RF lines for TBTS calibration- Gun study

Niki Vitoratou, Wilfrid Farabolini, Kashif Yaqub

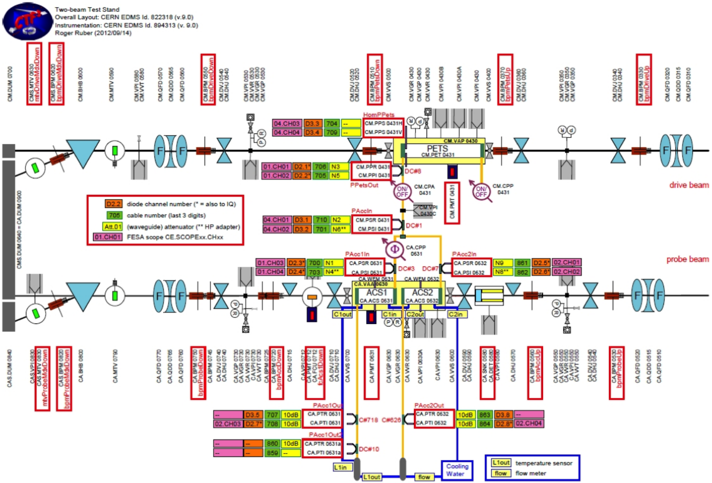
May 2014

Outline

1. RF lines for TBTS calibration
2. Gun study

RF lines for TBTS calibration

TBTS layout


Two-beam Test Stand
Overall Layout: CERN EDMS Id. 822318 (v.9.0)
Instrumentation: CERN EDMS Id. 894313 (v. 9.0)
Roger Ruber (2012/09/14)
D2.2 diode channel number (* = also to IQ)
705 cable number (last 3 digits)
Att.01 (waveguide) attenuator (** HP adapter)
01.CH01 FESA scope CE.SCOPExx.CHxx
PETS
ACS1
ACS2
drive beam
probe beam
HomPPets
PPetsOut
PAccIn
PAcc1In
PAcc2In
PAcc1Out
PAcc2Out
PAcc1Out2
Cooling Water
L1out temperature sensor
flow flow meter

Measured signals

- Injection point at the waveguide attenuator after RF 50 dB coupler
- Measures in V with Matlab after background offset suppression

Signal description	Coupler name	Cable name
PETS Ref.	CM.PPR 0431	706
PETS Output	CM.PPI 0431	705
ACSboth Ref.	CM.PSR 0431	710
ACSboth Input	CM.PSI 0431	701
ACSup Ref	CA.PSR 0632	861
ACSup Input	CA.PSI 0632	862
ACSup Output	CA.PTI 0632	864
ACSdown Ref	CA.PSR 0631	700
ACSdown Input	CA.PSI 0631	703
ACSdown Output	CA.PTI 0631	708

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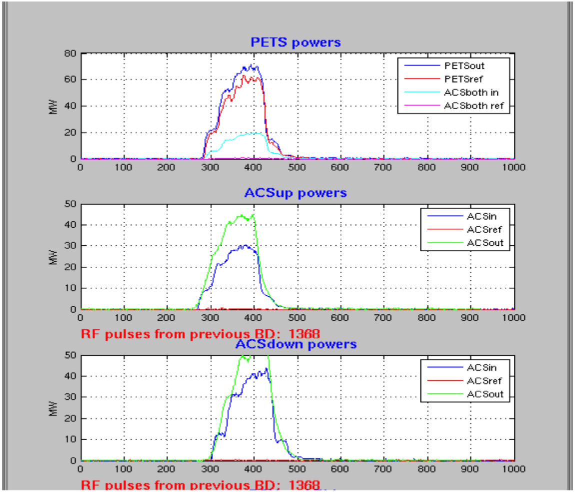
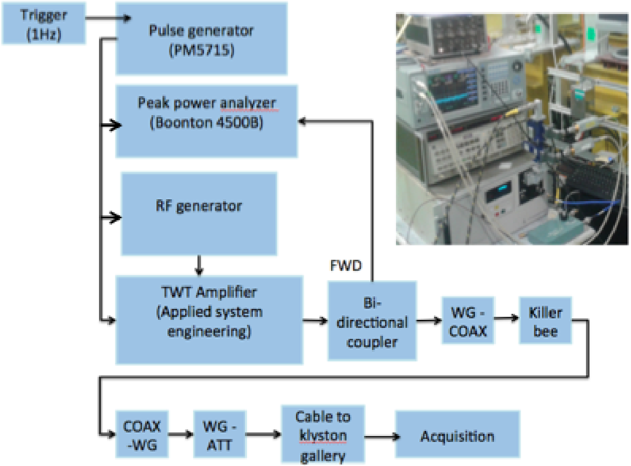
Previous results

