Partecipazione a PADME
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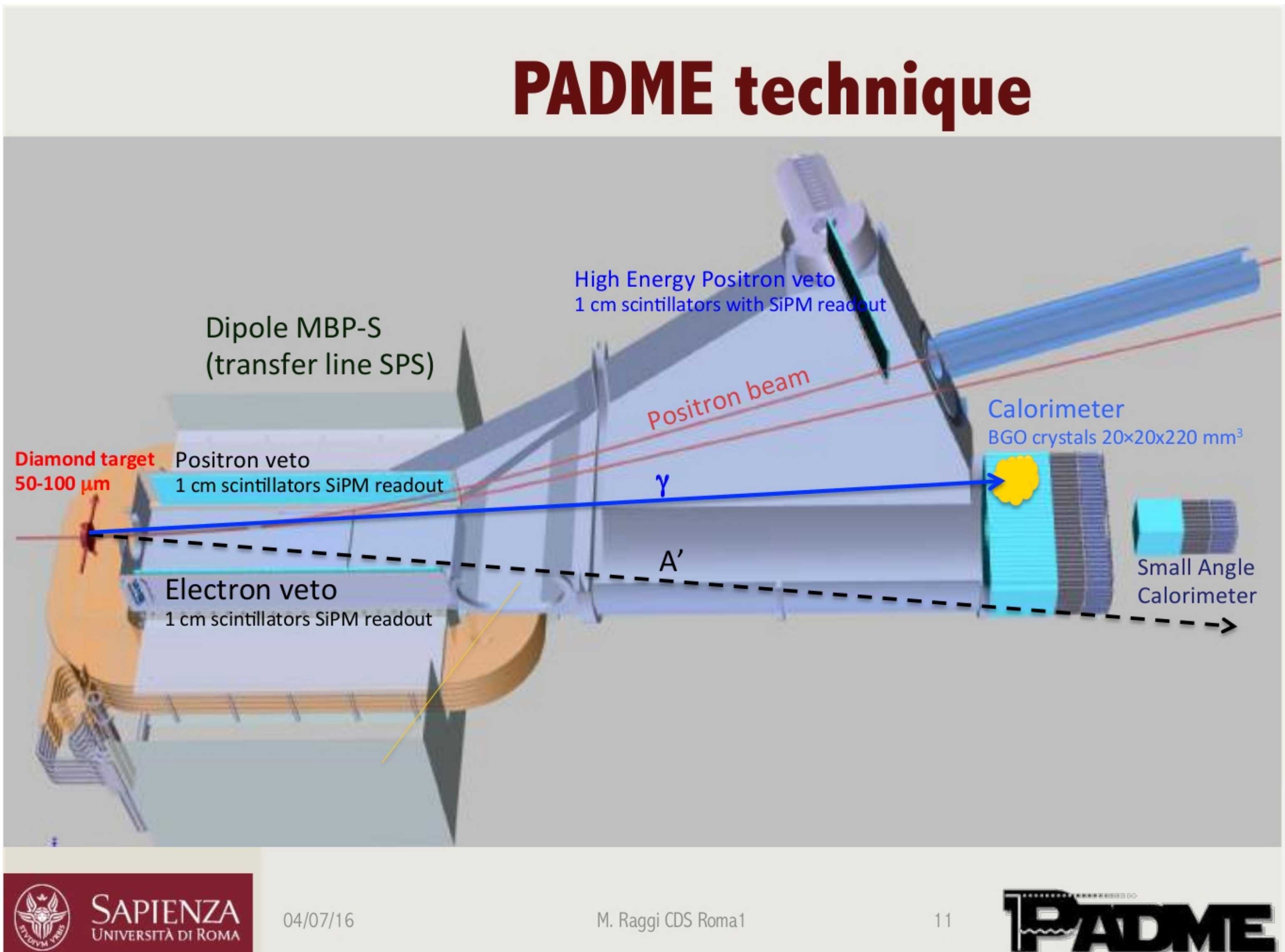

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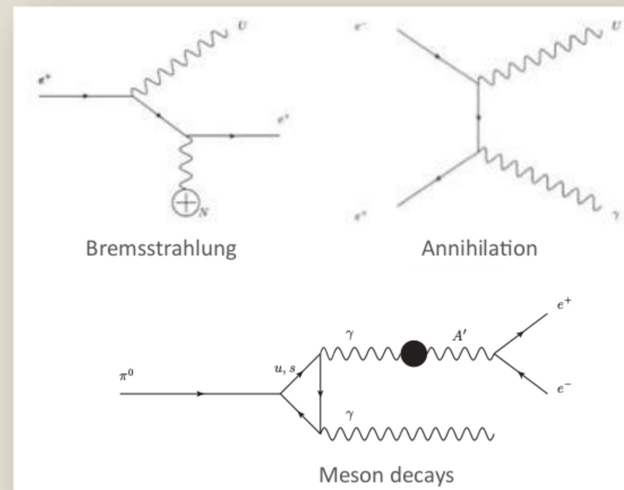
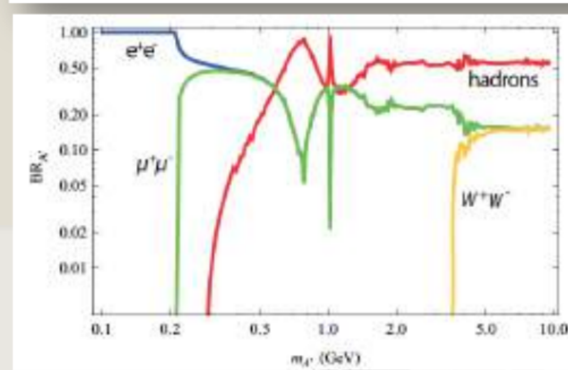
A' production and decays

