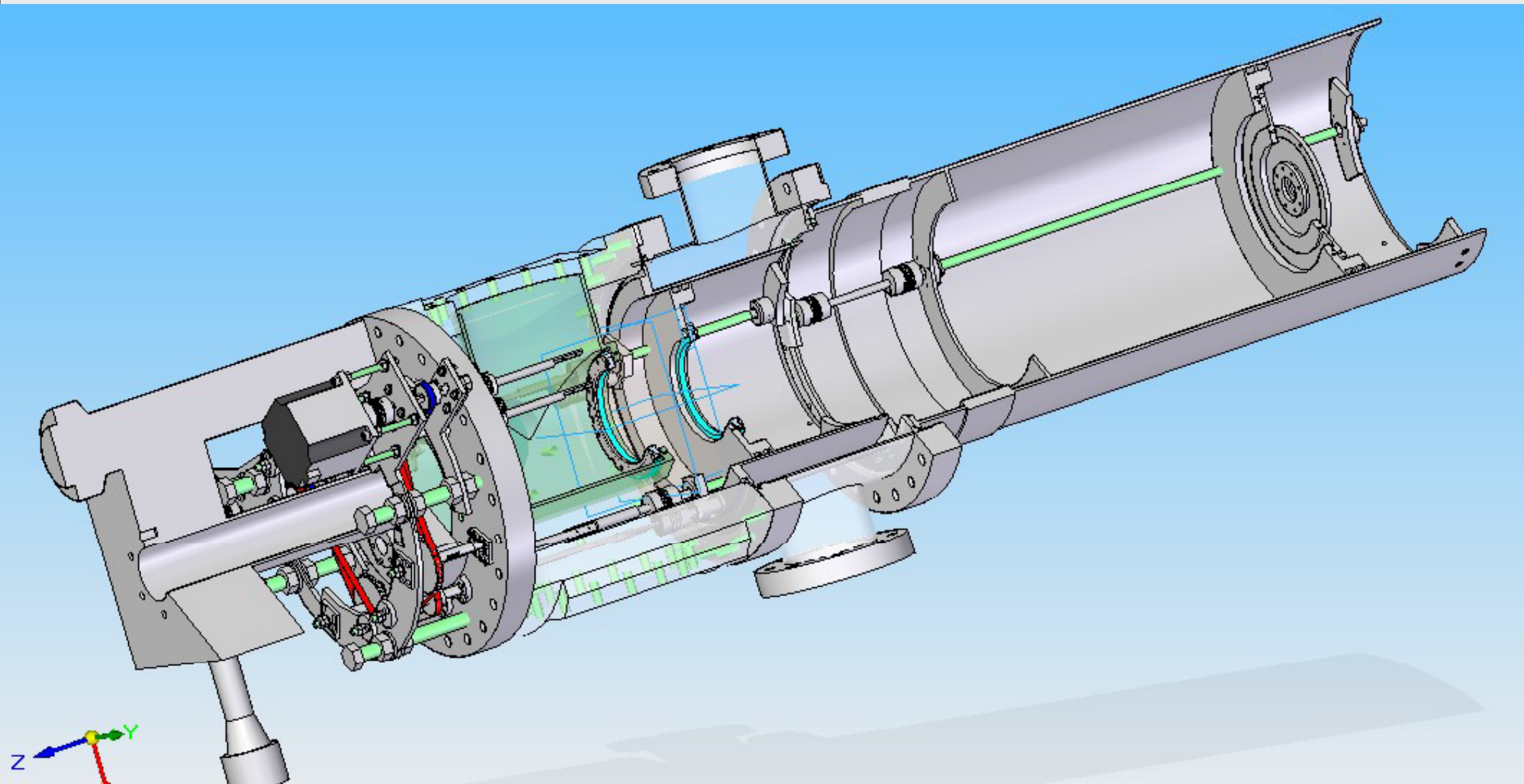


What doesn't:



The Challenge: gas curtain

What exists: **What doesn't:**

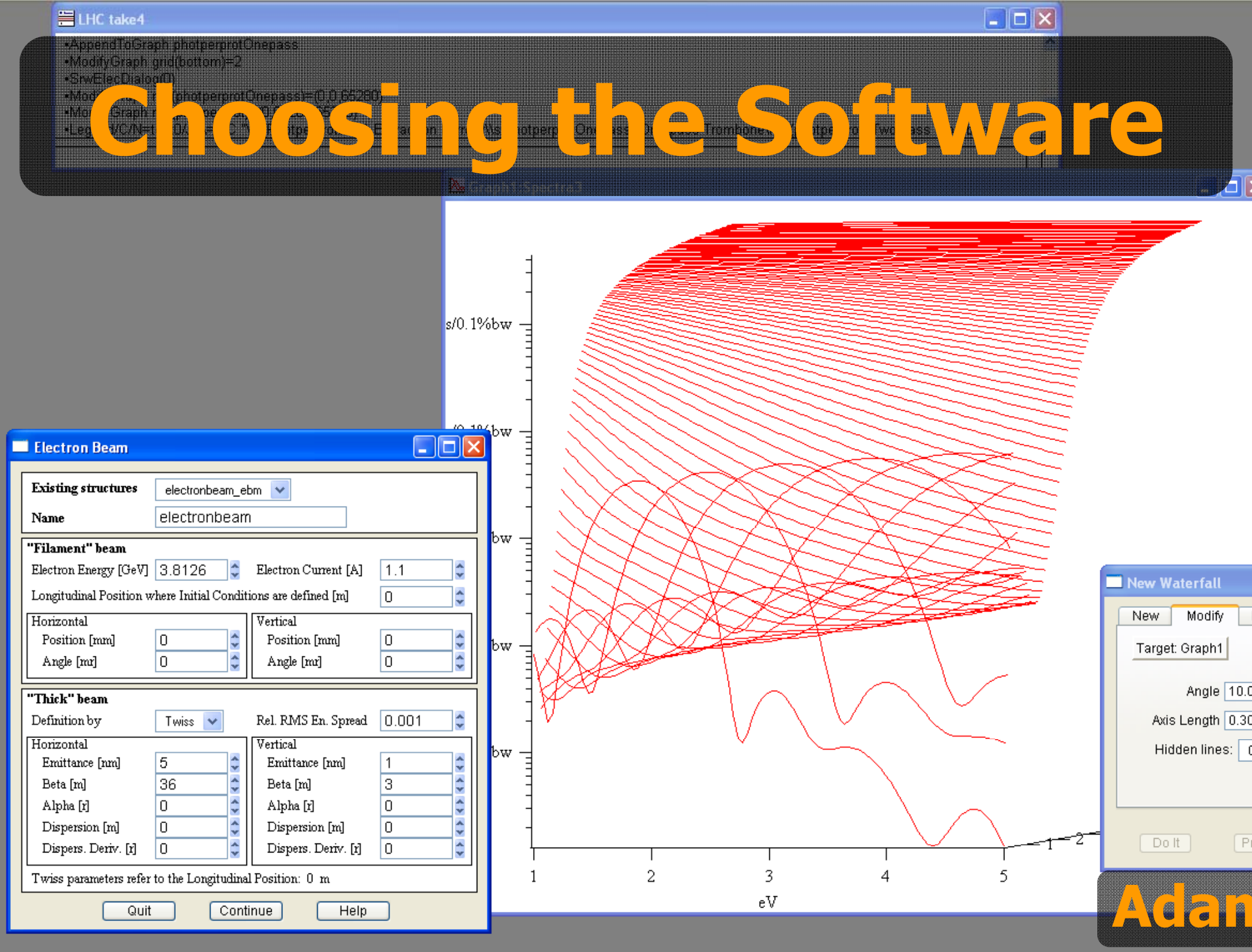


Theory & Simulation

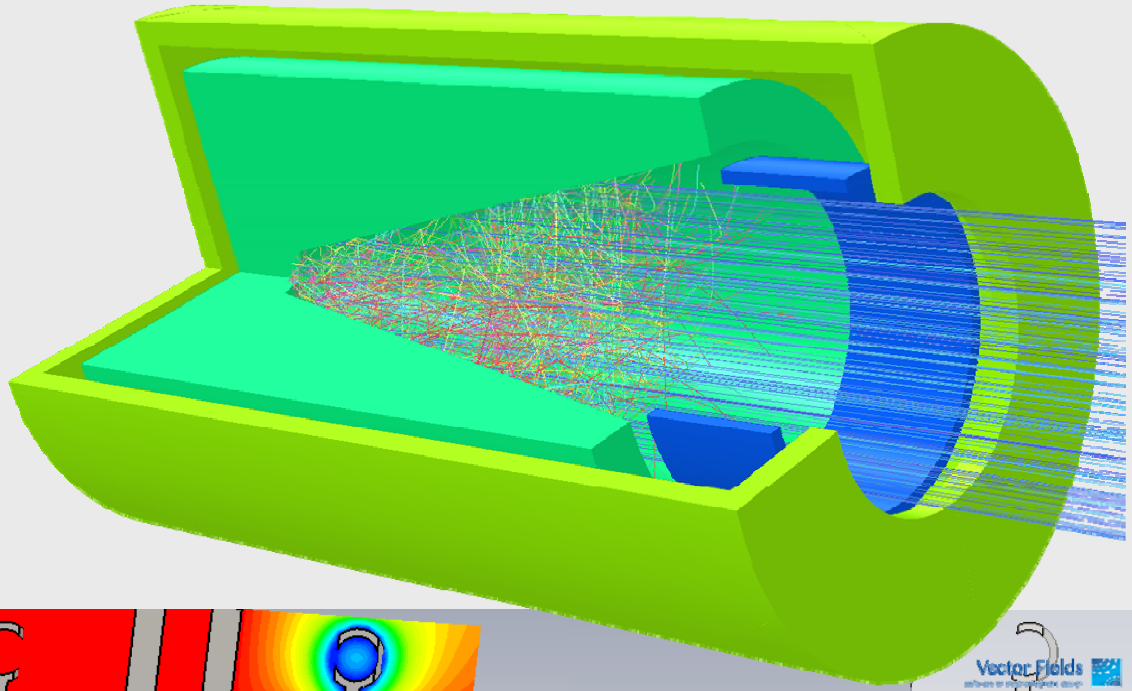
Understanding our detectors

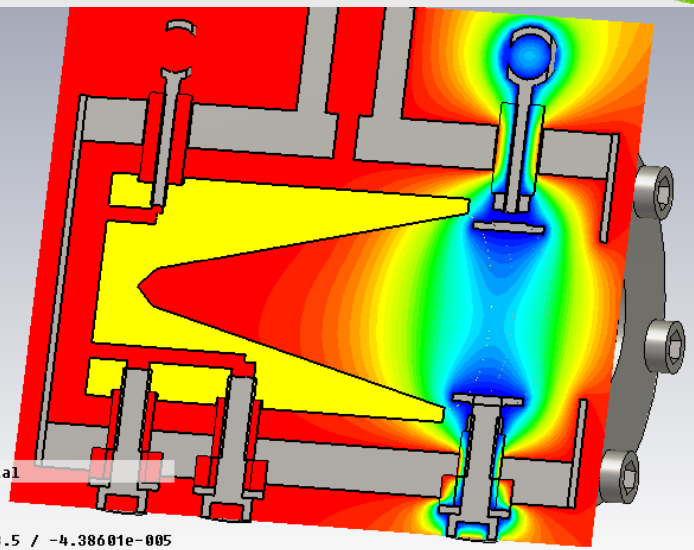
- How does the detector react?
- What will the results mean?
- How can we optimise the performance?