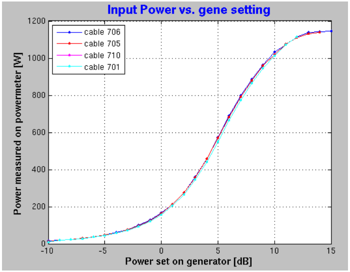


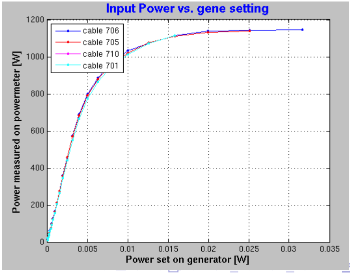
System layout



Correspondence of generator power to power-meter

- Scan of generator's power by step of 1 dB
- Measurements of power on power meter
- Conversion dB to W using the formula : $P_{(W)} = 1W * 10^{(P_{(dB)}/10)}$
- Extend the region of interest out of the linear behavior of the RF generator





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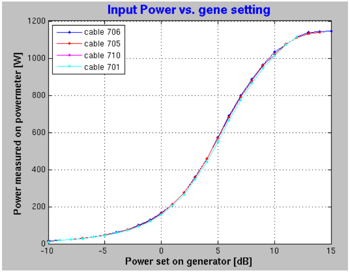

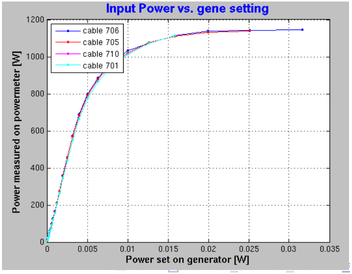

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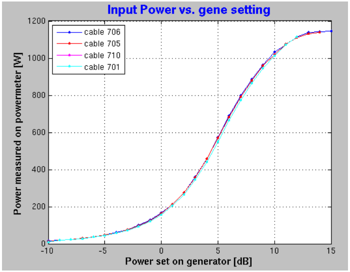

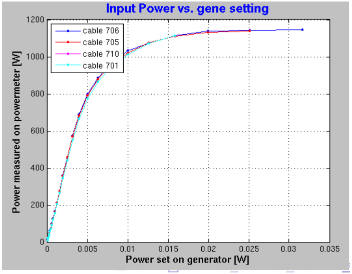

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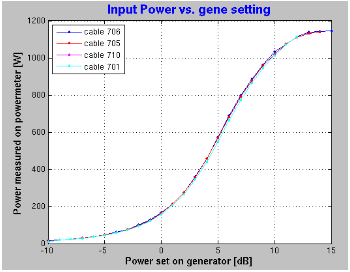
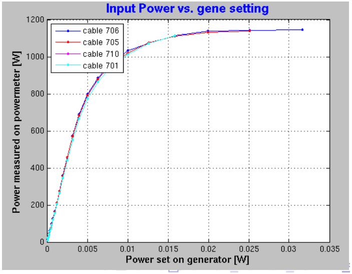
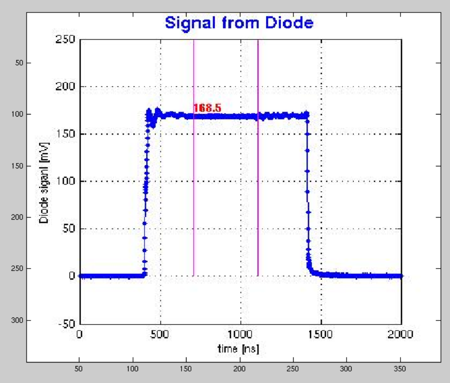




