Kyiv, March 2015

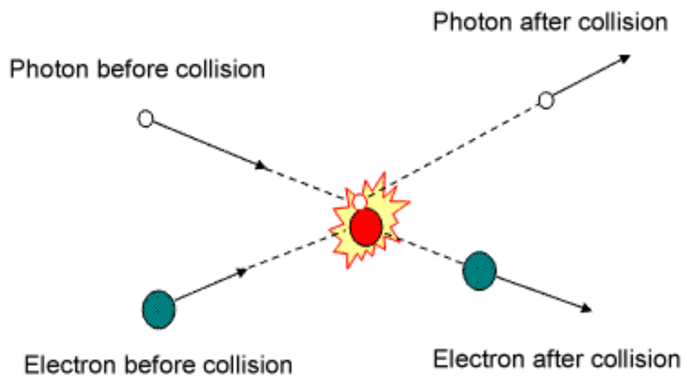
Nicolas Delerue (LAL, Orsay)

delerue@lal.in2p3.fr

The MightyLaser and ThomX Projects: Compton scattering based light sources

Work supported by the EQUIPEX program – Ministère de la recherche, Ile-de-France region, CNRS-IN2P3 and Université Paris Sud XI

Compton scattering



$$\mathrm{Flux}_{cw} \propto \frac{\lambda P_L I_e \sigma_T}{\sqrt{\sigma_{electron}^2 + \sigma_{laser}^2}}$$

- I_e: electron beam intensity
- P_L: laser power

λ: laser beam wavelength

$\sigma_{electron}$=electron beam size r.m.s

σ_{laser}=laser beam size r.m.s

- Compton (Thomson) scattering is the exchange of energy that occurs when a photon collides with an electron.
- It can be used to boost low energy (IR) photons to X-rays energy by colliding them with high energy electrons.
- The source of photons is typically a laser (IR => eV).
- The cross-section for this process is very low.

Compton Scattering as a X-ray source

•Compton effect

- **We are working on R&D toward a light source based on Compton Back Scattering (CBS)**

- **Why CBS?**
- CBS is by far the most efficient photon energy amplifier : $\omega_{diff}=4\gamma^2\ \omega_{laser}$, ThomX => γ~100 => it is possible to have at one's disposal hard X rays with a relatively low energy electron machine.

- But for a light source: $\sigma \sim 6.6524\ 10^{-25}\ cm^2$, it is low!!!!!

  - Thomx target is a high AVERAGE flux so we need many electrons and photons colliding in a small volume at high frep => CHOICE:

  - Storage ring + high average power laser amplified in a Fabry Perot resonator (French collaboration among different kinds of expertise)

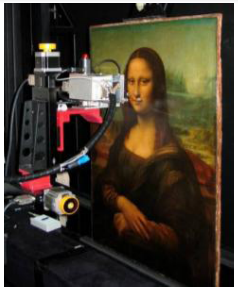
- CBS attractiveness :
- 1) Directivity (relativistic boost) = > f= $1/\gamma$ around the electron direction
- 2) Energy angle dependence => monochromatic by diaphragm
- 3) Polarized if needed
- 4) Backscattered spectrum cut off => Energy dependence on collision angle

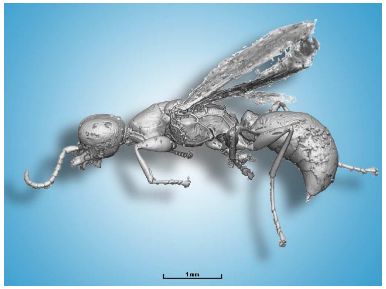
Scientific Case

•Cultural heritage and medical science

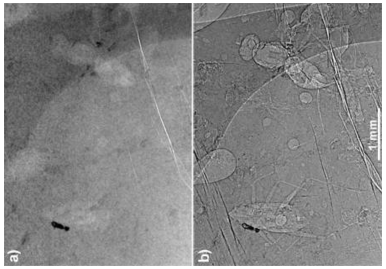
- Transfer of the SR techniques to these new machines. Many fields can be interested…
- At present two contributors: Medical field (ESRF, INSERM Grenoble)
  Cultural Heritage (C2RMF CNRS – Louvre Museum)

•Painting analysis



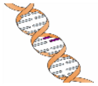


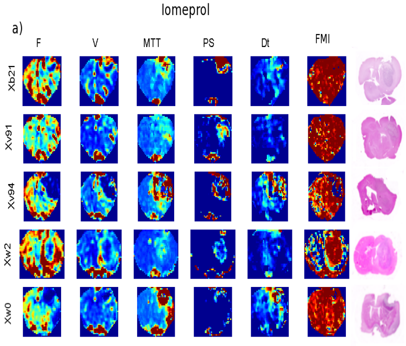
•Paleontology
•Non-destructive analysis

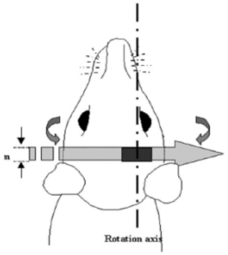


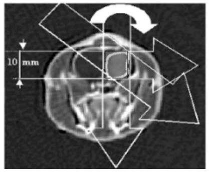
•*K-edge imaging* (Pb→white, Hg→ vermilion…) of a Van-Gogh's painting
•J. Dik et al., *Analytical Chemistry*, **2008**, *80*, 6436

•Physiopathology and Contrast agents,
•Dynamic Contrast Enhancement SRCT
•Convection Enhanced Delivery =>Stereotactic Synchrotron RT



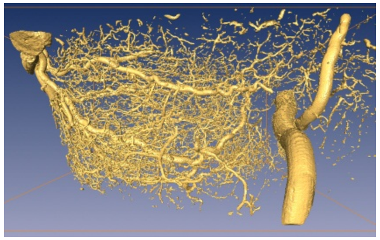




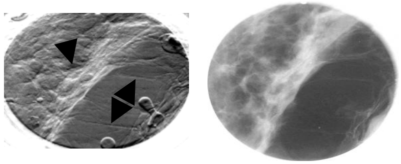


•Biston et al, Cancer Res 2004, 64, 2317-23

•Imaging,
•Mammography
•Microtomography



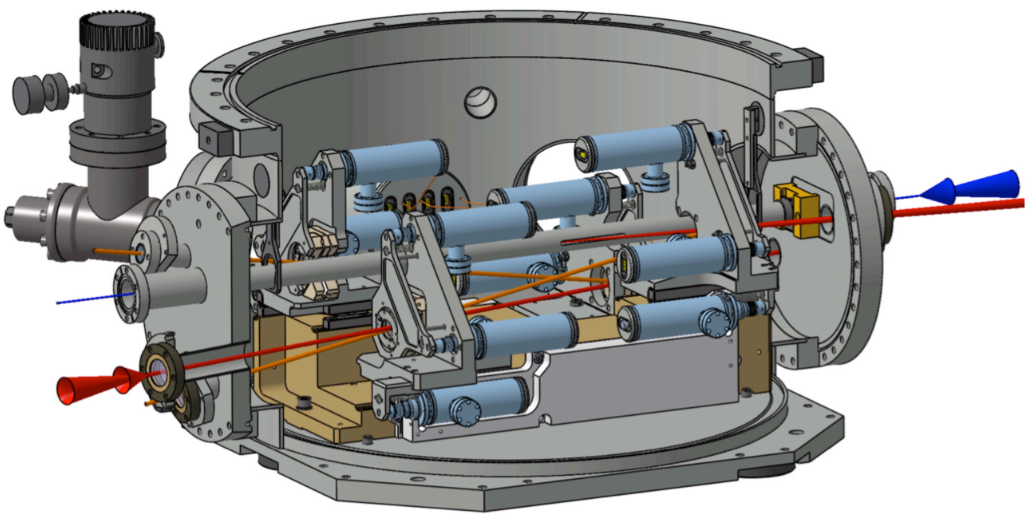
•J Cereb Blood Flow and Metab, 2007. 27 (2):292-303.



•Journal of Radiology 53, 226-237 (2005)

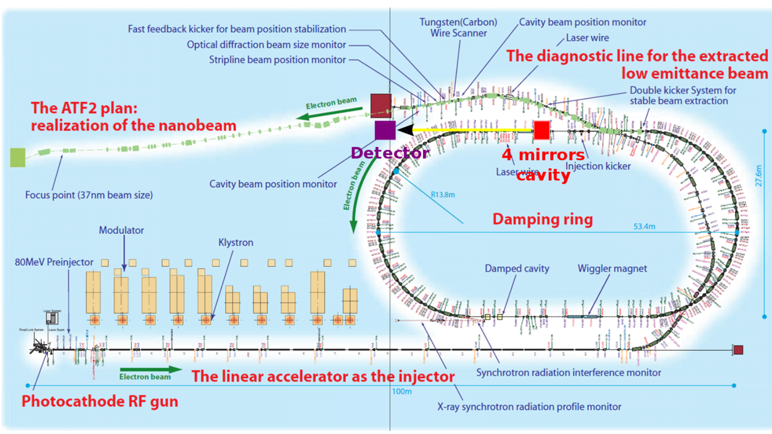
• Acknowledgments to G.Le Duc, P.Walter

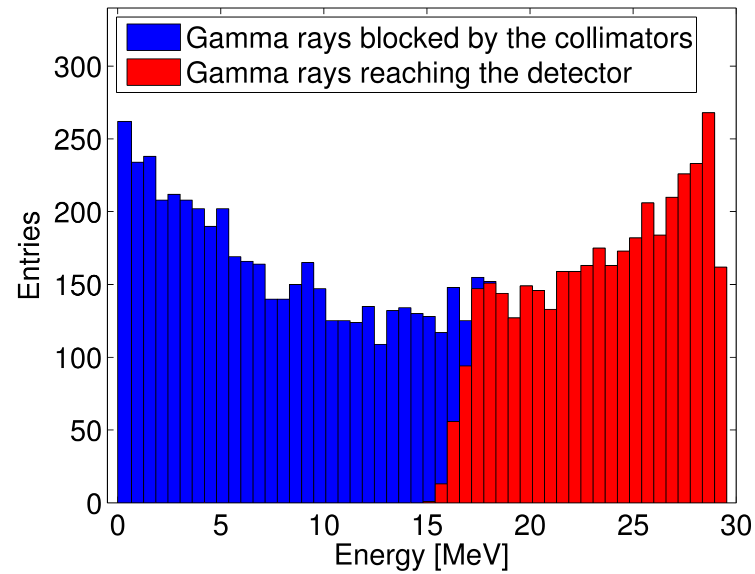
- Because the Compton cross section is so low one needs to « recycle » the photons.
- LAL has extensive experience with Fabry Perot cavities
  => use a Fabry-Perot cavity to recirculate the photon.
- The average laser power needed is very
  => R&D needed: MightyLaser



Mighty laser at KEK

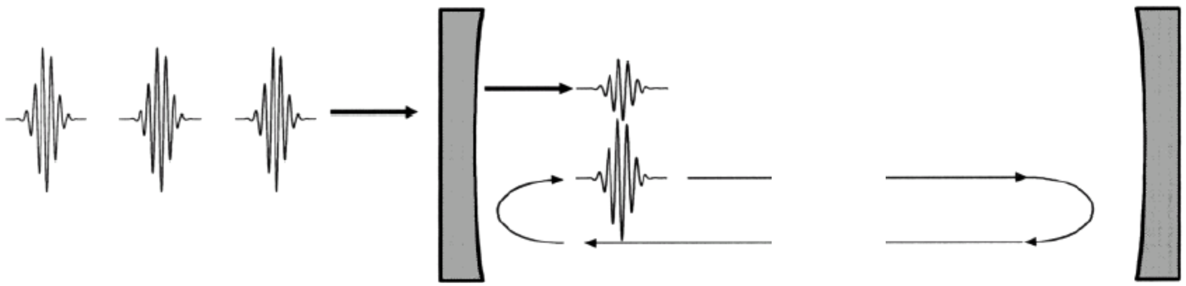
- To demonstrate our Compton production scheme we have installed a Fabry-Perot cavity at the ATF at KEK.
- Our goal is to show that we can deliver a high instantaneous luminosity and a high integrated luminosity.
- ATF = 1,3 GeV => gamma ~25 MeV





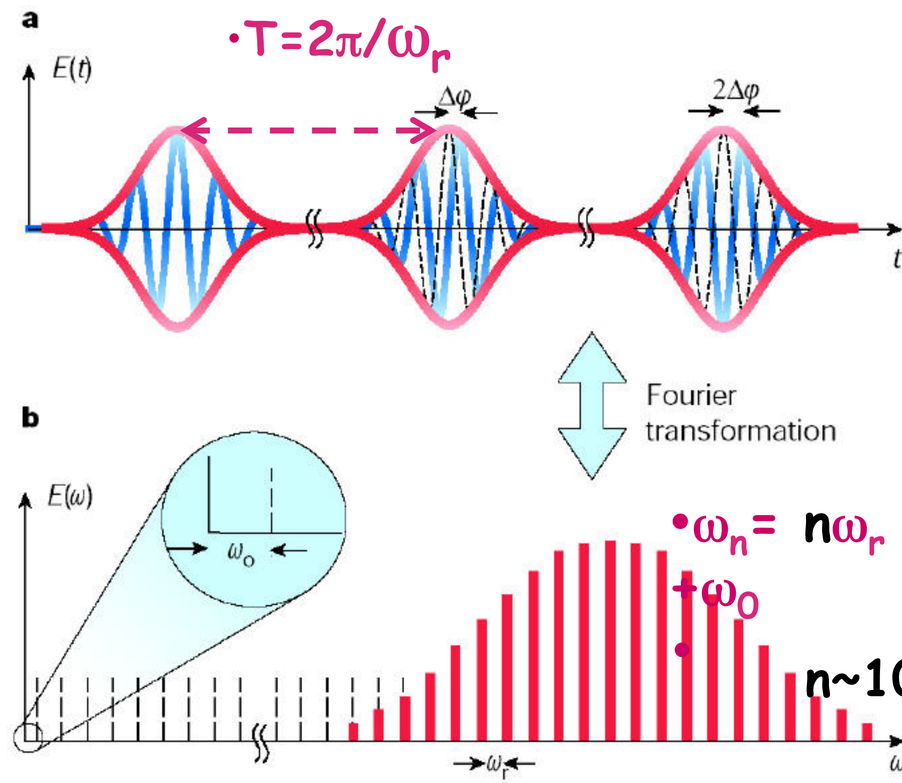
Laser pulse stacking

- Fabry-Perot cavity allows significant enhancement factors on the laser power (1000-10000).
- This is very difficult
  => frequency combs
  => demonstrated in an accelerator with a CW laser by LAL at HERA
  => current prototype with pulsed laser tested by LAL at KEK in Japan.



•Pulsed_laser/cavity feedback technique

•Specificity ➔ properties of passive mode locked laser beams



•Frequency comb
➔ all the comb
must be locked to the cavity

•➔ Feedback with
2 degrees of freedom :

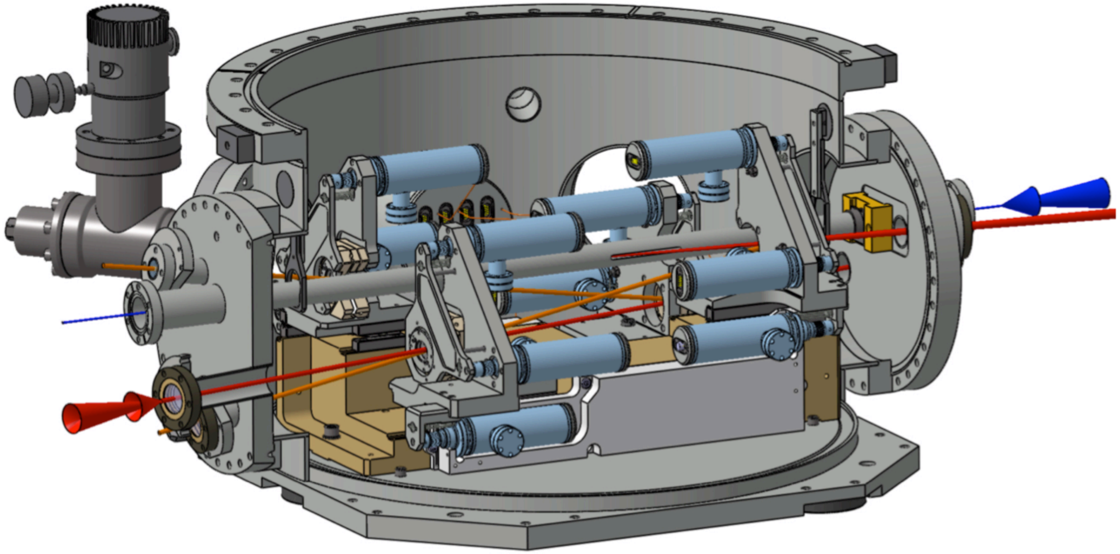
• **control of the Dilatation & translation (PZT)**

•T. Udem et al. Nature 416 (2002) 233

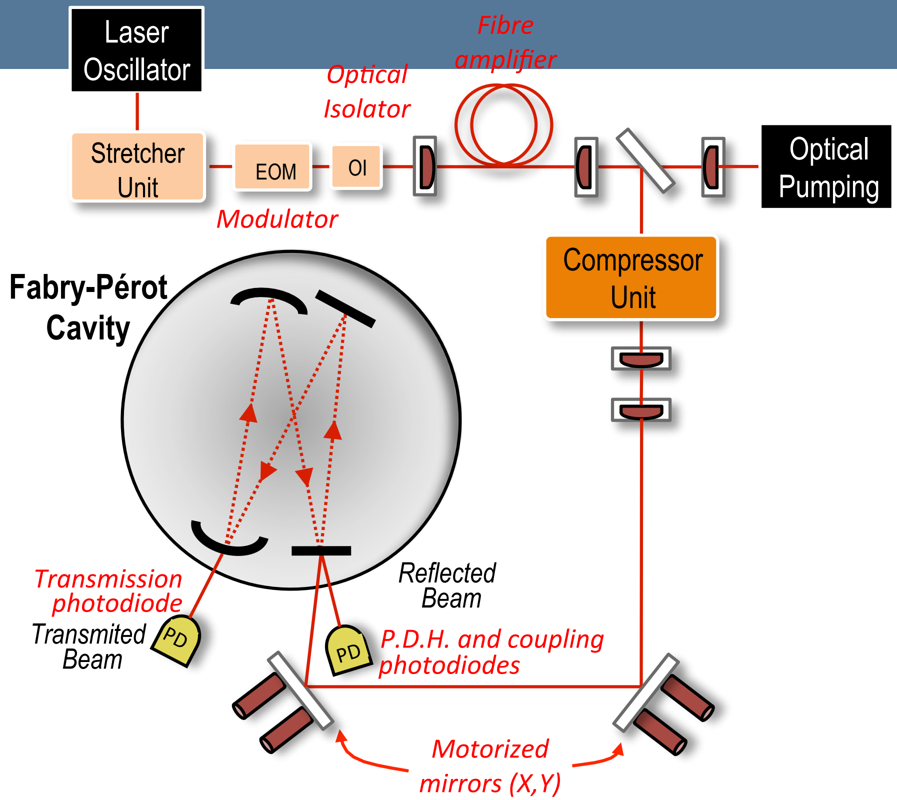
•State of the art (Garching MPI) : **~70kW,** 2ps pulses @78MHz, stored in a cavity
(O.L.35(2010)2052) **~20kW,** 200fs pulses @78MHz

The cavity

- A 4-mirrors non planar cavity is used to stack laser pulses.
- Length: 1.68m => f=178.5MHz (fATF/2)
- A non-planar geometry ensures that the laser pulses are polarised circularly.
- Installed at KEK during summer 2010.
- We achieved a cavity finesse (stacking power) of 30 000.
- Performances were limited by the thermal deformation of the mirrors.

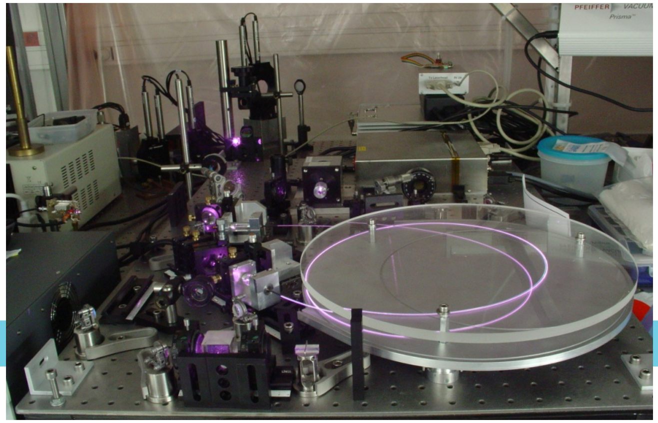


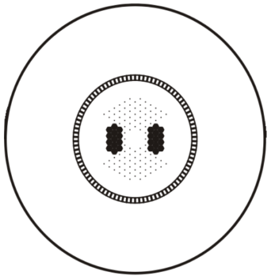
The laser

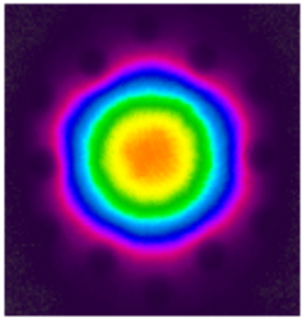


- Seed purchased commercially with low noise specifications.
- Repetition rate: 178.5 MHz
- Chirped pulse amplification
- Amplification in Yb doped fibre for better performances.
- Double stabilisation system:
  - laser on cavity
  - cavity on accelerator

  => low noise is critical for our operations.
- Design power: 50W (upgrade to higher power foreseen)
- Here also we are limited by thermal effects on the mirrors.

