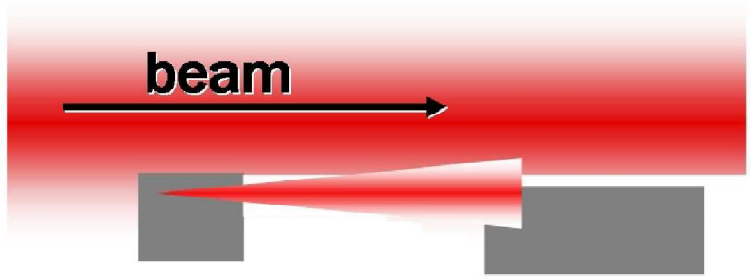
Эксперимент UA9 в CERN

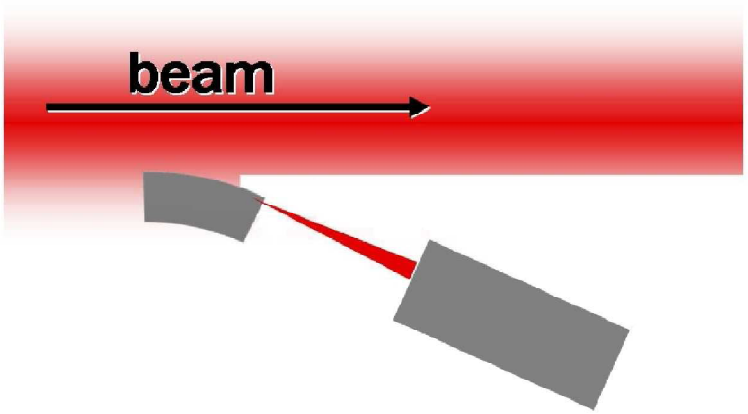
Ю.М.Иванов

Кристаллическая коллимация (вывод) пучков заряженных частиц высоких энергий

Традиционная коллимация



Кристаллическая коллимация



От H8-RD22 к UA9

2006 – объемное отражение 400 ГэВ протонов

2007 – многократное объемное отражение в нескольких кристаллах

– каналирование и объемное отражение отрицательных частиц

– излучение при объемном отражении электронов и позитронов

2008 – аксиальное каналирование и объемное отражение

– многократное объемное отражение в нескольких кристаллах

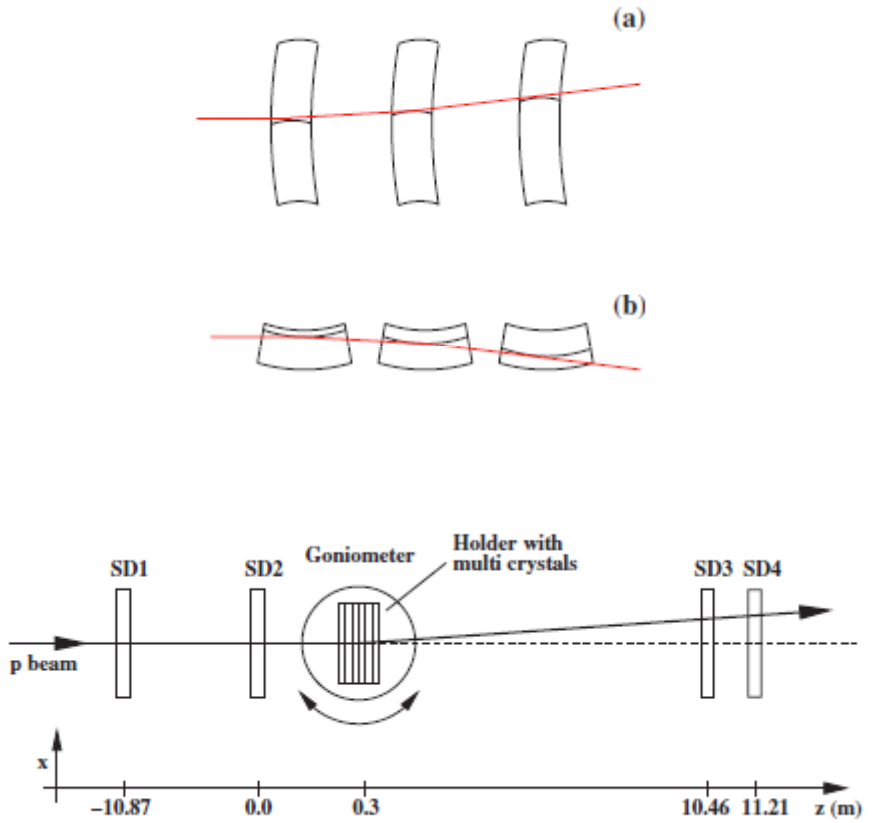
– многократное объемное отражение в одном кристалле

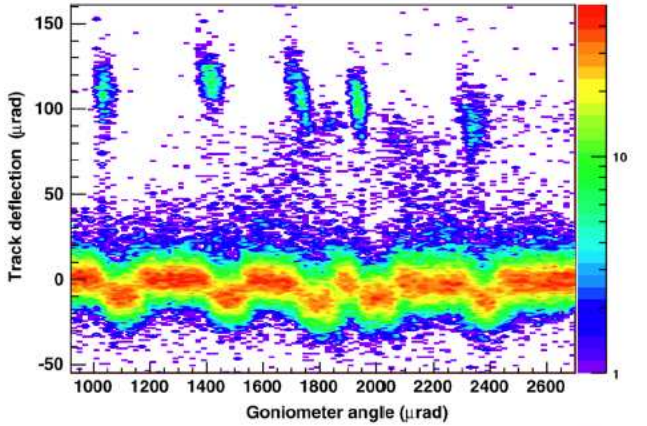
2009 – запуск эксперимента UA9 по коллимации пучка в кольце ускорителя SPS изогнутыми кристаллами

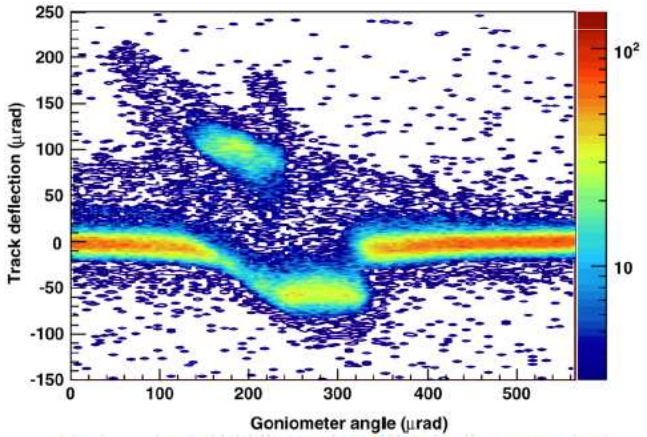
Публикации 2009 г.