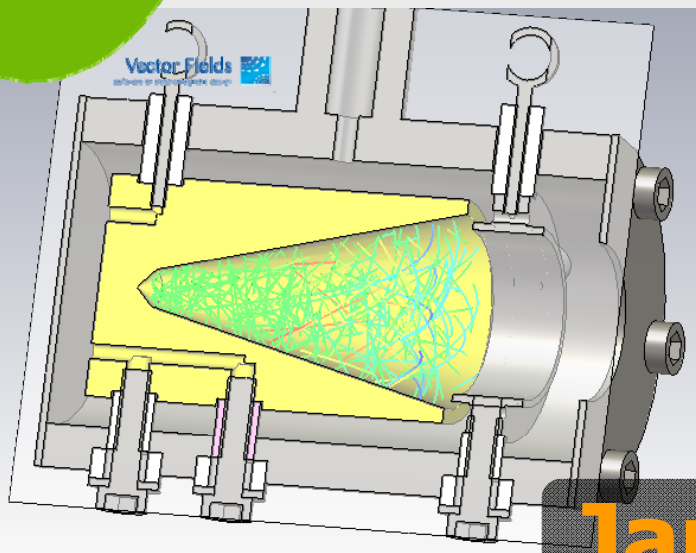
Choosing the Software



Choosing the Software

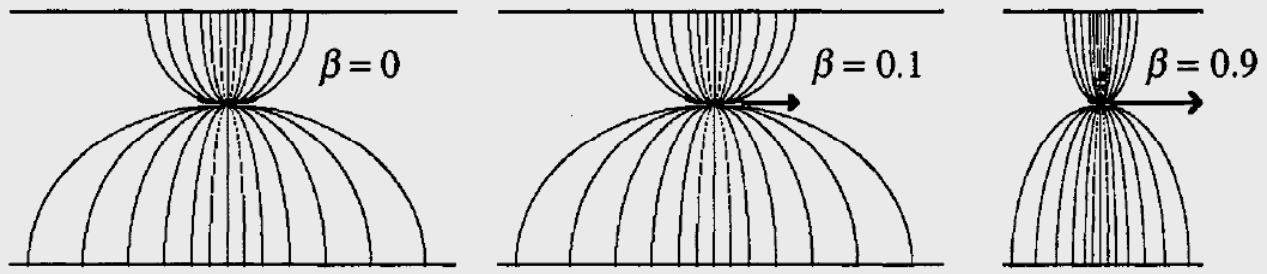




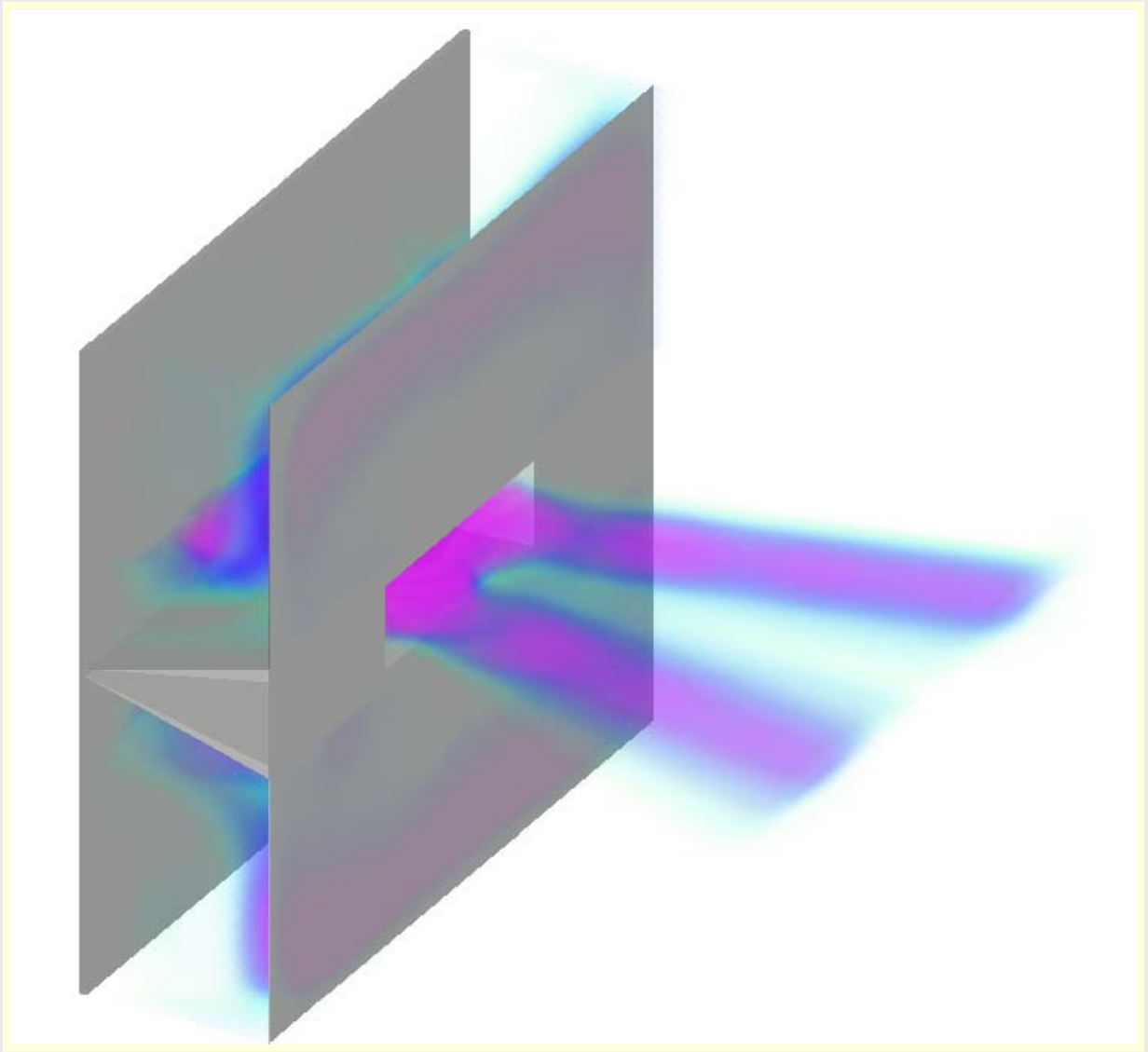


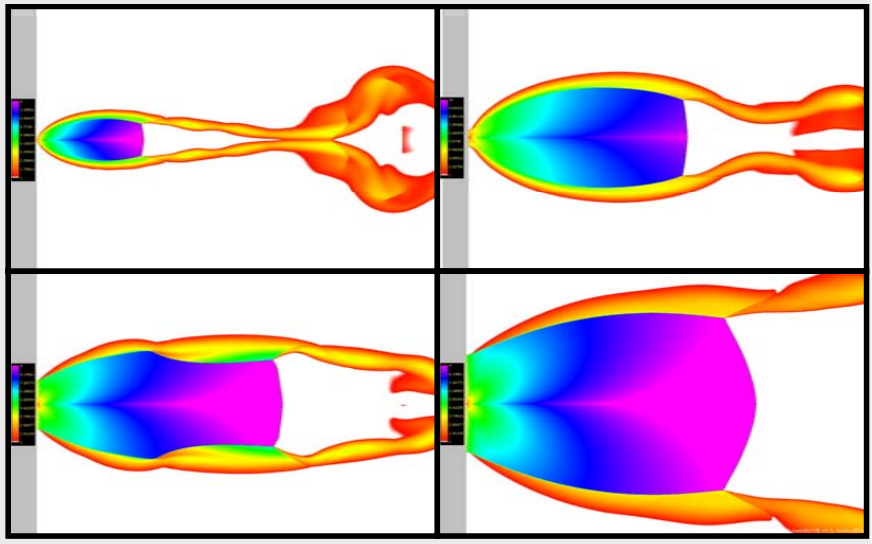
Janusz

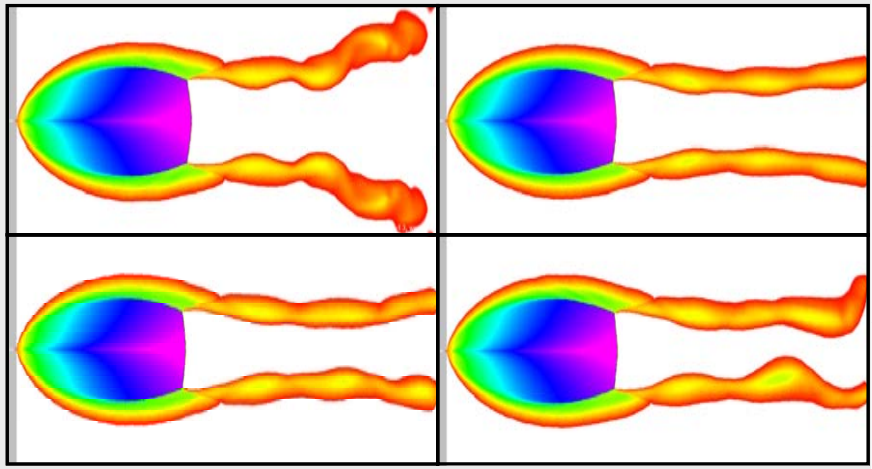
Choosing the Software



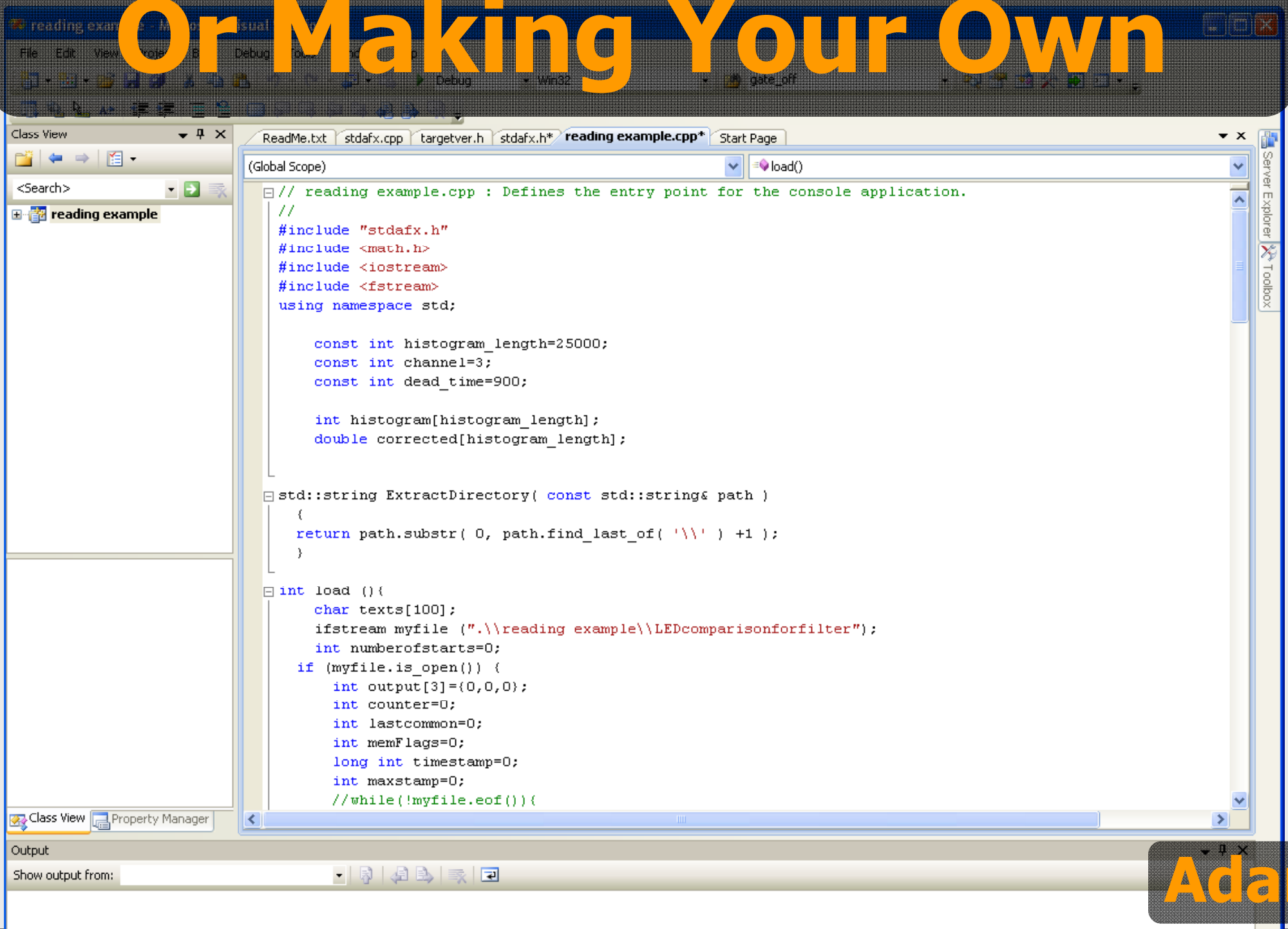
Choosing the Software





