GRED (SERDI)

LAL

Date 24/06/2016

Activités de l’équipe

Nom de l’équipe: GRED

Responsable scientifique local: Véronique Puill

DAS référent: Christian Olivetto

Principales activités scientifiques de l’équipe

Activité accélérateurs: UA9 – CpFM : développement d’un détecteur chargé de mesurer l’efficacité de la collimation du faisceau du SPS par un cristal courbé de Si

Autres : Cherenkov Lab : R&D détecteurs Cherenkov (détecteurs, intégration, microélectronique)

- CORTO : développement et construction d’un telescope à rayons cosmiques
- LSST : test de production des ASICs de la caméra CCD
- EUSO-Ballon : équipement d’un nouveau ballon pour un lancement en 2017 en Nouvelle Zélande
- SuperNemo : calibration des feuilles sources du démonstrateur
- ATLAS : simulation du détecteur à l’avant et participation aux tests en faisceau

- Nb approximatif de publications/proceedings par an : 2

Projets techniques accélérateur dans lesquels l’équipe est impliquée

UA9- CpFM : conception, fabrication et mise en œuvre de la chaine de détection pour le SPS (2 détecteurs différents) et le LHC.
Durée du projet: 5 ans (2013 → 2018)
Financements : LAL et IN2P3

Membres de l'équipe

6 permanents :

- Véronique PUILL, IR1, LAL, UA9* 40 %, Cherenkov Lab 10 %
- Léonid BURMISTROV, IR2, LAL, UA9* 50 %, ATLAS 20 %, CORTO 15 %, Cherenkov Lab 15 %
- Vincent CHAUMAT, AI, LAL, UA9* 25 %, Cherenkov Lab 15 %, CORTO 10 %
- Patrick Halin, T, LAL, UA9* 20 %
- Pierre Barrillon, IR2, LAL, LSST 50 %, Euso-Ballon 50 %
- Pia Loaiza, IR2, LAL, SuperNemo 100 %

1 CDD :

- Sébastien DUBOS, CDD IR (09/2015 -> 09/2018), LAL, financement LAL puis IN2P3, UA9* 100 %

1 Thésard :

Andrii Nagaï, thèse de 2013 à 2016 sur le développement d'une

* Thématique accélérateur

GRED

UA9- CpFM

UA9-CpFM – description générale

Nom/acronyme projet : UA9- CpFM

Responsable scientifique national: Achille Stocchi
Responsable scientifique local: Véronique Puill
Responsable technique local: Véronique Puill

Autres laboratoires impliqués

- INFN Rome
- CERN
- Université de Kiev

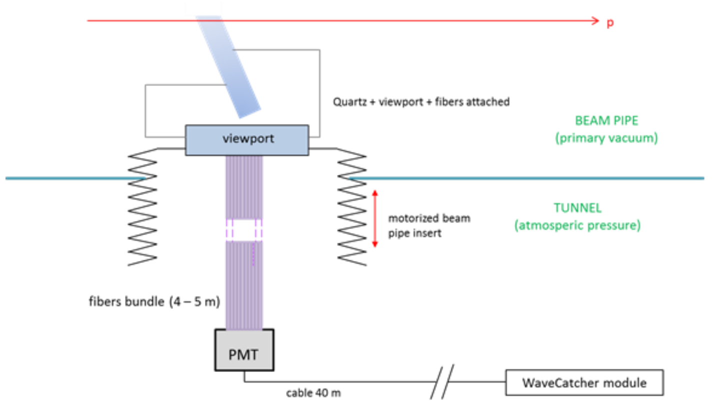
Description scientifique et technique

UA9 est une expérience de collimation du faisceau de protons du SPS utilisant un cristal courbé de Silicium. L'interaction cohérente (canalisation) des protons du halo du faisceau (source de bruit de fond) avec ce cristal permet de défléchir de façon importante les protons et donc d'améliorer l'efficacité de la collimation.

L'étude du processus de canalisation requiert le développement d'un nouveau type de détecteur inséré dans le vide primaire du tube faisceau et fonctionnant dans un milieu radioactif très hostile. Le LAL a la responsabilité du développement du détecteur chargé de mesurer l'efficacité de la collimation en comptant le nombre de protons du halo défléchis par le cristal courbé avec une précision de 5 %. En collaboration avec le CERN et l'INFN, nous avons conçu puis installé dans le SPS le détecteur CpFM : Cherenkov proton Flux Measurement.

Ce projet complet comportant des études de simulation, de la conception et du montage mécanique, de la caractérisation de photodétecteurs et le développement de l'électronique de lecture associée, a impliqué tous les services techniques et administratif du laboratoire.

The CpFM concept



In vacuum detector to limit the increase of the impedance budget

1.interception of the channeled beam (1 to 100 protons) by a quartz
radiator (retractable finger)
2. emission of Cherenkov light readout by a rad-hard PMT
3. PMT amplified signal readout by the WaveCatcher module

UA9-CpFM- ressources

Membres de l'équipe impliqués:

- Véronique PUILL, IR1, Chef de projet, design, tests, 40 %,
- Léonid BURMISTROV, IR2, simulation, conception, tests, analyse, 50 %
- Vincent CHAUMAT, AI, électronique, optique, conception, tests, 25 %
- Patrick Halin, T, mécanique, 20 %

1 CDD:

Sébastien DUBOS, IR (09/2015 -> 09/2018), financement LAL puis IN2P3, conception, tests, analyse, 100 %

Liste des personnels techniques impliqués:

4 permanents

- D. Breton, IR TPN, électronique, 5 %
- J. Maalmi, IR2, électronique, 5 %
- F. Campos, T, câblage, 5 %

Sources de financement 2015 (hors CDDs)

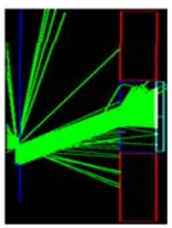
- 2013 : 30 k€ LAL (R&D studies)
- 2014 : 20 k€ IN2P3
- 2015 : 25 k€ IN2P3, 8 k€ LAL
- 2016 : 36 k€ IN2P3

UA9-CpFM- faits marquants

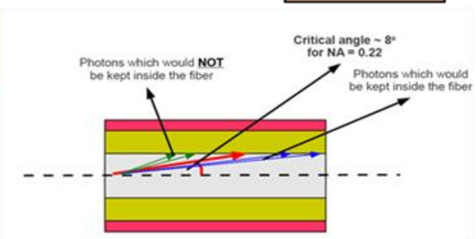
2013

January — June — October — December

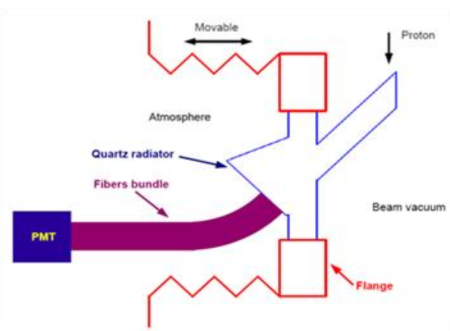
Simulation Studies Design → **LAL CS approval** → **CpFM proto (LAL made) beam test @ BTF → proof of principle** → **Simulation of the last geometry / Building of the final proto**



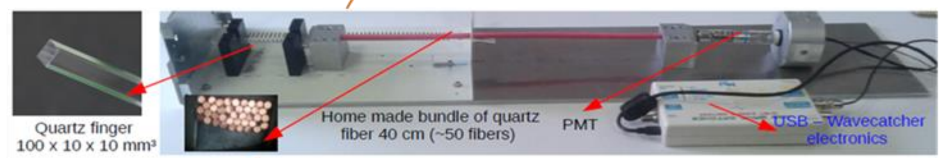
One of the 30 geometries simulated with Geant4

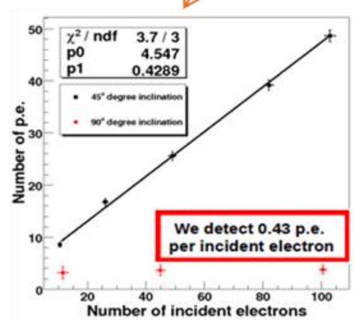


Study of the light transmission inside the fibers

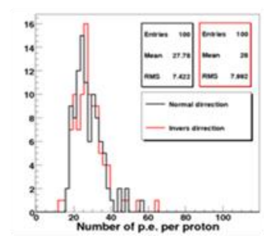


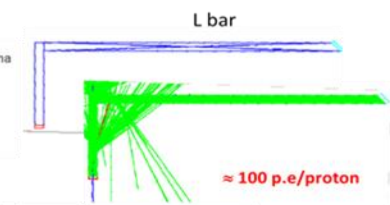
First CpFM geometry → too complicated to build

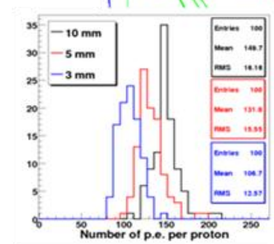




Good agreement (10 %) between simulation and measurements







UA9-CpFM- faits marquants

2014

January

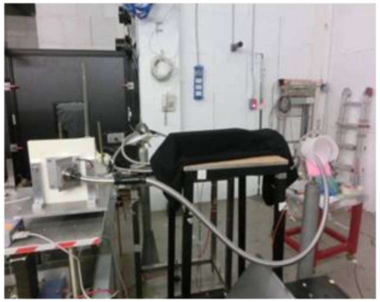
Building of the final proto: at LAL and in specialized companies (quartz, mechanics, fibers, …). Characterization of the PMTs (gain, linearity)

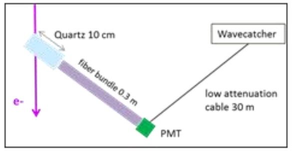
Quartz/quartz fibers bundle

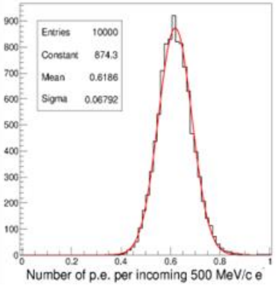
PMT

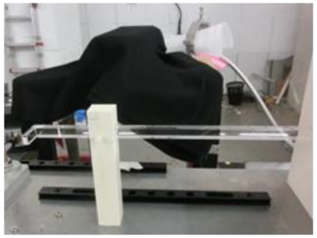
April

CpFM final proto beam test @ BTF → OK for the SPS









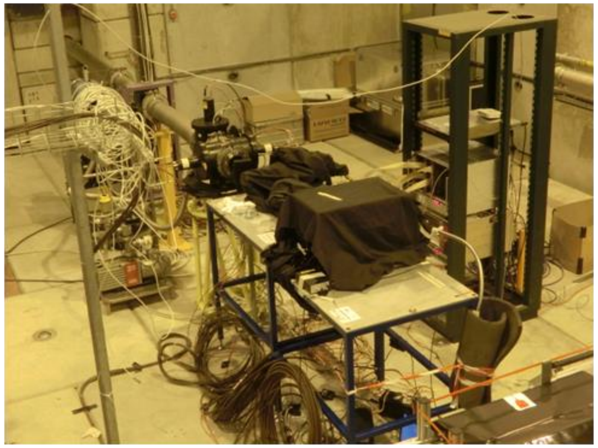
0,6 p.e/incident e-

Resolution = **15 %** with a I bar

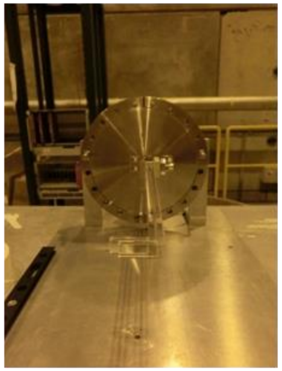
October- November

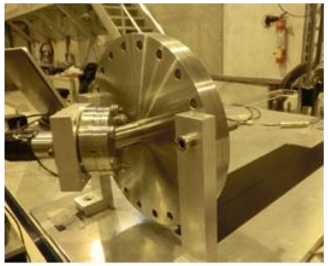
Building of the CpFM for SPS

Beam test in H8 (CERN)



