IRIDE photo-production Workshop

INFN, Laboratori Nazionali di Frascati, June 10th-11th, 2013

Workshop
foto-produzione
a IRIDE

INFN Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati
10 - 11 Giugno 2013

E' in corso di elaborazione una proposta per una nuova grande infrastruttura di ricerca per la fisica applicata e fondamentale denominata IRIDE.

Concepita come uno strumento innovativo ed evolutivo per indagini in un ampio campo di applicazioni scientifiche, tecnologiche ed industriali, sarà una "fabbrica di fasci intensi di particelle", utilizzando linac super-conduttori ad alto duty-cicle, accoppiati a laser di alta potenza.

IRIDE sarà in grado di produrre flussi elevati di elettroni, fotoni (dai raggi infrarossi ai raggi gamma), neutroni, protoni, pioni, positroni ed eventualmente muoni, per una vasta comunità scientifica nazionale ed internazionale interessata ad utilizzare sorgenti avanzate di radiazioni e particelle.

Nel workshop verranno discusse in particolare le potenzialita' della sorgente di neutroni da foto-produzione.
Essi possono essere sfruttati sia per ricerca fondamentale sia applicata e industriale.

Le tecniche che potrebbero infatti essere disponibili sono:

* studio dei materiali tramite attivazione neutronica
* controlli non distruttivi tramite radiografia e tomografia neutronica
* controlli distruttivi tramite irraggiamento neutronico ("chip irradiation")
* sviluppo di rivelatori a neutroni

Dettagli dell'evento si possono trovare in http://agenda.infn.it/event/IRIDE_Neutroni
La prima parte del workshop sara' dedicata a discussioni specialistiche, mentre il pomeriggio dell'11 giugno sara' dedicato alla discussione con i potenziali utilizzatori.

Contatti: Massimo.Ferrario@lnf.infn.it, Riccardo.Faccini@roma1.infn.it, Paolo.Valente@roma1.infn.it

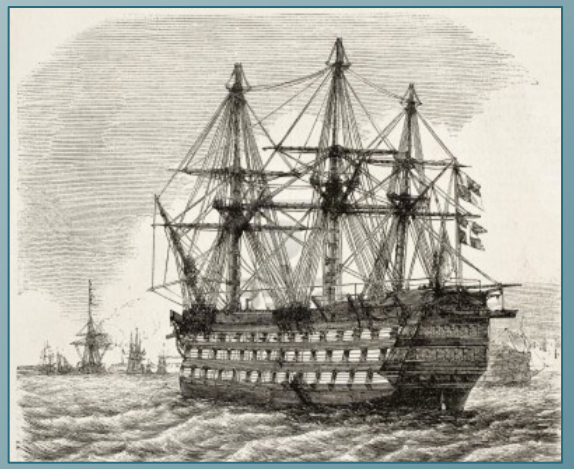
Introduction

Paolo Valente, INFN Roma

History of the project

December 2012

- Call for a possible new flag-ship project for the INFN
- "Coalescence" of many initiatives and proposals on:
  - X-FEL
  - Compton backscattering source
  - THz radiation production
  - Plasma wake-field acceleration
  - gamma-gamma, e-gamma and electron-positron collisions
  - **Neutron photo-production source**



The basic idea

- Twin super-conducting, high duty cycle RF linacs (e.g. 1.5 GeV+1.5 GeV), capable of delivering a high average current
- High energy laser

Interest and collaboration from ENEA, CNR and many universities

January 29th, 2013

- Massimo Ferrario presents the IRIDE concept to the INFN Board of directors

History of the project

14th-15th March, 2013

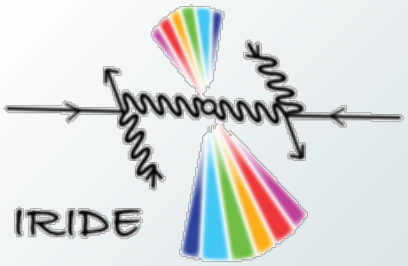
First two-day meeting in Frascati:

- http://agenda.infn.it/conferenceTimeTable.py?confId=6006
- Aimed at defining the requirements for the electron beams (intensity, energy, **time structure**)
- Working groups set-up: http://wiki.infn.it/strutture/lnf/da/lego/home

- WG1 LINACS design
- WG2 Free Electron Laser
- WG3 THz source
- WG4 Neutron Source
- WG5 Photon Machine optical systems
- WG6 Nuclear Photonics
- WG7 e-gamma Collider
- WG8 photon-photon Collider
- WG9 e-e- and e+e- collisions
- WG10 Advanced accelerator experiments
- WG11 Site and Infrastructure
- Timeline and Costs

Commitment for writing a **White Book**:

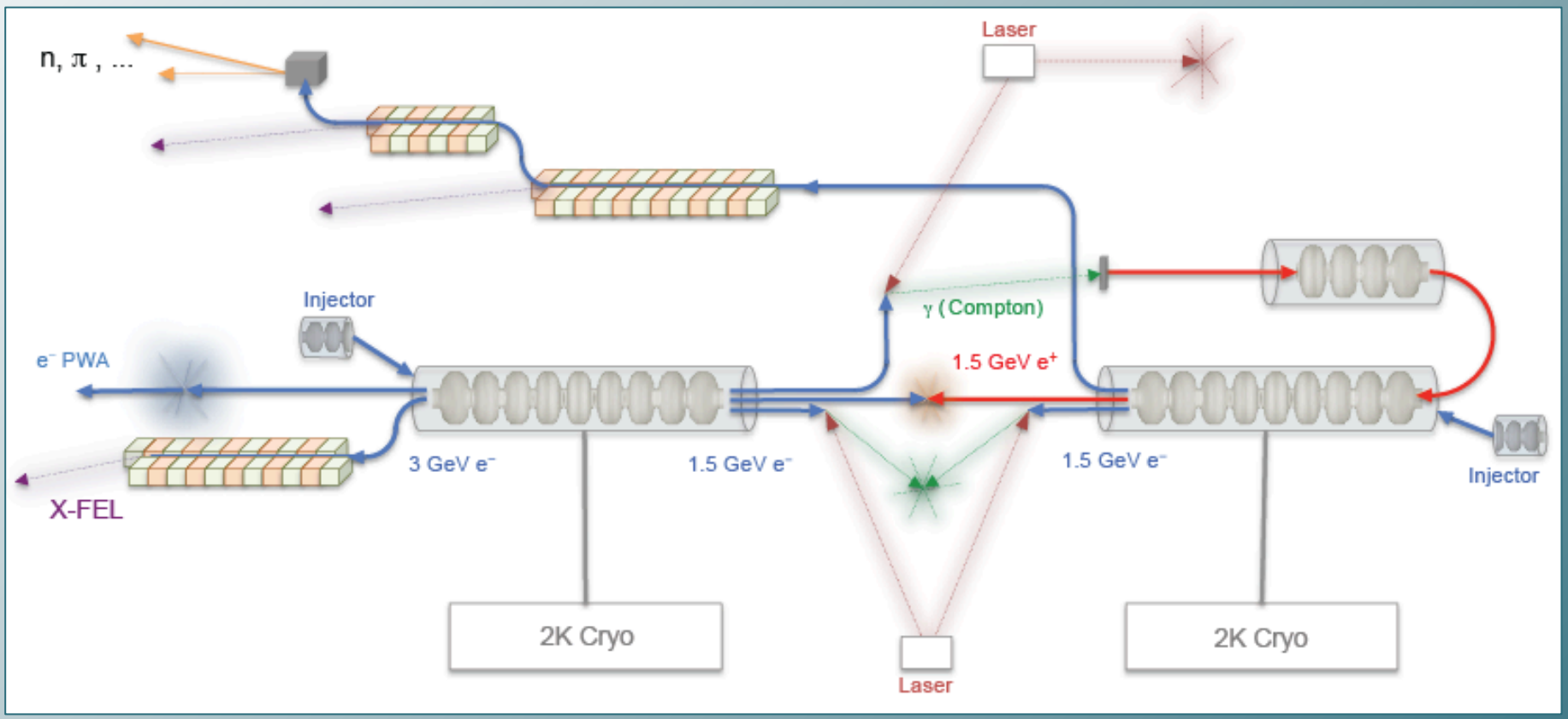
- Science cases
- Project basic components and their main parameters
- Needed infrastructures
- A first cost assessment
- By the end of summer 2013



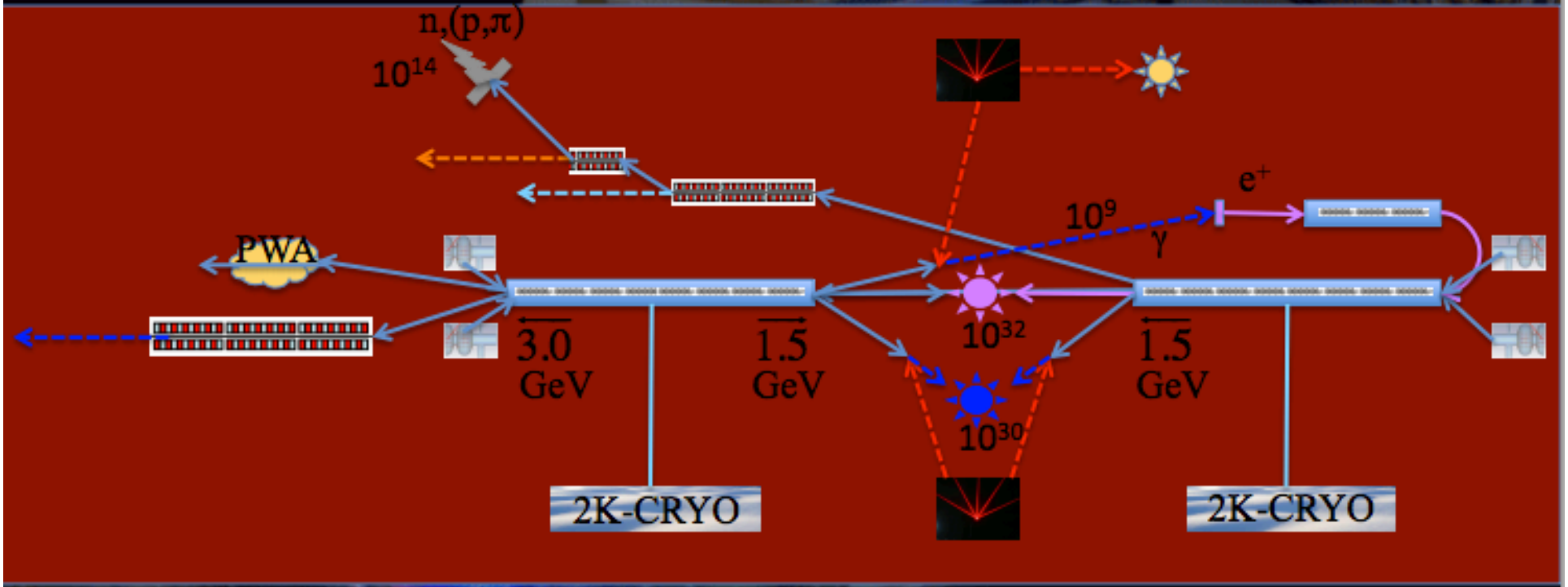
WG4 tasks

- **Interest from Research** (A. Pietropaolo, F. Grazzi, A. Paciaroni, S. Magazù, F. Migliardo, M.T. Caccamo, ...)
- **Target shielding and Moderators** (L. Quintieri, P. Valente, S. Bartalucci, ...)
- **Beamlines and Detectors R&D** (A. Pietropaolo, P. Valente, A. Orecchini, F. Migliardo, R. La Torre, P. Zona, ...)
- **Charged particles photo-production** (R. Faccini, F. Broggi, G. Cavoto, E. Ripiccini,...)
- **Interactions with industry** (R. Faccini , P. Valente , F. Murtas, S. Bartalucci, G. Organtini, V. Bocci, S. Magazù, M.T. Caccamo, R. La Torre, F. Broggi, ...)

