RD_MUCOL

Muon Colliders – attività INFN

Nadia Pastrone
INFN TORINO
Istituto Nazionale di Fisica Nucleare
Sezione di Torino

- ✓ Stato delle attività a livello internazionale
- ✓ Attività in corso RD_MUCOL
- ✓ Possibili sviluppi – da verificare nelle prossime settimane
- ✓ Aggiornamenti per CSN1 @ luglio

Dal 2021: RD_MUCOL (@ CSN1) ~17.5 FTE / 90 fis/ing in 13 sezioni
Sinergie con progetti in CSN5: INFN-MC e altri chiusi o nuovi
Attività in progetti EU: aMUSE, I.FAST, AIDAinnova + altri in preparazione

Contesto internazionale

https://muoncollider.web.cern.ch/

- CERN Medium Term Plan 2021-2025 - dedicated budget line – 2MCHF/year

mainly to cover machine up to MDI activities: (5 FTE staff, 6 fellows, 4 students, 1 associate)/year

- International Design Study based at CERN ➔ MoC ready to be signed

the project encompasses physics, machine, detector and Machine Detector Interface

- European LDG Accelerator R&D Roadmap by end 2021

dedicated Muon Beams Panel - but also High field magnets, RF and ERL

- European ECFA Detector R&D Roadmap by end 2021

Muon collider @ 10 TeV is considered as one of the targeted facilities emerging from the EPPSU

- US SnowMass Muon Collider Forum since 2020 ➔ restarting now

share ideas and studies across frontiers

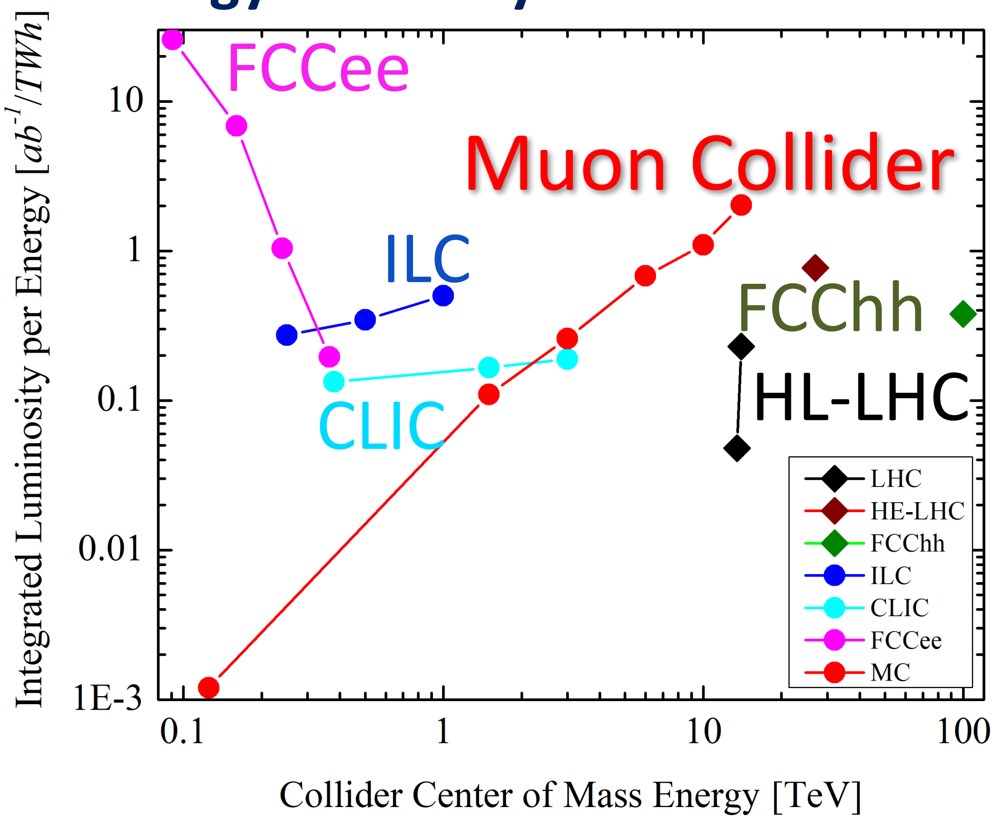
- Snowmass/P5 process in the US by spring 2023

Many LoI presented – White papers due by March 2022

Workshop/Meeting recenti

- Muon Collider Physics&Detector Workshop June 2-4
  https://indico.cern.ch/event/1037447/
- First Muon Community Meeting May 20-21
  https://indico.cern.ch/event/1030726/
- APS – AprilMeeting 4 sessions Muon Collider Symposium
  https://april.aps.org/

Energy Efficiency of Future Colliders



https://doi.org/10.1038/s41567-020-01130-x

Overwhelming physics potential:

- **Precision measures**
- **Discovery searches**

Challenging Machine Design:

- **Key issues/risks**
- **R&D plan - synergies**

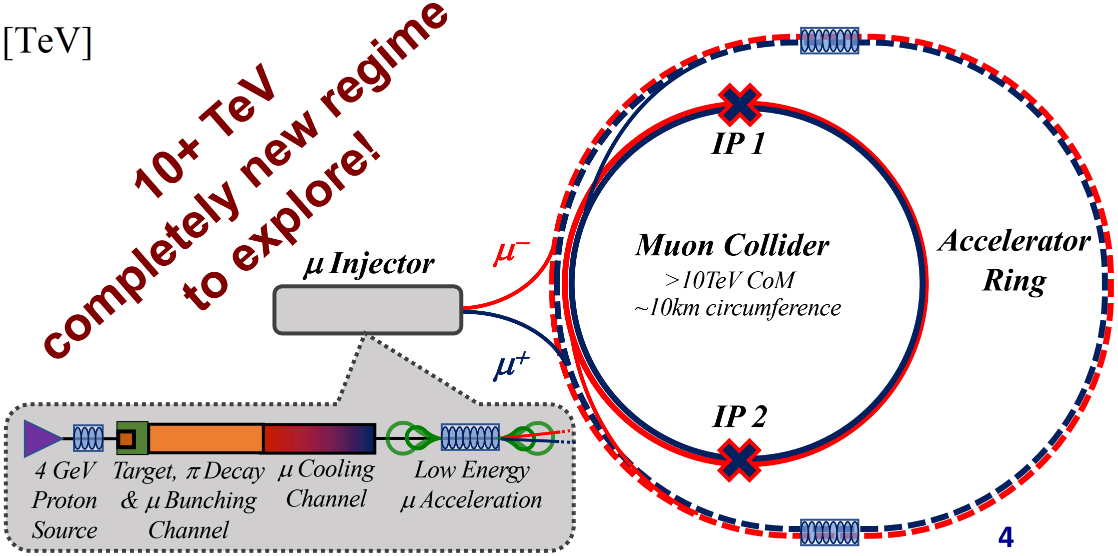
Proton driver production
Baseline @ International Design Study

ASSUMPTION/IP

$\mathcal{L} = (E_{CM}/10\text{TeV})^2 \times 10\ ab^{-1}$

@ 3 TeV	~	1 ab^{-1}	5 years
@ 10 TeV	~	10 ab^{-1}	5 years
@ 14 TeV	~	20 ab^{-1}	5 years

10+ TeV completely new regime to explore!



International Muon Collider Collaboration

Daniel Schulte

Objective:

In time for the next European Strategy for Particle Physics Update, the study aims to **establish whether the investment into a full CDR and a demonstrator is scientifically justified**.

It will provide a baseline concept, well-supported performance expectations and assess the associated key risks as well as cost and power consumption drivers. It will also identify an R&D path to demonstrate the feasibility of the collider.

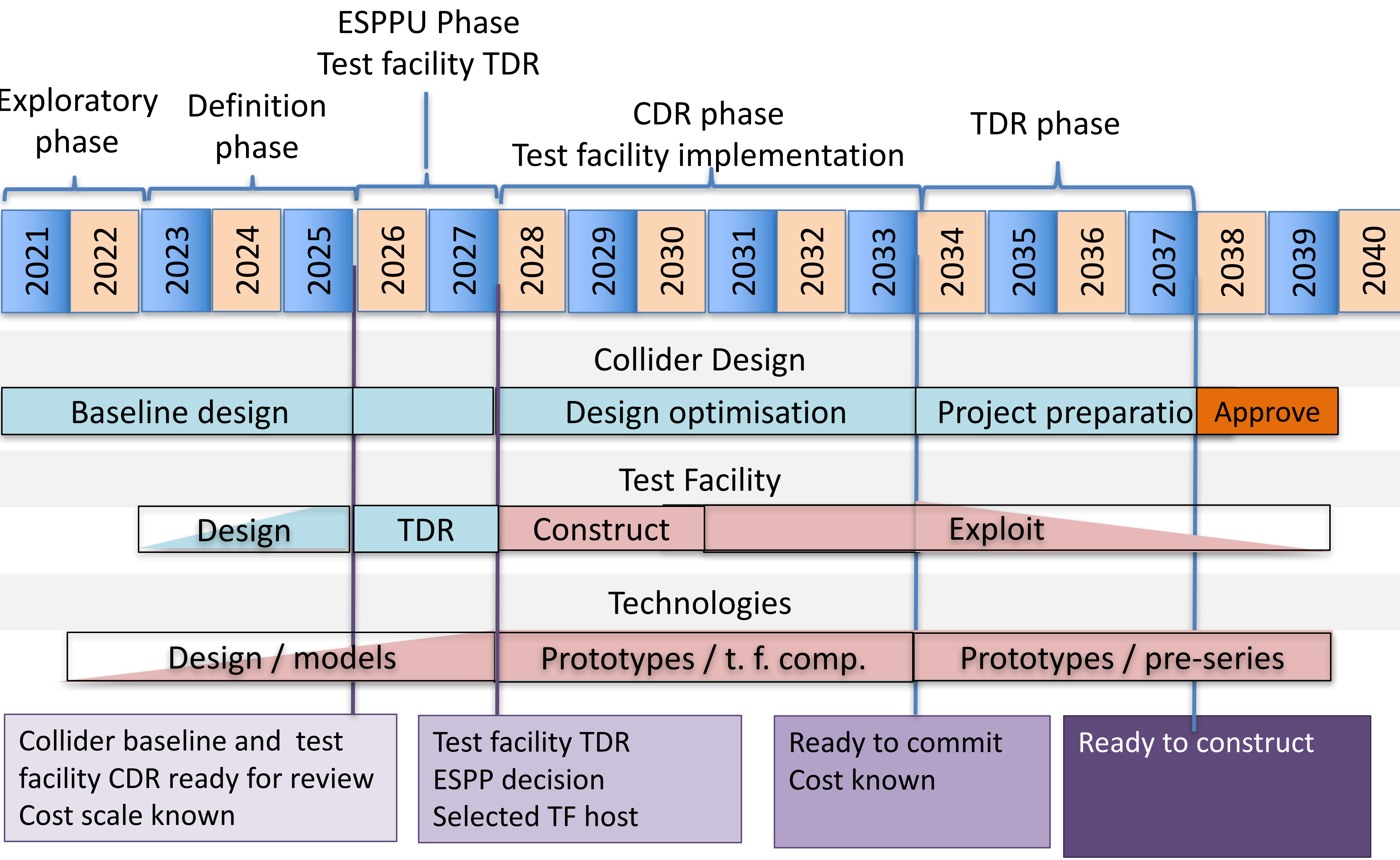
Scope:

- Focus on two energy ranges:
  - **3 TeV**, if possible with technology ready for construction in 10-20 years
  - **10+ TeV**, with more advanced technology, **the reason to do muon colliders**
- Explore synergy with other options (neutrino/higgs factory)
- Define **R&D path**

Deliverable:

- Report supporting that the muon collider is a realistic option, including description of required R&D programme to arrive at CDR
- Conceptual design report for test facility

Technically Limited Long-Term Timeline



Luminosity Goals

Target integrated luminosities

$\sqrt{s}$	$\int \mathcal{L} dt$
3 TeV	$1\ \mathrm{ab}^{-1}$
10 TeV	$10\ \mathrm{ab}^{-1}$
14 TeV	$20\ \mathrm{ab}^{-1}$

Note: currently no staging
Would only do 10 or 14 TeV

- Tentative parameters achieve goal in 5 years
- FCC-hh to operate for 25 years
- Might integrate some margins
- Aim to have two detectors

Now study if these parameters lead to realistic design with acceptable cost and power