- ***Experimental study of the radiation emitted by 180-GeV/c electrons and positrons volume-reflected in a bent crystal,*** **Physical Review A 79, 012903 (2009)**
- ***Observation of Multiple Volume Reflection of Ultrarelativistic Protons by a Sequence of Several Bent Silicon Crystals,*** **Physical Review Letters 102, 084801 (2009)**
- ***Observation of nuclear dechanneling for high-energy protons in crystals,*** **Physics Letters B 680 (2009) 129–132**
- ***High-efficiency deflection of high-energy negative particles through axial channeling in a bent crystal,*** **Physics Letters B 680 (2009) 301–304**
- ***Observation of channeling and volume reflection in bent crystals for high-energy negative particles,*** **Physics Letters B 681 (2009) 233–236**
- ***First observation of multiple volume reflection by different planes in one bent silicon crystal for high-energy protons,*** **Physics Letters B 682 (2009) 274–277**

Multiple volume reflection by a sequence of several bent silicon crystals







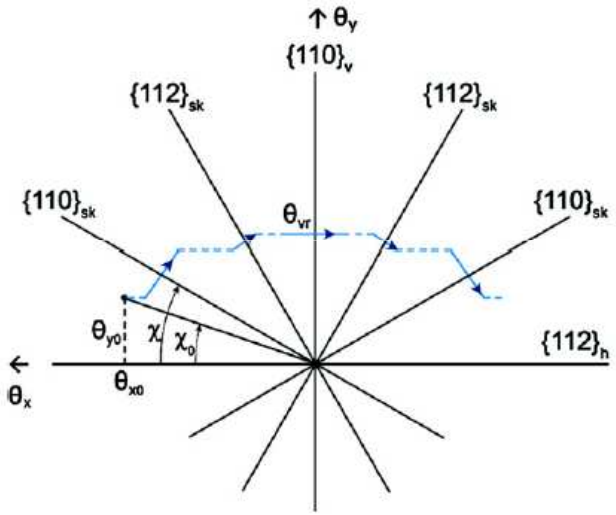
$\theta = 52.96 \pm 0.14\ \mu\text{rad}$

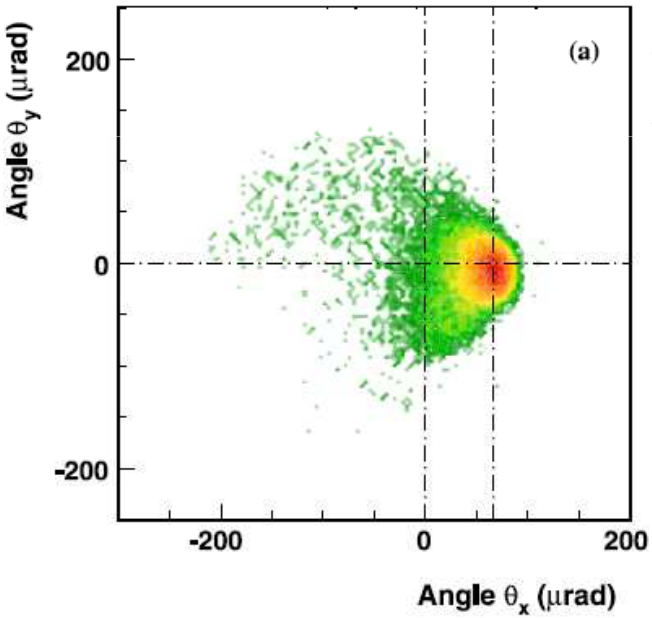
$\varepsilon = 0.90 \pm 0.01 \pm 0.03$

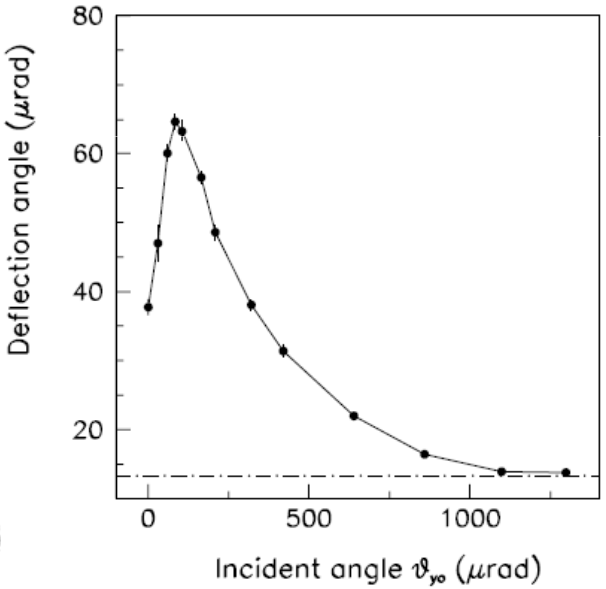
Multiple volume reflection by different planes in one bent silicon crystal

$$\theta_m = (66.53 \pm 0.27)\ \mu\text{rad}$$

$$P_d(\theta_x > 0) = (83.86 \pm 0.26)\%$$



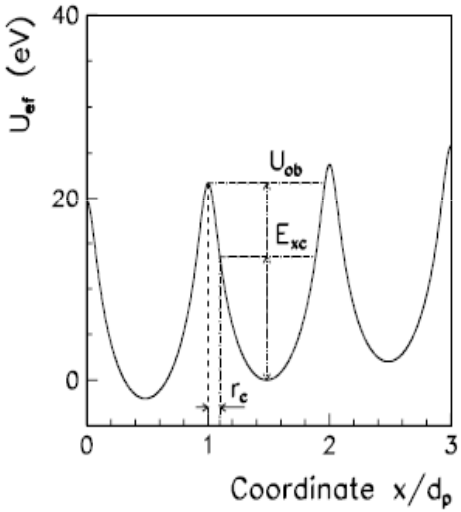


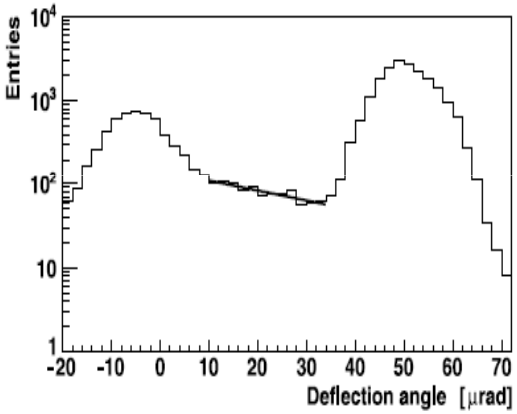


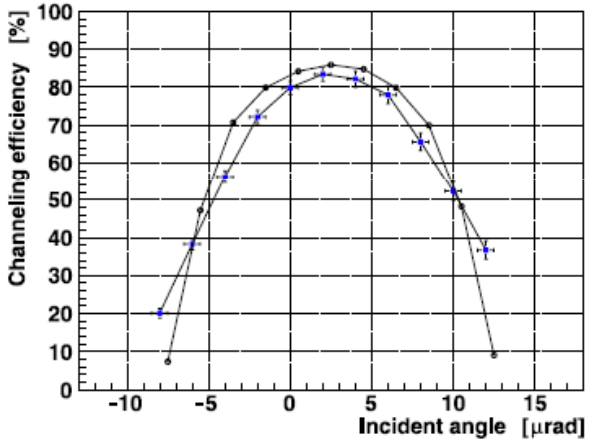
Observation of nuclear dechanneling for high-energy protons in crystals

$$L_n = (1.53 \pm 0.35_{\text{stat}} \pm 0.20_{\text{syst}})\ \text{mm}$$

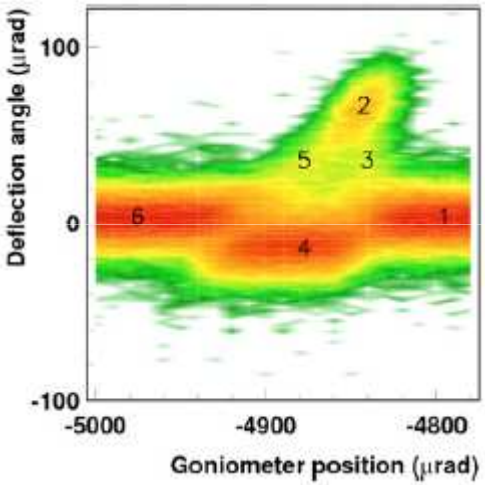
$$P_d = (83.4 \pm 1.6_{\text{stat}} \pm 0.9_{\text{syst}})\%$$