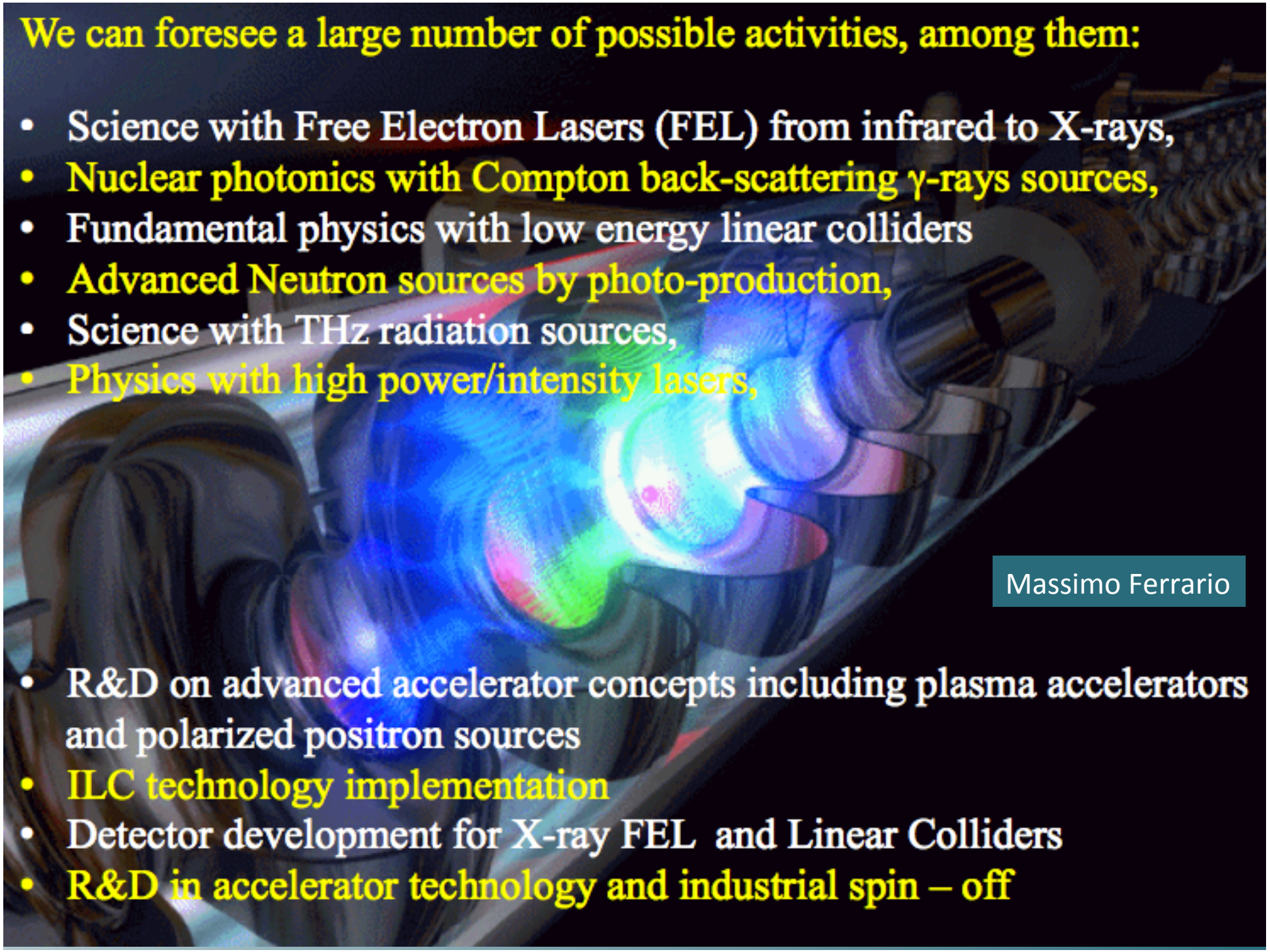
IRIDE overview



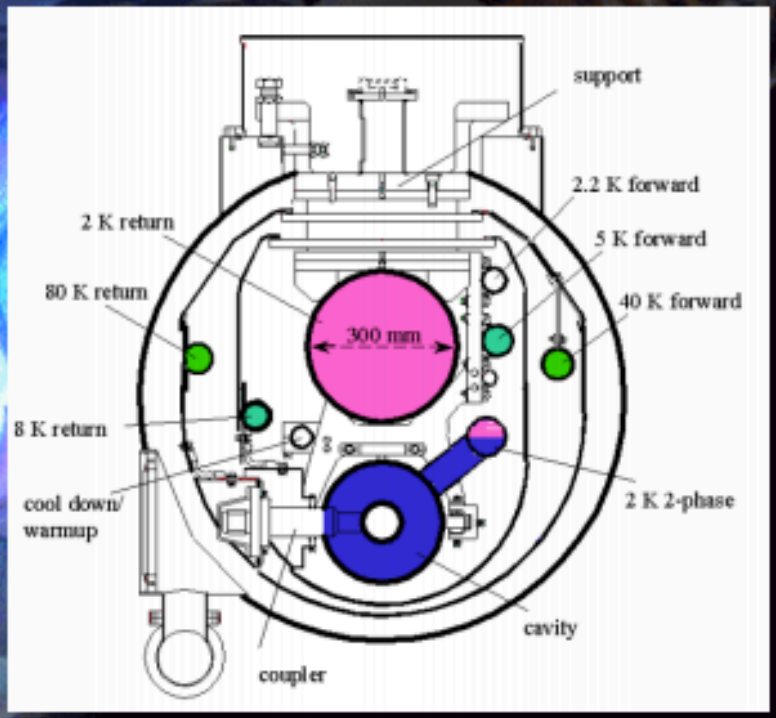
I R I D E is a large infrastructure for fundamental and applied physics research. Conceived as an innovative and evolutionary tool for multi-disciplinary investigations in a wide field of scientific, technological and industrial applications, it will be a high intensity "particle beams factory".



