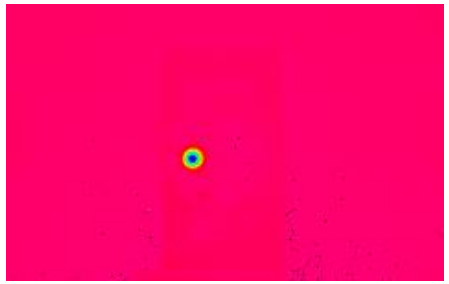
AWAKE Electron Sources for Run 2

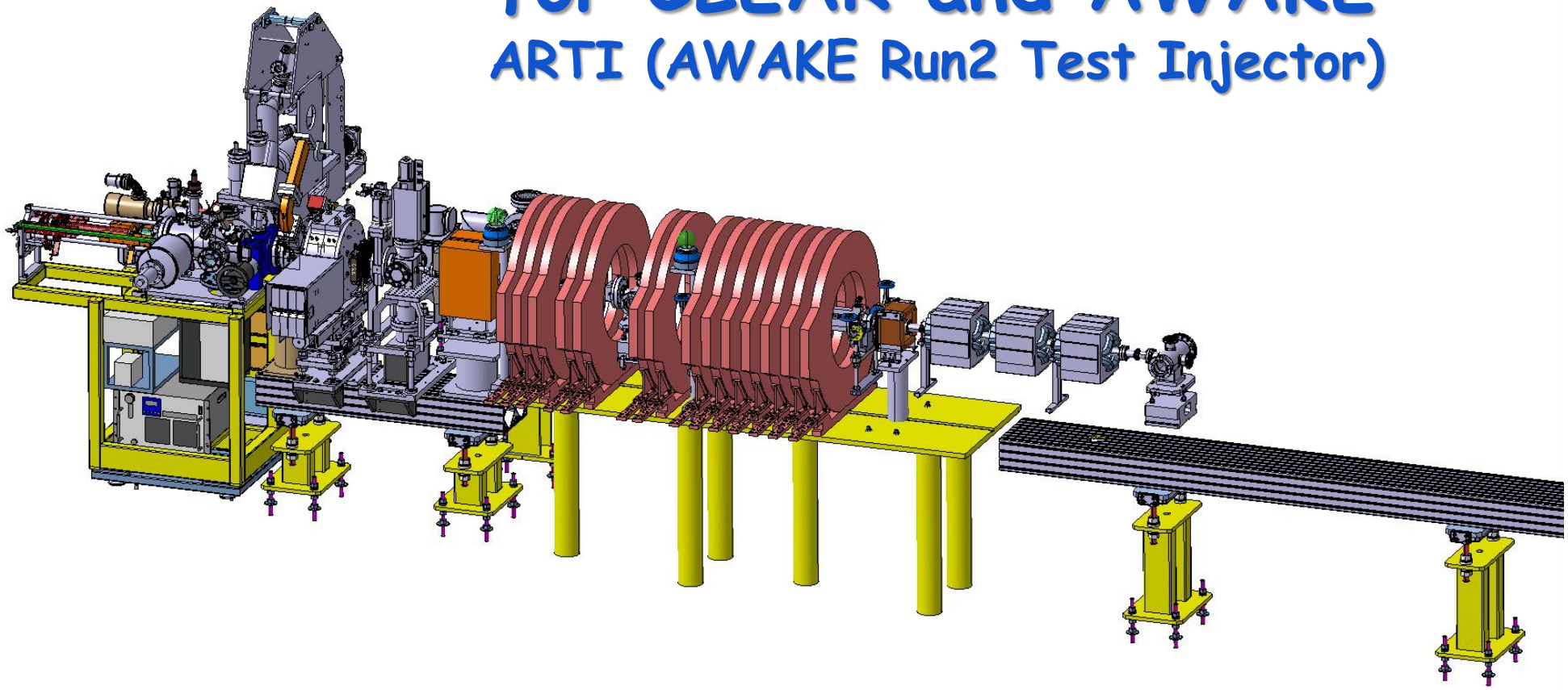
- ❑ **Run2 prototype in CTF2 (ARTI)**
- ❑ **First results with beam**
- ❑ **Conclusion and outlook**



AWAKE collaboration meeting 25-26 April, Uppsala
Steffen Doebert, J. Arnesano

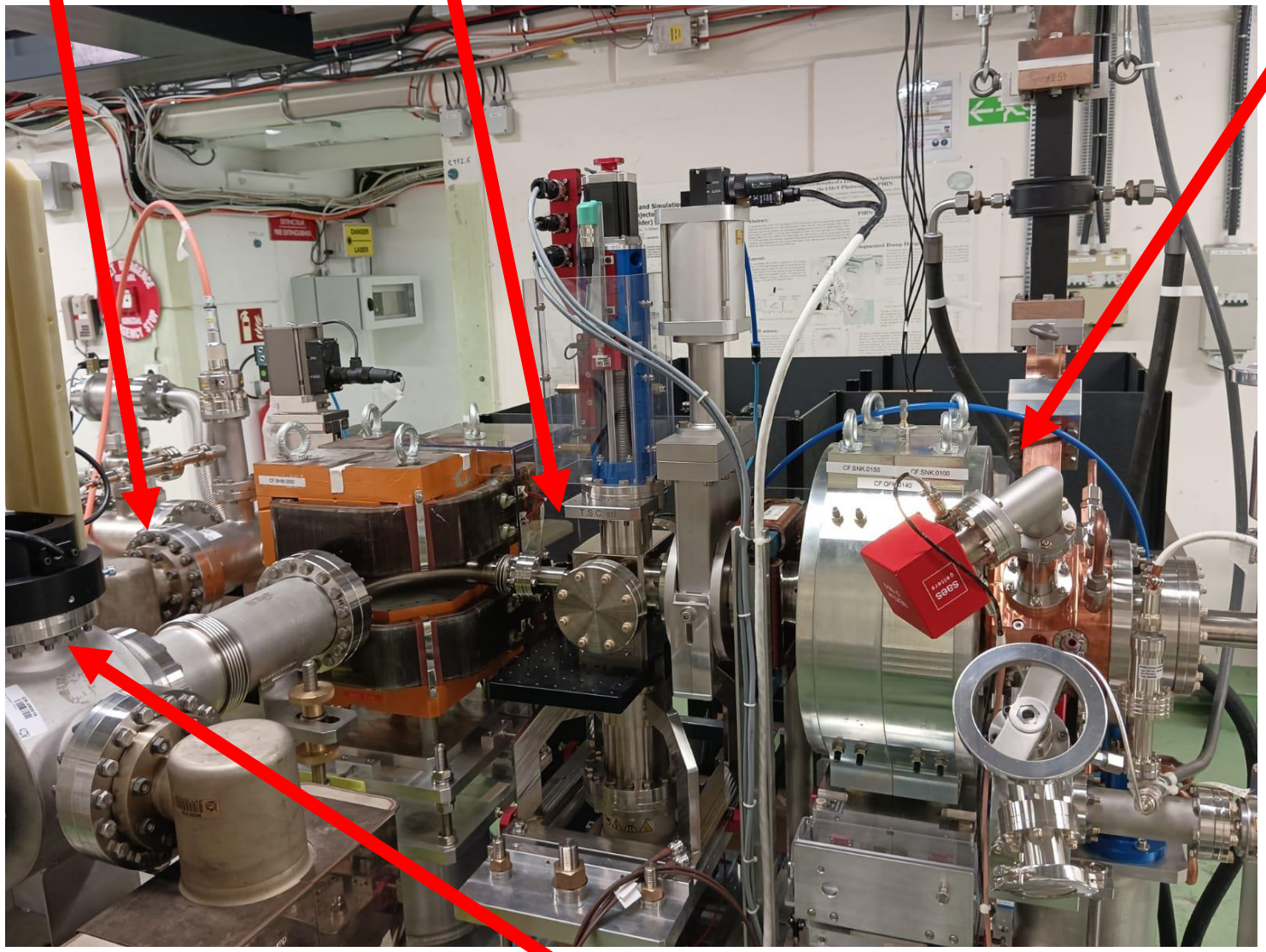
Injector prototype in CTF2 for CLEAR and AWAKE

ARTI (AWAKE Run2 Test Injector)



Reduced scale prototype, 60 MeV, T24 as buncher and PSI-linearizing structure for acceleration.
Goal: demonstrate the velocity bunching and emittance preservation with x-band
Prototyping of key hardware

ARTI in CTF2



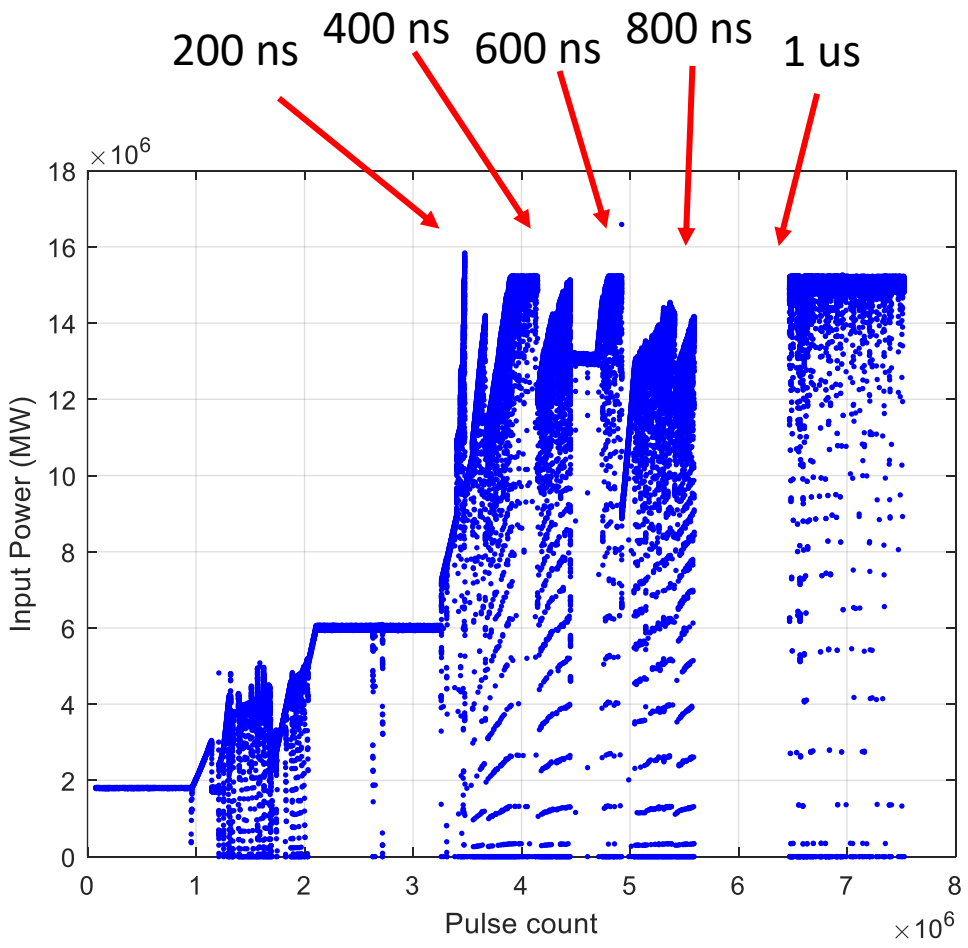
Status:

- **Phase 1 installed and operational**
- **All safety documentation finished**
- **DSO tests successfully performed**
- **Beam permit obtained**
- **Diagnostics installed and being commissioned**
- **Laser table installed and equipped**
  Laser aligned and synchronised

