

Beam Diagnostics: a PhD Students' Perspective

Adam, Janusz, Massimiliano

Content

- ① **PhD Project Start-Up**
- ② **Theory & Simulation**
- ③ **Experimental Bits**

PhD Project Start-Up

Understanding the Task

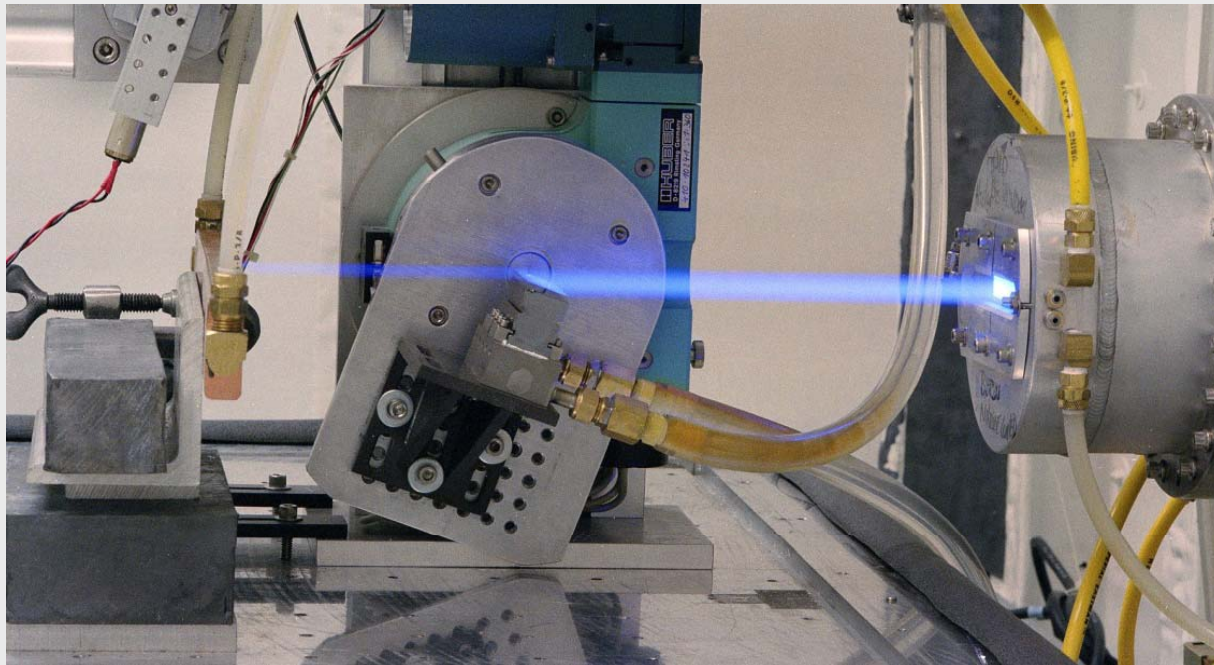
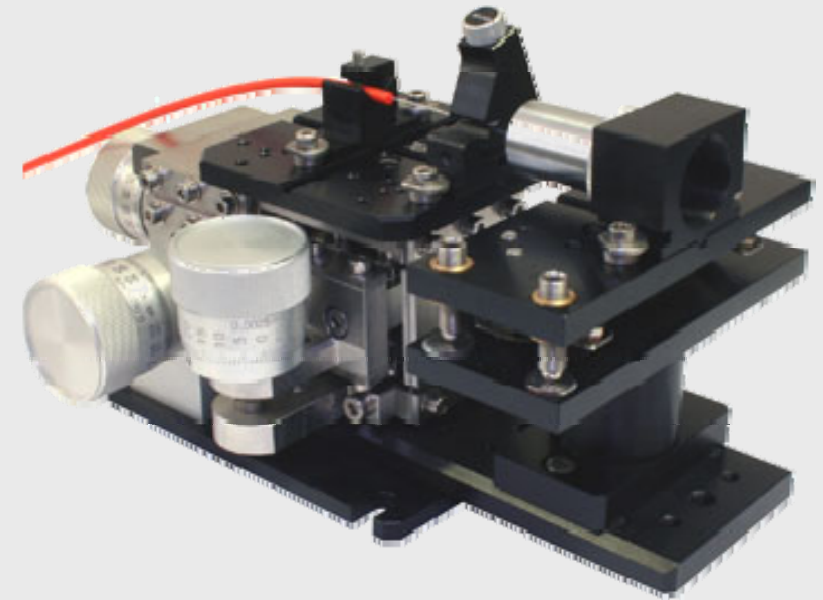
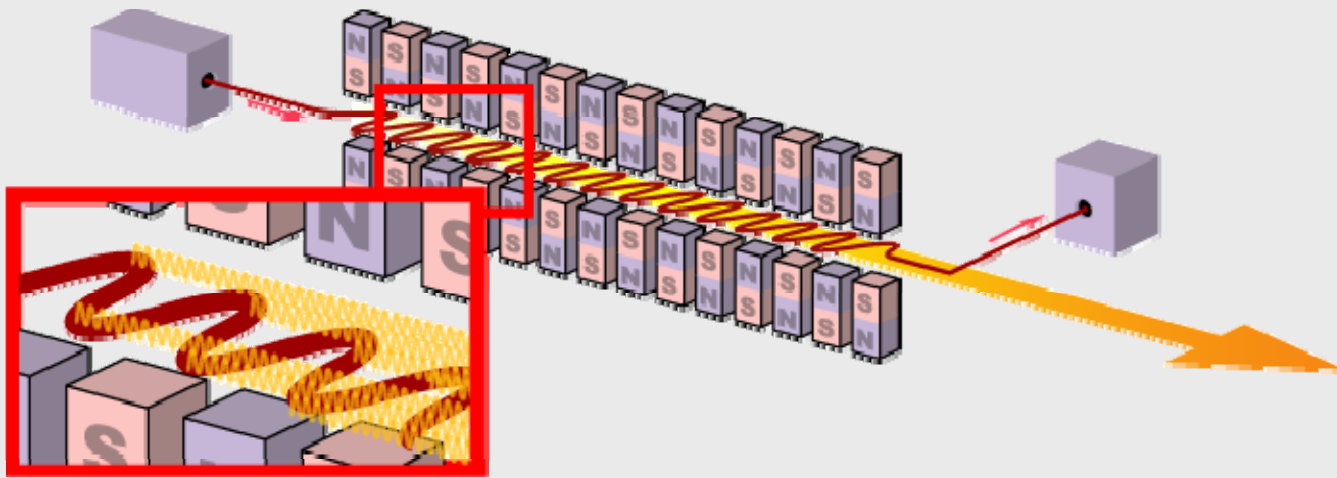
- **What needs to be done?**
- **What has been done already?**
- **What do we need to develop?**
- **What are the challenges?**

Projects: Adam

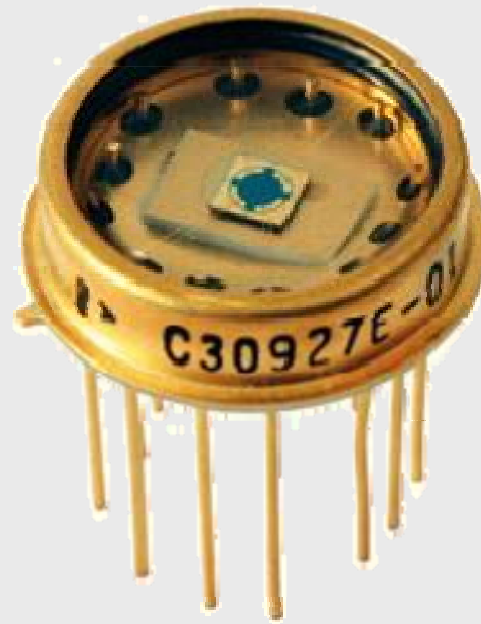
Development of a Longitudinal Beam Distribution Monitor for LHC

The Challenge

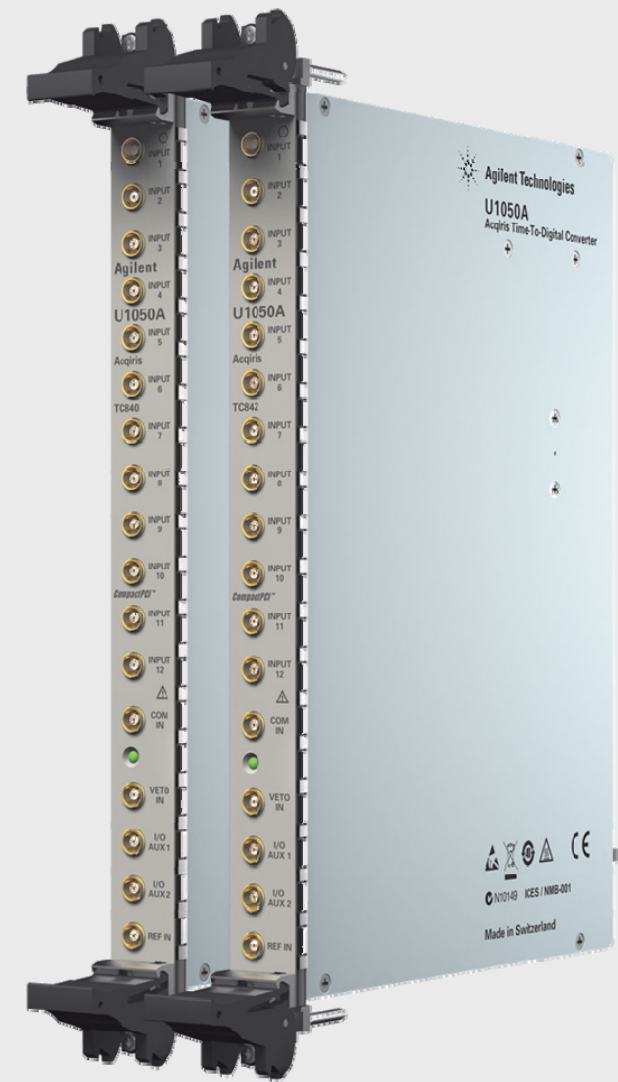
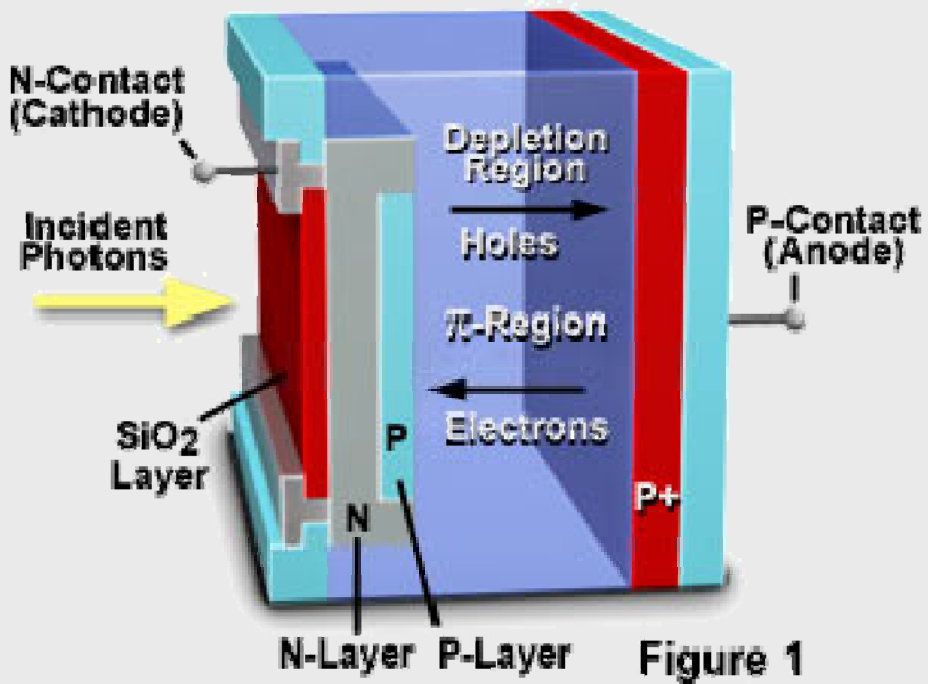
- **What exists:**
 - Continuous bunch shape measurements**
(eg. wall-current monitor)
 - Fast bunch length measurements**
(eg. electro-optic methods)
 - High dynamic range measurements**
(e.g. deflecting cavity)
- **What doesn't:**
 - Something that combines them all**



How to interact with the beam?



Avalanche Photodiode



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

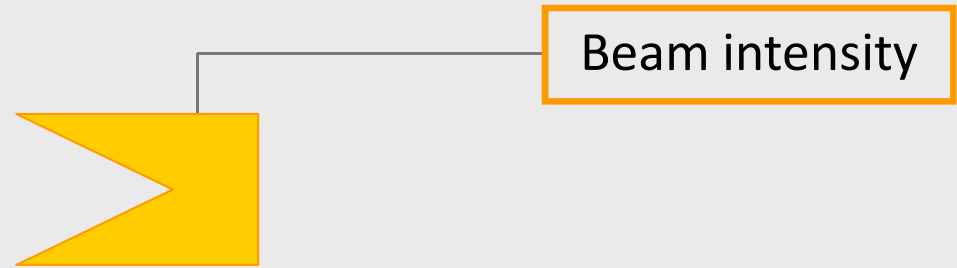
- **What doesn't:**

Monitors optimised for exotic machines:

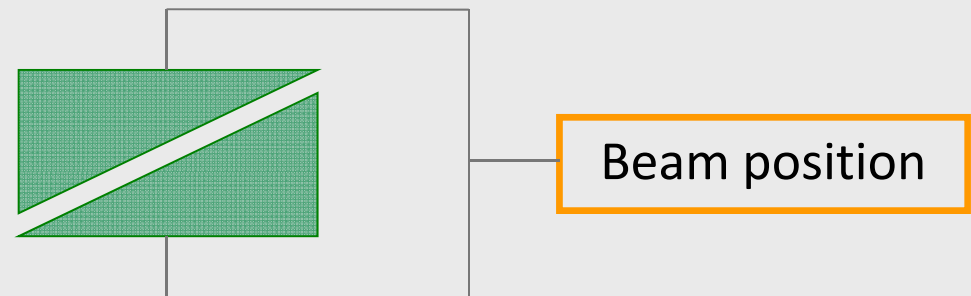
- **Particle types:** antiprotons & ions
- **Low energies:** **20 – 300 keV**
- **Few particles:** **$<2 \times 10^7$**
- **Low currents:** **down to 100 fA**
- **High vacuum:** **$<10^{-11}$ mbar**

