Discussion and path towards a decision for baseline

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Questions & Observations

- Crystals have been successfully used for TOTEM data taking
  - But with tighter collimator settings
- Crystals promise a factor 5 to 10 improved cleaning [but not yet observed for Pb!]
  - B1V and B2V with protons; but not for B1H
  - But study done without TCLDs; TCLD in MB8 or MB9
  - Efficiency during ramp?
- Can we apply results from the SPS UA9 test directly to the LHC?
  - Measurements in the LHC with high intensity protons prohibited by 'dump power'
  - Limited measurement time with ions!!!
- Are we ready to specify the preferred choice of crystal?
  - 110 strip type crystals versus Quasi Mosaic type crystals
  - How important is torsion?
- Are we ready to specify the required crystal properties for LHC?
  - Comparison with simulation shows good agreement for B1V and a significant difference for B1H
- Are we ready to specify the required goniometer for LHC?
  - Problems observed with B2-H alignment?
  - Intervention strategies and procedures?

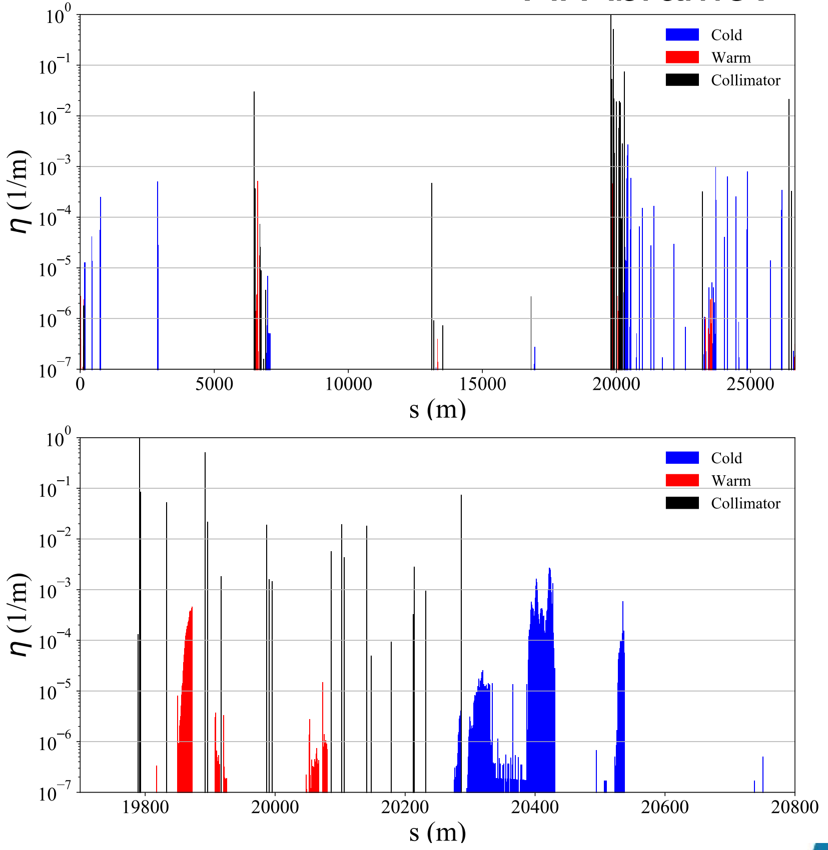
Questions & Observations

- We have already crystals installed in the LHC! So the question is not
  ‘Do we want crystals in the LHC’, but rather
  ‘What do we need to change wrt what we have already’
- Do we have enough / of the right type / crystals ready for installation in LS2?
- Do we have the ‘right’ procedures and processes in place for validating the crystals for installation in LHC?
- What do we need to improve for ion simulations?
- ……….