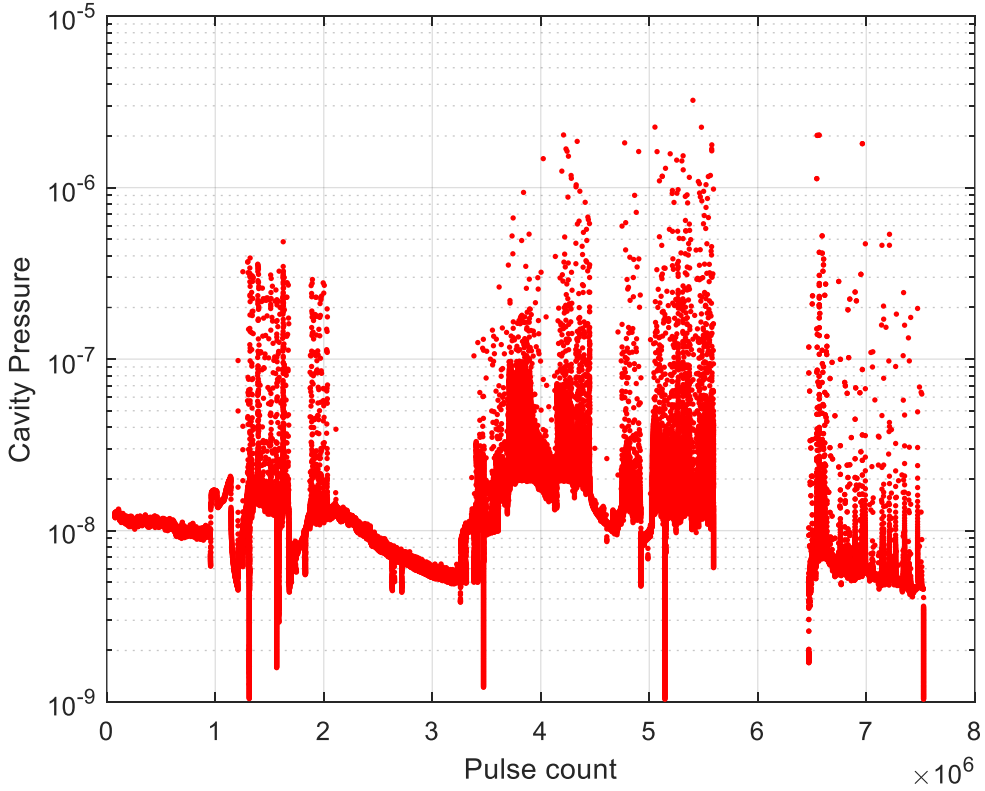
➢ **First beam tests were successful and promising**

RF-gun build by INFN Frascati.

RF Conditioning data from the INFN RF-GUN in CTF2



RF-gun conditioned to 120 MV/m on the cathode



Counting: 1-5k breakdowns depending on threshold

→ Very good result, promising for future reliable operation

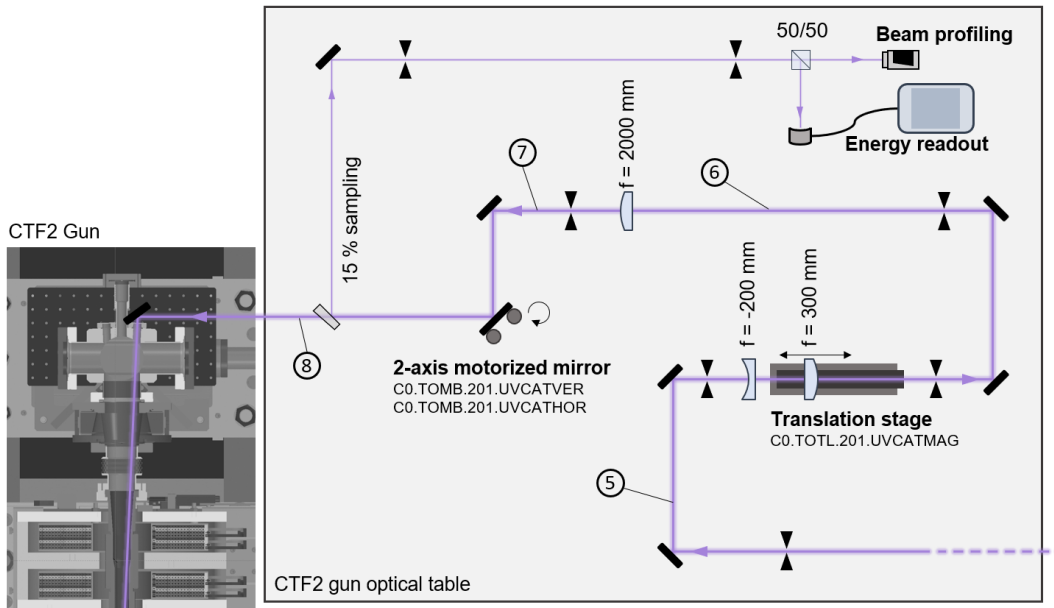
ARTI photoinjector laser

Eduardo Granados (SY-STI)

Miguel Martinez Calderon (SY-STI)

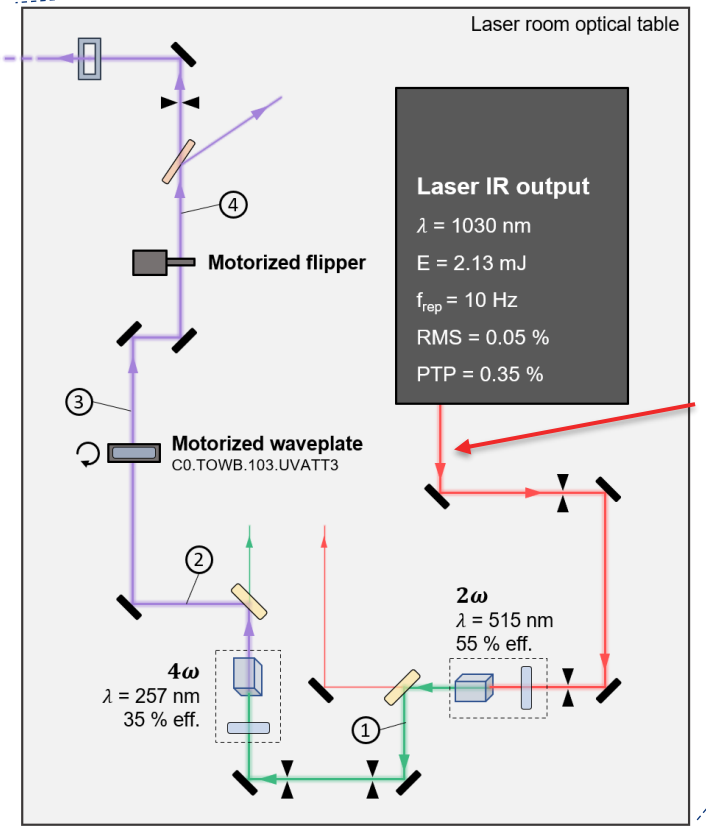
Baptiste Groussin (SY-STI)

Setup at CLEAR laser lab

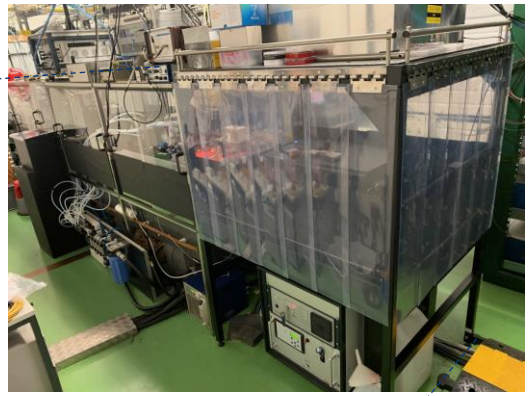


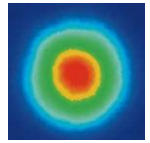
		E (μJ)	RMS (%)	PTP (%)
515 nm	1	1240	0.06	0.48
	2	480	0.09	0.56
	3	435	0.07	0.53
	4	427	0.07	0.45
257 nm	5	369	0.16	0.95
	6	304	0.45	5.39
	7	286	0.61	5.89
	8	245	1.04	11.70

Optical setup of CTF2 Photoinjector laser and energy stability



Dedicated laminar flow tent



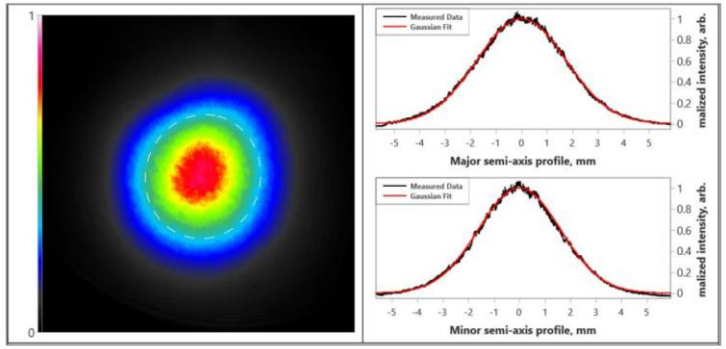


Conversion efficiency:

- IR to green ~60%
- Green to UV ~30%
- Overall ~ **18%**

IR to UV conversion stages

Output at 1030 nm

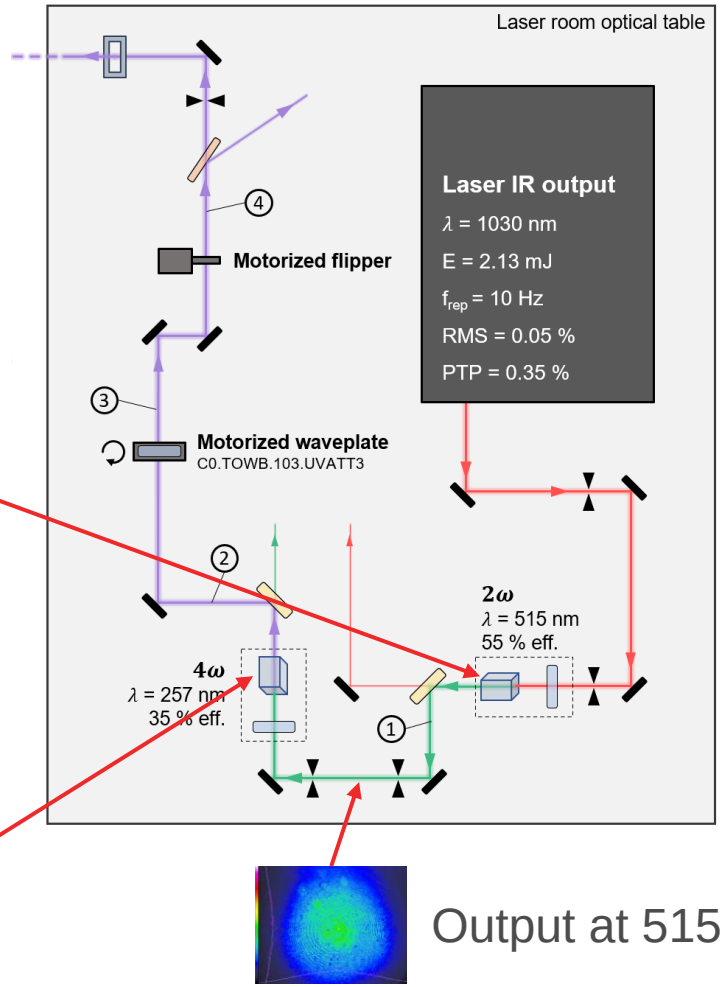


SHG BBO CRYSTALS. Type 1, Thickness = 2.0 mm

Aperture, mm	θ, deg	φ, deg	Coating	Catalogue number	Price, EUR
6×6	23.4	90	AR/AR @ 515+1030 nm	BBO-654H	480
8×8	23.4	90	AR/AR @ 515+1030 nm	BBO-854H	630
10×10	23.4	90	AR/AR @ 515+1030 nm	BBO-1054H	835