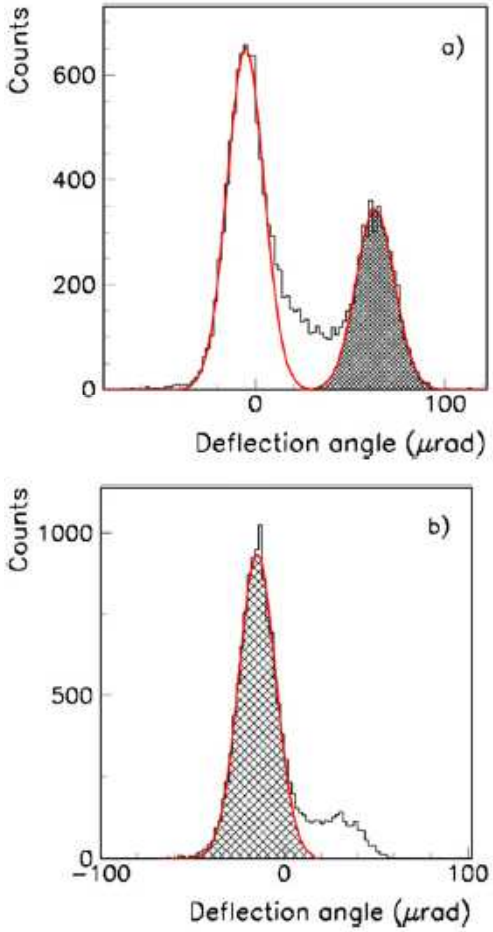






Channeling and volume reflection in bent crystals for high-energy negative particles