Diode channels

- Obtain the absolute RF power on the various channels
- Bounded set of values inside the red lines



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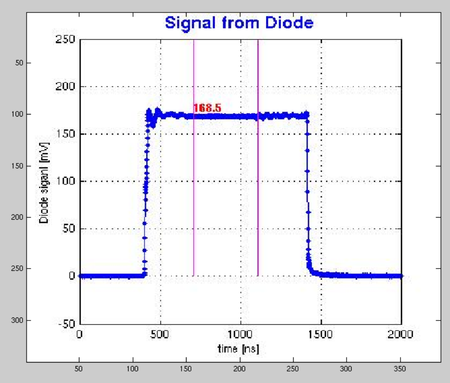

Calibration of diode signals

Data acquisition process

- Scan of injected power from -10dB to 10dB
- Measurements of diode signals (mV) by step of 1dB (Matlab program)
- Record data from diode signal at 0db and 6 or10dB
- Conversion from mV to W through in interpolation polynome

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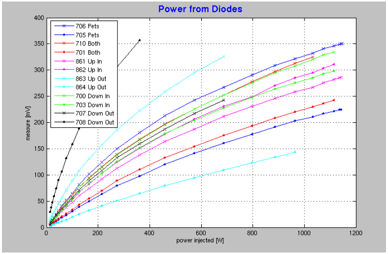
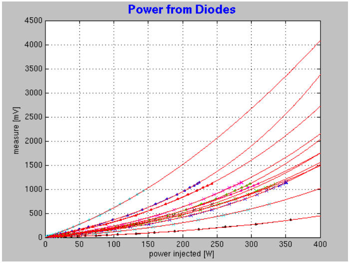
Power from Diodes

- Power from Diodes versus injected power
- 12 cables - channels
- Fit third order polynomial curves and calculation of coefficients $y = ax^3 + bx^2 + cx + d$
- Calibration of diode signal using the coefficients.





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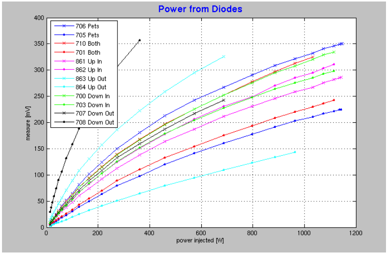

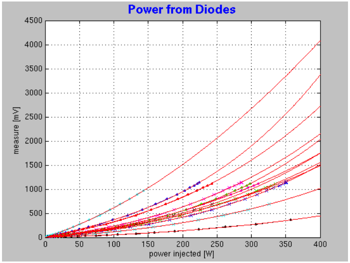

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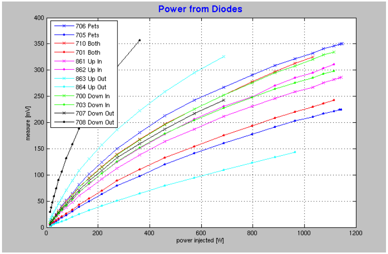

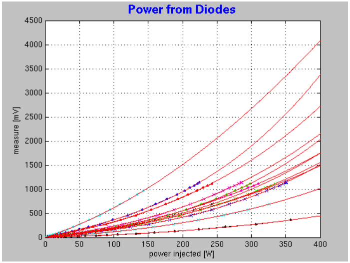

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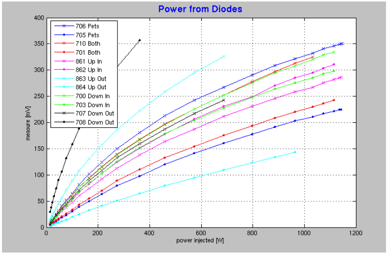
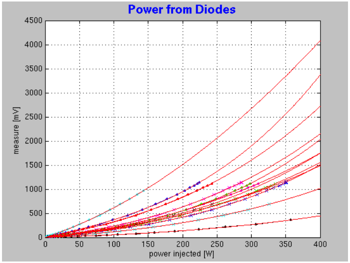
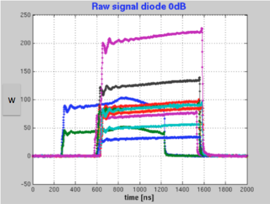
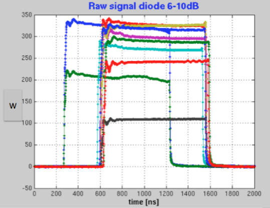




