INFN Ferrara

Diego Bettoni

Channeling 2010

Ferrara, 03 October 2010

INFN Ferrara in a Snapshot

- Founded in the 1980s
- 25 employees, 85 associates.
- Technical and technological services:
  - Mechanics Workshop and Design
  - Electronics
  - Computing
- Administrative Services

Research Activity

- Activity organized in the 5 traditional research lines of INFN (HEP, Astroparticle/Neutrino, Nuclear Physics, Theory, Technology/ Interdisciplinary)
- Sinergy with Physics Department
- Experiments at the INFN National Labs (LNF, LNL, LNGS) and overseas (CERN, SLAC, GSI, FZJ, JLAB).
- Characterizing activities:

  Experimental:
  - Nucleon Structure
  - CP Violation (K, B)
  - Precision measurements/Fundamental Physics

  Theory:
  - Neutrinos. Astroparticle.
  - Standard Model Physics.
  - Computational Physics and LQCD.

High-Energy Physics

BaBar

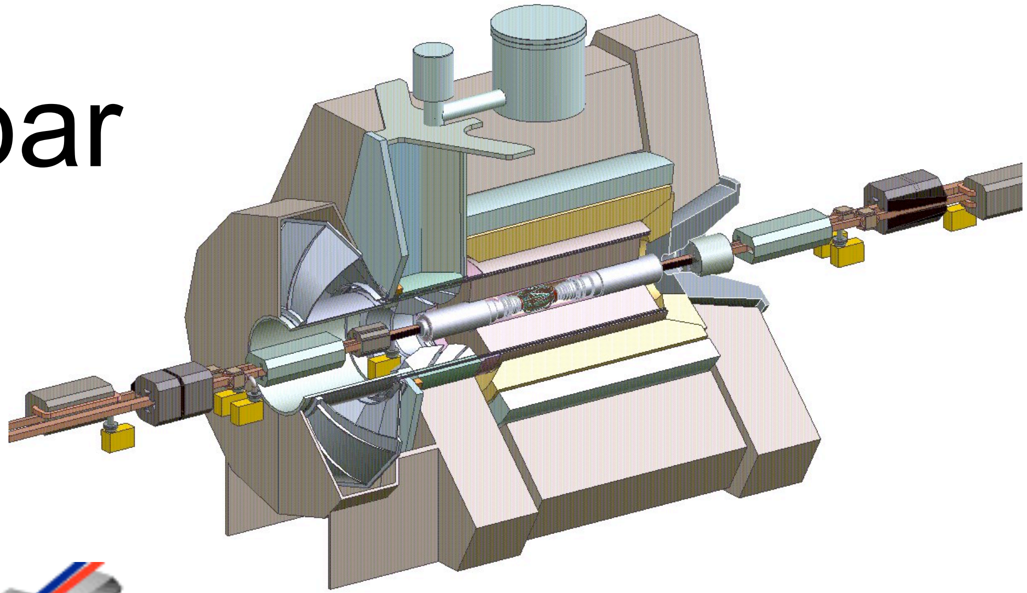
SuperB

LHCb

NA62

UA9

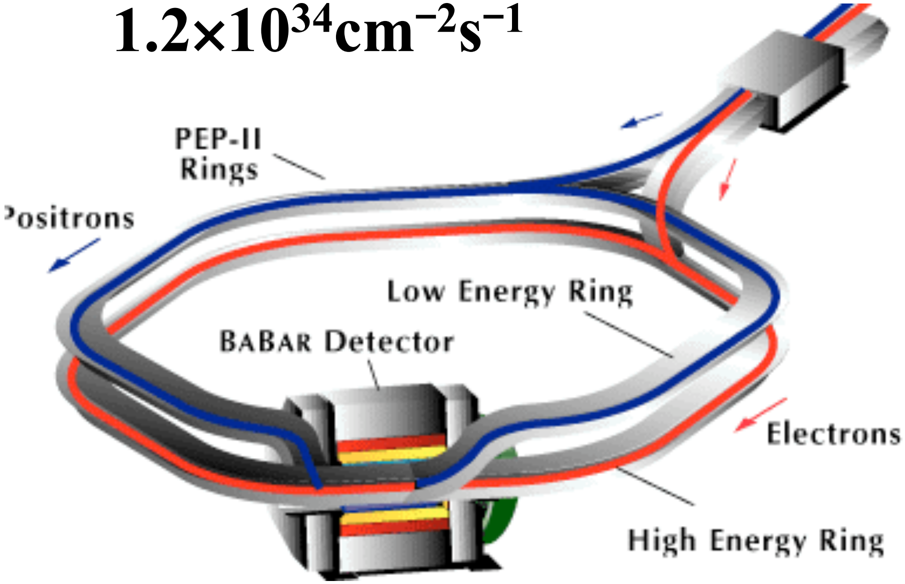
Babar



PEP-II at SLAC

9GeV (e^-) × 3.1GeV (e^+)
peak luminosity:

$1.2\times10^{34}cm^{-2}s^{-1}$

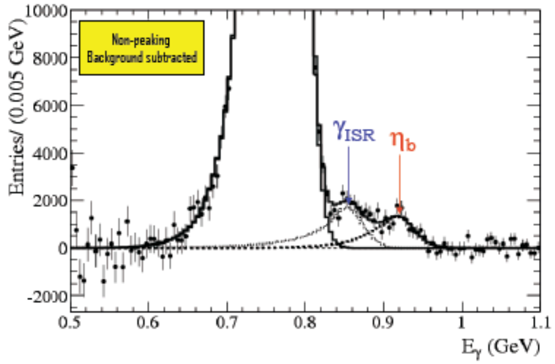


BaBar Activities in Ferrara

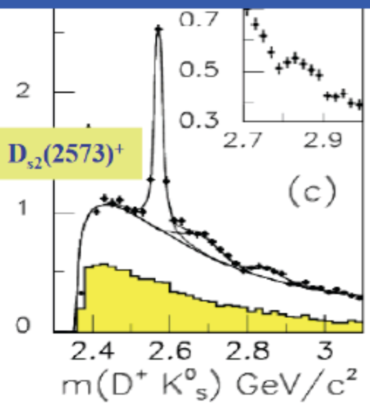
- Detector
  - Mechanics of microvertex detector
  - New High-voltage system of old (RPC based) muon detector
  - New muon detector (LST based)
- Physics
  - V_{ub}
  - Quarkonium Spectroscopy and search for new states

B factories recent results

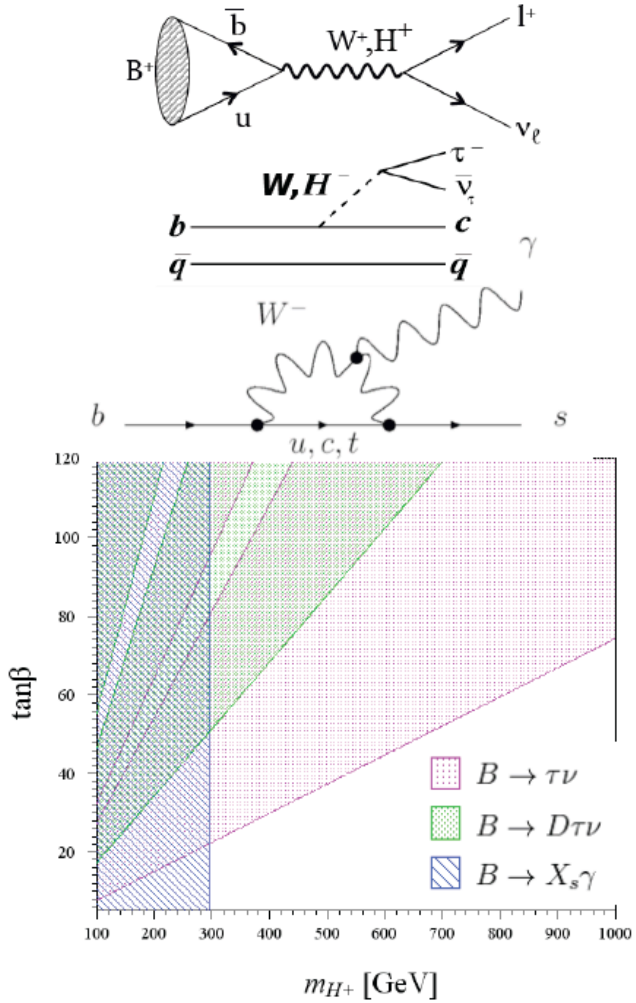
η_b discovery $\Upsilon(3S)\rightarrow\gamma\eta_b(1S)$



New DK state(s) at 2.86GeV/c²



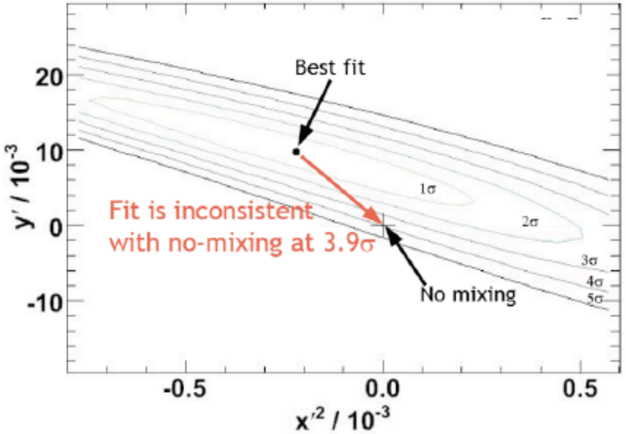
Limits on New Physics (2HDM-II) from B rare decays



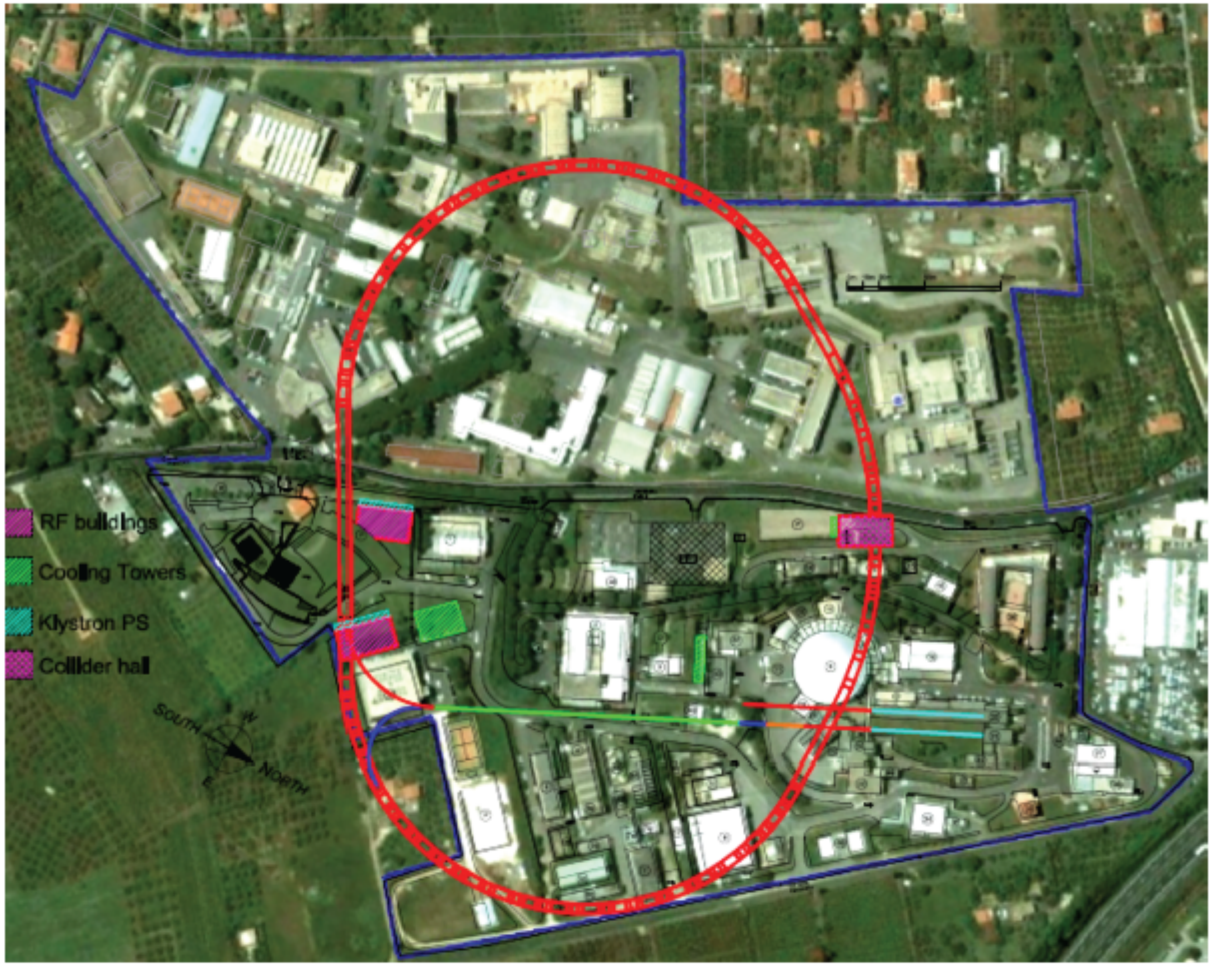
Evidence of D^0 mixing

See backup slides

See G. Casarosa talk at this conference



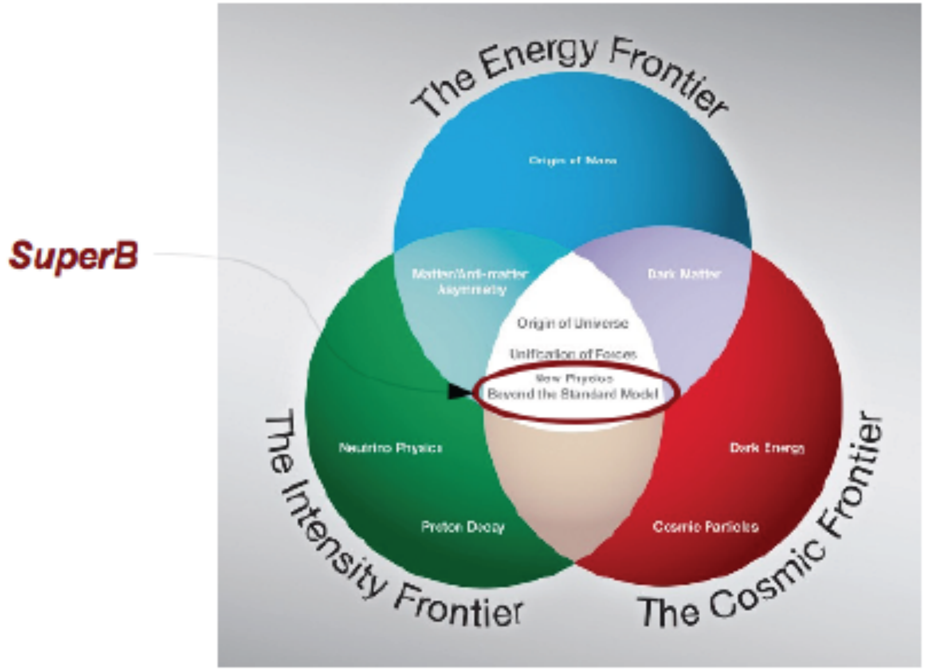
High-Luminosity ($L=10^{36} cm^{-2}s^{-1}$) flavor factory



SuperB Physics

- Exploration of CKM parameters at 1% precision.

- New physics:
  - in search for CP violation in D decays,
  - in search LFV in tau decays,
  - in search CP violation in tau decays.

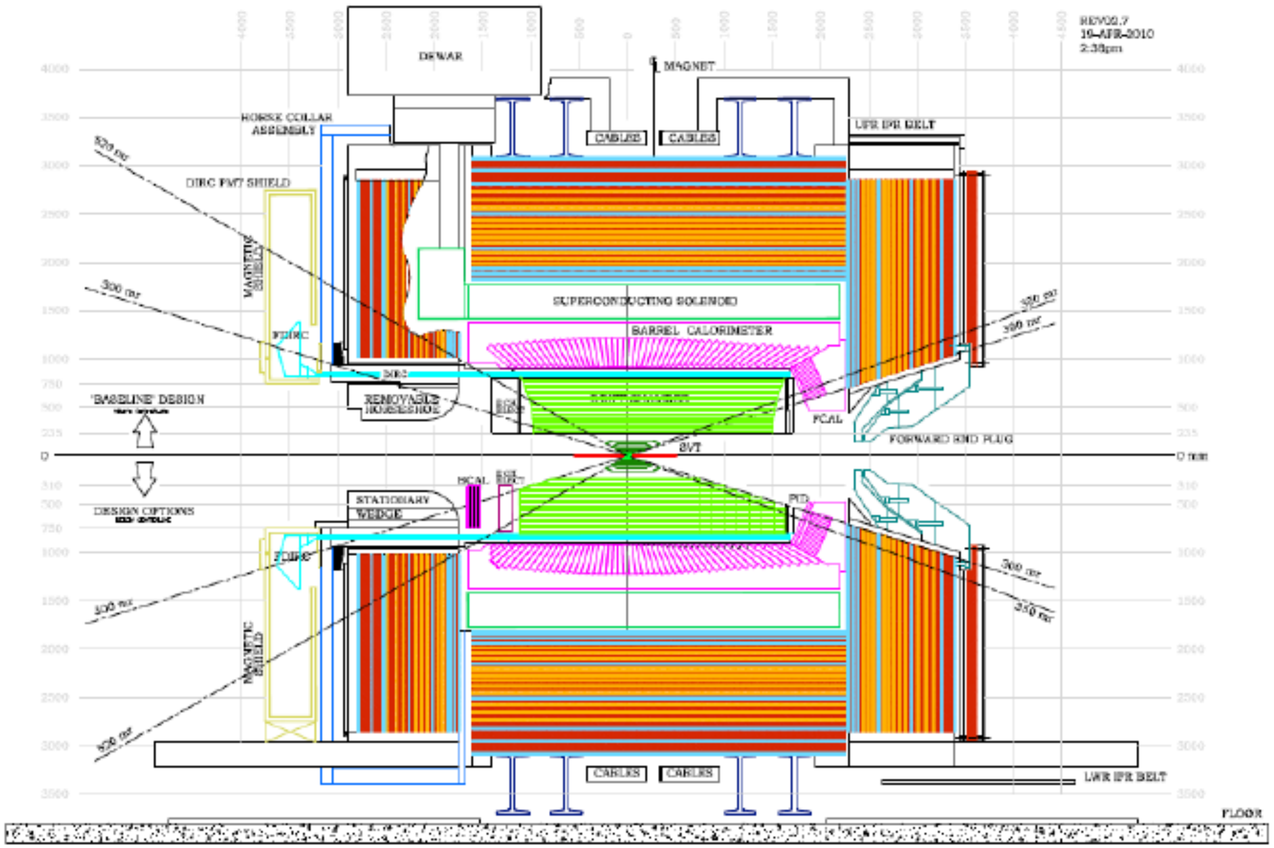


- Sensitivity to NP phenomena
  - up to energies ~ 30 Tev (beyond LHC energies)

