INTERNATIONAL WORKSHOP ON FUTURE LINEAR COLLIDERS
LCWS11
GRANADA _ SPAIN
26-30 SEPTEMBER 2011

Positrons sources & related activities for ILC/CLIC at LAL Orsay laboratory

Olivier Dadoun, dadoun@lal.in2p3.fr

Outline

I. Chaikovska, R. Chiche, N. Delerue, D. Jehanno, F. Labaye, V. Soskov & F. Zomer
R. Chehab, P. Lepercq, F. Poirier (until begin 2011), A. Variola & C. Xu

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

Introduction

High intensity e^+ requires at ILC / CLIC

- Radiator : intense source of photons is needed
  - Polarized : undulator & laser-Compton
  - Unpolarized : amorphous & crystal
- Converter : material with a high Z (W)
- Capture section after the converter
  - Optical Matching Device to focus the e^+
  - Pre-injector to accelerate the beam before injection to DR

Introduction

High intensity e^+ requires at ILC / CLIC

- Radiator : intense source of photons is needed
  - Polarized : undulator & laser-Compton → CLIC baseline & ILC option
  - Unpolarized : amorphous & crystal
- Converter : material with a high Z (W)
- Capture section after the converter
  - Optical Matching Device to focus the e^+
  - Pre-injector to accelerate the beam before injection to DR

Introduction

High intensity e^+ requires at ILC / CLIC

- Radiator : intense source of photons is needed
  - Polarized : undulator & laser-Compton → CLIC baseline & ILC option
  - Unpolarized : amorphous & crystal → CLIC baseline & ILC under investigation
- Converter : material with a high Z (W)
- Capture section after the converter
  - Optical Matching Device to focus the e^+
  - Pre-injector to accelerate the beam before injection to DR

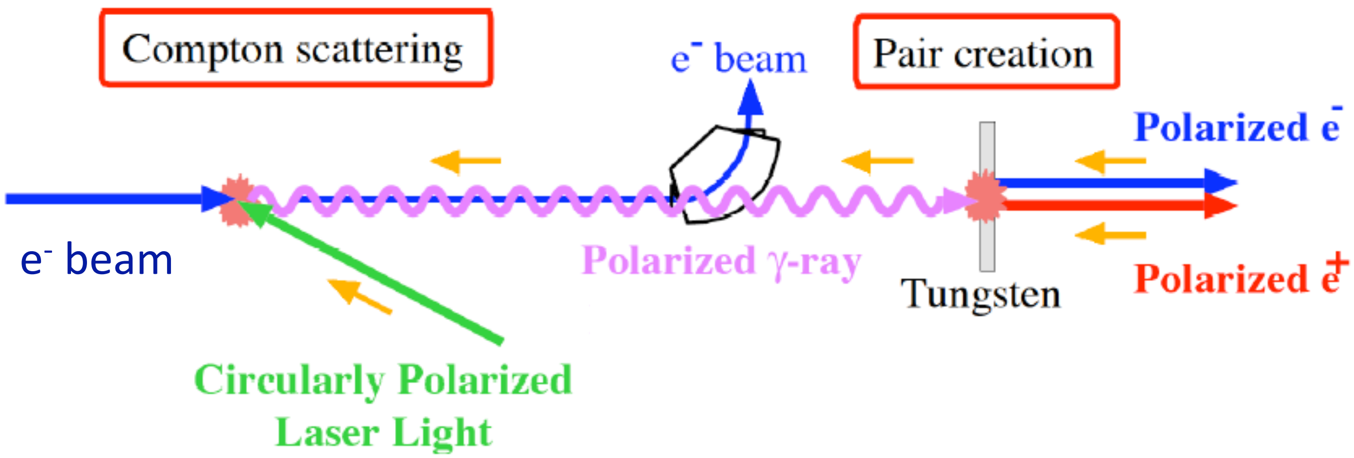
Introduction

High intensity e^+ requires at ILC / CLIC

- Radiator : intense source of photons is needed
  - Polarized : undulator & laser-Compton → CLIC baseline & ILC option
  - Unpolarized : amorphous & crystal → CLIC baseline & ILC under investigation
- Converter : material with a high Z (W)
- Capture section after the converter
  - Optical Matching Device to focus the e^+
  - Pre-injector to accelerate the beam before injection to DR