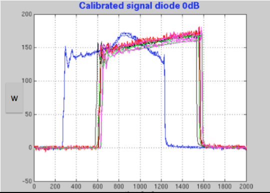
Calibrated diode signals

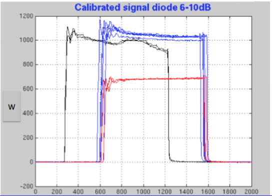
- All diode signals for a same injected power before calibration



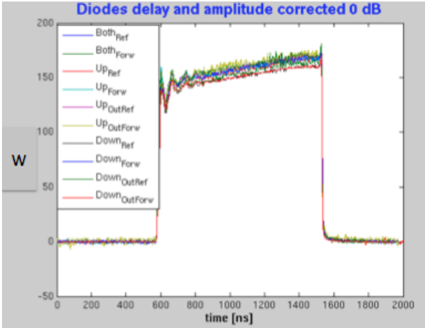


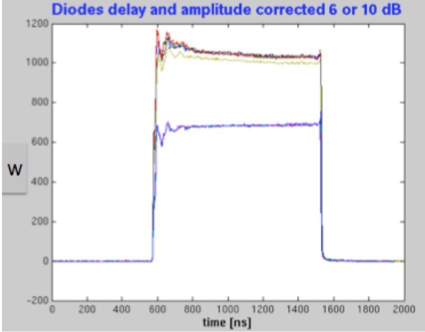
- All diode signals for a same injected power after calibration (polynome)



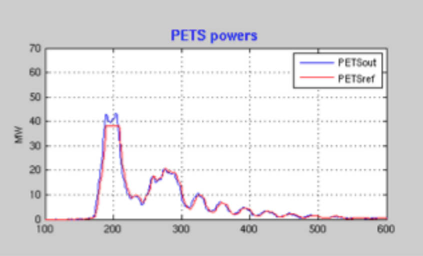


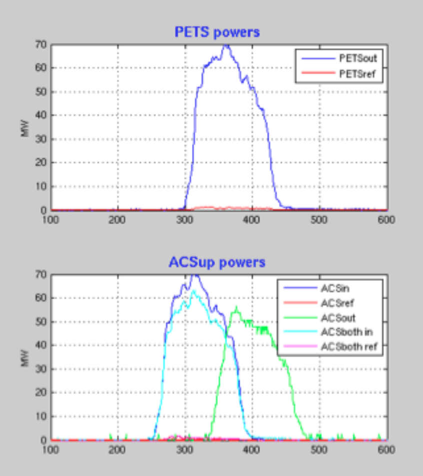
Correction of delay





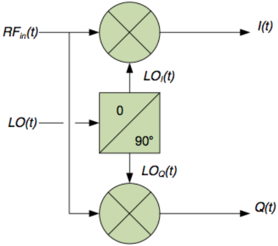
Operational results for power measured with diodes



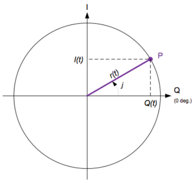


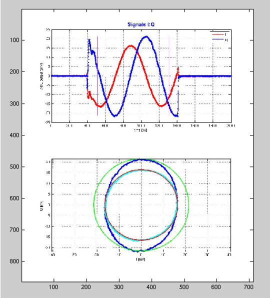
I/Q channels

- The IQ demodulators give :
    - in-phase (I)
    - quadrature (Q) components of electric field
- the power and relative phase of the electric field determined
- The RF input signal is down mixed with the local oscillator
- LO is phase shifter by 90° giving quadratic signals I and Q