NP(Λ) found at LHC	NP(Λ) not found at LHC
* determine the NP FV and CPV couplings * look for heavier states * study the flavour structure of NP	* look for indirect NP signals * understand where they come from * exclude regions in the parameter space

SuperB in Ferrara

- Muon detector in the Instrumented Flux Return using scintillating fibers as active detector
- Full Simulation
- Distributed Monte Carlo Production



The LHCb experiment

- Study b-hadron decays with high statistics and precision to improve the knowledge of the Standard Model and search for indirect effects of New Physics
  - complementary to direct search experiments ATLAS/CMS

- Advantages of beauty physics at hadron colliders:
  - bb cross section at LHC: $\sigma_{bb} \sim 300 - 500\ \mu b$ at $\sqrt{s} = 10 - 14$ TeV
    - (e+e- cross section at $\Upsilon(4s)$ is 1 nb)
  - Access to all quasi-stable b-flavoured hadrons
- The challenge
  - Multiplicity of tracks (~30 tracks per rapidity unit)
  - Rate of background events: $\sigma_{inel} \sim 60$ mb

- LHCb "nominal" running conditions:
  - Luminosity limited to ~$2 \times 10^{32}\ cm^{-2}\ s^{-1}$ by not focusing the beam as much as ATLAS and CMS
    - ~ 0.4 pp interaction/bunch to maximize the probability of single interaction
    - ==> LHCb will reach nominal luminosity soon after start-up
  - $2 fb^{-1}$ per nominal year (10^7s), ~ 10^{12} bb pairs produced per year

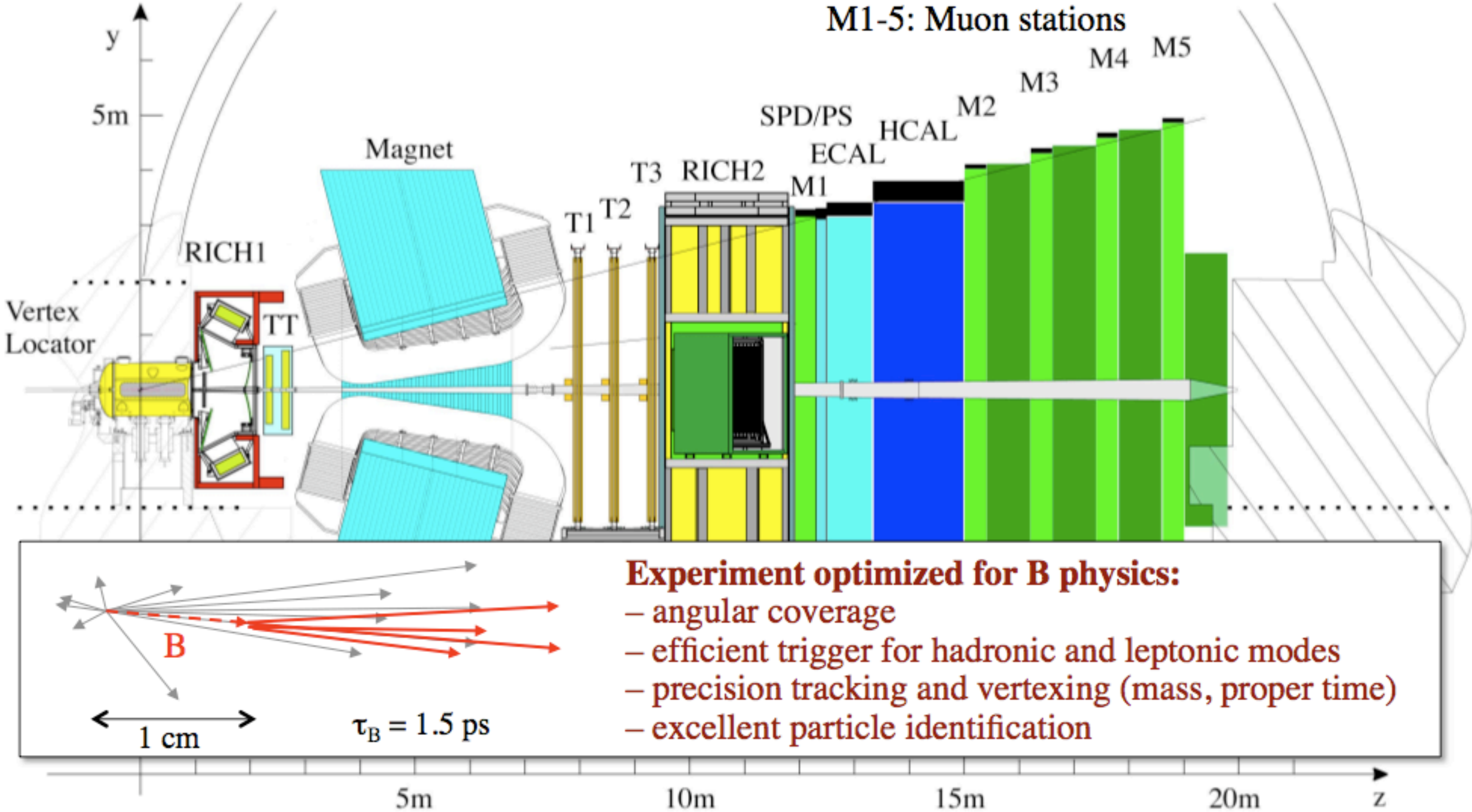
The LHCb physics goals

- Selected key measurements:
  - Search for $B_s \rightarrow \mu\mu$
  - Mixing-induced CP violation in $B_s \rightarrow J/\Psi\phi$, $B_s \rightarrow \phi\phi$
  - Charmless 2-body B decays
  - CKM angle γ from tree-level B decays
  - $B_s \rightarrow \gamma\phi$ and other radiative B decays
  - Asymmetries in $B_d \rightarrow K^*ll$ decays
- Roadmap document:
  - LHCb-PUB-2009-029, **arXiv:0912.4179v2 [hep-ex]**, Feb 2010
  - Main assumptions:
    - Nominal LHC running conditions: $\sqrt{s}$ = 14 TeV, 2fb^{-1}/year $\sigma_{bb} \sim 500\ \mu b$

- 2010-2011 run at 7 TeV:
  - no dramatic effect on physics reach (a factor 1/2 foreseen in σ_{bb} and σ_{cc})
  - Design luminosity for LHCb: 2×10^{32} cm^{-2} s^{-1} on average expected to be reached in 2011
  - lower luminosities in 2010 allow for lower trigger thresholds
    - Charm physics possible in the first data

LHCb detector

VELO: Vertex Locator
TT, T1-3: Tracking stations
RICH1-2: Ring Imaging Cherenkov detectors
ECAL, HCAL: Calorimeters
M1-5: Muon stations

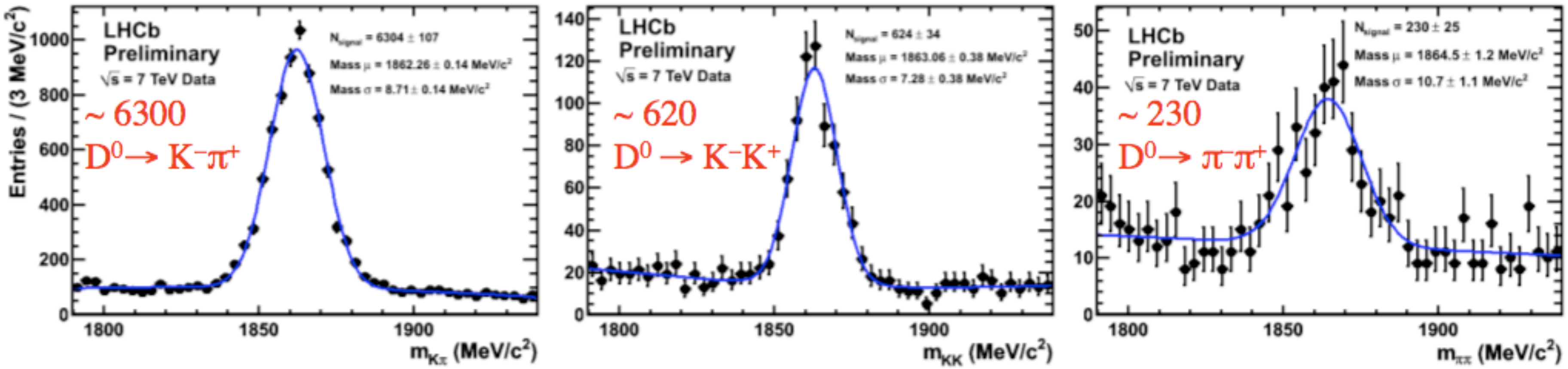


Experiment optimized for B physics:
– angular coverage
– efficient trigger for hadronic and leptonic modes
– precision tracking and vertexing (mass, proper time)
– excellent particle identification

Activities in Ferrara

- 2010 finalized the **spatial alignment** of the muon detector using Cosmics & Collision data.
  - Recovered a displacement of 3.5mm in one half station not in agreement with the survey measurement
  - Precision O(1mm)
- Study of the muon chamber efficiency with Cosmics and Collision data
  - sumbitted a paper on the performances of the muon detector
- Contribution to the RoadMap document for the analysis of phis measurement (Bs-->Jpsiphi, B-->HH)
  - 4 LHCb public notes
- Work in collaboration with Milano to measure the bb cross section in ”B”-->$XD^{*\pm}\mu\nu$ (D^0-->$K\pi$/D^0-->$K3\pi$) (D^*->πD^0)
  - ICHEP2010

Charmed mesons

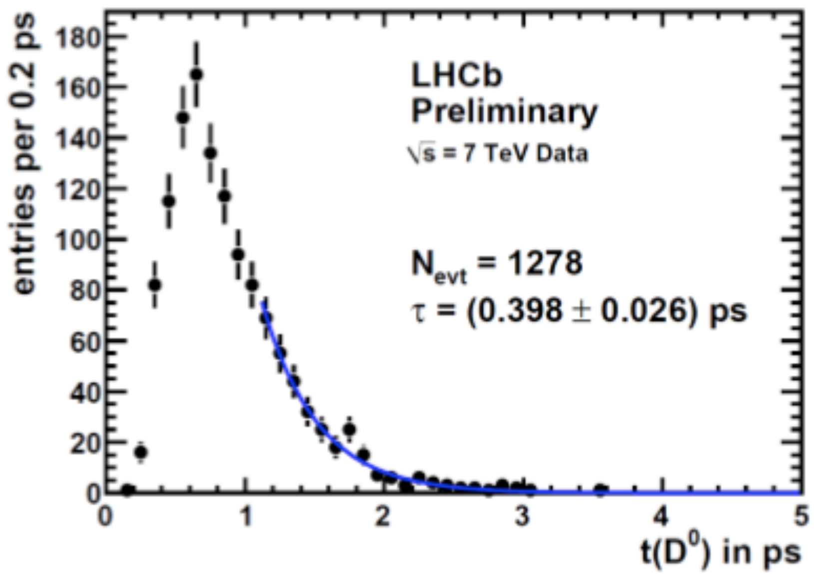


LHCb Lifetime fit gives:

$\tau(D^0)$ = (0.398 ± 0.026) ps

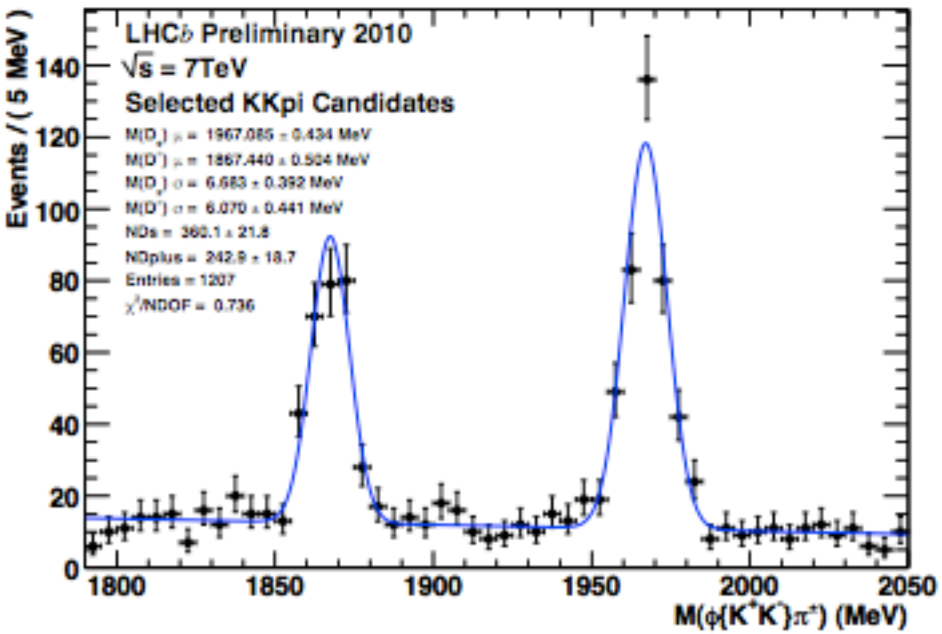
In good agreement with PDG:

$\tau(D^0)$ = (0.4101 ± 0.0015) ps



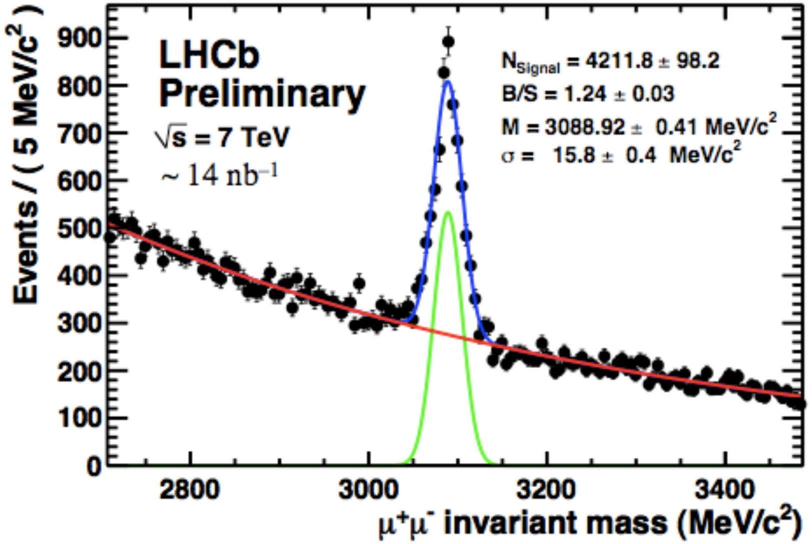
Charmed mesons

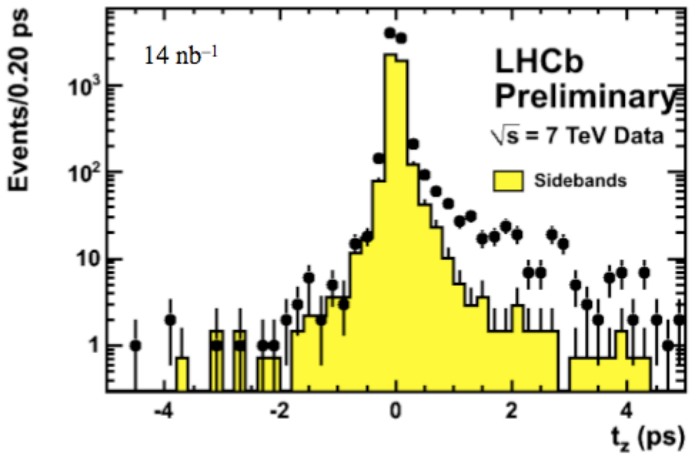
- ICHEP (2010): production cross section of "prompt" D0, D*, $D^{\pm}$, D_s in p_T,η bins O(1000) evnts. Precision~10-20%

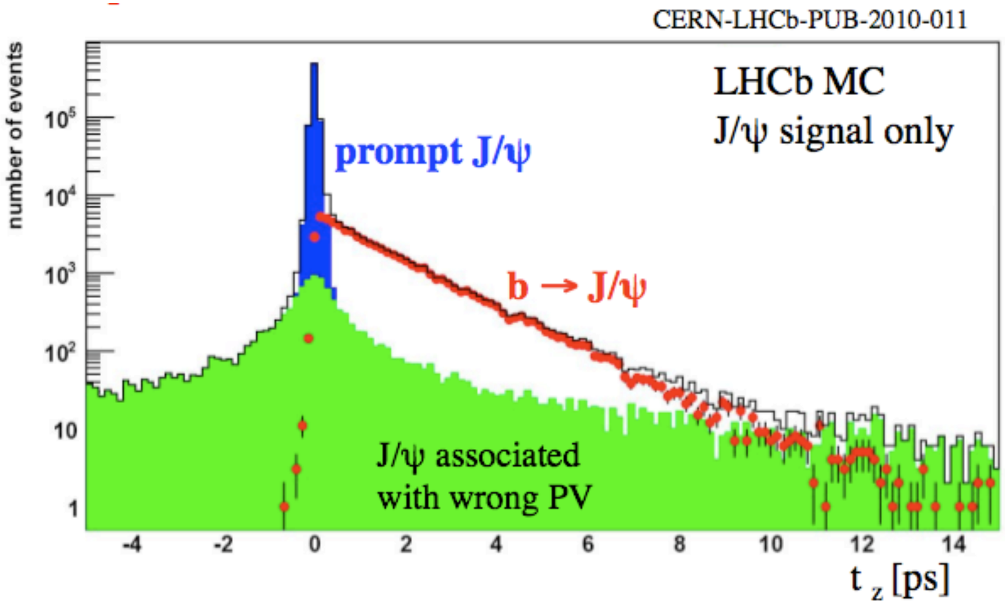


J/Ψ (--> μμ) production

- ICHEP(2010): production cross section of "prompt" and "from B" Jpsi in p_T,η bins
- prompt J/Ψ very interesting in its own right:
  - colour-octet model predicts well cross sections seen at Tevatron, but not polarisation
- make fist measurement of b--> J/Ψ production:
  - important for initial tuning of b spectrum in LHCb Monte Carlo