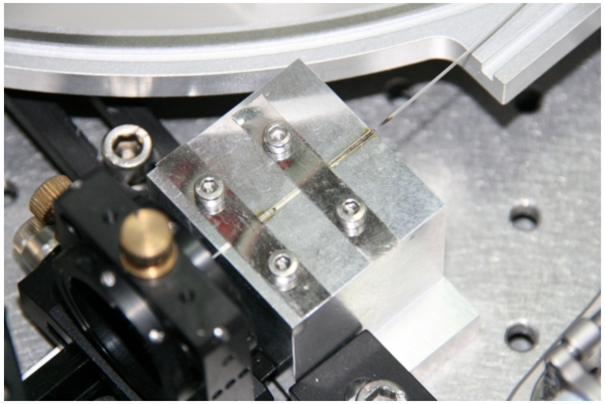




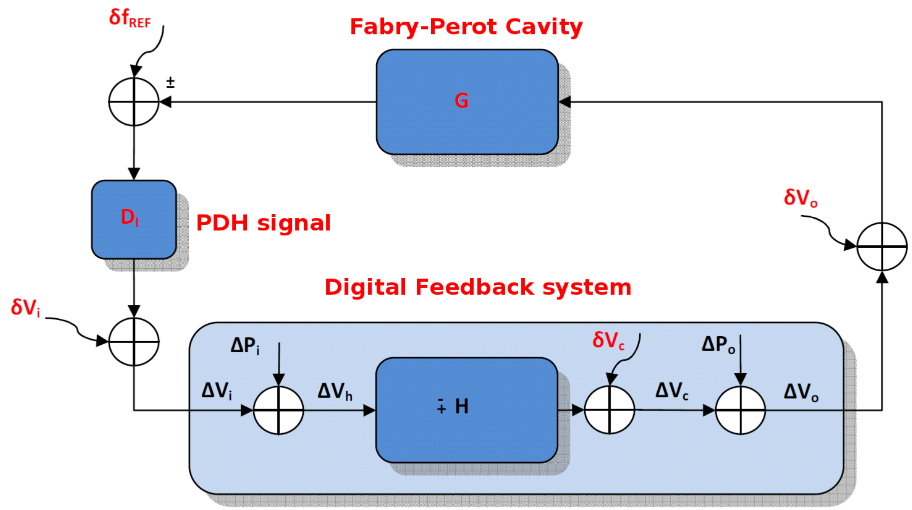


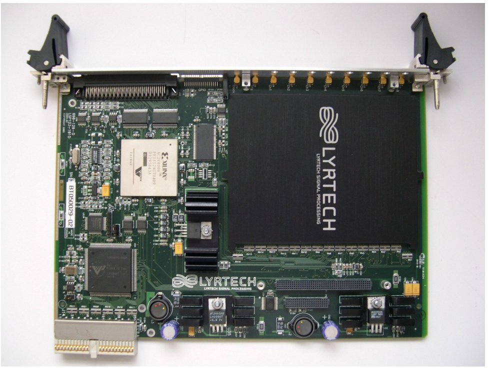
Laser amplification issues

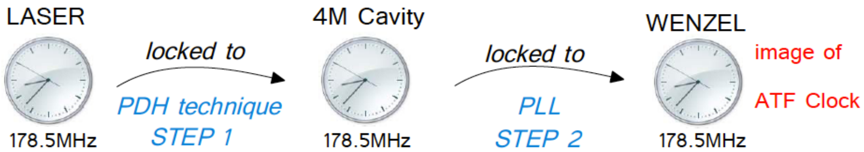
- Reaching our design performances we was more difficult than anticipated
- Several factors:
  - We experienced difficulties injecting the pump radiation in the core of the fibre
   => need pump with smaller numerical aperture
  - Heating of the fibre limits the power we can inject (we damaged several fibres)
  => improved cooling system
  - Our EO modulator has been damaged
  => need replacement.
  - Commercial laser failure (many!)
  => being repaired
- We are currently working on an improved design to make operations more reliable.



Digital feedback system

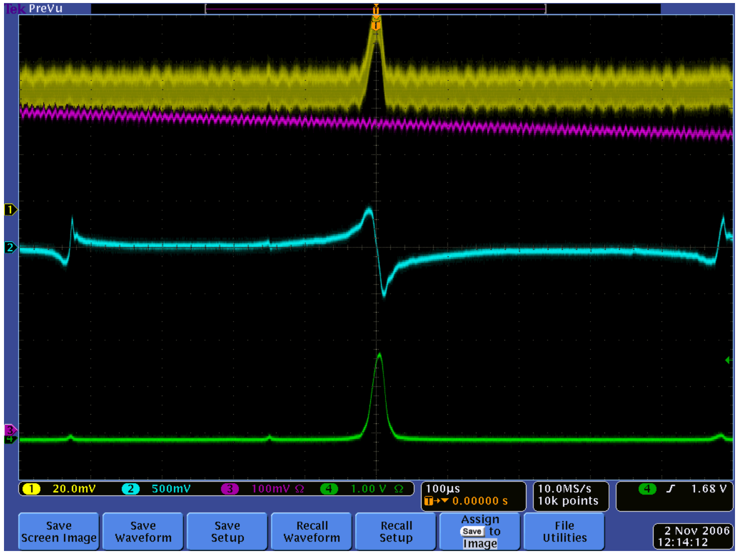






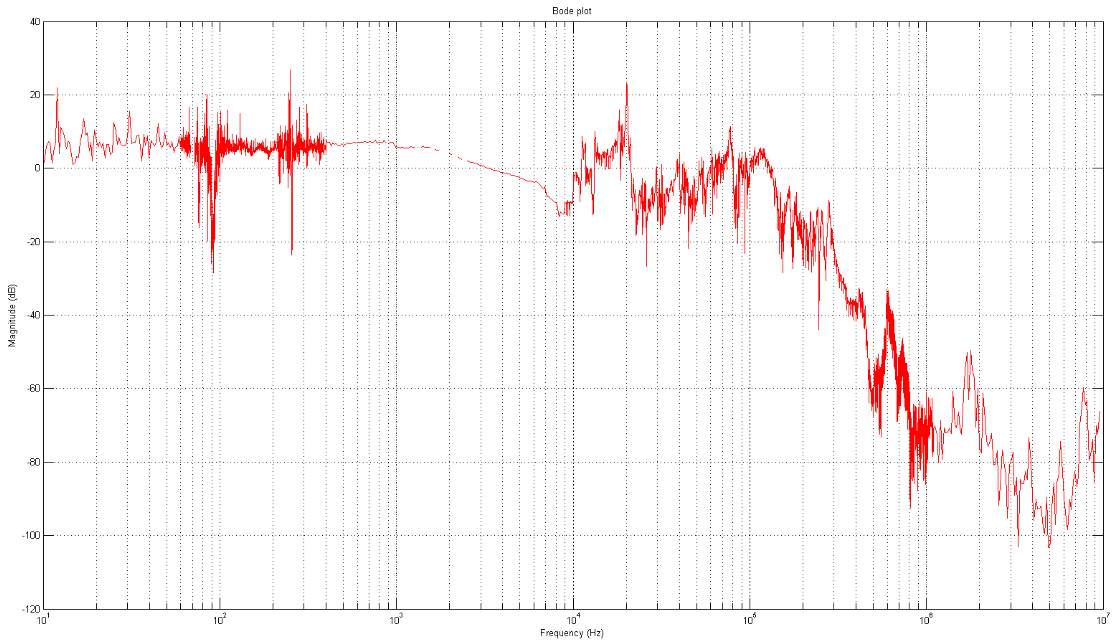
- To ensure that the laser pulses are properly stacked in the cavity we use a double digital feedback system to adjust its length.
- Such system gives us more flexibility than an analogue one.
- Based on a FPGA Virtex II board.
- The laser is locked on the cavity using the Pound Drever Hall technique.
- The cavity is locked on the ATF clock using a phase lock loop.

Cavity stabilisation: Pound Drever Hall technique



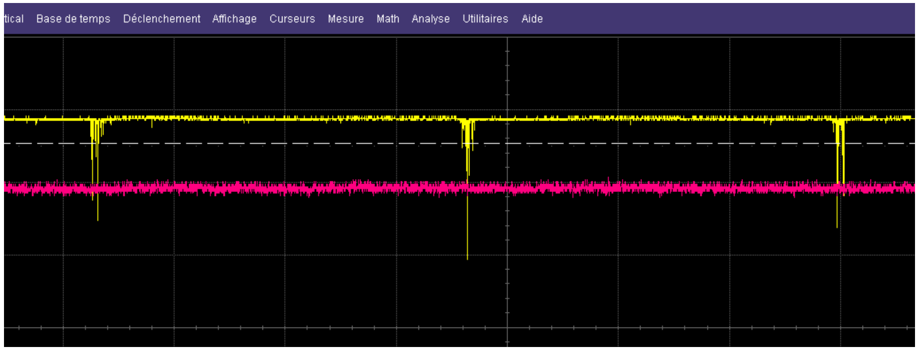
- We use the Pound Drever Hall technique to stabilise the cavity.
- The laser signal is modulated before being injected in the cavity.
- When close from the correct cavity length the signal "reflected" on the coupling port of the cavity is linearly proportional to the correction to be applied on the piezo actuator to adjust the laser cavity length.

Feedback resonances

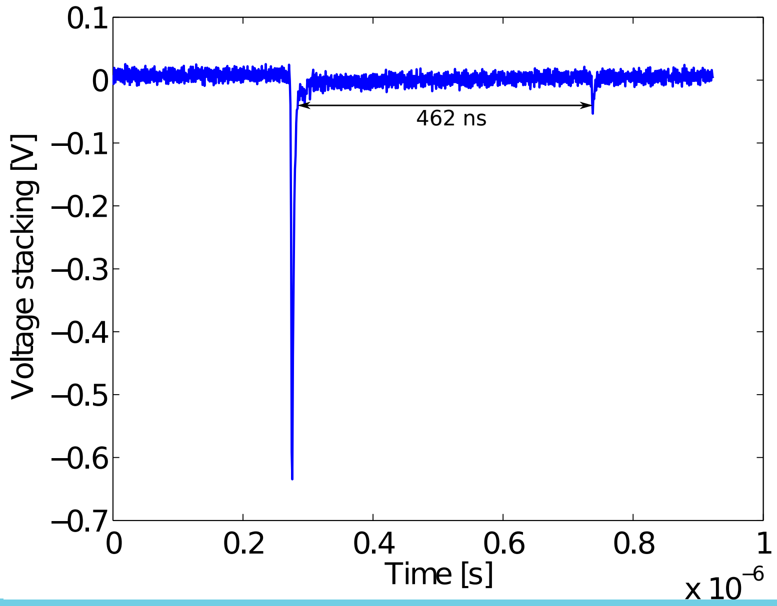


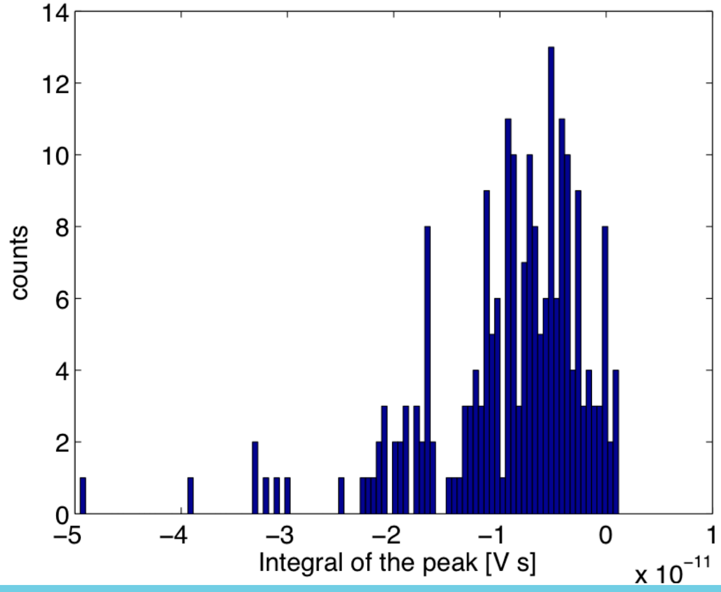
- To optimize the locking of the laser on the cavity, the transfer function of the system (cavity, piezo,…) must be measured.
- This allows to adjust the gain and the bandwidth of the feedback system to avoid resonances.

First data taking



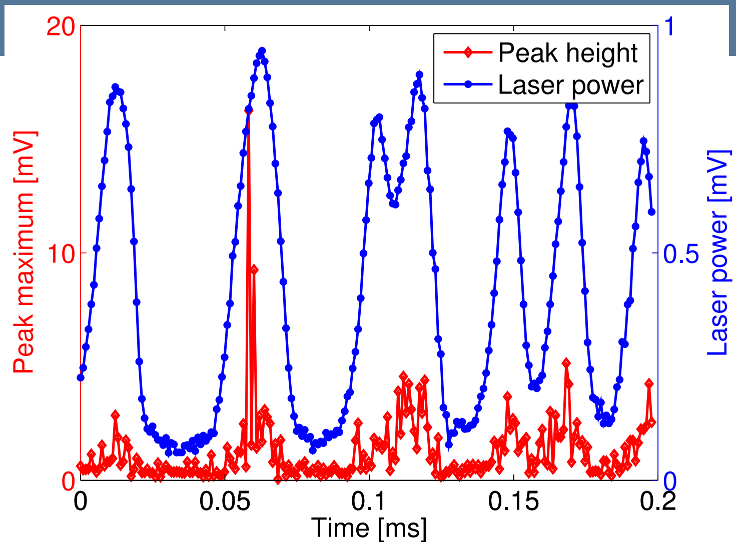
- We achieved electron-laser collision during our first data taking shift and during each data taking run after.
- Iryna Chaikovska PhD thesis.

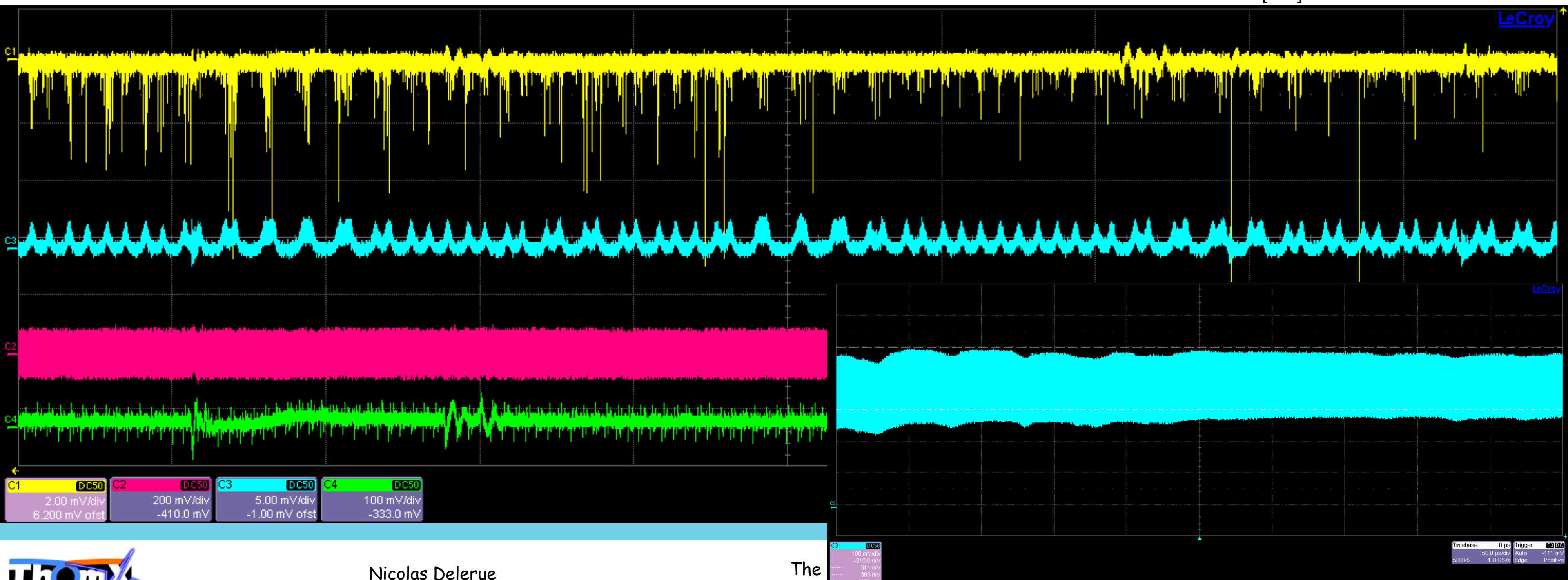




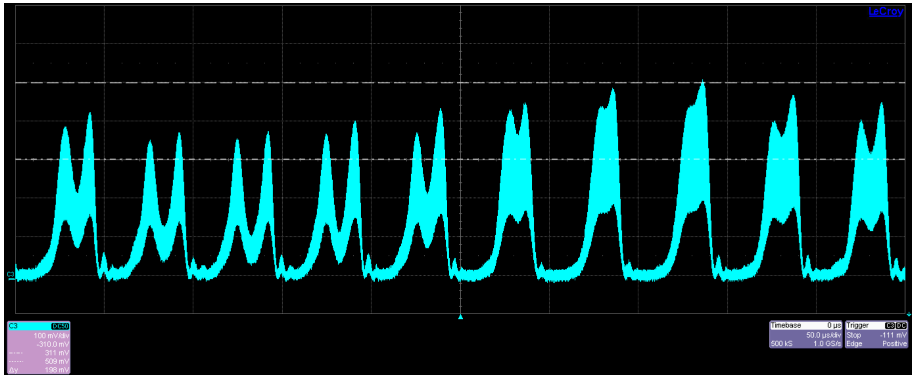
Cavity stability & Power fluctuations

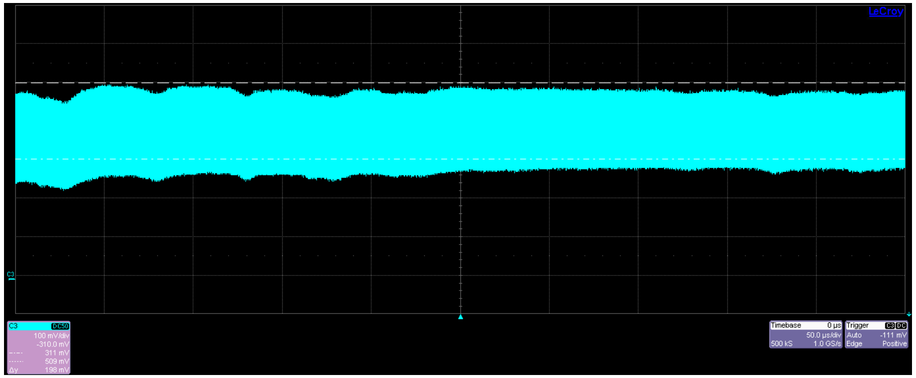
- During our early data taking shifts we noticed significant fluctuations of the power stored in the cavity (blue trace) and consequently of the gamma ray yield (yellow trace).
- This issue was resolved later by changing the filters in the digital feedback (but no Compton data have been taken with these filters yet).



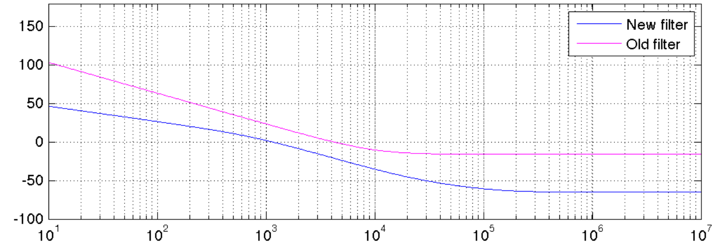


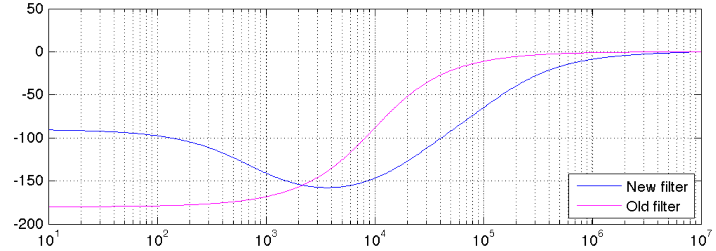
Improved gain





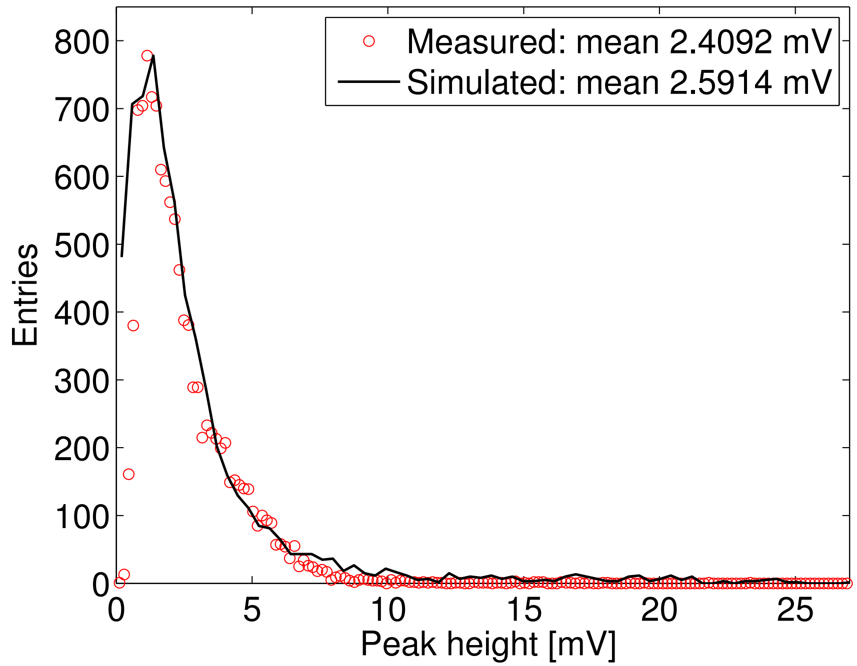
- Optimizing the filters in the feedback system can significantly improve the stability of the laser power stored in the cavity and therefore the flux of Compton produced.