- A' can be produced in e^+ collision on target by:
  - Bremsstrahlung: $e^+N \rightarrow e^+NA'$
  - Annihilation: $e^+e^- \rightarrow \gamma A'$
  - Meson decays
- If no dark matter candidate lighter than the A' boson exists:
  - $A' \rightarrow e^+e^-$, $\mu^+\mu^-$, hadrons, "visible" decays
  - For $M_{A'}$<210 MeV A' only decays to e^+e^- with $BR(e^+e^-)=1$
- If any dark matter particle χ with $2M_\chi < M_{A'}$ exists
  - A' will dominantly decay into pure DM
  - BR(l+l-) suppressed by factor ε^2
  - $A' \rightarrow \chi\chi$ ~ 1. These are the so called decays to "invisible"





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The PADME approach to A' searches

The goal

- Perform a dark sector search as much as possible model independent
  - Remove assumption on A' decays and on the dark sector structure
- Minimize the number of interactions and parameters in the data interpretation
  - Need only to parameterize the production mechanism needs only coupling to electrons
- Provide a strong and unquestionable experimental evidence for A'
  - Measure mass and coupling simultaneously

The way

- Search for the process $e^+e^- \to \gamma A'$ $A' \to$ Inv. by measuring the final state missing mass
  - Independent from the A' decay mechanism, A' lifetime, nature and mass of the dark matter χ
- Measure ε^2 from rate and missing mass and $M_{A'}$
  - Completely constrain the minimal A' model
- Measure ε^2 with minimal theoretical uncertainties

$$\frac{\sigma(e^+e^- \to U\gamma)}{\sigma(e^+e^- \to \gamma\gamma)} = \frac{N(U\gamma)}{N(\gamma\gamma)} * \frac{Acc(\gamma\gamma)}{Acc(U\gamma)} = \epsilon^2 * \delta,$$

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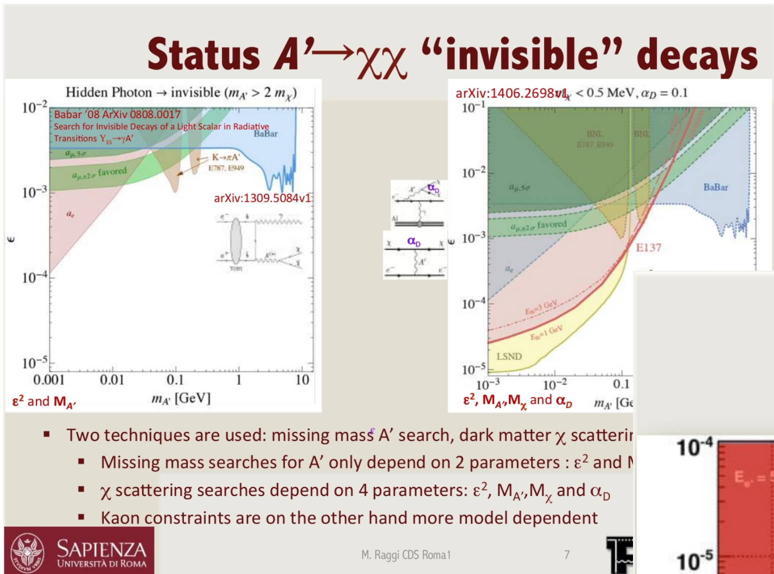