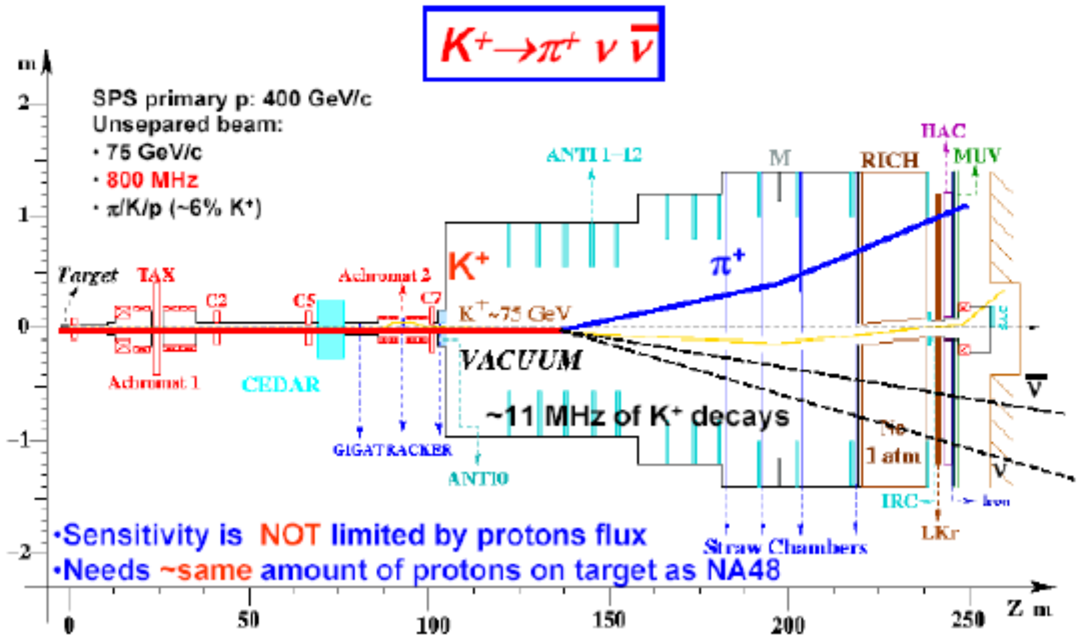




NA62

K→πνν : theory

$$B^{TH}(K^+ \to \pi^+ \nu \overline{\nu}(\gamma)) = (0.85 \pm 0.07) \times 10^{-10}$$



(A. Ceccucci, Moriond ew 09)

NA62 - FE 2011

Activity

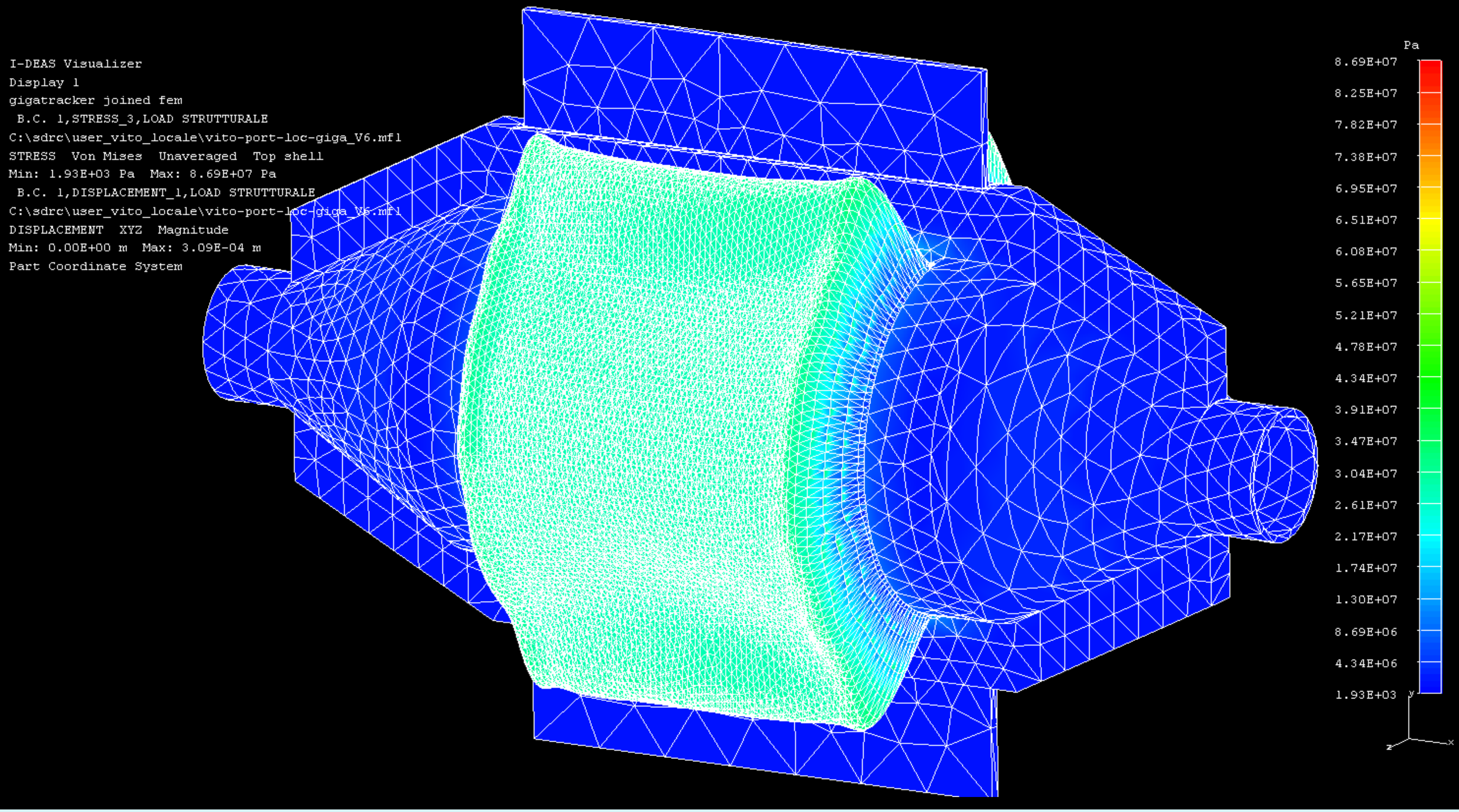
•Gigatracker development: high-resolution pixel detector for high intensity.

•design and realization of R/O electronics.

• design and test of the mechanical support.

•performance evaluation of a PC-based 0-level trigger system.

NA62 SILICON PIXEL DETECTOR

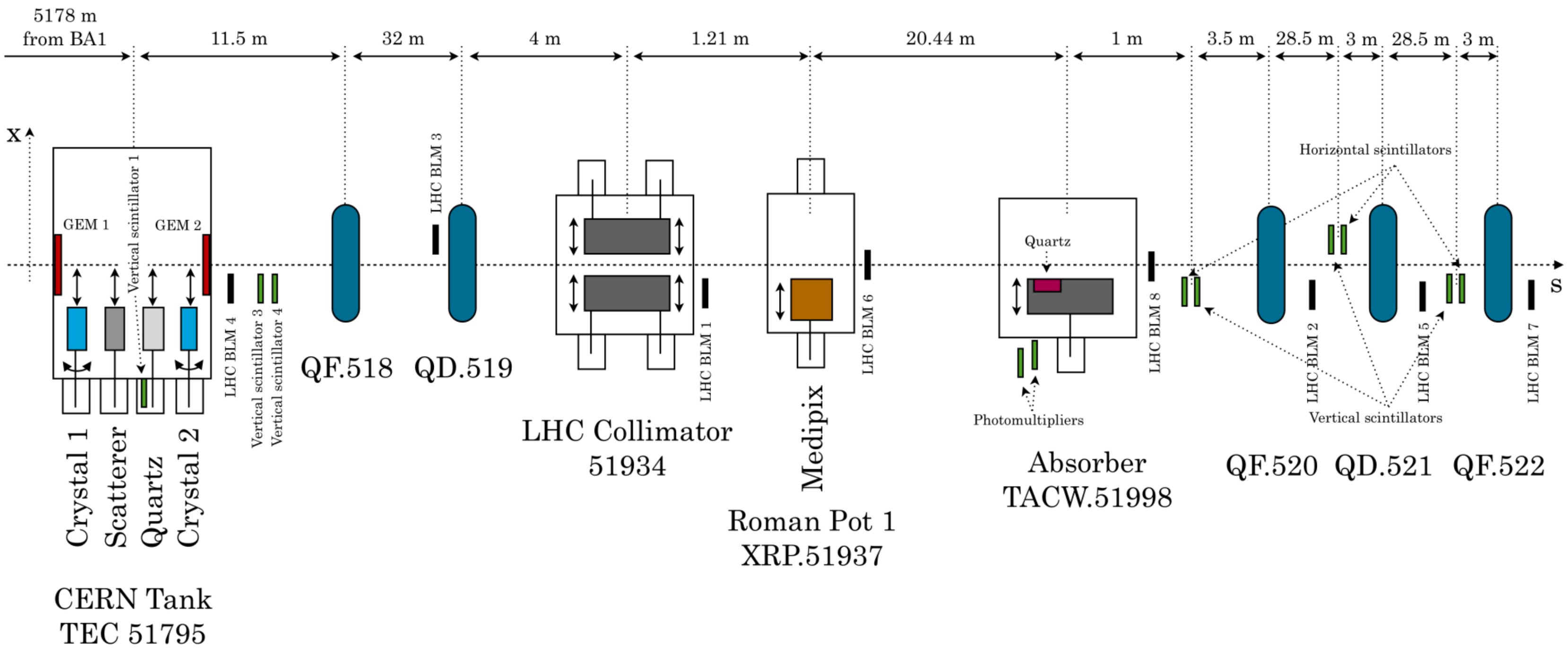


VESSEL COOLING DESIGN

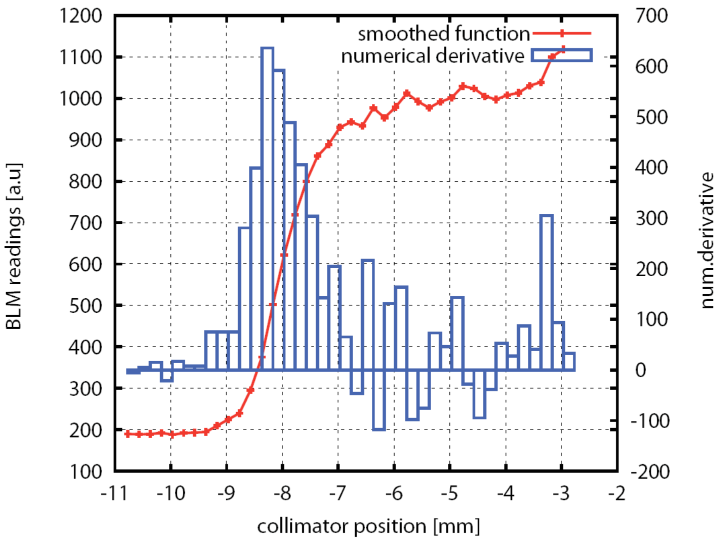
UA9

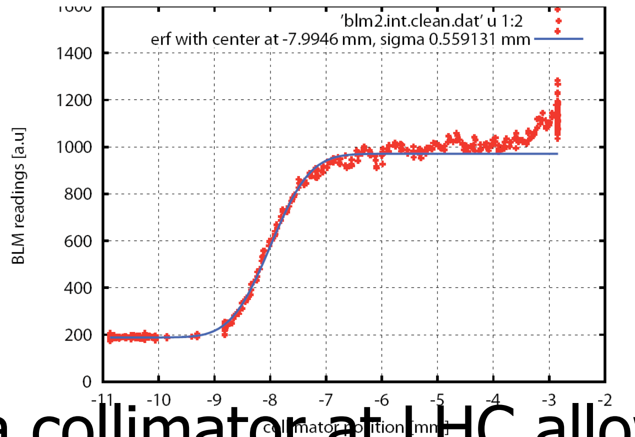
UA9 is a **CERN** experiment studying the possibility to collimate the beam halo in the SPS using coherent interactions with bent crystals.

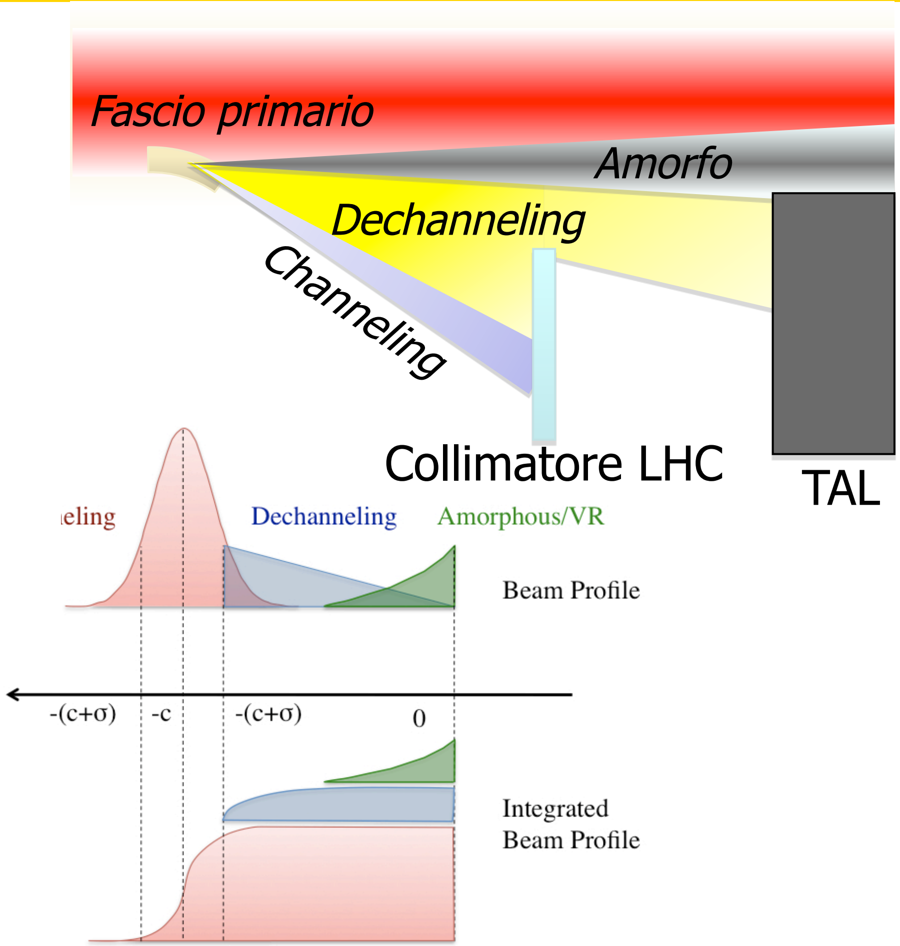
Out of four crystals, two have been developed by INFN-FE



LHC Collimator







Using a collimator at LHC allows the measurement of the channeling efficiency, which turns out to be bigger than 74 %

Activities in Ferrara

•Develop Crystals with bendings and sizes optimized for LHC

•Optimize holders to avoid torsions in crystals

•Crystal with focusing lens

•Data taking at the SPS

Astroparticle and Neutrinos

Borex

PVLAS

Borex - Ferrara’s group activities

2010

- The team contributed to the analysis of the first geo-neutrinos data from Borexino: in particular the activity was focused on the expected signals from geo-neutrinos and antineutrinos from the reactors [Physics Letters B687 (2010) 299–304].

- The team published the preliminary results for the geo-neutrinos from ^{214}Bi decay [Physical Review C81, 034602 (2010)] and it started a new set of measurements in CTF.

- The team is involved in the organization of 4th Neutrino Geoscience at LNGS (6-8 October 2010).

2011

- The team is going to study the local contribution to the geo-neutrino signal at LNGS: the results will be crucial for interpreting of the next geo-neutrinos data.

- By using the new data about ^{214}Bi and ^{212}Bi decays collected in CTF, the team is going to perform a new analysis of geo-neutrinos spectra.