L bar not enough polished → selection of the I bar



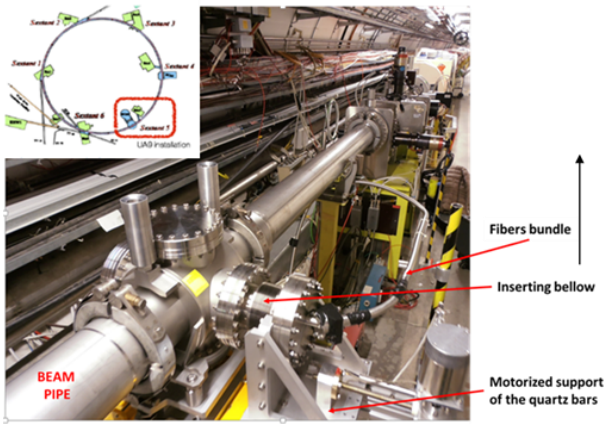


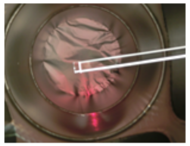
UA9-CpFM- faits marquants

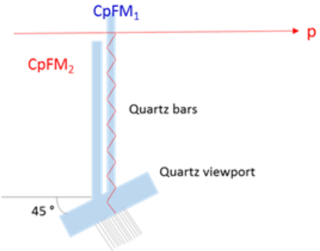
2015

January | July | October- November

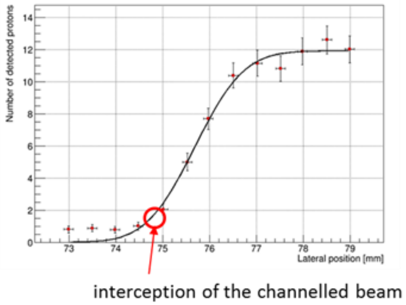
Installation of the CpFM inside the SPS beam pipe → **First results of operation in the SPS: 8th of July** → **3 data taking periods for UA9 in SPS**



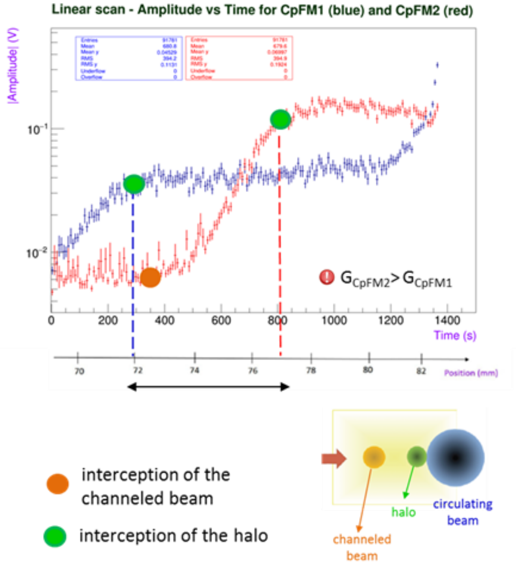




Scan of a 270 GeV proton beam in the SPS



- ✓ Clear CpFM signal, no electromagnetic perturbations
- ✓ Sensitivity to 1 incident proton



CpFM is the only calibrated detector in the UA9 experimental set up that measures the number of deflected particle with a precision of 15 %

UA9-CpFM- faits marquants

2016

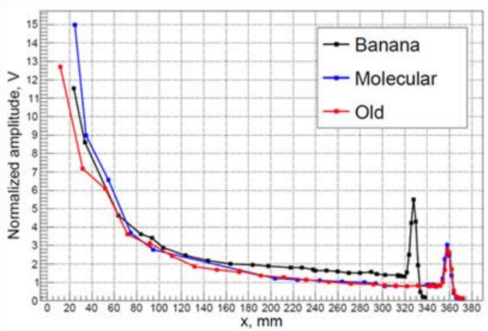
February — April — June

Presentation of the UA9 activities to the LAL CS →

Recommandation du CS (février 2016)

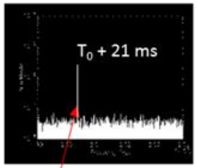
Le CS encourage la poursuite de l'ensemble des activités de développement des CpFM, et en priorité la finalisation des activités de tests sur le SPS (**upgrade, analyse et publication**).

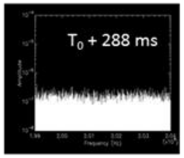
Beam tests at BTF & H8 for the CpFM upgrade for SPS and the validation of the CpFM for slow extraction



Response of the CpFM as a function of the electron impinging position on the quartz bar

1s CpFM acquisition at 2 GHz

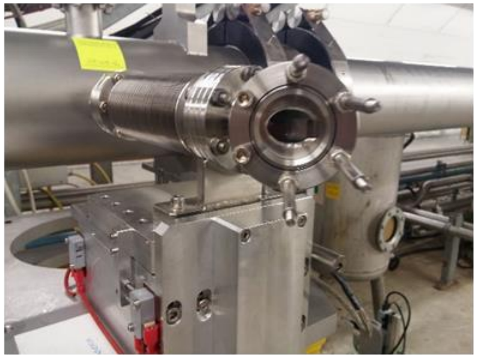




200 MHz structure imposed by the SPS accelerating RF system

Debunching → no 200 MHz

→ **Installation of the CpFM-SE in the SPS (TT20 section)**



UA9- évolution anticipée (3-5 ans)

SPS data analysis

2016

50 data sources: motors of the goniometer, of the CpFM inserter, scintillators counters, Medipix signal, CpFM signals, beam characteristics, …

Our proposal : **develop a common software tool** to harmonize the stored data formats in order to ease the analysis. Aim : start exploiting the detector during the UA9 runs in view of **performing the measurement of the collimation efficiency** and to **support studies of the diffusion dynamics** in cooperation with CERN accelerator physicists

→ **general article about the CpFM**

Upgrade of the CpFM-SPS

2016

- **Replacement the I-bar** with very well polished L-bar (already at LAL) → improvement of the resolution (aim = 5 %), decrease of the cross-talk
- **Checking of the fibres bundles** and measurement of a correction coefficient
- **Replacement of the PMT** (and measurement of the radiation impact on their main characteristics)

UA9- évolution anticipée (3-5 ans)

CpFM-SE   2016 - 2017

- **Beam test at H8 at high intensity** (10^7 protons/bunch) in order to check the linearity of the PMTs (April 2016)
- **Upgrade of the readout electronics** (to record 4 s)
- Production of an adequate software appropriate for the data storing and for **FFT analysis**
- **Installation** in SPS-TT20 (end 2016) → article about the CpFM-SE
- Participation to the **data taking** (2017)

CpFM for LHC   2016 - 2018

Request from Stefano Redaelli (responsible for the LHC Collimation Project): design and install a CpFM outside the vacuum pipe that measures the losses of one or several bunches over several turns (need of a fast detector with high dynamic range).
Work will be distributed between LAL and INFN at the next Steering Committee (before March)

- **Studies** to explore the harsh operating conditions of the CpFM in the LHC tunnel (**high radiation and temperature): PMT, quartz** and **fibre** irradiation at CERN
- **Design and building** of the detection chain
- **R&D on the flange/quartz welding** (collaboration with CSNSM ?)
- **Beam tests, calibration**
- **Installation** in the LHC → general article about the CpFM-LHC
- Participation to the **data taking and analysis**

UA9- attentes (vis-à-vis de l'IN2P3)

Evolution anticipée en termes de personnels et de ressources financières -> Attentes vis-à-vis de l'IN2P3 concernant :

- **Les personnels :** nous permettre de continuer à proposer des stages sur cette activité (2 M2 en 2014 et 2015, 1 en 2016) + thèse en co-tutelle avec l'Université de Kiev à partir de septembre (LAL et CERN)

- **Les finances :** continuer le soutien aux activités UA9 → budget nécessaire pour 2017

	Référence de la dépense	2017	Commentaires
	alimentation BT pour les amplis		
	modules WaveCatcher 8 voies		pour les TB puis l'installation au LHC
	petit matériel (câbles, connecteurs, colle optique...)	1250	
	frais livraison (tous matériels)	500	
CpFM SE	support mécanique pour fixer le PMT à la bride		
	readout electronique		extension de la carte COBRA pour enregistrer 8 s
Upgrade SPS	barreau quartz polissage amélioré		dudget 2015
IRRADIATIONS	PMTs rad-hard (2 types) + embases + ampli		tests possiblement destructifs
	morceaux de quartz		
	fibres optiques (2 types)		
	supports mécaniques		
PROTOTYPE LHC	1 PMT rad-hard + embase+ ampli		embase home made - serviront de spare pour le CpFM LHC
	petit bundle de fibres quartz (30 cm)		
	1 barreau de quartz		puis spare pour le CpFM LHC
	support mécanique		
CpFM LHC	supports mécaniques pour TB	500	
	2 PMTs rad-hard + embases+ ampli	3800	
	faisceaux de fibres optiques quartz/quartz 10 m	18000	
	2 barreaux de quartz	7000	
	cables coax faible atténuation (300 m)	5000	
	Coût CpFM UA9	**36050**	

	lieu et nature de la mission	2017
Missions	3 TB, 3 MD et 3 réunions/an CERN (3 personnes)	8000
	TB au BTF (2 semaines x 2 personnes)	2600
	irradiations (4 jours au CERN x 2 personnes)	2048
	Coût total missions CpFM	**12648**

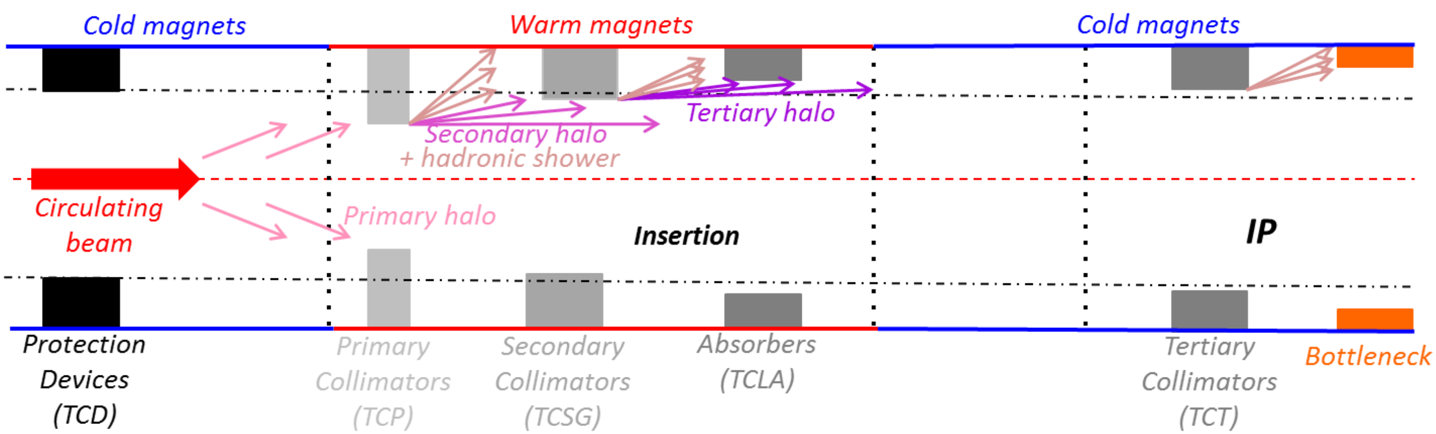
BACKUP

Beam collimation

The collimator job is to **control and safely dispose of the halo particles** that are produced by unavoidable beam losses from the circulating beam core beam losses (caused by collisions at the interaction points, the interaction of the beam particles with residual gas, intra-beam scattering, …)