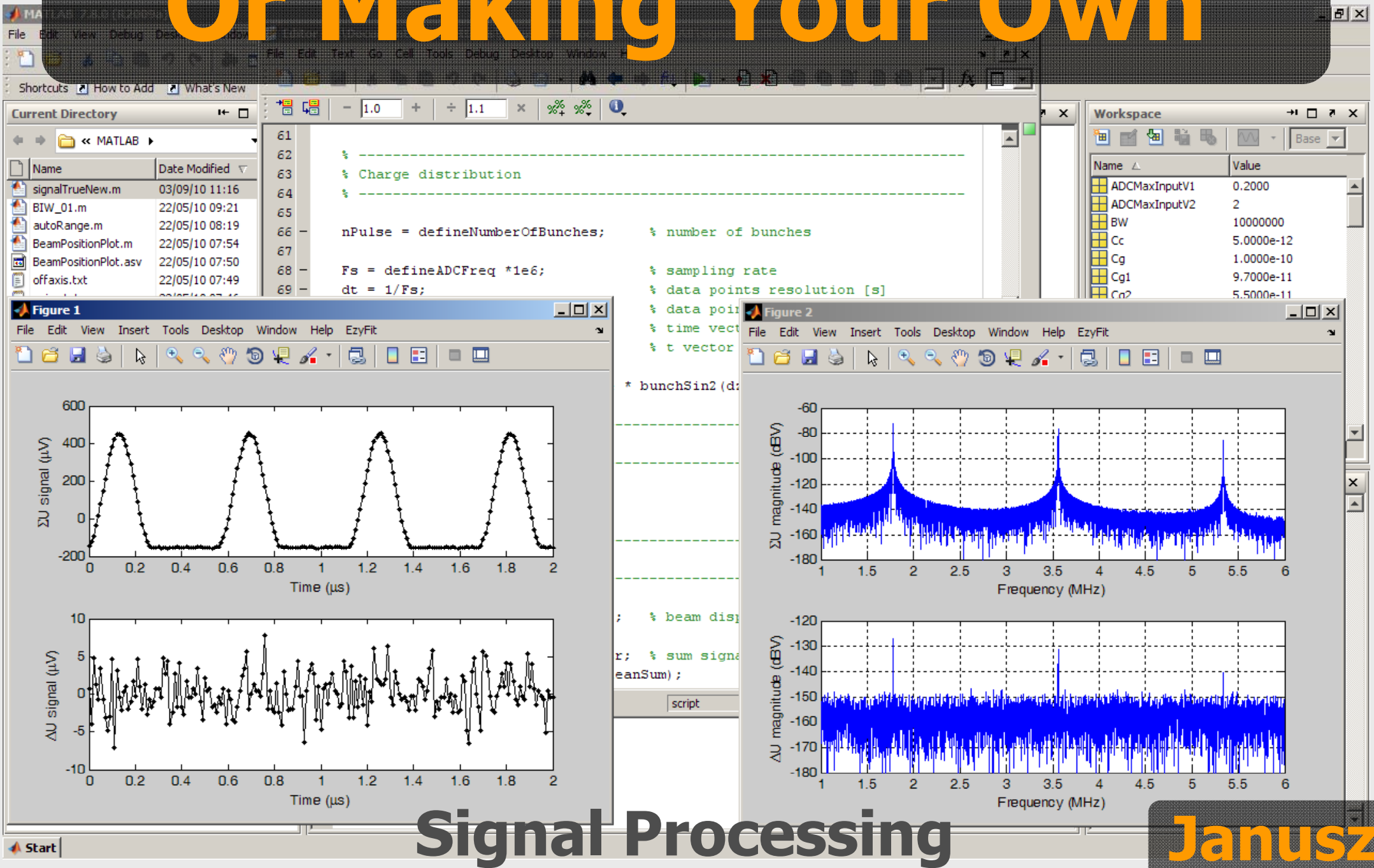


Or Making Your Own



Adam

Or Making Your Own

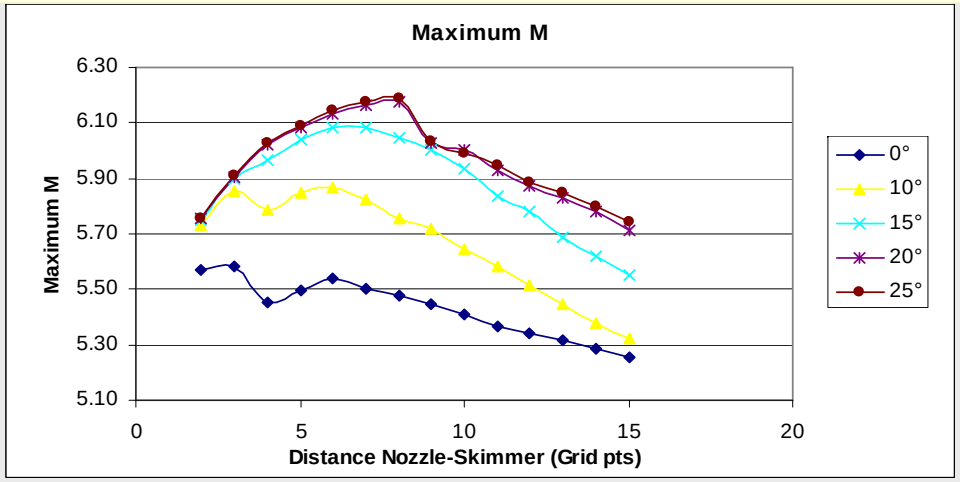


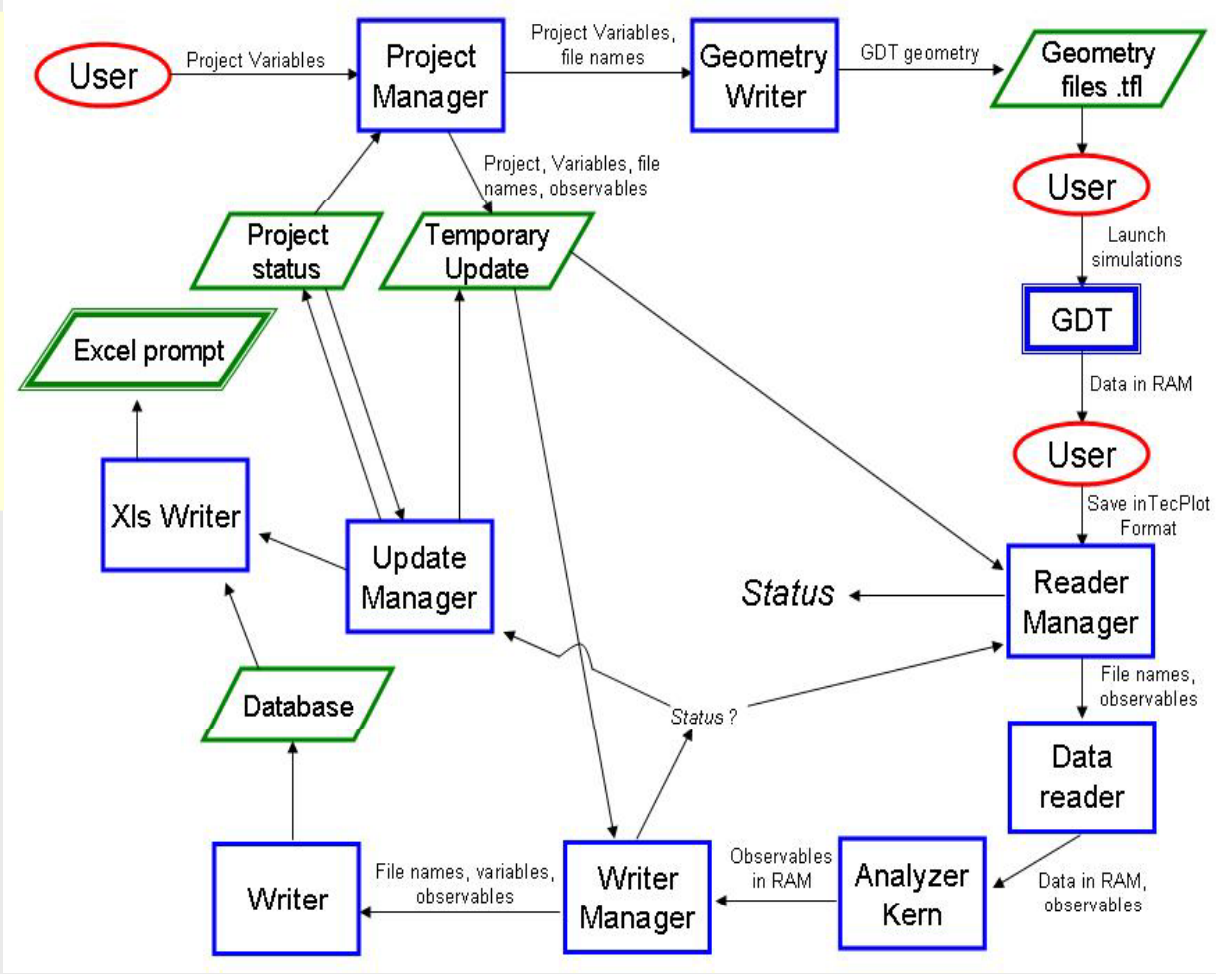
Signal Processing

Janusz

Or Making Your Own

	M_{max}	CM_{max}	M_{max} 70%	D	W
α	β, SD	β, SD	↘	↘	↗
β	α	α	↘	⌒	→
SW	↗	↗	↘	↘	↗
SD	α	α	α	⌒	⌒
Dist	↘	↗	↘	α, β	α, β