$\theta_d = (63.24 \pm 0.24)$ μrad

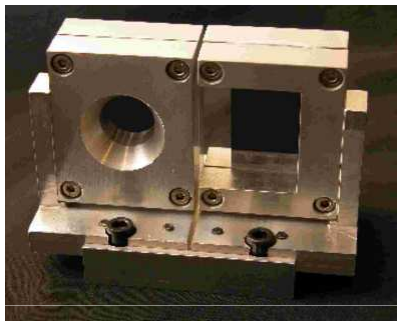
$P_d = (30.24 \pm 0.38)\%$

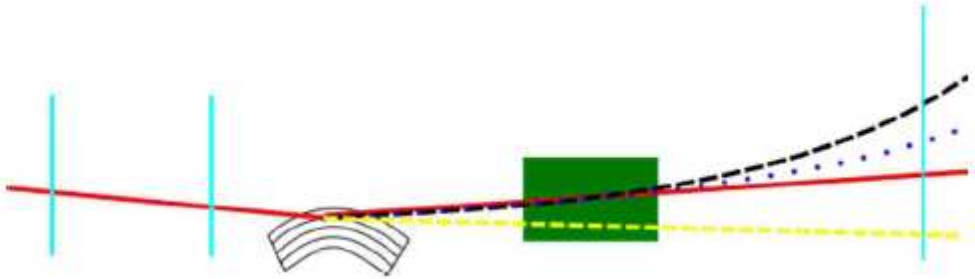
$\theta_{vr} = (-14.64 \pm 0.12)$ μrad

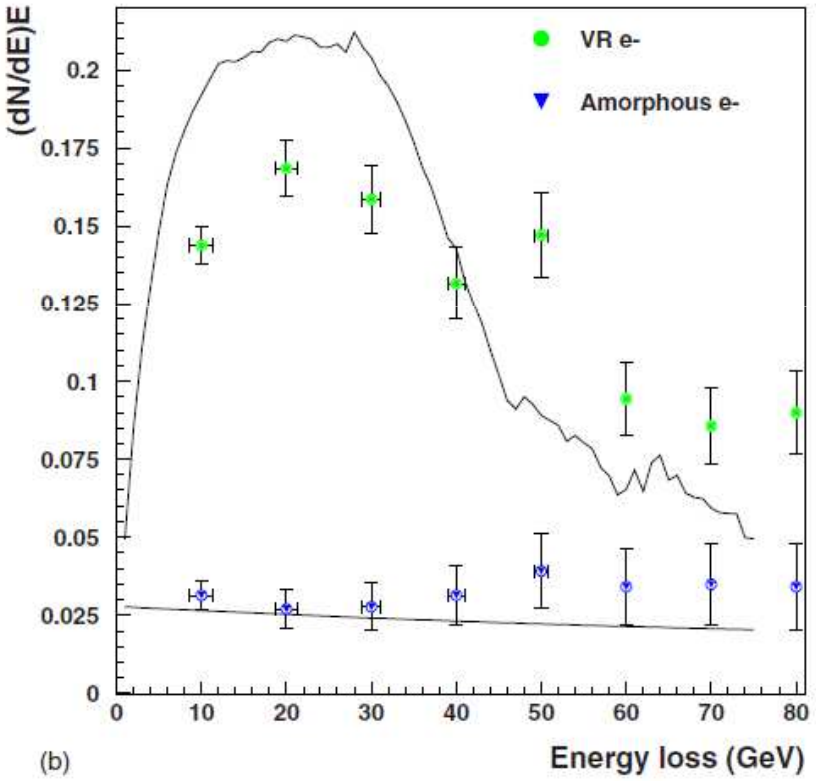
is about $0.8\theta_c$

$P_{vr} = (82.74 \pm 0.28)\%$

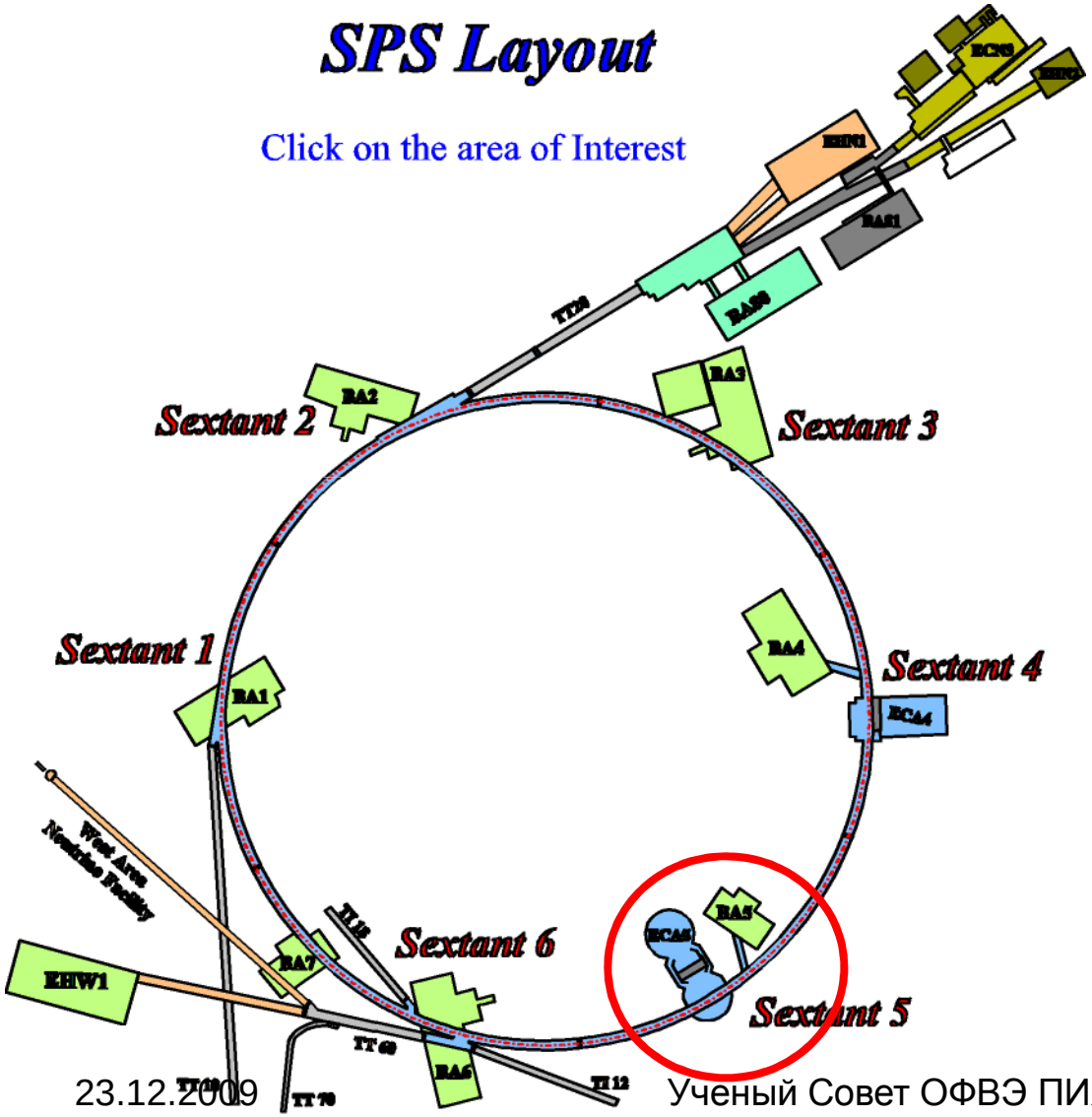
Radiation emitted by 180-GeV/c electrons and positrons volume-reflected in a bent crystal