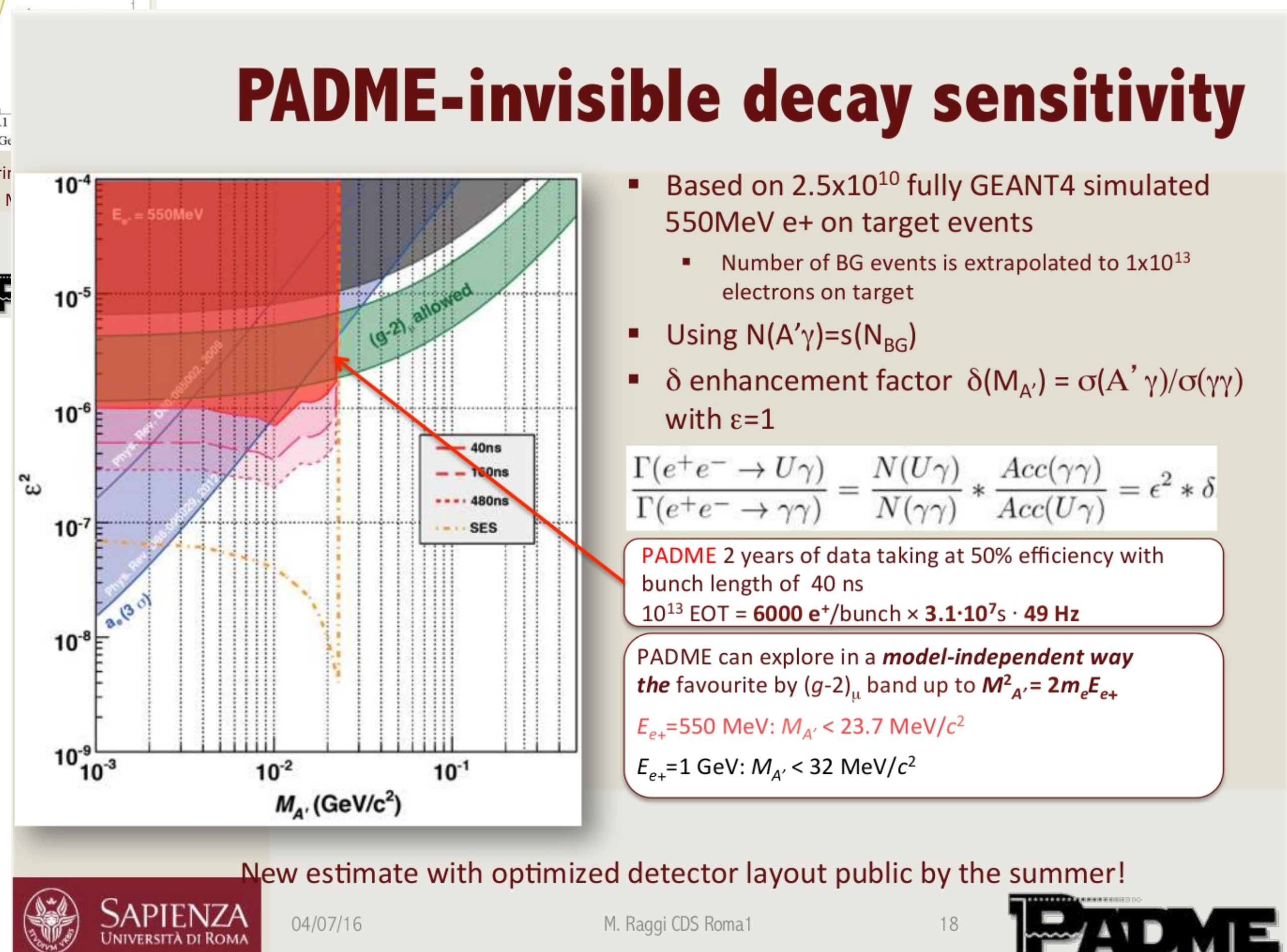

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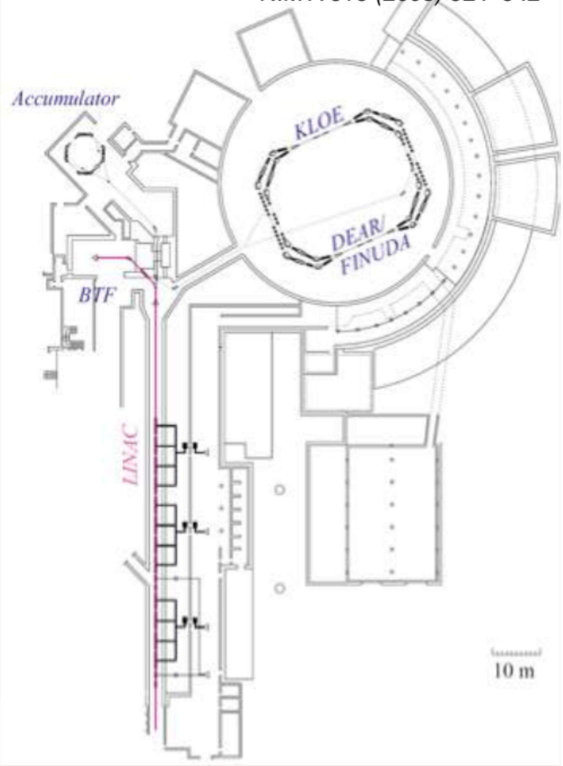
DAΦNE Beam Test Facility (BTF)

	electrons	positrons
Maximum beam energy (E_{beam})[MeV]	750 MeV	550 MeV
Linac energy spread [Δp/p]	0.5%	1%
Typical Charge [nC]	2 nC	0.85 nC
Bunch length [ns]	1.5 - 40	
Linac Repetition rate	1-50 Hz	1-50 Hz
Typical emittance [mm mrad]	1	~1.5
Beam spot σ [mm]	<1 mm	
Beam divergence	1-1.5 mrad	