Based on a combination of a high duty cycle radio-frequency superconducting electron linac (SC RF LINAC) and of high energy lasers it will be able to produce a high flux of electrons, photons (from infrared to γ-rays), neutrons, protons, pions and eventually positrons, that will be available for a wide national and international scientific community interested to take profit of the most advanced particle and radiation sources.


We can foresee a large number of possible activities, among them:
• Science with Free Electron Lasers (FEL) from infrared to X-rays,
• Nuclear photonics with Compton back-scattering γ-rays sources,
• Fundamental physics with low energy linear colliders
• Advanced Neutron sources by photo-production,
• Science with THz radiation sources,
• Physics with high power/intensity lasers,
Massimo Ferrario
• R&D on advanced accelerator concepts including plasma accelerators and polarized positron sources
• ILC technology implementation
• Detector development for X-ray FEL and Linear Colliders
• R&D in accelerator technology and industrial spin – off

INFN is in a leading position in the SC RF technology, with knowledge and strong capabilities in the design, engineering and industrial realization of all the main component of a superconducting radiofrequency accelerator.



INFN strongly participated to TESLA since the early design stages through the final engineering and shares the know-how and has the recognized intellectual property of several main components one of which is the cryo-module concept and its evolution.

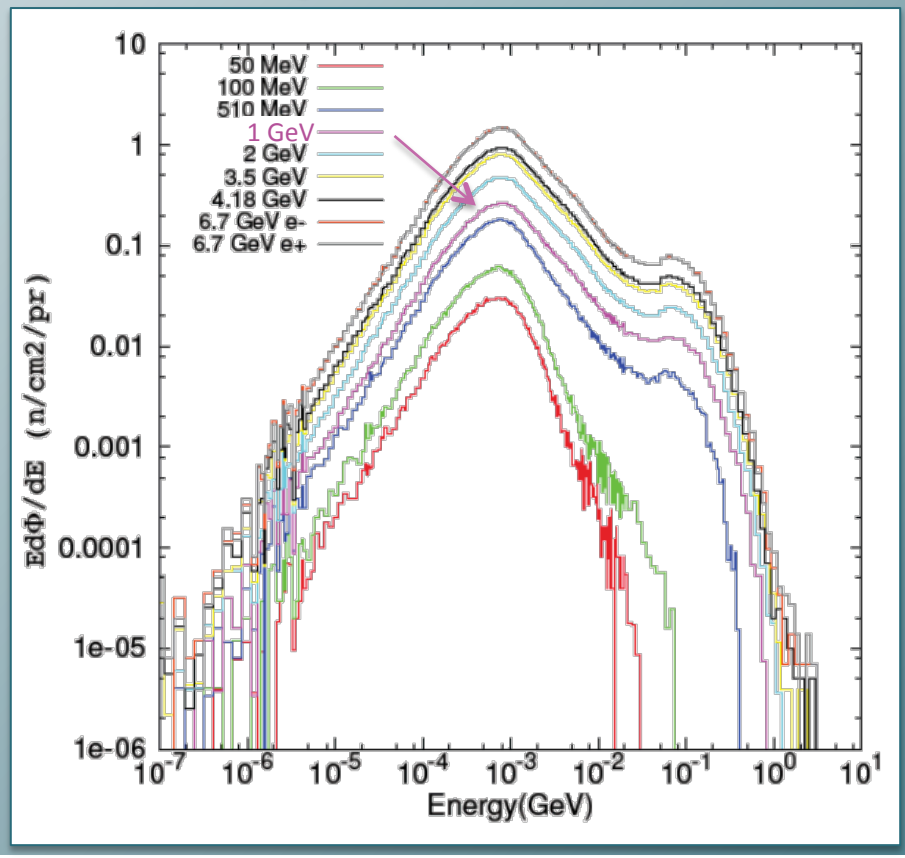
Neutron production by electron beam

Electrons on a **high Z target**:

- Bremsstrahlung emission
- (γ,n) reactions + evaporation

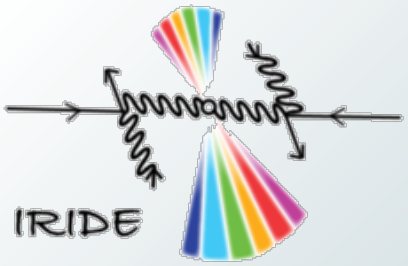
Yield ~ **0.7 n**/primary electron at E_e>1 GeV on a (W,Ta) target

Of course spallation sources can profit of a much larger yield/primary



	Proposed Beam configurations and comparisons with other facilities	*PIETROPAOLO, Antonino*
11:00	*Aula Conversi, Laboratori Nazionali di Frascati*	10:45 - 11:05