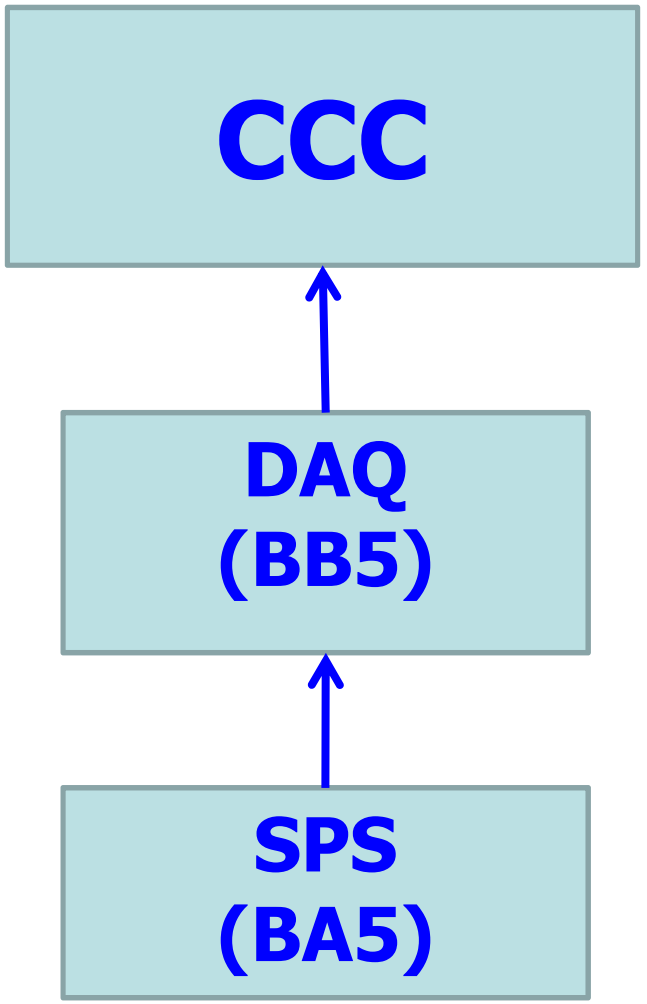




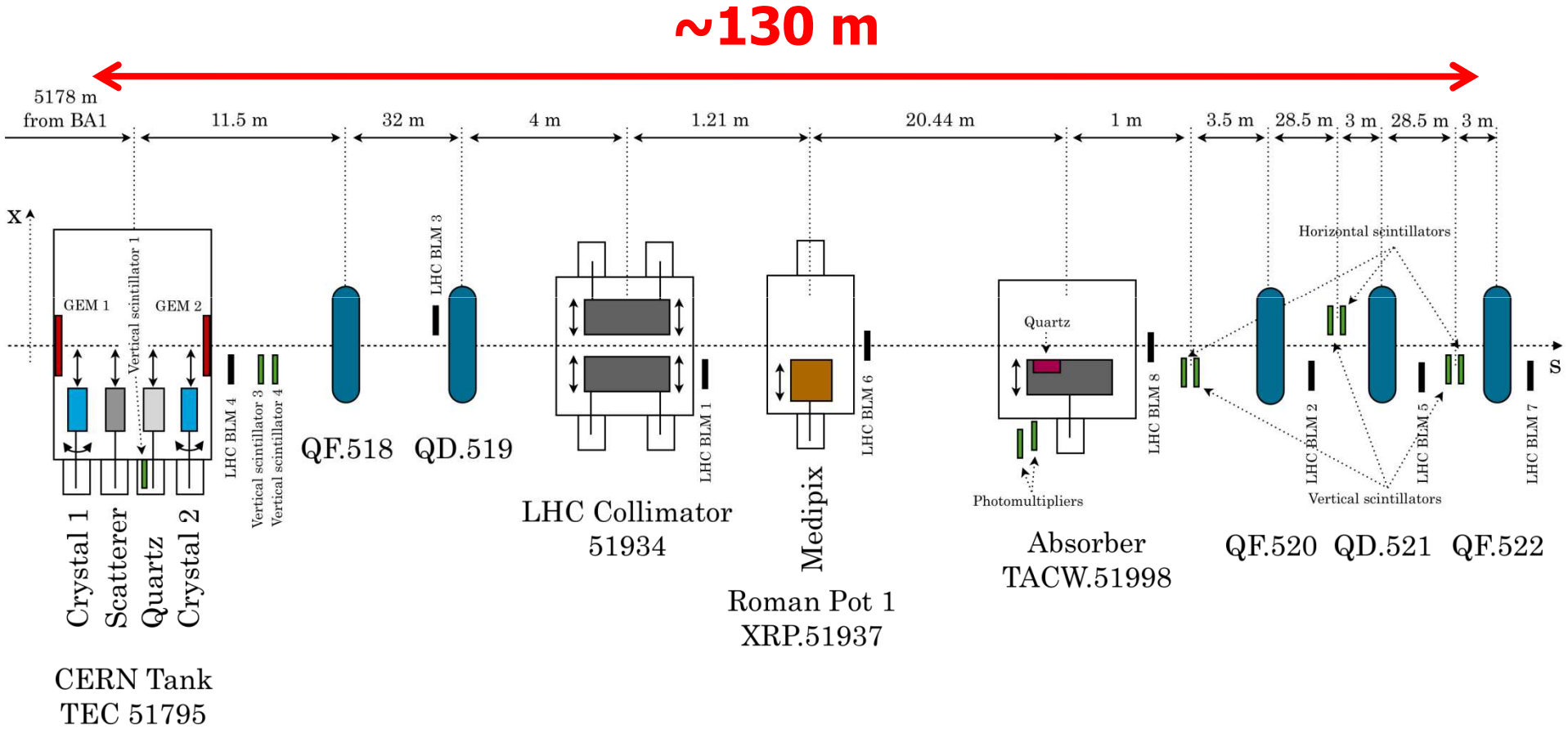


Эксперимент UA9 в CERN

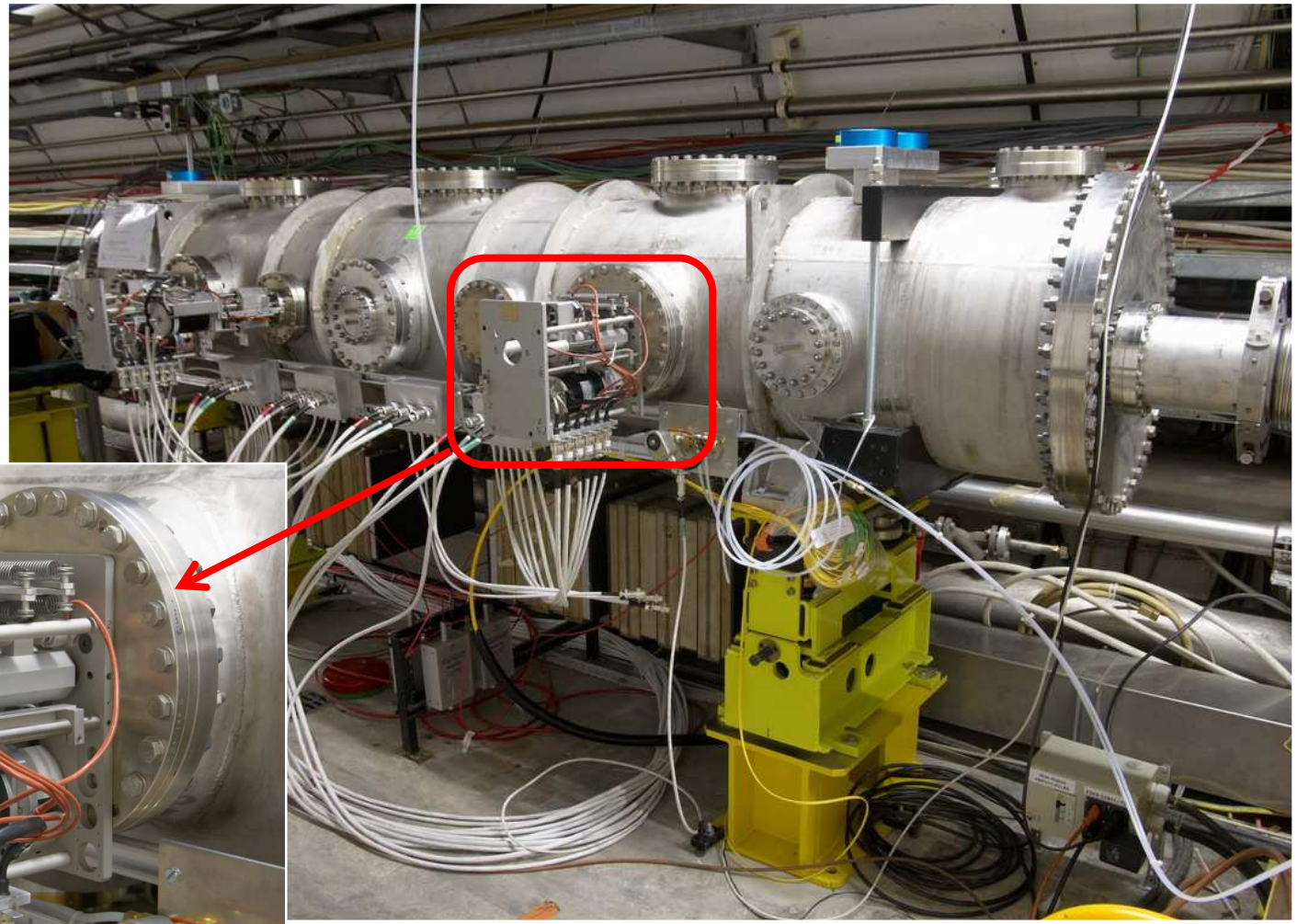




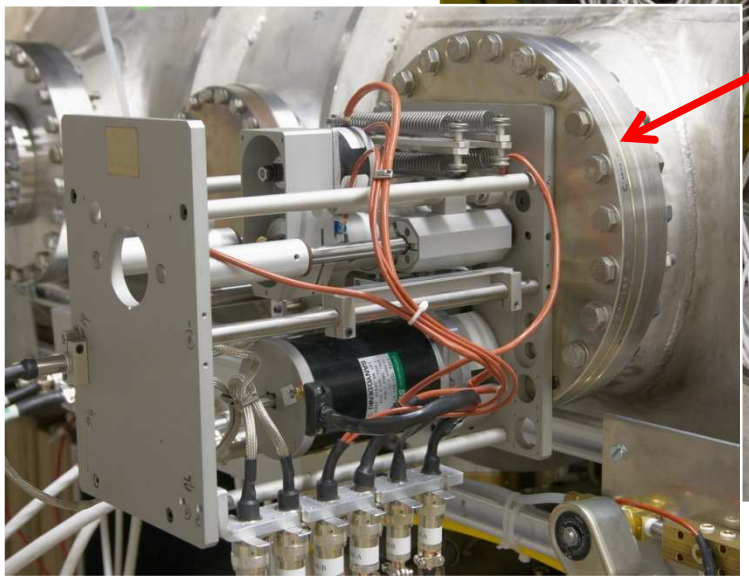
Расположение установки UA9 на кольце SPS