The halo particles are removed by a cascade of amorphous targets:

1. Primary and secondary collimators intercept the diffusive primary halo.
2. Particles are repeatedly deflected by Multiple Coulomb Scattering also producing hadronic showers
3. Particles are finally stopped in the absorber



Daniele Mirarchi, A&T Seminar, CERN

Main roles of the LHC collimation system:

- ✓ Minimization of possible magnet quench
- ✓ Protect the machine from fast accidental losses
- ✓ Avoid high radiation levels displaced all around the accelerator

R&D for the upgrade of the LHC collimation system

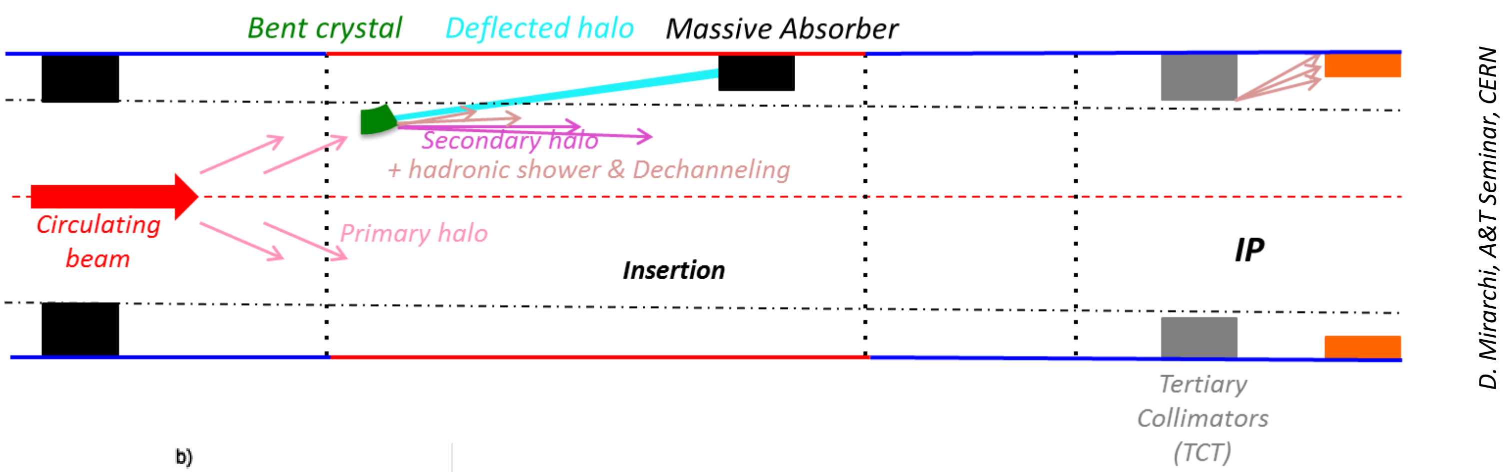
Present collimation system designed to handle 360 MJ of stored energy in the machine

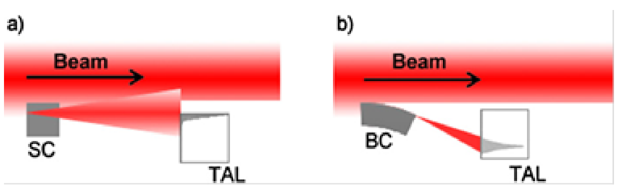
→ **Hi-Lumi** upgrade an increase up to about **700 MJ** is foreseen

The connected increased circulating intensity of about a factor two, calls for:

- **Improved cleaning** performances
- **Reduction of** induced **impedance** by collimators → Reduction of the beam instabilities

Crystals collimation which aims are to **improve the cleaning and reduce the impedance** is one of the R&D projects approved for the LHC collimation





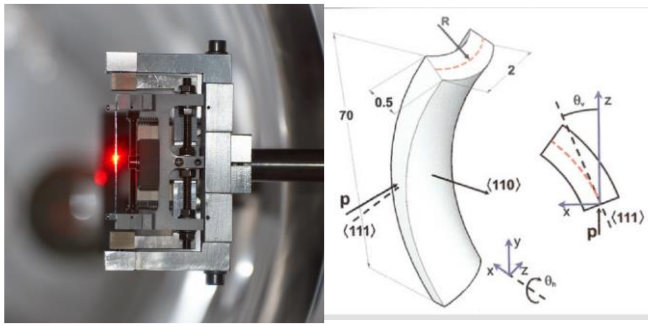
Yu.M. Ivanov

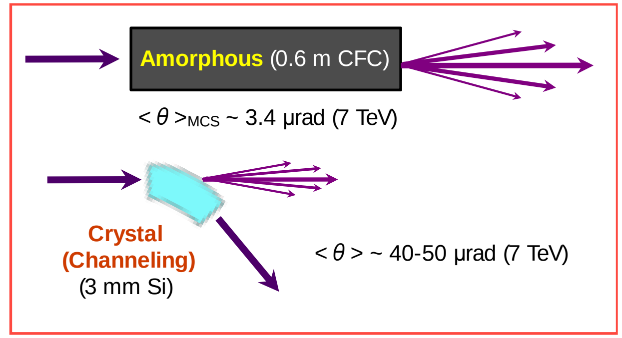
(a) Collimation scheme using a solid state primary collimator scatterer (SC).
(b) Collimation scheme with a bent crystal (BC) as a primary collimator. **Halo particles are deflected and directed onto the absorber far from its edge**

The UA9 mission

Investigate bent crystals as primary collimators in hadron colliders

- Bent crystals work as a "smart deflectors" on primary halo particles (W. Scandale 10.1103/PhysRevSTAB.11.063501)

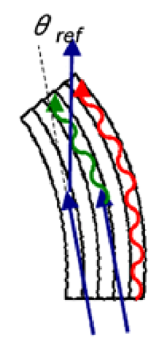




- If crystalline planes are correctly oriented, particles are subjected to a coherent interaction (channeling):

✓ large angle deflection also at high energy
✓ reduced interaction probability (e.g. diffractive events, ion fragmentation/dissociation)
✓ reduced impedance (less secondary collimators, larger gaps)

✗ small angular acceptance
✗ concentration of the losses on a single absorber



The UA9 Collaboration is investigating how to use bent crystals as primary collimators/deflectors:

- operational and machine protection concerns are considered in cooperation with the Collimation Team
- 3 installations (since 2014): SPS North Area (H8), SPS (since 2008), LHC

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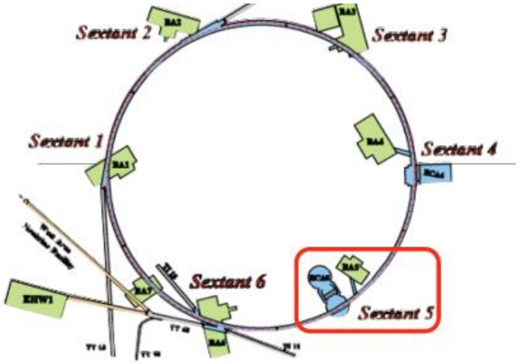
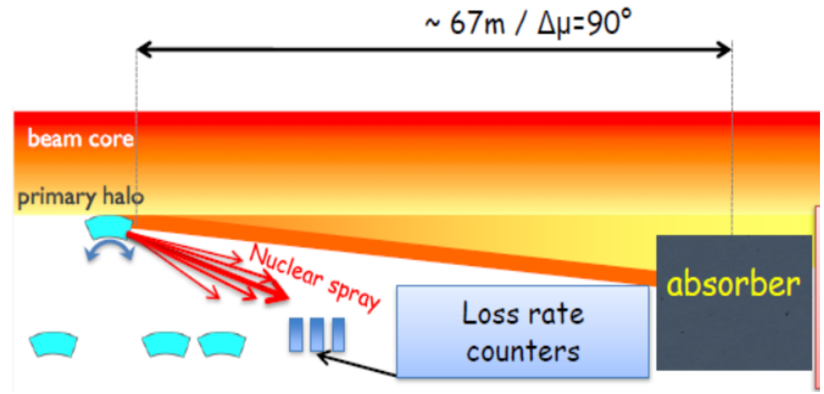
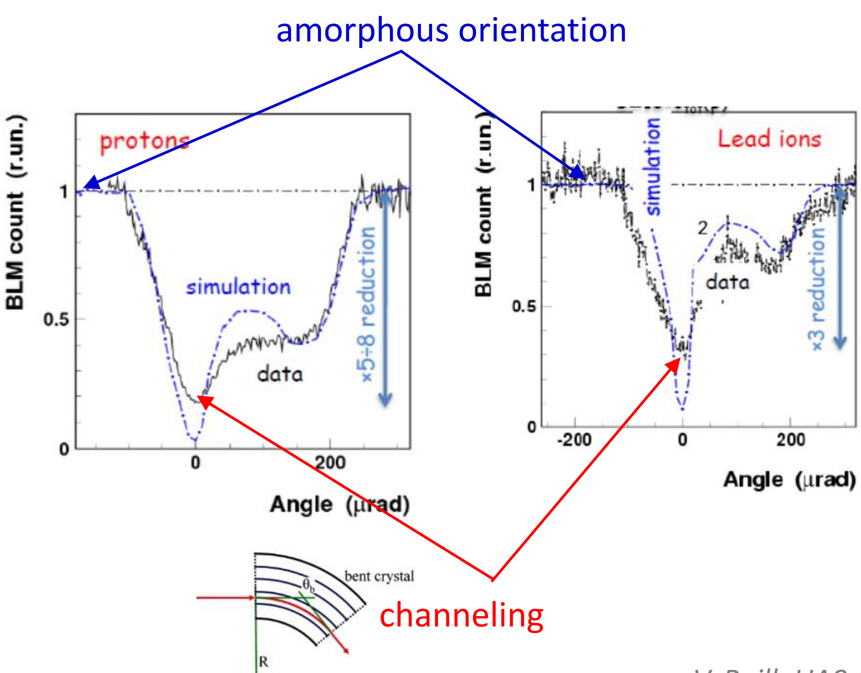
UA9 SPS





W. Scandale, SPSC 2012

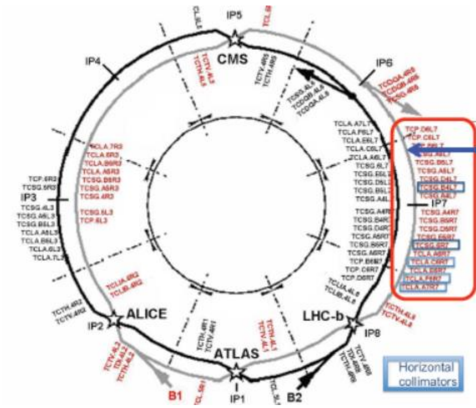
Particles well channelled by the crystal don't approach the planar channel walls closely → no nuclear interactions → beam losses measured by the BLM instrument (Beal Loss Monitor) are strongly reduced



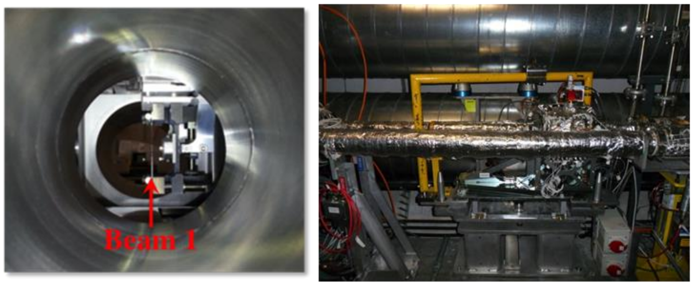
- Extensive tests with 120-270 GeV protons and Pb ions since 2009
- Single bunch and multibunch dedicated beams
- **Fast and reproducible crystal alignment**
- **Clear loss reduction with respect to an amorphous orientation up to x 20 reduction**