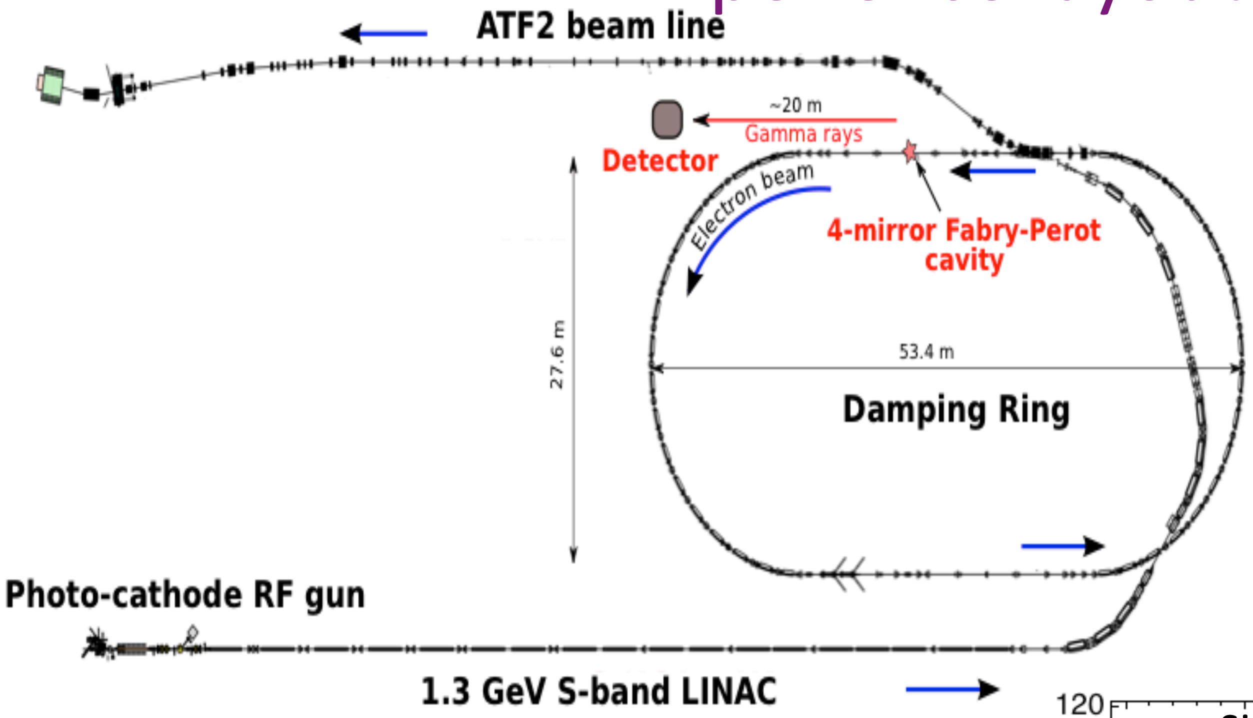
→ ILC & CLIC

e^+ production principle based on Compton scheme



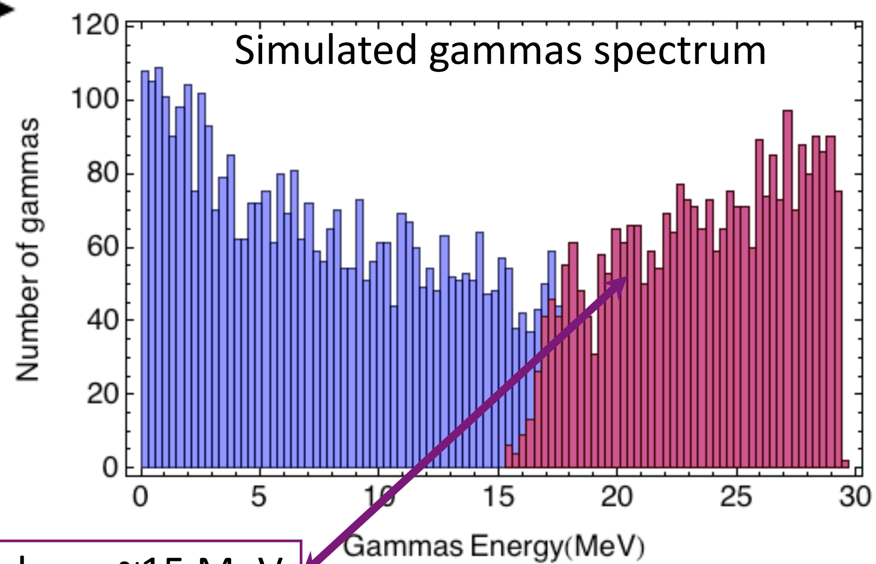
Experience layout

I. Chaikovska



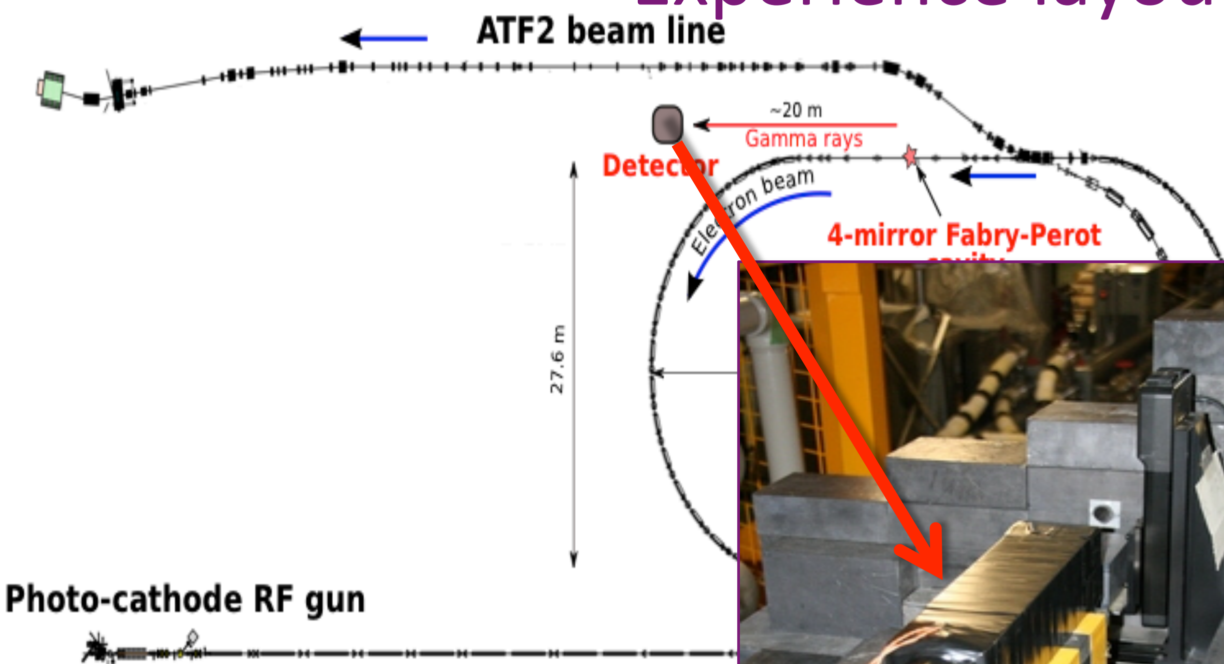
Electron energy	1.28 GeV
Electron charge	~1.6 nC
Revolution period	463 ns
Electron bunch length	25 ps
Bunch spacing	5.6 ns

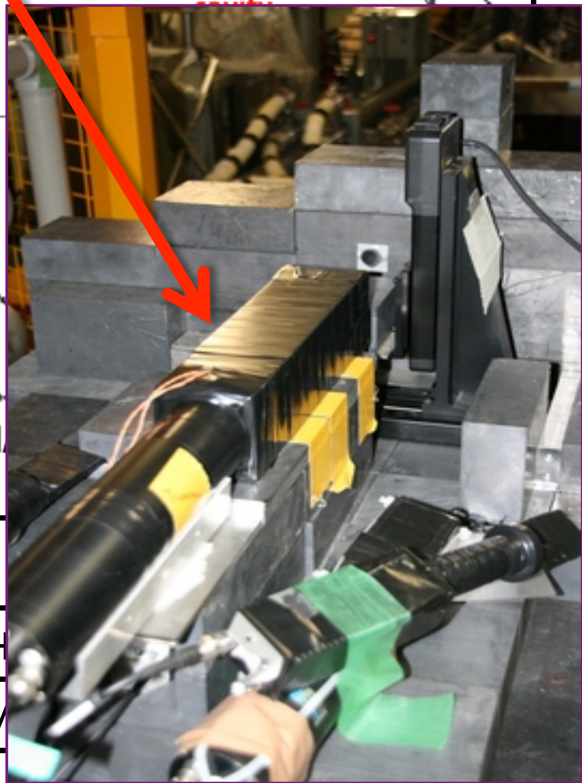
LASER photon energy	1.2 eV
LASER frequency	178.5 MHz
Power stored in cavity	~ 200 W
Crossing angle	8 deg.
LASER pulse length	20 ps



The collimators only accept photons with an energy above ~15 MeV

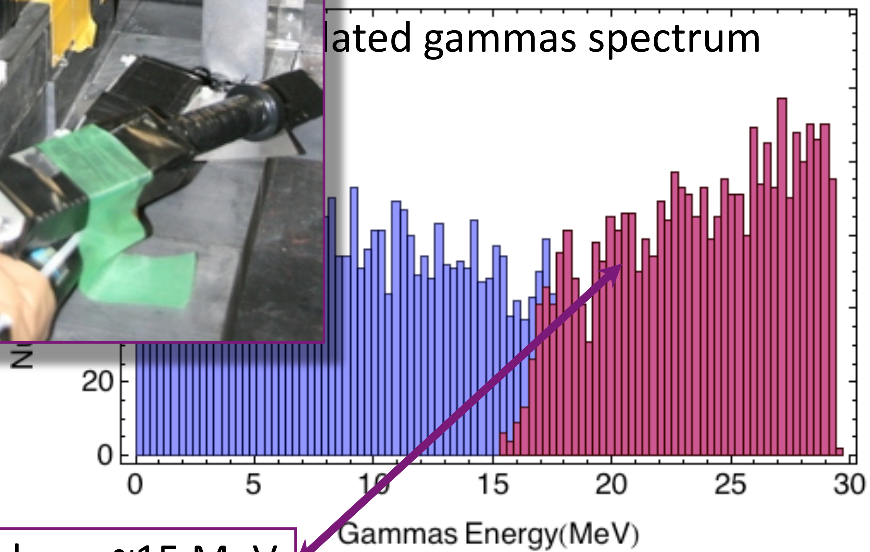
Experience layout





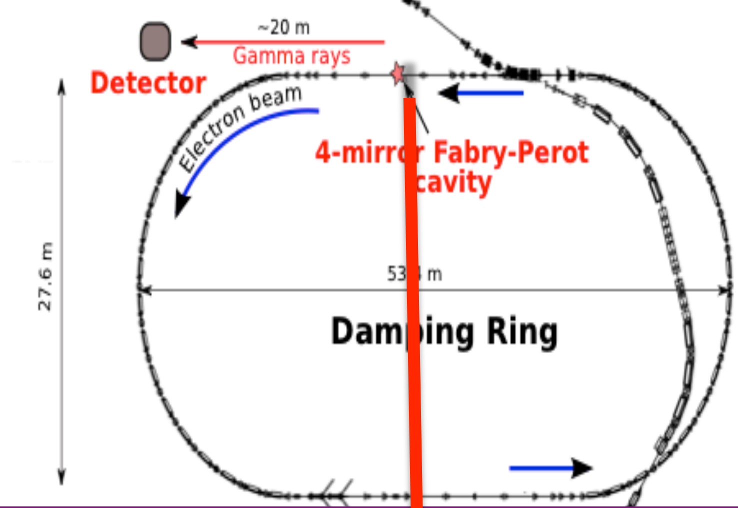
Electron energy	1.28 GeV
Electron charge	~1.6 nC
Revolution period	463 ns
lectron bunch length	25 ps
Bunch spacing	5.6 ns

LASER photon energy	1.2 eV
LASER frequency	178.5 MH
Power stored in cavity	~ 200 W
Crossing angle	8 deg.
LASER pulse length	20 ps