Detectors

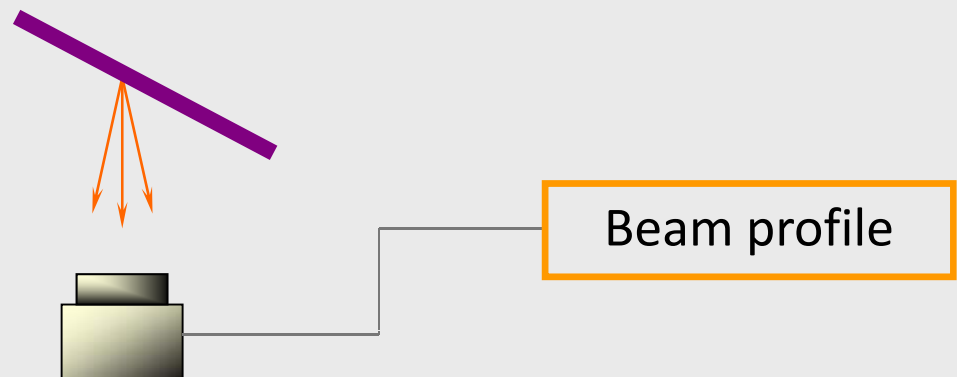
- **Faraday Cup**



- **Capacitive Pick-Up**



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



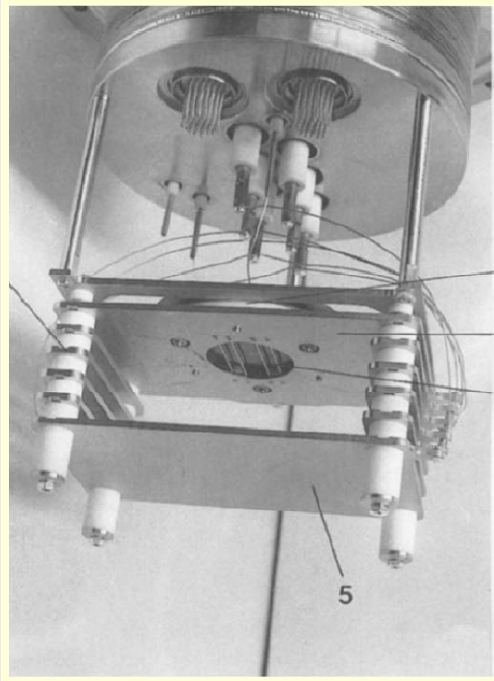
Challenges

- **Intensity**
 - Current range: $\mu\text{A} \rightarrow \text{fA}$
 - Close to noise limitations (fA)
 - No standard UHV components for low level measurements
- **Position**
 - Low signal: $\sim 250 \text{ nV @ } 0.1 \text{ mm}$
 - Noise level: $> 2.5 \mu\text{V @ } 20 \text{ MHz}$
 - Low velocity: $0.025 \text{ c} \rightarrow 0.006 \text{ c}$
- **Profile**
 - Low energy: $< 300 \text{ keV}$
 - Low intensity: $\sim 10^6 \text{ pps (sub-pA)}$
 - Particles: antiprotons AND protons

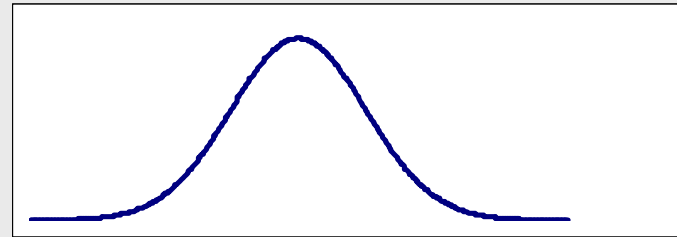
Projects: Massimiliano

Development of a Modified Neutral Beam Scanner

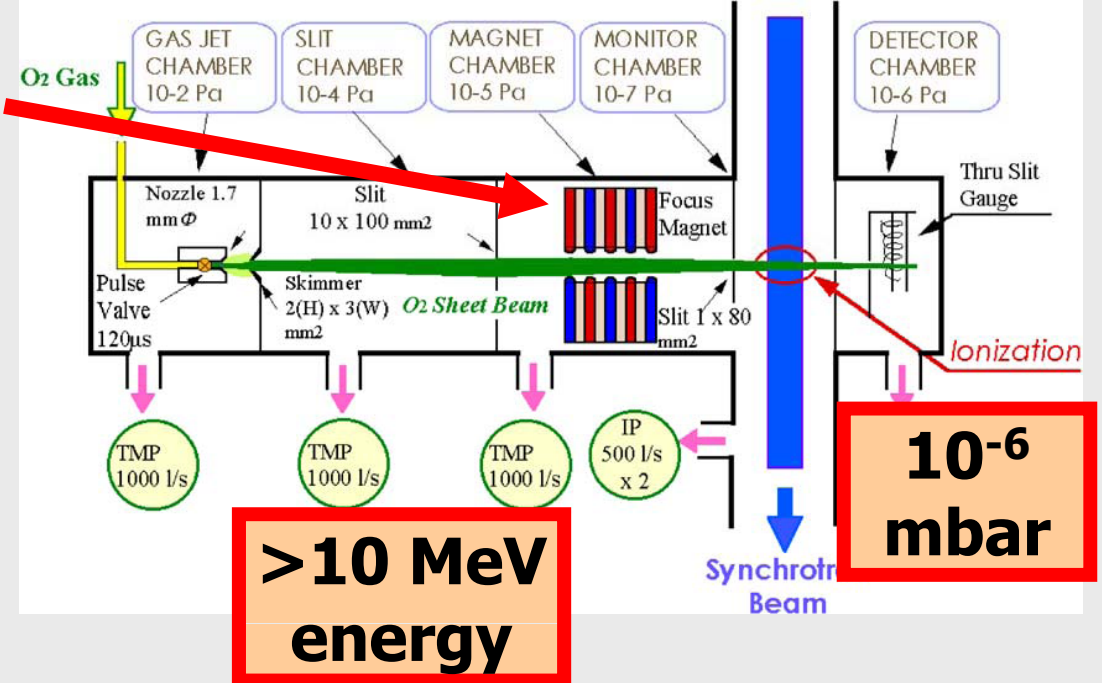
State of the Art



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

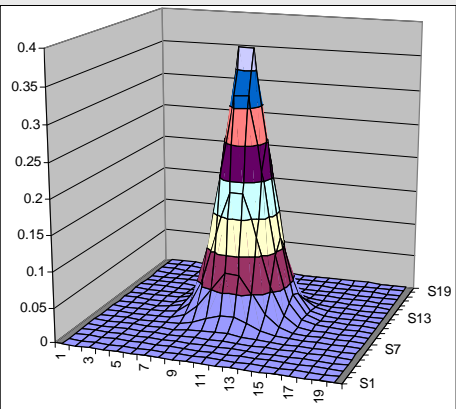


>2 Tesla



10^{-6} mbar

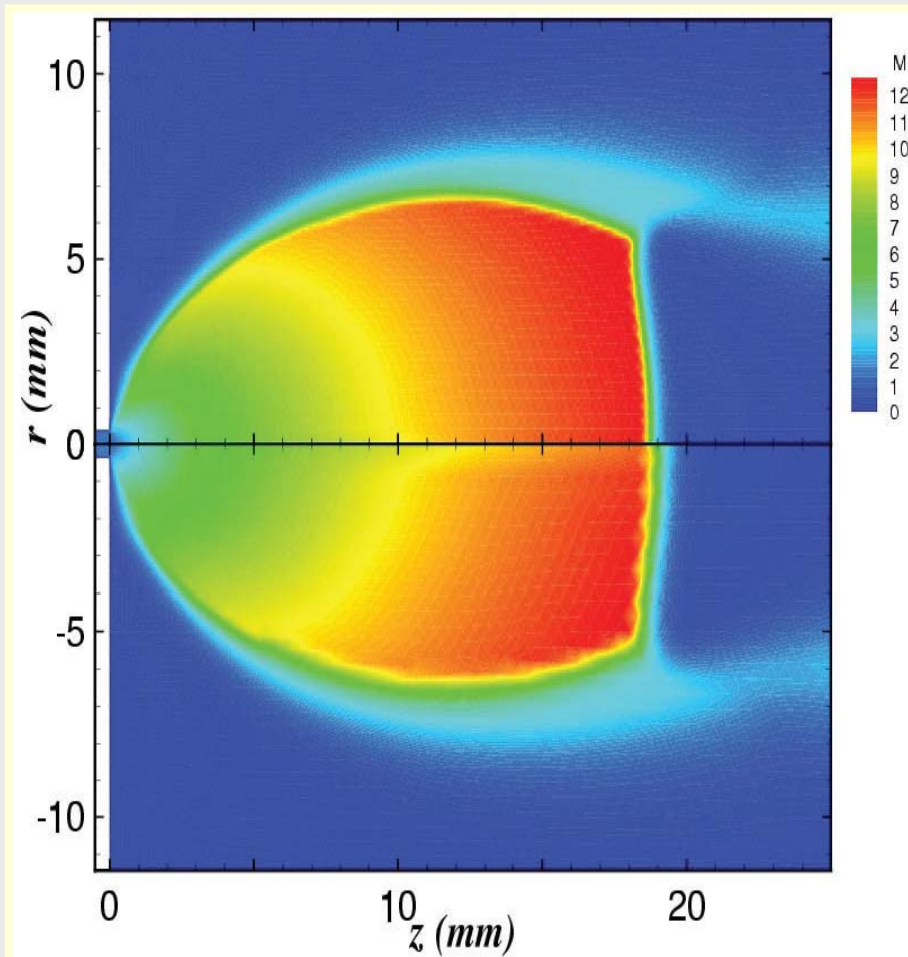
>10 MeV energy



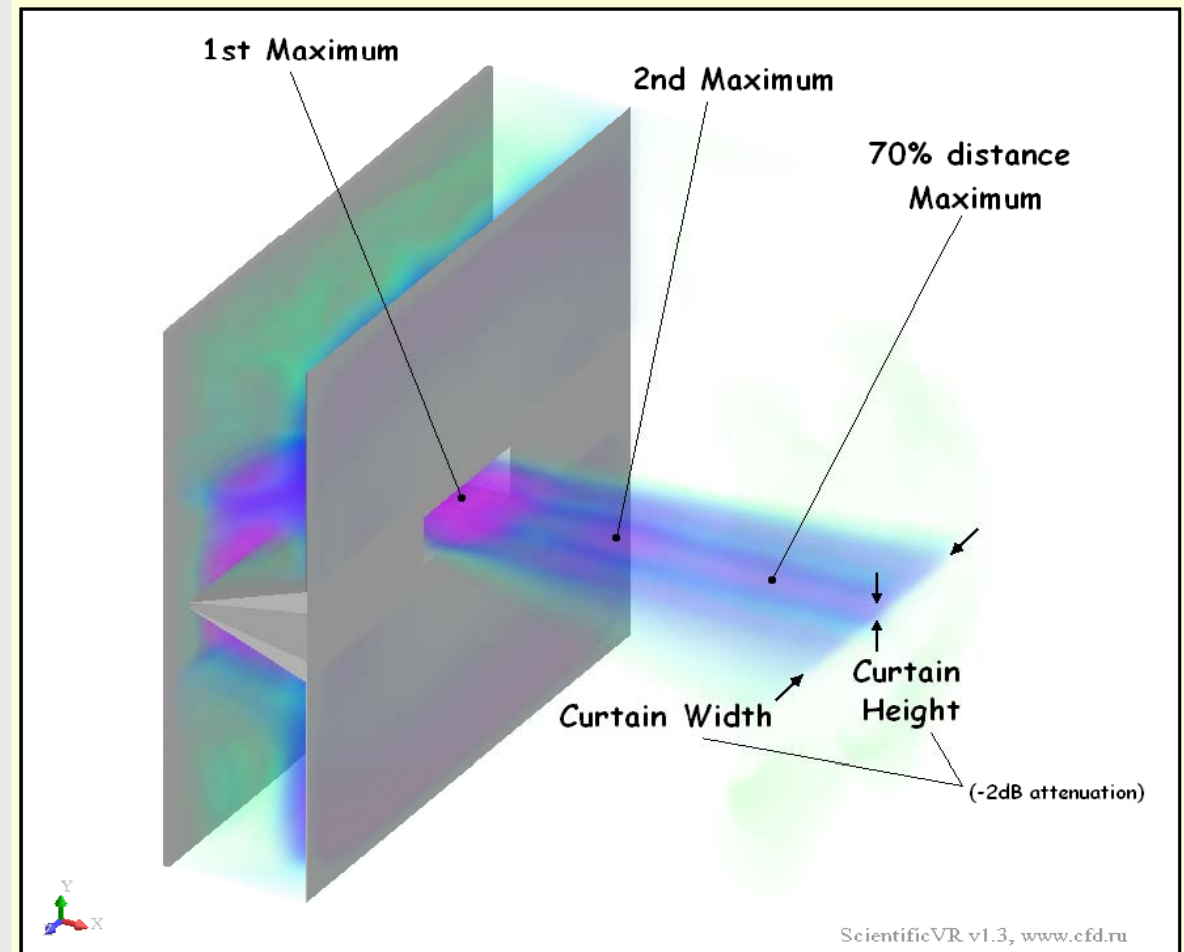
- 2D profiles

The Challenge: gas curtain

What exists:



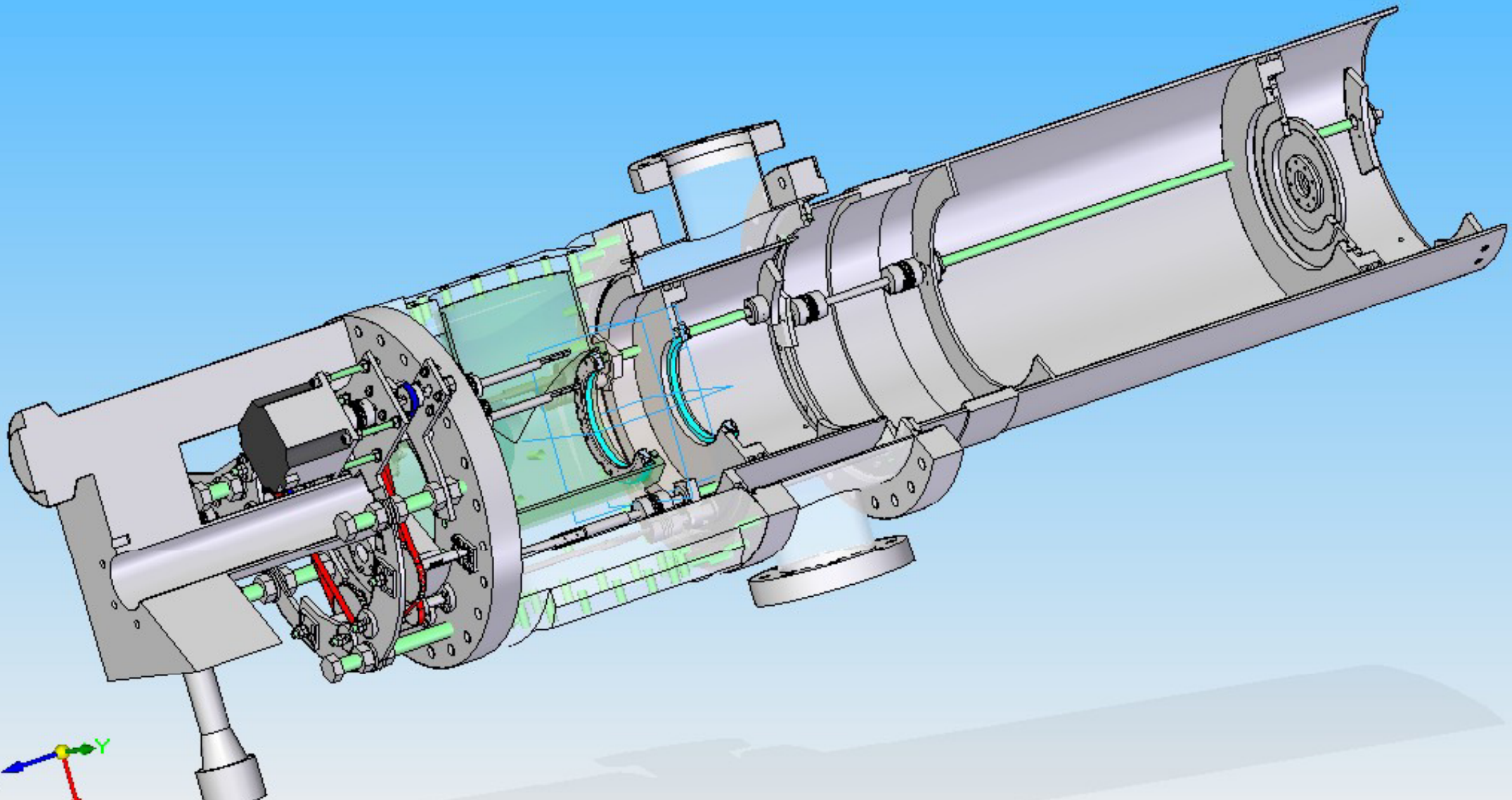
What doesn't:



The Challenge: gas curtain

What exists:

What doesn't:



Theory & Simulation

Understanding our detectors

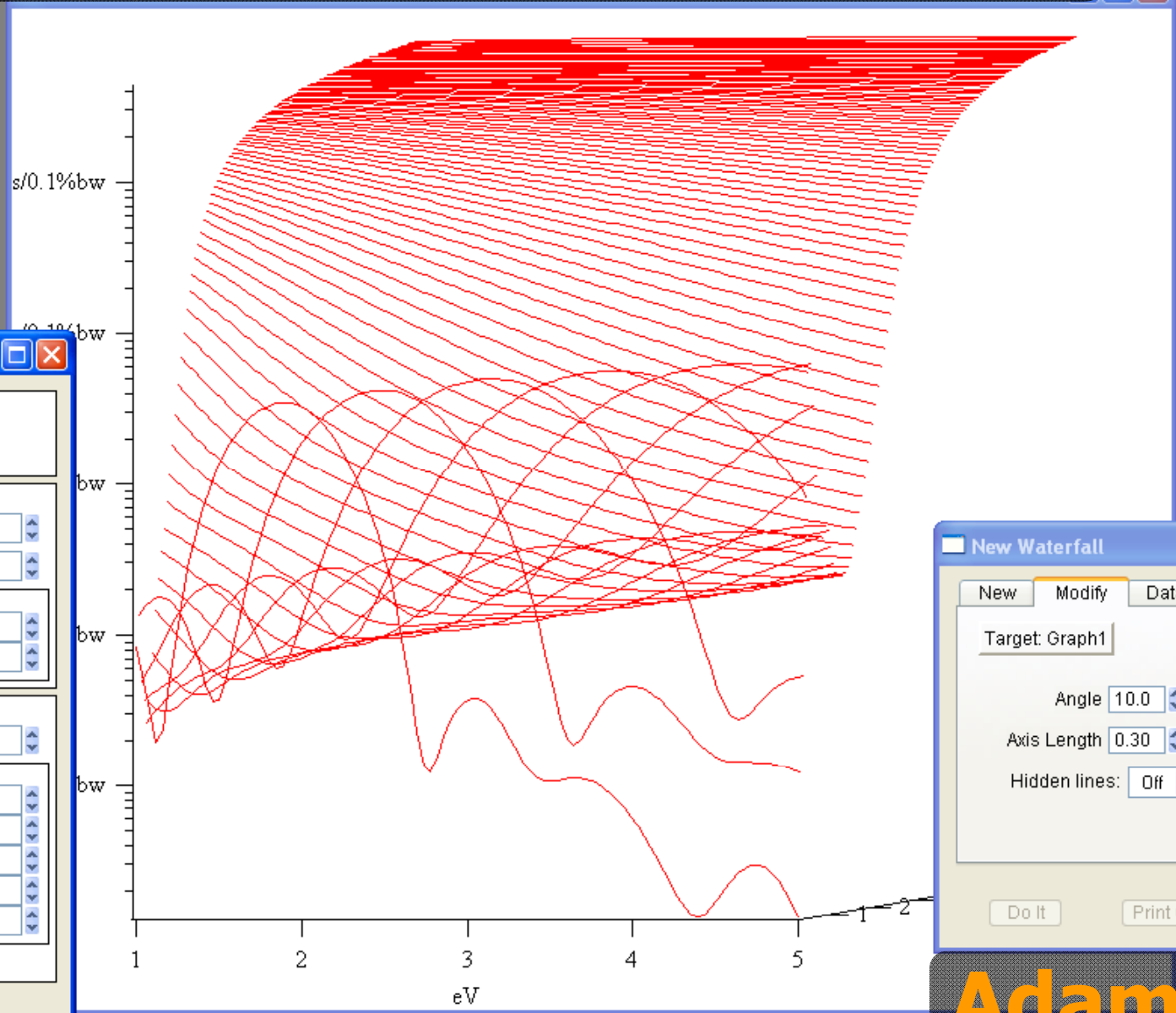
- **How does the detector react?**
- **What will the results mean?**
- **How can we optimise the performance?**

```

*AppendToGraph photperprotOnepass
*ModifyGraph grid(bottom)=2
*SwElectDiag(0)
*Mod... (photperprotOnepass)=0.065260)
*Mod... Graph...
*Lev... (C/N=...

```

Choosing the Software



Electron Beam

Existing structures: electronbeam_ebm
 Name: electronbeam

"Filament" beam

Electron Energy [GeV]: 3.8126 Electron Current [A]: 1.1
 Longitudinal Position where Initial Conditions are defined [m]: 0

Horizontal		Vertical	
Position [mm]: 0	Angle [mrad]: 0	Position [mm]: 0	Angle [mrad]: 0

"Thick" beam

Definition by: Twiss Rel. RMS En. Spread: 0.001

Horizontal		Vertical	
Emittance [nm]: 5	Beta [m]: 36	Emittance [nm]: 1	Beta [m]: 3
Alpha [x]: 0	Dispersion [m]: 0	Alpha [x]: 0	Dispersion [m]: 0
Dispers. Deriv. [x]: 0		Dispers. Deriv. [x]: 0	

Twiss parameters refer to the Longitudinal Position: 0 m

Buttons: Quit, Continue, Help

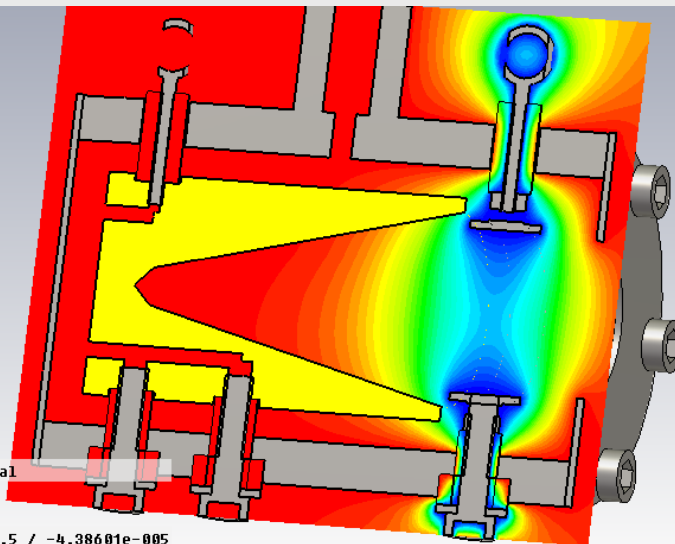
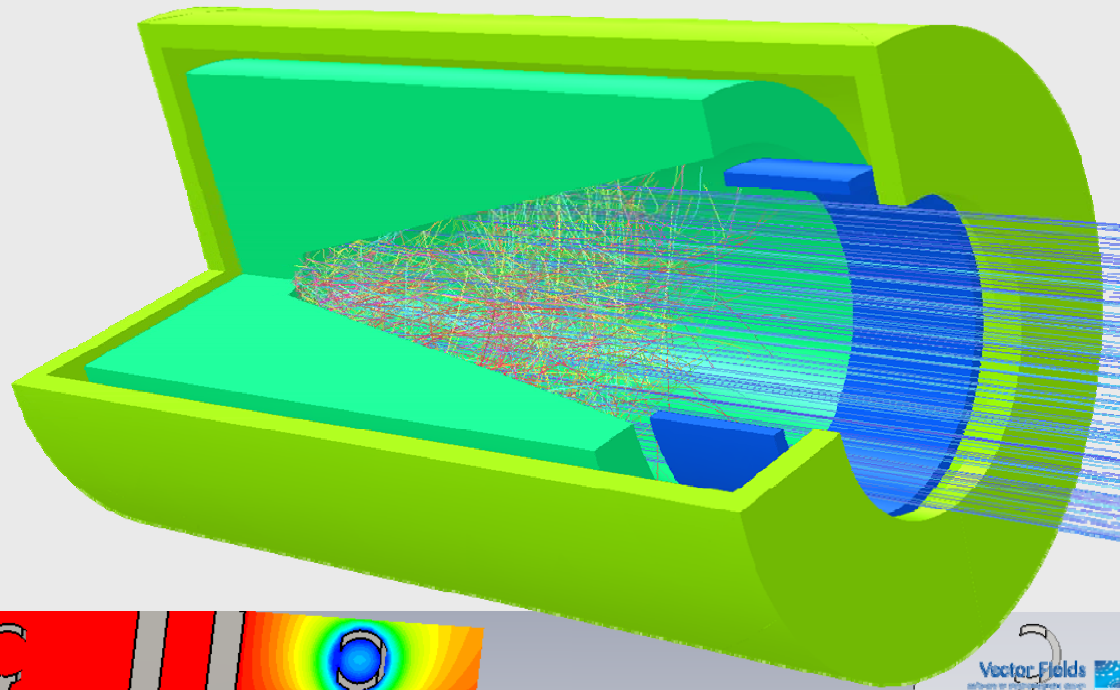
New Waterfall

Target: Graph1

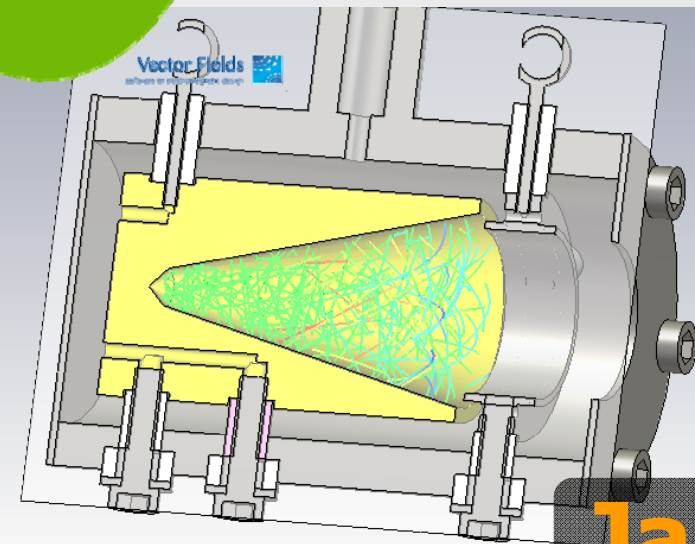
Angle: 10.0
 Axis Length: 0.30
 Hidden lines: Off

Buttons: Do It, Print Cmd

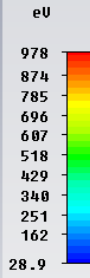
Choosing the Software



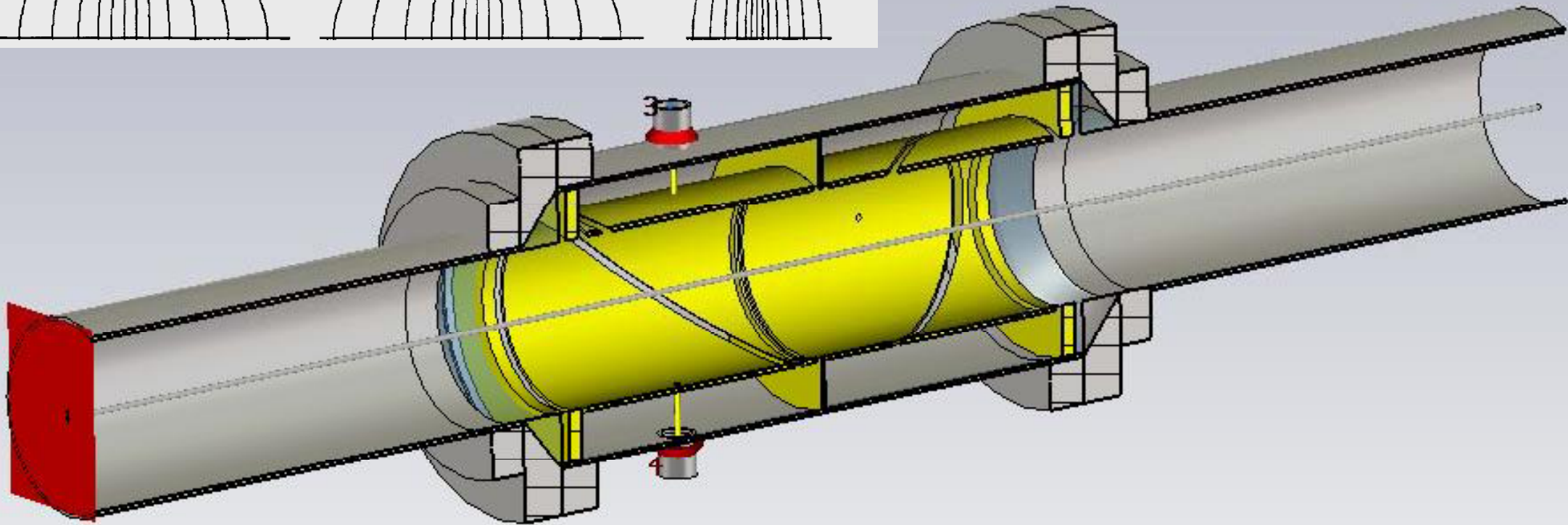
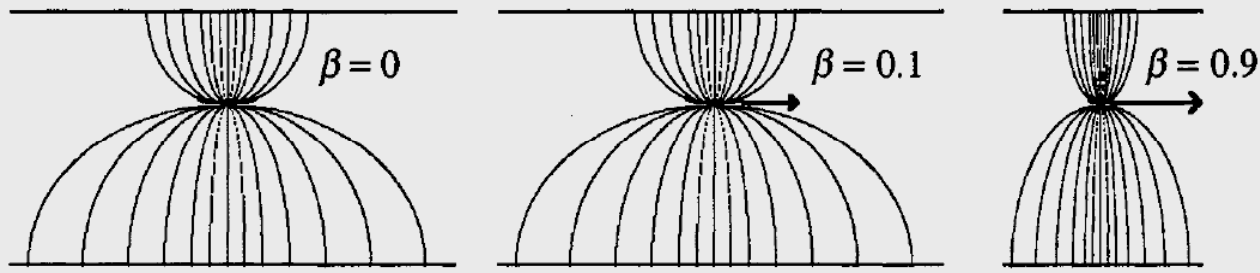
Type Electric Potential
Monitor Potential
Plane at z 0
Maximum-2d 0 V at -25 / -38.5 / -4.38601e-005