Results

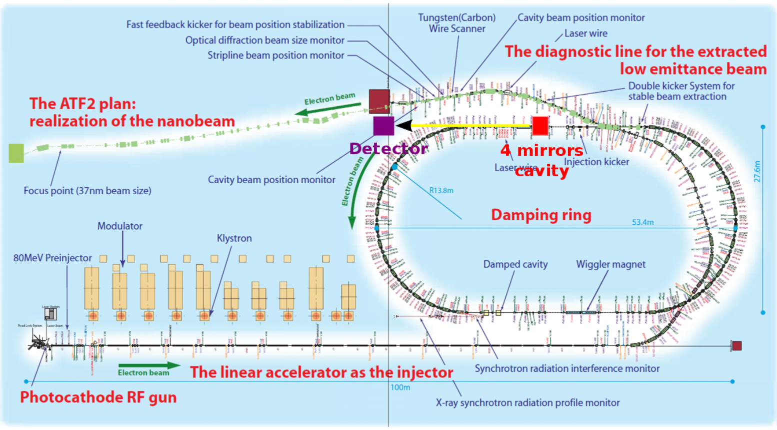
- The data taken have been analysed in details.
- Average power in the cavity was only about 100 watts.
- The highest instantaneous flux observed correspond to 38 gammas/crossing.
- 2 publications detailling these results:
  - 2012 *JINST 7* P01021
  - 2012 *JINST 7* P01017



Electron pulse structure	Total intensity over 0.2 ms	Energy deposited over 0.2 ms	Integrated flux over 0.2 ms	Integrated flux over 1 s	Systematic error
1 train	893 mV	23750	990 γ	$\sim 4.9 \times 10^6\ \gamma$	7%
2 trains	910 mV	24210	1010 γ	$\sim 5.0 \times 10^6\ \gamma$	7%
3 trains	1010 mV	26800	1120 γ	$\sim 5.6 \times 10^6\ \gamma$	7%

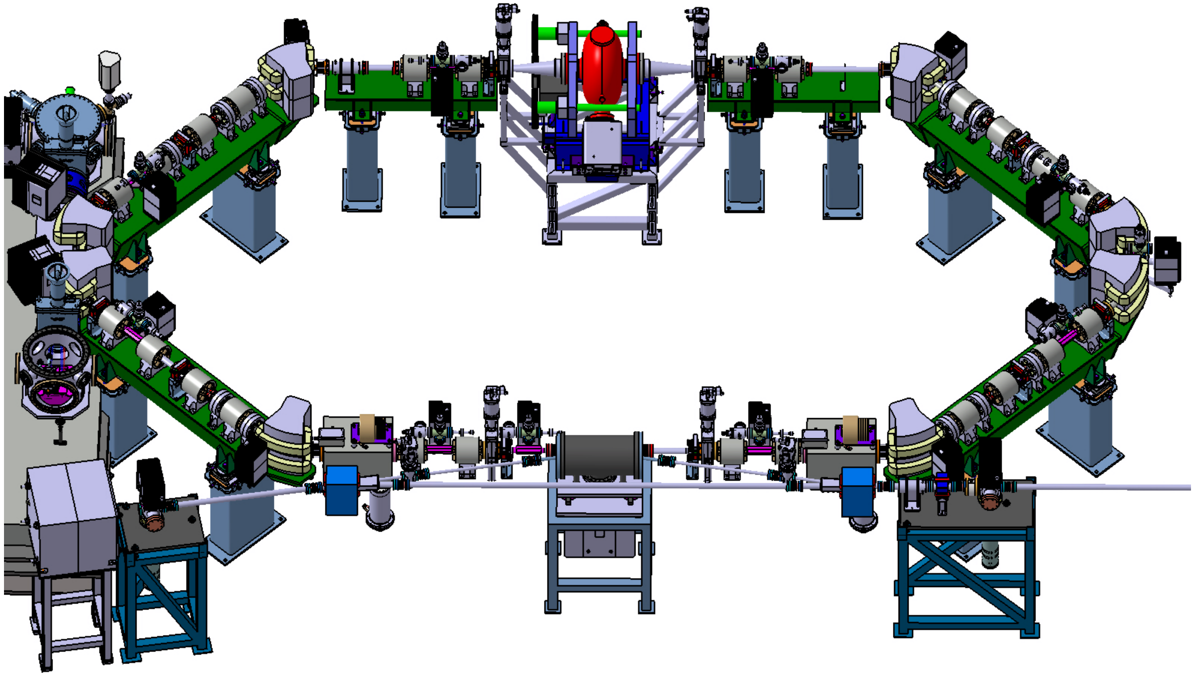
MightyLaser outlook

- The experiment suffered from the earthquake in March 2011 and recovery has been slow due to damages to the laser but we got improved results in 2013.
- R&D done at LAL with the laser system allowed us to store 100kW in the cavity (but limited by thermal effects).
- The experience we have already accumulated will be very valuable for ThomX
- Possible solution for a (polarized) positron source at the ILC/CLIC.



ThomX

- The LAL experience with Fabry-Perot cavities has led to the idea of using them to build a Compton scattering based light source: ThomX
- The project has been funded through a dedicated call for research infrastructures.

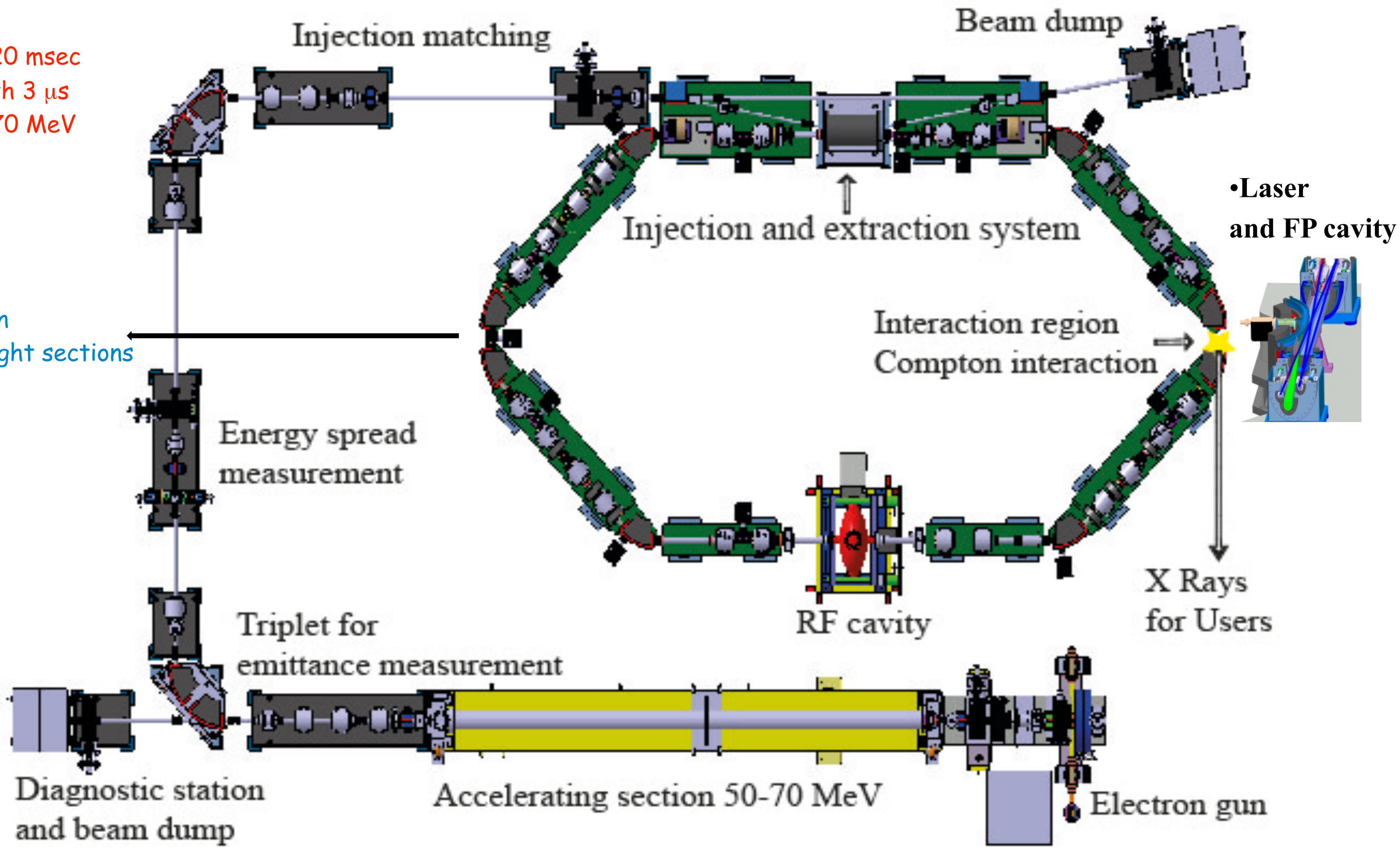


How it works

•ThomX scheme and design

- •Cycle Frep = 20 msec
- •RF pulse length 3 μs
- •Energy 50 - 70 MeV

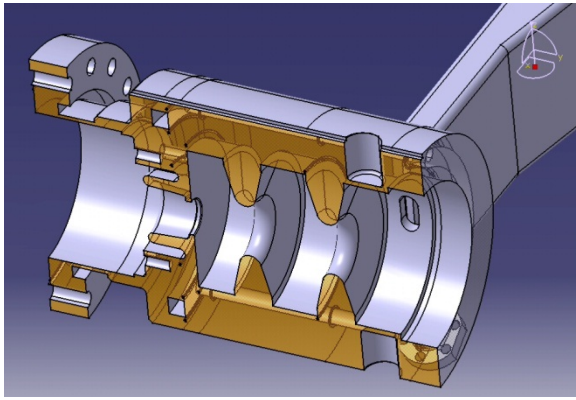
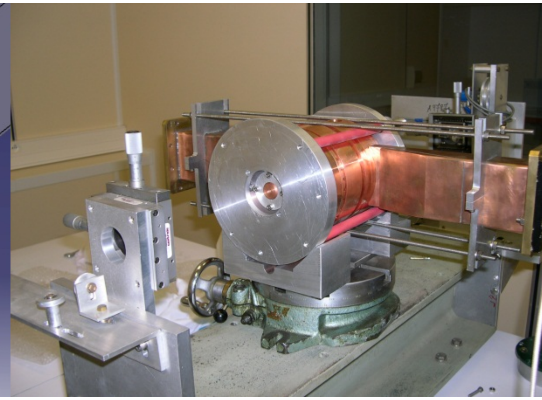
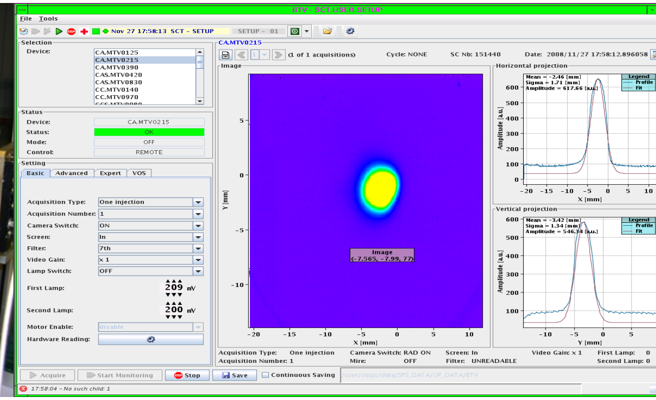
- •2 Ips
- •Easy integration
- •Frees the straight sections
- •CSR line



• Acknowledgments to M.Jore, M Lacroix

Injector

•Electron gun and accelerating section

•Probe Gun, LAL Design,

•Already tested in the CTF facility for high current

•Accelerating section => LIL type section

•4.6 m, 135 cells, 2.998.46 MHz @ 31 C°, mode $2\pi/3$.

•Q = 14800, 12.6 MV/m for the 50 MeV case

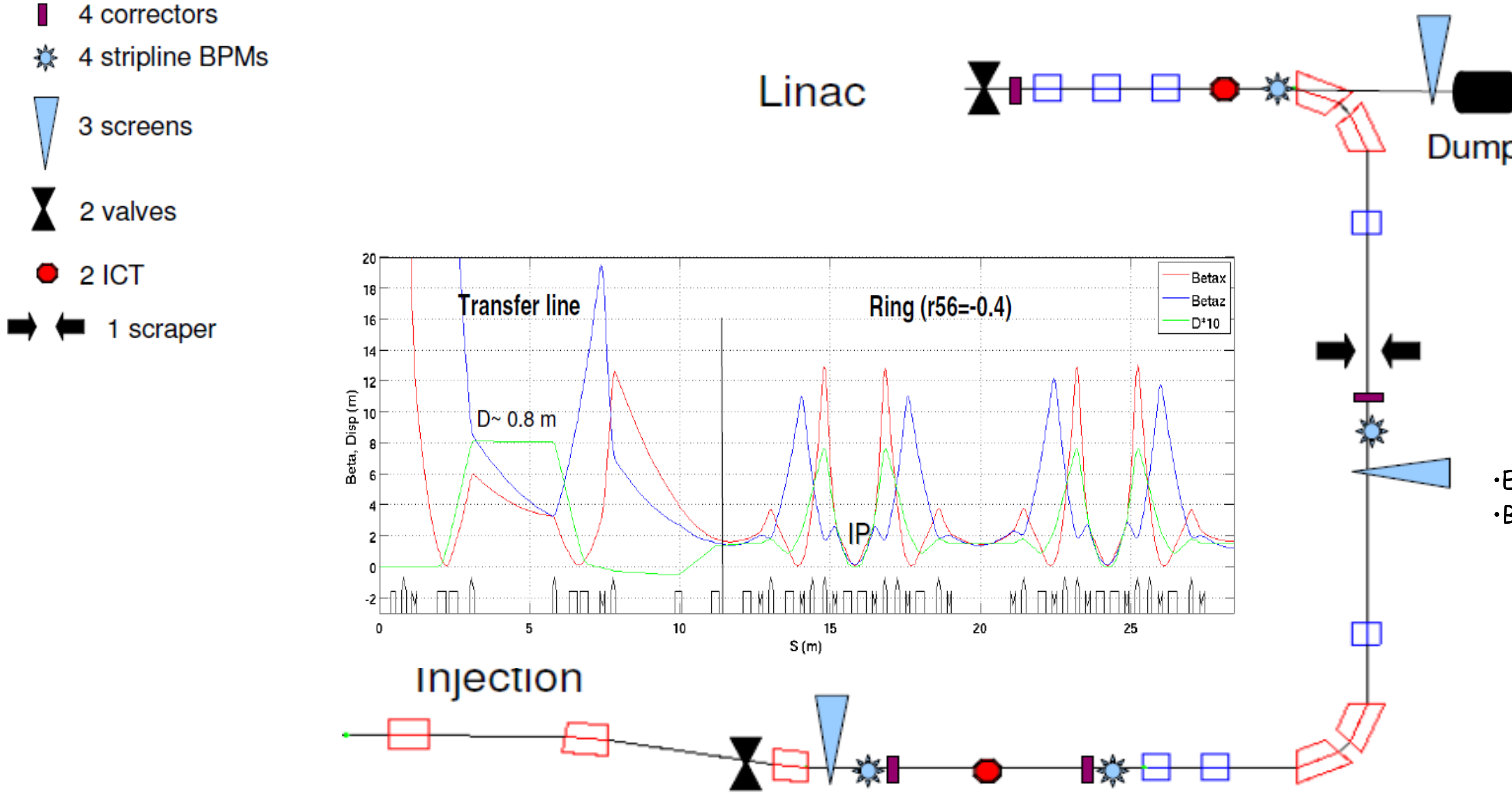
•Entrance => 160 cm from the cathode

•Phase stability required $\Delta\phi \leq 1°$

• Acknowledgments to R.Roux, P.Marchand, J.P.Pollina

Transfer line

•Transport and diagnostics



•Emittance
•Beam size
•Steering

•Energy Spread
•Beam steering

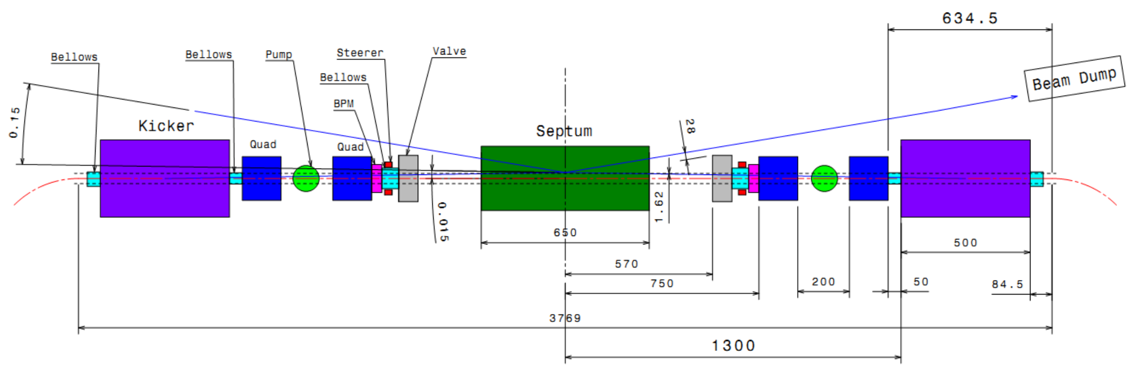
•Longitudinal and transverse emittance
•Dispersion matching (2 BPM)
•Orbit steering (2 coorrectors)

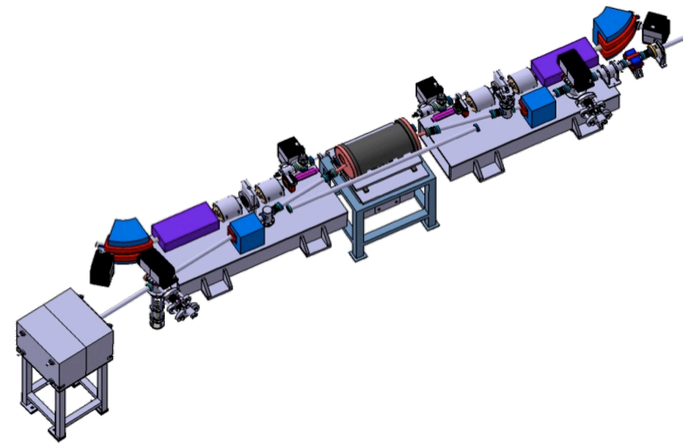
• Acknowledgments to A.Loulergue

Injection

One septum, two kickers

Injection section

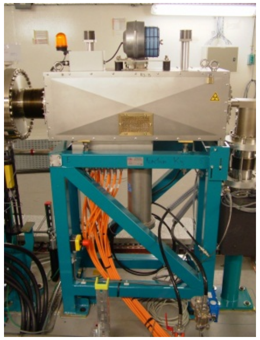


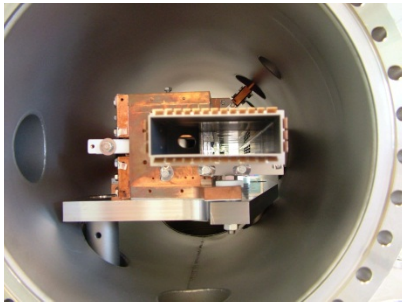


Equipment	Active length	Overall length	Transverse Beam stay clear		Septum thickness	Ceramic thickness
	(mm)	(mm)	H (mm)	V(mm)	(mm)	(mm)
Septum magnet	250	650	30	12	3	
Injection kicker	250	450	40	28		6
extraction kicker	250	450	40	28		6

Equipment	Deviation	Magnetic field length	Peak current	Charging voltage	Pulse shape	Pulse duration	Repetition rate (max)
	(mrad)	(mT)	(A)	(V)		(µs)	(Hz)
Septum magnet	150	100	960	150	full sine	130	50
Injection kicker	15	10	420	12500	half sine	0.050	50
extraction kicker	15	10	420	12500	half sine	0.050	50

•R&D => pulsed power supplies for the kicker magnets (ring revolution 56 ns) = > a very high di/dt (~20 kA/µs), fast rise time and fast blocking of the negative current, and a very small time jitter