UA9 LHC

A prototype crystal collimation system was designed and installed in the LHC to validate the feasibility of this concept at the LHC during Run II



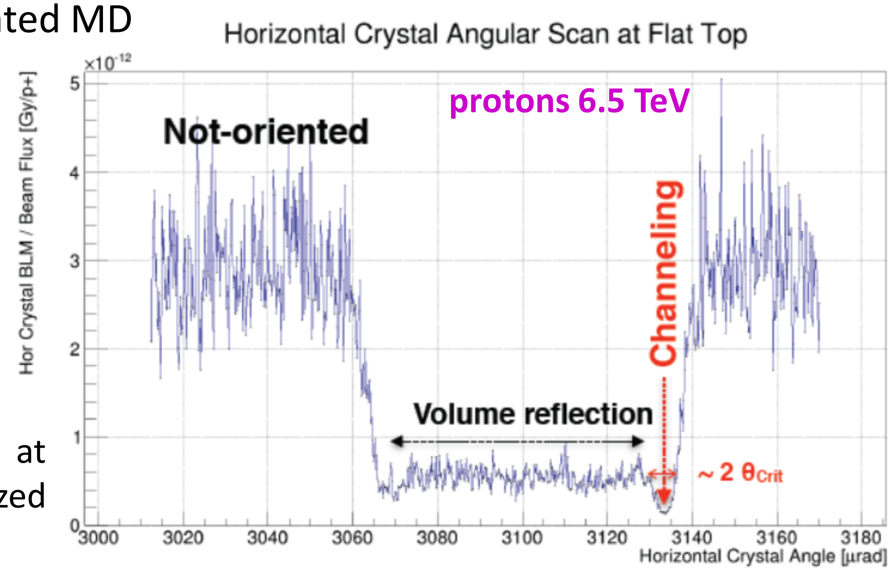
Silicon Strip crystal and piezo goniometer installed in IR7-B1 (horizontal plane)



Crystal test at the LHC supported in **2015** with 3 dedicated MD

Channeling observed for the first time with LHC beams

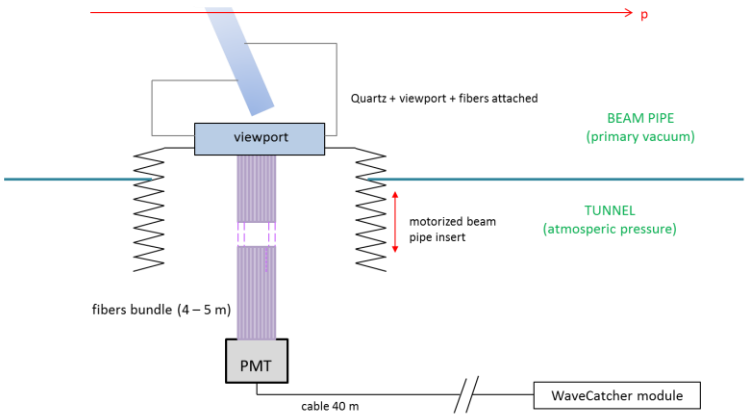
- **Protons: 6.5 TeV (record)**
- **Pb ions: 450 GeV (record)**



Losses recorded with BLM at goniometer position normalized to beam flux

The CpFM concept

Aim of the CpFM: count the number of deflected protons with a precision of about 5% in the LHC environment (mean value over several bunches)



In vacuum detector to limit the increase of the impedance budget

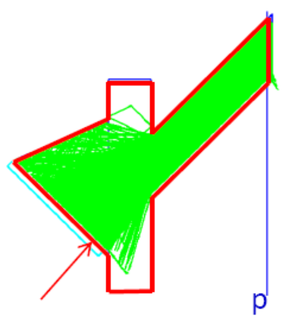
1.interception of the channeled beam by a quartz radiator (retractable finger)

2. emission of Cherenkov light readout by a PMT placed 1 m from the beam pipe (light brought by silica fibers)

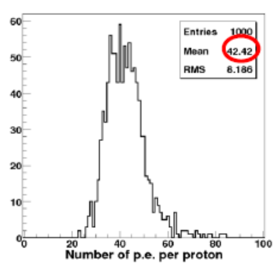
3. PMT amplified signal readout by the WaveCatcher module

Our proposal in June 2013

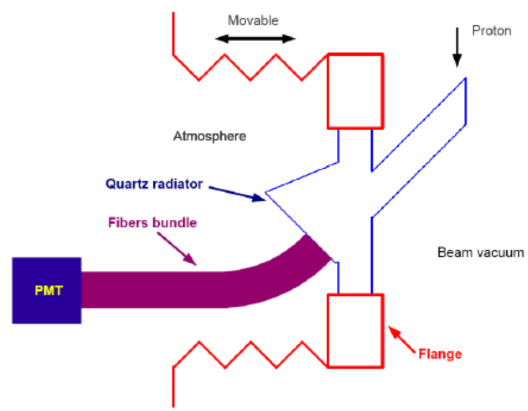
Quartz radiator + viewport + fiber adapter = single piece



Fiber adapter to optimize the entrance of the photons inside the fibers



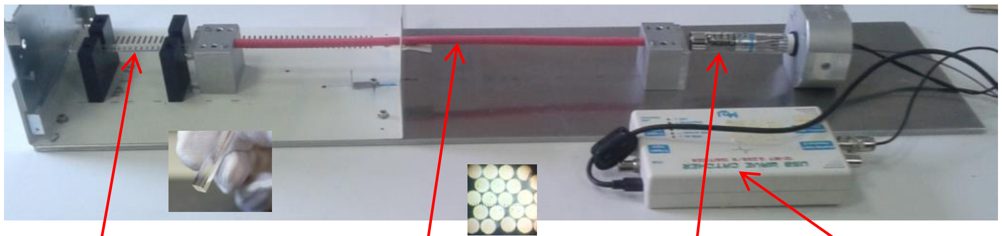
taking into account a PMT with Bialkali PC + CE



≈ 420 photons/proton at the quartz piece output

CpFM Proof of principle

Building of the CpFM prototype at LAL (« home made » fibers bundle) in September 2013



Quartz type (7980-UV-0D FUSED SILICA)
Fibers quartz/quartz (AS600/660UVST)
PMTs (R762 or R7378A)
Coaxial cable (CKB50)
Readout electronics (WaveCatcher)

all the CpFM components chosen for the SPS

Tests of the CpFM at BTF (Frascati, Italy) in October

- Comparison of the measurements and the simulations → good agreement
- Checking of the optimum orientation of the quartz bar with respect to the beam → 45 °
- Measurement of the signal attenuation in the cable → - 20 % for 30 m

CONCLUSION

CpFM in its « quasi » SPS configuration is able to detect single particle

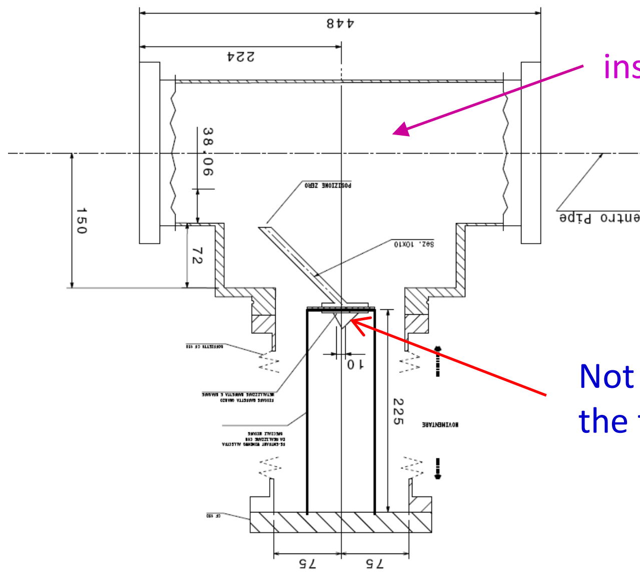
→  for the installation in SPS

Change in the CpFM geometry

Mechanical integration problem

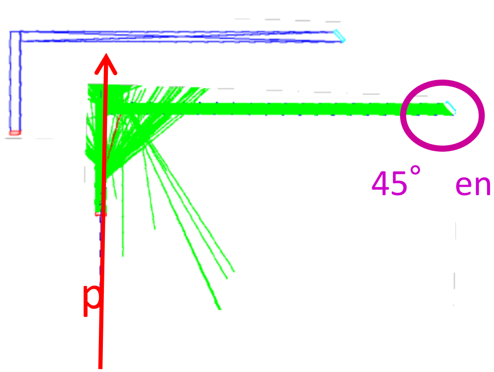
INFN team who was in charge of the mechanical support of the CpFM designed a tank that did not take into account the curvature of the bundle …

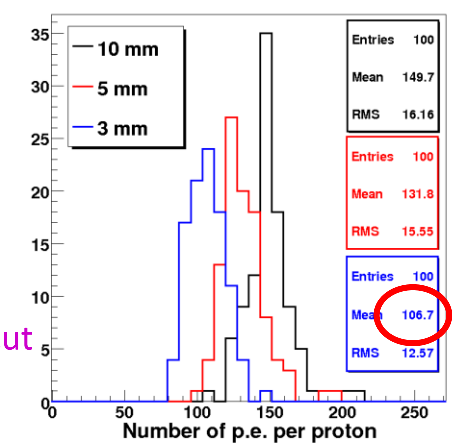
need to find a new quartz bar geometry



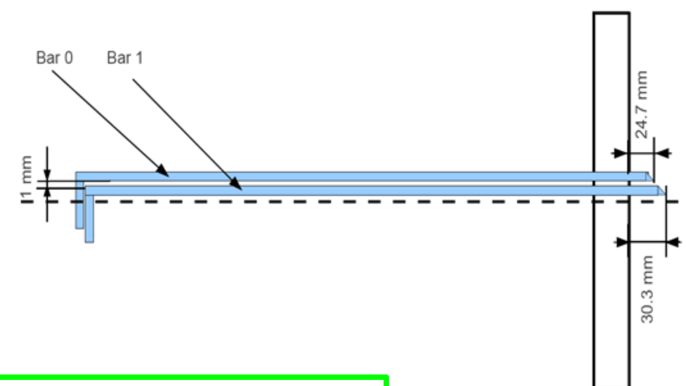
Geometry optimization

L-shape





Adding of a second channel in order to substract the background



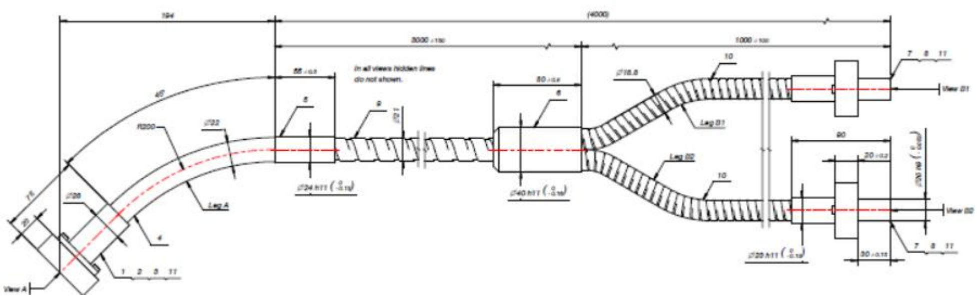
The final geometry is fixed in December 2013, 6 months after the CS approval