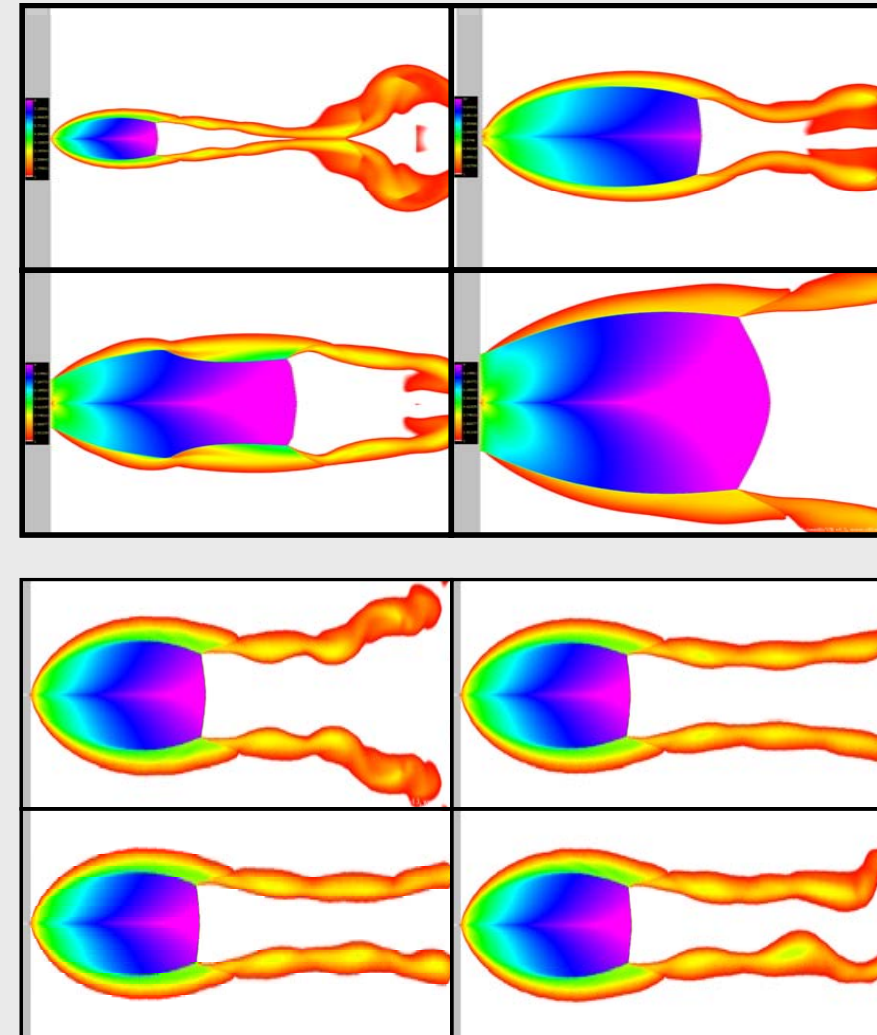
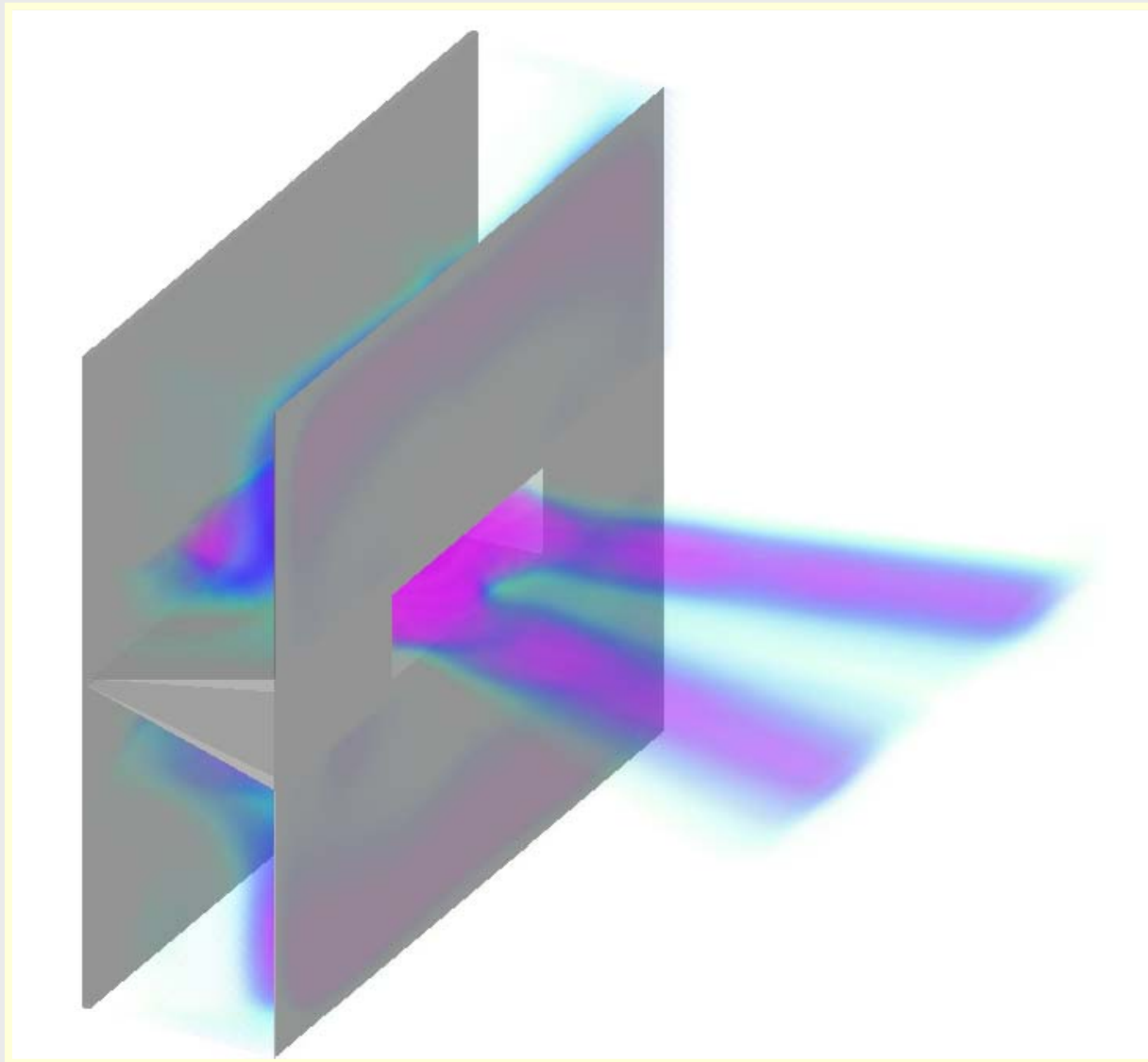
Type Energy
Time 4.093e-009 s



Choosing the Software



Choosing the Software

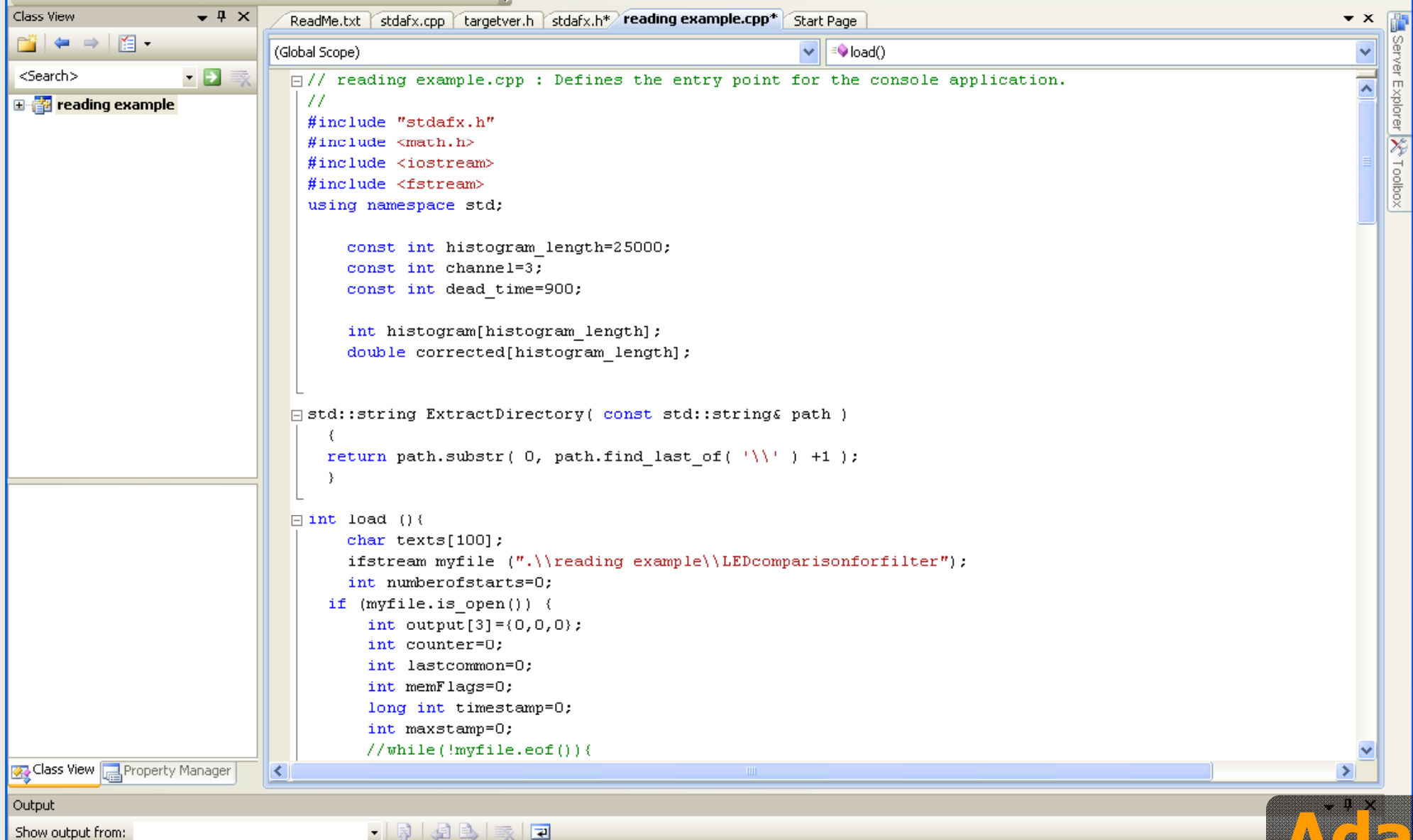


11/09/2010

Beam Diagnostics: a PhD Student's Perspective

Massimiliano

Or Making Your Own



```
(Global Scope)
load()

// reading example.cpp : Defines the entry point for the console application.
//
#include "stdafx.h"
#include <math.h>
#include <iostream>
#include <fstream>
using namespace std;

const int histogram_length=25000;
const int channel=3;
const int dead_time=900;

int histogram[histogram_length];
double corrected[histogram_length];

std::string ExtractDirectory( const std::string& path )
{
    return path.substr( 0, path.find_last_of( '\\\' ) +1 );
}

int load () {
    char texts[100];
    ifstream myfile (".\\reading example\\LEDcomparisonforfilter");
    int numberofstarts=0;
    if (myfile.is_open()) {
        int output[3]={0,0,0};
        int counter=0;
        int lastcommon=0;
        int memFlags=0;
        long int timestamp=0;
        int maxstamp=0;
        //while(!myfile.eof()){
```

Or Making Your Own

The image displays a MATLAB environment with several windows:

- Current Directory:** Lists files in the MATLAB folder, including `signalTrueNew.m`, `BIW_01.m`, `autoRange.m`, `BeamPositionPlot.m`, `BeamPositionPlot.asv`, and `offaxis.txt`.
- Code Editor:** Shows MATLAB code for signal processing:

```
61  
62  
63 % Charge distribution  
64  
65  
66 nPulse = defineNumberOfBunches; % number of bunches  
67  
68 Fs = defineADCFreq * 1e6; % sampling rate  
69 dt = 1/Fs; % data points resolution [s]  
% data points  
% time vector  
% t vector  
* bunchSin2(d  
% beam disp  
r; % sum sign  
eanSum);  
script
```
- Workspace:** Lists variables and their values:

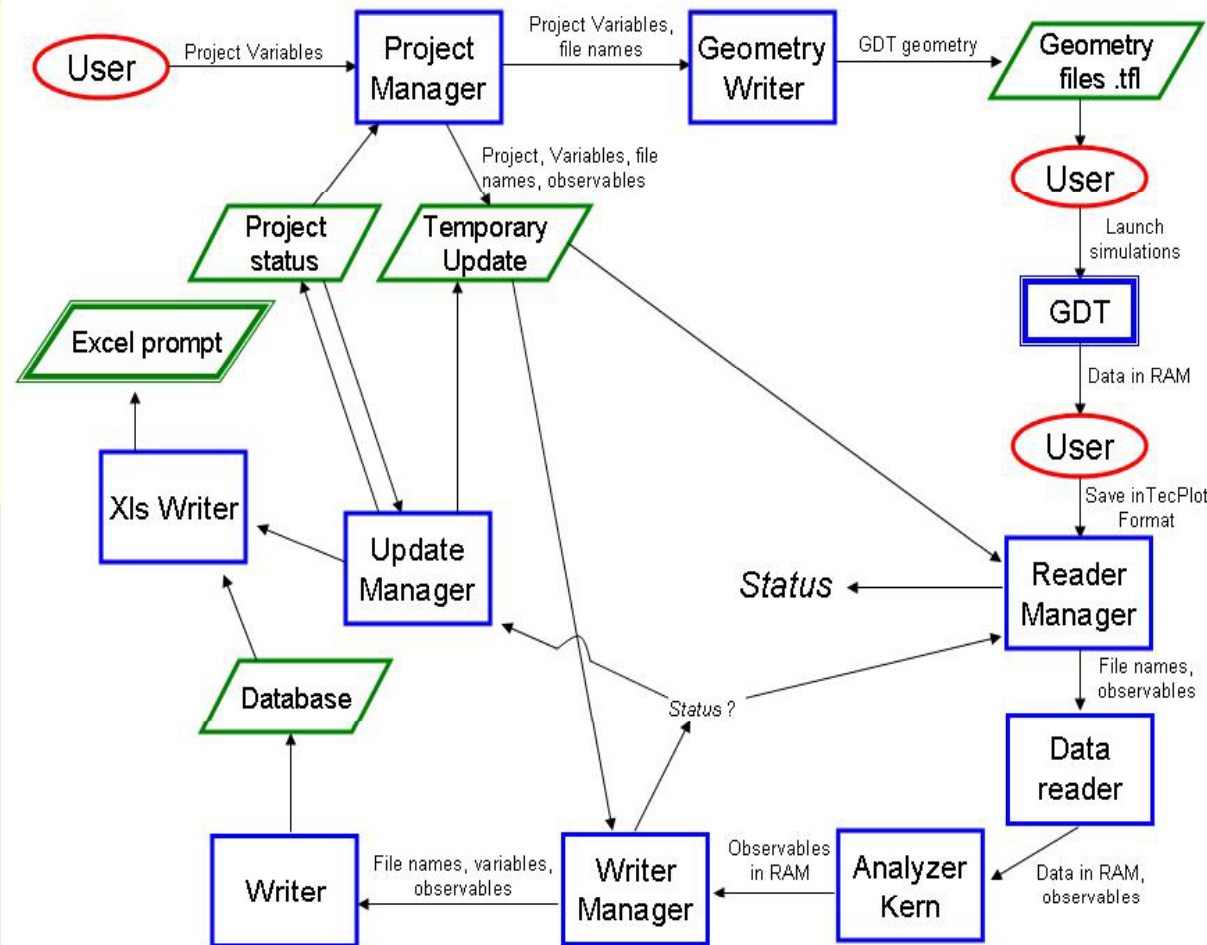
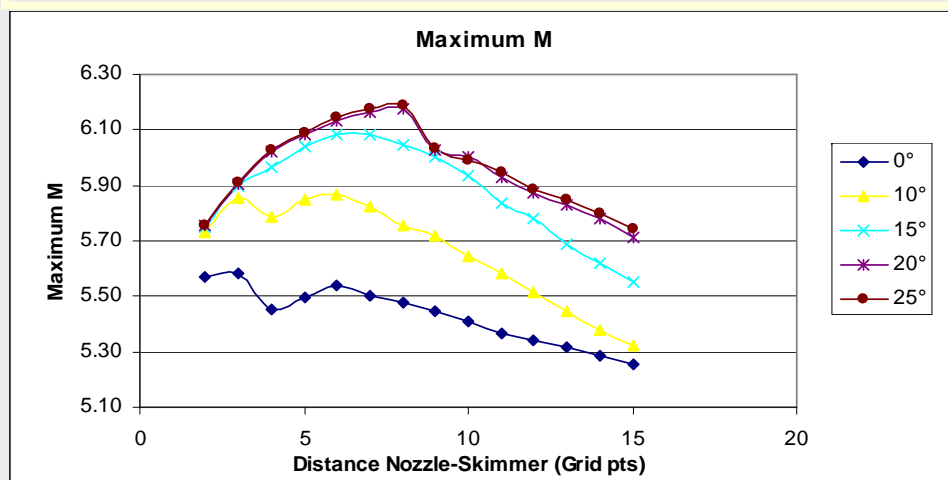
Name	Value
ADCMaxInputV1	0.2000
ADCMaxInputV2	2
BW	10000000
Cc	5.0000e-12
Cg	1.0000e-10
Cg1	9.7000e-11
Cn2	5.5000e-11
- Figure 1:** Two time-domain plots. The top plot shows ΣU signal (μV) vs Time (μs) with a periodic signal. The bottom plot shows ΔU signal (μV) vs Time (μs) with a noisy signal.
- Figure 2:** Two frequency-domain plots. The top plot shows ΣU magnitude (dBV) vs Frequency (MHz) with peaks at approximately 1.8, 3.5, and 5.5 MHz. The bottom plot shows ΔU magnitude (dBV) vs Frequency (MHz) with a noisy spectrum.

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



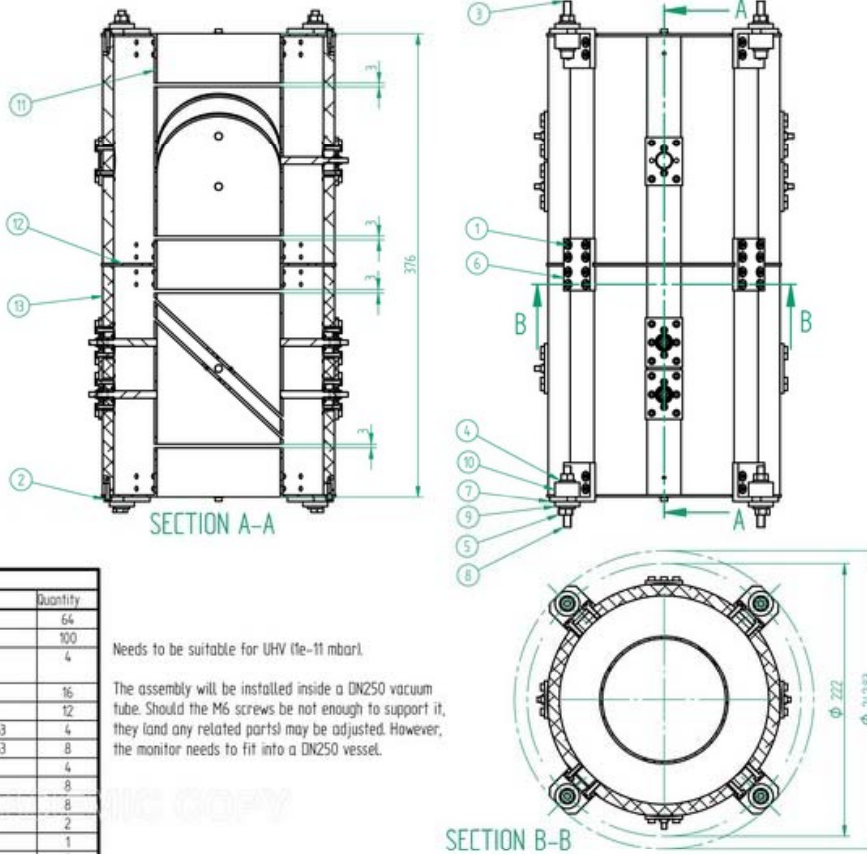
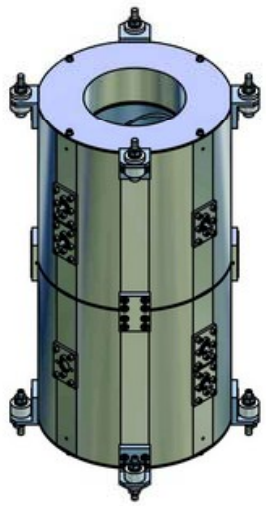
**Being Exposed
to New Fields**



**Being Exposed
to New Fields**



**Being Exposed
to New Fields**



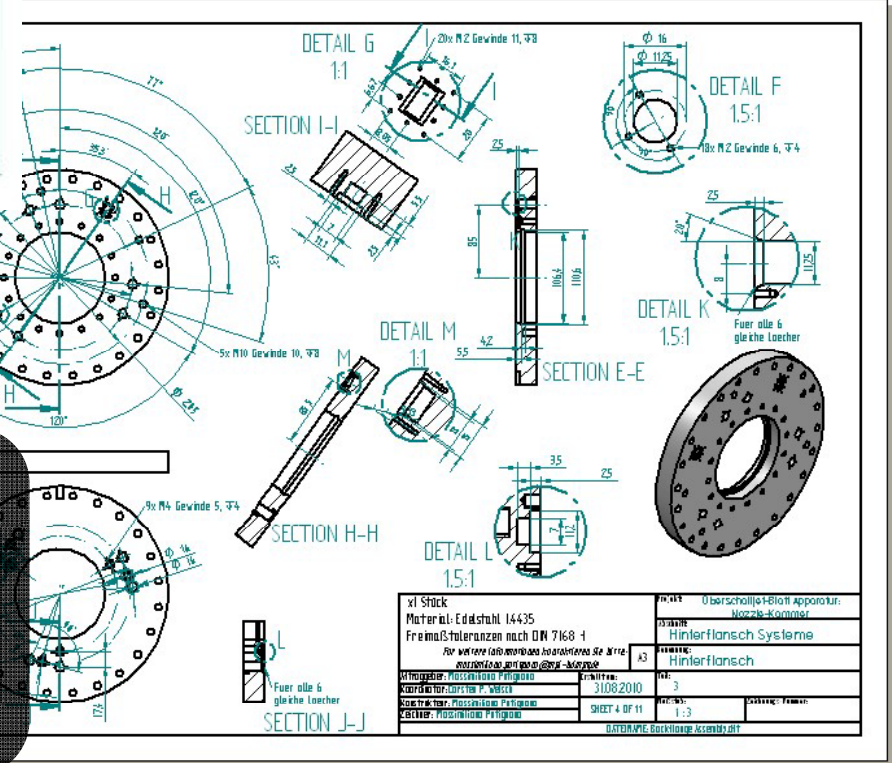
1 Beam Position Monitor				
Item	Name	Drawing	Material	Quantity
1	Cap screw ISO 4762 - M4 x 12		Stainless steel 316	64
2	Cap screw ISO 4762 - M3 x 12		Stainless steel 316	100
3	Cap screw ISO 4762 - M6 x 40 vented		Stainless steel 316	4
4	Washer ISO 7092 - 6		Stainless steel 316	16
5	Nut ISO 4032 - M6		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	3.1	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	Stainless steel 316L	2

Needs to be suitable for UHV (le-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.

PHIC COPY

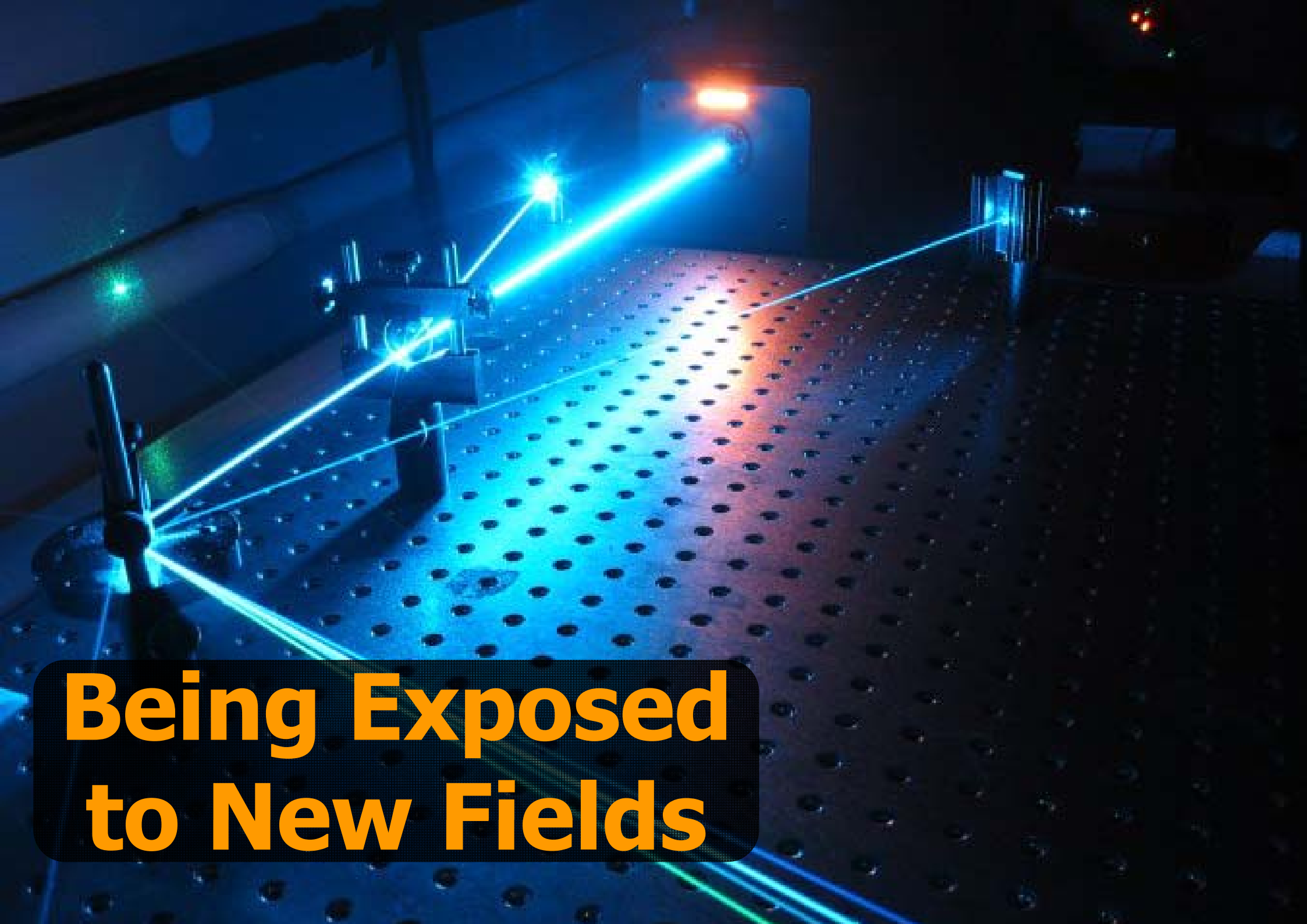
Being Exposed to New Fields



xl Stück	Material: Edelstahl 14435	Fremsitztoleranzen nach DIN 7168 -1	Für weitere Informationen kontaktieren Sie Mr. Martin G. am g@ipg.de
Überschall-Blotz Apparat: Nov28-Kammer	Hinterflansch Systeme	Hinterflansch	3
31082010	3	1:3	
SHEET 4 OF 11	DATE: 08/11/2010		