NIM A 515 (2003) 524–542



- Able to provide electrons and positrons
  - Duty cycle 50*40 ns= $2x10^{-7}$ s
    work in progress to reach 160 ns ideas for 480 ns
  - Request submitted for energy upgrade to reach ~1GeV.
- The accessible $M_{A'}$ region is limited by E_{beam}
  - 0-22 MeV can be explored with 550 MeV e^{+} beam
  - Up to ~30 MeV with 1 GeV positrons

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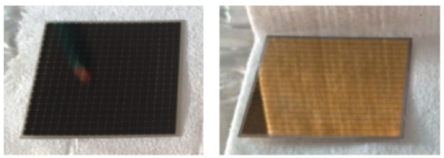
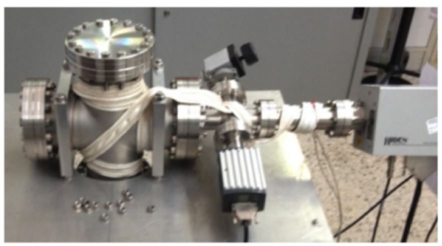
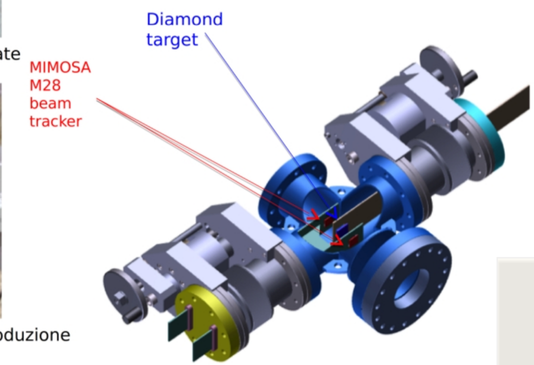
Beam region and vacuum chamber



Target in diamante con strip sia grafitate sia metallizzate



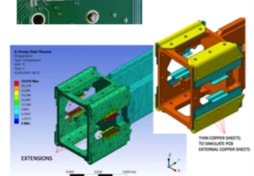
Movimentazione in vuoto pronta. Scheda carrier in produzione

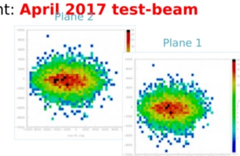


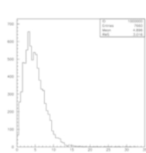
- Lato "diamante" pronto, lato "tracker" design finale

MIMOSA tracking

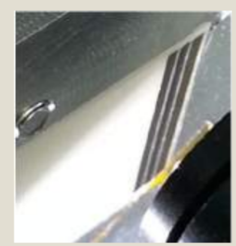
- Based on MIMOSA M28 (monolithic active pixel, 0.35 μm technology), by IPHC Strasbourg, but **in vacuum** (never implemented, so far)
  - 20.8 μm pitch, 20.2×22.7 mm² area
  - 50 μm thickness
- Mechanics and cooling
  - Linear stage mirrored from the diamond side
  - Support and cooling structure details **designed**
  - New board and cooling support **being produced** for final testing
- Sensors: OK
- DAQ, software
  - In advanced development: **April 2017 test-beam**

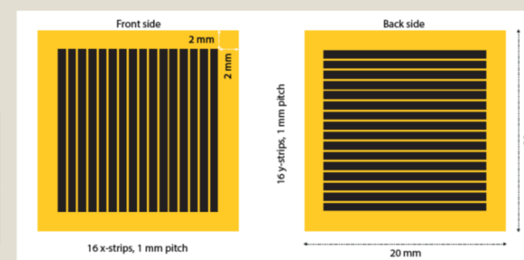






PADME diamond target





- Diamond is the rigid material with the best ee(γγ)/Brem. ratio (Z=6)
- Measure charge and position of 5000-10000 positron/bunch
  - Below millimeter precision in X-Y coordinates
  - Better than 10% charge measurement
- Polycrystalline diamonds 50-100 μm thickness:
  - 16x1mm² strip and X-Y readout in a single detector
  - Readout strips are graphitized by using a laser to avoid metallization
  - PADME prototype 50μmx20×20mm² produced and tested in October 2015