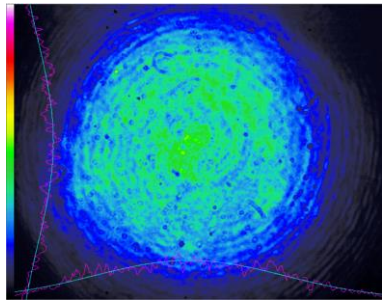
BBO FOR 4HG @ 1030 nm

Aperture, mm	Thickness, mm	θ, deg	φ, deg	Coating	Catalogue number	Price, EUR
6×6	0.1	50	90	P/P @ 515/257 nm	BBO-641H	600
6×6	0.15	50	90	P/P @ 515/257 nm	BBO-642H	570
6×6	0.2	50	90	P/P @ 515/257 nm	BBO-643H	550
6×6	0.3	50	90	P/P @ 515/257 nm	BBO-644H	535



Output at 515 nm

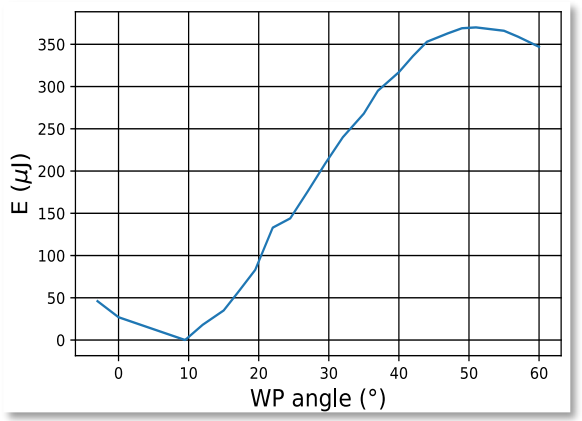
Output at 257.5 nm



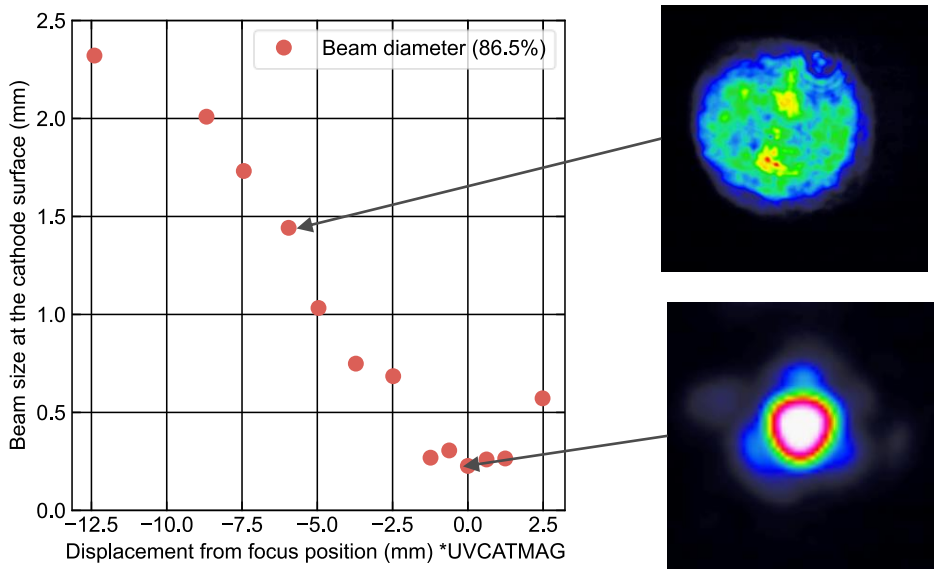
Peak (X,Y)R [µm]	(2351.7, 1554.4) 2819.0
Centroid (X,Y)R [µm]	(4131.2, 3306.5) 5291.5
Peak % Resp. [%]	65.1
Eff. Area [mm²]	16.856
Fluence [J/cm²]	0.803
Eff. Diameter 86.5% [mm]	Invalid
Aper. Diameter 86.5% [mm]	0.066
Knife Edge 84.0% [mm]	7.839, 7.350
Ellipticity	
Major, Minor 86.5% [mm]	7.852, 7.061
Circularity	0.899
Gaussian Fit 86.5%	
Coefficient	0.862, 0.857
Aperture Uniformity	
Min, Mean, Max [digital]	24277.0, 27091.0, 30476.0
Sigma, RMS [digital]	1849.5, 27152.9
Image Uniformity	
Min, Mean, Max [digital]	6.0, 12219.9, 42656.0
Flat Top 14.0%	
Beam Uniformity	0.390
Plateau Uniformity	0.003
Flatness Factor	0.381
Edge Steepness	1.000

Spot on cathode control and performance

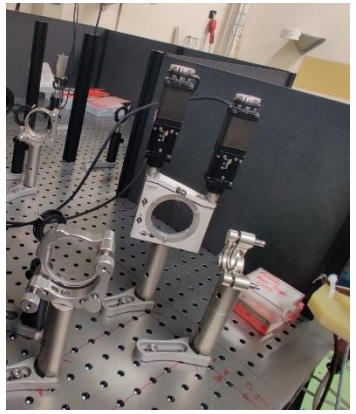
UV pulse energy control



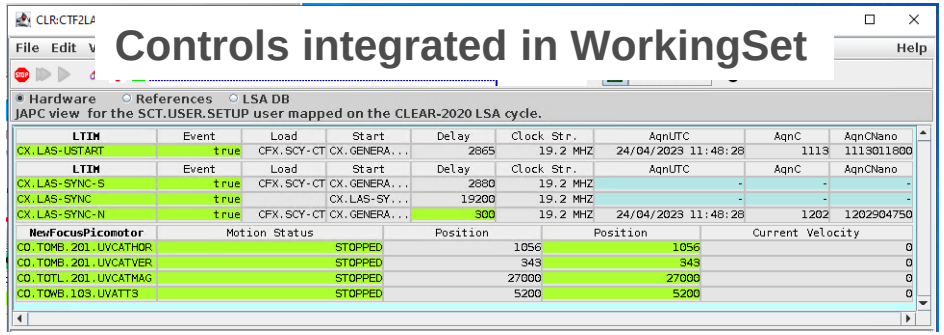
UV spot size control



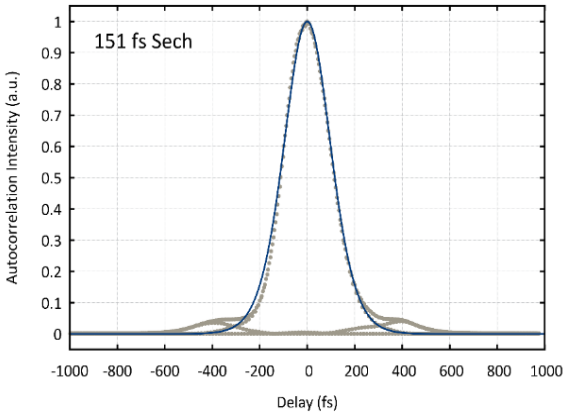
UV position on cathode



Controls integrated in WorkingSet

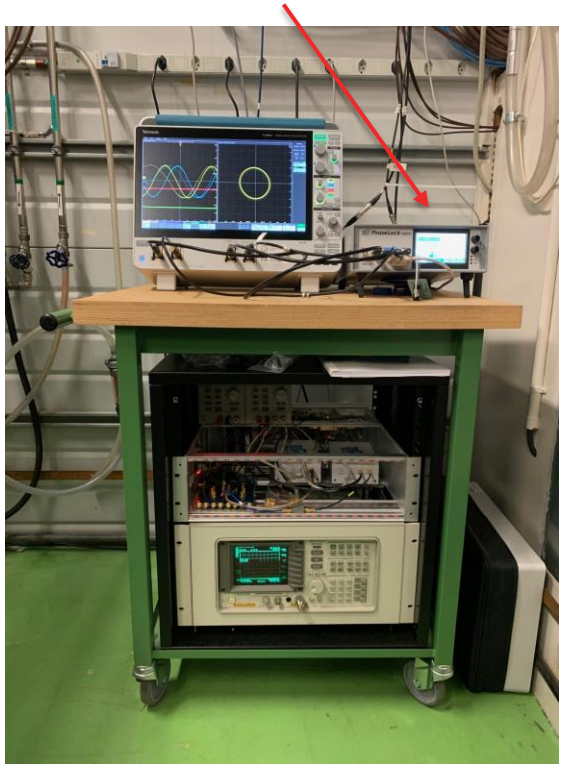


UV pulse duration



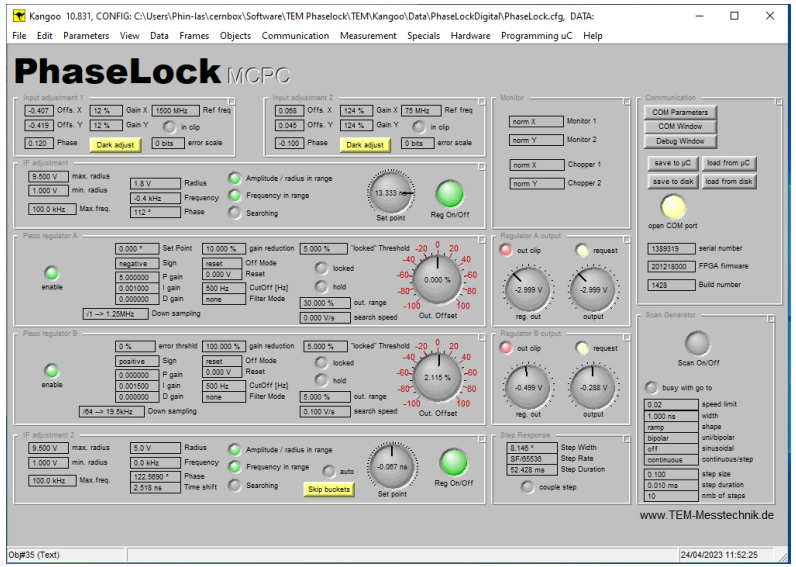
RF synchronization performance

From TEM Messtechnik

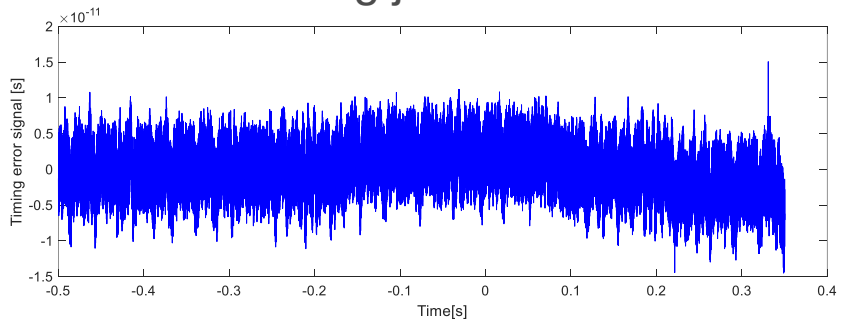


Thanks to Ben Wooley!