I/Q Signals after RF injection 5 MHz offseted



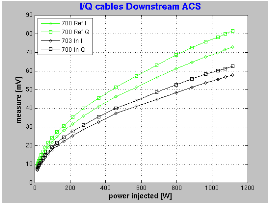


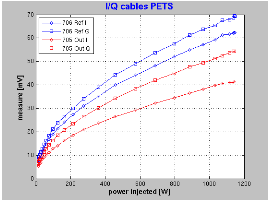
- $I(t) = r(t)\cos(\theta(t))$
- $Q(t) = r(t)\sin(\theta(t))$
- $r(t) = \sqrt{I^2(t) + Q^2(t)}$
- $\theta(t) = \tan^{-1} Q(t)/I(t)$

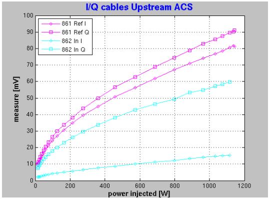
Calibration of I/Q signals

Data acquisition process

- Scan of injected power from -10dB to 10dB
- Measurements of I/Q signals (peak to peak mV) by step of 1dB (Matlab program)
- Store data of I/Q signals at 0db and 6-10dB
- Conversion from mV to W

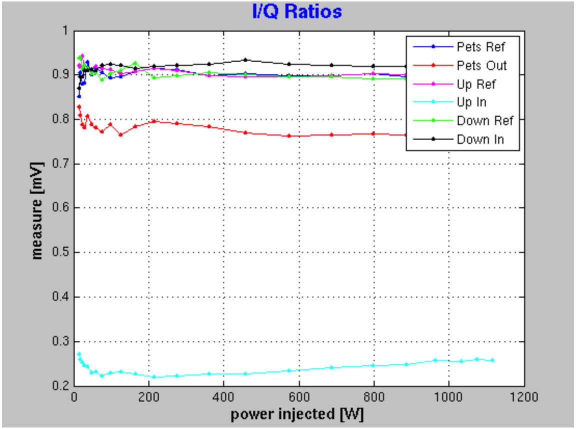






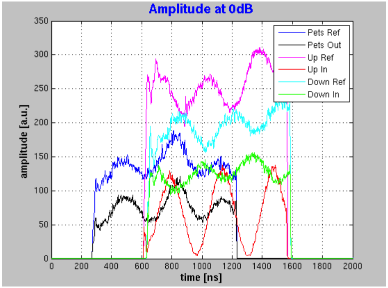
Calculation of I/Q Ratios

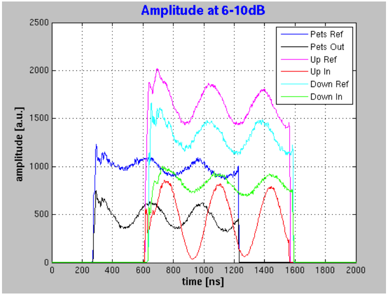
- I signal is divided by Q signal for each measurement
- Ratio = I(mV)/Q(mV)



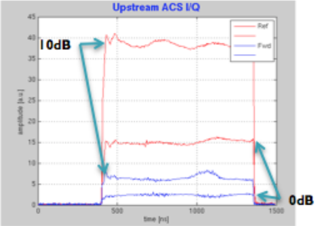
Calculation of amplitude before I/Q equalization

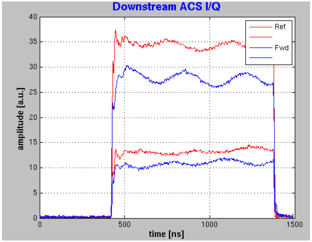
- Calculation of Amplitude using the formula :
  $A = \sqrt{I^2 + Q^2}$