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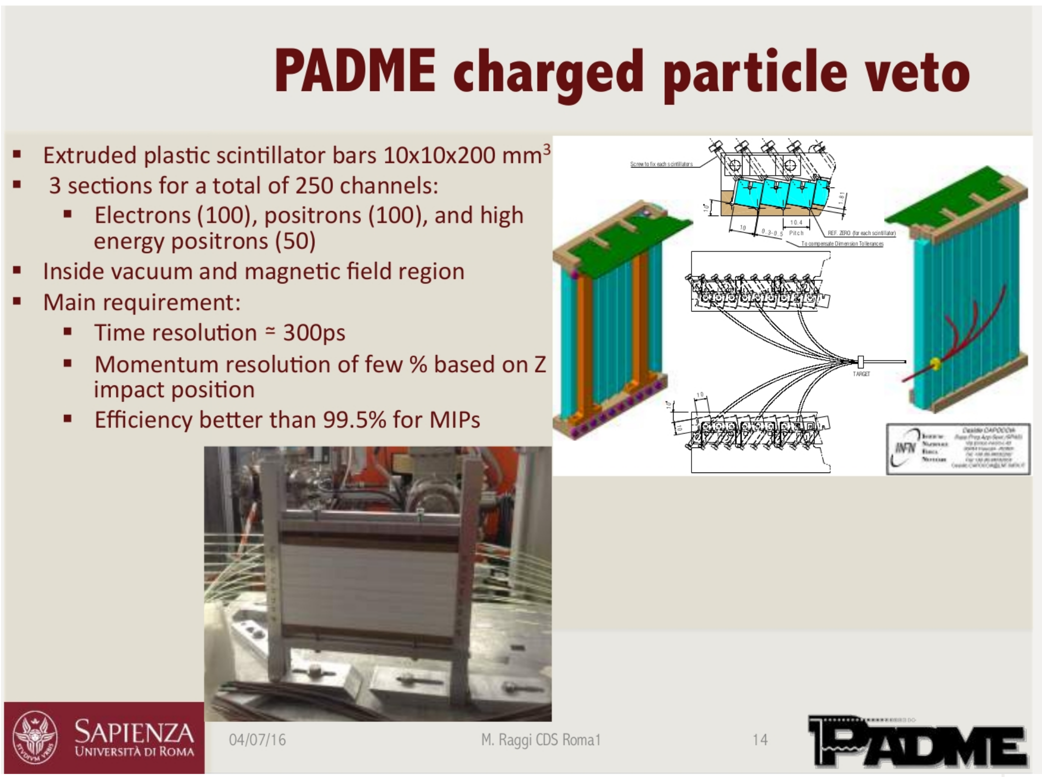

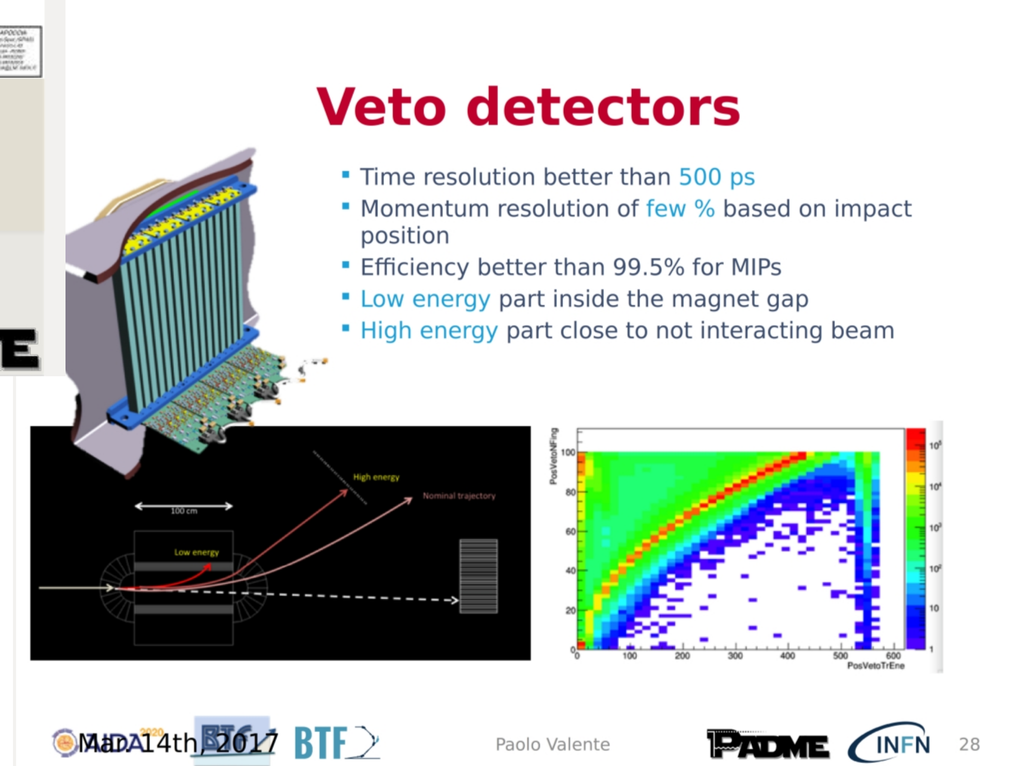

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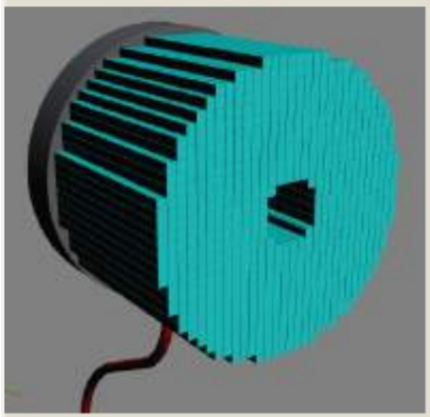
PADME ECal