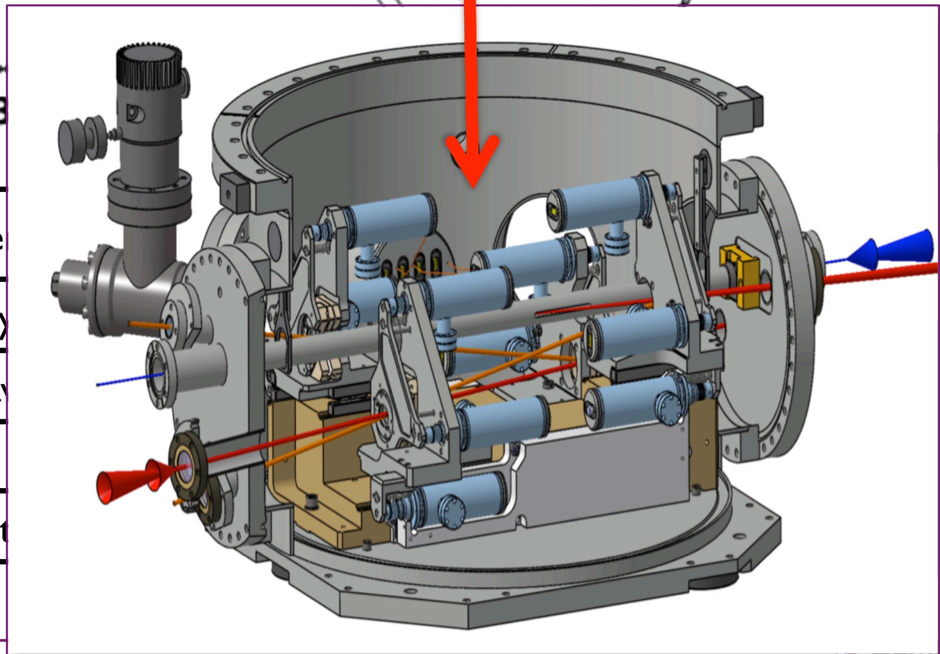
The collimators only accept photons with an energy above ~15 MeV

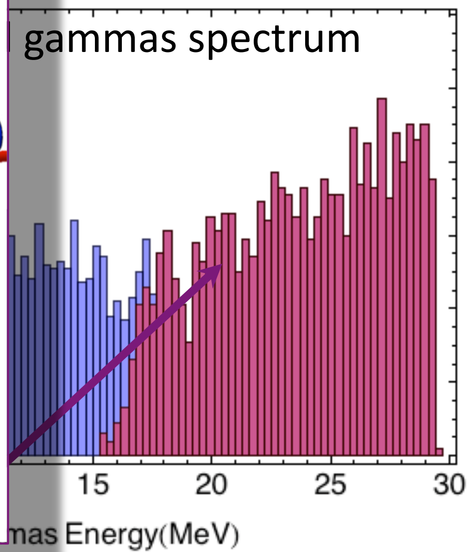
Experience layout



Electron energy	1.28 GeV
Electron charge	~1.6 nC
Revolution period	463 ns
Electron bunch length	25 ps
Bunch spacing	5.6 ns

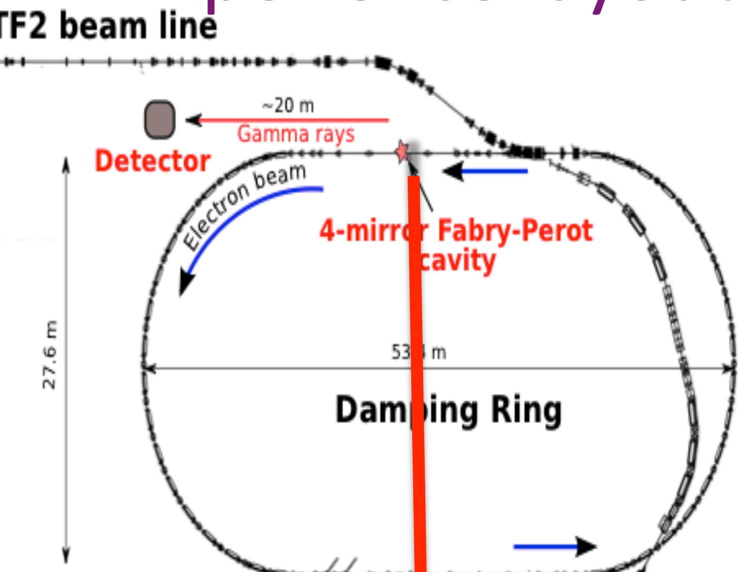
LASER photon ene	
LASER frequency	
Power stored in ca	
Crossing angle	
LASER pulse lengt	





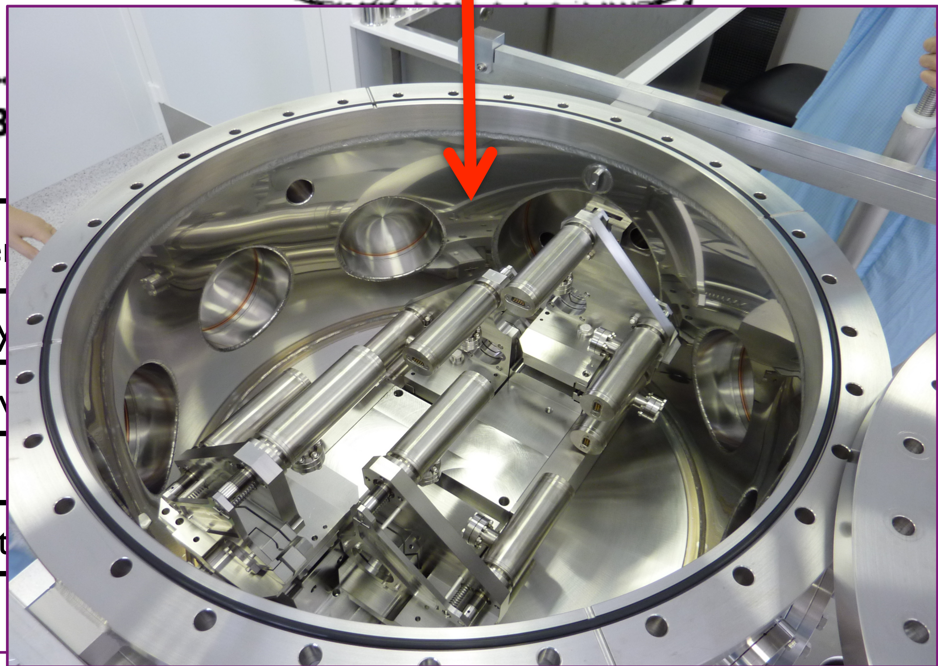
The collimators only accept photons with an energy above ~15 MeV

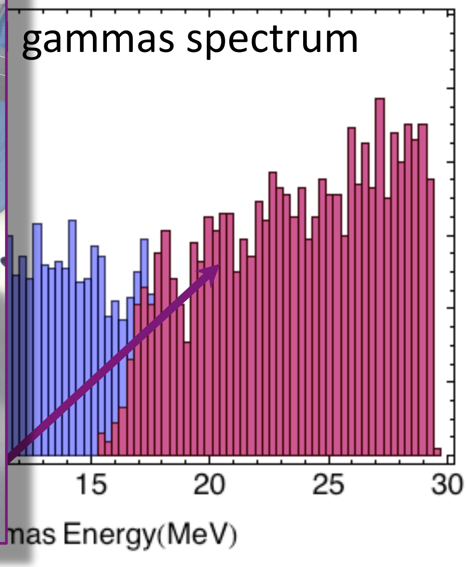
Experience layout



Electron energy	1.28 GeV
Electron charge	~1.6 nC
Revolution period	463 ns
Electron bunch length	25 ps
Bunch spacing	5.6 ns

LASER photon ene
LASER frequency
Power stored in cav
Crossing angle
LASER pulse lengt