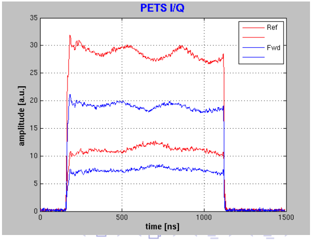




Calibrated amplitude

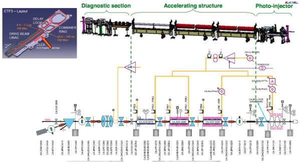


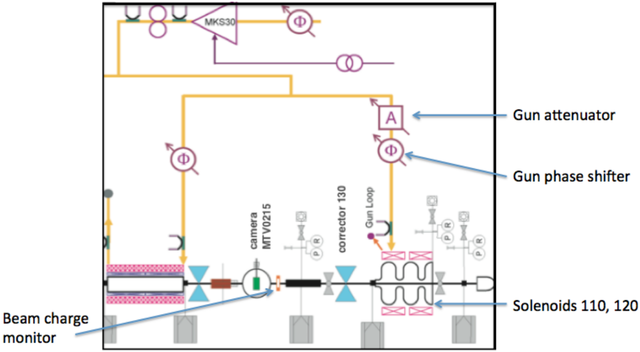




Gun study

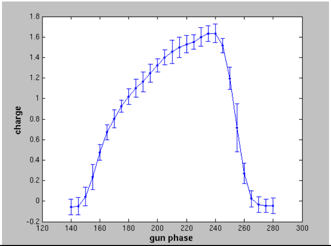
Califes layout

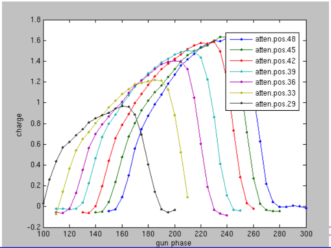




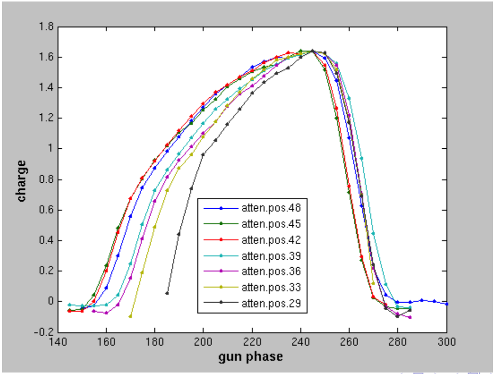
Data acquisition process

- Measurements of charge (Matlab program) scanning gun phase by step of 5
- Error bars using std from many acquisitions
- Well centered beam at camera MTV215 using correctors CA.DHG/DVG0130
- Focused beam using solenoids CA.SNH0110, CA.SNI0120
- Repeat the procedure for various values of gun attenuation positions



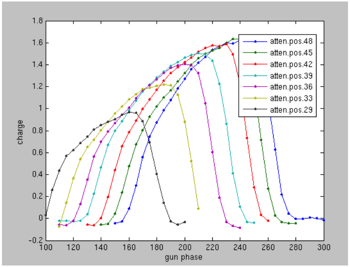


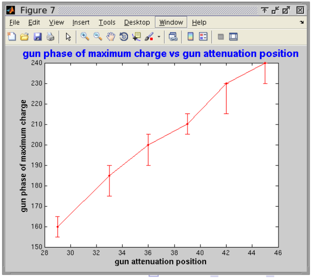
- Calculate
  - the shift of crest
  - The ratio between the various charge peaks
- Superposition of the curves
- Phase acceptance decreases with attenuatio



Gun phase of maximum charge vs gun attenuation position

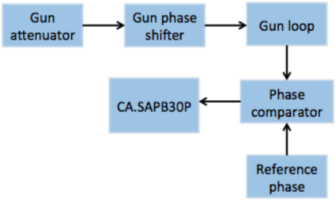
- Obtain the gun phase that corresponds to the maximum charge, for all the various attenuation positions
- Errors estimation from std of maximum charge
  $c_{max} - c_i < k * std_{max}$
- Slope: x deg per y attenuator displacement