Pb ion cleaning – HL-LHC v1.2

A. Abramov

- Using optics HL-LHC v1.2 – ion version for v1.4 under development (R. de Maria)
- TCLD shields well the first loss cluster, but the second one remains almost unchanged
- Pb ion cleaning remains a factor ~100 worse than proton cleaning



Normalization of energy deposition studies

- Normalizing loss power to the two design loss scenarios:
  - 12 minute beam lifetime, to be sustained for 10 s
  - 1 h beam lifetime, to be sustained "infinitely"

- Assumptions on beam conditions for HL-LHC

	# bunches	# particles/bunch	Loss rate 12 min.	Loss rate 1 h.	Loss power (12 min.)	Loss power (1 h)
Protons	2760	2.3e11	8.81e11 p/s	1.76e11 p/s	988 kW	198 kW
Pb Ions	1248	2.1e8	3.64e8 Pb/s	7.28e7 Pb/s	33 kW	6.7 kW

Simulated peak power load on DS magnets

C. Bahamonde - Tuesday's talk

TCLD position		PROTONS (mW/cm³) Cell 8/9 *MB**	PROTONS Cell 8/9 *MQ*	PROTONS Cell 8/9 *11T*	PROTONS Cell 11 *MB**	PROTONS Cell 11 *MQ*	IONS (mW/cm3) Cell 8/9 *MB**	IONS Cell 8/9 *MQ*	IONS Cell 8/9 *11T*	IONS Cell 11 *MB**	IONS Cell 11 *MQ*
No TCLD	0.2h	**21**	9.9	-	12	13	**57**	27	-	**57**	36
	1h	**4.2**	2	-	2.4	2.6	**11**	5.4	-	**11**	7.2
MBB.8	0.2h	6.6	8.1	11	8.7	13	5.4	15	21	**36**	33
	1h	1.3	1.6	2.2	1.7	2.6	1.1	3	4.2	**7.2**	6.6
MBA.9	0.2h	6.0	8.1	**48**	<0.3	<0.3	6.0	3.6	**33**	<0.003	<0.003
	1h	1.2	1.6	**9.6**	<0.06	<0.06	1.2	0.7	**6.6**	<0.0006	<0.0006

*Quench limit for MB could be ~20 mW/cm³ for steady state losses at 6.37Z TeV)

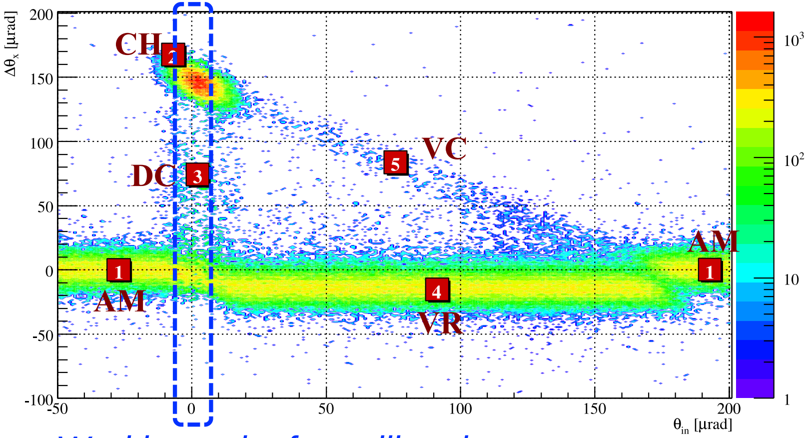
Total power in cryogenic cells (W)

C. Bahamonde - Tuesday's talk

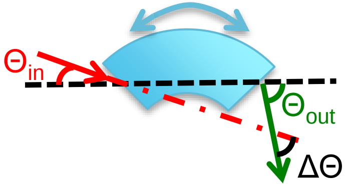
TCLD position		PROTONS Half-cells 8	9	10	11*	CC	12	IONS Half-cells 8	9	10	11*	CC	12
No TCLD	0.2h	50	**740**	15	**280-310**	100	10	10	**985**	35	**910-1015**	270	25
	1h	10	**148**	3	**56-62**	20	2	2	**197**	9	**182-203**	54	5
MBB.8	0.2h	210	100	10	230-265	85	10	351	135	20	569-635	115	20
	1h	42	20	2	46-53	17	2	70	27	4	112-127	23	4
MBA.9	0.2h	51	475	3	2.1-2.2	<1	<1	9	758	<1	<1	<1	<1
	1h	10	95	<1	<1	<1	<1	2	152	<1	<1	<1	<1