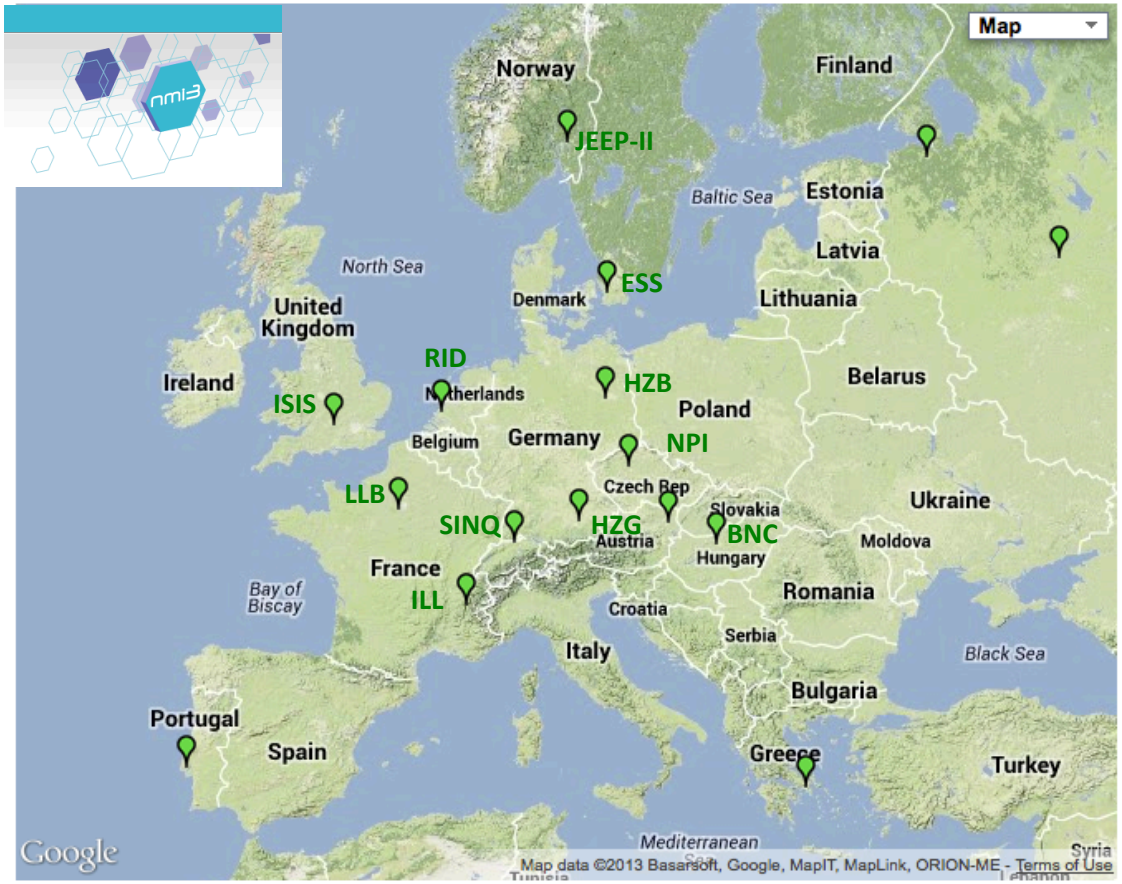
- A **Frascati project** since many years (S. Bartalucci)
- A **prototype** at the Beam Test Facility (n@BTF), using the 60 W DAFNE linac



Why another neutron source?

Deposited Power [kW]	Primary Electron Energy [GeV]	Expected Average Neutron Emission rate [n/s]
30	1	1.3 E+14
250	1	1.0 E+15
400	1	1.7 E+15

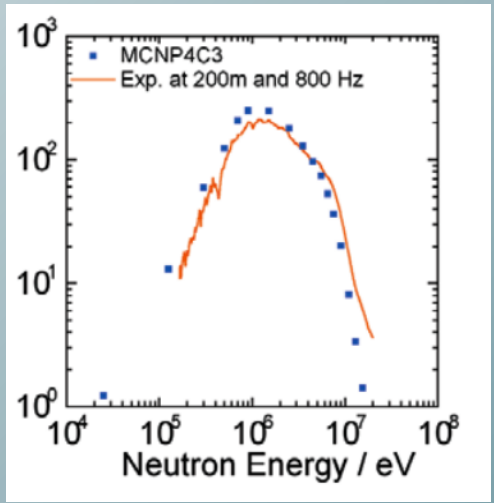
http://nmi3.eu/neutron-research/where.html



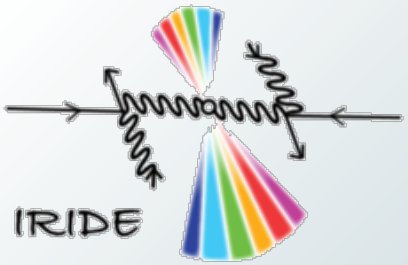
A good example of electron-driven neutron source

A notable facility in Europe: **GELINA** (Geel, Belgium)

- 140 – 70 MeV, S-band electron linac
- 10 kW maximum beam power
- 800 Hz max repetition rate
- U-Mo rotating target
- 12 neutron lines (10 m to 400 m)
- **3.4×10^{13} n/s at the target**
- Two light water moderators



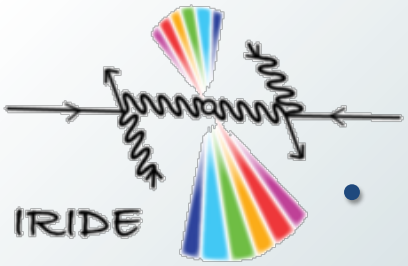
The Gelina Facility	*JAN, Heyse*
Aula Conversi, Laboratori Nazionali di Frascati	11:05 - 11:35



Neutron applications

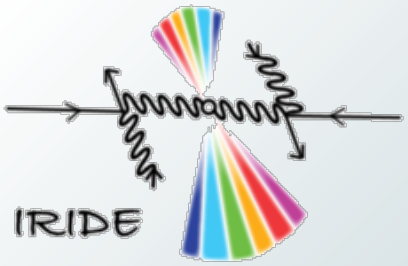
- Neutron **imaging** (radiography and tomography)
- Neutron **scattering** (diffraction, small angle, reflectometry, quasi-elastic, inelastic,…)
- Neutron **irradiation**
- Accelerator-driven sub-critical reactor (ADS)

	IRIDE neutron source potentialities	*SACCHETTI, francesco*	
12:00	*Aula Conversi, Laboratori Nazionali di Frascati*	11:35 - 12:05	
14:00	**Possible techniques and beamlines: overview**	*MAGAZU, Salvatore*	
	Aula Conversi, Laboratori Nazionali di Frascati	14:00 - 14:20	
	Neutrons in biology: structure and dynamics	*PACIARONI, Alessandro*	
	Aula Conversi, Laboratori Nazionali di Frascati	14:20 - 14:40	
	Possible techniques and beamlines: small angle	*FIORI, Fabrizio*	
15:00	*Aula Conversi, Laboratori Nazionali di Frascati*	14:40 - 15:10	
	Neutron Diffraction - Neutron Imaging Instruments and Applications & An overview of the Italian Users Community	*GRAZZI, Francesco*	
	Aula Conversi, Laboratori Nazionali di Frascati	15:15 - 15:45	
	Electron driven subcritical reactor for ADS studies	*BARTALUCCI, Sergio*	
	Aula Conversi, Laboratori Nazionali di Frascati	10:40 - 11:00	