Parameter:	ρ	MP	X_0^*	R_M^*	dE^*/dx	λ_I^*	τ_{decay}	λ_{max}	$n^\natural$	Relative output†	Hygro-scopic?	$d(LY)/dT$
Units:	g/cm^3	°C	cm	cm	MeV/cm	cm	ns	nm				%/°C‡
NaI(Tl)	3.67	651	2.59	4.13	4.8	42.9	245	410	1.85	100	yes	−0.2
BGO	7.13	1050	1.12	2.23	9.0	22.8	300	480	2.15	21	no	−0.9
BaF_2	4.89	1280	2.03	3.10	6.5	30.7	650^s	300^s	1.50	36^s	no	-1.9^s
							0.9^f	220^f		4.1^f		0.1^f
CsI(Tl)	4.51	621	1.86	3.57	5.6	39.3	1220	550	1.79	165	slight	0.4
CsI(pure)	4.51	621	1.86	3.57	5.6	39.3	30^s	420^s	1.95	3.6^s	slight	−1.4
							6^f	310^f		1.1^f		
$PbWO_4$	8.3	1123	0.89	2.00	10.1	20.7	30^s	425^s	2.20	0.3^s	no	−2.5
							10^f	420^f		0.077^f		
LSO(Ce)	7.40	2050	1.14	2.07	9.6	20.9	40	402	1.82	85	no	−0.2
$LaBr_3$(Ce)	5.29	788	1.88	2.85	6.9	30.4	20	356	1.9	130	yes	0.2

- Cylindrical shape: radius 300 mm, depth of 220 mm
  - Inner hole 60-80 mm radius
  - 656 crystals 20x20x220 mm^3
- Material BGO: high LY, high ρ, small X_0 and RM, long τ_{decay}, (free form L3 calorimeter)
- Expected performance:
  - $\sigma(E)/E = 1.1\%/\sqrt{E} \oplus 0.4\%/E \oplus 1.2\%$ superB calorimeter test at BTF [NIM A 718 (2013) 107–109]
  - $\sigma(\theta)$ ~ 1-2 mrad
  - Angular acceptance (20 – 75) mrad

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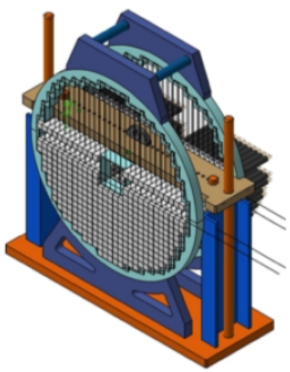
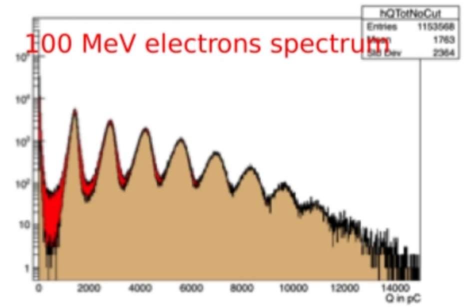
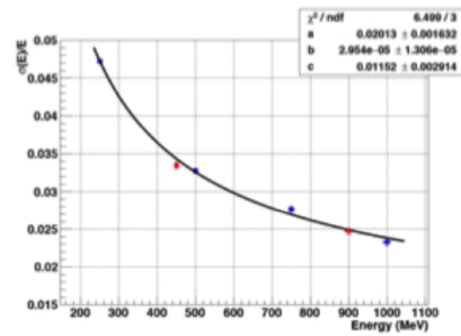
~600 cristalli BGO

Calorimetro







Nucl.Instrum.Meth. A862 (2017) 31-35

- Several **test-beams** for validating PMT and divider choices, paint, glue, assembly procedure…
  - Results in line with expectations from L3 experience: ≈2% at 1 GeV, excellent linearity up to ≈1 GeV
  - Moreover, 13 pC/MeV, 5±1 pC pedestal: threshold well below 1 MeV
- Conclusions:
  - HZC XP1911 PMT's OK; divider type "B" OK
  - 80 μm paint sufficient for light tightness at **few % level**, OK from the mechanical point of view
  - Add TEDLAR foils (50 μm) for dropping optical cross-talk to **zero**
    - **Recuperati alcuni mq (sufficienti a tutto il calorimetro) a costo e tempo zero da LHCb: GRAZIE!**
  - Polished surfaces of cut crystals OK
  - **No radiation damage on PMT's**
  - Radiation damage on BGO at the dose level expected from literature **recovered** by high temperature annealing