**Being Exposed
to New Fields**

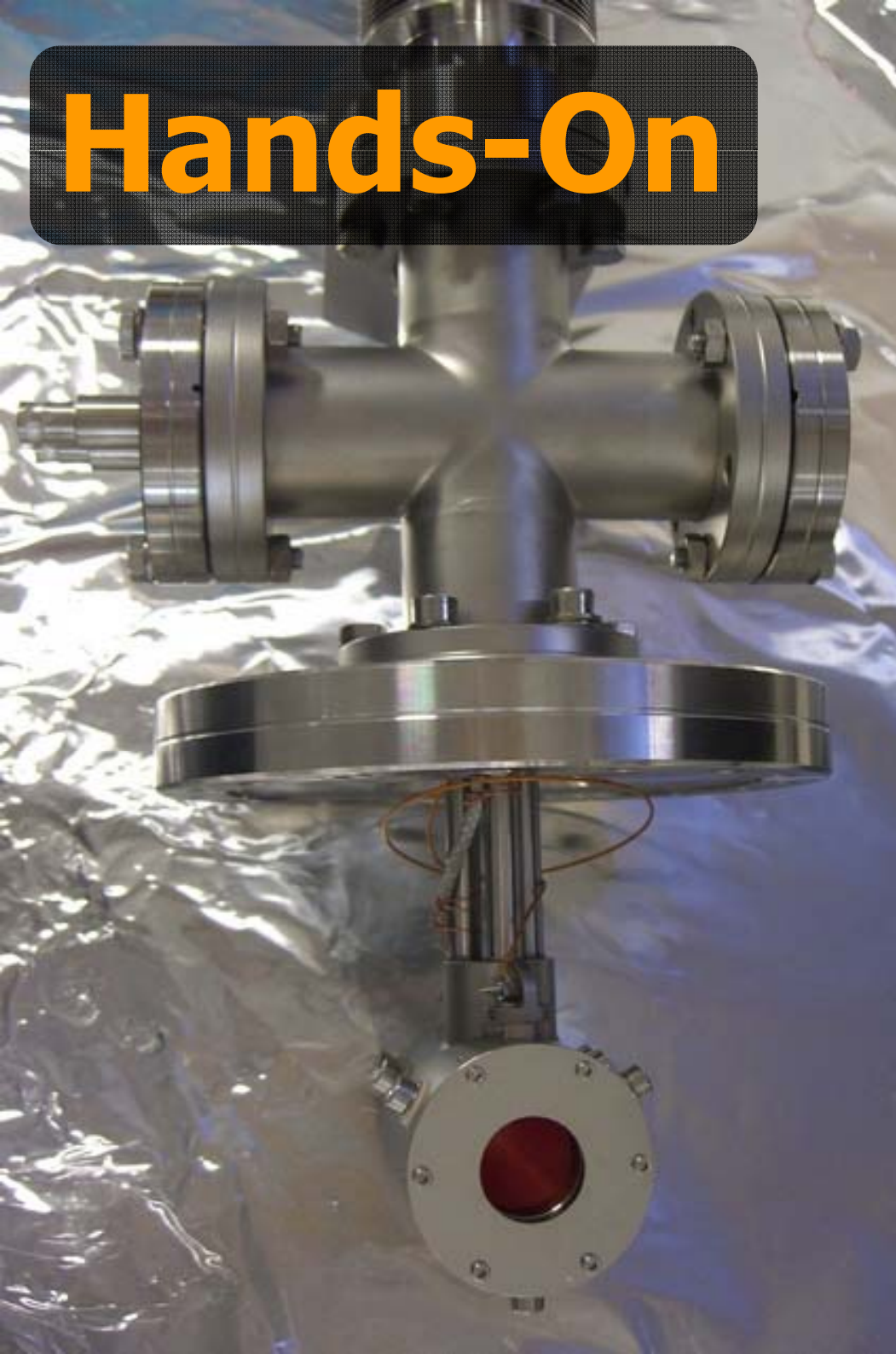


**Being Exposed
to New Fields**

Hands-On



Hands-On



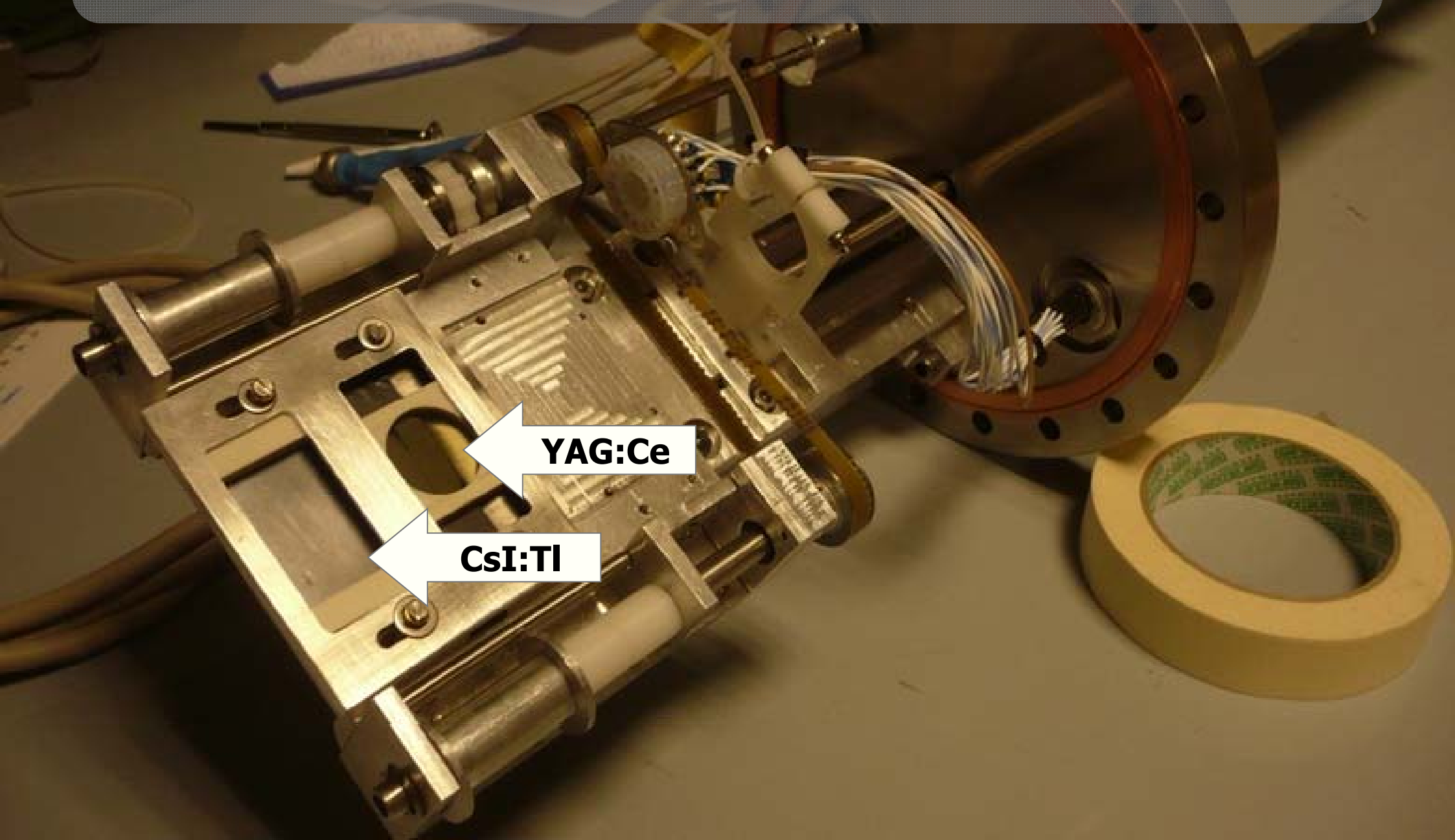
Hands-On



Legs-Out

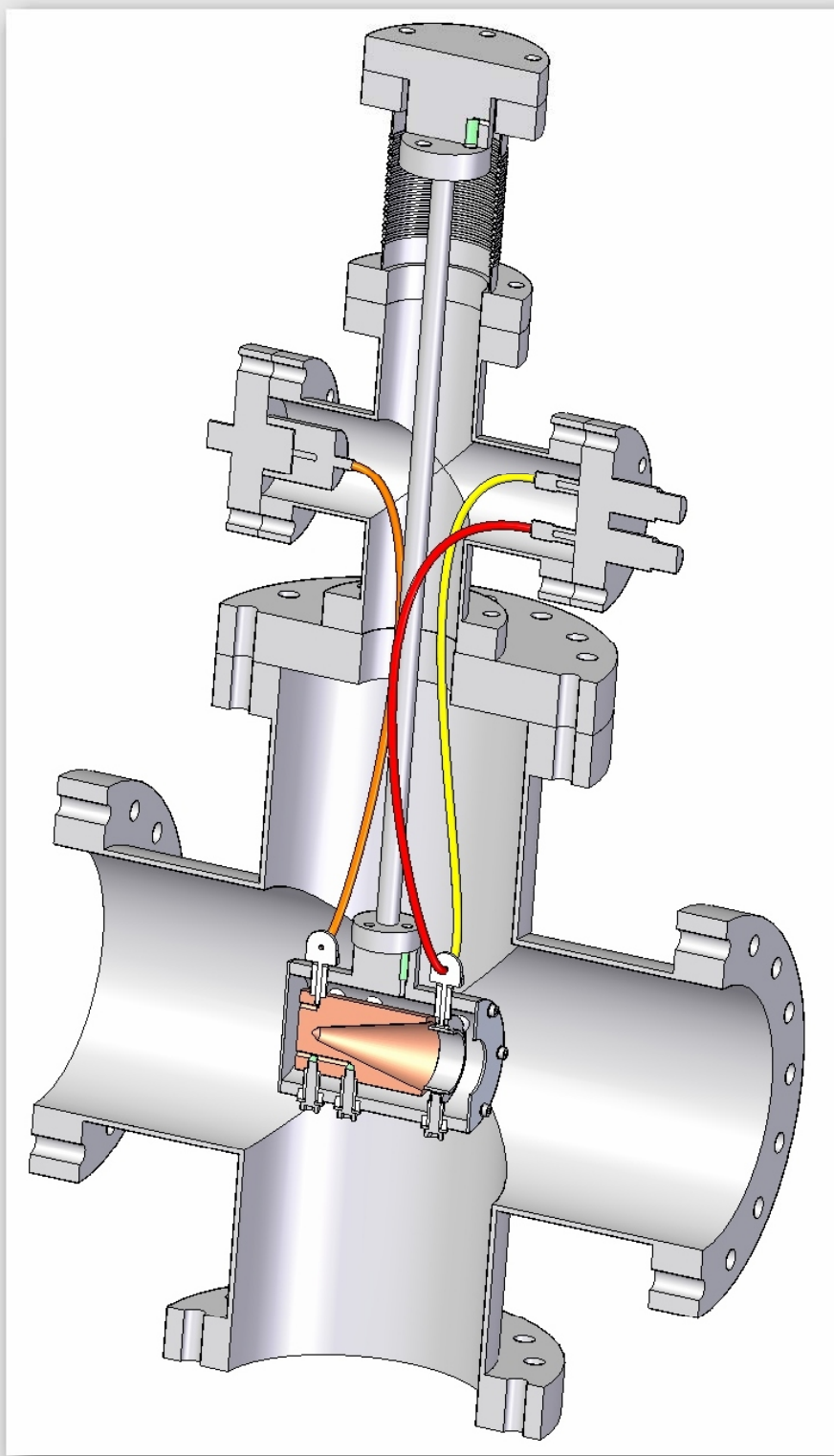
Our Achievements