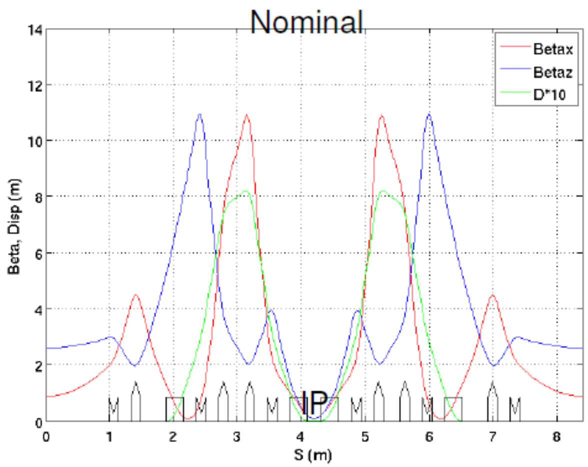


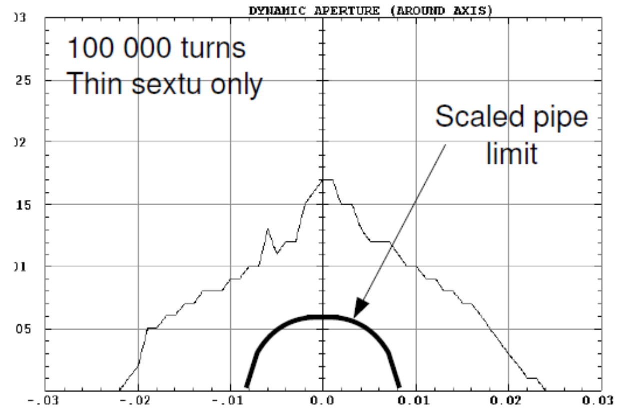


• Acknowledgments to P.Lebasque, T Vandenberghe

Ring

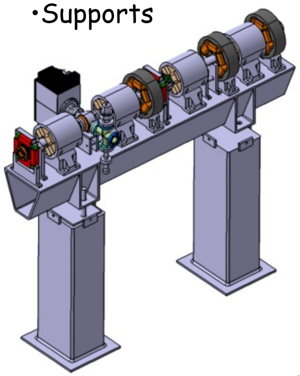
Linear optics and mechanics



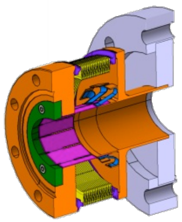


$\beta_x = \beta_z = 1.8$

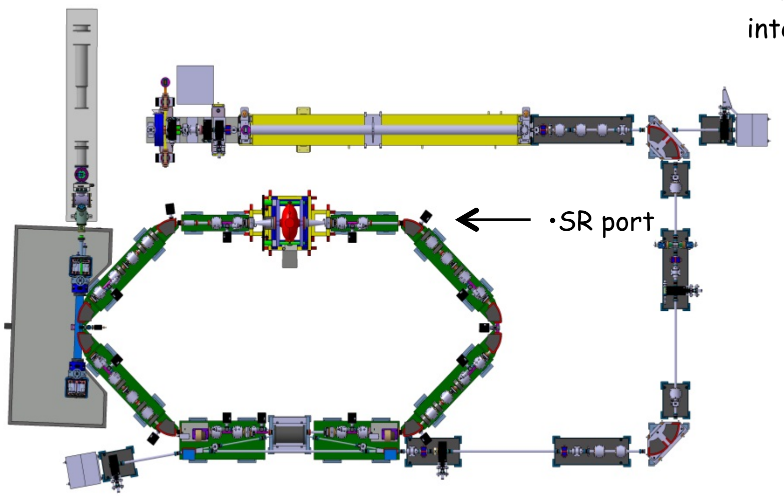
• Supports



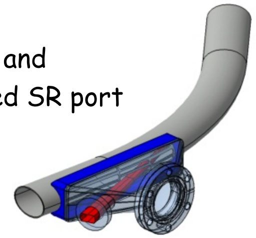
• Bellows



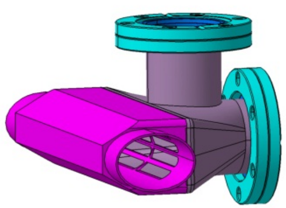
• X Line



• Pumping and integrated SR port



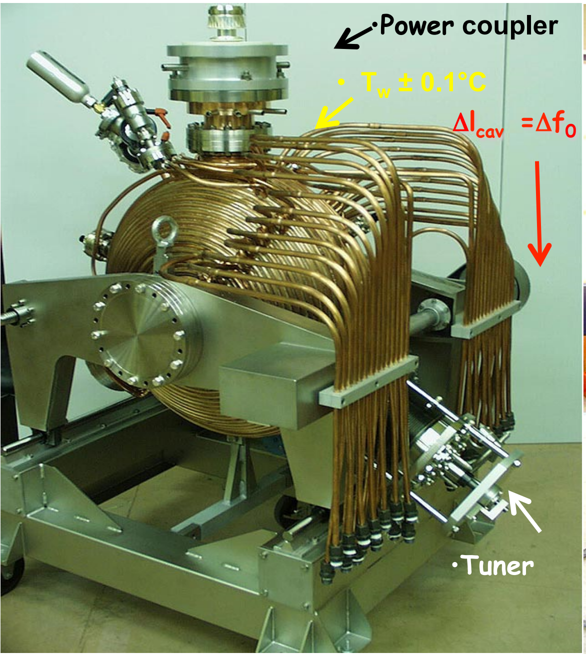
• Pumping ports

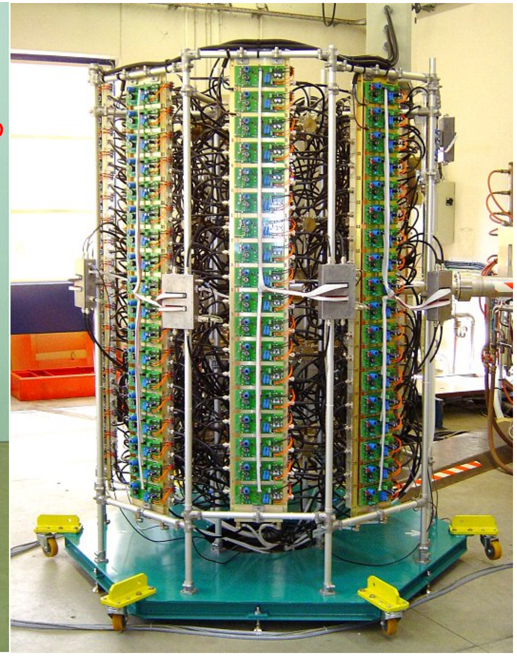


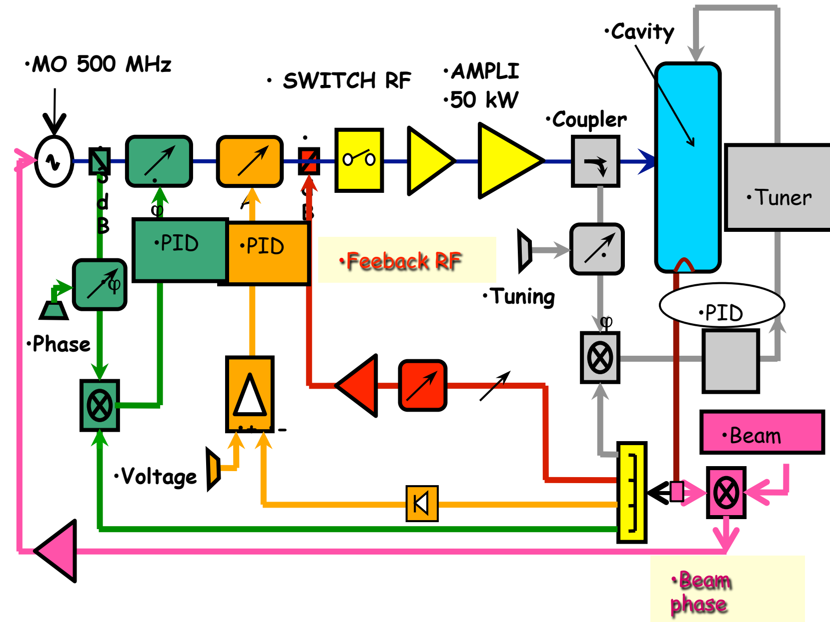
• Acknowledgments to A.Loulergue, T.Vandenberghe, C.Prevost, B Mericer, A. Gonnin, R.Marie

Ring RF

Cavity, Rf source and feedback







•'Elettra' type cavity
•3 different tuning knobs
•Temperature (30÷60 C°, ±0.05 C°)
•Mechanical length adjustment Δl
•Tuner on the equator

•'SOLEIL' type transistor amplifier
•No HT, modularity (easy to maintain)
•Tested (5 years, +25,000h of operation)
•Operational efficiency 99.995%
•1 Module @352 MHz 330W => Can be extended to 500 MHz

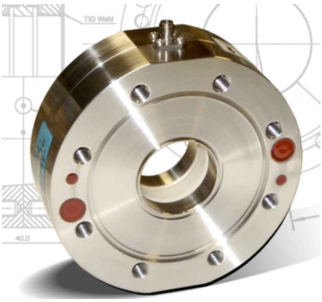
•'Slow and Fast feedback
•Slow Amplitude, phase , frequency loops
•Fast RF FB
• Phase loop => beam oscillations @ 500 kHz, $\Delta\Phi_{inj}$, HOM,…

• Acknowledgments to P.Marchand

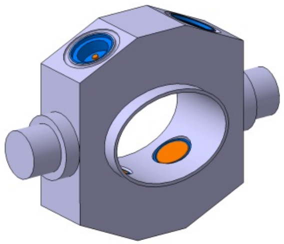
Diagnostics

Linac, transfer line and ring

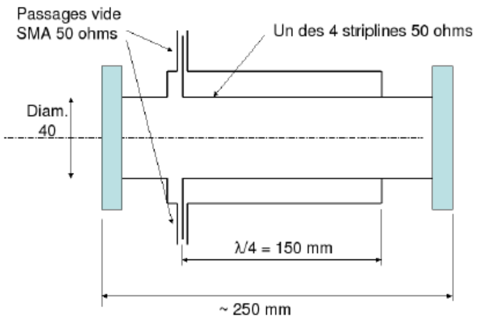
- **In-flange Integrating Current Transformer**
- 5.0 Vs/C sensitivity
- Electronics: BCM-IHR with 2 ranges: 0.8 -2 nC
- Acquisition: ADC 12 bits 100kHz



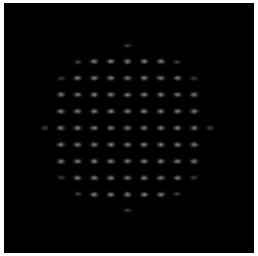
- 17 Button BPM in the ring.
- Absolute precision: < 50 µm
- Resolution: ~ 1 µm

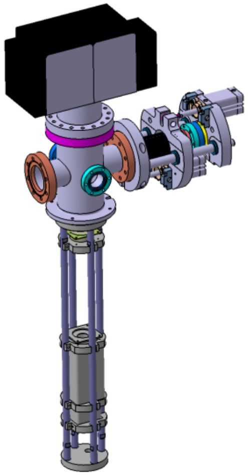


- Linac Stripline BPMs: λ/4,
- 500 MHz, resolution = 100 µm for 1 nC



- 1 Pepper pot

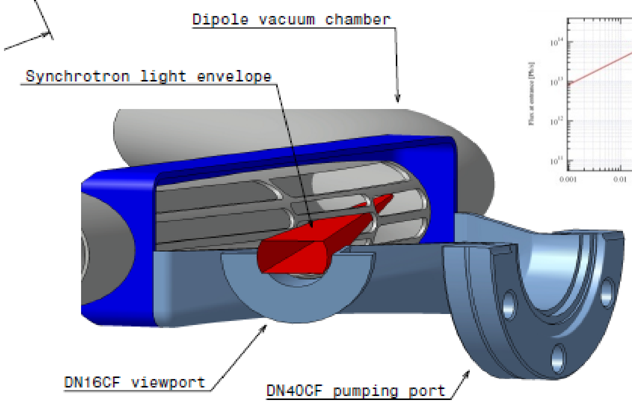


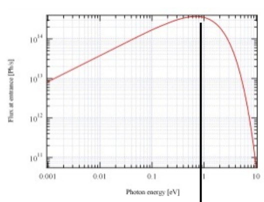


- Diagnostic Station:
- 1 design for a set of diagnostics at 4 different locations
- Elements: 2 or 3 screens
- 1 OTR : 25 mm diameter, 100 µm aluminized silicon wafer
- 1 YAG(Ce) : 25 mm diameter, 100 µm thick,
- Crystals: 1 sapphire screen
- Stepper motor to mount the screens
- View port: Fused Silica DN 60 CF
- 1 CCD: Basler with gigabit ethernet
- 1or 2 objective (s)

- Beam losses => fiber system

- 1 SR light port
- Extraction @ 15 ° - 63 mrad x 32 mrad aperture
- Dipole BM5



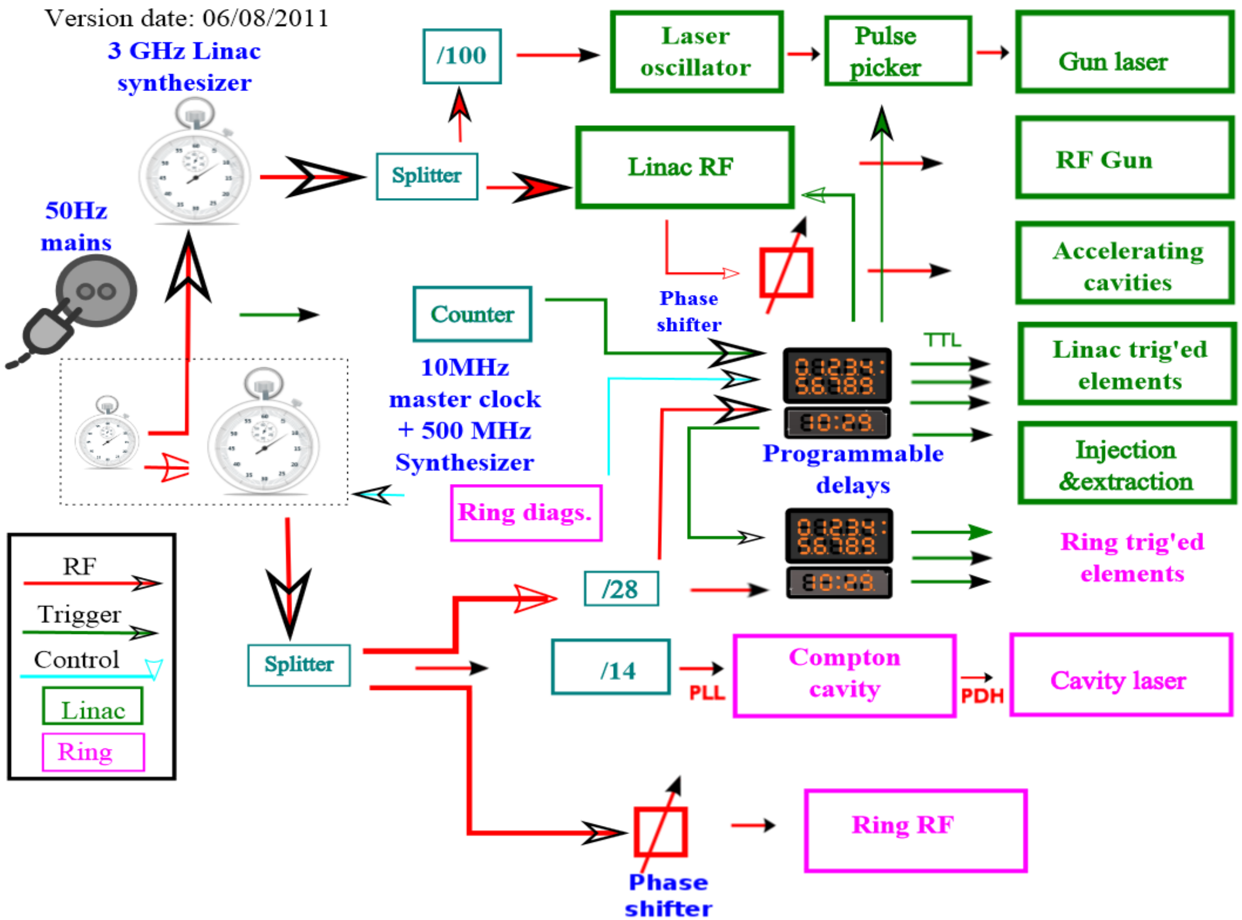


- 1 eV

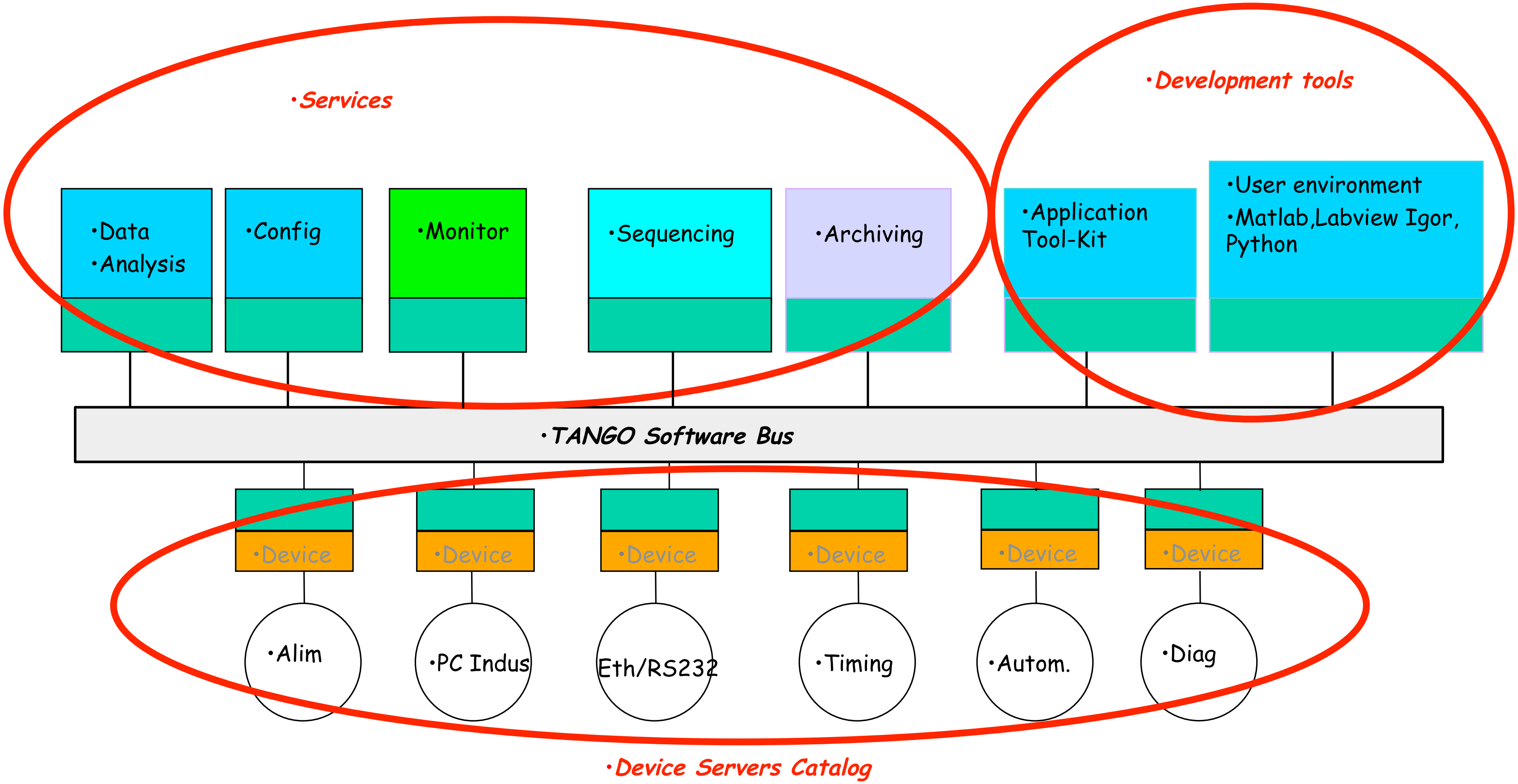
• Acknowledgments to J.C Denard, M.Labat, N Delerue, M.Jore, L.Cassinari, N.Hubert

Syncronisation

Dual clock system



Controls



• Acknowledgments to X.Renon

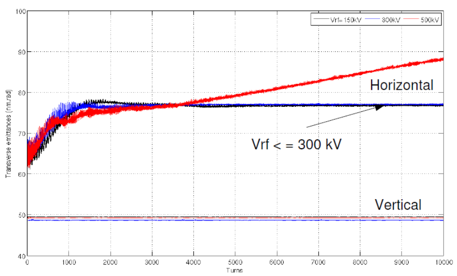
Beam Dynamics

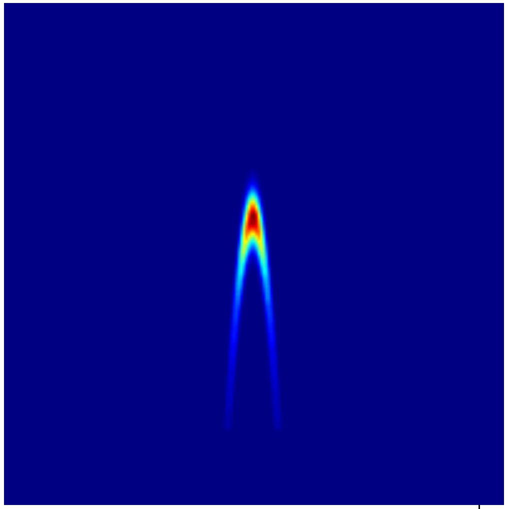
Injection and instabilities. Compton effect

- Transient dynamics (no equilibrium)
- Compton recoil
- Collective instabilities
- CSR, Ions, Vacuum scattering, IBS…..
- Injection mismatching

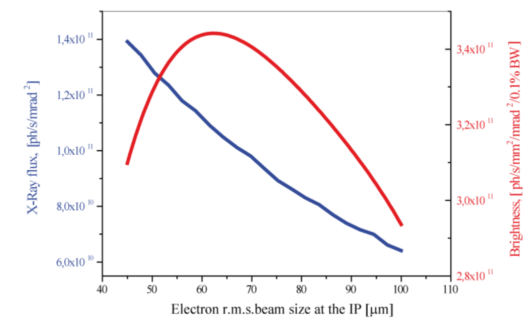
- Feedbacks!!!!
- Ion clearing
- Simulations

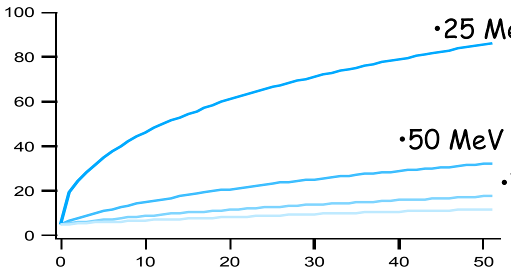
- 3 Phases
- Injection
- Turbulent regime
- Stabilization (thousand turns)

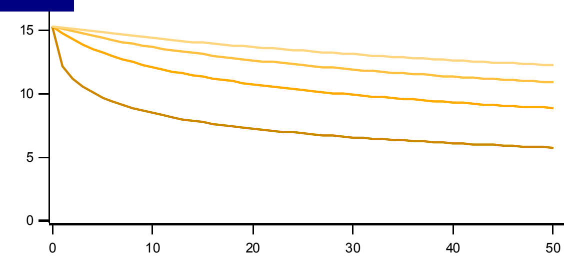




•Careful to the brillance !!!