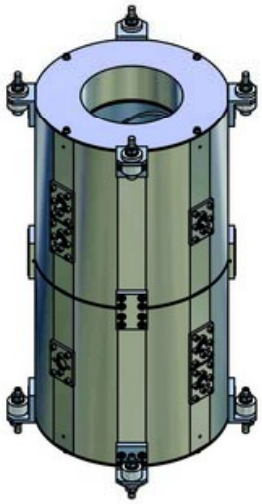
C++ modules

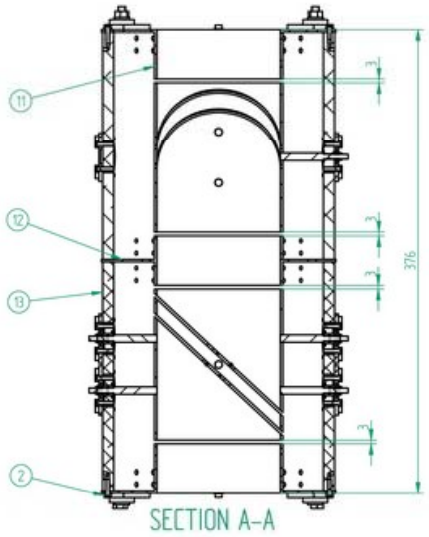
Experimental Bits

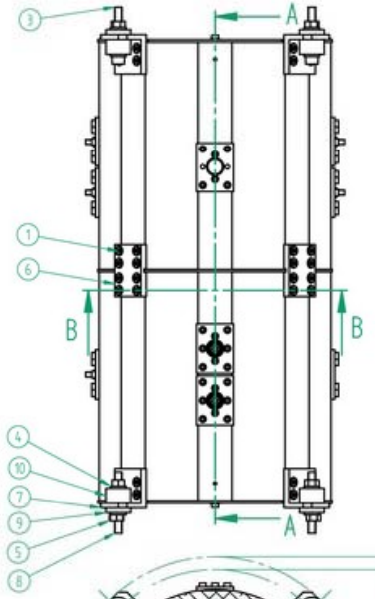

Being Exposed
to New Fields

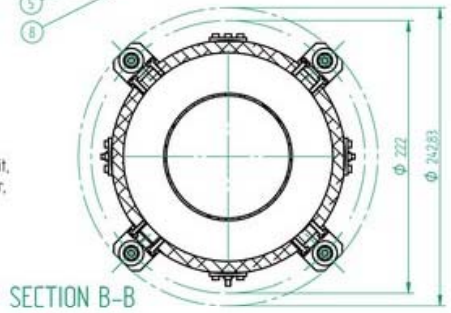

Being Exposed
to New Fields


Being Exposed
to New Fields







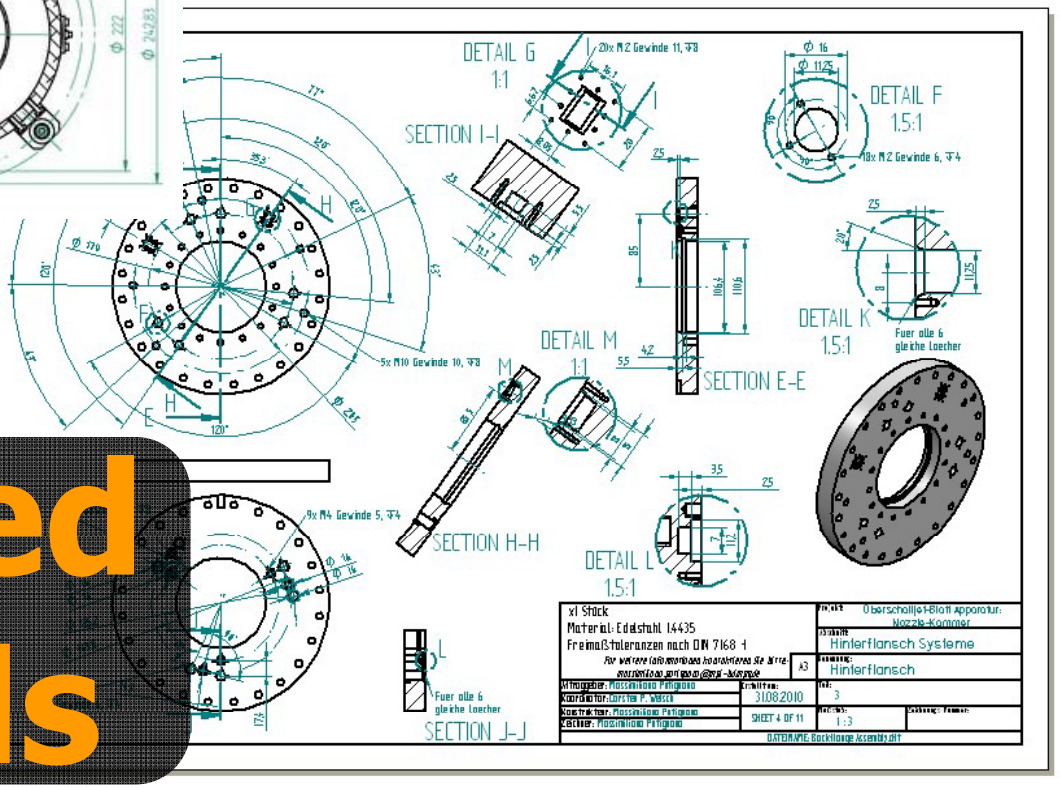


1 Beam Position Monitor

Item	Name	Drawing	Material	Quantity
1	Cap screw ISO 4762 - M4 x 12		Stainless steel 314	64
2	Cap screw ISO 4762 - M3 x 12		Stainless steel 314	100
3	Cap screw ISO 4762 - M6 x 40 vented		Stainless steel 314	4
4	Washer ISO 7092 - 6		Stainless steel 314	16
5	Nut ISO 4032 - M6		Any	12
6	Clamp	2.1	Aluminium 6061 or 6063	4
7	Holder	2.2	Aluminium 6061 or 6063	8
8	Vented support rod M6	13.1	Stainless steel 316L	4
9	Ceramic split bush - male	3.1	MACOR	8
10	Ceramic split bush - female	3.2	MACOR	8
11	Front plate	4.1	Stainless steel 316L	2
12	Middle plate	4.2	Stainless steel 316L	1
13	Pick-up assembly	5		2

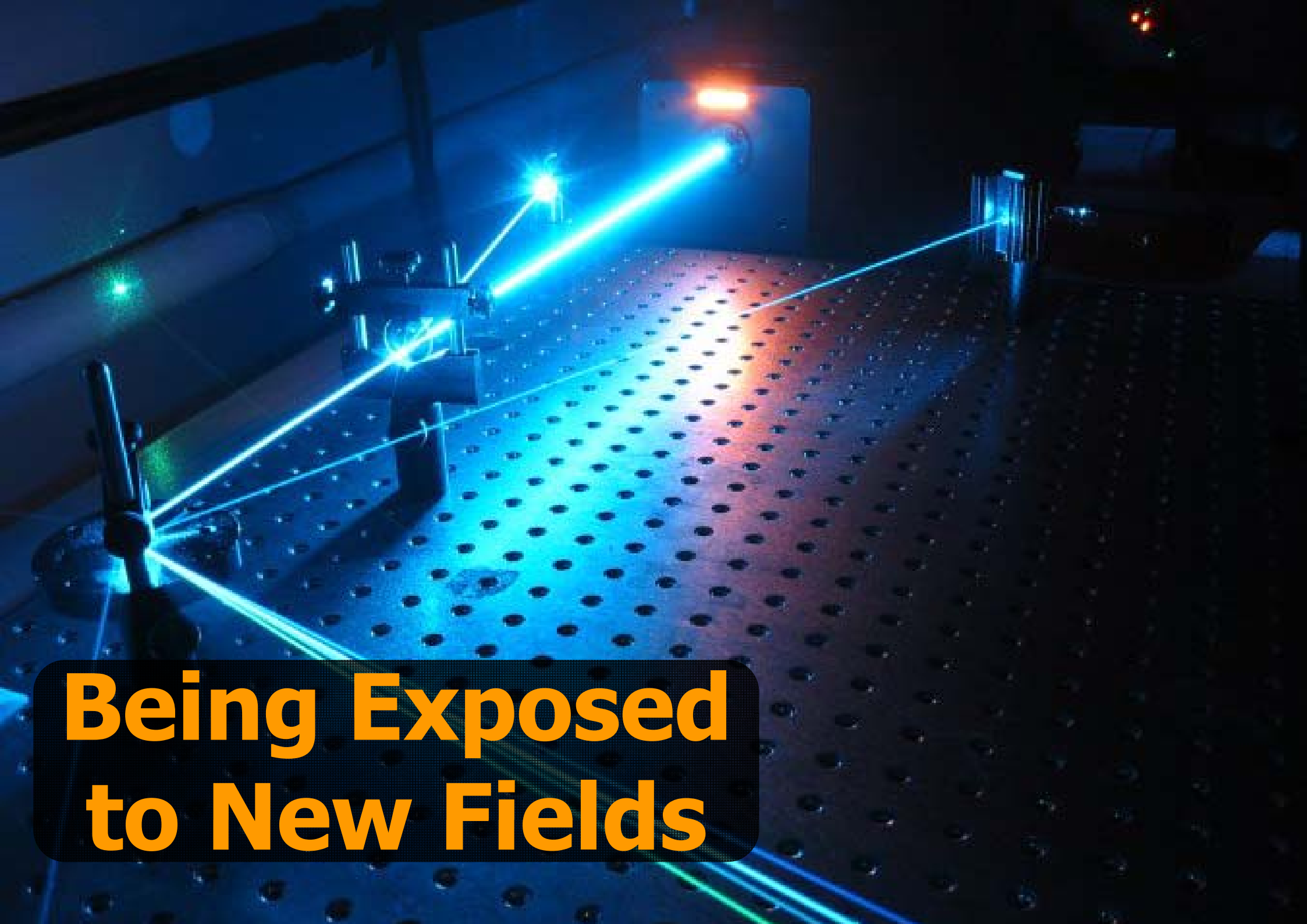
Needs to be suitable for UHV (1e-11 mbar).

The assembly will be installed inside a DN250 vacuum tube. Should the M6 screws be not enough to support it, they (and any related parts) may be adjusted. However, the monitor needs to fit into a DN250 vessel.