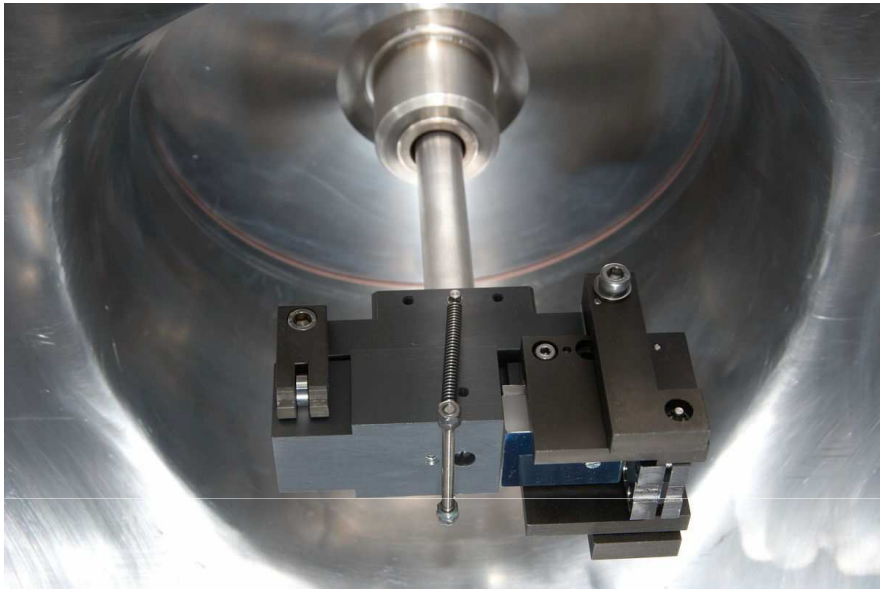
Вакуумный танк с гониометрами для двух кристаллов