Scintillating Screens



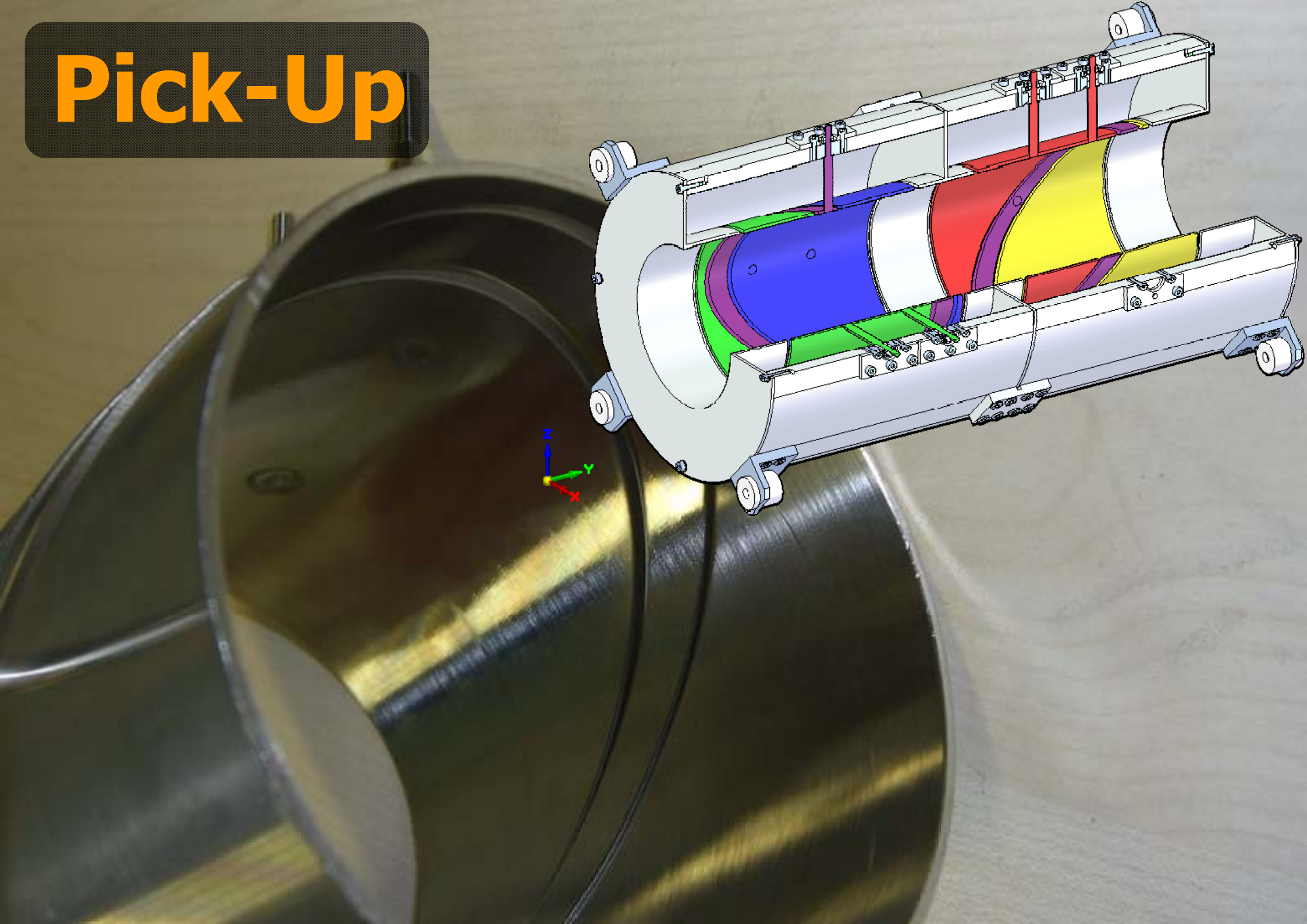
← **YAG:Ce**

← **CsI:Tl**

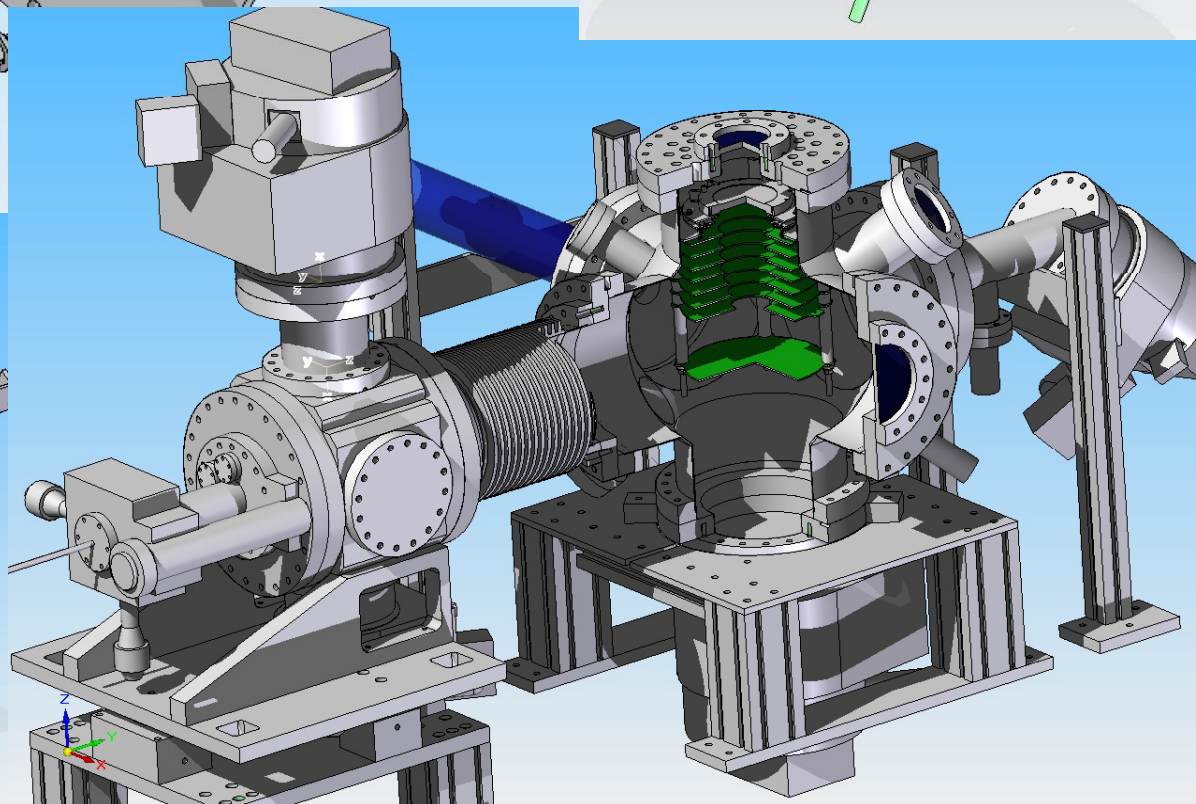
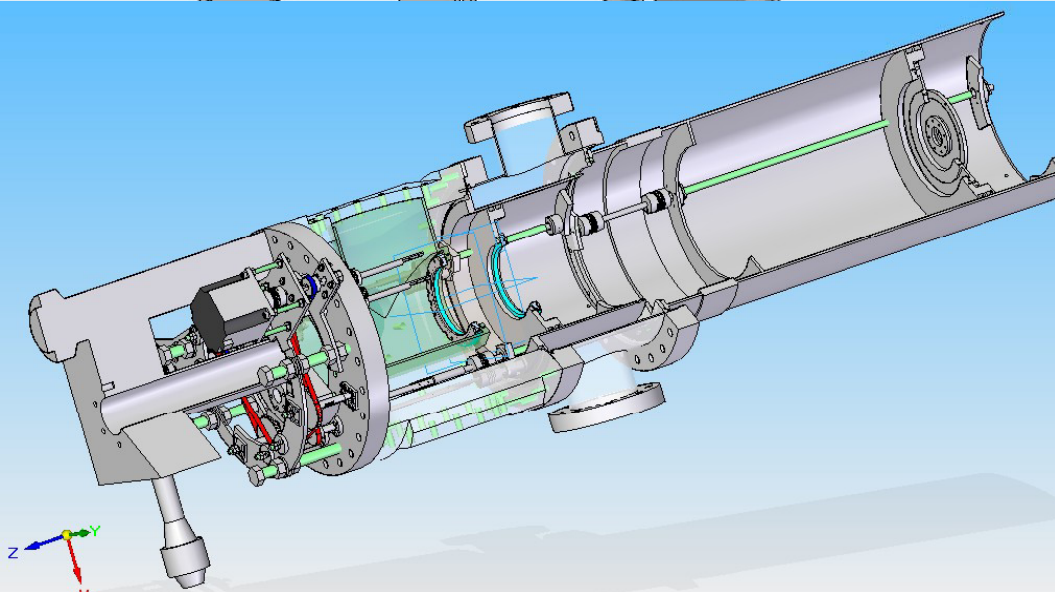
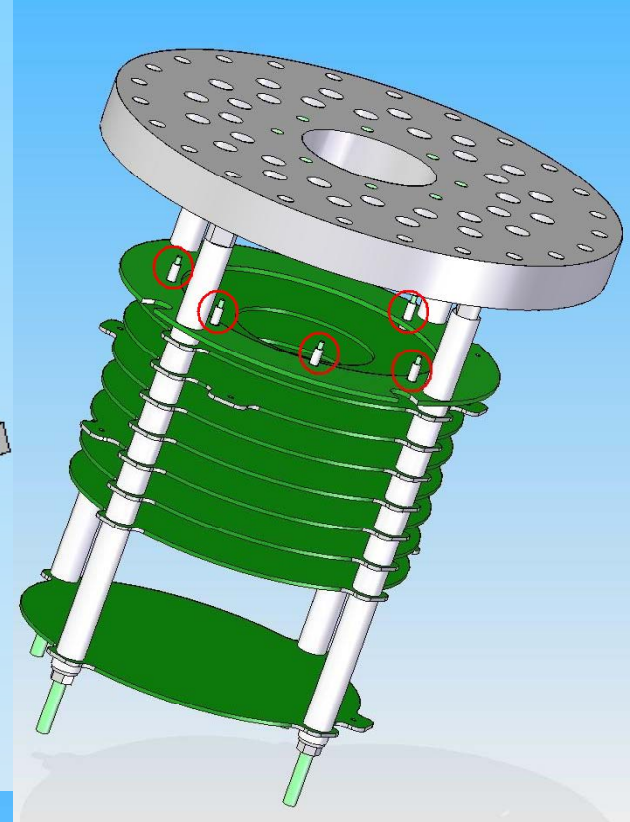
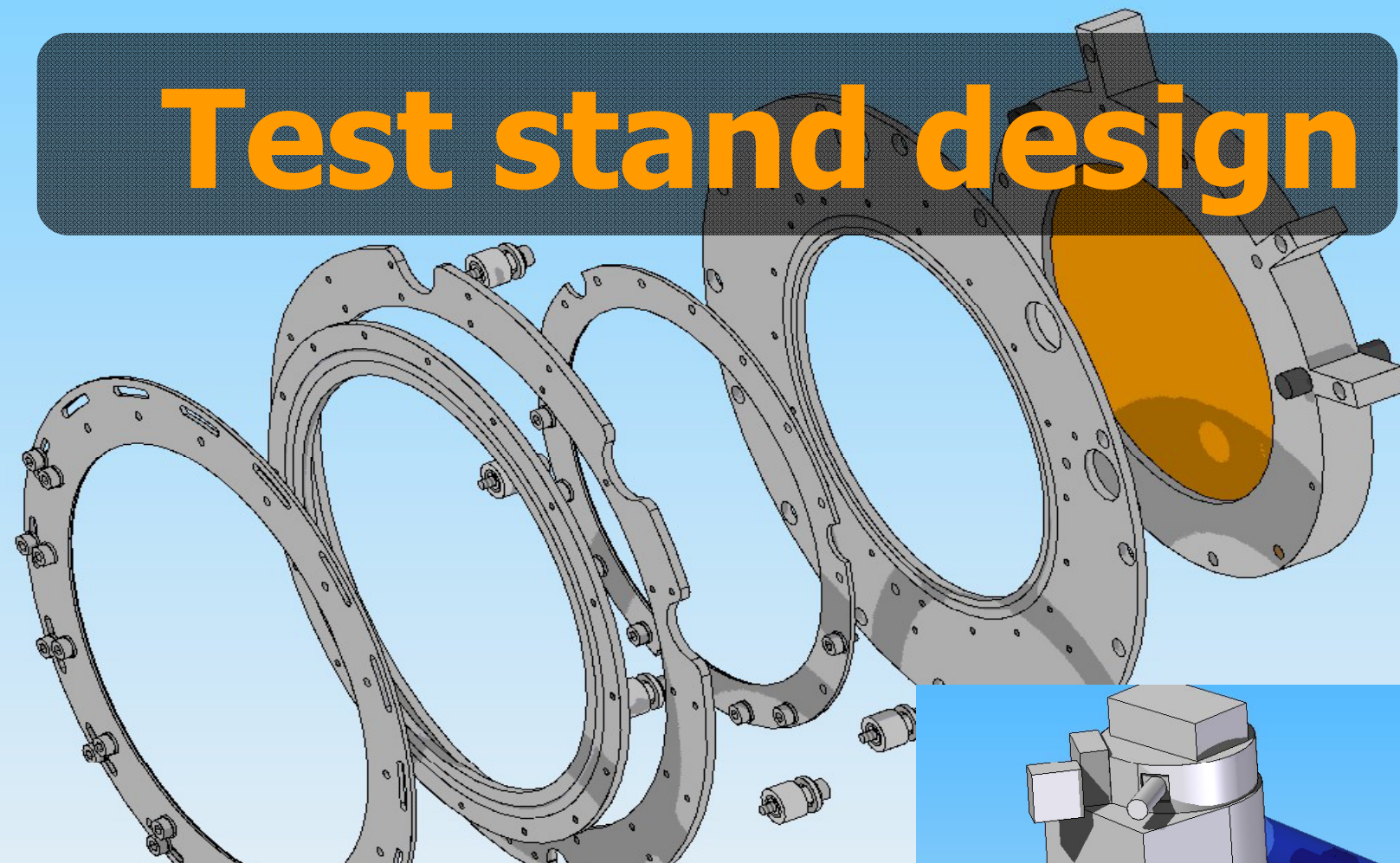