• Acknowledgments to A.Loulergue, C.Bruni

Beam Dynamics

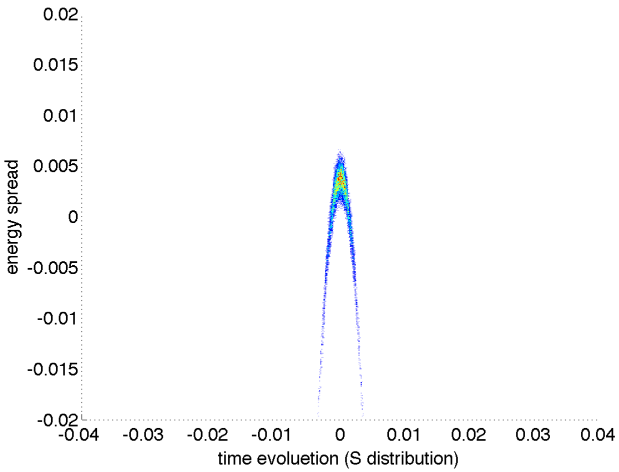
Injection and instabilities. Compton effect

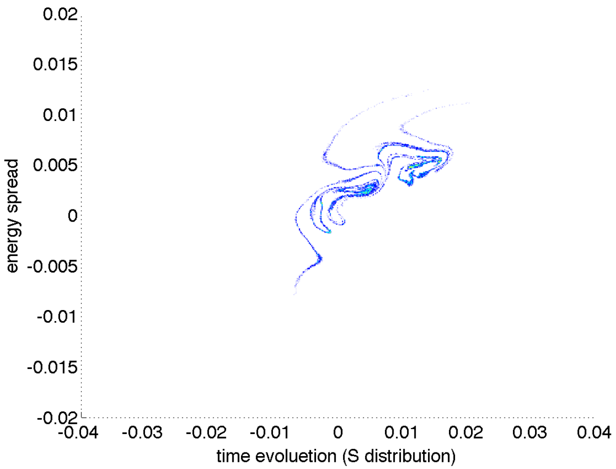
- Transient dynamics (no equilibrium)
- Compton recoil
- Collective instabilities
- CSR, IBS.....
- Injection mismatching

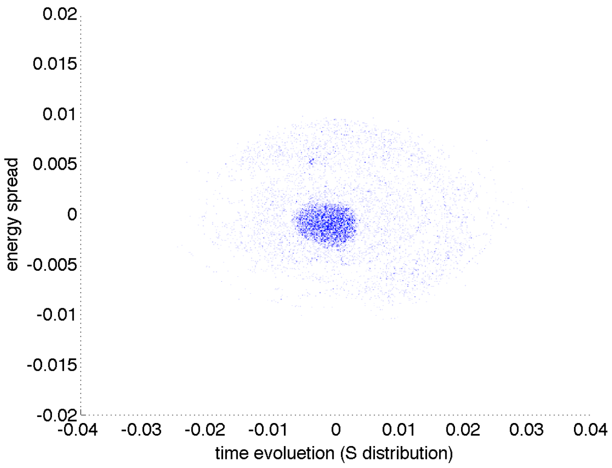
- Feedbacks!!!!
- Simulations

→

- 3 Phases
- Injection
- Turbulent regime
- Stabilization (thousand turns)

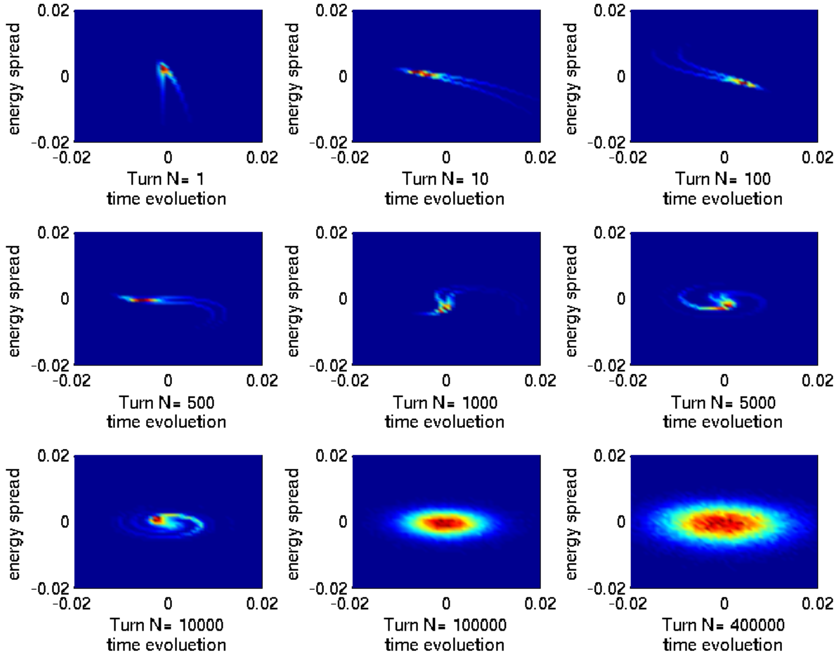


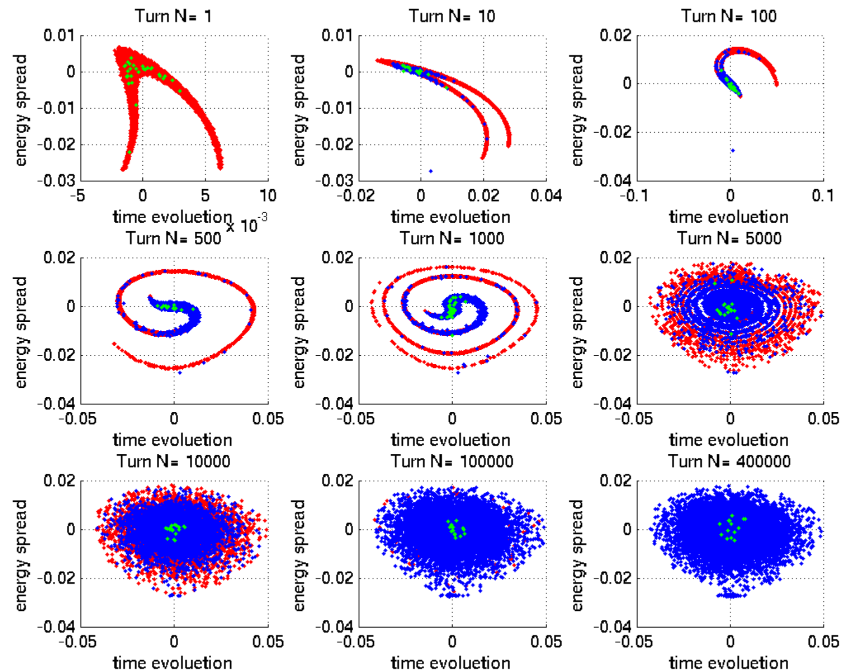




• Acknowledgments to Illya drebot

Result of simulations with CSR





Simulations of linear beam propagation with momentum compaction of second order and longitudinal feedback. With CBS.

• Acknowledgments to Illya drebot

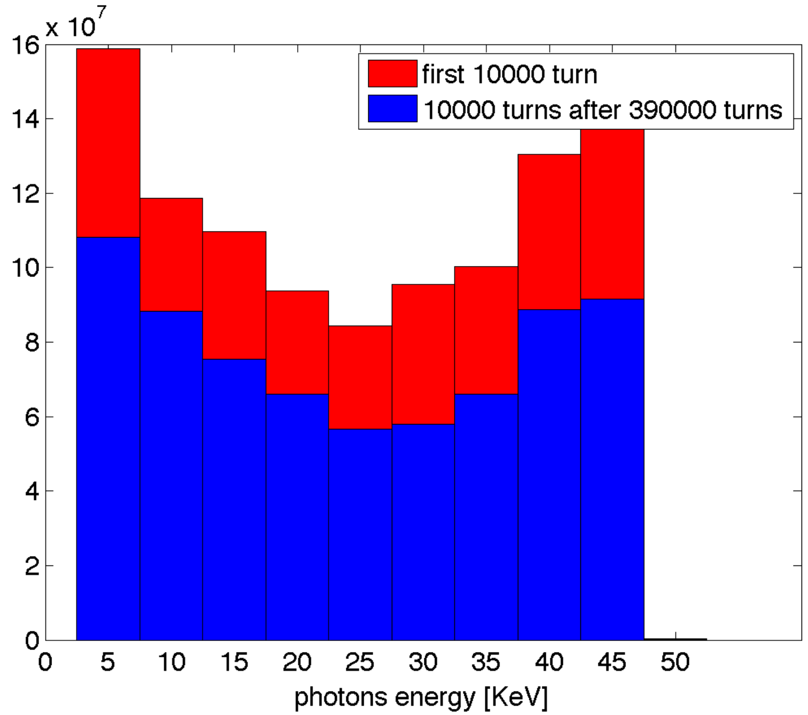
Compton Back Scattering

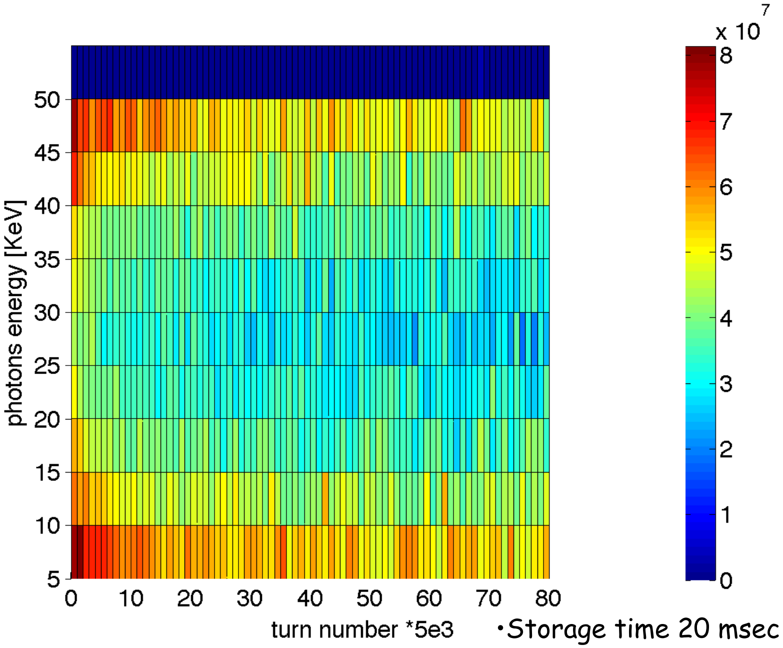
For simulating CBS we chose code CAIN written by K. Yokoya

CAIN: Conglomerat d'ABEL et d'interactions nonlineaires.
P. Chen, G. Horton-Smith, T. Ohgaki, A.W. Weidemann, K. Yokoya,
Nucl.Instrum.Meth.A355:107-110,1995.

And interface it to matlab.

•Compton random energy recoil

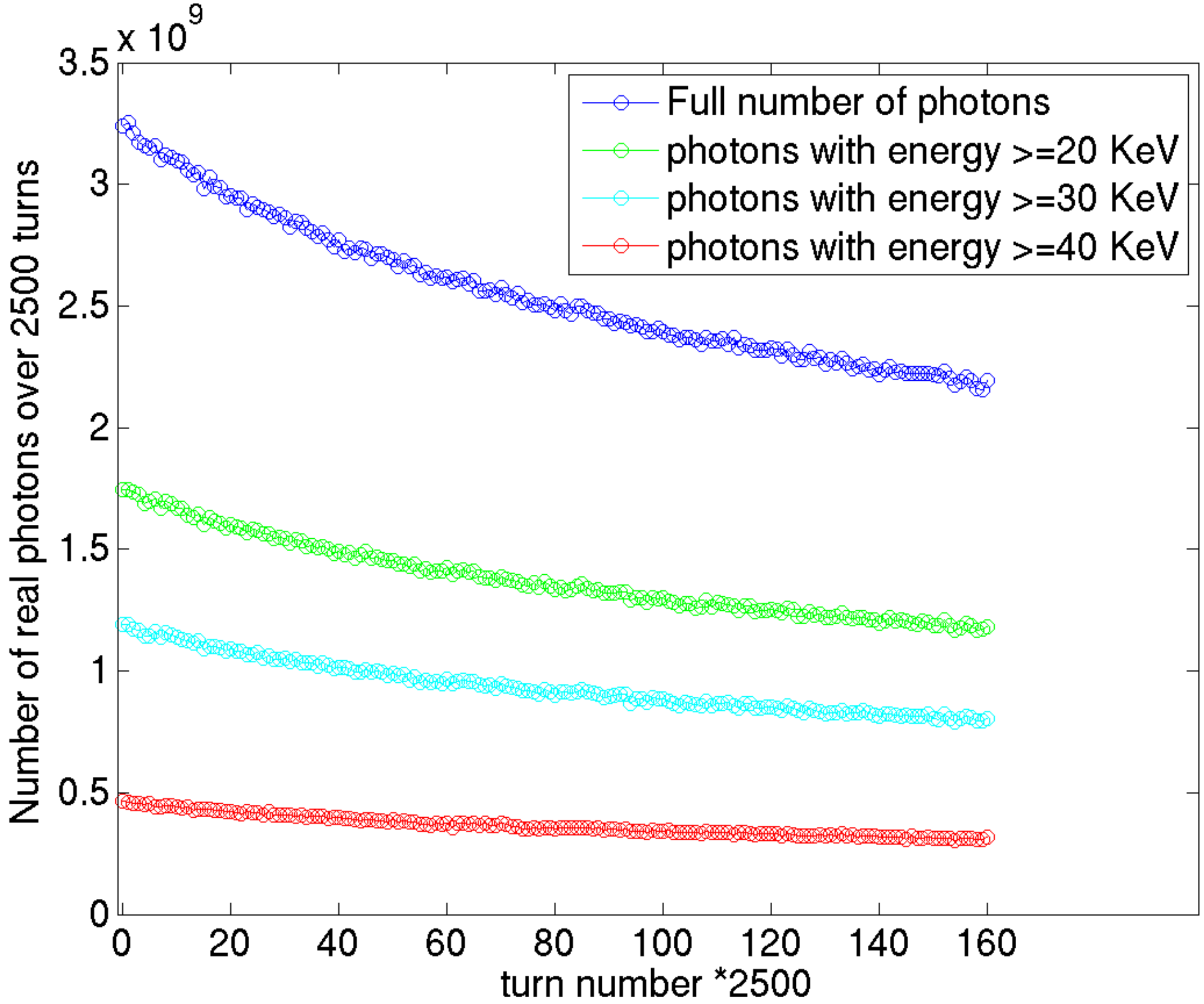




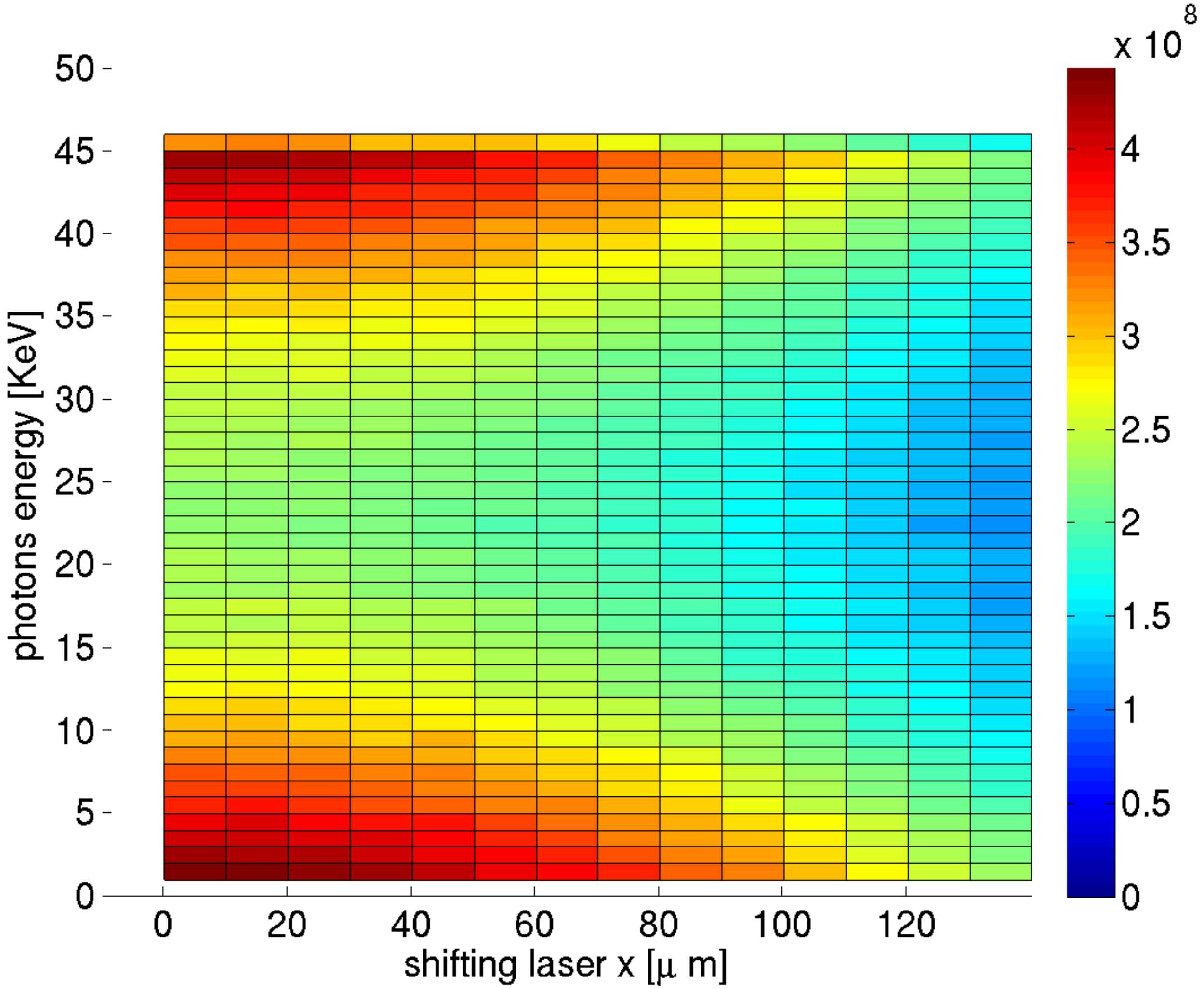
•Storage time 20 msec

• Acknowledgments to Illya drebot

Result of simulations



Result of simulations

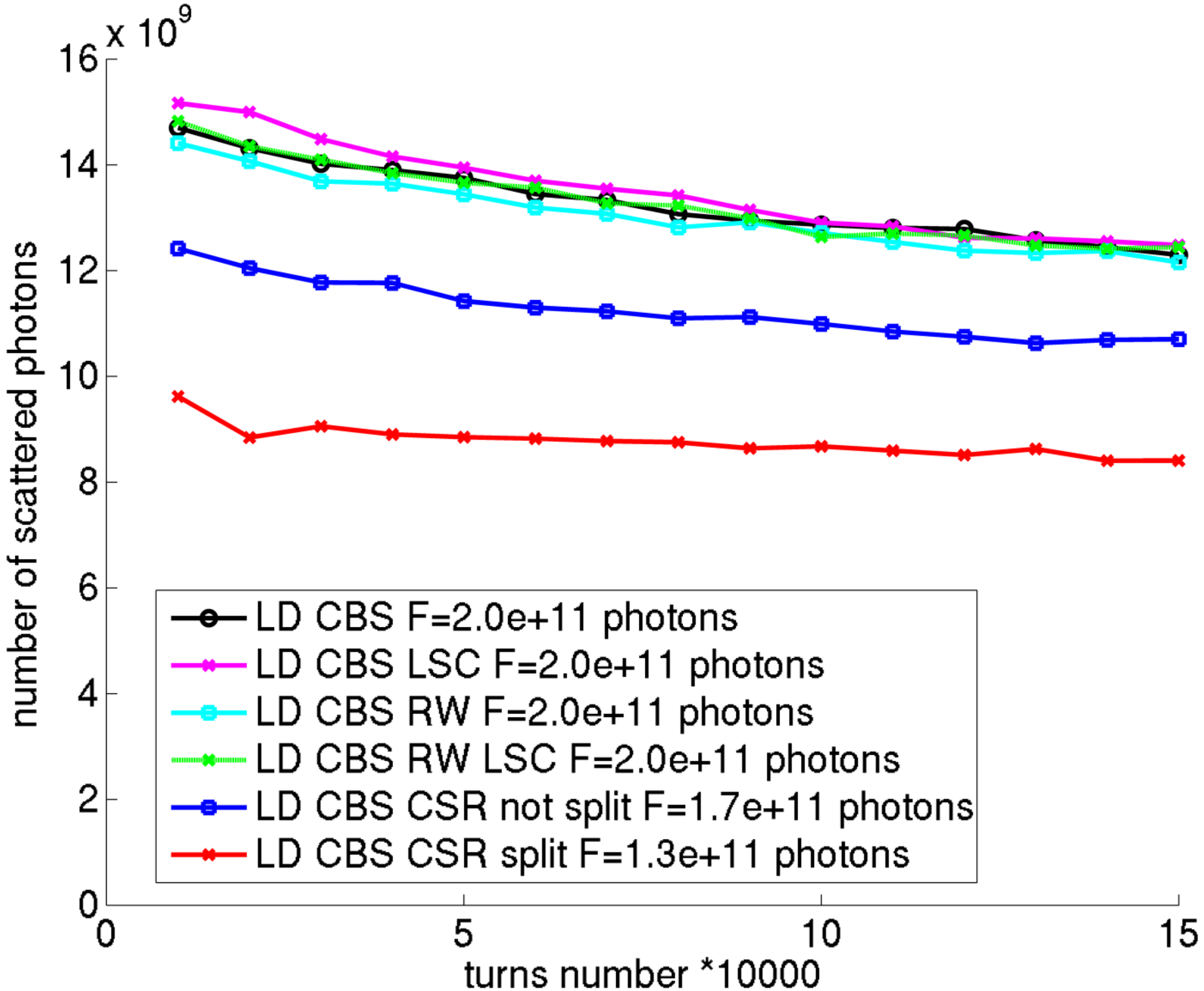


• Acknowledgments to Illya drebot

Result of simulations

Compton backscattering flux for different beam dynamics effects.