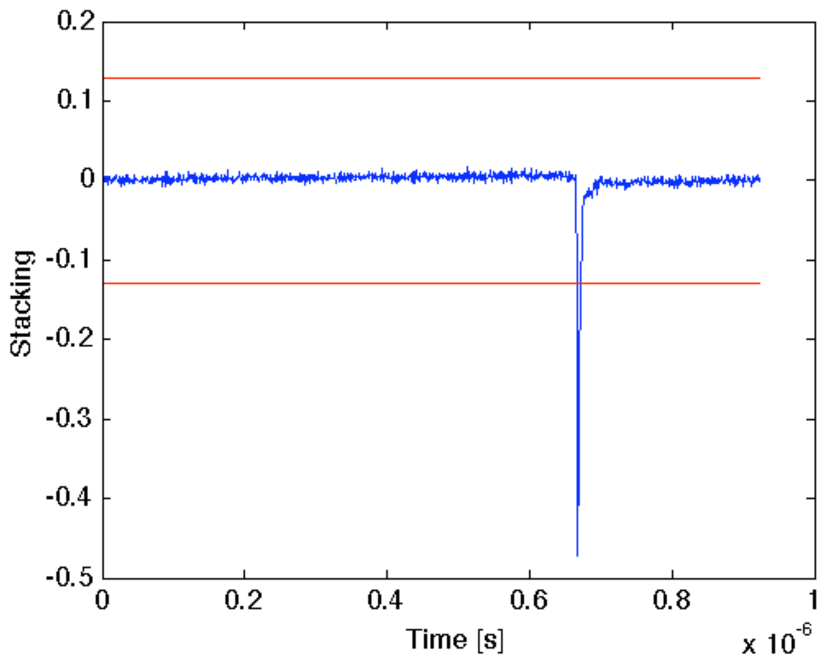
The collimators only accept photons with an energy above ~15 MeV

Data analysis, best results.

I. Chaikovska

Best integrated flux

Electron pulse structure	Integrated flux over 0.2 ms	Integrated flux over 1 s (extrapolated)
1 train	1265 γ	6.3E+06 γ
2 trains	1289 γ	6.4E+06 γ
3 trains	1428 γ	7.1E+06 γ

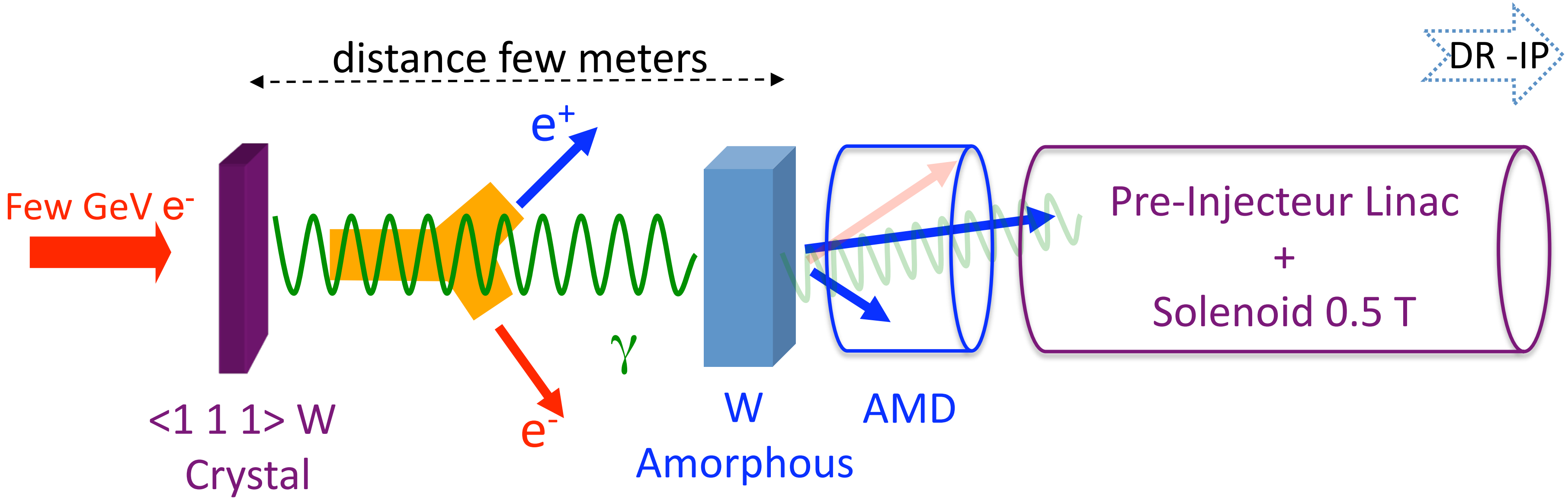


In average, approximately 4 γ are produced per bunch crossing. As the repetition frequency of the collisions is about 1 MHz the flux of γ rays achieved so far is ~4×10^6 γ/s

Hybrid scheme

- The conventional scheme using a thick amorphous target presents some difficulties due to high energy deposition
  - Heating → melting target
  - Energy deposition density → target breakdown
    Peak Energy Density Deposition, PEDD < 35 J/g (SLC)
- Decreasing the energy deposition
  - → Reduce the target thickness
  - → Limit the energy in the target
- One solution has been developed since some years using the association of a crystal and an amorphous targets : hybrid source
  - Use a thin crystal radiator to provide an important photon flux

Hybrid scheme : presentation

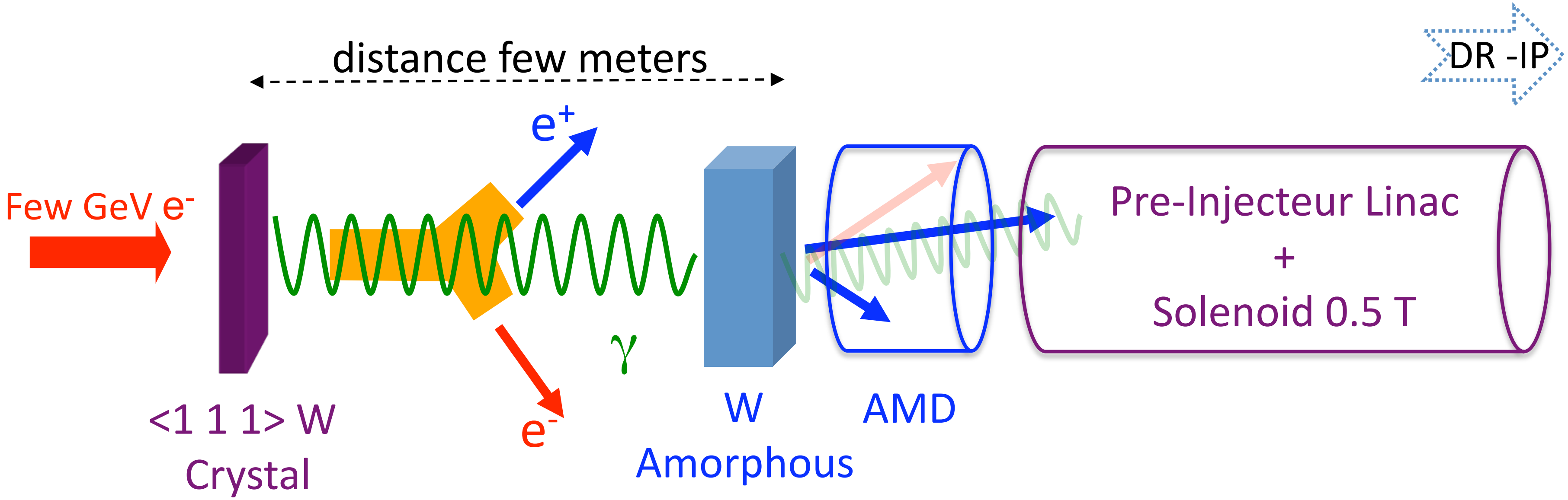


1. Crystal W thickness few mm
2. Amorphous thickness several mm ★
3. Optical Matching Device ★
4. Pre-injector linac encapsulated in axial magnetic field ★

★ ➔ study can be interesting for other positrons sources production

Use the hybrid scheme to present our studies.