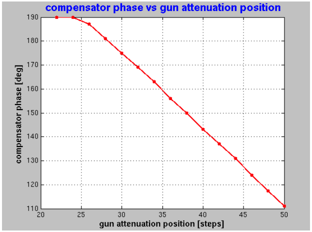




Attenuator phase drift as function of position

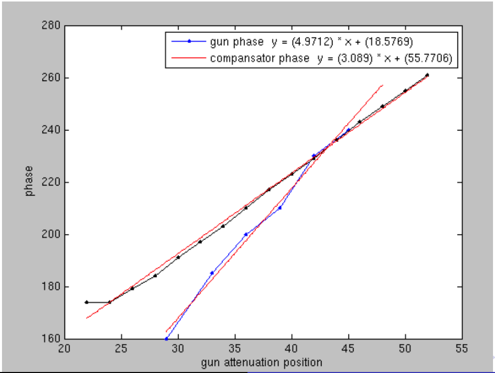
- Attenuator is not a phase free device but can be calibrated independently
- Vary gun attenuation position by step of 2
- Keep stable the CA.SAPB30P signal amplitude (Gun coupler output mixed with a reference variable phase signal)
- Question: is the CA.SAPB30P signal sensitive to the amplitude as well ?



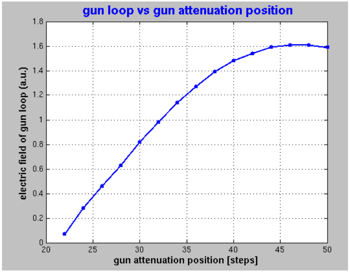


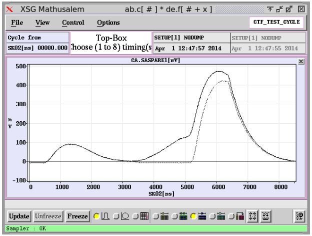
Gun phase – compensator phase

- Linear fitting of gun phase vs gun attenuation position
- Linear fitting of compensator phase vs gun attenuation position and rotation
- Different slopes due to non relativistic electrons effects in the gun (accelerating phase depends of their energy)



Gun loop signal as function of attenuator position





- Beam energy at gun output vs. gun loop signal
- Measure the electric field from the gun loop signal

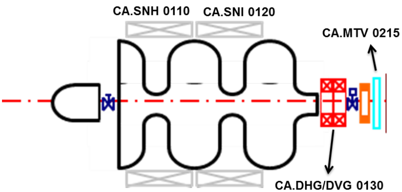
Purpose

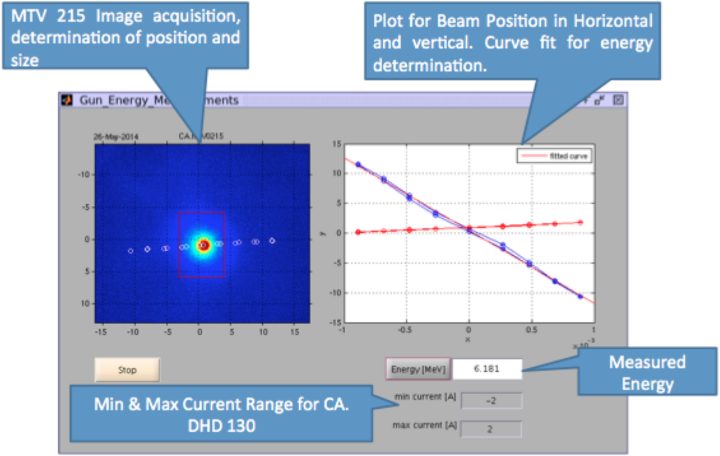
Measurement of beam energy at gun exit systematically and correlate it with:

- Gun attenuation
- Gun Phase

Scheme

Scanning the Beam horizontally with CA.DHG 130 and relating the beam position with energy.