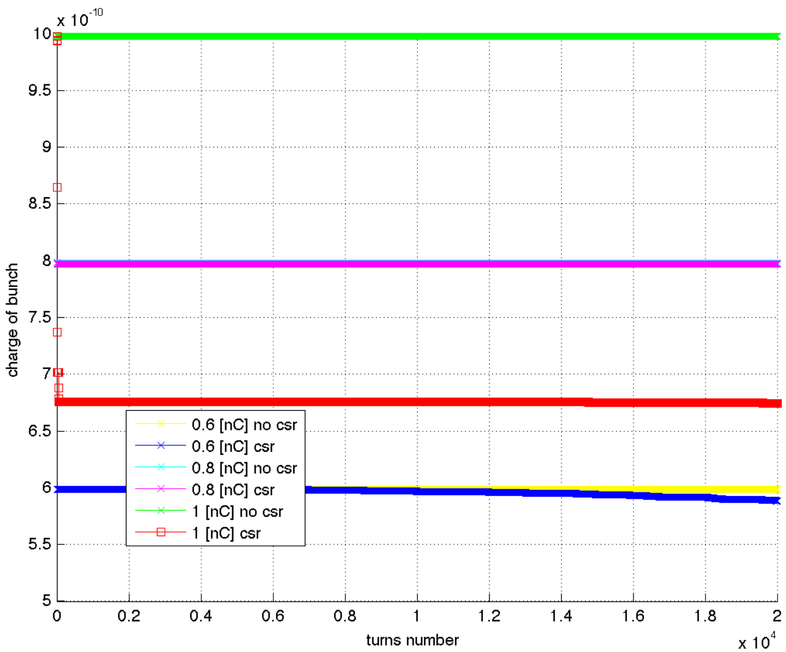
In the case of the CSR simulations, if the beam did not split 97% of the particle survived (blue) and 50% survived in the case the beam did split (red).
F is the total flux integrated over 150000 turns.

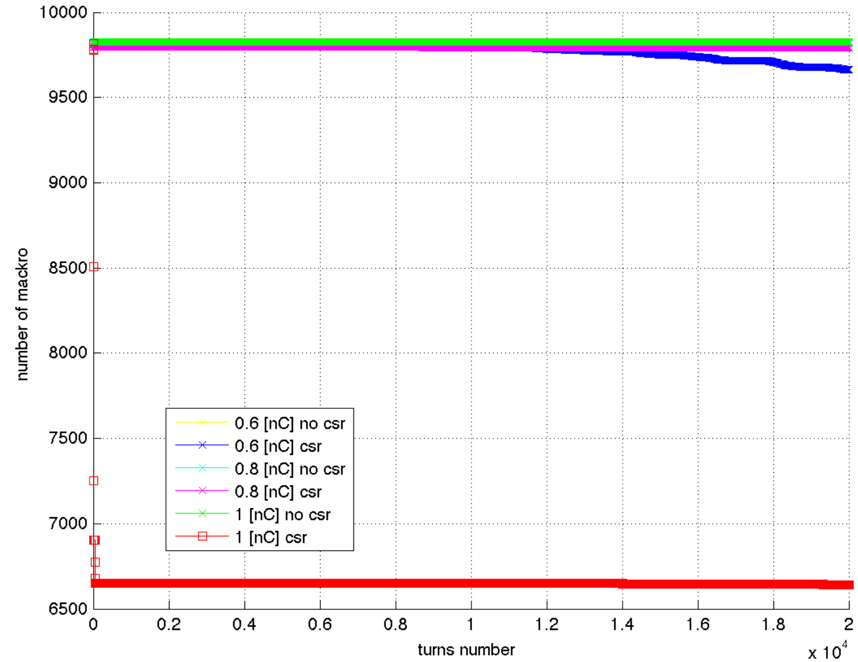


• Acknowledgments to Illya drebot

Result of simulations with CSR

We notice quite big instabilities during simulation with CSR.





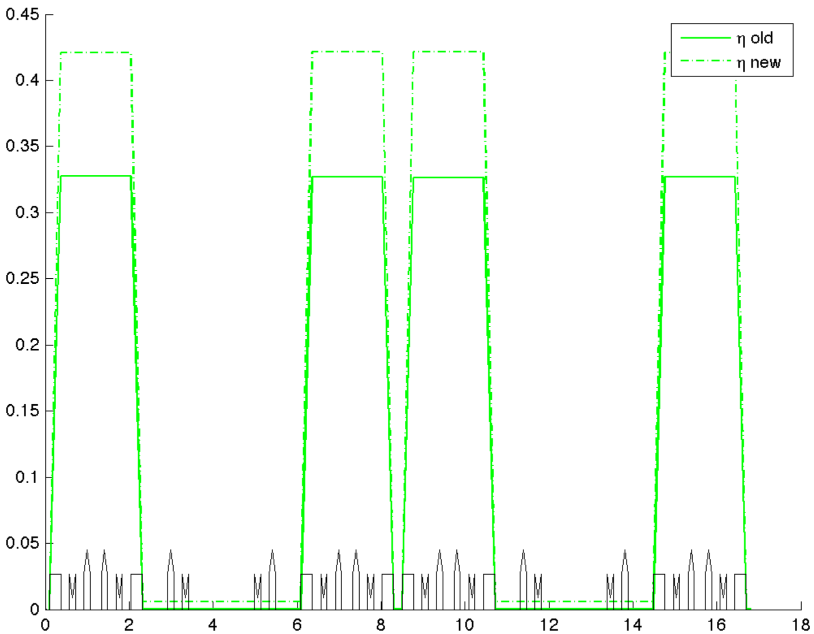
Dependence of bunch charge and number of macro particles from the initial charge of the bunch.

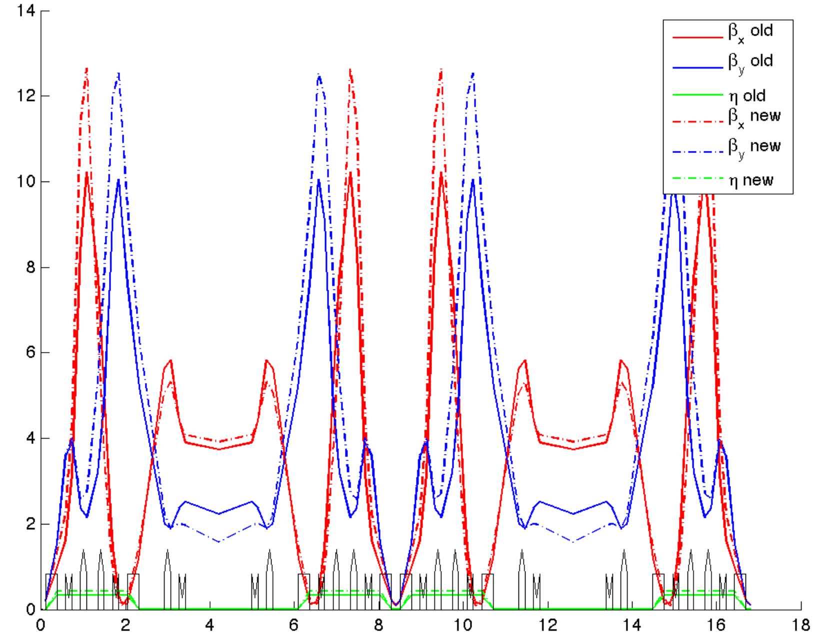
As we can see 0.8 nC is the limit charge for effect of CSR in ThomX

• Acknowledgments to Illya drebot

Result of simulations with CSR

To reduce effect of CSR and prevent splitting we need to change the dispersion in such way that, during propagation of the bunch in the ring, the dispersion not change as a step function but from some small but finite value. This dispersion now has the profile presented on plot.

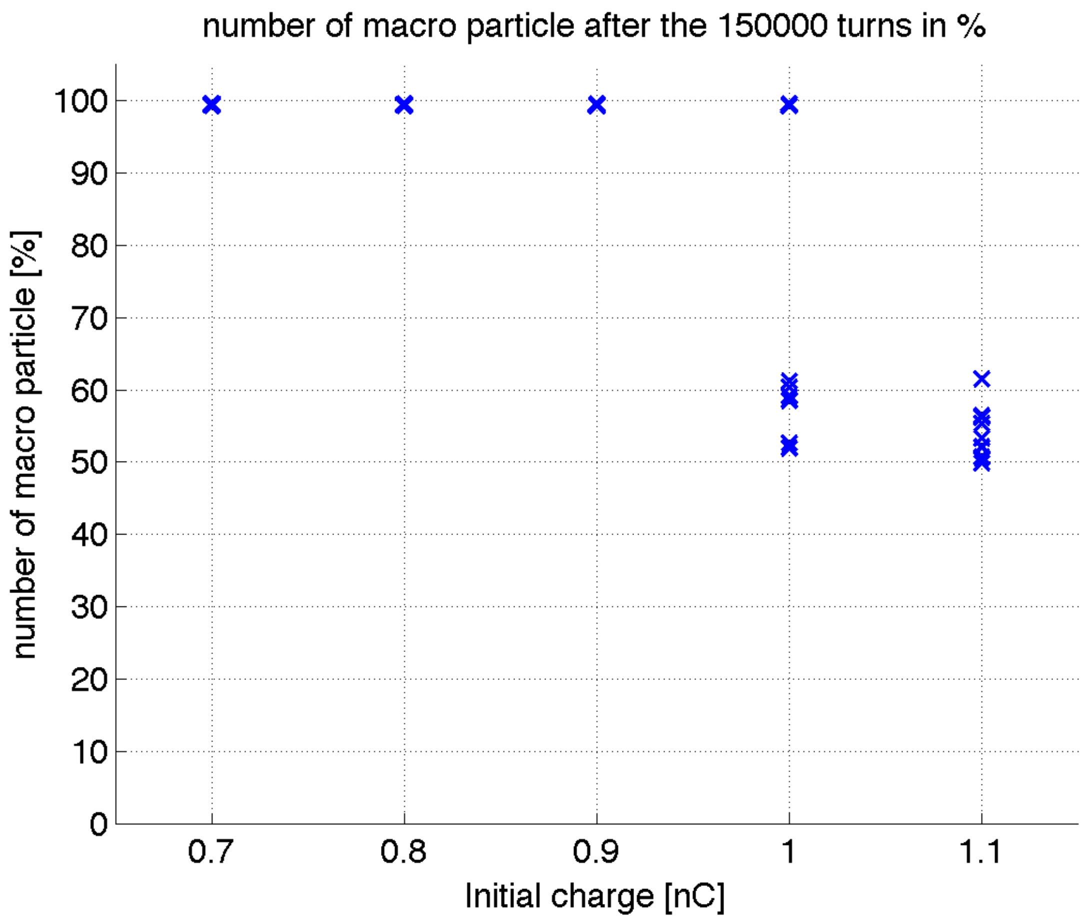




• Acknowledgments to Illya drebot, A. Loulergues

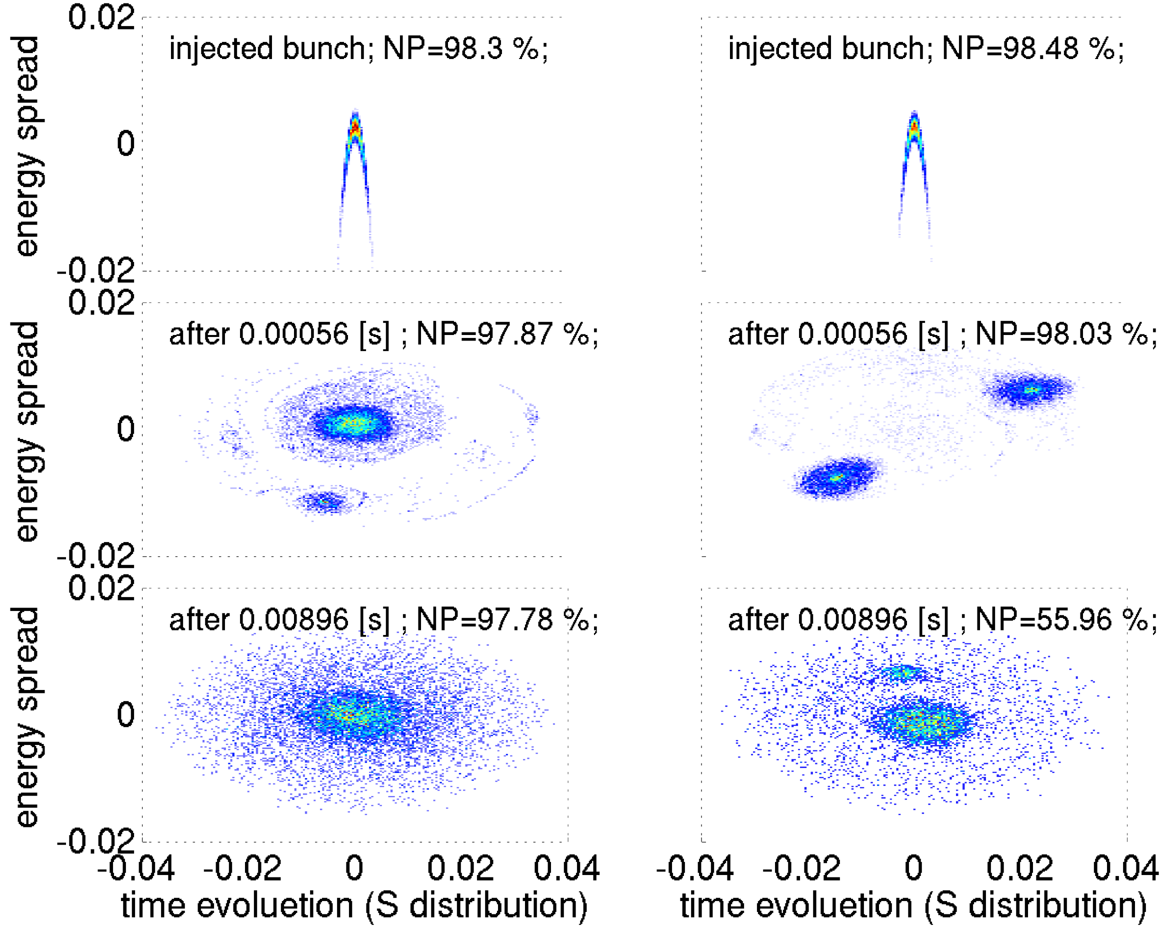
Result of simulations with CSR

Changing dispersion give the possibility to move the limit charge of the injected bunch from 0.8 nC to 1 nC.



• Acknowledgments to Illya drebot

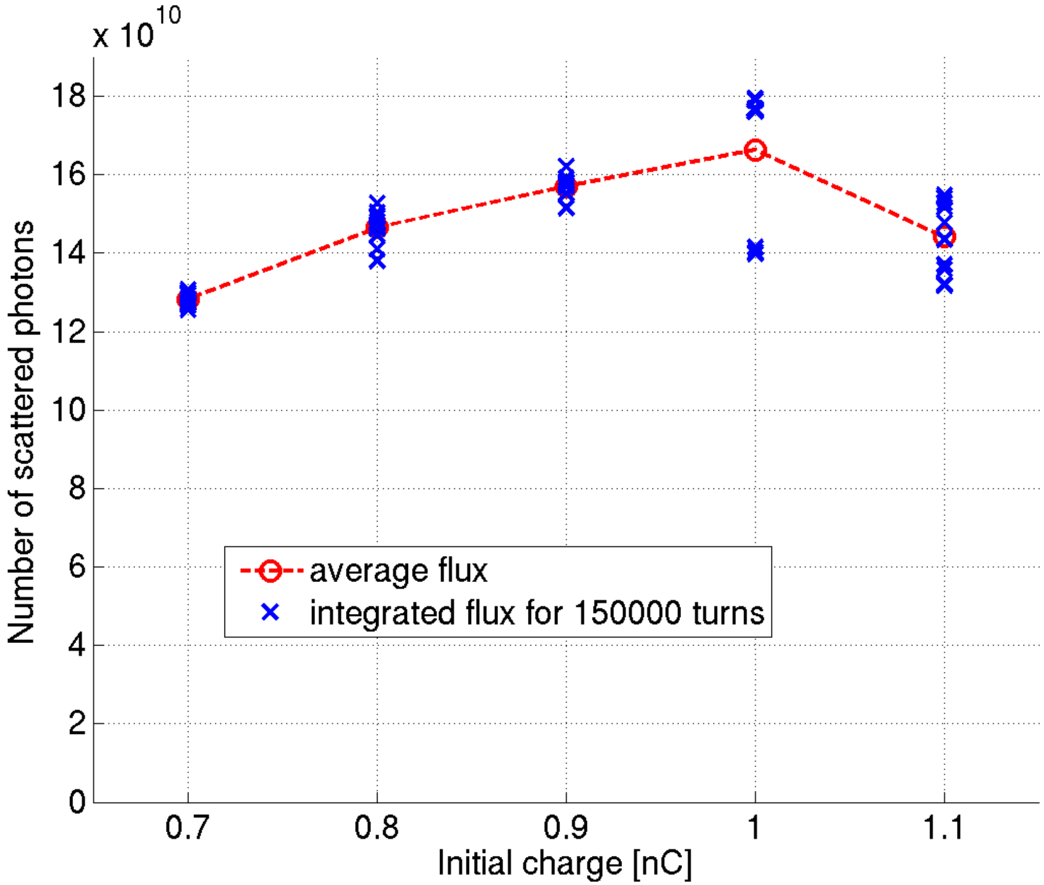
Evolutions of longitudinal phasespace. Left is for CSR without splitting and losses. Right is for CSR with split bunch leading to severe losses.



• Acknowledgments to Illya drebot

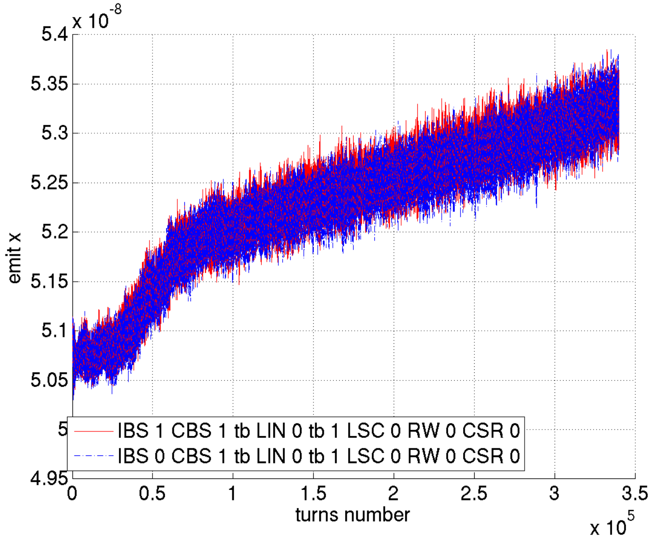
Result of simulations with CSR

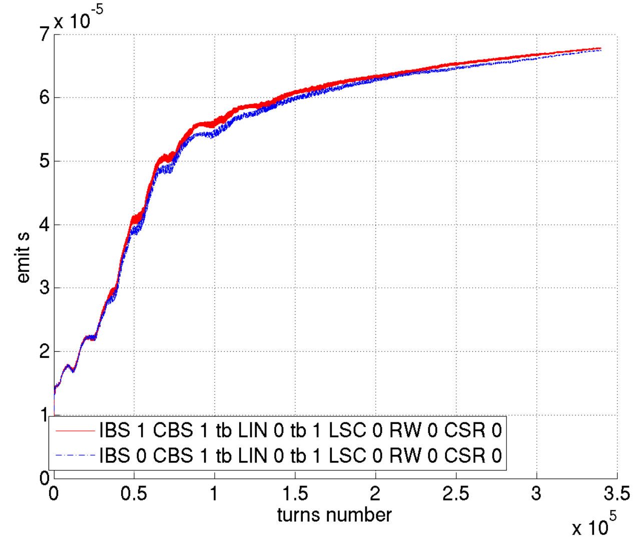
The number of Compton scattered photons for different initial charge of the injected bunch.