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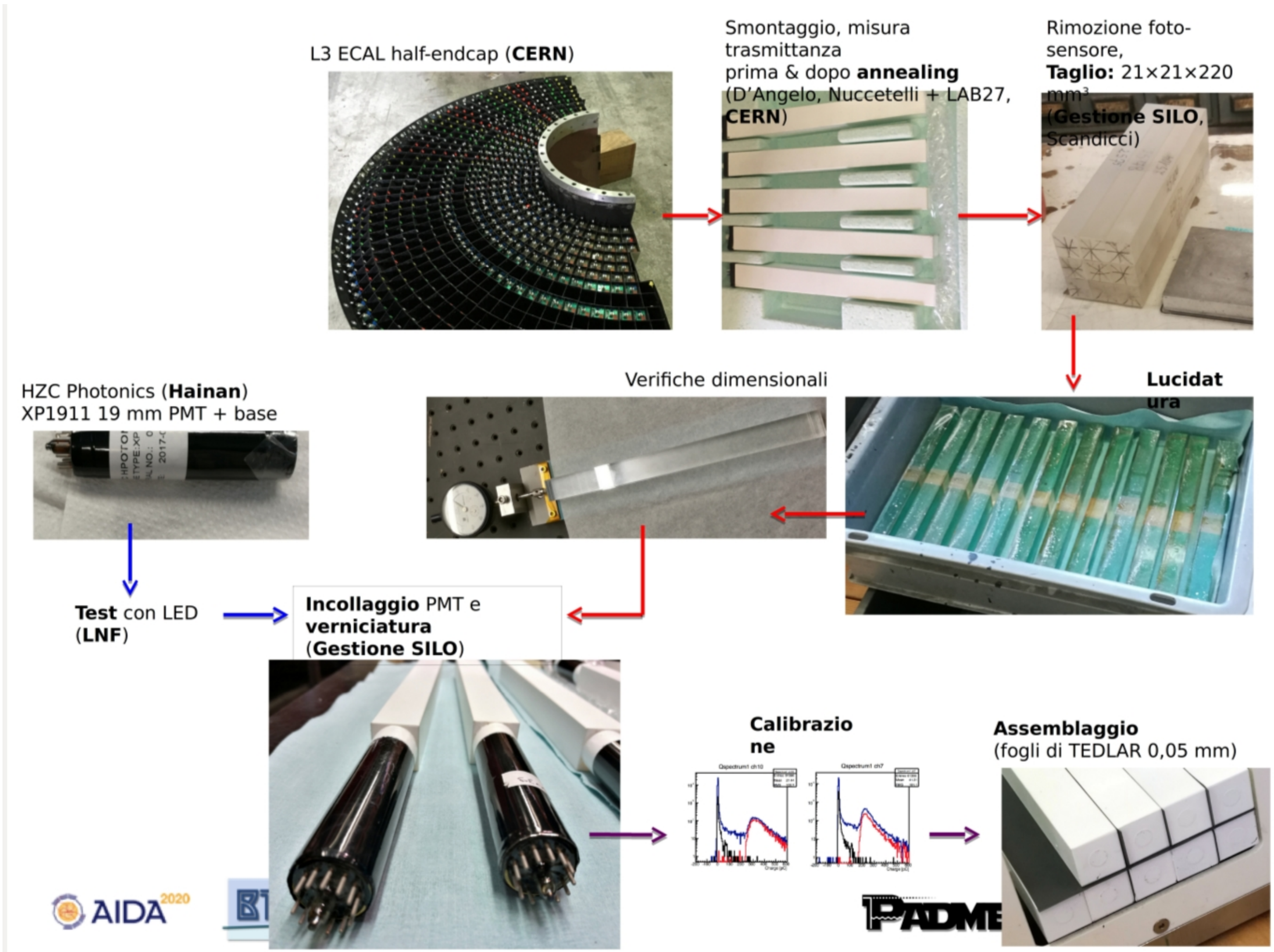

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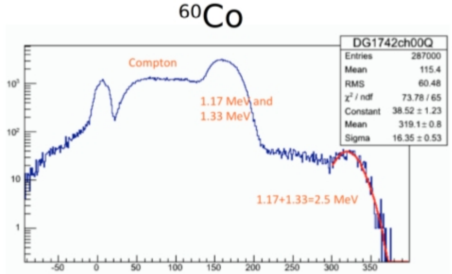
Calorimetro QA/QC

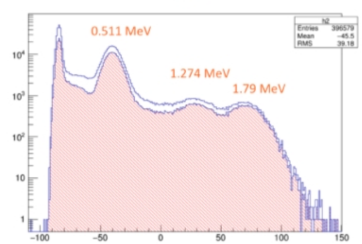
Belle-II lab, ed. 29

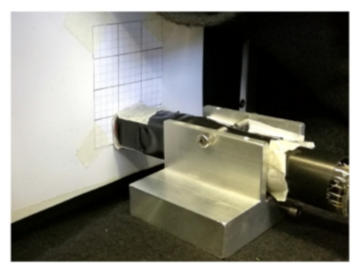
- Quality assurance/control & calibration:
  - LED pulsing for **PMT QA/QC** and gain measurement
  - Cosmic rays/radio-active source test-stand for finished crystal+PMT **assemblies calibration**