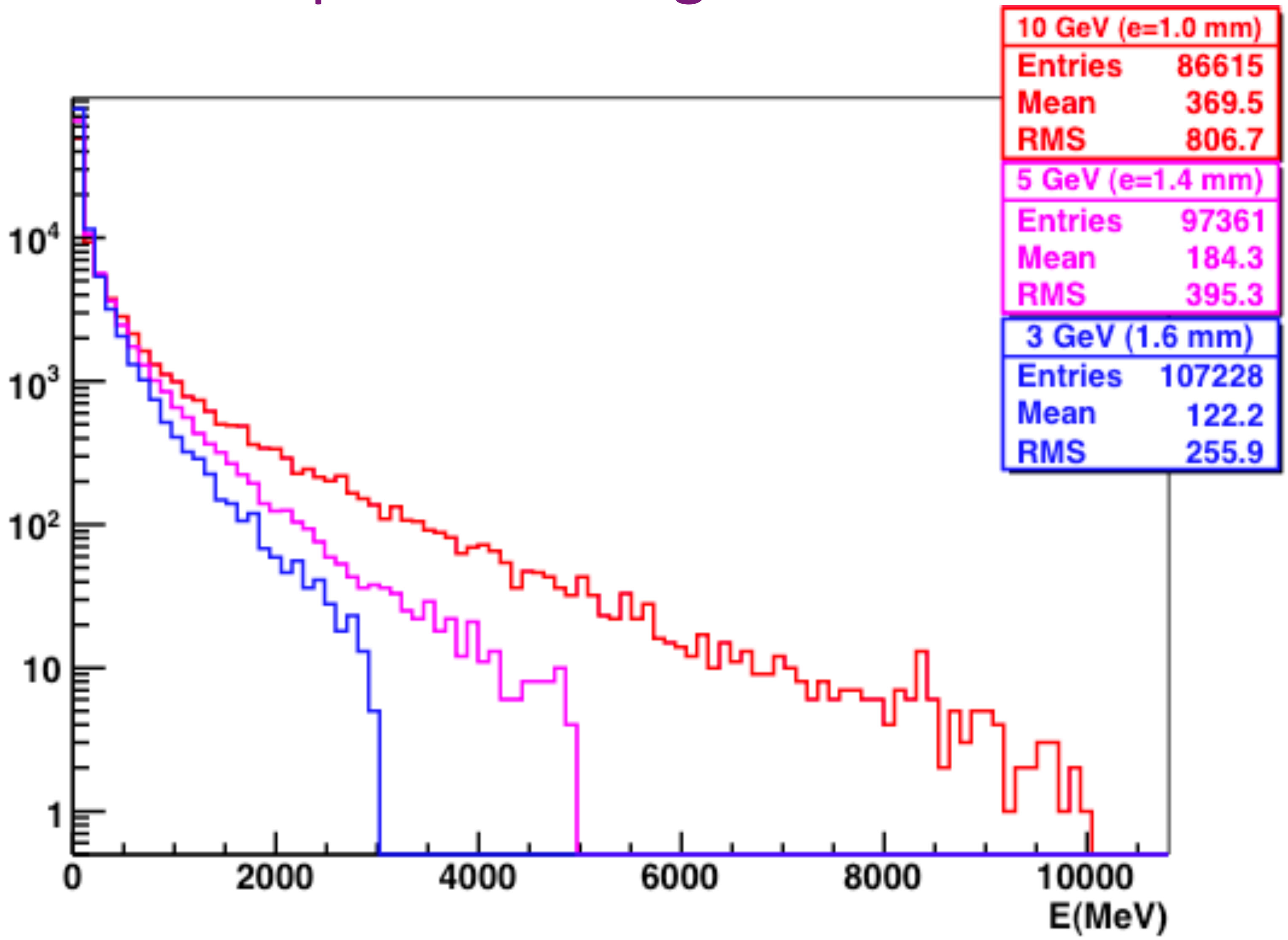
Hybrid scheme : presentation



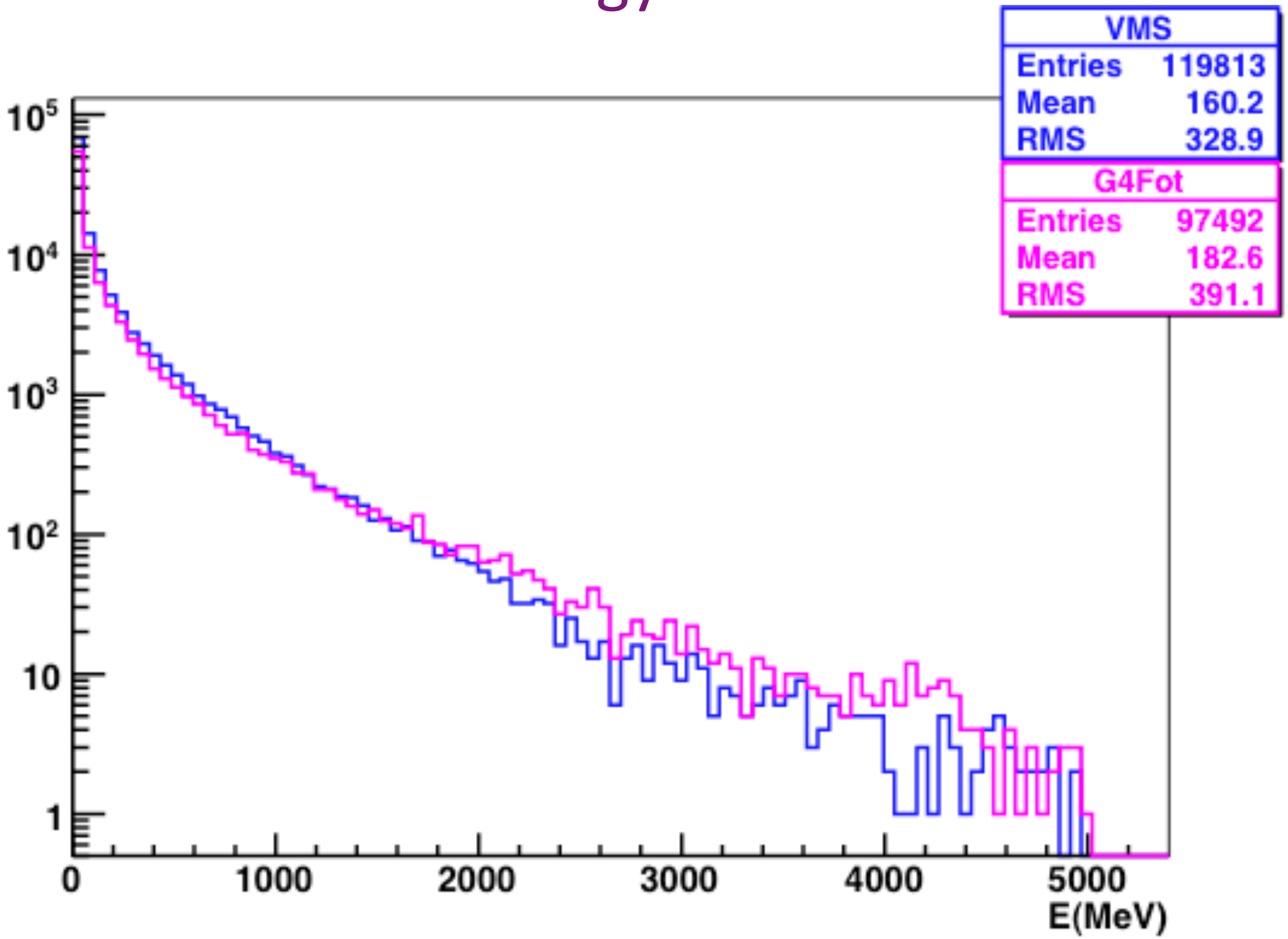
1. Crystal W thickness few mm

   Simulation the crystal behaviour inside Geant4 : G4Fot

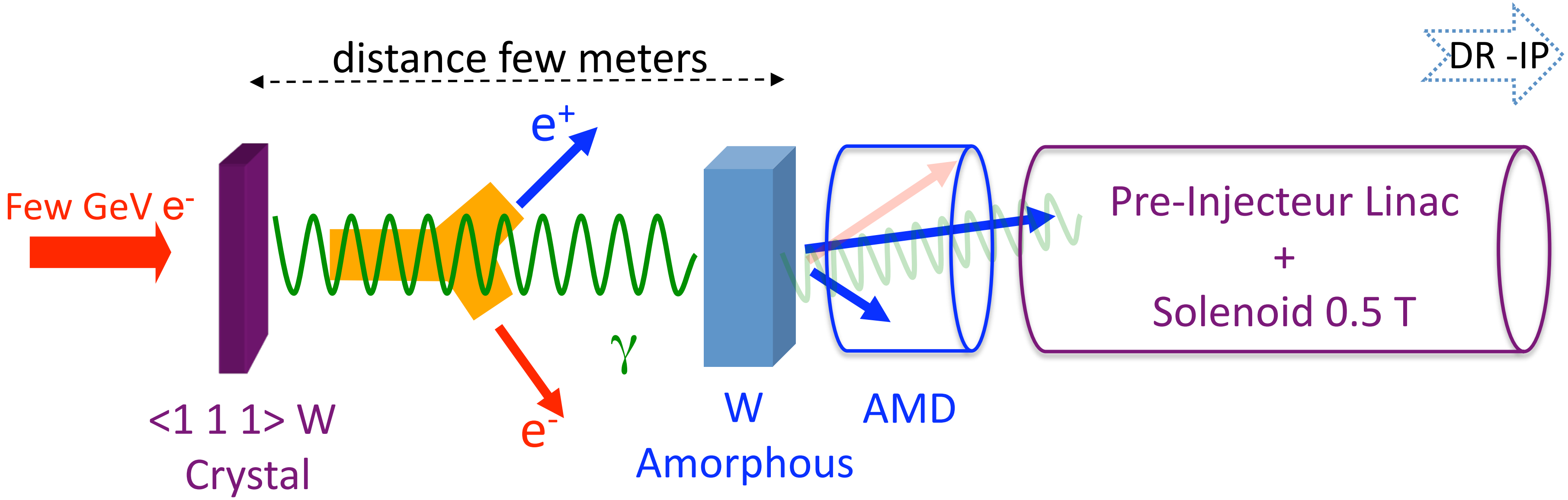
Results: photon energies distributions



Benchmark: 5 GeV incident e- beam (t=1.4 mm) Photon energy distribution



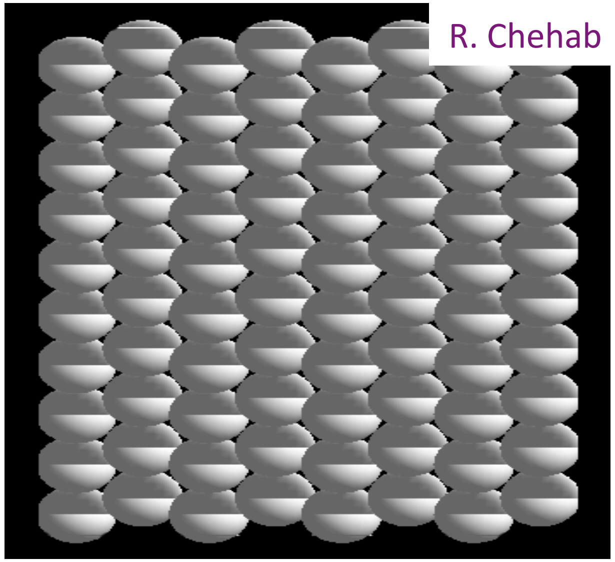
Hybrid scheme : presentation



1. Crystal W thickness few mm
2. Amorphous thickness several mm

   Granular amorphous target for power energy dissipation

Amorphous study