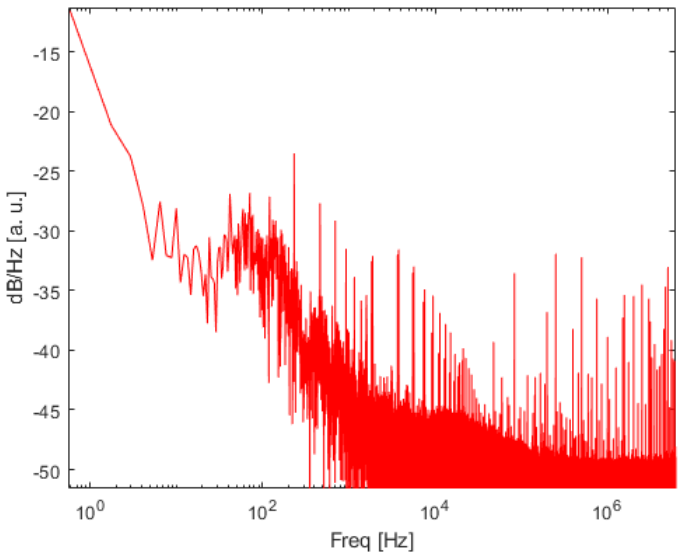
RF locking remote control panel



Timing jitter so far



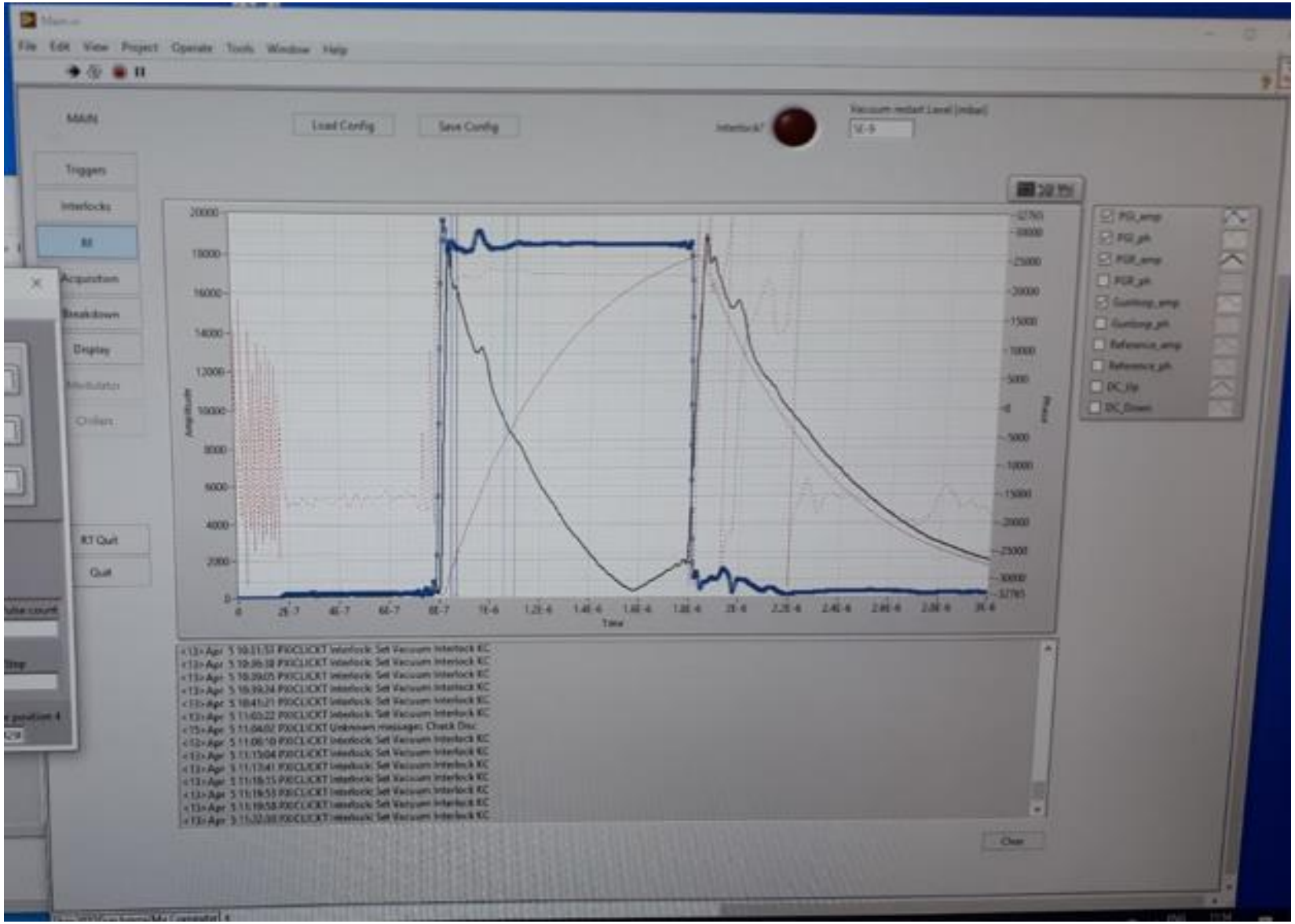
Phase noise spectrum



Integrated 1 Hz – 1 MHz ~ 1.5 ps RMS

Lots of room for improvement…

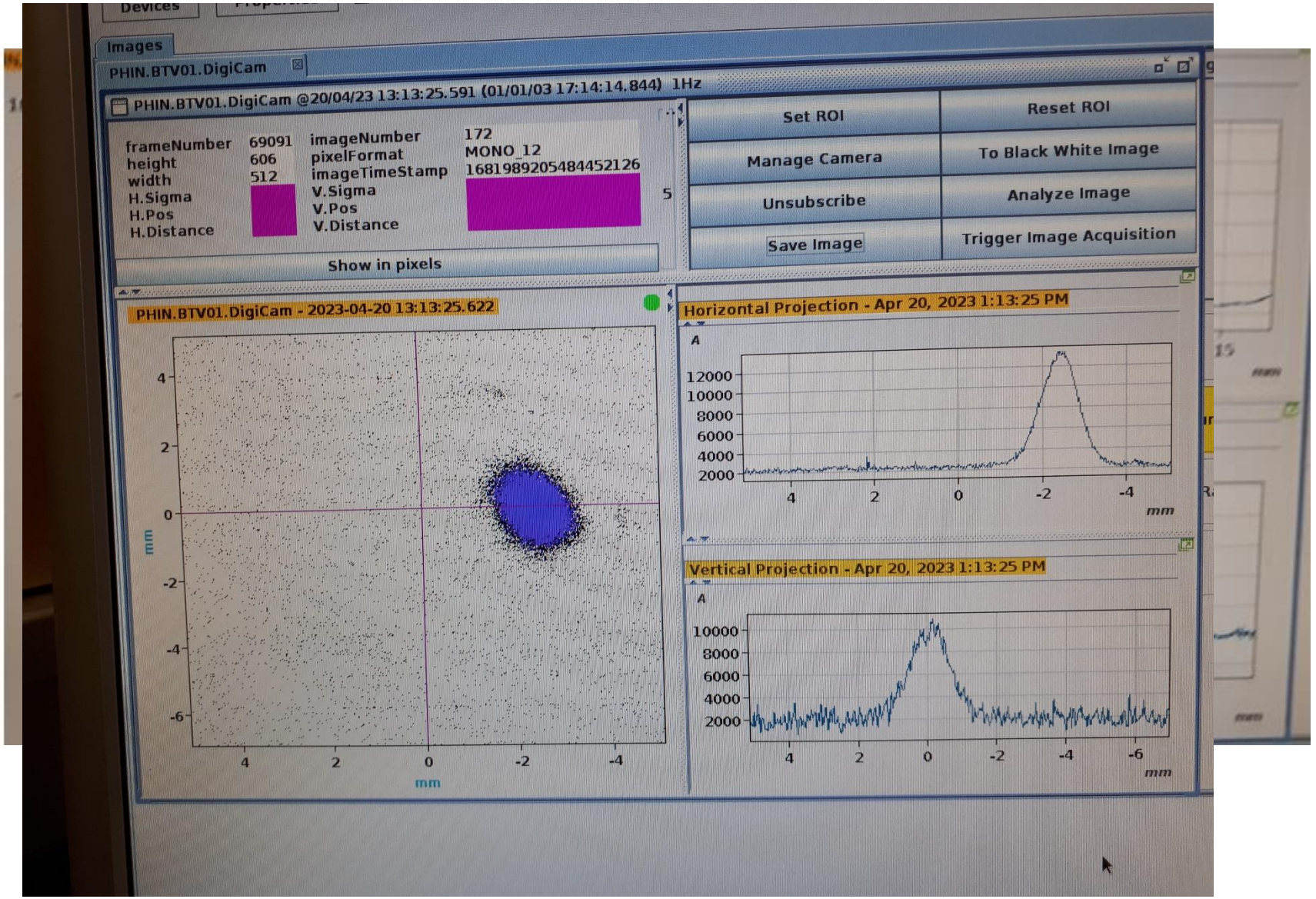
First results with beam



RF set-up:
Input Power: 13 MW
Gradient: 114 MV/m

Waring: calibrations still floating

First results with beam

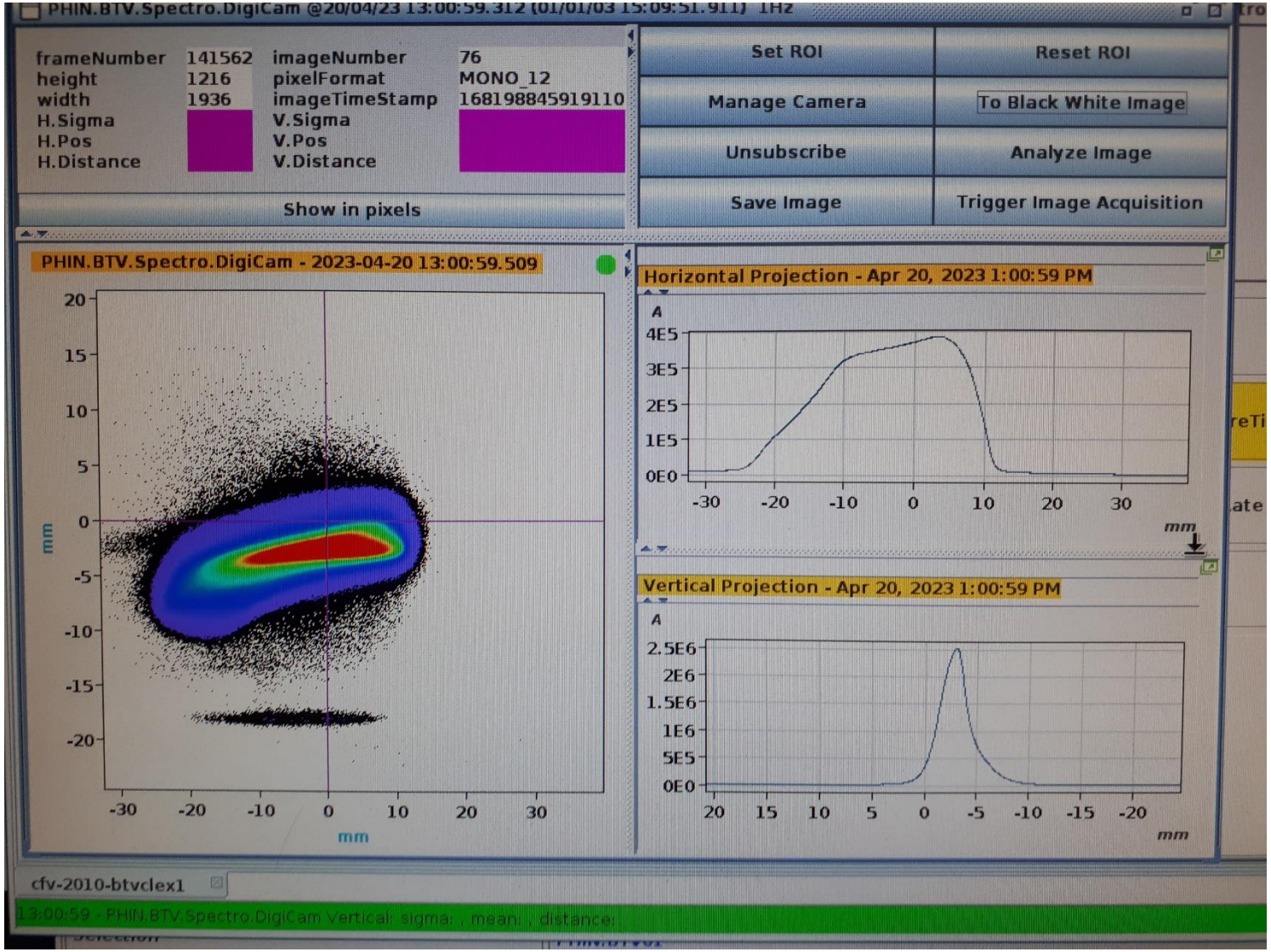


Beam on Screen:
Beam size: ~ 0.5 mm sigma

Yes it is really so beautiful !