Borexino: expectations and results

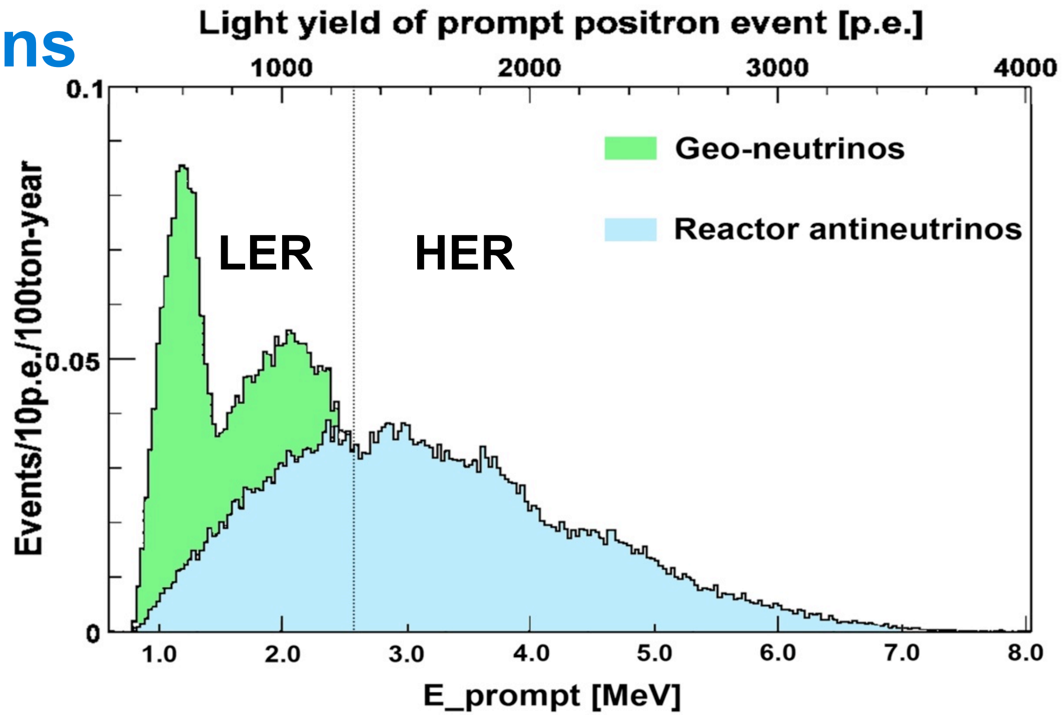
- Predict a total of **20.7** events in 24 months

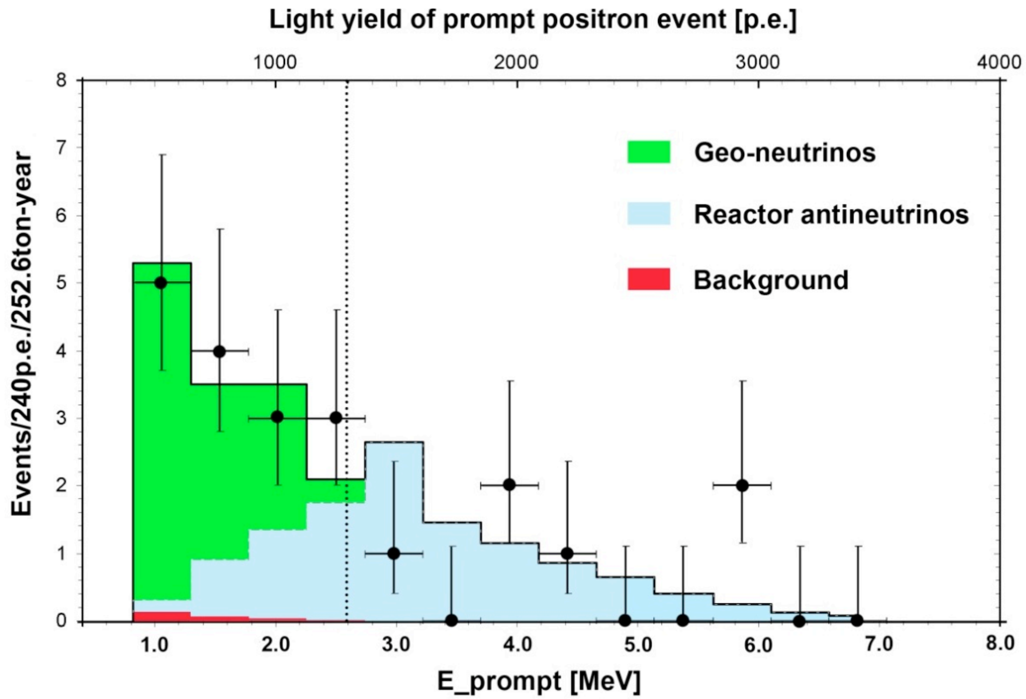
(R=14.0 ; G=6.3 ; Bk=0.4)

- The HER can be used to test the experiment sensitivity to reactors
- In the LER one expects comparable number of geo-ν and reactor-ν
- Observe **21** events in 24 months, attributed to

R=10.7 $_{-3.4}^{+4.3}$
G= 9.9 $_{-3.4}^{+4.1}$
BK=0.4

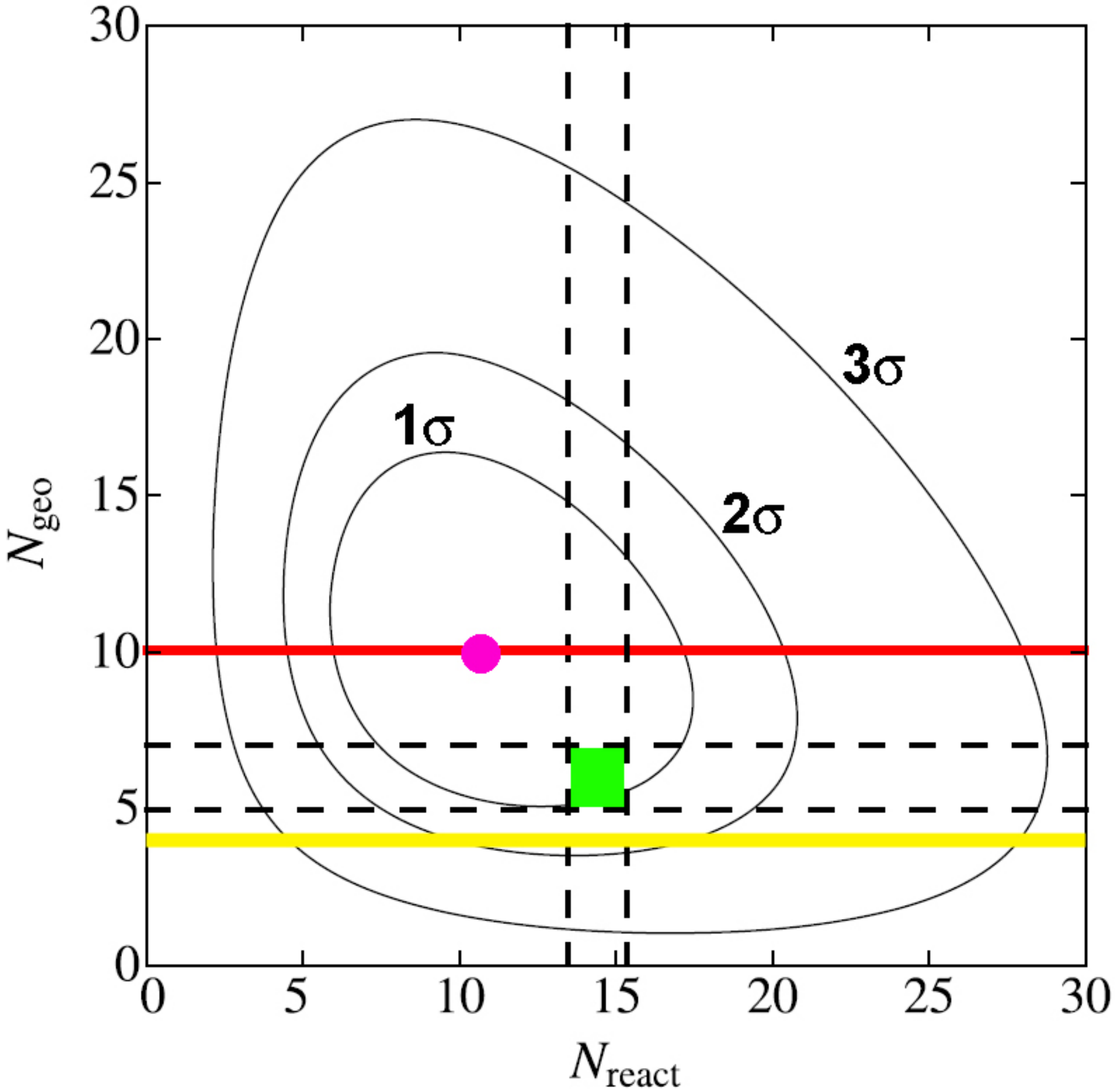
- One event per month experiment!



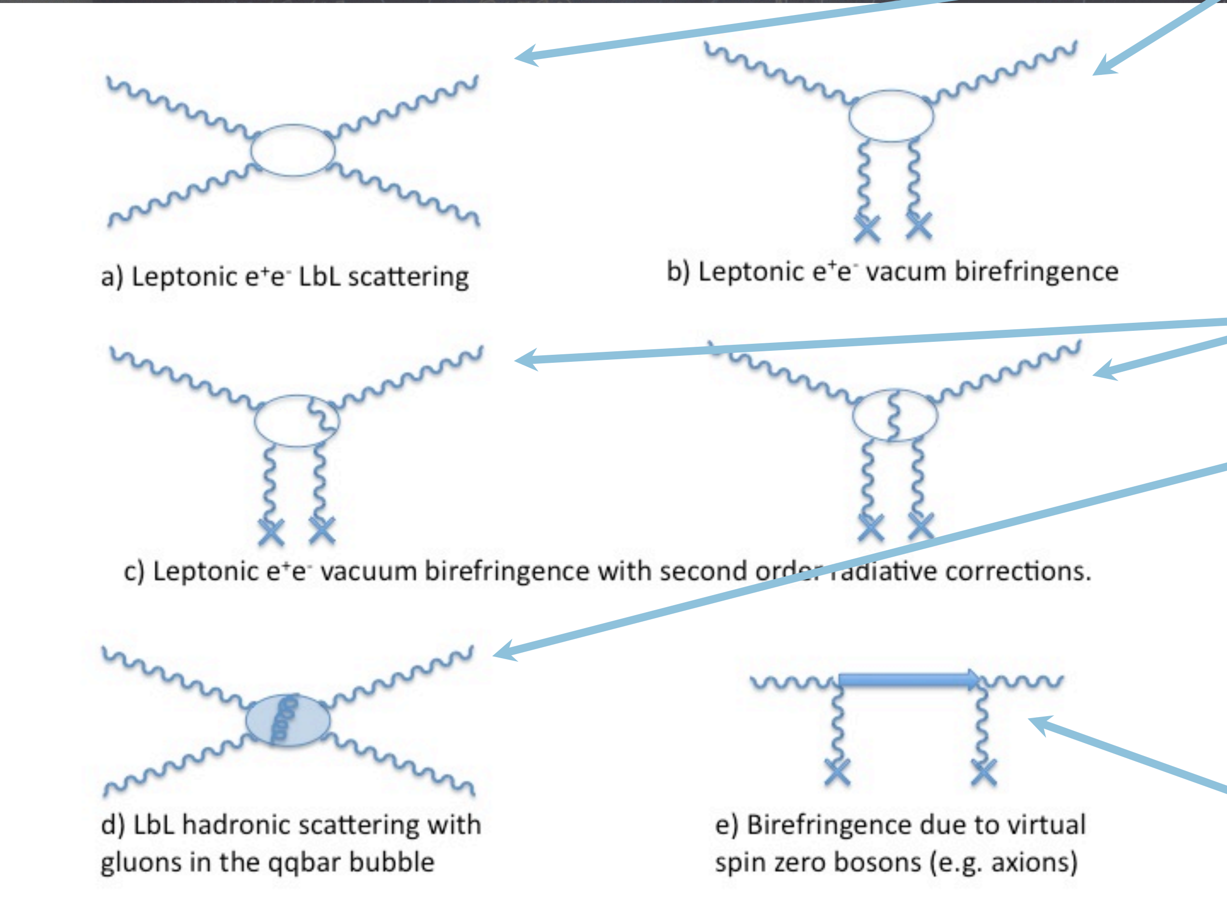


The significance of the observation

- Geo-ν = 0 is excluded with CL of 99.997 C.L. (corresponding to 4σ)
- The **Best Fit** is:
  - within 1σ from the **BSE (Bulk Silicate Earth)** prediction;
  - close to the **fully** radiogenic model;
  - some 2σ from the **minimal** radiogenic model



PVLAS

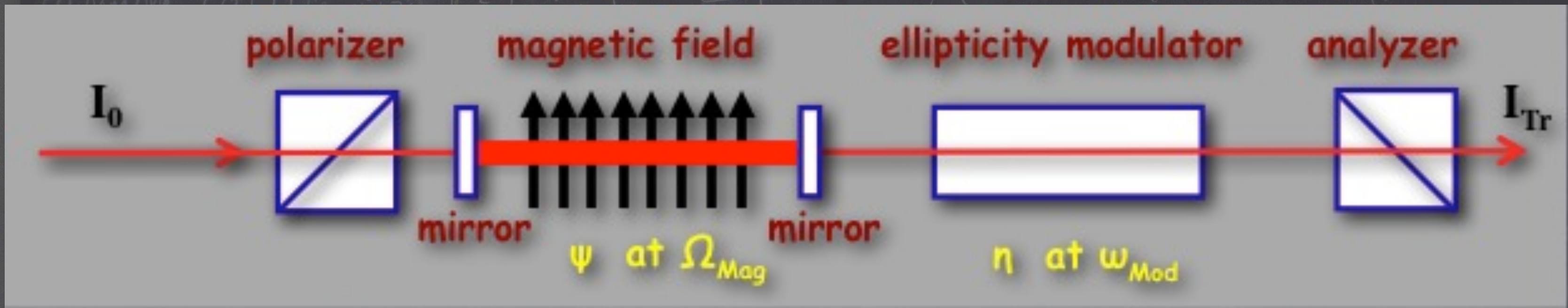


- Described by Euler-Heisenberg lagrangian.
- 1.45% correction
- Hadronic Contributions. Open problem in muon g-2
- Contributions from new particles coupling to two photons.

$$\Delta n_{QED} = 3A_eB^2 = 4 \cdot 10^{-24} B^2\ T^{-2}$$

Measurement Technique

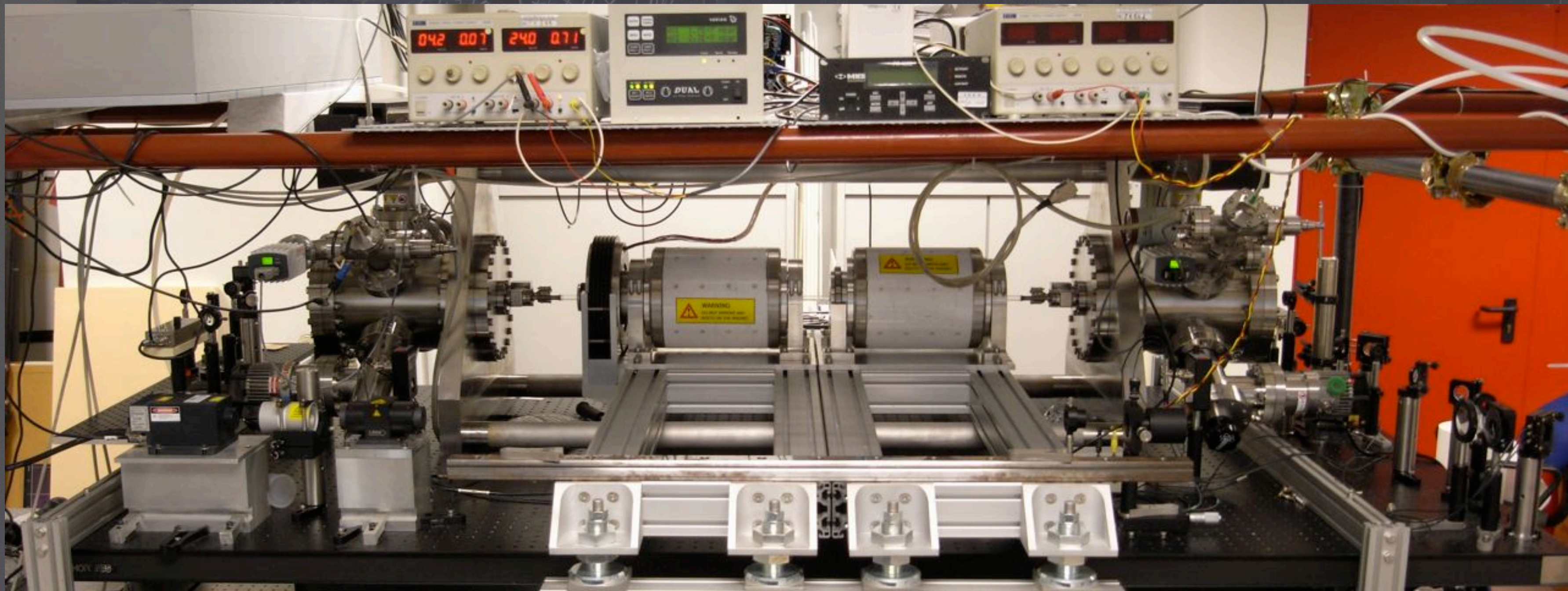
Apparatus: precision ellipsometer to measure the ellipticity acquired by a LASER beam traversing a magnetic field



- **Optical resonant cavity** for signal amplification
- **Heterodyne technique** for high sensitivity
- High **time- varying magnetic feld** for heterodyne

Present status Development of a test setup in Ferrara

- compact realization of the ellipsometer
- maximum insulation from seismic and environmental noise
- usage of permanent magnets
- usage of orientable pairs of rotating magnets for diagnostics



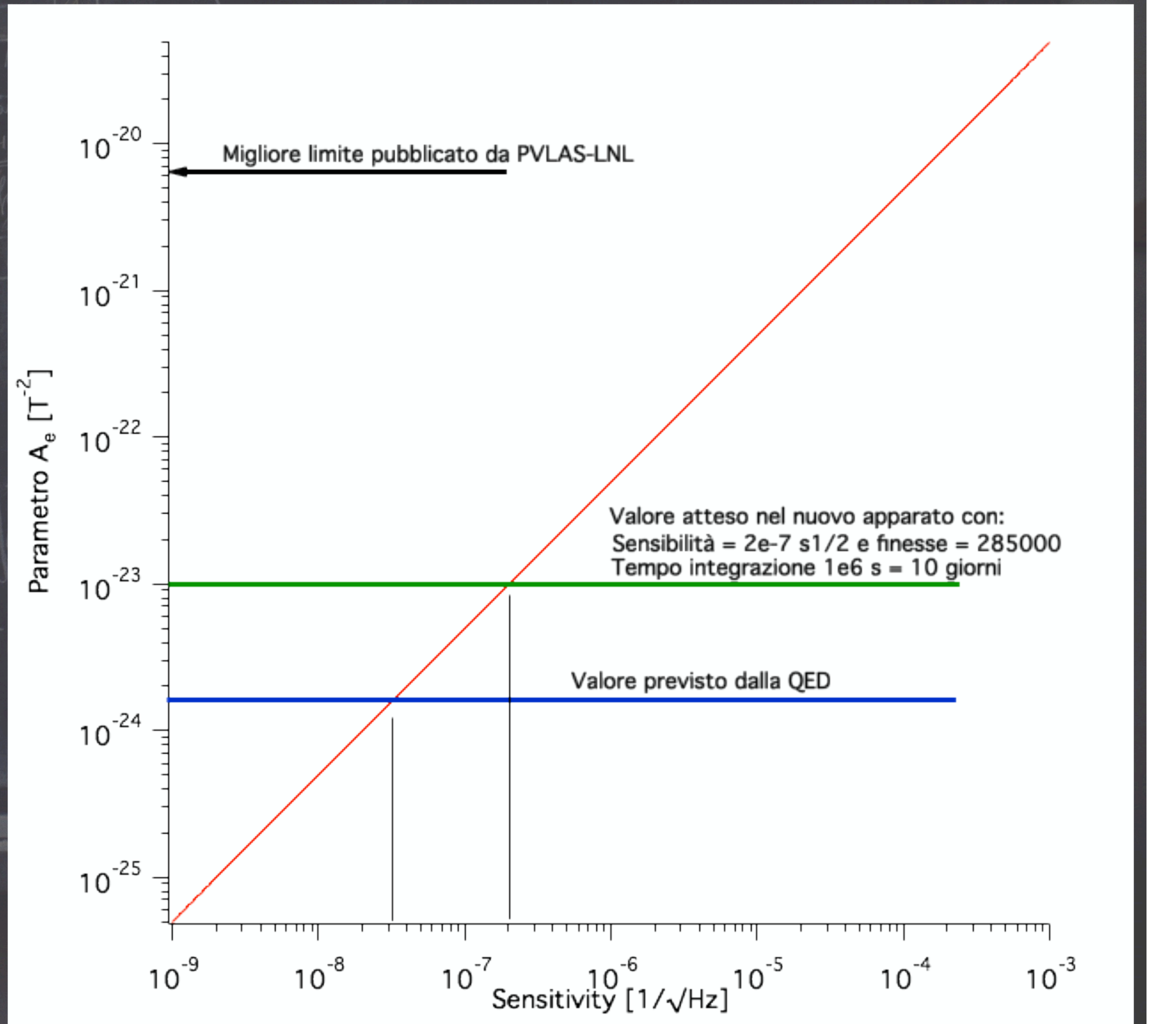
Future: full experiment to be built and carried out in Ferrara