Realization of the CpFM for the SPS

Goal : calibrate the CpFM at BTF in April 2014 and at H8 in May

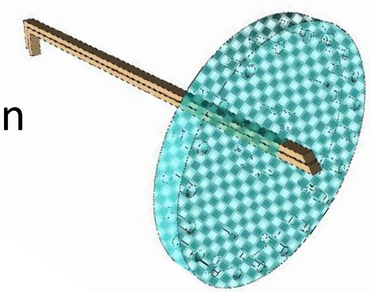
3 principal technical difficulties (possible show-stoppers …):

- L-shape quartz bars with high polishing quality : only 1 company found (TRIOPTICS) that accepts to do it



- 2x 100 quartz/quartz fibres bundle of 4 m (very fragile)

- Brazing of the bars to the flange : INFN took charge of it (American company (MORGAN WESGO) specialized in products for vacuum)

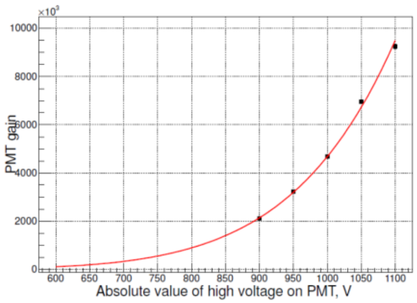


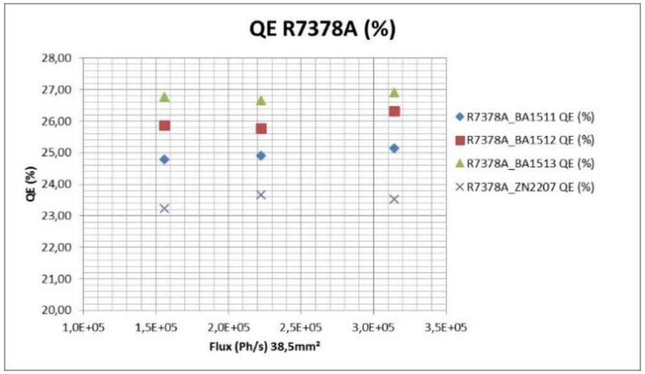
All the components were ordered in December

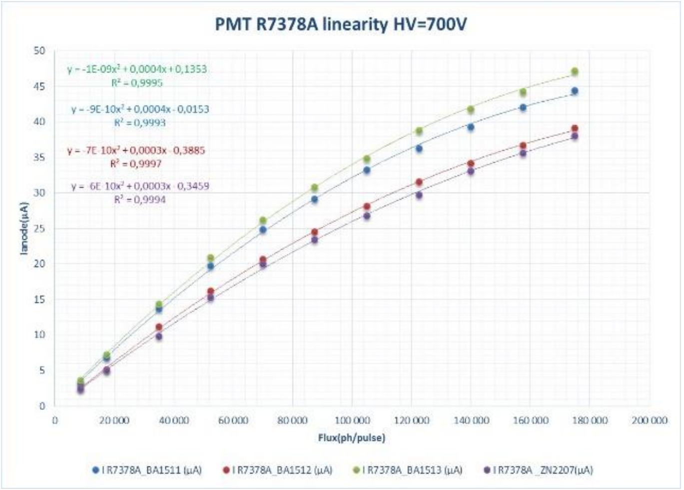
What went very well ….

PMTs calibration

R7378A BA1513



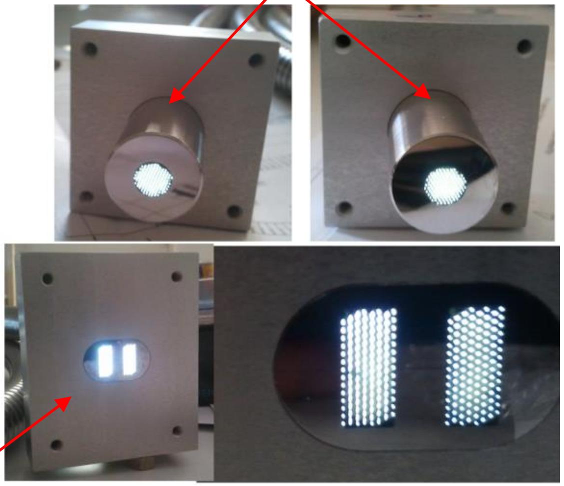




Fibers bundle

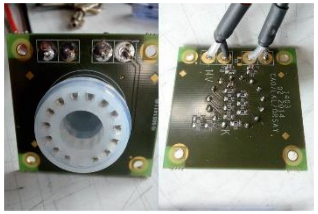
12th of March (2 weeks before the TB …)

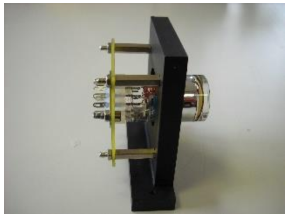
PMT side

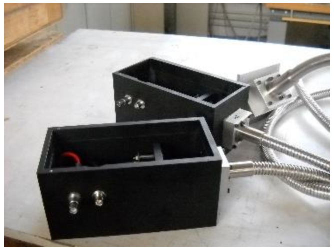


Quartz bars side

PMTs socket and housing (LAL)







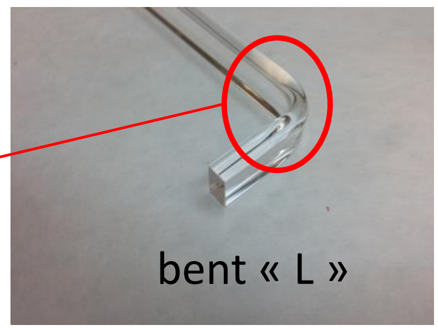
and what did not … at all

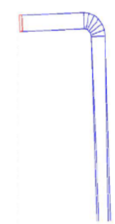
Quartz bar realization

The American company (sub contractor of the French company TRIOPTICS) factory burnt during the Christmas holiday → they had to subcontract the production of our bars in order to respect the delivery date → **the "L" bar is bent**

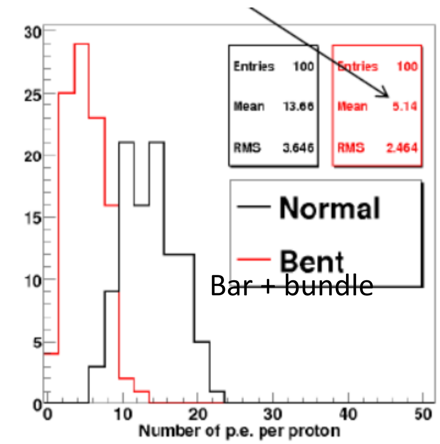
2 BARS sent to LAL on the 15th of February and 2 others to Morgan Wesgo in USA for the brazing

Lost of a factor 2 by comparison with a straight configuration

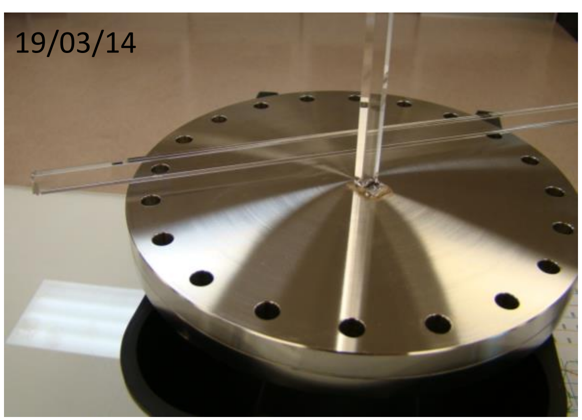


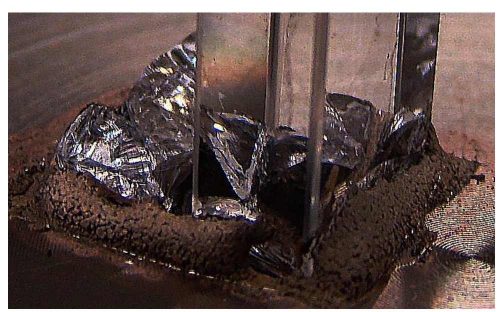


simulation



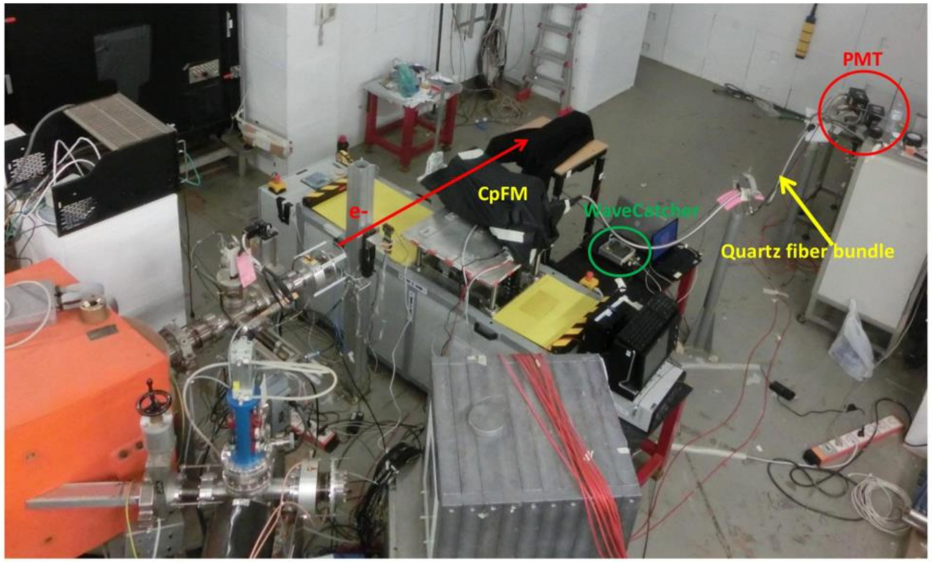
Quartz bar and flange brazing





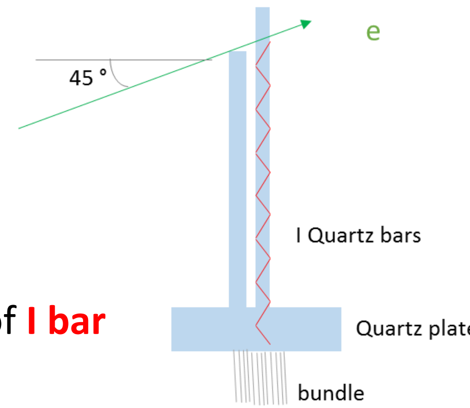
Breaking of the 2 bars during the brazing process !!! …

CpFM Beam tests at BTF (April 2014)

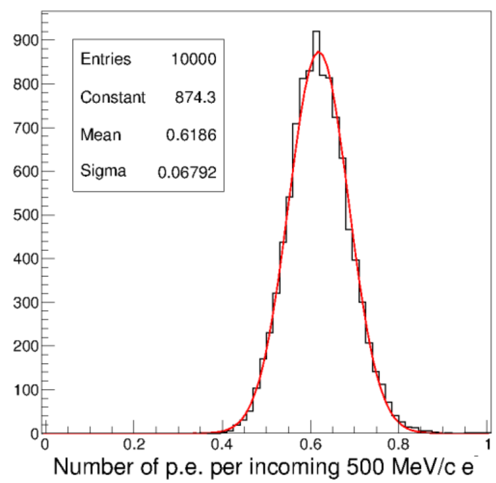


New plans:

- Checking of the **backup CpFM geometry** : 'I" bars + quartz viewport + bundle (instead of L bar passing through the flange + bundle)
- Measurement with the "bent L" quartz bar



Conclusions:



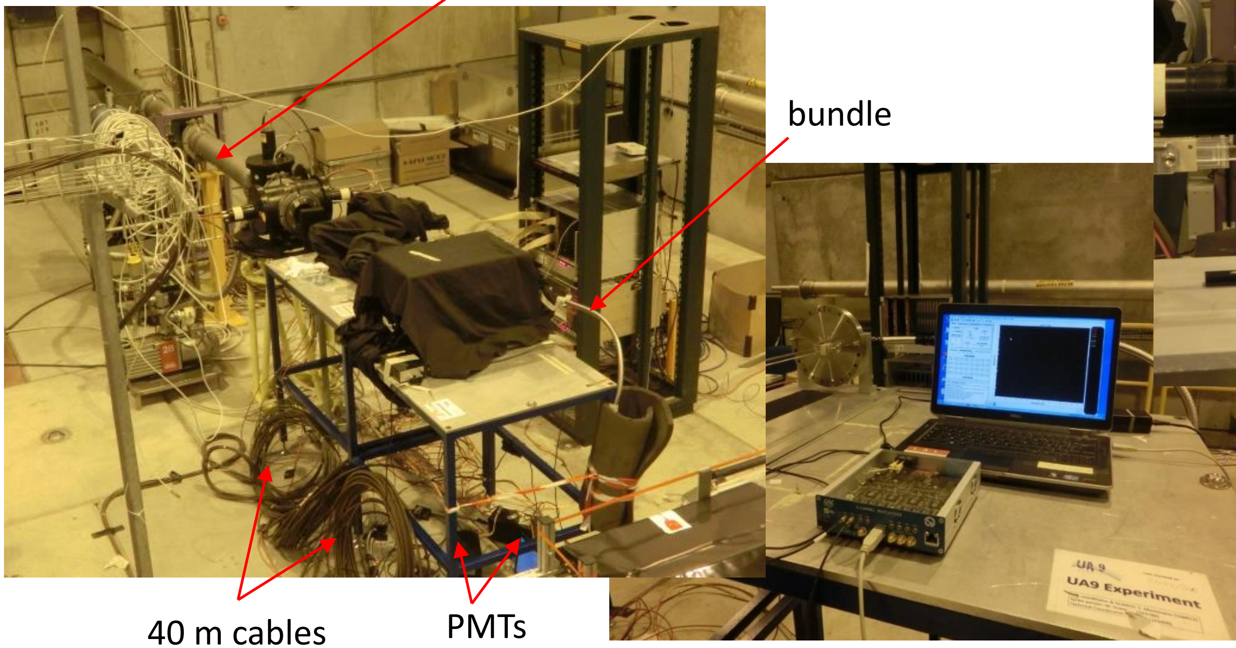
- Bent L bars not enough polished → using of **I bar**
- Quartz window decreases the signal by a factor 2
- **0.62 p.e. per incoming electron for the final configuration :**
I bar + window + 4 m fibers bundle + PMT + 30 m cable + WaveCatcher

⇩

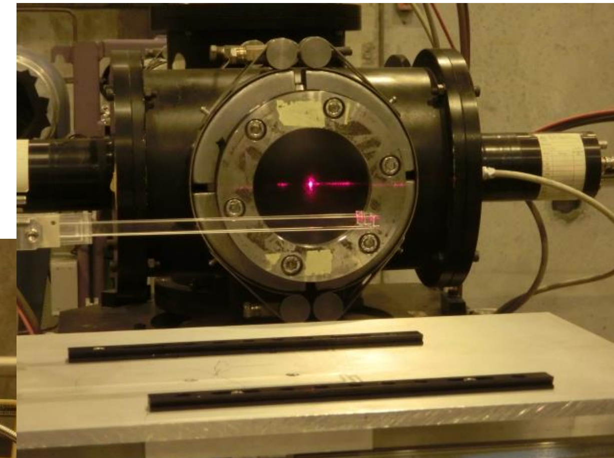
resolution = 15 % for 100 incoming electrons

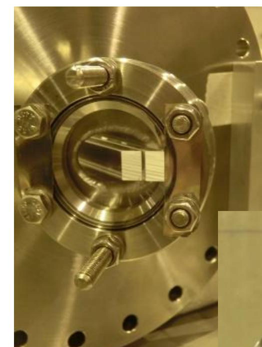
CpFM Beam Tests in H8 (May – June 2014)

400 GeV/c p , 180 GeV/c π^+



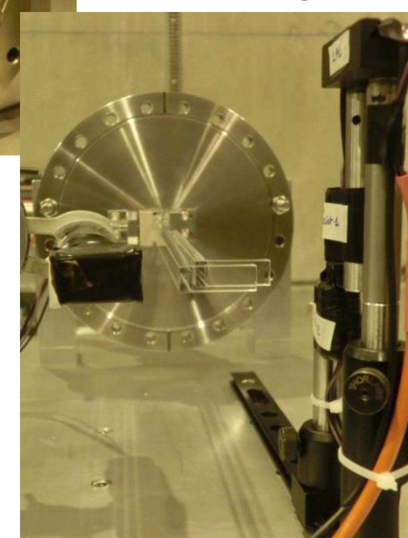
WaveCatcher module





Quartz bars end touching the 45 ° viewport

L bars connected to the flange



1. Test of the new L bars from OPTICO AG

- I bar : 0.63 p.e/proton
- L bar : 0.23 p.e/proton

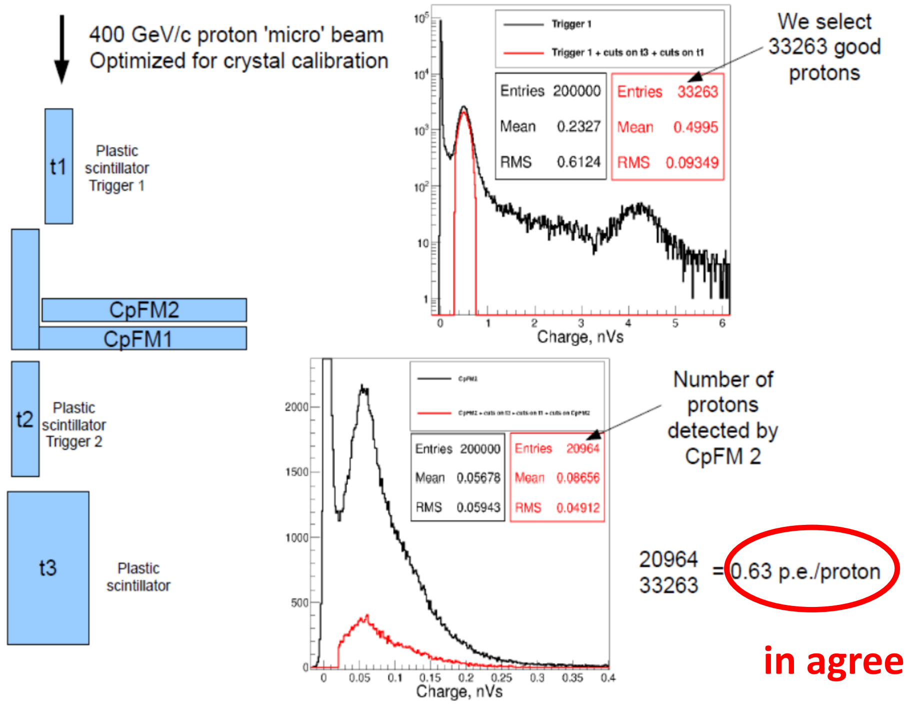
➡ we chose the I bar

2. Check of the calibration performed at BTF

3. Measurement of the cross-talk

CpFM Beam Tests in H8 (May – June 2014)

Calibration with of the I bar configuration (with 400 GeV/c proton beam)