Waring: calibrations still floating

First results with beam



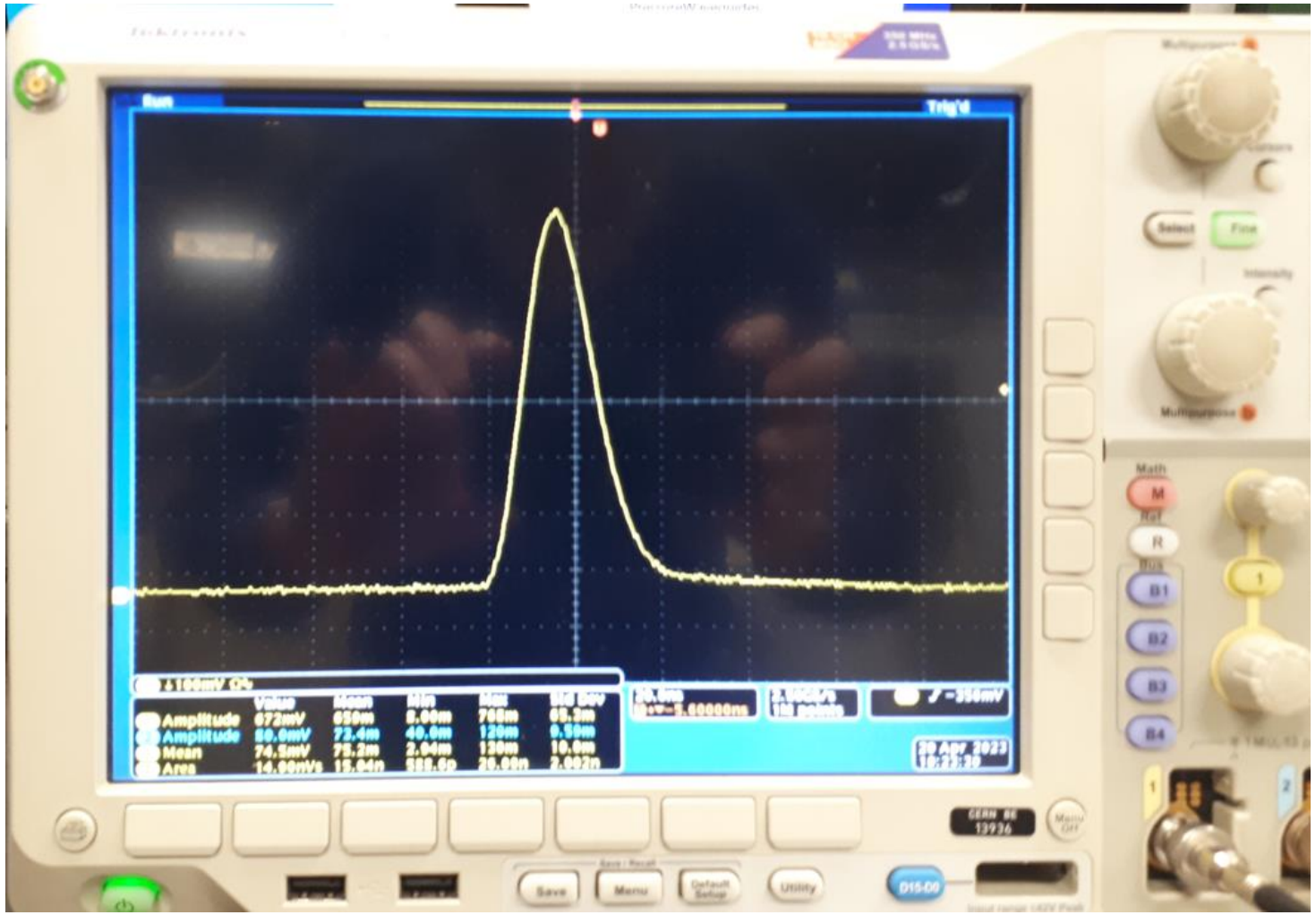
Beam in spectrometer.
Energy: ~ 5.7 MeV

Energy spread: ~ 185 keV

We still have some issues with the magnet setting which was limited by software

Waring: calibrations still floating

First results with beam



Beam charge:
Faraday Cup: up to 440 pC
This example ~ 300 pC

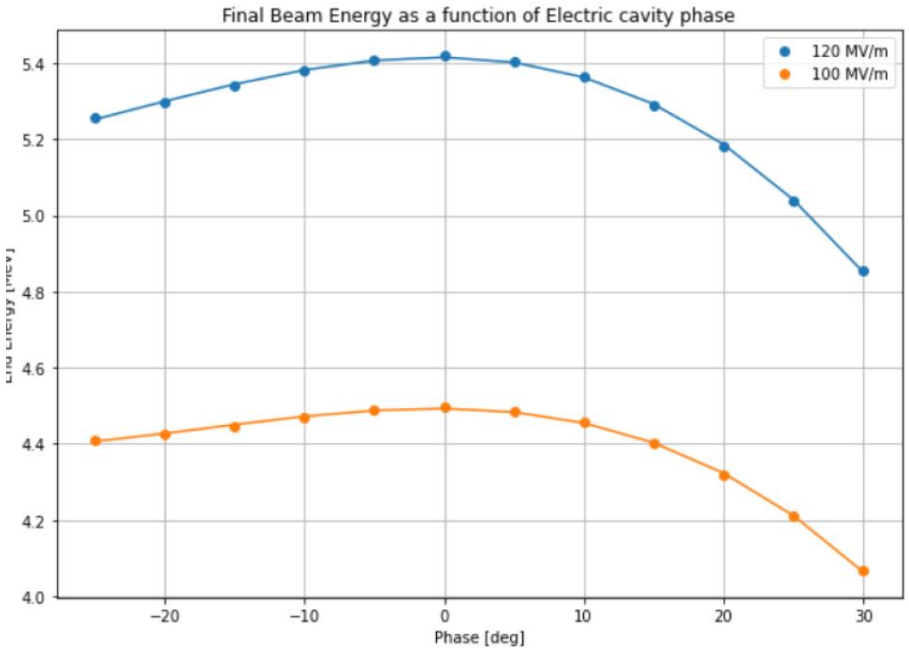
Waring: calibrations still floating

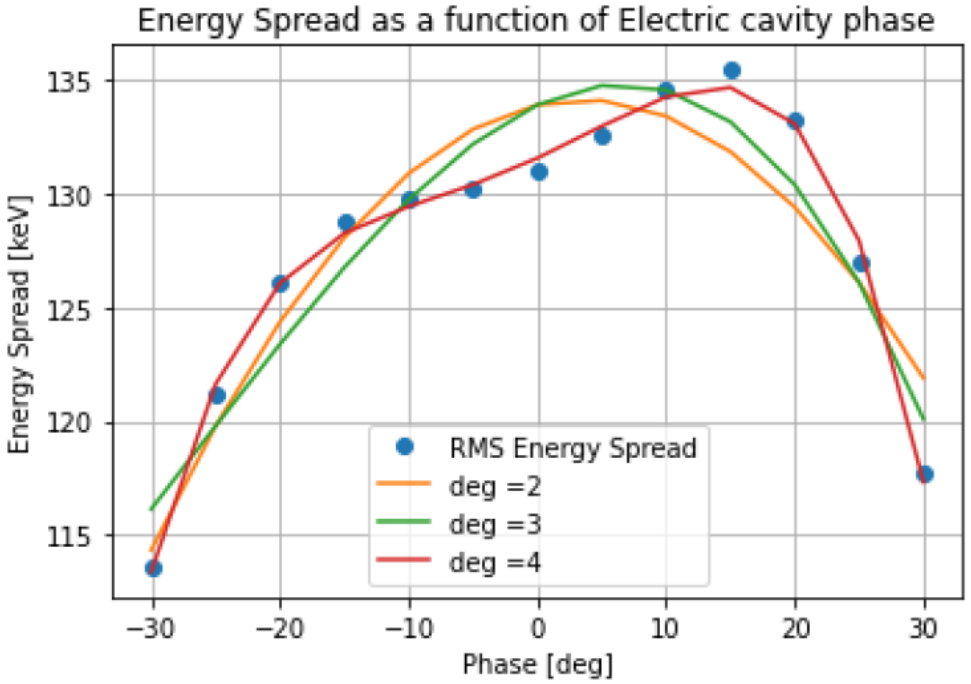
Copper Qe: 9 x 10^{-4}

Very promising for Copper cathodes

No dark current basically not measurable for time being:
< 5 pC (preliminary)

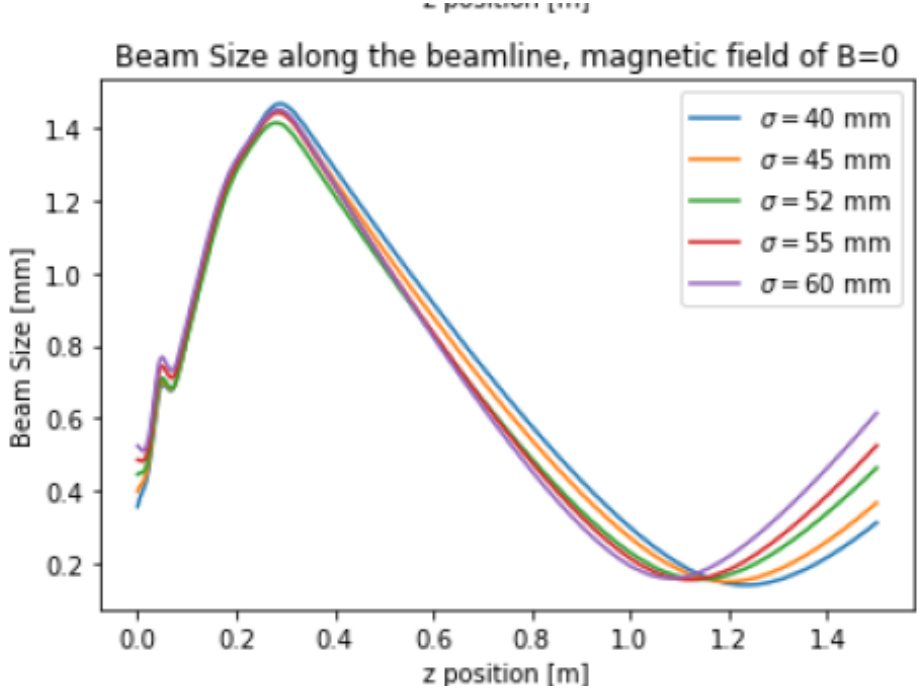
Simulations

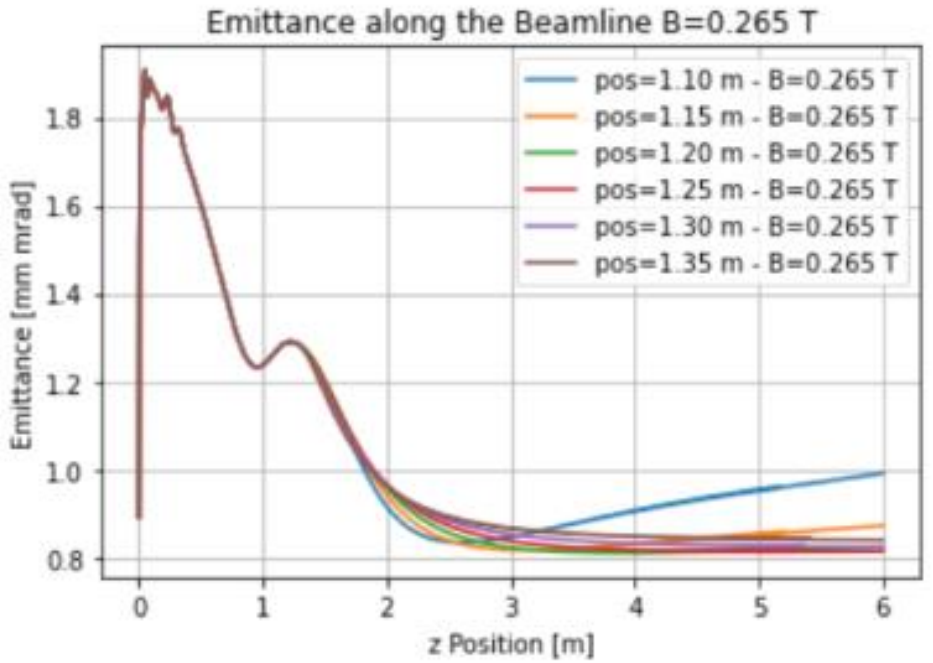




We measured for time being 5.7 MeV and 185 keV for the non optimised beam ?!?