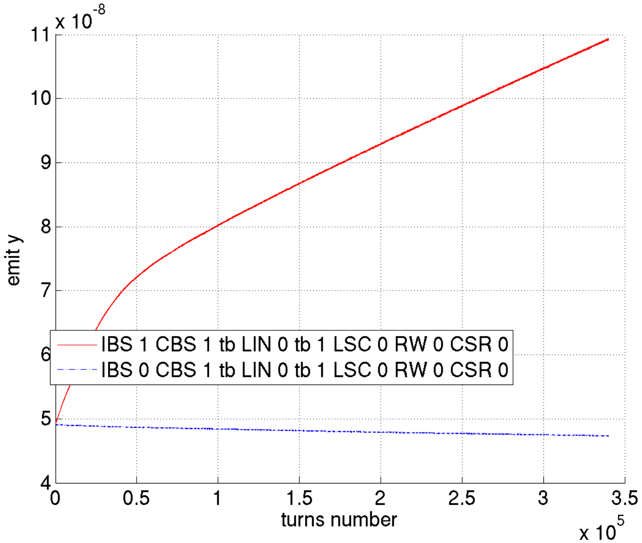


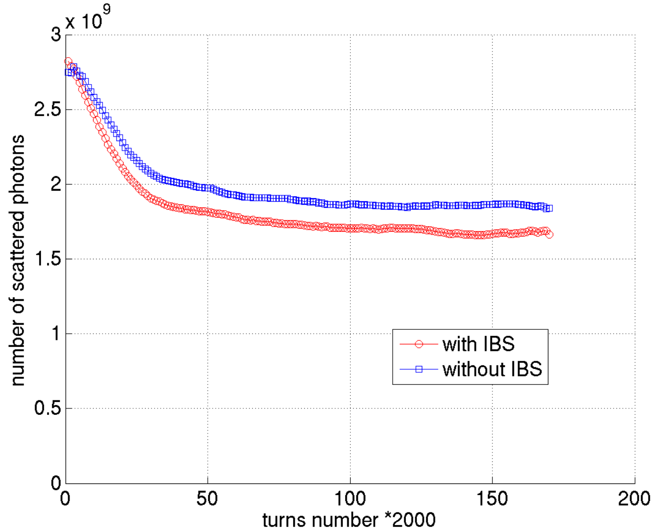
• Acknowledgments to Illya drebot

Influence of IBS on the flux of scattered photons





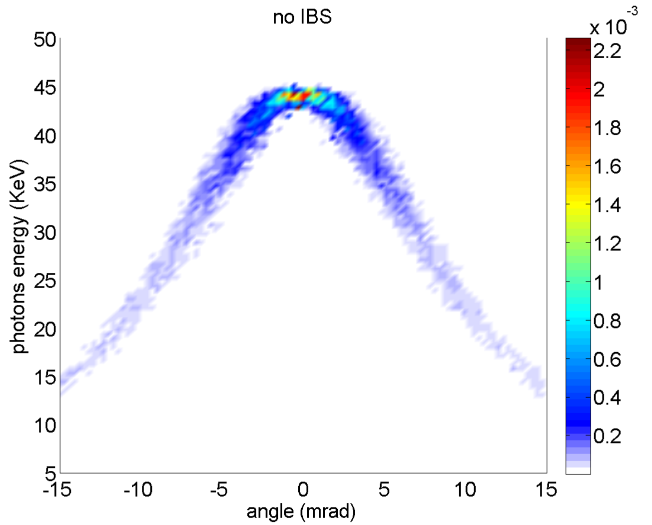


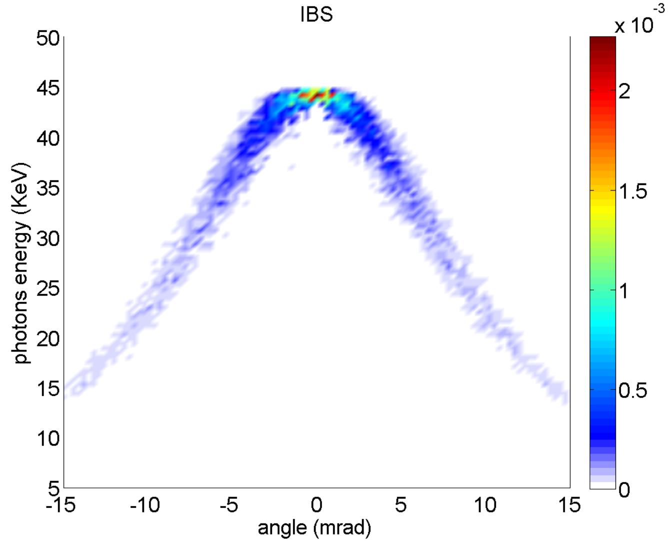


• Acknowledgments to Illya drebot

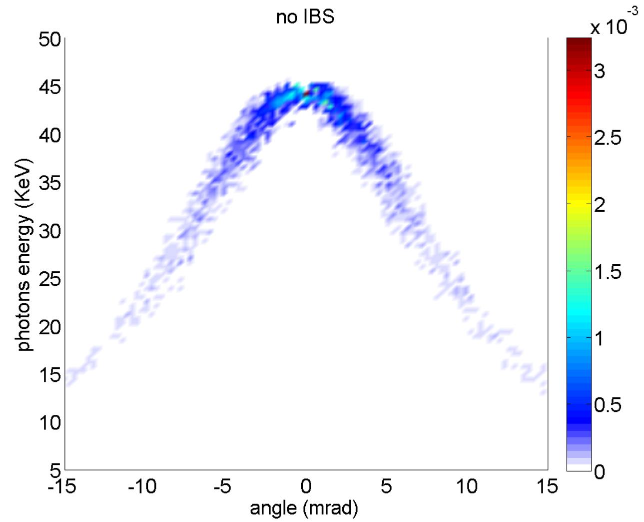
Influence of IBS on the spectrum of scattered photons

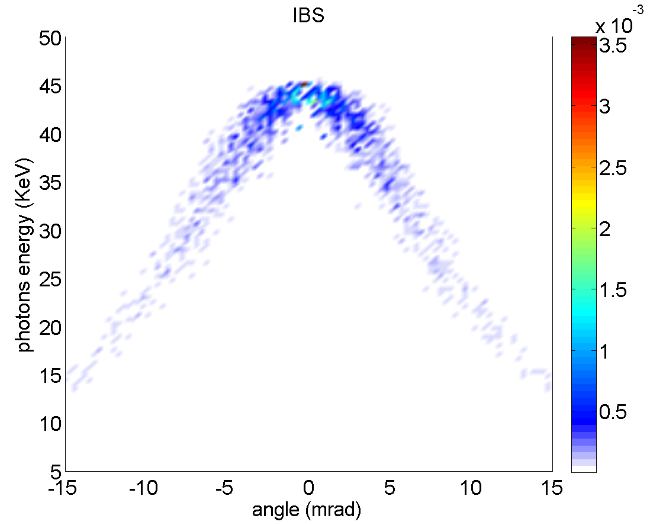
For first 10000 turns





For 10000 turns after 330000 turns

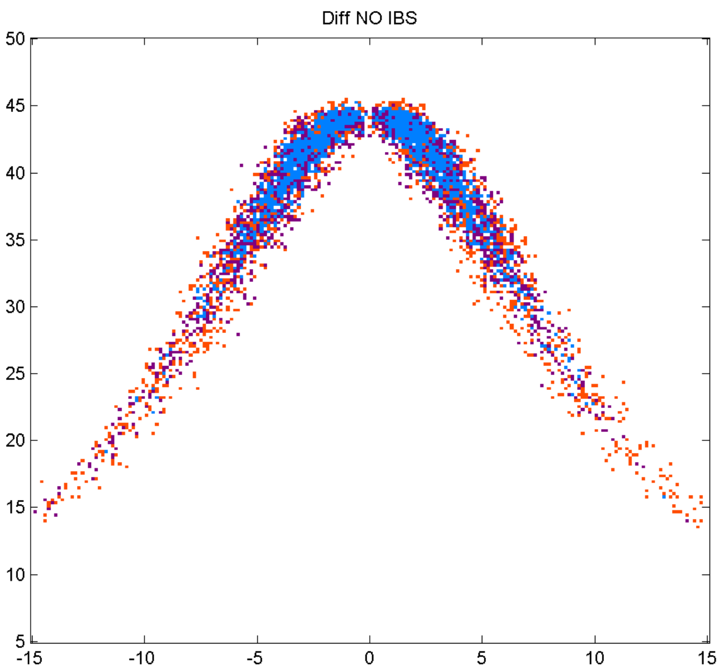


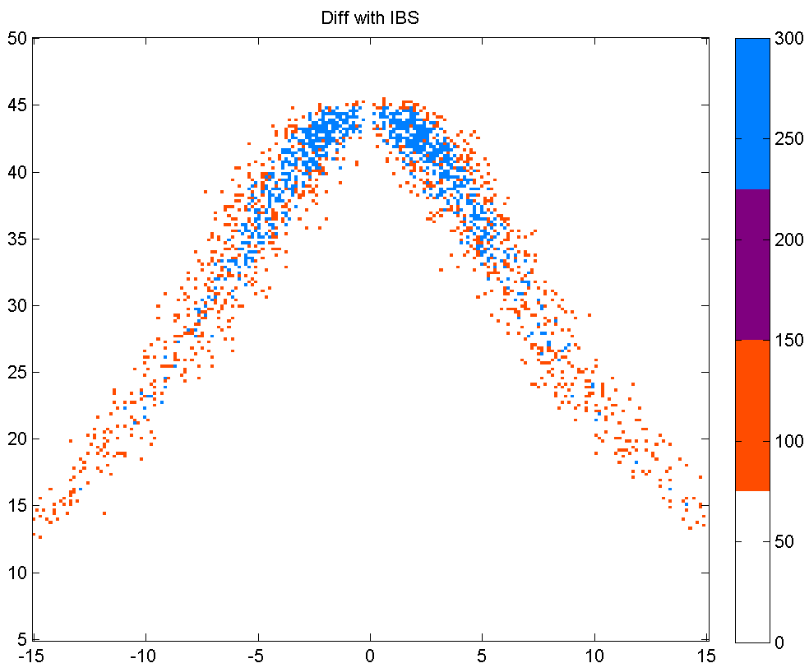


- Acknowledgments to Illya drebot

Influence of IBS on the spectrum of scattered photons

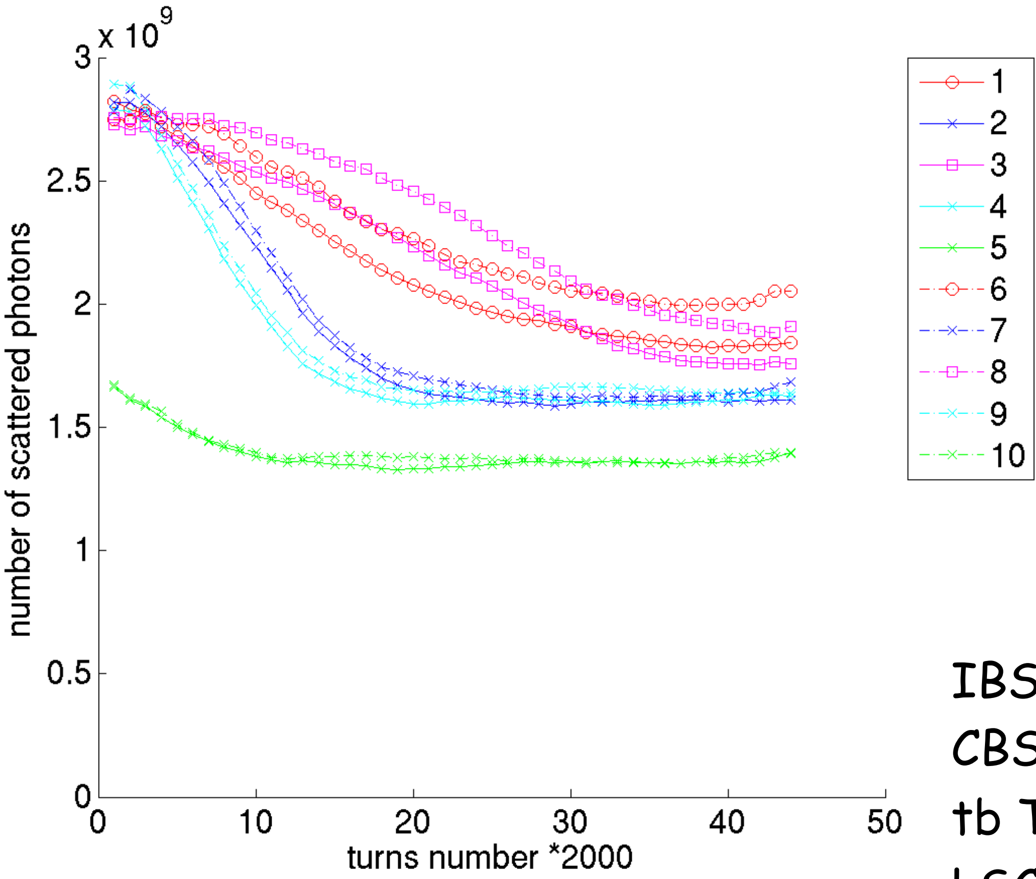
Diffenence between energy distribution on scattered angle between integrated flux for first 10000 turns and for 10000 turns after 330000 turns





• Acknowledgments to Illya drebot

Influence of different effect on the number of scattered photons



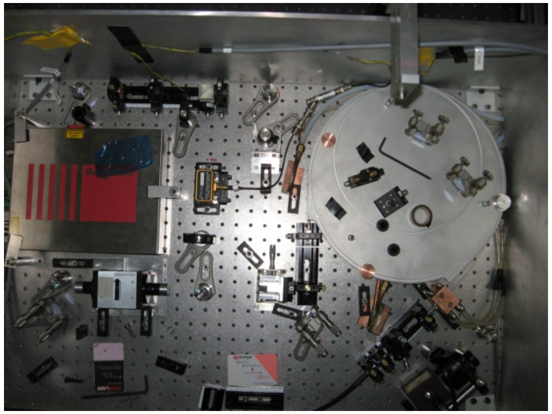
- 1 IBS 1 CBS 1 tb 1 LSC 0 RW 0 CSR 0
- 2 IBS 1 CBS 1 tb 1 LSC 1 RW 0 CSR 0
- 3 IBS 1 CBS 1 tb 1 LSC 0 RW 1 CSR 0
- 4 IBS 1 CBS 1 tb 1 LSC 1 RW 1 CSR 0
- 5 IBS 1 CBS 1 tb 1 LSC 1 RW 1 CSR 1
- 6 IBS 0 CBS 1 tb 1 LSC 0 RW 0 CSR 0
- 7 IBS 0 CBS 1 tb 1 LSC 1 RW 0 CSR 0
- 8 IBS 0 CBS 1 tb 1 LSC 0 RW 1 CSR 0
- 9 IBS 0 CBS 1 tb 1 LSC 1 RW 1 CSR 0
- 10 IBS 0 CBS 1 tb 1 LSC 1 RW 1 CSR 1

IBS Intrabeam scattering
CBS Compton Back Scattering
tb Tracking Bunch
LSC Longitudinal Space Charge
RW Resistive Wall
CSR Coherent Synchrotron Radiation

- Acknowledgments to Illya drebot

Laser

•The MightyLaser experience



•CPA for Mighty Laser

•Oscillator
•178 MHz

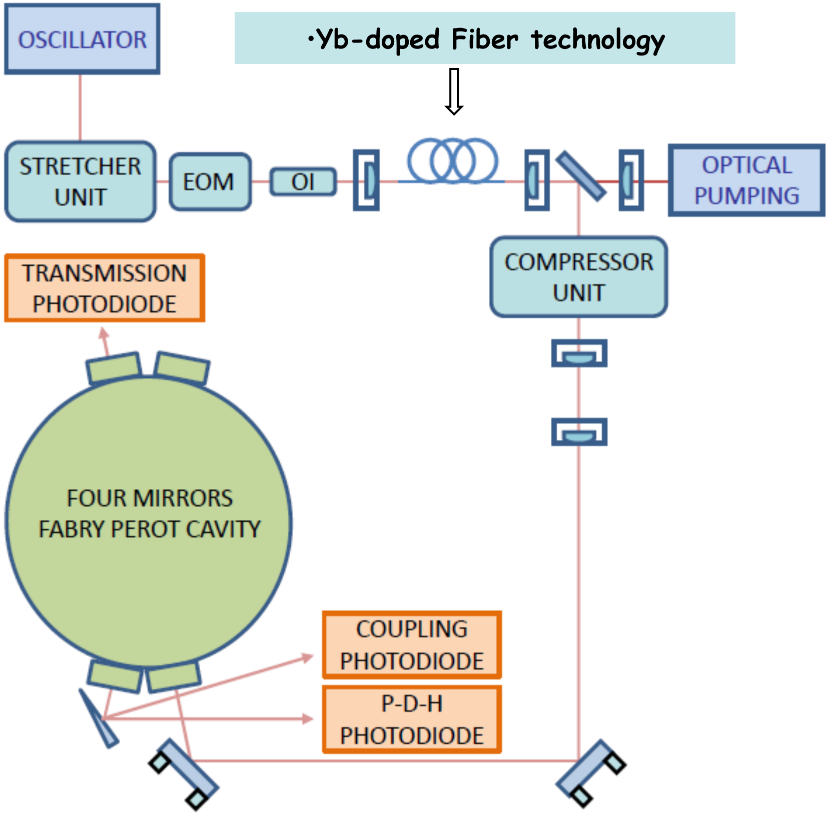
•Stretcher
•unit

•Fiber amplifier
50 W

•Compressor
•unit

•FP Cavity

- •E = 281 nJ
- •T = 100 ps
- •P_{peak} = 2,8 kW
- •I = 42 kW/cm^2
- •B = 0,24 rad



•**Compatible with low noise amplification**

• Acknowledgments to E.Cormier, V.Soskov, F.Labaye

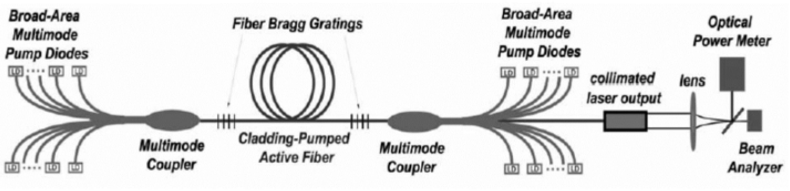
Laser

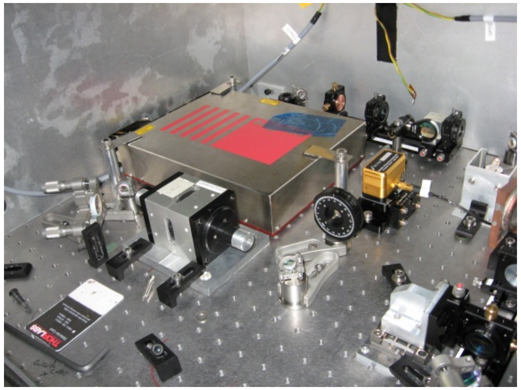
•Towards ThomX, (178 => 35 MHz)

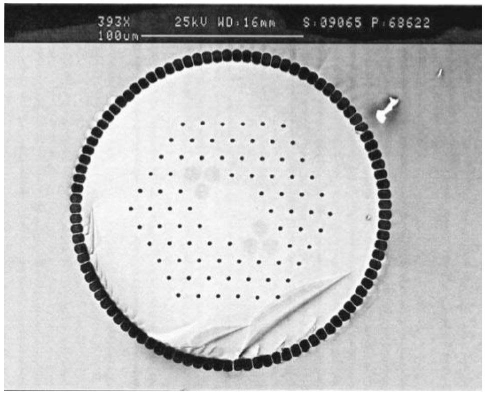
•<u>New developments:</u>

- Integration (all-fibered)
  - ○ Mode adaptors (tapers)
  - ○ Fiber connectorization
  - ○ Specialty fiber splicing
  - ○ Integrated optics
  - • (EOM, CVBG, Isolators, …)
  - ○ High power beam combiners
  - ○ Fiber end facet preparation
  - • (sealing, polishing, endcap, ….)
  - ○ Tests (heat management, losses,
  - • mode quality, reflections, …
  - •

•Architecture (fiber or hybrid)
  - ○ Design of new large core fibers
  - ○ Design of integrated
  - • stretcher-compressor units
  - ○ Evaluation of hybrid architectures
  - • Fiber + Bulk