Tentative target parameters
Scaled from MAP parameters

Comparison:
CLIC at 3 TeV: 28 MW

Parameter	Unit	3 TeV	10 TeV	14 TeV
L	$10^{34}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$	1.8	20	40
N	10^{12}	2.2	1.8	1.8
f_r	Hz	5	5	5
P_{beam}	MW	5.3	14.4	20
C	km	4.5	10	14
<B>	T	7	10.5	10.5
ε_L	MeV m	7.5	7.5	7.5
σ_E / E	%	0.1	0.1	0.1
σ_z	mm	5	1.5	1.07
β	mm	5	1.5	1.07
ε	µm	25	25	25
$\sigma_{x,y}$	µm	3.0	0.9	0.63

Situazione attuale

- Collaborazione internazionale basata al CERN

  ➔ Design Study progetta una facility con sito @ CERN
- Lavoro Design Study suddiviso in WP
  - Distribuzione impegni come input al Collaboration Board ➔ Addenda al MoC

  ➔ forte connesssione con preparazione Roadmap – Muon Panel
  - Discussione e assegnazione attività da cofinanziare su prossimi progetti EU - Design Study ➔ test facility o parti cruciali della macchina – riunioni in corso
  - Stakeholders meeting per discutere contributi e impegno -
- Si parla di test facilities e di dimostratore ➔ certamente necessario dimostrare alcuni stadi di muon cooling (finale?) e farlo al CERN
  - Si prevede un programma di studi di prototipi in parallelo
  - Piani finanziari diversi a seconda del livello di preparazione della test facility:
    - Definizione dello scopo: CDR, TDR, …
    - Preparazione hardware necessario (test RF, disegno magneti, …)
  - Sinergie da esplorare: ad es. con ESS, nuSTORM/ENUBET

Attività in pianificazione

International MUON Collider Collaboration

- **Physics Potential**
- **Physics/Detector simulation**
- **Machine Detector Interface**
- Cooling + Targets
- Magnet
- RF
- Proton complex
- High Energy Complex
- Test facilities
- Synergies
- Detectors R&D

Ongoing INFN activities – synergies

- **Physics simulations:** direct/indirect discovery reach – VBF/VBS – precise Higgs measures
  - benchmarks at different energies steer machine parameters and experiment design
- **Experiment and Physics Validation** at different center of mass energies:
  - flexible framework: background and detector simulation, event reconstruction
  - detector requirements/performances ➔ **Detector R&D also within AIDAinnova**
- **Machine Detector Interface (MDI)** at different energies sets ➔ FLUKA**:**
  - beam induced background shaped by machine design/nozzles ➔ **experiment design**
- **LEMMA studies ➔ positron beam studies for FCCee with IJCL**
- **Targets/crystals simulations and R&Ds/test beams**
- **New interests INFN-Accelerators: Magnets, RF, beam dynamics, collective effects**

APPROVED EU projects

RISE project: aMUSE – INFN, UniPD, HZDR, LIP, PSI, UniRM on Muon Collider - US FNAL, BNL

I.FAST – MUST – MUon collider **STrategy** network – (***INFN****, CERN, CEA, CNRS, KIT, PSI, UKRI)*

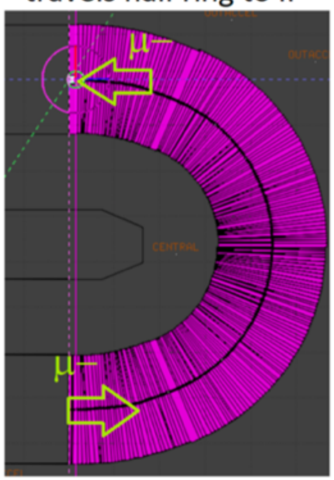
AIDAinnova – R&D trackers with timing/rad-hard crystals for calo/fast gas detectors/software framework future accelerators

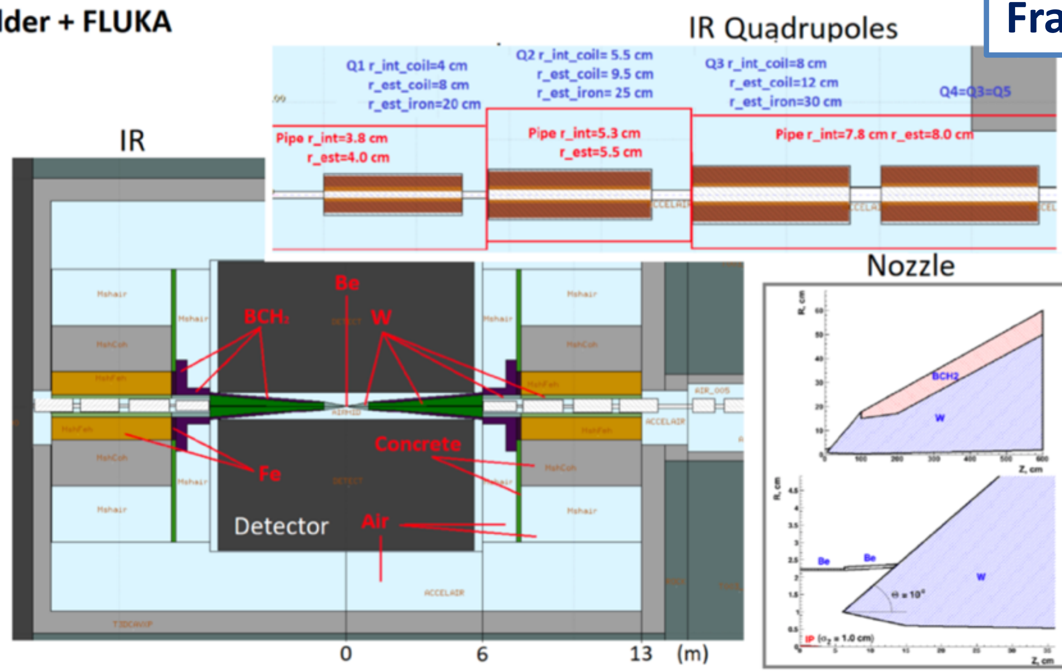
Machine Detector Interface
Layout Description @1.5 TeV

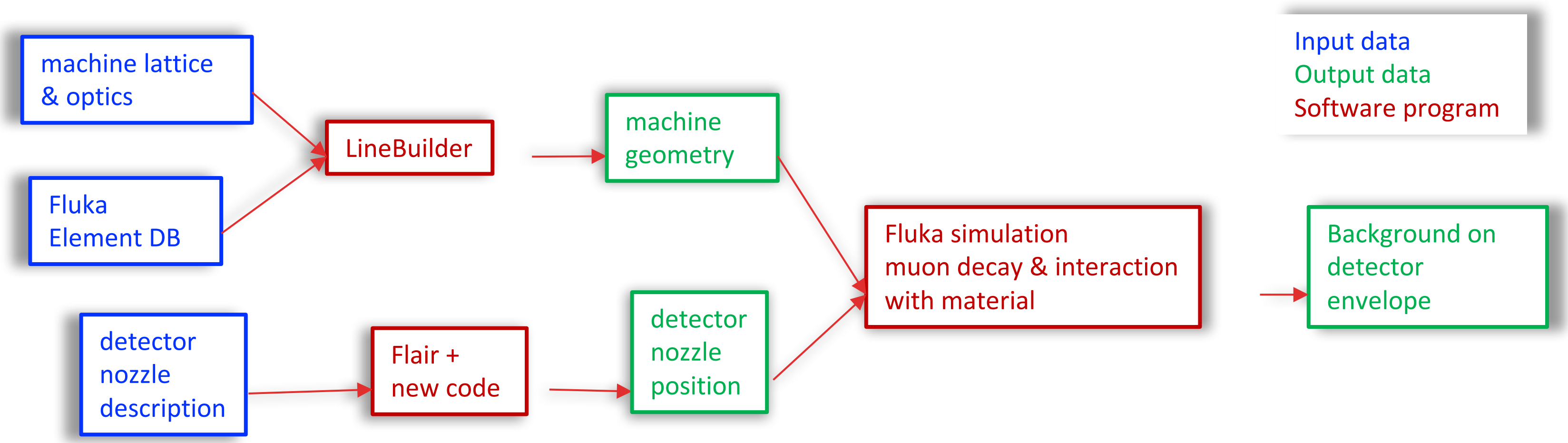
Francesco Collamati et al

Simulation tool: **LineBuilder + FLUKA**
Data analysis: **Python**

750 GeV muon beam travels half ring to IP

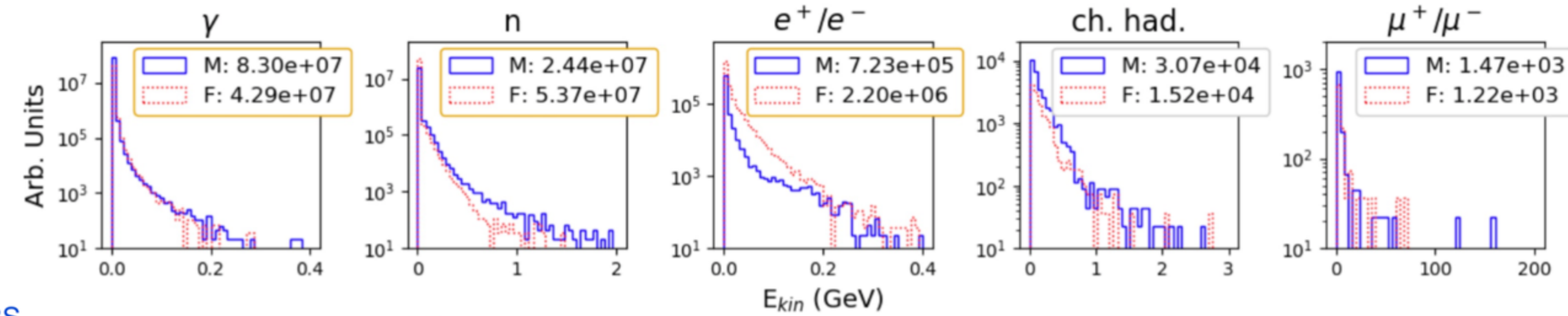




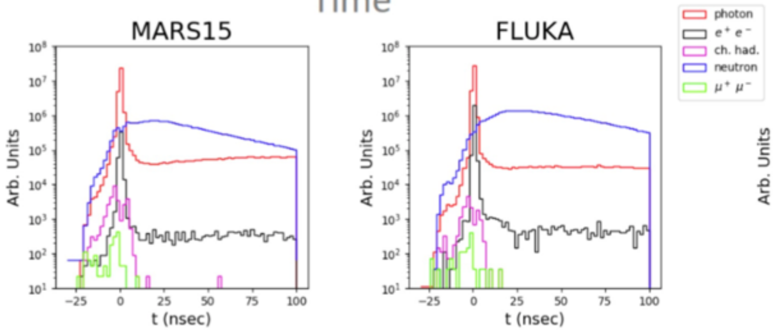


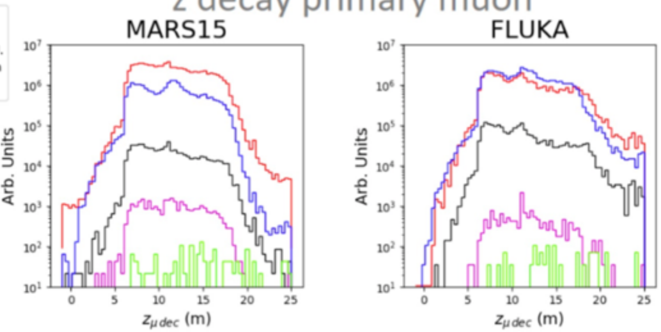
International MUON Collider Collaboration

The 1.5TeV case benchmark
MARS-FLUKA Results Comparison



MARS
FLUKA





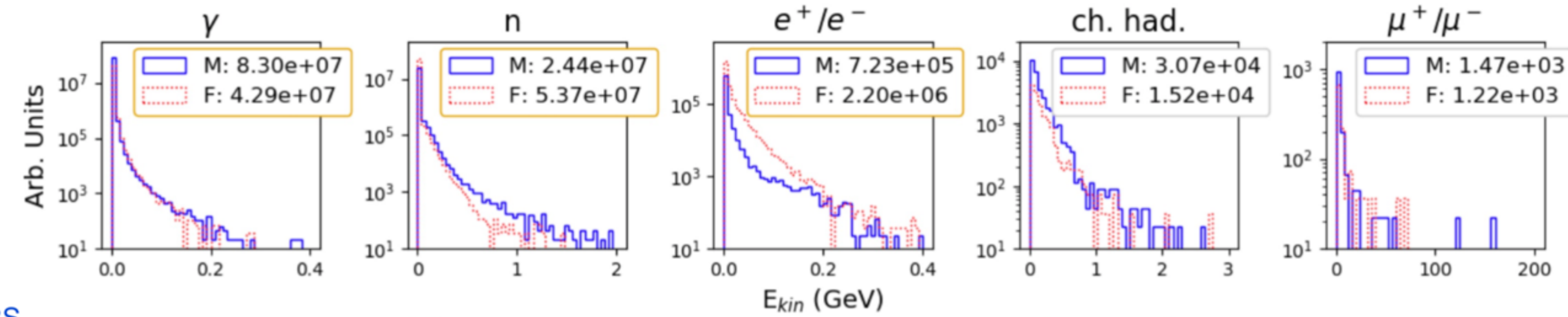
Residual discrepancies in **particles time and energy distribution**:

- Minor layout differences (passive elements, absorbers)
- Intrinsic differences between codes

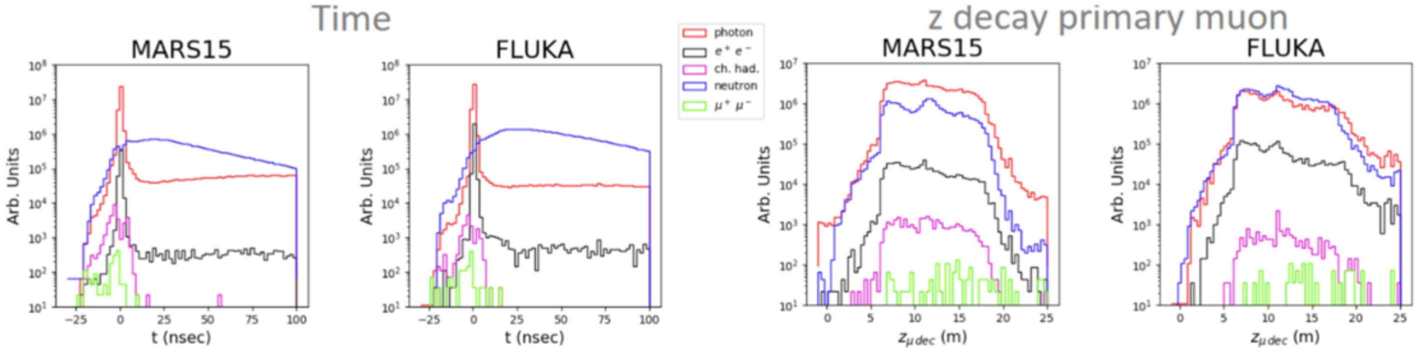
Camilla Curatolo et al.

The 1.5TeV case benchmark

MARS-FLUKA Results Comparison



MARS
FLUKA



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- Intrinsic differences between codes

Next steps: simulation studies

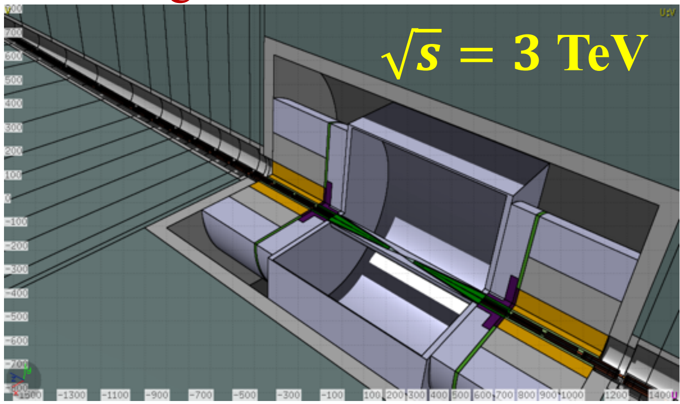
Results are in publication ***(arXiv:2105.09116)***

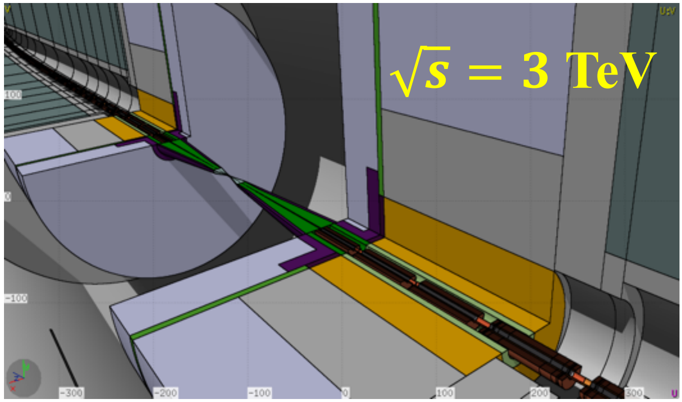
Donatella Lucchesi

- Study Beam-Induced Background at $\sqrt{s} = 3$ TeV, use MAP IR and the nozzle of $\sqrt{s} = 1.5$ TeV, then
  - Optimize nozzle
  - Optimize IR

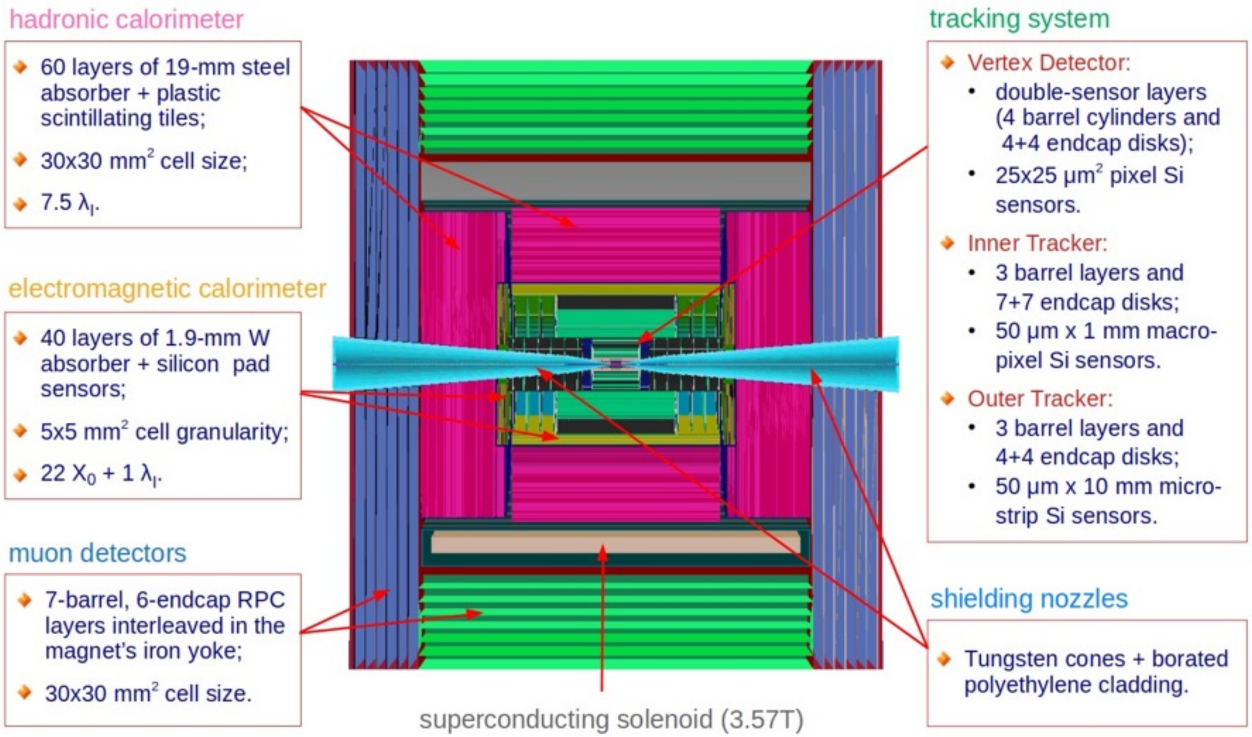
- Detector studies are just at the first step, a lot of room for improvements!
- Physics objects performance are very good even if not optimize, room for improvements in particular with ML techniques
- Dedicated studies and optimization is needed for the forward region, covered by the nozzle

A. Mereghetti





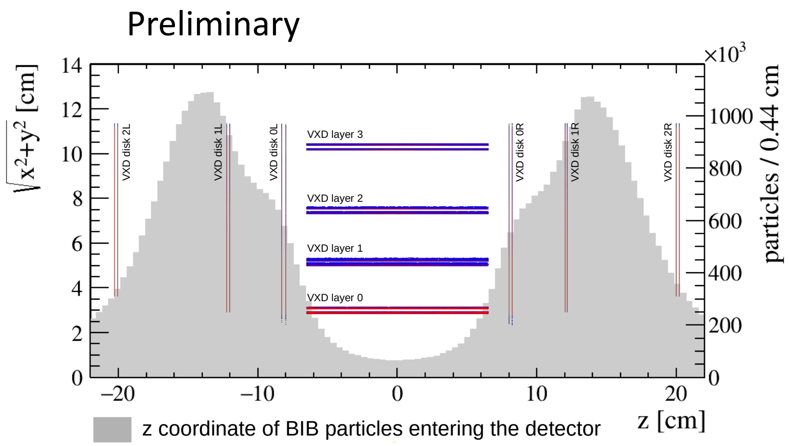
Detector - Full simulation

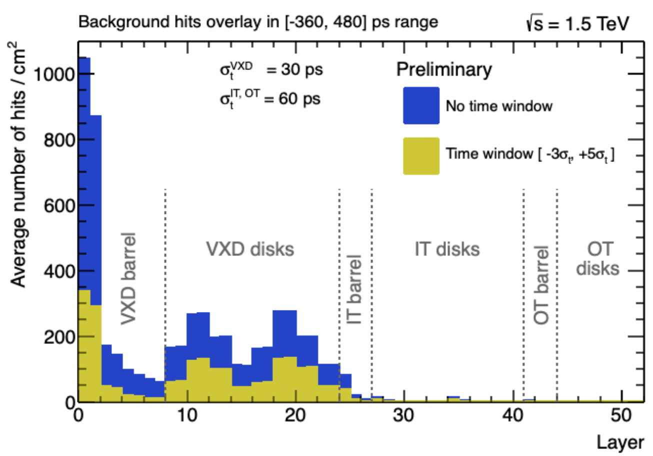


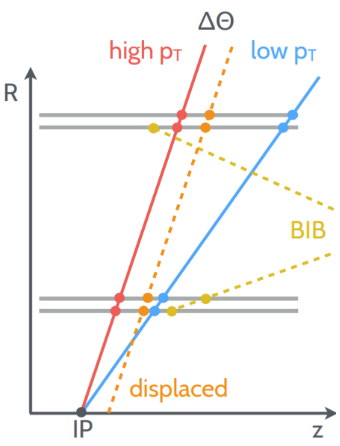
CLIC Detector technologies adopted with important modifications to cope with BIB

TO BE IMPROVED TUNED at higher $\sqrt{s}$

Tracker detector considerations





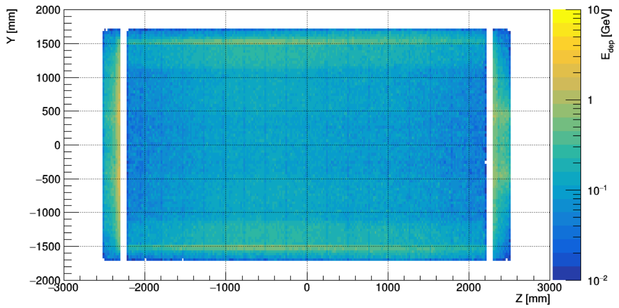


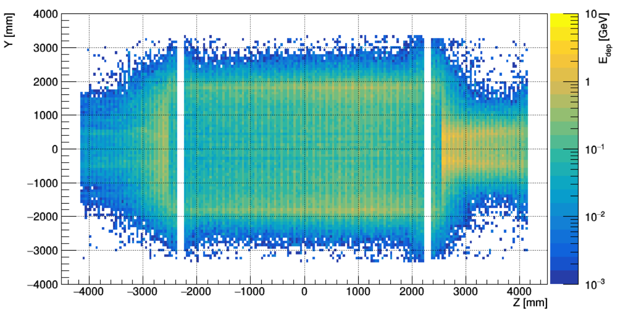
- Timing window applied to reduce hits from out-of-time BIB
- Granularity optimized to ensure $\lesssim$ 1% occupancy
- Realistic digitization in progress ➔ BIB suppression based on cluster shape
- If primary vertex could be known before ➔ effective angular matching of hit doublets
- To be tuned in presence of secondary vertices or long-lived particles