Spazio parametrico da colmare

$$\mathcal{L}_{\mathrm{EH}} = \frac{1}{2\mu_0}\left(\frac{\vec{E}^2}{c^2} - \vec{B}^2\right) + \frac{A_e}{\mu_0}\left[\left(\frac{\vec{E}^2}{c^2} - \vec{B}^2\right)^2 + 7\left(\frac{\vec{E}}{c}\cdot\vec{B}\right)^2\right]$$

- $\Delta n = 3A_eB^2$

- Con i parametri attuali sull'apparato di test portati sul nuovo apparato si colmano quasi 3 ordini di grandezza in A_e



Nuclear and Hadron Physics

PANDA
PAX
JLAB12
Olympus

The landscape

Spectroscopy (Exotic, glueball)
Charmonium
Hypernuclei
EM Form Factors

Jefferson Lab
Exploring the Nature of Matter

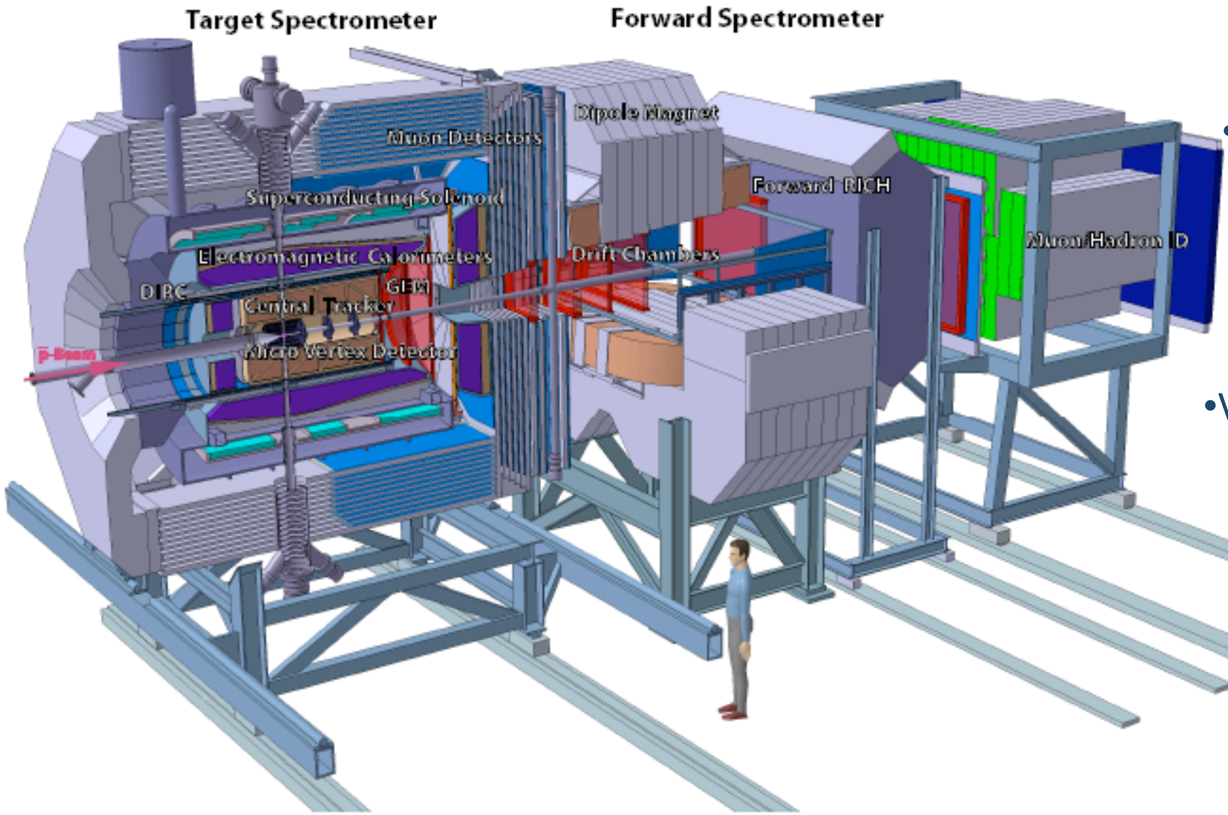
Spin Lab
Si Lab

Polarized Antiproton EXperiments

Transversity / Tensor charge
Phases of time-like FFs
P-pbar interactions

3D nucleon description
TMDs + GPDs
EM Form Factors

PANDA Detector



Detector Requirements

- (Nearly) 4π solid angle coverage (partial wave analysis)
- High-rate capability (2×10^7 annihilations/s)
- Good PID (γ, e, μ, π, K, p)
- Momentum resolution ($\approx$ 1 %)
- Vertex reconstruction for D, K^0_s, Λ
- Efficient trigger
- Modular design
- Pointlike interaction region
- Lepton identification
- Excellent calorimetry
- Energy resolution
- Sensitivity to low-energy photons

PANDA Physics Program

- QCD BOUND STATES
  - CHARMONIUM
  - GLUONIC EXCITATIONS
  - HEAVY-LIGHT SYSTEMS
  - STRANGE AND CHARMED BARYONS
- NON PERTURBATIVE QCD DYNAMICS
- HADRONS IN THE NUCLEAR MEDIUM
- NUCLEON STRUCTURE
  - GENERALIZED DISTRIBUTION AMPLITUDES (GDA)
  - DRELL-YAN
  - ELECTROMAGNETIC FORM FACTORS
- ELECTROWEAK PHYSICS

FAIR/PANDA/Physics Book i

Physics Performance Report for:

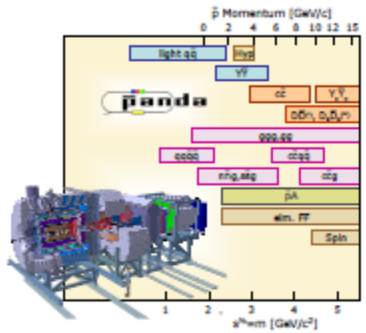
$\overline{\text{P}}$ANDA

(AntiProton Annihilations at Darmstadt)

Strong Interaction Studies with Antiprotons

$\overline{\text{P}}$ANDA Collaboration

To study fundamental questions of hadron and nuclear physics in interactions of antiprotons with nucleons and nuclei, the universal $\overline{\text{P}}$ANDA detector will be build. Gluonic excitations, the physics of strange and charm quarks and nucleon structure studies will be performed with unprecedented accuracy thereby allowing high-precision tests of the strong interaction. The proposed $\overline{\text{P}}$ANDA detector is a state-of-the-art internal target detector at the HESR at FAIR allowing the detection and identification of neutral and charged particles generated within the relevant angular and energy range.
This report presents a summary of the physics accessible at $\overline{\text{P}}$ANDA and what performance can be expected.



ArXiV:0903.3905

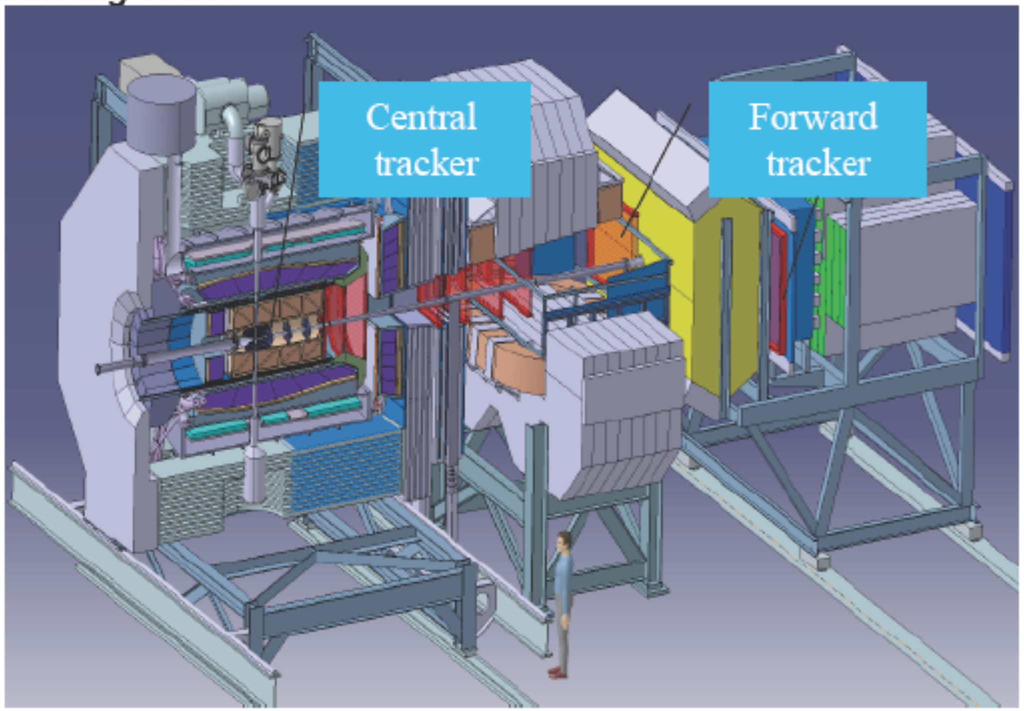
Tracking activity

Four groups are involved in the R&D activity for tracking:
Pavia, Torino_mu, Ferrara, LNF.

Pavia & Torino are working on the software development. Pavia have the responsibility of the whole tracking code.

Ferrara is in charge for the Forward tracking with ST. They are developing prototypes and contribute to the general design of the FS.

LNF is in charge for the global coordination and is contributing to the design of the Central Tracker



Polarized Antiproton eXperiments

Nucleon structure: polarized reactions

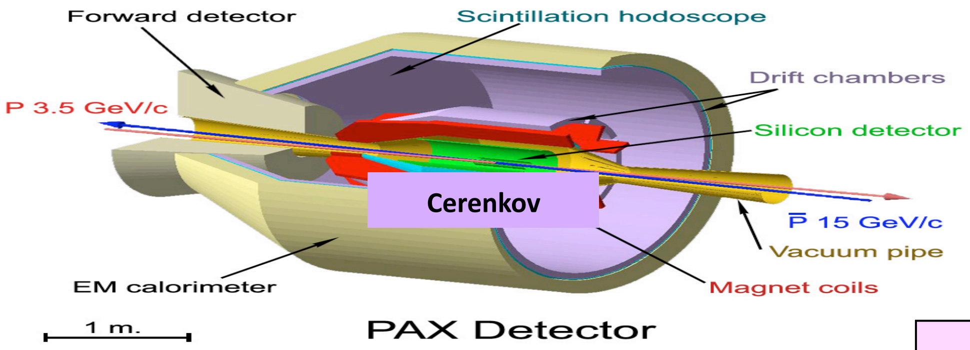
Parton distribution: transversity

pbar-p elastic

$$p^{\uparrow}\bar{p}^{\uparrow} \rightarrow p\bar{p}$$

Proton EFFs

$$p^{\uparrow}\bar{p}^{\uparrow} \rightarrow e^{+}e^{-}$$



Drell-Yan

$$p^{\uparrow}\bar{p}^{\uparrow} \rightarrow e^{+}e^{-}X$$

SSA

$$\bar{p}p^{\uparrow} \rightarrow DX, l^{+}l^{-}X$$

Charmonium

$$p^{\uparrow}\bar{p}^{\uparrow} \rightarrow J/\psi X$$

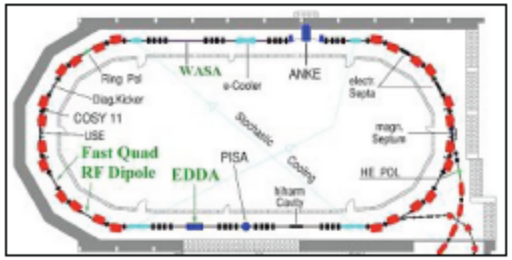
Fixed target experiment (√s<2 GeV):
- pol./unpol. pbar beam (p<4 GeV/c)
- internal H polarized target

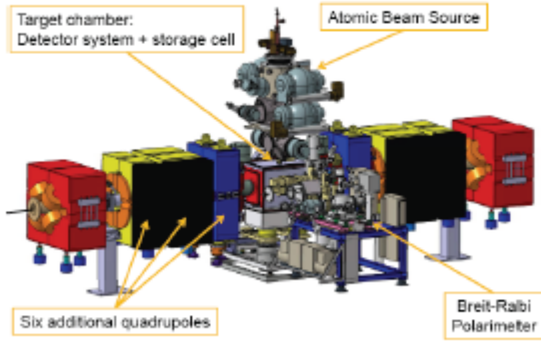
Asymmetric collider (√s=15 GeV):
- polarized antiprotons in HESR (p=15 GeV/c)
- polarized protons in CSR (p=3.5 GeV/c)