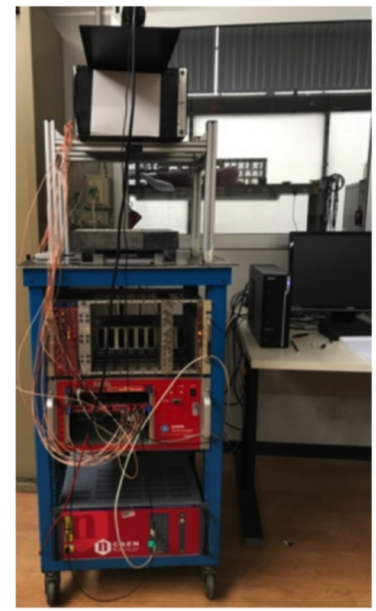
^{60}Co



^{22}Na







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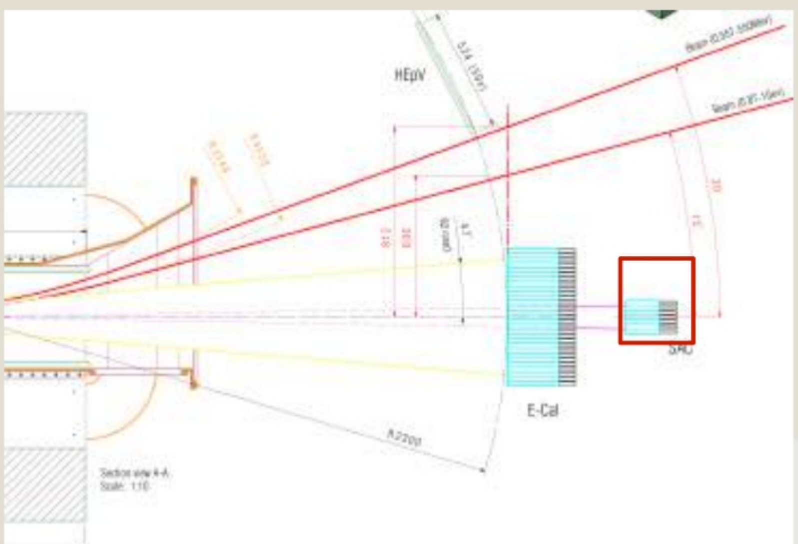
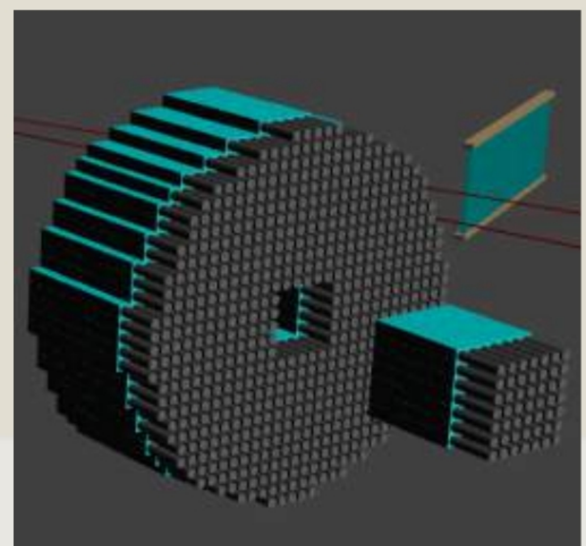
Small angle calorimeter

- BGO calorimeter cannot tolerate the Bremsstrahlung the rate in the very central crystals
  - Inner hole 4-8 cm radius
- Small angle calorimeter aim to tolerate a rate of the order of 10 clusters per 40 ns
- The only fast enough inorganic crystal is BaF2 with a fast PMT readout
  - Test of the maximum tolerable rate and double pulse resolution with CAEN V1742 in July
- Can a Cherenkov radiator be used?





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Summary/2

- **Installation of PADME**
  - PADME dipole should enter the BTF hall **before** the installation of the BTF new lines
  - Operation of PADME dipole requires power cables and cooling pipes
    - Existing cables and pipes probably OK per the PADME magnet but not enough also for the new BTF magnets
  - **Most** of the operations for PADME installation can be performed **independently** from the BTF new lines **installation**
  - **Critical to complete PADME setup construction by the end of 2017**
    - **3 months overall for installation and commissioning in the BTF hall, taking into account interference with BTF upgrade activities**
- **Interference**
  - **Commissioning** of the new BTF lines will require **closing the experimental areas**, thus stopping all PADME installation activities (a few days also needed for installation of shielding blocks in the access area)
  - **Early completion of PADME installation** implies more time available for testing, **both** for the new lines commissioning and for **the LINAC optimization** (for the **PADME positron beam**)
  - In principle installation of PADME and components of new lines are **compatible**, apart from obvious incompatibilities: usage of crane, access to PADME area with large components after second line installation, etc.

BTF e PADME teams

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