Other detector considerations

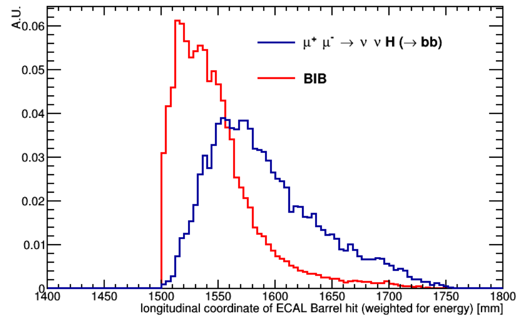
Calorimeters

BIB deposits large amount of energy in both ECAL and HCA



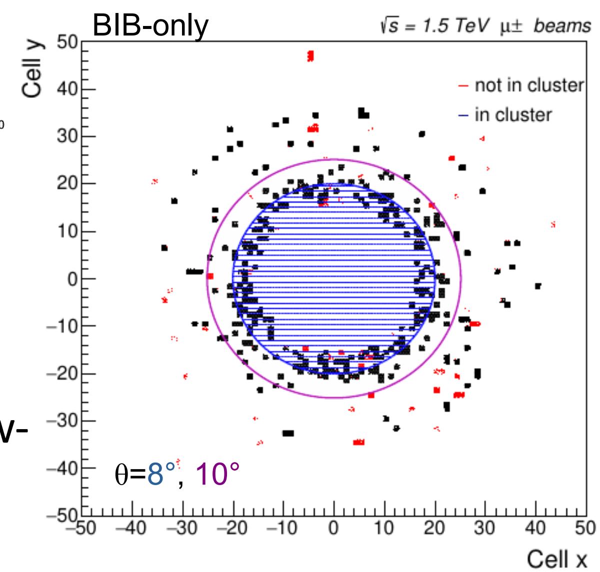


Timing and shower profile should be used in clusters reconstructions



Muon System

Low BIB contribution, concentrated in the low-radius endcap region



Detector – R&D

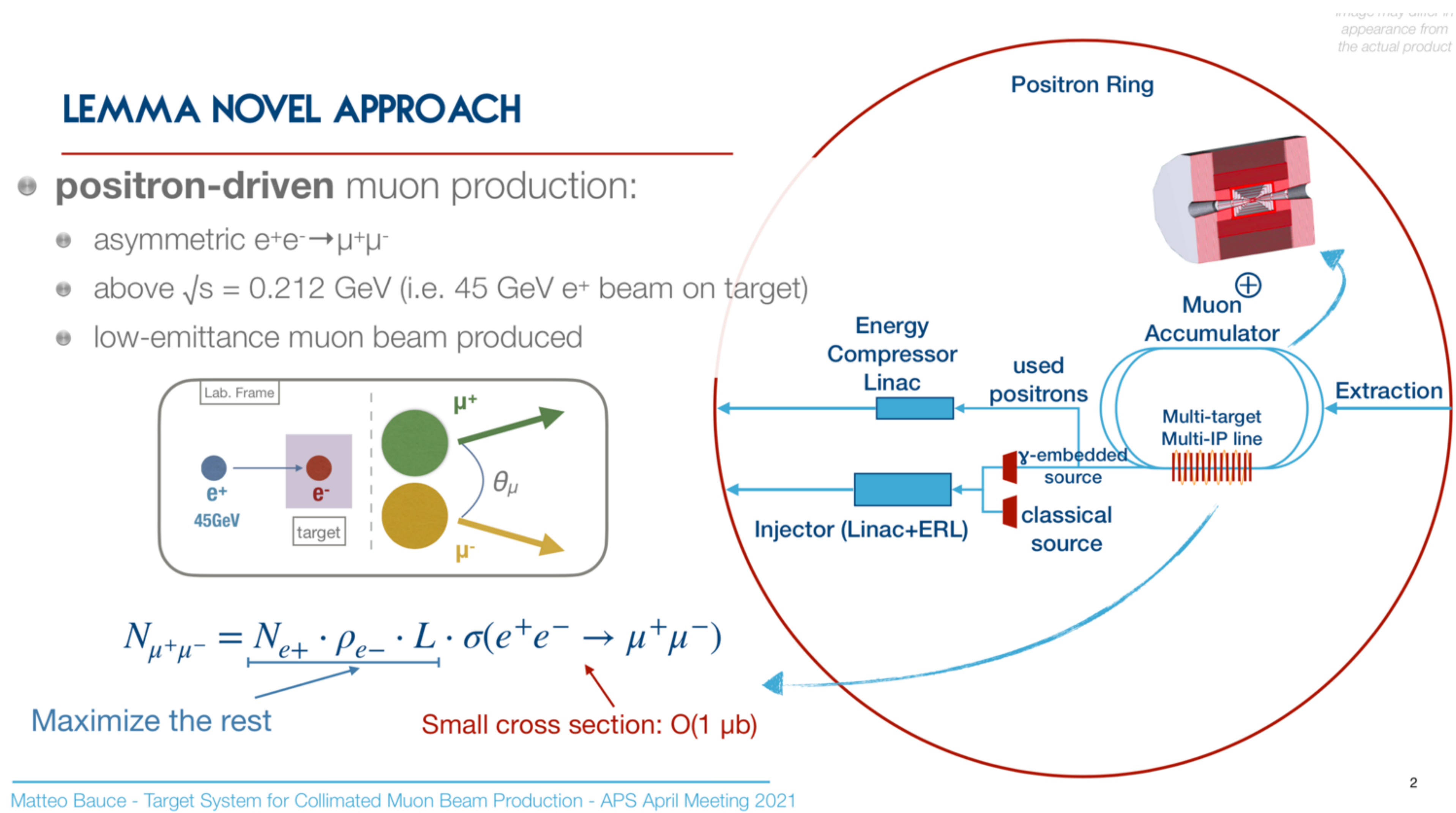
anche in sinergia con AIDAinnova

- Tracker – mainly LGAD …   RDS
- Calorimeters:
  - presentazione Ivano Sarra ECAL
  - HCAL to be investiated
- Muon detectors: under study

Calcolo @ PD++

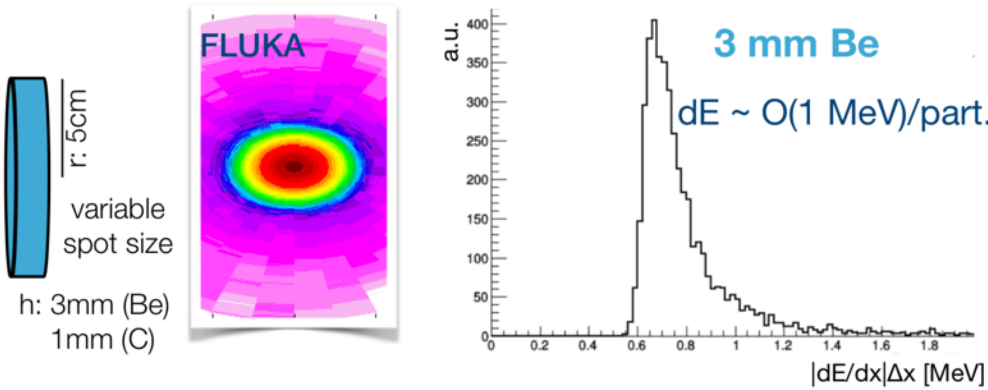
- 10 keuro – anticipo 2020 @ PD – spesi subito per un server
- Risorse disponibili al CNAF: 150 TB di disco + 6 CE con possibilità di sottomettere 10 jobs in simultanea
- **La scadenza di Snowmass è stata spostata di un anno**: la produzione massiva non è ancora iniziata, ci stiamo dedicando ad ottimizzare il modello di calcolo
- Circa 30 eventi di beam-induced background completi sono stati simulati, + diversi campioni di segnale
- Stiamo spostando i file da Cloud-Veneto (dove per ora lo spazio è praticamente esaurito) allo SE del CNAF
- Al momento il limite principale è la RAM richiesta da alcuni job che è superiore al limite massimo ammesso sulla grid (Cloud-Veneto garantisce maggiore flessibilità in questo senso)
- Stiamo lavorando per ottimizzare

Bersagli – LEMMA @ RM1-RM3-LNL- MIB

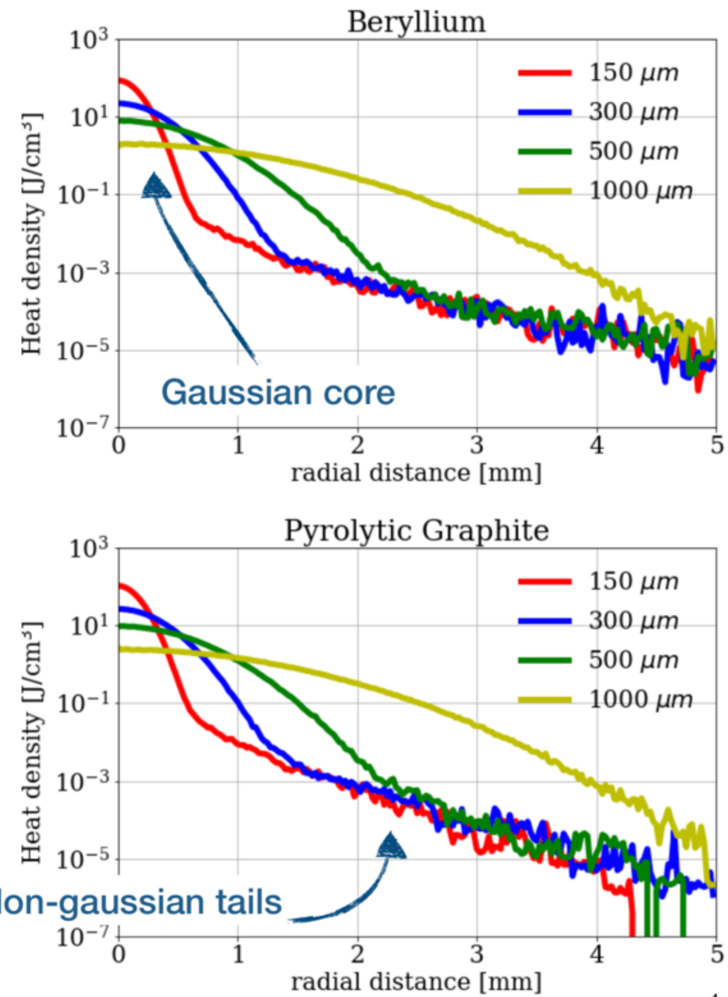


Simulations

ENERGY DEPOSIT SIMULATION



- FLUKA simulation of deposited energy from a single positron bunch
- Converted into Heat density for different target materials and thicknesses



Bersagli – LEMMA @ RM1-RM3-LNL- MIB

Thermo-mechanical test for targets
Roma I @ Dipartimento SBAI + FISICA

Future R&D: theoretical activity

1. Numerical simulations for the evaluation of thermomechanical stresses on various muon collider architectures. The study can be extended to several targets (solids, liquids), several geometries, and eventually to other kind of particles

2. Theoretical-experimental fit for the determination of the thermal and elastic parameters of the targets. This activity should be performed together with the experimental activity for the nondestructive testing of materials.

This work will be pursued within the newly formed International Muon Collider collaboration.

Experimental plans

Future R&D: experimental activity

1. Measurement of the thermo-elastic properties of Graphite disks in a wide temperature range.

2. Measurement of thermal diffusivity and infrared emissivity via photo-thermal radiometry and infrared thermography. A training activity will be carried out to use the infrared camera in passive regime for emissivity measurements and surface temperature estimation, and in active regime with a lock-in system for the determination of internal fractures.

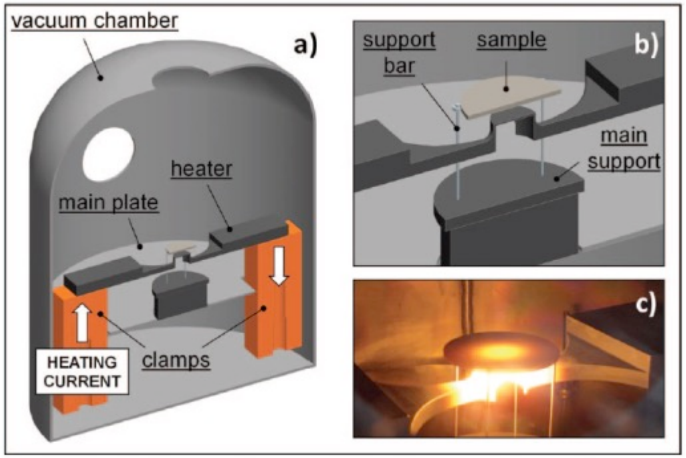
3. Detection of possible damage and thermomechanical stress when the target is subjected to intense laser beams. In fact, the thermomechanical performance of the target can be easily tested with photons bunches, instead of positron bunches, so to perform the measurements with an easier optical setup. The intensity and pulse duration of the optical source should be chosen so to generate analogous space-temporal temperature variations.