E(MeV) = 300 ∗Distance screen-corrector ∗ Magnetic lenght/dx/dB

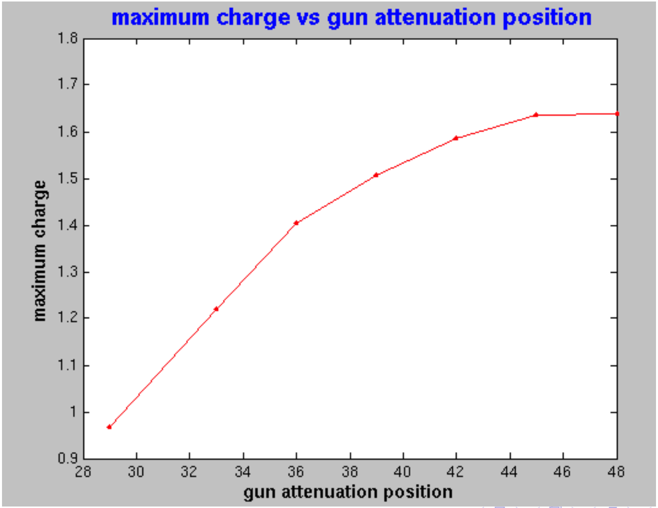
Initial Findings

- Measured energies are in range of 5-7 MeV depending upon RF Power, Gun Phase and Attenuation.
- here is slope in vertical,...could be optics′ misalignment!
- A visible hysteresis in horizontal corrector; when scanning is done in forward and backward directions.

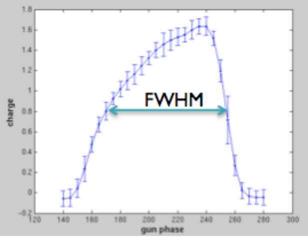
Future !!

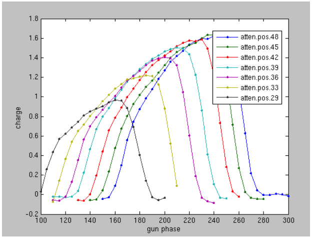
- Although the basic philosophy is implemented; the program needs improvements (more user friendly !!).
- Quantitative study of Gun-Phase and Attenuation as function of Gun energy

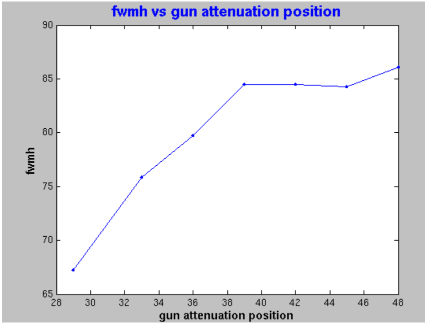
Charge at optimal phase as function of attenuator position



Phase acceptance as function of attenuator position

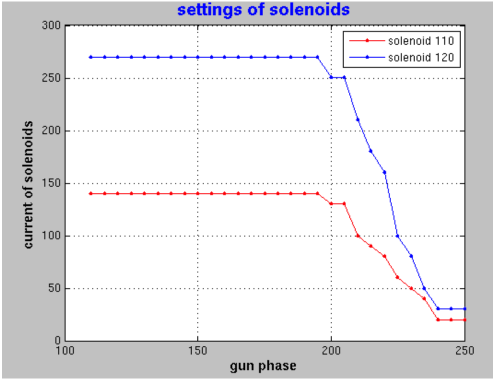




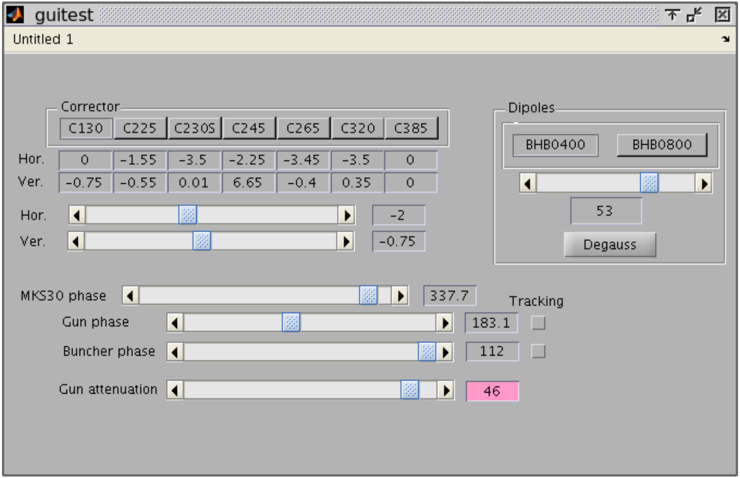


Settings of solenoids

- Use of solenoids to focuse the beam
- After the phase that corresponds to maximum charge,current of solenoids is lowered in order to keep the beam size approx. constant



Application of the gun study



Thank you!!!