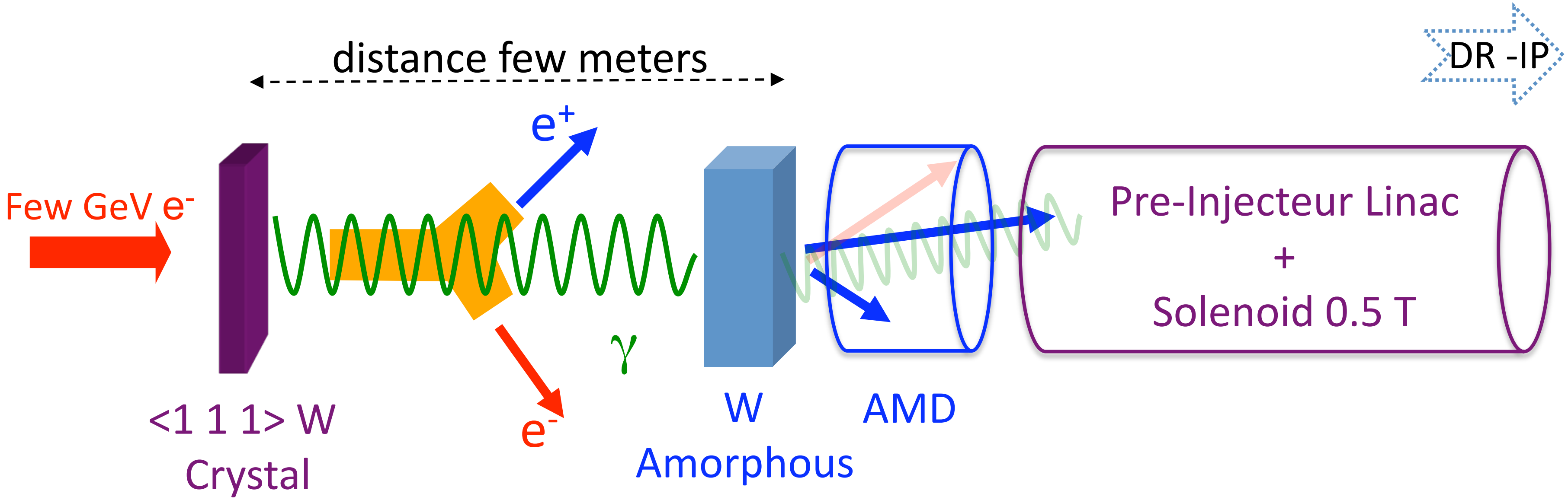


As already pointed out (see P. Pugnat, P. Sievers)
[J. Phys. G. Nucl. Part. Phys. 29 (2003) 1797-1800]

A granular converter made of small spheres of few mm radius offers the advantages of presenting a relatively high [surface/volume] ratio which is interesting for the power dissipation.

	Thickness	Yield	PEDD	ΔE_{dep}	N-layers	spheres number	Effective density
Unity	mm	e+/e-	GeV/ cm^3/e-	MeV/e-			$g.cm^{-3}$
Compact	8	13.3	2.18	523			19.3
Granular r=1mm	10.16	12.18	1.88	446	3	864	13.9
Granular r= 0.5mm	11.60	13.45	2.33	613	7	8064	13.9