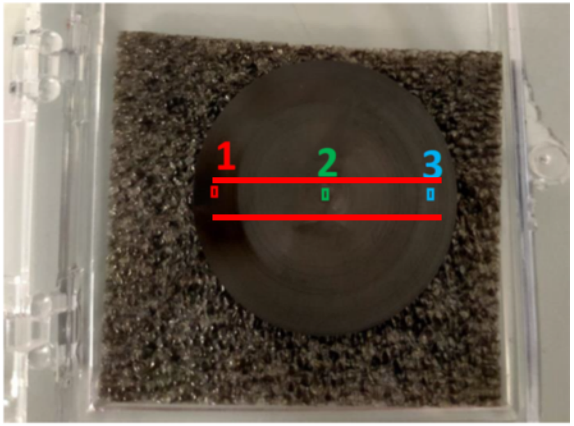
First surface profile scan with thermo-cycled graphite targets

Laboratorio di fisica delle superfici – Roma Tre

Targets provided by S.Corradetti (LNL) :

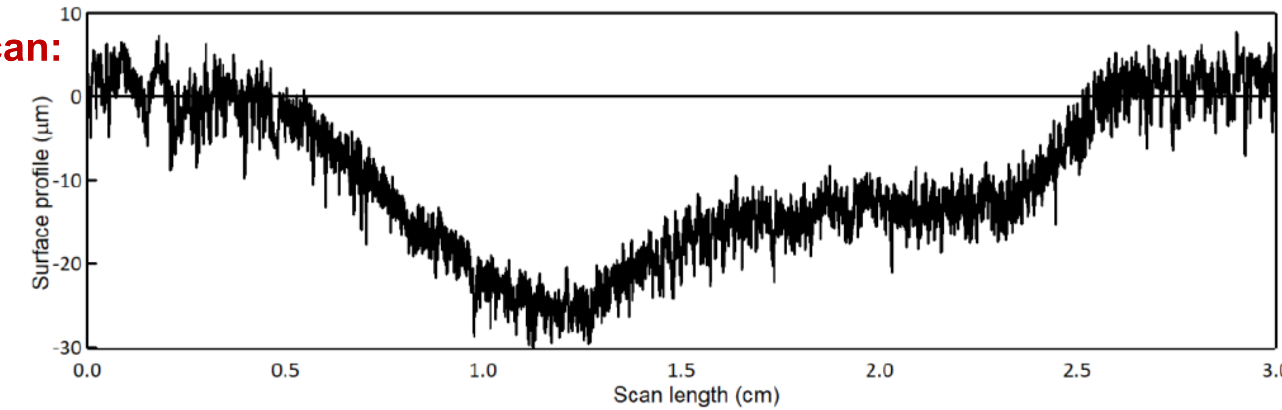
- 2 graphite disks: thickness 1 mm, radii 1.5 and 2.0 cm
- Machine cut @LNL in 2017 from graphite cylinders POCO EDM 3
- Both thermo cycled ~ 5 times in vacuum: Tmax ~ 1500 °C in the center (~1100 °C on the edges)
- Thermal conductivity measured (optimal function well reproduced)





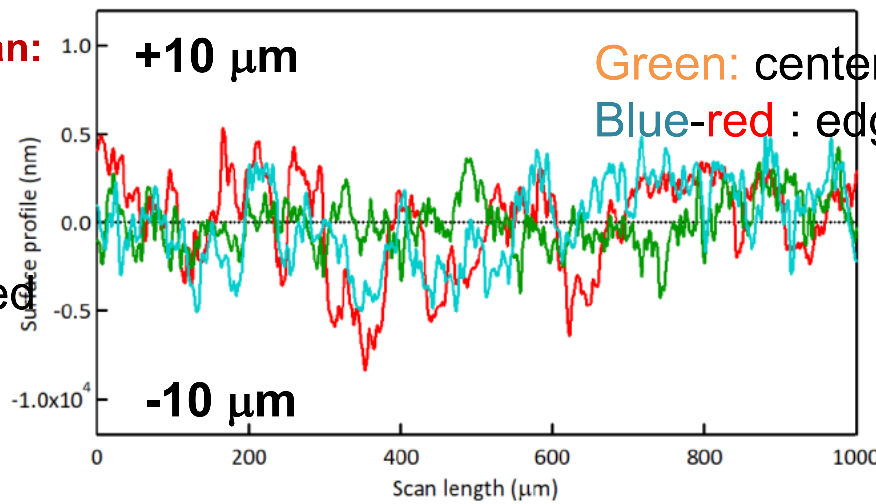
On each target Profile Scanned
3 regions 1x2 mm² and 2 segments «almost-diameters»

Diameter scan:



Area scan:

10 profile scans averaged in each selected region

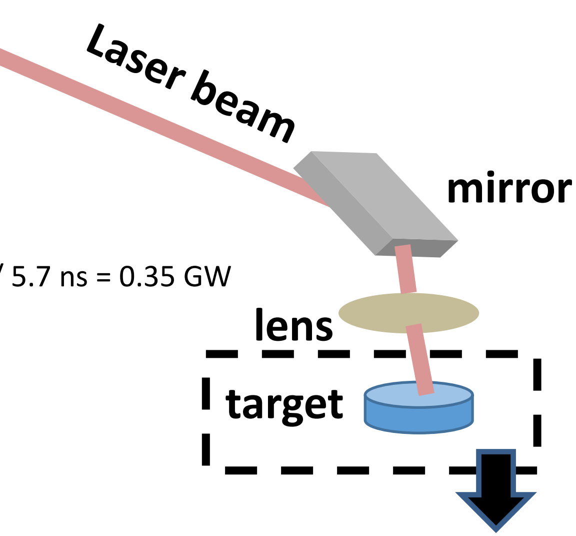


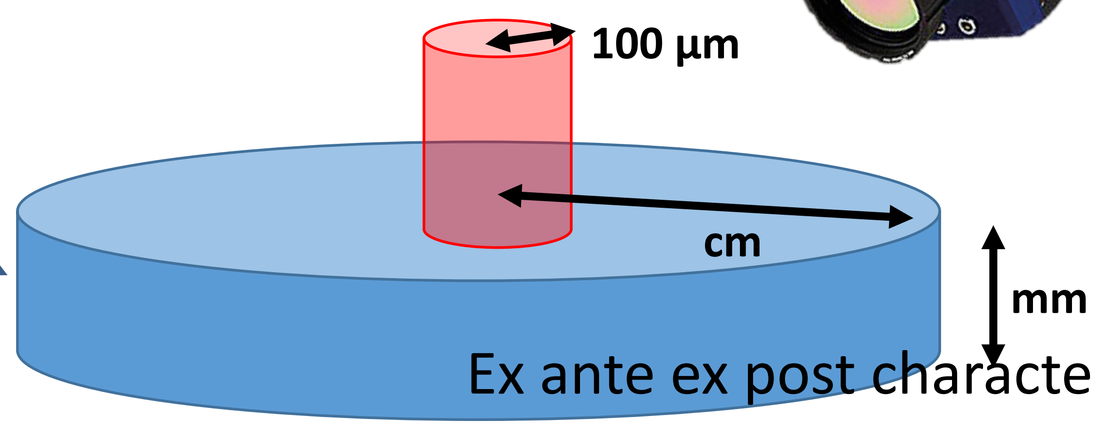
good local planarity

Significant surface effects on larger distances, to be understood

Nd:YAG laser
Bicocca + Roma I

Lunghezza_d'onda (nm) 1064
Laser output pulse energy (J) 0.69
Peak power (mW) STIMATO
= pulse energy (J) / Pulse width (s) = 0.69 / 5.7 ns = 0.35 GW
Average power (mW) 6900
Pulse repetition frequency (Hz) 10
Pulse width (s) 5.7ns





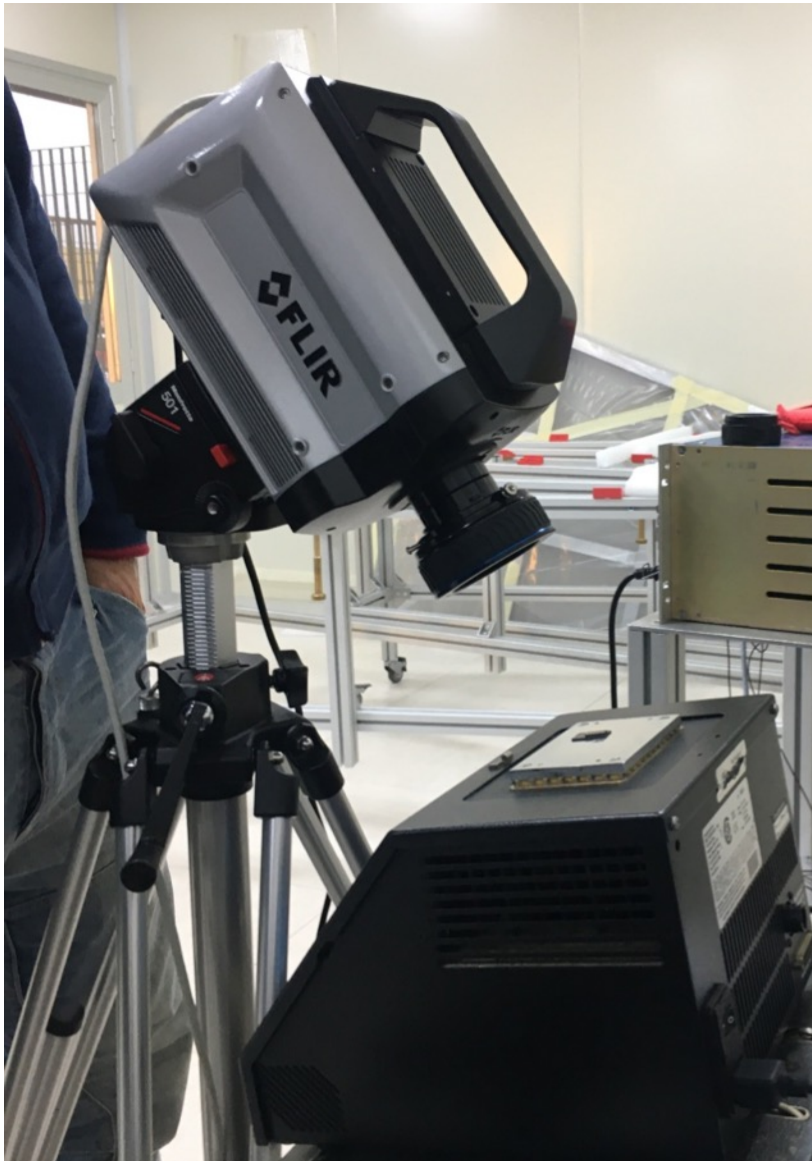
Infrared Camera
FLIR X6901sc SLS
LNF

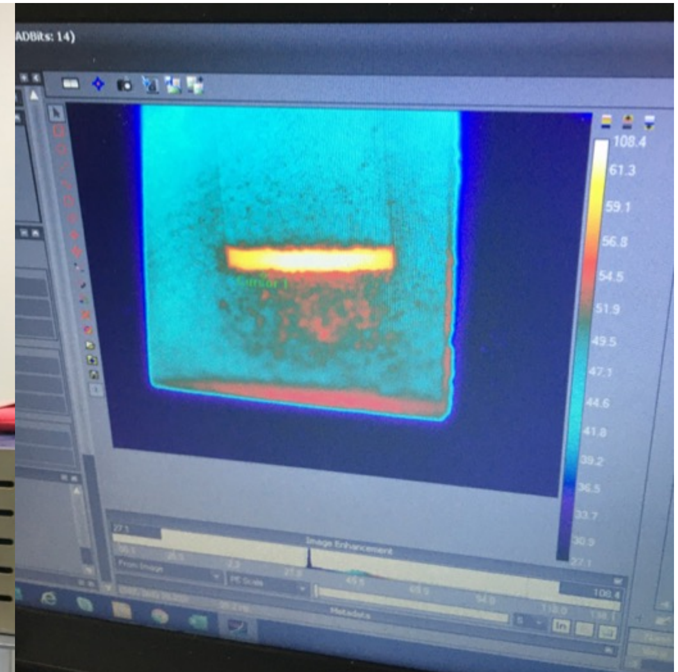
Ottica 17 mm, calibrata -80°C +300°C
Modifiche proposte
1) Ottiche di adattamento ad uso microscopi
2) Corso FLIR per aggiornamento utilizzo camera