The PAX phases

COSY

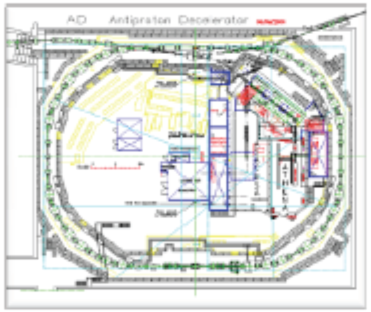
2009-2011



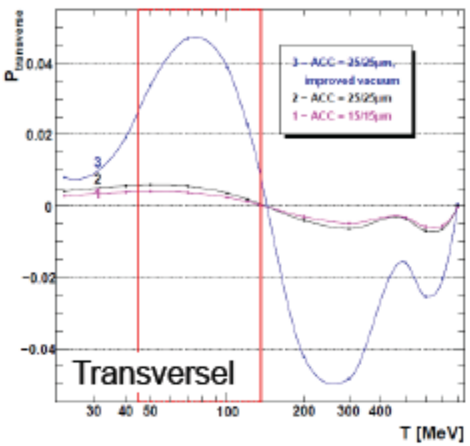


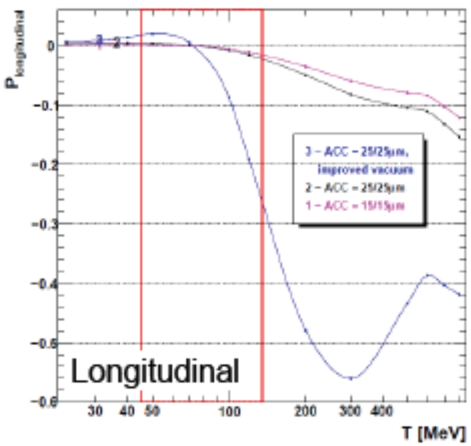
AD

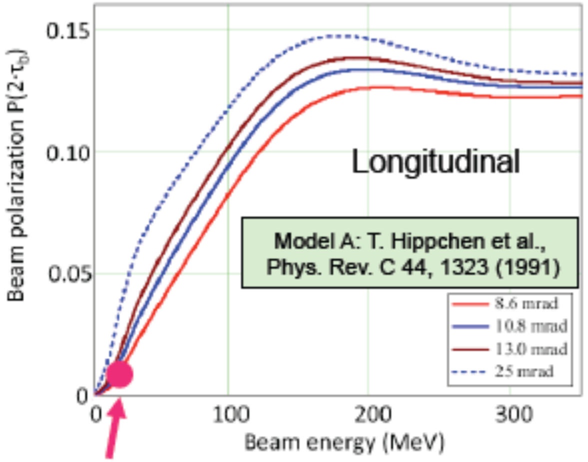
2012-2014



Strong dependence on the ring characteristics: vacuum, acceptance



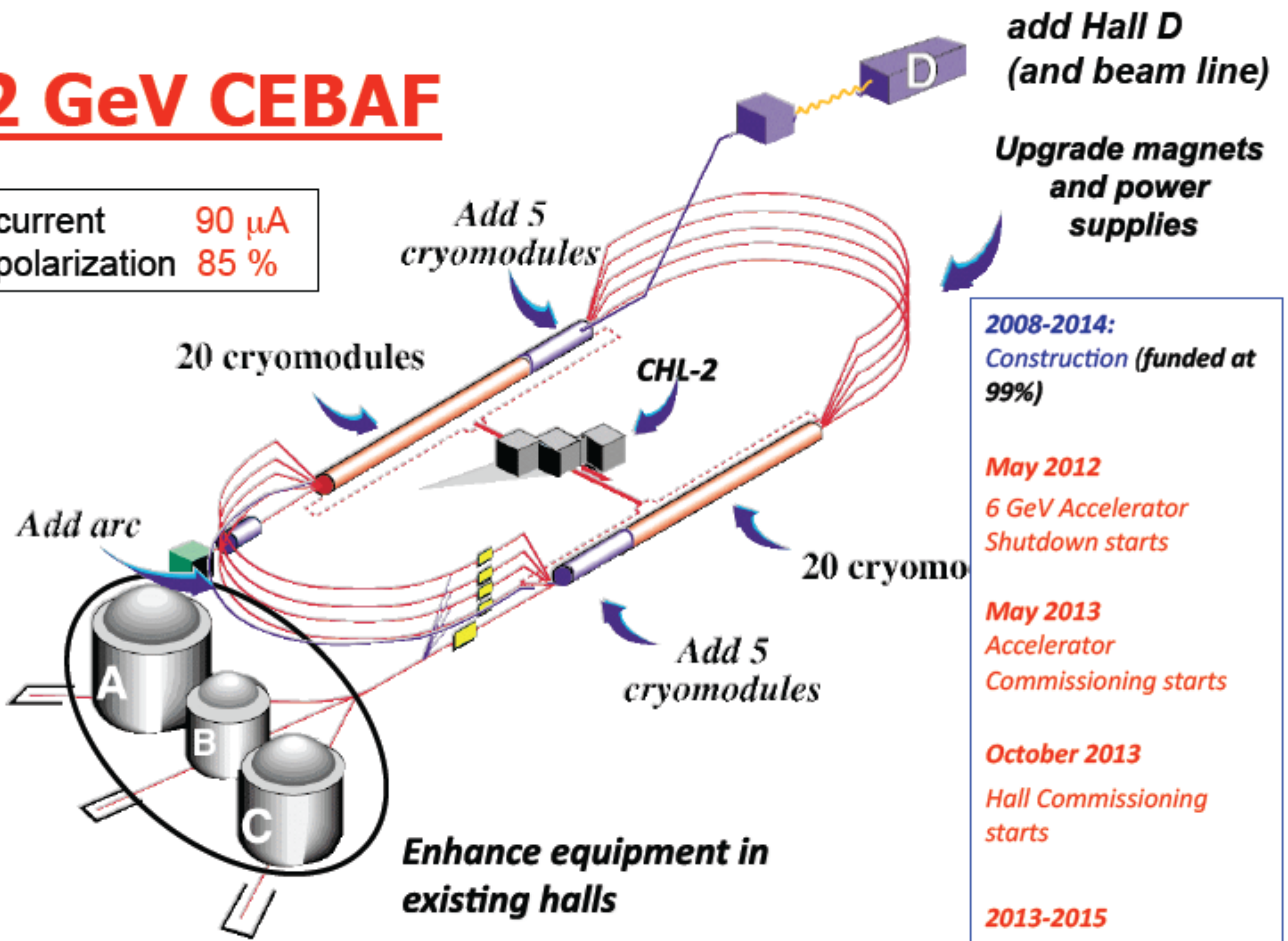




TSR: T = 23 MeV, Ψ_{acc} = 4.4 mrad

12 GeV CEBAF

Beam current	90 μA
Beam polarization	85 %



2008-2014:
Construction **(funded at 99%)**

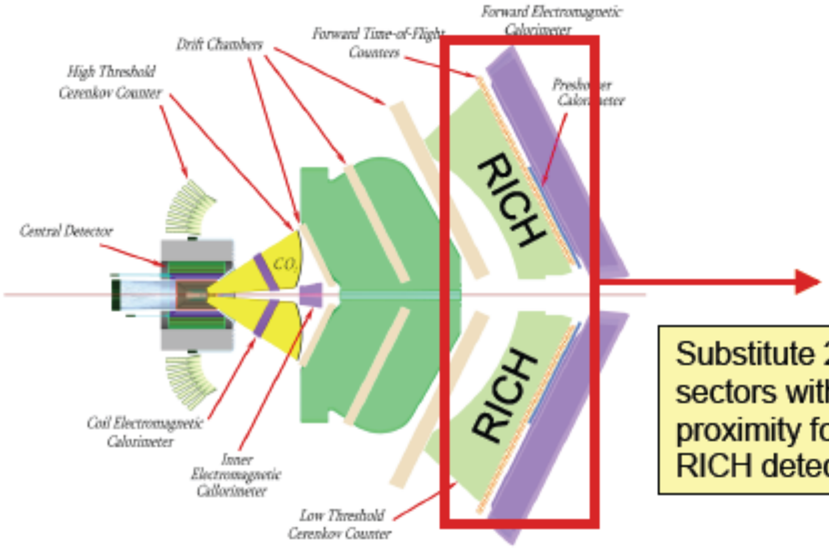
May 2012
6 GeV Accelerator Shutdown starts

May 2013
Accelerator Commissioning starts

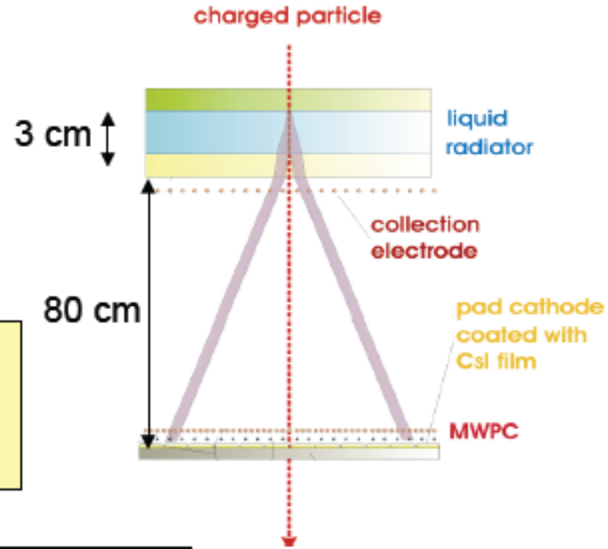
October 2013
Hall Commissioning starts

2013-2015
Pre-Ops (beam commissioning)

RICH detector for CLAS12



Substitute 2 LTCC sectors with a proximity focusing RICH detector



GeV/c	1	2	3	4	5	6	7	8	9	10
π/K	TOF									
					LTCC					
								HTCC		
π/p			TOF							
						LTCC				
								HTCC		
K/p		TOF								
										LTCC

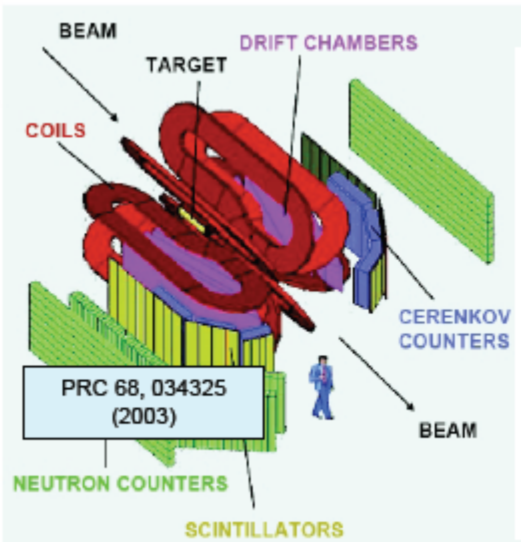
OLYMPUS @ DESY

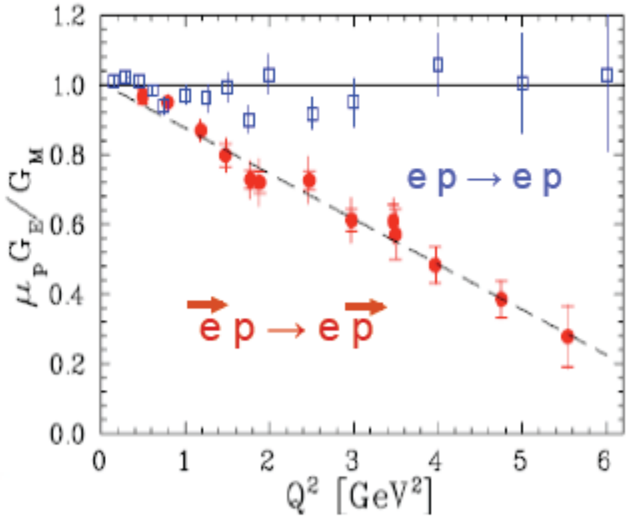
Installation: 2011
Data: taking: 2011-2012

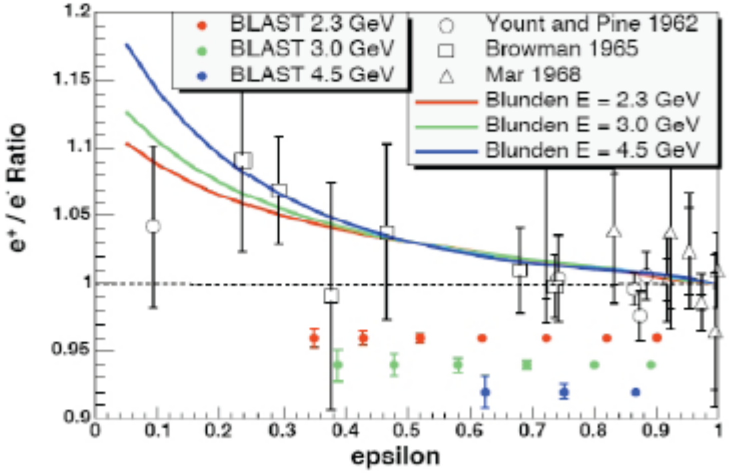
Ferrara invited to be involved in cell forniture and maintenance of the internal gas target

The BLAST Detectors

- Left-right symmetric
- Large acceptance:
  $0.1 < Q^2/(GeV/c)^2 < 0.8$
  $20^\circ < q < 80^\circ$, $-15^\circ < \phi < 15^\circ$
- COILS $B_{max} = 3.8$ kG
- DRIFT CHAMBERS
  Tracking, PID (charge)
  $dp/p=3\%$, $dq = 0.5^\circ$
- CERENKOV COUNTERS
  e/p separation
- SCINTILLATORS
  Trigger, ToF, PID (p/p)
- NEUTRON COUNTERS
  Neutron tracking (ToF)





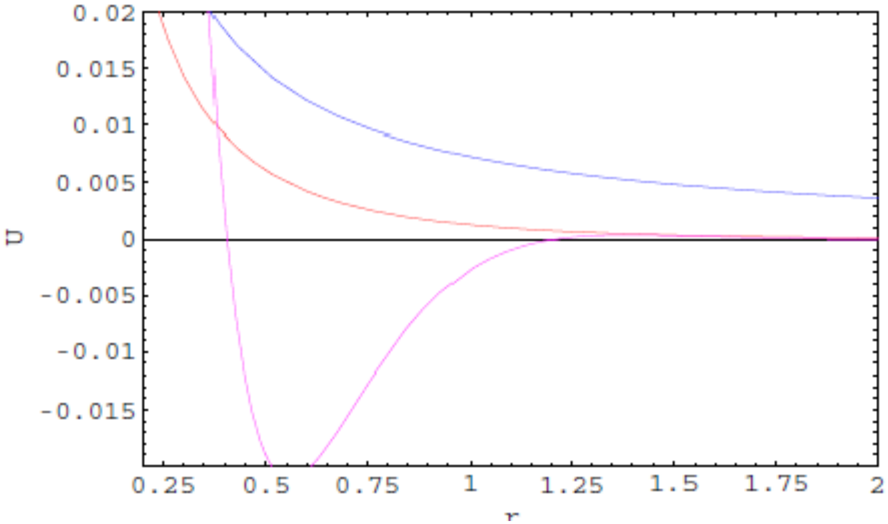


Theory

What happens when an electric charge is surrounded by a BEC?

- Vacuum → standard Coulomb potential $U \sim \frac{Q_1 Q_2}{r}$
- Plasma → screening and Yukawa potential: $U \sim \frac{Q_1 Q_2}{r} \exp^{-m_D r}$
- Plasma including a Bose condensate:

$$U(r)_{pole} = \frac{Q_1 Q_2}{4\pi r} \exp\left(-\sqrt{e/2} m_2 r\right) \cos\left(\sqrt{e/2} m_2 r\right).$$



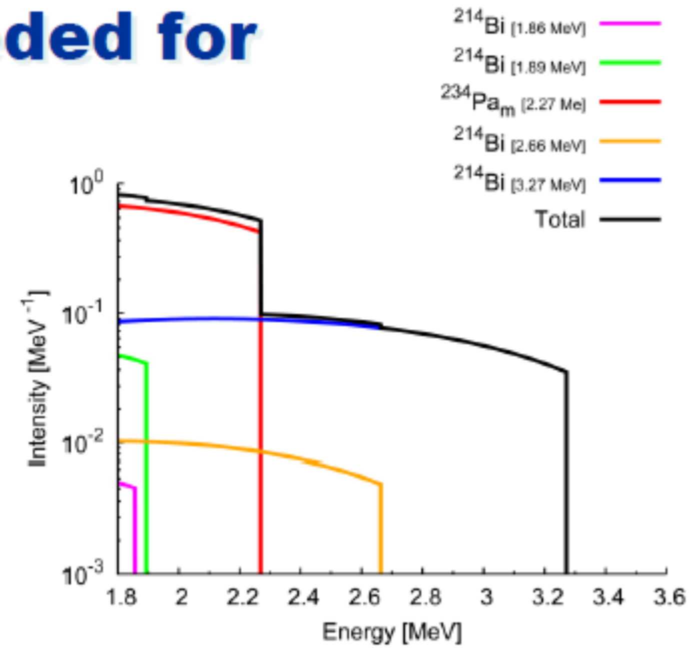
Nuclear physics inputs needed for geo-neutrino studies*

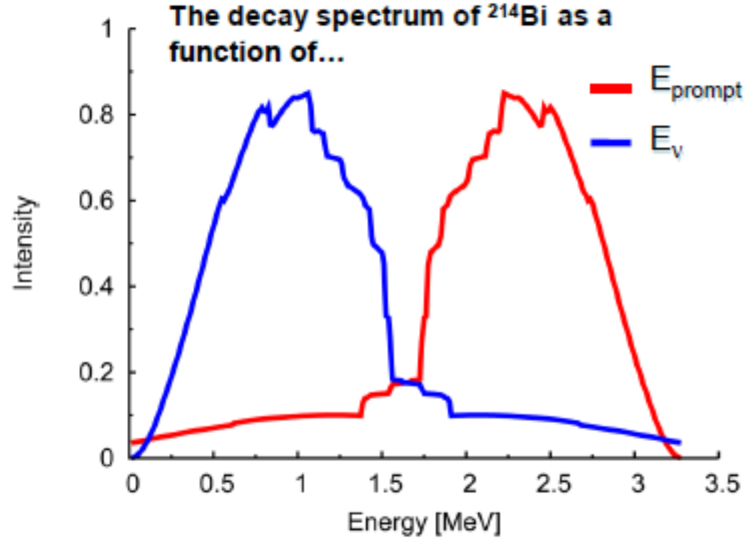
✓ Neutrino spectra are necessary for calculating the geo-neutrino signal. So far, they are derived from theoretical calculations. We propose to measure them directly.

✓ For each nuclear decay, the neutrino energy E_ν and the "prompt energy" $E_{prompt} = T_e + E_\gamma$ are fixed by energy conservation: $Q = E_\nu + E_{prompt}$

✓ Measure E_{prompt} and will get E_ν

✓ With CTF @ LNGS a method for experimental determination of geo-neutrino spectra has been developed measuring the "prompt energy" of ^{214}Bi decay





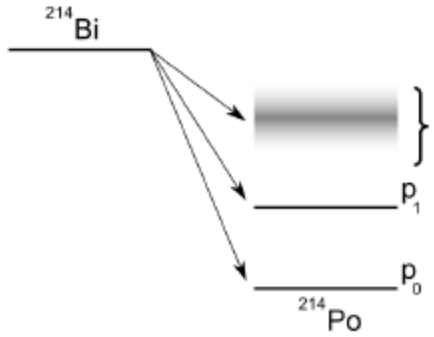
* G. Bellini, G. Fiorentini, A. Ianni, M. Lissia, F. Mantovani and O. Smirnov

Study of ^{214}Bi decay with CTF @ LNGS

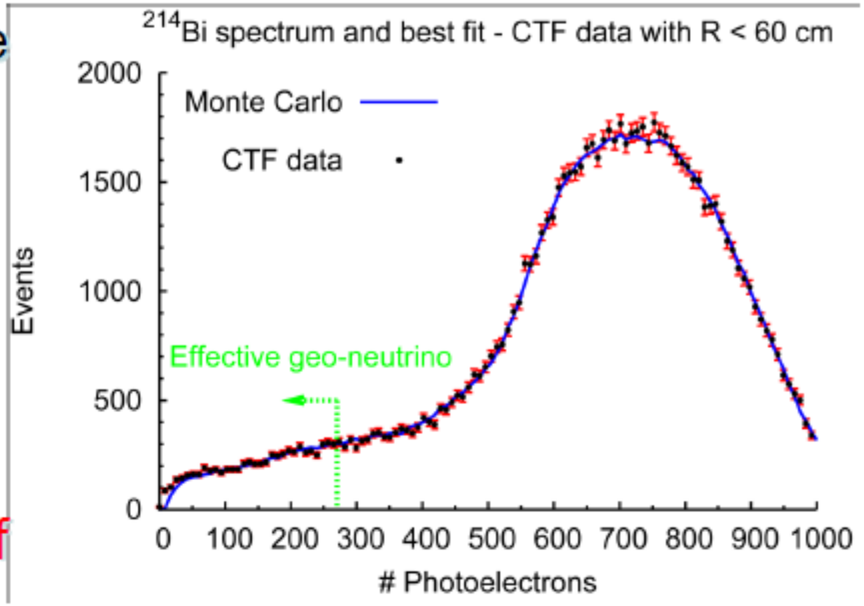
- ✓ Geo-neutrinos are produced through β and β-γ transitions:

$$X \rightarrow X' + e + \bar{\nu}_e \qquad X \rightarrow X'^{*} + e + \bar{\nu}_e$$
$$\hookrightarrow X' + n\gamma$$

- ✓ For geo-neutrino studies only the ground and first excited state are relevant.
- ✓ By using data from a ^{222}Rn contamination of CTF, we measured the feeding probabilities p_0 and p_1 of these states.
- ✓ The result is consistent and of comparable accuracy with that found in Table of Isotopes (derived from indirect measurements of γ line intensities and theoretical assumptions)



E_γ(max) [keV]	S_{U+Th}(%)
... 1894	0
2663	1.6
3272	46



	CTF	TOI
p_0	0.174 ± 0.004	0.182 ± 0.006
p_1	0.021 ± 0.005	0.017 ± 0.006

New Physics beyond the Standard Model ...

- ... of Particle Physics ...

Esiste nuova fisica oltre il MS delle particelle!

(neutrini, problema del flavor e CP, problema della gerarchia, etc)

Possibile soluzione: <u>minimal walking TECHNICOLOR</u>

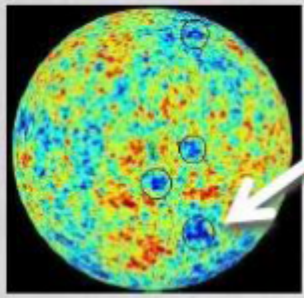
Per questioni di consistenza (anomalie), accanto ai TechniQuark, ci sono TechniLeptoni che si comportano come una 4 famiglia leptonica con scala al TeV.

- ... and of Cosmology

Esiste nuova fisica oltre il MS della cosmologia?