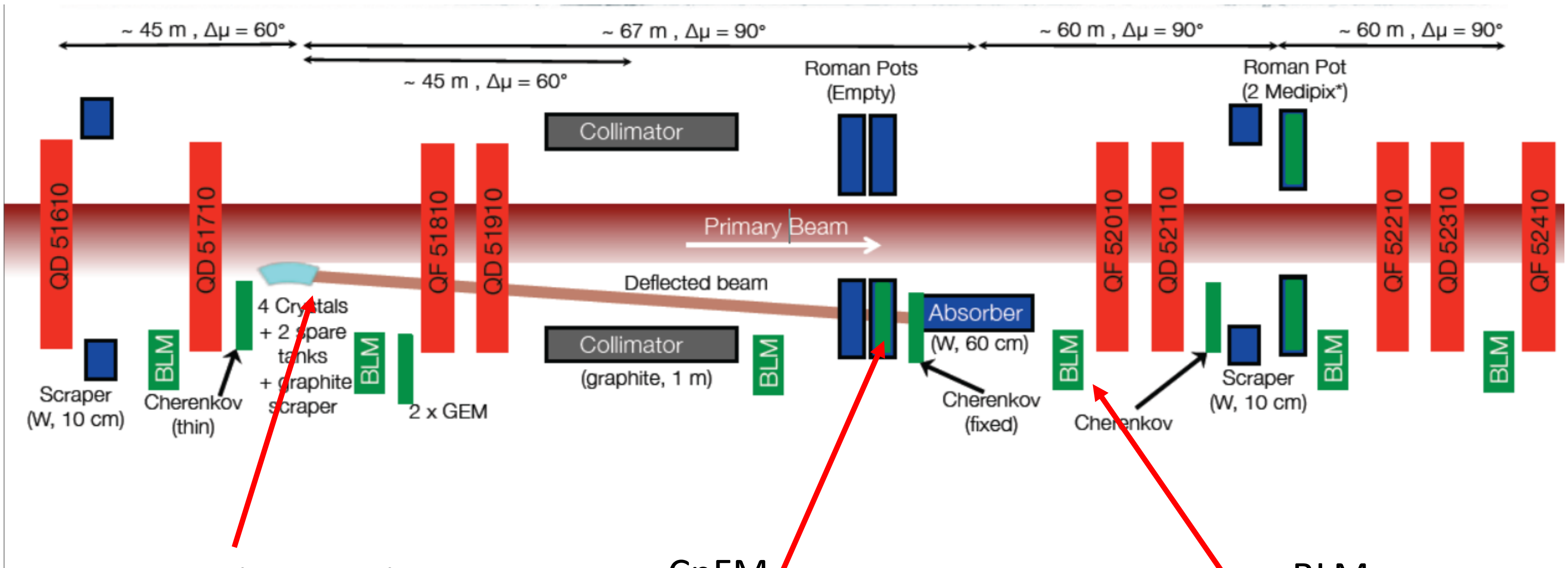


in agreement with the BTF results

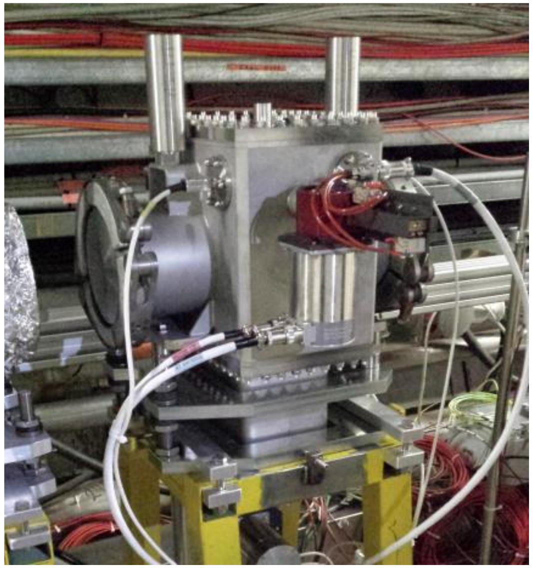
Measurement of the cross-talk

Cross-talk between $CpFM_1$ and $CpFM_2 \approx 15$ %

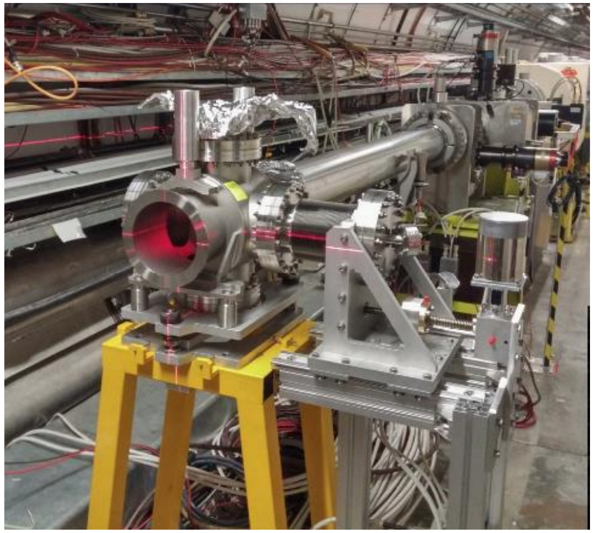
UA9 in the SPS: Experimental setup



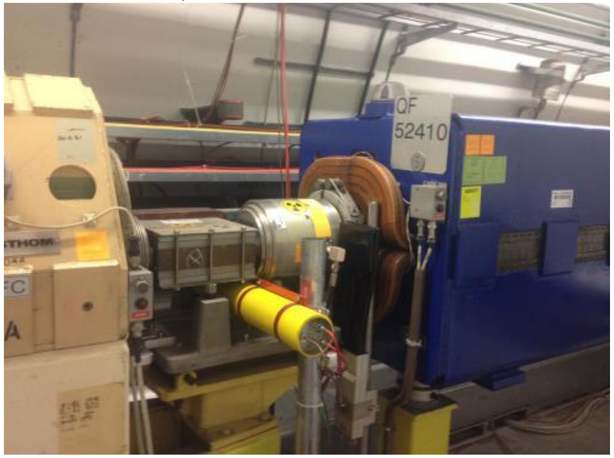
LHC-type piezo-gonio



CpFM

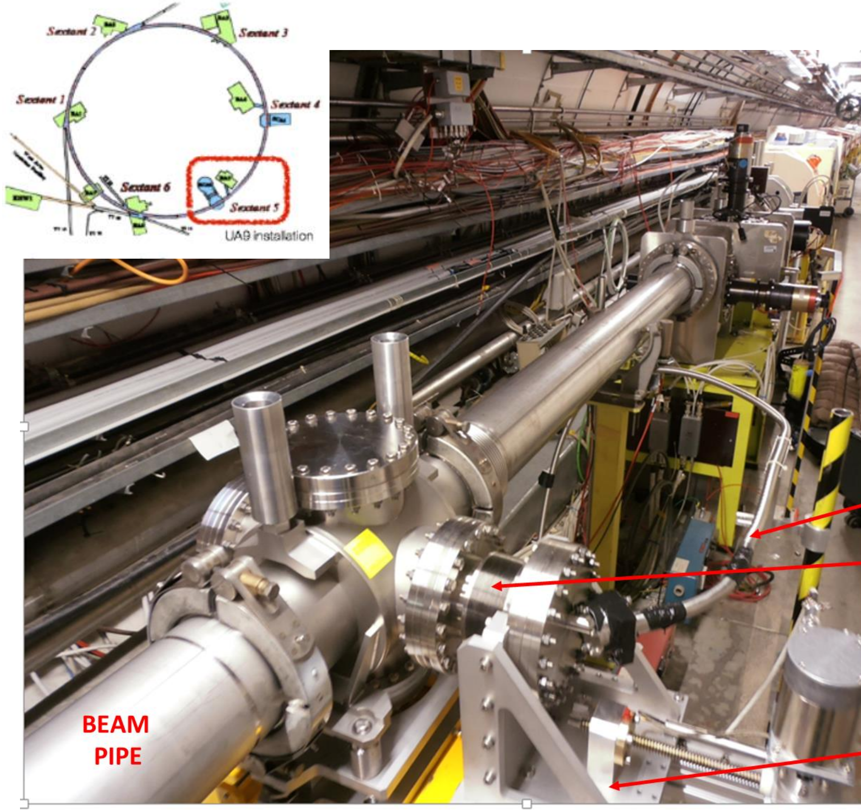


BLM



CpFM installation on SPS – January 2015

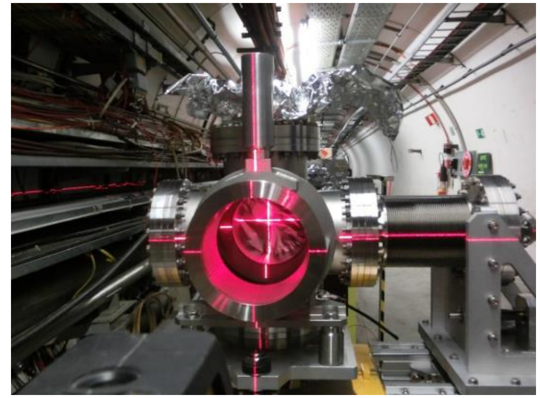
The CpFM was successfully installed on the SPS in January 2015, 58 m downstream the crystal.

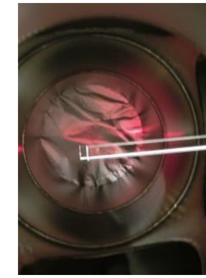


Fibers bundle

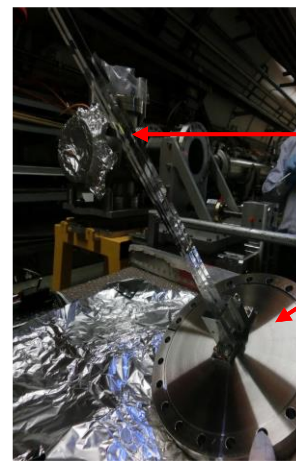
Inserting bellow

Motorized support of the quartz bars



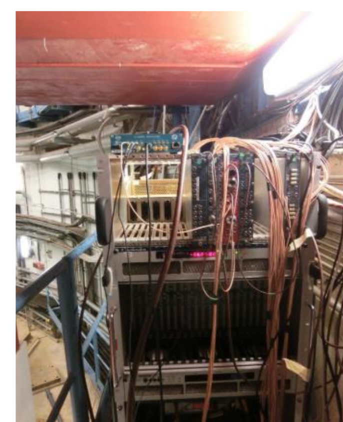


alignment of the quartz bars



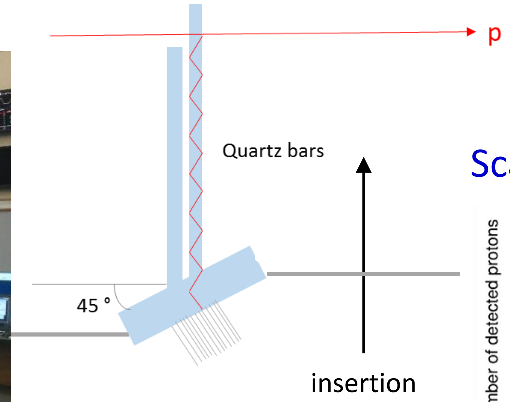
Quartz bars

flange

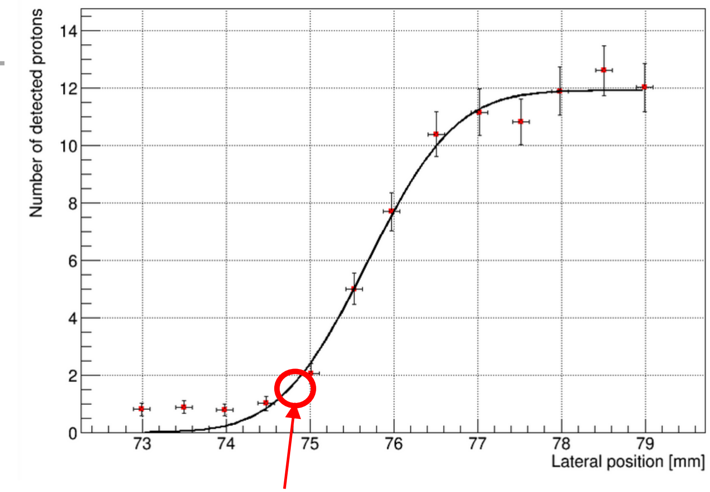


- Tank and motorized support (INFN)
- PMT HV supply and WaveCatcher module remotely controlled

CpFM running in SPS – July 2015 First test



Scan of a 270 GeV proton beam in the SPS



interception of the channelled beam

→ **angular spread of the channelled beam at 2σ = 21. ± 2 μrad**

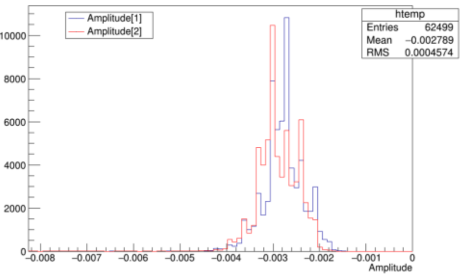
in good agreement with the critical angle at 270 GeV

- ✓ Clear CpFM signal, no electromagnetic perturbations
- ✓ Sensitivity to 1 incident proton

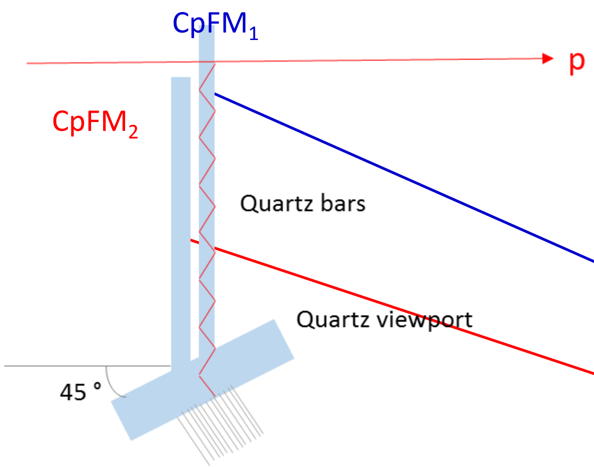
CpFM tests during SPS MD in October & November 2015

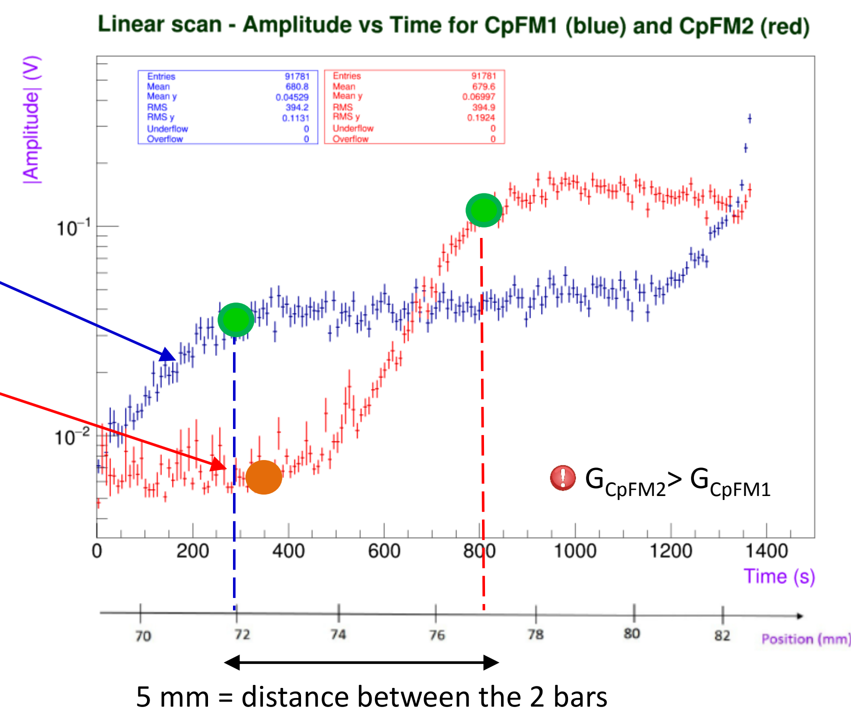
<u>Parking position</u>: difference in amplitude between the 2 channels $CpFM_2 > CpFM_1$ (8 %)

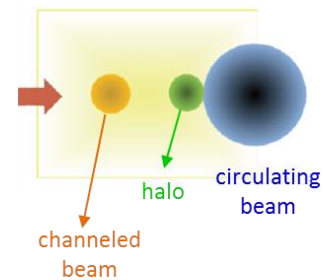
- ❖ Broken fibers inside the bundle after the installation ?
- ❖ Bad optical coupling between the viewport and the bundle ?