Graphite Target
PoliTo – Legnaro - CERN

Ex ante ex post characterization
Roma 3 + Roma 1

IR Thermography measurements @ LNF before calibration (Swedom) of the camera



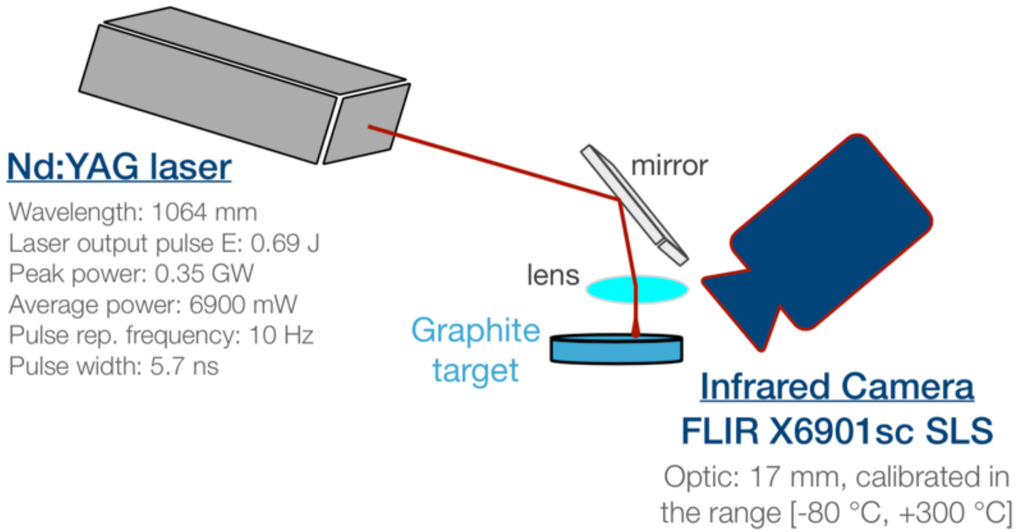


Beam test planning

PLANNING AHEAD

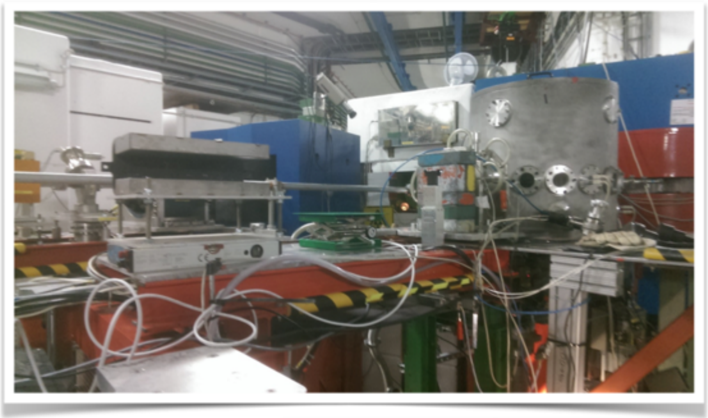
Target crash test with photons

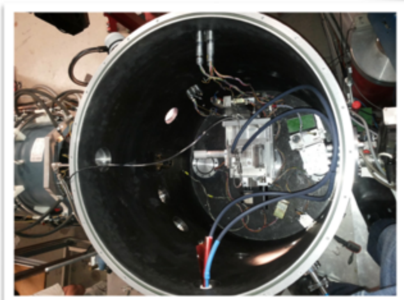
Ex ante ex post characterisation



Irradiation tests with electrons at MAinzer Microtron facility (Mainz, D)

Beam intensities: 1 nA — 50 μA
Beam spot size: down to 10 μm





Compare model predictions with experimental data!

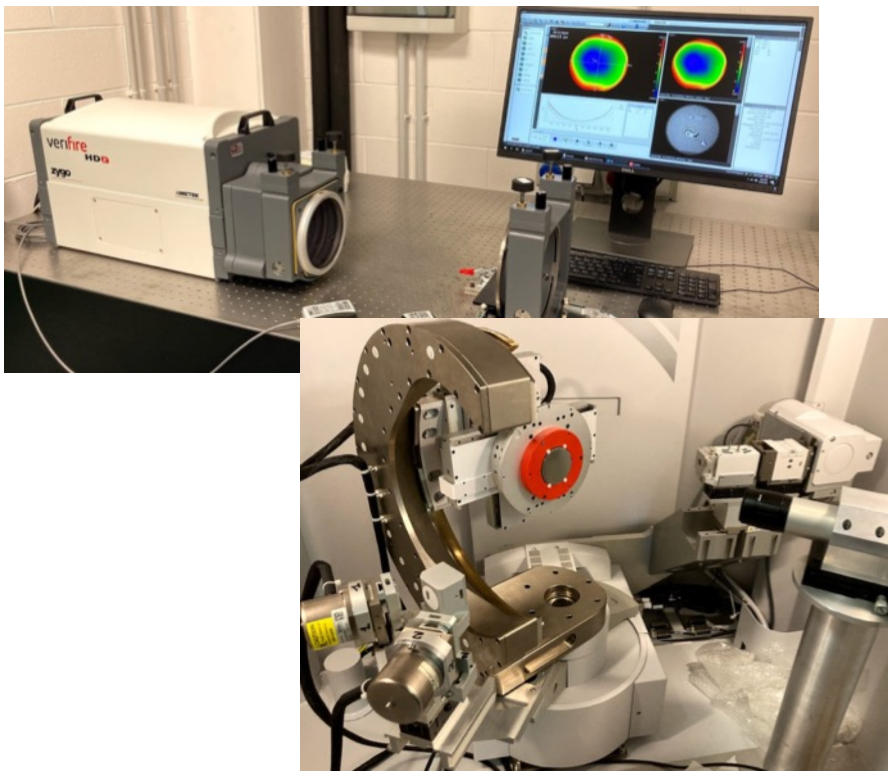
Attività: cristalli @ FE

1. **CRISTALLI CURVI**:
   - realizzazione di un cristallo curvo in silicio per studiare la deflessione di fasci di muoni: tale interazione non è mai stata osservata sperimentalmente, e risulterebbe utile in vista della collimazione e manipolazione di fasci in un muon collider
   - ottimizzazione dei parametri del cristallo da definire in collaborazione coi vari gruppi della collaborazione, in particolare col gruppo del CERN.

2. **CRISTALLI PER SORGENTE DI POSITRONI**:
   - progettazione di targhette cristalline (non curvate, cristalli ad alto Z) con geometria idonea alla sorgente di LEMMA: progettazione Monte Carlo in collaborazione con IJCL
   - uno degli aspetti cruciali da studiare riguarda la resistenza di questi materiali quando esposti a fasci di particelle di elevata intensità e/o per molto tempo

     → la qualità cristallografica di questi bersagli sarà investigata prima e dopo l'irradiazione con fasci di elettroni di elevata intensità e/o per diverso tempo (es. con protoni ad HiRadMat o all'acceleratore MAMI con fascio continuo di elettroni di circa 1 GeV in Germania) tramite tecniche utilizzate per la determinazione del danno indotto da radiazione su materiali cristallini (diffrazione di raggi-x con luce di sincrotrone per caratterizzare il bulk dei cristalli e diffrazione di raggi-x ad alta risoluzione con sorgenti da laboratorio, Rutherford backscattering in modalità channeling presso le strutture INFN di Legnaro).

1. Cristalli per deflessione di muoni

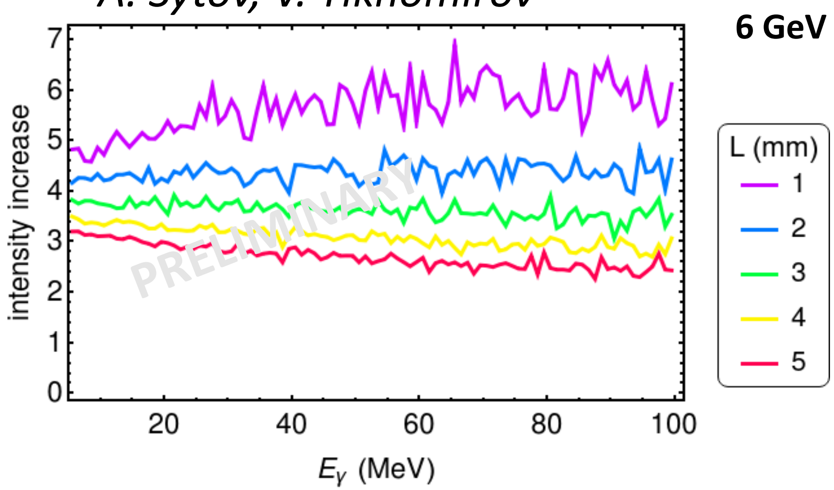


- M. Romagnoni already started the manufacturing of bent crystals and designed a setup for x-ray characterization
- A. Mazzolari designed a dedicated bending device
- Prime material charachterized through high-resolution x-ray diffraction and laser interferometry

2. Cristalli per sorgenti di positroni

- Monte Carlo simulation to optimize the W crystal target length. Between 1 and 2 mm should be the best choice

A. Sytov, V. Tikhomirov



- M. Romagnoni already started the W samples crystallographic characterization via XRD and plan to characterize also a sample purchased by the IJCL. ➔ Si pianifica di fare dei test in RBS a LNL in collaborazione con D. De Salvador (UNIPD&LNL) nei prossimi mesi
- L. Bandiera is coordinating the preparation of an irradiation test at MAMI (October 18-25) in collaboration with I. Chaikovska (IJCL)

  ➔ 3 people will be involved on site
- Strong synergy with the FCCee positron source activities
- The status of simulations presented in a talk at the IPAC'21 conference:
  L. Bandiera et al. "*Intense Channeling radiation as a tool for an hybrid crystal based positron source for future colliders*" on the 25^{th} May 2021

RICHIESTA SBLOCCO sj: 4 keu

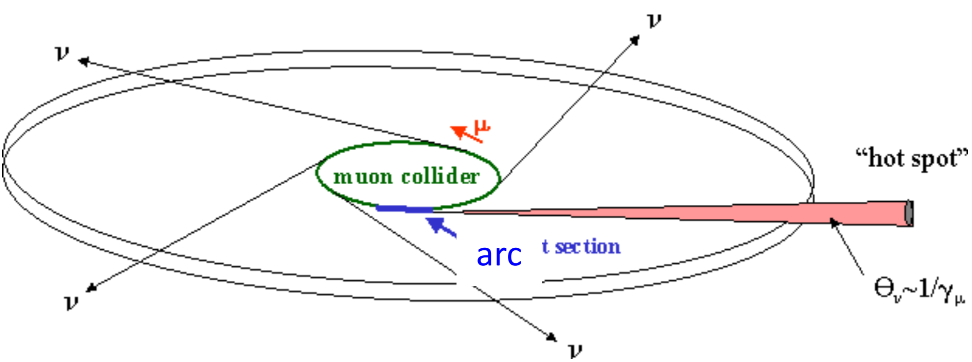
per effettuare le topografie a raggi-x presso ERSF: caratterizzazioni fondamentali prima e dopo aver esposto il fascio al cristallo al fine di valutare gli effetti del fascio sulla struttura del cristallo

extras

Deliverables for the Roadmap

- Should focus on concrete programme that we want to propose
- What is needed as input for next for Strategy update to make informed decisions?
  - What will be reasonable concerns regarding the muon collider feasibility?
  - What do we need before to address the concern?
  - What do we need to prepare for the test facility?
  - And the other R&D programme?
- Probably should think in terms of scope from the beginning
  - For each R&D item define how much detail will be needed
- Summarise R&D challenges to justify programme and also what we leave out
- CERN DG (and others) would like to have cost scale for test facility and collider as soon as possible (within a year if possible)