(ossia MSparticelle+inflazione+DM+DE)

Si, se e.g. nel CMB si misurano anomalie rispetto all'inflazione



<u>COLD SPOT</u> osservato da WMAP (2006), emisfero boreale vicino alla costellazione Eridano

<u>IPOTESI</u> potrebbe trattarsi di un "VUOTO" (regione sottodensa)

Collaborazione con A.Notari (Heidelberg)

- **Phenomenology**: ElectroWeak Corrections for High Energy cross sections ($Q \gg M_W$)
  - EW Double Log corrections Resumations ($\frac{\alpha_W}{4\pi} \log^2 \frac{Q^2}{M_W^2} \sim 10\%$ for $Q \sim 1\ TeV$)
  - EW Evolution equations (like the DGLAP for QCD)
  - Applications: phenomenology at LHC, ILC and High Energy Cosmic Rays.
- **Cosmology**: Massive Gravity induced by Spontaneous Breaking of Lorentz Symmetry
  - Is GR *stable* when coupled to a dark sector breaking Lorentz symmetry (vev of a vector or tensor field)? Cosmological implications:
  - *Massive propagating Gravitons*
  - *Modifications of Newton Law with power corrections:* $1 - G_N\ \frac{M}{r} \to 1 - G_N\ \frac{M}{r} + S\ r^{\gamma}$, $S =$*scalar charge*
  - *Extra propagating scalar degrees of freedom during Universe evolution*

Computational Physics

- Numerical methods and algorithms for theoretical physics:
  - Improved Monte Carlo methods for hard systems
  - Statistical physics of spin-glass
  - Matching algorithms to new computer achitectures
- Physics of turbulent fluids
  - Statistical properties of convective turbulence
- Aurora Science
  - development of a computing system optimized for LQCD using commercial processors connected to APE. Development of a 20 Tflop prototype to prove the feasibility of the project.

Main research activity: SM phenomenology at hadron colliders

- Continuos upgrade of the Monte Carlo Event Generator `ALPGEN`

  M. Mangano, M. Moretti, F. Piccinini, R. Pittau and A.D. Polosa, JHEP0307 (2003)

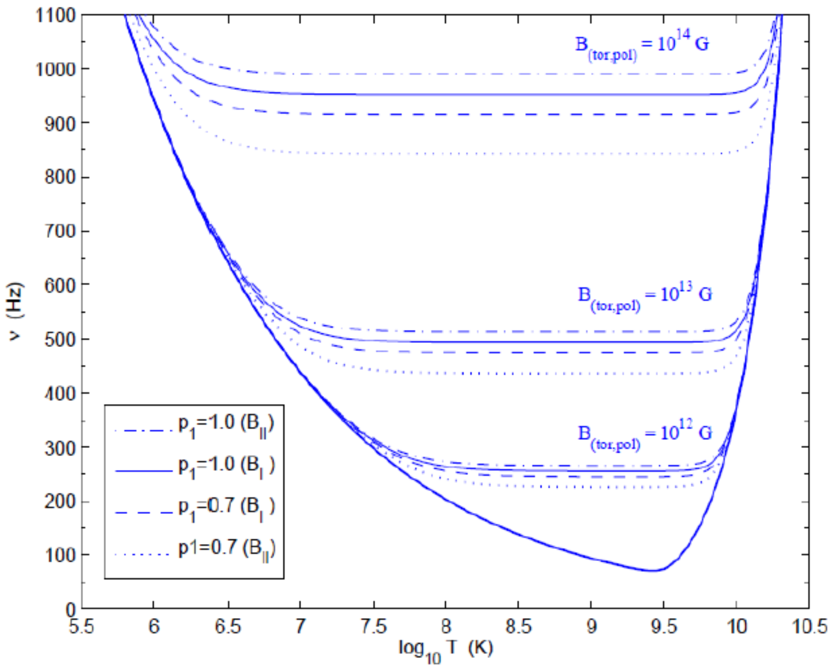
  1. Extensively used by CDF, D0, ATLAS and CMS
  2. Based on F. Caravaglios and M. Moretti, Phys. Lett. B358 (1995)

- Higgs physics phenomenology
- Drell-Yan
- Authomatic NLO corrections

Quark Matter

- Chiral quark model with vector mesons:
  - as a model for hadron structure
  - to describe hot dense matter
- Implications for astrophysics
  - structure of a rapidly rotating compact star
  - supernova explosion and Gamma Ray Bursts

limiting rotation frequencies for a compact star in an LMXB



Technology and Interdisciplinary

Beats

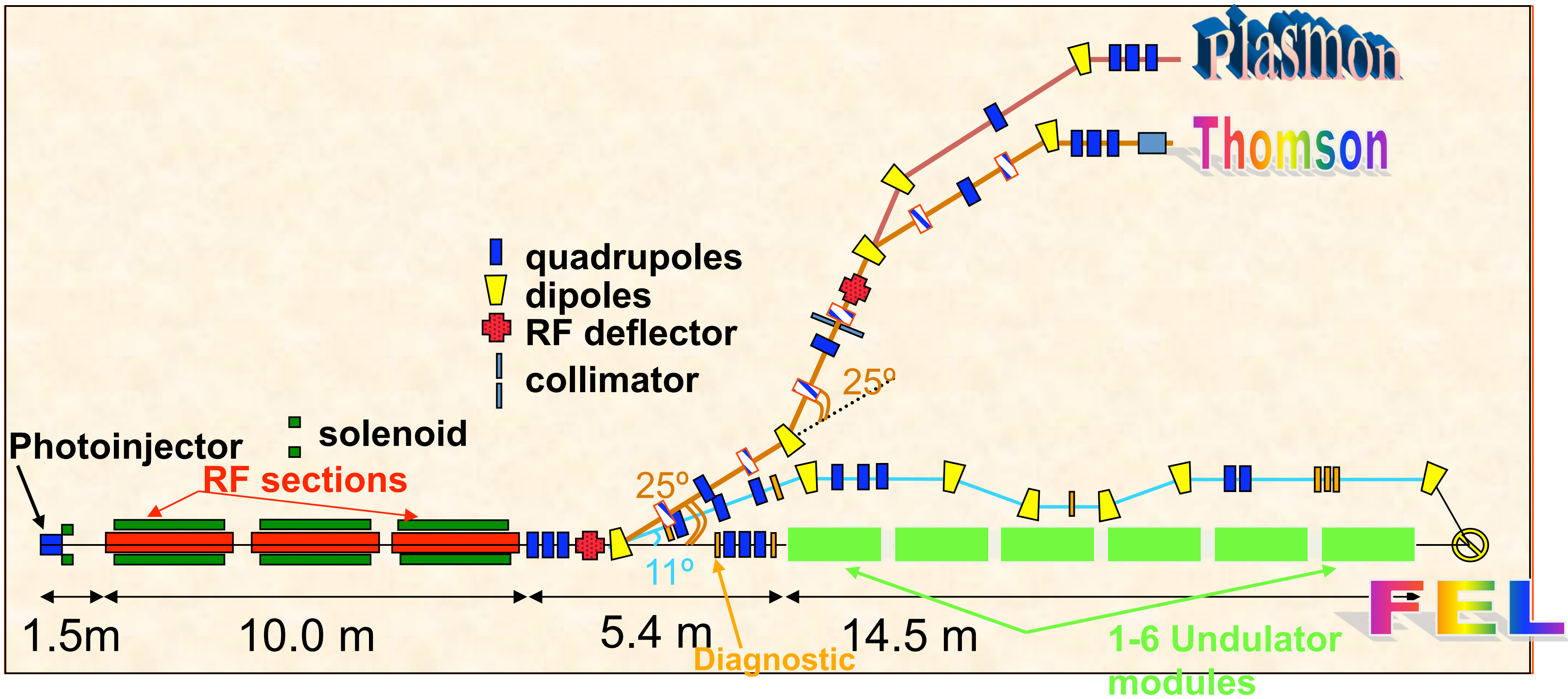
Coherent

Francium

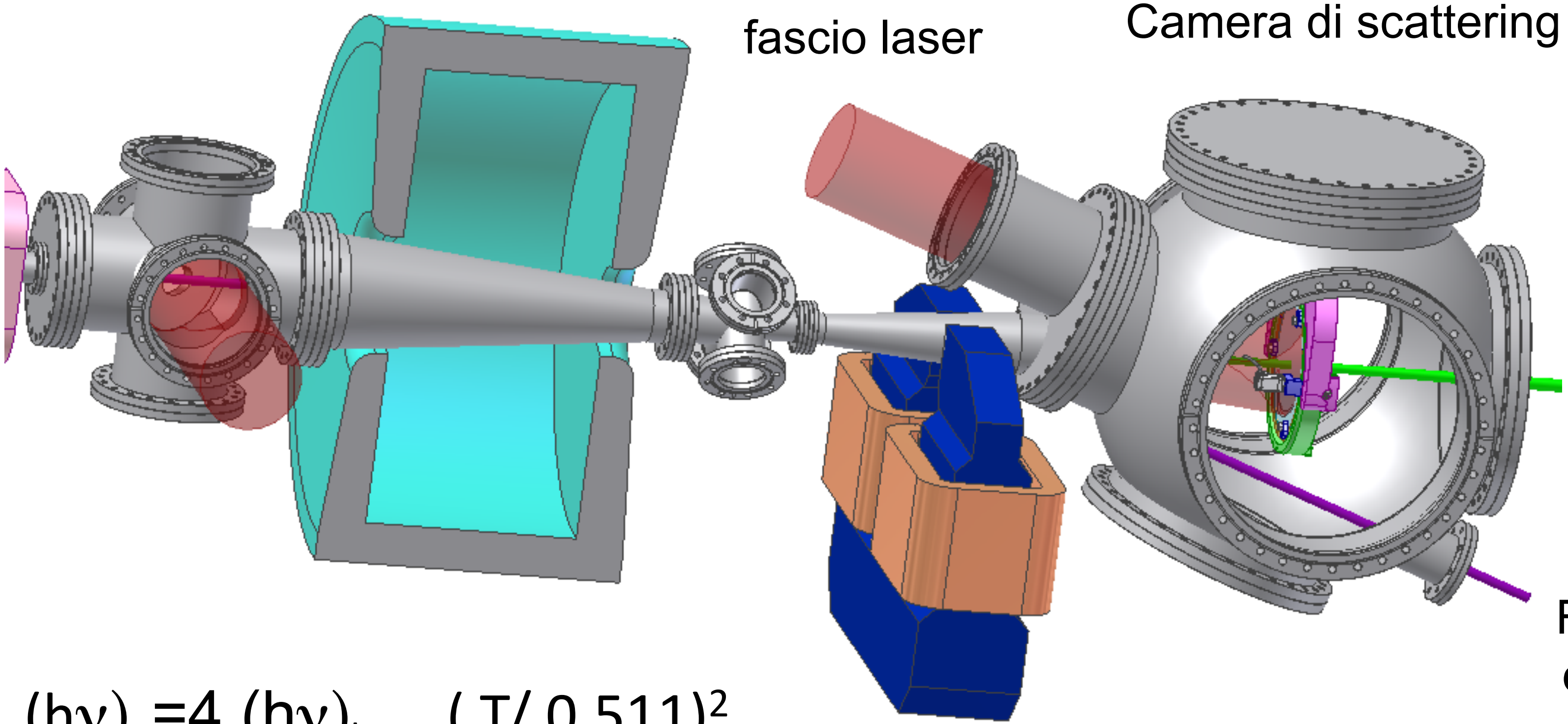
Beats-2

Investigate possible applications of monochromatic X rays produced through inverse Compton scattering to

- Medicine (mammography, angiography)
- Archeometry, strategic materials, study of ultrafast processes



In Ferrara: assembly and characterization of the imaging Thomson line at 20 KeV for applications to mammography.



$$(h\nu)_X = 4\,(h\nu)_{laser}\,(T/0.511)^2$$

$(h\nu)_{laser}$ = 1.2 eV
T = 30.28 MeV
$(h\nu)_X$ = 20 keV mammografia

Impulso laser: 6 ps, 5 J
pacchetto e^- : 1 nC , l: 2 mm (rms)
Impulso X: 10 ps, 10^9 fotoni per interazione
α emissione: 12 mrad

COHERENT

COHERENT is the continuation of the research acitivities started in the **NTA-HCCC** project.

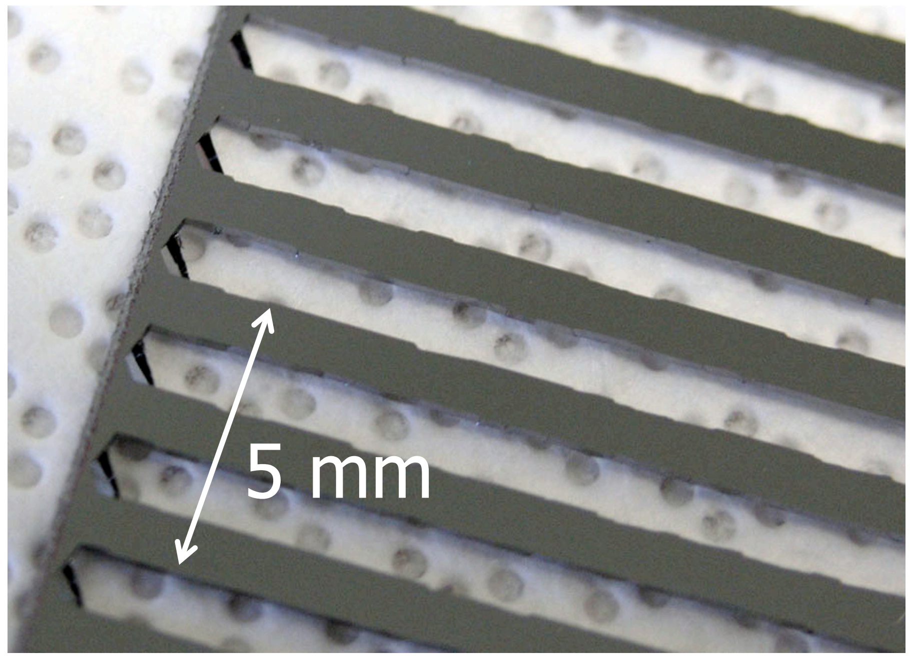
Goals of this experiment:

•Study the possibility to manipulate high-energy particle beams by means of coherent beam-crystal interactions (channeling and volume reflection in axial and planar modes).

•Study of the radiation emitted in the beam-crystal interaction.

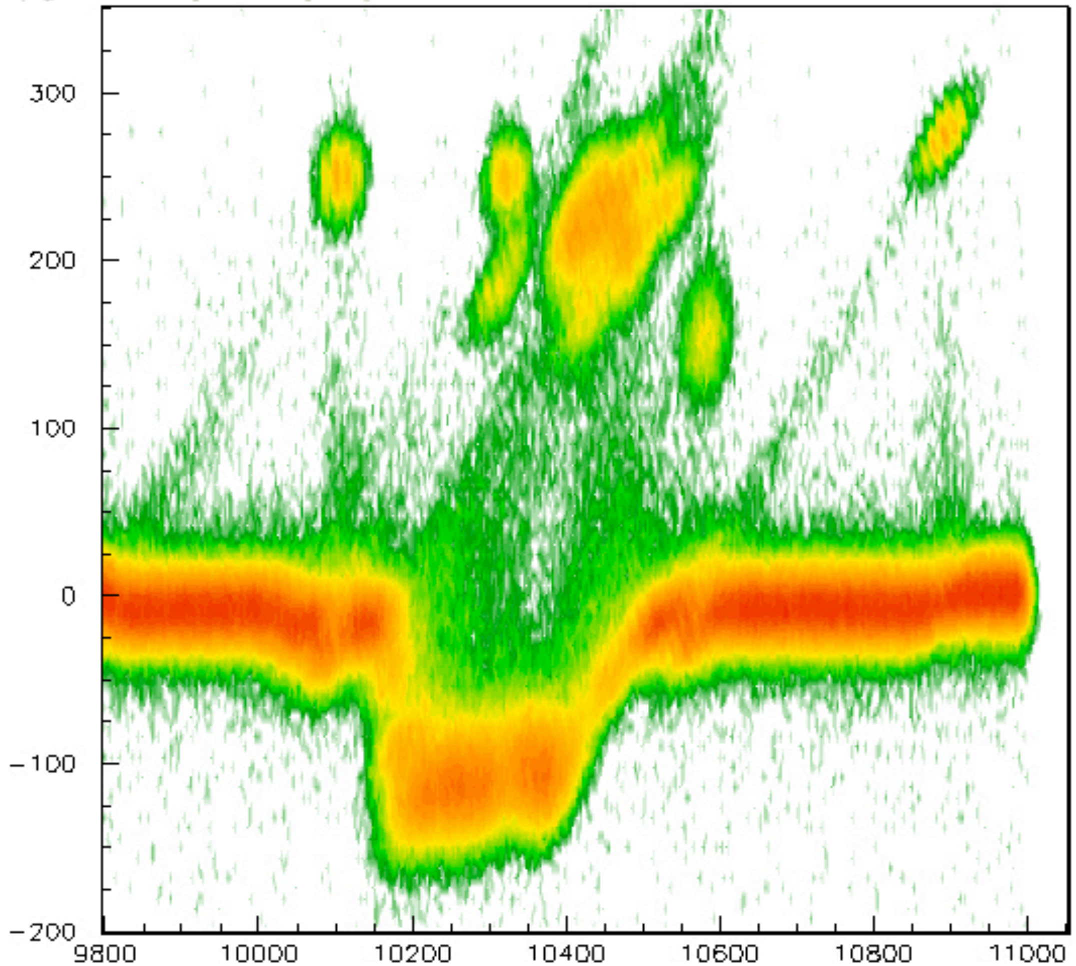
Multistrip and Holder

Construction of multistrip and holders capable to feature high levels of alignment.