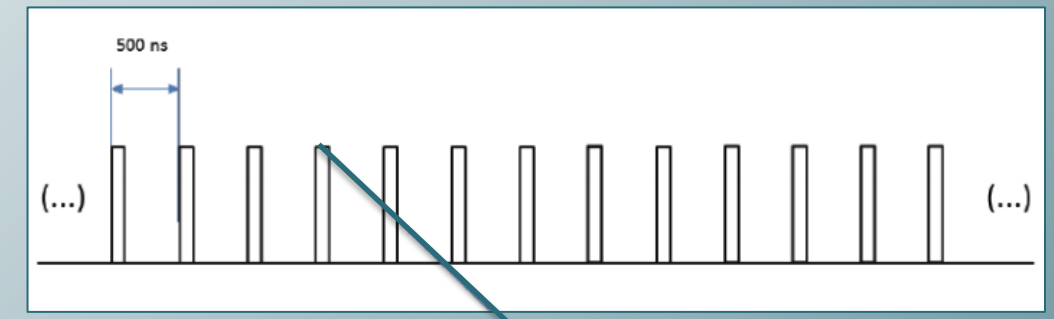


A neutron source in IRIDE

- A neutron source in the IRIDE complex would be interesting for different communities of users if capable of providing:
  - An "intense" neutron flux in the interesting energy region
  - User-friendly beam-lines
    - Instruments, access, etc.
- Even though **not competitive** with spallation sources and reactors in terms of absolute flux, a photo-production facility with a significant neutron yield would help to:
  - Increase the available beam-time and enlarge the community
  - Develop new technologies and detectors
  - Provide training for beam-line scientists, accelerator experts, computing, electronics, detectors
- Essentially two scenarios:
  - **Continuous**
  - **Pulsed**



a. Continuous source



Charge in one bunch: **Q = 1 nC**
Bunch rate: **R = 1 MHz**
Average current: **<I> = Q*R = $10^{-9}*10^{6}$= 1 mA**

# of electrons/second: **N_e=Q*R/e= 10^{-3}C s^{-1}/e=0.625×10^{16} s^{-1}**
T = Q*R*Y/e= 1.25×10^{15} n/s @target for Y=0.2
T = Q*R*Y/e= 5.0×10^{15} n/s @target for Y=0.8

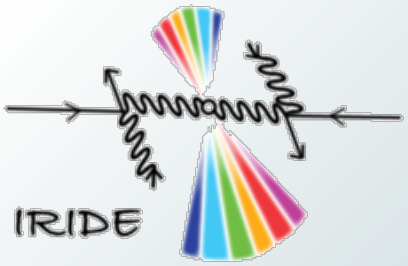
- 400 kW beam at 2 MHz repetition rate
- Peak current 200 A
- Emittance 1 mm×mrad

Techniques:

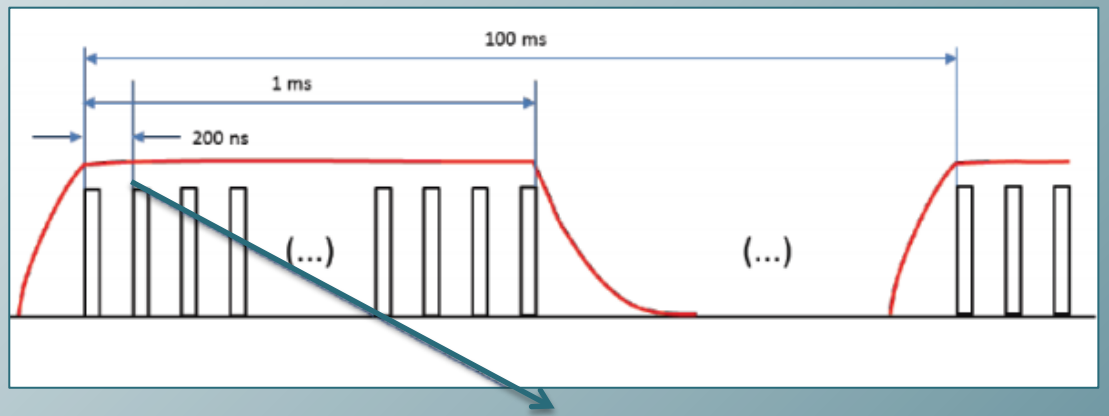
- Very interesting for imaging (tomography and radiography)
- Using monochromators, it would be possible to perform measurements with diffraction, SANS, reflectrometry

Cons and Pros:

- Of course no time-of-flight technique can be used in continous mode…
- …The neutron source can be the beam-dump of other IRIDE applications/experiments/facilities



b. Pulsed source



Charge in one bunch: **Q = 1 nC**
Bunch rate: **R = 1.3 GHz**
Burst width: **W = 500 ns**
Repetition (burst) rate: **r = 50 Hz**
Beam loading: 20%
Average current: **<I>** = Q*R*W*r = **32.5 μA**

# of electrons/second: N_e=Q*R*W*r/e= **2.03×10^{14} s^{-1}**
T = #e*Y = **1.625×10^{14} n/s** @target for Y=0.8

- 3 mA pulse current, 30 kW beam
- 5 MHz intrapulse repetition rate
- Charge in one bunch: **Q < 1 nC** (typical 600 pC)
- Peak current 600 A
- Burst width up to 1 ms
- Repetition rate few tens of Hz
- Emittance 1 mm×mrad

Techniques:

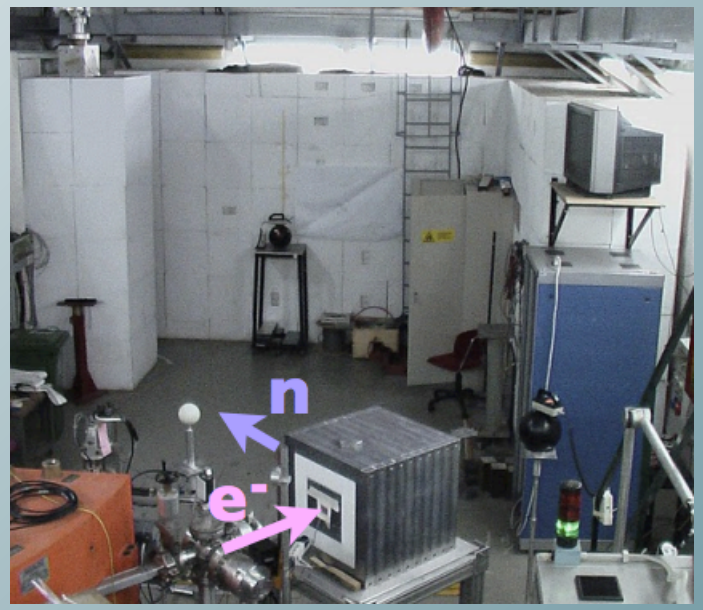
- Diffraction with time of flight, 20× better wrt scenario a.
- Similar performance for SANS and reflectometry
- Energy resolved imaging

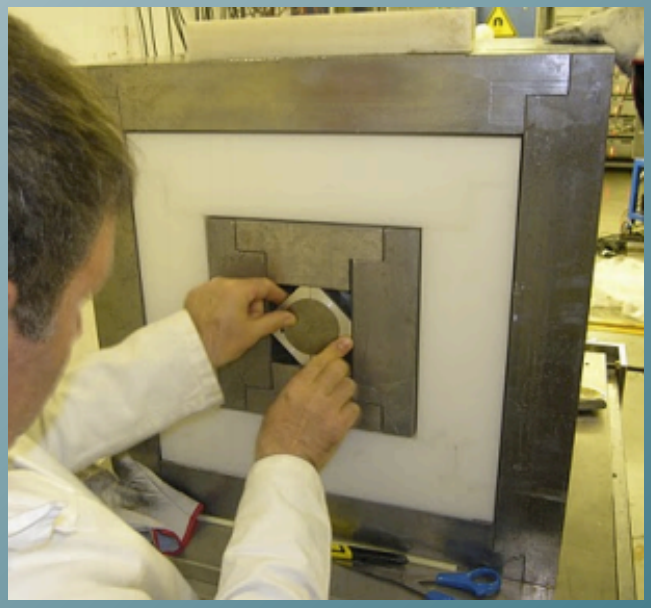
Cons and Pros:

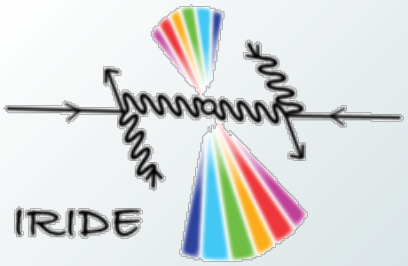
- Time structure is important: probably difficult to run in "parasitic" mode with other experiments/facilities
- Lower yield wrt continous mode…
- …but time-of-flight can be used

A closer look to the possible neutron source

	Proposed source description	*QUINTIERI, Lina*
	Aula Conversi, Laboratori Nazionali di Frascati	16:05 - 16:35
	Considerations on shielding	*FERRARI, Anna*
17:00	*Aula Conversi, Laboratori Nazionali di Frascati*	16:35 - 17:05
	Neutron spectrometry from eV to GeV at neutron beam-lines: the NESCOFI@BTF project	*BEDOGNI, Roberto*
	Aula Conversi, Laboratori Nazionali di Frascati	17:05 - 17:20