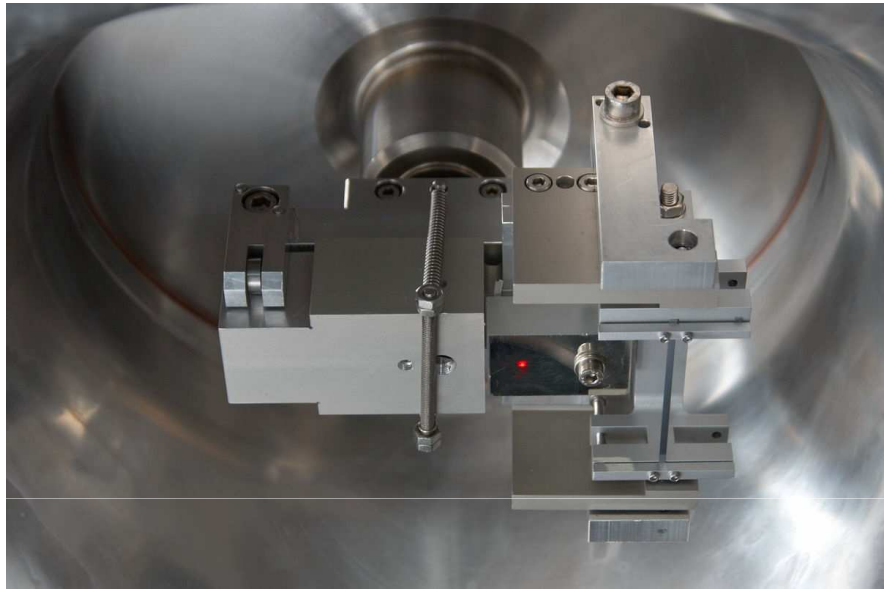


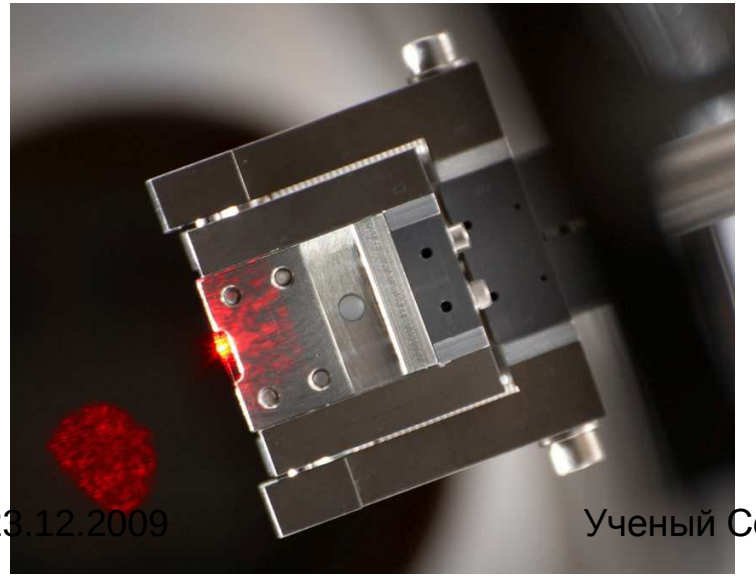
Гониометр

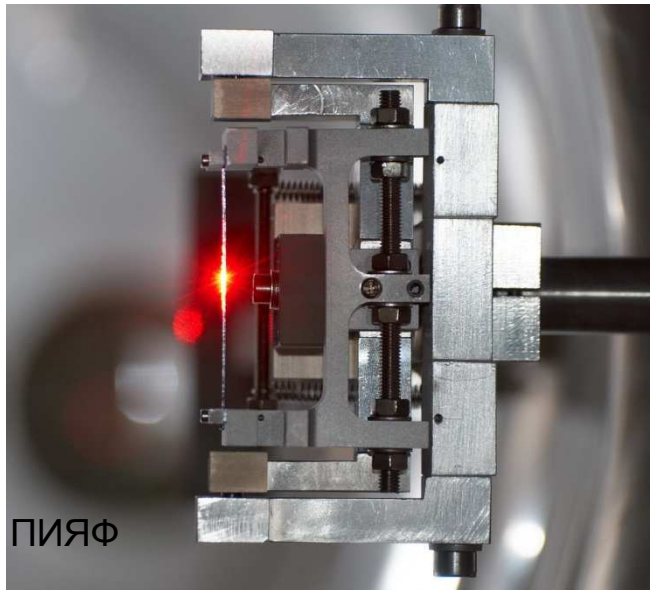


Установленные на гониометры кристаллы



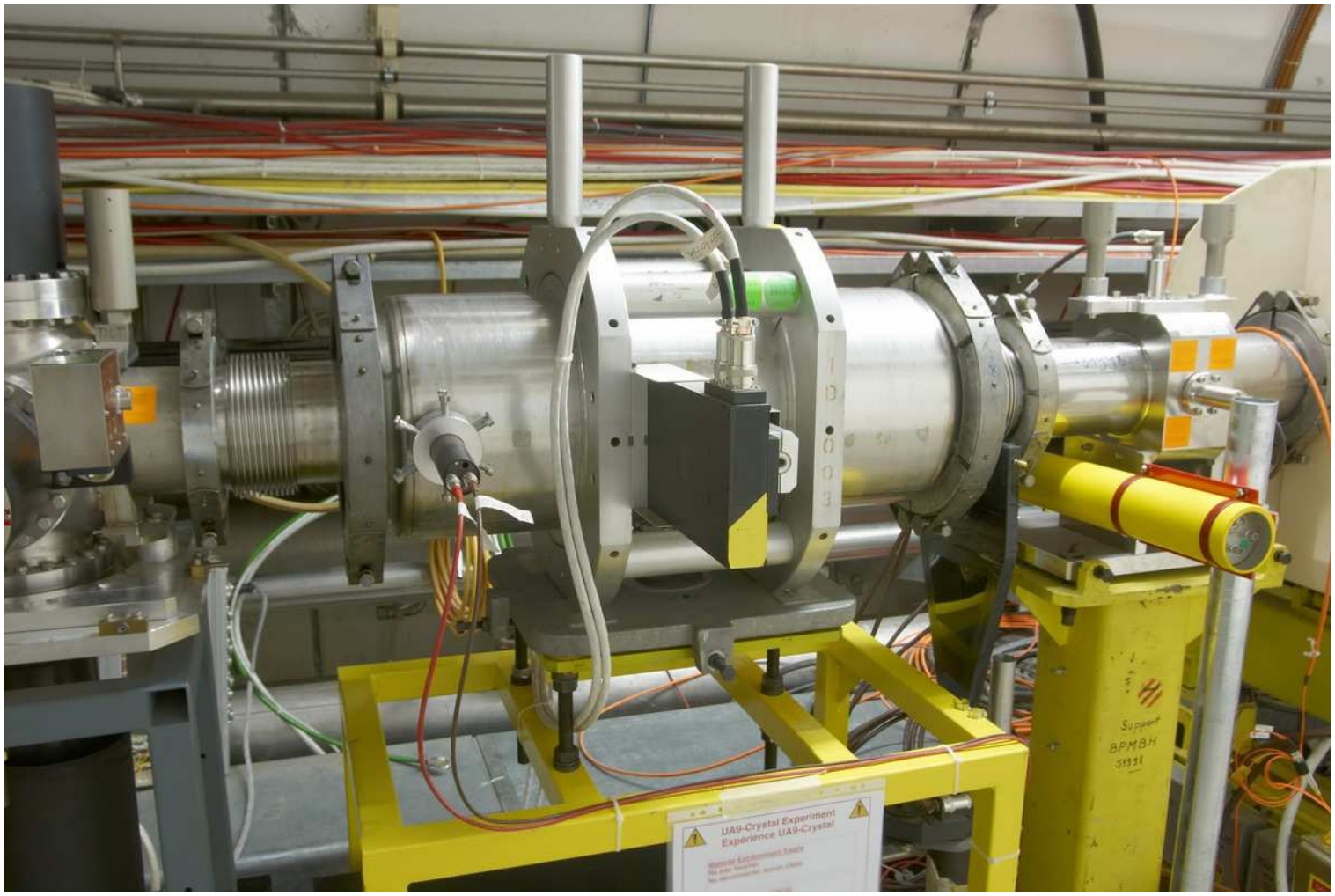




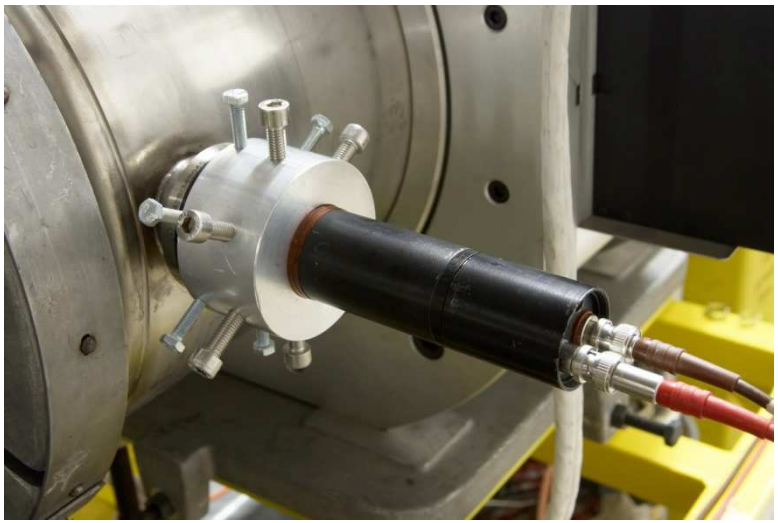


LHC коллиматор

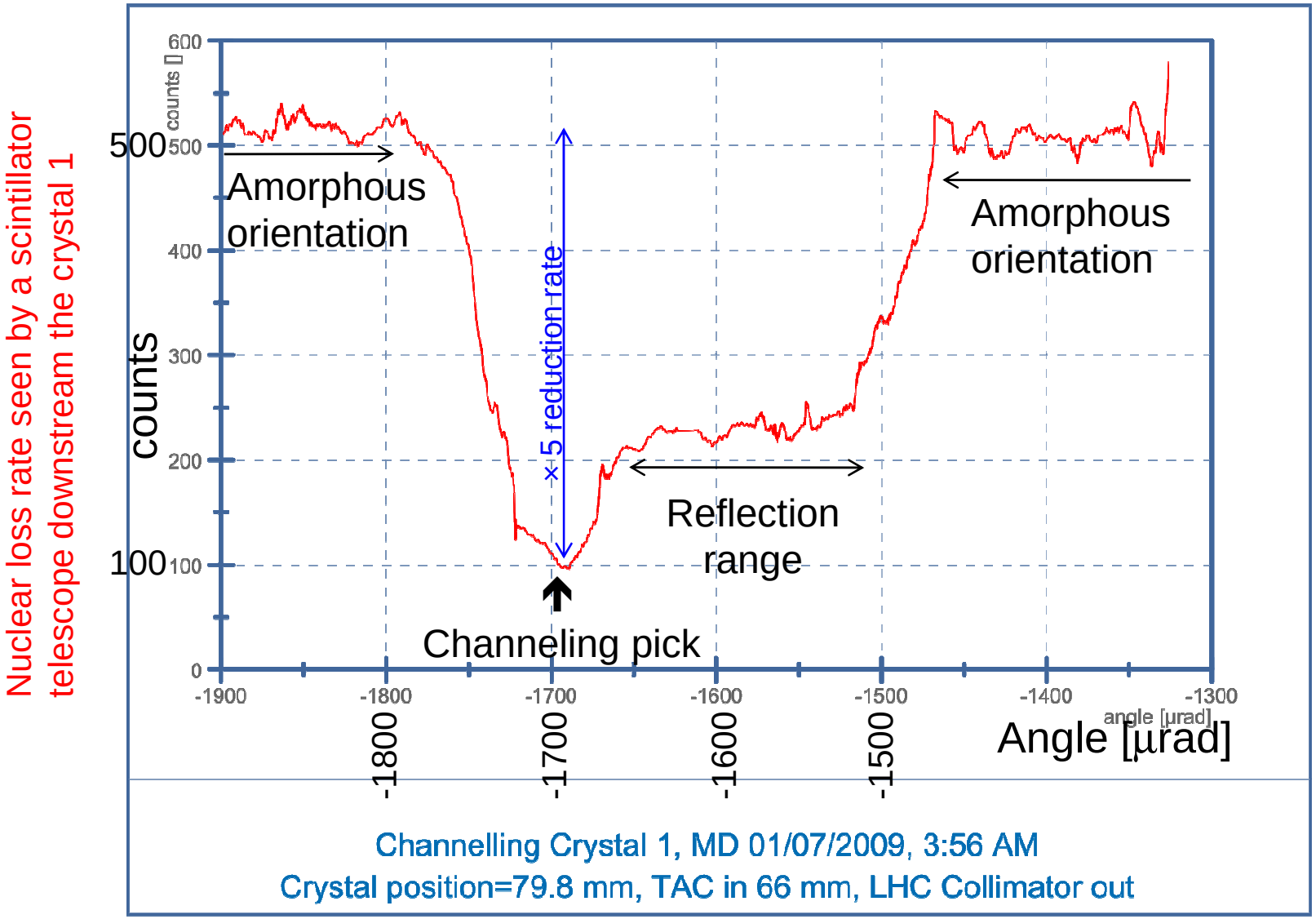
Коллиматор отклоненного пучка



Черенковский детектор перед коллиматором отклоненного пучка

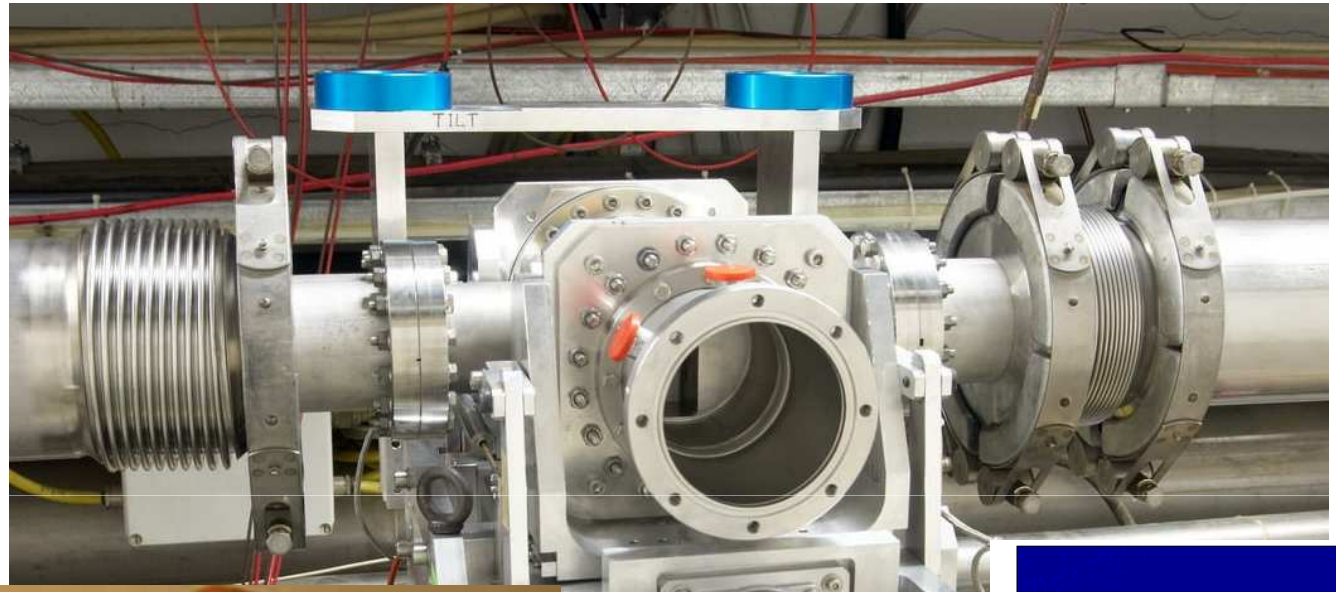


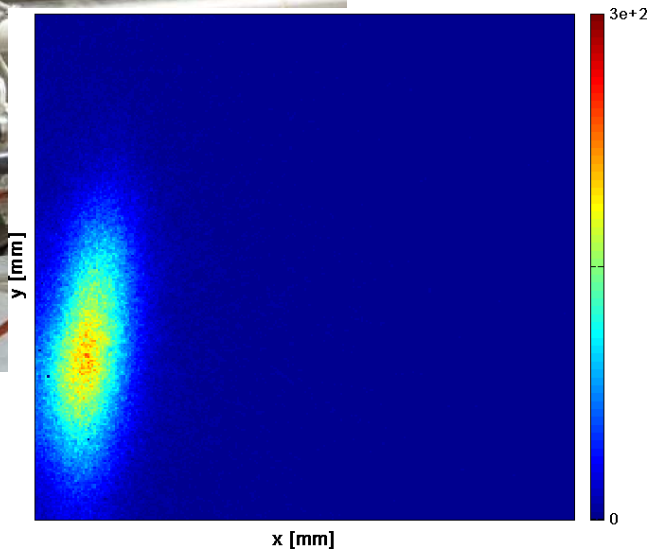
Результат углового сканирования кристаллом



- *Nuclear loss rate* (including diffractive) strongly depressed

Пиксельный детектор MediPix






CERN

Summary of 2009 results

- Many positive indications in the SPS data
  - Easy operation of the crystal in the SPS in collider mode
  - Large collimation efficiency up to 85 % for 92 % expected from simulations
  - Strong reduction of the nuclear rate in channeling
  - No leakage of the collimation system (but this is an expected result in a quasi-linear machine)
- Some points need clarifications
  - More reproducible goniometer,
  - Crystals in planar mode instead of quasi-axial mode
  - More instrumentation and collimators to observe the far-from-collimation area
  - More stable accelerator
  - We need an improved hardware and more running time in the SPS at least for one more year
  - The available results are so encouraging that it is wise and starting the preparatory work for a test LHC

Future plans

- Install the IHEP goniometer with two new crystals
- New station in the dispersive area of the SPS after the crystal-collimation set (upstream of QF5-22) containing
  - stopper
  - Cherencov in vacuum
  - Roman pot 2 with medipix
  - The aim is to detect the collimation leakage and the diffractive events
- Two crystals in the LHC
- The activity in NA (H8/H4) and in the SPS will be focused on the specific need of the test in LHC