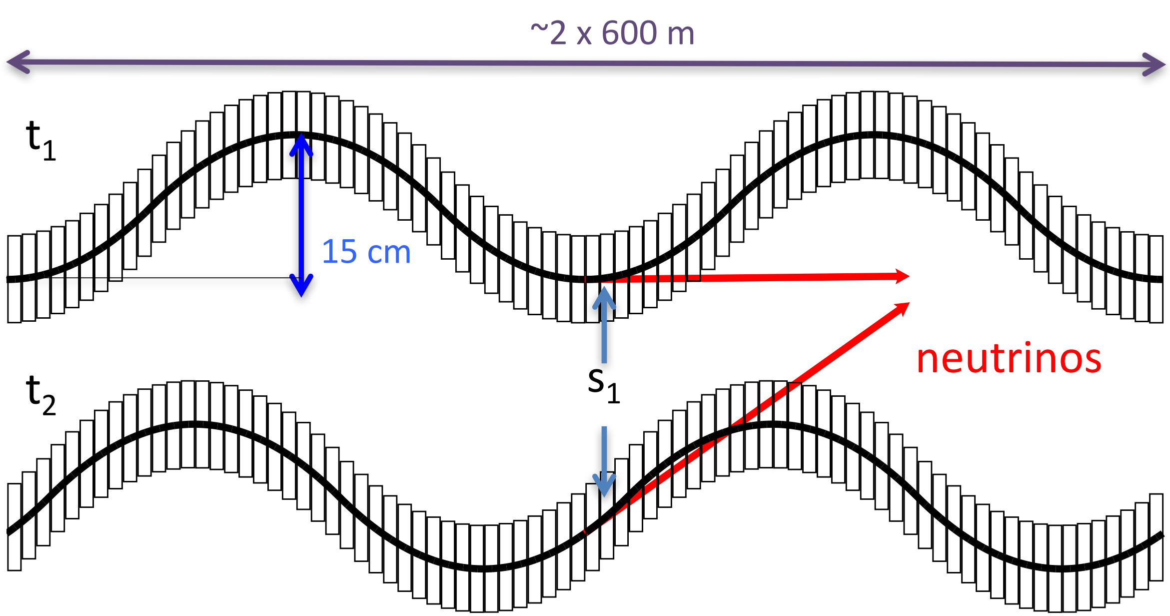
Neutrino Flux Mitigation



Legal limit 1 mSv/year
MAP goal < 0.1 mSv/year
Our goal: arcs below threshold for legal procedure < 10 μSv/year
LHC achieved < 5 μSv/year

3 TeV, 200 m deep tunnel is about OK

Need mitigation of arcs at 10+ TeV: idea of Mokhov, Ginneken to move beam in aperture
our approach: move collider ring components, e.g. vertical bending with 1% of main field



Opening angle ± 1 mradian

14 TeV, in 200 m deep tunnel comparable to LHC case

Need to study mover system, magnet, connections and impact on beam

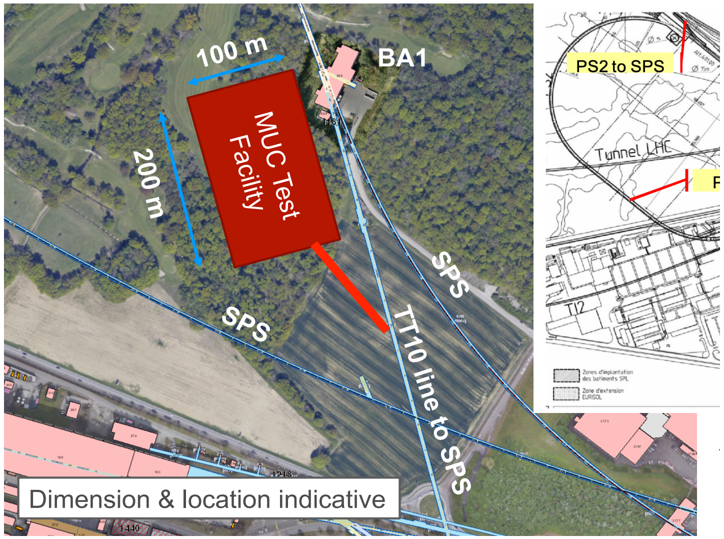
Working on different approaches for experimental insertion

Demonstration Programme

Core test facility to demonstrate muon cooling
- needs muon production with reasonable intensity but below real collider (e.g. 10 kW target)
- Identify potential sites
  - At least one good candidate at CERN
  - ESS, US labs?

Willingness of TIARA to supports as EU Design Study
Need to define scope and involvement for EU and prepare commitments

Models and prototypes of key components
- magnets
- RF systems
- target
- …



Programme needs to be modular
Tentative rough cost scale 500 CHF
Initial test facility material cost about 150 MCHF?

But not to forget:
- The collider justifies the demonstration programme

FLIR X6901- Features

FLIR

FLIR X6901sc SLS

P/N: 29421-201

Document identity

Publ. No.: 29421-201
Commit: 61327
Language:
Modified: 2019-11-20
Formatted: 2019-11-20

Website

http://www.flir.com

Customer support

http://support.flir.com

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Detector data	
Detector Type	Strained-Layer Superlattice
Spectral Range	7.5 µm (lower), 11.5-12.5 µm (upper)
Resolution	640 x 512
Detector Pitch	25 µm
Thermal Sensitivity/NETD	≤ 45 mK (≤ 40 mK typical)
Well Capacity	11.0 M electrons
Operability	≥ 98% (≥ 99% typical)
Sensor Cooling	Closed cycle rotary
Electronics	
Readout Type	Snapshot
Readout Modes	Asynchronous integrate while read Asynchronous integrate then read
Synchronization Modes	Genlock, Sync-in, Sync-out
Image Time Stamp	Internal IRIG-B decoder clock TSPI accurate time stamp
Integration Time	270 ns to 687 sec
Pixel Clock	355 MHz
Frame Rate (Full Window)	Programmable; 0.0015 Hz to 1004 Hz
Subwindow Mode	Flexible windowing down to 32 x 4 (steps of 32 columns, 4 rows)
Dynamic Range	14-bit
On-Camera Image Storage	RAM (volatile): 16 GB, up to 26000 frames, full frame SSD (non-volatile): >4 TB
Radiometric Data Streaming	Simultaneous Gigabit Ethernet (GigE Vision), Camera Link, CoaXPress (CXP)
Standard Video	HDMI, SDI, NTSC, PAL
Command and Control	GigE, USB, RS-232, Camera Link, CXP (GenICam protocol supported over GigE or CXP)

TERMOCAMERA LWIR SLS AD ALTE PRESTAZIONI

FLIR X6900sc SLS

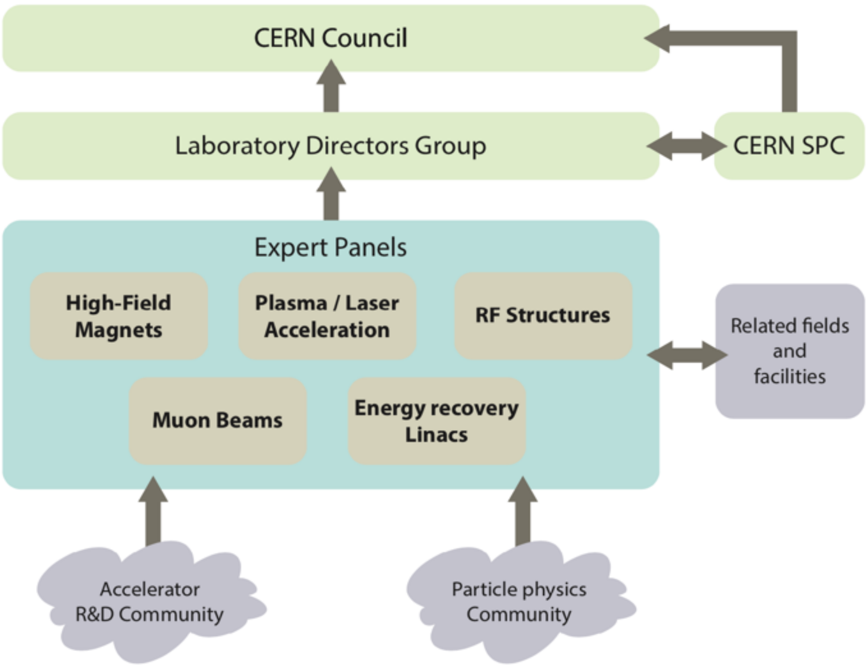
MODELLO: FLIR X6900SC SLS LWIR

Vai alla pagina di supporto »

La FLIR X6900sc SLS è una termocamera LWIR straordinariamente veloce e ad elevata sensibilità progettata per scienziati, ricercatori e ingegneri. Il sensore strained layer superlattice (SLS) offre velocità di integrazione più brevi, bande di temperatura più ampie e una migliore uniformità rispetto alle attuali alternative LWIR o MWIR. Dotata di funzioni di triggering avanzate, registrazione su RAM/SSD e di una ruota portafiltri motorizzata a quattro posizioni, questa termocamera è perfetta per effettuare fermi immagine di eventi ad alta velocità, sia in laboratorio che sul campo di prova.

Accelerator R&D roadmap

Fabiola Gianotti (CERN), LHCP, 7 June 2021



From 2020 ESPP:

"Innovative accelerator technology underpins the physics reach of high-energy and high-intensity colliders. It is also a powerful driver for many accelerator-based fields of science and industry"

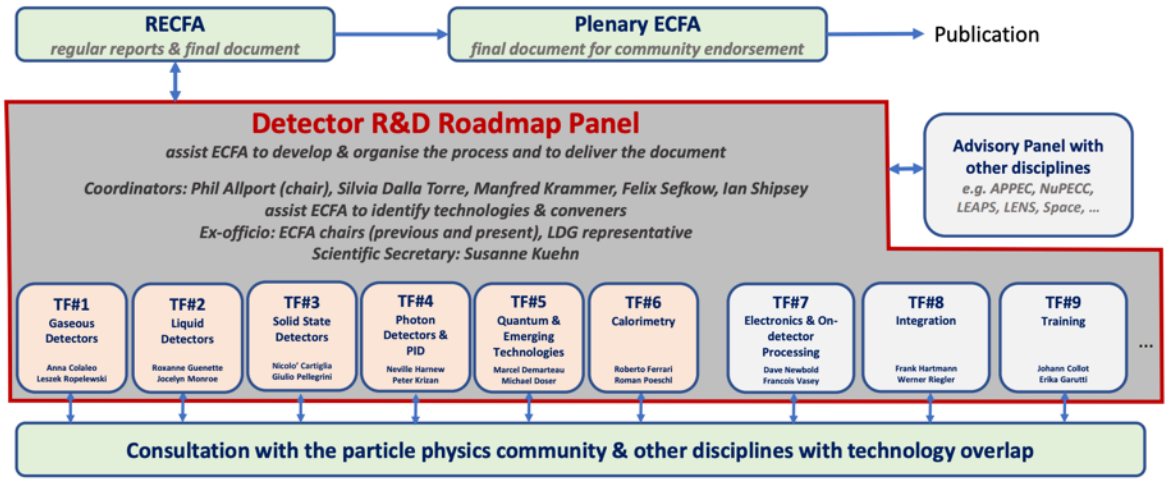
"The particle physics community should ramp up its efforts focused on advanced accelerator technologies, in particular that for high-field superconducting magnets, including high-temperature superconductors."

"The technologies under consideration include high-field magnets, high-temperature superconductors, plasma wakefield acceleration and other high-gradient accelerating structures, bright muon beams, energy revovery linacs."

"A roadmap should prioritise the technology, taking into account synergies with international partners and other communities … Deliverables for this decade should be defined in a timely fashion and coordinated among CERN and national laboratories and institutes."

Detector R&D roadmap

Fabiola Gianotti (CERN), LHCP, 7 June 2021



From 2020 ESPP:

"The success of particle physics experiments relies on innovative instrumentation and state-of-the-art infrastructures."

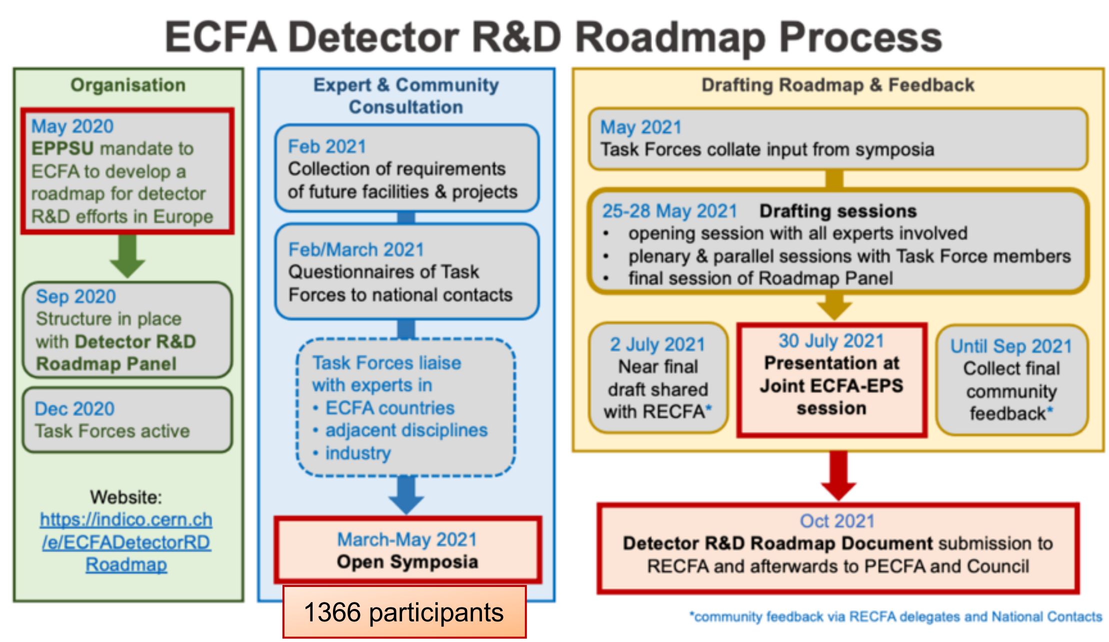
"The community must maintain a strong focus on instrumentation."