Simulations

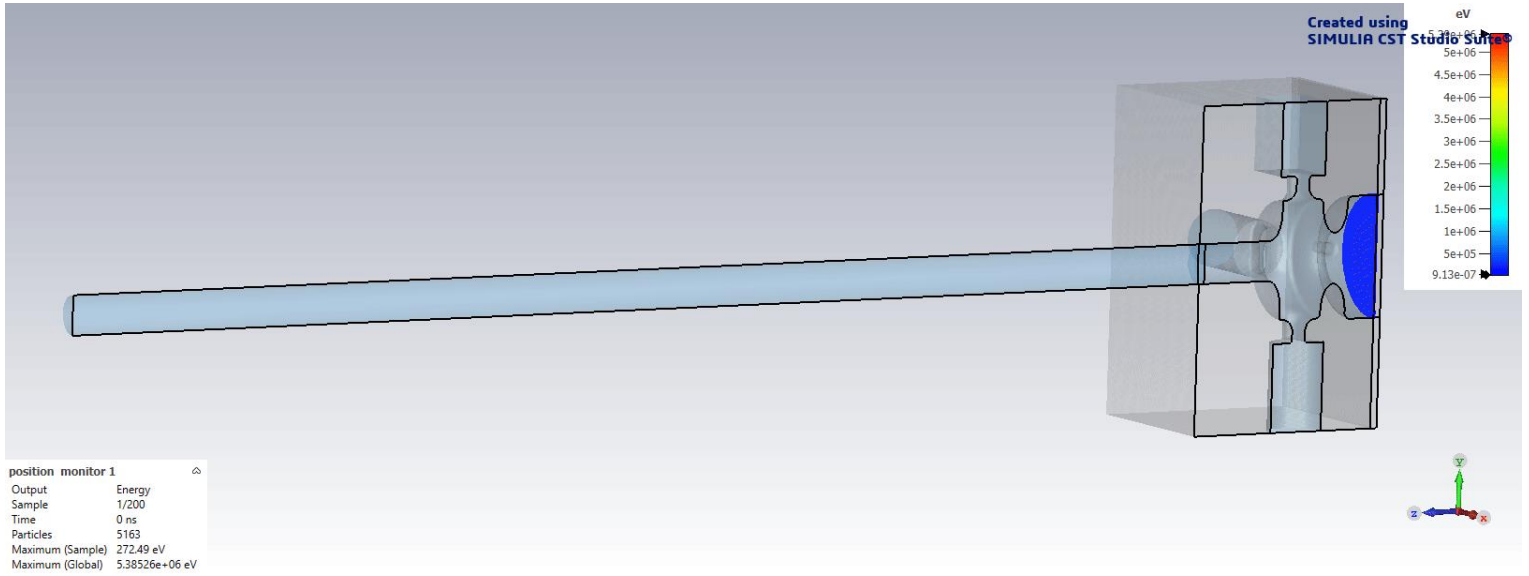




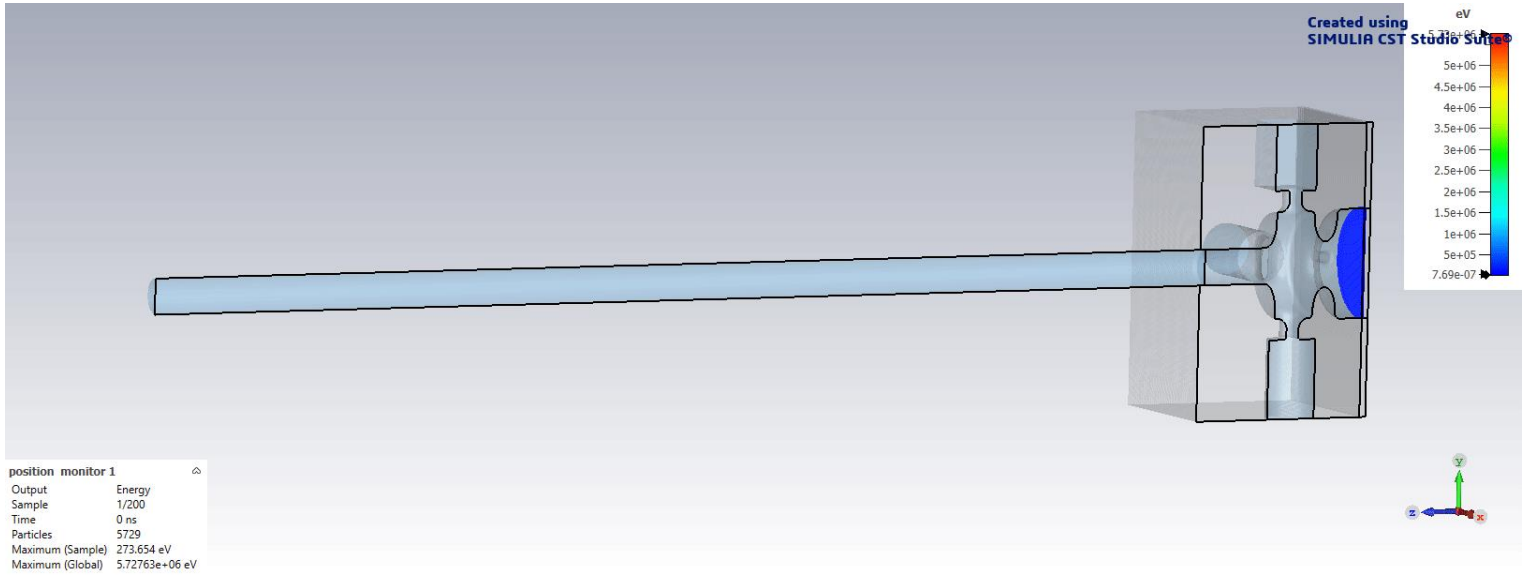
Measured beam size around 0.5 mm, no emittance estimation yet