Faraday Cup

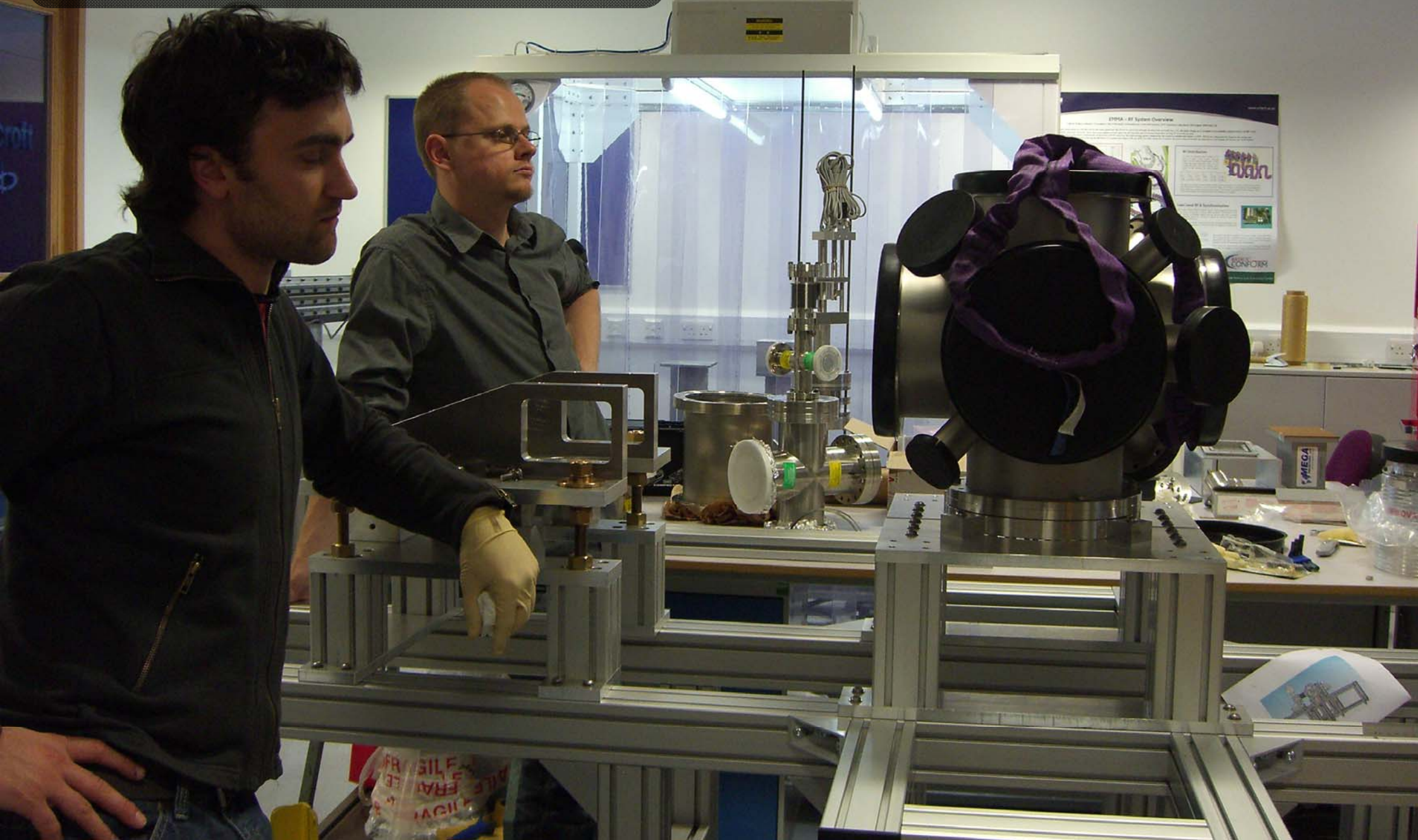
Pick-Up



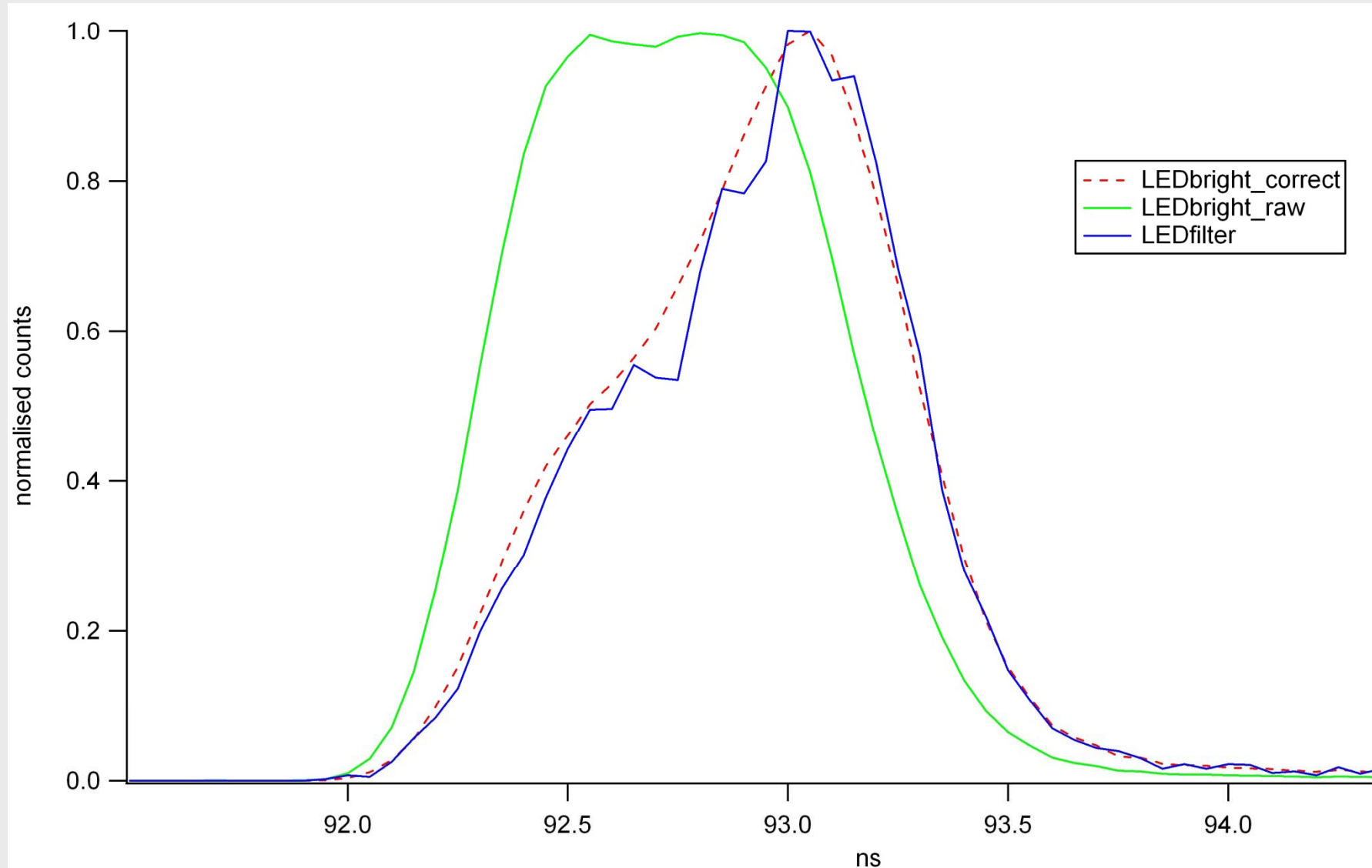
Test stand design



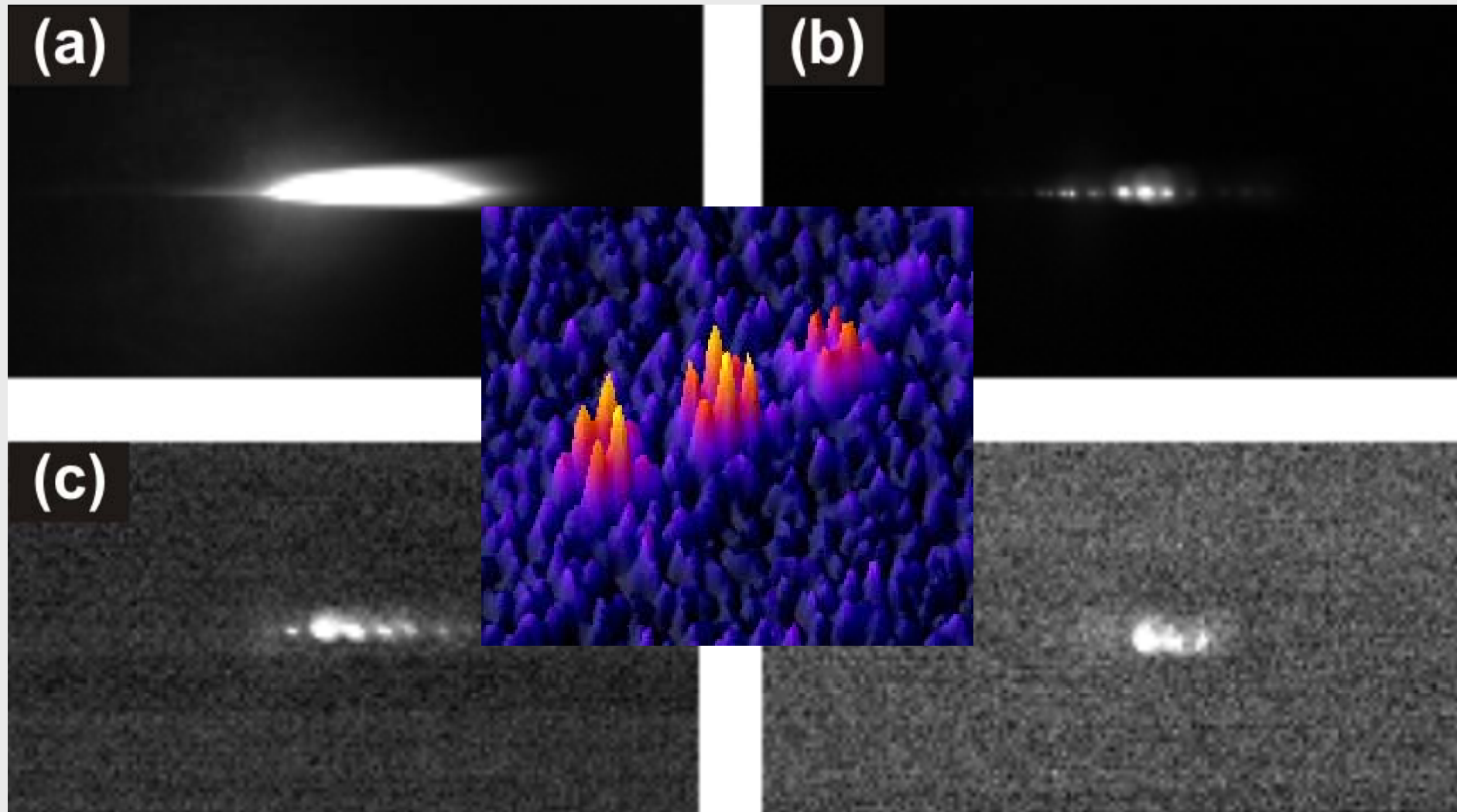
Test stand



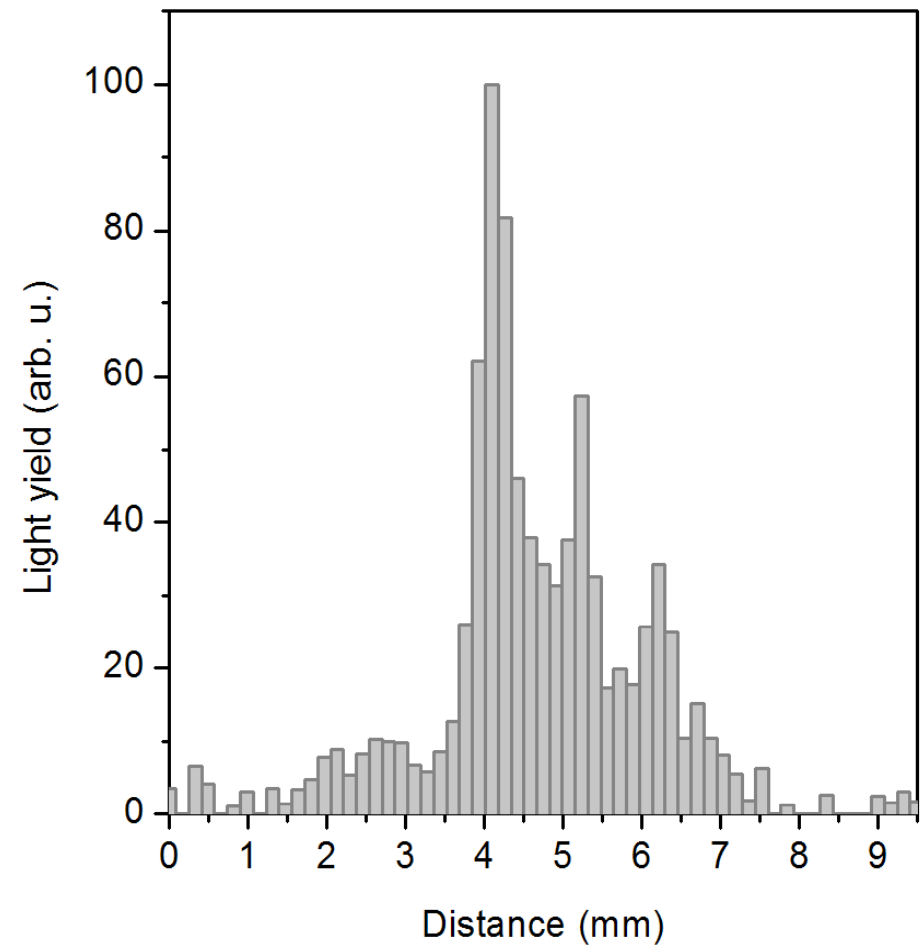
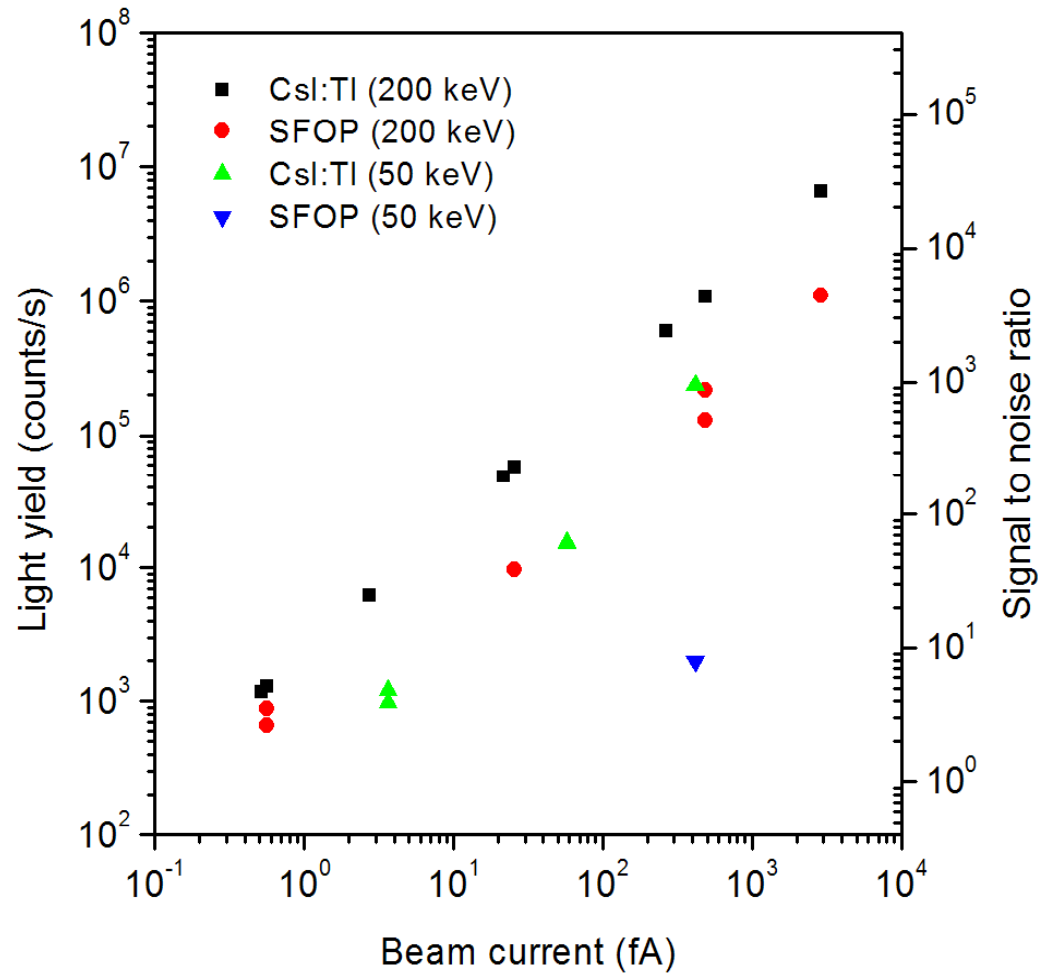
Measurements: Adam



Measurements: Janusz

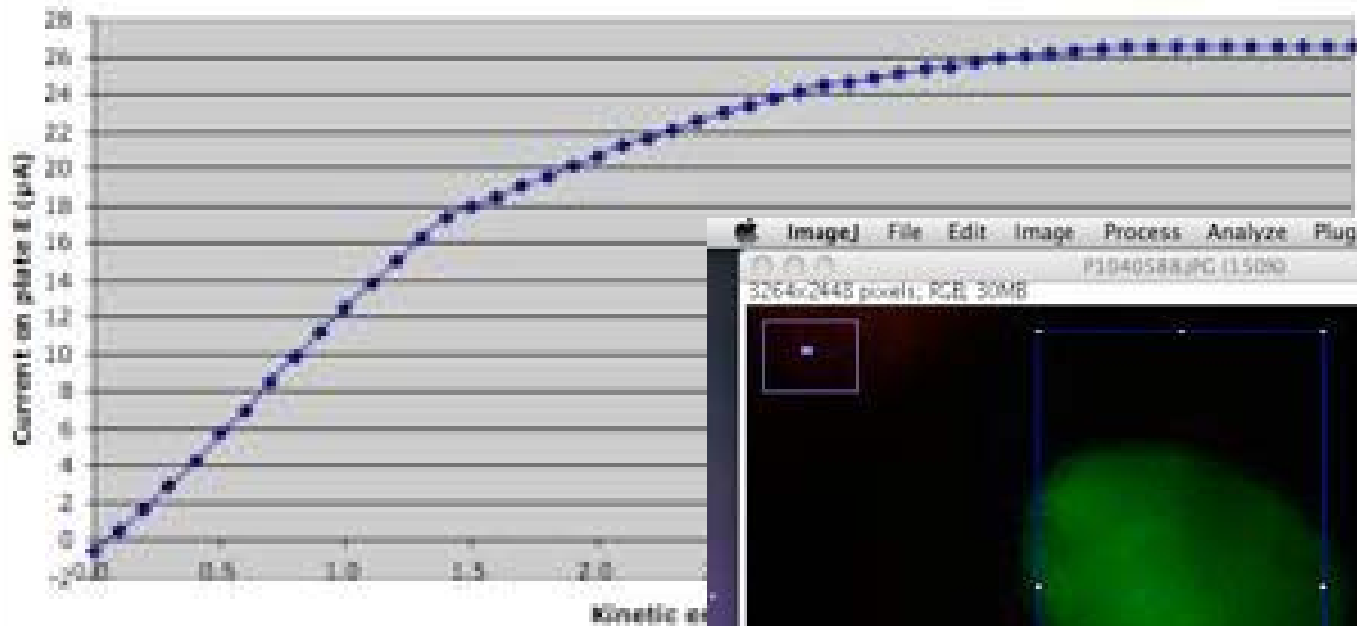


Measurements: Janusz



Measurements: Max

Current on plate II as kinetic energy varies



A screenshot of the ImageJ software interface. The main window displays a green beam profile on a black background, with a blue rectangular selection box around it. A smaller window titled 'Plot of P1040588' shows a line graph of the beam profile's intensity. The x-axis is 'Distance (pixels)' from 0 to 200, and the y-axis is 'Gray Value' from 0 to 20. A blue horizontal line is drawn across the peak of the profile at approximately y=13.5. The status bar at the bottom shows 'x=164.07, y=11.65, angle=0.50, length=91.11'.

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