"Detector R&D programmes and associated infrastructures should be supported at CERN, national institutes, laboratories and universities."

CERN: "R&D for future detectors" strategic initiative established in 2018

"The community should define a global detector R&D roadmap."

"The roadmap should identify and describe a diversified detector R&D portfolio that has the largest potential to enhance the performance of the particle physics programme in the near and long term."



Attività

SEDE	RL	PHYSICS	FULL SIM	TARGETS	XTAL	LEMMA	Lumi	MDI	Exper	Tracker	Calo	Muons	TestBeam-LEMMA	Calcolo	Magnets R&D
BA	A. Colaleo	x	x	x					x			x	x	x	
BO	F. Maltoni	x													
FE	A. Mazzolari			x	x										
LNF	M. Boscolo			x		x					x		x		
LNL	S. Corradetti			x											
MI	A. Bacci					x									
MIB	M. Bonesini			x											
PD	D. Lucchesi	x	x				x	x	x		x		x	x	
PV	C. Ricciardi	x	x				x	x	x			x	x		
RM1	F. Anulli	x	x	x				x	x				x		
RM3	A. Passeri			x											
TO	N. Amapane	x	x	x			x	x	x	x	x		x		
TS	S. Levorato	x	x				x	x	x	x				x	

Richieste Complessive 2021

In K€

Struttura	A carico dell'I.N.F.N.																						A carico di altri enti
	missioni		consumo		altri_cons		seminari		trasporti		licenze-SW		manutenzione		inventario		apparati		spservizi		**TOTALI**		
BA.DTZ	13.50		13.50																		**27.00**		
BO	6.00																				**6.00**		
FE	9.00		25.00										11.00								**45.00**		
LNF	17.00		10.00																		**27.00**		
LNL	7.00		5.00																		**12.00**		
MI	10.00																				**10.00**		
MIB	4.50		5.00										4.00								**13.50**		
PD	20.00		30.00												5.00						**55.00**		
PV.DTZ	8.00																				**8.00**		
RM1	12.00		2.00																		**14.00**		
RM3.DTZ	6.00		4.50																		**10.50**		
TO	16.00	45.00	65.00																		**81.00**	**45.00**	
TS.DTZ	3.00														5.00						**8.00**		
	132.00	*45.00*	**160.00**										**15.00**		**10.00**						***317.00***	***45.00***	

Calcolo Tier1: Disco e CPU

Anagrafica

SEZIONE	NOME COGNOME	TIPO	CONTRATTO	QUALIFICA	RICERCATORI		TECNOLOGI		TOT. PERS.	FTE	FTE / PERS.
BA					0.95 fte	9 pers.	0 fte	pers.	9	1.0	0.106
BO					0.95 fte	4 pers.	0 fte	pers.	4	1.0	0.238
FE					0.4 fte	3 pers.	0.1 fte	1 pers.	4	0.5	0.125
LNF					1.8 fte	6 pers.	1.1 fte	4 pers.	10	2.9	0.290
LNL					0.15 fte	1 pers.	0.25 fte	4 pers.	5	0.4	0.080
MI					0.25 fte	2 pers.	0 fte	pers.	2	0.3	0.125
MIB					0.3 fte	2 pers.	0.1 fte	1 pers.	3	0.4	0.133
PD					3.65 fte	12 pers.	0.75 fte	3 pers.	15	4.4	0.293
PV					0.9 fte	5 pers.	0.3 fte	1 pers.	6	1.2	0.200
RM1					2.05 fte	7 pers.	0 fte	pers.	7	2.1	0.293
RM3					0.4 fte	5 pers.	0 fte	pers.	5	0.4	0.080
TO					1.9 fte	14 pers.	0.2 fte	2 pers.	16	2.1	0.131
TS					0.2 fte	1 pers.	0.2 fte	1 pers.	2	0.4	0.200
TOTALE					13.9 FTE	71 PERS.	3 FTE	17 PERS.	88	16.9	0.192

Sinergie con sigle/progetti in corso:

INFN-MC TimeSPOT

ERC e UFSD

AMUSE

Outreach – progetto CC3M

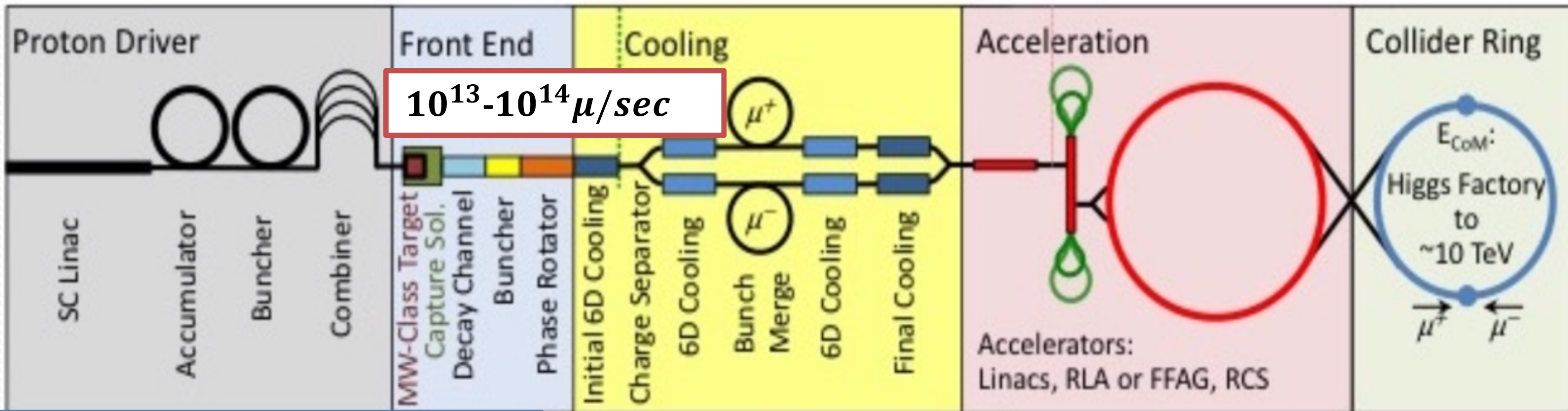
in fase di approvazione:

AIDAinnova I.FAST

CA e GE hanno espresso interesse

proton (MAP) vs positron (LEMMA) driven muon source

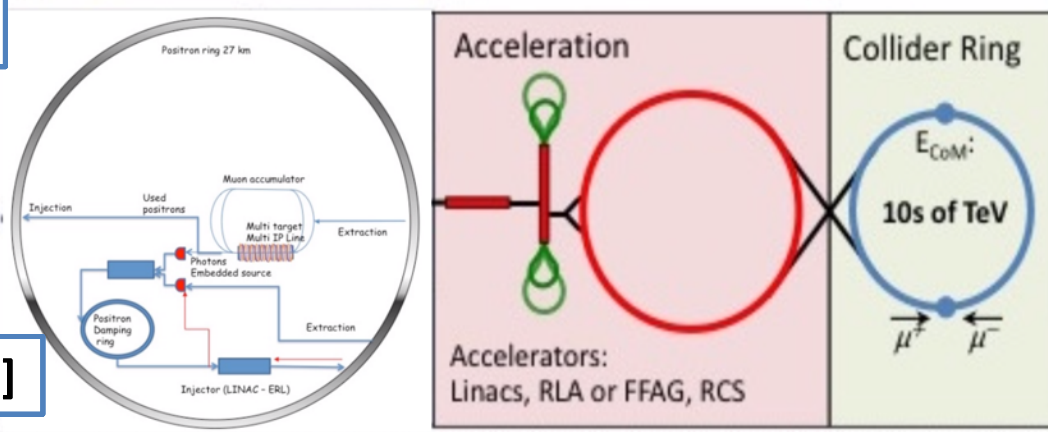
MAP



MUON JINST, shorturl.at/kxKU7

LEMMA

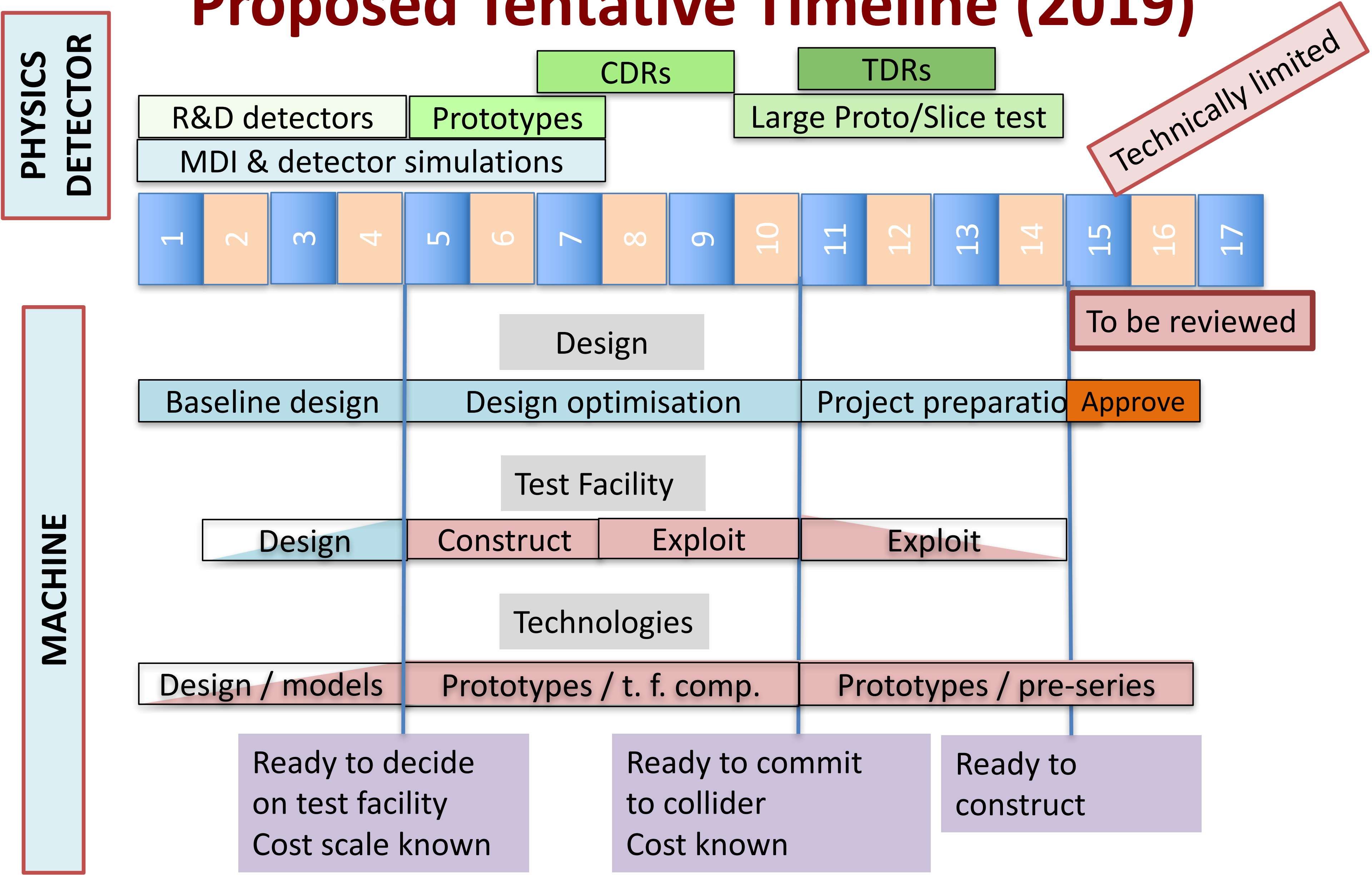
e+
source



arXiv:1905.05747v2 [physics.acc-ph]

➔ **need consolidation** to overcome technical limitations to reach higher muon intensities

Proposed Tentative Timeline (2019)



Physics Briefing Book [arXiv:1910.11775v2](https://arxiv.org/abs/1910.11775v2) [hep-ex]