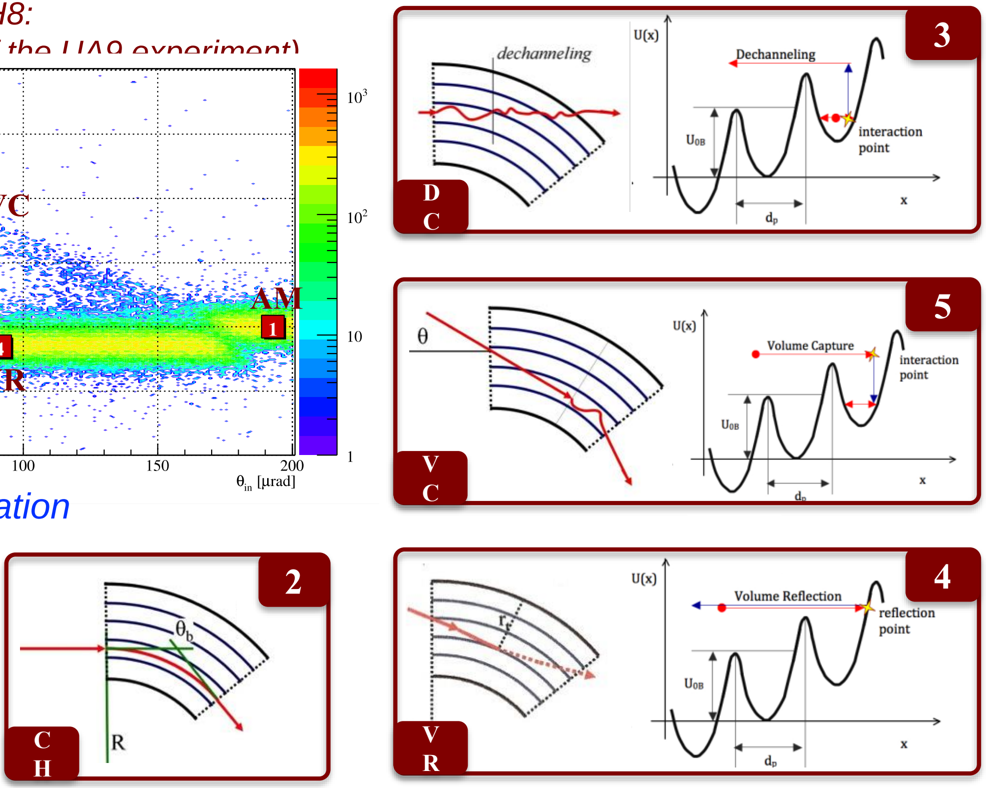
Coherent processes in bent crystals

***From test beam** on the CERN-SPS extraction line H8:*
(in the framework of the UA9 experiment)



Working point for collimation





Layout design goals and constraints

- Demonstration of **crystal channeling** with good efficiency **throughout the entire cycle**
- Demonstration that crystal collimation can **improve the cleaning efficiency**
- Minimize the **impact on the present IR7 layout**
  - ⮡ Fully operational for standard operations
- **Machine geometry** and an optimized design of the **goniometers**
  - ⮡ Horizontal/vertical crystal in the internal/top side of the machine
- **Space availability** in connection with required **optics parameters**
  - ⮡ Slots already equipped with collimator supports
- **Radiation doses** to personnel

Plans for possible operational deployment

Main challenge: safe disposal of **channeled beam on absorber**

Failure design scenario: τ = 0.2 h for 10 s

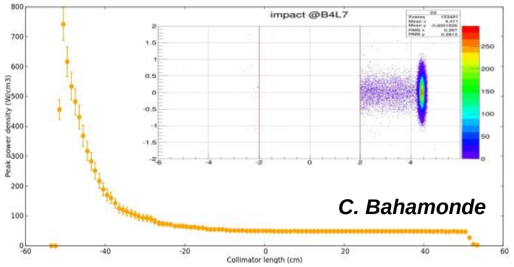
HL-LHC proton beams

A mini dump would be required
~1 MW over few mm^2

Anton: ➔ ca. 7m long beam dump!

Layout adequate for safe operations with ions!

HL-LHC heavy ion beams



Peak power density < 1 kW/cm^3

- **New interlock strategy** implemented to allow tests with high intensity Pb beams
- **End of Fill tests in 2018** heavy ions run to reproduce results obtained with Xe beams
- **If improved cleaning confirmed** and machine performance limited by present collimation

➔ **Adiabatic insertion of the crystal in the present collimation hierarchy**

Backup