  - Studies in the NA devoted to develop and investigate exotic new crystal will be followed with interest but will not longer engage CERN staff

Details for LHC proposal

- 2 crystals installed in LHC IR7 during the shutdown 2010/2011.

- Main goals
  - estimate of the collimation efficiency
  - detect the loss maps induced in the LHC ring.
  - confirm that crystal channeling can be exploited reliably also at energies higher than 120 and 400 GeV (and 1 TeV in the Tevatron).

- New features
  - Crystal collimation in a cryogenic environment (as in the Tevatron)
  - Halo control below the quench threshold of the LHC superconducting magnets,
  - Also in presence of a large halo flux induced by fast diffusive particle dynamics.

MC – ITN network 2010-2012 tasks

- **Monte Carlo-based model for particle-crystal interaction, simulation of the collimation process, verification of the model in test (CERN, INFN, PNPI, SLAC, FNAL)**
- **Nuclear reactions and diffractive events (Genova, SLAC, CERN, PNPI, INFN)**
- **Integration of control systems (CERN, INFN, PNPI, IHEP)**
- **Development of a radiation tolerant Ultra High Vacuum mechanical goniometer (CINEL, Trento University, CERN)**
- **Radiation tolerant mechanical systems (CERN, INFN, Trento, SLAC, FNAL)**
- **Radiation tolerant front-end electronics for fast readout (Imperial College, INFN, PNPI, CERN)**

MC – ITN network 2010-2012 tasks

- Detector based on Cherenkov radiator technology (PNPI, INFN, Imperial College, CERN)
- Detector based on silicon pixel technology (CERN, INFN, Imperial College)
- Telescopes based on silicon strip technology for test beams (Imperial College, INFN)
- Detector based on GEM technology (INFN, Genova, Imperial College)
- Beam loss monitors based on CVD diamond detectors (CIVIDEC, CERN, FNAL, IHEP)
- Short silicon crystals and bending frames (PNPI, Ferrara University, IHEP, CERN)