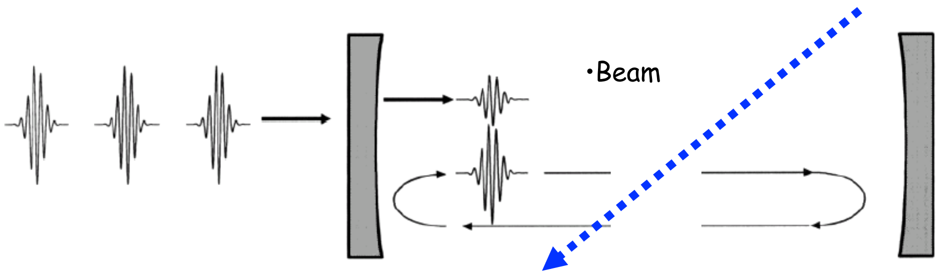




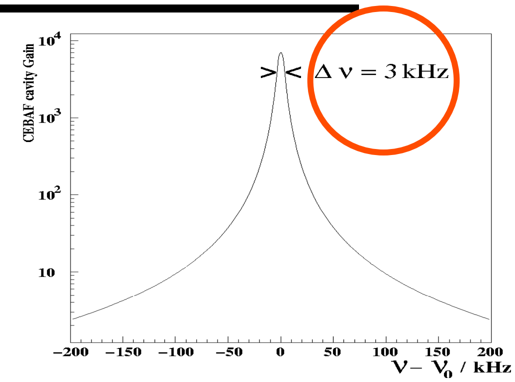
• Acknowledgments to E.Cormier, V.Soskov

Fabry-Perot cavity

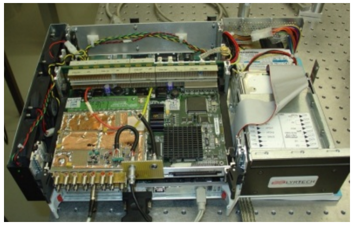
MightyLaser and PLIC experience

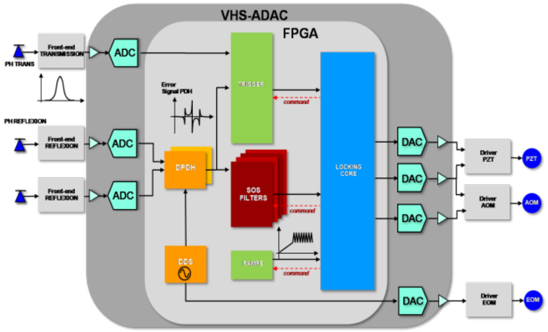


•Gain=1/(1-R)~10000

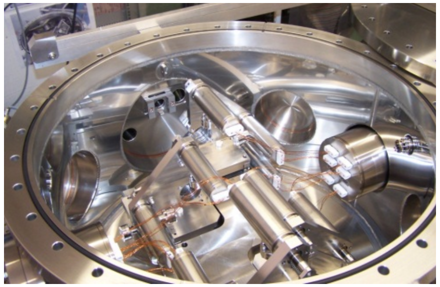


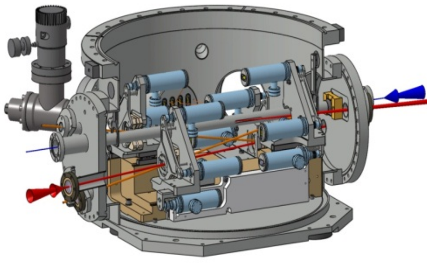
•Digital Pound-Drever-Hall feedback





•Vacuum and mechanics : MightyLaser experience



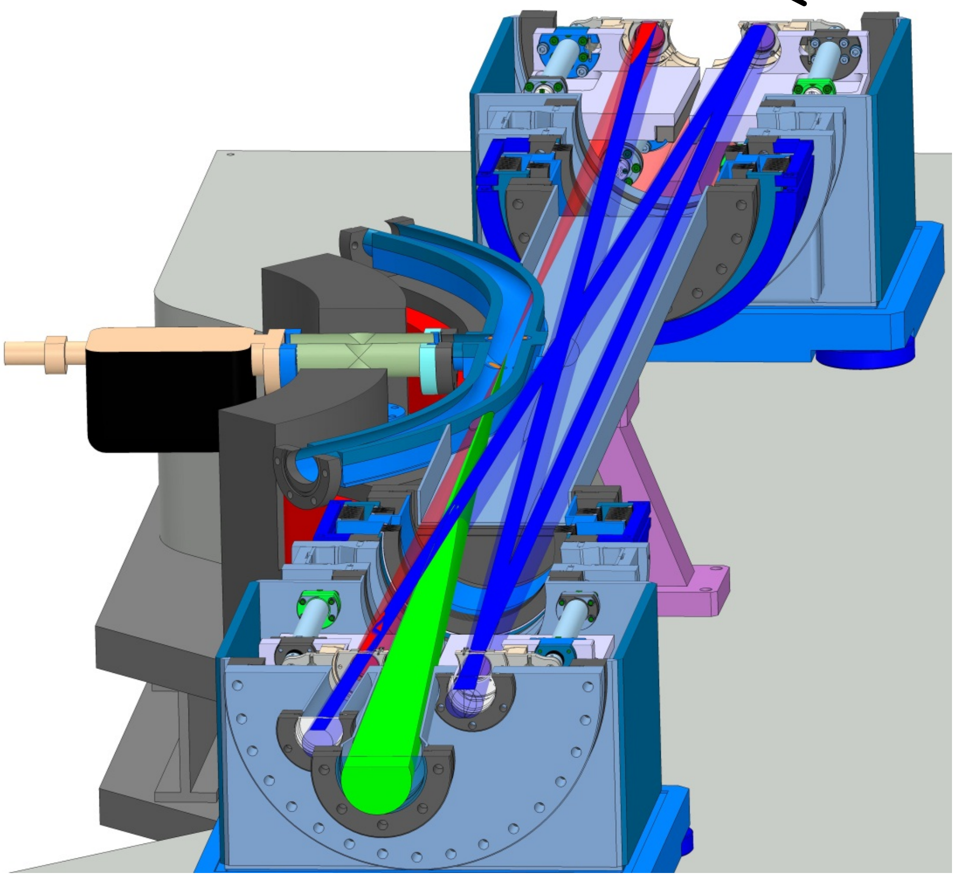


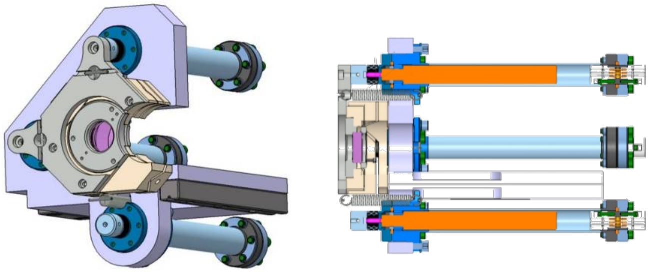
•PLIC and MightyLaser : record in stable finesse locking (30000).

• Acknowledgments to F.Zomer, R.Chiche, D.Jheanno, M.Lacroix, R.Cizeron

Fabry-Perot cavity

•Towards ThomX



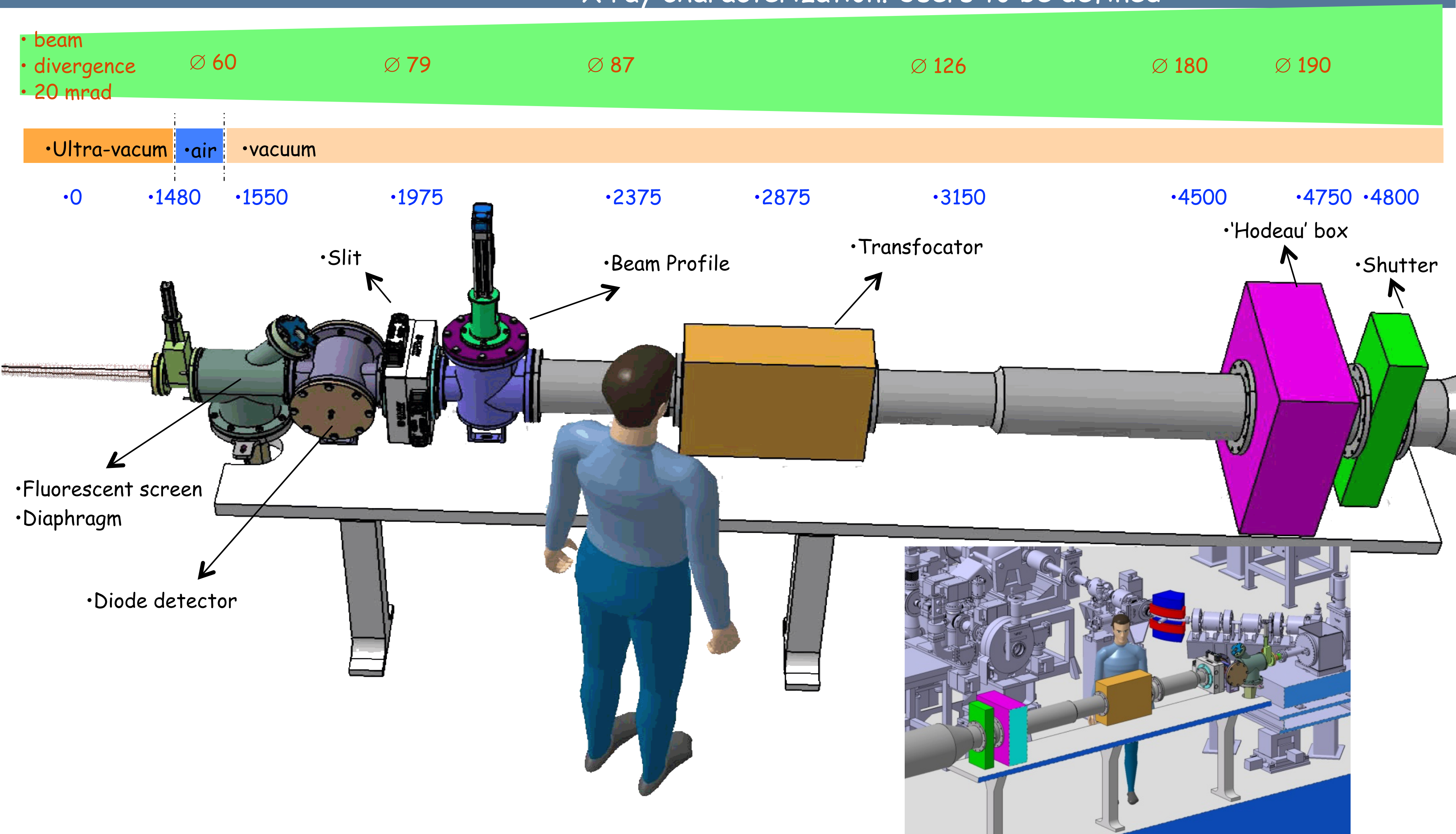


- Too long => Two monoblocks
- Dipoles Integration
- Dedicated BPM
- Bakable
- Easy to access, mounting
- 2 degrees collisions
- Laser insertion
- MightyLaser stabilization, adjustment

• Acknowledgments to M.Lacroix, Y.Peinnaud

X ray line

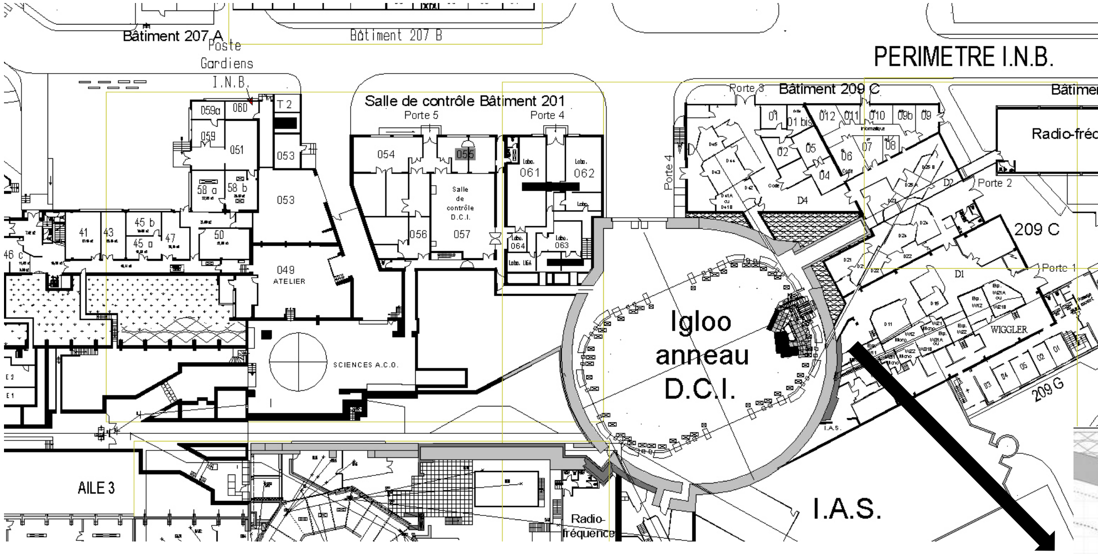
- X ray characterization. Users to be defined



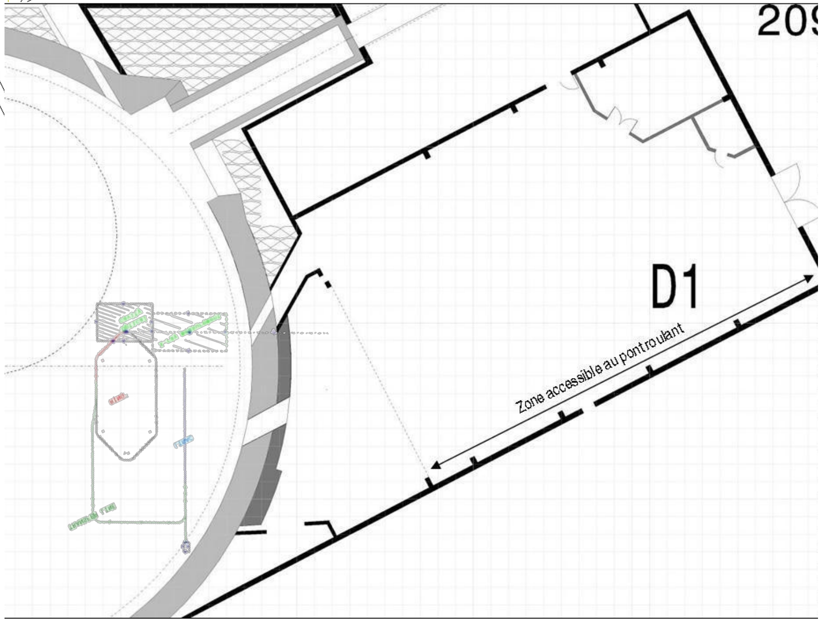
• Acknowledgments to M.Jacquet, J.L Hodeau, J.L Hazemann, P.Jeantet

Integration and Site

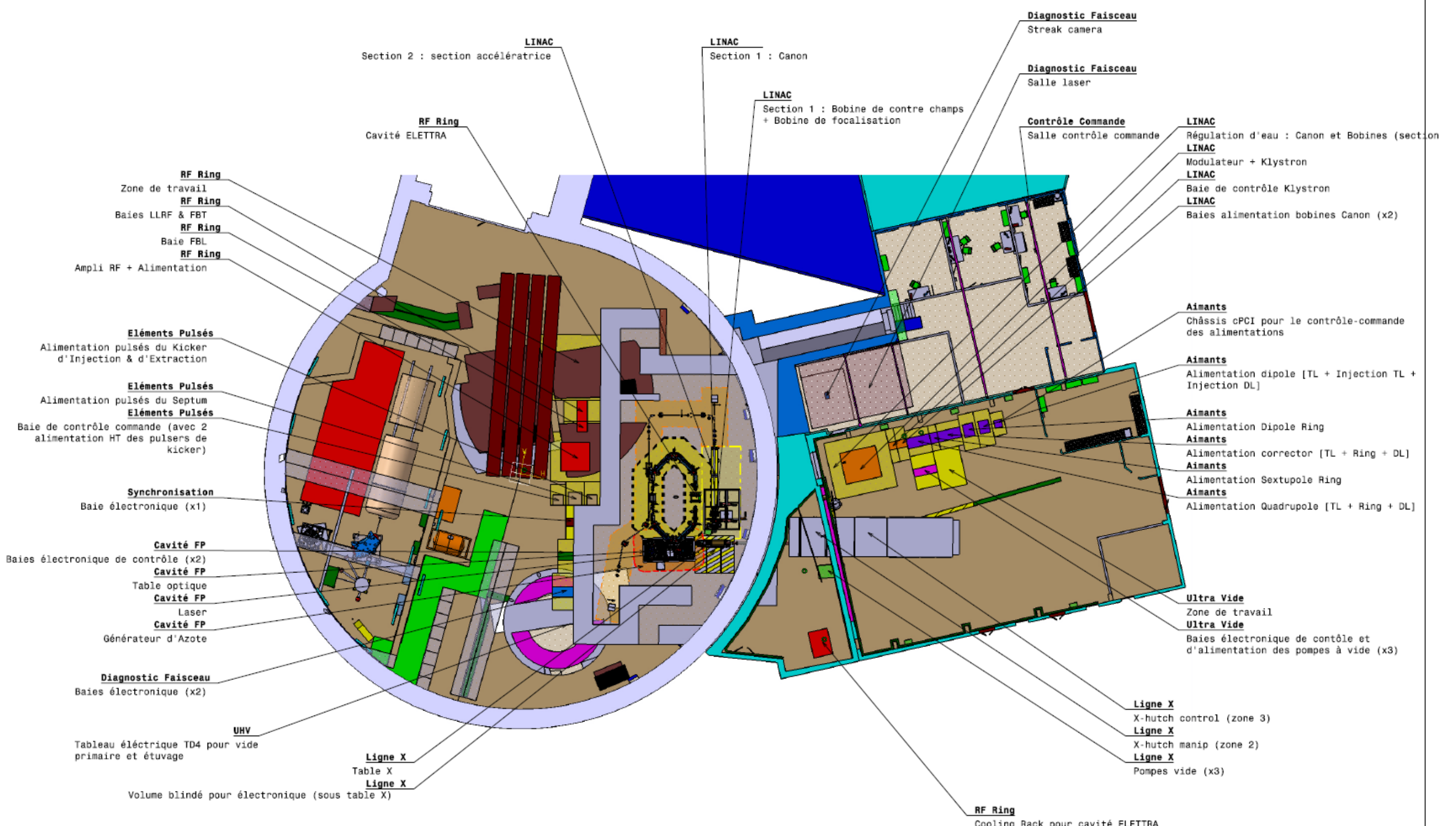
Paris-Sud University Campus



- OLD Orsay IGLOO



- Acknowledgments to A.Pichot, M .Tran



LINAC	JP. POLINA	
UHV	C. PREVOST	E. MISTRETTA
Ligne X	M. JACQUET	P. JEANTET
Synchronisation	N. DELERUE	
Ctrl Cmd	P. GAURON	
Diag. faisceau	L. CASSINARI	
Eléments pulsés	P. LEBASQUE	
Aimants	F. BOUVET	
RF Ring	P. MARCHAND	
Cavité FP	F. ZOMER	P. CORNEBISE
SS ensemble	Responsable	Corespondant tech.

Ind | Date | Modification | By

ID Smarteam : DRW0000 | Part/Product ID Smarteam : PRT0000

IGLEX
Implantation vC_3.12
Désignations générales

Gen. Tol.:
Material: ....
Mass:
Treatment: ....
Drawn by Damien LE GUIDEC 15/04/13
Checked by ... ../../10
Approved by ... ../../10

LABORATOIRE DE L'ACCELERATEUR LINEAIRE
Bat. 200, BP 34, 91898 ORSAY CEDEX FRANCE
Tel. 01 64 46 83 63 - Fax 01 64 46 83 47

Scale
I74 2E IP001
Index A

Expected beams characteristics

•Injector, ring, laser, Fabry-Perot resonator and the source

Injector	
Charge	1 nC
Laser wavelength and pulse power	266 nm, 100 μJ
Gun Q and Rs	14400, 49 MW/m
Gun accelerating gradient	100 MV/m @ 9.4 MW
Normalized r.m.s emittance	8 π mm mrad
Energy spread	0.36%
Bunch length	3.7 ps

Laser and FP cavity	
Laser wavelength	1030 nm
Laser and FP cavity Frep	36 MHz
Laser Power	50 – 100 W
FP cavity finesse / gain	30000 / 10000
FP waist	70 μm

Ring	
Energy	50 MeV (70 MeV possible)
Circumference	16.8 m
Crossing-Angle (full)	2 degrees
$B_{x,y}$ @ IP	0.2 m
Emittance x,y (without IBS and Compton)	3 10^{-8} m
Bunch length (@ 20 ms)	30 ps
Beam current	17.84 mA
RF frequency	500 MHz
Transverse / longitudinal damping time	1 s /0.5 s
RF Voltage	300 kV
Revolution frequency	17.8 MHz
σ_x @ IP (injection)	78 mm
Tune x / y	3.4 / 1.74
Momentum compaction factor α_c	0.013
Final Energy spread	0.6 %

Source	
Photon energy cut off	46 keV (@50 MeV), 90 keV (@ 70 MeV)
Total Flux	10^{11}-10^{13} ph/sec
Bandwidth (with diaphragm)	1 % - 10%
Divergence	$1/\gamma$ ~ 10 mrad without diaphragm @ 50 MeV

Conclusions

- Different kinds of expertise in French Labs => Compton X Rays source
- Collaboration established, TDR published
- Funded!!! Equipex (French minister), Ile-de-France Region, CNRS-IN2P3, Université Paris Sud XI
- Very nice accelerator and laser physics
- Beam dynamics and technology R&D
- Industrial collaboration and user access expected
- Education!!!
- Construction starts soon… Major equipments have been ordered.