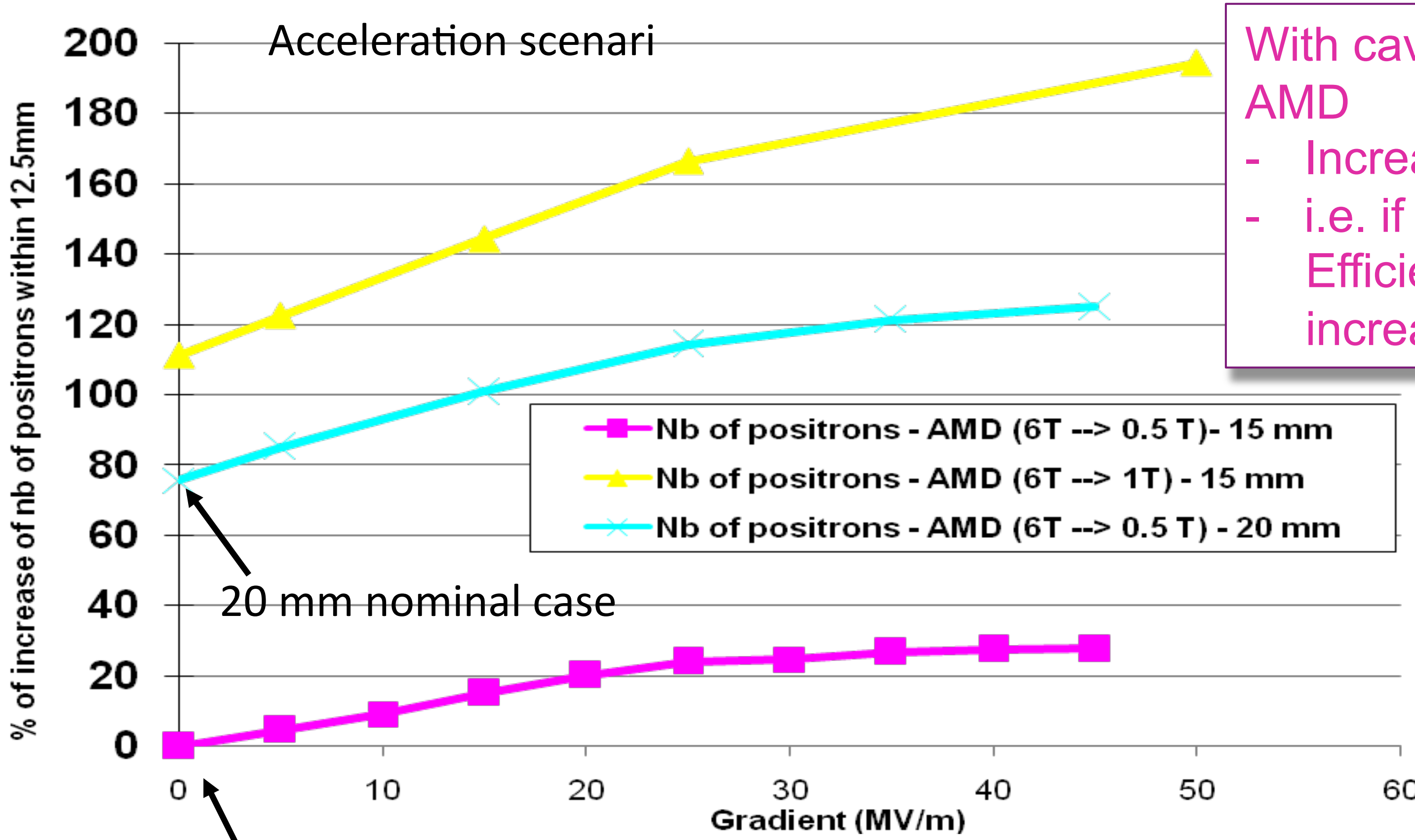
Hybrid scheme : presentation



1. Crystal W thickness few mm
2. Amorphous thickness several mm
3. Optical Matching Device
   An accelerating field within the Adiabatic Matching Device (AMD)

AMD study

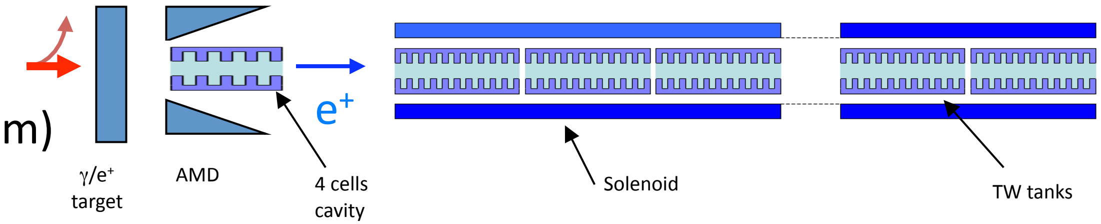
F. Poirier



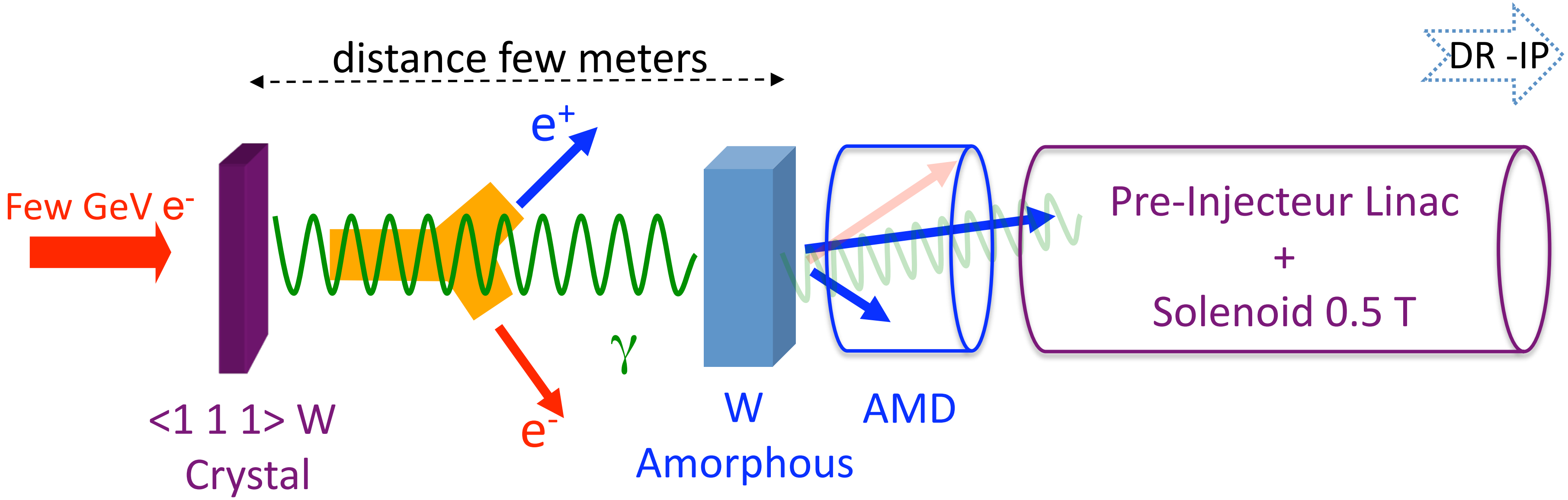
With cavity within the AMD

- Increase of gradient
- i.e. if 4cell=10MV/m, Efficiency is increased by 10%

Case (AMD 6T → 0.5 T and no cavity inside the AMD, but AMD inner r=15mm)



Hybrid scheme : presentation



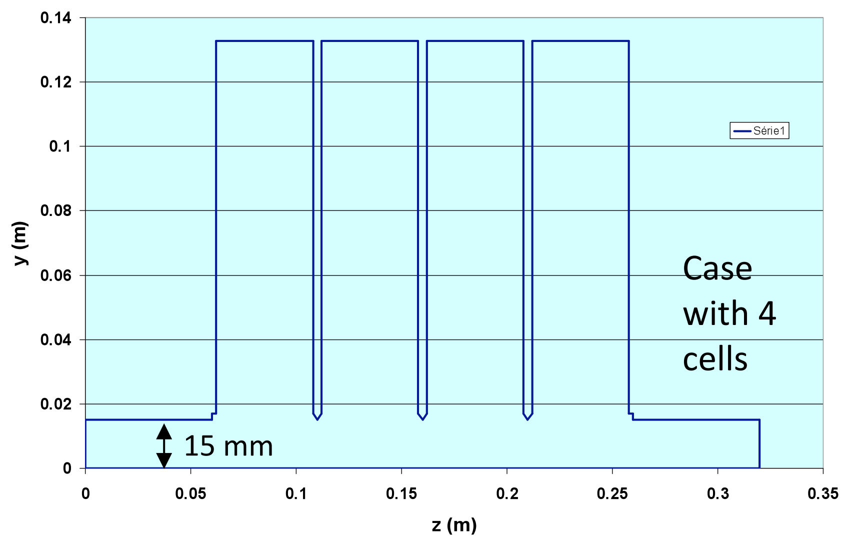
1. Crystal W thickness few mm
2. Amorphous thickness several mm
3. Optical Matching Device
4. Pre-injector linac encapsulated in axial magnetic field

Capture study

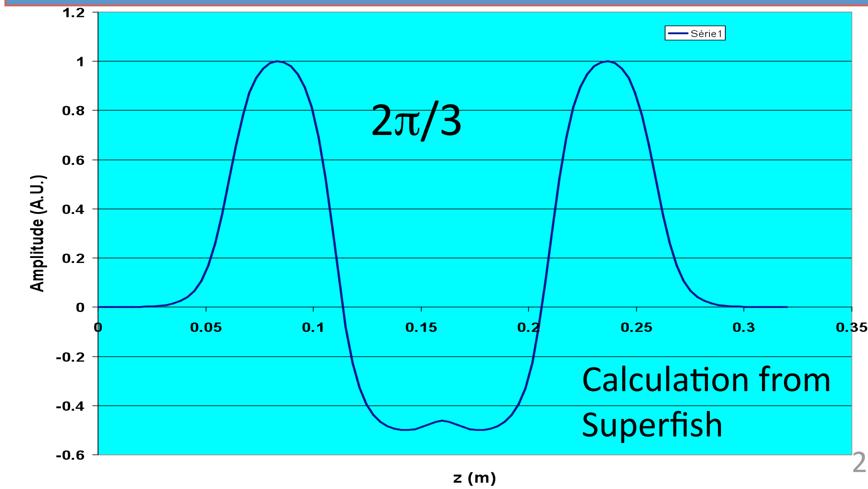
F. Poirier

- 2 GHz
- 84 accelerating cells constitute the TW tanks
  - Note: 84 cells + 2 half cells for couplers within ASTRA
  - $2\pi/3$ operating mode
- 4.36 m long
- 15 MV/m
- Up to 5 tanks are used to accelerate e+ up to 200 MeV