Being Exposed to New Fields


Being Exposed
to New Fields


Being Exposed
to New Fields

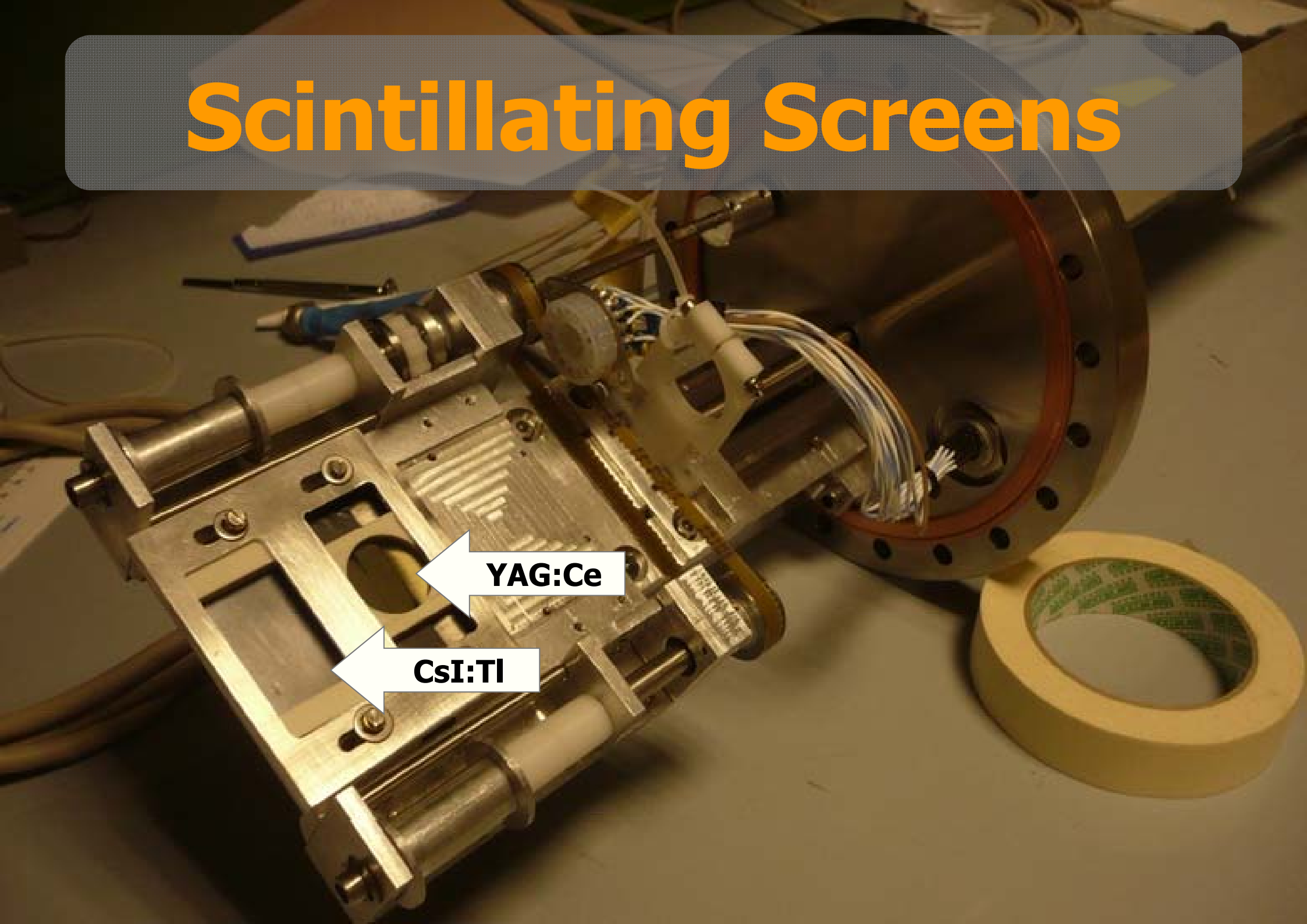
Hands-On

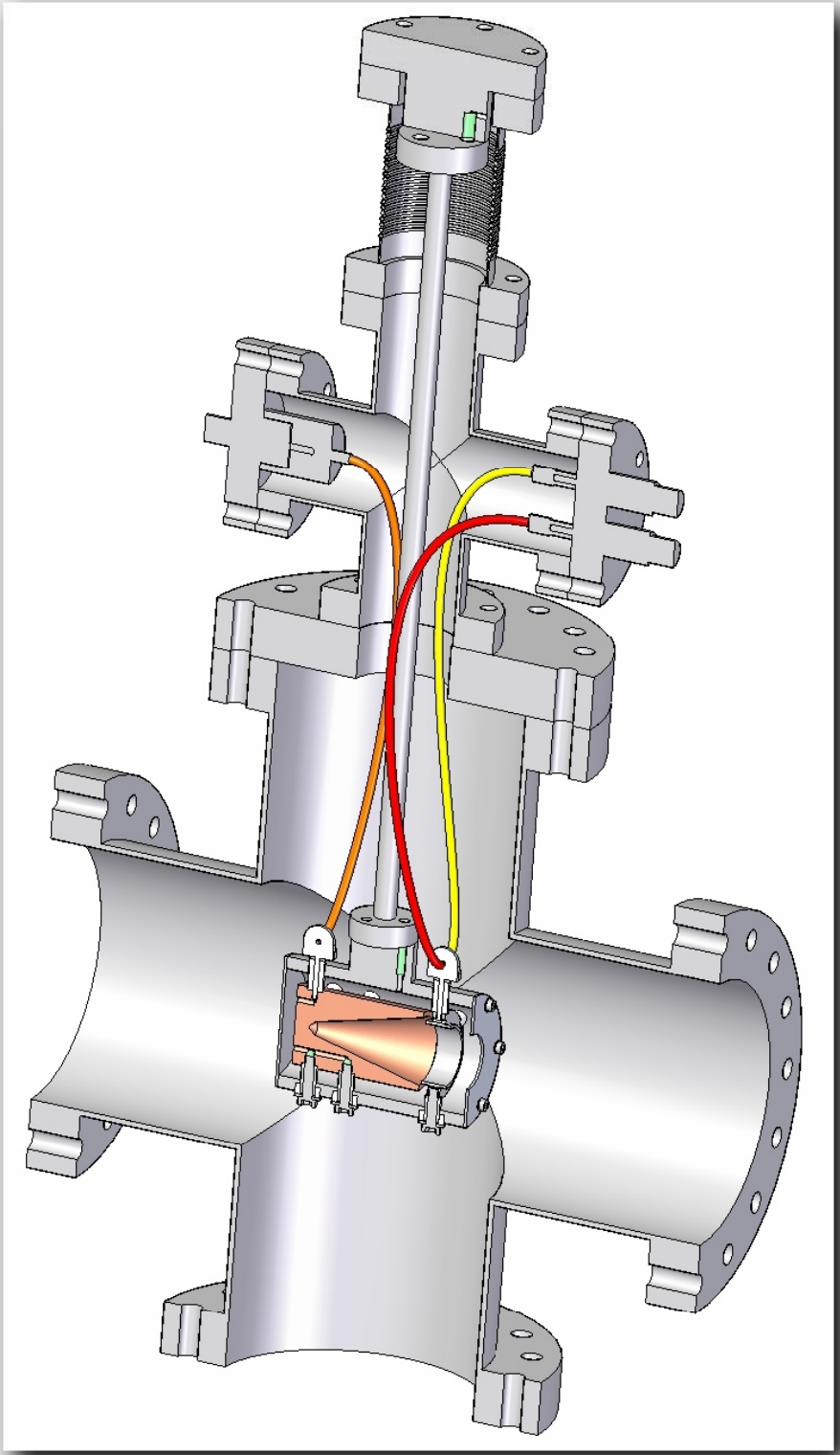
Hands-On

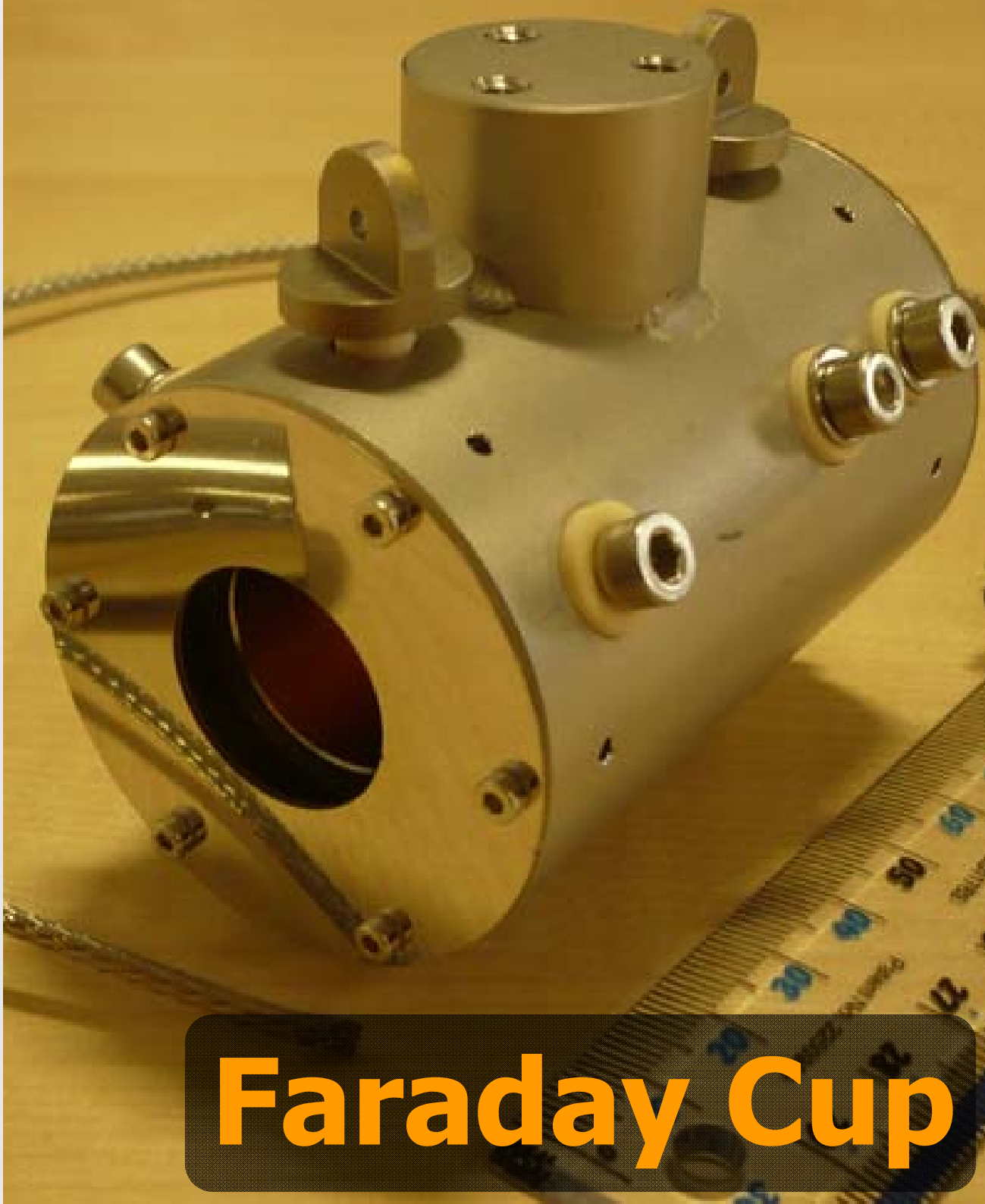

Hands-On
Legs-Out

Our Achievements

Scintillating Screens

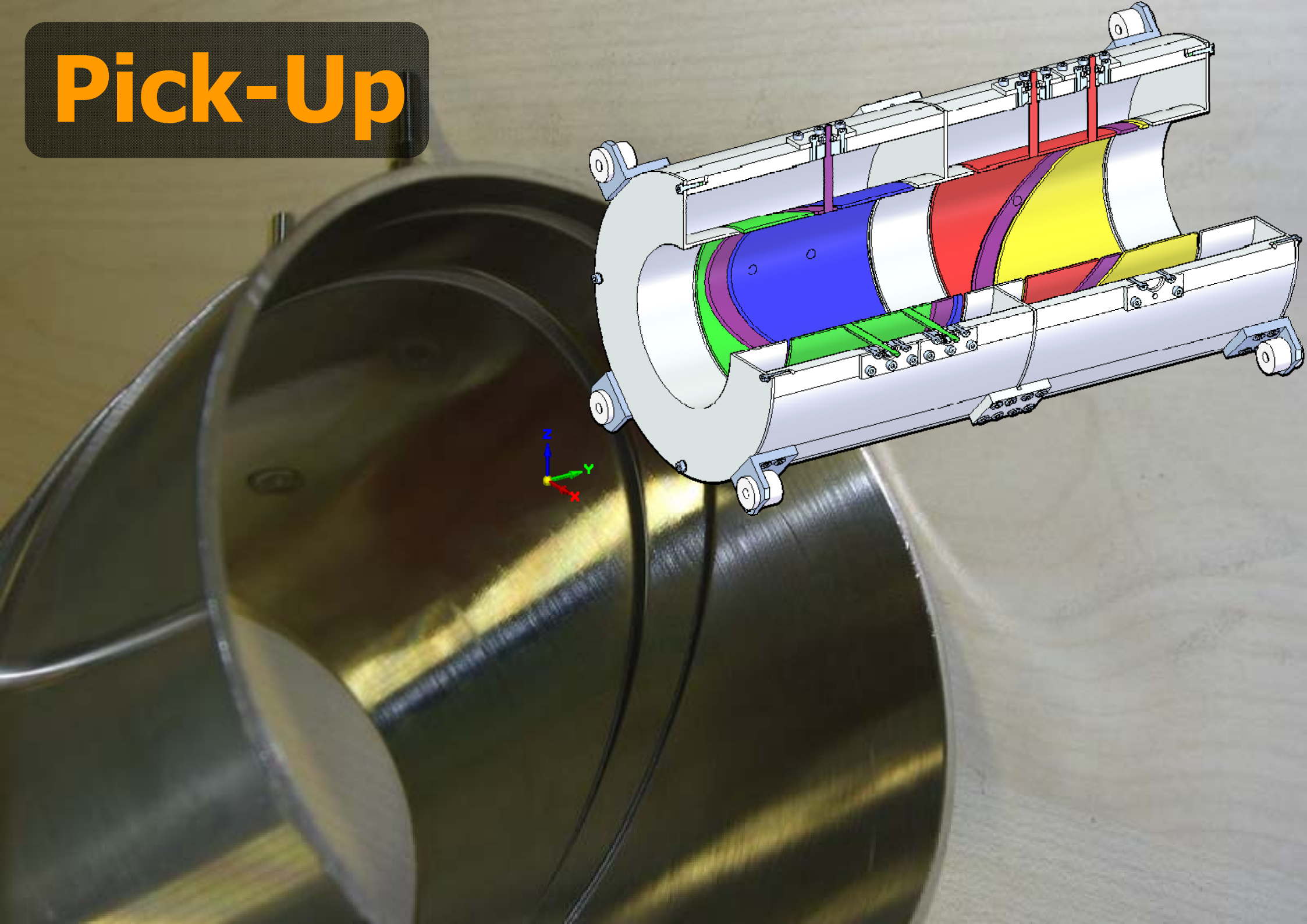