PIC Dark Current Simulations

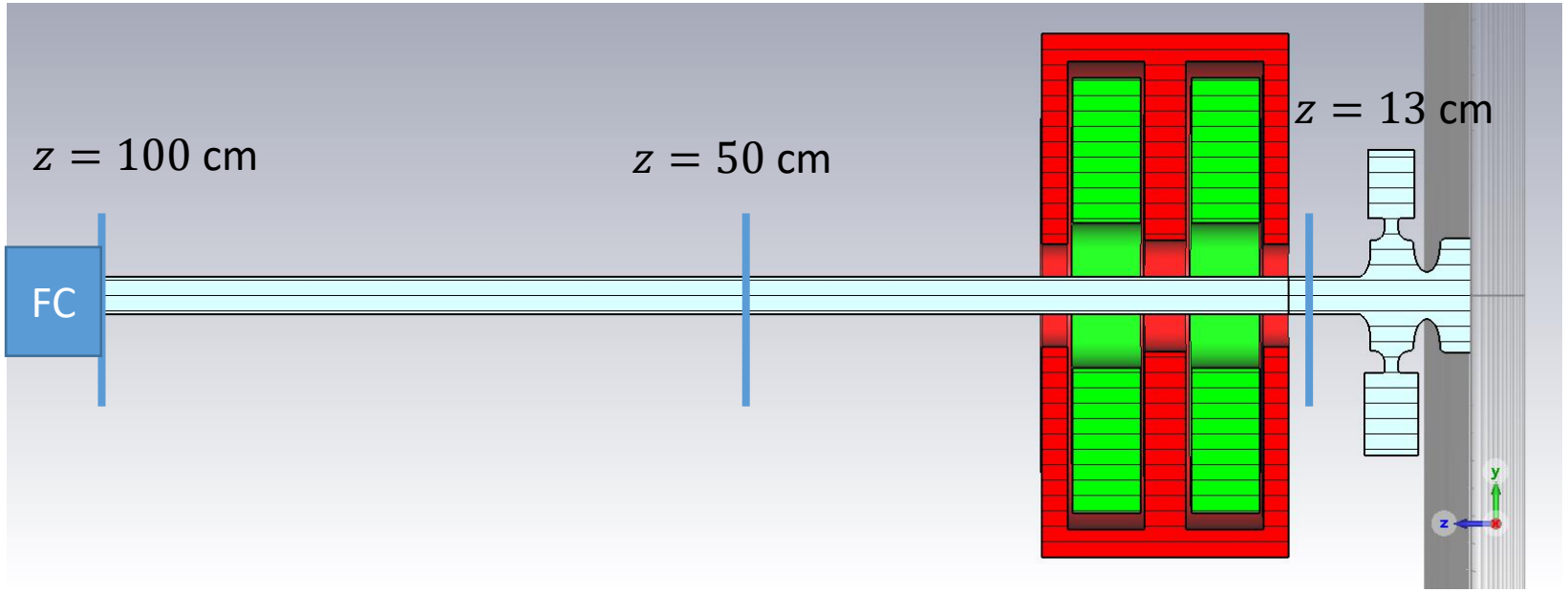
No Solenoid



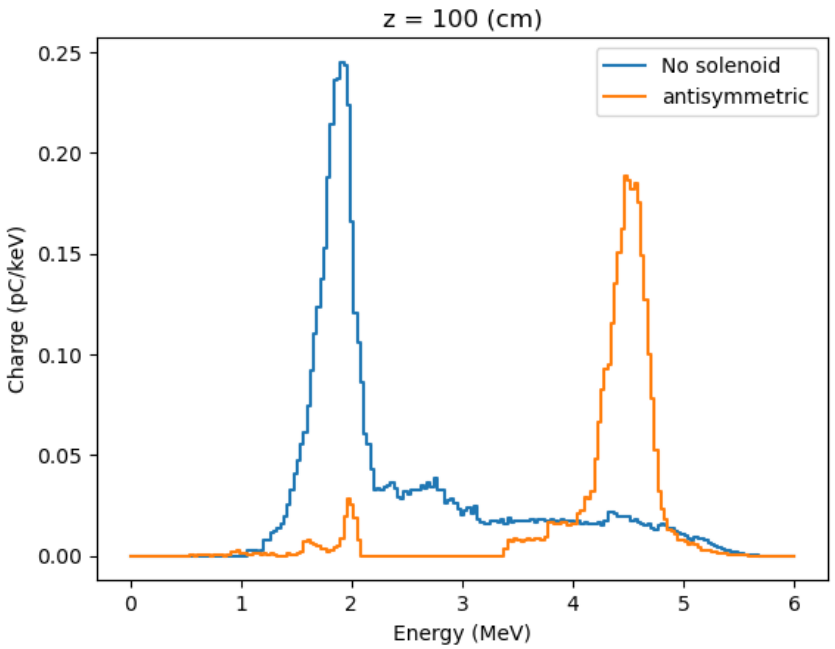
Solenoid: Antisymmetric mode

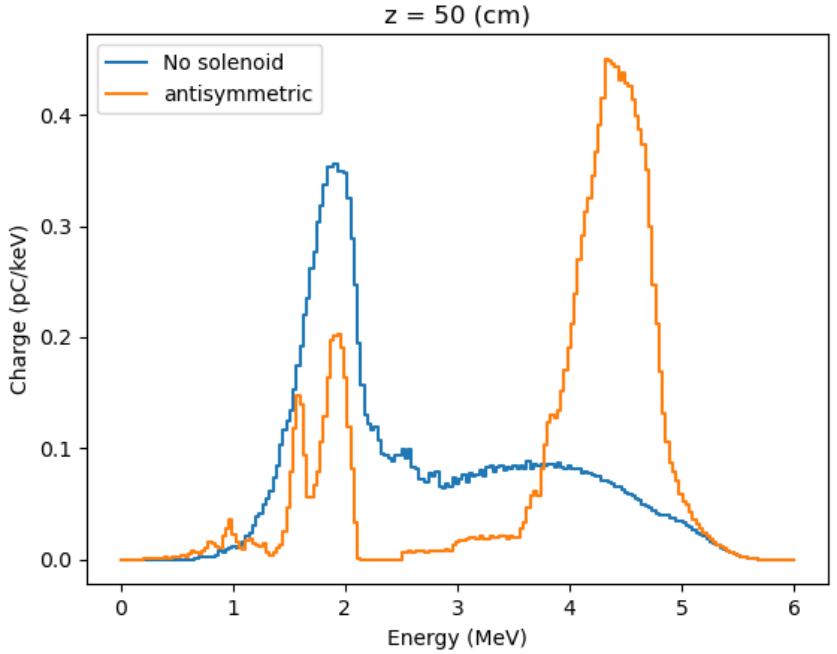


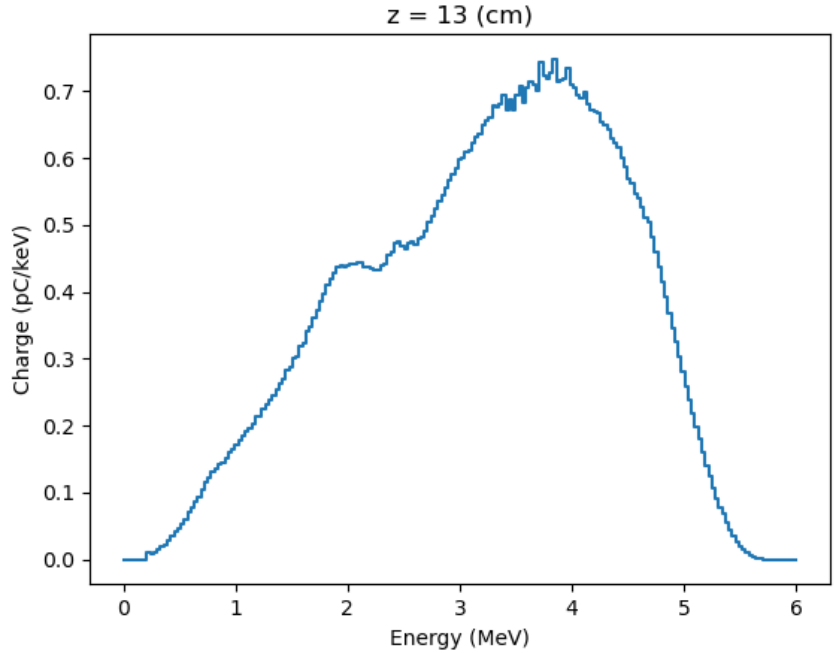
Dark Current Simulations



Pablo Martinez-Reviriego, IFIC



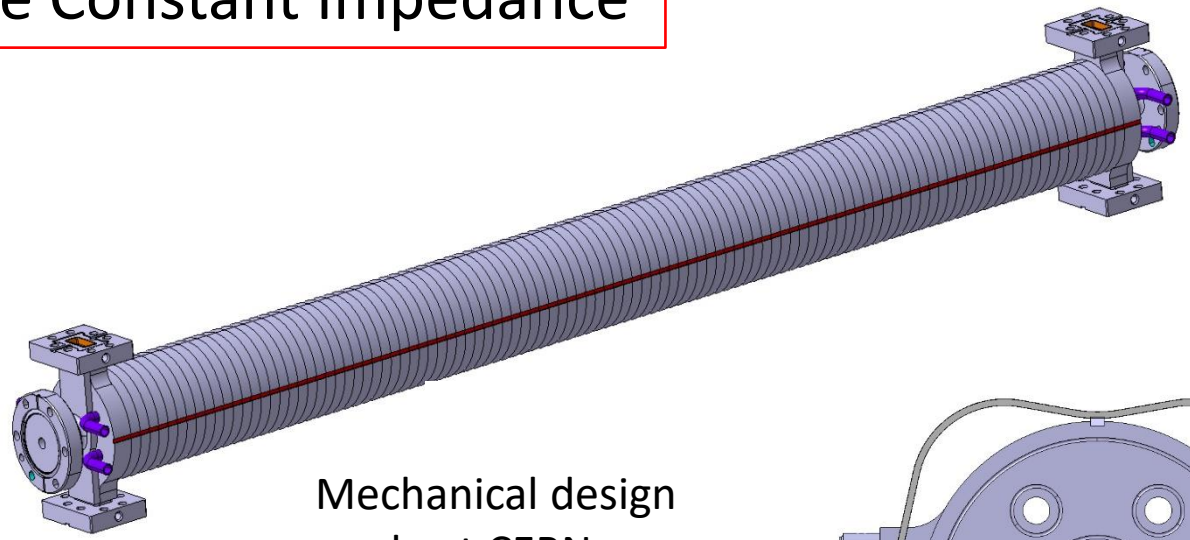


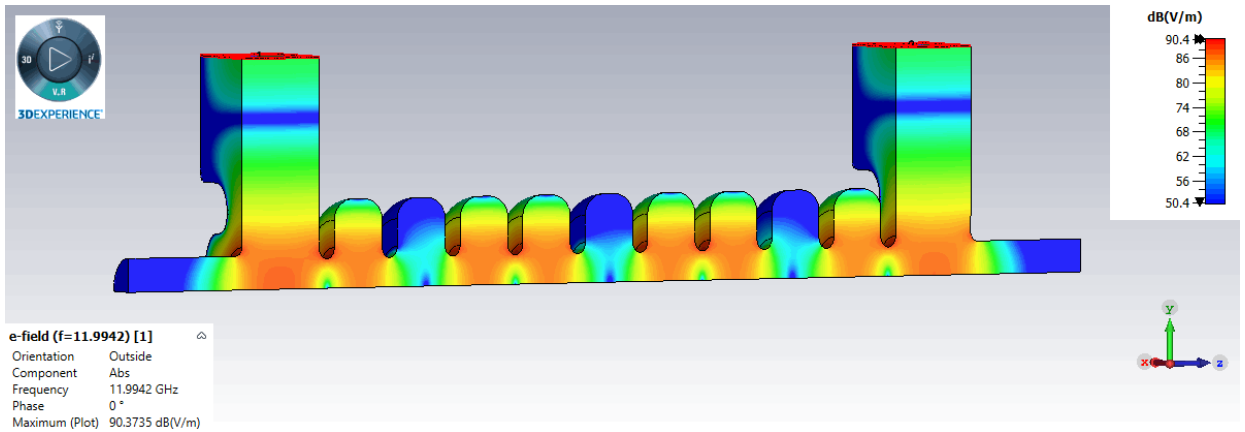


X-band structure developments

Travelling wave Constant Impedance

Shunt Impedance [MΩ/m]	100
Group Velocity vg/c [%]	2.4
Q-Factor	7061
Attenuation [1/m]	0.7
Length [m]	0.9

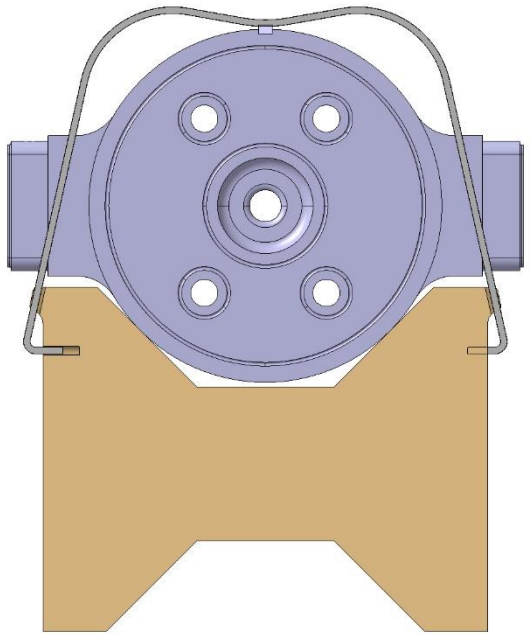




Mechanical design made at CERN

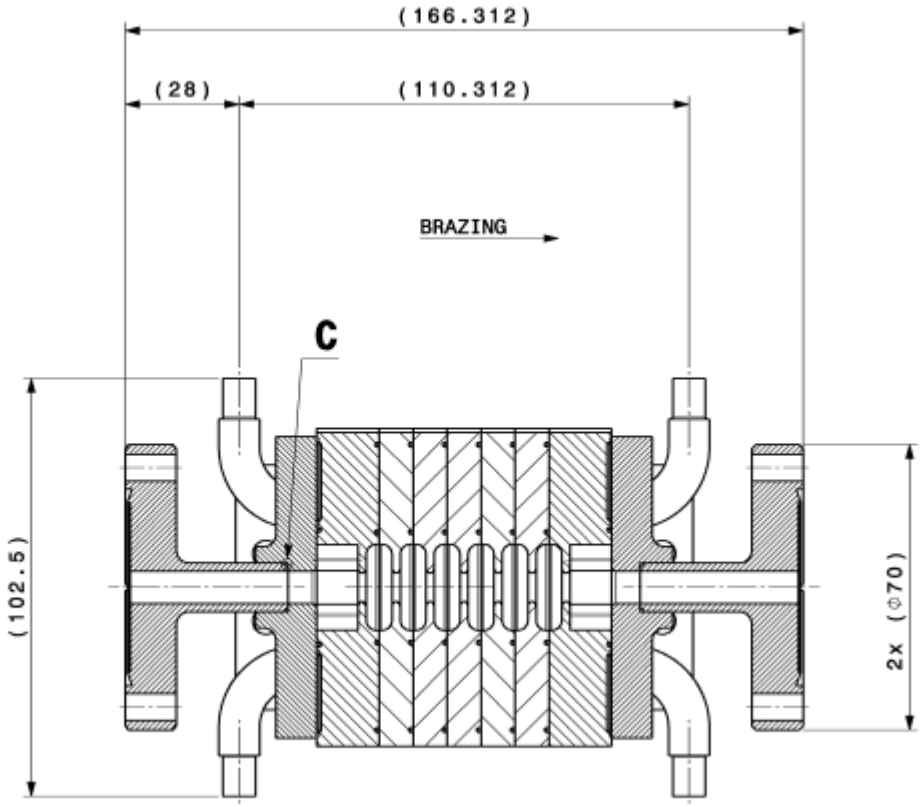
CLIC style tolerances
Vacuum brazing design