Typical cells dimension for the TW tanks



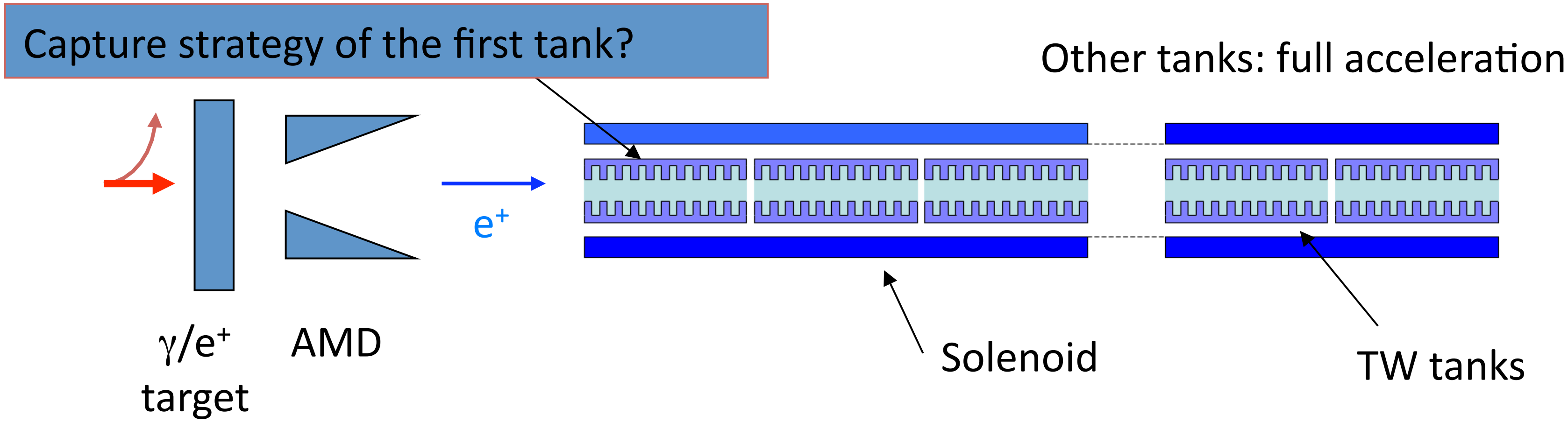
Typical electric field for the 4 cells cavity



First optimisation done on 15 mm iris (radius aperture) tanks but final results with 20 mm iris tanks

Capture study

F. Poirier



- Acceleration: Phase of the first tank tuned for use of maximum accelerating gradient for the first tank

  4 tanks are needed to reach ~200 MeV

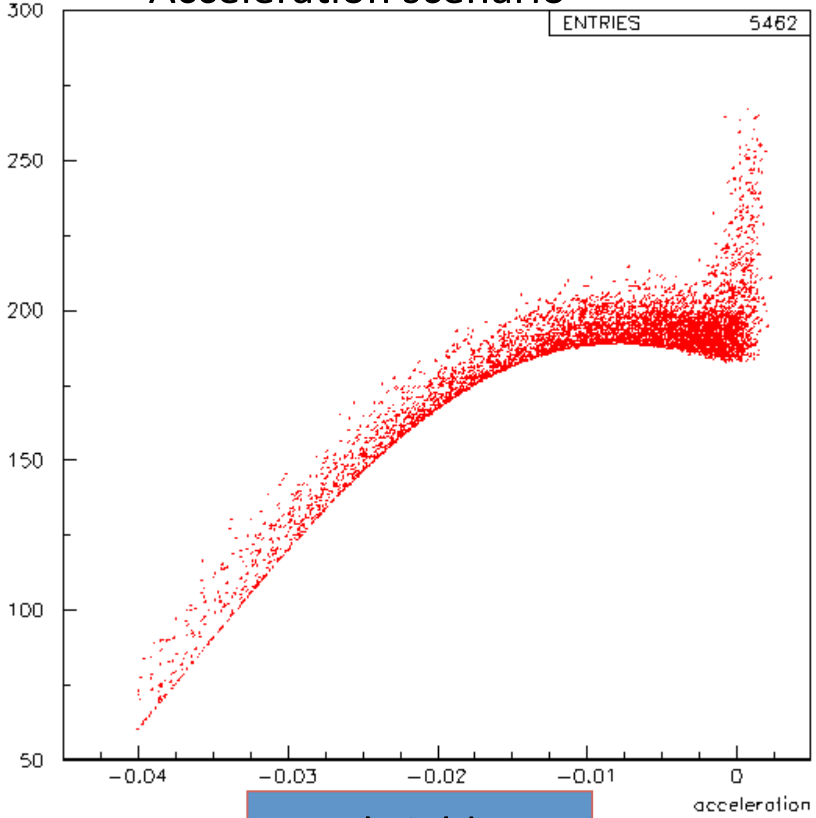
- Deceleration: adapt the phase and gradient of the first tank to capture a maximum of positrons

  5 tanks are needed to reach ~200 MeV

Capture study

F. Poirier

Acceleration scenario

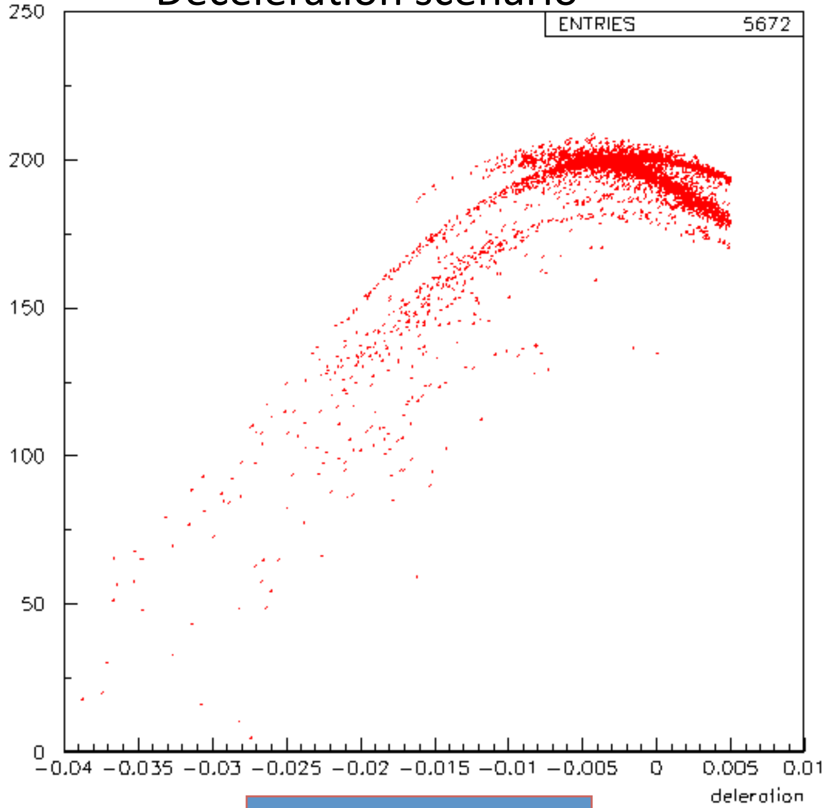


Total yield=0.9

Efficiency >165MeV=4621/6000= 0.77

(was 0.4 for 15 mm aperture)

Deceleration scenario



Total yield=0.95

Efficiency >165MeV=5335/6000= 0.89

(was 0.53 for 15 mm aperture)

This is the big advantage of the deceleration technique

Conclusion

- Man power and different LAL project
  - We finished the studies for CLIC and soon the study for the granular target.
  - We intend to maintain the effort on Mighty Laser and (in the limit of our possibilities) the activity on the hybrid target.
  - We expect additional man power to improve our participation in the fields related to linear collider.

- Thanks to our CERN colleagues : L. Rinolfi , P. Sievers, A. Vivoli