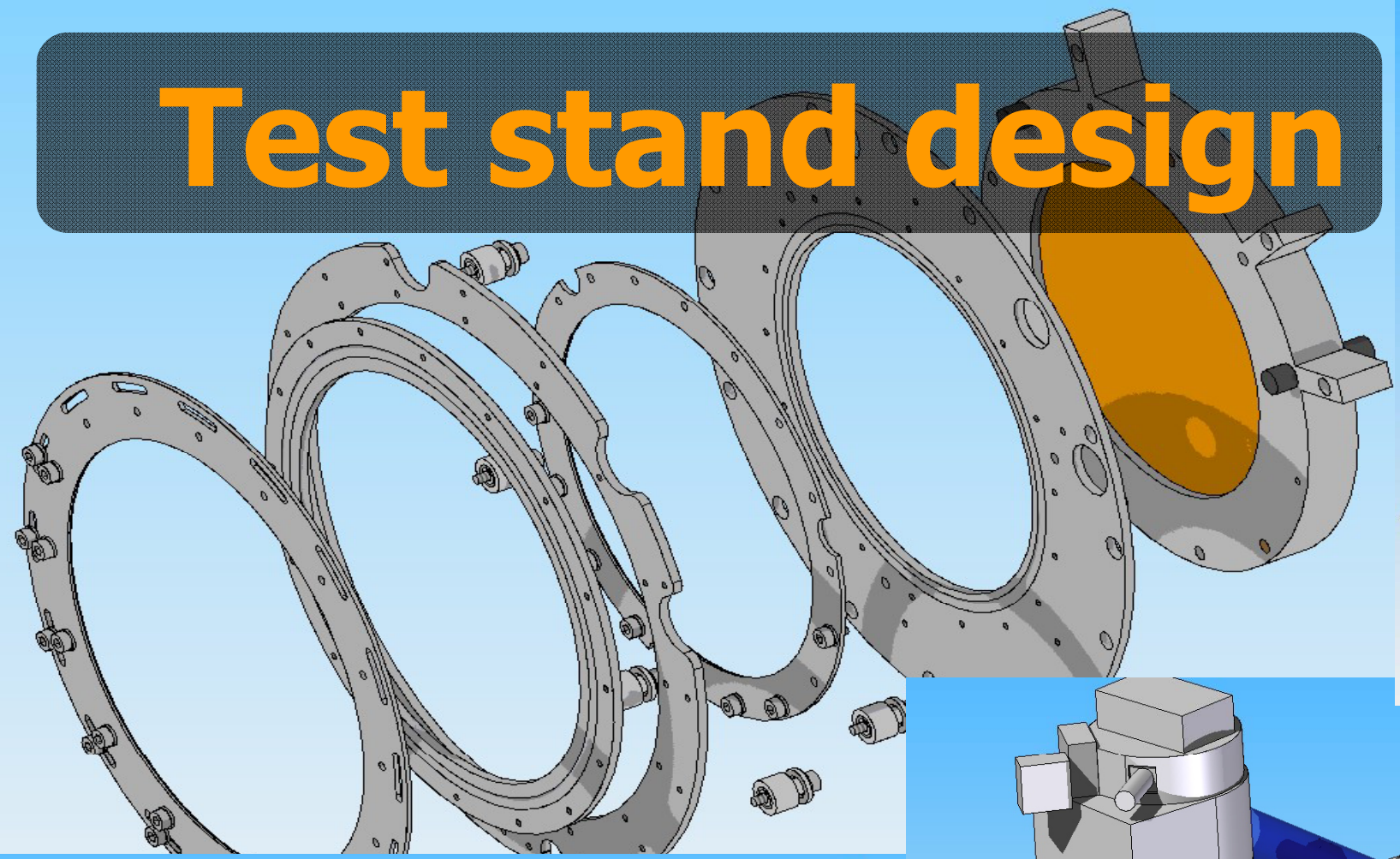


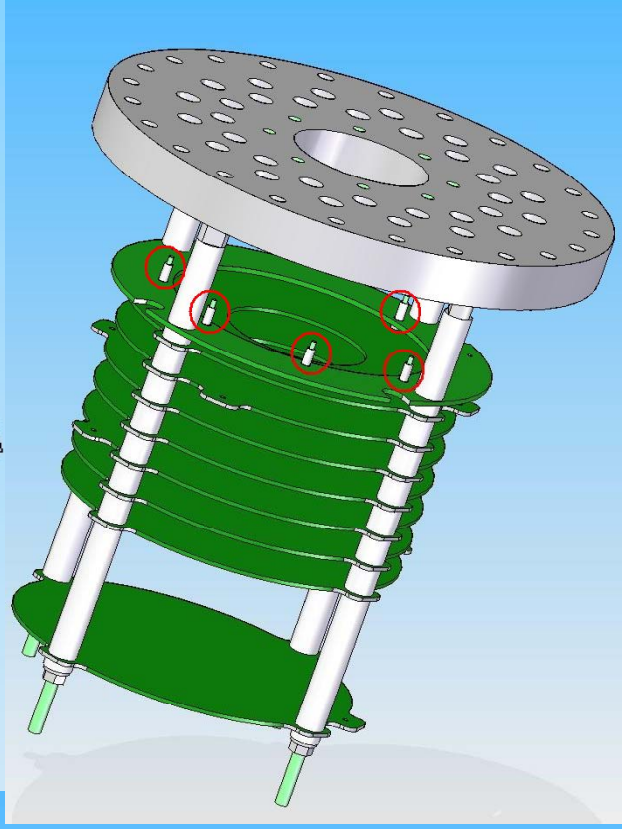
Faraday Cup

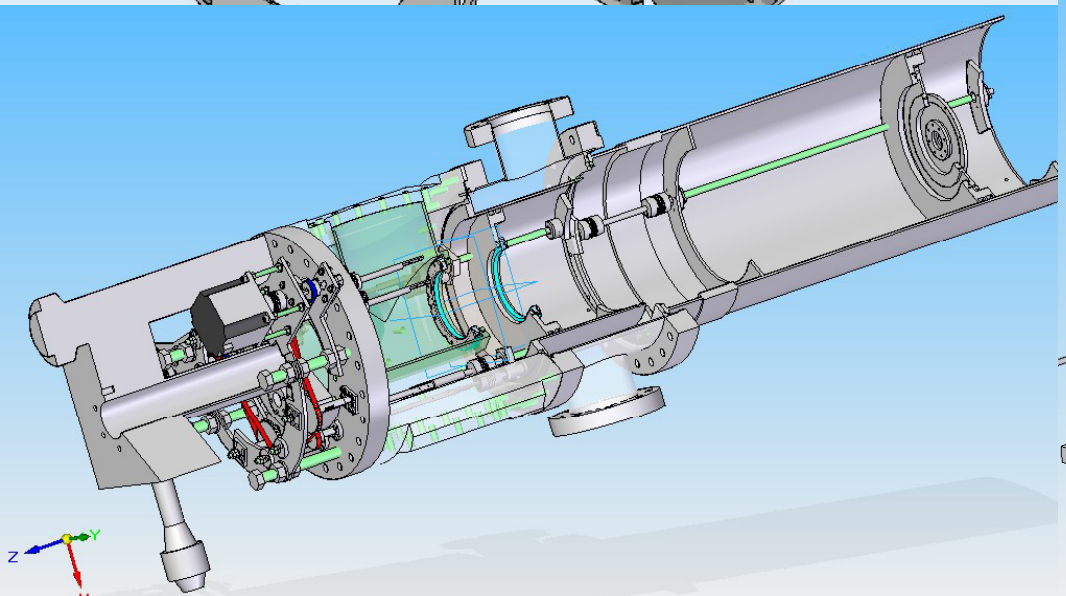
Pick-Up

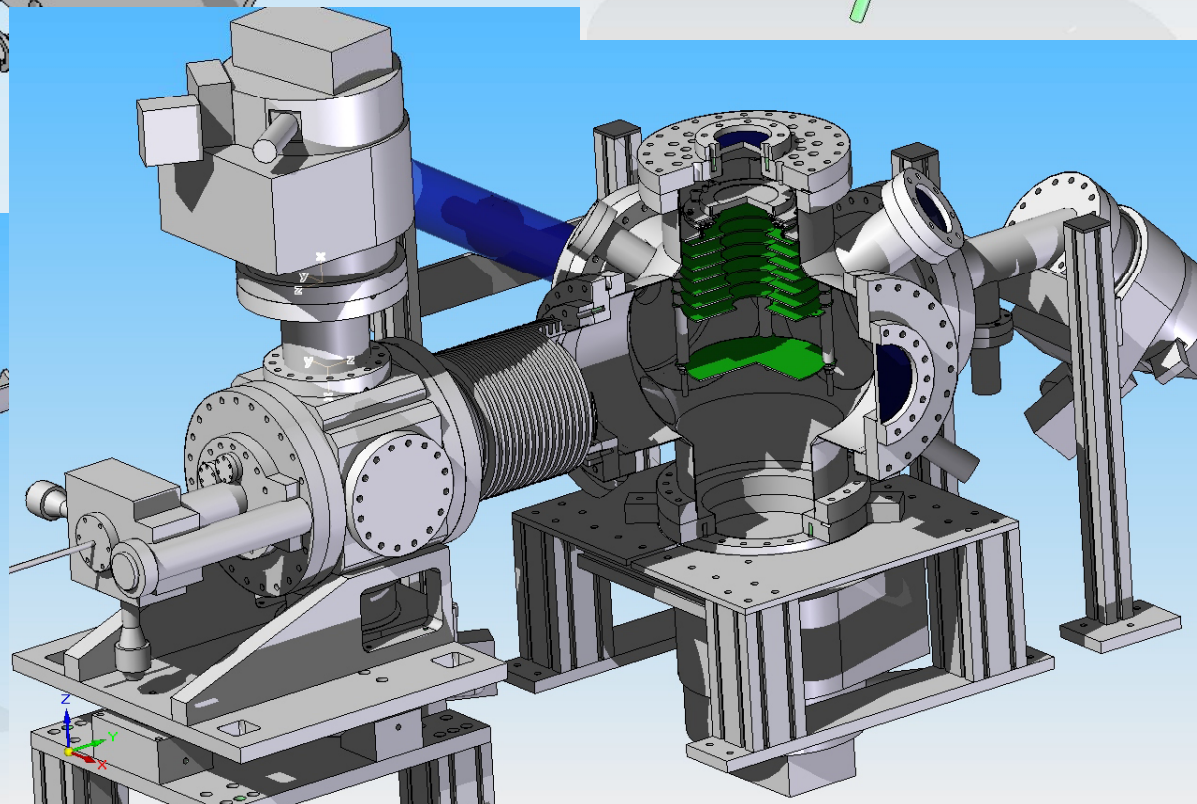


Test stand design

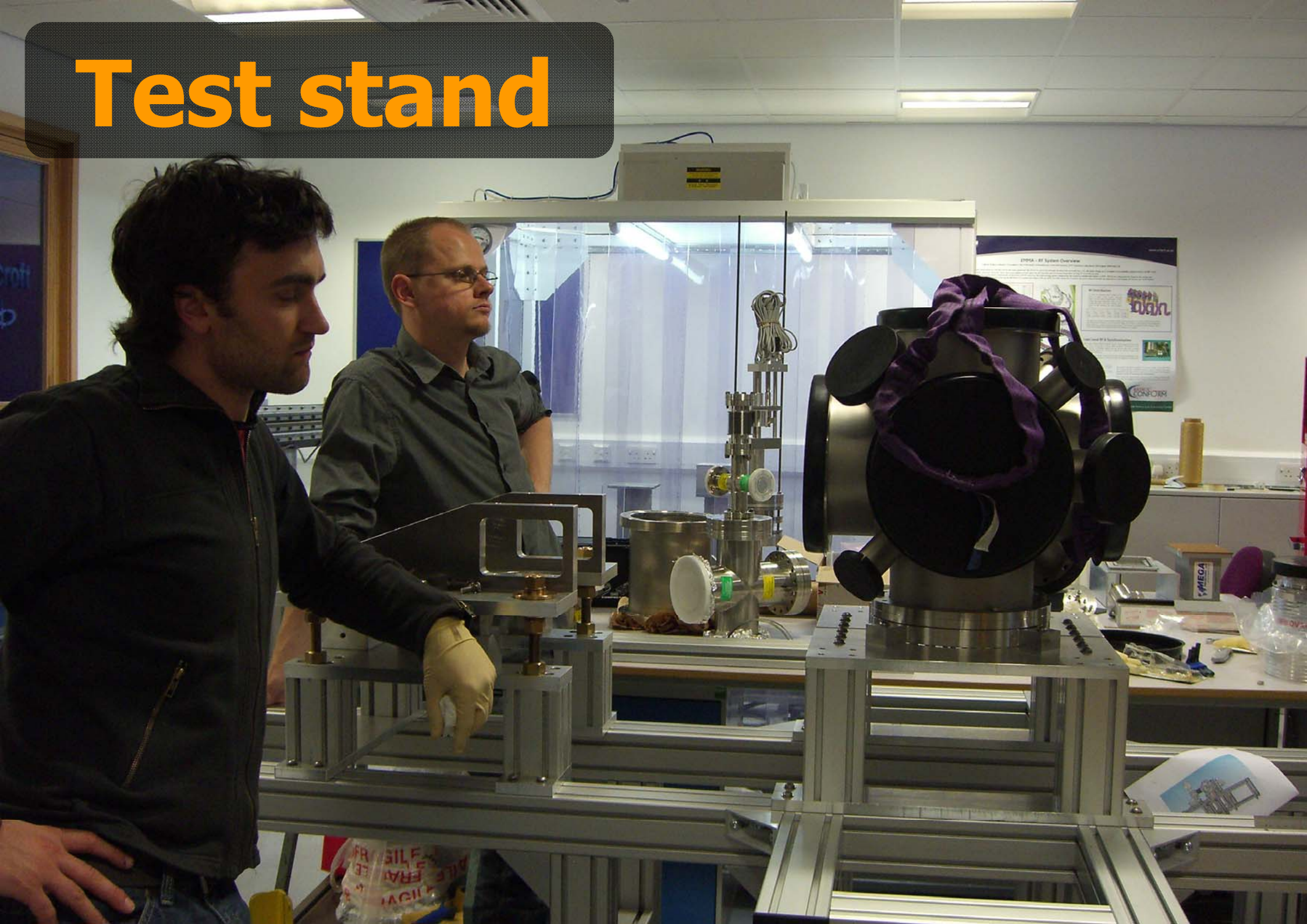




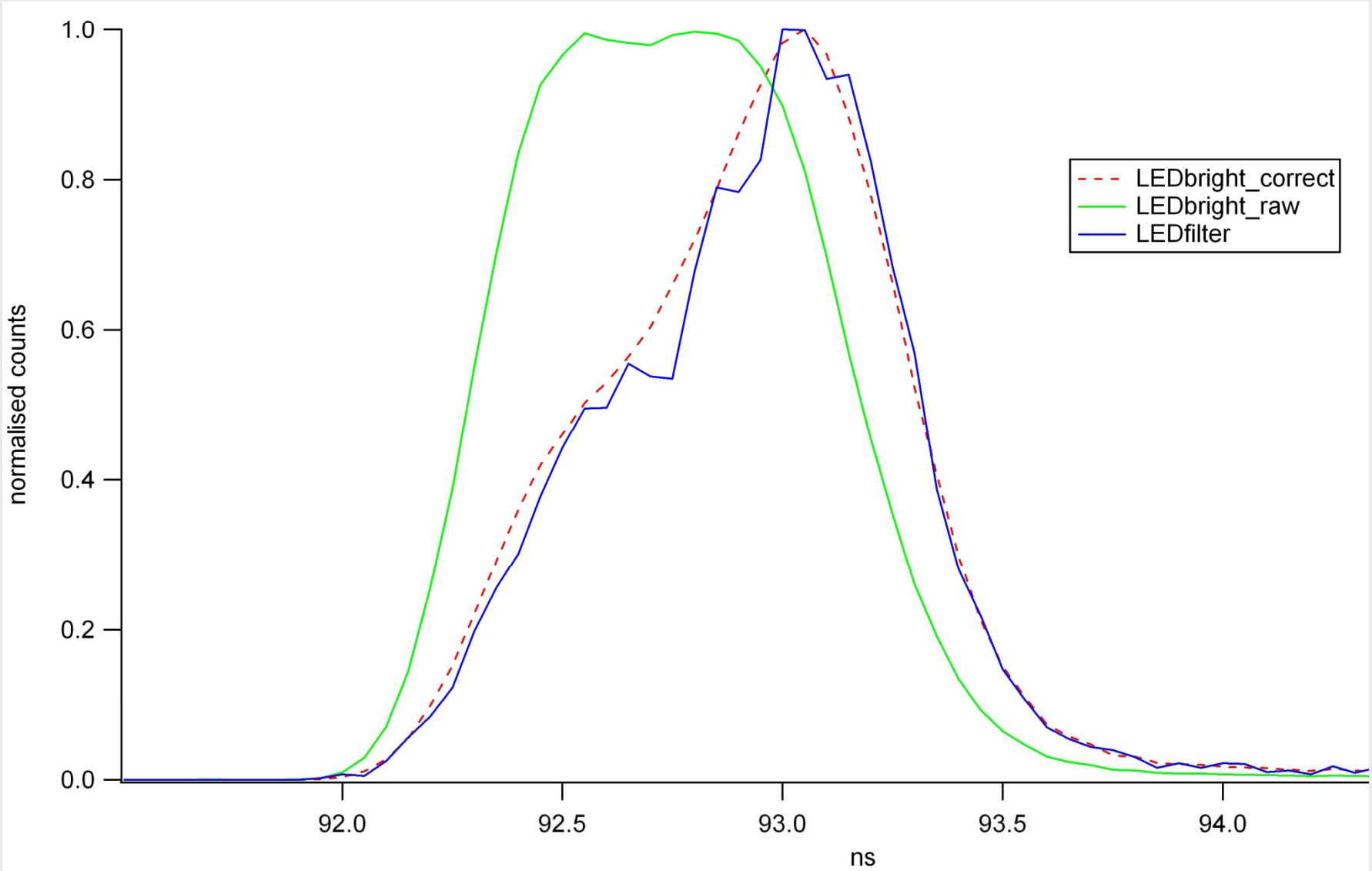