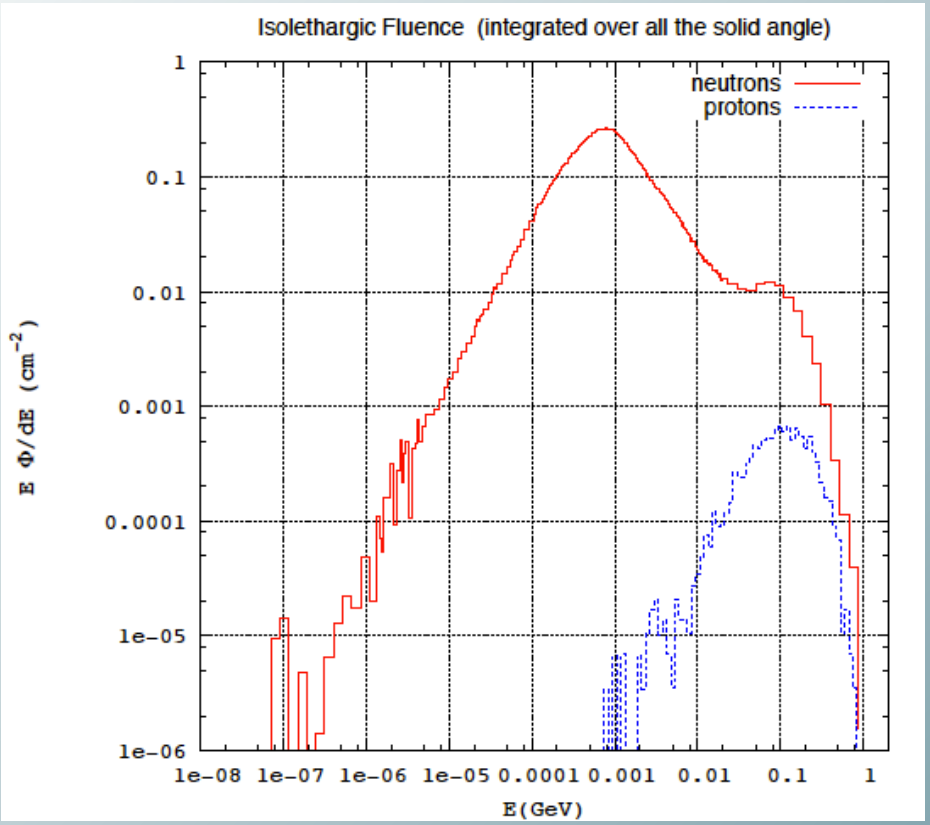


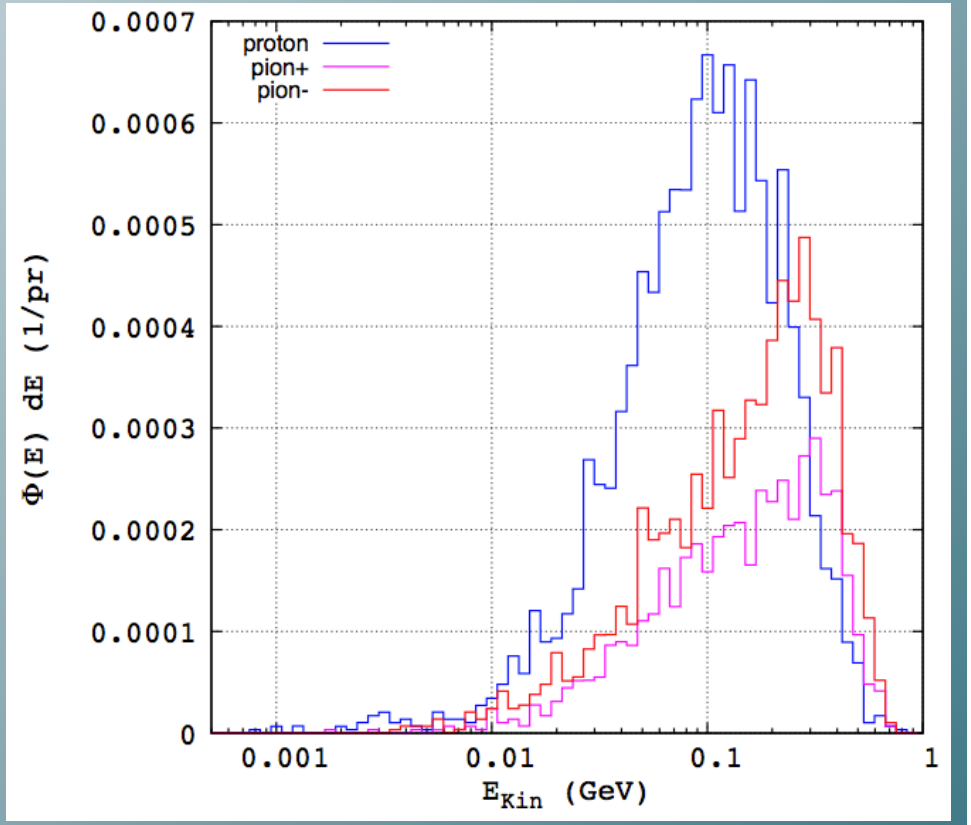
Neutron detectors

- ^{3}He detectors replacement
- Insensitivity/Discrimination of photons
- Shielding/noise from other particles
- Rate capability
- Energy measurement/threshold
- Position sensitive
- …

10:00	**Detector: Alternative detectors: GEM, Borated MediPix**	*MURTAS, Fabrizio*
	Aula Conversi, Laboratori Nazionali di Frascati	10:00 - 10:20
	Detectors: activities with radiative capture	*PIETROPAOLO, Antonino*
	Aula Conversi, Laboratori Nazionali di Frascati	10:20 - 10:40

More than neutrons





IRIDE White Book

- The material, information and discussions from these two days are precious elements for writing the neutron source chapter of the IRIDE White Book

Interaction with industries

14:00	**Il progetto IRIDE**	*INFN MANAGEMENT*
	Sala Direzione, Laboratori Nazionali di Frascati	14:00 - 14:15
	Possibili applicazione neutroni di IRIDE	*FACCINI, Riccardo*
	Sala Direzione, Laboratori Nazionali di Frascati	14:15 - 14:30
	Chip Irradiation per l'industria	*GERARDIN, Simone*
	Sala Direzione, Laboratori Nazionali di Frascati	14:30 - 14:50
	Applicazioni industriali radiazione THz	*LUPI, Stefano*
	Sala Direzione, Laboratori Nazionali di Frascati	14:50 - 15:00
15:00	**Applicazioni Industriali delle Tecniche Neutroniche**	*ROGANTE*
	Sala Direzione, Laboratori Nazionali di Frascati	15:00 - 15:15
	Tavola Rotonda	
	Sala Direzione, Laboratori Nazionali di Frascati	15:15 - 16:05
16:00		

Today
June 10th, 2013

11:00

Overview

Riccardo Faccini

Aula Conversi, Laboratori Nazionali di Frascati 10:30 - 12:35

12:00

13:00

Lunch break

Aula Conversi, Laboratori Nazionali di Frascati 12:35 - 14:00

14:00

Interest from Research

Lina Quintieri

15:00

Aula Conversi, Laboratori Nazionali di Frascati 14:00 - 15:45

Target shielding and Moderators

16:00

Antonino Pietropaolo

17:00

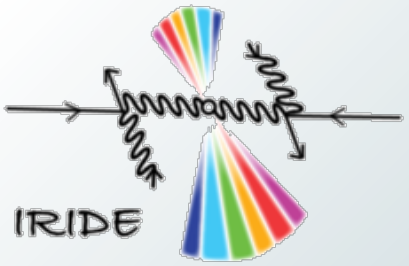
18:00

Aula Conversi, Laboratori Nazionali di Frascati 15:45 - 18:10

Tomorrow
June 11th, 2013

Enjoy the workshop,
and thank you for coming!


Viale Guido Carli
Viale Guido Carli
Via Michele Pantanella
Via Botte di Luciano
Via Botte di Luciano
Via del Fosso del Cavaliere
A1dir
E821
Via del Fontanile Tuscolano



PNR:
http://www.miur.it/Documenti/ricerca/pnr_2011_2013/PNR_2011-2013_23_MAR_2011_web.pdf