V. Carassiti et al.
RSI **81** (2010) 066106

Beam Test of Multistrips



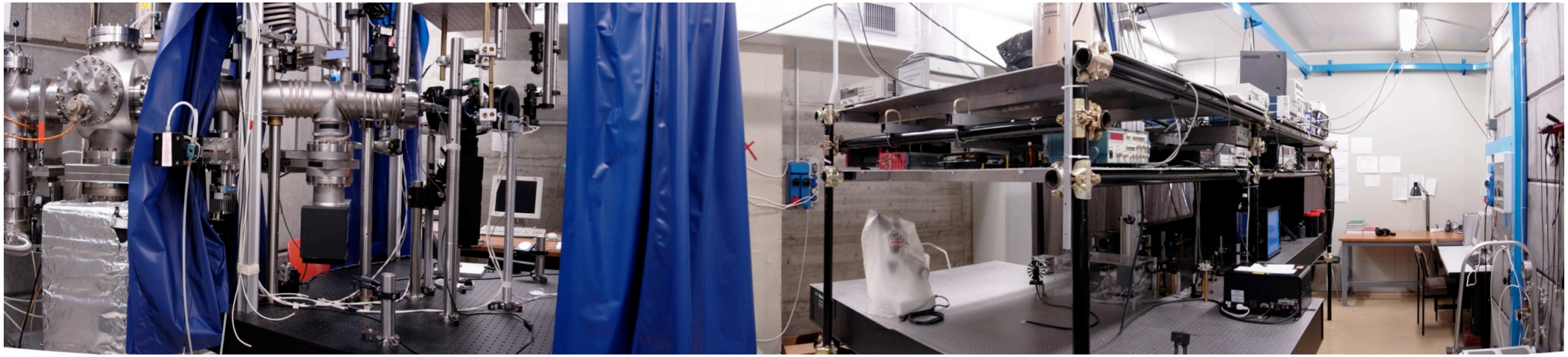
Multistrip:
-14 aligned strips
-angular acceptance: ~100 μrad
-Deflection angle: ~130 μrad
-Efficiency: 97 %

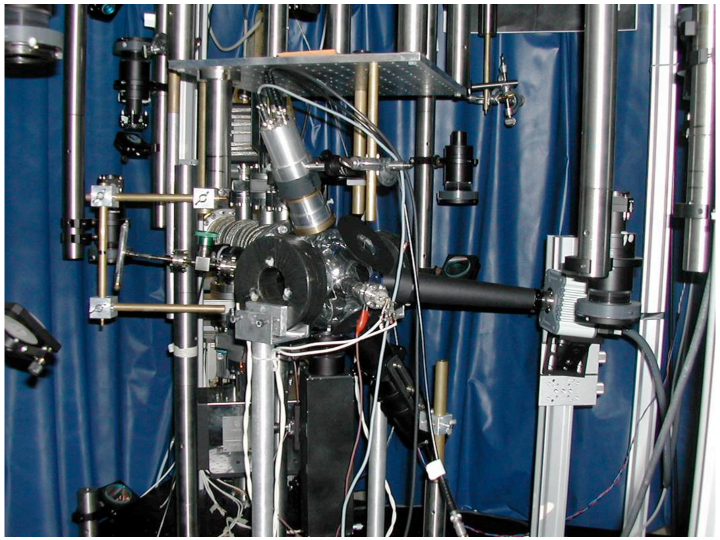
Crystal installed at the Tevatron

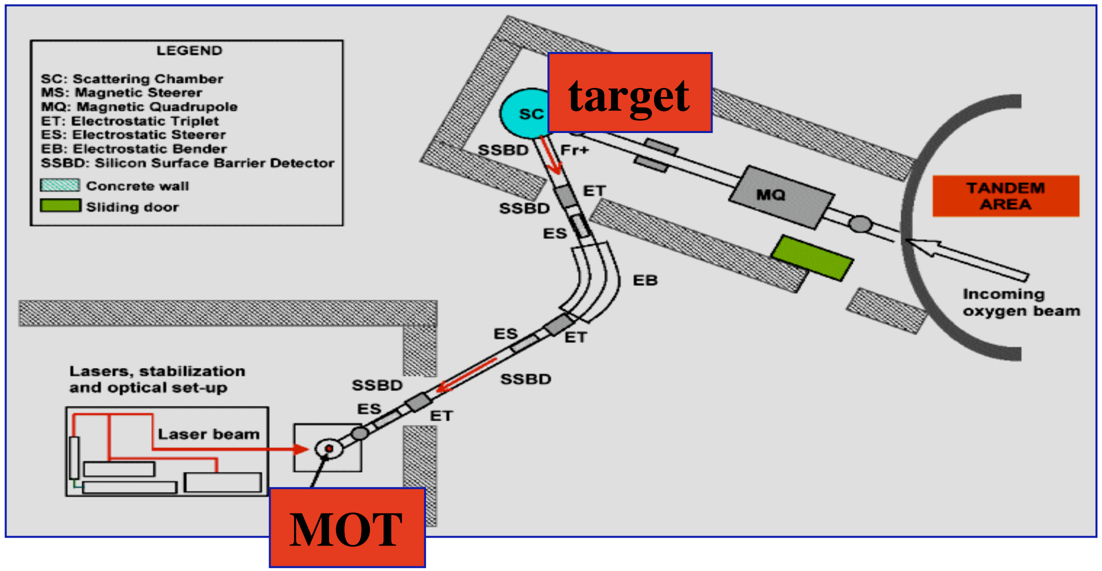
Francium

Ferrara, Legnaro, Pisa, Siena

- Trapping of radioactive atoms at LNL

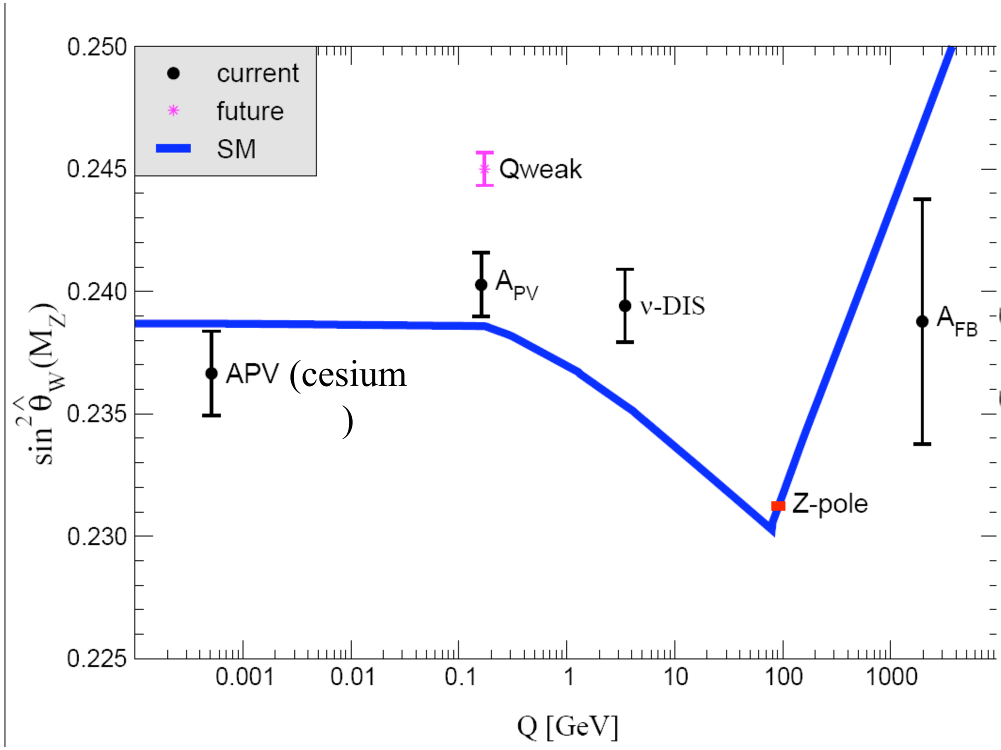


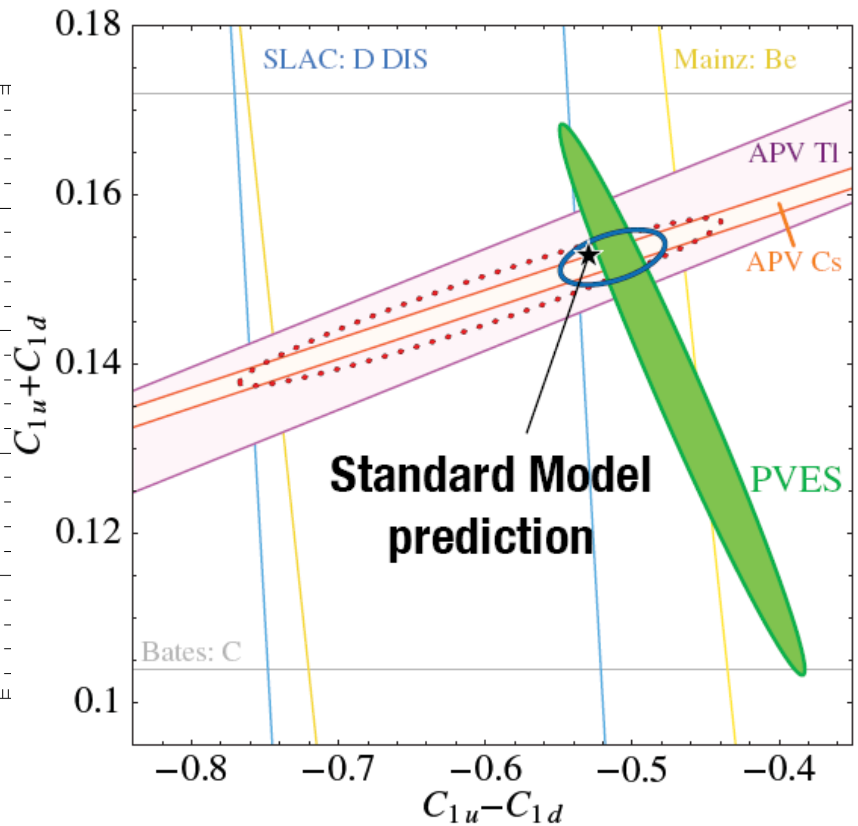




Long term goal of the research field

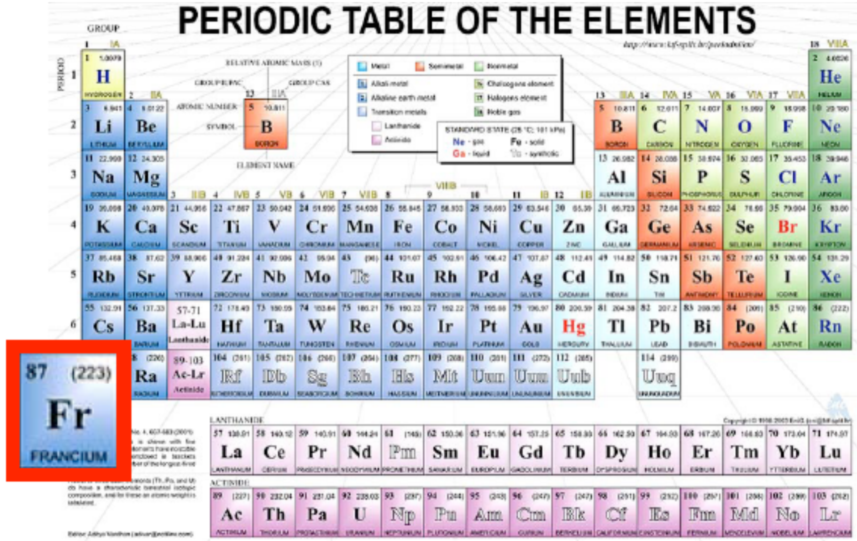
- Atomic parity violation (APV) experiments test weak force at low momentum transfers: electron-nucleon interaction parameterized by weak charge.





Atomic parity violation is complementary to parity-violating electron scattering (PVES) in determining the effective weak couplings of the quarks, to put constraints on New Physics

Francium is the best candidates for APV measurements

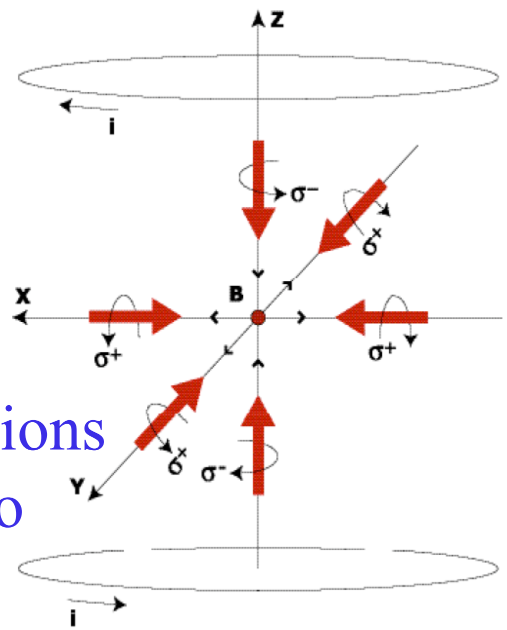


- Heaviest alkali metal: large nucleus and simple atomic structure

- **Enhancement of APV ($\sim Z^3$) effects**

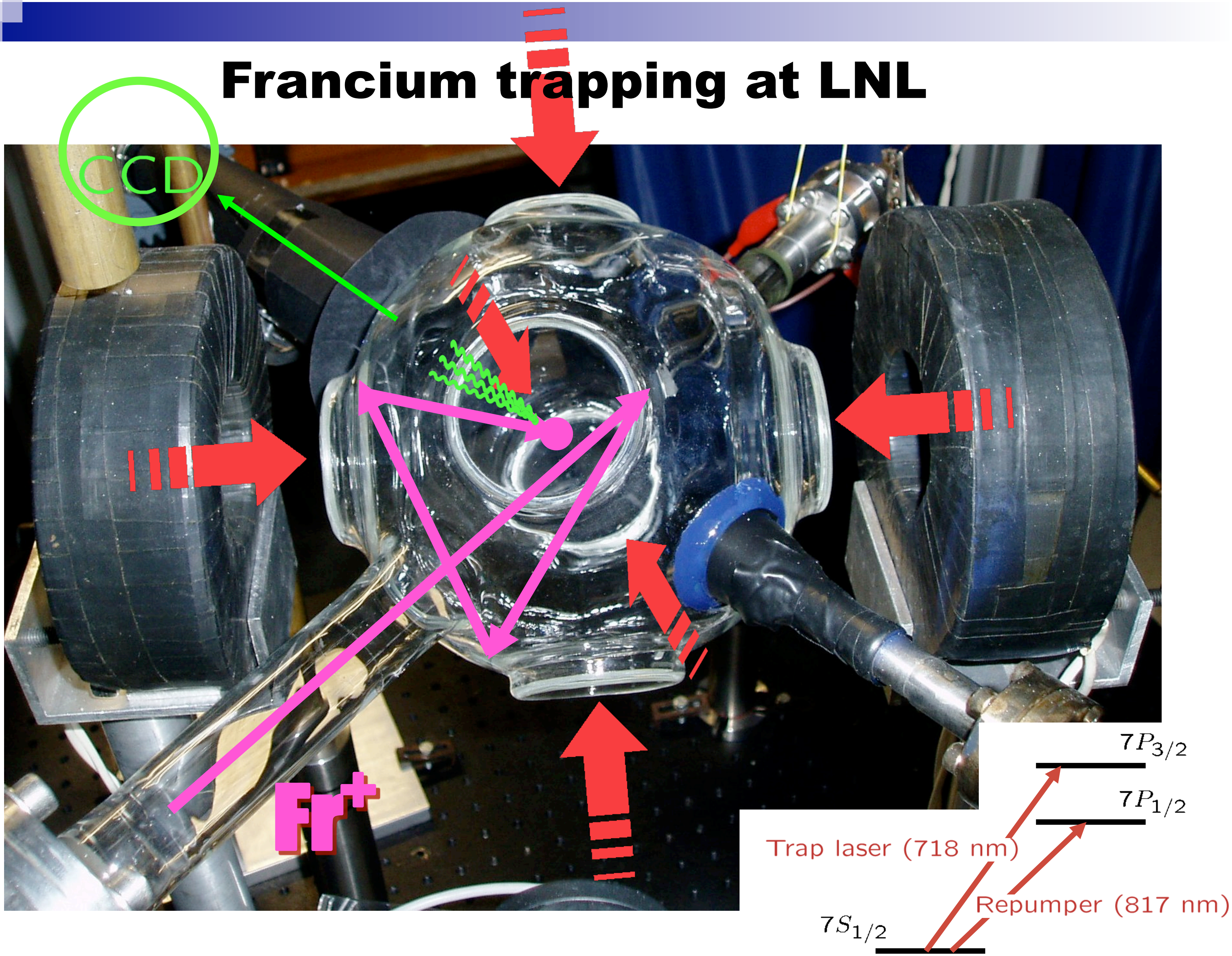
- Several isotopes with relatively long lifetimes (~minutes) to reduce systematics

- No stable isotopes, but scarcity compensated by accumulation in Magneto-Optical Trap →



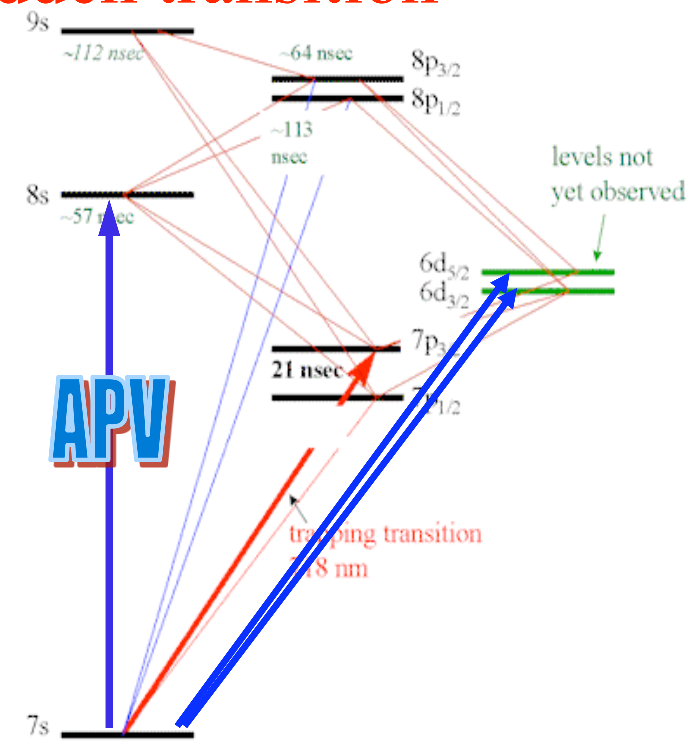
- Francium produced via fusion-evaporation reactions (O beam on Au target), released as ions, guided to MOT and neutralized by Yttrium foil

Francium trapping at LNL



Goals of the experiment

- Maximization of trapping efficiency and number of trapped francium atoms in a magneto-optical trap.
- Ability to excite and detect weak transitions (i.e. quadrupole transitions 7S-6D)
- Ability to excite and detect the forbidden transition 7S-8S, measurement of scalar and vector polarizabilities, fundamental to extract APV contribution
- Development of experimental techniques for precise transition frequency measurements.



Thank you !