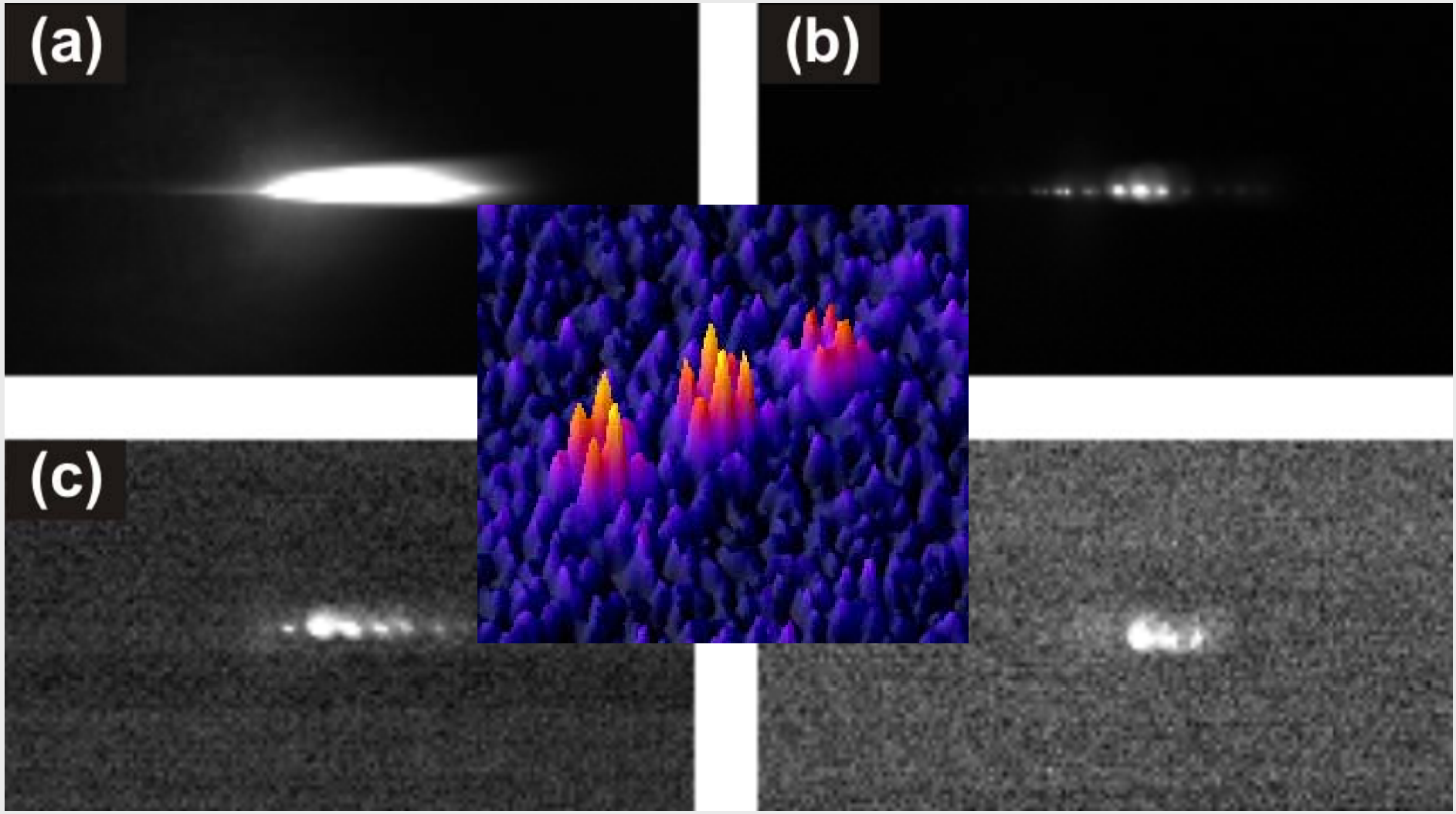
Test stand



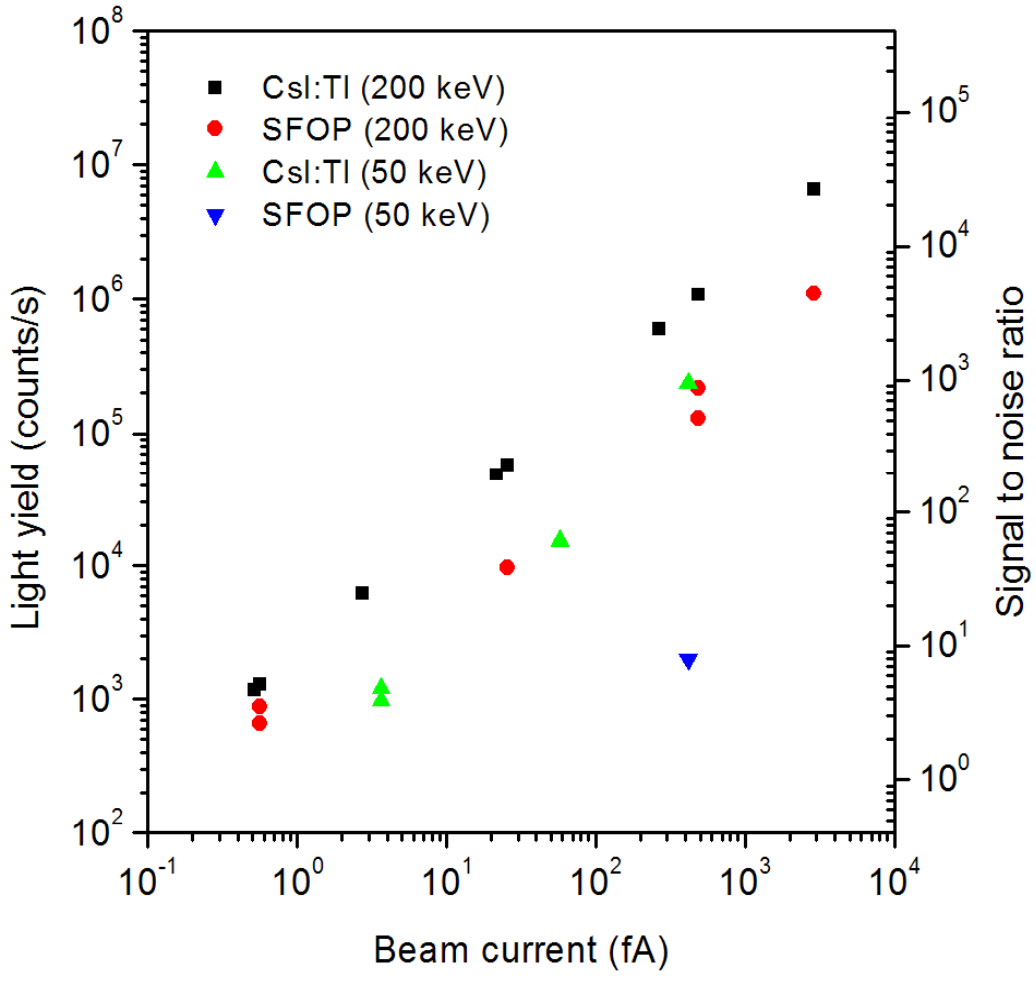
Measurements: Adam

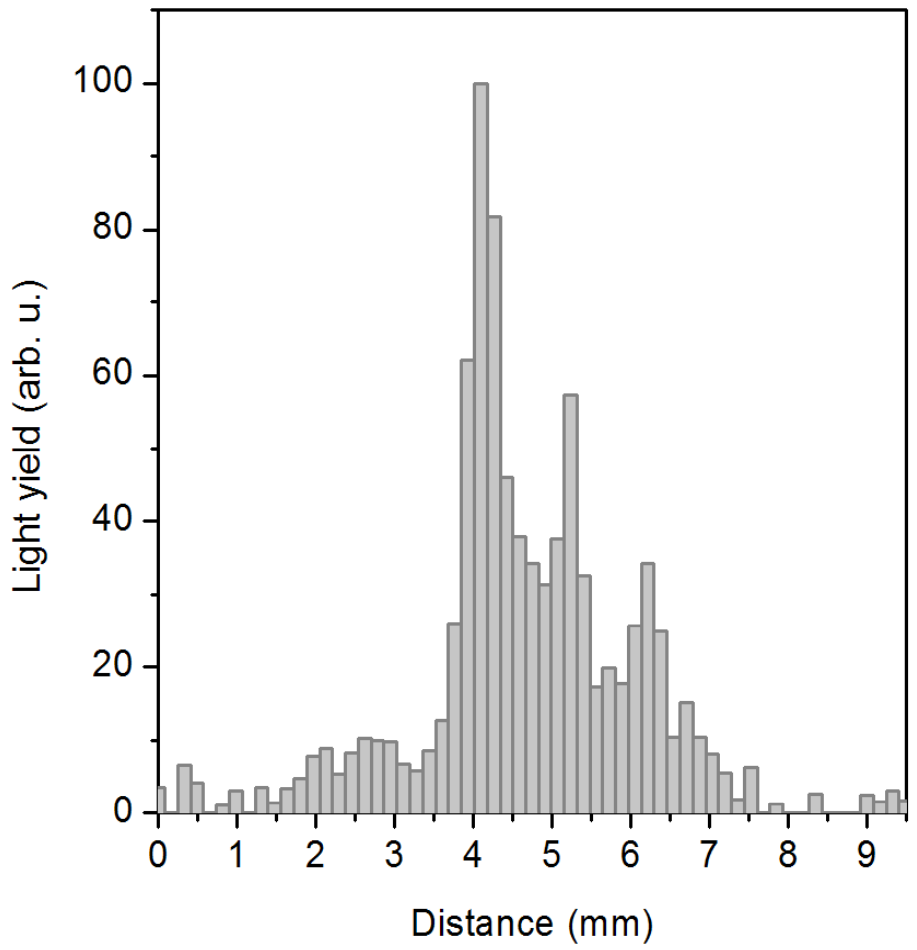


Measurements: Janusz

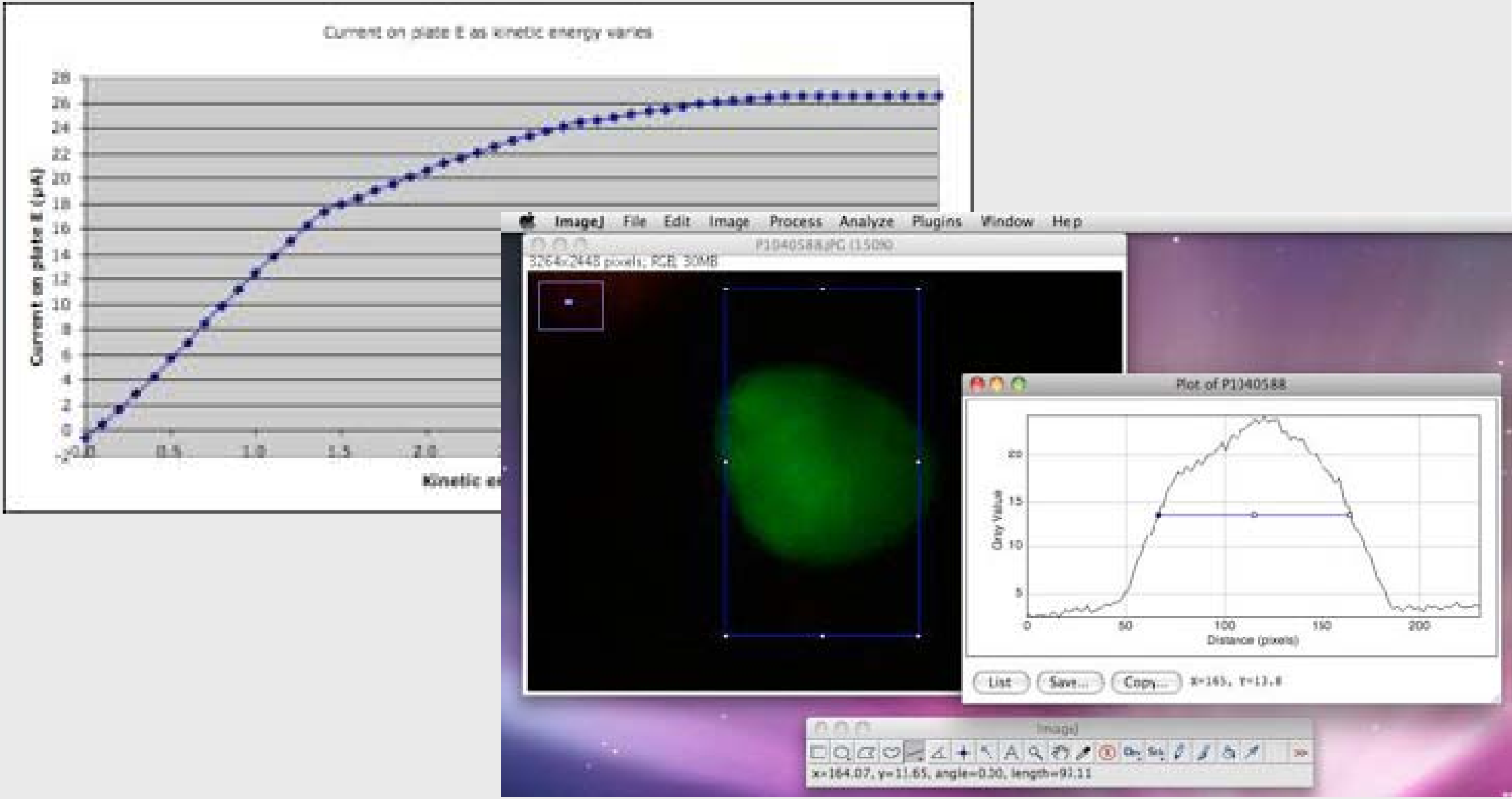


Measurements: Janusz





Measurements: Max



Further Steps

- **Adam:**
  - **Measurement with beam of single APD**
  - **Lab test of the double APD (> dynamic range)**
- **Janusz:**
  - **F-Cup measurements with beams (e^-, H^+)**
  - **BPM measurements with a stretched wire**
  - **Scintillators and SE monitor tests with pbars**
- **Massimiliano:**
  - **Experimental test stand commissioning**
  - **Jet-Curtain experimental analysis**