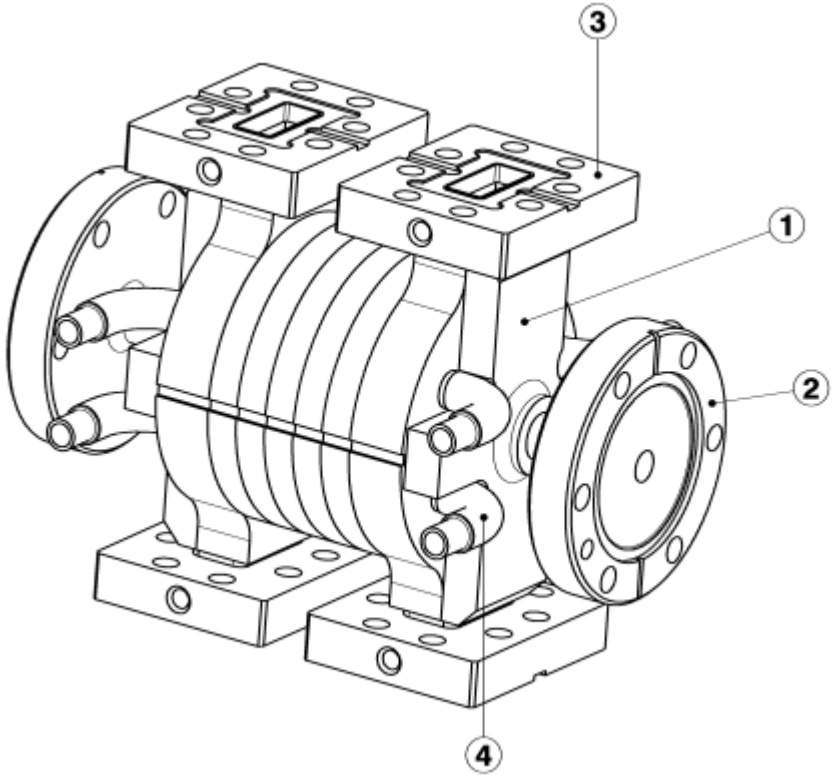
Structure to be inserted in a solenoid of 150 mm diameter bore radius



Designed by INFN Frascati, D. Alesini, M. Diomede, for CompactLight and EuPraxia

First short prototype under construction





C. Capelli, N. Chritin

Verify mechanical design, brazing assembly and tolerances needed
Maybe low power RF measurements but no high power test planned

Conclusion and outlook

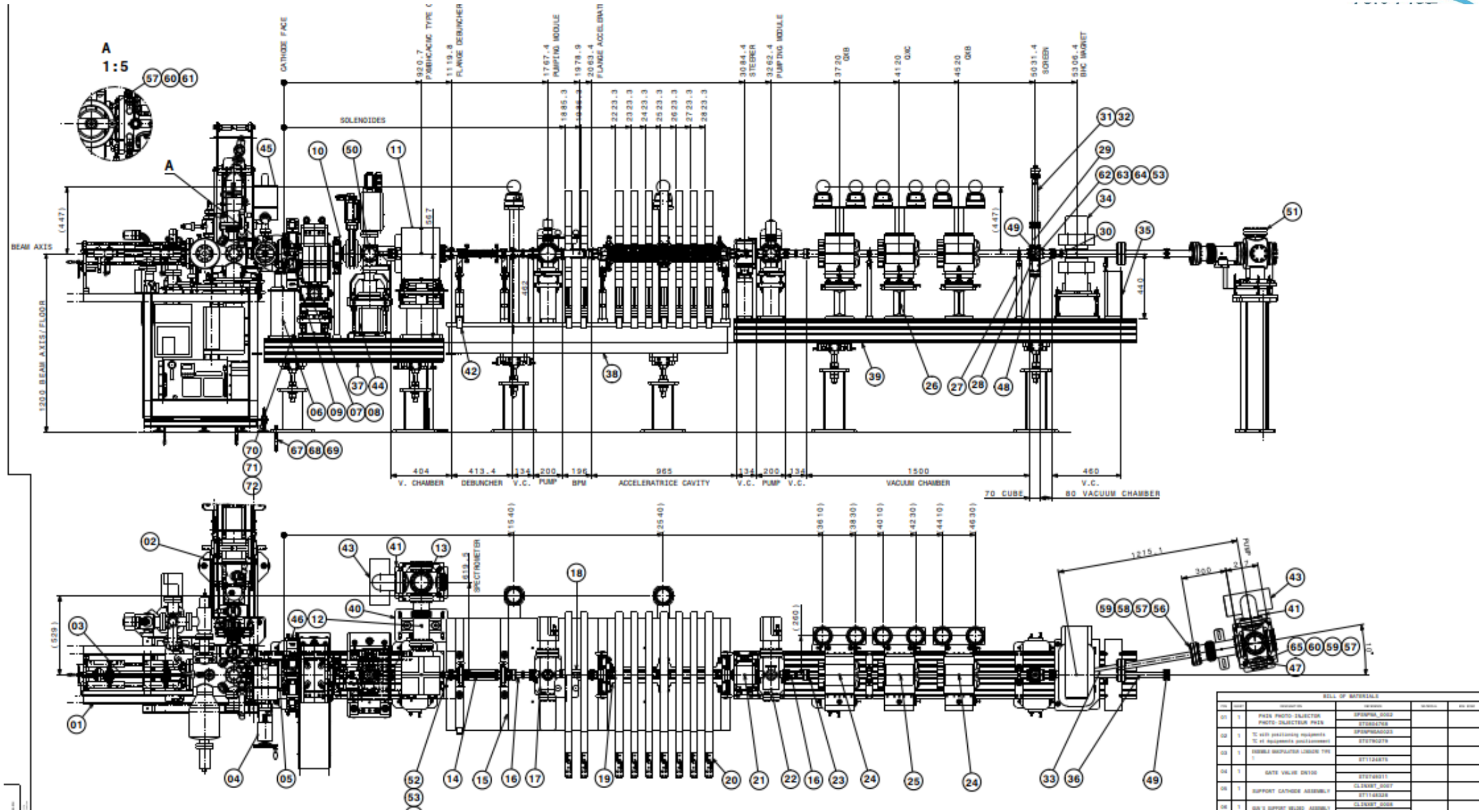
- Very good start of the beam commissioning. No major problems spotted so far
  Of course fine tuning is needed and systematic measurements.
  Clearly much more work to do !
  Apologises for the poor-man data acquisition

- Will alternate commissioning periods with installations periods to complete the injector

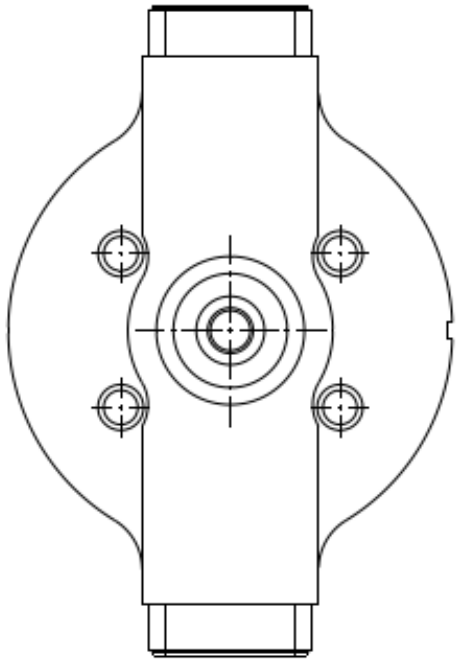
- Interesting times ahead, a first visible piece of the injector for Run 2c

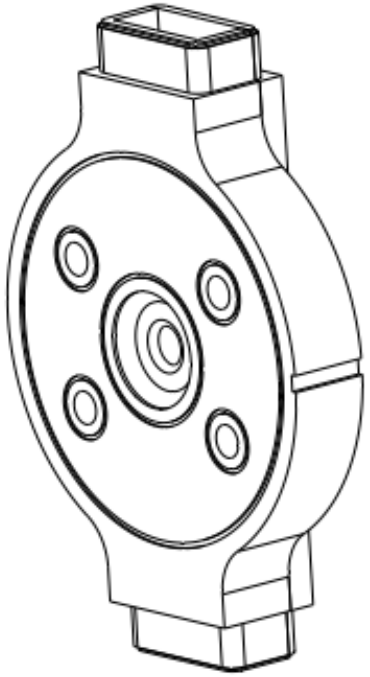
- Thanks to Jordan Arnesano for his contributions to AWAKE
  Welcome to Tobias Kulenkampff to take over in June

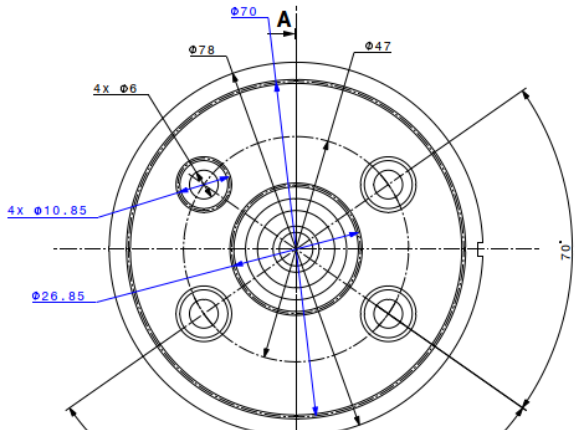
Additional material

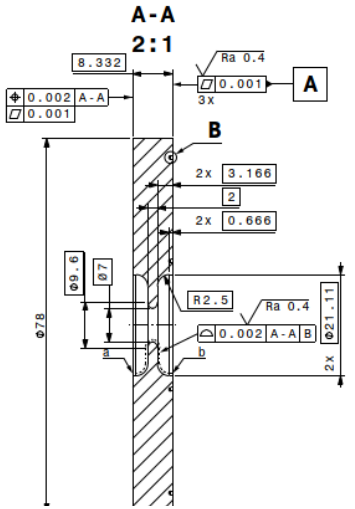

A
1:5
CATHODE FACE
SOLENOIDES
BEAM AXIS
1200 BEAM AXIS/FLOOR
404
V. CHAMBER
413.4
DEBUNCHER
134
V.C.
200
PUMP
196
BPM
965
ACCELERATRICE CAVITY
134
V.C.
200
PUMP
138
V.C.
1500
VACUUM CHAMBER
460
V.C.
70 CUBE
80 VACUUM CHAMBER
SPECTROMETER
BILL OF MATERIALS

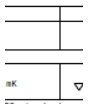
X-band accelerating structure
Mechanical design

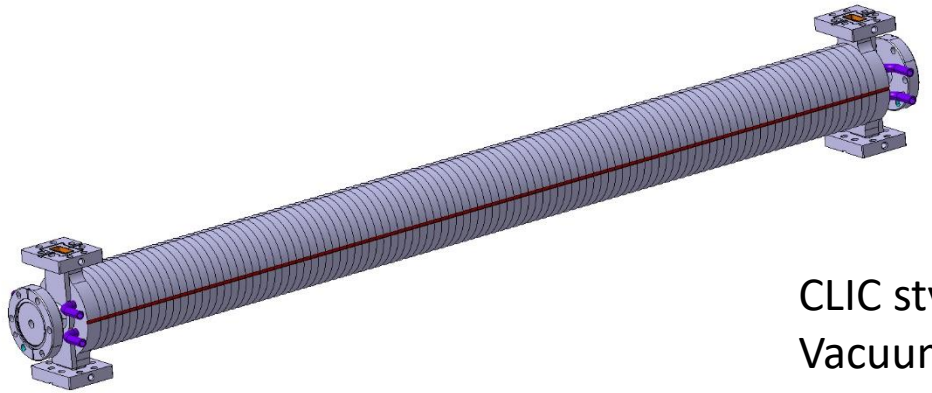












Structure to be inserted in a solenoid of
150 mm diameter bore radius

CLIC style tolerances
Vacuum brazing design

RF-Design made by D. Alesini, M. Diomede, INFN Frascati