Insertion of the CpFM inside the beam pipe

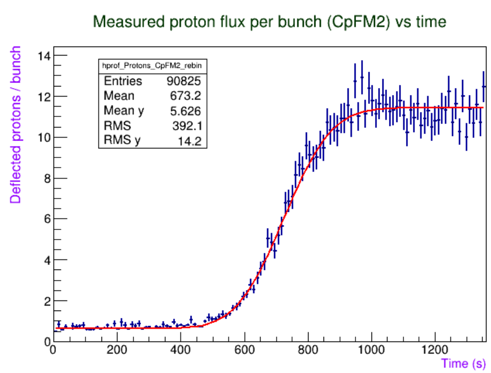






interception of the channeled beam

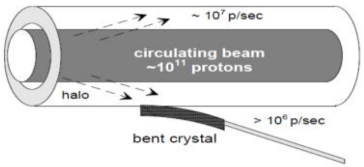
interception of the halo



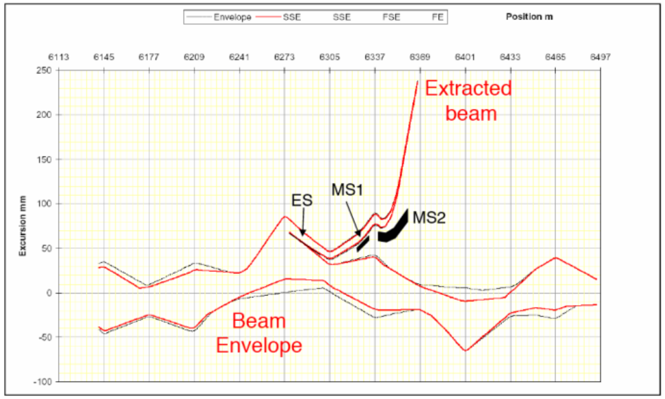
CpFM works well ! Need more tests to fully understand its behaviour

CpFM for SPS slow extraction

Request from the CERN Accelerator Beam Transfer group to test the basic concepts of crystal-assisted extraction, using as much as possible the UA9 hardware. **A CpFM will be inserted in TT20 to study the harmonic content of the extracted spill**. The detector should be robust enough for MDs and for standard high-intensity operation.



CERN SL/95-88 (AP)



Edms No. 1509966
7 May 2015

MEMORANDUM

To : Walter Scandale, Chairperson of the UA9 Collaboration

From : Frédérick Bordry, Director for Accelerators and Technology

c.c.: Paul Collier, Head of the Beams Department
José Miguel Jiménez, Head of the Technology Department
Roberto Saban, Head of the Engineering Department
Brennan Goddard, TE-ABT Group Leader

Subject : Slow extraction assisted by bent crystals in the SPS

Following the interest generated by the *Proposal for Investigating Slow Extraction Assisted by Bent Crystals in the SPS*, I would like to ask the support of the UA9 collaboration both for the studies and for the developments of hardware and software which these might entail.

STUDY OBJECTIVES

It is therefore decided to study the possible crystal assisted slow extraction scenarios in the SPS using the already installed UA9 experimental set-up. The study should comprise theoretical and experimental parts, and should be concluded by end 2018. The main objectives are:

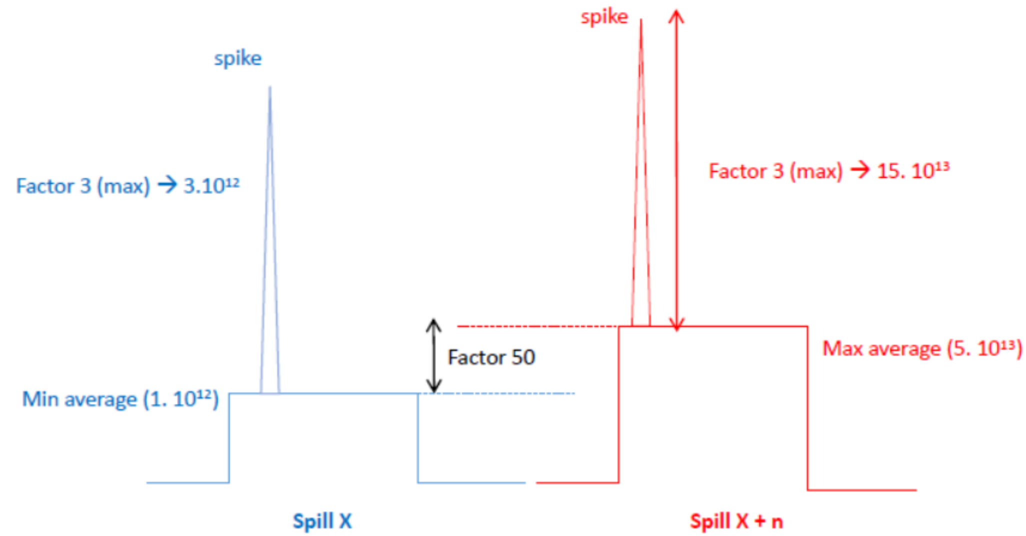
1. Investigate and develop a concept for crystal-assisted loss mitigation in the SPS for 450 GeV p+ slow extraction, aiming at a factor of 3 or more reduction at the ES.
2. Investigate the feasibility of crystals to replace ES as the initial beam-intercepting element in a slow extraction system, at 450 GeV in the SPS;
3. Simulate and specify the EM excitation needed for non-resonant slow extraction in SPS.
4. Define and implement baseline experiments to test slow-extraction assisted by bent crystals into one of the SPS extraction channel. The test should be initially performed using stored beams at 270 GeV, and could later be extended to 450 GeV with pulsed cycles. The new hardware required for the experiments, comprising crystals, goniomenters and detectors, should be defined by the initial study phase and first be characterized with tests in the laboratory and later in the H8 beam-line in the SPS North Area.

The study will also define or review the layout of the experiment, the simulation tools, the list of the hardware component (including the beam instrumentation), the key performance indicators, the integration needs, the costs, the beam time for each experiment, the experimental procedures, including the front-end and the application software.

CpFM-SE: requirements

Goal of the detector: describe the time-varying structure of the spill

- Beam intensity: from 1×10^{12} (min) to 5×10^{13} p+/spill (max) with possible spikes
- Length of spill/acquisition: 1 to 4 s
- Sampling rate: 400 MHz



$\Longrightarrow$ high dynamic range

$\Longrightarrow$ detector time response < 2ns

$\Longrightarrow$ high sampling rate

$\Longrightarrow$ large data buffering

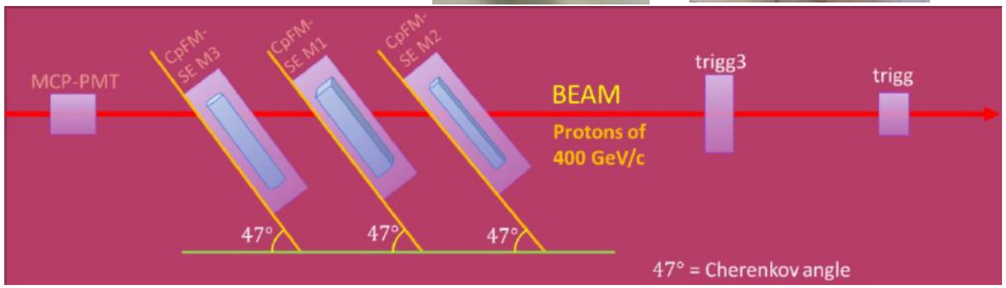
Timeline :

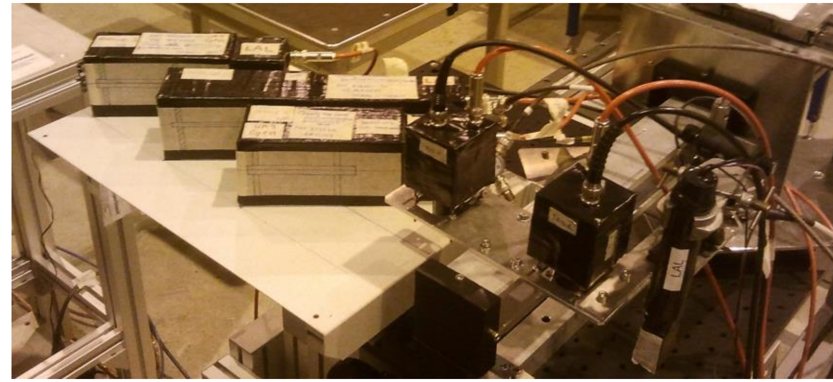
Installation end of 2016

Our proposal: CpFM without fibers bundle and with a different readout electronics (high-speed 8-bit digitizer card with 2 GS/s maximum sampling rate, 1 s of data recording)

CpFM-SE Test beam at CERN (June 2015)

Test of 2 different PMTs (R7378A and R9880)

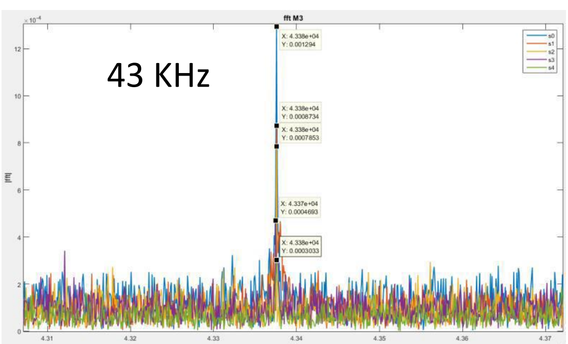


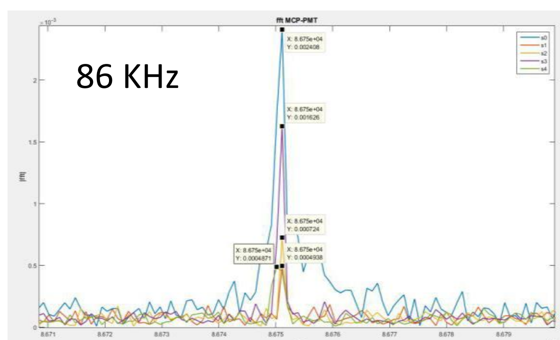


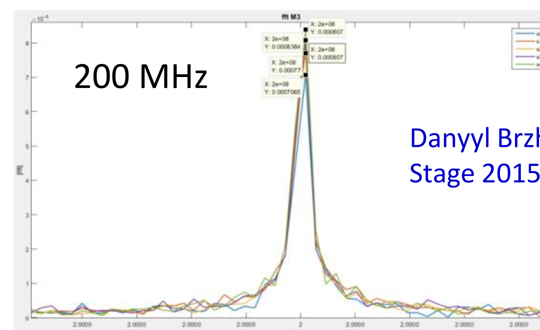
➡ Best PMT : the R7378A (the one we use for the CpFM-SPS) which has a fast rise time and good linearity (tested at LAL)

<u>Analysis of the signal (FFT)</u>

Harmonic contents of the spill : we observed the SPS revolution frequency of 43 kHz and its second harmonic (86 kHz) and the 200 MHz structure imposed by the SPS accelerating RF system,







Danyyl Brzhechko
Stage 2015

➡ CpFM-SE is able to detect the time-varying structure of the spilled beam